UCSD Embedded Linux Assignment 4

By

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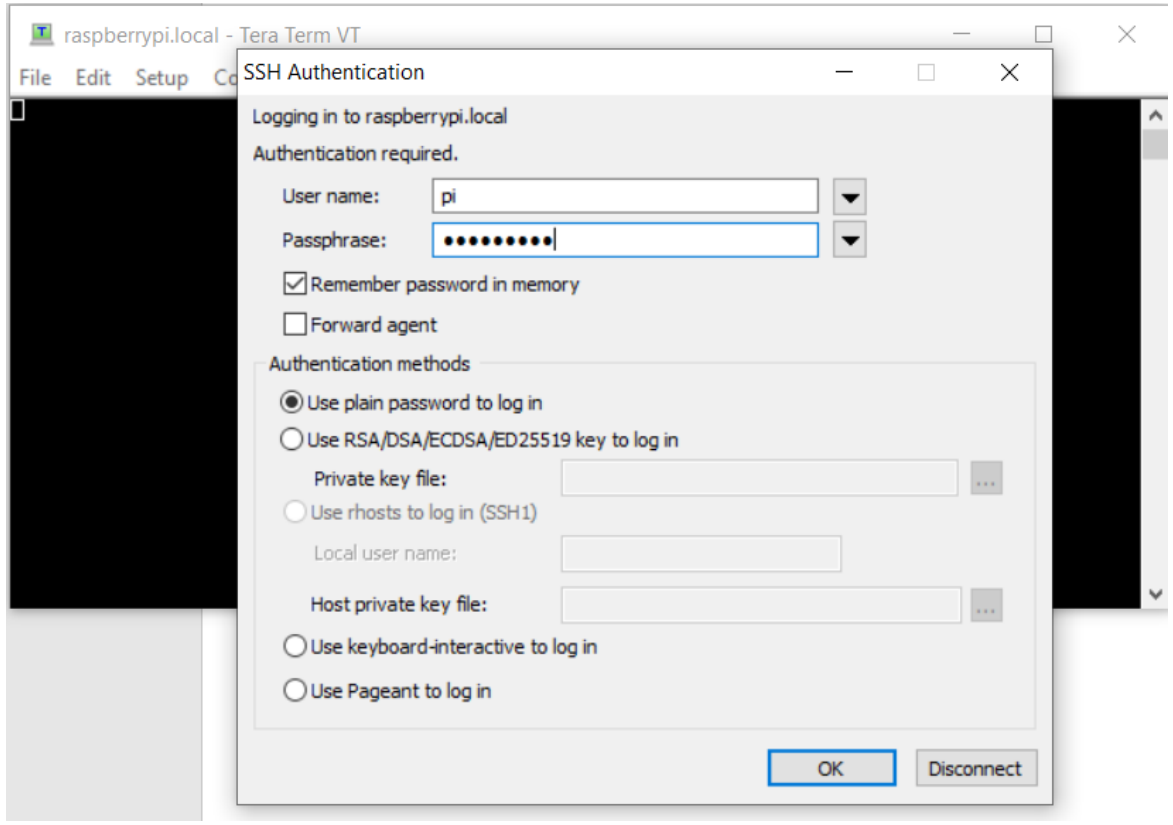
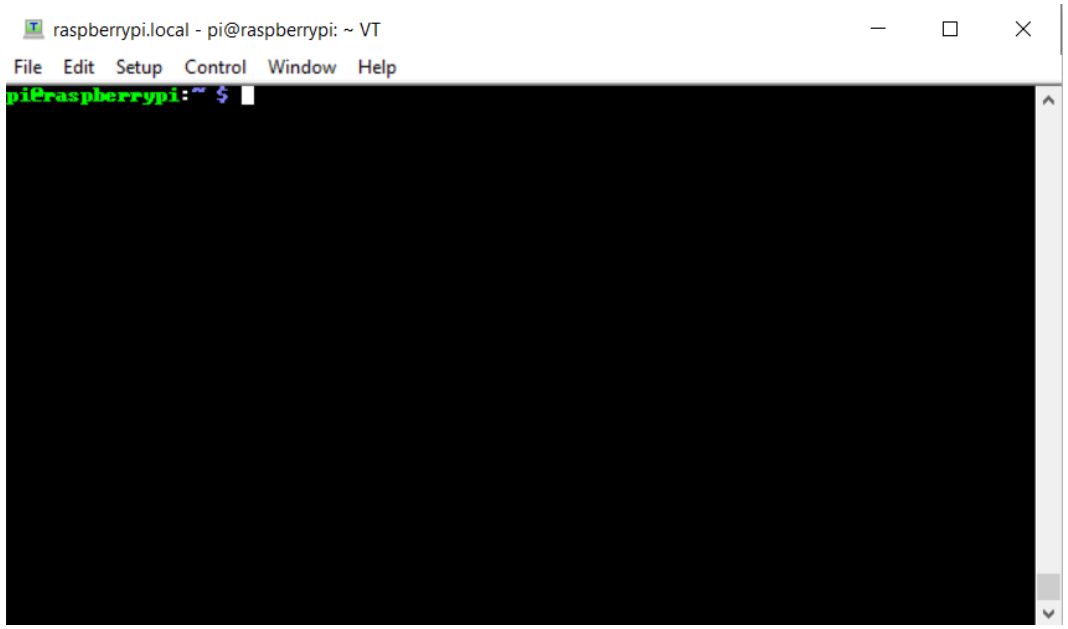
Step 1. Demo 1. RPi GPIO Access From C. Logon to RPi 4





