EDUCATIONAL PC OSCILLOSCOPE KIT

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Oscilloscope

- bandwidth: DC to 200 kHz ± 3 dB
- input impedance: 100 kohm / 20 pF
- maximum input voltage: 30 V (AC + DC)
- time base: 10 µs to 500 ms per division
- input range: 100 mV to 5 V/division
- input sensitivity: 3 mV display resolution
- readouts: True RMS, dBV, dBm, p to p, Duty cycle, Frequency...

Transmitter Recorder

- timescale: 20 ms/div to 2000 s/div
- max. recording time: 9.4 h/screen
- automatic storage of data
- record and display of screens
- automatic recording for more than 1 year
- max. number of samples: 100/s
- min. number of samples: 1 sample/20 s

Spectrum Analyzer

- frequency range: 0 .. 150 Hz to 75 kHz
- operating principle: FFT (Fast Fourier Transform)
- FFT resolution: 512 lines

General information

- markers for: amplitude/voltage & frequency/time
- expert or basic mode selection in software
- input coupling: DC and AC
- 8 bit resolution
- storage of display and data
- power supply through USB: +/- 200 mA
- uses Microsoft® human interface device (HID) driver, no external driver required
- dimensions: 94 x 94 mm / 3.7 x 3.7"

Min. system requirements

- IBM compatible PC
- Windows® XP, Vista, 7, 8 *
- SVGA display card (min. 1024 x 768)
- mouse
- free USB port 1.1 or 2.0

Download Software

For software, visit www.vellemanprojects.eu

* Windows™ is a registered trademark of Microsoft Corporation
1. Assembly (Skipping this can lead to troubles!)
Ok, so we have your attention. These hints will help you to make this project successful. Read them carefully.

1.1 Make sure you have the right tools:
- A good quality soldering iron (25-40W) with a small tip.
- Wipe it often on a wet sponge or cloth, to keep it clean; then apply solder to the tip, to give it a wet look. This is called ‘thinning’ and will protect the tip, and enables you to make good connections. When solder rolls off the tip, it needs cleaning.
- Thin raisin-core solder. Do not use any flux or grease.
- A diagonal cutter to trim excess wires. To avoid injury when cutting excess leads, hold the lead so they cannot fly towards the eyes.
- Needle nose pliers, for bending leads, or to hold components in place.
- Small blade and Phillips screwdrivers. A basic range is fine.
- For some projects, a basic multi-meter is required, or might be handy.

1.2 Assembly Hints:
- Make sure the skill level matches your experience, to avoid disappointments.
- Follow the instructions carefully. Read and understand the entire step before you perform each operation.
- Perform the assembly in the correct order as stated in this manual.
- Position all parts on the PCB (Printed Circuit Board) as shown on the drawings.
- Values on the circuit diagram are subject to changes, the values in this assembly guide are correct*.
- Use the check-boxes to mark your progress.
- Please read the included information on safety and customer service.

* Typographical inaccuracies excluded. Always look for possible last minute manual updates, indicated as ‘NOTE’ on a separate leaflet.

1.3 Soldering Hints:
1. Mount the component against the PCB surface and carefully solder the leads.
2. Make sure the solder joints are cone-shaped and shiny.
3. Trim excess leads as close as possible to the solder joint.
DO NOT BLINDLY FOLLOW THE ORDER OF THE COMPONENTS ON THE TAPE. ALWAYS CHECK THEIR VALUE WITH THE PARTS LIST!
## I. CONSTRUCTION

