Midwest Rural Energy Council

Instrument Basics
and
Common Measurement Errors

Wednesday 3/5/03-11:00 AM to 12:00 PM

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Topics to cover

Know what each measurement means
-
Know your connections
-
Know your instrument

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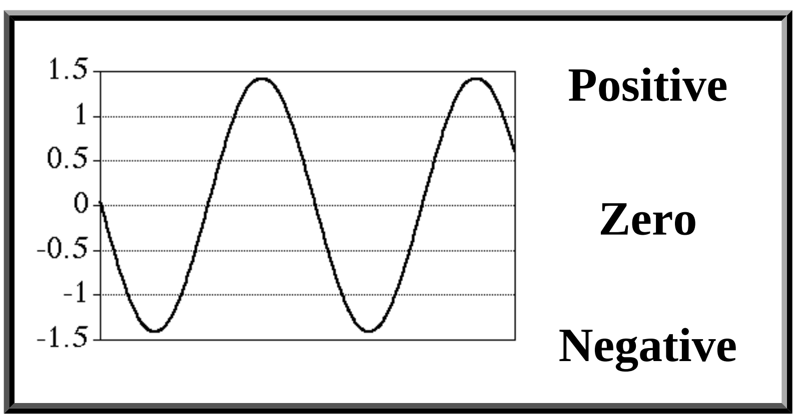
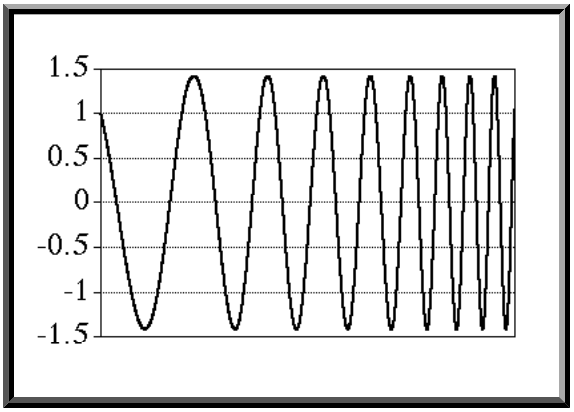
Just some basics on electrical measurement….

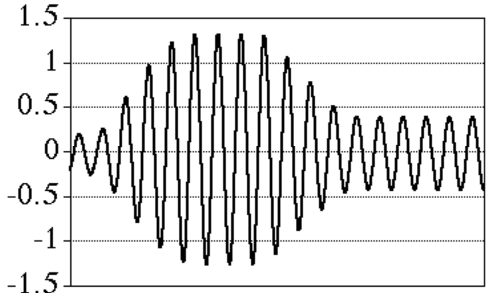
An AC voltage (or current) usually alternates between a positive and negative polarity



The RATE of alternation is the frequency of the AC voltage (or current)



The MAGNITUDE can change for an AC voltage (or current)

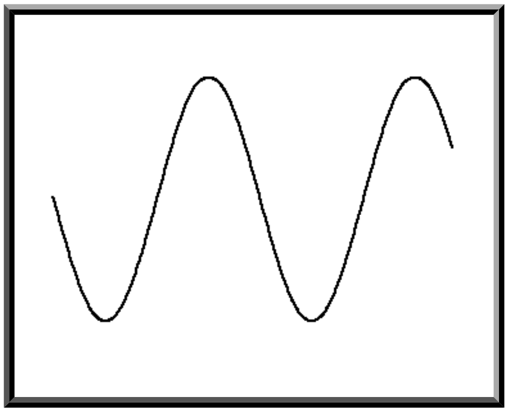


For AC only

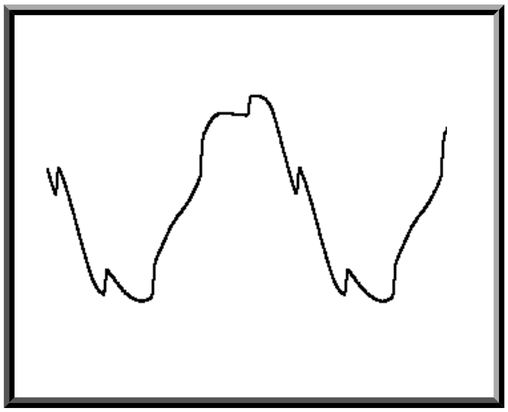
All AC voltages and currents are not pure sinusoids.

This can affect meters.

Pure Sinewave



Distorted wave form



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Harmonics Made Simple

Whenever a wave form deviates from a perfect sinusoidal wave form, it is said to be distorted.

ALL distorted wave forms have harmonics.

