

# **PLC Introduction for Arduino Friends**

**This isn't as big a jump as you think**

**Nick Winters (sphereinabox) 3/28/2024**

## **Slides, Code, Video available online**

- Code and slides will be on github:  
<https://github.com/sbhackerspace/>
- Video recording should be on sbhackerspace youtube:  
<https://www.youtube.com/@sbhackerspace>

# **Arduino**

# Arduino boards

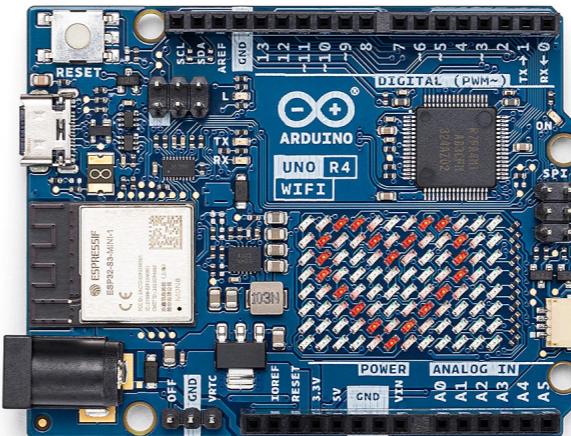
40 ARDUINO	 NUCLEO-64 STM32F303RE EVAL BRD STMicroelectronics	 NUCLEO-64 STM32F030RB EVAL BRD STMicroelectronics	 NUCLEO-144 STM32F419ZI EVAL BRD STMicroelectronics	 ARDUINO NANO RP2040 CONNECT Arduino	 EK-R764I RT8M1S00001BE Renesas Electronics Corporation	 DISCOVERY KIT WITH STM32H745X M STMicroelectronics	 NUCLEO-32 STM32F410RB EVAL BRD STMicroelectronics	102010026 SEEDUNO V4.3 ATMEGA32B DEV Seed Technology Co., Ltd
21 NO HDR	 NUCLEO-64 STM32G0B1RE EVAL BRD STMicroelectronics	 NUCLEO-64 STM32G431RB EVAL BRD STMicroelectronics	 NUCLEO-144 STM32F767ZI EVAL BRD Monolithic	 ARDUINO MKR ZERO W/ HDR ATSAMD21 Arduino	 CURIOSITY PIC32MZEF DEV BOARD 2. Microchip Technology	 DISCOVERY STM32F769 EVAL BRD STMicroelectronics	 NUCLEO-32 STM32F410RB EVAL BRD STMicroelectronics	102010248 SEEDUNO CORTEX-M0+ Seed Technology Co., Ltd
MMA QT	 NUCLEO-64 STM32Q431RB EVAL BRD STMicroelectronics	 NUCLEO-64 STM32Q431RB EVAL BRD STMicroelectronics	 NUCLEO-144 STM32U575ZI EVAL BRD STMicroelectronics	 ARDUINO NANO RP2040 CONNECT HDRS Arduino	 DISCOVERY STM20TB2-DK EVAL BRD STMicroelectronics	 ARDUINO IMX RT1050 EVAL BRD NXP USA Inc.	 NUCLEO-32 STM32F410RB EVAL BRD STMicroelectronics	102010168 SEEDUNO LUTUS V1.1 ATMEGA256 Seed Technology Co., Ltd
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V KIT 1d	 NUCLEO-64 STM32F410RE EVAL BRD STMicroelectronics	 FEATHER MD-BAS PROTO ATSAMD21G11 Adafruit Industries LLC	 ARDUINO LEONARDO W/ HDRS ATMEGA Arduino	 PIONEER CY8C42545AI EVAL BRD Infineon Technologies	 PORTENTA H7 LTE Arduino	 DISCOVERY STM32H757I EVAL BRD STMicroelectronics	 NUCLEO-64 STM32F030RB EVAL BRD STMicroelectronics	102010168 SEEDUNO LUTUS V1.1 ATMEGA256 Seed Technology Co., Ltd
L BRD	 NUCLEO-64 STM32L152RE EVAL BRD STMicroelectronics	 ARDUINO UNO R4 MINIMA Arduino	 ARDUINO MICRO ATMEGA32U4 EVAL BRD Arduino	 TEENSY 4.1 (HEADERS) SparkFun Electronics	 FREEDOM K64/K66 EVAL BRD NXP USA Inc.	 LINDUNO ONE LT3973/UM2884 BRD Analog Devices Inc.	 NUCLEO-32 STM32L011K4 EVAL BRD STMicroelectronics	102010168 SEEDUNO LUTUS V1.1 ATMEGA256 Seed Technology Co., Ltd
I8 EVAL BF	 NUCLEO-64 STM32F411RE EVAL BRD STMicroelectronics	 ARDUINO NANO ESP32 WITHOUT HEADERS Arduino	 CIRCUIT PLAYGROUND EXPRESS Adafruit Industries LLC	 ARDUINO NANO 33 BLE SENSE NO HDR Arduino	 SAM C21 XPLAINED PRO ATSAMC21 Microchip Technology	 AURIX TC371 LTE EVAL BRD Infineon Technologies	 NUCLEO-64 STM32F334RB EVAL BRD STMicroelectronics	102010168 SEEDUNO LUTUS V1.1 ATMEGA256 Seed Technology Co., Ltd
J16MHz	 NUCLEO-64 STM32F446ZE EVAL BRD STMicroelectronics	 NUCLEO-144 STM32F446ZE EVAL BRD STMicroelectronics	 METRO MD EXPRESS ATSAMD21G18 Adafruit Industries LLC	 ARDUINO NANO 33 BLE SENSE W/ HDR Arduino	 MSP432F032 EINK DEV KIT V1.1 M5Stack Technology Co., Ltd	 PORTENTA H7 LTE CONNECTED Arduino	 NUCLEO-32 STM32L412KB EVAL BRD STMicroelectronics	102010168 SEEDUNO LUTUS V1.1 ATMEGA256 Seed Technology Co., Ltd
3V/8MHz	 ARDUINO NANO EVERY WITH HEADERS Arduino	 NUCLEO-144 STM32L4R5ZI EVAL BRD STMicroelectronics	 ADAFRUIT MATRIX PORTAL - CIRCUIT Adafruit Industries LLC	 ARDUINO DUE ATSAM3X8E EVAL BRD Arduino	 DISCOVERY KIT WITH STM32H750XB M STMicroelectronics	 PORTENTA H7 Arduino	 NUCLEO-64 STM32F091RC EVAL BRD STMicroelectronics	102010168 SEEDUNO LUTUS V1.1 ATMEGA256 Seed Technology Co., Ltd
5 EVAL BRD	 NUCLEO-64 STM32F446RE EVAL BRD STMicroelectronics	 NUCLEO-144 STM32L496ZG EVAL BRD STMicroelectronics	 ARDUINO NANO 33 IOT Arduino	 ARDUINO MEGA2560 ATMEGA2560 Arduino	 DISCOVERY KIT WITH STM32H735G M STMicroelectronics	 PORTENTA H7 Arduino	 NUCLEO-32 STM32L412KB EVAL BRD STMicroelectronics	102010168 SEEDUNO LUTUS V1.1 ATMEGA256 Seed Technology Co., Ltd
EVAL BRD	 NUCLEO-64 STM32L476RG EVAL BRD STMicroelectronics	 NUCLEO-144 STM32L552ZE EVAL BRD STMicroelectronics	 ARDUINO Uno SMD R3 ATMEGA328 Arduino	 ADUCM3207/ADUCM3209 EVAL BRD Analog Devices Inc.	 DISCOVERY KIT WITH STM32H745X M STMicroelectronics	 PORTENTA H7 Arduino	 NUCLEO-64 STM32F091RC EVAL BRD STMicroelectronics	102010168 SEEDUNO LUTUS V1.1 ATMEGA256 Seed Technology Co., Ltd
C EVAL BRD	 METRO MINI 32V 2x2P100USB C Adafruit Industries LLC	 ARDUINO NANO 33 IOT WITH HEADERS Arduino	 ARDUINO NANO 33 IOT WITH HEADERS Arduino	 FREEDOM K64/K66 EVAL BRD NXP USA Inc.	 DISCOVERY KIT WITH STM32H745X M STMicroelectronics	 PORTENTA H7 Arduino	 NUCLEO-64 STM32F091RC EVAL BRD STMicroelectronics	102010168 SEEDUNO LUTUS V1.1 ATMEGA256 Seed Technology Co., Ltd
EVAL BRD	 STM32F411 BLACKPILL DEV BOARD DFRobot	 SAM21 MINI BREAKOUT ATSAMD21G11 SparkFun Electronics	 ARDUINO UNO R3 ATMEGA328P BOARD Arduino	 DISCOVERY STM32F7 EVAL BRD STMicroelectronics	 ARDUINO IMX RT1050 EVAL BRD NXP USA Inc.	 PORTENTA H8 Arduino	 NUCLEO-64 STM32F091RC EVAL BRD STMicroelectronics	102010168 SEEDUNO LUTUS V1.1 ATMEGA256 Seed Technology Co., Ltd
EVAL BRD	 ATMega32B XPLAINED MINI Microchip Technology	 FEATHER M4 EXPRESS ATSAMD51J19 Adafruit Industries LLC	 NUCLEO-144 STM32F732ZI EVAL BRD STMicroelectronics	 EVALUATION KIT FOR RAMMS Renesas Electronics Corporation	 STM32U5 DISCOVERY KIT FOR IOT STMicroelectronics	 PORTENTA H8 Arduino	 NUCLEO-64 STM32F091RC EVAL BRD STMicroelectronics	102010168 SEEDUNO LUTUS V1.1 ATMEGA256 Seed Technology Co., Ltd
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[photocrop some images of search results for various arduino-compatible boards as big sea of stuff]

There's a huge variety of Arduino boards, and I'm trying to avoid spending all day talking about the differences between them.

