

Technology Assessment and Application Guide for Mini-Electronic Voltage Regulator (EVR)TM

1015866

Technology Assessment and Application Guide for Mini-Electronic Voltage Regulator (EVR)TM

1015866

Technical Update, December 2008

EPRI Project Manager

B. Howe

DISCLAIMER OF WARRANTIES AND LIMITATION OF LIABILITIES

THIS DOCUMENT WAS PREPARED BY THE ORGANIZATION(S) NAMED BELOW AS AN ACCOUNT OF WORK SPONSORED OR COSPONSORED BY THE ELECTRIC POWER RESEARCH INSTITUTE, INC. (EPRI). NEITHER EPRI, ANY MEMBER OF EPRI, ANY COSPONSOR, THE ORGANIZATION(S) BELOW, NOR ANY PERSON ACTING ON BEHALF OF ANY OF THEM:

(A) MAKES ANY WARRANTY OR REPRESENTATION WHATSOEVER, EXPRESS OR IMPLIED, (I) WITH RESPECT TO THE USE OF ANY INFORMATION, APPARATUS, METHOD, PROCESS, OR SIMILAR ITEM DISCLOSED IN THIS DOCUMENT, INCLUDING MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE, OR (II) THAT SUCH USE DOES NOT INFRINGE ON OR INTERFERE WITH PRIVATELY OWNED RIGHTS, INCLUDING ANY PARTY'S INTELLECTUAL PROPERTY, OR (III) THAT THIS DOCUMENT IS SUITABLE TO ANY PARTICULAR USER'S CIRCUMSTANCE; OR

(B) ASSUMES RESPONSIBILITY FOR ANY DAMAGES OR OTHER LIABILITY WHATSOEVER (INCLUDING ANY CONSEQUENTIAL DAMAGES, EVEN IF EPRI OR ANY EPRI REPRESENTATIVE HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES) RESULTING FROM YOUR SELECTION OR USE OF THIS DOCUMENT OR ANY INFORMATION, APPARATUS, METHOD, PROCESS, OR SIMILAR ITEM DISCLOSED IN THIS DOCUMENT.

ORGANIZATION(S) THAT PREPARED THIS DOCUMENT

Electric Power Research Institute (EPRI)

This is an EPRI Technical Update report. A Technical Update report is intended as an informal report of continuing research, a meeting, or a topical study. It is not a final EPRI technical report.

NOTE

For further information about EPRI, call the EPRI Customer Assistance Center at 800.313.3774 or e-mail askepri@epri.com.

Electric Power Research Institute, EPRI, and TOGETHER...SHAPING THE FUTURE OF ELECTRICITY are registered service marks of the Electric Power Research Institute, Inc.

Copyright © 2008 Electric Power Research Institute, Inc. All rights reserved.

CITATIONS

This document was prepared by

Electric Power Research Institute (EPRI)
942 Corridor Park Boulevard
Knoxville, TN 37932

Principal Investigator
B. Vairamohan

This document describes research sponsored by EPRI.

This publication is a corporate document that should be cited in the literature in the following manner:

Technology Assessment and Application Guide for Mini-Electronic Voltage Regulator (EVR).
EPRI, Palo Alto, CA: 2008. 1015866.

PRODUCT DESCRIPTION

Sustained interruptions, which usually require distribution circuit repair, are not the only events that cause problems for electric power customers. Momentary breaker and recloser operations before lockout can be just as detrimental to sensitive end-use equipment as the actual lockout itself. Voltage sag mitigation devices can effectively ride through the voltage disturbances caused by these events. This report evaluates one such power quality mitigation device, the Mini-Electronic Voltage Regulator (EVR)TM.

Background

Every year there are new power quality mitigation devices that come to the market. This project is aimed at understanding the capabilities and limitations of the emerging power quality mitigation devices so as to inform the readers the possible applications of such devices.

Objectives

- To evaluate the functional capabilities of the Mini-EVR by using a system compatibility test procedure developed by EPRI to characterize its performance
- To describe the operation of the Mini-EVR and its potential applications

Approach

In order to evaluate the Mini-EVR, the EPRI testing team subjected the device to various voltage sag and swell conditions. The team conducted several tests to see if the device meets the manufacturer's specifications and described the testing program and its results in detail in this report.

Results

The Mini-EVR uses solid-state switches and transformers with taps to adjust the output voltage in response to a variation at the input. During normal operating conditions, a control circuit monitors the output voltage of the unit. Should this voltage be above or below the nominal value of 120V +/- 3%, the solid-state switches are used to select an appropriate transformer tap selections to correct the output voltage. The Mini-EVRTM is specified to hold the output voltage within a margin of $\pm 3\%$ for an input voltage range of +10/-25%. Voltage sags (momentary under-voltages lasting for less than one second) can be responsible for a large percentage of equipment trips in both commercial and residential settings. In such cases, the Mini-EVR should protect the load by supplying additional voltage to compensate for any difference in the nominal voltage and the sag voltage

The Mini-EVR met most of its specifications. However, there are certain characteristics of this device, such as slower response time and the lack of an energy storage capability, which would make it less suitable to protect very sensitive equipment. The device provides the best protection within the voltage range of 80% to 105% of the nominal input voltage.

EPRI Perspective

EPRI's role is to bring together members, participants, the Institute's scientists and engineers, and other leading experts to work collaboratively on solutions to the challenges of generating and distributing electric power. In the area of power quality and system compatibility, EPRI periodically conducts studies and evaluations of new technologies. EPRI believes that continued involvement in this work helps bring to the forefront new issues and solutions that will eventually benefit the utilities, their customers and the public.

