SPI + I2C

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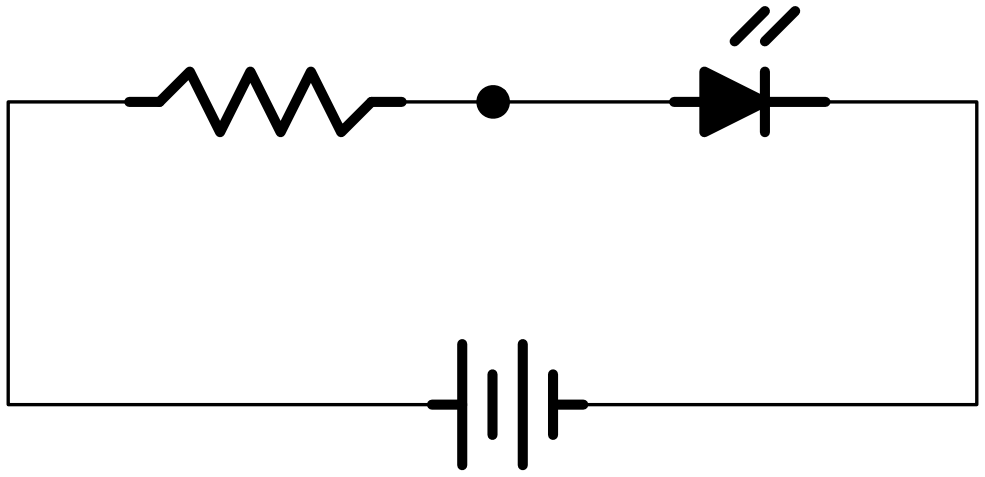
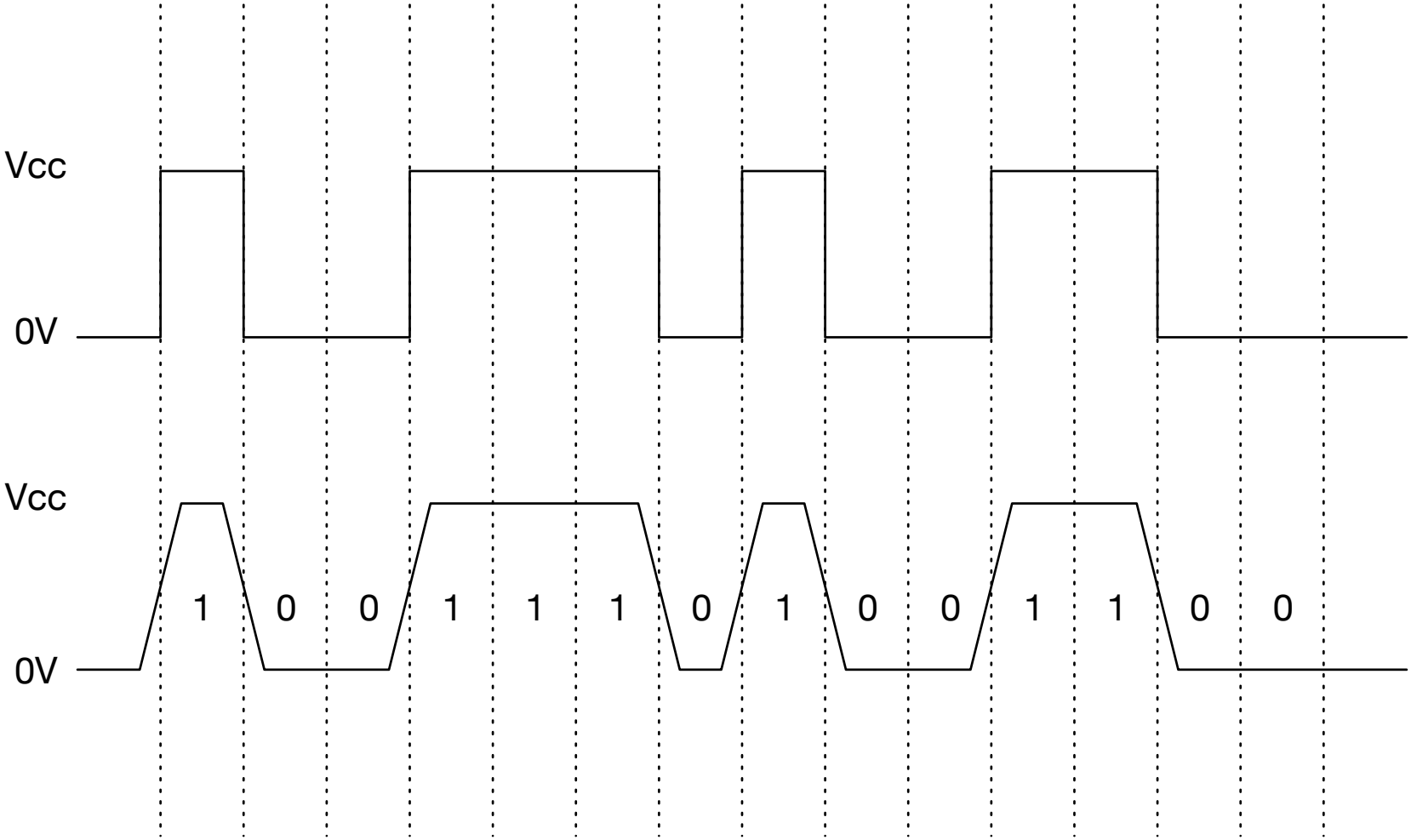
- Basic Electronics



