



DesignNews

Raspberry Pi 4B Application Development Using the C Programming Language

DAY 4: Coding a Raspberry Pi 4B SPI IoT Application

Sponsored by



Webinar Logistics

- Turn on your system sound to hear the streaming presentation.
- If you have technical problems, click “Help” or submit a question asking for assistance.
- Participate in ‘Group Chat’ by maximizing the chat widget in your dock.
- Submit questions for the lecturer using the Q&A widget. They will follow-up after the lecture portion concludes.

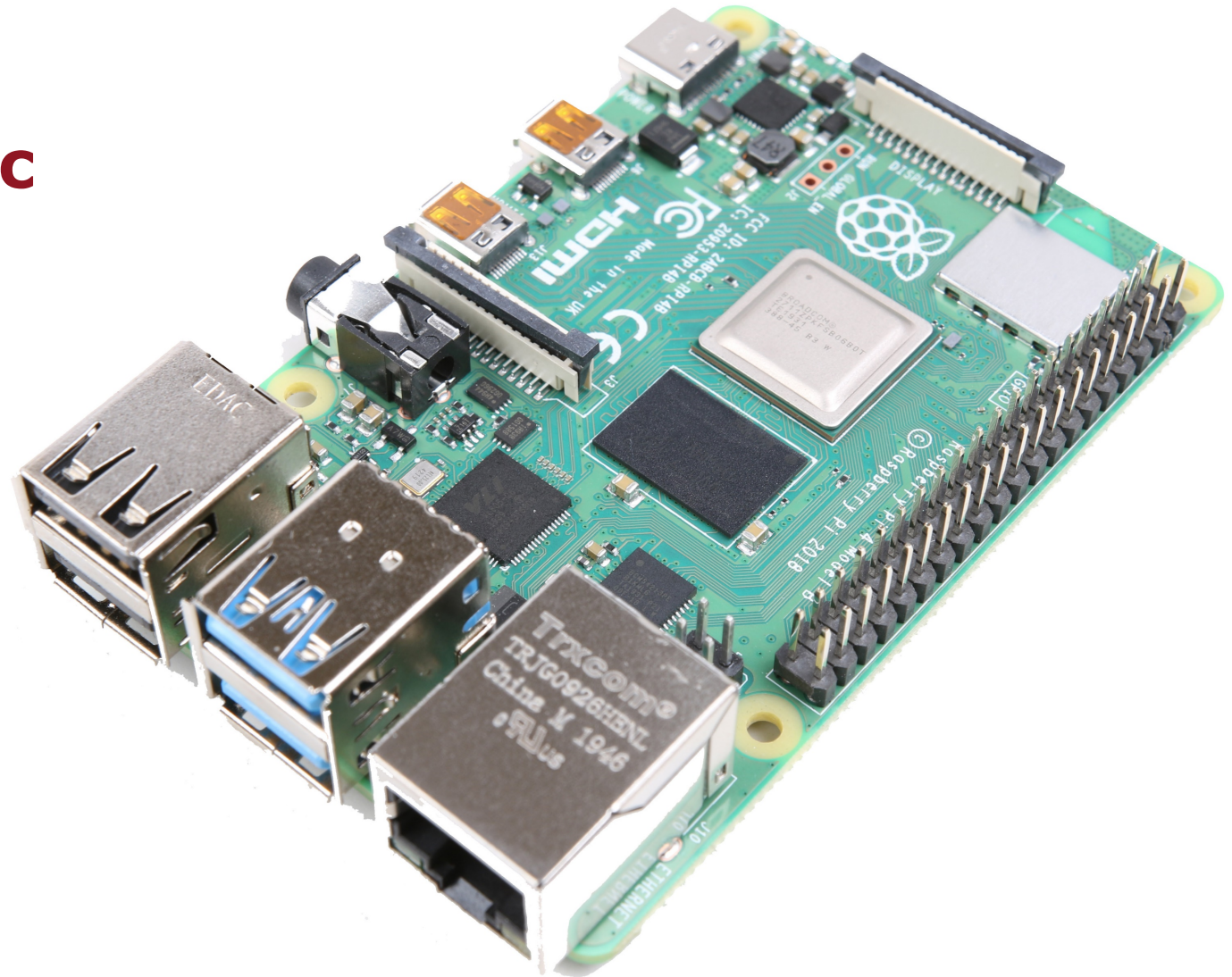


Fred Eady

Visit 'Lecturer Profile' in your console for more details.

