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Underground Distribution Sensors

Industry Scan on Distribution Systems Sensors

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Technical Update, March 2009

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PRODUCT DESCRIPTION

Rising costs of new infrastructure, increasing demand, and a declining number of available workers will drive utilities to operate as efficiently as possible. The practice of overbuilding infrastructure to improve or maintain reliability will be viewed as cost-inefficient. Utilities will be forced to operate distribution systems more dynamically and efficiently. Distribution sensors will help provide the needed information to utilities to achieve the goal of dynamic efficiency. The Underground Distribution Sensor Project evaluated the present state of medium-voltage distribution sensor technology by conducting an industry scan and identifying cost-effective and usable sensors in real-world application and sensor technologies that could evolve into usable devices for the future of distribution system monitoring.

Results and Findings

Recent developments have been made in faulted circuit indicators, temperature-sensing technologies, current-sensing technologies, and devices that combine multiple sensors into a single integrated unit with embedded communication capability. Many of these devices are hot-stick mountable, self-powered, and have several methods of data communication. These allow the sensors to be mounted anywhere in the distribution system.

As an example of how this technology could be applied, a device with integrated conductor-temperature sensing, current sensing, and Global Positioning Satellite (GPS) data could report a fault with the fault location, saving person-hours required to locate the faulted line. Other devices near the fault location report real-time conductor temperature and current, allowing operators to switch circuits appropriately and to return service to customers while the fault is being repaired, saving lost revenue and person-hours.

Another recent development is distributed fiber-optic temperature sensing, which allows real-time monitoring of conductor temperature with temperature accuracy of 1°C and location resolution of 1 m. Deployment of this technology combined with communications capabilities would allow utilities to load conductors to the maximum allowable temperature rating, if needed.

All sensors located while conducting this study were compiled into a Microsoft Access™ database with a brief description, Uniform Resource Locator (URL), manufacturer, product name, and approximate cost at the time the scan was conducted. All notes compiled during the research portion of the project are contained in a Microsoft OneNote™ file and a similar Hypertext Markup Language (HTML) document, both containing the same information.

Challenges and Objectives

Utilities interested in operating their distribution systems more efficiently and dynamically would benefit from the information contained in this report, the corresponding Microsoft Access database, and the Microsoft OneNote file. This information will allow utilities to choose an applicable distribution sensor or device based upon their system monitoring needs or desires without having to conduct product and cost research. The database and OneNote file will allow users to browse approximately 90 devices that are currently available, in development, or planned for future development. Further funding of similar projects to maintain and update the

database is important. Keeping an up-to-date record of distribution sensors currently available and in development would better equip utilities to choose the most cost-effective solution based on their distribution monitoring needs.

Applications, Value, and Use

The move toward a smart grid is fast approaching, and the need for real-time distribution system monitoring will greatly increase. Real-time management of the electric distribution system is the key result of the utilization of these types of sensors. The real-time data acquired from these sensors will reduce lost revenue and person-hours required to locate and repair faults. The data gathered from the sensors can be analyzed to diagnose problems and reduce future outages.

The distribution sensor market has a relatively small number of products currently available; however, technology in this area is advancing rapidly. Research shows that many promising integrated sensor devices are currently in development or testing. This market will be valuable as the need for real-time information is required for utilities to operate more efficiently and manage power distribution and rerouting more effectively.

Approach

This report aims to identify the distribution sensor technologies that are most likely to be used in real-world applications and those that could evolve into usable devices in the near future. This goal was achieved by conducting a widespread industry scan and patent search of distribution sensors and technologies. Sensors were then separated into the following eight categories: voltage, current, temperature, acoustic, vibration, optical, radio frequency interference (RFI), and corona. The results of the scan were analyzed, and those sensors or technologies deemed to be useful were further researched. The results were then analyzed using a cost-benefit analysis approach. The sensors that qualified as cost-effective were selected for testing, and the sensors deemed non-cost-effective were evaluated for potential future use. Many sensors in the non-cost-effective category were found to offer promising applications but are still in testing phases or were currently more expensive relative to the benefit(s) that they provided.

EPRI Perspective

The research findings yielded sensors from the underground and overhead distribution systems, and all are included in the results. Testing of the selected set of sensors will ramp up in 2009 at EPRI's Lenox, Massachusetts, laboratory.

Keywords

Distribution automation (DA)
Distribution monitoring
Distribution sensing
Sensors
Smart grid
Smart sensors

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INTRODUCTION

Electric power systems around the world have evolved from regulated monopolies toward a deregulated environment that consists of competing power producers and power marketers. The ability to operate competitively in this environment while maintaining an acceptable level of reliability is a major challenge for many in the power industry. In the process of moving toward a reliable, environmentally sound and affordable electricity future, sensors have played a vital role in improving safety, reliability, productivity, and energy efficiency. Sensors are widely used not only to monitor critical parameters of power systems, but also to monitor the condition of equipment. Today, sensors are becoming an indispensable part of power grids, with increasing numbers of applications every day.

This introductory section provides an overview of sensor technology and recent progress. It further summarizes the status of sensor applications in various areas of power delivery, with particular emphasis on its applications in condition monitoring. Gaps and development needs are discussed, and an outlook of future directions is also presented.

Business Drivers

In this deregulated, competitive world, utilities face numerous unprecedented challenges. Utilities need to control operational and maintenance costs while improving reliability, availability, and sustainability. Furthermore, utilities urgently need to manage risks and uncertainties for stakeholders while meeting increasingly stringent environmental and societal requirements. On top of all of these challenges, the nation's power infrastructure is aging. For example, the average service age of power transformers in North America is over 35 years, rapidly exceeding their original design limits. Managing the reliability of fleets of aging infrastructure is a daunting task. Any unplanned transformer outage can result in severe consequences, not only a substantial loss of revenue due to lost availability, but also costs of replacement and other associated maintenance expenses. These costs have continued to increase every year. Life extension and end-of-life management are two popular topics that have attracted considerable attention across the industry. In recent years, great emphasis has been placed on increased power flow in existing networks, which means critical assets may have to work even harder. This would lead to a reduction in the safety margin between normal operation and design limit. Indeed, the increasing demand for electricity is pushing the aging power grid to the breaking point and an unsustainable state.

"Business as usual" is not an option. In response to this situation, condition monitoring has emerged as an important enterprise solution as part of an asset management and operation and maintenance (O&M) strategy. Consequently, a wide range of sensors is being developed and deployed in many areas. The ability to monitor the performance and condition of critical equipment enables a shift from traditional time- and usage-based maintenance to condition-based maintenance (CBM).

Although equipment condition monitoring is the main theme for sensor applications in high-voltage transmission and substation areas, the primary sensor-related efforts in distribution systems are more system-oriented, focusing on fault detection and on smart metering for energy efficiency. Today, many utilities still rely on customers to report power failures and the location of these failures before crews are dispatched. Customers must also contact the utilities by telephone to learn the status of power restoration in their area. In addition, electricity consumption is measured mainly by analog meters at the consumer site, which are read manually on a regular basis. New development of fault detection/location, smart metering, and other sensor applications would substantially improve the productivity and efficiency in this area of outage detection and restoration.

With comprehensive deployment of sensor technology, the control and automation of power systems have evolved to a new level. Consequently, the reliability, productivity, grid efficiency, and demand management are considerably improved, in areas from transmission, substation, through distribution, all the way to customers.

The following are benefits of sensor applications in condition monitoring:

- Improve reliability through significant reduction of in-service catastrophic failures, which is important to personnel safety, revenue generation, environmental impact, and quality of power supply.
- Reduce costs by avoiding catastrophic losses and by reducing maintenance activities through the use of CBM strategy.
- Manage and reduce operational risks during emergency overloads; allow utility to overload equipment without significant loss of equipment life. (This will tend to maximize equipment utilization and extend its service life.)
- Provide relevant condition assessment data to key stakeholders (operation, maintenance, and planning), enabling business decisions to be made for either on-site refurbishment or replacement.

The following are possible considered applications of distribution sensors:

- Fault detection
- Fault localization (GPS)
- Power quality
- Cable insulation condition monitoring
- Equipment condition monitoring to monitor condition of critical equipment, including the following:

Power transformers
Geographic information system
Switchgear
Insulators
Cables

- Load monitoring and equalization
- Equipment diagnostics
- Temperature monitoring (transformer/conductor)

The following are benefits of monitoring distribution system parameters:

- Locating faults—reducing the time between fault occurrence and repair completion
- Detecting and relieving conditions that might otherwise lead to faults
- Enabling CBM
- Enabling dynamic loading

Key Parameters

Among all sensor applications, there are mainly two types of parameters: electrical parameters and non-electrical parameters. Electrical parameters include voltage, current, active and reactive power, harmonics, and transients. Non-electrical parameters include temperature, moisture, pressure, vibration, acoustic (ultrasonic), dielectric properties (for example, dissipation factor and permittivity), gases in headspace, dissolved gases in oil, photo-optical effect, mechanical stress and strain, displacement, and motion/speed.

In general, parameters that reflect system conditions and power quality are electrical parameters. Those used for equipment condition monitoring have a mix of electrical and non-electrical parameters. For instance, partial discharge (PD) detection may be conducted based on either electrical or acoustic signals from high-voltage equipment.

Challenges

In power delivery applications, sensors often operate in harsh environments. For outdoor applications, sensors are exposed to ultraviolet (UV) radiation, electromagnetic fields (EMFs), contamination, rain, snow, and extreme temperatures from –30°C to over 100°C in some cases (for example, if mounted on the top of a fully loaded transformer). Robust enclosure/packaging is important to ensure performance under these conditions. Although considerable progress has been made in the past two decades for sensor applications in power delivery, there are still gaps compared to the applications in other industries (for example, auto industry).

Several major challenges and drawbacks still hinder massive adoption of sensor technology in the electric utility industry. They are as follows:

- Reliability of sensors is most crucial to the success of sensor applications. One of the major concerns is the ability to maintain specified functionalities whenever they are needed. This means that sensors must be not only robust in a wide range of external environments, but also immune to long-term instability due to aging and drifting.
- Cost of sensor applications is a primary driver in adopting sensor technology. To be cost-effective, sensors must demonstrate life-cycle savings and a relative quick return on investment. Although premium on-line systems have been successfully deployed for critical

assets (such as generator step-up [GSU] transformers), they are still prohibitively expensive in many other equipment applications. Until alternative low-cost sensor systems are available, affordability is the major limiting factor for widespread deployment of sensors in the power delivery industry. A deployment decision based on risk versus cost (or return on investment) would always have to be made.

- Installation/maintenance of sensor systems is not a trivial task. It affects not only the total cost of applications, but also plays an important role in the performance of the sensor systems. Because a great portion of sensor applications are retrofits to existing equipment, sensor installation with minimal impact on system operation is much needed. Simplicity is a highly desirable attribute for installation and maintenance of sensors. With the advent of ad hoc wireless networks, "plug and play" of new sensor applications becomes feasible. Sensors detect each other and hence form a wireless network.
- Data management is also a critical part of sensor systems. Paradoxically, O&M personnel often face the problem of having too much data and too little information upon which to act. The large amount of data collected through on-line monitoring could be overwhelming and burdensome if not processed properly. Data communication, storage, trend analysis, visualization, and diagnostic algorithms must be effectively integrated into a single system. More importantly, the integrated system must generate actionable information to allow operators or maintenance personnel to respond as the situation requires.
- Location of sensors, particularly those installed on high-voltage transmission lines and high-voltage cables, are located far apart from each other. It is both technically and financially challenging to form a hard-wired distributed sensor network. In addition, sensors in power delivery applications are often operated under high voltage and in high electric stress environments; therefore, high-voltage isolation and operation free of PDs/corona are required. These increase the complexity and cost of sensor systems. Some sensor technologies might no longer be a viable solution based upon these requirements.

Once the industry confronts and makes progress in resolving these challenges, it is anticipated that wide-scale deployment of sensors will be achievable, and the benefits of this technology can be realized.

The Future

To support the reliable, environmentally sound and efficient electricity future, it is vitally important that utilities are able to timely and accurately evaluate the conditions of equipment and power systems whenever needed. To achieve this, future or new sensors have to show the following:

- Robust and reliable enough to operate under harsh environments through the life-cycle of the equipment
- Inexpensive enough that the utility can install sensors on most equipment and cost-effective to form distributed sensor networks
- Effective enough to enable improvements in reliability and performance of equipment

The development of such sensors will ultimately drive the wide applications of the continuous monitoring of transmission and distribution assets (for example, transmission lines, towers, poles, insulators, cables, transformers, and breakers). In addition to advances in sensor networks, significant progress is expected in the development of low-cost sensors and in data fusion and diagnostics. In general, new developments in monitoring systems have been moving from data acquisition to data interpretation, so that more actionable information can be generated and made available to operators.

The Energy Policy Act of 2005, rising energy costs, and an increase in demand for power are some of many catalysts for utility companies to strive to operate and manage power distribution systems more efficiently and effectively. There are many solutions to this problem. Potentially, the most promising solution is the dynamic operation of the power system. To execute this dynamic power management solution, a utility must have intelligence on what is actually occurring in its distribution system in real time. This intelligence must come from sensors monitoring key parameters throughout the distribution system. This project conducted a survey and industry scan to evaluate the state of the industry in medium-voltage (MV) distribution sensors. In conjunction with the state-of-the-industry evaluation, this report identifies usable, cost-efficient distribution sensors, and future sensors or sensor technologies that could prove even more useful in implementing this solution.

2
SENSOR OVERVIEW

A sensor is a device that responds to a physical, chemical, electrical, or optical quantity and produces an output that is measurable. Sensors have applications in most engineering and scientific domains, and new applications are introduced every day. Typical uses for sensors include process control, laboratory, test and scientific research, general industrial applications (for example, condition monitoring), military and aerospace, healthcare, environmental applications, the automobile and building industries, and consumer markets. Noticeably, there has been a significant increase in sensor applications in the automobile industry and consumer markets in recent years.

Sensors are typically classified into the following types, based on the type of energy they sense:

- Thermal sensors
  - Heat sensors
  - Temperature sensors (such as thermocouples, thermostats, and resistance temperature detectors [RTDs])
- Electromagnetic sensors
  - Transducers/devices for measuring current, voltage, or power
  - Sensors for electric field or magnetic field
  - Radar
  - Radio frequency interference (RFI)
- Mechanical sensors
  - Displacement and dimensional
  - Velocity or flow-rate
  - Acceleration
  - Mass (weight/density)
  - Force (stress, load, pressure, torque)
  - Acoustic
  - Other quantities (such as viscosity, hardness, dielectric properties)
- Chemical sensors (such as gas sensors)
- Optical radiation sensors
  - Infrared (IR) sensors
  - Fiber-optic sensors
  - Photodetectors
- Radiation sensors (such as Geiger counter)

Regardless of the classification, the following characteristics are important to sensor design and its application:

- **Sensitivity**: A sensor should be sensitive enough to provide meaningful results of detection.
- **Selectivity (applicable to chemical sensors)**: A sensor should have the ability to detect a specific specie with minimal interference from the other species.
- **Rate of response**: It is desirable to have a short response time, namely in seconds or minutes, depending on the application.
- **Accuracy**: The measurement should be close to the actual value detected. Regular calibration would ensure the accuracy of a sensor through its life-cycle.
- **Reliability**: A sensor should be able to operate reliably with minimal maintenance. Its response should be stable with minimal drifting during its life-cycle.
- **Simplicity**: A sensor or sensor system should be relatively easy to install, calibrate, and maintain in the field.
- **Affordability**: It is desirable to have a low total life-cycle cost for a sensor application.

Sensor technology has benefitted tremendously in recent years from advances made in semiconductors, fiber optics, optoelectronics, material science, and network/communication technology. New generations of sensors have been smaller, cheaper, more reliable, and have provided more and better functions. Some offer an integrated solution with **onboard** sensing, signal conditioning, and microprocessor capability on one chip. Indeed, sensors are a technology enabler for early detection, smart process control, and many applications that make a difference in the lives of many.

Rather than including an exhaustive review of all sensors and sensor technologies, the following discussion provides an overview of the fundamentals of some important sensors, their industrial applications, and highlights of recent progress made in the area. Of the sensor categories previously mentioned, eight distinct categories have been identified as particularly important to power distribution systems. These categories are voltage, current, temperature, vibration, corona, acoustic, optical, and RFI.

Gas Sensors

Gases are key measurements to monitor in many industries or domestic activities. Traditionally, analytical instruments, such as the mass spectrometer or chromatography, are used for gas analysis. However, these devices are expensive, cumbersome in size, complex in sample preparation and testing procedure, and time-consuming to use. Hence, it is hard to use the equipment for a real-time, on-line purpose, but rather for analysis in a laboratory environment. In response to the growing demand for gas detection and monitoring, solid state sensors have emerged as one of the major developments in the past decades. Two important groups of gas sensor applications are sensors for detecting single gases (for example, NO_x, CO, H_2, O_3, SO_2) and multisensor systems for discriminating odors or monitoring of general environmental changes. Sensors and sensor systems provide vital information for gas leak alarm, pollution monitoring, process control, and many other applications. They have become increasingly important in automobile, safety, environmental, food, healthcare, and industrial process control.

Sensitivity, selectivity, reliability, and the rate of response are critical performance characteristics for selecting gas sensors. Sensor structures and materials play an important role in the aforementioned sensor characteristics. Solid state gas sensors are designed and operated through varieties of principles and materials. As shown in Table 2-1, solid state gas sensors can be divided into six different classes. A brief discussion of several major solid state gas sensors is presented, because the information can help determine their applicability in detecting chemical by-products for high-voltage equipment condition monitoring.

Table 2-1
Types of solid state gas sensors with their principal detection mechanisms

Type of Sensors	Physical Indicators
Semiconductor gas sensors	Electrical conductivity
Field effect gas sensors (diodes, transistors, capacitors)	Work function (electrical polarization)
Piezoelectric sensors: surface acoustic wave, microcantilevers	A change in resonant frequency as a result of a change in mass
Optical sensors (fiber optical, thin film)	Optical parameters: reflection, interferometry, absorption, fluorescence, refractive index or optical path length
Catalytic gas sensors (Seebeck effect, pellistors, semistors)	Heat or temperature
Electrochemical gas sensors (potentiometric or amperometric)	Electromotive force or electrical current in a solid state electrochemical cell

Semiconductor Sensors

Semiconductor sensors, also known as *chemoresistive sensors*, are based on surface interaction between gas and a metal oxide surface. Both n-type (for example, S_nO_2) and p-type semiconductor oxides can be used as sensing materials for detecting different target gases, such as CO, CO_2, H_2, O_3, NO_x, and H_2O. The gas sensors detect gases from a change in the electrical resistance of a porous sensing component, based on the following mechanisms: (1) when in a reducing atmosphere, the absorbed oxygen atoms react with ambient molecules, releasing the trapped electrons to the sensing material, resulting in a decrease in resistance; and (2) when in an oxidizing atmosphere, oxygen atoms adsorb in the surface region of material and trap free electrons from the conduction band of the semiconductor, resulting in an increase in resistance. The working temperature at which these sensors are most efficient may vary depending on the sensing materials and target gases in the ambient. A heating element is often incorporated as part of a sensor, because operating temperatures usually range from 200°C to 400°C. A typical semiconductor gas sensor consists of a substrate in alumina or silicon, sensing layer, heater, and electrodes.

In general, these gas sensors have advantages of low cost, small size, and good sensitivity for a wide range of gaseous species. Furthermore, they can be easily integrated into a monitoring system in a cost-effective manner. Although they have enjoyed fast growth in many application areas, their selectivity and long-term stability are two major challenges that must be surmounted. For instance, a drift can be caused by changes in physicochemical properties of sensing materials. These changes are mainly microstructural and morphological in nature (such as size, number, and distribution of grains and intergranular boundaries in sensing elements), but they are also possible due to irreversible reactions with chemical species in the ambient surroundings. To address the long-term stability issue, a thermal pretreatment is introduced during the manufacturing process. The calcinations process can help reduce the material instability during the life of a sensor. Regular calibration is an important step to ensuring the long-term stability of sensors. A typical life expectancy of semiconductor sensors is about 10 years. Several mitigations (such as filters, catalytic additives to sensing materials, and optimization of sensing material and operating temperatures for specific gases) can be effectively used to improve the sensor selectivity under a mixed gaseous environment. The advent of nanostructured materials and the means to fabricate or pattern structures at the nanoscale have further paved the way for enhanced novel sensing capabilities with greater sensitivity, selectivity, and stability.

Field Effect Sensors

Similar to semiconductor gas sensors, field effect sensors are another class of solid state gas sensors seeing increased popularity in recent years. A field effect sensor consists of the following three elements: (1) a layer of catalytically active metal, such as platinum or palladium (Pd), whose outer surface is exposed to the target gases; (2) a layer of dielectric material, typically silicon dioxide or alumina; and (3) a doped silicone substrate. Depending on the configuration of these layers and connections to the external circuit, sensors can function as a capacitor, a transistor, or a resistor. Taking metal-insulator-semiconductor hydrogen sensors as an example, hydrogen is adsorbed to the surface of a platinum layer. A hydrogen molecule will further dissociate into two hydrogen atoms, which will diffuse rapidly through the catalytic metal layer. When hydrogen atoms arrive at the metal-dielectric interface, they are chemically bonded at the interface sites. This results in a shift of the work function at the metal oxide interface. The sensing mechanism is therefore essentially set to detect the property change related to the shift of the work function. Platinum and Pd are widely used in hydrogen sensing because they show a high and selective affinity for hydrogen.

IR Sensors

Because of their inherent advantages of immunity to EMF and insensitivity to environmental variations, optical sensors are being used with increasing popularity. Benefiting from the advances in optoelectronics, the use of IR technology in gas detection is becoming a viable and cost-effective solution today. IR sensors are capable of detecting many single or multiple gases that have absorption spectra in the near IR region. By transmitting a beam of IR radiation through the air, or through any particular gas volume, and detecting how much is transmitted at selected spectral lines, one may decide which gas species are present and how much of each. Most gases have their characteristic spectra in the IR. Those spectra derive from the molecule's composition in such a way that no two gases have the same IR spectrum. IR spectra are the

fingerprints of gases, and thus allow gases to be uniquely identified. The technology is only for gases whose molecules contain two unequal atoms. Hence, IR sensors are not applicable to gases such as hydrogen (H_2), nitrogen (N_2), oxygen (O_2), and noble gases.

Optical Gas Sensors

Optical sensors are also used for detection of gases. One example is the Pd-based hydrogen fiber optical sensor. Pd and its alloys are used in hydrogen sensing due to their high and selective affinity for hydrogen. When exposed to hydrogen, Pd experiences a volumetric expansion roughly proportional to the hydrogen concentration in the environment. This volumetric expansion can be measured optically either through monitoring the hydrogen-induced strain with a fiber Bragg grating (FBG) interrogation system or through monitoring the hydrogen-induced change of a refractive index (of Pd) with a refractive index sensor. The techniques described here have shown significant potential for optical sensing of gaseous hydrogen in the low-concentration regime necessary for long-term monitoring.

Optical Fibers

Optical fiber sensing is one of today's fastest developing technologies. The significant advantages that optical fiber sensors hold over conventional sensors for component testing, design validation, and structural health monitoring have long been understood. However, it is only in recent years that this unique technology has sufficiently matured to find true commercial application.

Typical optical sensors contain optical fiber, one or more optical sources, and a modulation scheme by which the measurand introduces a change in the optical signal that can be sensed at the detector and through the signal processing scheme used. Optical sensors can be divided into the following two groups: intrinsic or extrinsic. In intrinsic sensors, the interaction occurs within an element of the optical fiber itself, whereas with extrinsic sensors the optical fiber is used only to couple light, usually to and from the locations where the light beam is influenced by the measurand. In other words, sensing elements are part of the fiber for intrinsic sensors but external to the fiber for extrinsic sensors. Depending on the arrangement of sensing elements, the three major sensor schemes are point, distributed, and quasi-distributed. In distributed sensing, the measurand can be determined along the length of the fiber itself. This principle has been used in the measurement of temperature using nonlinear effects in fibers, such as Raman scattering. In the third type of sensing style, quasi-distributed, the measurand information is obtained at particular and predetermined points along the length of a fiber network. Here, the fiber has been sensitized or special materials have been introduced into the fiber loop to allow the measurement to be taken; this technique has been applied to temperature and chemical sensing.

Major advantages of optical sensors include the following: (1) great long-term stability under harsh environments (largely immune to electromagnetic induction [EMI], high voltage, radiation, chemicals, and high temperatures); (2) compactness and lightweight; (3) perfect galvanic separation; and (4) potential low-cost production with technologies "spun off" from optical communication areas.

FBG Sensors

There have been increasing numbers of FBG applications in structure health condition monitoring in recent years, where quasi-distributed measurements for important physical quantities, such as strain, temperature, pressure, ultrasound, acceleration, high magnetic field, and force, are required.

The sensing elements, Bragg gratings, can be inscribed directly in a standard optical fiber at any position, and several of them can be configured in a series in one fiber or in a parallel on different fibers and interrogated from the same light source, enabling flexible sensor configurations. The length of an FBG is typically around 1 cm and a series of Bragg gratings works as a set of discrete point sensors at chosen positions. A standard telecommunication fiber is used, and the fiber acts as both a discrete sensing element and as a means to transport signals. Because FBGs are conveniently used in reflection, the light source and detection device can be instrumented in one unit. FBG sensors generally require a broadband light source and a high resolution, wavelength-shift detection system.

FBG sensors have been reported for measurements of strain, temperature, pressure, vibration, and dynamic magnetic field, mostly in structural health monitoring applications. The FBG central wavelength varies with the change of these parameters experienced by the fiber and the corresponding wavelength shifts. One of the most important applications of FBG sensors to date has been in so-called *fiber-optic smart structures*, where FBGs are embedded into the structure itself to monitor their strain and temperature distribution.

In addition to the advantages related to typical fiber-optic sensors, FBG sensors have the following distinguishing advantages:

- Insensitive to fluctuation of power and signal level, because detection is based on wavelength shift
- Small diameter cable bundles and penetrations
- Quasi-distributed sensing capability at multiple points over long distances (from meters to kilometers) through multiplexing technologies
- Multiparameter sensing capability

In comparison to conventional sensors like thermocouples and strain gauges, an FBG sensor network significantly reduces the amount of required front-end electronics and harness. An innovative FBG sensor network enables simultaneous monitoring of all relevant structural and thermal load impacts on structures by dynamic strain, temperature, and vibration measurements. Such smart structures act like a human nerve system in the form of many locally distributed measurement points, either along one fiber only or by applying secondary multiplexing techniques along several fibers. These data can be collected by a single central optoelectronic detector.

Although, currently, there is no direct application of FBG technology in monitoring high-voltage apparatus, its promising ability of multiplexing and multitasking is very attractive. For instance, the prospect of a single FBG system for monitoring internal conditions of a transformer is

fascinating, where multiple important parameters such as hot-spot temperatures, strains due to mechanical forces, vibration, pressure, acoustic emission due to PDs, and dissolved gases can be detected and mapped by FBGs along the path of an optical fiber.

Other Industry Applications

Several other sensor applications are worth noting. Although these examples are from other industries, the underlying principles and concepts serve as references and may be leveraged for applications in the power delivery industry.

Electronic Nose

Electronic nose systems monitor air quality and have many applications in the food industry. A typical electronic nose consists of an array of chemical gas sensors and a data analysis unit. Most gas sensors used in an electronic nose are either metal-oxide semiconductors or conducting polymer resistive materials. Output signals from sensor arrays are evaluated with a pattern-recognition software program. Oftentimes, a neural network is used for pattern recognition and classification.

One major challenge in this application is the cross-sensitivity of individual sensors under a mixed gases atmosphere, because the selectivity of most low-cost sensors is far from ideal. However, using an array of different gas sensors could create significant improvements in reliability and precision. Through a calibration process with different lead gases under various conditions, it is possible to eliminate or significantly alleviate the cross-sensitivity issue and to minimize effects due to the influence of operating environments (for example, temperature, humidity, and pressure). An accurate concentration measurement is achievable in spite of the deficiency of the individual sensors.

This technology is of practical interest; a similar data fusion strategy may be applicable to solving cross-sensitivity issues in a solid state-based dissolved gas analysis (DGA) system for power transformers.

On-Line Oil Analysis

Lubricant wear-debris monitoring is an important part of machine condition monitoring. In addition to an off-line oil sample analysis, on-line direct detection is frequently used. In such a system, the oil flows through a sensor that is sensitive to the wear debris. This system provides a continuous estimation of the machine condition. A fiber-optic system is used to detect small particles and to evaluate the oil contamination levels. The system consists of a light source, a lens system, a sample cell, an optical electrical detector, and a signal processing unit. When light passes through the oil cell, it is scattered and absorbed by contaminants (fine particles). The light is then collected by a photodetector. Based on the attenuation of light intensity, the contamination level of oil can be evaluated accordingly.

This type of simple on-line optical sensor would be very attractive as a means to prevent excessive degradation in oil insulation. Likewise, it can be used to assess the overall oil quality on load tap changers, circuit breakers, power transformers, and other oil-filled high-voltage equipment.

Automobile Sensors

Sensors have been applied extensively in controlling the powertrain, chassis, and vehicle body in today's automobiles. With massive deployment and over a hundred different sensors in use for each vehicle, it is truly a successful sensor story to tell. Operating under relatively severe conditions (temperatures from –40°C to 125°C, vibration, and shock impact), automobile sensors seem to live up to requirements in accuracy, reliability, interchangeability, and cost. An important milestone for automobile sensors was in the early 1980s when the first microelectromechanical systems (MEMS)-based sensors were developed for pressure measurement in the engine control. Subsequently, accelerometers to detect crash events for air bag safety systems and angular-rate inertial sensors for vehicle stability chassis systems were also later advanced with MEMS-based technology. Leveraging the low cost due to batch processing and on-chip intelligence, MEMS made incredibly high performance sensors available, at the cost comparable to that of conventional sensors.

Transformers

Power transformers have proven to be reliable in normal operation with a global failure rate of 1–2%. The large investment in generating capacity after World War II, and continuing into the early 1970s, has resulted in a transformer population, which in theory is fast approaching the end of life.

Power transformers are the single largest investment in a substation. They are essential to reliable electric energy flow and are also among the costliest assets in the electrical grid.

Core, windings, insulation oil, bushing, and on-load tap-changer are the main active parts of the transformer insulation chain. The degradation of insulation systems is accompanied by changes in physical parameters or in the behavior of insulation systems. The degradation of insulation systems is a complex physical process. Because there are many competing mechanisms involved, multiple parameters act at the same time, thus making the interpretation extremely difficult.

The aging process in the oil/cellulose insulation system under thermal stress and its measurable effects is the result of chemical reactions in the dielectric. The temperature of the oil/paper dielectric is the critical aging parameter that changes the mechanical and electrical properties of the material. As this aging progresses, cellulose insulation undergoes a depolymerization process. As the cellulose chain gets shorter, the mechanical properties of paper, such as tensile strength and elasticity, degrade. Eventually, the paper becomes brittle and is not capable of withstanding short-circuit forces and normal vibrations. This situation characterizes the end of life of the solid insulation. Apart from high temperatures, other important parameters that affect the aging of the solid and liquid insulation include the presence of water and oxygen in the system.

Typical failure modes that are associated with transformer components are as follows:

- **Core**: Overheating breakdown in core plate insulation leads to circulating currents and usually sparking at the fault.
- **Core bolt and core clamping structure**: Breakdown of insulation between parts of the clamping structure results in circulating current, possibly sparking. Breakdown of insulation between core and core clamps and the tank leads to spark (fault).
- **Windings and interwinding insulation**: Overheating due to poor joints is a common fault in any part of the electrical circuit. Breakdown of interstrand insulation results in circulating current, causing overheating of insulation and hot spots at the point of fault. This can be a result of winding movement. A turn-to-turn fault produces a similar effect but with much more energy and can usually be detected and identified, whereas there is currently no diagnostic test to identify a strand-to-strand fault.
- **PDs**: Discharges can develop between various parts of the insulation structure as a result of contamination (including moisture) or due to poor impregnation or overstressing. A fault between windings usually results in serious damage; a fault from line to ground also usually results in serious damage.
- **Tank, flux shields, and fittings**: The breakdown of insulation between portions of the tank shields or between the shields and tank can lead to circulating current; this will be a function of load current. PDs can be also initiated from the ground potential surfaces of the tank and parts mounted on the tank. Circulating current in the tank due to proximity of heavy current conductors can produce hot spots in the tank and across gasket joints.

System abnormalities, loading, switching, and ambient condition normally contribute toward accelerated aging and sudden failure. In the absence of monitoring of critical components, the failure risk is always high. For early fault detection and real-time condition assessment, an on-line monitoring system in accordance with age and conditions of the asset would be an important tool. After an indication of abnormality, it is important to carry out off-line tests and diagnostics to ascertain the overall integrity and assessment to avoid unscheduled outages, financial/revenue losses, and environmental/collateral damages.

Most power transformers have some form of basic monitoring capability. Voltage, current, load, temperature, and cooling status are the most common operational parameters that are available through built-in sensors/devices. More sophisticated sensor technologies are developed and applied to monitoring the condition of transformers. For example, sensors are used to detect moisture, dissolved gas in mineral oil, PDs, and dissipation factor for different failure modes. These on-line condition monitoring systems vary in the options and capabilities provided, and, consequently, in their cost.

On-line monitoring allows failures to be detected in their early stages, before a functional failure occurs. Compared to off-line diagnostics, continuous on-line monitoring is most advantageous because of its ability to determine not only the severity of condition deterioration in real time, but also the rate of deterioration. If a quick deterioration is observed, an immediate response is warranted. On the other hand, if a slow deteriorating condition is detected, a delayed response might be adequate.

Sensors used for transformer condition monitoring are discussed in the following paragraphs.

Temperature

Transformer aging and its loading capability are limited by the winding temperature. To prevent excessive overload, power transformers are equipped with built-in temperature sensors to monitor oil and winding temperatures. Top oil temperatures (both top and bottom oil temperatures for newly manufactured units) are measured directly by temperature gauges (for example, capillary thermometers or RTDs). Because hot spots inside windings are not accessible to a regular RTD sensor due to high voltage risks, an indirect system (winding temperature indicator or [WTI]) is used to measure the winding temperature. Inside a WTI, a specially designed heater is placed in the thermal bellow. Through the secondary winding of bushing current transformer, the heater is driven by the current proportional to the load current passing through the transformer winding. The measured temperature, called *simulated winding temperature*, is therefore equivalent to the winding temperature. It is calibrated by transformer manufacturers at full load. Although the primary function of temperature sensors is to provide temperature control for attached cooling systems (for example, heat exchangers or fans), their on-line monitoring capability has been leveraged for the purpose of condition monitoring and loading optimization. More and more, temperature sensors are incorporated as a part of a multiple parameter on-line monitoring system, because they have been proven effective in identifying issues related to overload or malfunction of cooling systems. Together with advanced algorithms, these sensors offer a greater potential for better life management and loading optimization.

The performance of WTI is optimized for steady state or slowly changing loads. Hence, its readings are at best heavily averaged values and might represent only overall thermal conditions inside the transformer winding. WTI sensors are subject to errors caused by different time constants of the WTI and the actual winding. Furthermore, they cannot precisely predict the actual hot-spot conditions in the transformer, which, ultimately, is the most important factor that affects transformer life and its loading. To meet this emerging demand, fiber-optic temperature sensors were developed for direct measurement of hot spots. In such applications, fiber-optic sensors are embedded in a slotted spacer or attached to a conductor at locations of interest. To accurately measure the temperatures of a conductor, the paper insulation would have to be removed from the conductor first and then rewrapped once the installation work is done. There are mainly two types of fiber-optic sensors used for hot-spot measurement. Both are extrinsic types of sensors, in which fiber only carries signals to an external point sensor. The first type of sensor is based on detecting a shift of absorption edge, which is temperature-dependent. A semiconductor crystal, such as GaAs, is attached to the end of fiber optics as a sensing element. When the temperature at the sensor tip rises, the absorption edge shifts toward longer wavelengths. The second type of sensor is derived from a fluoroptic mechanism, because fluorescent signal decay is also temperature-dependent. The hotter the temperature, the faster it decays. Much effort has been focused on improving the robustness of the sensors, and the progress is evident. Today the survival rate after sensor installation and manufacturing processing is no longer a big concern as it was before. Direct measurement of winding hot-spot temperatures with multiple fiber-optic sensors has become a standard in some utilities for their critical transformers.

One caution related to the fiber-optic sensors is that both sensors have to be installed at assumed/predicted hot-spot locations, because they are point sensors. There may be a difference between the measured values and actual hottest temperatures, in some cases. Nevertheless, this is an important advancement, compared to the WTI technology. One possible remedy is to develop an intrinsic type of fiber-optic sensor (for example, FBG), in which the fiber serves as distributed sensing elements. The distributed fiber-optic sensors can be installed along a relatively longer path along the areas of interest, where the temperature distribution will be mapped. Although this technology is used in other applications, its efficacy for transformer applications has yet to be verified. The cost of such a system is expected to be more expensive.

Moisture

Excessive moisture level is a problem for transformers. It decreases the dielectric strength, accelerates cellulose decomposition, and causes the formation of bubbles at high operating temperatures which could lead to a catastrophic failure. To prevent in-service failure and avoid excessive aging, the moisture levels have to be controlled within certain limits (preferably within 1% in paper insulation). The ability to reliably detect moisture level not only allows assessment of the health of a transformer but also offers opportunities to rehabilitate a deteriorating transformer through additional on-site dry processing. New moisture sensors based on capacitive probes are available for continuous on-line monitoring. The sensor essentially consists of two electrodes with a hydroscopic dielectric film in between. The moisture level in oil is detected by measuring the change of capacitance caused by moisture. Moisture sensors are usually calibrated to water activity/relative saturation. Moisture content in paper insulation can therefore be derived from the water activity using equilibrium diagrams. As an invaluable indicator of the health of high-voltage equipment, on-line moisture monitoring will continue to be used to assess the insulation condition. Sensors for moisture include the GE Hydran and the Serveron, among others. The GridSense Transformer IQ can integrate one of these and the bushing power factor sensors from OMI. OMI is also in the process of developing an on-line SFRA system.

Vibration

Vibration analysis is a useful tool to assess the transformer condition, particularly its mechanical integrity. Vibration can result from loose parts (for example, core segment and winding) or malfunctioning bearings in oil pumps or fans. Every transformer is different; hence, a baseline vibration test is beneficial for future comparison. In the case of winding displacement caused by short circuit or severe deterioration of solid insulation, the vibration will increase silently. The vibration patterns of a container and its contents can reveal significant information related to its operating environment and integrity during transport, handling, and storage.

Frequency Response Analysis

Displacement or distortion of the windings or lead structure of power transformers can take place due to short-circuit forces or loss of rigidity and tightness associated with shrinking due to insulation aging. Damage can also occur during transportation from a manufacturer to the field.

A severe winding displacement/deformation can cause a major internal dielectric failure with catastrophic consequences.

Winding deformation may be determined by either frequency response analysis (FRA) or low voltage impulse (LVI). Both methods are based on a comparison of the response of the transformer windings before and after damage. The FRA method uses a sweep generator to apply a sinusoidal voltage at different frequencies to the terminals of a transformer winding. Amplitude and phase of the winding impedances or admittance are plotted directly as a function of frequency. The LVI method considers the application of an LVI to the winding and records the applied impulse and the response at the remote end of the winding.

FRA tests are typically conducted on site with the equipment off-line. However, it is possible to accomplish this as on-line diagnostics with a proper isolation of equipment from high voltage.

Overall Oil Quality

Overall oil quality is important to the internal insulation. Although several diagnostic methods are available for testing oil samples from in-service transformers, the on-line capability to reveal the condition of transformer oil in a timely manner is still highly desirable, particularly if it is cost-effective. The Centurion monitor from Weidmann is an on-line monitor for oil dielectric strength. Using a pulse voltage, the energy of oil breakdown is controlled and, therefore, it can be used invasively to determine the oil dielectric. This monitor is relatively sensitive to contamination, particulates, severe oil degradation due to discharges, and severe overheating issues.

Further development of sensors for detecting oil contamination in power transformers is needed, considering the criticality of oil insulation.

DGA Monitor

Dissolved gases in transformer oil are produced by deterioration of oil and oil-impregnated materials mainly due to the occurrence of PDs, arcing, and overheating. Consequently, the presence of dissolved gases in oil is one of most prominent indicators of defects and ongoing degradation processes. The content of individual component gases can, in turn, reveal the type and degree of the abnormality. To ensure the performance of power transformers, it is essential to timely and effectively detect and classify the type of faults. For this purpose, DGA has been used extensively by utilities around the world as a routine test to detect incipient faults in oil-impregnated transformers. Overwhelming numbers of publications are dedicated to the topic, particularly on the interpretation of DGA results.

The majority of DGAs are carried out in laboratories. The frequency of sampling typically ranges between one and three years, but, when there is a sign of a problem, sampling is done more frequently, perhaps two to three times per week in extreme cases, to determine the onset of any increasing trend in gas production. However, a better way of performing condition monitoring is to apply on-line DGA systems. Although most DGAs are still performed at off-site laboratories, the DGA on-line applications are used more and more by utilities to monitor their critical, or important, transformers.

Several types of DGA on-line monitors with different options are commercially available. These range from simple combustible gas monitors to true multigas monitors. Most of these commercial products also include a moisture sensor as a part of the system.

Different sensor technologies are involved in these DGA on-line monitors. For instance, a special membrane and fuel cell are used to detect hydrogen and other combustible gases in GE Hydran monitors. Morgan Schaffer's Calisto monitors use a similar hydrogen extraction technique but detect the trace hydrogen based on the thermal conductivity. Multigas monitors that are able to detect all eight characteristic gases are also available. The detecting principle of such a monitor from Kelman is based on photo-acoustic spectroscopy. Like IR sensors, different gases respond to different spectra of electromagnetic radiation when they are exposed to IR light. An acoustic signal that is proportional to the concentration of the gases can therefore be detected. Serveron took a different approach. Using gas chromatography technology and replacing the manual sampling, Serveron DGA on-line monitors are able to turn off-site lab analysis to an on-line monitoring solution. To further reduce these costs to a point where they would be competitive, compared to the off-site manual test, research attempts have been made in semiconductor sensors and field effect sensors. Issues of selectivity and stability were found in early prototypes based on semiconductor IC sensors. However, considerable progress has been made recently, particularly in the improvement of selectivity.

PD

The PD measurement can be made by electrical, acoustic, chemical, and optical methods. Electrical methods are normally used for detection of PDs, whereas acoustic methods are mainly used to determine the location of PDs.

With electrical methods, Rogowski coil and capacitive coupling devices are typically connected to the taps of high-voltage bushings. The basic function of the Rogowski coil is to inductively couple the small and fast PD signals and produce voltage outputs across its terminals.

For on-line PD applications, noise suppression is the most difficult challenge that must be overcome. Noise disturbances can be classified into the following three categories: sinusoidal continuous, impulse-shaped power frequency synchronized, and pulse-shaped randomly occurred interferences. The first two types are relatively easy to eliminate, but the last type has characteristics that are more or less similar to PD signals. Adaptive digital filtering techniques have been successful at removing some of these noises.

PD activities in power transformers can be monitored by acoustic sensors. Piezo-electric acoustic sensors attached to the transformer tank are used for detecting and locating PDs. To avoid the mechanical noise from transformers, these acoustic sensors typically operate under 20–300 kHz. The PD acoustic sensors can be used alone, or along with electrical sensors, for monitoring the condition of transformers. Furthermore, with an array of acoustic sensors, geometric locations of PD sources can be determined using either spherical or hyperbolic algorithms. Location accuracy of 30–150 mm is achievable in many cases. This is extremely useful in assessing the severity and potential impact of the damage and in troubleshooting and repair work. Acoustic sensors can be used either permanently for on-line monitoring purposes or on a temporary basis for diagnostic

purposes. These sensors have been proven effective for both cases. Data fusion based on the correlation among results from electrical, acoustic, and chemical (DGA) sensors has been proven most effective in on-line diagnostics.

Fiber Optics

Development of fiber-optic sensors for the on-line monitoring purposes is also reported by several research groups. The main advantages of the technology are its relatively noise-free characteristic (immune to electromagnetic compatibility) and Galvanic isolation from the high-voltage components. To leverage its advantages, optical sensors can be installed inside a transformer for better sensitivity, without compromising insulation integrity.

Multiple Parameters of On-Line Monitoring

The sensor applications discussed so far have been focused on specific failure modes; however, transformer failures can be related to different components and can involve multiple causes. So it is desirable to develop a comprehensive system that can detect different types of incipient faults using multiple sensing mechanisms. This system can monitor not only the active parts (such as windings and high-voltage leads) but also important accessories (such as on-load tap changer and bushings) to ensure the maximal benefit. For critical transformers (for example, GSU units), this type of monitoring is particularly important to minimize operational risks and achieve optimal use of the equipment. The good news is that such on-line multisensor systems are now commercially available and continue under development for further improvement.

These on-line systems monitor transformer performance and operating conditions that typically include the following: current and voltage/load, temperatures (ambient, oil, and winding), winding hot-spot temperature (with fiber-optic sensors), dissolved gases in oil, moisture, PD, cooling status, bushing monitor (dissipation factor or relative capacitance), and load-tap changer monitor (tap-changer position and vibration).

The sensors used are mostly based on mature technologies and are specific to transformer application. For instance, oil and winding temperatures are measured using built-in temperature gauges, whereas loading is calculated using voltage and current values from potential transformers and current transformers. PDs are detected through a Rogowski coil system or by acoustic emission; the on-load tap changer sensor uses an accelerometer for detecting contact wear through trending analysis. The gas sensor can be a simple combustible gas monitor or a multigas monitor with more diagnostic information. Oftentimes, not all sensors available are necessarily selected for installation. Depending on the specific requirements and the conditions of a particular transformer or a bank of transformers, on-line monitoring systems can be customized with a selection of different sensors.

Through installed sensors, data reflecting equipment conditions are collected and transferred to either a local decision center or a centralized diagnostics system. Software for a central station might include functions of data storage, diagnostic algorithm, and alarm management. Hence, incipient faults can be identified at an early stage through continuous monitoring. Continuous on-line monitoring helps identify incipient failures and provide O&M personnel sufficient time to

respond before a failure. With timely and more accurate information, intelligent decisions can be made (that is, preemptive replacement of old units can be arranged based on early warning).

