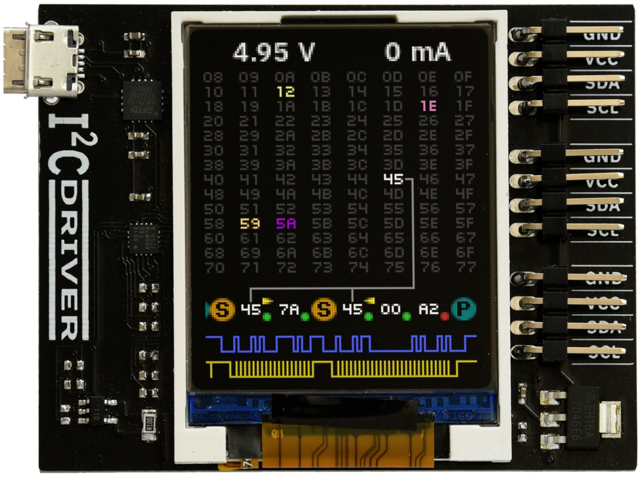


Last updated on May 31, 2019

Contents

1 Overview

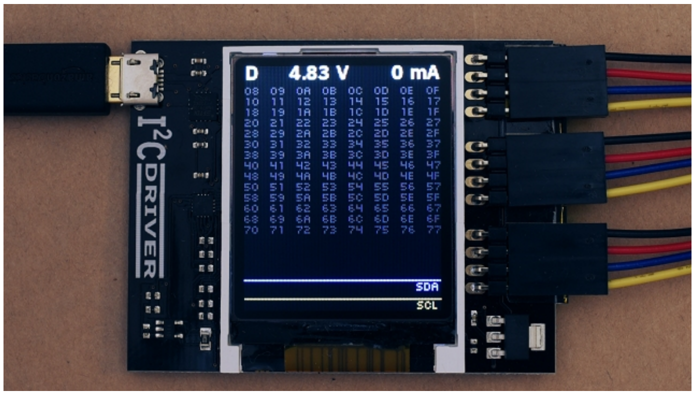
I^{2}CDriver is an easy-to-use, open source tool for controlling I^{2}C devices. It works with Windows, Mac, and Linux, and has a built-in color screen that shows a live dashboard of all the I^{2}C activity. It uses a standard FTDI USB serial chip to talk to the PC, so no special drivers need to be installed. The board includes a separate 3.3 V supply with voltage and current monitoring.

1.1 Features

- **Live display**: shows you exactly what it's doing all the time
- **Supports all I^{2}C features**: 7- and 10-bit I^{2}C addressing, clock stretching, bus arbitration, and sustained I^{2}C transfers at 400 and 100 kHz
- **I^{2}C pullups**: programmable I^{2}C pullup resistors, with automatic tuning
- **USB voltage monitoring**: USB line voltage monitor to detect supply problems, to 0.01 V
- **Target power monitoring**: target device high-side current measurement, to 5 mA
- **Three I^{2}C ports**: three identical I^{2}C ports, each with power and I^{2}C signals
- **Jumpers**: three sets of high-quality color coded 100mm jumpers included
- **3.3 V output**: output levels are 3.3 V, all are 5 V tolerant
- **Sturdy componentry**: uses an FTDI USB serial adapter, and Silicon Labs automotive-grade EFM8 controller
- **Open hardware**: the design, firmware and all tools are under BSD license
- **Flexible control**: GUI, command-line, C/C++, and Python 2/3 host software provided for Windows, Mac, and Linux

2 Getting Started

When you first connect I²CDriver to the USB port, the display blinks white for a moment then shows something like this:



Connect the three sets of colored hookup wires as shown, following the same sequence as on the colored label:

`GND`	black
`VCC`	red
`SDA`	blue
`SCL`	yellow

The top two signals carry power, the VCC line supplies 3.3 volts.

Across the top of the display I²CDriver continuously measures the USB bus voltage and the current output.

