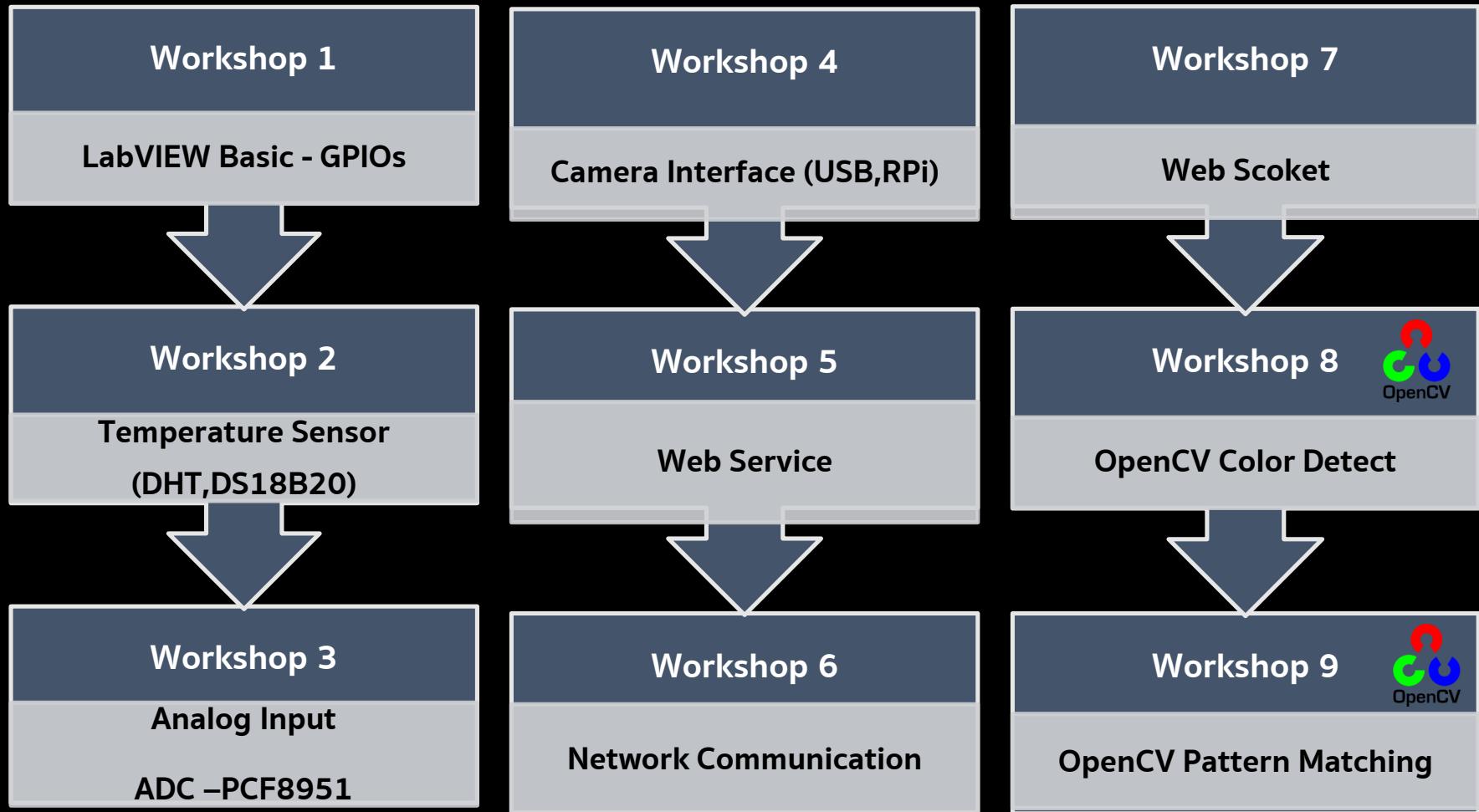
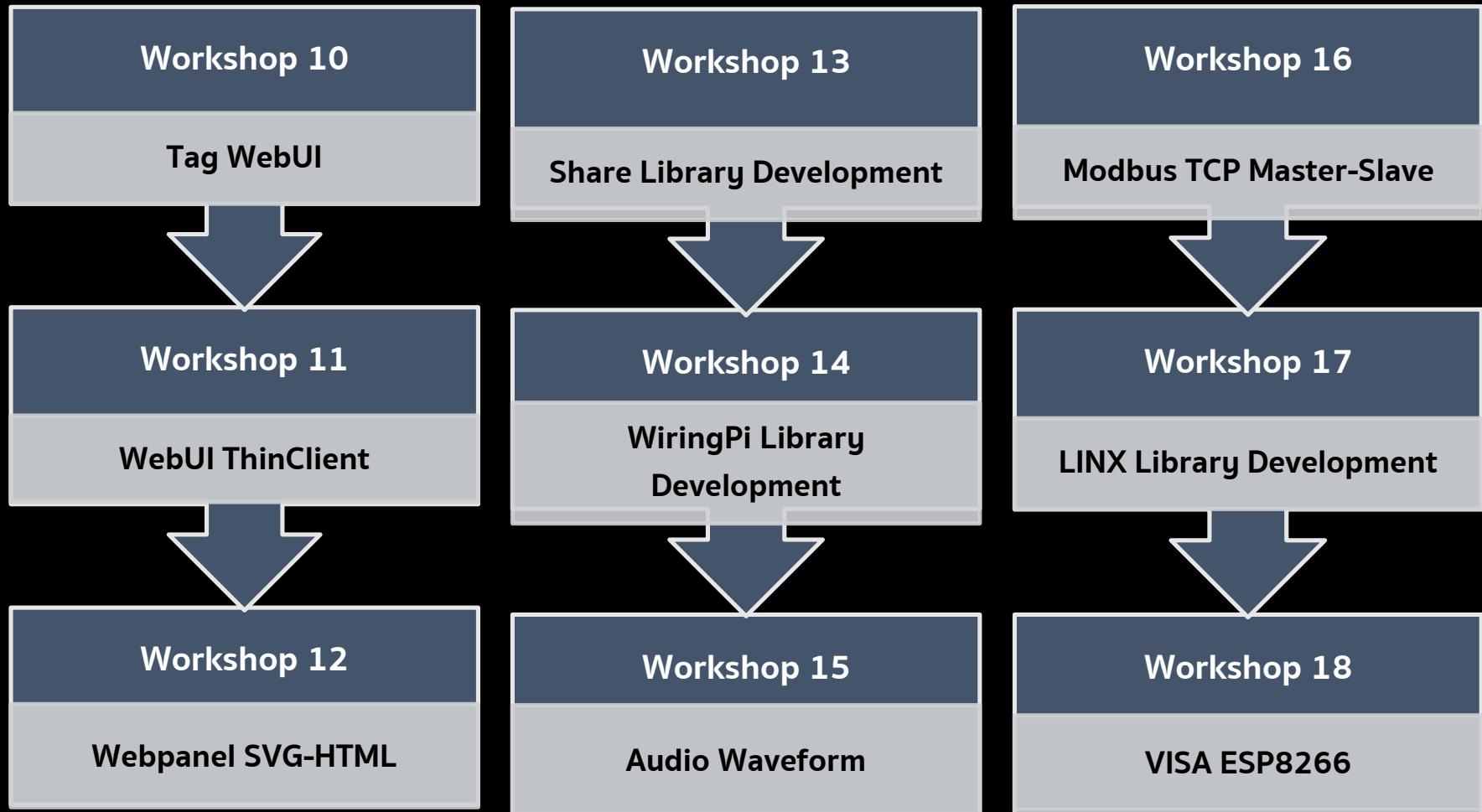


# Exercise 1/2

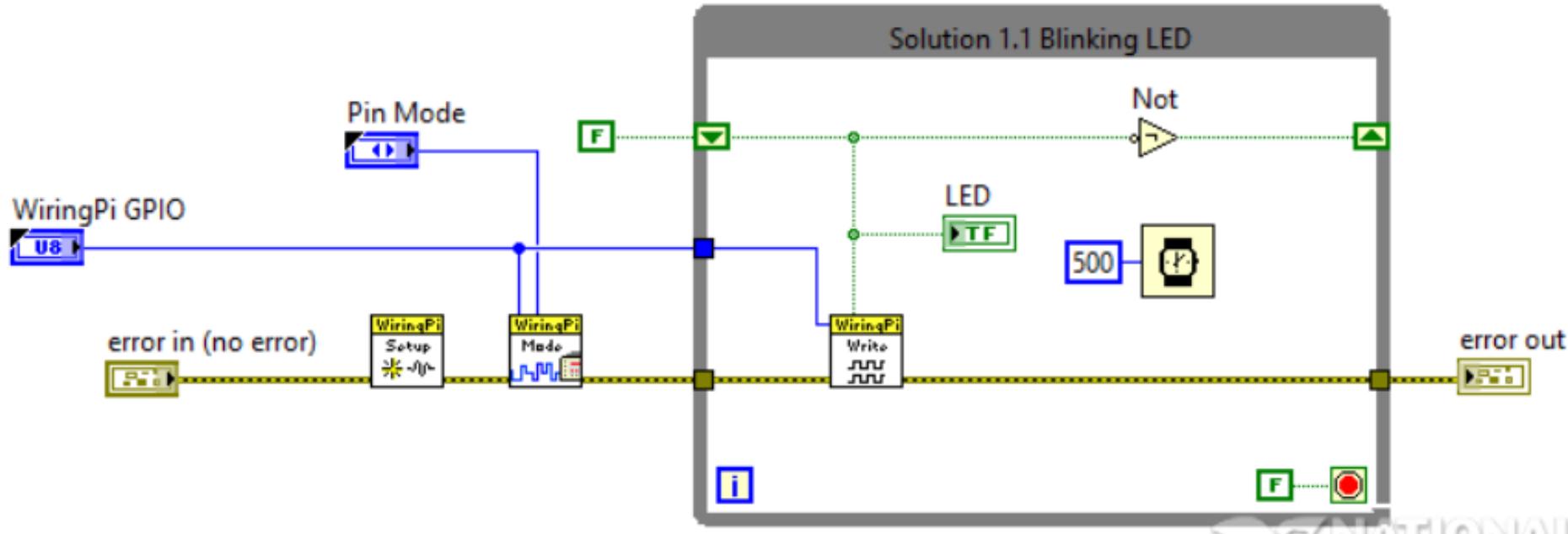


# Exercise 2/2



# 1

# Exercise 1 – GPIO



# The utilities software for Pi

- Transfer files โดยใช้ “FileZilla”
- Remote Desktop โดยใช้ “VNC Viewer”
- Remote Terminal “SmarTTY”

# VNC Viewer



VNC® Viewer

VNC Server: 192.168.5.1

Encryption: Let VNC Server choose

About... Options...

VNC Viewer - Authentication

VNC Server: 192.168.5.1:5900

Username: pi

Password: ••••••••

Catchphrase: Nerve Chicago cement. Tofu beetle shadow.

Signature: 41-ce-14-13-c2-2c-7e-a1

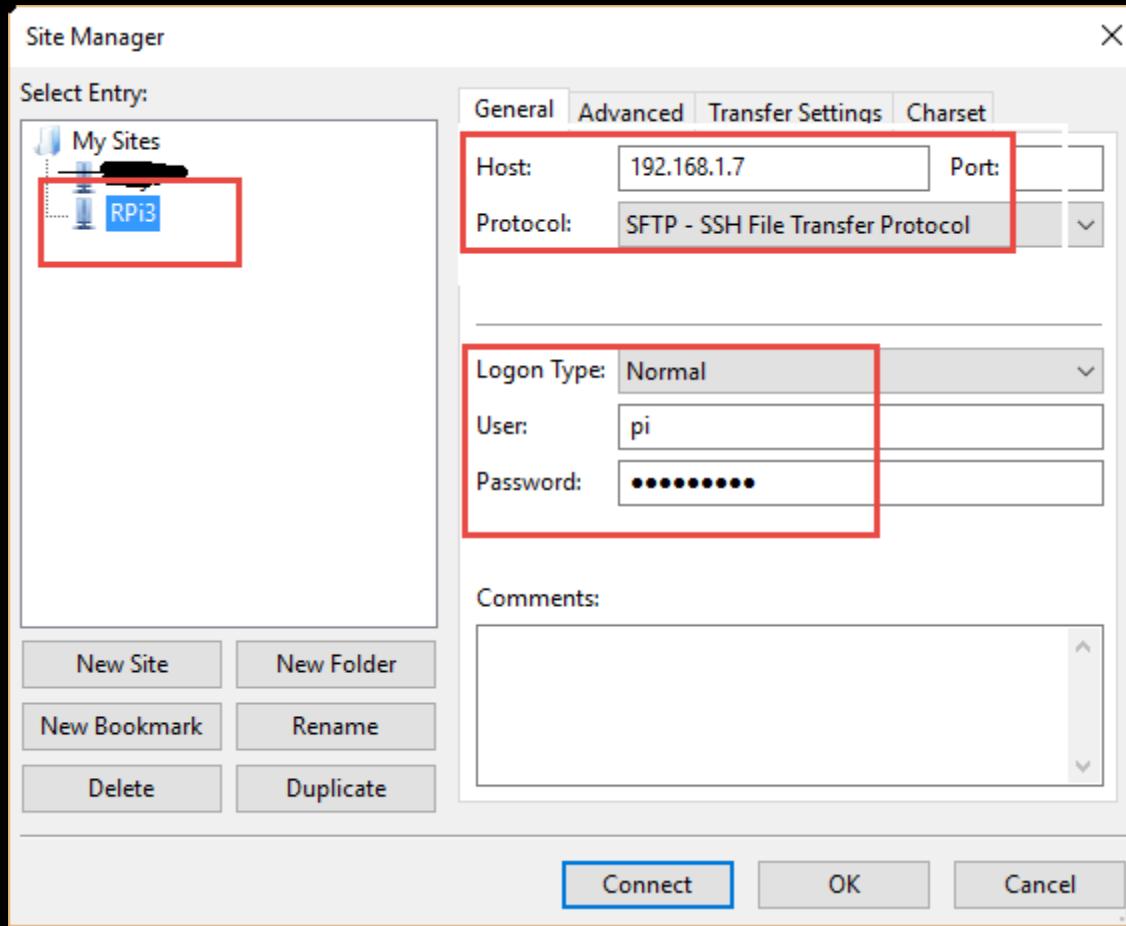
raspberrypi - VNC Viewer

www.qwavesys.com

Q-WAVE SYSTEMS ■■■

# Transfer files ໂາຍໃໝ່ “FileZilla”

- Protocol = SFTP (SSH File Transfer)



# Transfer files ໄາຍິ້ງ “FileZilla”



RPi3 - sftp://pi@192.168.1.7 - FileZilla

File Edit View Transfer Server Bookmarks Help New version available!

Host: \_\_\_\_\_ Username: \_\_\_\_\_ Password: \_\_\_\_\_ Port: \_\_\_\_\_ Quickconnect

Status: Listing directory /srv/chroot/labview/usr/local/lib  
 Status: Directory listing of "/srv/chroot/labview/usr/local/lib" successful  
 Status: Retrieving directory listing of '/srv/chroot/labview/usr/local/lib'...  
 Status: Listing directory /srv/chroot/labview/usr/local/lib  
 Status: Directory listing of "/srv/chroot/labview/usr/local/lib" successful  
 Status: Retrieving directory listing of "/home/pi"..."  
 Status: Listing directory /home/pi  
 Status: Directory listing of "/home/pi" successful

Local site: C:\Users\THEP\Desktop\

Remote site: /home/pi

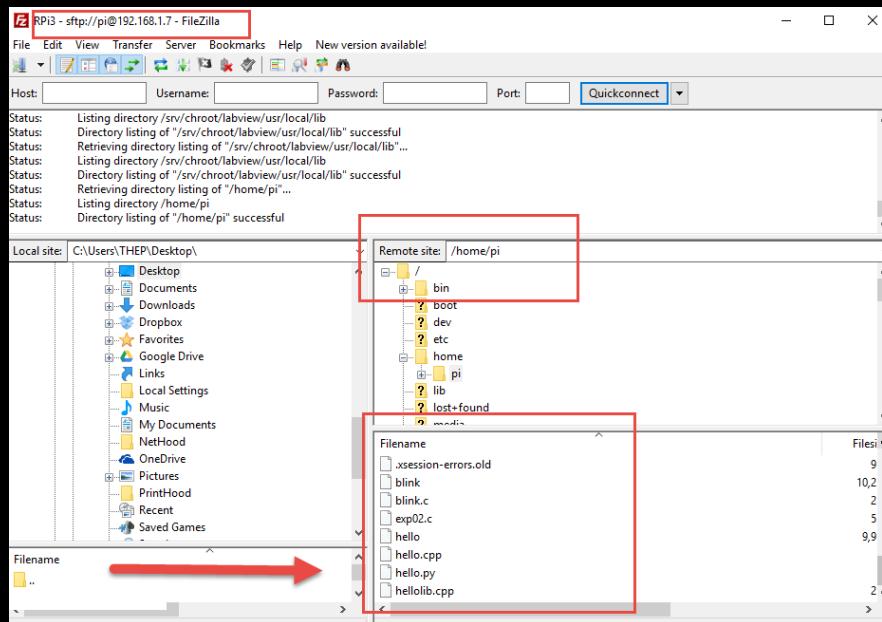
Filename	Filesize
.xsession-errors.old	9
blink	10,2
blink.c	2
exp02.c	5
hello	9,9
hello.cpp	2
hello.py	
hellolib.cpp	

**Red Boxes:** The top red box highlights the title bar and the connection information. The bottom red box highlights the file list on the right side of the interface.

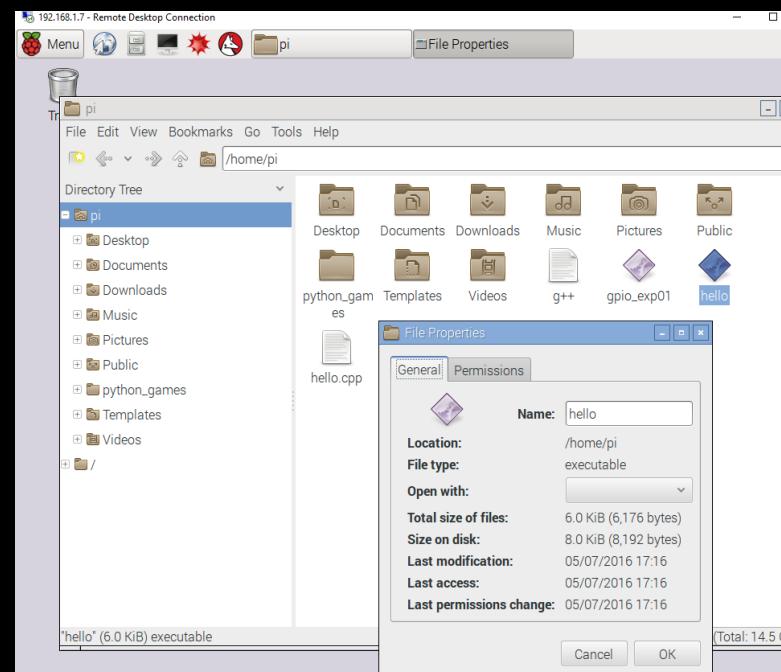
**Red Arrow:** A large red arrow points from the "Local site" section towards the "Remote site" section, indicating the direction of file transfer.

# File Explorer vs VNC Viewer

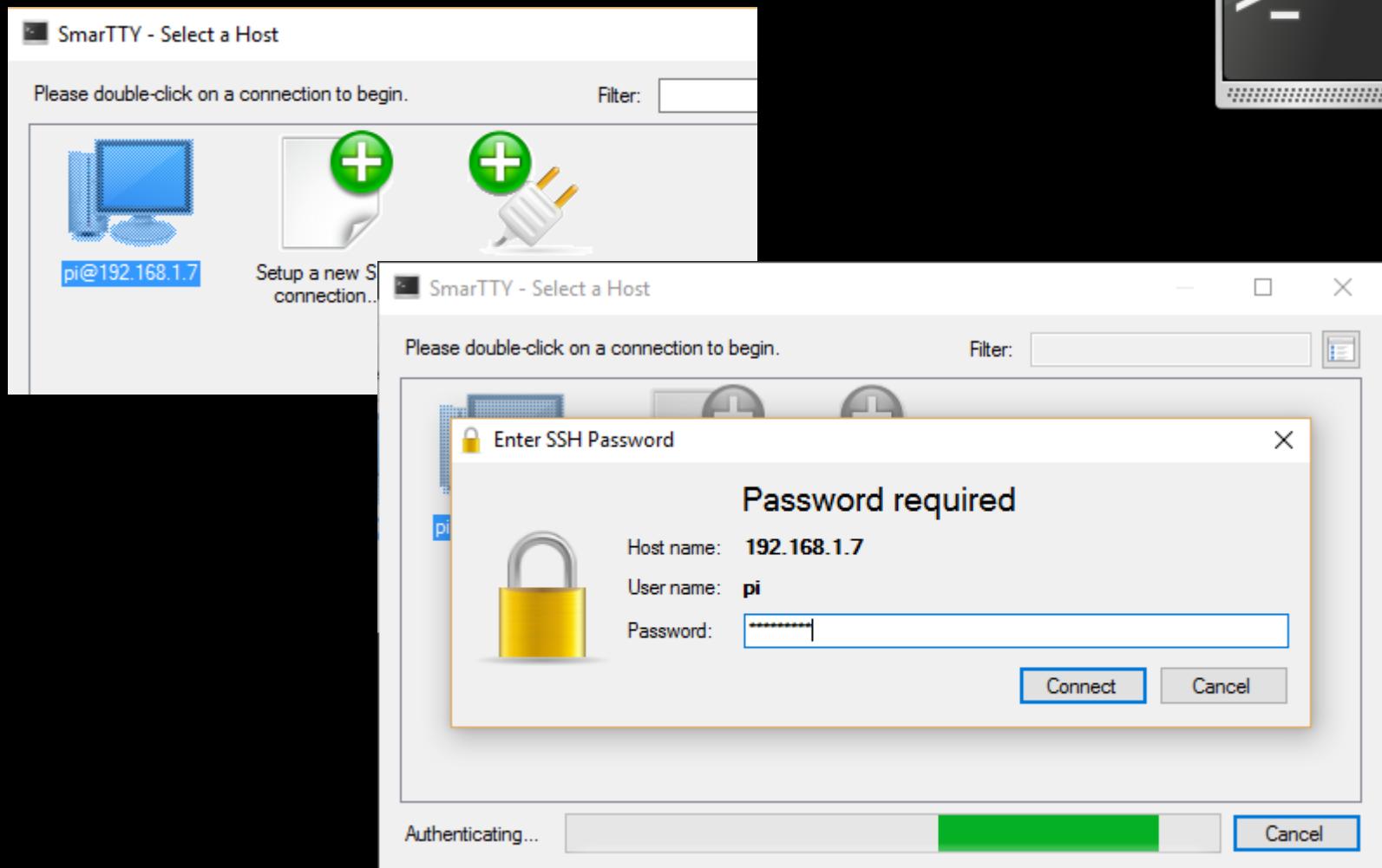
- **/home/pi**
- **/srv/chroot/labview**



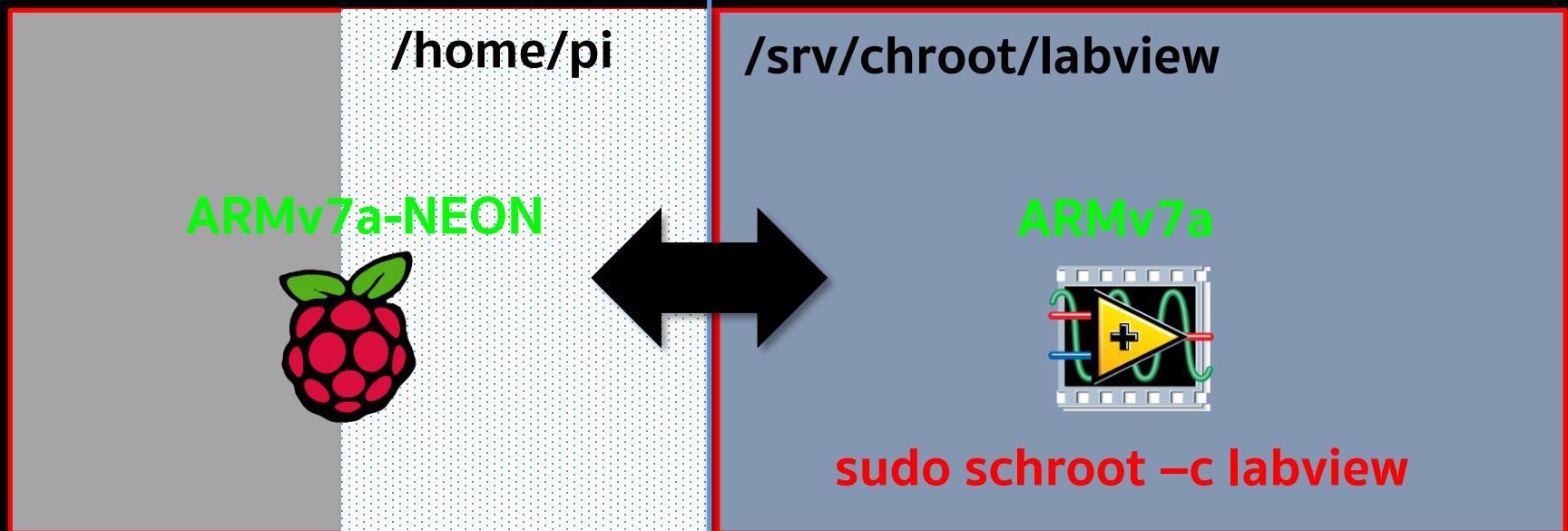
VS



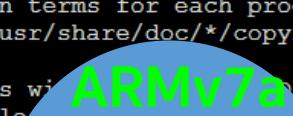
# Remote Terminal “SmarTTY”

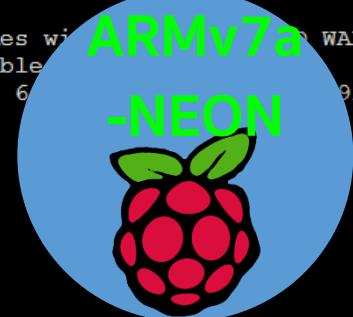


# Multiples Remote Terminal



```
The programs included with the Debian GNU/Linux  
the exact distribution terms for each program  
individual files in /usr/share/doc/*copyright  
  
Debian GNU/Linux comes with ABSOLUTELY NO WARRANTY.  
permitted by applicable law.  
Last login: Fri May  6 14:00:00 2016  
pi@raspberrypi:~ $
```





[www.qwavesys.com](http://www.qwavesys.com)

```
SmarTTY - 192.168.1.7
File Edit View SCP Settings Help
Last login: Fri May  6 20:44:02 2016 from 192.168.1.26
pi@raspberrypi:~ $ sudo schroot -c labview
shell-init: error retrieving current directory: getcwd
[...]
success
root@raspberrypi:~ # cd /
chdir: error retrieving current directory: getcwd: car
[...]
s
root@raspberrypi:~ #
bin      dev      home      sys      usr
boot     etc      lib       tmp      var
root@raspberrypi:~ #
```

A blue circular badge containing a yellow triangle with a black cross inside. A green ribbon-like shape is draped over the triangle. Below the triangle, there are two red curved lines resembling stylized arrows or waves.



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# Connect LEDs to Raspberry Pi

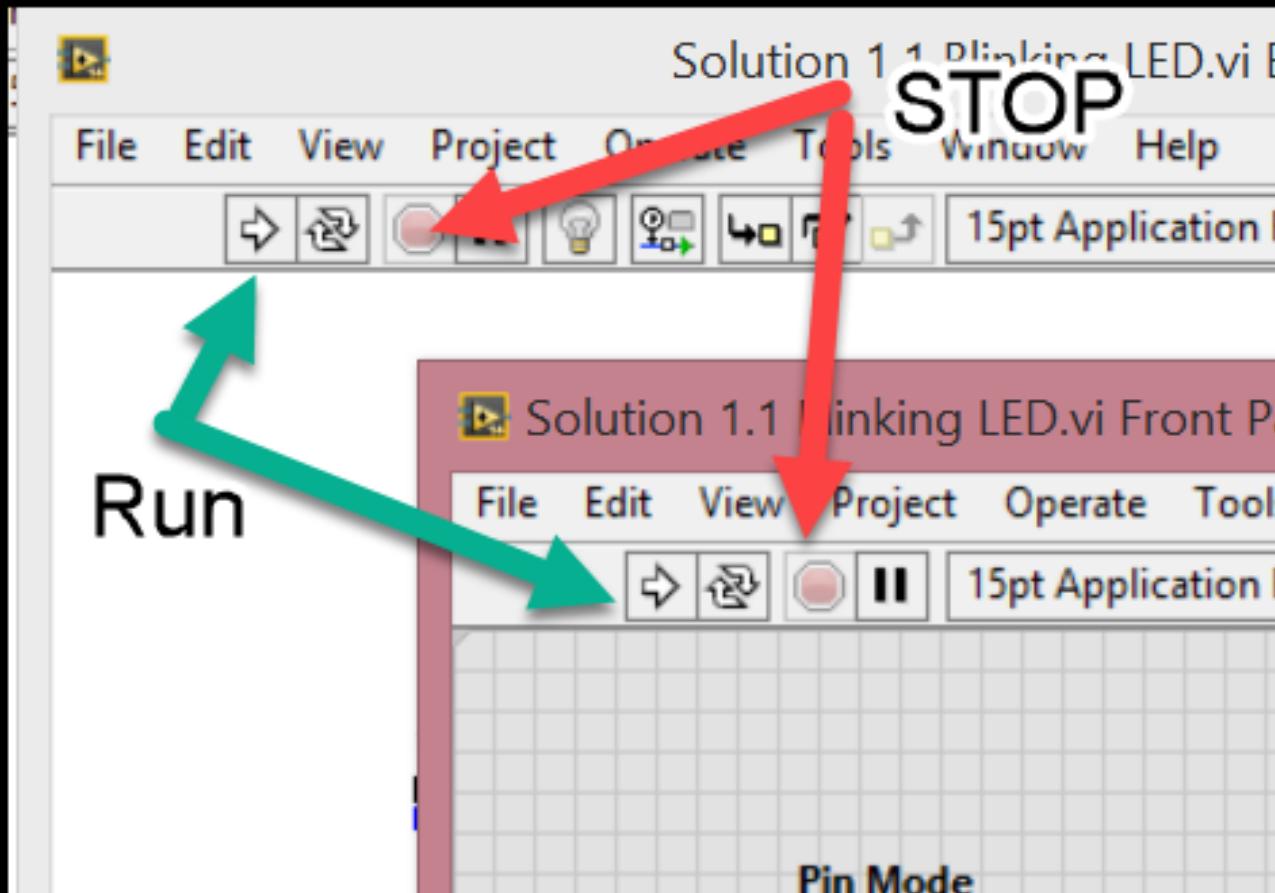
- LED 1 = Pin12 (GPIO1)
- LED 2 = Pin18 (GPIO5)
- \*Noted – This Pin Definition
- only work with WiringPi only.

Raspberry Pi 2 Model B (J8 Header)											
GPIO#	NAME									NAME	GPIO#
	3.3 VDC Power				1					5.0 VDC Power	
8	GPIO 8 SDA1 (I2C)			3	4					5.0 VDC Power	
9	GPIO 9 SCL1 (I2C)			5	6					Ground	
7	GPIO 7 GPCLK0			7	8					GPIO 15 TxD (UART)	15
	Ground			9	10					GPIO 16 RxD (UART)	16
0	GPIO 0			11	12					GPIO 1 PCM_CLK/PWM0	1
2	GPIO 2			13	14					Ground	
3	GPIO 3			15	16					GPIO 4	4
	3.3 VDC Power			17	18					GPIO 5	5
12	GPIO 12 MOSI (SPI)			19	20					Ground	
13	GPIO 13 MISO (SPI)			21	22					GPIO 6	6
14	GPIO 14 SCLK (SPI)			23	24					GPIO 10 CE0 (SPI)	10

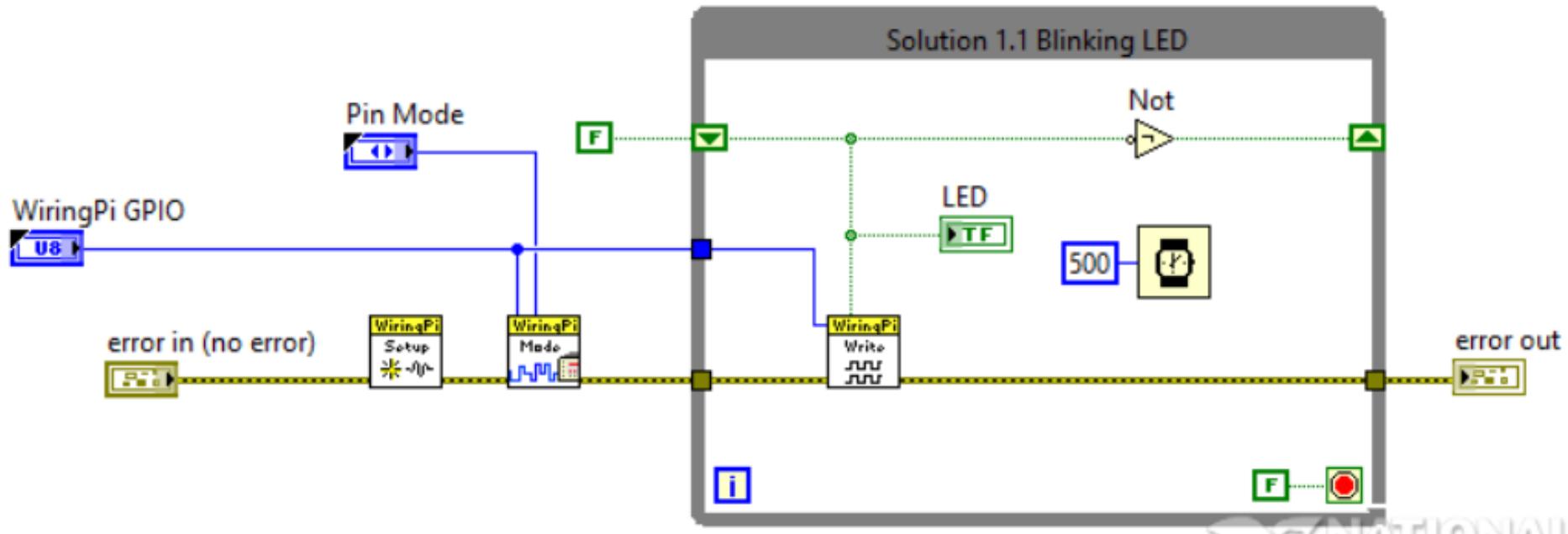
# Exercise 1 : Open LabVIEW Project

Name	Date modified	Type
Benchmarking Raspberry Pi GPIO Speed	10/13/2016 3:54 A...	Internet Shortcut
Exercise 1 Blinking LEDs.aliases	10/19/2016 2:08 PM	ALIASES File
Exercise 1 Blinking LEDs.lvlp	10/18/2016 3:22 A...	LVLPS File
Exercise 1 Blinking LEDs.lvproj	10/18/2016 3:22 A...	LabVIEW Project
Exercise 1.1 Blinking LED.vi	10/18/2016 2:20 A...	LabVIEW Instrument
Exercise 1.2 Blinking LED Multi Loop.vi	10/18/2016 2:15 A...	LabVIEW Instrument
Exercise 1.3 Blinking LED Time Loop.vi	10/18/2016 2:17 A...	LabVIEW Instrument
Exercise 1.4 PWM.vi	10/18/2016 2:18 A...	LabVIEW Instrument
Exercise 1.5 Read GPIO PWM.vi	10/18/2016 2:20 A...	LabVIEW Instrument
Special Pin Functions - Wiring Pi	5/8/2016 11:31 PM	Internet Shortcut
The GPIO utility - Wiring Pi	7/18/2016 12:15 A...	Internet Shortcut
WiringPi GPIO.png	5/10/2016 12:36 PM	PNG image

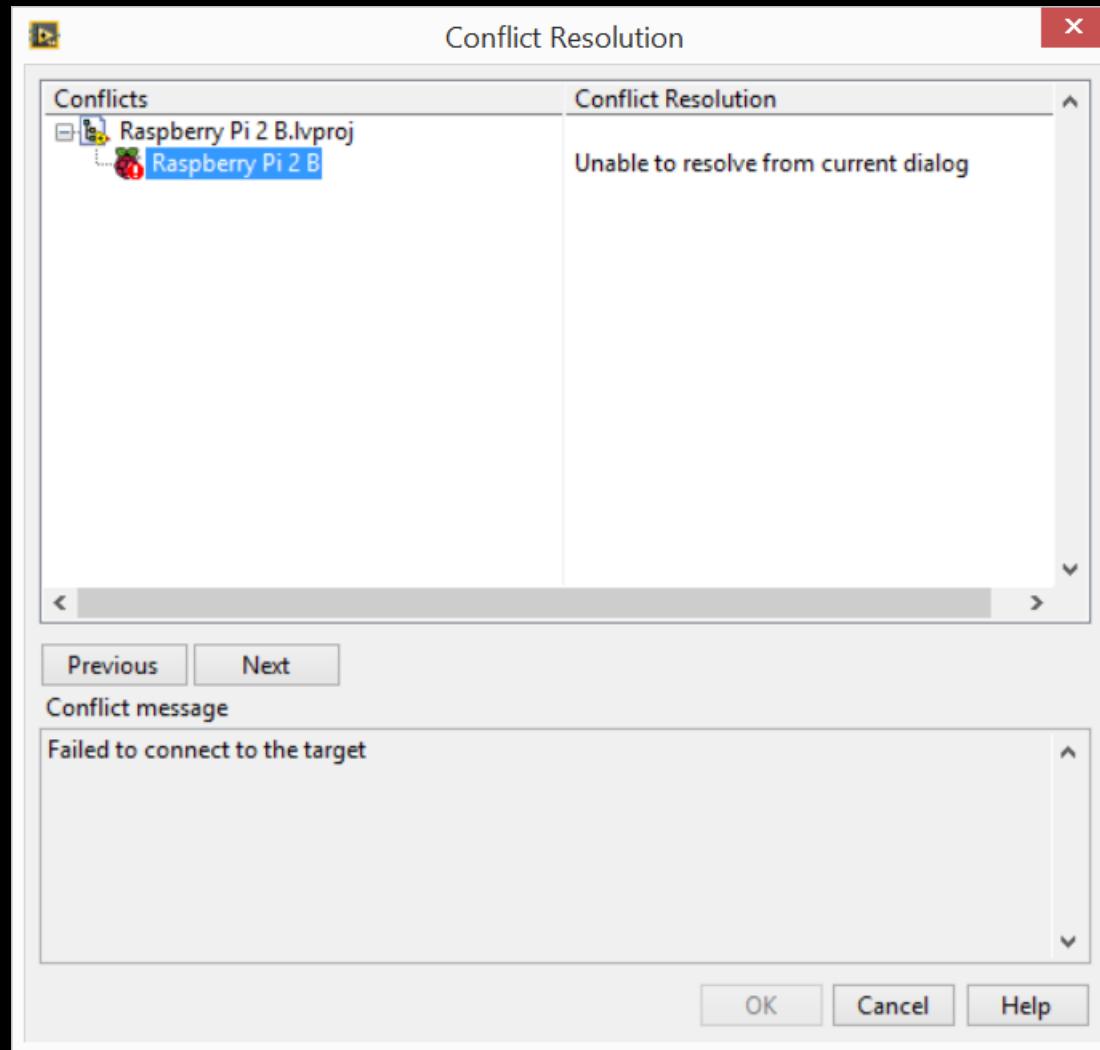
# Run&Abort Execution: STOP a VI



# Exercise 1.1 Blinking LED.vi



# Failed to Connect to the Target



# Force LabVIEW Run-Time to Start

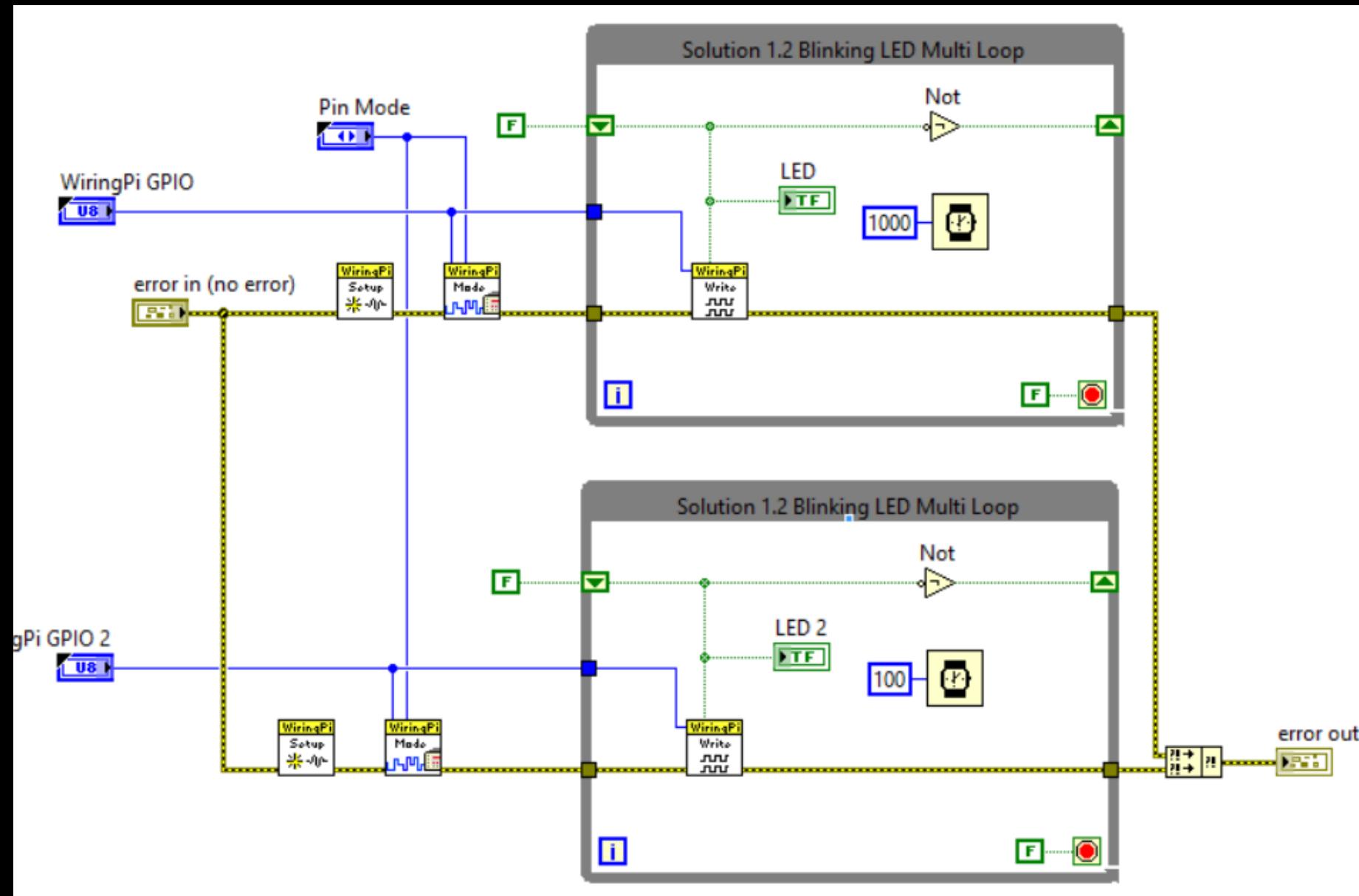
- > **sudo schroot --run-session -c lv -- /etc/init.d/nilvrt start**

```
Last login: Sun May  8 07:51:47 2016 from 192.168.1.101
pi@raspberrypi:~ $ sudo schroot --run-session -c lv -- /etc/init.d/nilvrt start
```

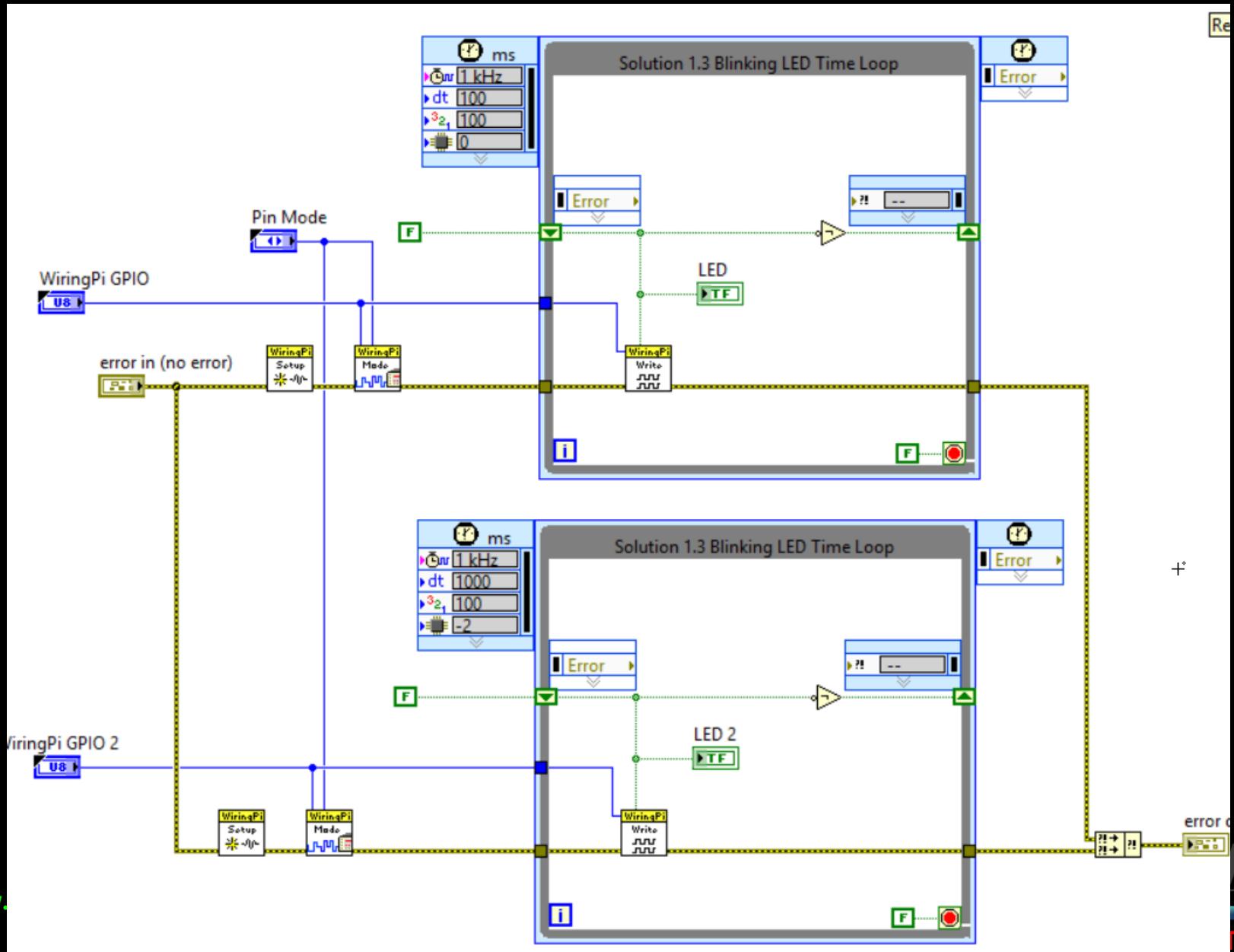
- > **./rtlv.sh**

```
pi@raspberrypi:~ $ ./rtlv.sh
shell-init: error retrieving current directory: getcwd: cannot
get current directory: Success
Starting LabVIEW
chdir: error retrieving current directory: getcwd: cannot
get current directory: Bad file descriptor
/lvrt is already running
5543
pi@raspberrypi:~ $
```

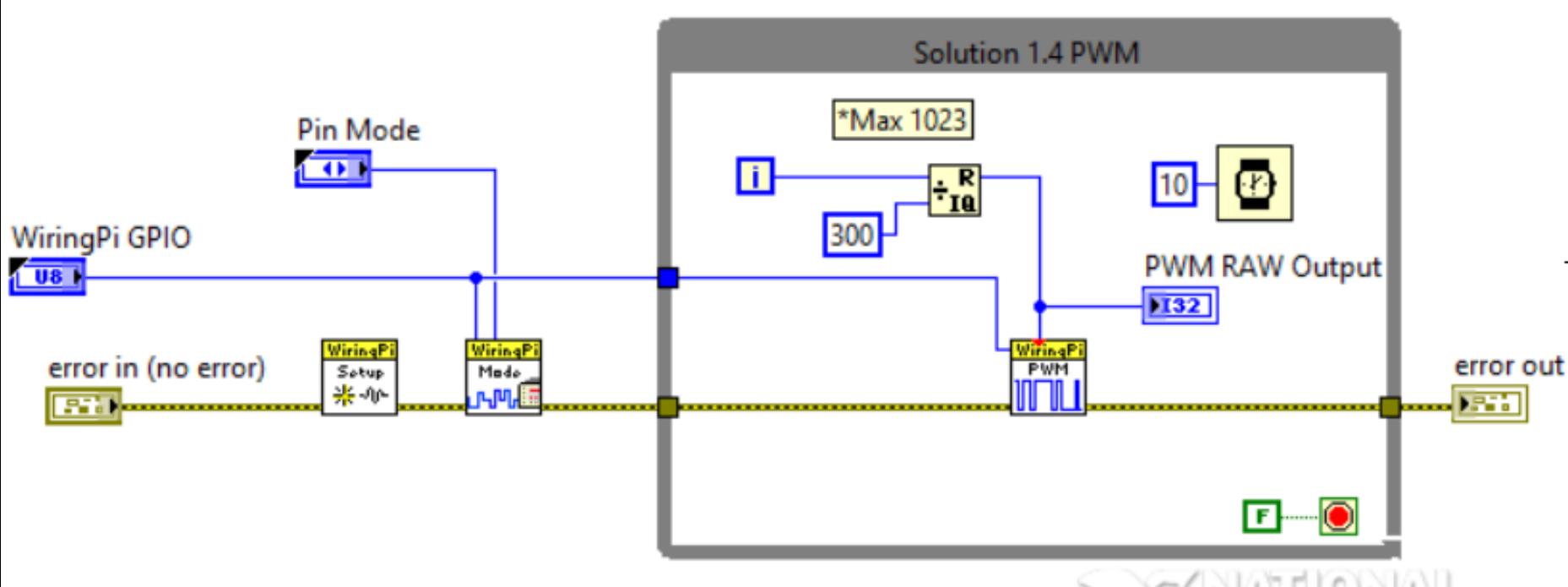
# Exercise 1.2 Blinking LED Multi Loop.vi



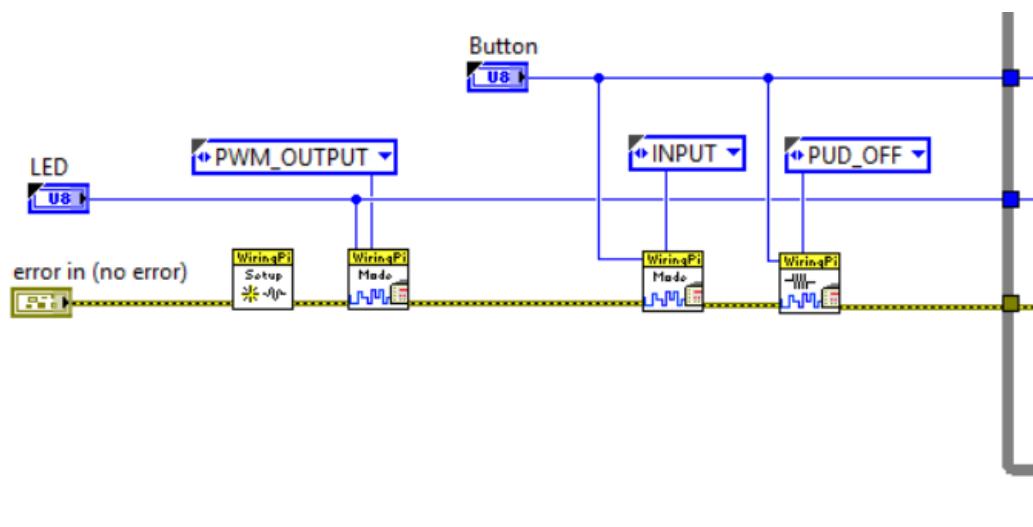
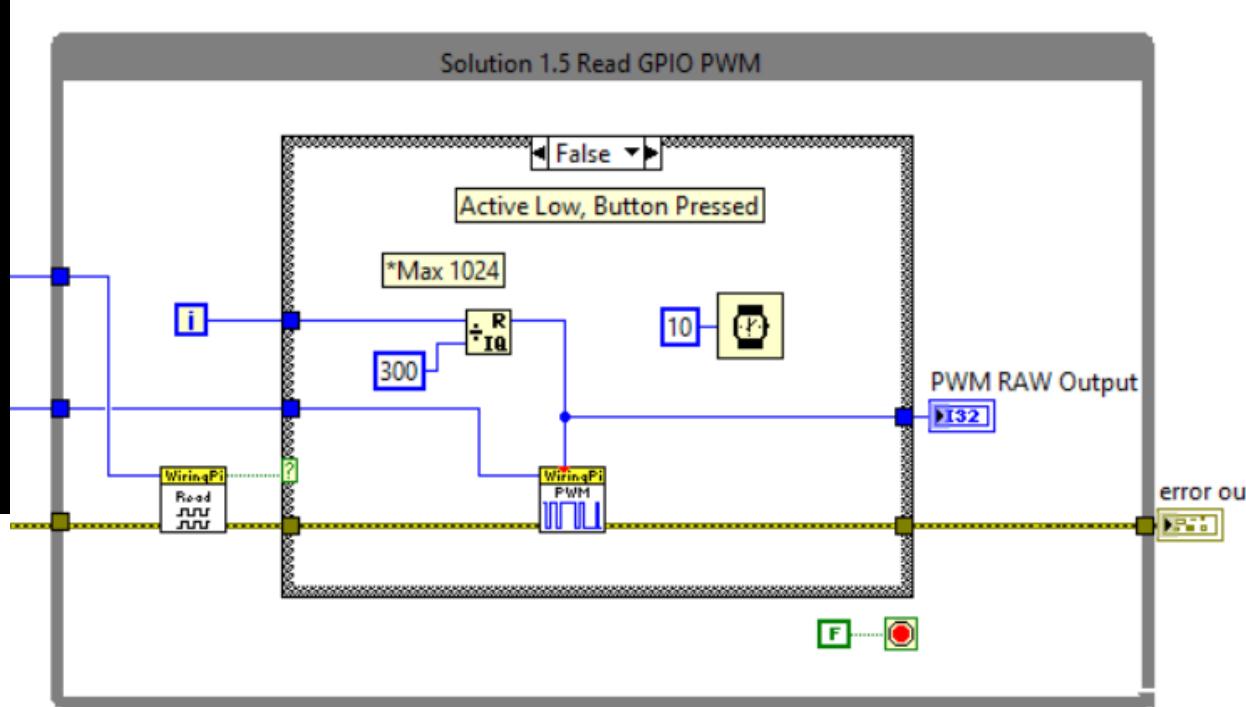
# Exercise 1.3 Blinking LED Time Loop.vi



