Application Note AN-101
InnoSwitch4-Pro Master Debugger

Master Debugger Arduino Overview and Guide

Introduction

The application of InnoSwitch4-Pro Family Arduino Library is discussed in this document. This code was designed to be highly portable with different microcontroller platforms. The use of Arduino compatible C++ language will make it easy for users to understand and modify the code according to their needs. This guide will allow the user to get sufficient

knowledge on how to operate the devices with the use of a simple microcontroller such as Arduino. The microcontroller used is an **Arduino Mega 2560** to satisfy the memory requirement of the master debugger file. An Arduino Uno 's memory will not be enough for this application.

Hardware Overview

InnoSwitch4-Pro

This demo runs on a 65W Reference Design Board (DER-961). In order to use the Master Debugger, remove the short on J2, J4, and J6 headers on the DER 961 board to disconnect the I^{2}C lines of the PIC microcontroller. Connect the SDA, SCL, and GND pins of the Arduino to

the J3 header to allow the Arduino to communicate to the InnoSwitch4-Pro through I^{2}C. The master debugger is also designed to work on the InnoSwitch3-Pro as long as the appropriate device is selected on the master debugger menu.
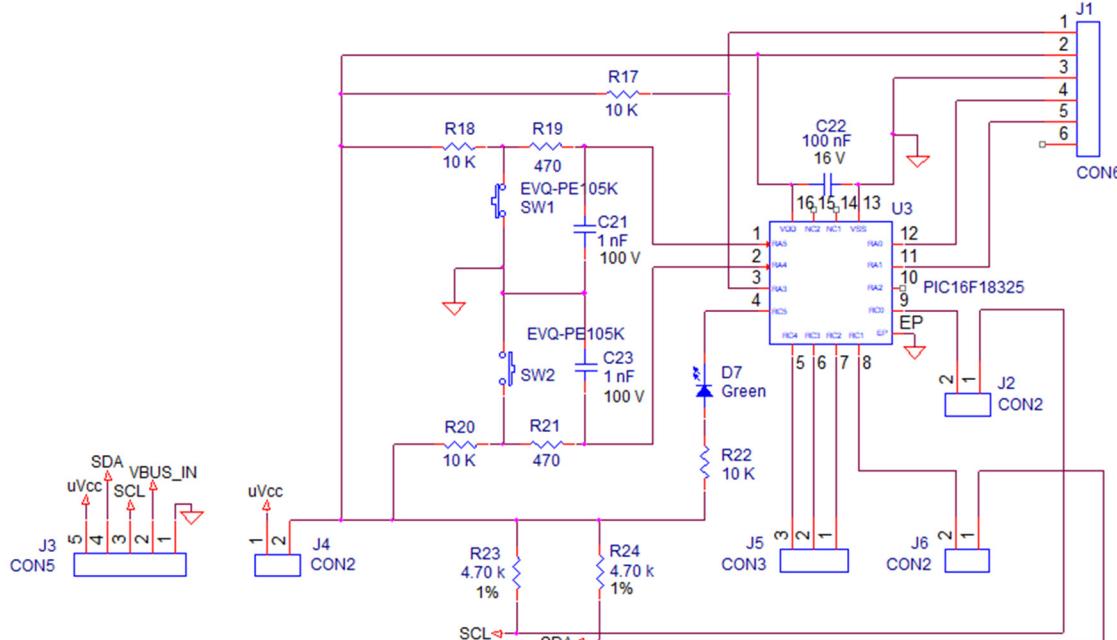

