# 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

# 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  $\rm I^2C$  lines of the PIC microcontroller. Connect the SDA, SCL, and GND pins of the Arduino to

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.

DOWER ntegrations<sup>™</sup>

the J3 header to allow the Arduino to communicate to the InnoSwitch4-Pro through I<sup>2</sup>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.

J1



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: DF R0374



# **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 DERobot Button Mapping





# Master Debugger Operation

This section explains each control and the information displays on the LCD. To browse through the menu:

# **Start-up Operation**

Welcome messages appear for a brief period during initialization.

- o Press **[UP]** or **[DOWN]**: Arrow Indicator  $[\rightarrow]$  shows the selection
- o Press [SELECT]: The selected option will be activated

InnoSwitch-Pro Master Debbugger Beta VersIon COPYRIGHT 2022

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<sup>2</sup>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.

→ 1 Inno 3 Pro Menu → 2 Inno 4 Pro 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 [ $\rightarrow$ ] is placed on On/Off CMDS

$\rightarrow$ 1	0	n	1	0	f	f		С	М	D	S
2	т	h	r	е	s	h	0	1	d	s	

Press [UP] or [DOWN] until arrow indicator [ $\rightarrow$ ] is ٠ placed on VBEN

#### $\rightarrow$ V B E N OFF

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

 $\rightarrow$  V B E N : OFF

 $\rightarrow$  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

or

Example for InnoSwitch4-PRo:

- How to turn on VBEN (Series Bus Switch): Press **[SELECT]** when the arrow indicator  $[\rightarrow]$  is placed on On/Off CMDS → 1 On/Off CMDS Thresholds 2 Press [UP] or [DOWN] until arrow indicator [ $\rightarrow$ ] is • placed on VBEN  $\rightarrow$  V B E N OFF/RS Press [SELECT], the colon indicator [:] shows that VBEN ٠ can now be adjusted : OFF/RS VBEN or
  - $\rightarrow$  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	υν	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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<ul> <li>Press [EXIT] to come back to the main</li> </ul>	menu
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# **Application Note**

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# 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.

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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

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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

#### Example for both InnoSwitch3-Pro and InnoSwitch4-Pro: Н

10	w to adjust	the Und	ervolt	age Fa	ult Res	ponse	e (UV)	L)
	-							

Press [SELECT] when the arrow indicator  $[\rightarrow]$  is placed on Fault Response menu .

			2	т	h	r	е	s	h	0	1	d	s				
		$\rightarrow$	3	F	a	u	1	t		R	e	s	p	0	n	s	
•	Press [UP] or [DOWN]	until	arrov	v indica	ator	<b>[</b> →	] is	pla	ced	on I	UVL						
			1	0	v	L					A	R					
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•	Press [SELECT], the cold	on inc	dicato	or <b>[:]</b> s	shov	vs tł	nat I	JVL	car	n no	w b	e ac	ljust	ted			
		$\rightarrow$	2	U	v	L				:	A	R					
•	Press [UP] or [DOWN]	o ch	ange	UVL.													
		$\rightarrow$	2	U	v	L				:	N	R					
•	Press [EXIT] to come ba	ck to	the	main r	nen	u											
			1	0	v	L					A	R					
		$\rightarrow$	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



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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	а	u	1	t		R	е	s	р	0	n	s
		$\rightarrow$	4	Т	e	1	е	m	е	t	r	У				
•	Press [UP] or [DOWN]	until	arrow	indica	ator	<b>[</b> →	] is	plac	ced	on l	Rs					
		$\rightarrow$	1	S	е	t		Р	0	i	n	t	s			
			2	F	a	u	1	t		R	e	s	p	0	n	s
•	Press [UP] or [DOWN] t	o ch	ange l	JVL.												
		$\rightarrow$	1	S	е	t		Ρ	0	i	n	t	s			
			2	F	a	u	1	t		R	e	s	p	0	n	s
•	Press [EXIT] to come ba	ck to	the n	nain n	nen	u										
			1	0	v	L					A	R				
		$\rightarrow$	2	U	v	L					N	R				

# **EEPROM Configuration**

The following options under EEPROM Config Menu are available.

