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EFFECTS OF CATHODIC PROTECTION AND INDUCED SIGNALS ON PIPELINE MEASUREMENT

Class # 3120.1

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Introduction

The effects of cathodic protection and other induced signals on pipeline measurement equipment can be quite profound. This paper will explore the sources and effects of induced signals, and the prevention of undesirable induced signals in custody transfer measurement equipment.

Effects of Induced Signals

Unwanted induced signals can cause a variety of problems with pipeline measurement systems namely:

- Drastic mis-measurement can occur in the form of extra or missing pulses on signals from meter pulse transmitters, on positive displacement meters or pre-amplifiers, and on turbine meters sent to receiving flow computers. Densitometer signals, Coriolis mass meter signals and ultrasonic meter signals can also be distorted.
- Subtle mis-measurement can occur on an intermittent basis by distortion of analog temperature and pressure signals or incorrect meter factors due to noise when proving.
- Digital and analog communication errors on communication buses can occur. Since most communication protocols check for and attempt to correct such errors, induced signals can cause very slow and inefficient communication or communication time outs.
- Unexplainable intermittent events can occur at random and are usually very difficult to troubleshoot and find. Once found, they may be easy to repair, but finding them is the problem. They can be any of the above-mentioned events that occur intermittently.

Sources of Induced Signals

Possible sources of induced signals are:

- Cathodic protection systems impress DC (direct current) on an underground pipeline from a sacrificial anode in order to prevent corrosion of the pipeline. When the pipeline comes above ground at a terminal, pump, or meter station, instruments must be protected from stray currents.
- Poor quality grounds characteristic of extremely dry and rocky soils or on ships can cause a myriad of problems. Most pulse discrimination circuits detect digital signals above a certain zero voltage (ground) reference. Ones and zeros are not properly discriminated if the reference changes due to the effect of circulating ground currents or high current devices.
- Improper type and/or installation of signal and control wiring can lead to problems of cross talk, unstable grounds and transmission of erroneous digital and analog signals.
- High voltage power lines can induce currents into parallel pipelines and system wires. The induced AC (alternating current) component can cause erroneous signals.
- Power surges can cause intermittent problems and even lead to outright failure of components. This can also happen from lightning storms.
- Poor quality DC power from power supplies that have “ripple” or impressed AC on the DC can also cause misinterpretation of ones and zeros in digital circuits.
- Radio or Television Transmission EMI (electromagnetic interference) or RFI (radio frequency interference) and portable communication equipment can induce signals into sensitive electronic circuits and cause problems.

Prevention Methods

Selection of proper equipment for the operating environment and correctly installing it eliminates most of the problems. Be sure the impedance of the sending and receiving circuits are compatible and follow the manufacturers’ advice regarding integrating the equipment into a system. Select a competent system integrator for the equipment rather than buying components from various vendors and then trying to make them play together.

Install a good ground grid. In some locations this is no problem, but some areas present challenges. Consult IEEE (Institute of Electrical and Electronic Engineers) and other standards regarding proper installation and measurement of ground grid characteristics. Some locations require periodic wetting of the soil around ground rods to assure good grounding. In warm climates, sometimes using air-conditioning condensate to water ground rods assures that they are kept wet. Grounds that carry current such as from large motors, heaters etc. should be completely separate from safety and reference grounds. All grounds should be connected to the central ground point as fingers are connected to the palm of the hand.

Proper isolation of cathodically protected segments of the pipeline from sensitive metering, temperature and pressure instruments using insulating flange kits is essential to avoid circulating currents and unstable grounds.

Reference different interconnected systems to the same ground wherever possible.

Install transmitters using shielded twisted pair wires with low capacitance. Let sending ends float and carry shields through junction boxes completely insulated from one another. Tie shields to ground only at receiving end. Do not allow shields to accidentally touch one another or ground from sending end of transmitter to receiving end.

Use power supplies with low ripple current and avoid half wave rectifiers.

Install lightning protection when required in locations of frequent storms.

Keep instrumentation terminals from corroding and keep them snugly connected. Use vapor phase corrosion inhibitors in J-Boxes to prevent corrosion. Use spring loaded termination devices to prevent loose connections due to vibration or heating.

Monitor nearby construction workers and their equipment. Disconnect transmitting equipment and cathodic protection when welding is being done on nearby piping or structure. Do not allow welders to use long lengths of pipe or structure as a ground conductor. Connect welding machine ground adjacent to welding work.

