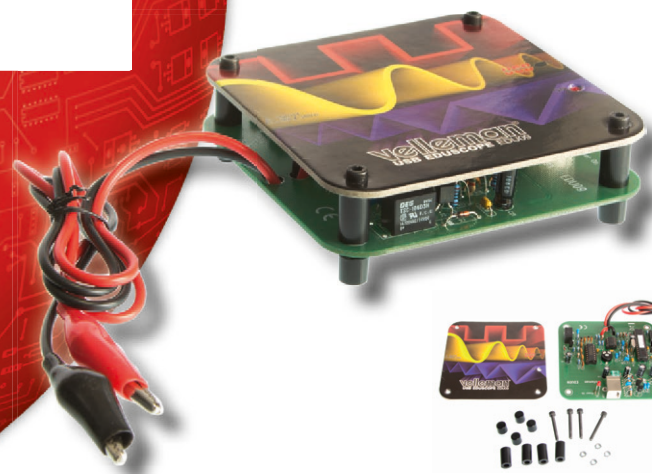
velleman® EDU kit

EDUCATIONAL PC OSCILLOSCOPE KIT

EDU09

DISCOVER THE WORLD OF ELECTRONICS



View Demo

WWW.VELLEMANPROJECTS.EU

Velleman N.V.
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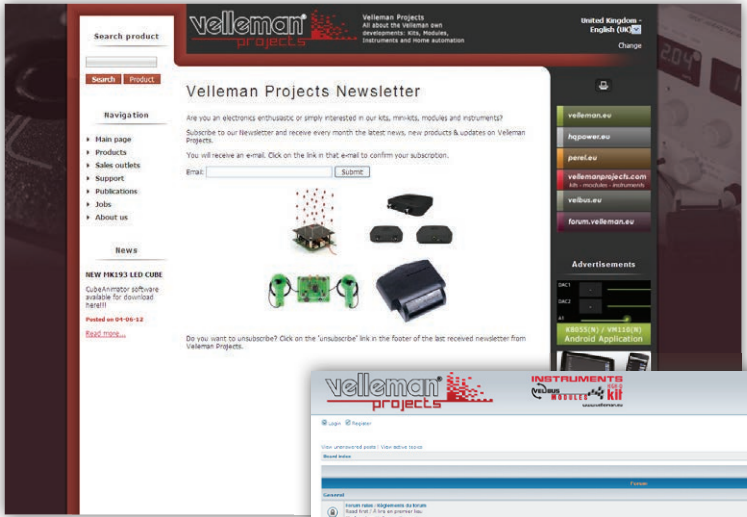
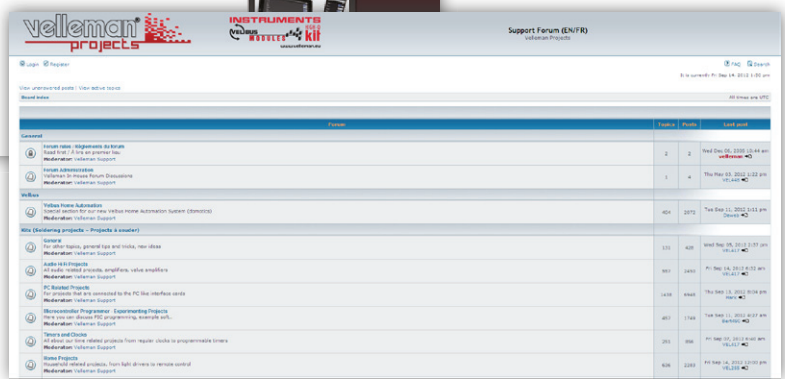
9890 Gavere
(België)





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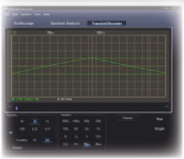
Oscilloscope

