Embedded Workshop

— — —

While you are waiting for the Workshop to begin…

1. Make sure you are connected to the local Wifi
   Guest Password: **???????????**
2. **Needed:**
   Laptop & Internet connection
   Raspberry Pi, any model, or BeagleBone.
   Monitor, Keyboard & Mouse
   USB and video cables.
   Don't forget your power cords.
   DS3231 module, LED(s) with limiting resistors
   Breadboard and jumper wires.
   DS3231 will be available for $2.00 each.

To make things easy please use Raspberry Pi with latest OS Raspbian Jessie w/Pixel to match what will be presented.
Version 1/11/2017 was used for this Workshop.

Please sign in

Name	Member Y/N	Email address

Raspberry Pi GPIO I2c SPI

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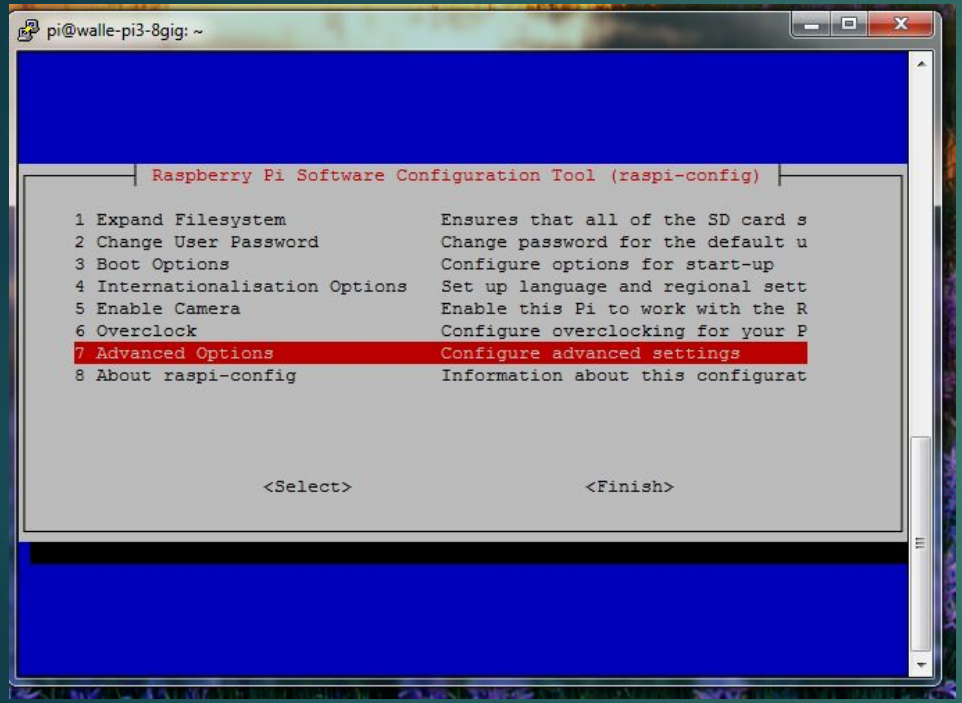
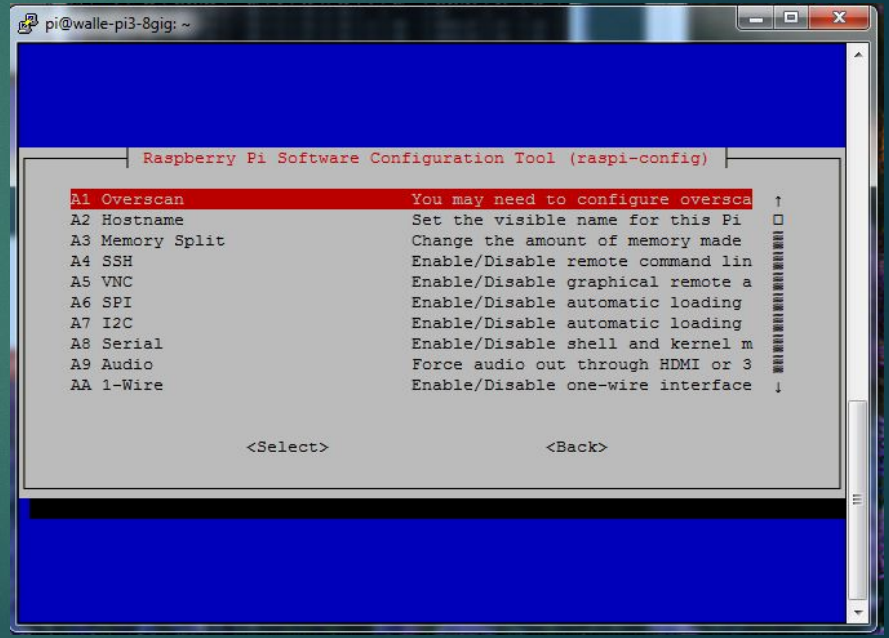
JAN 25, 2017

