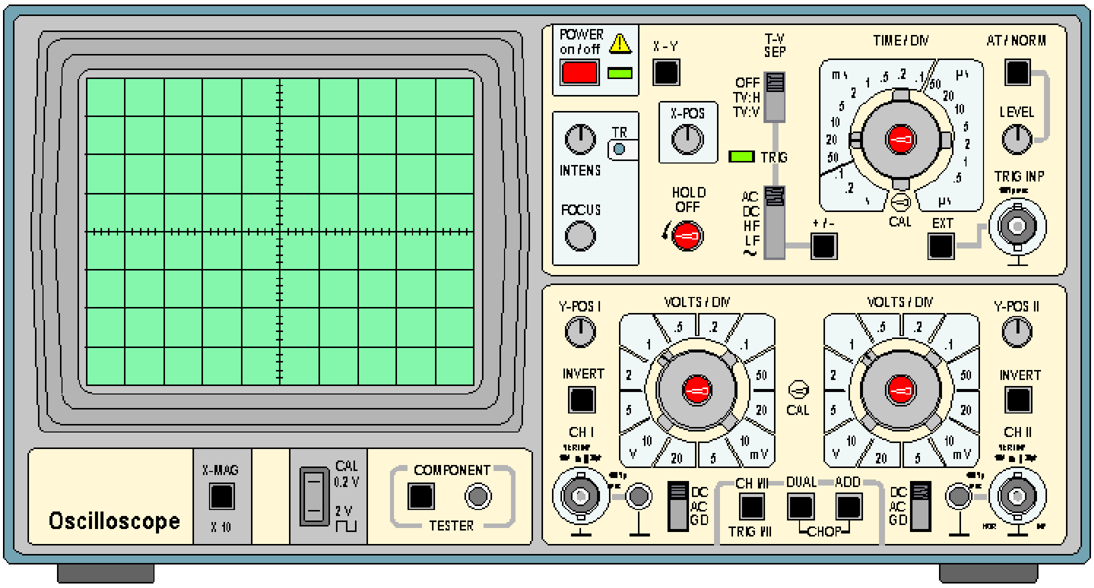
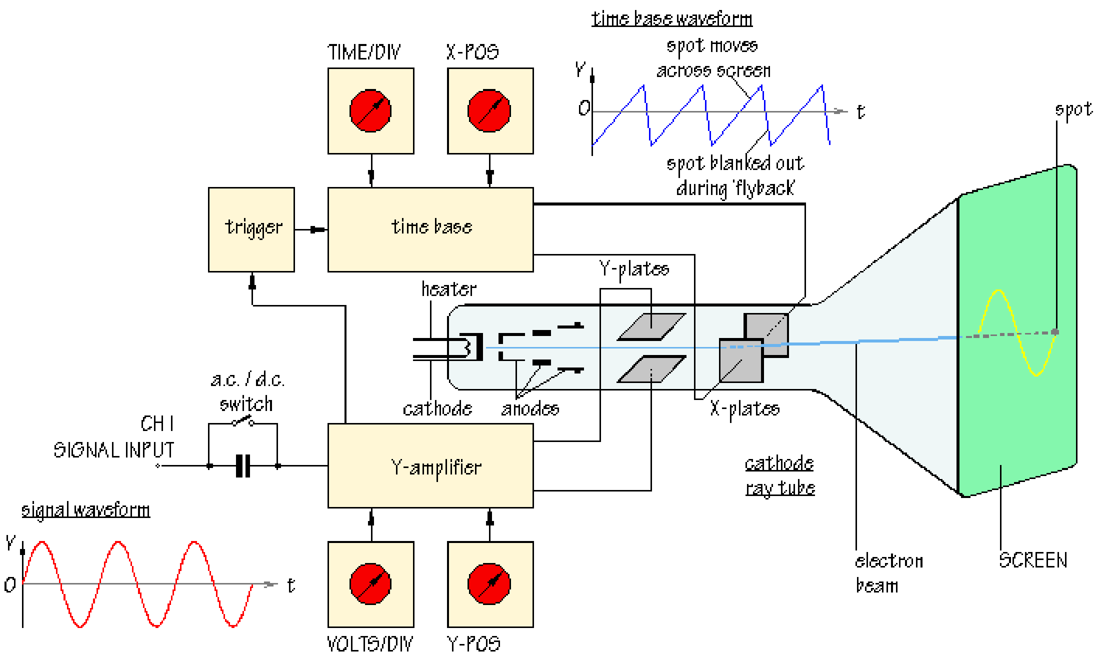
Use of instruments 212.55 – 212.60 (10%)

Oscilloscopes.



