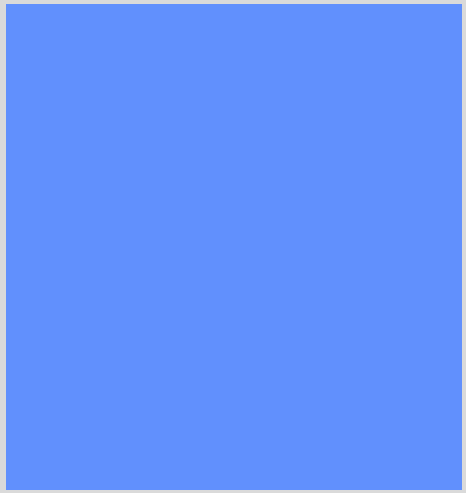
USE AND ABUSE OF OSCILLOSCOPES

Featuring the HP 54600B

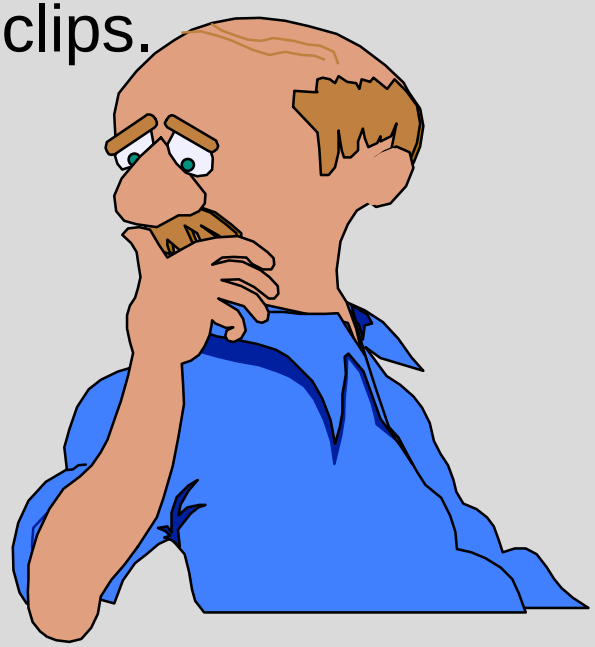
Digital Oscilloscope



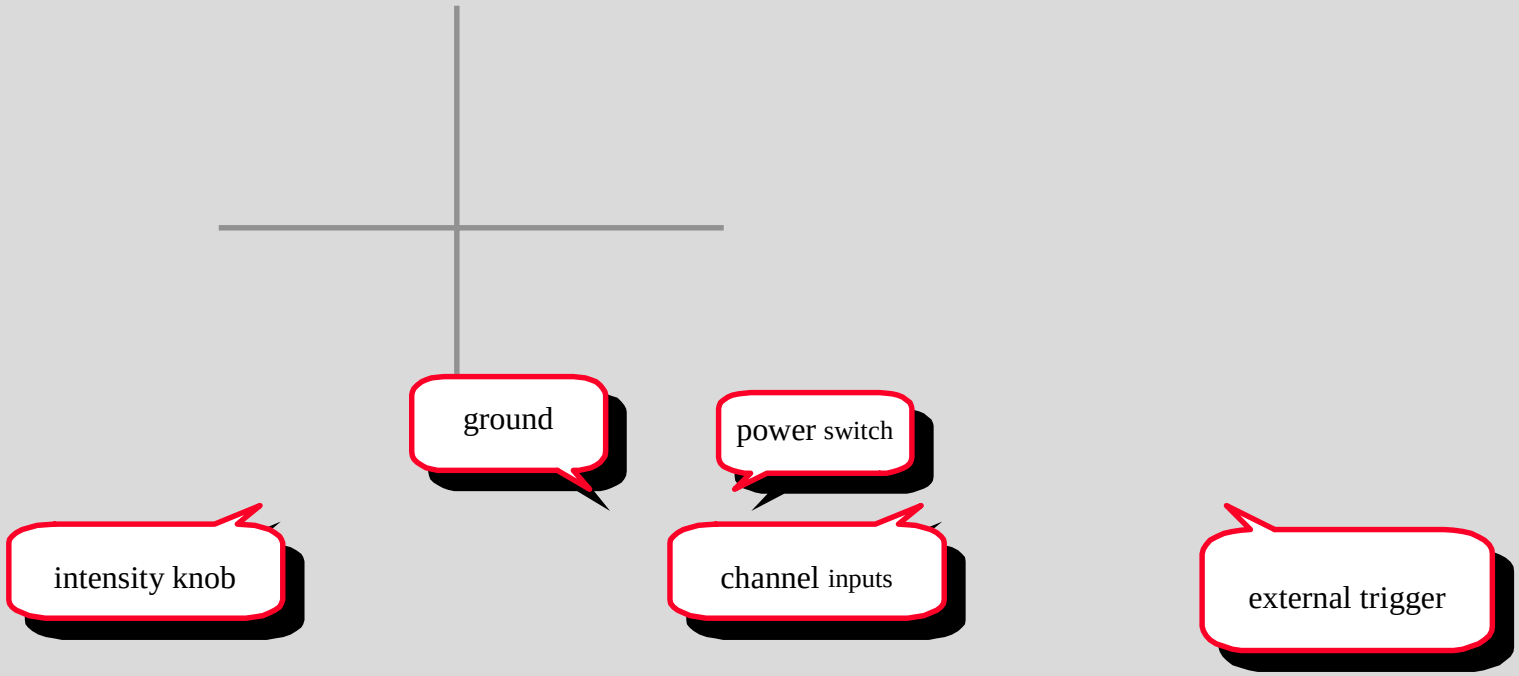
Safety Tips

Protect Yourself
Avoid contact with Voltage or Current Sources

- Use shrouded test leads and alligator clips.
- Connect leads to oscilloscope first.
- Connect probe to ground before connecting to high.
- Familiarize yourself with the manual.

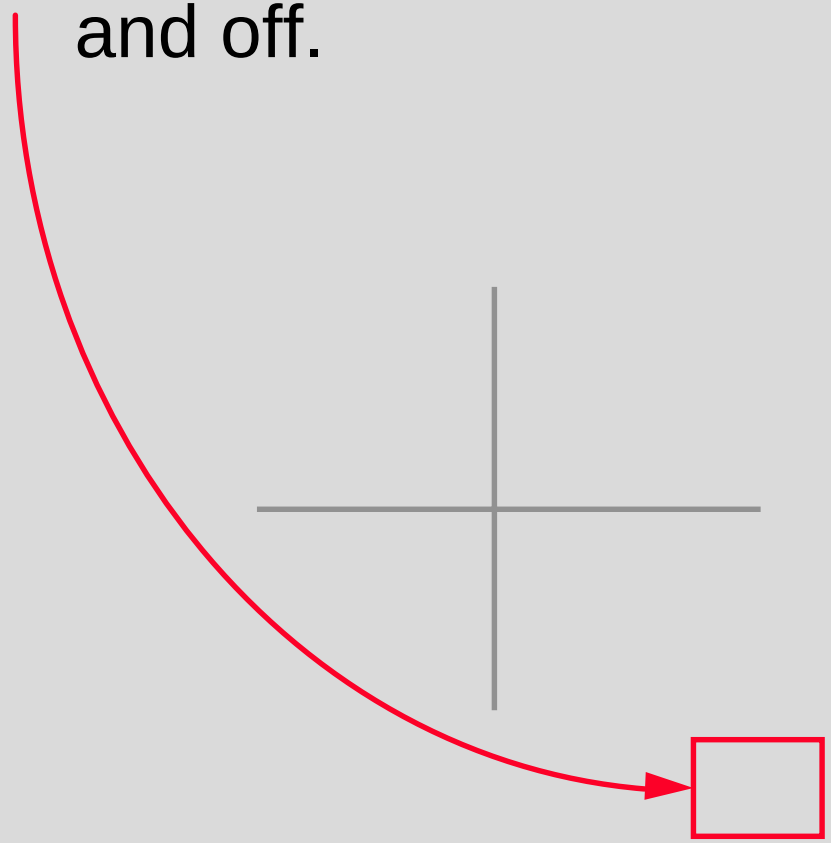


Introduction


ground
power switch
intensity knob
channel inputs
external trigger

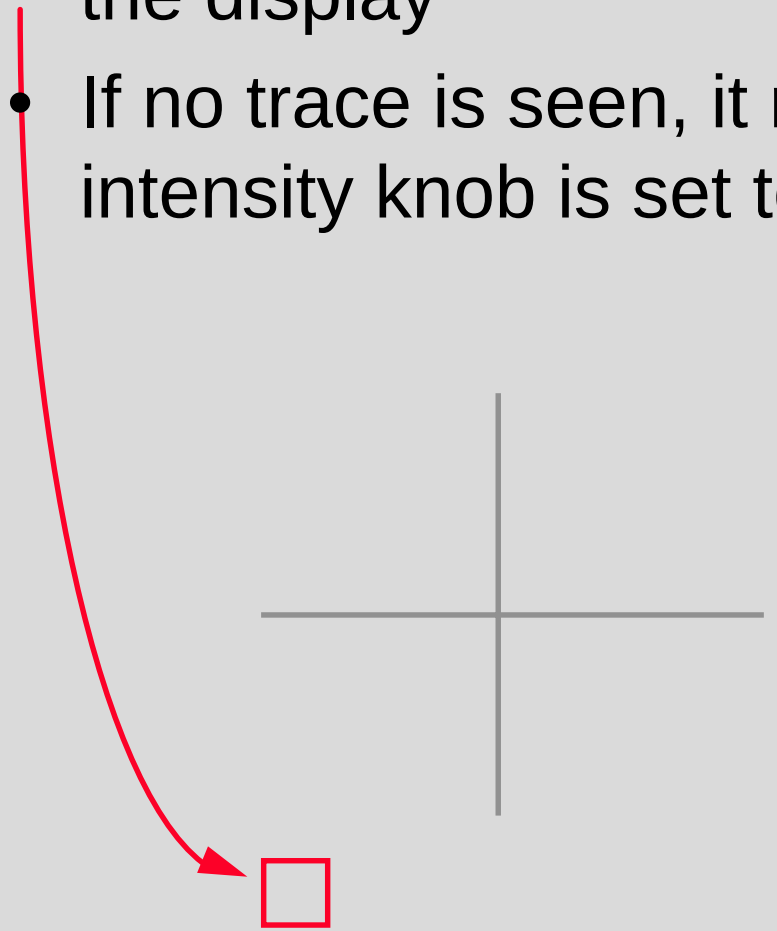
Power Switch

- This switch turns the oscilloscope on and off.



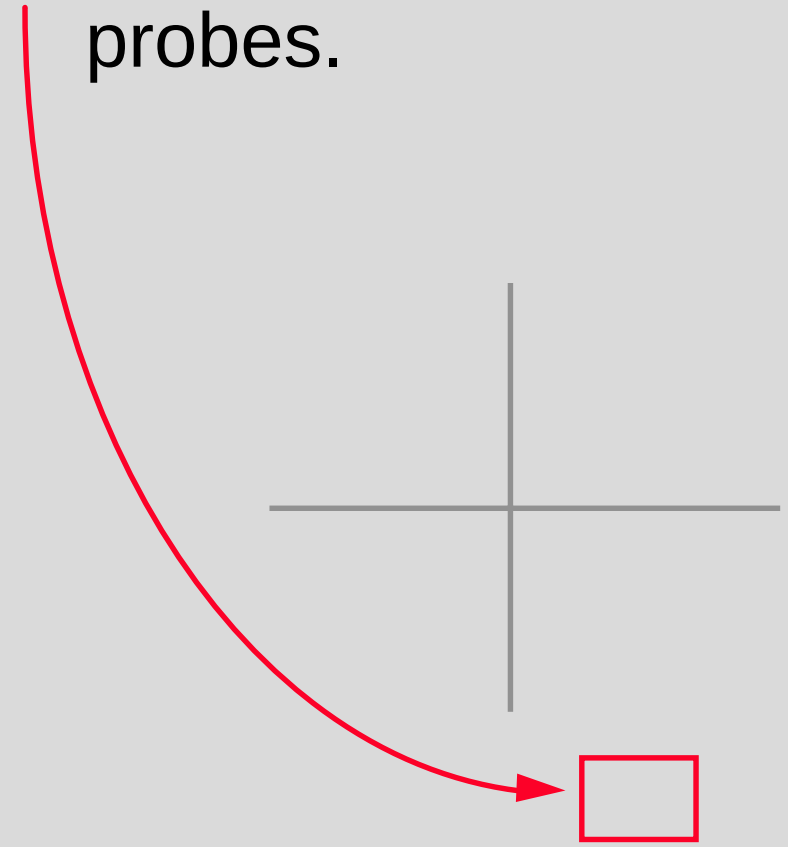
Intensity Knob

- This knob adjusts the brightness of the display
- If no trace is seen, it may be because the intensity knob is set too low.



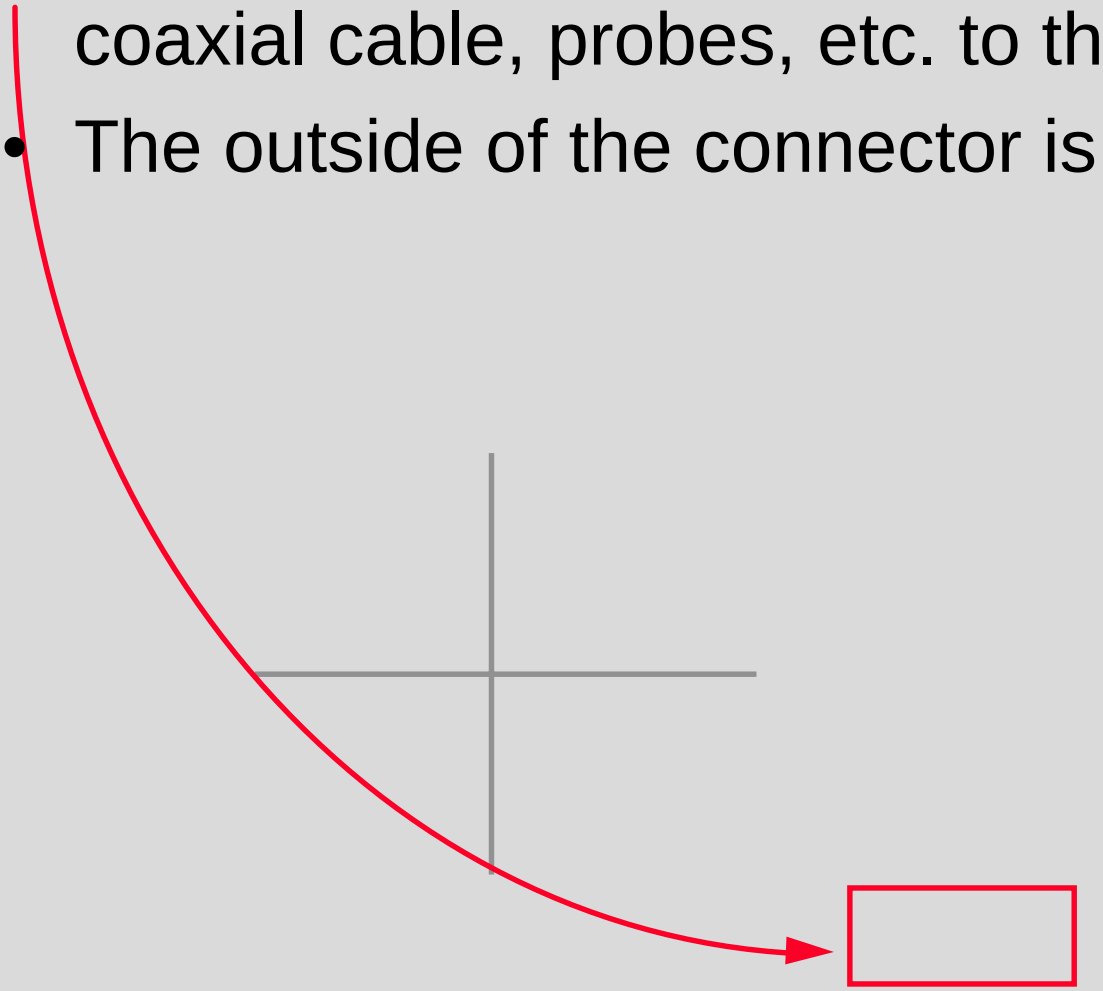
Ground Connection

- This connection may be used to ground probes.