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Important Characteristics of Voltage and Current Measurements

Peak Value

Peak to Peak Value

Average (RMS) Value

True RMS Value

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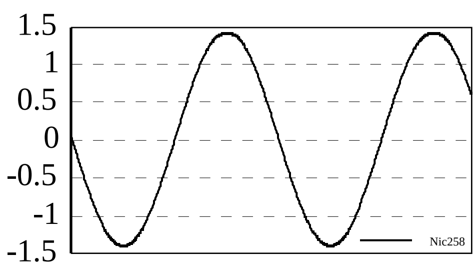
How Peak, Peak-to-Peak and RMS Compare



1.4 V Peak

1.0 V RMS(Avg)

1.0 V True RMS

2.8 V Pk-Pk

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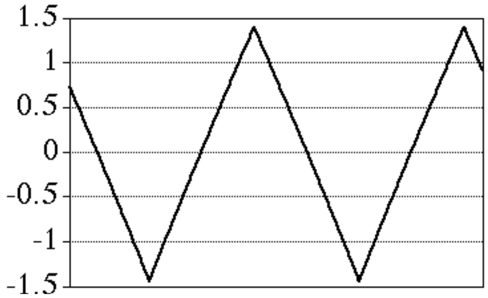
Triangular Waveform



1.4 V Peak

0.785 V RMS(Avg)

0.82 V True RMS

2.8 V Pk-Pk

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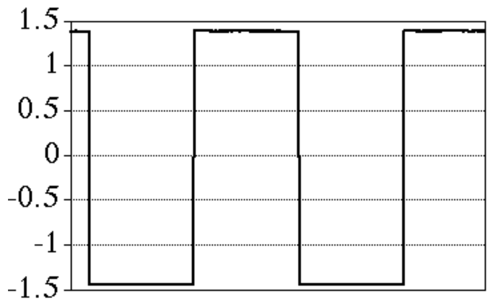
Square Waveform



1.4 V Peak

1.56 V RMS(Avg)

1.4 V True RMS

2.8 V Pk-Pk

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Switching Power Supply Current Waveform

1.4 V Peak

0.28 V RMS(Avg)

0.52 V True RMS

2.8 V Pk-Pk

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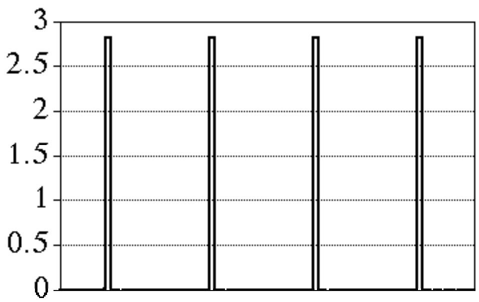
Short Duration Pulse Waveform



1.4 V Peak

If AC coupled!

0.24 V RMS(Avg)

0.56 V True RMS

2.8 V Pk-Pk

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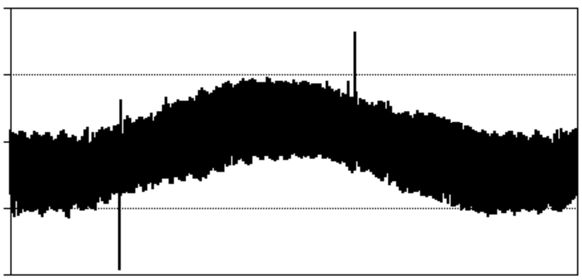
60 Hz in Noise



25 V Peak

7.7 V RMS(Avg)

11 V True RMS

50 V Pk-Pk

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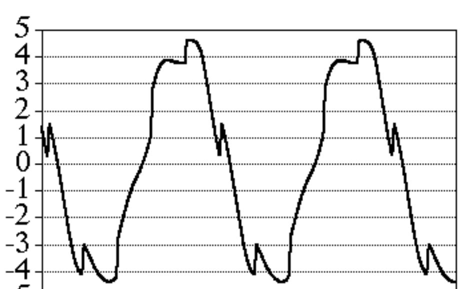
Distorted 60 Hz - Worst Case Stray Voltage Situation?



4.5 V Peak

3.07 V RMS(Avg)

3.13 V True RMS

9 V Pk-Pk

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Summary - True RMS or Average RMS Meter?

- If the waveform comes close to resembling a 60 Hz sinewave, both meters work fine.
- Most “on-farm” Cow-Contact voltages will be in this category.
- Neutral-to-earth voltages can be measured by either type of meter, or viewed on an oscilloscope.

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How DC blocking can affect your meter….

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Potential Problems with AC Meters

- When a meter is set to read AC volts, it is important that the meter BLOCKS the input of DC voltages.
- To make sure your meter reads only AC volts when in the AC mode do the following:

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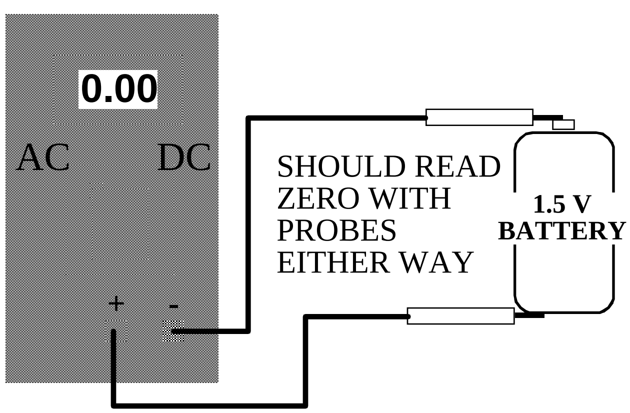
DC Blocking Test



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Instrument Bandwidth "BW"

Every instrument should be able to measure 60 Hertz frequencies correctly.

As we increase the frequency of the waveform the accuracy of the instrument may vary.

In most cases the instrument measures a value lower than the correct value.

Instrument Bandwidth "BW"….

For the next test we will apply a sine wave of varying frequency from

100 Hertz to 2,000,000 Hertz.

Instrument Bandwidth "BW"….

