System Board 6330

# MAXREFDES150# Pocket IO PLC Development Platform

Industry 4.0, the fourth revolution in manufacturing and process automation, poses a considerable challenge for PLC design engineers who are required to pack more functionality into enclosures that keep getting smaller. Higher I/O (input/output) density and smaller form factors also add to the design challenge in another basic way, a consequence of the inevitable power dissipation. The system must be more power efficient than ever to keep the PLC from overheating, especially in an application where fans and vents are generally not acceptable. Fortunately, new solutions are being developed by companies, such as Maxim Integrated, who are looking to leverage their integration capabilities in the evolving industrial market.

## Features

Two analog input channels ±12V, 24-bit ADC
Two analog input channels ±24mA, 24-bit ADC
Analog output channel 0V to ±12V, 16-bit DAC
Eight digital input channels 36V (max) configurable for IEC® 61131-2 input types 1, 2, and 3
Eight digital output channels; 640mA high-side switches or 640mA push-pull at 24V
Two RS-485 COM ports; half-duplex up to 42Mbps data rate
Three DC-motor controllers: 9V to 32V full-bridge DC-motor drivers, up to 2.5A peak motor current (supplied by separate power supply)
Four IO-Link master ports with M12 female connectors
Fully IO-Link version 1.1 compliant
TEConcept IO-Link master stack

## Applications

- Factory and process automation
- Building automation
- Robotic control
- Rapidly creating and prototyping new industrial control systems
- IO-Link sensors and actuators

## MAXREFDES150# contents

- Pocket IO: MAXREFDES150MAIN# and MAXREFDES150LED# stacked in plastic case with Intel Edison
- Connector attach board – MAXREFDES150ATACH#
- 40-pin female-female cable assembly–two off
- USB A to micro-USB B
- AC-to-DC (24VDC, 1A) power supply with adapters for regional outlets

## Introduction

Maxim's new Pocket IO™ development platform is a reference design integrating a total of 30 IO's consisting of four analog inputs, one analog output, eight digital inputs, eight digital outputs, two RS485 (Profibus-capable field busses), three encoder motor-control ports, and four IO-Link® masters. Maxim’s Pocket IO technology demonstration platform shows how analog integration can enable lower heat dissipation and faster throughput in a footprint that is less than ten cubic inches. Pocket IO connectivity is through USB or its own Wi-Fi® network. Code can be developed to run on the Intel® Edison using the popular and easy to use open-source Arduino®software IDE.

## Detailed Description of Hardware

Pocket IO is the brand name for MAXREFDES150#. The MAXREFDES150# consists of three different boards. The overall system block diagram is shown in **Figure 1**.

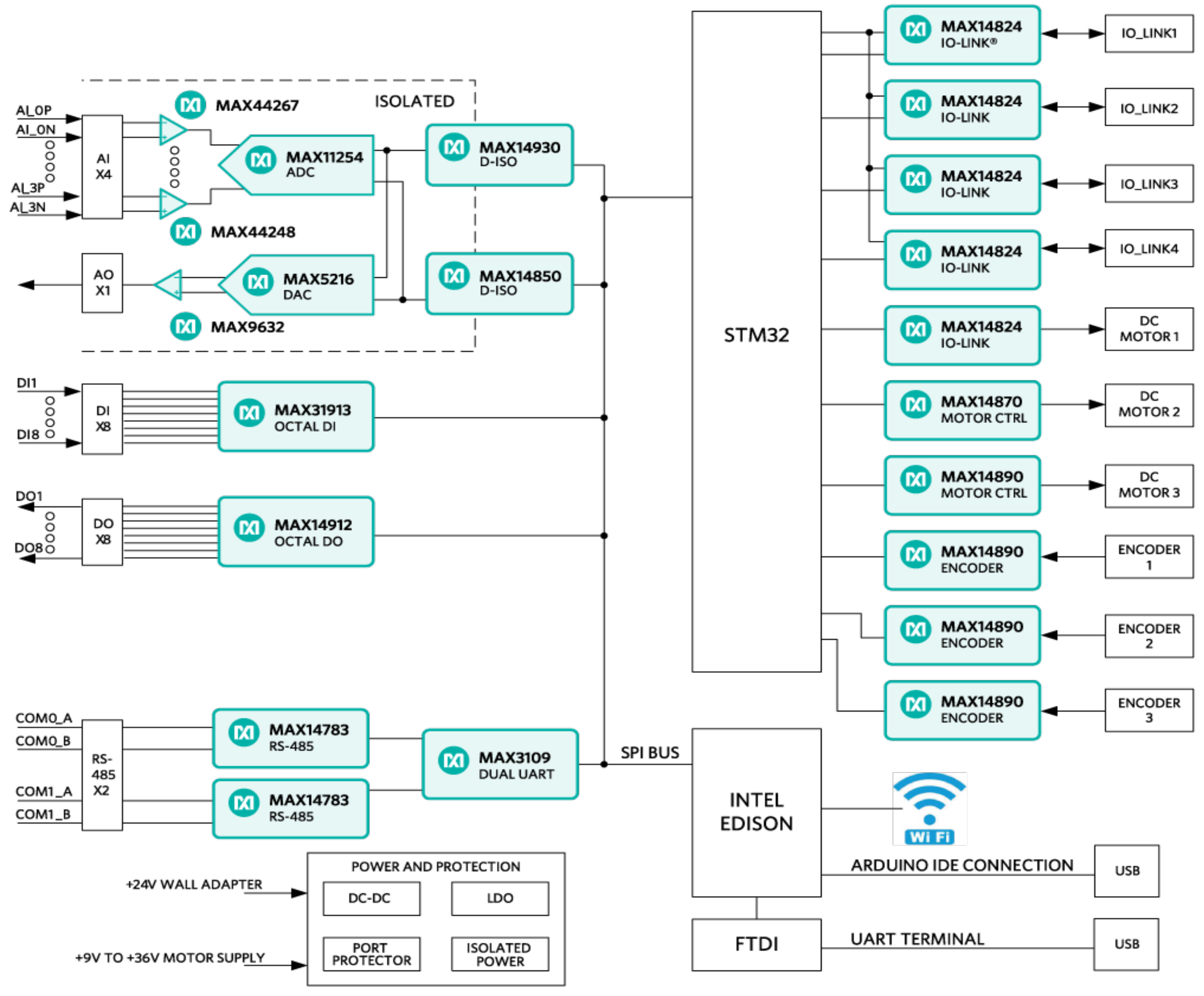


*Figure 1. MAXREFDES150# system block diagram.*

The ICs for the main functional blocks are within the Pocket IO case (the two boards are MAXREFDES150MAIN# and MAXREFDES150LED#) while the connectors are on a separate board (called MAXREFDES150ATACH#) which connects to Pocket IO using two 40-pin cable assemblies.

The control program for Pocket IO runs on the Intel Edison board, which is mounted on the MAXREFDES150MAIN# board. Separate STM microcontrollers are used to support the IO-Link masters (TEConcepts stack) and the DC-motor drivers.

## Power Supplies

A single 24V, 1A supply is used to power the Pocket IO and internal DC-DC, and LDO circuits are used to generate the various different voltage levels required by the analog and digital devices. **Note:** The maximum load this adapter can supply is 1A, which limits how many of the digital outputs are switching loads simultaneously since each of the eight outputs can handle loads of up to 640mA each. The user can use a different 24V supply with 5A (max) capacity. The 24V, 1A supply connects to the block barrel connector, shown on the left in **Figure 2**.

Pocket IO has three DC-motor controllers, each of which can support +9V to +32V full-bridge DC-motor drivers at up to 2.5A peak motor current. In order to support these higher voltages and currents, a separate user-supplied power supply is required, and connects to Pocket IO through the green three-way terminal. Terminal 1 is used (with Terminal 3) to test the polarity of the external supply (to protect Pocket IO motor drivers from reverse polarity connections). In normal-use mode Terminal 2 is the +9V to +32V connection and Terminal 3 is the ground or 0V connection.

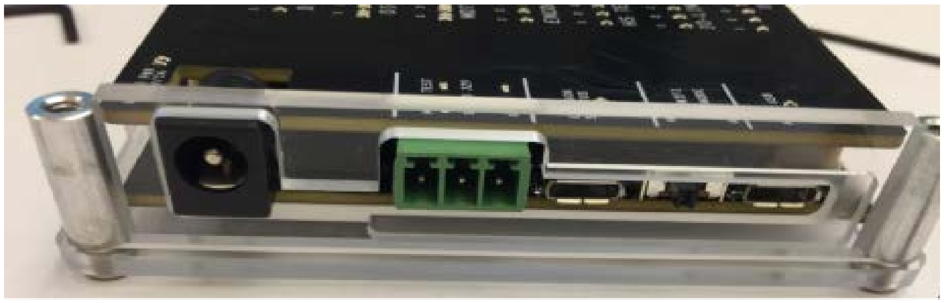


*Figure 2. MAXREFDES150# power inputs.*

## Connections

The main functional blocks are on the two PCBs within the Pocket IO case while the connectors are on a separate board, called MAXREFDES150ATACH# shown in **Figure 3**.

