Surge Testing the Communication Port

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Surge testing the power port of electronic equipment can determine the cause-and-effect relationship between power surges and equipment damage. In the last installment, we explored surge testing. In this article, we'll broaden our discussion to include the communication port of electronic equipment.

Electric utilities, insurance companies, manufacturers, and end users have shed some light on the destructive nature of power surges. The EPRI project, called *Analysis of Failure Mechanisms for Electrical and Electronic Equipment*, began this year with some exploratory testing in the laboratory.

Power quality investigators are primarily interested in the power port, but they are also concerned about the communication port of equipment that transmits and receives data during normal operation. For example, equipment, such as process controllers, will communicate via coaxial, telephone, and data cables. So what do communication signals have to do with the quality of power at the equipment power port? Surges carried by the power conductors can be coupled to the communication conductors and thereby carried to ultra-sensitive communication components such as semiconductors.

A Surge-Coupling Mechanism

Surges carried by the power conductors can be coupled to data conductors through various mechanisms. For example, data cable can connect equipment to other equipment. In this scenario, the data cable includes a signal-reference conductor that is connected to the equipment chassis and therefore ultimately connected to the equipment-grounding conductor of the power cord.

Consider the example of an adjustable-speed drive (ASD) in one area of a facility that is connected via a data cable to a programmable logic controller (PLC) in another area, as shown in **Fig. 1** below. The peak of a voltage surge caused by a nearby lightning strike may not arrive simultaneously at the two equipment power ports. In this case, the power conductors from the service entrance to the ASD are much shorter than those to the PLC. During a surge, the line-to-ground MOV in the ASD begins to conduct, diverting potentially damaging surge currents to the chassis ground as the current attempts to reach the grounding electrode at the service entrance.

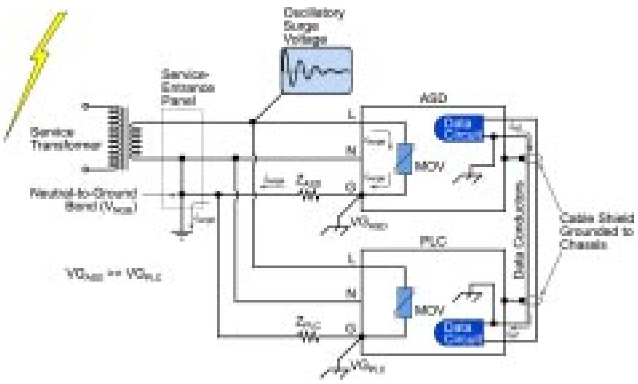

Fig. 1. *Surge current coupled from the power port to the data port.*

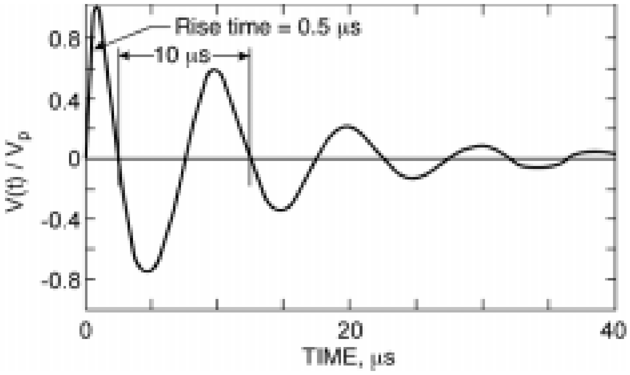

Fig. 2. *ANSI/IEEE Standard C62.41 ring wave.*

Fig. 3. *Test setup for surge testing the communication port of a motor and control system.*

Although components in the power port may be spared, some of the surge current may find its way to sensitive components in the data circuits.

As surge current flows through the impedance of the grounding conductor (Z_{ASD}) back to the service entrance, the voltage potential between the chassis ground (VG_{ASD}) and the neutral-to-ground bond at the service entrance (V_{NGB}) increases. Meanwhile, because the surge has not yet arrived at the PLC, its chassis voltage potential (VG_{PLC}) remains at the ground-reference potential of the service entrance (V_{NGB}). As a result, a large current (i_{ref}) flows through the data cable as the cable attempts to equalize the resulting voltage difference between the two chassis (VG_{ASD} - VG_{PLC}). This current and the voltage difference between the two chassis references can upset or damage sensitive semiconductors in data circuits.