Figure 1. DER 961 Controller Schematic

LCD Keypad Shield Overview

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

https://www.dfrobot.com/wiki/index.php/LCD_Keypad_Shield_V2.0_SKU:_DFR0374
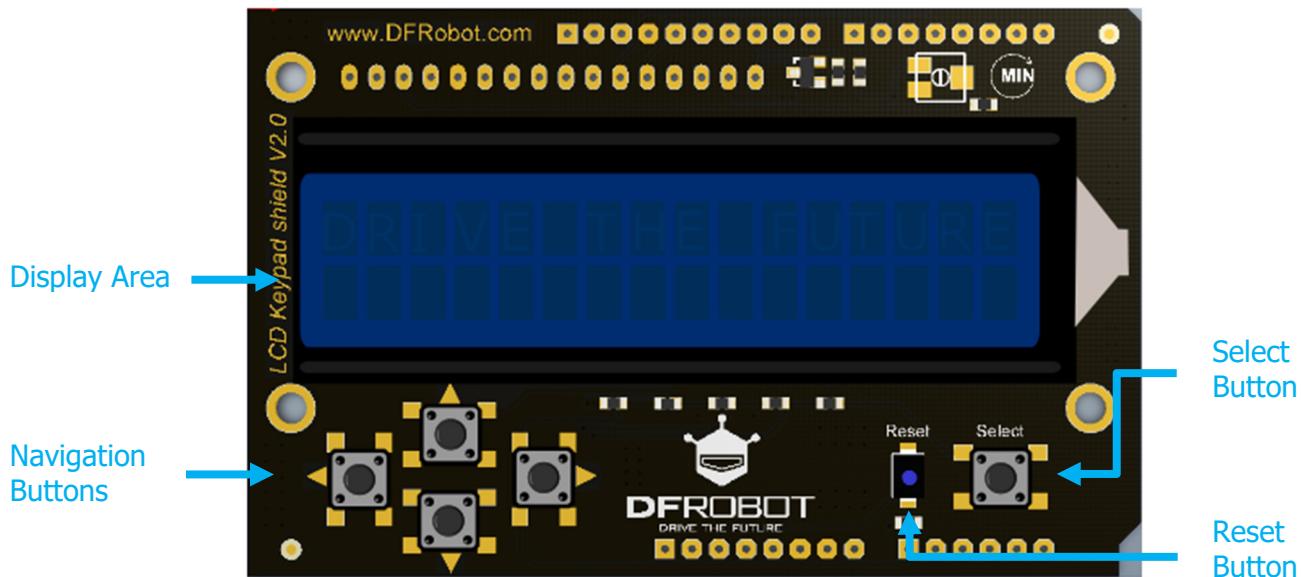
Figure 2. DFRobot LCD Shield

Button Mapping

The LCD display buttons are mapped a function described below:

Button	Function
UP	Menu Scroll Up, Increment Numbers
DOWN	Menu Scroll Down, Decrement Numbers
LEFT	Not Used
RIGHT	Exit Menu, Return
SELECT	Select Menu, Enter
RESET	Reset Arduino and LCD Keypad

Table 1. DFRobot Button Mapping

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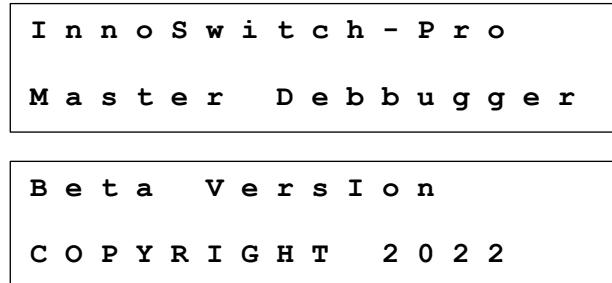
Master Debugger Operation

This section explains each control and the information displays on the LCD. To browse through the menu:
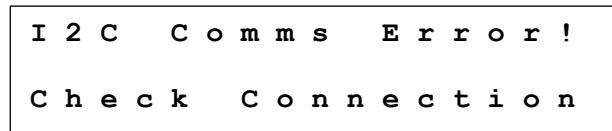
o   Press **[UP]** or **[DOWN]:** Arrow Indicator **[→]** shows the selection
o   Press **[SELECT]:** The selected option will be activated

Start-up Operation
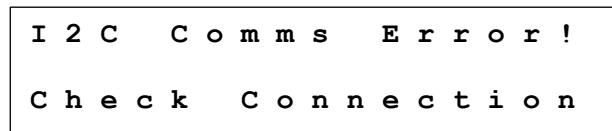
Welcome messages appear for a brief period during initialization.

```
InnoSwitch-Pro

Master  Debbugger
```

```
Beta  VersIon

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```

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.

```
I2C  Comms  Error!

Check  Connection
```

When I^{2}C communication becomes active, main menu will be activated. After the welcome messages, the main menu will be displayed.

```
I2C  Comms  Error!

Check  Connection
```

Main Menu

The initial menu will ask for what InnoSwitch-Pro family device is used. Select on InnoSwitch3-Pro option to continue to InnoSwitch3-Pro menu and registers. Select on InnoSwitch4-Pro option if the device being used is a InnoSwitch4-Pro.