3 Software installation

The source for all the I^{2}CDriver software is the repository. Available are:

- a Windows/Mac/Linux GUI
- a Windows/Mac/Linux command-line
- Python 2 and 3 bindings
- Windows/Mac/Linux C/C++ bindings

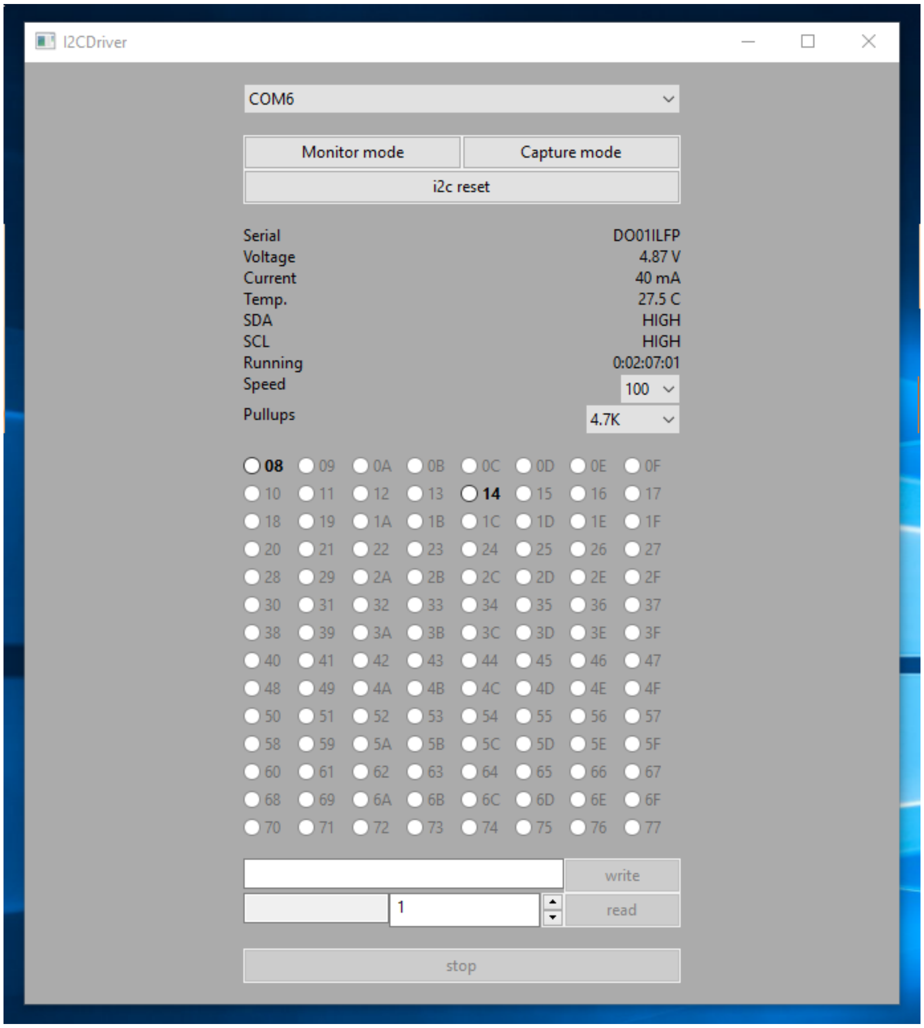
Installation of the GUI and command-line utilities varies by platform.

3.1 Windows

This installer contains the GUI and command-line utilities.

The GUI shortcut is installed on the desktop:

launching it brings up the control window:



COM6

Serial DO01ILFP
Voltage 4.87 V
Current 40 mA
Temp. 27.5 C
SDA HIGH
SCL HIGH
Running 0:02:07:01
Speed 100
Pullups 4.7K

○ **08**	○ 09	○ 0A	○ 0B	○ 0C	○ 0D	○ 0E	○ 0F
○ 10	○ 11	○ 12	○ 13	○ **14**	○ 15	○ 16	○ 17
○ 18	○ 19	○ 1A	○ 1B	○ 1C	○ 1D	○ 1E	○ 1F
○ 20	○ 21	○ 22	○ 23	○ 24	○ 25	○ 26	○ 27
○ 28	○ 29	○ 2A	○ 2B	○ 2C	○ 2D	○ 2E	○ 2F
○ 30	○ 31	○ 32	○ 33	○ 34	○ 35	○ 36	○ 37
○ 38	○ 39	○ 3A	○ 3B	○ 3C	○ 3D	○ 3E	○ 3F
○ 40	○ 41	○ 42	○ 43	○ 44	○ 45	○ 46	○ 47
○ 48	○ 49	○ 4A	○ 4B	○ 4C	○ 4D	○ 4E	○ 4F
○ 50	○ 51	○ 52	○ 53	○ 54	○ 55	○ 56	○ 57
○ 58	○ 59	○ 5A	○ 5B	○ 5C	○ 5D	○ 5E	○ 5F
○ 60	○ 61	○ 62	○ 63	○ 64	○ 65	○ 66	○ 67
○ 68	○ 69	○ 6A	○ 6B	○ 6C	○ 6D	○ 6E	○ 6F
○ 70	○ 71	○ 72	○ 73	○ 74	○ 75	○ 76	○ 77

