Title	***AN-85 InnoSwitch™3-Pro Master Debugger User's Guide***
Author	Applications Engineering Department
Date	June 6, 2019
Revision	1.0 - Beta

Summary

This application note describes the use of a tool made using an Arduino-UNO and an LCD Display shield which enabled evaluation of the power stage made using InnoSwitch3-Pro.

Information presented in this application note was used to develop the firmware for Arduino UNO and DFROBOT LCD keypad Shield.

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1 Introduction

This demo application runs on Reference Design RDK-641 (Figure 1) and Arduino UNO Rev3 SMD Board (Figure 2) and DFROBOT LCD Keypad shield v2.0 (Figure 3). The SDA, SCL and GND wires coming from the Arduino board needs to be connected to the RDK641 SDA, SCL and GND test points. Arduino board needs to be powered using external adapter.

Figure 1 – RDK-641 Board

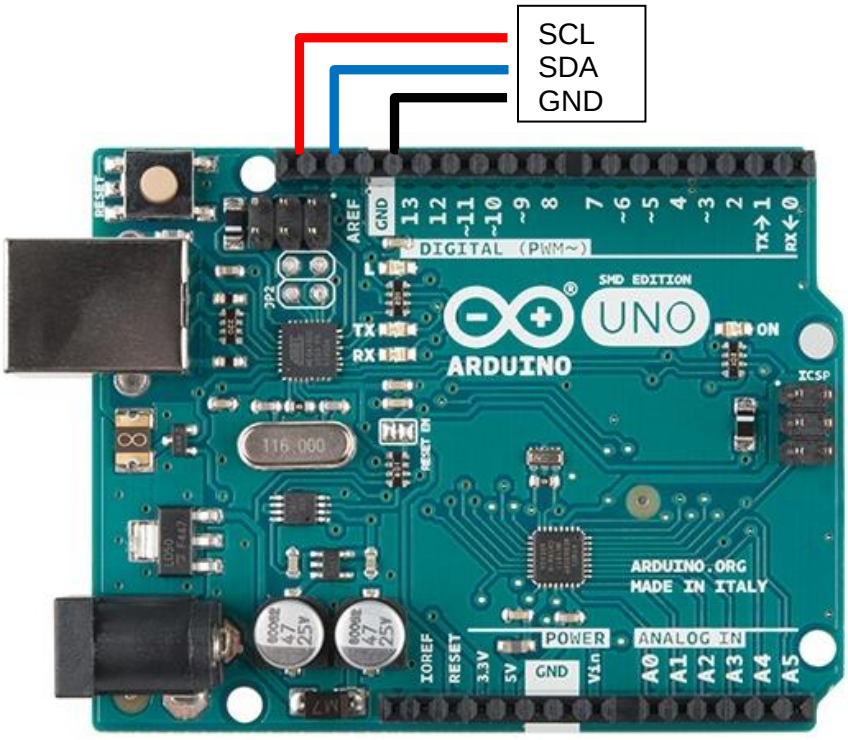

Figure 2 – Arduino UNO Rev3 SMD Board

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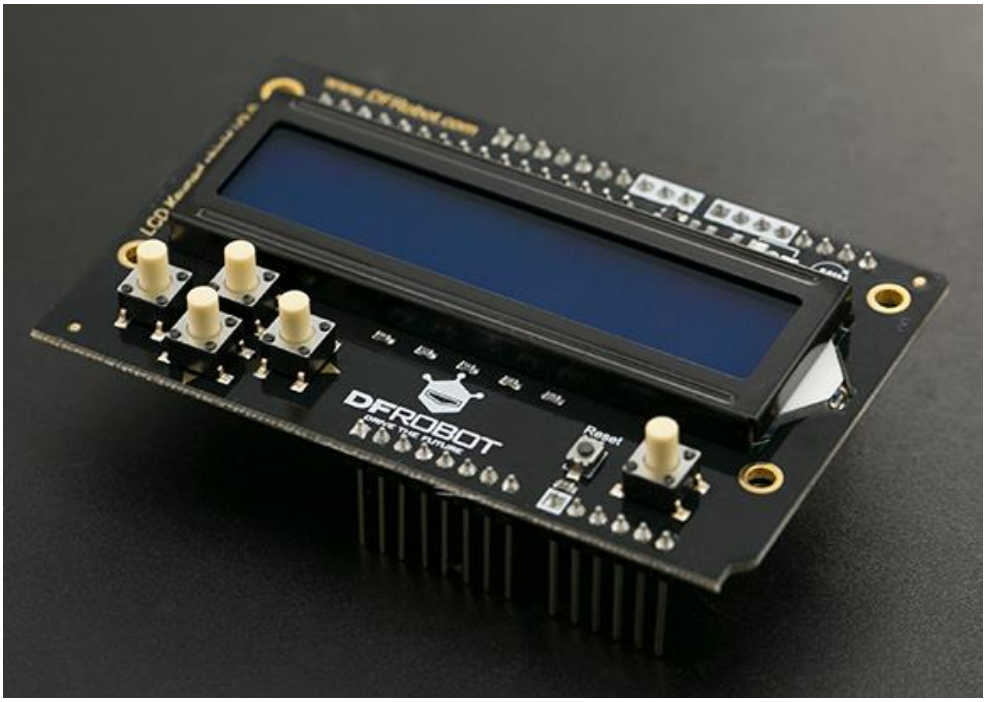