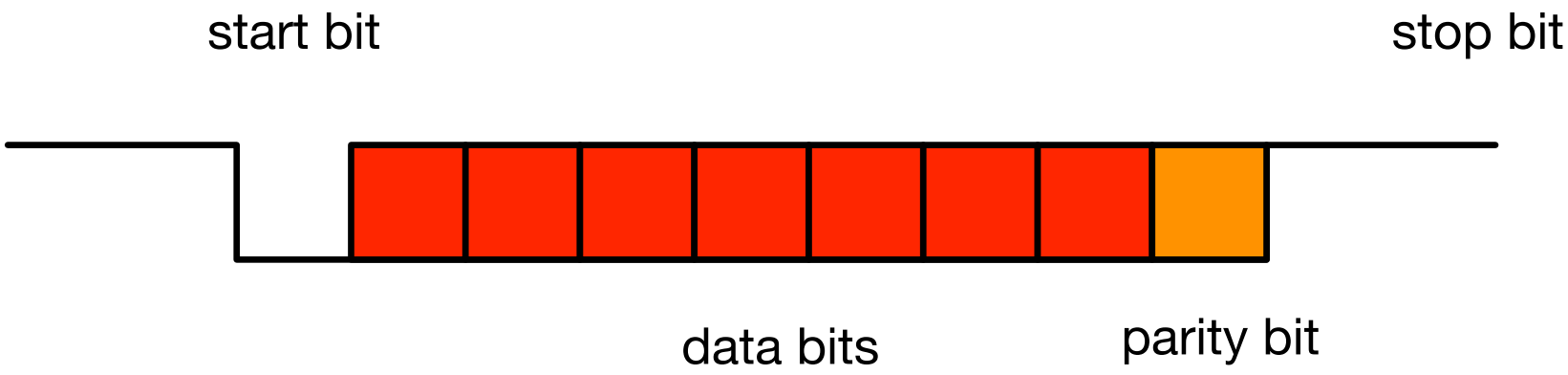
Today

- Embedded Communication

Waveforms



- asynchronous
- full duplex
- start, stop, and parity bits
- point to point



feature	disadvantage
two clocks	complexity
full duplex	
start, stop, and parity bits	overhead
point to point	wires

- 3 signals + 1 signal per slave
- single master
- synchronous
- full duplex
- relatively high speed up to few MHz
- no flow control

- 3 signals + 1 signal per slave
- synchronous
- full duplex
- relatively high speed
- only a few feet

SPI Signals

- Master generated clock SCK
- Master-Out-Slave-In MOSI data
- Master-In-Slave-Out MISO data
- Slave Select SS

