Title	***Getting Started with InnoSwitch™3-Pro Code Library using PIC16F18325***
Author	Applications Engineering Department
Document Number	Application Note 78 (AN-78)
Date	August 10, 2018
Revision	1.0

Summary

InnoSwitch3-Pro is a digitally controllable CV/CC QR flyback switcher IC with integrated high-voltage MOSFET, synchronous rectification and FluxLink feedback.

RDK-641 is a reference design board rated for 40 W output power and is programmable from 3 V to 20 V output voltage. This reference design features an on board PIC16F18325 microcontroller and uses the InnoSwitch3-Pro integrated power supply IC.

This application note describes use of code libraries provided by Power Integrations to develop control logic and firmware for customizing RDK-641.

Information presented in this application note can be used to develop firmware for PIC microcontrollers to interface with InnoSwitch3-Pro ICs

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Table of Contents

1 Introduction

This application note describes the structure and the application interface of the InnoSwitch3-Pro MCU Code Library as well as using it on a demo application. The code was designed to be highly portable to other microcontroller platforms, and was written in C language. This demo application runs on Reference Design RDK-641 (Figure 1), which can be easily configured to desired setting.

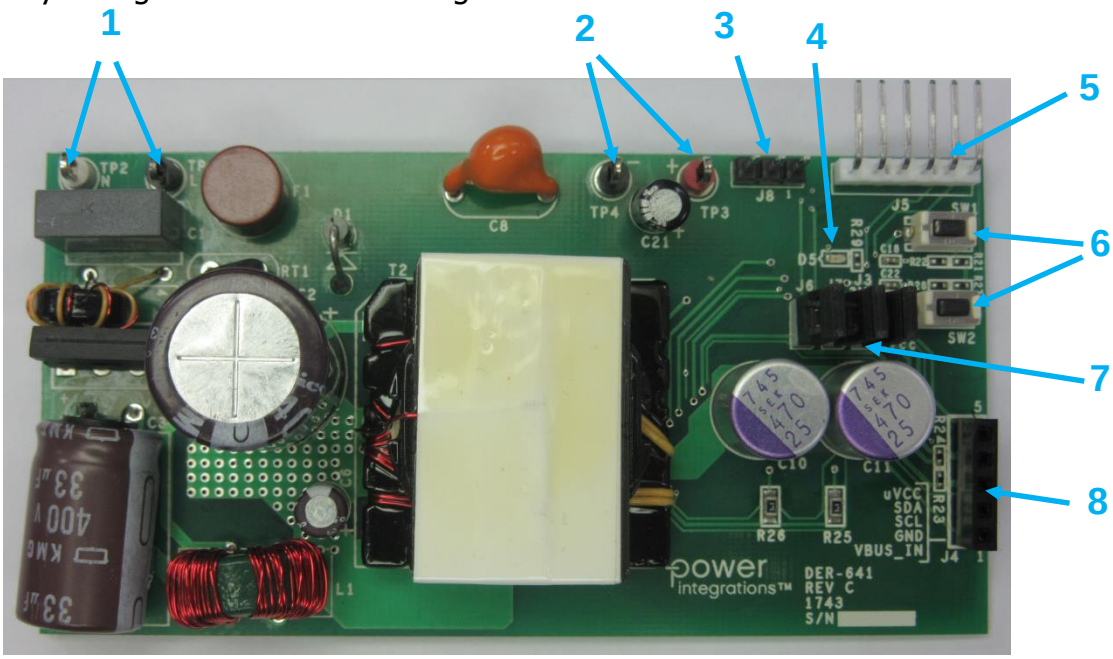


Figure 1 – RDK-641 Board Top.

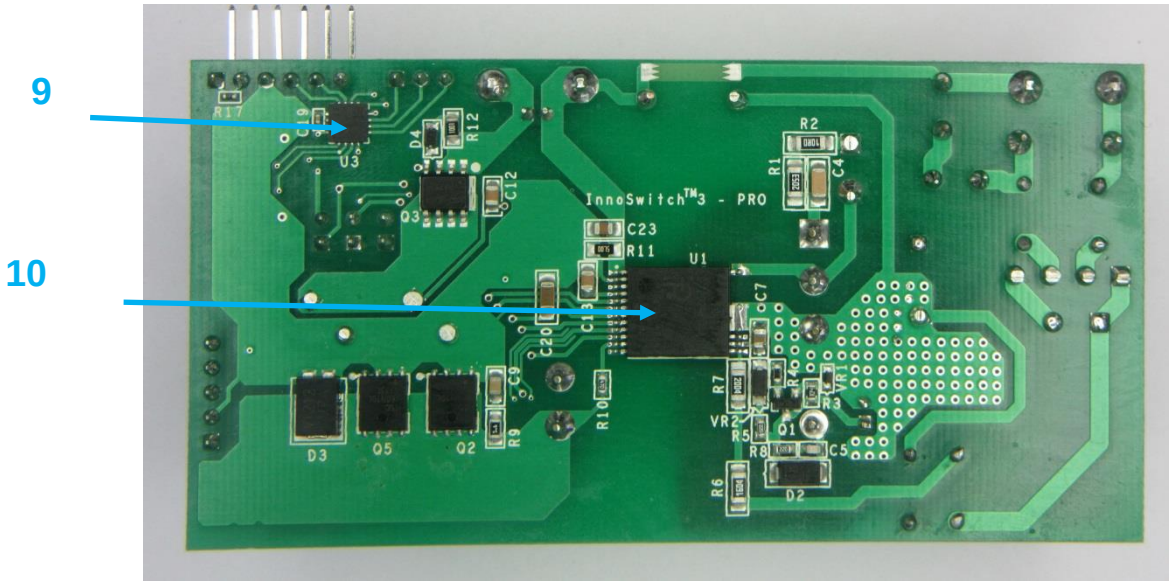


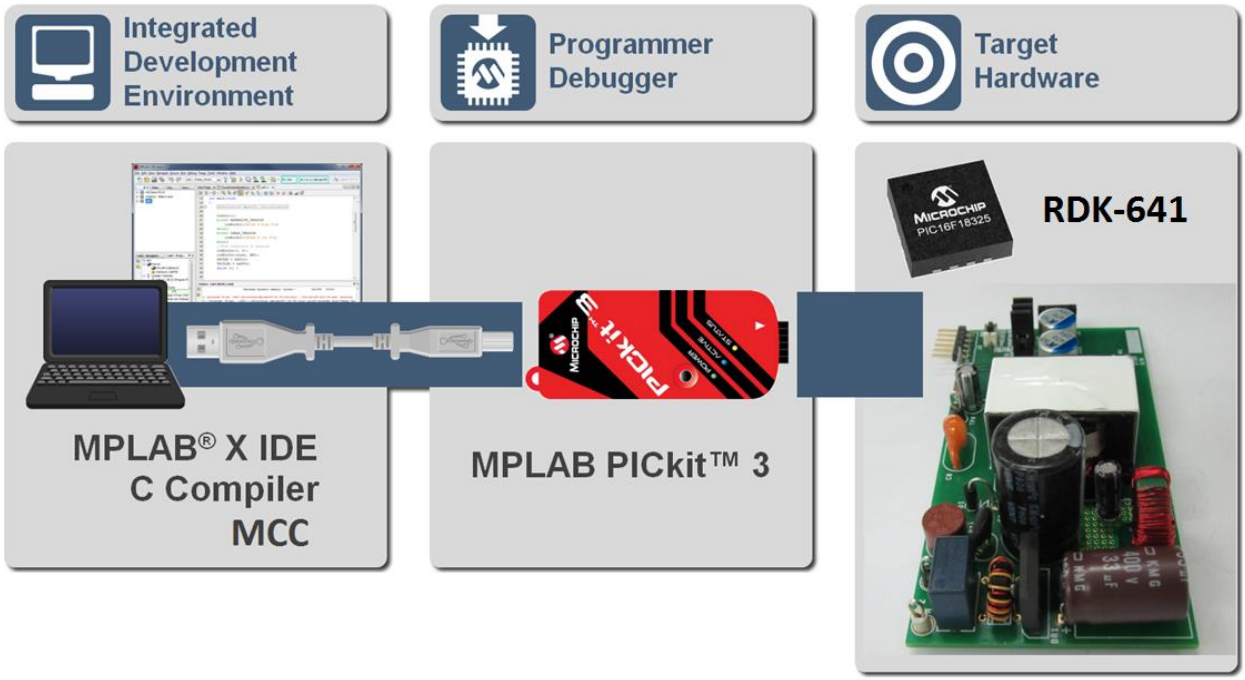
Figure 2 – RDK-641 Board Bottom.

