White Paper

Using Meters as Distribution Sensors for Capacitor Bank Monitoring

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The role capacitor banks play in maintaining power quality varies by utility. But regardless of how capacitors are deployed, the need for greater insight into their status and operation is growing. Changing load patterns and an increase in two-way power flows from distributed generation create new challenges for maintaining optimal voltage levels and managing harmonics on distribution feeders.

Capacitors serve to control voltage levels, manage VAR levels and absorb energy from line spikes. In this way, they can help maintain efficiency and improve power factor, reducing line losses and generation costs.

Maintenance and operation of capacitor banks is still a manual process for many utilities. Site inspections conducted on an annual basis or during switching operations don't always detect malfunctions, such as those caused by improper installation or changes on the circuit that impact the unit. A malfunctioning unit not only contributes to line losses, but can also create power quality and safety issues.

Operation and Monitoring

Capacitor bank operation control methods vary by utility. Historically, they have been operated either by timers or, in the case of seasonal applications, by manual switching. With the advent of smart grid networks and distributed grid intelligence, more capacitor banks are being automated to allow switching that more closely aligns to changing conditions on the circuit.

Potential issues impacting capacitor bank operation include failure of the switching mechanism or timer, blown fuses or incorrect installation leading to improper operation.

While automated controllers can provide confirmation of switching operations, many do not track and report indicators that are important to determining whether the capacitor bank is performing as desired. For utilities desiring a lower cost solution than installing a fully automated communicating capacitor bank controller, advanced meters are capable of monitoring capacitor health and providing operational status.

Meter as Distribution Sensor

The value of deploying advanced meters as distribution sensors has already been proven in a number of use cases. Utilities have deployed meters to monitor and report activity from downline distribution assets. Meters take on a distribution sensor role when used in a smart grid network for functions outside of measuring consumption for billing purposes.

Just like an effective distribution automation sensor, advanced meters contain local intelligence to perform operations based upon pre-defined conditions in the network. The potential is there to tap into "edge" decision-making capability that would eliminate the need to communicate with a central location for decision processing, thus improving network operations, system reliability and improved customer service.

Advanced meters have the capability to continuously measure system parameters and communicate that information on a timely basis for remote analysis of equipment. The use of an advanced meter to continuously monitor capacitor banks helps reduce operational costs associated with capacitor bank inspections and maintenance. Some of the capabilities of this type of monitoring program include leveraging an existing AMI communications network to remotely retrieve information that allows operators to assess the health and status in both stages of operation.

Meter values can be used to locate and troubleshoot common maintenance concerns, such as:

- **Blown cutout fuses**
- **Blown current limiting fuses**
- **Bad oil/vacuum switches**
- **Bad capacitor can**
- **Poor electrical connections**
- **Excessive harmonic content**

One example of a utility using the smart meter as a sensor for capacitor monitoring is Colorado Springs Utilities (CSU). In 2014, CSU installed Landis+Gyr's FOCUS AX residential meter in sockets connected to 66 overhead fixed capacitor banks. The program was originally set up to monitor two sizes of capacitor banks: 600 and 1200 kVARs. Meters were used to measure the neutral current of each capacitor bank with a threshold identified for each bank size. When the threshold was exceeded, the system notified the system operator with an email alert.

The program's first success involved discovery of a blown current-limiting fuse. Since this fuse does not provide an indication of being tripped, it was missed during an earlier field inspection. The utility also discovered excessive unfiltered harmonic currents present on some of the capacitor banks' neutral conductors. This led to the utility using a higher amperage threshold to account for non-fundamental frequency currents.

Many of the parameters captured by the meter can be recorded as load profile data for further analysis or be measured and retrieved as needed. The parameters may have configurable time frequencies which are required for the customer or utility's operational needs. In most cases, this information can be sent over the communications network to present the data in a useful and actionable format to either utility operations or the end customer.

Monitoring Procedures and Process at Colorado Springs Utilities

I. The first step involved installation of a potential transformer, socket and FOCUS AX meter with RF mesh communications directly beneath the capacitor bank as pictured:

II. Next, in Command Center – the AMI head-end software – a billing cycle was created for all cap bank meters so that we can generated a capacitor bank-only interval data file.

19	Billing Cycle 19
20	Billing Cycle 20
21	Billing Cycle 21
Cap Bank Meters Only	This billing cycle was created to group all the Cap Bank Meters into one group to generate a separate load profile interval extract

III. Each meter being used for monitoring was assigned to the capacitor bank cycle:

Billing Cycle Membership List

List of meters in selected billing cycle.

