Industrial Application of the SEL-734 Meter

INTRODUCTION

The Facilities Department at Schweitzer Engineering Laboratories, Inc. (SEL) oversees and maintains the power system for seven buildings totaling over 250,000 square feet. This facility in Pullman, Washington, is the world headquarters of SEL. As a result of the company's growing need for power, the Facilities and Property Manager initiated an investigation of the power system for the Manufacturing building.

The investigation raised two issues. The first concerns the existing capabilities of the 480 V and 208 V service for the building. With the growing demand for power, would the power system for the building need to be upgraded? The second concern is whether harmonics induced by manufacturing equipment within the building were adversely affecting power quality.

ISSUE 1: ADEQUACY OF POWER SYSTEM TO MANUFACTURING BUILDING

Background

Currently, an SEL-351 Relay monitors the 480 V three-phase power system used by Manufacturing. The SEL-351 meters the primary voltage entering the building. The current entering the building, approximately 600 A, is too great to measure directly, which necessitates using current transformers (CTs). Split-core CTs built by E. O. Schweitzer Manufacturing, Co., LLC step down the current by a ratio of 200:1. In the future, SEL will add CTs to the 208 V system to monitor the single-phase power system. The split-core construction of the EOS Manufacturing CTs makes it easy to add monitoring without interrupting the electric supply.

The SEL-351 is capable of metering consumed energy as the Facilities Department requested. This relay, however, will not measure harmonics induced in the system. These harmonics are measured by an SEL-734 Revenue Meter added to the Manufacturing building instrumentation. The SEL-734 also records load profile information, using fifteen-minute demand intervals. The load profile information includes VARs, watts, power factor, and harmonics. As an added benefit,

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the processing rate of 8,000 samples-per-second allows more detailed power quality information such as voltage sag-swell-interrupt (VSSI) recording of transient events.

Managing Energy Demand Through Use of the SEL-734

The load profile information the SEL-734 collects can be graphed to provide a better understanding of power demands. Figure 1 shows kW information collected during the month of August. The electricity supplier bills for two components: energy used in watt-hours and power required in kilowatts as 15-minute peak demand. The supplier bills SEL $2.75 for each kilowatt of peak demand. Load profile information helps the facilities manager manage loads by shifting operations that are not time sensitive away from peak demand intervals.

The term "peak shaving" refers to limiting the maximum demand through shedding loads, time-shifting loads, or adding power generation. The predictive demand logic in the SEL-734 determines if a preset demand threshold will be exceeded. When used in conjunction with a generator to reduce peak demand, this logic reduces energy bills. Figure 1 shows that running a generator about two hours per month can reduce the peak demand by 50 kW.