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

Number	Description	Label
1	AC Input Terminals	TP1, TP2
2	DC Output Terminals	TP3, TP4
3	MCU GPIO Headers	J8
4	Green LED Indicator	D5
5	PICkit3 Programming Header	J5
6	Push Buttons	SW1, SW2
7	µVCC and I2C Isolation Jumpers	J3, J6, J7
8	External Interface Header	J4
9	PIC16F18325 microcontroller	U3
10	InnoSwitch3-Pro IC	U1

2 System Requirements

The following are required to run the InnoSwitch3-Pro demo application:



- MPLAB X IDE version 4.05 or later
- MPLAB XC8 Compiler version 1.44 or later
- MPLAB code configurator version 4.15.6 or later
- PICkit 3 Programmer
- RDK-641 Board rev C
- InnoSwitch3-Pro MCU Code Library version 1.0.0

3 Hardware Overview

The Reference Design (RDK-641) hardware consists of a flyback conversion stage based on the InnoSwitch3-Pro IC, 8-bit Microchip microcontroller (PIC16F18325), interface headers and the user interface elements: two push buttons and a green LED.

The InnoSwitch3-Pro can be controlled using it's on board microcontroller or by an external I^2C Master through the interface header.

This demo application uses the on board microcontroller as an I^2C Master and InnoSwitch3-Pro as slave device.

SDA and SCL lines (I^2C) are provided with pull-up resistors R24 and R23 on the board. The µVCC output of the InnoSwitch3-Pro provides 3.6 V pull up voltage for the SDA and SCL signals.

To further ease in development, the following documents are available and recommended as supplemental reference resources:

- RDR-641 - 40 W Variable Output (3 V to 8 V, 5 A; 8 V – 20 V Constant Power) Supply Using InnoSwitch3-Pro and Microchip's PIC16F18325 Microcontroller
- AN-74 InnoSwitch3-Pro Programming Manual

3.1 *Debounce Switches*

The RDK-641 board is preprogrammed to update the output voltage in response to the debounce switches that are present on the board. When Idle, the microcontroller I/O lines to which the switches are connected are pulled high (+3.3 V). When the switches are pressed, they are grounded. On each button press I^2C commands are generated to do the following below.

Switch 1 (SW1) Capabilities:

Single Click	1 V Increment
Double Click	1 V Decrement

Switch 2 (SW2) Capabilities:

Single Click	200 mv Increment
Double Click	200 mv Decrement

3.2 **Headers and Jumpers Settings**

The table provides the description for each jumper available on the board.

Jumper	Description	Settings
J3	µVCC and MCU Supply Jumper	If installed, the µVCC output pin of the InnoSwitch3-Pro will provide power to the on board microcontroller and provide pull up voltage to the I^2C lines
J6 , J7	I^2C Lines Isolation Jumper	The user can select whether or not the SDA and SCL lines from the MCU will be connected to the InnoSwitch3-Pro

The following headers are also available on the board.

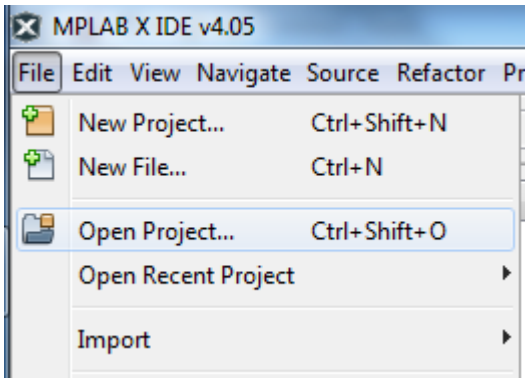
Header	Description	Settings
J4	InnoSwitch3-Pro I2C lines Header	When J6 and J7 are removed, an external I^2C Master can be connected through these headers
J5	PICkit3 Programming Header	For MCU Firmware Update using PICkit3 In-Circuit Debugger/Programmer
J8	MCU GPIO Header	The pins on this header can be used as Debug Pins

4 Library Usage

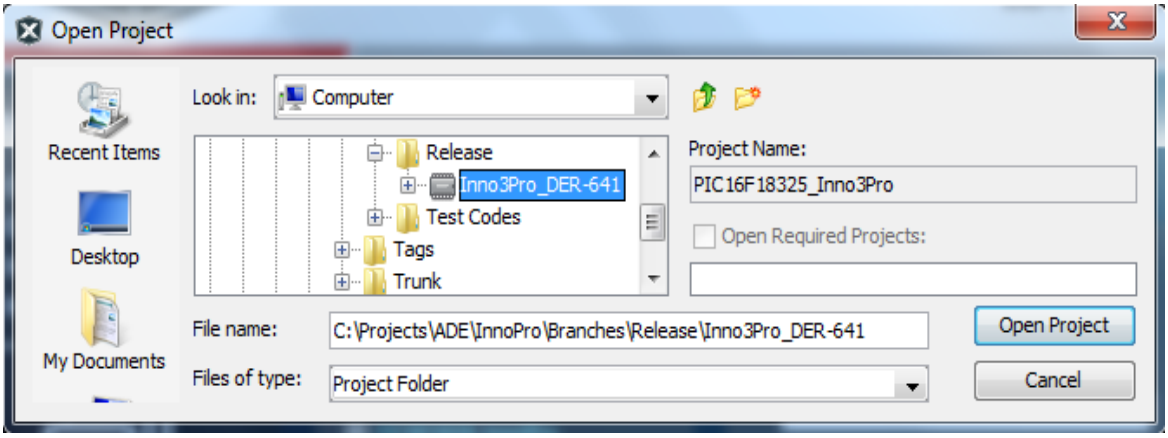
- Download the InnoSwitch3-Pro MCU Code library from the Power integrations website.

  https://ac-dc.power.com/products/innoswitch-family/innoswitch3-pro/

- Unzip the folder, and open MPLAB X IDE
- Navigate to *File > Open Project*

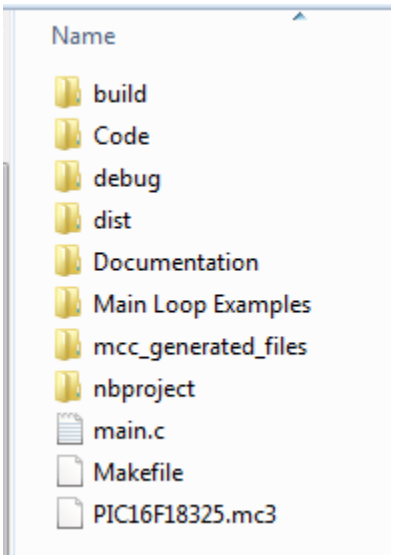


  - Navigate to the file's location and open it.