Keywords

Power quality

Voltage sag

Voltage swell

Inrush

Voltage stabilizer

Electronic voltage regulator

Sag mitigation

CONTENTS

1 INTRODUCTION	1-1
Problems Associated With Voltage Fluctuations.....	1-1
Voltage Sag Mitigation Device	1-1
Mini-EVR™ Operation.....	1-2
Company Overview.....	1-3
2 MINI-EVR™ CHARACTERIZATION TESTS	2-1
Mini-EVR™ Characterization tests.....	2-1
Test Description	2-1
Rationale	2-1
Objectives	2-1
Test Setup.....	2-1
Test Results	2-3
Voltage Regulation Tests	2-3
Response Time	2-5
Inrush Current	2-7
SEMI F47 Standard Compliance and ILB Characterization Tests	2-8
3 APPLICATION OF THE MINI-EVR™	3-1
Typical Mini-EVR™ Application	3-1
Key Parameters for Specifying a Mini-EVR™	3-1
Inrush Current	3-1
Installation	3-1
Sizing of the Mini-EVR™	3-2
Switching (or Response) Time	3-3
Comparison With Similar Power Conditioners	3-3
4 SUMMARY	4-1
A SPECIFICATION OF MINI EVR.....	A-1

LIST OF FIGURES

Figure 1-1 Photograph of the 3kVA Mini-EVR™ From Utility Systems Technologies, Inc.....1-2

Figure 1-2 Simplified Schematic of the Mini-EVR™1-3

Figure 2-1 Block Diagram of the Voltage Sag Test Setup2-2

Figure 2-2 Test Setup at EPRI Laboratory in Knoxville, TN.....2-2

Figure 2-3 Input and Output Voltage Characteristic of Mini-EVR™2-3

Figure 2-4 Mini-EVR™ Response to a 12 Cycle Sag to 50% of Nominal Voltage.....2-4

Figure 2-5 Response of Mini-EVR™ to a 60 Cycle Sag to 80% of Nominal Voltage.....2-5

Figure 2-6 Response Time of Mini-EVR™ During a Voltage Sag Down to 80% of Nominal
Voltage With Duration of 60 Cycle (50% load).....2-6

Figure 2-7 Inrush Current After a Voltage Sag Event, Peak Current Value is 112A.....2-7

Figure 2-8 SEMI F47 Curve and the Mini-EVR™ Voltage-Sag Ride Through Curve2-8

Figure 3-1 Terminal Screws for Installation3-2

LIST OF TABLES

Table 2-1 Summary of Voltage Sag Test Performed on the Mini-EVR™ at 100% Load Condition	2-6
Table 3-1 Comparison of Power Conditioners	3-3

1

INTRODUCTION

Problems Associated With Voltage Fluctuations

Sustained interruptions, which usually require distribution circuit repair, are not the only events that cause problems for electric power customers. The momentary breaker and recloser operations before lockout can be just as detrimental to sensitive end-use equipment as the actual lockout itself. For example, semiconductor manufacturing plants can be especially vulnerable to momentary interruptions. The total time required to produce a semiconductor chip may be as long as 30 days, with numerous critical processes involved. The chip can be ruined anytime in this process if a voltage sag or momentary interruption causes a sensitive machine to trip or causes abnormal operation. Other industries that are sensitive to voltage sags and momentary interruptions include plastics, rubber, paper, textiles, glass, and steel manufacturing plants.

Most plants can ride through these voltage drops by virtue of their mechanical and electrical inertia. However, this is not the case with electrically held-in contactors and relays that control the machinery. Contactors can drop out within 5 to 20 milliseconds after the start of voltage sags as slight as 75% of nominal voltage. Often these contactors can be responsible for shutdown of the entire process. This can be complicated, time-consuming, and expensive to the electric power customer.

Voltage Sag Mitigation Device

There are numerous voltage sag mitigation devices on the market that can effectively ride through the voltage disturbances. This report describes evaluation of the Utility Systems Technologies, Incorporated device called the Mini-EVR™ as a voltage sag mitigation device. The tested unit (Model number: MEVR-030-120-60) was a single phase unit with an operating voltage and frequency of 120V and 60 Hz and rated for 3 kVA. The Mini EVR available in the range of 1kVA to 15kVA. A photo of the Mini-EVR™ test sample is shown in Figure 1-1. Key specifications and features for the product line are given in Appendix-A.

Electronic voltage regulators are single-phase power conditioners designed to maintain an output voltage at a constant level even though the input voltage is varying. Critical to the device operation is the response time of the correction. As stated above, some sensitive devices can fail to operate properly even for single cycle voltage sags at less than 75% of nominal voltage.



Figure 1-1
Photograph of the 3kVA Mini-EVR™ From Utility Systems Technologies, Inc.

Mini-EVR™ Operation

The Mini-EVR™ uses solid state switches and transformers with taps to adjust the output voltage in response to a variation at the input. The functional schematic shown in Figure 1-2 illustrates the operation of the device.

During normal operating conditions, a control circuit monitors the output voltage of the unit. Should this voltage be above or below the nominal value of 120V +/- 3%, the solid state switches are used to select an appropriate transformer tap selections to correct the output voltage. The Mini-EVR™ is specified to hold the output voltage within a margin of $\pm 3\%$ for an input voltage range of +10/-25%.

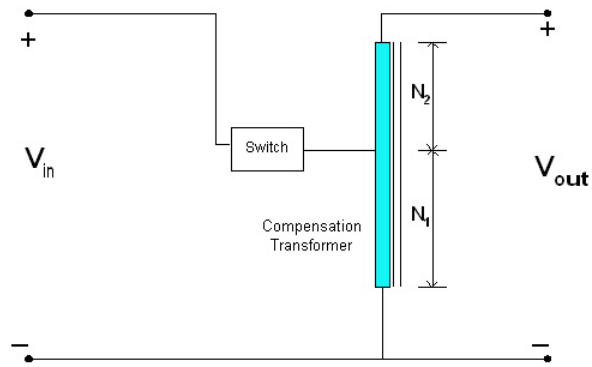


Figure 1-2
Simplified Schematic of the Mini-EVR™

Company Overview

Utility Systems Technologies, Inc has been manufacturing electronic voltage regulation products since 1991. The company has several voltage mitigation and power conditioning product lines such as Sure-Volt, Sag Fighter and mini EVR. The company has head quartered in Latham, New York.

2

MINI-EVR™ CHARACTERIZATION TESTS

Mini-EVR™ Characterization tests

The following section covers the test conducted at the EPRI Knoxville, Tennessee laboratory on a 3kVA Mini-EVR unit. The tests include a SEMI F47 standard compliance test, industrial load bank (ILB) characterization test, and inrush current test. In order to simulate the voltage sag conditions, EPRI's custom-made portable sag (Porto Sag) generator was used.

Test Description

Rationale

Voltage sags (momentary under-voltages lasting for less than one second) can be responsible for a large percentage of equipment trips in both commercial and residential settings. In such cases, the Mini-EVR™ should protect the load by supplying additional voltage to compensate for any difference in the nominal voltage and the sag voltage. The tests performed determine whether the device operates as specified by the vendor and whether the response time of the Mini-EVR™ is sufficiently fast to protect sensitive devices.