## Common Arduino Elements

- Programmable in Arduino IDE
- Expansion by stackable headers
- Often breakout connectors



<https://store-usa.arduino.cc/products/uno-r4-wifi>

## Arduino Shields



todo: photo of arduino shields

# Arduino Demos

Arduino Blink example: LED on board blinks

NucleoHello: LED turns on when user button (blue) is down. Incrementing numbers print to serial

# **Demo: I2C**

NucleoQwiicCombined: I2C oled display displays reading from i2c light sensor

# Demo: Wokwi

Button turns light on

Second Button turns light off

<https://wokwi.com/projects/393481762830392321>

Show:

- \* Code
- \* Debugger (beta)

# Demo: Arduino IDE Debug

<https://docs.arduino.cc/software/ide-v2/tutorials/ide-v2-debugger/>

My demo is using STM32 Nucleo F401RE board which includes the debug adapter on the board, and was also in my Arduino-compatible collection

The \$48 Arduino Zero is similar in that it includes the debug adapter on board

The other examples in the blog post need a \$100 Atmel ICE or similarly expensive debug adapter to get going

Unfortunately, the AVR based arduinos can't be debugged in the Arduino IDE this way even with the correct debug adapter. They can be debugged using other IDEs however, but those might not be compatible with the arduino cores and libraries.

## The humble relay

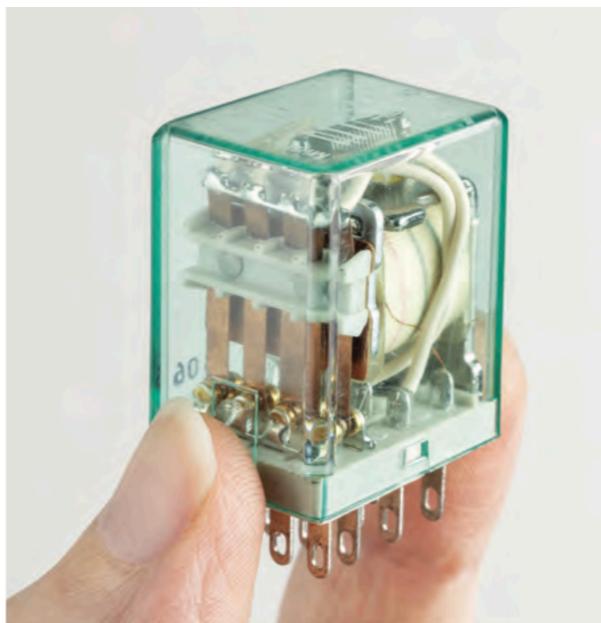
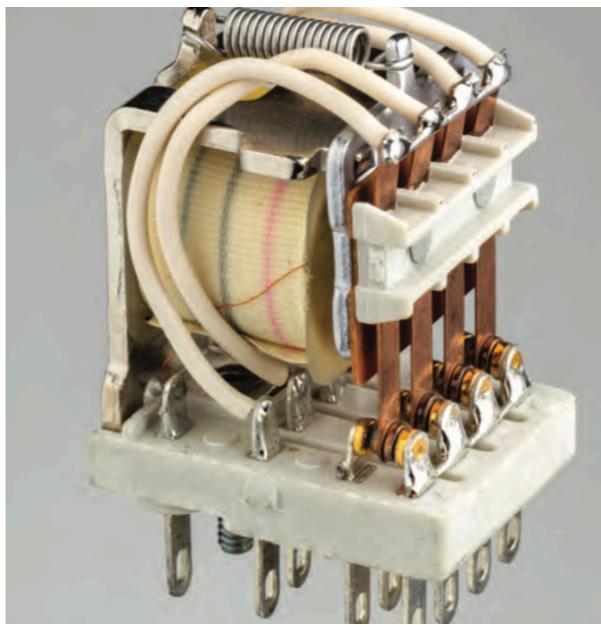


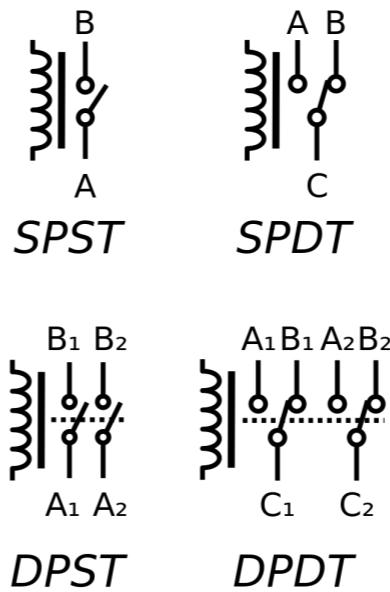
Photo from the book “Open Circuits”  
<https://www.opencircuitsbook.com/>

## **Relay Internals**



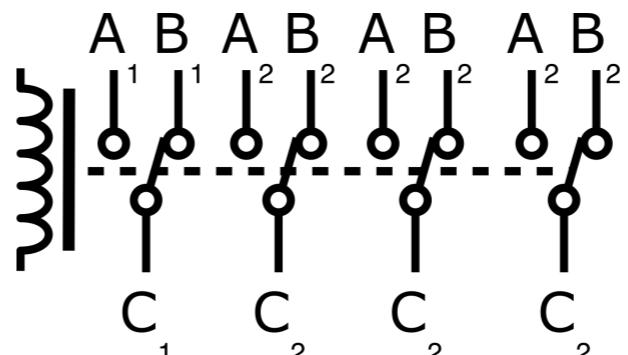
This one has 4 contacts that switch from NC to NO side when pulled by coil

## Relay Symbol



[https://en.m.wikipedia.org/wiki/File:Relay\\_symbols.svg](https://en.m.wikipedia.org/wiki/File:Relay_symbols.svg)

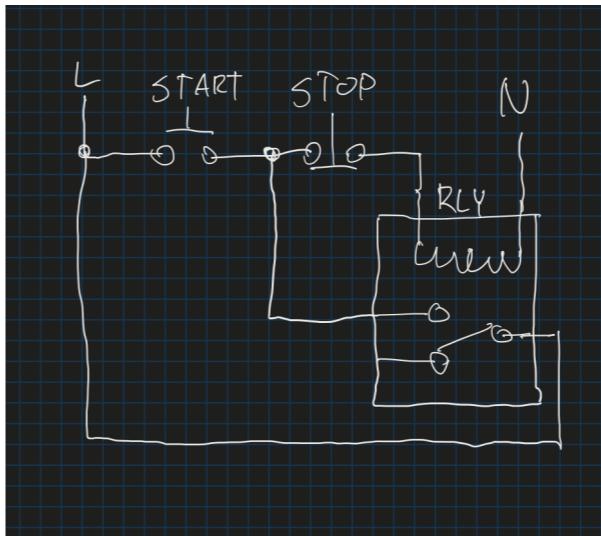
## Relay Symbol



*QPQT*

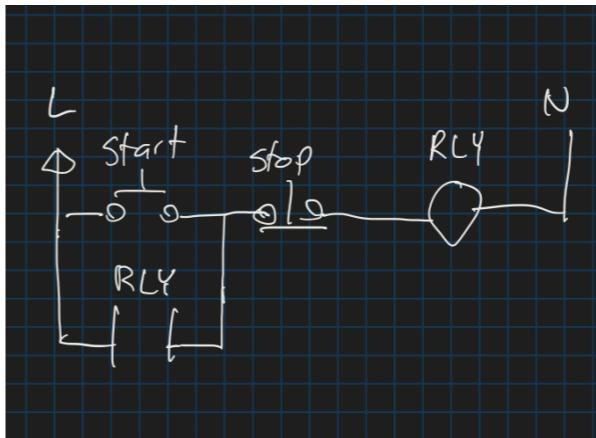
Modified from [https://en.m.wikipedia.org/wiki/File:Relay\\_symbols.svg](https://en.m.wikipedia.org/wiki/File:Relay_symbols.svg)

## Start + Stop Circuit with Relay



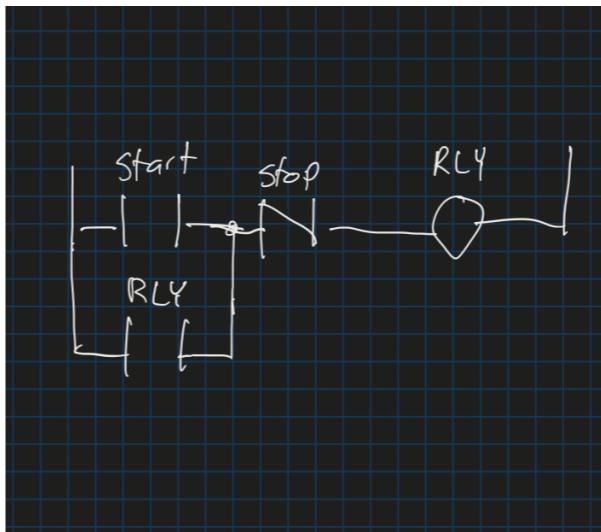
## Relay Logic

Split apart the relay contact  
and coil

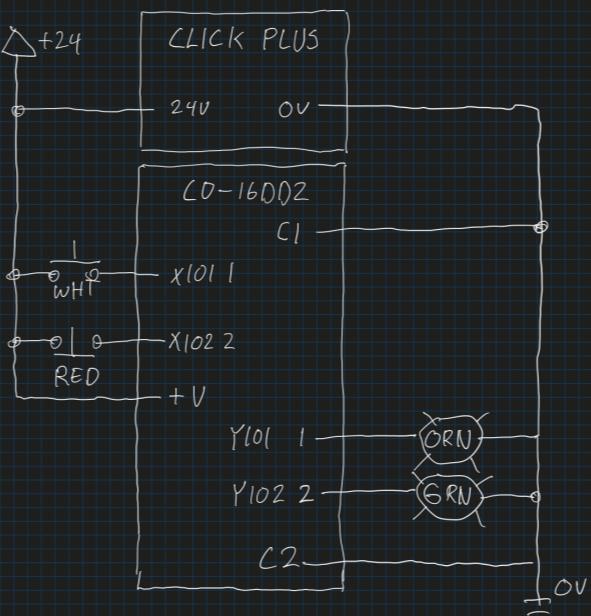


## Ladder Logic

**Draw inputs as contacts too**



# PLC Wiring



Click 24V power, button and lamp wiring diagram

Drawn in ladder style: +24V on left, 0V on right

# Demo: Programmable Logic Controller (PLC)

Click Plus demos

ClickHello:

