https://www.halvorsen.blog

LabVIEW LINX and Raspberry Pi

Using **SPI** and **I2C** Interfaces

Hans-Petter Halvorsen

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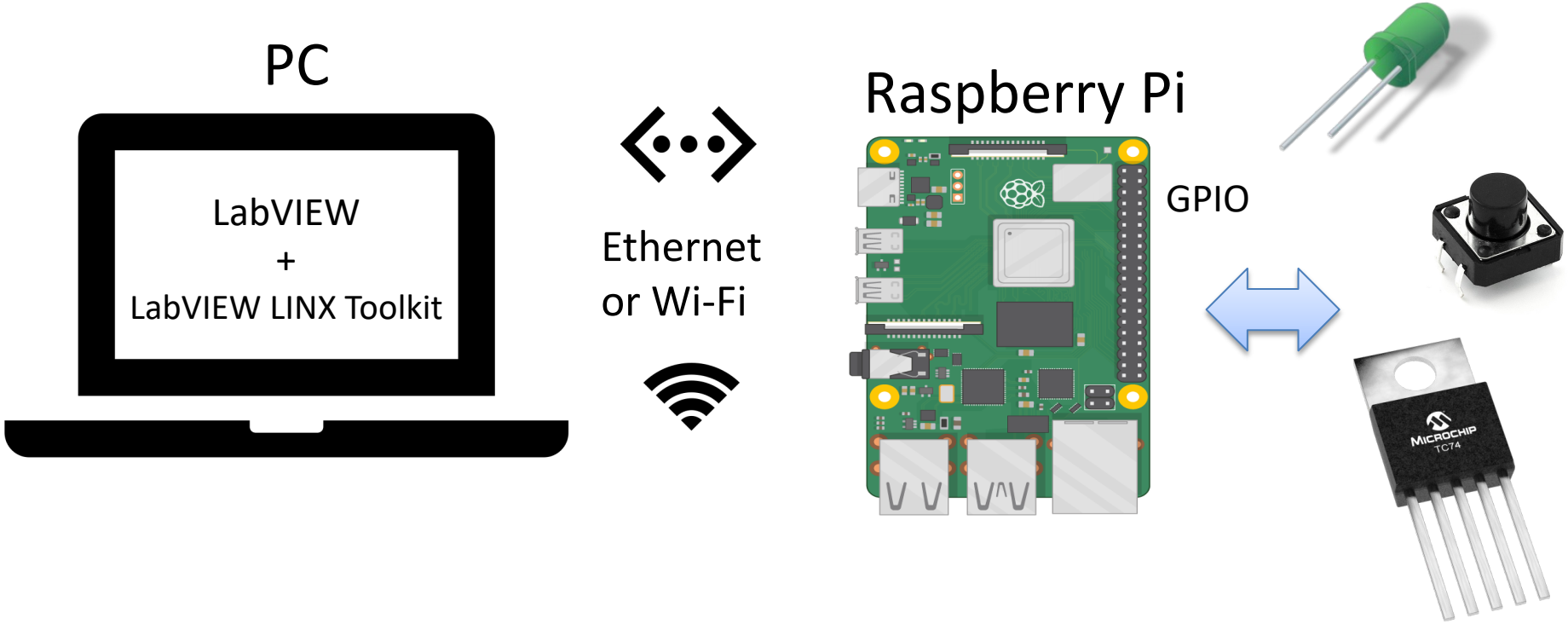
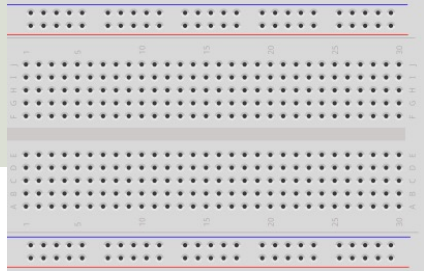
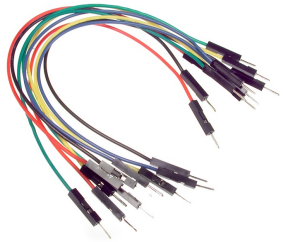
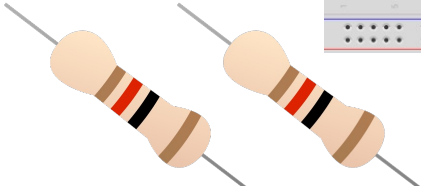
LabVIEW + LabVIEW LINX Toolkit

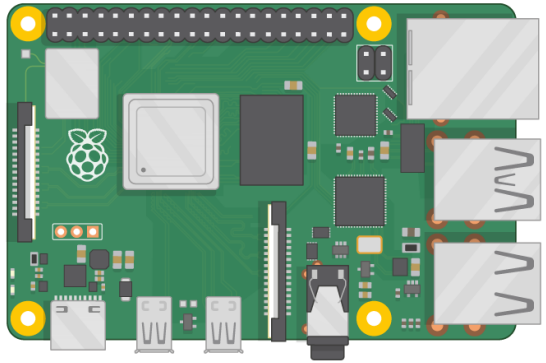


Hardware









- Raspberry Pi
- Breadboard
- Wires (Jumper Wires)
- Resistors ($R = 270\Omega$)
- LED, Push Button
- Sensors/Components with SPI/I2C Interface

Hardware and Software

- Host PC (Windows PC)
  - LabVIEW
  - LabVIEW LINX Toolkit
  - (LabVIEW Real-Time Module)
- Raspberry Pi with Raspberry Pi OS
  - Connected to Wi-Fi
  - SSH Enabled

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Raspberry Pi and LabVIEW LINX

Hans-Petter Halvorsen

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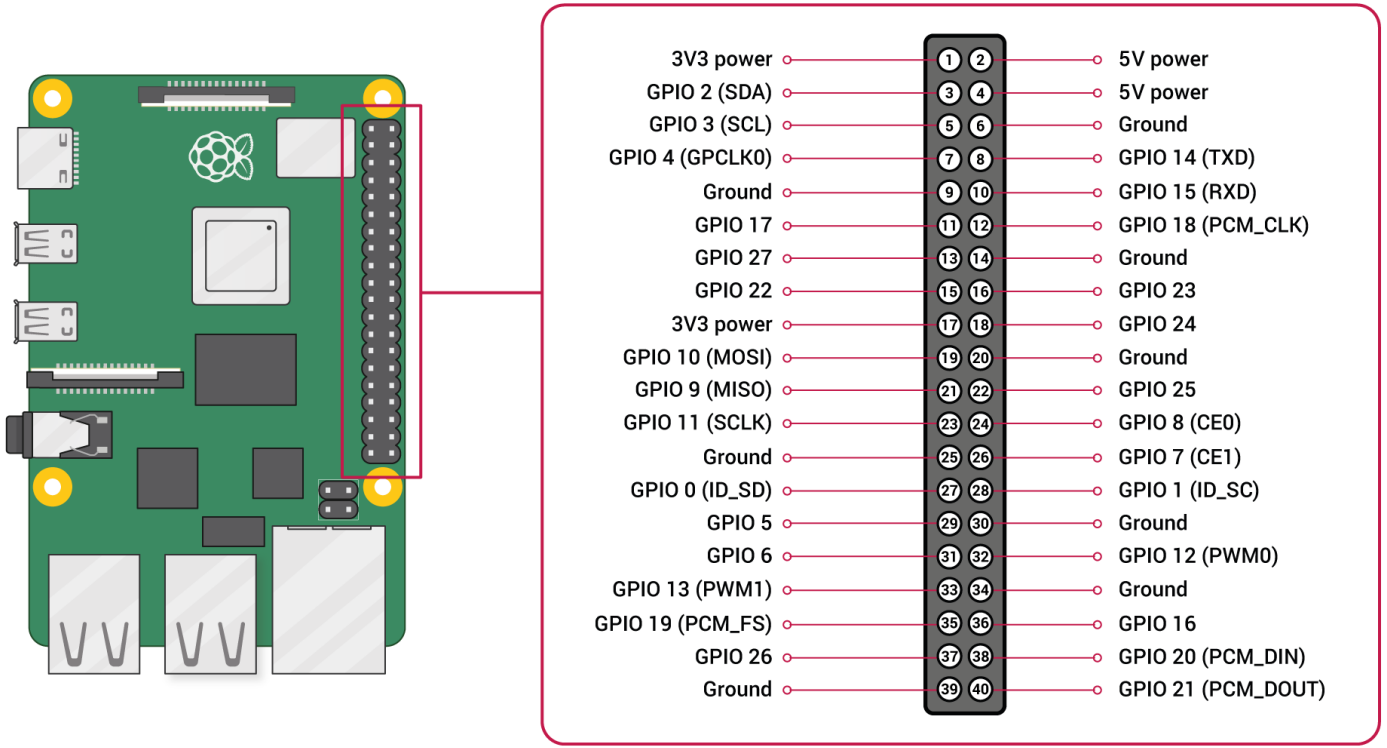
GPIO



A powerful feature of the Raspberry Pi is the GPIO (general-purpose input/output) pins. The Raspberry Pi has a 40-pin GPIO header as seen in the image

Resources

Raspberry Pi and Installation of Raspberry Pi OS have been covered in more detail in other available Tutorials.

These Tutorials are available on my Blog and YouTube:

- Raspberry Pi - https://youtu.be/sPZqZDdsrkc
- Raspberry Pi Installation and Remote Access - https://youtu.be/NsxZTQysah8

Blog:

https://www.halvorsen.blog/

YouTube Channel @Industrial IT and Automation

https://www.youtube.com/IndustrialITandAutomation

https://www.halvorsen.blog

LabVIEW LINX Toolkit

Hans-Petter Halvorsen

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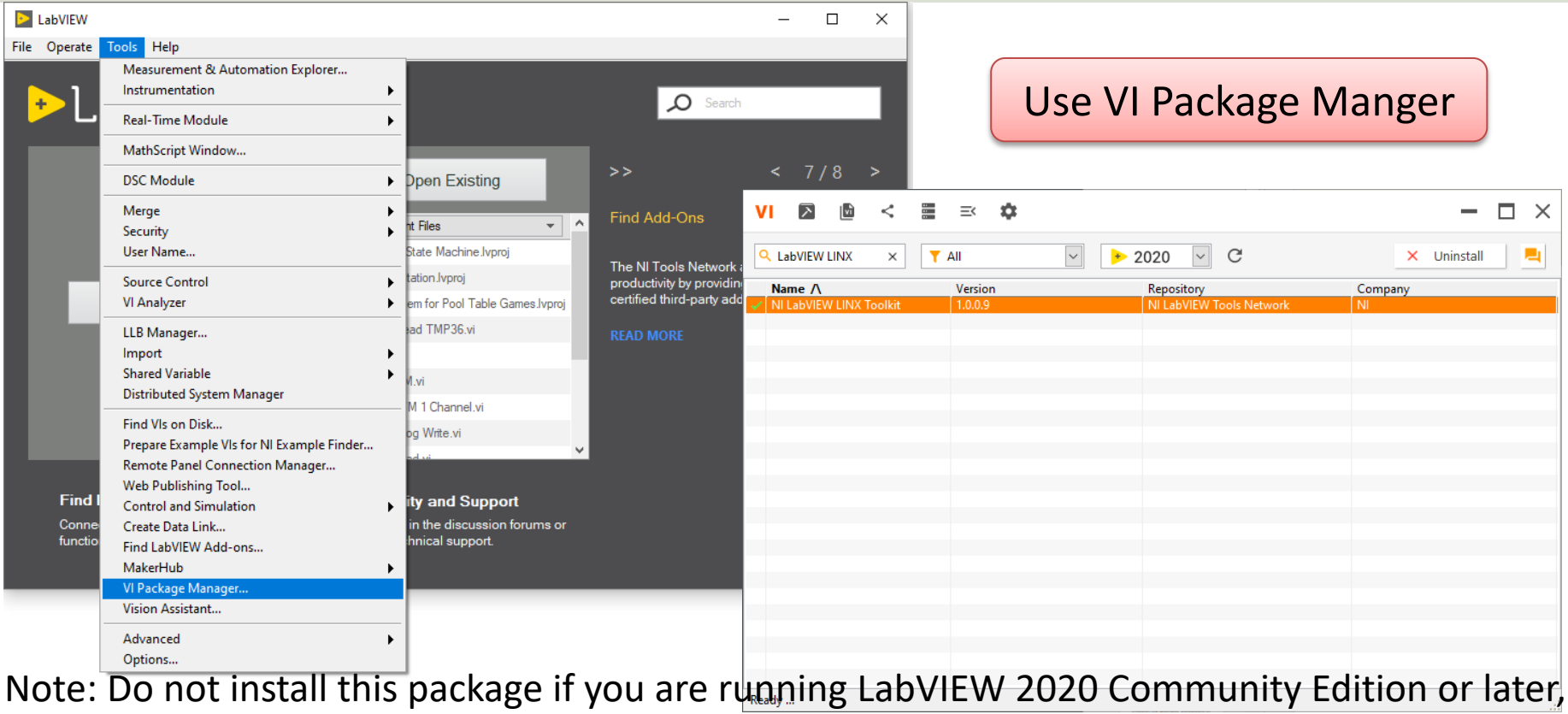
LabVIEW LINX Toolkit

