DRV8711EVM User’s Guide

This document is provided with the DRV8711 customer evaluation module (EVM) as a supplement to the DRV8711 datasheet. It details the hardware implementation of the EVM.

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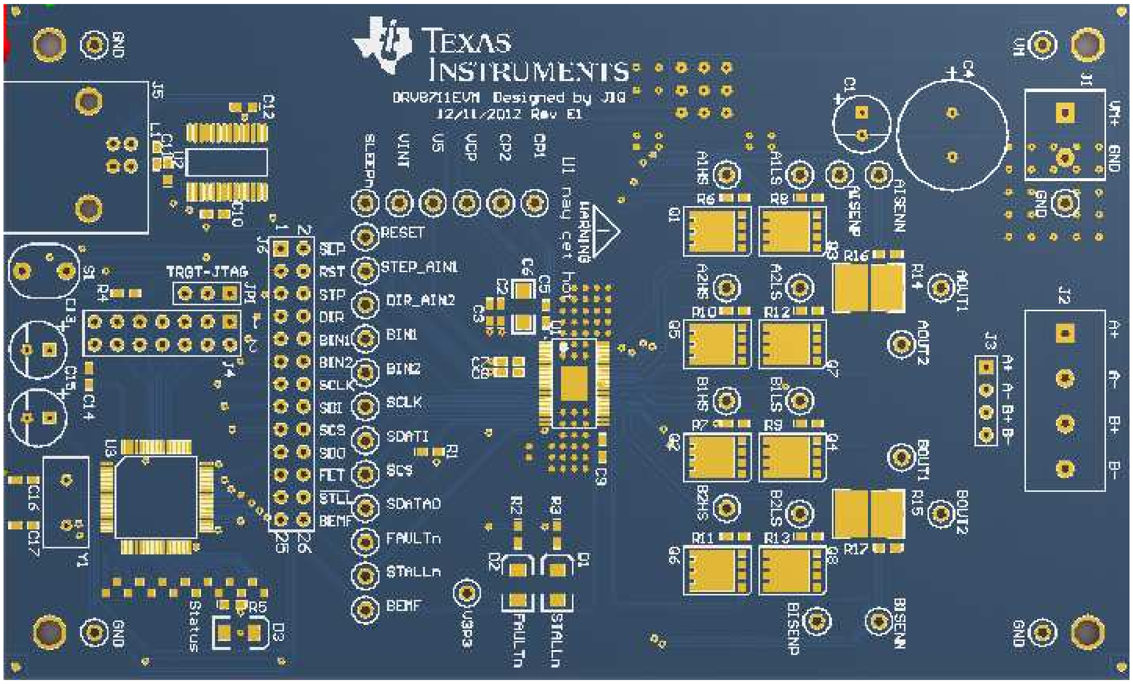
1 PCB (Top View)



2 Introduction to PCB

The DRV8711EVM is a complete solution for evaluating the DRV8711 stepper motor controller. It includes a MSP430F2617 to control the DRV8711. Power is provided externally, up to 52 V, through the power header. The USB interface is provided to communicate with the MSP430F2617 through a graphical user interface (GUI).

The DRV8711EVM is configured such that only connections to the universal serial bus (USB), motor and power supply are required.

2.1 Connectors

The DRV8711EVM uses a combination of headers for the application and monitoring of power. For the EVM, a single power supply rail is necessary. The minimum recommended input voltage (VM+) for the EVM is 8 V and the maximum recommended input voltage is 52 V. Please see the DRV8711 datasheet for the complete voltage range information of the driver. When the USB is connected to the board a red LED (D3) in the lower left corner begins blinking.

Power for the DRV8711 is available through connector J1. The J1 connector is located on the top right corner of the EVM.

The motor connections are provided through connectors J2 and J3. Connectors J2 and J3 are located on the lower right of the EVM.

The USB connection (J5) is located on the upper left of the EVM. It is used to connect the PC to the EVM. The GUI is used to control the stepper motor.

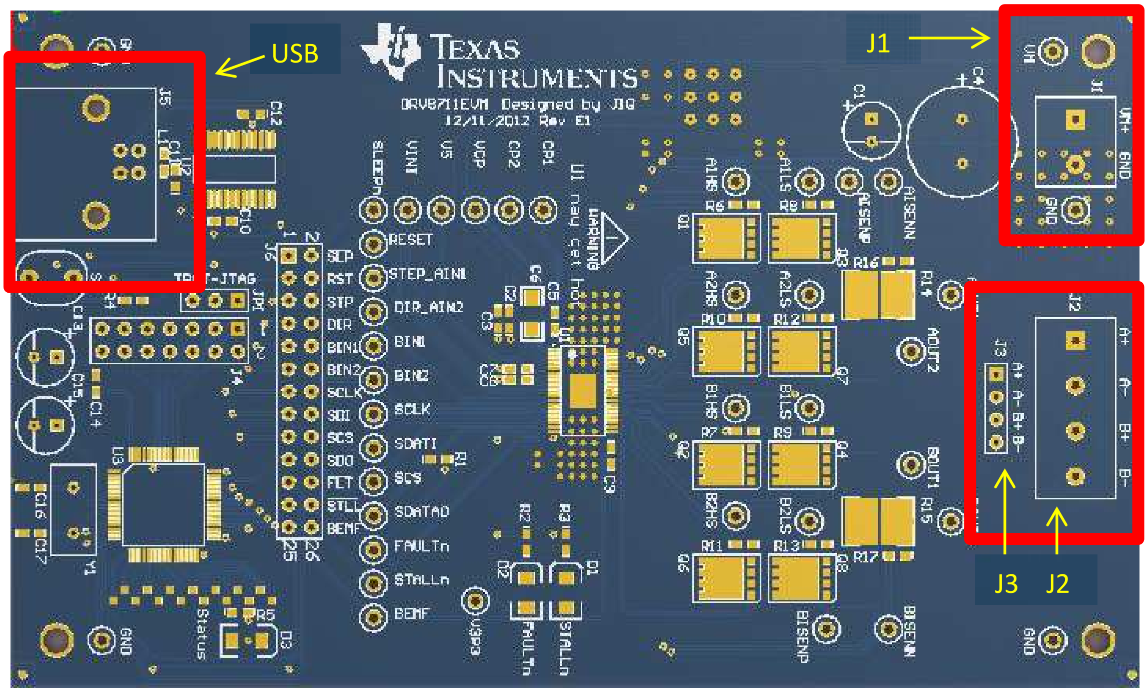


Figure 1. Connections

2.2 Test Points

Test points are provided and labeled according to the inputs and outputs of the DRV8711 motor driver. Test points are also provided to observe the power FET signals.

2.3 Jumpers

There are two jumpers (JP1 and J6) on the EVM that are normally installed.

Jumper JP1 is used to reprogram the MSP430F2617, it is normally connected from JTAG to the center pin. JP1 is not required for operation and may not be installed.

Jumper J6 contains a row of 13 jumpers connecting the MSG430F2617 to the DRV8711 inputs and outputs. This allows the MSP430F2617 to control the DRV8711 through the supplied GUI.

For normal operation right out of the box all of the jumpers of J6 should be installed. The jumpers can be removed to isolate the microcontroller (MCU).

If a signal is to be interfaced externally, the signal can be attached to either the test stakes or the driver side of J6.

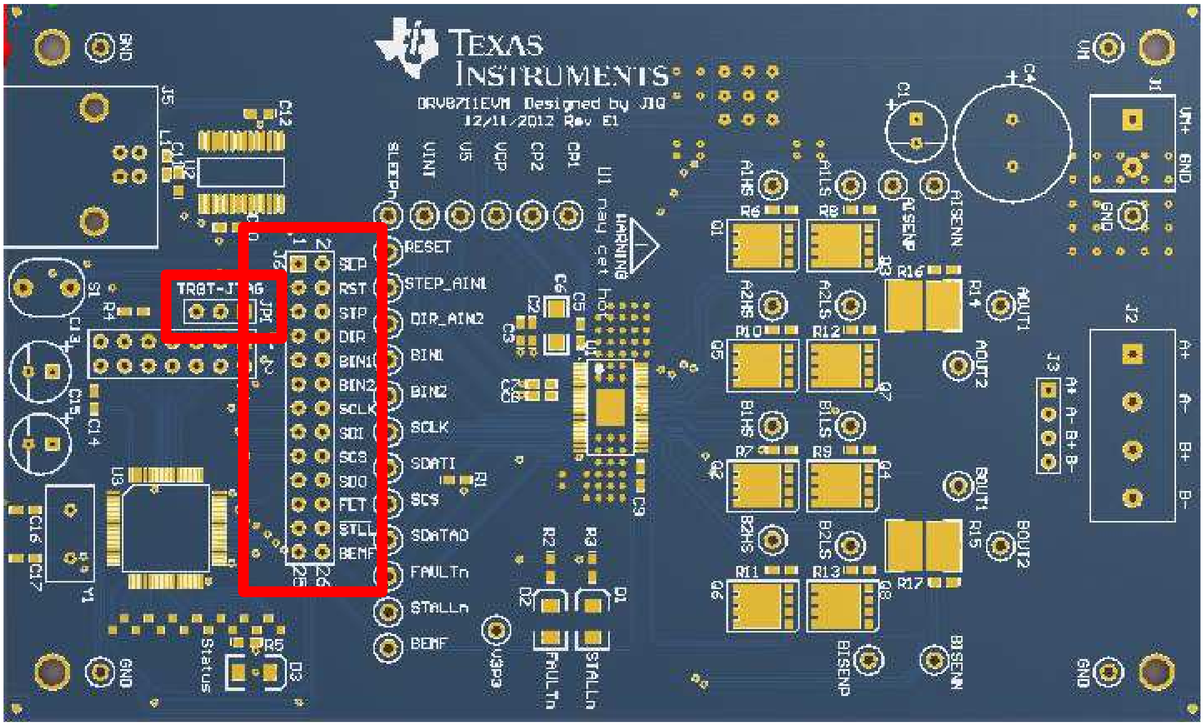


Figure 2. Jumpers

2.4 *Motor Outputs*

Two motor connectors are provided on headers J2 and J3.