- Copy inputs to outputs

ClickStartStop:

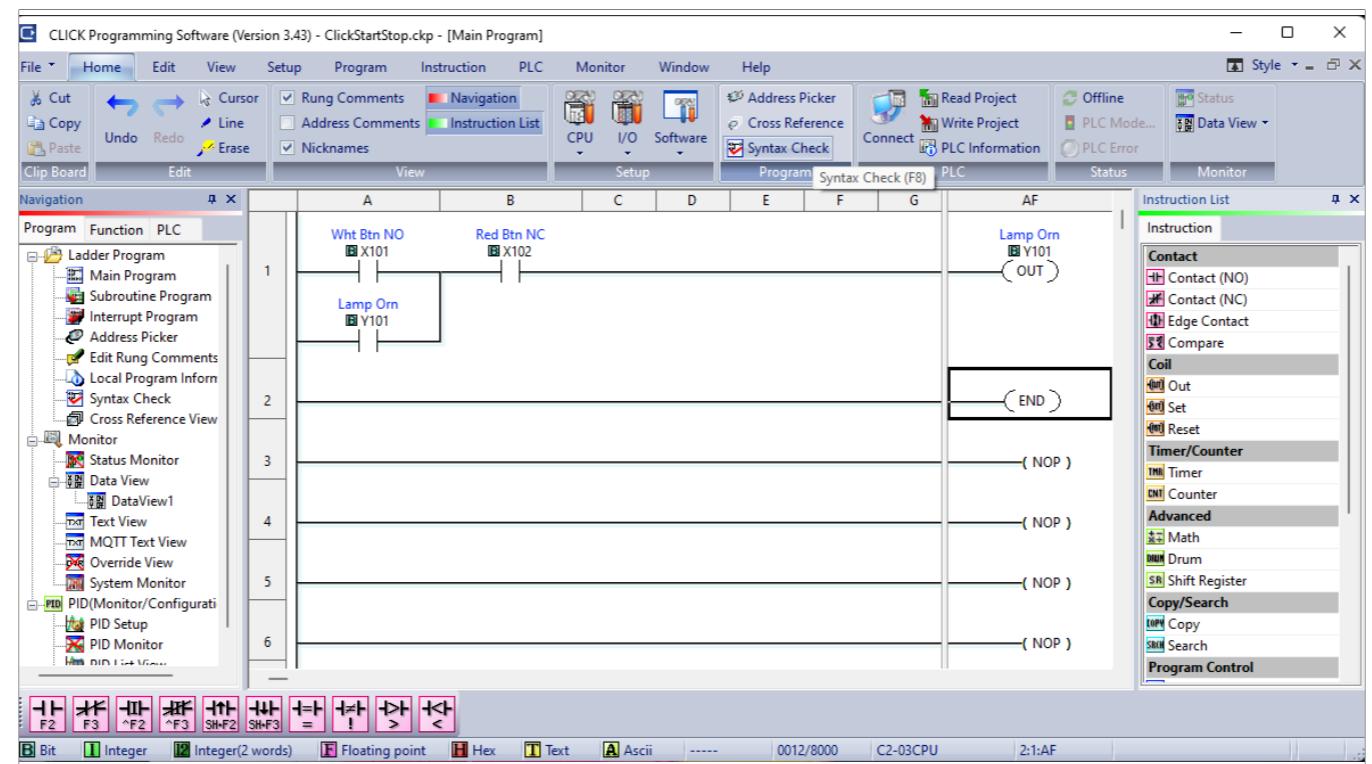
- white button turns orange lamp on
- red button turns orange lamp off

Show the ladder logic code for this

... it looks like the relay logic for this

but when connected we can see the current status of each contact.

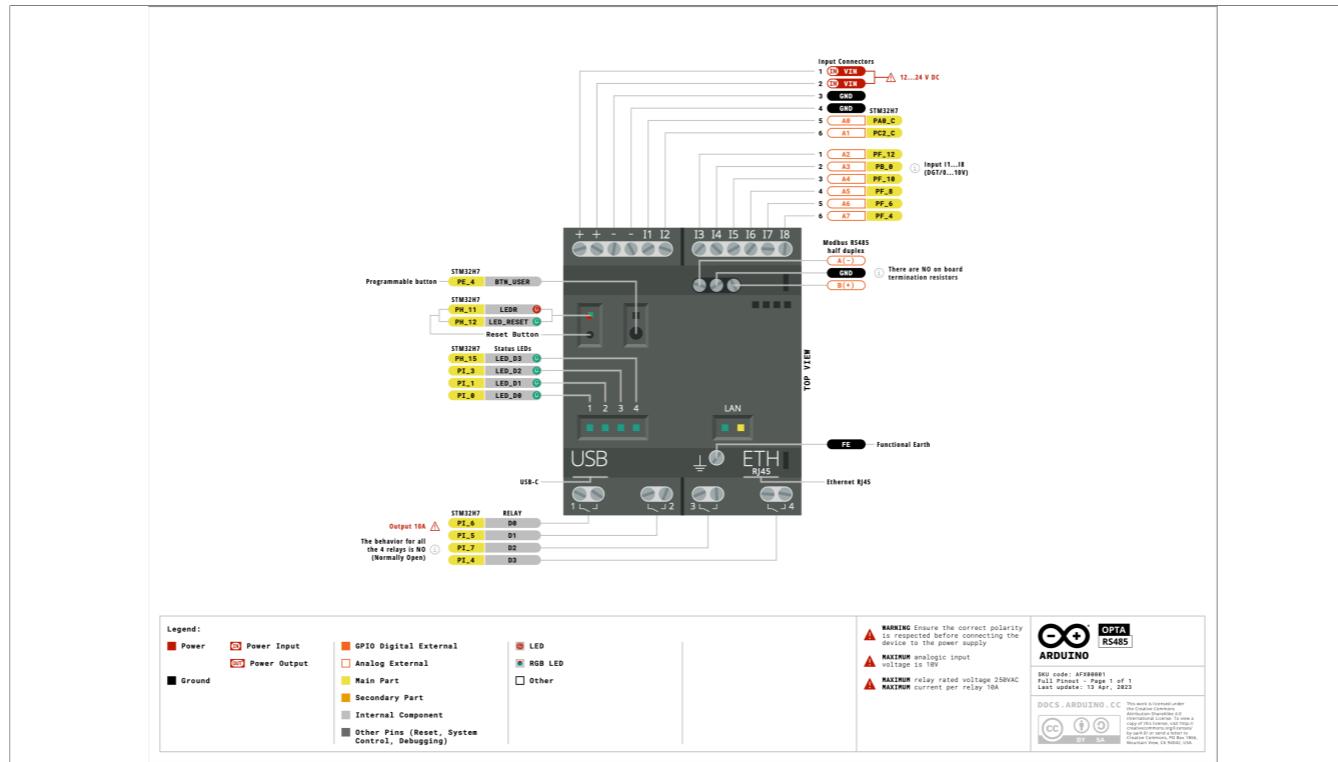
Click the status button in the top right after uploading if it's not showing.



TODO: Click PLC screenshot of ladder logic code

(this was just shown in the demo)

