

Ride-Through Performance of a Web Process Enhanced by a Constant-Voltage Transformer

Background Automated industrial processes are becoming increasingly complex, often brimming with nuances even process-design engineers struggle to understand. In the modern industrial facility, many electrical and electronic devices are routinely integrated into automated processes, increasing the potential for compatibility problems. As process-control devices are innovated, they are often retrofitted to existing processes, introducing the potential for additional compatibility problems. Although characterizing the tolerance of a process component to under- and overvoltages has been a fairly straightforward laboratory procedure, characterizing an entire process—how the various components behave and interact during under- and overvoltages—has been beyond the capability of ordinary laboratory

procedures. To overcome this limitation, PEAC developed a mock web process to simulate an entire industrial process in the laboratory. As shown in Figure 1, the miniature web process includes the components found in a common automated industrial web process such as a newspaper web, wire drawing, or plastic film. Once an entire industrial process can be simulated, various power-conditioning devices—such as the constant-voltage transformer—can be reliably evaluated for on-site performance.

Objective The objective of the tests performed at the EPRI Power Electronics Applications Center (PEAC) Power Quality Test Facility was to characterize the ability of a constant-voltage transformer to enhance the ride-through performance of a typical automated industrial process.

Test Setup A single-phase, 210-VA constant-voltage transformer (CVT) was tested by loading the mock web process as shown in Figure 2 (page 2). By switching from nominal ac voltage to a variable voltage source, a power disturbance simulator created voltage sags lasting from one to 500 cycles and with amplitudes from 99 percent down to zero percent of the nominal voltage. These voltage sags were applied to the control-voltage bus of the web process. Before testing, 1) the programmable logic controller (PLC) was programmed to run a two-motor web process and was set in the RUN mode, 2) a true RMS voltmeter was used to calibrate the output voltage of the variable voltage source, and 3) the process was started from the operator panel. A computer monitored the central processing unit (CPU) of the PLC to determine whether the CPU operated properly during and after each test. A four-channel digitizing signal analyzer was used to monitor the control-voltage bus, the status of the master control relay (MCR), the web position, and the speed of the bottom spool, which supplies material to the top spool.