```
→1Inno3Pro  Menu

→2Inno4Pro  Menu
```

The InnoSwitch3-Pro and InnoSwitch4-Pro registers are grouped together according to functionality. The InnoSwitch3-Pro and InnoSwitch4-Pro share the same main menu selections. These 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

On/Off Commands

The following options are under **On/Off Commands** Menu. InnoSwitch3-Pro and InnoSwitch4-Pro have minor differences in range of values for some registers.

InnoSwitch3-Pro

Item	Menu	Function	Range	Default
1	VBEN	Series Bus Switch	ON/OFF	OFF
2	BLEEDER	Activate Bleeder Functions	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

InnoSwitch4-Pro

Item	Menu	Function	Range	Default
1	VBEN	Series Bus Switch	ON/OFF RST/OFF NRST	OFF RST
2	BLEEDER	Activate Bleeder Functions	ON/ON AD/OFF	OFF
3	VDIS	Load Discharge	ON/ON NR/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

Example for InnoSwitch3-Pro:
How to turn on **VBEN** (Series Bus Switch):
- Press **[SELECT]** when the arrow indicator **[→]** is placed on On/Off CMDS

```
→ 1   O n / O f f   C M D S
  2   T h r e s h o l d s
```

- Press **[UP]** or **[DOWN]** until arrow indicator **[→]** is placed on VBEN

```
→ V B E N           O F F
```

- Press **[SELECT]**, the colon indicator **[:]** shows that VBEN can now be adjusted

```
→ V B E N           : O F F
```
or
```
→ V B E N           : O N
```

- 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

Example for InnoSwitch4-PRo:
How to turn on **VBEN** (Series Bus Switch):
- Press **[SELECT]** when the arrow indicator **[→]** is placed on On/Off CMDS

```
→ 1   O n / O f f   C M D S
  2   T h r e s h o l d s
```

- Press **[UP]** or **[DOWN]** until arrow indicator **[→]** is placed on VBEN

```
→ V B E N           O F F / R S
```

- Press **[SELECT]**, the colon indicator **[:]** shows that VBEN can now be adjusted

```
→ V B E N           : O F F / R S
```
or
```
→ V B E N           : O N
```

- 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

Thresholds

The following options are under **Thresholds** Menu. InnoSwitch3-Pro and InnoSwitch4-Pro have some minor differences in range of values.

InnoSwitch3-Pro

Item	Menu	Function	Range	Default	Default Tuning	Fine Tuning
1	Rs	Current Sense Resistor	1 ~ 20 mOhm	5.25 mOhm	1 mOhm	0.01 mOhm
2	CV	Output Voltage	3 ~ 24 V	5V	1 V	20 mV
3	OVA	Over Voltage Threshold	6.2 ~ 25 V	6.2V	1 V	100 mV
4	UVA	Under Voltage 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 LSB	5 LSB	1 LSB
7	VKP	Constant Output Power Knee Voltage	5.3 ~ 24 V	24 V	1 V	100 mV

InnoSwitch4-Pro

Item	Menu	Function	Range	Default	Default Tuning	Fine Tuning
1	Rs	Current Sense Resistor	1 ~ 20 mOhm	9.10 mOhm	1 mOhm	0.01 mOhm
2	CV	Output Voltage	3 ~ 24 V	5V	1 V	20 mV
3	OVA	Over Voltage Threshold	3.3 ~ 25 V	6.2V	1 V	100 mV
4	UV	Under Voltage Threshold	2.7 ~ 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 ~ 192 LSB	192 LSB	5 LSB	1 LSB
7	VKP	Constant Output Power Knee Voltage	5.3 ~ 24 V	24 V	1 V	100 mV

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Example for both **InnoSwitch3-Pro** and **InnoSwitch4-Pro**:
How to adjust the **Output Voltage** (**CV**):

- Press **[SELECT]** when the arrow indicator **[→]** is placed on Thresholds menu

```
→ 1   O n / O f f   C M D S
  2   T h r e s h o l d s
```

- Press **[UP]** or **[DOWN]** until arrow indicator **[→]** is placed on CV

```
  1   R s       9 . 1 0 m O h m
→ 2   C V       5 . 0 0 V
```

- Press **[SELECT]**, the colon indicator **[:]** shows that CV can now be adjusted

```
→ 2   C V     : 5 . 0 0 V
```

- Press **[UP]** or **[DOWN]** to adjust CV by 1 V. User can HOLD **[UP]** or **[DOWN]** to make faster adjustments
- Press **[SELECT]** to change the adjustment step from default tuning of 1 V to the fine tuning of 20 mV

Default Tuning [UP]

```
→ 2   C V     : 5 . 0 0 V
```

```
→ 2   C V     : 6 . 0 0 V
```

Fine Tuning [UP]

```
→ 2   C V     > 6 . 0 0 V
```

```
→ 2   C V     > 6 . 0 2 V
```

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

```
→ 2   C V       6 . 0 2 V
```

Example for both **InnoSwitch3-Pro** and **InnoSwitch4-Pro**:
How to adjust the **Current Sense Resistor** Value (**Rs**)

- Press **[SELECT]** when the arrow indicator **[→]** is placed on Thresholds menu

