Oscilloscope Applications

Presented by: Paul Ortmann, P.E.
Senior Electrical Engineer
Idaho Power Company
portmann@idahopower.com

A scope can be a...
Meter
Camera
Recorder
Stopwatch
Power Analyzer
And?

An application example:
Real and reactive power, with voltage, current, and volt-amp waveforms

Scopes for stray voltage
Regulatory threshold:
1 volt RMS, steady-state, 60Hz AC, across 500 Ω

What if the contact voltage isn’t steady-state, or 60Hz?

Stray voltage:
Conventional / Unconventional
Contact voltage is intermittent or at significantly higher frequency than 60Hz or the common harmonics. Grounding and bonding may not be a problem.

What is a cow’s response threshold?
1.7V-pk at 60Hz

2.4V-pk at 500Hz

60V-pk at 50kHz

600V-pk at 500kHz

for 5%!

Cow response threshold

The behavioral response threshold is even higher for short transients!
Exposure types

- Monophasic
- Biphasic
- Multiple Cycle

Strength / frequency / duration

Behavioral response for 5% most sensitive cows, sine waves, muzzle to hooves exposure

Monophasic, 40V peak, 20µs phase duration

Typical characteristics of recorders and multimeters

- Bandwidth: 45Hz to 1, 20, or 100kHz
- Min/Max: RMS, 1-60Hz cycle to 100ms
- Steady-state: based on average of up to 1 minute
- Suitable for conventional stray voltage work

Recorder and multimeter limitations

- Minimal phase duration or peak voltage data (may capture waveform with recorder)
- Transients may be significantly diluted by the RMS calculation algorithm
- Meter does not measure time between transients

Recorder limitations example

- Maximum RMS cow-contact voltage during a 12-hour period
- Not enough data for peak voltage, phase duration, and waveform type
Recorder limitations:
Bandwidth

<table>
<thead>
<tr>
<th>Measurement</th>
<th>SVM ch1</th>
<th>SVM ch2</th>
<th>SVM ch3</th>
<th>SVM ch4</th>
</tr>
</thead>
<tbody>
<tr>
<td>60.4 Hz</td>
<td>1.010</td>
<td>1.006</td>
<td>1.010</td>
<td>1.009</td>
</tr>
<tr>
<td>601 Hz</td>
<td>1.003</td>
<td>0.994</td>
<td>0.996</td>
<td>0.997</td>
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<tr>
<td>1.995 kHz</td>
<td>1.000</td>
<td>0.987</td>
<td>0.971</td>
<td>0.972</td>
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<tr>
<td>3.919 kHz</td>
<td>1.001</td>
<td>0.775</td>
<td>0.728</td>
<td>0.734</td>
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<tr>
<td>6 kHz</td>
<td>1.005</td>
<td>0.120</td>
<td>0.117</td>
<td>0.120</td>
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<tr>
<td>10.01 kHz</td>
<td>1.009</td>
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<td>0.012</td>
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</tbody>
</table>

SVM-10 will only record about 10 to 20mV on a 1V 10kHz signal. That’s O.K., If we know...

With a scope we can answer the questions

What does the waveform look like?
Biphasic, monophasic, multicyle?

Time between transients?
Phase duration?
Peak voltage?

High frequency and transient voltage sources

Continuous, high frequency
Variable speed drives
Radio transmitters
RFID systems

Intermittent transients
Motor starting
Switching transients
Electric fencers

Transient Examples:
Motor starting

Multiple-cycle increase in voltage at the normal system frequency.

Typical durations are 3 to 30 cycles.

Transient Examples:
Switching transients

High frequency (short phase duration), multi-cycle event, decays very quickly

Commonly due to motors switching off

Transient Examples:
Electric fencers

Monophasic pulse with a 10-50 microsecond phase duration; repeats at about one second intervals
Capturing waveforms

Continuous waveforms:
"Auto" mode, then adjust

Transients:
Gradually adjust trigger level, vertical and horizontal axes

Finding signal sources: Waveform comparison

Same device

Different devices

Finding signal sources: Timing

Use scope to measure time between transients, from seconds to minutes

Find devices that operate at the same interval

Useful for fencers, refrigerators, float switches, etc.

Finding signal sources

The time-of-arrival method

The oscilloscope is used to capture the signals at two separate locations on the same neutral-grounding system simultaneously

Based on the order in which the signals arrive at the oscilloscope, the direction that the transient was traveling can be determined

In this case, the transient originated closer to location A than to location B.

When an oscilloscope may be helpful

Dairy has fencers, adjustable speed drives, RFID systems or other known high frequency/transient sources

Contact voltage or NEV recording has repetitive "spikes"

Spot measurements of contact voltage momentarily “jump” during switching

The customer has concerns about transients
Questions?