Exploratory Testing

Before drafting a protocol for surge testing the communication ports of equipment, it is important to explore the effects of applying surges directly to the data cable between an ASD and PLC. Does an elevation in potential between the cable shield and equipment chassis get coupled to the data conductors?

The 100kHz ring wave from ANSI/ IEEE Standard C62.41, shown in **Fig. 2** on page 13, can be used for testing such a hypothetical situation. The ring wave is a decaying oscillatory waveform with an initial rise time of 0.5 microseconds (μs) and a wavelength of 10 μs. As opposed to the combination wave, which was used to test the power port of equipment and surge-protective devices (SPDs), the ring wave is suitable for applying surges to data cabling or communication ports that often do not have SPDs at the port input terminals.

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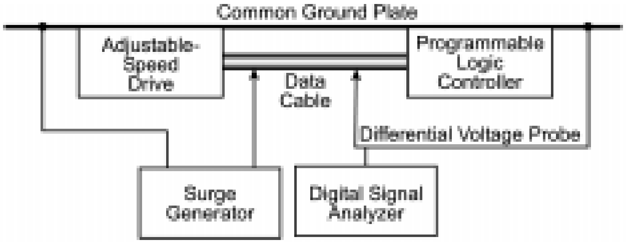

Fig. 4. *Simplified diagram of test setup for exploratory surge testing of the communication port.*

In the laboratory, a surge generator with a plug-in module for the 100kHz ring wave was used to test five ASDs and five PLCs. We followed the test protocol and used the specification for the ring waveform in the IEC surge-testing standard IEC Standard 61000-4.5. Each PLC was matched with an ASD, which was connected to a 0.5-hp motor. The test setup with the motor-and-control system is shown in **Fig. 3**. The PLC was connected to the 3-phase, 480V voltage via a step-down transformer, which supplied single-phase, 120V power. A digital signal analyzer monitored and recorded the voltage at the equipment power port, as shown in **Fig. 4**.

During testing, the amplitude was varied by ramping it up in 500V increments or so for each trial. Because the equipment under test was operating as a system—the PLC and ASD were actually controlling a spinning induction motor—it was easy to determine whether a surge damaged either the PLC or the ASD during a trial.

Test Results

Applying ring-wave surges to the shield of a data cable yielded some interesting preliminary results. For example, surges as low as a 500V peak resulted in equipment damage. Also, when equipment failed during a trial, the damage was often catastrophic and, based on cursory observation, occurred in the power-supply areas of the equipment. One trial resulted in a catastrophic failure of components in an ASD power supply that sent flaming projectiles through the equipment-venting grill. The time-lapse photographs shown in **Fig. 5** on page 15 illustrate the potentially damaging effects of a surge applied to a data cable.

Fig. 6 and **7** on page 15 show examples of recorded waveforms during surge testing a motor and control system. Fig. 6 shows the results of a trial where the voltage peaked at about 750V. This voltage was recorded from one of the data conductors, illustrating that the elevation in potential between the cable shield and equipment chassis was coupled to a data conductor. In this particular trial, both the ASD and PLC survived the surge.

