

# Common Measurement Errors

## Part 1



**Phasor Labs**

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# Topics to cover

Know what each measurement means

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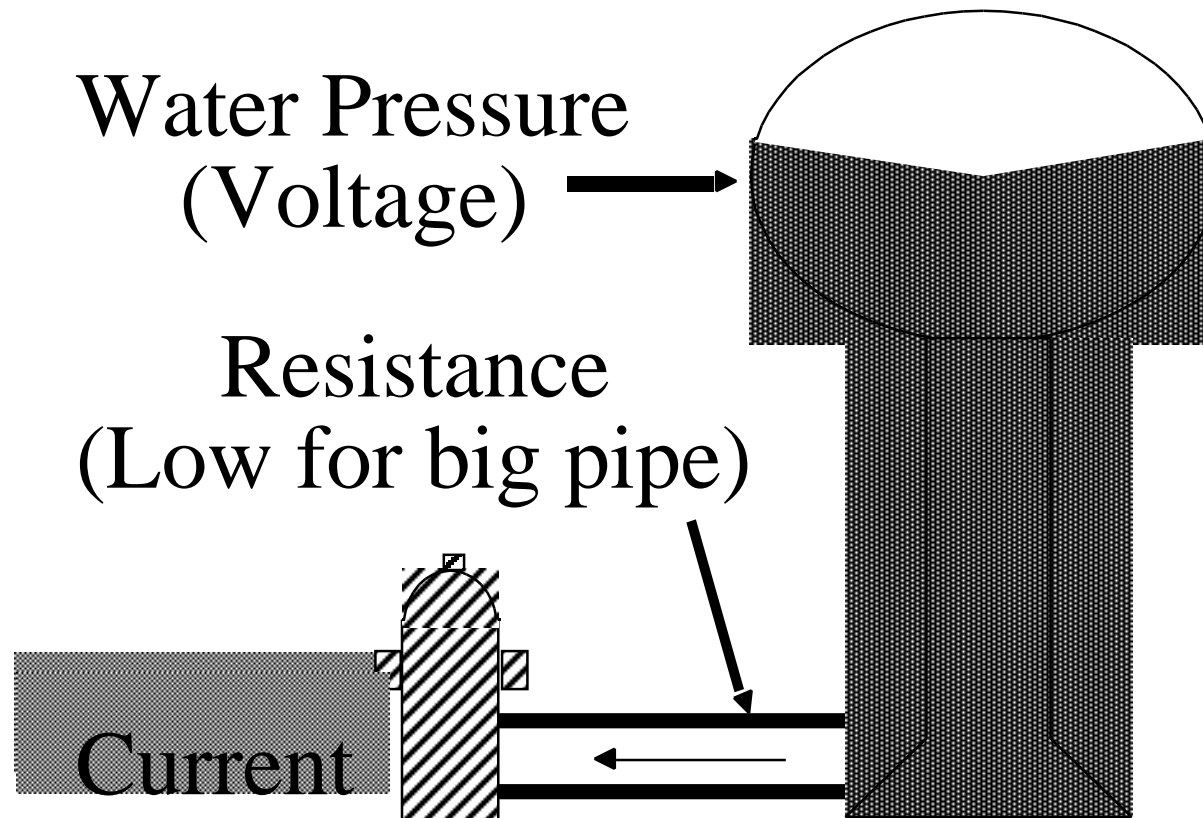
Know your connections

-

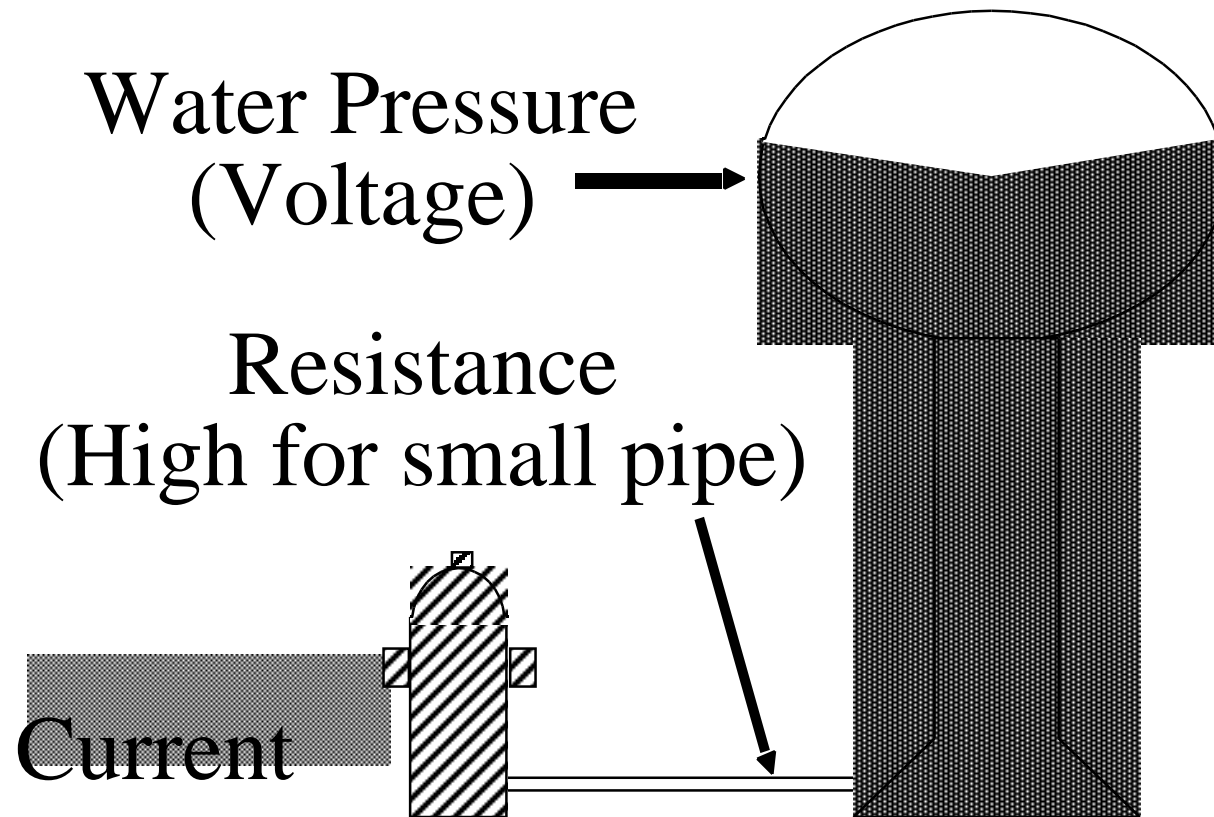
Know your instrument

# Just some basics on electrical measurement....

# AC and DC Voltage or Current - Review



# AC and DC Voltage or Current - Review



Voltage is the **Pressure**  
that forces the **Current**  
through the **Resistance**  
of the animal

# DC Voltage

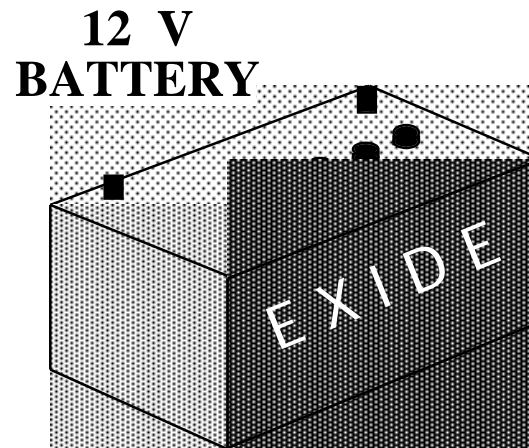
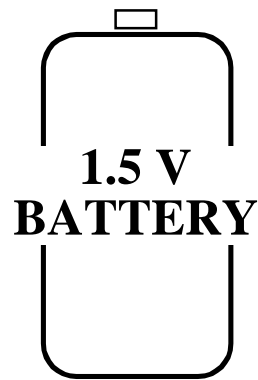
When discussing the difference between AC and DC all comments apply equally to voltage or current.

# Polarity

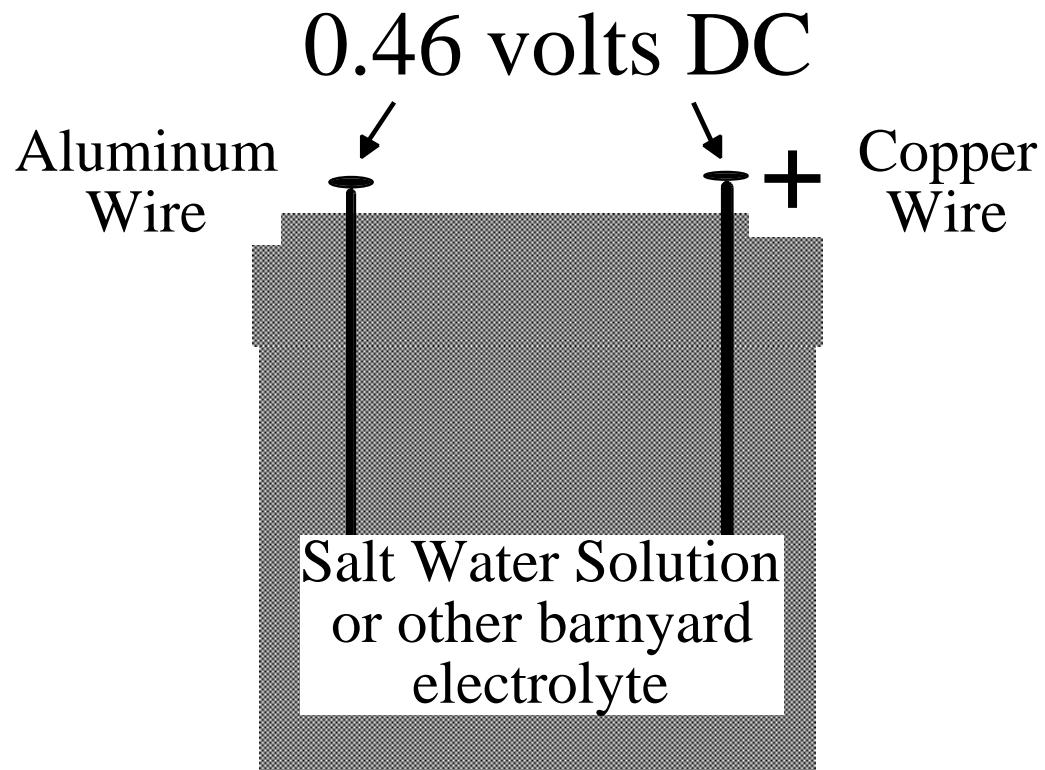
A **DC** voltage (or current) may have a positive or negative polarity.

