GRIDCO SYSTEMS™

# ASSURING CUSTOMER SERVICE VOLTAGE WITH GRIDCO SYSTEMS EMPOWER™ SOLUTION

APPLICATION NOTE

CHALLENGE

## An Evolving Challenge: Maintaining Voltage Compliance

Driven by continuous asymmetric load growth, aging assets, and, congruently, increased generation and power flow complexity on the distribution grid, utilities are finding an increasing number of customers are consistently receiving voltage outside of the compliance range. As a result, these out of range voltage levels result in challenges, including:

- End of line feeder brown-outs
- Increased ANSI voltage range violations leading to more customer complaints
- Reduced commercial/industrial equipment performance
- Heightened safety and environmental concerns

SOLUTION

## The Right Solution for Voltage Assurance

The Gridco Systems emPower™ solution deploys a distributed architecture effectively decoupling the distribution grid at key locations to address specific challenges. Enabled by utility-grade power electronics, utilities have the capability of providing smooth, sub-cycle voltage control to:

- Avoid expensive and time consuming utility equipment upgrades
- Manage the impact of new load growth
- Prevent excessive utility/customer equipment deterioration and failure
- Maintain prolonged ANSI C84.1 compliance by addressing the specific problem areas

## The Challenge of Delivering Voltage within Limits

For normal residential and commercial (120-600V) service, utilities design their distribution circuits to deliver the steady state voltage within ANSI C84.1 Range A (114-126V or +/- 5% nominal) limits. Maintaining actual service voltage within these limits is a fundamental task of distribution engineers who need to continuously take into account feeder line losses, demand fluctuations, and changing load patterns. Recently, the challenge of this fundamental task has escalated, particularly on long distribution feeders, areas where load profiles are changing at higher frequency, and areas with high penetration of local, distributed generation. Insufficient voltage levels, above or below limits, anywhere on the feeder can trigger a multitude of well-known power disturbances including voltage sags, brownouts, and even blackouts.

In order to meet regulatory requirements, utilities need a solution that can provide the speed and granularity that is necessary to deliver voltage within specified ANSI limits to customers located close to the substation down to the final, end-of-line, load on the network. This solution must provide utilities with pinpoint voltage control to solve today's compliance challenges and new future challenges as they arise – continuously, cost-effectively and with minimum disruption to existing operations.

## Limitations of Today's Voltage Management Solutions

While many states and utilities have their own range of customer voltage delivery, ANSI C84.1 Range A service voltage standard is the generally accepted benchmark for utilities to assure safe and reliable power delivery to all customer segments. Delivering steady state voltage above or below this range can cause customer equipment to operate inefficiently or, in worse cases, cause temporary or permanent damage leading to increased complaints. Longer, older, and at lower voltage class (4kV/12kV) feeders tend to suffer from excessive voltage drop and are often responsible for under-delivering voltage to customers. Feeders experiencing these characteristics and/or increasing load profiles are suspected to experience larger voltage drops down the line. Distribution engineers generally use one of several historical methods in attempt to address the voltage assurance challenge.

### Raising Substation Voltage

The initial, most common, strategy to assure feeder voltage levels remain within limits consists of raising the substation voltage close to the upper ANSI service limit at the head of the feeder. As loads are applied to various feeder points downstream of the substation, voltage drops will result as a function of the increasing impedance. The longer the feeder and the larger the loads, the higher the voltage drop a feeder will experience as depicted in Figure 2. Therefore, using a Load Tap Changer (LTC) to raise the voltage to its highest possible level will help ensure the voltage levels will remain within service range to the very end of the feeder line. However, given longer feeders with increasing loads, increasing voltage at the substation will not suffice to maintain customer at the end of the line to stay above the ANSI limit, especially during peak load time periods. Moreover, increasing voltage at the substation on a regular basis causes excessive mechanical wear-and-tear on LTCs (often already nearing the end of operational life), increases overvoltage risk and raises prices to consumers in close proximity to the substation, and conflicts with achieving any progress through energy conservation initiatives. Also, LTCs can only manage voltage at the substation, providing a centralized point of voltage control that cannot adequately address the varying customer loads localized along a feeder.

