Digital multimeter

Measurement of any quantity is a result of comparison between the quantity to be measured and a definite world wide standard. The instruments which are used for such comparison are called **measuring instruments**. In electronics measurement three basic quantities current, voltage and power are important to measure. The measurement of these quantities can be used to obtain measurement of some other quantities and also can be used to analyze performance of different electronic circuits, devices and components. The measuring instruments which are used to measure current flowing in a circuit are called **ammeter** while the instruments are used to measure voltage across two points are called **voltmeter.** The instruments which are used to measure power are called **power meters** or **wattmeters**. Measuring instruments can be classified as analog instruments and digital instruments.

Digital voltmeters:

Digital voltmeters are generally called DVM, measures voltage across two points in a circuit and display the voltage in the form of discrete numerical instead of pointer deflection on the digital display. Such voltmeter can be used to measure a.c. as well as d.c. voltage.

Working of any digital voltmeter can be understood by block diagram as shown in figure-1.

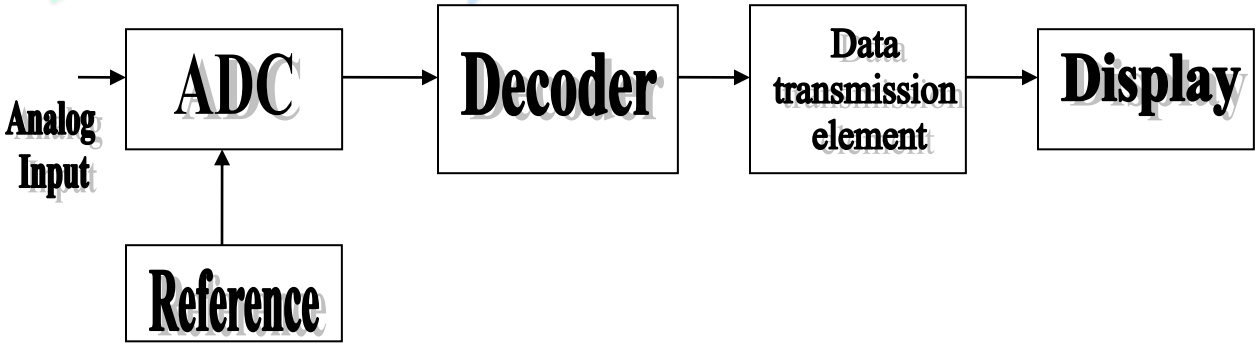


Figure-1 Basic block diagram of DVM

The most important part, we can say heart, of DVM is analog to digital converter (ADC), which converts any analog signal into digital. ADC gives analog input voltage in the form of binary digital values as its output. Binary digital values can be represented as BCD code, decimal code, binary code etc., to convert binary digital code of analog input into any other code decoder is used in DVM. To transmit digitally coded analog input to display device some data transmission

element is required. The data transmission element may be latches, counters, etc. as per the requirement. Every ADC requires a reference. The reference is generated internally and reference generator circuitry depends on the type of ADC technique used. In this discussion we are going to consider only ramp type digital voltmeter.

Ramp-type Digital Voltmeter:

This DVM is known as ramp type DVM, because to convert analog input into digital form ramp signal is used as a reference signal. Analog to digital converter (ADC) circuit (in figure-2) used in this DVM is called ramp type ADC.

