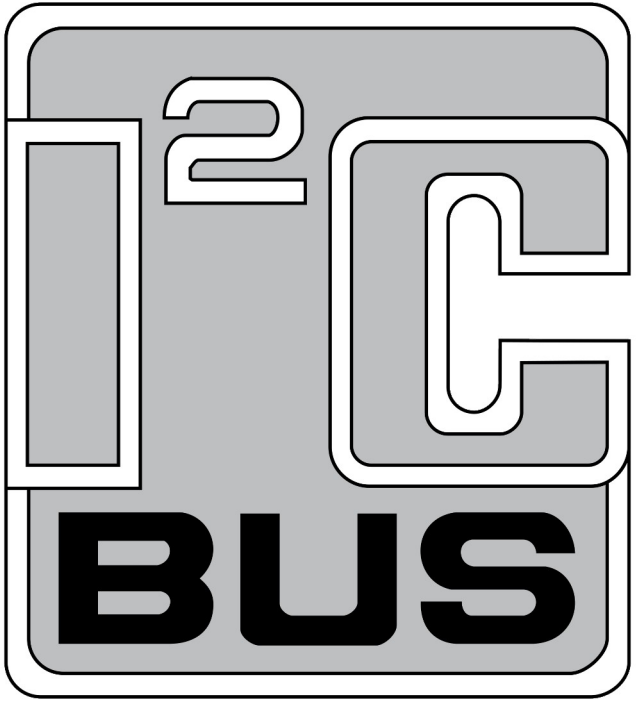
Inter-Integrated Circuit Bus



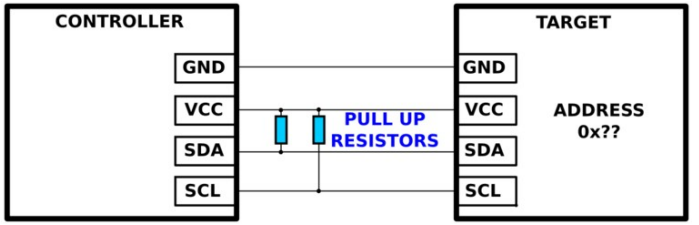
Introduction

- Inter-Integrated Circuit – I2C or I^2C
- Developed by Philips Semiconductors in 1982
- Synchronous, Multi-controller/multi-target, serial communication bus
- Sometimes is referred to as System Management Bus (SMBus)
  - Different, Intel developing SMBus in 1995
  - SMBus is a subset of I2C
- Current Standard

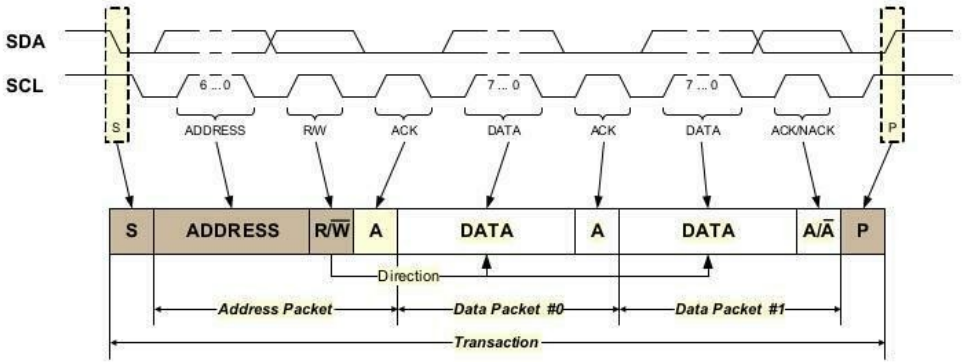
Basics

- Controller – Host device, historically known as master
- Target or peripheral – Device that the controller talks with, historically known as slave
- Several different transfer modes
  - Original 1982 mode – 100 kHz
  - Fast-mode – 400 kHz
  - Fast-mode plus – 1 MHz
  - High-speed mode – 3.4 MHz
  - Ultra-fast mode – 5 MHz
- Standard allows for any speed from 0 kHz to 5 MHz

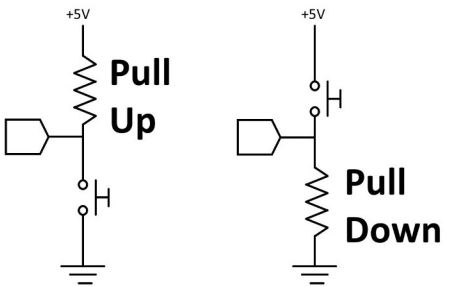
Basics (cont.)