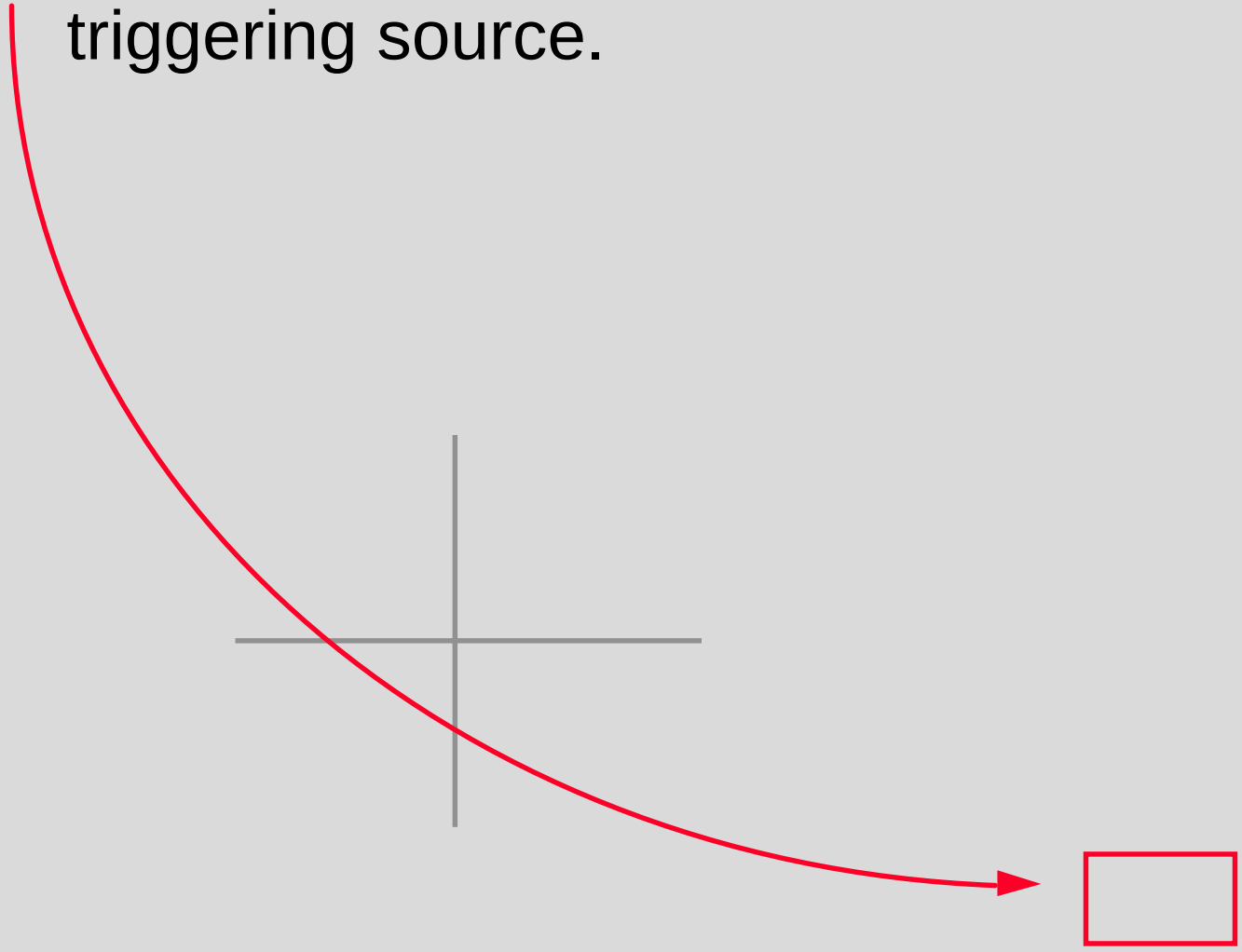
Signal Inputs (1 & 2)

- These connections are used to connect coaxial cable, probes, etc. to the oscilloscope.
- The outside of the connector is grounded.

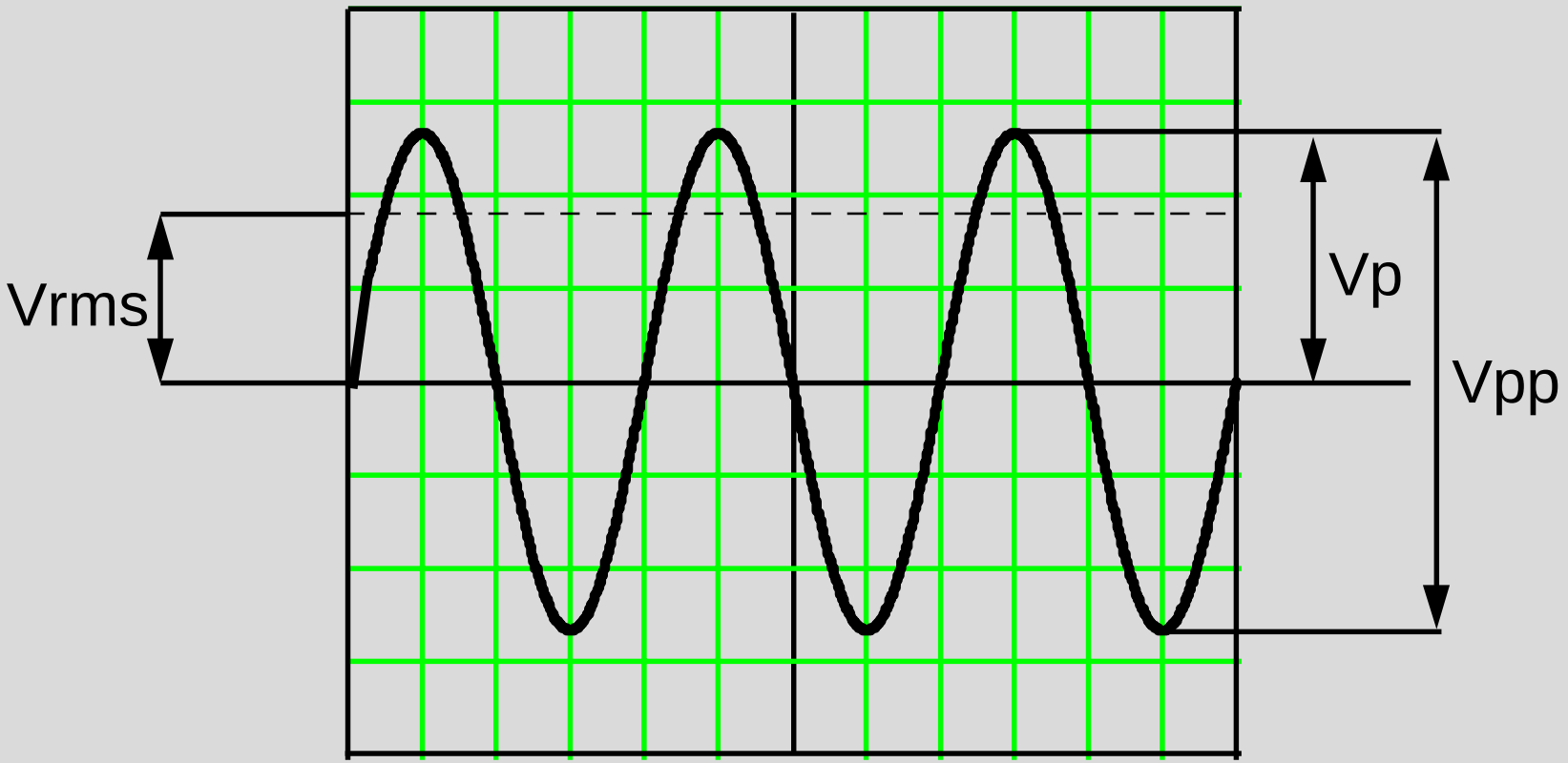


External Trigger

- This connector is used to connect an external triggering source.

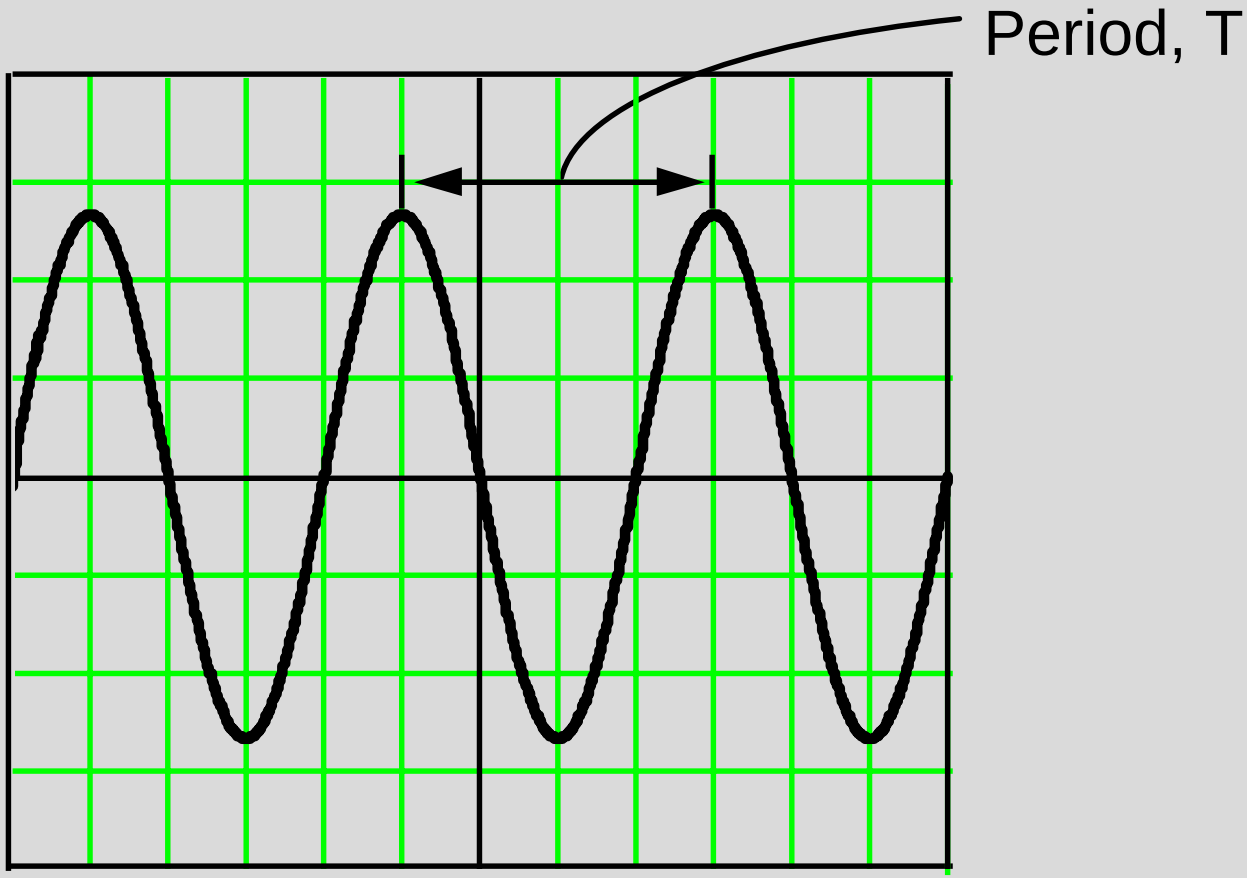


Voltage Indicators



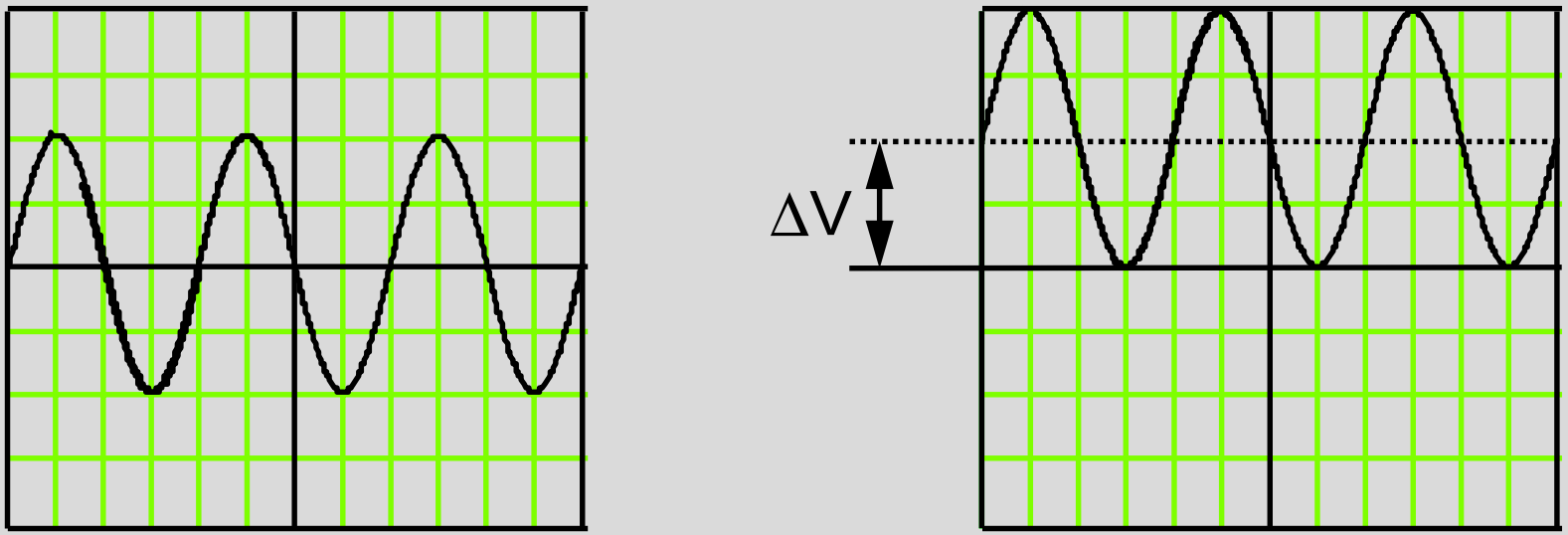
Vrms = Vp · .707 (Sine wave)

Frequency and Period

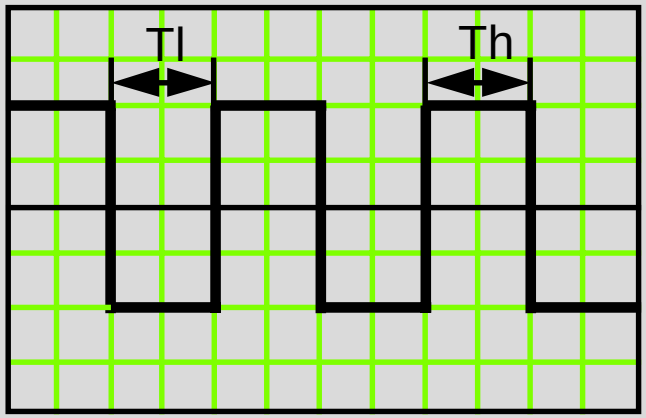


$f = 1/T$ $\omega = 2\pi f$

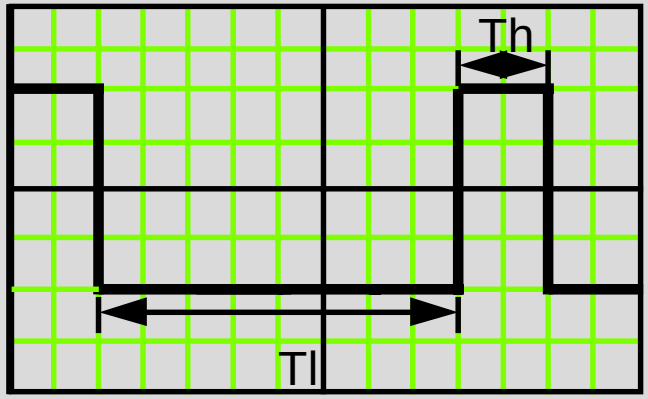
DC Offset



Duty Cycle



50 % (Square Wave) Tl = Th

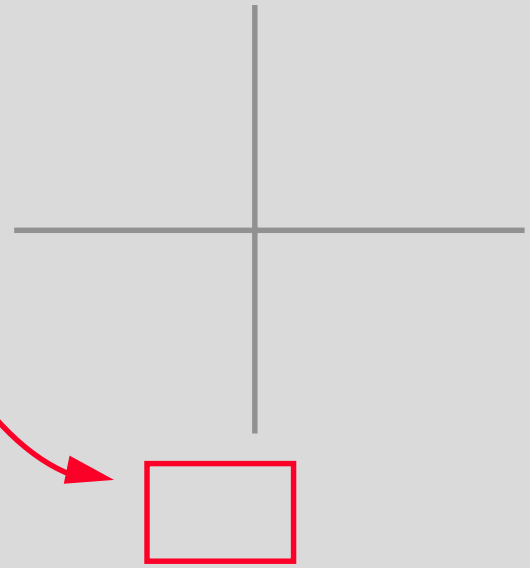


Less than 50% (Pulse Train) Tl ≠ Th

Calibration

Oscilloscope Calibration

- To check the oscilloscope calibration, connect a probe to channel one and to the calibration prong.
- If the oscilloscope does not read approx. 5V and 1.2 kHz, notify lab supervisor.