- 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…
- record length: 1k samples
- sampling frequency: 62.5 Hz to 1.5 MHz
- sample history function
- auto set-up function
- pre-trigger function : on 0.1 ms/div .. 500 ms/div ranges
- persistence options: Colour graded, Variable and Infinite

Transient 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 trademarks of Microsoft Corporation

assembly hints

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

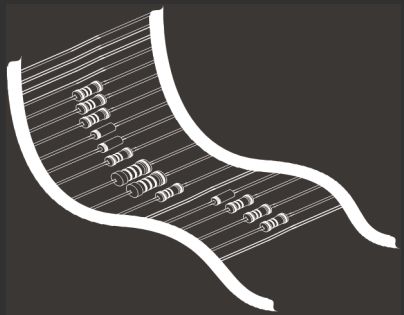
* Typographical inaccuracies excluded. Always look for possible last minute manual updates, indicated as 'NOTE' on a separate leaflet.

1.3 Soldering Hints :

1. Mount the component against the PCB surface and carefully solder the leads

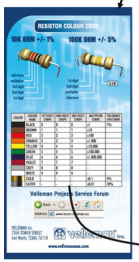
2. Make sure the solder joints are cone-shaped and shiny

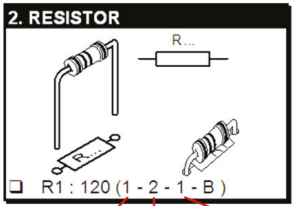
3. Trim excess leads as close as possible to the solder joint



REMOVE THEM FROM THE TAPE ONE AT A TIME !

Included in this kit



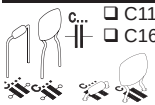


COLOUR	COLOUR NAME	1ST DIGIT/ STRIPE	2ND DIGIT/ STRIPE	3RD DIGIT/ STRIPE	MULTIPLIER STRIPE	TOLE 4TH
	BLACK	0	0	0	x1	1%
	BROWN	1	1	1	x10	
	RED	2	2	2	x100	
	ORANGE	3	3	3	x1.000	
	YELLOW	4	4	4	x10.000	
	GREEN	5	5	5	x100.000	
	BLUE	6	6	6	x1.000.000	

DO NOT BLINDLY FOLLOW THE ORDER OF THE COMPONENTS ON THE TAPE. ALWAYS CHECK THEIR VALUE WITH THE PARTS LIST!

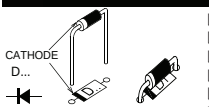
I. CONSTRUCTION

1 Ceramic Capacitors



- ❑ C11...C13 : 100nF (104)
- ❑ C16...C19 : 100nF (104)

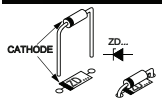
2 Diodes



Watch the polarity!

- ❑ D1 : BAT85
- ❑ D2 : BAT85
- ❑ D3 : BAT85
- ❑ D4 : BAT85
- ❑ D5 : BAT85
- ❑ D6 : BAT85
- ❑ D7 : BAT85

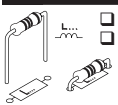
3 Zenerdiode



Watch the polarity!

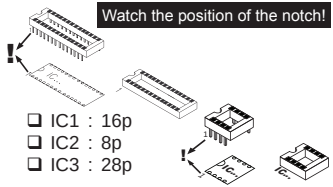
- ❑ ZD1 : 5V1

4 Choke



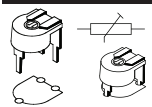
- ❑ L1 : 100µH (1 - 0 - 1 - B)
- ❑ L2 : 100µH (1 - 0 - 1 - B)

5 IC socket



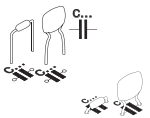
- ❑ IC1 : 16p
- ❑ IC2 : 8p
- ❑ IC3 : 28p

6 Trimmer



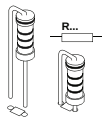
- ❑ RV1: 4K7

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)
- ❑ C20 : 1µF (105)
- ❑ C21 : 1µF (105)
- ❑ C22 : 1µF (105)
- ❑ C23 : 1µF (105)
- ❑ C24 : 1µF (105)

