IOT Robots

2014

ISS Robots

Controllori, Attuatori, Sensori

MICROCOMPUTER

- Raspberry Pi

MICROCONTROLLER

- Arduino

- Motor driver
- Batterie

Sensori

- Ultrasonic Sensor
- Infrared line sensor
- Infrared distance sensor
- Camera

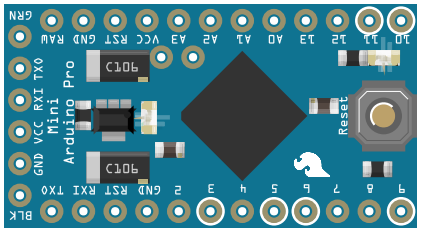
Attuatori

- DC Motor
- Servo
- Stepper Motor

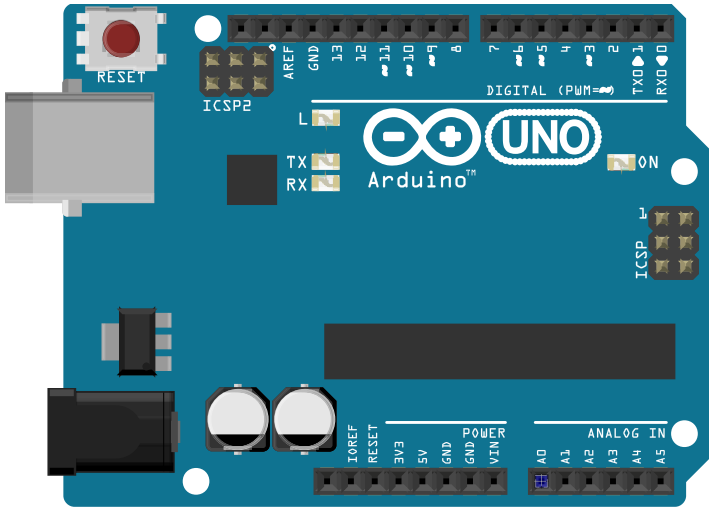
Arduino

Arduino

- ProMini



- Uno (Rev 3)



