Electrical and Electronic Measurements

Lecture 6: Digital Voltmeters

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Lecture Outline:

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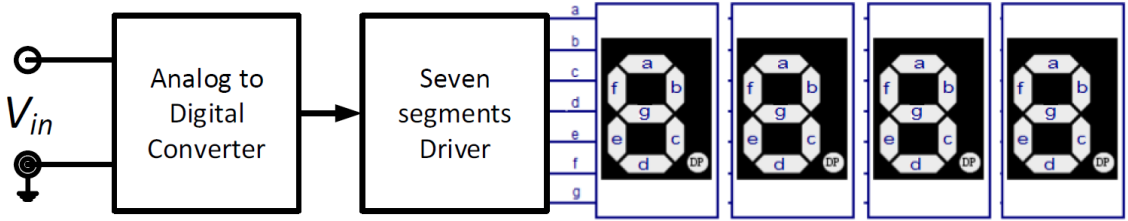
Introduction:

- Two types will be covered: **Ramp-type** and **Dual slope Integrator** DVMs.
- Digital voltmeters (DVM) are essentially **analog-to-digital converters** with **digital displays** to indicate the measured voltage.



Digital Voltmeter Basic Block Diagram

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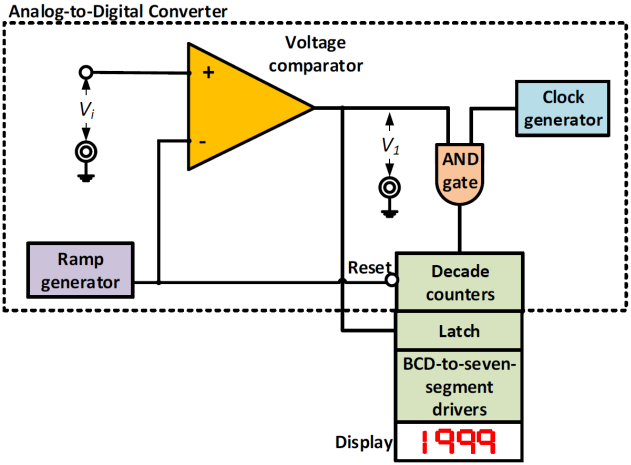
Ramp Type Digital Voltmeters:

- A ramp signal is generated.
- the comparator compares the input V_i with the ramp V_r.

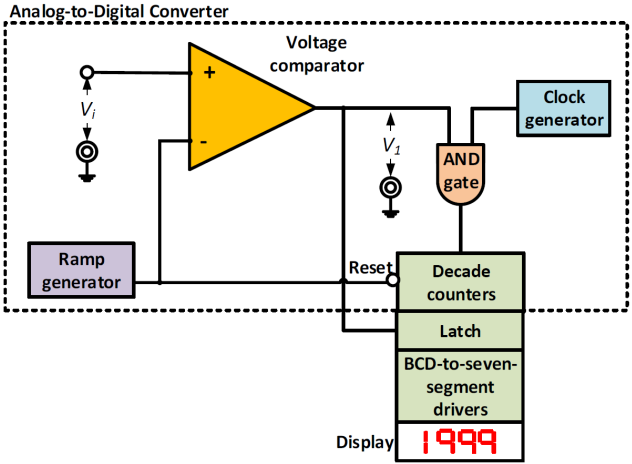
$$V_1 = \left\{ \begin{array}{ll} 1, & \text{if } V_i \geq V_r \\ 0, & \text{if } V_i < V_r \end{array} \right\}$$

- If the comparator output V_1 is high, the counting circuit will count the pulses from clock generator.
- If the output V_1 is low, the counting will stop.
- $\boxed{N_{pulses} \propto V_i}$.
- The value of V_i will be displayed

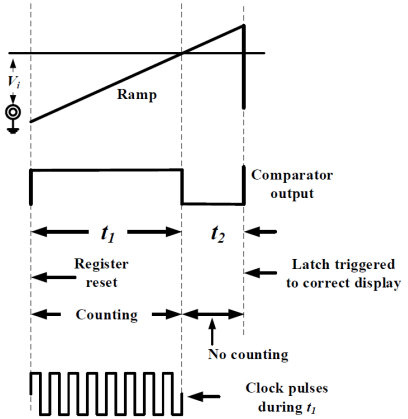


Ramp type DVM block

Ramp Type Digital Voltmeters:



Ramp type DVM block

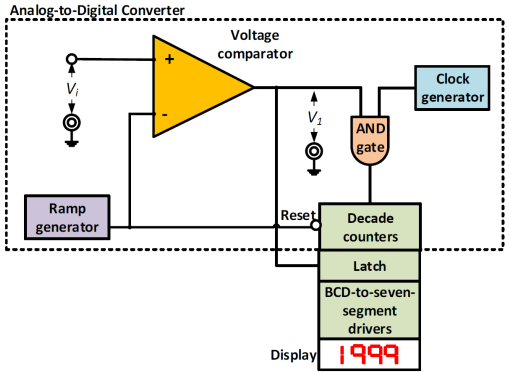


DVM waveform

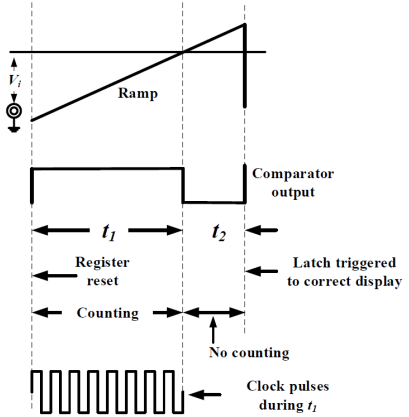
Ramp Type Digital Voltmeters:

The use of the Latch:

- The latch isolates the display from the counting circuit during the t_1.
- It will connect the display to the counting circuit at the rising edge of the comparator output.



Ramp type DVM block



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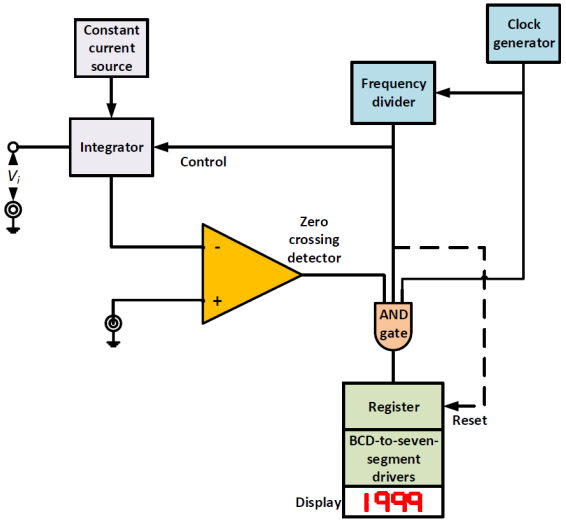
Dual Slope Digital Voltmeters:

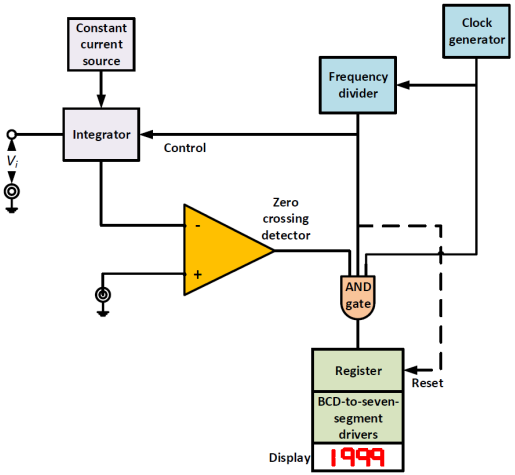


Dual Slope DVM block

Limitations of Ramp type DVM

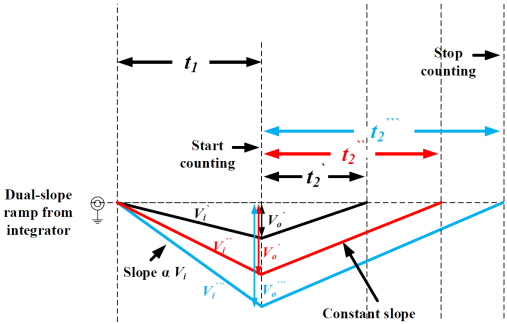
- The ramp type DVM **requires precise ramp voltage and precise time periods**. (Not accurate)
- The Dual-slope-integrator DVM eliminates this requirement.