5 Folder Contents

The InnoSwitch3-Pro Code library consists of various folders and files as shown below

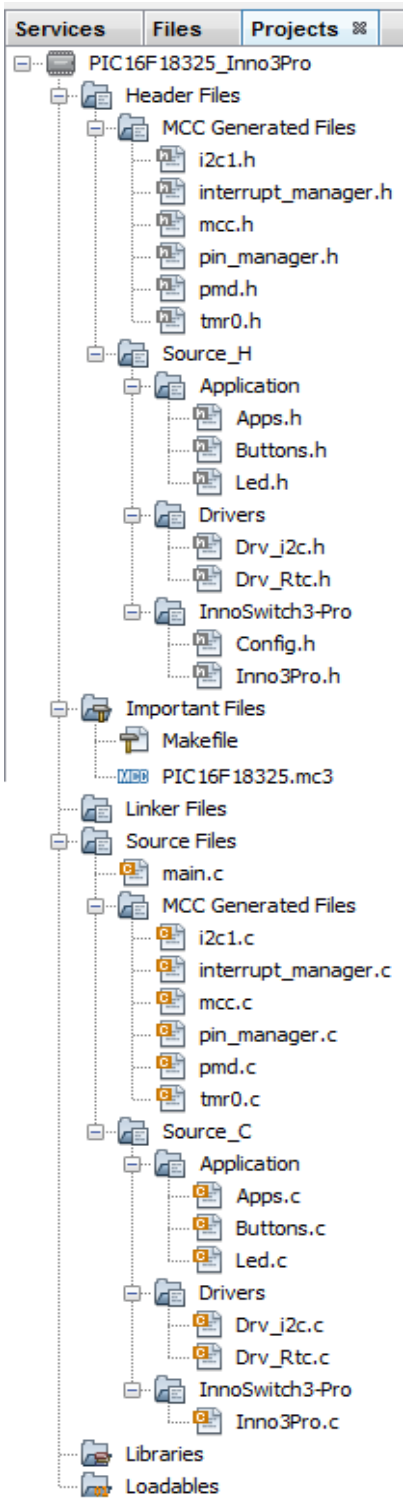


Folder and files summary:

- **build** - Contains all of the intermediate files (*.o, *.o.d) generated by the compiler
- **Code** - Contains the InnoSwitch3-Pro *.c and *.h files
- **debug** - Contains files generated when the project was built in debug mode.
- **dist** - Contains all of the output files (*.elf, *.hex) generated by the linker
- **Documentation** - Contains the Doxygen HTML Documentation
- **Main Loop Example** - Contains the InnoSwitch3-Pro Main Application Examples (*.c)
- **mcc_generated_files** - Contains Generated and Drivers *.c and *.h files
- **nbproject** - Contains your project's settings, such as which files are included, which tools are selected
- **main** - Active Main Application (*.c) File
- **Makefile** - Auto Generated Make File
- **code configurator** - Microchip Code Cofigurator (*.mc3) File

5.1 *Project Structure*

The image below shows the project when opened on MPLABX



5.2 *Files Description*

The Code library is layered and modular, implemented in, 'Clock Driver', 'InnoSwitch3-Pro Driver' and 'InnoSwitch3-Pro API'. The Library architecture block diagram is schematically presented in Figure3.

Below is a brief description of each layer:

- **InnoSwitch3-Pro API**
  - Simple Interface to control InnoSwitch3-Pro. This handles command sequences and timings, register settings, threshold calculations, odd-parity implementation, telemetry and readback

    Related Files:
    Inno3Pro.c , Inno3Pro.h - Contains the main Library APIs
    Config.h - Contains all the configuration parameters of the Library
- **InnoSwitch3-Pro Driver**
  - Manages the I2C Packet format based on the InnoSwitch3-Pro datasheet for Write and Read transactions

    Related Files:
    Drv_i2c.c, Drv_i2c.h
- **Clock Driver**
  - Module used for generating delays and timings involved for InnoSwitch3-Pro Control.
  - Similar with around Arduino 'millis()' and 'micros()' functions

    Related Files:
    Drv_Rtc.c , Drv_Rtc.h
- **User Interface**
  - API for LED and button de-bouncing

    Related Files:
    Buttons.c, Buttons.h
    Led.c, Led.h
- **Application**
  - Application layer

    Related Files:
    App.c, App.h, main.c

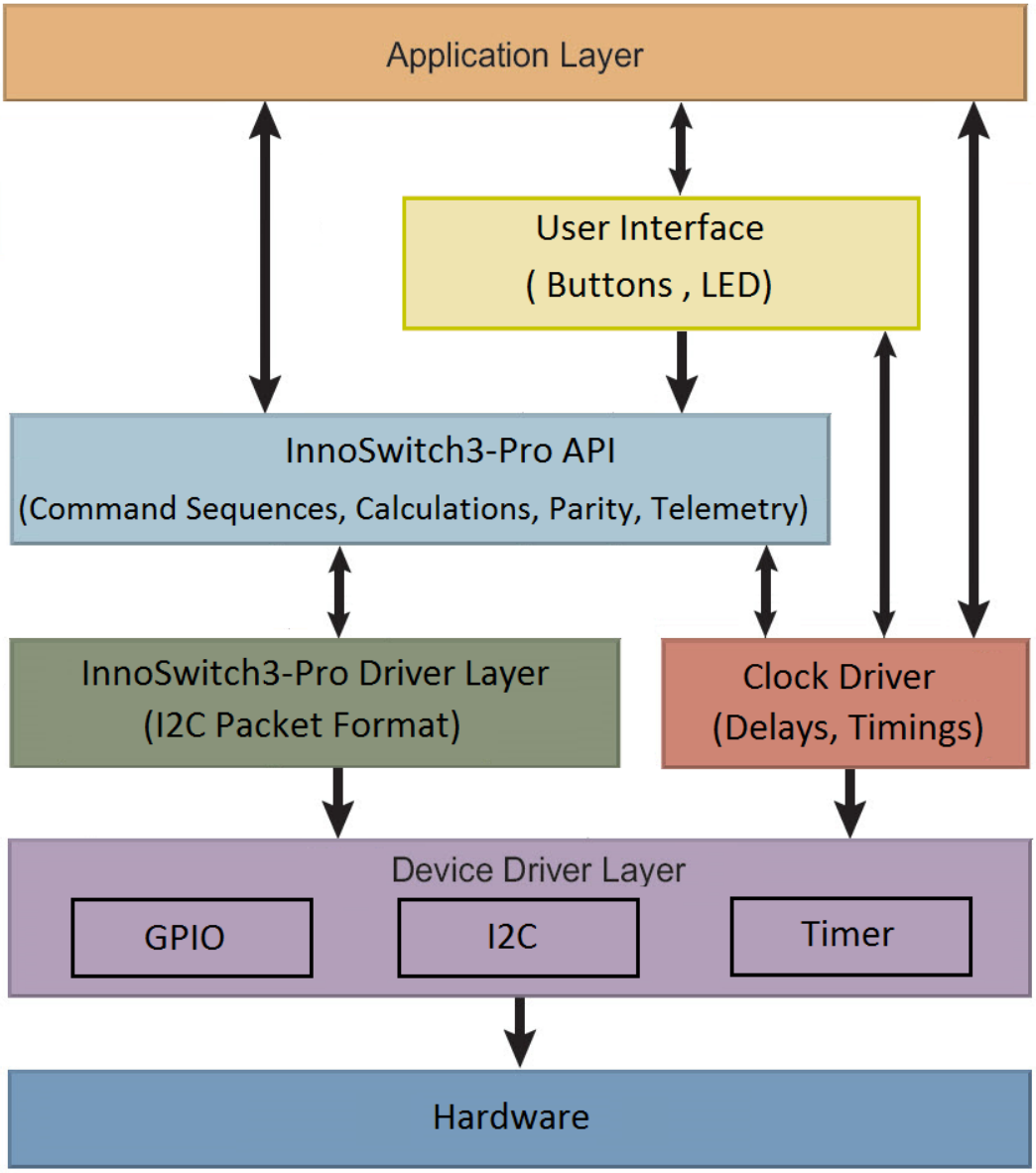


Figure 3 – Firmware Architecture.

6 Application Example

This section describes the step-by-step procedures for setting up the firmware.

