Universidad
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Session 4
Laboratory Instrumentation and Measurement Techniques

Electronic Components and Circuits

Isabel Pérez /José A. Garcia-Souto

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Basic Instrumentation Electronic Laboratory

SKILLS

- To understand the power supply working modes
- To know the waveform generator panel control and to use the electrical equivalent circuit of a waveform generator
- To review the multimeter use
- To learn the basic use of the oscilloscope, to know the panel control and to understand how the syncronism works

Basic Instrumentation Electronic Laboratory

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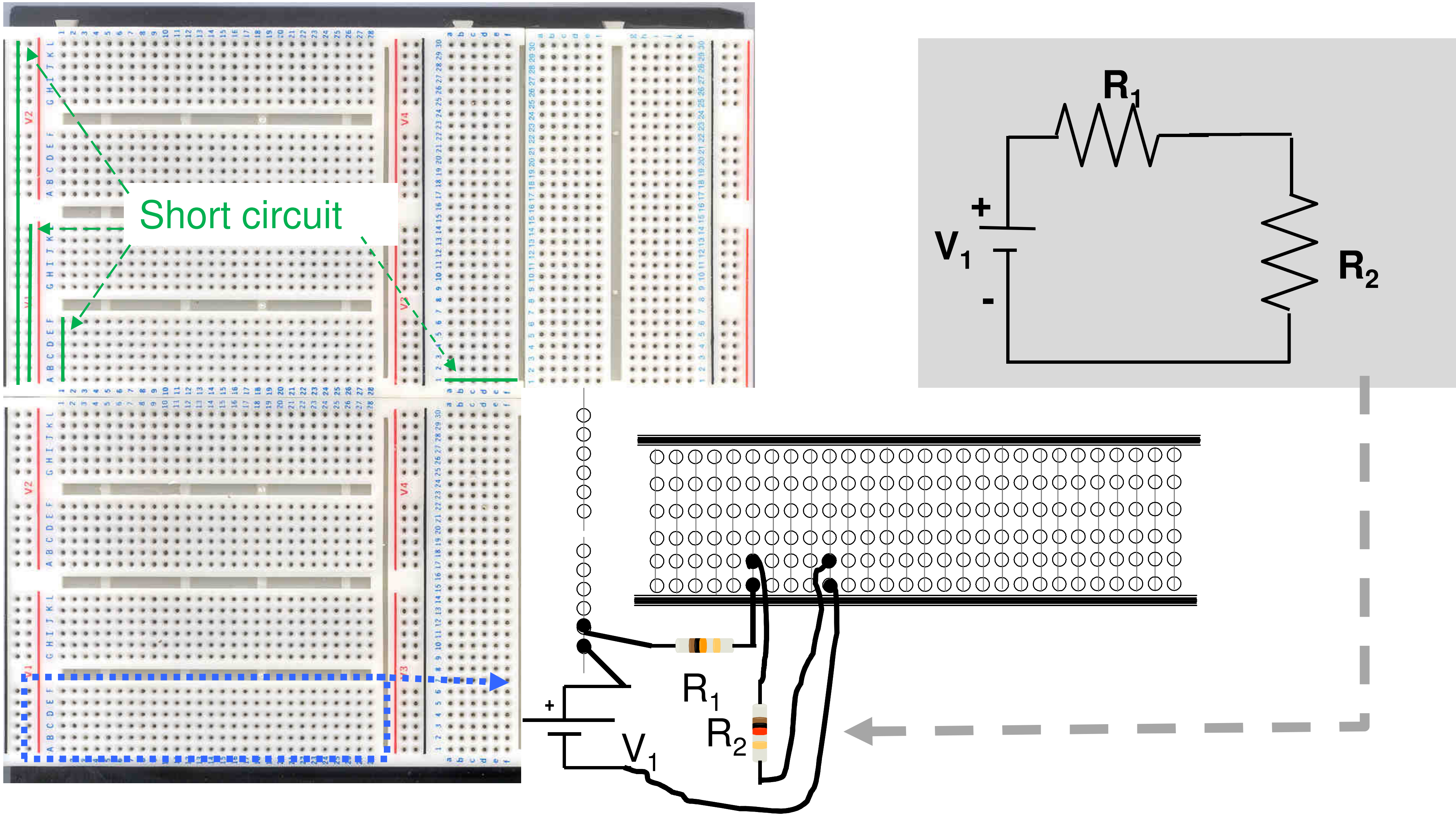
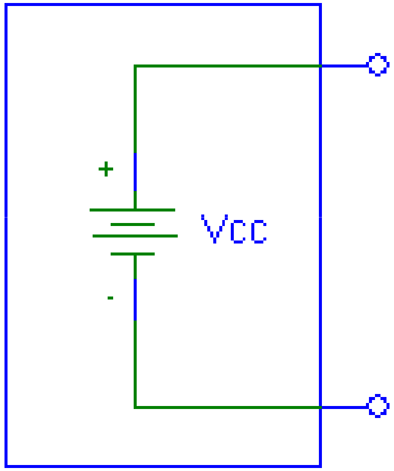
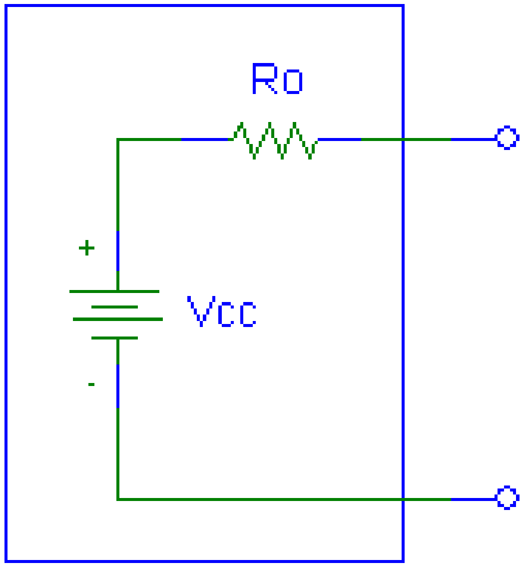
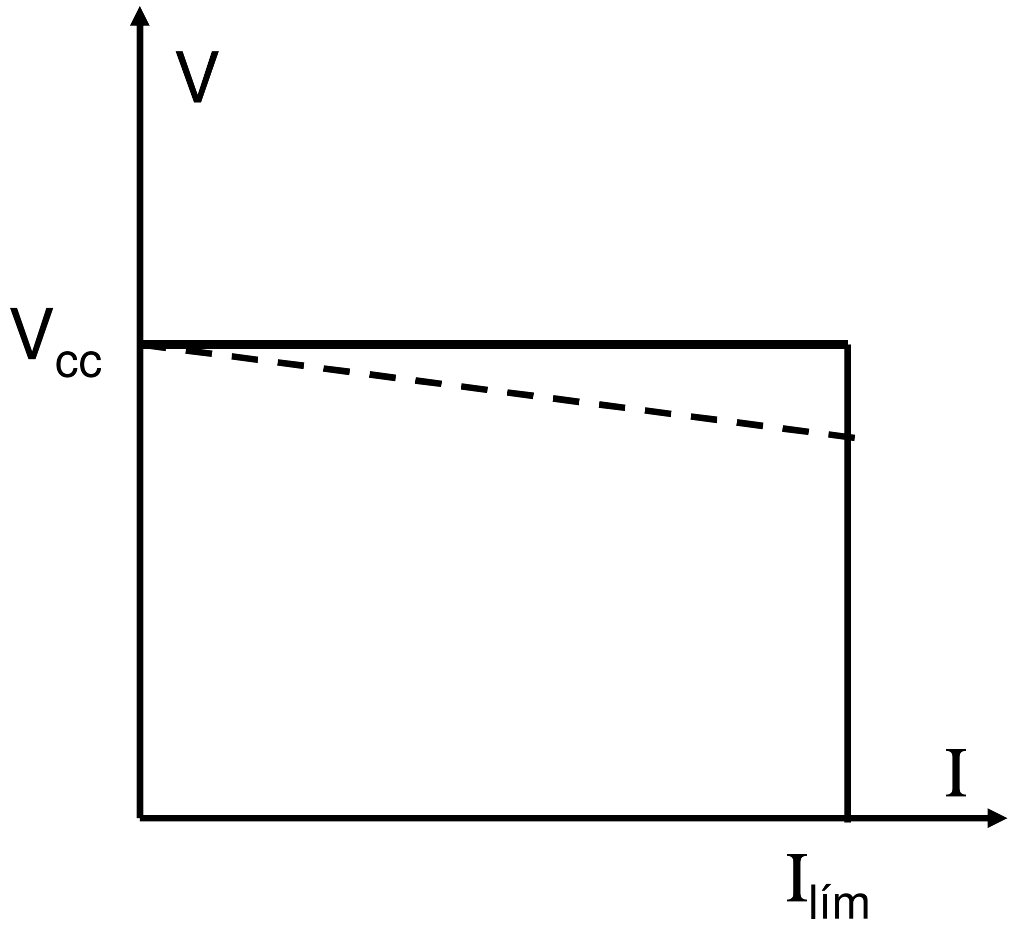
Protoboard



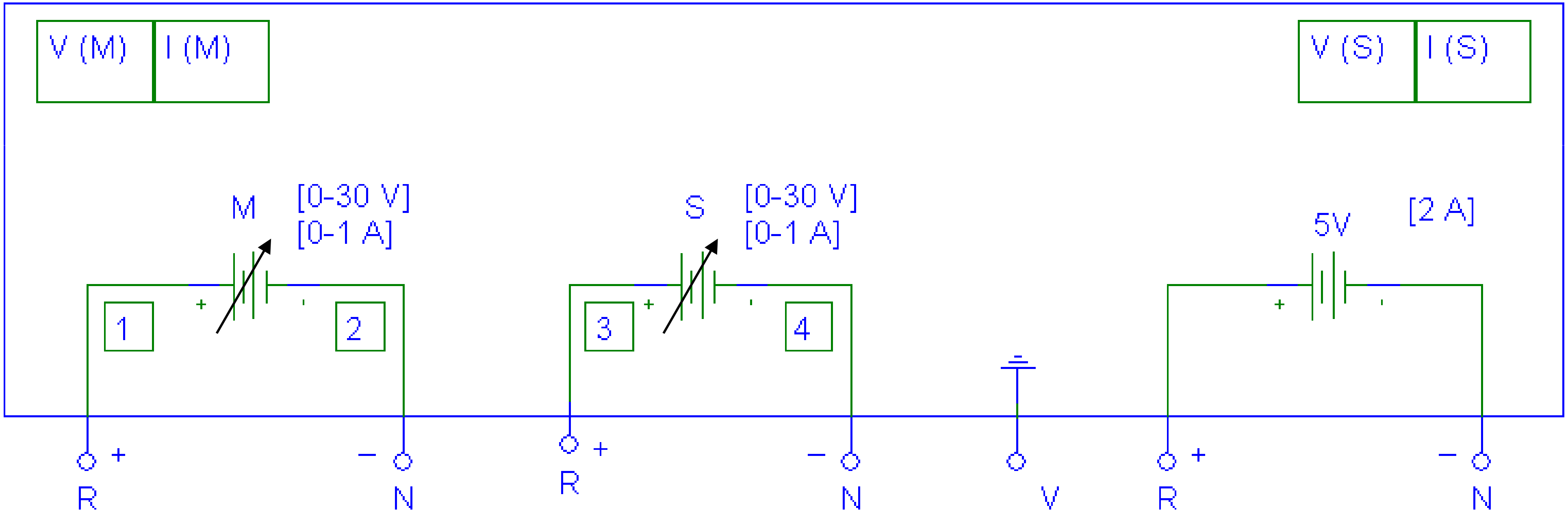
Power Supply (CC)





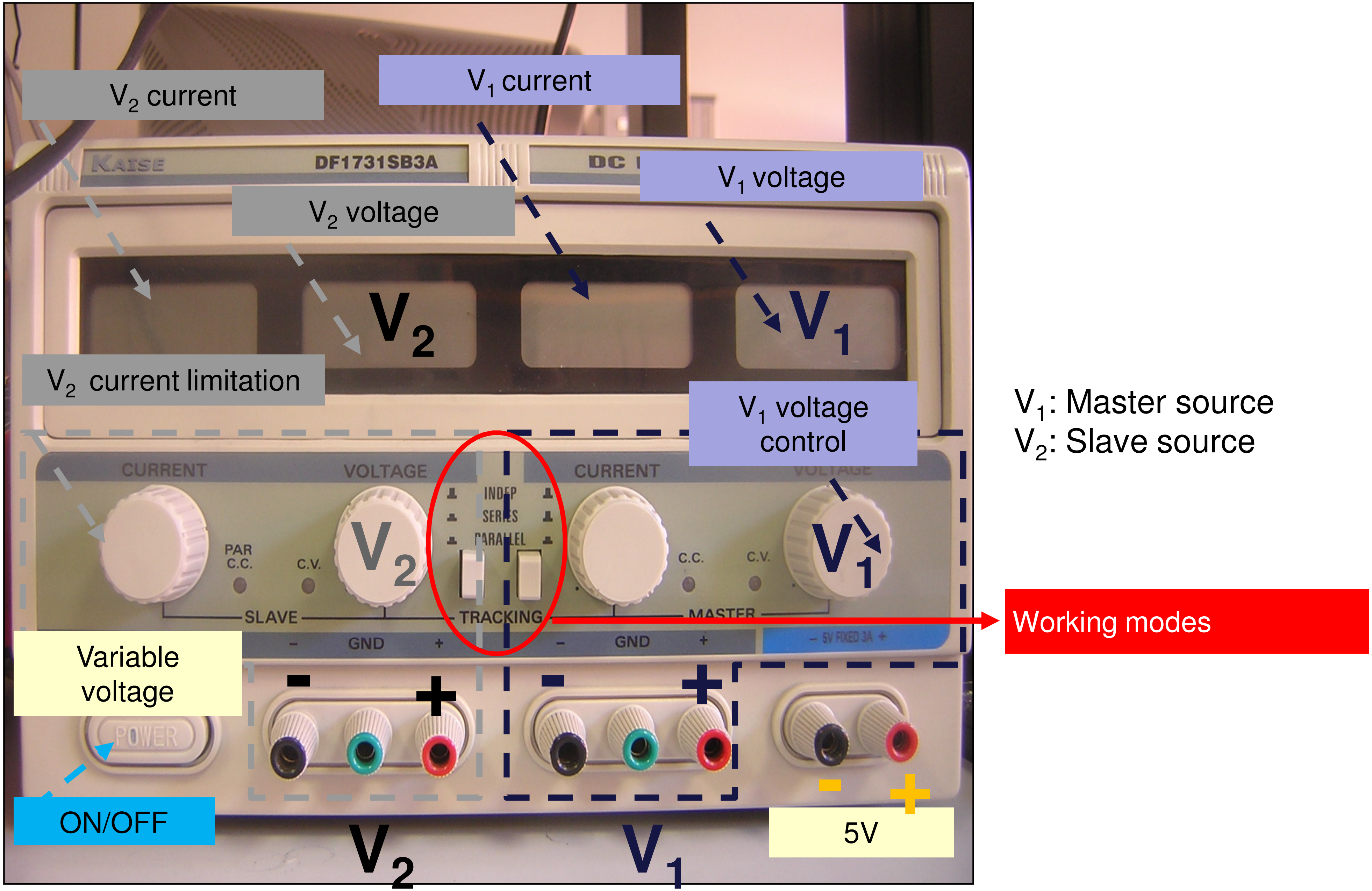


Power Supply (CC)