1

If there is only one serial device, the I^{2}CDriver device should be automatically selected. If there is more than one device, select its COM port from the pull-down menu at the top. Once connected, you can select a connected I^{2}C device and write and read data.

The command line utility `i2ccl` is also installed. For example to display status information:

```
c:\>"c:\Program Files\Excamera Labs\I2CDriver\i2ccl.exe" COM6 i
uptime 8991 4.957 V 30 mA 25.8 C SDA=1 SCL=1 speed=100 kHz
```

See below for more information on the command-line syntax.

3.2 Linux

The GUI is included in the `i2cdriver` Python package, compatible with both Python 2 and 3. To install it, open a shell prompt and do:

```
sudo pip install i2cdriver
```

Then run it with

```
i2cgui.py
```

For the command-line tool, clone the repository, then do:

```
cd i2cdriver/c
make -f linux/Makefile
sudo make -f linux/Makefile install
i2ccl /dev/ttyUSB0 i
```

and you should see something like:

```
uptime 1651 4.971 V 0 mA 21.2 C SDA=1 SCL=1 speed=100 kHz
```

3.3 MacOS

The GUI is included in the `i2cdriver` Python package, compatible with both Python 2 and 3. To install it, open a shell prompt and do:

```
sudo pip install i2cdriver
```

Then run it with

```
i2cgui.py
```

For the command-line tool, clone the repository , then do:

```
cd i2cdriver/c
make -f linux/Makefile
sudo make -f linux/Makefile install
i2ccl /dev/cu.usbserial-D000QS8D i
```

(substituting your actual I^{2}CDriver's ID for `D000QS8D`) and you should see something like:

```
uptime 1651 4.971 V 5 mA 21.2 C SDA=1 SCL=1 speed=100 kHz
```

Note that the port to use is `/dev/cu.usbserial-XXXXXXXX`, as explained here.

4 APIs

4.1 Python 2 and 3

The I^{2}CDriver bindings can be installed with `pip` like this:

```
 pip install i2cdriver
```

then from Python you can read an LM75B temperature sensor with:

```
>>> import i2cdriver
>>> i2c = i2cdriver.I2CDriver("/dev/ttyUSB0")
>>> d=i2cdriver.EDS.Temp(i2c)
>>> d.read()
17.875
>>> d.read()
18.0
```

