Title	***InnoSwitch™3-Pro Toggle Board (TST-047) User's Guide***
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Summary

AN-84 describes a tool (TST-047) which enables test and debug of InnoSwitch3-Pro based power supplies.

The TST-047 enables a set of operating conditions to be programmed into the InnoSwitch3-Pro IC. Once programmed, these settings are stored in a Non-volatile memory and are automatically transferred to the InnoSwitch3-Pro IC whenever the power is cycled. This allows testing of the InnoSwitch3-Pro based power stage without the need for an external Microcontroller.

This tool is especially helpful when repeated tests are to be performed such as EMI or safety tests and the InnoSwitch3-Pro based power stage is to be set to a specific operating point. This is useful when conducting thermal tests or tests where the unit is being modified and there is a need for the InnoSwitch3-Pro to get configured with a specific set of parameters after each power cycle.

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Table of Contents

1 Introduction

This manual is a user's guide for the InnoSwitch3-Pro Toggle Board (TST-047). The InnoSwitch3-Pro Toggle Board is a tool designed to control the InnoSwitch3-Pro power supply

The document describes what constitutes the board, how it works and how to use it with InnoSwitch3-Pro. It also contains the schematic, bill of materials, printed circuit board layout.

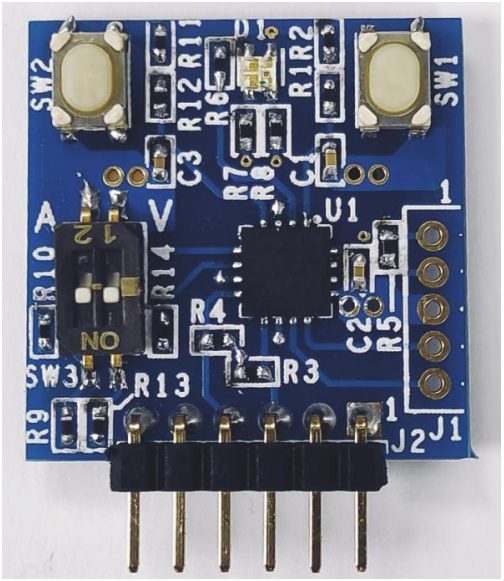

Figure 1 – Top view of InnoSwitch3-Pro Toggle Board.

Figure 2 – Bottom view of InnoSwitch3-Pro Toggle Board.