- Targets are identified by unique address
  - Original standard allowed for 7-bit address (128 addresses, 112 available)
  - Current standard allows for 10-bit address (1024 addresses)
  - 7-bit addressing is still very common
- Requires two lines
  - SDA – **S**erial **DA**ta
  - SCL – **S**erial **Cl**ock

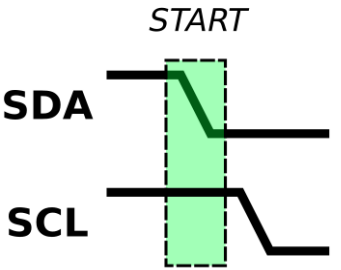


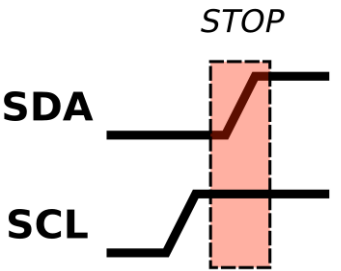
- Data is sent via transactions. More complex than UARTs.
- Open drain, pull-up resistors are required.
  - Open drain means they can pull line low but not high

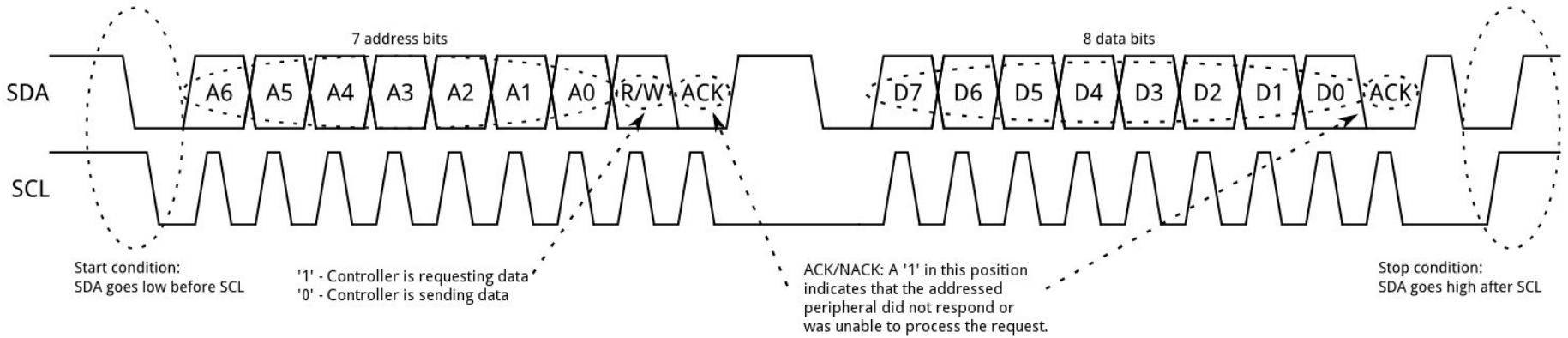


Transaction

- START – beginning of a transaction
- Address is 7-bits big endian (MSB first)
- ACK/NACK – Acknowledge/Not Acknowledge
  - Sent after each byte of data
- Data is 8-bit chucks followed by ACK/NACK
- STOP – ending of a transaction







Pull-Up Resistors

- Pull up to logic voltage level (5V or 3.3V), not power voltage (Vin)
- Rule of thumb: Start at 4.7 kΩ and then go down if need be
  - Depends on cable length
  - I2C intended for short distances (2-3 feet of cable max)
- Some controller devices have internal pull-up resistors
  - Arduino – 1.5 kΩ
  - ESP32 – 45 kΩ with max 75 µA (i.e., ~0.25 mW)
- Some target devices have pull-up resistors.
- Only need one each for SDA and SCL on entire bus.

Closing Remarks

- Some have standardized connector for I2C
  - Sparkfun – Qwiic
  - Adafruit – STEMMA/STEMMA QT
- For long runs of I2C cabling, a bus extender may be used.
  - Uses RJ-45 connector (i.e., ethernet connector)