Probe Calibration

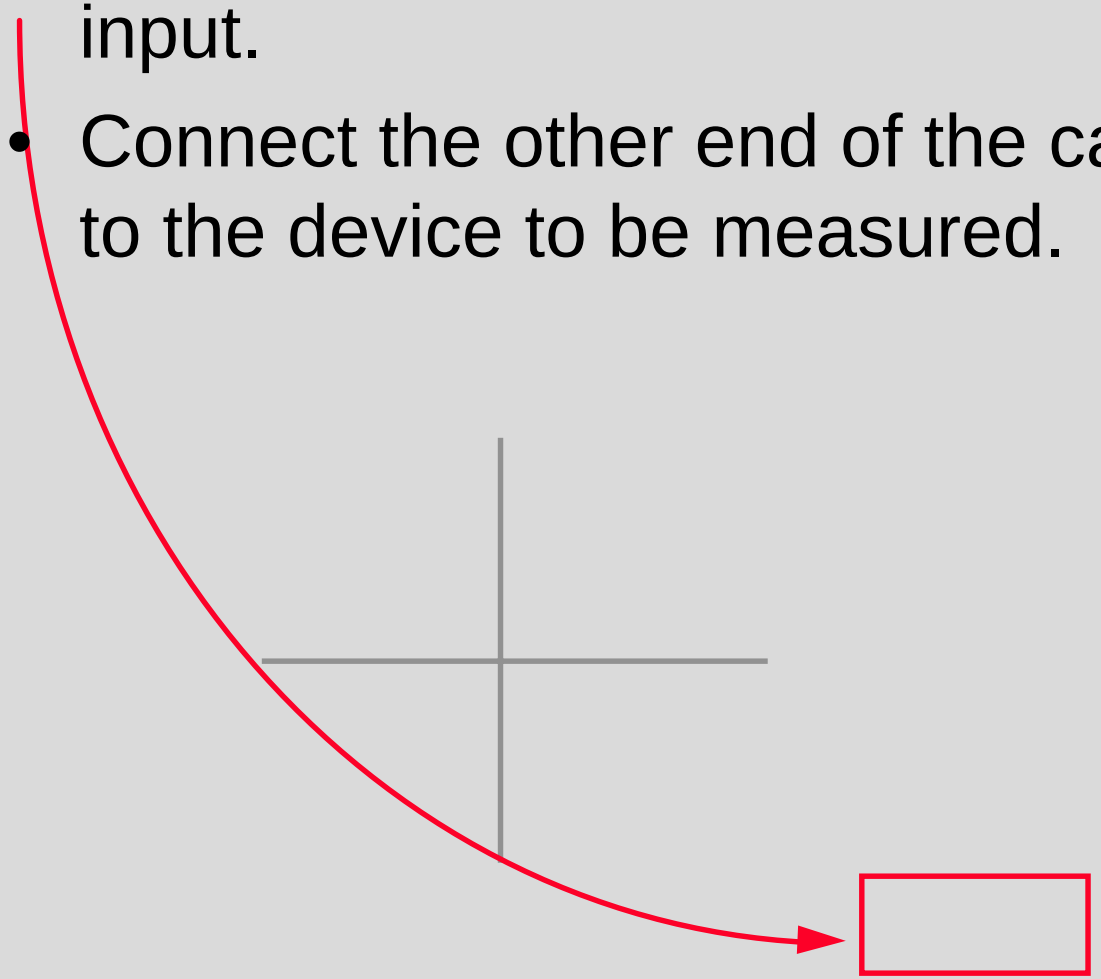
- With the probe still connected to the calibration prong, check to see if the wave is square.
- If the wave is not square, use a small screwdriver to adjust the probe until the wave is square.

Properly Calibrated Overcompensated Undercompensated

General Oscilloscope Overview

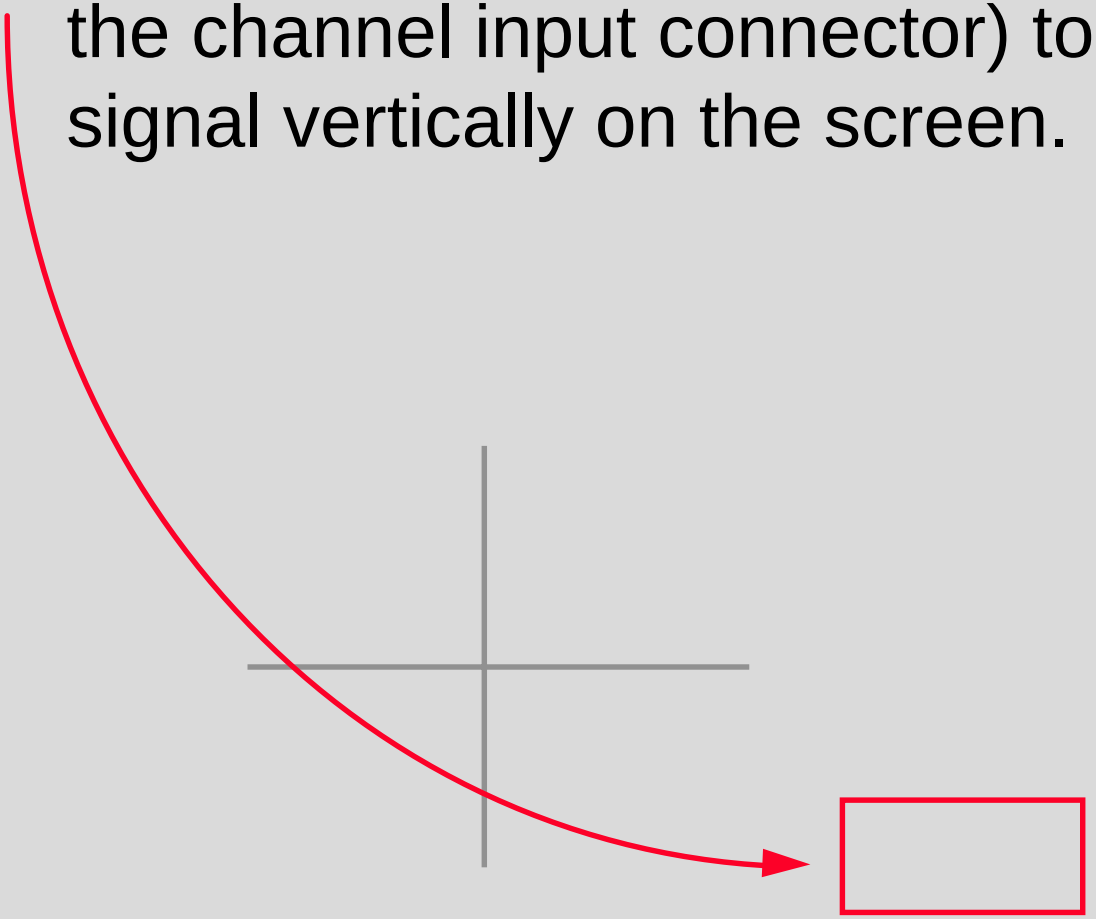
Connecting a Signal

- Make sure the input voltage level ≤400 V.
- Connect a BNC cable or a probe to a channel input.
- Connect the other end of the cable or probe to the device to be measured.



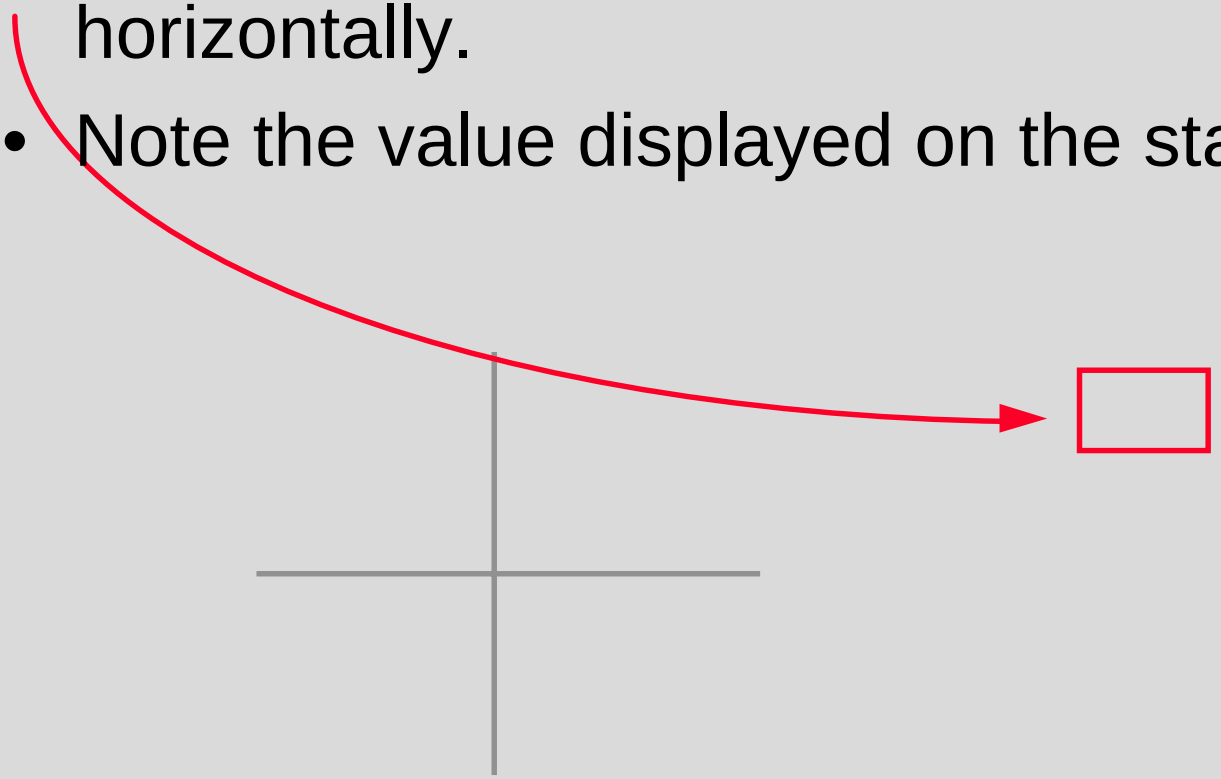
Positioning a Signal Vertically

- Use the vertical position knob (located above the channel input connector) to position the signal vertically on the screen.



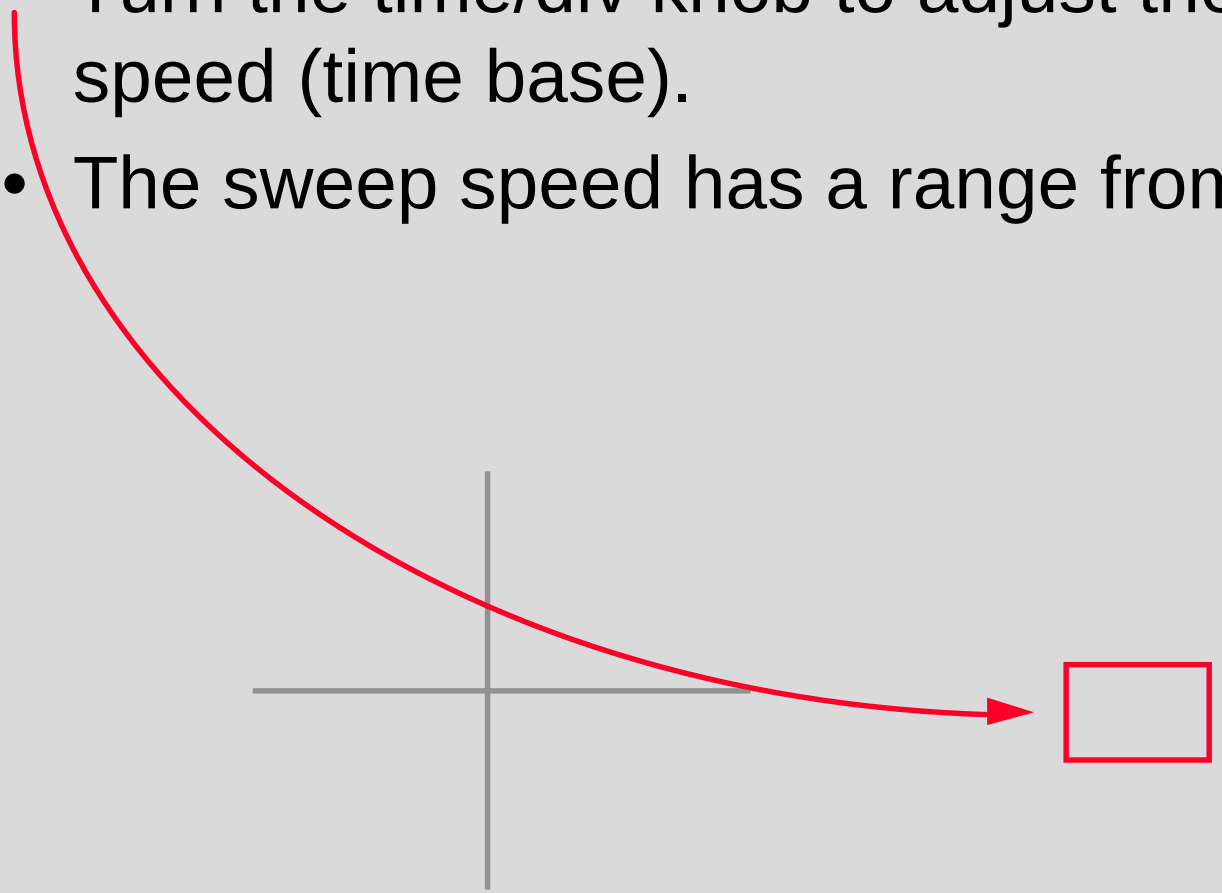
Positioning a Signal Horizontally

- Use the delay knob to move the signal horizontally.
- Note the value displayed on the status line.



Setting the Time Base

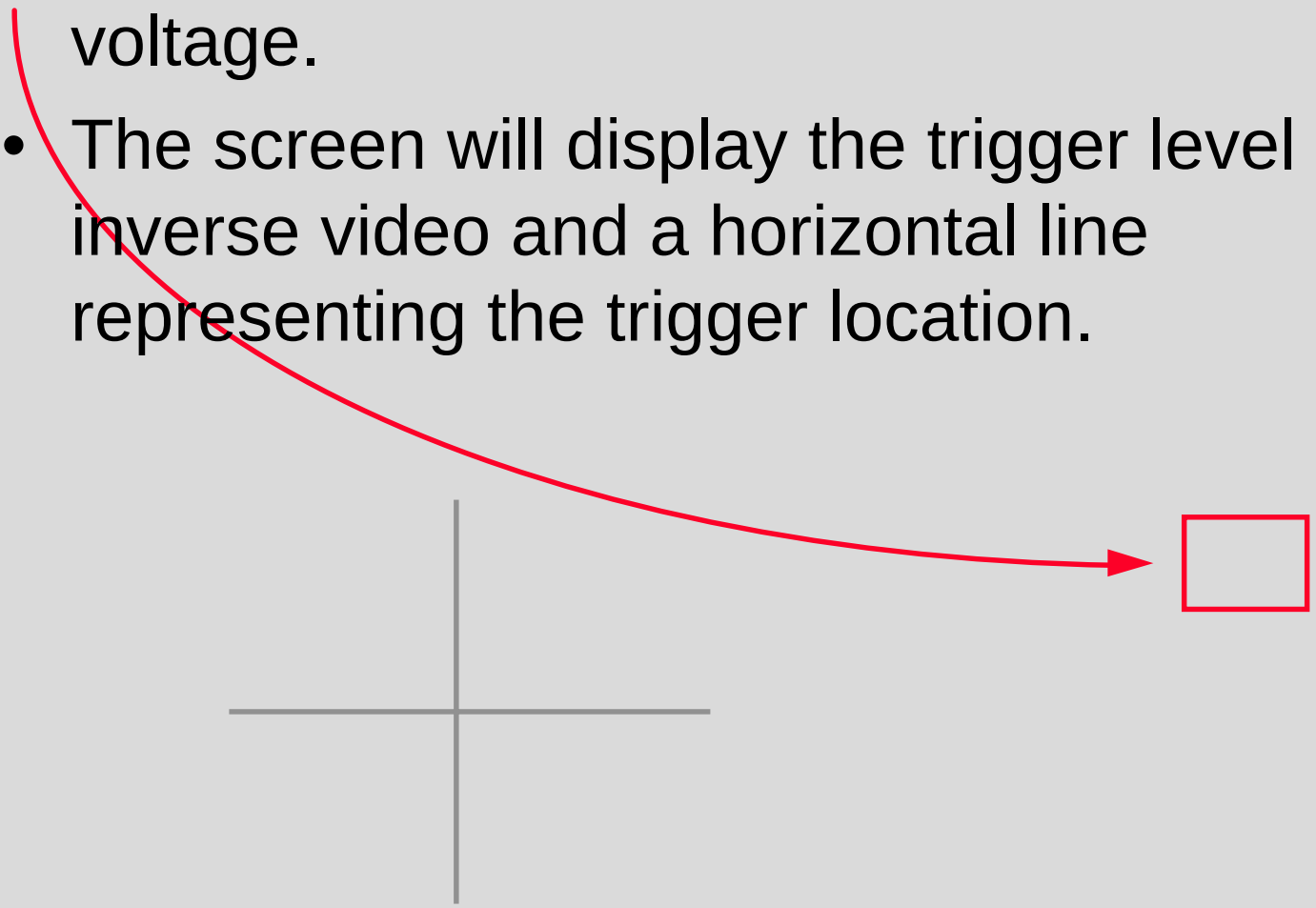
- Turn the time/div knob to adjust the sweep speed (time base).
- The sweep speed has a range from 2ns to 5s.



