EnergyIdeas Clearinghouse

PTR #6.4
June 2008

Product & Technology Review

MicroPlanet® Voltage Regulators

Line voltage regulators intended primarily to save energy by conservation voltage regulation (CVR) in residential and small commercial applications.

Products

- Low Voltage Regulator™ (LVR™) 120/240 volt split phase 160 amp pole-mounted regulator
- High Voltage Regulator™ (HVR™) 120/240 volt split phase 160 amp regulator for single-family or duplex residential and small commercial applications
- Enterprise Voltage Regulator 3P™ (EVR 3P) 120/208 volt 3-phase 400 amp regulator for small commercial applications. Models as high as 3000 amp ratings may be forthcoming, such as a 277/480 volt 225 amp model that may go as high as 3000 amps (could be available as early as 3rd quarter 2008).

Manufacturer

The product is manufactured in California by Flextronics, a major contract manufacturer. However, the product was conceived and developed by MicroPlanet Technology Corp. and is marketed and supported by MicroPlanet. The MicroPlanet corporate contact information is:

MicroPlanet Technology Corp.
7777 – 62nd Ave. NE, Bldg. 11
Seattle, WA 98115
Telephone: (206) 625-0851
Fax: (206) 625-0999
Email: *products@microplanetltd.com*
Website: *www.microplanet.com/*

Photographs courtesy of MicroPlanet Technology Corp., Seattle WA

Distributor

Michael Sheehan, Vice President, Technical Sales
Telephone: (206) 625-0851
Fax: (206) 625-0999
Email: *msheehan@Microplanetltd.com*

Product History

Development started in April 2001 with utility engineers. Prototypes and test units were built through 2003. The HVR and LVR are now available to utilities only. The 3-phase models are available to both utilities and end users.

Product Function and Application

The following information was primarily

Product & Technology Reviews (PTR) are developed for Northwest electric utilities. EnergyIdeas Clearinghouse engineers review published literature for objective, independent test results. No primary testing was conducted by the reviewer for the preparation of this document. PTR factsheets describe the technology, discuss available data, and suggest additional testing needed to verify energy saving claims.
For more information: *www.EnergyIdeas.org/ptr*

provided by the manufacturer and is not evaluated here. The MicroPlanet products can either boost or reduce voltage to obtain an optimal level that meets American National Standards Institute (ANSI) minimums. The HVR and LVR target residential and small commercial applications with single phase 120/240 volt service. The EVR 3P targets small and mid-sized businesses with 120/208 three-phase service.

The HVR works at the 200 amp service entrance of a commercial or residential building and the LVR is mounted on a utility pole. Both are good for 240 amps maximum and 160 amps continuous service. ANSI requires that 120-volt, single-phase service remains between 114 volts and 126 volts. Though the HVR is intended for applications where reducing the voltage is the priority, and the LVR for applications where voltage needs to be boosted, they can both reduce voltage to a programmed minimum, e.g. 115.5 volts. They can also boost voltage by as much as 8.33% if necessary to reach target voltage. The target voltage setting can be adjusted.

The advantage of regulating voltage is to keep the voltage as low as possible while maintaining appliance efficiency and reducing overall power requirements. Voltage boost capability is present and intended to ensure sufficient voltage for proper operation of loads, such as at points near the end of a distribution line where under-voltage can occur when utilities implement CVR at the feeder level. The voltage regulator products also contain transient voltage surge suppression and short-circuit protection.

The EVR 3P is a three-phase voltage regulator that also equalizes phase-to-neutral voltages, effectively eliminating any significant voltage unbalance that can overheat motors and reduce their efficiency.

Energy Savings Claims

The following information was provided primarily by the manufacturer and is not evaluated in this section.

On its website MicroPlanet claims that "MicroPlanet's advanced technology can reduce electricity usage from 5-12% in many residential and commercial locations…" <*www.microplanetltd.com/section.asp?catid=1053&pageid=2651*> (accessed May 8, 2008). The product works by accomplishing conservation voltage regulation (CVR).