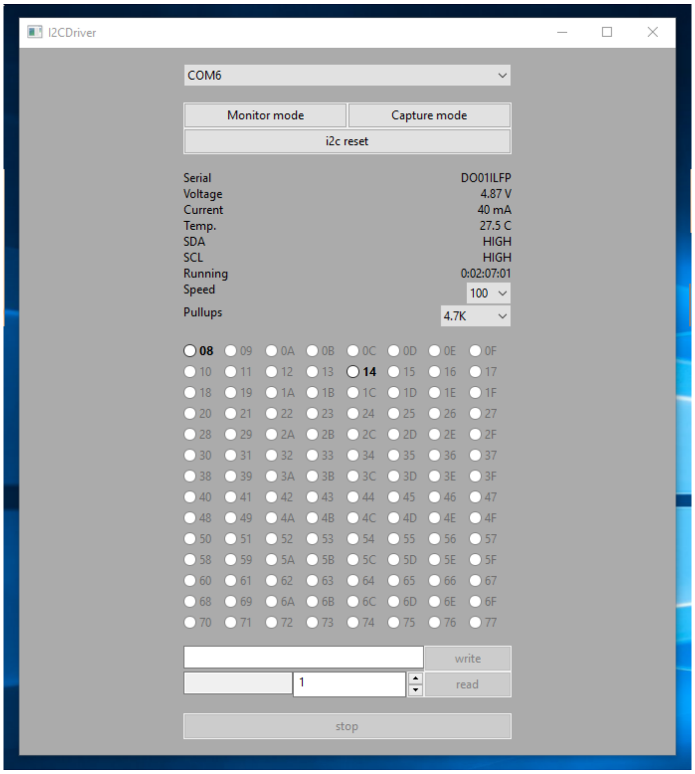
You can print a bus scan with:

```
>>> i2c.scan()
-- -- -- -- -- -- -- --
-- -- -- -- -- -- -- --
-- -- -- -- 1C -- -- --
-- -- -- -- -- -- -- --
-- -- -- -- -- -- -- --
-- -- -- -- -- -- -- --
-- -- -- -- -- -- -- --
-- -- -- -- -- -- -- --
48 -- -- -- -- -- -- --
-- -- -- -- -- -- -- --
-- -- -- -- -- -- -- --
-- -- -- -- -- -- -- --
68 -- -- -- -- -- -- --
-- -- -- -- -- -- -- --
[28, 72, 104]
```

The Python GUI (which uses wxPython) can be run with:

```
python i2cgui.py
```

which depending on your distribution looks something like this:



COM6

Serial	DO01ILFP
Voltage	4.87 V
Current	40 mA
Temp.	27.5 C
SDA	HIGH
SCL	HIGH
Running	0:02:07:01
Speed	100
Pullups	4.7K

1

There are more examples in the samples folder in the repository.

The module has extensive help strings:

```
>>> help(i2cdriver)
```

displays the API documentation.

4.1.1 Reference

`class i2cdriver.I2CDriver`(*port='/dev/ttyUSB0'*, *reset=True*)

A connected I2CDriver.

Variables

- `product` – product code e.g. i2cdriver1
- `serial` – serial string of I2CDriver
- `uptime` – time since I2CDriver boot, in seconds
- `voltage` – USB voltage, in V
- `current` – current used by attached device, in mA
- `temp` – temperature, in degrees C
- `scl` – state of SCL
- `sda` – state of SDA
- `speed` – current device speed in KHz (100 or 400)
- `mode` – IO mode (I2C or bitbang)
- `pullups` – programmable pullup enable pins
- `ccitt_crc` – CCITT-16 CRC of all transmitted and received bytes

`__init__`(*port='/dev/ttyUSB0'*, *reset=True*)

Connect to a hardware i2cdriver.

Parameters

- `port` (*str*) – The USB port to connect to
- `reset` (*bool*) – Issue an I2C bus reset on connection

`setspeed`(*s*)

Set the I2C bus speed.

Parameters `s` (*int*) – speed in KHz, either 100 or 400

`setpullups`(*s*)

Set the I2CDriver pullup resistors

Parameters `s` – 6-bit pullup mask

`scan`(*silent=False*)

Performs an I2C bus scan. If silent is False, prints a map of devices. Returns a list of the device addresses.

```
>>> i2c.scan()
-- -- -- -- -- -- -- --
-- -- -- -- -- -- -- --
-- -- -- -- 1C -- -- --
-- -- -- -- -- -- -- --
-- -- -- -- -- -- -- --
-- -- -- -- -- -- -- --
-- -- -- -- -- -- -- --
-- -- -- -- -- -- -- --
48 -- -- -- -- -- -- --
-- -- -- -- -- -- -- --
-- -- -- -- -- -- -- --
-- -- -- -- -- -- -- --
68 -- -- -- -- -- -- --
-- -- -- -- -- -- -- --
[28, 72, 104]
```

`reset`()

Send an I2C bus reset

`start`(*dev*, *rw*)

Start an I2C transaction

Parameters

- `dev` – 7-bit I2C device address
- `rw` – read (1) or write (0)

To write bytes `[0x12,0x34]` to device `0x75`:

```
>>> i2c.start(0x75, 0)
>>> i2c.write([0x12,034])
```

(continues on next page)

(continued from previous page)

```
>>> i2c.stop()
```

`read`(*l*)

Read l bytes from the I2C device, and NAK the last byte

`write`(*bb*)

Write bytes to the selected I2C device

Parameters `bb` – sequence to write

`stop`()

stop the i2c transaction

`regrd`(*dev*, *reg*, *fmt='B'*)

Read a register from a device.

