Crashcourse Oscilloscope and Logic Analyzer

By
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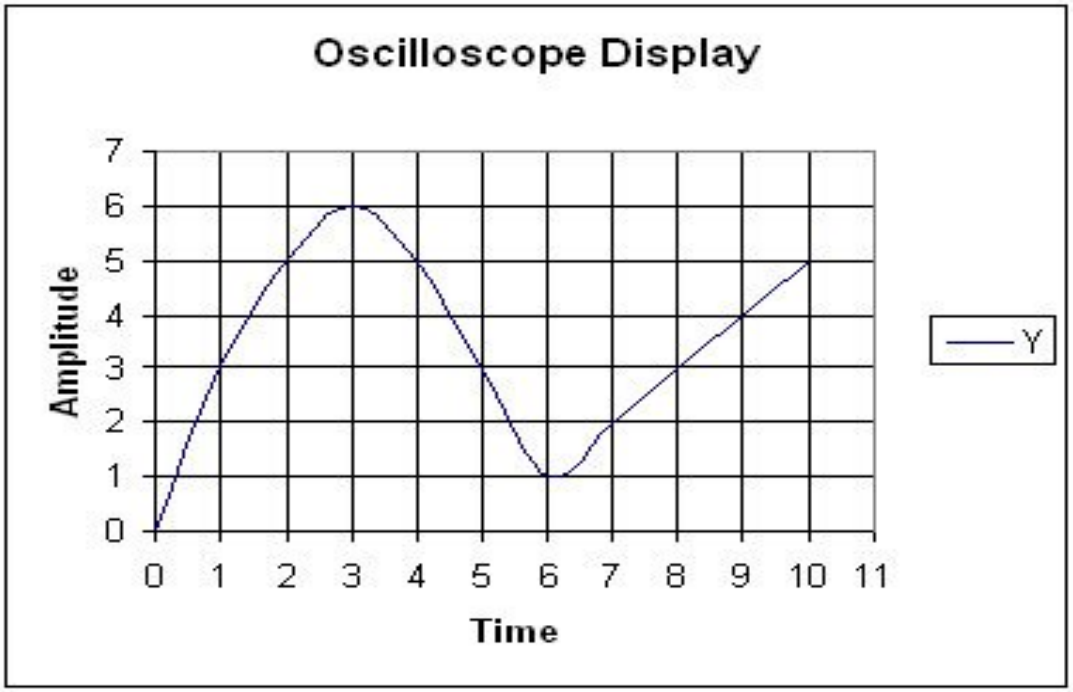
Introduction

- Who am I?
- Who are you and what do you want to learn?
- What kind of problems have you been confronted with?