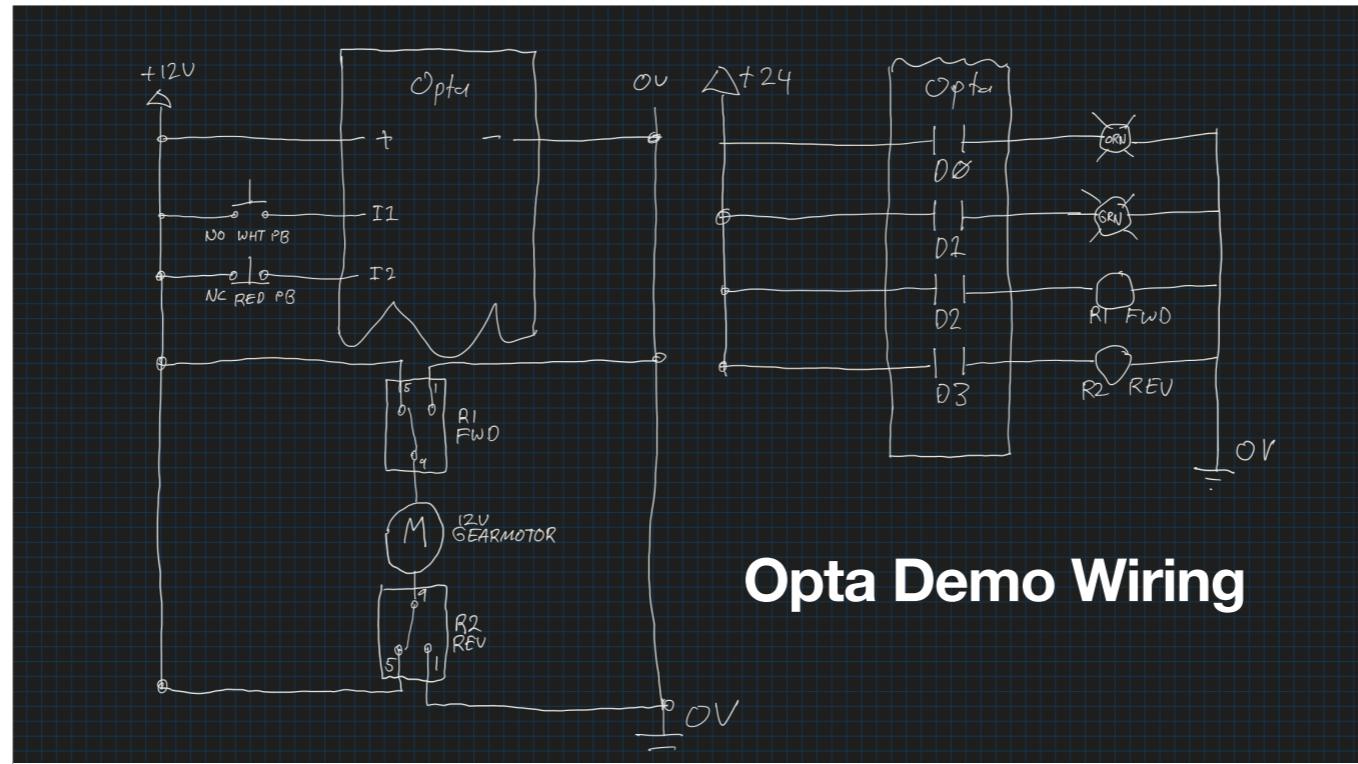
**Yes but Arduino?**



This has the arduino logo right on it

Opta pinout RS485 first page of

<https://docs.arduino.cc/resources/pinouts/opta-full-pinout.pdf>



Wiring schematic for opta  
12V power powers inputs

Notes:

- The inputs are 24V tolerant, for buttons would have worked fine. I wanted to show 0-10V analog with slide potentiometer but ran out of time
-

# Demo: Opta with Arduino IDE

What demos?

OptaTestInputs:

- Read the inputs to serial console

OptaTestOutputs:

- Turn on the different outputs one at a time. Like blink but with 4 lights

# Opta: Arduino IDE Summary

You can program it like an Arduino with Arduino IDE

- Turn LEDs on and off
- Analog read
- Print to serial
- etc

## Demos: Opta with PLC IDE

Demos:

- OptaLadderStartStop start/stop
- Ladder blink

# **Can I type my code in please?**

Ladder logic is an option

But from Arduino, you'll be find structured text more approachable

# Structured Text

The same shapes but new names

Table 1

	Arduino C++	Structured Text
<b>Assignment</b>	x = 5;	x := 5;
<b>Varable declaration</b>	int x = 10;	x : INT := 5;
<b>Array declaration</b>	bool myArray[4] = {false, true, false, true};	MyArray : ARRAY[0..3] OF BOOL := [0,1,0,1];
<b>Pointers</b>	int *pointerToInt = &MyInt;	Foo : POINTER TO INT := ADR(MyInt);

# Structured Text

## Control Flow

Table 1

	Arduino C++	Structured Text
<b>If then</b>	if (x > 0) { //	IF (X > 0) THEN //
<b>Else if</b>	} else if (x < 0) { //	ELSIF (X < 0) THEN //
<b>Else</b>	} else { // }	ELSE // END_IF
<b>For loop</b>	for (int i = 0; i < 10; i++) { // }	FOR I := 0 TO 7 DO // END_FOR
<b>While loop</b>	while (x < 5) { // }	WHILE X < 5 DO ; // statement required END WHILE

# Structured Text

## Control Flow

Table 1

	<b>Arduino C++</b>	<b>Structured Text</b>
<b>Switch</b>	<pre>switch (x) {     case 0:         //         break;     case 1:         //         break;     default:         // }</pre>	CASE X OF 0: // note: doesn't fall through like in c++ 1: // note: doesn't fall through like in c++ ELSE // note: doesn't fall through like in c++ END_CASE
<b>Break out of loop</b>	<pre>break;</pre>	EXIT;
<b>Return</b>	<pre>return;</pre>	RETURN;

## **Structured Text: User data type**

```
MyStructure: STRUCT
    BooleanField : BOOL;
    IntegerField : INT;
    FloatField : REAL;
END_STRUCT;
```

## **Structured Text: Enum**

```
MyEnumeration: DINT (
    FIRST := 0,
    SECOND := 1,
    LAST := 2
);
```

# Demo: Structured Text

OptaStStartStop

Same start stop demo, but as structured text

Also added counter we can watch go up

# Demo: Program organization

OptaFunctionBlockSubprocedureBlink

Show that you can mix and match multiple languages and programming units, similar to making a class in c++

When you start debugging this, notice that the fbBlink has a drop-down for the current instance.

You can have multiple instances of the stuff you declare in this way

And those things can be ladder, structured text, function block, or SFC which isn't in this talk.

**But what if I need more?**

## Common PLC Features

- Expansion modules
- Communication Interfaces

CPU:	Internal:	Module:	Module:	Module:	Module:
C2-03CPU	Edit	C2-14D1	Edit	C0-16CDD2	Edit
				C0-04AD-1	Edit
				C0-04RTD	Edit
				C0-08TR-3	Edit
5A CLICK PLUS PLC, WiFi/Bluetooth, Ethernet, serial, micro-B USB, microSD slot	8 DC Inputs (sink/source), 6 DC Sinking Outputs (0.1A/point)	8-Pt DC Input and 4-Channel Analog Current Input	4-Channel RTD Input	8-Point Relay Output Module 6-240VAC or 6-27VDC, 3A/pt	
\$205.00 -130mA	\$58.00 -50mA	\$82.00 -80mA	\$128.00 -20mA	\$217.00 -25mA	\$61.00 -90mA

TODO: photo of click demo, or screenshot of configurator

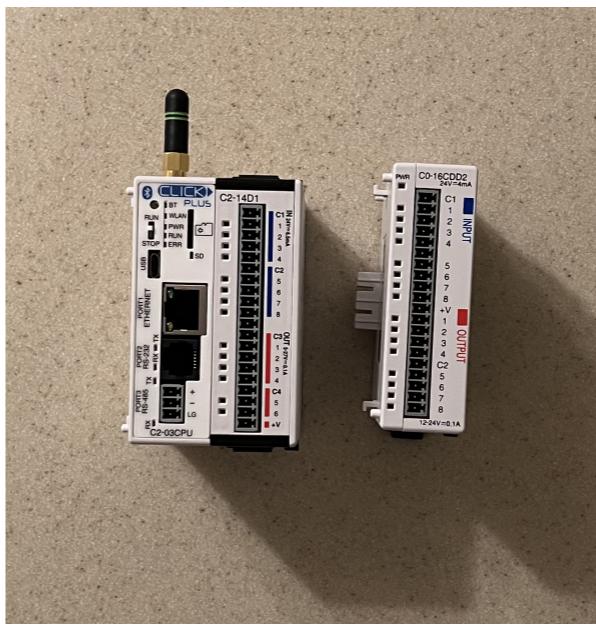
Stuff to point out:

- Expansion modules: Internal and external I/O modules

Communication interfaces:

- RS485 3-pin terminal block
- Ethernet (connected to switch)
- RS232 (RJ something socket)
- Wifi
- MicroSD logging

## PLC + I/O Module



todo: Photo of Click PLC with expansion module not connected

## PLC Input Modules

- Digital 24VDC (sourcing or sinking)
- Digital 24VAC
- Digital 100-240VAC
- Analog 4-20mA
- Analog 0-10VDC
- Analog RTD temperature sensor
- Analog thermocouple sensor
- DC incremental quadrature Encoder or pulse counter

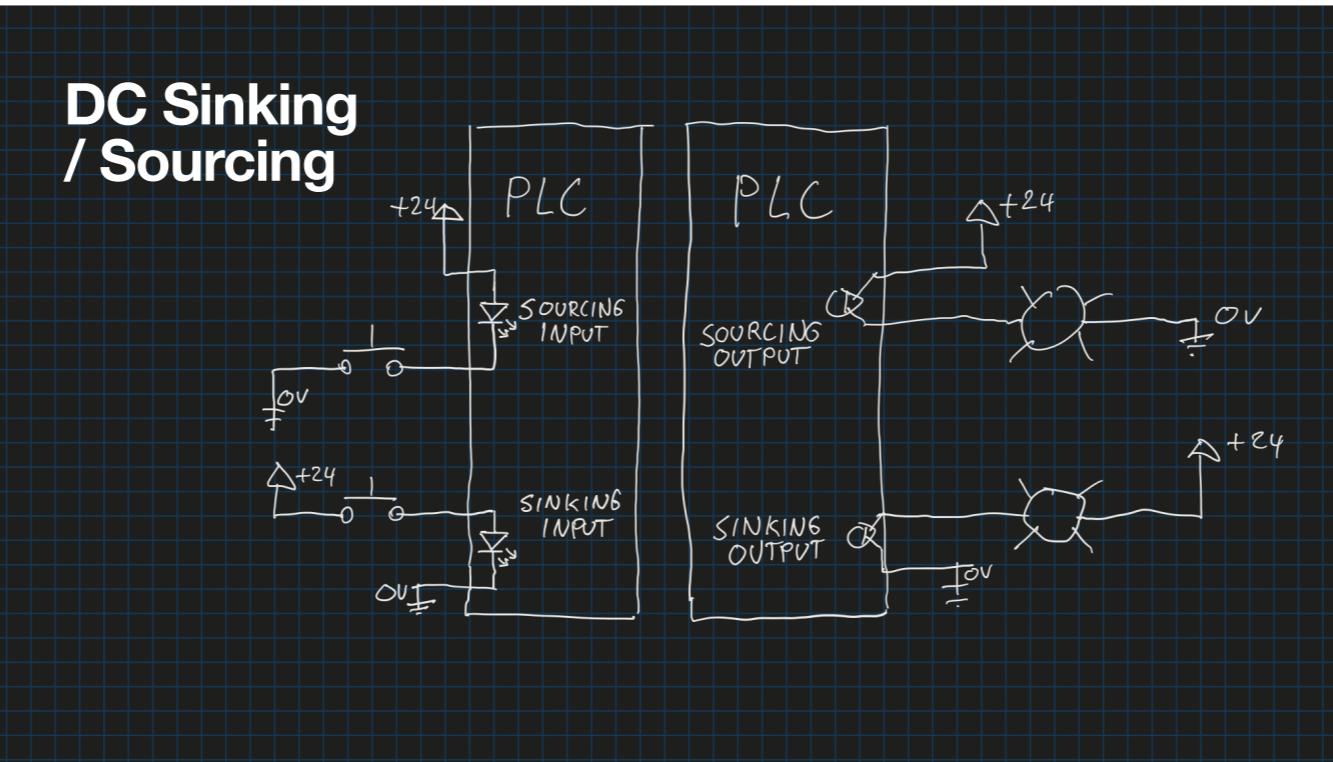
zoo of different I/O option types....

