

IN 221 (AUG) 3:0

Sensors and Transducers

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Welcome!

Course

IN 221 (AUG) 3:0

Sensors and Transducers

Introductory course on sensors and transducers

Class Hours

MWF 12:00 to 13:00

Lecture Hall 1, IAP

Instructors

- Manish Arora
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- Chandni Usha
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- Jayanth G. R.
- Atanu Mohanty

What is a sensor?

- Device that can be used to detect or measure a given physical quantity.
- Almost always used with other electronics.

Examples of sensors

- Microphone
- Photodiode, LDR (Light Dependent Resistor)
- CCD array (imaging element in digital camera)
- Thermocouple, thermistor
- Search coil, Hall sensor
- Antenna
- Piezoelectric sensors
- Chemical and gas sensors
- Bio-sensors

What is a transducer?

- Device that converts one form of energy to another.
- Usually the input is an electrical signal and the output is some other physical quantity.
- Actuator: Transducer whose output is mechanical motion.
- There are many kinds of transducers.

Examples of transducers

- Loudspeaker
- LED (Light Emitting Diode)
- Heater
- Coil
- Antenna
- Motors of various kinds
- Piezoelectric actuators

Examples

Example 1: Smartphone

- Transducers: Speaker, display, buzzer motor
- Sensors: Microphone, camera, accelerometer

Example 2: Making Plastic Sheets from Molten Plastic

- Transducers: Motor, heater
- Sensors: Thickness, temperature, chemical

Example 3: Generic Closed Loop Control System

- The *plant* will have *transducers*.
- The *feedback* signals will come from *sensors*.

Functional view

- Sensor
Physical quantity \rightarrow Electrical signal
- Transducer
Electrical signal \rightarrow Physical quantity

Applications of sensors and transducers

- Industry
 - Manufacturing
 - Construction
 - Power generation
 - Chemical
 - Pharmaceutical
- Household appliances
- Agriculture
- Traffic management
- Security
- Weather monitoring
- Scientific research

Points to note

- The same device can be used as a sensor and a transducer.
 - Piezoelectric device
 - Antenna
 - Loudspeaker
- Response is not always linear or even continuous.
- There are many different kinds sensors and transducers.
- Based on a very wide range of working principles.
- Requires knowledge of all branches of science and engineering.

Types of Sensors

Packaged vs. Constructed

- Many types of sensors are available in packaged form.
- Still, in industrial work, engineers often make their own sensors.

Types of Output

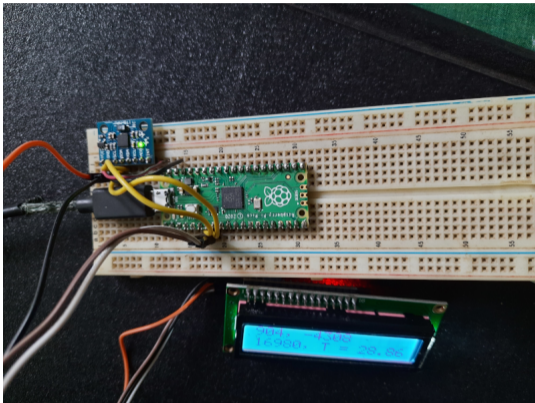
- Analogue output
 - Voltage proportional to the quantity
 - PWM (Pulse Width Modulation): Pulse width proportional to the quantity
 - Note: PWM is still considered analogue and NOT digital.
- Digital output
 - Parallel output
 - Serial output: One of several protocols
 - I²C
 - SPI
 - ...

Two Examples of Sensor Modules

- ① Accelerometer MPU6050
- ② Pressure and temperature sensor BMP 280

Other examples of readily available sensor and actuator modules will be discussed in the future.

Example 1: Accelerometer MPU6050

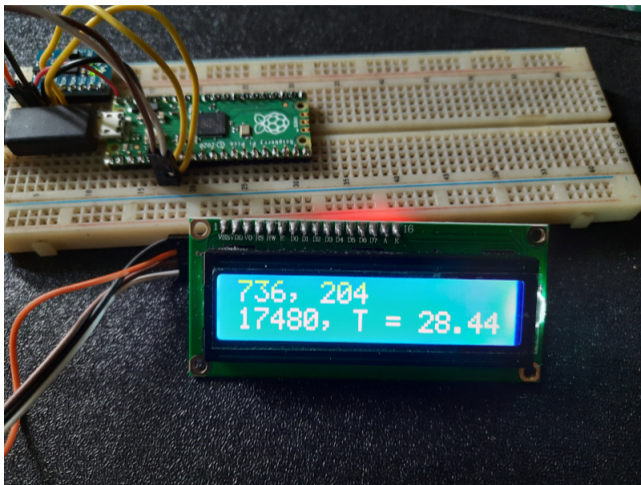


Small board: 16 mm × 20 mm, MPU6050 Accelerometer module (\approx Rs. 115)