The magnitude of the voltage (or current) may vary,  
**but the polarity does not change.**

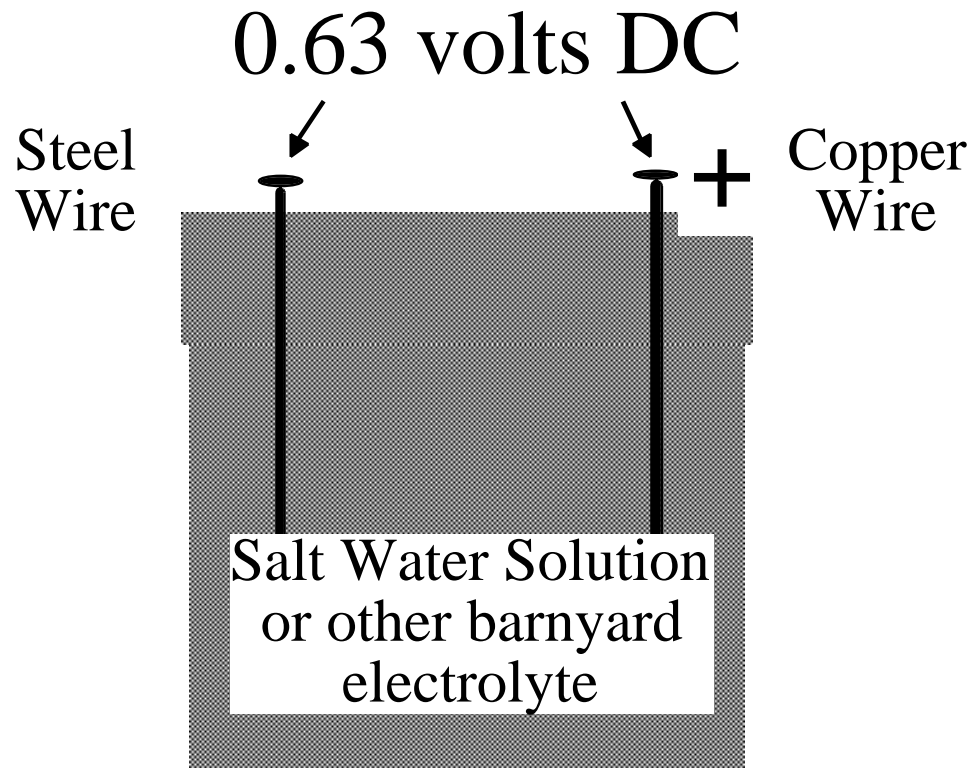
# DC Usually Comes From Batteries



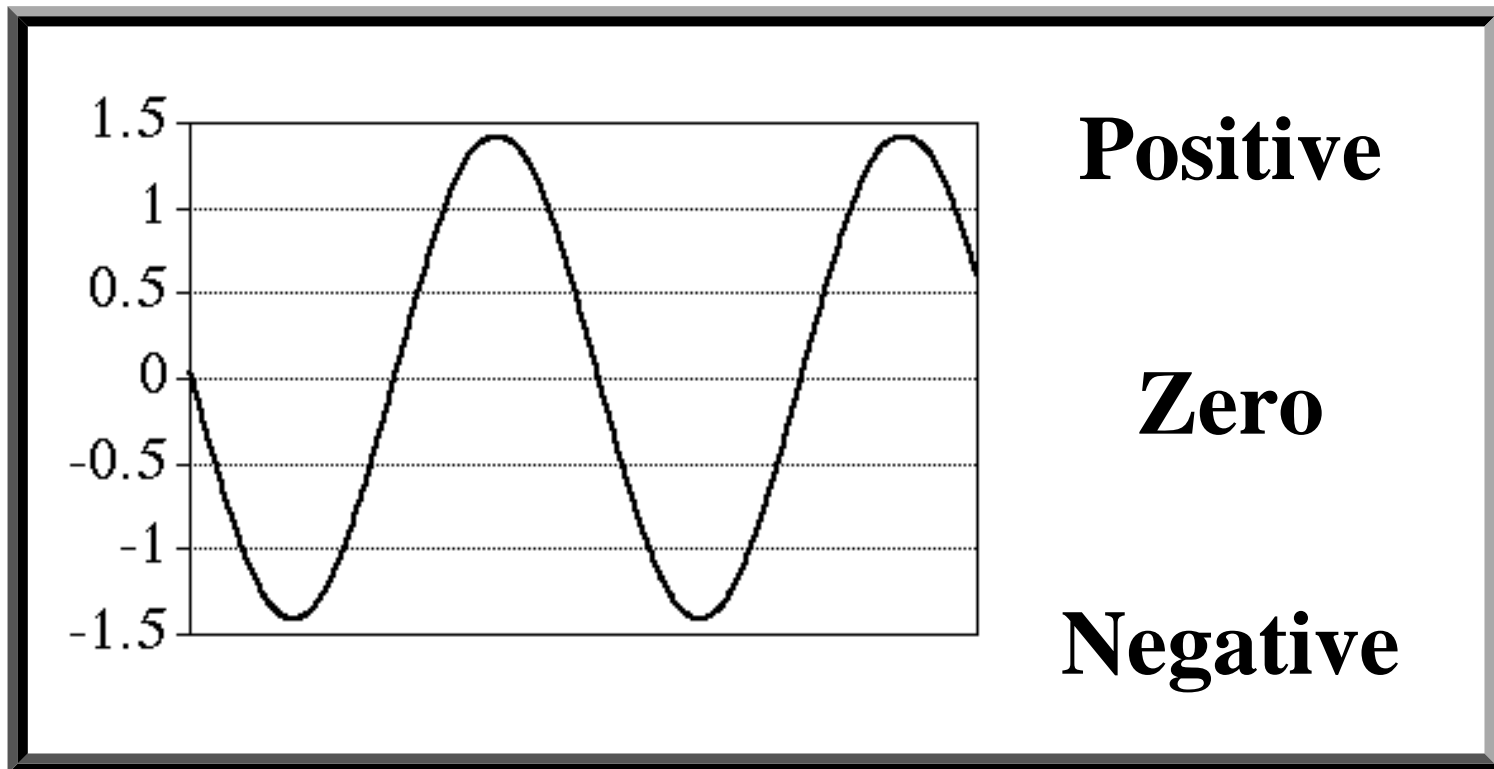
DC also comes from dis-similar metals



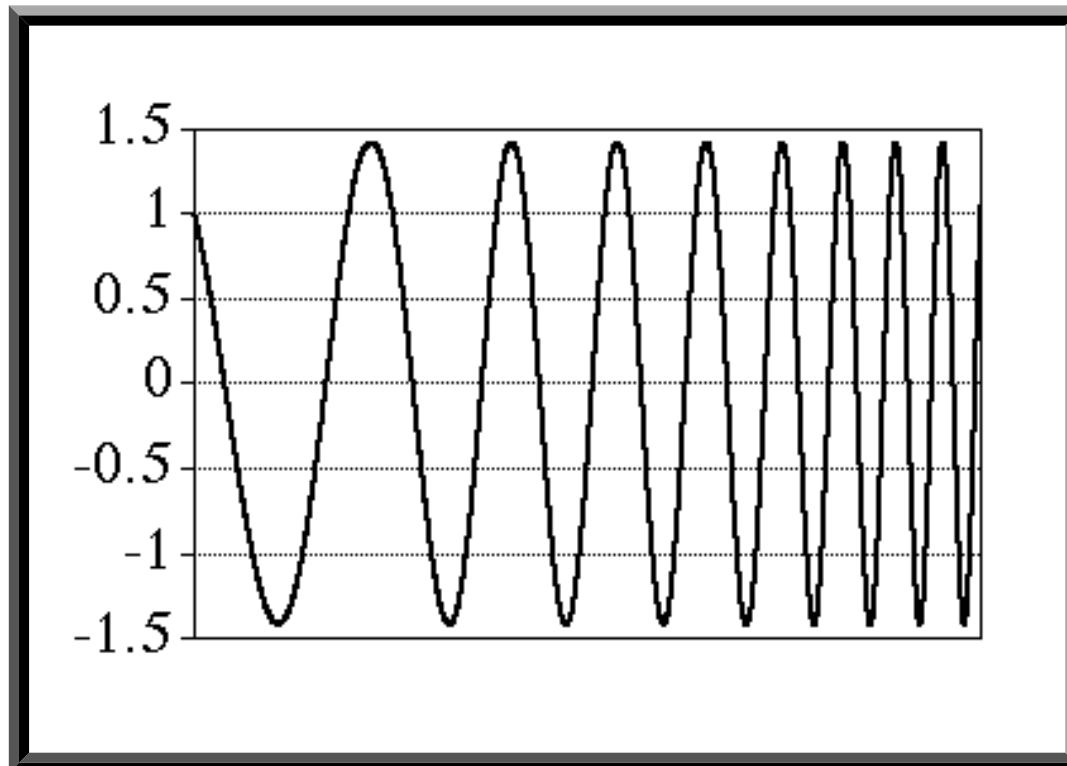
The type of metal determines the voltage



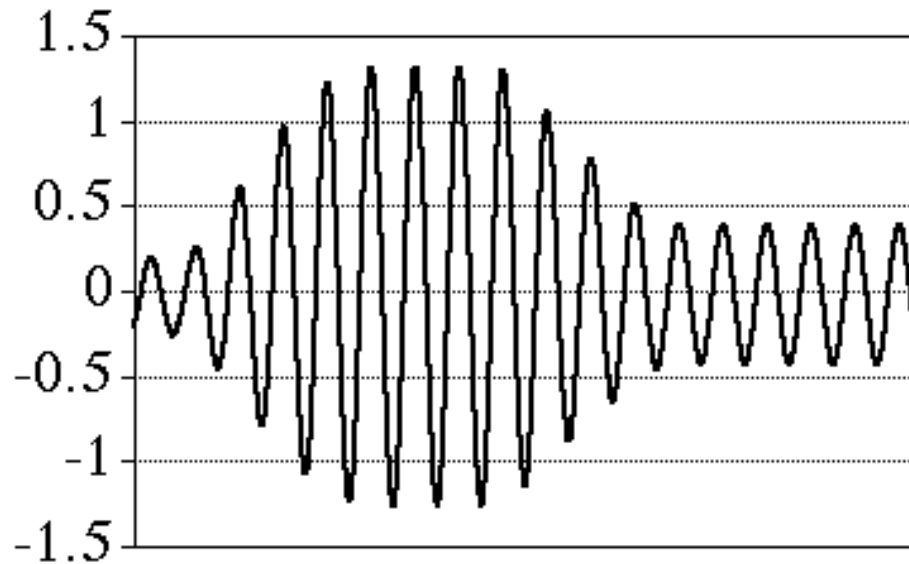
An AC voltage (or current) usually alternates between a positive and negative polarity



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



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



# Comparison of AC and DC

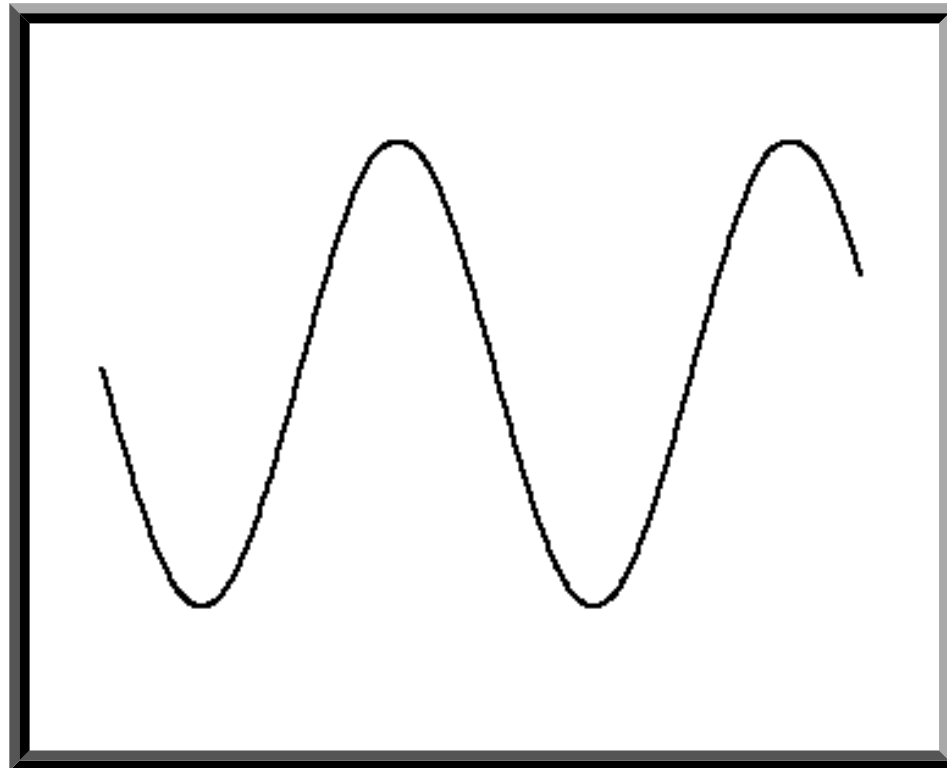
- An RMS value is a way to compare AC and DC voltage or currents.
- A milk house heater powered with 120 volts DC would produce the same amount of heat as it would when powered by 120 volts RMS AC.