ATmega 328

RAM 2K

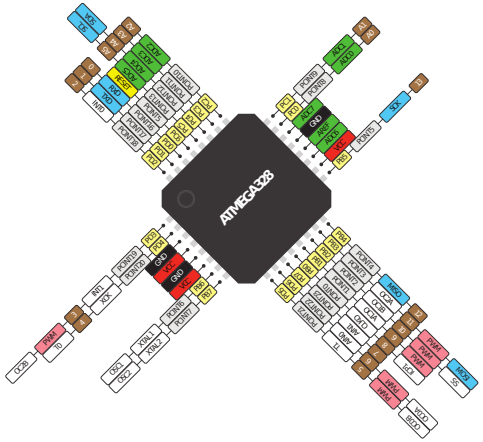
Flash 32K

Timers

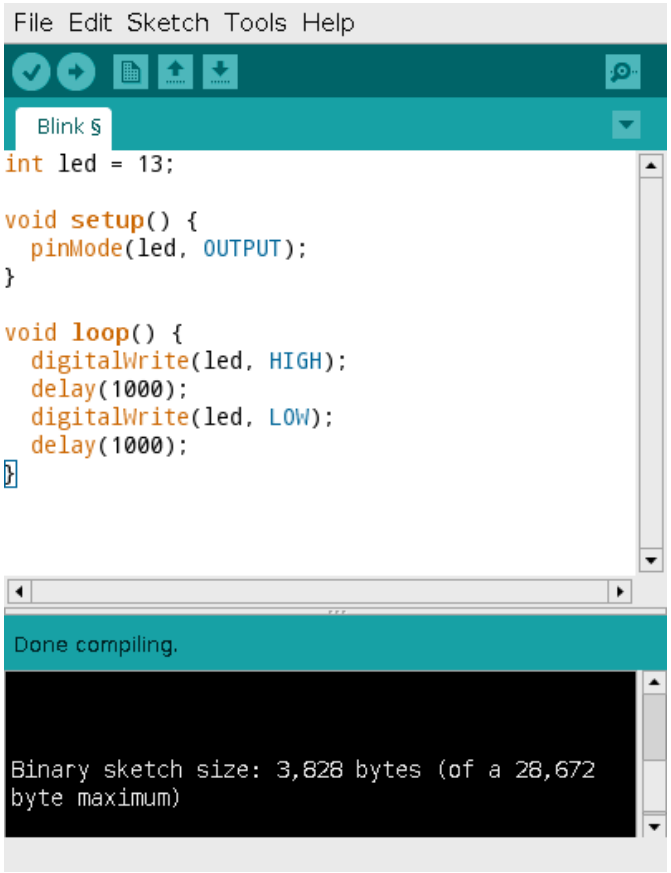
UART

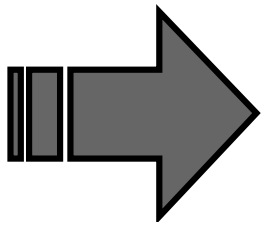
I2C

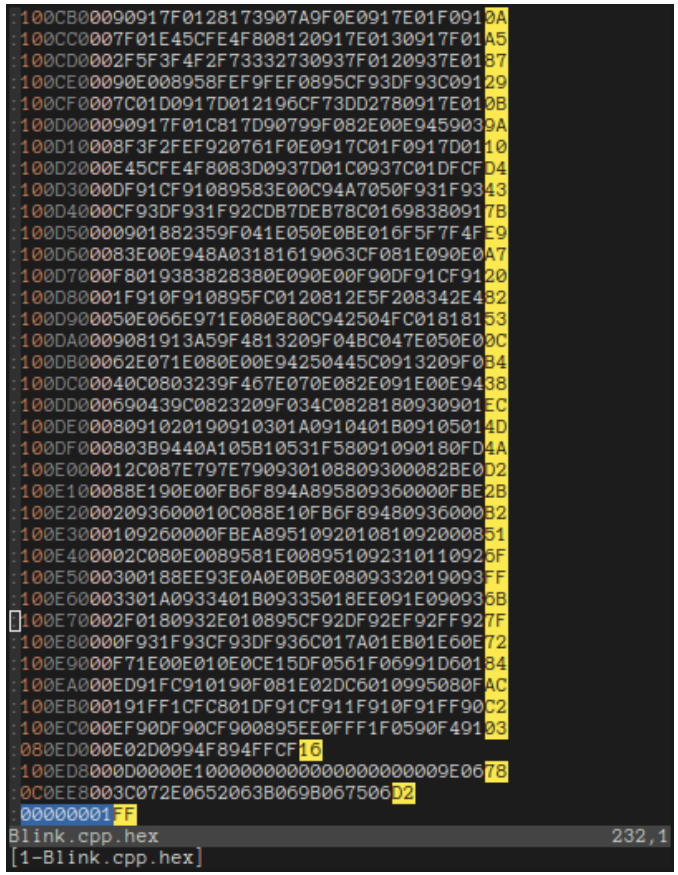
SPI



Arduino Programming







INTERPRETER **FIRMWARE** **OPERATION SYSTEM**

Arduino Programmazione

Struttura del programma

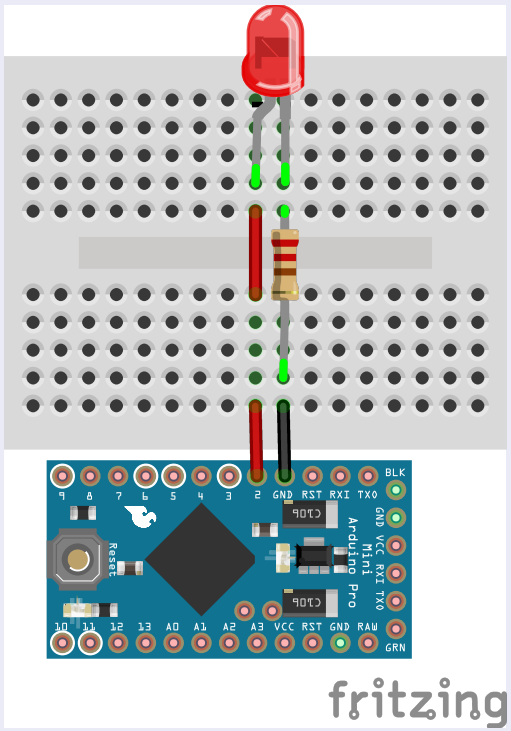
File Edit Sketch Tools Help

Blink

```
/*
  Blink
  Turns on an LED on for one second, then off for one second, repeatedly.

  This example code is in the public domain.
 */

// Pin 13 has an LED connected on most Arduino boards.
// give it a name:
int led = 13;

// the setup routine runs once when you press reset:
void setup() {
  // initialize the digital pin as an output.
  pinMode(led, OUTPUT);
}

// the loop routine runs over and over again forever:
void loop() {
  digitalWrite(led, HIGH);   // turn the LED on (HIGH is the voltage level)
  delay(1000);               // wait for a second
  digitalWrite(led, LOW);    // turn the LED off by making the voltage LOW
  delay(1000);               // wait for a second
}
```

Done compiling.

```
Binary sketch size: 3,828 bytes (of a 28,672 byte maximum)
```



Arduino Button

polling

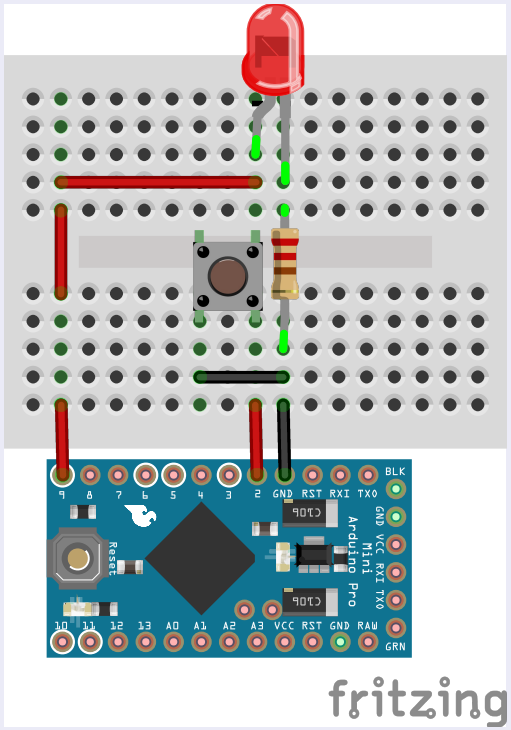
File Edit Sketch Tools Help

sketch_may15b §

```
void setup(){
  Serial.begin(9600);
  pinMode(2, INPUT_PULLUP);
  pinMode(13, OUTPUT);
}

void loop(){
  int sensorVal = digitalRead(2);
  Serial.println(sensorVal);
  if (sensorVal == HIGH) {
    digitalWrite(13, LOW);
  }
  else {
    digitalWrite(13, HIGH);
  }
}
```

Done compiling.

```
Binary sketch size: 4,476 bytes (of a 28,672
byte maximum)
```



Arduino Button

interrupt

File Edit Sketch Tools Help

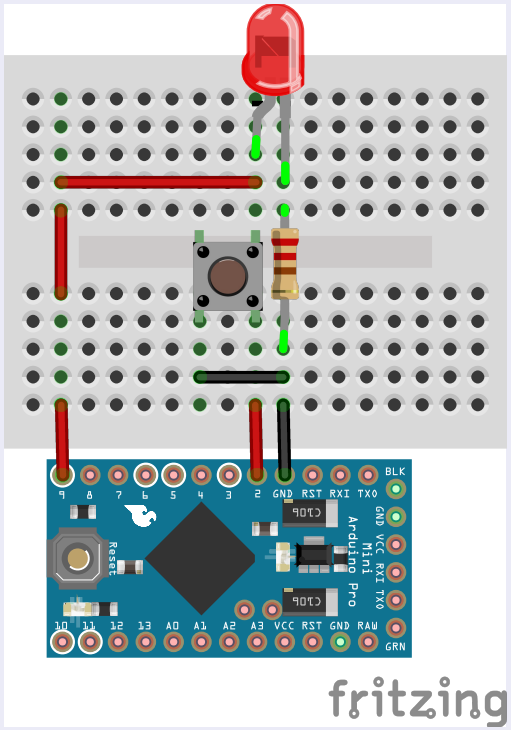
sketch_may15a §

```
int pin = 13;
volatile int state = LOW;

void setup(){
  pinMode(pin, OUTPUT);
  attachInterrupt(0, blink, CHANGE);
}

void loop(){
  digitalWrite(pin, state);
}

void blink(){
  state = !state;
}
```

Done compiling.

```
Binary sketch size: 4,446 bytes (of a 28,672
byte maximum)
```

1 SparkFun Pro Micro 5V/16MHz on /dev/ttyACM0



Raspberry Pi

Single Board Computer

- CPU ARM11 700Mhz
- 512 RAM
- 2 USB
- Ethernet port
- HDMI
- 3.5 mm audio
- GPIO
  - **Digital I/O**
  - PWM pin
  - Serial
  - I2C