- Working modes
  - Independent - Series
  - Track - Parallel
- Maximum current adjustment ($I_{lím}$)

Power Supply (CC)



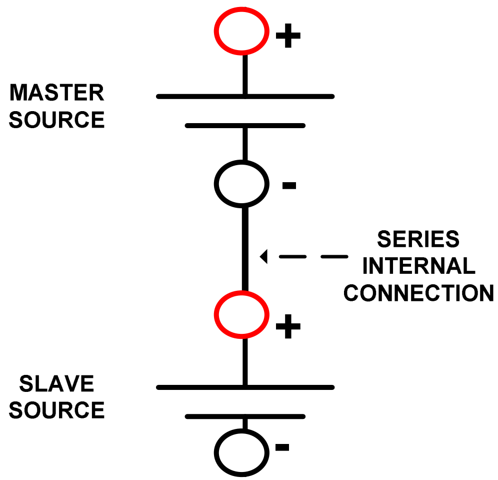
V_1: Master source
V_2: Slave source

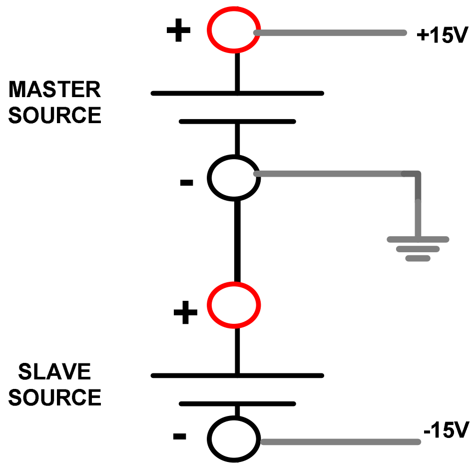
Power Supply(CC)

Working modes

- **Independent mode**: Master and Slave sources work separately

- **Series mode**: Master and slave sources are connected in series. The voltage control from master source selects the voltage. The slave source supplies the same voltage.

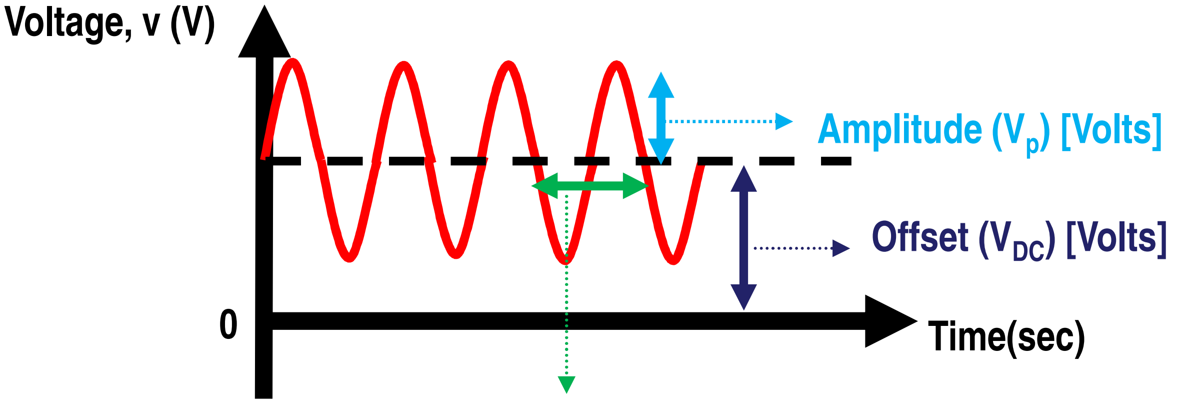




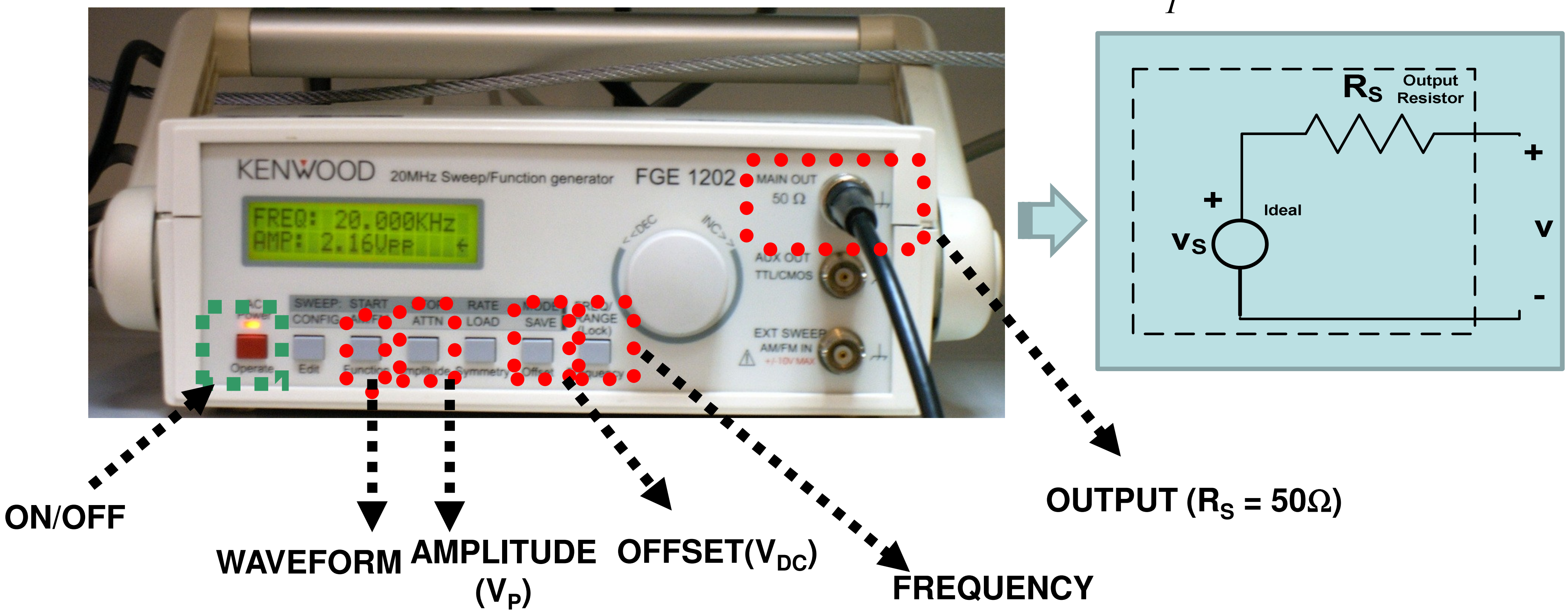
Example. To have a ±15V power supply

- **Parallel mode**: Master and slave sources are connected in parallel

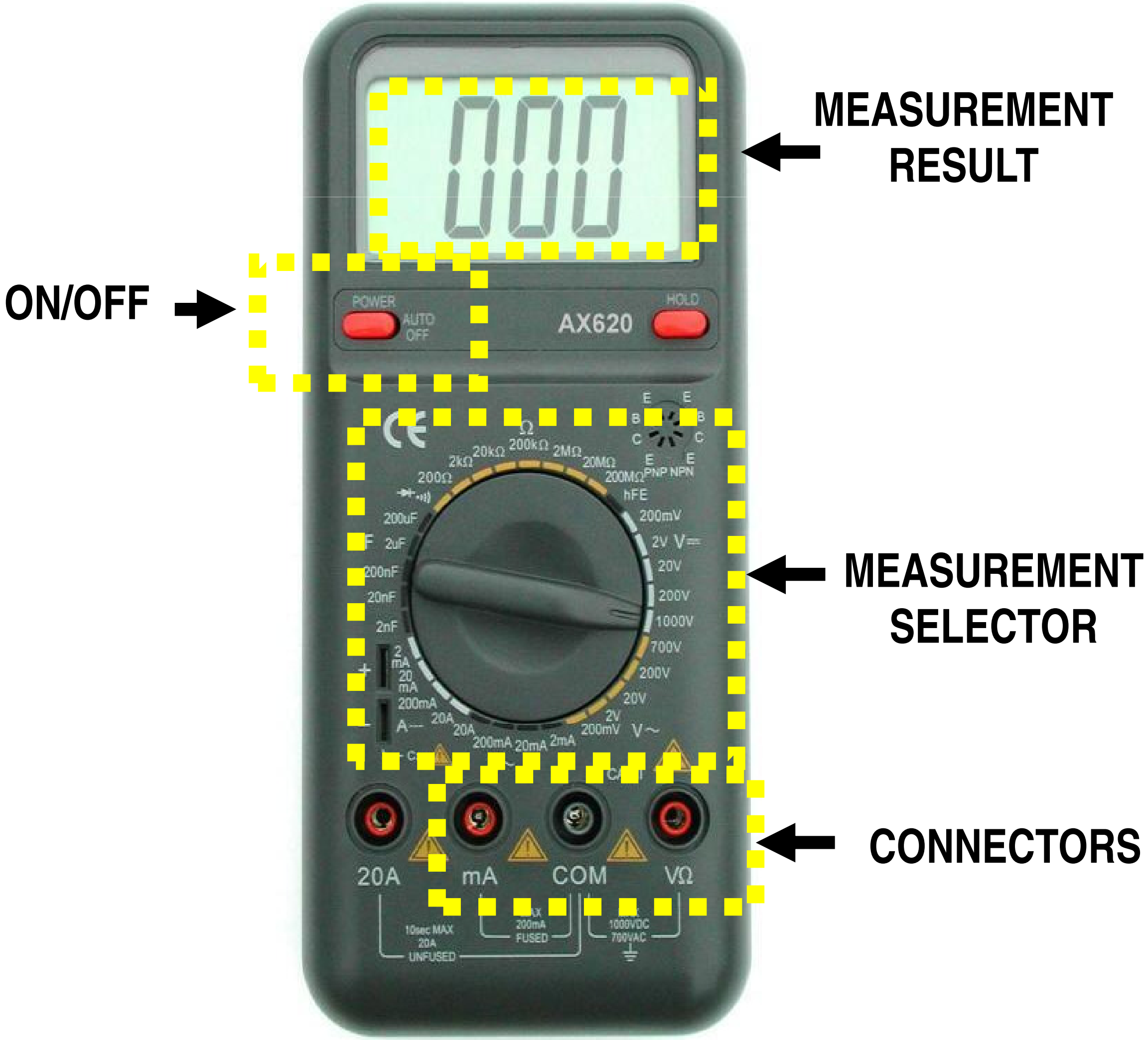
Waveform Generator



Period (T) [seconds]; Frequency, f: $f = \frac{1}{T}\left[s^{-1} o Hz\right]$



Multimeter



- Voltage and current measurements (DC and AC), resistance, continuity check…

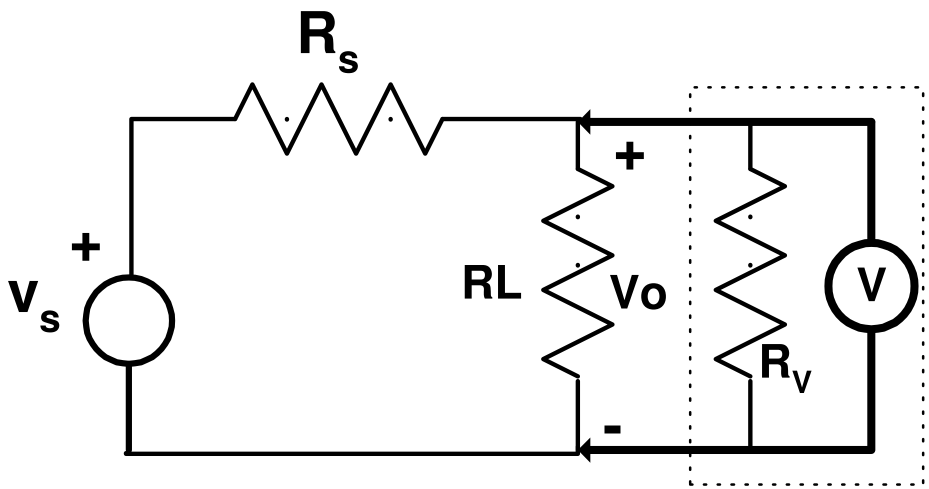
Multimeter

Voltage measurement

(AC mode: real value only *True RMS* Multimeters)

Parallel connection

Example:



V: ideal voltmeter

R_V: Voltmeter input resistance (≅MΩ)