Enable GPIO, I2C and SPI

sudo raspi-config





PI Pin Out

- **Make sure you are connecting to the correct Pins!**
- **Not all Pin Outs documentation is going to match your Pi.**
- **Make sure you know what the Pin you have chosen can do what you want.**
  - Example: using gpio2 & gpio3 pins to blink an LED and then discover you also need I2C.
  - Example: using gpio14 and gpio15 to blink and LED and then discover you want an RS232 connection. (TX – RX)
- **Carefully connect to the 3.3 – 5.0 & GND!**

Raspberry Pi 3 GPIO Header

Pin#	NAME		NAME	Pin#
01	3.3v DC Power		DC Power 5v	02
03	GPIO02 (SDA1 , I²C)		DC Power 5v	04
05	GPIO03 (SCL1 , I²C)		Ground	06
07	GPIO04 (GPIO_GCLK)		(TXD0) GPIO14	08
09	Ground		(RXD0) GPIO15	10
11	GPIO17 (GPIO_GEN0)		(GPIO_GEN1) GPIO18	12
13	GPIO27 (GPIO_GEN2)		Ground	14
15	GPIO22 (GPIO_GEN3)		(GPIO_GEN4) GPIO23	16
17	3.3v DC Power		(GPIO_GEN5) GPIO24	18
19	GPIO10 (SPI_MOSI)		Ground	20
21	GPIO09 (SPI_MISO)		(GPIO_GEN6) GPIO25	22
23	GPIO11 (SPI_CLK)		(SPI_CE0_N) GPIO08	24
25	Ground		(SPI_CE1_N) GPIO07	26
27	ID_SD (I²C ID EEPROM)		(I²C ID EEPROM) ID_SC	28
29	GPIO05		Ground	30
31	GPIO06		GPIO12	32
33	GPIO13		Ground	34
35	GPIO19		GPIO16	36
37	GPIO26		GPIO20	38
39	Ground		GPIO21	40