Here are the bench test results with approximately 0.5 volts rms input:

Frequency	Tektronix	Fluke	Dranetz
100 Hz	0.517	0.495	0.5
1,000 Hz	0.519	0.496	0.5
10 kHz	0.521	0.498	0.4
100 kHz	0.518	0.496	0.1
2,000 kHz	0.853	0.879	0.0

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Instrument Bandwidth "BW"….

If we increase the frequency the errors become greater. For these bench tests the input was approximately 0.5 volts RMS input:

Frequency	Tektronix	Fluke
10 MHz	0.511	0.506
20 MHz	0.456	0.382
50 MHz	0.440	0.005
100 MHz	0.315	0.000

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Instrument Bandwidth “BW”….

As we increase the frequency there are other factors that can cause erroneous readings.

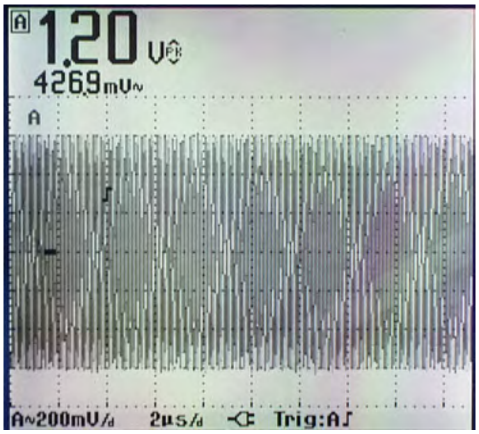
We will observe these phenomena during the lab tests.

Sampling Rates

A digital instrument measures by sampling the varying input voltage or current and then calculating the result.

If the rate of sampling is too low, the unit may miss a short impulse.

Sampling Rates…...



Another problem with low sampling rates is "aliasing"

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Making current measurements... correctly….

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Instantaneous AC Current Meters Clamp-on Types

Many meters that read or record voltage can easily deal with AC current by the addition of a AC current probe.

- Measuring very low AC and DC VOLTAGES (0.5 volts and below) are simple to accomplish with digital meters.
- Measuring low current values in the milliampere region can be risky when a CLAMP-ON current device is used.

Using True RMS Meters, I Found The Following:

Actual Test mA	1000:1 CT & 200 uA Scale	1000:1 CT & 2 mA Scale
15	1.9	9
20	2.6	15
30	4.1	22
50	8	38
150	55	130
200	85	176

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What's the best clamp-on type to use?

What's the best way to measure stray currents or leakage currents?

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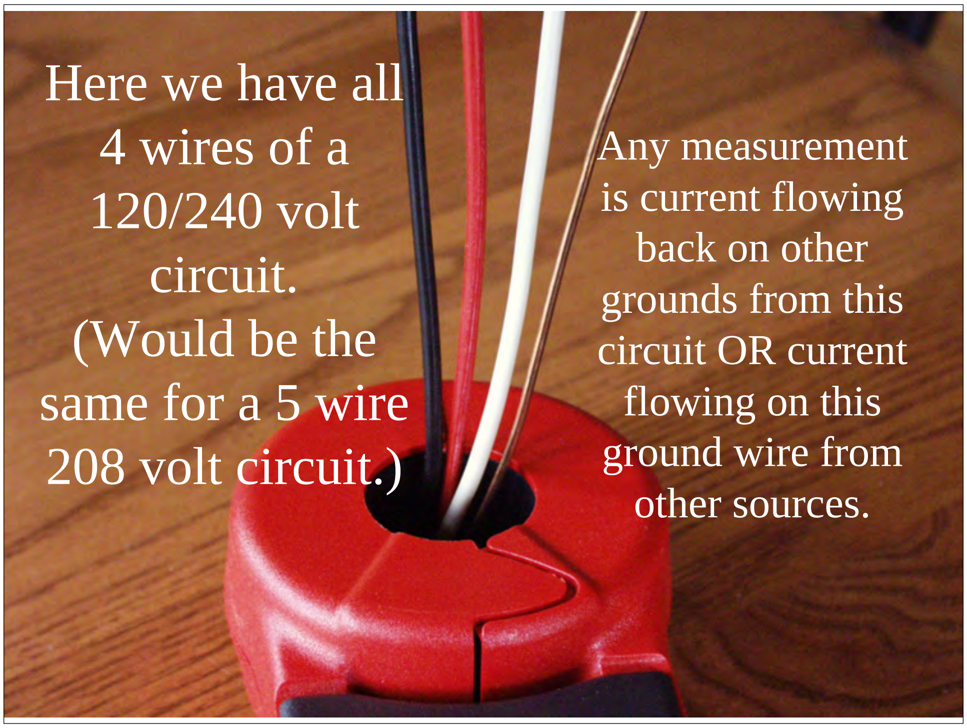
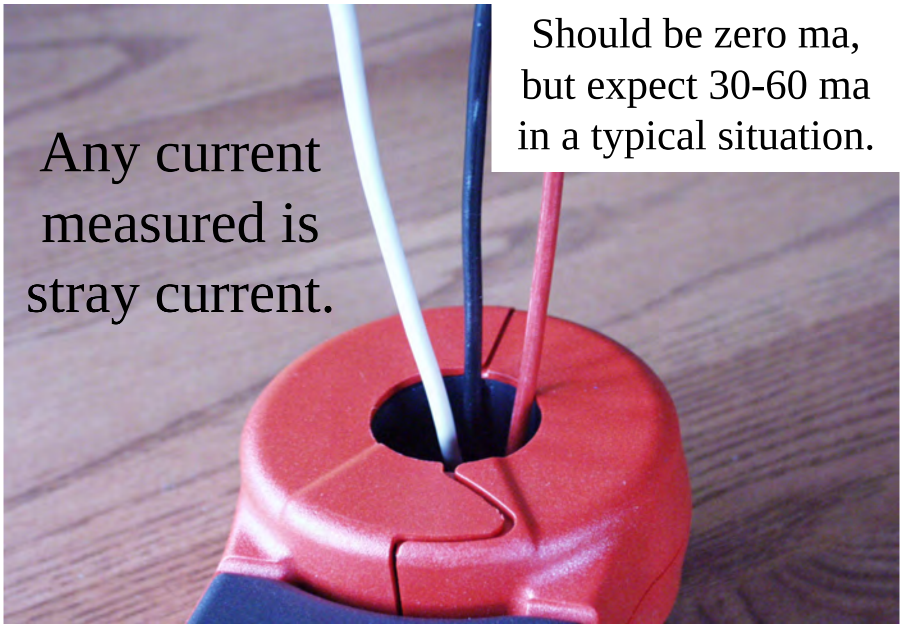
Use "zero sequence" metering