Header J2 is intended to be used with the supplied motor. To connect the supplied motor to header J2 with the wires.

Table 1. Motor Connections

Wire Color	Terminal
Black	A+
Green	A–
Red	B+
Blue	B–

An alternate connection is provided through header J3. Connect the motor to pins A+, A-, B+, and B- of header J3.

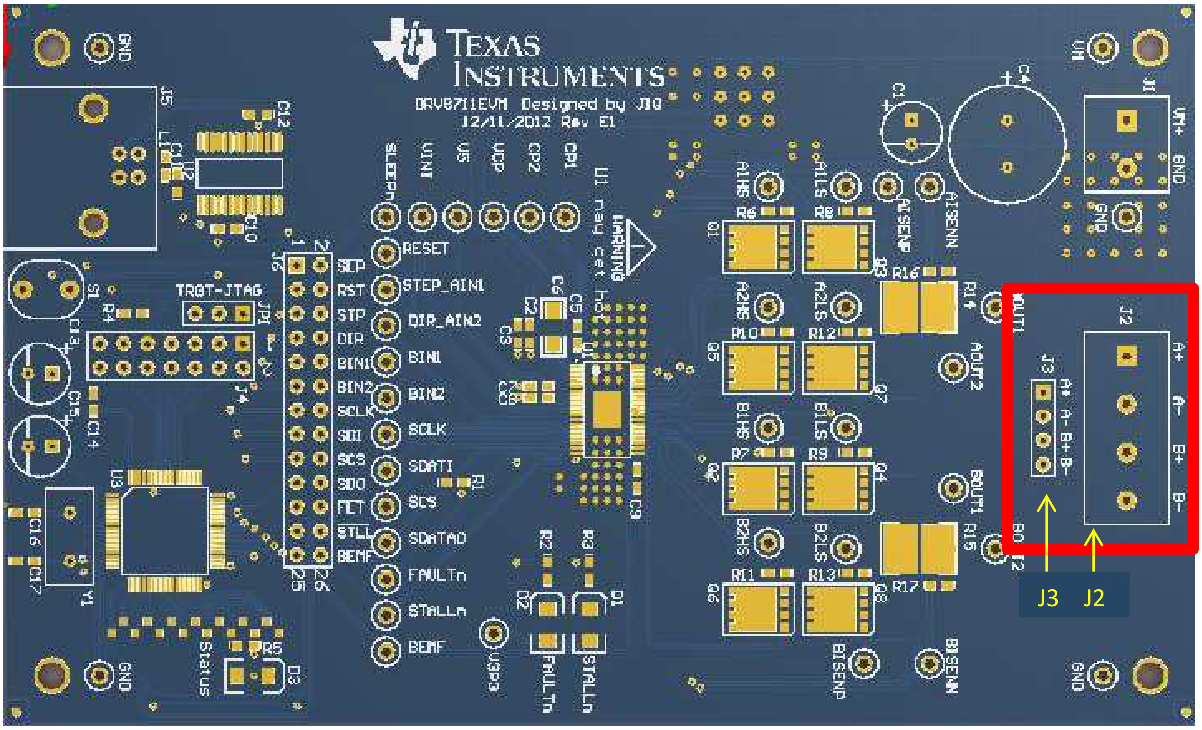


Figure 3. Motor Outputs

3 GUI Software Installation

The following section explains the location and the procedure for installing the software properly.

NOTE: Ensure that no USB connections are made to the EVM until the installation is completed. The installer will also install Python 2.7.2, FTDI Driver, and LabVIEW 2014 RTE, along with the GUI installation.

3.1 System Requirements

- Minimum Supported OS -Windows 7 (32 Bit, 64 Bit)
- Recommended RAM - 4 GB or higher
- Recommended CPU Operating Speed – 3.3 GHz or higher

3.2 Installation Procedure

The following procedure will help you install the DRV8711 GUI.

1. Double click on the Setup_DRV8711_EVM.exe as shown below.

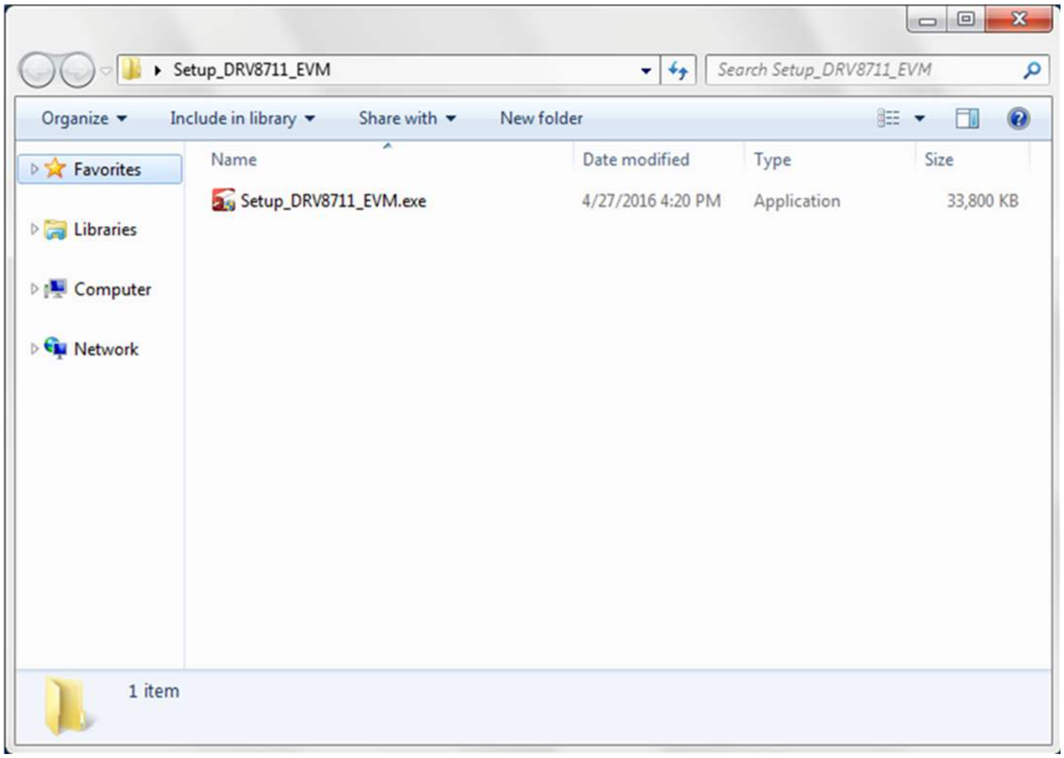


Figure 4. Setup_DRV8711_EVM.exe

2. A screen shown below will appear indicating installer initialization. Click Next button.

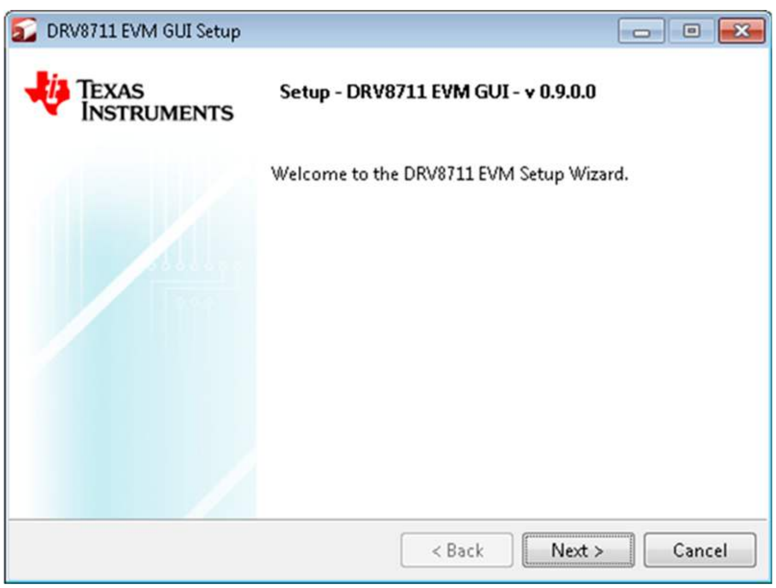


Figure 5. Installation Initialization

3. The License Agreements will appear.
   a. A Screen as shown will appear, displaying the license agreement of DRV8711 EVM GUI. Please read through the agreement carefully and enable the “I Accept the License Agreement” radio button and press the Next button.

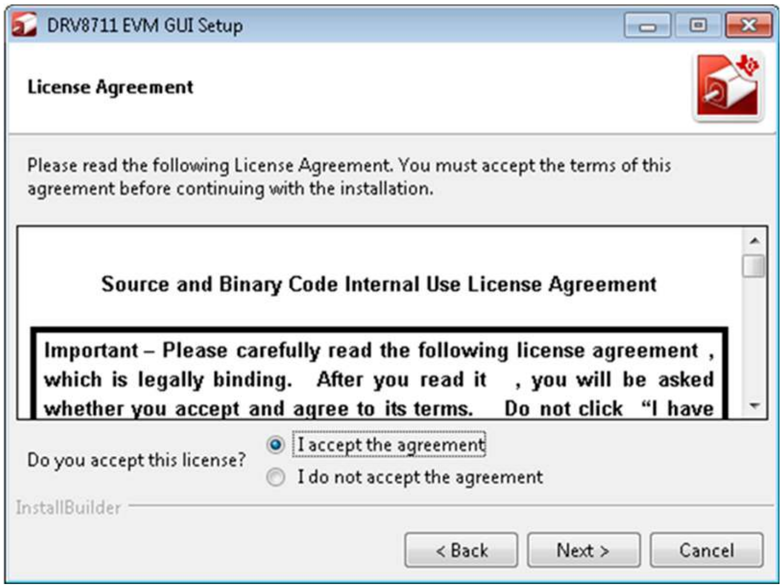


Figure 6. License Agreement

b. A Screen as shown below will appear, displaying the license agreement of National Instruments. Please read through the agreement carefully and enable the "I Accept the License Agreement" radio button and press the Next button.