- The LabVIEW LINX Toolkit adds support for Arduino, Raspberry Pi, and BeagleBone embedded platforms
- I have used LabVIEW LINX in combination with Arduino in other Tutorials
- We will use Raspberry Pi in this Tutorial

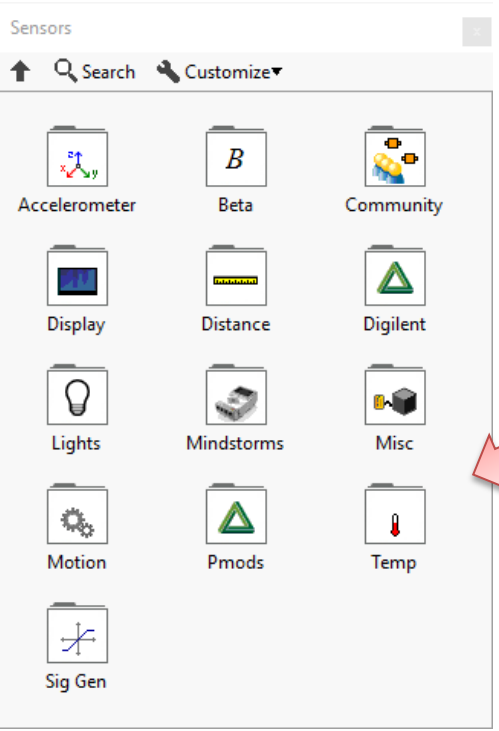
Installing LabVIEW LINX Toolkit

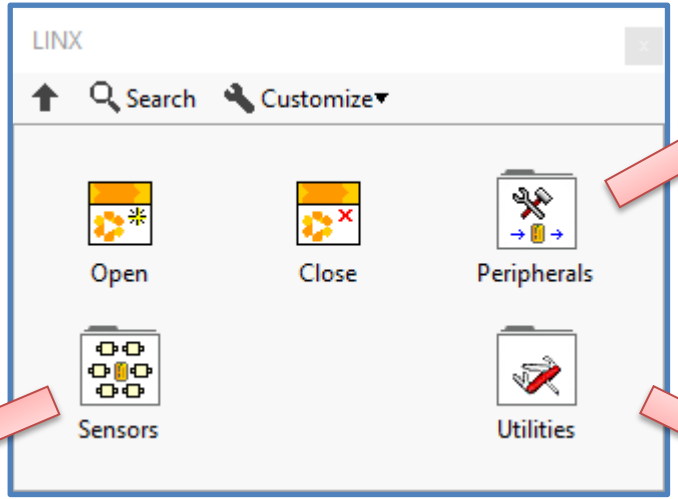


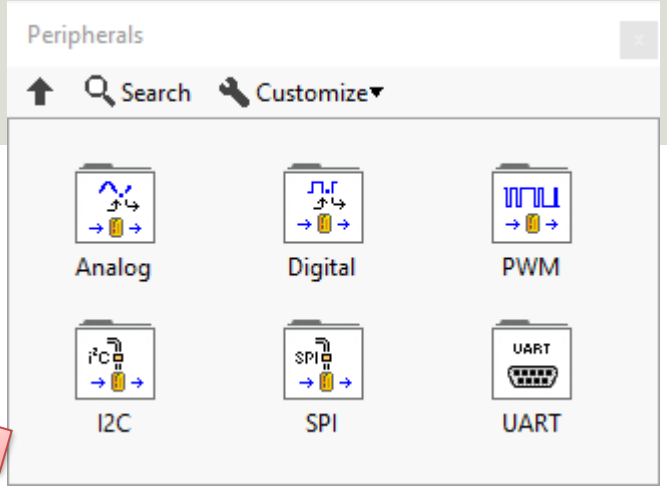
Use VI Package Manger

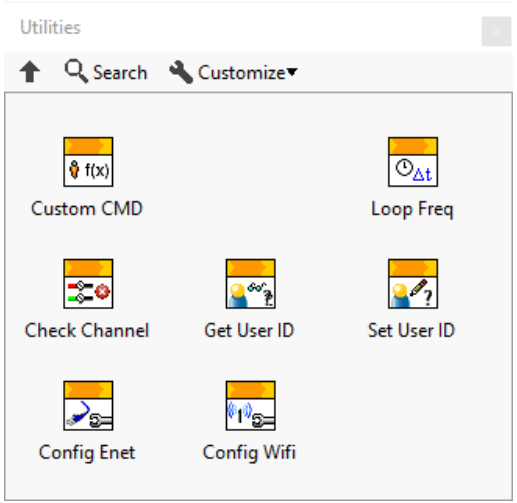
Note: Do not install this package if you are running LabVIEW 2020 Community Edition or later, as the Community Edition already includes the LabVIEW LINX Toolkit

