USB Oscilloscopes
Real Time Embedded Systems

www.atomicrhubarb.com/embedded

Lecture 1 - January 17, 2012

Topic
Section Topic

• Where in the books
  – Catsoulis chapter/page
  – Simon chapter/page
  – Zilog UM197 (ZNEO Z16F Series Flash Microcontroller Contest Kit User Manual)
  – Zilog UM171 (ZiLOG Developer Studio II—ZNEO User Manual)
  – Zilog PS220 (ZNEO Z16F Series Product Specification)
  – Zilog UM188 (ZNEO CPU Core User Manual)
  – Assorted datasheets
USB Oscilloscopes
Cheap ones, like < $200

(ok, maybe a few just under $300)
What you want

- Fluke
- Color
- Portable
- 2.5 Gs/s
- 200MHz
But ...

- $4200 + probes, case, battery, charger
Beware

- Because of the price range we are looking at (less than $200 or so), expect that the performance and/or capability will be reduced as well.

- Most are slow and will capture 2-5 million samples/second.

- Typically, the maximum signal frequency you will be able to capture and see will be 500 Khz to 1 Mhz.
Warning!!
Specs vary widely.
Read the products specifications carefully!
Oscilloscope vs Logic Analyzer

- Some of these cheap-o devices will do ONE or the OTHER, a few will do BOTH.

What’s the difference?
How many data points we need
Oscilloscope Properties

Bandwidth specification

- Related to the speed of the waveforms that can be measured.
- Define by electrical bandwidth as the point at which the amplitude of a sine wave input is attenuated to 70.7% of the true value of the signal relative to its level at a lower reference frequency.
- The oscilloscope specification for bandwidth will typically be quoted in the format: Bandwidth = -3dB at 1500 MHz.
- If the oscilloscope specification for the -3dB point is not sufficiently high it will be found that the edges of pulses and square waves will be slowed as a result of the reduction of the high frequency components.
Oscilloscope Properties

Oscilloscope sample rate

- The sample rate is specified in samples per second (S/s).
- The faster the oscilloscope samples the waveform, the greater the resolution of the detail on the waveform and with greater sample rates the less the likelihood that any critical information will be lost.
- The oscilloscope takes in the waveform from the voltage input and then digitizes it, after which it is processed. For the display it is necessary to construct the waveform. To avoid aliasing, the Nyquist theorem dictates that the sampling frequency should be twice that of the highest frequency components to be displayed. However this makes some assumptions about repetitive waveforms, so the oscilloscope should have a sample rate at least 2.5 times that of the highest frequency
USB Oscilloscope DiSco

- www.hobbylab.us
- $170
- 2-channel oscilloscope
- 2-channel spectrum analyzer.
- 2-channel recorder
- 16-channel logic analyzer
- Decoding of the interface UART, SPI, I2C, 1-Wire, etc.
- 8-channel logic generator
- Logic analyzer: 1 KHz...8 MHz
- Oscilloscope: 100 Hz...200 KHz
### I2C Timing Chart

#### Settings
- **Clock channel (SCL)**: 100 Kb/s
- **Data channel (SDA)**: 100 Kb/s
- **Transfer speed**: 100 Kb/s

#### Transfer Table

<table>
<thead>
<tr>
<th>#</th>
<th>Start</th>
<th>Address</th>
<th>R/W</th>
<th>ACK</th>
<th>Data</th>
<th>ACK</th>
<th>Stop</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Start</td>
<td>1010000</td>
<td>W</td>
<td>NACK</td>
<td>11111111</td>
<td>NACK</td>
<td>Stop</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>00000000</td>
<td></td>
<td>NACK</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>01010101</td>
<td></td>
<td>NACK</td>
<td></td>
<td></td>
<td>Stop</td>
</tr>
<tr>
<td>4</td>
<td>Start</td>
<td>1010000</td>
<td>W</td>
<td>NACK</td>
<td>11111111</td>
<td>NACK</td>
<td></td>
</tr>
</tbody>
</table>
USBee SX Logic Analyzer, Signal Generator with SPI, I2C and Async Decoders

- [http://www.usbee.com/sx.html](http://www.usbee.com/sx.html)
- $140
- logic analyzer
- digital signal generator
- includes an ASYNC, I2C and SPI Serial Bus Decoder.
Decoding Asynchronous serial bus transactions between the X1 and X2 cursors.

