

# sensor workshop

## Content

```

/home/richard/
├── List of programs
├── Basic program for all sensors ★★★★★
├── Sensors on micro:bit (internal)
│   ├── Light ★★★★★
│   ├── Temperature ★★★★★
│   ├── Acceleration ★★★★★
│   └── Magnetic field ★★★★★
├── Contact sensors (switch)
│   ├── Aluminium foil switch ★★★★★
│   └── Projects (ext. links)
├── Resistive sensors (ohmic)
│   ├── Potentiometer ★★★★★
│   ├── Photoresistor ★★★★★
│   └── Thermistor ★★★★★
├── Non-contact sensors @distance
│   ├── Infrared distance sensor ★★★★★
│   └── Ultrasonic distance sensor ★★★★★
├── Complex sensor systems I2C bus
│   ├── Temperature & Humidity sensor ★★★★★ (library required)
│   └── Color Sensor ★★★★★ (library required) + reference card
└── Further reading, datasheets, manuals etc.
    
```

## Sensor

What is it?



17.5.22



Do you know any?

## Sensor

LAT *sentire* – perceive, feel, experience, realize,...

- GB Sensor, detector
- DE Sensor, (Messgrößen-)Aufnehmer, (Mess-)Fühler
- FR Capteur
- PL Czujnik
- HU Érzékelő
- UA Давач [davač]
- RU Датчик [datčik]
- CZ Senzor, čidlo, snímač
- SK Snímač

DEF: Information resource for the control system (e.g. brain)

DEF: A device which detects or measures a physical property and records, indicates, or otherwise responds to it.



## Human senses

- taste
- smell
- touch
- hearing
- sight



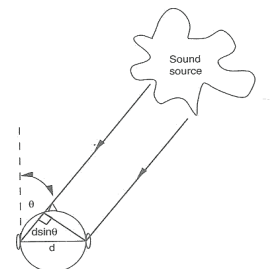
Is this true?

## Hearing

– is also the positioning system

- Combination of:
- Interaural time difference (ITD)
 
$$\Delta t = d \sin(\theta) / c$$

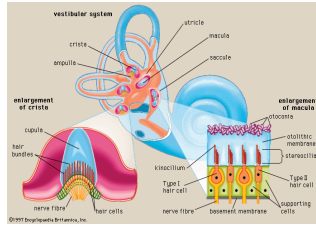
*c* -- speed of sound wave [m/s]
- Interaural intensity difference (IID)



**Pose** – is also the part of the hearing

- Statocinetics organ
- 3 perpendicular channels measure rotational acceleration

Cartesian system!



## Sensors and robots

Built-in 11 sensors, motor control coprocessor and SLAM technology for correct position and speed adjustment

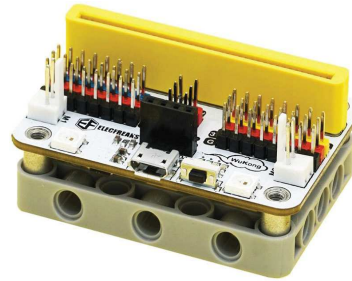


external / internal

Source: <https://www.viomi.com/>

## Wukong interface board

1+ 47,88-52,90 € without micro:bit



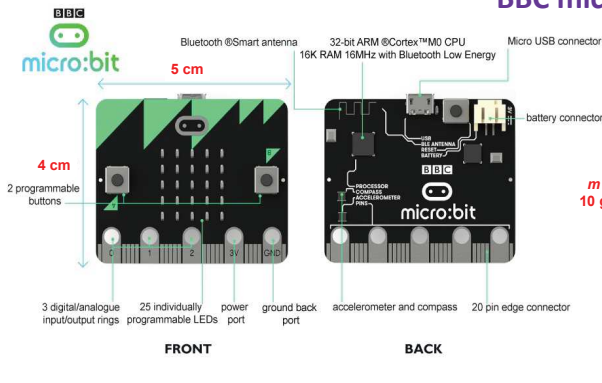
- 4x blue LED (effects)
- 4x Neopixel RGB LED
- 1x speaker
- 2x DC motor interface (H-bridge)
- 8x servo motor interface 5V
- 8x universal interface SVG 3,3V