6.1 *Step-By-Step Procedure*

6.1.1 Header Files Inclusion

The Library header files contain all of the function declarations and macro definitions. This must be included in the main page as shown.

```
#include "Drv_Rtc.h"
#include "Drv_i2c.h"
#include "Inno3Pro.h"
#include "Config.h"
```

6.1.2 InnoSwitch3-Pro Initialization

Before continuous execution of the main code, the status of System Ready Signal is monitored to ensure the InnoSwitch3-Pro is ready to receive I^2C commands. Afterwards initialization commands are sent to the device to configure the default settings. This initialization routine disables the watchdog timer and Fast VI Limit. UVL timer is also initialized to 64ms.

```
Inno3Pro_Initialization();

void main(void)
{
   //Main Loop Codes
}
```

6.1.3 Basic Control Functions

Inno3Pro_Write_VI(Volts, Amps)

Updates the Output Voltage and Constant Current Setting

- Follows a certain sequence of I2C commands in order to avoid inadvertent triggering of UV or OV faults.
- Controls the VOUT pin strong bleeder when decreasing the voltage from High to Low Setting.
- Automatically updates the Over Voltage (OVA) and Under Voltage (UVA) settings.

  OVA is 124% of CV Setpoint
  UVA is fixed to 3V Setting

Inno3Pro_Write_Volts(Volts)

Updates the Output Voltage without Bleeder Control

Inno3Pro_Write_Amps(Amps)

Sets the Constant Current Setting

Inno3Pro_Write_Over_Volts(Value)

Sets the Over Voltage Setting

Inno3Pro_Write_Under_Volts(Value)

Sets the Under Voltage Setting

Inno3Pro_Write_Cable_Drop_Comp(Value)

Sets the Cable Drop Compensation Value

Inno3Pro_Write_Volt_Peak(Value)

Sets the Constant Output Power Threshold

Inno3Pro_Vbus_Switch_Control(Value)

Used for Turning On or Off the Bus Voltage Switch

Inno3Pro_Bleeder_Enable(Value)

Used for Turning On or Off the VOUT pin strong bleeder

Note: The BLEEDER must not be enabled for extended period of time to prevent excessive power dissipation in the controller

6.1.4 Basic Code Example

6.1.4.1 Example 1 – Inno3Pro_Basic.c

Demonstrates the basic usage of InnoSwitch3-Pro MCU Code Library.

- Initial commands are sent using the InnoSwitch3-Pro Initialization Routine.
- The main routine using write VI sets the output voltage to 5V and constant current to 6 A.
- Output overvoltage is automatically set to 6.2 V and Under voltage is set to 3.6 V.
- Cable Drop Compensation is programmed to 300 mV.
- Constant power is knee voltage is set to 7 V and then Vbus Switch is turned ON.
- This example application does not use the on board push buttons.

This code example is presented in "Main Loop Examples\ Inno3Pro_Basic.c"
Copy and paste these contents to "main.c" and compile.

```
//MPLAB Code Configurator Header File
#include "mcc_generated_files/mcc.h"

//Step  1  :  Add the Header Files
#include "Code/Drv_i2c.h"
#include "Code/Drv_Rtc.h"
#include "Code/Config.h"
#include "Code/Inno3Pro.h"


void main(void)
{
    // Initialize the device - PIC16F18325
    SYSTEM_Initialize();
    INTERRUPT_GlobalInterruptEnable();
    INTERRUPT_PeripheralInterruptEnable();


    //Step 2 :  Write Initial Commands to InnoSwitch3-Pro
    Inno3Pro_Initialization();


    //Step 3 :  Call the Functions on the Main Loop
    while (1)
    {


      // Main Loop Variable Initialization
      float fVolts = 5;                         //Initialize Voltage at 5V
      float fAmps = 6;                          //Initialize Constant Current at 6A
      float fCableDropComp = 300;               //Initialize Cable Drop Compensation to 300mv
      float fVoltPeak = 7;                      //Initialize Knee Voltage at 7V
      float fVbusEn = 1;                        //Initialize Vbus Enable to at ON


      //Library Call in the Mainloop
      Inno3Pro_Write_VI               ( fVolts  , fAmps   );     //Set Voltage and current
      Inno3Pro_Write_Cable_Drop_Comp  ( fCableDropComp    );     //Set Cable Drop Compesation
      Inno3Pro_Write_Volt_Peak        ( fVoltPeak         );     //Set Constant Output Power Knee Voltage
      Inno3Pro_Vbus_Switch_Control    ( fVbusEn           );     //Set Vbus Enable

    }
}
```

6.1.4.2 Example 2 - Inno3Pro_Basic_Volts_Amps_OV_UV.c

Demonstrates the basic usage of InnoSwitch3-Pro MCU Code Library.

- Initial commands are sent using the InnoSwitch3-Pro Initialization Routine.
- Output overvoltage is set to 6.2 V and Output Under voltage is programmed to 3.6 V
- The Main Routine sets the output voltage to 5 V and constant current current to 6 A.
- Cable Drop Compensation is programmed to 300 mV.
- Constant power is knee voltage is set to 7 V and then Vbus Switch is turned ON.
- This example application does not use the on board push buttons.

This code example is presented on
"Main Loop Examples \ Inno3Pro_Basic_Volts_Amps_OV_UV.c"

Copy and paste these contents to "main.c" and compile.

```
//MPLAB Code Configurator Header File
#include "mcc_generated_files/mcc.h"

//Step  1  :  Add the Header Files
#include "Code/Drv_i2c.h"
#include "Code/Drv_Rtc.h"
#include "Code/Config.h"
#include "Code/Inno3Pro.h"


void main(void)
{

    // Initialize the device - PIC16F18325
    SYSTEM_Initialize();
    INTERRUPT_GlobalInterruptEnable();
    INTERRUPT_PeripheralInterruptEnable();


    //Step 2 :  Write Initial Commands to InnoSwitch3-Pro
    Inno3Pro_Initialization();


    //Set Over Voltage Protection
    Inno3Pro_Write_Over_Volts(6.2);

    //Set Uncer Voltage Protection
    Inno3Pro_Write_Under_Volts(3.6);

    //Step 3 :  Call the Functions on the Main Loop
    while (1)
    {

        // Main Loop Variable Initialization
        float fVolts = 5;                       //Initialize Voltage at 5V
        float fAmps = 6;                        //Initialize Constant Current at 6A
        float fCableDropComp = 300;             //Initialize Cable Drop Compensation to 300mv
        float fVoltPeak = 7;                    //Initialize Knee Voltage at 7V
        float fVbusEn = 1;                      //Initialize Vbus Enable to at ON

        // Library Call in the Mainloop
        Inno3Pro_Write_Amps(fAmps);                         //Set Constant Current
        Inno3Pro_Write_Volts(fVolts);                       //Set Voltage
        Inno3Pro_Write_Cable_Drop_Comp(fCableDropComp);     //Set Cable Drop Compesation
        Inno3Pro_Write_Volt_Peak(fVoltPeak);                //Set Constant Output Power Knee Voltage
        Inno3Pro_Vbus_Switch_Control(fVbusEn);              //Set Vbus Enable
    }

}
```

7 Programming the MCU

7.1 *Step-By-Step Procedure*

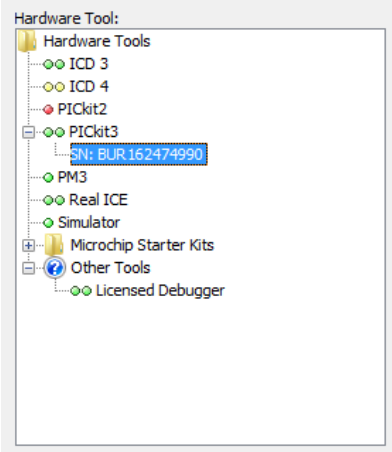
This section provides a step by step guide on updating the firmware on the RDK-641 demo board. Before following the steps below make sure AC input is off.

7.1.1 Setup PICKit3, PC and RDK-641

- The white triangle on the PICkit3 should line up with pin 1 of the programming header as shown on image below.