"CVR lowers the voltage at which electrical power is delivered and yields on average, a 1% energy savings for each 1% in voltage reduction down to 114V." <*www.microplanetltd.com/section.asp?pageid=2581*> (accessed May 8, 2008)

Regarding the products targeted to small and mid-sized businesses, the website further claims that, "MicroPlanet systems also correct voltage imbalance, which is one of the leading causes of motor overheating and failure. In addition to conserving energy, MicroPlanet's products can correct a 7-8% incoming voltage imbalance to less than 1%. Also, the EVR 3P creates no harmonic distortion of the voltage sine wave." <*www.microplanetltd.com/section.asp?catid=1053&pageid=2653*> (accessed May 8, 2008)

Non-Energy Benefits

The manufacturer claims that some lights and appliances last longer when operated at lower voltage and that the devices will protect connected loads from voltage spikes.

Independent Testing Results

Sacramento Municipal Utility District's (SMUD) Customer Advanced Technologies program has done a preliminary investigation of the MicroPlanet HVR. They contracted with the Davis Energy Group to assess how the efficiency, cooling capacity, power, power factor, and harmonics of 3- to 5-ton air conditioning equipment are impacted by voltage changes. Although this only assessed the steady-state performance of one load type, results showed favorable performance. They followed this up with a case study that is summarized in the following section. For more detail, see References (Bisbee 2007).

The device has also been tested by the Electric Power Research Institute (EPRI) Power Electronics Applications Center (PEAC) Corporation. However, this was developmental testing of a pre-production prototype and modifications were made during and as a result of this testing. In developmental testing, the test unit was shown to perform correctly and efficiently as a voltage regulator in both raising (boost) and lowering (buck) situations. The unit was used to power a resistance heater, a computer and a motor. The performance of these loads varied in accord with expectations based on their well-documented relationships of power and efficiency to voltage.

The testing report is proprietary because it was not performed on the final product.

Products associated with the utility meter and upstream from the meter are considered utility hardware and in most cases do not have to be UL listed. However, MicroPlanet has voluntarily had their products tested by Canadian Standards Association to UL standards.

Case Studies

1. Sacramento Municipal Utility District (SMUD)

A field test case study was conducted under sponsorship of SMUD in 2006. This testing was in addition to earlier lab testing. Both are reported in Customer Advanced Technologies Program Technology Evaluation Report: MicroPlanet HVR (Bisbee 2007).

SMUD technicians conducted a test at a produce packing plant that was experiencing voltage fluctuations at their busiest time of the year. Unfortunately, the MicroPlanet HVR model under test exhibited some erratic behavior that was never diagnosed and the test was discontinued. The next year testing was resumed with a new model of HVR with outside contractor ADM Associates Inc. conducting the monitoring.

In the 2007 field test, ADM metered the main service entrance and also submetered some individual loads in the facility. To determine savings, the monitoring methodology specified that the HVR be turned on or bypassed on alternate days over approximately a four-month monitoring period. The real and reactive power totals were compared between the subpopulations of on days and bypassed days. This sort of frequent switching between the measure being engaged and being disengaged is a much more reliable field test than one with a base period followed by an engaged period. This is because it tends to better balance out changes in productivity, weather, and other extraneous causes for load variation.

The HVR operated each test day as it was intended to by stabilizing the voltage at a level near the low end of the ANSI allowable range at approximately 114 volts. On alternate days when the HVR was bypassed, voltage fluctuated between 122 and 126 volts. This fact alone confirms its success as a stabilizing voltage regulator able to accomplish conservation voltage regulation (CVR).

This case study reports on the savings measured in this particular facility, which were 6.8% energy savings over the whole facility. Similar results could be expected in this facility from any voltage regulating apparatus that provided stable voltage at the same level. Conversely, the HVR could produce different levels of savings and performance change with a different mix of loads or a different base case voltage condition. See the discussion of conservation voltage reduction in the "Alternative Products and Strategies" section.

In this facility, as could reasonably be expected, the savings were not the same for all submetered loads. The savings were greatest in the carrot room where the energy consumption was reduced by 25.6%. However the lighting level in this room, lit by metal halide lamps, dropped 22%. The greatest savings where there was no performance degradation was in air conditioning, which enjoyed an energy reduction of 9.5%. Surprisingly, there was little change in light output in the T8 fluorescent lighting circuits with electronic ballasts even though energy dropped by 9.8%.

2. The Northwest Energy Efficiency Alliance (NEEA)

As part of a Distribution Efficiency Initiative (DEI), NEEA is conducting research to assess the energy saving potential of conservation voltage regulation. The purpose of the research is not to evaluate the MicroPlanet product, but they used the MicroPlanet to control voltage so that they could assess the energy saving potential of voltage control. A major component of the Phase 1 project was a load research study in which participating utilities installed MicroPlanet voltage regulators on homes in the Northwest. Home electric energy is being monitored with the units being cycled on and off on alternate days for a comparison.