Triggering the Signal

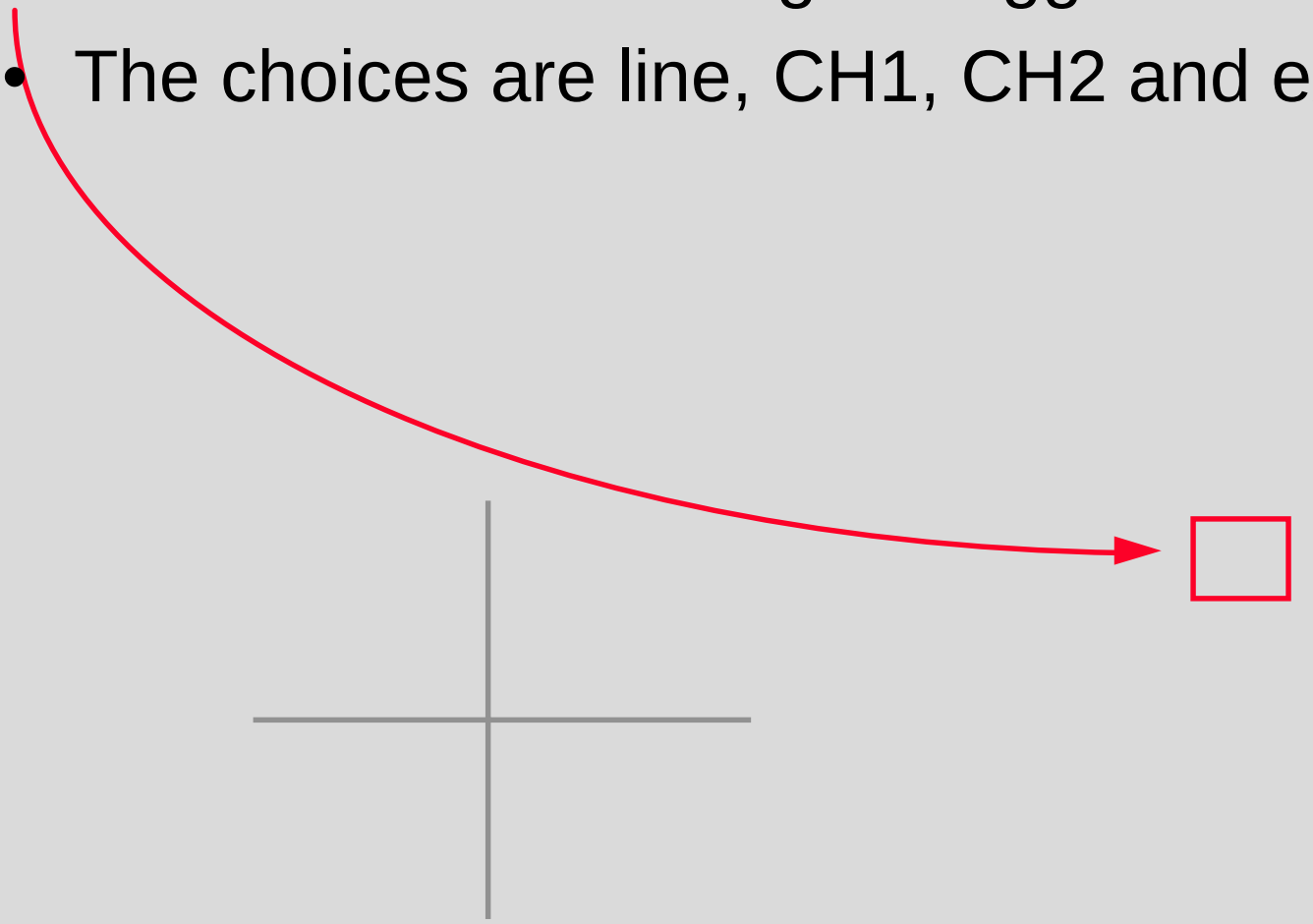
Using the Level Knob

- Use the level knob to set the trigger voltage.
- The screen will display the trigger level in inverse video and a horizontal line representing the trigger location.



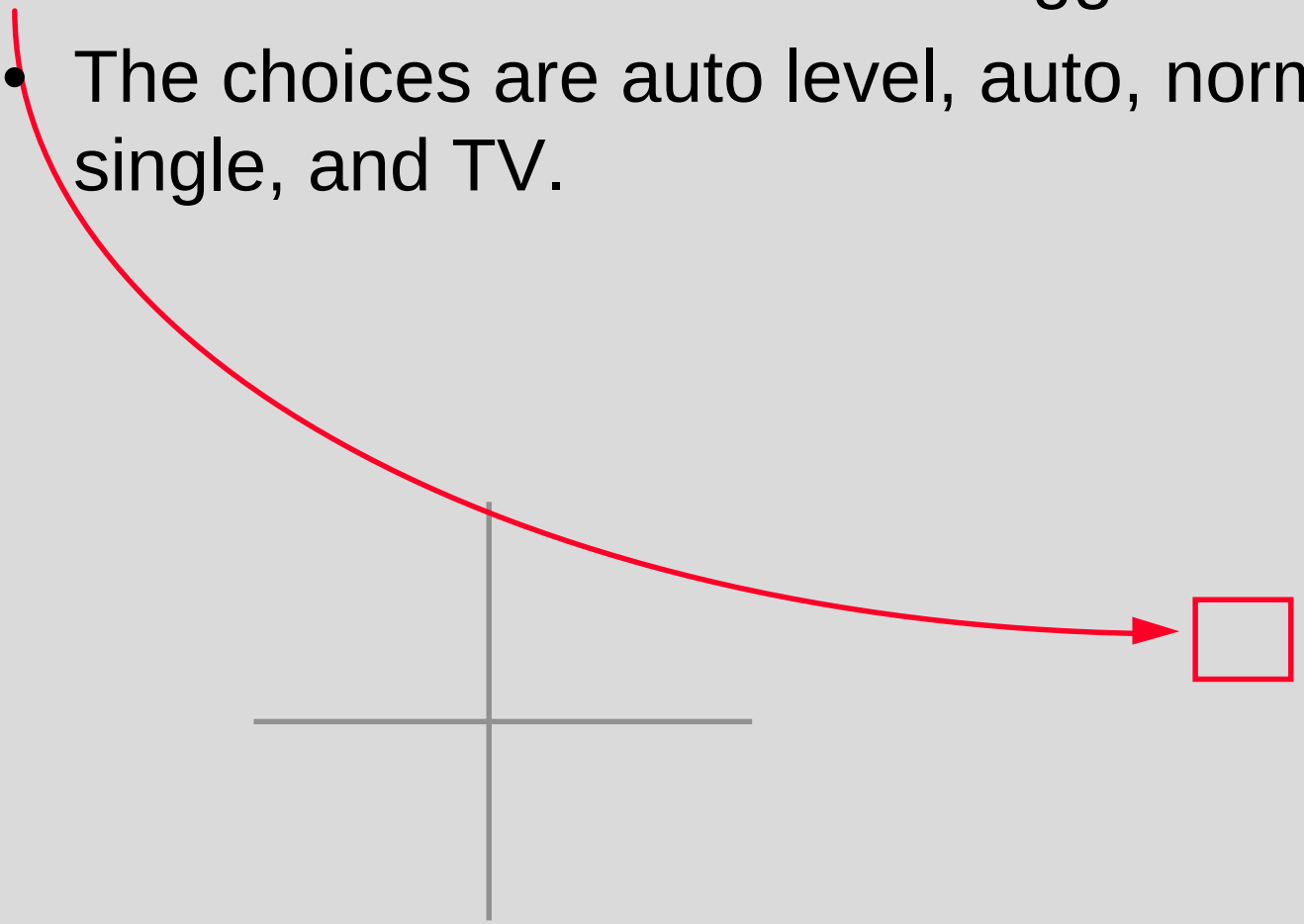
Source Menu

- Use this menu to assign a trigger source.
- The choices are line, CH1, CH2 and external.



Mode Menu

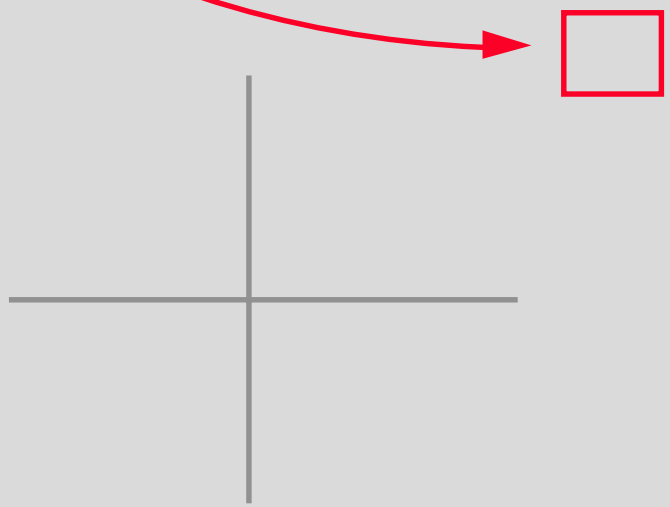
- Use this menu to choose a trigger mode.
- The choices are auto level, auto, normal, single, and TV.



Making Automatic Measurements

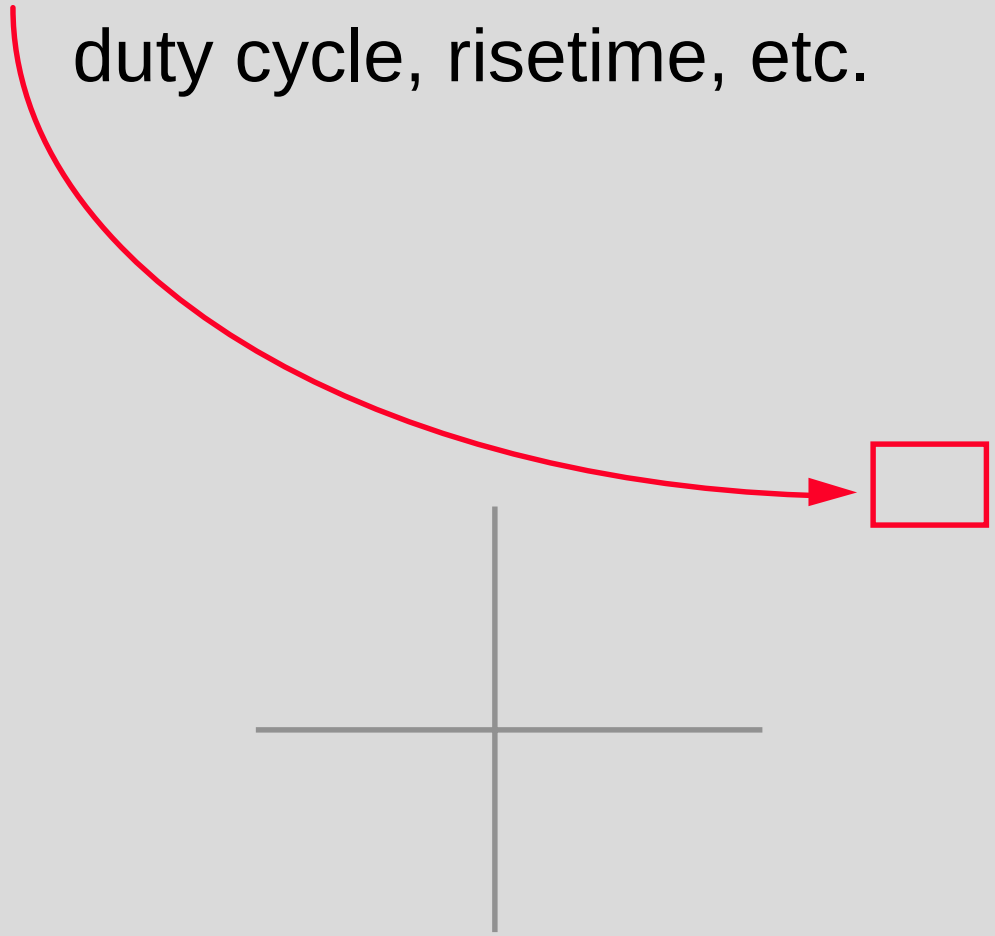
Voltage Menu

- Use this menu to make automatic voltage measurements.
- Measurements include peak to peak voltage, rms voltage, max voltage, etc. The choice is made using the softkeys below the display.



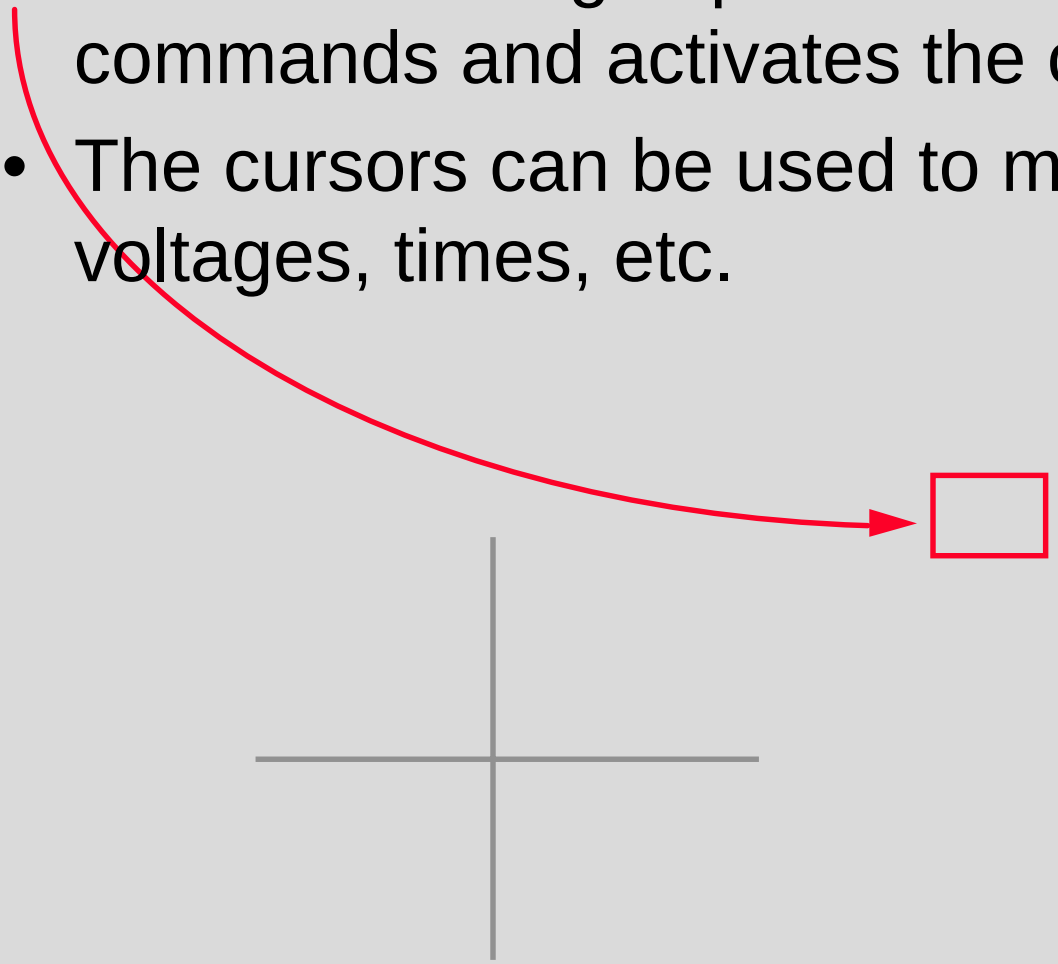
Time Menu

- Use this menu to measure frequency, period, duty cycle, risetime, etc.