- DC sourcing/sinking inputs and outputs
- relay output
- analog (0-10V or 4-20mA)
- Encoder (counter, position, speed)
- Temperature (RTD, thermocouple)

## PLC Output Modules

- Digital 24VDC sourcing
- Digital 24VDC sinking
- Digital 17-240VAC
- Digital Relay AC/DC (normally open contact)
- Analog 4-20mA
- Analog 0-10VDC
- Motion path quadrature, or step + direction
- Analog Pulse frequency output

The motion path quadrature, step+dir, pulse frequency output aren't available without special conditions. On click they're only available on the first internal module of certain types. On other PLCs they are only available on some of the IO connection directly on the CPU unit.



The inputs often can be wired either sinking or sourcing in groups by having LEDs paired in both directions by swapping the where a common wire is connected.

On the outputs, swapping sourcing/sinking means changing between PNP and NPN transistors so this is something you need to answer before you buy the output module.

# PLC Connectivity

- RS485 serial: Modbus RTU
- Ethernet: Modbus TCP
- And more...



The RS485 serial port is the 3 terminals near the top.

Ethernet port is near the bottom right.

Modbus RTU is a protocol built on top of RS485 physical layer, like how HTTP is built on top of TCP-IP

Similarly, Modbus TCP is built on top of TCP-IP

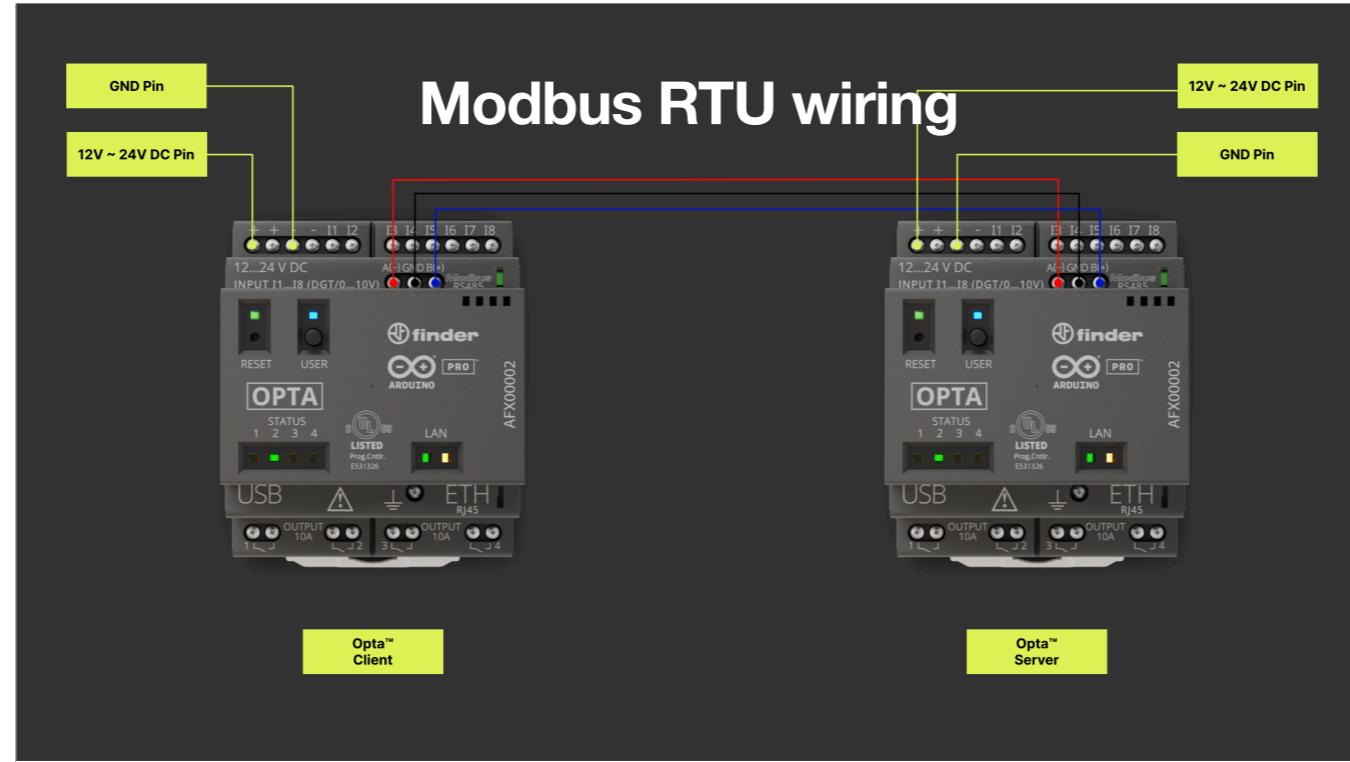
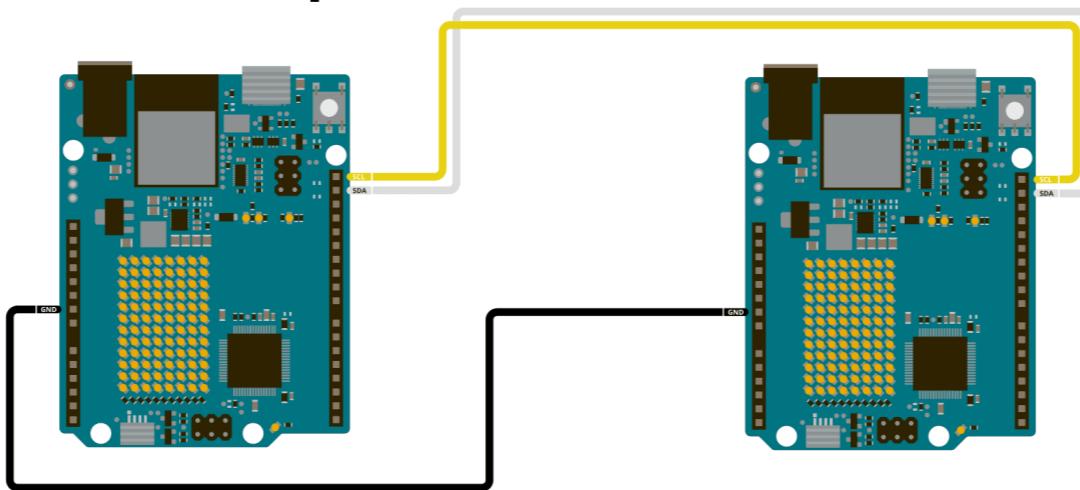


Image from <https://docs.arduino.cc/tutorials/opta/getting-started-with-modbus-rtu/>

You can connect several devices this way, and with Modbus RTU your PLC can talk to them all with one RS485 port... but like I2C the devices need unique addresses

Like I2C, but unlike RS232 or UART/FTDI serial, you connect the A- pins to each other, and the B+ pins to each other.

**It's the same picture**



I2C wiring example <https://docs.arduino.cc/learn/communication/wire/>

I don't mean that RS485 modbus RTU is literally I2C, but that it's the same shape you've used before

## I2C is conceptually similar to Modbus RTU

Table 1

	I2C (Arduino Wire library)	RS485 Modbus RTU
Typical circuit length	A few feet	Tens of feet
Max addresses		127
Typical device count limit		12
Device limit	Cable capacitance limits data rate	Cable capacitance limits data rate

Not really all that different

I pulled the device count numbers out of my ass or other sources I can't quickly find to cite

## Modbus Communication

Server sits around waiting for connections

Client actively connects to server

[function codes and addresses?]