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								ten	1			ме	enu						FL	unct	ion													
								1		Sa	ve	Coi	nfi	g 1		Sav	ve the current	con	fig	uratio	on s	settii	ngs	to E	EP	ROM	1							
								2		Lc	ad	Coi	nfi	g 1		Loa	ad the previou	isly s	sav	ed co	onfi	gura	tior	Se	ttin	gs								
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How to load default config from **EEPROM** 

		•	Pr or	ess 1 EE	[SE PRC	E <b>LEC</b> DM r	CT] nen	whe u	en t	he a	Irro\	w in	dica	itor	[→]	is p	blaced
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	2		L	0	a	d		С	0	n	f	i	g				
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L	0	a	d	е	d		D	е	f	a	u	1	t				
L	0	a	d	е	d	!											

#### **FW Version**

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

v	0	1	•	0	0	•	0	0					
W	W	w	•	р	0	W	е	r	•	С	0	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	0	4	Ρ	r	0	м	е	n	u	
→ <b>3</b>	F	i	r	m	W	a	r	е	v	е	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.
<u>More info</u>
```

### 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

💿 Inn	oPro_Ma	ster_Debugger   Arduino 1.8.16		
File Edi	t Sketch	Tools Help		
	Pro Mast	Auto Format Archive Sketch Fix Encoding & Reload	Ctrl+T	
	10_11030	Manage Libraries	Ctrl+Shift+I	
Inn	oSwitch	Serial Monitor Serial Plotter	Ctrl+Shift+M Ctrl+Shift+L	
C	ompany:	WiFi101 / WiFiNINA Firmware Updater		
St	ummary:	Board: "Arduino Mega or Mega 2560"	>	Boards Manager
H	ardware	Processor: "ATmega2560 (Mega 2560)" Port: "COM14 (Arduino Mega or Mega 2560)" Get Board Info	>	Arduino Yún Arduino Uno Arduino Duemilanove or Diecimila
		Programmer: "AVRISP mkll" Burn Bootloader	>	Arduino Nano Arduino Mega or Mega 2560
		and InnoSwitch4-Pro power supply r	eference de	Arduino Mega ADK Arduino Leonardo
01	note	For Master Debugger Example update Multiplier to 1 in "Inno4ProConfig Reason is to change the unit from	Constant C .h" and "In Amperes to	Arduino Leonardo ETH Arduino Micro Arduino Esplora Arduino Mini
		<pre>#define INNO4PRO_CC_SET_PT_MULT</pre>	1	Arduino Ethernet
		<pre>#define INNO3PRO_CC_SET_PT_MULT</pre>	1	Arduino Fio
0.	author	CS/JV - PIPH Applications		Arduino BT LilyPad Arduino USB



### In *Tools > Processor*, Select the processor to be: ATmega 2560 (2560)

InnoPro_Mast	ter_Debugger   Arduino 1.8.16						
le Edit Sketch	Tools Help						
	Auto Format	Ctrl+T					
	Archive Sketch						
InnoPro_Mast	Fix Encoding & Reload						
**	Manage Libraries	Ctrl+Shift+I					
InnoSwitch	Serial Monitor	Ctrl+Shift+M					
	Serial Plotter	Ctrl+Shift+L					
Company:	WiFi101 / WiFiNINA Firmware Updater						
Summary:	Board: "Arduino Mega or Mega 2560"		monstrates the				
	Processor: "ATmega2560 (Mega 2560)"		<ul> <li>ATmega2560 (Mega 2560)</li> </ul>				
Hardware	Port: "COM14 (Arduino Mega or Mega 25	ATmega1280					
	Get Board Info						
	Programmer: "AVRISP mkll"		> pad Shield V2.0 SKU: DFR				
	Burn Bootloader		0				
	and InnoSwitch4-Pro power suppl	ly reference de	sign				
Gnote	For Master Debugger Example update Constant Current						
	Multiplier to 1 in "Inno4ProConfig.h" and "Inno4ProConfig.h"						
	Reason is to change the unit fr	rom Amperes to	Constant Current (CC) LSB				
	<pre>#define INNO4PRO_CC_SET_PT_MULT</pre>	r 1					