Objectives

The objectives of the tests are multifold as follows:

1. To characterize the performance of the device, and verify that it meets the manufacturer's specifications
2. To find the response time of the Mini-EVR™ in switching to the compensation transformer during voltage sags
3. To determine the maximum inrush current by the load that the Mini-EVR™ can withstand
4. To determine the sag protection envelope of the Mini-EVR™
5. To uncover any application issues that will be valuable to the end-user

Test Setup

Figure 2-1 shows a schematic for the voltage sag test conducted on the Mini-EVR™. Initially the Mini-EVR™ (or unit under test – UUT) is loaded up to 50% of the rated loading. An EPRI designed voltage sag generator is used to apply voltage sags of various magnitudes and durations, including the points specified in the SEMI F47 standard. Tests are then repeated at full load (100% loading) with the same test conditions. The input and the output voltages and currents of the Mini-EVR™ are monitored and recorded for analysis.

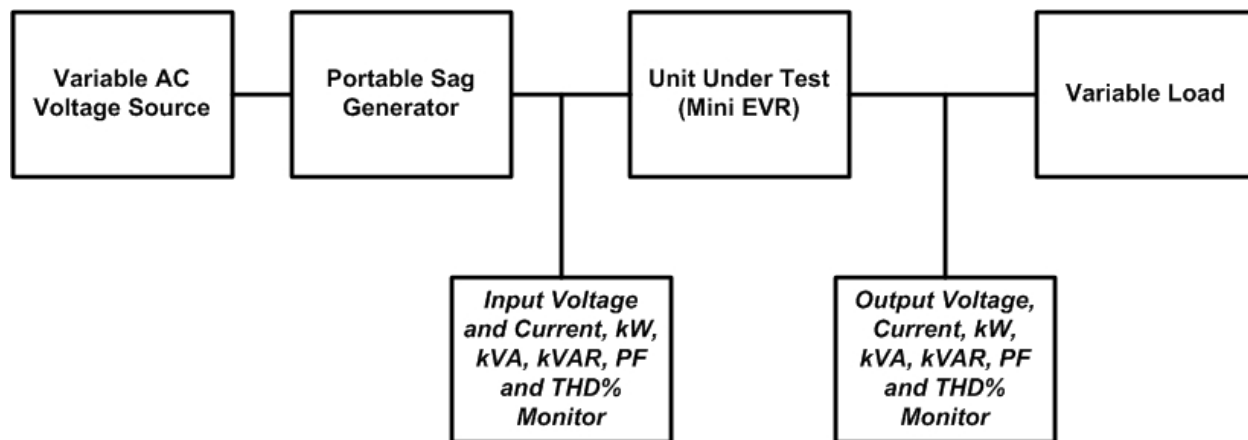


Figure 2-1
Block Diagram of the Voltage Sag Test Setup

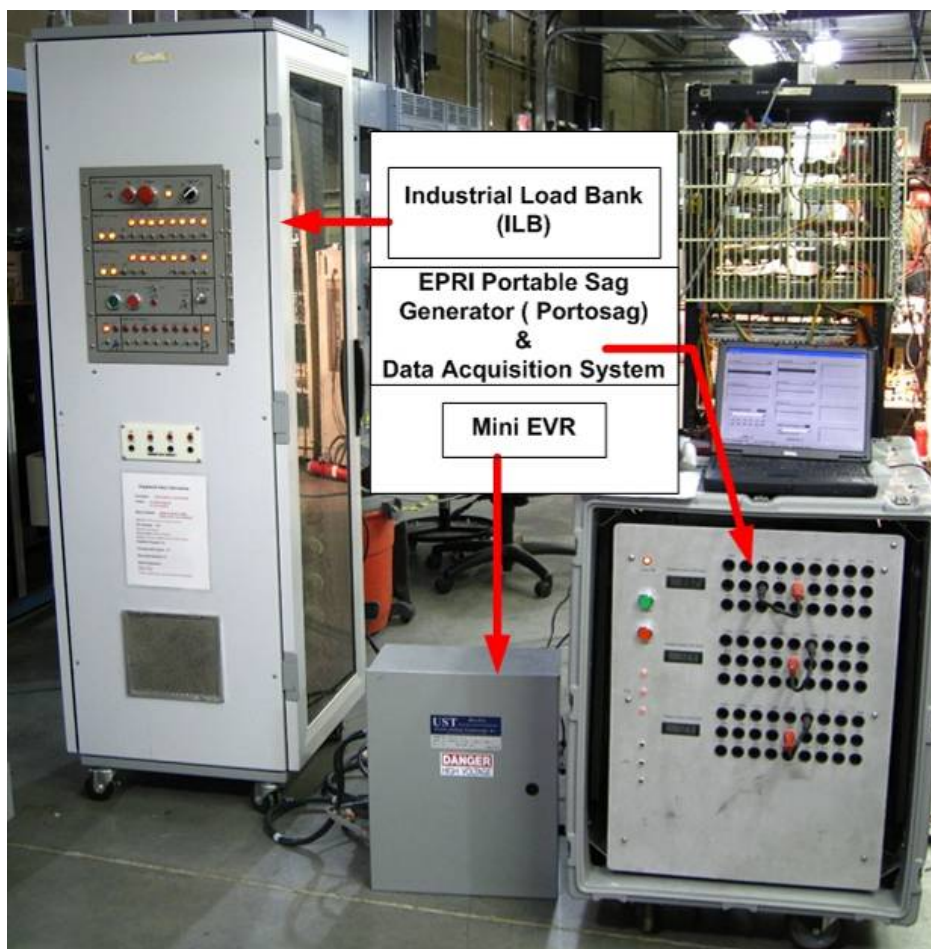


Figure 2-2
Test Setup at EPRI Laboratory in Knoxville, TN

Test Results

The results of the sag testing of the Mini-EVR™ are summarized below.

Voltage Regulation Tests

During normal operating conditions, a control circuit monitors the output voltage of the unit. Should this voltage be above or below the nominal value of 120 V +/- 3%, the solid state switches are used to select an appropriate transformer tap selections to correct the output voltage. The Mini-EVR™ is specified to hold the output voltage within a margin of $\pm 3\%$ for an input voltage range of +10 to -25%.

To verify this performance specification, EPRI conducted a simple test during which the input voltage was gradually increased from 95 V RMS to 135 V RMS. The test was repeated at five different levels of load between no load and full load. Since the tap locations are discrete, the output voltage varies in step fashion for input voltage changes as illustrated in the test results shown in Figure 2-3.