Step 2. RPi 4 Baseline

raspberrypi.local - pi@raspberrypi: ~ VT

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```
pi@raspberrypi:~ $ uname -a
Linux raspberrypi 6.1.21-v8+ #1642 SMP PREEMPT Mon Apr  3 17:24:16 BST 2023 aarc
h64 GNU/Linux
pi@raspberrypi:~ $ cat /etc/os-release
PRETTY_NAME="Raspbian GNU/Linux 11 (bullseye)"
NAME="Raspbian GNU/Linux"
VERSION_ID="11"
VERSION="11 (bullseye)"
VERSION_CODENAME=bullseye
ID=raspbian
ID_LIKE=debian
HOME_URL="http://www.raspbian.org/"
SUPPORT_URL="http://www.raspbian.org/RaspbianForums"
BUG_REPORT_URL="http://www.raspbian.org/RaspbianBugs"
pi@raspberrypi:~ $
```

Step 3. sudo apt-get update

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```
pi@raspberrypi:~ $ sudo apt-get update
Err:1 http://archive.raspberrypi.org/debian bullseye InRelease
  Temporary failure resolving 'archive.raspberrypi.org'
Err:2 http://raspbian.raspberrypi.org/raspbian bullseye InRelease
  Temporary failure resolving 'raspbian.raspberrypi.org'
Reading package lists... Done
W: Failed to fetch http://raspbian.raspberrypi.org/raspbian/dists/bullseye/InRelease  Temporary failure resolving
 'raspbian.raspberrypi.org'
W: Failed to fetch http://archive.raspberrypi.org/debian/dists/bullseye/InRelease  Temporary failure resolving 'a
rchive.raspberrypi.org'
W: Some index files failed to download. They have been ignored, or old ones used instead.
pi@raspberrypi:~ $
```