# For AC only

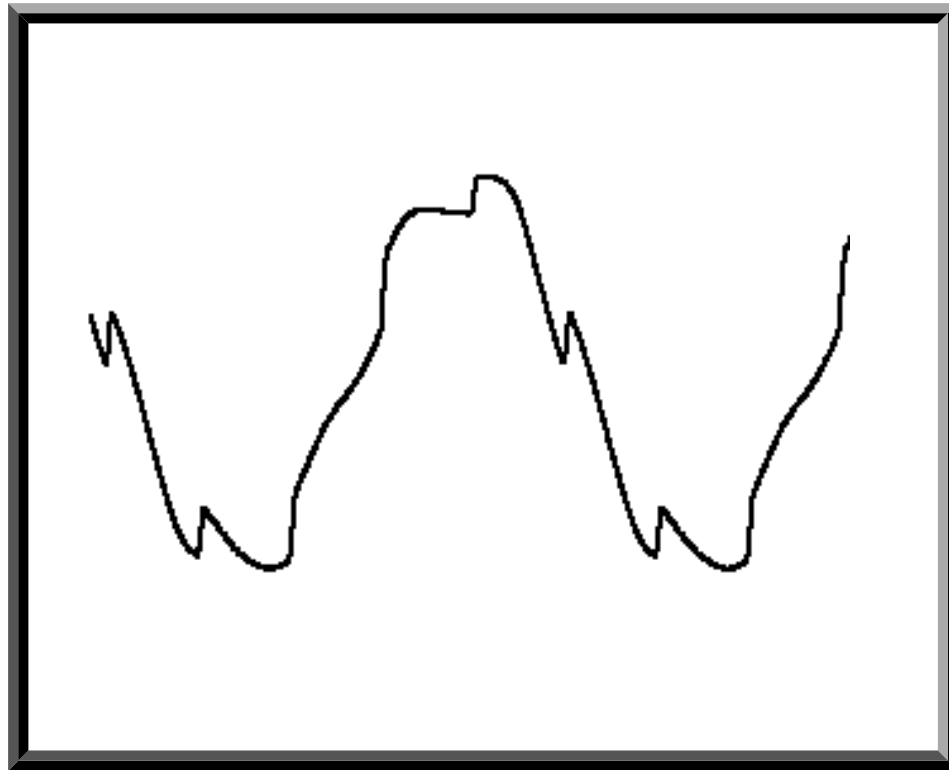
All AC voltages and currents are not pure sinusoids.

This can affect meters.

# Pure Sinewave



# Distorted wave form



# 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.

# Important Characteristics of Voltage and Current Measurements

Peak Value

Peak to Peak Value

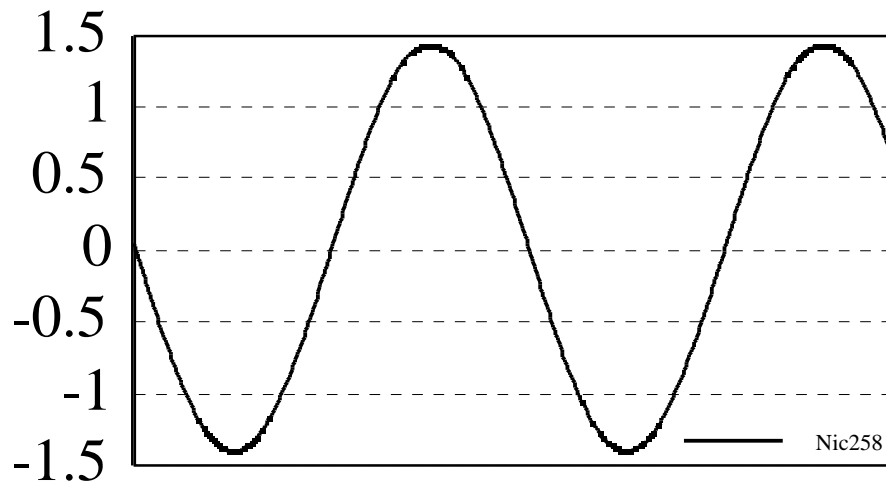
Average (RMS) Value

True RMS Value

# When Does RMS = RMS?

When a meter has trouble accurately reading a waveform, there usually is a difference in “Average” RMS and “True” RMS values

# How Peak, Peak-to-Peak and RMS Compare



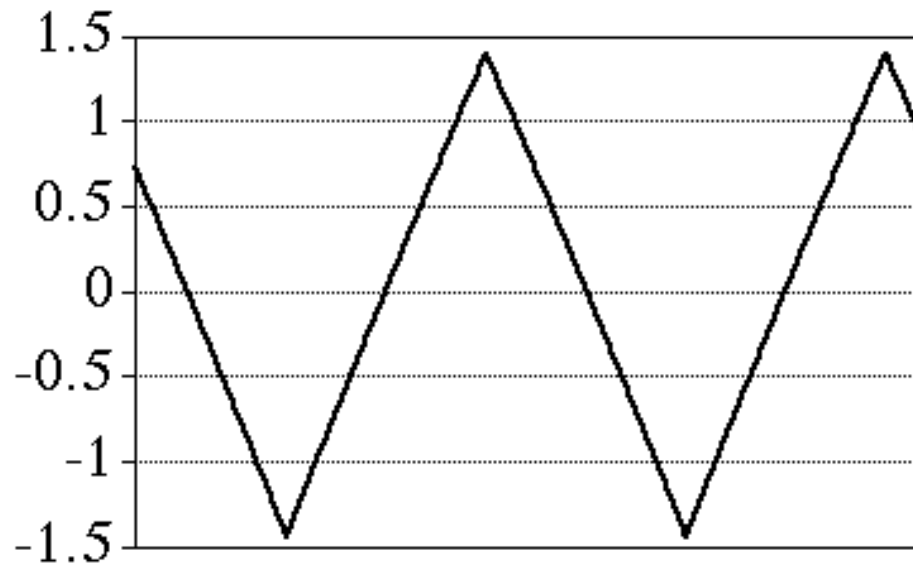
1.4 V Peak

1.0 V RMS(Avg)

1.0 V True RMS

2.8 V Pk-Pk

# Triangular Waveform



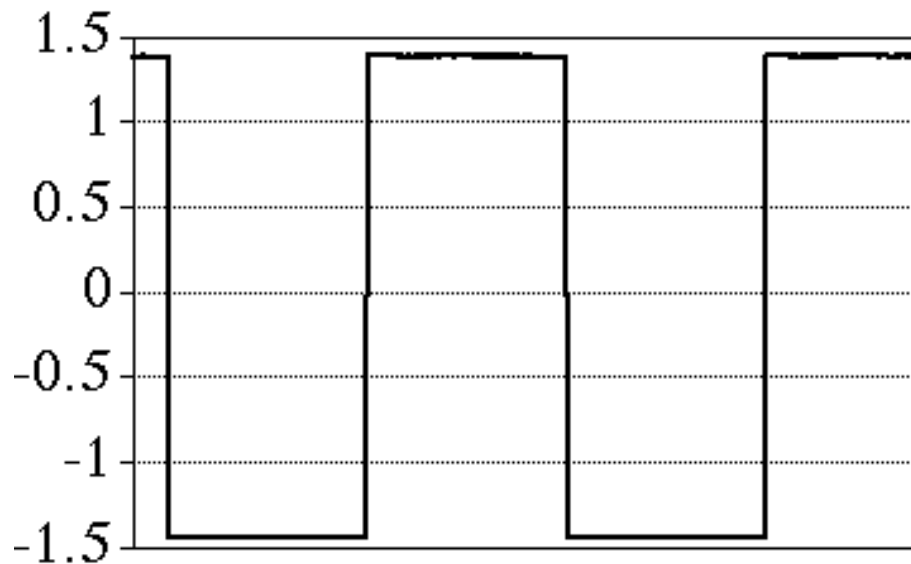
1.4 V Peak

0.785 V RMS(Avg)

0.82 V True RMS

2.8 V Pk-Pk

# Square Waveform



1.4 V Peak

1.56 V RMS(Avg)

1.4 V True RMS

2.8 V Pk-Pk

# Switching Power Supply Current Waveform



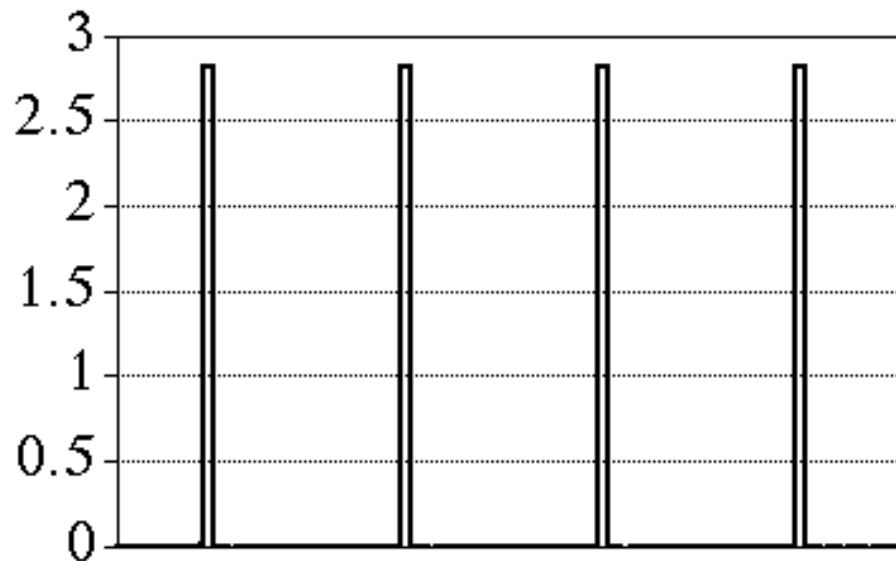
1.4 V Peak

0.28 V RMS(Avg)

0.52 V True RMS

2.8 V Pk-Pk

# Short Duration Pulse Waveform



1.4 V Peak

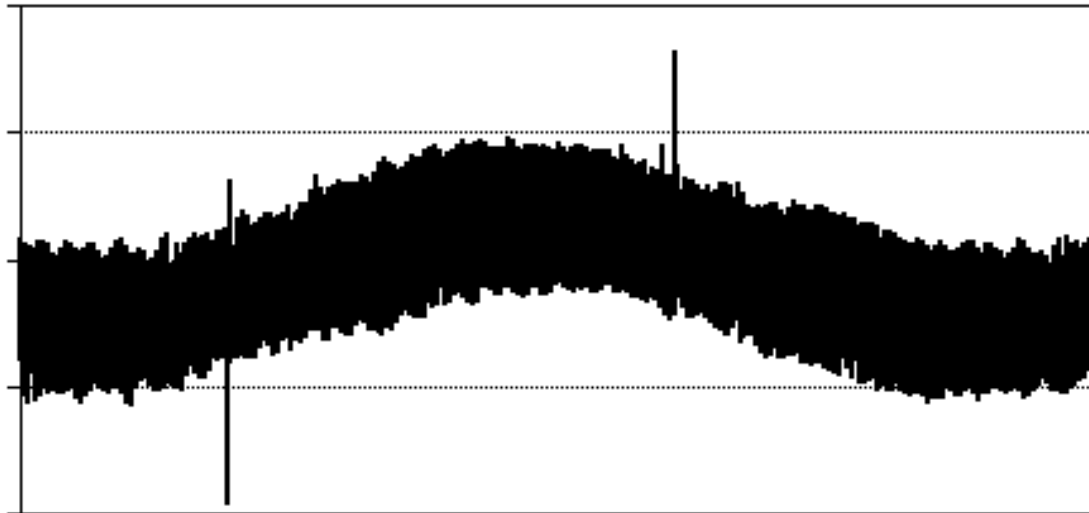
If AC coupled!

