Crashcourse Oscilloscope and Logic Analyzer

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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 screwdriver!
Probes 2

Probe Compensated Correctly

Probe Undercompensated

Probe Overcompensated

Note Proper Amplitude of a 1 MHz Test Signal

Note Reduced Amplitude of a 1 MHz Test 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 occurs
  - **Auto**
    - Refreshes the display periodically when no trigger occurs
- **Hold off**
  - Blocks the trigger system for a certain time before a new trigger event can happen.
ADC Stage

Real-time Sampling

Waveform Constructed with Sample Points

Sampling Rate

Equivalent-Time Sampling

Waveform Constructed with Sample Points

1st Acquisition Cycle

2nd Acquisition Cycle

3rd Acquisition Cycle

nth Acquisition Cycle
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, overshoot, 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 lines 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 in 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 externally 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 dissembled 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
  - Else on XXXX go to level Y.
  - 2. Then find XXXX
  - Else on XXXX go to level Y.
  - 3. Trigger on XXXX.
- 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:
  - I²C
  - SPI
  - 1-Wire
  - USB
  - CAN
Links

• Images, citations taken from:
  • http://uenics.evansville.edu/~amr63/equipment/scope/oscilloscope.html
  • http://www.pcb schematics.com/testing-equipment-oscilloscope-analyzer/51-digital-testing-equipment

• Cross platform logic analyser software
  • http://sigrok.org/wiki/Main_Page