# Exercise 1.4 PWM.vi

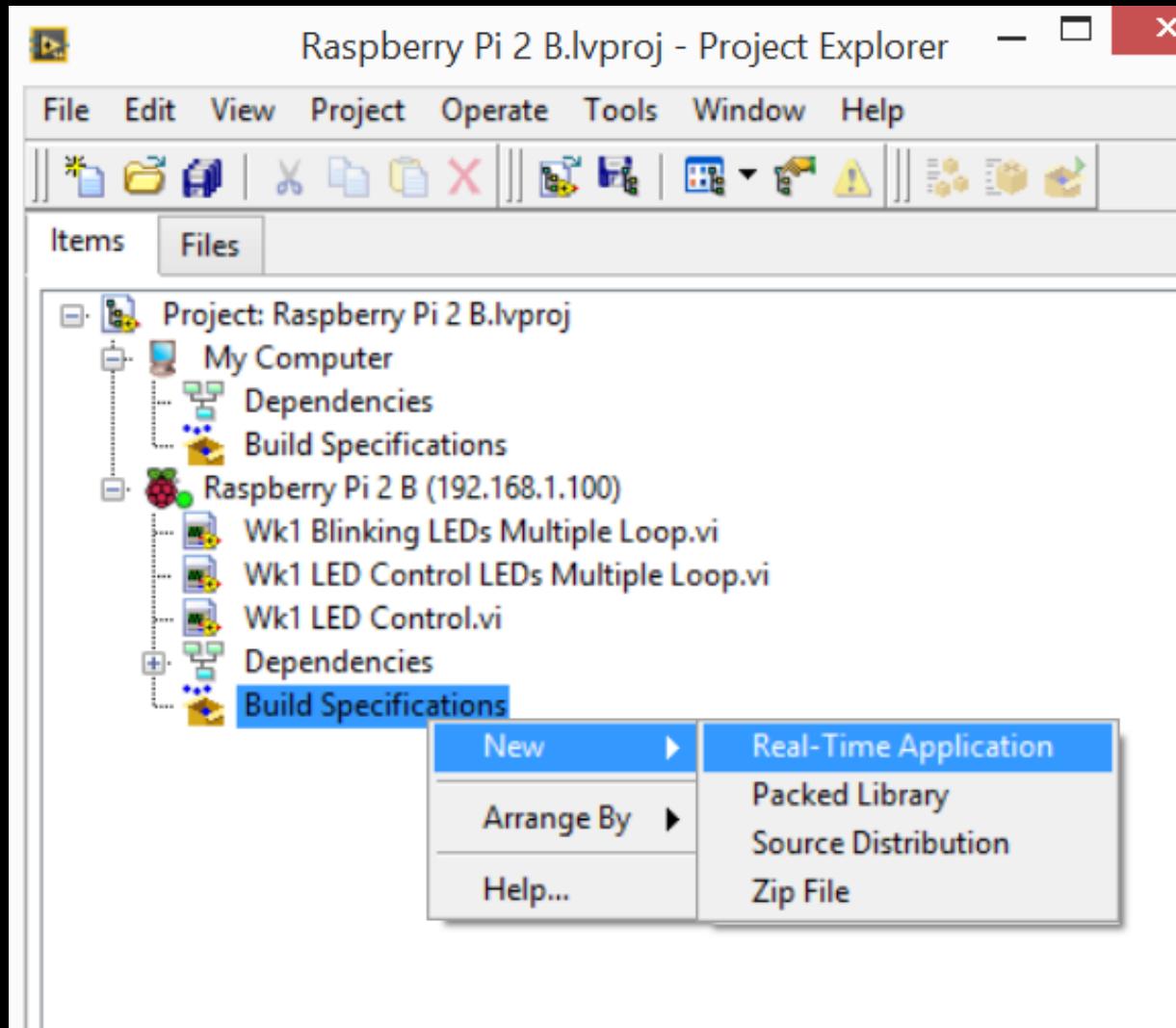


# Exercise 1.5 Read GPIO PWM.vi

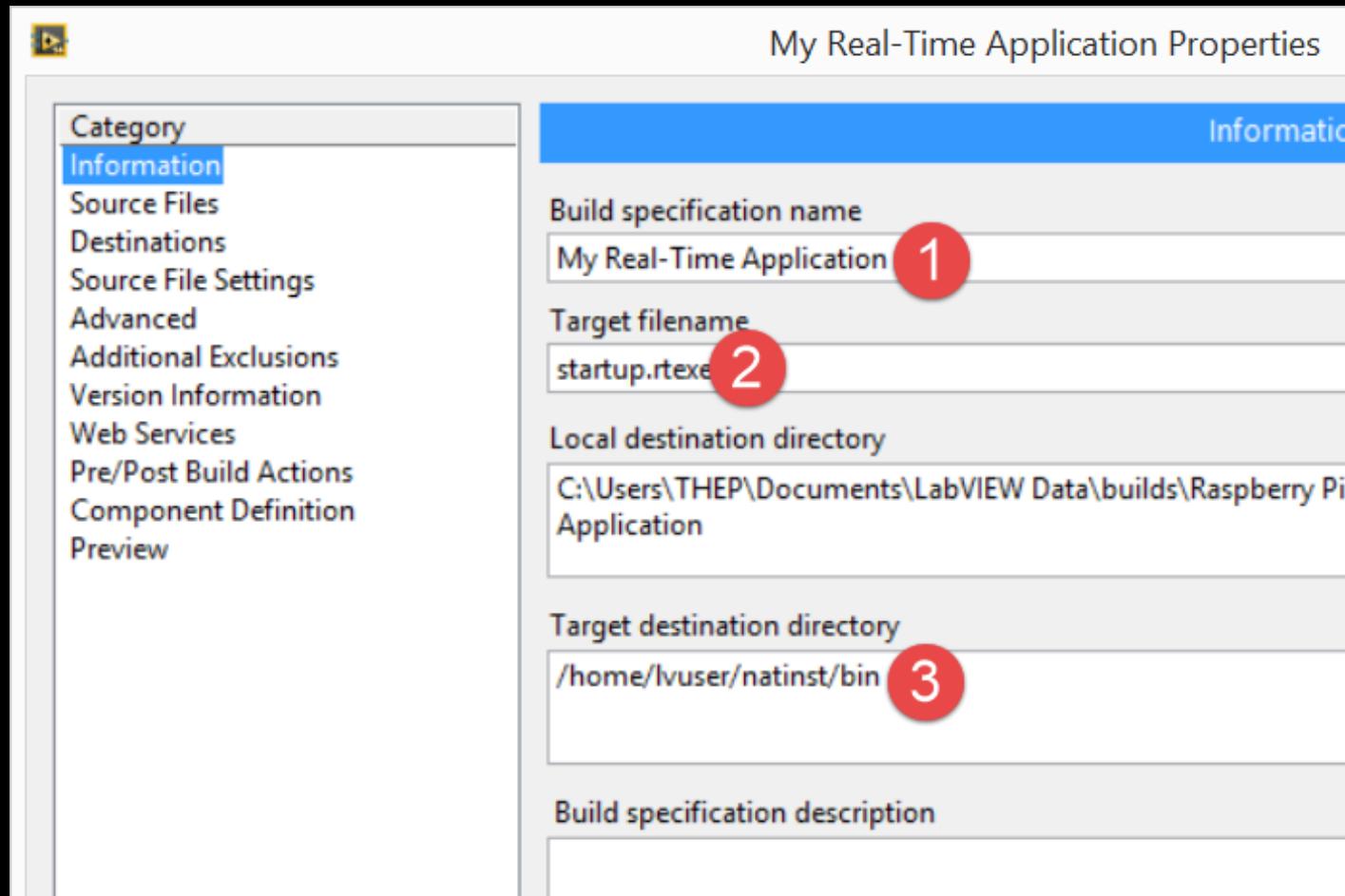


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**SYSTEMS** ■■■  
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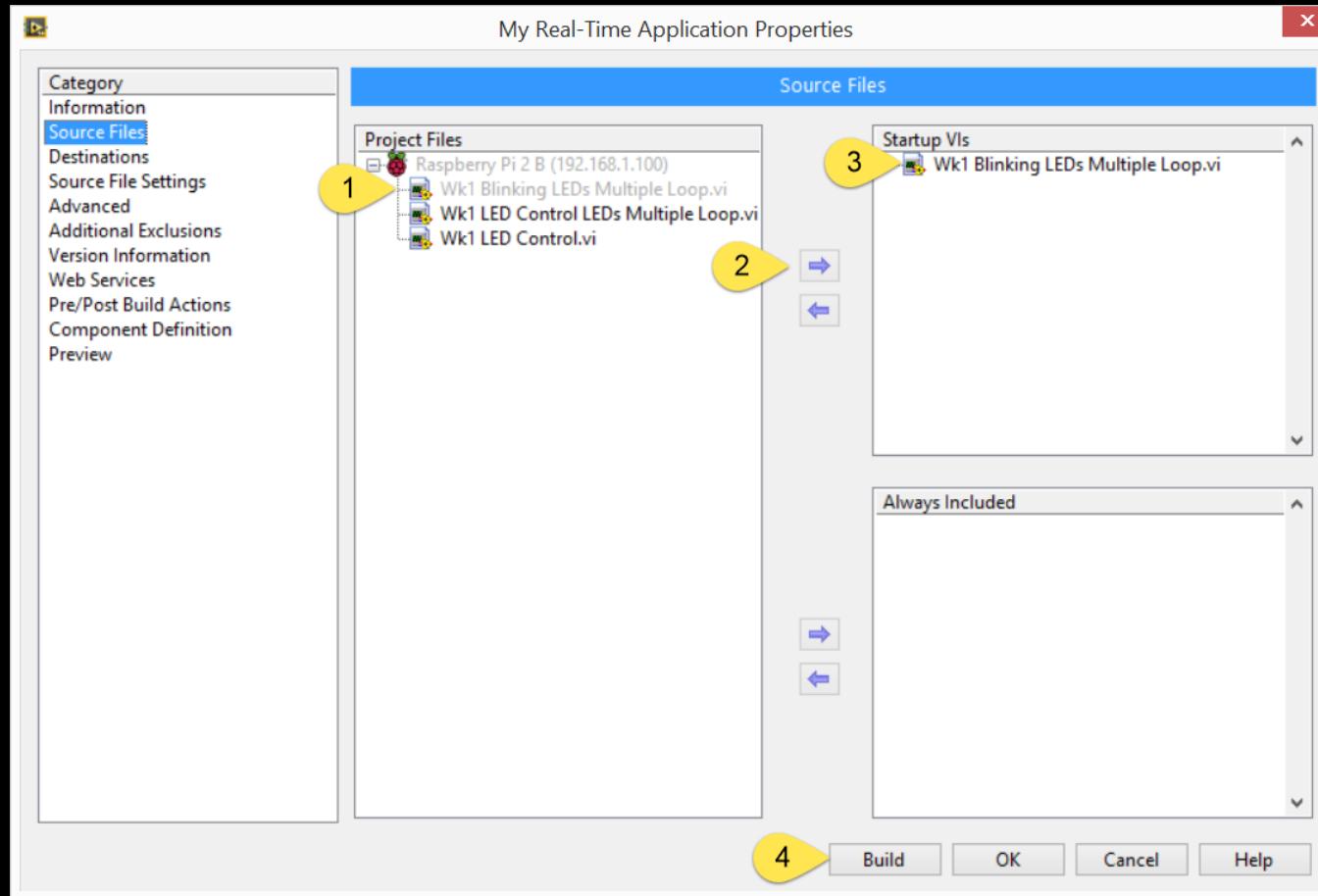
# Create a Executable Application



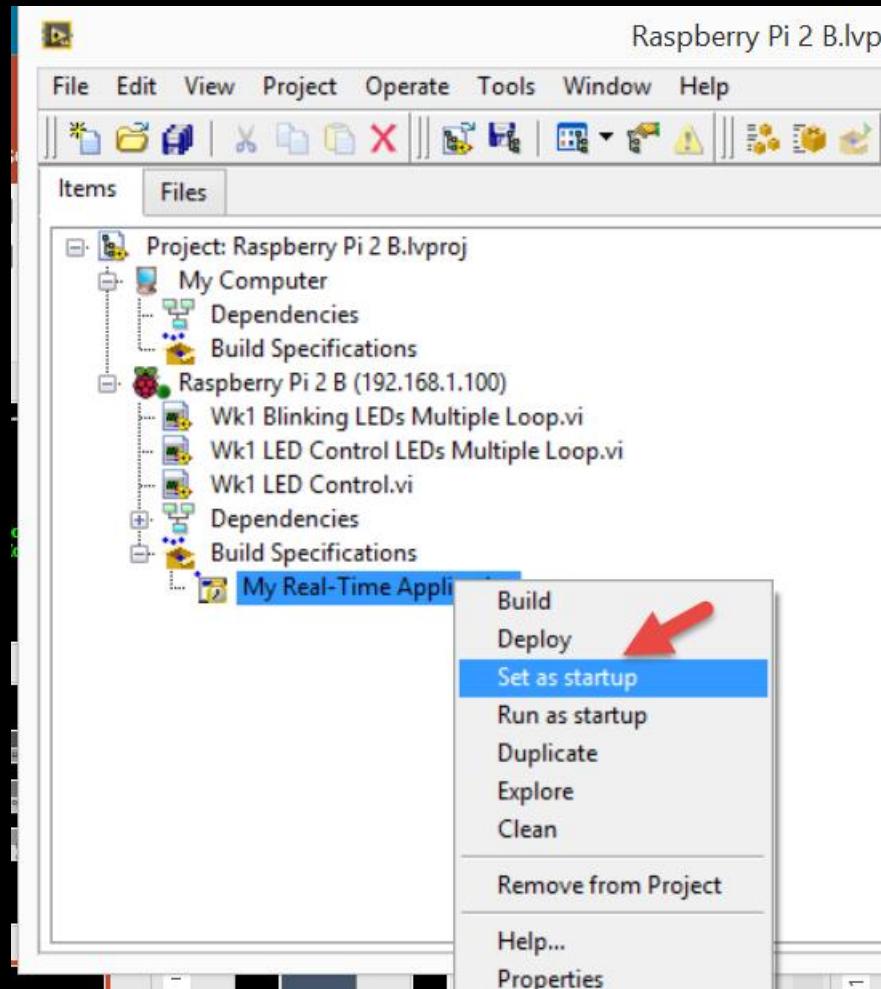
# Information



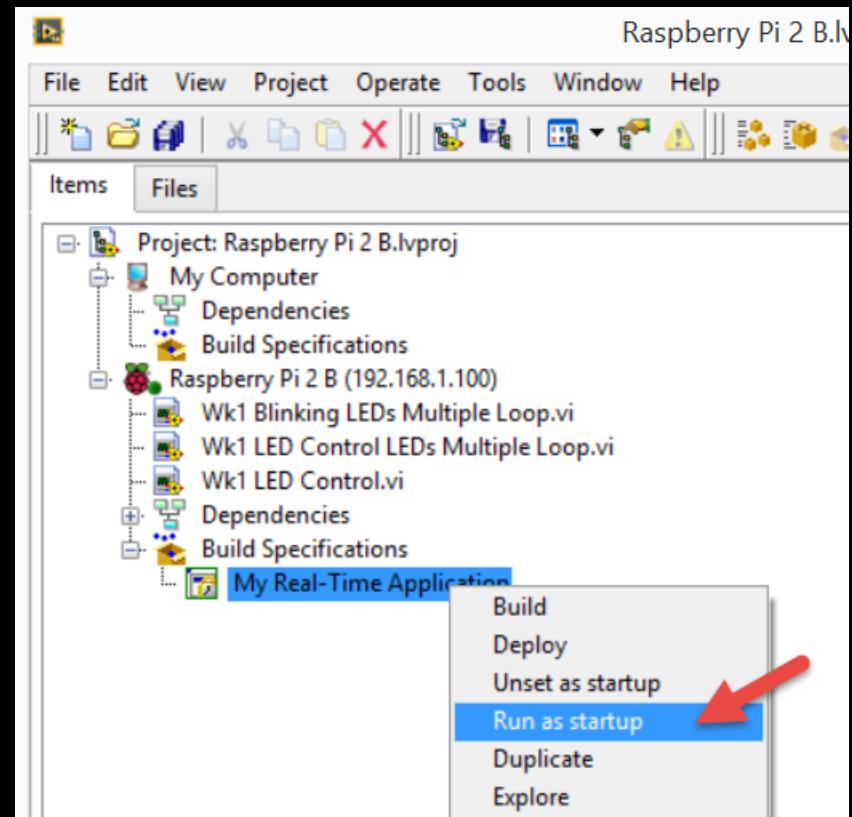
# Setting - Source File > Build



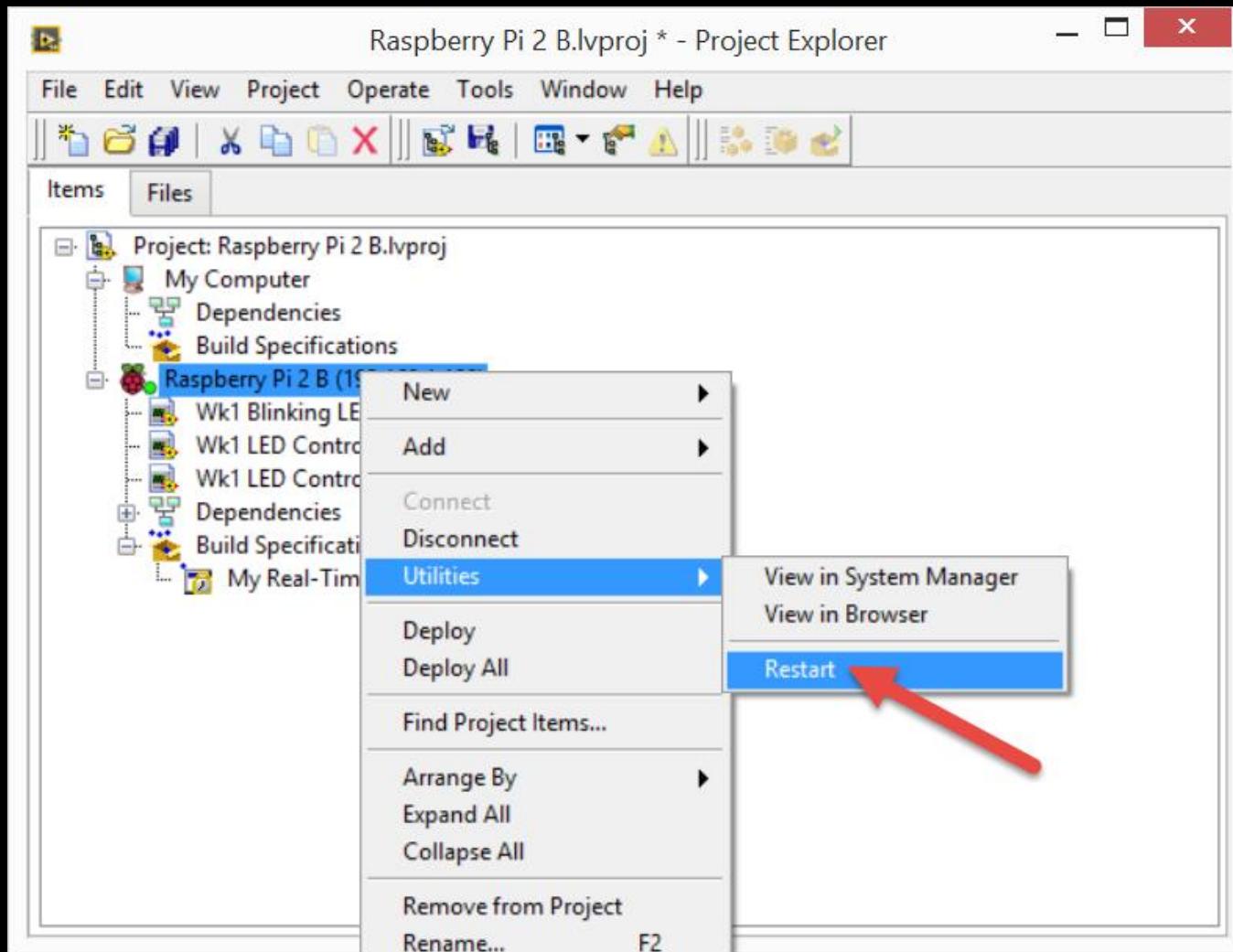
# Setting > Set/Run at Start-up



## Deploy the Code



# Restart : LabVIEW Run-Time (Service)



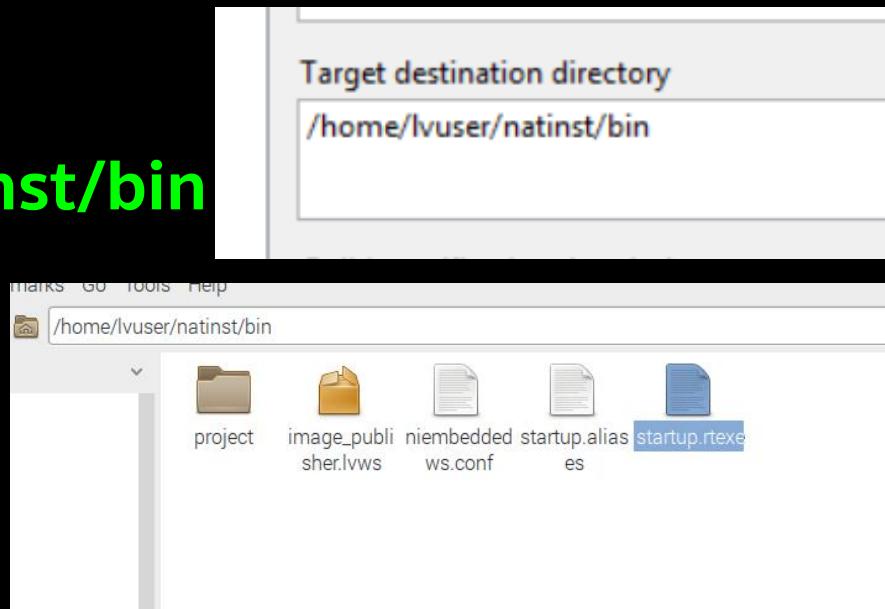
# Reboot the Pi using Command line

- > **reboot**

```
pi@raspberrypi:~ $  
pi@raspberrypi:~ $ reboot  
===== AUTHENTICATING FOR org.freedesktop.login1.reboot =====  
Authentication is required for rebooting the system.  
Multiple identities can be used for authentication:  
1. ,,, (pi)  
2. root  
Choose identity to authenticate as (1-2): 1  
Password:
```

# Remove : Startup App

- > **cd /home/pi/lvuser/natinst/bin**



- > **sudo rm startup.rtexe**

```
pi@raspberrypi:/home/lvuser/natinst/bin $ sudo rm startup.rtexe
pi@raspberrypi:/home/lvuser/natinst/bin $ ls
image_publisher.lvws niembeddedws.conf project startup.aliases
pi@raspberrypi:/home/lvuser/natinst/bin $
```

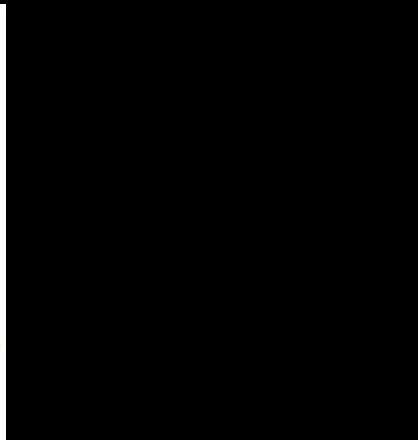
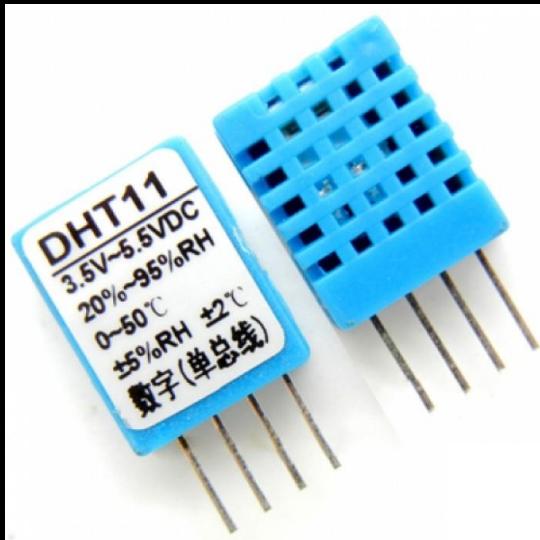
- \*Optional

- > **./rm\_lv\_startup.sh**

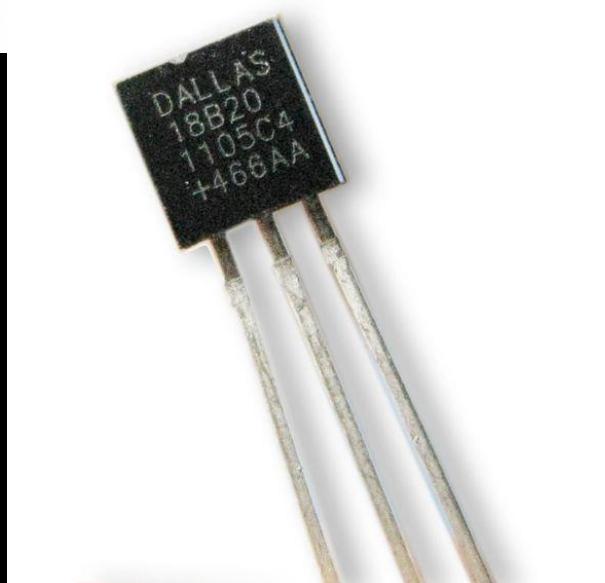
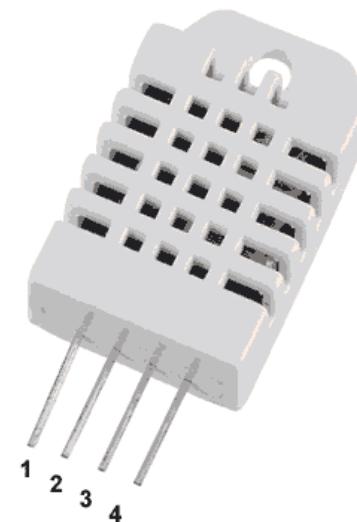
```
#!/bin/bash
sudo rm /home/lvuser/natinst/bin/startup.rtexe
```

2

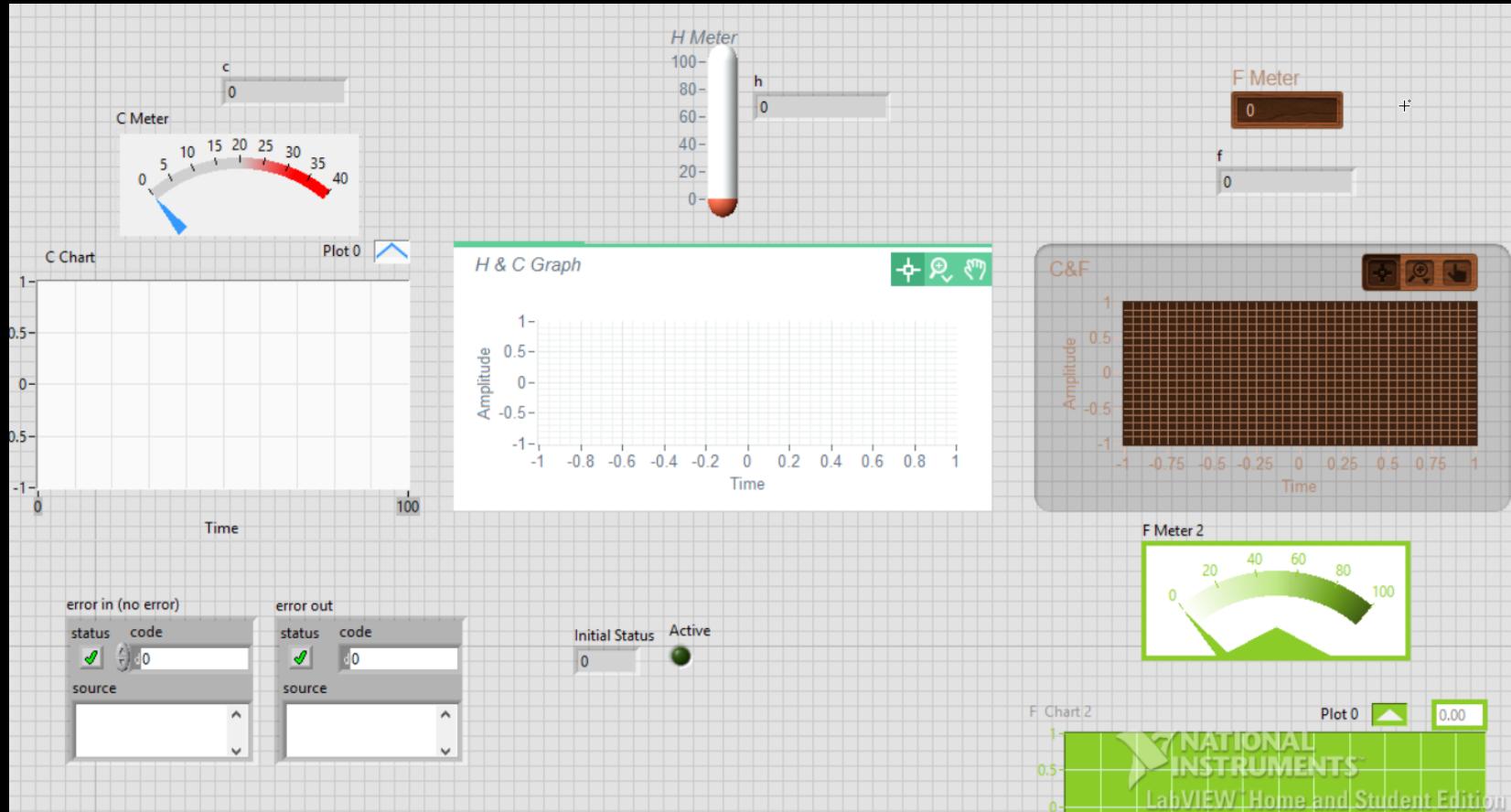
# Exercise 2 Temp Sensor



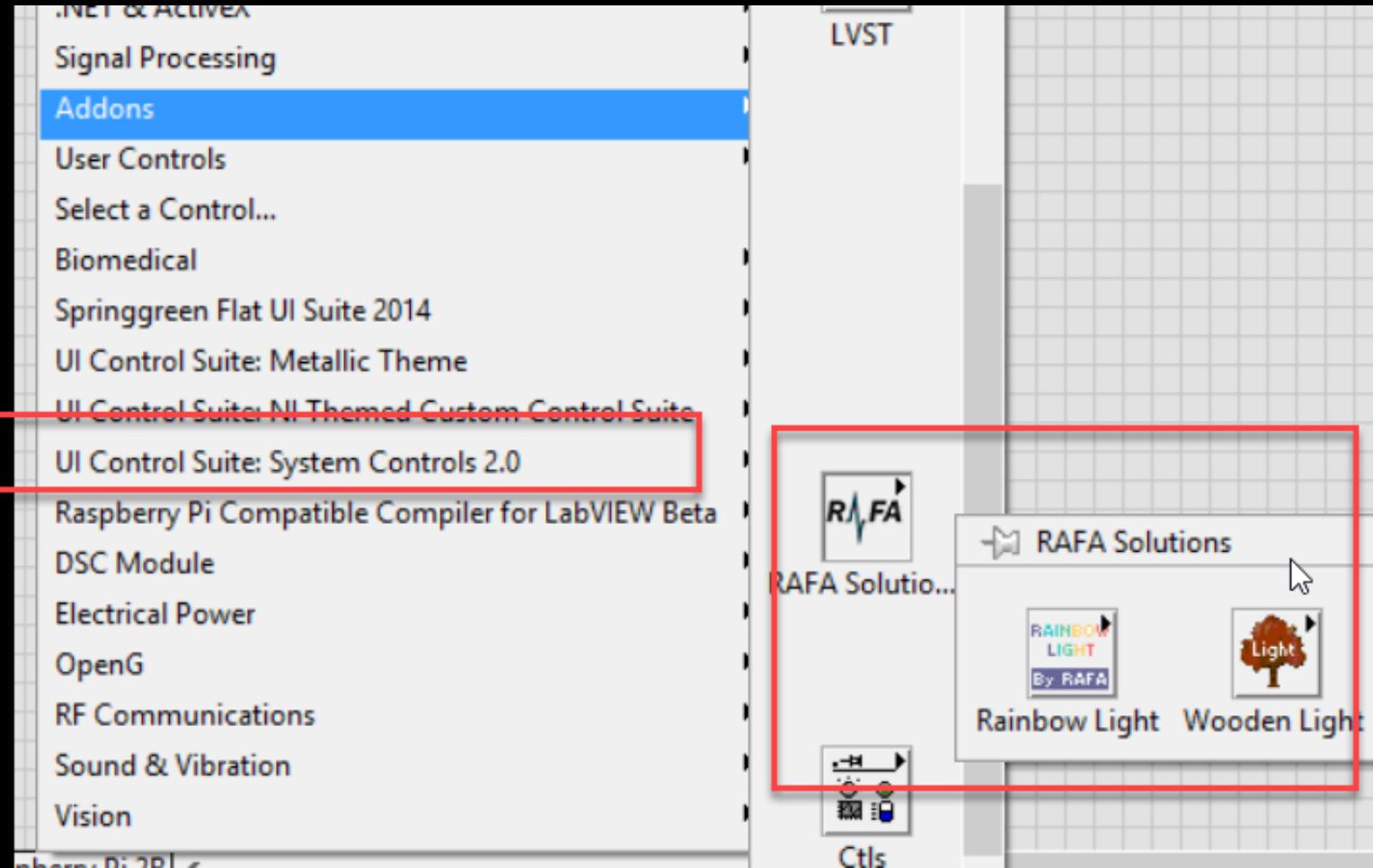
DHT22 pins	
1	VCC
2	DATA
3	NC
4	GND



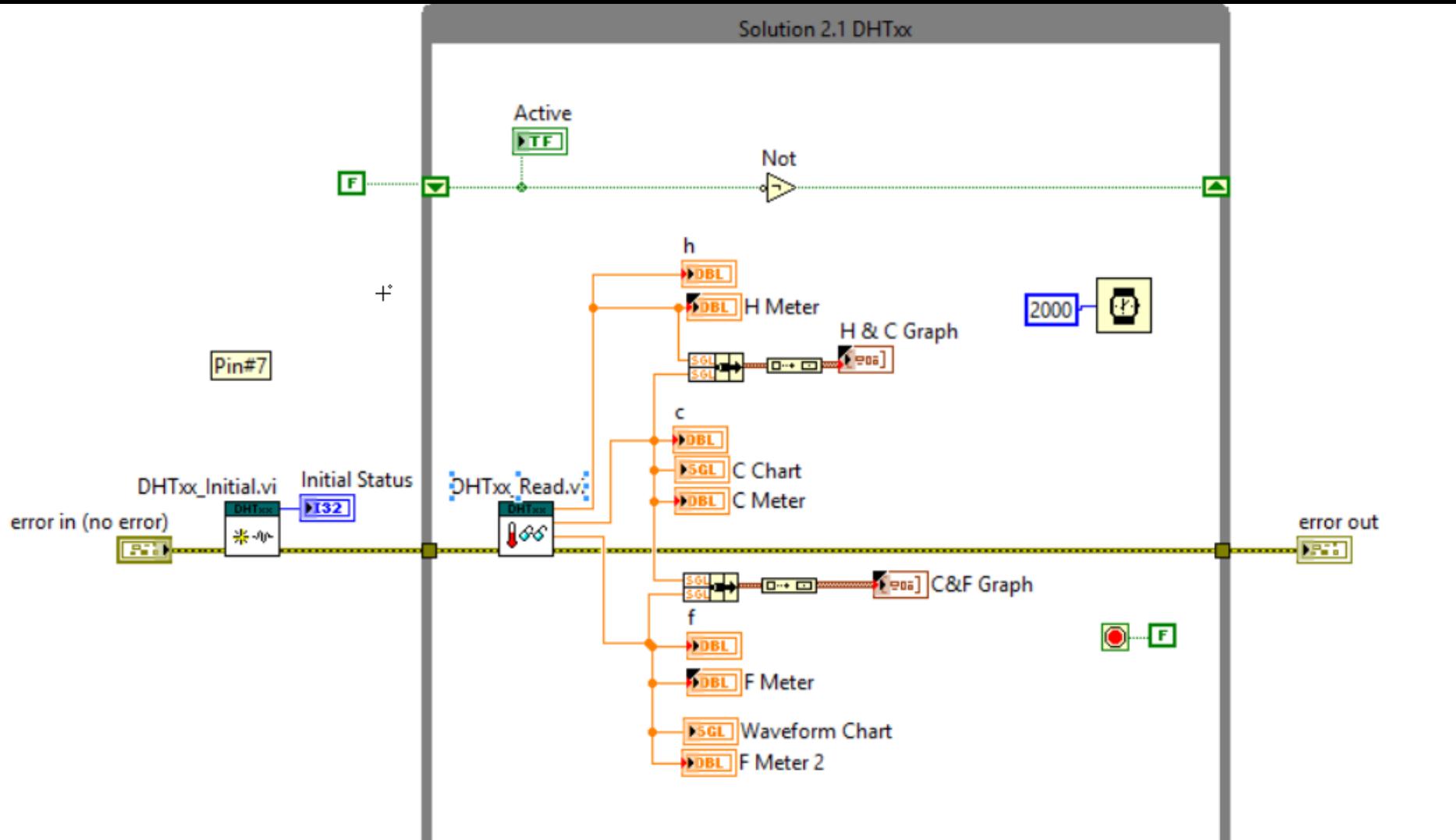
# Exercise 2.1 DHTxx



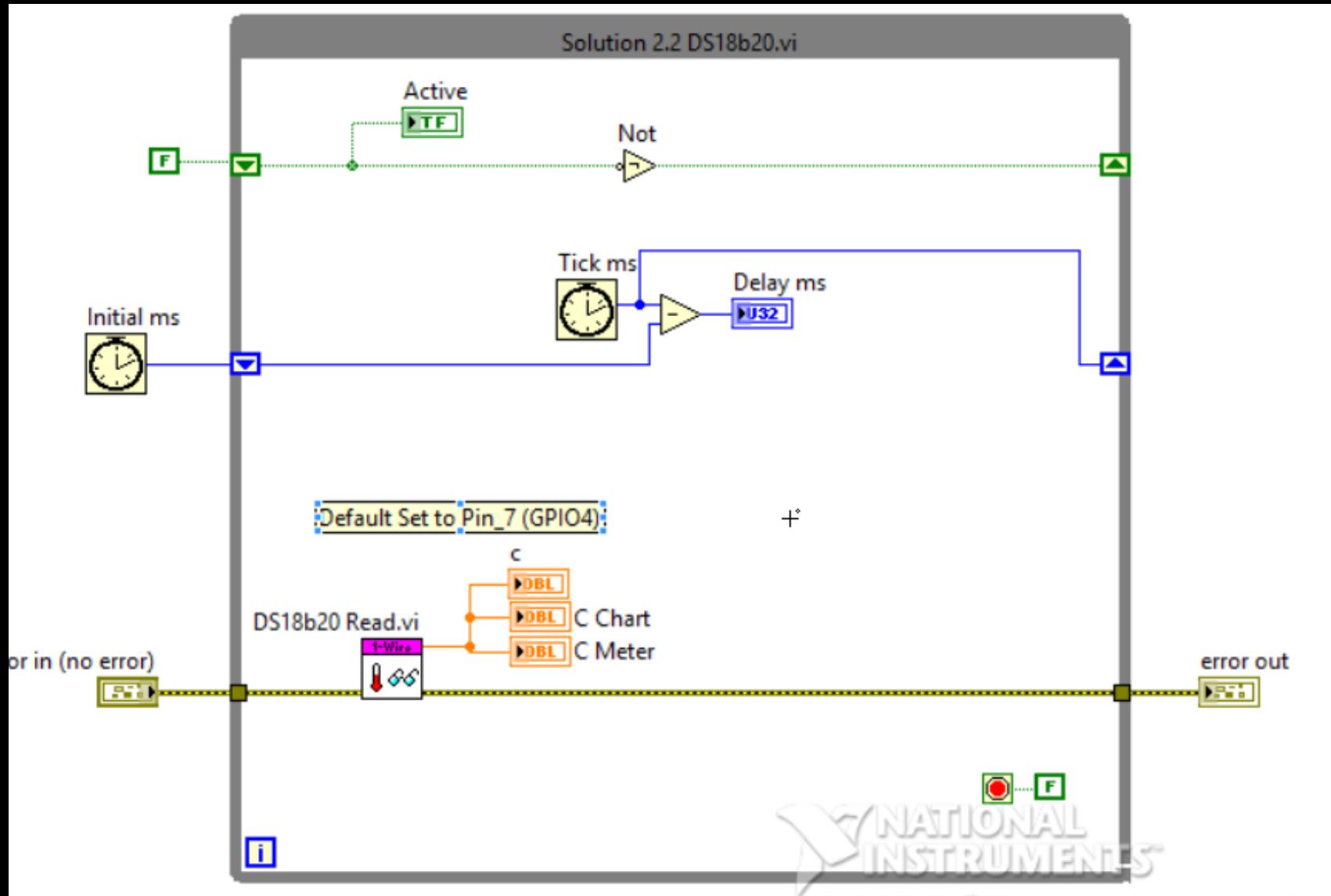
# Control/Indicator Toolkit



# Exercise 2.1 DHTxx

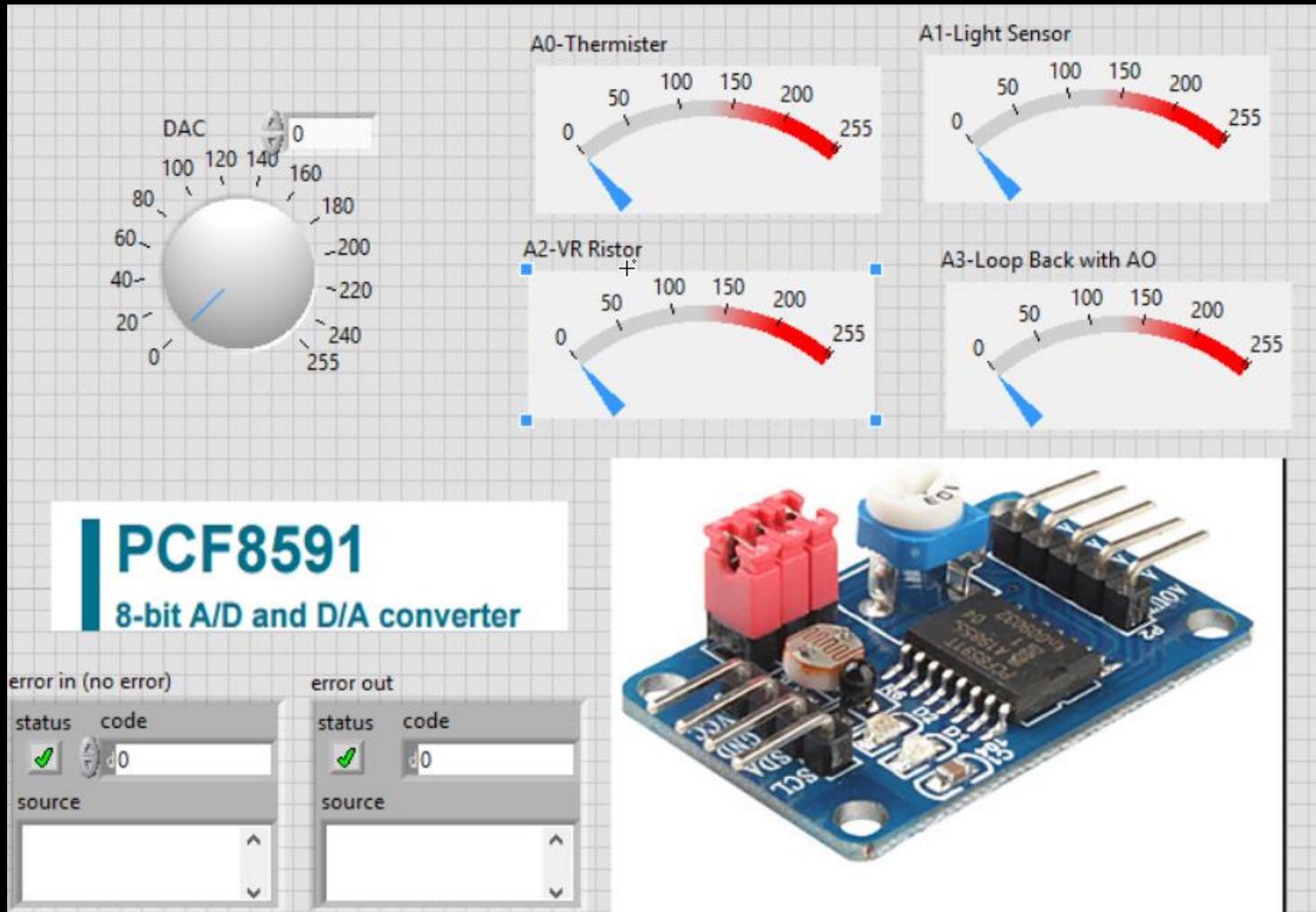


# Exercise 2.2 DS18b20



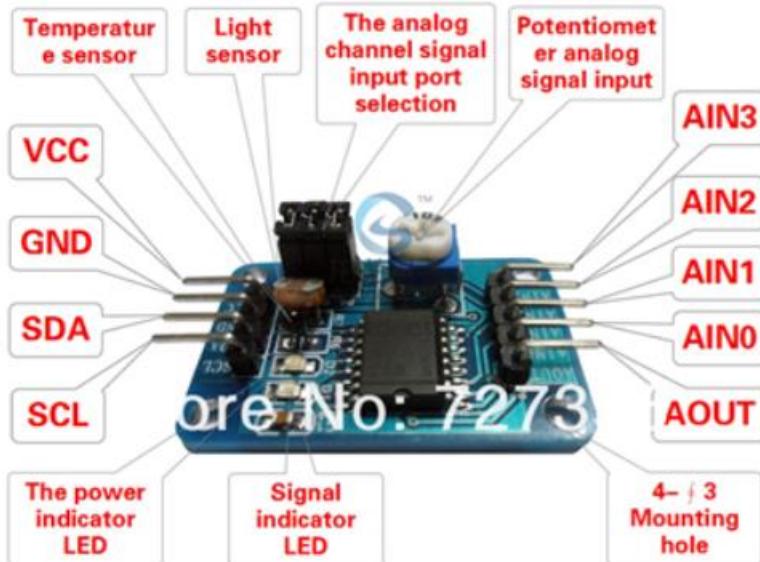
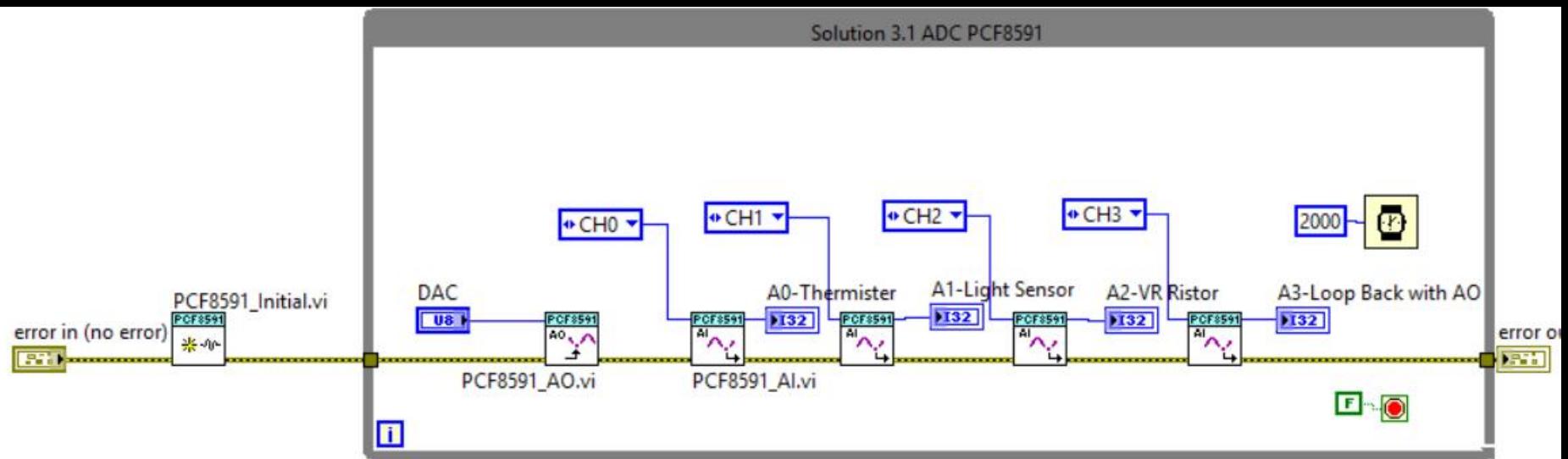
# 3

# Exercise 3 ADC



Connect the shorting cap P4 P4 , select thermistor access circuit  
 Connect the shorting cap P5 P5 , select photoresistor access circuit  
 Connect the shorting cap P6 P6 , select 0-5V Adjustable voltage access circuit

# Exercise 3.1 ADC PCF8591.vi



**Calculations**

The board normally uses the 3.3v supply as the reference voltage, so:

The input voltage is determined with:

$$v_{in} = \text{value} * 3.3 / 255$$

and the output voltage is:

$$v_{out} = \text{value} / 255 * 3.3$$

or to find the value for a given voltage:

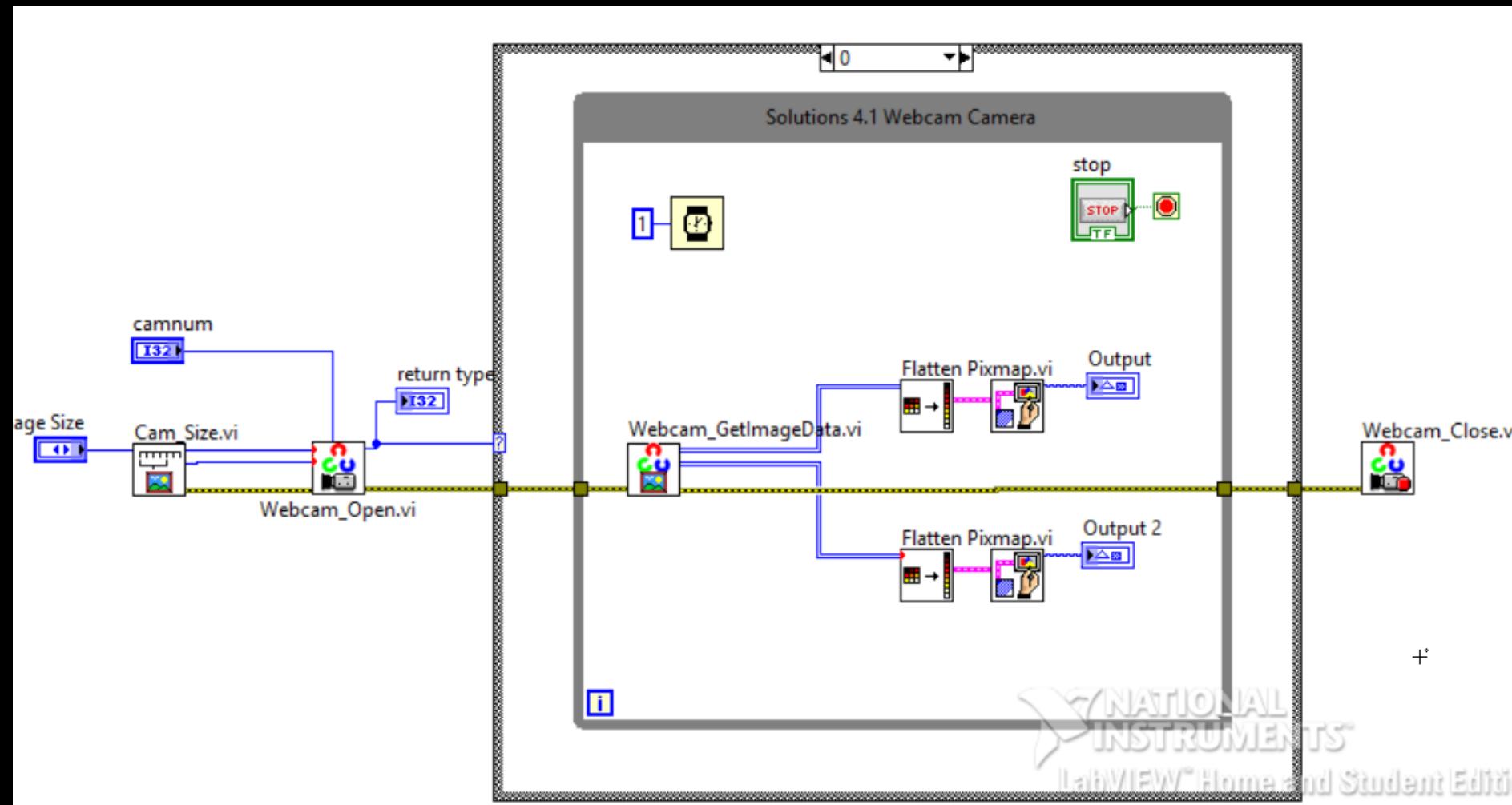
$$\text{value} = v_{out} / 3.3 * 255$$

# 4

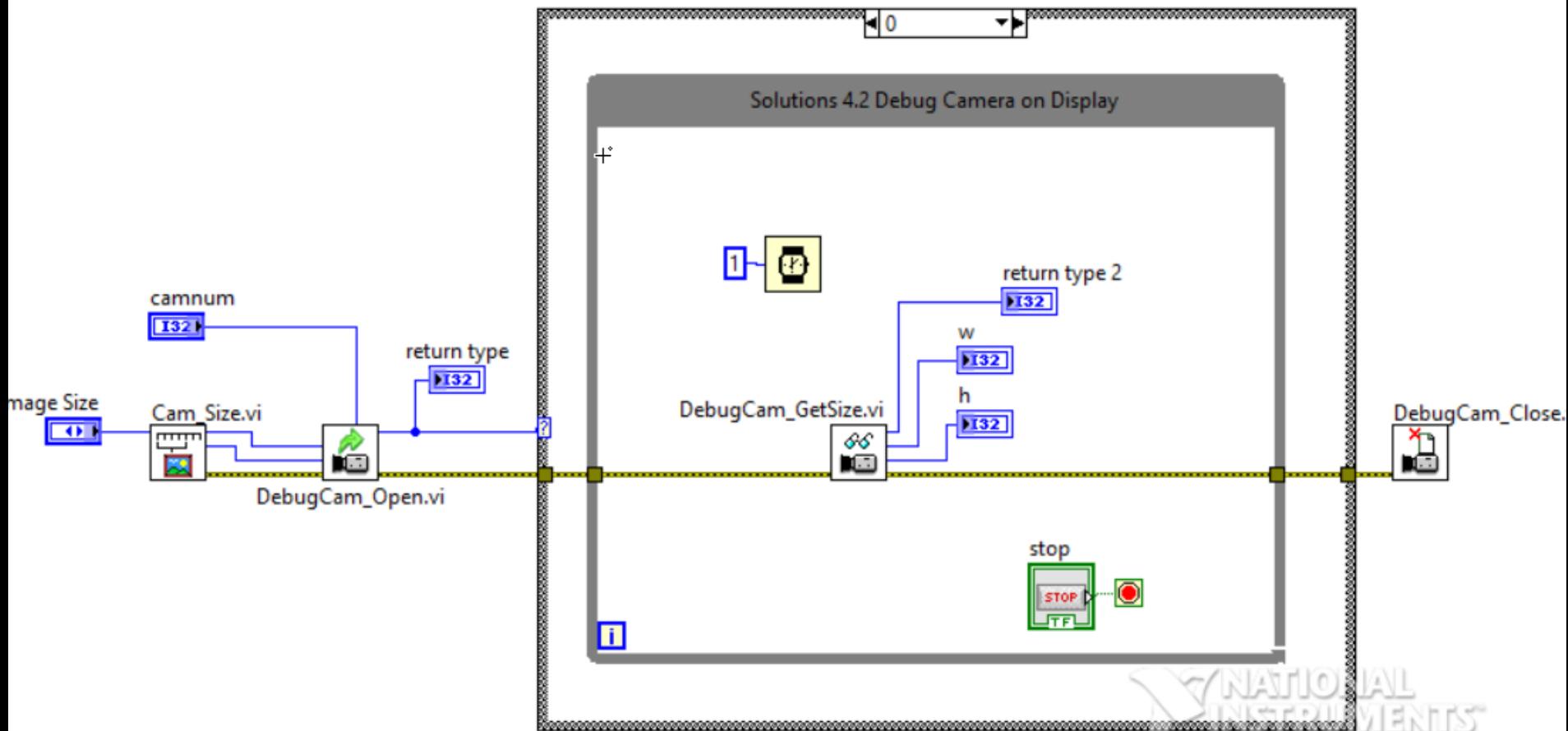
# Exercise 4 Camera



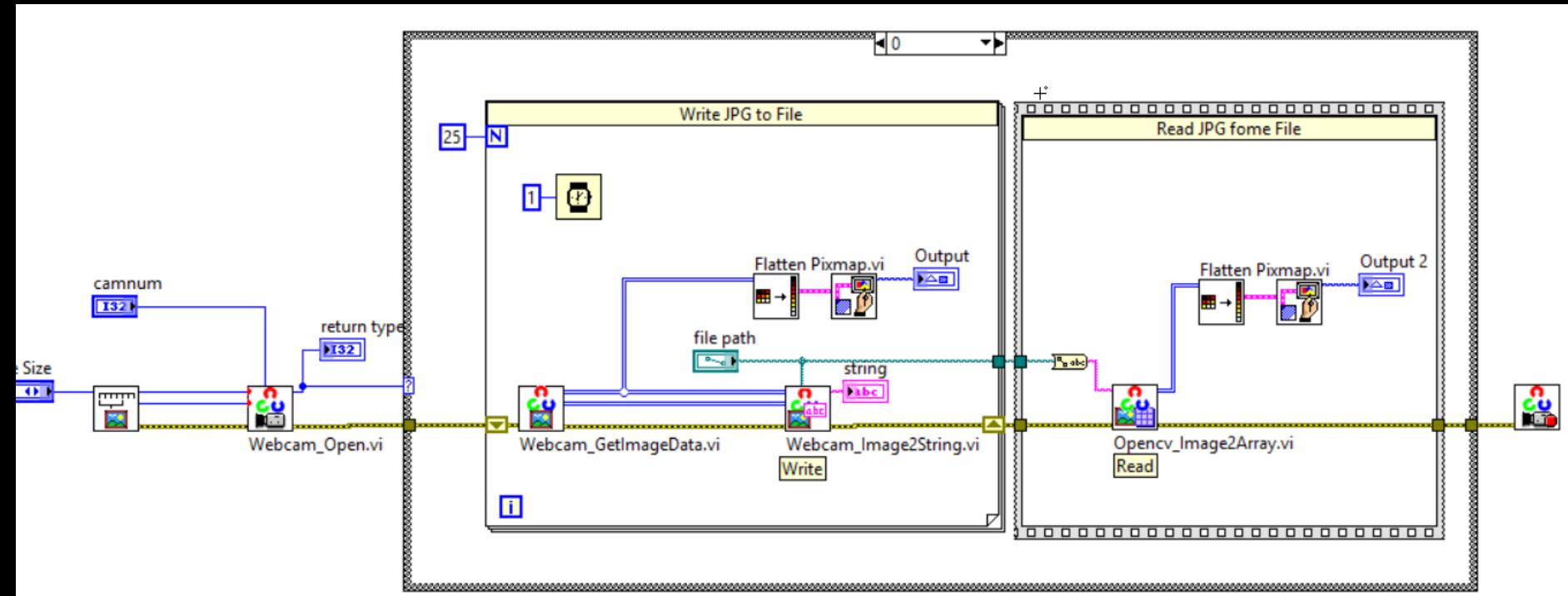
# Exercise 4.1 Webcam Camera



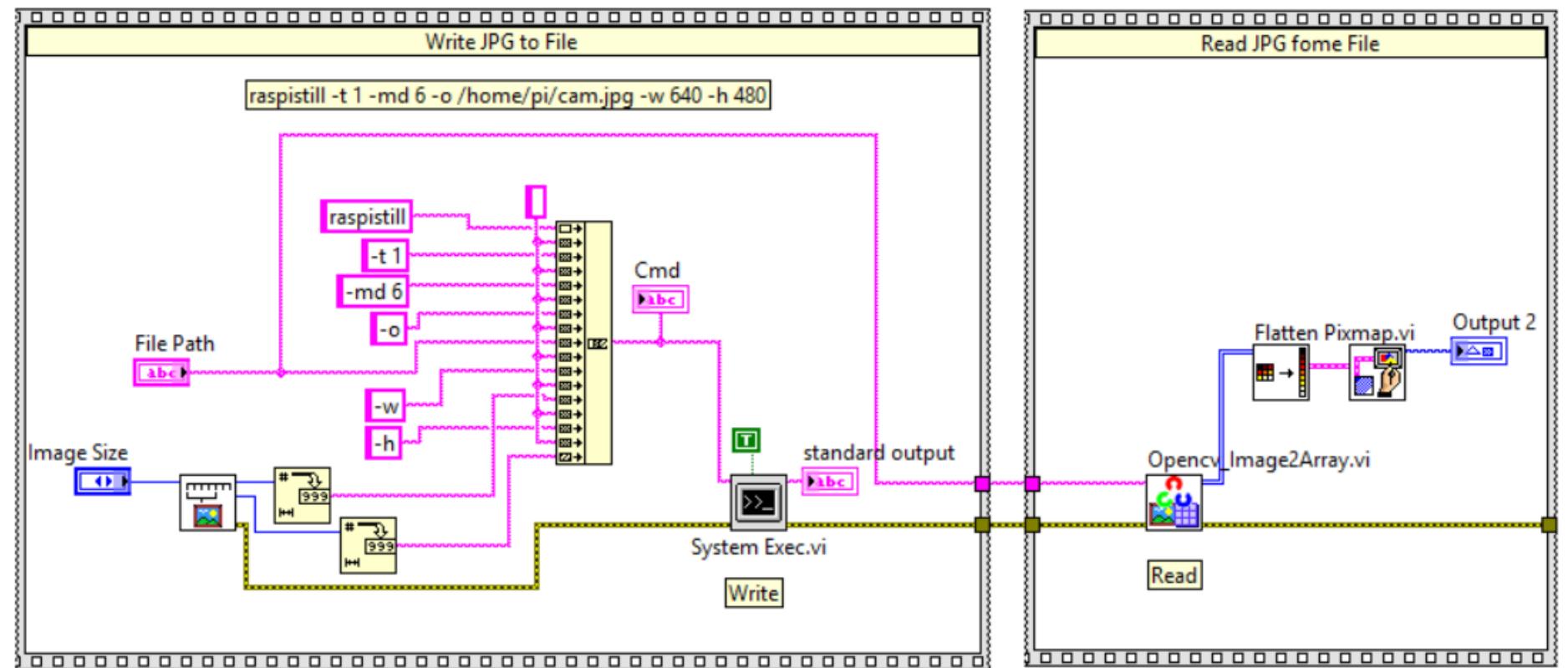
# Exercise 4.2 Debug WebCam on Display



# Exercise 4.3 Webcam to JPG

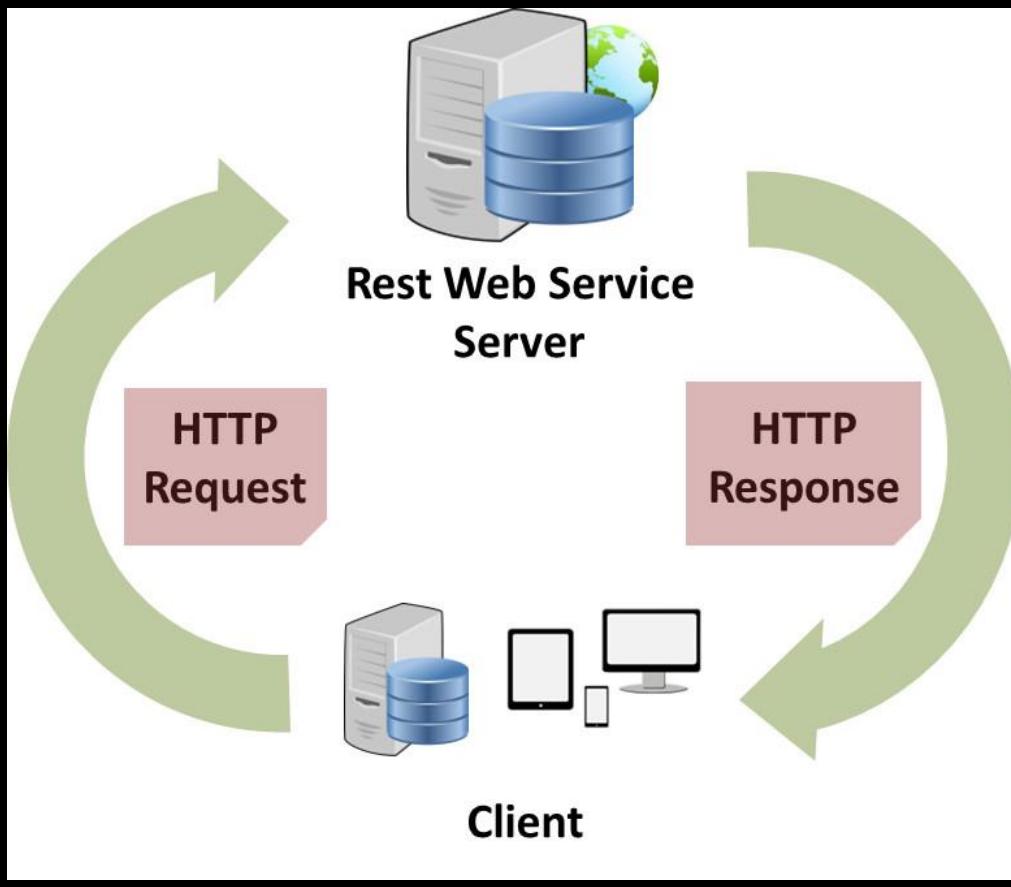


# Exercise 4.4 RPi Cam to JPG



# 5

# Exercise 5 Webservice

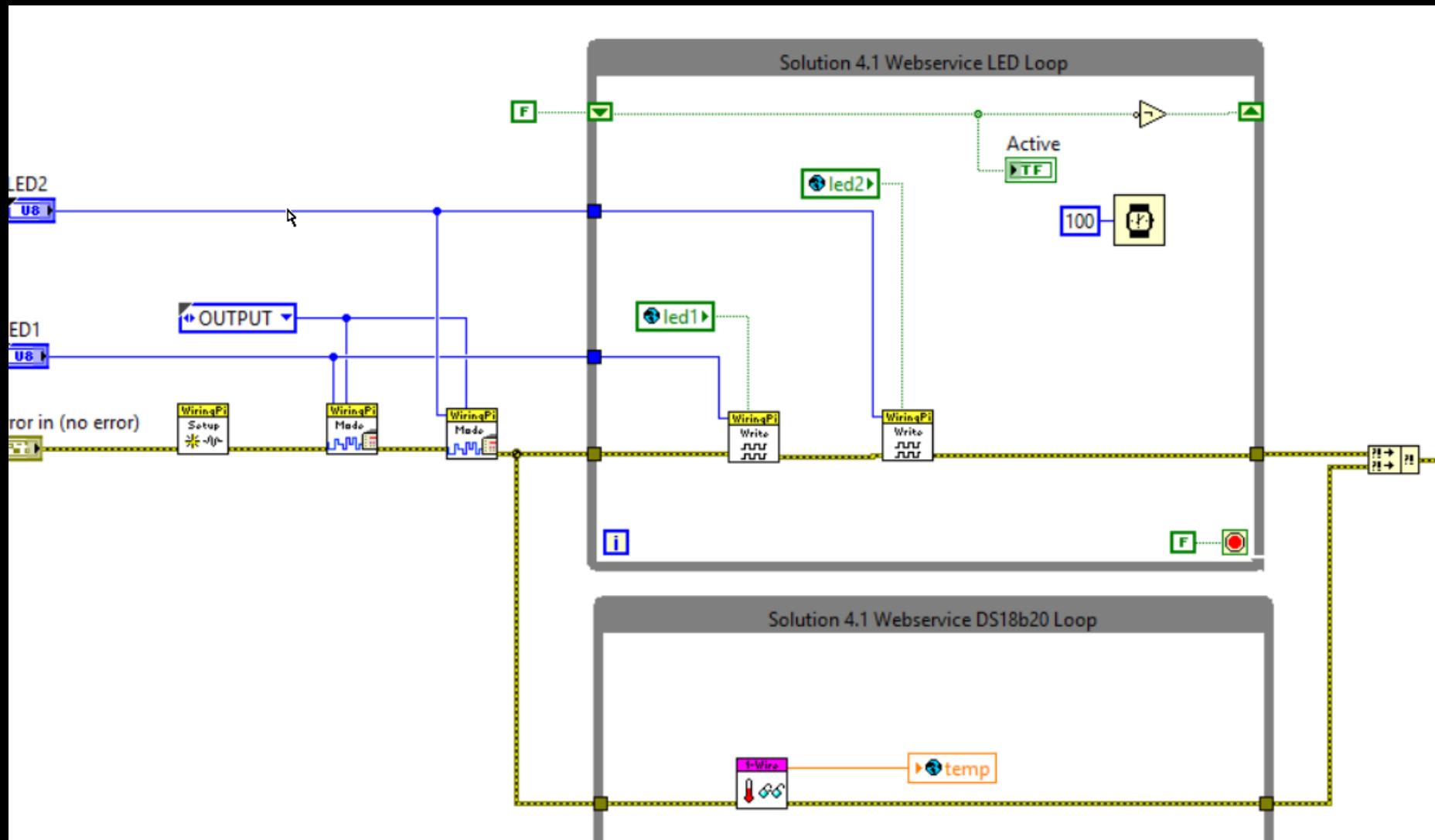


## Creating RESTful Web Service

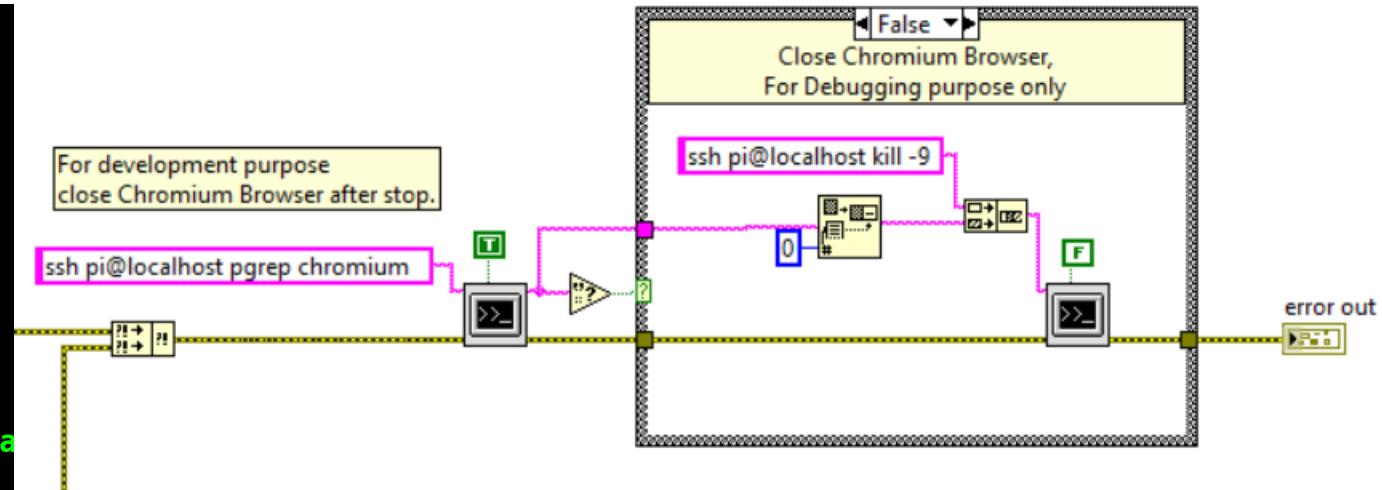
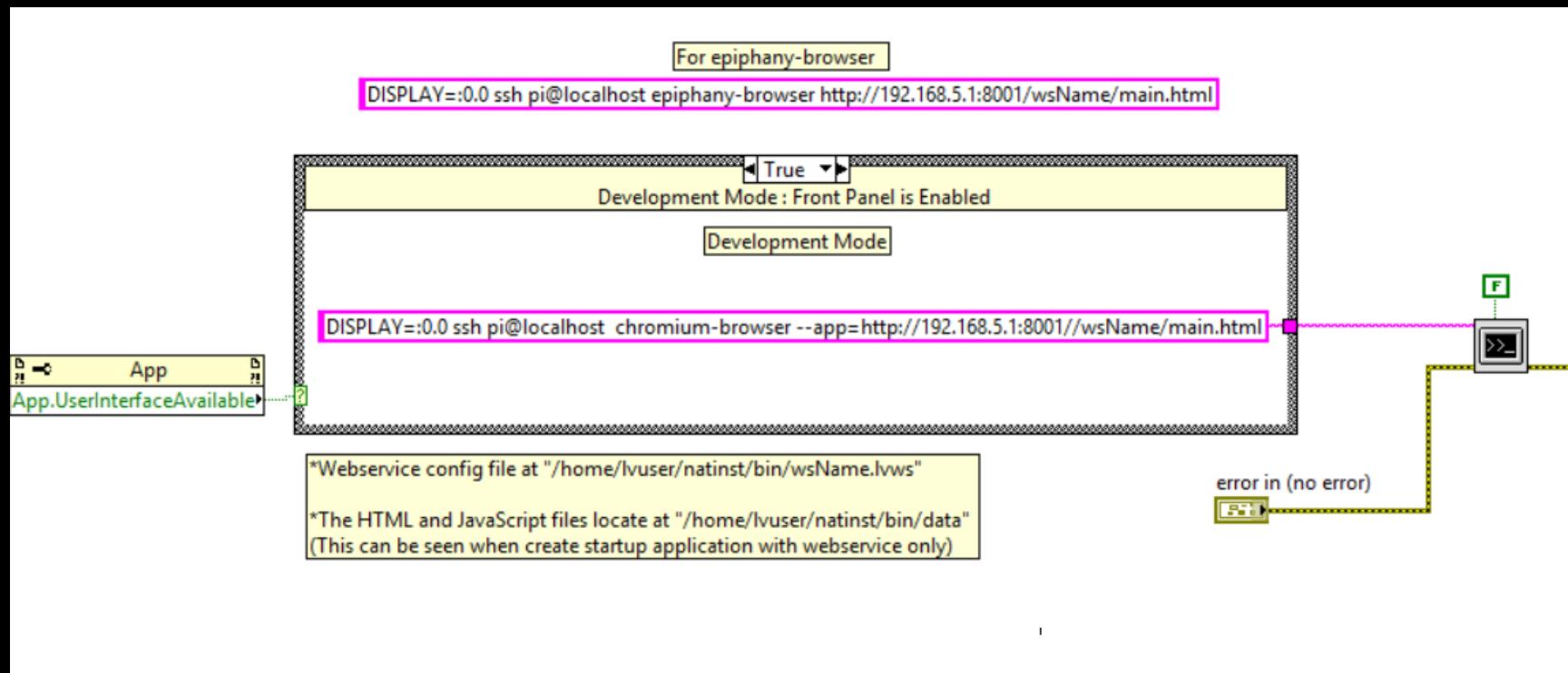
This tutorial will create a web service say user management with following functionalities:

Sr. No.	HTTP Method	URI	Operation	Operation Type
1	GET	/UserService/users	Get list of users	Read Only
2	GET	/UserService/users/1	Get User with Id 1	Read Only
3	PUT	/UserService/users/2	Insert User with Id 2	Idempotent
4	POST	/UserService/users/2	Update User with Id 2	N/A
5	DELETE	/UserService/users/1	Delete User with Id 1	Idempotent
6	OPTIONS	/UserService/users	List the supported operations in web service	Read Only

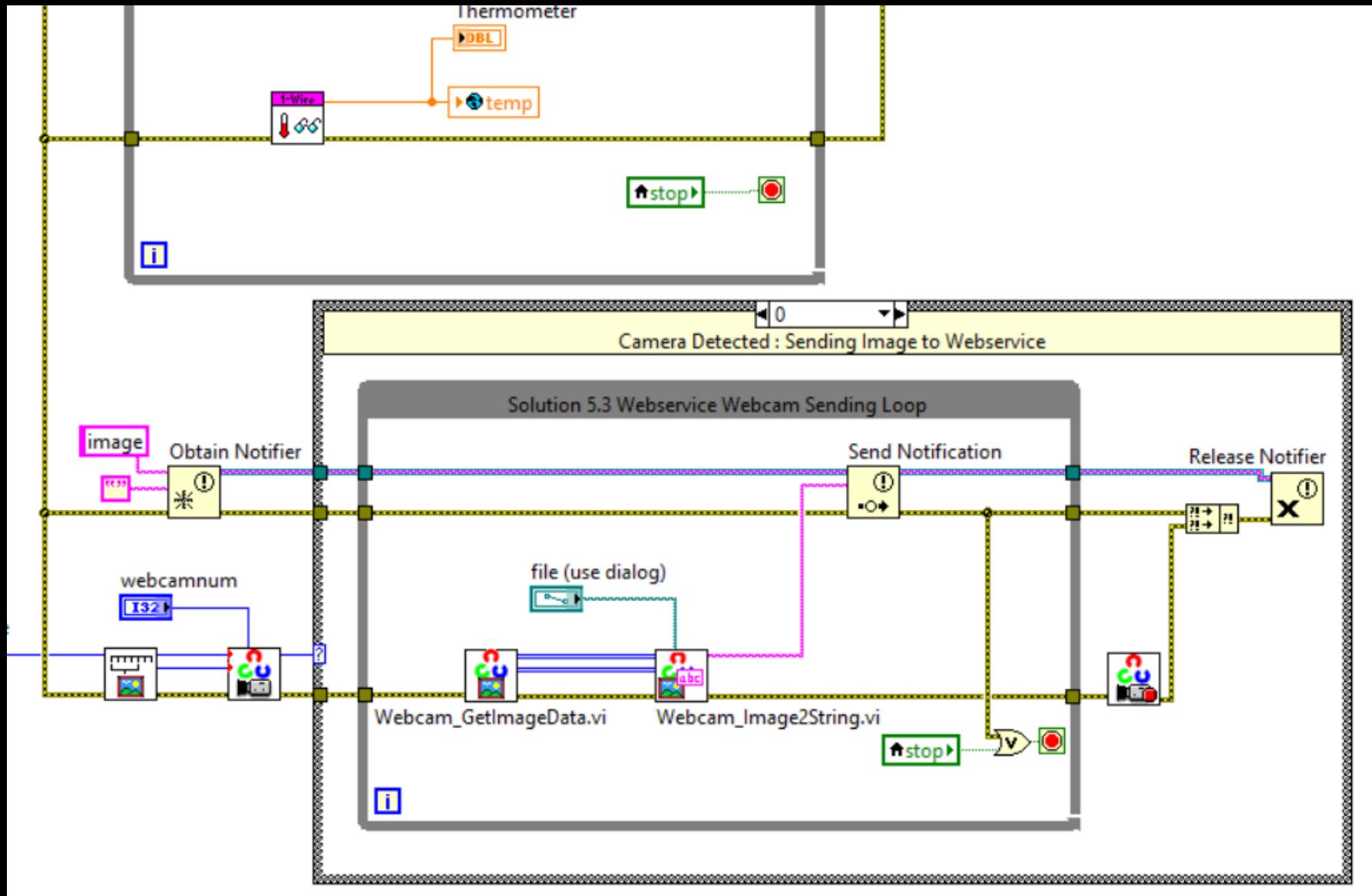
# Exercise 5.1 Webservice



# Exercise 5.2 Webservice Pi Browser



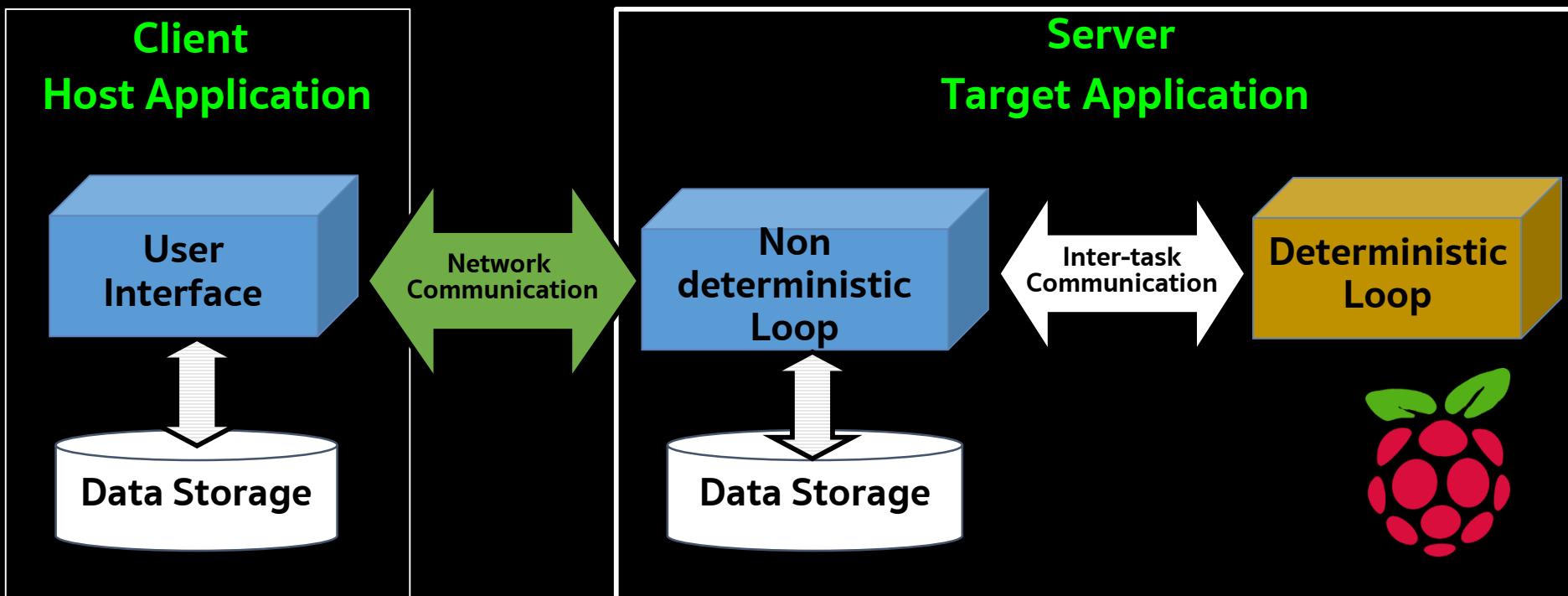
# Exercise 5.3 Webservice Webcam



# 6

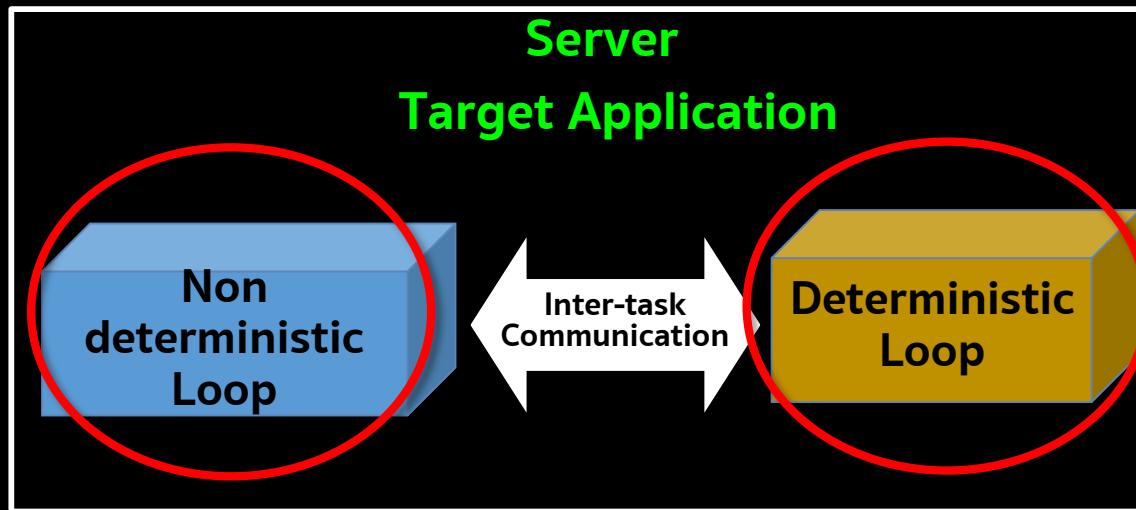
# Exercise 6 Network Communication (TCP)

- Host –Target Application Architecture



# Target Application

- ประมวลผลแบบทันทีทันใจ Real-Time Loop
- ทำงานเฉพาะเจาะจงตามพัิงก์ชั้นที่ออกแบบ
- ติดต่อกับ I/O, Hardware, Data Logger
- ทำงาน Background ไม่ต้องมี User Interface



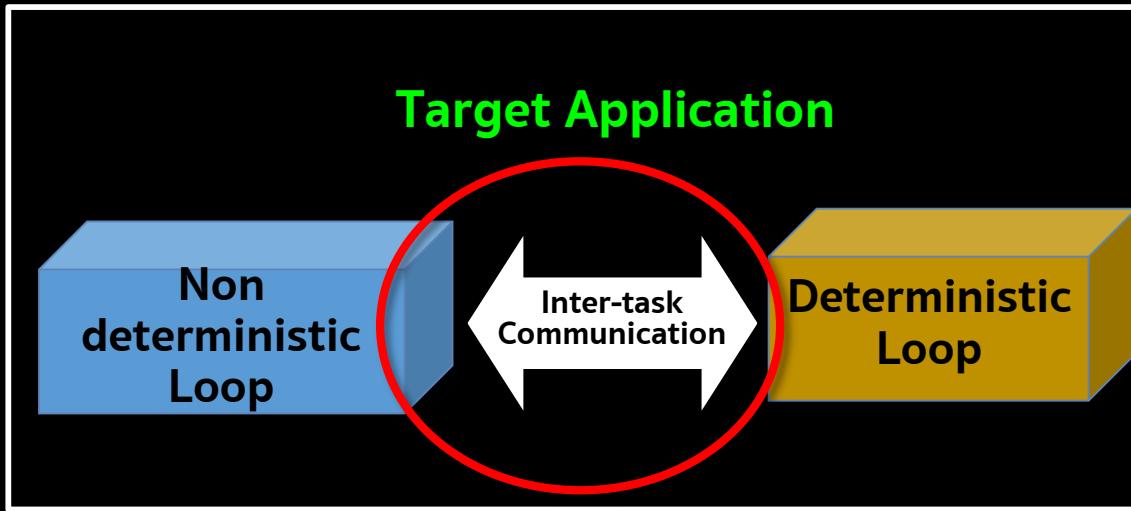
## Non-deterministic task examples

- Network Communication
- Data logging

## Deterministic task examples

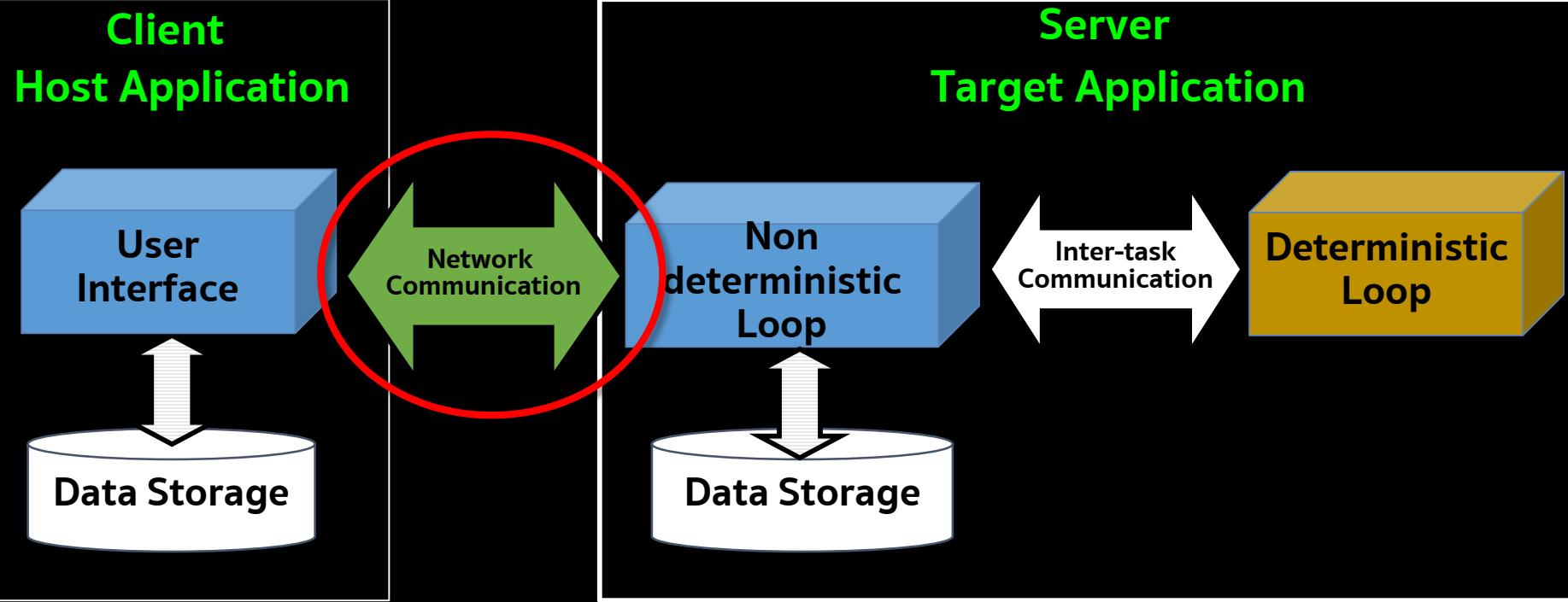
- Control loop
- Safety monitoring

# Sharing Data Locally on RasPi Target

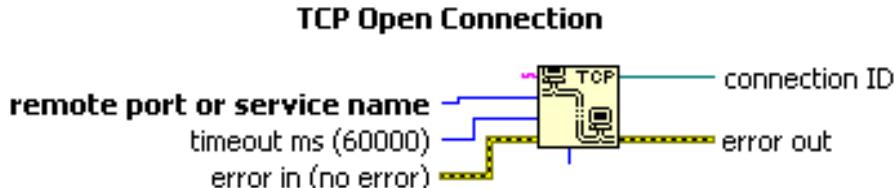


Use case	Description	Examples
Latest value	Only need to share the latest value	<ul style="list-style-type: none"> <li>Check if another loop has stopped</li> <li>Monitoring current I/O values</li> </ul>
Every value	Need to share every value written using multi-element buffer. Cannot lose any values.	<ul style="list-style-type: none"> <li>Send data to non-deterministic file logging loop</li> <li>Send data to non-critical data processing and analysis loop</li> </ul>

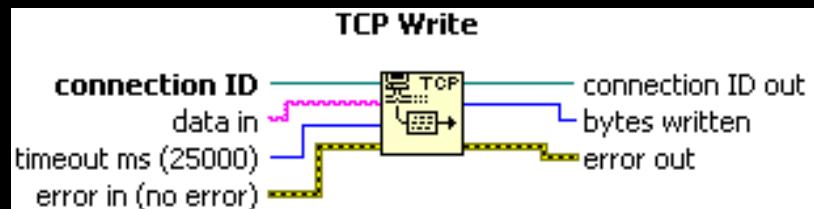
# Network Communication



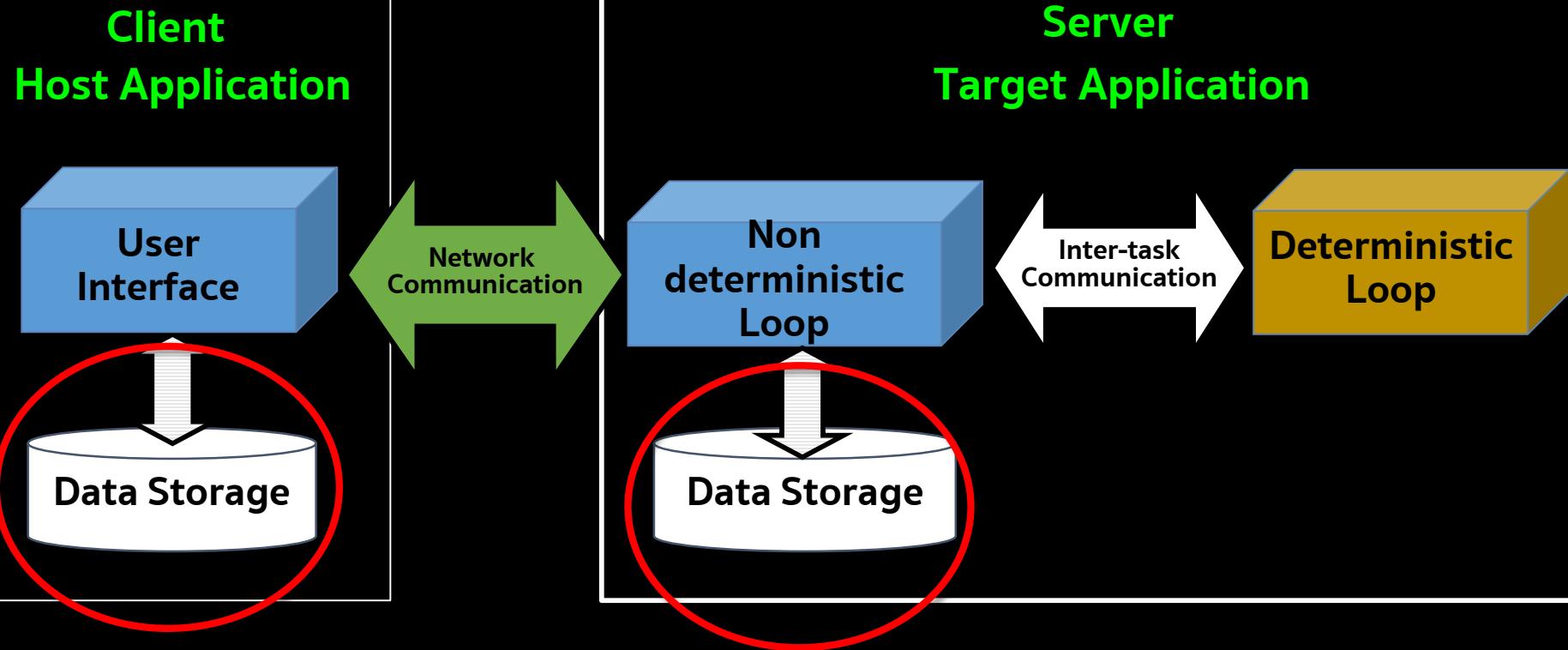
- Methods
- TCP, UDP => STM Library



53

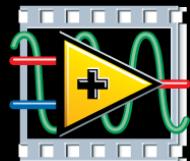
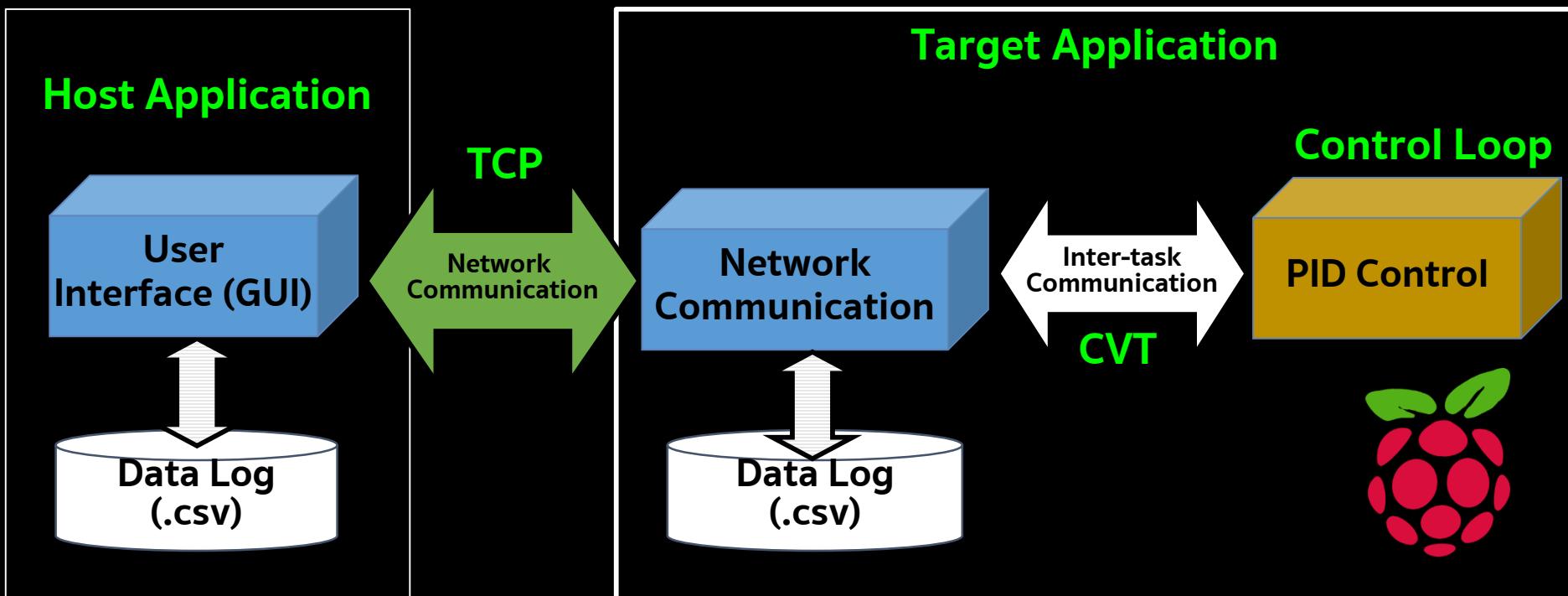


# Data Storeage (File I/O)

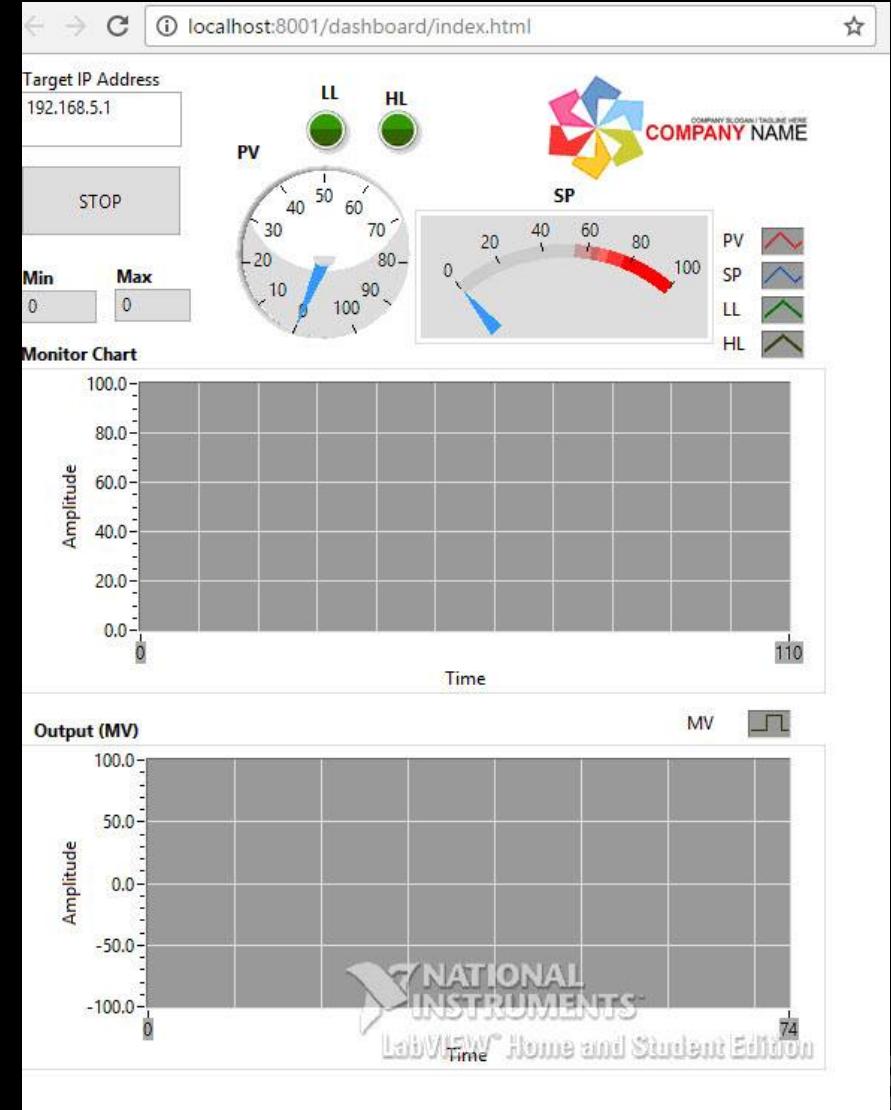
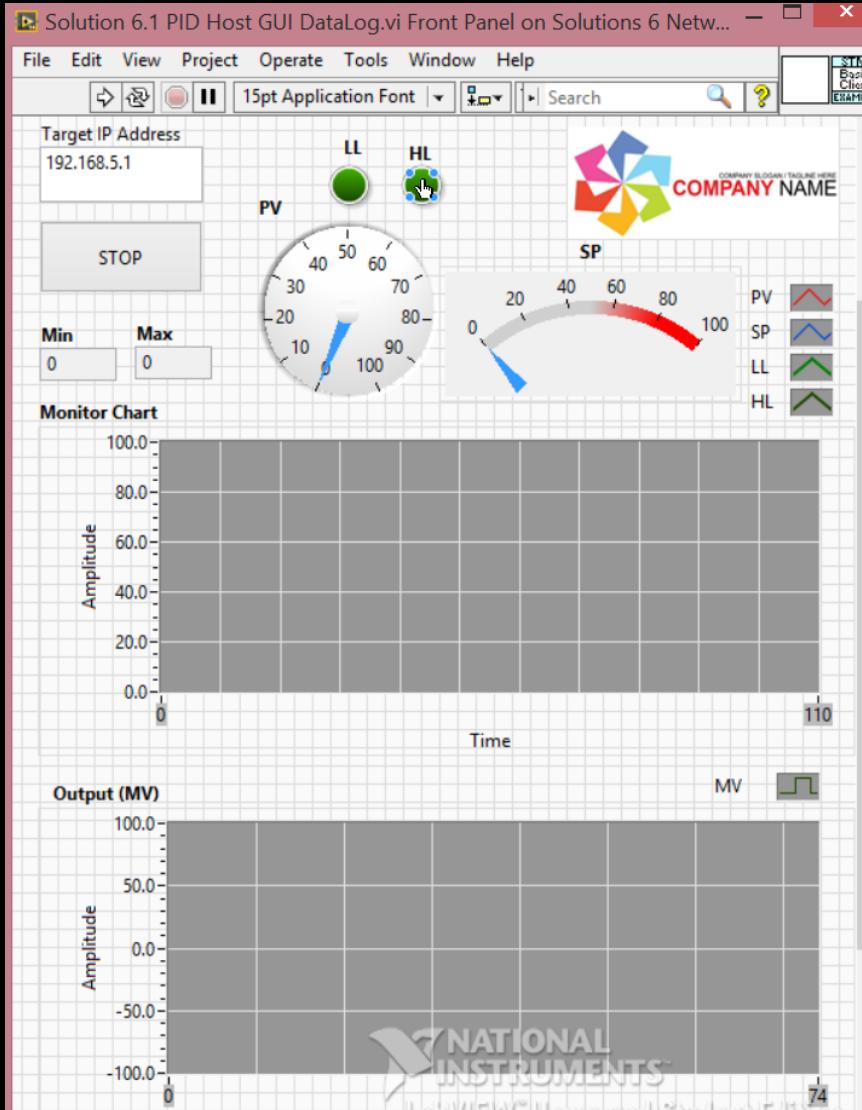