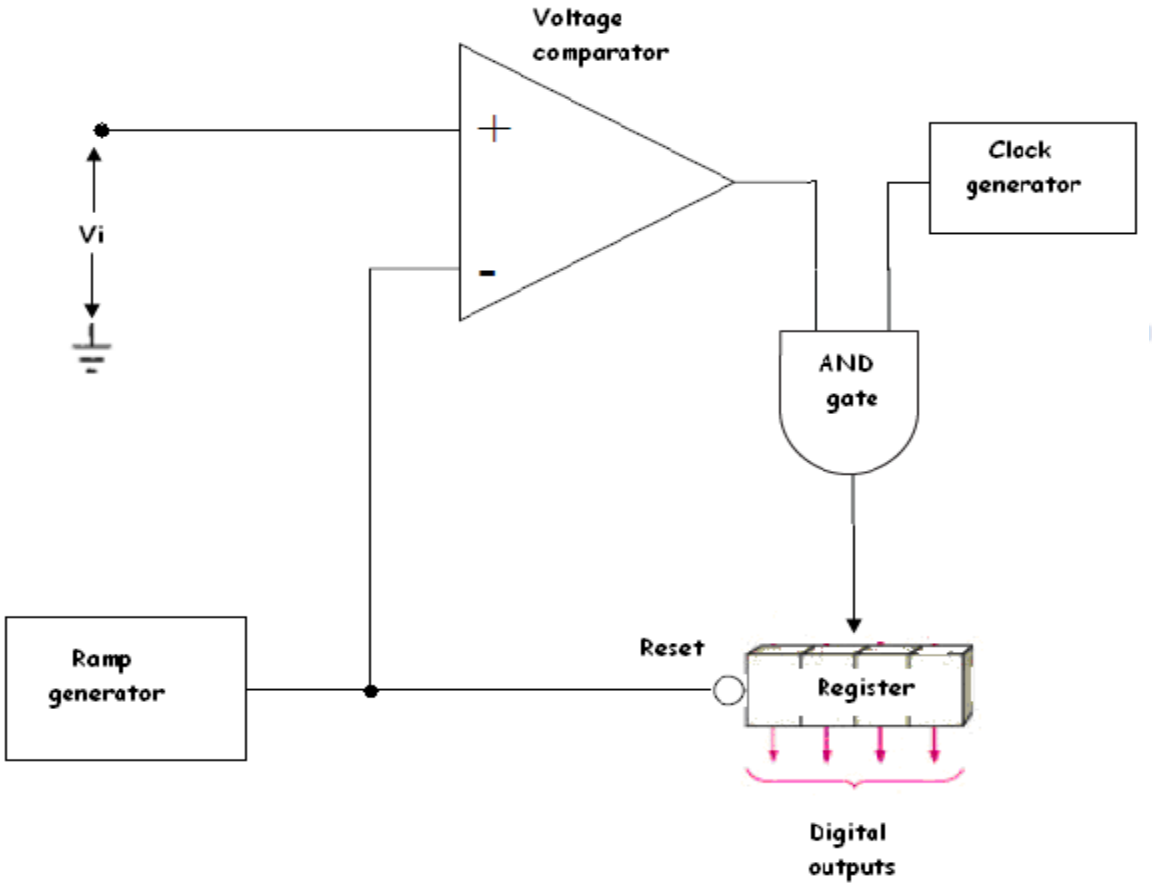


Figure-2 Ramp type analog to digital converter

The ramp voltage starts from ground level and increases at a constant rate, as shown in figure-3. The ramp is fed to one input of a voltage comparator, and the analog input voltage (V_i) is applied to the other comparator input terminal. During the time that the ramp voltage (V_r) is below the level of Vi, the comparator output is high; and this allows pulses from the clock generator to pass

through the AND gate to the counting circuits (register). When V_r becomes exactly equal to V_i, the comparator output switches to a low level, thus stopping further clock pulses from toggling the counting circuits. The time period (t_1) of the comparator high output is directly proportional to input voltage V_i. Thus, because the counting circuits are toggled only during t_1, the count is the digital equivalent of the analog input.