LabVIEW Palette

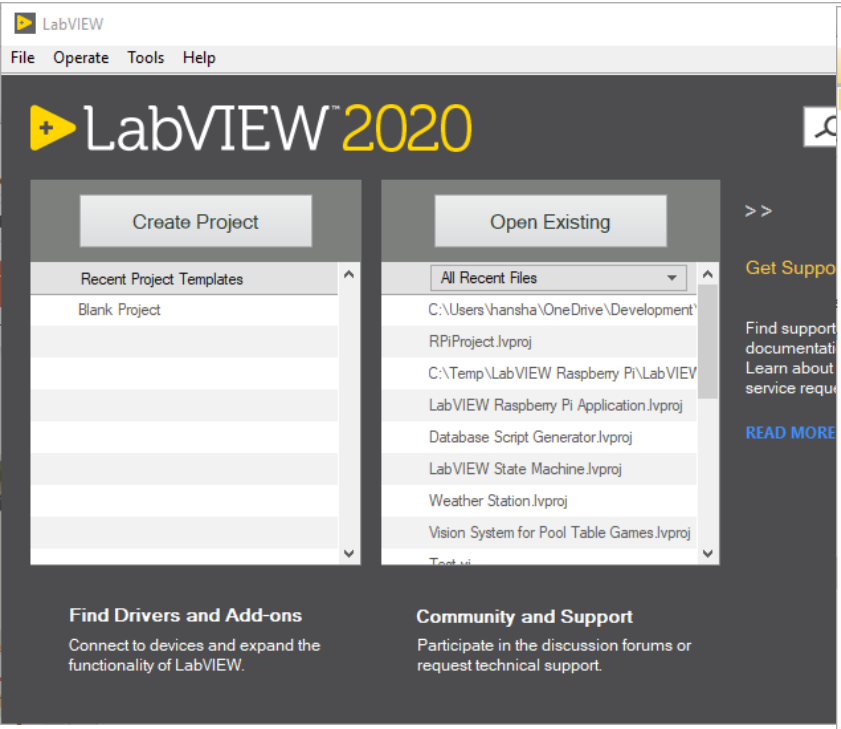


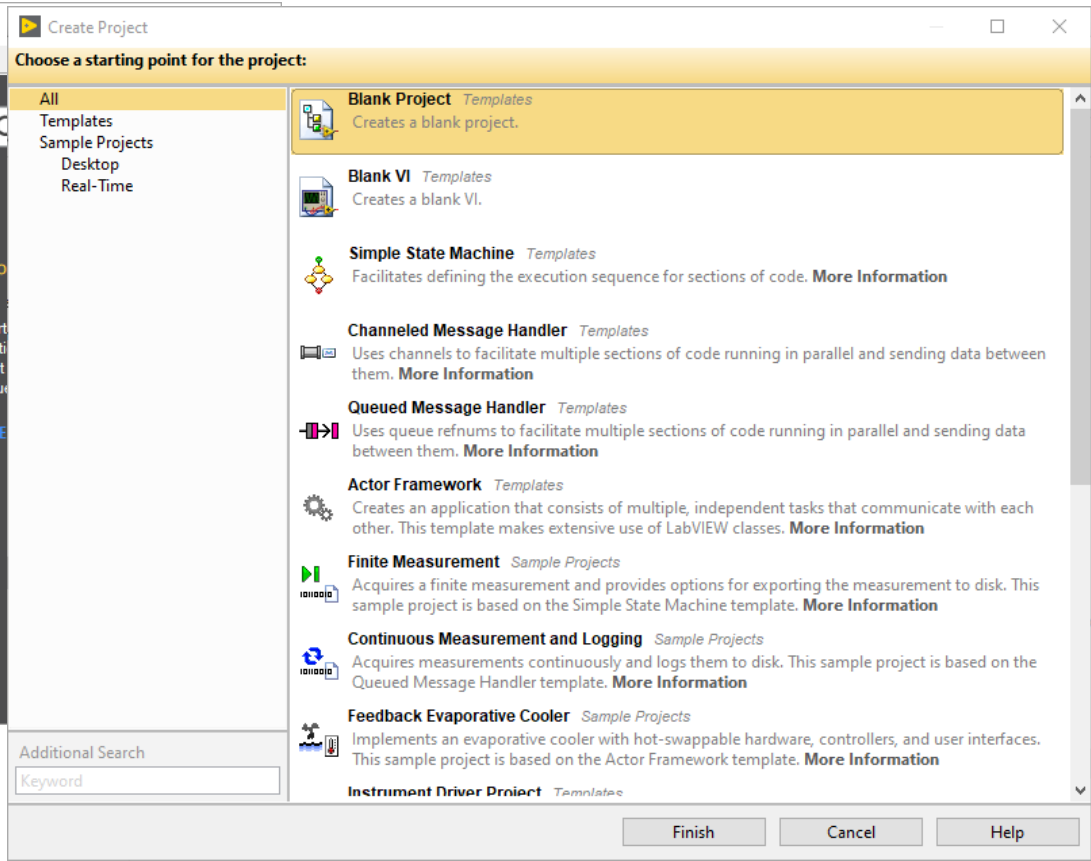




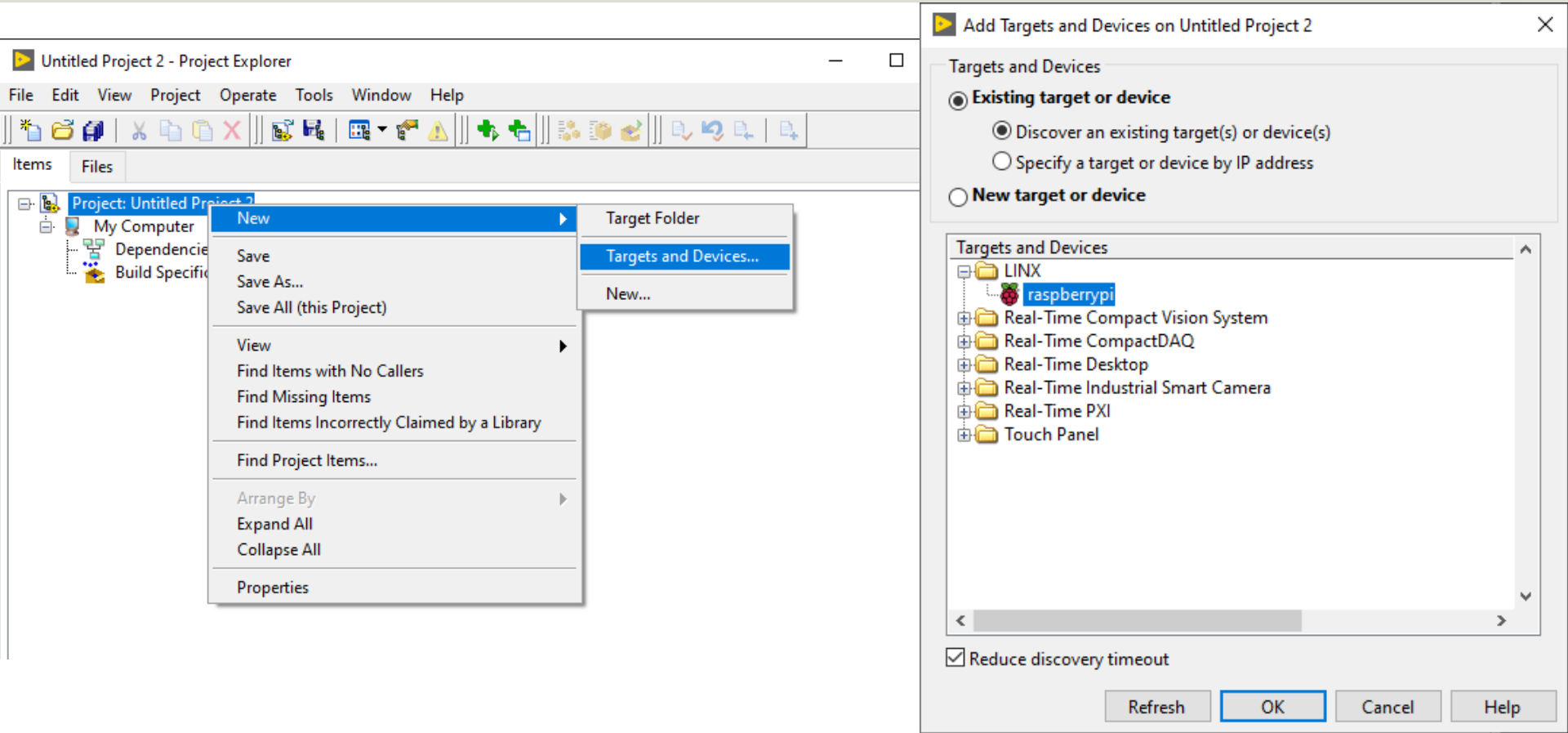


Create your Raspberry Pi Project

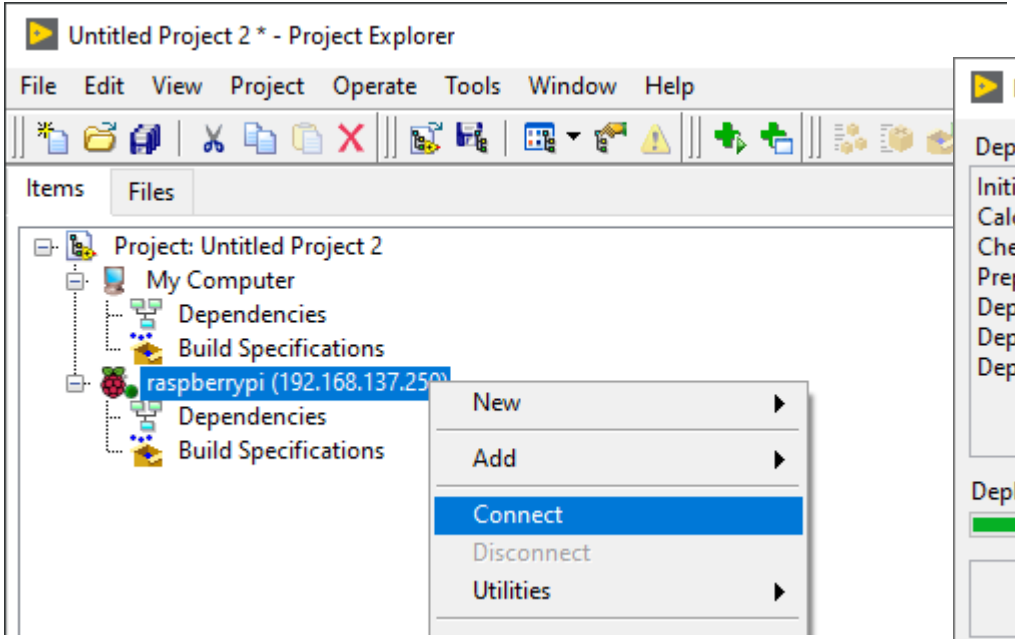


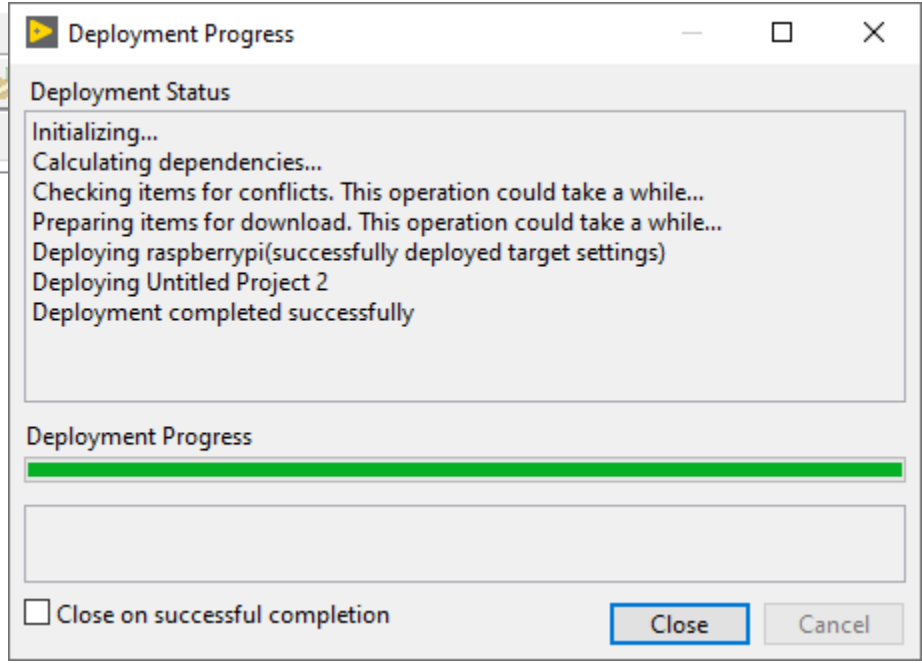


Create your Raspberry Pi Project

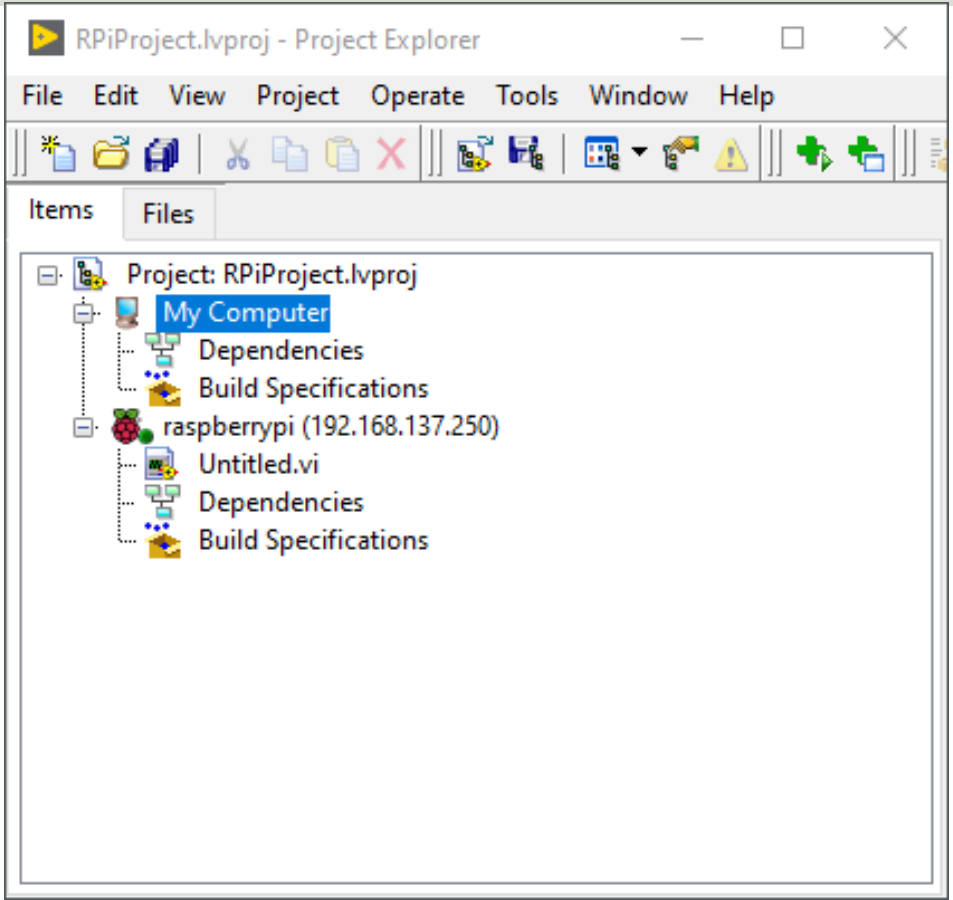


Create your Raspberry Pi Project





LabVIEW Project Explorer



You are now ready to start creating LabVIEW Code that control the GPIO pins on the Raspberry Pi device

Resources

Introduction to Raspberry Pi and LabVIEW LINX has been given in another Tutorial.

- LabVIEW LINX and Raspberry Pi - xxx

Blog:

https://www.halvorsen.blog/

YouTube Channel @Industrial IT and Automation

https://www.youtube.com/IndustrialITandAutomation

SPI and I2C Interfaces

Hans-Petter Halvorsen

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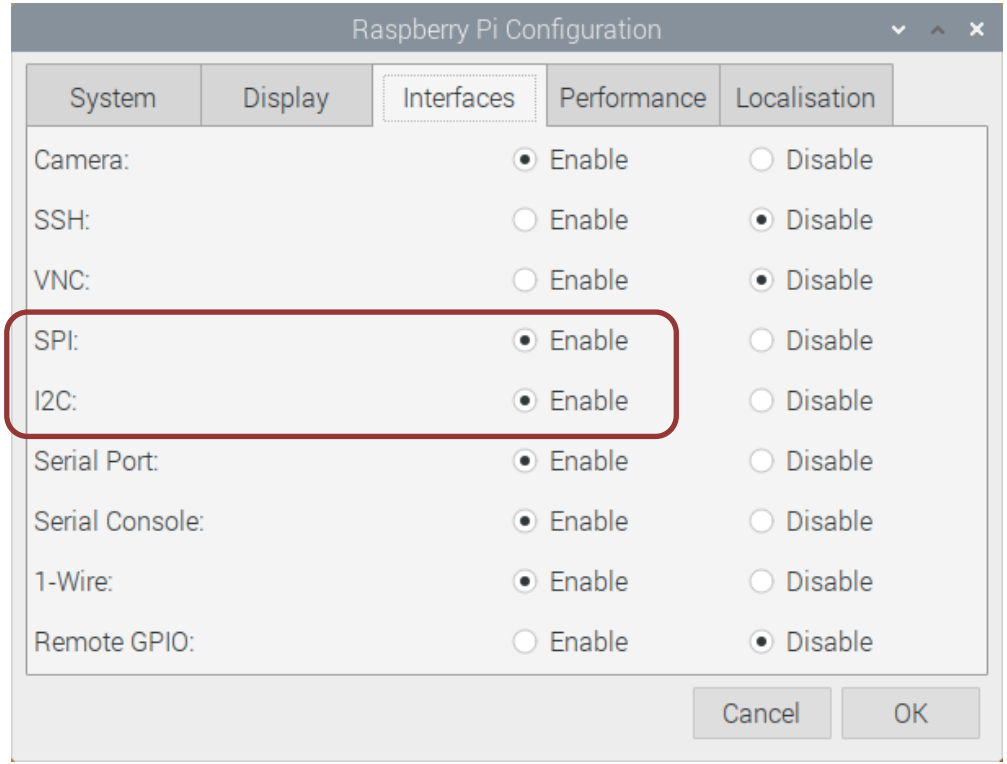
Raspberry Pi Configuration

You need to Enable **SPI** and **I2C**



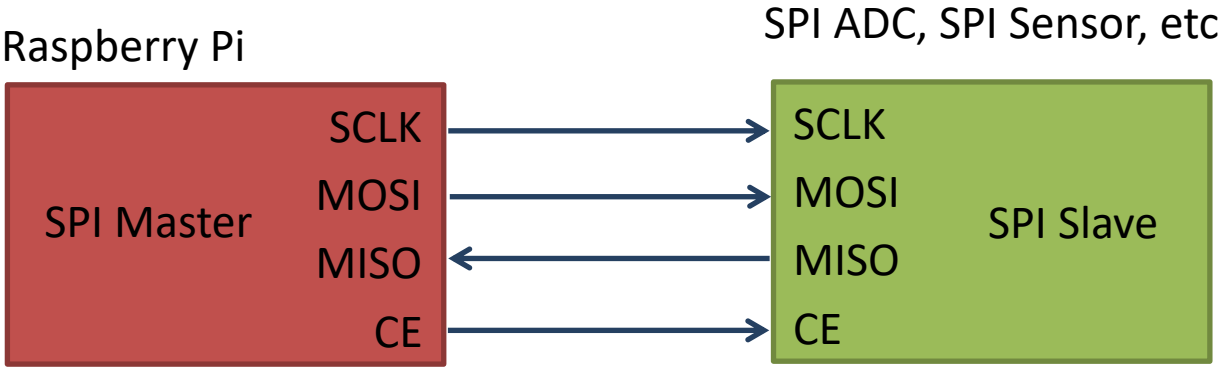
SPI

- Serial Peripheral Interface (SPI)
- 4–Wire Protocol (SCLK, CE, MOSI, MISO)
- SPI is an interface to communicate with different types of electronic components like Sensors, Analog to Digital Converts (ADC), etc. that supports the SPI interface
- Thousands of different Components and Sensors supports the SPI interface

https://www.raspberrypi.org/documentation/hardware/raspberrypi/spi/

SPI

SPI devices communicate in full duplex mode using a master-slave architecture with a single master