One of the challenges in power delivery is to optimize asset utilization by operating existing equipment at increased capacity levels, in many cases, exceeding nameplate ratings. By monitoring the transformer winding and oil temperatures and the weather and electrical load, the thermal rating of power transformers can usually be increased without increasing risk or expediting the degradation of the transformer insulation. Such a dynamic method is capable of yielding an increase of 5–15% in the effective thermal rating of most power transformers, and, if equipment temperatures are measured, the assumed thermal parameters for the equipment can be checked and the performance of the cooling system verified. Real-time, on-line monitoring with dynamic loading capability enables load planners to dynamically load a transformer to optimum limits without compromising reliability. The dynamic model can be updated once every 10 minutes. This frequency of update provides the system operators with a real-time view of the **loadability** or feasibility of temporary overload capability. Dynamic loading makes the most effective use of the transformer and provides the operator real-time information on how to load the unit.

When considering the installation of on-line monitoring systems, size, condition, and criticality of a power transformer must be analyzed. Especially for aged transformers and, in general, at strategic locations in the electrical network, on-line monitoring is necessary and valuable. By preventing major failures, the costs for outages, repair, and associated collateral damage can be avoided. To be more cost-effective, it is desirable to be able to monitor simultaneously multiple transformers with a single system.

Deployment of sensors for on-line transformer monitoring helps electric utilities manage their expensive transformer assets more reliably and operate them with a greater margin of safety, enabling them to minimize or delay the costs of repairing or replacing these valuable assets. An accurate condition assessment and appropriate action to the abnormality will prevent catastrophic failures. The asset's life could be extended by implementing reliability-centered maintenance. Savings are significant not only because additional investment may be postponed, but also because of avoided costs due to unplanned outages (replacement, environmental cleanup, customer and collateral damage, increased insurance, and so on).

Future Trends

Due to technology advancements and the low cost of analog-to-digital converters, signal processing has increasingly shifted from the system level to the sensor level. In addition to the benefit of alleviating the higher system, local digitization at the sensor level also significantly improves the signal transmission capability. With an onboard microprocessor, it is possible to offer embedded smart functions, such as on-line self-test and self-calibration. This improves reliability and reduces installation and maintenance costs. With onboard processing capability, the signal processing can also be shifted from hardware to software. Physical or mathematical models can be used to compensate for certain effects, and thus improve the precision of a sensor. As a result, signal processing algorithms have become an increasingly crucial part of sensor design and development.

One of the most significant progressions in sensor technology in recent years has been the development of MEMS. MEMS offer high-volume manufacturable systems with small dimensions, low-power consumption, and higher reliability. As cost-effective solutions, MEMS sensors are inherent components in automobile, mobile phone, and medical systems. The rapid progress in MEMS and manufacturing technologies, in general, offer opportunities for the production of sensors and sensor systems at low cost-to-performance ratios. Currently, investment in MEMS is relatively high, initially resulting in integrated sensors that are commercially viable in the consumer and automobile markets only, which benefit from their mass production. Nevertheless, other markets could well benefit by adapting the sensor chips to meet their needs.

Application of sensor arrays is also a promising development. A multisensor system can be used to enhance the accuracy of detection through synergetic effects offered by same or multiple types of sensors. An array of the same sensors can be used to improve reliability through redundancy and to improve stability through majority logic averaging to exclude the devices that are very different from the average, then averaged again for the output. This is a way to use unreliable devices to obtain reliable functions. On the other hand, arrays of different sensors may be organized together to better perform a desired function. For instance, the use of seismic, acoustic, passive infrared, and magnetic sensors in an integrated Unattended Ground Sensor System, in combination with data fusion algorithms, effectively eliminates the noises associated with different types of sensors and renders good detection reliability for indentifying intruders within a protected area. Sophisticated signal processing methods based on data fusion are more effective than more commonly used threshold-based algorithms. Multisensors offer superior performance with higher levels of precision and reliability compared to single-sensor systems.

Moreover, with large amounts of sensing components, which is not unusual for some complicated applications, the electric wiring of spatially distributed systems becomes complex and presents a significant challenge. Here, wireless communication is a better choice in terms of installation, maintenance, and the associated costs. Wireless sensors can be placed in locations once inaccessible for conventional sensors. To fully leverage this advantage, energy-harvesting technology is often used along with wireless sensors, so that a wire connection is no longer needed even for the power supply. For a large sensor network, where hard-wiring for power supply and communication is not feasible, wireless communication and energy harvesting will be needed.

Overall, the efforts and activities in sensor development are directed toward cost reduction, improvement in accuracy and reliability, and better response. Novel designs with high performance, new manufacturing technologies, and sophisticated signal processing capabilities are the new frontiers of sensor technology, driving to a next generation of sensors. From integrated smart sensors to wireless sensor networks, to MEMS and nanotechnology, the future of the field is limitless.

3
SENSOR ANALYSIS

Industry Scan

The overall view of sensors was narrowed to those specific to power distribution systems and separated into eight subcategories. The categories identified were voltage, current, temperature, vibration, optical, RFI, acoustic, and corona. The industry scan portion of the project involved a widespread search for any sensors that could be used on electric power distribution systems and categorized into one or more of the eight predetermined categories. Scan methods included patent searches, Internet searches, and a survey of manufacturer/sales representatives. All information collected during the scan was organized with Microsoft OneNote. OneNote is a software program that acts as a digital notepad, into which the user can copy and paste items from various electronic sources. OneNote also allows for the embedding of files such as PDFs. As illustrated in the screenshot in Figure 3-1, in the OneNote file created for the industry scan, the tabs along the top of the screen are the categories of sensors, such as corona, current, and temperature. Along the right side of the screen are links to each sensor in the selected category or tab. OneNote lends itself naturally to processes such as research and is an excellent means to distribute and share compiled information.

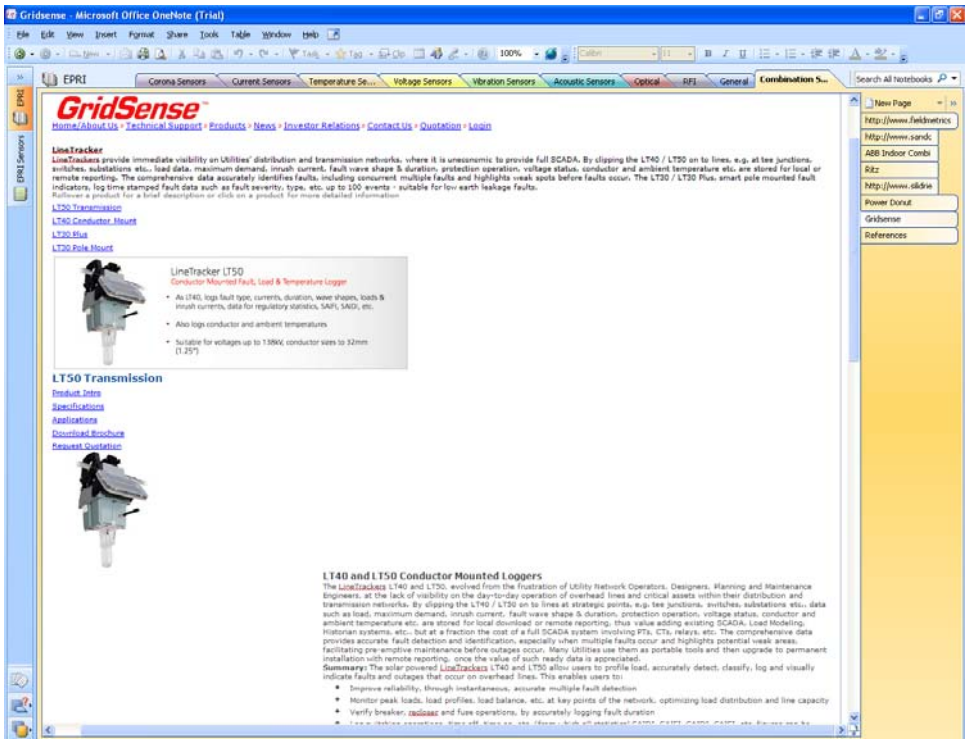

Figure 3-1
Screenshot of Microsoft OneNote file

Scan Results

Results of the industry scan were analyzed, and the sensors or technologies deemed to be useful were further researched. The results were analyzed using a cost-benefit analysis approach. The sensors that qualified as cost-effective were selected for testing by the Electric Power Research Institute (EPRI). Results of the testing will be published in a later report upon completion of testing. Sensors deemed non-cost-effective were evaluated for potential future use. Many sensors in this category were found to offer promising applications, but they are still in testing phases or were currently more expensive relative to the benefit(s) they provided.

Because acoustic, RFI, and optical technologies tend to be used to detect a parameter in a separate sensor category, for the purposes of analysis and discussion, sensors using those technologies are discussed in the category of the respective parameter that the sensor is designed to report on. Reformulating sensor categories in this way yielded the following new categories: voltage, current, temperature, vibration, acoustic/RFI/corona, and multisensors.

Voltage

Overall, distribution voltage sensors discovered during the industry scan are very limited in functionality and capability. There are opportunities for improvement in this category; however, the most impressive of the voltage sensors fall into the multisensor category and will be discussed in their respective section. The most useful of the voltage sensors picked from the database are listed as follows:

- Schweitzer Engineering Laboratories (SEL) offers a full line of electrostatic reset (ER) fault circuit indicators. These devices derive their power from the potential gradient that surrounds high voltage conductors. These devices sense the collapse of the electric field that surrounds the conductor, at which time the device displays a visual indication in the form of a target flag and possibly a light emitting diode (LED), depending on the specific model chosen. These devices are inexpensive, easily deployed (hot-stick mountable), self-powered, and offer some useful information, but only by visual indication.
- Optisense offers 35-, 25-, and 15-kV class optical voltage sensors. These devices use a unique optical voltage measurement technique that offers high accuracy and dependability. This optical method allows for galvanic isolation of the voltage being measured from the signal. The sensor connects to a digital signal processor for signal interpretation, which can then be accessed through an RS-232 port. This device is innovative in that it uses optics for voltage measurement, which allows for complete isolation. However, having to communicate with the device locally through RS-232 is inconvenient.
- Rauckman Utility Products offers a device known as the Voltwitch. This device is an innovative drive-by voltage indicator that is installed in a vehicle much like a radar detector. This device allows the driver to follow a distribution line and obtain an indication of whether the overhead lines are energized.
- Telemetric offers the Telemetric Voltage Monitor (TVM) family of products and services. The TVM products are available in single-, two-, and three-phase arrangements. These devices allow utilities to monitor and report power interruptions, overvoltage and undervoltage alarms, and power reliability status throughout their distribution systems.

These products communicate through cellular data service to the Telemetric-Xchange server. Customers can log in to Telemetric's server to access data, or they can use Telemetric's supervisory control and data acquisition (SCADA) Xchange software, which allows integration of TVM data from the server to the utility's SCADA system through DNP 3.0. Telemetric offers a variety of packages. Each installation and package is custom built for the customer's needs. All cellular data and access to the Xchange server data are included in a package that has a recurring monthly fee. Although there is a recurring fee, Telemetric offers a turnkey solution for distribution monitoring with zero investment in infrastructure.

- FieldMetrics offers the FMPT sensor. FMPT is a high-accuracy voltage measurement solution for transmission and distribution utility applications. This device has a patent-pending design that is currently undergoing field testing; however, the device can still be purchased. The device weighs 20% less than conventional sensors and can accommodate a variety of unconventional mounting schemes. This device is self-powered, can communicate through short- or long-range wireless, and can export data in an .xls format.

Current

Current sensors or integrated devices with current sensing capability appeared more frequently during the industry scan than any other type of sensor. Faulted circuit indicators (FCI) represent the majority of the sensors in this category. Many FCIs are evolving into devices that offer not only visual indication of a faulted line, but also are self-powered and offer remote fault indication through a communications interface. These types of devices are expected to be extremely important in the years to come.

- Thomas & Betts offers several series of fault indicators, including the Elastimold TPM series, Elastimold UCM series, and Elastimold OLM series. The TPM series are test-point-mounted fault indicators that offer visual indication for locating faulted cables and equipment on underground distribution systems. The UCM series are cable-mounted visual indicators for use on underground distribution systems. The OLM series are line-mounted indicators for use on overhead distribution systems. These FCIs are self-powered, incorporate a solid state current sensor, and include advanced circuit logic that prevents indicator tripping unless an overcurrent condition is followed by a loss in system voltage. Trip and reset operations are automatic. These indicators are for use in systems from 5–35 kV.
- SEL AutoRANGER series is an overhead-mountable FCI that provides visual indication of a faulted line. The device is intelligent in that it offers inrush restraint, separate distinct trip levels from 50–1200 A, and distinct indication of either a temporary or permanent fault.
- SEL Underground AutoRANGER series FCIs are designed for use on underground distribution systems. This series is self-powered and offers automatic trip level selection from 50–1200 A, based upon sampled load current. The Underground AutoRANGER can also be used with the SEL RadioRANGER system, which allows for remote fault indication through a handheld wireless fault reader. This handheld fault reader identifies the sensor and provides fault indication and phase information. Although helpful, in practice this system offers a very short communication range to the wireless handheld reader.

- The SEL LINAM series FCIs are designed for use on underground distribution systems. This series incorporates wired remote indicators with an LED for enhanced visual fault indication and eliminates the need for opening up enclosures to discover faults. These devices offer inrush restraint, automatic reset, and the ability to communicate the fault to a SCADA input through an auxiliary contact.
- Joslyn Hi-Voltage offers Fisher Pierce Series 1301 high accuracy line post current sensors. These sensors can be used for capacitor switching, load surveying, or protective relaying. The sensor consists of a porcelain line post insulator with an embedded coil that is inductively coupled to the conductor and outputs a voltage proportional to the line alternating current. These sensors are offered in 15-, 25-, and 35-kV options.
- Joslyn Hi-Voltage offers the Fisher Pierce Radio Faulted Circuit Indicator system. This system allows for current sensors to be mounted overhead, underground, or on pad-mount distribution systems; the sensors wirelessly communicate a fault to a handheld receiver. Wireless communication is typically 150 ft, allowing a lineman to easily locate a fault while in a moving vehicle.
- The ABB SEI601 is a system composed of eight small clamp-on AC/DC current sensors that connect to a receiver by a Category 5 cable. The receiver communicates to a computer that uses wave analysis software to provide real-time analog and digital information, fault and disturbance analysis, and real-time monitoring of evolving load.
- Cooper Power Systems offers an expansive line of FCIs. Cooper S.T.A.R. FCIs offer underground, overhead, pad, switchgear, and sector cabinet mounting options. The S.T.A.R. FCIs are also manufactured in ER, delayed reset, current reset, low-voltage reset, manual reset, and test point reset (TPR) options. This series of FCI indicates a fault through a fisheye, orange, highly reflective target.
- Cooper Power Systems S.T.A.R. Pathfinder FCIs are available in TPR for overhead monitoring and ER for underground monitoring. The Pathfinder FCIs are similar to the traditional S.T.A.R. FCIs but are equipped with a communications interface. These devices can be equipped to communicate through cellular, UtiliNet, or FlexNet. When a Pathfinder FCI indicates a fault, it communicates the fault to a central location. The information is then routed by Cooper's GridAdvisor Exchange. Cooper's GridAdvisor allows utilities to access real-time fault information through a custom, secure web site, or it may be configured to communicate to existing operations systems platforms such as SCADA or OMS using various protocols, including DNP 3.0, ICCP, and MultiSpeak®.
- Power Delivery Products offers three different FCIs for monitoring of overhead and underground distribution systems. The Overhead FCIs are available with a mechanical flag or LED indication and use load tracking to automatically establish a trip level that coordinates with the circuit load. This information is stored internally for 72 hours. The super high intensity LEDs provide a very bright visual indication. All overhead units may be equipped with a radio transmitter and paired with a receiver that is mounted nearby, such as on a pole below an overhead FCI. During a fault event, the receiver will report the fault by closing a contact, which may be connected to a SCADA system, or by cellular communication.

- Power Delivery Products underground FCIs are offered in electronic and mechanical versions and as self-powered versions. The electrical versions provide fault indication by LED or audible alarm, whereas the mechanical version indicates through a flag. Some versions of the underground FCIs also offer the previously mentioned load tracking capability for automatic adjustment of trip level. These units may be connected to an interface, through a fiber-optic cable up to 30 ft long, which closes a remote terminal unit (RTU) contact upon a fault. The utilization of a Telemetric cellular RTU allows for wireless fault reporting.

Temperature

Real-time temperature monitoring of conductors and transformers is becoming more important as the push to improve efficiency continues for utilities. The temperature sensors uncovered during the industry scan offer many promising options to accomplish the task of real-time temperature monitoring. One advancement is the distributed temperature sensor (DTS) system to monitor kilometer-long strands of conductor with high resolution of temperature and location, all using an embedded fiber-optic cable and analyzing equipment. This equipment, although seen as very useful and important, is still very expensive and offered by only a few manufacturers.

- Telepathx offers a device known as the *Intelligent Insulators Current Leakage Sensor*. This device is a noninvasive, radiofrequency identification solution for monitoring faulting distribution insulators. These devices remain dormant until the thermal threshold for an insulator is reached. Once these devices are activated by a fault, the fault is reported wirelessly with the exact time and location of the faulty insulator.
- Arteche offers the temperature measuring sensor. This device is mounted to the overhead conductor and measures instantaneous temperature of the line, then transmits the data to a computer for viewing, through Short Message Service message over the cellular telephone network.
- Shaw Energy Delivery Services offers the thermal rate system. This system consists of thermal rate monitors (TRMs), which are installed along the line. The TRMs are replicas of the conductor using the same material, diameter, and surface. The TRMs are oriented in the same direction as the line being monitored to establish how the present weather conditions are affecting the thermal capacity of the conductor. IEEE-738 equations are used to calculate the current carrying capacity of the monitored conductor based on the weather conditions.
- Roctest offers the FOT-F and FOT-N temperature transducers. These temperature probes are compact in size and immune to EMI and RFI. The probes are also corrosion resistant and measure temperature using optical technology. These probes are versatile and can be mounted in almost any fashion to monitor the temperature of any object or medium on or in which it is mounted. The probes do require a readout or data-logging device with a fiber-optic interface.
- Cannon Technologies TSP probe is an RTU-compatible analog temperature sensor that monitors a transformer's top oil temperature. For transformers that have top oil indicators that cannot be removed, Cannon offers the TSS, which is a surface-mount temperature sensor. The TSP and TSS are powered off of the RTU current loop and supply at 4–20 mA output proportional to the oil temperature.

- GE Power offers the well-type RTD sensor. This sensor is an insertion-type, which mounts inside the thermal well. GE also offers a magnetic-mount transformer temperature sensor. The well-type and magnetic-type RTDs are powered from the monitoring unit's current loop and provide a 4–20 mA output proportional to temperature.
- SensorTran offers the DTS 5100 system. This system uses optical fibers to provide real-time dynamic temperature with high accuracy and resolution providing up to 40,000 discrete temperature points along a line. SensorTran offers systems that can monitor spans of line from 4–18 km with spatial resolution of 1 m.
- Sumitomo offers the Op-Thermo DTS system. This system uses only a single optical fiber to provide continuous and real-time temperature measurements at thousands of points. The system hardware is a small box that connects to the user's computer through RS-232. This system has user-configurable zones and alarms and can autonomously record measurements. The Op-Thermo system comes in several models with range capabilities of 1–15 km with spatial resolution down to 1/2 m at short distances and 1 m at long distances.
- Sensornet offers the Sentinel DTS Range system. This system uses a multiplexing module that allows the ability to produce multiple double-ended measurements. This system allows for user-configurable zones and alarms. The system can monitor up to 60 km of fiber-optic cable with temperature resolutions of 0.01°C.

Vibration

Devices designed specifically for monitoring of conductors and distribution equipment were very scarce. If the need to monitor a conductor or distribution equipment is needed, the industry trend is to make use of a standard industrial accelerometer and associated measuring equipment. There appears to be little advancement of these types of sensors developed specifically for power distribution systems.

- Roctest offers the PAVICA, a unique, small, and lightweight vibration logging sensor. The PAVICA measures the frequency and amplitude of vibration and stores the data in a high-definition matrix for processing. The results of the matrix yield a rough estimate of the life expectancy of the conductors under study, based on IEEE and CIGRE standards and procedures. The device is battery-powered and designed to be deployed for up to three months at a time. Normal deployment is two to four weeks.
- Polytec offers the IVS-200 industrial vibration sensor. This device is a ruggedized laser Doppler vibrometer. This device is mounted on a fixed object, and an eye-safe laser is aimed and focused onto the object being monitored.

Optical

Sensors that use optics to monitor system parameters are a prime example of the latest sensor advancement. The latest devices and those in development that use optics measure parameters such as current, temperature, and vibration. These sensors are described in their respective sections of this report. These types of devices offer significant advantages over conventional sensors because of their complete isolation from the circuit or device. Devices in this category are lightweight in comparison to their conventional counterparts, are immune to EMI/RFI/lightning, and offer higher accuracy. Currently available DTS systems are the latest in

temperature monitoring advancement. These systems use an optical fiber embedded in the conductor and processing equipment to monitor and record temperature along long spans of conductor several kilometers in length with high spatial and temperature resolution and accuracy.

RFI/Acoustic/Corona

Corona is a luminous PD that can indicate failing insulators or a possible fault. Corona is very difficult to detect directly therefore it is common practice to detect its effects. RFI and detection of the acoustic signature of corona are the most common methods. There are recent developments in visual methods to detect corona using a UV camera, but, unfortunately, these visual detection devices are still expensive.

- Syntronics offers the Corona Finder. This is a portable device that provides real-time UV viewing. This allows high-voltage conductors and equipment to be quickly and thoroughly inspected for evidence of corona discharge. Although very innovative, this device requires a substantial financial investment.
- Radar Engineers offers an extensive line of corona detection and PD detection equipment, both for permanent installation and portable use. These devices detect RFI to find the general location of corona discharge. Once in the general area of discharge, the equipment uses acoustic sensors to pinpoint the location of corona discharge. Portable corona sensors offered are practical and affordable, ranging from a parabolic acoustic sensor with a laser pointer for exact location of discharge to a hot-stick line sniffer, which allows for the location of corona discharge from a bucket truck. Permanently mounted sensors and equipment are normally used for the detection of corona associated with switchgear and electrical cabinets. Radar Engineers is currently testing a possible new handheld corona sensor that would allow for the detection of corona in electrical cabinets.
- Exacter, Inc. offers a corona detection service. The service has a monthly recurring cost for a turnkey solution. The EXACTER Outage-Avoidance System provides an early warning of failing transformers, regulators, insulators, cutouts, lightning arrestors, and so on. The service provides location data and problem severity information for maintenance scheduling and prioritization.

Multisensors

Multisensors are devices that integrate several sensor capabilities into one device. These types of devices are the bulk of recent advancements in distribution sensor technology. Devices that measure current, voltage, and temperature would be very useful if they were compact, cost-efficient, and offered data communication.

- USi-Power currently offers the Power Donut2. This breakthrough device monitors current, voltage, temperature, and line sag of overhead conductors. This device is completely self-contained, allowing for hot-stick installation. The device is self-powered and comes in a variety of communication options to suit the utility. Currently, this device is expensive and has not yet reached mass production. A new model is being tested that offers full waveform capturing, event logging, and GPS clock.

- Promethean Devices is testing a low-cost, non-contact, high-accuracy sensor for simultaneous real-time determination and monitoring of line sag, temperature, current, and ampacity. This device is still in the prototype and testing phase. Very little information is available on this device or its inventors.
- Airak's Patented Optical Current Sensor System is an innovative, safe, and easy to install optical current sensor. The device is small, lightweight, immune to EMI/RFI, and has zero risk of explosive failure. The inventor appears to have obtained a U.S. Navy contract for the device and does not appear to be pursuing the utility market at this time.
- GridSense offers the LT40/LT50 model sensors. These devices are hot-stick mountable and measure voltage and current. The LT50 also measures conductor and ambient temperature. All parameters are stored onboard and made available for local download or remote reporting through several communication options. These devices are self-powered and communicate using cellular data, SCADA, or data link. Data link is a dashboard-mounted device that collects the stored data from the LT40/LT50 as a vehicle passes.
- Lindsey Manufacturing offers Current and Voltage Monitoring Insulators. These insulators can be implemented in distribution automation (DA) schemes and allow utilities to monitor, coordinate, and operate distribution systems in real time from a remote location.
- Lindsey Manufacturing offers the Multicore Sensor. This device is designed to be installed without de-energizing or cutting the main conductor. This device is accurate within 2% of the actual value of current and voltage. The sensor uses a deep V-groove, which places the current path at the center of multiple-sensing cores. This device is offered in 15-, 25-, and 35-kV models.
- Lindsey Manufacturing offers the Elbow Sense voltage and current sensor. This device uses current transformer and voltage sensing technology. This sensor is easily retrofitted to existing padmount or submersible equipment. This device can also be used with outdoor, overhead equipment that uses standard elbows.
- Tollgrade's LightHouse solution is designed to provide a real-time, turnkey grid intelligence solution. This system monitors system voltage, current, and also measures the 3rd Harmonic. This system is still in the pilot program stages of development for 4- to 35-kV systems. This system measures current and voltage system parameters and transmits the data over a self-configuring wireless mesh network to a central location for analysis and monitoring.
- SURETECH offers the SURETECH VI-x Monitoring System. This device measures, processes, and logs electrical parameter data on MV equipment and systems. The system measures voltage and current and exports kW, kVA, kVAR, kWh, kVAh, kVARh, power factor, phase angle, and frequency. The processing is done by the microprocessor-based Smart Load Processor and offers an external communication interface through RS-232.

Industry Scan Findings

Recent developments have been made in FCIs, temperature sensing technologies, current sensing technologies, and devices that combine multiple sensors into a single integrated unit with embedded communication capability. Many of these devices are hot-stick mountable, self-powered, and have several methods of data communication. These allow the mobile devices to be mounted anywhere in the distribution system. A device with integrated conductor temperature

sensing, current sensing, and GPS data could report a fault with the fault location, saving person hours required to locate the faulted line. Other devices in the vicinity report real-time conductor temperature and current, allowing utilities to switch circuits appropriately and return service to customers while the fault is being repaired, saving lost revenue and person hours.

Optical sensing devices are among the fastest growing in the distribution sensor market. Recent developments in distributed fiber-optic DTS, which allows real-time monitoring of conductor temperature with temperature accuracy of 1°C and location resolution of 1 m, is a very promising addition to the electric power distribution sensor arena. The information equipment such as DTS systems would allow utilities to load conductors to the maximum allowable temperature rating, if needed. Other recent developments in optical sensing technologies are strain-measuring devices. These devices use an optical fiber in a similar manner as the DTS systems, but they are able to measure parameters such as conductor sag in real time.

Although there are several sensors available and targeted toward electric power distribution systems, the industry is still lacking in a variety of smart sensing devices, which are able to measure key parameters such as voltage, current, and temperature and communicate this information through some wireless means to a central location for processing. Other areas where the industry is deficient is in underground distribution sensors. The industry scan revealed that most sensors commercially available are intended for overhead distribution application. There are several possible factors that can account for this unbalance. One possible explanation might be that, statistically, there are significantly more overhead distribution faults than underground distribution faults, and, therefore, the need for up-to-date information on overhead systems is the driving force for more sensor development in that area.

Overall, several distribution sensors are available for overhead and underground use. Most are designed for one specific purpose. Many sensors offer promising options for utilities to gain much-needed information about the status of their distribution system. Many technologies are being adapted from other industries to the electric power distribution industry, but there is still much room for improvement and diversity in distribution sensing devices.

4
TESTING

Approach to Testing

Numerous EPRI-member utilities have expressed interest in developing a better understanding of the functionality and capabilities of the currently available sensors for use in electric power distribution systems. This desire for knowledge goes beyond what can be learned from reviewing specification sheets and product literature. It is with this in mind that EPRI is undertaking laboratory testing of numerous commercialized sensor products.

The primary goals of the EPRI testing are to evaluate the accuracy, sensitivity, and ease of use of the sensor products selected for testing. This involves designing laboratory tests that challenge the sensors according to their stated specifications while still replicating real-world application conditions to the greatest extent possible.

Sensors Selected for Testing

EPRI selected nine sensors, summarized in Table 4-1, for further testing, based on each sensor's specific capabilities and input from utility collaborators. As a group, the sensors chosen for testing cover overhead and underground power distribution applications and measure a variety of parameters, including volts, amps, VARs, power factor, temperature, and fault indication. Other sensor products might be added to the test group as they are identified.

Table 4-1
Sensors selected for EPRI testing

Make	Model	Sensing Parameters	Overhead or Underground	Further Information
Cooper	S.T.A.R. FCI PathFinder	FCI	UG	www.cooperpower.com
GridSense	LT40	LL, FEW, PF	OH	www.gridsense.net
Grupodriel	Sensodriel	V, I	OH	www.silidriel.com
Lindsey	ElbowSense	V, I	UG	www.lindsey-usa.com
Lindsey	MultiCore	V, I	OH	www.lindsey-usa.com
Piedmont	Line Post	V, I	OH	www.pb-i.com
Power Delivery Products	FCI Load Tracker	FCI	UG	www.powerdeliveryproducts.com
SEL	AutoRANGER Underground FCI and RadioRANGER	FCI	UG	www.selinc.com
Tollgrade	Lighthouse	V, I, T, PF, FEW	OH	www.tollgrade.com

FEW = fault event waveshape, FCI = faulted circuit indicator, I = current, LL = load logging, PF = power factor, T = conductor temperature, V = voltage

Cooper S.T.A.R. Pathfinder Variable Trip FCI

The Cooper S.T.A.R. Pathfinder FCI detects fault current on underground distribution systems and provides a visible indication of detection. The FCI, shown in Figure 4-1, is suitable for use on 200-A separable connectors and 600-A terminators with voltage test points and can be installed with a shotgun-style hot stick.

The Cooper FCI indicates fault current detection through an LED display. The display will flash for a period of four hours after a fault event and can be manually reset, or the unit will automatically reset when the system is re-energized.

The FCI uses a variable trip design that trips, based upon a current rise above a **normal** load current threshold and requires a minimum of 200 A, combined load and fault current, in order to function properly. The FCI is weatherproof and submersible and conforms to IEEE Std. 495-1986.

Figure 4-1
Cooper S.T.A.R. Pathfinder FCIs

GridSense LineTracker LT40 CMS

The LineTracker LT40 (see Figure 4-2) is a conductor-mounted load logger and fault recorder. The units are powered by an onboard solar panel and a sealed lead-acid battery and can be installed and removed on live conductors with a hot stick.

Figure 4-2
GridSense LineTracker LT40 three-phase kit

The load profiling feature of the LT40 records average current up to 3000 A over a user-defined window of 1 to 60 minutes. The LT40 has enough onboard memory to store up to 85 days worth of load profiling data.

When event monitoring is triggered, the LT40 records the date and time, root-means-square (RMS) fault and inrush currents, fault current waveform, voltage on/off, cycles to trip, number of trips, outage duration, and device health information. A single unit is capable of storing over 100 RMS fault recordings and 34 fault waveforms with each waveform being 12 cycles in duration.

Data downloads and configuration uploads can be accomplished with a variety of communication technologies. For local communication, 125 feet or less, the LT40 uses unlicensed low-power radio frequency signals. Standard remote communication options on the LT40 are cellular (GSM, GPRS, and CDMA), and satellite signals with other communication methods are available on special request.

Grupodriel Sensodriel

The Sensodriel is a post-type polymer insulator with voltage- and current-sensing capabilities. Models are available for 15-, 25-, and 35-kV class systems. The unit's sensing capabilities are based on two independent sensors; voltage readings are taken with a resistive device, and current readings are taken with an inductive device.

The Sensodriel is rated for currents up to 750 A and cantilever loads up to 970 lb (440 kg). The unit has a galvanized steel lower end fitting and an aluminum upper cap with a screw-tensioned conductor clamp. The 15- and 25-kV class units have a stated accuracy of 0.5%, and the 35-kV class unit has a stated accuracy of 1%.

Lindsey ElbowSense Current and Voltage Monitors

Lindsey ElbowSense current and voltage monitors fit standard 600-A, T-body connectors for 15-, 25-, and 35-kV class equipment. The sensors are suitable for use on pad-mounted, outdoor, submersible, and overhead equipment that use standard elbows.

The ElbowSense voltage monitor plug replaces the standard insert furnished with 600-A, T-body elbow assemblies. The sensor uses a resistive voltage divider to measure an AC signal proportional to the phase-to-ground voltage. Both current and voltage sensors are quoted to have accuracies of 1%.

Lindsey MultiCore

The Lindsey MultiCore sensor is a post-type design molded from Polysil® polymer concrete. The sensor can be used in place of any standard vertical-mount insulator and installed using live line work practices. The conductor is fastened into a deep groove on the top of the insulator, thus placing the conductor in the center of multiple measurement cores. Sensors are available for 15-, 25-, and 35-kV class systems, all with cantilever strengths of 2800 pounds (1270 kg). Voltage accuracy is quoted at ±1% and current accuracy at ±2%.

Piedmont Line Post Sensor

The Piedmont line post sensor houses current and voltage sensors in a post insulator body molded from cycloallphatic epoxy. Models are available for 15-, 25-, and 35-kV class systems. The sensor can be used in place of any standard vertical-mount insulator and installed using live line work practices. The top of the sensor features a lay-in conductor groove and a swing-link clamp to secure conductors from #6 AWG to 954 MCM.

The current-sensing feature yields linear output voltages proportional to the current flowing in the conductor up to 30 kA without saturation. Sensing accuracy varies by voltage class with the 15-kV class sensor offering 1% accuracy for current and voltage readings. Accuracy drops to 2% for the 25-kV class and 3% for the 35-kV class sensors for both current and voltage.

Power Delivery Products FCI Load Tracker

The Power Delivery Products FCI Load Tracker, shown in Figure 4-3, is a closed-core FCI designed to provide a high degree of proximity immunity. This is a manual test and reset unit with an LED lamp to indicate fault detection. The Load Tracker units are a one-size-fits-all device and can be applied by a hot stick.

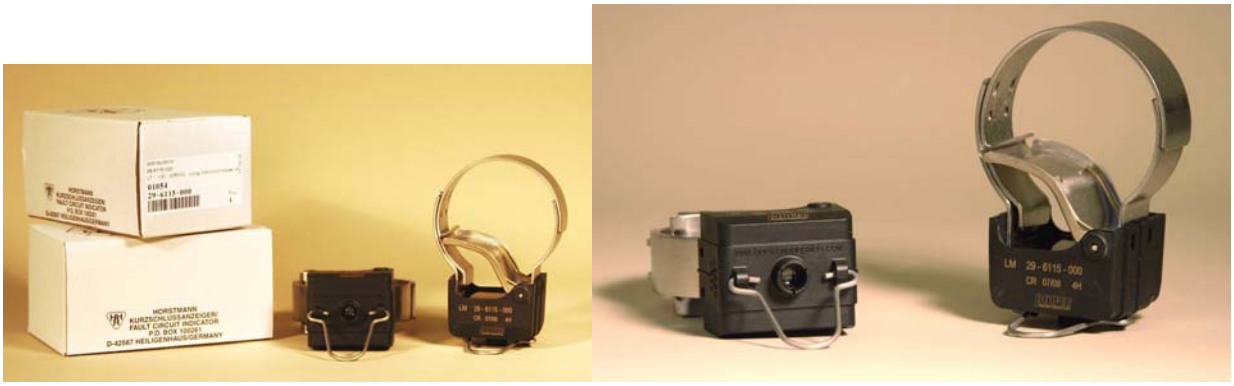

Figure 4-3
Power Delivery Products FCI load trackers

Schweitzer Engineering Laboratories AutoRANGER FCI and RadioRANGER

The Schweitzer Engineering Laboratories (SEL) RadioRANGER wireless fault indication system (see Figure 4-4) is intended to help utility troubleshooting crews locate faults from the street level. The RadioRANGER system consists of a wireless interface radio and one or more FCIs.

Figure 4-4
SEL AutoRANGER fault indicators and RadioRANGER wireless communication system

AutoRANGER URD FCIs

The AutoRANGER URD is an FCI for use on underground systems and is available in single-phase and three-phase configurations. The FCI features automatic trip level adjustment based on sampled load current, making it suitable for applications with fault currents ranging from 50–1200 A. This is a self-powered unit that draws supply power from the cable that it is monitoring, although units with an LED fault indication (optional) do require a lithium battery.

RadioRANGER Wireless Interface Radio

The RadioRANGER interface is used to wirelessly communicate the status of multiple underground (or overhead) FCIs to a remote fault reader. This allows utility personnel to quickly retrieve FCI status from the road level without having to access faults or other underground infrastructure.

Each wireless interface can accommodate up to 12 SEL AutoRANGER FCIs, each with a unique ID. Furthermore, the wireless interface is submersible, maintenance-free, and has an estimated life of 15 years assuming 40 faults per year. The wireless interface is polled by a handheld remote fault reader to display the wireless interface ID as well as the fault status of each FCI. Faulted phases are indicated visually with an LED and through an audible alarm.

Tollgrade's Lighthouse System

Tollgrade's Lighthouse system is a suite of sensors and communication devices designed to provide real-time line data through a wireless mesh network. The Lighthouse MV sensor measures current, power factor, and conductor temperature. It also tracks line outage and restoration and records fault current waveforms.

Lighthouse MV units can be applied to energized lines with a hot stick and automatically configure themselves into the 900-MHz wireless mesh network. The sensors are inductively powered from the line that they are monitoring and have onboard energy storage, providing ride-through capabilities during line outages.

The wireless mesh network consists of Lighthouse MV sensors deployed on overhead lines and pole-mounted Lighthouse AG aggregation points. Data are transmitted from the sensors to the aggregation points, where it is then sent back to a server for viewing or integration into utility enterprise systems (usually OMS or SCADA). Communication between sensors and aggregation points is accomplished through a 900-MHz frequency-hopping spread spectrum wireless mesh network, whereas the Lighthouse AG supports a variety of backhaul media, including digital cellular, fiber, and DSL.

Planned Tests for Sensor Accuracy and Sensitivity

EPRI's primary goals for this research are to evaluate the accuracy, sensitivity, and ease of use of the sensor products selected for testing. This will be accomplished through a series of laboratory tests that challenge the sensors according to their stated specifications while replicating real-world application conditions to the greatest extent possible.

A review of the sensors selected for testing reveals that the parameters measured by the sensors can be grouped into six main categories as follows:

- **Voltage**: trending (percentage change) and reporting present conditions
- **Load current**: RMS load logging and reporting present conditions
- **Fault current**: fault indication, RMS logging, fault waveshape recording
- **Conductor temperature**: logging and reporting present conditions
- **Outage and restoration**: time, date, cycles to trip, multiple reclosing attempts, inrush current
- **Power factor**: reporting present conditions

Most of the sensors in the test group do not measure all of the parameters listed; some of the sensors are very specific in nature, whereas others offer a larger array of sensing capabilities. Therefore, each sensor will be tested according to its stated capabilities. The accuracy and precision exhibited by the sensors in measuring the various line parameters under consideration can be assessed through a series of laboratory tests:

- **Voltage presence and trending test**: used to examine the sensor's ability to detect voltage presence, accurately report line voltage, and detect changes in line voltage. This investigation will make use of a test circuit with the ability to vary voltage over a large range (0–50 kV). Each sensor with voltage-measuring capabilities will be installed on the test circuit, and a series of tests will be performed by energizing and de-energizing the line as well as increasing and decreasing line voltage at various ramp rates.
- **Current detection and load logging tests**: used to examine the sensor's ability to track and report line load current. A test line with an adjustable load will be used. Each sensor that reports instantaneous load current will be tested at multiple load levels. The sensors that also provide load logging functionality will be tested over the course of several hours with varying load shape.
- **Power factor tests**: used to examine the sensor's ability to measure power factor using the same test line as the load logging tests. The power factor on the test line can be modified by changing the nature of the load on the line. Tests will be performed with leading, lagging, and unity power factor.
- **Fault event detection and recording test**: used to evaluate the sensor's ability to recognize and record fault events. These tests will be performed using two different test circuit configurations. In the first configuration, the sensor's ability to detect and record faults will be assessed by rapidly and dramatically increasing the line current by switching large loads onto the line. In the second configuration, fault detection will be evaluated by creating long duration arcing faults on the test line. It is estimated that the arcing fault can be made to draw 500–1000 A on the test line with an arcing current characteristic.
- **Conductor temperature tests**: used to evaluate the sensor's ability to measure conductor temperature by heating the conductor (either artificially or by electrical current flow) and measuring the line temperature with a high-accuracy measuring device very near the physical location at which the sensor is measuring the line temperature. This test will be repeated over a range of conductor temperatures.

In all tests, a calibrated and highly accurate data acquisition system will be used to provide control measurement by which to compare the output from the sensors under test. A DayCor camera and a radar engineer's kit will also be used throughout testing to examine for evidence of corona generation or radio frequency noise broadcast due to the sensors' presence on the line.

EPRI's High Voltage Test Laboratory in Lenox, Massachusetts

The EPRI Lab in Lenox, Massachusetts, is a unique facility located in a rural setting, featuring outdoor test lines (see Figure 4-5). Originally built by the General Electric Company in the late 1950s, the lab's capabilities were expanded several times over the following decades to its current abilities to accommodate test voltages up to 15,000-kV AC, 1500-kV DC, and 4-MV impulse waves.

Today, the laboratory offers a wide range of test capabilities for both transmission-level and distribution-level investigations. Of particular interest for distribution-related investigations are several AC test sets accommodating testing up to 200-kV AC, the 500-kV impulse test generator, arc flash testing capabilities, and the residential distribution test yard. The distribution test yard features 2000 ft of overhead distribution line, approximately 500 ft of underground distribution line, 9 distribution transformers, and 18 service drops to simulated residences.

Figure 4-5
EPRI's high-voltage test facility in Lenox, MA

5
CONCLUSIONS

The ideal sensor would be small and lightweight, harvest all of its power requirements from the circuit or equipment being monitored, measure multiple parameters, perform analysis functions internally, quickly transmit the data over long distances at a high data rate, tag the data with the location, time, and date of origin, be portable, easily installable, and inexpensive. The ideal sensor would also be interoperable and adaptable to a number of different systems such as advanced metering infrastructure (AMI), DA, and SCADA.

A relatively large number of sensors are available from various manufacturers specifically targeted at the electric distribution market. However, it is apparent that product development continues, and the market is by no means saturated with variety and diversity. Many sensors were developed to meet a particular need, such as voltage and current sensing for capacitor bank control, but they are now being adapted to other applications. Adapting an existing product to a new application often adds value; however, further innovation is needed in both the methods of measurement and the parameters that are measured.

One of the challenges inherent in building sensors for use on MV lines is achieving isolation between the monitored line and grounded parts and protecting the user and other connected equipment. Sensors that are installed in contact with bare conductors depend upon wireless links or fiber-optic cable to transmit the sensory data to a collection point. Sensors in this category with onboard active electronics either rely totally on internal batteries or harvest some or all of their power requirements from the EMF of the conductor or from sunlight. For wireless data transmission, this challenge limits the range and frequency of reporting, in many cases. It is desirable for sensors designed for permanent installation not to require periodic battery changes. Some current and voltage sensors based on optical technology overcome this by placing only optical elements near energized parts. The optoelectronics and communications interfaces are located in an accessible, nonenergized location and can be powered by secondary voltage.

Measured Parameters

The distribution system of the future has been the focus of numerous trade publication articles and conference papers. The parameters traditionally addressed in distribution modeling and planning voltage and current are key to the operation of future distribution systems. There are many ways that voltage and current may be sensed across the system. As AMI becomes commonplace, the revenue meters become a source of data, indicating voltage and current at the metering points. Other equipment, such as reclosers and capacitor controls, can also provide voltage and current data and other parameters of interest such as power and power factor.

Distribution sensors can be deployed to measure voltage and current at other critical locations on the system, and these measurements can be supplemented by the data from the sources mentioned previously. Dynamic loading schemes might dictate the need for real-time conductor temperature measurements, and schemes for power factor control might require measurement of real and reactive power.

Fault location and preventive maintenance programs might require fault current indication and waveform capture such as those performed by Tollgrade's Lighthouse sensors, and these data might be used to supplement fault records from reclosers and protective relays.

Other parameters that might be indicative of impending equipment failures include corona and the associated RFI. Cracked or dirty insulators and bushings and loose connections often produce corona and RFI before the problem has developed to the point of creating a fault. To date, devices for sensing these parameters are relatively expensive and mainly consist of portable inspection equipment, which is not designed for permanent installation on distribution lines.

MV underground cables can undergo incipient, self-clearing faults prior to permanent failure. At least one brand of recloser control has incorporated logic for the detection of these events. It is conceivable that current sensors designed for use on underground cables could incorporate a sensing algorithm for this behavior and signal detection of these events. Such sensors could be installed on cables that are deemed at risk for such failures due to the insulation type or cable age.

Another application of distribution sensors to provide early warning of equipment failure is a sensor for the detection of high distribution transformer temperatures. These devices could provide enough early warning to prevent equipment damage and service interruptions.

Communications

Many of the sensors identified facilitate the conversion of one physical or electrical parameter into an electrical signal, and others also include the measurement and communication of the sensed quantity. One of the more advanced sensors, Tollgrade's Lighthouse, uses spread spectrum radio and forms a mesh network between sensors and a backhaul communications interface. This backhaul device can then be connected to a number of different communications infrastructures such as cellular, fiber optic, or IEEE 802.11. Communications seem to be the area in which most of the currently available sensors are lacking. For maximum flexibility, sensors should be available with options for interfacing with the following communications media:

- Cellular
- 900 MHz unlicensed spread spectrum data radios by the leading manufacturers
- IEEE 802.11 (WiFi)
- IEEE 802.15.4 (ZigBee)
- Leading wireless AMI systems

Data Stream Management and Interoperability

Assuming the advent of economical, communications-enabled sensors, an extensive deployment could reasonably be expected. To prevent an overwhelming tide of unwieldy data, it is important that the next-generation sensors incorporate features to allow seamless integration with other systems such as AMI and SCADA. It will likely be important for sensors to be capable of tagging data points with time, date, location, and parameter type (such as current, voltage, and temperature). Sensors might need to carry onboard storage and be capable of delivering data to different hosts, as needs arise.

To maximize bandwidth, some sensors will need to preprocess readings, converting the raw data into succinct and actionable information.

Packaging

The size, weight, and shape of sensors are important because of the effects of wind and the danger of vandalism. Sensors should not create a hazard to line workers or to animals, should not increase the likelihood of a fault, and should not attract undue attention, which can lead to vandalism. For example, line post sensors are almost unnoticeable when they are properly installed. By contrast, some new multifunction sensors are large and obtrusive.

As the volume of sensors produced increases, it is expected that prices will decrease. At a certain point, it should become feasible to integrate sensors into equipment, such as incorporating temperature monitoring into distribution transformers or status monitoring into fused cutouts.