Figure 3 – DFROBOT LCD Keypad Shield V2.0

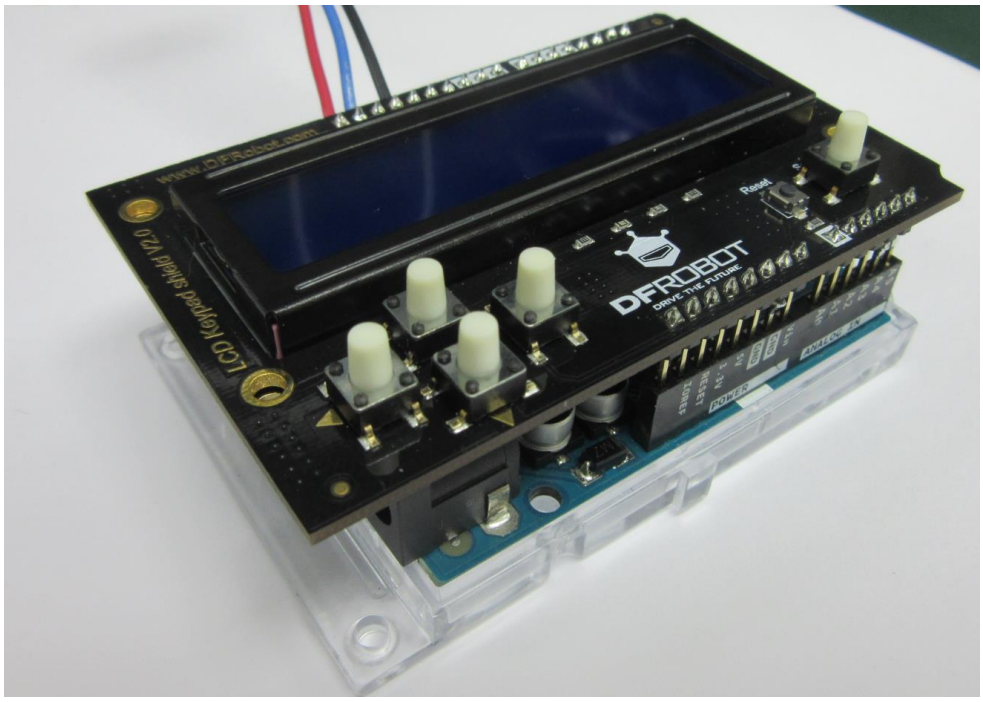

Figure 4 – DFROBOT LCD Keypad Shield V2.0 Connected to Arduino Uno

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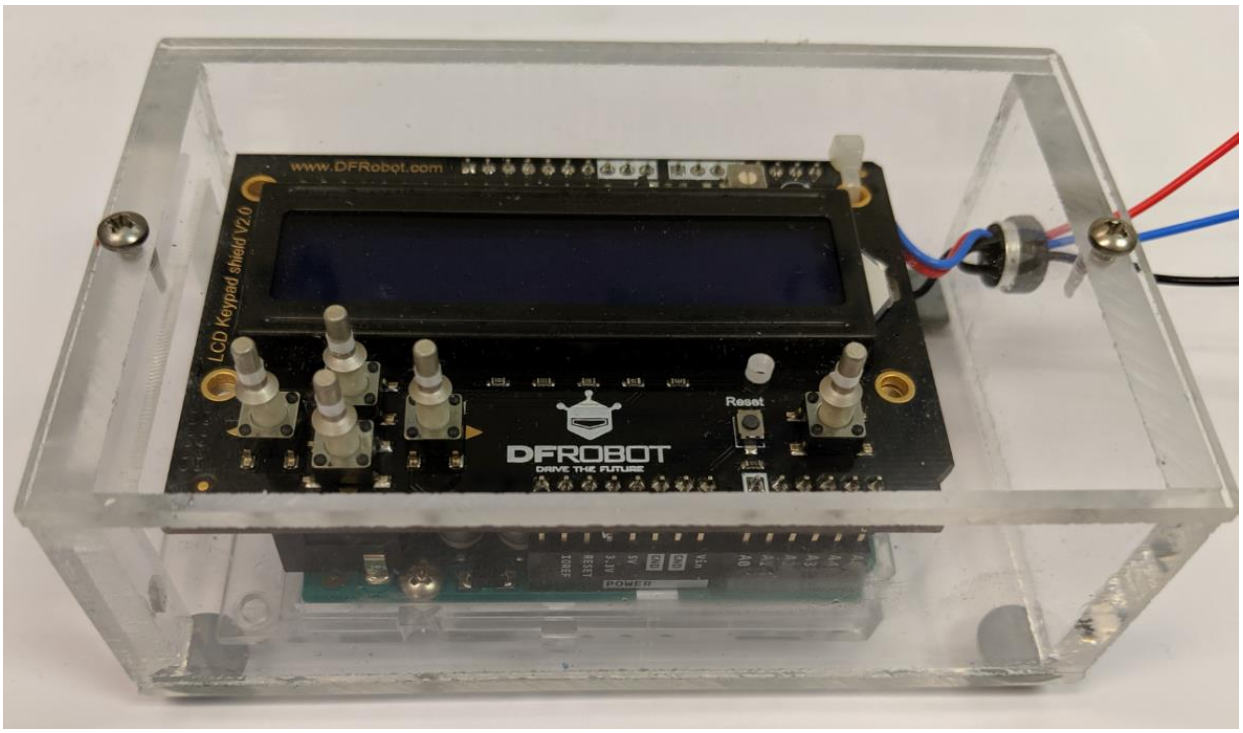

Figure 5– Completely assembled unit inside an enclosure

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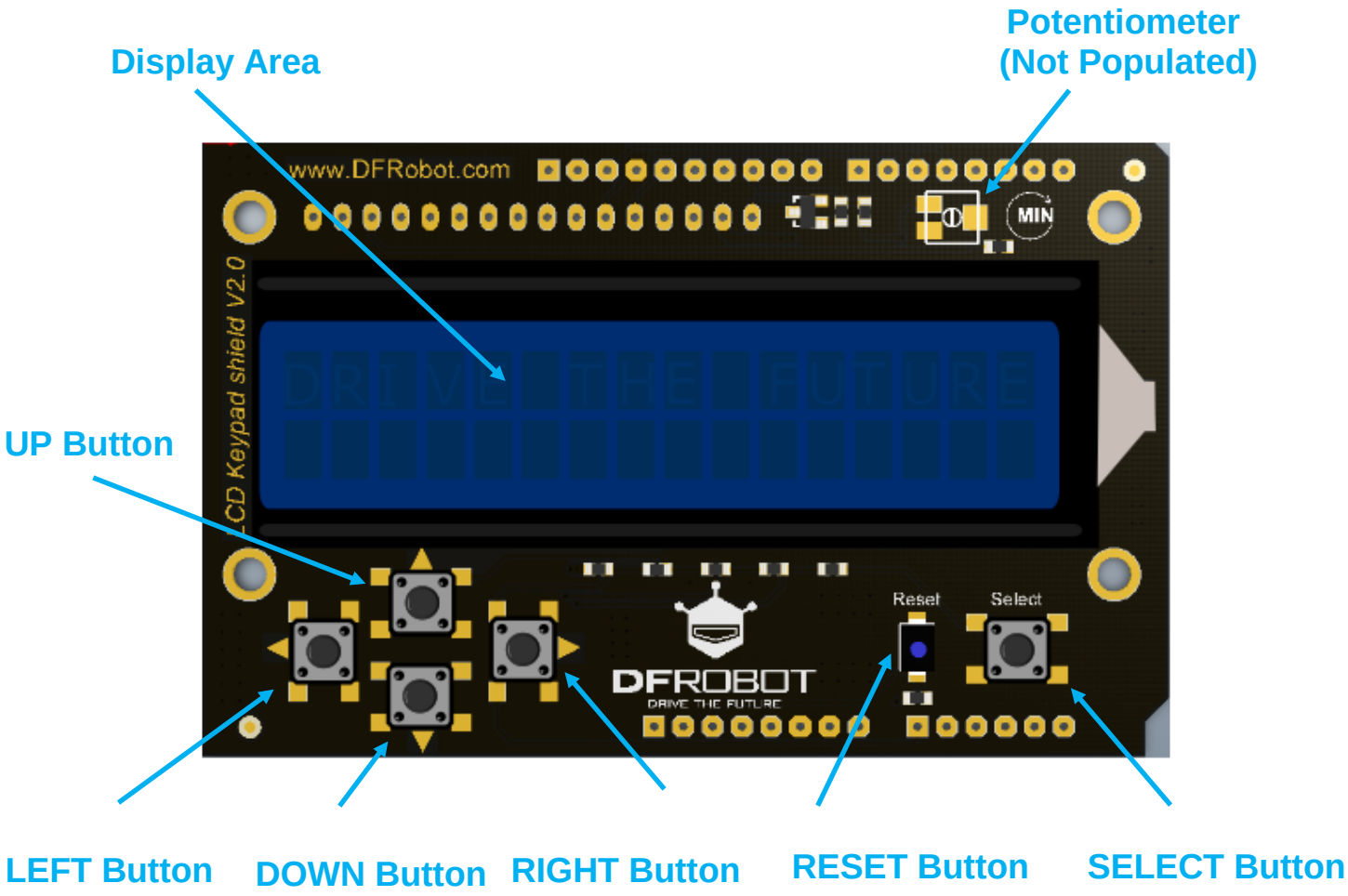
2 Hardware Overview

2.1 *LCD Keypad Shield Overview*

The LCD Keypad Shield V2.0 is a 2 line, 16 characters Arduino LCD display expansion shield. The shield consist of 6 input buttons: 1 menu select button, 4 control buttons and 1 small reset Button. This shield is perfect for stand-alone project with its own user interface.