In block form a scope can be viewed as follows.



Controls:

Brillance/Brightness/Intensity.
This controls the brightness of the spot by adjusting the grid-cathode ptential.

Focus control:
Allows the spot diameter to be adjusted by varying the votage on the middle anode with respect to the two outer anodes.

Y-controls.
Consists of two separate elements,
Volts/div scales the amplitude of the tance on the screen. Sometimes
also called Volts/cm, or channel gain, thus a single vertical disision can represent from 5mV to 20V.

Y-Pos enables the signal trace to be positioned at any vertical position on the screen.

There are generally two input channels (A and B), each cahnnel will have seperatet Y-controls.

X-Controls.
Consists of two controls.
Time/div: this expands the signal trace about the centre of the screen, may also be called time/cm or Time base speed. Thus a signal horizontal division can represt from 0.5µs to 200ms.
X-pos move the sigal trace horizontally .

Sync/trigger.
Enables stable signal traces to be obtained on screen, the trigger awaits the input to achieve a preset level which then triggers the timebase to start sweeping. Thus the periodic input signal apears to always start at the same point in time.

AC/DC/Gnd switch.
Enables a series capacitor to be include in the input line.

On DC, cap is out of circuit and display shows both DC and AC compnets of signals.

On AC cap is in series and it blocks any DC component of signal,thus only shows ac componets. Care should be used when measurng square wave, not to have input on AC.

On Gnd, the scope input is connected to zero volts, and the position of the zero volt line may be adjusted, using the Y-pos control to a desired level, normally either the bottom of the screen or along the center graticule line.

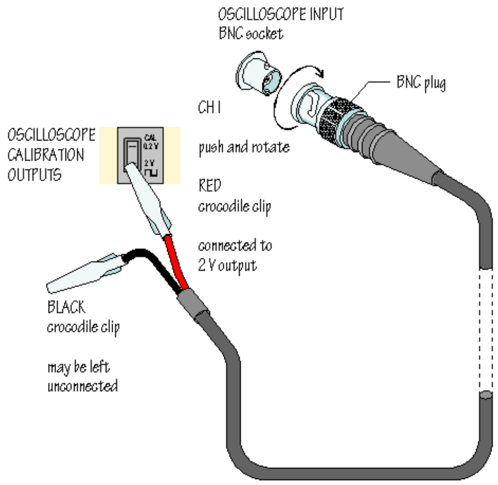
Timebase mode.
Can be used to select between **ALT**ernate and **CHOP** (or switch)**.** Since only one electron gun exists inside the scope then in order to disply two traces at once it is necessary to share the gun between the inputs.

When in ALT mode, alternate complete sweeps of the timebase is assigned to each input, thus the gun alternates between inputs. Due to the persistance of the screen both traces remain on the screen. Alt mode is suitable for not slow inputs (!). That is if ALT is used to display slow inputs, Time/div > 50ms/div then trace 1 will fade while only half way through trace 2 and vis versa.

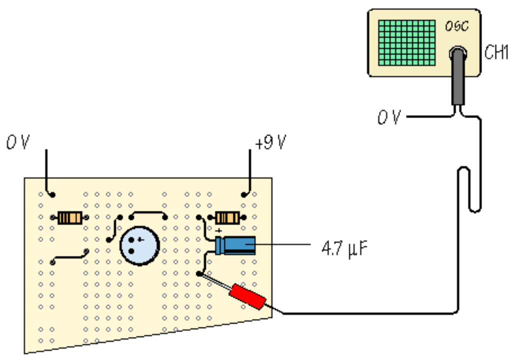
Chop mode on each sweep the timebase is divided into a lot of smaller slices ,on very other slices the electron gun diplays a particular trace. ie
trace 1 on slice 1,3,5,7…
trace 2 on slice 2,4,6,8…
Thus two traces appear on the screen. If the frequency of the inputy signal is comparable to the duration of the slices then the traces will appear to be 'bitty'.