### 1. Ceramic Capacitors
- C11...C13: 10nF (104)
- C16...C19: 100nF (104)

### 2. Diodes
- D1: BAT85
- D2: BAT85
- D3: BAT85
- D4: BAT85
- D5: BAT85
- D6: BAT85
- D7: BAT85

### 3. Zener diode
- ZD1: 5V1

### 4. Choke
- L1: 100µH (1 - 0 - 1 - B)
- L2: 100µH (1 - 0 - 1 - B)

### 5. IC socket
- IC1: 16p
- IC2: 8p
- IC3: 28p

### 6. Trimmer
- RV1: 4K7

### 7. Ceramic Capacitors
- C1: 2,2pF (2.2)
- C2: 6,8pF (6.8)
- C3: 10pF (10)
- C4: 15pF (15)
- C5: 27pF (27)
- C6: 27pF (27)
- C7: 47pF (47)
- C8: 100pF (101)
- C9: 470pF (471)
- C10: 680pF (681)
- C14: 1µF (105)
- C15: 1µF (105)

### 8. Vertical resistors
- R1: 2,2Ω (2 - 2 - B - B)
- R2: 2,2Ω (2 - 2 - B - B)
- R3: 100Ω (1 - 0 - 1 - B)
- R4: 100Ω (1 - 0 - 1 - B)
- R5: 680Ω (6 - 8 - 0 - 0 - 1)
- R6: 680Ω (6 - 8 - 0 - 0 - 1)
- R7: 680Ω (6 - 8 - 0 - 0 - 1)
- R8: 1KΩ (1 - 0 - 0 - 1 - 1)
- R9: 1KΩ (1 - 0 - 0 - 1 - 1)
- R10: 1KΩ (1 - 0 - 0 - 1 - 1)
- R11: 1KΩ (1 - 0 - 0 - 1 - 1)
- R12: 1KΩ (1 - 0 - 0 - 1 - 1)
- R13: 1KΩ (1 - 0 - 0 - 1 - 1)
- R14: 1K1 (1 - 1 - 0 - 1 - 1)
- R15: 1K5 (1 - 5 - 2 - B)
- R16: 1K5 (1 - 5 - 2 - B)
- R17: 2K2 (2 - 2 - 2 - B)
- R18: 2K7 (2 - 2 - 2 - B)
- R19: 5K1 (5 - 1 - 0 - 1 - 1)
- R20: 7K5 (7 - 5 - 0 - 1 - 1)
- R21: 10KΩ (1 - 0 - 0 - 2 - 1)
- R22: 10KΩ (1 - 0 - 0 - 2 - 1)

*metalfilm resistor!
Construction

- R23: 11kΩ (1-1-0-2-1)*
- R24: 15kΩ (1-5-0-2-1)*
- R25: 20kΩ (2-0-0-2-1)*
- R26: 20kΩ (2-0-0-2-1)*
- R27: 20kΩ (2-0-0-2-1)*
- R28: 75kΩ (7-5-0-2-1)*

9 Transistors
- T1: BC337
- T2: BC337
- T3: BC327

10 Voltage regulator
- VR1: LM317LZ

11 Relay switch
- RL1: TSC-106D3H or eq.

12 USB connector
- SK3

13 Electrolytic capacitors
- C25: 10µF
- C26: 10µF
- C27: 10µF
- C28: 10µF
- C29: 10µF
- C30: 100µF
- C31: 100µF

14 Quartz crystal
- X1: 4MHz

15 IC’s
- IC1: CD74HCT4052E
- IC2: TLV272IP
- IC3: VKEDU09 (programmed PIC18F24J501-ISP)

Watch the position of the notch!
**16 LED**

**STEP 1:** Mount the LED. Do not solder yet.

**STEP 2:** Assemble the unit but do not yet tighten the bolts. Position the LED so that it stays just below the cover plate.

**STEP 3:** Turn the unit 180°

**STEP 4:** Solder one lead and check the position. If OK, solder the second connection.

**STEP 5:** Disassemble the unit.

- **LD1:** red

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**Watch the polarity!**
Assembly

17 Mounting the test leads

**STEP 1:** Cut off the banana plug from the test leads.

**STEP 2:** Strip both cables and twist the wire ends of each cable.

**STEP 3:** Solder the wires.

**STEP 4:** Mount both cables as shown in the drawing.

**STEP 5:** Solder the cables on the PCB.

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**II. SOFTWARE INSTALLATION**

**Step 1:** Download the EDU09 software on our website: www.vellemanprojects.eu

**Step 2:** Open the file and select the software.

**Step 3:** Select “next” to begin the installation procedure.

**Step 4:** Accept the license agreement

**Step 5:** Select the destination on your PC.
Step 6: Select the start menu folder

Step 7: Select additional tasks you would like to be performed.

