Title	***Getting Started with InnoSwitch™3-Pro Code Library using Arduino***
Author	Applications Engineering Department
Document Number	Application Note 77 (AN-77)
Date	September 6, 2018
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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 40W output power and is programmable from 3V to 20V 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 Arduino code libraries provided by Power Integrations to develop control logic and firmware for customizing RDK-641.

Information presented in this application note was used to develop firmware for Arduino UNO.

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1 Introduction

This application note describes the structure and the application interface of the InnoSwitch3-Pro Arduino 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 to be compatible with the Arduino library standards. This demo application runs on Reference Design RDK-641 (Figure 1) and Arduino UNO (Figure 3).

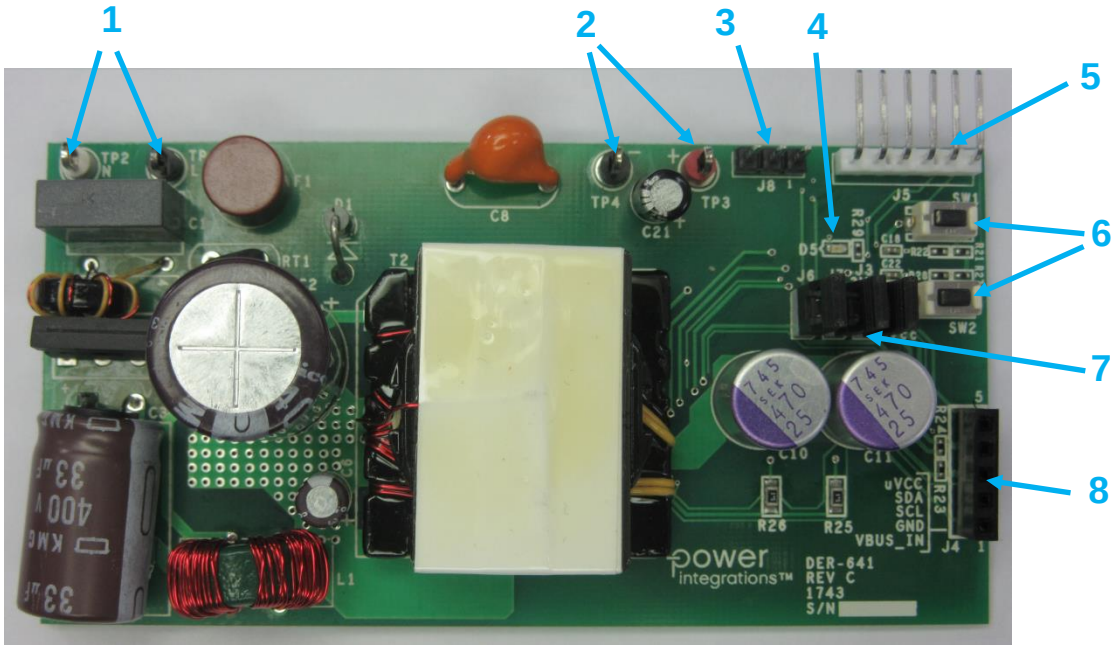

Figure 1 – RDK-641 Board Top

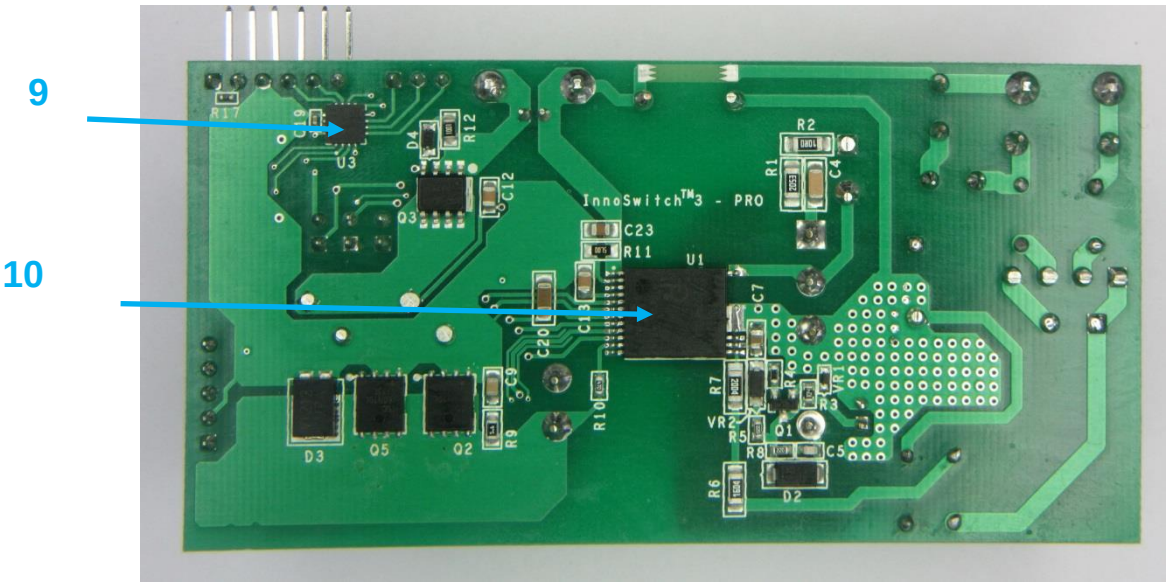

Figure 2 – RDK-641 Board Bottom

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The RDK-641 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	uVCCand I^2C Isolation Jumpers	J3, J6, J7
8	External Interface Header	J4
9	PIC16F18325 microcontroller	U3
10	InnoSwitch3-Pro IC	U1

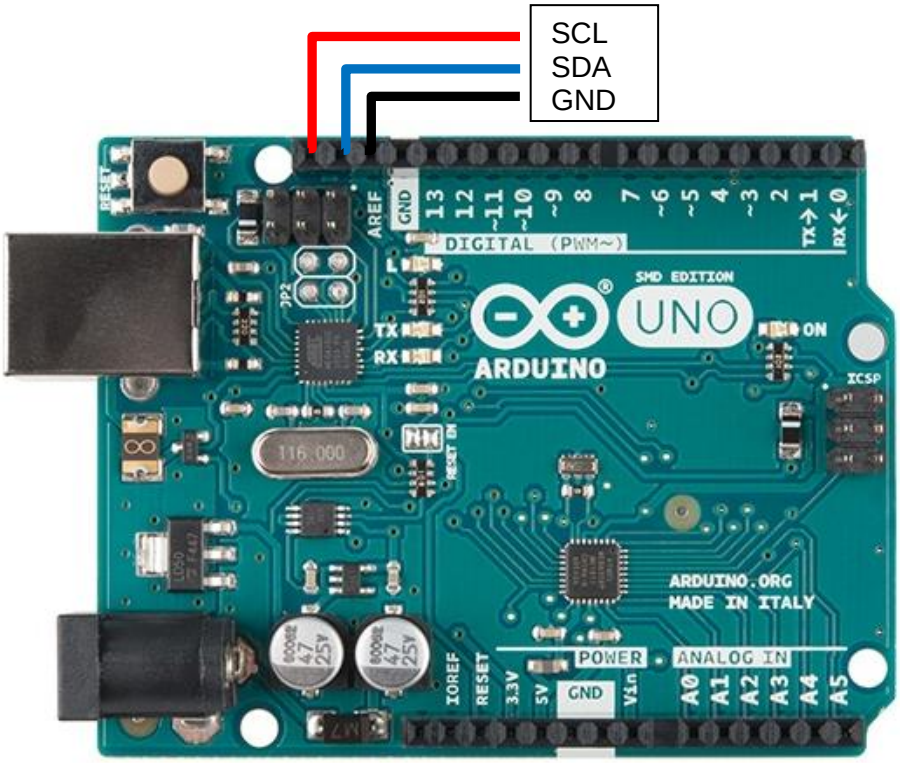

Figure 3 – Arduino Uno Rev 3

2 System Requirements

The following are required to run the 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 1.0.0

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3 Hardware Overview

The Reference Design (RDK-641) hardware consists of an 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 does not use the on board microcontroller but an Arduino Uno as an I^2C Master and InnoSwitch3-Pro as slave device.