Hence
Alt is suitable for medium to high freq signals
Chop is suitable for low frequency signals

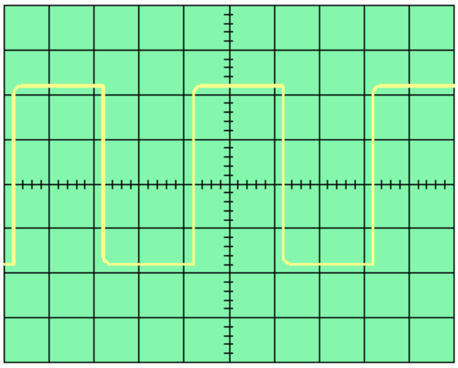
Applications.
To display a signal on the scope connect a lead to one of the inputs as shown



Then connect to the circuit as required, the Red lead to the test point, the back lead to zero volts.



Then adjust the timebase, CH1 Volts per division, Chi pos and trigger settings until something like this appears.



Normally you'd like to have at least two periods displayed.
Also Amplitude of signal should take up as much of the screen as possible. If two traces are being displayed then either assign top half of screen to CH1, bottom half to CH2, or arrange for both to be centered about the center graticule line.

Note the setting of the Volt/div, time/div and where zero volts is.

Lets say they are as follows,
Volts/div = 2
Time/div = 0.2 ms
Zero volts along graticule line.

Then the amplitude of the waveform is from
–1.8 div to +2.2 div
or
-3.6 V to +4.4 V

This waveform consists of a square wave with a d.c offset.
The offset = 0.5 x (V_{max} + V_{min})
Offset = 0.5 (4.4+ -3.6)
= 0.4 V
Amp of square wave
pk-pk amp = (Vmax – Vmin)
= 4V

Peak amplitude
Amp = 0.5 x (Vmax – Vmin)
= 2V

The period of the waveform is from
0.2 div to 4.2 div or 2.2 div to 6.2 or half of 0.2 div to 8.2 div
ie
40µs to 0.84 ms or 0.44ms to 1.24ms or 0.5 x (40µs to 1.64 ms)