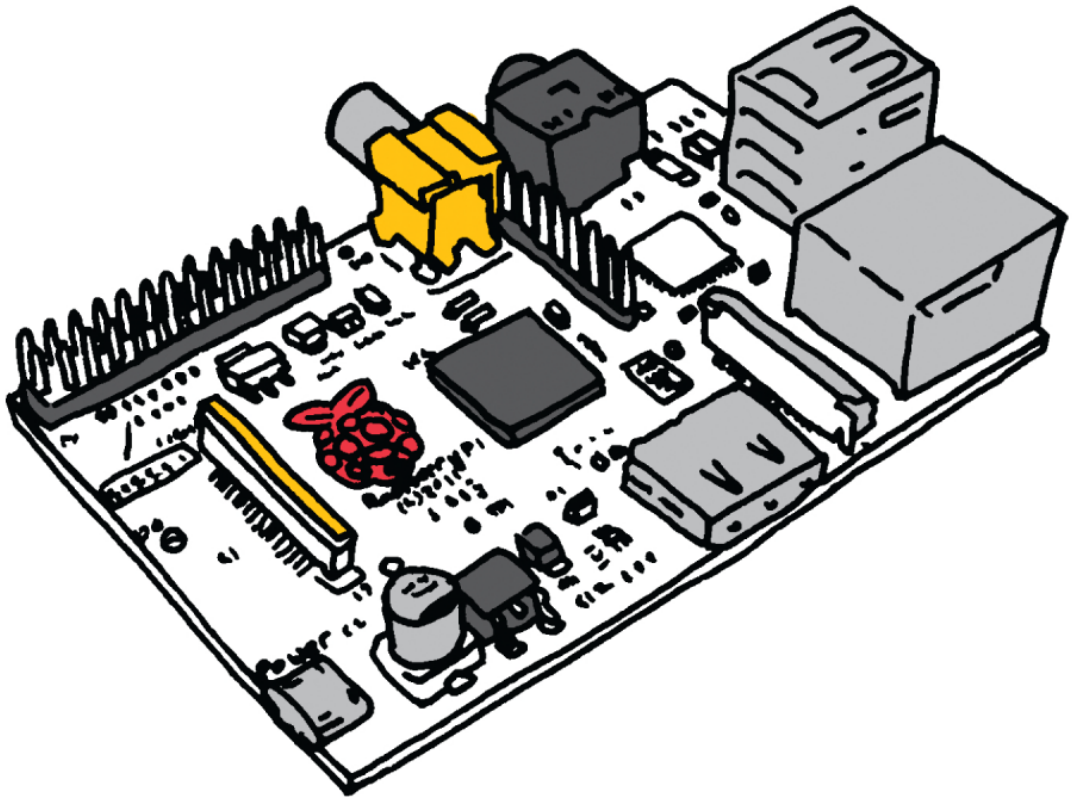


Figura: RASPBERRY PI MODEL B

Raspberry Pi

Software

Sistemi operativi

- Raspbian(Debian)
- Pidora (Fedora Remix)
- Arch Linux
- RISC OS
- E molti altri sistemi

E' possibile installare Android, anche se non e' supportato ufficialmente.

Linguaggi di programmazione

- Python
- Java
- Bash
- C / C++
- Ruby
- Perl
- ...

Raspbian

Versione custom per il corso

Software Aggiuntivo

- Server DHCP
- Tool e librerie per la progettazione
  - wiringPI
  - OpenCV
  - RaspiCam
  - Java
  - pi4j
  - vim
- Server VNC accessibile al 192.168.137.2:1
- Trasferimento del file tramite protocollo SMB
- Configurazione wifi facilitata
- `https://137.204.107.21/www-files/2015-01-31-raspbian_iot.img.7z`

RASPBERRY PI PINOUT

Alternative Functions

Raspberry Pi B
Rev 1 P1 GPIO Header

	Pin No.		
3.3V	1	2	5V
SDA0	3	4	5V
SCL0	5	6	GND
GPCLK0	7	8	TXD
GND	9	10	RXD
GPIO17	11	12	PWM
GPIO21	13	14	GND
GPIO22	15	16	GPIO23
3.3V	17	18	GPIO24
MOSI	19	20	GND
MISO	21	22	GPIO25
SCLK	23	24	CE0
GND	25	26	CE1

Raspberry Pi A/B
Rev 2 P1 GPIO Header

	Pin No.		
3.3V	1	2	5V
SDA1	3	4	5V
SCL1	5	6	GND
GPCLK0	7	8	TXD
GND	9	10	RXD
GPIO17	11	12	PWM
GPIO27	13	14	GND
GPIO22	15	16	GPIO23
3.3V	17	18	GPIO24
MOSI	19	20	GND
MISO	21	22	GPIO25
SCLK	23	24	CE0
GND	25	26	CE1

Raspberry Pi B+
B+ J8 GPIO Header

	Pin No.		
3.3V	1	2	5V
SDA1	3	4	5V
SCL1	5	6	GND
GPCLK0	7	8	TXD
GND	9	10	RXD
CE1_1	11	12	PWM0/CE0_1
GPIO27	13	14	GND
GPIO22	15	16	GPIO23
3.3V	17	18	GPIO24
MOSI_0	19	20	GND
MISO_0	21	22	GPIO25
SCLK_0	23	24	CE0_0
GND	25	26	CE1_0
DNC	27	28	DNC
GPCLK1	29	30	GND
GPCLK2	31	32	PWM0/GPIO12
PWM1/GPIO13	33	34	GND
PWM1/MISO_1	35	36	CE2_1
GPIO26	37	38	MOSI_1
GND	39	40	SCLK_1

Key

Power +	UART
GND	SPI
I²C	GPCLK
GPIO	

Figura: RASPBERRY PI PINOUT

Programmazione GPIO

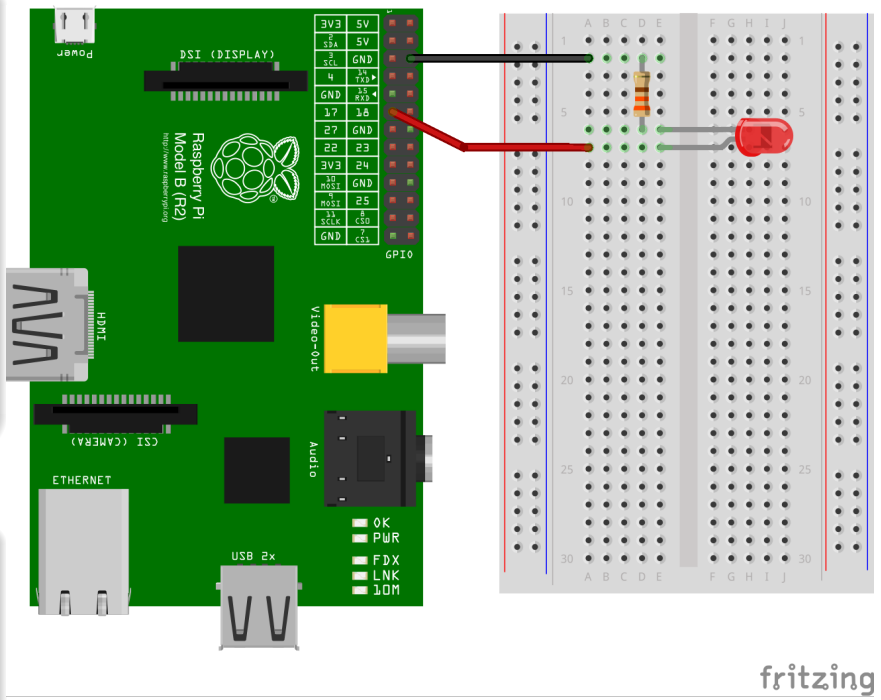
E' possibile gestire GPIO tramite un filesystem virtuale.

- "/sys/class/gpio" è un'interfaccia di controllo in user space
  - "export" permette di esportare il controllo di GPIO in user space.(*echo 19 > export*)
  - "unexport" rimuove la risorsa da user space (*echo 19 > unexport*)
- /sys/class/gpio/gpioN/ è un'interfaccia di controllo di un singolo GPIO
  - "direction" imposta GPIO come Input o Output (*echo in > direction*)
  - "value" legge il valore di GPIO (*cat value*)
  - ...