SDA and SCL lines pull-up resistors R24 and R23 respectively are available on the board. The output of the InnoSwitch3-Pro provides 3.6V pull up voltage from its µVCC output pin.

To further ease in development, the following documents are available and recommended as supplemental reference resources I^2C

- 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 *Headers and Jumpers Settings*

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

Jumper	Description	Settings
J3	uVCC and MCU Supply Jumper	If connected the uVCC 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 I^2C lines Header	When J6 and J7 are removed, an external I^2C Master can be connected through these header
J5	PICkit3 Programming Header	For MCU Firmware Update using PICkit3 In-Circuit Debugger/Programmer
J8	MCU GPIO Header	This can be used as Debug Pins

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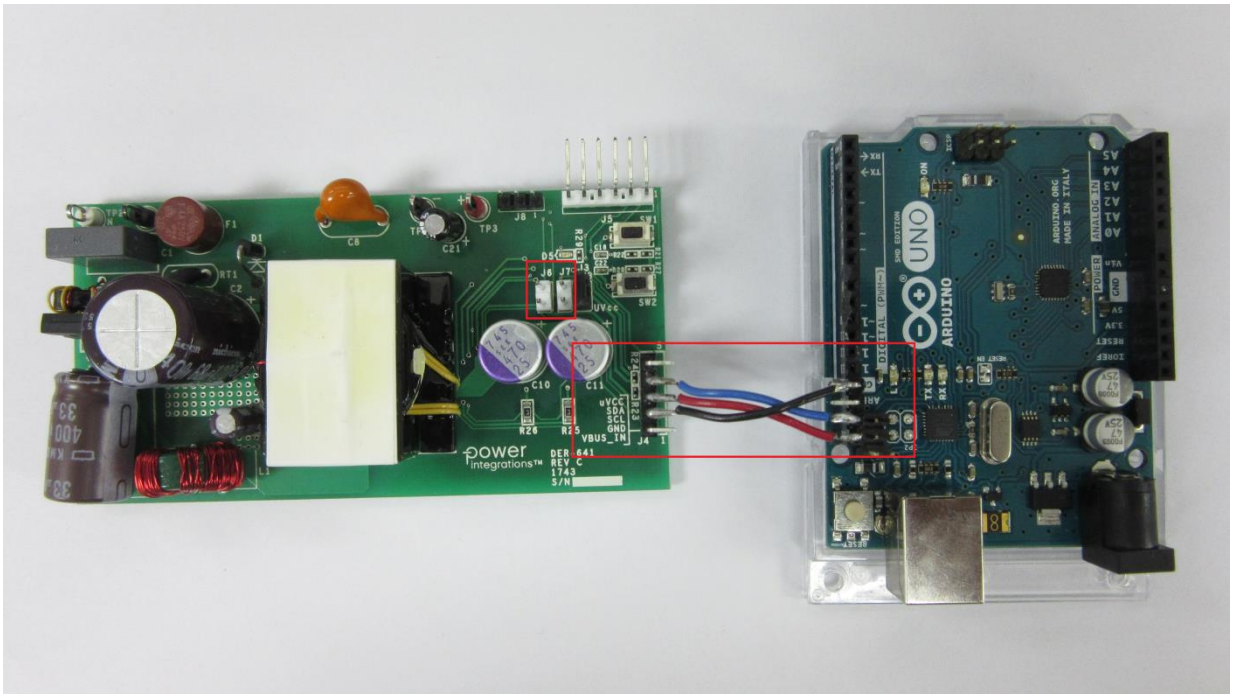
By configuring the I^2C lines isolation jumpers, the RDK-641 board can be controlled using Arduino UNO.

Connection details:

- Remove Jumpers J6 and J7 and retain Jumper J3
- Connect J4 to Arduino Uno I^2C lines (SDA, SCL and GND).
- Make sure to check the I^2C labels of J4 and Arduino UNO board



- Wires on the Image above
  - Blue – SDA
  - Red – SCL
  - Black – GND

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4 InnoSwitch3-Pro Arduino Code Library

To simplify the technicalities on controlling the InnoSwitch3-Pro, a simple code library is provided as a reference.

The library contains all the registers needed for controlling the device. These registers are organized as Command Registers and Telemetry registers. Command registers are sent to the device for performance control and Telemetry Registers are for reading back values.

Computation Macros are presented to aid in set point calculations. Register default values are also defined to simplify writing to the required registers at device initialization.

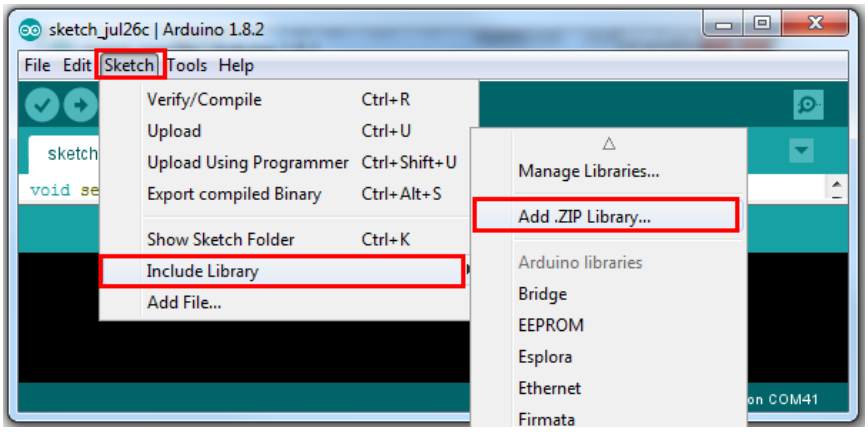
The InnoSwitch3-Pro Arduino code library is available from the Power integrations website.

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

4.1 *Library Installation*

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

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.

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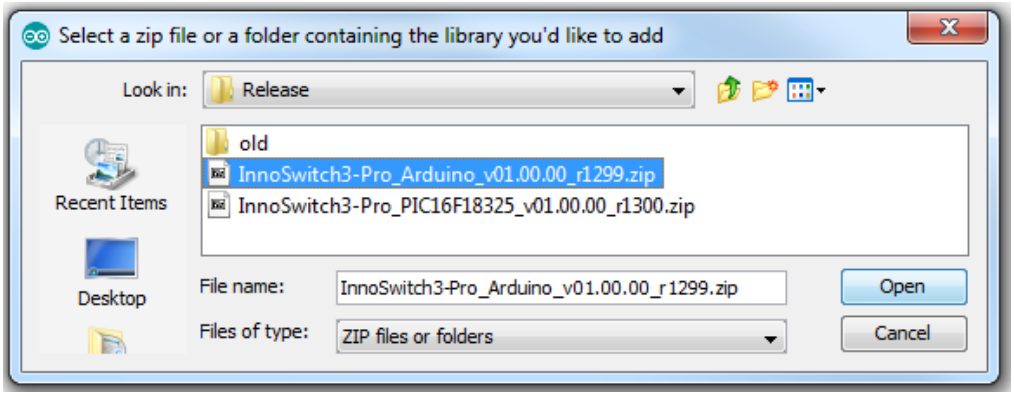
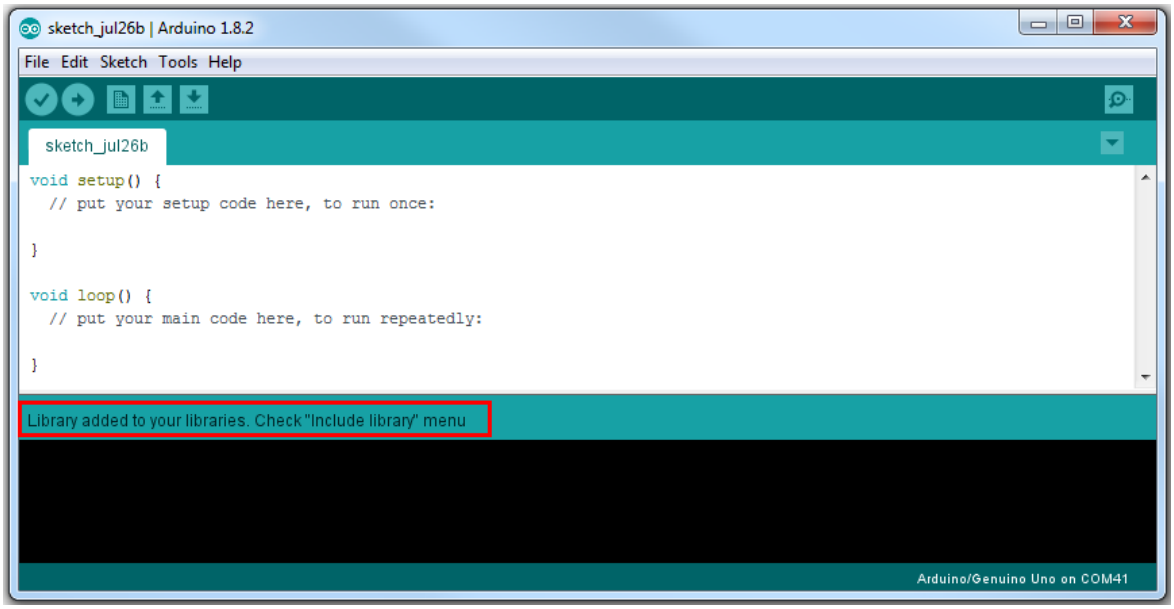