Thus period is 0.8ms.
Frequency is related to period as

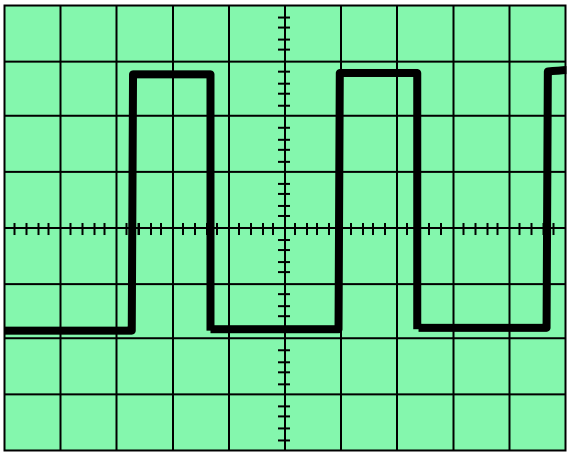
$$frequency = \frac{1}{period}$$

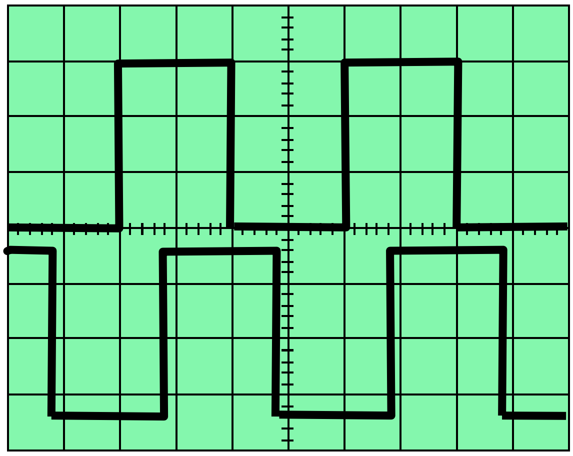
=> freq $=1/0.8 \times 10^{-3}$

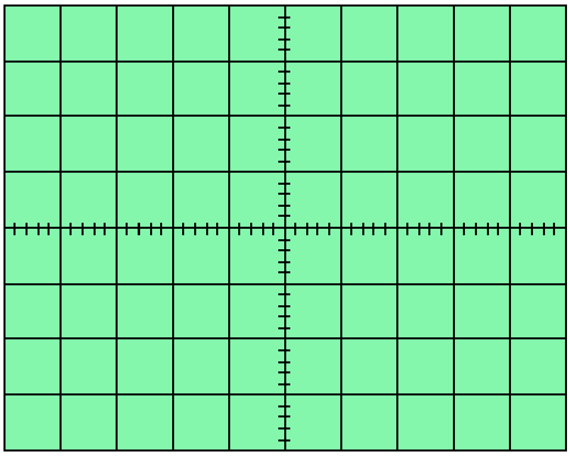
$=1250$ Hz

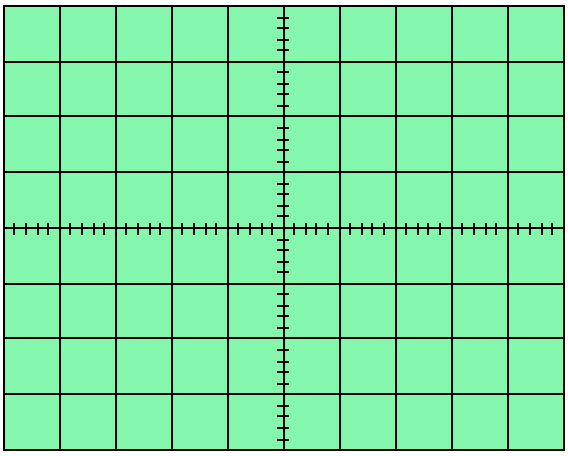
Hence the signal shown is a 0.4 V dc with a 1250Hz, 2V peak squarewave.

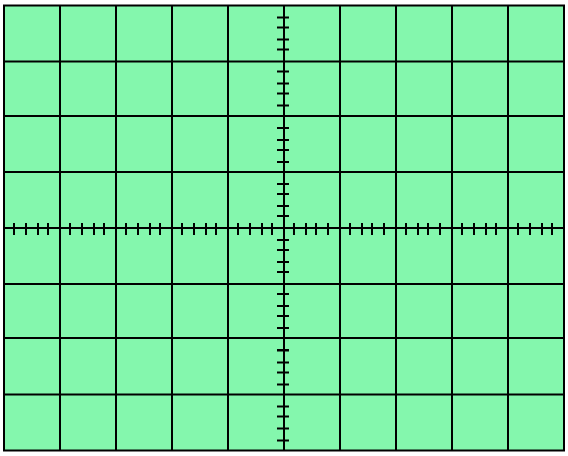
Other examples:

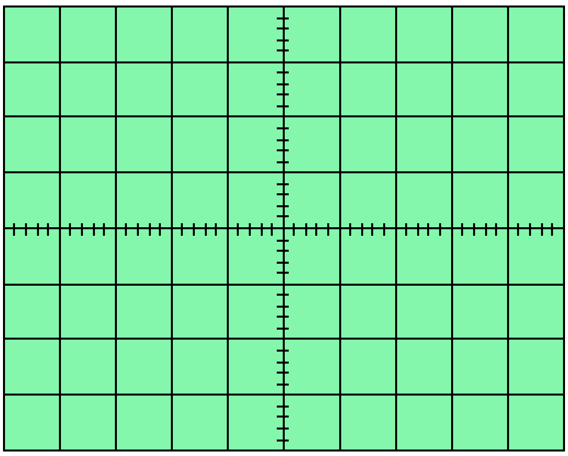


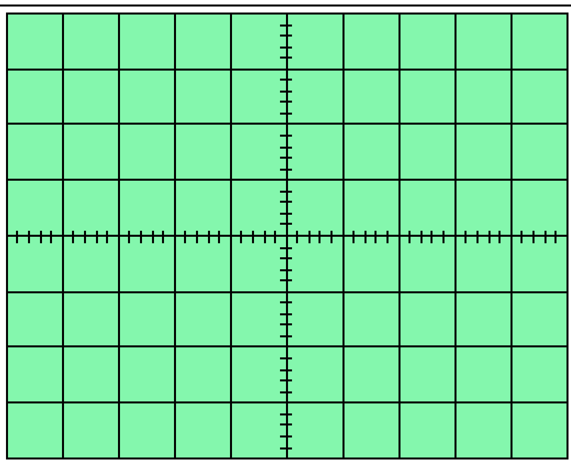












Usein probes to improve osciloscope performance.

The functions of an osciloscope probe are

- To transmit an accurate representation of the signal from the probe tip to the scope.
- To attenaute or amplify the signal before it reaches the scope.
- To prevent the scope from unduly loading the signal source, thus giving a false reading.
- To convert special signals, such as current, high voltage and Amplitude Modulated signals into a form which can be measured on the scope.

There are several types of probes such as passive probes, active probes, current probes, high voltage probes and demodulating/rectifing probes.

Passive probes, only attenaute, typically 10:1, 50:1, 100:1.

Active probes are used when th i/p impedance of the probe and scope system must be very high, or where very long cable are to be used.

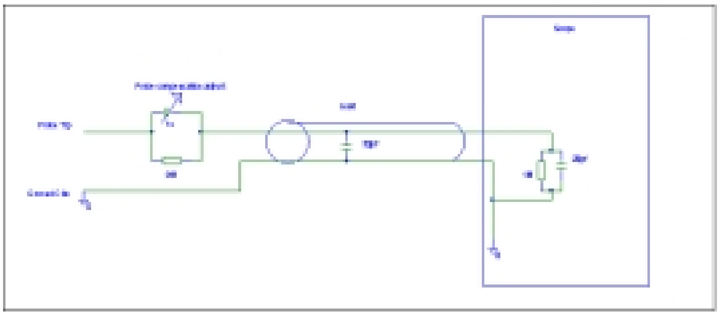
Current probes, for measuring current in circuit.

High voltage probes , for detecting voltages above 50kV.

Demodulating/rectifing probes enable the information to be extracted form AM signal from an ariel say.

An oscilloscope inpu can be viewed as having an input impedance of 1MΩ and in input capactance of 20pF. When th capactance of the lead is taken into account, about 30pF then when we connect a lead to a circuit we are effectively IMΩ//50pF in parallel with the component under test.

This input impedance may be too low and thus load the circuit, or even cause it to burst into oscillation. The scope is no longer acting as a 'low profile' instrument, but rather a bull in a china shop.
A solution is to use high impedance peobe. A popular choice is the standard divide by 10 probe.



To DC signals it simply acts as a potential divider and divides signal by 10.
By adjusting Ccomp to 1/9th of the parallel cap of C_{lead} and C_{in} the probe becomes a divide by ten at all frequencies. In practice you adjust the probe by connecting it to Cal or Prob adj pont on the scope. On the probe is a small adjustable point that you rotate until the screen displays a clean square wave.

A multiplier probe is an active probe that can be used to amplify very small signals at the tip of the probe, before transmitting them down the lead to the scope input.

Rectifing probe.
AM de-mod

Instrument Terms.

Resolution.

The resolution of a measuring instrument refers to the smallest change in the measured quanity that can be detected and accuretly read instrument

On an analog instrument, resolution is determined by the number of divisions on the scale and the range of the instrument.

Here on the second scale the minor divisions are 1/8 th of a large division. The meter range can be set to 6V, 30V, 120V, 240V and so the resolutions are:

0.125 V	on 6V range
0.625 V	on 30V scale
2.5 V	on 120V scale
5V	on 240V scale

The minor divisions are the smallest reliable quanties that can be measured by the instrument, the meter reading should be taken as the nearest minor divisions. Thus on the 240 V range a reading of 122.456V shows the user is a poor reader , they should have read 120V

Accuracy

This is how close to the true value of the measured variable the meter reads. Error is the lack of accuracy.