- active high/low on
- low Mhz

Simplest Transaction

master	slave
SS low	
0	Temperature Data
SS high	

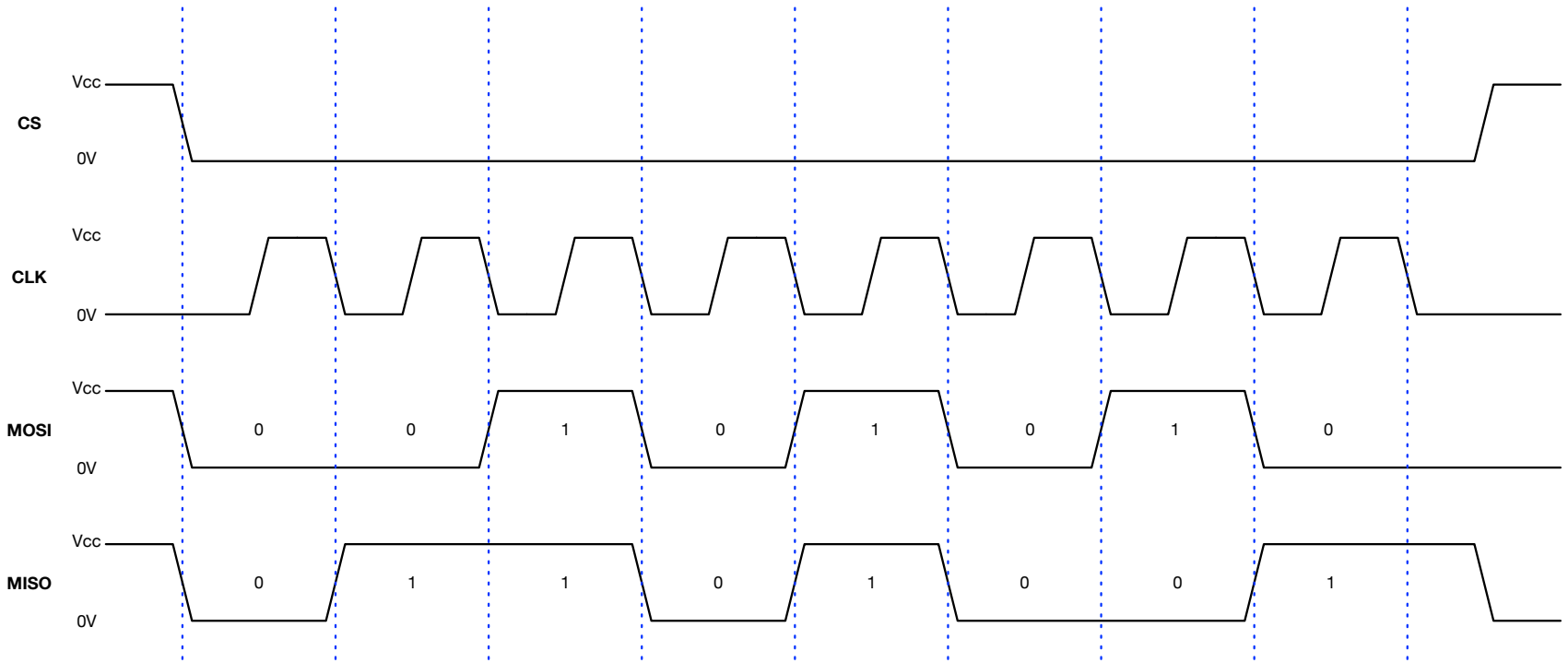
Write Register Transaction

master	slave
SS low	