If you run all the wires of a circuit through a "donut type" current transformer, whatever is measured is current that is not staying on the wires as planned. This is the "stray current" we are looking for.





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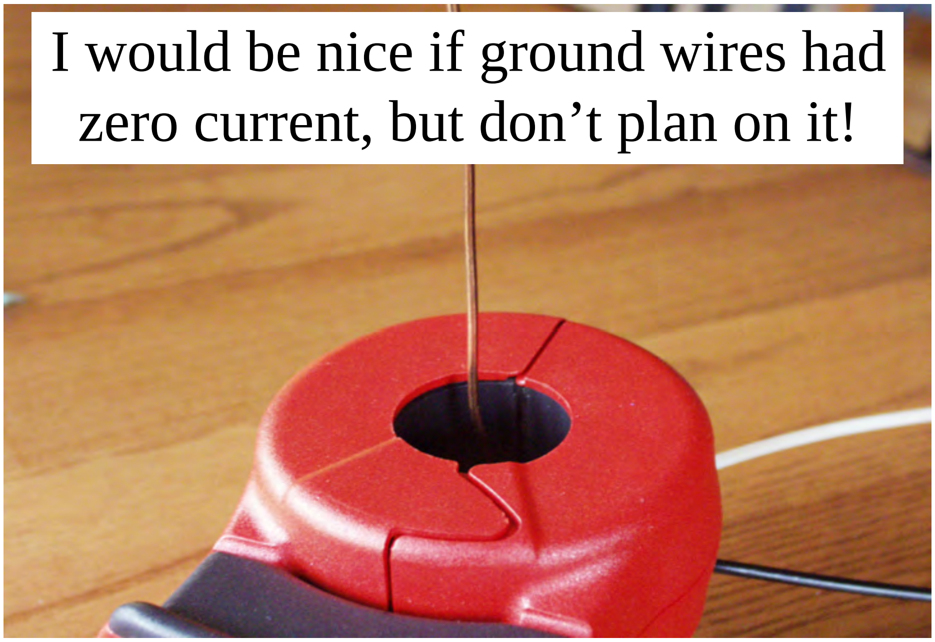
I would be nice if ground wires had zero current, but don't plan on it!



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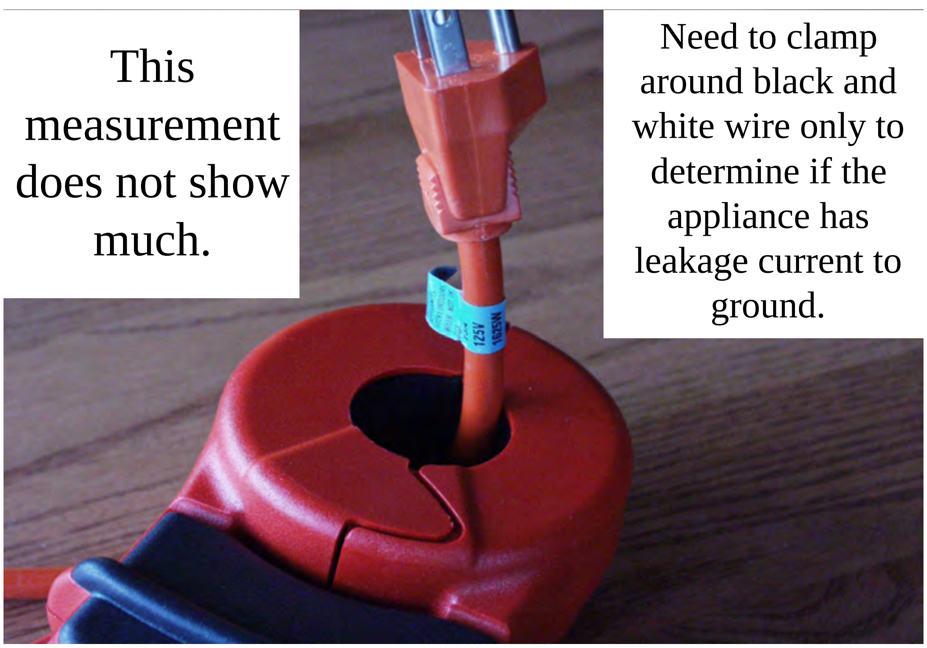
This measurement does not show much.