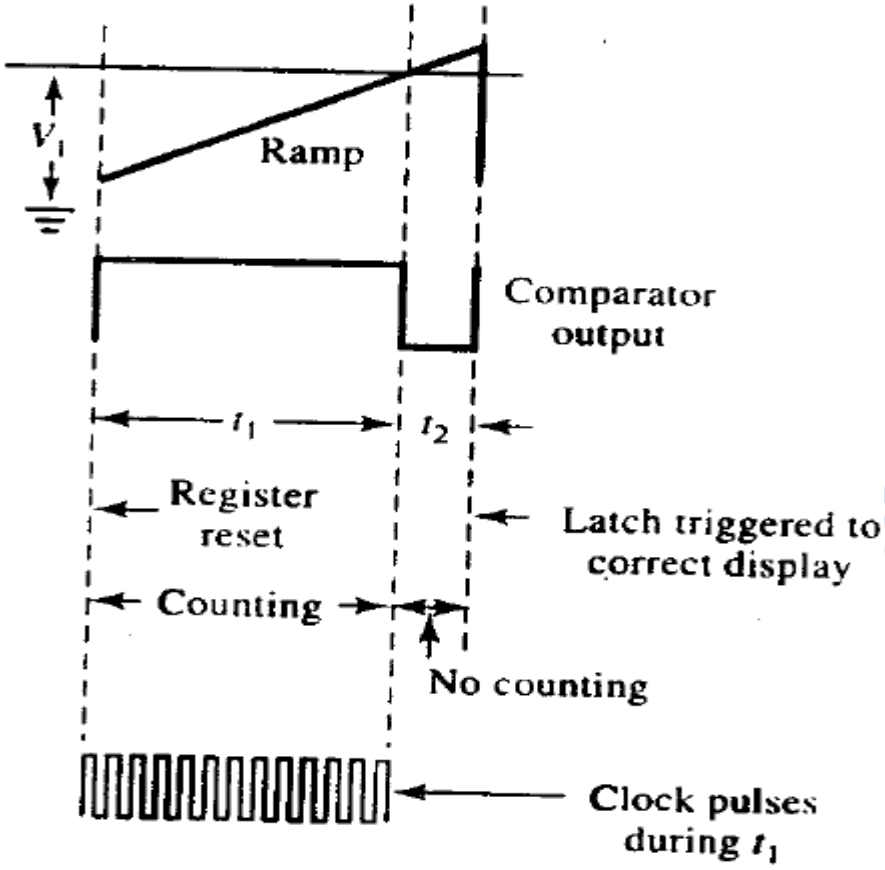


Figure-3

The negative-going voltage step at the end of the resets the register to its zero condition before the cycle of ramp generation and counting recommences. If the counting circuits are simple the digital output will be in binary form. If a cascade of decode counters is employed the output is in binary-coded decimal (BCD).

If a pulse waveform is used to toggle a digital counter for a time period of exactly 1 second, the counter registers the number of pulses that occur per second; that is, it registers the frequency of the input waveform. If the count is 1000, the frequency is 1000 pulses per second. A digital

frequency meter is a digital counter combined with an accurate timing system. Conversely, an accurate frequency source combined with a digital counter can be used for the time measurements. If a 1MHz frequency (time period of 1μs) is used to toggle the counting circuits for the time to be measured, the counter registers the time directly in microseconds.

The ramp type digital voltmeter (DVM) essentially consists of a ramp-type analog-to-digital converter, a set of seven-segment numerical displays and the necessary BCD-to-segment drivers. Figure-4 represents ramp-type digital voltmeter using ramp type analog to digital converter. In this block diagram we can see a latch is included with ramp type analog to digital converter, counting circuitry, BCD-to seven segment decoder/drivers and digital read out. If latch were not present, the digital readouts would be reset to zero at the commencement of the counting time (t_1), change rapidly as the count progresses throughout t_1, and remain constant for time t_2. Thus, the display would be virtually unreadable. The latch circuit isolate the display from the counting circuits during the time that counting is in progress. The positive-going edge of the comparator output waveform at the end of the time t_1 briefly triggers the latch to connect the decoders/drivers to the counting circuits when counting is ceased. This corrects (or updates) the display, if necessary, and otherwise allows it to remain constant and readable.