A
MS ACCESS DATA BASE REPORT

Queries: Acoustic Sensors

Sensor Name	Manufacturer	Sensor Type	Brief Description	Cost	Anticipated Use
– 244(tenatively)	– Radar Engineers	– RFI, Acoustic, Corona	– Still in testing. Basic summary would be a handheld model of the 247-b. Called switch gear sniffer. Use RFI detector to find cabinet of Corona occurance and then acoustic to pinpoint Corona location.	– 0	– Use of RFI to get into general location of Corona and then use acoustic to pinpoint Corona Location.
– UltraTEV Plus+	– EA Technology	– Acoustic, Corona	– The UltraTEV Plus+ measures PD activity in the form of ultrasonic and transient earth-voltage (TEV) signals, but provides operators with considerably more comprehensive information about emission levels. Ultrasonic emissions are displayed as decibel readings as well as being converted into audible signals, which can be heard through the headphones supplied. TEV signals appear on the menu-driven color LCD screen as numerical values, as a bar graph and as a green-amber-red indication.	– 0	–
– SDT 170 with parabolic Dish	– Martech	– Acoustic, Corona	– The SDT 170MD (Multifunctional/Datalogger) is the complete ultrasonic inspection and predictive maintenance trending machine. With all the features of the SDT 170S Standard and SDT 170M Multifunctional, we've added a customisable data logger that interfaces directly with you PC via DataManager software.	– 7500	– Detect Corona behind electrical cabinet doors. With Use of parabolic disc, can pinpoint corona with lazer sight. Normally sold to factories. Withstand a 3m drop test.
– Partial Discharge Sensors	– GE Power	– Acoustic, Corona	– Partial discharge sensors are self-contained, acoustic sensors utilizing piezo electric element technology. The sensors provide continuous readings and are designed for field use in transformers and load tap changers. Two types of partial discharge sensor options are available: internal tank sensing and external tank sensing. Both designs include weatherproof enclosures for protection.	– 0	– No longer manufactured.

Sensor Name	Manufacturer	Sensor Type	Brief Description	Cost	Anticipated Use
– PD-TM500A	– PowerPD, Inc.	– Acoustic, Corona	– The PD-TM Series: are non-portable, mounted type units. PD-TM500, 1000, 1500 are online diagnostic systems that continuously monitors partial discharge in equipment such as Transformers, GIS, and CGIS etc. This units detect, analyze, and locate the signal source of partial discharge or arcing. This test equipment is mounted on or near the electrical equipment under test, in a weather proof housing. (All PowerPD units include software, which allows accessibility of continuous monitoring from your home or office PC, via, remote internet)	– 34800	– Main use for substations and utilities.
– PD-MAT400A	– PowerPD, Inc	– Acoustic, Corona	– PD-MAT400A is a permanently mounted on-line Partial Discharge (PD) diagnostic system. This test device focuses on detecting and analyzing the generation of PD in equipment such as transformers, HV GIS circuit breakers, GIS ductwork, and CGIS using acoustic emission detection. The ability to link up to 32 units using an RS-422 allows the user a greater degree of protection for critical substation equipment. Each unit uses four Acoustic Emission (AE) sensors. This unit provides advanced warning of potential failures.	– 10500	–
– unknown	– ABB Power T&D Company Inc.	– Acoustic, Corona, Optical	– Acoustic optical system for partial discharge detection and location	– 0	–

Sensor Name	Manufacturer	Sensor Type	Brief Description	Cost	Anticipated Use
– Airborne Acoustic Transducer	– iPEC	– Acoustic, Corona	– The acoustic probe is designed for use on air insulated terminations where there is a clear sound path between the electrically stressed insulation and the probe. The sensor is extremely sensitive and can detect activity below 10pC. The probe has a magnetic base to allow coupling to steel enclosures and a swivel head so the detecting sensor can be aimed directly at the HV point.	– 0	–
– 250	– Radar Engineers	– Acoustic, Corona	– Parabolic Pinpointer Ultrasonic Locator for use from the ground	– 3100	– Use of RFI to get into general location of Corona and then use acoustic to pinpoint Corona Location.
– 247-B	– Radar Engineer	– Acoustic, RFI, Corona	– Hotstick Line Sniffer. RF & Ultrasonic Locator for use from a bucket.	– 950	– Use of RFI to get into general location of Corona and then use acoustic to pinpoint Corona Location.

Queries: Corona Sensors

Sensor Name	Manufacturer	Sensor Type	Brief Description	Cost	Anticipated Use
– 244(tenatively)	– Radar Engineers	– RFI, Acoustic, Corona	– Still in testing. Basic summary would be a handheld model of the 247-b. Called switch gear sniffer. Use RFI detector to find cabinet of Corona occurance and then acoustic to pinpoint Corona location.	– 0	– Use of RFI to get into general location of Corona and then use acoustic to pinpoint Corona Location.
– UltraTEV Plus+	– EA Technology	– Acoustic, Corona	– The UltraTEV Plus+ measures PD activity in the form of ultrasonic and transient earth-voltage (TEV) signals, but provides operators with considerably more comprehensive information about emission levels. Ultrasonic emissions are displayed as decibel readings as well as being converted into audible signals, which can be heard through the headphones supplied. TEV signals appear on the menu-driven color LCD screen as numerical values, as a bar graph and as a green-amber-red indication.	– 0	–
– Corona Finder	– Syntronics	– Optical, Corona	– Small and battery operated, the CoronaFinder is easy to take to the field. Real time UV viewing means that high voltage equipment can be quickly and thoroughly inspected for evidence of corona discharge that is visible only in the ultraviolet spectrum (see photograph below). Clearly identifiable corona discharge seen with the CoronaFinder can be photographed with an optional digital camera that attaches to the CoronaFinder. Click on the following link to "youtube" for video footage of a corona test inspection.	– 14035	– Corona Detection.
– SDT 170 with parabolic Dish	– Martech	– Acoustic, Corona	– The SDT 170MD (Multifunctional/Datalogger) is the complete ultrasonic inspection and predictive maintenance trending machine. With all the features of the SDT 170S Standard and SDT 170M Multifunctional, we've added a customisable data logger that interfaces directly with you PC via DataManager software.	– 7500	– Detect Corona behind electrical cabinet doors. With Use of parabolic disc, can pinpoint corona with lazer sight. Normally sold to factories. Withstand a 3m drop test.

Sensor Name	Manufacturer	Sensor Type	Brief Description	Cost	Anticipated Use
– Partial Discharge Sensors	– GE Power	– Acoustic, Corona	– Partial discharge sensors are self-contained, acoustic sensors utilizing piezo electric element technology. The sensors provide continuous readings and are designed for field use in transformers and load tap changers. Two types of partial discharge sensor options are available: internal tank sensing and external tank sensing. Both designs include weatherproof enclosures for protection.	– 0	– No longer manufactured.
– PD-TM500A	– PowerPD, Inc.	– Acoustic, Corona	– The PD-TM Series: are non-portable, mounted type units. PD-TM500, 1000, 1500 are online diagnostic systems that continuously monitors partial discharge in equipment such as Transformers, GIS, and CGIS etc. This units detect, analyze, and locate the signal source of partial discharge or arcing. This test equipment is mounted on or near the electrical equipment under test, in a weather proof housing. (All PowerPD units include software, which allows accessibility of continuous monitoring from your home or office PC, via, remote internet)	– 34800	– Main use for substations and utilities.
– PD-RD300A	– PowerPD, Inc	– Corona	– The PD-RD300A is the newest device in the PowerPD line of test equipment, which provides continuous monitoring of your metal clad switchgear (MCSG) assets. This device detects electromagnetic waves when surface tracking occurs on the insulation system. It determines the PD fault frequencies by scanning the 10 -100 MHz range. Data is collected in bursts (Envelop) by the count method. This trends the measurement of switchgear deterioration and will give early warning to prevent a catastrophic failure.	– 4700	– Cost is 4700+ depending on number of channels.

Sensor Name	Manufacturer	Sensor Type	Brief Description	Cost	Anticipated Use
– PD-MAT400A	– PowerPD, Inc	– Acoustic, Corona	– PD-MAT400A is a permanently mounted on-line Partial Discharge (PD) diagnostic system. This test device focuses on detecting and analyzing the generation of PD in equipment such as transformers, HV GIS circuit breakers, GIS ductwork, and CGIS using acoustic emission detection. The ability to link up to 32 units using an RS-422 allows the user a greater degree of protection for critical substation equipment. Each unit uses four Acoustic Emission (AE) sensors. This unit provides advanced warning of potential failures.	– 10500	–
– PD-MCC&G400A	– PowerPD, Inc	– Corona	– PD-MCC&G400A is an on-line Partial Discharge (PD) diagnostic system, which detects and analyzes the generation of PD in the power equipments such as Cable and Motor. Four High Frequency Current Transducer (HFCT) Sensors are installed ground line in power equipments to detect PD signals. The PD-MCC&G400A uses four High Frequency Current Transducers (HFCT), which are installed on the shield grounds of cables and case grounds of a motor. The HFCT senses any electrical discharge (PD) in the ground path and captures this signal. The PD-MCC&G400A, has the ability of linking up to 32 units by using a RS-485.	– 0	–
– unknown	– ABB Power T&D Company Inc.	– Acoustic, Corona, Optical	– Acoustic optical system for partial discharge detection and location	– 0	–

Sensor Name	Manufacturer	Sensor Type	Brief Description	Cost	Anticipated Use
– Cable and switchgear PD sensors	– iPEC	– Corona	– The HFCT 100/50 is a high frequency transducer designed specifically for picking up partial discharge signals. It has a split core ferrite to allow retrospective fitting to earth straps without the need for disconnection. The durable body has a hinge and a quick release latch making use quick and easy. The CT is constructed with an aluminium body to provide RF shielding and improved performance in noisy environments. This transducer is ideal for all earth and neutral PD monitoring applications.	– 0	–
– Airborne Acoustic Transducer	– iPEC	– Acoustic, Corona	– The acoustic probe is designed for use on air insulated terminations where there is a clear sound path between the electrically stressed insulation and the probe. The sensor is extremely sensitive and can detect activity below 10pC. The probe has a magnetic base to allow coupling to steel enclosures and a swivel head so the detecting sensor can be aimed directly at the HV point.	– 0	–
– M330	– Radar Engineers	– RFI, Corona	– RFI locators detect sparks and corona that cause radio and T.V. interference (RFI TVI). RF and ultrasonic receivers quickly pinpoint sparking hardware on powerlines.	– 1800	– Use of RFI to get into general location of Corona and then use acoustic to pinpoint Corona Location.
– 240-A	– Radar Engineers	– RFI, Corona	– HF-UHF RFI Locator 1.8-1000 MHZ Oscilloscope Display	– 4700	– Use of RFI to get into general location of Corona and then use acoustic to pinpoint Corona Location.
– 242	– Radar Engineers	– RFI, Corona	– AM-UHF RFI Locator 500 KHZ-1000 MHZ Oscilloscope Display A.M. Probe	– 5500	– Use of RFI to get into general location of Corona and then use acoustic to pinpoint Corona Location.

Sensor Name	Manufacturer	Sensor Type	Brief Description	Cost	Anticipated Use
– 250	– Radar Engineers	– Acoustic, Corona	– Parabolic Pinpointer Ultrasonic Locator for use from the ground	– 3100	– Use of RFI to get into general location of Corona and then use acoustic to pinpoint Corona Location.
– 247-B	– Radar Engineer	– Acoustic, RFI, Corona	– Hotstick Line Sniffer. RF & Ultrasonic Locator for use from a bucket.	– 950	– Use of RFI to get into general location of Corona and then use acoustic to pinpoint Corona Location.

Queries: Current Sensors

Sensor Name	Manufacturer	Sensor Type	Brief Description	Cost	Anticipated Use	Voltage Sensor	Expr1007	Temperature Sensor	Optical Sensor
Elastimold TPM Series	Thomas & Betts	Current	Test Point Mounted Fault Indicators provide a clear, visual means for locating faulted cables and equipment on underground distribution systems. Indicators are self-powered and consist of a solid state current sensor connected to a faulted circuit display. Designs incorporate advanced circuit logic, monitoring system protection operation and preventing indicator tripping unless an overcurrent condition is followed by a loss of system voltage. Trip and reset operations are automatic and the same indicator may be used for 5KV thru 35KV applications.	0		FALSE	FALSE	FALSE	FALSE
UCM Series	Thomas & Betts	Current	URD Cable Mounted Fault Indicators aid in locating faulted cables and equipment on underground distribution systems. Indicators are self powered and consist of a solid state current sensor connected to faulted circuit display.	100		FALSE	FALSE	FALSE	FALSE
OLM Standard	Thomas & Betts	Current	Overhead Line Fault Indicators aid in locating faulted circuits and equipment on overhead distribution systems. Indicators are self powered and consist of a solid state current sensor connected to a faulted circuit display. Designs incorporate advanced circuit logic, monitoring system protection operation and prevent indicator tripping unless an overcurrent condition is followed by a loss of system voltage. Trip and reset operations are automatic and the same indicator may be used for 5kV thru 35kV line-to-ground applications.	99		FALSE	FALSE	FALSE	FALSE
V2 Standard	Thomas & Betts	Current	Test Point Mounted Neon Voltage Indicators provide a convenient, visual method for determining the energized status of underground distribution circuits. The indicator consists of a self-powered voltage sensor connected to a neon light that flashes when energized. Flash rate is proportional to the system voltage and the same indicator may be used for 5KV thru 35KV applications.	30		FALSE	FALSE	FALSE	FALSE

Sensor Name	Manufacturer	Sensor Type	Brief Description	Cost	Anticipated Use	Voltage Sensor	Expr1007	Temperature Sensor	Optical Sensor
AutoRANGER	SEL	Current	When a fault occurs, two of the AutoRANGER's red LEDs will begin to flash. After one minute, the indicator will measure the system current. If it detects load current, the AutoRANGER's yellow LED will begin to flash and the red LEDs will turn off, indicating that the fault was temporary. However, if the fault indicator does not detect a load, its two red LEDs will continue to flash for the flash-clearing period to indicate a permanent fault.	150		FALSE	FALSE	FALSE	FALSE
Underground AutoRANGER	SEL	Current	Ensure the best fault-indicating solution for your underground application by choosing from a wide variety of single- and threephase display options, including remote displays that eliminate the need to open the enclosure to check the fault indicator's status.	100	Can be used with Radio Ranger fault location system. Identify the phase and location of underground faults with the handheld Remote Fault Reader. Wireless Interface ID, phase, and way distinctions display faultpath information in each vault while differentiating between fault indicators in adjacent vaults. A red LED and audible annunciation indicate the presence of a faulted phase. Radio Ranger system costs an additional $1005.00 and can be used with up to 12 sensors.	FALSE	FALSE	FALSE	FALSE
SEL LINAM Current Reset Fault Indicators	SEL	Current	Senses the load and fault currents on the conductor. Use the optional auxiliary contact to provide status indication to a SCADA input.	150	Use the optional auxiliary contact to provide status indication to a SCADA input.	FALSE	FALSE	FALSE	FALSE
Single-Phase Test Point Mounted Bolt Display FCI	SEL	Current	Install 1TPRB fault indicators in padmount transformers, subsurface load centers, or junction sectionalizing points. In single-phase underground loop applications, install the 1TPRB at the transformer. At sectionalizing junctions, place an indicator on each outgoing feed, just below the elbow pulling eye. SEL also offers the 1TPRB with an auxiliary contact feature. This model has the same compact, easy-to-use and apply package as the standard unit, but allows the utility to connect the fault indicator to a SCADA system.	78		FALSE	FALSE	FALSE	FALSE

Sensor Name	Manufacturer	Sensor Type	Brief Description	Cost	Anticipated Use	Voltage Sensor	Expr1007	Temperature Sensor	Optical Sensor
Underground Fault Sensor	Arteche	Current	The task of the ARTECHE Fault Indicator Relay is to detect the faulty line section and indicate the incidence so that, via remote signal transmission, for example, adequate actions are taken and the section affected can be quickly isolated.	0		FALSE	FALSE	FALSE	FALSE
Power Flex Current Sensor	Joslyn Hi-Voltage	Current	The Fisher Pierce Series 1301 high accuracy line post current sensors provide a reliable measuring method for distribution systems from zero to thousands of amperes. The current sensors may be used for capacitor switching, load surveying, or protective relaying.The sensor consists of a porcelain line post insulator with an embedded coil that is inductively coupled to the conductor. The voltage induced in the coil is directly proportional to the alternating current in the primary conductor. The Series 1301 high accuracy sensors may be used with the Series 4400/4500 AutoCap Capacitor Controllers for Var or Current control applications.	500	15kV, 25kV, 35kV	FALSE	FALSE	FALSE	FALSE
SEI601	ABB	Current	By simply attaching a small, non-intrusive, clamp-on AC/DC sensor to the relay wires and connecting its Cat5 cable to the supplied recording switch, real-time analog and digital information is readily available for analysis. The sensor is highly sensitive to a resolution of 10 microseconds and is capable of sensing millisecond transients with a 2% accuracy range. This clamp-on sensor, coupled with our waveform data analysis, is capable of fast line restoration, fault and disturbance analysis, and real time monitoring of evolving loads - all without the costs involved in upgrading to microprocessors.	3500	This system is composed of 8 current sensors, a reciever, and the analysis software for around $3500. This is a new product and very little information is currently available.	FALSE	FALSE	FALSE	FALSE
Radio Faulted Circuit Indicator System	Joslyn Hi-Voltage	Current	The Fisher Pierce Radio Faulted Circuit Indicator (RFCI) System utilizes wireless communication technology to assist in locating distribution system faulted circuits. RFCI's installed in overhead, underground, and padmount locations can be detected from handheld radio receivers. Linemen in a moving vehicle can quickly locate the RFCI and receive their status.	200	1547/1548 Series.	FALSE	FALSE	FALSE	FALSE
TPR	Cooper Power Systems	Current	Cooper Power Systems' S.T.A.R. Test Point Reset (TPR) faulted circuit indicators (FCIs) can be used on all 200 A and 600 A connectors having a voltage test point. Load levels do not effect the reset circuit. The unit automatically resets to the normal position when circuit voltage is restored.	110	70-110	FALSE	FALSE	FALSE	FALSE

Sensor Name	Manufacturer	Sensor Type	Brief Description	Cost	Anticipated Use	Voltage Sensor	Expr1007	Temperature Sensor	Optical Sensor
MR	Cooper Power Systems	Current	Cooper Power Systems' S.T.A.R. Manual Reset (MR) faulted circuit indicators (FCIs) can be used on overhead uninsulated, unshielded cable and unshielded insulated cable such as tree wire. The MR FCI can also be installed on padmounted distribution transformers, sector cabinets and switchgear applications. To reset the FCI, simply touch the reset tool to the MR housing.	110		FALSE	FALSE	FALSE	FALSE
LVR	Cooper Power Systems	Current	Cooper Power Systems' S.T.A.R. Low Voltage Reset (LVR) faulted circuit indicators (FCIs) can be installed on padmounted distribution transformers, or at a secondary voltage source. The unit automatically resets to the normal position when circuit voltage is restored.	135	$105-135	FALSE	FALSE	FALSE	FALSE
ER	Cooper Power Systems	Current	Cooper Power Systems' S.T.A.R. Electrostatic Reset (ER) faulted circuit indicators (FCIs) can be used on overhead uninsulated, unshielded cable and unshielded insulated cable, such as tree wire. They are powered from the voltage gradient between the line and the ground plane. Load levels do not affect the reset circuit. The unit automatically resets to the normal position when circuit voltage is restored.	110		FALSE	FALSE	FALSE	FALSE
DR	Cooper Power Systems	Current	Cooper Power Systems' S.T.A.R. Delayed Reset (DR) faulted circuit indicators (FCIs) can be installed on padmounted distribution transformers, sector cabinets, switchgear and overhead bare conductors. The unit automatically resets back to the normal position when reset time has expired.	40		FALSE	FALSE	FALSE	FALSE
CR	Cooper Power Systems	Current	Cooper Power Systems' S.T.A.R. Current Reset (CR) faulted circuit indicators (FCIs) can be installed on padmounted distribution transformers, sector cabinets, switchgear and overhead bare conductors. The unit automatically resets back to the normal position when the continuous current exceeds the 2.4 A reset value.	100	80-100	FALSE	FALSE	FALSE	FALSE
ER S.T.A.R. Pathfinder	Cooper Power Systems	Current	High Tech at Low-Tech Prices – The latest industry technology is now available at a price everyone can afford. Reduces Operating Costs, Reduces Inventory, Improves Power Quality, Finds the Fault the First Time. A pair of high luminous LEDs in addition to the FISHEYE display offer superior visibility in all outdoor environments. LED is rated for more than 1000 hours of flashing operation.	110	Can be used with outage advisor system for additional cost.	FALSE	FALSE	FALSE	FALSE

Sensor Name	Manufacturer	Sensor Type	Brief Description	Cost	Anticipated Use	Voltage Sensor	Expr1007	Temperature Sensor	Optical Sensor
TPR S.T.A.R. Pathfinder	Cooper Power Systems	Current	Cooper Power Systems S.T.A.R.™ PATHFINDER™ Variable Trip Test Point faulted circuit indicators (FCI) are designed to quickly and easily locate faulted sections of underground cable systems. These FCIs can be used on both 200 A separable connectors and 600 A terminators with a voltage test point. The removable sleeve allows for use on major manufacturers' loadbreak elbows.	110	$80-110 Can be utilized with outage advisor for remote fault detection for additional cost.	FALSE	FALSE	FALSE	FALSE
1514/15	Joslyn Hi-Voltage	Current	The Fisher Pierce Series 1514/15 Current- Reset Faulted Circuit Indicators locate faults quickly by monitoring line current. The 1514/15 FCIs locate faults quickly and isolate the source which reduces emergency labor, and decreases outages and revenue loss.	145		FALSE	FALSE	FALSE	FALSE
Overhead FCI's	Power Delivery Products	Current	Overhead Fault Indicators are available with a mechanical flag or LED indication. In addition to permanent installations to reduce outage time, these units are ideal for finding temporary, transient, or nuisance outages. Load Tracker capability is available in all overhead models.	185	Can be paired with a radio transmitter reciever unit which has a 40-50ft range(mount at bottom of pole below FCI) and when a fault is received, the unit closes a contact which can be connected to an RTU or Cellular RTU(Telemetric).	FALSE	FALSE	FALSE	FALSE
Underground FCI's	Power Delivery Products	Current	There are two major styles of Underground Faulted Circuit Indicators – Mechanical and Electronic. The Mechanical units offer years of economical fault indication. Rotor, submersible and fluid units are available with or without provisions for hotsick installation. Electronic units provide a wide range of options and are reset automatically. The one size fits all Load Tracker is the most advanced unit available today. All Electronic units are capable of remote indication through the use of fiber optic cable and all units can be upgraded to SCADA, or Cellular Reporting.	120	Fault is indicated via blinking led on the FCI. To remotely receive the fault indication, a fiber optic lead is connected to the LED socket while the opposite end is connected to a converter box, which will close a contact on an RTU or other device when a fault is detected.	FALSE	FALSE	FALSE	FALSE
Automation FCI's	Power Delivery Products	Current	Automation is provided on underground units through the Distribution automation relay and for overhead applications with the Radio Faulted Circuit Indicator. (RFCI). The RFCI mounted on an overhead circuit sends a radio signal to a receiver which is connected to your SCADA.	120	Can be paired with a radio transmitter reciever unit which has a 40-50ft range(mount at bottom of pole below FCI) and when a fault is received, the unit closes a contact which can be connected to an RTU or Cellular RTU(Telemetric).	FALSE	FALSE	FALSE	FALSE

Sensor Name	Manufacturer	Sensor Type	Brief Description	Cost	Anticipated Use	Voltage Sensor	Expr1007	Temperature Sensor	Optical Sensor
PF Live Plus	On-line Monitoring, Inc.	Current, Temperature	The PF Live Plus, a continuous on-line monitoring system, for monitoring power factor in high voltage capacitive bushings, is now available with an optional leakage current monitor for high voltage lightning arresters. The system includes a minimum set of three sensors permanently connected to a series of capacitive bushing taps, or lightning arresters. It is based on the field proven SOS Tan δ System. The system is capable of monitoring up to 32 direct connected sensors, and up to 256 wireless sensors.	0	The PF Live Plus system can also interface to signals from other devices, or IED's, such as: temperature sensors, DGA, or any 0-10Vdc, 10Vrms, 4-20mA, or 0-1mA signal.	FALSE	FALSE	FALSE	FALSE
HV Transducer Current Probe	SURETECH	Current	This range of current probes is used for measuring tan(delta) on HV apparatus, insulation resistance and capacitance under HV operational and test conditions. Leakage current is measured and its phase is compared with the HV reference excitation voltage's phase. The resistive component of current is separated from the capacitive component by Cos(phi) and Sin(phi) processing. These two parameters are then available on an RS232 link, for further processing by a PC computer using Excel or other spreadsheet. The probes can also output a 0-2Vdc signal that represents either capacitive or resistive current.	0		FALSE	FALSE	FALSE	FALSE
AC Current Sensors	SURETECH	Current	SURETECH AC Current sensors are available in various formats, including slip-on, or bar-primary. These sensors are available for single OR three phase measurements. The sensor uses Rogowski technology to measure AC currents. Rogowski technology does not respond to DC (zero output at zero frequency input), the sensors can be used to measure the AC component on a DC line. Care needs to be taken to specify frequencies being measured.	0		FALSE	FALSE	FALSE	FALSE

Optical Sensors

Text38	Text8	Text34	Text6	Text36	Text2
– The fixed frequency RFID Fob has a range of 100 to 125 meters and communicates with the TPX-GSM-100 Remote Transmission Unit (Access Point) or Telepathx compatible smart Meters, BPL/PLC & WIFI access points alerting you when and where a fuse has been acti	– Available in the following protocols 433Mhz Reactive RFID 900Mhz Reactive RFID 900Mhz Reactive 802.15.4 RFID 2.4Ghz Reactive 802.11g 2.4Ghz Reactive 802.15.4	– Telepathx	– RFID cutout fuse monitor	– Optical	– 0
– Small and battery operated, the CoronaFinder is easy to take to the field. Real time UV viewing means that high voltage equipment can be quickly and thoroughly inspected for evidence of corona discharge that is visible only in the ultraviolet spectrum (s	– Corona Detection.	– Syntronics	– Corona Finder	– Optical, Corona	– 14035
– Safe and Easy to Install -does not conduct electrical current - intrinsically isolated making it safe to personnel and interconnected equipment Small, Lightweight, Immune to EMI/RFI, Zero Risk of Explosive Failure, Intended for 54.5 KV Applications and Be	– Appear to have obtained U.S. Navy contract. Does not appear to be available to the public.	– unknown	– Airak's Patented Optical Current Sensor System	– Current, Optical	– 0

Text38	Text8	Text34	Text6	Text36	Text2
– FOT-F and FOT-N temperature transducers combine all the desired characteristics expected from the ideal sensor. Their compact size, immunity to EMI/RFI/lightning, resistance to corrosive environments, high accuracy and reliability make them the best choi	– Used to monitor a variety of systems. Could be used on transformers to monitor temperature or conductors, however installation on conductors is not a normal procedure. Requires a readout or datalogging device with fiber-optic interface.	– Roctest	– FOT-F FOT	– Temperature, Optical	– 250
– Fiber Optic Temperature laser radar. The FTR is composed of a fiber optic temperature sensing and measureing unit and a computer display to show temperature distribution along a conductor up to 6km in length.	– Contacted a rep. Emailed kabuto@hitachi-cable.com Should be getting back with me soon to give pricing.	– Hitachi	– FTR	– Temperature, Optical	– 0
– Acoustic optical system for partial discharge detection and location	–	– ABB Power T&D Company Inc.	– unknown	– Acoustic, Corona, Optical	– 0
– A novel photoacoustic spectrometer (PA) has been developed for in-situ detection of SF6 leaks in low concentrations. The developed system is equipped with a sound alarm system and has been tested in the laboratory for very minute SF6 leaks. This newly dev	–	– unknown	– Optical Sensors	– Optical	– 0
– System for monitoring high-tension cables in air stretches as well as a use of the same. The system comprises at least one optic fiber fastened to the high tension cable, the optic fiber including at least one Bragg grating with known reflection character	–	– Leiv Eiriksson Nyfotek AS	– System for monitoring cables	– Optical	– 0

Text38	Text8	Text34	Text6	Text36	Text2
– Polytec's IVS-200 Industrial Vibration Sensor is a ruggedized laser Doppler vibrometer for non-contact, on-line production vibration testing. An eye-safe visible laser is aimed and focused onto the part being measured. IVS-200 is easily retrofitted into	–	– Polytec	– IVS-200	– Vibration, Optical	– 23250
– FLIR provides utilities with the most advanced thermal imaging solutions to support the monitoring programs that keep the vital electrical power grid up and running. FLIR ThermaCAM infrared cameras have revolutionized predictive/preventive maintenance in	–	– Flir Systems, LTD	– Infrared Cameras	– Optical, Temperature	– 0

RFI Sensors

Manufacturer	Sensor Type	Brief Description	Cost	Anticipated Use
Radar Engineers	RFI, Acoustic, Corona	Still in testing. Basic summary would be a handheld model of the 247-b. Called switch gear sniffer. Use RFI detector to find cabinet of Corona occurance and then acoustic to pinpoint Corona location.	0	Use of RFI to get into general location of Corona and then use acoustic to pinpoint Corona Location.
Radar Engineers	RFI, Corona	RFI locators detect sparks and corona that cause radio and T.V. interference (RFI TVI). RF and ultrasonic receivers quickly pinpoint sparking hardware on powerlines.	1800	Use of RFI to get into general location of Corona and then use acoustic to pinpoint Corona Location.
Radar Engineers	RFI, Corona	HF-UHF RFI Locator 1.8-1000 MHZ Oscilloscope Display	4700	Use of RFI to get into general location of Corona and then use acoustic to pinpoint Corona Location.
Radar Engineers	RFI, Corona	AM-UHF RFI Locator 500 KHZ-1000 MHZ Oscilloscope Display A.M. Probe	5500	Use of RFI to get into general location of Corona and then use acoustic to pinpoint Corona Location.
Radar Engineer	Acoustic, RFI, Corona	Hotstick Line Sniffer. RF & Ultrasonic Locator for use from a bucket.	950	Use of RFI to get into general location of Corona and then use acoustic to pinpoint Corona Location.
Exacter, Inc.	RFI	The EXACTER® Outage-Avoidance System provides early warning of failing transformers, regulators, insulators, cutouts, lightning arrestors, and more, utilizing advanced sensor-array technology. Geospatial mapping provides location data and problem severity for maintenance prioritization and outage avoidance.	3000	Unit price per month (survey themselves), they produce reports of faulty components. Also do turnkey services. Monitor overhead distribution by listening to RF signatures, then data is analyzed by the service. Price for rental is 3000-6000/month for a unit depending on setup. Turnkey pricinig is done on a custom basis.

Queries: Selected for Testing

Sensor Name	Manufacturer	Sensor Type	Brief Description	Cost	Anticipated Use
– Elastimold TPM Series	– Thomas & Betts	– Current	– Test Point Mounted Fault Indicators provide a clear, visual means for locating faulted cables and equipment on underground distribution systems. Indicators are self-powered and consist of a solid state current sensor connected to a faulted circuit display. Designs incorporate advanced circuit logic, monitoring system protection operation and preventing indicator tripping unless an overcurrent condition is followed by a loss of system voltage. Trip and reset operations are automatic and the same indicator may be used for 5KV thru 35KV applications.	– 0	–
– UCM Series	– Thomas & Betts	– Current	– URD Cable Mounted Fault Indicators aid in locating faulted cables and equipment on underground distribution systems. Indicators are self powered and consist of a solid state current sensor connected to faulted circuit display.	– 100	–
– OLM Standard	– Thomas & Betts	– Current	– Overhead Line Fault Indicators aid in locating faulted circuits and equipment on overhead distribution systems. Indicators are self powered and consist of a solid state current sensor connected to a faulted circuit display. Designs incorporate advanced circuit logic, monitoring system protection operation and prevent indicator tripping unless an overcurrent condition is followed by a loss of system voltage. Trip and reset operations are automatic and the same indicator may be used for 5kV thru 35kV line-to-ground applications.	– 99	–

Sensor Name	Manufacturer	Sensor Type	Brief Description	Cost	Anticipated Use
– V2 Standard	– Thomas & Betts	– Current	– Test Point Mounted Neon Voltage Indicators provide a convenient, visual method for determining the energized status of underground distribution circuits. The indicator consists of a self-powered voltage sensor connected to a neon light that flashes when energized. Flash rate is proportional to the system voltage and the same indicator may be used for 5KV thru 35KV applications.	– 30	–
– LT40	– GridSense	– Voltage, Current	– By clipping the LT40 / LT50 on to lines at strategic points, e.g. tee junctions, switches, substations etc., data such as load, maximum demand, inrush current, fault wave shape & duration, protection operation, voltage status, conductor and ambient temperature etc. are stored for local download or remote reporting, thus value adding existing SCADA, Load Modeling, Historian systems, etc.. but at a fraction the cost of a full SCADA system involving PTs, CTs, relays, etc.	– 1800	– up to 69 KV, can communicate down to data link, which is a dashboard mounted device. Also have a scada solution, cellphone, etc. Must be mounted to bare conductor. Has regowski coil. Had a dimensionless voltage readout which can be used to calculate actual fault position within a pole during an event. Data link is about $500 upgrade. Hotstick mountable.
– LT50	– GridSense	– Voltage, Current, Temperature	– By clipping the LT40 / LT50 on to lines at strategic points, e.g. tee junctions, switches, substations etc., data such as load, maximum demand, inrush current, fault wave shape & duration, protection operation, voltage status, conductor and ambient temperature etc. are stored for local download or remote reporting, thus value adding existing SCADA, Load Modeling, Historian systems, etc.. but at a fraction the cost of a full SCADA system involving PTs, CTs, relays, etc.	– 3100	– up to 138KV, can communicate down to data link, which is a dashboard mounted device. Also have a scada solution, cellphone, etc. Must be mounted to bare conductor. Has regowski coil. Had a dimensionless voltage readout which can be used to calculate actual fault position to a pole during an event. Data link is about $500 upgrade. Hotstick mountable.

Sensor Name	Manufacturer	Sensor Type	Brief Description	Cost	Anticipated Use
– AutoRANGER	– SEL	– Current	– When a fault occurs, two of the AutoRANGER's red LEDs will begin to flash. After one minute, the indicator will measure the system current. If it detects load current, the AutoRANGER's yellow LED will begin to flash and the red LEDs will turn off, indicating that the fault was temporary. However, if the fault indicator does not detect a load, its two red LEDs will continue to flash for the flash-clearing period to indicate a permanent fault.	– 150	–
– Underground AutoRANGER	– SEL	– Current	– Ensure the best fault-indicating solution for your underground application by choosing from a wide variety of single- and threephase display options, including remote displays that eliminate the need to open the enclosure to check the fault indicator’s status.	– 100	– Can be used with Radio Ranger fault location system. Identify the phase and location of underground faults with the handheld Remote Fault Reader. Wireless Interface ID, phase, and way distinctions display faultpath information in each vault while differentiating between fault indicators in adjacent vaults. A red LED and audible annunciation indicate the presence of a faulted phase. Radio Ranger system costs an additional $1005.00 and can be used with up to 12 sensors.
– SEL LINAM Current Reset Fault Indicators	– SEL	– Current	– Senses the load and fault currents on the conductor. Use the optional auxiliary contact to provide status indication to a SCADA input.	– 150	– Use the optional auxiliary contact to provide status indication to a SCADA input.

Sensor Name	Manufacturer	Sensor Type	Brief Description	Cost	Anticipated Use
– Single-Phase Test Point Mounted Bolt Display FCI	– SEL	– Current	– Install 1TPRB fault indicators in padmount transformers, subsurface load centers, or junction sectionalizing points. In single-phase underground loop applications, install the 1TPRB at the transformer. At sectionalizing junctions, place an indicator on each outgoing feed, just below the elbow pulling eye. SEL also offers the 1TPRB with an auxiliary contact feature. This model has the same compact, easy-to-use and apply package as the standard unit, but allows the utility to connect the fault indicator to a SCADA system.	– 78	–
– Underground Fault Sensor	– Arteche	– Current	– The task of the ARTECHE Fault Indicator Relay is to detect the faulty line section and indicate the incidence so that, via remote signal transmission, for example, adequate actions are taken and the section affected can be quickly isolated.	– 0	–
– Power Donut 2	– USI Power	– Voltage, Current, Temperature	– The Power-Donut2™ is an engineering instrumentation platform whose functions include: data acquisition, data monitoring and logging the parameters of high voltage overhead conductors. The Power-Donut2™ is completely self- contained, allowing for hot stick installation with no required outage. The product is available with communication options that integrate with new or existing monitoring and control systems. The Power-Donut2™ is a versatile platform with which to implement several utility engineering applications. Accurate, reliable and economical, the Power-Donut2™ is an ideal accessory for High Voltage Overhead Conductor Systems.	– 14500	– Will be mass produced soon. Price should drop. Currently Testing new model which will offer full waveform capturing and event logging as well as offer GPS clock.

Sensor Name	Manufacturer	Sensor Type	Brief Description	Cost	Anticipated Use
– Power Flex Current Sensor	– Joslyn Hi-Voltage	– Current	– The Fisher Pierce Series 1301 high accuracy line post current sensors provide a reliable measuring method for distribution systems from zero to thousands of amperes. The current sensors may be used for capacitor switching, load surveying, or protective relaying. The sensor consists of a porcelain line post insulator with an embedded coil that is inductively coupled to the conductor. The voltage induced in the coil is directly proportional to the alternating current in the primary conductor. The Series 1301 high accuracy sensors may be used with the Series 4400/4500 AutoCap Capacitor Controllers for Var or Current control applications.	– 500	– 15kV, 25kV, 35kV
– Airak's Patented Optical Current Sensor System	– unknown	– Current, Optical	– Safe and Easy to Install -does not conduct electrical current - intrinsically isolated making it safe to personnel and interconnected equipment Small, Lightweight, Immune to EMI/RFI, Zero Risk of Explosive Failure, Intended for 54.5 KV Applications and Below, Automated Manufacturing, Increased Dynamic Range and Bandwidth, Hot Stick Mountable.	– 0	– Appear to have obtained U.S. Navy contract. Does not appear to be available to the public.

Sensor Name	Manufacturer	Sensor Type	Brief Description	Cost	Anticipated Use
– Multicore Sensor	– Lindsey Manufacturing	– Voltage, Current	– The Multicore Sensor is designed to be installed without de-energizing or cutting the main conductor. This sensor does not require any special calibration for conductor diameter to produce its 2% accurate output. It can be vertically mounted to replace any standard insulator. The deep groove design places the current path at the center of multiple sensing cores that are embedded inside the solid insulator. Overall symmetry of the internal sensing system ensures high accuracy.	– 760	– Prices range from $760-1190 15kV Current + Voltage Multicore Sensor $760 25kV Current + Voltage Multicore Sensor $920 35kV Current + Voltage Multicore Sensor $1,190
– Current and Voltage Monitoring Insulators	– Lindsey Manufacturing	– Voltage, Current	– Many electric utilities are using Distribution Automation (DA) for both overhead and underground systems. DA systems enable a utility to monitor, coordinate and operate distribution systems in real time mode from remote locations. Utilities that have installed DA systems have experienced the greatest benefits in the following areas: Reduced customer outage minutes per year, Increased revenues due to faster restoration in problem areas, Reduced customer complaints, Reduced system losses.	– 790	– 15kV Current + Voltage Sensor $790 25kV Current + Voltage Sensor $950 35kV Current + Voltage Sensor $1,220 46kV Current + Voltage Sensor $2,480
– Smart Pin	– Lindsey Manufacturing	– Voltage, Current	– The SmartPin current and voltage sensing system is a low cost solution for monitoring overhead distribution lines. The system consists of three sensor pins capable of supporting standard pin insulators (vertical orientation) and a control box for calibration and display of readings. Each sensor pin contains a hall effect current sensor and a capacitive voltage divider.	– 0	– not available.

Sensor Name	Manufacturer	Sensor Type	Brief Description	Cost	Anticipated Use
– Elbow Cap	– Lindsey Manufacturing	– Voltage, Current	– The ElbowCap current and voltage sensing system is a low cost solution for monitoring underground distribution feeders. The system consists of three sensors that snap onto the capacitive test point of standard 200A and 600A elbows with a control box for calibration and display of readings. Each sensor contains a hall effect current sensor and a capacitive voltage divider (with the same features as the SmartPin).	– 0	– not available.
– Elbow Sense	– Lindsey Manufacturing	– Voltage, Current	– Lindsey ElbowSense Current and Voltage Monitors use proven CT and voltage sensor technology from the original Lindsey CVMI and fit standard 600 amp T-body 15, 25 and 35kV connectors. They are easily retrofitted to existing padmount or submersible equipment. These sensors may also be used with outdoor, overhead mounted equipment that use standard elbows.	– 300	– Current Monitoring Rings $300 Voltage Monitoring Plugs (qty 1-3) $660
– LightHouse	– Tollgrade	– Current, Temperature	– Tollgrade's LightHouse solution is designed to provide real-time grid intelligence by using sensors that continuously monitor key circuit parameters and transmit them over a self-configuring wireless mesh network to a central location.	– 700	– 4-35kV. Still in pilot programs. Hot stick mountable. Also measures 3rd harmonic.
– DRMCC-T3	– Dynamic Ratings	– Current, Temperature	– Replaces several control devices, providing control, monitoring & data aquisition for the entire transformer. This device has several sensors which may be connected to monitor several aspects of a transformer.	– 18000	– Can consollidate any other outside IED information, can controll transformer cooling. Pricing is $12000-18000 depending on options. Installation can be done as full turn key, $15000, or as a supervisory only install for which the price would vary.

Sensor Name	Manufacturer	Sensor Type	Brief Description	Cost	Anticipated Use
– Promethean Devices	– unknown	– Current, Temperature	– Low-Cost, Non-Contact, High Accuracy Sensor for the Simultaneous, Reliable, Real-time Determination and Monitoring of HV Transmission Line Sag, Temperature, Current, and Ampacity.	– 0	– No contact informaion. Website is under construction.
– SEI601	– ABB	– Current	– By simply attaching a small, non-intrusive, clamp-on AC/DC sensor to the relay wires and connecting its Cat5 cable to the supplied recording switch, real-time analog and digital information is readily available for analysis. The sensor is highly sensitive to a resolution of 10 microseconds and is capable of sensing millisecond transients with a 2% accuracy range. This clamp-on sensor, coupled with our waveform data analysis, is capable of fast line restoration, fault and disturbance analysis, and real time monitoring of evolving loads - all without the costs involved in upgrading to microprocessors.	– 3500	– This system is composed of 8 current sensors, a reciever, and the analysis software for around $3500. This is a new product and very little information is currently available.
– Radio Faulted Circuit Indicator System	– Joslyn Hi-Voltage	– Current	– The Fisher Pierce Radio Faulted Circuit Indicator (RFCI) System utilizes wireless communication technology to assist in locating distribution system faulted circuits. RFCI's installed in overhead, underground, and padmount locations can be detected from handheld radio receivers. Linemen in a moving vehicle can quickly locate the RFCI and receive their status.	– 200	– 1547/1548 Series.
– TPR	– Cooper Power Systems	– Current	– Cooper Power Systems' S.T.A.R. Test Point Reset (TPR) faulted circuit indicators (FCIs) can be used on all 200 A and 600 A connectors having a voltage test point. Load levels do not effect the reset circuit. The unit automatically resets to the normal position when circuit voltage is restored.	– 110	– 70-110

Sensor Name	Manufacturer	Sensor Type	Brief Description	Cost	Anticipated Use
– MR	– Cooper Power Systems	– Current	– Cooper Power Systems' S.T.A.R. Manual Reset (MR) faulted circuit indicators (FCIs) can be used on overhead uninsulated, unshielded cable and unshielded insulated cable such as tree wire. The MR FCI can also be installed on padmounted distribution transformers, sector cabinets and switchgear applications. To reset the FCI, simply touch the reset tool to the MR housing.	– 110	–
– LVR	– Cooper Power Systems	– Current	– Cooper Power Systems' S.T.A.R. Low Voltage Reset (LVR) faulted circuit indicators (FCIs) can be installed on padmounted distribution transformers, or at a secondary voltage source. The unit automatically resets to the normal position when circuit voltage is restored.	– 135	– $105-135
– ER	– Cooper Power Systems	– Current	– Cooper Power Systems' S.T.A.R. Electrostatic Reset (ER) faulted circuit indicators (FCIs) can be used on overhead uninsulated, unshielded cable and unshielded insulated cable, such as tree wire. They are powered from the voltage gradient between the line and the ground plane. Load levels do not affect the reset circuit. The unit automatically resets to the normal position when circuit voltage is restored.	– 110	–
– DR	– Cooper Power Systems	– Current	– Cooper Power Systems' S.T.A.R. Delayed Reset (DR) faulted circuit indicators (FCIs) can be installed on padmounted distribution transformers, sector cabinets, switchgear and overhead bare conductors. The unit automatically resets back to the normal position when reset time has expired.	– 40	–

Sensor Name	Manufacturer	Sensor Type	Brief Description	Cost	Anticipated Use
– CR	– Cooper Power Systems	– Current	– Cooper Power Systems' S.T.A.R. Current Reset (CR) faulted circuit indicators (FCIs) can be installed on padmounted distribution transformers, sector cabinets, switchgear and overhead bare conductors. The unit automatically resets back to the normal position when the continuous current exceeds the 2.4 A reset value.	– 100	– 80-100
– ER S.T.A.R. Pathfinder	– Cooper Power Systems	– Current	– High Tech at Low-Tech Prices – The latest industry technology is now available at a price everyone can afford. Reduces Operating Costs, Reduces Inventory, Improves Power Quality, Finds the Fault the First Time. A pair of high luminous LEDs in addition to the FISHEYE display offer superior visibility in all outdoor environments. LED is rated for more than 1000 hours of flashing operation.	– 110	– Can be used with outage advisor system for additional cost.
– TPR S.T.A.R. Pathfinder	– Cooper Power Systems	– Current	– Cooper Power Systems S.T.A.R.™ PATHFINDER™ Variable Trip Test Point faulted circuit indicators (FCI) are designed to quickly and easily locate faulted sections of underground cable systems. These FCIs can be used on both 200 A separable connectors and 600 A terminators with a voltage test point. The removable sleeve allows for use on major manufacturers' loadbreak elbows.	– 110	– $80-110 Can be utilized with outage advisor for remote fault detection for additional cost.
– 1514/15	– Joslyn Hi-Voltage	– Current	– The Fisher Pierce Series 1514/15 Current-Reset Faulted Circuit Indicators locate faults quickly by monitoring line current. The 1514/15 FCIs locate faults quickly and isolate the source which reduces emergency labor, and decreases outages and revenue loss.	– 145	–

Sensor Name	Manufacturer	Sensor Type	Brief Description	Cost	Anticipated Use
– Overhead FCI's	– Power Delivery Products	– Current	– Overhead Fault Indicators are available with a mechanical flag or LED indication. In addition to permanent installations to reduce outage time, these units are ideal for finding temporary, transient, or nuisance outages. Load Tracker capability is available in all overhead models.	– 185	– Can be paired with a radio transmitter reciever unit which has a 40-50ft range(mount at bottom of pole below FCI) and when a fault is received, the unit closes a contact which can be connected to an RTU or Cellular RTU(Telemetric).
– Underground FCI's	– Power Delivery Products	– Current	– There are two major styles of Underground Faulted Circuit Indicators – Mechanical and Electronic. The Mechanical units offer years of economical fault indication. Rotor, submersible and fluid units are available with or without provisions for hotsick installation. Electronic units provide a wide range of options and are reset automatically. The one size fits all Load Tracker is the most advanced unit available today. All Electronic units are capable of remote indication through the use of fiber optic cable and all units can be upgraded to SCADA, or Cellular Reporting.	– 120	– Fault is indicated via blinking led on the FCI. To remotely receive the fault indication, a fiber optic lead is connected to the LED socket while the opposite end is connected to a converter box, which will close a contact on an RTU or other device when a fault is detected.
– Automation FCI's	– Power Delivery Products	– Current	– Automation is provided on underground units through the Distribution automation relay and for overhead applications with the Radio Faulted Circuit Indicator. (RFCI). The RFCI mounted on an overhead circuit sends a radio signal to a receiver which is connected to your SCADA.	– 120	– Can be paired with a radio transmitter reciever unit which has a 40-50ft range(mount at bottom of pole below FCI) and when a fault is received, the unit closes a contact which can be connected to an RTU or Cellular RTU(Telemetric).