Need to clamp around black and white wire only to determine if the appliance has leakage current to ground.

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AEMC Model 3710

About $1800

Measures loop resistance and leakage current.

Here is one meter I use..

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Preferred meter…

A.W. Sperry

Model DSA-2413

About $450

Measures from

1 ma to 1,000 A

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A word of caution...

Brushing your teeth is important…..

Keeping your jaws clean is just as important.

Inspect the jaws on the clamp-on unit. The smallest amount of debris can affect your measurement.

Don’t let your leads lead you a-stray….

The type of connection you make can affect what you measure.

For the following experiments I am going to apply a 2 microsecond (μsec) pulse to one end of the leads, our "cow contact" end.

The scope will be at the other end of the leads and represent your meter, scope or other measuring device.

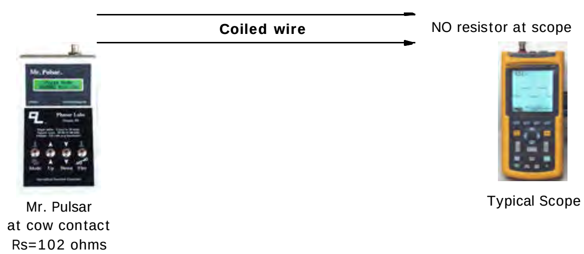
The question is: Do you accurately measure what is happening at the cow contact end?

Why use a short duration impulse?

If a 2 microsecond (μsec) impulse can be measured without significant change in "Duration" or "Magnitude", then all voltage waveforms from 60 Hertz to over 1,000,000 Hertz will be measured accurately.

Experiment A

What happens if I use two (2) single conductor wires to the cow contact point and leave 100 feet of each wire coiled on a separate plastic spools?



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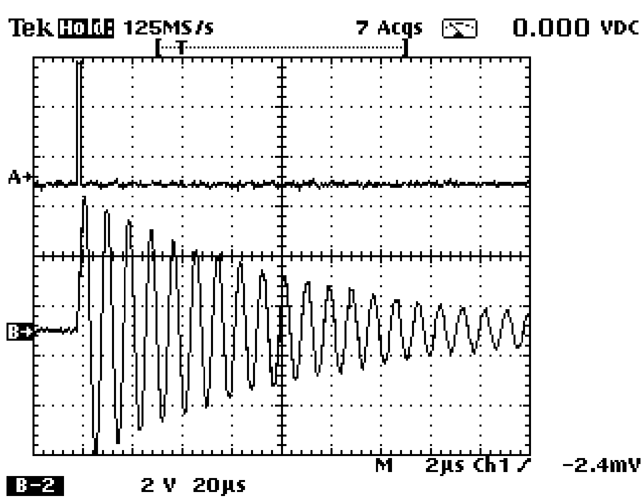
The upper trace A is a 2 microsecond (µsec) impulse from the test unit. The lower trace B is what was recorded at the scope.

Note the ringing due to the inductance of the coil.

Also the larger P-P voltage!



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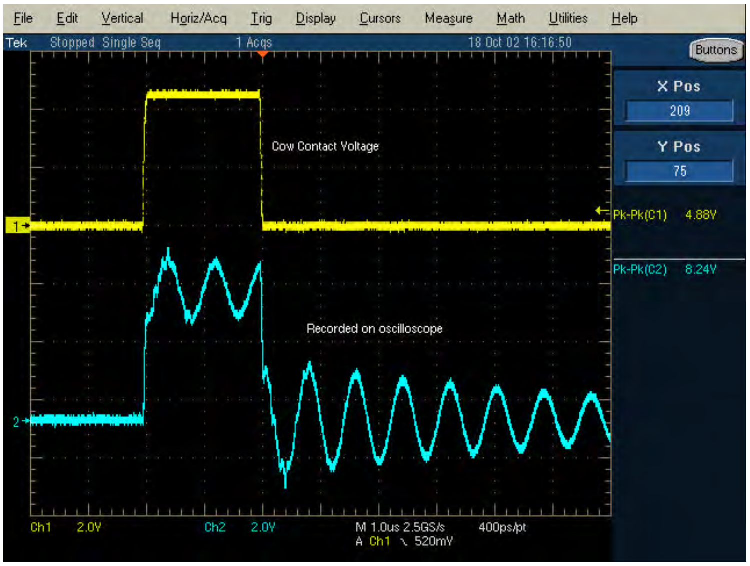
Same experiment-different spool of wire



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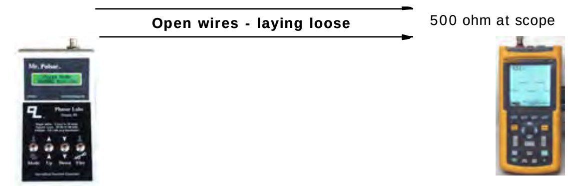
Experiment B

What happens if I use single conductor wires to the cow contact point and laid the wires out in a parallel line pattern? (100 foot)



I ADDED a 500 ohm resistor at the scope.