Error = 100% - accuracy

=> Accuracy = 100% - Error

Accuracy is usally rated as some percentage of the Full-scale deflection of the meter. If the meter has has an accuracy of ±2% then the true value of the measured variable is the meter reading ±2% of range

ie error on a range of 6V is

Error = ±0.02 x 6V

= ±0.12 V

Thus if the meter displays

5V the true voltage is somewhere between 4.88V and 5.12V

1V the true voltage is somewhere between 0.88V and 1.12V

When using several readings to calculate a result, then the %error of the final result is the sum of the %errors of the initial values.
Eg Calculate resistance

$V = 12. \pm 3\%$

$I = 3 \pm 4\%$

$\Rightarrow R = 12\ \Omega \pm 7\%$

How to write down the reading.
If on the 6V scale and the needle is over the 3V division, should the reading be recorded as 3V ,3.0V, 3.00V, 3.000V?

ANS: The reading should be recorded with the appropiate number of significant digits (3.0 has two significant digits.).

5V states that the voltage was obtained in such a manner that it is closer to 5 than it was to either 4 or 6.
5.0V states the voltage was closer to 5V than to 4.9 or 5.1V.
5.00V states the voltage was closer to 5V than to 4.99 or 5.01V.

Therefore for our meter we should write the reading as 3.0V. It would be incorrect to record the reading as 3V.

Likewise when calculating results from readings, the number of significant digits in result should equal the lower number of significant digits in initial readings.
Eg calculate resistance given that

$V = 4.484V$

$I = 1.0\ A$

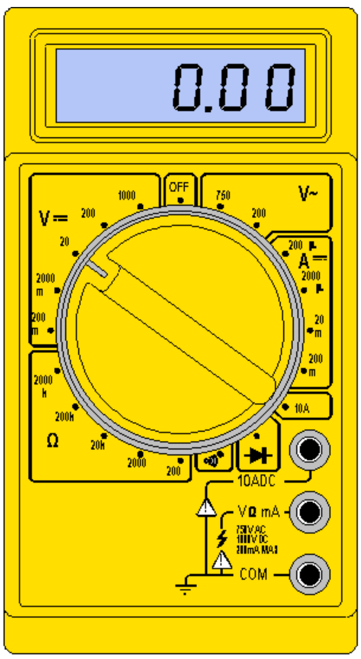
$\Rightarrow R = 4.5\ \Omega$ **,**

not:

$R = 4\ \Omega$

$R = 4.484\ \Omega$

Using Digital multimeters.



When using a DMM it is important to realise the significance of resolution. Generally DMM have what are known as 3 ½ digits displays. That is they can display numbers in the range $\pm$1999, where the decimal point can be moved. Usually giving ranges of 20mV, 2V, 20V, 200V etc

These meters can display to 4 significant numbers so the resolutions are

Range	Resolution
200 V	0.1 V
20 V	0.01V
2 V	0.001 V
200 mV	0.0001V

DMM generally have accuracys of 0.5%
Analog meters have accuracy of about 2%

Error resulting from using instruments.
A meter affects the circuit to which it is connected and alters the quanity it has to measure.

An Ammeter causes least disturbance when it has very low internal impedance.

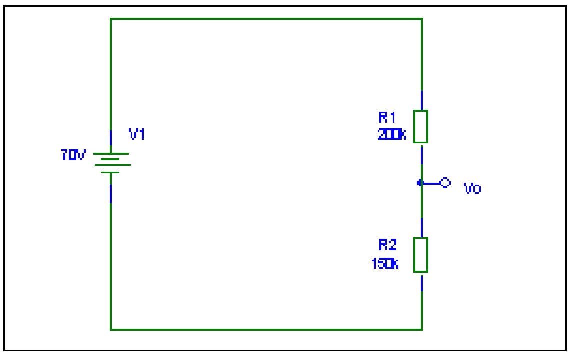
A voltmeter causes least disturbance when its resistance is very large and only a small current is needed to produce a full-scale deflection. For a good quality analog meter on a dc range 50µA is typical and in this case the sensitivity of the voltmeter is said to be 20,000ΩV^{-1} , ie 1V gives a current of 1V/20000Ω = 1/20000 A = 50µA.