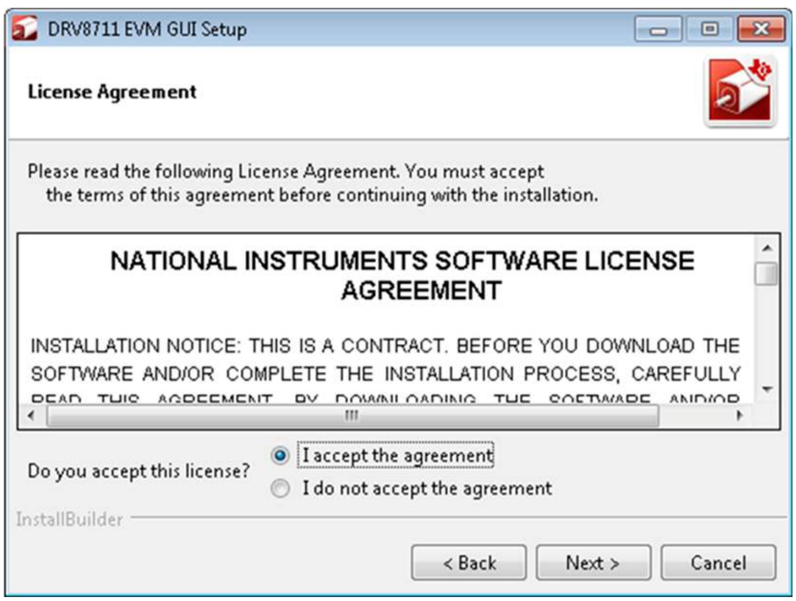


Figure 7. National Instruments License Agreement

4. Set the default directory for the GUI installation and press the Next button. It is highly recommended to keep the default values as provided in the installer.

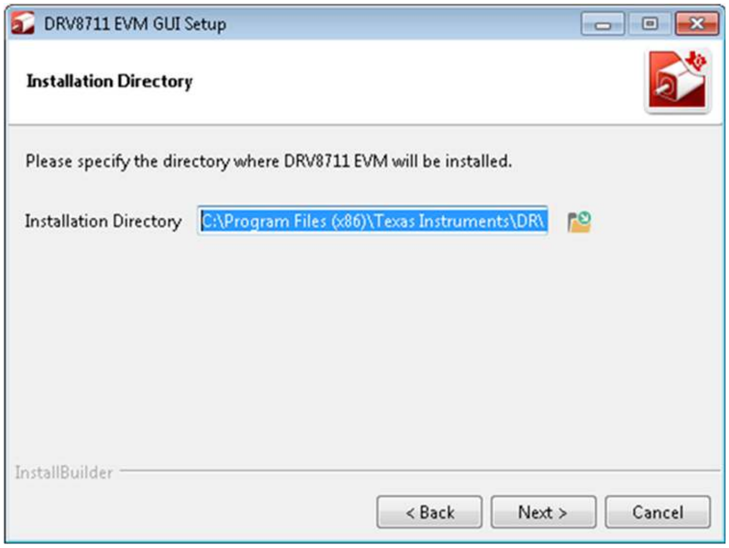


Figure 8. Installation Directory

5. A screen as shown will appear. This is to select the components to install. Do not select the PythonInstaller option. Click Next to continue installation. The LabVIEW RTE component will be checked out if the LabVIEW RTE 2014 is already installed on the PC.

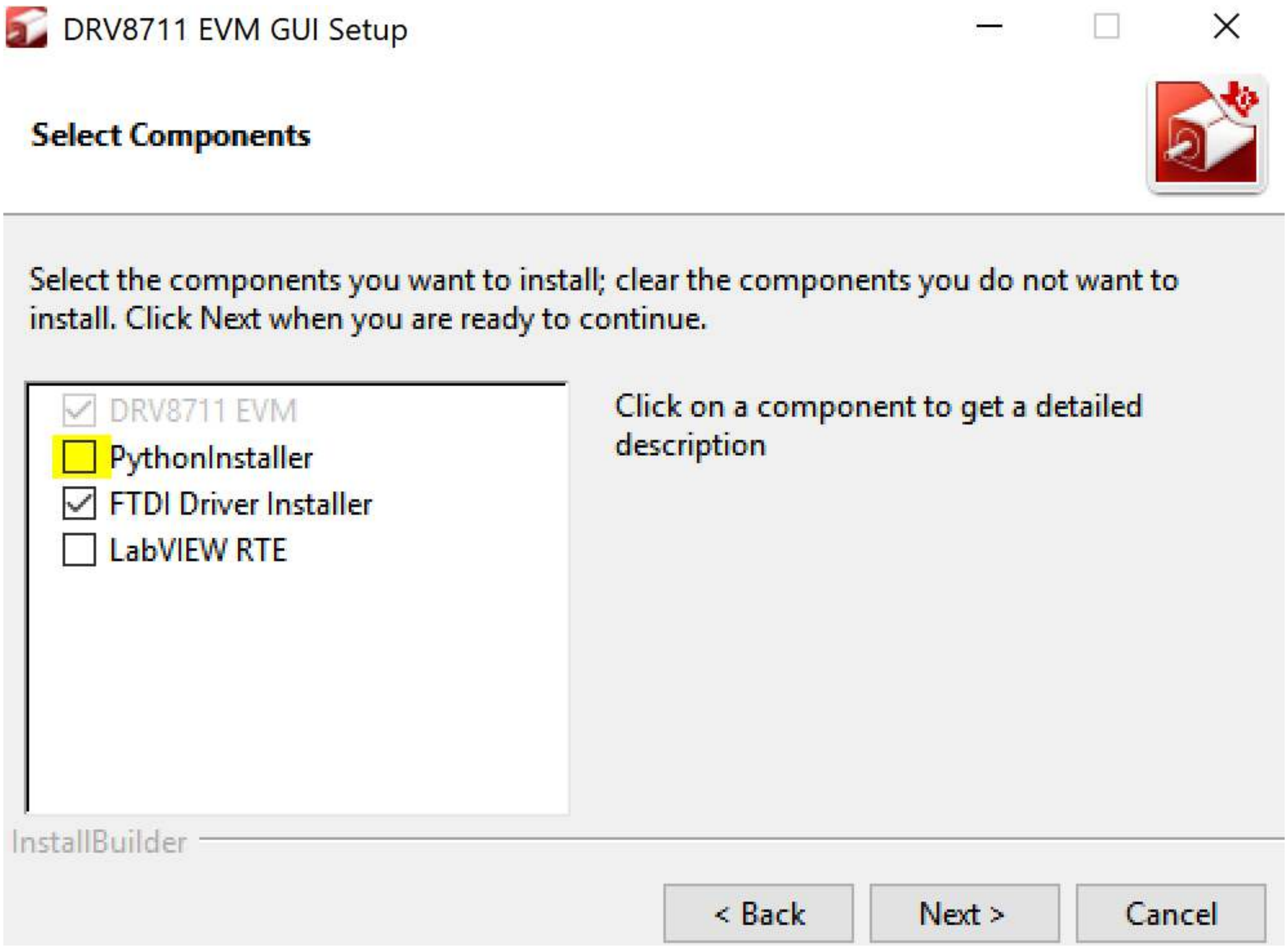


Figure 9. Component Selection

6. If LabVIEW RTE is selected as a component to install, a screen will appear as shown below. Configure the proxy settings as required. This is to download the LabVIEW RTE 2014 from ni.com, Click Next to continue the installation.

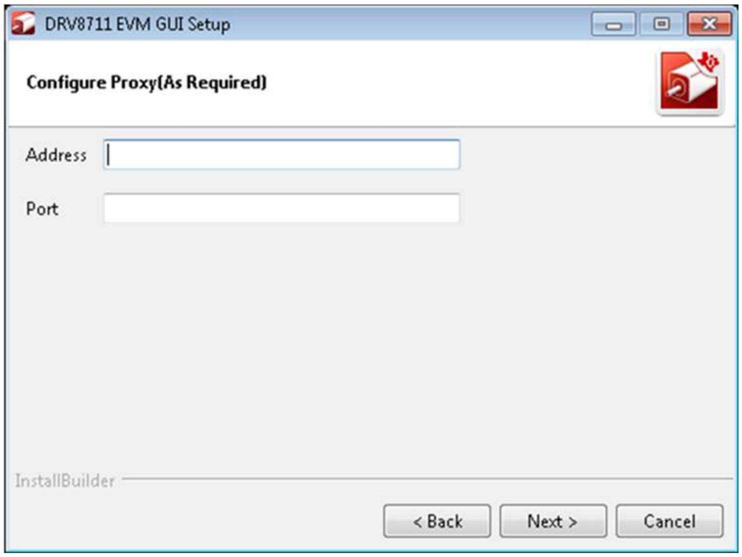


Figure 10. Configure Proxy

7. A screen as shown will appear. Click Next to begin the installation.

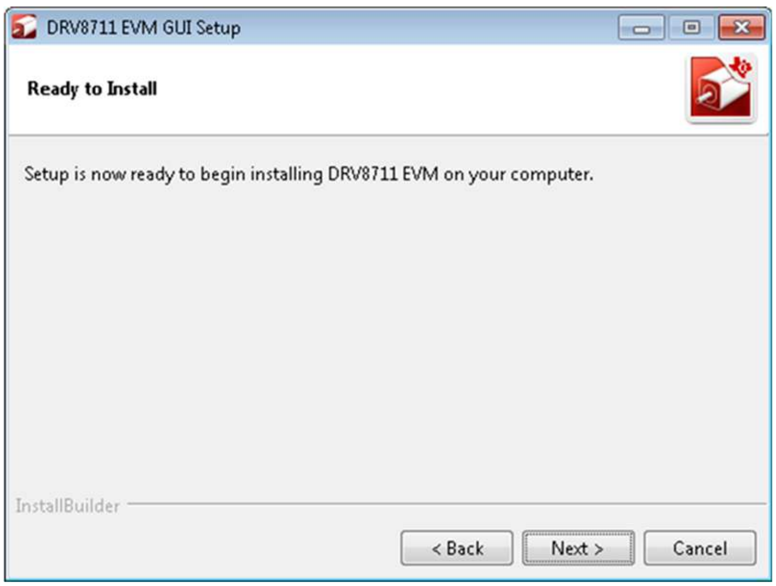


Figure 11. Ready to Install

8. If the LabVIEW RTE 2014 is selected as a component to install, LabVIEW RTE will be downloaded and performs a silent mode installation.