```
  1   O n / O f f   C M D S
→ 2   T h r e s h o l d s
```

- Press **[UP]** or **[DOWN]** until arrow indicator **[→]** is placed on Rs

```
→ 1   R s       9 . 1 0 m O h m
  2   C V       5 . 0 0 V
```

- Press **[SELECT]**, the colon indicator **[:]** shows that Rs can now be adjusted

```
→ 1   R s     : 9 . 1 0 m O h m
```

- Press **[UP]** or **[DOWN]** to adjust Rs by 1 mOhm. User can HOLD **[UP]** or **[DOWN]** to make faster adjustments
- Press **[SELECT]** to change the adjustment step from default tuning of 1 mOhm to the fine tuning of 0.01 mOhm

Default Tuning [UP]

```
→ 1   R s     : 9 . 1 0 m O h m
```

```
→ 1   R s     : 1 0 . 1 0 m O h
```

Fine Tuning [UP]

```
→ 1   R s     > 9 . 1 0 m O h m
```

```
→ 1   R s     > 1 0 . 1 1 m O h
```

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

```
→ 1   R s       1 0 . 1 1 m O h
```

Example for **InnoSwitch3-Pro**
How to adjust the **Constant Current Regulation** Value (**CC**)

- Press **[SELECT]** when the arrow indicator **[→]** is placed on Thresholds menu

```
  1   O n / O f f     C M D S
→ 2   T h r e s h o l d s
```

- Press **[UP]** or **[DOWN]** until arrow indicator **[→]** is placed on CC

```
  5   C D C       0    m V
→ 6   C C       1 2 8   L S B
```

- Press **[SELECT]**, the colon indicator **[:]** shows that CC can now be adjusted

```
→ 6   C C     : 1 2 8   L S B
```

- Press **[UP]** or **[DOWN]** to adjust CC by 5 LSB. User can HOLD **[UP]** or **[DOWN]** to make faster adjustments
- Press **[SELECT]** to change the adjustment step from default tuning of 5 LSB to the fine tuning of 1 LSB

Default Tuning [DOWN]

```
→ 6   C C     : 1 2 8   L S B
```
```
→ 6   C C     : 1 2 3   L S B
```

Fine Tuning [DOWN]

```
→ 6   C C     > 1 2 3   L S B
```
```
→ 6   C C     > 1 2 2   L S B
```

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

```
→ 6   C C       1 2 2   L S B
```

Example for **InnoSwitch4-Pro**
How to adjust the **Constant Current Regulation** Value (**CC**)

- Press **[SELECT]** when the arrow indicator **[→]** is placed on Thresholds menu

```
  1   O n / O f f     C M D S
→ 2   T h r e s h o l d s
```

- Press **[UP]** or **[DOWN]** until arrow indicator **[→]** is placed on CC

```
  5   C D C       0    m V
→ 6   C C       1 9 2   L S B
```

- Press **[SELECT]**, the colon indicator **[:]** shows that CC can now be adjusted

```
→ 6   C C     : 1 9 2   L S B
```

- Press **[UP]** or **[DOWN]** to adjust CC by 5 LSB. User can HOLD **[UP]** or **[DOWN]** to make faster adjustments
- Press **[SELECT]** to change the adjustment step from default tuning of 5 LSB to the fine tuning of 1 LSB

Default Tuning [DOWN]

```
→ 6   C C     : 1 9 2   L S B
```
```
→ 6   C C     : 1 8 7   L S B
```

Fine Tuning [DOWN]

```
→ 6   C C     > 1 8 7   L S B
```
```
→ 6   C C     > 1 8 6   L S B
```

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