(some places still call them master and slave. Perhaps confusingly the master is the client, and slave is the server sitting around waiting for commands)

# Modbus Commands

Function type		Function name	Function code	Comment	
Data Access	Bit access	Physical Discrete Inputs	Read Discrete Inputs	2	
		Internal Bits or Physical Coils	Read Coils	1	
			Write Single Coil	5	
			Write Multiple Coils	15	
	16-bit access	Physical Input Registers	Read Input Registers	4	
		Internal Registers or Physical Output Registers	Read Multiple Holding Registers	3	
			Write Single Holding Register	6	
			Write Multiple Holding Registers	16	
	File Record Access		Read/Write Multiple Registers	23	
			Mask Write Register	22	
			Read FIFO Queue	24	
			Read File Record	20	
			Write File Record	21	
		Read Exception Status	7	serial only	
		Diagnostic	8	serial only	

Image from wikipedia <https://en.wikipedia.org/wiki/Modbus>

You're likely only going to deal with coil (bit) function codes: 2, 1, 5, 15

And 16 bit function codes 3, 6, 16, 23

# Eat your vegetables data sheets

Figure 26:  
AS72651 I<sup>2</sup>C Master Device Virtual Register Set Overview

Addr	Name	<D7>	<D6>	<D5>	<D4>	<D3>	<D2>	<D1>	<D0>
0x00	HW Version								
0x01	HW Version H								
0x02	HW Version L								
0x03	FW Version								
0x04	FW Version H								
0x05	FW Version L								
0x04	Configuration	SRST	INT	GAIN	BANK	DATA_RDY	FRST		
0x05	Integration Time	Integration Time							
0x06	Temperature	Temperature							
0x07	LED Configuration	READ_ERR	LED_DRV		ENABLED_DRV	LED_INT	ENABLED_LED_INT		
0x08	RAW value R, G, A	RAW value H							
0x09	RAW value R, G, A	RAW value L							
0x0A	RAW value S, H, B	RAW value H							
0x0B	RAW value S, H, B	RAW value L							
0x0C	RAW value T, I, C	RAW value H							
0x0D	RAW value T, I, C	RAW value L							
0x0E	RAW value U, J, D	RAW value H							
0x0F	RAW value U, J, D	RAW value L							
0x10	RAW value V, K, E	RAW value H							
0x11	RAW value V, K, E	RAW value L							
0x12	RAW value W, L, F	RAW value H							
0x13	RAW value W, L, F	RAW value L							

Read with Function Code	Register Addresses	Contents	Data	Ind	Values / Dependencies	Multiplicator Unit
		Input Registers				
	30000	Memory Reference				
		ACTUAL MEASUREMENTS				
4	30101	Phase valid measurement	T1	Bit 0	Invalid measurement phase 1	
4	30103	Run time	T3		seconds	x1 seconds
4	30105	Frequency	T5			x1 Hz
4	30107	U1	T5			x1 V
4	30113	Uavg (phase to neutral)	T5			x1 V
4	30126	I1	T5			x1 A
4	30136	Iavg	T5			x1 A
4	30138	S1	T5			x1 A
4	30140	Active Power Total (Pt)	T6			x1 W
4	30142	Active Power Phase L1 (P1)	T6			x1 W
4	30148	Reactive Power Total (Qt)	T6			x1 var
4	30150	Reactive Power Phase L1 (Q1)	T6			x1 var
4	30156	Apparent Power Total (St)	T5			x1 VA
4	30158	Apparent Power Phase L1 (S1)	T5			x1 VA
4	30164	Power Factor Total (PFt)	T7			x1
4	30166	Power Factor Phase 1 (PF1)	T7			x1
4	30172	Power Angle Total (atan2(Pt,Qt))	T17			x1°
4	30173	J1 (angle between U1 and I1)	T17			x1°
4	30181	Internal Temperature	T17			x1 °C
4	30182	U1 THD%	T16			x1 %
4	30188	I1 THD%	T16			x1 %
		I/O STATUS				
4	30191	Alarm Status Flags(G1, G2)	T1	Bit 0..4	Group 1 Limit 1 .. 4	

I don't expect you to read this

Left: I2C table p28 from [https://cdn.sparkfun.com/assets/c/2/9/0/a/AS7265x\\_Datasheet.pdf](https://cdn.sparkfun.com/assets/c/2/9/0/a/AS7265x_Datasheet.pdf)

Right: [https://cdn.findernet.com/app/uploads/2021/09/20090052/Modbus-7M24-7M38\\_v2\\_30062021.pdf](https://cdn.findernet.com/app/uploads/2021/09/20090052/Modbus-7M24-7M38_v2_30062021.pdf)

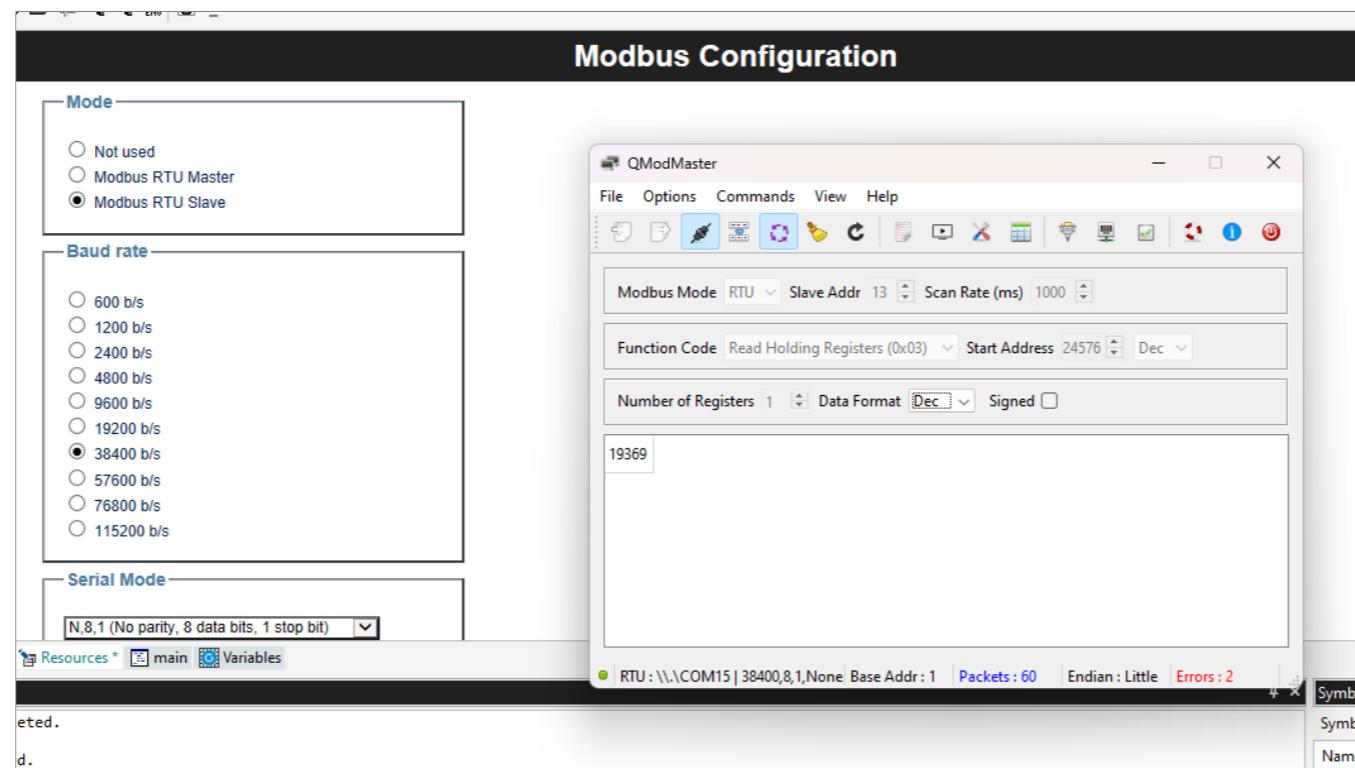
# Demo: Opta Modbus RTU Server

OptaPlcModbusTcpServer sample. Load structured text counter app and show counter increasing