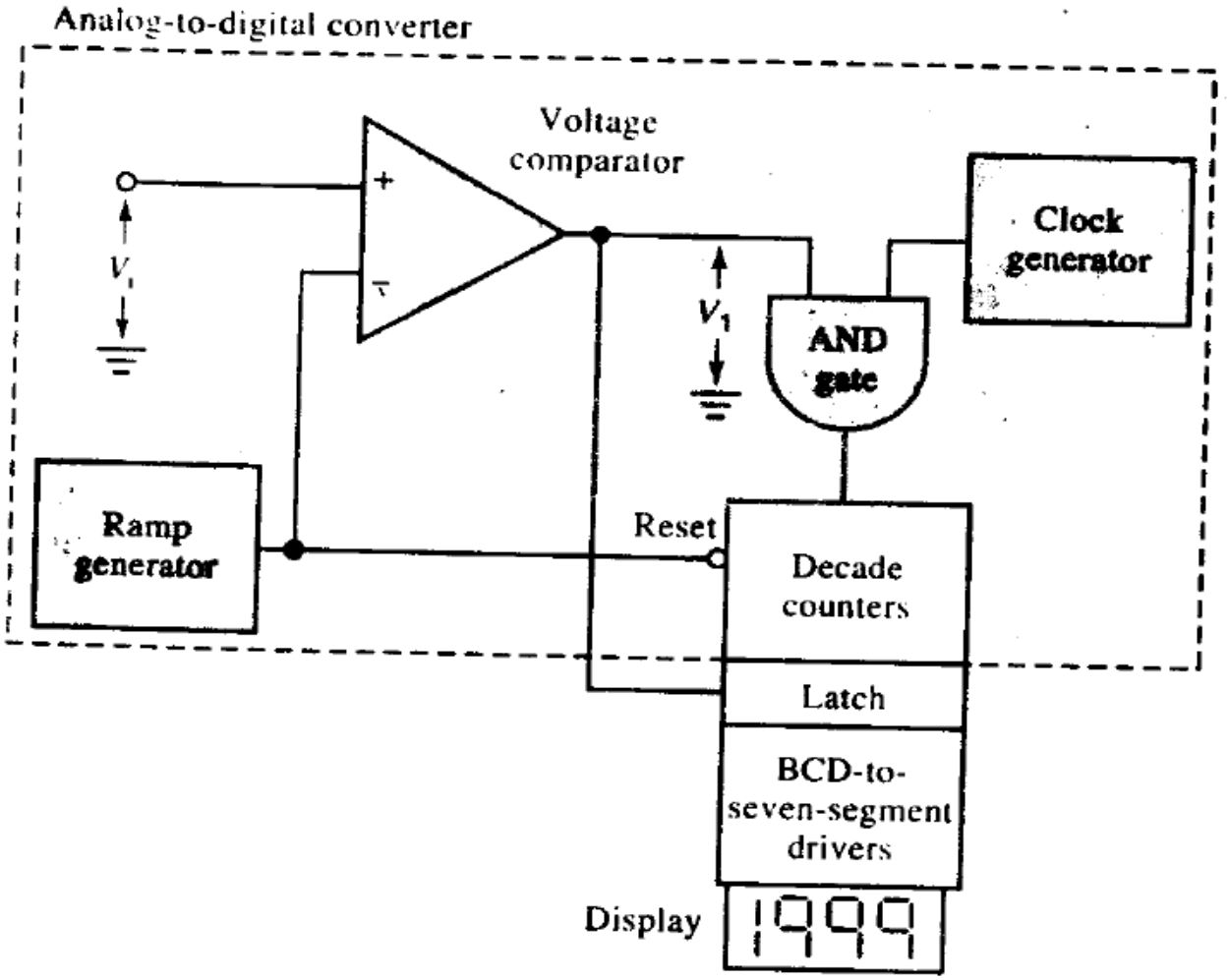


Figure-4 Digital voltmeter system

A display/enable control, which open-circuits the supply voltage to the display devices, is sometimes used instead of a latch. The display is simply switched off during the counting time, and on when counting ceases. When the display time and counting time are brief enough, the on/off frequency of the display is so high that the eye sees only a constant display.

Advantages of digital voltmeter:

The DVMs have number of advantages over conventional analog voltmeters, which are,

1. Due to the digital display, the human reading errors, interpolation errors and parallax errors are reduced.
2. They have input range from +1.000V to +1000V with the automatic range selection and the overload indication.

3. The accuracy is high up to ± 0.005% of the reading.
4. The resolution is better as 1μV reading can be measured on 1V range.
5. The input impedance is as high as 10MΩ.
6. The reading speed is very high due to digital display.
7. They can be programmed and well suited for computerized control.
8. The output in digital form can be directly recorded and it is suitable for further processing also.
9. With the development of IC chips, the cost of DVMs, size and power requirements of DVMs are drastically reduced.
10. Due to small size, are portable.
11. The BCD output can be saved and printed or used for digital processing.