The following documents are available as reference

https://www.dfrobot.com/wiki/index.php/LCD_Keypad_Shield_V2.0_SKU:_DFR0374

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2.2 *Buttons Mapping*

For this application, the buttons have different functions in different display menus. The mapping function descriptions are described on the table below:

BUTTON	Function
UP	Menu Scroll Up , Increment Numbers
DOWN	Menu Scroll Down, Decrement Numbers
LEFT	Not Used
RIGHT/ EXIT	Exit Menu or Return
SELECT/ENTER	Select Menu , Enter
RESET	Reset Arduino and LCD

3 LCD Menu Operation

This section explains each control and the information displays on the LCD.

3.1 *Start Up Operation*

Welcome messages appear as initial display. Each message will be displayed At a duration of 2.5 seconds.

1st welcome message

```
InnoSwitch3-Pro
Master Debugger
```

2nd welcome message

```
Beta Version
COPYRIGHT 2018
```

It is expected that before powering up the tool, that I2C communication is working and RDK-641 provides the pull up voltage to the I2C bus. If RDK-641 is not active a failure of the I2C communication is expected and this will result a failure message as shown below. If the below message does not show up then there is possibility for the SDA or SCL line to be shorted to GND.

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```
I2C Comms Error!
Check Connection
```

When I2C communication becomes active, main menu will be activated. After welcome messages, the main menu will be displayed.

```
→1 On/Off CMDS
 2 Thresholds
```

3.2 *Main menu*

InnoSwitch3-Pro registers are grouped together according to functionality.

The following options under Main Menu are available:

Item	Menu	Function	Description
1	On/Off CMDS	On and Off Commands	Registers that can be Enabled or disabled
2	Thresholds	Thresholds	Contains Threshold and Set point adjustments
3	Fault Respons	Fault Response	Contains Response and Timing related registers
4	Telemetry	Telemetry	Read back Registers
5	Eeprom Config	EEPROM Configurations	Saving of user inputs to EEPROM
6	FW Version	Firmware Version	Current Code Revision

- How to browse the **MAIN menu**
  - Press [UP] or [DOWN] , Arrow Indicator [→] shows the selection
  - Press [SELECT] , The selected option will be activated

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3.3 *On/Off Commands*

The following options under “On/Off Commands Menu” are available

Item	Menu	Function	Range	Default
1	VBEN	Series Bus Switch	ON/OFF	OFF
2	BLEEDER	Activate Bleeder Function	ON/OFF	OFF
3	VDIS	Load Discharge	ON/OFF	OFF
4	PSU-OFF	Latch-off Device	ON/OFF	OFF
5	FAST VI	Speed of CV/CC Update	ON/OFF	ON
6	CVO	Constant-Voltage Only	ON/OFF	OFF

- How to turn on VBEN (Series Bus Switch)
  - After entering **On/Off CMDS** menu
  - Press [UP] or [DOWN] until Arrow Indicator [>] is placed on VBEN

```
→1 VBEN     OFF
```

  - Press [SELECT] , Colon Indicator [:] shows that VBEN can now be adjusted

```
→1 VBEN    :OFF
```

  - Press [UP] or [DOWN] to change the parameter configuration. The command value gets executed right away
  - Press [EXIT] or [SELECT] to stop allowing any more changes to the value
  - Press [EXIT] to come back to the main menu

Notes: Enabling the VBEN register automatically disables the VDIS register
Enabling the VDIS register will automatically disable the VBEN

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3.4 *Thresholds*

The following options under “Thresholds Menu” are available

Item	Menu	Function	Range	Default	Default Tuning	Fine Tuning
1	Rs	Current Sense Resitor	1 ~ 20 mOhm	5.25 mOhm	1 mOhm	0.01 mOhm
2	CV	Output Voltage	3 ~ 24 V	5 V	1 V	20 mV
3	OVA	Overvoltage Threshold	6.2 ~ 25 V	6.2 V	1 V	100 mV
4	UVA	Undervoltage Threshold	3 ~ 24 V	3.6 V	1 V	100 mV
5	CDC	Cable Drop Compensation	0 ~ 600 mV	0 V	50 mV	50 mV
6	CC	Constant Current Regulation	25 ~ 128 LSB	128 V	5 LSB	1 LSB
7	VKP	Constant Output Power Knee Voltage	5.3 ~ 24 V	24 V	1 V	100 mV

- How to Adjust Output Voltage (CV) by default tuning
  - After entering **Thresholds** menu
  - Press [UP] or [DOWN] until Arrow Indicator [→] is placed on CV
  - Press [SELECT] , Colon Indicator [:] shows that CV can now be adjusted with Default Tuning of 1V

```
→2 CV   :5.00 V
```

  - Press [UP] or [DOWN] to adjust CV by 1V
    - User can HOLD [UP] or [DOWN] keys to make faster adjustments
  - Press [EXIT] to save the settings and stop allowing anymore changes
  - Press [EXIT] to come back to the main menu

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- How to Adjust Output Voltage (CV) by fine tuning

  - After entering **Thresholds** menu
  - Press [UP] or [DOWN] until Arrow Indicator [→] is placed on CV
  - Press [SELECT] , Colon Indicator [:] will appear

```
→2 CV  :5.00 V
```

  - Again, Press [SELECT]
    - Arrow Indicator [>] beside the number, indicates Fine Tuning of 20mV

```
→2 CV  >5.02 V
```

  - Press [UP] or [DOWN] to adjust CV by 20mV
    - User can HOLD [UP] or [DOWN] keys to make faster adjustments
  - Press [EXIT] or [SELECT] to save the settings and stop allowing anymore changes
  - Press [EXIT] to come back to the main menu

Note: On Adjusting Output voltage, make sure Overvoltage and Under voltage are already adjusted so it will not trigger a fault

- How to Adjust Current Sense Resistor value (Rs)

  - After entering **Thresholds** menu
  - Press [UP] or [DOWN] until Arrow Indicator [→] is placed on Rs
  - Press [SELECT] , Colon Indicator [:] shows that CV can now be adjusted with Default Tuning of 1mOhm