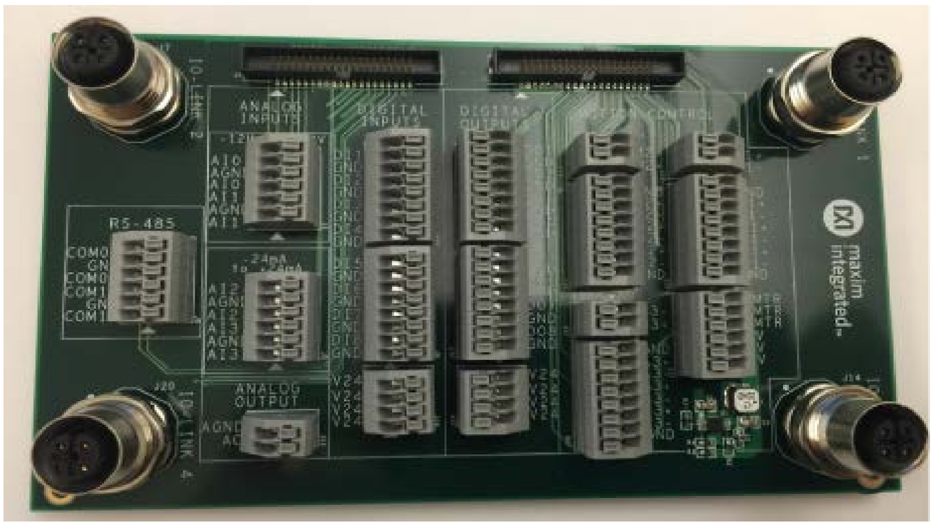


*Figure 3. MAXREFDES150ATACH#.*

## LED Indicators

**Figure 4** explains the functions of the LED indicators for MAXREFDES150#.

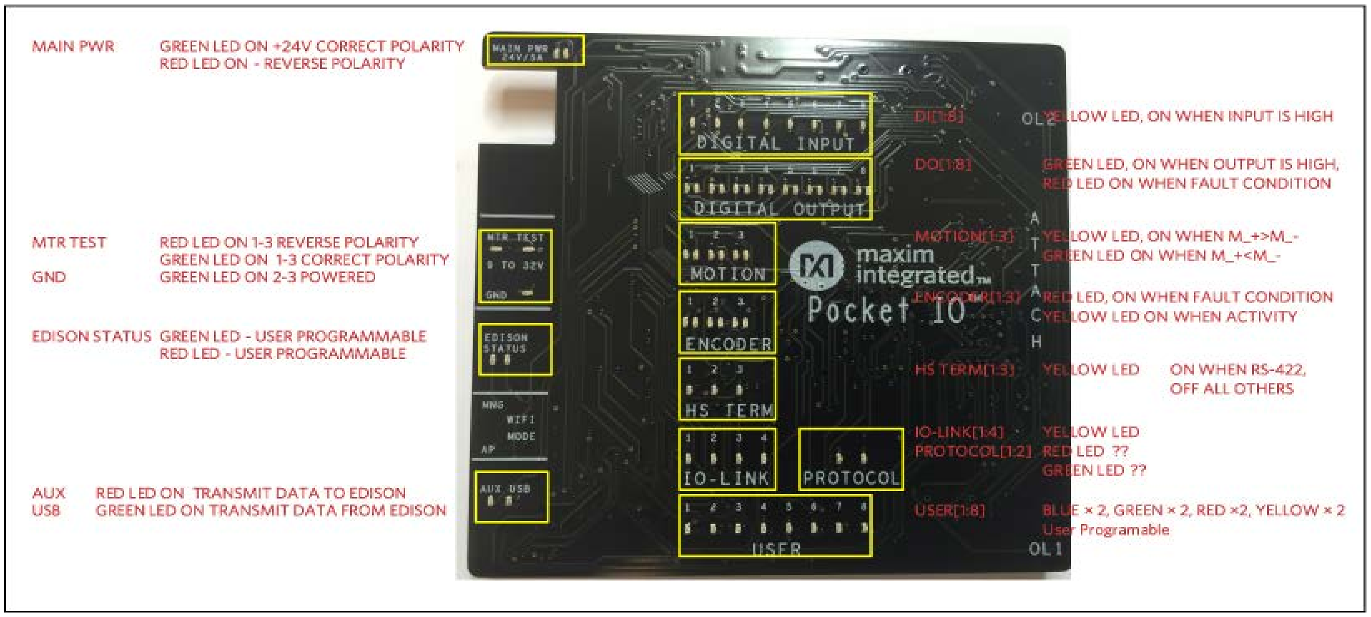

MAIN PWR
GREEN LED ON +24V CORRECT POLARITY
RED LED ON - REVERSE POLARITY
MTR TEST
GND
RED LED ON 1-3 REVERSE POLARITY
GREEN LED ON 1-3 CORRECT POLARITY
GREEN LED ON 2-3 POWERED
EDISON STATUS
GREEN LED - USER PROGRAMMABLE
RED LED - USER PROGRAMMABLE
AUX
USB
RED LED ON TRANSMIT DATA TO EDISON
GREEN LED ON TRANSMIT DATA FROM EDISON
MAIN PWR 24V/5A
MTR TEST
0 TO 32V
GND
EDISON STATUS
MNG
WIFI MODE
AP
AUX USB
DIGITAL INPUT
DIGITAL OUTPUT
MOTION
ENCODER
HS TERM
IO-LINK
PROTOCOL
USER
maxim integrated
Pocket IO
ATTACH
OL2
OL1
DI[1:8]
YELLOW LED, ON WHEN INPUT IS HIGH
DO[1:8]
GREEN LED, ON WHEN OUTPUT IS HIGH,
RED LED ON WHEN FAULT CONDITION
MOTION[1:3]
YELLOW LED, ON WHEN M_+>M_-
GREEN LED ON WHEN M_+<M_-
ENCODER[1:3]
RED LED, ON WHEN FAULT CONDITION
YELLOW LED ON WHEN ACTIVITY
HS TERM[1:3]
YELLOW LED
ON WHEN RS-422,
OFF ALL OTHERS
IO-LINK[1:4]
YELLOW LED
PROTOCOL[1:2]
RED LED ??
GREEN LED ??
USER[1:8]
BLUE × 2, GREEN × 2, RED ×2, YELLOW × 2
User Programable

*Figure 4. Pocket IO LEDs.*

## Detailed Description of Software

When building up a quick application, or when prototyping some feature, the quickest and easiest way to program Pocket IO, is through the Arduino application. Though not a full-code development, debugging environment, the Arduino sketch technique has a lot to offer, including:

- A familiar interface, instantly recognizable by many
- A full C/C++ compiler
- Access to many useful features built into the Linux OS resident in the Intel Edison processor
- Access to Pocket IO features through an included library
- Access to library updates as they become available

With so much capability packed into one small enclosure, the interface to manage all this is crucial. Each of Pocket IO's 10 resources has its own API. **Figure 5** shows the software architecture for Pocket IO using Arduino IDE to compile code to run on the onboard Intel Edison CPU.

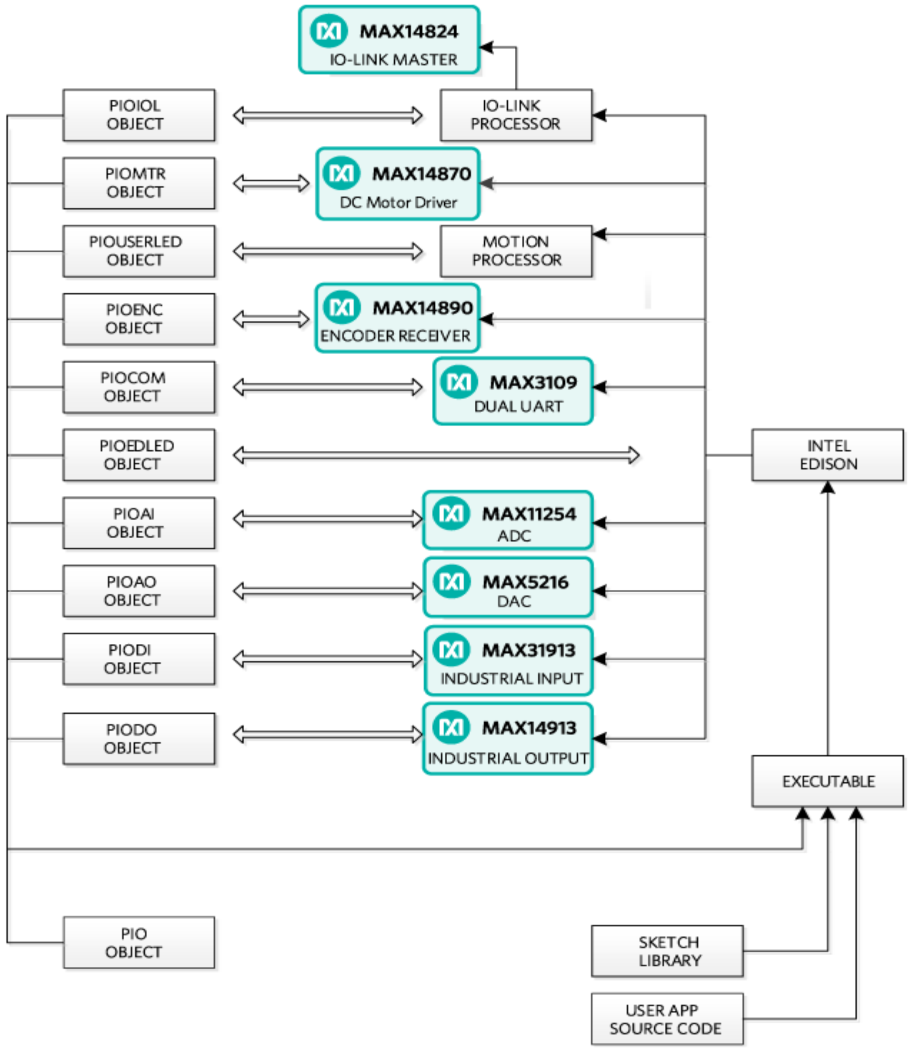


*Figure 5. Pocket IO software architecture.*

The following sections are details about API and some techniques, many Linux-specific, that enhance the capability of your applications.

## Detailed Pocket IO API

These sections, organized alphabetically by Pocket IO feature, details the API available to control Pocket IO through sketch.

Note: For information about how to access software revision codes from Pocket IO, consult Boardinfo.ino in the Pio section of the Examples in sketch.

### Analog Input

Pocket IO features two analog voltage inputs and two analog current inputs, all easily accessible through sketch. The voltage channels read anything between -12V and +12V whereas the current channels read anything between -24mA and +24mA. Pocket IO features a MAX11254 24-bit ADC featuring built-in two-point calibration compensation, which the API accommodates.

The API selects from among four channels, as follows:

| Channel | API Mnemonic | Attach Board Symbol |
|---|---|---|
| First Voltage | AI0 | AI0+/AI0- |
| Second Voltage | AI1 | AI1+/AI1- |
| First Current | AI2 | AI2 AI2+/AI2- |
| Second Current | AI3 | AI3 AI3+/AI3- |

Note: The analog input and output circuitry grounds are isolated from the ground of the rest of Pocket IO. The AGND labels on the attach board indicate this separate analog ground. If you accidentally return an analog signal, either from one of the analog inputs or from the analog output, to the more common GND, there can be unexpected results.

**Calibration**

The following code snippet shows how to perform a two-point calibration. Commonly, the user locks in the calibration, so it does not need to be done again, and calibration rarely needs to be done. Calibration comes in handy when attaching further circuitry to the analog inputs, and accuracy is to be maintained ahead of this extra circuitry. Pocket IO comes factory-calibrated for best accuracy at the connection points of the attach board.

The code snippet uses port AI0 as an example, but the code is the same regardless of which port is being calibrated. Each channel keeps its own unique calibration parameters.

```
// Makes Pocket IO analog input API available

// #include

PioAi pioAi; // Instances an analog input interface object

pioAi.init(); // Always needed for analog input pioAi.initCal(AI0); //Commences calibration

/*

* Put code here to apply +12 volts at the point of calibration

* if channel AI0 or channel AI1, or to apply +24mA if channel

* AI2 or AI3.
```

```
*

* Do not proceed until the voltage or current is applied and * stable.

*/

pioAi.setFullCal(AI0); // +12V or +24mA measured

/*

* Put code here to apply 0 volts or -24mA at the point of

* calibration.

*

* Do not proceed until the voltage or current is applied and * stable.

*/

pioAi.setZeroCal(AI0); // 0V or -24mA measured

 delay(1000); // needed for ADC to calc corrections

// This method call takes the required corrections for that

 // channel and stores it in non-volatile memory

pioAi.storeCal(AI0);
```

**Reading an Analog Sample**

Samples can be read either as a float or as a raw binary code from the ADC. The following code snippet shows how it is done. Because the sample rate is determined by the ADC itself, the user must select from one of the MAX11254 sample times as shown in the following table. Longer sample times result in readings with lower noise. This affects multiple sample reads. For example, with AI_RATE_1_9_SPS, after a first read, the thread calling a read method a second time is blocked for about 526msec.

| MAX11254 Sample Rate (sps) | API Mnemonic |
|---|---|
| 1.9 | AI_RATE_1_9_SPS |
| 15.6 | AI_RATE_15_6_SPS |
| 31.2 | AI_RSTE_31_2_SPS |
| 62.5 | AI_RATE_62_5_SPS |
| 250 | AI_RATE_250_SPS |
| 500 | AI_RATE_500_SPS |
| 1000 | AI_RATE_1000_SPS |

```
// Makes Pocket IO analog input API available

//

#include // no init() method

PioAi pioAi; // instances an analog input interface object

pioAi.init(); // always needed for analog input

// Loads a previously stored calibration for that channel,

// usually done once at setup

//

pioAi.restoreCal(AI0);

>while (XXX)

{

>// Reads one sample as a raw binary code

//

uint32_t code = pioAi.readCode(AI0, AI_RATE_1_9_SPS);

// The returned code is in offset binary, where 0V is

// 2^23, 12V is 2^23+2^23 = 2^24, and -12V is // 2^23 – 2^23 = 0

//

// In the case of current, the calibration is done is

// firmware, so the returned code is not relevant

// float toVolts = (float) (code – 8388608) * 12.0 / 8388608;

// Or you can do it easier this way, for reading current,

// this is the best way.

// float volts = pioAi.readFloat(AI0, AI_RATE_1_9_SPS);

}
```

### Analog Output

Pocket IO provides one analog output, capable of any output voltage between 0V and 12V. Since there is only one analog output channel, there is no need to select channels. The API consists of only one method call, and no init() is needed for analog out.