Shedule

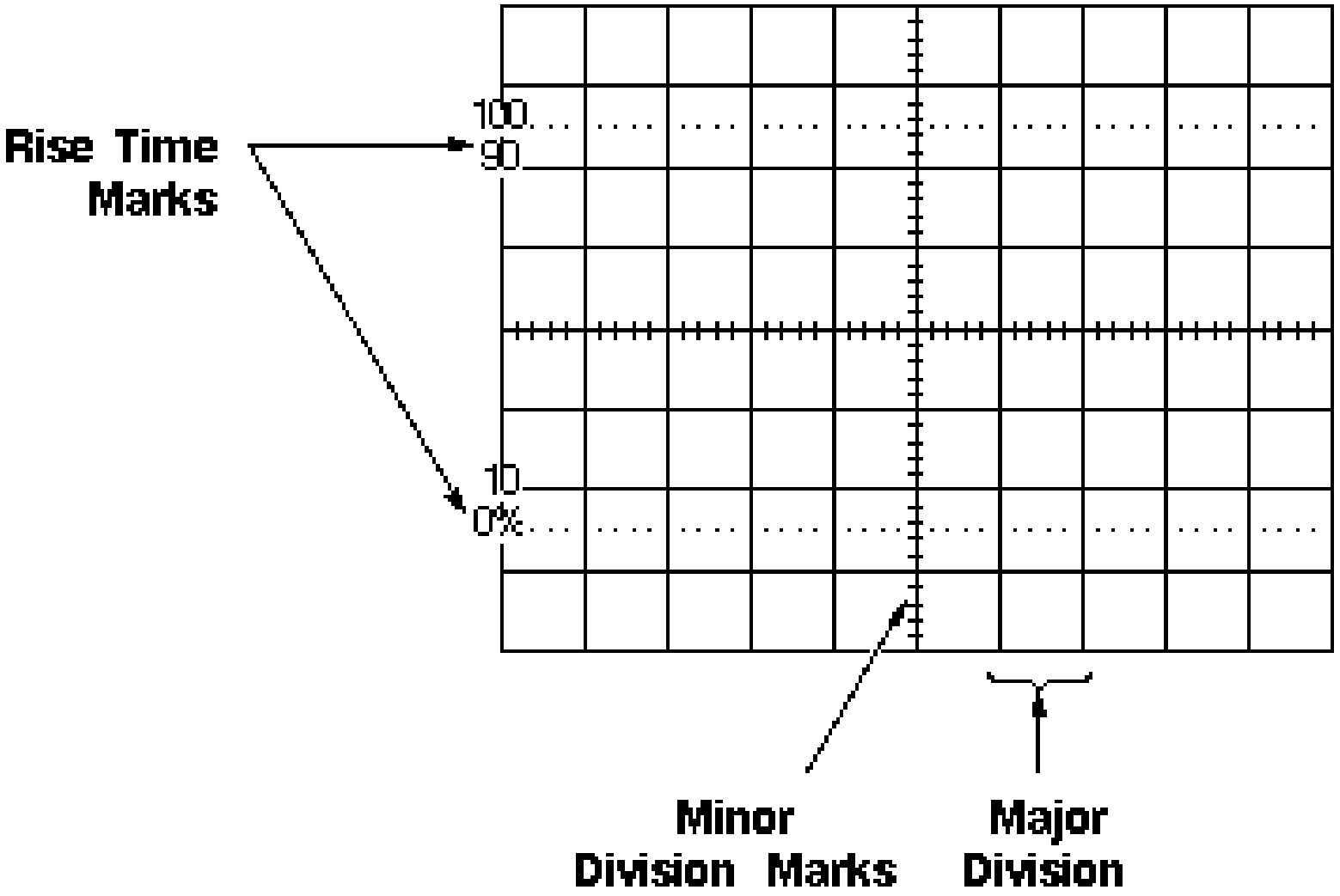
- Oscilloscope
  - Overview
  - Display, Read the output
  - Probes
  - Input Stage
  - Horizontal System
  - Trigger System
  - ADC Stage
  - Measurements
  - Accuracy
- Logic Analyzer
  - Overview
  - Timing Analyzer
  - State Analyzer
  - Logic Analyzer
  - Sequencing
  - Protocol Decoder
- Links