```
→ 6   C C       1 8 6   L S B
```

Fault Response

The following options are under **Fault Response Commands** Menu. InnoSwitch3-Pro and InnoSwitch4-Pro have some minor differences in the number and function of each register.

InnoSwitch3-Pro

Item	Menu	Function	Range	Default
1	OVL	Overvoltage Fault Response	NR/LO/AR	AR
2	UVL	Undervoltage Fault Response	NR/LO/AR	AR
3	ISSC	IS-pin Short Fault Response	NR/LO/AR	NR
4	ISSCfrq	IS-pin Short Detection Frequency	50kHz/30kHz/40kHz/60kHz	50 kHz
5	UVL TMR	UVL Fault Timer	8ms/16ms/32ms/64ms	64 ms
6	WDOG	Watchdog Communication Rate Monitor	No Watchdog/0.5s/1s/2s	No Watchdog
7	CVOL	Constant Voltage Mode Fault Response	NR/LO/AR	NR
8	CVOL TMR	Constant Voltage Fault Timer	8ms/16ms/32ms/64ms	8 ms
9	OTP	Secondary Over-temperature Fault Hysteresis	40°C/60°C	40°C

InnoSwitch4-Pro

Item	Menu	Function	Range	Default
1	OVL	Overvoltage Fault Response	NR/LO/AR/DO	AR
2	UVL	Undervoltage Fault Response	NR/LO/AR/DO	AR
3	UVL TMR	UVL Fault Timer	8ms/16ms/32ms/64ms	64 ms
4	CCSC	Output Short-Circuit Fault Detection	NR/LO/AR/DO	AR
5	ISSC	IS-pin Short Fault Response	NR/LO/AR/DO	NR
6	ISSCfrq	IS-pin Short Detection Frequency	50kHz/30kHz/40kHz/60kHz	50 kHz
7	ISSCCC	IS-pin Short Current Limit Threshold	16/32/64/80/96/112	80 LSB
8	WDOG	Watchdog Communication Rate Monitor	No Watchdog/0.5s/1s/2s	No Watchdog
9	CVOL	Constant Voltage Mode Fault Response	NR/LO/AR/DO	NR
10	CVOL TMR	Constant Voltage Fault Timer	8ms/16ms/32ms/64ms	8 ms
11	OTP	Secondary Over-temperature Fault Hysteresis	40°C/60°C	40°C

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Example for both **InnoSwitch3-Pro** and **InnoSwitch4-Pro**:

How to adjust the **Undervoltage Fault Response** (**UVL**)

- Press **[SELECT]** when the arrow indicator **[→]** is placed on Fault Response menu

```
  2   T h r e s h o l d s
→ 3   F a u l t   R e s p o n s
```

- Press **[UP]** or **[DOWN]** until arrow indicator **[→]** is placed on UVL

```
  1   O V L        A R
→ 2   U V L        A R
```

- Press **[SELECT]**, the colon indicator **[:]** shows that UVL can now be adjusted

```
→ 2   U V L        : A R
```

- Press **[UP]** or **[DOWN]** to change UVL.

```
→ 2   U V L        : N R
```

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

```
  1   O V L        A R
→ 2   U V L        N R
```

Telemetry

The following read-back registers under Telemetry are available. These values are updated live.

Set Points

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	Over Voltage Threshold
9	UV THR	Under Voltage Threshold
10	CDC	Cable Drop Compensation Set-Point

Fault Response

Item	Menu	Function
1	RSP OVA	Over Voltage Response
2	RSP UVA	Under Voltage Response
3	RSP CCSC	Output Short-Circuit Response
4	RSP ISSC	IS-pin Short Response
5	TMR UVA	Under Voltage Timer
6	TMR WDOG	Watchdog Timer
7	RSP CVO	Constant Voltage Only Mode Response
8	TMR CVO	Constant Voltage Only Mode Timer

Common Registers

Item	Menu	Function
1	Reg VBEN	Series Bus Switch Control
2	Reg BLEEDER	Active Bleeder Control
3	Reg PSUOFF	Latch-Off Device
4	Reg FASTVI	Speed of CV/CC Update
5	Reg CVONLY	Constant Voltage Only Mode
6	REG OTPHYS	Over-Temperature Hysteresis

Example for both **InnoSwitch3-Pro** and **InnoSwitch4-Pro**:
How to adjust read telemetry values (**Set-Points**)

- Press **[SELECT]** when the arrow indicator **[→]** is placed on Telemetry menu

```
   3   F a u l t   R e s p o n s
→ 4   T e l e m e t r y
```

- Press **[UP]** or **[DOWN]** until arrow indicator **[→]** is placed on Rs

```
→ 1   S e t   P o i n t s
   2   F a u l t   R e s p o n s
```

- Press **[UP]** or **[DOWN]** to change UVL.

```
→ 1   S e t   P o i n t s
   2   F a u l t   R e s p o n s
```

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

```
   1   O V L       A R
→ 2   U V L       N R
```

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

Example for both **InnoSwitch3-Pro** and **InnoSwitch4-Pro**:

How to save to **EEPROM**

- Press **[SELECT]** when the arrow indicator **[→]** is placed on EEPROM menu

```
   3   F a u l t   R e s p o n s
→ 4   E e p r o m   C o n f i g
```

- Press **[UP]** or **[DOWN]** until arrow indicator **[→]** is placed on Save Config

```
→ 1   S a v e   C o n f i g
   2   L o a d   C o n f i g
```

- Press **[SELECT]** to save the and a message confirmation will show