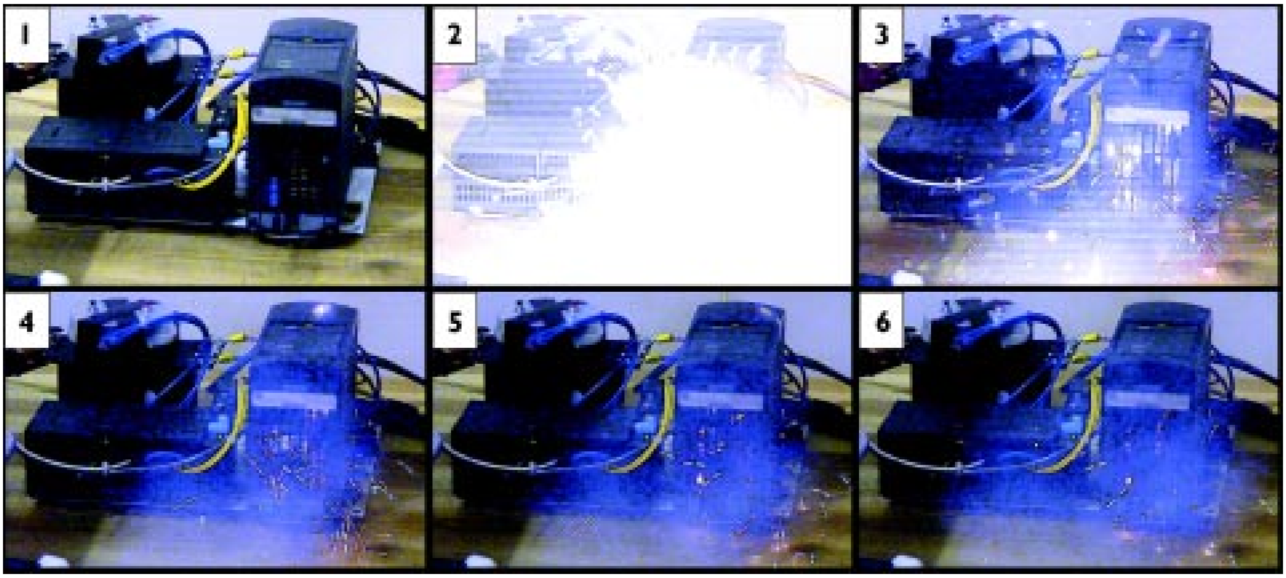

Fig. 5. *An ASD transformed into a Roman candle by a 2kV ring wave.*

Fig. 7 below shows a ring wave that damaged an ASD. During this trial, the voltage peaked at about 1,900V. The voltage was coupled to the data conductor, but according to initial observations, the damage was not limited to the data circuits.

Preliminary results show that some of the equipment to survive the surge levels called for in the ASD and PLC IEC product standards—even though they were CE-marked—indicated that the equipment meets IEC standards.

What do you do with a lab full of fried ASDs and PLCs? First of all, we'll add a few more to the pile before we complete our testing. On our way to developing a solid protocol, we will conduct more exploratory testing in the laboratory. The protocol will enable us to test the communication ports of equipment with refined expectations. Then, as with equipment damaged during power-port testing, each piece of equipment will be restored to a working condition in order to inventory the damage and determine modes of failure. If you would like information about joining the project, *Analysis of Failure Mechanisms for Electrical and Electronic Equipment*, e-mail Rick Langley at rlangley@epri-peac.com. **PQ**

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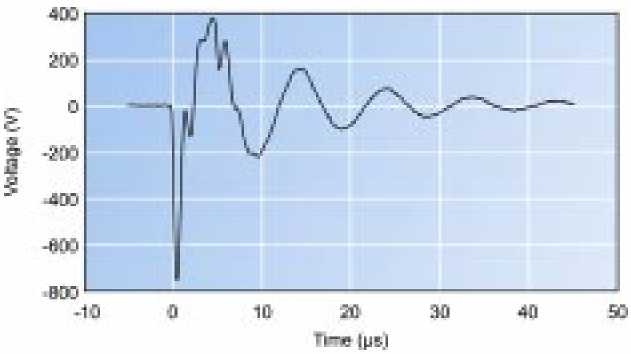

Fig. 6. *Recorded voltage waveform during a single trial with a peak voltage of about 750V (waveform taken on a data conductor).*

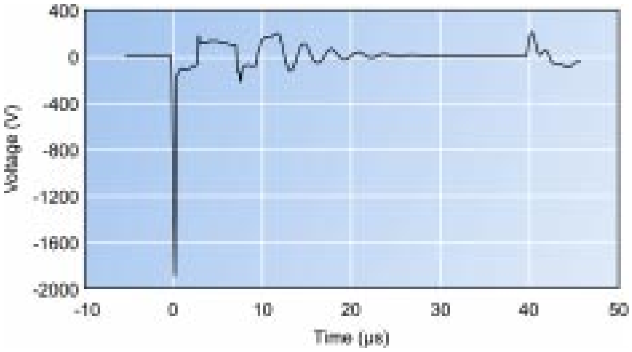

Fig. 7. *Recorded voltage waveform during a single trial with a peak voltage of about 1,900V (waveform taken on a data conductor).*