Sensor Name	Manufacturer	Sensor Type	Brief Description	Cost	Anticipated Use
– PF Live Plus	– On-line Monitoring, Inc.	– Current, Temperature	The PF Live Plus, a continuous on-line monitoring system, for monitoring power factor in high voltage capacitive bushings, is now available with an optional leakage current monitor for high voltage lightning arresters. The system includes a minimum set of three sensors permanently connected to a series of capacitive bushing taps, or lightning arresters. It is based on the field proven SOS Tan δ System. The system is capable of monitoring up to 32 direct connected sensors, and up to 256 wireless sensors.	– 0	– The PF Live Plus system can also interface to signals from other devices, or IED's, such as: temperature sensors, DGA, or any 0-10Vdc, 10Vrms, 4-20mA, or 0-1mA signal.
– SURETECH VIx Monitoring System	– SURETECH	– Voltage, Current	– The SURETECH Vix monitoring system senses, processes and logs electrical parameters to data flash memory, on MV (Medium Voltage) equipment. Sensor outputs are fed to a SURETECH SLP (Smart Load Processor), which samples Voltage, Current, Phase angle and Quadrant, and processes all electrical parameters including Import / Export of: kW, kVA, kVARs, kWH, kVAH, kVARH; Power Factor, Phase angle, Frequency and others if required. All of this is available in THE SAFEST, most compact, and most cost-effective package.	– 0	–

Sensor Name	Manufacturer	Sensor Type	Brief Description	Cost	Anticipated Use
– HV Transducer Current Probe	– SURETECH	– Current	– This range of current probes is used for measuring tan(delta) on HV apparatus, insulation resistance and capacitance under HV operational and test conditions. Leakage current is measured and its phase is compared with the HV reference excitation voltage's phase. The resistive component of current is separated from the capacitive component by Cos(phi) and Sin(phi) processing. These two parameters are then available on an RS232 link, for further processing by a PC computer using Excel or other spreadsheet. The probes can also output a 0- 2Vdc signal that represents either capacitive or resistive current.	– 0	–
– AC Current Sensors	– SURETECH	– Current	– SURETECH AC Current sensors are available in various formats, including slip-on, or bar-primary. These sensors are available for single OR three phase measurements. The sensor uses Rogowski technology to measure AC currents. Rogowski technology does not respond to DC (zero output at zero frequency input), the sensors can be used to measure the AC component on a DC line. Care needs to be taken to specify frequencies being measured.	– 0	–

Sensor Name	Manufacturer	Sensor Type	Brief Description	Cost	Anticipated Use
– MetPod/Metpod lite(skinnier version of MetPod)	– FieldMetrics Inc.	– Voltage, Current	– The MetPod is our first product release based on our patent-pending technology. An integrated VT, clamp-on CT and meter, it meets 0.2 accuracy class requirements and has passed full dielectric type-tests. The MetPod offers a wireless link and self diagnostics in a low-cost, lightweight, scalable, sturdy, environmentally green package which is easily installed in almost any location and orientation.	– 3000	– Testing in the field currently. Using 900MHz modem for communication.3000-3500 for field trial units.
– CS/CSV	– S&C	– Voltage, Current	– S&C CS Line Post Current Sensors and CSV Line-Post Current/Voltage Sensors provide an economical, effective way to measure current and voltage (optional) for your capacitor control and other applications. The CS/CSV Sensors are well-suited for working with our IntelliCAP® or IntelliCAP PLUS® Automatic Capacitor Controls with VAR sensing. You can add current sensing to your system for a minimal cost, without sacrificing the accuracy you need.	– 650	– CS Line Post Current Sensor 14.4 KV 904-001124-00 $ 650 ea 25 904-001125-00 $819 ea 34.5 904-001126-00 $1075 ea CSV Line Post Current/Voltage Sensor 14.4 904-001128-01 $ 1225 ea 25 904-001129-01 $ 1388 ea 34.5 904-001130-01 $ 1800 ea

Sensor Name	Manufacturer	Sensor Type	Brief Description	Cost	Anticipated Use
– SENSODRIEL	– Grupodriel	– Voltage, Current	– The current and voltage sensor called "SENSODRIEL" is a post type insulator for classes 15, 25 and 34.5 capable of reading precisely current and voltage from nominal values to short circuit allowing the determination of line parameters including "power factor". Sensodriel conforms to the strictest manufacturing standards and is designed to work in high saline and industrial pollution zones, delivering reliable readings without exhibiting flashover, corona or tracking. It has two independent grounded sensors. A resistive device for voltage readings an an inductive device for current readings.	– 150	– Our sensor is not capable of burden, It must be connected to impedances of the order of 1 Megaohm, or larger. Our voltage precision is better than 0.5% in other words, under controlled conditions a measurement between any two sensors is below 1% (-.5% t0+.5%). Our current reading is the same in the lab, and may vary some if geometry is affected by close non planned electrical currents. Our sensor can stay in outdoors for many years, more than 10 and maybe many more. $150.00 -15kV $250.00 - 35kV

Sensor Name	Manufacturer	Sensor Type	Brief Description	Cost	Anticipated Use
– Discos System	– Powersense	– current, voltage	– The PowerSense Overhead Line Solution has been designed for overhead line installations with or without substations. The solution is based on PowerSense's optical DISCOS® Sensor technology and a specially designed Linux-based RTU module. The DISCOS® System Sensors are installed directly onto the MV and the LV power lines and has been designed to be retrofitted to any existing power equipment. Installation of the DISCOS® System on the MV lines can be done live and does not require powering down the distribution transformers. Installation of the DISCOS® System on the LV lines can also be done live and without making any electrical or physical itervention in the installation.	– 0	– Discos system offers a variety of sensors and modules to create a customized Discos system. Discos offers indoor current sensors, IO modules, LV interfaces, MV interfaces, Opti Module, Outdoor combined current and voltage sensor, outdoor current sensor, and the smartcom RTU module. All current and voltage sensing is donve via optical sensing utilizing the Faraday Effect. The Faraday Effect is the polarization of light due to the presence of a magnetic field.

Sensor Name	Manufacturer	Sensor Type	Brief Description	Cost	Anticipated Use
– MDP - Megger Distribution Profiler	– Megger	– voltage, current	– The Megger MDP series of distribution profilers provides power utilities with the most accurate and extensive information ever to precisely evaluate loading on feeders/overhead lines and to identify needed upgrades or replacement. Three different models range from a simple “current-only” version to the most advanced unit that offers a number of market-requested features. Each MDP can be easily upgraded to the next model at any time.	– 0	– Choice of three models that record currents up to 1000 amps, with an additional 200 amp over-range Waveform capture and harmonic analysis up to the 32nd order Power and power factor – Accurate data capture via advanced MDP software Lightweight, durable unit housed in a weatherable urethane case Sturdy battery compartment with easy plug-in access for quick data retrieval

Sensor Name	Manufacturer	Sensor Type	Brief Description	Cost	Anticipated Use
– CMD	– SSI power	– Voltage, Current	– The CMD is not limited to substation applications, being equally well suited for application on distribution lines, subtransmission lines, transmission lines, and EHV transmission lines. In line applications the CMD provides the functions of real-time line current monitoring and “phone home” fault locating (fault circuit indicator [FCI]). For its line applications the CMD is highly useful in assisting utilities in meeting their NERC reliability requirements through the reduction of SAIDI and CAIDI minutes. The CMD is also an excellent solution for Smart Grid automation projects.	– 0	–
– Transform	– kinects	– Current, Voltage, Temperature	– By providing up to hourly data for voltage and current loading, and proximity temperature reading for the transformer, utility will have unprecedented access to equipment performance and status data to have a clear, continuous view of the asset conditions. The awareness of possible equipment fault or failure conditions will significantly help utilities to manage their predictive maintenance and replacement program to minimize the risk of catastrophic failures which may cause consumer liability and impact to utility revenue. Given the aging electricity infrastructure and the need for proper planning and implementation of system upgrade, North American utilities, regulators, and government are keenly interested in improving their capability to make timely investment decisions.	– 0	–

Sensor Name	Manufacturer	Sensor Type	Brief Description	Cost	Anticipated Use
– CE Mesh	– PSI	– Voltage, Current	– Monitor the Current, Voltage, & Phase Angle on all 3 Phases of Network Transformers and manholes. The Secondary Network Monitoring System has demonstrated excellent communications reliability. CDMA communications from below grade in transformer vaults is easy to install and provides excellent communications reliability. CEMesh® PLC communications has proved itself as a viable communications backbone for generalized measurements in Secondary Networks. Ready for Field Deployment on your Secondary Network	– 0	– PSI's State of the Art Secondary Network Monitoring System will enable utilities to see and measure electrical problems in their network before they happen and then will direct service crews to the exact location for a safe and effective repair.

Sensor Name	Manufacturer	Sensor Type	Brief Description	Cost	Anticipated Use
– FDAM	– PSI	– Voltage, Current	– Accurate Map Overlays Integrated Monitoring & Diagnostics Low Cost Telecom FDAM initiates communications Voltage before and after the fault is reported You own the data! AES 256 Bit Data Encryption option Scalable FDAM System is ready for deployment across your service territory. No Battery is Used by the FDAM No Maintenance is Required for the FDAM	– 0	–

Temperature Sensors

Sensor Name	Manufacturer	Sensor Type	Brief Description	Cost	Anticipated Use
– LT50	– GridSense	– Voltage, Current, Temperature	– By clipping the LT40 / LT50 on to lines at strategic points, e.g. tee junctions, switches, substations etc., data such as load, maximum demand, inrush current, fault wave shape & duration, protection operation, voltage status, conductor and ambient temperature etc. are stored for local download or remote reporting, thus value adding existing SCADA, Load Modeling, Historian systems, etc.. but at a fraction the cost of a full SCADA system involving PTs, CTs, relays, etc.	– 3100	– up to 138KV, can communicate down to data link, which is a dashboard mounted device. Also have a scada solution, cellphone, etc. Must be mounted to bare conductor. Has regowski coil. Had a dimensionless voltage readout which can be used to calculate actual fault position to a pole during an event. Data link is about $500 upgrade. Hotstick mountable.
– Intelligent Insulators Current Leakage Sensors	– Telepathx	– Temperature	– Telepathx Pinpoint sensors are the first non invasive RFID solution for monitoring faulting distribution insulators, they alert you via wireless connection when the thermal threshold has been reached providing energy maintenance personnel exact time and location of fault within seconds.	– 0	– Available in the following protocols 433Mhz Reactive RFID 900Mhz Reactive RFID 900Mhz Reactive 802.15.4 RFID 2.4Ghz Reactive 802.11g 2.4Ghz Reactive 802.15.4

Sensor Name	Manufacturer	Sensor Type	Brief Description	Cost	Anticipated Use
– DTS Units	– SensorTran	– Temperature	– The SensorTran DTS 5100 range of intelligent DTS systems provide real-time dynamic temperature with high accuracy and fine resolution, providing up to 40,000 discrete temperature points along optical fiber(s).	– 0	– • on-board Ethernet-enabled computer with open communications architecture • autonomous data collection and storage • multiple zones and alarms • flexible data, alarm and remote control/access communications • self-diagnostics, auto start & safe shut-down • simple and intuitive calibration, configuration and operation • application-specific graphical data visualization and user-interfaces • easy and fast installation with modular cabinet packages including power back-up, displays and keyboards
– OP-Thermo	– Sumitomo	– Temperature	– Op-Thermo & only one line of Optical Fiber is necessary to measure continuous & real-time temperature profile at thousands of points along the fiber without any data transmission devices.	– 0	–

Sensor Name	Manufacturer	Sensor Type	Brief Description	Cost	Anticipated Use
– Sentinel DTS Range	– Sensor Net	– Temperature	– This DTS system has been designed with safety in mind and tested to some of the industry's most rigorous standards. With the addition of a multiplexing module it can easily be configured to produce multiple double-ended measurements. User configurable zones and alarms functionality are also available for a wide variety of applications.	– 0	–
– Temperature measuring sensor(SMT)	– Arteche	– Temperature	– The Temperature Measurement Sensor SMT has been designed to measure the instantaneous temperature of the line, transmitting it to a PC via an SMS message.	– 0	– The Temperature Measuring Sensor (SMT) gives real temperature of Tranmision or Distribution aereal networks cable. The information is sent by SMS to a receiver that storage and present these data. Easy to install, even with energized line, in aprox. 10'. High Voltage only.

Sensor Name	Manufacturer	Sensor Type	Brief Description	Cost	Anticipated Use
– Thermal Rate System	– Shaw Energy Delivery Services	– Temperature	– It consists of ThermalRate™ Monitors (TRMs), which are installed along the line. The TRM is a replica of the line conductor, with the same material, diameter, and surface. It is oriented in the same direction as the line to establish how the present weather conditions are affecting the thermal capacity of the actual conductor. Standard IEEE-738 equations are used. Since there is no contact with the actual line, installation is fast and inexpensive. No line outage is ever required for installation. Each TRM includes wireless communications using the standard SCADA DNP3 protocol so system integration is simple. Both normal and emergency ratings are provided.	– 0	– Determining the actual current capacity of a high voltage transmission line.
– Power Donut 2	– USI Power	– Voltage, Current, Temperature	– The Power-Donut2™ is an engineering instrumentation platform whose functions include: data acquisition, data monitoring and logging the parameters of high voltage overhead conductors. The Power-Donut2™ is completely self- contained, allowing for hot stick installation with no required outage. The product is available with communication options that integrate with new or existing monitoring and control systems. The Power-Donut2™ is a versatile platform with which to implement several utility engineering applications. Accurate, reliable and economical, the Power-Donut2™ is an ideal accessory for High Voltage Overhead Conductor Systems.	– 14500	– Will be mass produced soon. Price should drop. Currently Testing new model which will offer full waveform capturing and event logging as well as offer GPS clock.

Sensor Name	Manufacturer	Sensor Type	Brief Description	Cost	Anticipated Use
– FOT-F FOT	– Roctest	– Temperature, Optical	– FOT-F and FOT-N temperature transducers combine all the desired characteristics expected from the ideal sensor. Their compact size, immunity to EMI/RFI/lightning, resistance to corrosive environments, high accuracy and reliability make them the best choice for tem perature measurements in harsh environments. Our fi ber optic temperature gauges are based on the thermal expansion of highly stable glass, allowing precise, stable, and repeatable measurements.	– 250	– Used to monitor a variety of systems. Could be used on transformers to monitor temperature or conductors, however installation on conductors is not a normal procedure. Requires a readout or datalogging device with fiber-optic interface.
– TSP probe	– Cannon Technologi es	– Temperature	– The Model TSP probe provides an RTU compatible analog input that is proportional to the transformer's top oil temperature. The probe can be used with an existing RTU, or as part of an Substation Advisor® System. For transformers with existing top oil indicators that cannot be removed because of cooling control, the Model TSS surface mount temperature sensor is available.	– 425	– TSP Oil Temperature Probe $425
– TSS and TSA sensors	– Cannon Technologi es	– Temperature	– Model TSS and TSA sensors provide an analog current that is proportional to the surface on which the sensor is mounted (TSS) or to the temperature of the ambient air (TSA). The sensor is powered from the loop current and therefore it does not require a separate power connection. The sensors may be used as-is or with a custom 4-20 mA signal conditioner. The sensor can be installed alone or as part of a Substation Advisor® System.	– 225	– TSS Surface Temperature Sensor $225 TSA Ambient Temperature Sensor $225

Sensor Name	Manufacturer	Sensor Type	Brief Description	Cost	Anticipated Use
– Well-Type RTD Temperature Sensor	– GE Power	– Temperature	– The insertion-type RTD temperature sensor mounts inside the thermal well. It connects to the transmitter, which sends a 4-20 mA signal back to the monitor	– 325	– 3 types: 133 Well 325 Temperature element 823 installed in monitoring cabinet
– Magnetic Mount Temperature Sensor	– GE Power	– Temperature	– The magnetic mount temperature sensor attaches to the transformer with a magnet. The sensor is self-contained and in a weatherproof housing. The RTD has a built-in 4-20 mA transmitter that is powered from the monitoring unit. The sensor is supplied with forty feet (12 m) of twisted, shielded pair wire (attached) and thermal compound.	– 522	–
– LightHouse	– Tollgrade	– Current, Temperature	– Tollgrade's LightHouse solution is designed to provide real-time grid intelligence by using sensors that continuously monitor key circuit parameters and transmit them over a self-configuring wireless mesh network to a central location.	– 700	– 4-35kV. Still in pilot programs. Hot stick mountable. Also measures 3rd harmonic.
– DTS	– Southwire Company	– Temperature	– The measurement technology Southwire is exploring is called Distributed Temperature Sensing (DTS), and it uses fiber optic strands contained in the overhead conductor. By monitoring key optical fiber characteristics, grid operators can get an accurate, span-by-span temperature profile of conductor runs up to 15 miles.	– 0	–
– FTR	– Hitachi	– Temperature, Optical	– Fiber Optic Temperature laser radar. The FTR is composed of a fiber optic temperature sensing and measureing unit and a computer display to show temperature distribution along a conductor up to 6km in length.	– 0	– Contacted a rep. Emailed kabuto@hitachi-cable.com Should be getting back with me soon to give pricing.

Sensor Name	Manufacturer	Sensor Type	Brief Description	Cost	Anticipated Use
– RF Smart Monitor System	– unknown	– Voltage, Temperature, Vibration	– The RF Smart Monitor System is designed to allow the user to remotely collect machine vibration and temperature data without the need for cabling. This system, which is designed to monitor a wide variety of machine components.	– 0	–
– DRMCC-T3	– Dynamic Ratings	– Current, Temperature	– Replaces several control devices, providing control, monitoring & data aquisition for the entire transformer. This device has several sensors which may be connected to monitor several aspects of a transformer.	– 18000	– Can consollidate any other outside IED information, can controll transformer cooling. Pricing is $12000-18000 depending on options. Installation can be done as full turn key, $15000, or as a supervisory only install for which the price would vary.
– Promethean Devices	– unknown	– Current, Temperature	– Low-Cost, Non-Contact, High Accuracy Sensor for the Simultaneous, Reliable, Real-time Determination and Monitoring of HV Transmission Line Sag, Temperature, Current, and Ampacity.	– 0	– No contact informaion. Website is under construction.

Sensor Name	Manufacturer	Sensor Type	Brief Description	Cost	Anticipated Use
– Ditest - LTM	– Omnisens	– Temperature	– The DITEST-LTM combines OMNISENS DITEST measuring technique with “best-in-industry” dedicated sensing cable, data processing, user-friendly interface and application oriented visualization tools. DITEST-LTM Solution is optimized for long distance monitoring applications with extensive application know-how and field experience. Distributed temperature monitoring over more than 40 km per channel with meter localization Fast acquisition time with maintained eprformance - 1 minute Extended monitoring capabilities; up to 250 km with single instrument allowing the monitoring of remote areas. High optical loss budget (high dynamic range >10dB) - Margin for errors in installation, varying fiber attenuation. Permanent continuous monitoring with the automatic detection of abnormal conditions and interface with third party’ systems	– 0	–
– Fiber Optic strain and temperature sensing system	– OZ Optics	– Temperature	– OZ Optics now offers the ForesighTM series of fiber optic distributed strain and temperature sensors. The new sensor system provides high resolution and accurate strain and temperature monitoring over very long distances. The sensor uses standard optical telecommunications fiber, thereby leveraging the enormous economies of scale from fiber optic communication networks. The new system is ideal for temperature and strain monitoring of oil & gas pipelines, bridges, dams, security fences and power lines.	– 0	–

Sensor Name	Manufacturer	Sensor Type	Brief Description	Cost	Anticipated Use
– Infrared Cameras	– Flir Systems, LTD	– Optical, Temperature	– FLIR provides utilities with the most advanced thermal imaging solutions to support the monitoring programs that keep the vital electrical power grid up and running. FLIR ThermaCAM infrared cameras have revolutionized predictive/preventive maintenance inspection programs. Their smart, Web-ready design allow utilities to monitor remote substations and critical assets 24x7 via the Internet. FLIR cameras feature lightweight and rugged design for easy field use. With interchangeable lenses and a wide array of unique accessories, these cameras are ready to handle any situation.	– 0	–
– Transform	– kinects	– Current, Voltage, Temperature	– By providing up to hourly data for voltage and current loading, and proximity temperature reading for the transformer, utility will have unprecedented access to equipment performance and status data to have a clear, continuous view of the asset conditions. The awareness of possible equipment fault or failure conditions will significantly help utilities to manage their predictive maintenance and replacement program to minimize the risk of catastrophic failures which may cause consumer liability and impact to utility revenue. Given the aging electricity infrastructure and the need for proper planning and implementation of system upgrade, North American utilities, regulators, and government are keenly interested in improving their capability to make timely investment decisions.	– 0	–

Sensor Name	Manufacturer	Sensor Type	Brief Description	Cost	Anticipated Use
– Reflex	– Sabrifa	– Temperature	– The rugged, splash-proof enclosure is designed to withstand the most punishing industrial environments. For industrial needs, Reflex units can be installed together on a special 19 in. rack-mounted plates. For special applications, like transformer hot spot monitoring, Safibra can offer you more instruments from Neoptix, like T/Guard, or portable Nomad, or multichannel Omniflex.	– 0	–
– T-Guard	– Sabrifa	– Temperature	– The Neoptix™ T/Guard™ is a multi-channel fiber optic temperature monitoring system for power transformer hot spot measurements. The T/Guard™ system has been developed with long-term performance and stability in mind. This fiber-optic temperature monitoring system for power transformers offers accuracy, toughness and long-term resistance to failure. Coupled with the T/Guard system, the Neoptix™ T2™ fiber-optic temperature probe provides accurate and direct temperature monitoring of transformer windings. This solution provides a realistic, real-time view of winding conditions that is quicker and more accurate than top oil thermocouple measurements, and greatly complements indirect measurements based on thermal models.	– 0	–

Sensor Name	Manufacturer	Sensor Type	Brief Description	Cost	Anticipated Use
– Distributed Temperature System N4385A / N4386A	– Agilent	– Temperature	– DTS technology measures a temperature profile along an optical fiber over several kilometers. The Agilent DTS performs measurements down to 1 meter spatial resolution with less than 0.1°C temperature resolution providing thousands of measurement points in a single trace capture. This technology is used in a large range of applications including: power transmission & distribution cable monitoring, pipeline leakage detection, and oil well performance monitoring. Agilent's two complementary DTS instruments, the Indoor N4385A and Outdoor N4386A, provide reliable measurements in critical 24/7 monitoring applications. The highly integrated opto-electronic design insures repeatable measurements throughout an extremely wide operating temperature range – enabling worry-free and accurate monitoring!	– 0	–

Sensor Name	Manufacturer	Sensor Type	Brief Description	Cost	Anticipated Use
– Ditest - AIM	– Omnisens	– Temperature	– DITEST-AIM integrates OMNISENS core sensing technology DITEST-STA optimized for long distance monitoring applications with extensive application know-how and field experience. DITEST-STA Monitoring distance : > 30 km per sensor Operates with standard singlemode optical fibers Spatial resolution : 1 m (*) Temperature resolution : < 0.5°C (*) Strain resolution : < 10 microstrain (*) Optical loss budget : >10 dB (*)	– 0	– Measurement of temperature and strain of an overhead conductor.

Vibration Sensors

Sensor Name	Manufacturer	Sensor Type	Brief Description
– Power Donut 2	– USI Power	– Voltage, Current, Temperature	– The Power-Donut2™ is an engineering instrumentation platform whose functions include: data acquisition, data monitoring and logging the parameters of high voltage overhead conductors. The Power-Donut2™ is completely self- contained, allowing for hot stick installation with no required outage. The product is available with communication options that integrate with new or existing monitoring and control systems. The Power-Donut2™ is a versatile platform with which to implement several utility engineering applications. Accurate, reliable and economical, the Power-Donut2™ is an ideal accessory for High Voltage Overhead Conductor Systems.
– PAVICA	– Roctest	– Vibration	– The PAVICA is a unique, small, lightweight instrument used to monitor and analyse vibrations in overhead transmission lines. The PAVICA measures the frequency and amplitude of all vibration cycles over all sampling periods, stores the data in a high-definition matrix and processes the results to provide a rough estimate of the life expectancy of conductors under study. These measurements and evaluation methods are based on the IEEE Standard on conductor vibration measurement and the CIGRE procedure for estimation of lifetime.
– RF Smart Monitor System	– unknown	– Voltage, Temperature, Vibration	– The RF Smart Monitor System is designed to allow the user to remotely collect machine vibration and temperature data without the need for cabling. This system, which is designed to monitor a wide variety of machine components.
– IVS-200	– Polytec	– Vibration, Optical	– Polytec's IVS-200 Industrial Vibration Sensor is a ruggedized laser Doppler vibrometer for non-contact, on-line production vibration testing. An eye-safe visible laser is aimed and focused onto the part being measured. IVS-200 is easily retrofitted into existing lines because the laser interferometer optics and electronics are all contained within a single, compact and robust industrial housing (IP 64). The primary application of the IVS-200 is the monitoring of, with the goal of reducing, defects, noise and vibration in manufactured parts ranging from microelectronics to transmissions.

Queries: Voltage Sensors

Sensor Name	Manufacturer	Sensor Type	Brief Description	Cost	Anticipated Use
– LT40	– GridSense	– Voltage, Current	– By clipping the LT40 / LT50 on to lines at strategic points, e.g. tee junctions, switches, substations etc., data such as load, maximum demand, inrush current, fault wave shape & duration, protection operation, voltage status, conductor and ambient temperature etc. are stored for local download or remote reporting, thus value adding existing SCADA, Load Modeling, Historian systems, etc.. but at a fraction the cost of a full SCADA system involving PTs, CTs, relays, etc.	– 1800	– up to 69 KV, can communicate down to data link, which is a dashboard mounted device. Also have a scada solution, cellphone, etc. Must be mounted to bare conductor. Has regowski coil. Had a dimensionless voltage readout which can be used to calculate actual fault position within a pole during an event. Data link is about $500 upgrade. Hotstick mountable.
– LT50	– GridSense	– Voltage, Current, Temperature	– By clipping the LT40 / LT50 on to lines at strategic points, e.g. tee junctions, switches, substations etc., data such as load, maximum demand, inrush current, fault wave shape & duration, protection operation, voltage status, conductor and ambient temperature etc. are stored for local download or remote reporting, thus value adding existing SCADA, Load Modeling, Historian systems, etc.. but at a fraction the cost of a full SCADA system involving PTs, CTs, relays, etc.	– 3100	– up to 138KV, can communicate down to data link, which is a dashboard mounted device. Also have a scada solution, cellphone, etc. Must be mounted to bare conductor. Has regowski coil. Had a dimensionless voltage readout which can be used to calculate actual fault position to a pole during an event. Data link is about $500 upgrade. Hotstick mountable.

Sensor Name	Manufacturer	Sensor Type	Brief Description	Cost	Anticipated Use
– Beacon Electrostatic Reset	– SEL	– Voltage	– SEL BEACON® electric field reset fault indicators (BER) derive their operating power from the potential gradient around high-voltage power lines. The BERs inrush restraint option prevents false tripping that might otherwise occur because of reclosing operations When the upstream protection operates, the indicator senses the collapse of the voltage field and prohibits tripping until the utility is able to restore normal system conditions. The BERs versatility and reliability have made it a favorite for utilities working to improve their reliability statistics. The BER indicates with both a target and an LED. However, only the red LED display is battery-powered. As a result, the BER will continue to indicate via its red target even after the battery powering the LED has been depleted.	– 130	–

Sensor Name	Manufacturer	Sensor Type	Brief Description	Cost	Anticipated Use
– Overhead Electrostatic Reset	– SEL	– Voltage	– SEL electric field reset fault indicators (type E-ERL) derive their operating power from the potential gradient around high-voltage power lines. The E-ERL's inrush restraint option blocks targeting for recloser operations. When the upstream protection operates, the indicator senses the collapse of the voltage field and prohibits tripping until the utility is able to restore normal system conditions. The E-ERL's versatility and reliability have made it a favorite for utilities working to improve their reliability statistics.	– 82	–
– 35 kV Class Outdoor Voltage Sensor	– Optisense	– Voltage	– The Optisense outdoor voltage sensor enables high voltage measurement in a compact package at a lower installed cost than with conventional technology. Optical sensing technology allows for galvanic isolation of the signal from the voltage being measured. Digital signal processing electronics can supply analog or digital output signals for control and decision-making. These sensors are now available in 15 kV, 25 kV and 35 kV classes.	– 0	–

Sensor Name	Manufacturer	Sensor Type	Brief Description	Cost	Anticipated Use
– 15 kV Class Embedded Voltage Sensor	– Optisense	– Voltage	– The Optisense indoor voltage sensor enables high voltage measurement in a compact package at a lower installed cost than with conventional technology. Optical sensing technology allows for galvanic isolation of the signal from the voltage being measured. Digital signal processing electronics can supply analog or digital output signals for control and decision-making.	– 0	–
– Power Donut 2	– USI Power	– Voltage, Current, Temperature	– The Power-Donut2™ is an engineering instrumentation platform whose functions include: data acquisition, data monitoring and logging the parameters of high voltage overhead conductors. The Power-Donut2™ is completely self- contained, allowing for hot stick installation with no required outage. The product is available with communication options that integrate with new or existing monitoring and control systems. The Power-Donut2™ is a versatile platform with which to implement several utility engineering applications. Accurate, reliable and economical, the Power-Donut2™ is an ideal accessory for High Voltage Overhead Conductor Systems.	– 14500	– Will be mass produced soon. Price should drop. Currently Testing new model which will offer full waveform capturing and event logging as well as offer GPS clock.

Sensor Name	Manufacturer	Sensor Type	Brief Description	Cost	Anticipated Use
– Voltwitch	– Rauckman Utility Products	– Voltage	– VoltWitch is an innovative drive-by voltage indicator that is installed in a line truck or utility vehicle like a radar detector. Instead of sensing radar signals, the VoltWitch senses energized overhead power lines.	– 513	–
– VisiVolt	– ABB	– Voltage	– VisiVolt™ – Passive Voltage Indicator is a busbar-mounted-type indicator of voltage presence developed to be used in outdoor and indoor systems. It is adapted for permanent installation on busbars and naked or insulated metal conductors in medium voltage systems. VisiVolt™ indicates the presence of voltage by displaying a large, well visible lightning arrow sign on its LCD. The VisiVolt™ silicone elastomer enclosure ensures performance in outdoor conditions while its fluorescent orange color provides good visibility among the other elements of the system.	– 0	–

Sensor Name	Manufacturer	Sensor Type	Brief Description	Cost	Anticipated Use
– TVM	– Telemetric	– Voltage	– The Telemetric Voltage Monitor (TVM) family of products offer a cost-effective voltage monitoring, interruption detection, and power quality solution. The TVM is available in single phase (TVM1) and two three phase versions, TVM3-120V and TVM3-277V. With these products, electric utilities can monitor and report power interruptions, over/under voltage alarms, and power reliability status throughout their distribution system, or at critical commercial/industrial customers. With Telemetric's SCADA-Xchange™ and Reliability Monitoring System software, customers can integrate the TVM data into their SCADA, Energy Management, or Outage Management Systems.	– 0	– Report momentary and sustained power outage. Over/under voltage events. Integrated cellular module. Provide cellular data service and hosted application to view network of sensors.
– Multicore Sensor	– Lindsey Manufacturing	– Voltage, Current	– The Multicore Sensor is designed to be installed without de-energizing or cutting the main conductor. This sensor does not require any special calibration for conductor diameter to produce its 2% accurate output. It can be vertically mounted to replace any standard insulator. The deep groove design places the current path at the center of multiple sensing cores that are embedded inside the solid insulator. Overall symmetry of the internal sensing system ensures high accuracy.	– 760	– Prices range from $760-1190 15kV Current + Voltage Multicore Sensor $760 25kV Current + Voltage Multicore Sensor $920 35kV Current + Voltage Multicore Sensor $1,190

Sensor Name	Manufacturer	Sensor Type	Brief Description	Cost	Anticipated Use
– Current and Voltage Monitoring Insulators	– Lindsey Manufacturing	– Voltage, Current	– Many electric utilities are using Distribution Automation (DA) for both overhead and underground systems. DA systems enable a utility to monitor, coordinate and operate distribution systems in real time mode from remote locations. Utilities that have installed DA systems have experienced the greatest benefits in the following areas: Reduced customer outage minutes per year, Increased revenues due to faster restoration in problem areas, Reduced customer complaints, Reduced system losses.	– 790	– 15kV Current + Voltage Sensor $790 25kV Current + Voltage Sensor $950 35kV Current + Voltage Sensor $1,220 46kV Current + Voltage Sensor $2,480
– Smart Pin	– Lindsey Manufacturing	– Voltage, Current	– The SmartPin current and voltage sensing system is a low cost solution for monitoring overhead distribution lines. The system consists of three sensor pins capable of supporting standard pin insulators (vertical orientation) and a control box for calibration and display of readings. Each sensor pin contains a hall effect current sensor and a capacitive voltage divider.	– 0	– not available.

Sensor Name	Manufacturer	Sensor Type	Brief Description	Cost	Anticipated Use
– Elbow Cap	– Lindsey Manufacturing	– Voltage, Current	– The ElbowCap current and voltage sensing system is a low cost solution for monitoring underground distribution feeders. The system consists of three sensors that snap onto the capacitive test point of standard 200A and 600A elbows with a control box for calibration and display of readings. Each sensor contains a hall effect current sensor and a capacitive voltage divider (with the same features as the SmartPin).	– 0	– not available.
– Elbow Sense	– Lindsey Manufacturing	– Voltage, Current	– Lindsey ElbowSense Current and Voltage Monitors use proven CT and voltage sensor technology from the original Lindsey CVMI and fit standard 600 amp T-body 15, 25 and 35kV connectors. They are easily retrofitted to existing padmount or submersible equipment. These sensors may also be used with outdoor, overhead mounted equipment that use standard elbows.	– 300	– Current Monitoring Rings $300 Voltage Monitoring Plugs (qty 1-3) $660
– RF Smart Monitor System	– unknown	– Voltage, Temperature, Vibration	– The RF Smart Monitor System is designed to allow the user to remotely collect machine vibration and temperature data without the need for cabling. This system, which is designed to monitor a wide variety of machine components.	– 0	–

Sensor Name	Manufacturer	Sensor Type	Brief Description	Cost	Anticipated Use
– SURETECH VI-x Monitoring System	– SURETECH	– Voltage, Current	– The SURETECH Vix monitoring system senses, processes and logs electrical parameters to data flash memory, on MV (Medium Voltage) equipment. Sensor outputs are fed to a SURETECH SLP (Smart Load Processor), which samples Voltage, Current, Phase angle and Quadrant, and processes all electrical parameters including Import / Export of: kW, kVA, kVARs, kWH, kVAH, kVARH; Power Factor, Phase angle, Frequency and others if required. All of this is available in THE SAFEST, most compact, and most cost-effective package.	– 0	–
– MetPod/Metpod lite(skinnier version of MetPod)	– FieldMetrics Inc.	– Voltage, Current	– The MetPod is our first product release based on our patent-pending technology. An integrated VT, clamp-on CT and meter, it meets 0.2 accuracy class requirements and has passed full dielectric type-tests. The MetPod offers a wireless link and self diagnostics in a low-cost, lightweight, scalable, sturdy, environmentally green package which is easily installed in almost any location and orientation.	– 3000	– Testing in the field currently. Using 900MHz modem for communication.3000-3500 for field trial units.

Sensor Name	Manufacturer	Sensor Type	Brief Description	Cost	Anticipated Use
– FMPT	– FieldMetrics Inc	– Voltage	– The FMPT voltage sensor is a high accuracy voltage measurement solution for transmission and distribution utility applications. By combining high-reliability components in a patent-pending design, the FMPT uses no insulating oil or SF6 gas, yet provides a robust dielectric design meeting Pollution Class II requirements with class 0.3 metering accuracy and class 3P protection accuracy from -40 to +70 °C.	– 2500	– Still in development. New technology. Design is complete, however waiting for a customer for fieldtest. $2500-$2700 Ballpark cost range.
– CS/CSV	– S&C	– Voltage, Current	– S&C CS Line Post Current Sensors and CSV Line-Post Current/Voltage Sensors provide an economical, effective way to measure current and voltage (optional) for your capacitor control and other applications. The CS/CSV Sensors are well-suited for working with our IntelliCAP® or IntelliCAP PLUS® Automatic Capacitor Controls with VAR sensing. You can add current sensing to your system for a minimal cost, without sacrificing the accuracy you need.	– 650	– CS Line Post Current Sensor 14.4 KV 904-001124-00 $ 650 ea 25 904-001125-00 $819 ea 34.5 904-001126-00 $1075 ea CSV Line Post Current/Voltage Sensor 14.4 904-001128-01 $ 1225 ea 25 904-001129-01 $ 1388 ea 34.5 904-001130-01 $ 1800 ea

Sensor Name	Manufacturer	Sensor Type	Brief Description	Cost	Anticipated Use
– SENSODRIEL	– Grupodriel	– Voltage, Current	– The current and voltage sensor called "SENSODRIEL" is a post type insulator for classes 15, 25 and 34.5 capable of reading precisely current and voltage from nominal values to short circuit allowing the determination of line parameters including "power factor". Sensodriel conforms to the strictest manufacturing standards and is designed to work in high saline and industrial pollution zones, delivering reliable readings without exhibiting flashover, corona or tracking. It has two independent grounded sensors. A resistive device for voltage readings an an inductive device for current readings.	– 150	– Our sensor is not capable of burden, It must be connected to impedances of the order of 1 Megaohm, or larger. Our voltage precision is better than 0.5% in other words, under controlled conditions a measurement between any two sensors is below 1% (-.5% t0+.5%). Our current reading is the same in the lab, and may vary some if geometry is affected by close non planned electrical currents. Our sensor can stay in outdoors for many years, more than 10 and maybe many more. $150.00 -15kV $250.00 - 35kV

Sensor Name	Manufacturer	Sensor Type	Brief Description	Cost	Anticipated Use
– Discos System	– Powersense	– current, voltage	– The PowerSense Overhead Line Solution has been designed for overhead line installations with or without substations. The solution is based on PowerSense's optical DISCOS® Sensor technology and a specially designed Linux-based RTU module. The DISCOS® System Sensors are installed directly onto the MV and the LV power lines and has been designed to be retrofitted to any existing power equipment. Installation of the DISCOS® System on the MV lines can be done live and does not require powering down the distribution transformers. Installation of the DISCOS® System on the LV lines can also be done live and without making any electrical or physical itervention in the installation.	– 0	– Discos system offers a variety of sensors and modules to create a customized Discos system. Discos offers indoor current sensors, IO modules, LV interfaces, MV interfaces, Opti Module, Outdoor combined current and voltage sensor, outdoor current sensor, and the smartcom RTU module. All current and voltage sensing is donve via optical sensing utilizing the Faraday Effect. The Faraday Effect is the polarization of light due to the presence of a magnetic field.

Sensor Name	Manufacturer	Sensor Type	Brief Description	Cost	Anticipated Use
– MDP - Megger Distribution Profiler	– Megger	– voltage, current	– The Megger MDP series of distribution profilers provides power utilities with the most accurate and extensive information ever to precisely evaluate loading on feeders/overhead lines and to identify needed upgrades or replacement. Three different models range from a simple "current-only" version to the most advanced unit that offers a number of market-requested features. Each MDP can be easily upgraded to the next model at any time.	– 0	– Choice of three models that record currents up to 1000 amps, with an additional 200 amp over-range Waveform capture and harmonic analysis up to the 32nd order Power and power factor Accurate data capture via advanced MDP software Lightweight, durable unit housed in a weatherable urethane case Sturdy battery compartment with easy plug-in access for quick data retrieval
– CMD	– SSI power	– Voltage, Current	– The CMD is not limited to substation applications, being equally well suited for application on distribution lines, subtransmission lines, transmission lines, and EHV transmission lines. In line applications the CMD provides the functions of real-time line current monitoring and "phone home" fault locating (fault circuit indicator [FCI]). For its line applications the CMD is highly useful in assisting utilities in meeting their NERC reliability requirements through the reduction of SAIDI and CAIDI minutes. The CMD is also an excellent solution for Smart Grid automation projects.	– 0	–

Sensor Name	Manufacturer	Sensor Type	Brief Description	Cost	Anticipated Use
– Powermonic PM5	– Gridsense	– voltage	– The PM5 is a low cost, in situ monitor that is placed at strategic LV locations facitlitating real time reporting of voltage disturbances in the field to improve power quality and reliability. A cost effective network wide monitoring system that's simple to install and easy to operate. Location maps can be uploaded for graphical representation of the network, helping with resource allocation . Rapidly expand your monitoring capabilities by adding additional PM5 units. Supports regulatory benchmarks, such as SAIDI, SAIFI, CAIDI and CAIFI indicis.	– 0	– he PM5 simply plugs into the 110-240 volt electrical outlet and connects in parallel to the existing telephone line to transfer critical operational data to a central master station (MONITOR SYSTEM). The use of low cost Dual Tone Multiple Frequency (DTMF) technology allows shorter connection times than typical modems. The PM5 transfers real time data for: Under & Over Voltage events outside preset limits, e.g. 240V+ 6%, -10% Voltage Interruptions/Outages Voltage restoration Device health & status reporting

Sensor Name	Manufacturer	Sensor Type	Brief Description	Cost	Anticipated Use
– Transform	– kinects	– Current, Voltage, Temperature	– By providing up to hourly data for voltage and current loading, and proximity temperature reading for the transformer, utility will have unprecedented access to equipment performance and status data to have a clear, continuous view of the asset conditions. The awareness of possible equipment fault or failure conditions will significantly help utilities to manage their predictive maintenance and replacement program to minimize the risk of catastrophic failures which may cause consumer liability and impact to utility revenue. Given the aging electricity infrastructure and the need for proper planning and implementation of system upgrade, North American utilities, regulators, and government are keenly interested in improving their capability to make timely investment decisions.	– 0	–

Sensor Name	Manufacturer	Sensor Type	Brief Description	Cost	Anticipated Use
– CE Mesh	– PSI	– Voltage, Current	– Monitor the Current, Voltage, & Phase Angle on all 3 Phases of Network Transformers and manholes. The Secondary Network Monitoring System has demonstrated excellent communications reliability. CDMA communications from below grade in transformer vaults is easy to install and provides excellent communications reliability. CEMesh® PLC communications has proved itself as a viable communications backbone for generalized measurements in Secondary Networks. Ready for Field Deployment on your Secondary Network	– 0	– PSI's State of the Art Secondary Network Monitoring System will enable utilities to see and measure electrical problems in their network before they happen and then will direct service crews to the exact location for a safe and effective repair.