# PID Control Application

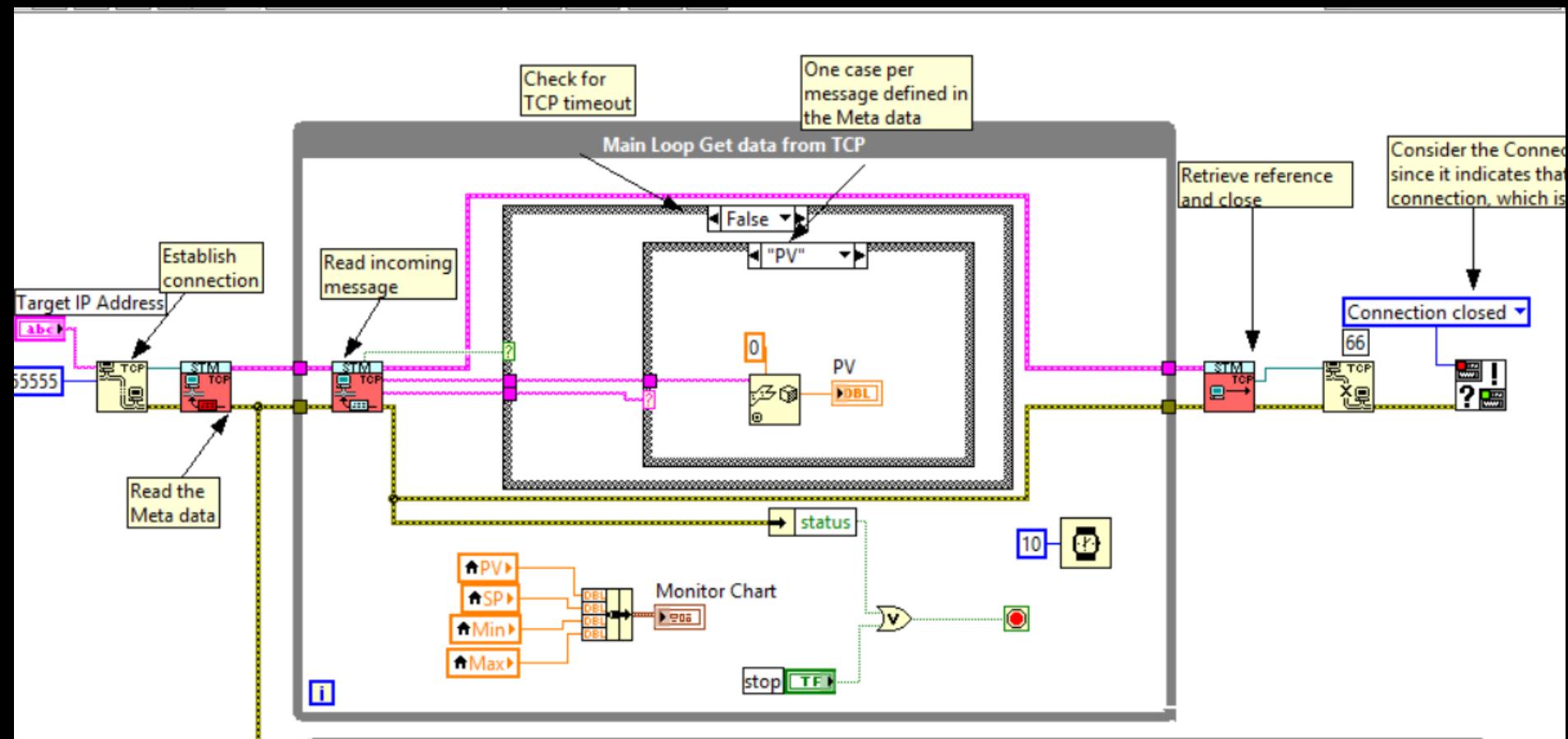
- **Embedded PID Control Application**



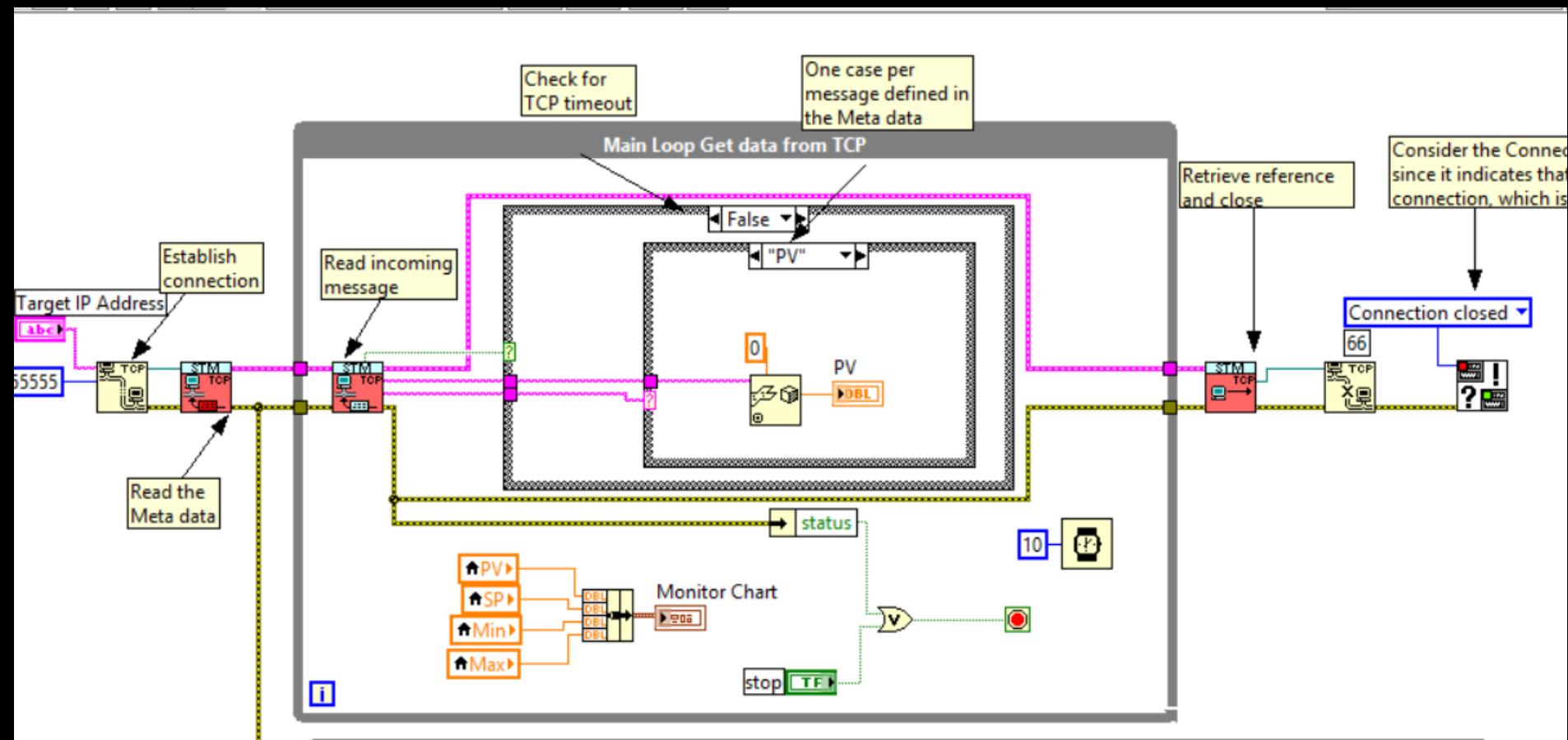
# Exercise 6.1 PID Host GUI DataLog



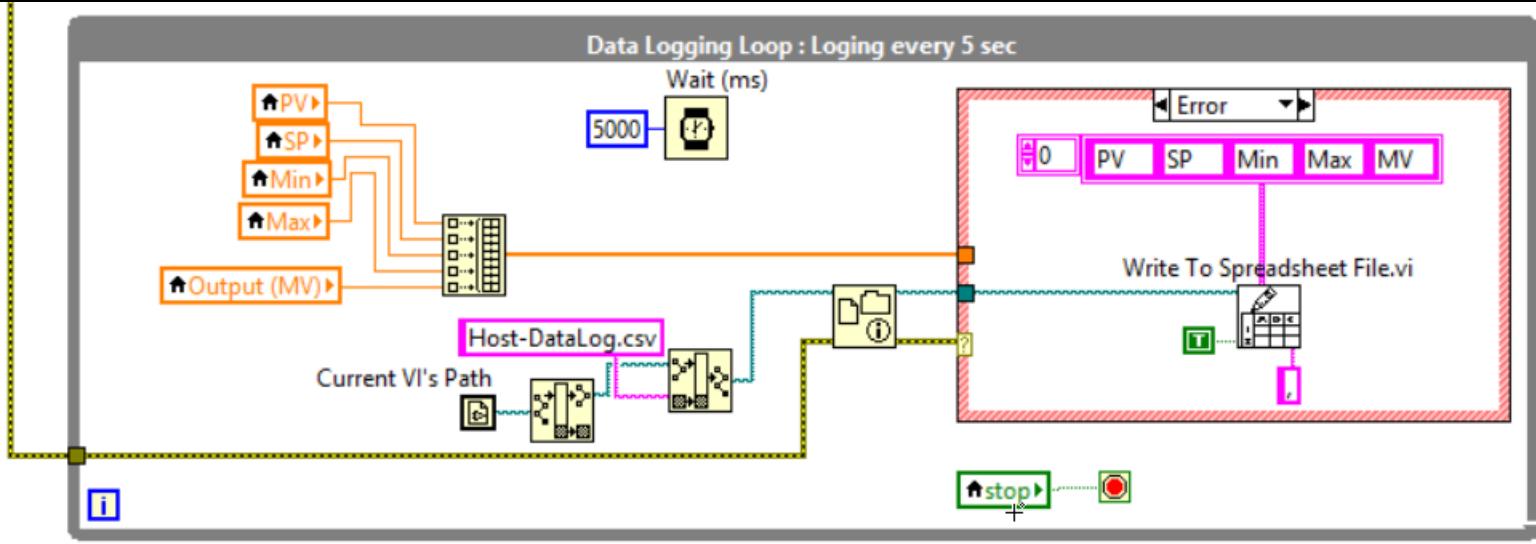
# Exercise 6.1 – Network Comm Loop



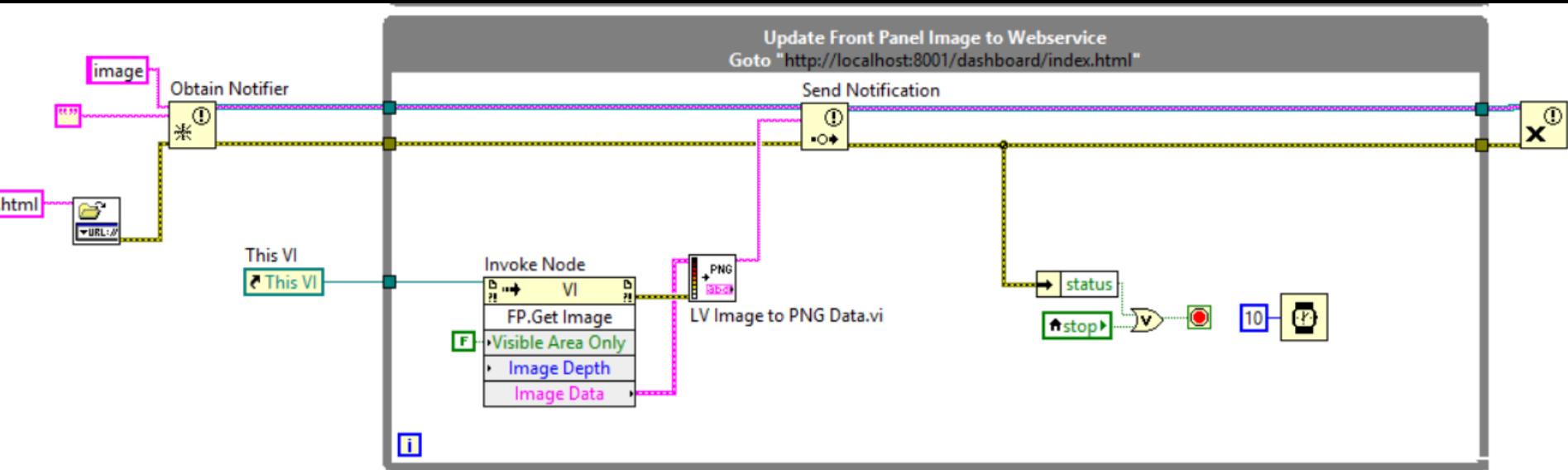
# Exercise 6.1 – Network Comm Loop



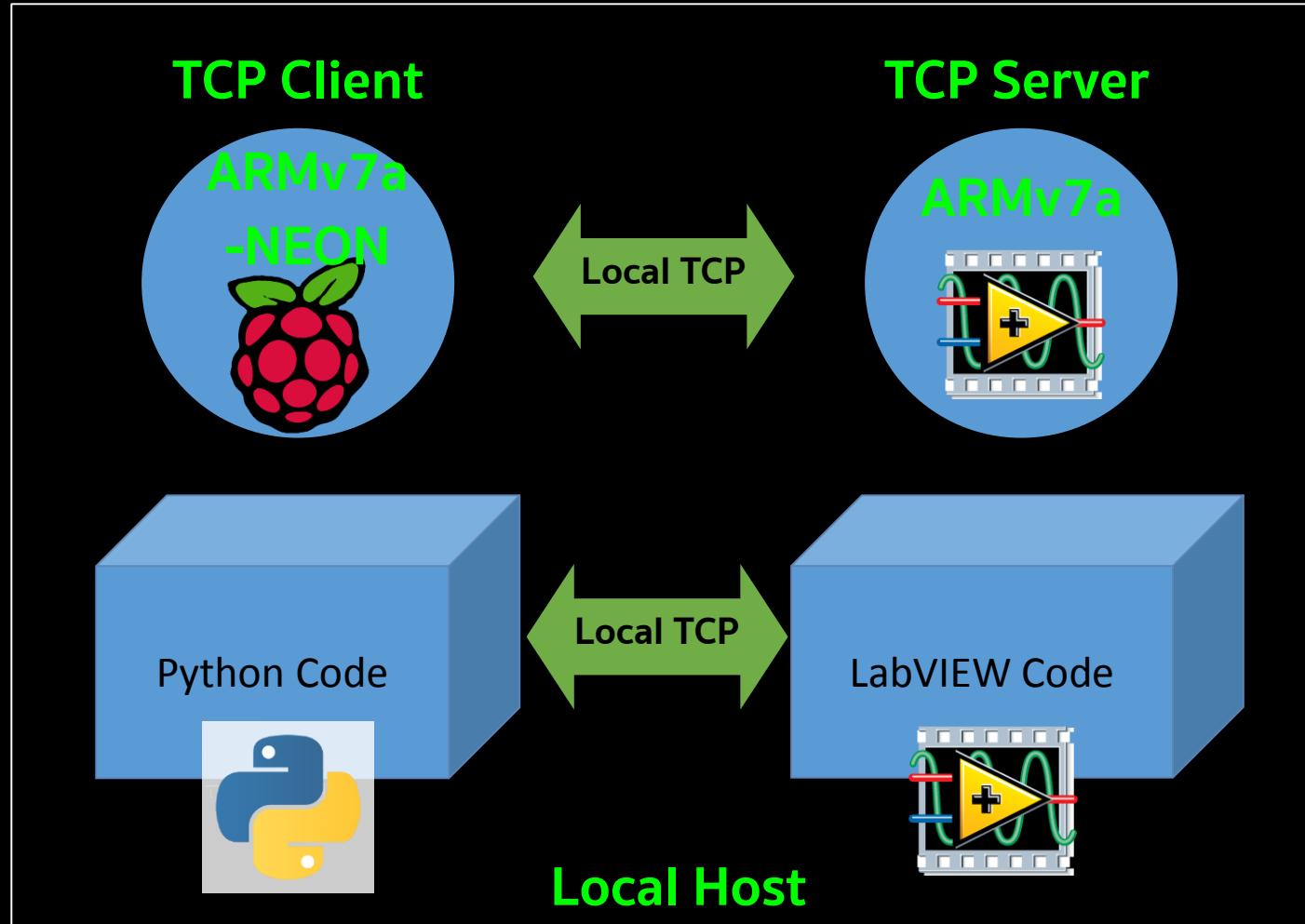
# Exercise 6.1 – Data Logging Loop



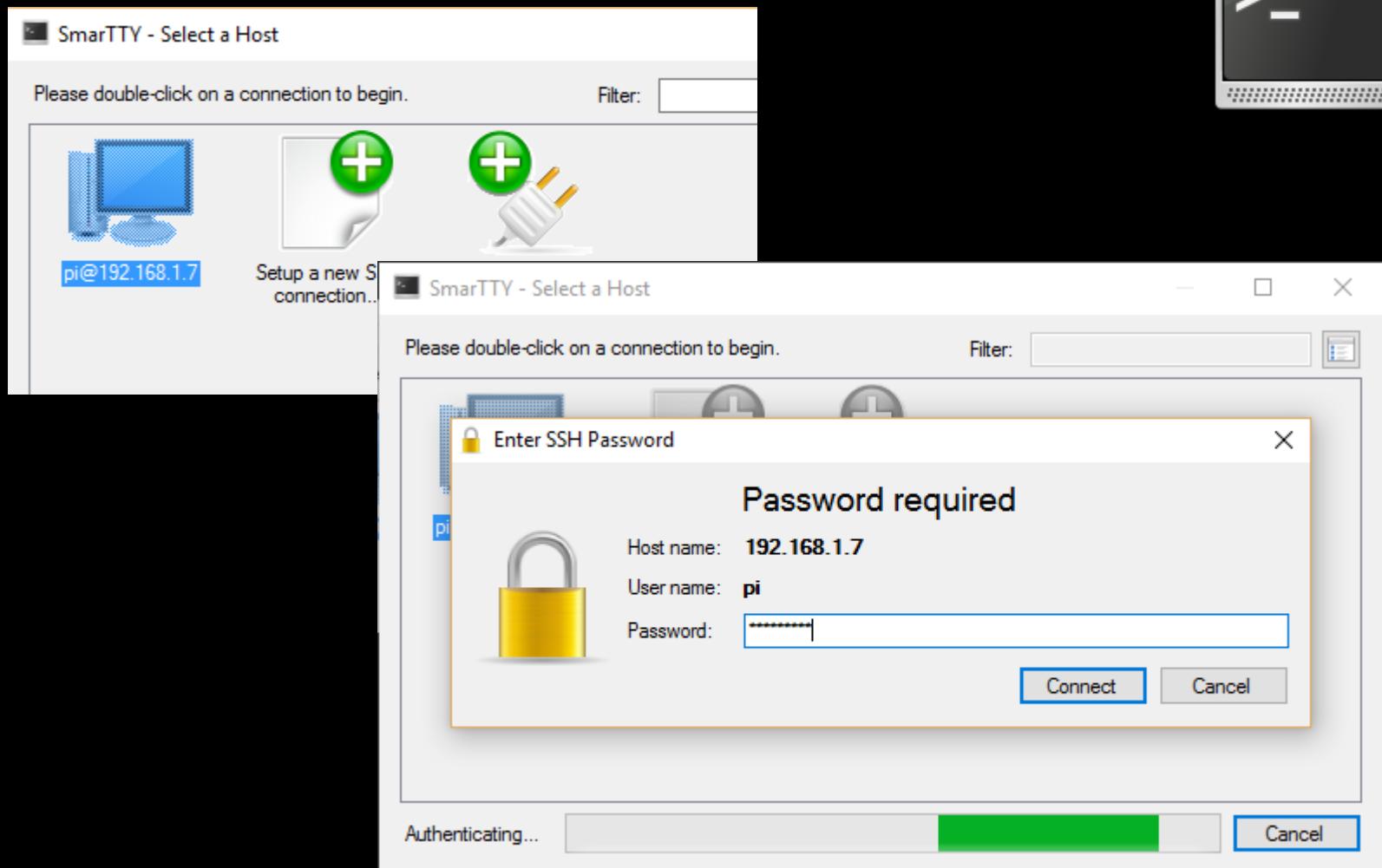
# Exercise 6.1 – Update Front Panel Loop



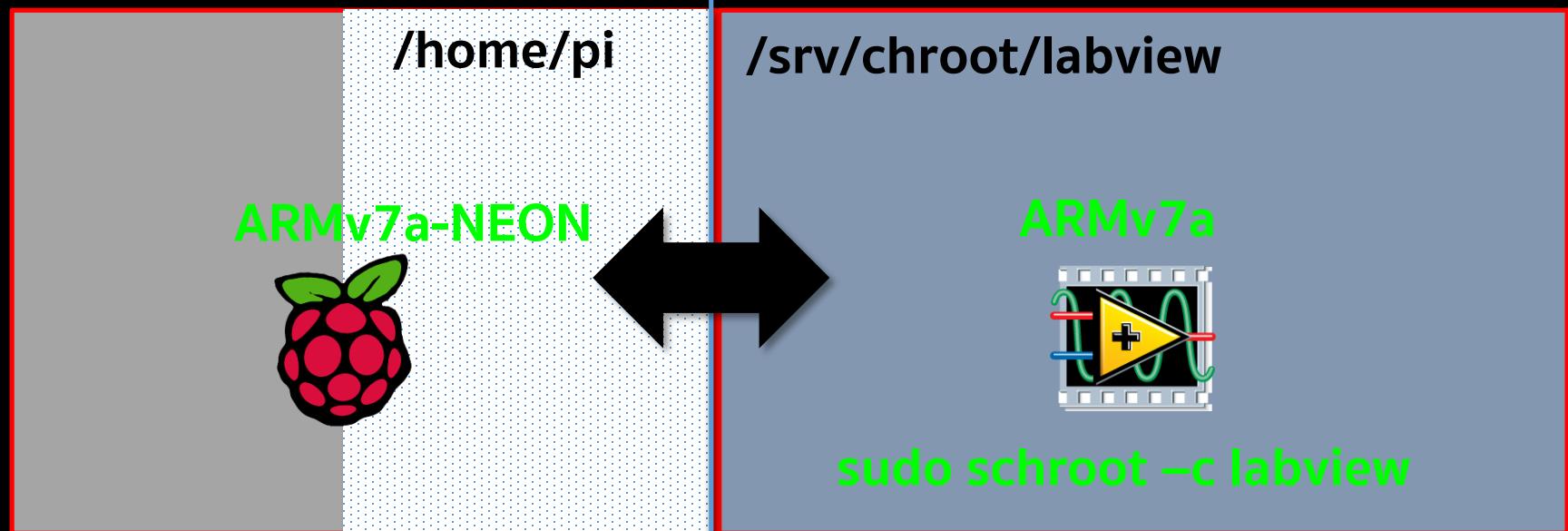
# Python Client – LabVIEW Server



# Remote Terminal “SmarTTY”



# Working with Two Platform



```
SmarTTY - 192.168.1.7
File Edit View SCP Settings Help

The programs included with the Debian GNU/Linux
the exact distribution terms for each program
individual files in /usr/share/doc/*copyright

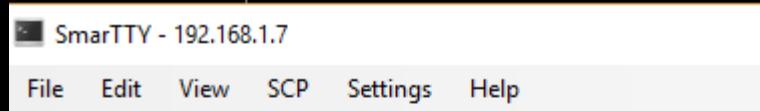
Debian GNU/Linux comes with ABSOLUTELY NO WARRANTY,
permitted by applicable law.
Last login: Fri May 6 20:44:02 2016 from 192.168.1.26
pi@raspberrypi:~ $
```

**ARMv7a  
-NEON**

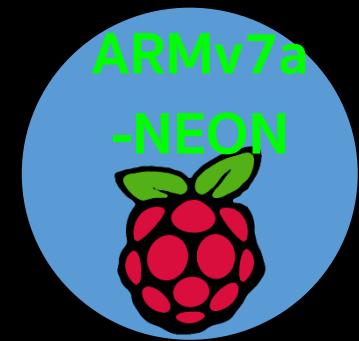
```
SmarTTY - 192.168.1.7
File Edit View SCP Settings Help
Last login: Fri May 6 20:44:02 2016 from 192.168.1.26
pi@raspberrypi:~ $ sudo schroot -c labview
shell-init: error retrieving current directory: getcwd
success
root@raspberrypi:#
chdir: error retrieving current directory: getcwd
s
root@raspberrypi:#
bin dev lib
boot etc lib
root@raspberrypi:#
sys tmp var
```

**ARMv7a**

# Using Text Editor “leafpad”



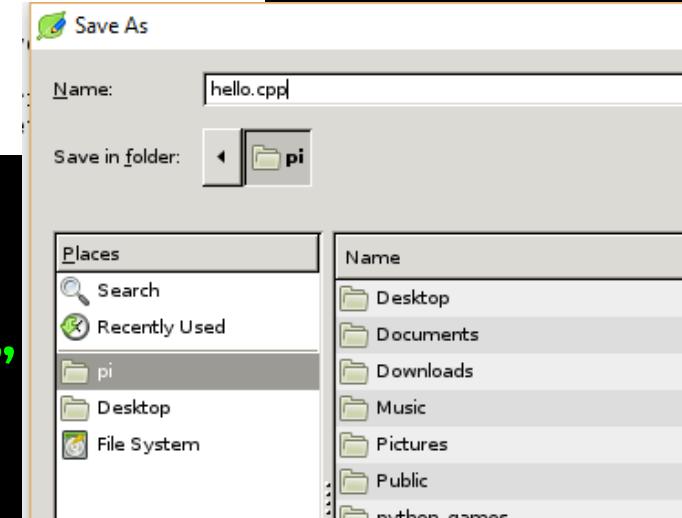
- > leafpad



Debian GNU/Linux comes with no warranty.  
permitted by applicable law.  
Last login: Fri May 6 19:30  
pi@raspberrypi:~ \$ leafpad

```
#include <stdio.h>

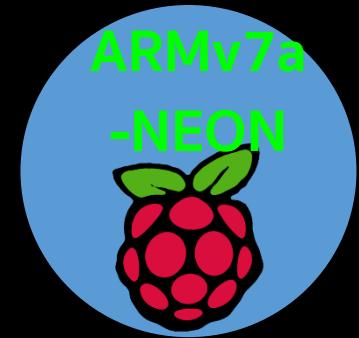
int main(void)
{
    printf("Hello world!\n");
    return 0;
}
```



- Save at Location
- “/home/pi/ python\_tcp\_client.py”

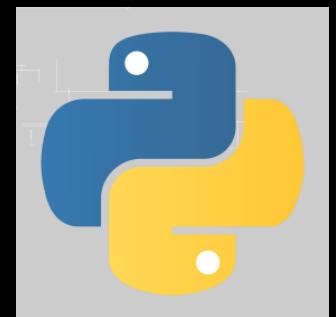
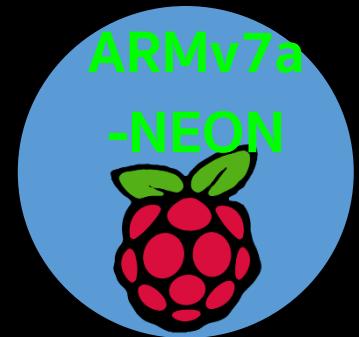
# Python Code “python\_tcp\_client.py”

- **import sys**
- **import socket**
- **host = 'localhost'**
- **port = 50001**
- **size = 1024**
- **s = socket.socket(socket.AF\_INET,  
socket.SOCK\_STREAM)**
- **s.connect((host, port))**
- **count=0**
- **data='Hello, LabVIEW!'**



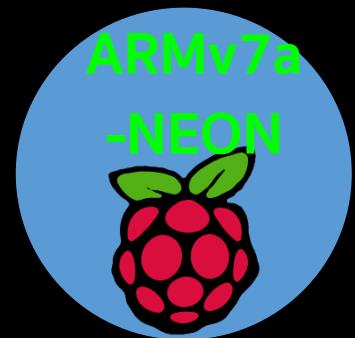
# Python Code (c/o)

- **# Send data string and read data from LabVIEW**
- **while (count < 10):**
- **s.send('Hello, LabVIEW!')**
- **data = s.recv(size)**
- **print 'Received:', data**
- **count = count + 1**
- **s.close()**



# Run Python Code

- > **python python\_tcp\_client.py**

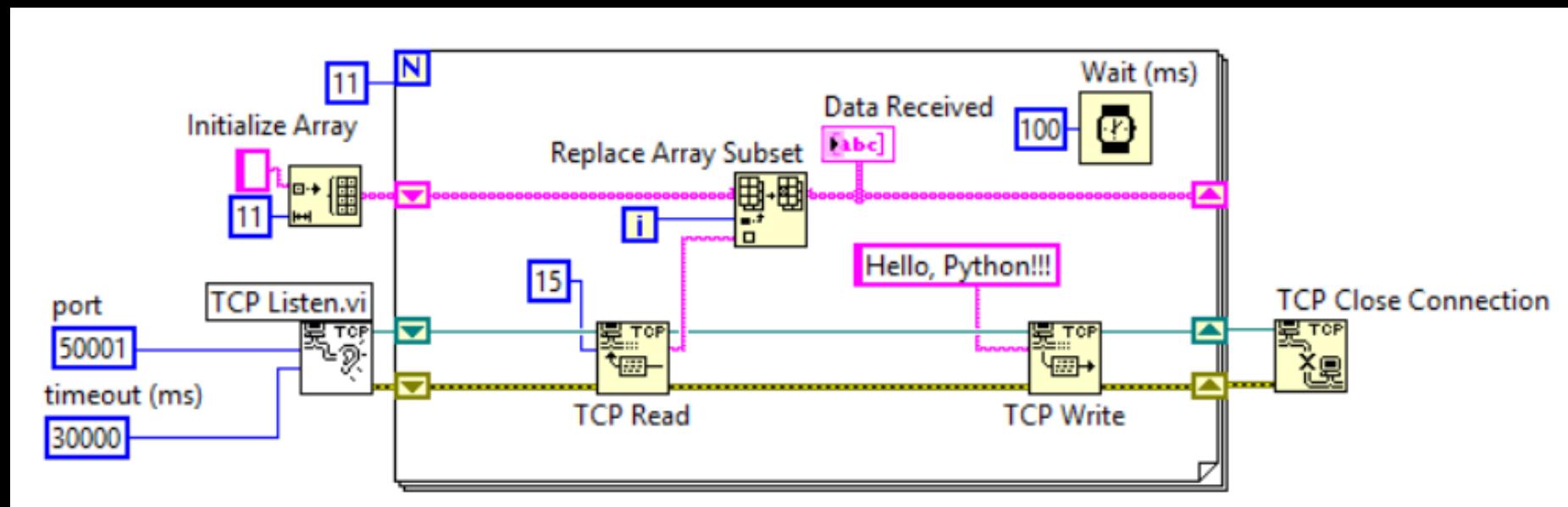


SmarTTY - 192.168.1.104

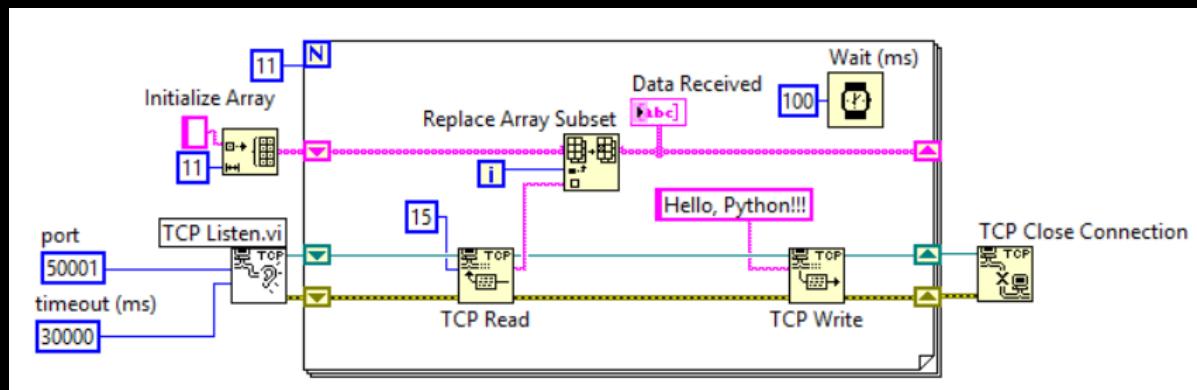
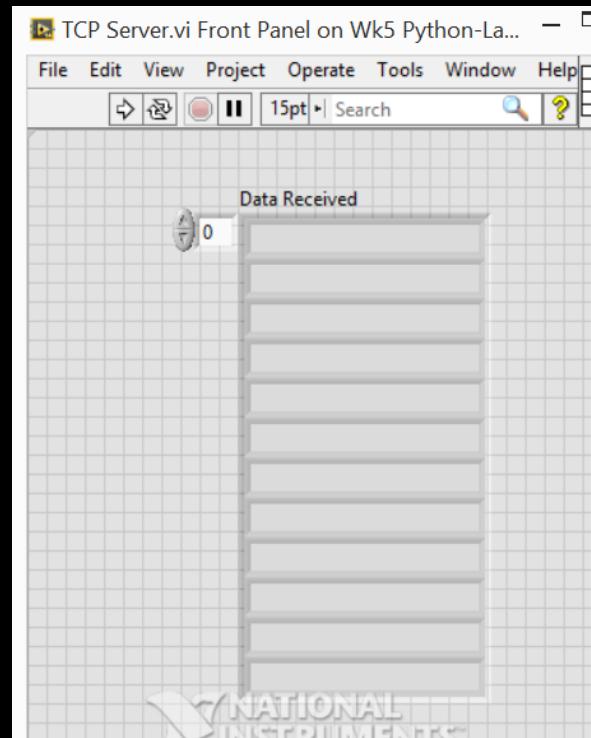
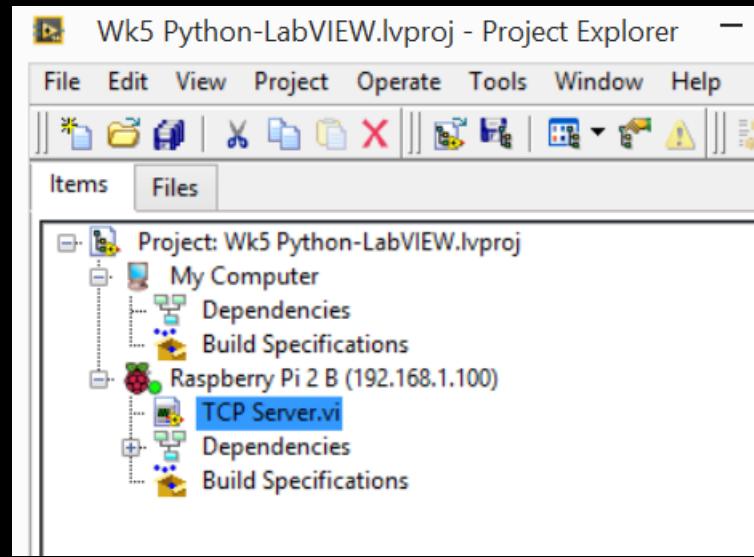
```
Last login: Sun May  8 05:52:06 2016 from 192.168.1.104
pi@raspberrypi:~ $ pwd
/home/pi
pi@raspberrypi:~ $ ls
Desktop      gpio_exp01      Music
Documents    hello          Penguins.jpg
Downloads   hello.cpp      Penguins_template.jpg
g++          hellolib.cpp   Pictures
pi@raspberrypi:~ $ python python_tcp_client.py
```

# LabVIEW Code “TCP Server.vi”

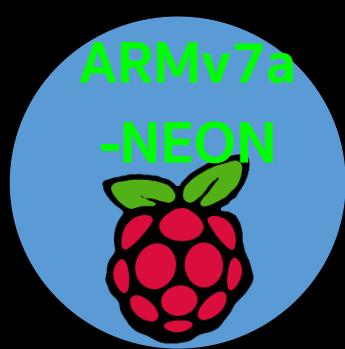
ARMv7a



# Server : LabVIEW Project File



# Hello LabVIEW + Python over Local TCP



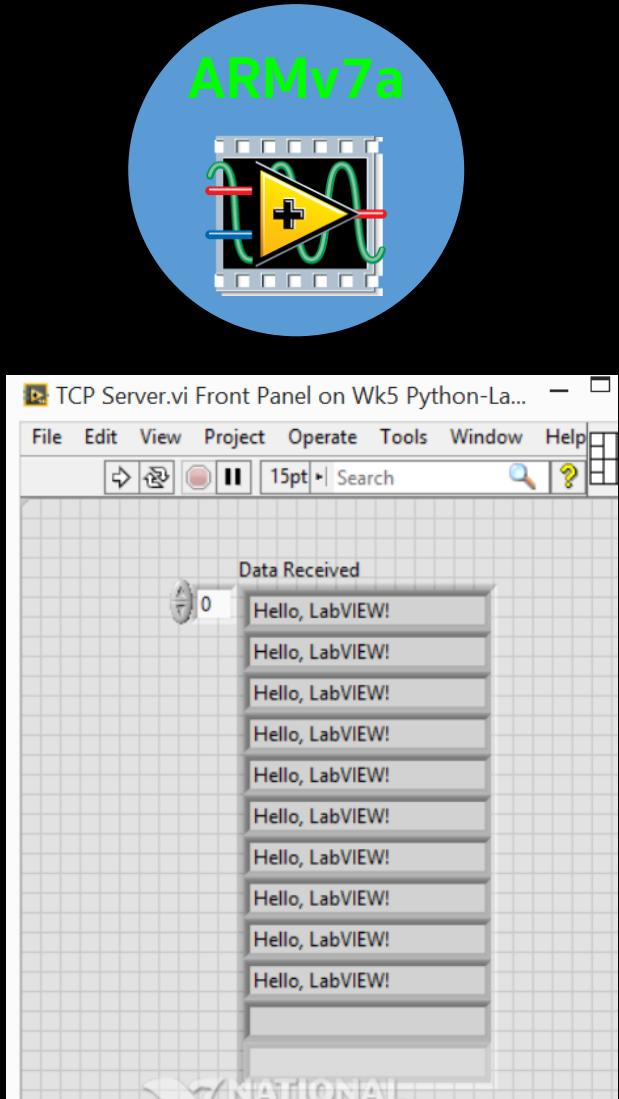
SmarTTY - 192.168.1.104

```

File Edit View SCP Settings Help
Last login: Sun May  8 05:52:06 2016 from 192.168.1.104
pi@raspberrypi:~ $ pwd
/home/pi
pi@raspberrypi:~ $ ls
Desktop  gpio_exp01  Music
Documents  hello      Penguins.jpg
Downloads  hello.cpp  Penguins_template.jpg
g++        hellolib.cpp Pictures
pi@raspberrypi:~ $ python python_tcp_client.py
Received: Hello, Python!!!
pi@raspberrypi:~ $ ~

```

Local TCP



# Many Tools for GUI Development

- PyGTK: GTK+ for Python
- PyQt (Qt Designer)
- Tkinter
- wxPython



wxPython

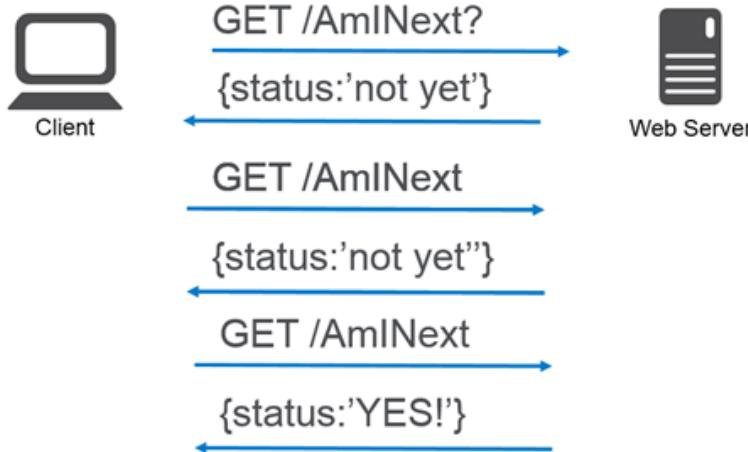


Tk

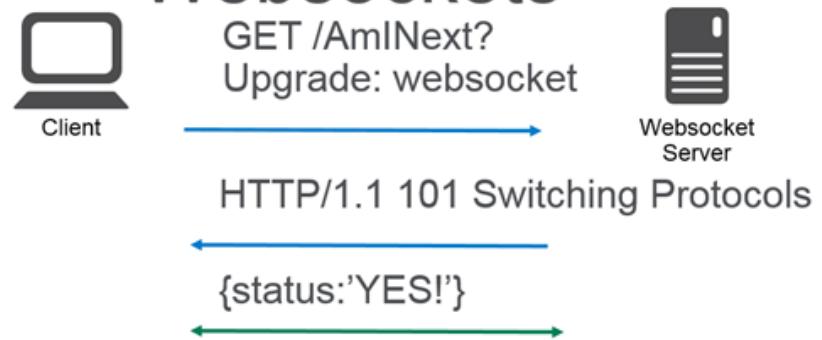
7

# WebSoket

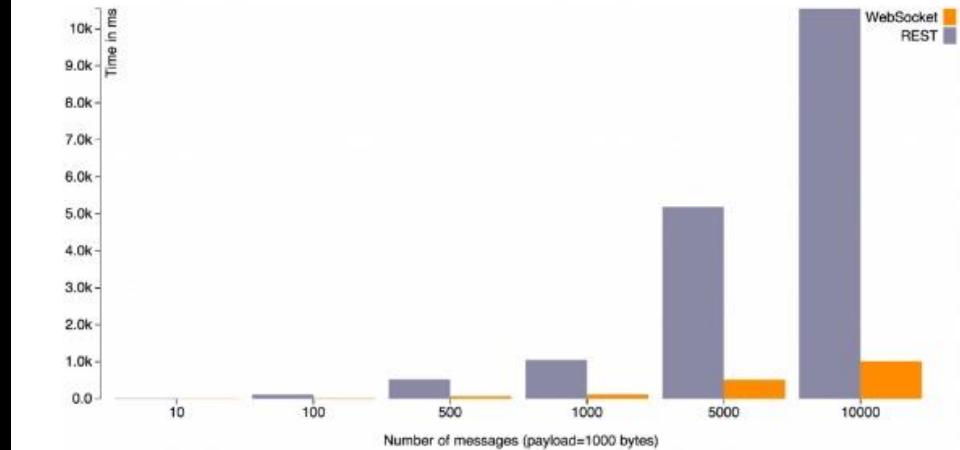
## HTTP/1.1



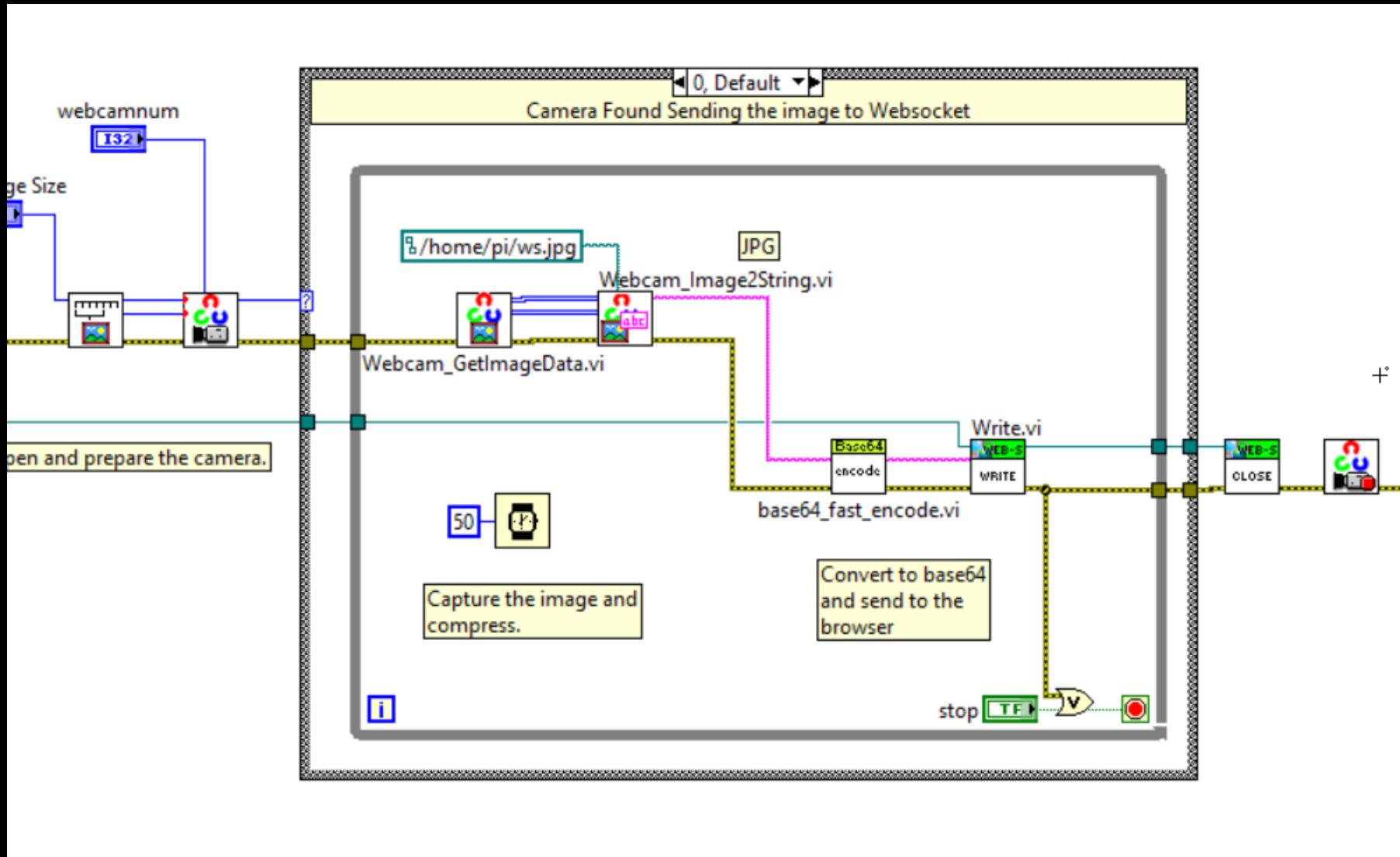
## Websockets



WS vs HTTP: processing time



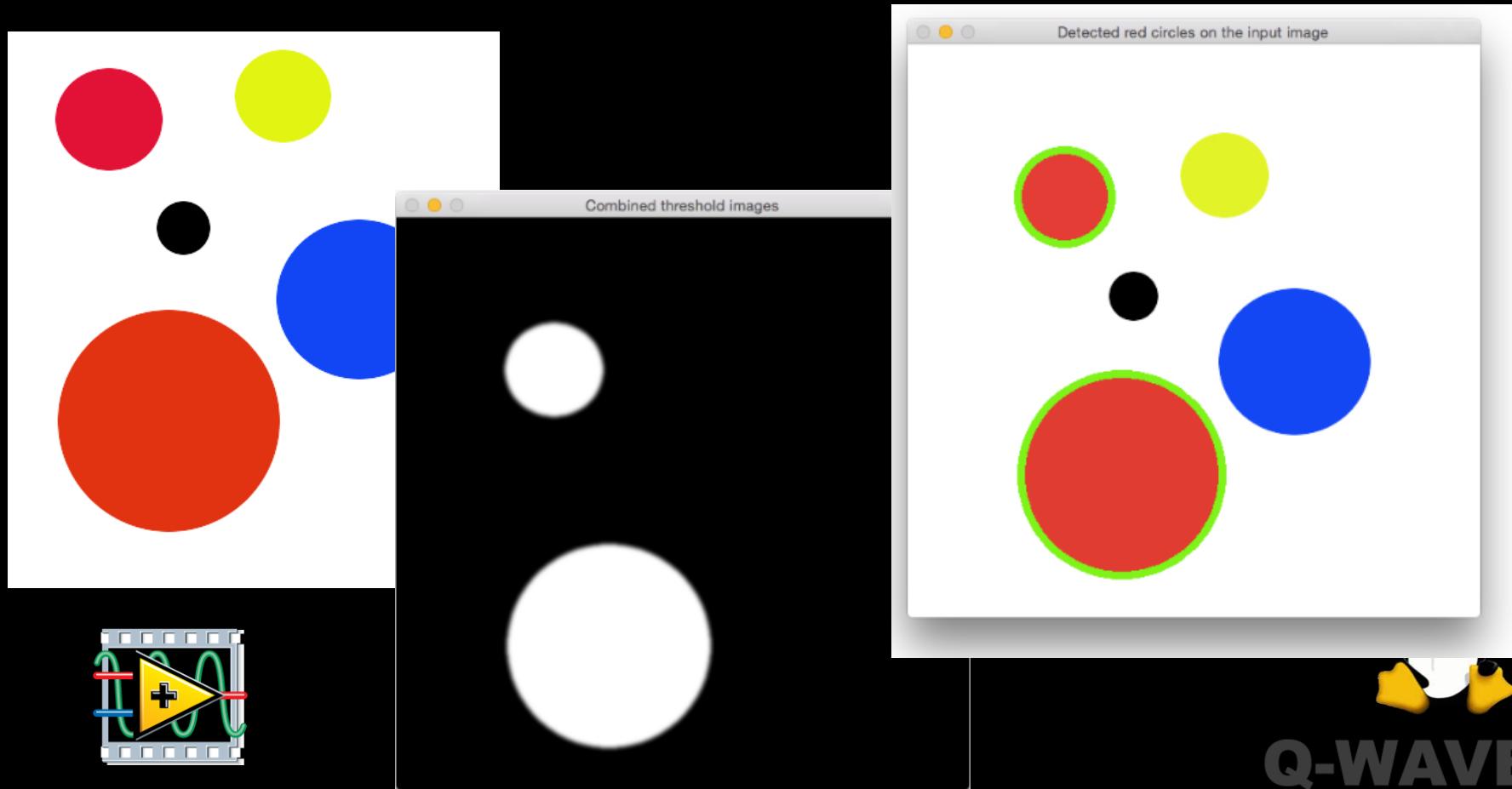
# Exercise 7 WebSocket



# 8

# Exercise 8 OpenCV : Color Tracking

- <https://solarianprogrammer.com/2015/05/08/detect-red-circles-image-using-opencv/>



# Online Color picker,

- <http://colorizer.org/>

Color picker, calculator and generator with high precision and contrast test. Converts also RGB, HEX, HSL, HSV/HSB, CMYK and CIE-LAB colors and lots of other formats. In the Hex-field, you can write a known color name, too.

- ▶ RGB(A)
- ▶ HSL(A)
- ▼ HSV / HSB
- Hue**
- Saturation
- Value/Brightness
- ▶ CMYK
- ▶ Lab (CIELAB, CIE-L\*ab, L\*a\*b)
- ▶ YPbPr (similar to YCbCr & YUV)
- ▶ Xyz
- ▶ Misc

Change color of

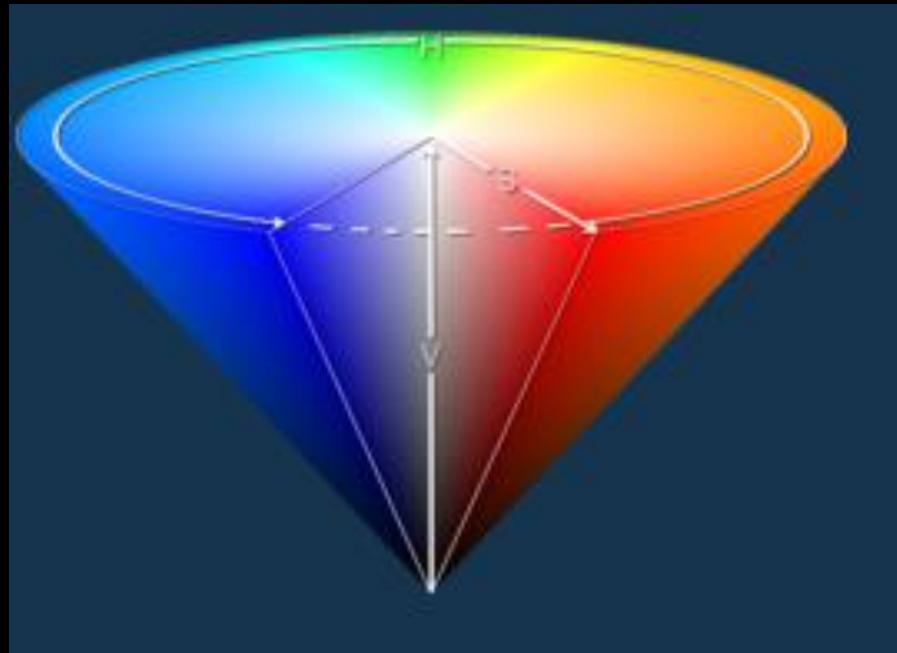
[Schemes](#) [More Conversions](#)

MAX 360

MAX 360

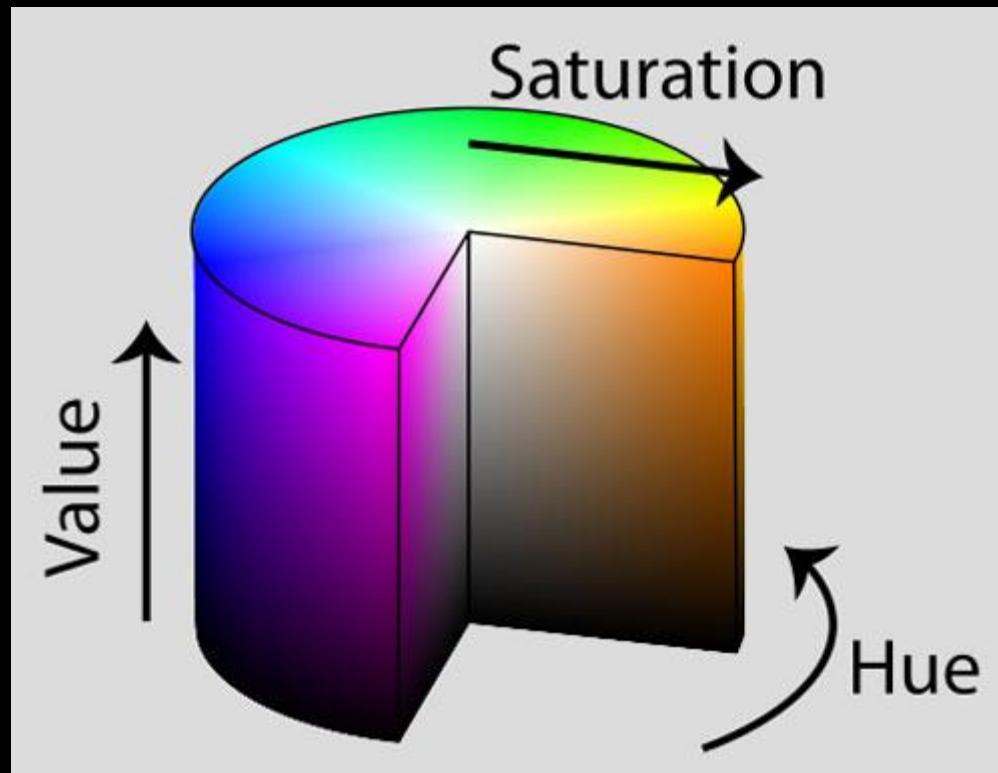
# HSB (Hue, Saturation, Brightness(Value))

- OpenCV using HSV Scale:
- H = 0-180
- S = 0-255
- V = 0-255
- colorizer.org HSV Scale:
- H = 0-360
- S = 0-100
- V = 0-100



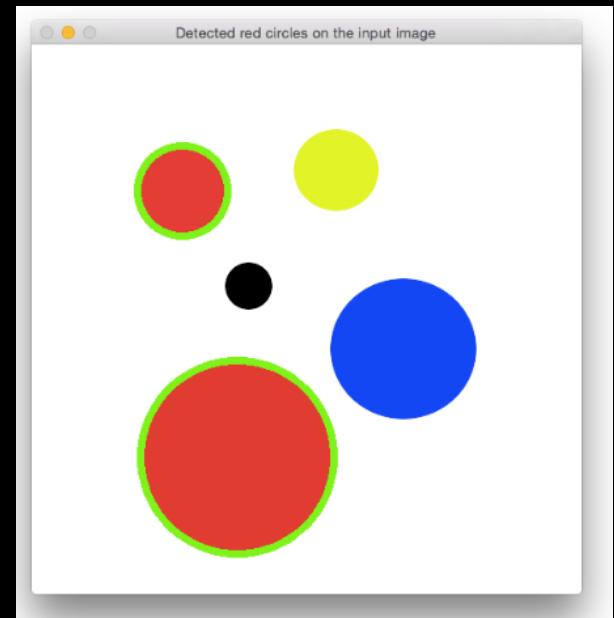
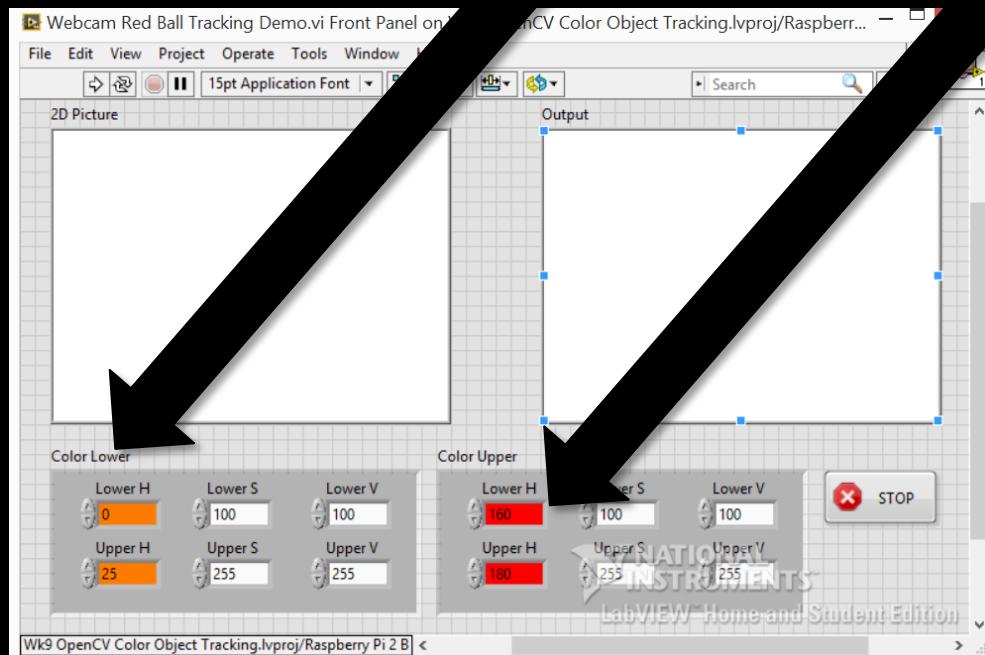
# Why using HSV ?

- Identify a particular color using a **single value**, the **Hue**, instead of three values.