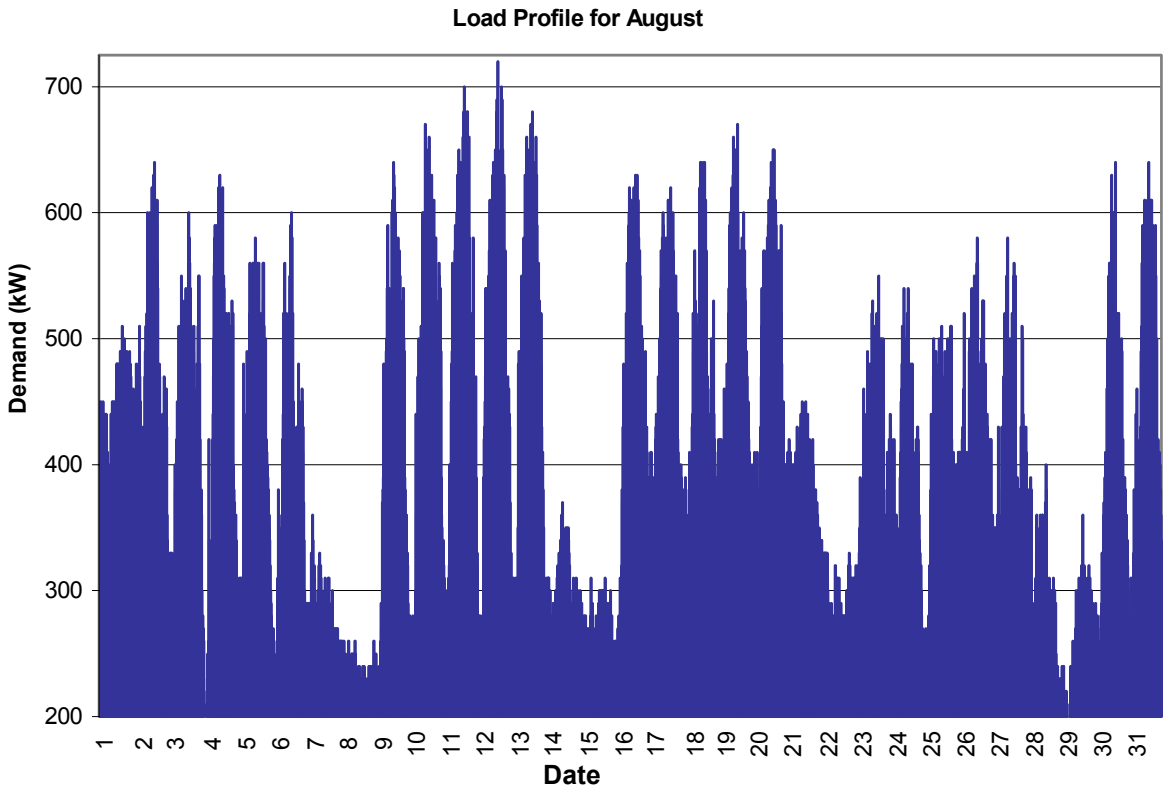

Figure 1: SEL Manufacturing Building Demand During August 2004

At SEL, a diesel generator running for 2 hours a month costs $14 and saves a peak demand charge of $137.50.

Diesel Generator Cost Analysis: $0.14/kWh • 50 kW • 2 hrs/month = $14/month

In other parts of the country, peak demand charges are many times the rate shown for the Pullman, Washington, facility. By implementing peak shaving on large loads in areas of high peak demand charges, the facilities manager can offset the cost of the meter during the first month of use.

Upgrading the Manufacturing Building Power Transformer

The 480 V power transformer located outside the Manufacturing building is rated for 750 kVA. During the summer, the air conditioning load increases the Manufacturing building load to more than 750 kVA. Power transformers operate normally up to full load but become inefficient and overheat when operated at loads greater than rated capacity. After reviewing load profile information from August 2004, the Facilities and Property Manager at SEL worked with the electricity supplier to install a 1500 kVA transformer.

Electricity bills note absolute maximum 15-minute demand, but these bills do not provide sufficient detail necessary for planning electrical system upgrades. The SEL-734 provides this detail through 15-minute load profile records, eliminating the need for a temporary power analyzer and data logger. The 15-minute load profile data from the SEL-734 reveals when the 480 V power transformer operates above the rated capacity. SEL shared the load profile data with the supplier who agreed to upgrade the transformer. The load profile information ensured that the power transformer was upgraded before system overloading occurred.

Issue 2: Power Quality

Power Factor

The VARs the SEL-734 meters and records are also useful for planning. The rate schedule of the electricity provider warns that a continuous power factor less than 90 percent results in VAR charges. This increases the electricity bill because sub-90 percent power factor demand incurs a $0.50/kVAR charge. Plotting the recorded power factor shows the duration of sub-90 percent power-factor intervals. Keeping the power factor greater than 90 percent is managed easily through use of capacitor banks. (See SEL Application Guide, AG2004-03 *Setting the SEL-734 Meter for Protection and Control of Distribution Capacitor Banks*.)

Voltage Sag-Swell-Interrupt Recording

An important power quality measurement is voltage sag-swell-interrupt recording. Machines used in Manufacturing are sensitive to short-duration voltage sags. Measuring the time and duration of such events is important to an understanding of whether critical manufacturing processes are affected. Figure 2 shows the voltage sag during the switch to a backup diesel generator. Comparing the duration of voltage sag to the ride-through time for a machine indicates whether manufacturing equipment can sustain such events.