```
E e p r o m   S a v i n g
S u c c e s s f u l !
```

How to load config from **EEPROM**

- Press **[SELECT]** when the arrow indicator **[→]** is placed on EEPROM menu

```
   3   F a u l t   R e s p o n s
→ 4   E e p r o m   C o n f i g
```

- Press **[UP]** or **[DOWN]** until arrow indicator **[→]** is placed on Load Config

```
   1   S a v e   C o n f i g
→ 2   L o a d   C o n f i g
```

- Press **[SELECT]** to save the and a message confirmation will show

```
N e w   C o n f i g
L o a d e d !
```

How to load default config from **EEPROM**
- Press **[SELECT]** when the arrow indicator **[→]** is placed on EEPROM menu

```
   3   F a u l t   R e s p o n s
 → 4   E e p r o m   C o n f i g
```

- Press **[UP]** or **[DOWN]** until arrow indicator **[→]** is placed on Load Default

```
   2   L o a d   C o n f i g
 → 3   L o a d   D e f a u l t
```

- Press **[SELECT]** to save the and a message confirmation will show

```
 L o a d e d   D e f a u l t
 L o a d e d !
```

FW Version

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

```
 v 0 1 . 0 0 . 0 0
 w w w . p o w e r . c o m
```

Example for both **InnoSwitch3-Pro** and **InnoSwitch4-Pro**:
How to check the **Firmware Version**
- Press **[SELECT]** when the arrow indicator **[→]** is placed on **Firmware ver.** in the initial menu list