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2 System Diagrams

2.1 *Schematic Diagram*

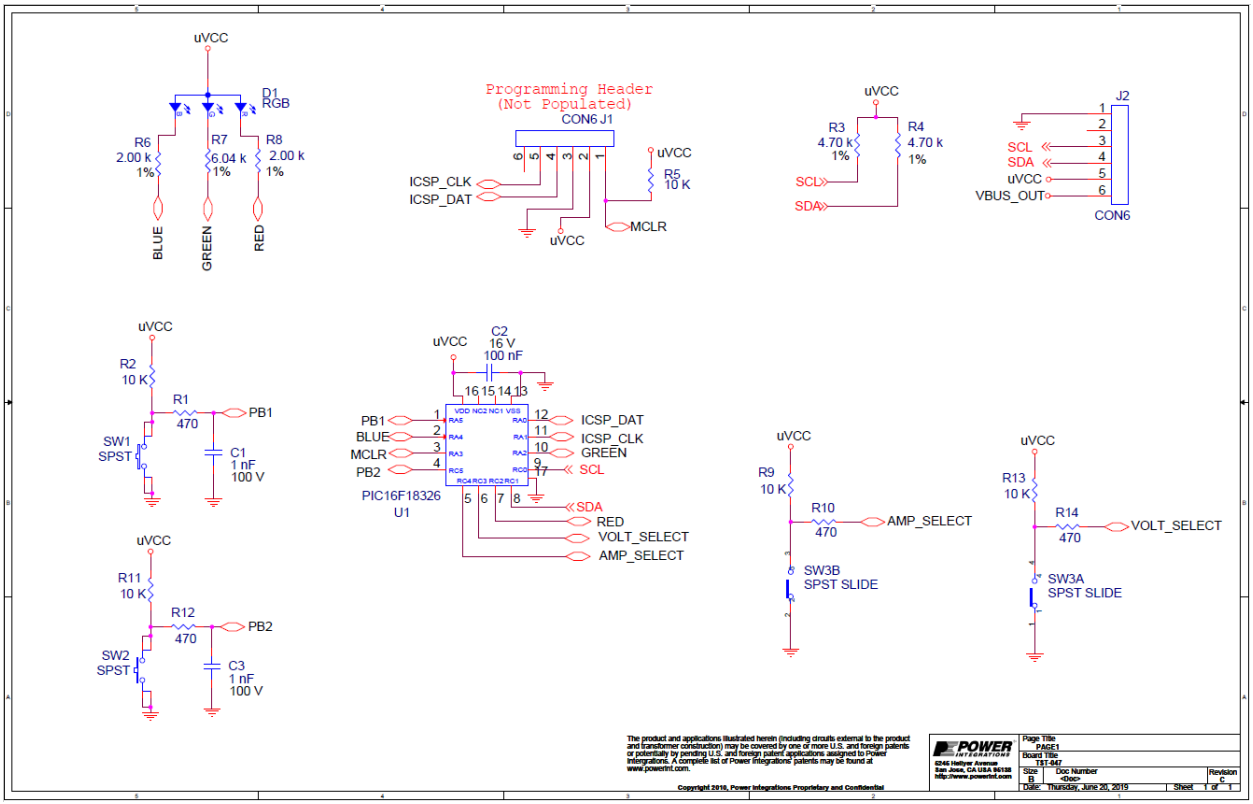

Figure 3 – Schematic.

3 Board Layout

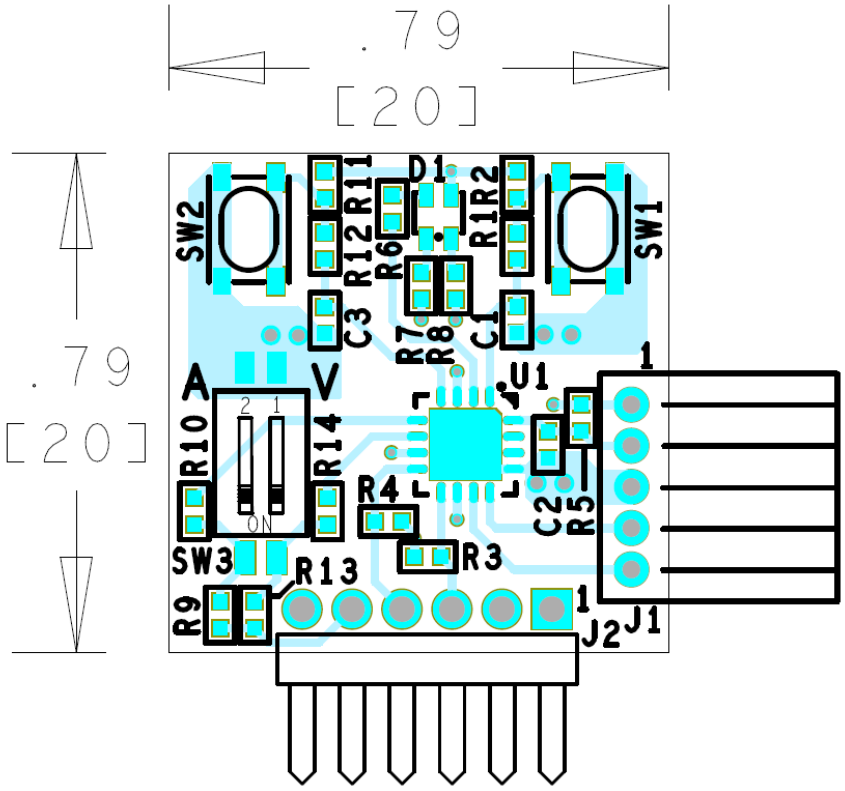

Figure 4 – PCB Top Layout.