Oscilloscope

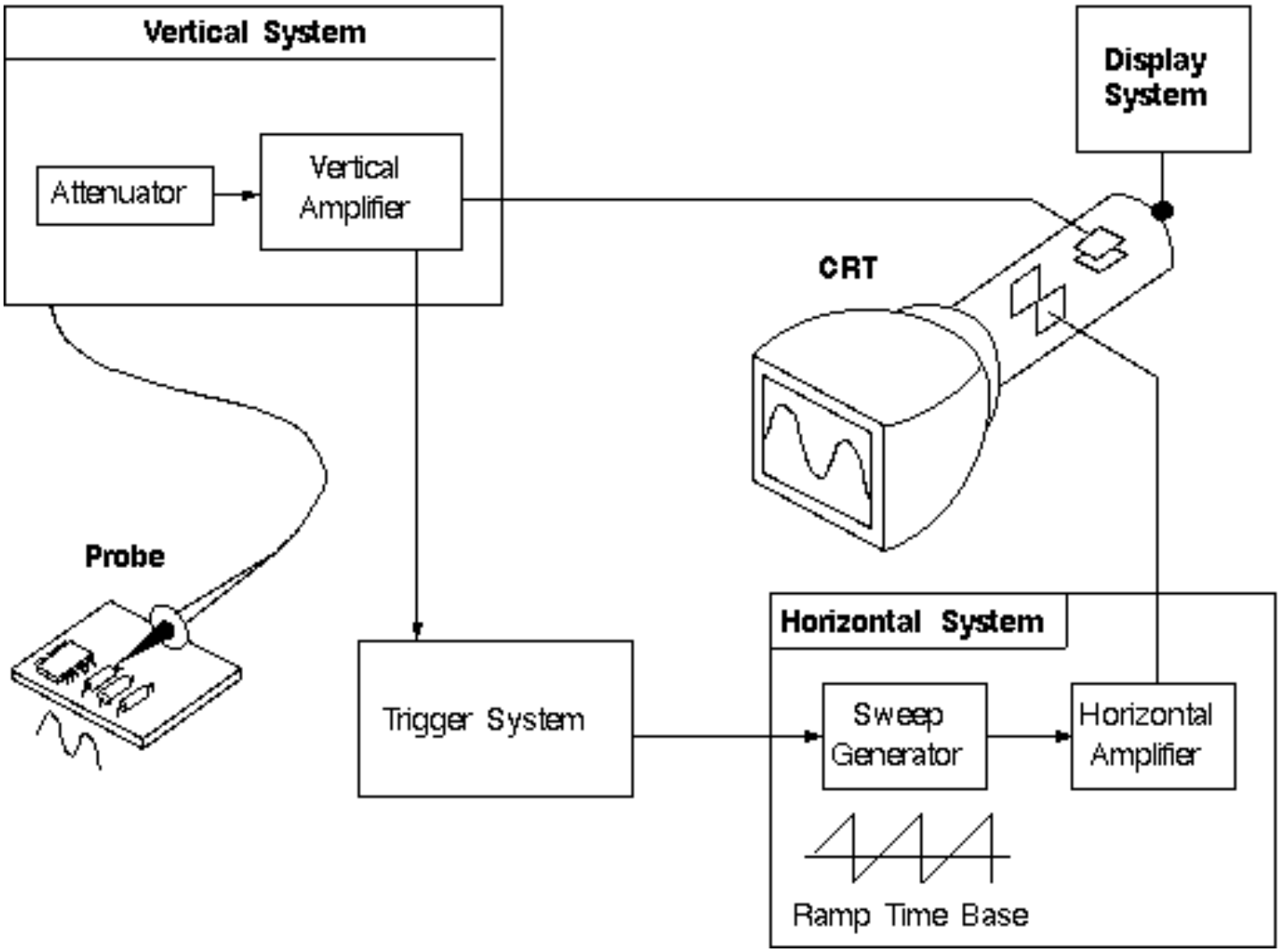


- You can determine the time and voltage values of a signal.
- You can calculate the frequency of an oscillating signal.
- You can see the "moving parts" of a circuit represented by the signal.
- You can tell if a malfunctioning component is distorting the signal.
- You can find out how much of a signal is direct current (DC) or alternating current (AC).