4.2 **Library Installation Complete**

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



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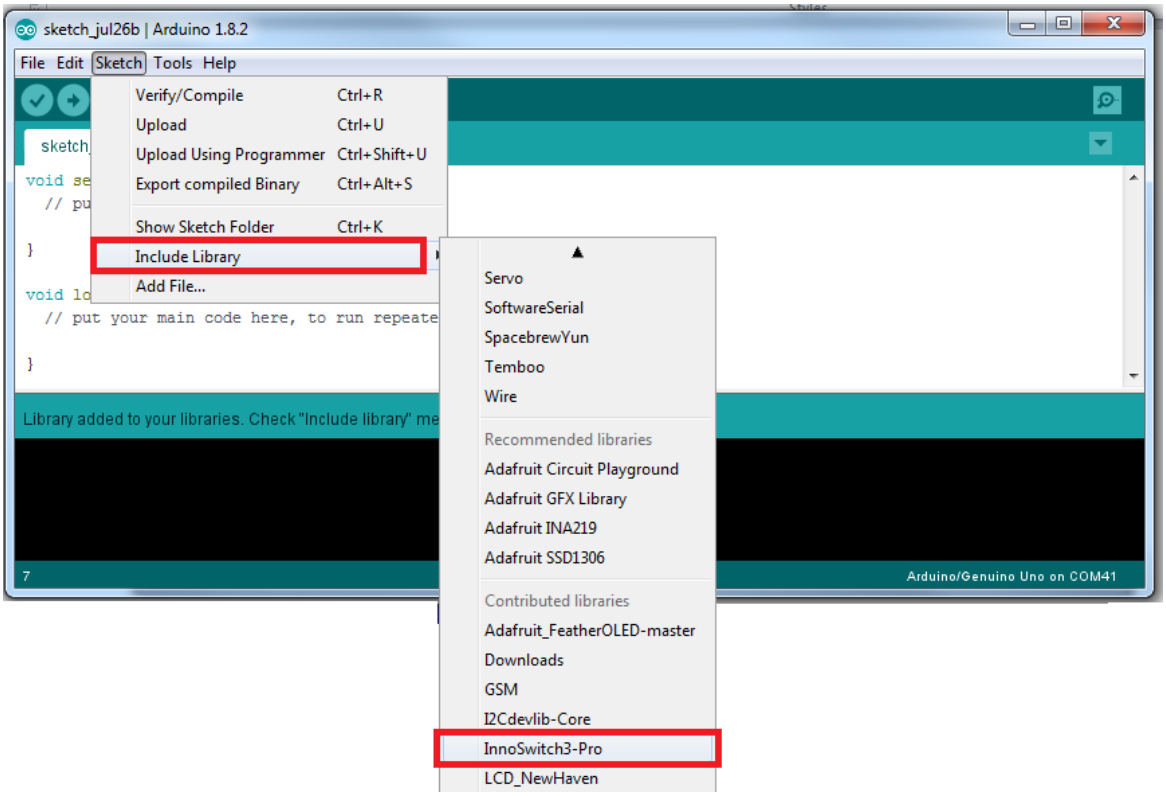

For windows users, the library can be viewed on this directory:

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

4.3 Library Examples

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

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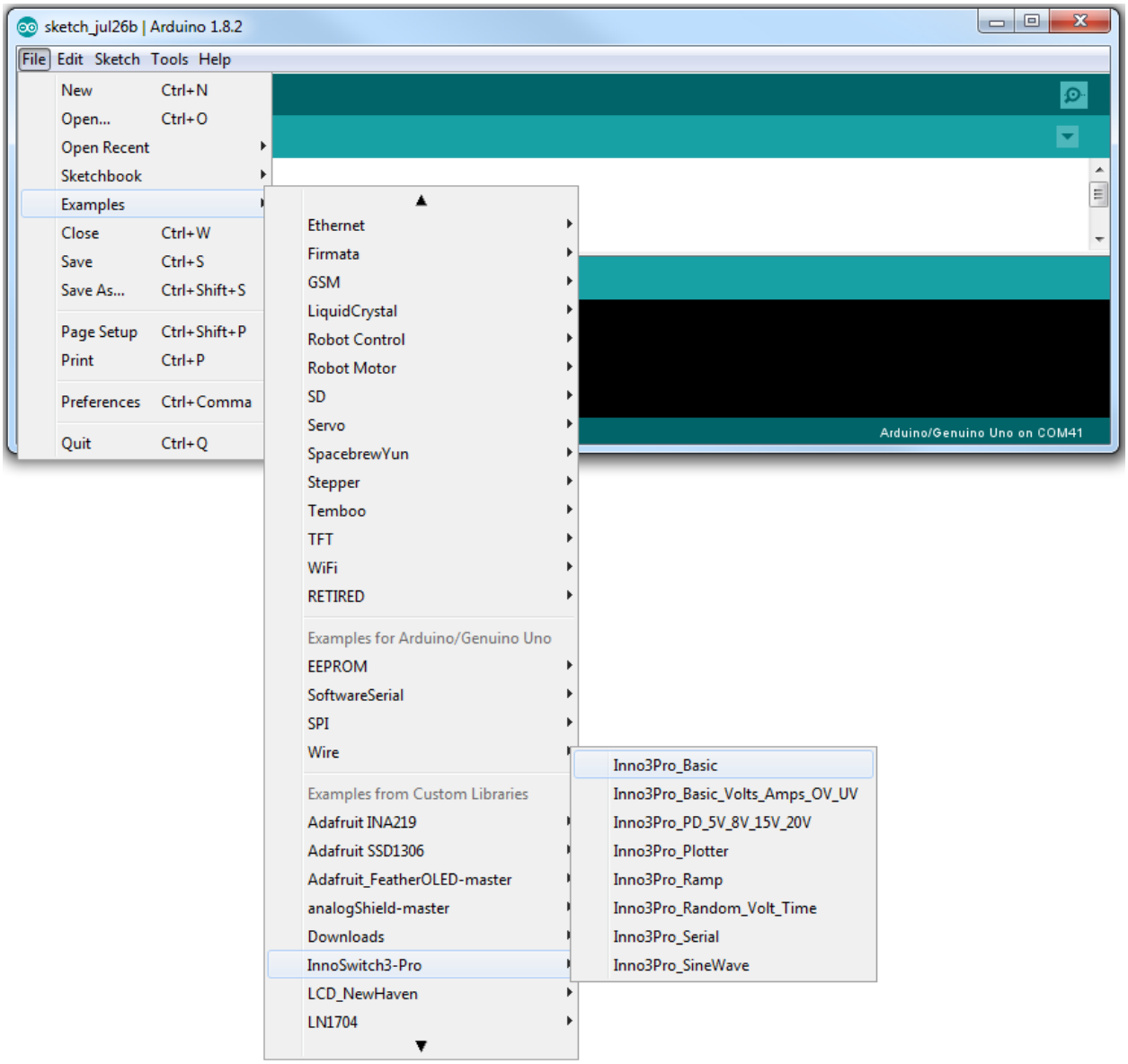