The call to the method is a raw 16-bit code to the DAC. To drive a specific voltage, it must first be converted to a 16-bit equivalent for the DAC, as shown in the code snippet below.

```
// Makes Pocket IO analog output API available

// #include PioAo pioAo;

// instances an analog output interface object

const float DAC_CONV = 5443.106; // codes per volt

float voltageOut = 1.250; // desired output voltage

uint16_t codeDAC = (uint16_t) (voltageOut * DAC_CONV);

// Returns the argument to the method, as a uint16_t, which

// is usually ignored

//

uint16_t intCodeDAC = pioAo.writeCode(codeDAC);

// Could also do it this way

// uint16_t intCodeDAC = pioAo.writeCode(voltageOut * DAC_CONV);
```

**Communications (RS-485)**

Pocket IO provides serial communication through two RS-485 ports. Each port is half-duplex, and is preset for 115.2KBAUD at 8N2 (eight data bits, no parity, two stop bits).

Select from among the 2 channels as follows:

| Channel | API Mnemonic | Attach Board Symbol |
|---|---|---|
| 0 | COM0 | COM0A/COM0B |
| 1 | COM1 | COM1A/COM1B |

The API permits independent reading and writing for each channel. For any given channel, writes supersede reads. No harm occurs if multiple RS-485 transceivers drive a bus at the same time though this means any received data would be corrupted. Use protocol to ensure only one transceiver drives the bus at a time.

```
// Makes Pocket IO COMMS API available

// #include PioCom

pioCom; // instances a COMMS interface object

pioCom.init(); // always needed for COMMS
```

```
uint8_t bytes = {‘H’, ‘e’, ‘l’, ‘l’, ‘o’, ‘,’,’ ‘, ‘W’, ‘o’, ‘r’, ‘l’, ‘d’, ‘!’, \0};

// First param must be either COM0 or COM1

// Second param is a pointer to an array of bytes

// Third param is the number of bytes to transfer

//

// Maximum of 128 bytes can be sent. If a previous write

// has not yet completed, then the number of bytes that

// can be written is 128 – (number of bytes left to send)

// // If you send more than 128 bytes, the transmitted data

// will be corrupted. // PioCom.write (COM0, bytes, sizeof(bytes));
```

Reading data from an RS-485 port is similar to writing, with the added complication that you do not necessarily know how many bytes have been received. The following code snippet shows how to read data.

```
// Makes Pocket IO COMMS API available

//

#include PioCom pioCom;

// instances a COMMS interface object pioCom.init();

// always needed for COMMS

// Needed once before first read

// pioCom.clearInterrupts(COM0); uint8_t receiveBuffer [100]; uint8_t receiveCount;

// First param must be either COM0 or COM1

// Second param is an array to receive data

// Third param is the size of the buffer

// Fourth param will get the number of bytes actually read

//

// The receive buffer will be filled with a number of bytes

// received since a previous read method call. If this is less

// than the size of the buffer, then the buffer is

// partially filled. Otherwise, the buffer is filled and
// a subsequent read can obtain further read data.

//

// Note that data will be corrupted if more than 128 bytes

// have been received since a previous read method call.

//

// If there is no data, the fourth param will be set to zero

//

pioCom.read(COM0, receiveBuffer,

sizeof(receiveBuffer), &receiveCount);

// Do you want to test if there is pending data to be

// received? This method call returns the number of // bytes waiting to be read

//

// Useful for conditional mutex

//

uint8_t howManyBytes = pioCom.readRxFifoLevel(COM0);
```

**Digital Input**

Pocket IO has eight individual IEC-compliant industrial digital inputs. These inputs connect to binary sensors, such as limit switches, proximity sensors, distance sensors, and user switches. These inputs can be read individually, or as a group, through sketch.

Eight LEDs on the display panel indicate the state of each of these digital inputs. The LEDs are extinguished if driven low or left open, and illuminate when the corresponding input is driven logic high. The following table connects the individual inputs to the values returned through the API

| Channel | Bit Mask | API Mnemonic | Attach Board Symbol |
|---|---|---|---|
| 1 | 0x01 | DI1 | DI1 |
| 2 | 0x02 | DI2 | DI2 |
| 3 | 0x04 | DI3 | DI3 |
| 4 | 0x08 | DI4 | DI4 |
| 5 | 0x10 | DI5 | DI5 |
| 6 | 0x20 | DI6 | DI6 |

|  |  |  |  |
|---|---|---|---|
| 7 | 0x40 | DI7 | DI7 |
| 8 | 0x80 | DI8 | DI8 |

Additionally, the user has access to the debounce feature of the MAX31913 industrial digital input device. This feature reduces chattering of particularly noisy digital inputs. This debounce is global, applying to all digital inputs simultaneously used by Pocket IO. The following code snippet shows how to access these inputs as well as how to manage debounce.

```
// Makes Pocket IO digital input API available

//

#include PioDi pioDi;

;// Instances a DI interface object pioDi.init();

pioDi.init(); // always needed for DI

 // Gets all 8 inputs at once, correspondence between

;

 // bits and inputs given in the table above



 // uint8_t allDigitalInputs = pioDi.readInput();



 // Overloaded method also reads individual digital input



 // channels. Returns ‘0’ or ‘1’



 //



// In this case, checks the state of channel 7 only

// uint8_t specificDigitalInput = pioDi.readInput(DI7);

// This is how to set the debounce. Set as follows:

// 0x00 – no debounce

// 0x01 – 25usec of debounce
// 0x02 – 750usec of debounce

// 0x03 through 0xff – 3msec of debounce

//

// A possibly corrected value is returned, for example if you

// try to set 0x10, 0x03 will be returned

// uint8_t realDebounce = pioDi.writeDebounce(0x02);

// The currently operational debounce setting can be checked

// uint8_t whichDeboucne = pioDi.readDebounce();
```

**Digital Output**

Pocket IO supports eight industrial digital outputs, each capable of driving 24V at greater than 640mA. The API supports many of the features of the MAX14913 or MAX14912 digital output driver IC, including output modes and fault detection.

Each digital output channel can be in one of two modes. High-side mode, as its name implies, only drives a channel high (nominal 24V). Many existing actuators and indicators work best in high-side mode. To have faster output driver switching, each output channel can also be configured to push-pull mode. Since both a high and a low are actively driven, there is no longer a natural decay of the wiring slowing down the transitions from high to low. The following table shows how to specify these through the API.

| Mode | API Mnemonic |
|---|---|
| High-Side | HS_MODE |
| Push-Pull | PP_MODE |

Each individual digital output can be driven high or low. The Pocket IO front panel allows easy confirmation of the output state, illuminating a green LED for each output being driven high. A matching red LED indicates that a fault has occurred on that output. This most commonly happens when accidentally tying two digital outputs together when they drive conflicting logic levels.

| Channel | Bit Mask | API Mnemonic | Attach Board Symbol |
|---|---|---|---|
| 1 | 0x01 | DO1 | DO1 |
| 2 | 0x02 | DO2 | DO2 |
| 3 | 0x04 | DO3 | DO3 |

|  |  |  |  |
|---|---|---|---|
| 4 | 0x08 | DO4 | DO4 |
| 5 | 0x10 | DO5 | DO5 |
| 6 | 0x20 | DO6 | DO6 |
| 7 | 0x40 | DO7 | DO7 |
| 8 | 0x80 | DO8 | DO8 |

The following code snippets show how to command the digital outputs and manage the mode settings of Pocket IO.

```
// Makes Pocket IO digital output API available

// #include PioDo pioDo;

// instances a DO interface object

// no init() method

// Commonly, set the output mode once before

// driving outputs

//

// first param:

// - 0x00 means set all to high-side more

// - 0x01 – 0xff means set all to push-pull mode

// pioDo.setModeAll(PP_MODE);

// can also set the mode of individual outputs


// here, half of the outputs are set to high-side

// for (int i = DO5; i <= DO8; i++) { pioDo.setMode(i, HS_MODE); }

// The mode can be confirmed through this method call

;

;

{ // code here for push-pull

} else {

// code here for high-side

}
```

The Pocket IO display panel indicates fault conditions on digital outputs by illuminating a red LED. This fault condition can also be detected through the API. There is a lot more to faults than can be described here, so for more details about fault conditions, refer to the MAX14912/MAX14913 data sheet.

```
// Is there a fault condition on digital output channel 4?

//

// The second argument indicates whether to clear faults or

// not. True causes faults to be cleared.

//

if (pioDo.readFault(DO4, false))

{

// we have a fault on DO4

}

// grab all the fault conditions at once

// If (pioDo.readFaultAll(true) & 0x0f)

{

// we have a fault on one or more of

// DO1 through DO4

}
```

**Edison LED**

Some Pocket IO resources are not directly related to industrial inputs and outputs. One of these resources is the two LED at the left of the display panel, labelled “EDISON STATUS.” One red and one green LED are purely under the user’s control. The LEDs can be used to indicate progress, status, or activity.

The following code snippet shows how to access the LEDs.

```
PioEdLed pioEd;

;// Instances an Edison LED object pioEd.init();

// Always needed for Edison LED while (true)

{ pioEd.writeLed(GREEN, 0x01); // illuminate

delay(500);
pioEd.writeLed(RED, 0x01);

delay(500); pioEd.writeLed(GREEN, 0x00);

// extinguish delay(500);

pioEd.writeLed(RED, 0x00);

}
```

**Encoders**

Pocket IO has the capability to manage up to three motion-control channels. For many motion-control applications, controlling a motor is enough. For more precise scenarios, feedback is obtained, often from incremental encoders. This section discusses the three incremental encoder interfaces built into Pocket IO.

Incremental encoders communicate position information through two (most common), three (somewhat common) or four (less common) signals. Two-signal encoders are called A and B. Each edge communicates some fraction of a revolution. For example, when using a 4,000 pulses-per-revolution encoder, if you count only the rising edges of the A signal, you can see 1,000 such edges per revolution of the encoder shaft. If you count all edges of both the A and B signals, you can see 4,000 such edges per revolution of the encoder shaft. The timing of the A and the B signals is such that the direction can also be unambiguously determined. The Pocket IO incremental encoder interface uses the A and the B signals to maintain a position count based on the rising edges of the A signal.

A third signal, if it exists, is labelled the Z signal. Sometimes called an index pulse, this optional signal indicates the zero-degree point of the encoder shaft. Pocket IO currently ignores the Z signal. If a fourth signal exists, it is usually labelled the Y signal, and is used to indicate a fault condition in the encoder. Pocket IO has no means to connect to a Y signal.

Incremental encoders have been around for many decades now. Because of this, these encoders are available in a variety of signaling formats, and the MAX14890E encoder used in pocket IO is designed to handle this multiplicity.

Each signal has a “+” connection point and a “-” connection point. For example, the first encoder A signal connects through signals A1+ and A1-. How these are connected to depends on whether the signal format is single-ended or differential. For example, to connect a TTL A encoder signal to Pocket IO encoder channel 1, tie the signal to A1+, and tie the return to A1-. For differential signaling, tie the encoder A+ signal to A1+ and the encode A- signal to A1-. Because of the large common mode tolerance range of the MAX14890E used in Pocket IO, differential encoders usually function well even with no grounds tied between the encoder and Pocket IO.

Several front-panel LED indicators speak to the encoder interface. The yellow LED in the ENCODER section indicates encoder activity whereas the corresponding red LED indicates that an encoder channel has experienced a fault situation. Additionally, the yellow LED in the HS TERM section illuminates when Pocket IO attaches the high-speed RS-422 termination to the corresponding encoder channel.