0.24 V RMS(Avg)

0.56 V True RMS

2.8 V Pk-Pk

# 60 Hz in Noise



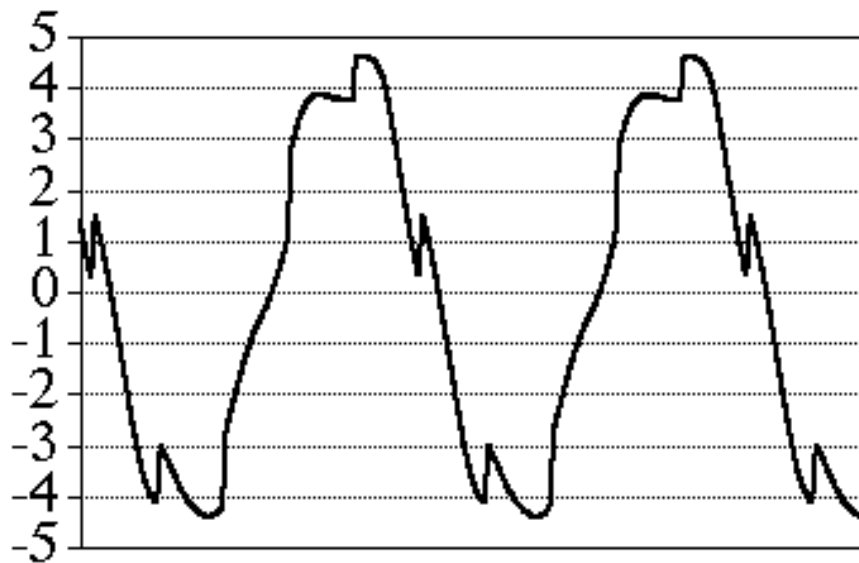
25 V Peak

7.7 V RMS(Avg)

11 V True RMS

50 V Pk-Pk

# 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

# Summary - True RMS or Average RMS Meter?

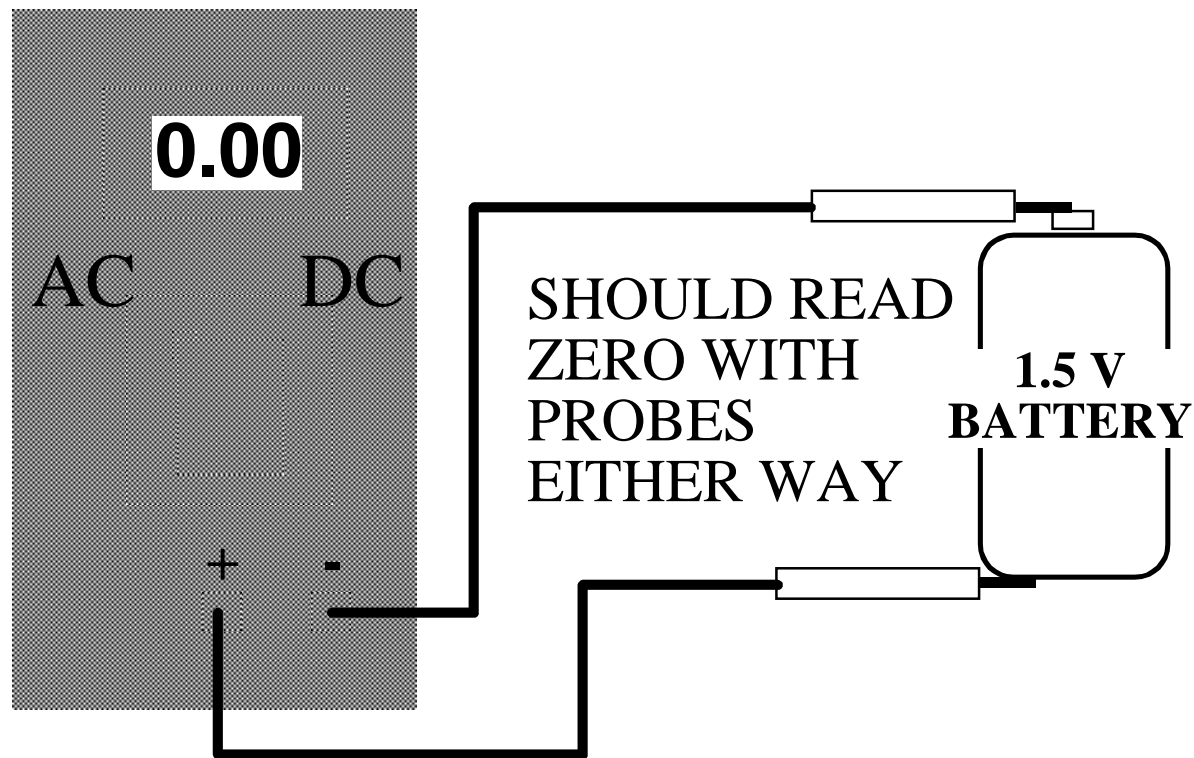
- If the waveform comes close to resembling a 60 Hz sine wave, the error will be minimal.
- Most “on-farm” Cow-Contact voltages will be in this category.
- Neutral-to-earth voltages should be measured by both types of meters, or viewed on an oscilloscope.

# How DC blocking can affect your meter....

# 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:

# DC Blocking Test



# Making current measurements... correctly....

# 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:

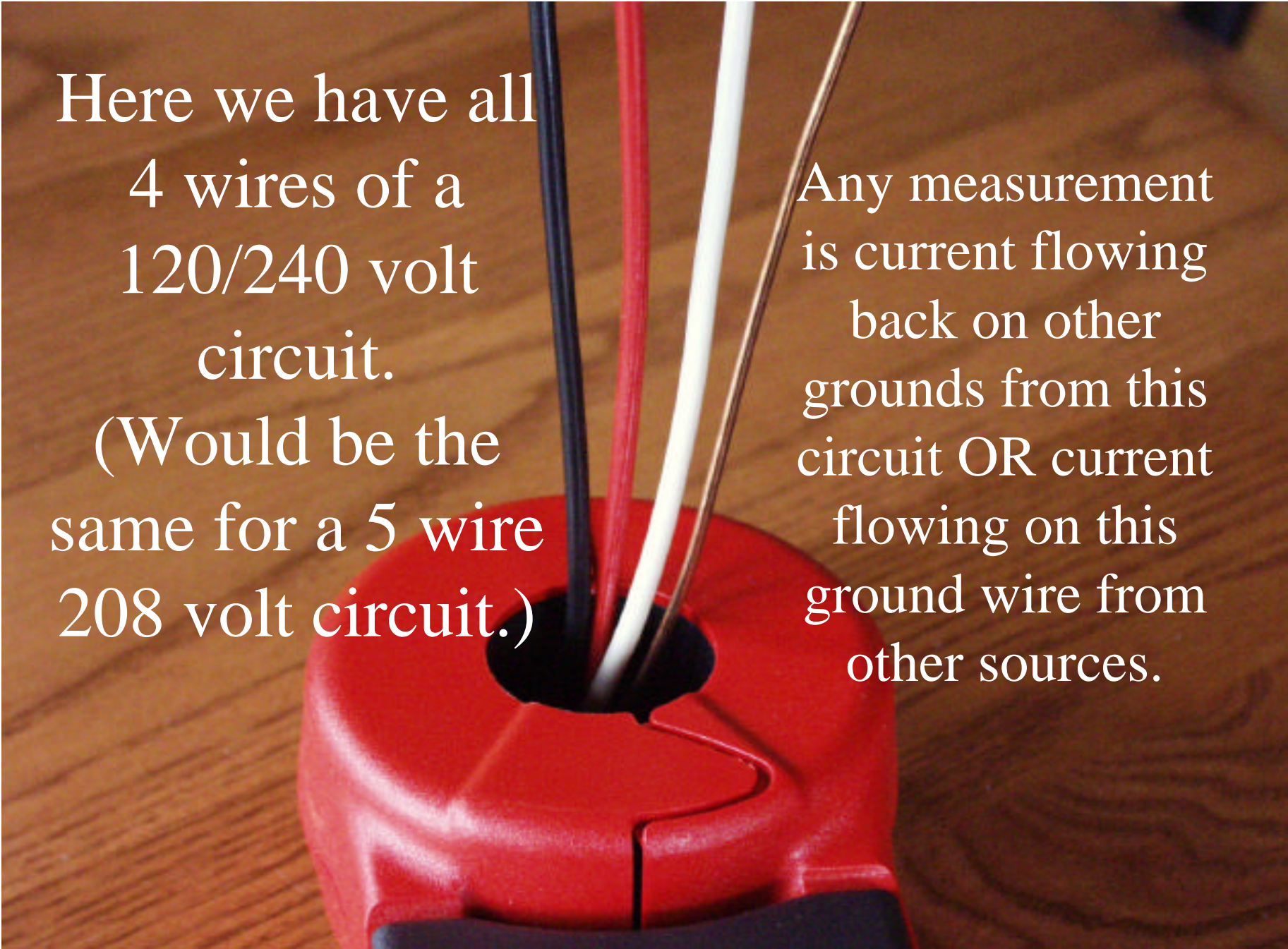
Actual Test mA -----	1000:1 CT & 200 uA Scale -----	1000:1 CT & 2 mA Scale -----
15	1.9	9
20	2.6	15
30	4.1	22
50	8	38
150	55	130
200	85	176