Step 4. sudo apt-cache search gpio

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```
pi@raspberrypi:~ $ sudo apt-cache search gpio
airspyhf - HF+VHF software defined radio receiver - user runtime
gpiod - Tools for interacting with Linux GPIO character device - binary
ledmon - Enclosure LED Utilities
libgpiod-dev - C library for interacting with Linux GPIO device - static libraries and headers
libgpiod-doc - C library for interacting with Linux GPIO device - library documentation
libgpiod2 - C library for interacting with Linux GPIO device - shared libraries
libpigpio-dev - Client tools for Raspberry Pi GPIO control
libpigpio1 - Library for Raspberry Pi GPIO control
libpigpiod-if-dev - Development headers for client libraries for Raspberry Pi GPIO control
libpigpiod-if1 - Client library for Raspberry Pi GPIO control (deprecated)
libpigpiod-if2-1 - Client library for Raspberry Pi GPIO control
pigpio - Raspberry Pi GPIO control transitional package.
pigpio-tools - Client tools for Raspberry Pi GPIO control
pigpiod - Client tools for Raspberry Pi GPIO control
python-periphery-doc - Peripheral I/O (Documentation)
python3-libgpiod - Python bindings for libgpiod (Python 3)
python3-periphery - Peripheral I/O (Python3 version)
python3-pigpio - Python module which talks to the pigpio daemon (Python 3)
python3-rpi.gpio - Module to control Raspberry Pi GPIO channels (Python 3)
rpi.gpio-common - Module to control Raspberry Pi GPIO channels (common files)
stm32flash - STM32 chip flashing utility using a serial bootloader
svxlink-gpio - GPIO control scripts SvxLink amateur radio server
python-gpiozero - Simple API for controlling devices attached to a Pi's GPIO pins.
python-gpiozero-doc - Simple API for controlling devices attached to a Pi's GPIO pins.
python-pigpio - Python module which talks to the pigpio daemon (Python 2)
python3-gpiozero - Simple API for controlling devices attached to a Pi's GPIO pins.
raspi-gpio - Dump the state of the BCM270x GPIOs
raspi-gpio-dbgsym - debug symbols for raspi-gpio
pi@raspberrypi:~ $
```

Step 5. dpkg -L libpigpio-dev

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```
pi@raspberrypi:~ $ dpkg -L libpigpio-dev
/.
/usr
/usr/include
/usr/include/pigpio.h
/usr/lib
/usr/share
/usr/share/doc
/usr/share/doc/libpigpio-dev
/usr/share/doc/libpigpio-dev/changelog.Debian.gz
/usr/share/doc/libpigpio-dev/copyright
/usr/share/man
/usr/share/man/man3
/usr/share/man/man3/pigpio.3.gz
/usr/lib/libpigpio.so
pi@raspberrypi:~ $
```

Step 6. sudo apt-get install libpigpio-dev

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```
pi@raspberrypi:~ $ sudo apt-get install libpigpio-dev
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
libpigpio-dev is already the newest version (1.79-1+rpt1).
libpigpio-dev set to manually installed.
The following package was automatically installed and is no longer required
:
  libfuse2
Use 'sudo apt autoremove' to remove it.
0 upgraded, 0 newly installed, 0 to remove and 0 not upgraded.
pi@raspberrypi:~ $
```

Step 7. View and understand the /usr/include/pigpio.h file

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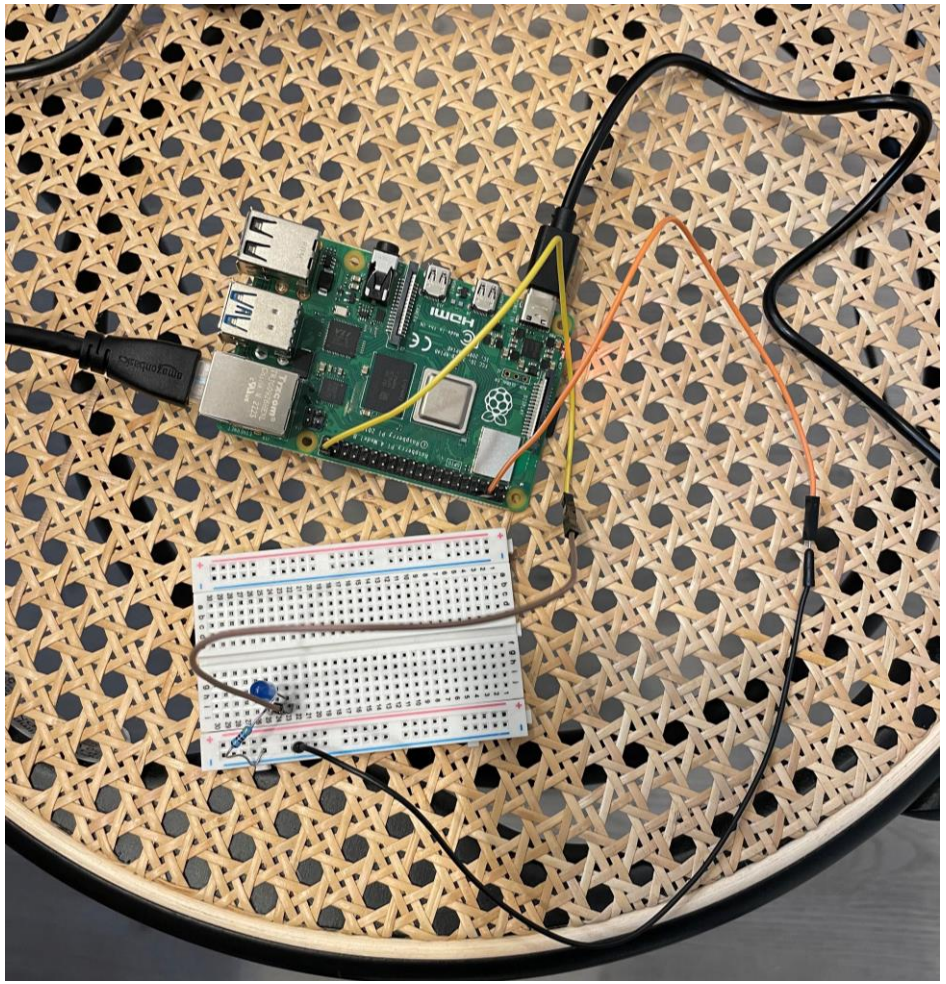
```
#include <stddef.h>
#include <stdint.h>
#include <pthread.h>