8 Vertical resistors

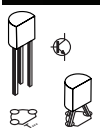


- ❑ R1 : 2,2Ω (2 - 2 - B - B)
- ❑ R2 : 2,2Ω (2 - 2 - B - B)
- ❑ R3 : 100Ω (1 - 0 - 1 - B)
- ❑ R4 : 100Ω (1 - 0 - 1 - B)
- ❑ R5 : 680Ω (6 - 8 - 0 - 0 - 1)*
- ❑ R6 : 680Ω (6 - 8 - 0 - 0 - 1)*
- ❑ R7 : 680Ω (6 - 8 - 0 - 0 - 1)*
- ❑ R8 : 1KΩ (1 - 0 - 0 - 1 - 1)*
- ❑ R9 : 1KΩ (1 - 0 - 0 - 1 - 1)*
- ❑ R10 : 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 - 7 - 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 !

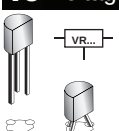
- ❑ R23 : 11KΩ (1 - 1 - 0 - 2 - 1)*
- ❑ R24 : 15KΩ (1 - 5 - 0 - 2 - 1)*
- ❑ R25 : 20KΩ (2 - 0 - 0 - 2 - 1)*
- ❑ R26 : 20KΩ (2 - 0 - 0 - 2 - 1)*
- ❑ R27 : 20KΩ (2 - 0 - 0 - 2 - 1)*
- ❑ R28 : 75KΩ (7 - 5 - 0 - 2 - 1)*

9 Transistors



- ❑ T1 : BC337
- ❑ T2 : BC337
- ❑ **T3: BC327**

10 Voltage regulator

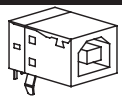


❑ VR1 : LM317LZ

11 Relay switch

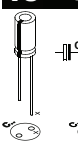
❑ RL1: TSC-106D3H or eq.

12 USB connector



❑ SK3

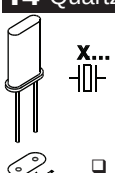
13 Electrolytic capacitors



Watch the polarity!

- ❑ C25 : 10µF
- ❑ C26 : 10µF
- ❑ C27 : 10µF
- ❑ C28 : 10µF
- ❑ C29 : 10µF
- ❑ C30 : 100µF
- ❑ C31 : 100µF

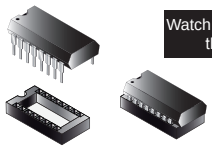
14 Quartz crystal



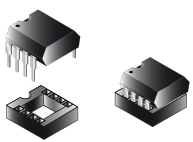
❑ X1 : 4MHz

15 IC's

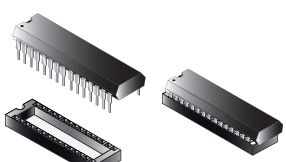
Watch the position of the notch!



❑ IC1 : CD74HCT4052E



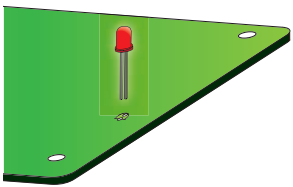
❑ IC2 : TLV272IP

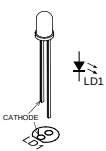


❑ IC3 :VKEDU09
(programmed PIC18F24J501-ISP)

16 LED

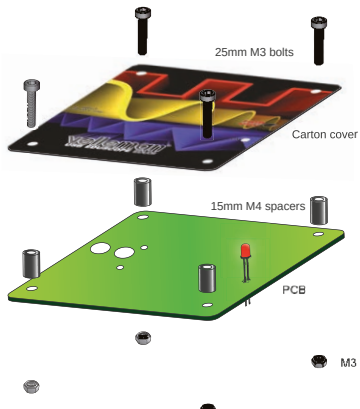
STEP 1: Mount the LED.
Do not solder yet.