integrated battery

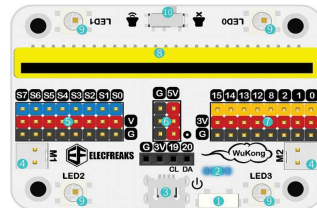
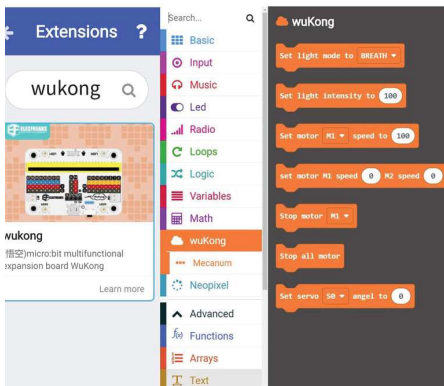
LEGO compatible mechanical mount

<https://www.electfreaks.com/wukong-board-with-lego-holder-for-micro-bit.html>

## BBC micro:bit



search "wukong" in makecode



### Onboard resources instruction (the front side)

1. Power switch	2. Power indicating LED	3. USB power supply
4. Motor connection X2	5. Servo-drive connection	6. 5v connection
7. 8-way GVS connection	8. micro:bit adapter	9. Rainbow LED X4
10. Buzzer switch		

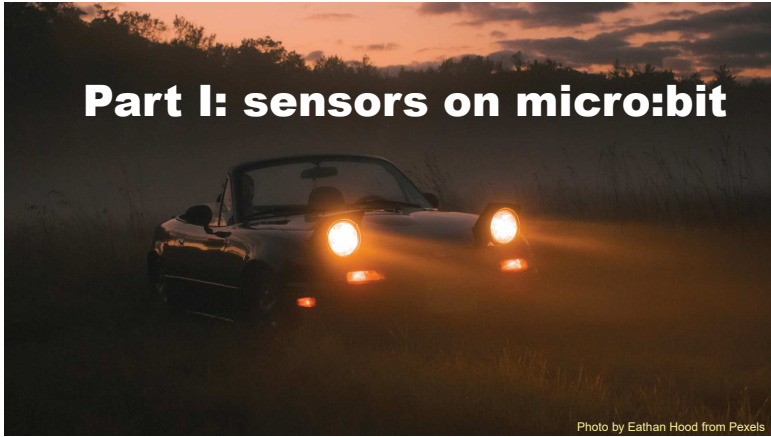
## Sense-Think-Act



My front sensor detects a wall 5 cm...

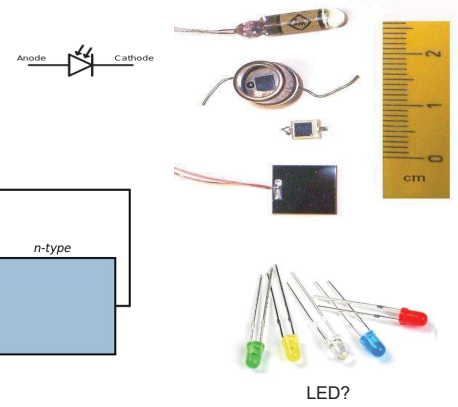
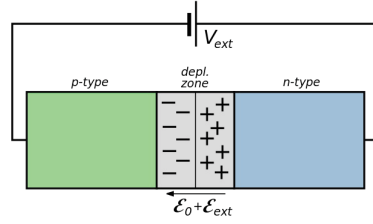
Mhm... that seems too close, I should stop or turn away...

Let's switch off the motors -stop.