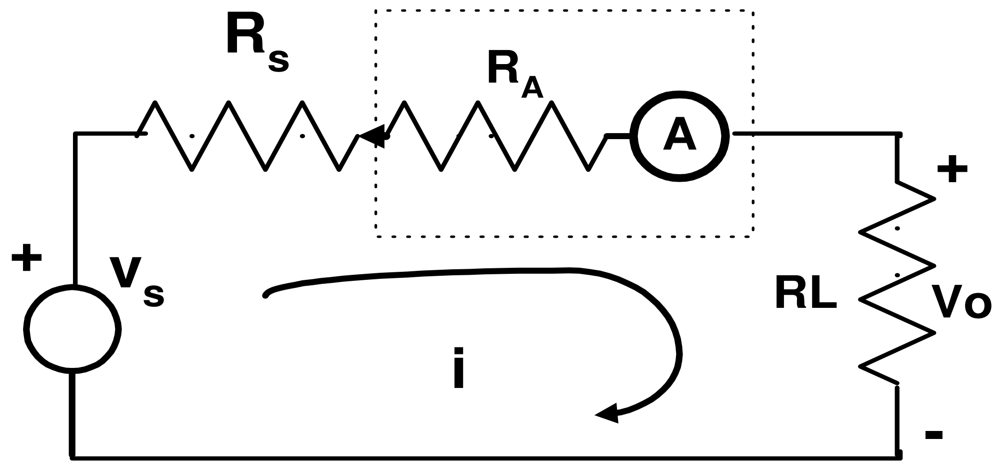
Multimeter

Current measurement

(AC mode: real value only *True RMS* Multimeters)

Series connection

Example:

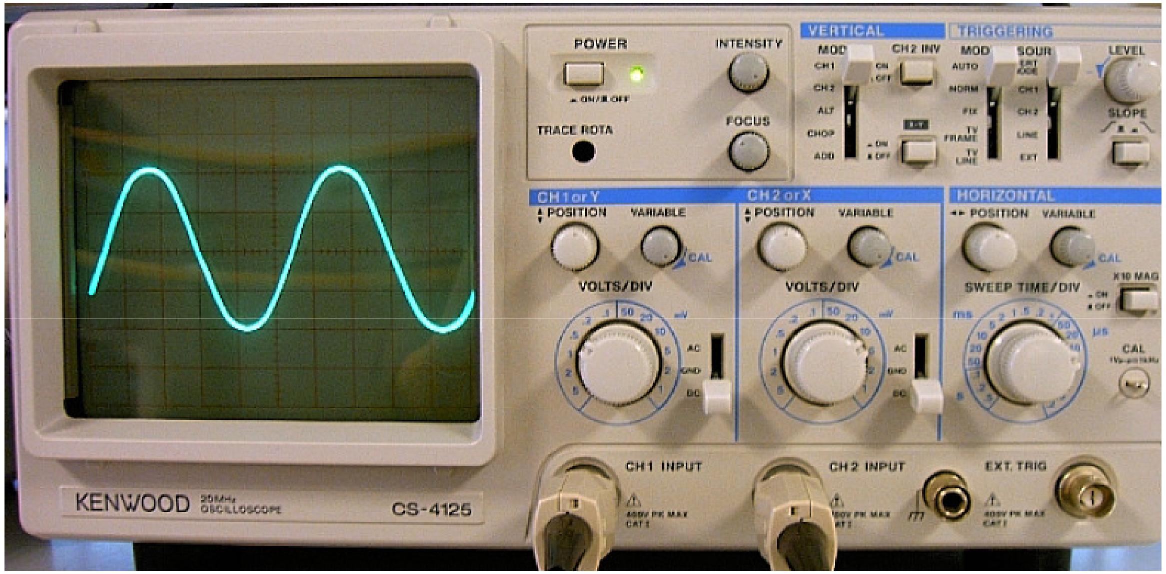


A: Ideal amperemeter

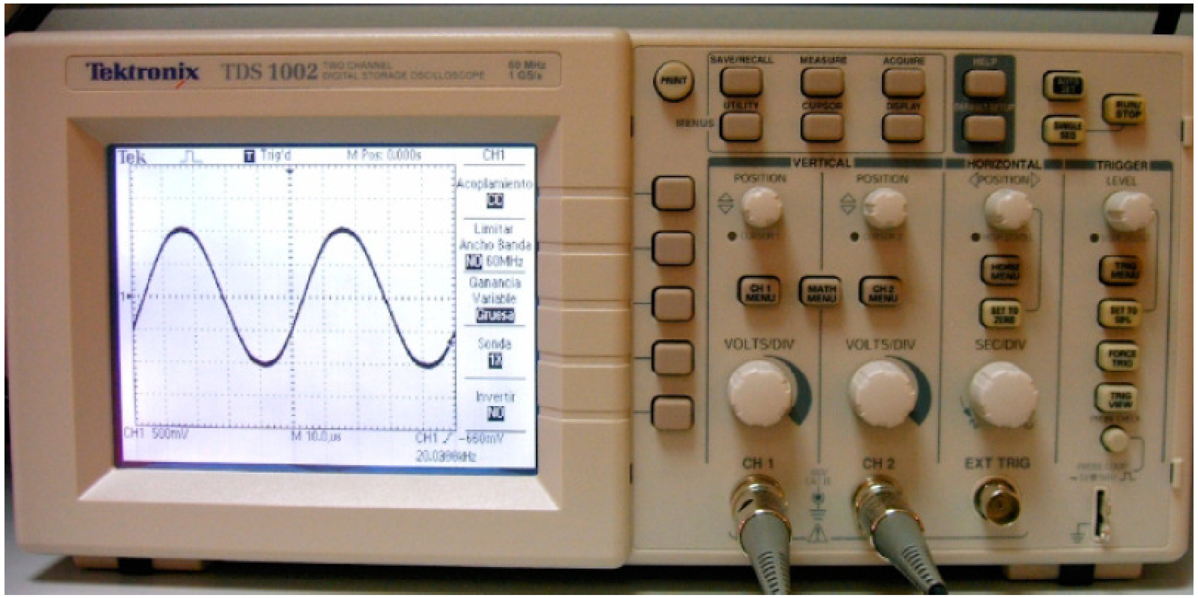
R_A: Amperemeter input resistance (≅Ω)