Digital multimeters:

The digital multimeter is an instrument which is capable of measuring a.c. voltages, d.c. voltages, a.c. and d.c. currents and resistances over several ranges. The basic circuit of a digital multimeter is always a d.c. voltmeter as shown in figure-5. The parameter which is to be measured has to be converted into voltage form firstly. Then if parameter in the form of voltage is analog will be converted into digital form by ADC. Digital data can now be displayed in the form of BCD, decimal or digital form. Digital multimeter can also be interfaced to other suitable device through interface terminal.

To measure voltage, firstly rotate knob to a.c. or d.c. voltage terminal whatever be the required. Then voltage will be converted into digital form, and then will be displayed.

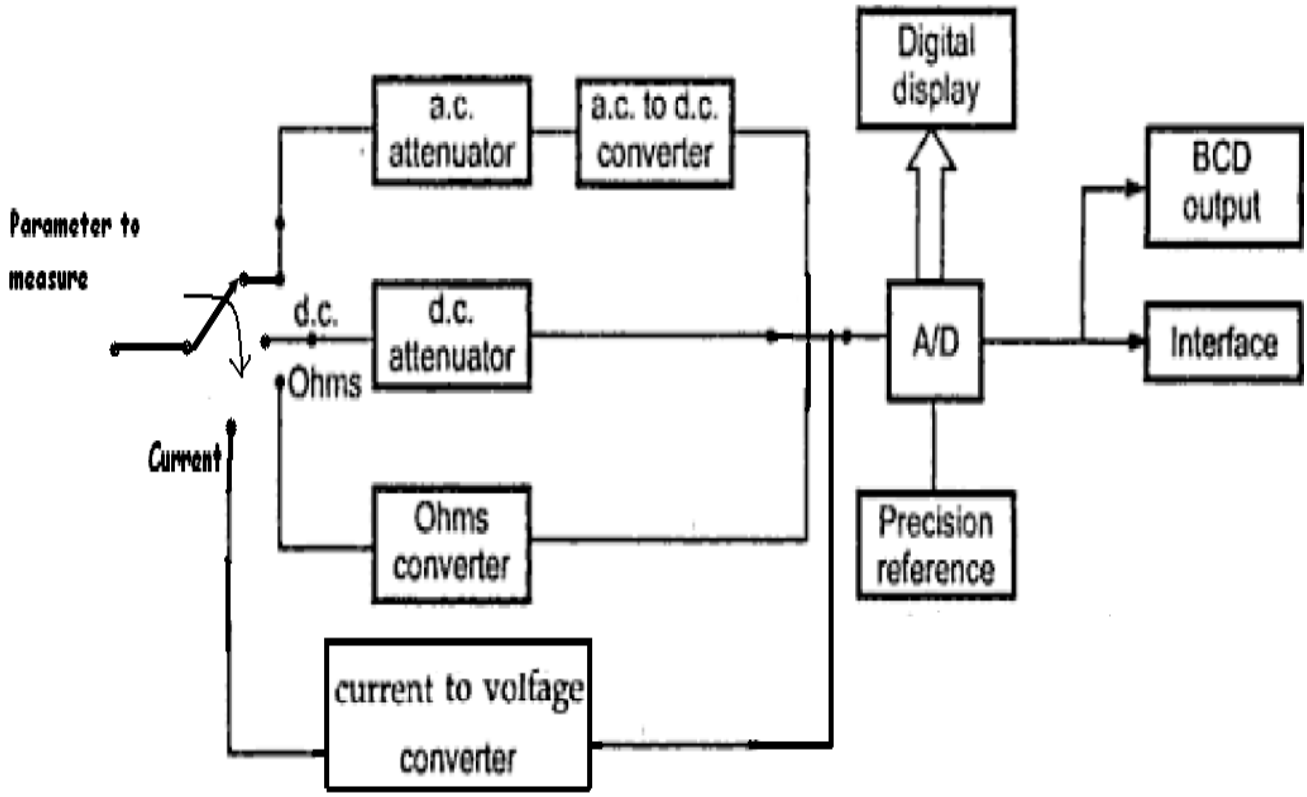


Figure-5 Block diagram of digital multimeter

For current, firstly rotate knob to current terminal then current will be converted into voltage form by using current to voltage converter. Then voltage will be converted into digital form and will be displayed.