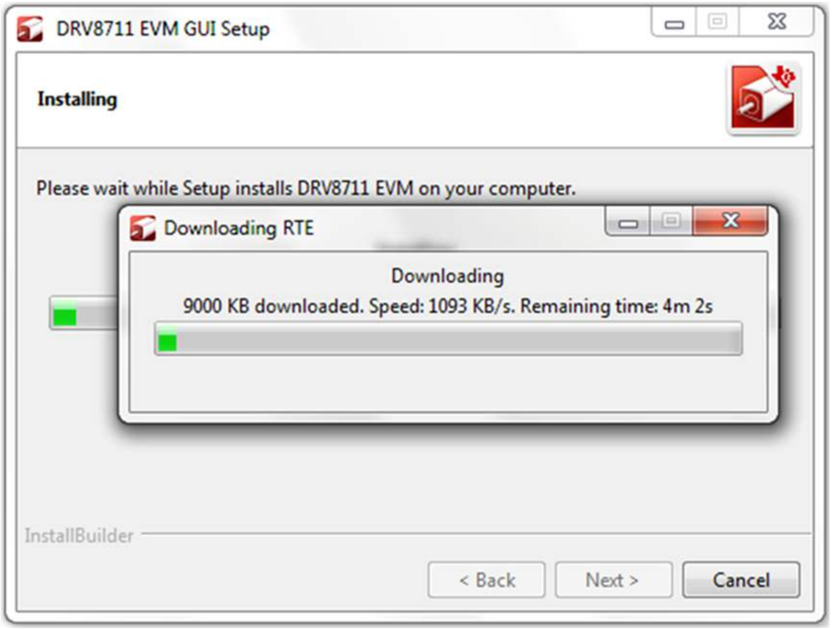


Figure 12. Downloading RTE

9. Once the Download is completed, LabVIEW will begin with the self-extraction as shown below.

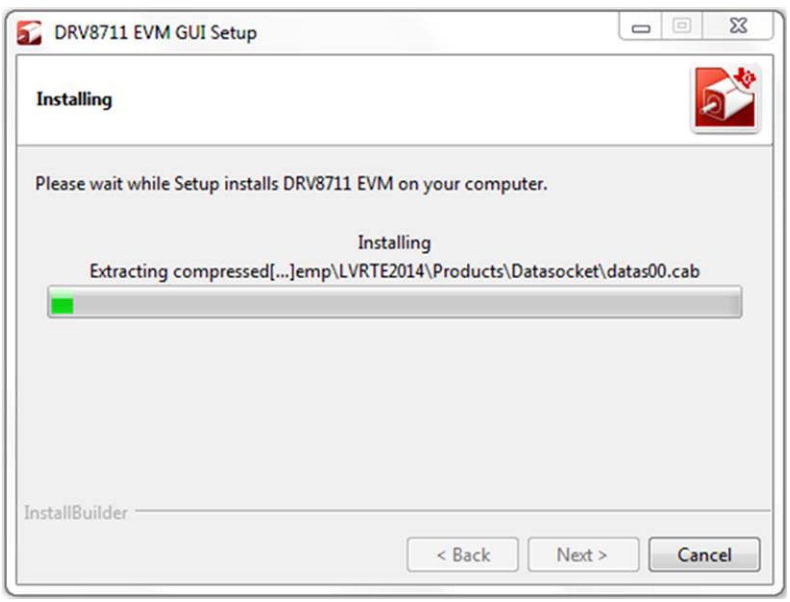


Figure 13. LabVIEW RTE Self Extraction

10. A Screen will appear as shown below. It shows the LabVIEW RTE Installation.

Figure 14. LabVIEW RTE Installation Initialization

11. A display as shown below will appear which indicates the progress of LabVIEW RTE installation.

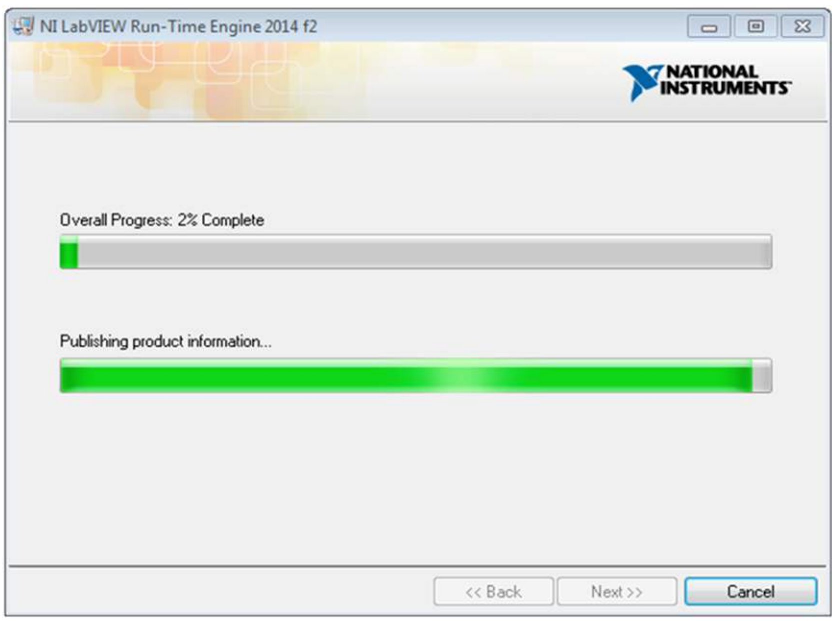


Figure 15. Installation of LabVIEW RTE in Progress

12. Once the LabVIEW RTE is installed, the DRV8711 EVM GUI Component will be fitted.
13. The installer will begin self-extraction of other components and proceed with the installation.
14. FTDI Installation will begin. A screen as shown in the figure will appear, click Extract to proceed.

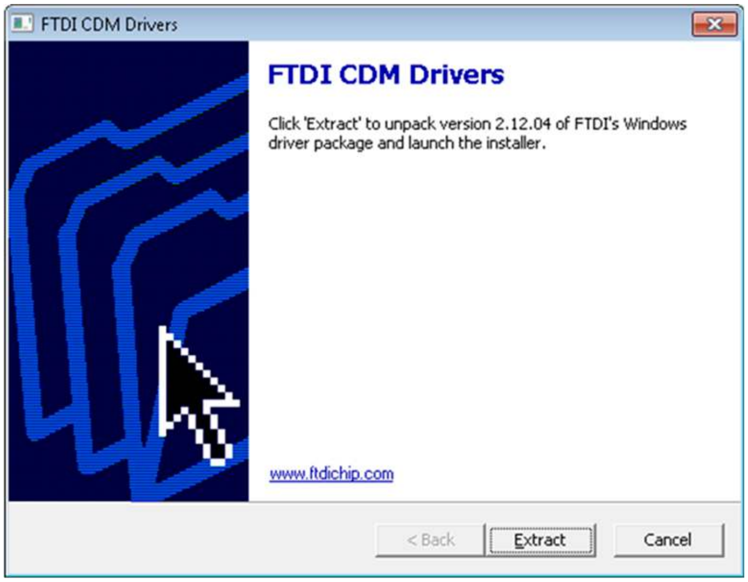


Figure 16. FTDI Installation Initialization

15. A screen as shown in the figure will appear, click Next to proceed.

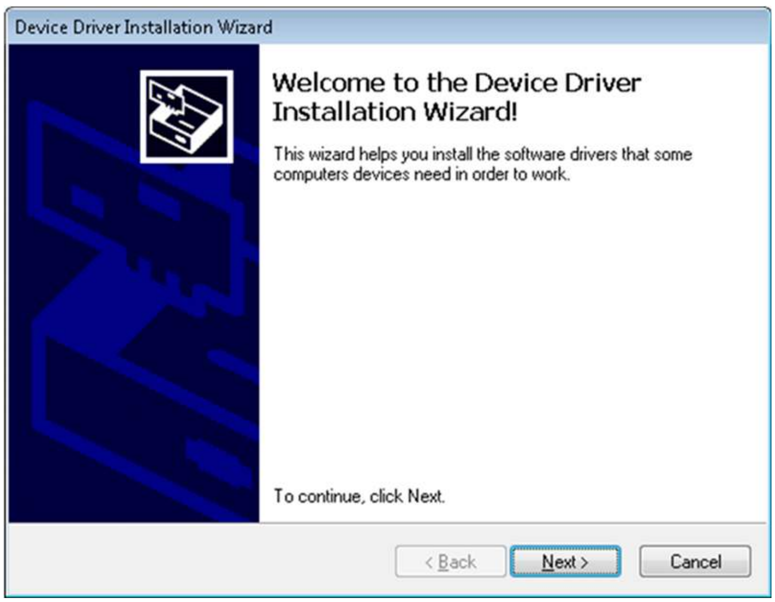


Figure 17. Driver Installation Wizard

16. The License Agreement will appear on screen as shown below
    a. Read through the License Agreement carefully and Enable the “I Accept this Agreement” radio button and Click on Next