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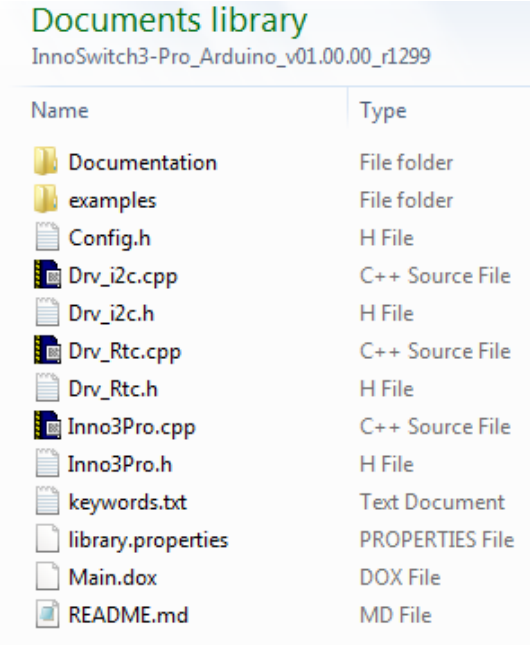
5 Folder Contents

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



Folder and files summary:

- **Examples** - Contains the InnoSwitch3-Pro Main Application Examples (*.ino)
- **Documentation** - Contains the Doxygen HTML Documentation
- ***.cpp and .h** - Library source and header files
- **Library.properties** - Arduino Library files format
- **Keywords.txt** - List of keywords for the library, provided syntax coloring
- **Main.dox** - Doxygen file
- **README.md** - Compatibility list

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5.1 *File Description*

The Arduino 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 Control Interface to control InnoSwitch3-Pro. This handles Command Sequences and Timings, Register Settings, Threshold Calculations, Parity Implementation, Telemetry

    Related Files:

    Inno3Pro.h - Contains the core of the library
    Inno3Pro.cpp

    Config.h - Contains the Configuration Parameters of the Library

- **InnoSwitch3-Pro Driver**
  - Manages the I^2C Packet format based on the InnoSwitch3-Pro Datasheet for Write and Read Transactions
  - Built using Arduino Wire Library

    Related Files:
    Drv_I2C.cpp
    Drv_I2C.h

- **Clock Driver**
  - Module used for generating delays and timings involved for InnoSwitch3-Pro Control.
  - Built using Arduino 'millis()' and 'micros()' functions

    Related Files:
    Drv_Rtc.cpp
    Drv_Rtc.h

- **Application**
  - Application Layer

    Related Files:
    Inno3Pro_Basic.ino
    Inno3Pro_Basic_Volts_Amps_OV_UV.ino

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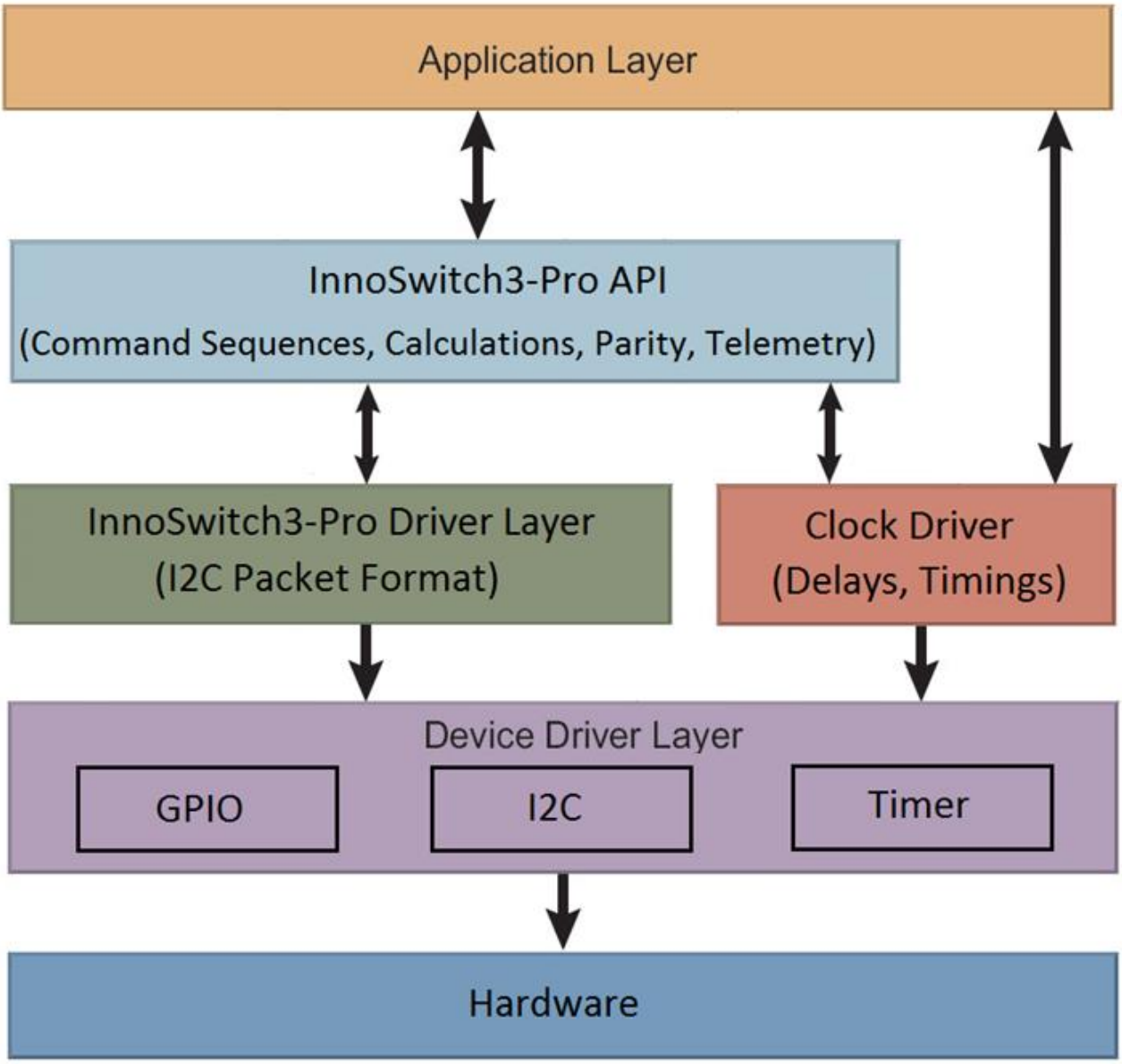

Figure 3 – Firmware Architecture

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6 Application Example

This section describes the step-by-step procedures for setting up the Arduino sketch for InnoSwitch3-Pro.

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 Class Instance Creation

Construct a Class instance to call the functions inside **Inno3Pro_Application**. Constructing a Class instance of **Inno3Pro_Rtc** is Optional.

```
Inno3Pro_Application     Inno3ProApp;
Inno3Pro_Rtc             Inno3ProClk;
```

6.1.3 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.