Display, Read the output

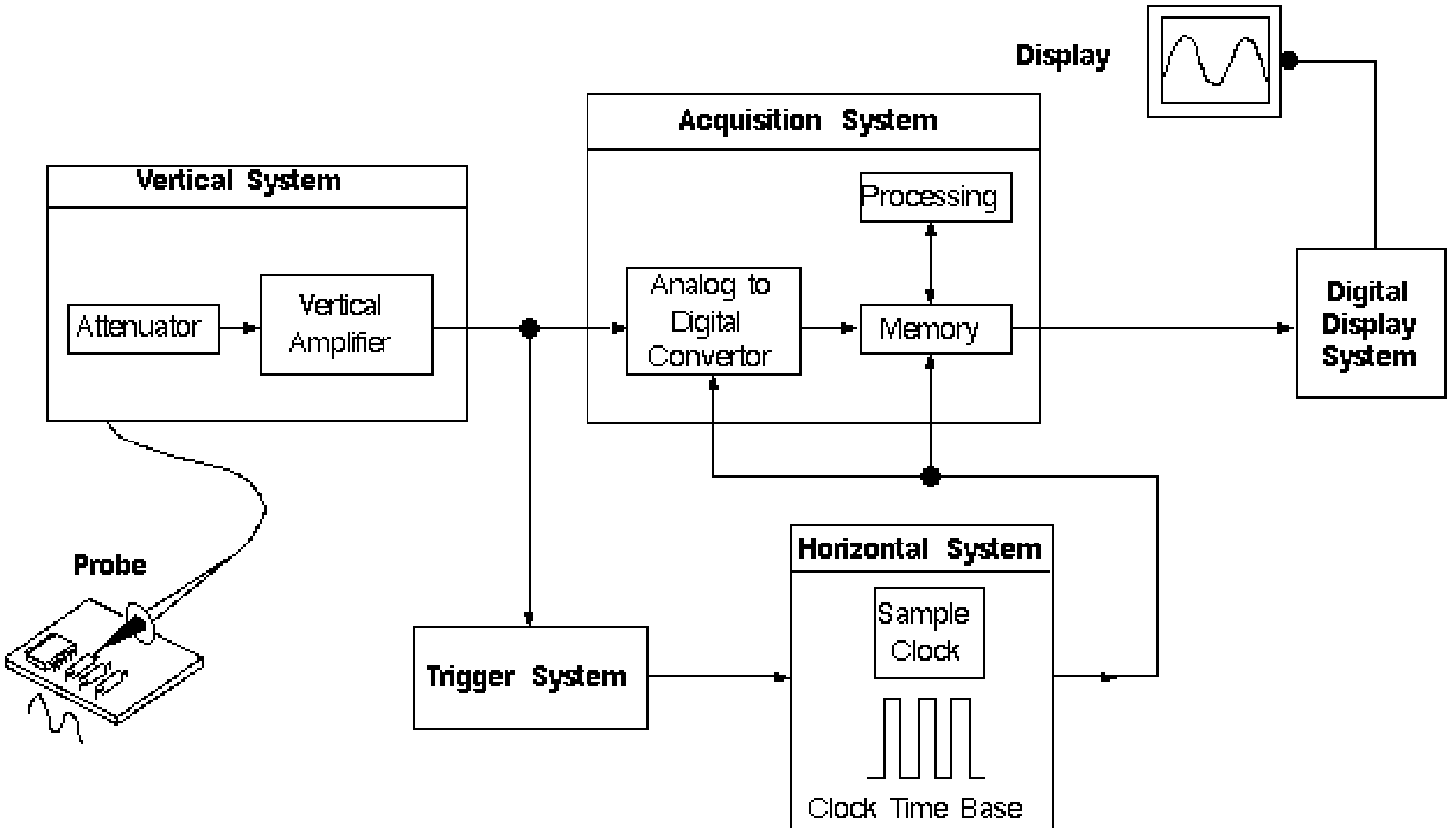


Oscilloscope, overview



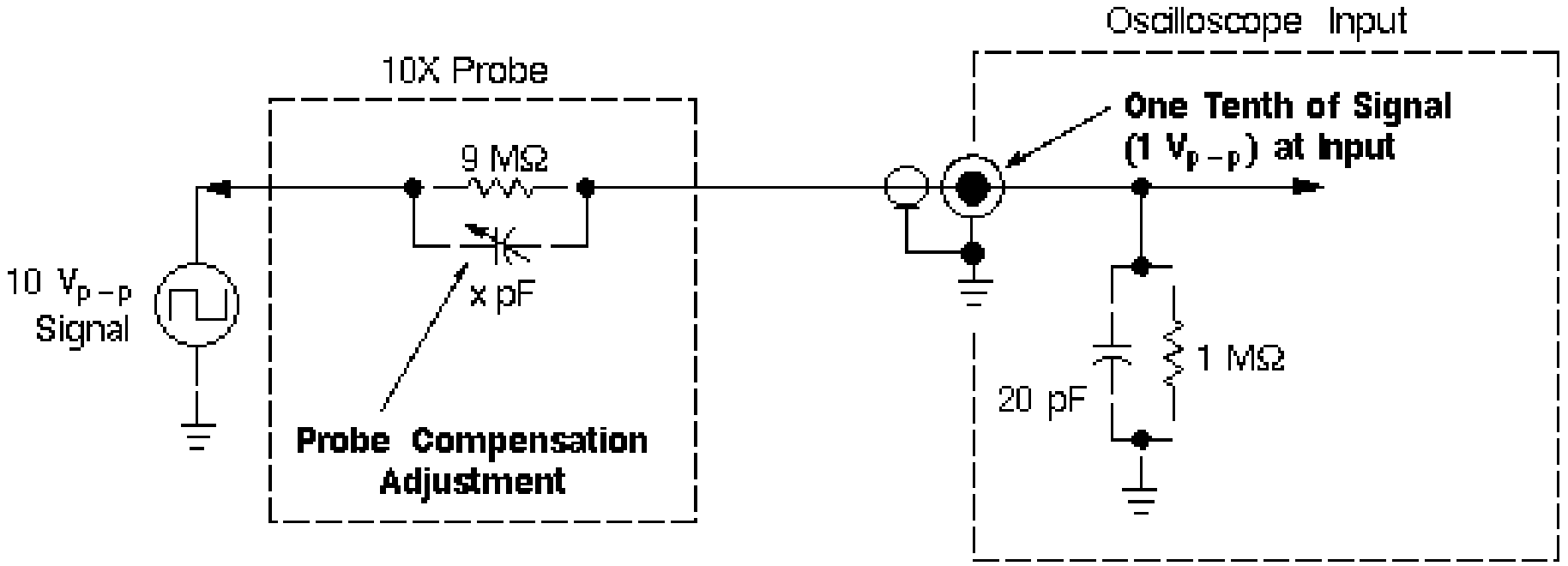
Blockdiagramm of a analog Scope

Oscilloscope, overview 2



Blockdiagramm of a Digital Storage Oscilloscope (DSO)