AGENDA

- **Voltmeter Circuitry**
- **Voltmeter Firmware Logic**
- **Compile and Debug**
- **SPI Write with pigpio**



Voltmeter Firmware Logic – Extract 12 bits

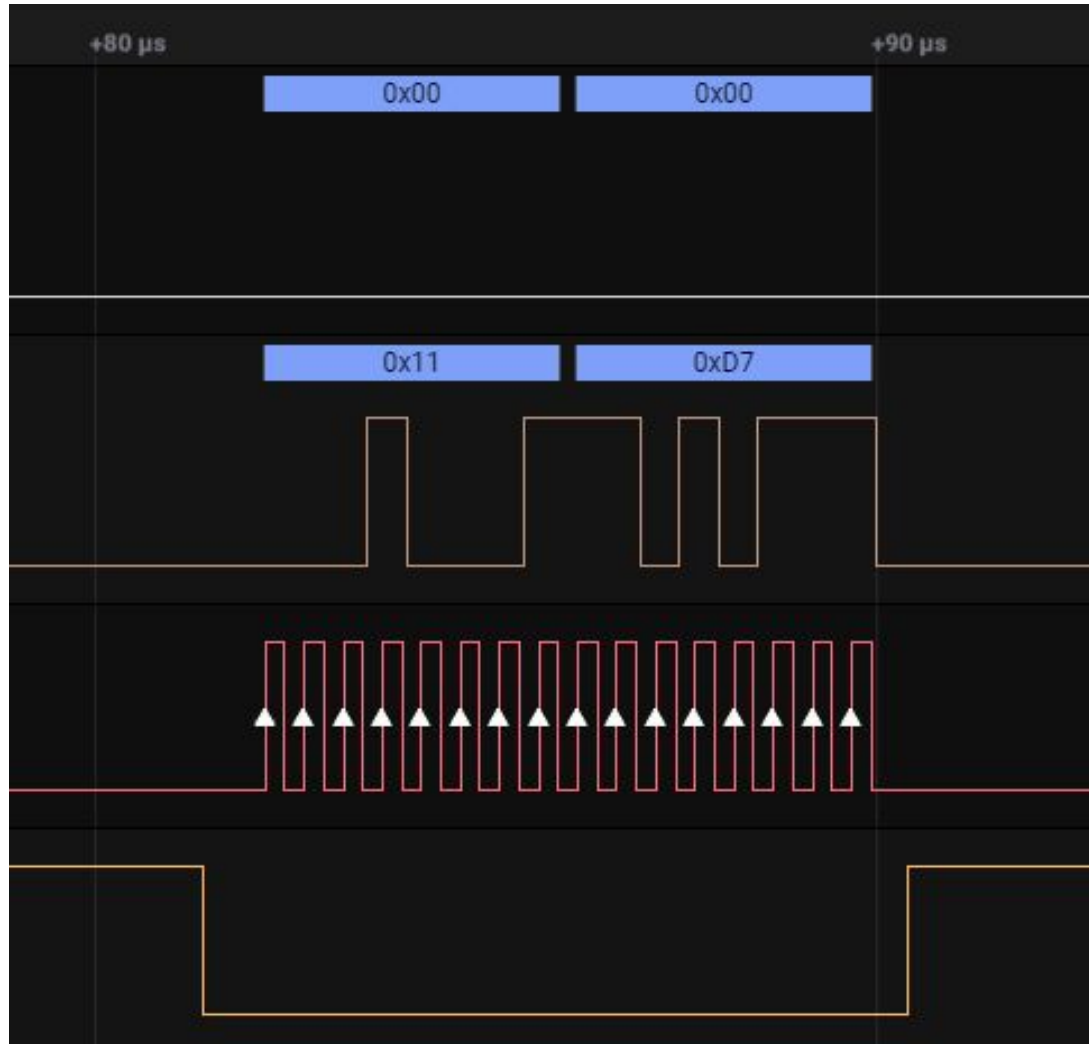


The image displays a digital logic analyzer interface with a waveform view on the left and an analyzers panel on the right. The waveform view shows multiple digital signals (D0-D5) and two analog voltage traces (A8, A9). The analyzers panel shows a list of SPI transactions with columns for Type, Start, Duration, mosi, and miso.

Type	Start	Duration	mosi	miso
enable	1.681372 ms	4 ns		
result	1.682172 ms	3.752 μs	0x00	0x11
result	1.686172 ms	3.752 μs	0x00	0xD7
disable	1.690388 ms	4 ns		
enable	11.771548 ms	4 ns		
result	11.772332 ms	3.752 μs	0x00	0x11
result	11.776332 ms	3.752 μs	0x00	0xD7
disable	11.780544 ms	4 ns		
enable	21.860616 ms	4 ns		
result	21.861404 ms	3.752 μs	0x00	0x11
result	21.865404 ms	3.752 μs	0x00	0xD7
disable	21.869636 ms	4 ns		
enable	31.947948 ms	4 ns		
result	31.948964 ms	3.756 μs	0x00	0x11
result	31.952964 ms	3.756 μs	0x00	0xD8
disable	31.957236 ms	4 ns		
enable	42.035168 ms	4 ns		
result	42.036148 ms	3.752 μs	0x00	0x11
result	42.040148 ms	3.752 μs	0x00	0xD7
disable	42.044388 ms	4 ns		
enable	52.086316 ms	4 ns		
result	52.087324 ms	3.756 μs	0x00	0x11
result	52.091324 ms	3.756 μs	0x00	0xD7
disable	52.095512 ms	4 ns		
enable	62.17676 ms	4 ns		