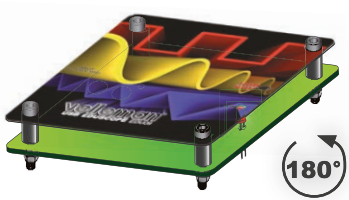


❑ LD1 : red

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°



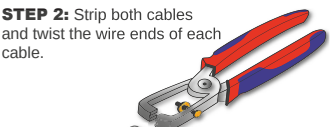
STEP 4: Solder one lead and check the position. If OK, solder the second connection.

STEP 5: Disassemble the unit.

17 Mounting the test leads

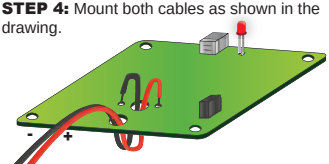
STEP 1: Cut off the banana plug from the test leads.

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.



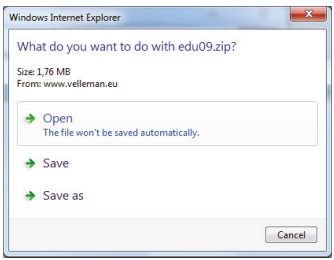
Tip: Start with one cable and then do the other.

Step 5: Solder the cables on the PCB.

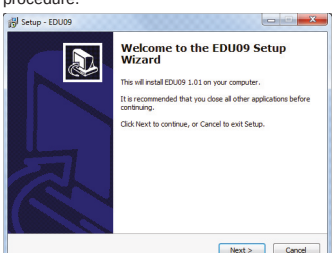
II. SOFTWARE INSTALLATION

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

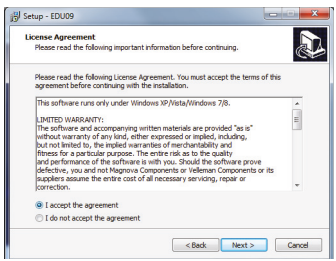
Step 2: open the file en select the software.



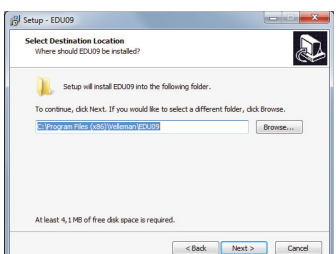
Step 3: Select “next” to begin the installation procedure.



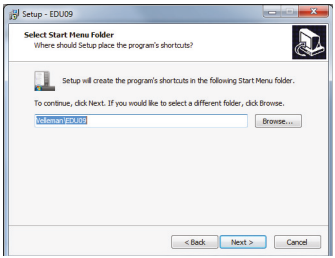
Step 4: Accept the license argeement



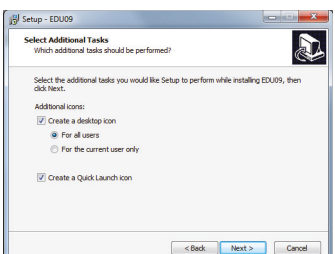
Step 5: Select the destination on your PC



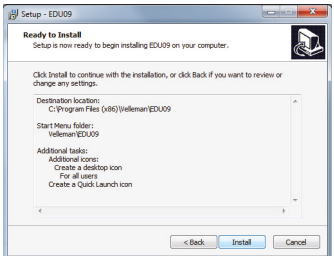
Step 6: Select the start menu folder



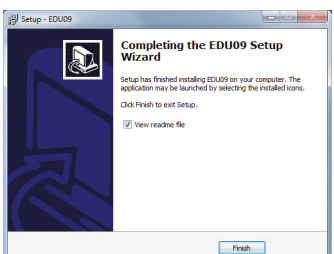
Step 7: Select additional tasks you would like to be performed.