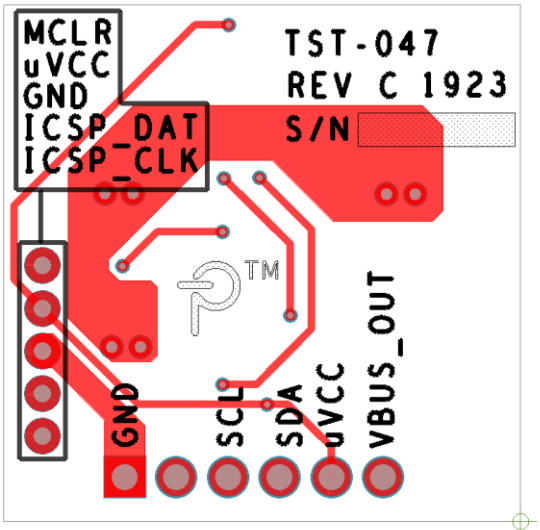

Figure 5 – PCB Bottom Layout.

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4 Hardware

4.1 *Assembly*

The top assembly of the board is shown below.

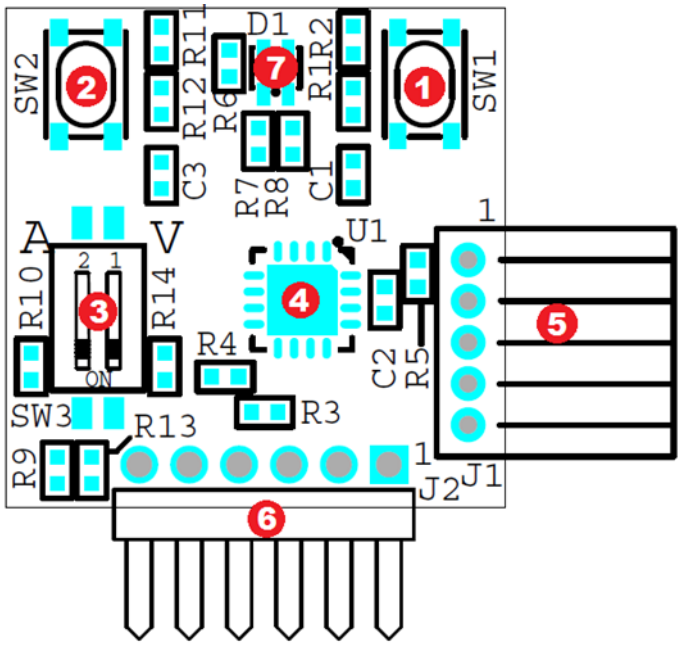

Figure 6 – Assembly.

The board's key features are indicated on the table below.

Number	Description	Label
1	Increment Switch	SW1
2	Decrement Switch	SW2
3	CC/CV/VKP Selection Switch	SW3
4	PIC16F18326	U1
5	PICkit3 Programming Header	J1
6	Connector to PSU	J2
7	RGB LED Indicator	D1

5 Functional Description

5.1 *Switches*

- At power ON, any adjustments can be made within the first 5 minutes. A countdown timer will lock the button functionality after its timeout. No request will be processed after 5 minutes even if the buttons were pressed.

- When the user wants to re-adjust the settings but the buttons state is already locked, a reset operation will be needed (requires power cycling).

The switches table summary below provides the following specific functions:

5.2 *One Click or Single Click*

Push Buttons	CV	CC	VKP
SW1	+1V	+5 LSB	+1V
SW2	-1V	-5 LSB	-1V

5.3 *Two Clicks or Double click*

Push Buttons	CV	CC	VKP
SW1	+200mV	+1 LSB	+200mV
SW2	-200mV	-1 LSB	-200mV

5.4 *Adjustment Range*

Register	Adjustment Range	Default
CV	3 ~ 20 V	5V
CC	25 ~ 128 LSB	128
VKP	5.3 ~ 24V	7V
CDC	Fixed	300mV

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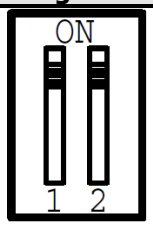
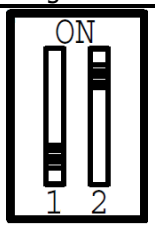
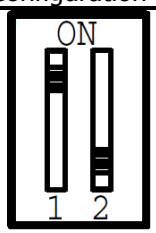
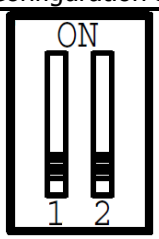
5.5 *Slide Switch (SW3)*

V and A markings on the PCB correspond to Voltage and Current respectively. Based on the settings of the slide switches the register to be updated is selected.