The 400 kHz clock frequency for I^2C communication is set-up on initialization.

```
void setup()
{
    Inno3ProApp.Inno3Pro_Initialization();
}
```


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6.1.4 Basic Control Functions

Updates the Output Voltage and Constant Current Setting

- Follows a certain sequence of I^2C 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.Inno3Pro_Write_VI( Volts, Amps )
```

Updates the Output Voltage without Bleeder Control

```
Inno3Pro.Inno3Pro_Write_Volts( Volts )
```

Sets the Constant Current Setting

```
Inno3Pro.Inno3Pro_Write_Amps( Amps )
```

Sets the Over Voltage Setting

```
Inno3Pro.Inno3Pro_Write_Over_Volts( Value )
```

Sets the Under Voltage Setting

```
Inno3Pro.Inno3Pro_Write_Under_Volts( Value )
```

Sets the Cable Drop Compensation Value

```
Inno3Pro.Inno3Pro_Write_Cable_Drop_Comp( Value )
```

Sets the Constant Output Power Threshold

```
Inno3Pro.Inno3Pro_Write_Volt_Peak( Value )
```

Used for Turning On or Off the Bus Voltage Switch

```
Inno3Pro.Inno3Pro_Vbus_Switch_Control( Value )
```

Used for Turning On or Off the VOUT pin strong bleeder

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

```
Inno3Pro.Inno3Pro_Bleeder_Enable ( Value )
```


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6.1.5 Basic Code Examples

6.1.5.1 Example 1 - Inno3Pro_Basic.ino

Demonstrates the basic usage of InnoSwitch3-Pro Arduino 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 current to 5.1A.
- Cable Drop Compensation is programmed to 300mV.
- Constant power is knee voltage is set to 7V and then Vbus Switch is turned ON

This code example is presented on "examples\Inno3Pro_Basic\Inno3Pro_Basic.c"
Copy and paste these contents to your Arduino sketch.

```
//Step  1  :  Add the Header Files
#include <Drv_Rtc.h>
#include <Drv_i2c.h>
#include <Inno3Pro.h>
#include <Config.h>

//Step  2  :  Create the class instance
Inno3Pro_Application Inno3ProApp;

//Step 3 :  Write Initial Commands to Inno Pro
void setup()
{
  Inno3ProApp.Inno3Pro_Initialization();
}

//Step 4 :  Call the Functions on the Main Loop
void loop()
{
      //Control Functions Set-Up

      // 5V, 5.1A , Voltage and Constant Current
      Inno3ProApp.Inno3Pro_Write_VI(5 , 5.1);

      // 300mV    , Cable Drop Compesation
      Inno3ProApp.Inno3Pro_Write_Cable_Drop_Comp(300);

      // 7V       , Constant Output Power Knee Voltage
      Inno3ProApp.Inno3Pro_Write_Volt_Peak(7);

      // ON       , Vbus Enable
      Inno3ProApp.Inno3Pro_Vbus_Switch_Control(1);
}
```


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6.1.5.2 Example 2 - Inno3Pro_Basic_Volts_Amps_OV_UV.ino

Demonstrates the basic usage of InnoSwitch3-Pro Arduino Library.

- Initial commands are sent using the InnoSwitch3-Pro Initialization Routine.
- Output Over voltage is set to 6.2V and Output Under voltage is programmed to 3.6V
- The Main Routine sets the output voltage to 5V and constant current current to 5.1A.
- Cable Drop Compensation is programmed to 300mV.
- Constant power is knee voltage is set to 7V and then Vbus Switch is turned ON

This code example is presented on "examples\Inno3Pro_Basic_Volts_Amps_OV_UV\ Inno3Pro_Basic_Volts_Amps_OV_UV.ino"
Copy and paste these contents to your Arduino sketch.

```
//Step  1  :  Add the Header Files
#include <Drv_Rtc.h>
#include <Drv_i2c.h>
#include <Inno3Pro.h>
#include <Config.h>

//Step  2  :  Create the class instance
Inno3Pro_Application Inno3ProApp;

//Step 3 :  Write Initial Commands to Inno Pro
void setup()
{
  //Write Initialization
  Inno3ProApp.Inno3Pro_Initialization();

  //Set Over Voltage Protection
  Inno3ProApp.Inno3Pro_Write_Over_Volts(6.2);

  //Set Uncer Voltage Protection
  Inno3ProApp.Inno3Pro_Write_Under_Volts(3.6);
}

//Step 4 :  Call the Functions on the Main Loop
void loop()
{
     //Control Functions Set-Up