An ac meter with a sensitivity of 500ΩV^{-1} would require a current of 1/500 A = 2mA for a full scale deflection.

The actual resistance of the meter depends on the range choosen as well as the sensitivity. For example if the sensitivity is 20kΩV^{-1}, then it's input resistance on the
1V range is 20k x 1 = 20kΩ,
10V range is 20k x 10 = 200kΩ.

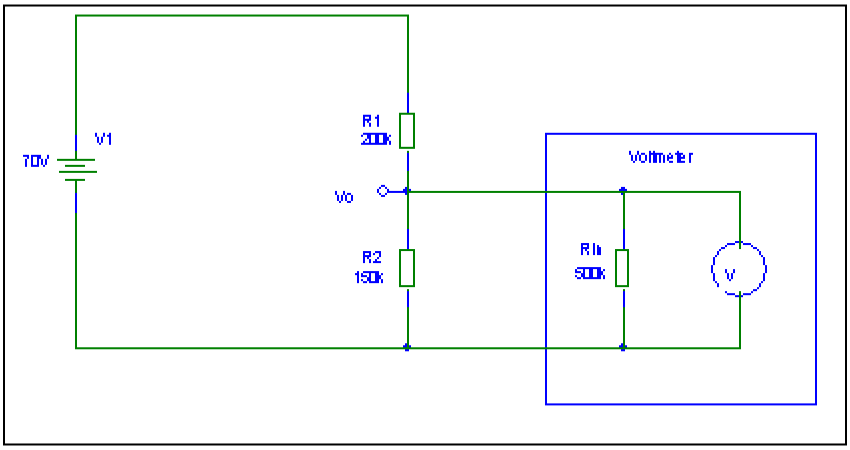
The increase in input resistance is due to the extra resistors in the meter being connected by the range switch. For a particular sensitivity, the higher the range the greater is the input resistance of the meter and the less it loads the circuit being tested.

Digital voltmeters generally have input resistances of about 10 MΩ, which unlike analog meters does not change with different ranges.



Suppose we want to measure the voltage Vo. We know that
Vo = V1 R2/(R1 + R2)
= 30V

If we use a voltmeter with input sevsivity of $10k\Omega V^{-1}$ on a 50V range then the input resistance of the meter is
Rin = $10 \times 10^3 * 50$
= 500 kΩ



Now the voltgae that will be seen by the meter is
Vo = V1 150//500/(150//500 + 200)
= 25.6 V

If the meter has an accuracy of ±2% then the value displayed will be
Vdisp = 25.6 ±0.02 x 50
= 25.6 ±1 V
ie somewhere between 24.6 and 26.6 V

If the meter has a resolution on the 50V scale of 0.5 V then the possible display voltages will be
24.5, 25.0, 25.5, 26.0 or 26.5 V

If instead a DMM was used with internal impedance of 10 MΩ then the measured voltage will be

Vo = V1 10M//150k/(10M//150K + 200k)

= 29.75V
Which is closer to the true value.

Accuracy 0.5%
On the 200V range
Vdisp = 29.75 ± 0.5 x 200
= 29.75 ± 1V

Resolution 200V range is 0.1 V
Vdisp = 29.8 ± 1V

Sources of error in using instruments:

- Instrument loads circuit (changes value)
- Accuracy of meter (sum of %errors)
- Resolution of meter. (lowest resolution)

Logic Probe and Logic Pulsers.

Digital ICs often fail and trouble shooting with an oscilloscope requires extra work. Because pulse activity is generally present on functioning digital ICs, logic probes and pulsers can be used to easily determine if an IC is working.

Logic probes and pulsers are designed to analysis and troubleshoot static and dynamic conditions of logic circuitry. Used together , they make it possible to test sequential circuits such as flip-flops, counters and micro-processors.

A digital logic probe provides a visual dsplay of logic states such as 'high-level', pulsing or open circuit (bad).

A Logic pulser can be used to inject a known sequence into the circuit, to which the correct response is known.