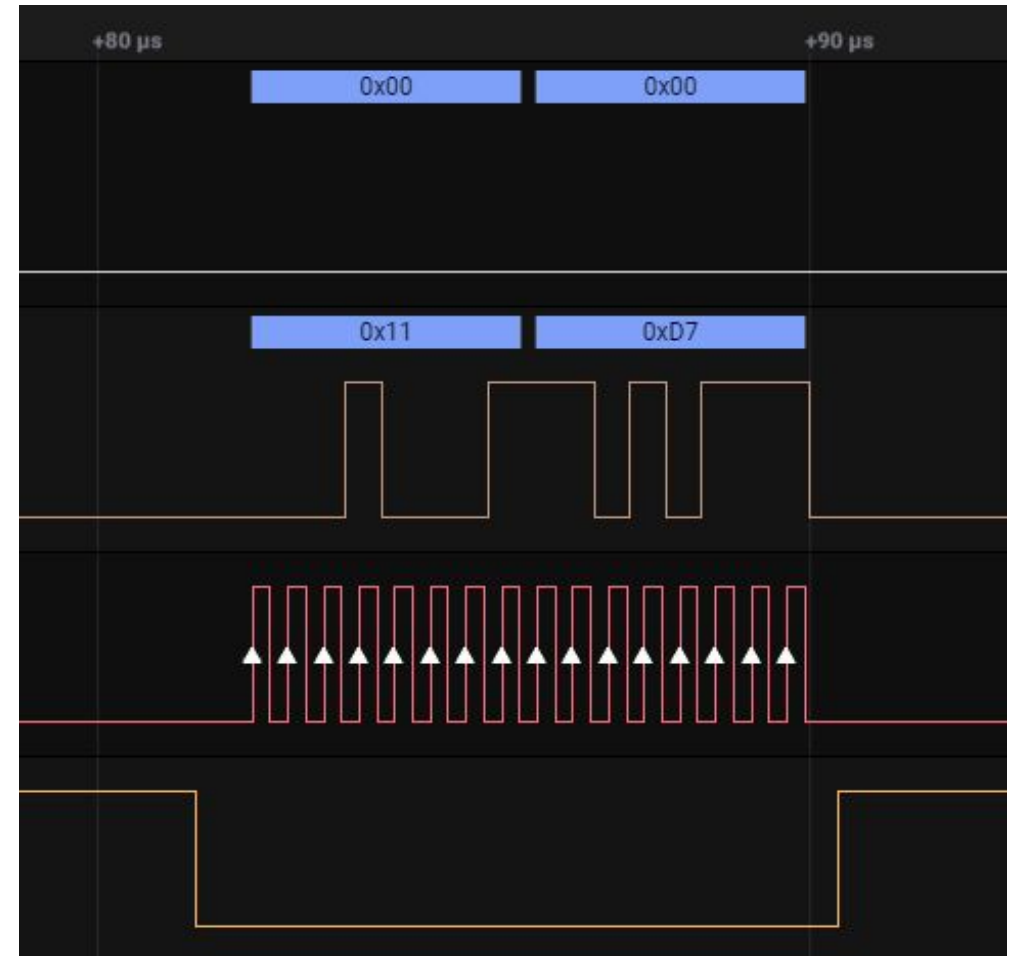
Voltmeter Firmware Logic – Extract 12 bits

? ? 0 B11 B10 B09 B08 B07 B06 B05 B04 B03 B02 B01 B00 B00



Voltmeter Firmware Logic – Extract 12 bits

? ? 0 B11 B10 B09 B08 B07 B06 B05 B04 B03 B02 B01 B00 B00
??01 0001 1101 0111

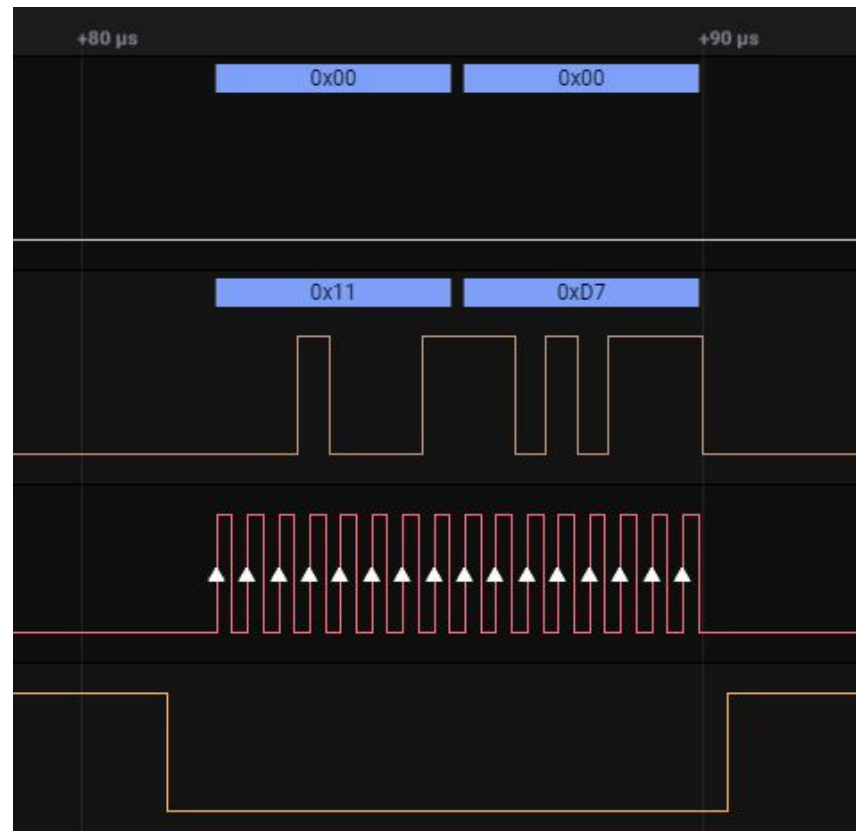


Voltmeter Firmware Logic – Extract 12 bits

? ? 0 B11 B10 B09 B08 B07 B06 B05 B04 B03 B02 B01 B00 B00

??01 0001 1101 0111

rawVoltage = make16(??010001,11010111)