```
   2   I n n o 4 P r o   M e n u
 → 3   F i r m w a r e   V e r .
```

Programming

Refer to AN-104 Application Note InnoSwitch-Pro Family Arduino Library for the library the library installation. Install the arduino menu library found below.

ArduinoMenu library
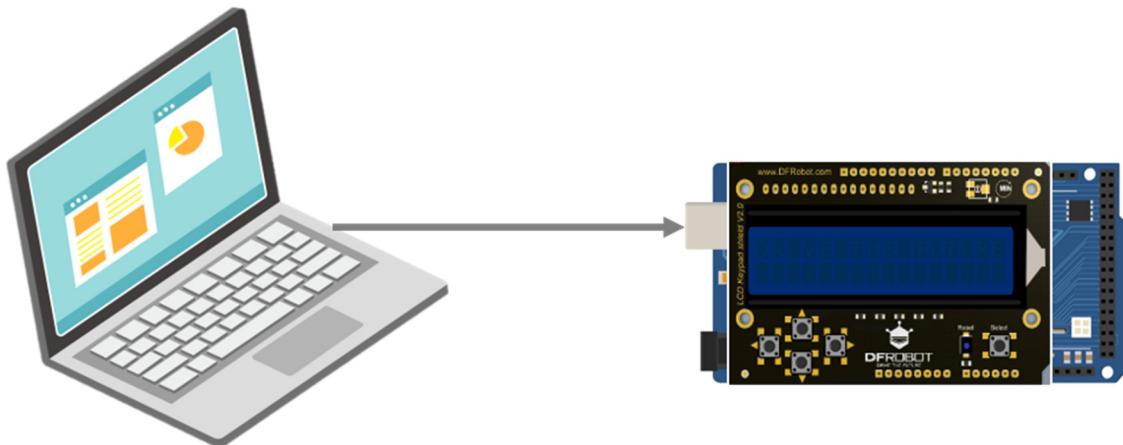
by **neu-rah, ruihfazevedo@gmail.com** Version **4.21.4 INSTALLED**
Generic menu/interactivity system Easy to define menu system with sub-menus and associated function to call. Works from serial to Web depending on the hardware.
More info
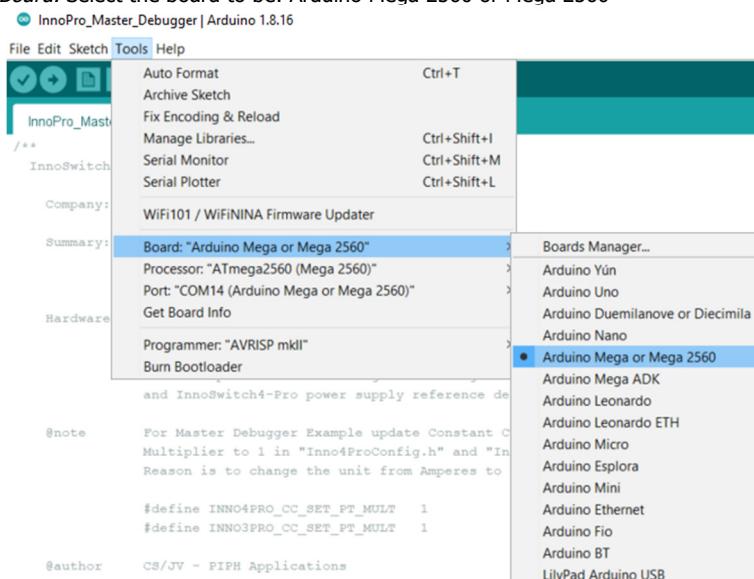
Setup
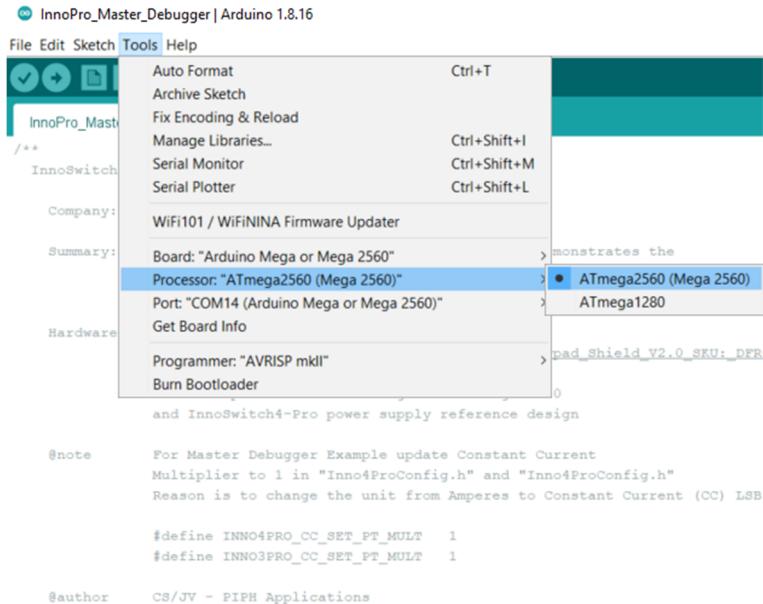
Connect the Arduino Mega 2560 to the PC using a USB A to B cable.
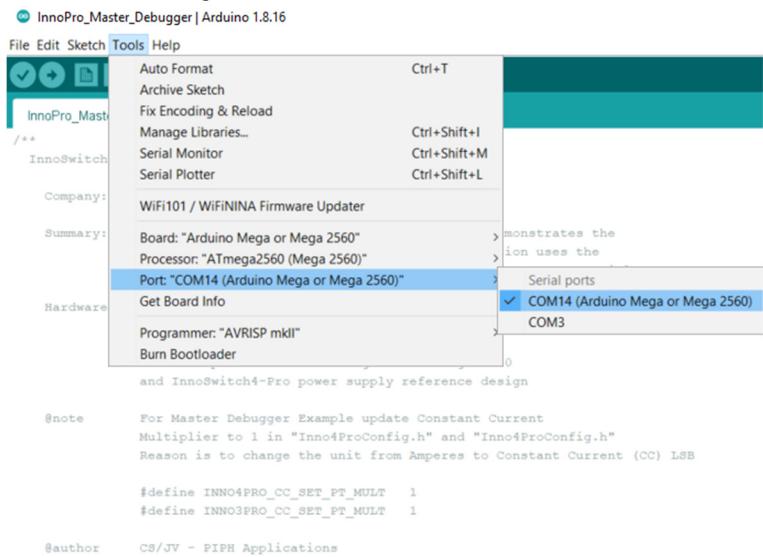