```
→1 Rs :5.26 mOhm
```

  - Press [UP] or [DOWN] to adjust Rs by 1 mOhm
    - User can HOLD [UP] or [DOWN] keys to make faster adjustments
  - Press [EXIT] to save the settings and stop allowing anymore changes
  - Press [EXIT] to come back to the main menu

Note: Failure to update the correct Current Sense resistor value the same with what is connected on the InnoSwitch3-Pro will result to inaccuracy of Average Current (AVG A) and Measured Current Readings (CURR) on telemetry menu

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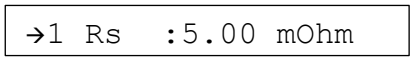
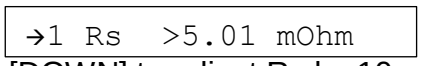
- How to Adjust Current Sense Resistor value (Rs) by fine tuning

  - After entering **Thresholds** menu
  - Press [UP] or [DOWN] until Arrow Indicator [→] is placed on Rs
  - Press [SELECT] , Colon Indicator [:] will appear



  - Again, Press [SELECT]
    - Arrow Indicator [>] beside the number, indicates Fine Tuning of 10mOhm



  - Press [UP] or [DOWN] to adjust Rs by 10mOhm
    - User can HOLD [UP] or [DOWN] keys to make faster adjustments
  - Press [EXIT] or [SELECT] to save the settings and stop allowing anymore change
  - Press [EXIT] to come back to the main menu

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3.5 *Fault Response*

The following options under “Fault Response Menu” are available

Item	Menu	Function	Range	Default
1	OVL	Overvoltage Fault Response	NR – No Response LO – Latch Off AR – Auto-Restart	AR
2	UVL	Undervoltage Fault Response	NR – No Response LO – Latch Off AR – Auto-Restart	AR
3	ISSC	IS-pin Short Fault Response	NR – No Response LO – Latch Off AR – Auto-Restart	NR
4	ISSCfrq	IS-pin Short Detection Frequency	50Khz/30Khz/ 40Khz/60Khz	50Khz
5	UVL TMR	UVL Fault Timer	8ms/16ms/ 32ms/64ms	64ms
6	WATCHDOG	Communication Rate Monitor	OFF/0.5s/1s/2s	OFF
7	CVOL	Constant Voltage Mode Fault Response	NR – No Response LO – Latch Off AR – Auto-Restart	NR
8	CVOL TMR	Constant Voltage Fault Timer	8ms/16ms/ 32ms/64ms	8ms
9	OTP	Secondary Over-Temperature Fault Hysteresis	40 deg/ 60 deg	40 deg

- How to Adjust UVL (Under Voltage Fault Response) to NR (No Response)
  - After entering **Fault Response** menu
  - Press [UP] or [DOWN] until Arrow Indicator [→] is placed on UVL
  - Press [SELECT] , Colon Indicator [:] shows that UVL can now be adjusted

    ```
    →2 UVL   :AR
    ```

  - Press [UP] or [DOWN] to set the parameter to NR
  - Press [EXIT] or [SELECT] to save the settings and stop allowing anymore change
  - Press [EXIT] to come back to the main menu

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3.6 *Telemetry*

The following options under “Telemetry” are available. These are updated live.

Item	Menu	Function
1	AVG V	Average Output Voltage
2	AVG A	Average Output Current
3	VOLT	Measured Output Voltage
4	CURR	Measured Output Current
5	CV SP	Output Voltage Set-Point
6	CC SP	Constant Current Set-Point
7	VKP SP	Constant Power Threshold
8	OV THR	Overvoltage Threshold
9	UV THR	Undervoltage Threshold
10	CDC SP	Cable Drop Compensation Set-Point

- Press [EXIT] to come back to the main menu

3.7 *EEPROM Configuration*

The following options under “Eeprom Config Menu” are available

Item	Menu	Function
1	Save Config 1	Save the current configuration settings to EEPROM
2	Load Config 1	Load the previously saved configuration Settings
3	Load Default	Load the default EEPROM configuration Settings

Eeprom Configurations when activated automatically replaces the values on the threshold settings.

- How to Save to EEPROM (`Save Config 1`)
  - After entering **Eeprom Config** menu
  - Press [UP] or [DOWN] until Arrow Indicator [→] is placed on Save Config 1
  - Press [SELECT], message confirmation will show.

```
Eeprom Saving
Successful!
```

  - Press [EXIT] to come back to the main menu

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- How to Load to previously saved EEPROM values(`Load Config 1`)

  - After entering **Eeprom Config** menu
  - Press [UP] or [DOWN] until Arrow Indicator [→] is placed on Load Config 1
  - Press [SELECT], message confirmation will show.

```
New Config
Loaded!
```

  - Press [EXIT] to come back to the main menu

- How to Load to Default EEPROM values(`Load Default`)

  - After entering **Eeprom Config** menu
  - Press [UP] or [DOWN] until Arrow Indicator [→] is placed on Load Default
  - Press [SELECT], message confirmation will show.

```
Loaded Default
Configurations!
```

  - Press [EXIT] to come back to the main menu

3.8 *FW Version*

The following display will show when **FW Version** menu is activated