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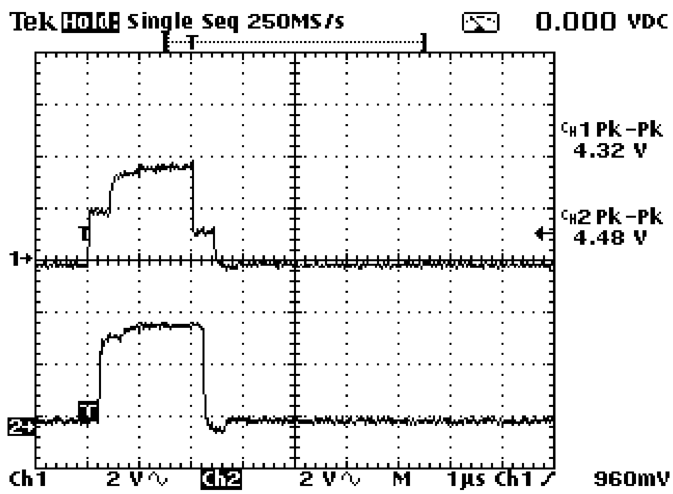
The upper trace 1 is a 2 microsecond (μsec) impulse from the test unit.
The lower trace 2 is what was recorded at the scope.

Note that the distortion and magnitude changes are relatively small.



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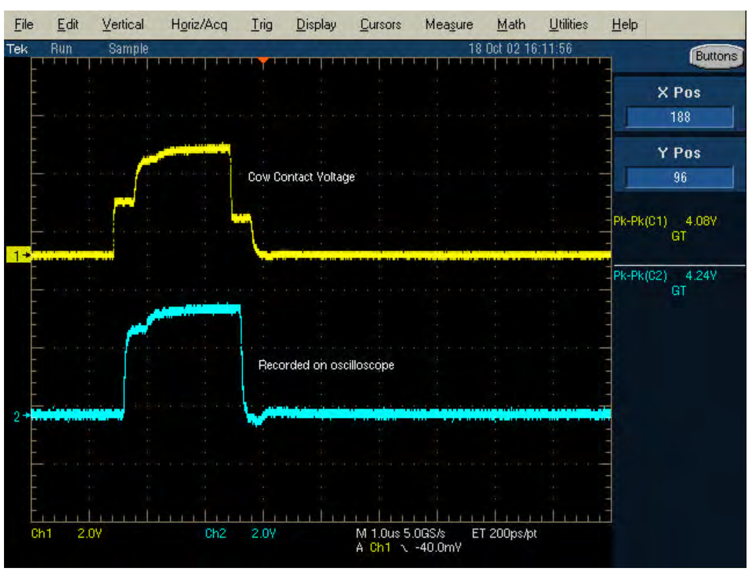
Same experiment - different time



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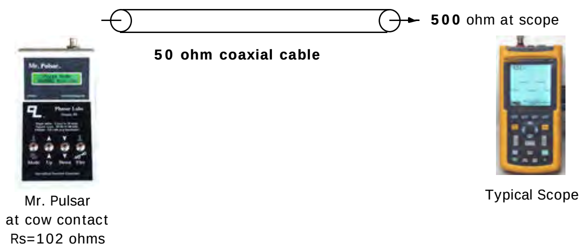
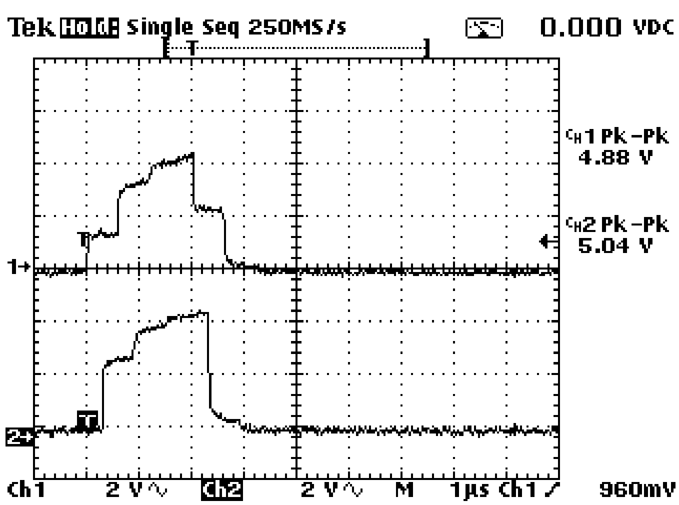
Experiment C

What happens if I use 50 ohm coaxial cable?
(100 foot)

I ADDED a 500 ohm resistor at the scope.