Oscilloscope

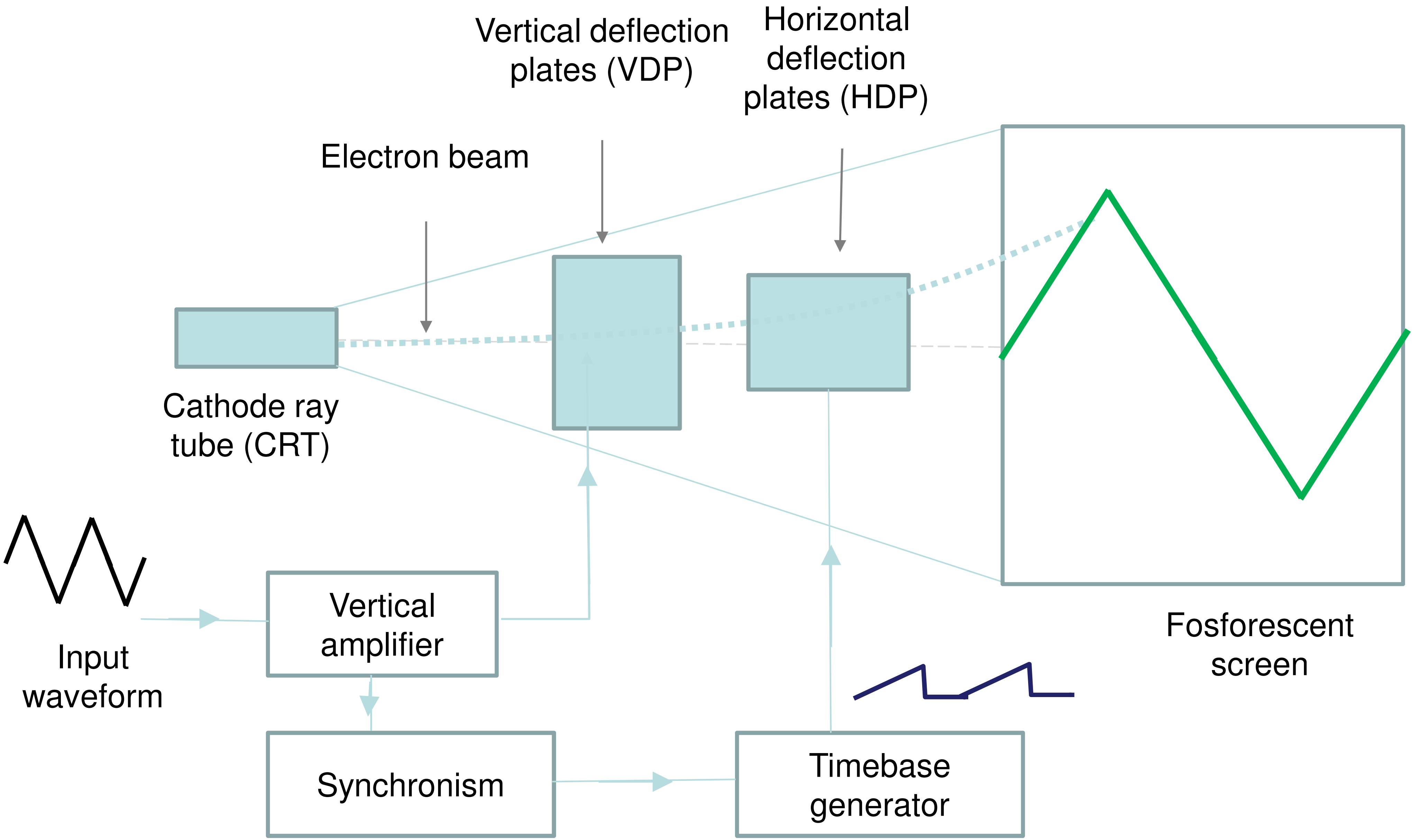
ANALOG OSCILLOSCOPE



DIGITAL OSCILLOSCOPE

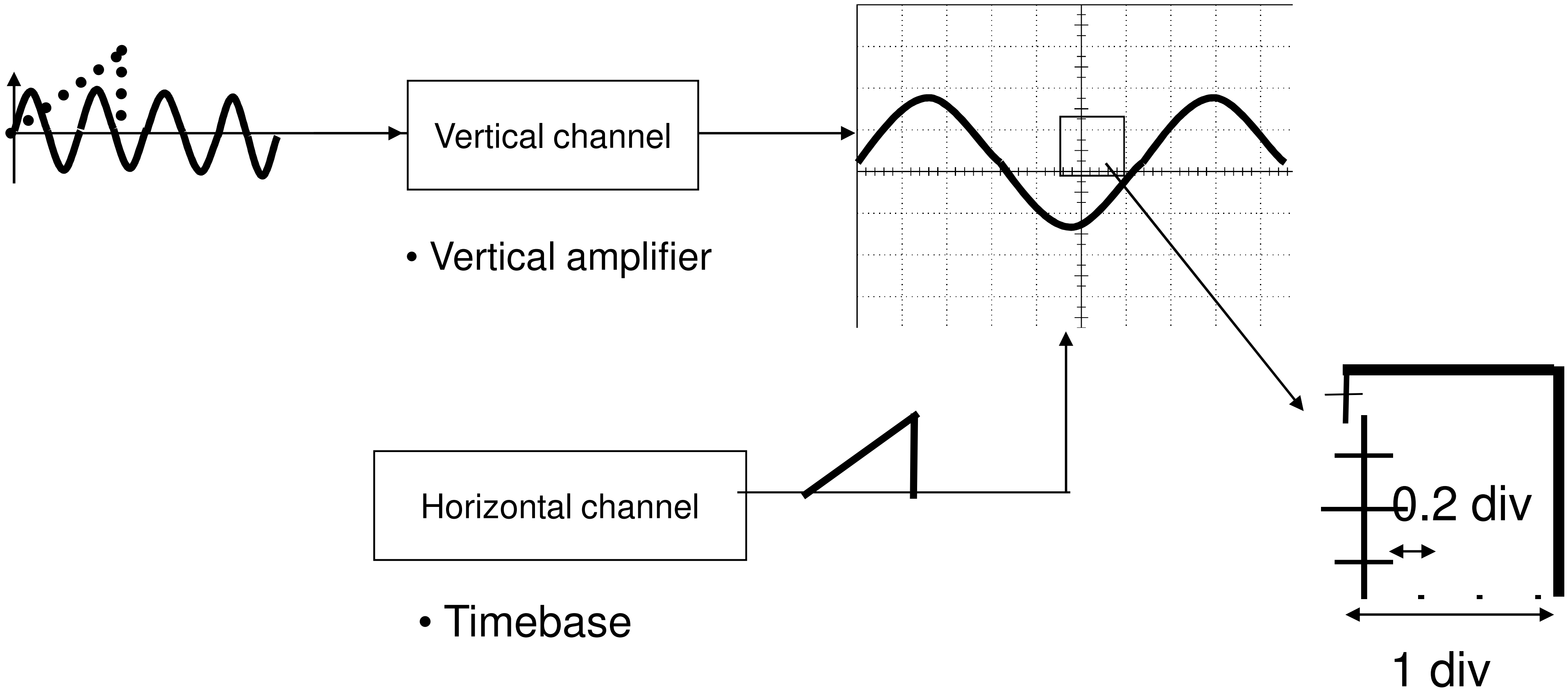


Oscilloscope



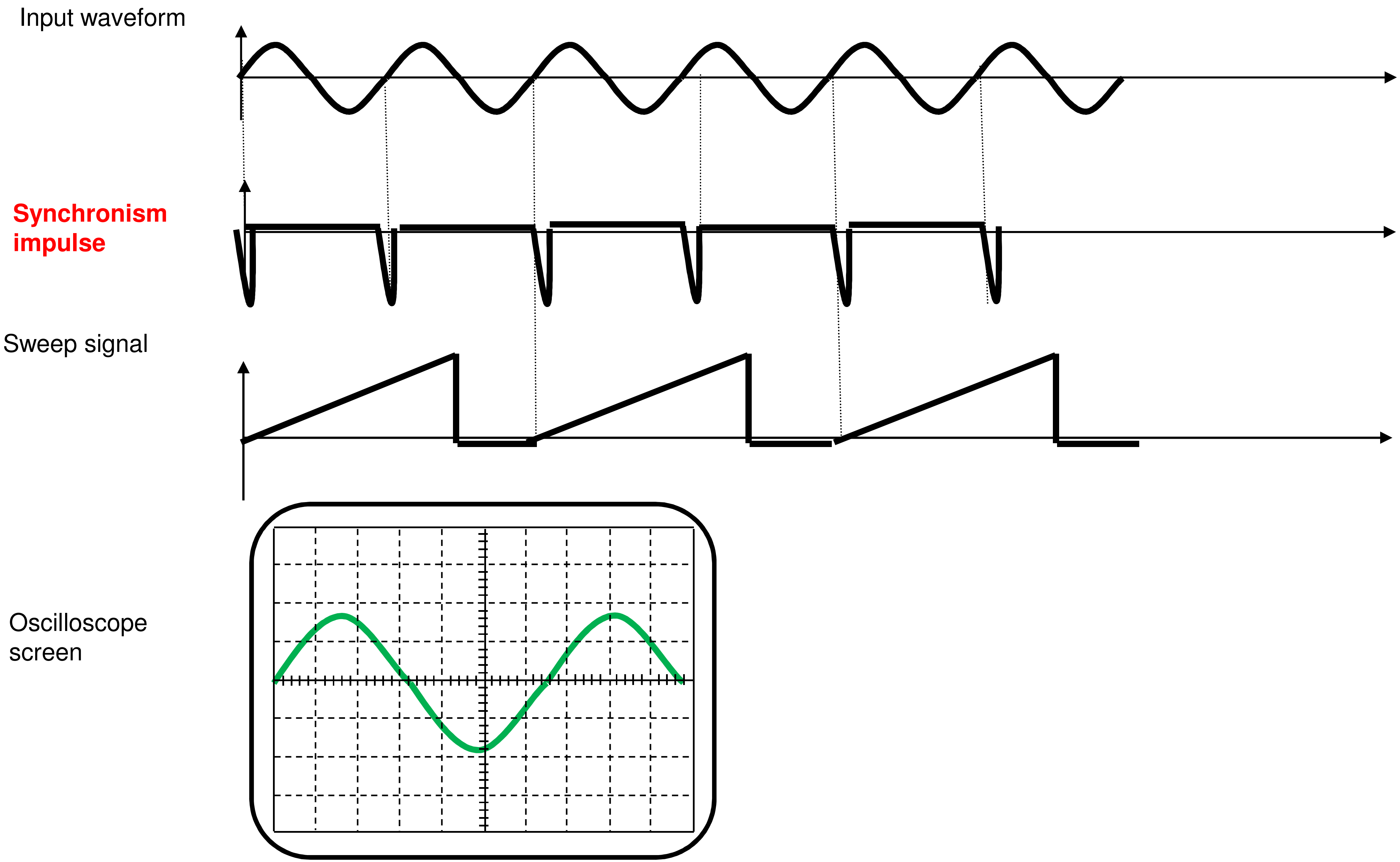
Oscilloscope

To visualize on the screen a voltage waveform as a function of time



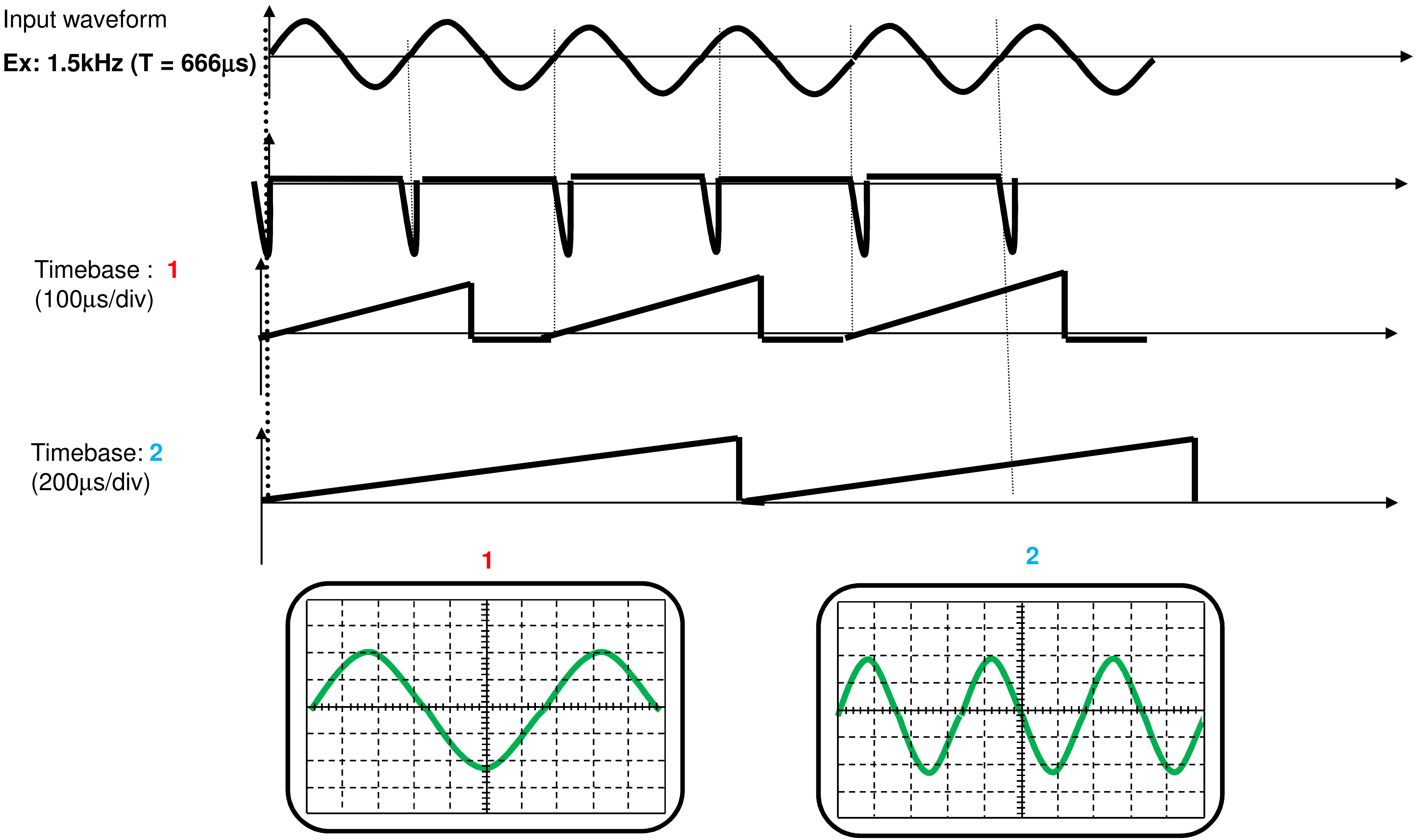
Oscilloscope

TRIGGERED SWEEP



Oscilloscope

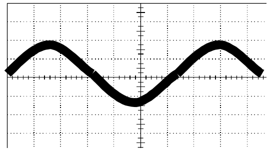
TIMEBASE (SEG/DIV)

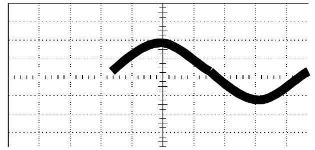


Oscilloscope

HORIZONTAL CHANNEL

- **Horizontal position control**





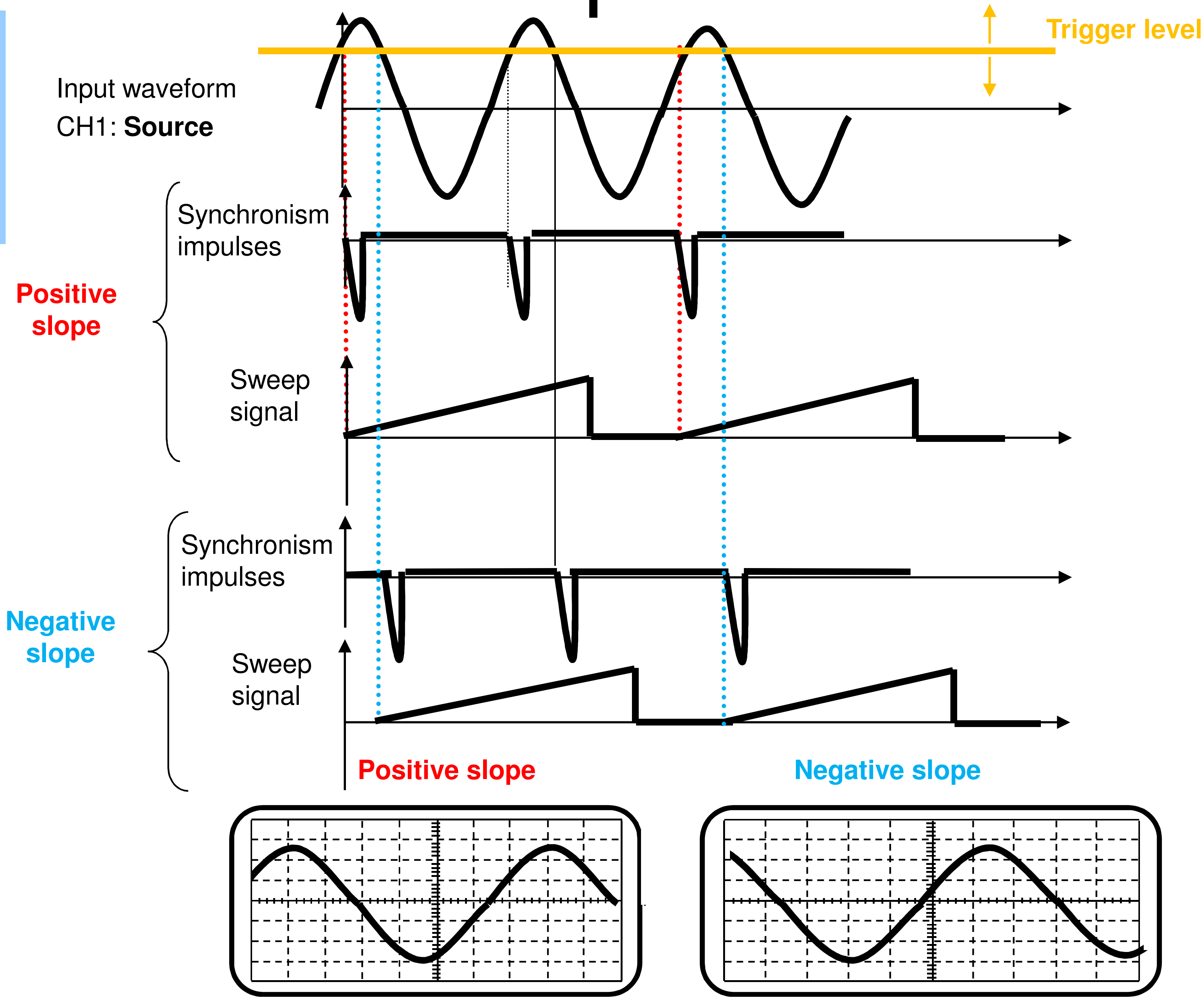
- **Vernier (CAL)**

Trigger

- **Trigger source**: Waveform to generate the syncronism impulses
  - Any input channel
  - An external source, other than the signal applied to an input channel
  - The power source signal (Line)
  - A signal internally generated by the oscilloscope
- **Trigger level**:
- **Trigger slope** (positive or negative)