#define PIGPIO_VERSION 79

/*TEXT

pigpio is a C library for the Raspberry which allows control of the GPIO.

*Features*

o hardware timed PWM on any of GPIO 0-31

o hardware timed servo pulses on any of GPIO 0-31

o callbacks when any of GPIO 0-31 change state

o callbacks at timed intervals

o reading/writing all of the GPIO in a bank as one operation

o individually setting GPIO modes, reading and writing

o notifications when any of GPIO 0-31 change state

o the construction of output waveforms with microsecond timing

o rudimentary permission control over GPIO

o a simple interface to start and stop new threads

o I2C, SPI, and serial link wrappers

o creating and running scripts

*GPIO*

ALL GPIO are identified by their Broadcom number.

*Credits*

The PWM and servo pulses are timed using the DMA and PWM peripherals.

This use was inspired by Richard Hirst's servoblaster kernel module.

*Usage*
```

Step 8. Let’s Connect LED to GPIO Pin 21



Step 9. led21_blink.c part 1

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```
pi@raspberrypi:~ $ cat led21-blink.c
#include <stdio.h>
#include <pigpio.h>
#include <signal.h>
#include <unistd.h>

#define    LED_PIN 21

int running = 1;
void handle_sig_int(int sig) {
    running = 0;
}

int main() {
    int result = gpioInitialise();
    if(result < 0) {
        fprintf(stderr, "gpioInitialise() failed\n");
        result = 1;
        goto getOut;
    }

    result = gpioSetMode(LED_PIN, PI_OUTPUT);
    if(result < 0) {
        fprintf(stderr, "gpioSetMode() failed\n");
        result = 1;
        goto getOut;
    }

    // We need to use signals
    int cfg = gpioCfgGetInternals();
    cfg |= PI_CFG_NOSIGHANDLER;
    gpioCfgSetInternals(cfg);

    signal(SIGINT, handle_sig_int);

    int toggle = 1;

    while(running) {
        sleep(1);
        result = gpioWrite(LED_PIN, toggle);
```

Step 10. led21_blink.c part 2

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```
    running = 0;
}

int main() {
    int result = gpioInitialise();
    if(result < 0) {
        fprintf(stderr, "gpioInitialise() failed\n");
        result = 1;
        goto getOut;
    }

    result = gpioSetMode(LED_PIN, PI_OUTPUT);
    if(result < 0) {
        fprintf(stderr, "gpioSetMode() failed\n");
        result = 1;
        goto getOut;
    }

    // We need to use signals
    int cfg = gpioCfgGetInternals();
    cfg |= PI_CFG_NOSIGHANDLER;
    gpioCfgSetInternals(cfg);

    signal(SIGINT, handle_sig_int);

    int toggle = 1;

    while(running) {
        sleep(1);
        result = gpioWrite(LED_PIN, toggle);
        if(result < 0) break;
        toggle ^= 1; // Toggle bit
     }