Each Pocket IO encoder channel has its own signal format selection, communicated to the API by consulting the following table.

| Standard | API Mnemonic |
|---|---|
| Single-ended | SEHTL |
| Differential HTL | DHTL |
| RS-422 | RS422 |
| TTL | TTL |

Select from among the 3 encoder channels as follows:

| Channel | API Mnemonic | Attach Board Symbols |
|---|---|---|
| 1 | ENC1 | A1+, A1-, B1+, B1-, Z1+, Z1- |
| 2 | ENC2 | A2+, A2-, B2+, B2-, Z2+, Z2- |
| 3 | ENC3 | A3+, A3-, B3+, B3-, Z3+, Z3- |

This code snippet shows how to set encoder signal formats, and how to obtain encoder information.

```
// Make Pocket IO encoder API available

// #include PioEnc pioEnc;

// Instances an encoder interface object pioEnc.init();

// Always needed for encoders

// This sets the encoder 3 signal mode to TTL

// pioEnc.setMode(ENC3, TTL);

// The encoder interface maintains a position for each

// encoder. The position count is incremented for each

// clockwise pulse obtained by the encoder, and is
// decremented for each counterclockwise pulse of the

// encoder. So, if you read a position, move 500 pulses

// clockwise, then 499 pulses counterclockwise, your new

// position will be one count higher than the previous // position.

//

// The position is maintained as a 32-bit int, so commonly

// no overflow/underflow maintenance is needed in code.

//

// This is how to obtain the current position of encoder 1

// int positionNow = pioEnc.getCount(ENC1);

// You can also reset the encoder to zero at any time.

// pioEnc.initCount(ENC1);
```

## Motor Control

A nice feature of Pocket IO is the ability to control up to three brushed DC motors. A separate green-colored connector supplies the motors, permitting the use of motors from 4.5V to 32V. During startup and other high-speed changes, each motor is limited to about two amperes of drive current. Because the motor driver is a full-bridge MAX14870 device, there is no ground connection to the motor, only to its two terminals.

The Pocket IO indicator panel shows the motor driving state for each motor port. A green LED illuminates when driving a motor clockwise, and a yellow LED illuminates when driving a motor counterclockwise. The higher the speed, the brighter the LED.

To adjust motor speed, Pocket IO provides an 8-bit PWM control for each motor independently. Select from among the 3 motor channels referring to the following table:

| Channel | API Mnemonic | Attach Board Symbol |
|---|---|---|
| 1 | M1 | M1+/M1- |
| 2 | M2 | M2+/M2- |
| 3 | M3 | M3+/M3- |

The API maintains a concept of rotation direction. When driving clockwise, the “+” connection averages a higher voltage than the “-“ connection. When driving counterclockwise, the “+” connection averages a lower voltage than the “-“ connection. The following table shows how to describe this.

| Direction | API Mnemonic |
|---|---|
| Clockwise | CLOCKWISE |
| Counterclockwise | COUNTERCLOCKWISE |

'Stopping' a motor can mean two different things. In one case, it can mean actively braking the motor with significant resistance to motion. In the other case, it can mean coasting, where there is little resistance to motion.

In the case of a DC-brushed motor, the difference can be significant. If the motor is part of some internal mechanism where there is no expected movement, then braking is the correct approach. With braking, forcing movement of the motor can prematurely wear out the motor brushes. However, if there can be movement of the motor after stopping, coasting is probably the better approach. The disadvantage of coasting is that the motor does not stop suddenly, so may excurse past where you want to stop.

In some situations, you would like to stop motion solidly, but still permit a user to move a mechanism by hand. A good compromise in this situation is to brake the motor for a short time, and then coast the motor.

The following table summarizes the possible states of motion for the motors.

| State of Motion | Enable | Direction | Speed |
|---|---|---|---|
| Running one direction | True | CLOKCWISE | Any |
| Running other direction | True | COUNTERCLOKCWISE | Any |
| Braking | True | Any | Zero |
| Coasting | Flase | Any | Any |

The following code snippet shows how to manage the motors through Pocket IO.

```
// Make Pocket IO motor API availa  e

//

#include PioMtr pioMtr; // Instances a motor interface object
```

```
// No init() needed

// Motor 1 to half speed one direction

//

// The second argument to the writeSpeed method

// is between 0 (no motion) and 255 (full motion)

// pioMtr.writeEnable(M1, true); pioMtr.writeDirection(M1, CLOCKWISE); pioMtr.writeSpeed(M1, 128);

// half speed // Motor is running, want to reverse direction

// and still run at half speed // pioMtr.writeDirection(M1, COUNTERCLOCKWISE);

// Compromise stopping technique

/// First brake and then coast a short


// brake delay (100);

// good value for most small motors pioMtr,writeEnable(M1, false);

// now coast // The various values can be read back

// if (pioMtr.readEnable(M1))

{ // do something if M1 is enabled

} uint8_t myDirection = pioMtr.readDirection(M1);

uint8_t mySpeed = pioMtr.readSpeed(M1);
```

## User LED

Some Pocket IO resources are not directly related to industrial inputs and outputs. One of these resources is the eight-user LED toward the bottom of the display panel, labelled “USER.” You have two blue, red, yellow, and green LEDs, that can be used to indicate anything (under the user’s control).

The following table correlates USER LED with code.

| User LED | API Mnemonic |
|---|---|
| 1 | LED1 |
| 2 | LED2 |
| 3 | LED3 |
| 4 | LED4 |
| 5 | LED5 |

| | |
|---|---|
| 6 | LED6 |
| 7 | LED7 |
| 8 | LED8 |

The following code snippet shows how to control the user LED.

```
// Makes Pocket IO user LED API available

// #include PioUserLed pioUser;

// Instances a user LED interface object

// init() method not needed

// This is how to control the user LED

//

// Illuminated LED if second param != 0

//

pioUser.writeLed(LED5, 1);

delay(1000); pioUser.writeLed(LED5, 0);

// Can also query the current state of any LED

//

uint8_t stateLED5 = pioUser.readLed(LED5);
```

## Quick Start

Required equipment

- MAXREFDES150# Case (Pocket IO) with MAXREFDES150ATACH#
- Two 40-pin cable assemblies
- 24V, 1A power supply
- USB cable
- Windows® PC with a USB Port
- Arduino IDE Software

The first step is to connect the Pocket IO and the connector board, and then to install and configure the Arduino-based software tools.

**Power Supplies**

A single 24V, 1A supply is used to power the Pocket IO and internal DC-DC, and LDO circuits are used to generate the various different voltage levels required by the analog and digital devices.

**Note:** The maximum load this adapter can supply is 1A, which limits how many of the digital outputs are switching loads simultaneously since each of the eight outputs can handle loads of up to 640mA each. The user can use a different 24V supply with 5A (max) capacity. The 24V, 1A supply connects to the block barrel connector, shown on the left in **Figure 2**.

**Connections**

The main functional blocks are on the two PCBs within the Pocket IO case while the connectors are on a separate board, called MAXREFDES150ATACH# shown in Figure 3, which connects to Pocket IO using two 40-pin cable assemblies as shown in **Figures 6**, **7** and **8**.

For testing MAXREFDES150# connect the Pocket IO boards in the plastic case to the MAXREFDES150ATACH# board using the two cable assemblies. Note each cable is the same, but one connector has a plastic 'key' to mate correctly to the male connectors on the MAXREFDES150ATACH# board. Start by connecting to the MAXREFDES150ATACH# board making sure the red line on the cable matches the Pin 1 triangle on J1 and J9 for the MAXREFDES150ATACH# board (Figure 6).

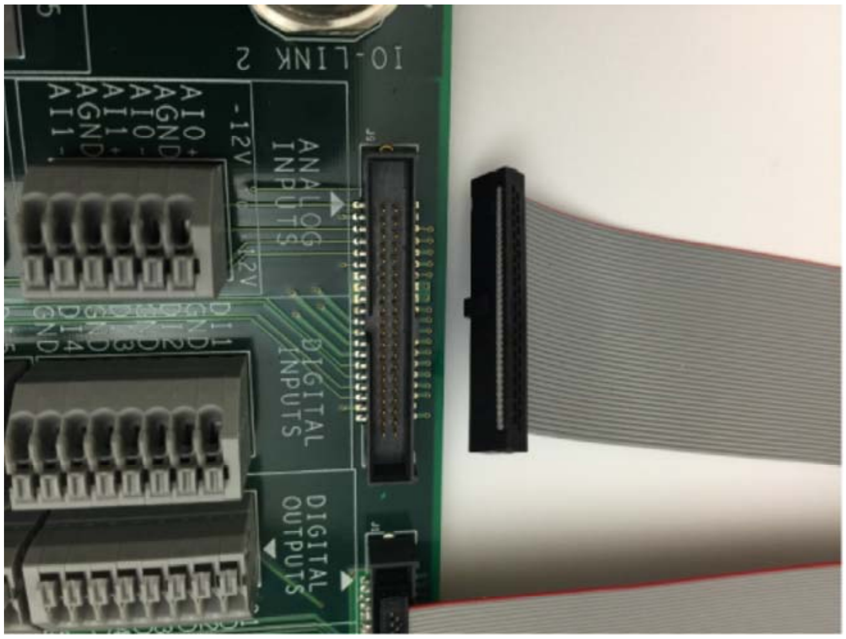


*Figure 6. Connecting Cable Assembly to MAXREFDES150ATACH#.*

Then connect the two cables to the male connectors at the rear of the Pocket IO plastic case; note how the red line on the cable is on the left hand side (Figure 7).

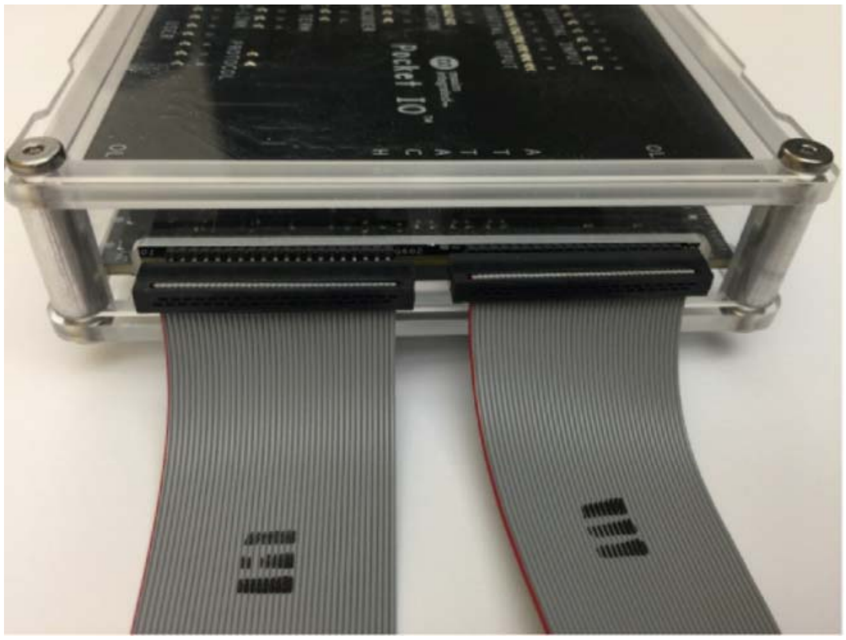


*Figure 7. Cable Assembly to Pocket IO.*

Make sure you do not cross the two cables (Figure 8).

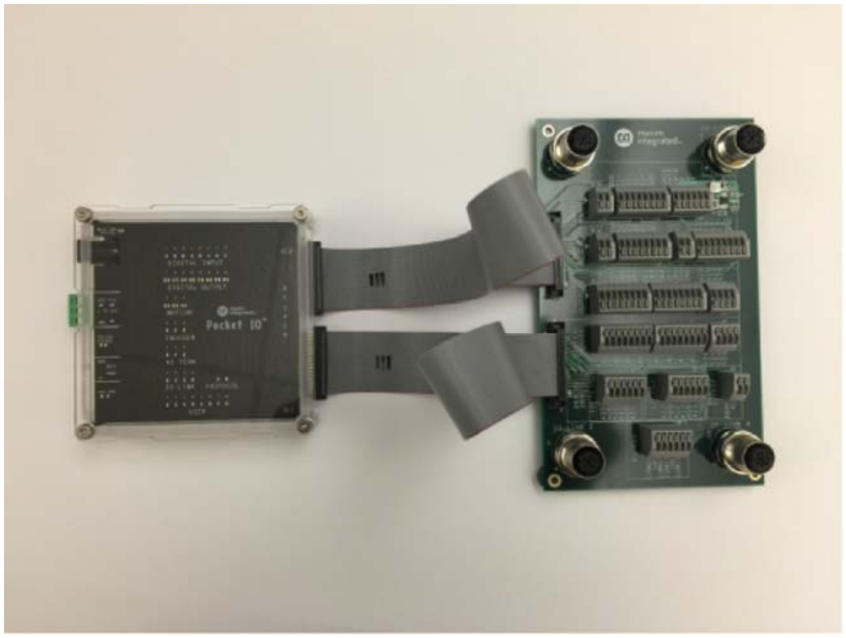


*Figure 8. Pocket IO Connected to MAXREFDES150ATACH#.*

Finally, take the 24V wall adapter and select the correct fixture for the local power outlet; the kit is supplied with adapters for England, Europe, USA and Australia standards **(Figure 9)**.