Step 8: Select “Install” for installing the software.

Step 9: Click “finish” to exit setup

Step 10: Connect the unit with the pc.
III. CALIBRATION

There is no external driver necessary, the EDU09 uses the internal Microsoft Windows HID driver, these will loaded automatic.

- Set RV1 to the middle position.
- Connect the EDU09 oscilloscope to the USB slot of the PC. The red led should light.
- Run the installed software EDU09.EXE
- If it is connected for the first time, calibration procedure will start automatically.
- If it does not start automatically: In the Options menu select “Calibrate” and then click OK to start the calibration. Wait until calibration is successful.

**Advanced calibration:** Fine tuning of the input amplifier circuit (requires a 1.5V battery)

This calibration is not really necessary, you must only do this, if you want a higher precision of your measurements

- In the ‘Options’-menu select “Expert Settings”.
- In the ‘View’-menu select “Waveform Parameters...”.
- In the ‘Waveform Parameters’-window select the check box “DC Mean”.

- Measure the output of the battery with a multimeter and remember it.
- Connect the battery to the oscilloscope’s input.
- Set Volts/Div. to “0.5V” and click the “Run” button.
- Adjust trimmer RV1 until the displayed “DC Mean” value in the ‘Waveform Parameters’-window corresponds with the measured value.
- Remove battery.

IV. ASSEMBLY

Your scope is now ready for use.
Make sure to check out our EDU6 Oscilloscope tutor kit. It features lots of information and a number of experiments to familiarise yourself with the basics of an oscilloscope.
OSCILLOSCOPE TERMINOLOGY

1. **Volts/div**: Determines how many volts the signal at the input must swing for the trace to move one division.
2. **Time/div**: Determines the time the trace needs to scan from the left hand side to the right hand side of a division.
3. **Division**: Imaginary or visible grid on the oscilloscope screen. It helps estimating signal amplitude and period.
4. **Period (T)**: Duration of one cycle of the AC waveform (= 1/f)

5. **Frequency (f)**: The number cycles of the AC waveform per sec.
6. **Trace**: ‘line’ that is drawn on the screen, which represents the signal at the input.
7. **Amplitude**: How far does the signal ‘swing’in a direction. Expressed in mV or V. For repetitive signals: Vpeak.
8. **Peak-to-peak**: Difference between most positive and most negative swing of the signal. 2xVpeak for sinusoidal signals.

**AC coupling**: The oscilloscope only displays the AC component of a signal, any DC level is ignored.

**Analog**: Analog scopes use the incoming signal to deflect an electron beam, which scans from left to right on the screen. The electron beam leaves an image on the screen which represents the signal you’ve applied. Analog signals are continuously variable. See also ‘Digital’.

‘**Auto-setup’ mode**: The oscilloscope automatically selects a setting for Volts/div and Time/div in such a way that one or more periods of signal are displayed correctly.

**Clipping**: When the ‘top’ or ‘bottom’ or both extremes of a signal are cut-off (‘clipped’), e.g. because the signal cannot swing any further due to power supply limitations. An undesired property of amplifiers that are driven beyond their specs.
**DC coupling:** The oscilloscope displays both the AC and the DC component of a signal.

**Digital:** Digital scopes perform an analog to digital conversion on the incoming signal and handle all the calculations and displaying in the digital domain. Digital signals feature only two fixed levels, usually 0V and +5V. See also ‘Analog’.