## Installing Voltage Regulators and Capacitor Banks

Another common strategy for utilities, usually augmenting the use of an LTC at the substation, is to install and utilize voltage regulators and/or capacitor banks to level the primary voltage profile throughout multiple points along a feeder. Like substation LTCs, these devices are also subject to mechanical wear-and-tear, making them unsuitable for increasingly unpredictable demand patterns and harsh environments. Moreover, increased operations to continuously maintain voltage assurance lead to higher chances for catastrophic failure with significant safety and environmental implications. Voltage regulators and capacitor banks are also challenging to coordinate because of slower operation speeds and the voltage rise impact variance related to capacitor banks and the upstream impedance. As indicated earlier, this equipment provides bulk compensation on the primary distribution level, thus lacking the granularity to address specific customer voltage issues along secondary segments throughout the feeder. As a result, with new load growth and distribution grid complexity, utilities lack the control equipment to more safely and reliably address new high/low voltage excursions beyond required service limits and are left only with static, expensive and time consuming options as the means to address the problem.

## Reconductoring Lines

Another option being commonly considered is the reconductoring of primary and secondary lines at areas of the feeder experiencing significant voltage drop, typically those with larger loads and longer lines. With thicker conductor installed, the impedance of the line decreases and, as a result, reduces the overall voltage drop along the feeder or on a secondary segment directly to the end customer. However, such initiatives are often intricate and costly ($50K+/mile for overhead primary and much more for underground lines), disruptive (direct buried secondary), and consume valuable time and manpower. In addition, this static approach will not provide any situational visibility or awareness for future operations to address new challenges as distribution grid complexity increases.

## Replacing Transformers

The final common strategy for addressing steady state voltage compliance is to “upsize” the distribution transformer. Replacing the existing transformer with a larger, higher KVA rated unit will help decrease the feeder impedance and reduce the voltage drop to the end customer serviced by that transformer. However, this static method to address low feeder voltages provides limited effectiveness, depending on loading, in providing any significant voltage drop reduction. This method also lacks the scalability to address potential future load growth where the problem could reappear. Moreover, similar to reconductoring, this method is burdened with the additional upfront equipment and installation costs as well as increased load losses that typically come with installing a larger unit. Given the existing options available to address voltage assurance, the opportunity presents itself for utilities to consider alternative approaches to meeting one of the most fundamental needs of their customers.

## The Right Solution to Ensure Reliable Customer Service Voltage

The Gridco Systems emPower™ Solution consists of three product families: In-Line Power Regulators™ (IPR), Distributed Grid Controllers™ (DGC), and the Grid Management and Analytics Platform™ (GMAP).

This advanced solution combines utility-grade power electronics and distributed networking architecture to decouple the secondary from the primary feeders at locations along the distribution grid to address specific challenges associated with maintaining voltage levels within allowable range, effectively acting as a local voltage regulator. The Gridco Systems IPR can quickly and continuously respond to changes in grid conditions and customer loads in order to ensure adequate voltage delivery. This utility-owned solution provides a cost-effective alternative and/or enhancement to typical voltage management strategies by providing precise, continuous and dynamic voltage management at the secondary, as close to the loads as possible. Available in pad-mount and pole-mount configurations for installation on the LV side of the distribution transformer as displayed in **Figure 1**, IPRs regulate voltage to ensure that customer service voltage stays within ANSI limits.

A solution that can be distributed at certain points throughout the feeder, IPRs are installed directly wherever voltage assurance is required to address the specific problem. These problem areas are beginning to appear in greater numbers typically as low voltage at the end of a long, heavily loaded feeder and as high voltage resulting from new distributed energy resource installations. Utilizing power electronics, deployment of the IPR enables utilities to dynamically (within one cycle) regulate secondary load voltage up to +/- 10% of the nominal rating to a chosen setpoint or deadband limit and remedy these outlying voltage points without increasing the coordination complexity and decreasing the overall life of existing voltage control assets. As a result, utilities now have a strategy for maintaining voltage assurance today and, in parallel, proactively address the evolving challenge in the future. **Figure 1** shows an example of the secondary voltage levels before and after an IPR installation on a low voltage secondary bus at the end of a feeder.

With options for both overhead and underground feeders, the IPR provides utilities with the unique ability to boost and buck voltage over a wide range at the distribution transformer and regulate down to each customer off the secondary feeder, effectively decoupling the secondary from the primary. This decoupling enables the utility to maintain reduced voltage across the feeder while adhering to customer voltage delivery limits, protecting voltage-sensitive loads, and ensuring optimal efficiency of loads. The IPR can also ensure that customers are protected from voltage rise and other over-voltage conditions by maintaining steady state voltage for customers within the upper ANSI range limit. Combined with DGCs, the utility has complete visibility to configure, control, and monitor the fleet of IPR devices through the SCADA system and/or the Gridco Systems GMAP.