## Light detection photodiode

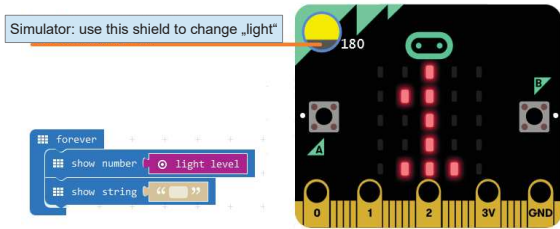
- + fast
- low sensitivity



## Light sensor

Values: 0 -- 255 [-]

Simulator: use this shield to change „light“



Let's try to play with light sensor...

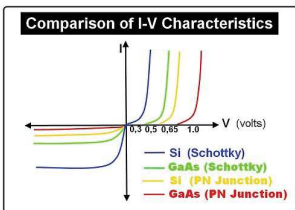


<http://makecode.microbit.org>

<http://www.robotics.sk/w>

## Temperature diode

- + linearity
- + low price



**VISHAY** 1N4148 Vishay Semiconductors

Small Signal Fast Switching Diodes

**FEATURES**

- Silicon epitaxial planar diode
- Electrically equivalent diodes: 1N4148 - 1N914
- Material categorization: for definitions of compliance please see [www.vishay.com/doc?99912](http://www.vishay.com/doc?99912)

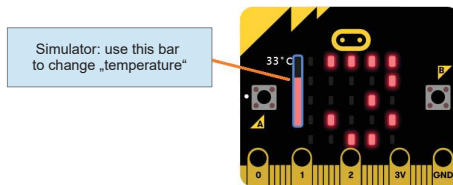
**APPLICATIONS**

- Extreme fast switches

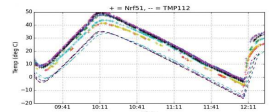
RoHS COMPLIANT

## Temperature sensor

Simulator: use this bar to change „temperature“

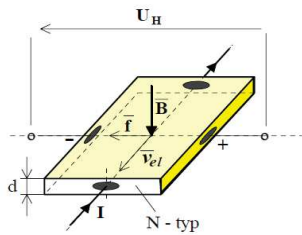


Values: -5 -- 50 [°C]  
+/- 4 °C  
offset: <12 °C unofficial



Source: <https://devzone.nordicsemi.com/f/nordic-q-a/5997/nrf51822-temp-internal-temperature-sensor-characteristic>

## Magnetic field sensor: Hall effect



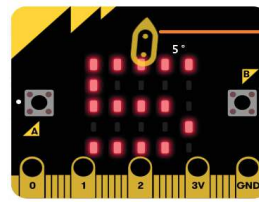
Hall voltage

$$U_H = \frac{IB}{ned}$$

where

$I$  - current,  
 $B$  - intensity of mag. field,  
 $d$  - thickness of material,  
 $n$  = density of mobile charges,  
 $e$  = electron charge.

## Magnetic field sensor

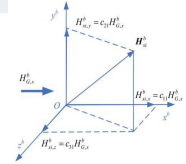


Simulator only

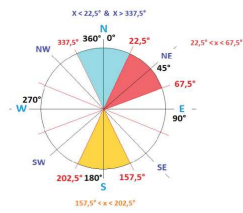
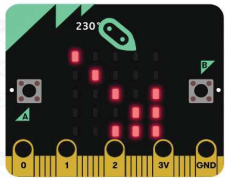
```

forever
  serial write value "Mag" = compass heading (*)
  pause (ms) 100
  magnetic force (µT) x v
  
```

Values: 0 - 360 [°deg]  
 +/- 2048 [µT]

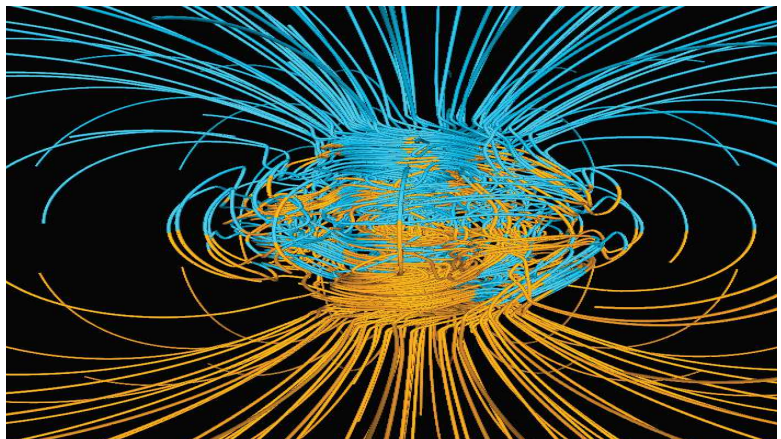
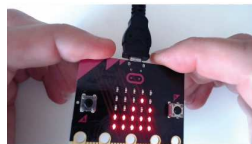


