Electronic Instrumentations and Measurements, Part 2

Lecture 1: Digital Voltmeters

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October 2016

Part 2 Contents:

- Digital Voltmeters.
- Digital Frequency meters.
- Sensor and Transducers:
  - Displacement, position and proximity sensors.
  - Velocity and motion sensors.
  - Force sensors.
  - Fluid pressure, liquid flow and liquid level sensors.
  - Temperature sensors.
  - Light sensors.

Part 2 Examination

Exam on Part 2 will be on: **Monday, 28/11/2016** Tuesday 21/11/2017

Lecture Outline:

1. Introduction to Digital Voltmeters.
2. Ramp Type Digital Voltmeters.
3. Dual Slope Digital Voltmeters.
4. Range Changing.
5. Digital Voltmeter Accuracy.
6. Types of Digital Multi-meters.

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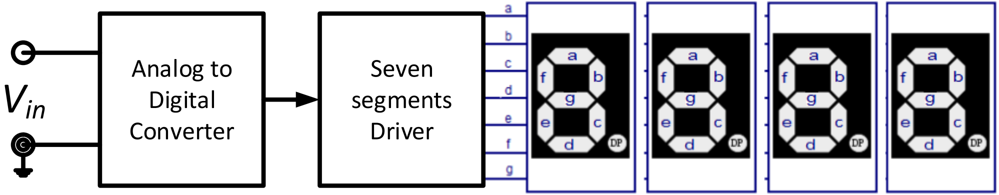
Introduction to Digital Voltmeters:

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



Digital Voltmeter Basic Block Diagram

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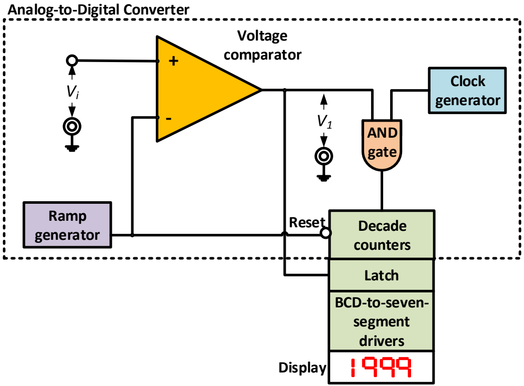
Ramp Type Digital Voltmeters:



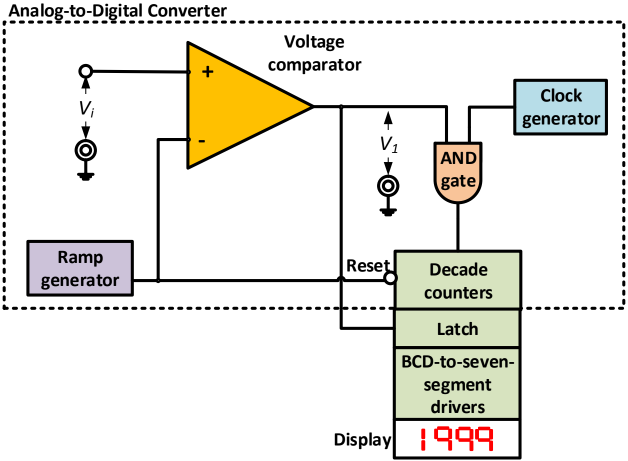
Ramp type DVM block

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

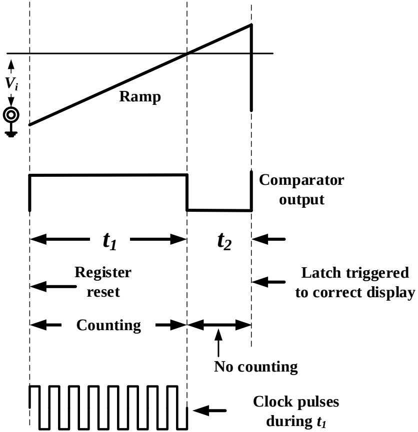
$$V_1 = \begin{cases} 1, & \text{if } V_i \geq V_r \\ 0, & \text{if } V_i < V_r \end{cases}$$

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

Ramp Type Digital Voltmeters:



Ramp type DVM block

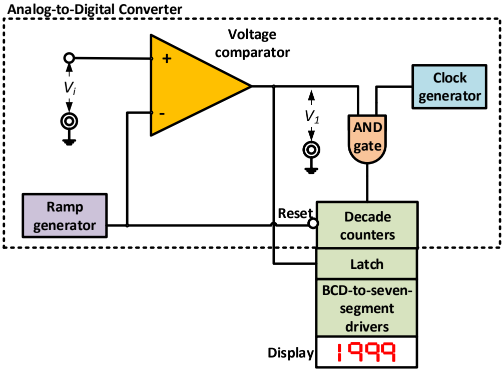


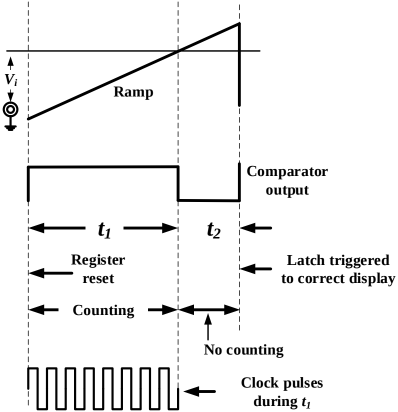
DVM waveform

Ramp Type Digital Voltmeters:

The use of the Latch:

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





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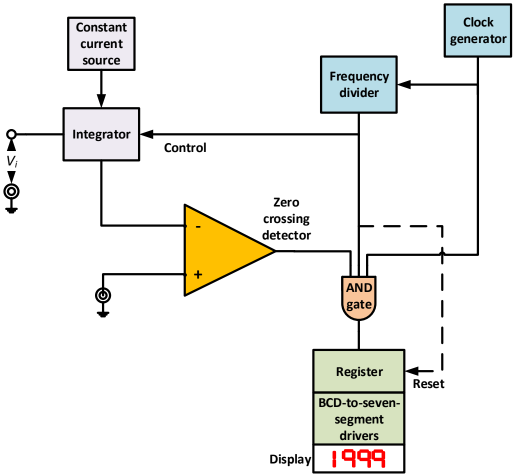
Dual Slope Digital Voltmeters:

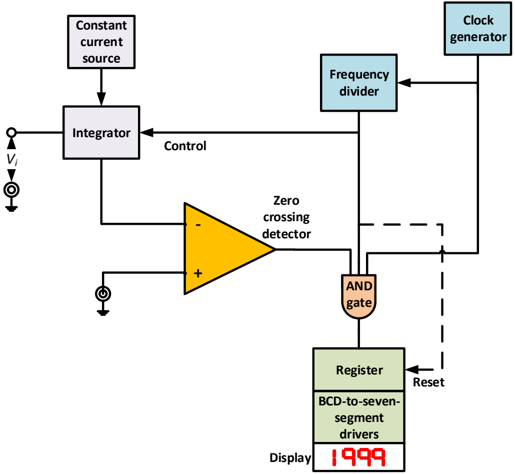


Dual Slope DVM block

Limitations of Ramp type DVM

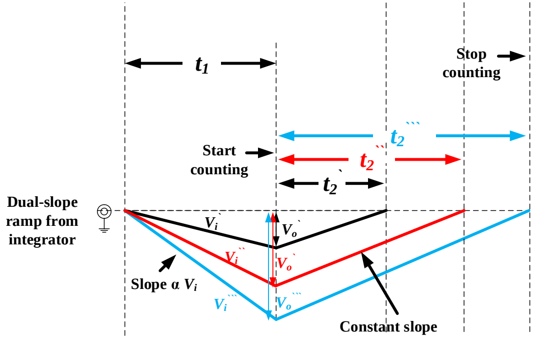
- The ramp type DVM requires precise ramp voltage and precise time periods. (Not accurate)
- The *Dual-slope-integrator DVM* eliminates this requirement.

Dual Slope Digital Voltmeters:

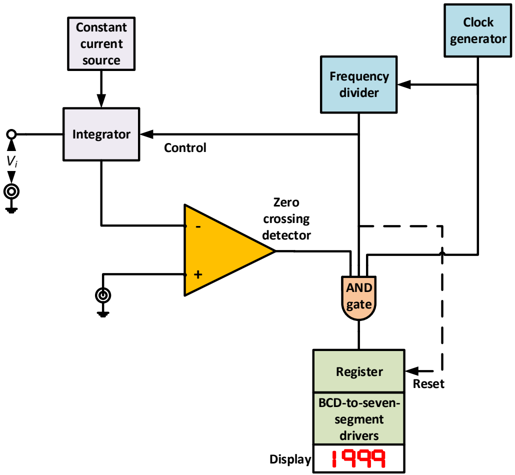


Dual Slope DVM block

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



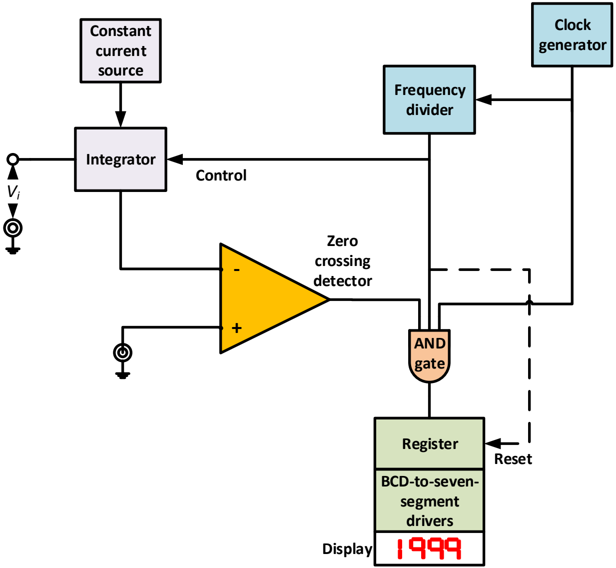
Dual Slope Digital Voltmeters:

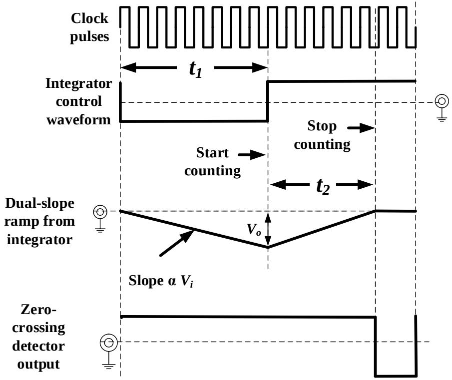


Dual Slope DVM block

- The **control** signal is derived from the clock generator and a frequency divider.
- During the charging, the integrator is charged to V_o that is depend on V_i.
- During the discharging, the integrator is discharged in constant rate in duration t_2 that is depend 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.

Ramp Type Digital Voltmeters:





DVM waveform

Ramp Type Digital Voltmeters:

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

(1) During charging:

$$V_o = -V_i t_1$$

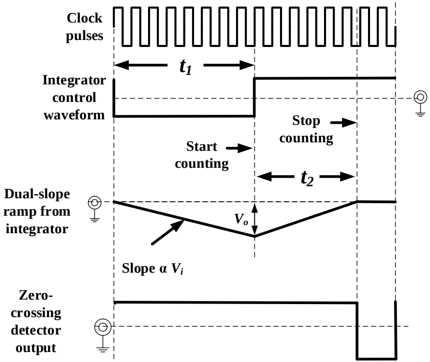
(2) During discharging:

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

So,

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

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



DVM waveform

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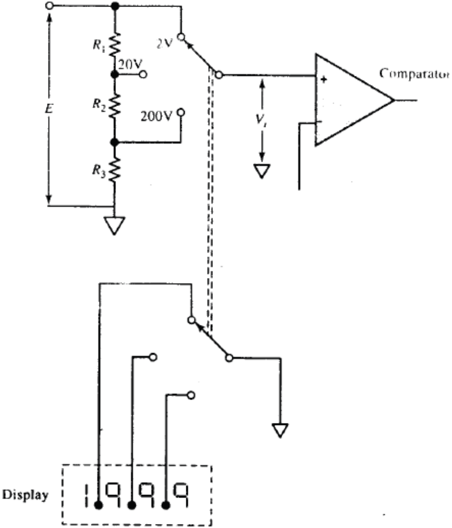
Range Changing:

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

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



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).

Example

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

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

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Types of Digital Multi-meters:

Hand-held Multimeter

Bench-type Multimeter

Types of Digital Multi-meters:

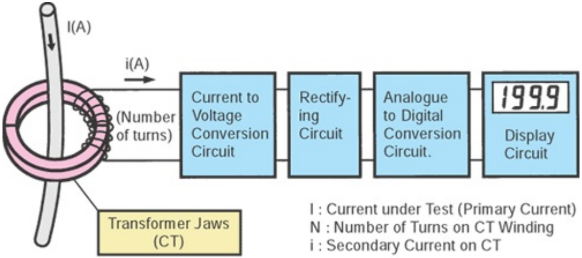
Clamp Meters

Clamp Meter

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

Types of Digital Multi-meters:

Clamp Meters



$$i = \frac{I}{N} \text{ (A)}$$

How Do Clamp Meters Operate ?

AC clamp meters operate on the principle of current transformer(CT) used to pick up magnetic flux generated as a result of current flowing through a conductor. Assuming a current flowing through a conductor to be the primary current, you can obtain a current proportional to the primary current by electromagnetic induction from the secondary side(winding) of the transformer which is connected to a measuring circuit of the instrument. This permits you to take an AC current reading on the digital display.

End of Lecture

Best Wishes