Write Cmd	0
Register Address	0
Register Data	0
SS high	

Read Register Transaction

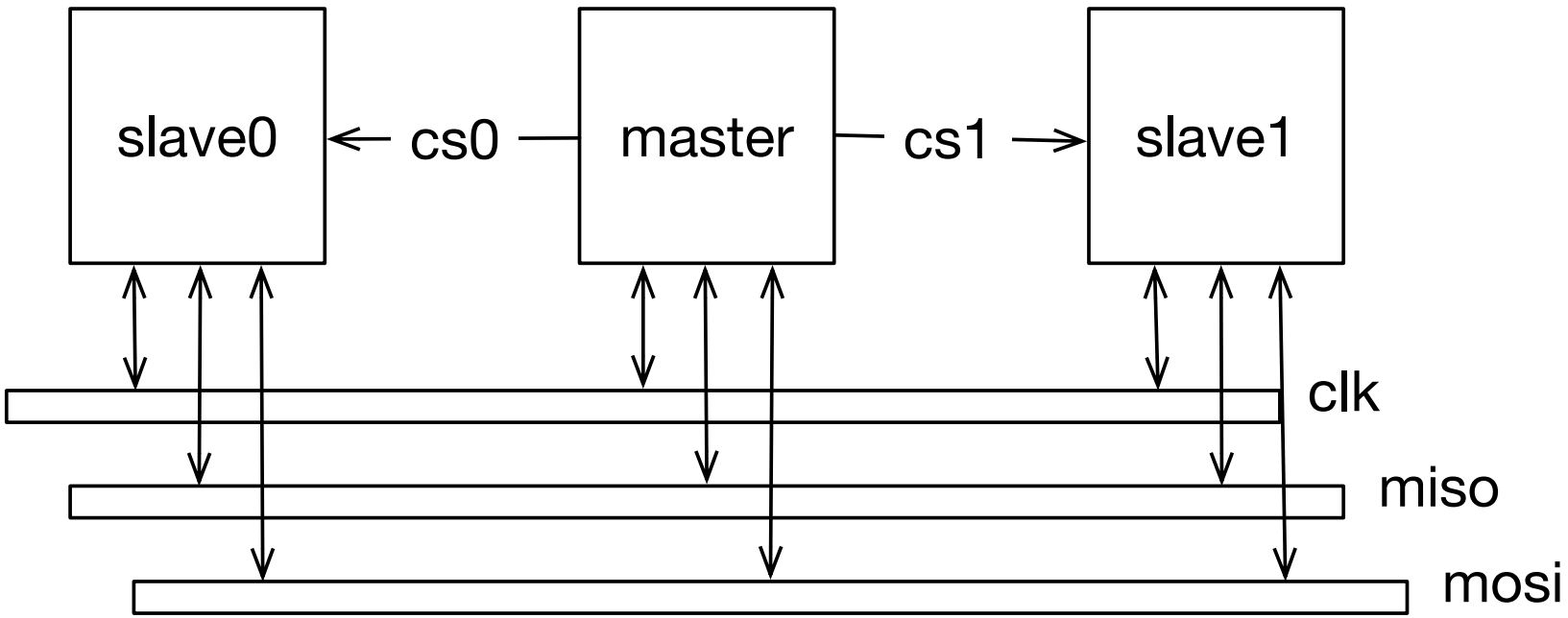
master	slave
SS low	
Read Cmd	0
Register Address	0
0	Register Data
SS high	