    // Main Loop Variable Initialization
    float fVolts = 5;                          //Initialize Voltage at 5V
    float fAmps = 5.1;                         //Initialize Constant Current at 5.1A
    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
    Inno3ProApp.Inno3Pro_Write_Amps(fAmps);                    //Set Constant Current
    Inno3ProApp.Inno3Pro_Write_Volts(fVolts);                  //Set Voltage
    Inno3ProApp.Inno3Pro_Write_Cable_Drop_Comp(fCableDropComp); //Set Cable Drop Compesation
    Inno3ProApp.Inno3Pro_Write_Volt_Peak(fVoltPeak);           //Set Constant Output Power Knee Voltage
    Inno3ProApp.Inno3Pro_Vbus_Switch_Control(fVbusEn);         //Set Vbus Enable
}
```


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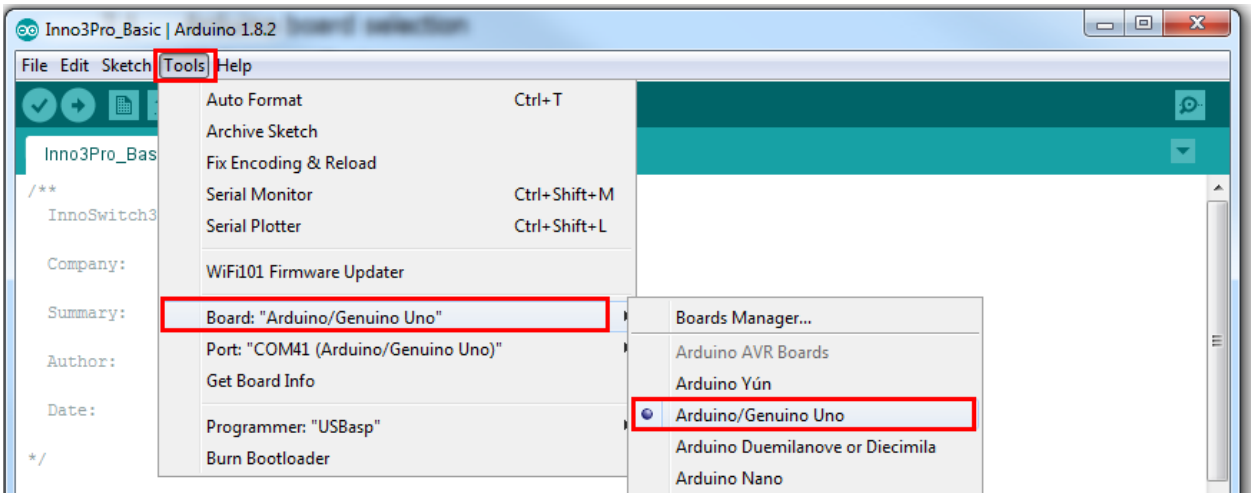
7 Building the Project

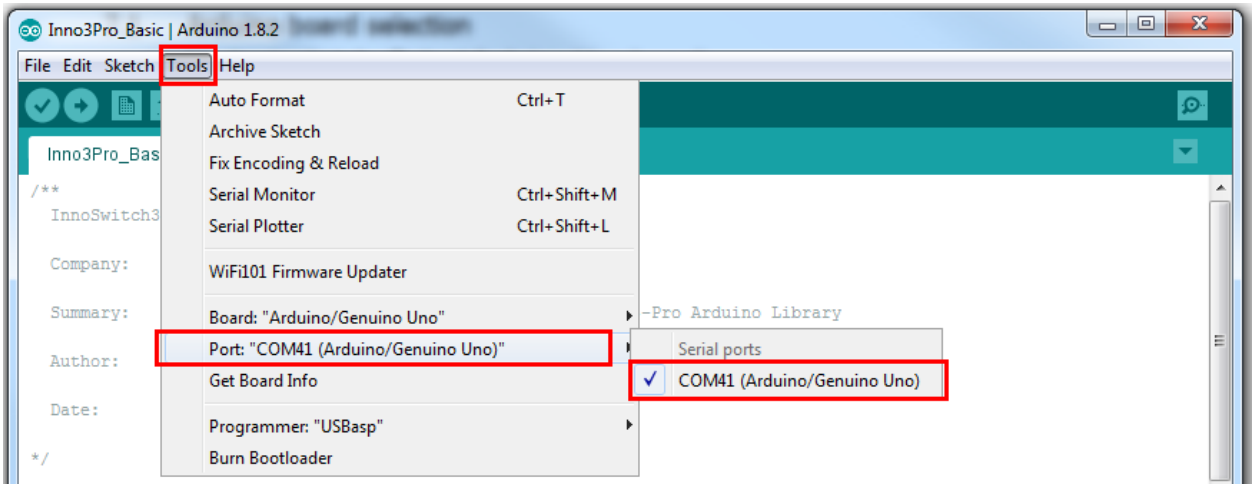
7.1 Arduino board selection

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



7.2 Select the Active Com Port

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



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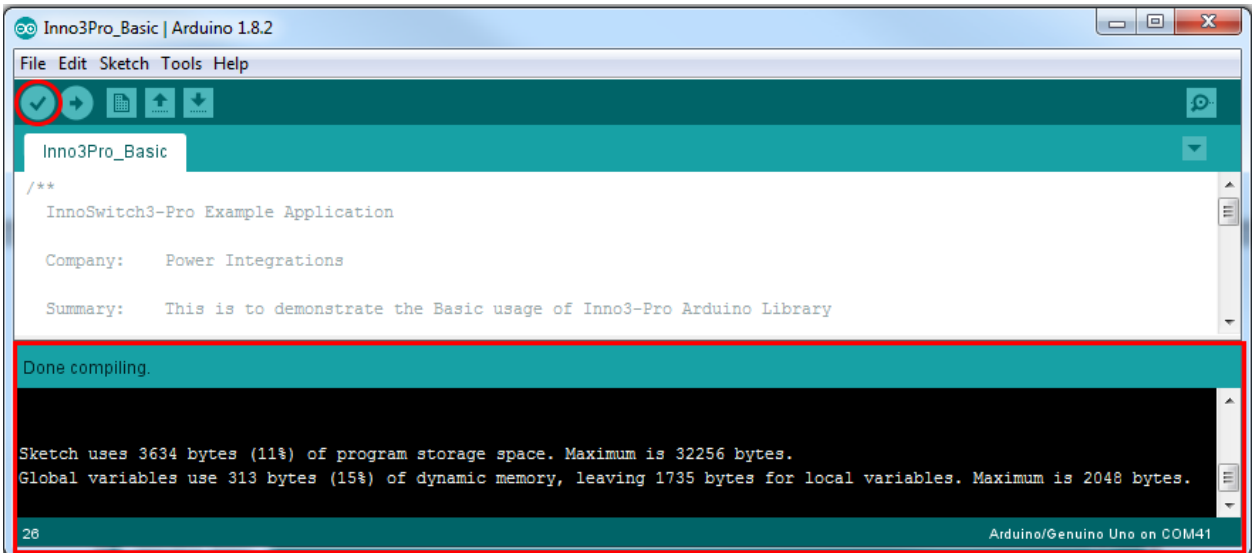
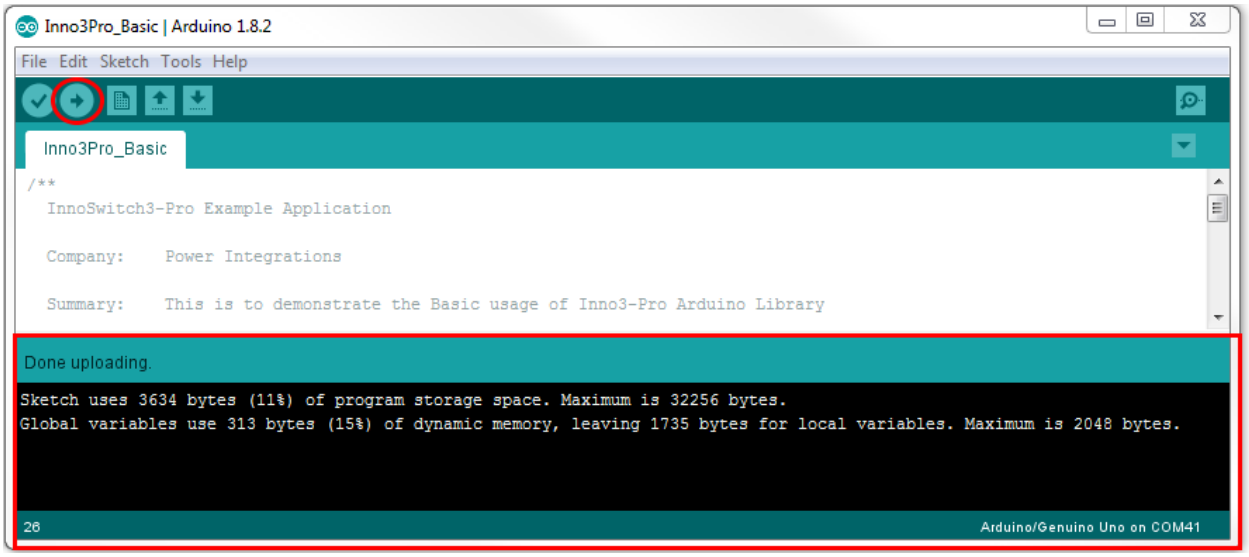