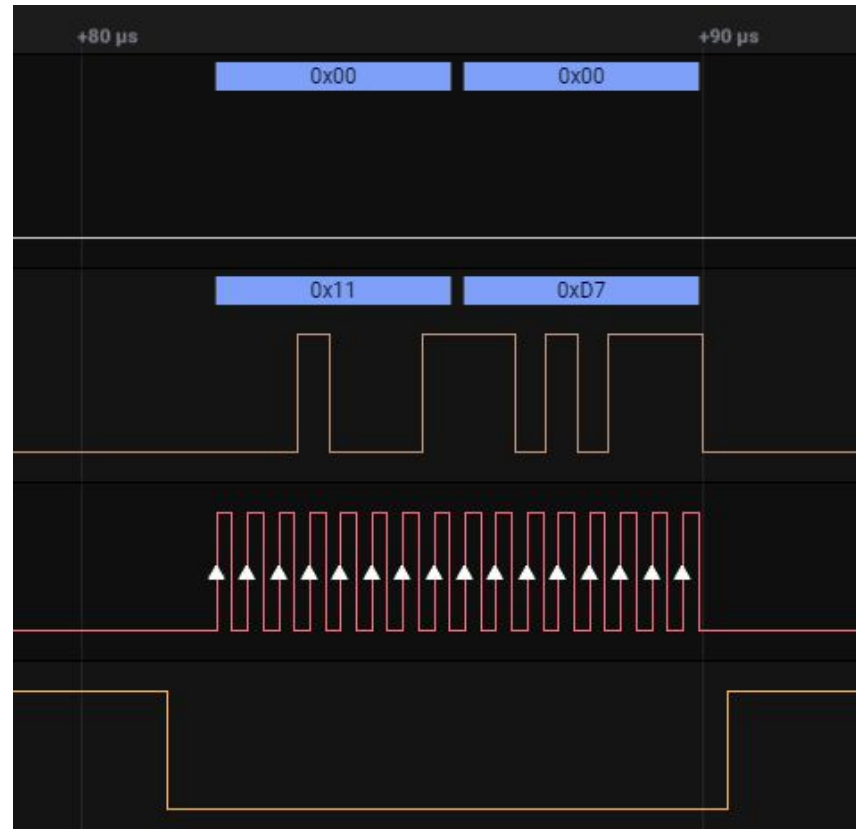


Voltmeter Firmware Logic – Extract 12 bits

? ? 0 B11 B10 B09 B08 B07 B06 B05 B04 B03 B02 B01 B00 B00

rawVoltage = 0b??01000111010111

rawVoltage = rawVoltage >> 1

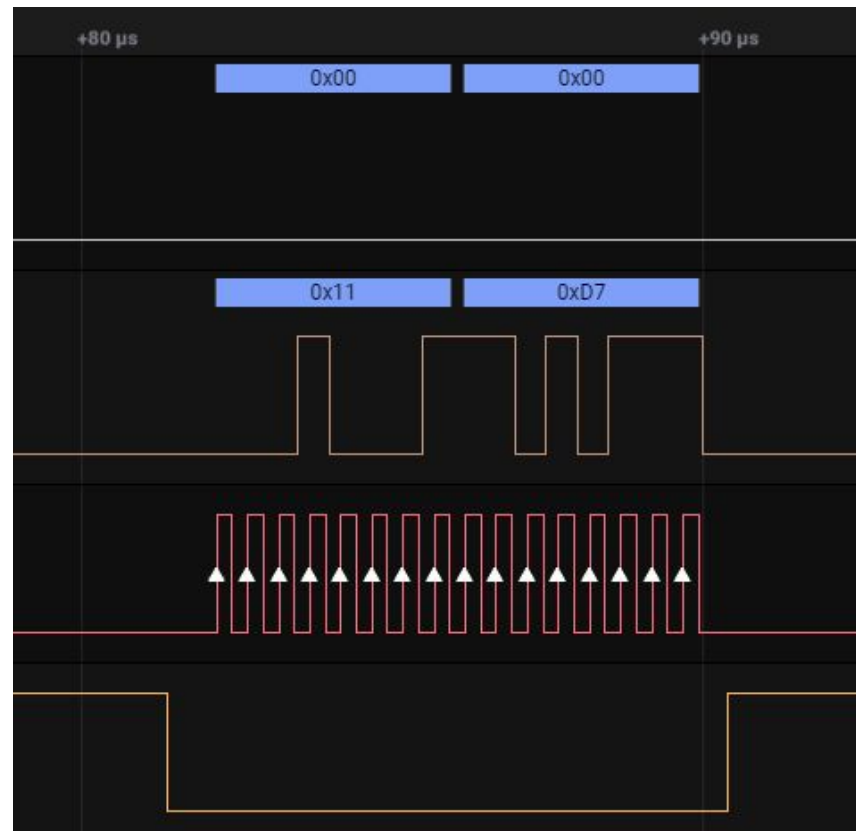


Voltmeter Firmware Logic – Extract 12 bits

? ? 0 B11 B10 B09 B08 B07 B06 B05 B04 B03 B02 B01 B00 B00

rawVoltage = 0bx??0100011101011

rawVoltage = rawVoltage & 0x0FFF



Voltmeter Firmware Logic

```

24 uint16_t spi0Handle;
25
26 uint8_t spiRxPkt[2];
27 uint16_t rawVoltage;
28 float voltage;
29
30 // SHORT VOLTMETER INPUTS TO DETERMINE OFFSET VOLTAGE
31 uint16_t offset = 0x0000;
32
33 //*****
34 /* READ VOLTAGE
35 //*****
36 int main(void)
37 {
38     if(gpioInitialise() < 0) //init pigpio
39     {
40         return 1;
41     }
42
43     spi0Handle = spiOpen(0,1000000,0); //open SPI0 at 1M baud
44
45     do{
46         spiRead(spi0Handle,spiRxPkt,2); //read voltmeter
47         rawVoltage = make16(spiRxPkt[0],spiRxPkt[1]); //form a 16-bit value
48         rawVoltage = rawVoltage >> 1; //discard extra LSB
49         rawVoltage = rawVoltage & 0x0FFF; //eliminate 3 MSB trash bits
50         voltage = (rawVoltage - offset) * 16.6667; //convert to millivolts
51         gpioSleep(PI_TIME_RELATIVE, 1, 0); //delay
52     }while(1);
53 }

```

Compile and Debug - Voltmeter

eclipse-workspace - piCproject/src/piCproject.c - Eclipse IDE

File Edit Source Refactor Navigate Search Project Run Window Help

Debug piCproject Debug on: --

Debug Project Explorer

<terminated> piCproject Debug [C/C++ Remote Application]

<terminated, exit value: 0> Remote Shell

<terminated, exit value: 0> /usr/bin/gdb-multiarch (9.2)

```

1 //*****
2 /** Name      : piCproject.c
3 /** Author   : FE
4 /** Version  : CEC Day 4
5 /** Copyright : Your copyright notice