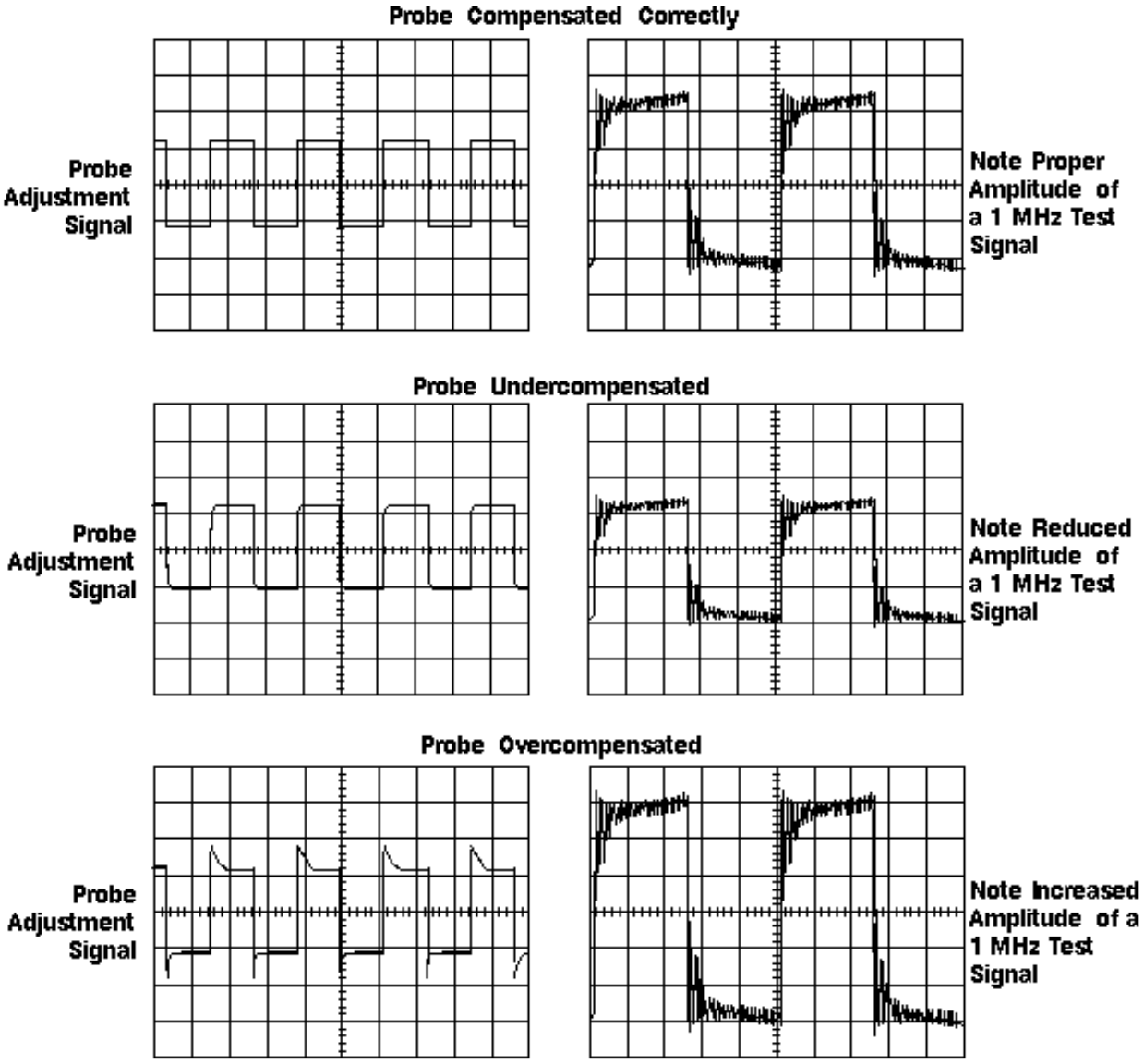
Probes



Schematic of a typical passive probe and the oscilloscope input

Probe calibration: always use a plastic srewdriver!

Probes 2


Probe Compensated Correctly
Probe Adjustment Signal
Note Proper Amplitude of a 1 MHz Test Signal
Probe Undercompensated
Probe Adjustment Signal
Note Reduced Amplitude of a 1 MHz Test Signal
Probe Overcompensated
Probe Adjustment Signal
Note Increased Amplitude of a 1 MHz Test Signal