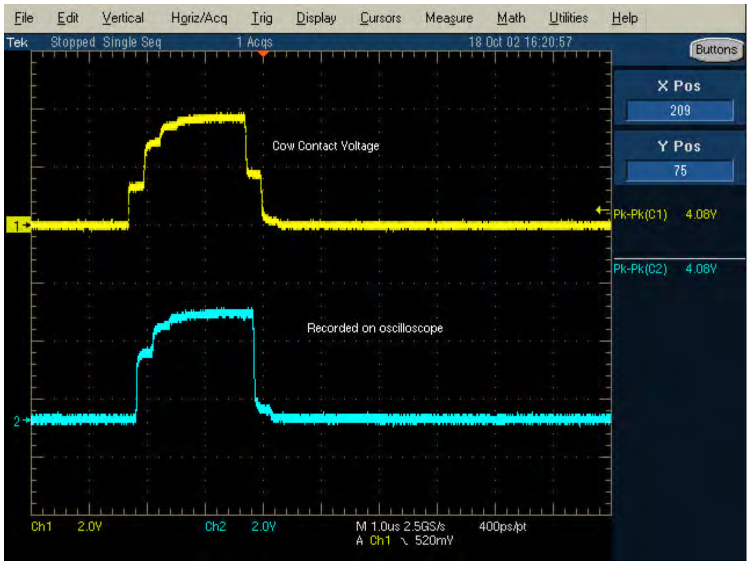


The upper trace 1 is a 2 microsecond (µsec) impulse from the test unit.
The lower trace 2 is what was recorded at the scope.



Note that the distortion and magnitude changes are greater than the single wires.

Same experiment-different time



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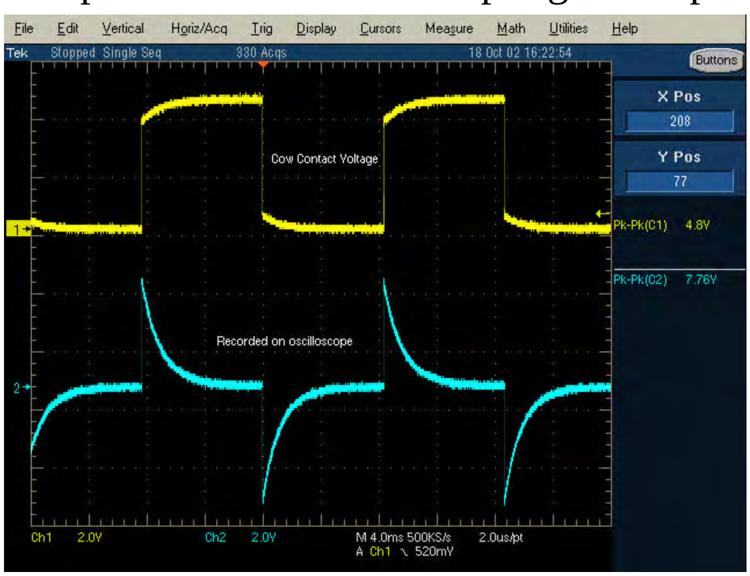
Same experiment - Left AC coupling on scope



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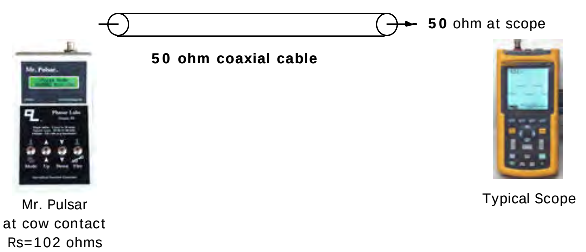
Experiment D

What happens if I use 50 ohm coaxial cable?
(100 foot)

I ADDED a 50 ohm resistor at the scope.



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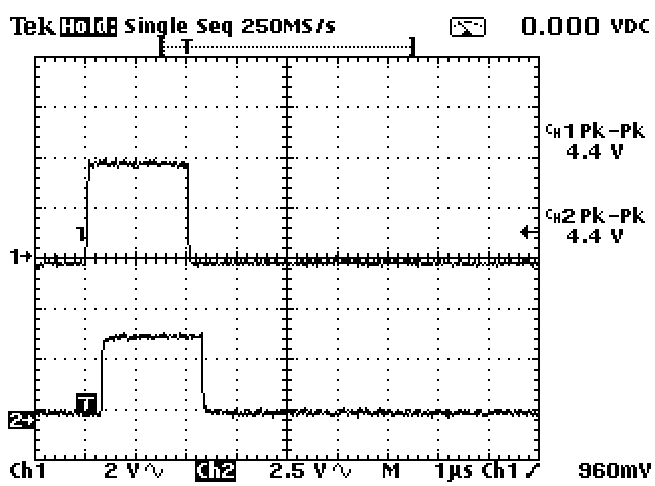
The upper trace 1 is a 2 microsecond (µsec) impulse from the test unit.
The lower trace 2 is what was recorded at the scope.

Note that the minimum change in duration and magnitude occurs. There is some reduction in magnitude.



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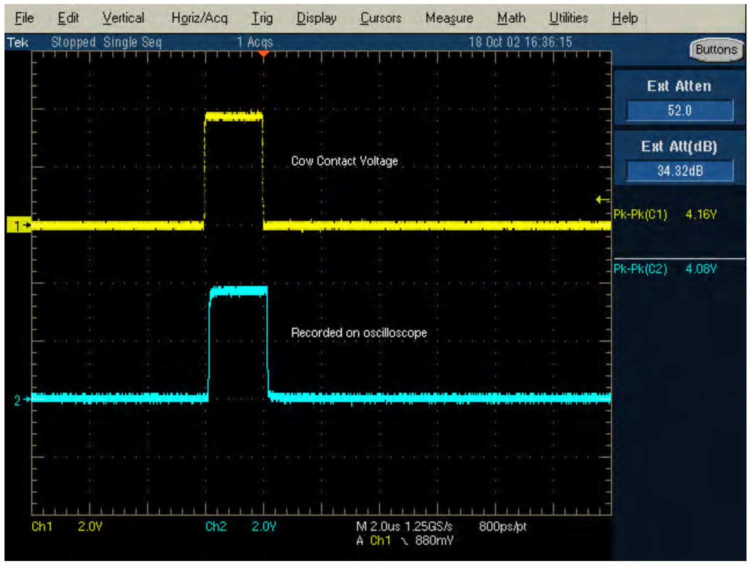
Same experiment - different time



