Start Small when Solving Voltage Sag Problems

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There has been a lot of discussion recently about *custom power* solutions to power quality problems. The term is generally used in reference to large solutions applied on distribution system. These solutions take advantage of power electronics to condition the voltage supplied to customers with equipment that could be impacted by voltage variations. Examples include the distribution voltage restorer (DVR) and primary static switch.

The most common problem for most industrial customers is voltage sags - momentary voltage variations that cause critical equipment to drop out and interrupt processes. Custom power equipment can improve the quality of supply for these customers but the equipment is quite expensive and must be justified based on the costs of the impacts. A better approach usually involves looking closely at the specific equipment that is being impacted by voltage sags and seeing if it is possible to improve the performance (ride through characteristics) without the requirement to protect the entire plant.

I don't want to throw cold water on the custom power concept. There are many examples where protection of significant portions of the plant may be the most economical way to solve the problem. In these cases, new energy storage technologies and power electronics configurations will play a major role. In fact, Power Quality magazine will have an article in the next issue looking at some of these new technologies and where they can be applied effectively. However, when you are looking for the most economical solution for improving the process ride through during voltage sags, you will usually want to start at the individual loads that are the most sensitive.

The ride through capability of individual loads can often be improved with modifications to the control circuits (increasing the delay on tripping for undervoltages to about one second will prevent trips for almost all voltage sags), protection of the controls themselves, or protection of other low power components that are sensitive to voltage sags. Remember that a process is as sensitive as its weakest link – any device in a process can cause the whole process to trip during a voltage sag. It doesn't make any difference if the sensitive component is just a low power controller.

To illustrate this concept of protecting the low power equipment first, here are three examples where the ride through capability of important processes were improved with relatively inexpensive modifications. These examples are complements of Mike Hillhouse at Entergy. Mike is one of the experts in troubleshooting voltage sag problems and finding the optimum solution for improving the process performance.

1. Motor starters cause motor loads to trip unnecessarily.

Pumps, compressors, fans, and other motor loads often drop out during voltage sags. If they are part of an important process, they can shut down entire process. This is unnecessary and it is not even good for the motors. Most voltage sags last for less than 10 cycles. These voltage sags are not going to cause any problem for the motor. In fact, the additional duty associated with restarting the motor after it is tripped is a greater stress on the motor than the very short duration undervoltage associated with the voltage sag.

Then, why do they trip? Low voltage motor controllers typically use starters with ac magnetic coils, as illustrated in Figure 1. These magnetic starters will typically drop out for voltage sags in the range of 40-70% voltage, depending on the manufacturer and particular model. The dropout occurs very quickly (less than 2 cycles) so even the very short duration voltage sags will cause them to drop out.