The SPI bus specifies four logic signals:

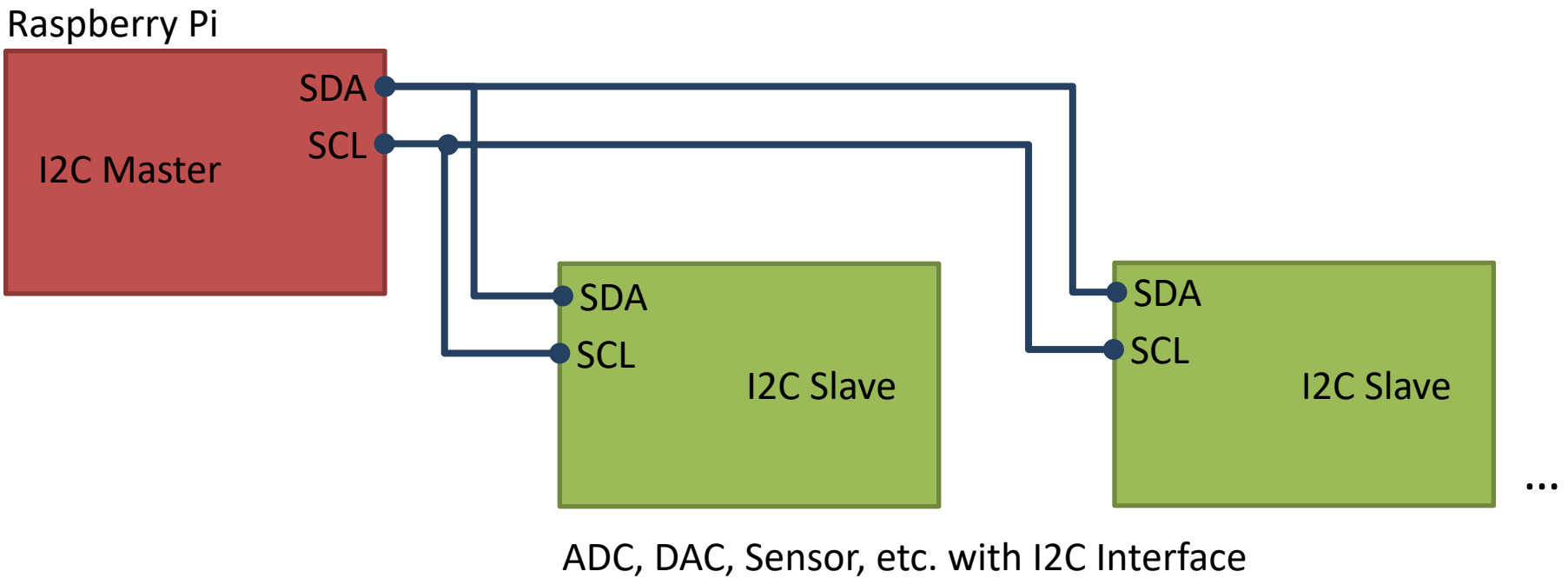
- **SCLK**: Serial Clock (output from master)
- **MOSI**: Master Out Slave In (data output from master)
- **MISO**: Master In Slave Out (data output from slave)
- **CE** (often also called SS - Slave Select): Chip Select (often active low, output from master)

I2C

- I2C is a multi-drop bus
- 2-Wire Protocol (SCL + SDA)
- Multiple devices can be connected to the I2C pins on the Raspberry Pi
- Each device has its own unique I2C address

I2C

Multiple devices can be connected to the I2C pins on the Raspberry Pi
Master – Device that generates the clock and initiates communication with slaves
Slave – Device that receives the clock and responds when addressed by the master.



SPI/I2C

- Digital Sensors typically use either the SPI or the I2C communication protocol
- The Arduino UNO has built-in hardware support for SPI and I2C communication

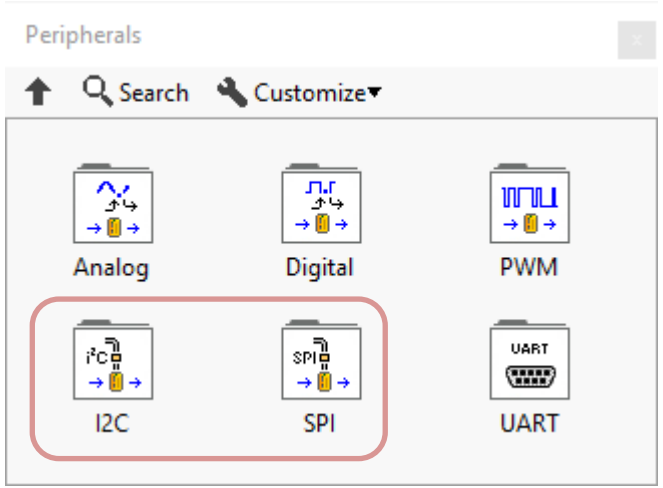
SPI

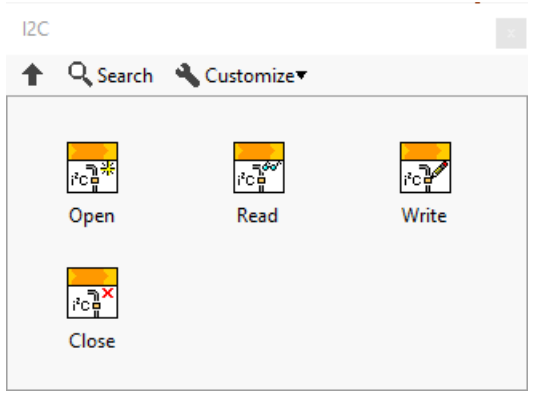
- 4-Wire Protocol
- SPI supports full-duplex. Data can be sent and received at the same time
- Higher data transfer rate than I2C
- Complex wiring if more than one Slave

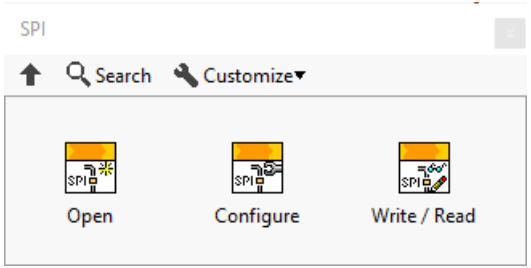
I2C

- 2-Wire Protocol
- I2C supports only half-duplex. Data cannot be sent and received at the same time
- Lower data transfer rate than SPI
- Multiple Slaves are easier

SPI/I2C in LabVIEW LINX







TC74 Temperature Sensor with I2C

Hans-Petter Halvorsen

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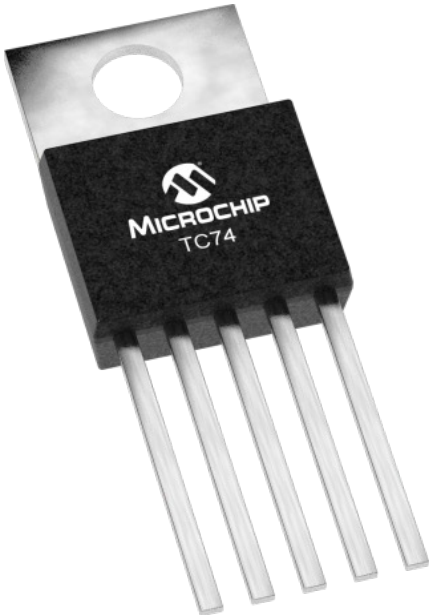
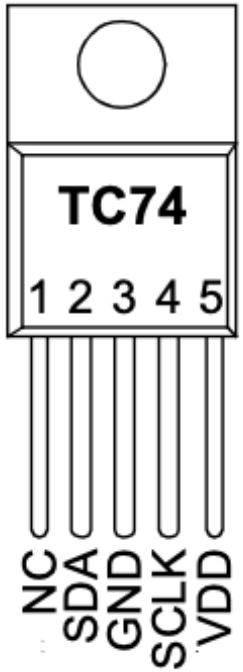
TC74 Temperature Sensor

SMBus/I2C Interface

TC74A0-5.0VAT



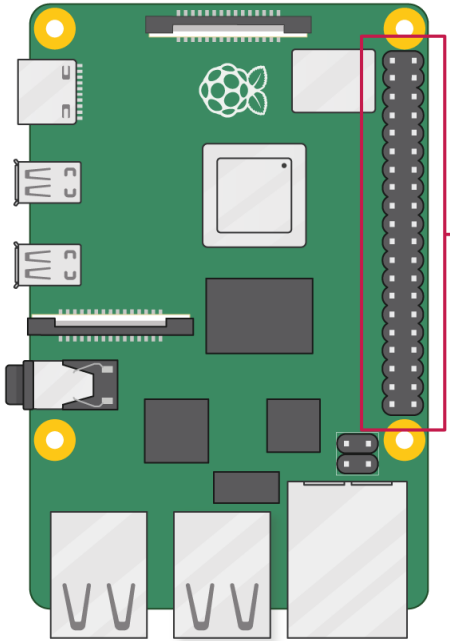


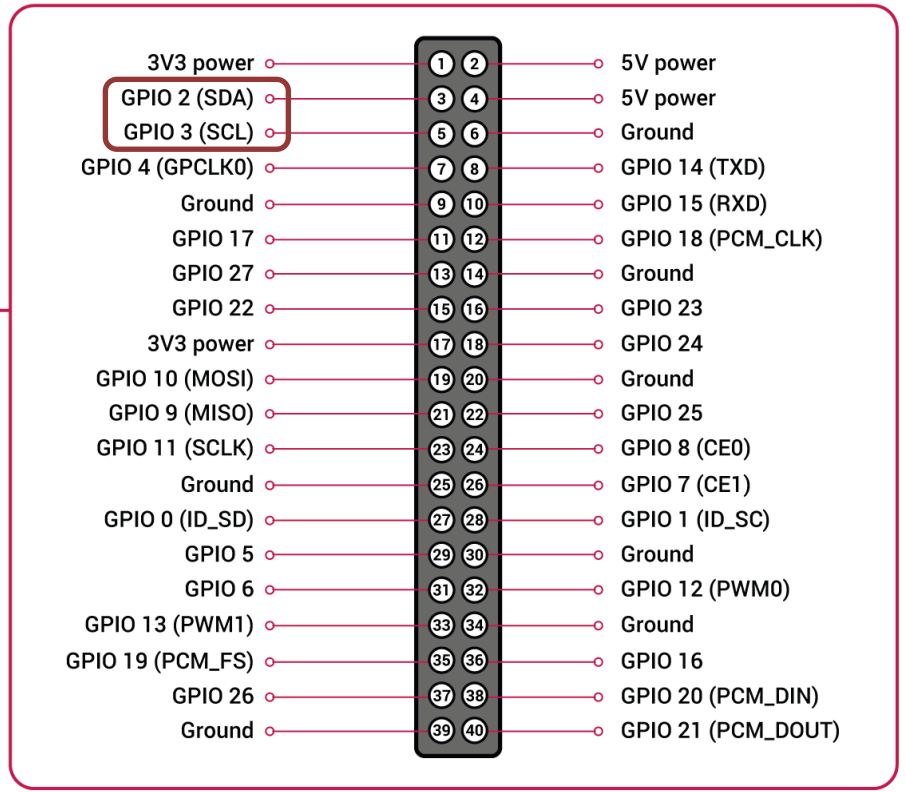
- The TC74 acquires and converts temperature information from its onboard solid-state sensor with a **resolution of ±1°C**.
- It stores the data in an internal register which is then read through the serial port.
- The system interface is a slave SMBus/I2C port, through which temperature data can be read at any time.
- Device Address: **0x48**