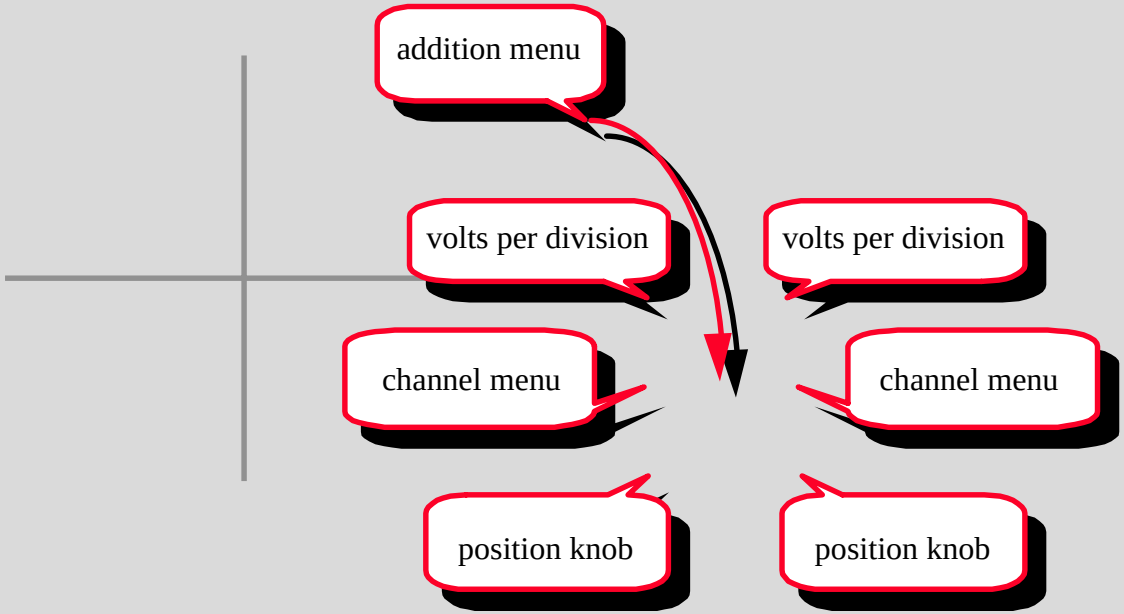


Cursor Menu

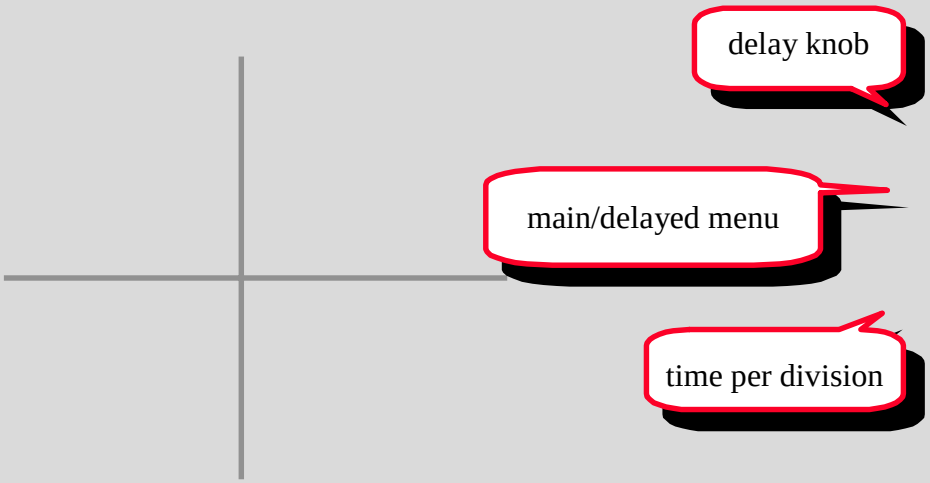
- This menu brings up a list of cursor commands and activates the cursor knob.
- The cursors can be used to measure specific voltages, times, etc.



Vertical Section


addition menu
volts per division
channel menu
position knob
volts per division
channel menu
position knob

Horizontal Section


delay knob
main/delayed menu
time per division

Trigger Section

source menu

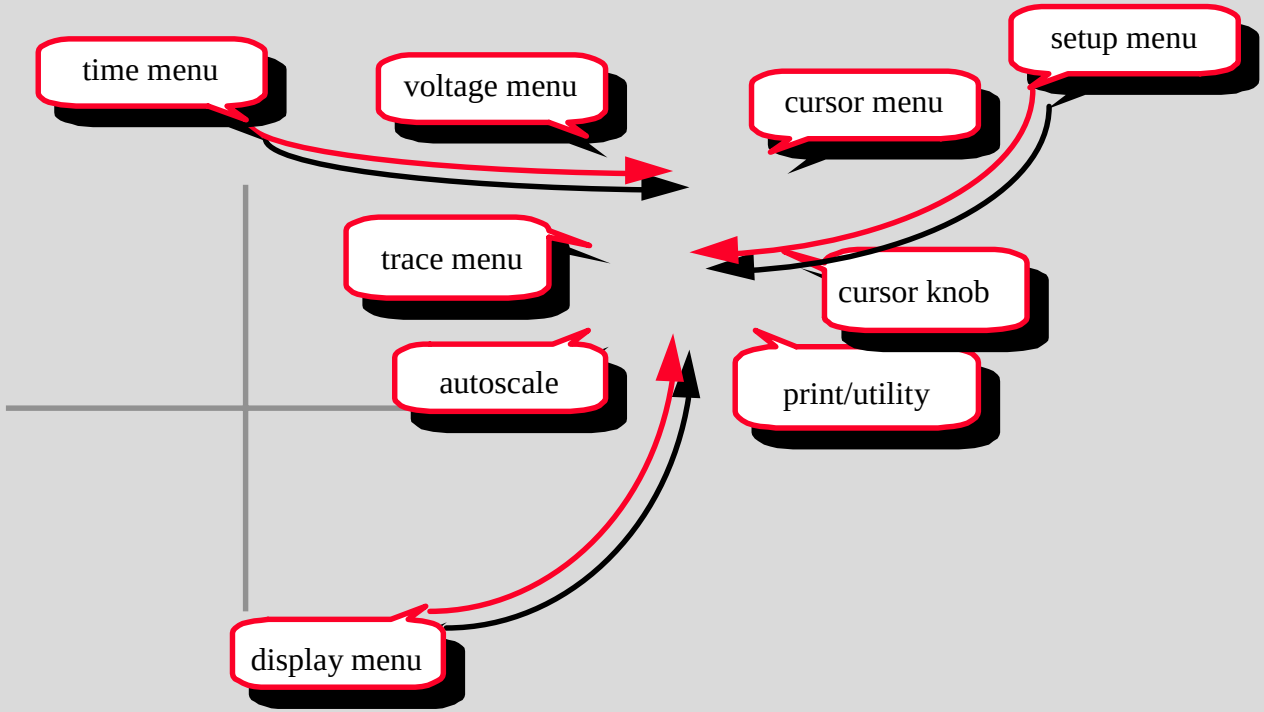
trigger level knob

mode menu

slope/coupling menu

holdoff knob

Miscellaneous Sections


time menu
voltage menu
cursor menu
setup menu
trace menu
cursor knob
autoscale
print/utility
display menu

Storage Section

run key

erase key

stop key

autostore

Presentation by
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Senior, Manufacturing Systems Engineering, GMI
Jeff Hana
Freshman, Engineering, GMI

Equipment Provided by
Hewlett-Packard, Electronic Measurement Division

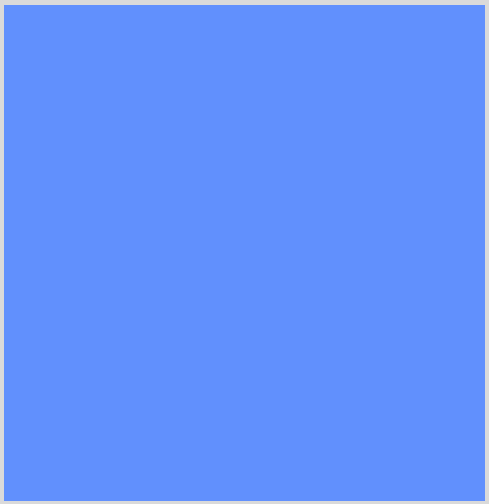
For More Information

- HP 54600B User's Guide
- HP 54654A Training Kit
- HP H1300A video: "Use & Abuse of Digitizing Oscilloscopes"

USE AND ABUSE OF OSCILLOSCOPES

Featuring the HP 54600B

Digital Oscilloscope



Introduction

- Safety Tips
- Front & Rear Panel Layout
- Signal Features

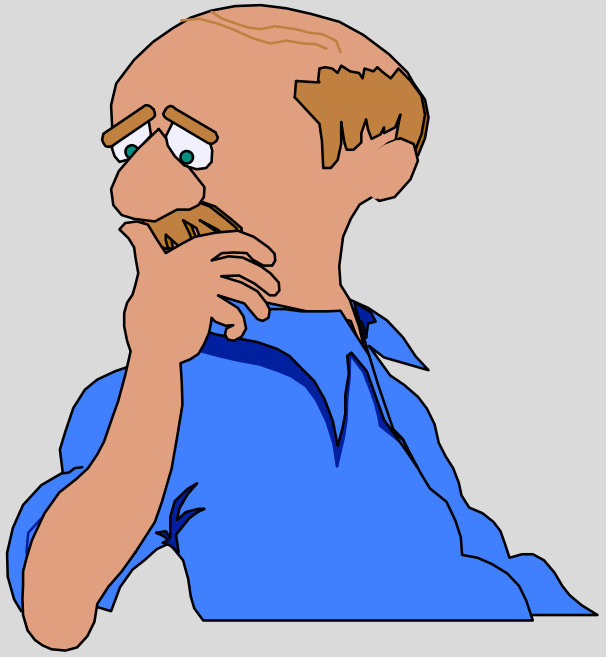
Safety Tips

Protect Yourself: Avoid contact with Voltage or Current Sources

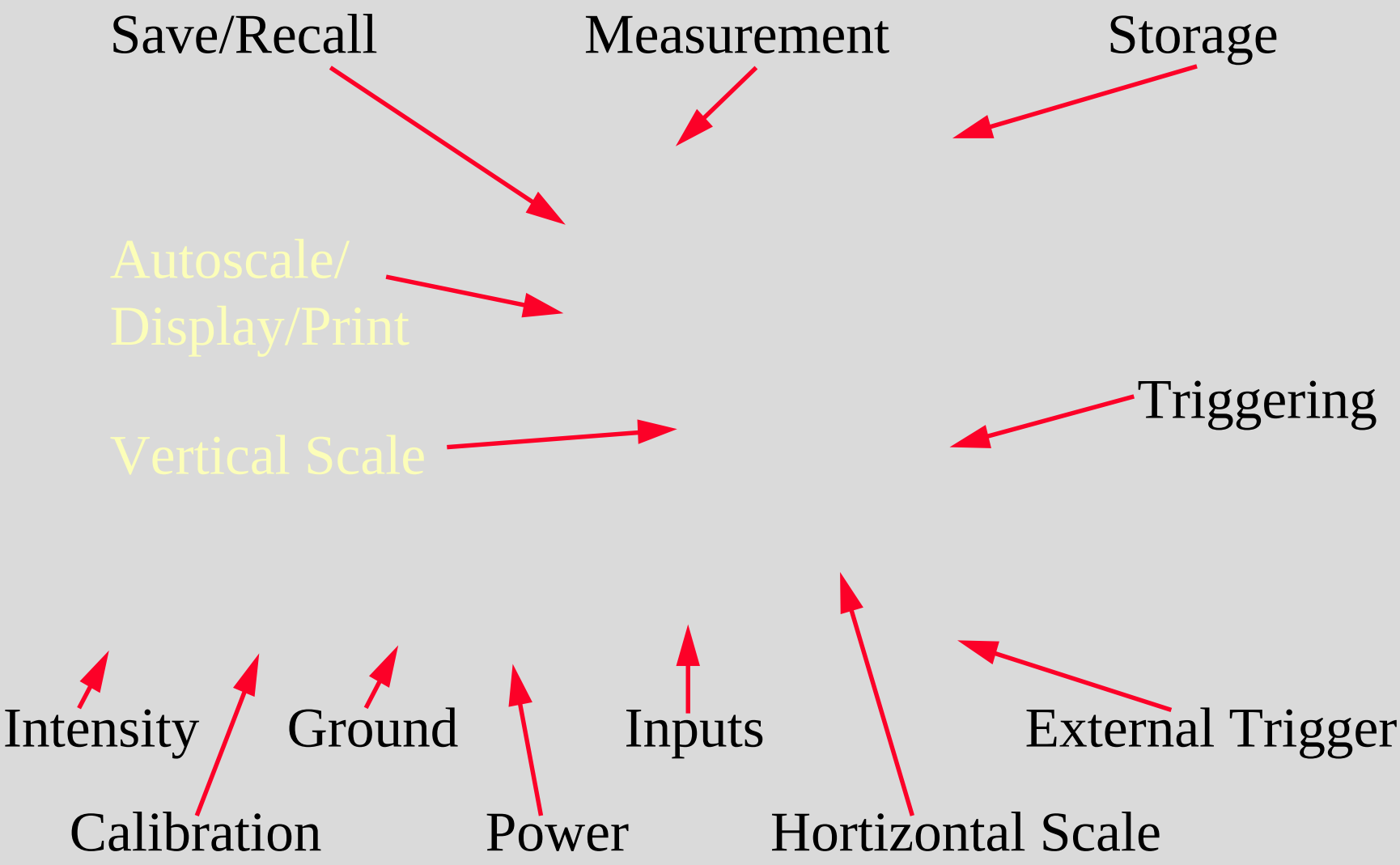
- Use shrouded test leads and alligator clips.
- Leads: Connect to oscilloscope first;
  Connect/disconnect at source so loose lead is dead.
- Connect probe to ground before connecting to high.