Sensor Name	Manufacturer	Sensor Type	Brief Description	Cost	Anticipated Use
– FDAM	– PSI	– Voltage, Current	– Accurate Map Overlays Integrated Monitoring & Diagnostics Low Cost Telecom FDAM initiates communications Voltage before and after the fault is reported You own the data! AES 256 Bit Data Encryption option Scalable FDAM System is ready for deployment across your service territory. No Battery is Used by the FDAM No Maintenance is Required for the FDAM	– 0	–

Reports: Acoustic Sensors

Text38	Text8	Text34	Text6	Text36	Text2
– Acoustic optical system for partial discharge detection and location	–	– ABB Power T&D Company Inc.	– unknown	– Acoustic, Corona, Optical	– 0
– The UltraTEV Plus+ measures PD activity in the form of ultrasonic and transient earth-voltage (TEV) signals, but provides operators with considerably more comprehensive information about emission levels. Ultrasonic emissions are displayed as decibel readi	–	– EA Technology	– UltraTEV Plus+	– Acoustic, Corona	– 0
– Partial discharge sensors are self-contained, acoustic sensors utilizing piezo electric element technology. The sensors provide continuous readings and are designed for field use in transformers and load tap changers. Two types of partial discharge sensor	– No longer manufactured.	– GE Power	– Partial Discharge Sensors	– Acoustic, Corona	– 0
– The acoustic probe is designed for use on air insulated terminations where there is a clear sound path between the electrically stressed insulation and the probe. The sensor is extremely sensitive and can detect activity below 10pC. The probe has a magnet	–	– iPEC	– Airborne Acoustic Transducer	– Acoustic, Corona	– 0
– The SDT 170MD (Multifunctional/Datalogger) is the complete ultrasonic inspection and predictive maintenance trending machine. With all the features of the SDT 170S Standard and SDT 170M Multifunctional, we've added a customisable data logger that interfac	– Detect Corona behind electrical cabinet doors. With Use of parabolic disc, can pinpoint corona with lazer sight. Normally sold to factories. Withstand a 3m drop test.	– Martech	– SDT 170 with parabolic Dish	– Acoustic, Corona	– 7500

Text38	Text8	Text34	Text6	Text36	Text2
– PD-MAT400A is a permanently mounted on-line Partial Discharge (PD) diagnostic system. This test device focuses on detecting and analyzing the generation of PD in equipment such as transformers, HV GIS circuit breakers, GIS ductwork, and CGIS using acousti	–	– PowerPD, Inc	– PD-MAT400A	– Acoustic, Corona	– 10500
– The PD-TM Series: are non-portable, mounted type units. PD-TM500, 1000, 1500 are online diagnostic systems that continuously monitors partial discharge in equipment such as Transformers, GIS, and CGIS etc. This units detect, analyze, and locate the signal	– Main use for substations and utilities.	– PowerPD, Inc.	– PD-TM500A	– Acoustic, Corona	– 34800
– Hotstick Line Sniffer. RF & Ultrasonic Locator for use from a bucket.	– Use of RFI to get into general location of Corona and then use acoustic to pinpoint Corona Location.	– Radar Engineer	– 247-B	– Acoustic, RFI, Corona	– 950
– Parabolic Pinpointer Ultrasonic Locator for use from the ground	– Use of RFI to get into general location of Corona and then use acoustic to pinpoint Corona Location.	– Radar Engineers	– 250	– Acoustic, Corona	– 3100
– Still in testing. Basic summary would be a handheld model of the 247-b. Called switch gear sniffer. Use RFI detector to find cabinet of Corona occurance and then acoustic to pinpoint Corona location.	– Use of RFI to get into general location of Corona and then use acoustic to pinpoint Corona Location.	– Radar Engineers	– 244(tenatively)	– RFI, Acoustic, Corona	– 0

Reports: Corona Sensors

Text38	Text8	Text34	Text6	Text36	Text2
– Acoustic optical system for partial discharge detection and location	–	– ABB Power T&D Company Inc.	– unknown	– Acoustic, Corona, Optical	– 0
– The UltraTEV Plus+ measures PD activity in the form of ultrasonic and transient earth-voltage (TEV) signals, but provides operators with considerably more comprehensive information about emission levels. Ultrasonic emissions are displayed as decibel readi	–	– EA Technology	– UltraTEV Plus+	– Acoustic, Corona	– 0
– Partial discharge sensors are self-contained, acoustic sensors utilizing piezo electric element technology. The sensors provide continuous readings and are designed for field use in transformers and load tap changers. Two types of partial discharge sensor	– No longer manufactured.	– GE Power	– Partial Discharge Sensors	– Acoustic, Corona	– 0
– The acoustic probe is designed for use on air insulated terminations where there is a clear sound path between the electrically stressed insulation and the probe. The sensor is extremely sensitive and can detect activity below 10pC. The probe has a magnet	–	– iPEC	– Airborne Acoustic Transducer	– Acoustic, Corona	– 0
– The HFCT 100/50 is a high frequency transducer designed specifically for picking up partial discharge signals. It has a split core ferrite to allow retrospective fitting to earth straps without the need for disconnection. The durable body has a hinge and	–	– iPEC	– Cable and switchgear PD sensors	– Corona	– 0

Text38	Text8	Text34	Text6	Text36	Text2
– The SDT 170MD (Multifunctional/Datalogger) is the complete ultrasonic inspection and predictive maintenance trending machine. With all the features of the SDT 170S Standard and SDT 170M Multifunctional, we've added a customisable data logger that interfac	– Detect Corona behind electrical cabinet doors. With Use of parabolic disc, can pinpoint corona with lazer sight. Normally sold to factories. Withstand a 3m drop test.	– Martech	– SDT 170 with parabolic Dish	– Acoustic, Corona	– 7500
– The PD-RD300A is the newest device in the PowerPD line of test equipment, which provides continuous monitoring of your metal clad switchgear (MCSG) assets. This device detects electromagnetic waves when surface tracking occurs on the insulation system. It	– Cost is 4700+ depending on number of channels.	– PowerPD, Inc	– PD-RD300A	– Corona	– 4700
– PD-MCC&G400A is an on-line Partial Discharge (PD) diagnostic system, which detects and analyzes the generation of PD in the power equipments such as Cable and Motor. Four High Frequency Current Transducer (HFCT) Sensors are installed ground line in power	–	– PowerPD, Inc	– PD-MCC&G400A	– Corona	– 0
– PD-MAT400A is a permanently mounted on-line Partial Discharge (PD) diagnostic system. This test device focuses on detecting and analyzing the generation of PD in equipment such as transformers, HV GIS circuit breakers, GIS ductwork, and CGIS using acousti	–	– PowerPD, Inc	– PD-MAT400A	– Acoustic, Corona	– 10500
– The PD-TM Series: are non-portable, mounted type units. PD-TM500, 1000, 1500 are online diagnostic systems that continuously monitors partial discharge in equipment such as Transformers, GIS, and CGIS etc. This units detect, analyze, and locate the signal	– Main use for substations and utilities.	– PowerPD, Inc.	– PD-TM500A	– Acoustic, Corona	– 34800

Text38	Text8	Text34	Text6	Text36	Text2
– Hotstick Line Sniffer. RF & Ultrasonic Locator for use from a bucket.	– Use of RFI to get into general location of Corona and then use acoustic to pinpoint Corona Location.	– Radar Engineer	– 247-B	– Acoustic, RFI, Corona	– 950
– Still in testing. Basic summary would be a handheld model of the 247-b. Called switch gear sniffer. Use RFI detector to find cabinet of Corona occurance and then acoustic to pinpoint Corona location.	– Use of RFI to get into general location of Corona and then use acoustic to pinpoint Corona Location.	– Radar Engineers	– 244(tenatively)	– RFI, Acoustic, Corona	– 0
– RFI locators detect sparks and corona that cause radio and T.V. interference (RFI TVI). RF and ultrasonic receivers quickly pinpoint sparking hardware on powerlines.	– Use of RFI to get into general location of Corona and then use acoustic to pinpoint Corona Location.	– Radar Engineers	– M330	– RFI, Corona	– 1800
– HF-UHF RFI Locator 1.8-1000 MHZ Oscilloscope Display	– Use of RFI to get into general location of Corona and then use acoustic to pinpoint Corona Location.	– Radar Engineers	– 240-A	– RFI, Corona	– 4700
– AM-UHF RFI Locator 500 KHZ-1000 MHZ Oscilloscope Display A.M. Probe	– Use of RFI to get into general location of Corona and then use acoustic to pinpoint Corona Location.	– Radar Engineers	– 242	– RFI, Corona	– 5500

Text38	Text8	Text34	Text6	Text36	Text2
– Parabolic Pinpointer Ultrasonic Locator for use from the ground	– Use of RFI to get into general location of Corona and then use acoustic to pinpoint Corona Location.	– Radar Engineers	– 250	– Acoustic, Corona	– 3100
– Small and battery operated, the CoronaFinder is easy to take to the field. Real time UV viewing means that high voltage equipment can be quickly and thoroughly inspected for evidence of corona discharge that is visible only in the ultraviolet spectrum (s	– Corona Detection.	– Syntronics	– Corona Finder	– Optical, Corona	– 14035

Reports: Current Sensors

Text38	Text8	Text34	Text6	Text36	Text2
– Test Point Mounted Fault Indicators provide a clear, visual means for locating faulted cables and equipment on underground distribution systems. Indicators are self-powered and consist of a solid state current sensor connected to a faulted circuit display	–	– Thomas & Betts	– Elastimold TPM Series	– Current	– 0
– URD Cable Mounted Fault Indicators aid in locating faulted cables and equipment on underground distribution systems. Indicators are self powered and consist of a solid state current sensor connected to faulted circuit display.	–	– Thomas & Betts	– UCM Series	– Current	– 100
– Overhead Line Fault Indicators aid in locating faulted circuits and equipment on overhead distribution systems. Indicators are self powered and consist of a solid state current sensor connected to a faulted circuit display. Designs incorporate advanced ci	–	– Thomas & Betts	– OLM Standard	– Current	– 99
– Test Point Mounted Neon Voltage Indicators provide a convenient, visual method for determining the energized status of underground distribution circuits. The indicator consists of a self-powered voltage sensor connected to a neon light that flashes when e	–	– Thomas & Betts	– V2 Standard	– Current	– 30
– When a fault occurs, two of the AutoRANGER's red LEDs will begin to flash. After one minute, the indicator will measure the system current. If it detects load current, the AutoRANGER's yellow LED will begin to flash and the red LEDs will turn off, indicat	–	– SEL	– AutoRANGER	– Current	– 150

Text38	Text8	Text34	Text6	Text36	Text2
– Ensure the best fault-indicating solution for your underground application by choosing from a wide variety of single- and threephase display options, including remote displays that eliminate the need to open the enclosure to check the fault indicator's st	– Can be used with Radio Ranger fault location system. Identify the phase and location of underground faults with the handheld Remote Fault Reader. Wireless Interface ID, phase, and way distinctions display faultpath information in each vault while differe	– SEL	– Underground AutoRANGER	– Current	– 100
– Senses the load and fault currents on the conductor. Use the optional auxiliary contact to provide status indication to a SCADA input.	– Use the optional auxiliary contact to provide status indication to a SCADA input.	– SEL	– SEL LINAM Current Reset Fault Indicators	– Current	– 150
– Install 1TPRB fault indicators in padmount transformers, subsurface load centers, or junction sectionalizing points. In single-phase underground loop applications, install the 1TPRB at the transformer. At sectionalizing junctions, place an indicator on ea	–	– SEL	– Single-Phase Test Point Mounted Bolt Display FCI	– Current	– 78
– The task of the ARTECHE Fault Indicator Relay is to detect the faulty line section and indicate the incidence so that, via remote signal transmission, for example, adequate actions are taken and the section affected can be quickly isolated.	–	– Arteche	– Underground Fault Sensor	– Current	– 0
– The Fisher Pierce Series 1301 high accuracy line post current sensors provide a reliable measuring method for distribution systems from zero to thousands of amperes. The current sensors may be used for capacitor switching, load surveying, or protective re	– 15kV, 25kV, 35kV	– Joslyn Hi-Voltage	– Power Flex Current Sensor	– Current	– 500

Text38	Text8	Text34	Text6	Text36	Text2
– By simply attaching a small, non-intrusive, clamp-on AC/DC sensor to the relay wires and connecting its Cat5 cable to the supplied recording switch, real-time analog and digital information is readily available for analysis. The sensor is highly sensitive	– This system is composed of 8 current sensors, a reciever, and the analysis software for around $3500. This is a new product and very little information is currently available.	– ABB	– SEI601	– Current	– 3500
– The Fisher Pierce Radio Faulted Circuit Indicator (RFCI) System utilizes wireless communication technology to assist in locating distribution system faulted circuits. RFCI's installed in overhead, underground, and padmount locations can be detected from h	– 1547/1548 Series.	– Joslyn Hi-Voltage	– Radio Faulted Circuit Indicator System	– Current	– 200
– Cooper Power Systems' S.T.A.R. Test Point Reset (TPR) faulted circuit indicators (FCIs) can be used on all 200 A and 600 A connectors having a voltage test point. Load levels do not effect the reset circuit. The unit automatically resets to the normal pos	– 70-110	– Cooper Power Systems	– TPR	– Current	– 110
– Cooper Power Systems' S.T.A.R. Manual Reset (MR) faulted circuit indicators (FCIs) can be used on overhead uninsulated, unshielded cable and unshielded insulated cable such as tree wire. The MR FCI can also be installed on padmounted distribution transfor	–	– Cooper Power Systems	– MR	– Current	– 110
– Cooper Power Systems' S.T.A.R. Low Voltage Reset (LVR) faulted circuit indicators (FCIs) can be installed on padmounted distribution transformers, or at a secondary voltage source. The unit automatically resets to the normal position when circuit voltage	– $105-135	– Cooper Power Systems	– LVR	– Current	– 135

Text38	Text8	Text34	Text6	Text36	Text2
– Cooper Power Systems' S.T.A.R. Electrostatic Reset (ER) faulted circuit indicators (FCIs) can be used on overhead uninsulated, unshielded cable and unshielded insulated cable, such as tree wire. They are powered from the voltage gradient between the line	–	– Cooper Power Systems	– ER	– Current	– 110
– Cooper Power Systems' S.T.A.R. Delayed Reset (DR) faulted circuit indicators (FCIs) can be installed on padmounted distribution transformers, sector cabinets, switchgear and overhead bare conductors. The unit automatically resets back to the normal positi	–	– Cooper Power Systems	– DR	– Current	– 40
– Cooper Power Systems' S.T.A.R. Current Reset (CR) faulted circuit indicators (FCIs) can be installed on padmounted distribution transformers, sector cabinets, switchgear and overhead bare conductors. The unit automatically resets back to the normal positi	– 80-100	– Cooper Power Systems	– CR	– Current	– 100
– High Tech at Low-Tech Prices – The latest industry technology is now available at a price everyone can afford. Reduces Operating Costs, Reduces Inventory, Improves Power Quality, Finds the Fault the First Time. A pair of high luminous LEDs in addition	– Can be used with outage advisor system for additional cost.	– Cooper Power Systems	– ER S.T.A.R. Pathfinder	– Current	– 110
– Cooper Power Systems S.T.A.R.™ PATHFINDER™ Variable Trip Test Point faulted circuit indicators (FCI) are designed to quickly and easily locate faulted sections of underground cable systems. These FCIs can be used on both 200 A separable connectors and 600	– $80-110 Can be utilized with outage advisor for remote fault detection for additional cost.	– Cooper Power Systems	– TPR S.T.A.R. Pathfinder	– Current	– 110
– The Fisher Pierce Series 1514/15 Current-Reset Faulted Circuit Indicators locate faults quickly by monitoring line current. The 1514/15 FCIs locate faults quickly and isolate the source which reduces emergency labor, and decreases outages and revenue los	–	– Joslyn Hi-Voltage	– 1514/15	– Current	– 145

Text38	Text8	Text34	Text6	Text36	Text2
– Overhead Fault Indicators are available with a mechanical flag or LED indication. In addition to permanent installations to reduce outage time, these units are ideal for finding temporary, transient, or nuisance outages. Load Tracker capability is availab	– Can be paired with a radio transmitter reciever unit which has a 40-50ft range(mount at bottom of pole below FCI) and when a fault is received, the unit closes a contact which can be connected to an RTU or Cellular RTU(Telemetric).	– Power Delivery Products	– Overhead FCI's	– Current	– 185
– There are two major styles of Underground Faulted Circuit Indicators – Mechanical and Electronic. The Mechanical units offer years of economical fault indication. Rotor, submersible and fluid units are available with or without provisions for hotsick inst	– Fault is indicated via blinking led on the FCI. To remotely receive the fault indication, a fiber optic lead is connected to the LED socket while the opposite end is connected to a converter box, which will close a contact on an RTU or other device when	– Power Delivery Products	– Underground FCI's	– Current	– 120

Text38	Text8	Text34	Text6	Text36	Text2
– Automation is provided on underground units through the Distribution automation relay and for overhead applications with the Radio Faulted Circuit Indicator. (RFCI). The RFCI mounted on an overhead circuit sends a radio signal to a receiver which is conne	– Can be paired with a radio transmitter reciever unit which has a 40-50ft range(mount at bottom of pole below FCI) and when a fault is received, the unit closes a contact which can be connected to an RTU or Cellular RTU(Telemetric).	– Power Delivery Products	– Automation FCI's	– Current	– 120
– The PF Live Plus, a continuous on-line monitoring system, for monitoring power factor in high voltage capacitive bushings, is now available with an optional leakage current monitor for high voltage lightning arresters. The system includes a minimum set of	– The PF Live Plus system can also interface to signals from other devices, or IED's, such as: temperature sensors, DGA, or any 0-10Vdc, 10Vrms, 4-20mA, or 0-1mA signal.	– On-line Monitoring, Inc.	– PF Live Plus	– Current, Temperature	– 0
– This range of current probes is used for measuring tan(delta) on HV apparatus, insulation resistance and capacitance under HV operational and test conditions. Leakage current is measured and its phase is compared with the HV reference excitation voltage's	–	– SURETECH	– HV Transducer Current Probe	– Current	– 0
– SURETECH AC Current sensors are available in various formats, including slip-on, or bar-primary. These sensors are available for single OR three phase measurements. The sensor uses Rogowski technology to measure AC currents. Rogowski technology does not r	–	– SURETECH	– AC Current Sensors	– Current	– 0

Report: EPRI Report

Text34	Text6	Text36	Text38	Text8
– ABB	– VisiVolt	– Voltage	– VisiVolt™ – Passive Voltage Indicator is a busbar-mounted-type indicator of voltage presence developed to be used in outdoor and indoor systems. It is adapted for permanent installation on busbars and naked or insulated metal conductors in medium voltage	–
– ABB	– SEI601	– Current	By simply attaching a small, non-intrusive, clamp-on AC/DC sensor to the relay wires and connecting its Cat5 cable to the supplied recording switch, real-time analog and digital information is readily available for analysis. The sensor is highly sensitive	This system is composed of 8 current sensors, a reciever, and the analysis software for around $3500. This is a new product and very little information is currently available.
ABB Power T&D Company Inc.	unknown	Acoustic, Corona, Optical	Acoustic optical system for partial discharge detection and location	
Agilent	Distributed Temperature System N4385A / N4386A	Temperature	DTS technology measures a temperature profile along an optical fiber over several kilometers. The Agilent DTS performs measurements down to 1 meter spatial resolution with less than 0.1°C temperature resolution providing thousands of measurement points in	

Text34	Text6	Text36	Text38	Text8
Arteche	Temperature measuring sensor(SMT)	Temperature	The Temperature Measurement Sensor SMT has been designed to measure the instantaneous temperature of the line, transmitting it to a PC via an SMS message.	The Temperature Measuring Sensor (SMT) gives real temperature of Tranmision or Distribution aereal networks cable. The information is sent by SMS to a receiver that storage and present these data. Easy to install, even with energized line, in aprox. 10'.
Arteche	Underground Fault Sensor	Current	The task of the ARTECHE Fault Indicator Relay is to detect the faulty line section and indicate the incidence so that, via remote signal transmission, for example, adequate actions are taken and the section affected can be quickly isolated.	
Cannon Technologies	TSP probe	Temperature	The Model TSP probe provides an RTU compatible analog input that is proportional to the transformer's top oil temperature. The probe can be used with an existing RTU, or as part of an Substation Advisor® System. For transformers with existing top oil indi	TSP Oil Temperature Probe $425
Cannon Technologies	TSS and TSA sensors	Temperature	Model TSS and TSA sensors provide an analog current that is proportional to the surface on which the sensor is mounted (TSS) or to the temperature of the ambient air (TSA). The sensor is powered from the loop current and therefore it does not require a se	TSS Surface Temperature Sensor $225 TSA Ambient Temperature Sensor $225

Text34	Text6	Text36	Text38	Text8
Cooper Power Systems	TPR S.T.A.R. Pathfinder	Current	Cooper Power Systems S.T.A.R.™ PATHFINDER™ Variable Trip Test Point faulted circuit indicators (FCI) are designed to quickly and easily locate faulted sections of underground cable systems. These FCIs can be used on both 200 A separable connectors and 600	$80-110 Can be utilized with outage advisor for remote fault detection for additional cost.
Cooper Power Systems	ER	Current	Cooper Power Systems' S.T.A.R. Electrostatic Reset (ER) faulted circuit indicators (FCIs) can be used on overhead uninsulated, unshielded cable and unshielded insulated cable, such as tree wire. They are powered from the voltage gradient between the line	
Cooper Power Systems	LVR	Current	Cooper Power Systems' S.T.A.R. Low Voltage Reset (LVR) faulted circuit indicators (FCIs) can be installed on padmounted distribution transformers, or at a secondary voltage source. The unit automatically resets to the normal position when circuit voltage	$105-135
Cooper Power Systems	ER S.T.A.R. Pathfinder	Current	High Tech at Low-Tech Prices – The latest industry technology is now available at a price everyone can afford. Reduces Operating Costs, Reduces Inventory, Improves Power Quality, Finds the Fault the First Time. A pair of high luminous LEDs in addition	Can be used with outage advisor system for additional cost.

Text34	Text6	Text36	Text38	Text8
Cooper Power Systems	MR	Current	Cooper Power Systems' S.T.A.R. Manual Reset (MR) faulted circuit indicators (FCIs) can be used on overhead uninsulated, unshielded cable and unshielded insulated cable such as tree wire. The MR FCI can also be installed on padmounted distribution transfor	
Cooper Power Systems	DR	Current	Cooper Power Systems' S.T.A.R. Delayed Reset (DR) faulted circuit indicators (FCIs) can be installed on padmounted distribution transformers, sector cabinets, switchgear and overhead bare conductors. The unit automatically resets back to the normal positi	
Cooper Power Systems	TPR	Current	Cooper Power Systems' S.T.A.R. Test Point Reset (TPR) faulted circuit indicators (FCIs) can be used on all 200 A and 600 A connectors having a voltage test point. Load levels do not effect the reset circuit. The unit automatically resets to the normal pos	70-110
Cooper Power Systems	CR	Current	Cooper Power Systems' S.T.A.R. Current Reset (CR) faulted circuit indicators (FCIs) can be installed on padmounted distribution transformers, sector cabinets, switchgear and overhead bare conductors. The unit automatically resets back to the normal positi	80-100

Text34	Text6	Text36	Text38	Text8
Dynamic Ratings	DRMCC-T3	Current, Temperature	Replaces several control devices, providing control, monitoring & data aquisition for the entire transformer. This device has several sensors which may be connected to monitor several aspects of a transformer.	Can consollidate any other outside IED information, can controll transformer cooling. Pricing is $12000-18000 depending on options. Installation can be done as full turn key, $15000, or as a supervisory only install for which the price would vary.
EA Technology	UltraTEV Plus+	Acoustic, Corona	The UltraTEV Plus+ measures PD activity in the form of ultrasonic and transient earth-voltage (TEV) signals, but provides operators with considerably more comprehensive information about emission levels. Ultrasonic emissions are displayed as decibel readi	
Exacter, Inc.	Exacter	RFI	The EXACTER® Outage-Avoidance System provides early warning of failing transformers, regulators, insulators, cutouts, lightning arrestors, and more, utilizing advanced sensor-array technology. Geospatial mapping provides location data and problem severity	Unit price per month(survey themselves), they produce reports of faulty components. Also do turnkey services. Monitor overhead distribution by listening to RF signatures, then data is analyzed by the service. Price for rental is 3000-6000/month for a u
FieldMetrics Inc	FMPT	Voltage	The FMPT voltage sensor is a high accuracy voltage measurement solution for transmission and distribution utility applications. By combining high-reliability components in a patent-pending design, the FMPT uses no insulating oil or SF6 gas, yet provides a	Still in development. New technology. Design is complete, however waiting for a customer for fieldtest. $2500-$2700 Ballpark cost range.

Text34	Text6	Text36	Text38	Text8
FieldMetrics Inc.	MetPod/Metpod lite(skinnier version of MetPod)	Voltage, Current	The MetPod is our first product release based on our patent-pending technology. An integrated VT, clamp-on CT and meter, it meets 0.2 accuracy class requirements and has passed full dielectric type-tests. The MetPod offers a wireless link and self diagno	Testing in the field currently. Using 900MHz modem for communication.3000-3500 for field trial units.
Flir Systems, LTD	Infrared Cameras	Optical, Temperature	FLIR provides utilities with the most advanced thermal imaging solutions to support the monitoring programs that keep the vital electrical power grid up and running. FLIR ThermaCAM infrared cameras have revolutionized predictive/preventive maintenance in	
GE Power	Magnetic Mount Temperature Sensor	Temperature	The magnetic mount temperature sensor attaches to the transformer with a magnet. The sensor is self-contained and in a weatherproof housing. The RTD has a built-in 4-20 mA transmitter that is powered from the monitoring unit. The sensor is supplied with f	
GE Power	Well-Type RTD Temperature Sensor	Temperature	The insertion-type RTD temperature sensor mounts inside the thermal well. It connects to the transmitter, which sends a 4-20 mA signal back to the monitor	3 types: 133 Well 325 Temperature element 823 installed in monitoring cabinet
GE Power	Partial Discharge Sensors	Acoustic, Corona	Partial discharge sensors are self-contained, acoustic sensors utilizing piezo electric element technology. The sensors provide continuous readings and are designed for field use in transformers and load tap changers. Two types of partial discharge sensor	No longer manufactured.

Text34	Text6	Text36	Text38	Text8
Gridsense	Powermonic PM5	voltage	The PM5 is a low cost, in situ monitor that is placed at strategic LV locations facitlitating real time reporting of voltage disturbances in the field to improve power quality and reliability. A cost effective network wide monitoring system that's simple	The PM5 simply plugs into the 110-240 volt electrical outlet and connects in parallel to the existing telephone line to transfer critical operational data to a central master station (MONITOR SYSTEM). The use of low cost Dual Tone Multiple Frequency (DTMF)
GridSense	LT50	Voltage, Current, Temperature	By clipping the LT40 / LT50 on to lines at strategic points, e.g. tee junctions, switches, substations etc., data such as load, maximum demand, inrush current, fault wave shape & duration, protection operation, voltage status, conductor and ambient temper	up to 138KV, can communicate down to data link, which is a dashboard mounted device. Also have a scada solution, cellphone, etc. Must be mounted to bare conductor. Has regowski coil. Had a dimensionless voltage readout which can be used to calculate act
GridSense	LT40	Voltage, Current	By clipping the LT40 / LT50 on to lines at strategic points, e.g. tee junctions, switches, substations etc., data such as load, maximum demand, inrush current, fault wave shape & duration, protection operation, voltage status, conductor and ambient temper	up to 69 KV, can communicate down to data link, which is a dashboard mounted device. Also have a scada solution, cellphone, etc. Must be mounted to bare conductor. Has regowski coil. Had a dimensionless voltage readout which can be used to calculate act
Grupodriel	SENSODRIEL	Voltage, Current	The current and voltage sensor called "SENSODRIEL" is a post type insulator for classes 15, 25 and 34.5 capable of reading precisely current and voltage from nominal values to short circuit allowing the determination of line parameters including "power fa	Our sensor is not capable of burden, It must be connected to impedances of the order of 1 Megaohm, or larger. Our voltage precision is better than 0.5% in other words, under controlled conditions a measurement between any two sensors is below 1% (-.5% t0
Hitachi	FTR	Temperature, Optical	Fiber Optic Temperature laser radar. The FTR is composed of a fiber optic temperature sensing and measureing unit and a computer display to show temperature distribution along a conductor up to 6km in length.	Contacted a rep. Emailed kabuto@hitachi-cable.com Should be getting back with me soon to give pricing.

Text34	Text6	Text36	Text38	Text8
iPEC	Airborne Acoustic Transducer	Acoustic, Corona	The acoustic probe is designed for use on air insulated terminations where there is a clear sound path between the electrically stressed insulation and the probe. The sensor is extremely sensitive and can detect activity below 10pC. The probe has a magnet	
iPEC	Cable and switchgear PD sensors	Corona	The HFCT 100/50 is a high frequency transducer designed specifically for picking up partial discharge signals. It has a split core ferrite to allow retrospective fitting to earth straps without the need for disconnection. The durable body has a hinge and	
Joslyn Hi-Voltage	1514/15	Current	The Fisher Pierce Series 1514/15 Current- Reset Faulted Circuit Indicators locate faults quickly by monitoring line current. The 1514/15 FCIs locate faults quickly and isolate the source which reduces emergency labor, and decreases outages and revenue los	
Joslyn Hi-Voltage	Power Flex Current Sensor	Current	The Fisher Pierce Series 1301 high accuracy line post current sensors provide a reliable measuring method for distribution systems from zero to thousands of amperes. The current sensors may be used for capacitor switching, load surveying, or protective re	15kV, 25kV, 35kV

Text34	Text6	Text36	Text38	Text8
Joslyn Hi-Voltage	Radio Faulted Circuit Indicator System	Current	The Fisher Pierce Radio Faulted Circuit Indicator (RFCI) System utilizes wireless communication technology to assist in locating distribution system faulted circuits. RFCI's installed in overhead, underground, and padmount locations can be detected from h	1547/1548 Series.
kinects	Transform	Current, Voltage, Temperature	By providing up to hourly data for voltage and current loading, and proximity temperature reading for the transformer, utility will have unprecedented access to equipment performance and status data to have a clear, continuous view of the asset conditions	
Leiv Eiriksson Nyfotek AS	System for monitoring cables	Optical	System for monitoring high-tension cables in air stretches as well as a use of the same. The system comprises at least one optic fiber fastened to the high tension cable, the optic fiber including at least one Bragg grating with known reflection character	
Lindsey Manufacturing	Multicore Sensor	Voltage, Current	The Multicore Sensor is designed to be installed without de-energizing or cutting the main conductor. This sensor does not require any special calibration for conductor diameter to produce its 2% accurate output. It can be vertically mounted to replace an	Prices range from $760-1190 15kV Current + Voltage Multicore Sensor $760 25kV Current + Voltage Multicore Sensor $920 35kV Current + Voltage Multicore Sensor $1,190
Lindsey Manufacturing	Current and Voltage Monitoring Insulators	Voltage, Current	Many electric utilities are using Distribution Automation (DA) for both overhead and underground systems. DA systems enable a utility to monitor, coordinate and operate distribution systems in real time mode from remote locations. Utilities that have inst	15kV Current + Voltage Sensor $790 25kV Current + Voltage Sensor $950 35kV Current + Voltage Sensor $1,220 46kV Current + Voltage Sensor $2,480

Text34	Text6	Text36	Text38	Text8
Lindsey Manufacturing	Smart Pin	Voltage, Current	The SmartPin current and voltage sensing system is a low cost solution for monitoring overhead distribution lines. The system consists of three sensor pins capable of supporting standard pin insulators (vertical orientation) and a control box for calibrat	not available.
Lindsey Manufacturing	Elbow Cap	Voltage, Current	The ElbowCap current and voltage sensing system is a low cost solution for monitoring underground distribution feeders. The system consists of three sensors that snap onto the capacitive test point of standard 200A and 600A elbows with a control box for c	not available.
Lindsey Manufacturing	Elbow Sense	Voltage, Current	Lindsey ElbowSense Current and Voltage Monitors use proven CT and voltage sensor technology from the original Lindsey CVMI and fit standard 600 amp T-body 15, 25 and 35kV connectors. They are easily retrofitted to existing padmount or submersible equipmen	Current Monitoring Rings $300 Voltage Monitoring Plugs (qty 1-3) $660
Martech	SDT 170 with parabolic Dish	Acoustic, Corona	The SDT 170MD (Multifunctional/Datalogger) is the complete ultrasonic inspection and predictive maintenance trending machine. With all the features of the SDT 170S Standard and SDT 170M Multifunctional, we've added a customisable data logger that interfac	Detect Corona behind electrical cabinet doors. With Use of parabolic disc, can pinpoint corona with lazer sight. Normally sold to factories. Withstand a 3m drop test.

Text34	Text6	Text36	Text38	Text8
Megger	MDP - Megger Distribution Profiler	voltage, current	The Megger MDP series of distribution profilers provides power utilities with the most accurate and extensive information ever to precisely evaluate loading on feeders/overhead lines and to identify needed upgrades or replacement. Three different models r	Choice of three models that record currents up to 1000 amps, with an additional 200 amp over-range Waveform capture and harmonic analysis up to the 32nd order Power and power factor Accurate data capture via advanced MDP software Lightweight, durable
Omnisens	Ditest - LTM	Temperature	The DITEST-LTM combines OMNISENS DITEST measuring technique with “best-in-industry” dedicated sensing cable, data processing, user-friendly interface and application oriented visualization tools. DITEST-LTM Solution is optimized for long distance monitori	
Omnisens	Ditest - AIM	Temperature	DITEST-AIM integrates OMNISENS core sensing technology DITEST-STA optimized for long distance monitoring applications with extensive application know-how and field experience. DITEST-STA Monitoring distance : > 30 km per sensor Operates with standard s	Measurement of temperature and strain of an overhead conductor.

Text34	Text6	Text36	Text38	Text8
On-line Monitoring, Inc.	PF Live Plus	Current, Temperature	The PF Live Plus, a continuous on-line monitoring system, for monitoring power factor in high voltage capacitive bushings, is now available with an optional leakage current monitor for high voltage lightning arresters. The system includes a minimum set of	The PF Live Plus system can also interface to signals from other devices, or IED's, such as: temperature sensors, DGA, or any 0-10Vdc, 10Vrms, 4-20mA, or 0-1mA signal.
Optisense	35 kV Class Outdoor Voltage Sensor	Voltage	The Optisense outdoor voltage sensor enables high voltage measurement in a compact package at a lower installed cost than with conventional technology. Optical sensing technology allows for galvanic isolation of the signal from the voltage being measured.	
Optisense	15 kV Class Embedded Voltage Sensor	Voltage	The Optisense indoor voltage sensor enables high voltage measurement in a compact package at a lower installed cost than with conventional technology. Optical sensing technology allows for galvanic isolation of the signal from the voltage being measured.	
OZ Optics	Fiber Optic strain and temperature sensing system	Temperature	OZ Optics now offers the ForesighTM series of fiber optic distributed strain and temperature sensors. The new sensor system provides high resolution and accurate strain and temperature monitoring over very long distances. The sensor uses standard optical	
Polytec	IVS-200	Vibration, Optical	Polytec's IVS-200 Industrial Vibration Sensor is a ruggedized laser Doppler vibrometer for non-contact, on-line production vibration testing. An eye-safe visible laser is aimed and focused onto the part being measured. IVS-200 is easily retrofitted into	

Text34	Text6	Text36	Text38	Text8
Power Delivery Products	Automation FCI's	Current	Automation is provided on underground units through the Distribution automation relay and for overhead applications with the Radio Faulted Circuit Indicator. (RFCI). The RFCI mounted on an overhead circuit sends a radio signal to a receiver which is conne	Can be paired with a radio transmitter reciever unit which has a 40-50ft range(mount at bottom of pole below FCI) and when a fault is received, the unit closes a contact which can be connected to an RTU or Cellular RTU(Telemetric).
Power Delivery Products	Overhead FCI's	Current	Overhead Fault Indicators are available with a mechanical flag or LED indication. In addition to permanent installations to reduce outage time, these units are ideal for finding temporary, transient, or nuisance outages. Load Tracker capability is availab	Can be paired with a radio transmitter reciever unit which has a 40-50ft range(mount at bottom of pole below FCI) and when a fault is received, the unit closes a contact which can be connected to an RTU or Cellular RTU(Telemetric).
Power Delivery Products	Underground FCI's	Current	There are two major styles of Underground Faulted Circuit Indicators – Mechanical and Electronic. The Mechanical units offer years of economical fault indication. Rotor, submersible and fluid units are available with or without provisions for hotsick inst	Fault is indicated via blinking led on the FCI. To remotely receive the fault indication, a fiber optic lead is connected to the LED socket while the opposite end is connected to a converter box, which will close a contact on an RTU or other device when
PowerPD, Inc	PD-MCC&G400A	Corona	PD-MCC&G400A is an on-line Partial Discharge (PD) diagnostic system, which detects and analyzes the generation of PD in the power equipments such as Cable and Motor. Four High Frequency Current Transducer (HFCT) Sensors are installed ground line in power	

Text34	Text6	Text36	Text38	Text8
PowerPD, Inc	PD-MAT400A	Acoustic, Corona	PD-MAT400A is a permanently mounted on-line Partial Discharge (PD) diagnostic system. This test device focuses on detecting and analyzing the generation of PD in equipment such as transformers, HV GIS circuit breakers, GIS ductwork, and CGIS using acousti	
PowerPD, Inc	PD-RD300A	Corona	The PD-RD300A is the newest device in the PowerPD line of test equipment, which provides continuous monitoring of your metal clad switchgear (MCSG) assets. This device detects electromagnetic waves when surface tracking occurs on the insulation system. It	Cost is 4700+ depending on number of channels.
PowerPD, Inc.	PD-TM500A	Acoustic, Corona	The PD-TM Series: are non-portable, mounted type units. PD-TM500, 1000, 1500 are online diagnostic systems that continuously monitors partial discharge in equipment such as Transformers, GIS, and CGIS etc. This units detect, analyze, and locate the signal	Main use for substations and utilities.
Powersense	Discos System	current, voltage	The PowerSense Overhead Line Solution has been designed for overhead line installations with or without substations. The solution is based on PowerSense's optical DISCOS® Sensor technology and a specially designed Linux-based RTU module. The DISCOS® Syste	Discos system offers a variety of sensors and modules to create a customized Discos system. Discos offers indoor current sensors, IO modules, LV interfaces, MV interfaces, Opti Module, Outdoor combined current and voltage sensor, outdoor current sensor,

Text34	Text6	Text36	Text38	Text8
PSI	CE Mesh	Voltage, Current	Monitor the Current, Voltage, & Phase Angle on all 3 Phases of Network Transformers and manholes. The Secondary Network Monitoring System has demonstrated excellent communications reliability. CDMA communications from below grade in transformer vaults	PSI's State of the Art Secondary Network Monitoring System will enable utilities to see and measure electrical problems in their network before they happen and then will direct service crews to the exact location for a safe and effective repair.
PSI	FDAM	Voltage, Current	Accurate Map Overlays Integrated Monitoring & Diagnostics Low Cost Telecom FDAM initiates communications Voltage before and after the fault is reported You own the data! AES 256 Bit Data Encryption option Scalable FDAM System is ready for deployment acro	
Radar Engineer	247-B	Acoustic, RFI, Corona	Hotstick Line Sniffer. RF & Ultrasonic Locator for use from a bucket.	Use of RFI to get into general location of Corona and then use acoustic to pinpoint Corona Location.
Radar Engineers	242	RFI, Corona	AM-UHF RFI Locator 500 KHZ-1000 MHZ Oscilloscope Display A.M. Probe	Use of RFI to get into general location of Corona and then use acoustic to pinpoint Corona Location.
Radar Engineers	250	Acoustic, Corona	Parabolic Pinpointer Ultrasonic Locator for use from the ground	Use of RFI to get into general location of Corona and then use acoustic to pinpoint Corona Location.
Radar Engineers	244(tenatively)	RFI, Acoustic, Corona	Still in testing. Basic summary would be a handheld model of the 247-b. Called switch gear sniffer. Use RFI detector to find cabinet of Corona occurance and then acoustic to pinpoint Corona location.	Use of RFI to get into general location of Corona and then use acoustic to pinpoint Corona Location.

Text34	Text6	Text36	Text38	Text8
Radar Engineers	M330	RFI, Corona	RFI locators detect sparks and corona that cause radio and T.V. interference (RFI TVI). RF and ultrasonic receivers quickly pinpoint sparking hardware on powerlines.	Use of RFI to get into general location of Corona and then use acoustic to pinpoint Corona Location.
Radar Engineers	240-A	RFI, Corona	HF-UHF RFI Locator 1.8-1000 MHZ Oscilloscope Display	Use of RFI to get into general location of Corona and then use acoustic to pinpoint Corona Location.
Rauckman Utility Products	Voltwitch	Voltage	VoltWitch is an innovative drive-by voltage indicator that is installed in a line truck or utility vehicle like a radar detector. Instead of sensing radar signals, the VoltWitch senses energized overhead power lines.	
Roctest	FOT-F FOT	Temperature, Optical	FOT-F and FOT-N temperature transducers combine all the desired characteristics expected from the ideal sensor. Their compact size, immunity to EMI/RFI/lightning, resistance to corrosive environments, high accuracy and reliability make them the best choi	Used to monitor a variety of systems. Could be used on transformers to monitor temperature or conductors, however installation on conductors is not a normal procedure. Requires a readout or datalogging device with fiber-optic interface.
Roctest	PAVICA	Vibration	The PAVICA is a unique, small, lightweight instrument used to monitor and analyse vibrations in overhead transmission lines. The PAVICA measures the frequency and amplitude of all vibration cycles over all sampling periods, stores the data in a high-defi	The battery life in our Pavica is approx 3 months. This figure vary according to the sampling rate and sampling time as well as the ambient temperature. In the user manual, we give a formula that give the end-user the expected life of their battery for th

Text34	Text6	Text36	Text38	Text8
S&C	CS/CSV	Voltage, Current	S&C CS Line Post Current Sensors and CSV Line-Post Current/Voltage Sensors provide an economical, effective way to measure current and voltage (optional) for your capacitor control and other applications. The CS/CSV Sensors are well-suited for working wit	CS Line Post Current Sensor 14.4 KV 904-001124-00 $ 650 ea 25 904-001125-00 $819 ea 34.5 904-001126-00 $1075 ea CSV Line Post Current/Voltage Sensor 14.4 904-001128-01 $ 1225 ea 25
Sabrifa	T-Guard	Temperature	The Neoptix™ T/Guard™ is a multi-channel fiber optic temperature monitoring system for power transformer hot spot measurements. The T/Guard™ system has been developed with long-term performance and stability in mind. This fiber-optic temperature monitorin	
Sabrifa	Reflex	Temperature	The rugged, splash-proof enclosure is designed to withstand the most punishing industrial environments. For industrial needs, Reflex units can be installed together on a special 19 in. rack-mounted plates. For special applications, like transformer hot sp	
SEL	AutoRANGER	Current	When a fault occurs, two of the AutoRANGER's red LEDs will begin to flash. After one minute, the indicator will measure the system current. If it detects load current, the AutoRANGER's yellow LED will begin to flash and the red LEDs will turn off, indicat	

Text34	Text6	Text36	Text38	Text8
SEL	Beacon Electrostatic Reset	Voltage	SEL BEACON® electric field reset fault indicators (BER) derive their operating power from the potential gradient around high-voltage power lines. The BERs inrush restraint option prevents false tripping that might otherwise occur because of reclosing oper	
SEL	Overhead Electrostatic Reset	Voltage	SEL electric field reset fault indicators (type E-ERL) derive their operating power from the potential gradient around high-voltage power lines. The E-ERL's inrush restraint option blocks targeting for recloser operations. When the upstream protection ope	
SEL	Underground AutoRANGER	Current	Ensure the best fault-indicating solution for your underground application by choosing from a wide variety of single- and threephase display options, including remote displays that eliminate the need to open the enclosure to check the fault indicator's st	Can be used with Radio Ranger fault location system. Identify the phase and location of underground faults with the handheld Remote Fault Reader. Wireless Interface ID, phase, and way distinctions display faultpath information in each vault while differe
SEL	SEL LINAM Current Reset Fault Indicators	Current	Senses the load and fault currents on the conductor. Use the optional auxiliary contact to provide status indication to a SCADA input.	Use the optional auxiliary contact to provide status indication to a SCADA input.
SEL	Single-Phase Test Point Mounted Bolt Display FCI	Current	Install 1TPRB fault indicators in padmount transformers, subsurface load centers, or junction sectionalizing points. In single-phase underground loop applications, install the 1TPRB at the transformer. At sectionalizing junctions, place an indicator on ea	

Text34	Text6	Text36	Text38	Text8
Sensor Net	Sentinel DTS Range	Temperature	This DTS system has been designed with safety in mind and tested to some of the industry's most rigorous standards. With the addition of a multiplexing module it can easily be configured to produce multiple double-ended measurements. User configurable zon	
SensorTran	DTS Units	Temperature	The SensorTran DTS 5100 range of intelligent DTS systems provide real-time dynamic temperature with high accuracy and fine resolution, providing up to 40,000 discrete temperature points along optical fiber(s).	• on-board Ethernet-enabled computer with open communications architecture • autonomous data collection and storage • multiple zones and alarms • flexible data, alarm and remote control/access communications • self-diagnostics, auto start & safe shut-down
Shaw Energy Delivery Services	Thermal Rate System	Temperature	It consists of ThermalRate™ Monitors (TRMs), which are installed along the line. The TRM is a replica of the line conductor, with the same material, diameter, and surface. It is oriented in the same direction as the line to establish how the present weath	Determining the actual current capacity of a high voltage transmission line.
Southwire Company	DTS	Temperature	The measurement technology Southwire is exploring is called Distributed Temperature Sensing (DTS), and it uses fiber optic strands contained in the overhead conductor. By monitoring key optical fiber characteristics, grid operators can get an accurate, sp	

Text34	Text6	Text36	Text38	Text8
SSI power	CMD	Voltage, Current	The CMD is not limited to substation applications, being equally well suited for application on distribution lines, subtransmission lines, transmission lines, and EHV transmission lines. In line applications the CMD provides the functions of real-time li	
Sumitomo	OP-Thermo	Temperature	Op-Thermo & only one line of Optical Fiber is necessary to measure continuous & real-time temperature profile at thousands of points along the fiber without any data transmission devices.	
SURETECH	AC Current Sensors	Current	SURETECH AC Current sensors are available in various formats, including slip-on, or bar-primary. These sensors are available for single OR three phase measurements. The sensor uses Rogowski technology to measure AC currents. Rogowski technology does not r	
SURETECH	SURETECH VI-x Monitoring System	Voltage, Current	The SURETECH Vix monitoring system senses, processes and logs electrical parameters to data flash memory, on MV (Medium Voltage) equipment. Sensor outputs are fed to a SURETECH SLP (Smart Load Processor), which samples Voltage, Current, Phase angle and Qu	

Text34	Text6	Text36	Text38	Text8
SURETECH	HV Transducer Current Probe	Current	This range of current probes is used for measuring tan(delta) on HV apparatus, insulation resistance and capacitance under HV operational and test conditions. Leakage current is measured and its phase is compared with the HV reference excitation voltage's	
Syntronics	Corona Finder	Optical, Corona	Small and battery operated, the CoronaFinder is easy to take to the field. Real time UV viewing means that high voltage equipment can be quickly and thoroughly inspected for evidence of corona discharge that is visible only in the ultraviolet spectrum (s	Corona Detection.
Telemetric	TVM	Voltage	The Telemetric Voltage Monitor (TVM) family of products offer a cost-effective voltage monitoring, interruption detection, and power quality solution. The TVM is available in single phase (TVM1) and two three phase versions, TVM3-120V and TVM3-277V. With	Report momentary and sustained power outage. Over/under voltage events. Integrated cellular module. Provide cellular data service and hosted application to view network of sensors.
Telepathx	Intelligent Insulators Current Leakage Sensors	Temperature	Telepathx Pinpoint sensors are the first non invasive RFID solution for monitoring faulting distribution insulators, they alert you via wireless connection when the thermal threshold has been reached providing energy maintenance personnel exact time and l	Available in the following protocols 433Mhz Reactive RFID 900Mhz Reactive RFID 900Mhz Reactive 802.15.4 RFID 2.4Ghz Reactive 802.11g 2.4Ghz Reactive 802.15.4

Text34	Text6	Text36	Text38	Text8
Telepathx	RFID cutout fuse monitor	Optical	The fixed frequency RFID Fob has a range of 100 to 125 meters and communicates with the TPX-GSM-100 Remote Transmission Unit (Access Point) or Telepathx compatible smart Meters, BPL/PLC & WIFI access points alerting you when and where a fuse has been acti	Available in the following protocols 433Mhz Reactive RFID 900Mhz Reactive RFID 900Mhz Reactive 802.15.4 RFID 2.4Ghz Reactive 802.11g 2.4Ghz Reactive 802.15.4
Thomas & Betts	Elastimold TPM Series	Current	Test Point Mounted Fault Indicators provide a clear, visual means for locating faulted cables and equipment on underground distribution systems. Indicators are self-powered and consist of a solid state current sensor connected to a faulted circuit display	
Thomas & Betts	V2 Standard	Current	Test Point Mounted Neon Voltage Indicators provide a convenient, visual method for determining the energized status of underground distribution circuits. The indicator consists of a self-powered voltage sensor connected to a neon light that flashes when e	
Thomas & Betts	OLM Standard	Current	Overhead Line Fault Indicators aid in locating faulted circuits and equipment on overhead distribution systems. Indicators are self powered and consist of a solid state current sensor connected to a faulted circuit display. Designs incorporate advanced ci	
Thomas & Betts	UCM Series	Current	URD Cable Mounted Fault Indicators aid in locating faulted cables and equipment on underground distribution systems. Indicators are self powered and consist of a solid state current sensor connected to faulted circuit display.	