Datasheet: https://ww1.microchip.com/downloads/en/DeviceDoc/21462D.pdf

I2C Wiring on Raspberry Pi

GPIO 40 pins Connector

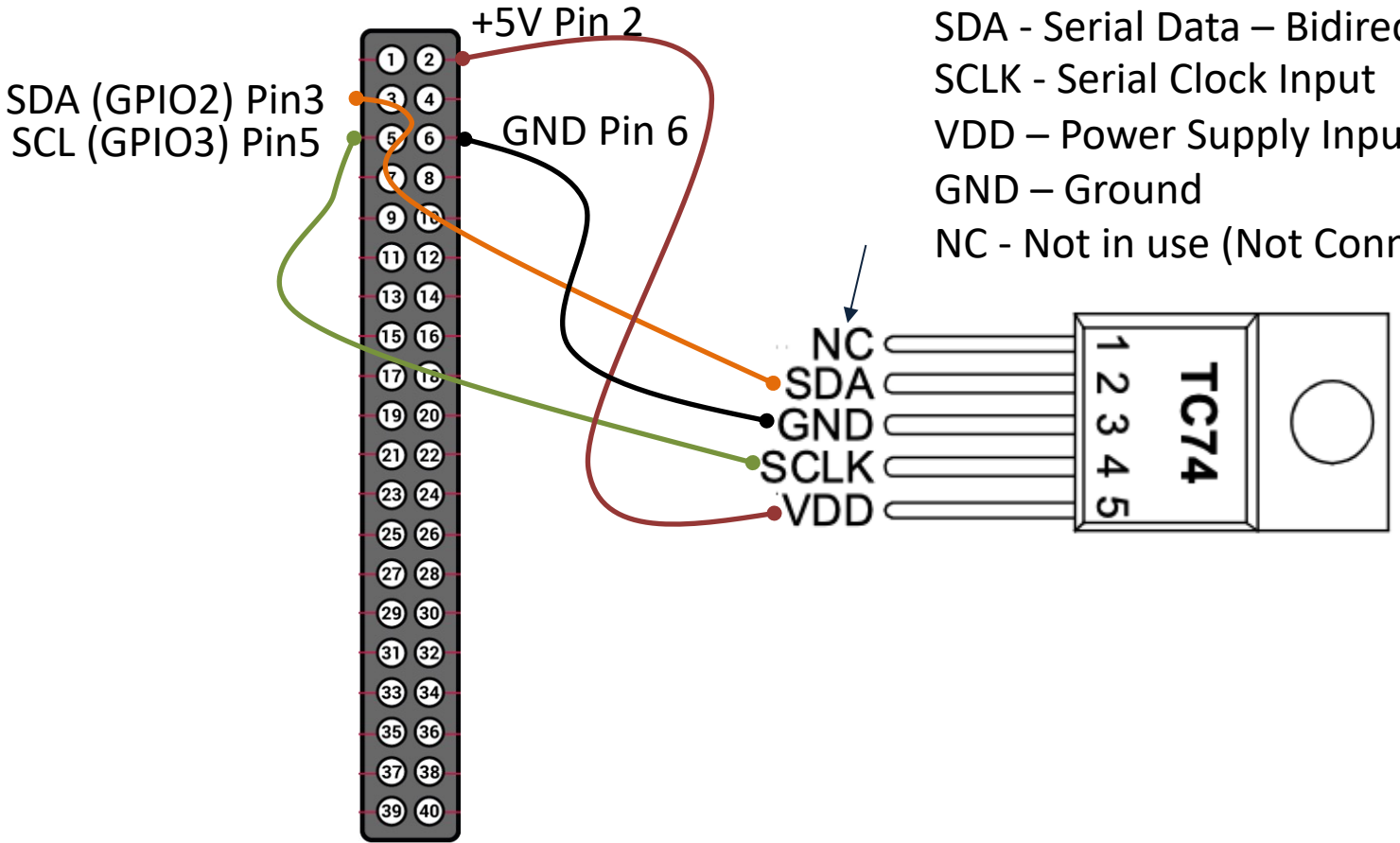




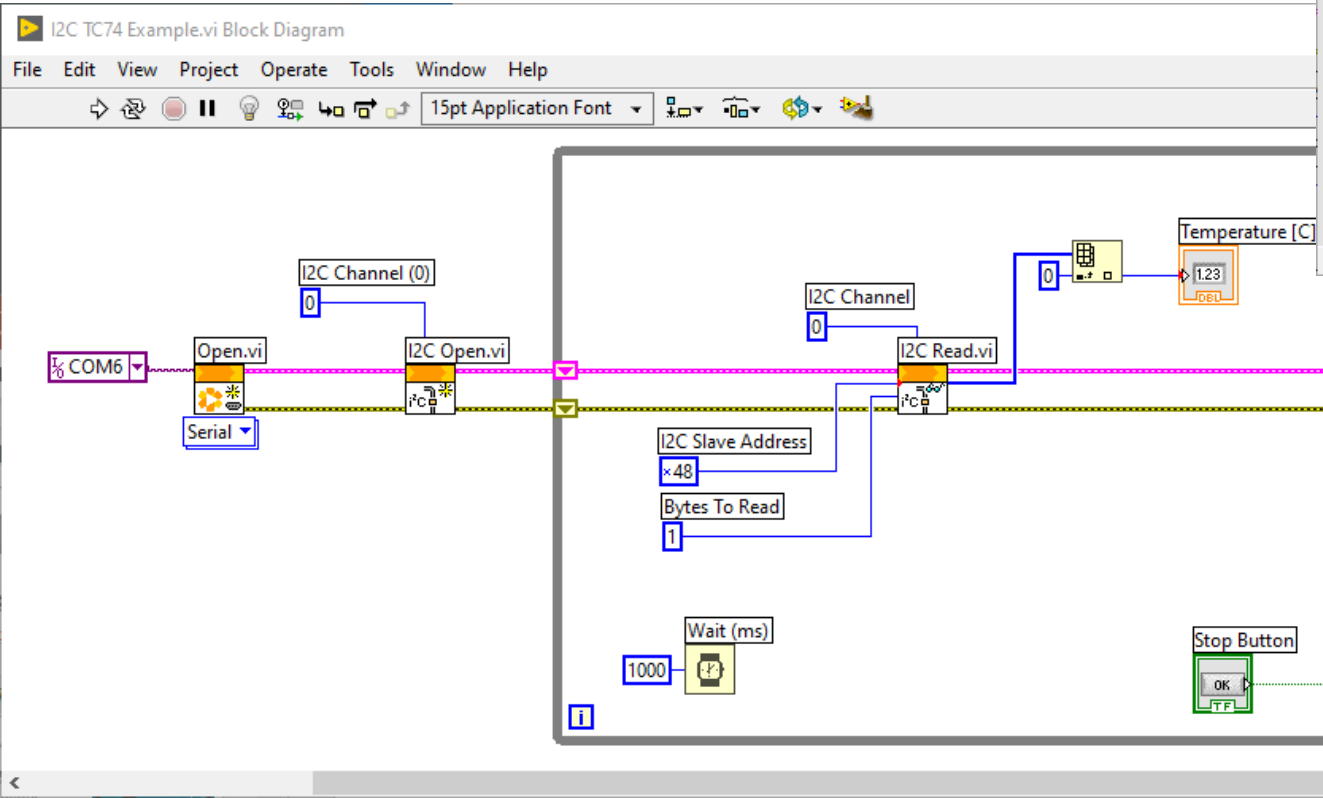
Note! The I2C pins include a fixed 1.8 kΩ pull-up resistor to 3.3v.

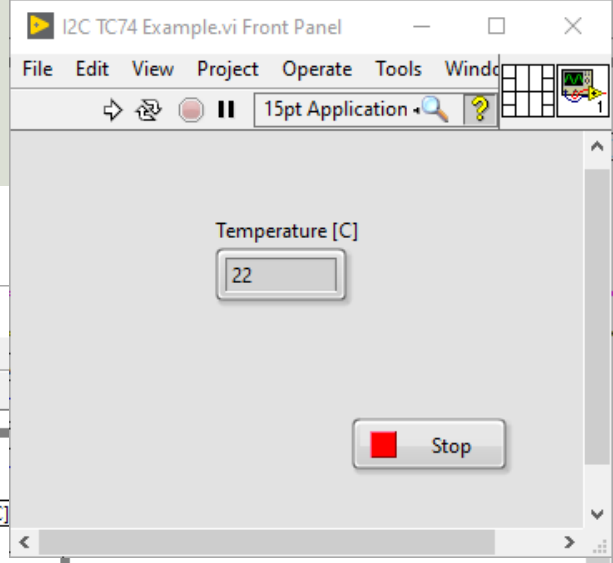
TC74 Wiring

Raspberry Pi GPIO Pins

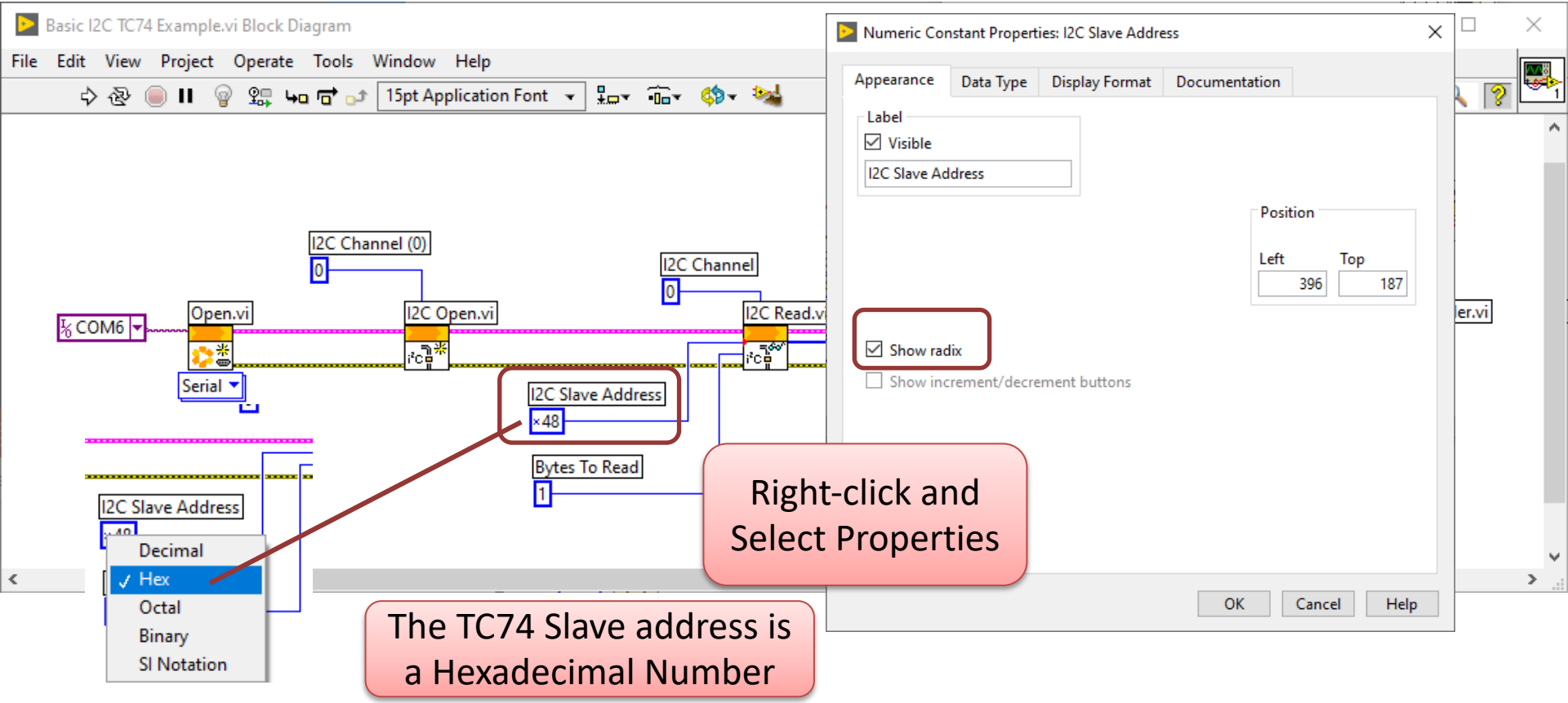


LabVIEW


I2C TC74 Example.vi Block Diagram
File Edit View Project Operate Tools Window Help
15pt Application Font
COM6
Open.vi
Serial
I2C Channel (0)
0
I2C Open.vi
I2C Channel
0
I2C Read.vi
I2C Slave Address
×48
Bytes To Read
1
0
Temperature [C]
1.23
DBL
Wait (ms)
1000
Stop Button
OK
TF
I2C Close.vi
Close.vi
Simple Error Handler.vi
Error


I2C TC74 Example.vi Front Panel
File Edit View Project Operate Tools Windo
15pt Application
Temperature [C]
22
Stop