Rev. 2
29/02/2016

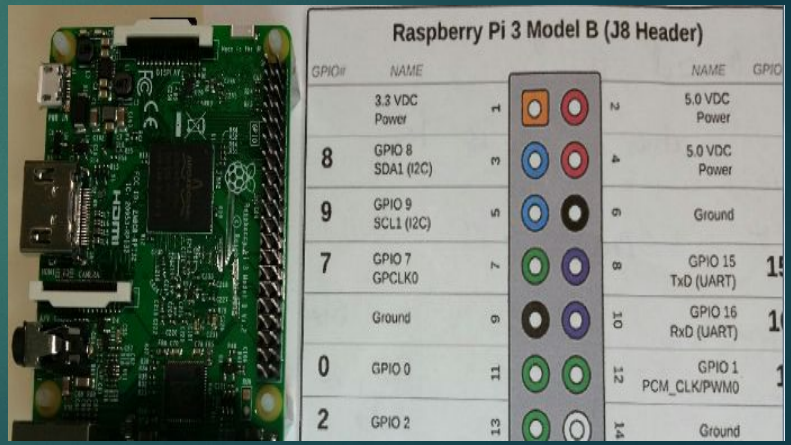
www.element14.com/RaspberryPi

gpio commands

```
pi@walle-pi3-8gig:~ $ gpio exports
GPIO Pins exported:
   4: in    1  none
  17: out   0  none
```

```
pi@walle-pi3-8gig:~ $ gpio readall
 +-----+-----+---------+------+---+---Pi 3---+---+------+---------+-----+-----+
 | BCM | wPi |   Name  | Mode | V | Physical | V | Mode | Name    | wPi | BCM |
 +-----+-----+---------+------+---+----++----+---+------+---------+-----+-----+
 |     |     |    3.3v |      |   |  1 || 2  |   |      | 5v      |     |     |
 |   2 |   8 |   SDA.1 | ALT0 | 1 |  3 || 4  |   |      | 5V      |     |     |
 |   3 |   9 |   SCL.1 | ALT0 | 1 |  5 || 6  |   |      | 0v      |     |     |
 |   4 |   7 | GPIO. 7 |   IN | 1 |  7 || 8  | 0 | IN   | TxD     | 15  | 14  |
 |     |     |      0v |      |   |  9 || 10 | 1 | IN   | RxD     | 16  | 15  |
 |  17 |   0 | GPIO. 0 |  OUT | 0 | 11 || 12 | 0 | ALT0 | GPIO. 1 | 1   | 18  |
 |  27 |   2 | GPIO. 2 |   IN | 0 | 13 || 14 |   |      | 0v      |     |     |
 |  22 |   3 | GPIO. 3 |   IN | 0 | 15 || 16 | 0 | IN   | GPIO. 4 | 4   | 23  |
 |     |     |    3.3v |      |   | 17 || 18 | 0 | IN   | GPIO. 5 | 5   | 24  |
 |  10 |  12 |    MOSI | ALT0 | 0 | 19 || 20 |   |      | 0v      |     |     |
 |   9 |  13 |    MISO | ALT0 | 0 | 21 || 22 | 0 | IN   | GPIO. 6 | 6   | 25  |
 |  11 |  14 |    SCLK | ALT0 | 0 | 23 || 24 | 1 | OUT  | CE0     | 10  | 8   |
 |     |     |      0v |      |   | 25 || 26 | 1 | OUT  | CE1     | 11  | 7   |
 |   0 |  30 |   SDA.0 |   IN | 1 | 27 || 28 | 1 | IN   | SCL.0   | 31  | 1   |
 |   5 |  21 | GPIO.21 |   IN | 1 | 29 || 30 |   |      | 0v      |     |     |
 |   6 |  22 | GPIO.22 |   IN | 1 | 31 || 32 | 0 | IN   | GPIO.26 | 26  | 12  |
 |  13 |  23 | GPIO.23 |   IN | 0 | 33 || 34 |   |      | 0v      |     |     |
 |  19 |  24 | GPIO.24 | ALT0 | 0 | 35 || 36 | 0 | IN   | GPIO.27 | 27  | 16  |
 |  26 |  25 | GPIO.25 |   IN | 0 | 37 || 38 | 0 | ALT0 | GPIO.28 | 28  | 20  |
 |     |     |      0v |      |   | 39 || 40 | 0 | ALT0 | GPIO.29 | 29  | 21  |
 +-----+-----+---------+------+---+----++----+---+------+---------+-----+-----+
 | BCM | wPi |   Name  | Mode | V | Physical | V | Mode | Name    | wPi | BCM |
 +-----+-----+---------+------+---+---Pi 3---+---+------+---------+-----+-----+
```