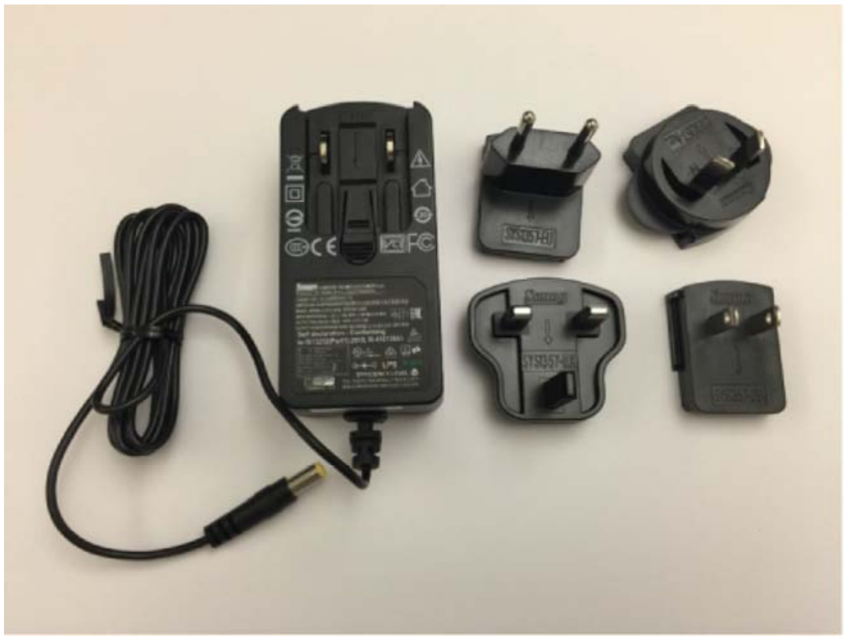


*Figure 9. Pocket IO power supply and adapters.*

Connect the 24V supply to the barrel connector on the plastic case (**Figure 10**).

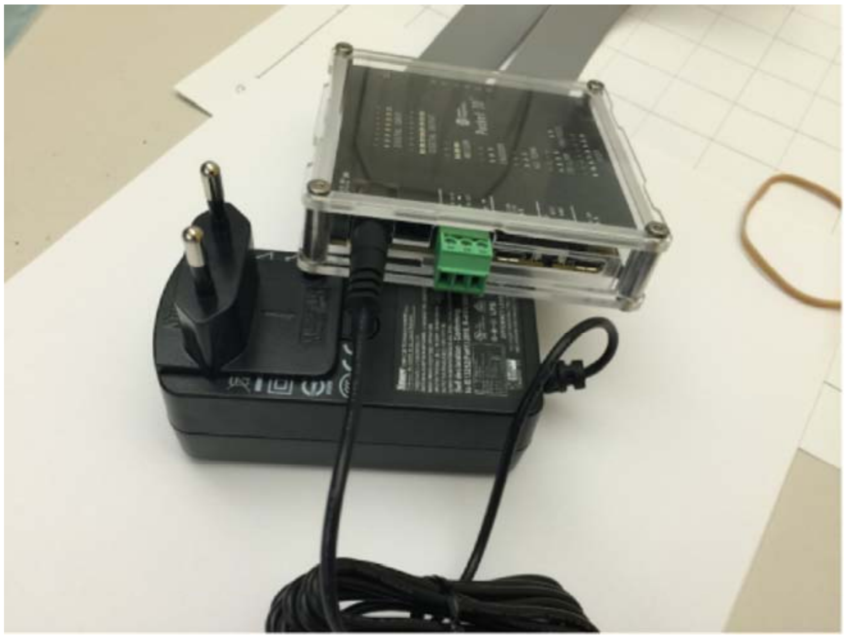


*Figure 10. Pocket IO with Power Supply Connected.*

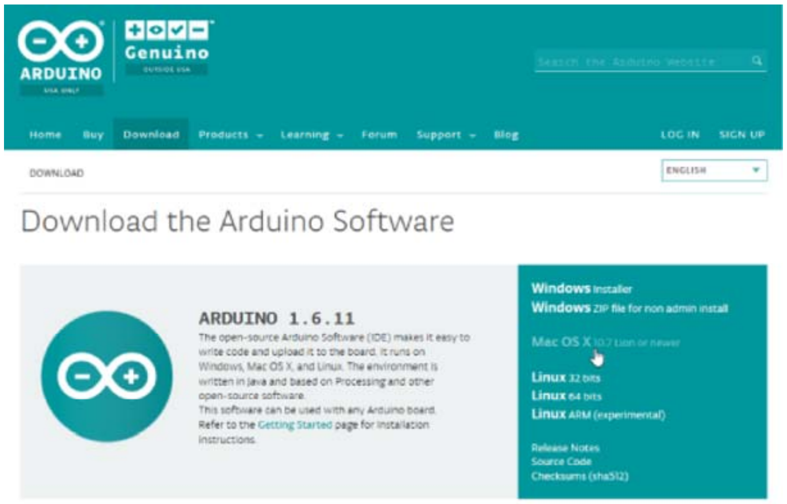
Pocket IO is now ready to be powered on and tested. Testing requires a PC loaded with Arduino software for Pocket IO.

**Procedure**

Maxim Pocket IO Arduino Installation Instructions

1. Download and install the latest Arduino IDE.
   a. Go to https://www.arduino.cc/en/Main/Software.

b. Select the appropriate OS link (Windows, MAC®, Linux®). For this Quick Start we assume the OS is Windows PC.



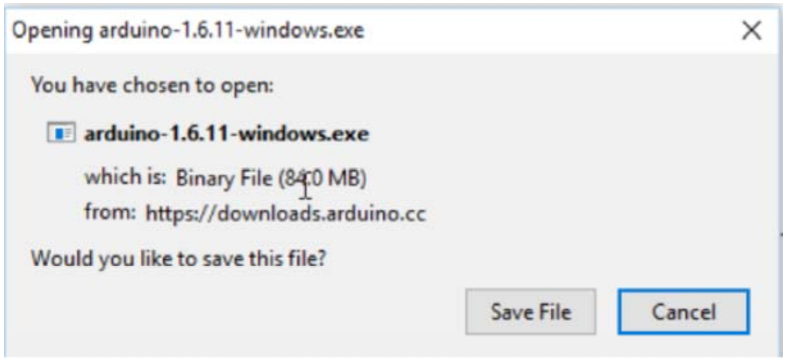
Download the Arduino Software

ARDUINO 1.6.11

The open-source Arduino Software (IDE) makes it easy to write code and upload it to the board. It runs on Windows, Mac OS X, and Linux. The environment is written in Java and based on Processing and other open-source software.
This software can be used with any Arduino board.
Refer to the Getting Started page for installation instructions.

Windows Installer
Windows ZIP file for non admin install
Mac OS X 10.7 Lion or newer
Linux 32 bits
Linux 64 bits
Linux ARM (experimental)
Release Notes
Source Code
Checksums (sha512)

c. Follow the prompts to download and save the file.



Opening arduino-1.6.11-windows.exe

You have chosen to open:

arduino-1.6.11-windows.exe

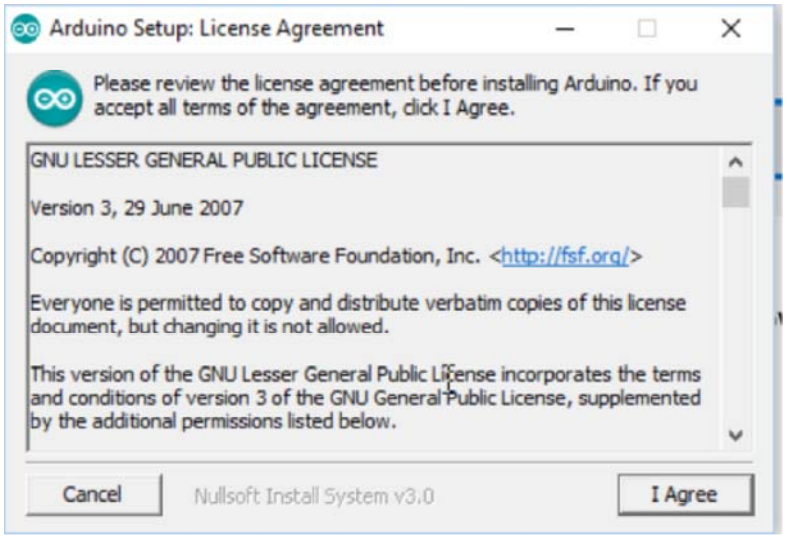
which is: Binary File (84.0 MB)
from: https://downloads.arduino.cc

Would you like to save this file?

2. Install the latest Arduino IDE.
   a. Once the download has completed double click **'Arduino-x.x.xx-windows.exe.'**

   b. Windows then prompts you to run this file, select **'Run.'**

   c. The Arduino setup displays the license agreement, select **'I Agree.'**



Arduino Setup: License Agreement

Please review the license agreement before installing Arduino. If you accept all terms of the agreement, click I Agree.

GNU LESSER GENERAL PUBLIC LICENSE

Version 3, 29 June 2007

Copyright (C) 2007 Free Software Foundation, Inc. <http://fsf.org/>

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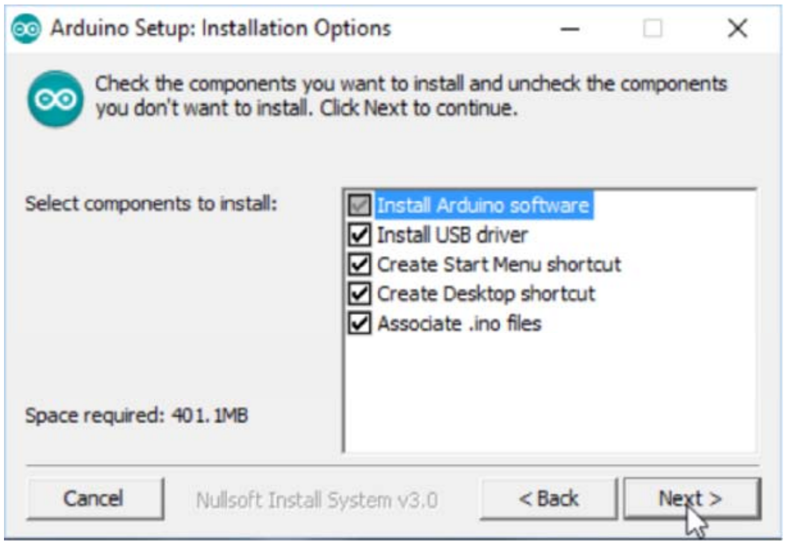
d. It prompts you to select components to install, select **'Next.'**



Arduino Setup: Installation Options

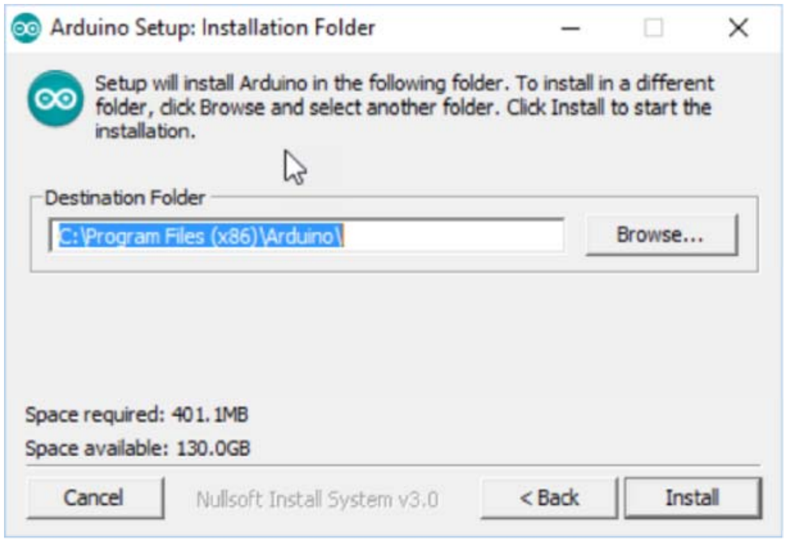
Check the components you want to install and uncheck the components you don't want to install. Click Next to continue.