Raspberry Pi GPIO Output

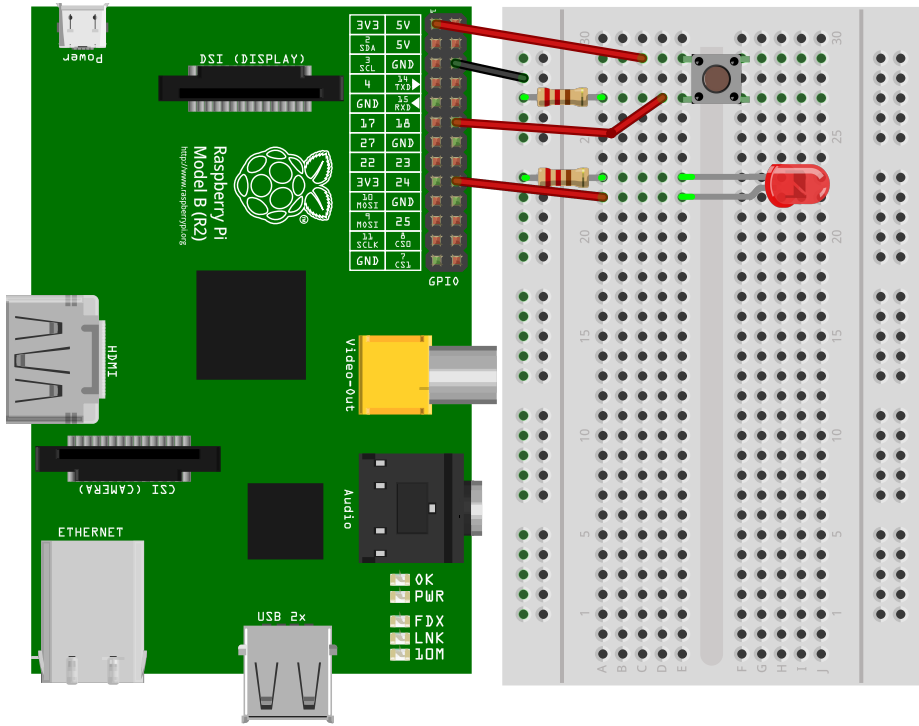
```
#!/bin/bash
echo 17 > /sys/class/gpio/export
echo out > /sys/class/gpio/gpio17/direction

while :
do
 echo 0 > /sys/class/gpio/gpio17/value
 sleep 0.2
 echo 1 > /sys/class/gpio/gpio17/value
 sleep 0.2
done
```

```
#!/bin/bash
gpio mode 0 out
gpio write 0 1
sleep 1
gpio write 0 0
```



Raspberry Pi

```
#!/bin/bash
echo 24 > /sys/class/gpio/export
echo out > /sys/class/gpio/gpio24/direction
echo 18 > /sys/class/gpio/export
echo in > /sys/class/gpio/gpio18/direction

while :
do
 cat /sys/class/gpio/gpio24/value >\
 /sys/class/gpio/gpio24/value
 sleep 0.2
done
```



Differenza tra Arduno e Raspberry Pi

	Arduino	Raspberry Pi
Processor	ATMega 328	ARM11
Clock Speed	16 MHz	700 MHz
Flash	32 KB	SD
RAM	2 KB	512 MB
I/O Current Max	40 mA	10 mA
Min Power	42 mA	700 mA
Register Width	8-bit	32-bit
Operating System	None	Linux and Other

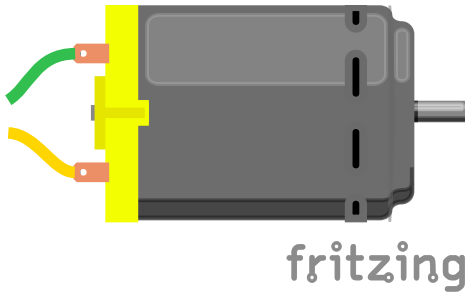
Tabella: Arduino Uno vs Raspberry

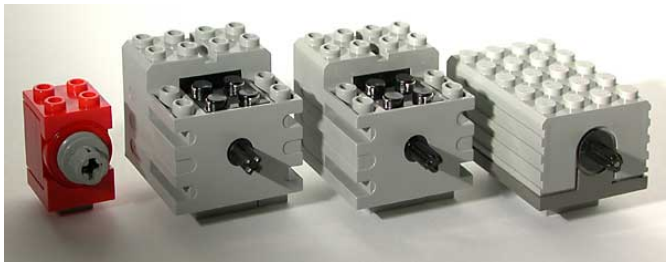
Microcontroller vs Microprocessor

DC Motor

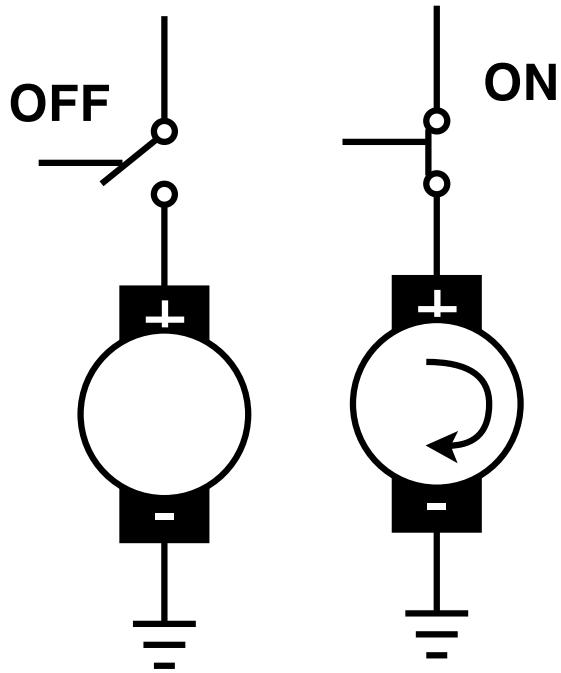
Controllo ON-OFF di motori DC

- DC Motors





Lego RCX DC Motors

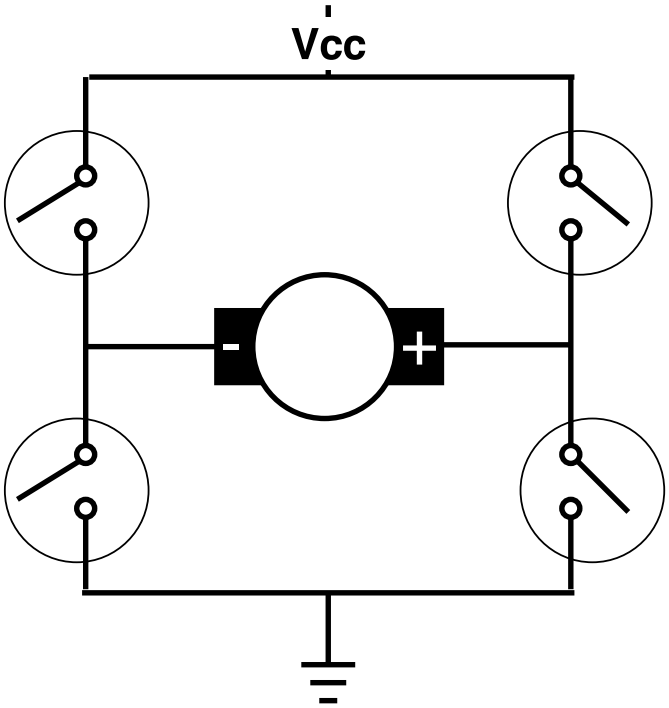


Quando l'interruttore è aperto il motore è fermo, quando è chiuso gira alla massima velocità

Attuatori

HBridge

- H Bridge (Motor Driver)