SPI Waveform



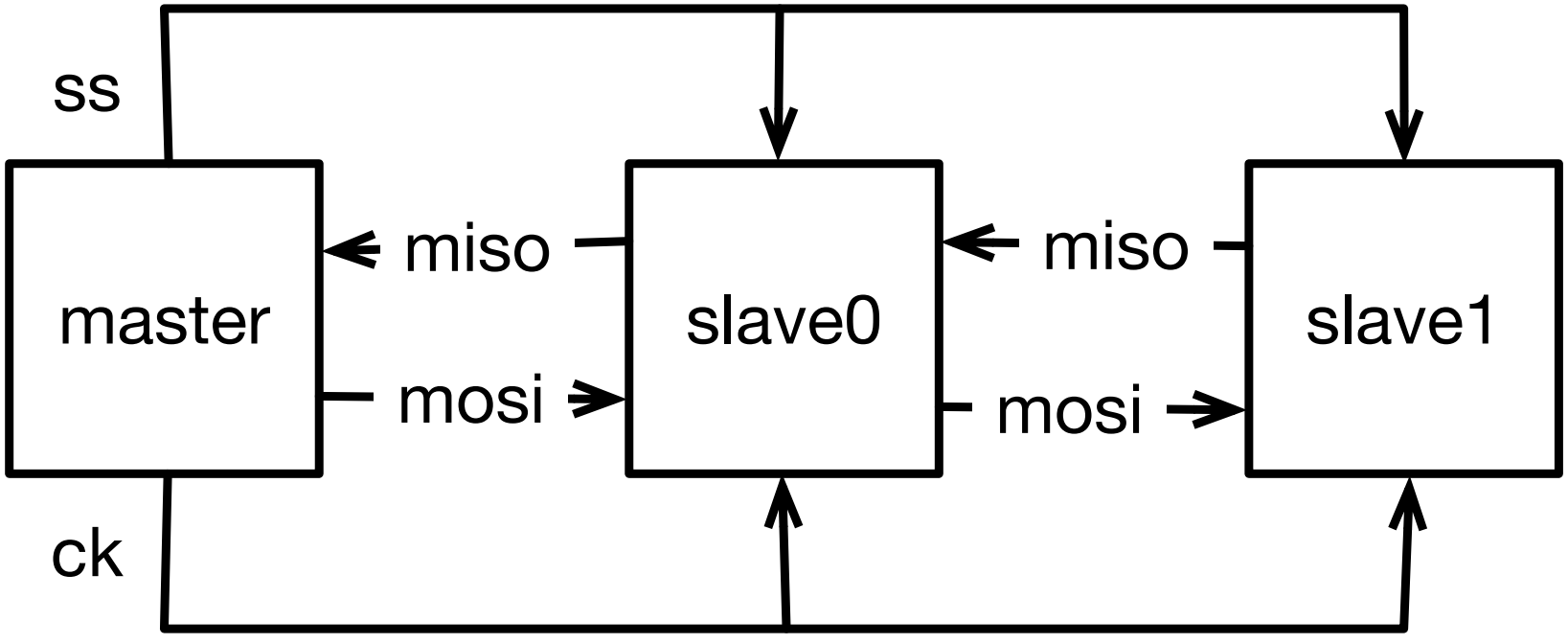
Multiple Slaves

- multiple slave selects
- MOSI, MISO, SCK on bus



Daisy Chained Slaves

- shared slave select
- shared SCK
- Daisy-chaned MOSI and MISO
- keep pumping data down chain



- can bit bang gpio or
- use few dedicated lines for the purpose

- bit order – endianess
- data mode – for when to sample data on clock edge
- clock divider – for speed of clock

- use logic analyzer like Saleae

for longer distance travel use

- slower clock
- special driver chips

```
SPI(PinName mosi, PinName miso, PinName sclk, PinName ssel=NC)
void format(int bits, int mode=0)
void frequency(int hz=1000000)
virtual int write(int value)
virtual void lock(void)
virtual void unlock(void)
```

Read Whoami


```
#include "mbed.h"

SPI spi(p5, p6, p7); // mosi, miso, sclk
DigitalOut cs(p8);

int main() {
  cs = 1; // Chip must be deselected
  // Setup the spi for 8 bit data, high steady state clock,
  // second edge capture, with a 1MHz clock rate
  spi.format(8,3);
  spi.frequency(1000000);
  cs = 0; // Select the device by seting chip select low
  // Send 0x8f, the command to read the WHOAMI register
  spi.write(0x8F);
  // Send a dummy byte to receive the contents of the WHOAMI register
  int whoami = spi.write(0x00);
  printf("WHOAMI register = 0x%X\n", whoami);
  cs = 1; // Deselect the device
}
```

from mbed website

- asynchronous SPI transfers
- can set up more work to be done
- callback on completion
- not implemented on all platforms
- will look into this more

What's Wrong with SPI?