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

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

# 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.



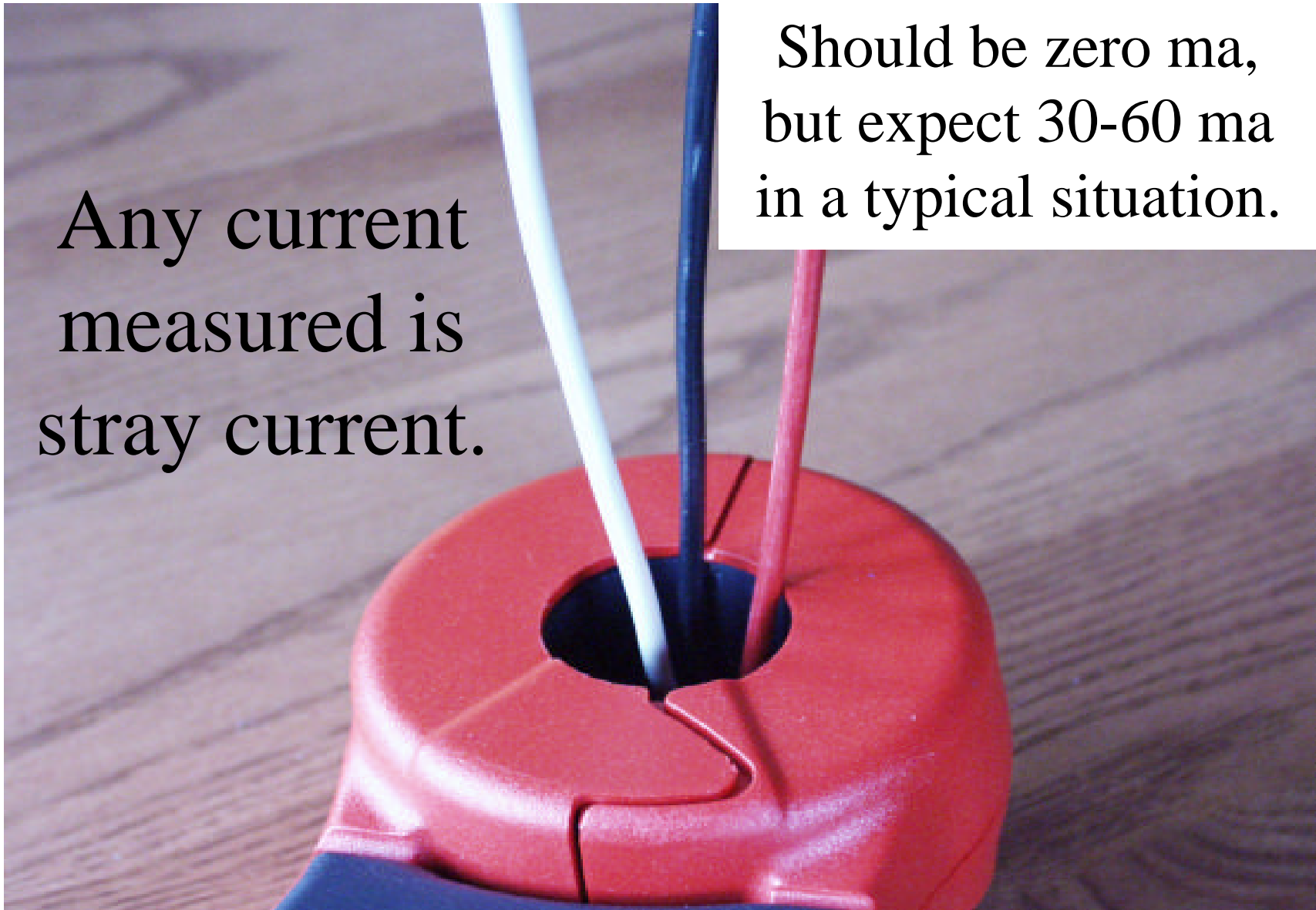
Here we have all  
4 wires of a  
120/240 volt  
circuit.

(Would be the  
same for a 5 wire  
208 volt circuit.)

Any measurement  
is current flowing  
back on other  
grounds from this  
circuit OR current  
flowing on this  
ground wire from  
other sources.

Any current  
measured is  
stray current.

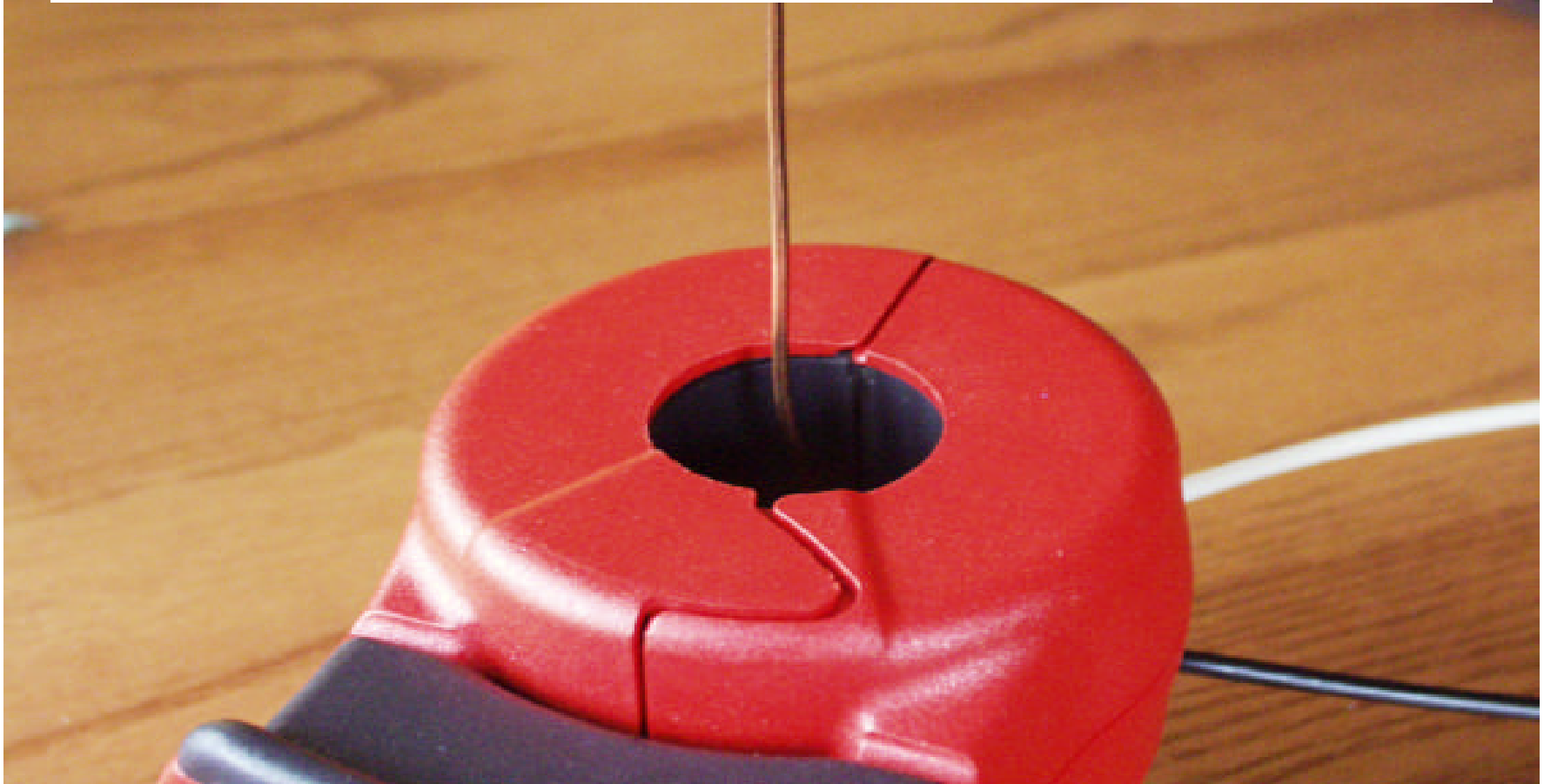
Should be zero ma,  
but expect 30-60 ma  
in a typical situation.



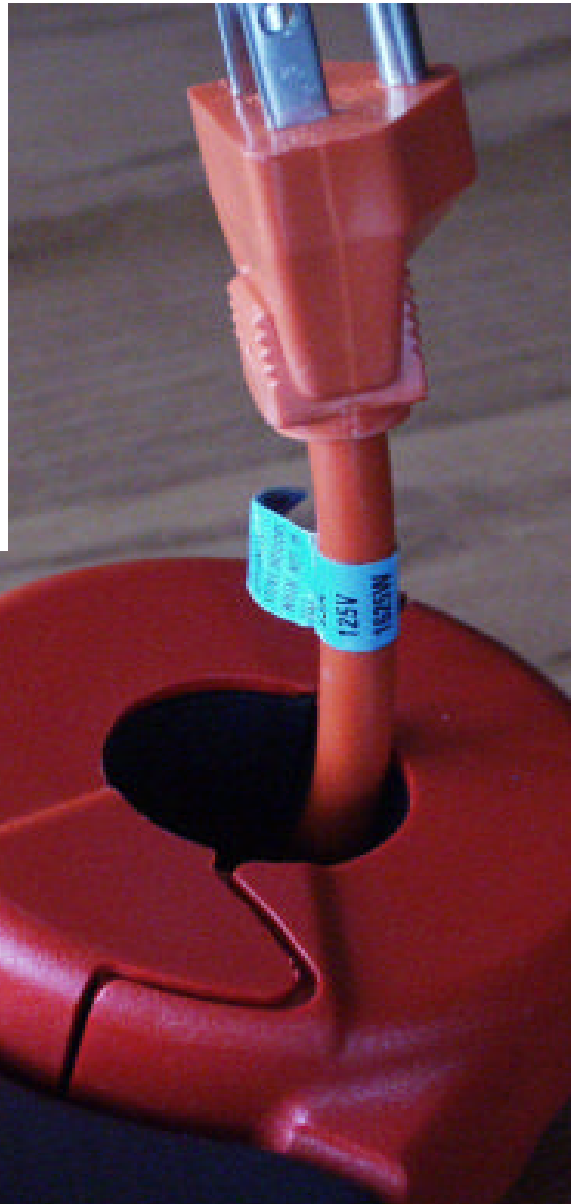
Careful here! Normal neutral current and stray current will be measured.



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



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.



AEMC Model 3710  
About \$1800  
Measures loop resistance  
and leakage current.

Here is one meter  
I use..

Preferred meter...

A.W. Sperry  
Model DSA-2413  
About \$450  
Measures from  
1 ma to 1,000 A

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45

# 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 ( $\mu\text{sec}$ ) 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?

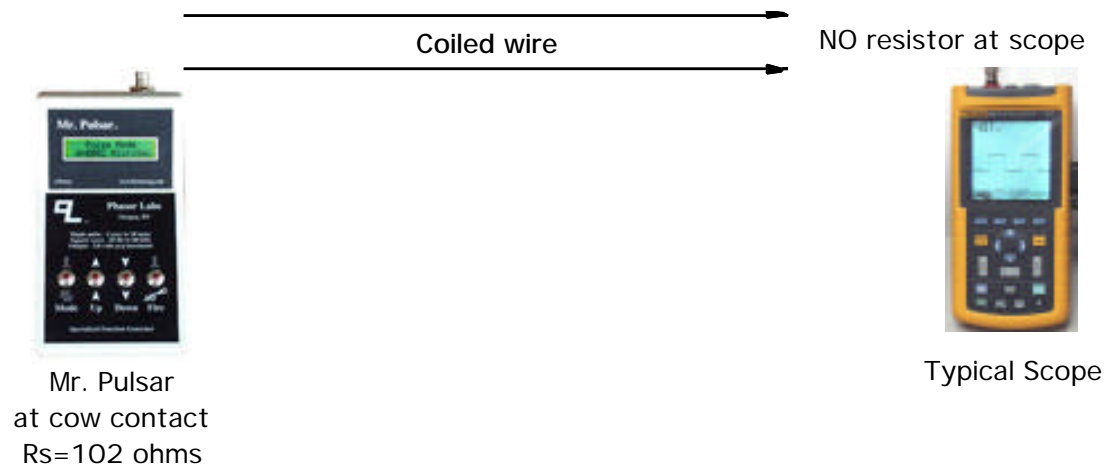
*If a 2 microsecond ( $\mu\text{sec}$ ) impulse can be measured without significant change in “Duration” or “Magnitude”, then all voltage waveforms from 60 Hertz to over 1,000,000 Hertz will be measured accurately.*

There are exceptions....