Purchase equipment with proper shielding and resistance to EMI and RFI. Shield devices sensitive to EMI and RFI from stray signals emitted by portable communication devices. Locate equipment away from transmitting towers.

Install fiber optic modems and cables for data transmission.

Some specific details of the phenomena mentioned above are illustrated below.

Cathodic Protection

Cathodic protection is an electrical charge that is put on the pipeline to help reduce corrosion. The cathodic protection system is usually a rectified positive going electrical signal that is representative of a modified sine wave as indicated in figure 1 below.

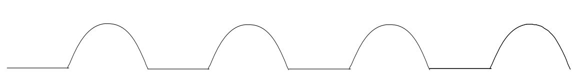

Figure 1

The frequency of the signal is usually a 60 Hz or a multiple of 60Hz. This Modified sine wave signal can be induced into pulse signals, analog loops or communication signals if proper insulation and grounding is not installed.

The proper method of insulation and grounding is indicated in the Figure 2 below

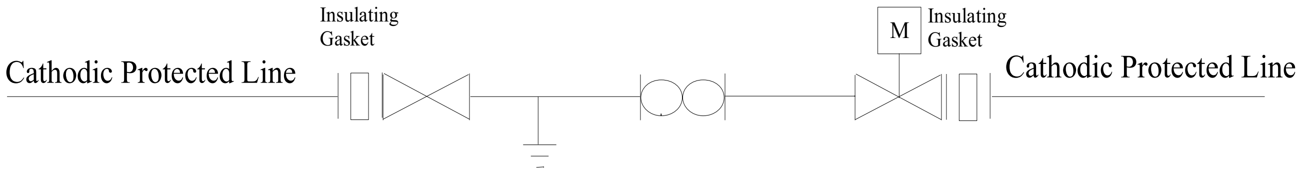

Figure 2

The problem is some insulating systems are not installed correctly. The gaskets are not installed correctly or there is a path of continuity across the insulating gaskets, such as conduit or pipe supports as indicated in figure 3 below.

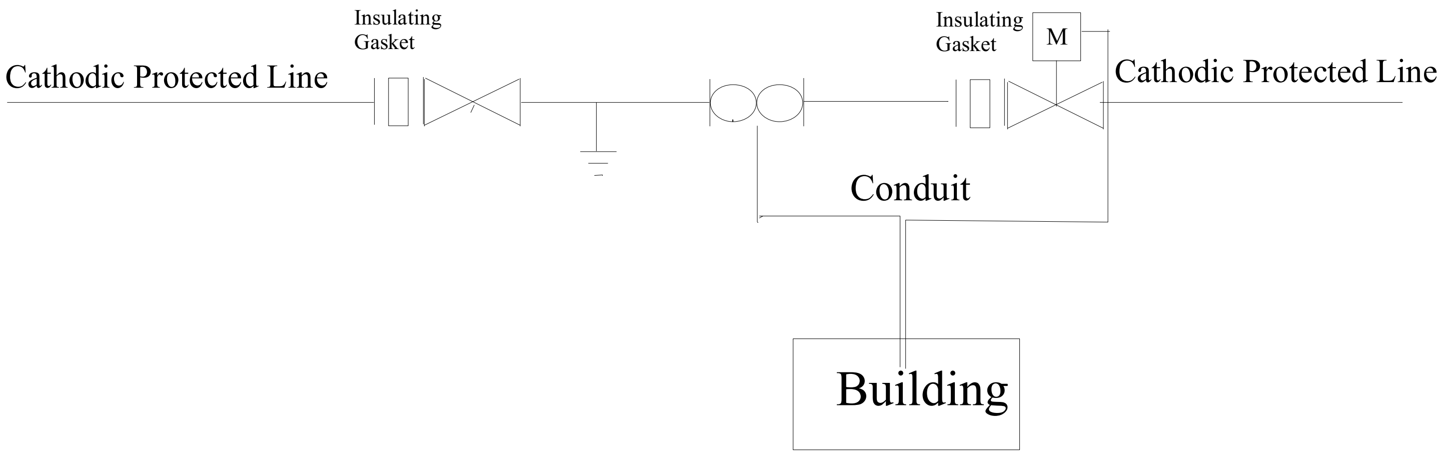

Figure 3

This situation can cause the cathodic protection current to be present on the meter and actually cause more problems if the meter run or conduit is grounded by having a high current flow which would induce a higher voltage on the signals.