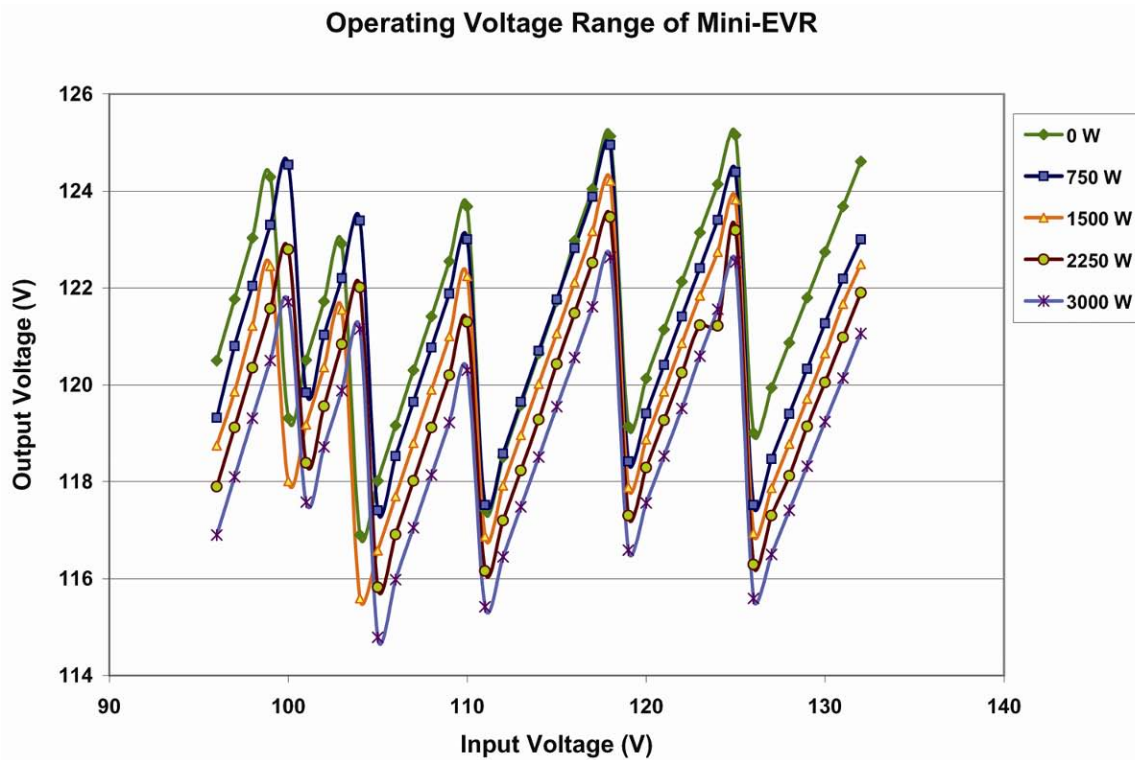


Figure 2-3
Input and Output Voltage Characteristic of Mini-EVR™

From the test data, it was found that the maximum voltage variation took place when Mini-EVR™ was loaded at the 3000W (full load) power level, with a variation of $\pm 4.34\%$ in the output voltage. According to our experience, this is very typical for a tap changer circuit. The

minimum voltage variation was observed when the load was 2250W, with a corresponding voltage variation of $\pm 3.48\%$.

According to the manufacturer's data sheet, tap switching in the Mini-EVR™ takes about 1 cycle to occur. Actual test data for transient voltage sags is illustrated in the sequence of figures given below. Figure 2-4 shows the input and output voltage waveforms of the Mini-EVR™ after the application of voltage sag with a sag depth of 50% through a portable sag generator at the EPRI Knoxville laboratory.

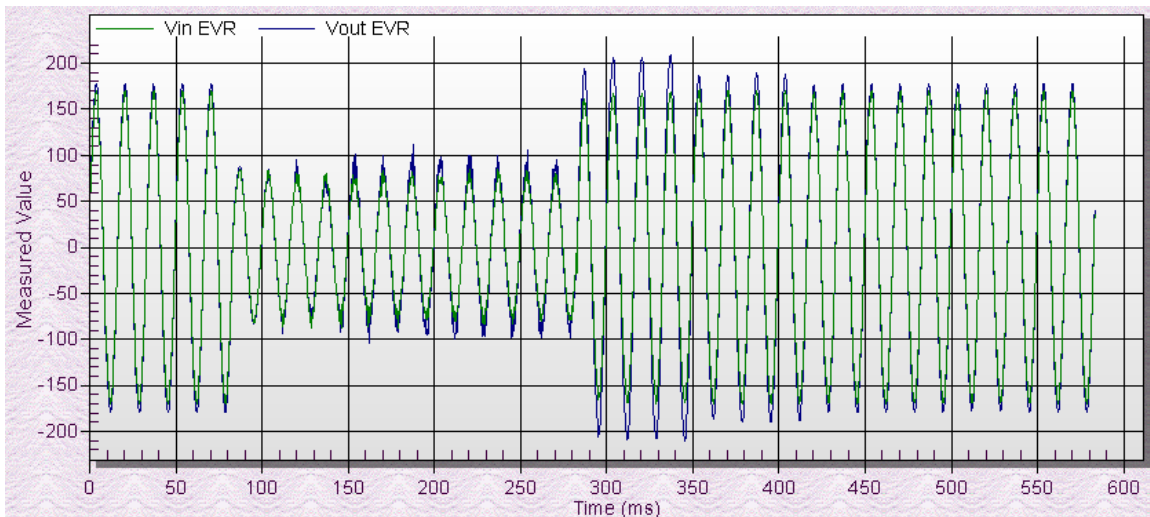


Figure 2-4
Mini-EVR™ Response to a 12 Cycle Sag to 50% of Nominal Voltage

In Figure 2-4 the Mini-EVR™ was subjected to a 12 cycle, 50% sag. After about 1.5 cycles it can be seen that the unit switched voltage taps and slightly increased the output voltage. Tap switching appears to occur at roughly 1.5 cycles intervals in a sequential fashion. The Mini-EVR™ is designed to provide voltage support down to an input voltage level of 75% of nominal. As can be seen, there is not sufficient range in the step up taps to compensate for a 50% sag. As the sag subsides it can also be seen that there is an overvoltage condition due to the delay in tap switching which persists for about 8 cycles, with the first 4 cycles being larger in amplitude.

