PQSoft Case Study

Voltage Sag Protection Using a Micro-SMES Device

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Abstract:

This case study describes the use of a micro superconducting magnetic energy storage (micro-SMES) device to improve power quality at a large semiconductor manufacturing facility by providing short term back-up power during utility system voltage sags and interruptions. This facility has critical electronic chip testing loads that are very sensitive to voltage variations. An explanation of why the micro-SMES was chosen instead of other technologies will be presented along with a brief overview of the technology as well as performance.

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RELATED STANDARDS

IEEE Std. 1159

GLOSSARY AND ACRONYMS

SMES	Superconducting Magnetic Energy Storage

INTRODUCTION

Voltage sags and momentary power interruptions are probably the most important power quality problems affecting industrial and large commercial customers. These events are usually associated with a fault somewhere on the supplying power system. Actual interruptions occur when the fault is on the circuit supplying the customer. Voltage sags are much more common since they can be associated with faults remote from the customer. Even voltage sags lasting only 4-5 cycles can cause a wide range of sensitive customer equipment to drop out.

A large semiconductor facility was experiencing equipment tripouts caused by voltage sags at one of their buildings. This building was fed from a 13.2 kV distribution circuit. There were 17 voltage sags causing a loss of load in their sensitive tester room during a 12 month period. Of those 17 events, 4 were on the 115 kV system and 13 were on the 13.2 kV distribution system. These events resulted in significant man-hours of lost productivity. Therefore, some type of ride-through device was needed to protect these loads. For this particular case, a micro-SMES device was installed.

CHIP TESTER SENSITIVITY

Electronic chip testers are very sensitive to voltage variations, and because of the complexity involved, often require 30 minutes or more to restart. In addition, the chips involved in the testing process can be damaged, and several days later, internal electronic circuit boards in the testers may fail. A chip tester consists of a collection of electronic loads, printers, computers, monitors, etc. If any one component of the total package goes down, the entire testing process is disrupted. The chip testers can be 50 kVA and larger in size.

The 17 voltage sags mentioned above ranged in magnitude from 14-100% below nominal. The testers typically dropped out if the voltage fell below 85% of nominal. The following figure is a summary of all the disturbances recorded during that time period. As can be seen from the figure, most voltage sags recorded fell very close to the trip setting of the chip testers (80-85%) and are less than 100 cycles in duration.

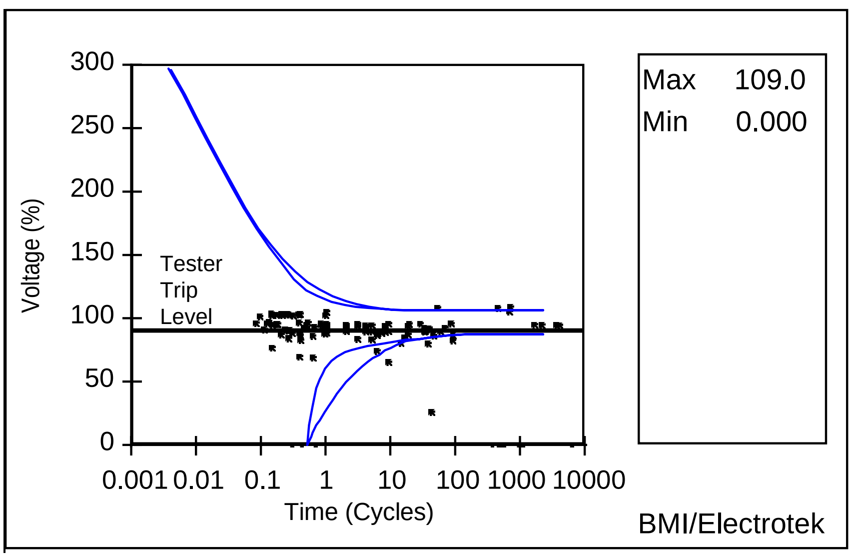

Figure 1 - Summary of Voltage Sag Events at Chip Tester Location

WHY USE A MICRO-SMES?

The micro-SMES was chosen as the ride through device to protect the tester loads for several reasons. The customer liked the mobile capability of the micro-SMES unit. The entire unit fits in a 48' semi-trailer and can easily be moved to other sites. The chip testers have been moved in the past, and the possibility exists that they could be moved in the future.

Another reason the micro-SMES was chosen over other ride through devices such as uninterruptible power supplies (UPSs) was its small space requirement. An equivalent rated UPS would have required much more physical space than the micro-SMES, and a costly addition to the building would have been required in order to house the UPS's batteries.

MICRO-SMES OPERATING PRINCIPLES

Micro-SMES devices utilize a superconducting magnet (Figure 2) to store energy in the same way a UPS uses batteries to store energy. The main advantage of the MICRO-SMES is the greatly reduced physical space needed for the magnet as compared to batteries. There are also a lot less electrical connections involved with MICRO-SMESs as compared to UPSs so the reliability should be greater and the maintenance requirements less. Initial MICRO-SMES designs have been tested in several locations with favorable results. The projected future costs of an MICRO-SMES should be competitive with UPSs.