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

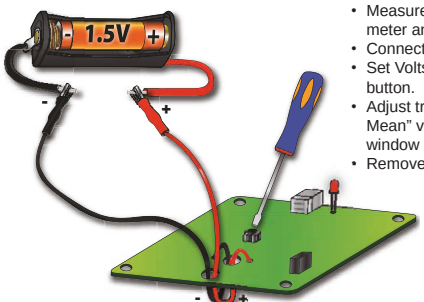
There is no external driver necessary, the EDU09 uses the internal Microsoft Windows HID driver, these will loaded automatic.

- 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)

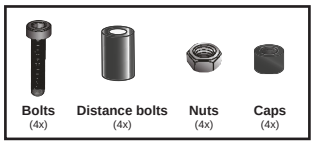
This calibration is not really necessary, you must only do this, if you want a higher precision of your measurements

- 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”.

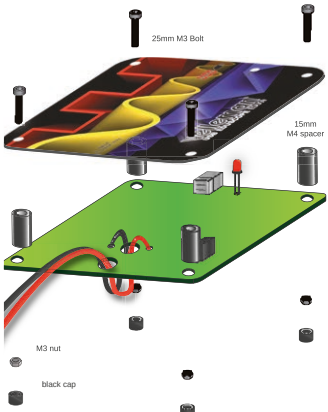


- Measure the output of the battery with a multi-meter and remember it.
- Connect the battery to the oscilloscope’s input.
- Set Volts/Div. to “0.5V” and click the “Run” button.
- Adjust trimmer RV1 until the displayed “DC Mean” value in the ‘Waveform Parameters’-window corresponds with the measured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

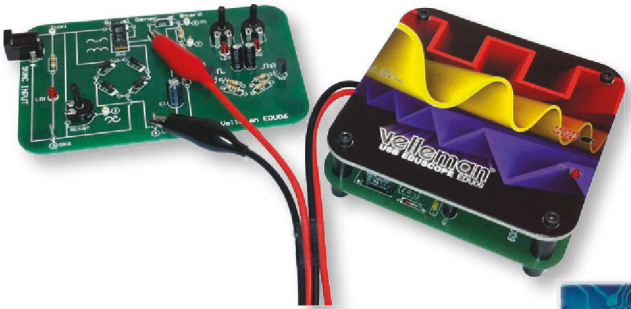
IV. ASSEMBLY



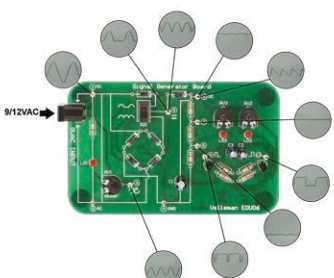
Mount the cover.

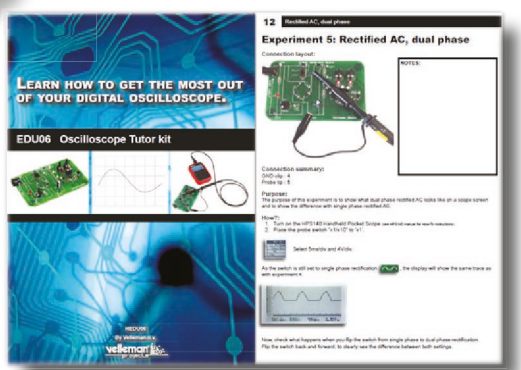


Your scope is now ready for use.



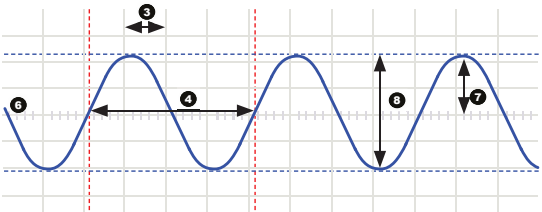
Make sure to check out our EDU6 Oscilloscope tutor kit. It features lots of information and a number of experiments to familiarise yourself with the basics of an oscilloscope.