RS485 modbus TCP connection directly to Opta

Connect Modbus RTU with QModMaster and show number incrementing there

Show mapping in PLC IDE between modbus address and global variable



## Modbus RTU read settings

the start address shows in public objects/status variables

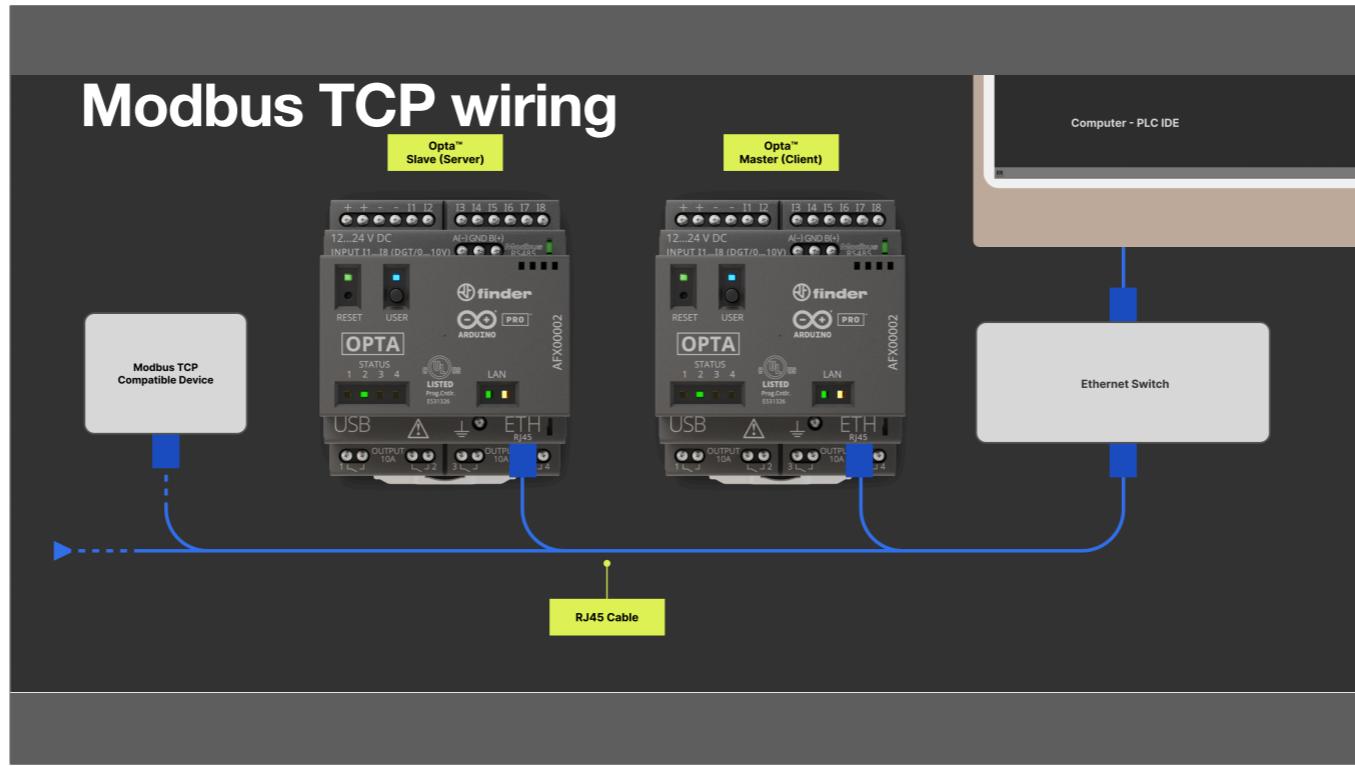
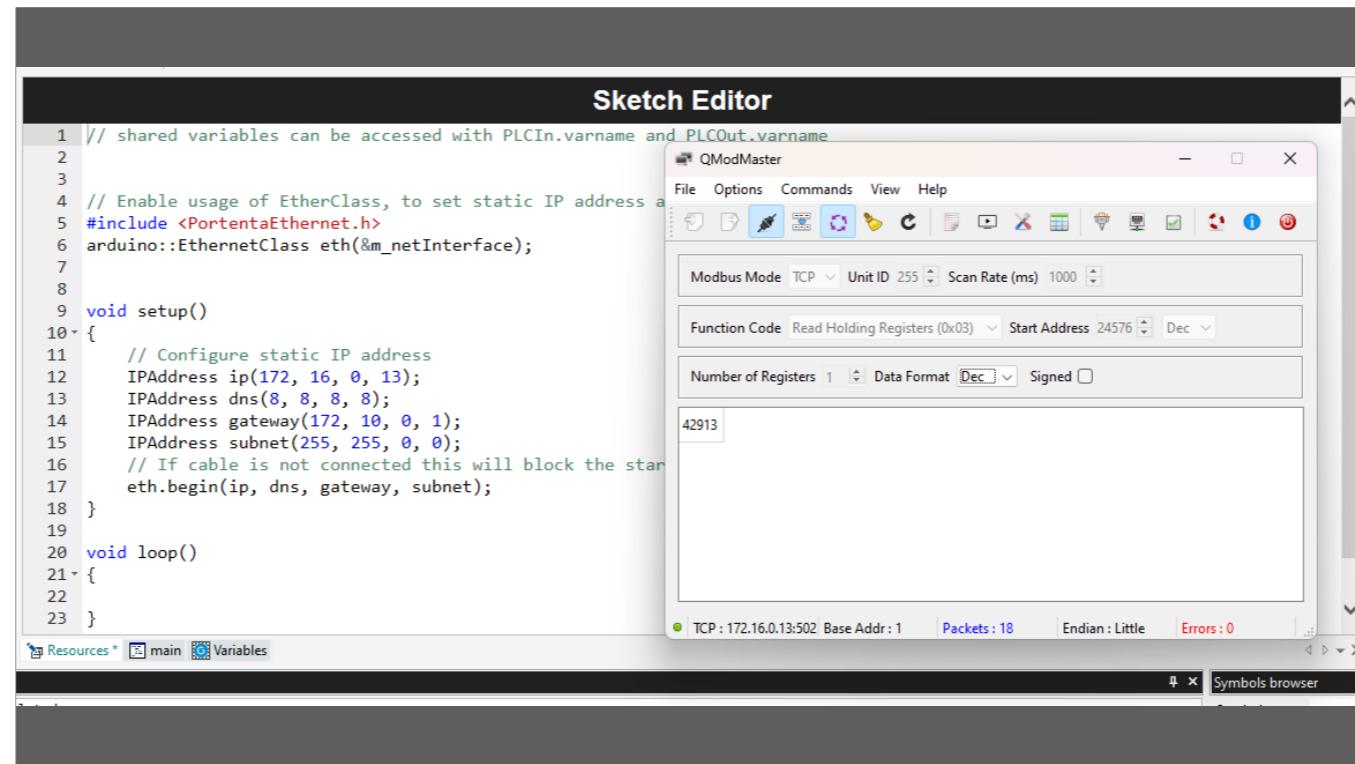


image from <https://docs.arduino.cc/tutorials/opta/opta-modbus-tcp-plc-ide/>



Modbus TCP connection screenshot

## I2C vs Modbus RTU vs Modbus TCP

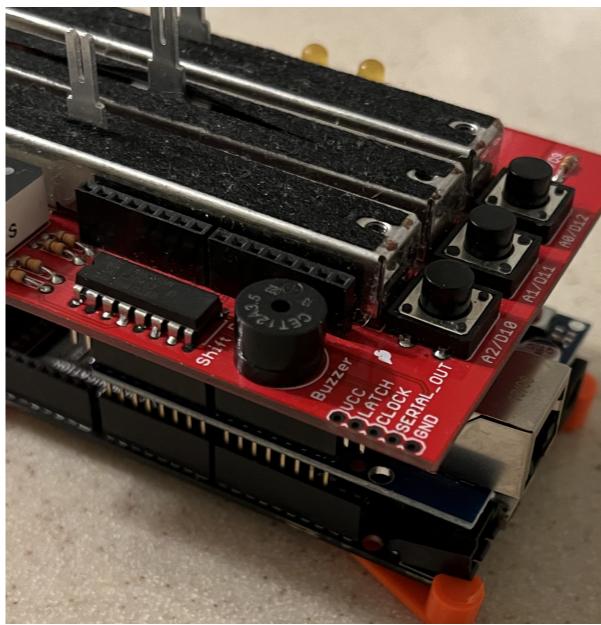
Table 1

	I2C (Arduino Wire library)	RS485 Modbus RTU	Modbus TCP
Typical circuit length	A few feet	Tens of feet	100 meters is fine with suitable cable
Max addresses		127	247 No practical limit
Typical device count limit		12	30 None
Device limit	Cable capacitance limits data rate	Cable capacitance limits data rate	No practical limit

Modbus TCP:

- Easier to wire
- No real cable length limitation

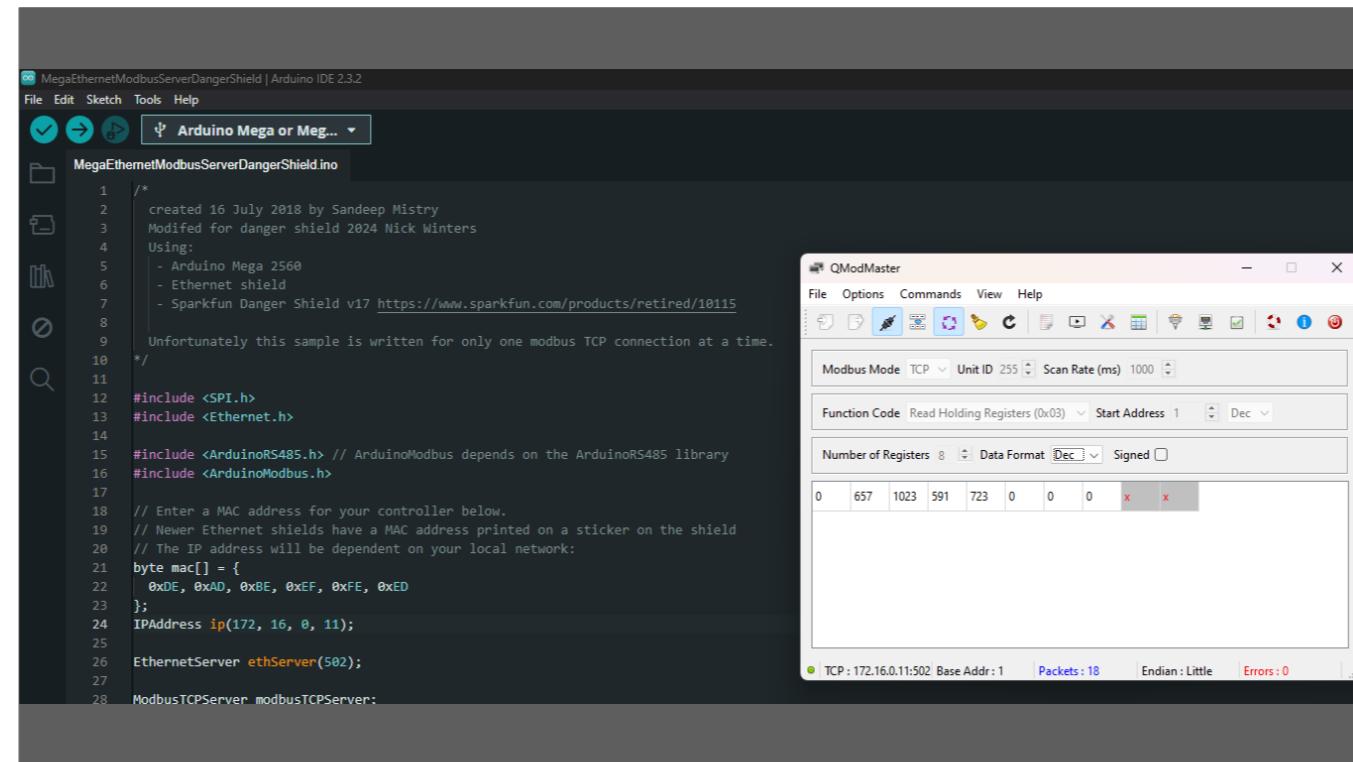
## Why Not Both?