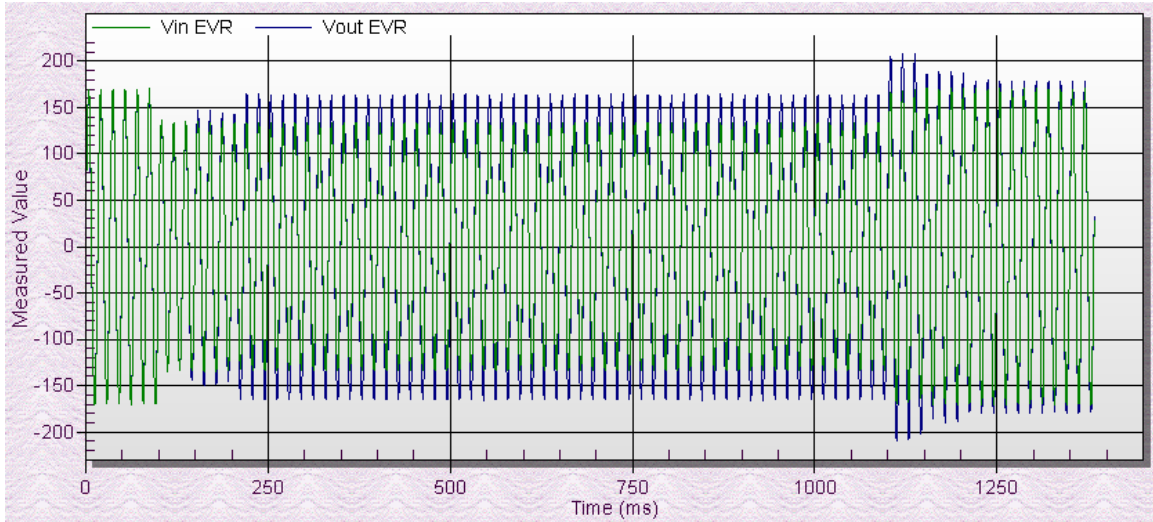


Figure 2-5
Response of Mini-EVR™ to a 60 Cycle Sag to 80% of Nominal Voltage

In Figure 2-5 the Mini-EVR™ was subjected to a 60 cycle sag to 80% of nominal voltage. Again, it can be seen that the voltage support does not occur for about 1.5 cycles after the start of the sag event and does not reach a fully compensated level for about 8 cycles. For sensitive loads the lack of voltage support for the initial 3 to 6 cycles could lead to unreliable behavior.

Response Time

Response time is the time taken by the Mini-EVR™ to switch from the input supply voltage to the corrected voltage during voltage sag conditions. This is an important issue for power conditioners because some sensitive loads can trip before the transfer is complete (less than one cycle). The Mini-EVR has a response time which is on the order of about 6 cycles (it appears that each tap change takes about 1.5 cycles to occur and it takes several tap changes to compensate for the voltage sag). The manufacturer's specifications indicate that the typical switchover time is one cycle, but this appears to be for a single step change in voltage and does not account for the need to take several steps to correct for a larger voltage sag. Figure 2-6 shows the total response time of the Mini-EVR, which is approximately 100ms, during a 60 cycle sag to 80% of nominal voltage.

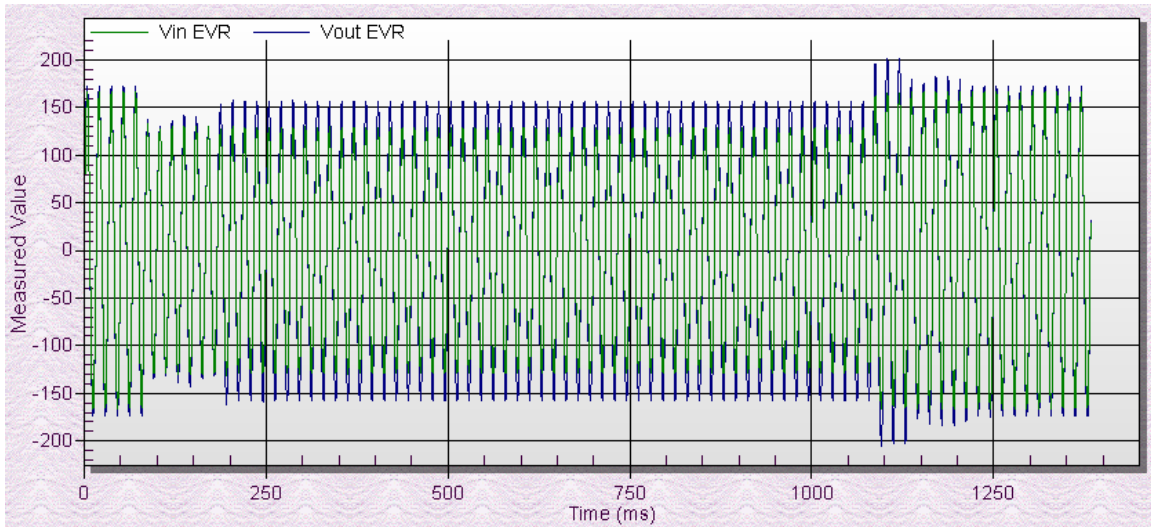


Figure 2-6
Response Time of Mini-EVR™ During a Voltage Sag Down to 80% of Nominal Voltage With Duration of 60 Cycle (50% load)

With a response time of several cycles, the Mini-EVR™ does not effectively prevent electrically held-in devices such as contactors and relays (which drop out from 5ms to 20ms after voltage sag) from dropping the load. During the full load tests the sensitive elements in the EPRI's industrial load bank, the PLC and the ice-cube relays dropped at voltage sag down to 50% of the nominal voltage for duration greater than 12 cycles. The Mini-EVR™ is unlikely to prevent semiconductor and similar industries from process shutdowns due to short-duration voltage fluctuations since the response time it not sufficiently fast to mitigate single cycle voltage sags.

The following table is the summary of the voltage sag tests performed on the Mini-EVR™ at 100% load condition.