7.3 Verify / Compile

- 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



7.4 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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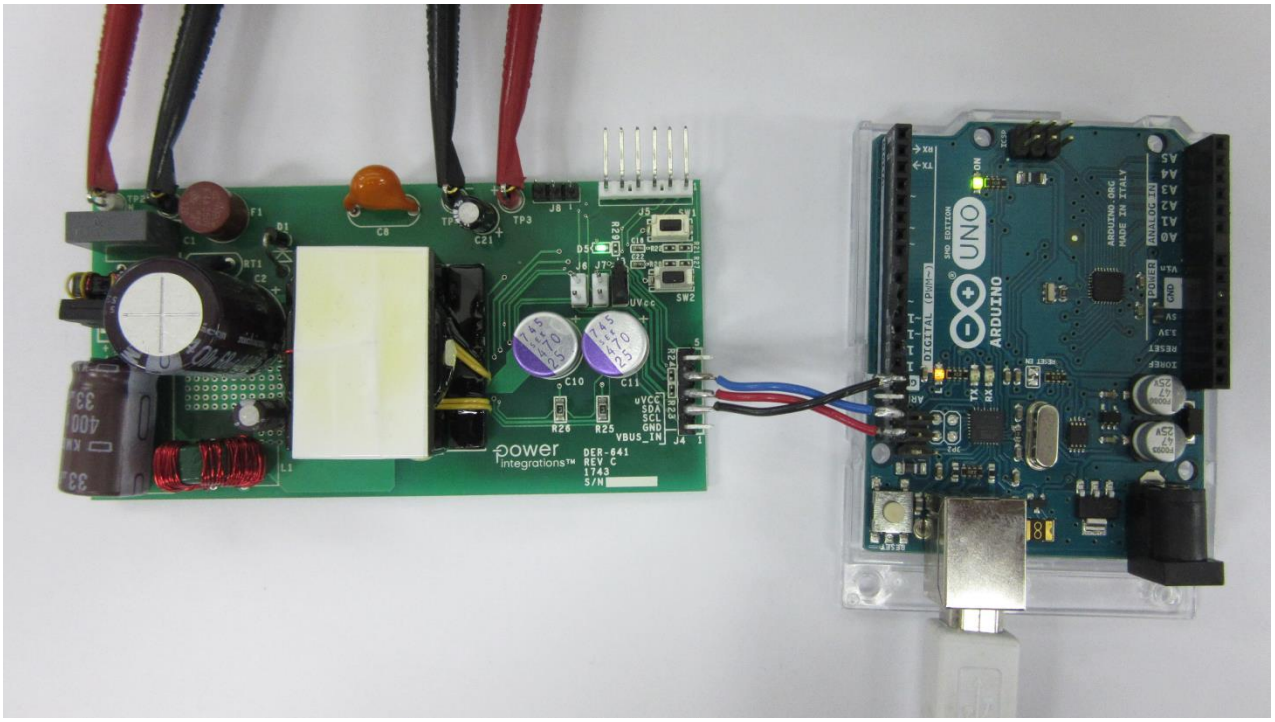
8 Demonstration of Operation

8.1 Running the Program

This section demonstrates code Example 1 or Example 2 in action.
Upon power up, the Arduino program is uploaded to InnoSwitch3-Pro.

100VAC was applied to the AC input terminals and output terminals were connected to a Chroma DC electronic load. Arduino Uno board is connected to a USB port.



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8.2 Constant voltage operation

- Image below shows the operation of RDK-641 at constant voltage of 5V and Full load of 5.1A

8.3 Constant current operation

- Image below shows the operation of RDK-641 at constant current mode

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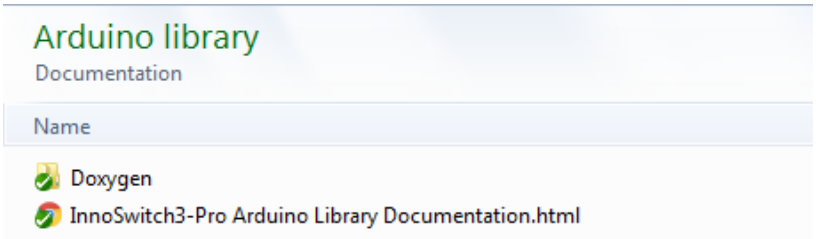
9 Doxygen Documentation

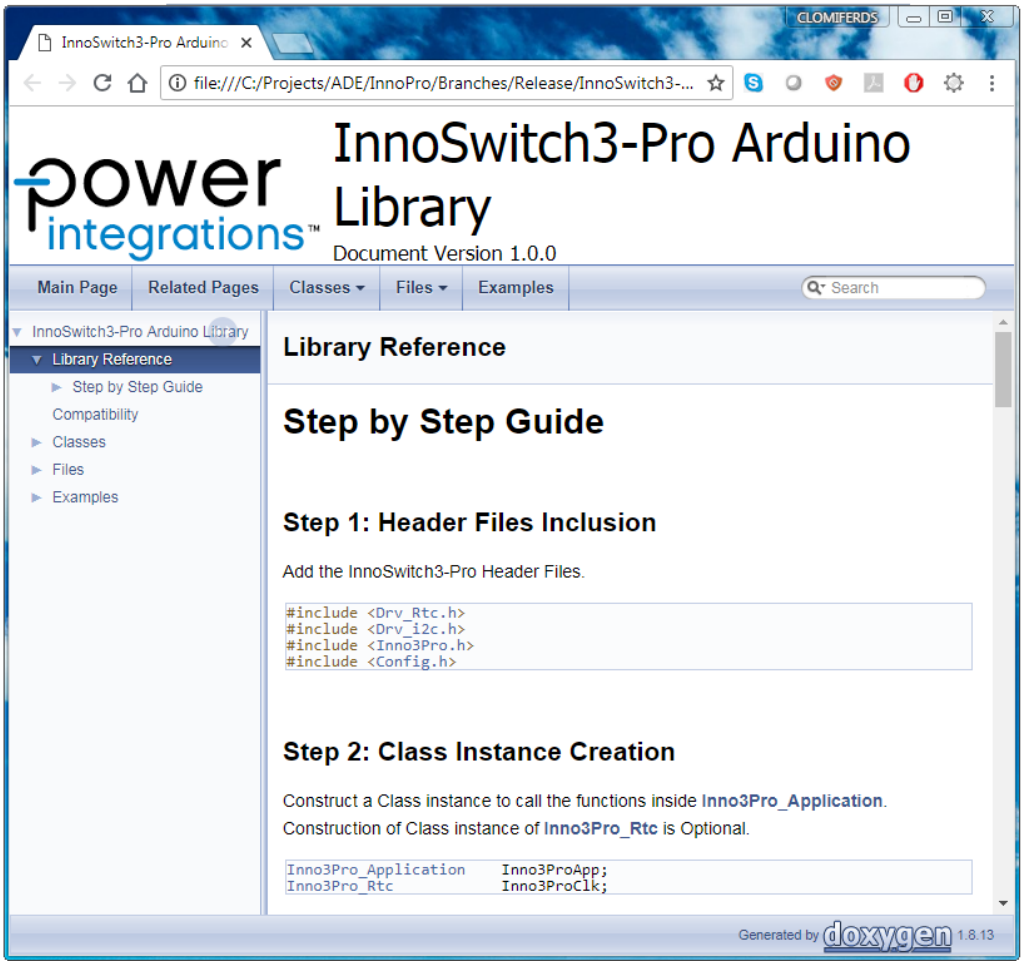