Slave Address



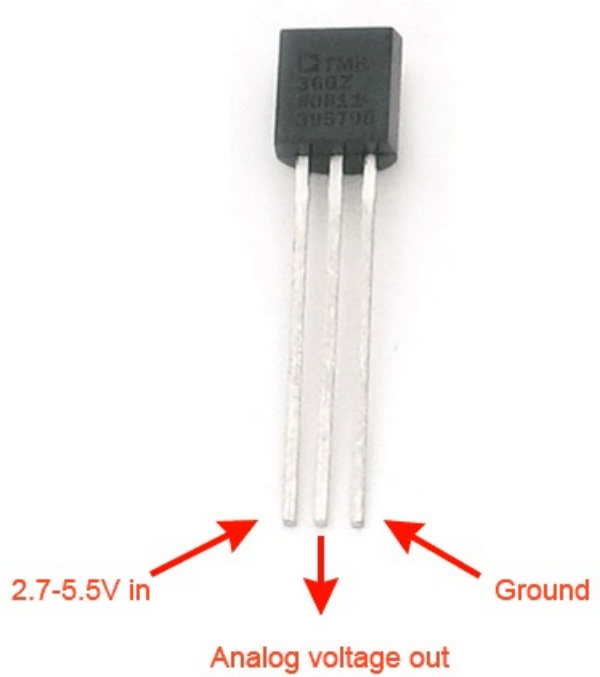
https://www.halvorsen.blog

TMP36

Temperature Sensor

Hans-Petter Halvorsen

TMP36 Temperature Sensor

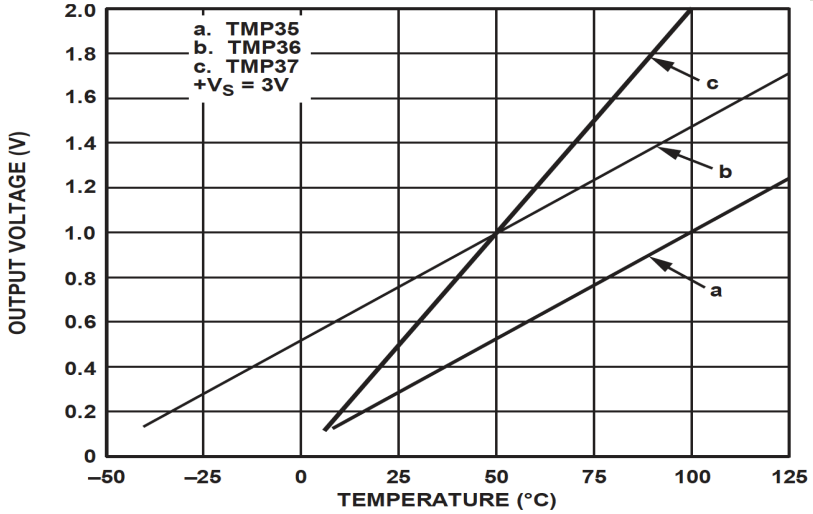


A Temperature sensor like TM36 use a solid-state technique to determine the temperature.

They use the fact as temperature increases, the voltage across a diode increases at a known rate.

https://learn.adafruit.com/tmp36-temperature-sensor

TMP36 Temperature Sensor



This gives:

$$y - 25 = \frac{50 - 25}{1 - 0.75}(x - 0.75)$$

Then we get the following formula:

$$y = 100x - 50$$

Convert from Voltage (V) to degrees Celsius

From the Datasheet we have:

$$(x_1, y_1) = (0.75V, 25°C)$$
$$(x_2, y_2) = (1V, 50°C)$$

There is a linear relationship between Voltage and degrees Celsius:

$$y = ax + b$$

We can find a and b using the following known formula:

$$y - y_1 = \frac{y_2 - y_1}{x_2 - x_1}(x - x_1)$$

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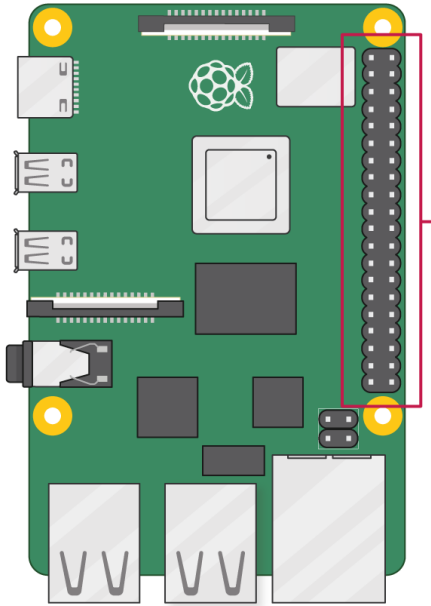
ADC – MCP3002

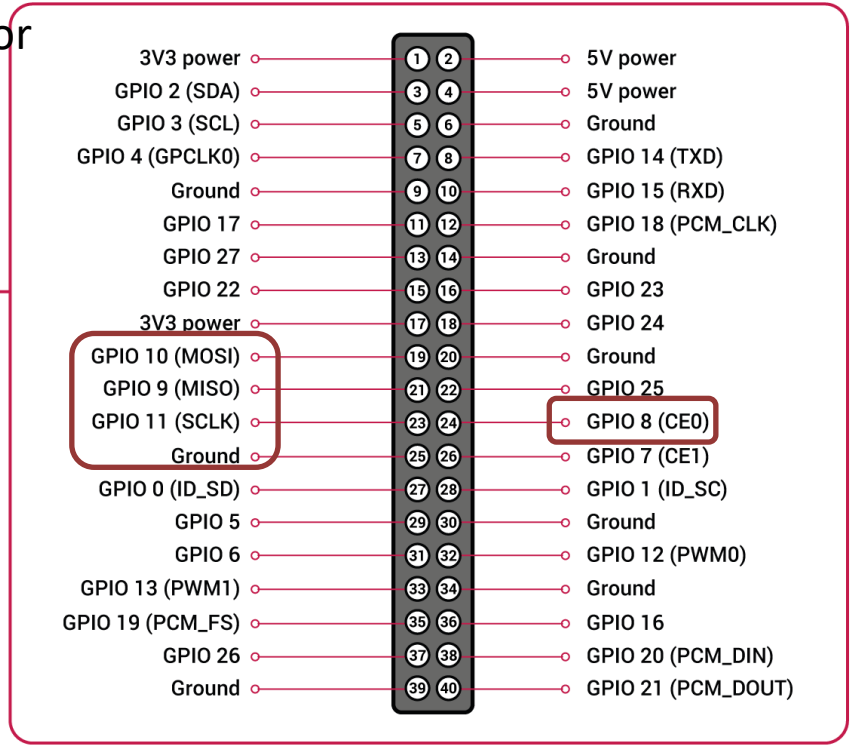
Analog to Digital Converter

Hans-Petter Halvorsen

SPI Wiring on Raspberry Pi

GPIO 40 pins Connector





ADC

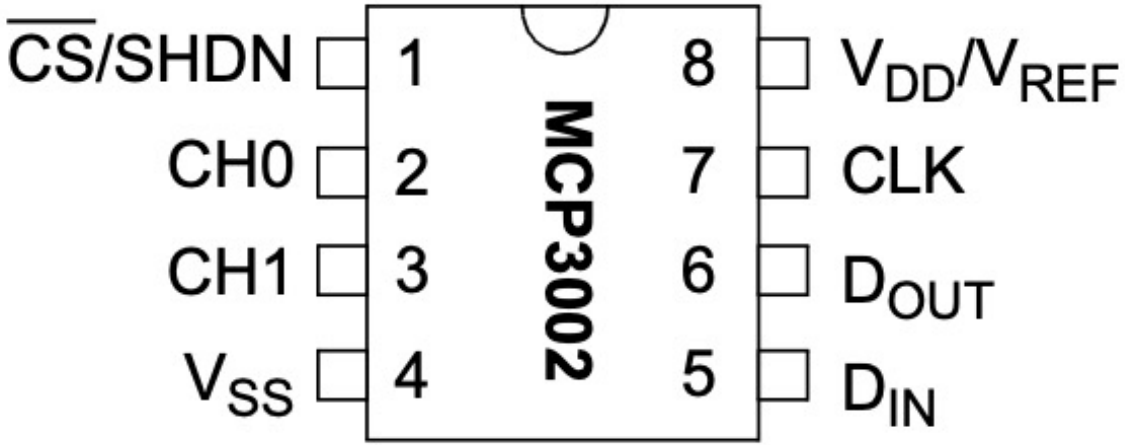
- The Raspberry Pi has only Digital pins on the GPIO connector
- If you want to use an Analog electric component or an Analog Sensor together with Raspberry Pi, you need to connect it through an external ADC chip
- ADC – Analog to Digital Converter

https://en.wikipedia.org/wiki/Analog-to-digital_converter

MCP3002 ADC chip

The MCP3002 is a 10-bit analog to digital converter with 2 channels (0-1).

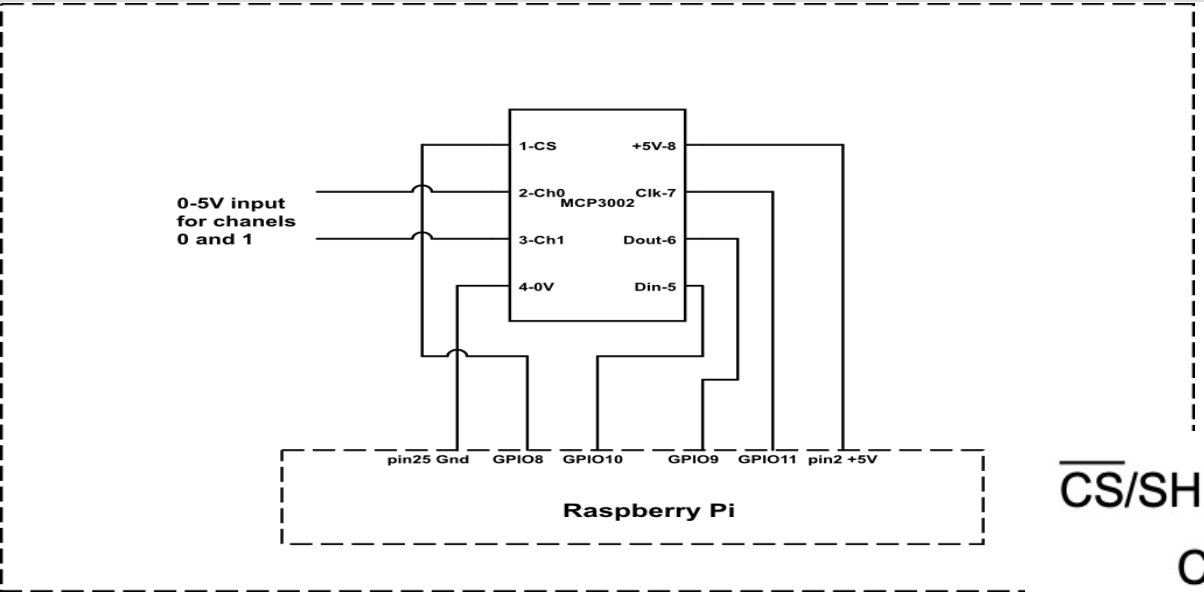
The MCP3002 uses a SPI Interface

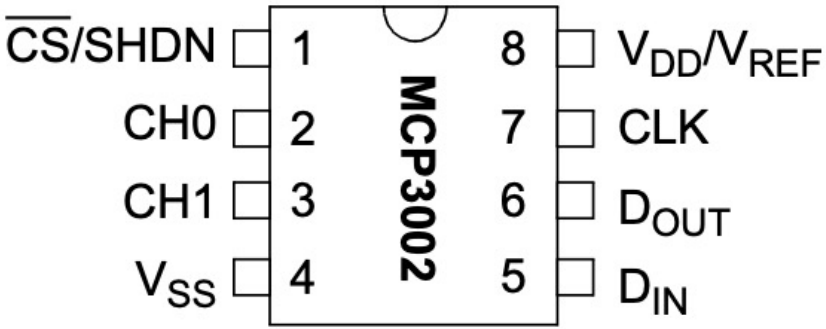


http://ww1.microchip.com/downloads/en/DeviceDoc/21294E.pdf

https://learn.sparkfun.com/tutorials/python-programming-tutorial-getting-started-with-the-raspberry-pi/experiment-3-spi-and-analog-input