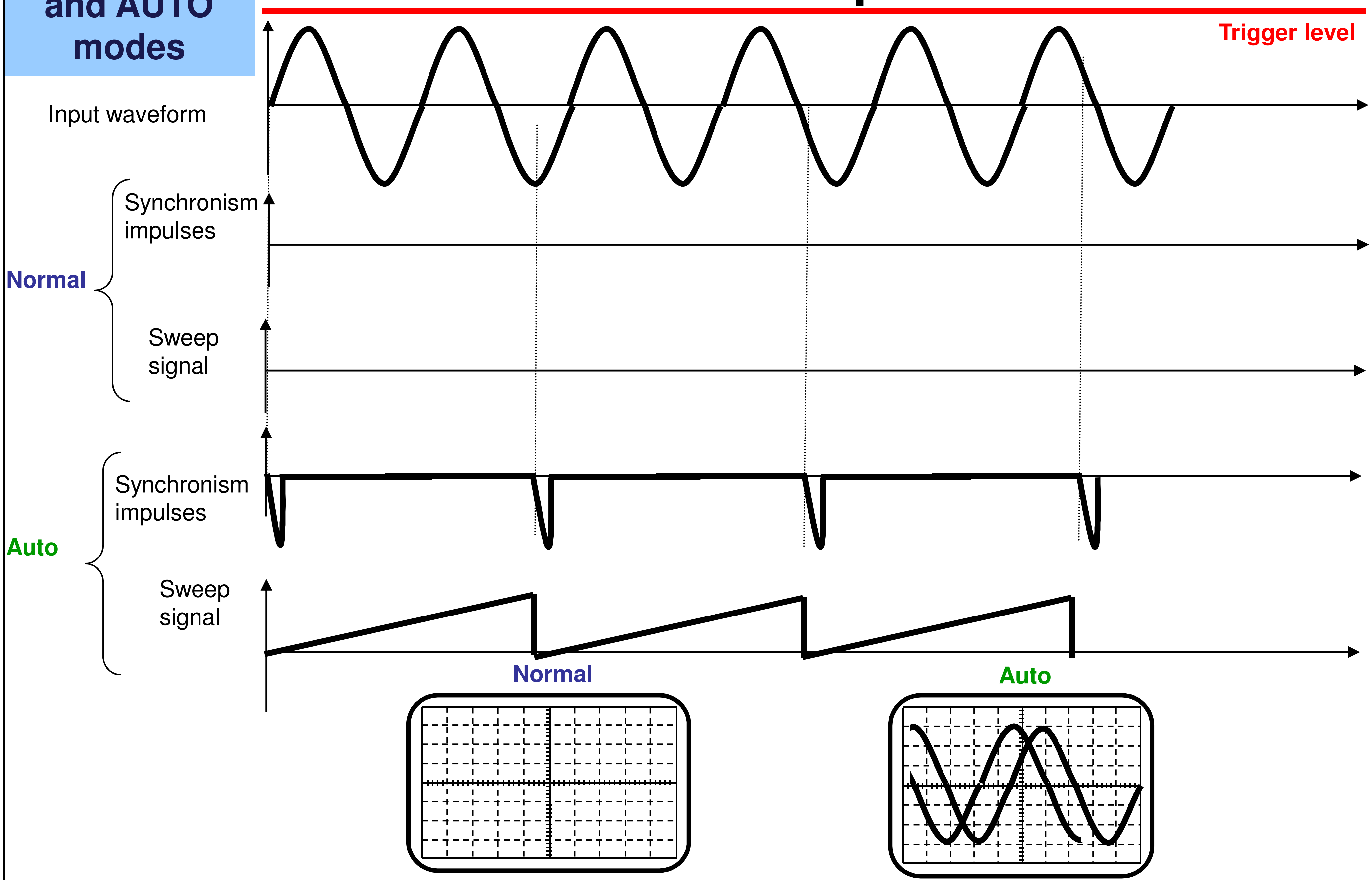
Oscilloscope

- **TRIGGER LEVEL**
- **TRIGGER SLOPE**



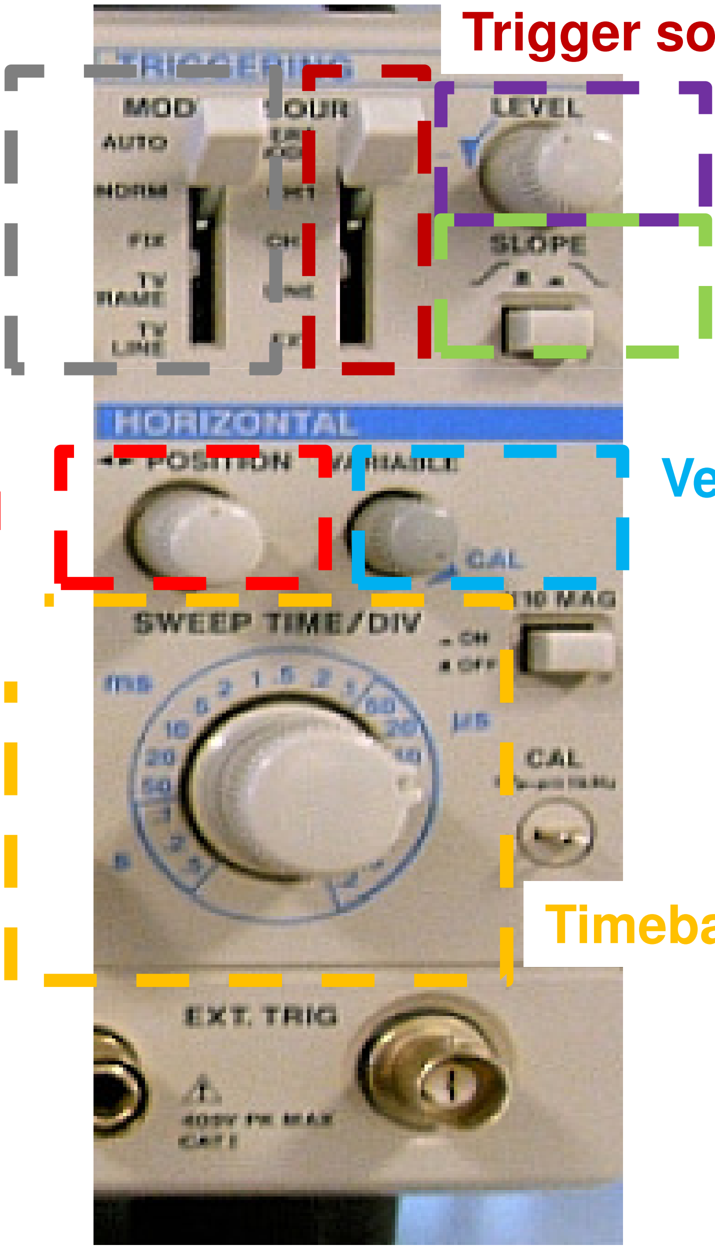
Oscilloscope

•NORMAL and AUTO modes



Oscilloscope

HORIZONTAL CHANNEL AND SYNCHRONISM



Trigger source

Trigger level

Trigger slope

Synchronism mode (Normal/Auto)

Horizontal position control

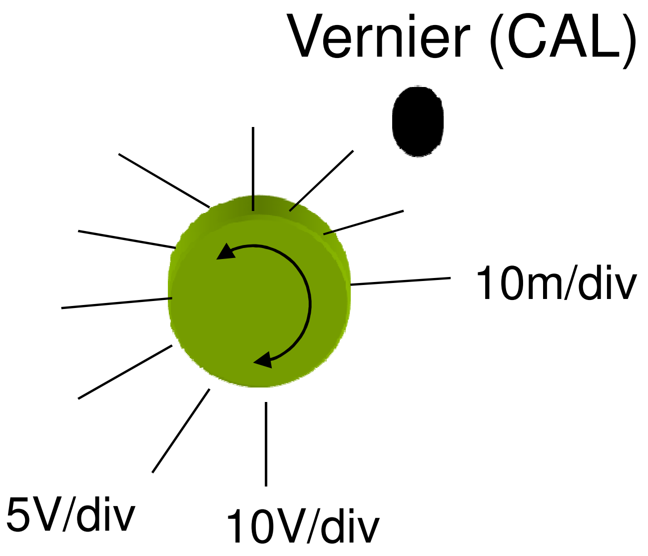
Vernier (CAL)

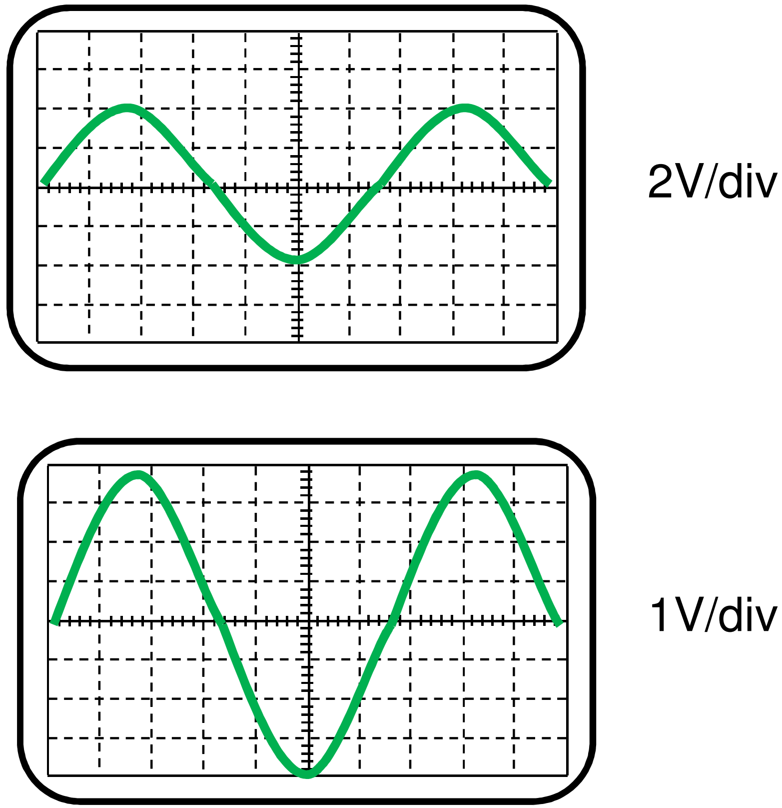
Timebase

Oscilloscope

VERTICAL CHANNEL

Vertical sensitivity control (VOLTS/DIVISION)

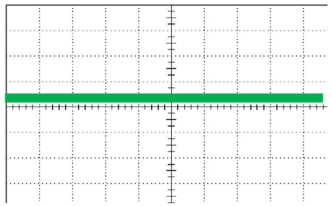




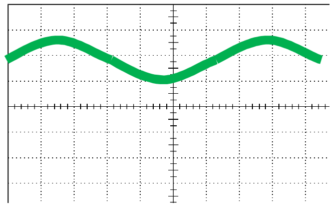
Oscilloscope

VERTICAL CHANNEL

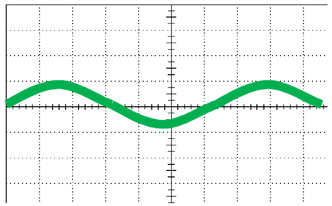
- INPUT MODE:
  - **GND**



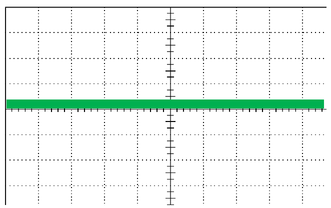
  - **<u>DC</u>**

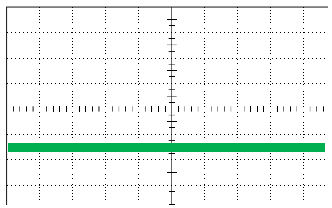


  - **AC: Only AC component**



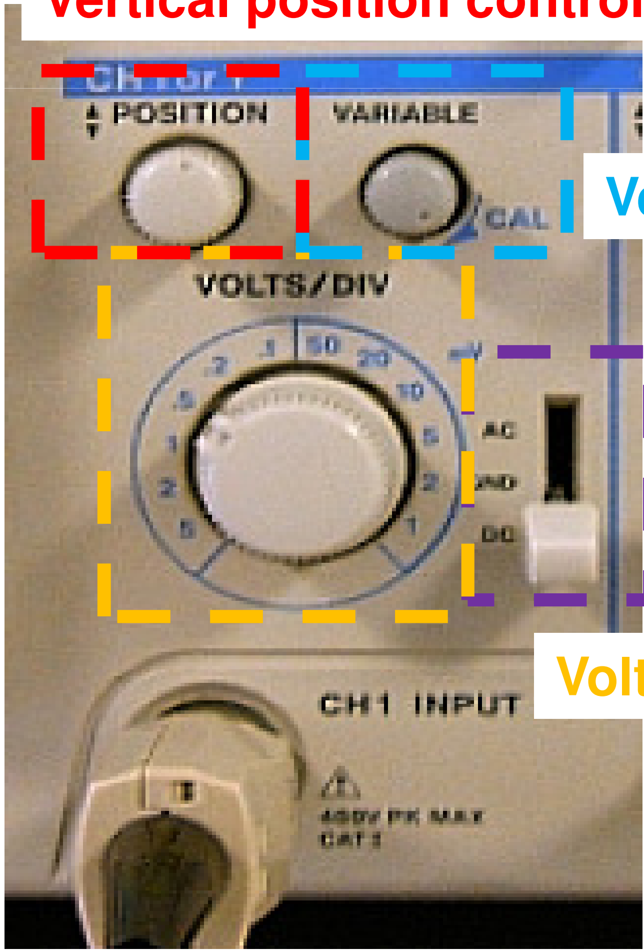
- Vertical position control





Oscilloscope

VERTICAL CHANNEL



Oscilloscope

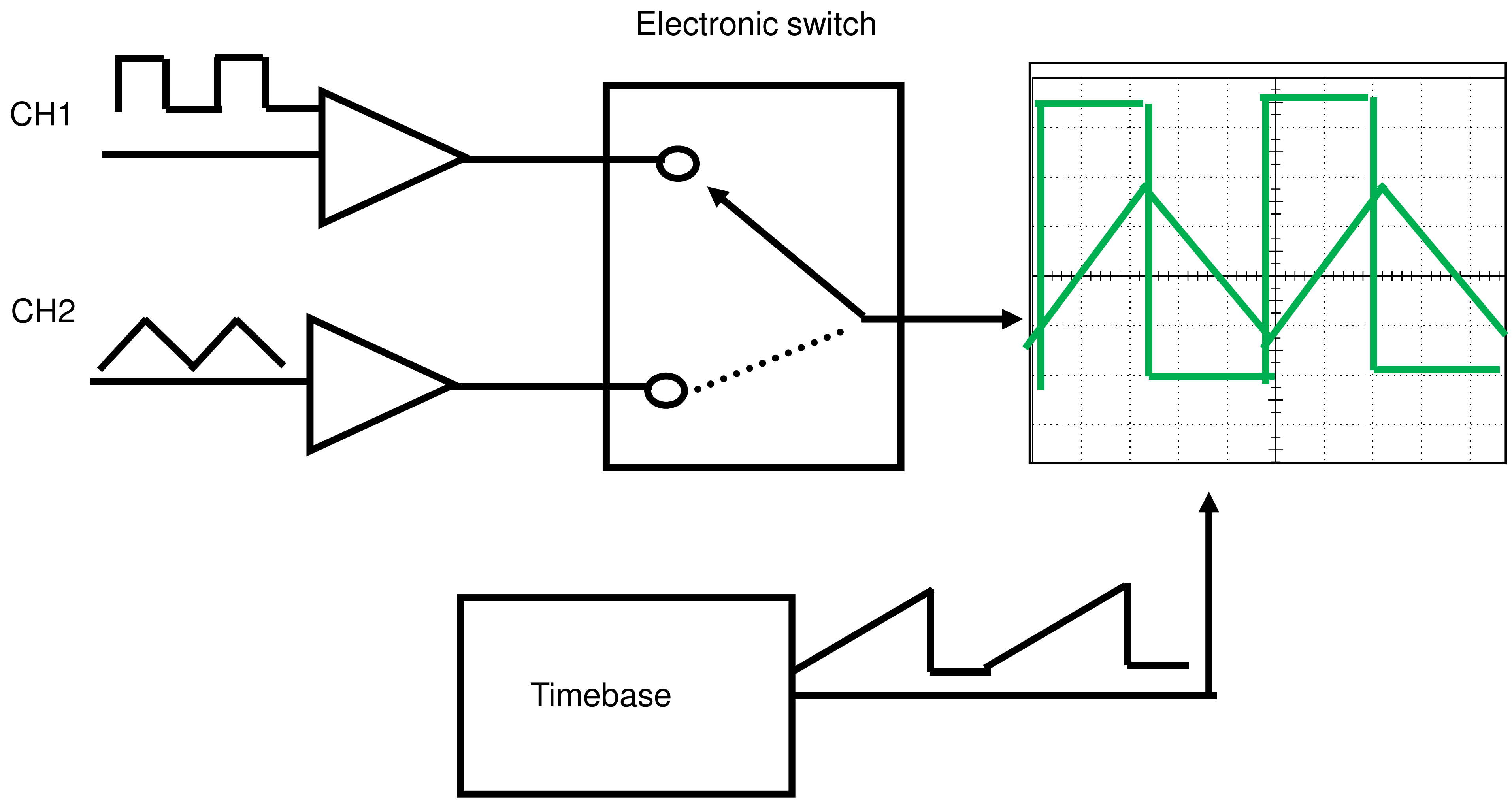
TWO CHANNELS OSCILLOSCOPES

- Waveforms on screen control
  - CHANNEL 1 (CH1)
  - CHANNEL 2(CH2)
  - **CH1 and CH2 SIMULTANEOUSLY**:
    - ALTERNATE MODE (ALT)
    - CHOPPED MODE (CHOP)
  - **CH1+CH2** or **CH1-CH2**