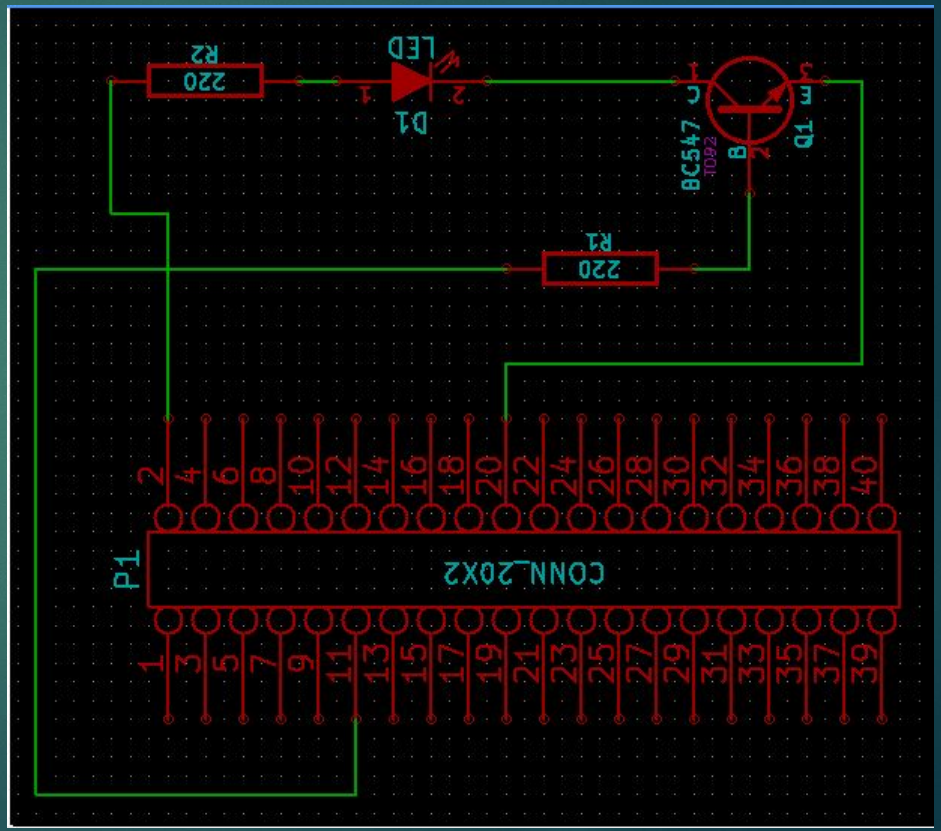
```
pi@walle-pi3-8gig:~ $ gpio -v
gpio version: 2.32
Copyright (c) 2012-2015 Gordon Henderson
This is free software with ABSOLUTELY NO WARRANTY.
For details type: gpio -warranty

Raspberry Pi Details:
  Type: Pi 3, Revision: 02, Memory: 1024MB, Maker: Embest
  * Device tree is enabled.
  * This Raspberry Pi supports user-level GPIO access.
    -> See the man-page for more details
    -> ie. export WIRINGPI_GPIOMEM=1
```



Write a bash script to control a Pin

- sudo nano flash.sh

```
#!/bin/bash
# short script flash LED gpio17
echo 17 > /sys/class/gpio/export
sleep 0.5
echo "out" > /sys/class/gpio/gpio17/direction
COUNTER=0
while [ $COUNTER -lt 100000 ]; do
        echo 1 > /sys/class/gpio/gpio17/value
        let COUNTER=COUNTER+1
        echo 0 > /sys/class/gpio/gpio17/value
done
echo 17 > /sys/class/gpio/unexport
```



Using a GPIO pin

- **Go to GPIO directory**
- **cd /sys/class/gpio**
- /sys/class/gpio $ **ls**
- export
- gpio
- gpiochip0
- gpiochip100
- Unexport
- **Configure "export" and "unexport" for full access:**
  chmod 222 export unexport

- Enable and Disable Pin 17
  - **echo 17 > /sys/class/gpio/export**
  - **echo 17 > /sys/class/gpio/unexport**
- Setup Pin 17 for output or input
  - **echo "out" > /sys/class/gpio/gpio17/direction**
  - **echo “high" > /sys/class/gpio/gpio17/direction**
  - **echo “low" > /sys/class/gpio/gpio17/direction**
  - **echo “in" > /sys/class/gpio/gpio17/direction**
- Set the High with a 1
  - **echo 1 > /sys/class/gpio/gpio17/value**
- Set the Low with a 0
  - **echo 0 > /sys/class/gpio/gpio17/value**

Using a GPIO pin (Bash Shell)

- **cd /sys/class/gpio**
- **chmod 222 export unexport**
- **echo 4 > export**
- **cd gpio4**
- **ls -l**
  - active_low
  - device -> ../../../3f200000.gpio
  - direction
  - edge
  - power
  - subsystem -> ../../../../../../class/gpio
  - uevent
  - value

- **cat direction**
  - in
- **echo out > direction (options: "in", "out", "low", "high")**
  - out
- **echo 1 > value (Turns the LED on)**
- **echo 0 > value (Turns the LED off)**
- **Type the following on the command line:**
  - **for i in {1..10}; do echo 1 > value; sleep 1; echo 0 > value; sleep 1; done**

```
pi@walle-pi3-8gig:~ $ gpio exports
GPIO Pins exported:
   4: in   1  none
  17: out  0  none
```