Select components to install:

- [x] Install Arduino software
- [x] Install USB driver
- [x] Create Start Menu shortcut
- [x] Create Desktop shortcut
- [x] Associate .ino files

Space required: 401.1MB

e. Next it shows the destination folder to install, select **'Install.'**



Arduino Setup: Installation Folder

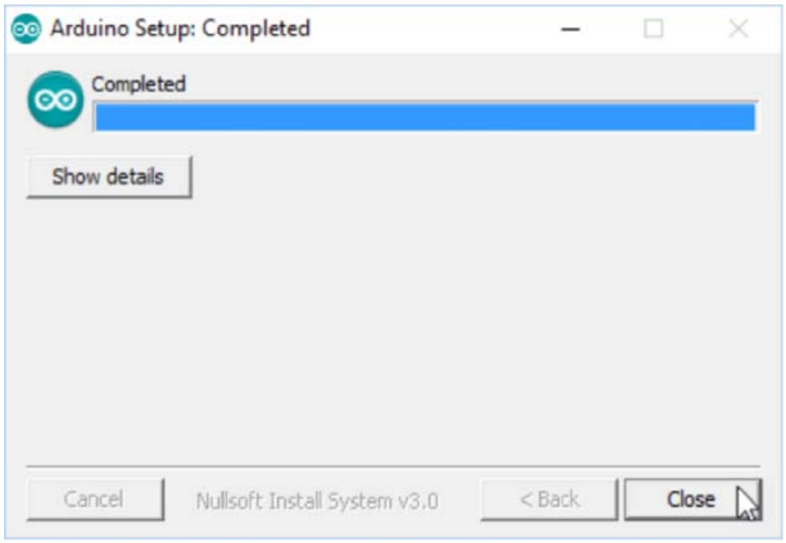
Setup will install Arduino in the following folder. To install in a different folder, click Browse and select another folder. Click Install to start the installation.

Destination Folder: C:\Program Files (x86)\Arduino\

Space required: 401.1MB

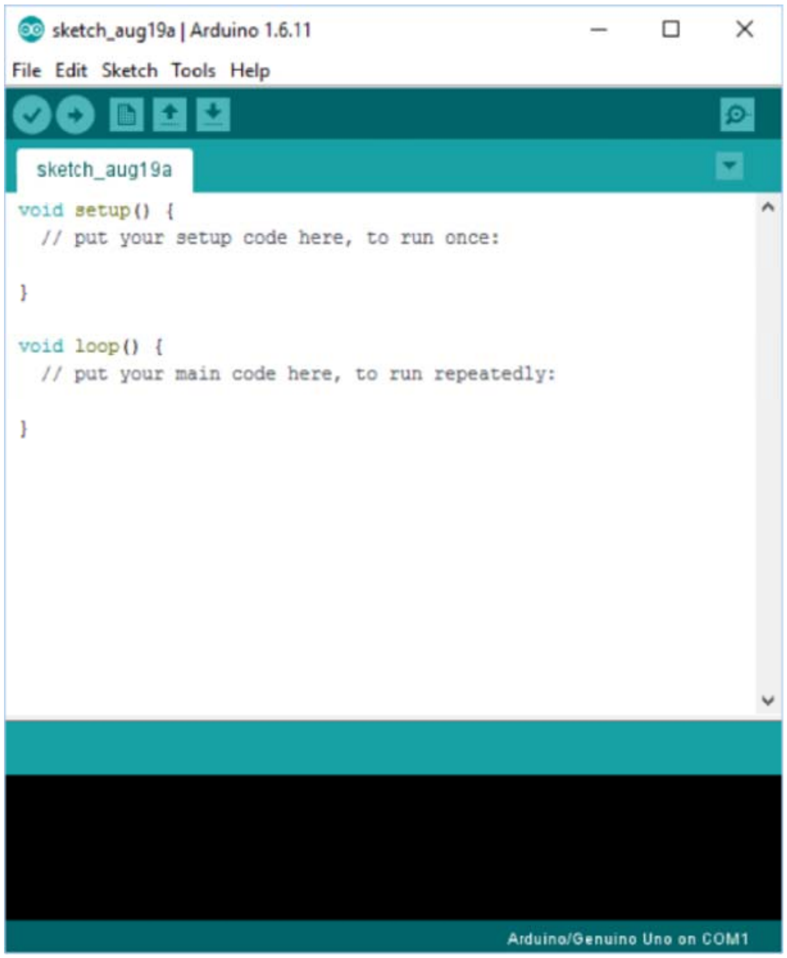
Space available: 130.0GB

f. When Arduino setup is completed select **'Close.'**



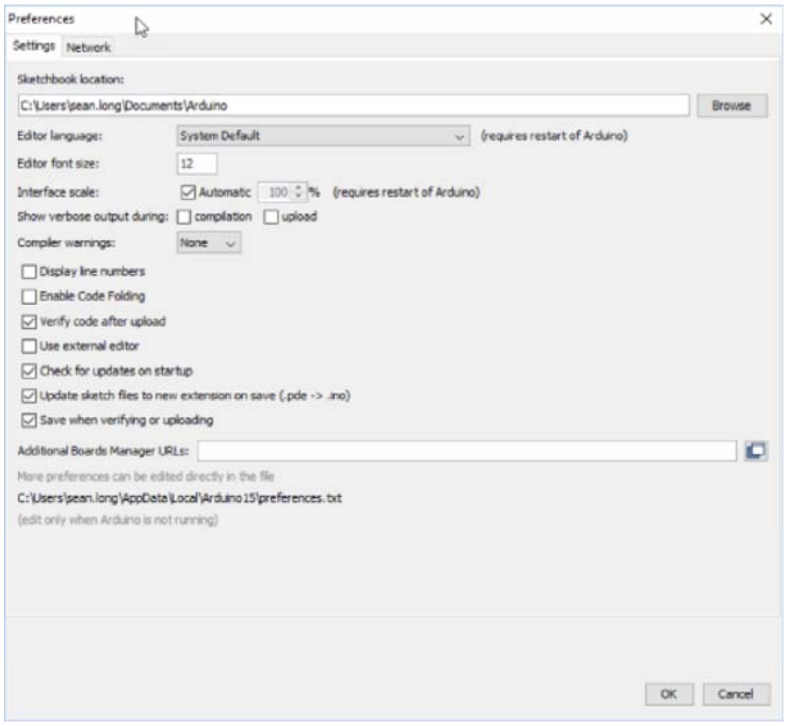
3. Install Maxim's Pocket IO Board.
   a. Locate the **'Arduino'** shortcut on your desktop and double click the icon to open the Arduino IDE.

   b. A window opens as shown below, select **File > Preferences**.


sketch_aug19a | Arduino 1.6.11
File Edit Sketch Tools Help
sketch_aug19a
Arduino/Genuino Uno on COM1

```
void setup() {
  // put your setup code here, to run once:

}

void loop() {
  // put your main code here, to run repeatedly:

}
```

c. In the **'Preferences'** window there is a section **'Additional Boards Manager URLs.'** Select this box.



Preferences

Settings | Network

Sketchbook location: C:\Users\sean.long\Documents\Arduino

Editor language: System Default (requires restart of Arduino)

Editor font size: 12

Interface scale: ☑ Automatic 100 % (requires restart of Arduino)

Show verbose output during: ☐ compilation ☐ upload

Compiler warnings: None

☐ Display line numbers

☐ Enable Code Folding

☑ Verify code after upload

☐ Use external editor

☑ Check for updates on startup

☑ Update sketch files to new extension on save (.pde -> .ino)

☑ Save when verifying or uploading

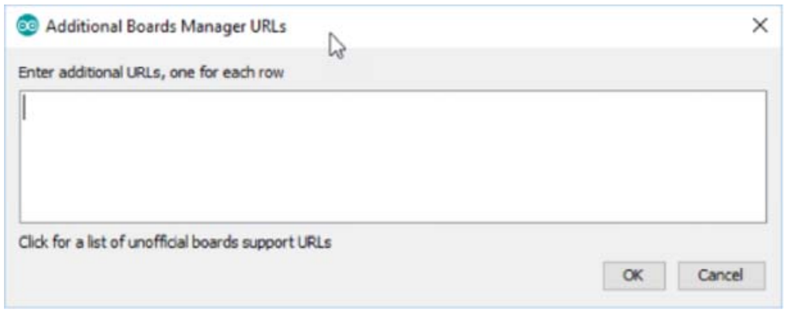
Additional Boards Manager URLs:

More preferences can be edited directly in the file

C:\Users\sean.long\AppData\Local\Arduino15\preferences.txt

(edit only when Arduino is not running)

d. In the box that opens, copy and paste the URL below into this window and select **'OK'**, then **'OK'** again.
https://raw.githubusercontent.com/maximTicer/pocketio/master/package_maxim_index.json

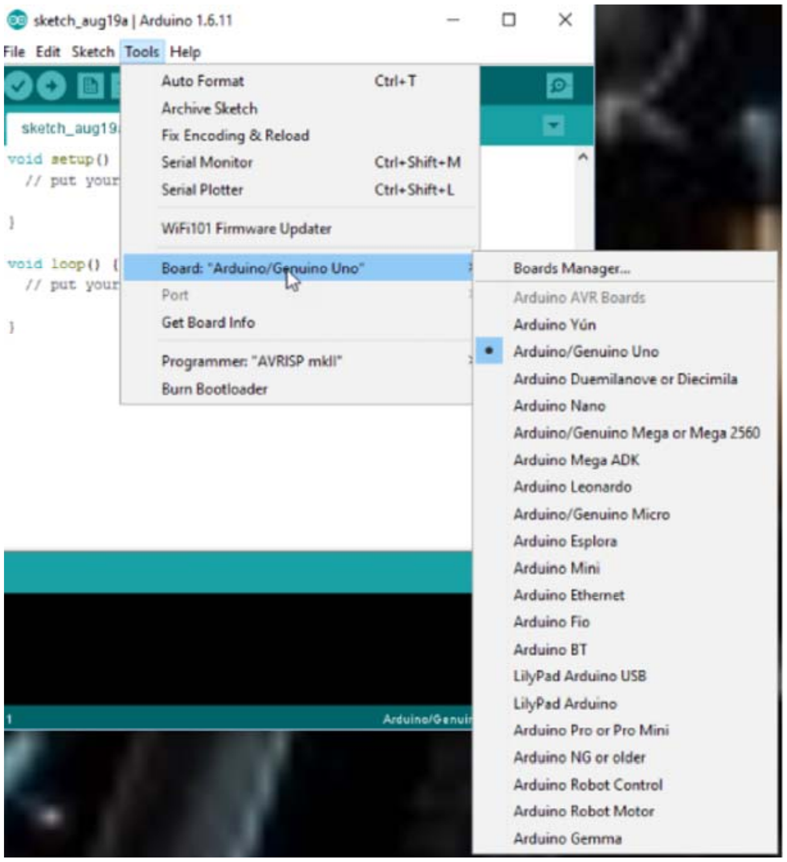


Additional Boards Manager URLs

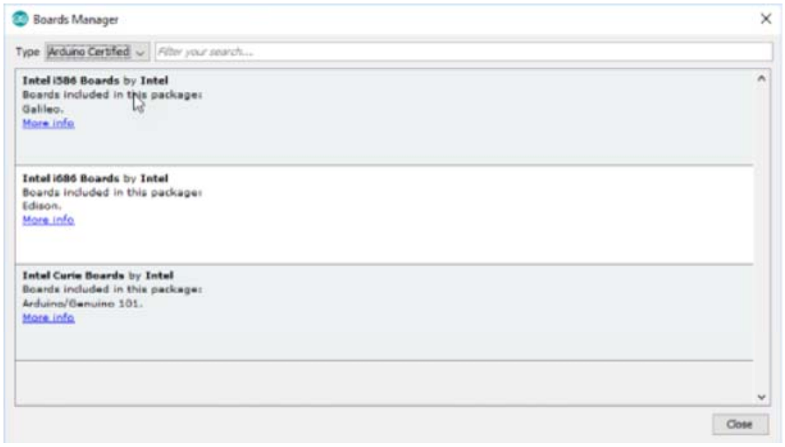
Enter additional URLs, one for each row

Click for a list of unofficial boards support URLs

e. Select **Tools > Board > Board Manager**.