*Figure 1: Decoupling Low Voltage Points*

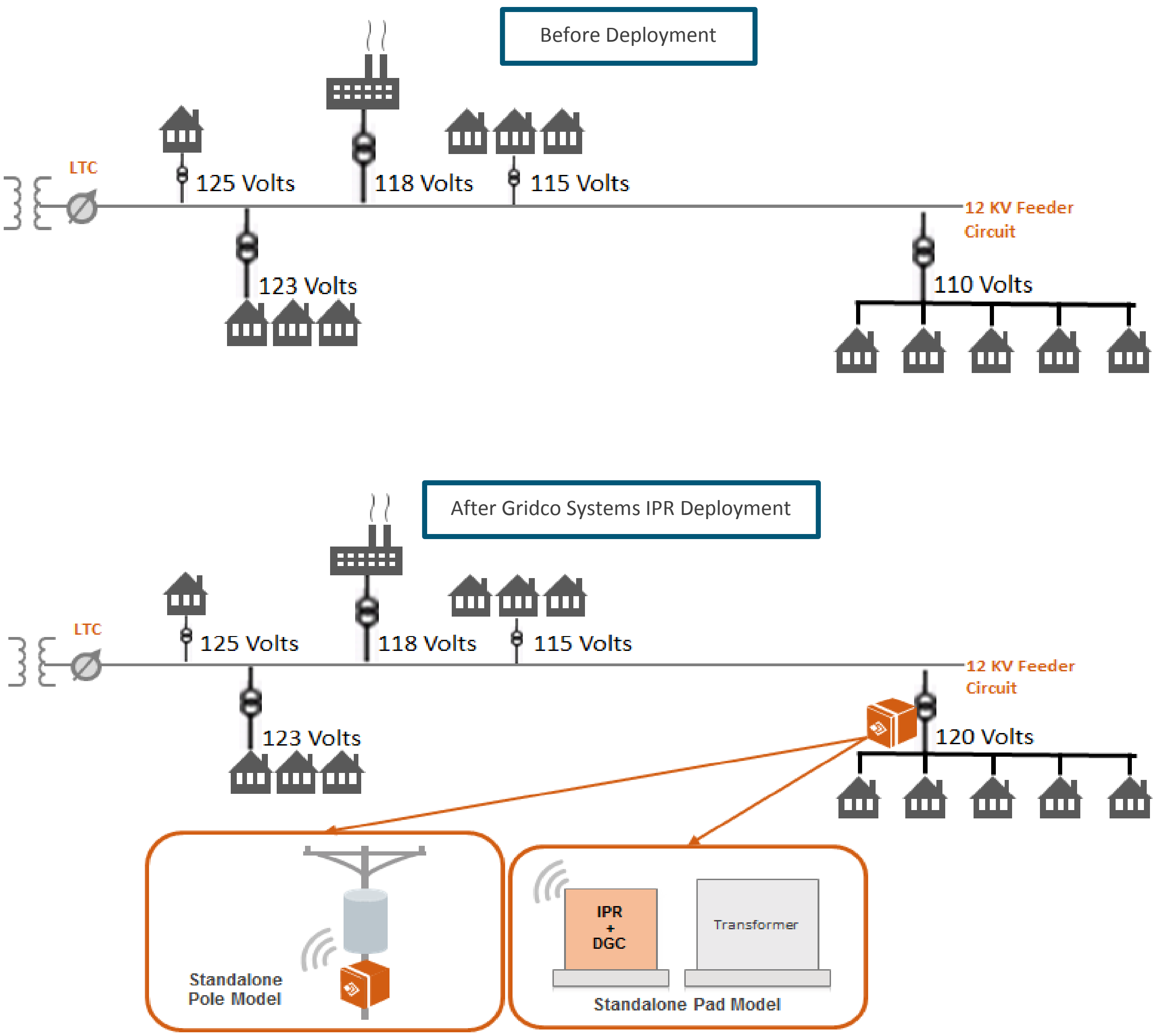
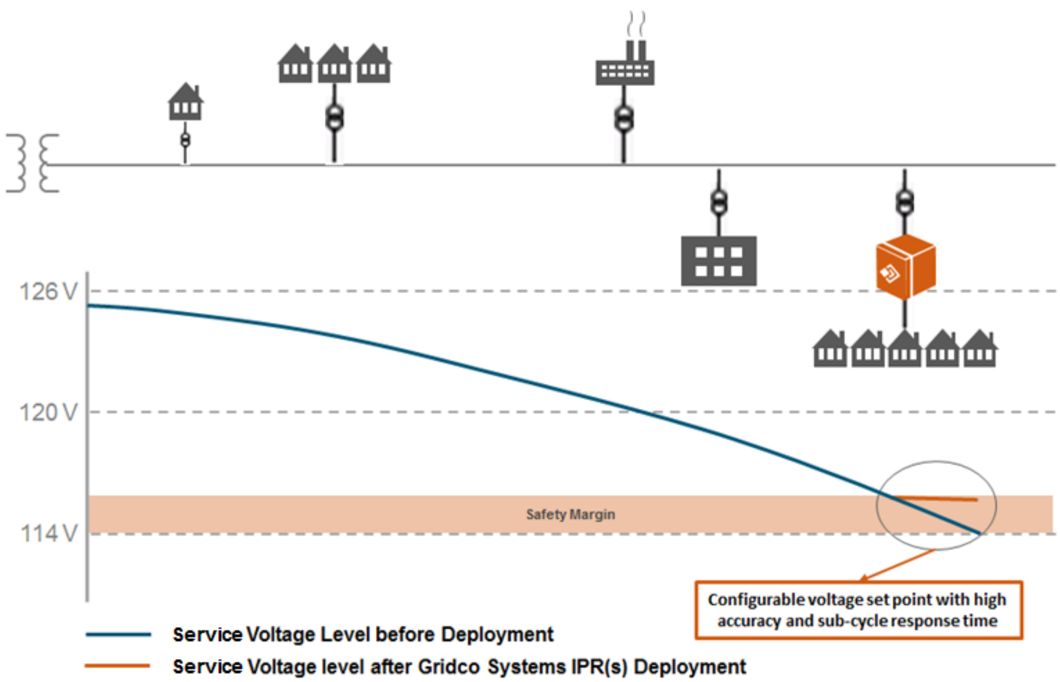