## Magnetic field sensor

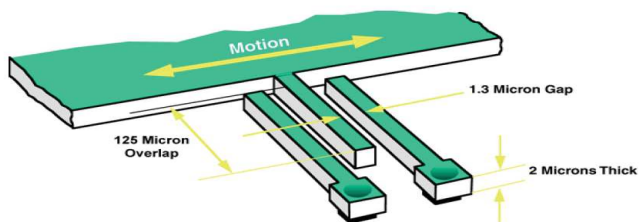


```

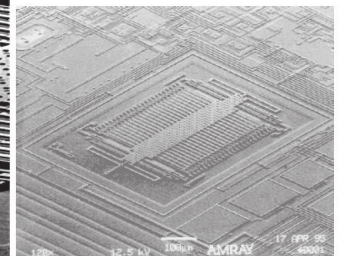
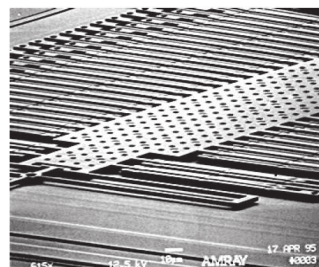
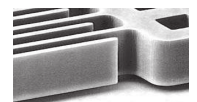
on start
  calibrate compass
  
```



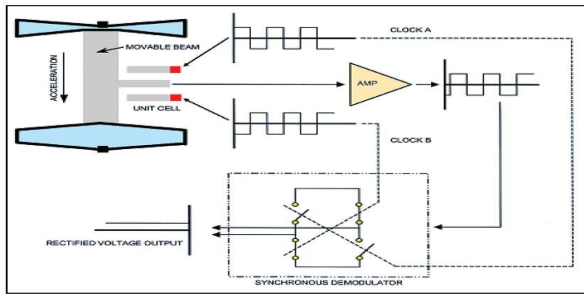
## 9. 4. Acceleration MEMS accelerometer



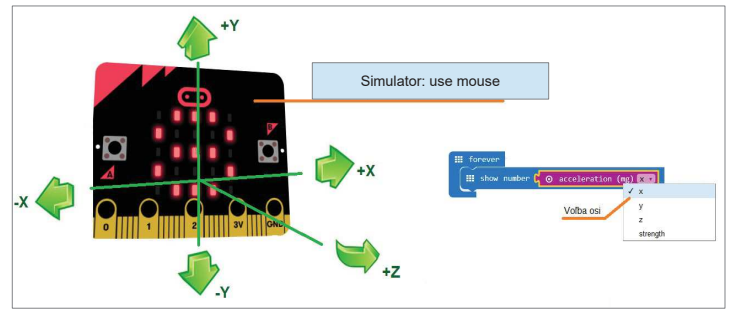
## 9. 4. Acceleration MEMS accelerometer