Dual Slope Digital Voltmeters:

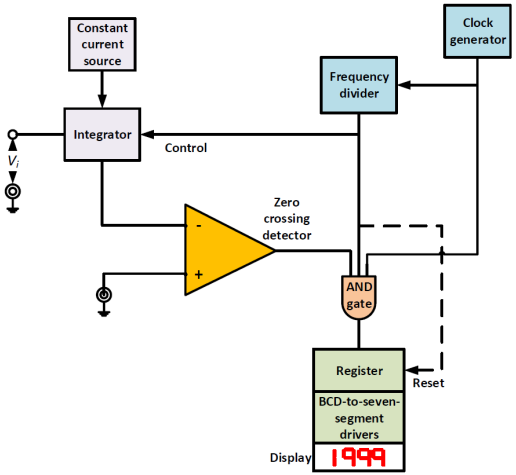


Dual Slope DVM block

- An integrator (e.g. capacitor) is either charged negatively from V_i or discharged at a constant rate according to the control signal.



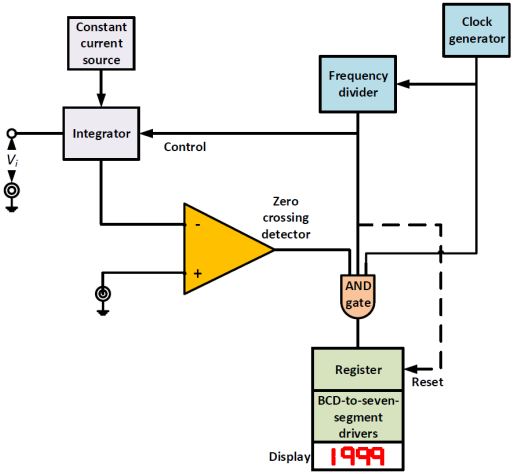
Dual Slope Digital Voltmeters:



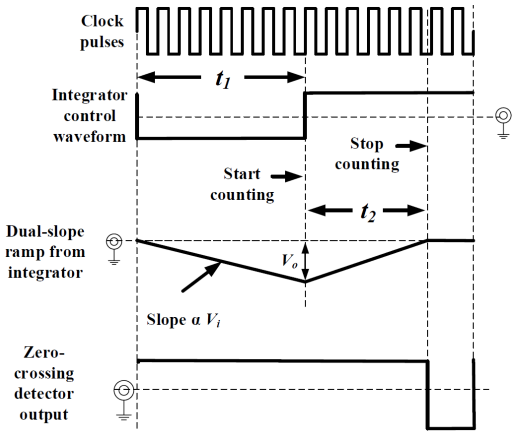
Dual Slope DVM block

- The control signal is derived from the **clock generator and a frequency divider**.
- During the charging time t_1, the integrator is charged to V_o that depends on V_i .
- During the discharging, the integrator is discharged in constant rate in duration t_2 that **depends on V_o and hence on V_i** .
- A voltage comparator is used as zero-crossing-detector to output high if integrator voltage is lower than zero.

Dual Slope Digital Voltmeters:



Dual Slope DVM block



DVM waveform

Dual Slope Digital Voltmeters:

How the Dual slope integrator DVM eliminates the need for accurate timing ?