SW3A (V)	SW3B (A)	Switch Configuration	Register Selection	LED Indicator
ON	ON	 Configuration 1	No Change	OFF
OFF	ON	 Configuration 2	CV	Red
ON	OFF	 Configuration 3	CC	Green
OFF	OFF	 Configuration 4	VKP	Blue

5.6 *LED*

The LED table summary provides the following specific conditions:

LED Status	Description
Blinking every 500 ms	Very First Power ON or Reset Configuration
RGB LED Off	Button Lock Activated or No change Selected
Red LED On	Constant Voltage (CV) Update Selected
Green LED On	Constant Current (CC) Update Selected
Blue LED On	Constant Output Power Knee Voltage (VKP) Update Selected

5.7 *I^2C*

The protocol board communicates with PSU using I^2C.

5.8 *MCU Signal Configuration*

The toggle board has been designed with PIC16F18326 with the following signal configurations:

Signal Label	Pin No	Device Pin Function	Pin Type	Description / Function
PB1	1	RA5	Input	SW1 Push Button
BLUE	2	RA4	Output	LED Blue
MCLR	3	MCLR	Input/Power	Master Clear (Reset) Input
PB2	4	RC5	Input	SW2 Push Button
AMP_SELECT	5	RC4	Input	Constant Current Select (SW3)
VOLT_SELECT	6	RC3	Input	Constant Voltage Select (SW3)
RED	7	RC2	Output	LED Red
SDA	8	RC1	Output	I2C Data
SCL	9	RC0	Output	I2C Clock
GREEN	10	RA2	Output	LED Green
ICSP_CLK	11	RA1	Not Used	Not Used
ICSP_DAT	12	RA0	Not Used	Not Used
---	13	VSS	Power	Ground reference for logic and I/O pins
---	14	NC	---	Not Connected
---	15	NC	---	Not Connected
---	16	VDD	Power	Positive Supply for Peripheral Logic and I/O Pins

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6 Usage Instructions

This section provides step by step instructions on how to operate the board correctly.

6.1 *Initial Usage/ Reset Operation*

- To use the board for the 1st time or to reset the saved setting on the EEPROM. Set the Slide switch to configuration 4 (SW3A – Off and SW3B – Off)

- After board power up, LED is expected to be blinking which means the board underwent a reset operation.

6.2 *CV Adjustment*

- Set the Slide switch to configuration 2 (SW3A – Off and SW3B – On)
- LED is expected to be RED in color when power is applied to the board
- Adjust CV by pressing the push buttons
  This setting will be automatically stored to the EEPROM
- Leave the Slide Switch configuration to either Configuration 1, 2, or 3.
  This will ensure that the saved configuration on the EEPROM will be used upon power cycle
- Button press will be automatically disabled after 5 mins and LED will be Off

6.3 *CC Adjustment*

- Set the Slide switch to configuration 3 (SW3A – On and SW3B – Off)
- LED is expected to be GREEN in color when power is applied to the board
- Adjust CC by pressing the push buttons
  This setting will be automatically stored to the EEPROM
- Leave the Slide Switch configuration to either Configuration 1, 2, or 3.
  This will ensure that the saved configuration on the EEPROM will be used upon power cycle
- Button press will be automatically disabled after 5 mins and LED will be Off