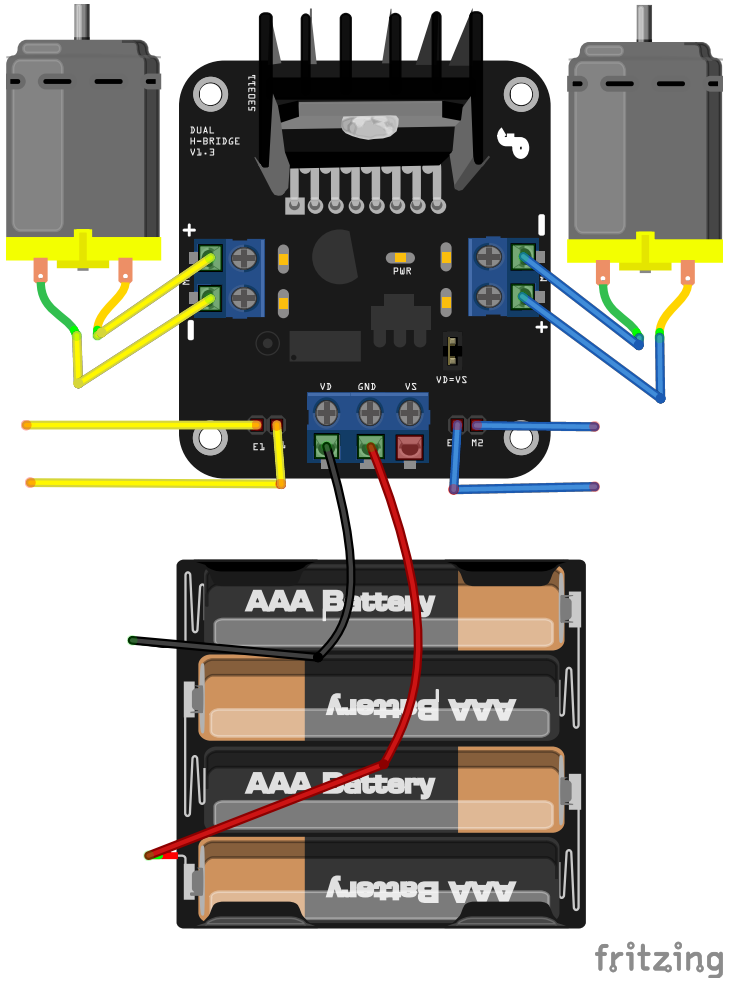


Figura: schema semplificato di un ponte H

Controllo di velocità

PWM Pulse Width Modulation

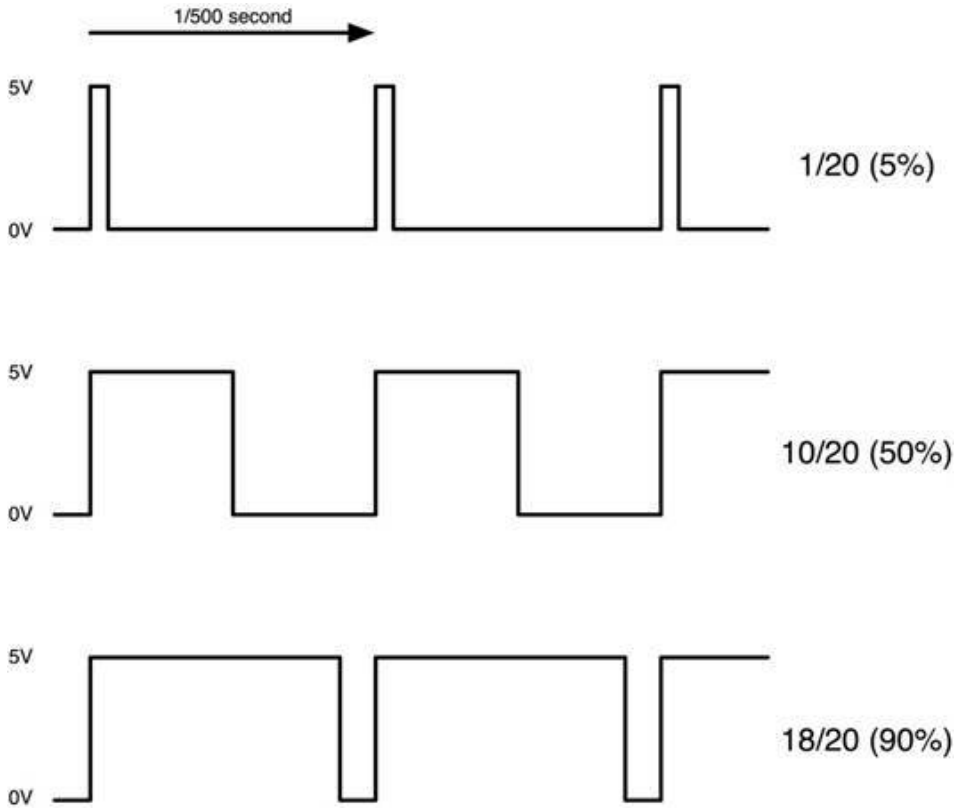


Figura: modulazione a variazione della larghezza d'impulso

Arduino UNO 5 pin predisposti per PWM

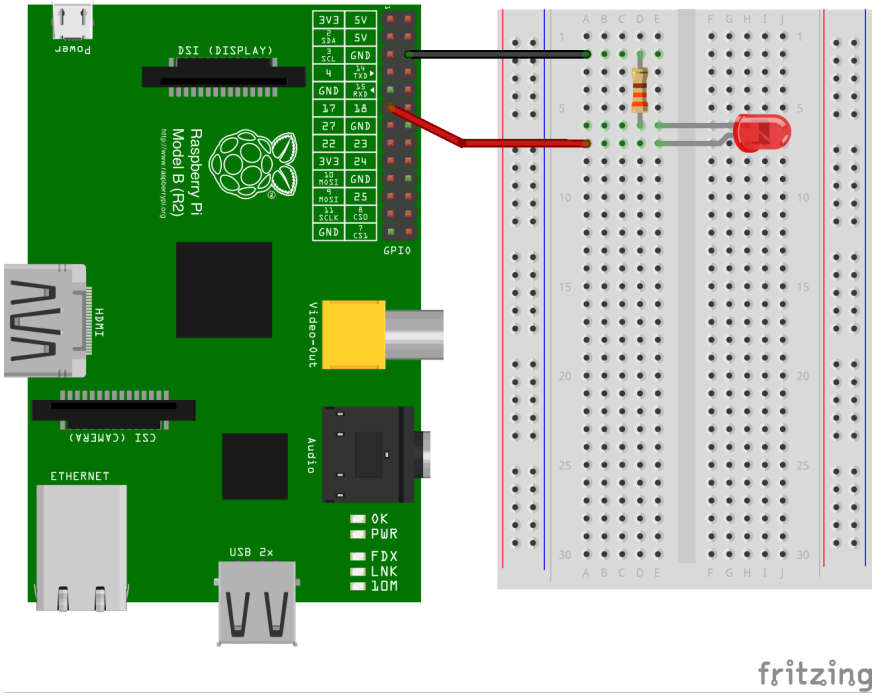
Raspberry Pi 1/2 pin supportano Hardware PWM, ma workaround è possibile.