Text34	Text6	Text36	Text38	Text8
Tollgrade	LightHouse	Current, Temperature	Tollgrade's LightHouse solution is designed to provide real-time grid intelligence by using sensors that continuously monitor key circuit parameters and transmit them over a self-configuring wireless mesh network to a central location.	4-35kV. Still in pilot programs. Hot stick mountable. Also measures 3rd harmonic.
unknown	Promethean Devices	Current, Temperature	Low-Cost, Non-Contact, High Accuracy Sensor for the Simultaneous, Reliable, Real-time Determination and Monitoring of HV Transmission Line Sag, Temperature, Current, and Ampacity.	No contact informaion. Website is under construction.
unknown	RF Smart Monitor System	Voltage, Temperature, Vibration	The RF Smart Monitor System is designed to allow the user to remotely collect machine vibration and temperature data without the need for cabling. This system, which is designed to monitor a wide variety of machine components.	
unknown	Optical Sensors	Optical	A novel photoacoustic spectrometer (PA) has been developed for in-situ detection of SF6 leaks in low concentrations. The developed system is equipped with a sound alarm system and has been tested in the laboratory for very minute SF6 leaks. This newly dev	
unknown	Airak's Patented Optical Current Sensor System	Current, Optical	Safe and Easy to Install -does not conduct electrical current - intrinsically isolated making it safe to personnel and interconnected equipment Small, Lightweight, Immune to EMI/RFI, Zero Risk of Explosive Failure, Intended for 54.5 KV Applications and Be	Appear to have obtained U.S. Navy contract. Does not appear to be available to the public.

Text34	Text6	Text36	Text38	Text8
USI Power	Power Donut 2	Voltage, Current, Temperature	The Power-Donut2™ is an engineering instrumentation platform whose functions include: data acquisition, data monitoring and logging the parameters of high voltage overhead conductors. The Power-Donut2™ is completely self- contained, allowing for hot stick	Will be mass produced soon. Price should drop. Currently Testing new model which will offer full waveform capturing and event logging as well as offer GPS clock.

Reports: Optical Sensors

Sensor Name	Manufacturer	Sensor Type	Brief Description	Cost	Anticipated Use
RFID cutout fuse monitor	Telepathx	Optical	The fixed frequency RFID Fob has a range of 100 to 125 meters and communicates with the TPX-GSM-100 Remote Transmission Unit (Access Point) or Telepathx compatible smart Meters, BPL/PLC & WIFI access points alerting you when and where a fuse has been activated. Bright pulsating LEDs also help in locating fuses at night.	0	Available in the following protocols 433Mhz Reactive RFID 900Mhz Reactive RFID 900Mhz Reactive 802.15.4 RFID 2.4Ghz Reactive 802.11g 2.4Ghz Reactive 802.15.4
Corona Finder	Syntronics	Optical, Corona	Small and battery operated, the CoronaFinder is easy to take to the field. Real time UV viewing means that high voltage equipment can be quickly and thoroughly inspected for evidence of corona discharge that is visible only in the ultraviolet spectrum (see photograph below). Clearly identifiable corona discharge seen with the CoronaFinder can be photographed with an optional digital camera that attaches to the CoronaFinder. Click on the following link to "youtube" for video footage of a corona test inspection.	14035	Corona Detection.

Sensor Name	Manufacturer	Sensor Type	Brief Description	Cost	Anticipated Use
Airak's Patented Optical Current Sensor System	unknown	Current, Optical	Safe and Easy to Install -does not conduct electrical current - intrinsically isolated making it safe to personnel and interconnected equipment Small, Lightweight, Immune to EMI/RFI, Zero Risk of Explosive Failure, Intended for 54.5 KV Applications and Below, Automated Manufacturing, Increased Dynamic Range and Bandwidth, Hot Stick Mountable.	0	Appear to have obtained U.S. Navy contract. Does not appear to be available to the public.
FOT-F FOT	Roctest	Temperature, Optical	FOT-F and FOT-N temperature transducers combine all the desired characteristics expected from the ideal sensor. Their compact size, immunity to EMI/RFI/lightning, resistance to corrosive environments, high accuracy and reliability make them the best choice for tem perature measurements in harsh environments. Our fi ber optic temperature gauges are based on the thermal expansion of highly stable glass, allowing precise, stable, and repeatable measurements.	250	Used to monitor a variety of systems. Could be used on transformers to monitor temperature or conductors, however installation on conductors is not a normal procedure. Requires a readout or datalogging device with fiber-optic interface.
FTR	Hitachi	Temperature, Optical	Fiber Optic Temperature laser radar. The FTR is composed of a fiber optic temperature sensing and measureing unit and a computer display to show temperature distribution along a conductor up to 6km in length.	0	Contacted a rep. Emailed kabuto@hitachi-cable.com Should be getting back with me soon to give pricing.
unknown	ABB Power T&D Company Inc.	Acoustic, Corona, Optical	Acoustic optical system for partial discharge detection and location	0	

Sensor Name	Manufacturer	Sensor Type	Brief Description	Cost	Anticipated Use
Optical Sensors	unknown	Optical	A novel photoacoustic spectrometer (PA) has been developed for in-situ detection of SF6 leaks in low concentrations. The developed system is equipped with a sound alarm system and has been tested in the laboratory for very minute SF6 leaks. This newly developed SF6 detection device utilizes a high quality factor resonant photoacoustic cell and continuous wave (CW) line tunable CO2 laser at 10.55 μm wavelength. Whenever SF6 is detected an acoustic signal is generated and no signal appears from ambient air if there is no leakage of SF6. An electret microphone is used for the detection of these acoustic signals	0	
System for monitoring cables	Leiv Eiriksson Nyfotek AS	Optical	System for monitoring high-tension cables in air stretches as well as a use of the same. The system comprises at least one optic fiber fastened to the high tension cable, the optic fiber including at least one Bragg grating with known reflection characteristics, a light source for emitting light within a known range of wavelengths into the optic fiber, and measuring devices for detection of light reflected from the Bragg grating in the fiber and for recognizing light reflected from each Bragg grating based on their known reflection characteristics.	0	

Sensor Name	Manufacturer	Sensor Type	Brief Description	Cost	Anticipated Use
IVS-200	Polytec	Vibration, Optical	Polytec's IVS-200 Industrial Vibration Sensor is a ruggedized laser Doppler vibrometer for non-contact, on-line production vibration testing. An eye-safe visible laser is aimed and focused onto the part being measured. IVS-200 is easily retrofitted into existing lines because the laser interferometer optics and electronics are all contained within a single, compact and robust industrial housing (IP 64). The primary application of the IVS-200 is the monitoring of, with the goal of reducing, defects, noise and vibration in manufactured parts ranging from microelectronics to transmissions.	23250	
Infrared Cameras	Flir Systems, LTD	Optical, Temperature	FLIR provides utilities with the most advanced thermal imaging solutions to support the monitoring programs that keep the vital electrical power grid up and running. FLIR ThermaCAM infrared cameras have revolutionized predictive/preventive maintenance inspection programs. Their smart, Web-ready design allow utilities to monitor remote substations and critical assets 24x7 via the Internet. FLIR cameras feature lightweight and rugged design for easy field use. With interchangeable lenses and a wide array of unique accessories, these cameras are ready to handle any situation.	0	

Reports: RFI Sensors

Text38	Text8	Text34	Text6	Text36	Text2
Still in testing. Basic summary would be a handheld model of the 247-b. Called switch gear sniffer. Use RFI detector to find cabinet of Corona occurance and then acoustic to pinpoint Corona location.	Use of RFI to get into general location of Corona and then use acoustic to pinpoint Corona Location.	Radar Engineers	244(tenatively)	RFI, Acoustic, Corona	0
RFI locators detect sparks and corona that cause radio and T.V. interference (RFI TVI). RF and ultrasonic receivers quickly pinpoint sparking hardware on powerlines.	Use of RFI to get into general location of Corona and then use acoustic to pinpoint Corona Location.	Radar Engineers	M330	RFI, Corona	1800
HF-UHF RFI Locator 1.8-1000 MHZ Oscilloscope Display	Use of RFI to get into general location of Corona and then use acoustic to pinpoint Corona Location.	Radar Engineers	240-A	RFI, Corona	4700
AM-UHF RFI Locator 500 KHZ-1000 MHZ Oscilloscope Display A.M. Probe	Use of RFI to get into general location of Corona and then use acoustic to pinpoint Corona Location.	Radar Engineers	242	RFI, Corona	5500
Hotstick Line Sniffer. RF & Ultrasonic Locator for use from a bucket.	Use of RFI to get into general location of Corona and then use acoustic to pinpoint Corona Location.	Radar Engineer	247-B	Acoustic, RFI, Corona	950
The EXACTER® Outage-Avoidance System provides early warning of failing transformers, regulators, insulators, cutouts, lightning arrestors, and more, utilizing advanced sensor-array technology. Geospatial mapping provides location data and problem severity	Unit price per month(survey themselves), they produce reports of faulty components. Also do turnkey services. Monitor overhead distribution by listening to RF signatures, then data is analyzed by the service. Price for rental is 3000-6000/month for a u	Exacter, Inc.	Exacter	RFI	3000

Reports: Selected for Testing

Text8	Text34	Text6	Text36	Text2
	Thomas & Betts	Elastimold TPM Series	Current	0
	Thomas & Betts	UCM Series	Current	100
	Thomas & Betts	OLM Standard	Current	99
	Thomas & Betts	V2 Standard	Current	30
up to 69 KV, can communicate down to data link, which is a dashboard mounted device. Also have a scada solution, cellphone, etc. Must be mounted to bare conductor. Has regowski coil. Had a dimensionless voltage readout which can be used to calculate act	GridSense	LT40	Voltage, Current	1800
up to 138KV, can communicate down to data link, which is a dashboard mounted device. Also have a scada solution, cellphone, etc. Must be mounted to bare conductor. Has regowski coil. Had a dimensionless voltage readout which can be used to calculate act	GridSense	LT50	Voltage, Current, Temperature	3100
	SEL	AutoRANGER	Current	150
Can be used with Radio Ranger fault location system. Identify the phase and location of underground faults with the handheld Remote Fault Reader. Wireless Interface ID, phase, and way distinctions display faultpath information in each vault while differe	SEL	Underground AutoRANGER	Current	100
Use the optional auxiliary contact to provide status indication to a SCADA input.	SEL	SEL LINAM Current Reset Fault Indicators	Current	150
	SEL	Single-Phase Test Point Mounted Bolt Display FCI	Current	78
	Arteche	Underground Fault Sensor	Current	0

Text8	Text34	Text6	Text36	Text2
Will be mass produced soon. Price should drop. Currently Testing new model which will offer full waveform capturing and event logging as well as offer GPS clock.	USI Power	Power Donut 2	Voltage, Current, Temperature	14500
15kV, 25kV, 35kV	Joslyn Hi-Voltage	Power Flex Current Sensor	Current	500
Appear to have obtained U.S. Navy contract. Does not appear to be available to the public.	unknown	Airak's Patented Optical Current Sensor System	Current, Optical	0
Prices range from $760-1190 15kV Current + Voltage Multicore Sensor $760 25kV Current + Voltage Multicore Sensor $920 35kV Current + Voltage Multicore Sensor $1,190	Lindsey Manufacturing	Multicore Sensor	Voltage, Current	760
15kV Current + Voltage Sensor $790 25kV Current + Voltage Sensor $950 35kV Current + Voltage Sensor $1,220 46kV Current + Voltage Sensor $2,480	Lindsey Manufacturing	Current and Voltage Monitoring Insulators	Voltage, Current	790
not available.	Lindsey Manufacturing	Smart Pin	Voltage, Current	0
not available.	Lindsey Manufacturing	Elbow Cap	Voltage, Current	0
Current Monitoring Rings $300 Voltage Monitoring Plugs (qty 1-3) $660	Lindsey Manufacturing	Elbow Sense	Voltage, Current	300
4-35kV. Still in pilot programs. Hot stick mountable. Also measures 3rd harmonic.	Tollgrade	LightHouse	Current, Temperature	700
Can consollidate any other outside IED information, can controll transformer cooling. Pricing is $12000-18000 depending on options. Installation can be done as full turn key, $15000, or as a supervisory only install for which the price would vary.	Dynamic Ratings	DRMCC-T3	Current, Temperature	18000
No contact informaion. Website is under construction.	unknown	Promethean Devices	Current, Temperature	0

Text8	Text34	Text6	Text36	Text2
This system is composed of 8 current sensors, a reciever, and the analysis software for around $3500. This is a new product and very little information is currently available.	ABB	SEI601	Current	3500
1547/1548 Series.	Joslyn Hi-Voltage	Radio Faulted Circuit Indicator System	Current	200
70-110	Cooper Power Systems	TPR	Current	110
	Cooper Power Systems	MR	Current	110
$105-135	Cooper Power Systems	LVR	Current	135
	Cooper Power Systems	ER	Current	110
	Cooper Power Systems	DR	Current	40
80-100	Cooper Power Systems	CR	Current	100
Can be used with outage advisor system for additional cost.	Cooper Power Systems	ER S.T.A.R. Pathfinder	Current	110
$80-110 Can be utilized with outage advisor for remote fault detection for additional cost.	Cooper Power Systems	TPR S.T.A.R. Pathfinder	Current	110
	Joslyn Hi-Voltage	1514/15	Current	145

Text8	Text34	Text6	Text36	Text2
Can be paired with a radio transmitter reciever unit which has a 40-50ft range(mount at bottom of pole below FCI) and when a fault is received, the unit closes a contact which can be connected to an RTU or Cellular RTU(Telemetric).	Power Delivery Products	Overhead FCI's	Current	185
Fault is indicated via blinking led on the FCI. To remotely receive the fault indication, a fiber optic lead is connected to the LED socket while the opposite end is connected to a converter box, which will close a contact on an RTU or other device when	Power Delivery Products	Underground FCI's	Current	120
Can be paired with a radio transmitter reciever unit which has a 40-50ft range(mount at bottom of pole below FCI) and when a fault is received, the unit closes a contact which can be connected to an RTU or Cellular RTU(Telemetric).	Power Delivery Products	Automation FCI's	Current	120
The PF Live Plus system can also interface to signals from other devices, or IED's, such as: temperature sensors, DGA, or any 0-10Vdc, 10Vrms, 4-20mA, or 0-1mA signal.	On-line Monitoring, Inc.	PF Live Plus	Current, Temperature	0
	SURETECH	SURETECH VI-x Monitoring System	Voltage, Current	0
	SURETECH	HV Transducer Current Probe	Current	0
	SURETECH	AC Current Sensors	Current	0
Testing in the field currently. Using 900MHz modem for communication.3000-3500 for field trial units.	FieldMetrics Inc.	MetPod/Metpod lite(skinnier version of MetPod)	Voltage, Current	3000
CS Line Post Current Sensor 14.4 KV 904-001124-00 $ 650 ea 25 904-001125-00 $819 ea 34.5 904-001126-00 $1075 ea CSV Line Post Current/Voltage Sensor 14.4 904-001128-01 $ 1225 ea 25	S&C	CS/CSV	Voltage, Current	650

Text8	Text34	Text6	Text36	Text2
Our sensor is not capable of burden, It must be connected to impedances of the order of 1 Megaohm, or larger. Our voltage precision is better than 0.5% in other words, under controlled conditions a measurement between any two sensors is below 1% (-.5% t0	Grupodriel	SENSODRIEL	Voltage, Current	150
Discos system offers a variety of sensors and modules to create a customized Discos system. Discos offers indoor current sensors, IO modules, LV interfaces, MV interfaces, Opti Module, Outdoor combined current and voltage sensor, outdoor current sensor,	Powersense	Discos System	current, voltage	0
Choice of three models that record currents up to 1000 amps, with an additional 200 amp over-range Waveform capture and harmonic analysis up to the 32nd order Power and power factor Accurate data capture via advanced MDP software Lightweight, durable	Megger	MDP - Megger Distribution Profiler	voltage, current	0
	SSI power	CMD	Voltage, Current	0
	kinects	Transform	Current, Voltage, Temperature	0
PSI's State of the Art Secondary Network Monitoring System will enable utilities to see and measure electrical problems in their network before they happen and then will direct service crews to the exact location for a safe and effective repair.	PSI	CE Mesh	Voltage, Current	0
	PSI	FDAM	Voltage, Current	0

Report: Sensor Application Table – Pt. 1

Report: Sensor Application Table – Pt. 2

Text38	Text8	Text34	Text2	Text4	Text6	Text36
VisiVolt™ – Passive Voltage Indicator is a busbar-mounted-type indicator of voltage presence developed to be used in outdoor and indoor systems. It is adapted for permanent installation on busbars and naked or insulated metal conductors in medium voltage		ABB	0	0	VisiVolt	Voltage
By simply attaching a small, non-intrusive, clamp-on AC/DC sensor to the relay wires and connecting its Cat5 cable to the supplied recording switch, real-time analog and digital information is readily available for analysis. The sensor is highly sensitive	This system is composed of 8 current sensors, a reciever, and the analysis software for around $3500. This is a new product and very little information is currently available.	ABB	3500	0	SEI601	Current
Acoustic optical system for partial discharge detection and location		ABB Power T&D Company Inc.	0	0	unknown	Acoustic, Corona, Optical
DTS technology measures a temperature profile along an optical fiber over several kilometers. The Agilent DTS performs measurements down to 1 meter spatial resolution with less than 0.1°C temperature resolution providing thousands of measurement points in		Agilent	0	0	Distributed Temperature System N4385A / N4386A	Temperature

Text38	Text8	Text34	Text2	Text4	Text6	Text36
The Temperature Measurement Sensor SMT has been designed to measure the instantaneous temperature of the line, transmitting it to a PC via an SMS message.	The Temperature Measuring Sensor (SMT) gives real temperature of Tranmision or Distribution aereal networks cable. The information is sent by SMS to a receiver that storage and present these data. Easy to install, even with energized line, in aprox. 10'.	Arteche	0	0	Temperature measuring sensor(SMT)	Temperature
The task of the ARTECHE Fault Indicator Relay is to detect the faulty line section and indicate the incidence so that, via remote signal transmission, for example, adequate actions are taken and the section affected can be quickly isolated.		Arteche	0	0	Underground Fault Sensor	Current
The Model TSP probe provides an RTU compatible analog input that is proportional to the transformer's top oil temperature. The probe can be used with an existing RTU, or as part of an Substation Advisor® System. For transformers with existing top oil indi	TSP Oil Temperature Probe $425	Cannon Technologies	425	0	TSP probe	Temperature
Model TSS and TSA sensors provide an analog current that is proportional to the surface on which the sensor is mounted (TSS) or to the temperature of the ambient air (TSA). The sensor is powered from the loop current and therefore it does not require a se	TSS Surface Temperature Sensor $225 TSA Ambient Temperature Sensor $225	Cannon Technologies	225	0	TSS and TSA sensors	Temperature

Text38	Text8	Text34	Text2	Text4	Text6	Text36
Cooper Power Systems S.T.A.R.™ PATHFINDER™ Variable Trip Test Point faulted circuit indicators (FCI) are designed to quickly and easily locate faulted sections of underground cable systems. These FCIs can be used on both 200 A separable connectors and 600	$80-110 Can be utilized with outage advisor for remote fault detection for additional cost.	Cooper Power Systems	110	0	TPR S.T.A.R. Pathfinder	Current
Cooper Power Systems' S.T.A.R. Electrostatic Reset (ER) faulted circuit indicators (FCIs) can be used on overhead uninsulated, unshielded cable and unshielded insulated cable, such as tree wire. They are powered from the voltage gradient between the line		Cooper Power Systems	110	0	ER	Current
Cooper Power Systems' S.T.A.R. Low Voltage Reset (LVR) faulted circuit indicators (FCIs) can be installed on padmounted distribution transformers, or at a secondary voltage source. The unit automatically resets to the normal position when circuit voltage	$105-135	Cooper Power Systems	135	0	LVR	Current
High Tech at Low-Tech Prices – The latest industry technology is now available at a price everyone can afford. Reduces Operating Costs, Reduces Inventory, Improves Power Quality, Finds the Fault the First Time. A pair of high luminous LEDs in addition	Can be used with outage advisor system for additional cost.	Cooper Power Systems	110	0	ER S.T.A.R. Pathfinder	Current

Text38	Text8	Text34	Text2	Text4	Text6	Text36
Cooper Power Systems' S.T.A.R. Manual Reset (MR) faulted circuit indicators (FCIs) can be used on overhead uninsulated, unshielded cable and unshielded insulated cable such as tree wire. The MR FCI can also be installed on padmounted distribution transfor		Cooper Power Systems	110	0	MR	Current
Cooper Power Systems' S.T.A.R. Delayed Reset (DR) faulted circuit indicators (FCIs) can be installed on padmounted distribution transformers, sector cabinets, switchgear and overhead bare conductors. The unit automatically resets back to the normal positi		Cooper Power Systems	40	0	DR	Current
Cooper Power Systems' S.T.A.R. Test Point Reset (TPR) faulted circuit indicators (FCIs) can be used on all 200 A and 600 A connectors having a voltage test point. Load levels do not effect the reset circuit. The unit automatically resets to the normal pos	70-110	Cooper Power Systems	110	0	TPR	Current
Cooper Power Systems' S.T.A.R. Current Reset (CR) faulted circuit indicators (FCIs) can be installed on padmounted distribution transformers, sector cabinets, switchgear and overhead bare conductors. The unit automatically resets back to the normal positi	80-100	Cooper Power Systems	100	0	CR	Current

Text38	Text8	Text34	Text2	Text4	Text6	Text36
Replaces several control devices, providing control, monitoring & data aquisition for the entire transformer. This device has several sensors which may be connected to monitor several aspects of a transformer.	Can consollidate any other outside IED information, can controll transformer cooling. Pricing is $12000-18000 depending on options. Installation can be done as full turn key, $15000, or as a supervisory only install for which the price would vary.	Dynamic Ratings	18000	15000	DRMCC-T3	Current, Temperature
The UltraTEV Plus+ measures PD activity in the form of ultrasonic and transient earth-voltage (TEV) signals, but provides operators with considerably more comprehensive information about emission levels. Ultrasonic emissions are displayed as decibel readi		EA Technology	0	0	UltraTEV Plus+	Acoustic, Corona
The EXACTER® Outage-Avoidance System provides early warning of failing transformers, regulators, insulators, cutouts, lightning arrestors, and more, utilizing advanced sensor-array technology. Geospatial mapping provides location data and problem severity	Unit price per month(survey themselves), they produce reports of faulty components. Also do turnkey services. Monitor overhead distribution by listening to RF signatures, then data is analyzed by the service. Price for rental is 3000-6000/month for a u	Exacter, Inc.	3000	1200	Exacter	RFI
The FMPT voltage sensor is a high accuracy voltage measurement solution for transmission and distribution utility applications. By combining high-reliability components in a patent-pending design, the FMPT uses no insulating oil or SF6 gas, yet provides a	Still in development. New technology. Design is complete, however waiting for a customer for fieldtest. $2500-$2700 Ballpark cost range.	FieldMetrics Inc	2500	0	FMPT	Voltage

Text38	Text8	Text34	Text2	Text4	Text6	Text36
The MetPod is our first product release based on our patent-pending technology. An integrated VT, clamp-on CT and meter, it meets 0.2 accuracy class requirements and has passed full dielectric type-tests. The MetPod offers a wireless link and self diagno	Testing in the field currently. Using 900MHz modem for communication.3000-3500 for field trial units.	FieldMetrics Inc.	3000	0	MetPod/Metpod lite(skinnier version of MetPod)	Voltage, Current
FLIR provides utilities with the most advanced thermal imaging solutions to support the monitoring programs that keep the vital electrical power grid up and running. FLIR ThermaCAM infrared cameras have revolutionized predictive/preventive maintenance in		Flir Systems, LTD	0	0	Infrared Cameras	Optical, Temperature
The magnetic mount temperature sensor attaches to the transformer with a magnet. The sensor is self-contained and in a weatherproof housing. The RTD has a built-in 4-20 mA transmitter that is powered from the monitoring unit. The sensor is supplied with f		GE Power	522	0	Magnetic Mount Temperature Sensor	Temperature
The insertion-type RTD temperature sensor mounts inside the thermal well. It connects to the transmitter, which sends a 4-20 mA signal back to the monitor	3 types: 133 Well 325 Temperature element 823 installed in monitoring cabinet	GE Power	325	0	Well-Type RTD Temperature Sensor	Temperature

Text38	Text8	Text34	Text2	Text4	Text6	Text36
Partial discharge sensors are self-contained, acoustic sensors utilizing piezo electric element technology. The sensors provide continuous readings and are designed for field use in transformers and load tap changers. Two types of partial discharge sensor	No longer manufactured.	GE Power	0	0	Partial Discharge Sensors	Acoustic, Corona
The PM5 is a low cost, in situ monitor that is placed at strategic LV locations facitlitating real time reporting of voltage disturbances in the field to improve power quality and reliability. A cost effective network wide monitoring system that's simple	he PM5 simply plugs into the 110-240 volt electrical outlet and connects in parallel to the existing telephone line to transfer critical operational data to a central master station (MONITOR SYSTEM). The use of low cost Dual Tone Multiple Frequency (DTMF)	Gridsense	0	0	Powermonic PM5	voltage
By clipping the LT40 / LT50 on to lines at strategic points, e.g. tee junctions, switches, substations etc., data such as load, maximum demand, inrush current, fault wave shape & duration, protection operation, voltage status, conductor and ambient temper	up to 138KV, can communicate down to data link, which is a dashboard mounted device. Also have a scada solution, cellphone, etc. Must be mounted to bare conductor. Has regowski coil. Had a dimensionless voltage readout which can be used to calculate act	GridSense	3100	0	LT50	Voltage, Current, Temperature

Text38	Text8	Text34	Text2	Text4	Text6	Text36
By clipping the LT40 / LT50 on to lines at strategic points, e.g. tee junctions, switches, substations etc., data such as load, maximum demand, inrush current, fault wave shape & duration, protection operation, voltage status, conductor and ambient temper	up to 69 KV, can communicate down to data link, which is a dashboard mounted device. Also have a scada solution, cellphone, etc. Must be mounted to bare conductor. Has regowski coil. Had a dimensionless voltage readout which can be used to calculate act	GridSense	1800	0	LT40	Voltage, Current
The current and voltage sensor called "SENSODRIEL" is a post type insulator for classes 15, 25 and 34.5 capable of reading precisely current and voltage from nominal values to short circuit allowing the determination of line parameters including "power fa	Our sensor is not capable of burden, It must be connected to impedances of the order of 1 Megaohm, or larger. Our voltage precision is better than 0.5% in other words, under controlled conditions a measurement between any two sensors is below 1% (-.5% t0	Grupodriel	150	0	SENSODRIEL	Voltage, Current
Fiber Optic Temperature laser radar. The FTR is composed of a fiber optic temperature sensing and measureing unit and a computer display to show temperature distribution along a conductor up to 6km in length.	Contacted a rep. Emailed kabuto@hitachi-cable.com Should be getting back with me soon to give pricing.	Hitachi	0	0	FTR	Temperature, Optical
The acoustic probe is designed for use on air insulated terminations where there is a clear sound path between the electrically stressed insulation and the probe. The sensor is extremely sensitive and can detect activity below 10pC. The probe has a magnet		iPEC	0	0	Airborne Acoustic Transducer	Acoustic, Corona

Text38	Text8	Text34	Text2	Text4	Text6	Text36
The HFCT 100/50 is a high frequency transducer designed specifically for picking up partial discharge signals. It has a split core ferrite to allow retrospective fitting to earth straps without the need for disconnection. The durable body has a hinge and		iPEC	0	0	Cable and switchgear PD sensors	Corona
The Fisher Pierce Series 1514/15 Current- Reset Faulted Circuit Indicators locate faults quickly by monitoring line current. The 1514/15 FCIs locate faults quickly and isolate the source which reduces emergency labor, and decreases outages and revenue los		Joslyn Hi-Voltage	145	0	1514/15	Current
The Fisher Pierce Series 1301 high accuracy line post current sensors provide a reliable measuring method for distribution systems from zero to thousands of amperes. The current sensors may be used for capacitor switching, load surveying, or protective re	15kV, 25kV, 35kV	Joslyn Hi-Voltage	500	0	Power Flex Current Sensor	Current
The Fisher Pierce Radio Faulted Circuit Indicator (RFCI) System utilizes wireless communication technology to assist in locating distribution system faulted circuits. RFCI's installed in overhead, underground, and padmount locations can be detected from h	1547/1548 Series.	Joslyn Hi-Voltage	200	0	Radio Faulted Circuit Indicator System	Current

Text38	Text8	Text34	Text2	Text4	Text6	Text36
By providing up to hourly data for voltage and current loading, and proximity temperature reading for the transformer, utility will have unprecedented access to equipment performance and status data to have a clear, continuous view of the asset conditions		kinects	0	0	Transform	Current, Voltage, Temperature
System for monitoring high-tension cables in air stretches as well as a use of the same. The system comprises at least one optic fiber fastened to the high tension cable, the optic fiber including at least one Bragg grating with known reflection character		Leiv Eiriksson Nyfotek AS	0	0	System for monitoring cables	Optical
The Multicore Sensor is designed to be installed without de-energizing or cutting the main conductor. This sensor does not require any special calibration for conductor diameter to produce its 2% accurate output. It can be vertically mounted to replace an	Prices range from $760-1190 15kV Current + Voltage Multicore Sensor $760 25kV Current + Voltage Multicore Sensor $920 35kV Current + Voltage Multicore Sensor $1,190	Lindsey Manufacturing	760	0	Multicore Sensor	Voltage, Current
Many electric utilities are using Distribution Automation (DA) for both overhead and underground systems. DA systems enable a utility to monitor, coordinate and operate distribution systems in real time mode from remote locations. Utilities that have inst	15kV Current + Voltage Sensor $790 25kV Current + Voltage Sensor $950 35kV Current + Voltage Sensor $1,220 46kV Current + Voltage Sensor $2,480	Lindsey Manufacturing	790	0	Current and Voltage Monitoring Insulators	Voltage, Current

Text38	Text8	Text34	Text2	Text4	Text6	Text36
The SmartPin current and voltage sensing system is a low cost solution for monitoring overhead distribution lines. The system consists of three sensor pins capable of supporting standard pin insulators (vertical orientation) and a control box for calibrat	not available.	Lindsey Manufacturing	0	0	Smart Pin	Voltage, Current
The ElbowCap current and voltage sensing system is a low cost solution for monitoring underground distribution feeders. The system consists of three sensors that snap onto the capacitive test point of standard 200A and 600A elbows with a control box for c	not available.	Lindsey Manufacturing	0	0	Elbow Cap	Voltage, Current
Lindsey ElbowSense Current and Voltage Monitors use proven CT and voltage sensor technology from the original Lindsey CVMI and fit standard 600 amp T-body 15, 25 and 35kV connectors. They are easily retrofitted to existing padmount or submersible equipmen	Current Monitoring Rings $300 Voltage Monitoring Plugs (qty 1-3) $660	Lindsey Manufacturing	300	0	Elbow Sense	Voltage, Current
The SDT 170MD (Multifunctional/Datalogger) is the complete ultrasonic inspection and predictive maintenance trending machine. With all the features of the SDT 170S Standard and SDT 170M Multifunctional, we've added a customisable data logger that interfac	Detect Corona behind electrical cabinet doors. With Use of parabolic disc, can pinpoint corona with lazer sight. Normally sold to factories. Withstand a 3m drop test.	Martech	7500	0	SDT 170 with parabolic Dish	Acoustic, Corona

Text38	Text8	Text34	Text2	Text4	Text6	Text36
The Megger MDP series of distribution profilers provides power utilities with the most accurate and extensive information ever to precisely evaluate loading on feeders/overhead lines and to identify needed upgrades or replacement. Three different models r	Choice of three models that record currents up to 1000 amps, with an additional 200 amp over-range Waveform capture and harmonic analysis up to the 32nd order Power and power factor Accurate data capture via advanced MDP software Lightweight, durable	Megger	0	0	MDP - Megger Distribution Profiler	voltage, current
The DITEST-LTM combines OMNISENS DITEST measuring technique with “best-in-industry” dedicated sensing cable, data processing, user-friendly interface and application oriented visualization tools. DITEST-LTM Solution is optimized for long distance monitori		Omnisens	0	0	Ditest - LTM	Temperature
DITEST-AIM integrates OMNISENS core sensing technology DITEST-STA optimized for long distance monitoring applications with extensive application know-how and field experience. DITEST-STA Monitoring distance : > 30 km per sensor Operates with standard s	Measurement of temperature and strain of an overhead conductor.	Omnisens	0	0	Ditest - AIM	Temperature

Text38	Text8	Text34	Text2	Text4	Text6	Text36
The PF Live Plus, a continuous on-line monitoring system, for monitoring power factor in high voltage capacitive bushings, is now available with an optional leakage current monitor for high voltage lightning arresters. The system includes a minimum set of	The PF Live Plus system can also interface to signals from other devices, or IED's, such as: temperature sensors, DGA, or any 0-10Vdc, 10Vrms, 4-20mA, or 0-1mA signal.	On-line Monitoring, Inc.	0	0	PF Live Plus	Current, Temperature
The Optisense outdoor voltage sensor enables high voltage measurement in a compact package at a lower installed cost than with conventional technology. Optical sensing technology allows for galvanic isolation of the signal from the voltage being measured.		Optisense	0	0	35 kV Class Outdoor Voltage Sensor	Voltage
T he Optisense indoor voltage sensor enables high voltage measurement in a compact package at a lower installed cost than with conventional technology. Optical sensing technology allows for galvanic isolation of the signal from the voltage being measured.		Optisense	0	0	15 kV Class Embedded Voltage Sensor	Voltage
OZ Optics now offers the ForesighTM series of fiber optic distributed strain and temperature sensors. The new sensor system provides high resolution and accurate strain and temperature monitoring over very long distances. The sensor uses standard optical		OZ Optics	0	0	Fiber Optic strain and temperature sensing system	Temperature

Text38	Text8	Text34	Text2	Text4	Text6	Text36
Polytec's IVS-200 Industrial Vibration Sensor is a ruggedized laser Doppler vibrometer for non-contact, on-line production vibration testing. An eye-safe visible laser is aimed and focused onto the part being measured. IVS-200 is easily retrofitted into		Polytec	23250	0	IVS-200	Vibration, Optical
Automation is provided on underground units through the Distribution automation relay and for overhead applications with the Radio Faulted Circuit Indicator. (RFCI). The RFCI mounted on an overhead circuit sends a radio signal to a receiver which is conne	Can be paired with a radio transmitter reciever unit which has a 40-50ft range(mount at bottom of pole below FCI) and when a fault is received, the unit closes a contact which can be connected to an RTU or Cellular RTU(Telemetric).	Power Delivery Products	120	0	Automation FCI's	Current
Overhead Fault Indicators are available with a mechanical flag or LED indication. In addition to permanent installations to reduce outage time, these units are ideal for finding temporary, transient, or nuisance outages. Load Tracker capability is availab	Can be paired with a radio transmitter reciever unit which has a 40-50ft range(mount at bottom of pole below FCI) and when a fault is received, the unit closes a contact which can be connected to an RTU or Cellular RTU(Telemetric).	Power Delivery Products	185	0	Overhead FCI's	Current
There are two major styles of Underground Faulted Circuit Indicators – Mechanical and Electronic. The Mechanical units offer years of economical fault indication. Rotor, submersible and fluid units are available with or without provisions for hotsick inst	Fault is indicated via blinking led on the FCI. To remotely receive the fault indication, a fiber optic lead is connected to the LED socket while the opposite end is connected to a converter box, which will close a contact on an RTU or other device when	Power Delivery Products	120	0	Underground FCI's	Current

Text38	Text8	Text34	Text2	Text4	Text6	Text36
PD-MCC&G400A is an on-line Partial Discharge (PD) diagnostic system, which detects and analyzes the generation of PD in the power equipments such as Cable and Motor. Four High Frequency Current Transducer (HFCT) Sensors are installed ground line in power		PowerPD, Inc	0	0	PD-MCC&G400A	Corona
PD-MAT400A is a permanently mounted on-line Partial Discharge (PD) diagnostic system. This test device focuses on detecting and analyzing the generation of PD in equipment such as transformers, HV GIS circuit breakers, GIS ductwork, and CGIS using acousti		PowerPD, Inc	10500		PD-MAT400A	Acoustic, Corona
The PD-RD300A is the newest device in the PowerPD line of test equipment, which provides continuous monitoring of your metal clad switchgear (MCSG) assets. This device detects electromagnetic waves when surface tracking occurs on the insulation system. It	Cost is 4700+ depending on number of channels.	PowerPD, Inc	4700	0	PD-RD300A	Corona
The PD-TM Series: are non-portable, mounted type units. PD-TM500, 1000, 1500 are online diagnostic systems that continuously monitors partial discharge in equipment such as Transformers, GIS, and CGIS etc. This units detect, analyze, and locate the signal	Main use for substations and utilities.	PowerPD, Inc.	34800	0	PD-TM500A	Acoustic, Corona

Text38	Text8	Text34	Text2	Text4	Text6	Text36
The PowerSense Overhead Line Solution has been designed for overhead line installations with or without substations. The solution is based on PowerSense's optical DISCOS® Sensor technology and a specially designed Linux-based RTU module. The DISCOS® Syste	Discos system offers a variety of sensors and modules to create a customized Discos system. Discos offers indoor current sensors, IO modules, LV interfaces, MV interfaces, Opti Module, Outdoor combined current and voltage sensor, outdoor current sensor,	Powersense	0	0	Discos System	current, voltage
Monitor the Current, Voltage, & Phase Angle on all 3 Phases of Network Transformers and manholes. The Secondary Network Monitoring System has demonstrated excellent communications reliability. CDMA communications from below grade in transformer vaults	PSI's State of the Art Secondary Network Monitoring System will enable utilities to see and measure electrical problems in their network before they happen and then will direct service crews to the exact location for a safe and effective repair.	PSI	0	0	CE Mesh	Voltage, Current
Accurate Map Overlays Integrated Monitoring & Diagnostics Low Cost Telecom FDAM initiates communications Voltage before and after the fault is reported You own the data! AES 256 Bit Data Encryption option Scalable FDAM System is ready for deployment acro		PSI	0	0	FDAM	Voltage, Current
Hotstick Line Sniffer. RF & Ultrasonic Locator for use from a bucket.	Use of RFI to get into general location of Corona and then use acoustic to pinpoint Corona Location.	Radar Engineer	950	0	247-B	Acoustic, RFI, Corona

Text38	Text8	Text34	Text2	Text4	Text6	Text36
AM-UHF RFI Locator 500 KHZ-1000 MHZ Oscilloscope Display A.M. Probe	Use of RFI to get into general location of Corona and then use acoustic to pinpoint Corona Location.	Radar Engineers	5500	0	242	RFI, Corona
Parabolic Pinpointer Ultrasonic Locator for use from the ground	Use of RFI to get into general location of Corona and then use acoustic to pinpoint Corona Location.	Radar Engineers	3100	0	250	Acoustic, Corona
Still in testing. Basic summary would be a handheld model of the 247-b. Called switch gear sniffer. Use RFI detector to find cabinet of Corona occurance and then acoustic to pinpoint Corona location.	Use of RFI to get into general location of Corona and then use acoustic to pinpoint Corona Location.	Radar Engineers	0	0	244(tenatively)	RFI, Acoustic, Corona
RFI locators detect sparks and corona that cause radio and T.V. interference (RFI TVI). RF and ultrasonic receivers quickly pinpoint sparking hardware on powerlines.	Use of RFI to get into general location of Corona and then use acoustic to pinpoint Corona Location.	Radar Engineers	1800	0	M330	RFI, Corona
HF-UHF RFI Locator 1.8-1000 MHZ Oscilloscope Display	Use of RFI to get into general location of Corona and then use acoustic to pinpoint Corona Location.	Radar Engineers	4700	0	240-A	RFI, Corona
VoltWitch is an innovative drive-by voltage indicator that is installed in a line truck or utility vehicle like a radar detector. Instead of sensing radar signals, the VoltWitch senses energized overhead power lines.		Rauckman Utility Products	513	0	Voltwitch	Voltage

Text38	Text8	Text34	Text2	Text4	Text6	Text36
FOT-F and FOT-N temperature transducers combine all the desired characteristics expected from the ideal sensor. Their compact size, immunity to EMI/RFI/lightning, resistance to corrosive environments, high accuracy and reliability make them the best choi	Used to monitor a variety of systems. Could be used on transformers to monitor temperature or conductors, however installation on conductors is not a normal procedure. Requires a readout or datalogging device with fiber-optic interface.	Roctest	250	0	FOT-F FOT	Temperature, Optical
The PAVICA is a unique, small, lightweight instrument used to monitor and analyse vibrations in overhead transmission lines. The PAVICA measures the frequency and amplitude of all vibration cycles over all sampling periods, stores the data in a high-defi	The battery life in our Pavica is approx 3 months. This figure vary according to the sampling rate and sampling time as well as the ambient temperature. In the user manual, we give a formula that give the end-user the expected life of their battery for th	Roctest	9600	0	PAVICA	Vibration
S&C CS Line Post Current Sensors and CSV Line-Post Current/Voltage Sensors provide an economical, effective way to measure current and voltage (optional) for your capacitor control and other applications. The CS/CSV Sensors are well-suited for working wit	CS Line Post Current Sensor 14.4 KV 904-001124-00 $ 650 ea 25 904-001125-00 $819 ea 34.5 904-001126-00 $1075 ea CSV Line Post Current/Voltage Sensor 14.4 904-001128-01 $ 1225 ea 25	S&C	650	0	CS/CSV	Voltage, Current

Text38	Text8	Text34	Text2	Text4	Text6	Text36
The Neoptix™ T/Guard™ is a multi-channel fiber optic temperature monitoring system for power transformer hot spot measurements. The T/Guard™ system has been developed with long-term performance and stability in mind. This fiber-optic temperature monitorin		Sabrifa	0	0	T-Guard	Temperature
The rugged, splash-proof enclosure is designed to withstand the most punishing industrial environments. For industrial needs, Reflex units can be installed together on a special 19 in. rack-mounted plates. For special applications, like transformer hot sp		Sabrifa	0	0	Reflex	Temperature
When a fault occurs, two of the AutoRANGER's red LEDs will begin to flash. After one minute, the indicator will measure the system current. If it detects load current, the AutoRANGER's yellow LED will begin to flash and the red LEDs will turn off, indicat		SEL	150	0	AutoRANGER	Current
SEL BEACON® electric field reset fault indicators (BER) derive their operating power from the potential gradient around high-voltage power lines. The BERs inrush restraint option prevents false tripping that might otherwise occur because of reclosing oper		SEL	130	0	Beacon Electrostatic Reset	Voltage

Text38	Text8	Text34	Text2	Text4	Text6	Text36
SEL electric field reset fault indicators (type E-ERL) derive their operating power from the potential gradient around high-voltage power lines. The E-ERL's inrush restraint option blocks targeting for recloser operations. When the upstream protection ope		SEL	82	0	Overhead Electrostatic Reset	Voltage
Ensure the best fault-indicating solution for your underground application by choosing from a wide variety of single- and threephase display options, including remote displays that eliminate the need to open the enclosure to check the fault indicator's st	Can be used with Radio Ranger fault location system. Identify the phase and location of underground faults with the handheld Remote Fault Reader. Wireless Interface ID, phase, and way distinctions display faultpath information in each vault while differe	SEL	100	0	Underground AutoRANGER	Current
Senses the load and fault currents on the conductor. Use the optional auxiliary contact to provide status indication to a SCADA input.	Use the optional auxiliary contact to provide status indication to a SCADA input.	SEL	150	0	SEL LINAM Current Reset Fault Indicators	Current
Install 1TPRB fault indicators in padmount transformers, subsurface load centers, or junction sectionalizing points. In single-phase underground loop applications, install the 1TPRB at the transformer. At sectionalizing junctions, place an indicator on ea		SEL	78	0	Single-Phase Test Point Mounted Bolt Display FCI	Current

Text38	Text8	Text34	Text2	Text4	Text6	Text36
This DTS system has been designed with safety in mind and tested to some of the industry's most rigorous standards. With the addition of a multiplexing module it can easily be configured to produce multiple double-ended measurements. User configurable zon		Sensor Net	0	0	Sentinel DTS Range	Temperature
The SensorTran DTS 5100 range of intelligent DTS systems provide real-time dynamic temperature with high accuracy and fine resolution, providing up to 40,000 discrete temperature points along optical fiber(s).	• on-board Ethernet-enabled computer with open communications architecture • autonomous data collection and storage • multiple zones and alarms • flexible data, alarm and remote control/access communications • self-diagnostics, auto start & safe shut-down	SensorTran	0	0	DTS Units	Temperature
It consists of ThermalRate™ Monitors (TRMs), which are installed along the line. The TRM is a replica of the line conductor, with the same material, diameter, and surface. It is oriented in the same direction as the line to establish how the present weath	Determining the actual current capacity of a high voltage transmission line.	Shaw Energy Delivery Services	0	0	Thermal Rate System	Temperature
The measurement technology Southwire is exploring is called Distributed Temperature Sensing (DTS), and it uses fiber optic strands contained in the overhead conductor. By monitoring key optical fiber characteristics, grid operators can get an accurate, sp		Southwire Company	0	0	DTS	Temperature

Text38	Text8	Text34	Text2	Text4	Text6	Text36
The CMD is not limited to substation applications, being equally well suited for application on distribution lines, subtransmission lines, transmission lines, and EHV transmission lines. In line applications the CMD provides the functions of real-time li		SSI power	0	0	CMD	Voltage, Current
Op-Thermo & only one line of Optical Fiber is necessary to measure continuous & real-time temperature profile at thousands of points along the fiber without any data transmission devices.		Sumitomo	0	0	OP-Thermo	Temperature
SURETECH AC Current sensors are available in various formats, including slip-on, or bar-primary. These sensors are available for single OR three phase measurements. The sensor uses Rogowski technology to measure AC currents. Rogowski technology does not r		SURETECH	0	0	AC Current Sensors	Current
The SURETECH Vix monitoring system senses, processes and logs electrical parameters to data flash memory, on MV (Medium Voltage) equipment. Sensor outputs are fed to a SURETECH SLP (Smart Load Processor), which samples Voltage, Current, Phase angle and Qu		SURETECH	0	0	SURETECH VI-x Monitoring System	Voltage, Current