**Distortion:** Undesired alteration of a signal due to external causes such as overloaded circuits, badly designed circuits, etc…

**Noise:** Undesired random addition to a signal.

**Ripple:** Unwanted periodic variation of a DC voltage.

**Signal:** Voltage applied to the input of the oscilloscope. The subject of your measurement.

**Sine wave:** Mathematical function that represents a smooth repetitive oscillation. The waveform shown at the start of this glossary is a sine wave.

**Spikes:** Fast, short duration transients in a signal.

**AC voltage:** (AC: Alternating Current) With AC, the flow of the current periodically reverses, as opposed to DC, where the current flows in one direction. An AC source does not have a polarity.

**Bandwidth:** Usually expressed in MHz. It is the frequency at which an applied sine wave will be displayed at an amplitude of around 70% of its original amplitude. More expensive scopes feature a higher bandwidth. Rule of thumb: the bandwidth of an oscilloscope needs to be at least 5 times higher than the frequency of the signal applied to the input of the scope. The EDU09 bandwidth goes up to 200KHz.

**DC reference:** DC measurement is always performed with respect to a ground level, so we need to define this ground level. If you do not set the DC reference, the readout might not be correct. In most cases, this ground level will be the center of the screen, however this is not mandatory.

**DC voltage:** (DC:Direct Current) With DC, the current flows in a single direction, it does not reverse. A DC source has a polarity, (+) and (-).
Oscilloscope terminology

Input coupling: The drawing shows typical oscilloscope input circuit. There are 3 possible settings: AC-coupling, DC coupling and GND.
With AC-coupling, a capacitor is put in series with the input signal. This capacitor blocks any DC component of the signal and passes only AC.
With DC coupling, the capacitor is bypassed and both the AC and DC component of the signal are passed. Low frequency signals (<20Hz) should always be displayed using DC coupling. Should AC coupling be used, the internal coupling capacitor will interfere with the signal and the displayed signal will not be correct.

Sample rate: Usually expressed in samples or megasamples/second, sometimes in MHz. It is the number of times per second the digital oscilloscope ‘looks’ at the signal at the input. The more it ‘looks’, the better it is able to recreate a faithful image of the waveform on the screen. Theoretically the sample rate needs to be twice the max. frequency of the applied signal, however, for best results a sample rate of 5 times the max. frequency is recommended. The EDU09 samplerate is 1,5Ms/s or 1,5MHz.

Sensitivity: Indicates the smallest change of the input signal that makes the trace move up or down on the screen. Usually expressed in mV.

Slope: It determines where the scope will trigger. This can be on the rising or on the falling slope of the signal.

Vrms: The rms voltage of an AC source represents the required DC voltage to generate the same amount of heat in a resistor as the AC source would do. For sinusoidal signals, $V_{rms} = V_{peak} / \sqrt{2}$
Supply voltage (V) - led voltage (V) = series resistance (ohms)

<table>
<thead>
<tr>
<th>Supply voltage (V)</th>
<th>Led voltage (V)</th>
<th>Series resistance (ohms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9V</td>
<td>1.7V</td>
<td>1460 ohm</td>
</tr>
</tbody>
</table>

Required resistor power handling = voltage over resistor x current passed through resistor

9V - (3 x 1.7V) x 0.005A = 0.036W

Recommended resistor:
- Use a 1k5 resistor
- Use an 820 ohm resistor

LEDs in series:

Example: 3 x red led (1.7V) on 9V battery
Required led current for full brightness: 5mA (this can be found in the datasheet of the led)

Supply voltage (V) - (number of leds x led voltage (V)) = series resistance (ohms)

<table>
<thead>
<tr>
<th>Supply voltage (V)</th>
<th>Number of led x Voltage (V)</th>
<th>Series resistance (ohms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9V</td>
<td>3 x 1.7V</td>
<td>780 ohm</td>
</tr>
</tbody>
</table>

Open collector outputs:

An open collector output can be compared to a switch which switches to ground when operated.

Example: How to switch an LED by means of an open collector output.