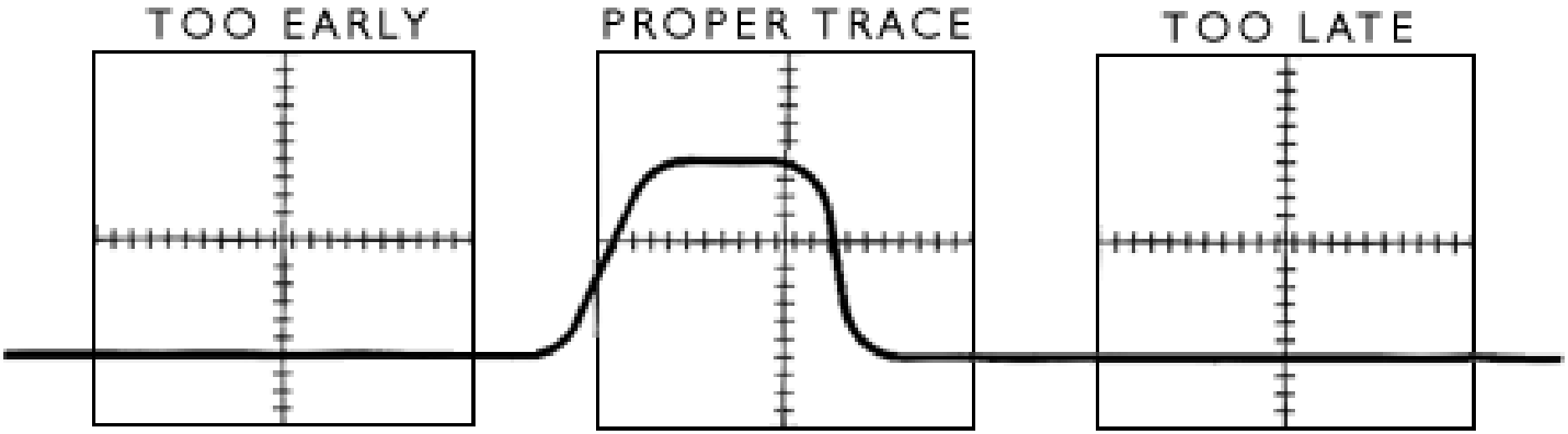
Input Stage

- Attentuation, Scaling
- Position (Moving up/down)
- Coupling (DC, AC, GND)
- More
  - Termination
  - Bandwidth Limit (Used for slower signals to reduce Noise)

Horizontal System

- Adjust the time length you measure
  - Digital: also adjust the sampling rate
- Adjust the position you are interested in relative to the trigger event.
- Digital: Allows you to „Zoom“ into a recorded signal

Trigger System



The most important system to give you the measurement result you are looking for!

Trigger System 2

Trigger Types

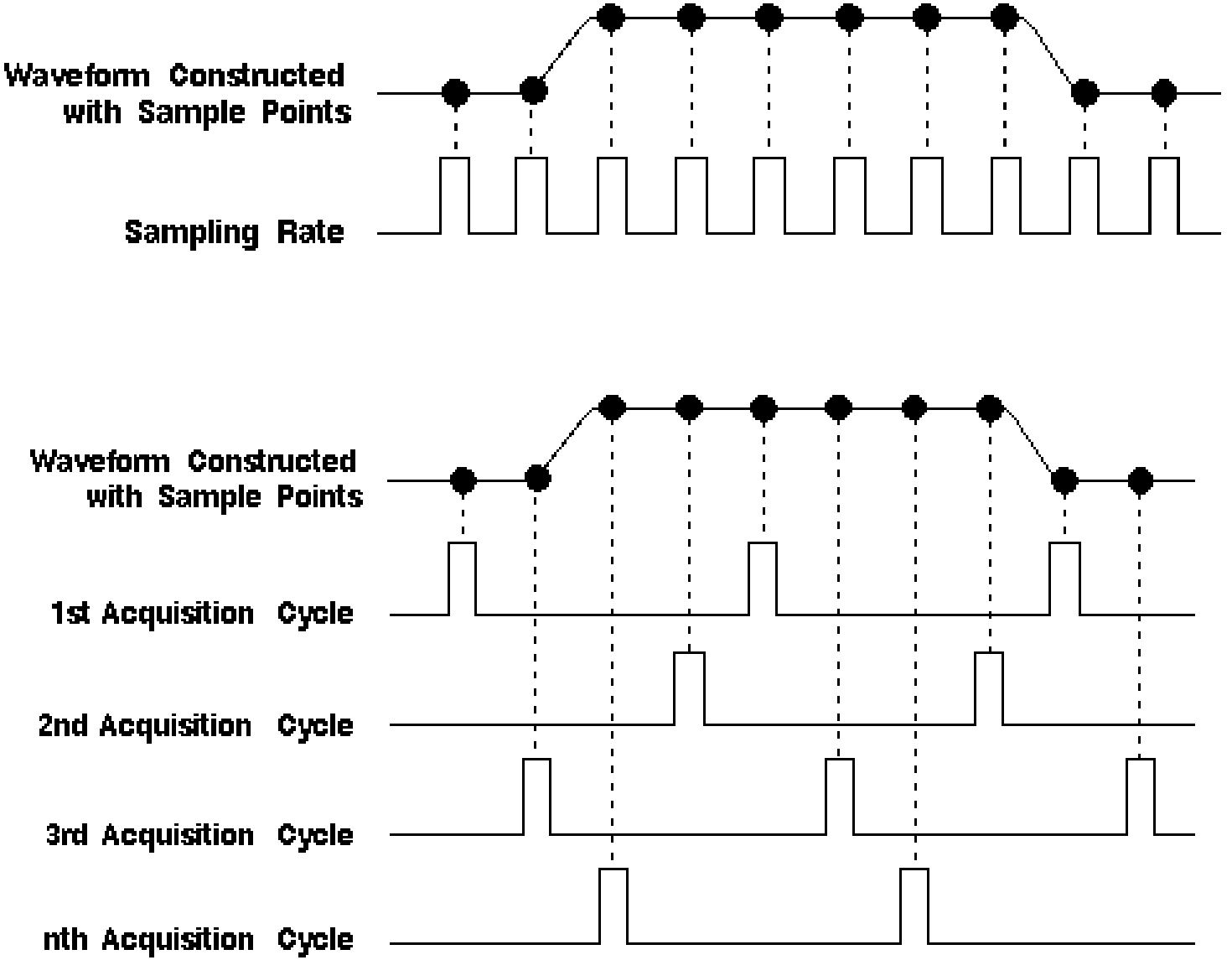
- Edge
  - Simple, most common
- Pulse
  - Good for digital circuits, searching timing bugs
- Video
  - Measurement on video devices