Interacting with GPIOs from a shell script

Shell script to blink LED connected to GPIO4

```
#!/bin/bash
#File: test1.sh
#wPi GPIO4 is BCM 23 if not using wPi it would be GPIO4
#Shell script to blink LED connected to GPIO4
export GREENLED=23
echo "Blink LED connected to GPIO$GREENLED"
sleep 0.5
echo "$GREENLED" > /sys/class/gpio/export
sleep 0.5
echo out > /sys/class/gpio/gpio"$GREENLED"/direction
sleep 0.5
for i in {1..10}
do
 echo 1 > /sys/class/gpio/gpio"$GREENLED"/value
 sleep 1
 echo 0 > /sys/class/gpio/gpio"$GREENLED"/value
 sleep 1
done
echo "$GREENLED" > /sys/class/gpio/unexport

```

Make it executable

- **After creating the shell script, change the file's mode such that it's executable.**
- **- Choose one - Each of these commands will set the user permission for execute:**
- **chmod u=rwx test1.sh**
- **chmod u+x test1.sh**
- **chmod 755 test1.sh**
- u is for user, g is for group, o is for others.
- r is for read permission, w is for write permission, x is for execute permission.

- Now, run your shell script
- $ ./test1.sh

Problems with your Program?

- Copied from Windows causes problems. Look for carriage returns.
- Here are some fixs:
- Look for 0D by using hexdump -C filename
- Remove Carriage Returns:
- cat filename | tr -d "\r \n" > filename2
- Nano filename & remove carriage returns

```
pi@walle-pi3-8gig:~ $ hexdump -C gpiotoggle.sh
00000000  23 21 2f 62 69 6e 2f 62  61 73 68 0a 2f 73 79 73  |#!/bin/bash./sys|
00000010  2f 63 6c 61 73 73 2f 67  70 69 6f 2f 65 78 70 6f  |/class/gpio/expo|
00000020  72 74 20 47 50 49 4f 3d  31 37 0a 73 6c 65 65 70  |rt GPIO=17.sleep|
00000030  20 30 2e 35 0a 65 63 68  6f 20 31 37 20 3e 20 2f  | 0.5.echo 17 > /|
00000040  73 79 73 2f 63 6c 61 73  73 2f 67 70 69 6f 2f 65  |sys/class/gpio/e|
00000050  78 70 6f 72 74 0a 73 6c  65 65 70 20 30 2e 35 0a  |xport.sleep 0.5.|
00000060  65 63 68 6f 20 22 6f 75  74 22 20 3e 20 2f 73 79  |echo "out" > /sy|
00000070  73 2f 63 6c 61 73 73 2f  67 70 69 6f 2f 67 70 69  |s/class/gpio/gpi|
00000080  6f 31 37 2f 64 69 72 65  63 74 69 6f 6e 0a 73 6c  |o17/direction.sl|
00000090  65 65 70 20 30 2e 35 0a  65 63 68 6f 20 22 6f 75  |eep 0.5.echo "ou|
000000a0  74 22 20 3e 20 2f 73 79  73 2f 63 6c 61 73 73 2f  |t" > /sys/class/|
000000b0  67 70 69 6f 2f 67 70 69  6f 24 47 50 49 4f 2f 64  |gpio/gpio$GPIO/d|
000000c0  69 72 65 63 74 69 6f 6e  0a 66 6f 72 20 69 20 69  |irection.for i i|
000000d0  6e 20 7b 31 2e 2e 35 30  7d 0a 64 6f 0a 65 63 68  |n {1..50}.do.ech|
000000e0  6f 20 31 20 3e 20 2f 73  79 73 2f 63 6c 61 73 73  |o 1 > /sys/class|
000000f0  2f 67 70 69 6f 2f 67 70  69 6f 31 37 2f 76 61 6c  |/gpio/gpio17/val|
00000100  75 65 0a 73 6c 65 65 70  20 30 2e 35 0a 65 63 68  |ue.sleep 0.5.ech|
00000110  6f 20 30 20 3e 20 2f 73  79 73 2f 63 6c 61 73 73  |o 0 > /sys/class|
00000120  2f 67 70 69 6f 2f 67 70  69 6f 31 37 2f 76 61 6c  |/gpio/gpio17/val|
00000130  75 65 0a 73 6c 65 65 70  20 30 2e 35 0a 65 63 68  |ue.sleep 0.5.ech|
00000140  6f 20 31 20 3e 20 2f 73  79 73 2f 63 6c 61 73 73  |o 1 > /sys/class|
00000150  2f 67 70 69 6f 2f 67 70  69 6f 31 37 2f 76 61 6c  |/gpio/gpio17/val|
00000160  75 65 0a 73 6c 65 65 70  20 30 2e 35 0a 65 63 68  |ue.sleep 0.5.ech|
00000170  6f 20 30 20 3e 20 2f 73  79 73 2f 63 6c 61 73 73  |o 0 > /sys/class|
00000180  2f 67 70 69 6f 2f 67 70  69 6f 31 37 2f 76 61 6c  |/gpio/gpio17/val|
00000190  75 65 0a 64 6f 6e 65 0a  65 63 68 6f 20 31 37 20  |ue.done.echo 17 |
000001a0  3e 20 2f 73 79 73 2f 63  6c 61 73 73 2f 67 70 69  |> /sys/class/gpi|
000001b0  6f 2f 75 6e 65 78 70 6f  72 74 0a 0a              |o/unexport..|
000001bc
```