Table 2-1
Summary of Voltage Sag Test Performed on the Mini-EVR™ at 100% Load Condition

S. No.	Voltage Sag Depth as a % of Nominal Voltage	Sag Duration (Cycles)	Results
1	0%	12- 60	No correction by the device. Input is directly applied to the loads.
2	10%	12 to 60	No correction by the device. Input is directly applied to the loads.
3	20%	12 to 60	No correction by the device. Input is directly applied to the loads.
4	30%	12 to 60	The unit begins correction after 3 cycles but the output voltage is 1.15 times the input voltage. The sensitive loads, namely, ice-cube relays, contactors and PLC are dropped.
5	40%	12 to 60	
6	50%	12 to 60	
7	60%	12 to 60	

Table 2-1 (continued)
Summary of Voltage Sag Test Performed on the Mini-EVR™ at 100% Load Condition

S. No.	Voltage Sag Depth as a % of Nominal Voltage	Sag Duration (Cycles)	Results
8	70%	< 30	Dropped only the motor load. The output voltage is 1.15 times the input voltage
9	70%	60	Loads are Protected
10	80%	12 to 60	The output voltage is 1.25 times input voltage. The loads are protected.
11	90%	12 to 60	The loads are protected. The output voltage is within the specifications.
12	105%-115%	12 to 60	The loads are protected and the output voltage is within the specifications.

Inrush Current

The Mini-EVR™ was subjected to a heavy inrush current under full load conditions by switching the load on and off frequently several times. These loads were varied from contactors and relays to motor loads. During our testing the Mini-EVR™ was able to handle inrush currents up to 128A peak which is slightly less than four times the rated current of 35.4A peak (for a typical inrush current waveform, see Figure 2-3). This result shows that for typical cases where there are inductive loads like motor loads connected, the Mini-EVR™ can handle the inrush currents. The Mini-EVR™ can also effectively handle the inrush current in loads involving contactors, relays, and programmable logic controllers, where the inrush current is generally in the order of four to five times the rated current.

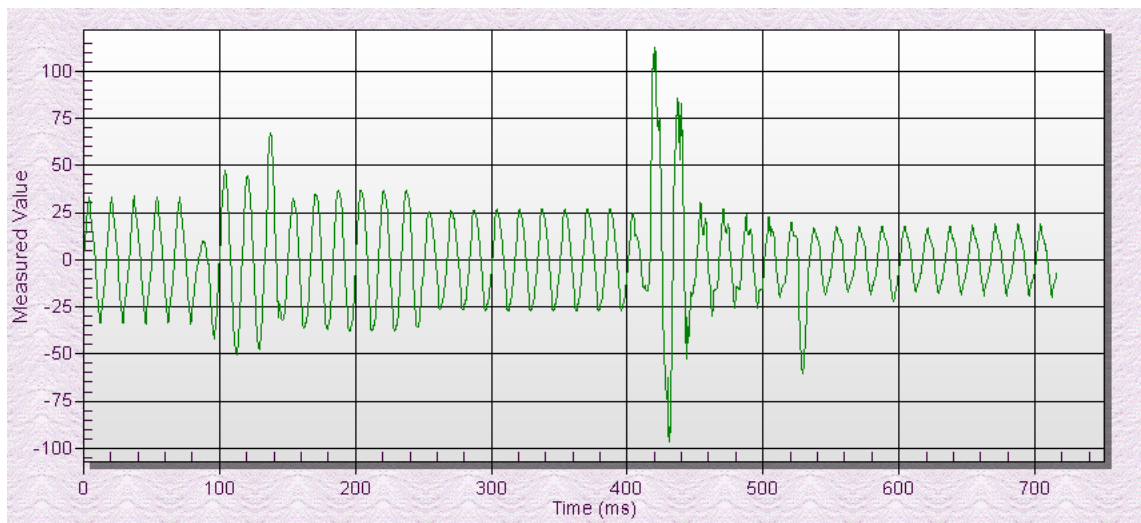
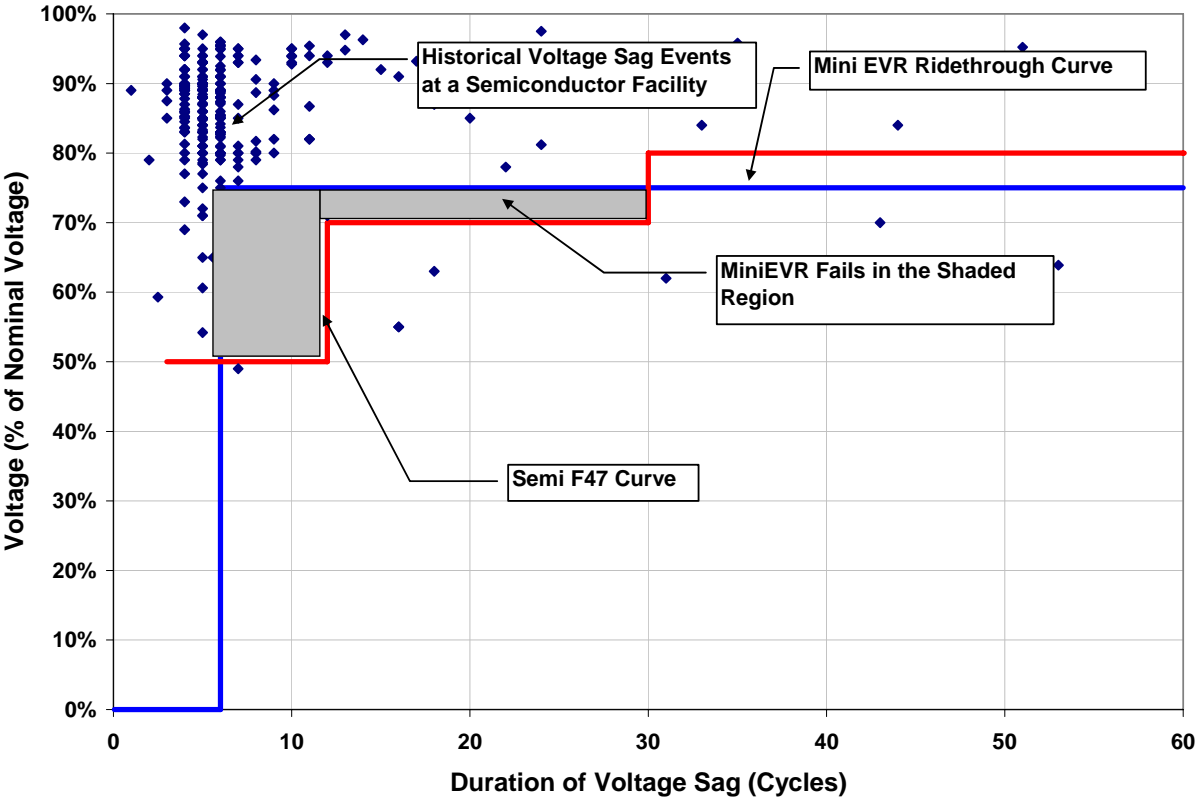


Figure 2-7
Inrush Current After a Voltage Sag Event, Peak Current Value is 112A

SEMI F47 Standard Compliance and ILB¹ Characterization Tests

Semi F47 is a stringent standard required by the Semiconductor industries to protect sensitive equipment in their facilities from voltage sags. Figure 2-8 shows the SemiF47 standard curve used by the industry. According to this curve, a power quality mitigation device is said to have passed the SemiF47 standard if it can protect the load from voltage sags on or above this curve. Any event below this curve may not be protected.