Other Induced Signals

Other sources of induced signals may cause more problems than cathodic protection. Power lines and high voltage power lines can produce induced signals of higher amplitude than cathodic protection systems. These signals can be induced even though there may be considerable space between the pipeline and the power line. In a lot of situations, pipelines and power lines are running along the same right of way for miles. Normally the pipelines are buried so people think the pipe is grounded. The earth around the pipe may not be a good conductor or the pipe may have a coating that acts like an electrical insulator. The miles of paralleling the power line can induce high voltage into the pipe and the coating or anything else giving an insulation effect makes the pipe into an effective big long wire. If this voltage goes to ground at one point the current at that point can be significant and cause very significant induced voltage. Construction work in the area can also produce disruptive noise signals. This could be from welding machines or internal combustion engines.

Low Amplitude Signals and Common Mode Rejection

Frequency signals generated by a turbine meter without a pre-amplifier will have amplitude of about 3 volts maximum. The normal amplitude of the signal may be as low as 0.1 volts. This type of signal is very susceptible to induced noise as the ratio of signal amplitude to noise amplitude is very high. Flow computers that read these types of signals normally use a system called common mode rejection. The flow computer will reject a signal that comes identically on both leads but reads the signal when on one lead or opposite each other.

This system will normally reject the noise signal when a regular signal is present unless the noise signal is near the same amplitude as the regular signal. When no signal from the flow computer is present, the flow computer may read the noise as flow. Typically what you will see is a significant flow rate when there is no flow signal being generated by the meter.

Amplified Frequency Signals

Amplified signals are signals that are produced by a pre-amplifier for a turbine meter from a system that produces a higher level of amplitude for an output. These signals are usually 5 volts or slightly less than the source voltage for the preamplifier. These signals are generally fairly resistant to induced noise having an effect.

The problem is the voltage reference point of the device reading the signal may be extremely low which can cause noise to be recognized as signal as shown in figure 4.

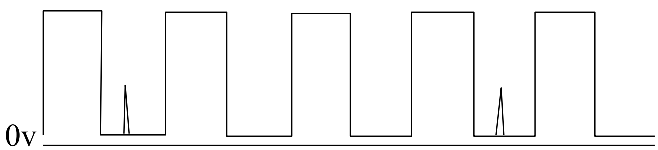

Figure 4

This can be a problem when two devices are reading the same signal and there is a significant difference in the voltage reference point of each device, as shown in figure 5.

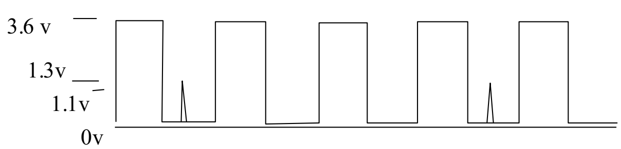

Figure 5

In this example the signal being produced was actually a 10-volt signal being produced by a PD meter optical pulser. The flow computer clamped the signal to 3.6 volts. The flow computer would recognize a signal that would go above 2.8 volts for a high reference and below 1.0 volt for a low reference. The other device reading the signal was a prover counter that would recognize a signal that went above 1.1 volt for a high reference and below .0.2 volts for a low reference. The flow computer would not recognize the noise spikes, the prover counter did count the spikes thus an incorrect meter factor was used for the meter.

Analog Signals

Noise riding on an analog signal can cause the signal to be measured incorrectly. Normally the mis-measurement will be high if the frequency of the noise is high. If the frequency of the noise is low, the signal may be read as higher as or lower than the actual analog signal as shown in figure 6.

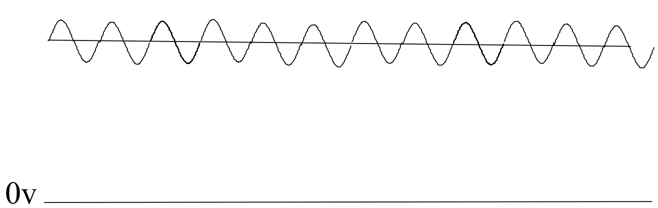

Figure 6

The effect of excessive noise on an analog signal can be compared to pulsation in orifice measurement.

Digital Signals

Digital signals are usually a serial signal that is produced by one device as a digital value and read by the other devices as the same digital value. Examples can be a Smart temperature transmitter talking to a flow computer or a flow computer talking to a DCS (data control system). Noise on a digital loop usually shows up as corrupted data, CRC (cyclic redundancy check) errors or failure to communicate due to communication time out or excessive retry's.