```
 v00.01.00 - Beta
www.power.com
```

The current Firmware is still on beta, firmware update maybe implemented on the next firmware revision.

- How to Exit FW Version

  - After entering **FW Version** menu
  - Press [EXIT] or [SELECT] to come back to the main menu

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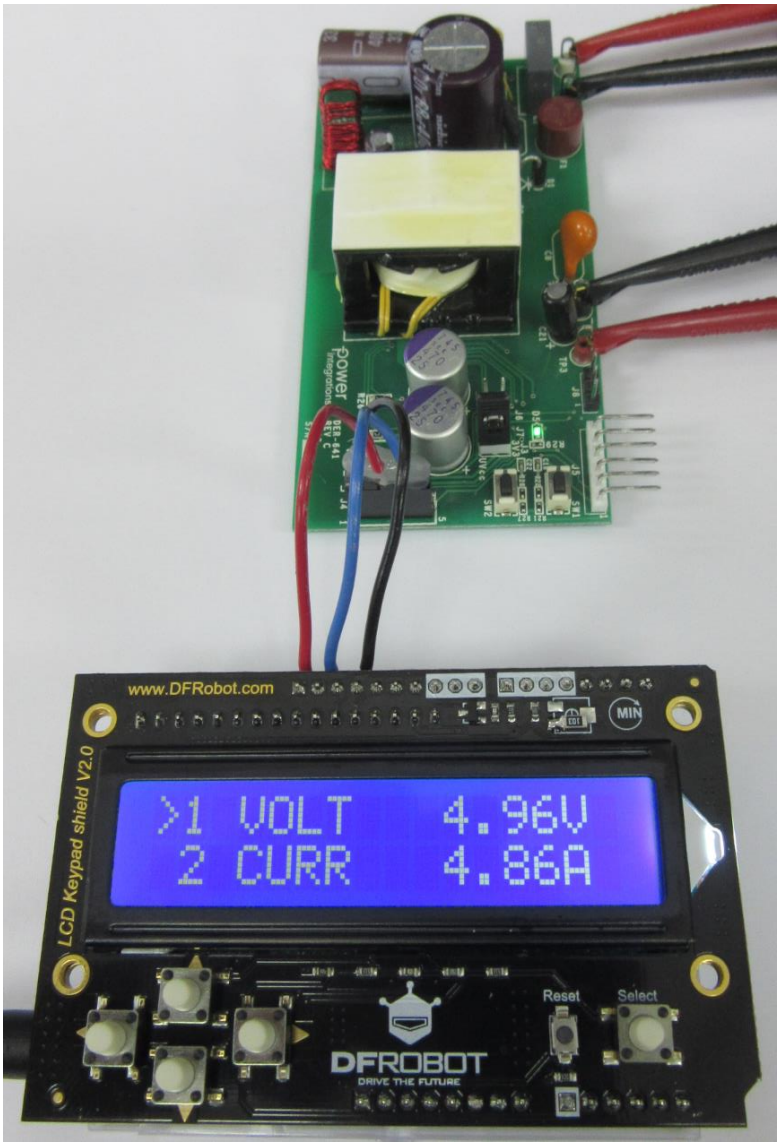
4 Demonstration of Operation

4.1 Running the Program

This section demonstrates the actual operation of the tool. Upon power up, the main menu is displayed and then 5V setting is applied on the LCD menu.

100VAC was applied to the AC input terminals and output terminals were connected to a Chroma DC electronic load. Arduino Uno board power is coming from an external adapter. Make sure the power supply under test doesn't have any external controller giving commands to the InnoSwitch3-Pro IC.

Image below shows the measured voltage and current.



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5 Building your own master debugger unit

5.1 *System Requirements*

The following are required to run this InnoSwitch3-Pro Arduino demo application

- Arduino Software version 1.8.2 or later
- Arduino UNO Rev3 SMD
- RDK – 641 Board rev C
- InnoSwitch3-Pro Arduino Library version 1.1.0 or Later
- DFROBOT LCD Keypad Shield V2.0

5.2 *Hardware modification*

A newly bought LCD shield has the display contrast set to minimum thus the actual display is hard to read, and since there is no potentiometer on the shield it is not possible to adjust the contrast.