Figure 2-8 shows the Mini-EVR™’s voltage sag ride-through capabilities at full-load conditions. This was developed using a programmable logic controller that trips on sags down to 80% of nominal for duration of 1 cycle. This device is one of the most sensitive in industry, so the curve was developed based on its trip level. Note that with the Mini-EVR™, the controller tripped for all tests with less than 80% of nominal voltage. The grey area shown in the figure represents the area where the load is not protected against the Semi F47 standard.



**Figure 2-8
SEMI F47 Curve and the Mini-EVR™ Voltage-Sag Ride Through Curve**

¹ ILB stands for Industrial Load Bank developed by EPRI.

3

APPLICATION OF THE MINI-EVR™

Typical Mini-EVR™ Application

The Mini-EVR™ is a single-phase device used to stabilize an AC power source's variations. Due to the slow response time of the Mini-EVR it is not applicable as a transient voltage sag mitigation device. The Mini-EVR™ is applicable in situations where the longer term (about 10 cycles or more) stability of an AC source is desirable.

Key Parameters for Specifying a Mini-EVR™

The sections below describe the parameters that should be considered by the customer before purchasing a Mini-EVR™ unit for a specific application.

Inrush Current

Inrush current is a major factor when buying any power conditioner. Typically, motor loads have a large inrush current and the power conditioner should be able to handle these. The Mini-EVR™ was tested for its inrush current capability and was found to be able to handle up to at least 4 times the rated current under full load conditions. The rated current was 35A_{pk} and the inrush current was close to 128A_{pk}, while the load consisted of many relays, contactors, power supplies and programmable logic controllers. Since Mini-EVR™'s are typically used to protect control circuits and other electrically held-in devices such as relays and contactors, this test showed that the Mini-EVR™ can effectively handle the inrush current in such situations.

Installation

The Mini-EVR™ is a single-phase power conditioner and comes in 1kVA, 1.5kVA, 2kVA, 3kVA, 5kVA, 10kVA, and 15kVA sizes. The connection and the installation are simple. It is housed in a standard NEMA enclosure and it can withstand ambient working temperatures up to 40°C. The Mini-EVR™ has a short-circuit current limit 10X for fault clearing conditions (as per the manufacturers specification). The customer should take these issues under consideration before installing the unit. Figure 3-1 shows the connection points for input and output.

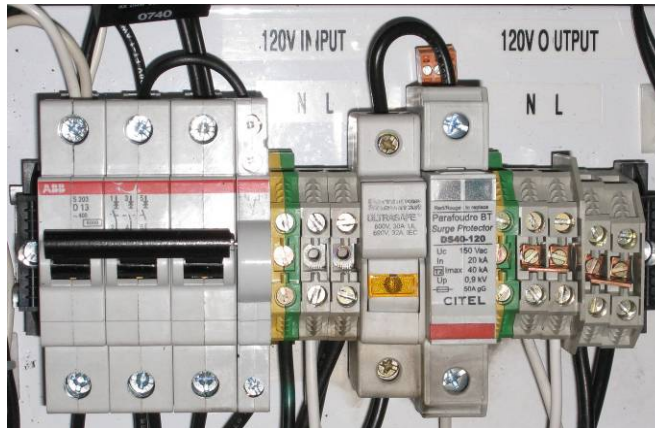


Figure 3-1
Terminal Screws for Installation

The manufacturer's installation procedures for the Mini-EVR™ are given below.

Installation Guide

1. Make sure the area where the Mini-EVR™ is to be installed is secured and that all electrical circuits are properly de-energized and locked out
2. Access the terminal connectors inside the Mini-EVR™ by removing the front cover or opening the door on the front of the unit
3. Determine the desired entry points for the source and load cabling **(NOTE: DO NOT run source and/or load cabling through any removable panel or door as this will impede access to the inside of the unit for inspection)**
4. Properly route, restrain and connect the source and load cabling inside the unit so that it is not in contact with any components or surfaces **(NOTE: Source and load cabling must be sized and installed in accordance with all applicable federal, state and local codes) (NOTE: Properly support or brace the enclosure sheet metal to prevent damage when pulling cables/wiring)**
5. The wiring of remote alarm contacts, surge suppressor(s) (MOVs) contacts and any other instrumentation provided inside the unit is optional. If installed, properly size and shield this wiring and route, restrain and connect it so that it is not in contact with any components or surfaces inside the unit
6. After installation of the source and load cabling, inspect **ALL** wiring and components inside the unit to ensure that all connections are tight and there are no signs of damage to the insulation, components or connectors **(NOTE: Report any signs of damage to wiring or components to the manufacturer before energizing the unit)**
7. Make sure that the auxiliary circuit breakers (CB2, CB3 and CB4, if applicable) are in the ON (closed) position and all fuses, if any, are in place and in good condition
8. Replace all panels removed and/or close all doors on the unit

Sizing of the Mini-EVR™

The Mini-EVR™ does not require any derating for inrush currents and can be sized to correspond directly with the load. According to the manufacturer the sizing of this device is independent of load powerfactor. For many devices, the load dictates the duration of ride-through based on the size of the energy storage element. For the Mini-EVR™, there is no energy storage element so there is no limitation for compensation.

Switching (or Response) Time

The response time of the power conditioner is another critical factor that determines the protection of the system. The Mini-EVR™ manufacturer-specified switchover time, from the input sag voltage to the corrected voltage is typically one cycle. The test results show that full output voltage support occurs anywhere from 3 to 8 cycles. The electrically held relays and contactors typically drop out within fraction of cycles, typically 1/4th to 1 cycle after the voltage sag. Thus the Mini-EVR™ may not protect these kinds of loads from dropping out during minor voltage fluctuations.

Comparison With Similar Power Conditioners

Table 3-1 gives a comparison of various power conditioners available on the market. These include the Mini-EVR™, constant voltage transformer (CVT), dip proofing inverter (DPI), and dynamic sag corrector (DySC)

The comparison in Table 3-1 shows how the performance characteristics of the Mini-EVR™ compare with those of the other devices. Each has its specific advantages and disadvantages, and their use is application specific. In order to properly specify the Mini-EVR™, the user must study the process and acquire some knowledge of the equipment to be protected. It should be noted that the Mini-EVR™ is a single-phase power conditioner and does not have any energy storing elements.