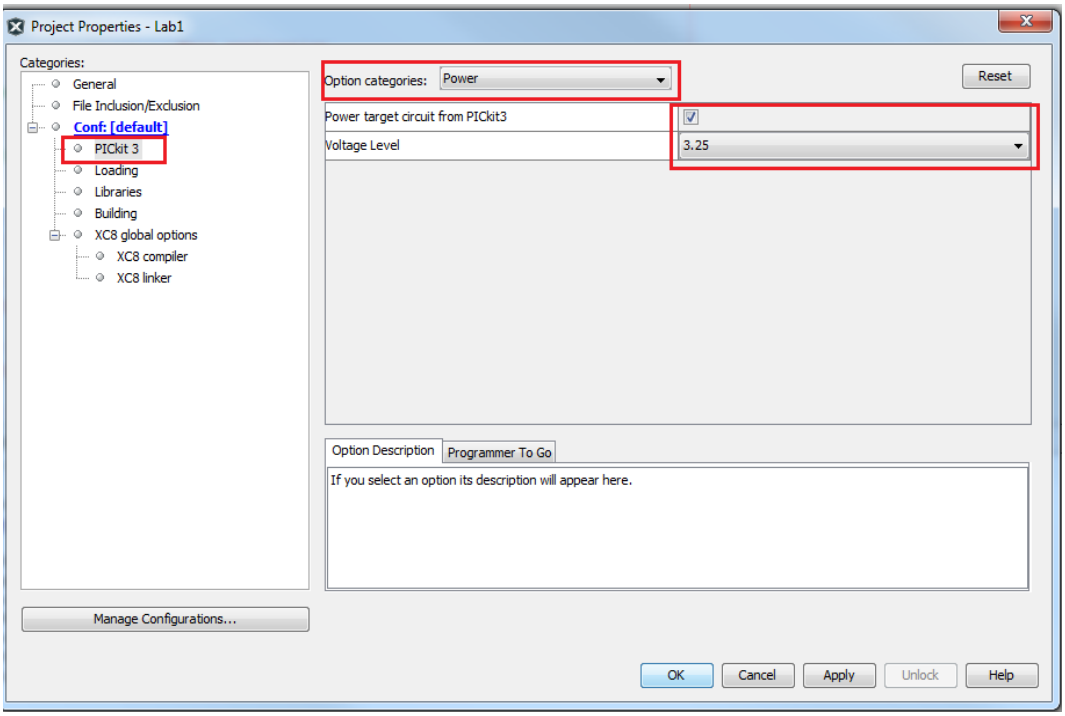
7.1.2 Verify PICkit3 Connection

- Open Project Properties
- From the main menu,
  Select File ▶ Project Properties
- Hardware Tool Shows the serial No of PICkit3



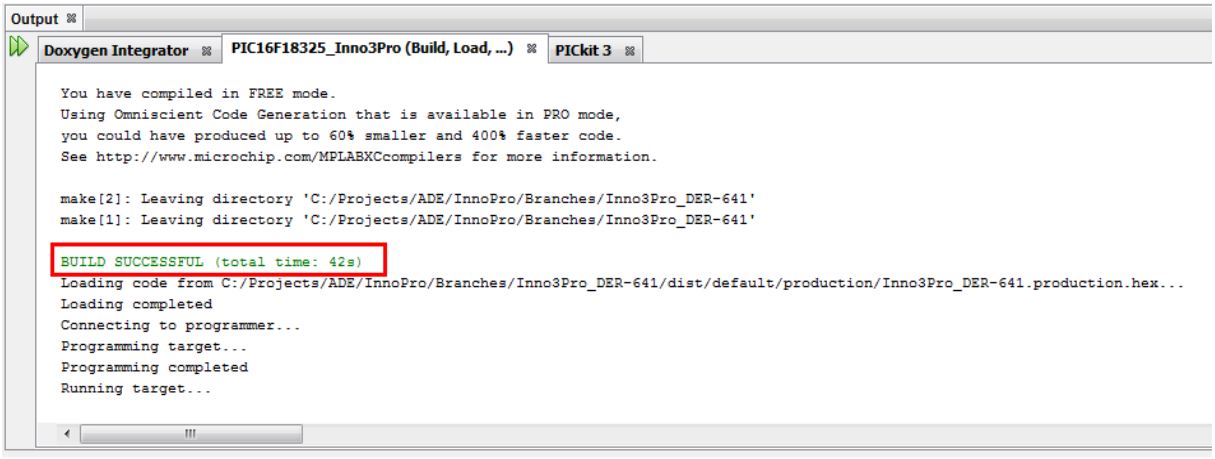
7.1.3 Enable power from PICkit3

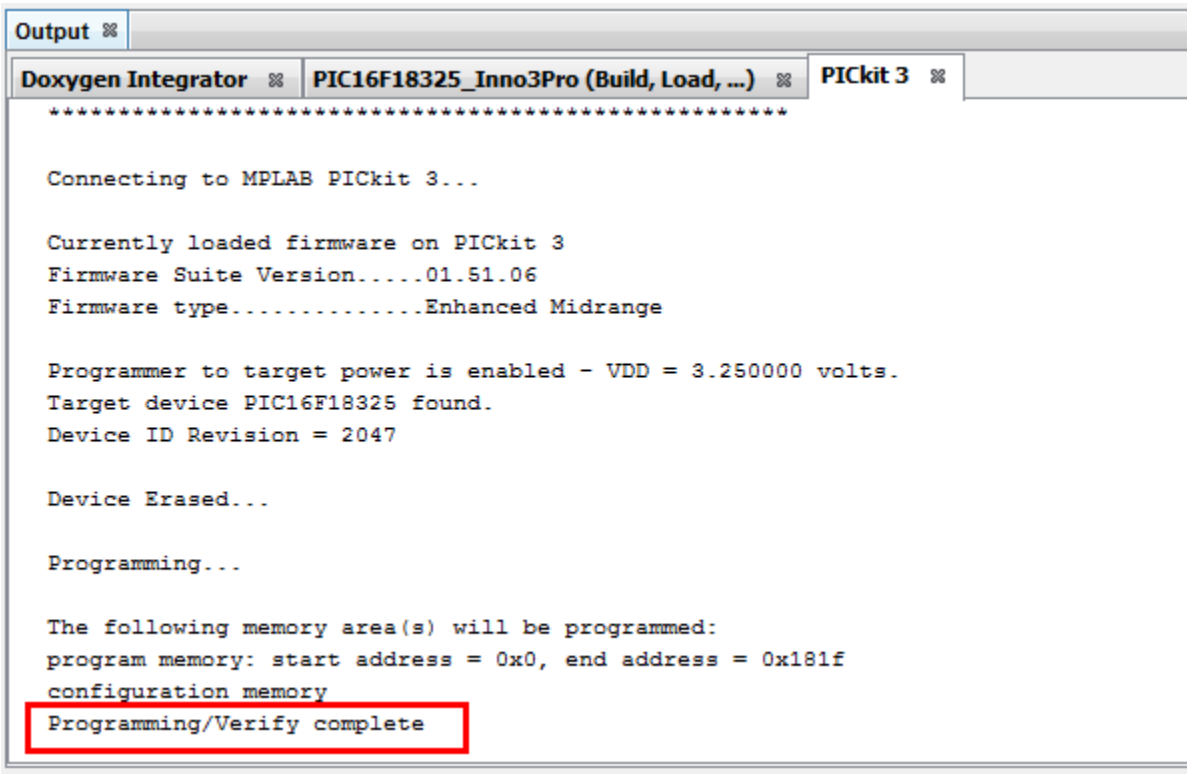
- Open Project Properties
- Select PICkit3 from Categories
- Choose Power from - 'Option Categories' combo box
- Check the Checkbox - 'Power target circuit from PICkit3'
- Set Voltage Level to 3.25V
- Click OK



7.1.4 Program the PIC16F18325 device

- Click on the Make and Program Device Icon 
- Project will be Built and downloaded through the programmer