*We can cover the exceptions after the  
experiment.*

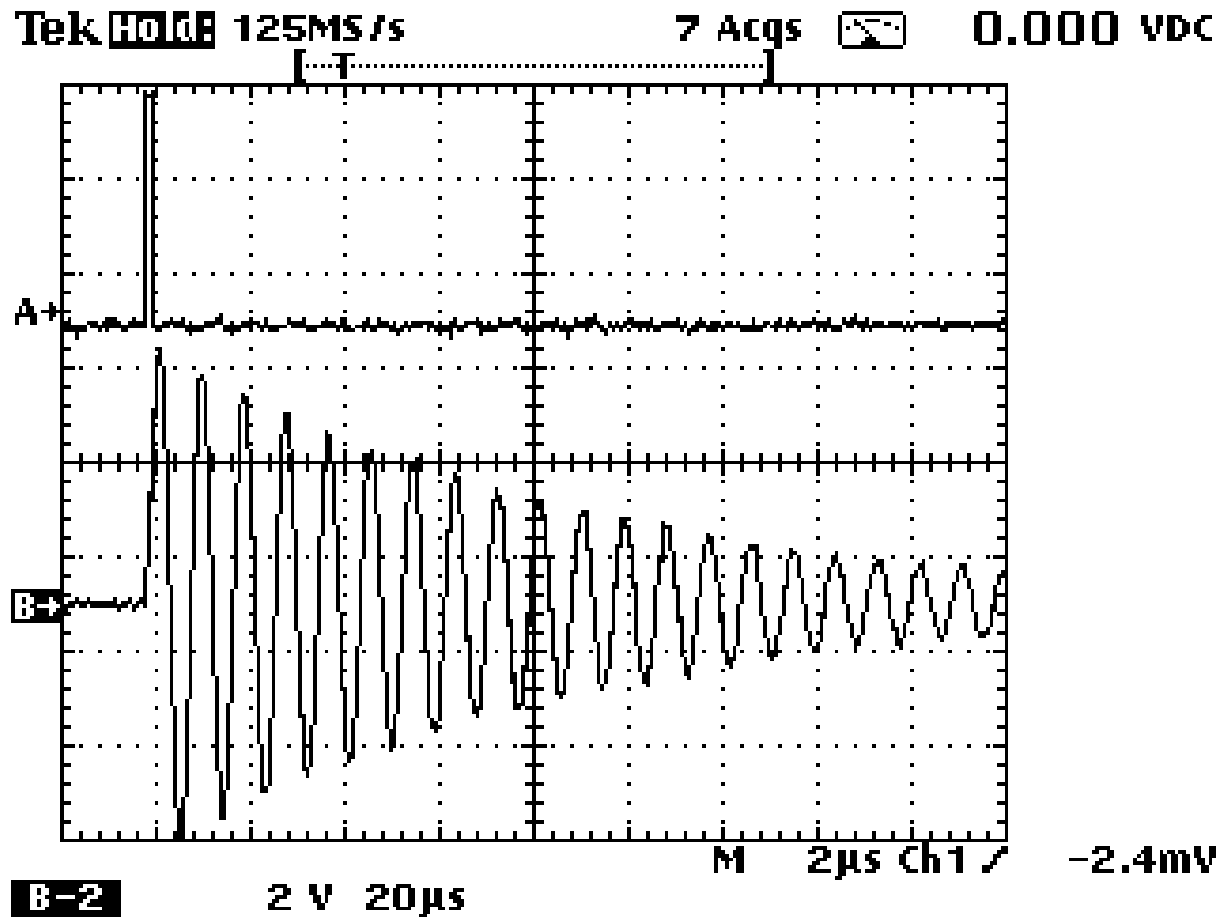
# Experiment A

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?



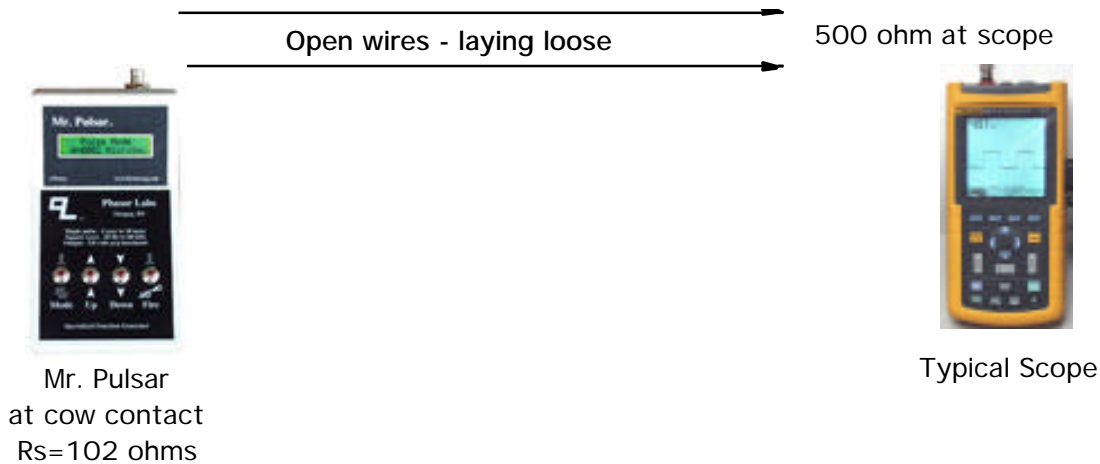
The upper trace A is a 2 microsecond ( $\mu\text{sec}$ ) impulse from the test unit.  
The lower trace B is what was recorded at the scope.

Note the ringing due to the inductance of the coil.  
Also the larger P-P voltage!



# Experiment B

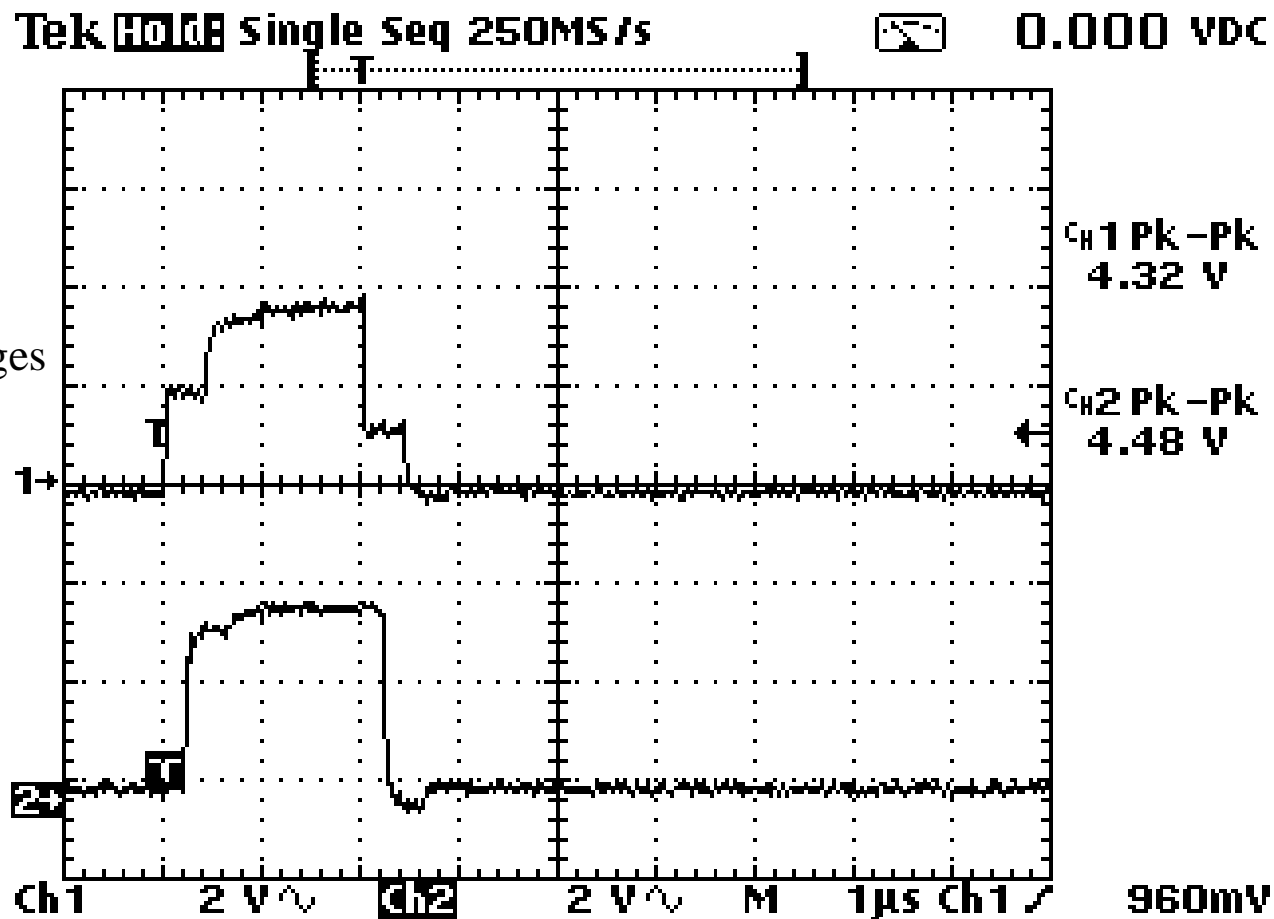
What happens if I use single conductor wires to the cow contact point and laid the wires out in a parallel line pattern? (100 foot)



I ADDED a  
500 ohm  
resistor at the  
scope.

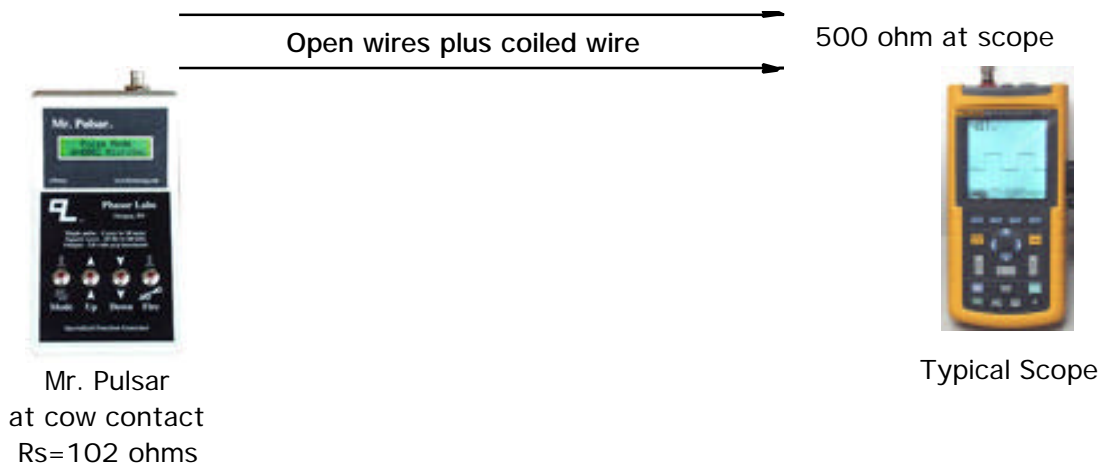
The upper trace 1 is a 2 microsecond ( $\mu\text{sec}$ ) impulse from the test unit.  
The lower trace 2 is what was recorded at the scope.

Note that the distortion and magnitude changes are relatively small. Note the “loading” of the test set by impedance reflections.