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 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)



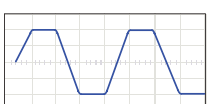
5. **Frequency (f):** The number cycles of the AC waveform per sec.
6. **Trace:** 'line' that is drawn on the screen, which represents the signal at the input.
7. **Amplitude:** How far does the signal 'swing'in a direction. Expressed in mV or V. For repetitive signals: Vpeak.
8. **Peak-to-peak:** Difference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

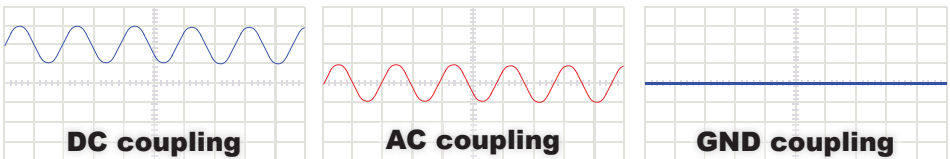
AC voltage: (AC: Alternating Current) With AC, the flow of the current periodically reverses, as opposed to DC, where the current flows in one direction. An AC source does not have a polarity.

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 (-).

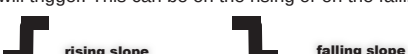
Input coupling: The drawing shows typical oscilloscope input circuit. There are 3 possible settings: AC-coupling, DC coupling and GND. With AC-coupling, a capacitor is put in series with the input signal. This capacitor blocks any DC component of the signal and passes only AC. With DC coupling, the capacitor 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.



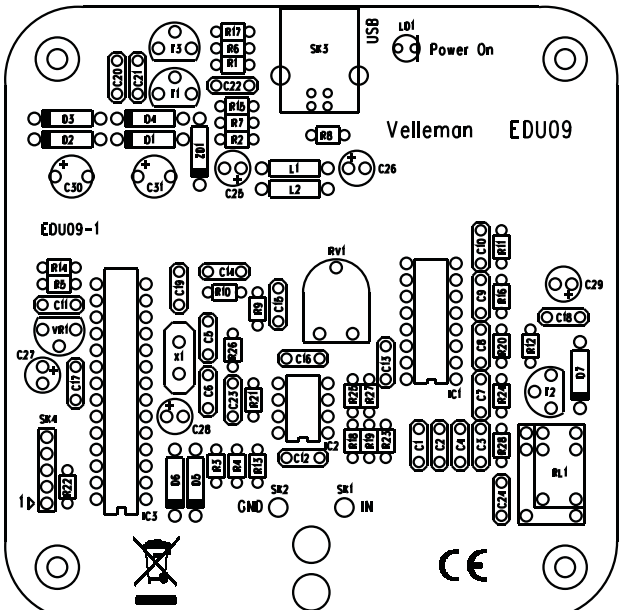
Sample rate: Usually expressed in samples or megasamples/second, sometimes in MHz. It is the number of times per second the digital oscilloscope 'looks' at the signal at the input. The more it 'looks', the better it is able to recreate a faithful image of the waveform on the screen. Theoretically the 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.

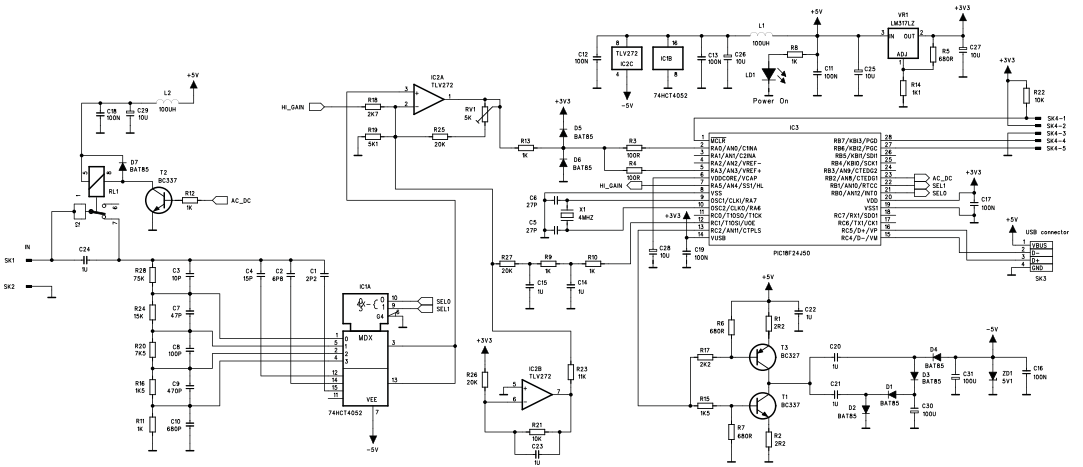
Sensitivity: Indicates the smallest change of the input signal that makes the trace move up or down on the screen.
Usually expressed in mV.