6.4 *VKP Adjustment*

- Set the Slide switch to configuration 4 (SW3A – Off and SW3B – Off). Since this is the same setting as the reset setting, the user should make sure that after power up, the switch is in configuration 1, 2 or 3 before bringing it to configuration 4 for adjusting Vkp.
- LED is expected to be BLUE in color when power is applied to the board
- Adjust VKP by pressing the push buttons
  This setting will be automatically stored to the EEPROM
- Leave the Slide Switch configuration to either Configuration 1, 2, or 3.
  This will ensure that the saved configuration on the EEPROM will be used upon power cycle
- Button press will be automatically disabled after 5 mins and LED will be Off

6.5 ***Use the last stored setting***

- Leave the Slide Switch configuration to either Configuration 1, 2, or 3.
- Do not make any adjustments
- EEPROM date will be uploaded to InnoSwitch3-Pro
- After 5 mins LED will be Off

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7 Operation

7.1 *Start-up operation*

- When power cycle is done, the board initially checks the setting of the slide switch.

- If SW3A and SW3B are both OFF, then the previously saved EEPROM Data will be erased and default configuration stored on the EEPROM is transferred to InnoSwitch3-Pro using I2C.

Register	EEPROM Default Configuration
CV	5V
CC	128 LSB
VKP	7V
CDC	300 mV

7.2 *Normal Operation*

When the toggle board is connected to an InnoSwitch3-Pro power stage and input supply is turned ON, the sequence of operation is as follows:

1. The power supply turns ON normally with 5V as usual but the bus switch remains OFF.
2. uVCC provides power to the toggle board.
3. Microcontroller on toggle board downloads the set point configurations from its memory and uploads it to InnoSwitch3-Pro
4. InnoSwitch3-Pro adjusts the output voltage and current limit accordingly.
5. Microcontroller uses telemetry to confirm InnoSwitch3-Pro is ready with the desired voltage.
6. Microcontroller asks InnoSwitch3-Pro to turn ON the bus switch immediately
    - bus switch will be on after 1 sec for voltage lesser than 5V
7. Correct output voltage then appears at the output.

Each time voltage, current, and/or VKP is adjusted, that information is stored in the EEPROM and downloaded automatically when power is cycled.

Once the EEPROM data has been updated, at every power cycle, the button timeout of 5min will automatically start counting and buttons will be disabled thereafter. This provides an opportunity to make any setting changes.

8 Bill of Materials

Complete list of the components used for the project.