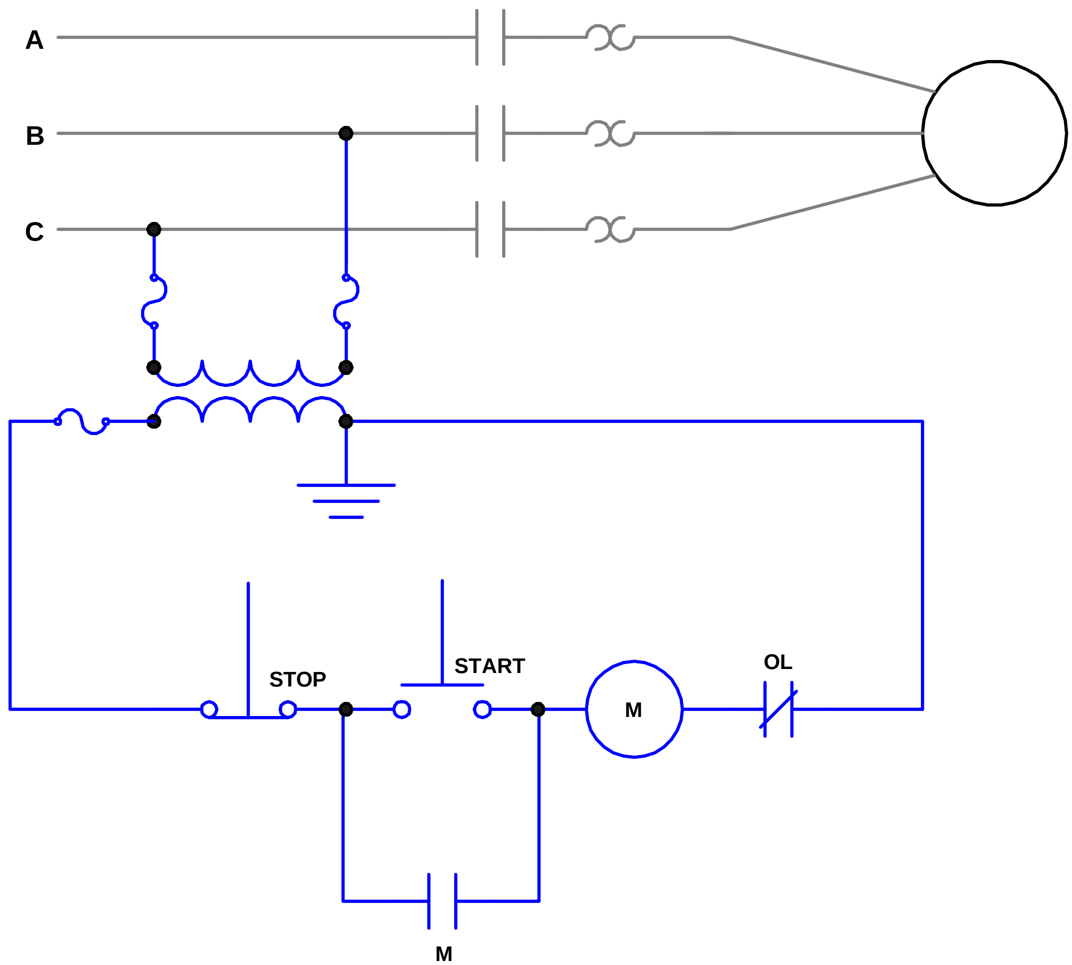

Figure 1. Typical motor starter with ac coil.

How can we improve the ride through of motors in these applications? Most of the voltage sags do not pose any problems for the motors, so the starters must be protected or modified so that they do not drop out on these short duration events. Two easy solutions are available:

a. Use a dc coil, instead of an ac coil. By inserting a dc coil in the circuit (Figure 2), ride through of the starter can be achieved down to about 10% voltage. The starter should only drop out for actual interruptions.
b. Power the starter through a constant voltage transformer (Figure 3), also known as a ferroresonant transformer. The CVT can provide an output voltage high enough to keep the starter from dropping out for input voltages as low as 30-40%. This should prevent dropout for almost all voltage sag conditions.

The advantage with either of these approaches is that the motor will still be tripped in the event of an actual interruption, when you want it to trip for protection. However, it should ride through the great majority of events that are just short duration sags.