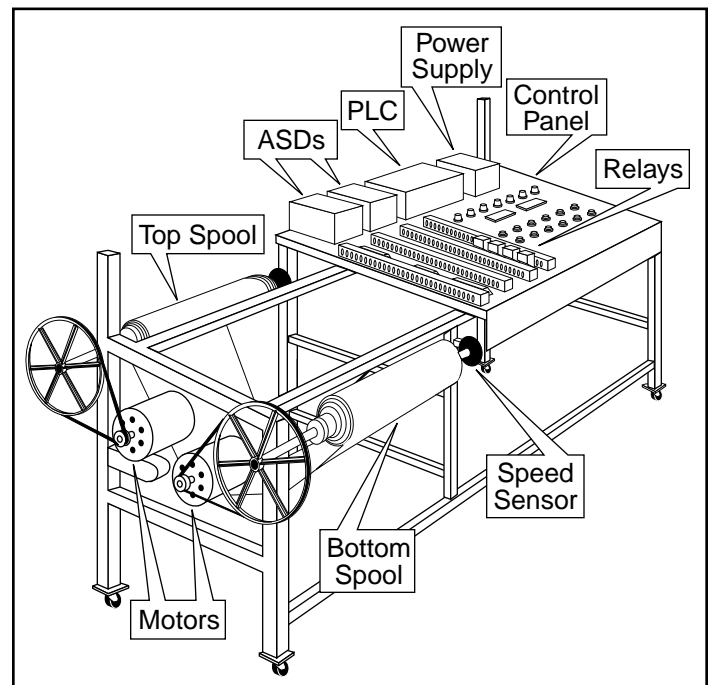


Figure 1. Mock Web Process

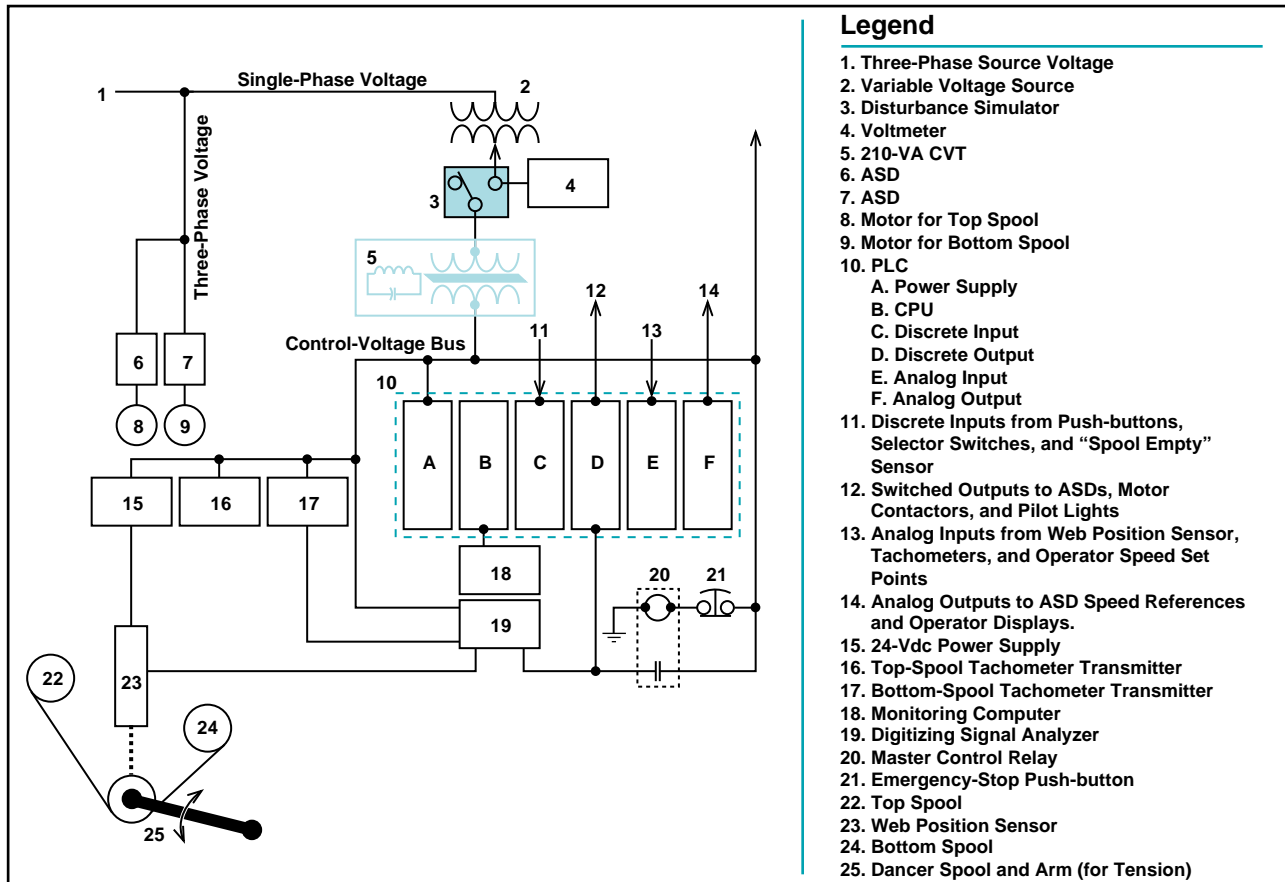


Figure 2. Test Setup

TEST RESULTS

Without CVT Applying voltage sags to the mock web process revealed two types of process malfunctions: 1) During voltage sags lasting two cycles or longer and 74 percent or less of the nominal voltage, the PLC shut down the process after the contacts of the MCR dropped out. When the MCR drops out, the PLC determines that the emergency-stop button has been pressed and shuts down the process. As shown in Figure 3, the bottom spool slows immediately after the

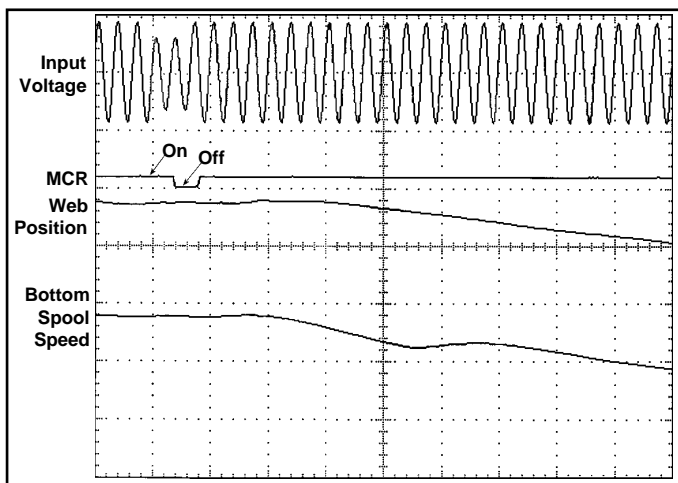


Figure 3. Example of a Process Shutdown

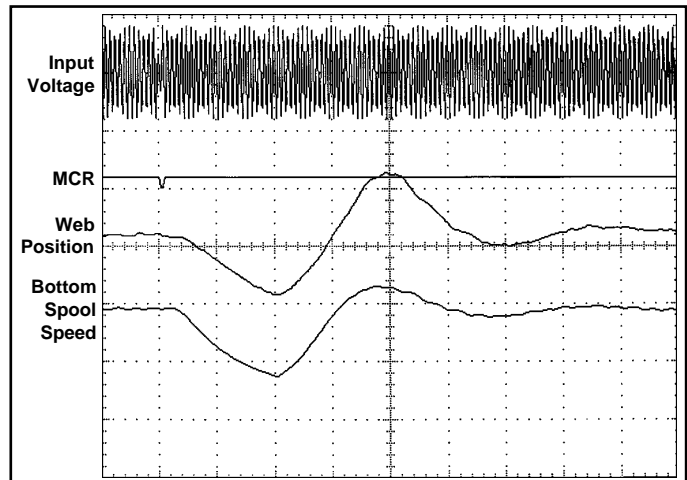


Figure 4. Example of a Process Fluctuation

MCR drops out. A few seconds later, the two motors driving the spools coast to a stop. 2) During voltage sags lasting less than two cycles and between 74 and 75 percent of the nominal voltage, the PLC did not trip. However, as shown in Figure 4, the web position and the speed of the bottom spool fluctuated significantly. Figure 5 shows the ride-through performance of the mock web process without a CVT, including both types of process malfunctions.