GPIO using C or C++ Programs using system() API

- **Interacting with GPIOs within a C / C++ program using system() API:**
- **Using a your favorite editor**
  - (We recommend "Geany", already installed on Raspberry Pi)
- **Enter the following C / C++ program:**
  - File: blinkgpio.cpp
- **Compile and link the above program, using gcc:**
  - gcc -o blinkgpio blinkgpio.cpp

GPIO using C or C++ Programs

- **Interacting with GPIOs within a C / C++ program:**
- **Using a your favorite editor**
  - (We recommend "Geany", already installed on Raspberry Pi)
- **Enter the following C / C++ program:**
  - File: gpiotest1.cpp
- **Compile and link the above program, using gcc:**
  - gcc -o gpiotest1 gpiotest1.cpp

GPIO using C or C++ Programs using Memory Mapped

- **Interacting with GPIOs within a C / C++ program using Memory Mapped GPIO:**
- **Using a your favorite editor**
  - (We recommend "Geany", already installed on Raspberry Pi)
- **Enter the following C / C++ program:**
  - File: gpio_map.cpp
- **Compile and link the above program, using gcc:**
  - gcc -o gpio_map gpio_map.cpp

I2C LINUX - i2c-tools

```
     0  1  2  3  4  5  6  7  8  9  a  b  c  d  e  f
00:          -- -- -- -- -- -- -- -- -- -- -- -- --
10: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
20: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
30: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
40: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
50: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
60: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
70: -- -- -- -- -- -- -- --
```

- cd /dev
- ls –al Look for i2c-1 i2c-0
  - ls /dev/i2c*
- i2cdetect –y 1

```
pi@walle-pi3-8gig:~ $ i2cdetect -y 1
     0  1  2  3  4  5  6  7  8  9  a  b  c  d  e  f
00:          -- -- -- -- -- -- -- -- -- -- -- -- --
10: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
20: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
30: -- -- -- -- -- -- -- -- -- -- -- -- 3c -- -- --
40: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
50: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
60: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
70: -- -- -- -- -- -- -- --
```

I2cdump –y

```
pi@walle-pi3-8gig:~ $ i2cdump -y 1 0x50 b
     0  1  2  3  4  5  6  7  8  9  a  b  c  d  e  f    0123456789abcdef
00: ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff    ................
10: ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff    ................
20: ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff    ................
30: ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff    ................
40: ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff    ................
50: ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff    ................
60: ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff    ................
70: ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff    ................
80: ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff    ................
90: ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff    ................
a0: ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff    ................
b0: ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff    ................
c0: ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff    ................
d0: ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff    ................
e0: ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff    ................
f0: ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff    ................
```