Metodi di controllo

SM sign-magnitude

LAP locked anti-phase

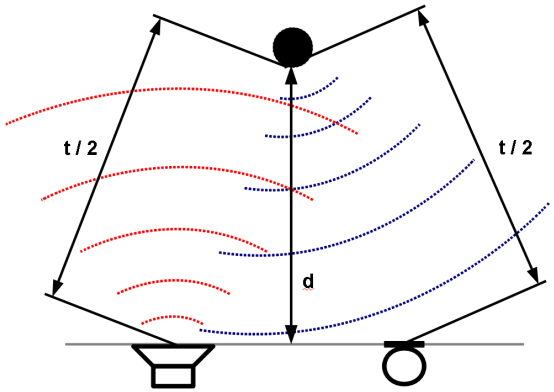
Esempio SoftPWM




```
35      com.pi4j.wiringpi.Gpio.wiringPiSetup();
36
37      // create soft-pwm pins (min=0 ; max=100)
38      SoftPwm.softPwmCreate(1, 0, 100);
39
40      // continuous loop
41      while (true) {
42          // fade LED to fully ON
43          for (int i = 0; i <= 100; i++) {
44              SoftPwm.softPwmWrite(1, i);
45              Thread.sleep(100);
46          }
47
48          // fade LED to fully OFF
49          for (int i = 100; i >= 0; i--) {
50              SoftPwm.softPwmWrite(1, i);
51              Thread.sleep(100);
52          }
53      }
```

Ultrasonic Sensor

Principio di funzionamento



Working Voltage 5V

Output Signal 0-5V

Sentry Angle max 15 degree

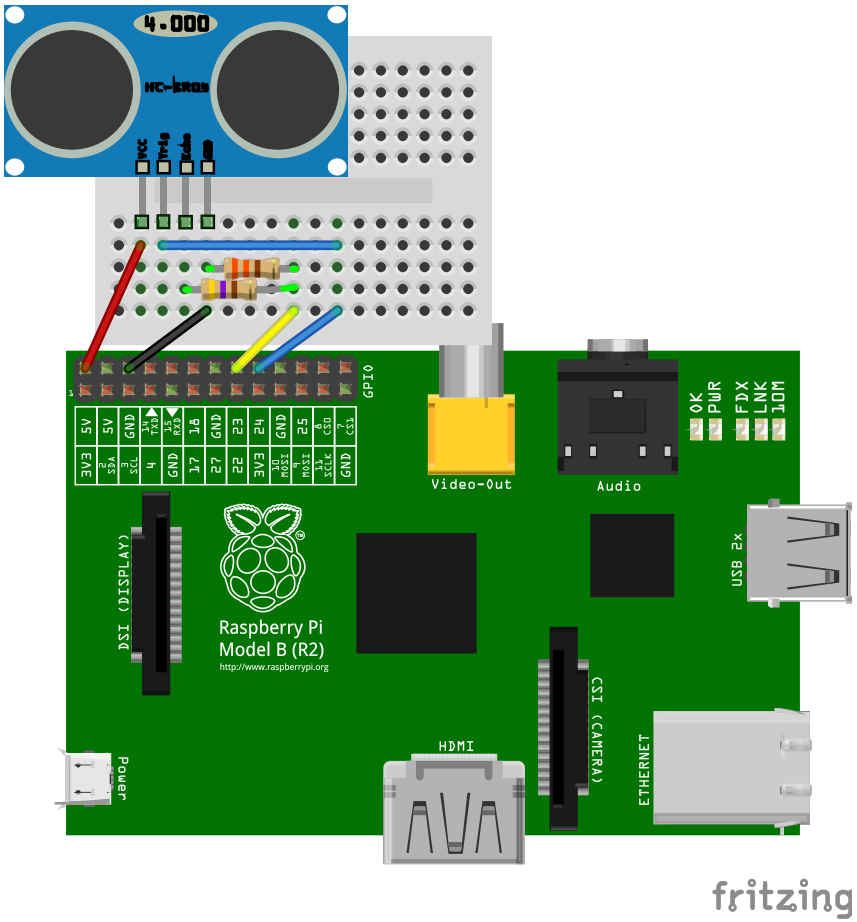
Working Current 15 mA

Working frequency 40Hz

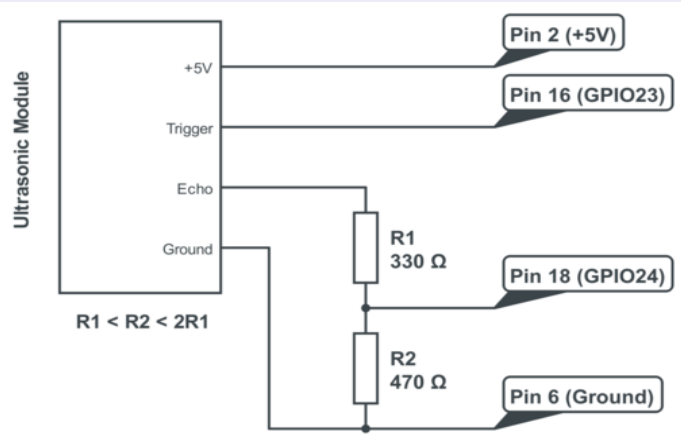
$$\textbf{distance} = \frac{\textbf{speed of sound} \times \textbf{time taken}}{2}$$

Ultrasonic sensor

Utilizzo con Raspberry Pi



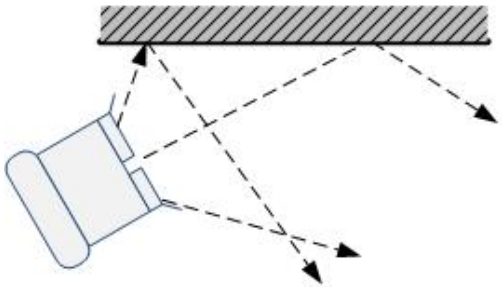
Partitore di tensione



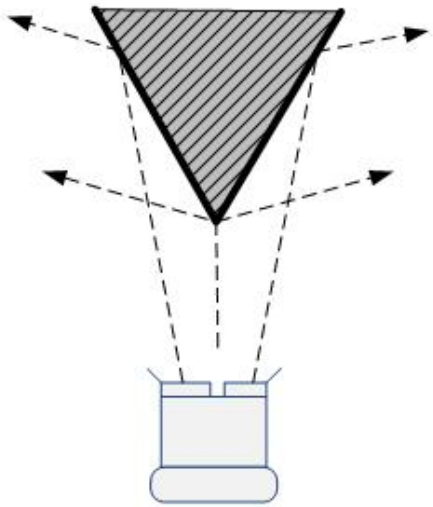

```
21 //Send trig pulse
22 digitalWrite(TRIG, HIGH);
23 delayMicroseconds(20);
24 digitalWrite(TRIG, LOW);
25 //Wait for echo start
26 while(digitalRead(ECHO) == LOW);
27 //Wait for echo end
28 long startTime = micros();
29 while(digitalRead(ECHO) == HIGH);
30 long travelTime = micros() - startTime;
31 //Get distance in cm
32 int distance = travelTime / 58;
33 return distance;
```