6 /** Description : SPI Voltmeter
7 //*****
8
9 #include <stdio.h>
10 #include <stdlib.h>
11 #include <stdarg.h>
12 #include "pigpio.h"
13
14 //CCS Macros
15 #define bitset(var, bitno) ((var) |= 1 << (bitno))
16 #define bitclr(var, bitno) ((var) &= ~(1 << (bitno)))
17 #define make8(var, offset) ((unsigned short)var >> (offset * 8) & 0x00FF
18 #define make16(varhigh, varlow) (((unsigned short)varhigh & 0xFF) * 0x100) + ((unsigned short)varlow
19 #define make32(var1, var2, var3, var4) \
20     ((unsigned short)var1 << 24) + ((unsigned short)var2 << 16) + \
21     ((unsigned short)var3 << 8) + ((unsigned short)var4)
22 #define make32i(var1, var2) ((unsigned short)var1 << 16) + ((unsigned short)var2)
23
24 uint16_t spi0Handle;
25
26 uint8_t spiRxPkt[2];
27 uint16_t rawVoltage;
28 float voltage;
29
30 // SHORT VOLTMETER INPUTS TO DETERMINE OFFSET VOLTAGE
31 uint16_t offset = 0x0000;
32
33 //*****
34 /** READ VOLTAGE
35 //*****
36 int main(void)
37 {

```

Variable Break Expressions Modules Disassemblies

Name	Value
spiRxPkt	
rawVoltage	
voltage	
+ Add new expression	

Console Registers Problems Executables Debugger Console Memory

<terminated> piCproject Debug [C/C++ Remote Application] Remote Shell (Terminated Jan 8, 2021, 1:45:00 PM)

```

gdbserver1 :2345 /home/pi/CECprojects/piCproject;exit
pi@cec:~$ gdbserver1 :2345 /home/pi/CECprojects/piCproject;exit
Process /home/pi/CECprojects/piCproject created; pid = 734
Listening on port 2345
Remote debugging from host 192.168.1.240
logout

```

Writable Smart Insert 13:1:397

Compile and Debug - Voltmeter

eclipse-workspace - piCproject/src/piCproject.c - Eclipse IDE

File Edit Source Refactor Navigate Search Project Run Window Help

Debug piCproject Debug on: --

Debug Project Explorer

piCproject Debug [C/C++ Remote Application]