Please wait...

'U' = 0x55
'S' = 0x53
'B' = 0x42
'e' = 0x65
'e' = 0x65
' ' = 0x20
'Z' = 0x5A
'X' = 0x58

Decoding SPI serial bus transactions between the X1 and X2 cursors.

Please wait...

SDO: 10 01 AF FE
SDI: 00 00 01 2C
SDO: 10 01 AF FE
SDI: 00 00 01 2C
SDO: 10 01 AF FE
SDI: 00 00 01 2C
SDO: 10 01 AF FE
SDI: 00 00 01 2C
SDO: 10 01 AF FE
SDI: 00 00 01 2C
Parallax USB Oscilloscope

- www.parallax.com
- $140 ($90)
- Dual channel oscilloscope
Janatek Annie-USB

- www.tiepie.com/uk/products/External_Instruments/Logic_Analyzers/Annie-USB.html
- € 339 ($250)
• Logic analyzer
• 8-bit Pattern generator
Saleae

- [www.saleae.com](http://www.saleae.com)
- $140
- Logic analyzer
- Serial bus decode (SPI, Serial, I2C, 1-wire)
Pico USB ADC-11

- www.picotech.com/data-acquisition.html
- $178
- Data logger
- Oscilloscope
- Spectrum analyser
- Meter
- API for
  - C and C++, Delphi, LabVIEW, Visual Basic
PoScope basic2 bundle

- [link](http://www.poscope.com/product.php?pid=13)
- € 156 ($190)
- 2-channels oscilloscope
- 2-channels spectrum analyzer
- 16-channels logic analyzer
- 2-channels recorder
- 5 channels square signal and PWM generator
- 8-channels pattern generator
Quite possibly the same basic unit as the Hobbylab oscilloscope
PS40M10 "Swordfish" Hand Held USB Oscilloscope

- $199
- http://www.usb-instruments.com/
Hand held device that combines the functions of Oscilloscope, Data Logger, Spectrum Analyser, Volt Meter and Frequency Meter in a single instrument.

- 40 M samples/sec
- 5 MHz bandwidth!
- Linux drivers!
DS1M12 "Stingray" 2+1 Channel PC Digital Oscilloscope / Logger

- $263
- http://www.usb-instruments.com/
• Same basic software as the swordfish.
• Dual channel
• 20 M samples/second
• 250 Khz
• Also Linux Drivers!
DSO-101 USB 2-Channel Oscilloscope

- [http://www.audon.co.uk/dso101.html](http://www.audon.co.uk/dso101.html)
- £139
- $199
- 20 MS/s sample rate
- 32KB memory depth per channel
- 2 MHz analog bandwidth
- Digital Triggering
- 8 bit vertical resolution
- Hardware preamp with 7 ranges, 50Vp-p to 50mVp-p
- Scope software for Windows **MAC** and Linux
DSO nano - Pocket size digital storage oscilloscope

- Not really a USB scope, but the price is right.
- $89 (SeeedStudio), $99 (Sparkfun)
DSO ...

- Display - 2.8” Color TFT LCD, 320×240
- Analog bandwidth 0 - 1MHz
- Max sample rate 1Mspss 12Bits
- Sample memory depth 4096 Point
- Trigger modes: Auto, Normal, Single, None and Scan
- Functionalities: Automatic measurement: frequency, cycle, duty, Vpp, Vram, Vavg and DC voltage
DSO ...