A hardware modification is suggested to set the contrast to an acceptable setting.
This is done by adding a 10K SMD resistor (1210) in place of the potentiometer as shown below.

Add 4.7K Ohm pull up resistors on the I2C bus, each connected to SDA and SCL as shown on image below.

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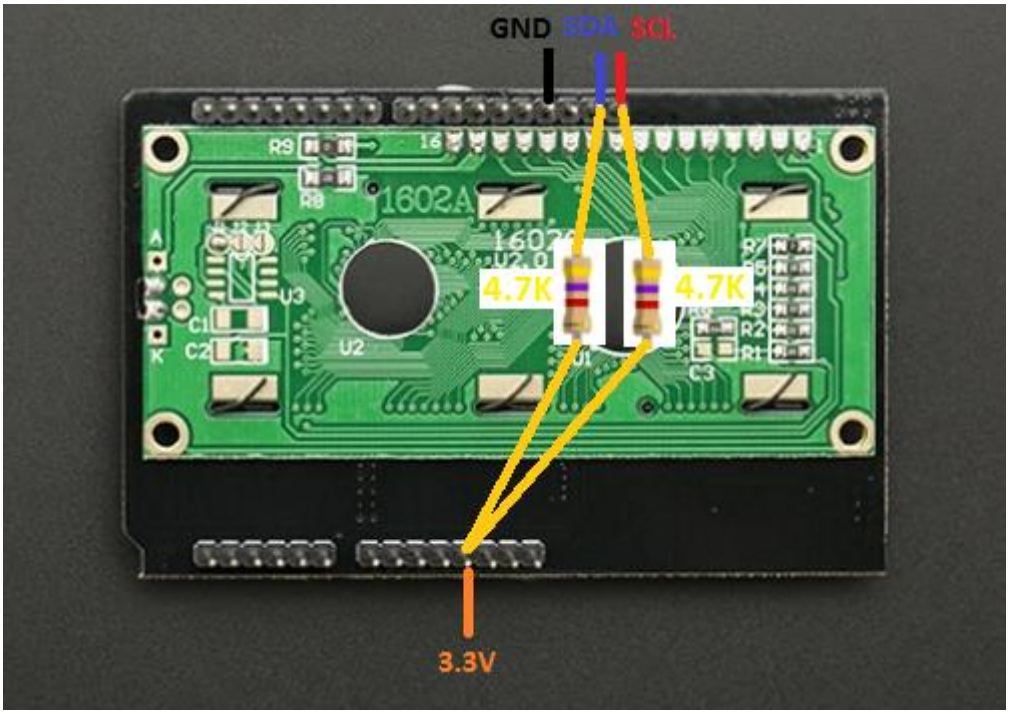

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5.3 *Open Source Arduino Libraries*

This demo application uses various open source materials available as Arduino libraries. Download and Install the following libraries.

- **InnoSwitch3-Pro Arduino Library**
  Author: Power Integrations

  https://ac-dc.power.com/design-support/articles/innoswitch3-pro-code-library-api-arduino/

  - New "InnoSwitch3-Pro_Arduino_v01.01.00_r1427.zip"
    - This was updated in order to combine InnoSwitch3-Pro Arduino library with other existing Arduino Libraries
  - **Note:** To avoid conflict, Make sure to delete the old one If already installed

- **Arduino Menu 4 Library**
  Author: Rui Azevedo
  Email: ruihfazevedo(@rrob@)gmail.com

  https://github.com/neu-rah/ArduinoMenu

- **LCD Keypad Shield Library - LCD count down timer**
  Author: Cohesive Computing

  http://www.cohesivecomputing.co.uk/hackatronics/arduino-lcd-menu-library/

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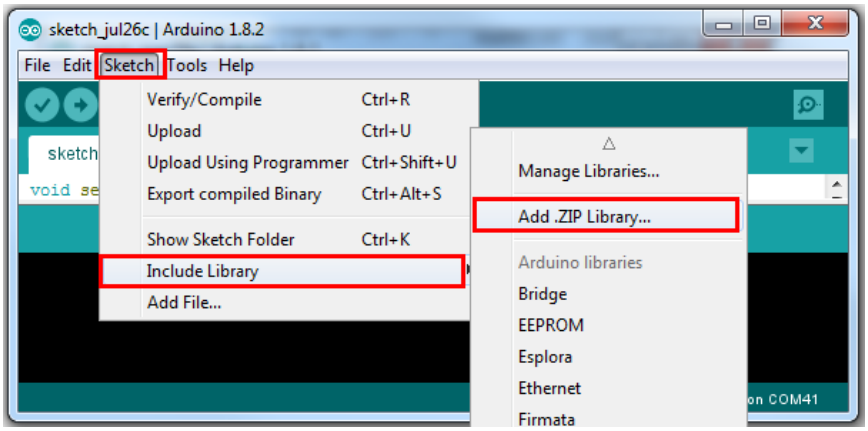
5.4 *Library Installation*

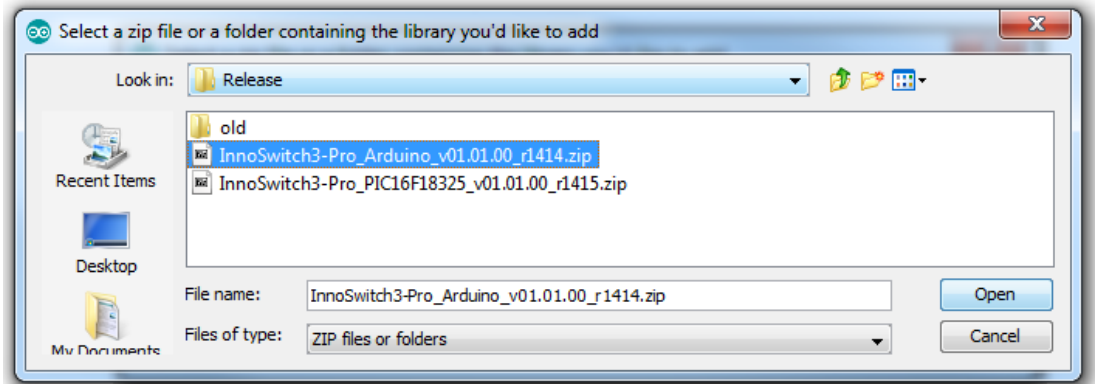