# Experiment C

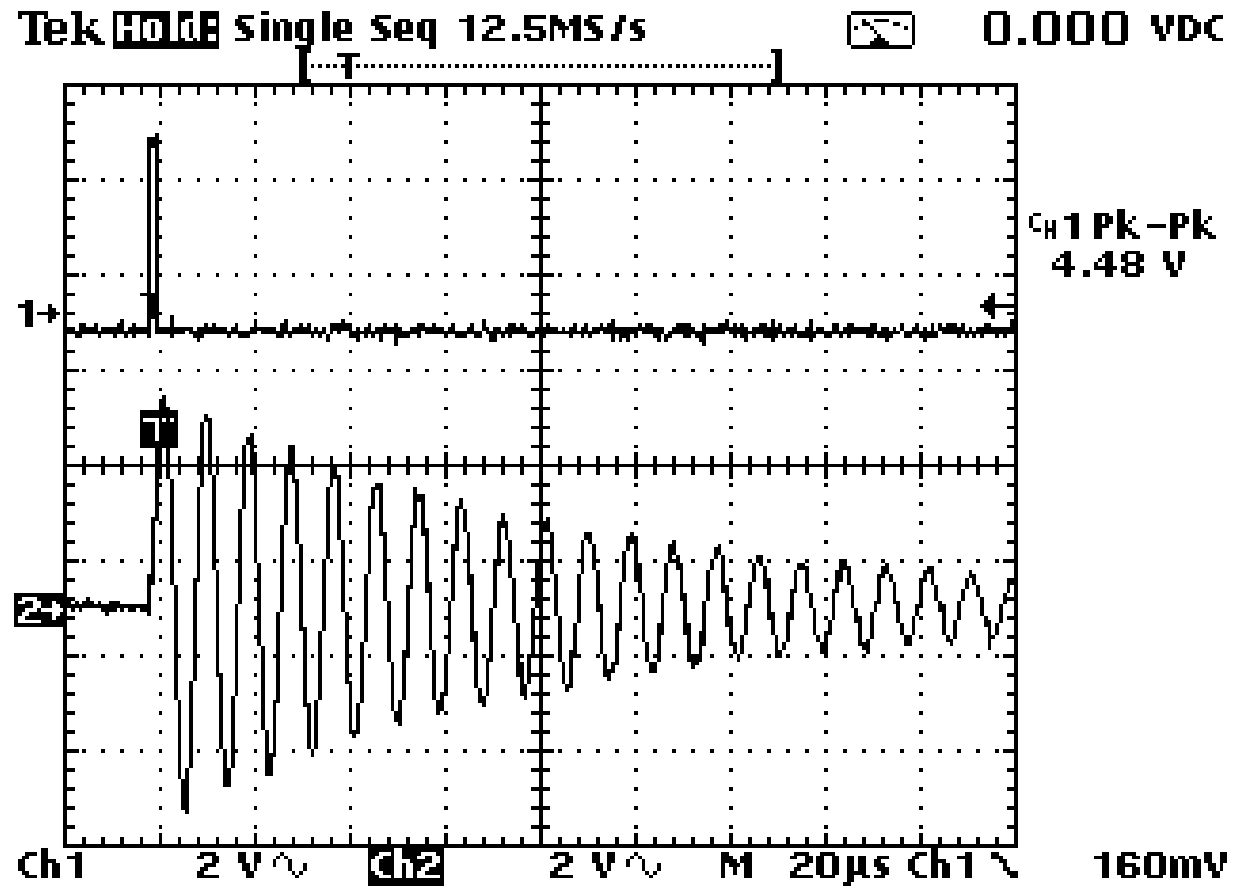
What happens if I use single conductor wires to the cow contact point and laid the wires out in a parallel line pattern, PLUS add the coiled wire? (200 foot)



I ADDED a  
500 ohm  
resistor at the  
scope.

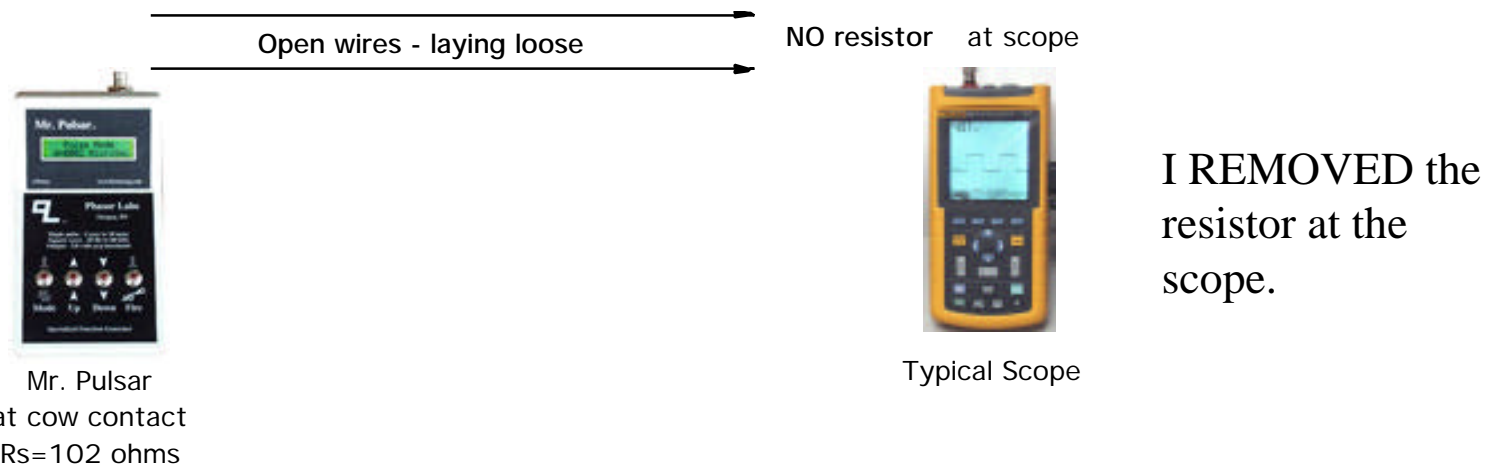
The upper trace 1 is a 2 microsecond ( $\mu\text{sec}$ ) impulse from the test unit.  
The lower trace 2 is what was recorded at the scope.

Note the  
problem with  
ringing and  
magnification  
remains



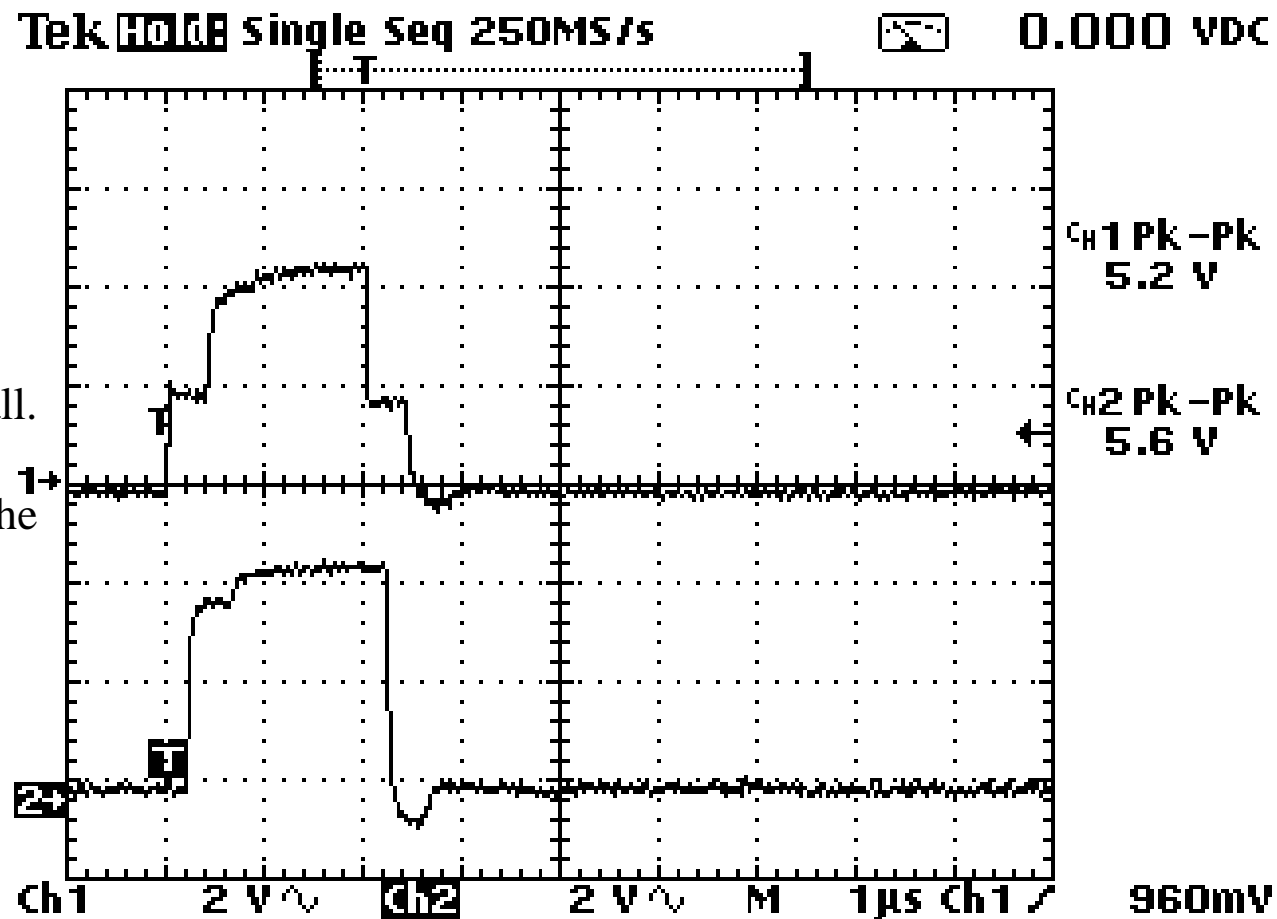
# Experiment D - similar to B

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



The upper trace 1 is a 2 microsecond ( $\mu\text{sec}$ ) 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. Note the “loading” of the test set by impedance reflections.



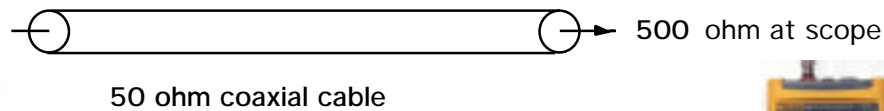
# Experiment E

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

I ADDED a **500**  
ohm resistor at the  
scope.



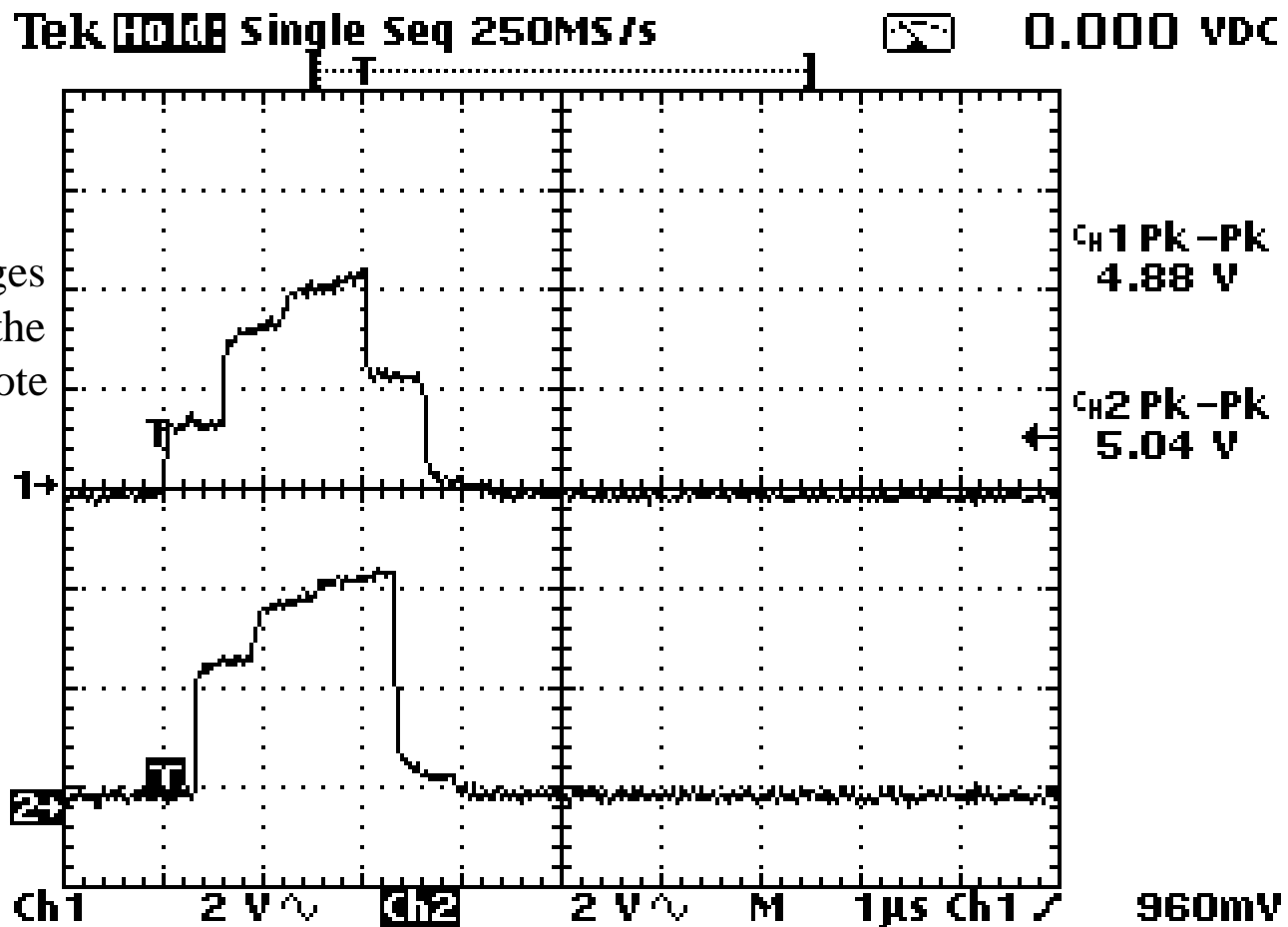
Mr. Pulsar  
at cow contact  
 $R_s = 102$  ohms



Typical Scope

The upper trace 1 is a 2 microsecond ( $\mu\text{sec}$ ) impulse from the test unit.  
The lower trace 2 is what was recorded at the scope.