Meters in Cycle Cap Bank Meters Only

Meter Number	Collector	Configuration Group	Station Groups	Install Date
0573742E	ParkView	LG RF Residential Configuration F		12/16/2014 6:22 AM
0573743E	University	LG RF Residential Configuration F		12/16/2014 6:22 AM
0573744E	SPRINGS AMI	LG RF Residential Configuration F		12/16/2014 6:22 AM
0573747E	University	LG RF Residential Configuration F		12/16/2014 6:22 AM
0573748E	Little Mesa	LG RF Residential Configuration F		12/16/2014 6:22 AM
0573749E	Drake	LG RF Residential Configuration F		12/16/2014 6:22 AM
0573751E	University	LG RF Residential Configuration F		12/16/2014 6:22 AM
0573752E	Ski Summit	LG RF Residential Configuration F		12/16/2014 6:22 AM
0573753E	ParkView	LG RF Residential Configuration F		12/16/2014 6:22 AM
0573754E	Drake	LG RF Residential Configuration F		12/16/2014 6:22 AM
0573755E	University	LG RF Residential Configuration F		12/16/2014 6:22 AM

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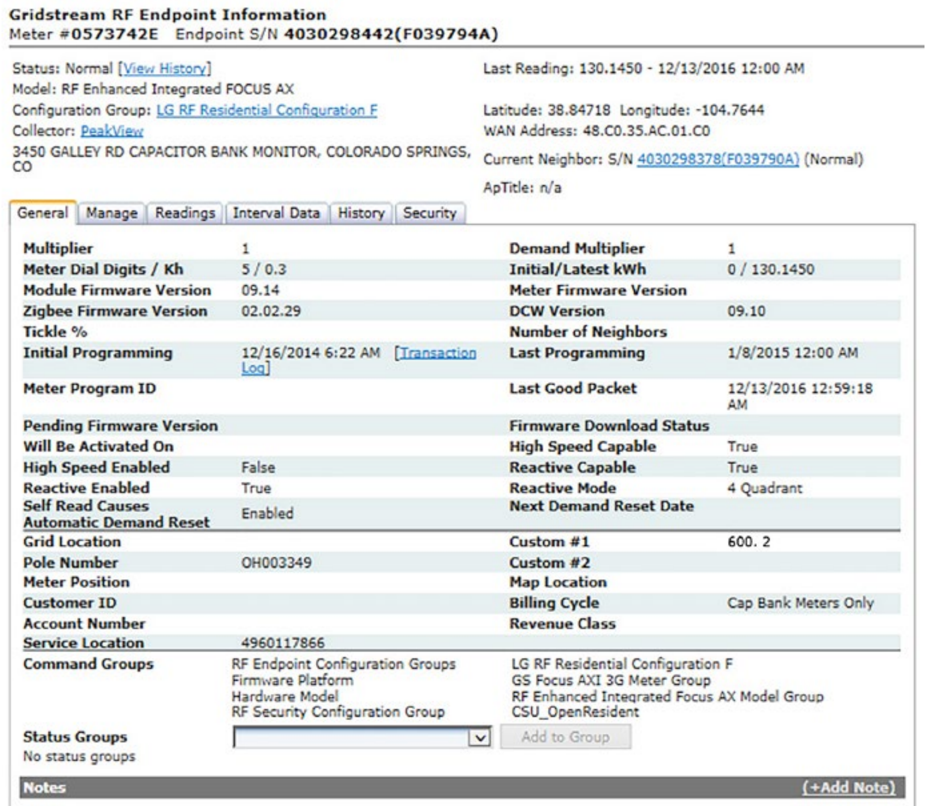
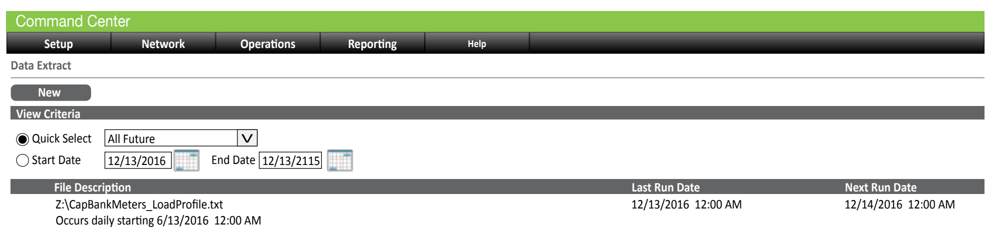
IV. The size of the capacitor bank and the secondary current threshold was added to the Endpoint information in Command Center:



V. An interval data extract was created for this capacitor bank cycle:



VI. An automated script is run at the Network Operations Center each day on yesterday's neutral current interval data for all capacitor meters. Any interval that runs above the threshold current (in the example meter above 2 amps secondary/20 amps primary for a 600 kVA transformer), will create an email that includes the meter number, pole number, size of the capacitor bank, secondary neutral current threshold, and number of the 96 daily intervals the neutral current was over the threshold.