- piCproject [767] [cores: 2]
 - Thread #1 [piCproject] 767 [core: 2] (Suspended: Breakpoint)
 - main() at piCproject.c:38 0x4005d8
 - Remote Shell
 - /usr/bin/gdb-multiarch (9.2)

```

18 #define make16(varhigh,varlow) (((unsigned short)varhigh & 0xFF)* 0x100) + ((unsigned short)varlow
19 #define make32(var1,var2,var3,var4) \
20 ((unsigned short)var1<<24)+((unsigned short)var2<<16)+ \
21 ((unsigned short)var3<<8)+((unsigned short)var4)
22 #define make32i(var1,var2) (((unsigned short)var1<<16)+((unsigned short)var2)
23
24 uint16_t spi0Handle;
25
26 uint8_t spiRxPkt[2];
27 uint16_t rawVoltage;
28 float voltage;
29
30 // SHORT VOLTMETER INPUTS TO DETERMINE OFFSET VOLTAGE
31 uint16_t offset = 0x0000;
32
33 //*****
34 /* READ VOLTAGE
35 //*****
36 int main(void)
37 {
38     if(gpioInitialise() < 0) //init pigpio
39     {
40         return 1;
41     }
42
43     spi0Handle = spiOpen(0,1000000,0); //open SPI0 at 1M baud
44
45     do{
46         spiRead(spi0Handle,spiRxPkt,2); //read voltmeter
47         rawVoltage = make16(spiRxPkt[0],spiRxPkt[1]); //form a 16-bit value
48         rawVoltage >> 1; //discard extra LSB
49         rawVoltage = rawVoltage & 0x0FFF; //eliminate 3 MSB trash bits
50         voltage = (rawVoltage - offset) * 16.6667; //convert to millivolts
51         gpioSleep(Pi_TIME_RELATIVE, 1, 0); //delay
52     }while(1);
53 }
54

```

Expression Type Value

Expression	Type	Value
spiRxPkt	uint8_t [2]	0x41100c <spiRxP
rawVoltage	uint16_t	0
voltage	float	0
+ Add new expressio		

Console Registers Problems Executables Debugger Console Memory

piCproject Debug [C/C++ Remote Application]

Last login: Fri Jan 8 13:39:20 2021 from 192.168.1.240

```

gdbserver1 :2345 /home/pi/CECprojects/piCproject;exit
pi@cec:~$ gdbserver1 :2345 /home/pi/CECprojects/piCproject;exit
Process /home/pi/CECprojects/piCproject created; pid = 767
Listening on port 2345
Remote debugging from host 192.168.1.240

```

Writable Smart Insert 38: 1: 1289

eclipse-workspace - piCproject/src/piCproject.c - Eclipse IDE

File Edit Source Refactor Navigate Search Project Run Window Help

Debug piCProject Debug on: --

Project Explorer

- piCProject Debug [C/C++ Remote Application]
 - piCProject [767] [cores: 0,1,2,3]
 - Thread #1 [piCProject] 767 [core: 2] (Suspended : Breakpoint)
 - main() at piCproject.c:51 0x400680
 - Thread #2 [piCProject] 768 [core: 3] (Suspended : Container)
 - Thread #3 [piCProject] 769 [core: 1] (Suspended : Container)
 - Thread #4 [piCProject] 770 [core: 0] (Suspended : Container)
 - Remote Shell
 - /usr/bin/gdb-multiarch (9.2)

```

19 #define make32(var1,var2,var3,var4) \
20 ((unsigned short)var1<<24)+((unsigned short)var2<<16)+ \
21 ((unsigned short)var3<<8)+((unsigned short)var4)
22 #define make32i(var1,var2) ((unsigned short)var1<<16)+((unsigned short)var2)
23
24 uint16_t spi0Handle;
25
26 uint8_t spiRxPkt[2];
27 uint16_t rawVoltage;
28 float voltage;
29
30 // SHORT VOLTMETER INPUTS TO DETERMINE OFFSET VOLTAGE
31 uint16_t offset = 0x07F9;
32
33 /******
34 /* READ VOLTAGE
35 /******
36 int main(void)
37 {
38     if(gpioInitialise() < 0)           //init pigpio
39     {
40         return 1;
41     }
42
43     spi0Handle = spiOpen(0,1000000,0); //open SPI0 at 1M baud
44
45     do{
46         spiRead(spi0Handle,spiRxPkt,2); //read voltmeter
47         rawVoltage = make16(spiRxPkt[0],spiRxPkt[1]); //form a 16-bit value
48         rawVoltage = rawVoltage >> 1; //discard extra LSB
49         rawVoltage = rawVoltage & 0x0FFF; //eliminate 3 MSB trash bits
50         voltage = (rawVoltage - offset) * 16.6667; //convert to millivolts
51         gpioSleep(Pi_TIME_RELATIVE, 1, 0); //delay
52     }while(1);
53 }
54

```

Variab Break Expre Modul Disass

Expression	Type	Value
spiRxPkt	uint8_t [2]	0x41100c <spiRxP
spiRxPkt[0]	uint8_t	15 '\017'
spiRxPkt[1]	uint8_t	242 'ò'
rawVoltage	uint16_t	2041
voltage	float	34016.7344
Add new expressio		

Name : rawVoltage
 Details:2041
 Default:2041
 Decimal:2041
 Hex:0x7f9
 Binary:1111111001
 Octal:03771