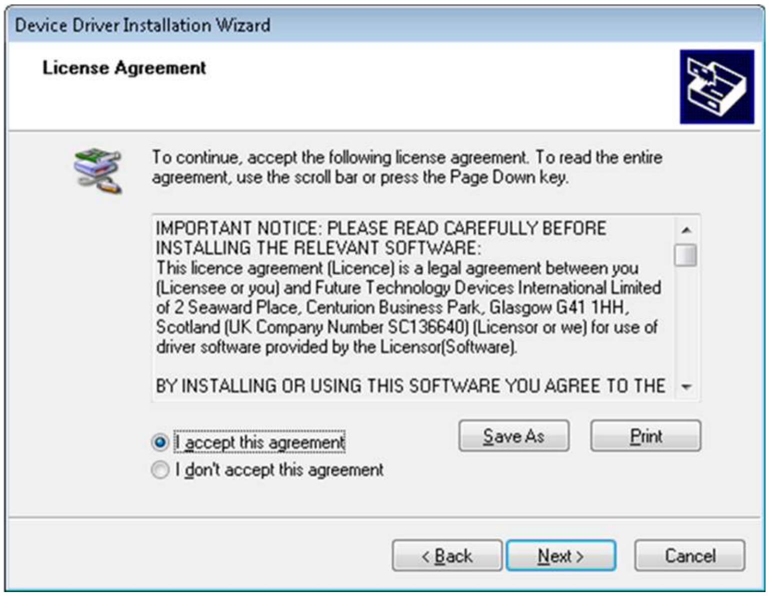


Figure 18. License Agreement for FTDI

17. Click Finish to complete the Driver Installation

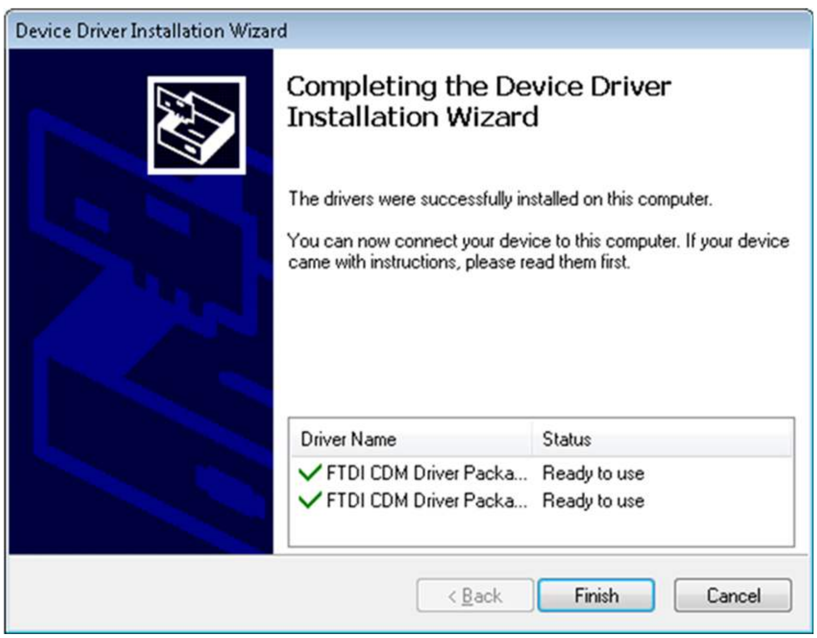


Figure 19. Driver Installation Completion

18. The following screen will appear denoting the completion of DRV8711 EVM GUI Installation. Click Finish.

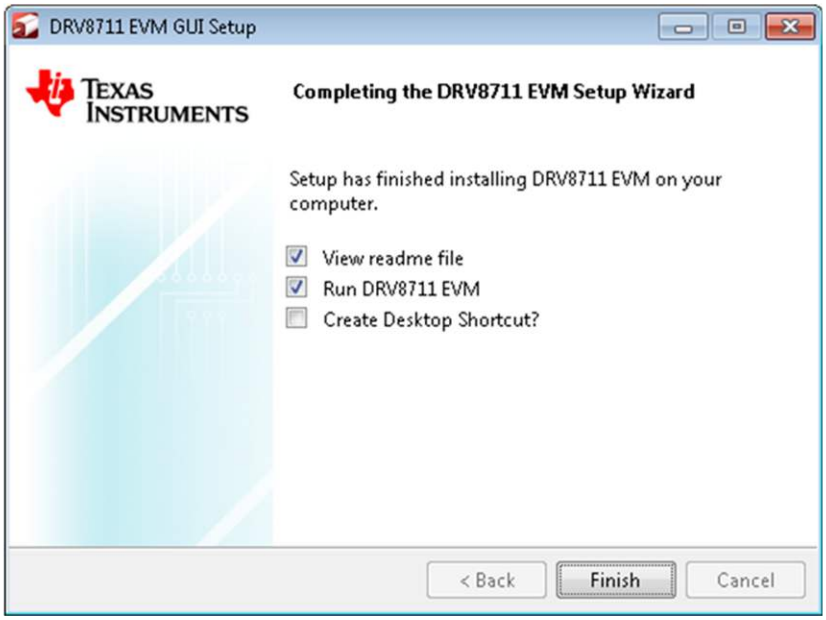


Figure 20. Installation Complete

19. Readme window will appear displaying the link for LV 2014 RTE
20. After finishing the installation, start the Python v2.7.8 installation by clicking the Windows x86 MSI Installer (2.7.8) from the following link:
    a. https://www.python.org/download/releases/2.7.8/
21. During the installation, make sure "Add python.exe to Path" is selected.

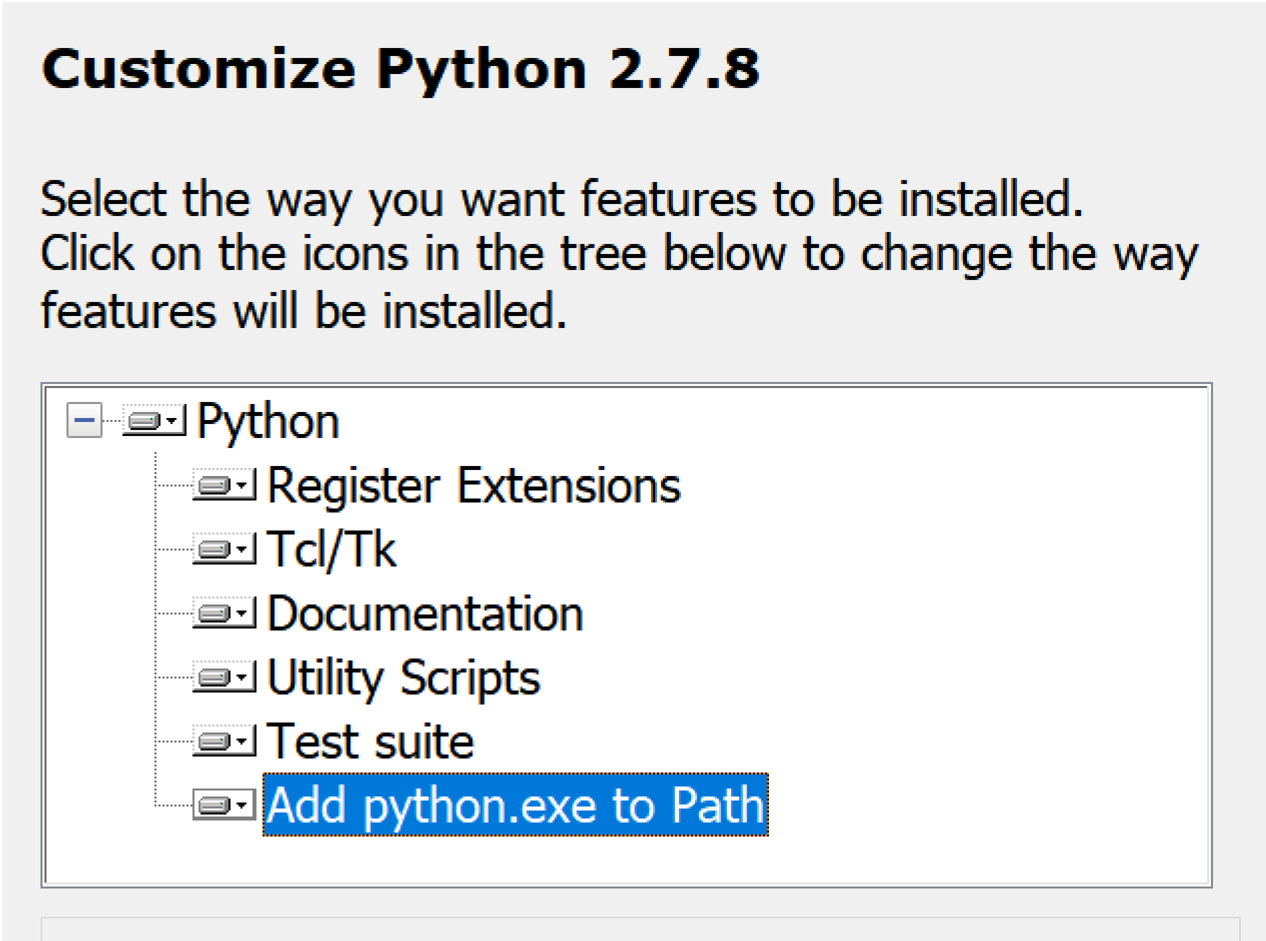


Figure 21. Customize Python 2.7.8 window

22. Then, go to the following directory and run all three of the files on this directory:
    a. C:\Program Files (x86)\Texas Instruments\DRV8711\Scripts
23. Then, run the DRV8711EVM GUI and click Yes on the following popup:

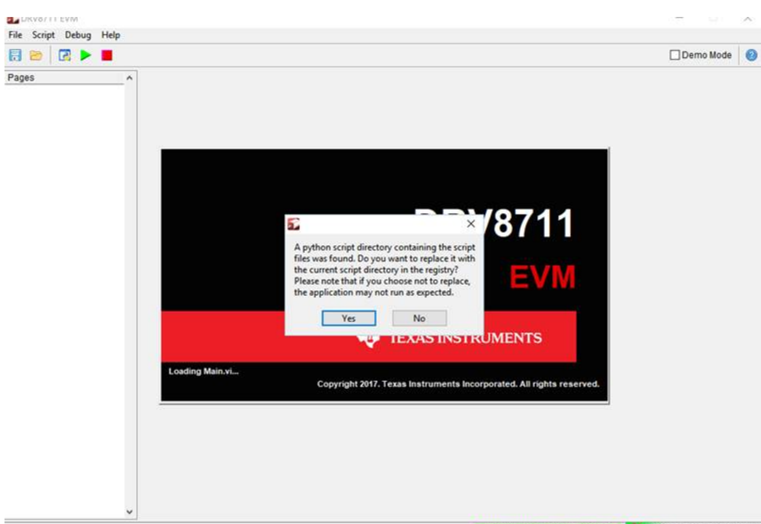


Figure 22. Python Script Directory Update

WARNING

The DRV8711 EVM GUI requires the LabVIEW Run-Time Engine 2014 to be installed before the GUI is executed. Please note the application is not compatible with other versions of LabVIEW Runtime Engine.