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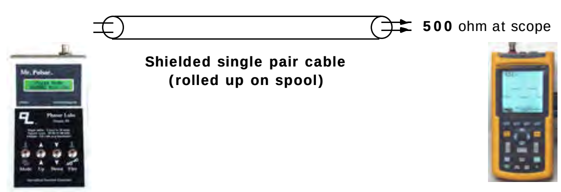
Experiment E

What happens if I use shielded cable with a twisted pair? (100 foot)



Mr. Pulsar
at cow contact
Rs=102 ohms

Typical Scope

I ADDED a 500 ohm resistor at the scope.

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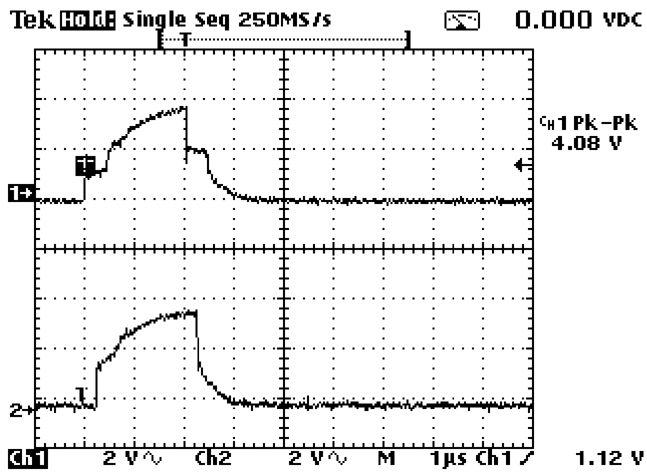
The upper trace 1 is a 2 microsecond (µsec) impulse from the test unit.
The lower trace 2 is what was recorded at the scope.

Note the "loading" of the test set by impedance reflections. Still not to bad!



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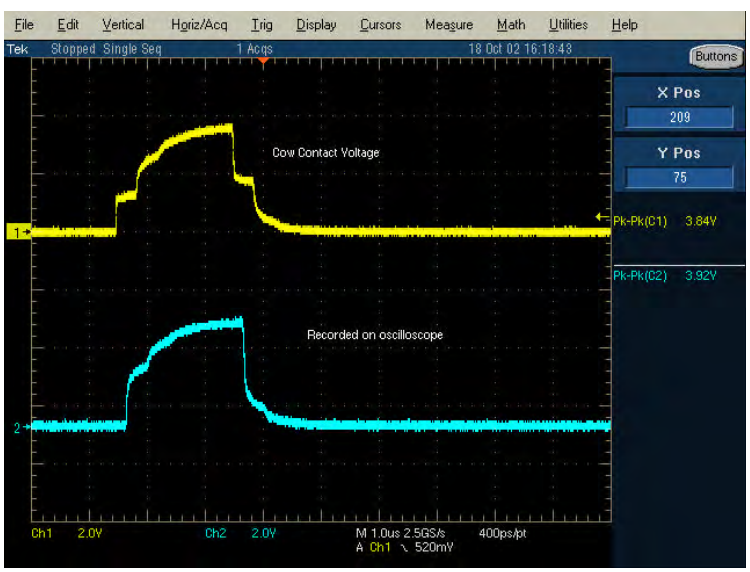
Same experiment - different time



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What's the best wire to use?

If you would like to locate the meter at a point remote from the CC point make the connection using a twisted pair shielded cable such as Belden type 1032A cable. This is a two conductor, twisted pair #18 copper wire cable with a foil shield. If this type of cable is not available, using two of the three wires in an extension cord works just fine. I suggest cutting the plug and receptacle off the cord before you use the wire so someone does not plug one end into the outlet while the meter or CC point is at the other end of the cable.

Now… the rest of the story

What is it that NONE of the above test lead connections can prevent?

What can provide a false reading at the scope or meter?

……Magnetic pickup

Shielded conductors, unless enclosed in steel conduit, are susceptible to induced voltages from nearby magnetic fields. The shielded conductors do attenuate electric fields.

What are some sources of magnetic fields on the farm?…..

Magnetic Fields...

A large current surge through a branch circuit or secondary service conductor.

Local storms create magnetic and electric fields.

Adjacent to ballasts or transformer windings.

Cow ID systems……… Any more????????

But… you say ...

I only measure for 60 Hertz steady state so why should I worry about test leads?

Why not use the best techniques possible, even if it is not required at this time.

How about checking for fencer/trainer pulses??

If you do not have the proper connection wire with you ...

You can measure short duration impulses simply by moving your scope to the cow contact point and use short leads from the scope.

Check with and without the 500 ohm resistor.

Be sure to disconnect the other wire connections to the cow contact point. Why??

To be continued……...

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