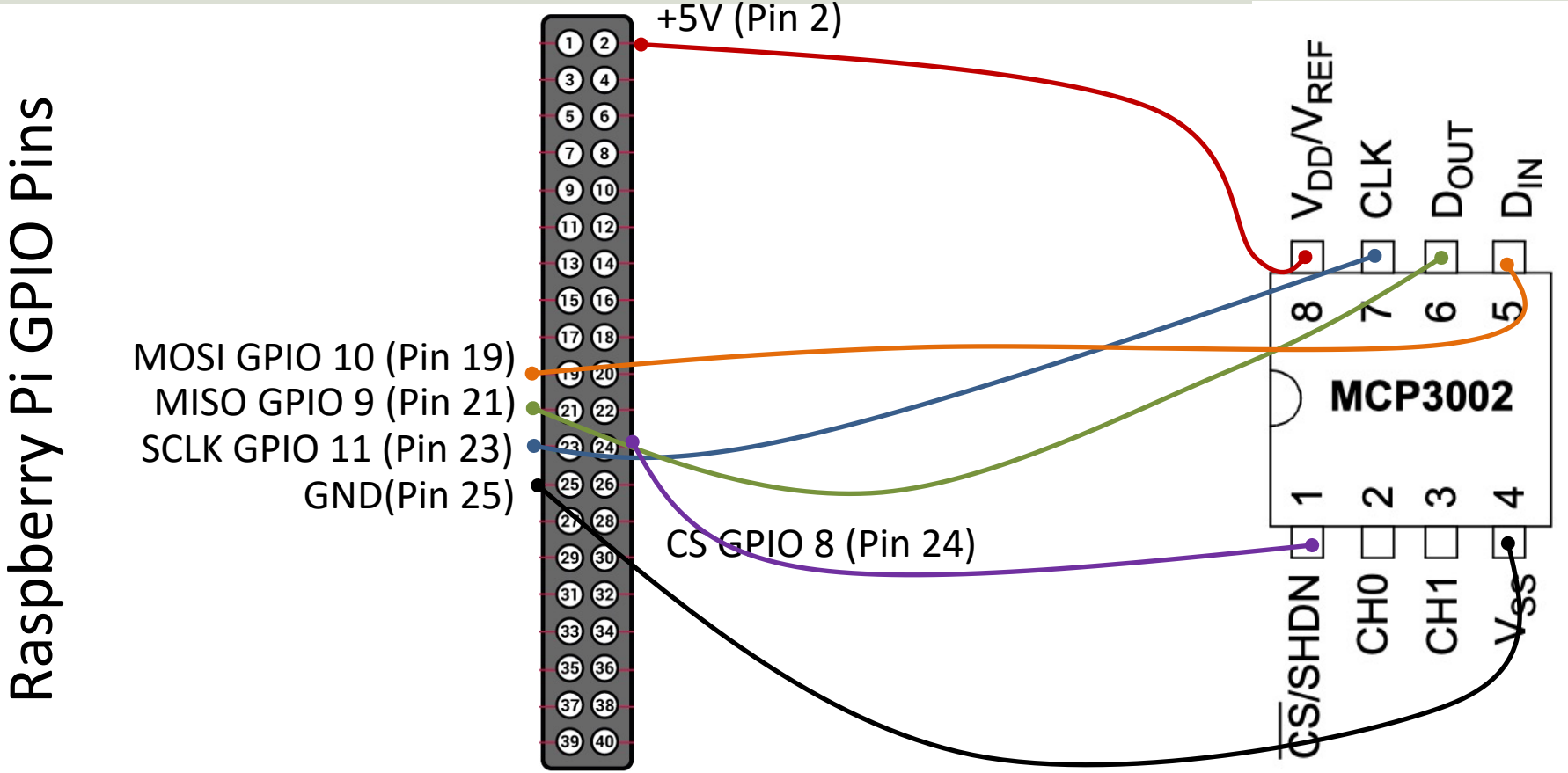
Wiring





https://sites.google.com/a/joekamphaus.net/raspberry-pi-spi-interface-to-mcp3002/

Wiring


Raspberry Pi GPIO Pins
+5V (Pin 2)
MOSI GPIO 10 (Pin 19)
MISO GPIO 9 (Pin 21)
SCLK GPIO 11 (Pin 23)
GND(Pin 25)
CS GPIO 8 (Pin 24)
1 2
3 4
5 6
7 8
9 10
11 12
13 14
15 16
17 18
19 20
21 22
23 24
25 26
27 28
29 30
31 32
33 34
35 36
37 38
39 40
VDD/VREF
CLK
DOUT
DIN
8 7 6 5
MCP3002
1 2 3 4
CS/SHDN
CH0
CH1
VSS

DAC - MCP4911

DAC – Digital to Analog Converter

Hans-Petter Halvorsen

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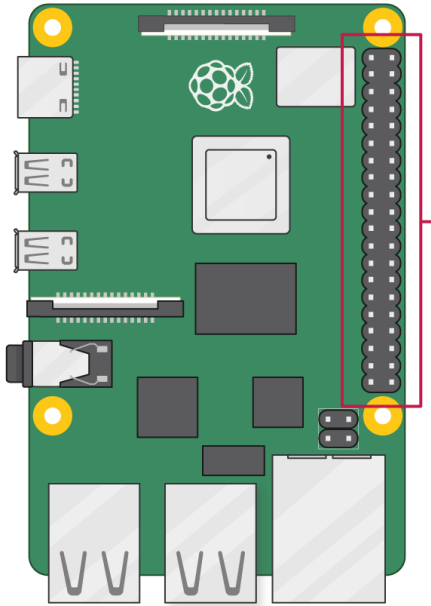
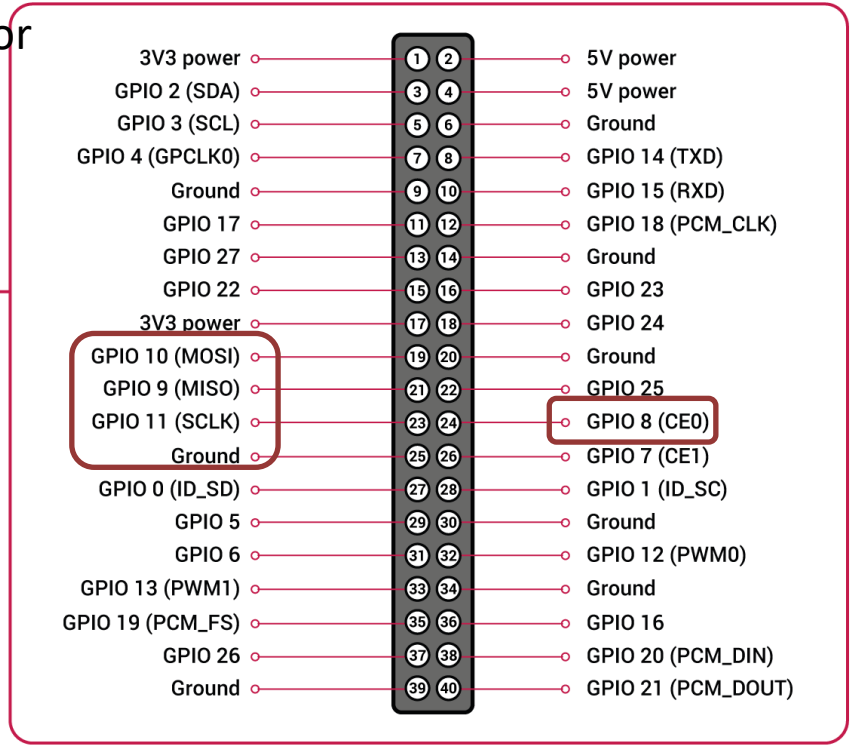
SPI Wiring on Raspberry Pi

GPIO 40 pins Connector





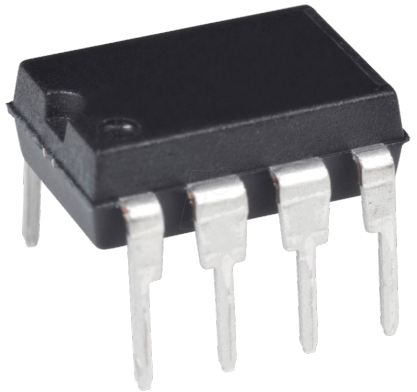
DAC – MCP4911

- DAC – Digital to Analog Converter
- Arduino UNO has no real Analog Out Channel – only Digital PWM channels
- We can use an external DAC in order to provide a real Analog Out
- MCP4911 is a single channel, 10-bit DAC with an external voltage reference and SPI interface

MCP49xx

MCP49xx is a family of DAC ICs:

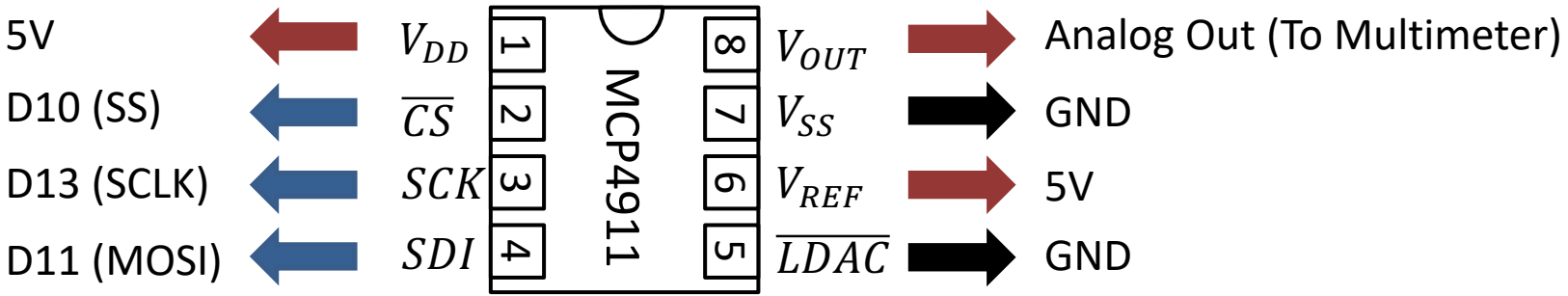
- MCP4901: 8-Bit Voltage Output DAC
- **MCP4911: 10-Bit Voltage Output DAC**
- MCP4921: 12-Bit Voltage Output DAC



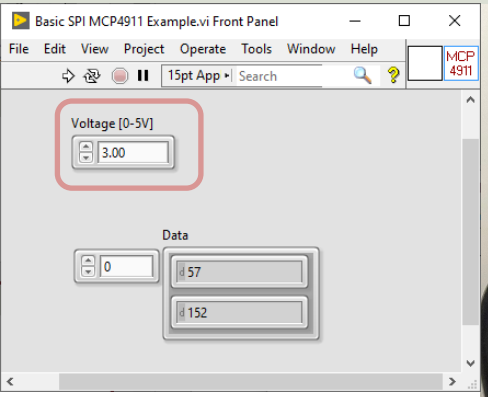
The different MCP49xx DACs work in the same manner, the only difference is the resolution (8, 10, or 12 resolution)