Oscilloscope

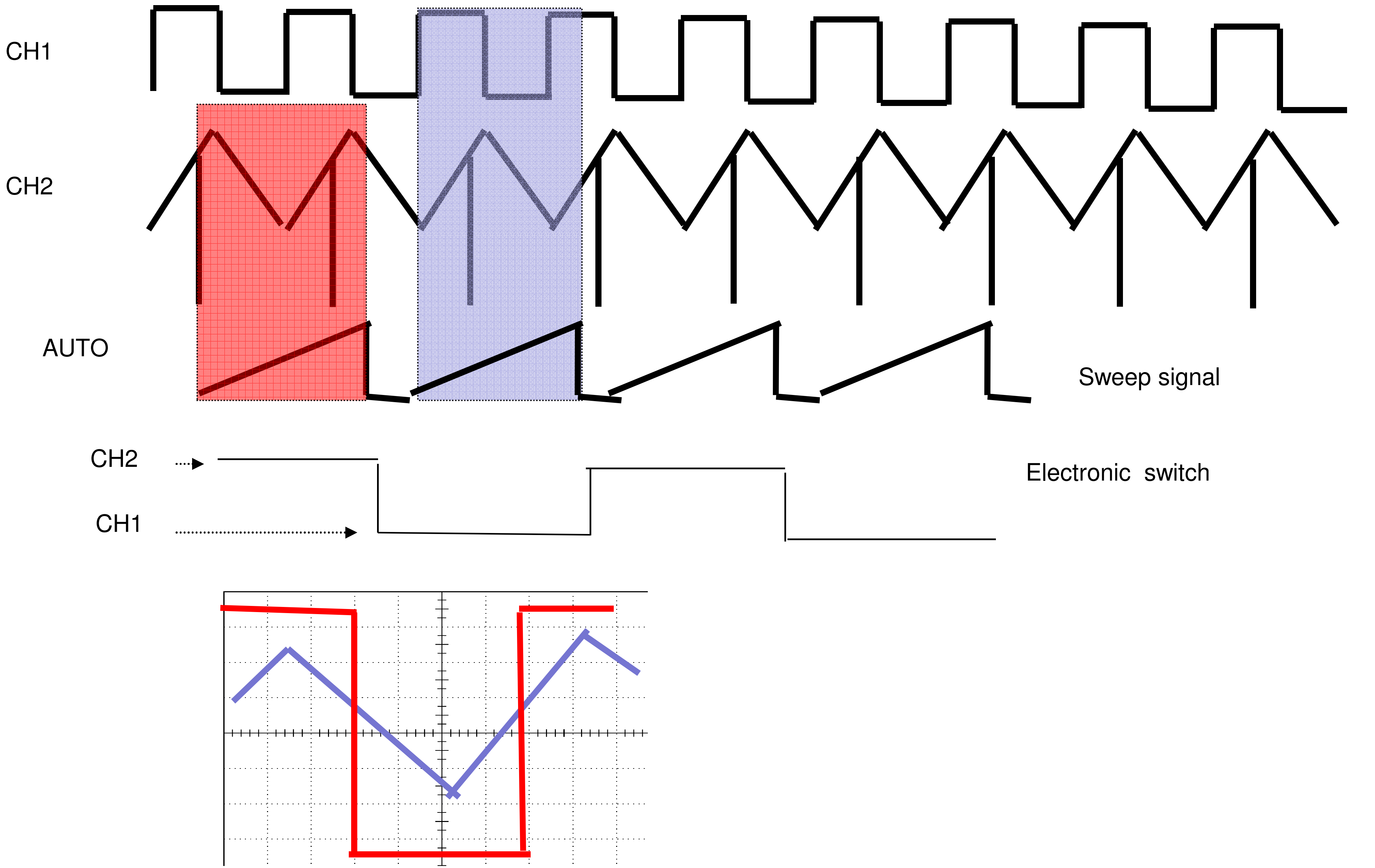
ALT and CHOP modes

• Oscilloscopes with two channels and only one electron beam



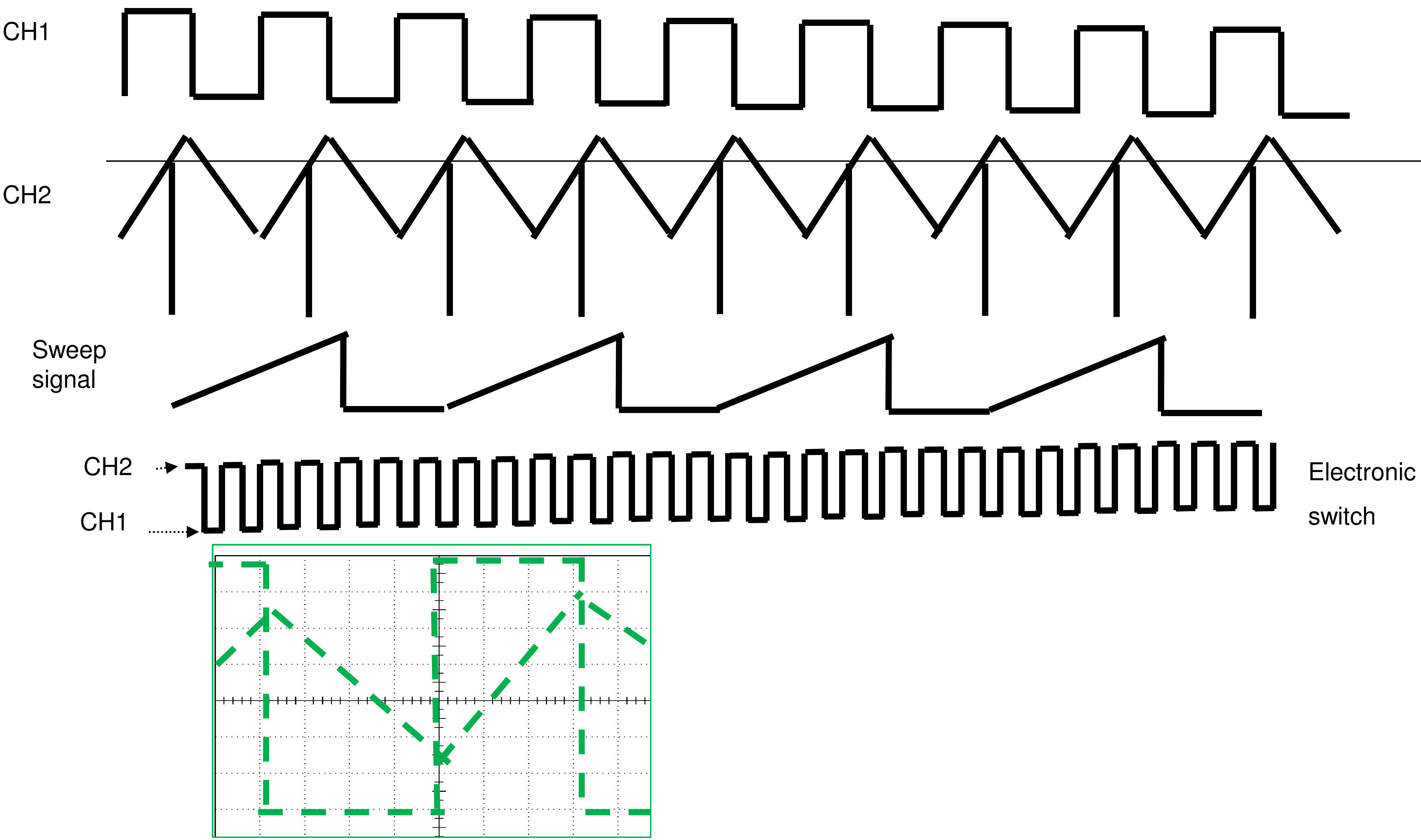
Oscilloscope

ALT MODE



Oscilloscope

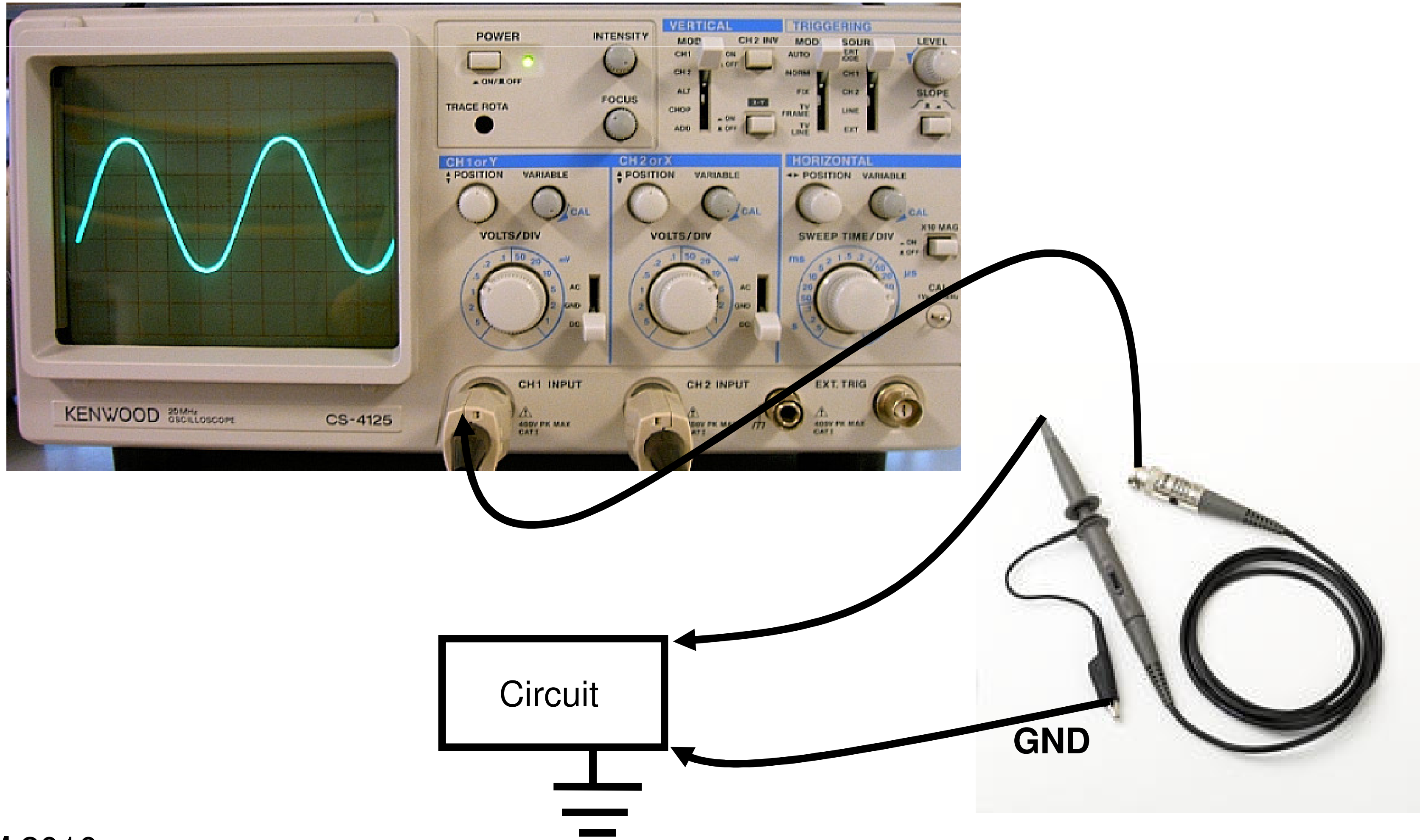
CHOP MODE



Oscilloscope

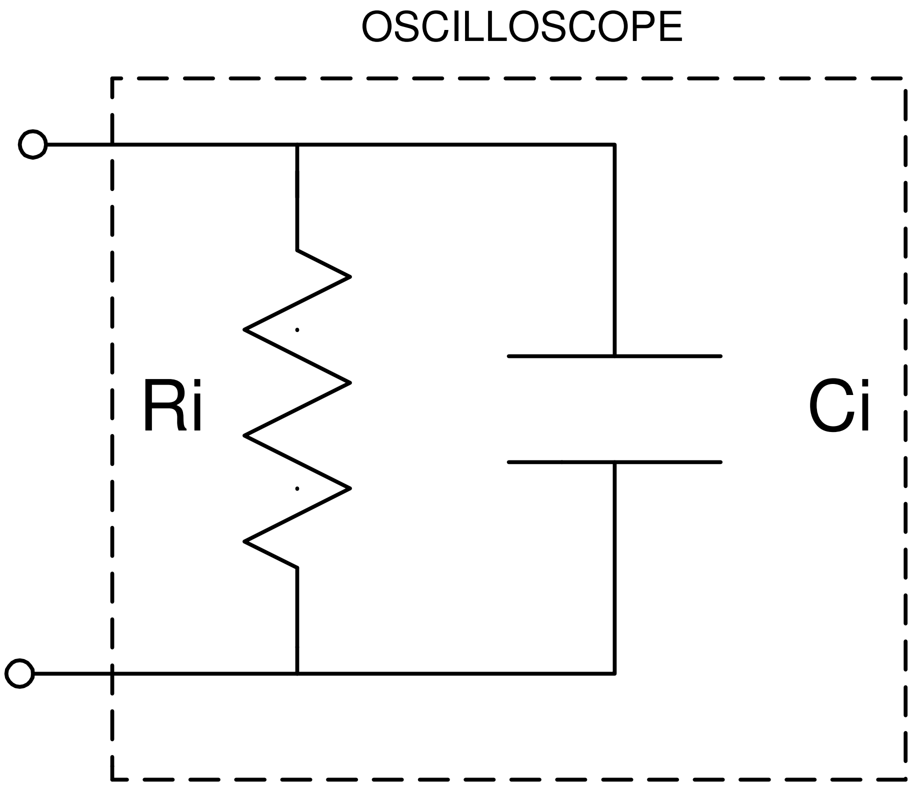
Voltage Probes

- **x1** (screen signal = input signal)
- **x10** (screen signal =(input signal)/10)