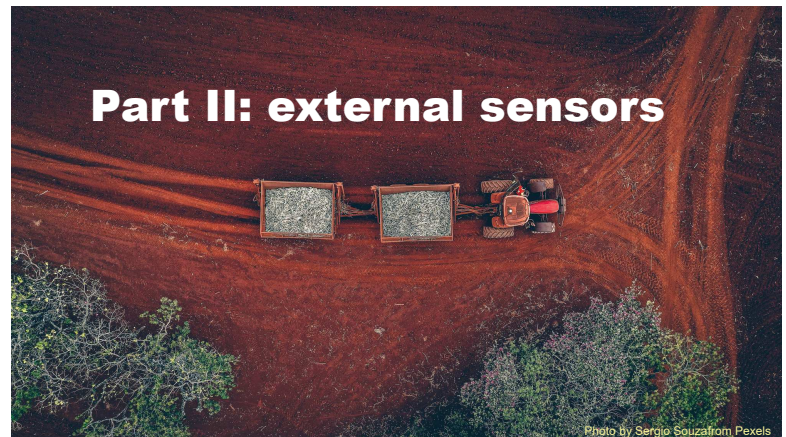
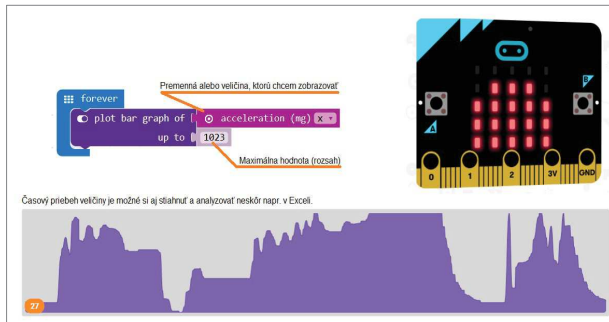
## 9. 4. Meranie zrýchlenia MEMS akcelerometer



## Akcelerometer



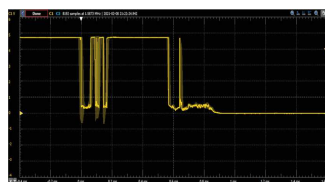
## Bar graph



## 2.1. Binary sensors Contact

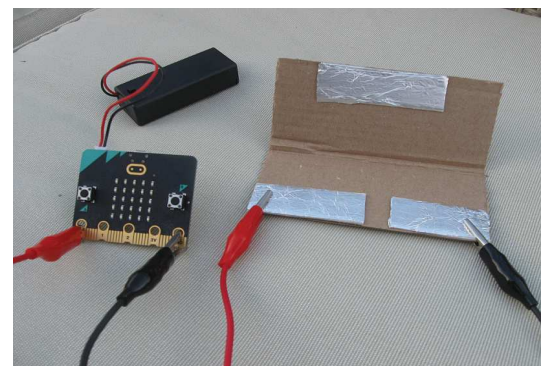


professional



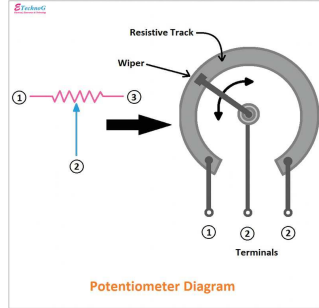
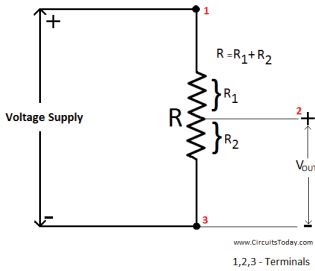
(de)bouncing

## 2.1. Binary sensors Contact

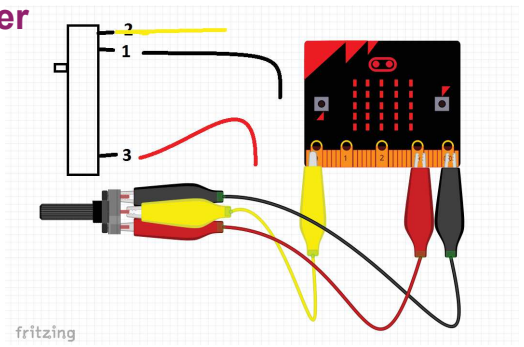


make your own  
(even bananas work!)