You can download National Instruments LabVIEW Run-Time Engine 2014 from the below link. http://www.ni.com/download/labview-run-time-engine-2014/4887/en/

NOTE: DRV8711 EVM GUI executable has been built in LabVIEW 2014 (32-bit) version, and it expects the LabVIEW Run Time Engine version to be LabVIEW Run Time Engine 2014 (32-bit) version.

4 DRV8711 EVM GUI Overview

The DRV8711 EVM GUI application is the software counterpart for the DRV8711 EVM. It allows the PC to connect to the MSP430F2617 MCU through a USB interface chip. Once the connection is established, and commands are sent, the MCU takes care of configuring control signals, running the stepper through acceleration and deceleration profiles, sending serial peripheral interface (SPI) data packets and pulse-width modulation (PWM) generation, and so forth.

The GUI is designed to allow testing without hardware intervention for all of the DRV8711 device functionality. Figure 23 shows the DRV8711EVM High-Level Page.

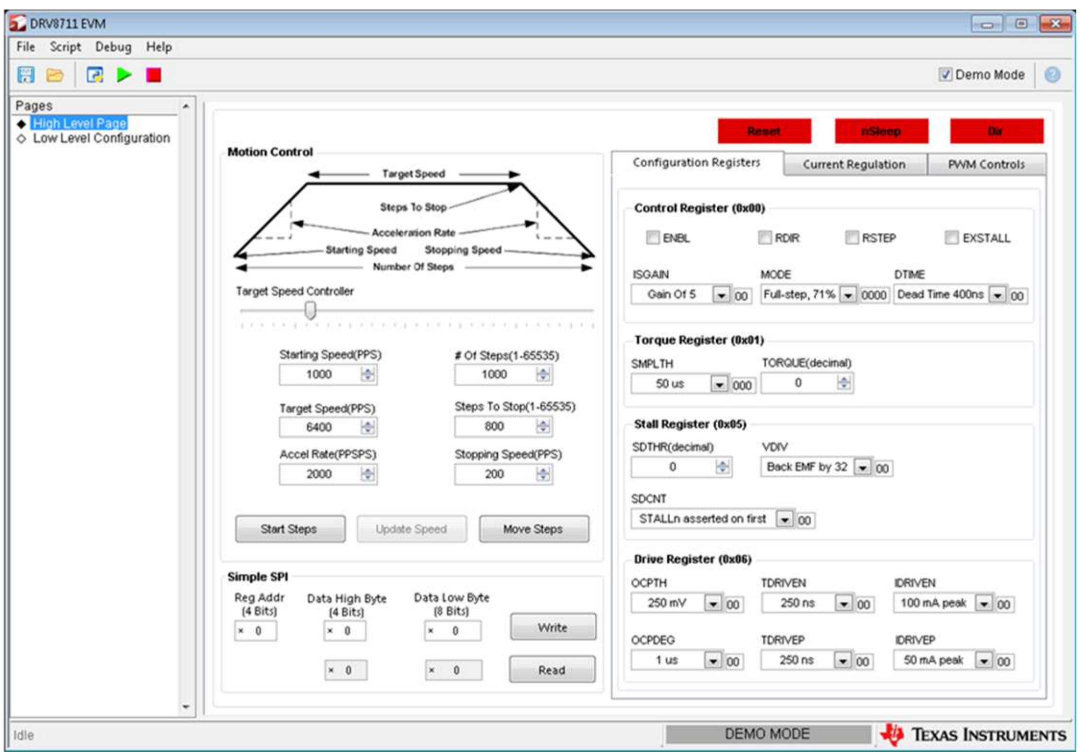


Figure 23. DRV8711 EVM Screen

4.1 Pages in GUI

The GUI has two pages

- High-Level Page
- Low-Level Page

On DRV8711, most of the control signals are available through internal SPI registers. Easy access to these SPI registers is spread among three different tabs in the High-Level Page. Control signals such as nSLEEP, DIR and RESET are available throughout the High-Level Page. A simple SPI frame is provided in High-Level Page in case the user wants to send particular SPI packets to the available registers.

The Low-Level Page is used to write the values directly into the registers. The Low-level Page has the representation of the Register map which makes the user easier to write the values for each bit in a register.

4.2 High Level Page

4.2.1 DRV8711 Control Signals

Once the application is communicating with the interface board, the control signals can be actuated by clicking on the respective command button. A signal with a logic LOW state is represented with the color red, whereas the same signal is represented with the color green once its state is switched to logic HIGH. The available control signals are RESET, nSLEEP and DIR.

Figure 24. Control Signals

4.2.2 Motion Control Frame

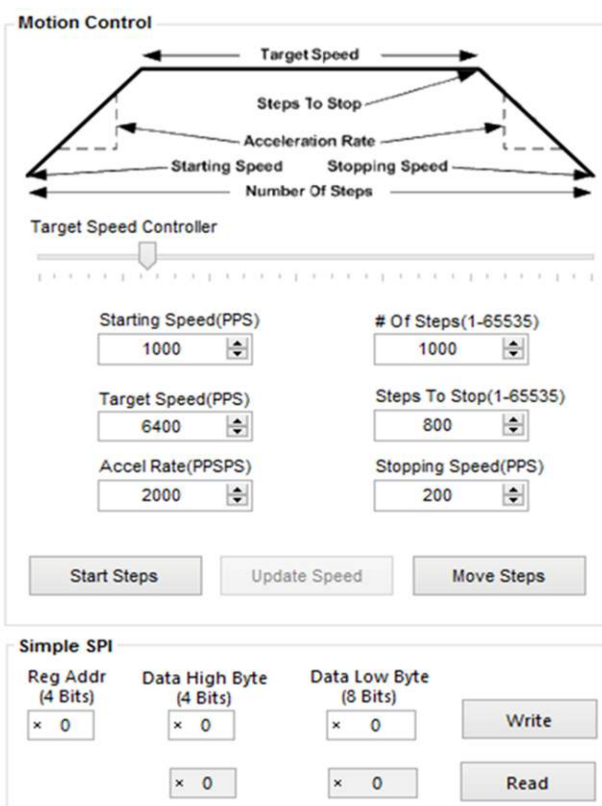


Figure 25. Motion Control Frame

This frame allows the configuration and running of the stepper with the direction specified by the DIR command button, and the other parameters such as current, decay mode, and micro-stepping resolution, is set by writing to their respective SPI registers. The motion control frame gathers user information regarding stepping rate or motor speed. An acceleration profile is employed to start at a programmable speed and increase stepping rate until reaching the programmable desired speed.

An internal 8-MHz timer is used to measure time and generate the steps in a timely manner. The Windows application transforms the entered number of PPS into the respective clock cycles needed for the timer to produce accurate STEP pulse timing.

The acceleration profile is coded inside of the MCU to accept both the Start Speed pulse per second (PPS) and Target Speed PPS as a clock cycle number. When the Start Steps command is issued (by pressing the Starts Step button), an Interrupt Service Routine (ISR) generates steps at a rate specified by the Start Speed PPS parameter.

The very same Starts Step command computes how frequent automatic speed updates are issued and a second timer is used to change the speed according to the programmed acceleration rate profile.

Once the Target Speed PPS is reached, the acceleration profile ends, and the motor stays running until the Stop Stepper command is issued (by pressing the Stop Stepper button). When the stepper is commanded to stop, the controller does as it did while accelerating, but in reverse to achieve deceleration until the Stop Speed PPS is reached, in which case the motor fully stops.

A second motor actuation is provided by the Move Steps command in which a programmed number of steps are issued and then the motor is stopped. The acceleration and deceleration profiles work similarly as before, except when the deceleration starts to happen and when the motor actually stops are a function of the Steps to Stop and Deceleration Rate parameters. The below Figure shows the acceleration profile the role each parameter plays during speed computation.

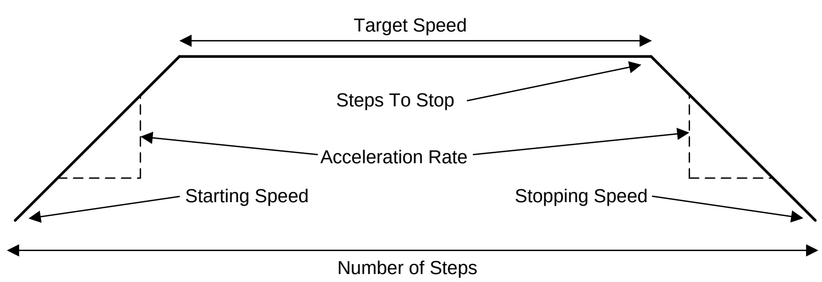
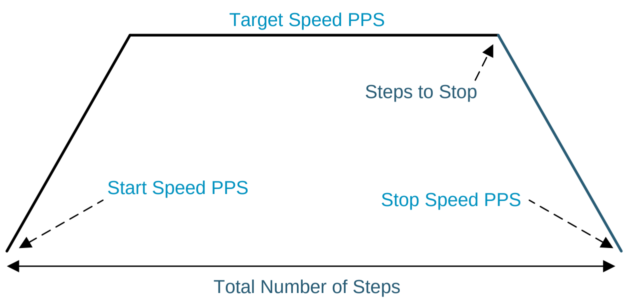


Figure 26. Acceleration Profile

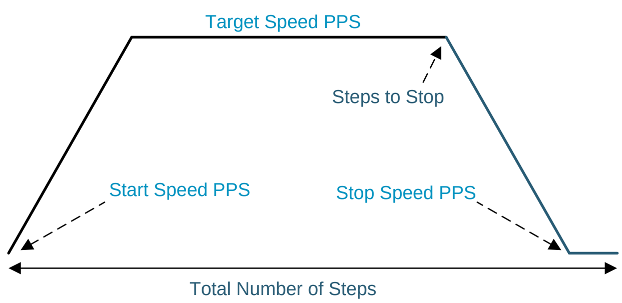
The following controls are available within the motor control frame:

- Start Speed PPS—Number of pulses per second (or full steps per second) at which the motor rotates at the beginning of an operation. The SW only allows a number as small as 200 PPS and can be taken to a number as large as 65535 PPS.
- Target Speed PPS—Number of desired pulses per second (or full steps per second) at which the motor operates. The acceleration profile starts from the Start Speed PPS and increases stepping rate until reaching the Desired Speed PPS. The SW only allows a number as small as 200 PPS and can be taken to a number as large as 32000 PPS.
- Acceleration Rate (0-5000)— A number from 0 to 5000 which acts as a stepping rate modifier to increase the Start Speed PPS up to Target Speed PPS.
- Stop Speed PPS—Number of pulses per second (or full steps per second) at which the motor stops rotating after the Stop Stepper command is invoked, and the deceleration profile is issued. The deceleration profile modifies the stepper speed from the Target Speed and into the Stop Speed. If the user desires to move the stepper a certain number of steps, this can be easily accomplished by using the Move Steps function. Parameters from the other frames are reused, and its utilization is as previously explained. Two new parameters have been added to control the limited number of steps actuation properly.
- Number Of Steps—How many steps the controller issues.
- Steps To Stop—The controller is continuously monitoring the step being issued, and when the current

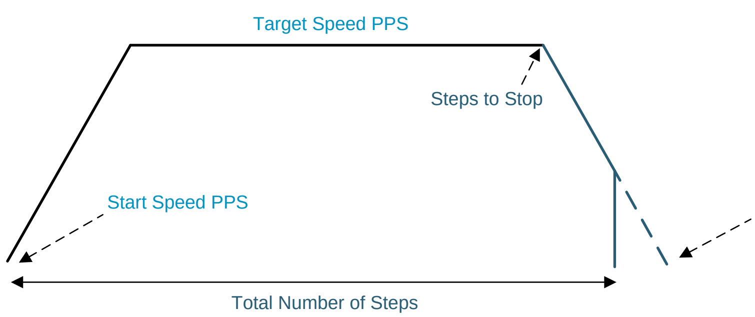
step is equal to the Steps To Stop parameter, a deceleration profile is issued. If Steps To Stop is larger than the Number Of Steps, then the motor stops abruptly without undergoing a deceleration profile. When a deceleration profile is issued, the controller decreases the speed until reaching the Stop Speed value. If the Number Of Steps parameter is met before the deceleration profile is complete, then the motor stops at the current speed. If the Stop Speed is fulfilled before all the Number of Steps are issued, then the motor rotates at the Stop Speed value until all the steps are executed. Ideally, the system must be tuned to resemble a case in which the controller executes all the commanded steps at speed as close as possible to the Stop Speed. In the event this is not feasible, due to the particular parameters being chosen, stopping the motor at speed very close to the Stop Speed is often good enough to ensure proper motion quality and application performance.



Motor Reaches Stop Speed at the Stop Speed



Motor Reaches Stop Speed before the Stop Speed is Reached



Motor runs out of Steps before reaching Stop Speed

Figure 27. Motor Control Examples

4.2.3 Configuration Tab

The configuration tab offers access to the Control, Torque, Stall and Drive Registers. A detailed explanation of these registers can be found in the datasheet.

Check boxes are supplied for single bit fields, whereas drop down combo boxes are provided for bit fields larger than one size. On all check boxes, a checked state implies HI, whereas an unchecked state implies LO.

Figure 28. Configuration Tab

4.2.4 Current Regulation Tab

The current regulation tab offers access to the Tblank, Decay and TimeOff registers. In order to make the current regulation selection easier, a diagram with text boxes and sliders is available. For each register, the respective numeric box, slider, and text box are linked. That is, the three fields are updated whenever either the numeric box or the slider are actuated. The numeric box displays information in decimal, whereas the text box offers the respective timing equivalent in microseconds.

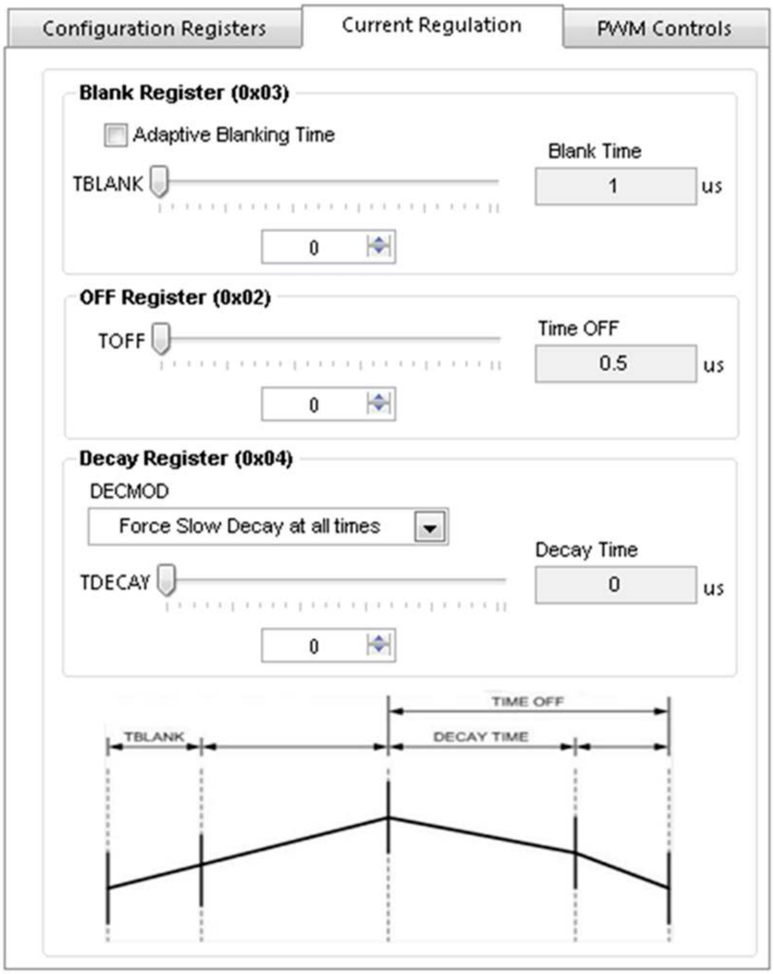


Figure 29. Current Regulation Tab

4.2.5 PWM Control

The PWM tab gives access to the four INx signals which can be pulse-width-modulated to apply speed and direction control to a pair of brushed DC motors. In order to enable the PWM mode, the PWM mode checkbox must be checked. This check box is actually a bit in the Time OFF register, so to effectively enter PWM mode, communications must have been set.

Checking and unchecking the PWM mode check box signals the MCU to send the respective SPI packet. The four PWM sliders are enabled once the PWM mode is engaged. The user can adjust PWM duty cycle by moving the respective slider bar.

Figure 30. PWM Control

4.2.6 Low Level Configuration Page

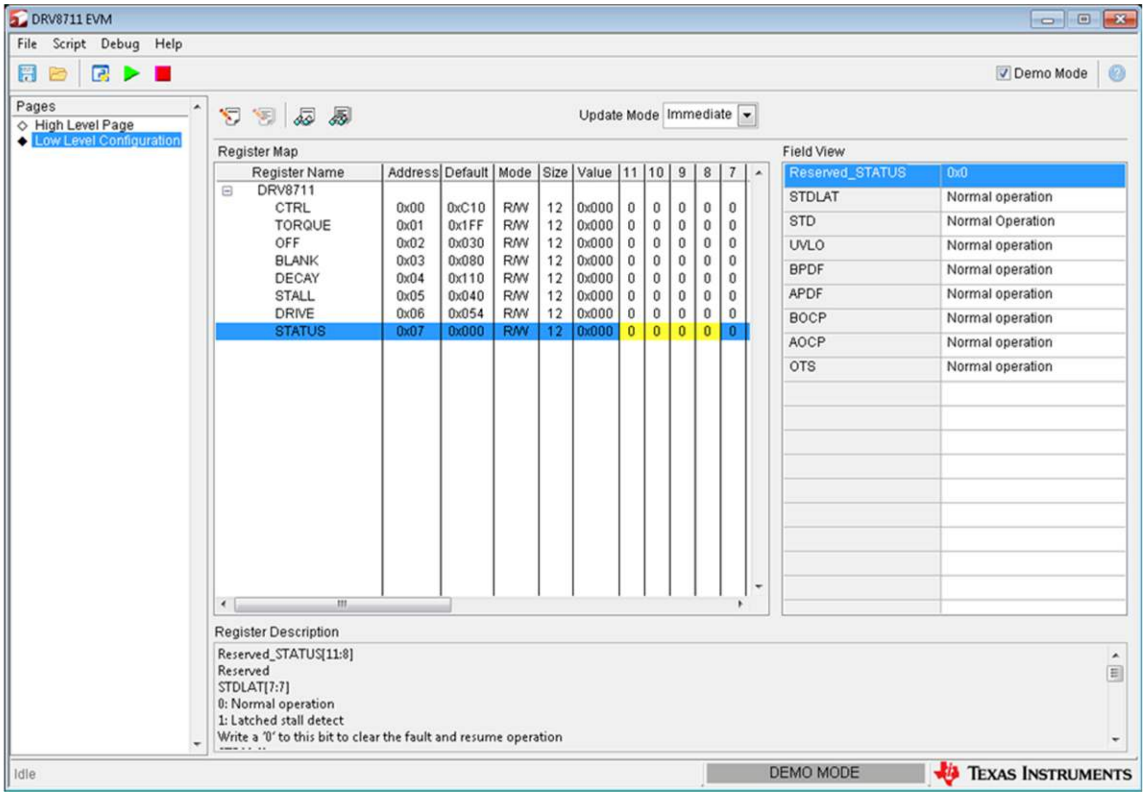


Figure 31. Low-Level Configuration Page

- Low-level configuration page provides a detailed view of all the registers that the device possesses.
- This page allows the users to read from and write to the registers.
- When a particular register is selected, the corresponding register description is displayed at the bottom left of the page.
- Register write modes
  - Immediate mode - The register values will be written to the device immediately.
  - Deferred mode - The register values will be written to the device when 'Write Register' or 'Write Modified' button is pressed. The changed register values will be highlighted in blue. When there is some pending changes and update mode is changed from manual to immediate, a dialog box will appear. Choose required operation to be carried on from the dialog box.