Oscilloscope

INPUT IMPEDANCE

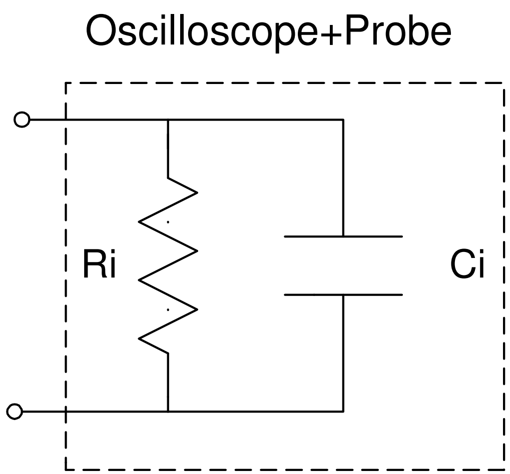


Ri = 1MΩ y Ci = 50pF

Oscilloscope

INPUT IMPEDANCE (OSCILLOSCOPE+PROBE)

x1 PROBE



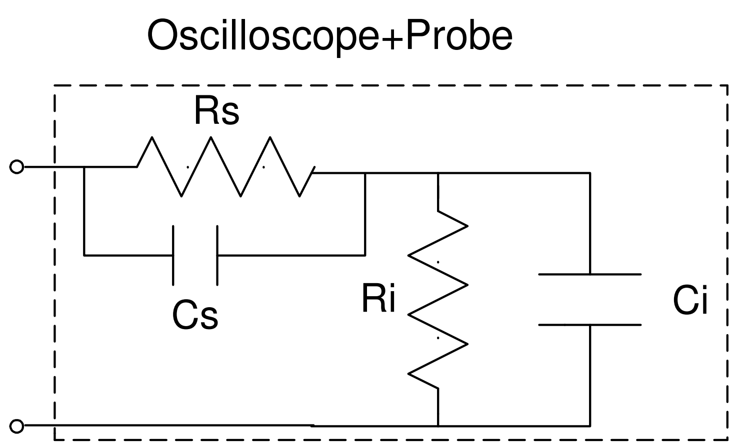
Zi

Ri = 1MΩ || Ci = 50pF

X10 PROBE

Compensated Probe

RsCs=RiCi



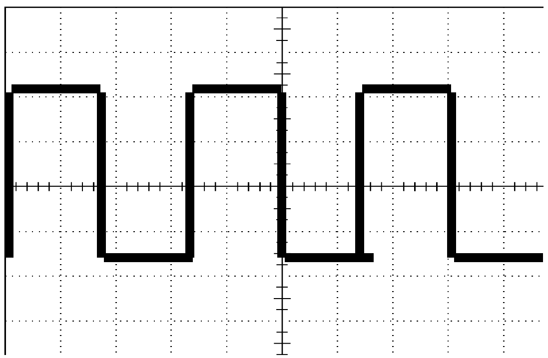
Zis = Zi*10

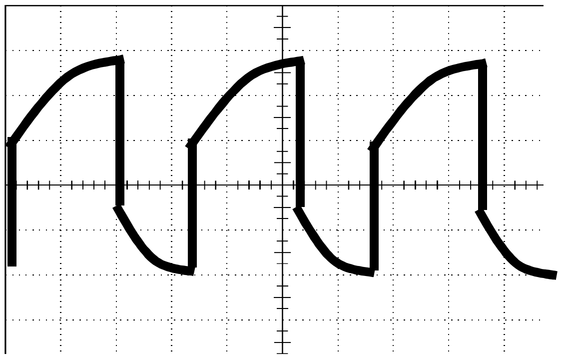
Ris = 10MΩ || Cis = 5pF

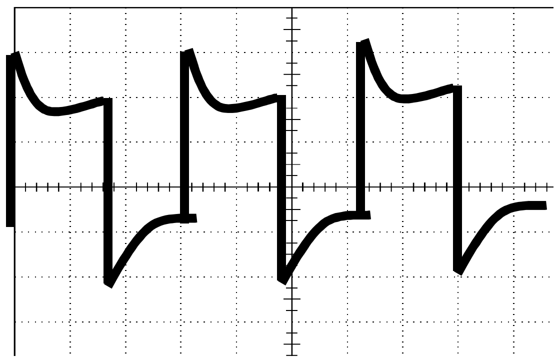
Oscilloscope

¿Compensated probe?

Oscilloscope signal
to test probe



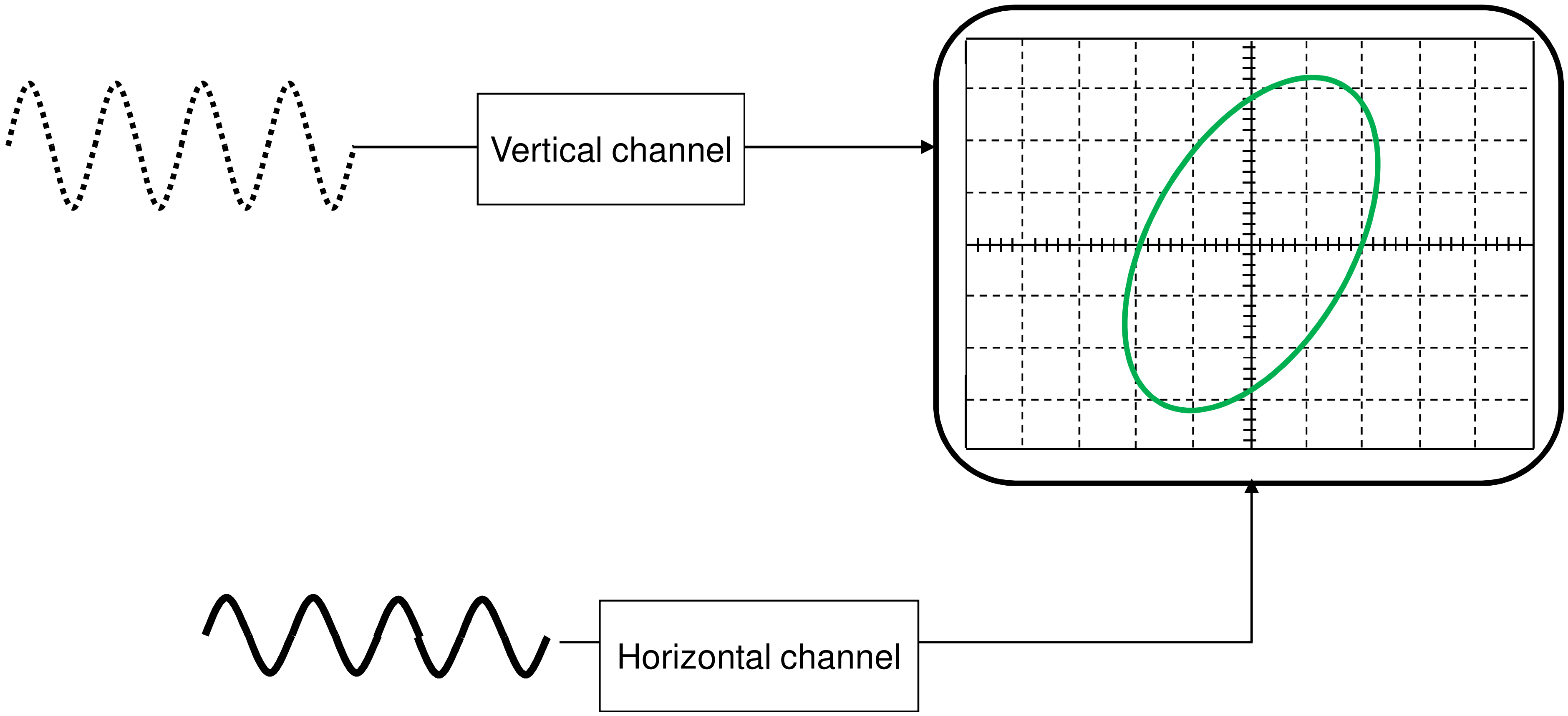




OK

Oscilloscope

XY MODE



Measurement techniques

SKILLS

- Time measurements (frequency, phase,delay)
- Input impedance measurement
- Output impedance measurement
- Load effects of measurement instruments

Phase measurement

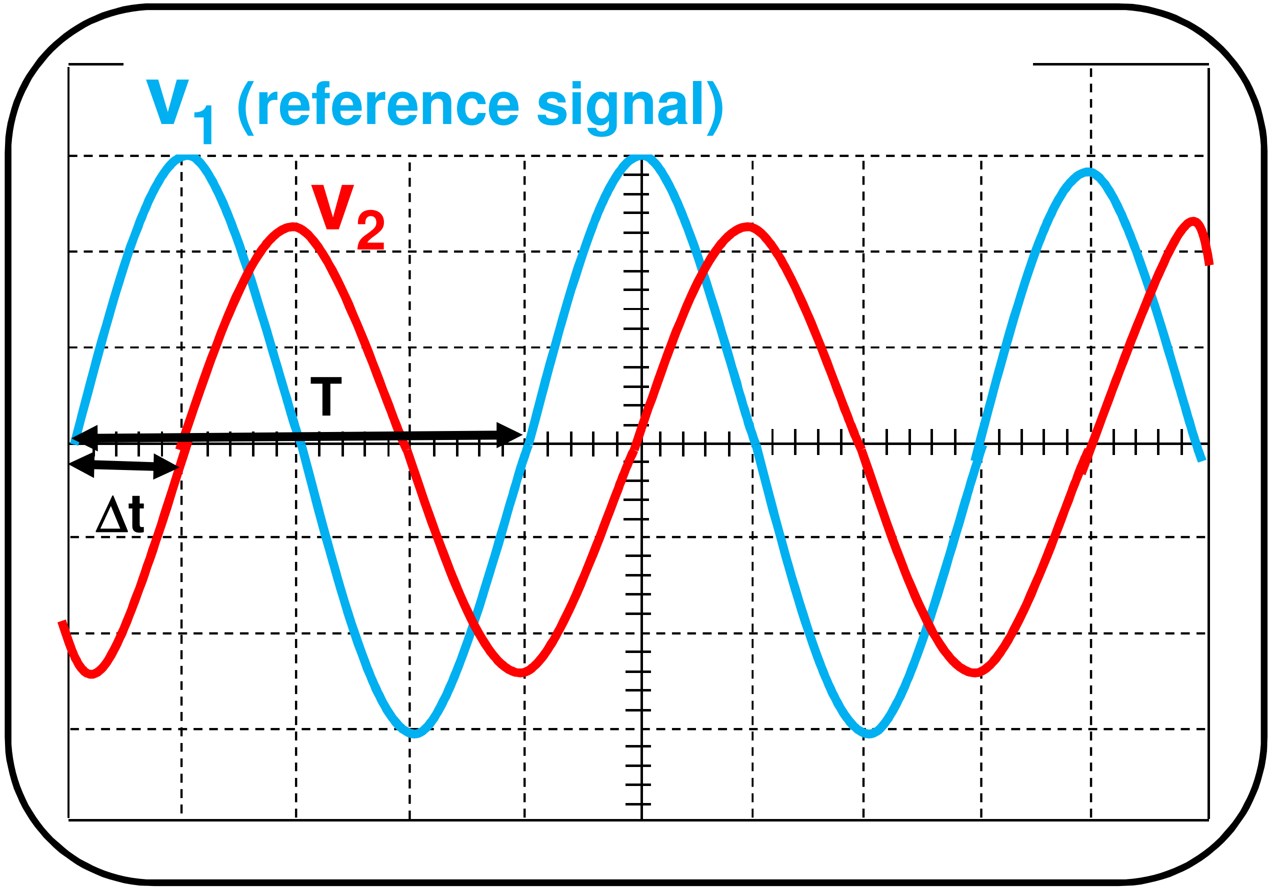
$v_1 = V_{1p} \cdot sen(\omega t)$

$v_2 = V_{2p} \cdot sen(\omega t + \theta)$

$360º \rightarrow T$

$\theta \rightarrow \Delta t$

$$\theta = \frac{360^o \cdot \Delta t}{T}$$

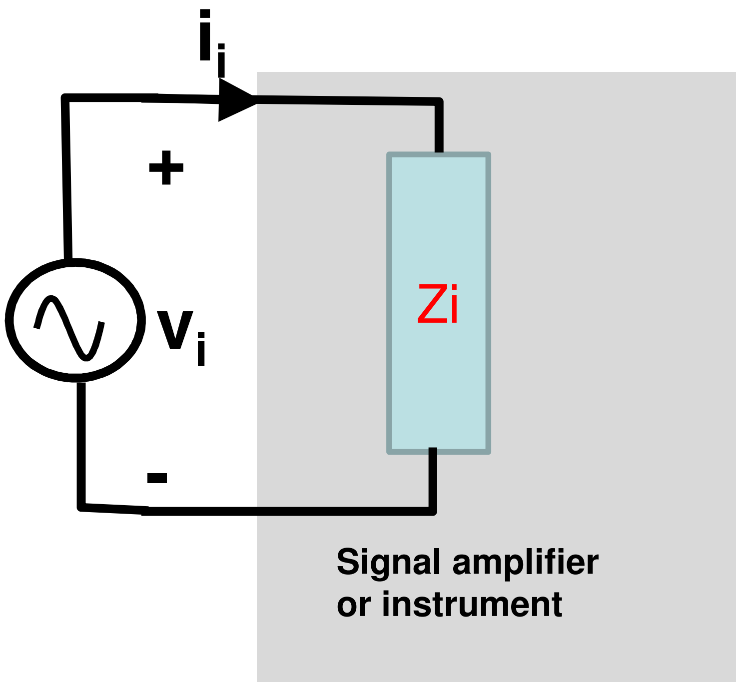


$-180º < \theta < +180º$

Signal delayed with respect to reference signal: θ **negative**

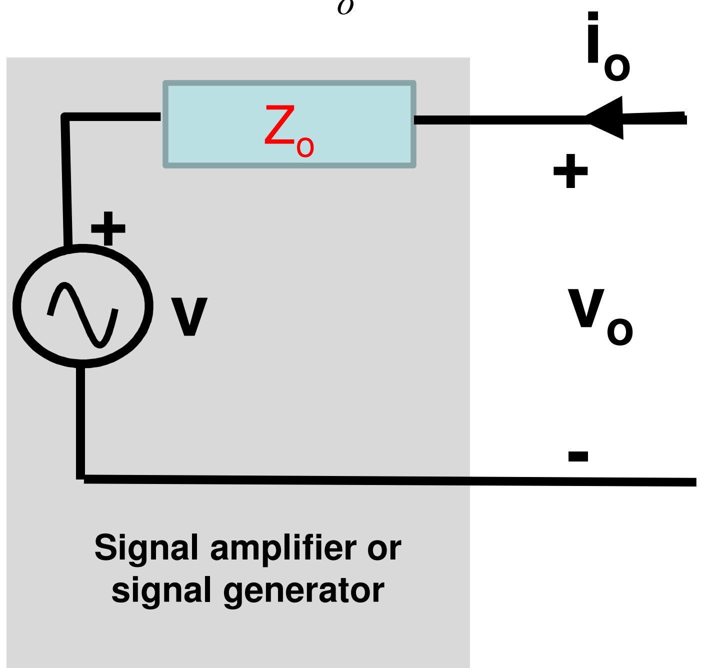
Signal advanced with respect to reference signal: θ **positive**