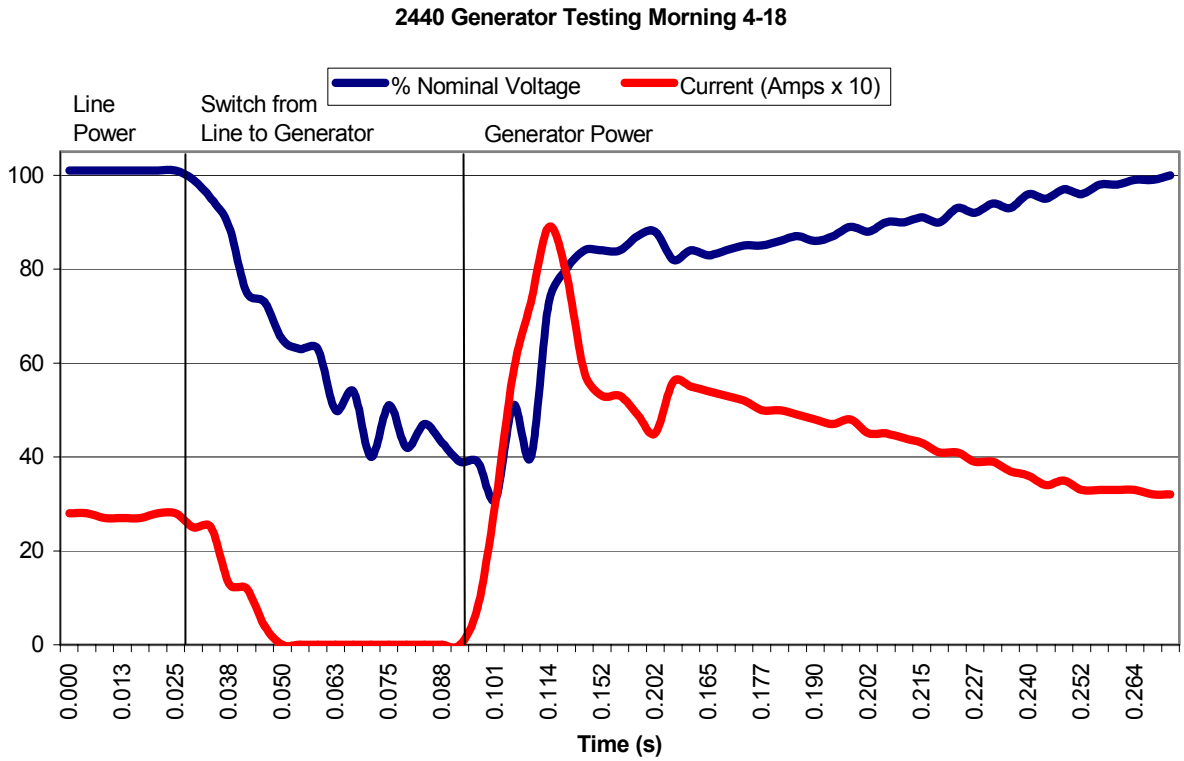

Figure 2: Sag-Swell During Generator Testing

The voltage sag-swell-interrupt recorder notes weather-related power quality issues, such as lightning storms. Dimming or blinking of overhead lights is an indication that a voltage drop occurred. The SEL-734 can record voltage sag/swell events and manage power quality during voltage drops to ensure that critical manufacturing equipment keeps running.

The internal logic of the SEL-734 can be programmed to warm up the backup generator if a series of voltage sag/swell events occur. Such programming enables a near instantaneous switch to backup power if a lightning strike interrupts power to the Manufacturing building. Figure 3 shows a series of voltage sags during a lightning storm.