This document describes all of the data structures and functions that are part of the library. Many of these functions are intended to be used internally by the stack layers. The main public interfaces that are expected to be used by user code are summarized in the Doxygen Documentation Folder.

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:



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9.2 Viewing the API Functions

- Under Inno3_Application Class List,
- Select and Open Function Summary and Description:

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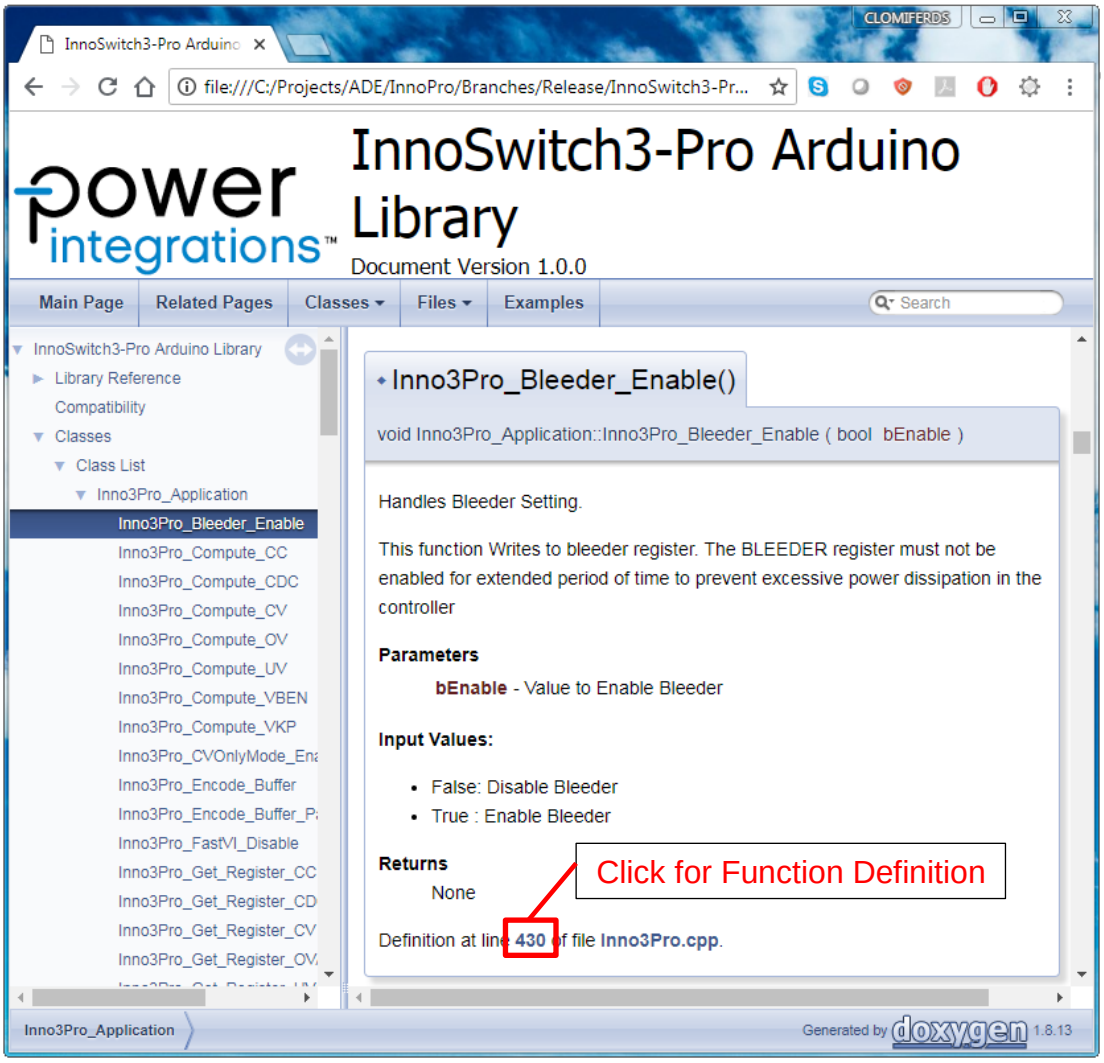
9.3 Functions summary

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



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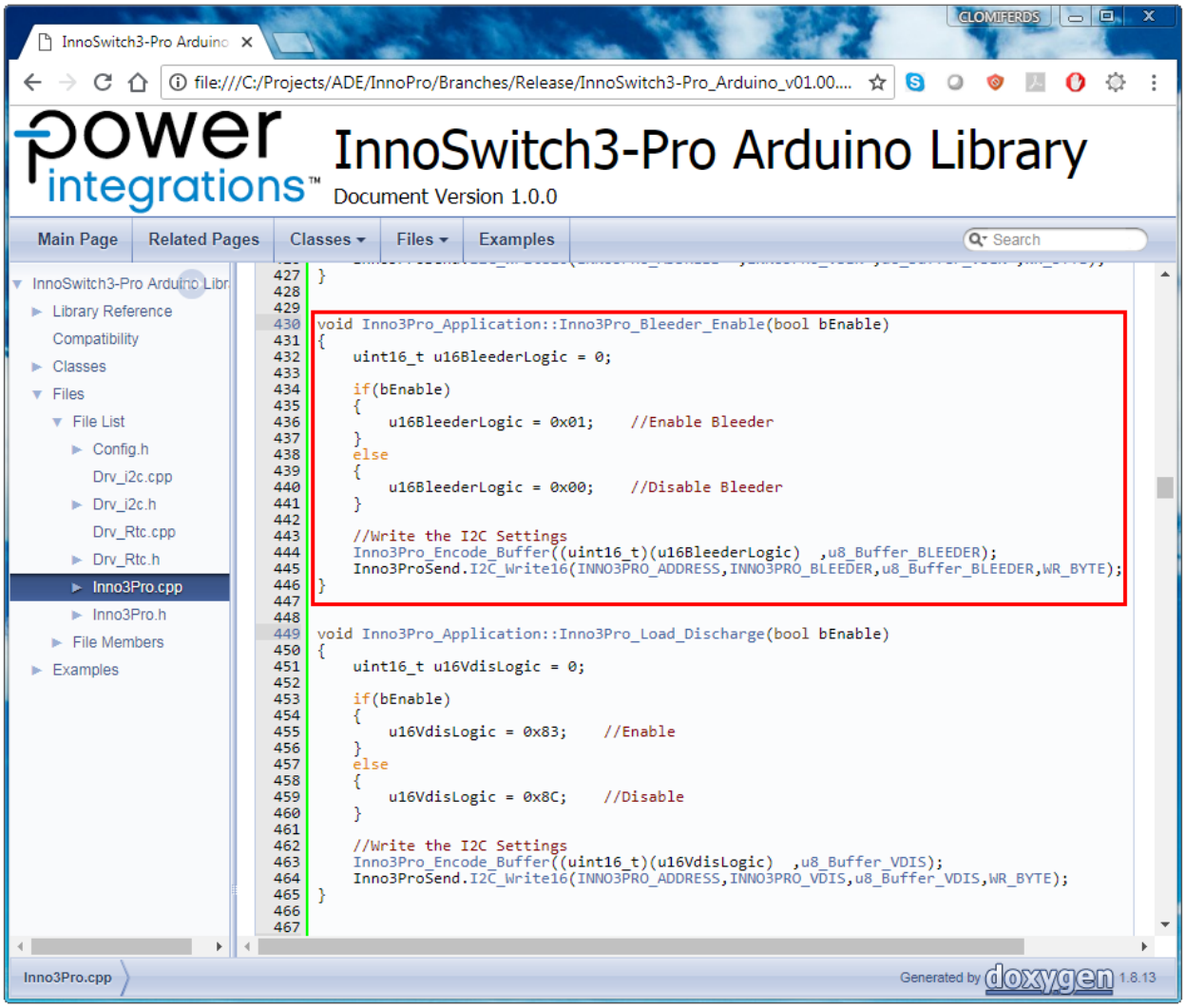
9.4 Functions definition

This section provides the actual body and implementation of the function



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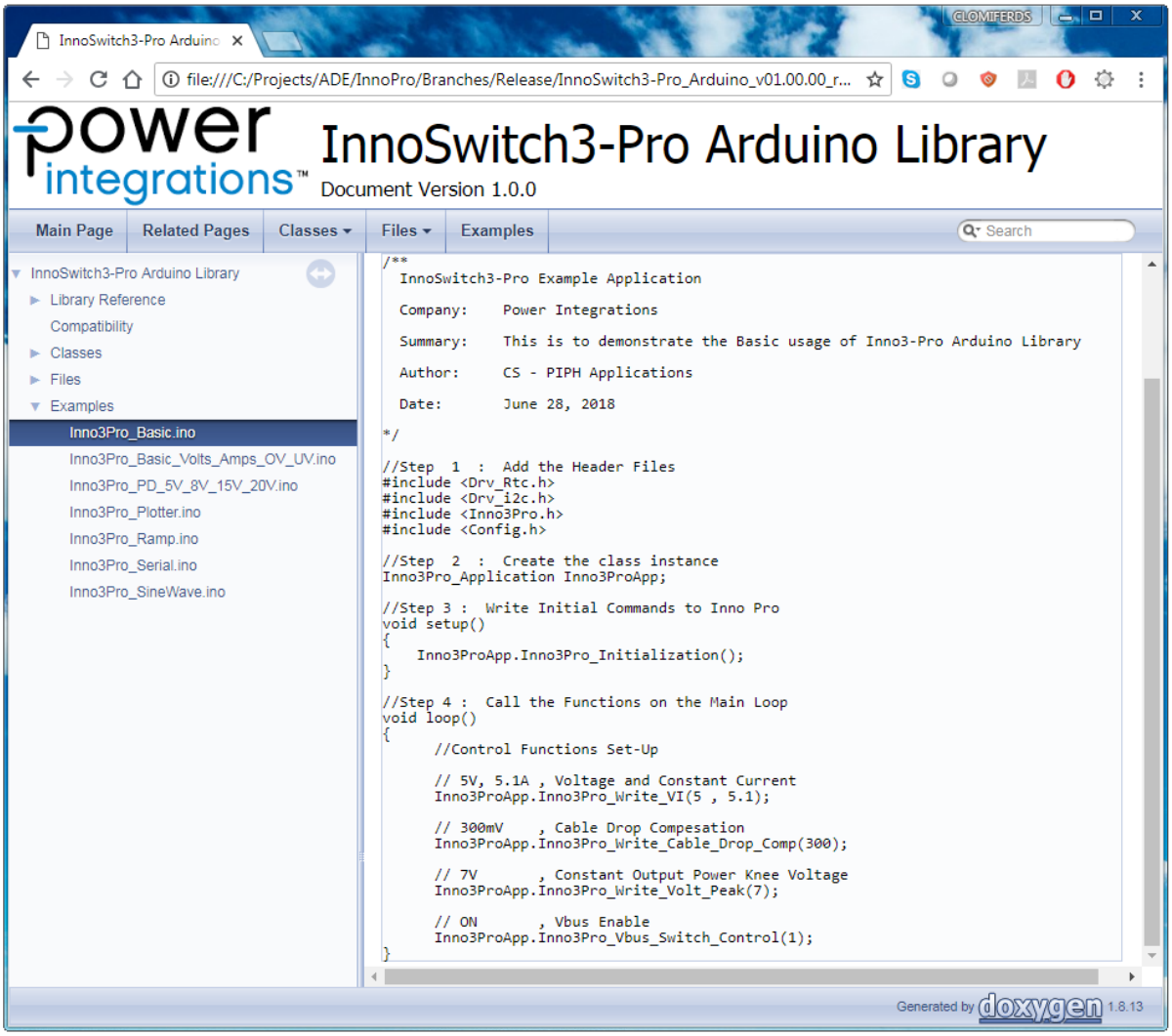
9.5 Examples

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



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10 Revision History

Date	Author	Revision	Description & changes	Reviewed
06-Sep-18	CS	1.0	Initial Release	Apps and Mktg

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