Input Impedance
Output Impedance



$$Z_i = \frac{v_i}{i_i}$$

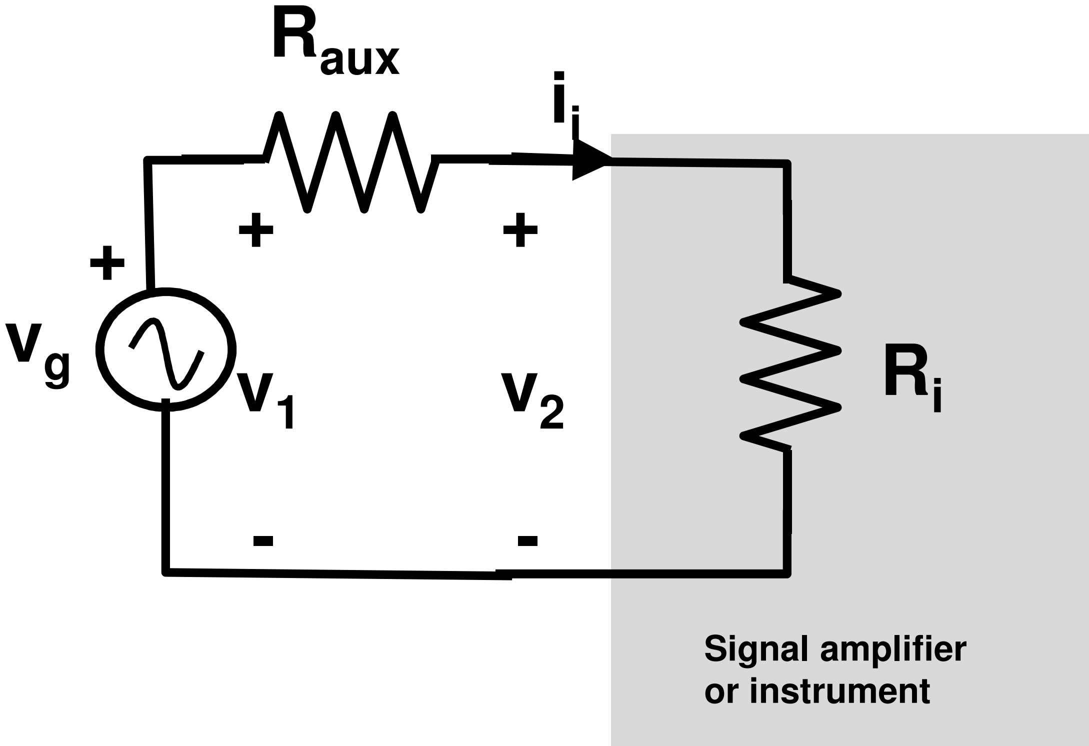
$$Z_o = \frac{v_o}{i_o}$$



Z_i resistive (R_i)

Z_o resistive (R_o)

Input Impedance Measurement



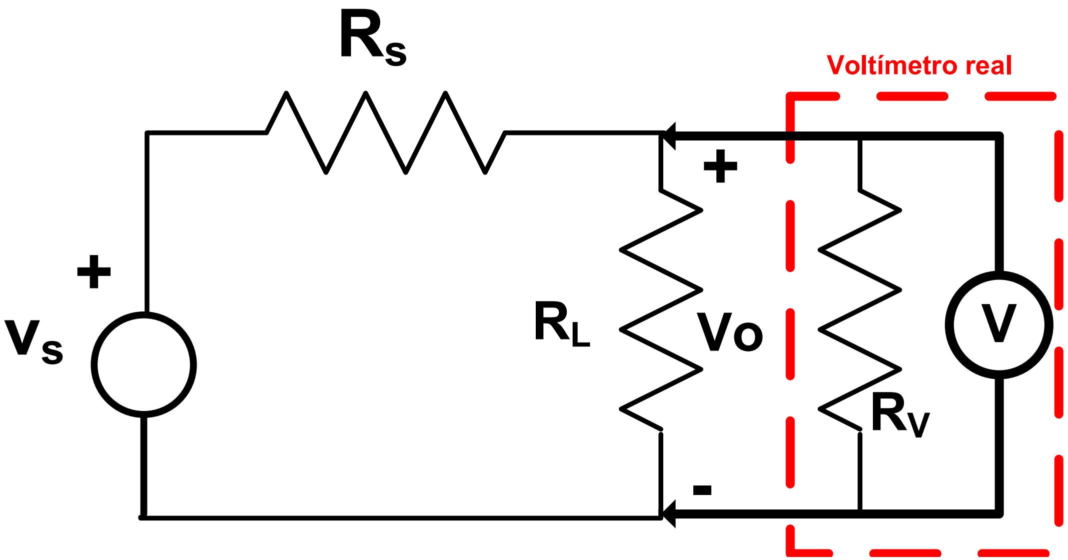
Procedure:

- To add R_{aux} resistor
- To measure v_1 and v_2 (simultaneously)

$$R_i = \frac{v_2}{i_i} = \frac{v_2}{\dfrac{v_1 - v_2}{R_{aux}}} = R_{aux} \cdot \frac{v_2}{v_1 - v_2}$$

- The best $R_{aux} = R_i$

Input Impedance
Load Effect

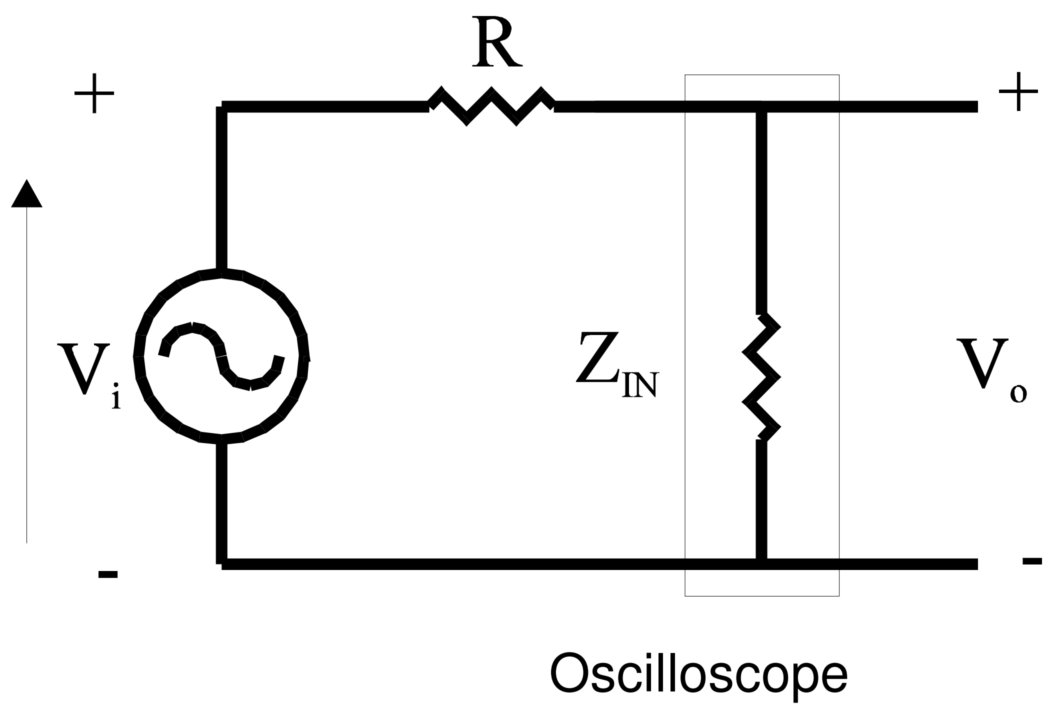


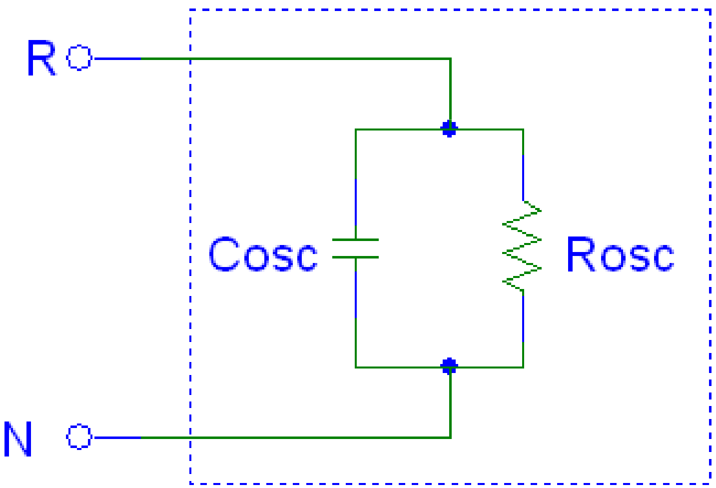
$R_{V:}$ Voltmeter input resistance

v_o theoretic: $v_o = v_s \dfrac{R_L}{R_s + R_L}$

Load effect, v_o voltmeter measurement: $v_o = v_s \dfrac{R_L \parallel R_V}{R_s + R_L \parallel R_V}$

Oscilloscope Input Impedance



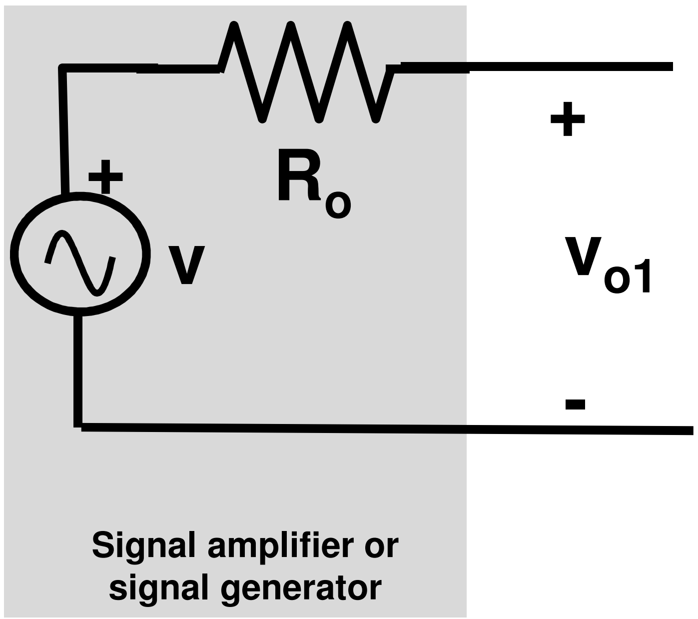


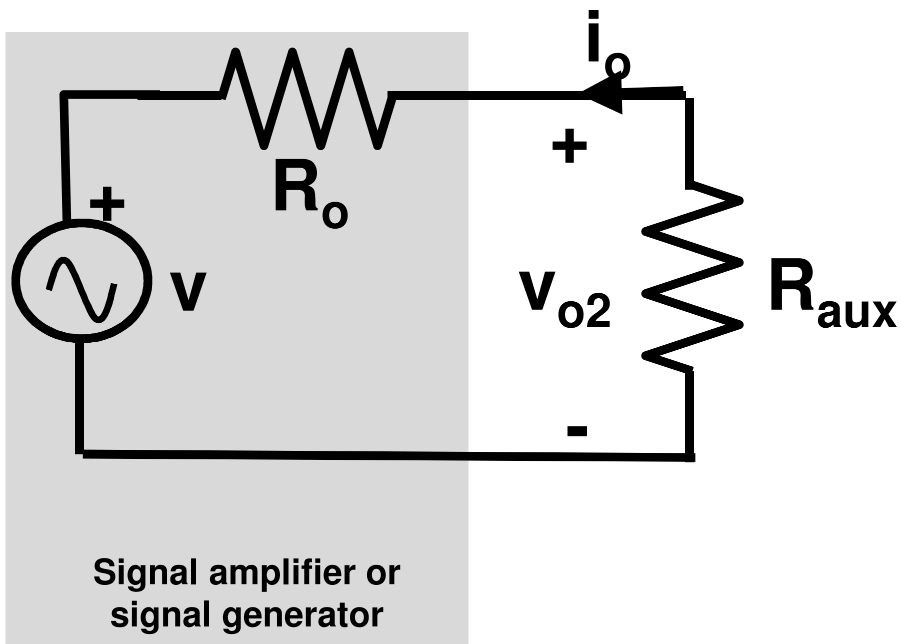
Example: $R_{Osc} \approx 1\ M\Omega$

$C_{Osc} = 25pF$

- Z_{IN} expression (magnitude and phase)
- Frequency effect: Low pass
- ¿Measurements to obtain Z_{IN}?

Output Impedance Measurement





Procedure:

- To measure $v_{o1} = v$
- To add R_{aux}
- To measure v_{02}

$$R_o = \frac{v_{o2} - v}{i_o} = \frac{v_{o2} - v_{o1}}{-\dfrac{v_{o2}}{R_{aux}}} = R_{aux} \cdot \frac{v_{o1} - v_{o2}}{v_{o2}}$$

- The best $R_{aux} = R_o$