**Figure 2** shows the Gridco Systems IPR strategy in place to maintain a sample feeder's service voltage level within assigned control margins by regulating the secondary voltage.

*Figure 2: Assuring Service Voltage*




## Advantages of Distributed, Dynamic, Decoupled Control

Gridco Systems IPRs bring unprecedented control to the edge of the grid, thus ensuring utilities maintain voltage compliance through accurate secondary voltage drop assumptions. For example, assuming a 5% secondary drop means that the utility must deliver primary voltage to the distribution transformer at 120V nominal to remain within ANSI compliance (above 114V). However, as more data becomes available through the deployment of new advanced metering infrastructure (AMI), results suggest that secondary voltage drops can vary significantly along the secondary and at times beyond their assumptions. As a result, the 5% drop assumption would be good in some locations, but not enough in others. Utilizing the IPR's dynamic voltage regulation capabilities at secondary locations experiencing large voltage drops empower utilities to address the problem locally without unnecessarily raising voltage levels and to safely assume a specific secondary voltage drop for which to assure customer service voltage compliance through the territory.

Maintaining voltage compliance within ANSI C84.1 service range limits is an evolving challenge as a function of increasing age, growth, and complexity of the distribution grid. The increase in customer complaints and potential for brown, and even black-outs are becoming a greater concern for utilities. The voltage regulation capabilities of the Gridco Systems emPower™ Solution make it an ideal and necessary tool supporting a new and/or enhancing existing voltage assurance strategies by:

- **Assuring secondary voltage levels of specific concerns are delivered to customers within ANSI limits** across a wide range of primary voltage.
- **Eliminates the need to step-up voltage at the substation or deploy new voltage regulators and capacitor banks** in order to compensate for excessive voltage drop along the feeder.
- **Reduces the frequency of operations of existing voltage control devices**, avoiding the environmental and safety issues of excessive wear-and-tear and potential catastrophic failures of LTCs, voltage regulators and capacitor banks. Instead, the IPR dynamically controls voltage as a result of changing local demand, without requiring constant changes to primary, bulk compensation devices.
- **Avoids the need for reconductoring or replacing transformers**, enabling better use of manpower and existing assets and adding enhanced visibility and situational awareness for future operations and maintenance.

With pinpoint distributed control, decoupling the primary from the secondary by dynamically and continuously regulating voltage has significant advantages for utilities to address the new challenges of today and ensure a robust distribution grid in the future.

## About Gridco Systems

Gridco Systems is a leader in agile grid infrastructure solutions, enabling utilities to more effectively integrate renewable and distributed generation, increase energy efficiency, manage peak capacity, and improve system reliability. The Gridco Systems emPower™ Solution combines modular power electronics, advanced controls, distributed networking, and power system analytics to deliver the industry's only end-to-end hardware and software platform purpose built to solve utilities' current and emerging distribution challenges in a distributed, dynamic, and decoupled fashion. To learn more, please visit www.gridcosystems.com.





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