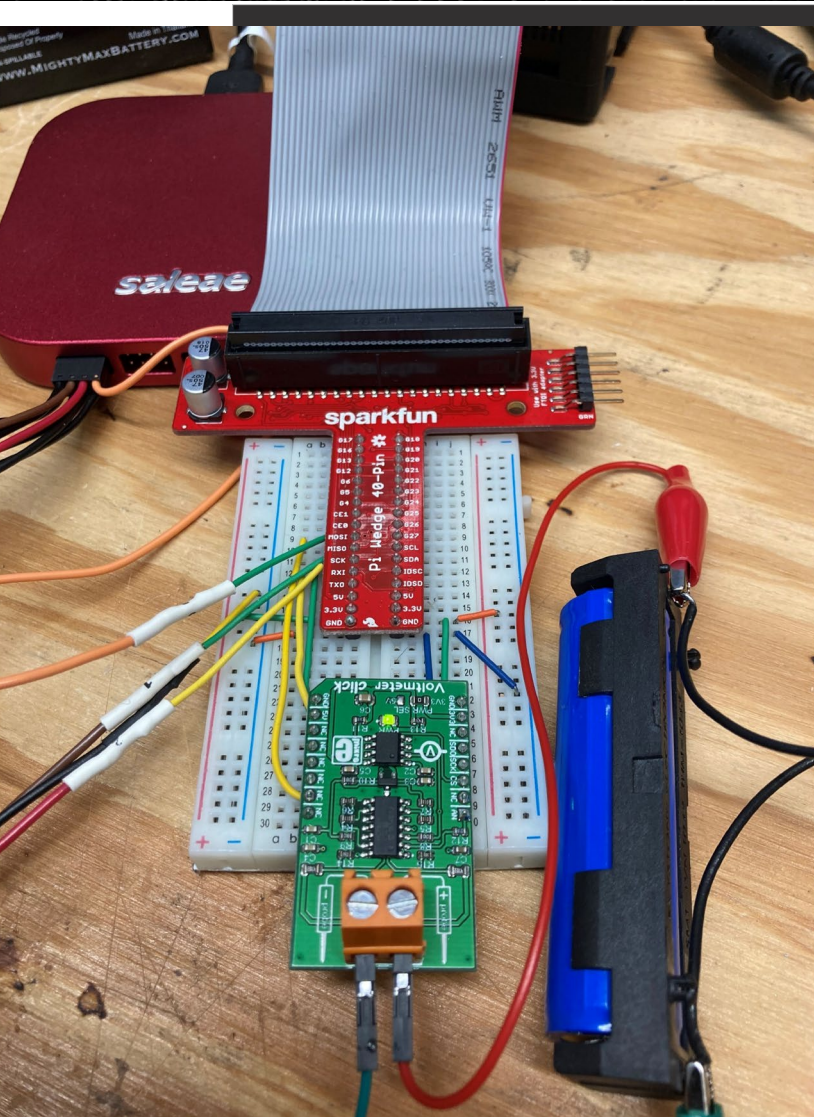
Console Registers Problems Executables Debugger Console Memory

piCProject Debug [C/C++ Remote Application]
 Last login: Fri Jan 8 13:39:20 2021 from 192.168.1.240

gdbserver1 :2345 /home/pi/CECprojects/piCproject;exit

pi@cec:~\$ gdbserver1 :2345 /home/pi/CECprojects/piCproject;exit
 Process /home/pi/CECprojects/piCproject created; pid = 767
 Listening on port 2345
 Remote debugging from host 192.168.1.240

Compile and Debug - Voltmeter



eclipse-workspace - piCproject/src/piCproject.c - Eclipse IDE

```

19 #define make32(var1,var2,var3,var4) \
20     ((unsigned short)var1<<24)+((unsigned short)var2<<16)+ \
21     ((unsigned short)var3<<8)+(unsigned short)var4)
22 #define make32i(var1,var2) ((unsigned short)var1<<16)+((unsigned short)var2)
23
24 uint16_t spi0Handle;
25
26 uint8_t spiRxPkt[2];
27 uint16_t rawVoltage;
28 float voltage;
29
30 // SHORT VOLTMETER INPUTS TO DETERMINE OFFSET VOLTAGE
31 uint16_t offset = 0x07F9;
32
33 //*****
34 /* READ VOLTAGE
35 //*****
36 int main(void)
37 {
38     if(gpioInitialise() < 0)           //init pigpio
39     {
40         return 1;
41     }
42
43     spi0Handle = spiOpen(0,1000000,0); //open SPI0 at 1M baud
44
45     do{
46         spiRead(spi0Handle,spiRxPkt,2); //read voltmeter
47         rawVoltage = make16(spiRxPkt[0],spiRxPkt[1]); //form a 16-bit value
48         rawVoltage = rawVoltage >> 1; //discard extra LSB
49         rawVoltage = rawVoltage & 0x0FFF; //eliminate 3 MSB trash bits
50         voltage = (rawVoltage - offset) * 16.6667; //convert to millivolts
51         gpioSleep(Pi_TIME_RELATIVE, 1, 0); //delay
52     }while(1);
53 }
54

```

Expression	Type	Value
spiRxPkt	uint8_t [2]	0x411010 <spiRxP
rawVoltage	uint16_t	2284
voltage	float	4050.00806
+ Add new expression		