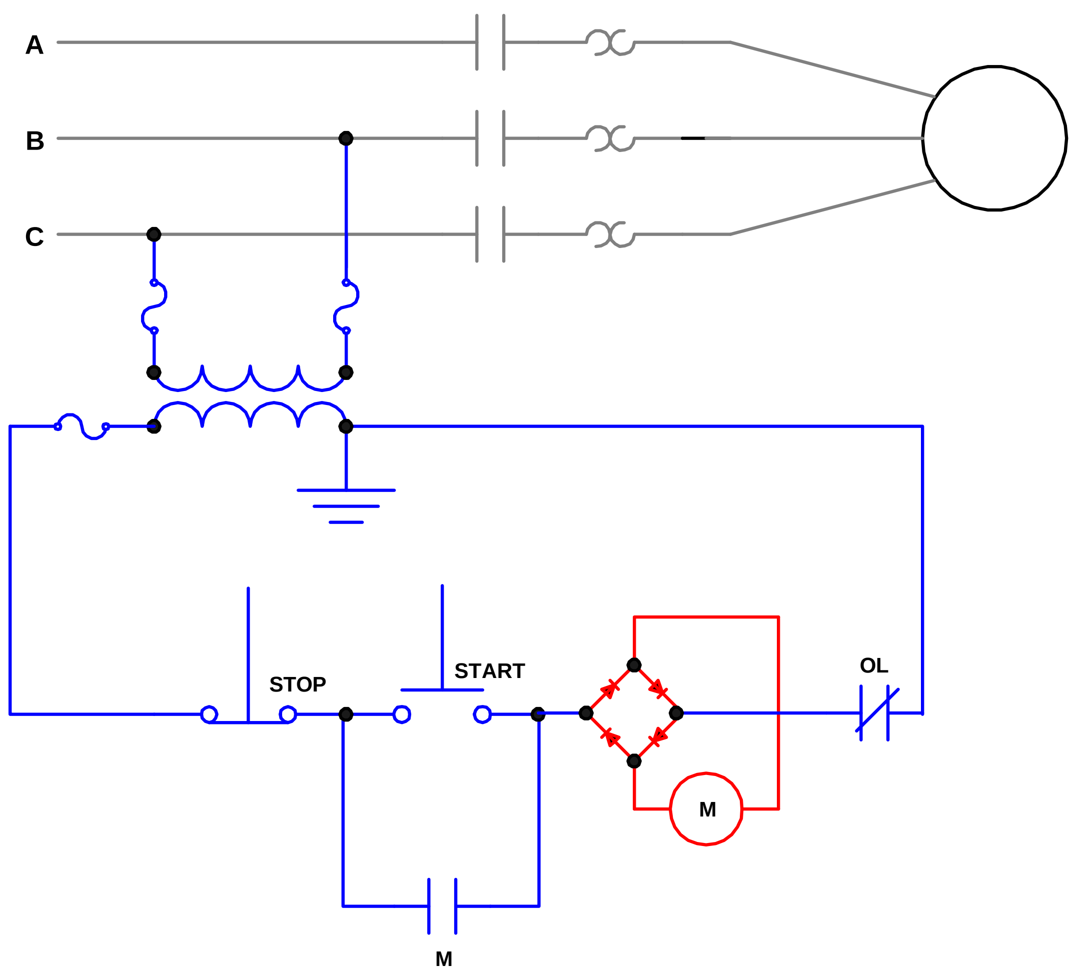

Figure 2. Using a dc coil in the starter to improve the voltage sag ride through.