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

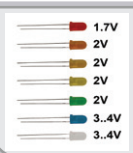


Vrms: The rms voltage of an AC source represents the required DC voltage to generate the same amount of heat in a resistor as the AC source would do. For sinusoidal signals, Vrms = Vpeak / sqrt(2)

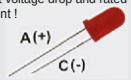

USB
LD1
Power On
SK3
R17
R6
R1
T3
T1
C20
C21
C22
R15
R7
R2
D3
D2
D4
D1
ZD1
R8
Velleman
EDU09
C30
C31
C25
L1
L2
C26
EDU09-1
RV1
R14
R5
C11
VR1
C27
C17
C19
C14
R10
R9
C15
C5
X1
R26
C6
C23
R21
C28
C16
C13
R25
R27
IC2
R18
R19
R23
C12
IC1
C10
R11
C9
R16
C8
R20
C7
R24
C3
R28
C1
C2
C4
C29
C18
R12
D7
T2
RL1
C24
SK4
R22
1
IC3
D6
D5
R3
R4
R13
SK2
GND
SK1
IN


+5V
L2
100UH
C18 100N
C29 10U
D7 BAT85
RL1
T2 BC337
R12 1K
AC_DC
IN
SK1
SK2
C24 1U
R28 75K
R24 15K
R20 7K5
R16 1K5
R11 1K
C3 10P
C7 47P
C8 100P
C9 470P
C10 680P
C4 15P
C2 6P8
C1 2P2
IC1A
74HC4052
MUX
VEE
SEL0
SEL1
-5V
HI_GAIN
IC2A TL272
R18 2K7
R19 5K1
RV1 5K
R25 20K
IC2B TL272
R26 20K
R23 1K
R21 10K
C23 1U
+3V3
D5 BAT85
D6 BAT85
R13 1K
R3 100R
R4 100R
C6 27P
C5 27P
X1 4MHZ
R27 20K
R9 1K
R10 1K
C15 1U
C14 1U
C12 100N
IC2C TL272
IC1B 74HC4052
C13 100N
C26 10U
L1 100UH
LD1 Power On
R8 1K
C11 100N
C25 10U
VR1 LM317LZ
IN OUT ADJ
R5 680R
C27 10U
R14 1K1
R22 10K
SK4-1
SK4-2
SK4-3
SK4-4
SK4-5
IC3
PIC18F24J50
MCLR
RA0/AN0/C1INA
RA1/AN1/C2INA
RA2/AN2/VREF-
RA3/AN3/VREF+
VDDCORE/VCAP
RA5/AN4/SS1/HLVDIN
VSS
OSC1/CLKI/RA7
OSC2/CLKO/RA6
RC0/T1OSO/T1CKI
RC1/T1OSI/UOE
RC2/AN11/CTPLS
VUSB
RB7/KBI3/PGD
RB6/KBI2/PGC
RB5/KBI1/SDI
RB4/KBI0/SCK
RB3/AN9/CTED2
RB2/AN8/CTED1
RB1/AN10/RTCC
RB0/AN12/INT0
VDD
VSS
RC7/RX1/SDO
RC6/TX1/CK1
RC5/D+/VP
RC4/D-/VM
AC_DC
SEL1
SEL0
C28 10U
C19 100N
C17 100N
USB connector
VBUS
D-
D+
GND
SK3
R6 680R
R1 2K2
C22 1U
R7 2K2
T3 BC327
R15 1K5
T1 BC337
R2 2R2
R8 680R
C20 1U
C21 1U
D2 BAT85
D4 BAT85
D3 BAT85
C31 100U
C30 100U
ZD1 5V1
C16 100N