Ultrasonic sensor

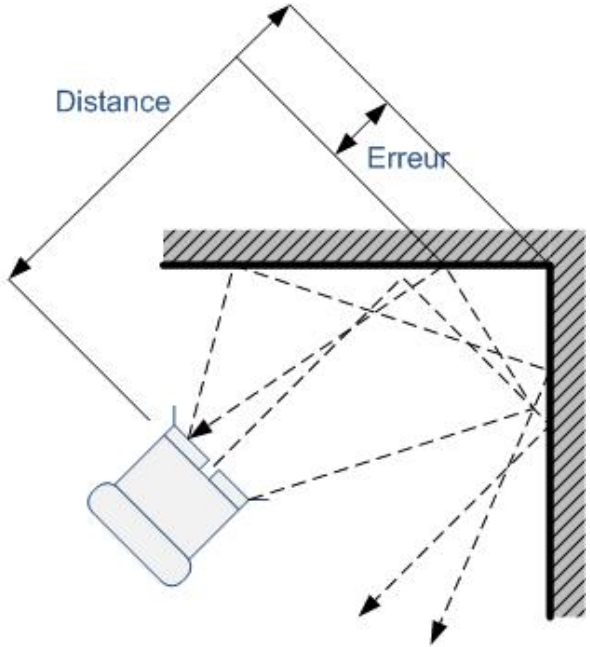
Problemi e limiti



Cas n°4

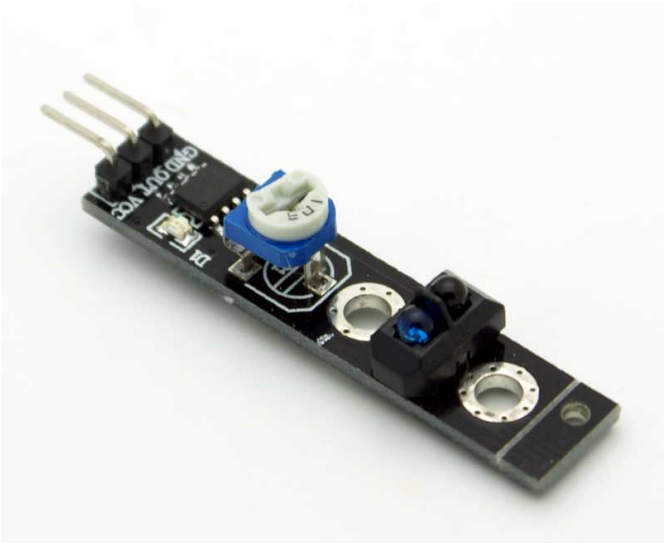


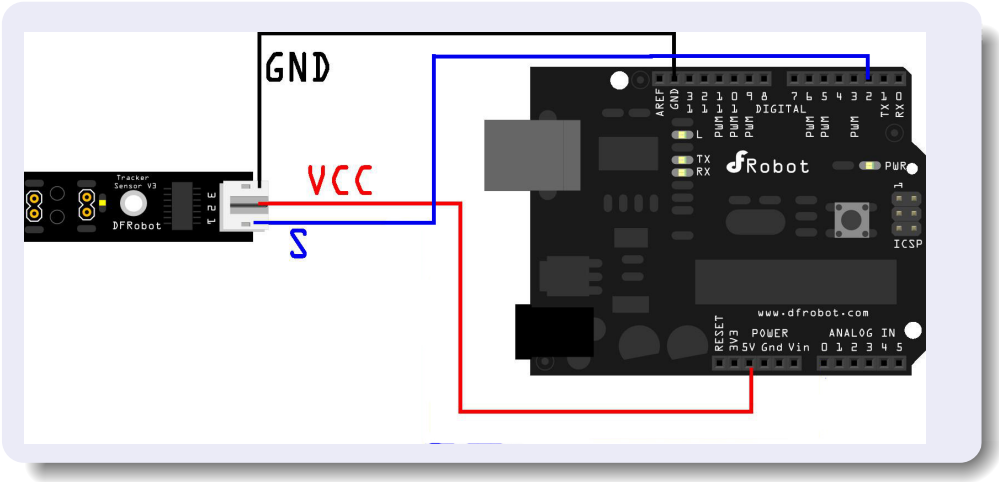
Cas n°5



Cas n°6

Line Sensor





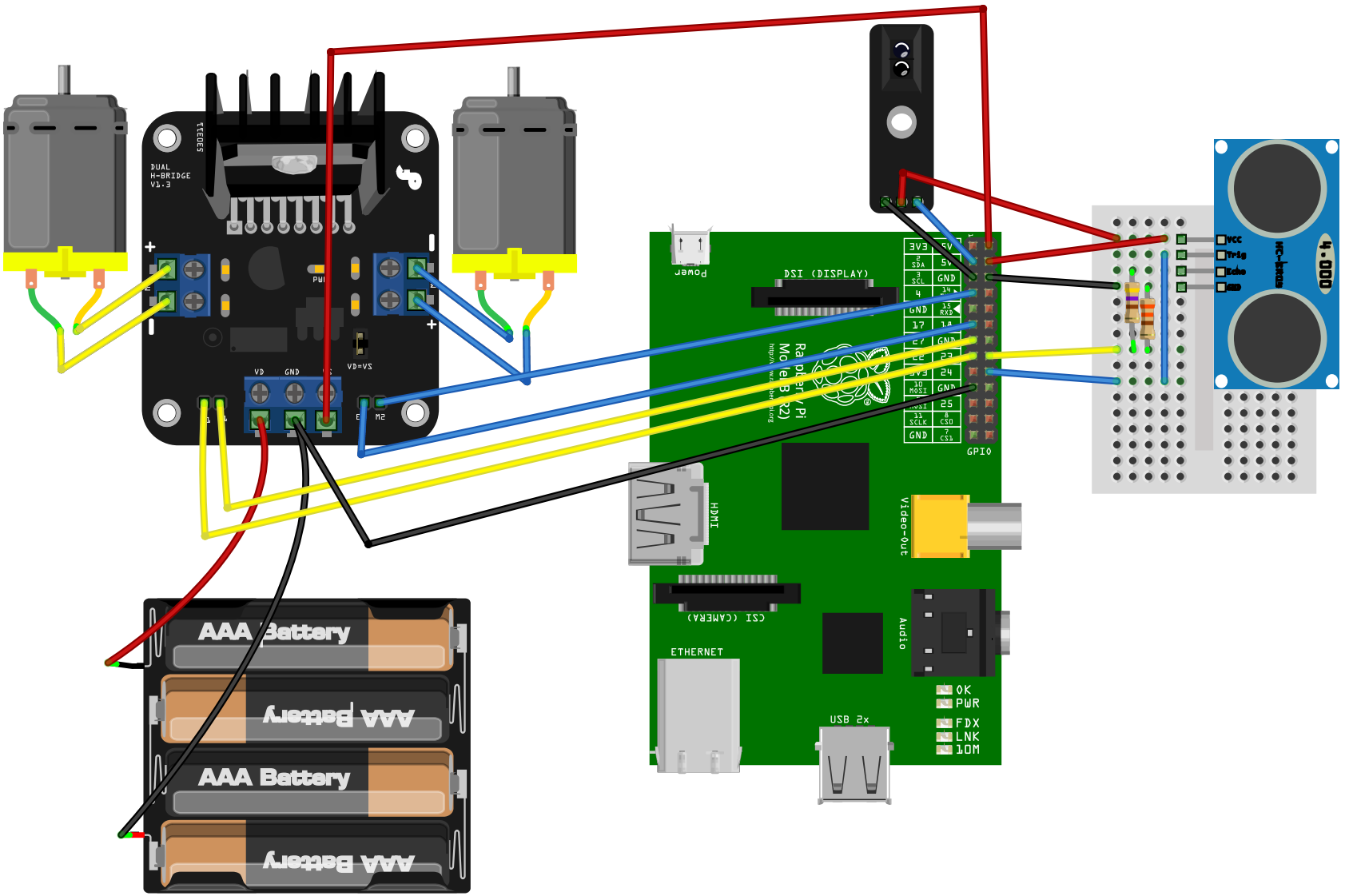
Power supply	+5V
Operating current	10mA

3-wire interface

1. signal
2. power
3. power supply negative

```
///Arduino Sample Code
void setup()
{
  Serial.begin(9600);
}
void loop()
{
  Serial.println(digitalRead(2)); // print the data from the sensor
  delay(500);
}
```