A second major component of Phase 1 was a pilot demonstration project in which participating utilities implemented voltage reduction strategies on 31 feeder lines from ten selected substations.

The primary objective of the two research efforts was to determine whether conservation voltage reduction resulted in documentable energy savings. Phase 1 of the project ran from 2003 through 2007. The final report, prepared by contractor R.W. Beck, shows that "operating a utility distribution system in the lower half of the acceptable voltage range (120-114 volts) saves energy, reduces demand, and reduces reactive power requirements without negatively impacting the customer. The energy savings results are within the expected values of 1 to 3 percent total energy reduction, 2 to 4 percent reduction in kW demand, and a 4 to 10 percent reduction in kvar demand." *(R. W. Beck, Inc. 2007)*

An important result of the study pertains to reliability. Of the original 413 homes with MicroPlanet equipment, attrition during the study was only 4.4% from customers moving, customers opting out of the study, issues with the equipment (real or perceived), equipment failure issues, and issues related to improper installation of the equipment. We do not know what portion of that 4.4% (if any) represented failure of MicroPlanet products. There was also equipment used for monitoring and telecommunicating energy data and switching the MicroPlanet for the alternate day operation as well as the human factors potentially contributing to this small 4.4% attrition. This suggests a high reliability for the MicroPlanet units.

MicroPlanet reports additional product test studies on their website. <*www.microplanetltd.com/section.asp?catid=1053&pageid=2633*> (accessed May 8, 2008).

Cost

There are a number of variables in pricing, such as quantity and level of technical support, but below is an approximation of how the various units are priced:

- LVR: $2,500 - $3,000;
- HVR for single family – currently $1,600, but expected to be below $1,000 in 2009;
- HVR for duplex units – currently $1,700, but expected to be below $1,000 in 2009;
- EVR 3P – from $8,000 to $150,000.

Alternative Products and Strategies

We have not been able to find directly comparable single-phase products for installation at the utility service entrance of residences or small commercial establishments. The Electrical Harmonizer-AVR™ from Legend Power Systems Inc. is a comparable product for three-phase applications. Earlier models had a presettable percentage voltage reduction and did not automatically adjust voltage in real time. The current AVR has automatic voltage regulation like the MicroPlanet EVR 3P. It is available in 400- to 1500-amp ratings for 480-600 volt service. Applications are mainly industrial. It may be a potential competitor for the forthcoming 277/480 volt MicroPlanet product, but it is currently marketed primarily to the 600-volt Canadian market.

Alternative strategies for improving voltage stability and consistency in a utility distribution system include reconductoring with larger conductors or providing more sophisticated voltage regulation systems within the utility distribution system. These strategies can sometimes be very costly, especially in low-density service areas. In fact NEEA's DEI study has shown that this kind of system upgrade is not necessarily an alternative to customer location voltage regulation. Selective use of MicroPlanet controllers can complement these strategies by allowing lower voltages at the substation bus and boosting voltage optimally for critical end of the feeder customers at times when it would otherwise fall below the target of about 115 volts.

Suggestions for Further Research and Testing
This product has been sufficiently tested to verify that it functions as it is supposed to by regulating voltage to an ideal level. However, choosing the optimal locations to install the MicroPlanet products requires judgment and engineering analysis.

Independent lab testing for the forthcoming 277/480 volt product line could be beneficial to verify stable control of voltage and balance, sustained operation at full load, phase unbalance correction capability, and meeting the manufacturer's claimed response times to voltage changes.

Additional Reviewer Comments and Analysis

Conservation voltage reduction (CVR) is a much-studied electric energy savings strategy. The hardest question to answer is not whether voltage is stabilized at a lower level but how much energy is saved because of it being stabilized at a lower level. Numerous studies on CVR have shown varying amounts of savings depending upon the mix of load types and the degree of over-optimal voltage in the base case. Energy savings due to CVR in some loads, such as lighting, can be accompanied by reduced output and changed efficiency of those loads.