getOut:
        gpioTerminate();
        return 0;
}
pi@raspberrypi:~ $
```

Step 11. build and run the code, the LED is indeed blinking

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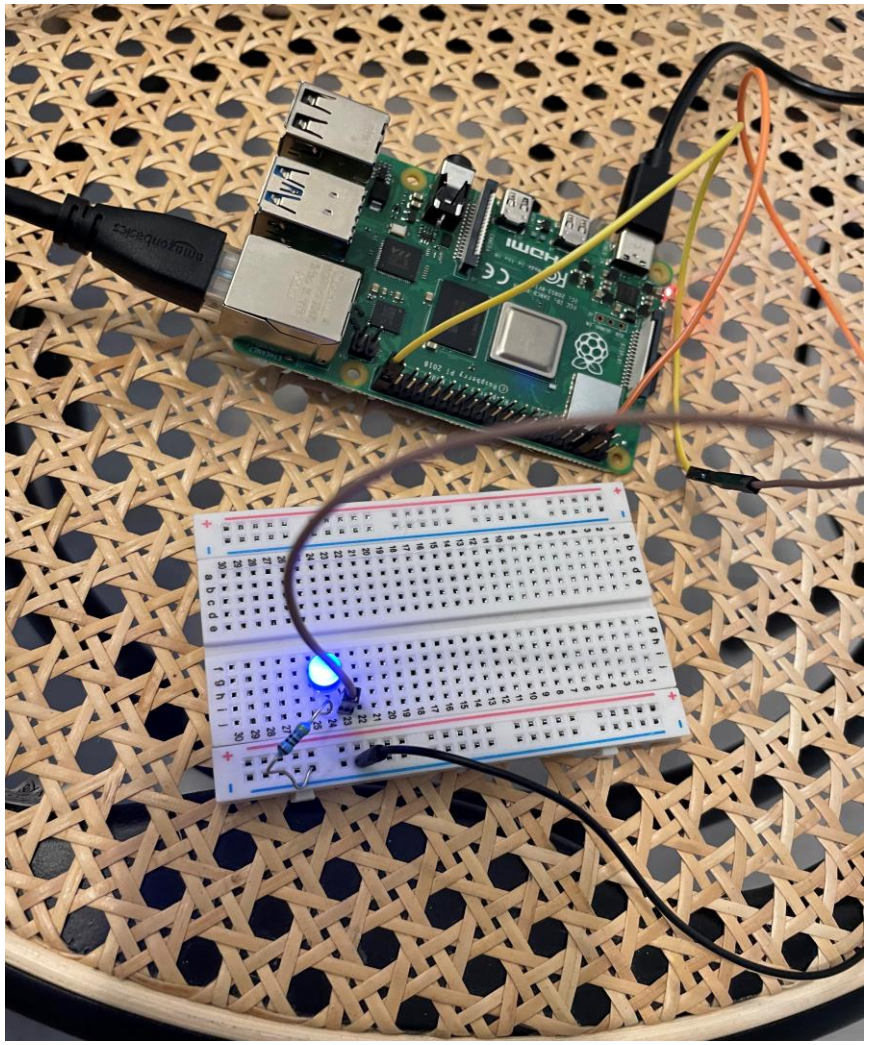
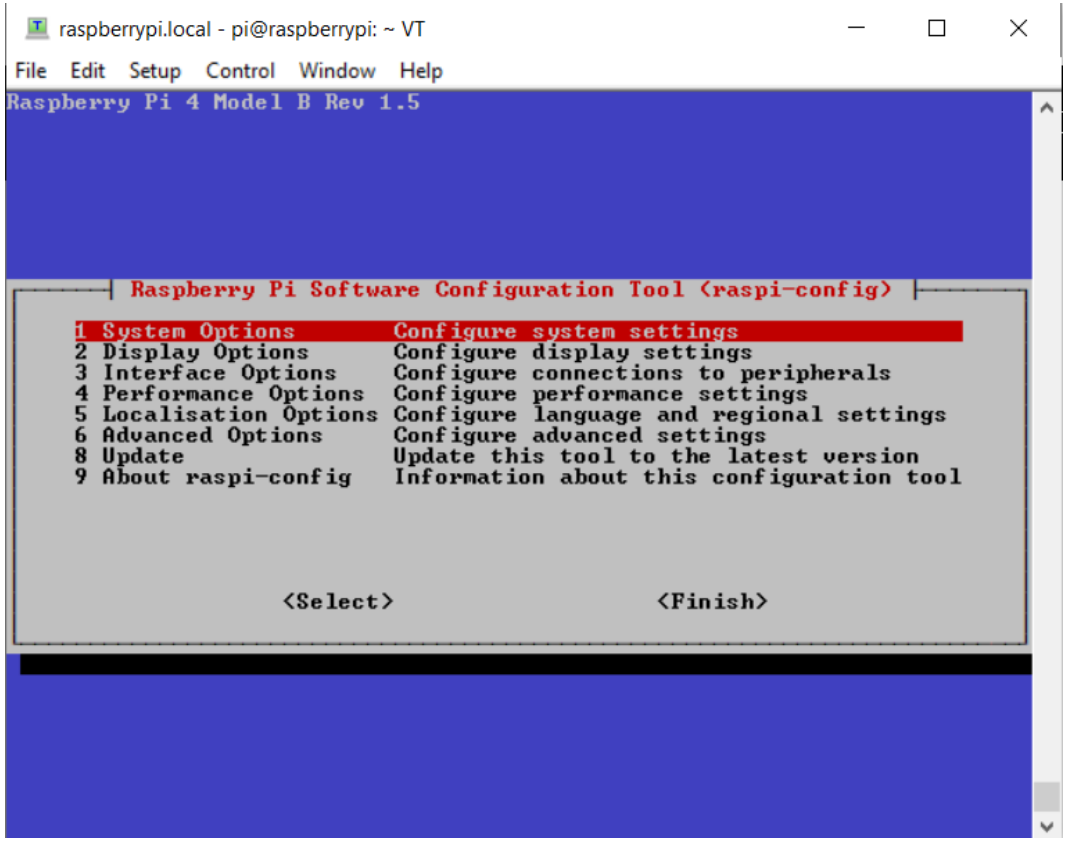
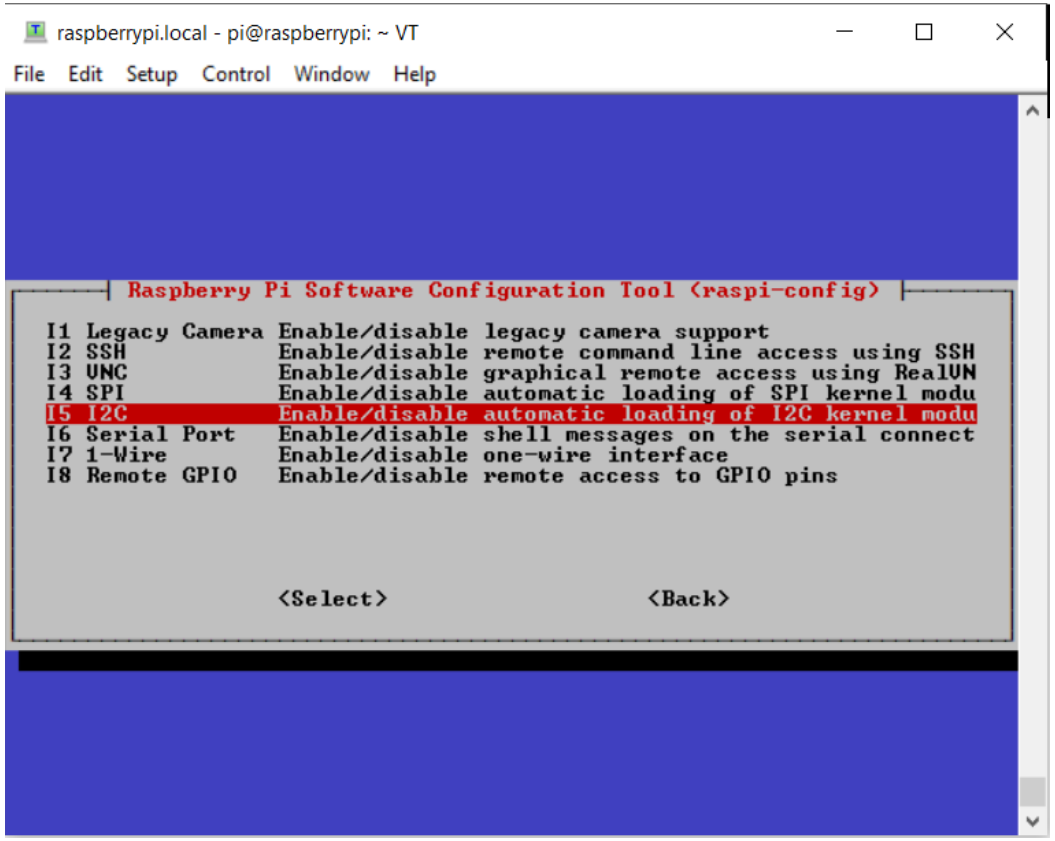
```
pi@raspberrypi:~ $ gcc -Wall -o led21-blink led21-blink.c -lpthread -lpigpio -lrt
pi@raspberrypi:~ $ ldd led21-blink
        /usr/lib/arm-linux-gnueabihf/libarmmem-${PLATFORM}.so => /usr/lib/arm-linux-gnueabihf/
libarmmem-v8l.so (0xf7eb6000)
        libpigpio.so.1 => /lib/libpigpio.so.1 (0xf7dbf000)
        libc.so.6 => /lib/arm-linux-gnueabihf/libc.so.6 (0xf7c6b000)
        libpthread.so.0 => /lib/arm-linux-gnueabihf/libpthread.so.0 (0xf7c3f000)
        /lib/ld-linux-armhf.so.3 (0xf7ecb000)
pi@raspberrypi:~ $ sudo ./led21-blink
```



Step 12. Demo 2 I2C Access from C. Configuration of I2C





Step 13. lsmod | head

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```
pi@raspberrypi:~ $ sudo raspi-config
pi@raspberrypi:~ $ lsmod | head
Module                  Size  Used by
i2c_bcm2835            16384  0
rfcomm                 53248  4
cmac                   16384  3
algif_hash             16384  1
aes_arm64              16384  3
aes_generic            36864  1 aes_arm64
algif_skcipher         16384  1
af_alg                 28672  6 algif_hash,algif_skcipher
bnep                   24576  2
pi@raspberrypi:~ $
```