(1) During charging:

$$V_o = -V_i t_1$$

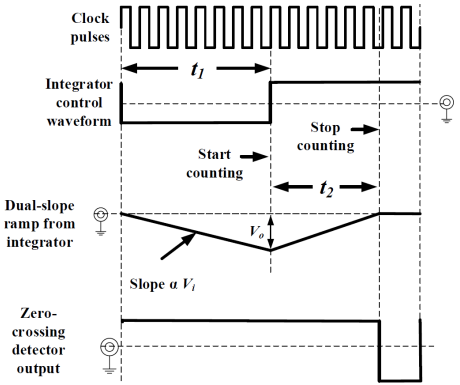
(2) During discharging:

$$V_o = K t_2 \quad K \text{ is constant}$$

So,

$$\boxed{V_i = -K \frac{t_2}{t_1}}$$

Thus the input voltage measurement is not dependent on the clock frequency, but depends on the ratio $\frac{t_1}{t_2}$.



DVM waveform

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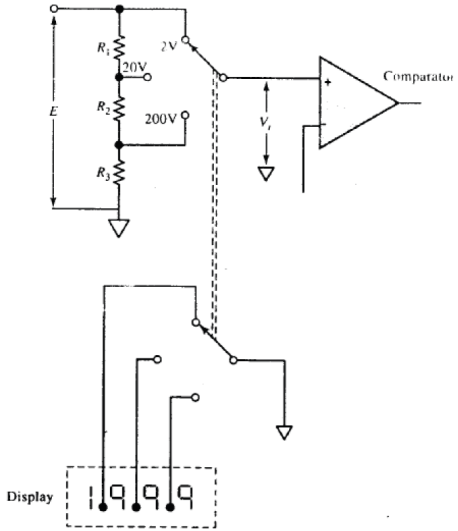
DVM Range Changing:

The attenuation circuit is used to select the range of input voltage:

- if $V_{in} \leq 1.999\ V$, the input is applied directly on the comparator.
- if $1.999\ V < V_{in} \leq 19.99\ V$, the input is attenuated and the decimal point is changed.
- and so on for $19.99\ V < V_{in} \leq 199.9\ V$



DVM Range Changing

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Digital Voltmeter Accuracy:

Accuracy in DVMs:

Digital voltmeter accuracy is usually stated as:

$$\pm(0.5\%\ rdg + 1 digit)$$

where 1 digit refers to the extreme right (least significant digit) that depends on the range.

Example

If the accuracy is $\pm(0.5\%\ rdg + 1\ digit)$
What is the maximum error of reading $1.800\ V$ on:
(1) the $2\ V$ scale.
(2) the $20\ V$ scale.

Solution:
(1) error $=$
$\pm[0.5\% \times 1.8V + 0.001] = \pm 0.01V$
(2) error $=$
$\pm[0.5\% \times 1.8V + 0.01] = \pm 0.019V$

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Types of Digital Multi-meters:

Hand-held Multimeter

Bench-type Multimeter

Types of Digital Multi-meters:

Clamp Meters:

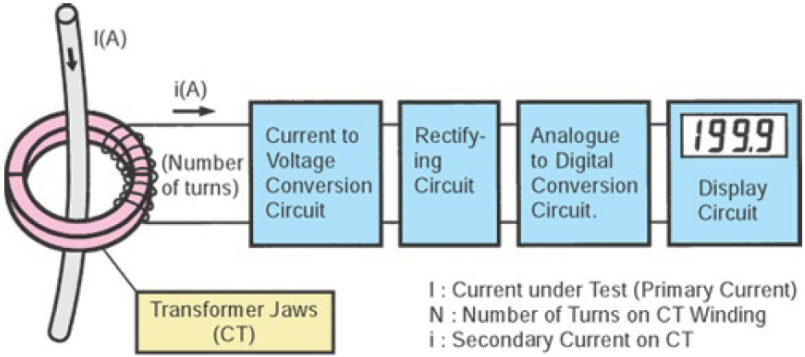
Advantage:

It is an electrical device having two jaws which open to allow **clamping around an electrical conductor**. This allows to measure electric current through conductor, without having to make physical contact with it, or **to disconnect it for insertion** through the probe.

Types of Digital Multi-meters:

How Do Clamp Meters Operate ?:

- A current transformer(CT) used to pick up magnetic flux generated as a result of current passing through a conductor.
- A secondary winding generates a current by electromagnetic induction that is proportional to the primary current.



End of Lecture

Best Wishes

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