f. Open the **'Boards Manager'** window and from the drop down Type menu select **'Certified.'**

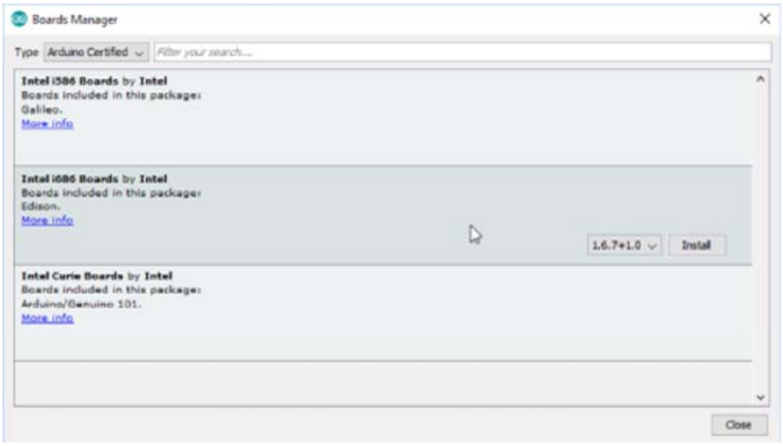


**Intel i586 Boards** by **Intel**
Boards included in this package:
Galileo.
More info

**Intel i686 Boards** by **Intel**
Boards included in this package:
Edison.
More info

**Intel Curie Boards** by **Intel**
Boards included in this package:
Arduino/Genuino 101.
More info

g. Select **'Intel i686 Boards by Intel'** for Edison and click **'Install'** to install rev 1.6.7+1.0 or later.

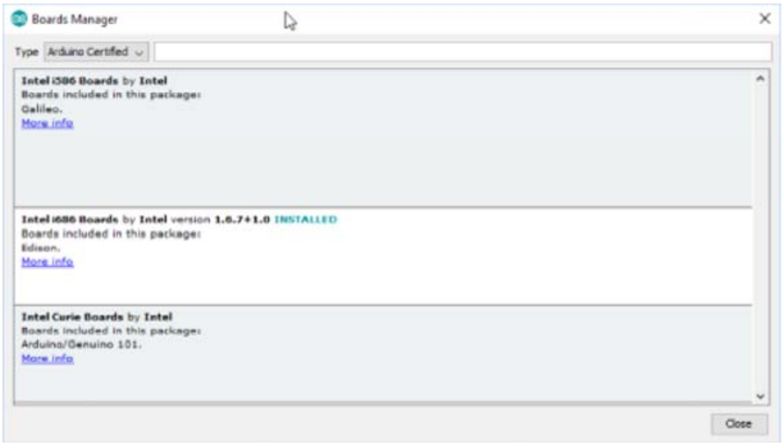


**Intel i586 Boards** by **Intel**
Boards included in this package:
Galileo.
More info

**Intel i686 Boards** by **Intel**
Boards included in this package:
Edison.
More info

**Intel Curie Boards** by **Intel**
Boards included in this package:
Arduino/Genuino 101.
More info

h. Once installation is completed, select **'Close.'**

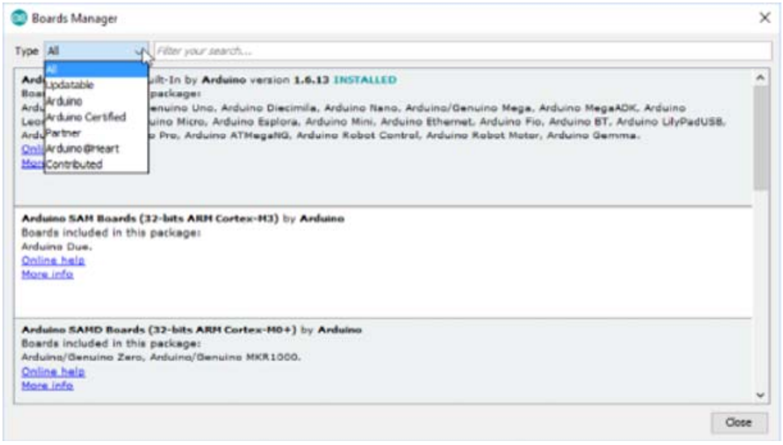


**Intel i586 Boards** by **Intel**
Boards included in this package:
Galileo.
More info

**Intel i686 Boards** by **Intel** version **1.6.7+1.0** INSTALLED
Boards included in this package:
Edison.
More info

**Intel Curie Boards** by **Intel**
Boards included in this package:
Arduino/Genuino 101.
More info

i. Open the **'Boards Manager'** window and from the drop down Type menu select **'Contributed.'**

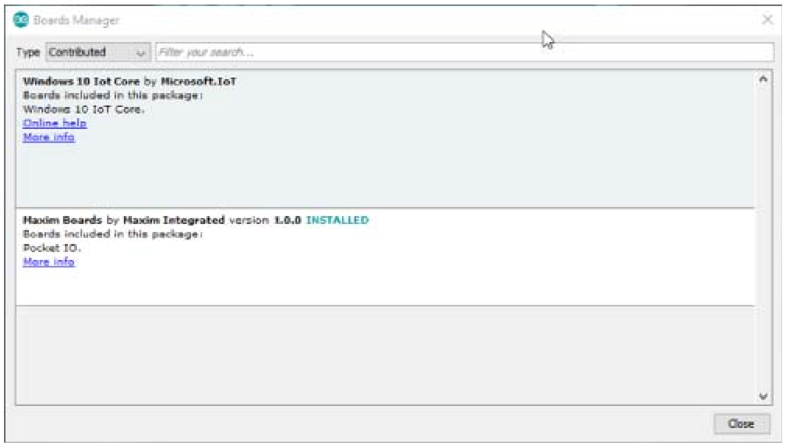


**Ard** ilt-In by **Arduino** version **1.6.13** INSTALLED
Boa package:
Ard enuino Uno, Arduino Diecimila, Arduino Nano, Arduino/Genuino Mega, Arduino MegaADK, Arduino
Leo uino Micro, Arduino Esplora, Arduino Mini, Arduino Ethernet, Arduino Fio, Arduino BT, Arduino LilyPadUSB,
Ard o Pro, Arduino ATMegaNG, Arduino Robot Control, Arduino Robot Motor, Arduino Gemma.
Onl
Mor

**Arduino SAM Boards (32-bits ARM Cortex-M3)** by **Arduino**
Boards included in this package:
Arduino Due.
Online help
More info

**Arduino SAMD Boards (32-bits ARM Cortex-M0+)** by **Arduino**
Boards included in this package:
Arduino/Genuino Zero, Arduino/Genuino MKR1000.
Online help
More info

j. Select 'Maxim Boards by Maxim Integrated' for Pocket IO and click **'Install.'**

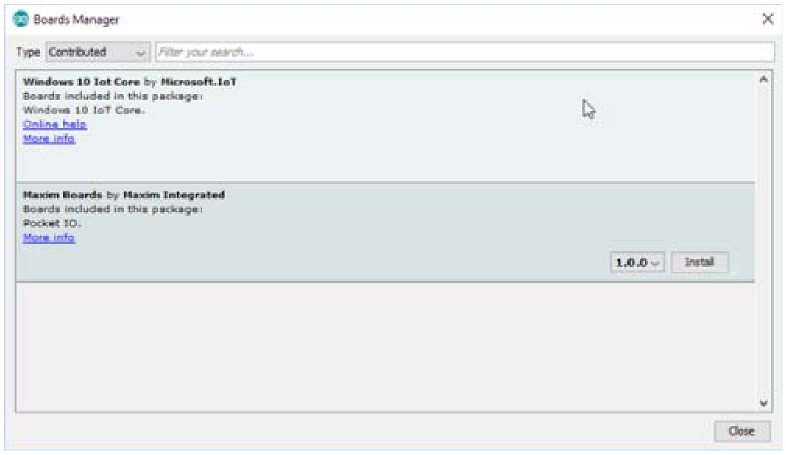

Boards Manager

Type Contributed | Filter your search...

**Windows 10 Iot Core** by **Microsoft.IoT**
Boards included in this package:
Windows 10 IoT Core.
Online help
More info

**Maxim Boards** by **Maxim Integrated** version **1.0.0** INSTALLED
Boards included in this package:
Pocket IO.
More info

k. Once installation is completed, select **'Close.'**

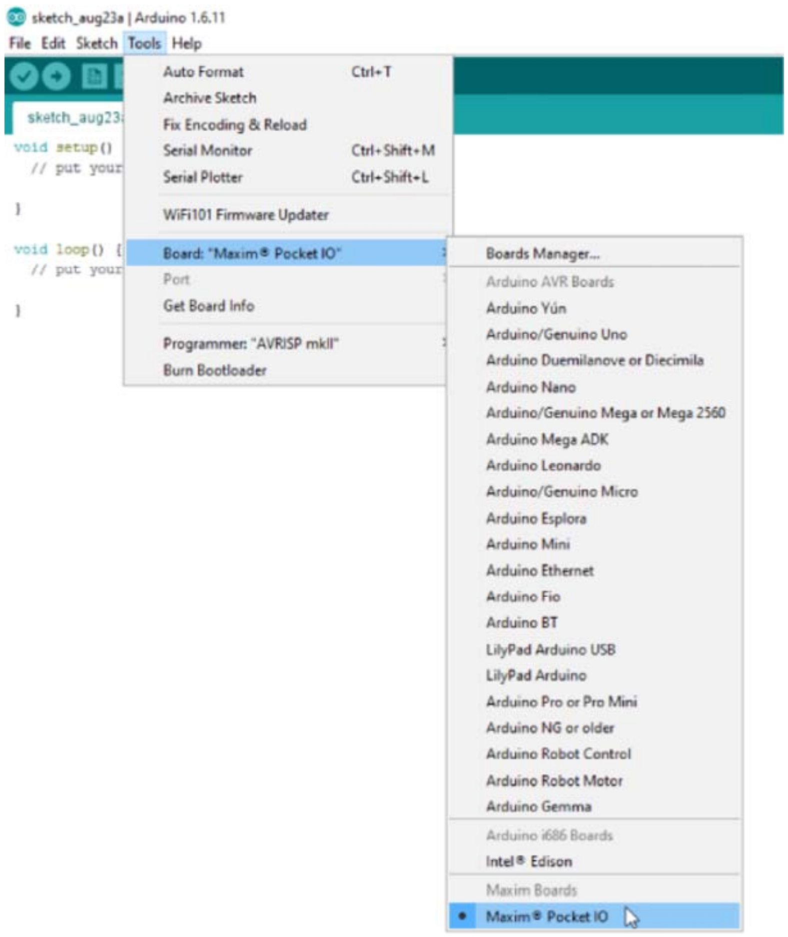

Boards Manager

Type Contributed | Filter your search...