Step 14. i2c-led.c file

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```
pi@raspberrypi:~ $ cat i2c-led.c
#include <stdio.h>
#include <pigpio.h>
#include <signal.h>
#include <unistd.h>

#define     MCP23008_I2C_ADDR 0x20

int running = 1;
void handle_sig_int(int sig) {
    running = 0;
}

int main() {
    int result = gpioInitialise();
    if(result < 0) {
        fprintf(stderr, "gpioInitialise() failed\n");
        result = 1;
        goto getOut;
    }

    // We need to use signals
    int cfg = gpioCfgGetInternals();
    cfg |= PI_CFG_NOSIGHANDLER;
    gpioCfgSetInternals(cfg);

    signal(SIGINT, handle_sig_int);

    unsigned i2cBus = 1;
    unsigned i2cAddr = MCP23008_I2C_ADDR;
    unsigned i2cFlags = 0;
    int i2cHandle = i2cOpen(i2cBus, i2cAddr, i2cFlags);
    if(i2cHandle < 0) {
        fprintf(stderr, "i2cOpen() failed\n");
        goto getOut;
    }

    // Set MCP23008 I/0 direction for all pins as output(0x00)
    unsigned i2cReg = 0;
    unsigned i2cValue = 0;
```

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```
    cfg |= PI_CFG_NOSIGHANDLER;
    gpioCfgSetInternals(cfg);

    signal(SIGINT, handle_sig_int);

    unsigned i2cBus = 1;
    unsigned i2cAddr = MCP23008_I2C_ADDR;
    unsigned i2cFlags = 0;
    int i2cHandle = i2cOpen(i2cBus, i2cAddr, i2cFlags);
    if(i2cHandle < 0) {
        fprintf(stderr, "i2cOpen() failed\n");
        goto getOut;
    }

    // Set MCP23008 I/0 direction for all pins as output(0x00)
    unsigned i2cReg = 0;
    unsigned i2cValue = 0;
    result = i2cWriteByteData(i2cHandle, i2cReg, i2cValue);
    if(result != 0) {
        fprintf(stderr, "i2cWriteByteData() failed\n");
        goto getOut;
    }

    // Toggle the pins connected to the MCP23008 I/0 expander
    i2cReg = 0x09;
    while(1) {
        i2cValue = 0xff;
        i2cWriteByteData(i2cHandle, i2cReg, i2cValue);
        sleep(5);
        i2cValue = 0;
        i2cWriteByteData(i2cHandle, i2cReg, i2cValue);
        sleep(5);
    }

getOut:
        if(i2cHandle >= 0) i2cClose(i2cHandle);
        gpioTerminate();
        return 0;
}
pi@raspberrypi:~ $
```

Step 15. build the code, build is successful. I do not have MCP23008 to test, so this is the end of my demo

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```
pi@raspberrypi:~ $ gcc -Wall -o i2c-led i2c-led.c -lpthread -lpigpio -lrt
pi@raspberrypi:~ $ sudo ./i2c-led
i2cWriteByteData() failed
pi@raspberrypi:~ $
```