TN215

Using the I²C Bus with a Rabbit Microprocessor

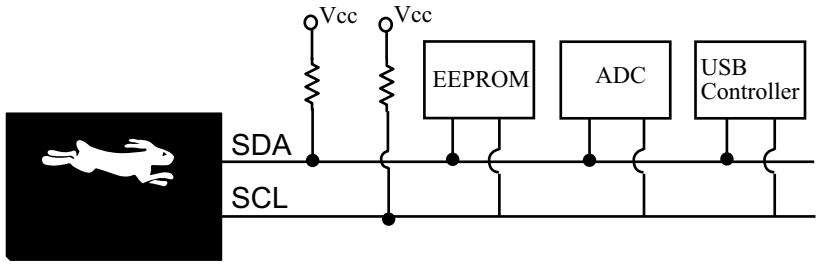
This document describes how to use the library, `I2C.LIB`, to enable the Rabbit 2000 microproccessor to communicate with I2C peripheral devices. The library covers the basic I2C protocol. You must have a Rabbit 2000 or newer Rabbit chip to use the I²C library. Most Dynamic C libraries are forward compatible; to verify this for a particular library read the comments at the top of the library file.

The term "I²C" comes from IIC, an acronym for Inter IC. The I²C bus is a popular way for a processor to communicate with peripheral chips on a board. Its simple and flexible nature make it a good choice for low-speed peripherals. There are a number of these that can be used by the Rabbit, including serial EEPROM chips, ADCs, and even more exotic types such as video switches and USB controllers.

Physical Properties of the I²C Bus

I²C is a synchronous serial bus that can be shared by several peripheral devices. The physical connection is made up of two wires (SCL and SDA) pulled up to a logic high level by resistors. All nodes on the bus use open-collector style drivers when controlling SCL or SDA. This prevents the possibility of contention between nodes.

Figure 1.



I²C Protocol

The master (i.e., the Rabbit) normally controls the clock line (SCL) and determines when a data transfer will occur. Peripherals are not able to interrupt the master. A data bit on the SDA line is normally latched before the clock goes into a high state. The master can signal a start (S) or stop (P) condition by violating this and creating a transition while the clock is high. A falling edge indicates a start, while a rising edge indicates a stop. This is followed by bits being clocked out normally, with the most significant bit first. At the end of each byte, the master generates an extra clock pulse, and the receiver of the byte (slave or master) generates an acknowledge bit (ACK). The ACK is a low state on SDA while SCL is high.

Since SDA is pulled up, an ACK will only be generated if the receiver intentionally pulls the line low.

Which Parallel Port to Use

There are 5 parallel ports on the Rabbit 2000. The I^{2}C library uses port D because it has open drain capabilities, which makes clock stretching easy to detect. Clock stretching is when a slave device needs more time to prepare to send a byte of data and so pulls SCL low to indicate that it is not yet ready.

Port D is hardcoded in `i2c.lib` with `#ifndef` directives. To use a different parallel port you must `#define` a few things in your application code, as well as change the function `i2c_init()`. Refer to `i2c.lib`, and specifically the comment "Define these to change basic bit handling," to see what needs to be done.

I^{2}C Library API

The functions in `I2C.LIB` handle the generic aspects of an I^{2}C interface. Drivers for specific I^{2}C peripheral devices can easily be built with these functions. The basic operations for a Rabbit I^{2}C master are:

- **Initialize the I^{2}C interface pins**

```
i2c_init()          // Sets up the SCL and SDA port pins for open-drain output
                    // Also initializes delay constant
```

- **Send a start condition**

```
i2c_start_tx()      // initiates I2C transmission by sending S (START)
i2c_startw_tx()     // initiates I2C transmission by sending S
                    // inserts delay after S pulse.
```

- **Send a byte of data**

```
i2c_write_char()    // Sends 8 bits to slave
i2c_wr_wait()       // Retries char write until slave responds
```

- **Listen for an Acknowledgement**

```
i2c_check_ack()     // Checks if slave pulls data low for ACK on clock pulse
```

- **Receive a byte of data**

```
i2c_read_char()     // Reads 8 bits from slave
```

- **Send an Acknowledgement**

```
i2c_send_ack()      // Sends ACK sequence to slave
i2c_send_nak()      // Sends NAK sequence to slave
```

- **Send a stop condition**

```
i2c_stop_tx()       // Sends P (STOP) to slave
```

These actions are combined in driver functions to communicate with a specific I^{2}C device. For additional information on this API, refer to the *Dynamic C Function Reference Manual* or use the "Function Lookup/Insert" feature on Dynamic C's Help menu.

Device Specific Functions

To write a set of functions for a given device, you will need to consult its datasheet and write functions for each of the operations you wish to perform. This is simple, since the master's tasks breaks down into a series of byte writes and byte reads. Examples of higher-level API functions written for specific devices are in `I2C_DEVICES.LIB`. This library contains implementations for a 24LC16 EEPROM and a MAX518 DAC.

After writing a byte, the master usually listens for an acknowledgement bit and and acts appropriately depending on if one is received or not. Not receiving an ACK from the slave does not always indicate an error. Several types of I^{2}C devices stop acknowledging while they are busy to indicate that they are not ready. EEPROMs doing a write operation and ADCs performing a conversion are good examples of this.

If the I^{2}C device only receives commands, then it is a simple matter sending it a Start, writing the command bytes to it, listening for an ACK after each one, and finally ending with a Stop. If the device sends data back to the master, the operation is more complex.

In this case, the master starts the transfer by sending a Start followed by one or more bytes. The slave should ACK each of these. At some point the master will begin reading bytes from the device and sending an ACK bit after each one. The master usually ends the transfer by not acknowledging the last byte and then sending a Stop condition.

Note that even while reading, the master still controls the clock (SCL), but the device is controlling SDA

Sample Programs

Sample programs are available in the directory where Dynamic C was installed, in the folder `Samples\I2C`. The program, `i2c_test.c`, writes a string to the beginning of the memory space of a Microchip 24LC16 serial EEPORM, and then reads it back. The program, `i2c_dac_sample.c`, tests the connection of the Rabbit to a MAX517/518/519 chip This sample will cycle through DAC values zero through 255, creating a sawtooth output.

Summary

Communicating with devices over an I^{2}C bus requires a tailored implementation for each device type. After reading this document and looking at the sample programs, you should be able to create an implementation for whatever device you will be using. The best resource for further informaion is the datasheet for the chip you are interfacing to the Rabbit. The better datasheets include an overview of I^{2}C in addition to specifics about communicating with the chip. The I^{2}C specification was developed by Philips Semiconductor and is available on their website: `www.semiconductors.philips.com`.