**Windows 10 Iot Core** by **Microsoft.IoT**
Boards included in this package:
Windows 10 IoT Core.
Online help
More info

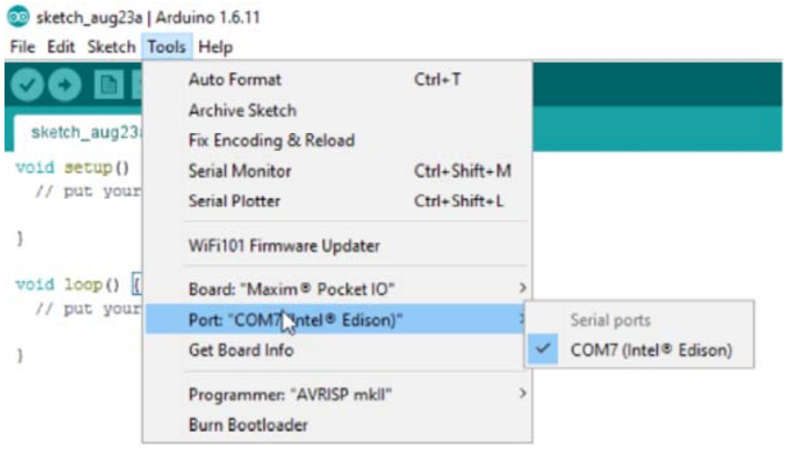
**Maxim Boards** by **Maxim Integrated**
Boards included in this package:
Pocket IO.
More info

4. Using the Pocket IO with Arduino IDE.
   a. To select Pocket IO as the target board, select **Tools > Board > Maxim Pocket I**O.

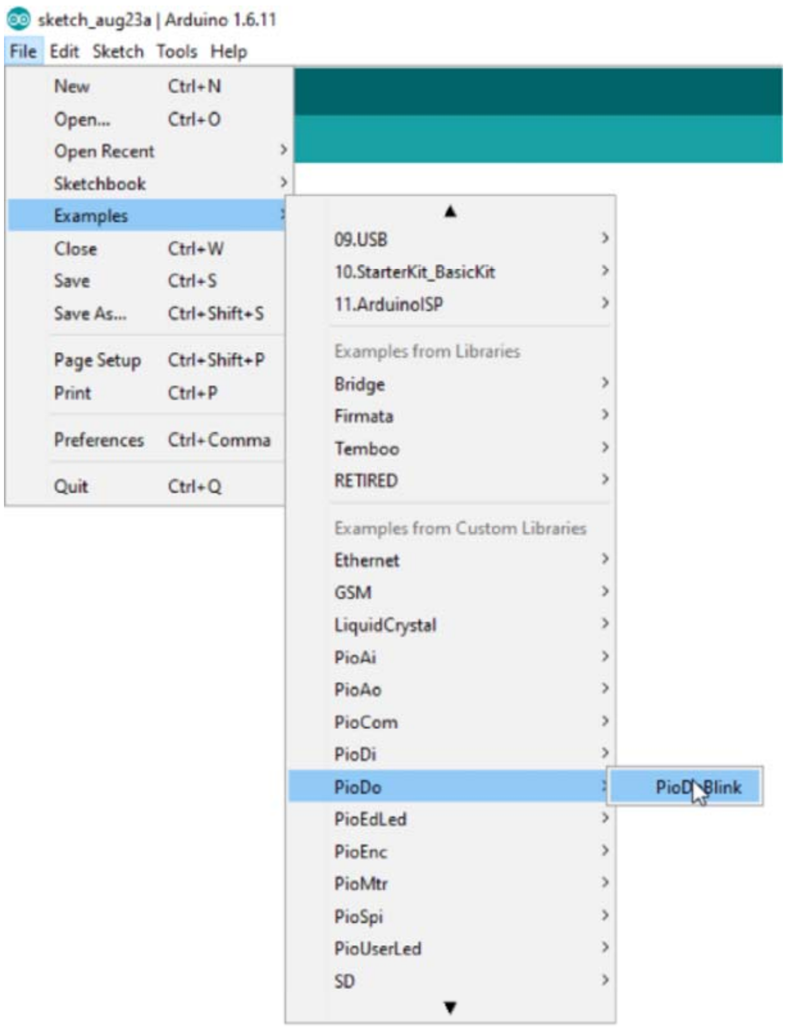


b. Make sure Pocket IO is powered with 24V, and connect the USB cable to the micro-USB connector labeled 'Edison Status' (the one nearest to the green connector). If device drivers are not automatically installed use this link to download and install the drivers:
http://downloadmirror.intel.com/24909/eng/IntelEdisonDriverSetup1.2.1.exe

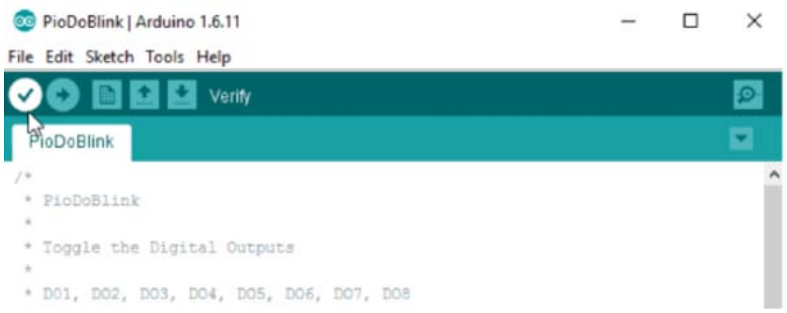
c. Select Tools > Port > COMXXX (where xxx is whichever COM port was selected when you plugged it in).


sketch_aug23a | Arduino 1.6.11
File Edit Sketch Tools Help
Auto Format Ctrl+T
Archive Sketch
Fix Encoding & Reload
Serial Monitor Ctrl+Shift+M
Serial Plotter Ctrl+Shift+L
WiFi101 Firmware Updater
Board: "Maxim® Pocket IO"
Port: "COM7 (Intel® Edison)"
Get Board Info
Programmer: "AVRISP mkII"
Burn Bootloader
Serial ports
✓ COM7 (Intel® Edison)

d. Next select **File > Examples > PioDo > PioDoBlink**.

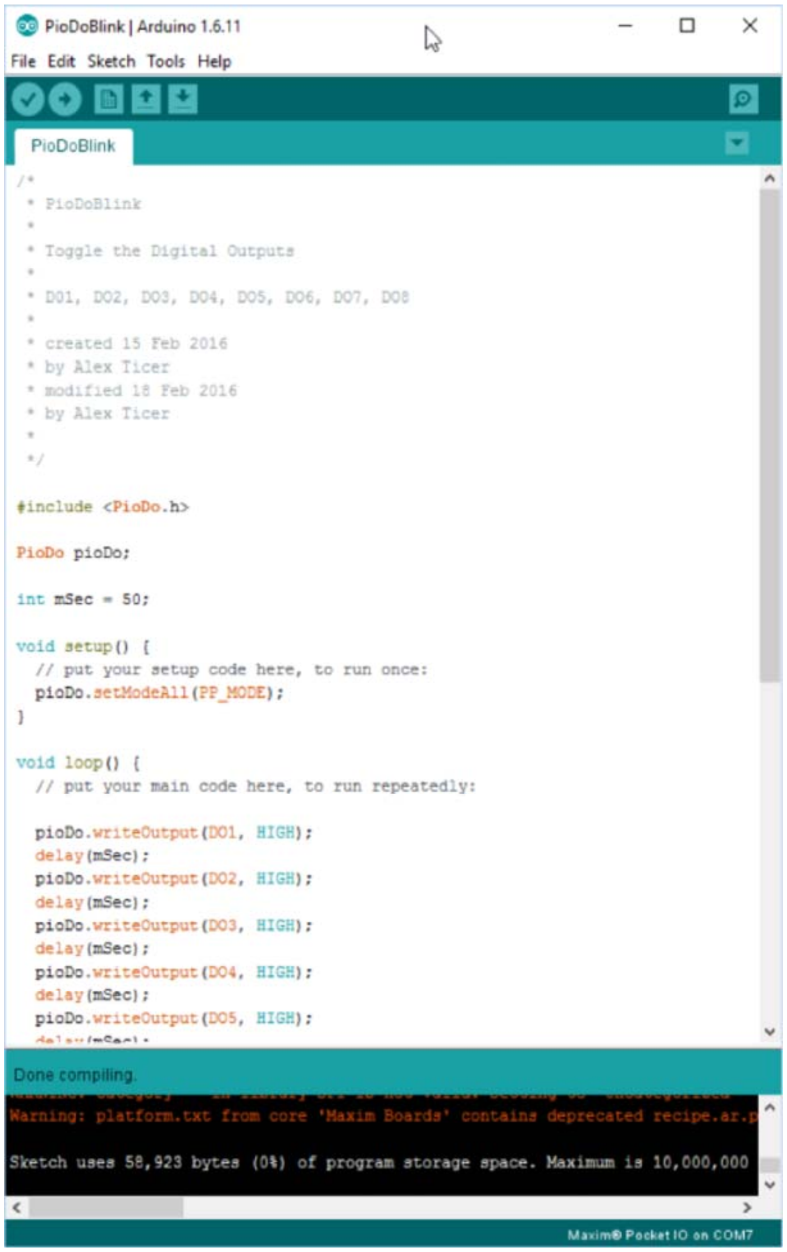


e. A new window should appear with the example sketch selected. Press the circular button with the check mark in the top left corner to **'Verify'** or compile the sketch.



```
/*
 * PioDoBlink
 *
 * Toggle the Digital Outputs
 *
 * DO1, DO2, DO3, DO4, DO5, DO6, DO7, DO8
```

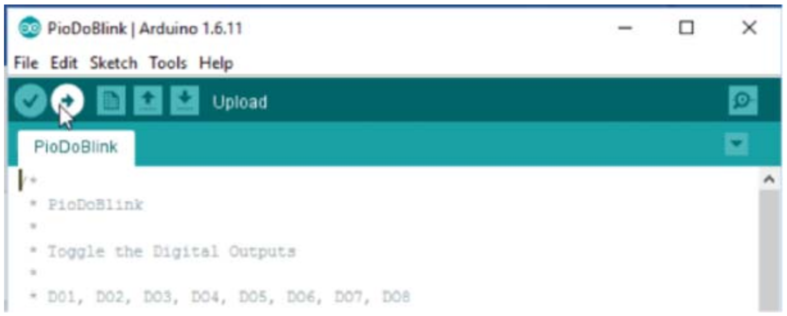
f. The window indicates it is compiling with a progress bar, and when finished, displays **'Done Compiling.'**



```
/*
 * PioDoBlink
 *
 * Toggle the Digital Outputs
 *
 * DO1, DO2, DO3, DO4, DO5, DO6, DO7, DO8
 *
 * created 15 Feb 2016
 * by Alex Ticer
 * modified 18 Feb 2016
 * by Alex Ticer
 *
 */

#include <PioDo.h>

PioDo pioDo;

int mSec = 50;

void setup() {
  // put your setup code here, to run once:
  pioDo.setModeAll(PP_MODE);
}

void loop() {
  // put your main code here, to run repeatedly:

  pioDo.writeOutput(DO1, HIGH);
  delay(mSec);
  pioDo.writeOutput(DO2, HIGH);
  delay(mSec);
  pioDo.writeOutput(DO3, HIGH);
  delay(mSec);
  pioDo.writeOutput(DO4, HIGH);
  delay(mSec);
  pioDo.writeOutput(DO5, HIGH);
```

```
Done compiling.
Warning: platform.txt from core 'Maxim Boards' contains deprecated recipe.ar.p

Sketch uses 58,923 bytes (0%) of program storage space. Maximum is 10,000,000
```

g. Now select the circular button with the right arrow, **'Upload'** transfers the data to the Edison and starts to run the compiled program.



```
/*
 * PioDoBlink
 *
 * Toggle the Digital Outputs
 *
 * DO1, DO2, DO3, DO4, DO5, DO6, DO7, DO8
```

h. After a few seconds the message **'Done Uploading'** is displayed and you can see the LEDs on the board flashing driven by the digital outputs.

i. A number of standard functions are included as examples to showcase the functionality of Pocket IO, or the user can develop their own sketches.