- Test signal  Built-in 10Hz~1MHz (1-2-5 Step)
- Waveform storage on SD card
- PC connection via USB as SD card reader
- Upgrade by bootloader via USB
- Open Source firmware:
  http://code.google.com/p/dsonano/
Intuitive & Easy to Use

iMSO-104 is the first mixed signal oscilloscope designed specifically for the iPhone, iPod touch, & iPad. It’s intuitive and easy to use, which is why it's the preferred scope for the next generation of inventors. But don't take our word for it. Download iMSO in the App Store and test drive the interface for free.

Product Specs

- iMSO-104 Mixed Signal Oscilloscope Hardware
- 1x10 Analog Probe
- Logic Harness (4 Digital + 1 Ground)
- SMD Grabbers (5 pieces)
- Bandwidth 5MHz
- Max sample rate 12MSPS
- Screwdriver for Analog Compensation Adjustment
- Analog tip covers (2 pieces)
Atten ADS1022C

ATTEN ADS1022C Digital Storage Oscilloscope
25MHz 500Msa

item #: ADS1022C

Retail price: US$0.00
Wholesale Price: US$277.70
Start from: 1 Unit(s)
Weight: 3.5 Kg(s)
This item is: FREE SHIPPING
NEW Handheld 3.8inch oscilloscope
usb(20MHz) HDS1021M

Price: **US $305.26 / piece** (1 - 5 pieces)
Bulk Price: **US $300.0 / piece** (>5 piece)
Quantity: 1 piece
Shipping Cost: **US $47.24**
To: **United States Via Hongkong Post Air Parcel**
Processing Time: Ships out within 3 days
Total Price: **US $352.50**

Buy Now  Add to Cart
Or build one ...
Simple USB 8 channels logic analyzer

- www.f6fbb.org/LogicAnalyzer/index.html
USB Logic Analyzer

- [http://cegt201.bradley.edu/projects/proj2006/usblal/](http://cegt201.bradley.edu/projects/proj2006/usblal/)
A logic analyzer displays logic levels, typically only a few channels. The digital logic analyzer which has selected display three logic levels, low, high channels are sampled by an external.

The FIFO interfaces to the computer protocol. The graphical user interface, possible three states of the sixteen levels, and interpretation.
USB Oscilloscope

- http://kotilainen.eu/oscilloscope/
Oscilloscope Mk 1

- http://www.1710.co.uk/cms/
- USB oscilloscope design, released under an open-source Creative Commons license
● Windows & Mac software
LED oscope
Another LED oscopes

• www.geocities.com/rlaude2000/ledscope.htm
LED OSCILLOSCOPE

KR LAUDERBAUGH  Rev 1.0  18-15-97  1 OF 2
What? Another one?

Do you suppose we could build an oscilloscope or logic analyzer using the ZNEO?
You betcha!
Like this ...

Signal Conditioning
- Level Adjust
- Optional Enhanced ADC
- Overvoltage protection

Input
- Analog
- Digital

Data
- ZNEO

Host Interface
- Serial USB
- Parallel USB

Plotting Software
- Oscilloscope
- Logic Analyzer

Software
- Plotting software
Input signal offset/amplitude adjust
For Logic Analyzer

- Use a 5v Zener Diode to prevent input of voltages greater than 5v.
Data Input, Data Output

Digital Data

Analog data

To host interface
USB device interface

- **Parallel data**
  - DLP-USB245M USB Adapter
  - 8 megabit/sec
  - www.dlpdesign.com

- **or**

- **Serial data**
  - DLP-USB232M USB Adapter
  - 3 megabit/sec
Other “Roll Your Own”

- Roll your own iphone oscilloscope

- Arduino Oscilloscope
  http://n.mtng.org/ele/arduino/oscillo.html

- Android Oscilloscope

- Oscione (another Android scope)
  http://android.serverbox.ch/?p=213
  http://web.fhnw.ch/technik/projekte/eit/Fruehling2010/DiCerRud/
References

• Oscium pad oscroppe
  http://www.oscium.com/products/imso-104
• Atten ADS 1000 series (ADS1022 = $270)
• DSO 2090
  http://www.amazon.com/100MS-Based-Digital-Storage-Oscilloscope/dp/B002Z34QUA
• HDS