Text38	Text8	Text34	Text2	Text4	Text6	Text36
This range of current probes is used for measuring tan(delta) on HV apparatus, insulation resistance and capacitance under HV operational and test conditions. Leakage current is measured and its phase is compared with the HV reference excitation voltage's		SURETECH	0	0	HV Transducer Current Probe	Current
Small and battery operated, the CoronaFinder is easy to take to the field. Real time UV viewing means that high voltage equipment can be quickly and thoroughly inspected for evidence of corona discharge that is visible only in the ultraviolet spectrum (s	Corona Detection.	Syntronics	14035	0	Corona Finder	Optical, Corona
The Telemetric Voltage Monitor (TVM) family of products offer a cost-effective voltage monitoring, interruption detection, and power quality solution. The TVM is available in single phase (TVM1) and two three phase versions, TVM3-120V and TVM3-277V. With	Report momentary and sustained power outage. Over/under voltage events. Integrated cellular module. Provide cellular data service and hosted application to view network of sensors.	Telemetric	0	0	TVM	Voltage
Telepathx Pinpoint sensors are the first non invasive RFID solution for monitoring faulting distribution insulators, they alert you via wireless connection when the thermal threshold has been reached providing energy maintenance personnel exact time and l	Available in the following protocols 433Mhz Reactive RFID 900Mhz Reactive RFID 900Mhz Reactive 802.15.4 RFID 2.4Ghz Reactive 802.11g 2.4Ghz Reactive 802.15.4	Telepathx	0	0	Intelligent Insulators Current Leakage Sensors	Temperature

Text38	Text8	Text34	Text2	Text4	Text6	Text36
The fixed frequency RFID Fob has a range of 100 to 125 meters and communicates with the TPX-GSM-100 Remote Transmission Unit (Access Point) or Telepathx compatible smart Meters, BPL/PLC & WIFI access points alerting you when and where a fuse has been acti	Available in the following protocols 433Mhz Reactive RFID 900Mhz Reactive RFID 900Mhz Reactive 802.15.4 RFID 2.4Ghz Reactive 802.11g 2.4Ghz Reactive 802.15.4	Telepathx	0	0	RFID cutout fuse monitor	Optical
Test Point Mounted Fault Indicators provide a clear, visual means for locating faulted cables and equipment on underground distribution systems. Indicators are self-powered and consist of a solid state current sensor connected to a faulted circuit display		Thomas & Betts	0	0	Elastimold TPM Series	Current
Test Point Mounted Neon Voltage Indicators provide a convenient, visual method for determining the energized status of underground distribution circuits. The indicator consists of a self-powered voltage sensor connected to a neon light that flashes when e		Thomas & Betts	30	0	V2 Standard	Current
Overhead Line Fault Indicators aid in locating faulted circuits and equipment on overhead distribution systems. Indicators are self powered and consist of a solid state current sensor connected to a faulted circuit display. Designs incorporate advanced ci		Thomas & Betts	99	0	OLM Standard	Current

Text38	Text8	Text34	Text2	Text4	Text6	Text36
URD Cable Mounted Fault Indicators aid in locating faulted cables and equipment on underground distribution systems. Indicators are self powered and consist of a solid state current sensor connected to faulted circuit display.		Thomas & Betts	100	0	UCM Series	Current
Tollgrade's LightHouse solution is designed to provide real-time grid intelligence by using sensors that continuously monitor key circuit parameters and transmit them over a self-configuring wireless mesh network to a central location.	4-35kV. Still in pilot programs. Hot stick mountable. Also measures 3rd harmonic.	Tollgrade	700	0	LightHouse	Current, Temperature
Low-Cost, Non-Contact, High Accuracy Sensor for the Simultaneous, Reliable, Real-time Determination and Monitoring of HV Transmission Line Sag, Temperature, Current, and Ampacity.	No contact informaion. Website is under construction.	unknown	0	0	Promethean Devices	Current, Temperature
The RF Smart Monitor System is designed to allow the user to remotely collect machine vibration and temperature data without the need for cabling. This system, which is designed to monitor a wide variety of machine components.		unknown	0	0	RF Smart Monitor System	Voltage, Temperature, Vibration

Text38	Text8	Text34	Text2	Text4	Text6	Text36
A novel photoacoustic spectrometer (PA) has been developed for in-situ detection of SF6 leaks in low concentrations. The developed system is equipped with a sound alarm system and has been tested in the laboratory for very minute SF6 leaks. This newly dev		unknown	0	0	Optical Sensors	Optical
Safe and Easy to Install -does not conduct electrical current - intrinsically isolated making it safe to personnel and interconnected equipment Small, Lightweight, Immune to EMI/RFI, Zero Risk of Explosive Failure, Intended for 54.5 KV Applications and Be	Appear to have obtained U.S. Navy contract. Does not appear to be available to the public.	unknown	0	0	Airak's Patented Optical Current Sensor System	Current, Optical
The Power-Donut2™ is an engineering instrumentation platform whose functions include: data acquisition, data monitoring and logging the parameters of high voltage overhead conductors. The Power-Donut2™ is completely self-contained, allowing for hot stick	Will be mass produced soon. Price should drop. Currently Testing new model which will offer full waveform capturing and event logging as well as offer GPS clock.	USI Power	14500	0	Power Donut 2	Voltage, Current, Temperature

Report: Temperature Sensors

Text38	Text8	Text34	Text6	Text36	Text2
By clipping the LT40 / LT50 on to lines at strategic points, e.g. tee junctions, switches, substations etc., data such as load, maximum demand, inrush current, fault wave shape & duration, protection operation, voltage status, conductor and ambient temper	up to 138KV, can communicate down to data link, which is a dashboard mounted device. Also have a scada solution, cellphone, etc. Must be mounted to bare conductor. Has regowski coil. Had a dimensionless voltage readout which can be used to calculate act	GridSense	LT50	Voltage, Current, Temperature	3100
Telepathx Pinpoint sensors are the first non invasive RFID solution for monitoring faulting distribution insulators, they alert you via wireless connection when the thermal threshold has been reached providing energy maintenance personnel exact time and l	Available in the following protocols 433Mhz Reactive RFID 900Mhz Reactive RFID 900Mhz Reactive 802.15.4 RFID 2.4Ghz Reactive 802.11g 2.4Ghz Reactive 802.15.4	Telepathx	Intelligent Insulators Current Leakage Sensors	Temperature	0
The SensorTran DTS 5100 range of intelligent DTS systems provide real-time dynamic temperature with high accuracy and fine resolution, providing up to 40,000 discrete temperature points along optical fiber(s).	• on-board Ethernet-enabled computer with open communications architecture • autonomous data collection and storage • multiple zones and alarms • flexible data, alarm and remote control/access communications • self-diagnostics, auto start & safe shut-down	SensorTran	DTS Units	Temperature	0
Op-Thermo & only one line of Optical Fiber is necessary to measure continuous & real-time temperature profile at thousands of points along the fiber without any data transmission devices.		Sumitomo	OP-Thermo	Temperature	0

Text38	Text8	Text34	Text6	Text36	Text2
This DTS system has been designed with safety in mind and tested to some of the industry's most rigorous standards. With the addition of a multiplexing module it can easily be configured to produce multiple double-ended measurements. User configurable zon		Sensor Net	Sentinel DTS Range	Temperature	0
The Temperature Measurement Sensor SMT has been designed to measure the instantaneous temperature of the line, transmitting it to a PC via an SMS message.	The Temperature Measuring Sensor (SMT) gives real temperature of Tranmision or Distribution aereal networks cable. The information is sent by SMS to a receiver that storage and present these data. Easy to install, even with energized line, in aprox. 10'.	Arteche	Temperature measuring sensor(SMT)	Temperature	0
It consists of ThermalRate™ Monitors (TRMs), which are installed along the line. The TRM is a replica of the line conductor, with the same material, diameter, and surface. It is oriented in the same direction as the line to establish how the present weath	Determining the actual current capacity of a high voltage transmission line.	Shaw Energy Delivery Services	Thermal Rate System	Temperature	0
The Power-Donut2™ is an engineering instrumentation platform whose functions include: data acquisition, data monitoring and logging the parameters of high voltage overhead conductors. The Power-Donut2™ is completely self- contained, allowing for hot stick	Will be mass produced soon. Price should drop. Currently Testing new model which will offer full waveform capturing and event logging as well as offer GPS clock.	USI Power	Power Donut 2	Voltage, Current, Temperature	14500
FOT-F and FOT-N temperature transducers combine all the desired characteristics expected from the ideal sensor. Their compact size, immunity to EMI/RFI/lightning, resistance to corrosive environments, high accuracy and reliability make them the best choi	Used to monitor a variety of systems. Could be used on transformers to monitor temperature or conductors, however installation on conductors is not a normal procedure. Requires a readout or datalogging device with fiber-optic interface.	Roctest	FOT-F FOT	Temperature, Optical	250

Text38	Text8	Text34	Text6	Text36	Text2
The Model TSP probe provides an RTU compatible analog input that is proportional to the transformer's top oil temperature. The probe can be used with an existing RTU, or as part of an Substation Advisor® System. For transformers with existing top oil indi	TSP Oil Temperature Probe $425	Cannon Technologies	TSP probe	Temperature	425
Model TSS and TSA sensors provide an analog current that is proportional to the surface on which the sensor is mounted (TSS) or to the temperature of the ambient air (TSA). The sensor is powered from the loop current and therefore it does not require a se	TSS Surface Temperature Sensor $225 TSA Ambient Temperature Sensor $225	Cannon Technologies	TSS and TSA sensors	Temperature	225
The insertion-type RTD temperature sensor mounts inside the thermal well. It connects to the transmitter, which sends a 4-20 mA signal back to the monitor	3 types: 133 Well 325 Temperature element 823 installed in monitoring cabinet	GE Power	Well-Type RTD Temperature Sensor	Temperature	325
The magnetic mount temperature sensor attaches to the transformer with a magnet. The sensor is self-contained and in a weatherproof housing. The RTD has a built-in 4-20 mA transmitter that is powered from the monitoring unit. The sensor is supplied with f		GE Power	Magnetic Mount Temperature Sensor	Temperature	522
Tollgrade's LightHouse solution is designed to provide real-time grid intelligence by using sensors that continuously monitor key circuit parameters and transmit them over a self-configuring wireless mesh network to a central location.	4-35kV. Still in pilot programs. Hot stick mountable. Also measures 3rd harmonic.	Tollgrade	LightHouse	Current, Temperature	700
The measurement technology Southwire is exploring is called Distributed Temperature Sensing (DTS), and it uses fiber optic strands contained in the overhead conductor. By monitoring key optical fiber characteristics, grid operators can get an accurate, sp		Southwire Company	DTS	Temperature	0

Text38	Text8	Text34	Text6	Text36	Text2
Fiber Optic Temperature laser radar. The FTR is composed of a fiber optic temperature sensing and measureing unit and a computer display to show temperature distribution along a conductor up to 6km in length.	Contacted a rep. Emailed kabuto@hitachi-cable.com Should be getting back with me soon to give pricing.	Hitachi	FTR	Temperature, Optical	0
The RF Smart Monitor System is designed to allow the user to remotely collect machine vibration and temperature data without the need for cabling. This system, which is designed to monitor a wide variety of machine components.		unknown	RF Smart Monitor System	Voltage, Temperature, Vibration	0
Replaces several control devices, providing control, monitoring & data aquisition for the entire transformer. This device has several sensors which may be connected to monitor several aspects of a transformer.	Can consollidate any other outside IED information, can controll transformer cooling. Pricing is $12000-18000 depending on options. Installation can be done as full turn key, $15000, or as a supervisory only install for which the price would vary.	Dynamic Ratings	DRMCC-T3	Current, Temperature	18000
Low-Cost, Non-Contact, High Accuracy Sensor for the Simultaneous, Reliable, Real-time Determination and Monitoring of HV Transmission Line Sag, Temperature, Current, and Ampacity.	No contact informaion. Website is under construction.	unknown	Promethean Devices	Current, Temperature	0
The DITEST-LTM combines OMNISENS DITEST measuring technique with “best-in-industry” dedicated sensing cable, data processing, user-friendly interface and application oriented visualization tools. DITEST-LTM Solution is optimized for long distance monitori		Omnisens	Ditest - LTM	Temperature	0

Text38	Text8	Text34	Text6	Text36	Text2
OZ Optics now offers the ForesighTM series of fiber optic distributed strain and temperature sensors. The new sensor system provides high resolution and accurate strain and temperature monitoring over very long distances. The sensor uses standard optical		OZ Optics	Fiber Optic strain and temperature sensing system	Temperature	0
FLIR provides utilities with the most advanced thermal imaging solutions to support the monitoring programs that keep the vital electrical power grid up and running. FLIR ThermaCAM infrared cameras have revolutionized predictive/preventive maintenance in		Flir Systems, LTD	Infrared Cameras	Optical, Temperature	0
By providing up to hourly data for voltage and current loading, and proximity temperature reading for the transformer, utility will have unprecedented access to equipment performance and status data to have a clear, continuous view of the asset conditions		kinects	Transform	Current, Voltage, Temperature	0
The rugged, splash-proof enclosure is designed to withstand the most punishing industrial environments. For industrial needs, Reflex units can be installed together on a special 19 in. rack-mounted plates. For special applications, like transformer hot sp		Sabrifa	Reflex	Temperature	0
The Neoptix™ T/Guard™ is a multi-channel fiber optic temperature monitoring system for power transformer hot spot measurements. The T/Guard™ system has been developed with long-term performance and stability in mind. This fiber-optic temperature monitorin		Sabrifa	T-Guard	Temperature	0

Text38	Text8	Text34	Text6	Text36	Text2
DTS technology measures a temperature profile along an optical fiber over several kilometers. The Agilent DTS performs measurements down to 1 meter spatial resolution with less than 0.1°C temperature resolution providing thousands of measurement points in		Agilent	Distributed Temperature System N4385A / N4386A	Temperature	0
DITEST-AIM integrates OMNISENS core sensing technology DITEST-STA optimized for long distance monitoring applications with extensive application know-how and field experience. DITEST-STA Monitoring distance : > 30 km per sensor Operates with standard s	Measurement of temperature and strain of an overhead conductor.	Omnisens	Ditest - AIM	Temperature	0

Report: Vibration Sensors

Text38	Text8	Text34	Text6	Text36	Text2
Polytec's IVS-200 Industrial Vibration Sensor is a ruggedized laser Doppler vibrometer for non-contact, on-line production vibration testing. An eye-safe visible laser is aimed and focused onto the part being measured. IVS-200 is easily retrofitted into		Polytec	IVS-200	Vibration, Optical	23250
The PAVICA is a unique, small, lightweight instrument used to monitor and analyse vibrations in overhead transmission lines. The PAVICA measures the frequency and amplitude of all vibration cycles over all sampling periods, stores the data in a high-defi	The battery life in our Pavica is approx 3 months. This figure vary according to the sampling rate and sampling time as well as the ambient temperature. In the user manual, we give a formula that give the end-user the expected life of their battery for th	Roctest	PAVICA	Vibration	9600
The RF Smart Monitor System is designed to allow the user to remotely collect machine vibration and temperature data without the need for cabling. This system, which is designed to monitor a wide variety of machine components.		unknown	RF Smart Monitor System	Voltage, Temperature, Vibration	0
The Power-Donut2™ is an engineering instrumentation platform whose functions include: data acquisition, data monitoring and logging the parameters of high voltage overhead conductors. The Power-Donut2™ is completely self- contained, allowing for hot stick	Will be mass produced soon. Price should drop. Currently Testing new model which will offer full waveform capturing and event logging as well as offer GPS clock.	USI Power	Power Donut 2	Voltage, Current, Temperature	14500

Report: Voltage Sensors

Text38	Text8	Text34	Text6	Text36	Text2
– By clipping the LT40 / LT50 on to lines at strategic points, e.g. tee junctions, switches, substations etc., data such as load, maximum demand, inrush current, fault wave shape & duration, protection operation, voltage status, conductor and ambient temper	– up to 69 KV, can communicate down to data link, which is a dashboard mounted device. Also have a scada solution, cellphone, etc. Must be mounted to bare conductor. Has regowski coil. Had a dimensionless voltage readout which can be used to calculate act	– GridSense	– LT40	– Voltage, Current	– 1800
– By clipping the LT40 / LT50 on to lines at strategic points, e.g. tee junctions, switches, substations etc., data such as load, maximum demand, inrush current, fault wave shape & duration, protection operation, voltage status, conductor and ambient temper	– up to 138KV, can communicate down to data link, which is a dashboard mounted device. Also have a scada solution, cellphone, etc. Must be mounted to bare conductor. Has regowski coil. Had a dimensionless voltage readout which can be used to calculate act	– GridSense	– LT50	– Voltage, Current, Temperature	– 3100
– SEL BEACON® electric field reset fault indicators (BER) derive their operating power from the potential gradient around high-voltage power lines. The BERs inrush restraint option prevents false tripping that might otherwise occur because of reclosing oper	–	– SEL	– Beacon Electrostatic Reset	– Voltage	– 130

Text38	Text8	Text34	Text6	Text36	Text2
– SEL electric field reset fault indicators (type E-ERL) derive their operating power from the potential gradient around high-voltage power lines. The E-ERL's inrush restraint option blocks targeting for recloser operations. When the upstream protection ope	–	– SEL	– Overhead Electrostatic Reset	– Voltage	– 82
– The Optisense outdoor voltage sensor enables high voltage measurement in a compact package at a lower installed cost than with conventional technology. Optical sensing technology allows for galvanic isolation of the signal from the voltage being measured.	–	– Optisense	– 35 kV Class Outdoor Voltage Sensor	– Voltage	– 0
– T he Optisense indoor voltage sensor enables high voltage measurement in a compact package at a lower installed cost than with conventional technology. Optical sensing technology allows for galvanic isolation of the signal from the voltage being measured.	–	– Optisense	– 15 kV Class Embedded Voltage Sensor	– Voltage	– 0
– The Power-Donut2™ is an engineering instrumentation platform whose functions include: data acquisition, data monitoring and logging the parameters of high voltage overhead conductors. The Power-Donut2™ is completely self- contained, allowing for hot stick	– Will be mass produced soon. Price should drop. Currently Testing new model which will offer full waveform capturing and event logging as well as offer GPS clock.	– USI Power	– Power Donut 2	– Voltage, Current, Temperature	– 14500

Text38	Text8	Text34	Text6	Text36	Text2
– VoltWitch is an innovative drive-by voltage indicator that is installed in a line truck or utility vehicle like a radar detector. Instead of sensing radar signals, the VoltWitch senses energized overhead power lines.	–	– Rauckman Utility Products	– Voltwitch	– Voltage	– 513
– VisiVolt™ – Passive Voltage Indicator is a busbar-mounted-type indicator of voltage presence developed to be used in outdoor and indoor systems. It is adapted for permanent installation on busbars and naked or insulated metal conductors in medium voltage	–	– ABB	– VisiVolt	– Voltage	– 0
– The Telemetric Voltage Monitor (TVM) family of products offer a cost-effective voltage monitoring, interruption detection, and power quality solution. The TVM is available in single phase (TVM1) and two three phase versions, TVM3-120V and TVM3-277V. With	– Report momentary and sustained power outage. Over/under voltage events. Integrated cellular module. Provide cellular data service and hosted application to view network of sensors.	– Telemetric	– TVM	– Voltage	– 0
– The Multicore Sensor is designed to be installed without de-energizing or cutting the main conductor. This sensor does not require any special calibration for conductor diameter to produce its 2% accurate output. It can be vertically mounted to replace an	– Prices range from $760-1190 15kV Current + Voltage Multicore Sensor $760 25kV Current + Voltage Multicore Sensor $920 35kV Current + Voltage Multicore Sensor $1,190	– Lindsey Manufacturing	– Multicore Sensor	– Voltage, Current	– 760

Text38	Text8	Text34	Text6	Text36	Text2
– Many electric utilities are using Distribution Automation (DA) for both overhead and underground systems. DA systems enable a utility to monitor, coordinate and operate distribution systems in real time mode from remote locations. Utilities that have inst	– 15kV Current + Voltage Sensor $790 25kV Current + Voltage Sensor $950 35kV Current + Voltage Sensor $1,220 46kV Current + Voltage Sensor $2,480	– Lindsey Manufacturing	– Current and Voltage Monitoring Insulators	– Voltage, Current	– 790
– The SmartPin current and voltage sensing system is a low cost solution for monitoring overhead distribution lines. The system consists of three sensor pins capable of supporting standard pin insulators (vertical orientation) and a control box for calibrat	– not available.	– Lindsey Manufacturing	– Smart Pin	– Voltage, Current	– 0
– The ElbowCap current and voltage sensing system is a low cost solution for monitoring underground distribution feeders. The system consists of three sensors that snap onto the capacitive test point of standard 200A and 600A elbows with a control box for c	– not available.	– Lindsey Manufacturing	– Elbow Cap	– Voltage, Current	– 0
– Lindsey ElbowSense Current and Voltage Monitors use proven CT and voltage sensor technology from the original Lindsey CVMI and fit standard 600 amp T-body 15, 25 and 35kV connectors. They are easily retrofitted to existing padmount or submersible equipmen	– Current Monitoring Rings $300 Voltage Monitoring Plugs (qty 1-3) $660	– Lindsey Manufacturing	– Elbow Sense	– Voltage, Current	– 300

Text38	Text8	Text34	Text6	Text36	Text2
– The RF Smart Monitor System is designed to allow the user to remotely collect machine vibration and temperature data without the need for cabling. This system, which is designed to monitor a wide variety of machine components.	–	– unknown	– RF Smart Monitor System	– Voltage, Temperature, Vibration	– 0
– The SURETECH Vix monitoring system senses, processes and logs electrical parameters to data flash memory, on MV (Medium Voltage) equipment. Sensor outputs are fed to a SURETECH SLP (Smart Load Processor), which samples Voltage, Current, Phase angle and Qu	–	– SURETECH	– SURETECH VI-x Monitoring System	– Voltage, Current	– 0
– The MetPod is our first product release based on our patent-pending technology. An integrated VT, clamp-on CT and meter, it meets 0.2 accuracy class requirements and has passed full dielectric type-tests. The MetPod offers a wireless link and self diagno	– Testing in the field currently. Using 900MHz modem for communication.3000-3500 for field trial units.	– FieldMetrics Inc.	– MetPod/Metpod lite(skinnier version of MetPod)	– Voltage, Current	– 3000
– The FMPT voltage sensor is a high accuracy voltage measurement solution for transmission and distribution utility applications. By combining high-reliability components in a patent-pending design, the FMPT uses no insulating oil or SF6 gas, yet provides a	– Still in development. New technology. Design is complete, however waiting for a customer for fieldtest. $2500-$2700 Ballpark cost range.	– FieldMetrics Inc	– FMPT	– Voltage	– 2500

Text38	Text8	Text34	Text6	Text36	Text2
– S&C CS Line Post Current Sensors and CSV Line-Post Current/Voltage Sensors provide an economical, effective way to measure current and voltage (optional) for your capacitor control and other applications. The CS/CSV Sensors are well-suited for working wit	– CS Line Post Current Sensor 14.4 KV 904-001124-00 $ 650 ea 25 904-001125-00 $819 ea 34.5 904-001126-00 $1075 ea CSV Line Post Current/Voltage Sensor 14.4 904-001128-01 $ 1225 ea 25	– S&C	– CS/CSV	– Voltage, Current	– 650
– The current and voltage sensor called "SENSODRIEL" is a post type insulator for classes 15, 25 and 34.5 capable of reading precisely current and voltage from nominal values to short circuit allowing the determination of line parameters including "power fa	– Our sensor is not capable of burden, It must be connected to impedances of the order of 1 Megaohm, or larger. Our voltage precision is better than 0.5% in other words, under controlled conditions a measurement between any two sensors is below 1% (-.5% t0	– Grupodriel	– SENSODRIEL	– Voltage, Current	– 150
– The PowerSense Overhead Line Solution has been designed for overhead line installations with or without substations. The solution is based on PowerSense's optical DISCOS® Sensor technology and a specially designed Linux-based RTU module. The DISCOS® Syste	– Discos system offers a variety of sensors and modules to create a customized Discos system. Discos offers indoor current sensors, IO modules, LV interfaces, MV interfaces, Opti Module, Outdoor combined current and voltage sensor, outdoor current sensor,	– Powersense	– Discos System	– current, voltage	– 0

Text38	Text8	Text34	Text6	Text36	Text2
– The Megger MDP series of distribution profilers provides power utilities with the most accurate and extensive information ever to precisely evaluate loading on feeders/overhead lines and to identify needed upgrades or replacement. Three different models r	– Choice of three models that record currents up to 1000 amps, with an additional 200 amp over-range Waveform capture and harmonic analysis up to the 32nd order Power and power factor Accurate data capture via advanced MDP software Lightweight, durable	– Megger	– MDP - Megger Distribution Profiler	– voltage, current	– 0
– The CMD is not limited to substation applications, being equally well suited for application on distribution lines, subtransmission lines, transmission lines, and EHV transmission lines. In line applications the CMD provides the functions of real-time li	–	– SSI power	– CMD	– Voltage, Current	– 0
– The PM5 is a low cost, in situ monitor that is placed at strategic LV locations facitlitating real time reporting of voltage disturbances in the field to improve power quality and reliability. A cost effective network wide monitoring system that's simple	– he PM5 simply plugs into the 110-240 volt electrical outlet and connects in parallel to the existing telephone line to transfer critical operational data to a central master station (MONITOR SYSTEM). The use of low cost Dual Tone Multiple Frequency (DTMF)	– Gridsense	– Powermonic PM5	– voltage	– 0

Text38	Text8	Text34	Text6	Text36	Text2
– By providing up to hourly data for voltage and current loading, and proximity temperature reading for the transformer, utility will have unprecedented access to equipment performance and status data to have a clear, continuous view of the asset conditions	–	– kinects	– Transform	– Current, Voltage, Temperature	– 0
– Monitor the Current, Voltage, & Phase Angle on all 3 Phases of Network Transformers and manholes. The Secondary Network Monitoring System has demonstrated excellent communications reliability. CDMA communications from below grade in transformer vaults	– PSI's State of the Art Secondary Network Monitoring System will enable utilities to see and measure electrical problems in their network before they happen and then will direct service crews to the exact location for a safe and effective repair.	– PSI	– CE Mesh	– Voltage, Current	– 0
– Accurate Map Overlays Integrated Monitoring & Diagnostics Low Cost Telecom FDAM initiates communications Voltage before and after the fault is reported You own the data! AES 256 Bit Data Encryption option Scalable FDAM System is ready for deployment acro	–	– PSI	– FDAM	– Voltage, Current	– 0

Sensor Name	Selected for Testing	Tested	Currently Available	Currently Sold to Utilities	Voltage Sensor	Current Sensor	Temperature Sensor	Acoustic Sensor	Vibration Sensor	Optical Sensor	RFI Sensor	Corona Sensor	Sensor Type	Planning on Testing	Organization Surveyed's Name
15 kV Class Embedded Voltage Sensor	Yes	No	Yes	Yes	Yes	No	No	No	No	No	No	No	Voltage	No	
1514/15	No	No	Yes	No	No	Yes	No	No	No	No	No	No	Current	No	stanruffin@aol.com
240-A	No	No	Yes	Yes	No	No	No	No	No	No	Yes	Yes	RFI, Corona	No	Fred Horning 503.256.3417
242	No	No	Yes	Yes	No	No	No	No	No	No	Yes	Yes	RFI, Corona	No	Fred Horning 503.256.3417
244(tenatively)	No	Yes	No	No	No	No	No	Yes	No	No	Yes	Yes	RFI, Acoustic, Corona	Yes	Fred Horning 503.256.3417
247-B	Yes	No	Yes	Yes	No	No	No	Yes	No	No	Yes	Yes	Acoustic, RFI, Corona	No	Fred Horning 503.256.3417
250	No	No	Yes	Yes	No	No	No	Yes	No	No	No	Yes	Acoustic, Corona	No	Fred Horning 503.256.3417
35 kV Class Outdoor Voltage Sensor	Yes	No	Yes	Yes	Yes	No	No	No	No	No	No	No	Voltage	No	
AC Current Sensors	No	No	Yes	No	No	Yes	No	No	No	No	No	No	Current	No	nj@suretech.co.za
Airak's Patented Optical Current Sensor System	No	No	No	No	No	Yes	No	No	No	Yes	No	No	Current, Optical	No	contactus@airak.com
Airborne Acoustic Transducer	No	No	Yes	Yes	No	No	No	Yes	No	No	No	Yes	Acoustic, Corona	No	email patrick@ipec.co.uk(contact out of town)
Automation FCI's	Yes	No	Yes	Yes	No	Yes	No	No	No	No	No	No	Current	No	Utility Sales Agency, LLC 615-324-9351
AutoRANGER	No	No	Yes	Yes	No	Yes	No	No	No	No	No	No	Current	No	SEL
Beacon Electrostatic Reset	No	No	Yes	Yes	Yes	No	No	No	No	No	No	No	Voltage	No	SEL
Cable and switchgear PD sensors	No	No	Yes	No	No	No	No	No	No	No	No	Yes	Corona	No	emailed patrick@ipec.co.uk(contact out of town)
CE Mesh	No	No	Yes	Yes	Yes	Yes	No	No	No	No	No	No	Voltage, Current	No	
CMD	No	No	Yes	Yes	Yes	Yes	No	No	No	No	No	No	Voltage, Current	No	
Corona Finder	No	No	Yes	Yes	No	No	No	No	No	Yes	No	Yes	Optical, Corona	No	Syntronics
CR	No	No	Yes	Yes	No	Yes	No	No	No	No	No	No	Current	No	alan.brookover@cooperindustries.com
CS/CSV	No	No	Yes	Yes	Yes	Yes	No	No	No	No	No	No	Voltage, Current	No	Joe Feyka(205) 985-4512 Ext. 3353
Current and Voltage Monitoring Insulators	No	No	Yes	Yes	Yes	Yes	No	No	No	No	No	No	Voltage, Current	No	1-626-969-3471/waiting on email w/pricing
Discos System	No	No	Yes	Yes	Yes	Yes	No	No	No	No	No	No	current, voltage	No	
Distributed Temperature System N4385A / N4386A	No	No	No	No	No	No	Yes	No	No	No	No	No	Temperature	No	
Ditest - AIM	No	No	No	No	No	No	Yes	No	No	No	No	No	Temperature	No	
Ditest - LTM	No	No	No	No	No	No	Yes	No	No	No	No	No	Temperature	No	
DR	No	No	Yes	Yes	No	Yes	No	No	No	No	No	No	Current	No	alan.brookover@cooperindustries.com
DRMCC-T3	No	No	Yes	Yes	No	Yes	Yes	No	No	No	No	No	Current, Temperature	No	1 262 746 1230
DTS	No	No	No	No	No	No	Yes	No	No	No	No	No	Temperature	No	
DTS Units	No	No	Yes	Yes	No	No	Yes	No	No	No	No	No	Temperature	No	
Elastimold TPM Series	No	No	Yes	No	No	Yes	No	No	No	No	No	No	Current	No	stanruffin@aol.com
Elbow Cap	No	No	Yes	Yes	Yes	Yes	No	No	No	No	No	No	Voltage, Current	No	1-626-969-3471/waiting on email w/pricing
Elbow Sense	Yes	No	Yes	No	Yes	Yes	No	No	No	No	No	No	Voltage, Current	No	1-626-969-3471/waiting on email w/pricing
ER	No	No	Yes	Yes	No	Yes	No	No	No	No	No	No	Current	No	alan.brookover@cooperindustries.com
ER S.T.A.R. Pathfinder	Yes	No	Yes	Yes	No	Yes	No	No	No	No	No	No	Current	No	alan.brookover@cooperindustries.com
Exacter	No	No	Yes	Yes	No	No	No	No	No	No	Yes	No	RFI	No	614-880-9320
FDAM	No	No	No	No	Yes	Yes	No	No	No	No	No	No	Voltage, Current	No	
Fiber Optic strain and temperature sensing system	No	No	Yes	No	No	No	Yes	No	No	No	No	No	Temperature	No	
FMPT	No	No	Yes	No	Yes	No	No	No	No	No	No	No	Voltage	Yes	727-698-1742(Pam Hamilton)

Sensor Name	Selected for Testing	Tested	Currently Available	Currently Sold to Utilities	Voltage Sensor	Current Sensor	Temperature Sensor	Acoustic Sensor	Vibration Sensor	Optical Sensor	RFI Sensor	Corona Sensor	Sensor Type	Planning on Testing	Organization Surveyed's Name
FOT-F FOT	No	No	Yes	Yes	No	No	Yes	No	No	Yes	No	No	Temperature, Optical	No	1.450.465.1113
FTR	No	No	Yes	No	No	No	Yes	No	No	Yes	No	No	Temperature, Optical	No	914-993-0990(left voicemail)
HV Transducer Current Probe	No	No	Yes	No	No	Yes	No	No	No	No	No	No	Current	No	nj@suretech.co.za
Infrared Cameras	No	No	Yes	Yes	No	No	Yes	No	No	Yes	No	No	Optical, Temperature	No	
Intelligent Insulators Current Leakage Sensors	No	No	Yes	Yes	No	No	Yes	No	No	No	No	No	Temperature	No	Telepathx
IVS-200	No	No	Yes	No	No	No	No	No	Yes	Yes	No	No	Vibration, Optical	No	emailed on website(german based company)
LightHouse	Yes	Yes	Yes	No	No	Yes	Yes	No	No	No	No	No	Current, Temperature	No	800-878-3399
LT40	No	No	Yes	Yes	Yes	Yes	No	No	No	No	No	No	Voltage, Current	No	1 916 372 4945
LT50	Yes	No	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	Voltage, Current, Temperature	No	1 916 372 4945
LVR	No	No	Yes	Yes	No	Yes	No	No	No	No	No	No	Current	No	alan.brookover@cooperindustries.com
M330	No	No	Yes	Yes	No	No	No	No	No	No	Yes	Yes	RFI, Corona	No	Fred Horning 503.256.3417
Magnetic Mount Temperature Sensor	No	No	Yes	No	No	No	Yes	No	No	No	No	No	Temperature	No	Karim 514-693-1445
MDP - Megger Distribution Profiler	No	No	No	No	Yes	Yes	No	No	No	No	No	No	voltage, current	No	
MetPod/Metpod lite(skinnier version of MetPod)	No	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No	Voltage, Current	No	727-698-1742(Pam Hamilton)
MR	No	No	Yes	Yes	No	Yes	No	No	No	No	No	No	Current	No	alan.brookover@cooperindustries.com
Multicore Sensor	No	No	Yes	Yes	Yes	Yes	No	No	No	No	No	No	Voltage, Current	No	1-626-969-3471/waiting on email w/pricing
OLM Standard	No	No	Yes	No	No	Yes	No	No	No	No	No	No	Current	No	stanruffin@aol.com
OP-Thermo	No	No	Yes	Yes	No	No	Yes	No	No	No	No	No	Temperature	No	
Optical Sensors	No	No	No	No	No	No	No	No	No	Yes	No	No	Optical	No	
Overhead Electrostatic Reset	No	No	Yes	Yes	Yes	No	No	No	No	No	No	No	Voltage	No	SEL
Overhead FCI's	No	No	Yes	Yes	No	Yes	No	No	No	No	No	No	Current	No	Utility Sales Agency, LLC 615-324-9351 Randy Earls
Partial Discharge Sensors	No	No	Yes	No	No	No	No	Yes	No	No	No	Yes	Acoustic, Corona	No	Karim 514-693-1445
PAVICA	No	No	Yes	Yes	No	No	No	No	Yes	No	No	No	Vibration	No	Rene DeBlois 1-450-465-1114 x 235
PD-MAT400A	No	No	Yes	Yes	No	No	No	Yes	No	No	No	Yes	Acoustic, Corona	No	David Eom @powerpd.net 1.949.457.3558
PD-MCC&G400A	No	No	Yes	Yes	No	No	No	No	No	No	No	Yes	Corona	No	David Eom @powerpd.net 1.949.457.3558
PD-RD300A	No	No	Yes	Yes	No	No	No	No	No	No	No	Yes	Corona	No	David Eom @powerpd.net 1.949.457.3558
PD-TM500A	No	No	Yes	Yes	No	No	No	Yes	No	No	No	Yes	Acoustic, Corona	No	David Eom @powerpd.net 1.949.457.3558
PF Live Plus	No	No	Yes	No	No	Yes	No	No	No	No	No	No	Current, Temperature	No	
Power Donut 2	No	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	No	No	No	Voltage, Current, Temperature	No	914-273-8727 (Larry Fish)
Power Flex Current Sensor	No	No	Yes	No	No	Yes	No	No	No	No	No	No	Current	No	stanruffin@aol.com
Powermonic PM5	No	No	No	No	Yes	No	No	No	No	No	No	No	voltage	No	
Promethean Devices	No	No	No	No	No	Yes	Yes	No	No	No	No	No	Current, Temperature	No	
Radio Faulted Circuit Indicator System	No	No	Yes	No	No	Yes	No	No	No	No	No	No	Current	No	stanruffin@aol.com
Reflex	No	No	No	No	No	No	Yes	No	No	No	No	No	Temperature	No	
RF Smart Monitor System	No	No	No	No	Yes	No	Yes	No	Yes	No	No	No	Voltage, Temperature, Vibration	No	
RFID cutout fuse monitor	No	No	Yes	Yes	No	No	No	No	No	Yes	No	No	Optical	No	
SDT 170 with parabolic Dish	No	No	Yes	Yes	No	No	No	Yes	No	No	No	Yes	Acoustic, Corona	No	PPM Tech. (615)-826-7109 Dennis Mullins

Sensor Name	Selected for Testing	Tested	Currently Available	Currently Sold to Utilities	Voltage Sensor	Current Sensor	Temperature Sensor	Acoustic Sensor	Vibration Sensor	Optical Sensor	RFI Sensor	Corona Sensor	Sensor Type	Planning on Testing	Organization Surveyed's Name
SEI601	No	No	Yes	No	No	Yes	No	No	No	No	No	No	Current	No	Diane Gross1-800-523-2620 ext. 2461
SEL LINAM Current Reset Fault Indicators	No	No	Yes	Yes	No	Yes	No	No	No	No	No	No	Current	No	
SENSODRIEL	Yes	No	Yes	No	Yes	Yes	No	No	No	No	No	No	Voltage, Current	No	silidriel@prodigy.net.mx
Sentinel DTS Range	No	No	Yes	Yes	No	No	Yes	No	No	No	No	No	Temperature	No	
Single-Phase Test Point Mounted Bolt Display FCI	No	No	Yes	Yes	No	Yes	No	No	No	No	No	No	Current	No	
Smart Pin	No	No	Yes	No	Yes	Yes	No	No	No	No	No	No	Voltage, Current	No	1-626-969-3471/waiting on email w/pricing
SURETECH VI-x Monitoring System	No	No	Yes	No	Yes	Yes	No	No	No	No	No	No	Voltage, Current	No	nj@suretech.co.za
System for monitoring cables	No	No	No	No	No	No	No	No	No	Yes	No	No	Optical	No	
Temperature measuring sensor(SMT)	No	No	Yes	Yes	No	No	Yes	No	No	No	No	No	Temperature	No	
T-Guard	No	No	No	No	No	No	Yes	No	No	No	No	No	Temperature	No	
Thermal Rate System	No	No	No	No	No	No	Yes	No	No	No	No	No	Temperature	No	
TPR	No	No	Yes	Yes	No	Yes	No	No	No	No	No	No	Current	No	alan.brookover@cooperindustries.com
TPR S.T.A.R. Pathfinder	Yes	No	Yes	Yes	No	Yes	No	No	No	No	No	No	Current	No	alan.brookover@cooperindustries.com
Transform	No	No	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	Current, Voltage, Temperature	No	
TSP probe	No	No	Yes	Yes	No	No	Yes	No	No	No	No	No	Temperature	No	alan.brookover@cooperindustries.com
TSS and TSA sensors	Yes	No	Yes	Yes	No	No	Yes	No	No	No	No	No	Temperature	No	alan.brookover@cooperindustries.com
TVM	No	No	Yes	No	Yes	No	No	No	No	No	No	No	Voltage	No	208-658-1292 x24
UCM Series	No	No	Yes	No	No	Yes	No	No	No	No	No	No	Current	No	stanruffin@aol.com
UltraTEV Plus+	No	No	Yes	No	No	No	No	Yes	No	No	No	Yes	Acoustic, Corona	No	email
Underground AutoRANGER	Yes	No	Yes	Yes	No	Yes	No	No	No	No	No	No	Current	No	
Underground Fault Sensor	No	No	Yes	No	No	Yes	No	No	No	No	No	No	Current	No	
Underground FCI's	Yes	No	Yes	Yes	No	Yes	No	No	No	No	No	No	Current	No	Utility Sales Agency, LLC 615-324-9351
unknown	No	No	No	No	No	No	No	Yes	No	Yes	No	Yes	Acoustic, Corona, Optical	No	None
V2 Standard	No	No	Yes	No	No	Yes	No	No	No	No	No	No	Current	No	stanruffin@aol.com
VisiVolt	No	No	Yes	No	Yes	No	No	No	No	No	No	No	Voltage	No	scott.webb@us.abb.com/passvi.plabb@pl.abb.com
Voltwitch	No	No	Yes	Yes	Yes	No	No	No	No	No	No	No	Voltage	No	http://www.rauckmanutility.com/homevoltwitch.htm
Well-Type RTD Temperature Sensor	No	No	Yes	No	No	No	Yes	No	No	No	No	No	Temperature	No	Karim 514-693-1445

Organization Surveyed's Name	Manufacturer	Sensor Name	Brief Description	Voltage Sensor	Current Sensor	Temperature Sensor	Acoustic Sensor	Vibration Sensor	Optical Sensor	RFI Sensor	Corona Sensor	Sensor Type	Currently Available	Currently Sold to Utilities	Tested	Planning on Testing	Website	Anticipated Use	Cost	Installation Cost
scott.webb@us.abb.com/passvi.plabb@pl.abb.com	ABB	VisiVolt	VisiVolt™ – Passive Voltage Indicator is a busbar-mounted-type indicator of voltage presence developed to be used in outdoor and indoor systems. It is adapted for permanent installation on busbars and naked or insulated metal conductors in medium voltage	#	#	#	#	#	#	#	#	Voltage	#	#	#	#	http://www.abb.com/product/seitp328/7ad2b7d4354afc36c125713b0042c415.aspx?productLanguage=us&country=US		0	0
Diane Gross1-800-523-2620 ext. 2461	ABB	SEI601	By simply attaching a small, non-intrusive, clamp-on AC/DC sensor to the relay wires and connecting its Cat5 cable to the supplied recording switch, real-time analog and digital information is readily available for analysis. The sensor is highly sensitive	#	#	#	#	#	#	#	#	Current	#	#	#	#	http://www.abb.com/product/db0003db004281/e08d1fe483dce018c125741d00345ccd.aspx	This system is composed of 8 current sensors, a reciever, and the analysis software for around $3500. This is a new product and very little information is currently available.	3500	0
None	ABB Power T&D Company Inc.	unknown	Acoustic optical system for partial discharge detection and location	#	#	#	#	#	#	#	#	Acoustic, Corona, Optical	#	#	#	#	www.patentstorm.us/patents/5530366.html		0	0
	Agilent	Distributed Temperature System N4385A / N4386A	DTS technology measures a temperature profile along an optical fiber over several kilometers. The Agilent DTS performs measurements down to 1 meter spatial resolution with less than 0.1°C temperature resolution providing thousands of measurement points in	#	#	#	#	#	#	#	#	Temperature	#	#	#	#	http://www.apsensing.com/download/Product%20Data%20Sheet.pdf		0	0

Organization Surveyed's Name	Manufacturer	Sensor Name	Brief Description	Voltage Sensor	Current Sensor	Temperature Sensor	Acoustic Sensor	Vibration Sensor	Optical Sensor	RFI Sensor	Corona Sensor	Sensor Type	Currently Available	Currently Sold to Utilities	Tested	Planning on Testing	Website	Anticipated Use	Cost	Installation Cost
	Arteche	Temperature measuring sensor(SMT)	The Temperature Measurement Sensor SMT has been designed to measure the instantaneous temperature of the line, transmitting it to a PC via an SMS message.	#	#	#	#	#	#	#	#	Temperature	#	#	#	#	http://www.arteche.com/web/frontoffice/verproducto.aspx?id_prod=97&idioma=2	The Temperature Measuring Sensor (SMT) gives real temperature of Tranmision or Distribution aereal networks cable. The information is sent by SMS to a receiver that storage and present these data. Easy to install, even with energized line, in aprox. 10'.	0	0
	Arteche	Underground Fault Sensor	The task of the ARTECHE Fault Indicator Relay is to detect the faulty line section and indicate the incidence so that, via remote signal transmission, for example, adequate actions are taken and the section affected can be quickly isolated.	#	#	#	#	#	#	#	#	Current	#	#	#	#	www.arteche.com		0	0
alan.brookover@cooperindustries.com	Cannon Technologies	TSP probe	The Model TSP probe provides an RTU compatible analog input that is proportional to the transformer's top oil temperature. The probe can be used with an existing RTU, or as part of an Substation Advisor® System. For transformers with existing top oil indi	#	#	#	#	#	#	#	#	Temperature	#	#	#	#	http://www.cannontech.com/products/TSP-PB.pdf	TSP Oil Temperature Probe $425	425	0
alan.brookover@cooperindustries.com	Cannon Technologies	TSS and TSA sensors	Model TSS and TSA sensors provide an analog current that is proportional to the surface on which the sensor is mounted (TSS) or to the temperature of the ambient air (TSA). The sensor is powered from the loop current and therefore it does not require a se	#	#	#	#	#	#	#	#	Temperature	#	#	#	#	http://www.cannontech.com/products/TSS-TSA-PB.pdf	TSS Surface Temperature Sensor $225 TSA Ambient Temperature Sensor $225	225	0