Protect the Scope:

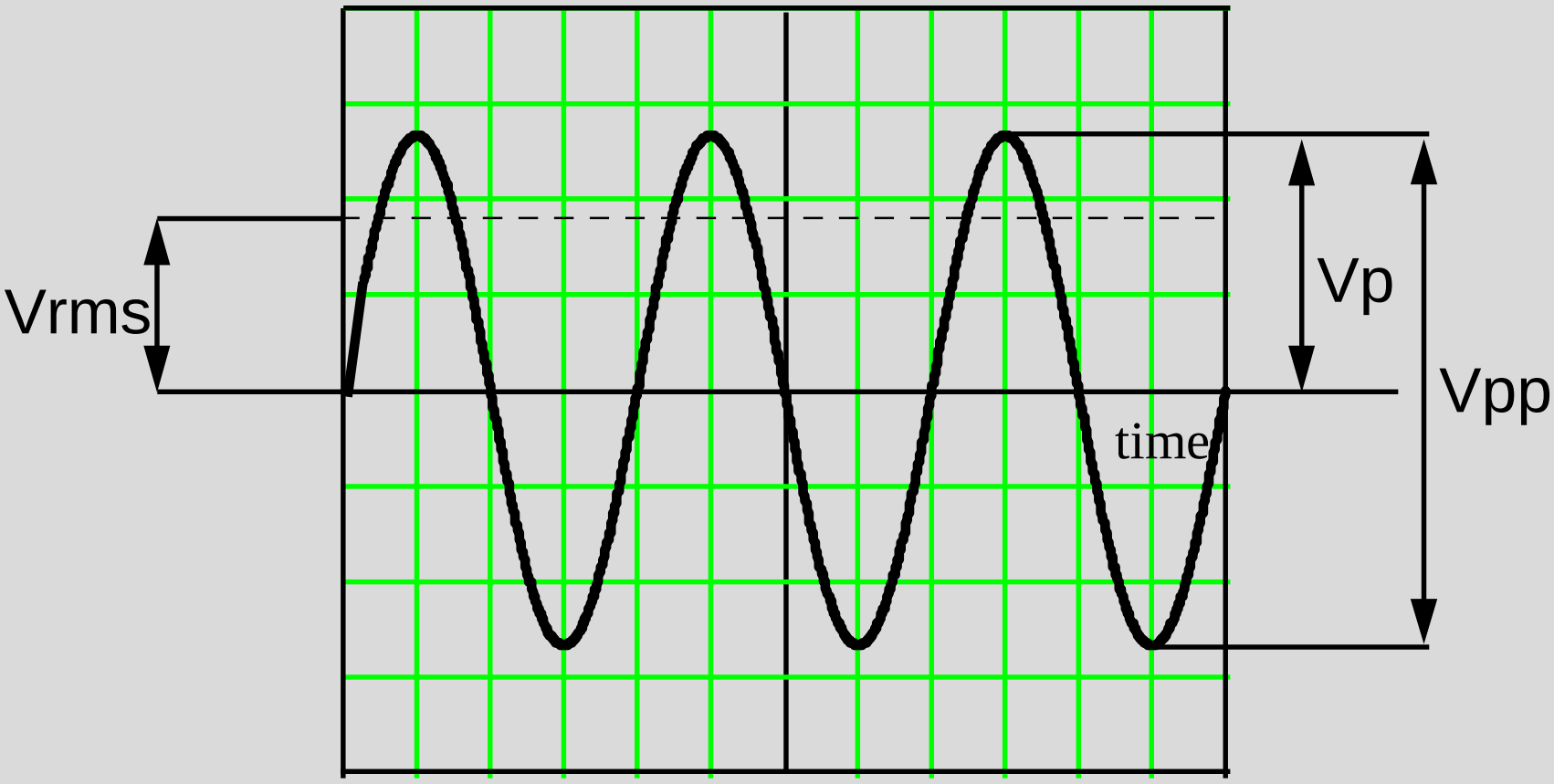
- 400V maximum on input.
- Use probes to reduce high voltages.
- Be familiar with user's guide.



Front Panel Features

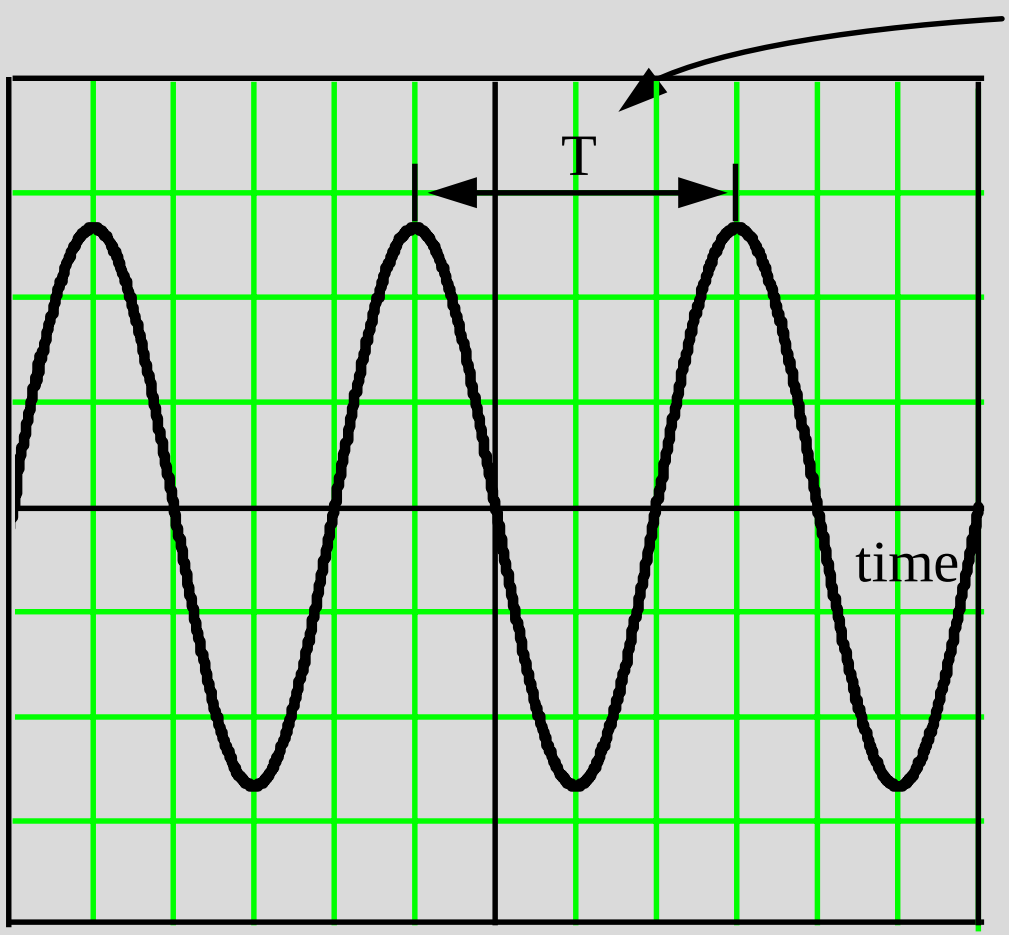


Voltage Indicators



Vrms = 0.707 Vp (Sine wave)

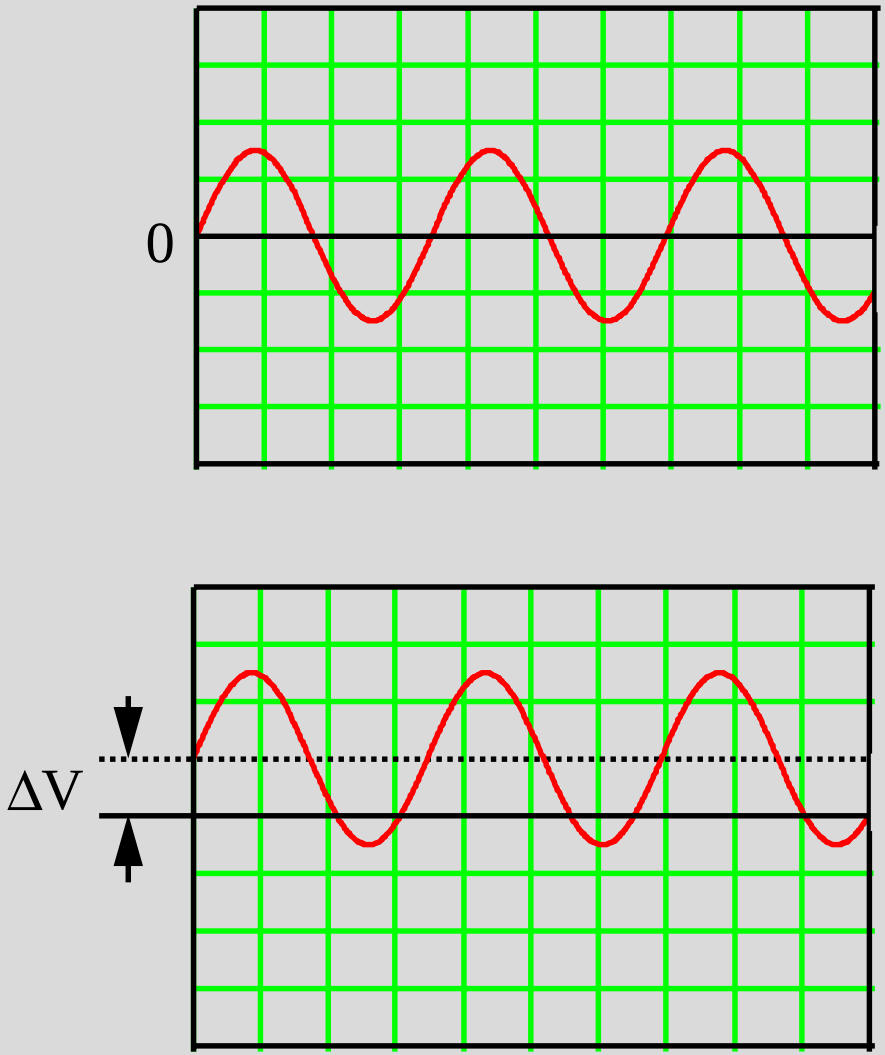
Frequency and Period



$$f = \frac{1}{T} \text{ Hz}$$

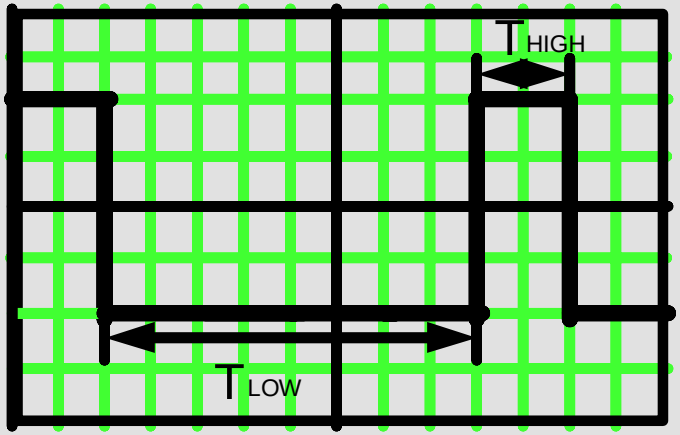
$$\omega = 2'\pi'f \text{ rad/s}$$

DC Offset



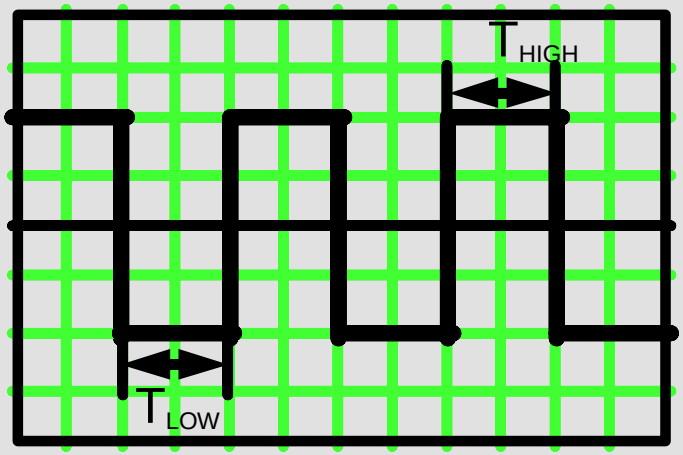
Duty Cycle - Pulse Waveforms

20%
Duty Cycle



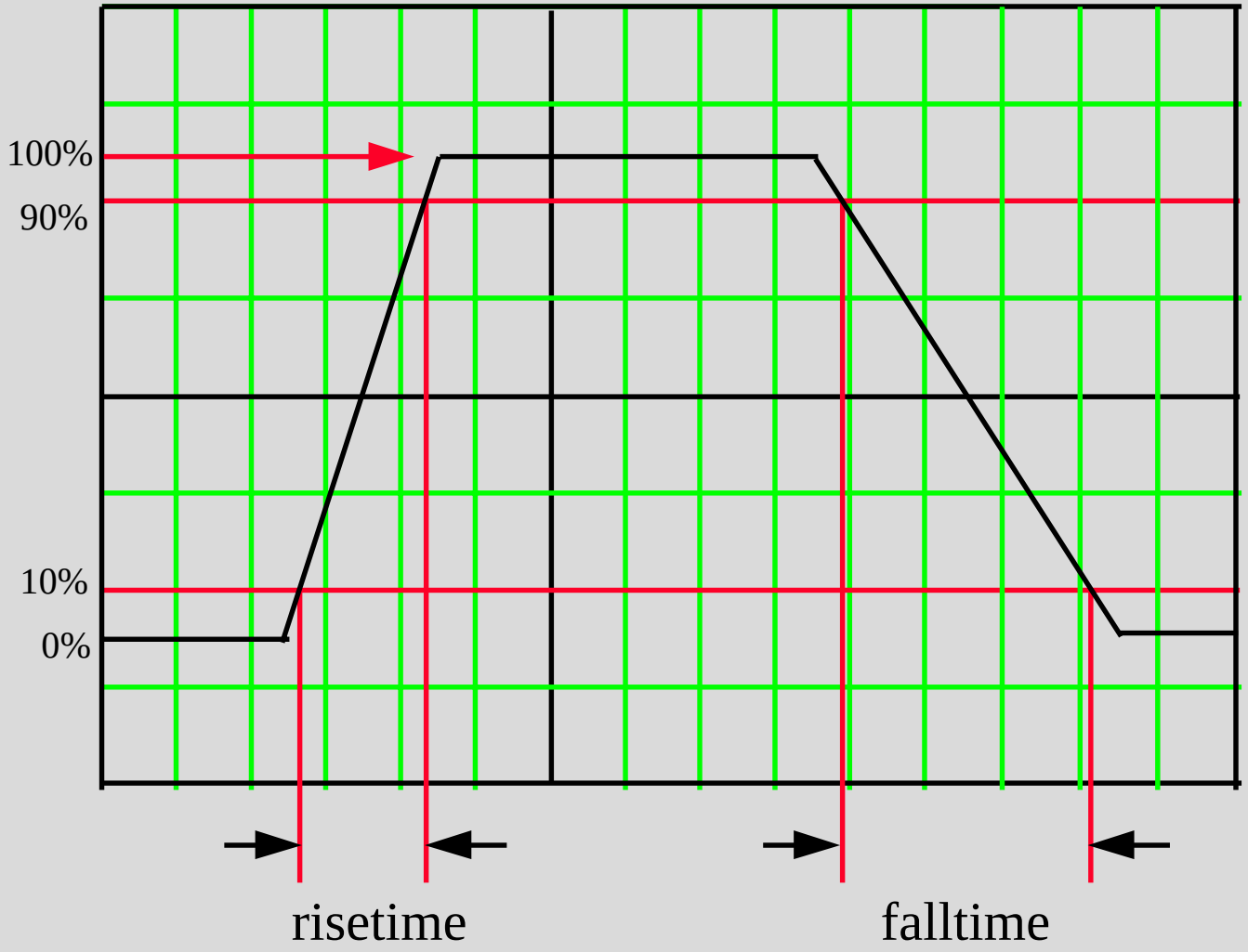
Duty Cycle = % of Period where signal is high