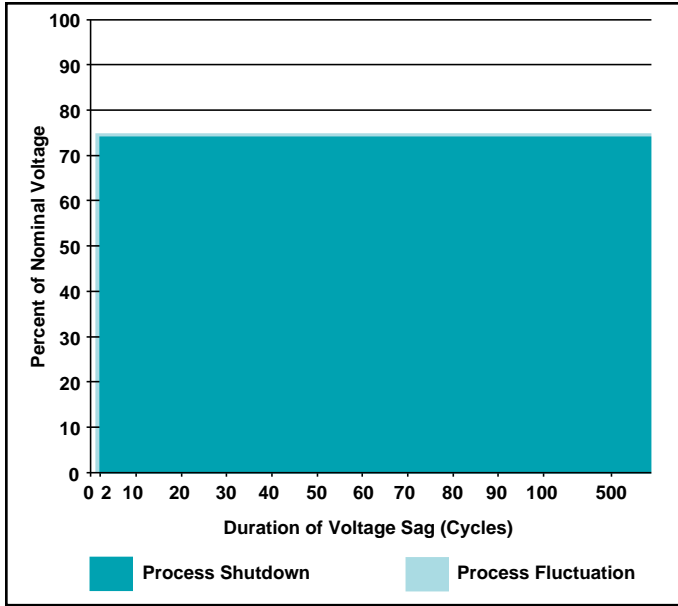


Figure 5. Process Ride-Through without CVT

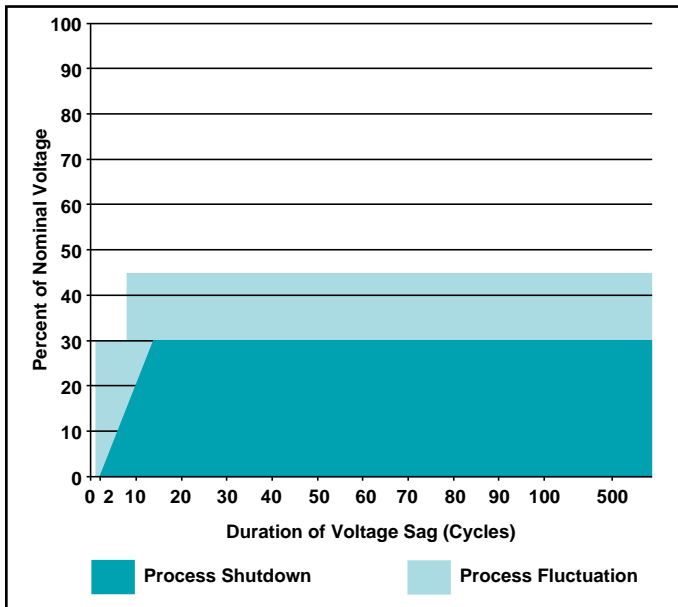


Figure 6. Process Ride-Through with CVT

With CVT A CVT was installed at the control-voltage input as shown in Figure 2. Once again, voltage sags caused process shutdowns and process fluctuations. Figure 6 shows the ride-through performance of the mock web process with a CVT installed. At eight cycles—which is the most common duration of voltage sags—the sag tolerance of the mock web process increased from 75 percent to 45 percent, a 40 percent improvement in process ride-through.

DISCUSSION

Like any automated process, the ride-through performance of the mock web process was only as good as its weakest link, which invariably proved to be the master control relay. Test results demonstrate that installing a CVT at the control voltage input greatly enhances the ride-through of the entire process. In this case, the area of process shutdown during undervoltages from one to 500 cycles was decreased by 60 percent. However, the potential for process fluctuations at eight cycles increased from one percent of the nominal voltage to 30 percent.

SIGNIFICANCE

For most manufacturers, the constant-voltage transformer is an effective way to enhance the ride-through tolerance of industrial processes. Only a few types of industrial processes require such precise process control that the increased potential for process fluctuations is an unacceptable consequence. For example, a wire extrusion process must maintain a constant spool speed and torque to ensure a consistent wire thickness. For manufacturers that require such precise control, an uninterruptible power supply can support the control voltage during voltage sags down to zero volts and lasting several seconds, although it is more expensive than an equivalently sized CVT. Without any power conditioning at all, however, most automated processes can be expected to periodically malfunction.

ACKNOWLEDGMENTS

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