In the Arduino IDE, Go to *Tools > Board.* Select the board to be: Arduino Mega 2560 or Mega 2560

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In *Tools > Processor*, Select the processor to be: ATmega 2560 (2560)
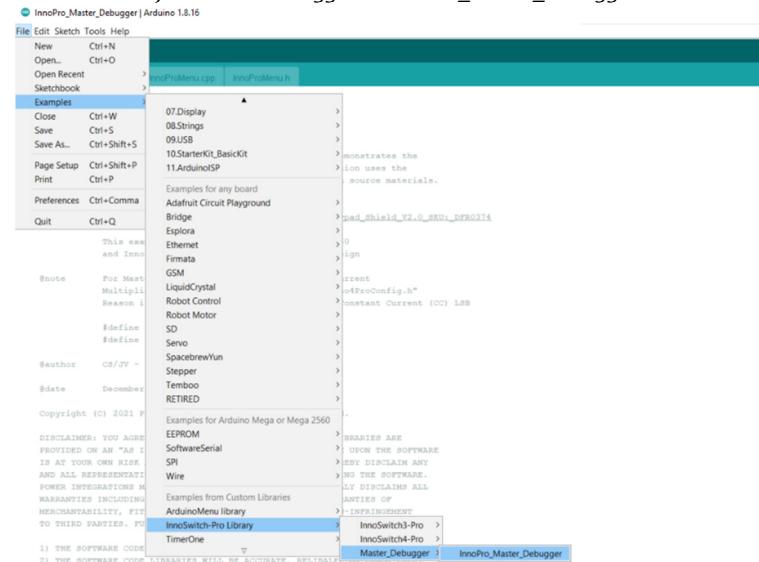
In *Tools > Port*, Select the port in which the Arduino Mega 2560 is found. In this case, the board is at COM14.
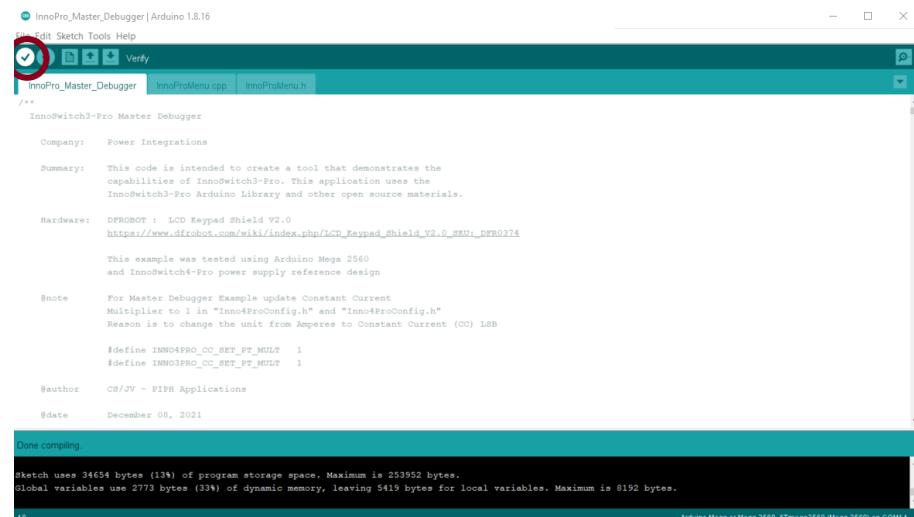
Master Debugger Upload

Go to *FILE > EXAMPLES > InnoSwitch-Pro Library > Master Debugger > InnoPro_Master_Debugger*
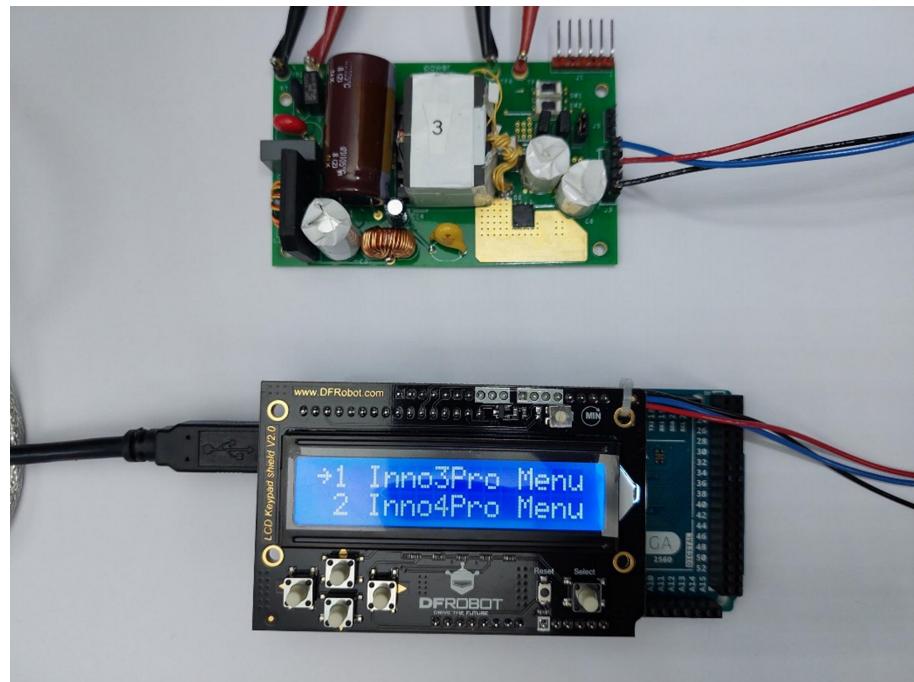
Verify the Arduino sketch

Upload the sketch

DER 961 with InnoSwitch-Pro Master Debugger

Revision	Notes	Date
A	Initial release.	01/20/23

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