AMC Exercises 002

2020-06-02, V001, rb

1. I²C

1.1: I2C (pronounce “I-to-C”) is a simplified abbreviation originating from I²C (“I-squared-C”) which in turn means IIC. IIC stands for “Inter-IC” meaning communication between or with ICs (Integrated Circuits). Sometimes the bus is also called two-wire-interface (TWI). What are the names and functions of these two wires?

1.2: What are the characteristics of a serial communication bus?

1.3: What is an I2C bus? What is it used for? Give examples.

1.4: How many bits per second can be transmitted by an I2C bus (typically)?

1.5: Several I2C devices (e.g. different sensor types) can be connected to the same bus and be controlled separately. How do the devices know to which command from the bus master (e.g. Arduino UNO) to react to?

2. IMU

Official Datasheet of MPU-6000/MPU-6050:
https://invensense.tdk.com/wp-content/uploads/2015/02/MPU-6000-Datasheet1.pdf

2.1: IMU stands for inertial measurement unit. The MPU-6050 is an IMU with “six degrees of freedom”. What does it mean?

2.2: Is the MPU-6050 chip a 5V or a 3.3V device? Search for “Absolute Maximum Ratings” in the official datasheet.

2.3: According to the Absolute Maximum Ratings it is save to operate the device at 5V. Nevertheless the typically recommended operating voltage seems to be VDD = 3.3V. So assume that in your design you decided to run the MPU-6050 with VDD=3.3V. The I2C bus consists of a Serial Data Line (SDA) and Serial Clock Line (SCL). In the case of VDD=3.3V, what would be the maximum allowable input voltage level for SDA and SCL, respectively?

2.4 Could you connect the I2C bus (SDA, SCL lines) of a 5V device directly without damaging the MPU-6050 operated at VDD=3.3V? The answer is: It depends. The MPU inputs are definitely not 5V tolerant when operated at VDD=3.3V. But the SCL and SDA bus lines require pull-up resistors since they are driven by open-collector (OC) or open-drain outputs. What that is will be explained in another lesson but you can think of an OC output being like a switch to GND. When it is closed it pulls the bus line down to ground, when it is open the pull-up resistor in the bus line will pull the voltage on the bus line up to whatever voltage supply the pull-up resistor is connected to. When these SDA and SCL line pull-ups are connected to 3.3V (and not 5V) the bus voltage level would not exceed 3.3V. This would be save. The question is whether in this case the communication with the 5V device with its own SDA and SCL connections is still reliable.

2.5: How many internal ADC channels does the MUP-6050 provide? What are they used for? Look at the block diagram in the official datasheet.

2.6: TheMPU-6050 is provided in a tiny QFN-24 IC package. What is it size?

2.7: The QFN-24 package provides 24 pins but several are unused (internally not connected, N.C.). How many pins of the package are used?

2.8: It is very difficult to connect to a QFN-24 package directly. Breakout boards are used to make the IC pins accessible on a larger pitch (distance between pins or “legs”). The GY-521 breakout board is used to make the pins of the MPU’s tiny package accessible for a breadboard layout (2.54 mm pitch size). There are more parts on the breakout board than just the MPU-6050. What are they mainly used for?

2.9: What is the typical resistance of the I2C pull-up resistors? Search for other I2C Arduino projects. The GY-521 has two 2.2kOhms resistors on-board, close to the SCL and SDA connections. These are used to pull-up SDA and SCL to 3.3V supply which is provided by the linear voltage regulator on-board.

3. Build an Electronic Spirit Level (Level-Meter)

Go to https://www.teawiki.net/teaching/doku.php?id=amc:topics:sensors:mpu-6050 and follow the tutorial.