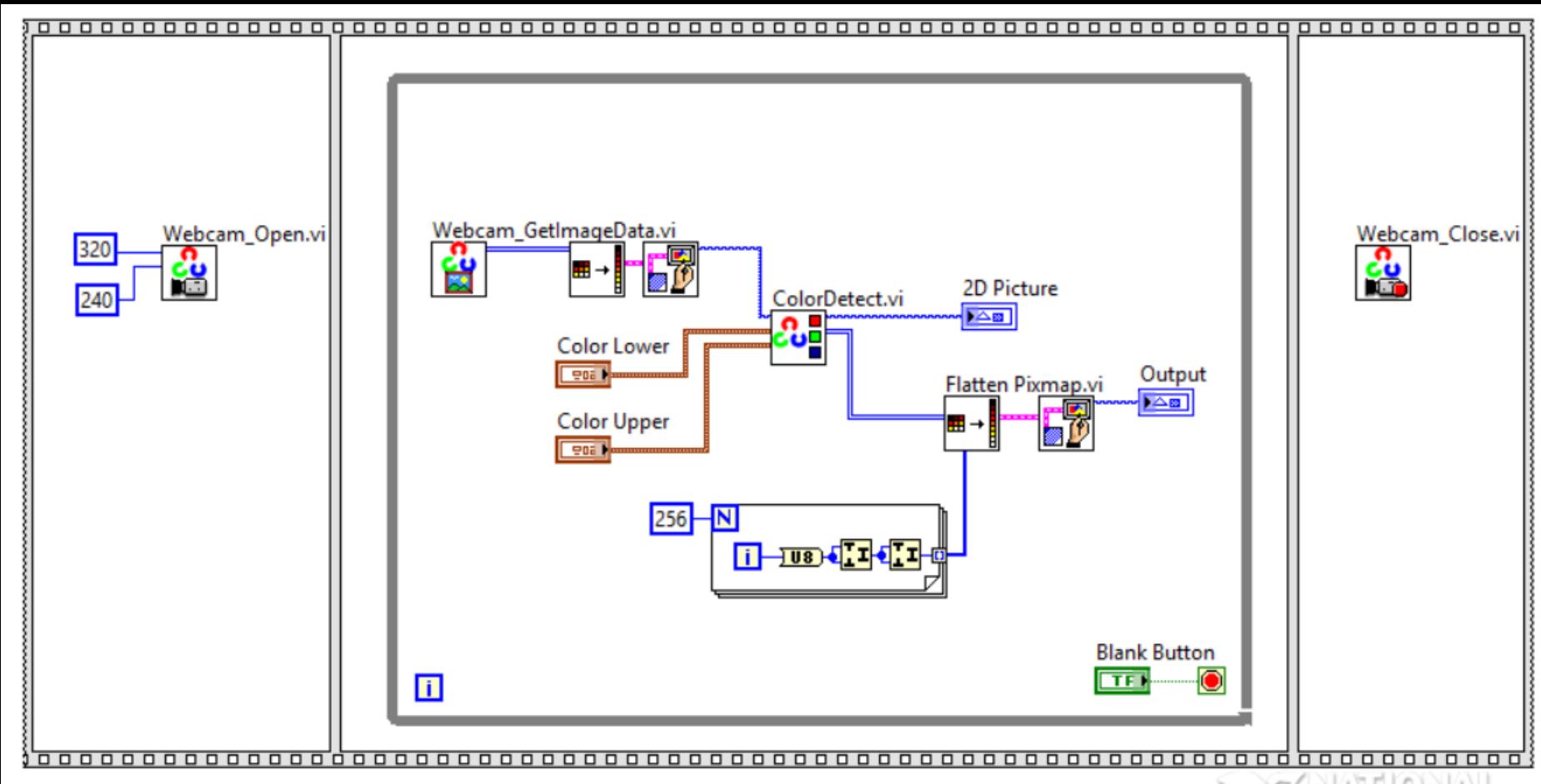


# Set the Lower (H) and Upper (H)

- Lower Range
- Upper Range



# Navigate a VI “Red Ball Tracking Demo”



# OpenCV Source Code (C++)

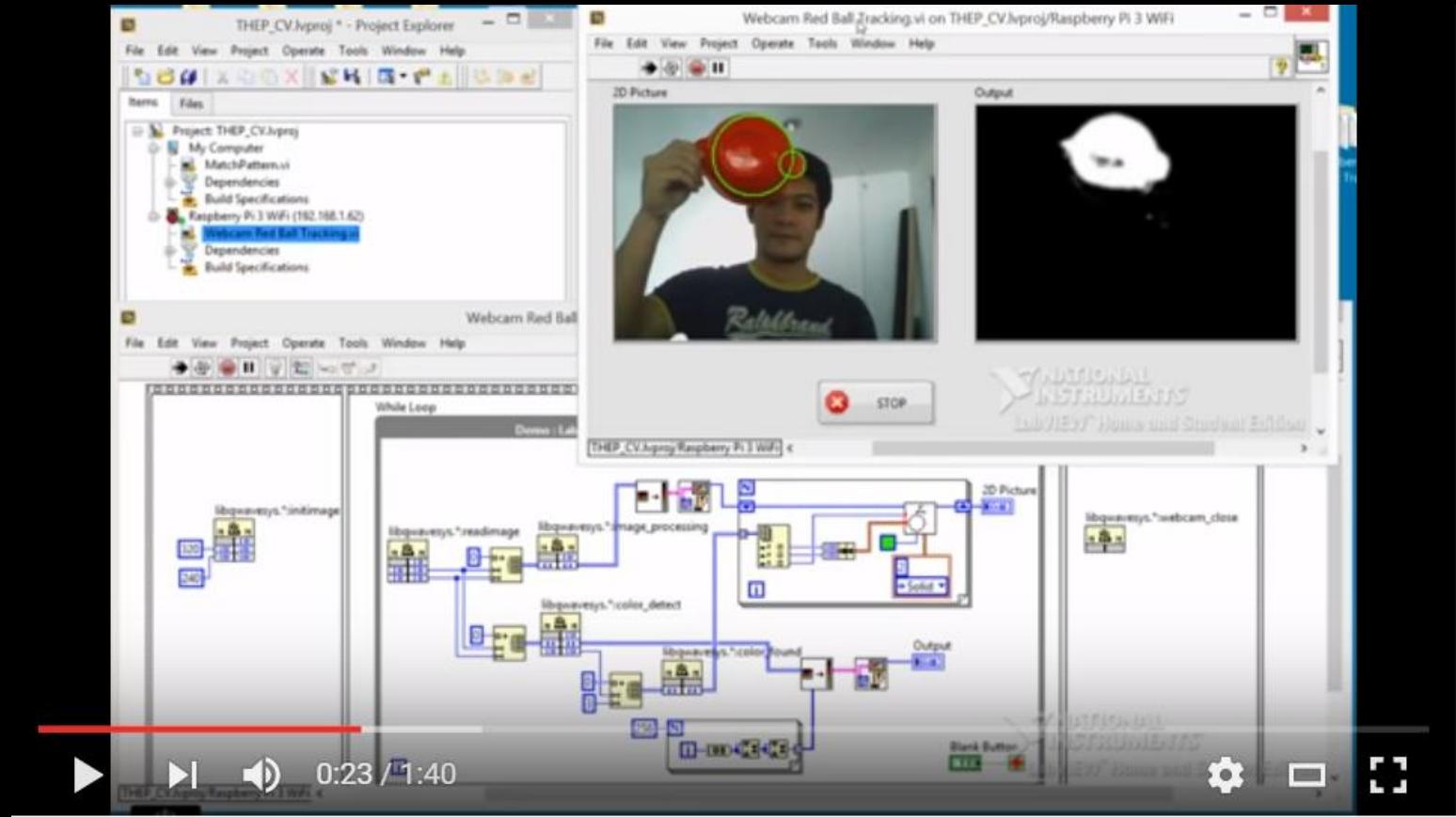
```

-----1-----2-----3-----4-----5-----6-----7-----8-----9-
1 #include "opencv2/core/core.hpp"
2 #include "opencv2/imgcodecs.hpp"
3 #include "opencv2/highgui/highgui.hpp"
4 #include "opencv2/imgproc/imgproc.hpp"
5 //#include "opencv2/core/fast_math.hpp"
6
7 #include <stdio.h>
8 #include <iostream>
9
10 using namespace std;
11 using namespace cv;
12
13 #ifdef __cplusplus
14 extern "C"
15 {
16 #endif
17     int webcam_open( int w, int h );
18     void webcam_close();
19     int webcam_getimagedata(int *data,
20     int webcam_getimagesize(int *img_r
21     int color_detect(uchar *data,uchar
22     void color_found(int *data);
23     int getimagefilesize(char *filename
24     int getimagedatafromfile(char *fil
25     int MyPatternMatch(uchar *img, uchar
26 #ifdef __cplusplus
27 }
28 #endif
102    int color_detect(uchar *data,uchar Alow_h,uchar Alow_s,uchar Alow_v,uchar Aupp_h,uchar Aupp_s,uchar Aupp_v)
103    {
104        Mat img_to_LV(mywebcam.img.rows, mywebcam.img.cols, CV_8U, &data[0]);
105        //img_to_LV = img_to_LV > 128;
106
107        Mat imgHSV;
108
109        cvtColor(mywebcam.img, imgHSV, COLOR_BGR2HSV); //Convert the captured frame from BGR
110
111        Mat lower_red_hue_range;
112        Mat upper_red_hue_range;
113        //inRange(imgHSV, Scalar(0, 100, 100), Scalar(10, 255, 255), lower_red_hue_range);
114        //inRange(imgHSV, Scalar(160, 100, 100), Scalar(179, 255, 255), upper_red_hue_range);
115        inRange(imgHSV, Scalar(Alow_h, Alow_s, Alow_v), Scalar(Aupp_h, Aupp_s, Aupp_v), lower_red_hue_range);
116        inRange(imgHSV, Scalar(Blow_h, Blow_s, Blow_v), Scalar(Bupp_h, Bupp_s, Bupp_v), upper_red_hue_range);
117
118        Mat red_hue_image;
119        addWeighted(lower_red_hue_range, 1.0, upper_red_hue_range, 1.0, 0.0, red_hue_image);
120        GaussianBlur(red_hue_image, red_hue_image, Size(9, 9), 2, 2);
121
122        HoughCircles(red_hue_image, mywebcam.circles, CV_HOUGH_GRADIENT, 1, red_hue_image.rows/16);
123
124        (*found) = mywebcam.circles.size();
125
126        // Note: For HSV, Hue range is [0,179], Saturation range is [0,255] and Value range is [0,255]
127        Mat hsv_channels[3];
128        split( red_hue_image, hsv_channels );
129
130        for( int i=0; i<3; i++ )
131        {
132            Mat_ channel(hsv_channels[i].rows, hsv_channels[i].cols);
133            for( int j=0; j<channel.rows; j++ )
134            {
135                for( int k=0; k<channel.cols; k++ )
136                {
137                    channel(j,k) = (uchar)(hsv_channels[i](j,k));
138                }
139            }
140        }
141
142        for( int i=0; i<mywebcam.circles.size(); i++ )
143        {
144            circle( mywebcam.img, mywebcam.circles[i], 5, Scalar(0,255,0), -1 );
145        }
146
147        imshow("Result", mywebcam.img);
148
149        if( waitKey(10) == 27 )
150        {
151            break;
152        }
153    }
154}

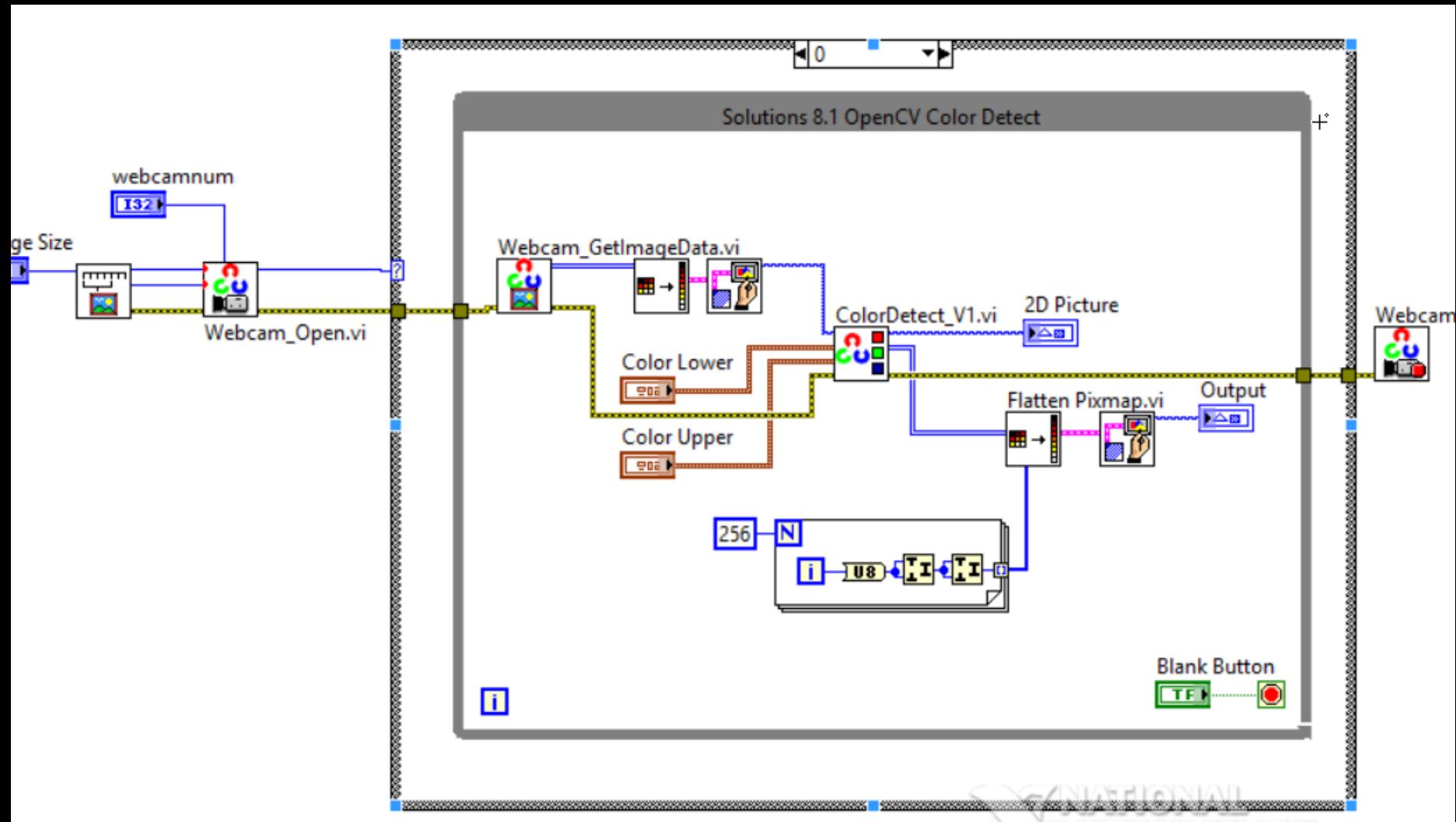
```

# Demo Clip VDO

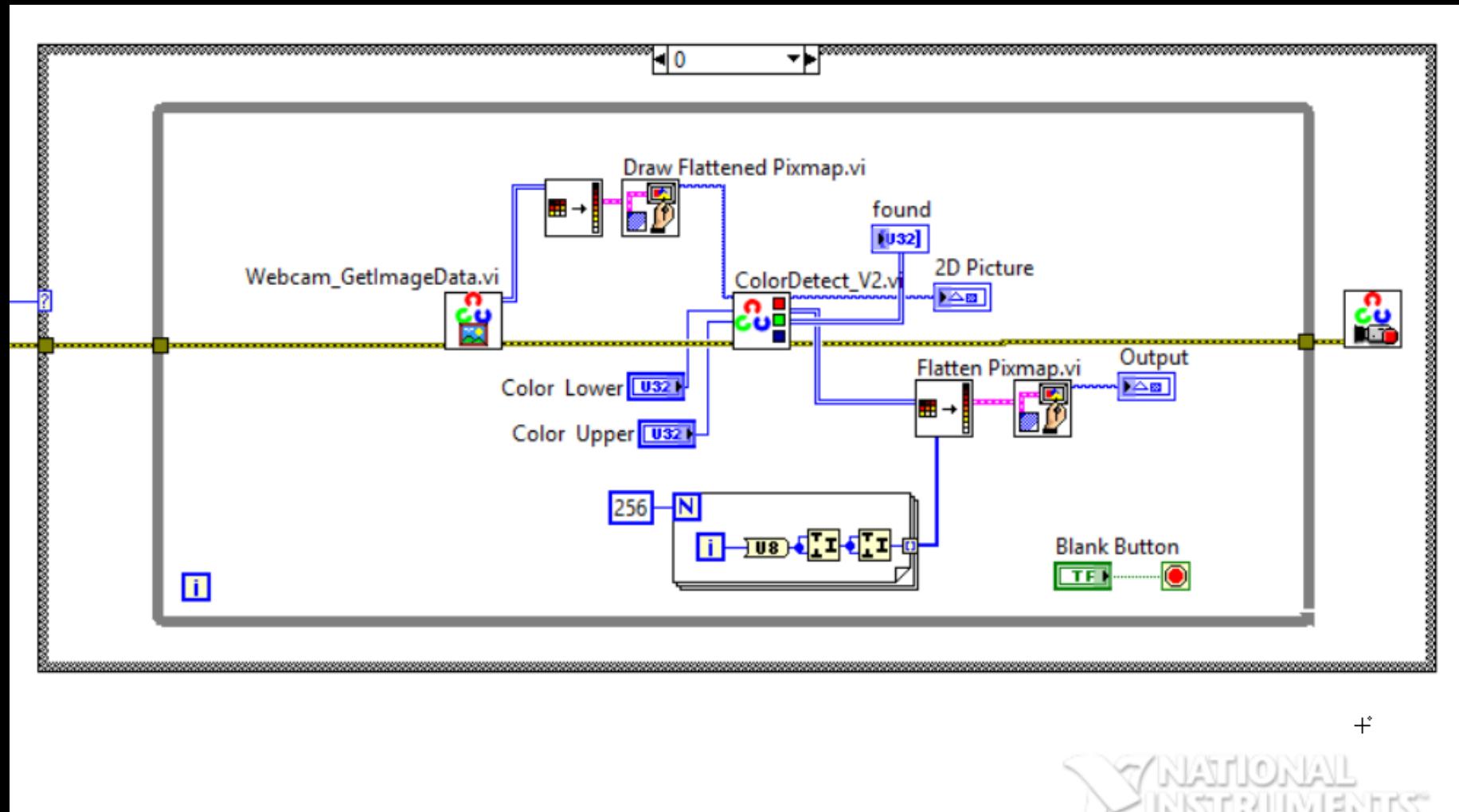
- <https://www.youtube.com/watch?v=pTU4Wn29FxY>



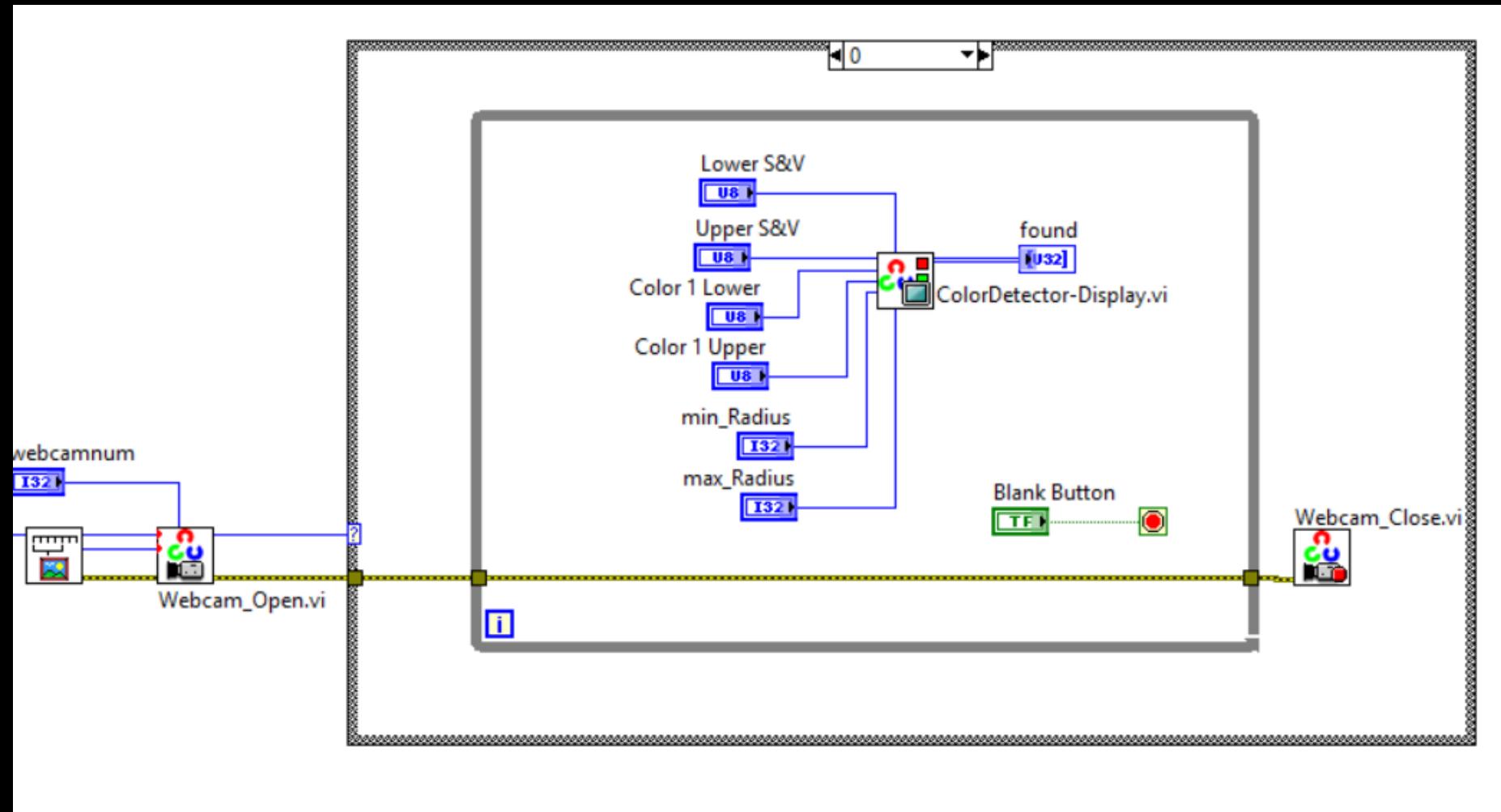
# Exercise 8.1 OpenCV Color Detect



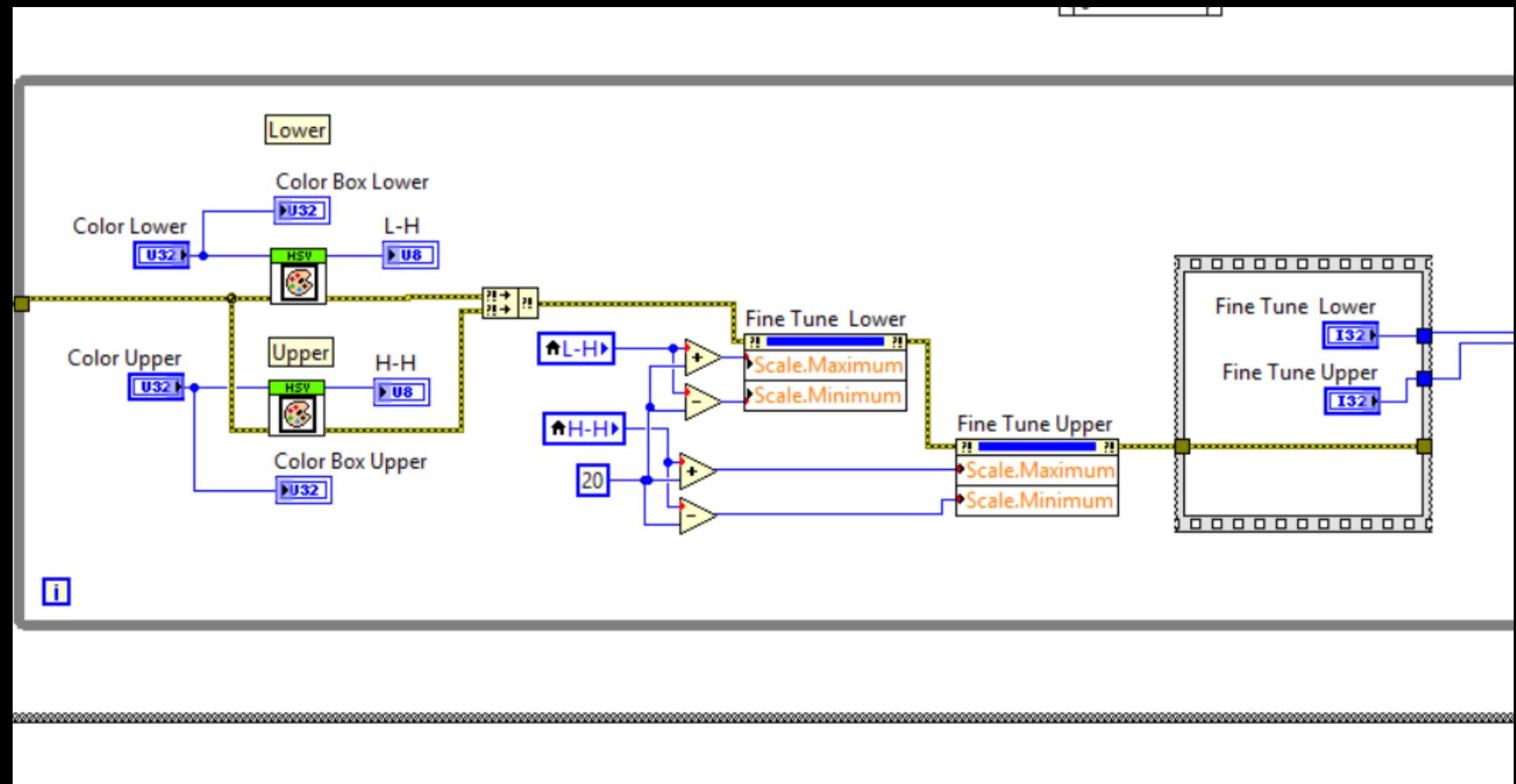
# Exercise 8.2 OpenCV Color Detect V2



# Exercise 8.3 OpenCV Color Detector-Display



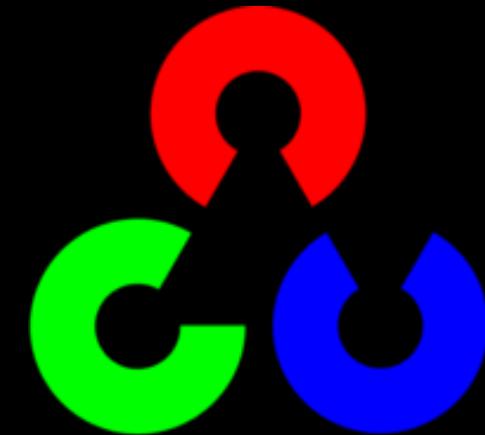
# Exercise 8.4 OpenCV Color Detector-Display\_V2



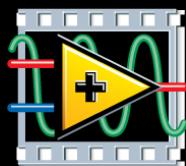
# 9

# Exercise 9: OpenCV Pattern Matching

- OpenCV is released under a BSD license and hence it's free for both academic and commercial use.
- It has C++, C, Python and Java interfaces and supports Windows, Linux, Mac OS, iOS and Android.
- OpenCV has more than 47 thousand people of user community and estimated number of downloads exceeding 9 million.
- Usage ranges from interactive art, to mines inspection, stitching maps on the web or through advanced robotics.



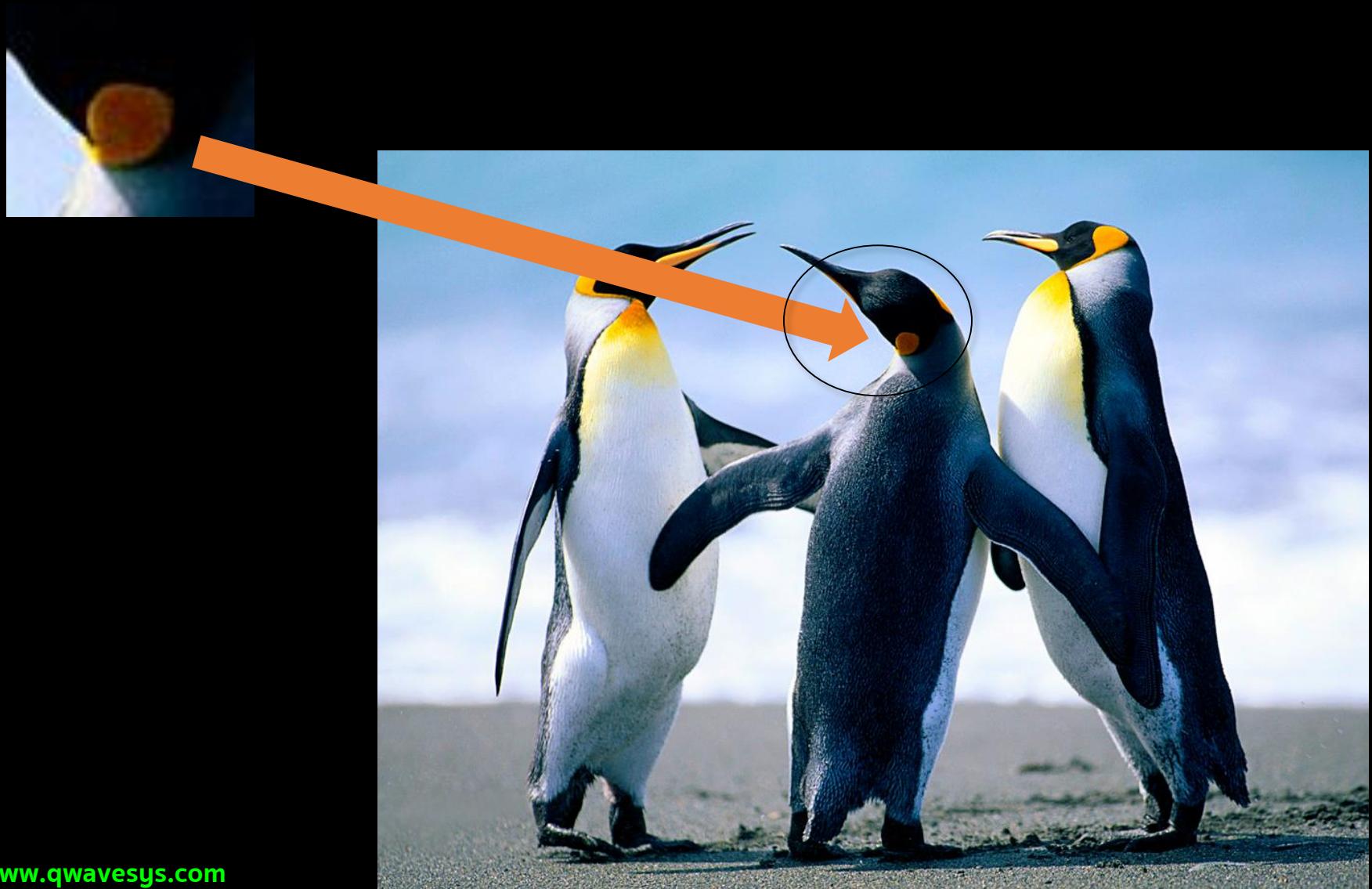
OpenCV



www.qwavesys.com

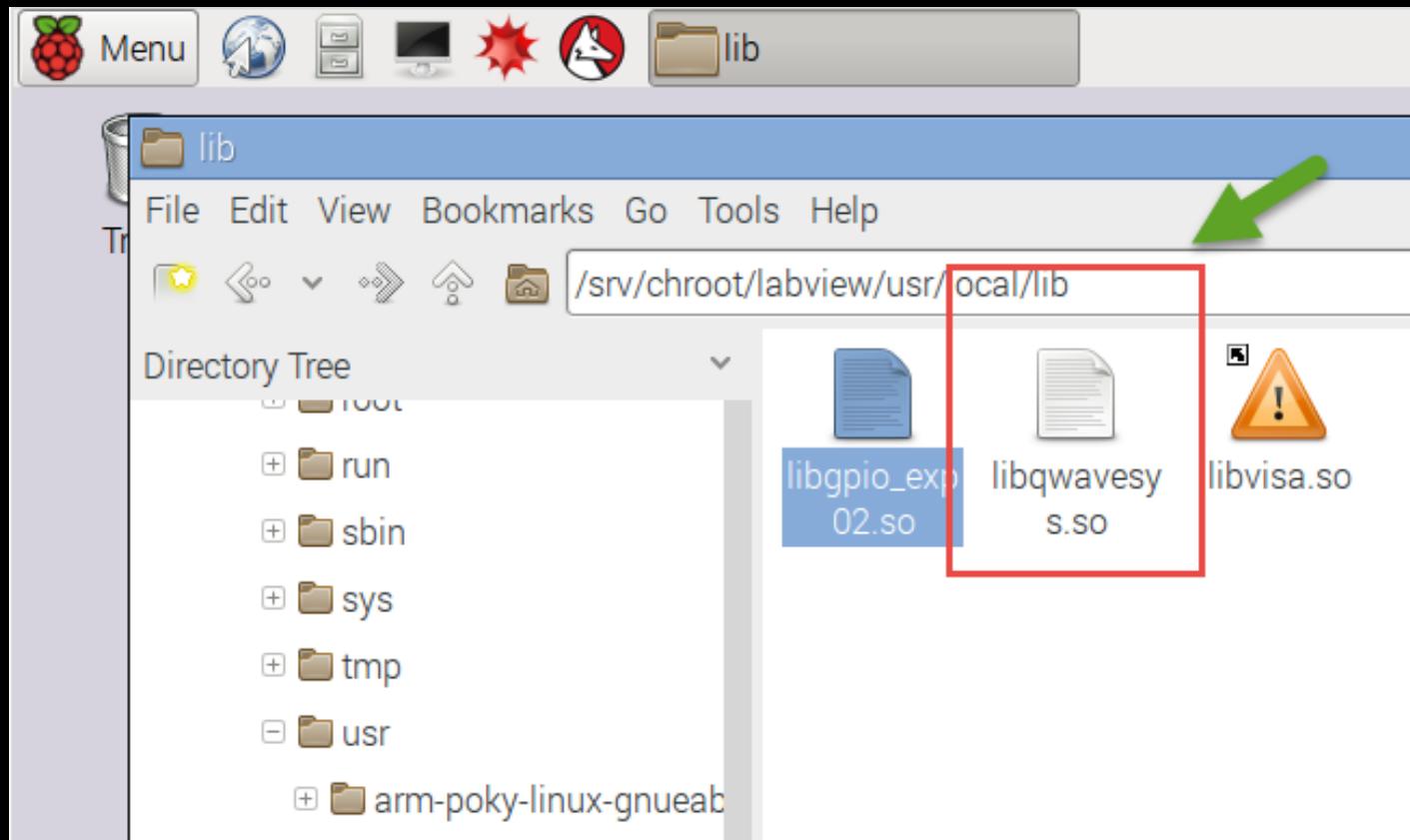
• <http://opencv.org/>

# Sample Image “Penguins”



# OpenCV “libqwavesys.co”

- **libqwavesys.so**



# MyPatternMatch Source Code (C++)

```

} int MyPatternMatch(uchar *img, uchar *templ, int img_cols, int img_rows, int templ_cols, int templ_rows, int *xL, int *xR, int *yT, int *yB, float *score)
{
    // store images in Mat type
    Mat src_image(img_rows, img_cols, CV_8U, &img[0]);
    Mat templ_image(templ_rows, templ_cols, CV_8U, &templ[0]);

    // create result matrix
    Mat result;
    int result_cols = src_image.cols - templ_image.cols + 1;
    int result_rows = src_image.rows - templ_image.rows + 1;
    result.create(result_cols, result_rows, CV_32FC1);
    // match and normalize
    matchTemplate(src_image, templ_image, result, CV_TM_CCORR_NORMED);
    normalize(result, result, 0, 1, NORM_MINMAX, -1, Mat());

    // Locate the best match
    double minVal, maxVal;
    Point minLoc, maxLoc;
    minMaxLoc(result, &minVal, &maxVal, &minLoc, &maxLoc, Mat());

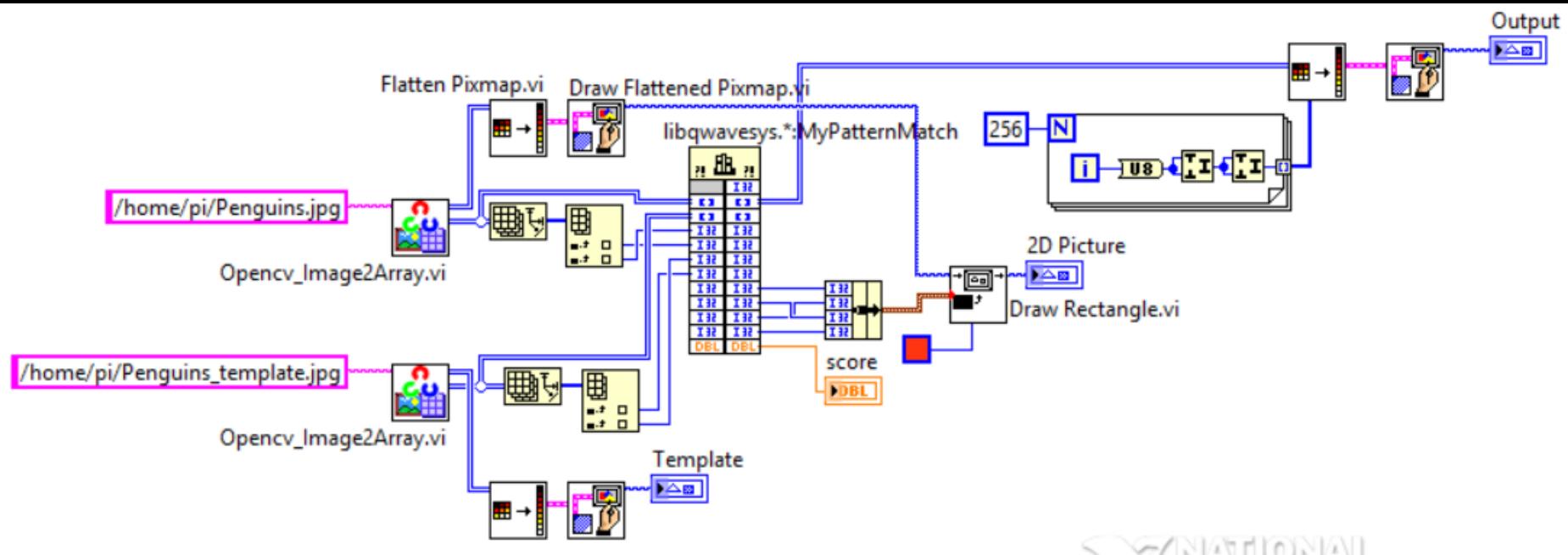
    rectangle(src_image, maxLoc, Point(maxLoc.x + templ_image.cols, maxLoc.y + templ_image.rows), Scalar::all(255), 2);

    // pass the pointer(s) to the bounding box value and match score
    (*xL) = maxLoc.x;
    (*xR) = maxLoc.x + templ_image.cols;
    (*yT) = maxLoc.y;
    (*yB) = maxLoc.y + templ_image.rows;
    (*score) = maxVal;

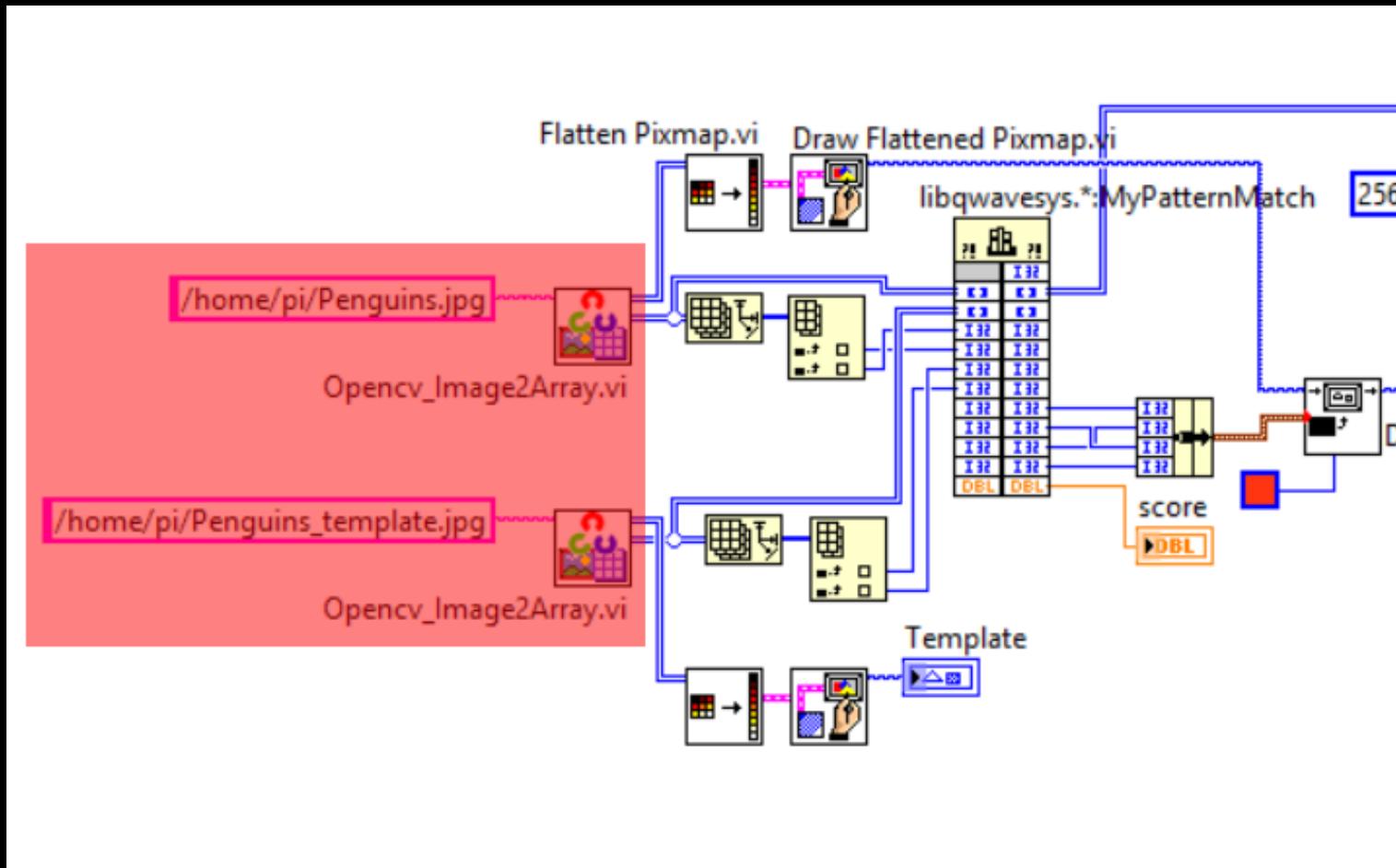
    return 0;
}

```

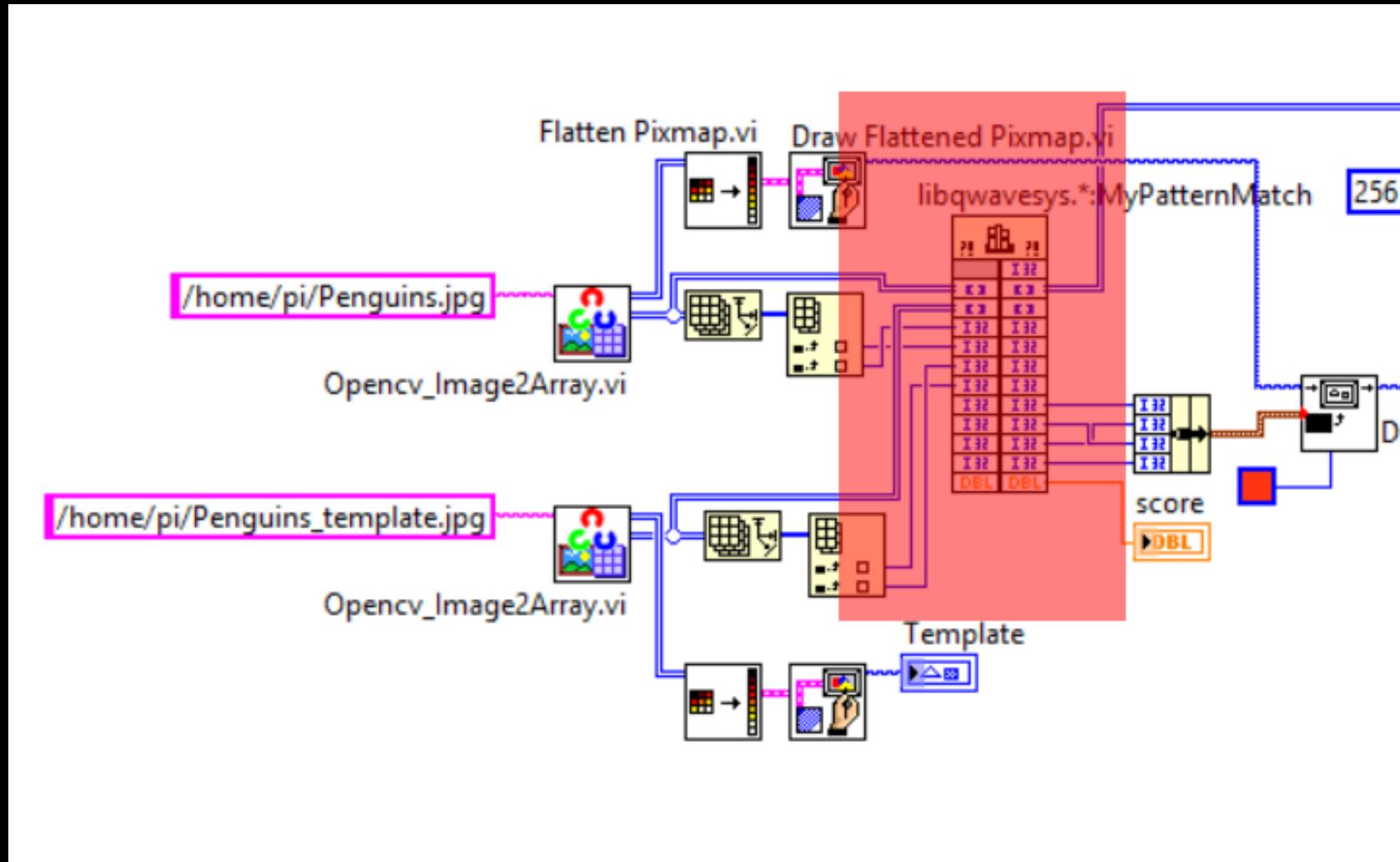
# Navigate a “Pattern Matching” VI



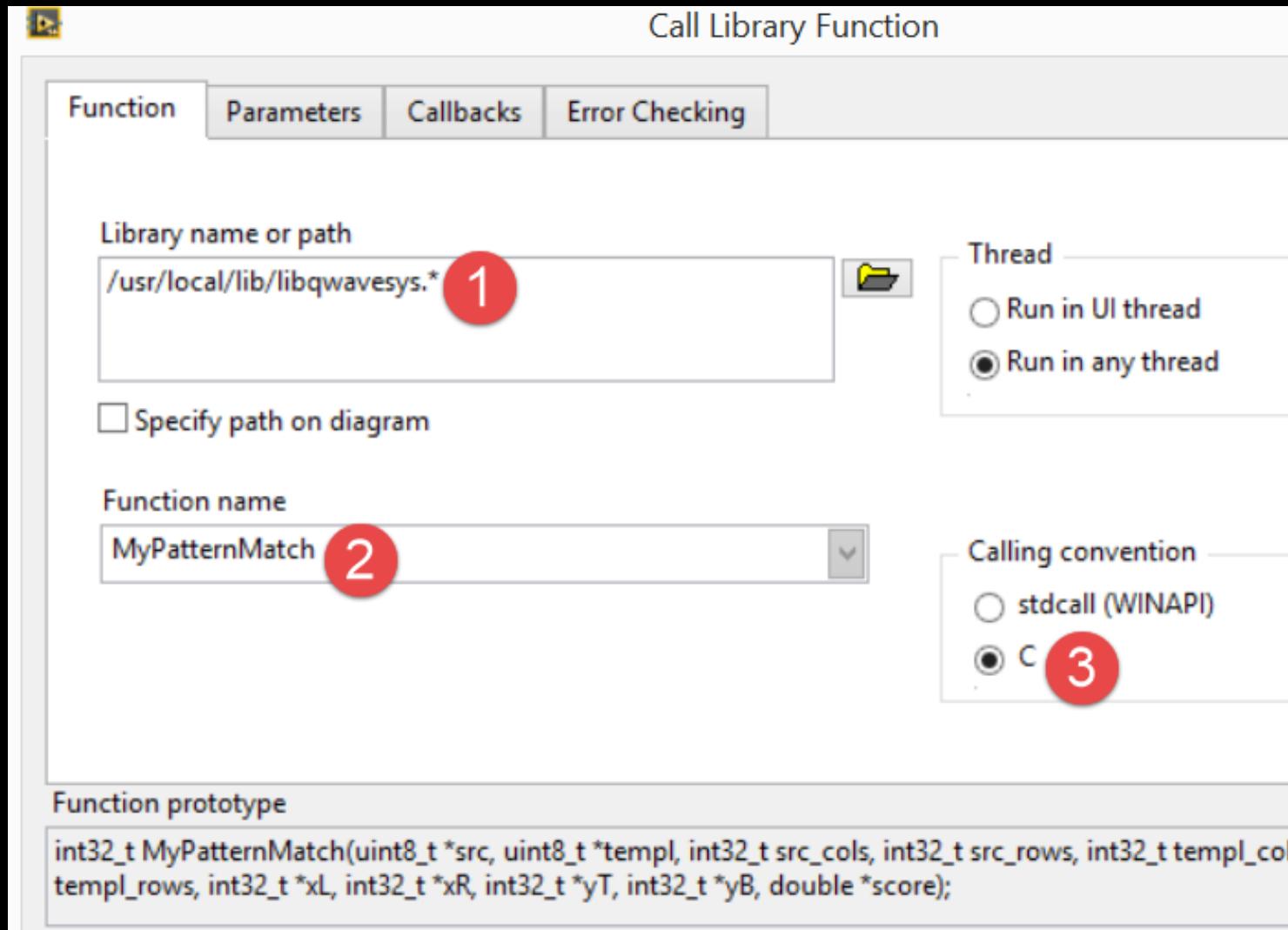
# Open Image File



# Call Share Library “MyPatternMatch”



# Call “MyPatternMatch” Library



# Define Parameters

Call Library Function

Function    Parameters    Callbacks    Error Checking

return type  
src  
templ  
src\_cols  
src\_rows  
templ\_cols  
templ\_rows  
xL  
xR  
yT  
yB  
score

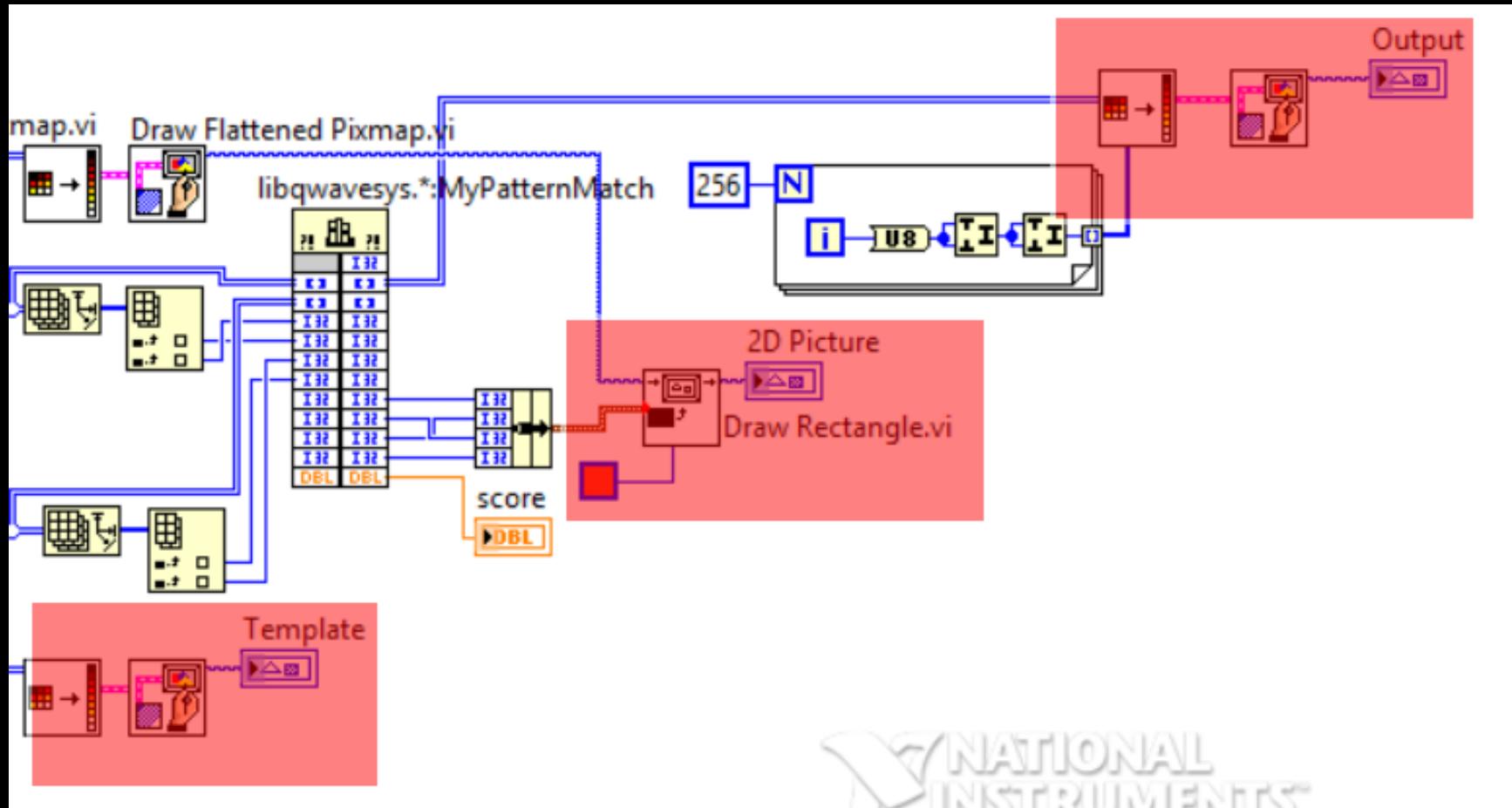
Current parameter

Name **src**  
Type **Array**  
Constant   
Data type **Unsigned 8-bit Integer**  
Dimensions **2**  
Array format **Array Data Pointer**

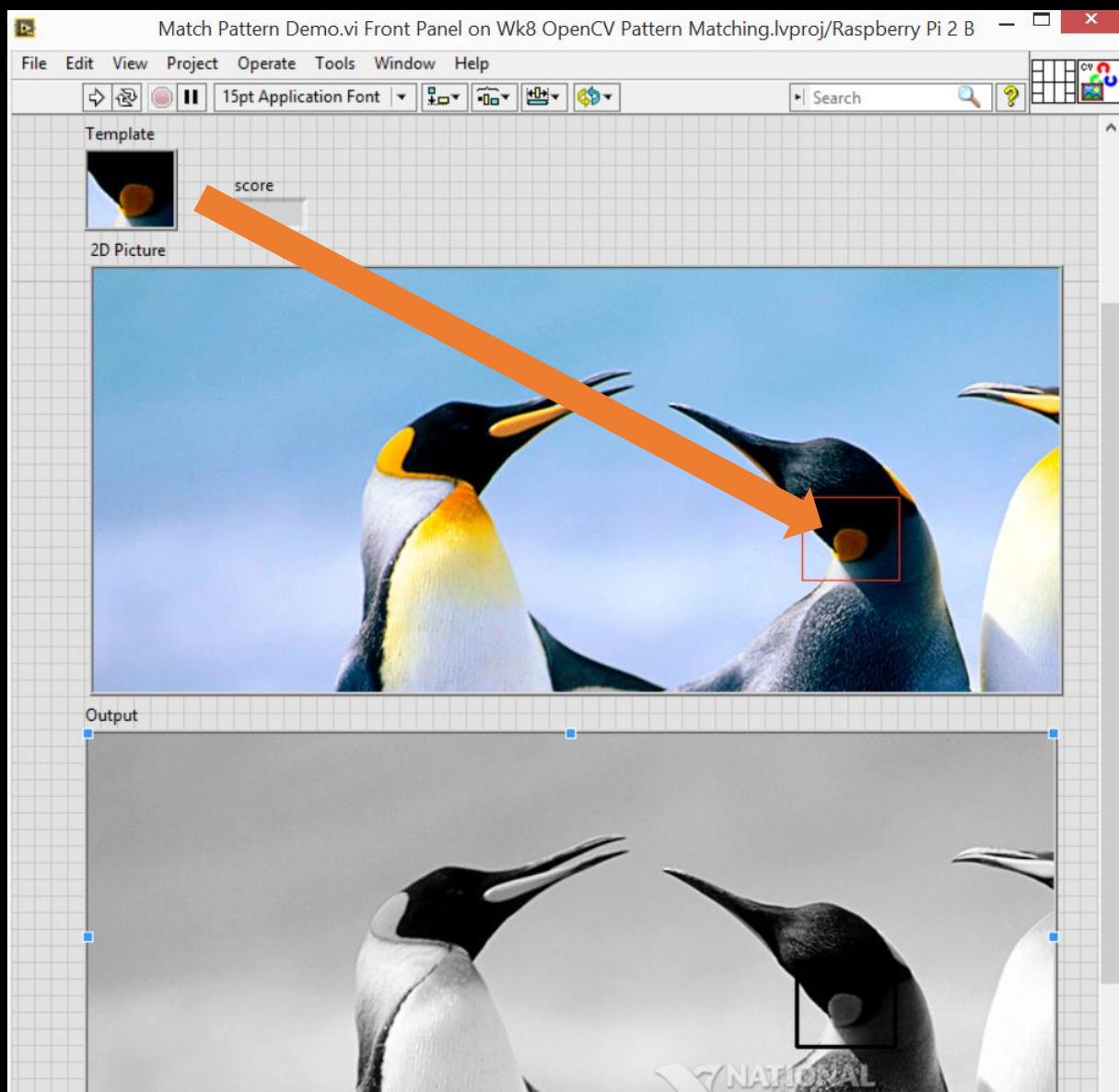
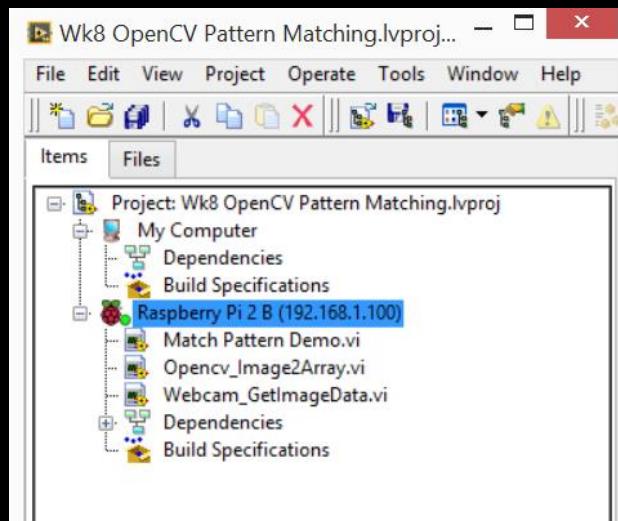
Function prototype

```
int32_t MyPatternMatch(uint8_t *src, uint8_t *templ, int32_t src_cols, int32_t src_rows, int32_t templ_cols, int32_t templ_rows, int32_t *xL, int32_t *xR, int32_t *yT, int32_t *yB, double *score);
```