Robot

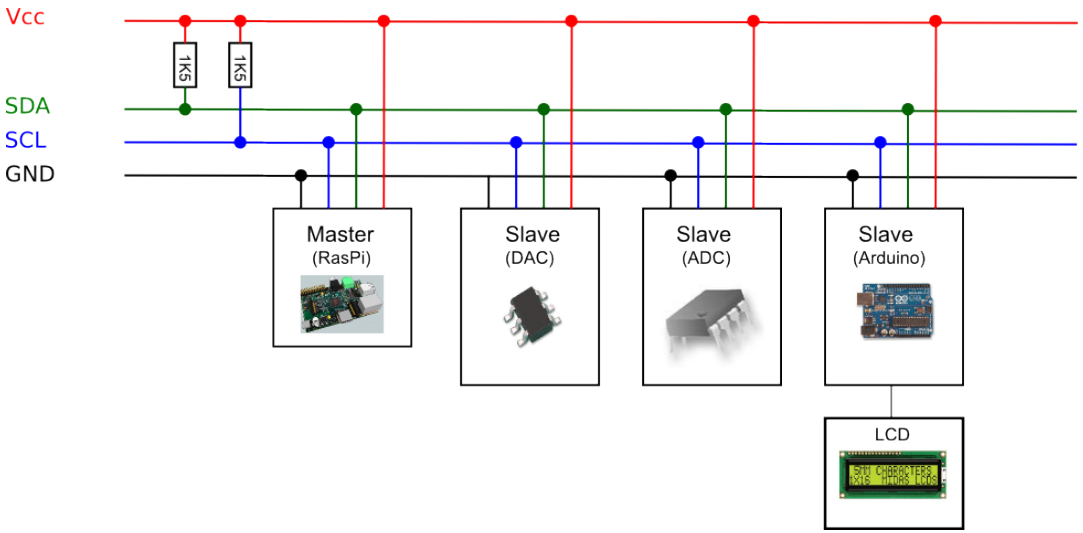


fritzing

I2C Bus

Inter Integrated Circuit

- Due linee seriali di comunicazione
  - SDA (Serial DAta) per i dati
  - SCL SCL (Serial CLock) per il clock
- Ogni dispositivo identificato dall'indirizzo univoco, e puó trasmettere o ricevere
- Master - il dispositivo che emette il segnale di clock
- Slave - il nodo che si sincronizza sul segnale di clock



Bussola digitale

HMC5883l

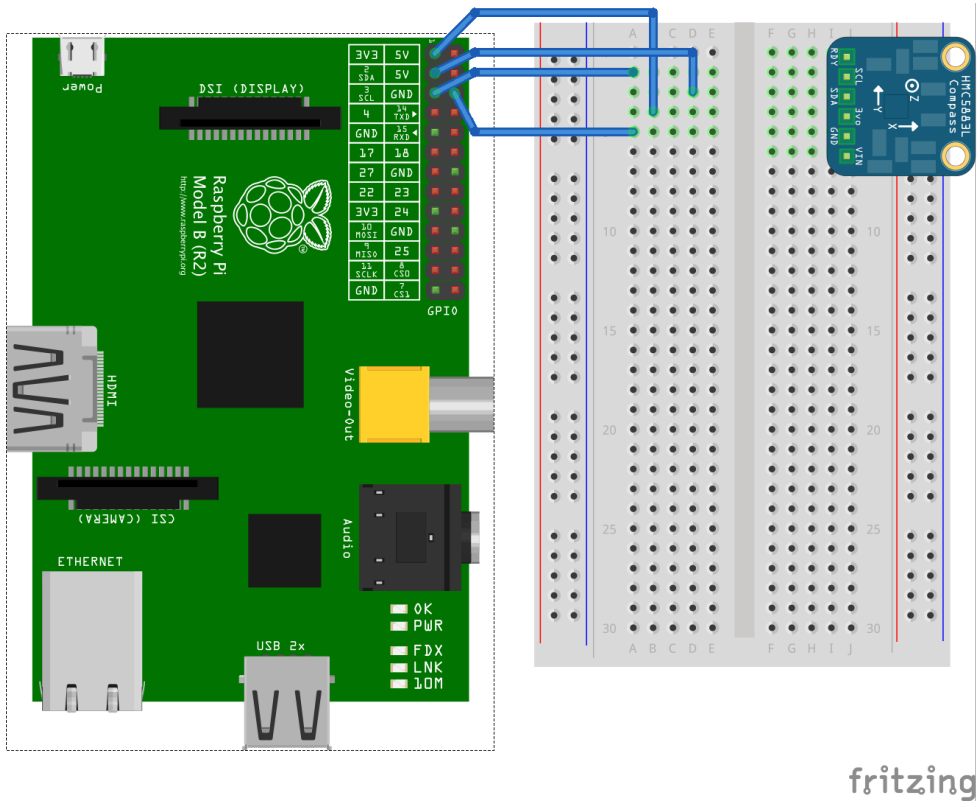
- Leggere i dati grezzi

```
int r = i2cDevice.read(address, data, 0, 6);

x=((data[0]&0xff)«8) + (data[1]&0xff);

y=((data[2]&0xff)«8) + (data[3]&0xff);

z=((data[4]&0xff)«8) + (data[5]&0xff);
```

- Applicare le correzioni
- Calcolare la direzione

```
Math.toDegrees(Math.atan2(compassx, compassy)
```

```
pi@raspberrypi ~ $ sudo i2cdetect -y 1
     0  1  2  3  4  5  6  7  8  9  a  b  c  d  e  f
00:          -- -- -- -- -- -- -- -- -- -- -- -- --
10: -- -- -- -- -- -- -- -- -- -- -- -- -- -- 1e --
20: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
30: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
40: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
50: -- -- -- 53 -- -- -- -- -- -- -- -- -- -- -- --
60: -- -- -- -- -- -- -- -- 68 -- -- -- -- -- -- --
70: -- -- -- -- -- -- -- 77
pi@raspberrypi ~ $
```



Raspberry Pi Camera

http://www.raspberrypi.org/documentation/usage/camera/README.md

Still resolution	5 Megapixel
Video modes	1080p30, 720p60 and 640x480p60 90
Picture formats	JPEG (accelerated) , JPEG + RAW , GIF , BMP , PNG , YUV420 , RGB888
Video formats	raw h.264 (accelerated)

```
#acquisire immagine i salvare come imge.jpg
raspistill -o image.jpg
#salvare immagine come png (-e png)
raspistill -e png -o image.png
#cambiare la risoluzione
raspistill -w 640 -h 360 -o image.jpg
#acquisire video di 5 secondi
raspivid -t 5000 -o video.h264
#video con bitrate 3.5MBits/s
raspivid -t 5000 -o video.h264 -b 3500000
#cambiare la risoluzione del video
raspivid -w 640 -h 360 -o video.h264
```

Raspberry Camera

Streaming video

- Raspberry Pi command

```
nc.traditional -l -p 1234 -c "exec raspivid -t 600000 -n -w 640 -h 360 -o -"
```

- Client side VLC setup