Different appliances react to voltage level differently. For example:

- Resistance heating devices draw more power and produce more heat with overvoltage. However, thermostats compensate by running the devices for shorter cycles so there are no savings to be gained by CVR; cycle times just increase to compensate.
- Electronic devices often run at about the same efficiency over a range of voltages and tend to draw fairly constant power over that range.
- Fans, blowers, and pumps driven by small single-phase motors tend to run slightly slower, move less air, and draw less power with reduced voltage. It may be important to ensure that the reduced flow is adequate for the application. If the flow is adequate, the energy saved could actually be more than the reduction in airflow, making fans, blowers, and pumps good candidates for reduced voltage.
- Compressor motors in refrigerators and air conditioning systems often run slightly more efficiently at reduced voltage. This is more pronounced in older, less efficient equipment.
- Energy can be saved by reducing voltage in lighting, but at the expense of an approximately proportional reduction in lighting levels. As with fans, this may or may not be acceptable for occupants.

The upshot of the above discussion is that some customers will save more than others with a given voltage reduction depending on their end use loads.

The two primary factors determining energy savings from CVR are voltage reduction and CVR factor, which is the ratio of energy savings to voltage reduction. It is difficult to predict the exact savings at a particular site without on-site monitoring. However, NEEA's DEI initiative found that the average supplied voltage in the Northwest is about 121 volts. Their target voltage is 115.5 volts, which allows some margin of voltage variation to ensure that they maintain the minimum allowable 114 volts. They also found that the effective mean CVR factor was 0.569 in homes controlled by MicroPlanet units and 0.69 when CVR was accomplished at the feeder level where service was mixed residential and light commercial. This means that every 1% reduction in voltage results in savings of 0.569% (or 0.69%). Other studies have found CVR factors ranging from 0.4 to 1.7.

Regulating from 121 down to 115.5 volts with the 0.569 CVR factor would give a savings of 2.7%. Savings would be 3.1% with a 0.69 CVR factor. If the voltage difference was only half as great, these savings would be only half as much.

Since we now have the major DEI study of CVR potential in the Northwest, our recommendation is to bypass MicroPlanet's projections of CVR factors and typical voltage differences and rely on the DEI study for projecting the savings from CVR in Northwest regional applications. Indications are that one can rely on the MicroPlanet manufacturer data for how the various members of their product family will perform at accomplishing voltage regulation.

Conclusion

MicroPlanet products provide conservation voltage reduction (CVR) for residential and small commercial electric utility customers. Credible field testing shows that they can effectively and reliably reduce voltage to a minimal acceptable level. They can also increase inadequate voltage to this level for utility customers at the end of a feeder line.

According to NEEA's research, the average supplied voltage in the region is 121 volts and the average ratio of energy savings to voltage reduction is 0.569. With a target voltage of 115.5 volts, this will yield an average energy savings of 4.3%. NEEA's research also concludes that, "Home voltage regulating devices can be effectively implemented to fix select voltage issues at a lower cost than the more traditional extension of primary lines, the addition of more transformers, or the replacement of secondary conductors. Fixing the voltage issues for a few locations will benefit the entire feeder and substation system by allowing the entire system to achieve a lower overall voltage reduction."

The technology will tend to be most cost-effective as a control strategy for utilities. The actual energy savings for a particular residence or business depends on their supplied voltage and their mix of loads. An individual customer should confirm cost-effectiveness for their supplied voltage and load mix before installing. Fans and incandescent lights will yield energy savings but produce less airflow or light, which may or may not be acceptable. Electric heaters will produce no savings because they will just run longer at lower voltage. Other equipment such as older refrigerators may operate more efficiently at lower voltages.

Additional Information

Electric utility staff can contact the *Energy*Ideas Clearinghouse for additional information on this or other energy technologies or products.

Contact:

Phone: 1-800-872-3568
Email: *info@EnergyIdeas.org*
Website: *www.EnergyIdeas.org*

The *Energy*Ideas Clearinghouse is a technical assistance service managed by the WSU Extension Energy Program with support from the Northwest Energy Efficiency Alliance.

Reviewer

Johnny Douglass, P.E.
Senior Industrial Engineer
WSU Extension Energy Program

Note: Product & Technology Reviews are peer reviewed by objective industry professionals prior to publishing.

References

Bisbee, Dave. *Customer Advanced Technologies Program Technology Evaluation Report: MicroPlanet HVR*, Sacramento Municipal Utility District, December 2007, <*www.smud.org/education-safety/images-safety/cat_pdf/MicroPlanet.pdf*> (accessed May 8, 2008).

R.W. Beck, Inc., *Northwest Energy Efficiency Alliance Distribution Efficiency Initiative Project Final Report*, December 2007.

WSUEEP 08-017