Meters Sending 'Current (RMS) Phase A' Intervals Exceeding AMPS Threshold

Report Run Date: 2016-08-11 12:00
Intervals Date: 08/10/2016
Cycle: Cap Bank Meters Only

No.	Meter	Pole	KVA	Threshold	Intervals Count
1	0573791E	OH013518	1200	5	36

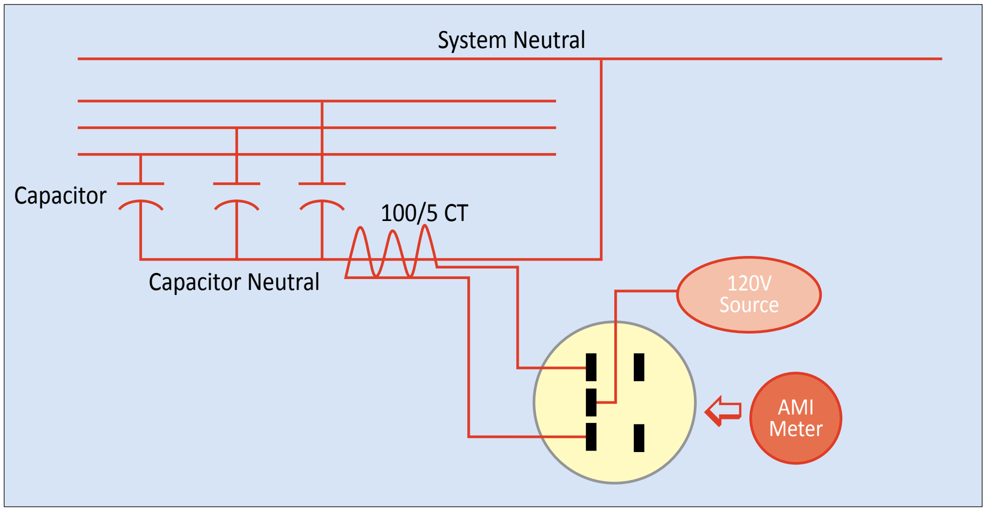
Program run timestamps: 2016-08-11-12:00:06 -to- 2016-08-11-12:00:-08
This script: 'C:\Scripts\CSU\CSU-CapBankMonitor.ps1' is running on computer : LGSCRIPT

(Example of an email alert sent to the Distribution Engineer)

Meter Deployment Process

The configuration of an advanced meter to act as a capacitor bank monitor requires that the meter selected is capable of capturing and reporting the selected values. Landis+Gyr's FOCUS AX meter platform is suitable when used with Landis+Gyr's RF mesh advanced metering network. In the future, there may be advantages for using a three-phase meter, such as the S4x, to take advantage of four-quadrant capabilities to monitor thresholds of RMS or Integral Reactive energy, Power Factor, Voltage and more.

The utility will need to mount an appropriate single phase socket that has the secondary neutral current running through the load terminals at the capacitor bank location. A potential transformer will also be needed to power the meter from the socket. (see diagram) This allows a standard single element current transformer rated meter (3S) to be inserted into the socket to begin monitoring. The Marwell meter socket has proven appropriate for this purpose and facilitates the necessary connections.



(Neutral current and voltage source wiring for a 3S meter socket)

Configuration of the meter in Landis+Gyr's AMI head-end software, Command Center, includes the steps outlined above. Once the meter is configured, specific alerts and reports can be run.

Conclusion

Advanced meters provide a wide range of applications beyond traditional metering functions when connected to an AMI network. The role of meters as distribution sensors is growing, as utilities experiment with applications that range from the consumer premise back up the circuit to the substation.

In the case of capacitor bank monitoring, advanced meters have proven useful as a low-cost alternative for obtaining timely and detailed alerts using the utility's existing communications infrastructure. These applications ultimately save utilities time and money by promoting effective operation of capacitors to maintain power quality, as well as providing another reference point for managing power flows on the circuit.