Parameters

- `dev` – 7-bit I2C device address
- `reg` – register address 0-255
- `fmt` – `struct.unpack()` format string for the register contents

If device 0x75 has a 16-bit register 102, it can be read with:

```
>>> i2c.regrd(0x75, 102, ">H")
4999
```

`regwr`(*dev*, *reg*, **vv*)

Write a devices register.

Parameters

- `dev` – 7-bit I2C device address
- `reg` – register address 0-255
- `vv` – sequence of values to write

To set device 0x34 byte register 7 to 0xA1:

```
>>> i2c.regwr(0x34, 7, [0xa1])
```

If device 0x75 has a big-endian 16-bit register 102 you can set it to 4999 with:

```
>>> i2c.regwr(0x75, 102, struct.pack(">H", 4999))
```

`monitor(s)`

Enter or leave monitor mode

Parameters `s` – `True` to enter monitor mode, `False` to leave

`getstatus()`

Update all status variables

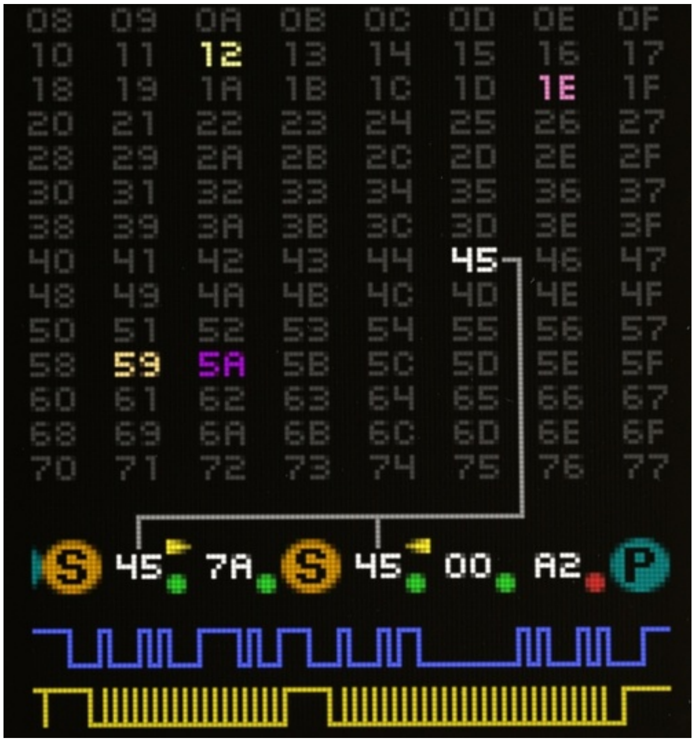
4.2 C/C++

I²CDriver is contained in a single source file with a single header. Both are in this subdirectory. Usage follows the Python API and is fairly self-explanatory.

5 Using I^{2}CDriver

5.1 The display

The main display on the screen has three sections. The top section is a heat-map showing all 112 legal I^{2}C addresses. Devices that are currently active are white. Inactive devices fade to yellow, purple and finally blue. The middle section is a symbolic interpretation of current I^{2}C traffic. Details on this are below. The bottom two lines show a representation of the SDA (blue) and SCL (yellow) signals.



08	09	0A	0B	0C	0D	0E	0F
10	11	12	13	14	15	16	17
18	19	1A	1B	1C	1D	1E	1F
20	21	22	23	24	25	26	27
28	29	2A	2B	2C	2D	2E	2F
30	31	32	33	34	35	36	37
38	39	3A	3B	3C	3D	3E	3F
40	41	42	43	44	45	46	47
48	49	4A	4B	4C	4D	4E	4F
50	51	52	53	54	55	56	57
58	59	5A	5B	5C	5D	5E	5F
60	61	62	63	64	65	66	67
68	69	6A	6B	6C	6D	6E	6F
70	71	72	73	74	75	76	77

The symbolic decode section shows I^{2}C transactions as they happen. Start and stop are shown as Ⓢ and Ⓟ symbols. After a Ⓢ symbol the address byte is shown, with a right arrow (write) or left arrow (read). There are gray lines connecting the address byte to its heat-map indicator. Following this is a series of data bytes. Each byte is shown in hex, with either a green dot (ACK) or red dot (NACK).