Console [C/C++ Remote Application]
Last login: Fri Jan 8 13:52:36 2021 from 192.168.1.240

```

gdbserver1 :2345 /home/pi/CECprojects/piCproject;exit
pi@cec:~$ gdbserver1 :2345 /home/pi/CECprojects/piCproject;exit
Process /home/pi/CECprojects/piCproject created; pid = 800
Listening on port 2345
Remote debugging from host 192.168.1.240

```

Writable Smart Insert 51:1:1741

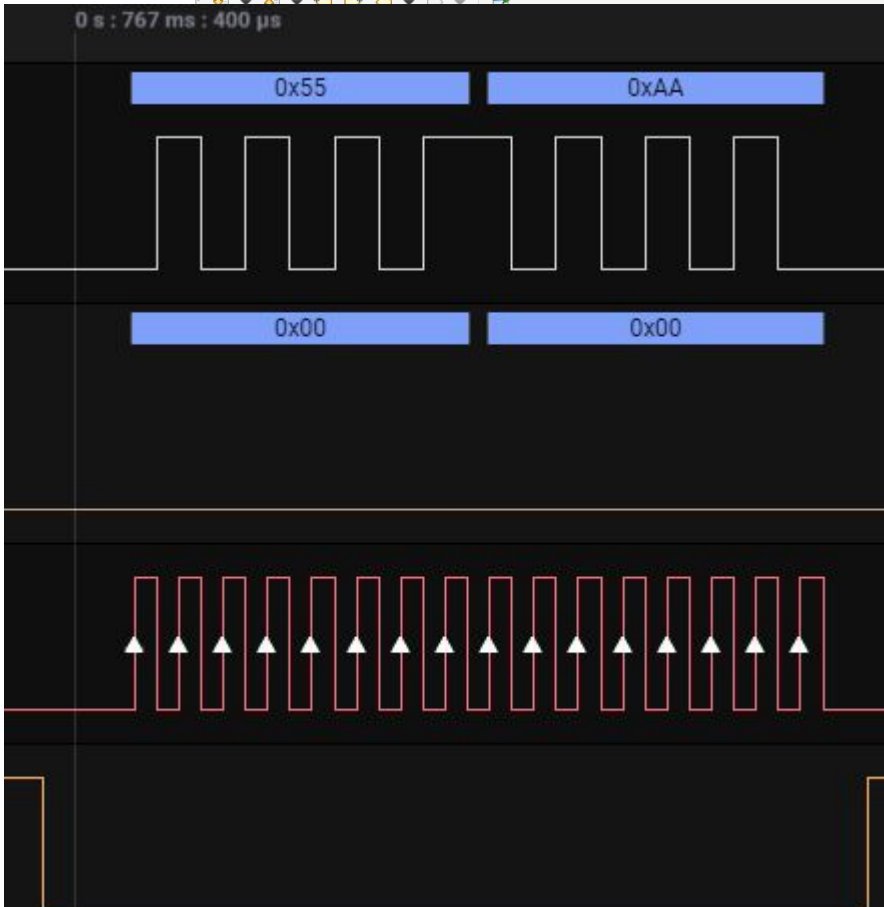
SPI Write – pigpio

eclipse-workspace - piCproject/src/piCproject.c - Eclipse IDE

File Edit Source Refactor Navigate Search Project Run Window Help

piCproject Debug on: --

0 s : 767 ms : 400 μs



```

ck_nanosleep() at 0xb6e5bedc
>
h>
h>
r, bitno) ((var) |= 1 << (bitno))
r, bitno) ((var) &= ~(1 << (bitno)))
,offset) ((unsigned short)var >> (offset * 8)) & 0x00FF
rhigh,varlow) (((unsigned short)varhigh & 0xFF)* 0x100) + (((unsigned short)varlow & 0x00FF)
r1,var2,var3,var4) \
short)var1<
short)var3<
var1,var2) (
le;
2];
2];
24 uint16_t spi0Handle;
25 uint8_t spiRxPkt[2];
26 uint8_t spiTxPkt[2];
27 uint8_t i;
28
29 int main(void)
30 {
31     if(gpioInitialise() < 0) //init pigpio
32     {
33         return 1;
34     }
35
36     spiTxPkt[0] = 0x55;
37     spiTxPkt[1] = 0xAA;
38
39     spi0Handle = spiOpen(0,1000000,0); //open SPI0 at 1M baud
40     do{
41         spiWrite(spi0Handle,spiTxPkt,2);
42         gpioSleep(PI_TIME_RELATIVE, 1, 0); //delay
43     }while(1);
44 }

```

Expression	Type	Value
spiTxPkt	uint8_t [2]	0x411010 <spiTx
spiTxPkt[0]	uint8_t	85 'U'
spiTxPkt[1]	uint8_t	170 'a'
+ Add new expressio		

Process /home/pi/CECprojects/piCproject created; pid = 683
Listening on port 2345
Remote debugging from host 192.168.1.240

lib64
libexec
libx32
local

Writable Smart Insert 31 : 1 : 1028

Thank you for attending

Please consider the resources below:

- <https://www.raspberrypi.org>
- <https://ubuntu.com>
- <https://www.eclipse.org>
- <https://mikroe.com>



DesignNews

Thank You

Sponsored by