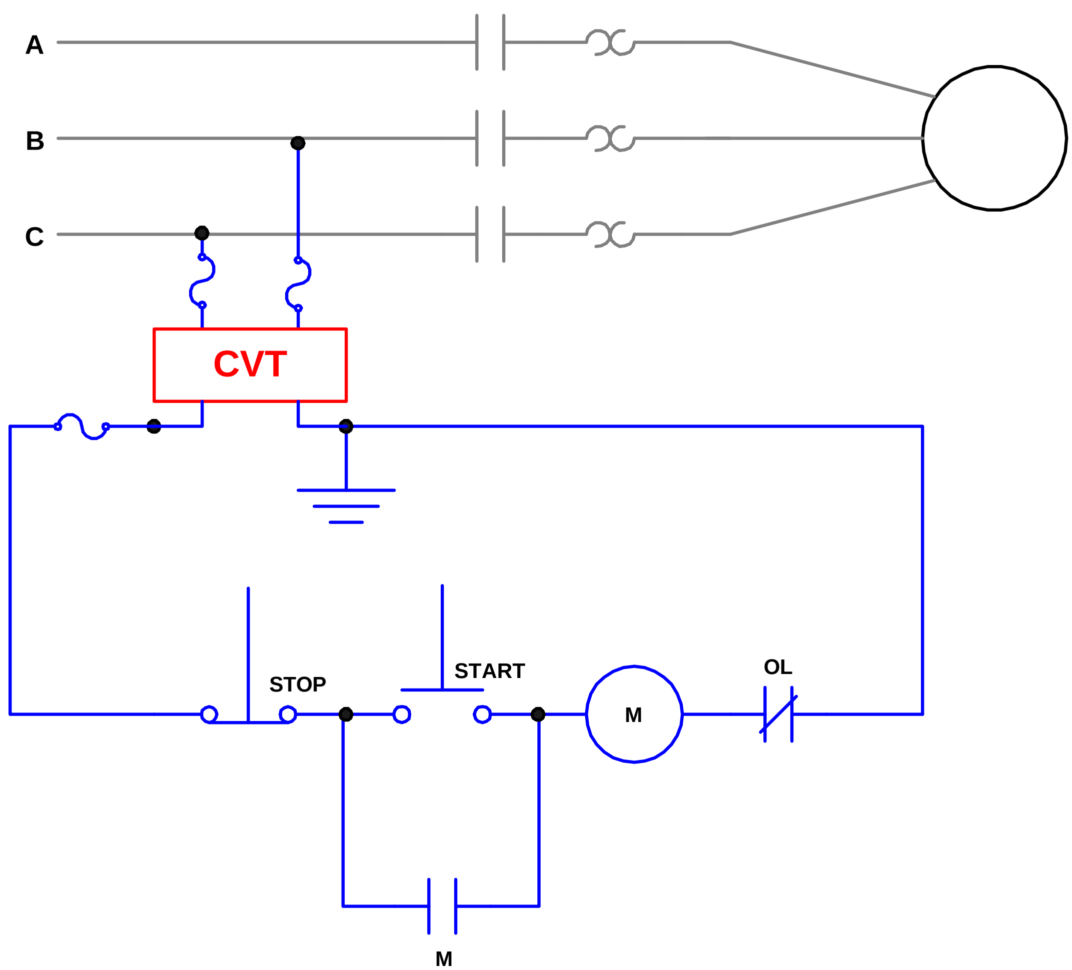

Figure 3. Using a CVT to power the ac coil. The CVT can provide ride through for sags down to about 40% voltage.

2. Chillers trip due to sensitivity of temperature controllers.

Chillers are often critical to processes. Semiconductor manufacturing, testing applications, hospitals, and many other applications have chillers that must be kept on line as part of the overall operation or process. Chillers that are tripping during voltage sags may be subject to the problems described above with the sensitivity of the magnetic starters in the motor controllers. However, these applications often have process controllers or temperature controllers that can be even more sensitive to voltage variations than the motor starters.

Figure 3 gives the voltage sag ride through characteristics of one temperature controller that was causing a chiller to trip at a semiconductor chip testing facility. The controller drops out for voltages below about 80% that last longer than about one cycle. The chiller had to remain on line to assure the integrity of the overall tests. As described above, the great majority of events that were causing the chiller to trip were short duration voltage sags that should not be any problem for the actual motor. The solution in this case is to protect the temperature controller with a CVT so that it can ride through voltage sags. Again, interruptions will cause the controller to drop out which is ok because we want to the motor to trip for actual interruptions. The effect of the CVT on the ride through characteristics of the temperature controller is also shown in Figure 3.

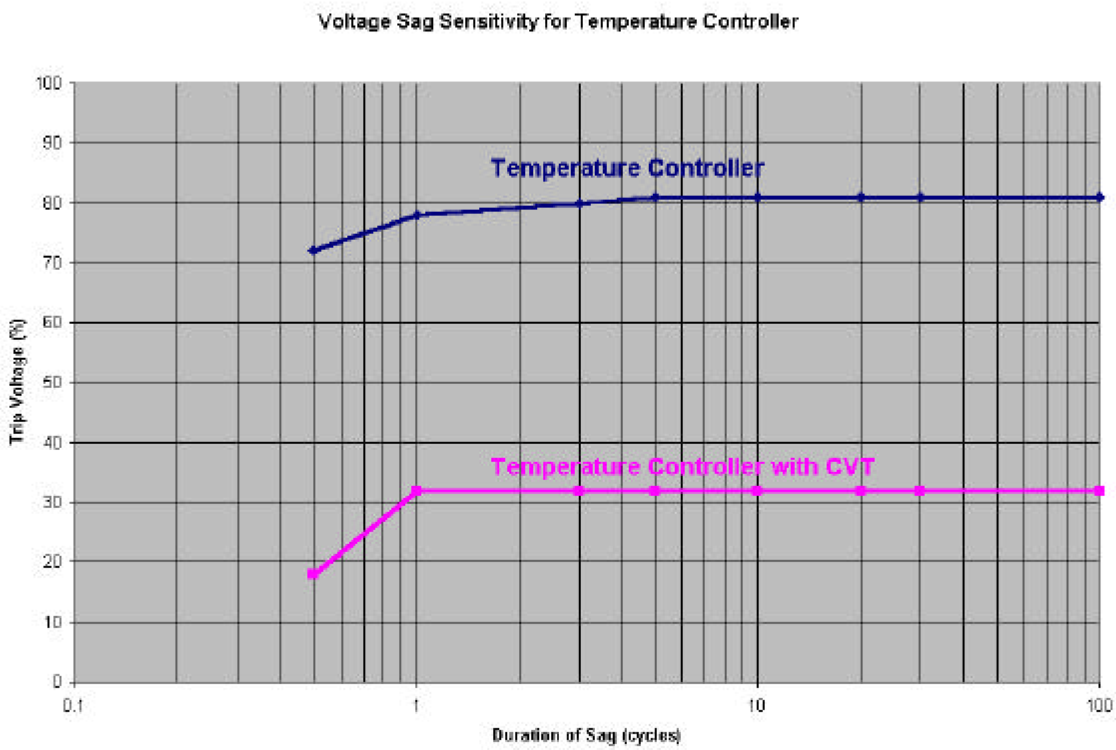

Figure 3. Voltage sag ride through characteristics of a temperature controller with and without a CVT.