So for example the above sequence is showing

- Start, write to address `45`
- Write byte `7A`
- Repeated Start, read from address `45`
- Read byte `00`
- Read byte `A2`
- Stop

The above sequence is very typical for reading registers from an I^{2}C Device. Note that the final NACK (red dot) is not an error condition, but the standard way of handling the last byte of read transaction.

5.2 The GUI

(TBD: describe how each button in the GUI works)

5.3 The command-line tool `i2ccl`

`i2ccl` is the same on all platforms.

The first parameter to the command is the serial port, which depends on your operating system. All following parameters are control commands. These are:

`i`	display status information (uptime, voltage, current, temperature)
`d`	device scan
`w` *dev bytes*	write *bytes* to I²C device *dev*
`p`	send a STOP
`r` *dev N*	read *N* bytes from I²C device *dev*, then STOP
`m`	enter I²C bus monitor mode

For example the command:

```
i2ccl /dev/ttyUSB0 r 0x48 2
```

reads two bytes from the I²C device at address 0x48. So with an LM75B temperature sensor connected you might see output like:

```
0x16,0x20
```

which indicates a temperature of about 22 °C.

I²C devices usually have multiple registers. To read register 3 of the LM75B, you first write the register address 3, then read two bytes as before:

```
i2ccl /dev/ttyUSB0 w 0x48 3 r 0x48 2
0x50,0x00
```

Which shows that register 3 has the value `0x5000`.

5.4 Monitor mode

In monitor mode, the I²CDriver does not write any data to the I²C bus. Instead it monitors bus traffic and draws it on the display. This makes it an ideal tool for troubleshooting and debugging I²C hardware and software.

To show that it is in monitor mode, the I²CDriver changes the character in the top-left of the display from `D` to `M`.

There are several ways of entering monitor mode:

- use the command-line tool:

```
i2ccl m
```

- from the GUI check the ”Monitor” box
- from Python issue:

```
i2c.monitor(True)
```

  and to exit:

```
i2c.monitor(False)
```

- connect a terminal to the I^{2}CDriver (at 1000000 8N1) and type the `m` character, then type any character to exit monitor mode

5.5 Capture mode

In capture mode, the I^{2}CDriver does not write any data to the I^{2}C bus. Instead it monitors bus traffic and transmits it via USB for recording on the PC.

5.5.1 Command line

There is a Python sample program that can be used to capture traffic on the command-line at `capture.py`.

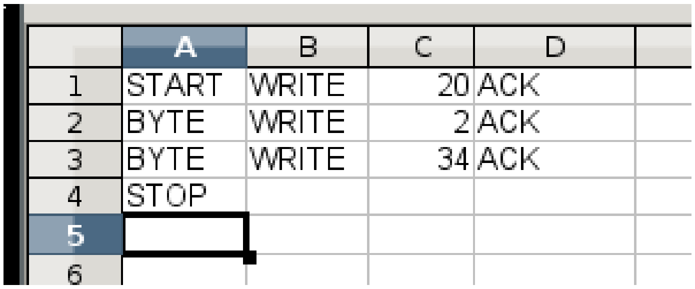
Running it with the I^{2}CDriver address as an argument puts the I^{2}CDriver into capture mode: the character in the top-left of the display changes from `D` to `C`.

```
$ python samples/capture.py /dev/ttyUSB0

Now capturing traffic to
    standard output (human-readable)
    log.csv
Hit CTRL-C to leave capture mode
<START 0x14 WRITE ACK>
<WRITE 0x02 ACK>
<WRITE 0x22 ACK>
<STOP>
^C
```

```
Capture finished
```

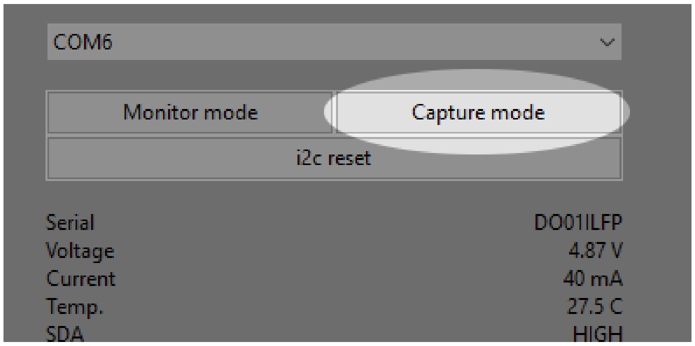
When run, it displays any traffic on standard output. It also writes a traffic summary to `log.csv` which can be examined and processed by any tool that can accept CSV files.