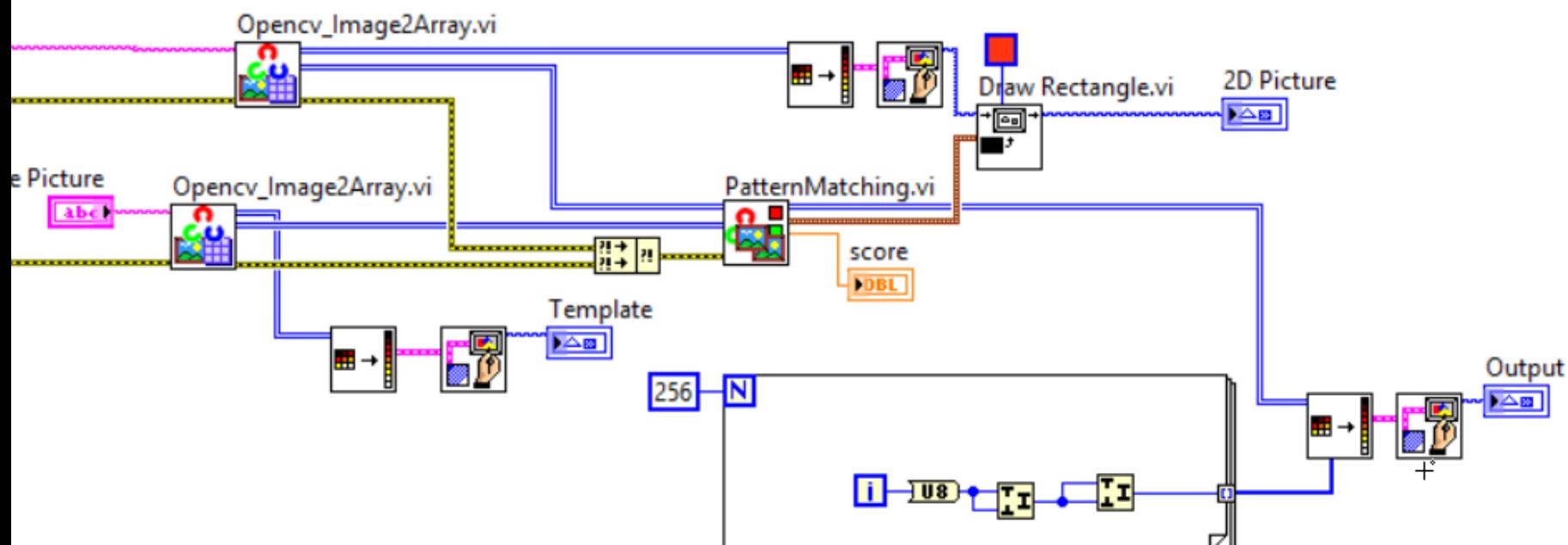
# Display an Image



# Result “Pattern Matching VI”



# Exercise 9 OpenCV Pattern Matching



NATIONAL  
INSTRUMENTS  
LabVIEW™ Home and

# 10

# Exercise 10 Tag WebUI

**Tag WebUI**

Graph Monitor Tags Set Values Status About

Update Rate (ms): 20

Dbl1	▼	Bool1
All Tags		
Update Rate (ms): 200 <input max="10000" min="100" type="range" value="200"/>		

Type	Tag Name	Permissions	Value
Boolean	Bool1	R/W	FALSE
Boolean	Bool2	R/W	FALSE
Double	Dbl1	R/-	-0.256899
String	Str1	R/W	

**Tag WebUI**

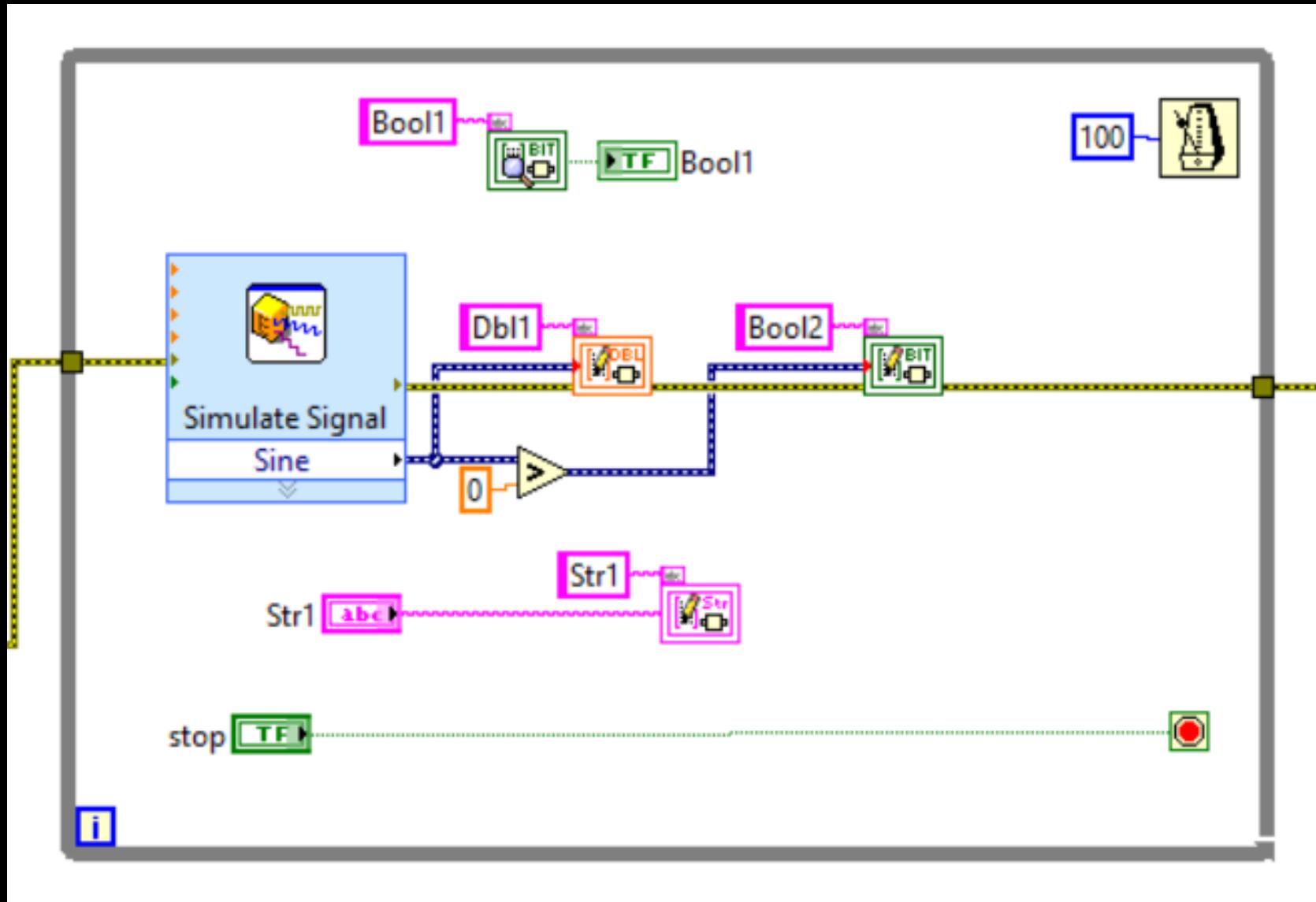
Graph Monitor Tags Set Values

**CPU**  
24.400000000000006%

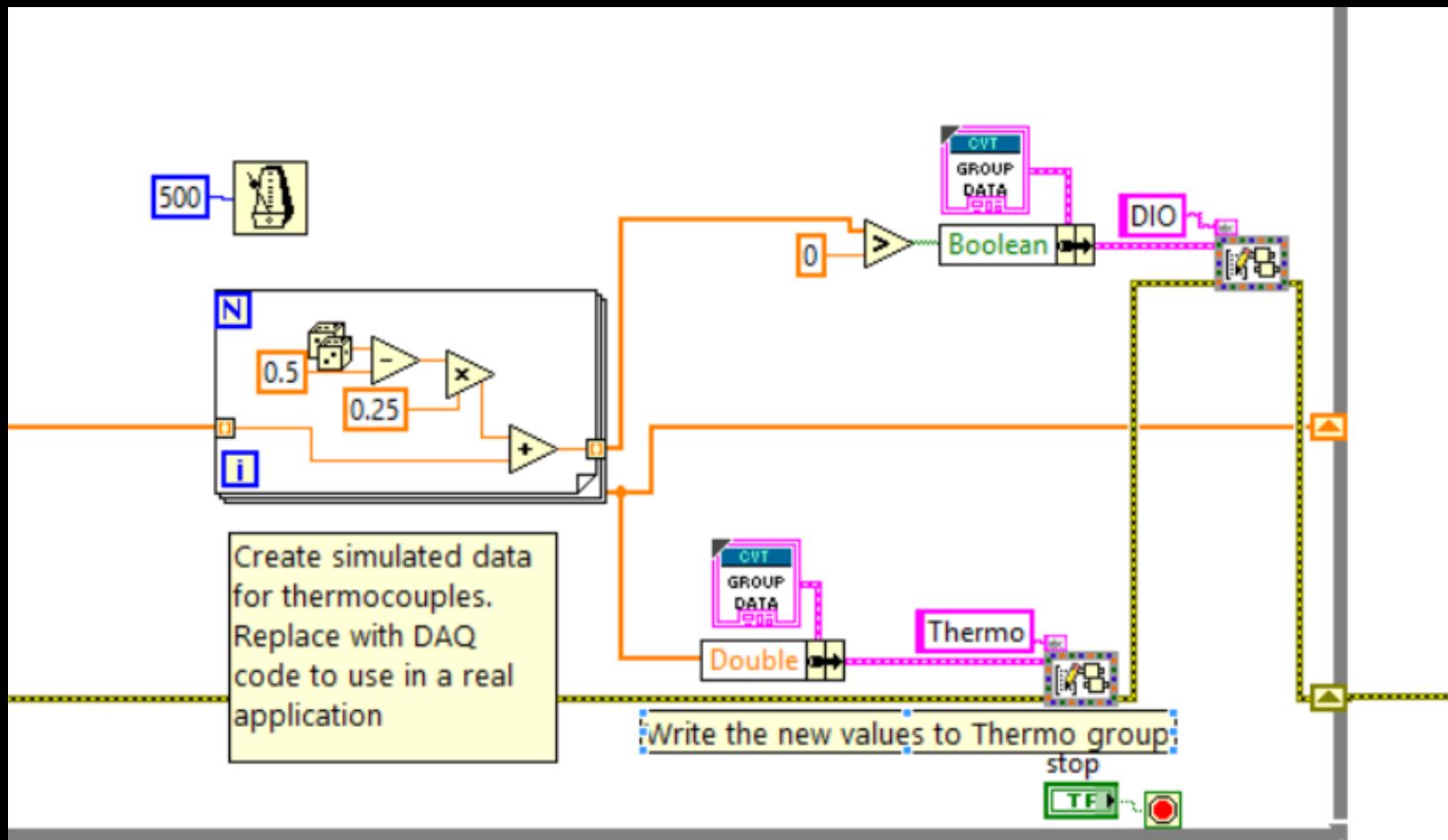
**Memory**  
283/862

www.qwavesys.com

# Exercise 10.1 Basic Write Tag WebUI

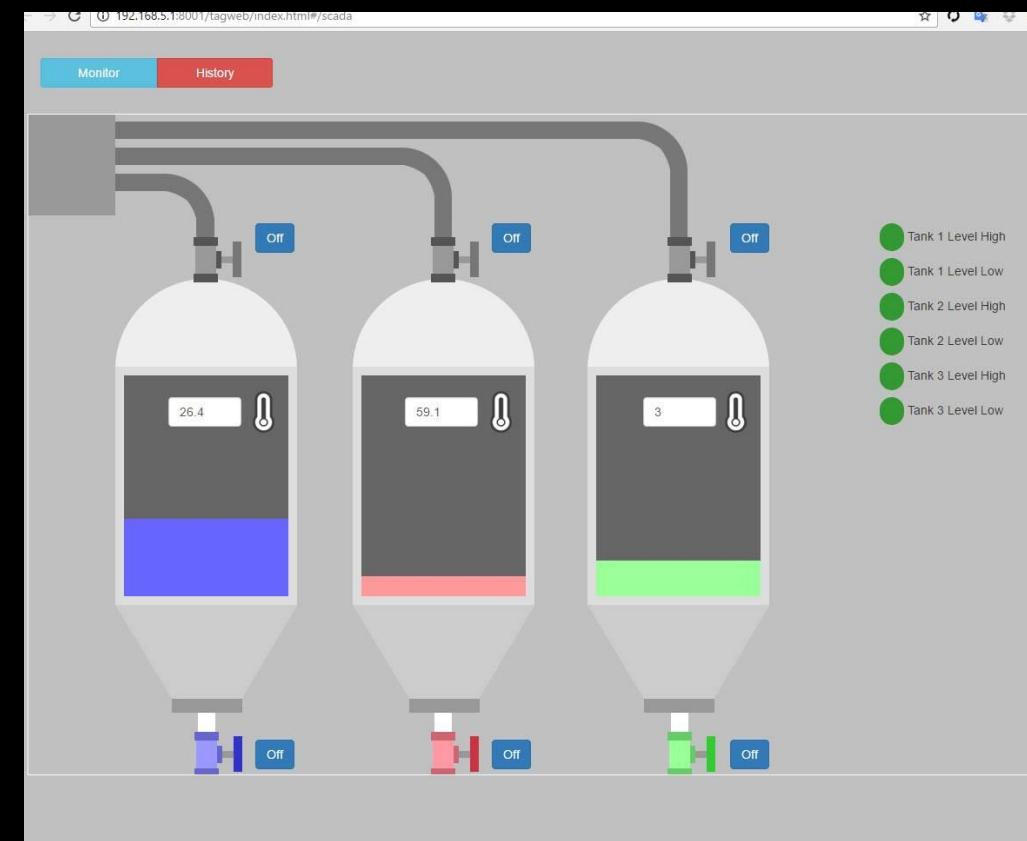
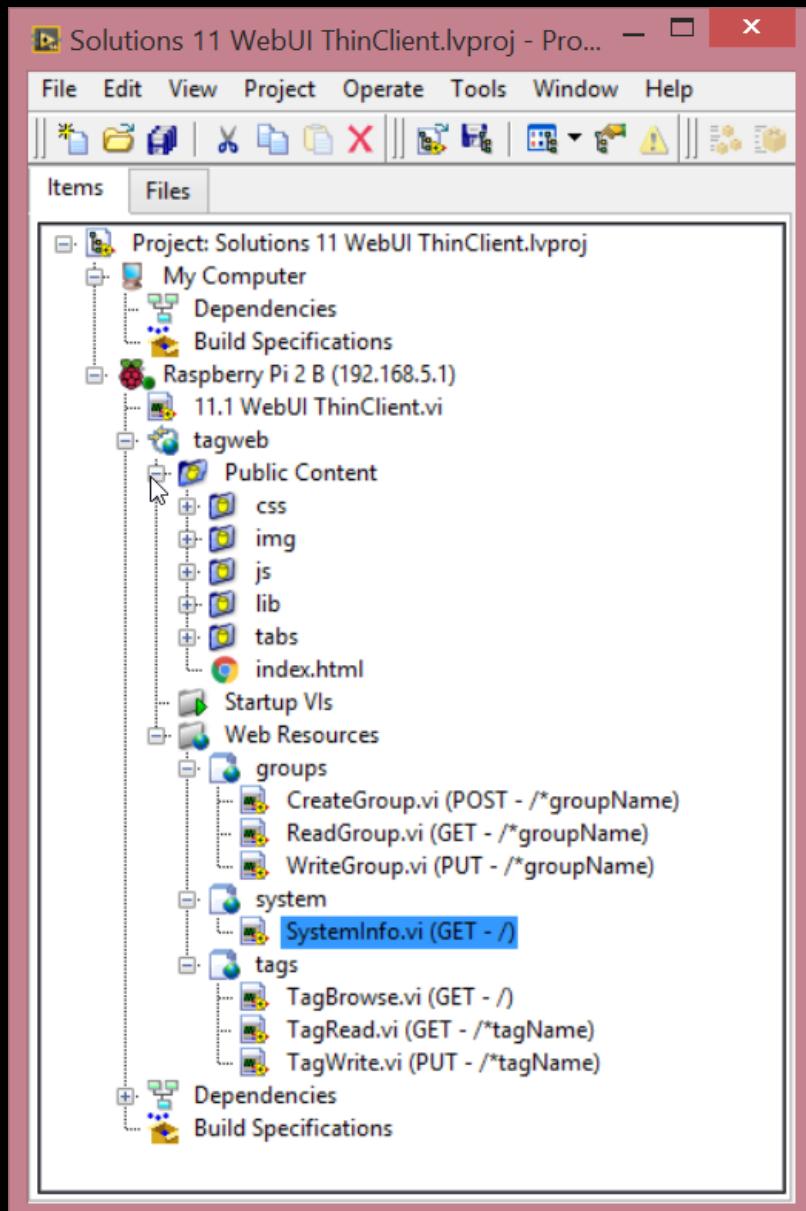


# Exercise 10.2 Example Thermocouple TagWebUI



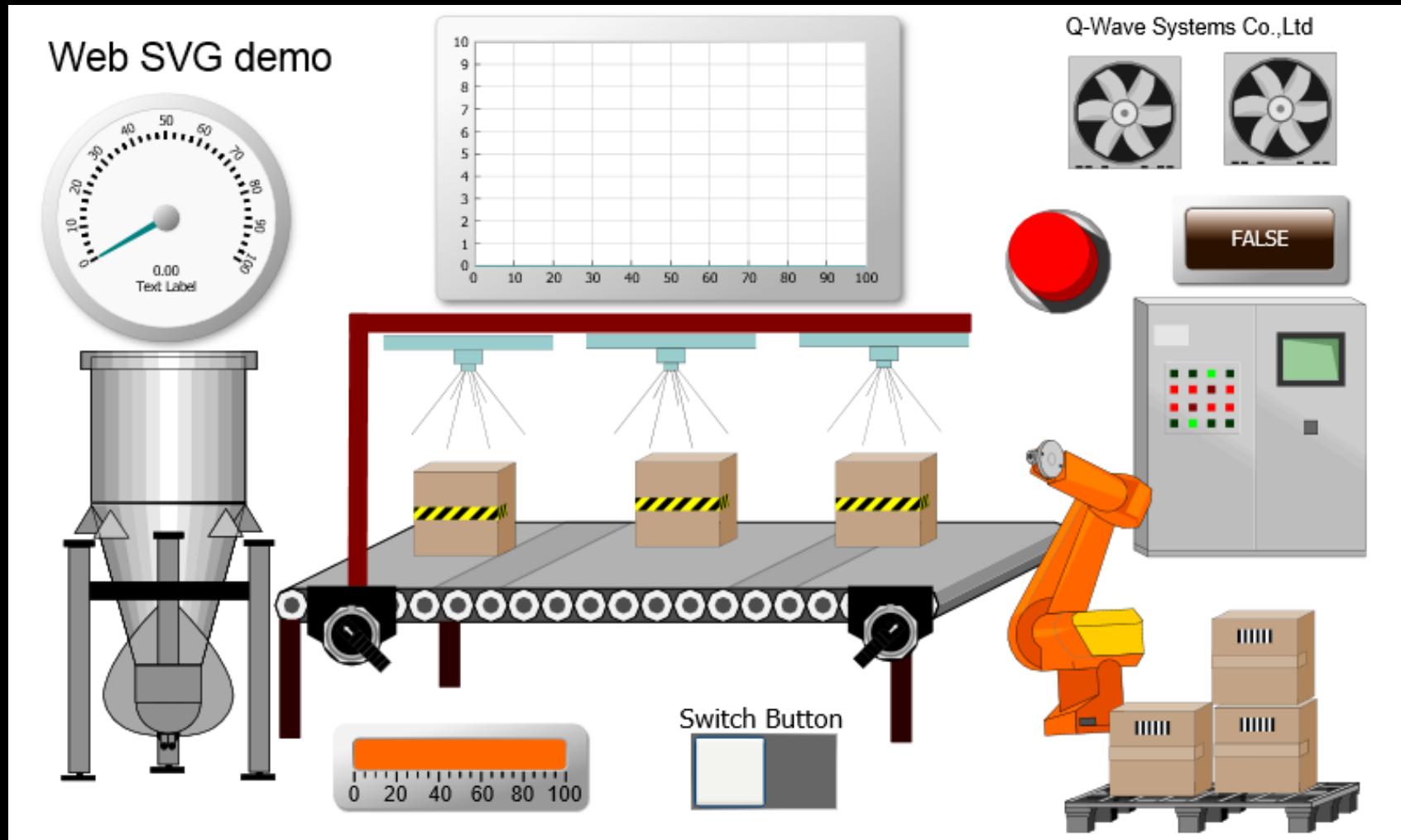
# 11

# Exercise 11 WebUI ThinClient



# 12

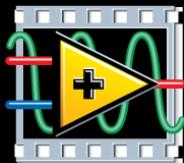
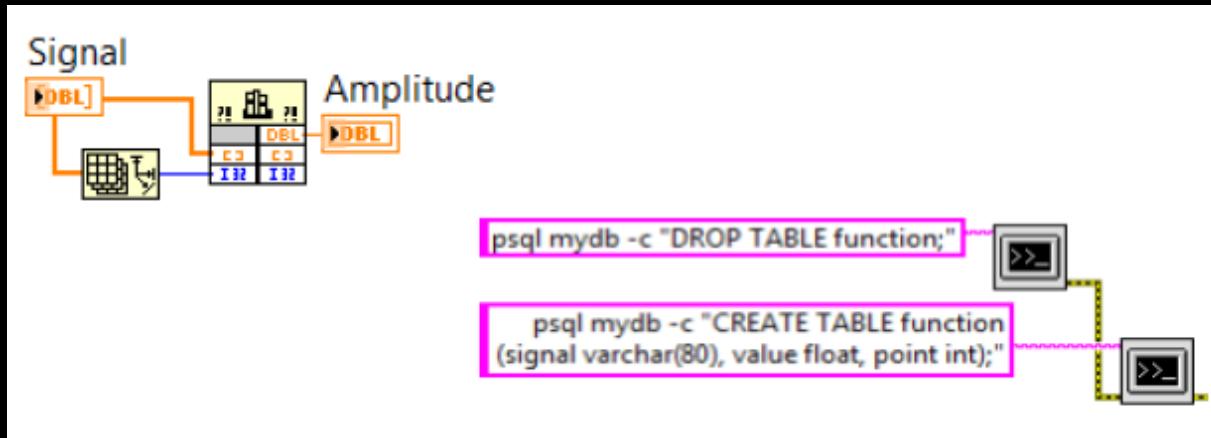
# Exercise 12 Webpanel SVG-HTML5



# 13

# Exercise 13 Share Library Development

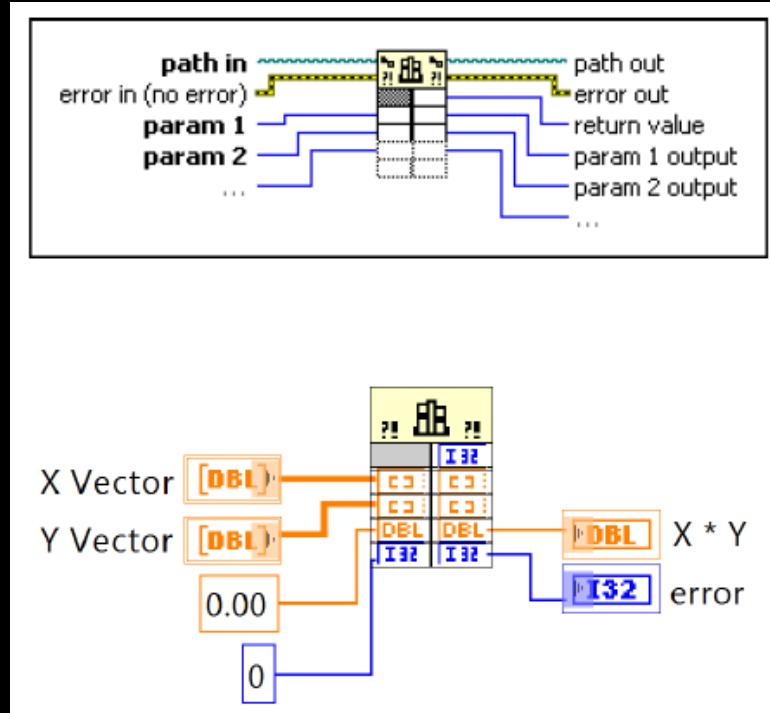
- การส่งค่า ระหว่าง LabVIEW และ Linux Run-Time
- 1. เรียนใช้ Call “Library Function Node”
- 2. เรียนใช้ “System Execution” calls



# Calling C/C++ Libraries with LabVIEW

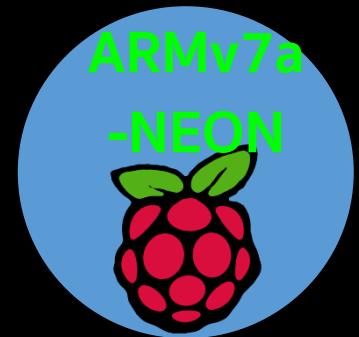
## Call Library Function Node (CLFN)

- Call a Linux shared library from LabVIEW (.so)
- Configure the library, function, parameters, return value
- Pass LabVIEW data types as inputs and returned as outputs to the C/C++ library function.

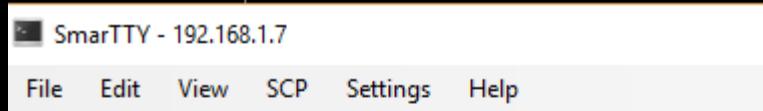


# 6.1 Create a “HelloWorld.cpp”

- **#include <stdio.h>**
- **int main(void)**
- {
- **printf("Hello world!\n");**
- **return 0;**
- }



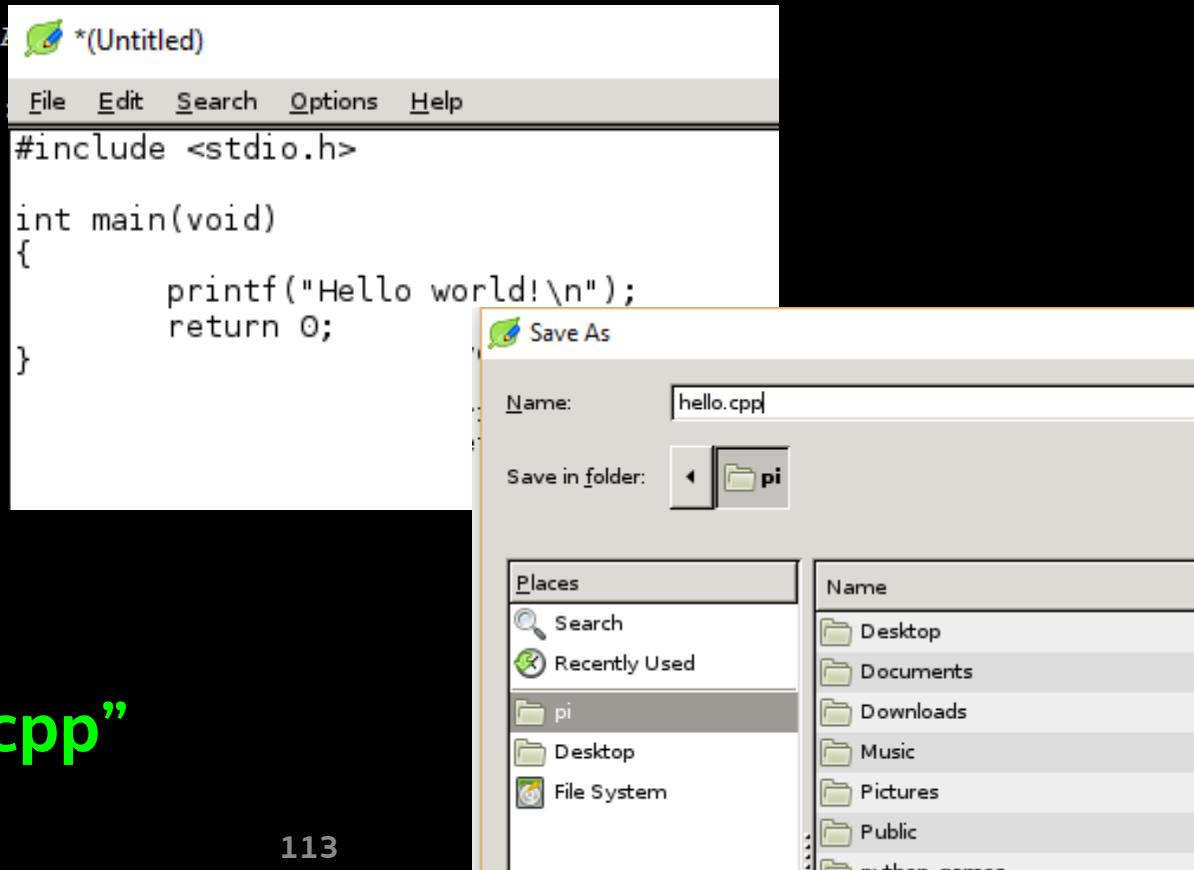
# Using Text Editor “leafpad”



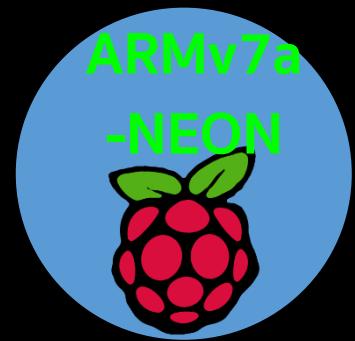
- > leafpad

The programs included with the Debian GN  
the exact distribution terms for each pr  
individual files in /usr/share/doc/\*/cop

```
Debian GNU/Linux comes with no  
permitted by applicable law.  
Last login: Fri May  6 19:30  
pi@raspberrypi:~ $ leafpad
```

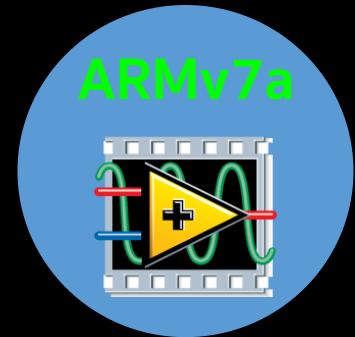


- Save at Location
- “/home/pi/hello.cpp”

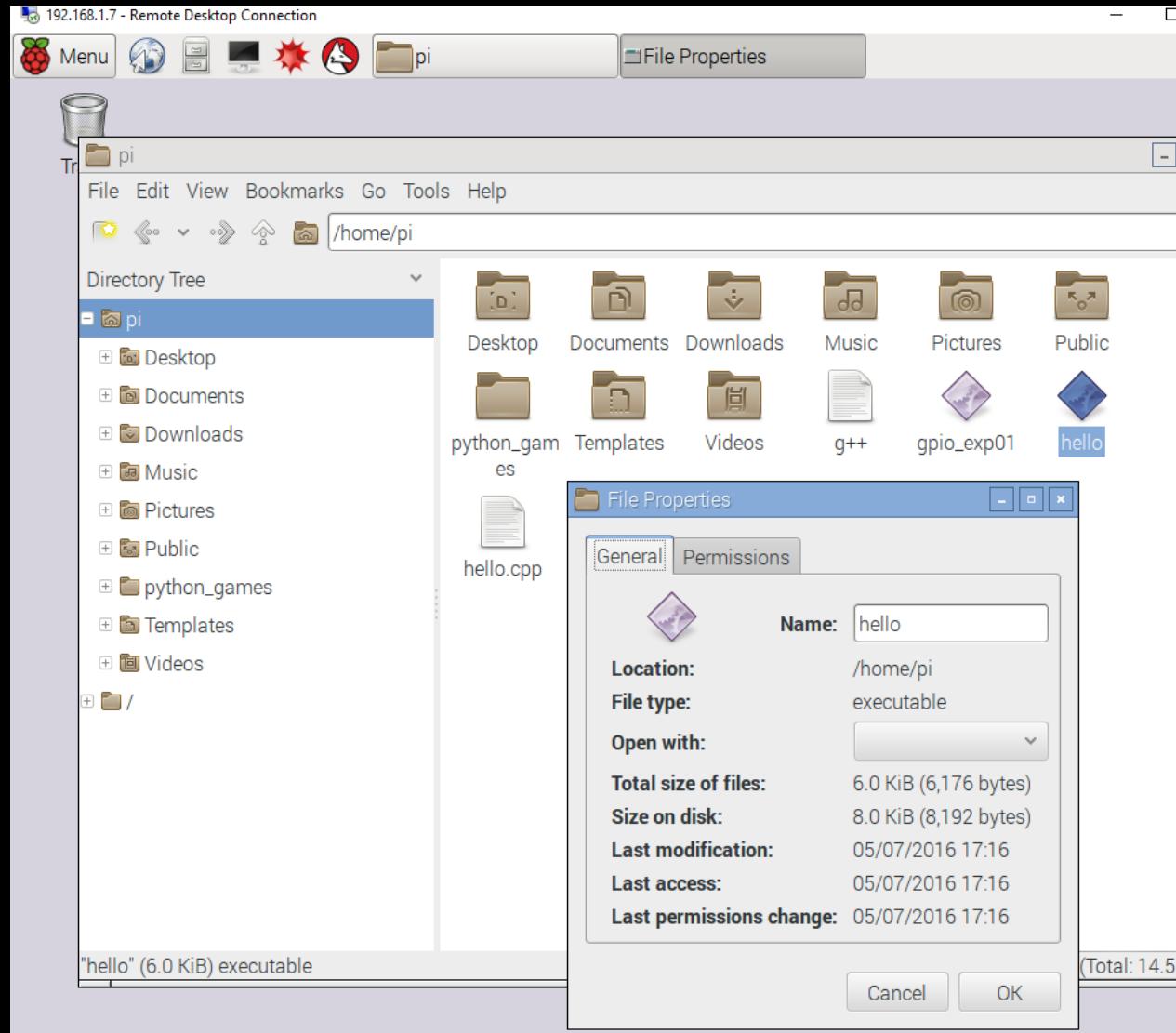


# Build executable

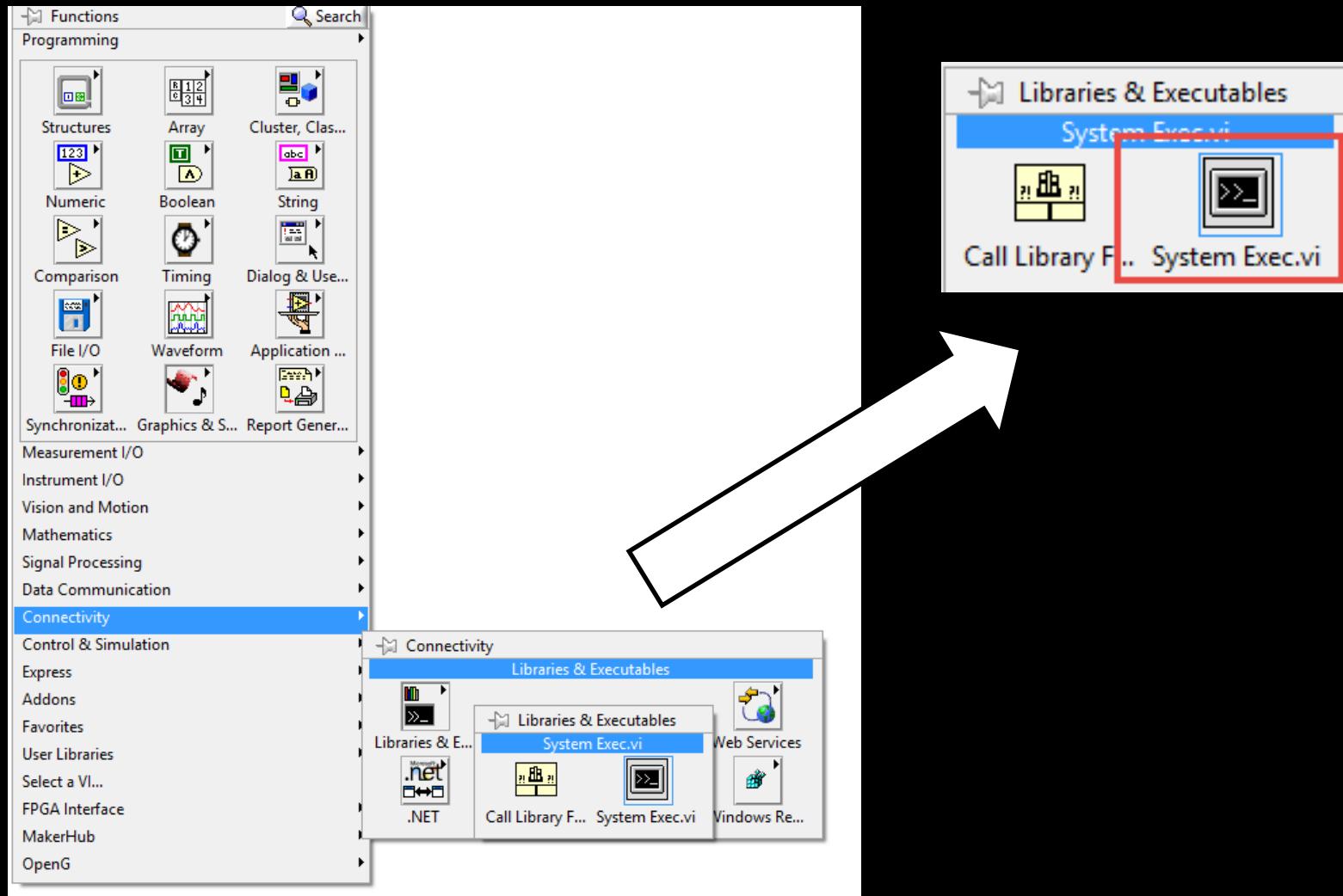
- ใช้คำสั่งเพื่อ Build executable in Linux using g++
- > g++ -std=c++0x /home/pi/hello.cpp -o/home/pi/hello
- เปิดโปรแกรม hello โดยใช้พิมพ์ “./hello”



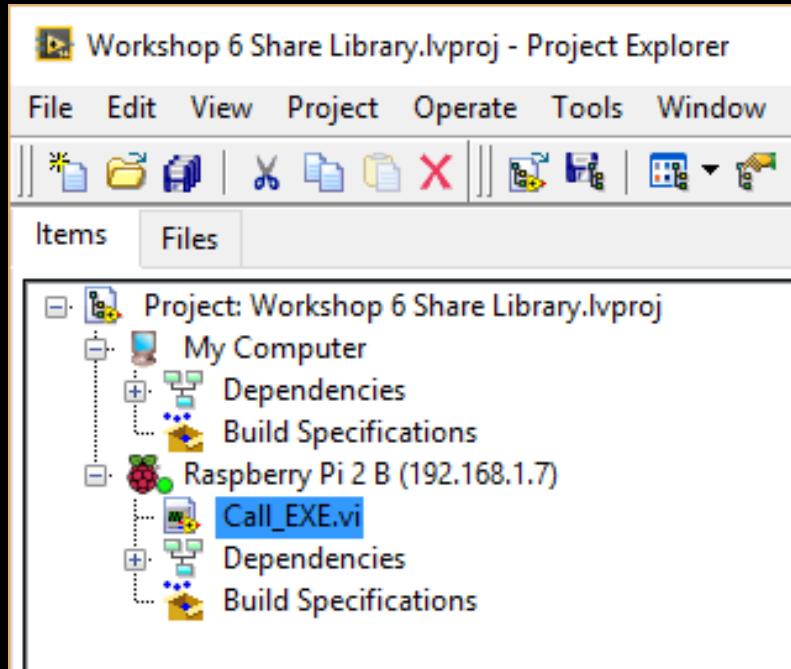
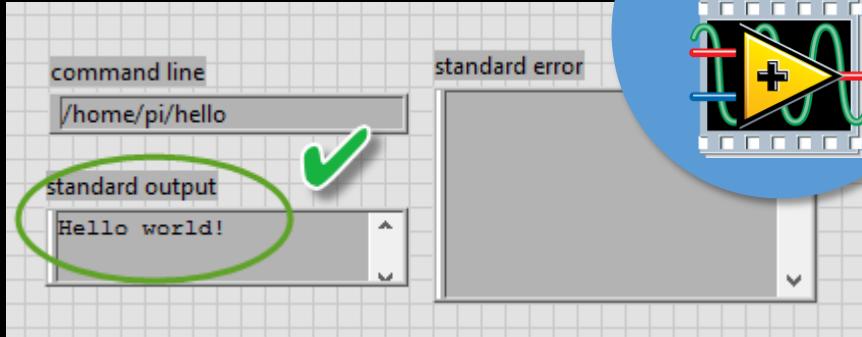
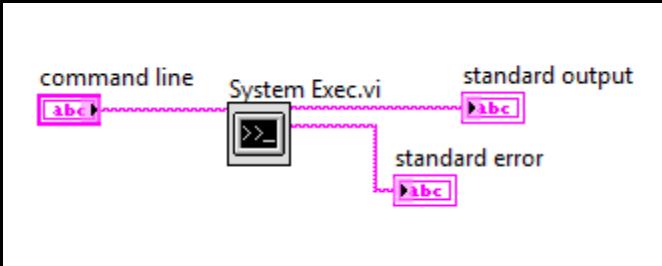
# File Manager Viewer



# “System Execution” calls in LabVIEW

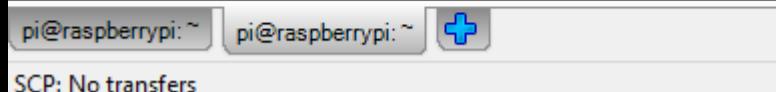


# Create LabVIEW Code



- > cd /home/pi
- > ./hello

root@raspberrypi:/home/pi# ./hello  
Hello world!



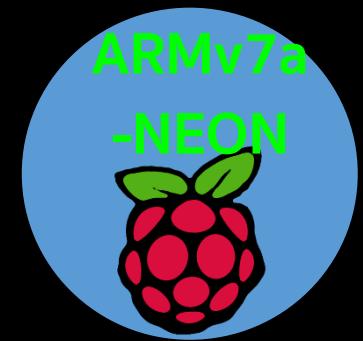
## 6.2 Create Share Object (.so)

```

• #include <stdio.h>
• #ifdef __cplusplus
• extern "C"
• {
• #endif
•     int add( int a, int b );
•     int sub( int a, int b );
• #ifdef __cplusplus
• }
• #endif
    
```

- **int add( int a, int b )**
- {
- **return (a+b);**
- }
  
- **int sub( int a, int b )**
- {
- **return (a-b);**
- }

# Using Text Editor “leafpad”



SmarTTY - 192.168.1.7  
File Edit View SCP Settings Help

```
The programs included with t
the exact distribution terms
individual files in /usr/sha
```

```
Debian GNU/Linux comes with
permitted by applicable law.
```

```
Last login: Fri May 6 19:30
```

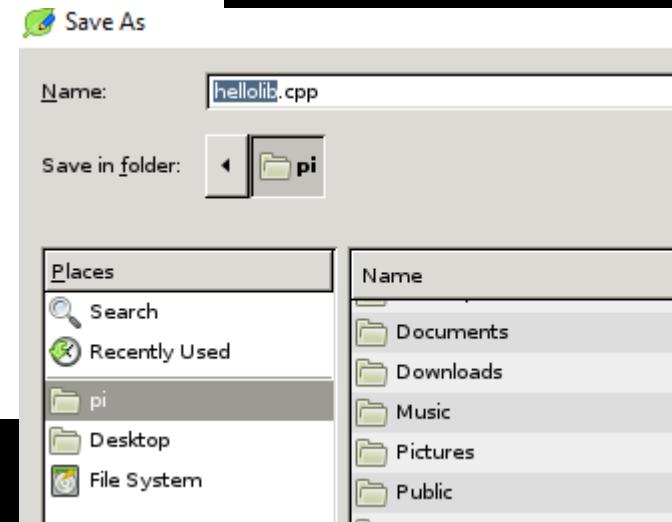
```
pi@raspberrypi:~ $ leafpad
```

\*(Untitled)

```
#include <stdio.h>
#ifndef __cplusplus
extern "C"
{
#endif
    int add( int a, int b );
    int sub( int a, int b );
#endif

int add( int a, int b )
{
    return (a+b);
}

int sub( int a, int b )
{
    return (a-b);
}
```

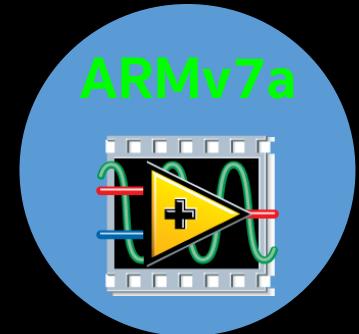


- Save at Location
- “/home/pi/hellolib.cpp”

# Build Share Object (.so)

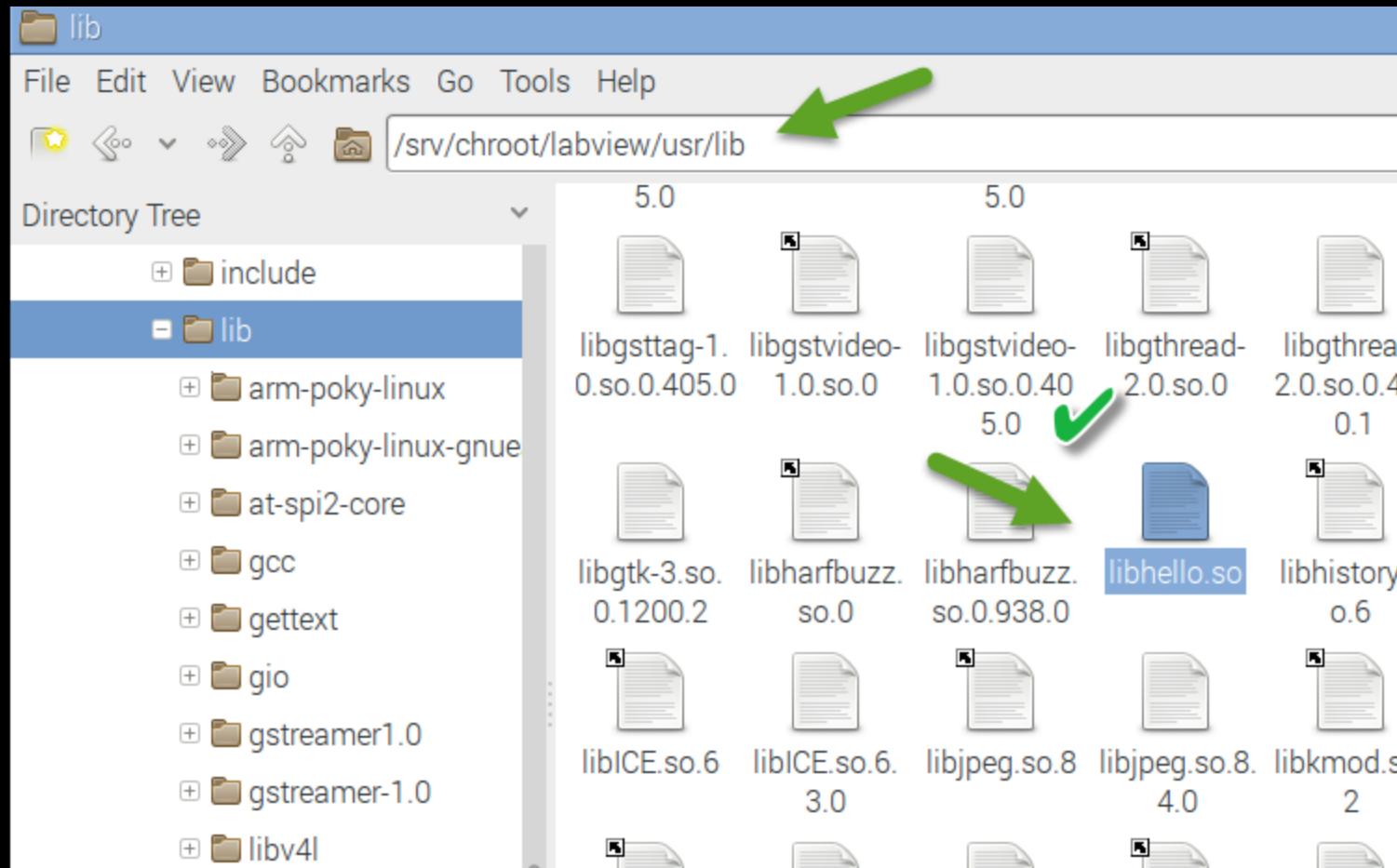
- ใช้คำสั่งเพื่อ Build Share Library/Object (.so)

- > `gcc -shared -o /usr/lib/libhello.so -fPIC /home/pi/hellolib.cpp`



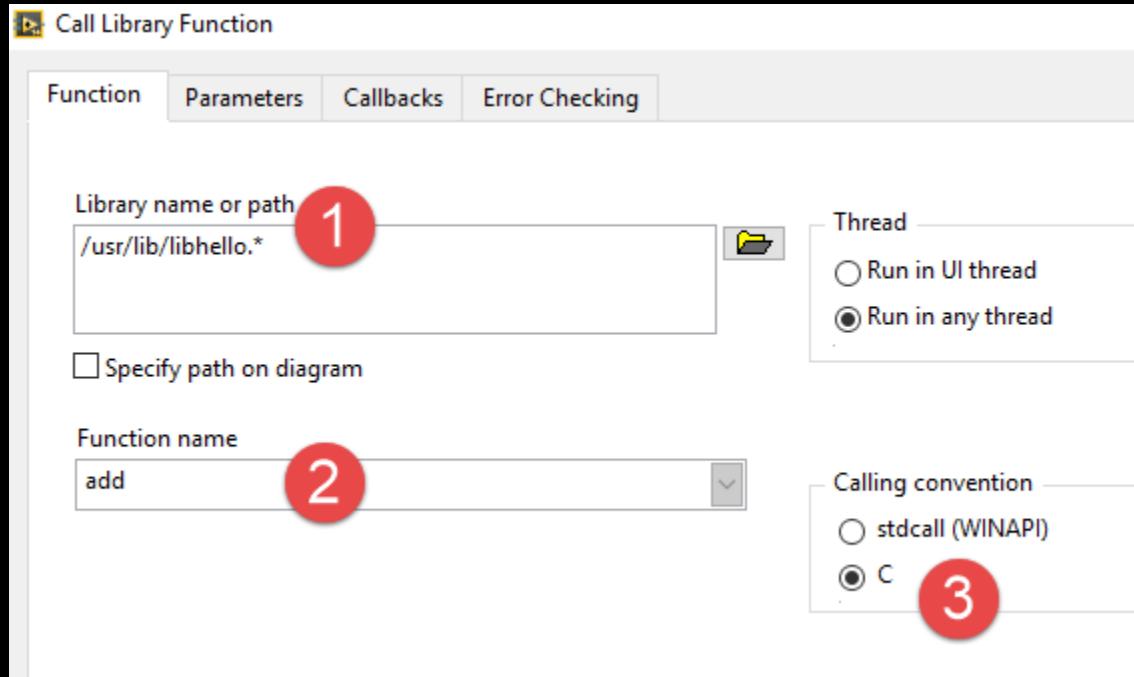
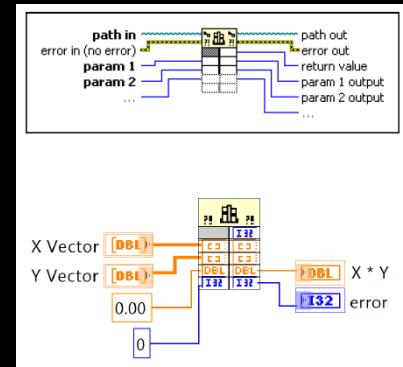
- Path ที่เก็บ Library คือ  
“/srv/chroot/labview/usr/lib/”

# File Manager Viewer



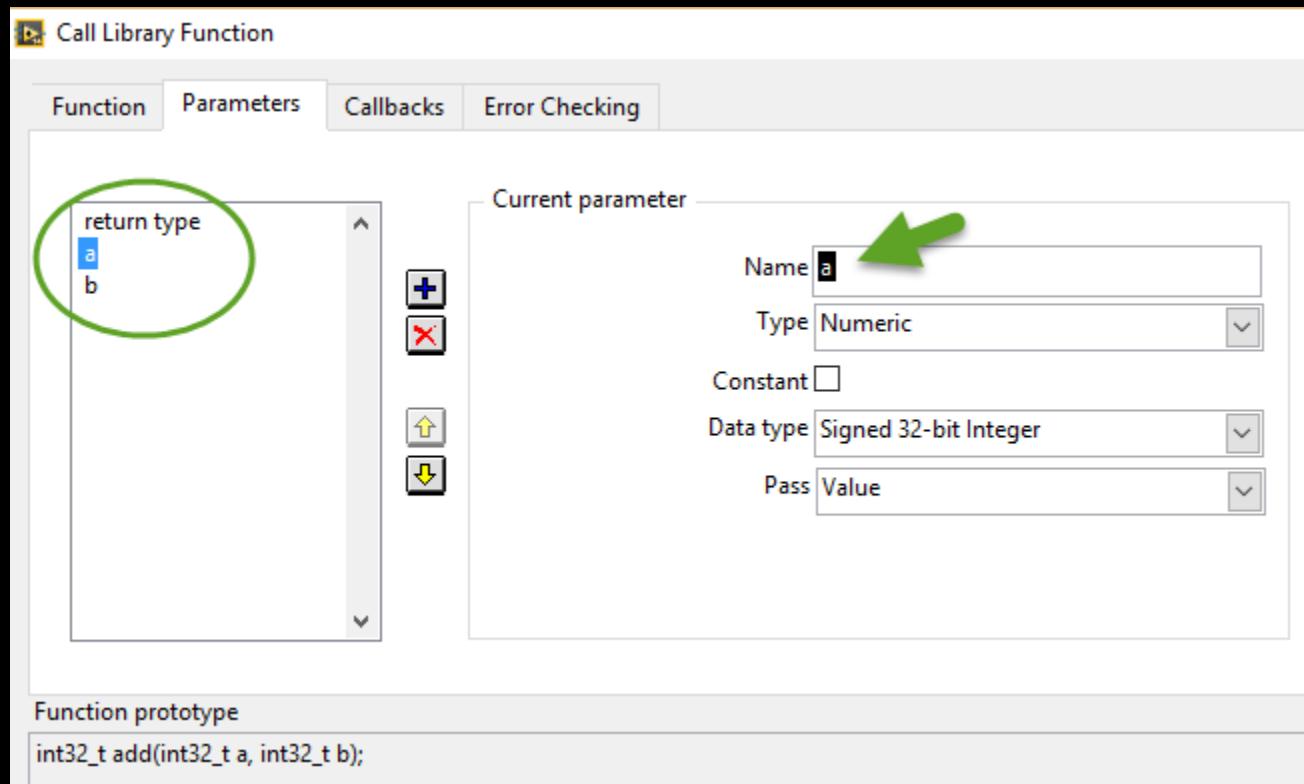
# Call “Library Function Node”

- กำหนด Path ของ Library “/usr/lib/”
- กำหนด Function
- เลือก Calling = “C”

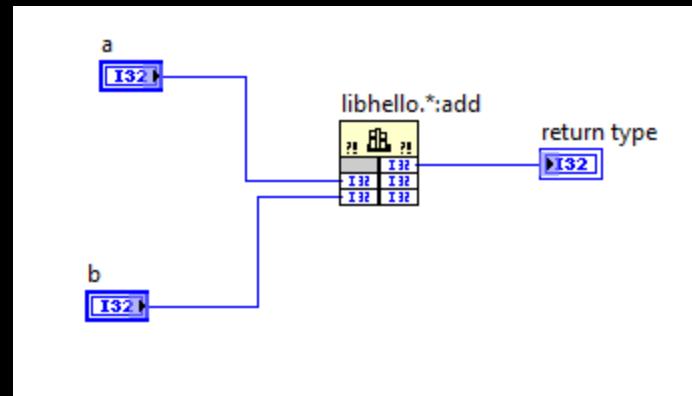
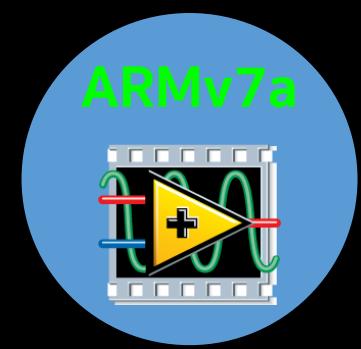
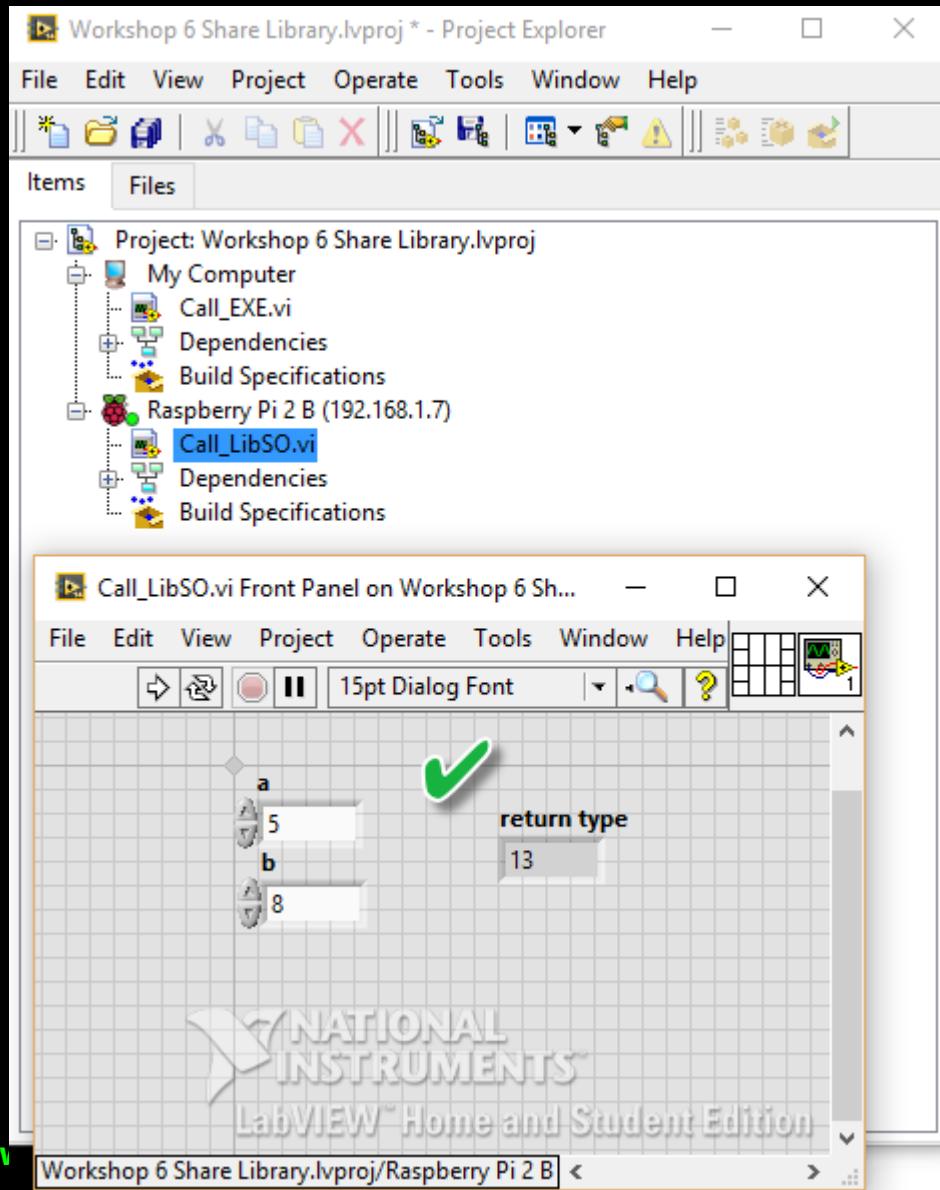


# Call “Library Function Node”

- สร้าง Parameter Input = A,B

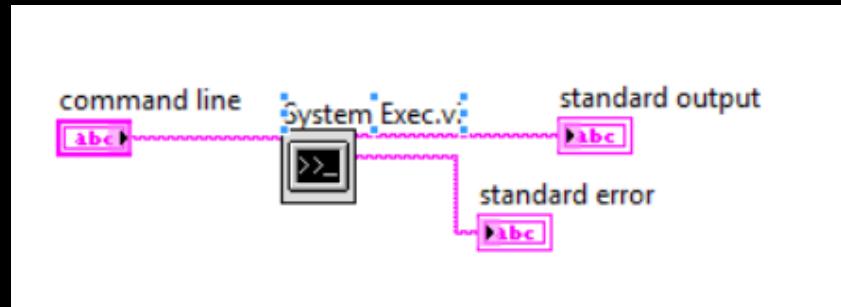
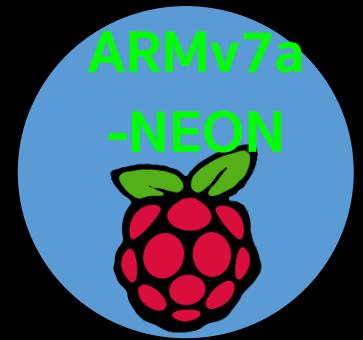


# Call “Library Function Node”



# Example : Calling SHH from Chroot

> ssh pi@localhost ./helloPi



# 14

# Exercise 14 WiringPi Library Development

- **Wiring Pi : GPIO Interface library for Raspberry Pi**

**Wiring Pi**  
*GPIO Interface library for the Raspberry Pi*



[Home](#) [News](#) [Examples/How-To](#) [Reference](#) **Extensions** [Download and Install](#) [Pins](#) [The GPIO utility](#) [Dev Lib](#)

**Contact**

[Home](#)

**About**

*WiringPi* is a GPIO access library written in C for the Raspberry Pi. It's released under the [GNU LGPLv3](#) license and can be used in many other languages with suitable wrappers (See below). I have used the Arduino "wiring" system<sup>1</sup>.