Ground Loops

Ground loops are not a function of induced noise. This situation can cause severe measurement problems when analog signals, such as 4-20 milliamp temperature transmitters or DP (differential pressure) transmitters are used.

More than one ground reference in an analog loop generally cause ground loops as shown in figure 7. Ground loops generally cause a signal to be read lower than the actual value. The problem is ground loops are not always consistent and will change during the day with temperature, ground moisture etc. For this reason ground loops usually cannot be calibrated out and must be corrected.

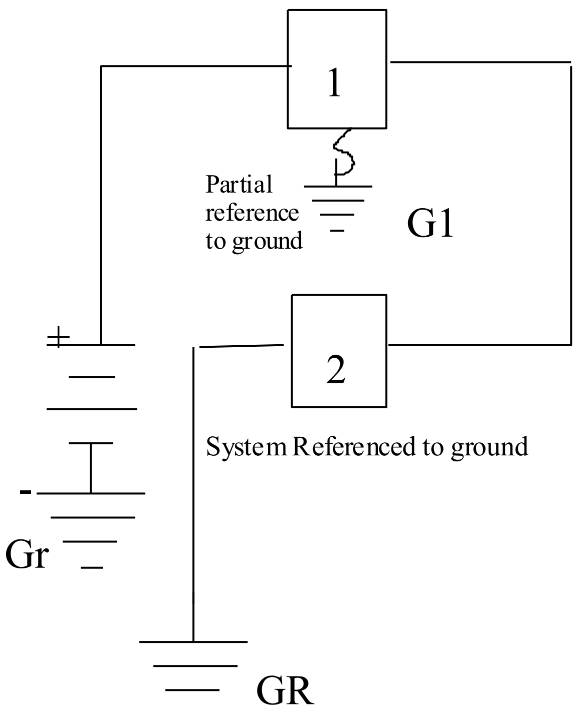

Figure 7

This system has the power referenced to ground. The partial ground of G1 allows current flow through the path of G1 to GR bypassing Device 2. In this case, device 1 would read the correct signal; device 2 would not read the correct signal.

Most loops are what we call floating loops (not referenced to ground). However the installation of surge protectors creates a reference to ground.

Voltage Referencing

Voltage referencing means having the device producing the signal referenced to the same voltage level as the signal reading the device. This also refers to understanding the requirements of the device reading the signal needs to recognize the signal. Understanding the characteristic of the signal is required such as wave shape, amplitude and reference to zero.

Voltage referencing becomes especially important when working with frequency signals such as turbine or PD meter signals that are proved, especially by a portable prover. A common practice is for a portable prover to connect the piping and connect prover counter to the meter via a right angle drive and a separate pulser or connect a turbine meter through separate pickup coil. This can create a problem because you are not proving the same pulse train that the measurement is performed on. If there is a difference in the pulse trains, it will create a measurement error that can be very difficult to identify.

Hooking the portable prover counter to the existing can cause voltage-referencing problems. This may mean the prover counter and flow computer are reading the same pulse train but does not mean the 2 devices are reading them the same way.

It is always recommended that when hooking portable proving equipment to prove a meter that a long count be performed to make sure the pulses used for proving are the same as the pulses used for measurement and the counters are recognizing the pulses the same.

Curing Induced Noise

Proper installation of insulating gaskets and grounding of the meters is a must. If the insulation gaskets are not properly installed, the problem may be exaggerated and made worse.

Use of foil wrapped, shielded twisted pairs that are in good condition and has proper shield grounding will significantly reduce induced noise. Shields should be grounded to an instrument ground at only one spot in the loop. Do not ground shields at more than one spot. Prevent the possibility of "accidental" intermittent grounds in J-boxes by insulating all shields and bare ground or drain wires. Continue the shield drains so the complete loop is protected.

Cables that are old or deteriorating due to age or environmental conditions can cause induced noise problem to become worse. Corrosion on the conductors can cause more noise to be induced.

The condition of the cable new does not always mean you have a good cable. The author has seen cables where the conductors have a break or a stretched spot. A broken conductor is usually easily found. A stretched conductor can be a source of numerous problems, including induced noise.

Conclusions

Proper specification, selection, integration, and installation of measurement instrumentation are essential to prevention of induced signal errors.

Solutions to induced signal problems are now easier to find with the help of the Internet and training schools.

New equipment is now more rugged and resistant to noise problems.

Acknowledgement

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