	A	B	C	D
1	START	WRITE	20	ACK
2	BYTE	WRITE	2	ACK
3	BYTE	WRITE	34	ACK
4	STOP			
5				
6				

5.5.2 GUI

The GUI also supports capture to CSV file.



Serial	DO01ILFP
Voltage	4.87 V
Current	40 mA
Temp.	27.5 C
SDA	HIGH

Clicking “Capture mode” starts the capture and prompts for a destination CSV file. The character in the top-left of the display changes from `D` to `C`. Capture continues until you click “Capture mode” again.

6 Examples

The Python `samples` directory contains short examples of using all Electric Dollar Store I2C modules:

Module	Function	Sample
DIG2	2-digit 7-seg display	EDS-DIG2.py
LED	RGB LED	EDS-LED.py
POT	potentiometer	EDS-POT.py
BEEP	Piezo beeper	EDS-BEEP.py
REMOTE	IR remote receiver	EDS-REMOTE.py
EPROM	CAT24C512 64 Kbyte EPROM	EDS-EPROM.py
MAGNET	LIS3MDL magnetometer	EDS-MAGNET.py
TEMP	LM75B temperature sensor	EDS-TEMP.py
ACCEL	RT3000C Accelerometer	EDS-ACCEL.py
CLOCK	HT1382 real-time clock	EDS-CLOCK.py

All demos and applications are run the same way, supplying the I2CDriver on the command-line. For example:

```
python EDS-LED.py COM16
```

Also included are some small applications which demonstrate combinations of modules.

6.1 Color Compass

Source code: EDS-color-compass.py

Color compass uses MAGNET and LED, reading the current magnetic field direction and rendering it as a color on the LED. As you twist the module, the color changes. For example there is a particular direction for pure red, as well as all other colors. The code reads the magnetic field direction, scales the values to 0-255, and sets the LED color.

6.2 Egg Timer

Source code: EDS-egg-timer.py

The demo uses POT, DIG2 and BEEPER to make a simple kitchen egg timer. Twisting the POT sets a countdown time in seconds, and after it's released the ticker starts counting. When it reaches “00” it flashes and beeps.

6.3 Take-a-ticket

Source code: EDS-take-a-ticket.py

This demo runs a take-a-ticket display for a store or deli counter, using REMOTE, DIG2 and BEEP modules. It shows 2-digit “now serving” number, and each time ’+’ is pressed on the remote it increments the counter and makes a beep, so the next customer can be served. Pressing ’-’ turns the number back one.

7 Technical notes

7.1 Port names

The serial port that I^{2}CDriver appears at depends on your operating system.

On **Windows**, it appears as COM1, COM2, COM3 etc. You can use the Device Manager or the `MODE` command to display the available ports. This article describes how to set a device to a fixed port.

On **Linux**, it appears as `/dev/ttyUSB0`, 1, 2 etc. The actual number depends on the order that devices were added. However it also appears as something like:

```
/dev/serial/by-id/usb-FTDI_FT230X_Basic_UART_D000QS8D-if00-port0
```

Where `D000QS8D` is the serial code of the I^{2}CDriver (which is printed on the bottom of each I^{2}CDriver). This is longer, of course, but always the same for a given device.

Similarly on **Mac OS**, the I^{2}CDriver appears as `/dev/cu.usbserial-D000QS8D`.

7.2 Decreasing the USB latency timer

I^{2}CDriver performance can be increased by setting the USB latency timer to its minimum value of 1 ms. This can increase the speed of two-way I^{2}C traffic by up to 10X.

On **Linux** do:

```
setserial /dev/ttyUSB0 low_latency
```

On **Windows** and **Mac OS** follow these instructions.