50%
Duty Cycle



Square Wave:
50% Duty Cycle

Risetime / Falltime - Pulse Waveforms



Angular Velocity

Magnetic Pickup

- Autoscale
- Averaging, Vpp

Cable Impedance

Patch Cords vs. Z-matched Co-ax

- Autoscale
- Main/delay,
  Risetime, Falltime,
  Vmax, Vmin, Vtop, Vbase

Natural Frequency

Accelerometer

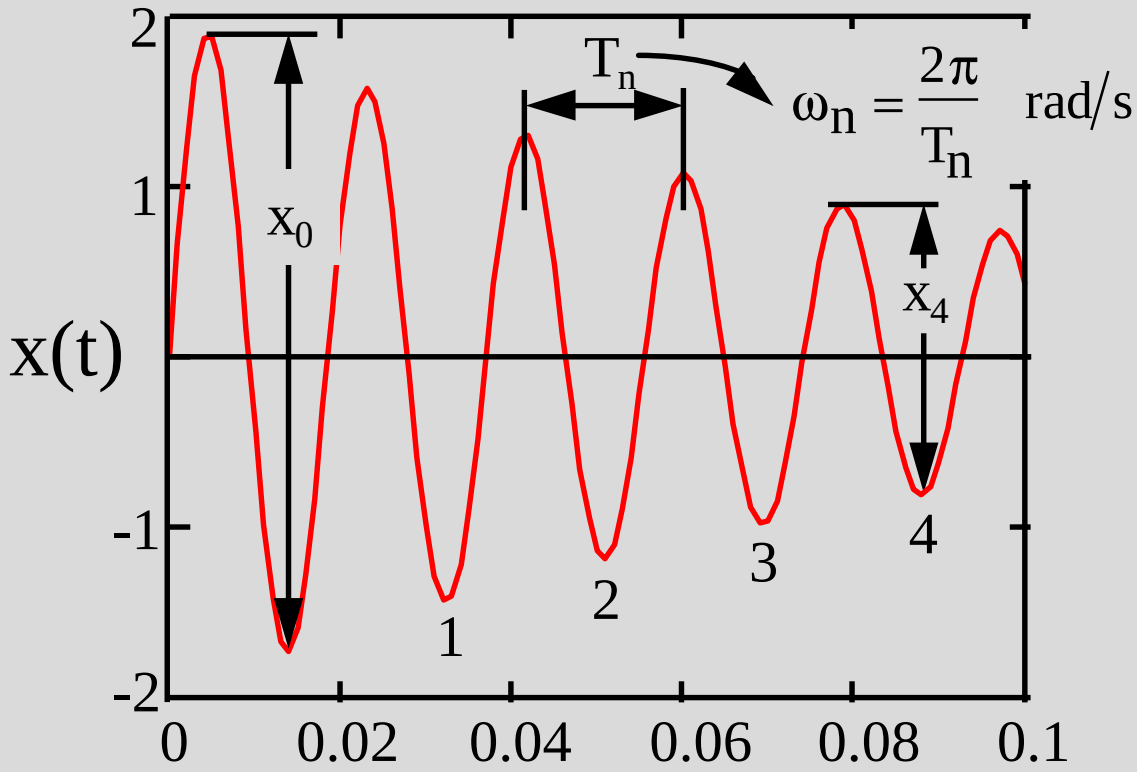
- Autoscale
- Roll Mode

Beam Frequency

Strain-Gaged Beam

- Single Trigger
- Single Triggering,
  Cursors,
  Time Reference,
  Storage

Beam Frequency & Damping



Logarithmic Decrement

$$\delta = \frac{1}{n} \ln \frac{x_o}{x_n}$$

$$\zeta \approx \frac{\delta}{2\pi}$$

Equation of Motion (mass normalized)

$$\ddot{x}(t) + 2\zeta\omega_n \dot{x}(t) + \omega_n^2 x(t) = \frac{f(t)}{m}$$

Voltage Across a Capacitor

Resistor and Capacitor

- Autoscale
- Trigger Channel, HF Reject

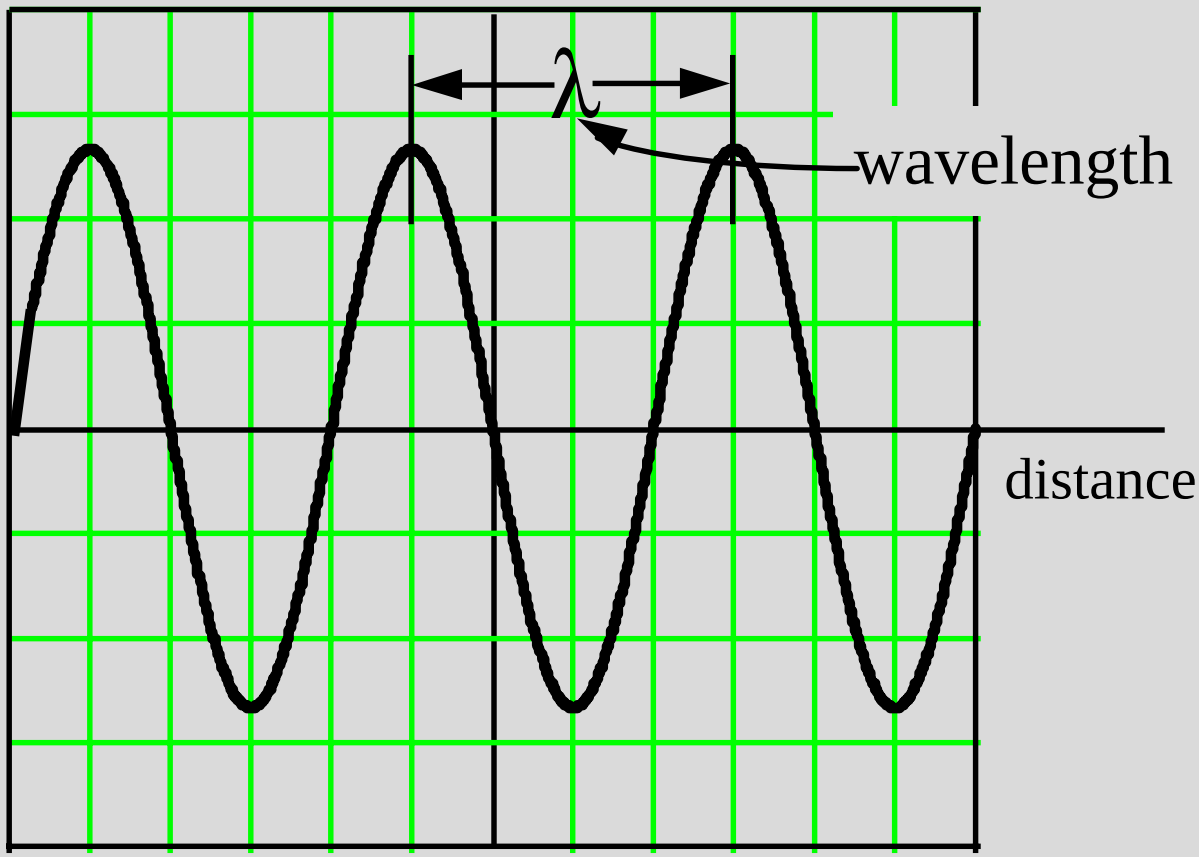
Speed of Sound

Speaker and Microphone

- Autoscale
- Averaging, Phase cursors, XY mode

Speed of Sound

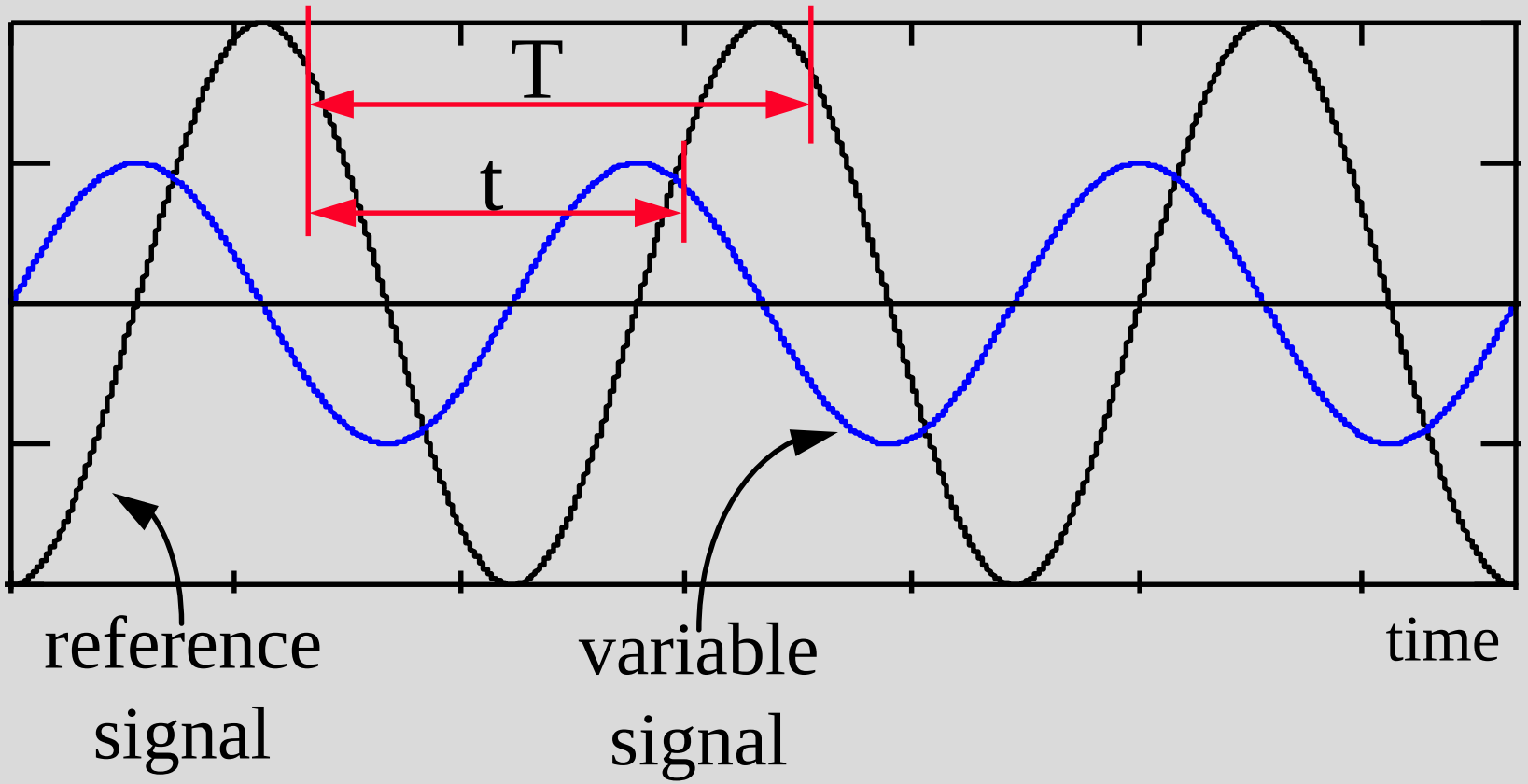
$$c = \lambda' f$$



c = speed of sound

f = frequency (Hz)

Phase Relationships



$$\text{Phase,} \quad \phi = \frac{t}{T} \prime 360°$$

Probe Calibration — Calibration Tab

- Autoscale
- Calibration, Vectors

Triggering a Serial Pattern

HP54654A Training Kit, pt 3

- Autoscale
- Trigger Holdoff

Detecting Periodic Glitches

HP54654A Training Kit, pt 4

- Autoscale
- Autostore

Detecting Narrow Pulses

HP54654A Training Kit, pt 6

- Autoscale
- Peak Detect

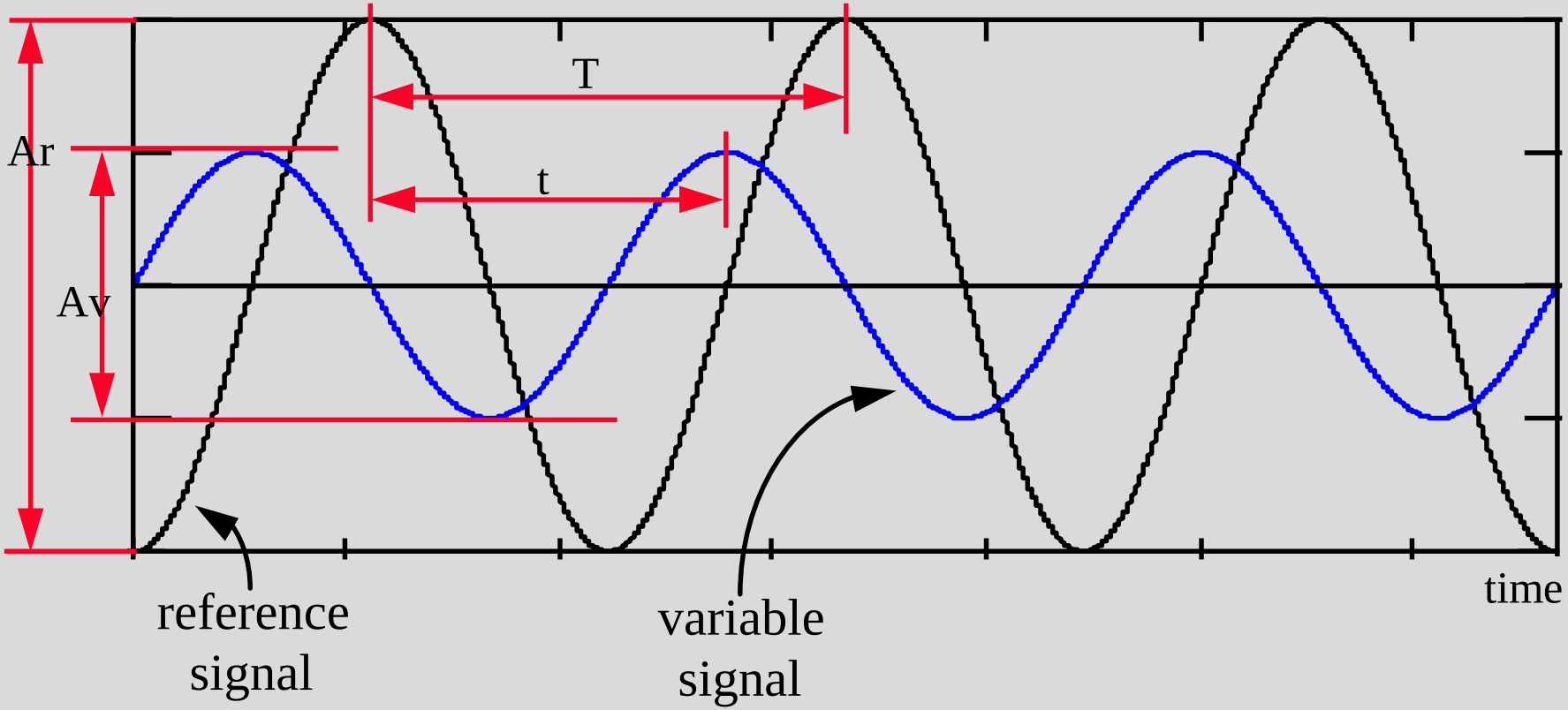
Impedance and Calibration

- Impedance
- Calibration
- Probe Effects

Impedance

- Magnitude and Phase Relationships
- Impedance Notation
- Impedance Examples
- Impedance Measurement

Magnitude & Phase Relationships



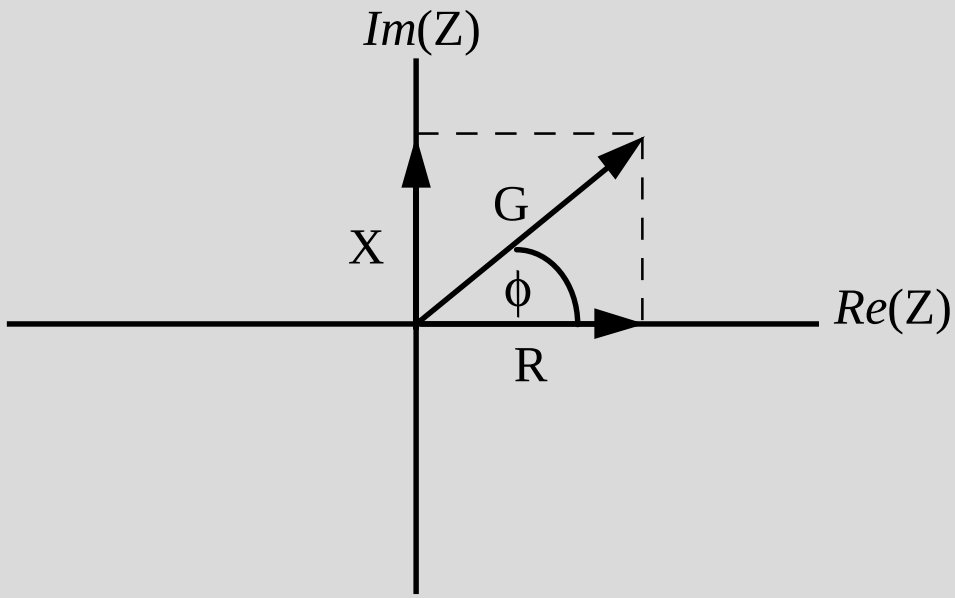
Magnitude Ratio

$$G = \frac{A_V}{A_R}$$

Phase

$$\phi = \frac{t}{T} \prime 360^\circ$$

Impedance Notation



Complex Notation

$$Z = R + jX$$

$$R = Re(Z) = G\cos\phi$$

$$X = Im(Z) = G\sin\phi$$

Magnitude/Phase Notation

$$Z = G \quad \phi$$

$$G = |Z| = \sqrt{R^2 + X^2}$$

$$\phi = \tan^{-1}\frac{X}{R}$$

Impedance Examples

Electrical Curcuits (Ohm's Law):

$$V = I' Z \qquad Z = \frac{V}{I}$$

Mechanical Impedance:

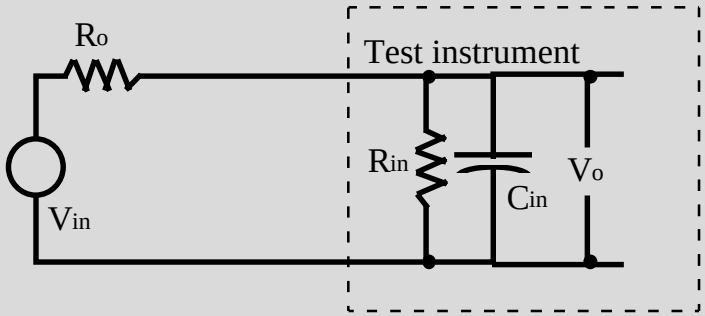
$$Z = \frac{\text{Force at a Point}}{\text{Velocity at the Point}}$$

Acoustic Impedance:

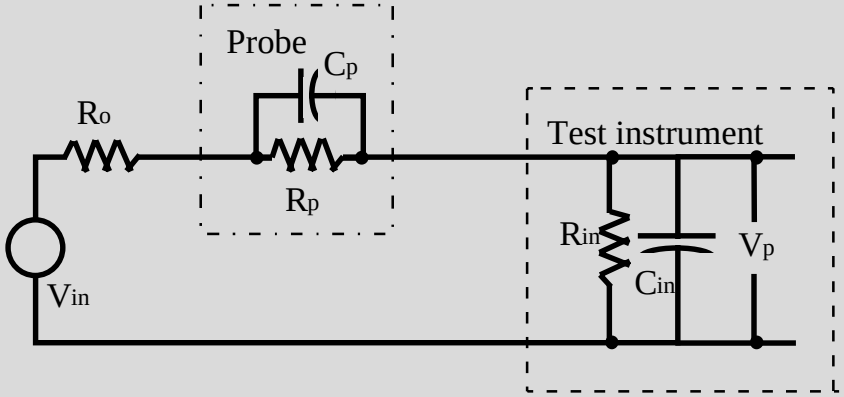
$$Z = \frac{\text{Avg. Sound Pressure over Surface (p)}}{\text{Volume Velocity thru Surface (u)}}$$

Measurement Impedance

Without Probe



With Probe



f = frequency (Hz)

$$Z_{in} = \frac{1}{\frac{1}{R_{in}} + j'2'\pi'f'C_{in}}$$

$$\frac{V_o}{V_{in}} = \frac{Z_{in}}{R_o + Z_{in}}$$

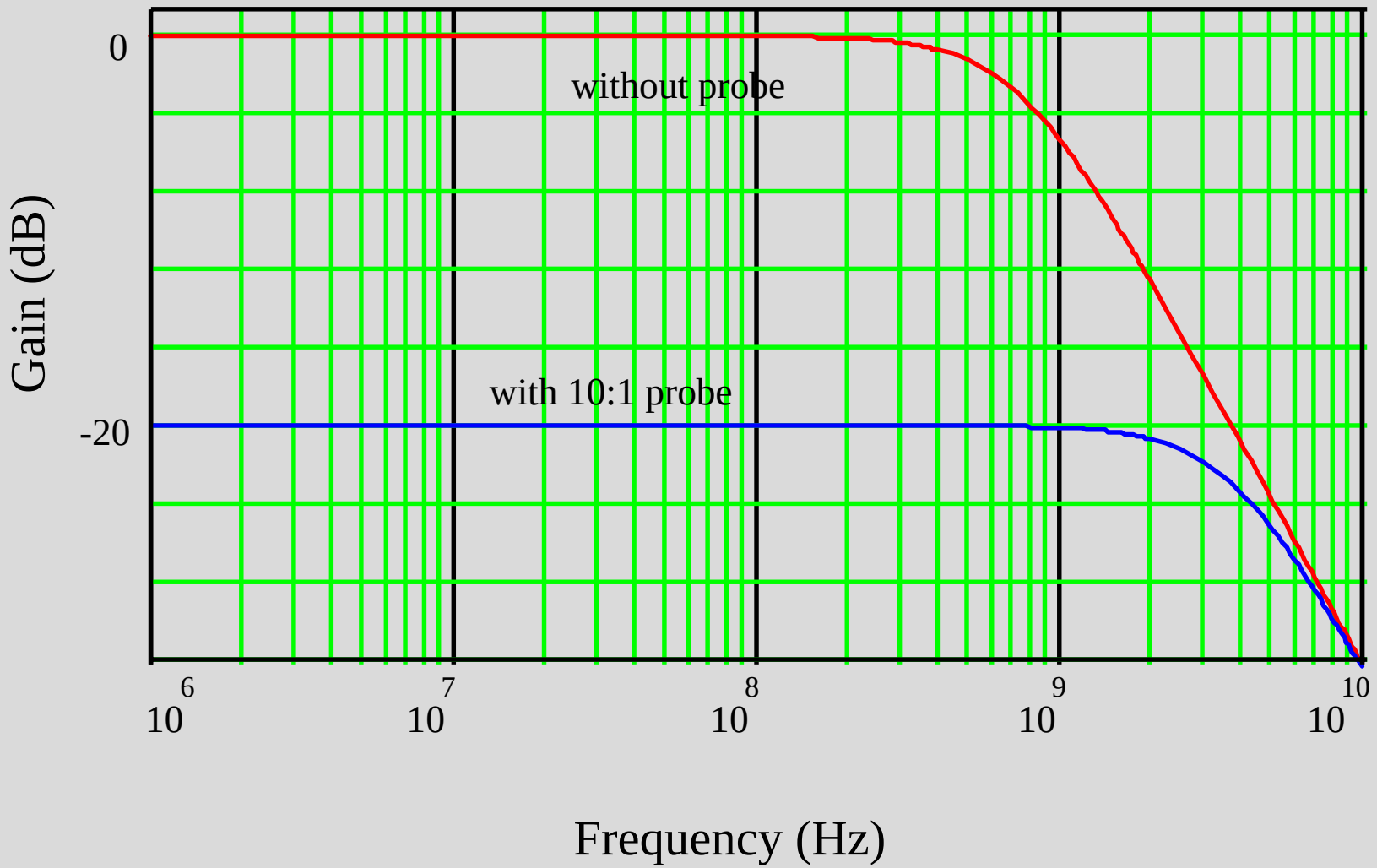
$$G_o = 20'\log\left|\frac{V_o}{V_{in}}\right|$$

$$Z_p = \frac{1}{\frac{1}{R_p} + j'2'\pi'f'C_p}$$

$$\frac{V_p}{V_{in}} = \frac{Z_{in}}{R_o + Z_{in} + Z_p}$$

$$G_p = 20'\log\left|\frac{V_p}{V_{in}}\right|$$

Gain Comparison



For HP54600B Digital Oscilloscope

HP54600B oscilloscope:

R_{in} = 1 MΩ

C_{in} = 13 pf

HP33120A function generator:

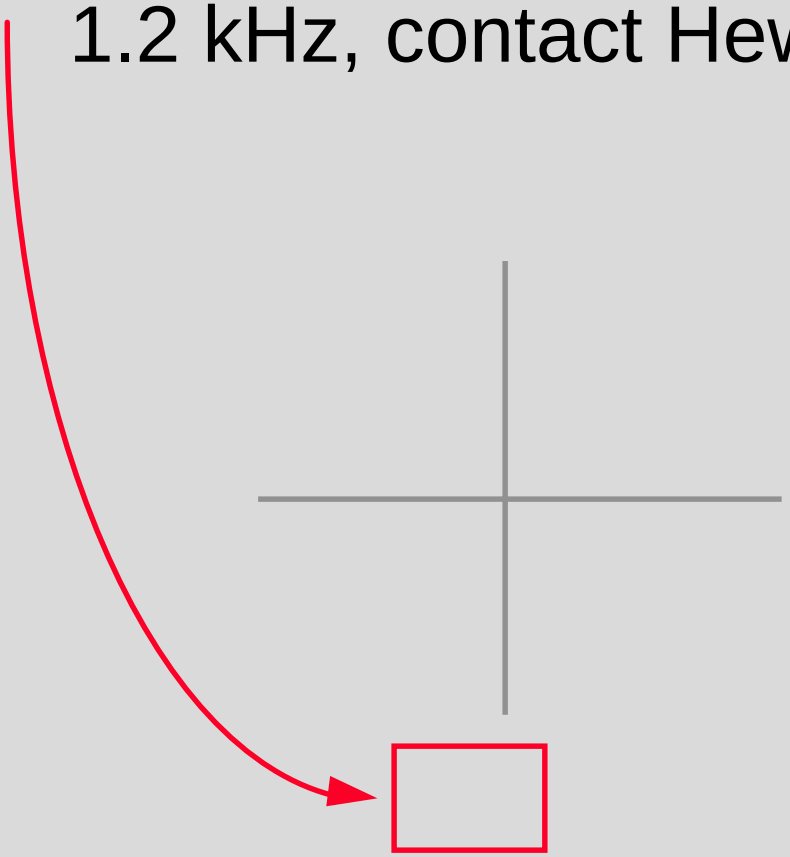
R_0 = 50 Ω

HP10071A X10 probe:

Tune to oscilloscope

Oscilloscope Calibration

- Connect probe to calibration lead
- If oscilloscope does not read approx. 5V and 1.2 kHz, contact Hewlett Packard.



Probe Calibration

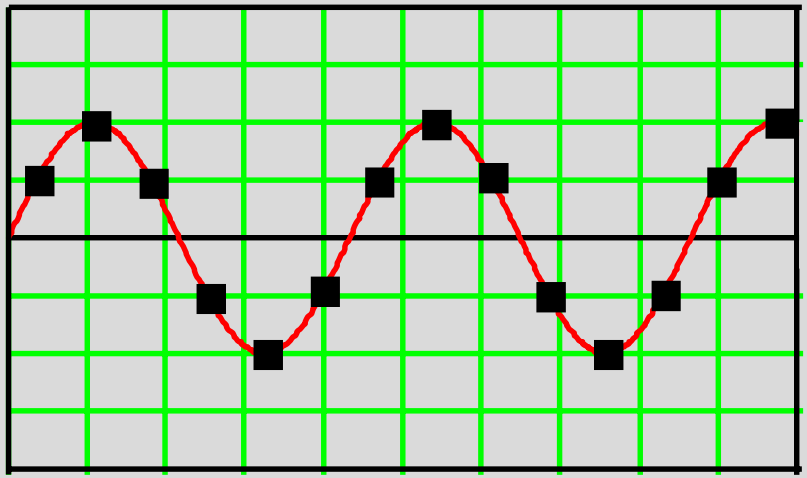
- Use calibration lead to check wave squareness
- If wave is not square, use a small screwdriver to adjust the probe until the wave is square.

Properly Calibrated Overcompensated Undercompensated

Digital Issues

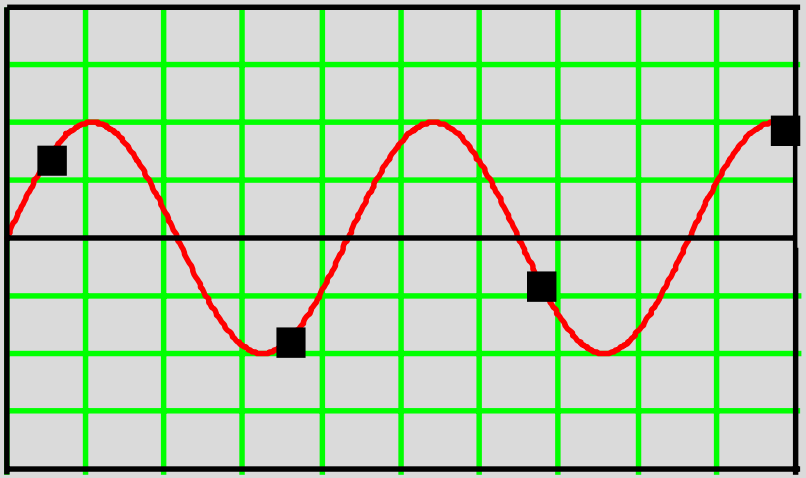
- Aliasing
- Triggering
- Analog vs. Digital

Aliasing



No Aliasing

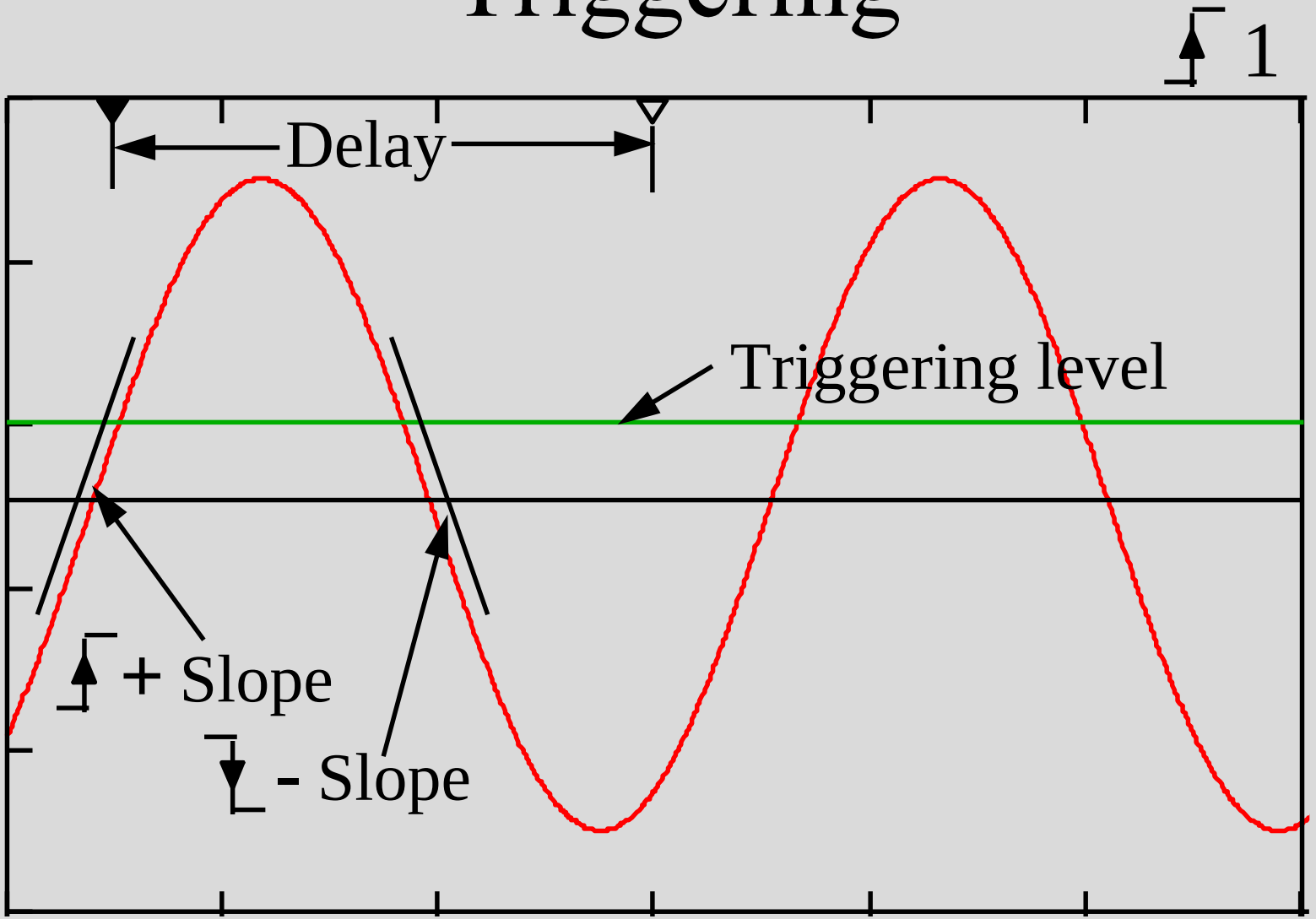
$f_{sampling} > 2\ f_{signal}$



Aliasing

$f_{sampling} < 2\ f_{signal}$

Triggering



Digital Advantages

- Image Storage - High Intensity
- Negative Time
- Simultaneous Multichannel Measurement
  (No Chop or Alternate)
- Automatic Measurements
- Hardcopy Output
- Export Data to Computer

HP54600B Special Features

- Autoscale
- Fast DisplayUpdate
- Self Test

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References

- Electronic Instrument Handbook 2nd Edition
  Clyde F. Coombs, Editor
  McGraw-Hill, New York, 1995

- Electronic Test Measurements, Theory and Applications
  Robert A. Witte
  Prentice-Hall, Englewood Cliffs, NJ, 1993

For More Information

- HP 54600 Series User and Service Guide
- Call HP Direct at 1-800-452-4844, or Contact Your Local HP Representative