- Trigger Source
  - Input channels, external Input, power input frequency
  - Coupling (DC, AC), Noise rejection (high-pass, low-pass)

Trigger System 3

- Trigger Modes
  - Normal
    - Refreshes the display on every trigger event
  - Single
    - Refreshes the display only once a trigger occours
  - Auto
    - Refreshes the display periodicaly when no trigger occours
- Hold off
    - Blocks the trigger system for a certain time before a new trigger event can happen.

ADC Stage



Real-time Sampling

Equivalent-Time Sampling

Measurements

- Analog (Manual):
  - Voltage
  - Time
- Digital (Automatic):
  - Voltage: Average, Peak, RMS, min/max
  - Periodtime, Frequency: Average, min/max
  - Puls: Duration, puls-to-pause ratio, delay
  - Combination: Rise and Fall Time, overshot, phase

Accuracy

- Horizontal Accuracy (Time)
  - Digital: Only depending on the Clock Source (typ. Accurat to very accurate)
  - Analog: Depending on the Clock source and linearity of the sweep generator
- Vertical Accuracy (Amplitude)
  - Digital: Depending on the probe and Input tollerance, input amplifier gain error, Voltage reference error, ADC non-linearity
  - Analog: Depending on the probe and Input tollerance, input amplifier gain error