7.3 Temperature sensor

The temperature sensor is located in the on-board EFM8 microcontroller. It is calibrated at manufacture to within 2 °C.

7.4 Raw protocol

I^{2}CDriver uses a serial protocol to send and receive I^{2}C commands. Connect to the I^{2}CDriver at 1M baud, 8 bits, no parity, 1 stop bit (1000000 8N1).

Because many I^{2}CDriver commands are ASCII, you can control it interactively from any terminal application that can connect at 1M baud. For example typing `u` and `s` toggles the CS line and `?` displays the status info.

Commands are:

`?`	transmit status info
`e` $byte$	echo $byte$
`1`	set speed to 100 KHz
`4`	set speed to 400 KHz
`s` $addr$	send START/addr, return status
0x80-bf	read 1-64 bytes, NACK the final byte
0xc0-ff	write 1-64 bytes
`a` N	read N bytes, ACK every byte
`p`	send STOP
`x`	reset I^{2}C bus
`r`	register read
`d`	scan devices, return 112 status bytes
`m`	enter monitor mode
`c`	enter capture mode
`b`	enter bitbang mode
`i`	leave bitmang, return to I^{2}C mode
`u` $byte$	set pullup control lines
`v`	start analog voltage measurement
`w`	read voltage measurement result

So for example to send this sequence:

The host should send:

`s 0x90`	Start write to device 45
`0xc0 0x7a`	Write 1 byte
`s 0x91`	Start read from device 45
`0x80`	Read 1 byte
`p`	Stop

The status response is always 80 characters, space padded. For example::

```
[i2cdriver1 DO01JUOO 000000061 4.971 000 23.8 I 1 1 100 24 ffff          ]
```

The fields are space-delimited:

identifier	always `i2cdriver1`
serial	serial code identifier
uptime	I^{2}CDriver uptime 0-999999999, in seconds
voltage	USB bus voltage, in volts
current	attached device current, in mA
temperature	junction temperature, in °C
mode	current mode, `I` for I^{2}C, `B` for bitbang
SDA	SDA line state, 0 or 1
SCL	SCL line state, 0 or 1
speed	I^{2}C bus speed, in KHz
pullups	pullup state byte
crc	16-bit CRC of all input and output bytes (CRC-16-CCITT)

The sample `confirm.py` shows the CRC-16-CCITT calculation.

7.5 Pull-up resistors

I^{2}CDriver has 6 programmable pull-up resistors, 3 each for SDA and SCL. 6 control bits each enable or disable a pull-up resistor. These bits are:

bit	resistor
0	2.2K to SDA
1	4.3K to SDA
2	4.7K to SDA
3	2.2K to SCL
4	4.3K to SCL
5	4.7K to SCL

At boot the two 4.7K resistors are enabled. By setting combinations of parallel resistors, a range of pull-up strengths can be achieved:

4.7K	4.3K	2.2K	pull-up strength
0	0	0	0 (i.e. no pull-up)
0	0	1	2.2K
0	1	0	4.3K
0	1	1	1.5K
1	0	0	4.7K
1	0	1	1.5K
1	1	0	2.2K
1	1	1	1.1K

Ordering this by useful resistances, the 3-bit combinations are:

3-bit value	Resistance
0	0
1	2.2K
2	4.3K
4	4.7K
5	1.5K
7	1.1K

In Python, the pullups are controlled by the `setpullups()` method, and the state can be read from the `pullups` variable. Both are 6-bit values as above.

The GUI has a control for the pull-up resistors. It sets the same pull-up strength for both SDA and SCL.

7.6 Specifications

DC characteristics

	min	typ	max	units
Voltage accuracy		0.01		V
Current accuracy		5		mA
Temperature accuracy		± 2		°C
SDA,SCL				
low voltage			0.6	V
high voltage	2.7		5.8	V
Output current			470	mA
Current consumption		25		mA

AC characteristics

	min	typ	max	units
I^{2}C speed	100		400	Kbps
Uptime accuracy		150		ppm
Uptime rollover		31.7		years
Startup time			200	ms

8 Support information

Technical and product support is available at support@i2cdriver.com

I^2CDriver is built and maintained by Excamera Labs.

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