Big board: 22 mm × 53 mm, Raspberry Pi Pico

Powered from the USB Port

Example 1: Accelerometer MPU6050

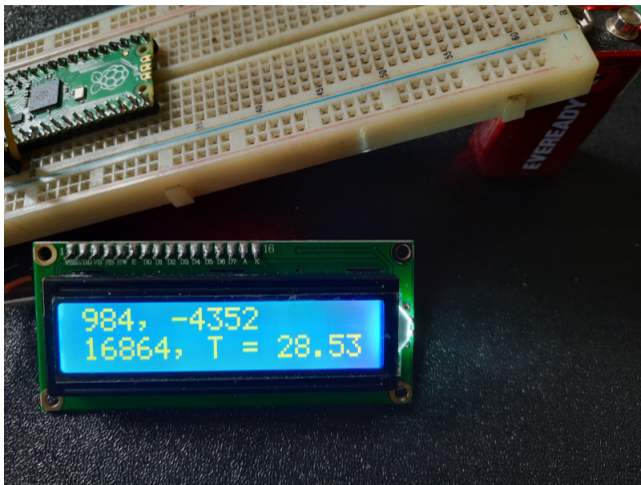


First line: x and y components of acceleration in device units

Second line: z component of acceleration in device units, temperature

Horizontal Board: a_z : 17480 device units

Example 1: Accelerometer MPU6050



First line: x and y components of acceleration in device units

Second line: z component of acceleration in device units, temperature

Tilted Board: a_z : 16864 device units

Example 1: Calculations

Length of breadboard: 16.5 cm

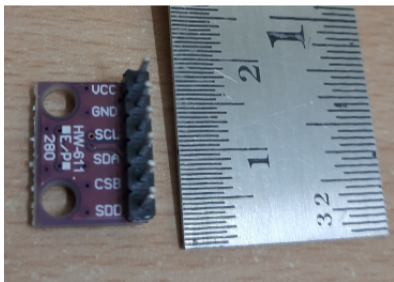
Height of battery: 4.3 cm

```
akm@akm:~/pico/pico-examples/i2c/lcd_1602_i2c$ lua  
Lua 5.3.3 Copyright (C) 1994-2016 Lua.org, PUC-Rio  
> math.deg(math.acos(16864/17480))  
15.256010576751  
> math.deg(math.asin(4.3/16.5))  
15.106026666421  
>
```

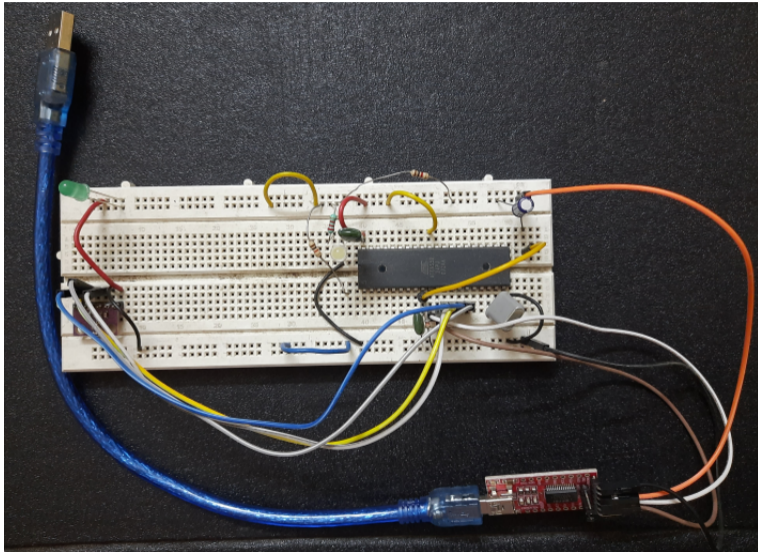
Tilt angle: \approx 15 degrees

Example 2: BMP 280

- Pressure and Temperature
- Inexpensive: \approx Rs. 70
- Supports both SPI and I²C
- Another sensor BME 280 can also measure humidity.



Example 2: System with BMP 280



Example 2: BMP 280 Output

```
readBMP280.tcl
ID: 58 Hex => (Bosch BMP 280)
Calibration Data: 226F1D6818FC3390C7D5D00B44019500F9FF8C3CF8C670170000
Readings: 7BAEB082A520
p = 908.0735 hPa = 681.1111 mmHg
T = 25.32 degree C
```

Questions to ask about any sensor or transducer

- How does this sensor or transducer work?
- How is it fabricated?
- What kind of electronics is used in this sensor or transducer?
- How can we get readings from this sensor?
- How can we drive this transducer?
- What are its applications?
- How much does it cost?

Evaluation

- 7 instructors
- \approx 6 lectures each
- 14 marks per instructor
 - Homework assignment
 - Examination in class
 - Take-home examination
- IISc Rules
 - Sessional: 50 marks
 - Final: 50 marks
- Attendance is important.
 - Low attendance \Rightarrow INCOMPLETE grade
 - Penalties specific to this course