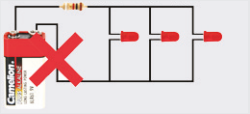
Leds and how to use them



Leds feature a specific voltage drop, depending on type and colour. Check the datasheet for exact voltage drop and rated current !



Never connect leds in parallel



How to Calculate the series resistor:

Example: operate a red led (1.7V) on a 9Vdc source.
Required led current for full brightness: 5mA (this can be found in the datasheet of the led)

$$\frac{\text{Supply voltage (V) - led voltage (V)}}{\text{required current (A)}} = \text{series resistance (ohms)}$$

$$\frac{9V - 1.7V}{0.005A} = 1460 \text{ ohm}$$

closest value : use a 1k5 resistor

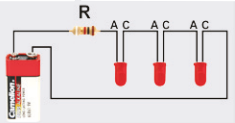
Required resistor power handling=
voltage over resistor x current passed trough resistor

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

a standard 1/4W resistor will do the job

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)



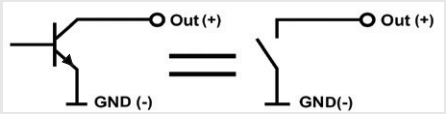
$$\frac{\text{Supply voltage (V) - (number of leds x led voltage (V))}}{\text{required current (A)}} = \text{series resistance (ohms)}$$

$$\frac{9V - (3 \times 1.7V)}{0.005A} = 780 \text{ ohm}$$

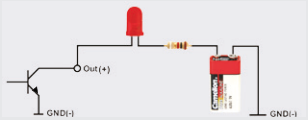
use an 820 ohm resistor

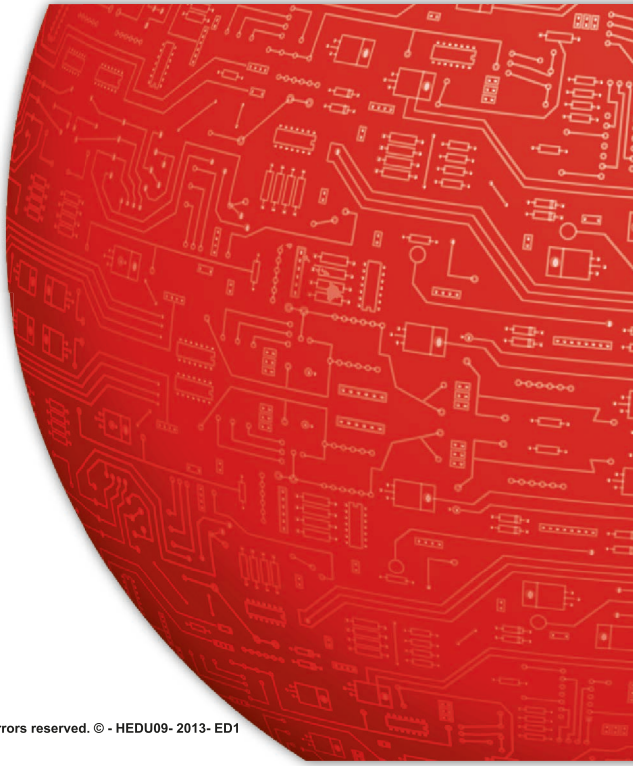
open collector outputs

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





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