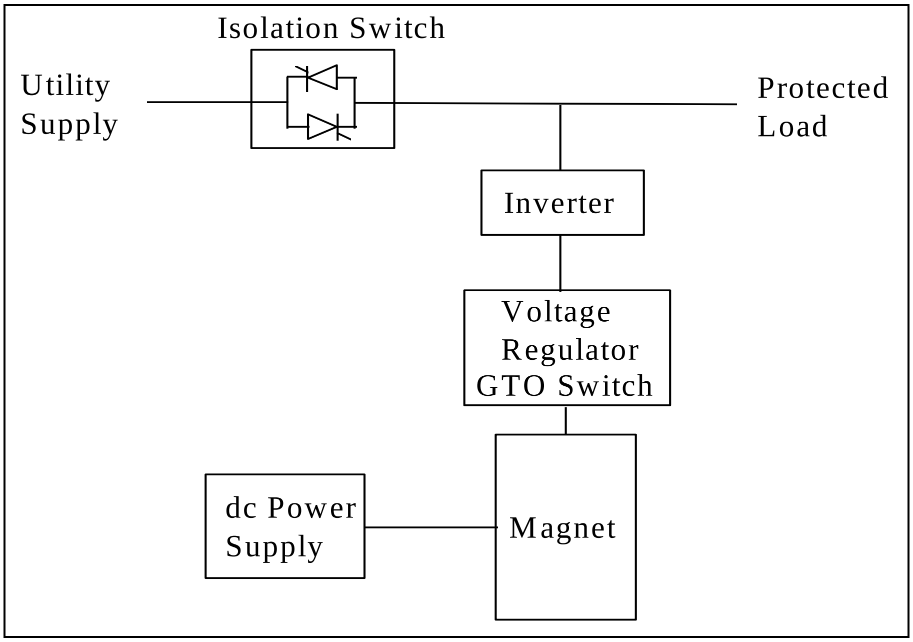

Figure 2 - Micro-SMES One-Line

When a voltage sag or momentary interruption occurs, the tester loads are isolated from the utility system with a fast-acting solid-state switch. The isolation switch can operate in less than a quarter-cycle, and opens when the utility supply falls below a pre-set value which, for this case, is 93%. Once opened, the tester loads receive their power from the two inverters, which in turn draw on the energy stored in the magnet. The dc current in the magnet is then redirected by the voltage regulator (GTO switch opens) and flows across the capacitor bank of the inverter. When the voltage on the capacitor bank reaches a pre-set level, the GTO switch recloses. The inverters convert this energy to ac power for the tester loads, which lowers the voltage on the capacitor, which then triggers the reopening of the GTO switch. When utility power returns to normal, the tester loads are resynchronized for 100 msec, after which, the isolation switch recloses.

MICRO-SMES PERFORMANCE

During the one year test program, the micro-SMES device operated successfully 34 times without any problems. Figure 3 shows measurements from the input and output of the device. The measurements show a voltage sag down to 74% of nominal voltage on the input and the corresponding output voltage of the micro-SMES.

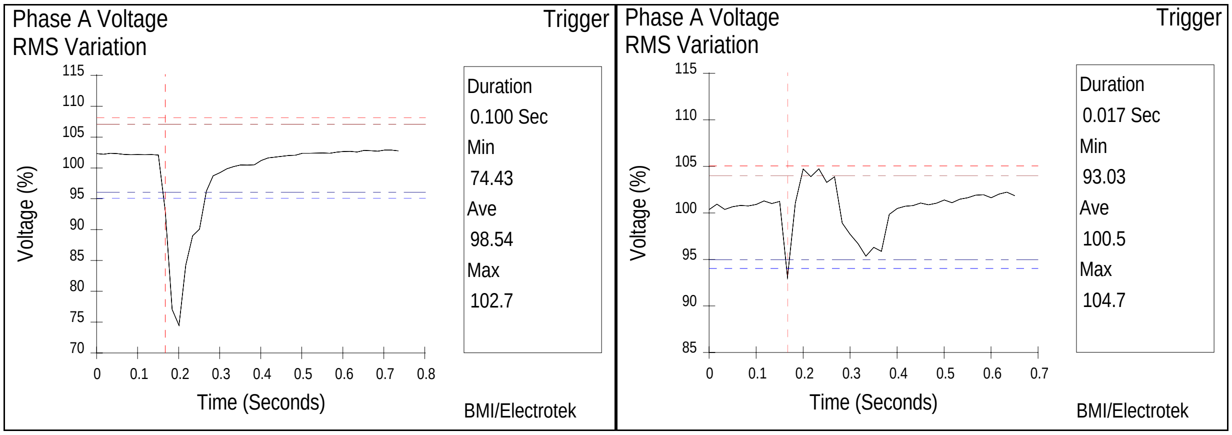

Figure 3 - Example Input/Output Waveforms

SUMMARY

The utility has addressed the power quality needs of an extremely important customer by using a state of the art superconducting storage system to provide short term back-up power to sensitive tester loads. The micro-SMES has already proven its effectiveness by enabling the protected tester loads to ride through several voltage sags, while unprotected loads have tripped.

REFERENCES

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