Organization Surveyed's Name	Manufacturer	Sensor Name	Brief Description	Voltage Sensor	Current Sensor	Temperature Sensor	Acoustic Sensor	Vibration Sensor	Optical Sensor	RFI Sensor	Corona Sensor	Sensor Type	Currently Available	Currently Sold to Utilities	Tested	Planning on Testing	Website	Anticipated Use	Cost	Installation Cost
alan.brookover@cooperindustries.com	Cooper Power Systems	TPR	Cooper Power Systems' S.T.A.R. Test Point Reset (TPR) faulted circuit indicators (FCIs) can be used on all 200 A and 600 A connectors having a voltage test point. Load levels do not effect the reset circuit. The unit automatically resets to the normal pos	#	#	#	#	#	#	#	#	Current	#	#	#	#	http://www.cooperpower.com/library/pdf/97034.pdf	70-110	110	0
alan.brookover@cooperindustries.com	Cooper Power Systems	MR	Cooper Power Systems' S.T.A.R. Manual Reset (MR) faulted circuit indicators (FCIs) can be used on overhead uninsulated, unshielded cable and unshielded insulated cable such as tree wire. The MR FCI can also be installed on padmounted distribution transfor	#	#	#	#	#	#	#	#	Current	#	#	#	#	http://www.cooperpower.com/library/pdf/sellsheet.pdf		110	0
alan.brookover@cooperindustries.com	Cooper Power Systems	LVR	Cooper Power Systems' S.T.A.R. Low Voltage Reset (LVR) faulted circuit indicators (FCIs) can be installed on padmounted distribution transformers, or at a secondary voltage source. The unit automatically resets to the normal position when circuit voltage	#	#	#	#	#	#	#	#	Current	#	#	#	#	http://www.cooperpower.com/library/pdf/lowvoltagereset.pdf	$105-135	135	0
alan.brookover@cooperindustries.com	Cooper Power Systems	ER	Cooper Power Systems' S.T.A.R. Electrostatic Reset (ER) faulted circuit indicators (FCIs) can be used on overhead uninsulated, unshielded cable and unshielded insulated cable, such as tree wire. They are powered from the voltage gradient between the line	#	#	#	#	#	#	#	#	Current	#	#	#	#	http://www.cooperpower.com/library/pdf/electrre.pdf		110	0
alan.brookover@cooperindustries.com	Cooper Power Systems	DR	Cooper Power Systems' S.T.A.R. Delayed Reset (DR) faulted circuit indicators (FCIs) can be installed on padmounted distribution transformers, sector cabinets, switchgear and overhead bare conductors. The unit automatically resets back to the normal positi	#	#	#	#	#	#	#	#	Current	#	#	#	#	http://www.cooperpower.com/library/pdf/delayed.pdf		40	0

Organization Surveyed's Name	Manufacturer	Sensor Name	Brief Description	Voltage Sensor	Current Sensor	Temperature Sensor	Acoustic Sensor	Vibration Sensor	Optical Sensor	RFI Sensor	Corona Sensor	Sensor Type	Currently Available	Currently Sold to Utilities	Tested	Planning on Testing	Website	Anticipated Use	Cost	Installation Cost
alan.brookover@cooperindustries.com	Cooper Power Systems	CR	Cooper Power Systems' S.T.A.R. Current Reset (CR) faulted circuit indicators (FCIs) can be installed on padmounted distribution transformers, sector cabinets, switchgear and overhead bare conductors. The unit automatically resets back to the normal positi	#	#	#	#	#	#	#	#	Current	#	#	#	#	http://www.cooperpower.com/library/pdf/circuit.pdf	80-100	100	0
alan.brookover@cooperindustries.com	Cooper Power Systems	ER S.T.A.R. Pathfinder	High Tech at Low-Tech Prices – The latest industry technology is now available at a price everyone can afford. Reduces Operating Costs, Reduces Inventory, Improves Power Quality, Finds the Fault the First Time. A pair of high luminous LEDs in addition	#	#	#	#	#	#	#	#	Current	#	#	#	#	http://www.cooperpower.com/library/pdf/99063.pdf	Can be used with outage advisor system for additional cost.	110	0
alan.brookover@cooperindustries.com	Cooper Power Systems	TPR S.T.A.R. Pathfinder	Cooper Power Systems S.T.A.R.™ PATHFINDER™ Variable Trip Test Point faulted circuit indicators (FCI) are designed to quickly and easily locate faulted sections of underground cable systems. These FCIs can be used on both 200 A separable connectors and 600	#	#	#	#	#	#	#	#	Current	#	#	#	#	http://www.cooperpower.com/library/pdf/pathfinder.pdf	$80-110 Can be utilized with outage advisor for remote fault detection for additional cost.	110	0
1 262 746 1230	Dynamic Ratings	DRMCC-T3	Replaces several control devices, providing control, monitoring & data aquisition for the entire transformer. This device has several sensors which may be connected to monitor several aspects of a transformer.	#	#	#	#	#	#	#	#	Current, Temperature	#	#	#	#	http://www.dynamicratings.com/pdf/general_downloads/T3SalesInformation/DRMCC-T3Brochure.pdf	Can consollidate any other outside IED information, can controll transformer cooling. Pricing is $12000-18000 depending on options. Installation can be done as full turn key, $15000, or as a supervisory only install for which the price would vary.	18000	15000

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email	EA Technology	UltraTEV Plus+	The UltraTEV Plus+ measures PD activity in the form of ultrasonic and transient earth-voltage (TEV) signals, but provides operators with considerably more comprehensive information about emission levels. Ultrasonic emissions are displayed as decibel readi	#	#	#	#	#	#	#	#	Acoustic, Corona	#	#	#	#	www.eatechnology.com		0	0
614-880-9320	Exacter, Inc.	Exacter	The EXACTER® Outage-Avoidance System provides early warning of failing transformers, regulators, insulators, cutouts, lightning arrestors, and more, utilizing advanced sensor-array technology. Geospatial mapping provides location data and problem severity	#	#	#	#	#	#	#	#	RFI	#	#	#	#	http://www.exacterinc.com/exacter.php	Unit price per month(survey themselves), they produce reports of faulty components. Also do turnkey services. Monitor overhead distribution by listening to RF signatures, then data is analyzed by the service. Price for rental is 3000-6000/month for a u	3000	1200
727-698-1742(Pam Hamilton)	FieldMetrics Inc	FMPT	The FMPT voltage sensor is a high accuracy voltage measurement solution for transmission and distribution utility applications. By combining high-reliability components in a patent-pending design, the FMPT uses no insulating oil or SF6 gas, yet provides a	#	#	#	#	#	#	#	#	Voltage	#	#	#	#	http://home.earthlink.net/~fieldmetrics/id9.html	Still in development. New technology. Design is complete, however waiting for a customer for fieldtest. $2500-$2700 Ballpark cost range.	2500	0
727-698-1742(Pam Hamilton)	FieldMetrics Inc.	MetPod/Metpodlite(skinnier version of MetPod)	The MetPod is our first product release based on our patent-pending technology. An integrated VT, clamp-on CT and meter, it meets 0.2 accuracy class requirements and has passed full dielectric type-tests. The MetPod offers a wireless link and self diagno	#	#	#	#	#	#	#	#	Voltage, Current	#	#	#	#	http://home.earthlink.net/~fieldmetrics/id9.html	Testing in the field currently. Using 900MHz modem for communication.3000-3500 for field trial units.	3000	0

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	Flir Systems, LTD	Infrared Cameras	FLIR provides utilities with the most advanced thermal imaging solutions to support the monitoring programs that keep the vital electrical power grid up and running. FLIR ThermaCAM infrared cameras have revolutionized predictive/preventive maintenance in	#	#	#	#	#	#	#	#	Optical, Temperature	#	#	#	#	http://www.goinfrared.com/industries/utilitymarket/		0	0
Karim 514-693-1445	GE Power	Partial Discharge Sensors	Partial discharge sensors are self-contained, acoustic sensors utilizing piezo electric element technology. The sensors provide continuous readings and are designed for field use in transformers and load tap changers. Two types of partial discharge sensor	#	#	#	#	#	#	#	#	Acoustic, Corona	#	#	#	#	http://www.gepower.com/prod_serv/products/substation_md/en/sensors/partial_sensor.htm	No longer manufactured.	0	0
Karim 514-693-1445	GE Power	Well-Type RTD Temperature Sensor	The insertion-type RTD temperature sensor mounts inside the thermal well. It connects to the transmitter, which sends a 4-20 mA signal back to the monitor	#	#	#	#	#	#	#	#	Temperature	#	#	#	#	http://www.gepower.com/prod_serv/products/substation_md/en/sensors/rtd_sensor.htm	3 types: 133 Well 325 Temperature element 823 installed in monitoring cabinet	325	0
Karim 514-693-1445	GE Power	Magnetic Mount Temperature Sensor	The magnetic mount temperature sensor attaches to the transformer with a magnet. The sensor is self-contained and in a weatherproof housing. The RTD has a built-in 4-20 mA transmitter that is powered from the monitoring unit. The sensor is supplied with f	#	#	#	#	#	#	#	#	Temperature	#	#	#	#	http://www.gepower.com/prod_serv/products/substation_md/en/sensors/magnetic_sensor.htm		522	0

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1 916 372 4945	GridSense	LT40	By clipping the LT40 / LT50 on to lines at strategic points, e.g. tee junctions, switches, substations etc., data such as load, maximum demand, inrush current, fault wave shape & duration, protection operation, voltage status, conductor and ambient temper	#	#	#	#	#	#	#	#	Voltage, Current	#	#	#	#	http://www.gridsense.net/products2.php	up to 69 KV, can communicate down to data link, which is a dashboard mounted device. Also have a scada solution, cellphone, etc. Must be mounted to bare conductor. Has regowski coil. Had a dimensionless voltage readout which can be used to calculate act	1800	0
1 916 372 4945	GridSense	LT50	By clipping the LT40 / LT50 on to lines at strategic points, e.g. tee junctions, switches, substations etc., data such as load, maximum demand, inrush current, fault wave shape & duration, protection operation, voltage status, conductor and ambient temper	#	#	#	#	#	#	#	#	Voltage, Current, Temperature	#	#	#	#	http://www.gridsense.net/products2.php	up to 138KV, can communicate down to data link, which is a dashboard mounted device. Also have a scada solution, cellphone, etc. Must be mounted to bare conductor. Has regowski coil. Had a dimensionless voltage readout which can be used to calculate act	3100	0

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	Gridsense	Powermonic PM5	The PM5 is a low cost, in situ monitor that is placed at strategic LV locations facitlitating real time reporting of voltage disturbances in the field to improve power quality and reliability. A cost effective network wide monitoring system that's simple	#	#	#	#	#	#	#	#	voltage	#	#	#	#	http://www.gridsense.net	he PM5 simply plugs into the 110-240 volt electrical outlet and connects in parallel to the existing telephone line to transfer critical operational data to a central master station (MONITOR SYSTEM). The use of low cost Dual Tone Multiple Frequency (DTMF)	0	0
silidriel@prodigy.net.mx	Grupodriel	SENSODRIEL	The current and voltage sensor called "SENSODRIEL" is a post type insulator for classes 15, 25 and 34.5 capable of reading precisely current and voltage from nominal values to short circuit allowing the determination of line parameters including "power fa	#	#	#	#	#	#	#	#	Voltage, Current	#	#	#	#	http://www.silidriel.com/nssensodrielE.htm	Our sensor is not capable of burden, It must be connected to impedances of the order of 1 Megaohm, or larger. Our voltage precision is better than 0.5% in other words, under controlled conditions a measurement between any two sensors is below 1% (-.5% t0	150	0
914-993-0990(left voicemail)	Hitachi	FTR	Fiber Optic Temperature laser radar. The FTR is composed of a fiber optic temperature sensing and measureing unit and a computer display to show temperature distribution along a conductor up to 6km in length.	#	#	#	#	#	#	#	#	Temperature, Optical	#	#	#	#	http://www.hitachi-cable.co.jp/ICSFiles/afieldfile/2005/11/07/EN602.pdf	Contacted a rep. Emailed kabuto@hitachi-cable.com Should be getting back with me soon to give pricing.	0	0

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emailed patrick@ipec.co.uk(contact out of town)	iPEC	Cable and switchgear PD sensors	The HFCT 100/50 is a high frequency transducer designed specifically for picking up partial discharge signals. It has a split core ferrite to allow retrospective fitting to earth straps without the need for disconnection. The durable body has a hinge and	#	#	#	#	#	#	#	#	Corona	#	#	#	#	http://www.ipec.co.uk/asm/solution/pd_sensors.php?site=2&section=2&subnav=3		0	0
email patrick@ipec.co.uk(contact out of town)	iPEC	Airborne Acoustic Transducer	The acoustic probe is designed for use on air insulated terminations where there is a clear sound path between the electrically stressed insulation and the probe. The sensor is extremely sensitive and can detect activity below 10pC. The probe has a magnet	#	#	#	#	#	#	#	#	Acoustic, Corona	#	#	#	#	http://www.ipec.co.uk/asm/solution/pd_sensors.php?site=2&section=2&subnav=3		0	0
stanruffin@aol.com	Joslyn Hi-Voltage	Power Flex Current Sensor	The Fisher Pierce Series 1301 high accuracy line post current sensors provide a reliable measuring method for distribution systems from zero to thousands of amperes. The current sensors may be used for capacitor switching, load surveying, or protective re	#	#	#	#	#	#	#	#	Current	#	#	#	#	http://www.joslynhivoltage.com/catPowerFlex1301.htm	15kV, 25kV, 35kV	500	0
stanruffin@aol.com	Joslyn Hi-Voltage	Radio Faulted Circuit Indicator System	The Fisher Pierce Radio Faulted Circuit Indicator (RFCI) System utilizes wireless communication technology to assist in locating distribution system faulted circuits. RFCI's installed in overhead, underground, and padmount locations can be detected from h	#	#	#	#	#	#	#	#	Current	#	#	#	#	http://www.joslynhivoltage.com/catRFCI.htm	1547/1548 Series.	200	0
stanruffin@aol.com	Joslyn Hi-Voltage	1514/15	The Fisher Pierce Series 1514/15 Current- Reset Faulted Circuit Indicators locate faults quickly by monitoring line current. The 1514/15 FCIs locate faults quickly and isolate the source which reduces emergency labor, and decreases outages and revenue los	#	#	#	#	#	#	#	#	Current	#	#	#	#	http://www.joslynhivoltage.com/catCurrentReset1514.htm		145	0

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	kinects	Transform	By providing up to hourly data for voltage and current loading, and proximity temperature reading for the transformer, utility will have unprecedented access to equipment performance and status data to have a clear, continuous view of the asset conditions	#	#	#	#	#	#	#	#	Current, Voltage, Temperature	#	#	#	#	http://www.kinectssolutions.com/products.php		0	0
	Leiv Eiriksson Nyfotek AS	System for monitoring cables	System for monitoring high-tension cables in air stretches as well as a use of the same. The system comprises at least one optic fiber fastened to the high tension cable, the optic fiber including at least one Bragg grating with known reflection character	#	#	#	#	#	#	#	#	Optical	#	#	#	#	http://www.patentstorm.us/patents/6784983.html		0	0
1-626-969-3471/waiting on email w/pricing	Lindsey Manufacturing	Multicore Sensor	The Multicore Sensor is designed to be installed without de-energizing or cutting the main conductor. This sensor does not require any special calibration for conductor diameter to produce its 2% accurate output. It can be vertically mounted to replace an	#	#	#	#	#	#	#	#	Voltage, Current	#	#	#	#	http://www.lindsey-usa.com/catalogs/CVMI/Multicore%20Sensor.pdf	Prices range from $760-1190 15kV Current + Voltage Multicore Sensor $760 25kV Current + Voltage Multicore Sensor $920 35kV Current + Voltage Multicore Sensor $1,190	760	0
1-626-969-3471/waiting on email w/pricing	Lindsey Manufacturing	Current and Voltage Monitoring Insulators	Many electric utilities are using Distribution Automation (DA) for both overhead and underground systems. DA systems enable a utility to monitor, coordinate and operate distribution systems in real time mode from remote locations. Utilities that have inst	#	#	#	#	#	#	#	#	Voltage, Current	#	#	#	#	http://www.lindsey-usa.com/CVMI.php	15kV Current + Voltage Sensor $790 25kV Current + Voltage Sensor $950 35kV Current + Voltage Sensor $1,220 46kV Current + Voltage Sensor $2,480	790	0

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1-626-969-3471/waiting on email w/pricing	Lindsey Manufacturing	Smart Pin	The SmartPin current and voltage sensing system is a low cost solution for monitoring overhead distribution lines. The system consists of three sensor pins capable of supporting standard pin insulators (vertical orientation) and a control box for calibrat	#	#	#	#	#	#	#	#	Voltage, Current	#	#	#	#	http://www.lindsey-usa.com/catalogs/CVMI/Lindsey-SmartPin.pdf	not available.	0	0
1-626-969-3471/waiting on email w/pricing	Lindsey Manufacturing	Elbow Cap	The ElbowCap current and voltage sensing system is a low cost solution for monitoring underground distribution feeders. The system consists of three sensors that snap onto the capacitive test point of standard 200A and 600A elbows with a control box for c	#	#	#	#	#	#	#	#	Voltage, Current	#	#	#	#	http://www.lindsey-usa.com/CVMI.php	not available.	0	0
1-626-969-3471/waiting on email w/pricing	Lindsey Manufacturing	Elbow Sense	Lindsey ElbowSense Current and Voltage Monitors use proven CT and voltage sensor technology from the original Lindsey CVMI and fit standard 600 amp T-body 15, 25 and 35kV connectors. They are easily retrofitted to existing padmount or submersible equipmen	#	#	#	#	#	#	#	#	Voltage, Current	#	#	#	#	http://www.lindsey-usa.com/CVMI.php	Current Monitoring Rings $300 Voltage Monitoring Plugs (qty 1-3) $660	300	0
PPM Tech. (615)-826-7109 Dennis Mullins	Martech	SDT 170 with parabolic Dish	The SDT 170MD (Multifunctional/Datalogger) is the complete ultrasonic inspection and predictive maintenance trending machine. With all the features of the SDT 170S Standard and SDT 170M Multifunctional, we've added a customisable data logger that interfac	#	#	#	#	#	#	#	#	Acoustic, Corona	#	#	#	#	http://sdt.be/04products/SDT170MD.html	Detect Corona behind electrical cabinet doors. With Use of parabolic disc, can pinpoint corona with lazer sight. Normally sold to factories. Withstand a 3m drop test.	7500	0

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	Megger	MDP - Megger Distribution Profiler	The Megger MDP series of distribution profilers provides power utilities with the most accurate and extensive information ever to precisely evaluate loading on feeders/overhead lines and to identify needed upgrades or replacement. Three different models r	#	#	#	#	#	#	#	#	voltage, current	#	#	#	#	http://www.megger.com/common/documents/MDP_DS_en_V02.pdf	Choice of three models that record currents up to 1000 amps, with an additional 200 amp over-range Waveform capture and harmonic analysis up to the 32nd order Power and power factor Accurate data capture via advanced MDP software Lightweight, durable	0	0
	Omnisens	Ditest - LTM	The DITEST-LTM combines OMNISENS DITEST measuring technique with “best-in-industry” dedicated sensing cable, data processing, user-friendly interface and application oriented visualization tools. DITEST-LTM Solution is optimized for long distance monitori	#	#	#	#	#	#	#	#	Temperature	#	#	#	#	http://www.omnisens.ch/ditest/3522-ditest-ltm.php		0	0
	Omnisens	Ditest - AIM	DITEST-AIM integrates OMNISENS core sensing technology DITEST-STA optimized for long distance monitoring applications with extensive application know-how and field experience. DITEST-STA Monitoring distance : > 30 km per sensor Operates with standard s	#	#	#	#	#	#	#	#	Temperature	#	#	#	#	http://www.omnisens.ch/ditest/3521-ditest-aim.php	Measurement of temperature and strain of an overhead conductor.	0	0

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	On-line Monitoring, Inc.	PF Live Plus	The PF Live Plus, a continuous on-line monitoring system, for monitoring power factor in high voltage capacitive bushings, is now available with an optional leakage current monitor for high voltage lightning arresters. The system includes a minimum set of	#	#	#	#	#	#	#	#	Current, Temperature	#	#	#	#	http://www.on-lineinc.com/pfliveplus.html	The PF Live Plus system can also interface to signals from other devices, or IED's, such as: temperature sensors, DGA, or any 0-10Vdc, 10Vrms, 4-20mA, or 0-1mA signal.	0	0
	Optisense	35 kV Class Outdoor Voltage Sensor	The Optisense outdoor voltage sensor enables high voltage measurement in a compact package at a lower installed cost than with conventional technology. Optical sensing technology allows for galvanic isolation of the signal from the voltage being measured.	#	#	#	#	#	#	#	#	Voltage	#	#	#	#	http://www.optisense.net/Documents/Optisense_Datasheet_Outdoor.pdf		0	0
	Optisense	15 kV Class Embedded Voltage Sensor	T he Optisense indoor voltage sensor enables high voltage measurement in a compact package at a lower installed cost than with conventional technology. Optical sensing technology allows for galvanic isolation of the signal from the voltage being measured.	#	#	#	#	#	#	#	#	Voltage	#	#	#	#	http://www.optisense.net/Documents/Optisense_Datasheet_Indoor.pdf		0	0
	OZ Optics	Fiber Optic strain and temperature sensing system	OZ Optics now offers the ForesighTM series of fiber optic distributed strain and temperature sensors. The new sensor system provides high resolution and accurate strain and temperature monitoring over very long distances. The sensor uses standard optical	#	#	#	#	#	#	#	#	Temperature	#	#	#	#	http://www.ozoptics.com/news/pr_157.html		0	0

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emailed on website(german based company)	Polytec	IVS-200	Polytec's IVS-200 Industrial Vibration Sensor is a ruggedized laser Doppler vibrometer for non-contact, on-line production vibration testing. An eye-safe visible laser is aimed and focused onto the part being measured. IVS-200 is easily retrofitted into	#	#	#	#	#	#	#	#	Vibration, Optical	#	#	#	#	http://www.polytec.com/int/158_898.asp		23250	0
Utility Sales Agency, LLC 615-324-9351 Randy Earls	Power Delivery Products	Overhead FCI's	Overhead Fault Indicators are available with a mechanical flag or LED indication. In addition to permanent installations to reduce outage time, these units are ideal for finding temporary, transient, or nuisance outages. Load Tracker capability is availab	#	#	#	#	#	#	#	#	Current	#	#	#	#	http://www.powerdeliveryproducts.com/overh.htm	Can be paired with a radio transmitter reciever unit which has a 40-50ft range(mount at bottom of pole below FCI) and when a fault is received, the unit closes a contact which can be connected to an RTU or Cellular RTU(Telemetric).	185	0
Utility Sales Agency, LLC 615-324-9351	Power Delivery Products	Underground FCI's	There are two major styles of Underground Faulted Circuit Indicators – Mechanical and Electronic. The Mechanical units offer years of economical fault indication. Rotor, submersible and fluid units are available with or without provisions for hotsick inst	#	#	#	#	#	#	#	#	Current	#	#	#	#	http://www.powerdeliveryproducts.com/underg.htm	Fault is indicated via blinking led on the FCI. To remotely receive the fault indication, a fiber optic lead is connected to the LED socket while the opposite end is connected to a converter box, which will close a contact on an RTU or other device when	120	0

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Utility Sales Agency, LLC 615-324-9351	Power Delivery Products	Automation FCI's	Automation is provided on underground units through the Distribution automation relay and for overhead applications with the Radio Faulted Circuit Indicator. (RFCI). The RFCI mounted on an overhead circuit sends a radio signal to a receiver which is conne	#	#	#	#	#	#	#	#	Current	#	#	#	#	http://www.powerdeliveryproducts.com/distauto.htm	Can be paired with a radio transmitter reciever unit which has a 40-50ft range(mount at bottom of pole below FCI) and when a fault is received, the unit closes a contact which can be connected to an RTU or Cellular RTU(Telemetric).	120	0
David Eom @powerpd.net 1.949.457.3558	PowerPD, Inc	PD-RD300A	The PD-RD300A is the newest device in the PowerPD line of test equipment, which provides continuous monitoring of your metal clad switchgear (MCSG) assets. This device detects electromagnetic waves when surface tracking occurs on the insulation system. It	#	#	#	#	#	#	#	#	Corona	#	#	#	#	http://www.powerpd.net/sub/pds.html	Cost is 4700+ depending on number of channels.	4700	0
David Eom @powerpd.net 1.949.457.3558	PowerPD, Inc	PD-MAT400A	PD-MAT400A is a permanently mounted on-line Partial Discharge (PD) diagnostic system. This test device focuses on detecting and analyzing the generation of PD in equipment such as transformers, HV GIS circuit breakers, GIS ductwork, and CGIS using acousti	#	#	#	#	#	#	#	#	Acoustic, Corona	#	#	#	#	http://www.powerpd.net/sub/pd_mat400a.html		10500	
David Eom @powerpd.net 1.949.457.3558	PowerPD, Inc	PD-MCC&G400A	PD-MCC&G400A is an on-line Partial Discharge (PD) diagnostic system, which detects and analyzes the generation of PD in the power equipments such as Cable and Motor. Four High Frequency Current Transducer (HFCT) Sensors are installed ground line in power	#	#	#	#	#	#	#	#	Corona	#	#	#	#	http://www.powerpd.net/sub/pd_mcc_g400a.html		0	0

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David Eom @powerpd.net 1.949.457.3558	PowerPD, Inc.	PD-TM500A	The PD-TM Series: are non-portable, mounted type units. PD-TM500, 1000, 1500 are online diagnostic systems that continuously monitors partial discharge in equipment such as Transformers, GIS, and CGIS etc. This units detect, analyze, and locate the signal	#	#	#	#	#	#	#	#	Acoustic, Corona	#	#	#	#	http://www.powerpd.net/sub/pd_tm500a.html	Main use for substations and utilities.	34800	0
	Powersense	Discos System	The PowerSense Overhead Line Solution has been designed for overhead line installations with or without substations. The solution is based on PowerSense's optical DISCOS® Sensor technology and a specially designed Linux-based RTU module. The DISCOS® Syste	#	#	#	#	#	#	#	#	current, voltage	#	#	#	#	http://sensethepower.com/	Discos system offers a variety of sensors and modules to create a customized Discos system. Discos offers indoor current sensors, IO modules, LV interfaces, MV interfaces, Opti Module, Outdoor combined current and voltage sensor, outdoor current sensor,	0	0
	PSI	CE Mesh	Monitor the Current, Voltage, & Phase Angle on all 3 Phases of Network Transformers and manholes. The Secondary Network Monitoring System has demonstrated excellent communications reliability. CDMA communications from below grade in transformer vaults	#	#	#	#	#	#	#	#	Voltage, Current	#	#	#	#	http://www.psinteg.com/LVNetMonitoring.html	PSI's State of the Art Secondary Network Monitoring System will enable utilities to see and measure electrical problems in their network before they happen and then will direct service crews to the exact location for a safe and effective repair.	0	0

Organization Surveyed's Name	Manufacturer	Sensor Name	Brief Description	Voltage Sensor	Current Sensor	Temperature Sensor	Acoustic Sensor	Vibration Sensor	Optical Sensor	RFI Sensor	Corona Sensor	Sensor Type	Currently Available	Currently Sold to Utilities	Tested	Planning on Testing	Website	Anticipated Use	Cost	Installation Cost
	PSI	FDAM	Accurate Map Overlays Integrated Monitoring & Diagnostics Low Cost Telecom FDAM initiates communications Voltage before and after the fault is reported You own the data! AES 256 Bit Data Encryption option Scalable FDAM System is ready for deployment acro	#	#	#	#	#	#	#	#	Voltage, Current	#	#	#	#	http://www.psinteg.com/FDAM.html		0	0
Fred Horning 503.256.3417	Radar Engineer	247-B	Hotstick Line Sniffer. RF & Ultrasonic Locator for use from a bucket.	#	#	#	#	#	#	#	#	Acoustic, RFI, Corona	#	#	#	#	http://www.radarengineers.com/rfitvi.htm	Use of RFI to get into general location of Corona and then use acoustic to pinpoint Corona Location.	950	0
Fred Horning 503.256.3417	Radar Engineers	244(tenatively)	Still in testing. Basic summary would be a handheld model of the 247-b. Called switch gear sniffer. Use RFI detector to find cabinet of Corona occurance and then acoustic to pinpoint Corona location.	#	#	#	#	#	#	#	#	RFI, Acoustic, Corona	#	#	#	#	http://www.radarengineers.com/rfitvi.htm	Use of RFI to get into general location of Corona and then use acoustic to pinpoint Corona Location.	0	0
Fred Horning 503.256.3417	Radar Engineers	M330	RFI locators detect sparks and corona that cause radio and T.V. interference (RFI TVI). RF and ultrasonic receivers quickly pinpoint sparking hardware on powerlines.	#	#	#	#	#	#	#	#	RFI, Corona	#	#	#	#	http://www.radarengineers.com/rfitvi.htm	Use of RFI to get into general location of Corona and then use acoustic to pinpoint Corona Location.	1800	0
Fred Horning 503.256.3417	Radar Engineers	240-A	HF-UHF RFI Locator 1.8-1000 MHZ Oscilloscope Display	#	#	#	#	#	#	#	#	RFI, Corona	#	#	#	#	http://www.radarengineers.com/rfitvi.htm	Use of RFI to get into general location of Corona and then use acoustic to pinpoint Corona Location.	4700	0

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Fred Horning 503.256.3417	Radar Engineers	242	AM-UHF RFI Locator 500 KHZ-1000 MHZ Oscilloscope Display A.M. Probe	#	#	#	#	#	#	#	#	RFI, Corona	#	#	#	#	http://www.radarengineers.com/rfitvi.htm	Use of RFI to get into general location of Corona and then use acoustic to pinpoint Corona Location.	5500	0
Fred Horning 503.256.3417	Radar Engineers	250	Parabolic Pinpointer Ultrasonic Locator for use from the ground	#	#	#	#	#	#	#	#	Acoustic, Corona	#	#	#	#	http://www.radarengineers.com/rfitvi.htm	Use of RFI to get into general location of Corona and then use acoustic to pinpoint Corona Location.	3100	0
http://www.rauckmanutility.com/homevoltwitch.htm	Rauckman Utility Products	Voltwitch	VoltWitch is an innovative drive-by voltage indicator that is installed in a line truck or utility vehicle like a radar detector. Instead of sensing radar signals, the VoltWitch senses energized overhead power lines.	#	#	#	#	#	#	#	#	Voltage	#	#	#	#	http://www.rauckmanutility.com/homevoltwitch.htm		513	0
1.450.465.1113	Roctest	FOT-F FOT	FOT-F and FOT-N temperature transducers combine all the desired characteristics expected from the ideal sensor. Their compact size, immunity to EMI/RFI/lightning, resistance to corrosive environments, high accuracy and reliability make them the best choi	#	#	#	#	#	#	#	#	Temperature, Optical	#	#	#	#	http://www.roctest.com/modules/AxialRealisation/img_repository/files/documents/FOT-E50173-W.pdf	Used to monitor a variety of systems. Could be used on transformers to monitor temperature or conductors, however installation on conductors is not a normal procedure. Requires a readout or datalogging device with fiber-optic interface.	250	0

Organization Surveyed's Name	Manufacturer	Sensor Name	Brief Description	Voltage Sensor	Current Sensor	Temperature Sensor	Acoustic Sensor	Vibration Sensor	Optical Sensor	RFI Sensor	Corona Sensor	Sensor Type	Currently Available	Currently Sold to Utilities	Tested	Planning on Testing	Website	Anticipated Use	Cost	Installation Cost
Rene DeBlois 1-450-465-1114 x 235	Roctest	PAVICA	The PAVICA is a unique, small, lightweight instrument used to monitor and analyse vibrations in overhead transmission lines. The PAVICA measures the frequency and amplitude of all vibration cycles over all sampling periods, stores the data in a high-defi	#	#	#	#	#	#	#	#	Vibration	#	#	#	#	http://www.roctest.com/modules/AxialRealisation/img_repository/files/documents/E5018B-050901.pdf	The battery life in our Pavica is approx 3 months. This figure vary according to the sampling rate and sampling time as well as the ambient temperature. In the user manual, we give a formula that give the end-user the expected life of their battery for th	9600	0
Joe Feyka(205) 985-4512 Ext. 3353	S&C	CS/CSV	S&C CS Line Post Current Sensors and CSV Line-Post Current/Voltage Sensors provide an economical, effective way to measure current and voltage (optional) for your capacitor control and other applications. The CS/CSV Sensors are well-suited for working wit	#	#	#	#	#	#	#	#	Voltage, Current	#	#	#	#	http://www.sandc.com/products/capacitorcontrols/currentvoltagesensors.asp	CS Line Post Current Sensor 14.4 KV 904-001124-00 $ 650 ea 25 904-001125-00 $819 ea 34.5 904-001126-00 $1075 ea CSV Line Post Current/Voltage Sensor 14.4 904-001128-01 $ 1225 ea 25	650	0
	Sabrifa	Reflex	The rugged, splash-proof enclosure is designed to withstand the most punishing industrial environments. For industrial needs, Reflex units can be installed together on a special 19 in. rack-mounted plates. For special applications, like transformer hot sp	#	#	#	#	#	#	#	#	Temperature	#	#	#	#	http://www.safibra.cz/english/index.html		0	0

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	Sabrifa	T-Guard	The Neoptix™ T/Guard™ is a multi-channel fiber optic temperature monitoring system for power transformer hot spot measurements. The T/Guard™ system has been developed with long-term performance and stability in mind. This fiber-optic temperature monitorin	#	#	#	#	#	#	#	#	Temperature	#	#	#	#	http://www.safibra.cz/english/produkty/senzory/teplota.html		0	0
SEL	SEL	AutoRANGER	When a fault occurs, two of the AutoRANGER's red LEDs will begin to flash. After one minute, the indicator will measure the system current. If it detects load current, the AutoRANGER's yellow LED will begin to flash and the red LEDs will turn off, indicat	#	#	#	#	#	#	#	#	Current	#	#	#	#	http://www.eosmfg.com/products/AR4.html		150	0
SEL	SEL	Beacon Electrostatic Reset	SEL BEACON® electric field reset fault indicators (BER) derive their operating power from the potential gradient around high-voltage power lines. The BERs inrush restraint option prevents false tripping that might otherwise occur because of reclosing oper	#	#	#	#	#	#	#	#	Voltage	#	#	#	#	http://www.eosmfg.com/products/BER.html		130	0
SEL	SEL	Overhead Electrostatic Reset	SEL electric field reset fault indicators (type E-ERL) derive their operating power from the potential gradient around high-voltage power lines. The E-ERL's inrush restraint option blocks targeting for recloser operations. When the upstream protection ope	#	#	#	#	#	#	#	#	Voltage	#	#	#	#	http://www.eosmfg.com/products/ERL.html		82	0

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	SEL	Underground AutoRANGER	Ensure the best fault-indicating solution for your underground application by choosing from a wide variety of single- and threephase display options, including remote displays that eliminate the need to open the enclosure to check the fault indicator's st	#	#	#	#	#	#	#	#	Current	#	#	#	#	http://www.eosmfg.com/products/AR_URD.html	Can be used with Radio Ranger fault location system. Identify the phase and location of underground faults with the handheld Remote Fault Reader. Wireless Interface ID, phase, and way distinctions display faultpath information in each vault while differe	100	0
	SEL	SEL LINAM Current Reset Fault Indicators	Senses the load and fault currents on the conductor. Use the optional auxiliary contact to provide status indication to a SCADA input.	#	#	#	#	#	#	#	#	Current	#	#	#	#	http://www.eosmfg.com/literature/LINAMCRflyer.pdf	Use the optional auxiliary contact to provide status indication to a SCADA input.	150	0
	SEL	Single-Phase Test Point Mounted Bolt Display FCI	Install 1TPRB fault indicators in padmount transformers, subsurface load centers, or junction sectionalizing points. In single-phase underground loop applications, install the 1TPRB at the transformer. At sectionalizing junctions, place an indicator on ea	#	#	#	#	#	#	#	#	Current	#	#	#	#	http://www.eosmfg.com/products/1TPRB.html		78	0
	Sensor Net	Sentinel DTS Range	This DTS system has been designed with safety in mind and tested to some of the industry's most rigorous standards. With the addition of a multiplexing module it can easily be configured to produce multiple double-ended measurements. User configurable zon	#	#	#	#	#	#	#	#	Temperature	#	#	#	#	http://www.sensornet.co.uk/technology/distributed-temperature-sensing/sentinel-dts-range/		0	0

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	SensorTran	DTS Units	The SensorTran DTS 5100 range of intelligent DTS systems provide real-time dynamic temperature with high accuracy and fine resolution, providing up to 40,000 discrete temperature points along optical fiber(s).	#	#	#	#	#	#	#	#	Temperature	#	#	#	#	http://www.sensortran.com/dtsunits.php	• on-board Ethernet-enabled computer with open communications architecture • autonomous data collection and storage • multiple zones and alarms • flexible data, alarm and remote control/access communications • self-diagnostics, auto start & safe shut-down	0	0
	Shaw Energy Delivery Services	Thermal Rate System	It consists of ThermalRate™ Monitors (TRMs), which are installed along the line. The TRM is a replica of the line conductor, with the same material, diameter, and surface. It is oriented in the same direction as the line to establish how the present weath	#	#	#	#	#	#	#	#	Temperature	#	#	#	#	http://eds.shawgrp.com/thermalrate.html	Determining the actual current capacity of a high voltage transmission line.	0	0
	Southwire Company	DTS	The measurement technology Southwire is exploring is called Distributed Temperature Sensing (DTS), and it uses fiber optic strands contained in the overhead conductor. By monitoring key optical fiber characteristics, grid operators can get an accurate, sp	#	#	#	#	#	#	#	#	Temperature	#	#	#	#	http://www.southwire.com/processGetArticle.do?commonId=5283ae6fef122010VgnVCM1000002702a8c0____		0	0
	SSI power	CMD	The CMD is not limited to substation applications, being equally well suited for application on distribution lines, subtransmission lines, transmission lines, and EHV transmission lines. In line applications the CMD provides the functions of real-time li	#	#	#	#	#	#	#	#	Voltage, Current	#	#	#	#			0	0

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	Sumitomo	OP-Thermo	Op-Thermo & only one line of Optical Fiber is necessary to measure continuous & real-time temperature profile at thousands of points along the fiber without any data transmission devices.	#	#	#	#	#	#	#	#	Temperature	#	#	#	#	http://www.sumitomoelectricusa.com/scripts/products/ofig/dts.cfm		0	0
nj@suretech.co.za	SURETECH	SURETECH VI-x Monitoring System	The SURETECH Vix monitoring system senses, processes and logs electrical parameters to data flash memory, on MV (Medium Voltage) equipment. Sensor outputs are fed to a SURETECH SLP (Smart Load Processor), which samples Voltage, Current, Phase angle and Qu	#	#	#	#	#	#	#	#	Voltage, Current	#	#	#	#	http://www.suretech.co.za/8_VIxSns04.pdf		0	0
nj@suretech.co.za	SURETECH	HV Transducer Current Probe	This range of current probes is used for measuring tan(delta) on HV apparatus, insulation resistance and capacitance under HV operational and test conditions. Leakage current is measured and its phase is compared with the HV reference excitation voltage's	#	#	#	#	#	#	#	#	Current	#	#	#	#	http://www.suretech.co.za/1_HVTrCP2.pdf		0	0
nj@suretech.co.za	SURETECH	AC Current Sensors	SURETECH AC Current sensors are available in various formats, including slip-on, or bar-primary. These sensors are available for single OR three phase measurements. The sensor uses Rogowski technology to measure AC currents. Rogowski technology does not r	#	#	#	#	#	#	#	#	Current	#	#	#	#	http://www.suretech.co.za/1_rogCur02.pdf		0	0
Syntronics	Syntronics	Corona Finder	Small and battery operated, the CoronaFinder is easy to take to the field. Real time UV viewing means that high voltage equipment can be quickly and thoroughly inspected for evidence of corona discharge that is visible only in the ultraviolet spectrum (s	#	#	#	#	#	#	#	#	Optical, Corona	#	#	#	#	http://www.syntronics.net/CoronaFinder.htm	Corona Detection.	14035	0

Organization Surveyed's Name	Manufacturer	Sensor Name	Brief Description	Voltage Sensor	Current Sensor	Temperature Sensor	Acoustic Sensor	Vibration Sensor	Optical Sensor	RFI Sensor	Corona Sensor	Sensor Type	Currently Available	Currently Sold to Utilities	Tested	Planning on Testing	Website	Anticipated Use	Cost	Installation Cost
208-658-1292 x24	Telemetric	TVM	The Telemetric Voltage Monitor (TVM) family of products offer a cost-effective voltage monitoring, interruption detection, and power quality solution. The TVM is available in single phase (TVM1) and two three phase versions, TVM3-120V and TVM3-277V. With	#	#	#	#	#	#	#	#	Voltage	#	#	#	#	http://209.85.165.104/search?q=cache:http://www.telemetric.net/info/Applications_LineVoltage.htm	Report momentary and sustained power outage. Over/under voltage events. Integrated cellular module. Provide cellular data service and hosted application to view network of sensors.	0	0
Telepathx	Telepathx	Intelligent Insulators Current Leakage Sensors	Telepathx Pinpoint sensors are the first non invasive RFID solution for monitoring faulting distribution insulators, they alert you via wireless connection when the thermal threshold has been reached providing energy maintenance personnel exact time and l	#	#	#	#	#	#	#	#	Temperature	#	#	#	#	http://www.telepathx.com/solutions.htm	Available in the following protocols 433Mhz Reactive RFID 900Mhz Reactive RFID 900Mhz Reactive 802.15.4 RFID 2.4Ghz Reactive 802.11g 2.4Ghz Reactive 802.15.4	0	0
	Telepathx	RFID cutout fuse monitor	The fixed frequency RFID Fob has a range of 100 to 125 meters and communicates with the TPX-GSM-100 Remote Transmission Unit (Access Point) or Telepathx compatible smart Meters, BPL/PLC & WIFI access points alerting you when and where a fuse has been acti	#	#	#	#	#	#	#	#	Optical	#	#	#	#	http://www.telepathx.com/solutions_cutout.htm	Available in the following protocols 433Mhz Reactive RFID 900Mhz Reactive RFID 900Mhz Reactive 802.15.4 RFID 2.4Ghz Reactive 802.11g 2.4Ghz Reactive 802.15.4	0	0

Organization Surveyed's Name	Manufacturer	Sensor Name	Brief Description	Voltage Sensor	Current Sensor	Temperature Sensor	Acoustic Sensor	Vibration Sensor	Optical Sensor	RFI Sensor	Corona Sensor	Sensor Type	Currently Available	Currently Sold to Utilities	Tested	Planning on Testing	Website	Anticipated Use	Cost	Installation Cost
stanruffin@aol.com	Thomas & Betts	Elastimold TPM Series	Test Point Mounted Fault Indicators provide a clear, visual means for locating faulted cables and equipment on underground distribution systems. Indicators are self-powered and consist of a solid state current sensor connected to a faulted circuit display	#	#	#	#	#	#	#	#	Current	#	#	#	#	http://www-public.tnb.com/util/docs/PC_VI_TPM.pdf		0	0
stanruffin@aol.com	Thomas & Betts	UCM Series	URD Cable Mounted Fault Indicators aid in locating faulted cables and equipment on underground distribution systems. Indicators are self powered and consist of a solid state current sensor connected to faulted circuit display.	#	#	#	#	#	#	#	#	Current	#	#	#	#	http://www-public.tnb.com/util/docs/PC_VI_UCM.pdf		100	0
stanruffin@aol.com	Thomas & Betts	OLM Standard	Overhead Line Fault Indicators aid in locating faulted circuits and equipment on overhead distribution systems. Indicators are self powered and consist of a solid state current sensor connected to a faulted circuit display. Designs incorporate advanced ci	#	#	#	#	#	#	#	#	Current	#	#	#	#	http://www-public.tnb.com/util/docs/PC_VI_OHD-LM.pdf		99	0
stanruffin@aol.com	Thomas & Betts	V2 Standard	Test Point Mounted Neon Voltage Indicators provide a convenient, visual method for determining the energized status of underground distribution circuits. The indicator consists of a self-powered voltage sensor connected to a neon light that flashes when e	#	#	#	#	#	#	#	#	Current	#	#	#	#	http://www-public.tnb.com/util/docs/PC_VI_VI.pdf		30	0
800-878-3399	Tollgrade	LightHouse	Tollgrade's LightHouse solution is designed to provide real-time grid intelligence by using sensors that continuously monitor key circuit parameters and transmit them over a self-configuring wireless mesh network to a central location.	#	#	#	#	#	#	#	#	Current, Temperature	#	#	#	#	http://www.tollgrade.com/lighthouse/index.html	4-35kV. Still in pilot programs. Hot stick mountable. Also measures 3rd harmonic.	700	0

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contactus@airak.com	unknown	Airak's Patented Optical Current Sensor System	Safe and Easy to Install - does not conduct electrical current - intrinsically isolated making it safe to personnel and interconnected equipment Small, Lightweight, Immune to EMI/RFI, Zero Risk of Explosive Failure, Intended for 54.5 KV Applications and Be	#	#	#	#	#	#	#	#	Current, Optical	#	#	#	#	http://www.airak.com/OCS.htm	Appear to have obtained U.S. Navy contract. Does not appear to be available to the public.	0	0
	unknown	RF Smart Monitor System	The RF Smart Monitor System is designed to allow the user to remotely collect machine vibration and temperature data without the need for cabling. This system, which is designed to monitor a wide variety of machine components.	#	#	#	#	#	#	#	#	Voltage, Temperature, Vibration	#	#	#	#	http://www.buzzle.com/editorials/7-30-2004-57266.asp		0	0
	unknown	Optical Sensors	A novel photoacoustic spectrometer (PA) has been developed for in-situ detection of SF6 leaks in low concentrations. The developed system is equipped with a sound alarm system and has been tested in the laboratory for very minute SF6 leaks. This newly dev	#	#	#	#	#	#	#	#	Optical	#	#	#	#	http://ieeexplore.ieee.org/xpl/freeabs_all.jsp?isnumber=21736&arnumber=1007706&count=20&index=12		0	0
	unknown	Promethean Devices	Low-Cost, Non-Contact, High Accuracy Sensor for the Simultaneous, Reliable, Real-time Determination and Monitoring of HV Transmission Line Sag, Temperature, Current, and Ampacity.	#	#	#	#	#	#	#	#	Current, Temperature	#	#	#	#	http://www.oe.energy.gov/DocumentsandMedia/High_Accuracy_Low_Cost_Sensors_for_Monitoring_Syracuse.pdf	No contact informaion. Website is under construction.	0	0
914-273-8727 (Larry Fish)	USI Power	Power Donut 2	The Power-Donut2™ is an engineering instrumentation platform whose functions include: data acquisition, data monitoring and logging the parameters of high voltage overhead conductors. The Power-Donut2™ is completely self- contained, allowing for hot stick	#	#	#	#	#	#	#	#	Voltage, Current, Temperature	#	#	#	#	http://www.usi-power.com/	Will be mass produced soon. Price should drop. Currently Testing new model which will offer full waveform capturing and event logging as well as offer GPS clock.	14500	0

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