Tutorial 3: I2C, Debouncing and PWM

Bhekanani Cele, CLXBHE005
Kwena Komape, KMPKWE002

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1 I2C, Debouncing and PWM

1.1 I2C

1. Messages are broken up into frames of data. Each message has an address frame that contains the binary address of the slave, and one or more data frames that contain the data being transmitted. The message also includes start and stop conditions, read/write bits, and ACK/NACK bits between each data frame.

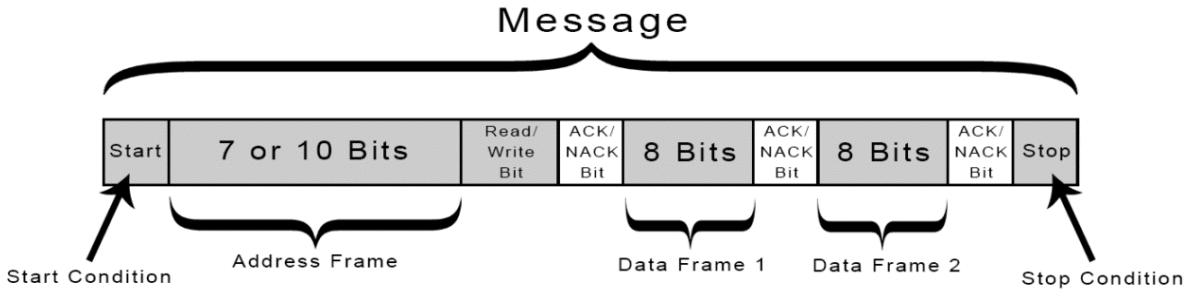

Figure 1: Message structure for I2C protocol

Address Frame: A 7 or 10 bit sequence unique to each slave that identifies the slave when the master wants to talk to it.
Read/Write Bit: A single bit specifying whether the master is sending data to the slave (low voltage level) or requesting data from it (high voltage level).
ACK/NACK Bit: Each frame in a message is followed by an acknowledge/no-acknowledge bit. If an address frame or data frame was successfully received, an ACK bit is returned to the sender from the receiving device.

2. I2C Advantages

   - **Simplicity.** I2C works as a 2-wire bus, needing only serial data (SDA) and serial clock (SCK) lines for data transmission and synchronization. SPI, on the other hand, requires four wires to control a single slave: Serial Clock (SCK), master out slave in (MOSI), master in slave out (MISO), and slave select (SS).

   - **Easy add-ons.** When users need more than one slave device, SPI implements an additional SS pin for each one. When an I2C system needs to implement new slave devices, they can simply "clip on" to the existing bus using a 7-bit addressing system to identify each module. This I2C scheme requires a proper address configuration but avoids the burden of extra wiring for each device.

3. **Start Condition:** The Serial Data line switches from a high voltage level to a low voltage level before the Serial Clock line switches from high to low.
Stop Condition: The Serial Data line switches from a low voltage level to a high voltage level after the Serial Clock line switches from low to high.

4. Timing Diagram

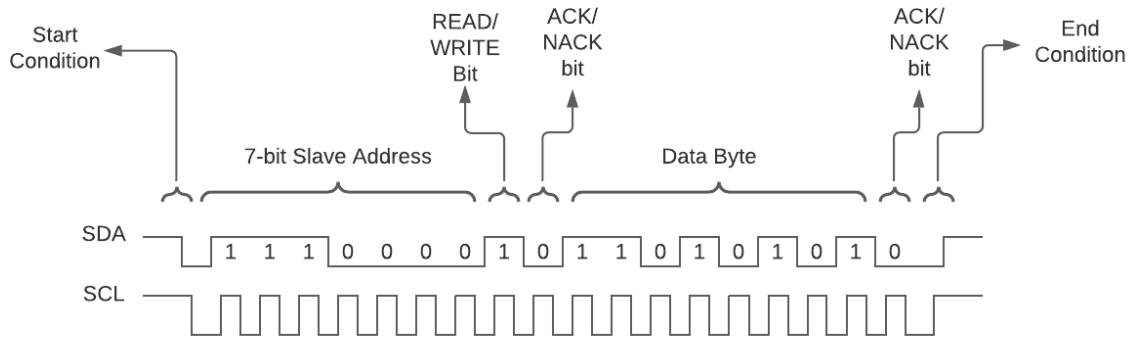

Figure 2: Timing diagram showing a Master sending 0b11010101 to slave at address 0b1110000

1.2 PWM

1. It uses a real-time scheduler to prioritize the generation of PWM signals by running individual threads, but since the operating system that is used on the Raspberry Pi performs multitasking, this solution is not effective since real time systems often require to process a continuous stream of incoming data, it also provides low timing resolution and high jitter.
2. Persistence of vision is the optical phenomenon where the illusion of motion is created because the brain interprets multiple still images as one. When multiple images appear in fast enough succession, the brain blends them into a single, persistent, moving image. Persistence of vision display creates a perception of an image; occupying a spatial portion in rapid succession.
3. The duty cycle describes the amount of time the signal is in a high (on) state as a percentage of the total time of it takes to complete one cycle while PWM frequnecy is the number of times per second that we repeat on and off cycle
4. Duty cycle