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Analysis of Voltage Measurements and Resistance in Inverting Amplifier

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Abstract – Current measurements are made on one of two ways. The first and most straightforward method is the reverse of the Resistance measurement. In this configuration, the unknown current is applied thru a known, but very small, resistance, and the resulting voltage is measured. Many hand held multi-meters will measure currents of up to 10 Amps. Frequently a second resistance value for current will be available that is larger, allowing much smaller currents to be measured accurately. The second method utilizes field effect properties of currents flowing thru conductors. By wrapping a coil of wire around the wire, the field effects of the current flow thru the wire will induce a current in the coil. In this way the current can be measured without the resistance being installed. This method is typically used for higher current flows and can be used for readings in the thousands of amps. Most hand held multi-meters that measure current will have a special input jack for the positive lead of the current measurement. Failure to change to this location can cause considerable damage to the multi-meter, since the total current flow would be trying to go thru the voltage measuring circuit.

Key words: Resistance measurement, multi-meters, input jack, coil.

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INTRODUCTION

In the world of mechanical devices today, most measurements are made by electronic instrumentation, not the crude mechanical devices of the past. Most of these newer devices are actually a modern combination of a mechanical device and electronic sensing element. Many of the measurements a mechanical engineer makes are done with specialized calibrated equipment, but some are still made with basic electronic instruments, and the readings interpreted by the operator. This research work is designed to introduce we to some of the more common basic instrumentation and its use. It will also allow we to conduct some measurements and familiarize werself with these instruments.

There are a wide variety of instruments on the market today, but the most common that a mechanical engineer would see include Multi-meters, Frequency Counters, Oscilloscopes, Strip chart recorders, Function Generators, and Spectrum Analyzers.

REVIEW OF LITERATURE

The multi-meter is the most common electronic instrumentation in use. It is a combination meter that is capable of measuring, resistance, voltage (AC and DC) and usually current. In addition some meters are capable of measuring capacitance, frequency and other variables. An example of one of these meters is the Fluke 189 hand held multi-meter.

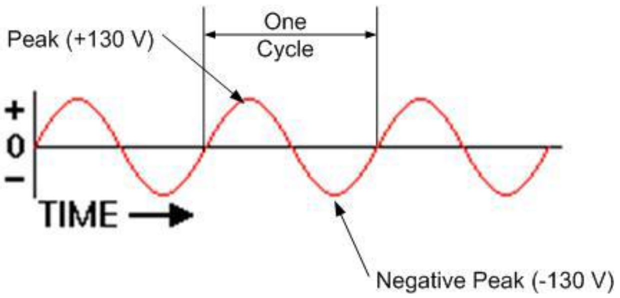
This type meter is very common in most shops and is portable and easily used. This meter is capable of measuring AC and DC Voltage (down to 0.000001 Volts and as high as 1000 Volts), Resistance, Capacitance, Temperature, Current (Down to 0.000001 Amps and as high as 10 Amps). In addition it is capable of catching maximum and minimum values and saving them in memory. A versatile meter like this is most commonly used by service personnel, but can easily be used by anyone. In addition this meter is a ***True RMS*** meter, which will be explained in more detail later.

In addition to handheld meters such as this one, less expensive hand held meters with less functions are available. On the other end of the spectrum, bench top meters such as the Fluke 47 and HP 3470 meters are common. These two bench top meters contrast each other with a very wide difference in resolution and accuracy.

Most meters, and multi-meters are classified in by the number of digits of the display. Each full digit registers 0 – 9, and a half digit will register only a 0 or a 1.

MATERIAL AND METHOD

A three and a half digit display would then be capable of measuring from -1999 to +1999, with the Cottrell decimal point being located some place in that range depending on the capability of the meter, and the measurement being taken. **1.1 Voltage Measurements** Voltage measurements come in two flavors, AC and DC. These stand for Alternating Current and Direct Current respectively. In the world of electronics, those signals that are steady or nearly steady voltages, those that change at rates of less than 1 cycle per second, are commonly referred to as DC measurements. Thos that have a generally repetitive wave form that change at rates faster than 1 cycle per second (or 1 hertz) are considered to be AC signals. The most common AC signal that we will encounter is the 60Hz AC wall power. This voltage varies with time at a rate of 60 cycles per second. The DC value is a measure of the average voltage over the period of time. If we look at one complete cycle of the AC waveform, we will see that the average value is 0. Does this mean that it has no voltage? The answer to that is no. In the world of AC waveforms the effective voltage is called the RMS voltage. Lets start by defining some terms. • **Peak Voltage** - The voltage value at the local maximum point in the cycle graph. The Voltage measure is from 0 to this maximum. • **Peak to Peak Voltage** – The Peak to Peak voltage is measured from the cycle minimum value to the cycle maximum value. As an example if the ac waveform below the P-P voltage would be 260 Volts (130 – (-130)). • **Average Voltage** – The