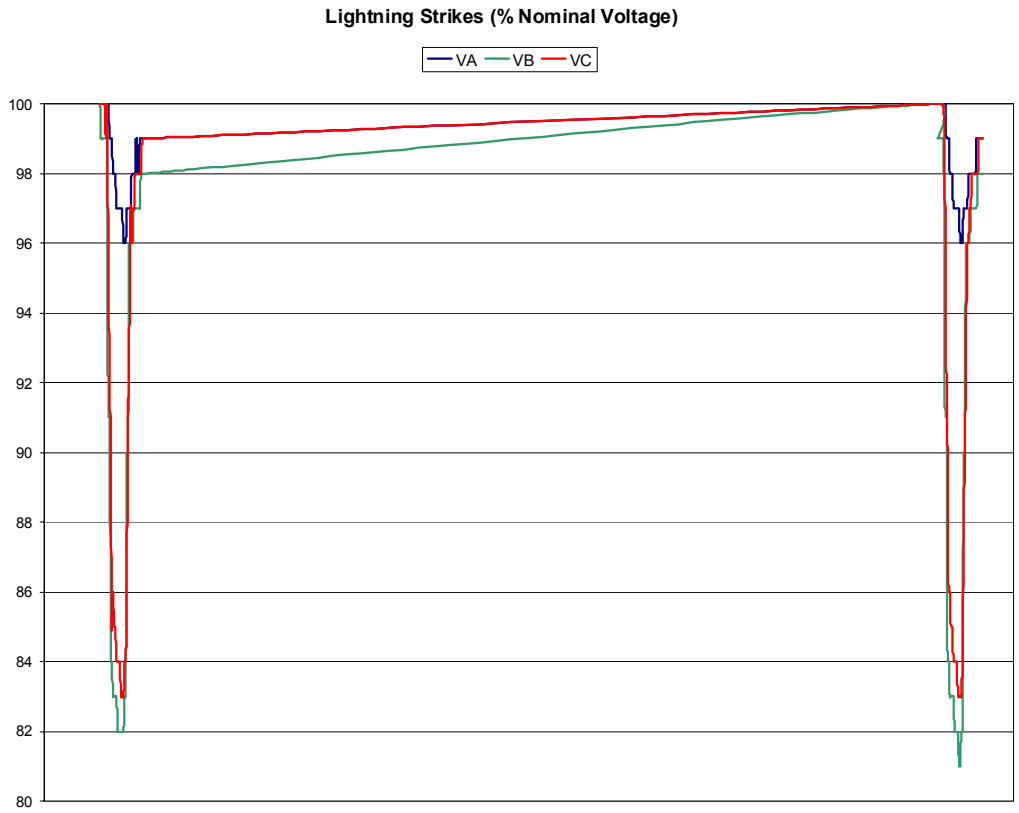

Figure 3: Voltage Sags During Lightning Storm

Harmonics

Harmonics metered on the building power system are plotted in Figure 4. Observe the presence of third harmonics induced by manufacturing equipment. Harmonics can cause inconsistent machine operation on the production floor. The SEL-734 records the date and time any of the second to fifteenth harmonics surpasses a preset threshold. Manufacturing planners use this time-stamped information to determine if harmonics are indeed the issue. Fixing a harmonics problem can be costly, but data collection is a standard function of the SEL-734. Use harmonic data the SEL-734 collects to plan future power system enhancements.

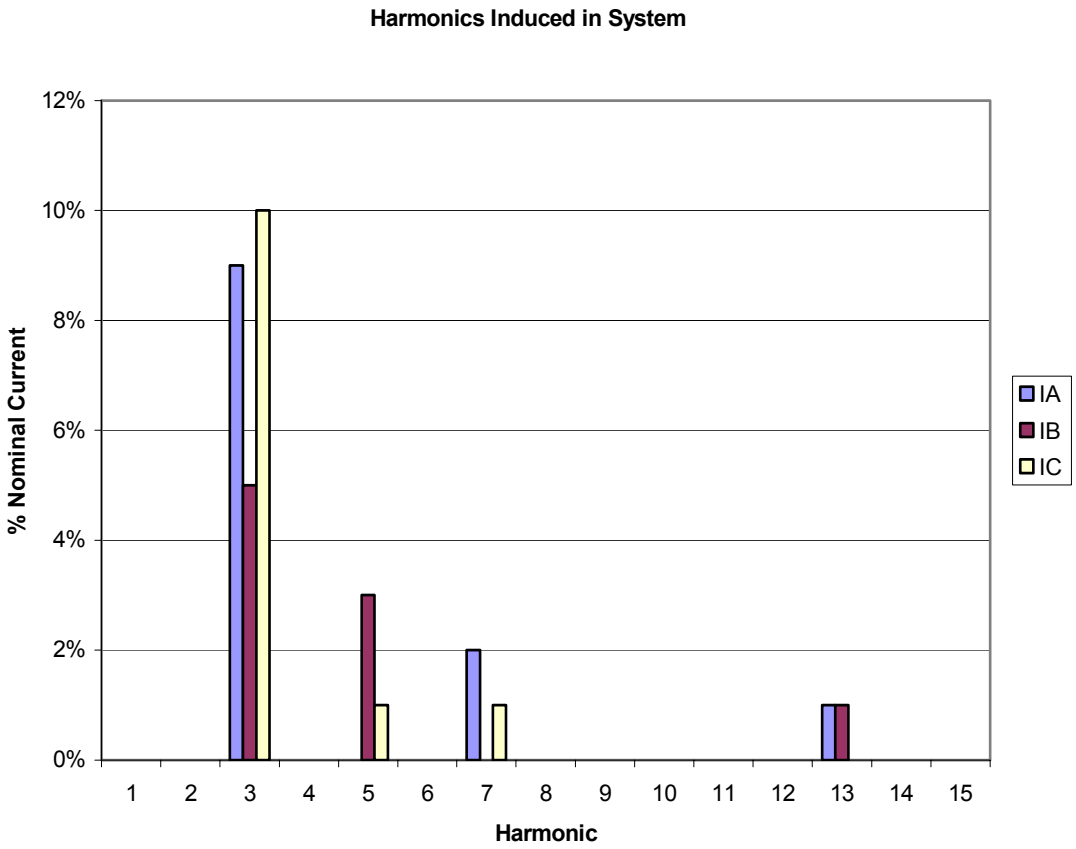

Figure 4: Harmonics in the Manufacturing Building Power System

CONCLUSIONS

The SEL-734 provides a valuable real-time record of facility power system information that is not realized from the monthly utility bill. Records of power quality trends help decrease machine downtime by providing a greater understanding of when events are likely to occur. Monitoring monthly demand helped determine an upgrade plan for the Manufacturing building 480 V power transformer. Power quality enhancements such as capacitor banks and uninterruptible power supplies can then be installed and controlled more effectively. Finally, cost savings from reducing peak demand charges and increasing the power factor make the SEL-734 a valuable asset to the manufacturing facility.