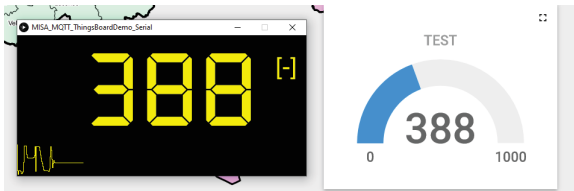
### 3.2. Resistive sensors Potentiometer



### 3.2. Resistive sensors Potentiometer



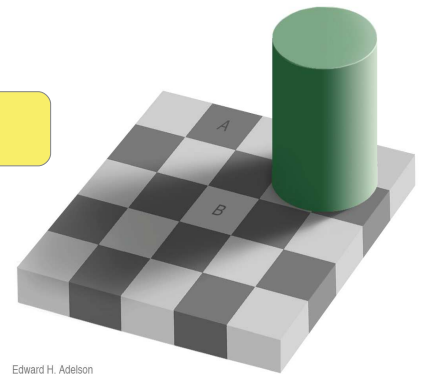
### Step aside: Potentiometer -- cloud demo



### 7. 4. Optical sensors Colour

DEF: Colour is the visual perceptual property deriving from the spectrum of light interacting with the photoreceptor cells of the eyes.

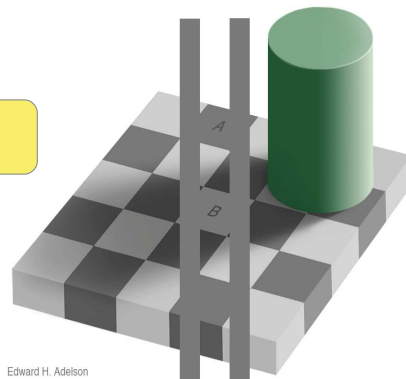
- Properties of the object
- Properties of the light
- Properties of the medium (air)
- Signal processing**



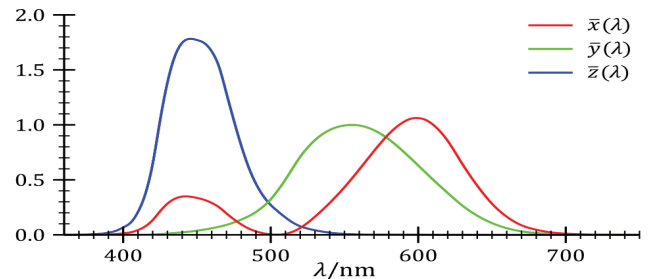
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- Properties of the object
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- Properties of the medium (air)
- Signal processing**



Farba



• CIE 1931 Standard Colorimetric Observer functions used to map blackbody spectra to XYZ coordinates

## APDS-9960

Digital Proximity, Ambient Light, RGB and Gesture Sensor

### Data Sheet

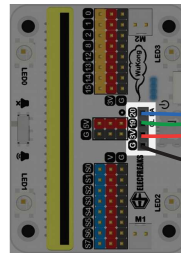


AVAGO  
TECHNOLOGIES

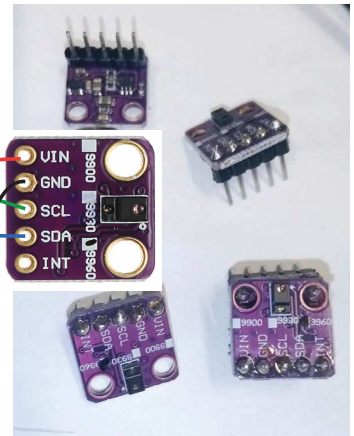


<https://github.com/KittenBot/pxt-apds9960>

## 7. 4. Optical sensors Colour



<https://github.com/KittenBot/pxt-apds9960>



## Closing remarks: think of...

- **Sampling period and sending period**  
(how often you really need to send data)
- **Range of values**
- **Units**  
(are those just ADC values, or floats with real units)
- **Does the sensor measure something real?**  
(e.g. photoresistor - lux, lumen, relative?)
- **Do I need to calibrate?**

## Finish

- **Which sensors were new for you?**
- **Did they work reliably?**
- **Did you identify some sources of errors?**
- **What didn't work as you assumed? Why?**



## That's all, folks

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<http://www.robotika.sk>  
<http://senzor.robotika.sk>