Item Number	Part Reference	Part Number	Quantity	Value	Description	Distributor Part Number	Distributor	Mfg	Mfg Part Number
1	C1	20-00843-00	1	1 nF	1 nF 100 V, Ceramic, X7R, 0402	490-4764-1-ND	Digi-Key	Murata	GCM155R72A102KA37D
2	C2	20-08759-00	1	100 nF	100 nF 16 V, Ceramic, X7R, 0402	1276-1001-1-ND	Digi-Key	Samsung	L05B104KO5NNNC
3	C3	20-00843-00	1	1 nF	1 nF 100 V, Ceramic, X7R, 0402	490-4764-1-ND	Digi-Key	Murata	GCM155R72A102KA37D
4	D1	15-01190-00	1	RGB	Red, Green, Blue (RGB), 621nm Red, 525nm Green, 465nm Blue, LED Indication - Discrete, 1.8V Red, 2.7V Green, 2.7V Blue 0606 (1616 Metric)	754-1972-1-ND	Digi-Key	Kingbright	APTF1616LSEEZGKQBKC
5	J1	35-00226-00	1	CON6	6 Position (1 x 6) header, 2 mm pitch, Right Angle (Not Populated)	WM4104-ND	Digi_Key	Molex	22-05-2061
6	J2	35-00489-00	1	CON6	6 Position (1 x 6) header, 2 mm pitch, Right Angle	798-A4B-6PA-2DS51	Mouser	Hirose Connector	A4B-6PA-2DS(51)
7	R1	05-06207-00	1	470	RES, 470, 5%, 1/10 W, Thick Film, 0402	P470JCT-ND	Digi-Key	Panasonic	ERJ-2GEJ471X
8	R2	05-03488-00	1	10 K	RES, 10 K, 5%, 1/16 W, Thick Film, 0402	311-10KJRCT-ND	Digi-Key	Yageo	RC0402JR-0710KL
9	R3	05-05899-00	1	4.70 k	RES, 4.70 k, 1%, 1/10 W, Thick Film, 0402	P4.70KLCT-ND	Digi-Key	Panasonic	ERJ-2RKF4701X
10	R4	05-05899-00	1	4.70 k	RES, 4.70 k, 1%, 1/10 W, Thick Film, 0402	P4.70KLCT-ND	Digi-Key	Panasonic	ERJ-2RKF4701X
11	R5	05-03488-00	1	10 K	RES, 10 K, 5%, 1/16 W, Thick Film, 0402	311-10KJRCT-ND	Digi-Key	Yageo	RC0402JR-0710KL
12	R6	05-05855-00	1	2.00 k	RES, 2.00 k, 1%, 1/10 W, Thick Film, 0402	P2.00KLCT-ND	Digi-Key	Panasonic	ERJ-2RKF2001X
13	R7	05-05911-00	1	6.04 k	RES, 6.04 k, 1%, 1/10 W, Thick Film, 0402	P6.04KLCT-ND	Digi-Key	Panasonic	ERJ-2RKF6041X
14	R8	05-05855-00	1	2.00 k	RES, 2.00 k, 1%, 1/10 W, Thick Film, 0402	P2.00KLCT-ND	Digi-Key	Panasonic	ERJ-2RKF2001X
15	R9	05-03488-00	1	10 K	RES, 10 K, 5%, 1/16 W, Thick Film, 0402	311-10KJRCT-ND	Digi-Key	Yageo	RC0402JR-0710KL
16	R10	05-06207-00	1	470	RES, 470, 5%, 1/10 W, Thick Film, 0402	P470JCT-ND	Digi-Key	Panasonic	ERJ-2GEJ471X
17	R11	05-03488-00	1	10 K	RES, 10 K, 5%, 1/16 W, Thick Film, 0402	311-10KJRCT-ND	Digi-Key	Yageo	RC0402JR-0710KL
18	R12	05-06207-00	1	470	RES, 470, 5%, 1/10 W, Thick Film, 0402	P470JCT-ND	Digi-Key	Panasonic	ERJ-2GEJ471X
19	R13	05-03488-00	1	10 K	RES, 10 K, 5%, 1/16 W, Thick Film, 0402	311-10KJRCT-ND	Digi-Key	Yageo	RC0402JR-0710KL
20	R14	05-06207-00	1	470	RES, 470, 5%, 1/10 W, Thick Film, 0402	P470JCT-ND	Digi-Key	Panasonic	ERJ-2GEJ471X
21	SW1	66-00216-00	1	SPST	SWITCH, TACTILE, SPST-NO, 0.02A, 15V, 4.2x3.2x2.5mm, 160gf, BLACK button	688-SKRPAB	Mouser	ALPS	SKRPABE010
22	SW2	66-00216-00	1	SPST	SWITCH, TACTILE, SPST-NO, 0.02A, 15V, 4.2x3.2x2.5mm, 160gf, BLACK button	688-SKRPAB	Mouser	ALPS	SKRPABE010
23	SW3	66-00364-00	1	SPST SLIDE	Slide Switch, Dual, SPST,25MA, 24V, SMD	CT2182LPST-ND	Digi-Key	CTS Electrocomponents	218-2LPST
24	U1	45-00448-00	1	PIC16F18326	IC, PIC, PIC®, XLP™, 16F Microcontroller IC, 8-Bit, 32MHz, 28KB (16K x 14,) FLASH 16-UQFN (4x4)	PIC16F18326-I/JQ-ND	Digi-Key	Microchip Technology	PIC16F18326-I/JQ

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9 Revision History

Date	Author	Revision	Description & changes	Reviewed
06-Jun-19	CS	1.0	Initial	Apps & Mktg
26-Jun-19	CS	1.1	* Added Summary Description * Updated Table Format * Added Adjustment Range Table * Changed J2 Header to 6 Position (1x6)	Apps & Mktg

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