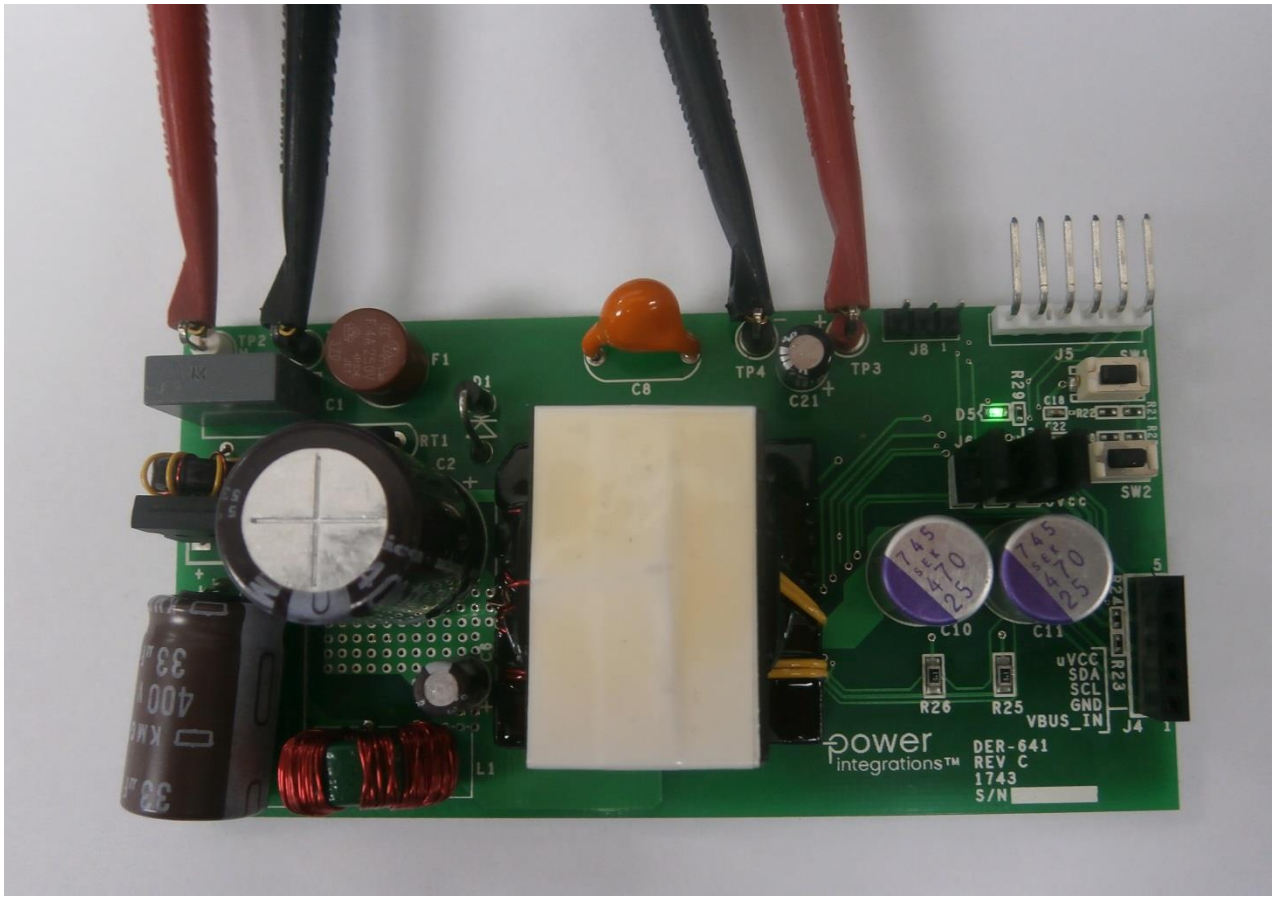


8 Demonstration of Operation

8.1 Running the Program

This section demonstrates code Example 1 or Example 2 in action. Upon power up, LED (D5) turns on which indicates that the µVCC from the InnoSwitch3-Pro supplied the microcontroller power.

100 VAC was applied to the AC input terminals and output terminals were connected to a Chroma DC electronic load.



8.2 Constant Voltage Operation

- Image below shows the operation of RDK-641 at constant voltage of 5V and Full load of 6A

8.3 Constant Current Operation

- Image below shows the operation of RDK-641 in constant current mode once the load resistance was reduced and resulted in constant current (CC) operation

9 Doxygen Documentation

This document describes all of the data structures and functions that are part of the library. Many of these functions are intended to be used internally by the stack layers. The main public interfaces that are expected to be used by user code are summarized in the Doxygen Documentation Folder.

9.1 Opening HTML File

- Search the InnoSwitch3-Pro code library folder and Browse to documentation folder ,then Open the *.html File