To measure resistance, rotate knob to resistance terminal and measure resistance. In this process resistance will be converted into voltage then it will be converted into digital form and will be displayed accordingly.

From above discussion we can see that digital multimeter can be used to measure multiple type parameters and can displayed data digitally. Therefore we call it digital multimeter. So, digital multimeter can also be displayed by following figure-6. This figure is just combination of figure-4 and figure-5. Left part of figure-6 shows conversion of multiple parameters into voltage form (from figure-5) and right part shows digital voltmeter (from figure-4) which displays parameters digitally.

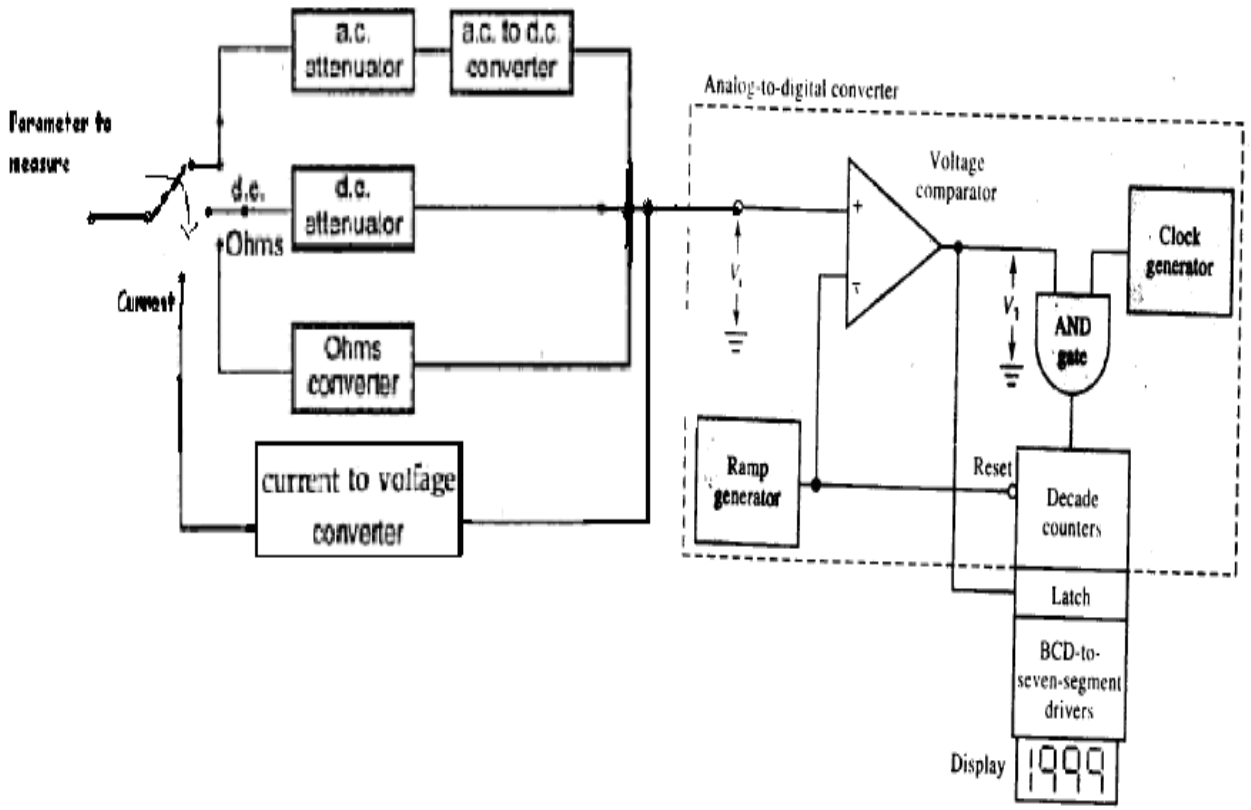
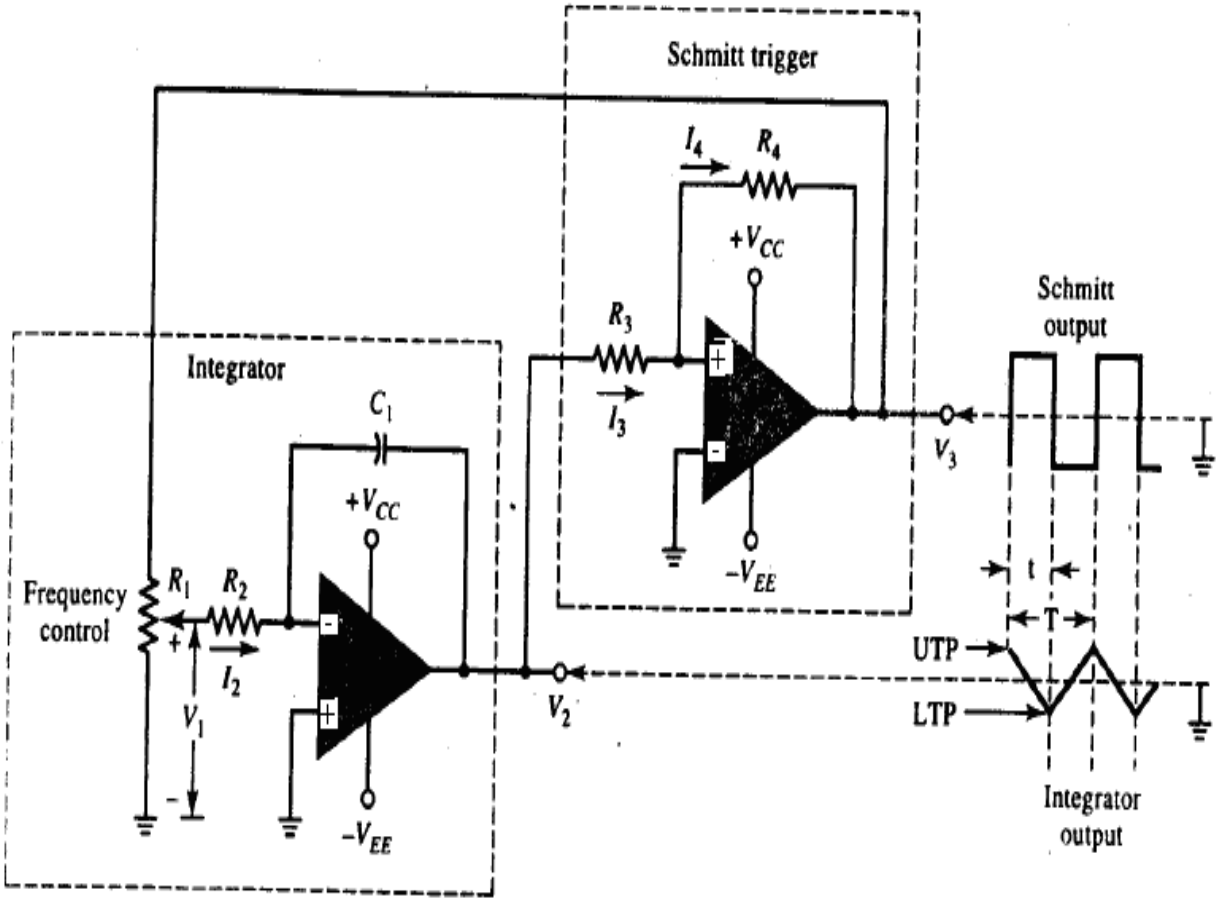


Figure-6 Digital Multimeter


Schmitt trigger
Integrator
Frequency control
R_1
R_2
C_1
$+V_{CC}$
$-V_{EE}$
I_2
V_1
I_3
R_3
I_4
R_4
V_2
V_3
Schmitt output
t
T
UTP
LTP
Integrator output