3. Boiler protection systems can be very sensitive to voltage sags.

Many processes include boilers or some other heating requirement that involves heating with natural gas. The boiler controls can often be the weak link in terms of the sensitivity to voltage sags. We have run into problems of this type in breweries and other applications where boilers are part of the process.

The boiler protection systems usually have flame safeguard systems that include an infrared or ultraviolet flame scanner and an amplifier to indicate that the flame is ok. Problems occur because the flame scanner itself is sensitive to voltage variations. During voltage sags, the flame scanner reacts by indicating a loss of flame. A second problem occurs with the gas valve solenoids. On loss of voltage, these solenoids fail closed, resulting in a shut down of the furnace. Figure 4 shows an example system that can be sensitive to voltage sags.

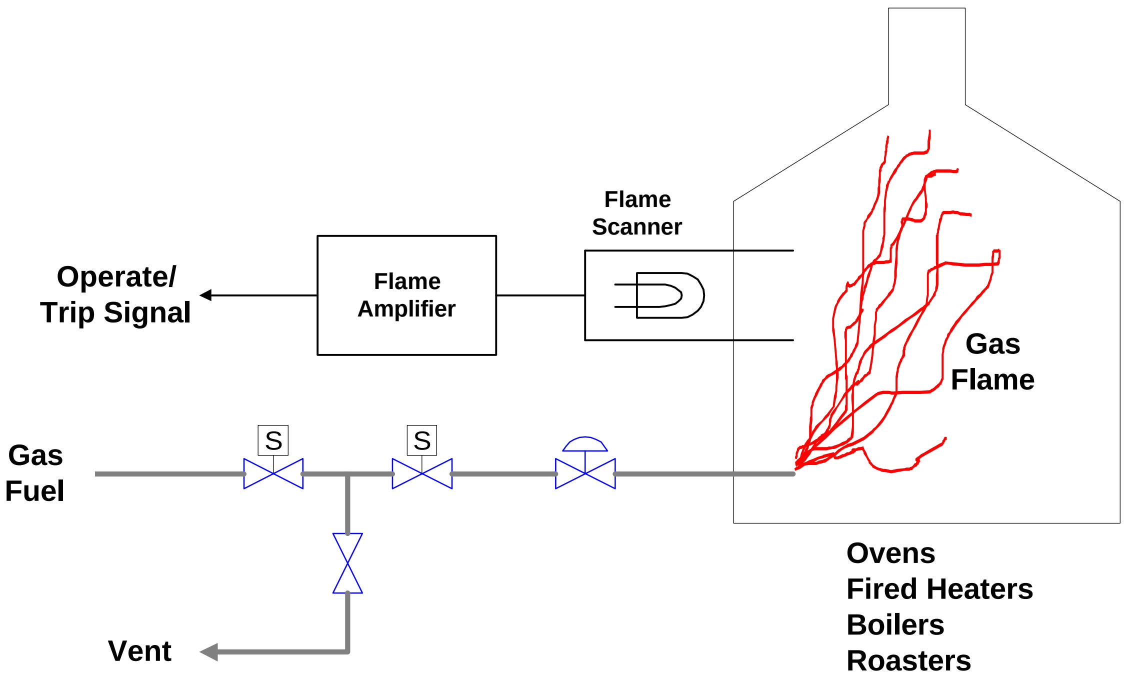

Figure 4. Simplified schematic showing the sensitive parts of the boiler protection and control system.

Both of these problems can be solved by powering the flame scanner and the ac solenoids through a constant voltage transformer (CVT). The ac solenoid problem can also be solved by using dc solenoids. Usually, the CVT can be installed in place of an existing control transformer that is already in place for these loads.

With simple solutions like those described above, many of your voltage sag problems can be solved. If these solutions do not improve performance sufficiently or if the protection is needed even for actual interruptions, then more expensive custom power solutions may be the next step.