Full installation guide can be found on the link below
https://www.arduino.cc/en/Guide/Libraries

The RDK641 doesn't need to be connected to Arduino at this stage. The Arduino needs to be only connected to the laptop.

In the Arduino IDE, navigate to *Sketch > Include Library > Add .ZIP Library*. At the top of the drop down list, select the option to "Add .ZIP Library".



Navigate to the .zip file's location and open it.



Repeat the process to install all the other libraries.

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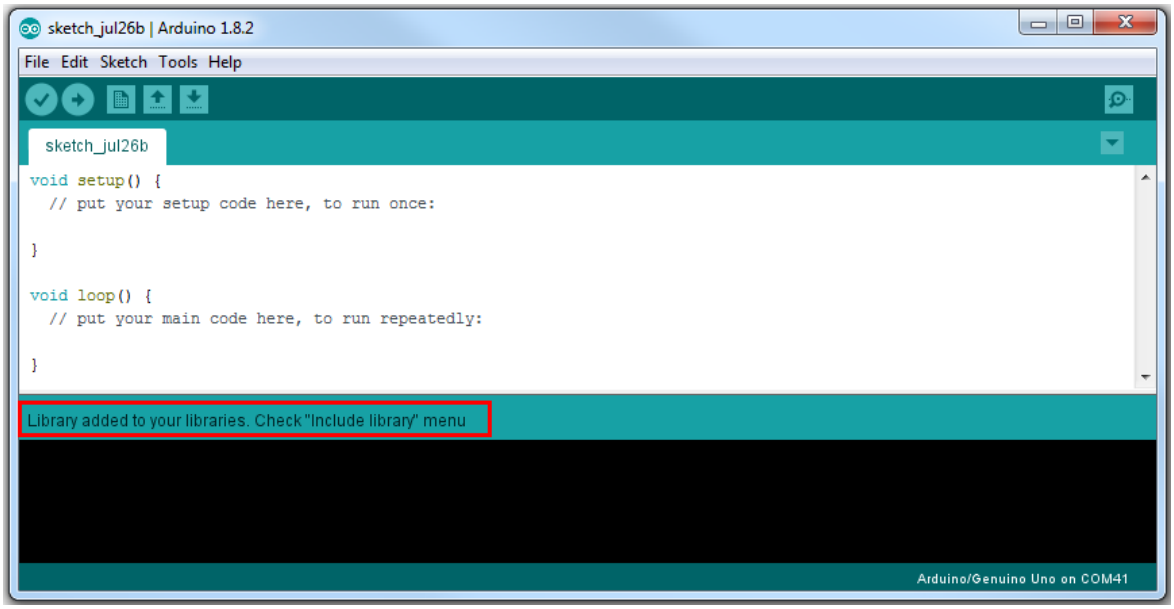
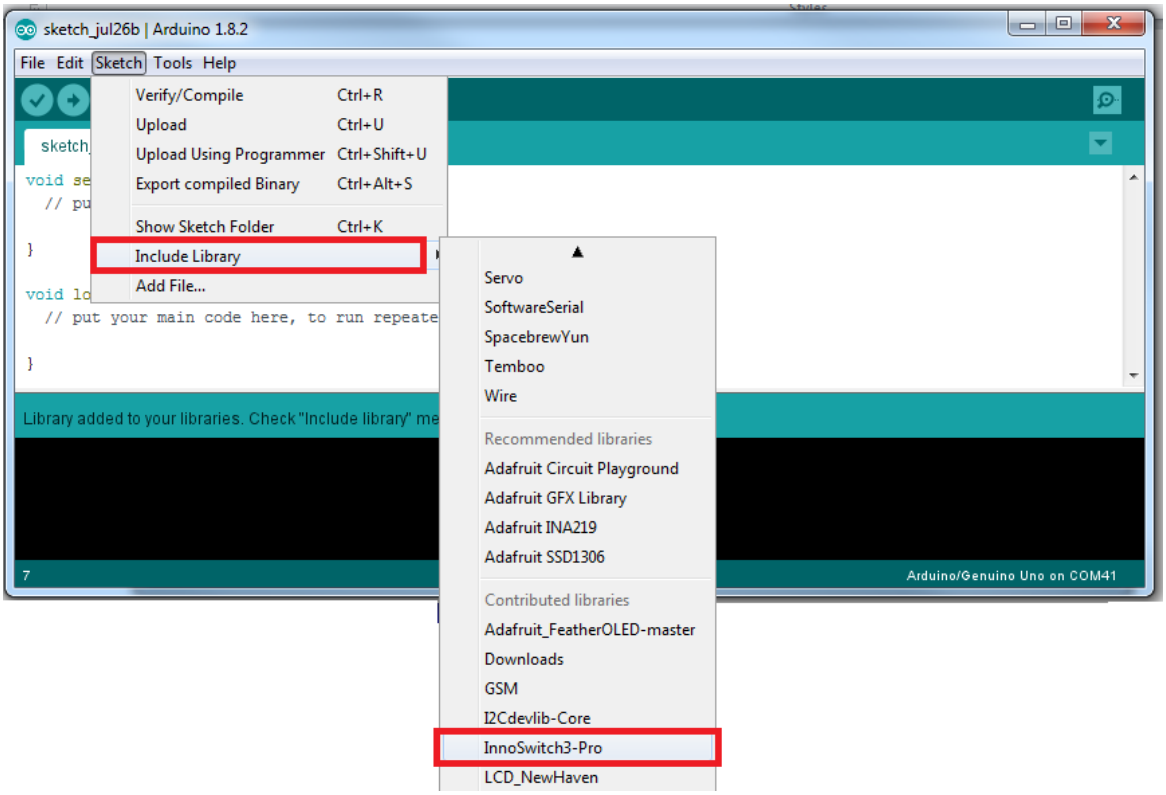
5.5 Library Installation Complete

Images below shows the InnoSwitch3-Pro library was added to the Arduino Library





For windows users, the library can be viewed on this directory:

- C:\Users\username\Documents\Arduino\libraries\

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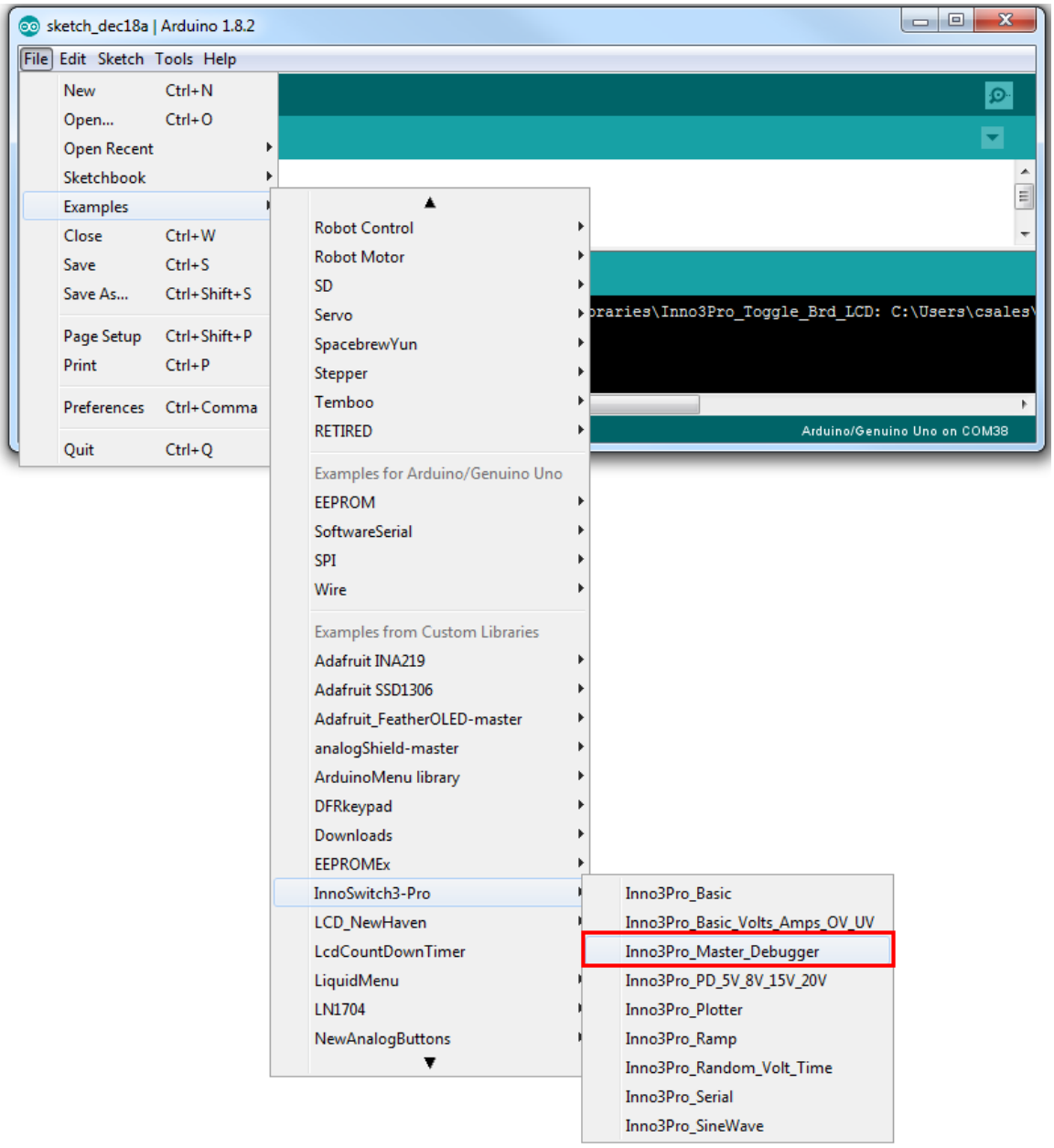
5.6 **Library Examples**

The Library will be available to use in sketches, *File > Examples*



Select “Inno3Pro_Master_Debugger” Example.

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5.7 *Firmware Configuration Update*

For the InnoSwitch3-Pro Master Debugger example, the Constant Current Regulation is Adjusted in terms of LSB resolution (Range: 25 to 128). This adjustment needs an update on the computations under configuration parameters on “Inno3ProConfig.h” file.

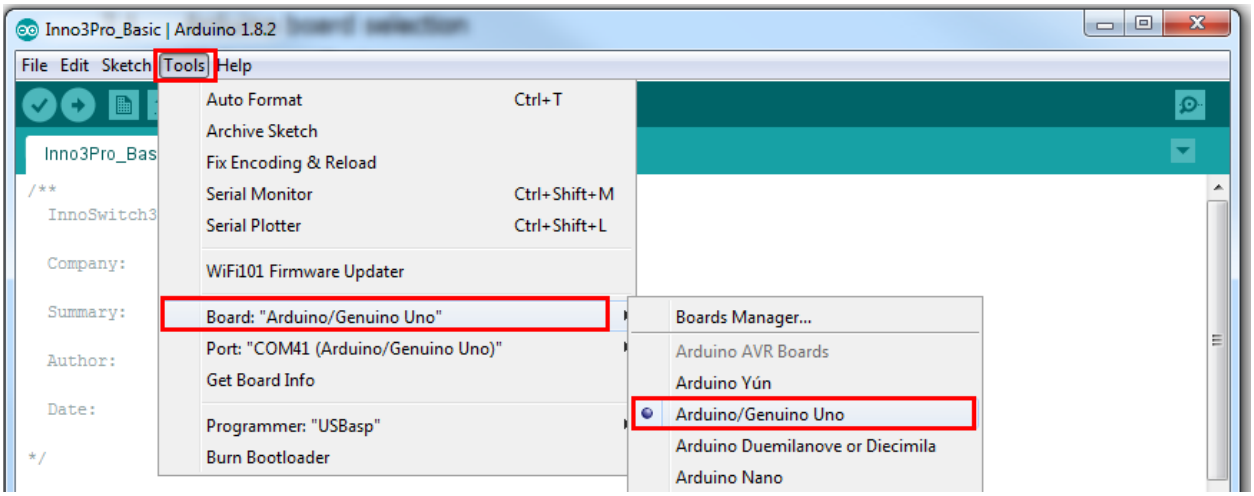
As shown below, Change CC Set Point to 1:

```
/**  CC Set Point Computation: */
#define INNO3PRO_CC_SET_PT_MULT                    (float)(1)
```

5.8 *Building and Compiling the Project*

5.8.1 Arduino board selection

- Under tools menu, Select Arduino UNO board
- Make sure your Arduino Uno is already connected to your computer through the USB port



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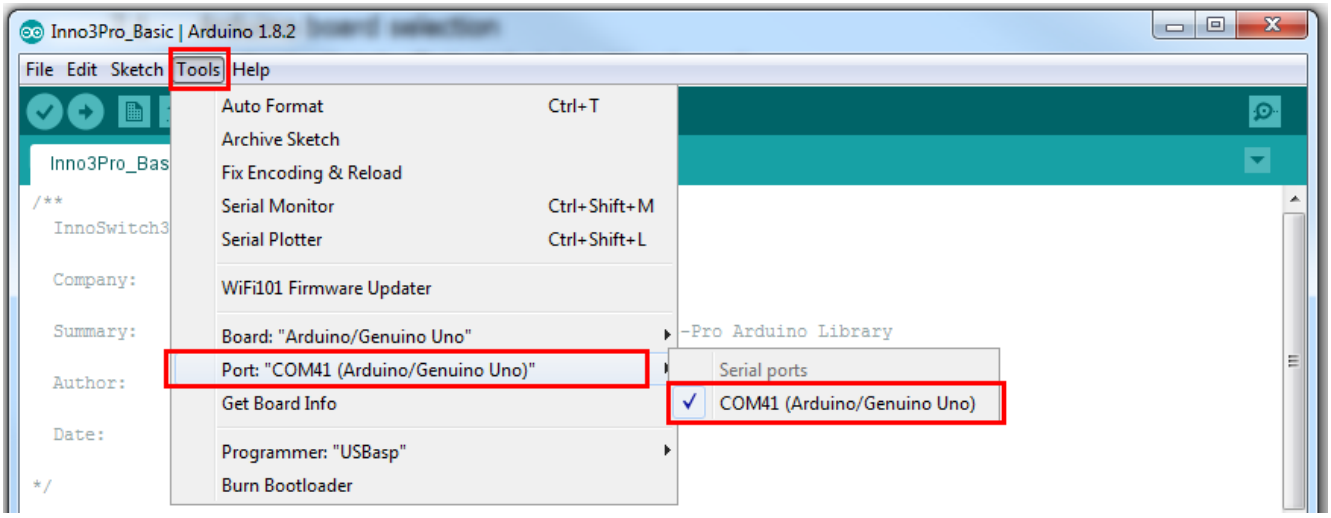
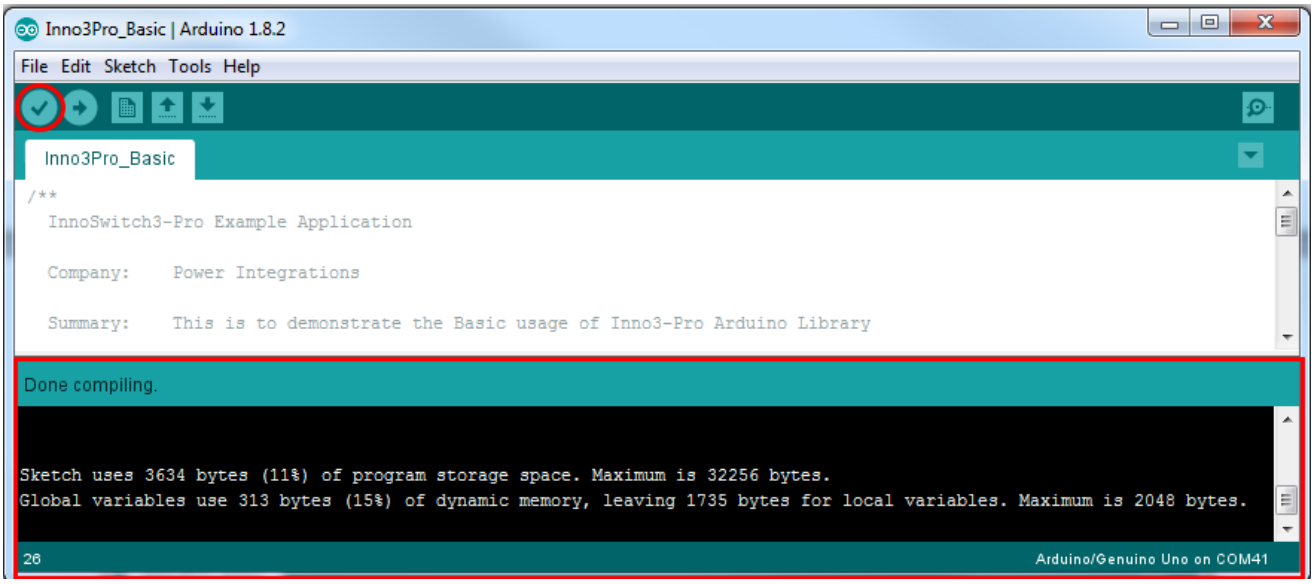
5.8.2 Select the Active Communication Port

- Under tools menu, Select the correct port
- For Arduino UNO, the name will appear next to the serial port



5.8.3 Verify / Compile

- Click the check icon to Verify
- After few seconds , “Done Compiling” should show up on the Notification Area
  This means the sketch is ready for uploading to the Arduino board



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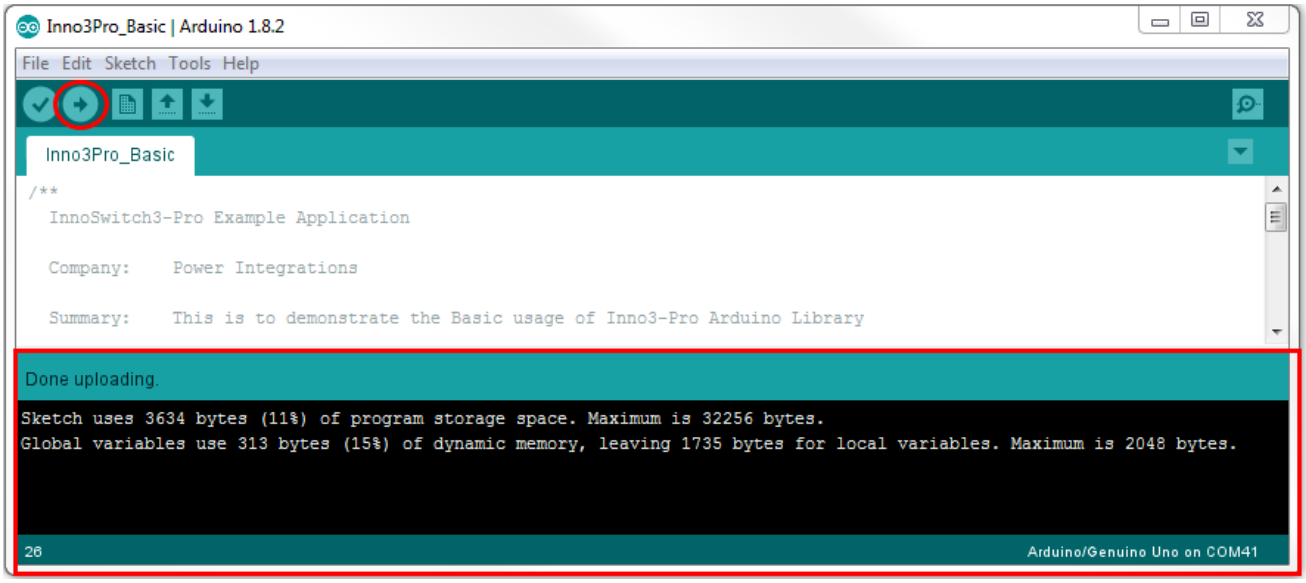
5.8.4 Upload

- Click the Arrow icon to Upload
- After few seconds , “Done Uploading” should show up on the Notification Area This means the upload was successful



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Tel: +1 408 414 9200 Fax: +1 408 414 9201
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6 Revision History

Date	Author	Revision	Description & changes	Reviewed
06-June-19	CS,AP	1.0	Beta	Apps and Mktg

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Tel: +1 408 414 9200 Fax: +1 408 414 9201
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Power Integrations Worldwide Sales Support Locations

WORLD HEADQUARTERS
5245 Hellyer Avenue
San Jose, CA 95138, USA.
Main: +1-408-414-9200
Customer Service:
Phone: +1-408-414-9665
Fax: +1-408-414-9765
e-mail: usasales@power.com

GERMANY (IGBT Driver Sales)
HellwegForum 1
59469 Ense, Germany
Tel: +49-2938-64-39990
Email: igbt-driver.sales@power.com

CHINA (SHANGHAI)
Rm 2410, Charity Plaza, No. 88,
North Caoxi Road,
Shanghai, PRC 200030
Phone: +86-21-6354-6323
Fax: +86-21-6354-6325
e-mail: chinasales@power.com

INDIA
#1, 14th Main Road
Vasanthanagar
Bangalore-560052
India
Phone: +91-80-4113-8020
Fax: +91-80-4113-8023
e-mail: indiasales@power.com

CHINA (SHENZHEN)
17/F, Hivac Building, No. 2, Keji Nan
8th Road, Nanshan District,
Shenzhen, China, 518057
Phone: +86-755-8672-8689
Fax: +86-755-8672-8690
e-mail: chinasales@power.com

ITALY
Via Milanese 20, 3rd. Fl.
20099 Sesto San Giovanni (MI) Italy
Phone: +39-024-550-8701
Fax: +39-028-928-6009
e-mail: eurosales@power.com

GERMANY (AC-DC/LED Sales)
Lindwurmstrasse 114
80337, Munich
Germany
Phone: +49-895-527-39110
Fax: +49-895-527-39200
e-mail: eurosales@power.com

JAPAN
Kosei Dai-3 Building
2-12-11, Shin-Yokohama,
Kohoku-ku, Yokohama-shi,
Kanagawa 222-0033
Japan
Phone: +81-45-471-1021
Fax: +81-45-471-3717
e-mail:
japansales@power.com

KOREA
RM 602, 6FL
Korea City Air Terminal B/D,
159-6
Samsung-Dong, Kangnam-Gu,
Seoul, 135-728 Korea
Phone: +82-2-2016-6610
Fax: +82-2-2016-6630
e-mail: koreasales@power.com

SINGAPORE
51 Newton Road,
#19-01/05 Goldhill Plaza
Singapore, 308900
Phone: +65-6358-2160
Fax: +65-6358-2015
e-mail:
singaporesales@power.com

TAIWAN
5F, No. 318, Nei Hu Rd.,
Sec. 1
Nei Hu District
Taipei 11493, Taiwan R.O.C.
Phone: +886-2-2659-4570
Fax: +886-2-2659-4550
e-mail: taiwansales@power.com

UK
Cambridge Semiconductor,
a Power Integrations company
Westbrook Centre, Block 5,
2nd Floor
Milton Road
Cambridge CB4 1YG
Phone: +44 (0) 1223-446483
e-mail: eurosales@power.com