Datasheet: https://www.microchip.com/en-us/product/MCP4911

MCP4911 - Arduino Wiring



Test Setup



Multimeter

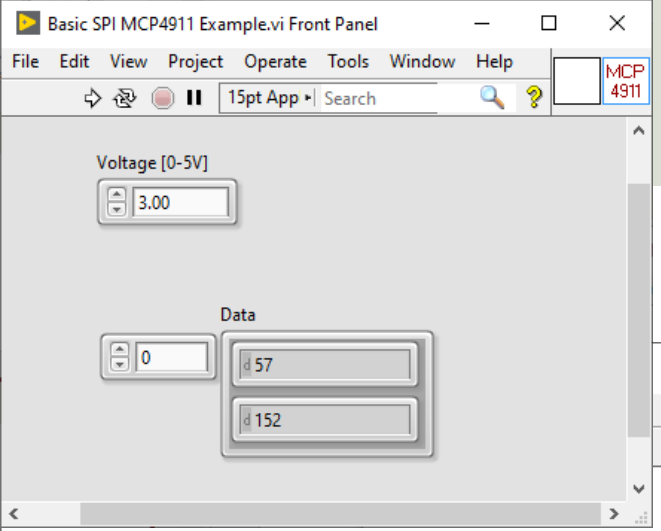
Arduino UNO

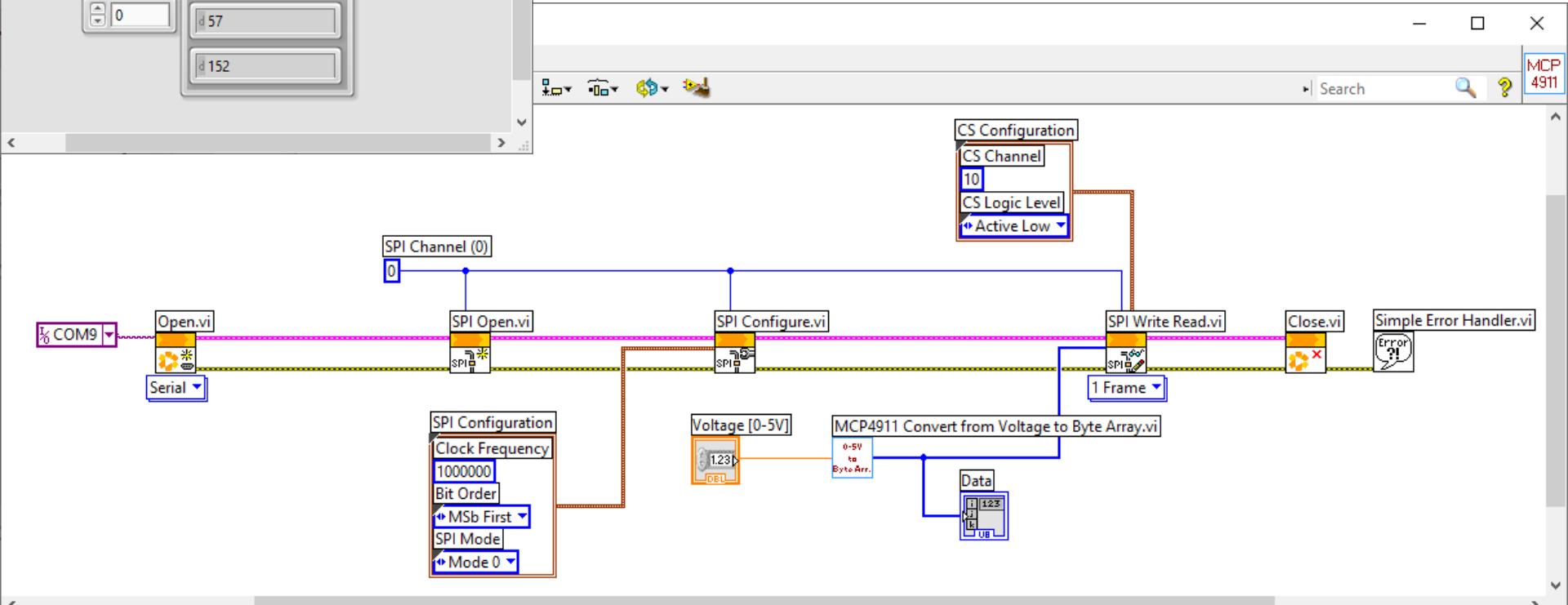
PC

Breadboard with MCP4911 DA and some wires to the Arduino

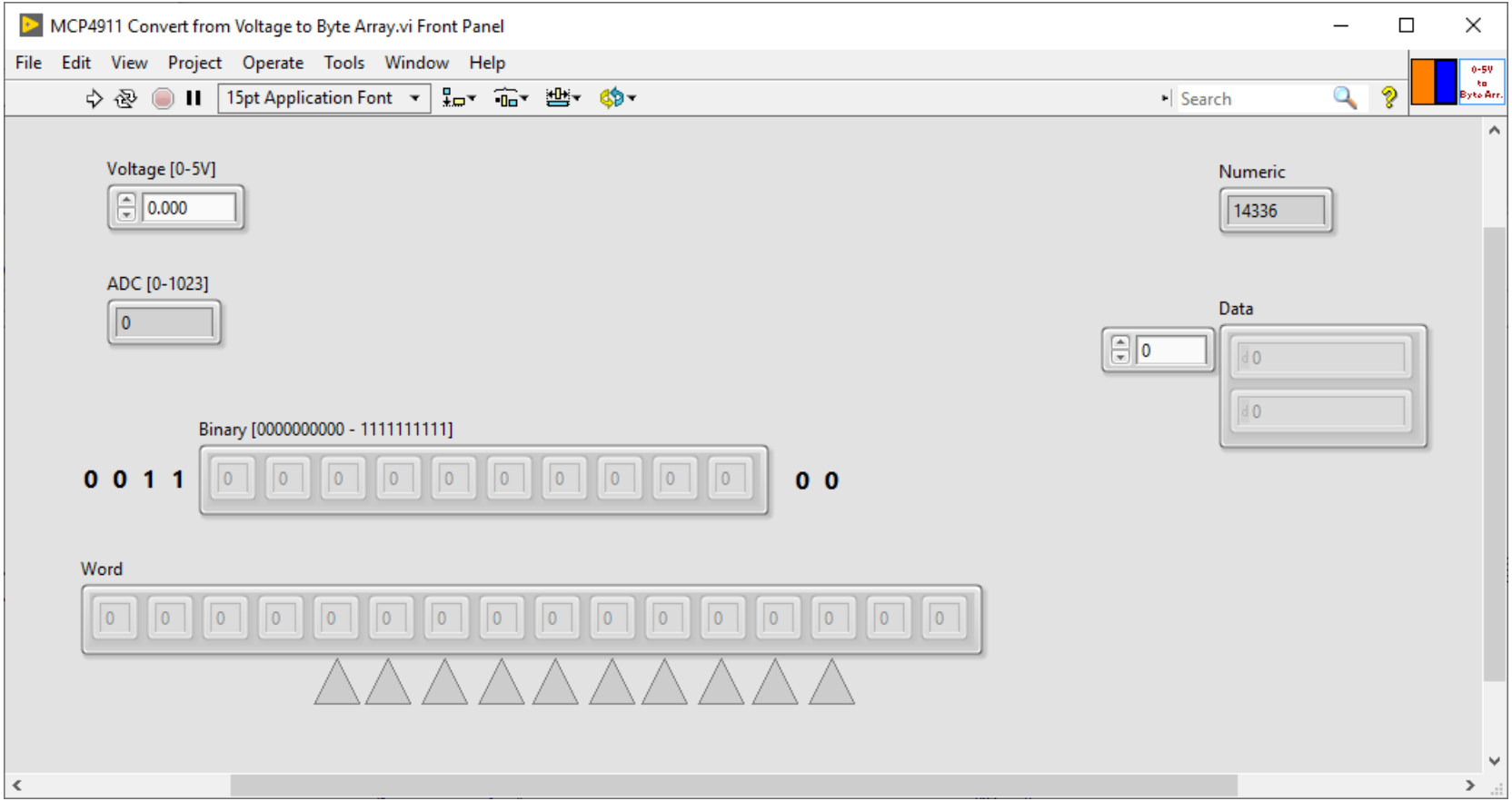
In the LabVIEW Application 3V is written to the MCP4911 DAC.
Then we can use a Multimeter to see if everything works as expected

LabVIEW

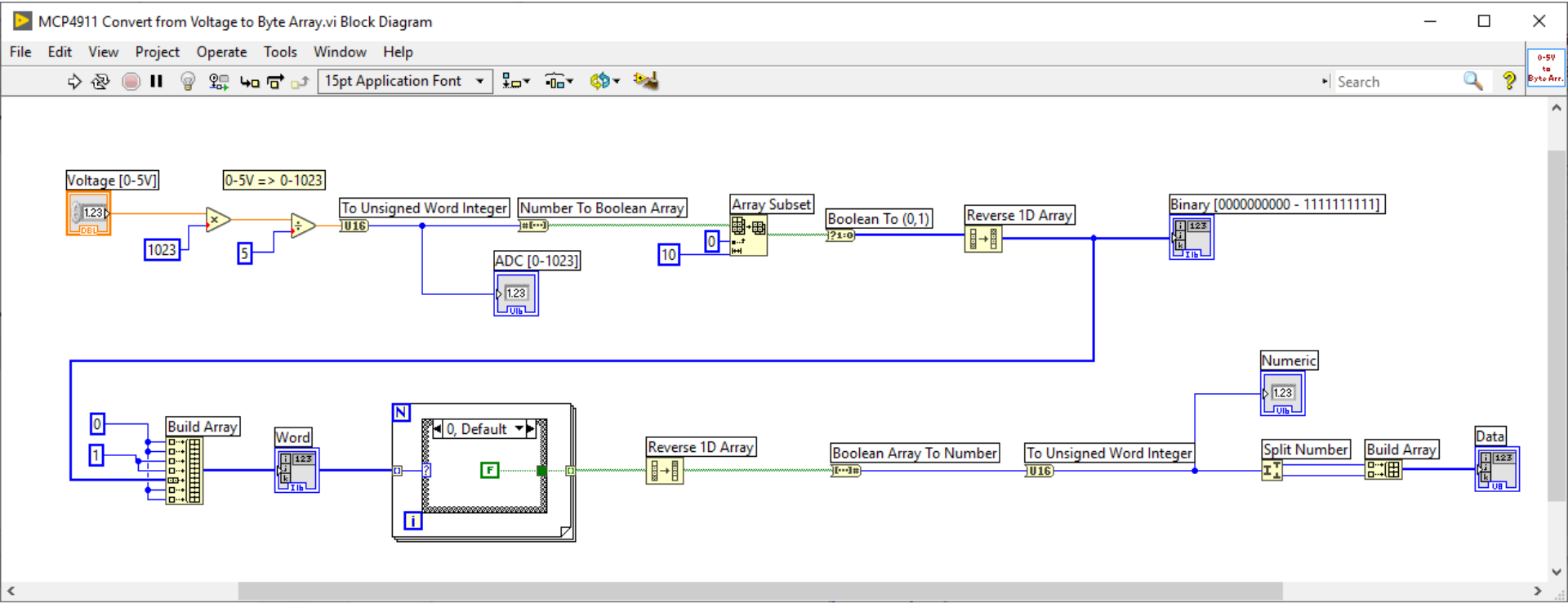

Basic SPI MCP4911 Example.vi Front Panel
File Edit View Project Operate Tools Window Help
15pt App
Search
MCP 4911
Voltage [0-5V]
3.00
Data
0
57
152


Search
MCP 4911
CS Configuration
CS Channel
10
CS Logic Level
Active Low
SPI Channel (0)
0
COM9
Open.vi
Serial
SPI Open.vi
SPI Configure.vi
SPI Write Read.vi
1 Frame
Close.vi
Simple Error Handler.vi
SPI Configuration
Clock Frequency
1000000
Bit Order
MSb First
SPI Mode
Mode 0
Voltage [0-5V]
1.23
MCP4911 Convert from Voltage to Byte Array.vi
Data

Convert from Voltage to Byte Array

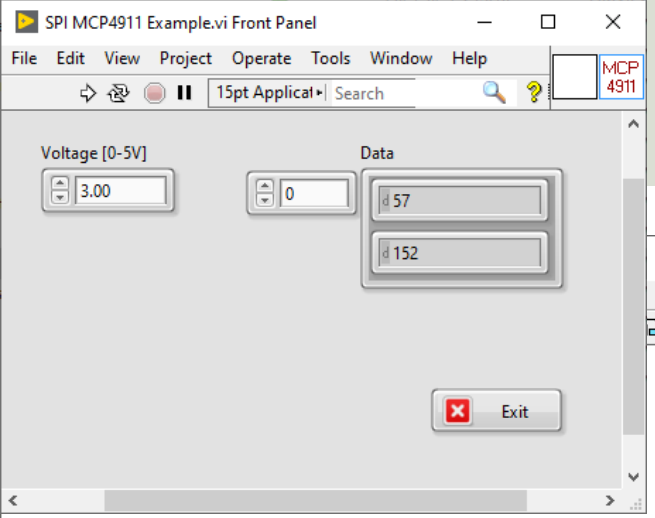


Convert from Voltage to Byte Array



LabVIEW

Continuous Writing Example:



Combined System

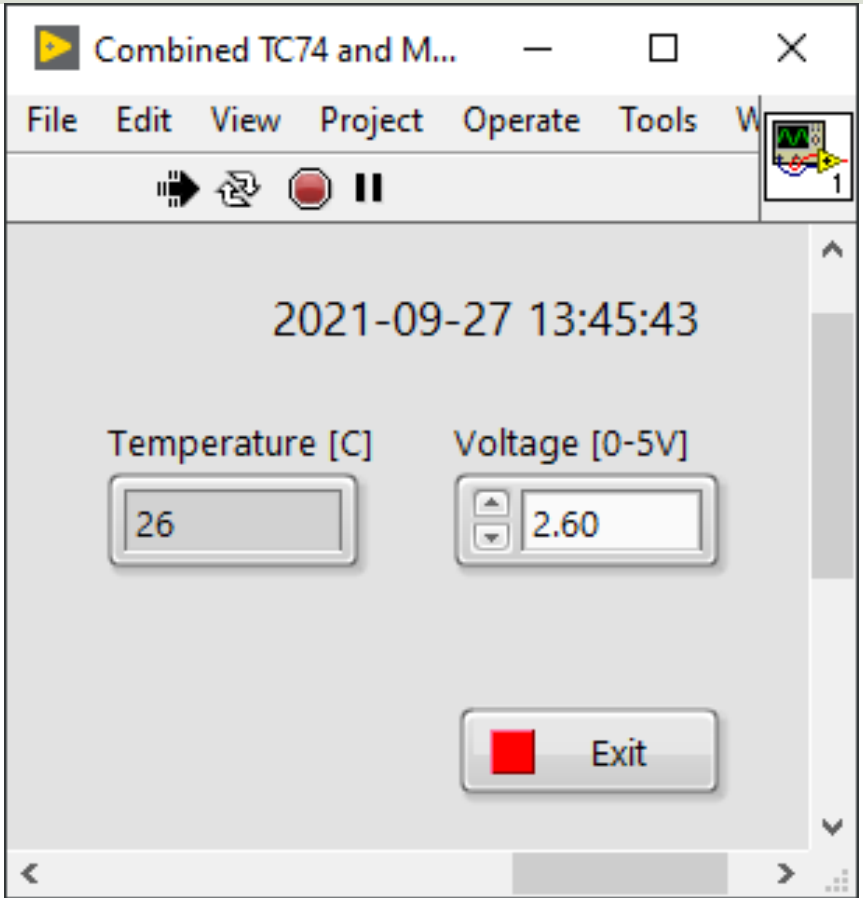
TC74 + MCP4911

I2C SPI

Hans-Petter Halvorsen

Table of Contents

TC74 (I2C) + MCP4911 (SPI)



Here is a basic example presented where reading TC74 Temperature Data is combined with writing values to the MCP4911 DAC.

It can easily be extended with, e.g., a PID Control System

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