	<pre>#define INNO3PRO_CC_SET_PT_MULD</pre>	r 1					

@author

CS/JV - PIPH Applications

In Tools > Port, Select the port in which the Arduino Mega 2560 is found. In this case, the board is at COM14. InnoPro\_Master\_Debugger | Arduino 1.8.16 File Edit Sketch Tools Help Auto Format Ctrl+T Archive Sketch Fix Encoding & Reload InnoPro\_Mast Manage Libraries... Ctrl+Shift+I Serial Monitor Ctrl+Shift+M Serial Plotter Ctrl+Shift+L WiFi101 / WiFiNINA Firmware Updater Board: "Arduino Mega or Mega 2560" Processor: "ATmega2560 (Mega 2560)" Port: "COM14 (Arduino Mega or Mega 2560)" Serial ports Get Board Info COM14 (Arduino Mega or Mega 2560) Hardware COM3 Programmer: "AVRISP mkll" Burn Bootloader and InnoSwitch4-Pro power supply reference design For Master Debugger Example update Constant Current Multiplier to 1 in "Inno4ProConfig.h" and "Inno4ProConfig.h" Ønote Reason is to change the unit from Amperes to Constant Current (CC) LSB #define INNO4PRO\_CC\_SET\_PT\_MULT
#define INNO3PRO\_CC\_SET\_PT\_MULT CS/JV - PIPH Applications Gauthor



# Master Debugger Upload

Go to FILE > EXAMPLES > InnoSwitch-Pro Library > Master Debugger > InnoPro\_Master\_Debugger

Edit Sketch	Tools Help			
New	Ctrl+N			
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open Recen	t >			
Sketchbook	>			
Examples	2	A		
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Save As	Ctrl+Shift+S	09.USB	>	
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	and Inno	Einesta	lign	
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	Reason i	Robot Control	Pionstant Current (CC)	LSB
		Kobot Motor	2	
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Copyrigh	t (C) 2021 P	Examples for Arduino Mena or Mena 2560		
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AND ATL	DEDDE SENTATI	SFI	MA THE SAPENADE	
POWER IN	TEGRATIONS M	wire	LY DISCLAIMS ALL	
WARRANTI	ES INCLUDING	Examples from Custom Libraries	ANTIES OF	
MERCHANT	ABILITY, FIT	ArduinoMenu library	> -INFRINGEMENT	
TO THIRD	PARTIES. FU	InnoSwitch-Pro Library	InnoSwitch3-Pro >	
		TimerOne	> InnoSwitch4-Pro >	
1) THE 3	OFTWARE CODE		Master Debugger 1	Incoder Manager Dataset

#### Verify the Arduino sketch

10Pro_Master_	Debugger InnoProMenu cpp InnoProMenu h	
noSwitch3-	Pro Master Debugger	
Company:	Power Integrations	
Summary:	This code is intended to create a tool that demonstrates the capabilities of InnoWitchJ-Frc. This application uses the InnoWitchJ-Fro Arduins Library and other open source materials.	
Hardware:	DFROBOT : LCD Keyped Shield V2.0 https://www.dfrobot.com/wiki/index.php/LCD_Keyped_Shield_V2.0_SKU:_DFR0374	
	This example was tested using Arduino Mega 2560 and Innodwitch4-Fro power supply reference design	
Gnote	for Master Debugger Example update Constant Current Multiplier to 1 in "InnofFreGordfig.h" mad "InnofFreGordfig.h" Reason is to change the unif from Amperes to Constant Current (CC) L08	
	define INNOFFRO_CC_ET_FT_MULT 1 Idefine INNOFFRO_CC_ETT_FT_MULT 1	
Gauthor	CS/JV - PIPH Applications	
Ødate	December 08, 2021	
compiling.		

#### Upload the sketch



#### DER 961 with InnoSwitch-Pro Master Debugger









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

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