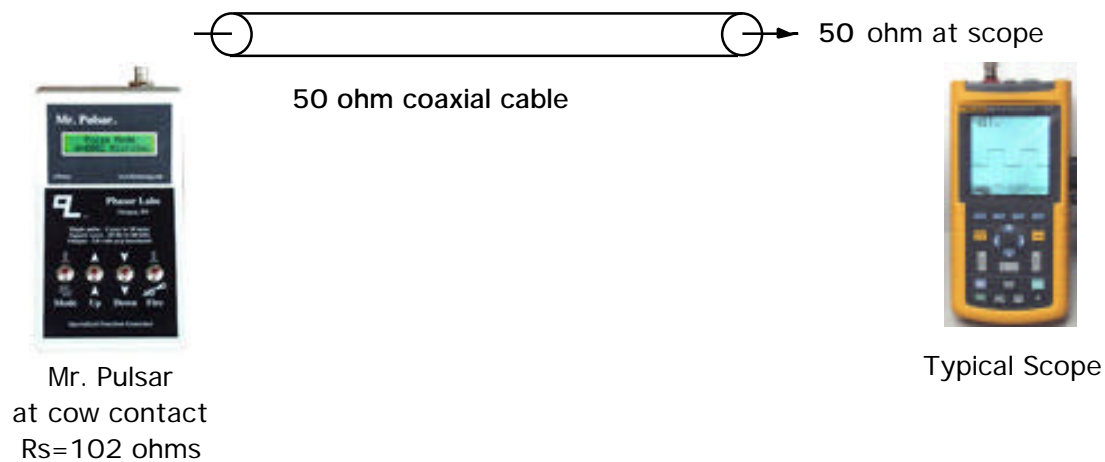
Note that the distortion and magnitude changes are greater than the single wires. Note the “loading” of the test set by impedance reflections.



# Experiment F

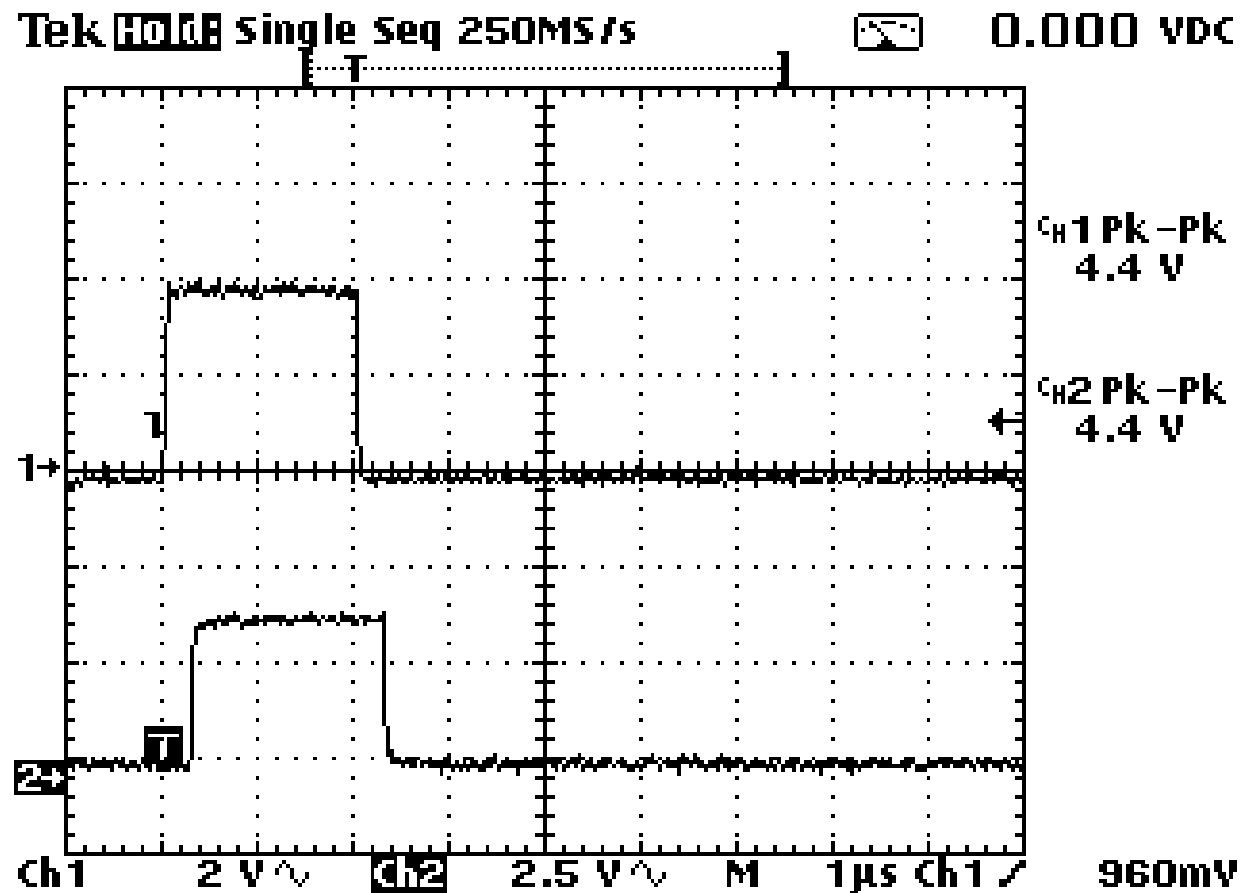
What happens if I use 50 ohm coaxial cable?  
(100 foot)

I ADDED a **50** ohm resistor  
at the scope.



The upper trace 1 is a 2 microsecond ( $\mu\text{sec}$ ) 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.

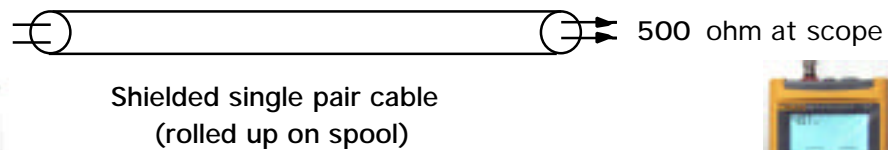


# Experiment G

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



Mr. Pulsar  
at cow contact  
 $R_s = 102$  ohms



Shielded single pair cable  
(rolled up on spool)

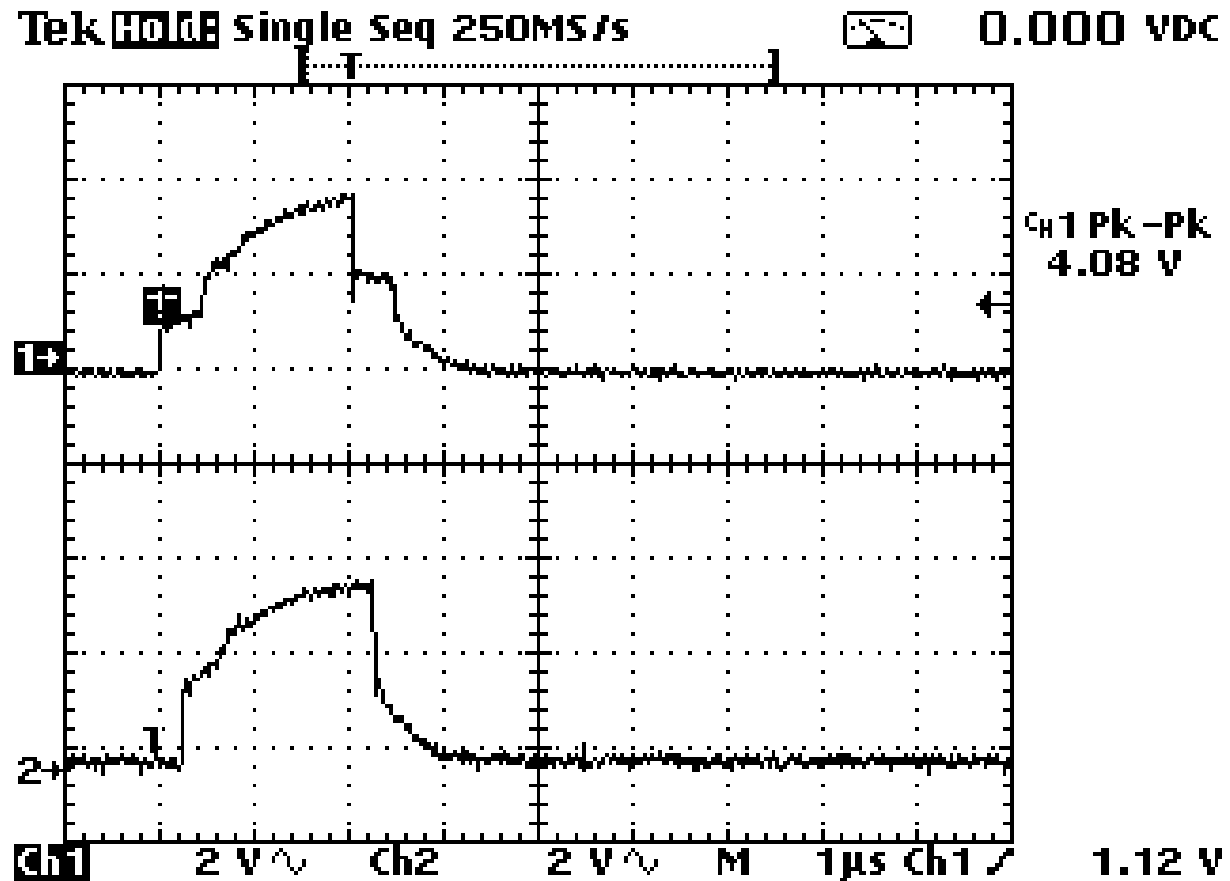


Typical Scope

I ADDED a  
500 ohm  
resistor at the  
scope.

The upper trace 1 is a 2 microsecond ( $\mu\text{sec}$ ) 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 pretty  
good!



## **Now... the rest of the story**

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

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 lead wire...**

To measure short duration impulses simply move 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.....**

See Part 2 to follow....

Keep an eye on:

**[www.phasorlabs.com](http://www.phasorlabs.com)**