The original [Raspberry Pi Model A and B](#) version has a 26-pin General Purpose Input/Output (GPIO) connector and buses. There are 8 general purpose digital pins which can be either digital outputs or inputs. One of these pins

I2C: MCP23016

I2C: MCP23008 & MCP23017

SPI: MCP23s08 & MCP23s17

Shift Register: 74x595

I2C: PCF8574

I2C: PCF8591 (Analog)

I2C: SN3218 – LED controller

Writing your own

Raspberry Pi... and many other... to people who... I computer with... a set of signals... programmed as... hardware PWM

Search Site

**Recent Posts**

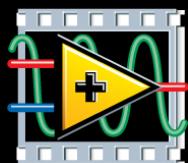
- wiringPi update to 2.29
- wiringPi updated for the new Pi v2
- wiringPi and the Raspberry Pi Compute board
- PiGlow added to the devLib
- WiringPi v2 (point 03) is released!

**Archives**

- September 2015
- February 2015



Gordon Henderson  
@drgon



# Pin Out & Special Pin Functions

- <http://wiringpi.com/pins/special-pin-functions/>

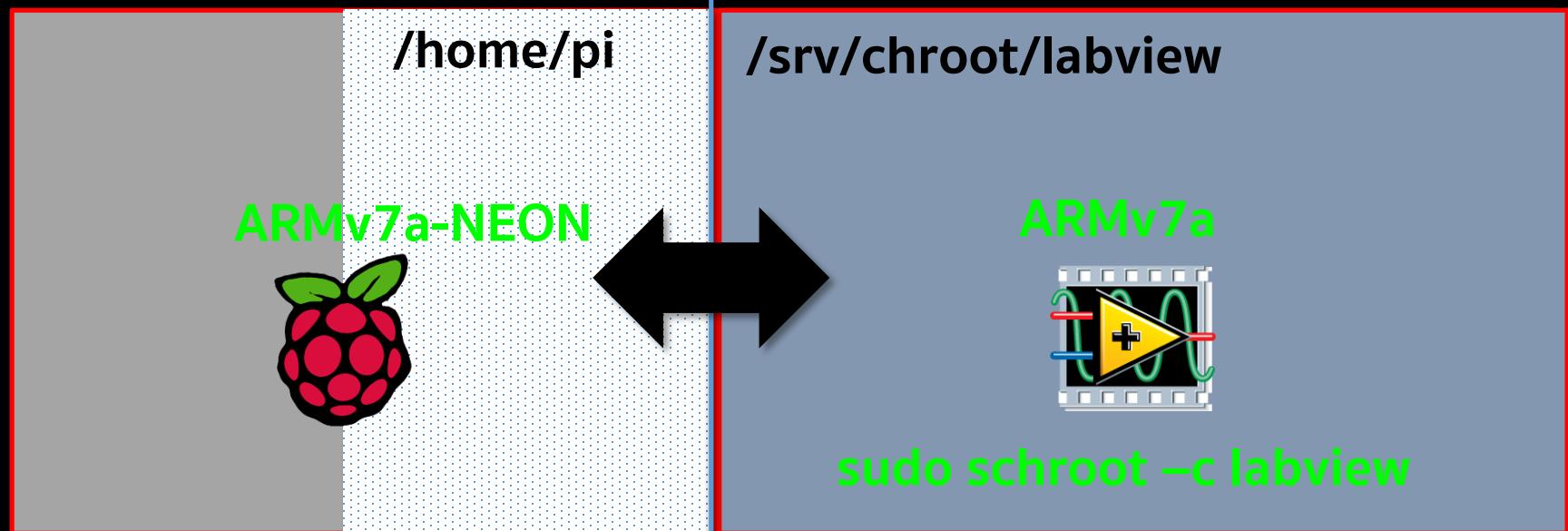
Raspberry Pi 2 Model B (J8 Header)			
GPIO#	NAME	NAME	GPIO#
	3.3 VDC Power	5.0 VDC Power	1
8	GPIO 8 SDA1 (I2C)	5.0 VDC Power	2
9	GPIO 9 SCL1 (I2C)	Ground	4
7	GPIO 7 GPCLK0	GPIO 15 TxD (UART)	15
	Ground	GPIO 16 RxD (UART)	16
0	GPIO 0	GPIO 1 PCM_CLK/PWM0	1
2	GPIO 2	Ground	14
3	GPIO 3	GPIO 4	4
	3.3 VDC Power	GPIO 5	5
12	GPIO 12 MOSI (SPI)	Ground	18
			20

13	GPIO 13 MISO (SPI)	21	GPIO 6	6
14	GPIO 14 SCLK (SPI)	23	GPIO 10 CE0 (SPI)	10
	Ground	25	GPIO 11 CE1 (SPI)	11
	SDA0 (I2C ID EEPROM)	27	SCL0 (I2C ID EEPROM)	
21	GPIO 21 GPCLK1	29	Ground	
22	GPIO 22 GPCLK2	31	GPIO 26 PWM0	26
23	GPIO 23 PWM1	33	Ground	
24	GPIO 24 PCM_FS/PWM1	35	GPIO 27	27
25	GPIO 25	37	GPIO 28 PCM_DIN	28
	Ground	39	GPIO 29 PCM_DOUT	29

**Attention!** The GPIO pin numbering used in this diagram is intended for use with WiringPi / Pi4J. This pin numbering is not the raw Broadcom GPIO pin numbers.

<http://www.pi4j.com>

# Working with Two Platform



```
SmarTTY - 192.168.1.7
File Edit View SCP Settings Help

The programs included with the Debian GNU/Linux
the exact distribution terms for each program
individual files in /usr/share/doc/*copyright

Debian GNU/Linux comes with ABSOLUTELY NO WARRANTY,
permitted by applicable
Last login: Fri May 6 20:44:02 2016 from 192.168.1.26
pi@raspberrypi:~ $
```

**ARMv7a  
-NEON**

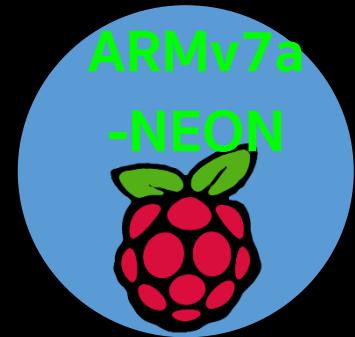
```
SmarTTY - 192.168.1.7
File Edit View SCP Settings Help

Last login: Fri May 6 20:44:02 2016 from 192.168.1.26
pi@raspberrypi:~ $ sudo schroot -c labview
shell-init: error retrieving current directory: getcwd
uccess
root@raspberrypi:~#
chdir: error retrieving current directory: getcwd
s
root@raspberrypi:~#
bin dev lib
boot etc lib
root@raspberrypi:~#
sys tmp var
```

**ARMv7a**

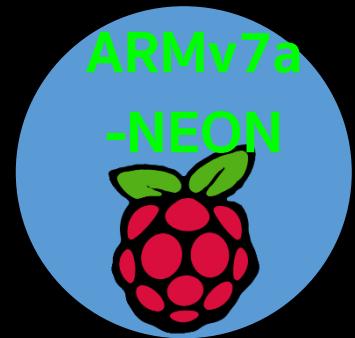
# Create a “exp02.c”

- **#include <wiringPi.h>**
- **#ifdef \_\_cplusplus**
- **extern "C"**
- **{**
- **#endif**
- **void mygpio\_init (char PIN, char MODE);**
- **void mygpio\_write (char PIN, char state);**
- **#ifdef \_\_cplusplus**
- **}**
- **#endif**



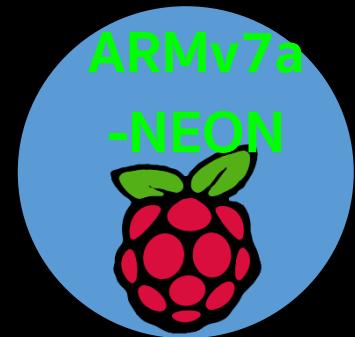
# Create a “exp02.c” (எது)

- **void mygpio\_init (char PIN, char MODE)**
- {
- **wiringPiSetup () ;**
- **pinMode (PIN, MODE) ;**
- }
  
- **void mygpio\_write (char PIN, char state)**
- {
- **digitalWrite (PIN, state);**
- }

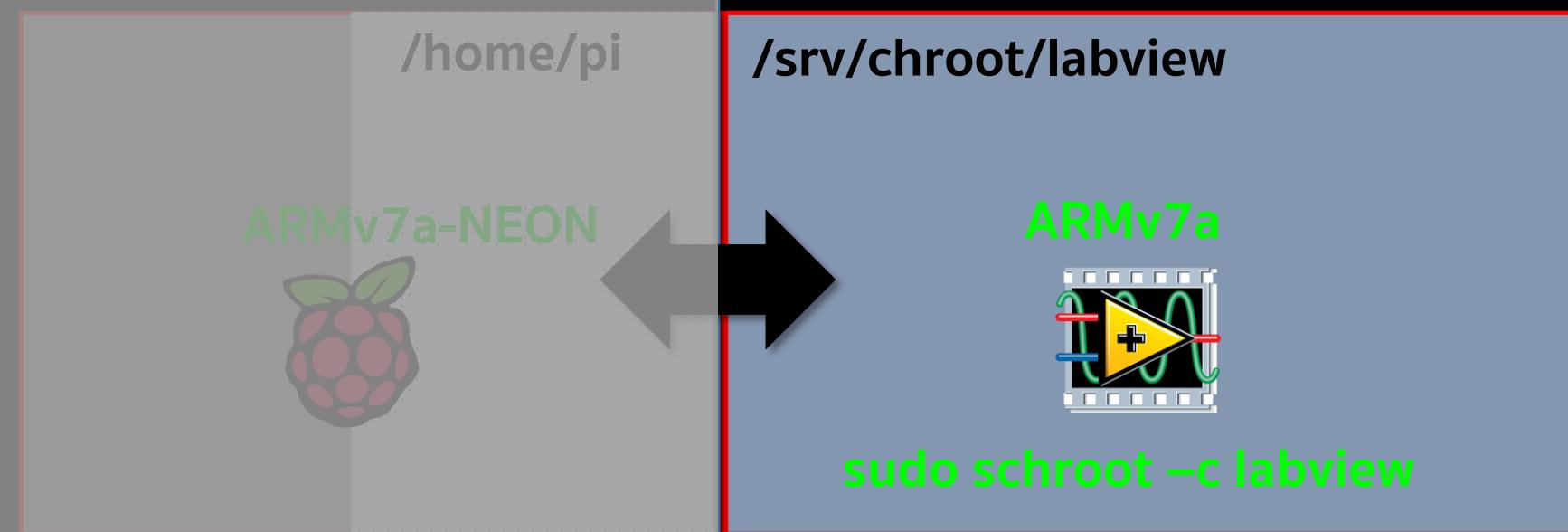


# Create a “exp02.c” (-cont)

```
• /*  
• #define INPUT          0  
• #define OUTPUT         1  
• #define PWM_OUTPUT     2  
• #define GPIO_CLOCK      3  
• #define SOFT_PWM_OUTPUT 4  
• #define SOFT_TONE_OUTPUT 5  
• #define PWM_TONE_OUTPUT 6  
• */
```

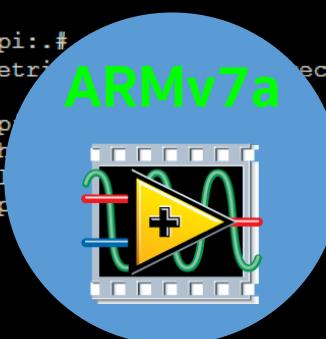


# Working with Two Platform



```
SmarTTY - 192.168.1.7
File Edit View SCP Settings Help
Last login: Fri May  6 20:44:02 2016 from 192.168.1.26
pi@raspberrypi:~ $ sudo schroot -c labview
shell-init: error retrieving current directory: getcwd
[REDACTED]
success
root@raspberrypi:#
chdir: error retr[REDACTED] directory: getcwd: car
s
root@raspberryp[REDACTED]
bin  dev  h[REDACTED]  sys  usr
boot etc  i[REDACTED]  n  tmp  var
root@raspberryp[REDACTED]
```



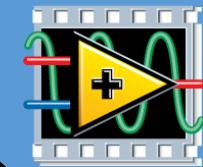


COMPANY CONFIDENTIAL CONTENT

# Build a Share Library “libgpio\_exp02.so”

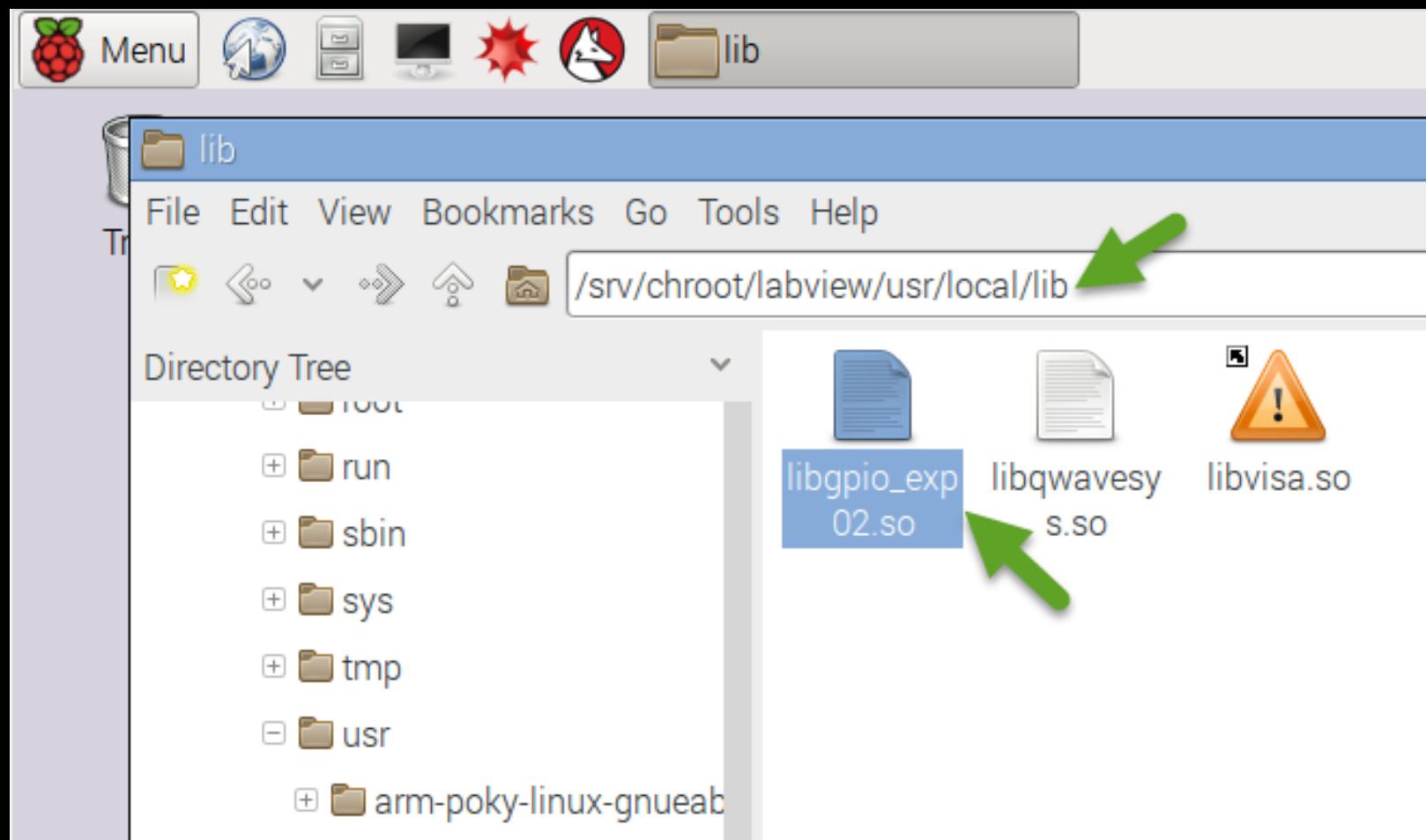
- ใช้คำสั่งเพื่อ Build WiringPi library in Linux using
- > gcc -shared -o /usr/local/lib/libgpio\_exp02.so -fPIC /home/pi/exp02.c -lwiringPi

ARMv7a

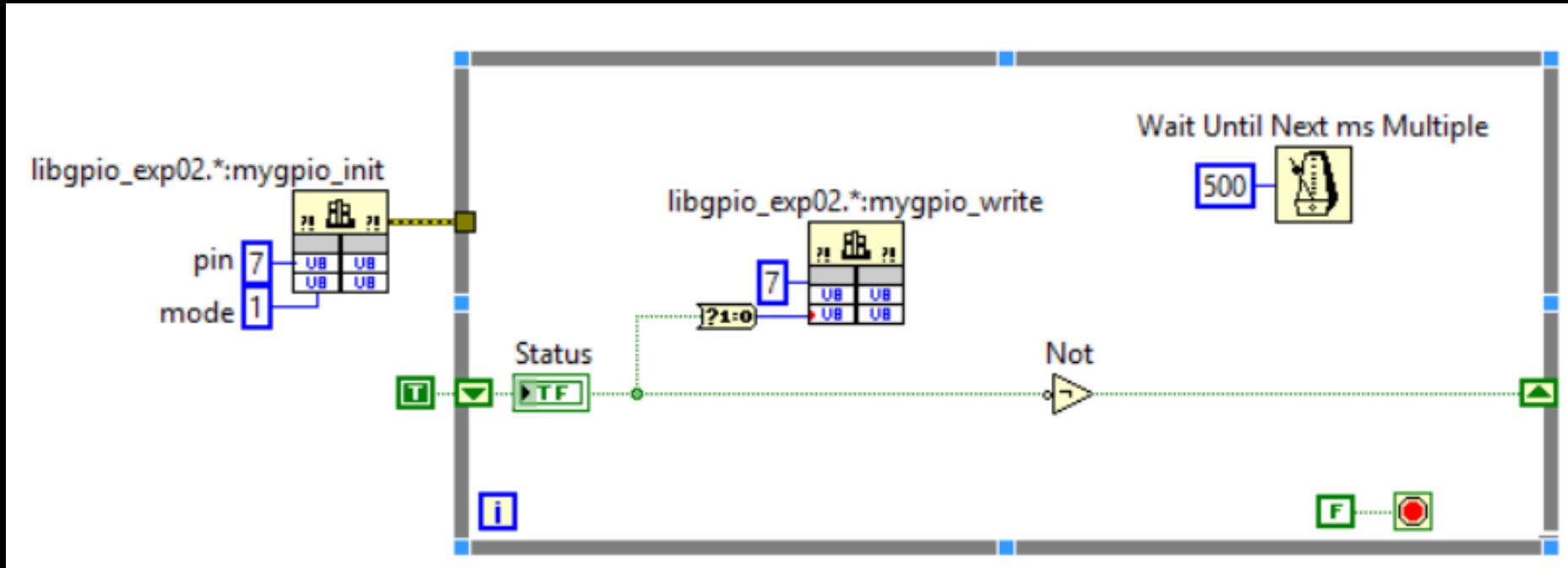


- คำสั่งพิเศษของ WiringPi Library ต้องต่อท้ายด้วย
- -lwiringPi

# File Manager Viewer

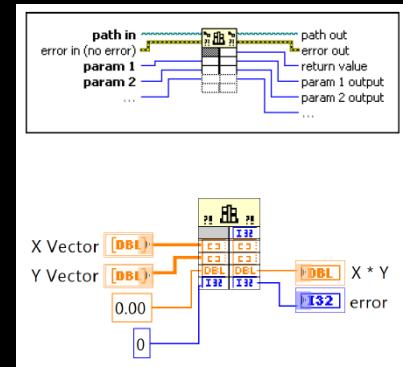


# Create “Blinking VI”

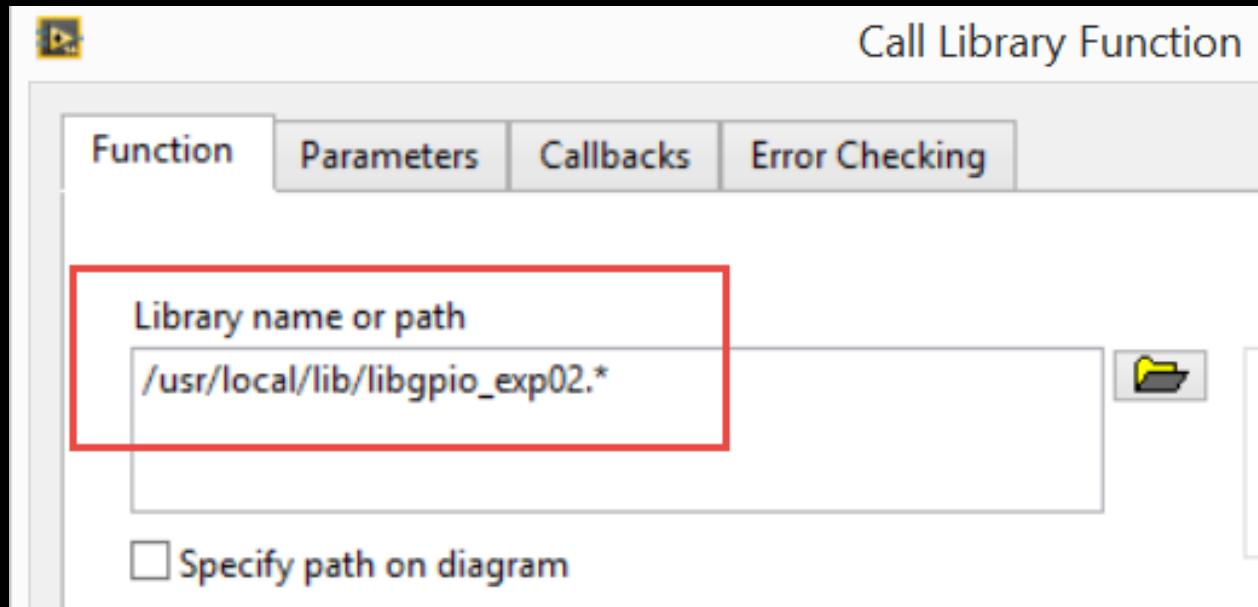


# Call “Library Function Node”

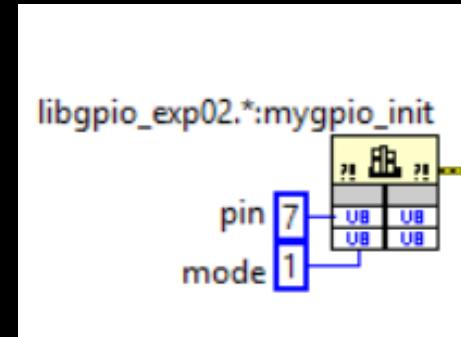
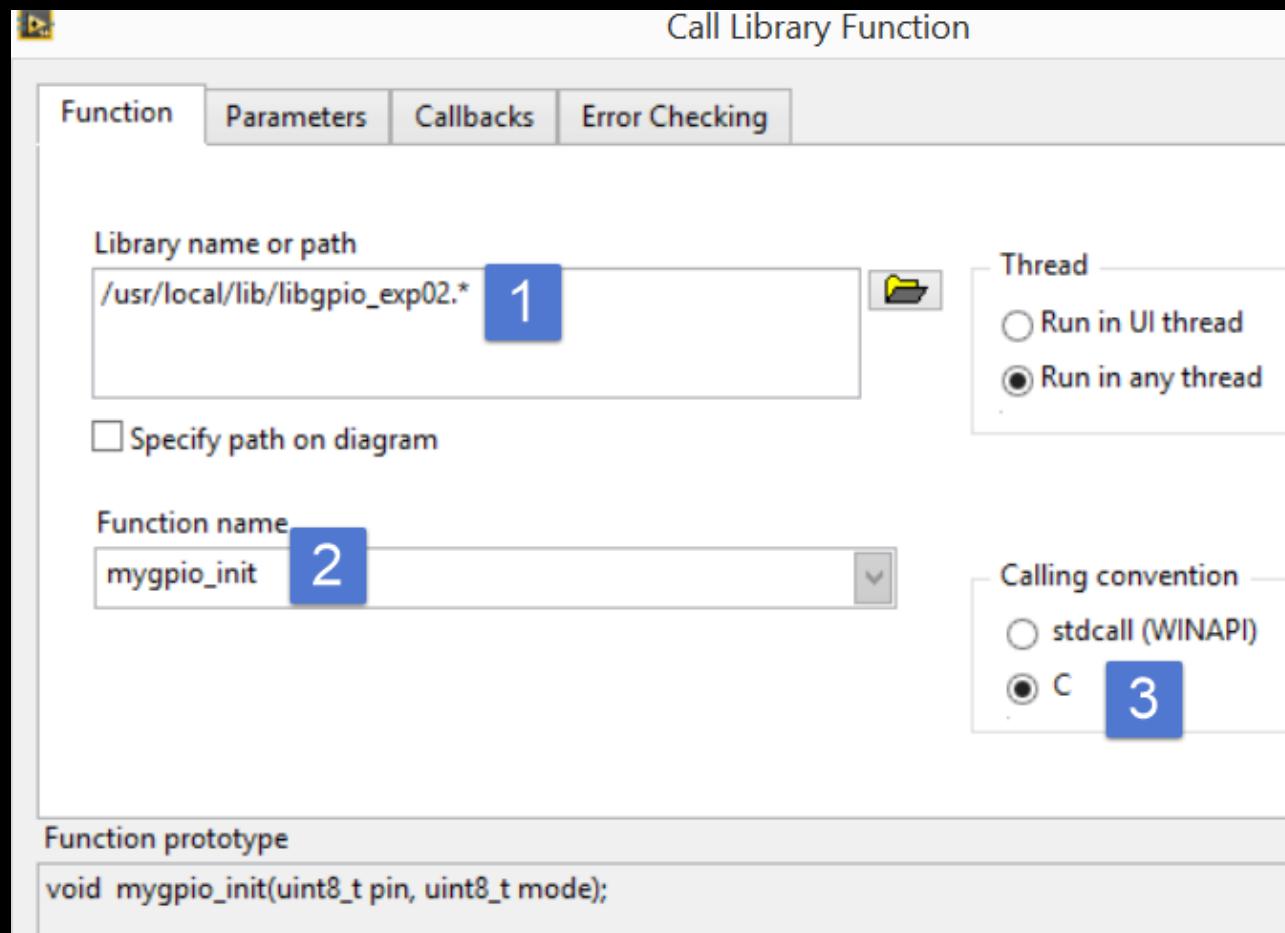
- กำหนด Path ของ Library “/usr/local/lib/”
- กำหนด Function
- เลือก Calling = “C”



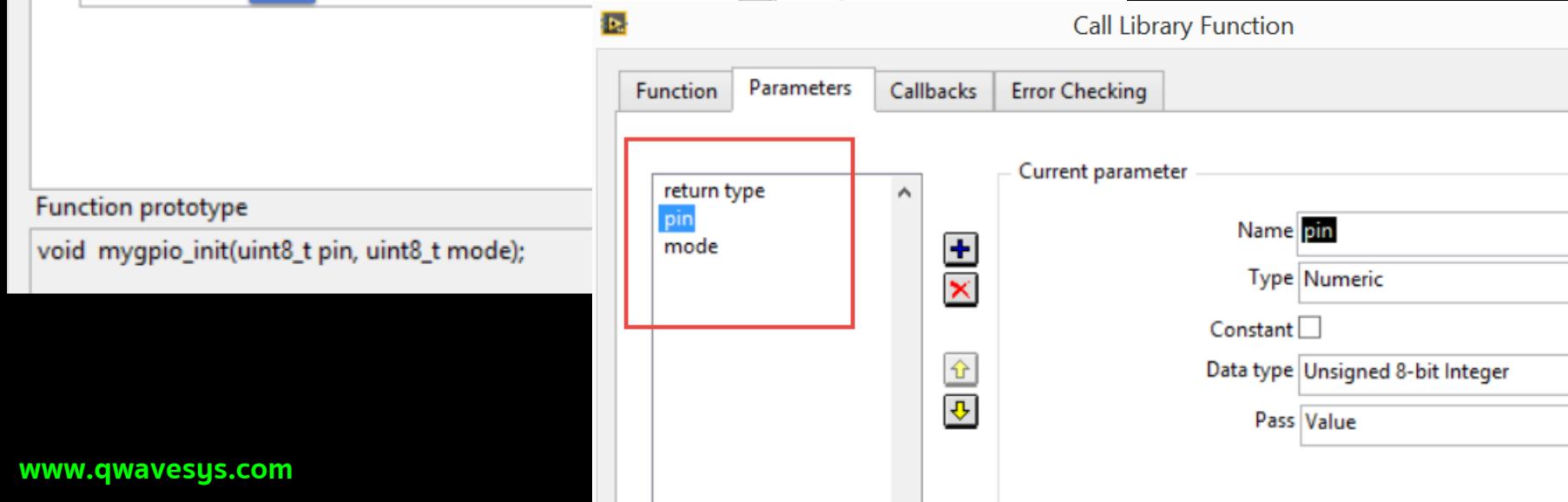
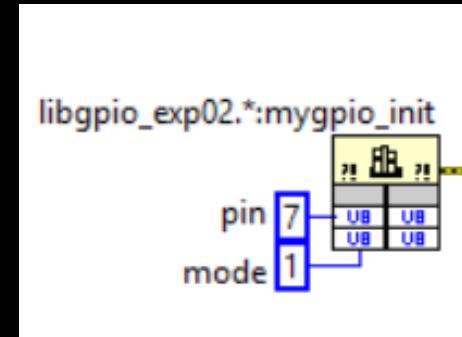
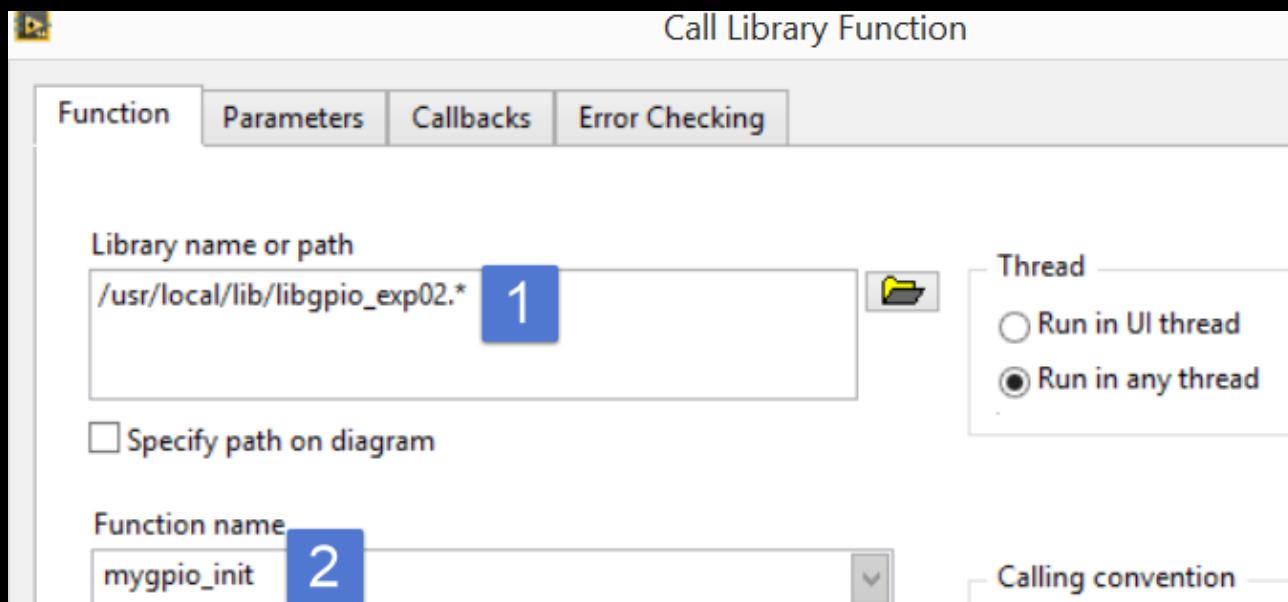
**“/usr/local/lib/libgpio\_exp02.\*”**



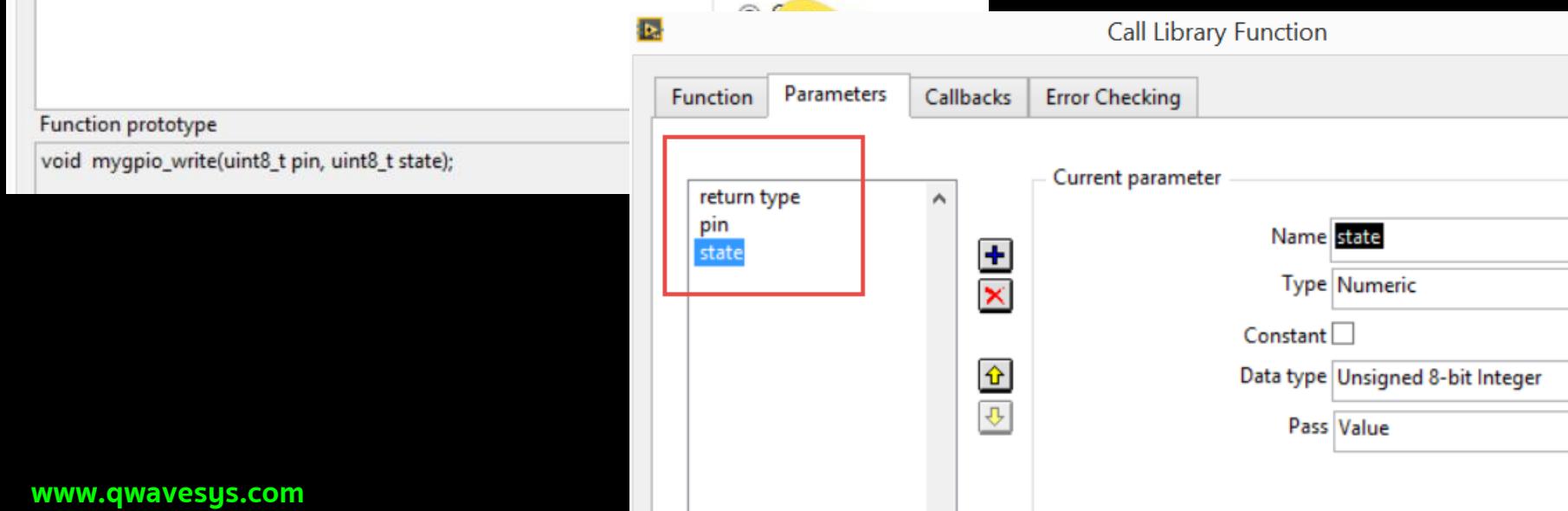
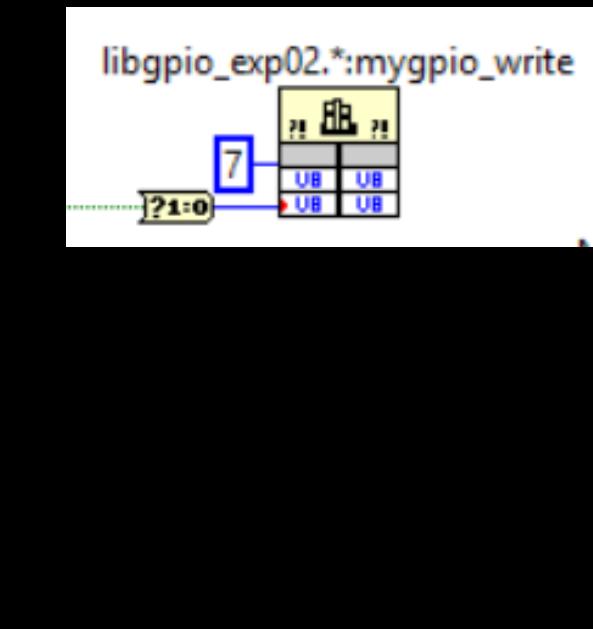
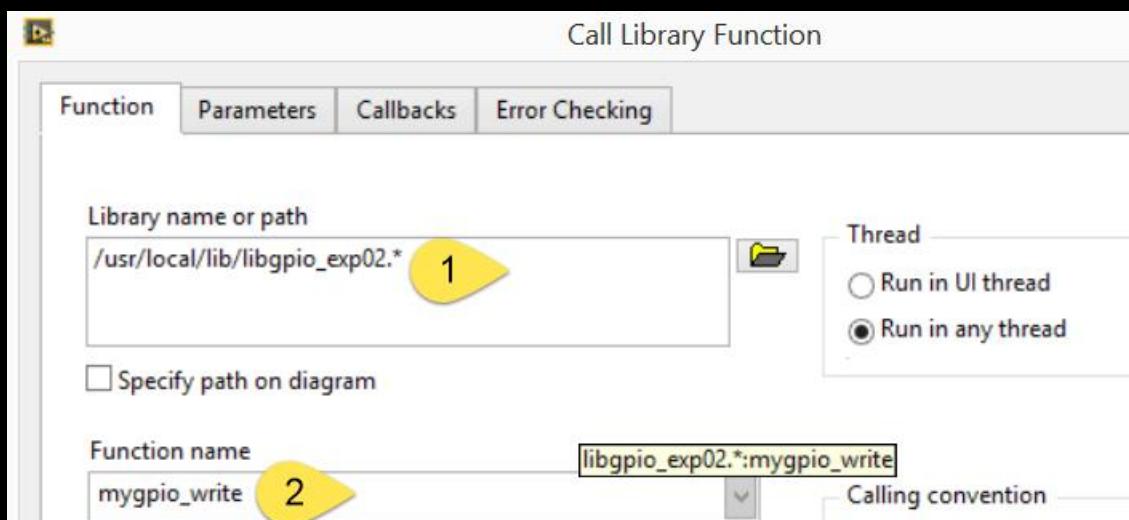
# Create “mygpio\_init” Function



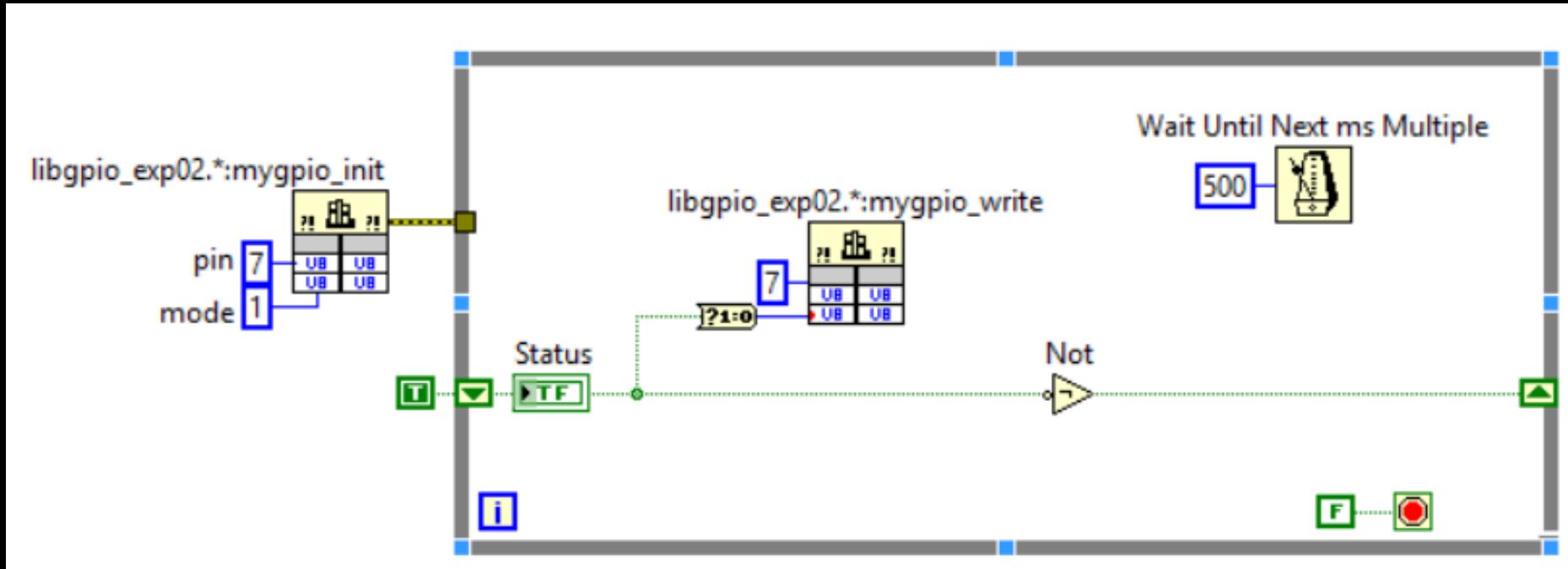
# Create “mygpio\_init” Function



# Create “mygpio\_write” Function

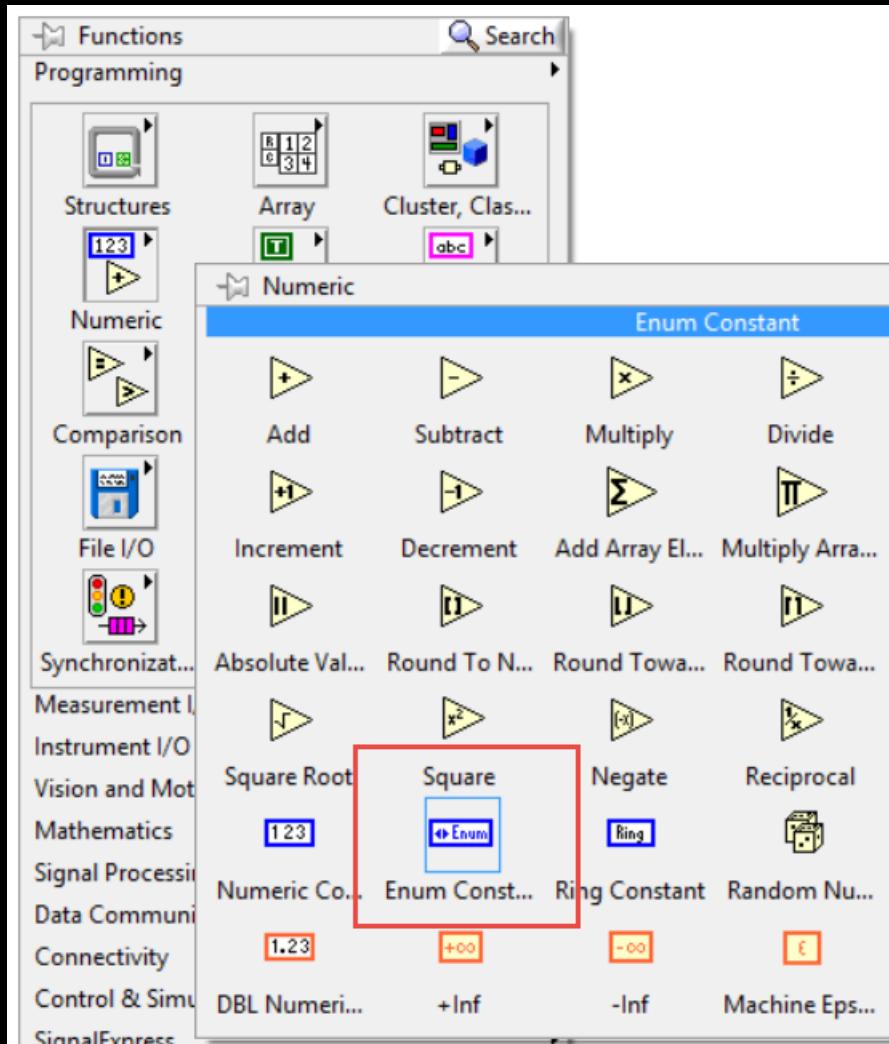


# Create “Blinking VI”



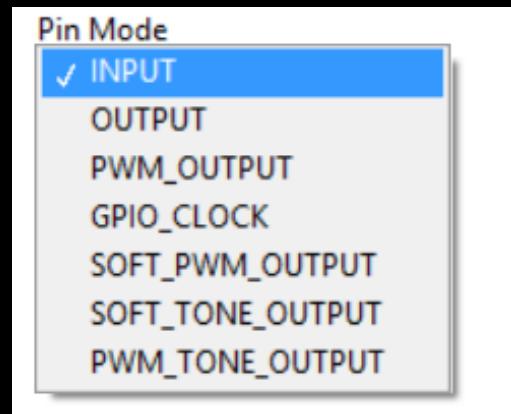
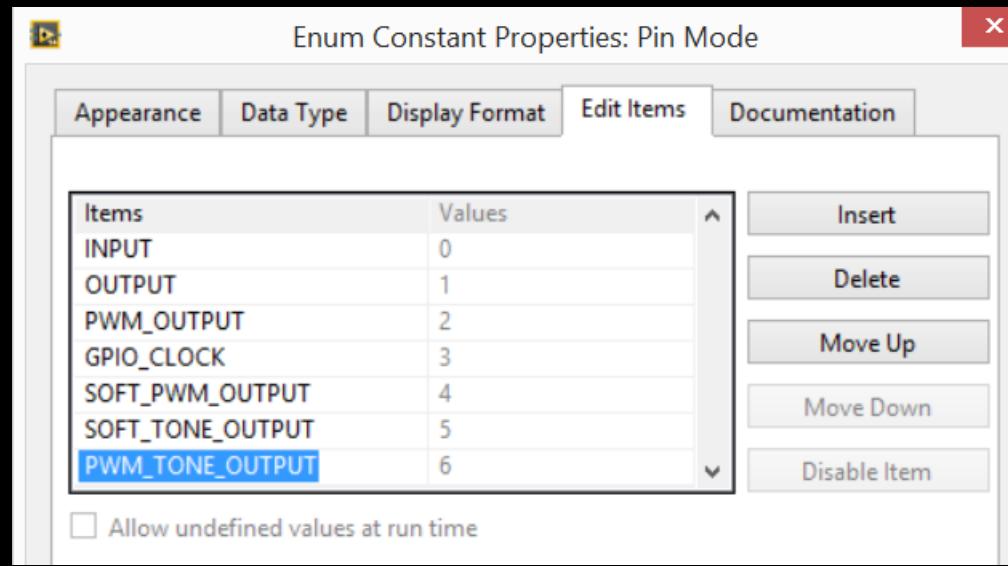
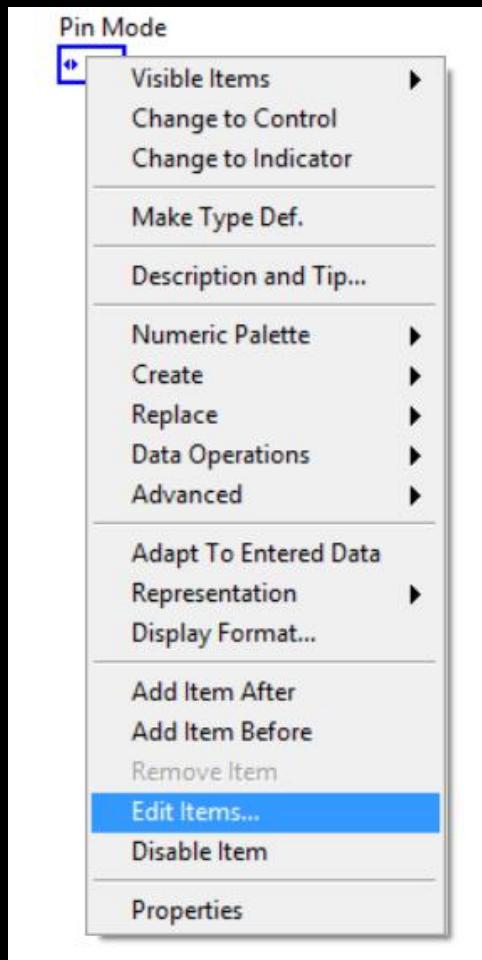
# Create “Enum” for Pin Mode

- “Enum Constant”



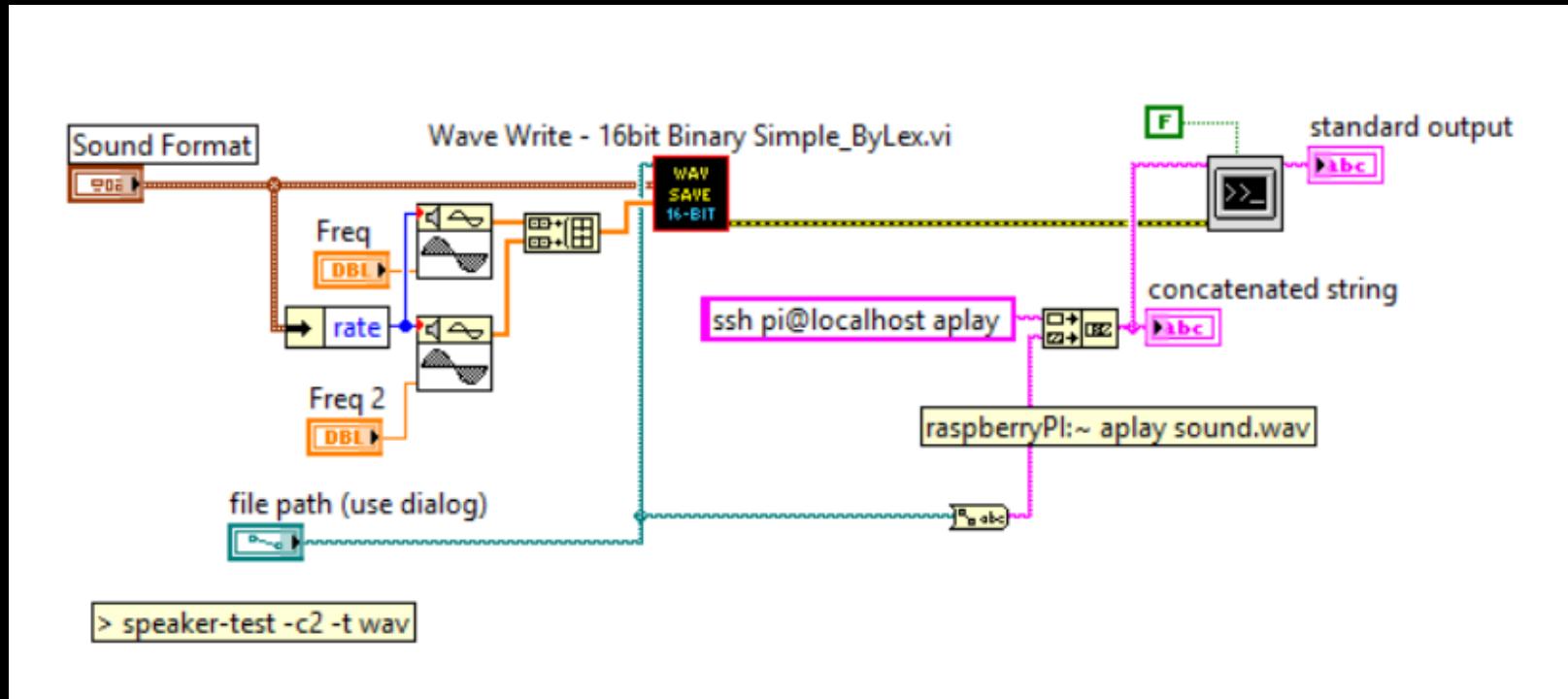
# Create “Enum” for Pin Mode (GPIO)