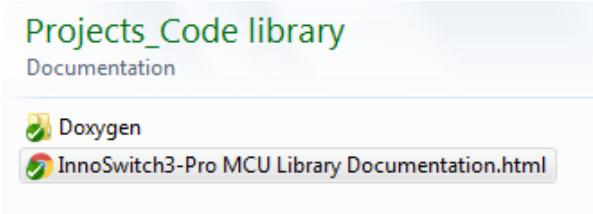
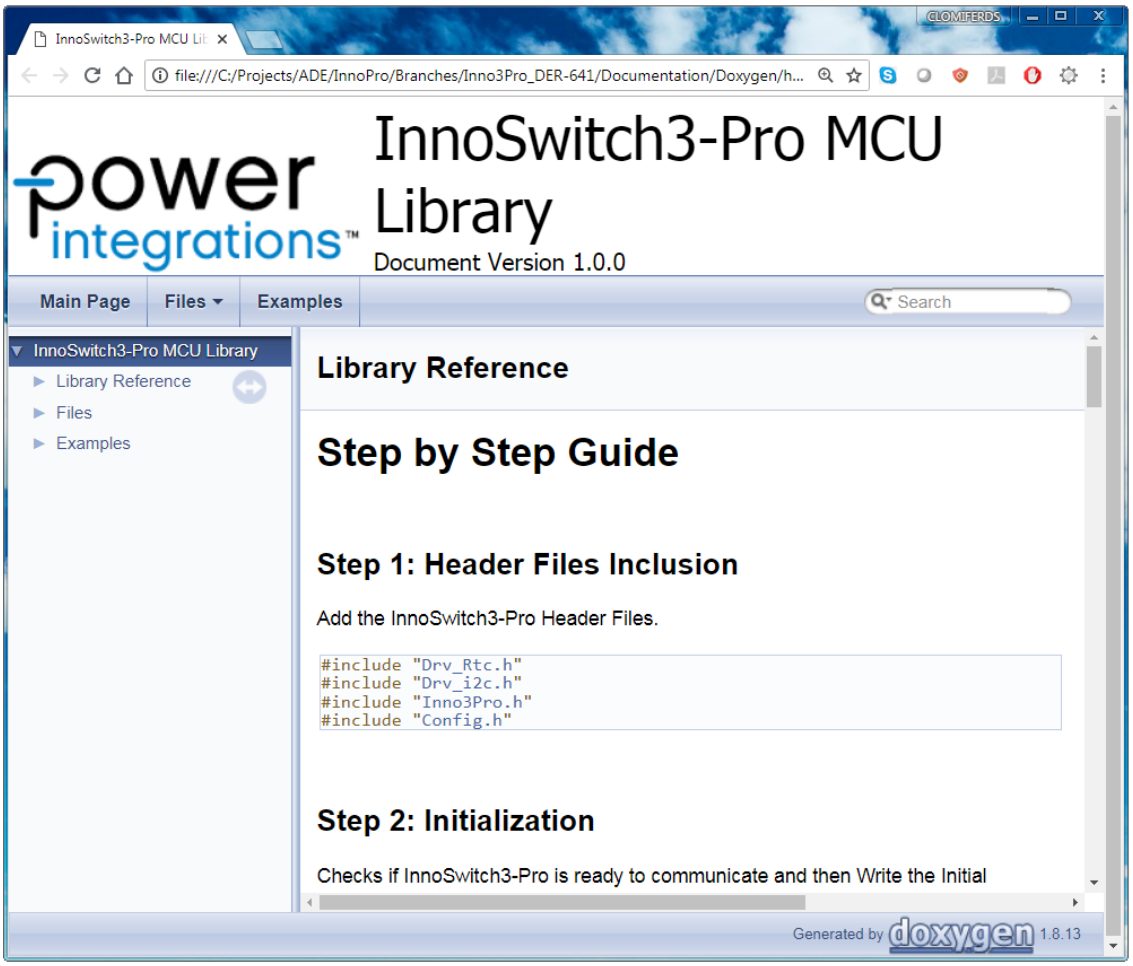
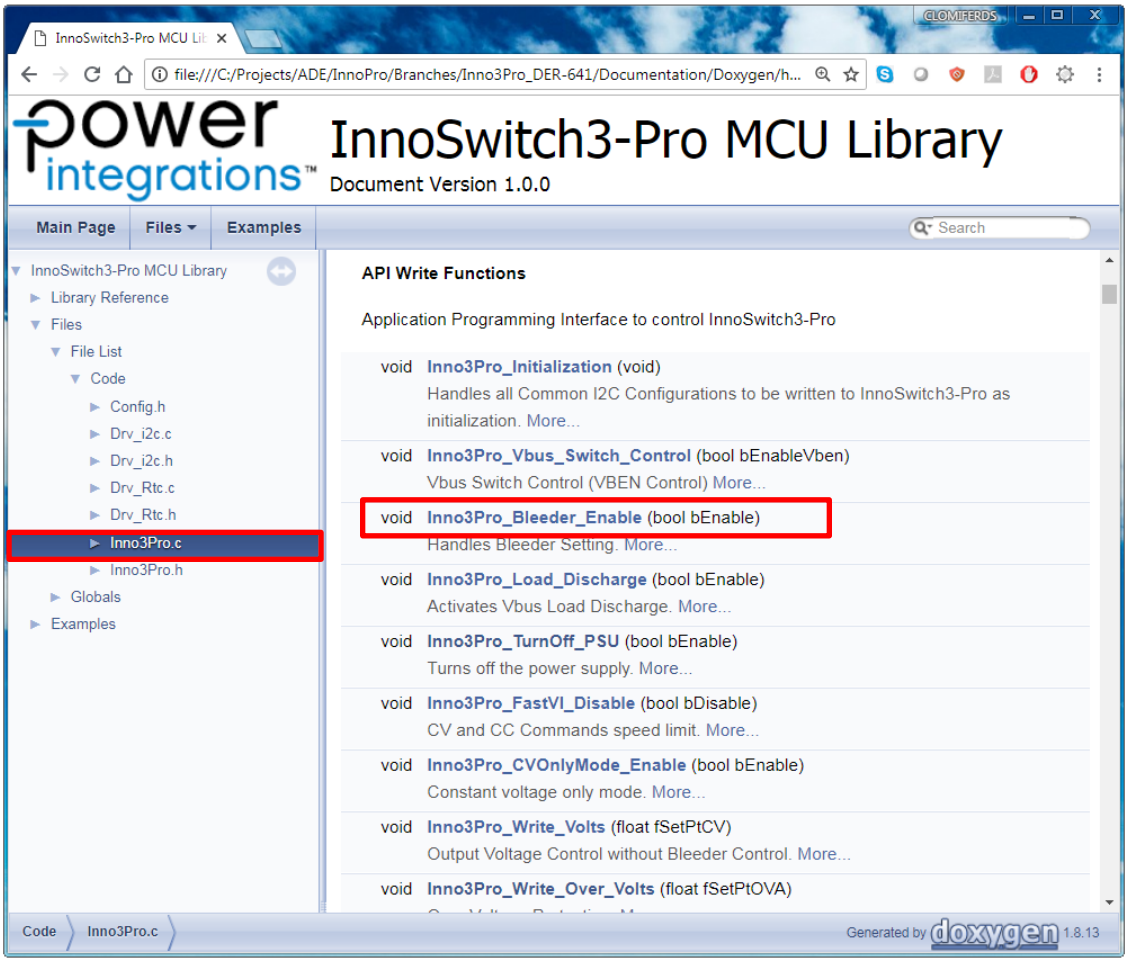


Image below shows the doxygen html file:



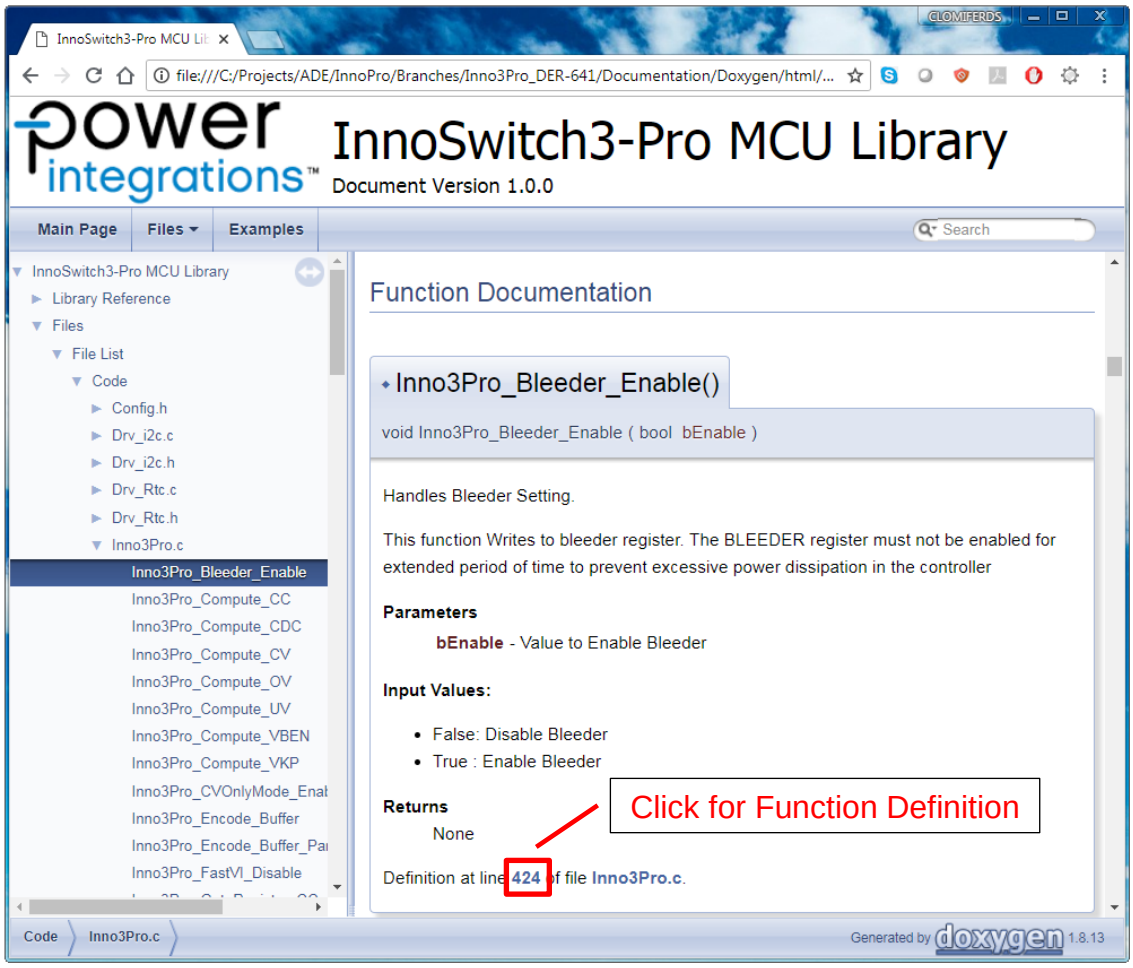
9.2 Viewing the API Functions

- Under File List > Code,
- Select and Open Function Summary and Description:



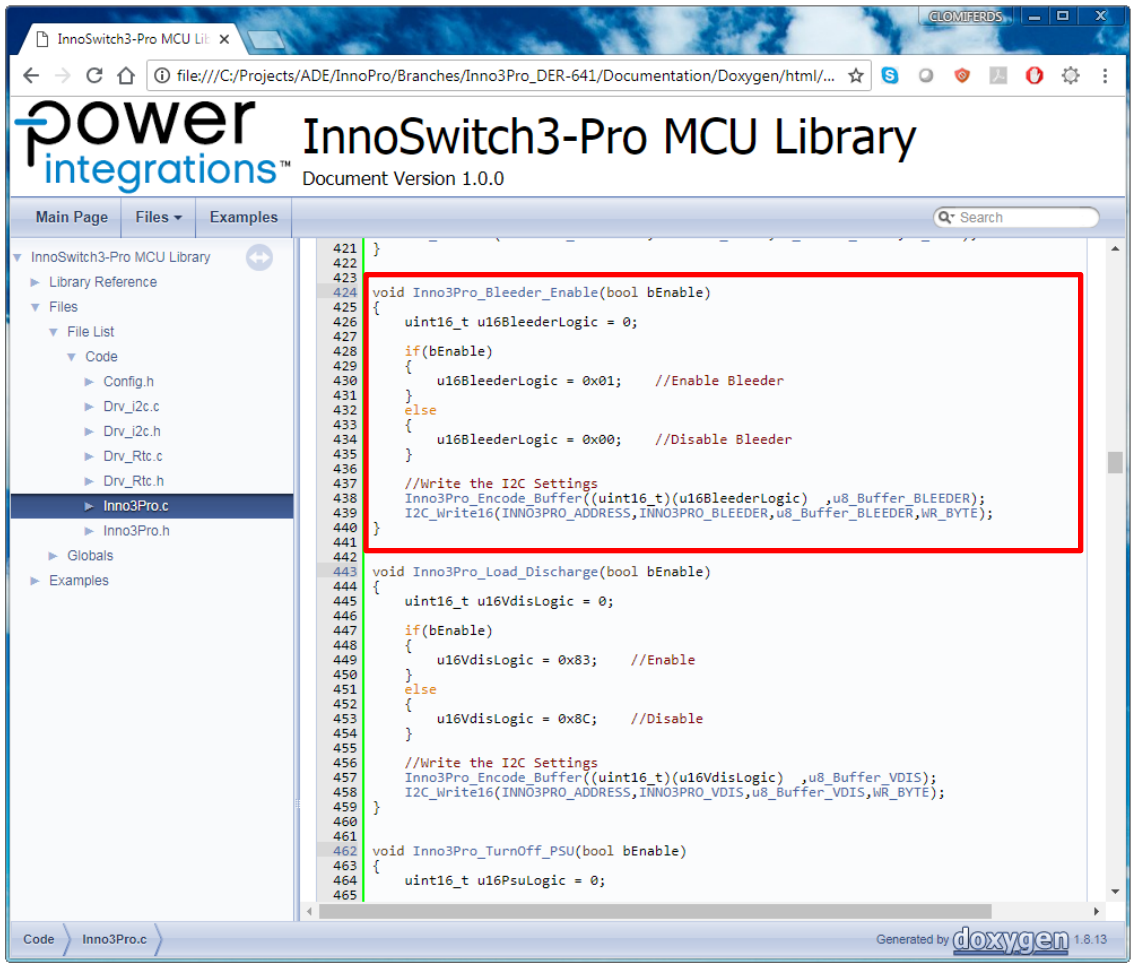
9.3 Functions Summary

This section provides details and summary of how the function works.



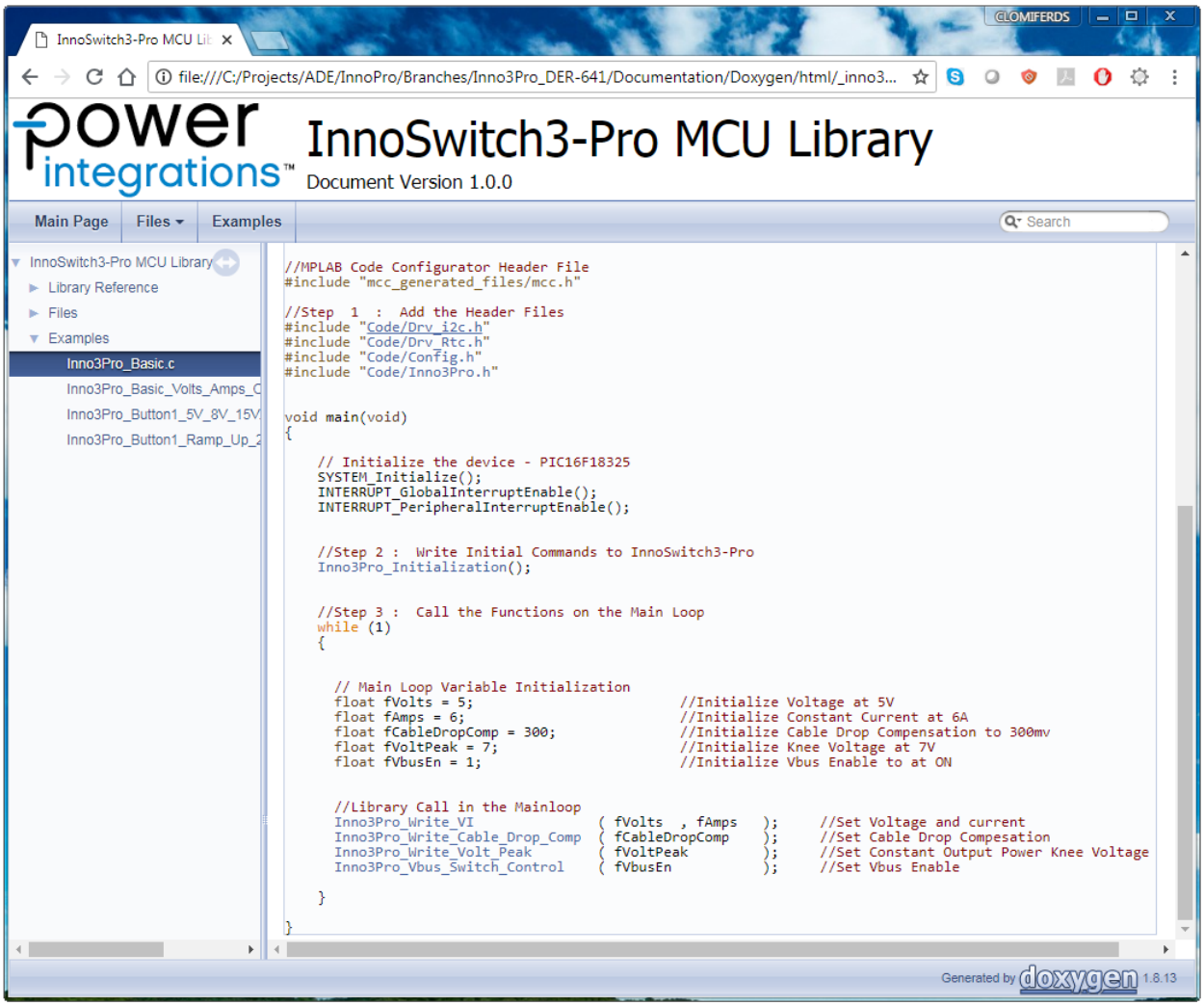
9.4 Functions Definition

This section provides the actual body and implementation of the function.



9.5 Examples

This section provides different examples that showcase the use of the library functions.



10 Revision History

Date	Author	Revision	Description & changes	Reviewed
10-Aug-18	CS	1.0	Initial Release.	Apps & Mktg

For the latest updates, visit our website: www.power.com

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