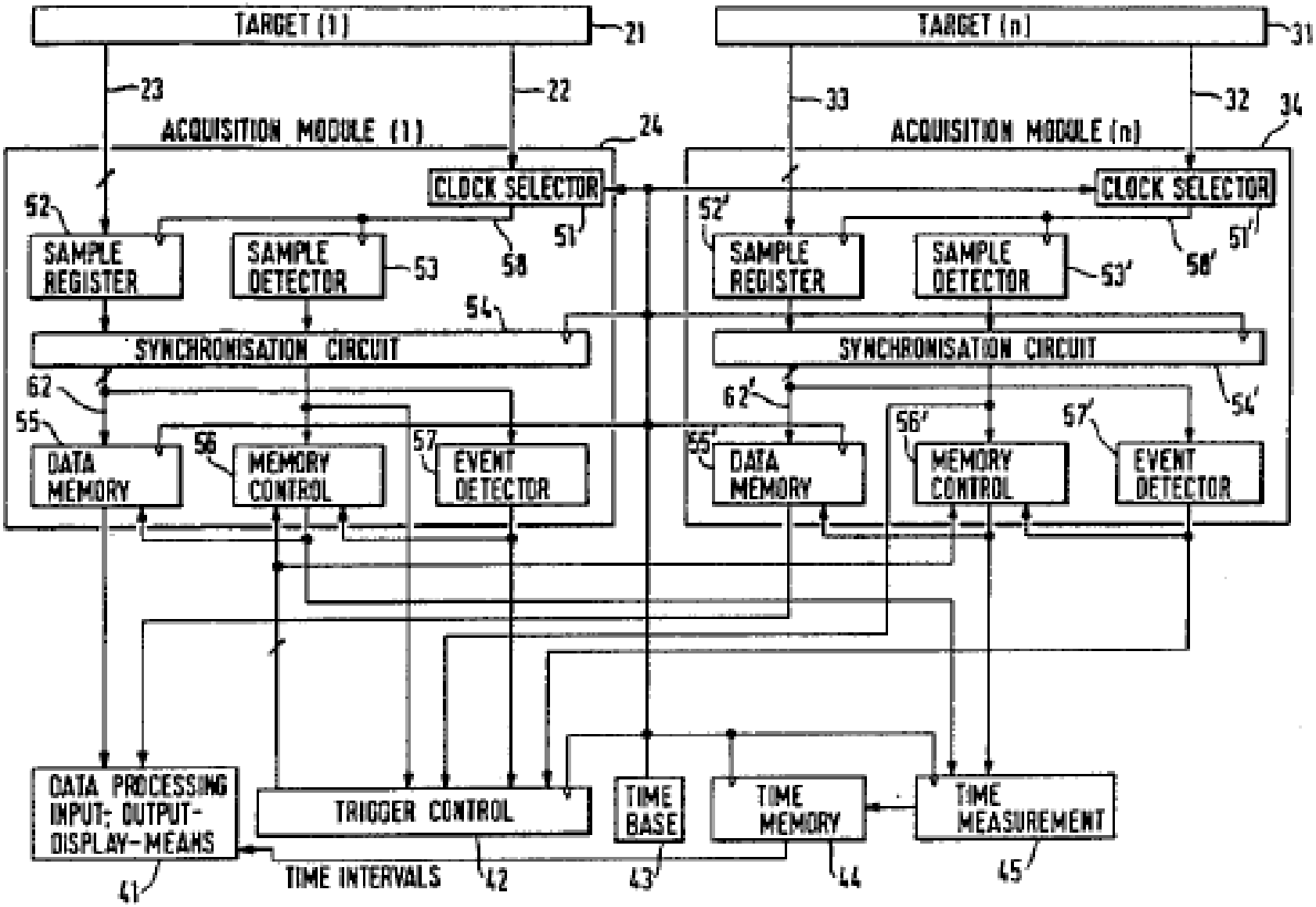
Logic Analyzer

- We normally use a logic analyzer whenever:
  - We need to see a number of signals at once.
  - We need to trigger on a pattern of highs and lows on several linens and see the result.

Logic analyzers are particularly useful when we are looking at time relationships of data on a bus e.g. a microprocessor address, data, or control bus.

- Logic analyzers are two analyzers at the same time:
  - 1. Timing analyzer.
  - 2. State analyzer.

Logic Analyzer Overview



Timing Analyzer

- Timing analyzer:
  - A timing analyzer is the part of a logic analyzer that is analogous to an oscilloscope. The timing analyzer displays information in the same general form as a scope, with the horizontal axis representing time and the vertical axis as voltage amplitude. Because the **waveforms** on both instruments are time-dependent, the displays is said to be in the "time domain".
  - A timing analyzer works by sampling the input wave forms to determine whether they are high or low. It cares about only one voltage threshold The **timing analyzer asynchronously samples** the system under test. It has an **internal clock** to control sampling.
- Triggering the timing analyzer:
  - "Triggering" in logic analyzer is often called "trace point": the logic analyzer **continuously captures data and stops the acquisition after the trace point is found** to display the data. A logic analyzer can show information after the trace point. Many analyzers trigger on a pattern of highs and lows across input lines. **Edge triggering is included** in logic analyzers. It allows, e.g. capturing data as the system under test is clocked.

State Analyzer

- A "state" for a logic circuit is a sample of a bus or line when its data is valid. State analyzers capture and store information from digital systems.
- A state analyzer **synchronously** samples the system since it gets its sampling **clock externaly from the digital system under test**.
  - State analyzers are primarily used to assist in software debugging by tracing and displaying the state flow in an algorithmic state machine such as microcomputer.
- Information of state logic analyzers may be displayed in a variety of ways among them:
  - State-flow binary and grouped binary.
  - State-flow hexadecimal format.
  - State-flow disasembled format.

Logic Analyzer

- As a rule of thumb, you might remember:
  - To use a state analyzer to check "what" happened on a bus
  - a timing analyzer to see "when" it happened.
- Therefore, state analyzer generally displays data in a listing format and a timing analyzer displays data as waveform diagram.

Sequencing

- Logic analyzer have "sequence levels", they allow you to qualify events more accurately than a single trigger point.
- Sequence levels usually look something like:
  - 1. Find XXXX
  - When on XXXX go to level 2.
  - 2. Then find YYYY
  - When on YYYY go to level 3.
  - 3. Trigger on ZZZZ.
- Sequence levels make possible selective storing. Selective storage means storing only a portion of a larger data stream this saves memory and time

Protocol Decoder

- Protocol analyzers decode the stream of bits flowing across a network and show you those bits in the structured format of the protocol.
- Available decoders vary from manufacturer to manufacturer. Examples:
  - I^2C
  - SPI
  - 1-Wire
  - USB
  - CAN

Links

- Images, citations taken from:
  - http://uenics.evansville.edu/~amr63/equipment/scope/oscilloscope.html
  - http://www.pcbschematics.com/testing-equipment-osciliscope-analyzer/51-digital-testing-equipment-logic-time-analyzer.html
- Cross plattform logic analyzer software
  - http://sigrok.org/wiki/Main_Page