Table 3-1
Comparison of Power Conditioners

Attributes	Mini-EVR™	CVT	DPI	DySC
Sag Depth (% remaining)	75%	40-50%	0% (interruption)	0% (interruption)
Sag Duration	Indefinite	Indefinite	< 2 Sec, depends on capacitors	2 cycles at 0%, 2 Sec max down to 50%
Sizing Requirement	Size for load	Oversize by 2.5X	Size for load	Size for load
Inrush current	No issue	Oversize for inrush also	No issue	No issue
Response time	3 to 8 cycles	No issue	½ cycle	2 ms
Maintenance	Low	Low	Low	Low

4

SUMMARY

The Mini-EVR is a single-phase power conditioner that can be used to mitigate long term voltage supply stability. The response time of the Mini-EVR™ is too slow to protect critical equipment sensitive to transient of less than a few cycles. It uses a simple but effective tap-switching arrangement on an autotransformer to compensate for a voltage drop in the input supply voltage.

The tests conducted at the EPRI Knoxville laboratory indicate that the Mini-EVR™ is slightly slow in its response time to be compliant with SEMI F47. The Mini-EVR™ finds application where long term voltage stability is desired as the name aptly says it regulates the voltage within the specifications.

The tests also show that the Mini-EVR™ can handle inrush currents of at least 4 times the rated Mini-EVR™ current. This is sufficient to start and maintain most typical control devices. Sizing the device is straightforward; the size can be directly matched to the load. The Mini-EVR™ can be a suitable choice to protect loads against steady state over or under- voltages and voltage fluctuations. It finds its application in wide areas such as food processing plants, manufacturing, industrial automation, pulp and paper industry and offices to name a few where stable voltage source is required.

A

SPECIFICATION² OF MINI EVR

Application		
Power Rating/Size (kVA)	1, 1.5, 2, 3, 5, 7.5, 10, 15 Larger sizes available	
Phase - Frequency (Hz)	Single phase - 50 or 60 Hz	
Voltages	120, 208, 220, 240, 380, 400, 440, 480, 600 typical Custom voltages available	For voltage step up or step down contact factory
Cable Entry - Connections	Side, bottom or top –hardwired to terminal blocks	
Regulation		
Standard Regulation	+10%/-25% input voltage with output voltage regulated to $\pm 3\%$	
Optional Regulation	$\pm 10\%$ input voltage with output voltage regulated to $\pm 2\%$	
Regulation Variation	None - constant for 0 to 100% load and any load power factor	
Operating Characteristics		
Overload/Inrush Capability	6000% - 1 cycle, 1000% - 1 second, 500% - 5 seconds, 200% - 1 min.; 1000% fault clearing	
Minimum Load	No minimum load	
Load Power Factor	No limitations, compatible with all load types	
Tap Switching	No load current interruption or waveform distortion on switching	
Zero Crossing Sensitivity	Tap switching independent of load current zero crossing	
Harmonic Distortion	No distortion added at any load or power factor	
Response Time	1 cycle typical regardless of load or load power factor	
Efficiency	99%	
Operating Frequency	$\pm 3\%$ of nominal frequency	
Unit/Load Protection		
Surge Suppression	Tested to ANSI/IEEE standard C62.41	
Failsafe Electronic Bypass	Actuates on hi-temperature, over-current, component failure without loss of load	
Construction		
Technology	Electronically-controlled tap switching series transformer design	
Switching Semiconductors	SCRs are not required to carry full unit current – non-full power semiconductors	
Controls	Microprocessor-based controls	
Cooling	Natural convection, no cooling fans used	
Autotransformer	Meets ANSI specs	
Enclosure	NEMA 1 standard	
Environmental Requirements		
Audible Sound Level	Meets NEMA standards	
Temperature - Humidity	Ambient 32 to 104°F (0 to 40°C) – Relative humidity 0-95% non-condensing	
Operating Altitude	0 to 10,000 ft (3000m)	
Common Options		
Split Phase Output	220/110v, 240/120v output	
Enclosures	NEMA 12, 3R, 4X or others	
Listings	Contact factory for specifics	

² Courtesy: Utility Systems Technologies, Inc

Export Control Restrictions


Access to and use of EPRI Intellectual Property is granted with the specific understanding and requirement that responsibility for ensuring full compliance with all applicable U.S. and foreign export laws and regulations is being undertaken by you and your company. This includes an obligation to ensure that any individual receiving access hereunder who is not a U.S. citizen or permanent U.S. resident is permitted access under applicable U.S. and foreign export laws and regulations. In the event you are uncertain whether you or your company may lawfully obtain access to this EPRI Intellectual Property, you acknowledge that it is your obligation to consult with your company's legal counsel to determine whether this access is lawful. Although EPRI may make available on a case-by-case basis an informal assessment of the applicable U.S. export classification for specific EPRI Intellectual Property, you and your company acknowledge that this assessment is solely for informational purposes and not for reliance purposes. You and your company acknowledge that it is still the obligation of you and your company to make your own assessment of the applicable U.S. export classification and ensure compliance accordingly. You and your company understand and acknowledge your obligations to make a prompt report to EPRI and the appropriate authorities regarding any access to or use of EPRI Intellectual Property hereunder that may be in violation of applicable U.S. or foreign export laws or regulations.

The Electric Power Research Institute (EPRI)

The Electric Power Research Institute (EPRI), with major locations in Palo Alto, California; Charlotte, North Carolina; and Knoxville, Tennessee, was established in 1973 as an independent, nonprofit center for public interest energy and environmental research. EPRI brings together members, participants, the Institute's scientists and engineers, and other leading experts to work collaboratively on solutions to the challenges of electric power. These solutions span nearly every area of electricity generation, delivery, and use, including health, safety, and environment. EPRI's members represent over 90% of the electricity generated in the United States. International participation represents nearly 15% of EPRI's total research, development, and demonstration program.

Together...Shaping the Future of Electricity

© 2008 Electric Power Research Institute (EPRI), Inc. All rights reserved.
Electric Power Research Institute, EPRI, and TOGETHER...SHAPING
THE FUTURE OF ELECTRICITY are registered service marks of the
Electric Power Research Institute, Inc.

 Printed on recycled paper in the United States of America

1015866