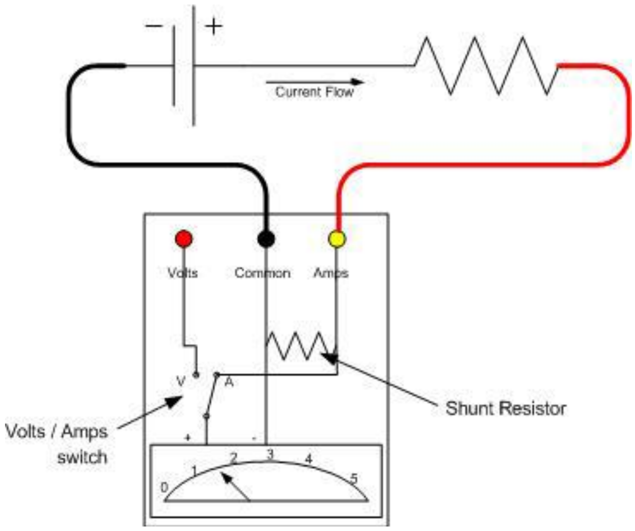
average voltage is the arithmatic average of the positive half of the cycle. In a standard sinusoidal wave form this value is 0.637 * Peak Voltage. • **RMS or Effective Voltage** – This is the Root-Mean-Square calculation of the AC signal. This is the measure of how much work can be done by the AC power source. The RMS value for a sinusoidal wave form is = .707 * Peak Voltage. For non sinusoidal signals, the RMS value must be calculated. Taking one cycle of AC signal and breaking it into many small samples, we can calculate the RMS value based on the following formula. As we can see in the following diagram, the RMS value is not the same thing as the average value. If the signal being measured is not truly sinusoidal or non-symmetric in any way, the RMS value will vary from the standard 0.707 value. In the above example we saw a sinusoidal waveform with a peak value of 130V. The RMS value of this signal would be 91.9 Volts. This is the value wer typical multi meter will read in the AC mode. • **True RMS** – A meter that will break down the waveform into tiny slices and make the mathematical RMS calculation (above) and display the result of this calculation is called a True RMS voltmeter. These meters will generate an accurate RMS value for even non- symmetric signals. In today's market there are literally thousands of small hand held millimeters. Most operate on the same principals. Each measurement is handled by the meter with some specific circuitry to convert the signal into a small DC voltage. This small DC voltage is the only actual measurement that the meter processes into the display. Most meters (Non-True RMS Meters) will convert the AC wave into a DC signal that represents the peak voltage value. This value is then converted to RMS by a 1.414:1 Voltage divider.

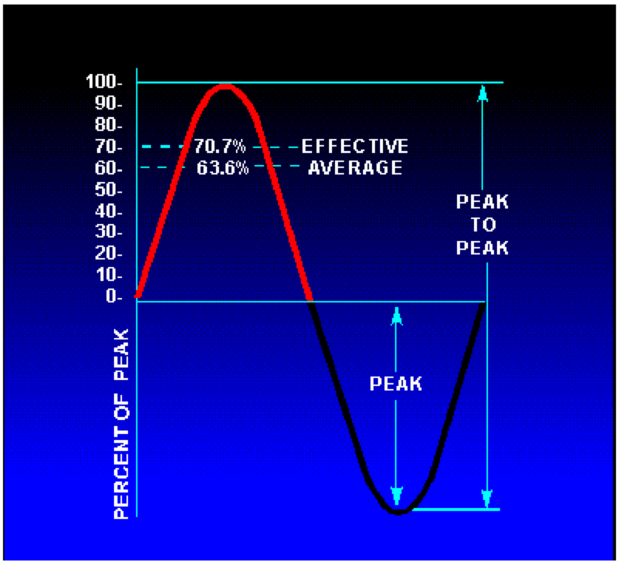
Both DC and AC voltage values are then fed thru a series of voltage divider networks, based on the range selection, to bring the final DC level under two volts. This value is then converted by an Analog to Digital conversion chip and displayed as a digital number.

RESISTANCE

Resistance measurement is conducted by the same method in all meters. A fixed, known current is applied to the resistance value that is being measured, and the resulting voltage developed is used to quantify the resistance value. This is all based on Ohm's law, which by now we should have been exposed to in wer Physics course. The range of the resistance determines the amount of current applied. Lower resistance values require higher current values to generate an accurately measurable voltage. All resistance readings are made in Ohms, or multiples of Ohms (K- x1,000 M – x1,000,000). In general readings above a few MegOhms are considered to be open circuits.

Current measurements are made on one of two ways. The first and most straightforward method is the reverse of the Resistance measurement. In this configuration, the unknown current is applied thru a known, but very small, resistance, and the resulting voltage is measured. Many hand held multi-meters will measure currents of up to 10 Amps. Frequently a second resistance value for current will be available that is larger, allowing much smaller currents to be measured accurately. The second method utilizes field effect properties of currents flowing thru conductors. By wrapping a coil of wire around the wire, the field effects of the current flow thru the wire will induce a current in the coil. In this way the current can be measured without the resistance being installed. This method is typically used for higher current flows and can be used for readings in the thousands of amps. Most hand held multi-meters that measure current will have a special input jack for the positive lead of the current measurement. Failure to change to this location can cause considerable damage to the multi-meter, since the total current flow would be trying to go thru the voltage measuring circuit. Some higher end meters will handle this with internal relays to avoid the problems caused by neglecting to switch the leads.





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INVERTING AMPLIFIER

The circuit shown below is called an inverting amplifier. The op amp in this circuit must be biased using DC voltage sources. (As is conventional, these DC sources are not shown in the drawing of the inverting amplifier. None-the-less, the sizes of these dc sources determine the voltage at which the op amp saturates.) In this example, ± 20 volt sources were used. As a consequence, the op amp saturates at ± 20 volts.

CONCLUSION

When the op amp is not saturated, the inverting amplifier produces an output voltage, Vo, that is proportional to the input voltage, Vs. The output voltage is measured using a voltmeter. The input voltage is the voltage of the voltage source. The constant of proportionality is called the gain of the inverting amplifier. The value of the gain of the inverting amplifier is determined by the resistances, Ri and Rf, of the two resistors in the the inverting amplifier.

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