- high speed
- 3 pins + pin per slave
- fast and full-duplex

- only two pins
- half-duplex
- shareable bus
- medium speed
- ack/nack per 8 bits

- SCL for clock and SDA for data
- pull up resistors 4.7K for active pull down bus
- open drain – pull down but not up
- up to 2-3m lengths

I2C Packets

- Start
- Address + R/W
- Data
- Stop

I2C Start

- 1->0 transition on SDA with SCL high
- First master wins
- Possible to do repeated starts

Address Frame

- 7-bit or 10-bit address
- R/W bit
- NACK/ACK bit from slave or not

Data Frames

- clock out data frames
- from master or slave depending on R/W

Stop Condition

- End of data frames
- 0->1 transition on SDA after 1->0 transition on SCL
- During normal data avoid stop condition

- No end condition after data frame
- Master maintains bus and continues transfer
- Any number of repeated starts is allowed
- Ends with stop condition

- Sometimes clock rate is too fast for slave
- During Ack/Nack period slave can hold the SCL line low after master releases it
- Master is required to not clock until slave releases it
- Limits to how long you can clock stretch

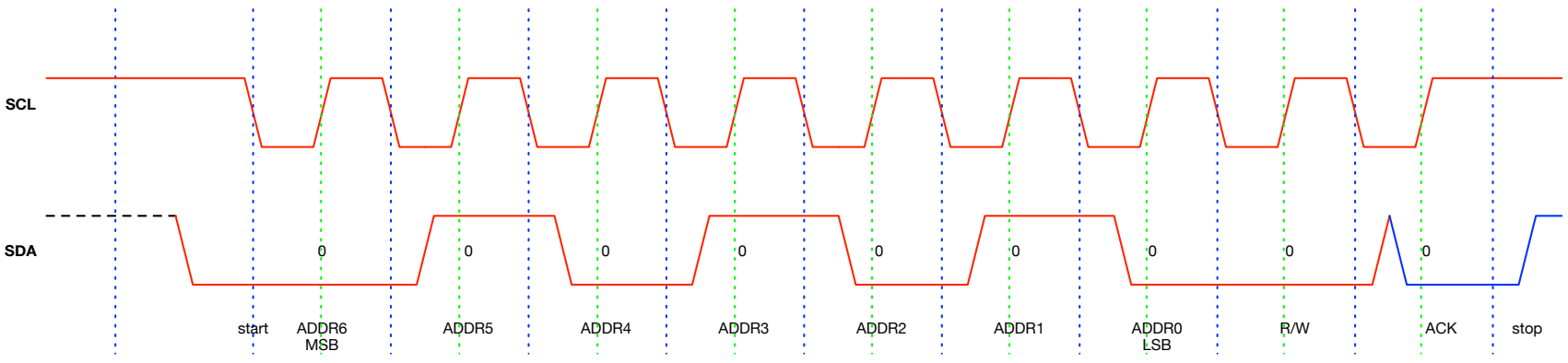
Write Transaction

master	slave
Start	
Device Address + WR	
	Ack
Write Cmd	
	Ack
Register Address	
	Ack
Register Data	
	Ack
Stop	

Read Transaction

master	slave
Start	
Device Address + WR	
	Ack
Read Cmd	
	Ack
Register Address	
	Ack
Start	
Device Address + RD	
	Ack
	Register Data
	NAck
Stop	

I2C Waveform



```
I2C(PinName sda, PinName scl)
void frequency(int hz)
int read(int address, char *data, int length, bool repeated=false)
int read(int ack)
int write(int address, const char *data, int length, bool repeated=false)
int write(int data)
void start(void)
void stop(void)
```

Read temperature from TC74


```
#include "mbed.h"

I2C i2c(p28, p27);
const int addr = 72;

int main() {
  char cmd;
  i2c.frequency(9600);
  while (1) {
    cmd = 0;
    i2c.write(addr, cmd, 1);
    wait(0.5);
    i2c.read(addr, cmd, 1);
    float tmp = (float)(cmd[0]) / 256.0;
    printf("Temp = %.2f\n", tmp);
} }
```

from mbed website

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- JITPCB Circuit Design

References

- https://developer.mbed.org/handbook/SPI and https://developer.mbed.org/handbook/I2C
- https://learn.sparkfun.com/tutorials/serial-peripheral-interface-spi and https://learn.sparkfun.com/tutorials/i2c
- https://en.wikipedia.org/wiki/Serial_Peripheral_Interface_Bus and https://en.wikipedia.org/wiki/I%C2%B2Cwikipedia