Have your PLC talk to Arduino or Vice Versa

# Demo: Arduino Modbus TCP

MegaEthernetModbusServerDangerShield



This started as the Modbus TCP server sample in arduino.

There are better samples that allow more than one connection like [https://github.com/AutomationDirect/P1AM-Examples/blob/master/P1AM-100\\_ModbusTCP\\_Server\\_HMI/P1AM-100\\_ModbusTCP\\_Server\\_HMI.ino](https://github.com/AutomationDirect/P1AM-Examples/blob/master/P1AM-100_ModbusTCP_Server_HMI/P1AM-100_ModbusTCP_Server_HMI.ino)

However this makes a good demo because I can play a different animation on the 7-segment when modbus is connected or not.

## More PLC Connectivity names

- CANopen
- Ethernet/IP
- EtherCAT
- IO-Link
- SERCOS III
- PROFINET
- PROFIBUS

Like SPI, or MIPI or whatever there are both more involved protocols or vendor specific ones

Ethernet/IP is worth calling out. It's the most popular for Allen Bradley / Rockwell, and when used there is super easy to load the an XML file with the structure and identifiers of the messages going back and forth. Unfortunately support isn't universal across PLC brands.

## **Other PLCs to mention**

## **Summary**

- PLC ladder logic is derived from relay logic
- Structured Text is approachable from Arduino
- You can talk to or from PLC with Arduino

What all did we cover?  
arduino is pretty cool

**Go off and automate things**

# **Questions?**

# **Extra slides**

## Demo Hardware: Click Plus PLC

Table 1

Image								
P/N	C2-03CPU	SE-ANT210	C2-14D1	C0-16CDD2	GCX3105	GCX3101	ECX2051-24L	ECX2052-24L
Desc	CLICK PLUS PLC, 24 VDC required, (1) option slot, WiFi LAN/Bluetooth, Ethernet, serial and microB-USB ports, microSD card slot, no on-board I/O.	STRIDE whip/straight 2.4 GHz WiFi antenna, IP65, connector mount. For use with SE-SL3011-WF VPN router and CLICK PLUS PLCs.	CLICK PLUS discrete combo module, Input: 8-point, 24 VDC, sinking/sourcing, Output: 6-point, 5-27 VDC, sinking, 0.1A/point. Removable terminal block included.	CLICK discrete combo module, Input: 8-point, 24 VDC, sinking/sourcing, Output: 8-point, 12-24 VDC, sourcing, 0.1A/point. Removable terminal block included.	AutomationDirect pushbutton, IP65, 22mm, momentary, (1) N.O. contact(s), plastic base, plastic bezel, Operator: white, flush, 30mm, round, plastic.	AutomationDirect pushbutton, IP65, 22mm, momentary, (1) N.C. contact(s), plastic base, plastic bezel, Operator: red, flush, 30mm, round, plastic.	AutomationDirect LED indicating light, permanent light function, IP65, 22mm, red, 30mm, round, plastic base, 24 VAC/VDC, full voltage.	AutomationDirect LED indicating light, permanent light function, IP65, 22mm, green, 30mm, round, plastic base, 24 VAC/VDC, full voltage.
Each	205.00	10.50	58.00	82.00	5.00	5.00	5.75	5.75

You could do cheaper for PLC education if you wanted to

- You could leave out the internal I/O module
- You can use a cheaper CPU. (I recommend ethernet one however. Needing the programming cable for cheapest click is annoying)
- You can get a training I/O with switches on it C0-08SIM

I chose this model because I wanted something that can read quadrature and output step+direction motion commands for work.

# Demo Hardware: Arduino Opta PLC

Table 1

Image									
P/N	HDR-15-12	HDR-60-24	Arduino Opta RS485	781-1C-SKT	781-1C-24D	GCX3105	GCX3101	ECX2051-24L	ECX2052-24L
Desc	AC/DC DIN RAIL SUPPLY 12V 15W	AC/DC DIN RAIL SUPPLY 24V 60W	Arduino Opta with RS485	AutomationDirect relay socket, 35mm DIN rail or panel mount. For use with 781 series cube relays.	AutomationDirect ice cube control relay, socket mount, encapsulated push-to-test, 24 VDC coil voltage, SPDT, (1) N.O., (1) N.C., 15A contact rating, 5-pin, LED indicator(s). Requires 781-1C-SKT mounting socket.	AutomationDirect pushbutton, IP65, 22mm, momentary, (1) N.O. contact(s), plastic base, plastic bezel, Operator: white, flush, 30mm, round, plastic.	AutomationDirect pushbutton, IP65, 22mm, momentary, (1) N.C. contact(s), plastic base, plastic bezel, Operator: red, flush, 30mm, round, plastic.	AutomationDirect LED indicating light, permanent light function, IP65, 22mm, red, 30mm, round, plastic base, 24 VAC/VDC, full voltage.	AutomationDirect LED indicating light, permanent light function, IP65, 22mm, green, 30mm, round, plastic base, 24 VAC/VDC, full voltage.
Each	17.37	27.44	160.80	4.50	5.00	5.00	5.00	5.75	5.75

Not listed: 12V gearmotor

The 12V supply is mostly for gear motor and I was going to demo a slide potentiometer but ran out of time

I typically use 24V at work, and the 12V coil relays were out of stock and I bought 24V lamps anyway hence the mixed voltages.

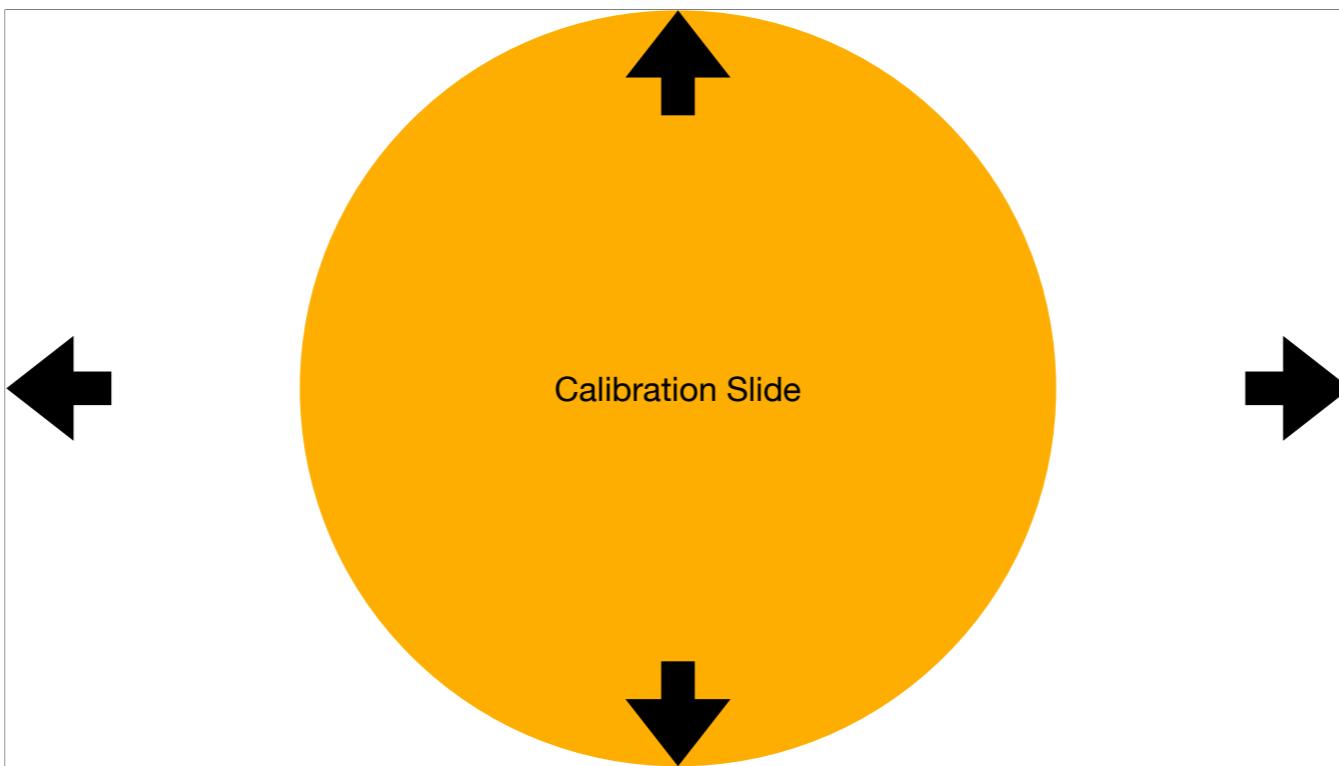
## Tools

- Sparkfun 4-in-1 USB cable
  - USB-C <https://www.sparkfun.com/products/21271>
  - USB-A <https://www.sparkfun.com/products/21272>

USB 4-in-1 cable

- USB-C to host <https://www.sparkfun.com/products/21271> or <https://www.digikey.com/en/products/detail/sparkfun-electronics/CAB-21271/18635159>
- USB-A to host: <https://www.sparkfun.com/products/21272> or <https://www.digikey.com/en/products/detail/sparkfun-electronics/CAB-21272/18635168>

wire stripper DN-WS



Verify the text is readable from the back of the room

The circle should be a circle

the arrows on the edges should be fully visible and shouldn't go off screen