- “Enum Constant”



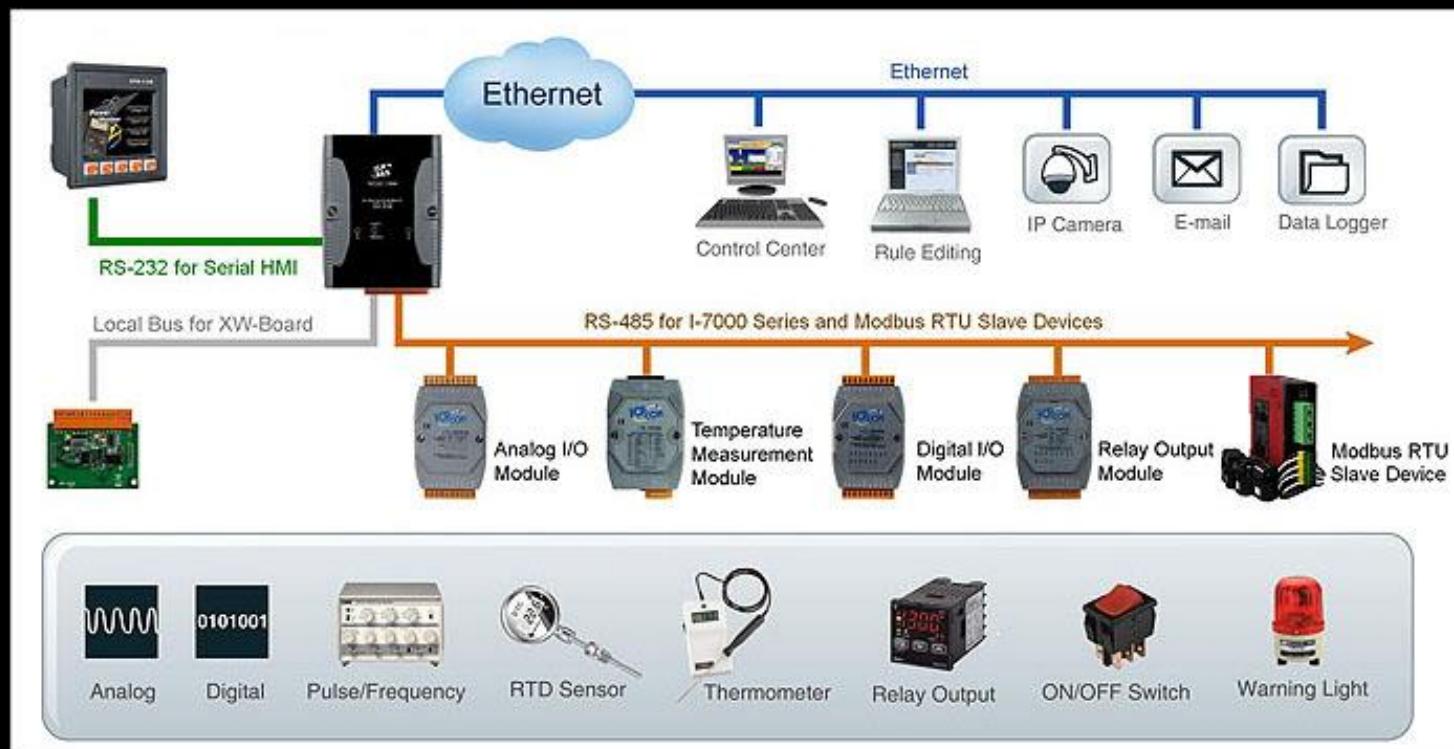
# 15

# Exercise 15 Audio Waveform



# 16

# Exercise 16 Modbus TCP Master-Slave

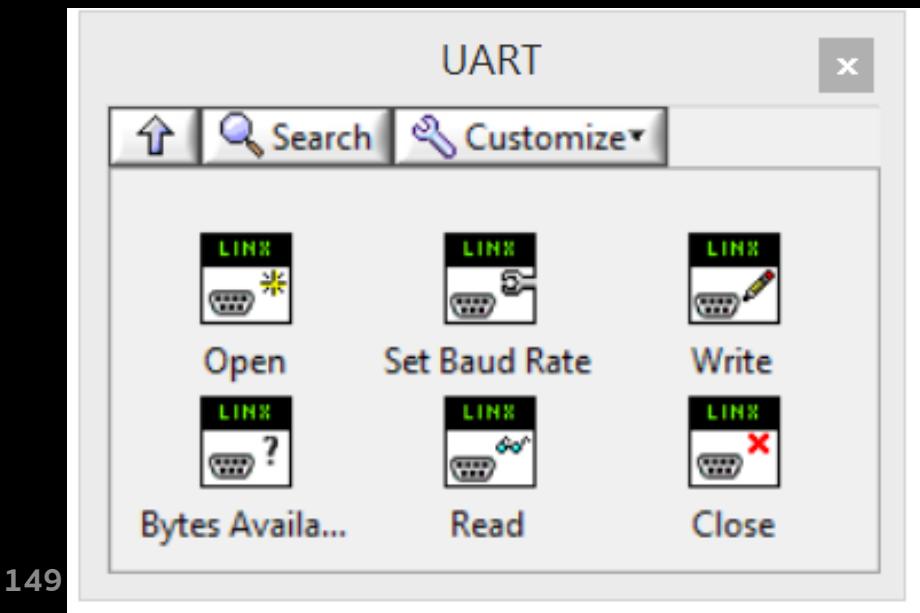
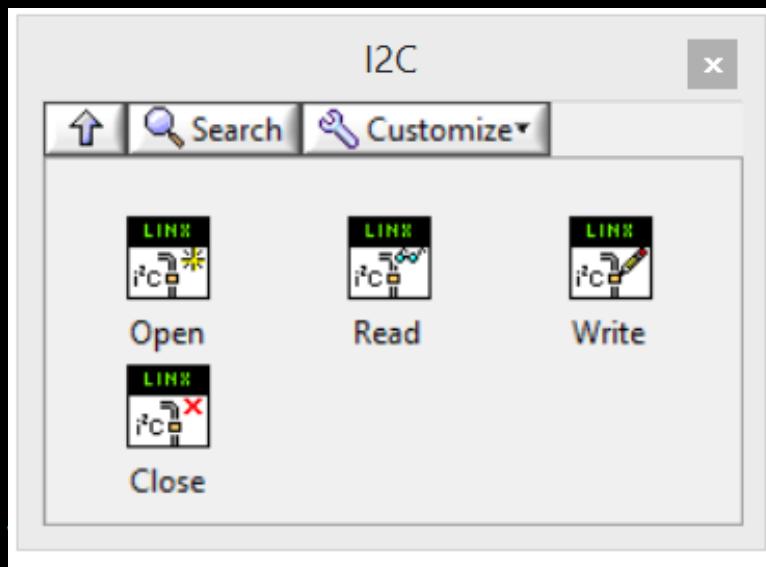
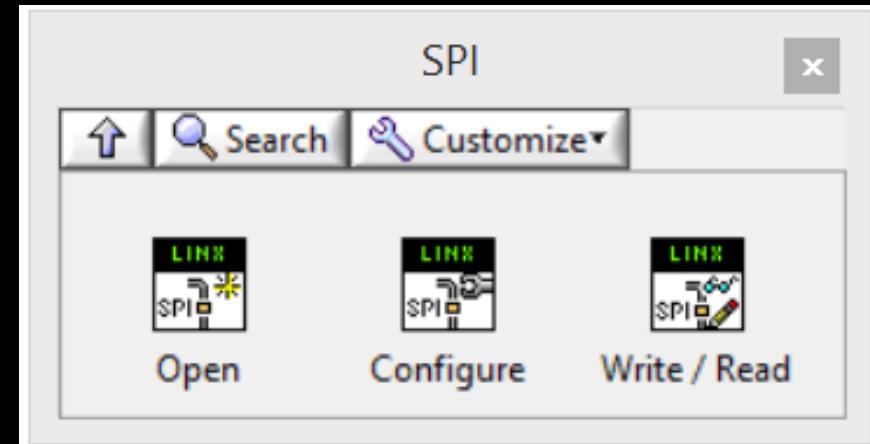


Coil/Register Numbers	Data Addresses	Type	Table Name
1-9999	0000 to 270E	Read-Write	Discrete Output Coils
10001-19999	0000 to 270E	Read-Only	Discrete Input Contacts
30001-39999	0000 to 270E	Read-Only	Analog Input Registers
40001-49999	0000 to 270E	Read-Write	Analog Output Holding Registers

# 17

# Exercise 17 LINX Library Development

- I2C
  - SPI
  - UART
- \*(PWM – Not support  
(08/2016))**



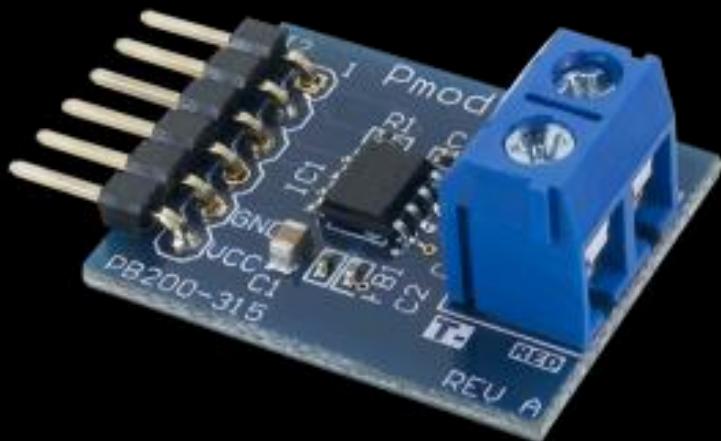
# LabVIEW Examples

- Help> Find Examples
- LINUX > LINUX – PmodTC1.vi

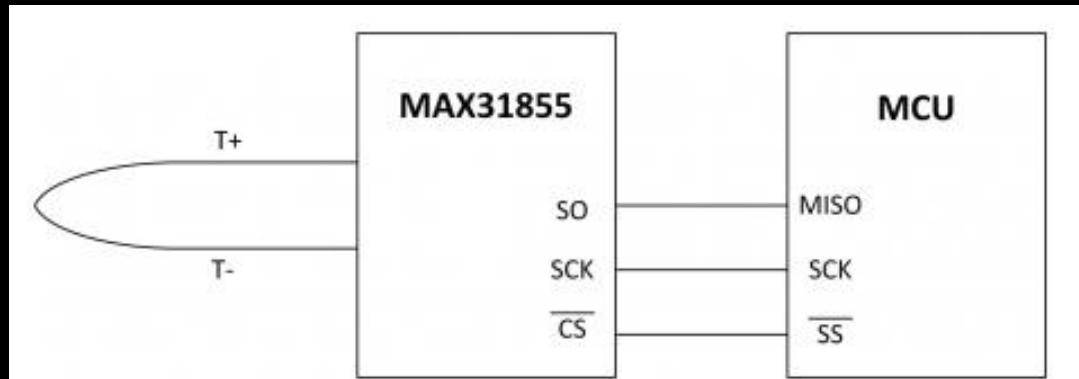
The screenshot shows the LabVIEW application window. The menu bar is visible with 'File', 'Operate', 'Tools', and 'Help' options. The 'Help' menu is open, showing 'Find Examples...', 'Show Context Help', 'Lock Context Help', 'LabVIEW Help...', and 'Explain Error...'. A red arrow points to the 'Find Examples...' option. Below the menu, there's a toolbar with icons for video, LabVIEW logo, and other functions. The main workspace shows the 'NI Example Finder' dialog. It has tabs for 'Browse' and 'Search'. The 'Search' tab is active, with an input field containing 'LINX' and a 'Search' button. A red arrow points to the search input field. Below the input field is a list of keywords: 'a', 'A-weighting', 'abort', 'aborting', 'absolute', 'AC', 'academic', 'accdb', 'acceleration', 'Accelerometer', 'Access', ...'. To the right is a list of example files with their icons: 'LINX - PmodGPS.vi', 'LINX - PmodGYRO.vi', 'LINX - PmodJSTK.vi', 'LINX - PmodMIC3.vi', 'LINX - PmodSONOR.vi', 'LINX - PmodTC1.vi' (highlighted with a red arrow), 'LINX - PmodTMP3.vi', 'LINX - SPI Loopback Benchmark.vi', 'LINX - SPI Loopback.vi', 'LINX - SSD1306 OLED.vi', 'LINX - Servo 1 Channel.vi', 'LINX - Set RGB LED Color.vi', 'LINX - Seven Segment Display.vi', 'LINX - TMP3x.vi', 'LINX - Thermistor Read.vi'. The 'LINX - PmodTC1.vi' entry is highlighted with a blue selection bar.

# SPI-Pmod TC1 (MAX31855)

- [https://reference.digilentinc.com/pmod/pmod/tc1/ref\\_manual](https://reference.digilentinc.com/pmod/pmod/tc1/ref_manual)



- K-type thermocouple-to-digital converter
- Wide temperature range of -73°C to 482°C with provided wire
- ±2°C accuracy from -200°C to 700°C
- 14-bit with 0.25°C resolution
- Cold-junction temperature compensation
- Small PCB size for flexible designs 1.0 in × 0.8 in (2.5 cm × 2.0 cm)
- 6-pin Pmod port with SPI interface
- Follows Digilent Pmod Interface Specification Type 2
- Library and example code available in resource center



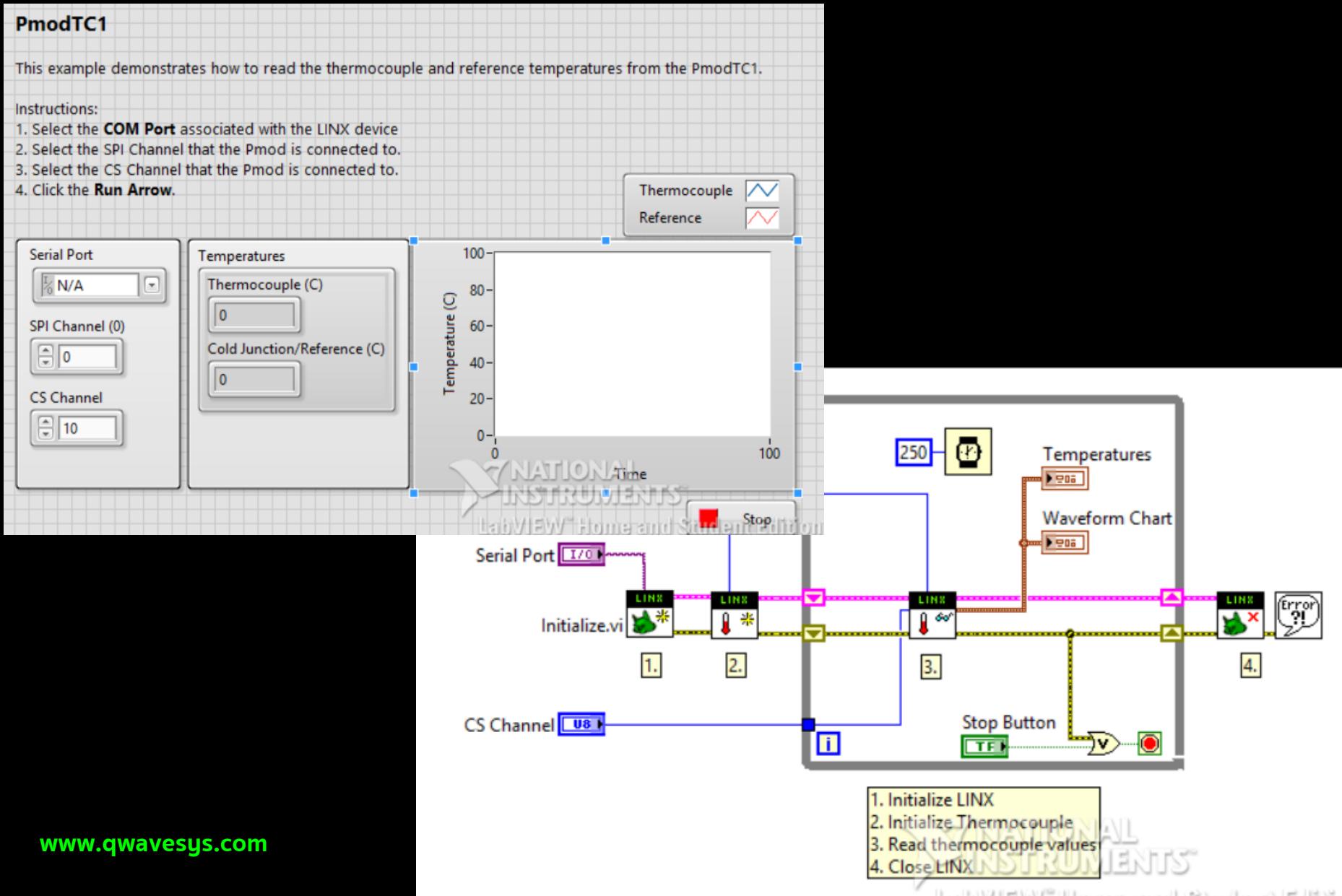
# LINX – Thermocouple MAX31855 (TC1)

## PmodTC1

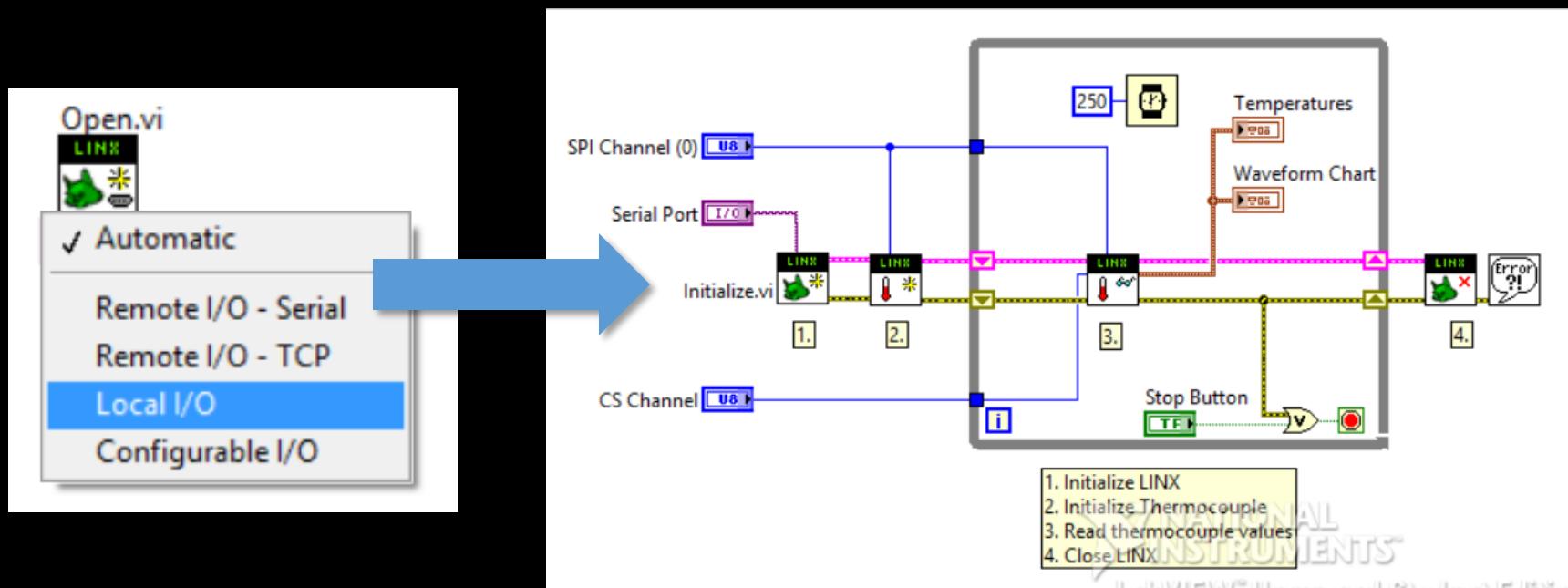
This example demonstrates how to read the thermocouple and reference temperatures from the PmodTC1.

### Instructions:

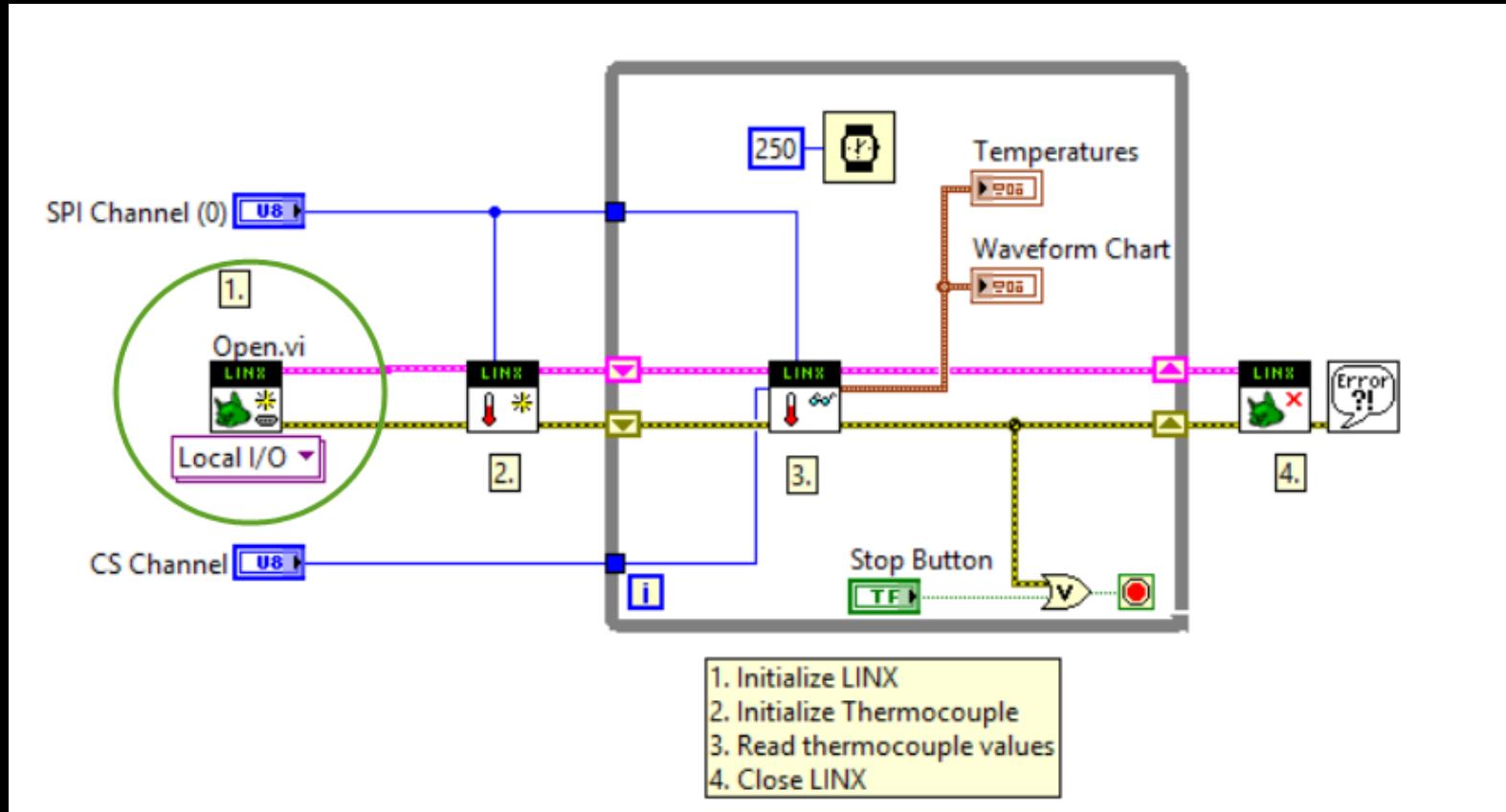
1. Select the **COM Port** associated with the LINX device
2. Select the SPI Channel that the Pmod is connected to.
3. Select the CS Channel that the Pmod is connected to.
4. Click the **Run Arrow**.



# Local I/O – Running on RasPi Target

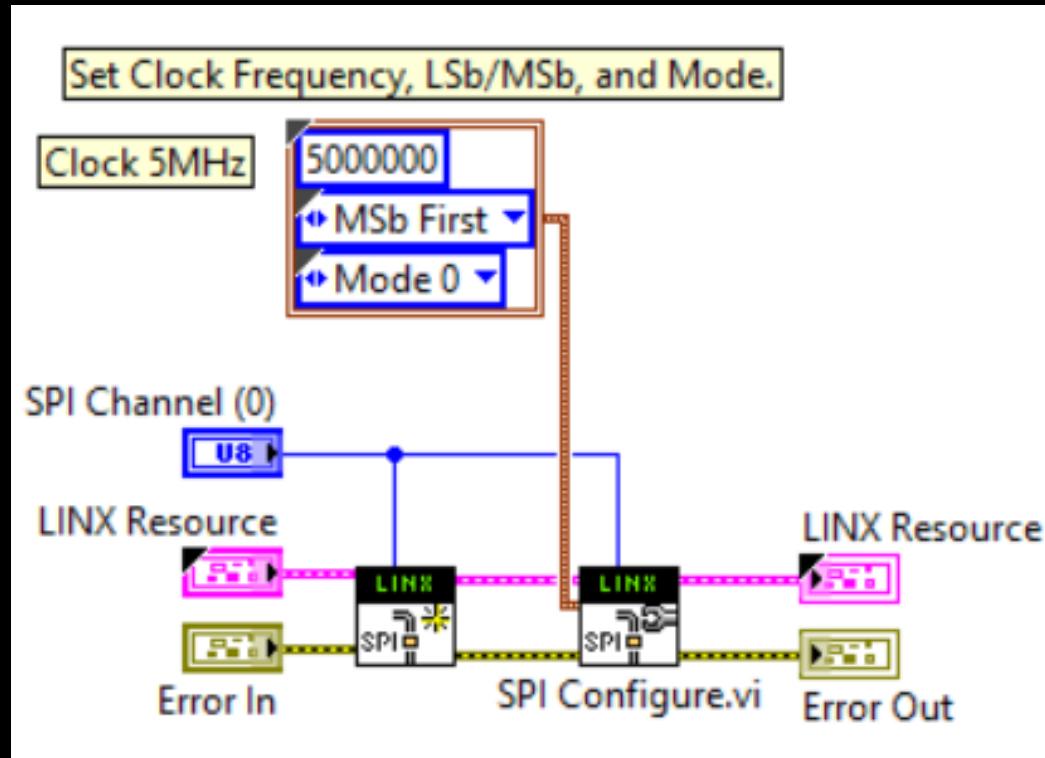


# Replace : Initialize VI -> Open.vi



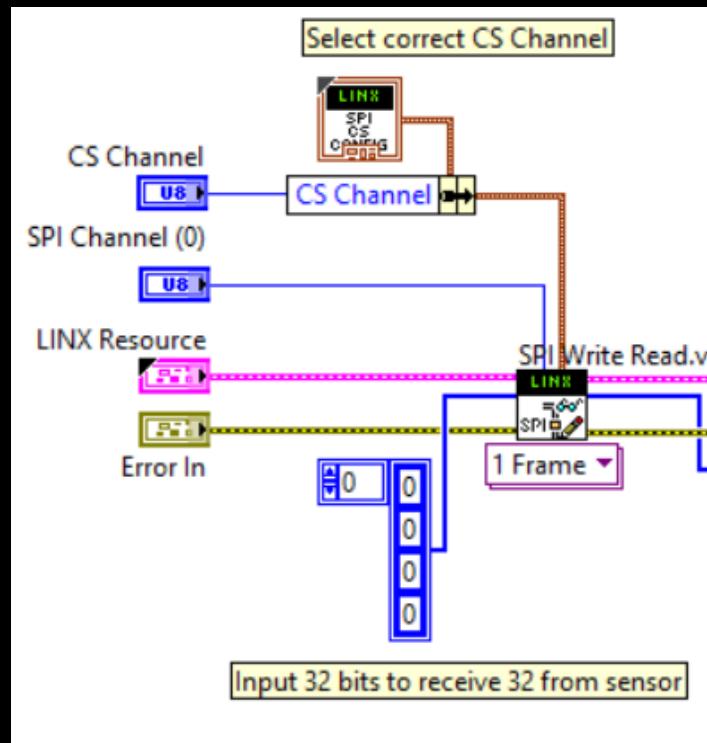
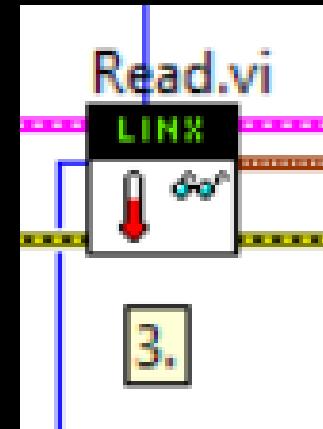
# Pmod TC1 Open VI

- Specifies the LINX device SPI channel
- Set Clock Frequency, LSb/MSb, and Mode.
- \*Read MSB First



# Pmod TC1 Read VI

- Specifies PmodTC1 chip select pin.
- Specifies the SPI channel
- Input 32 bits (U8x4) to receive 32 from sensor data.
- Read the data using SPI Write Read.vi



# MAX31855 – Memory Map

**Table 2. Memory Map—Bit Weights and Functions**

	14-BIT THERMOCOUPLE TEMPERATURE DATA				RES	FAULT BIT	12-BIT INTERNAL TEMPERATURE DATA				RES	SCV BIT	SCG BIT	OC BIT
BIT	D31	D30	...	D18	D17	D16	D15	D14	...	D4	D3	D2	D1	D0
VALUE	Sign	MSB $2^{10}$ (1024°C)	...	LSB $2^{-2}$ (0.25°C)	Reserved	1 = Fault	Sign	MSB $2^6$ (64°C)	...	LSB $2^{-4}$ (0.0625°C)	Reserved	1 = Short to V <sub>CC</sub>	1 = Short to GND	1 = Open Circuit

31

14 bit  
Temp Data

31

14

18

2

15

12 bit  
Internal Temp  
Data

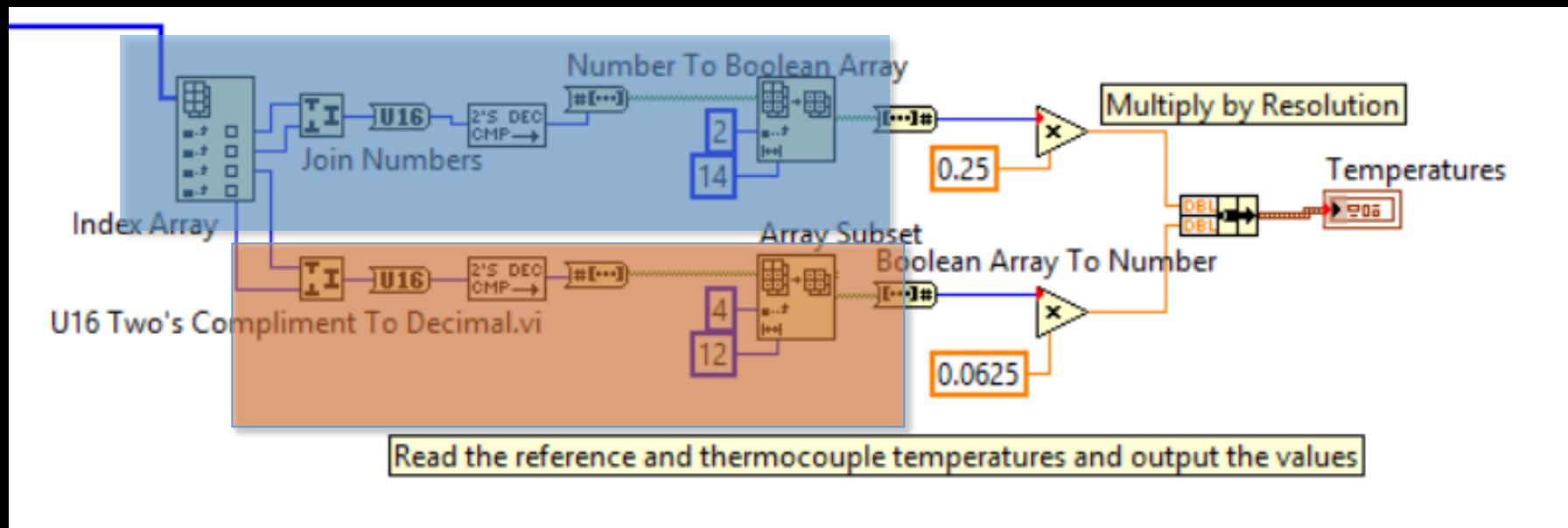
4

0

\*Read MSB First

# Format the Temperatures Data

- Read U8 data x 4 Array
- U8 x2 Array -> Join Numbers
- Convert U16 2's Compliment to Decimal
- Filtered the data using Array subset (14bit+12bit)
- Multiple by Resolution



# Basic of Two's Compliment Value

*Decimal Value = Normal Binary Value (without the sign bit)  
 - (Sign Bit) \* (Maximum Positive Binary Value + LSB)*

3-bits two's-complement integers		
Bits	Unsigned Value	2's Complement Value
011 <sup>1</sup>	3	3
010	2	2
001	1	1
000	0	0
111	7	-1
110	6	-2
101 <sup>2</sup>	5	-3
100	4	-4

8-bits two's-complement integers		
Bits	Unsigned Value	2's Complement Value
0111 1111	127	127
0111 1110 <sup>1</sup>	126	126
0000 0010	2	2
0000 0001	1	1
0000 0000	0	0
1111 1111	255	-1
1111 1110 <sup>2</sup>	254	-2
1000 0010	130	-126
1000 0010	129	-127
1000 0010	128	-128

- [https://reference.digilentinc.com/reference/twos\\_complement](https://reference.digilentinc.com/reference/twos_complement)

# Temp Data and Internal Temp Data

**Table 4. Thermocouple Temperature Data Format**

TEMPERATURE (°C)	DIGITAL OUTPUT (D[31:18])
+1600.00	0110 0100 0000 00
+1000.00	0011 1110 1000 00
+100.75	0000 0110 0100 11
+25.00	0000 0001 1001 00
0.00	0000 0000 0000 00
-0.25	1111 1111 1111 11
-1.00	1111 1111 1111 00
-250.00	1111 0000 0110 00

*Note:* The practical temperature ranges vary with the thermocouple type.

**Table 5. Reference Junction Temperature Data Format**

TEMPERATURE (°C)	DIGITAL OUTPUT (D[15:4])
+127.0000	0111 1111 0000
+100.5625	0110 0100 1001
+25.0000	0001 1001 0000
0.0000	0000 0000 0000
-0.0625	1111 1111 1111
-1.0000	1111 1111 0000
-20.0000	1110 1100 0000
-55.0000	1100 1001 0000

- **MAX = 1,600/4 = 400**
- **MIN = -250/4 = -62.5**

- **MAX = 127/16 = 7.93**
- **MIN = -55/16 = -3.43**

# Convert Temp to 'C

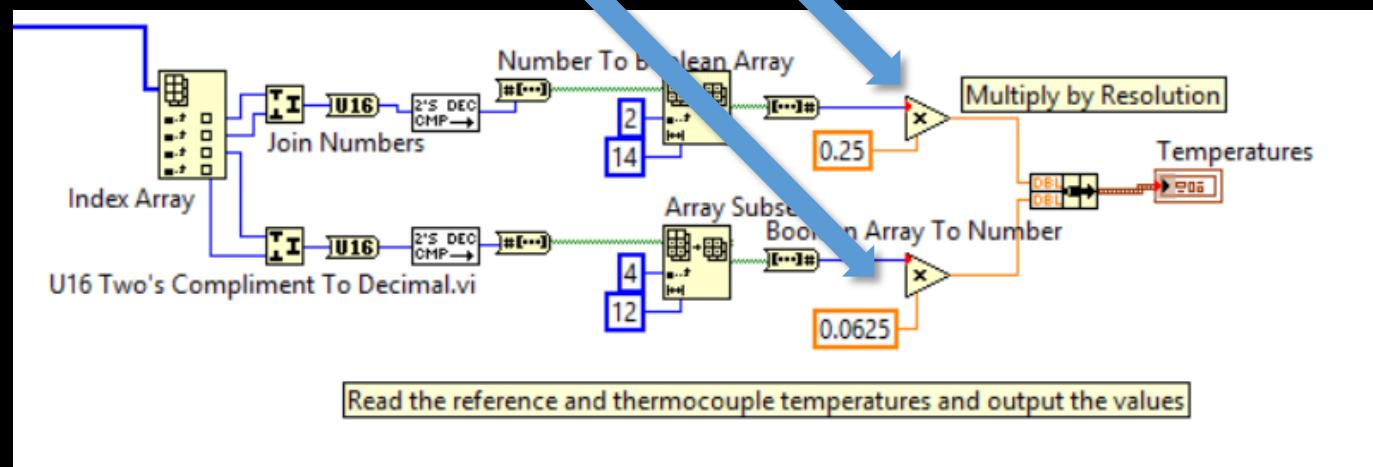
- Thermocouple Data x 0.25
- Cold-Junction Temperature x0.0625

## Cold-Junction Compensated Thermocouple-to-Digital Converter

### THERMAL CHARACTERISTICS (continued)

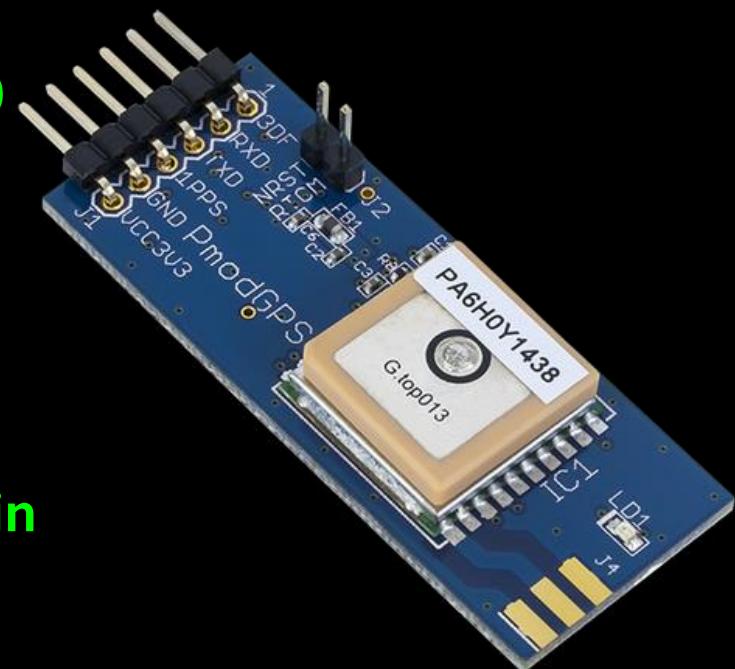
( $3.0V \leq V_{CC} \leq 3.6V$ ,  $T_A = -40^{\circ}C$  to  $+125^{\circ}C$ , unless otherwise noted.) (Note 4)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Thermocouple Temperature Data Resolution				0.25		°C
Internal Cold-Junction Temperature Error		$T_A = -20^{\circ}C$ to $+85^{\circ}C$ (Note 3)	-2	+2		°C
Cold-Junction Temperature Data Resolution		$T_A = -40^{\circ}C$ to $+125^{\circ}C$ (Note 3)	-3	+3		°C

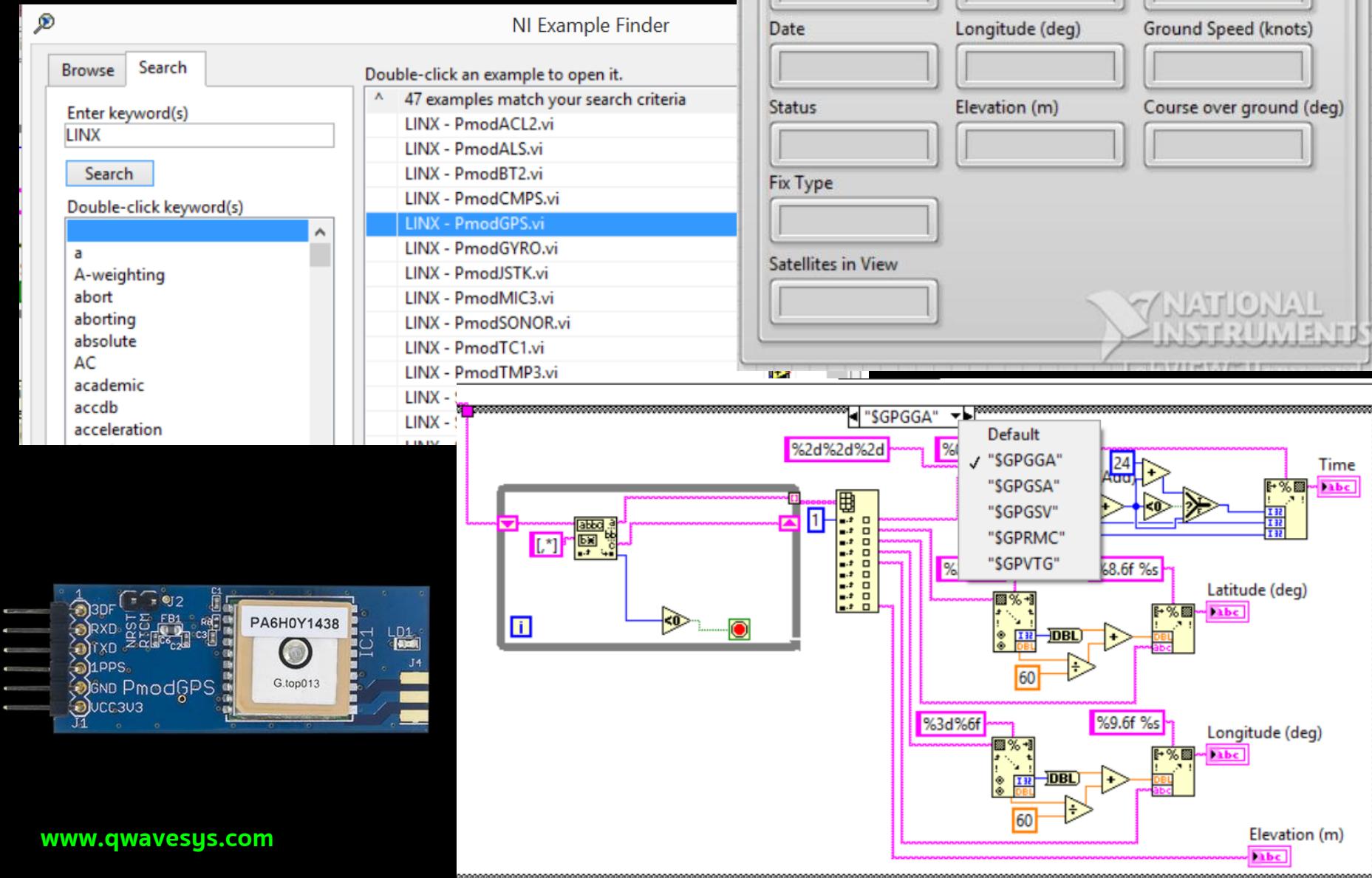


# UART-LINX Library Demo

- LINX Pmod GPS
  - <http://store.digilentinc.com/pmodgps-gps-receiver/>
  - GlobalTop FGPM-MOPA6H GPS antenna
- 
- Ultra-sensitive GPS module (-165 dBm)
  - Add 3m 2D satellite positioning accuracy to any embedded system
  - Low power consumption
  - Up to 10Hz update rate
  - NMEA (default) and RTCM protocols available
  - Small PCB size for flexible designs 2.0 in × 0.8 in (5.0 cm × 2.0 cm)
  - 6-pin Pmod connector with UART interface

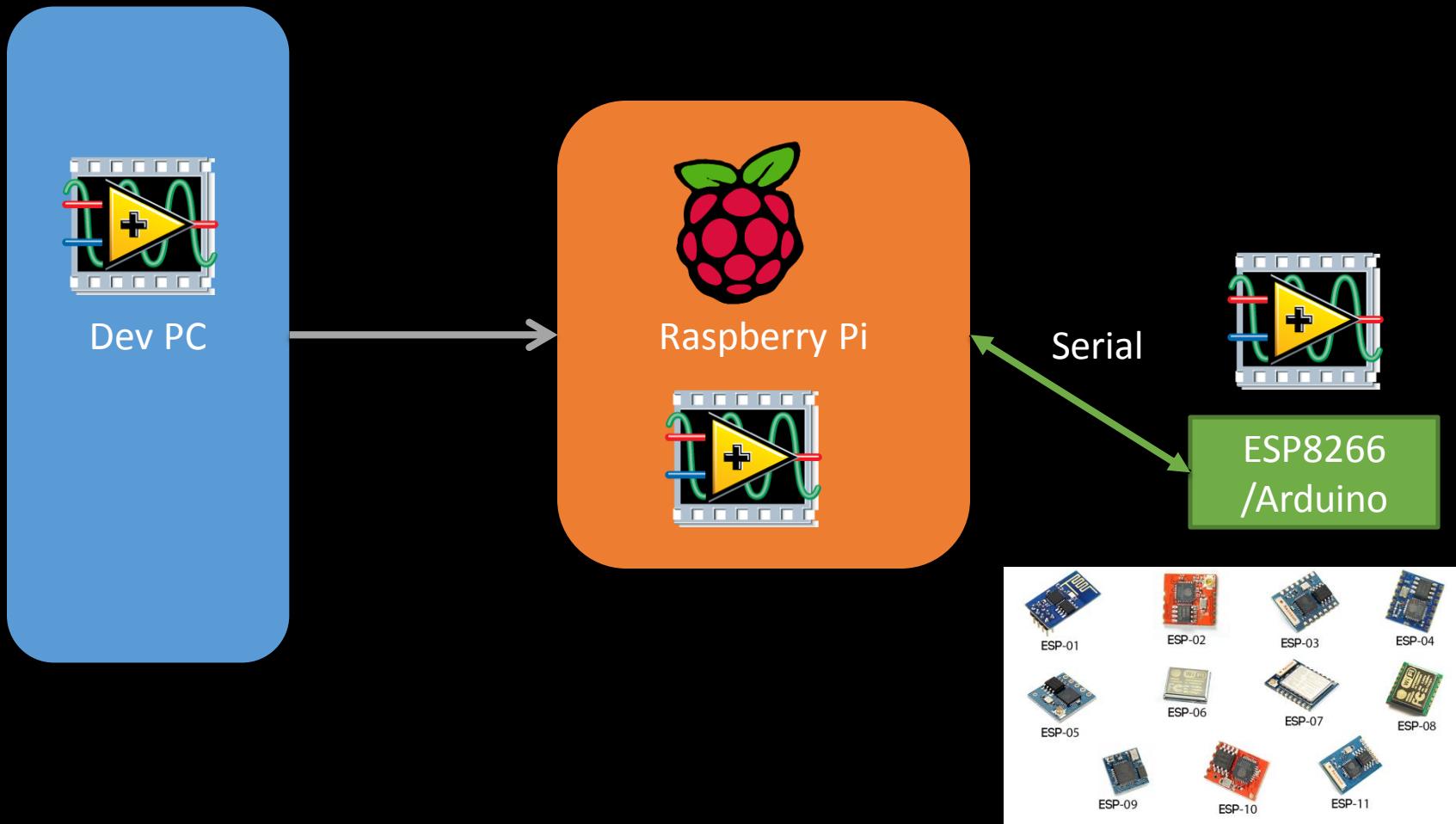


# LINX – PmodGPS.vi

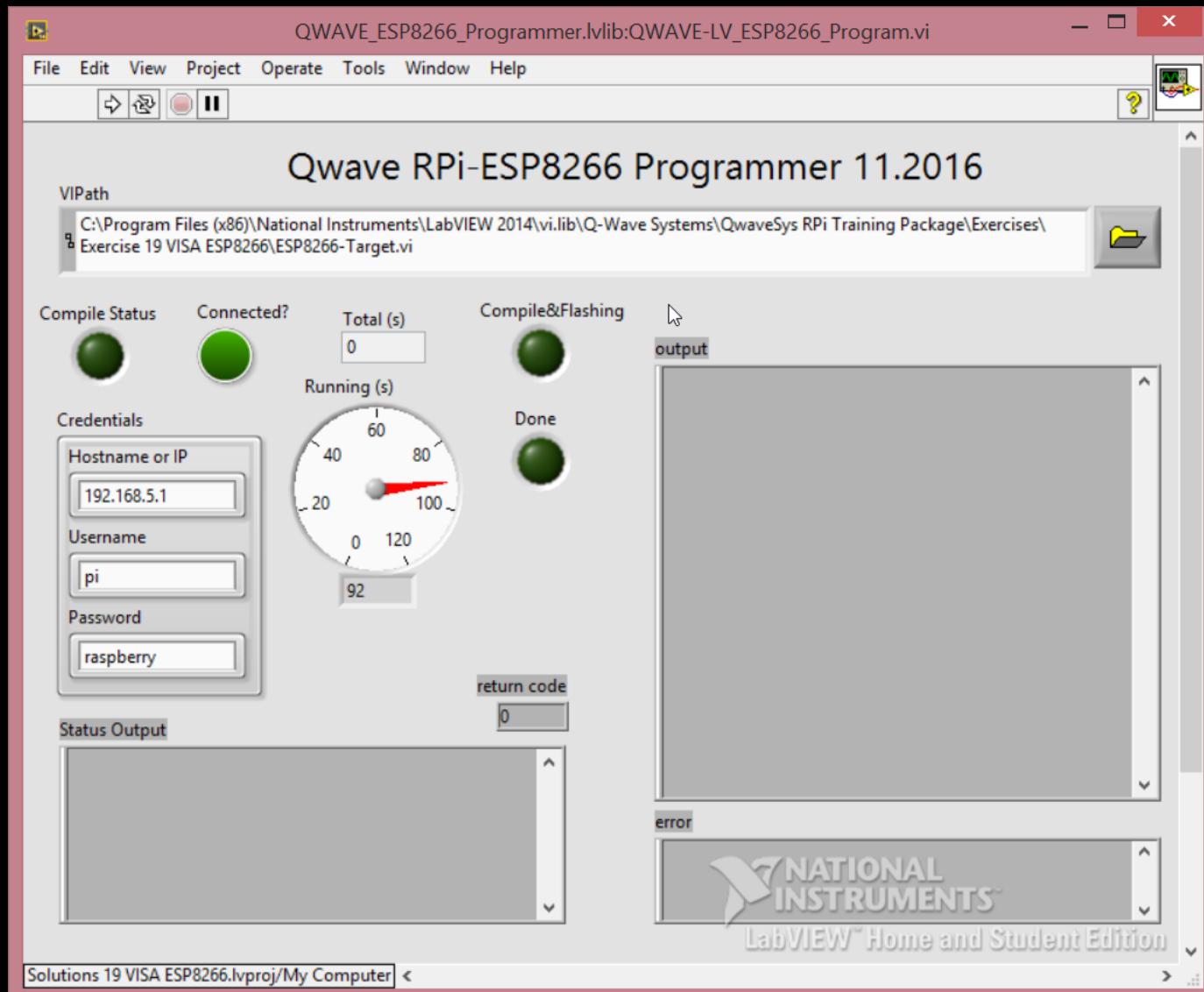


# 19

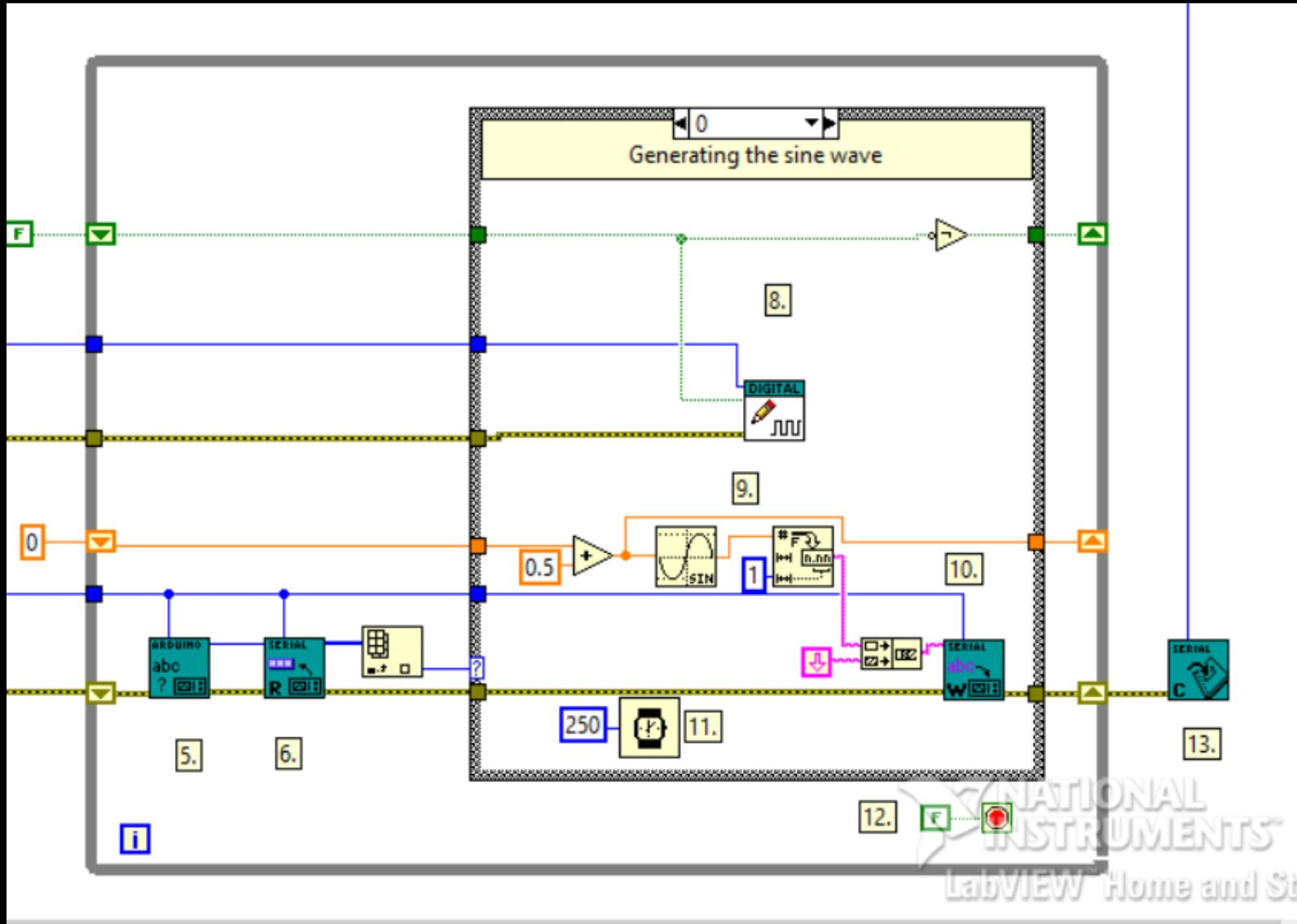
# Exercise 19 VISA ESP8266



# QWAVE-LV\_ESP8266\_Program



# Exercise 19 VISA ESP8266



# ESP8266-Target-AnalogRead