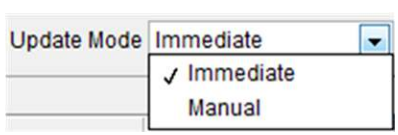


Figure 32. Update Mode

- Changing the Value of register can be done by
  - Register level operation
    - Select the register that has to be edited
    - Double click on the value column corresponding to the register
    - Enter the register value (Hex) in the edit box.

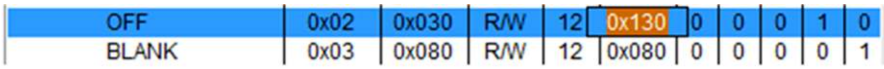


Figure 33. Register Level Value Page

- Field level Operation
  - Select the register that has to be edited
  - The fields corresponding to the register will be listed in the 'Field View' section
  - When you hover the mouse over the value of the field, an edit box will appear, and the corresponding bits will be highlighted. You can change the appropriate value in the edit box.

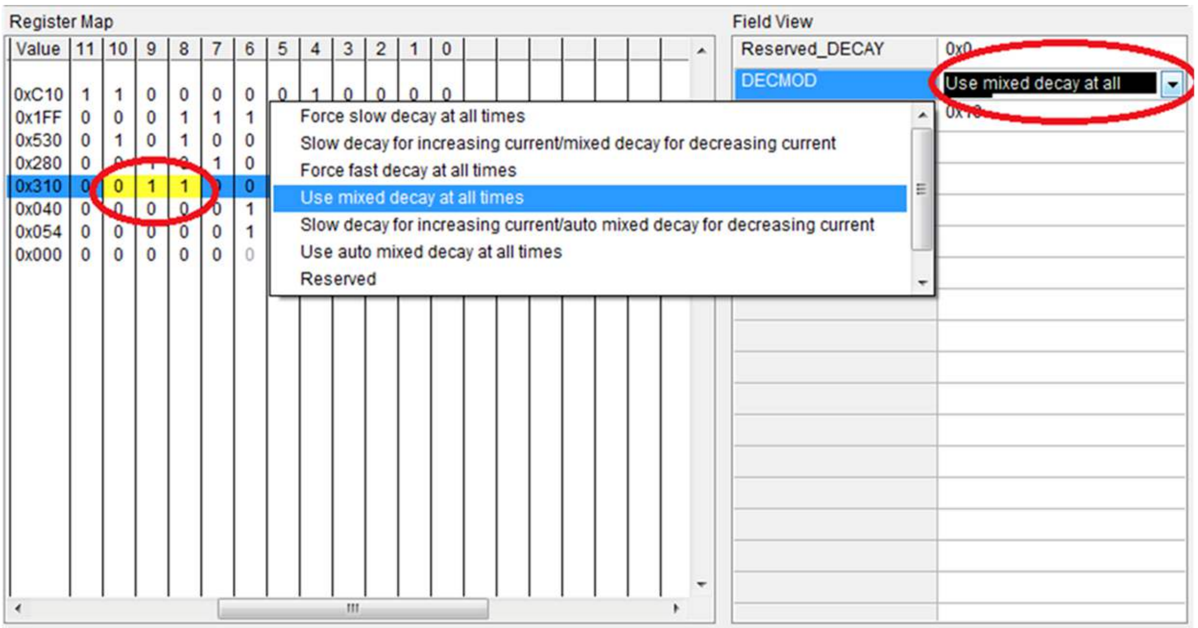


Figure 34. Field Level Value Change

- Bit level operation
  - Select the register that has to be edited.
  - The value of each bit in the register can be changed by clicking on the '0' or '1' in the corresponding bit column. The bits that are grayed out are read-only bits. These bits cannot be edited.

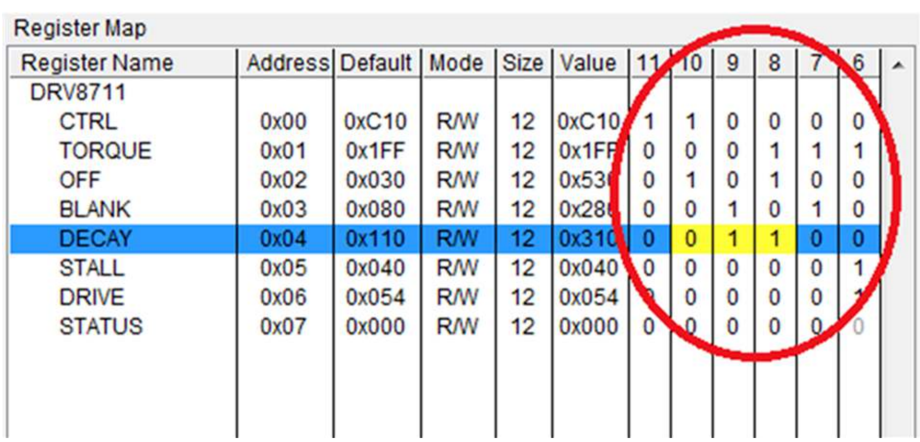


Figure 35. Bit Level Value Change

- Register Read and Write
  - Write Selected – When Write selected is clicked, the register which is chosen will be written by its value, and the Field view will also be updated.
  - Write Modified – When Write Modified is clicked, all the values of the registers which are modified will be written to the respective registers, and the Field view will also be updated.
  - Read Selected - When the Read Selected button is clicked, the value will be read from the device for the register which is chosen. The field view will also be updated with the values.
  - Read All – When Read All is clicked, the data is read from all the registers. The field view will also be updated with the values.

Figure 36. Low Level Page Operations

NOTE: The low level page will allow the user to only read/write the selected field/register, for example, it provides an abstract of the device's registers and not additional functionality associated with them.

The operation/functionality linked to a field/register other than the read/write operations is only handled in the high level page.

4.3 Menu Options

4.3.1 File

The File menu contains the options as shown in the below figure. Each of the options is explained below.

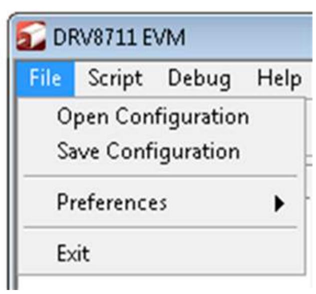


Figure 37. File Menu

- Open Configuration
  - If this option is clicked, it loads the configuration file which was saved earlier to bring the device to a known state.
  - Load Config will overwrite the existing data in registers with the value specified in the .cfg file loaded.
- Save Configuration
  - If this option is clicked, the current register configuration will be saved into a file which can be later loaded into the GUI using the Load option.
- Preferences
  - Show Dialog? - If this option is selected, if the user modifies some register value and changes the update mode to the “Immediate” then the user will be prompted with the dialog to take action for the modified values. If this option is not selected, then the user will not be prompted with the dialog the action will be based on Write Modified?

- Write Modified? - If this option is selected, then the modified values will be written to the register. If it is not selected, then the changes will be discarded.

- Exit
  - This is to Exit the application

4.3.2 Script

- Scripting is used to automate the device operations and reduces the time consumption in repeating similar operations.
- This is helpful in situations where performing a particular device function may require setting 10 to 15 registers on the device to a particular value. In these circumstances, scripts could be recorded and run whenever needed.
- In DRV8711 GUI, the scripting is done using Python because
  - It's easier to implement
  - More widely used
  - More user-friendly
- Recording and Running Scripts
  - Selecting the Launch Window again will open another untitled window, and the one opened last will be active.
  - The python window captures predefined actions only. While recording, no action has to be performed on the python window such as moving the cursor, entering data, and so forth
  - Start Recording - To start recording
    - Go to Scripts -> Launch Window in the DRV8711 GUI.

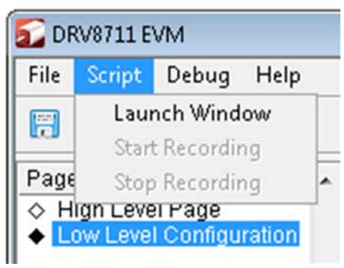


Figure 38. Script Menu

- In GUI window, traverse to the Scripts -> Start Recording option in the menu.
- This opens an untitled, empty Python window in IDLE IDE.

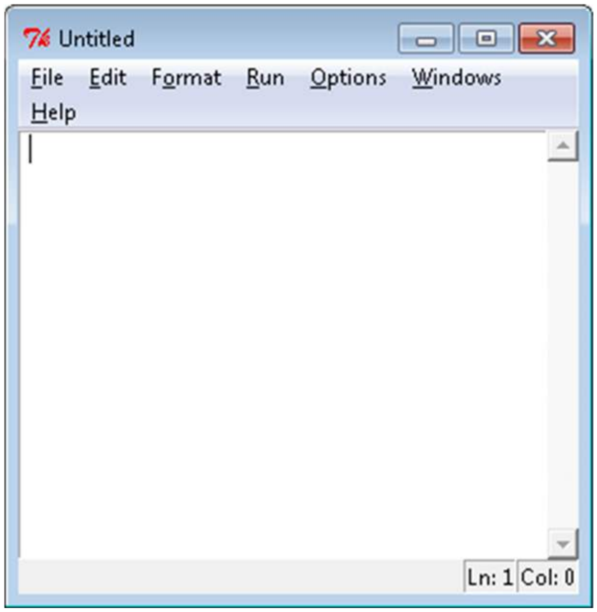


Figure 39. Launch Macro

- Once the python window is launched, the Start Recording option will be enabled in the same Script menu, in the GUI window
- Whatever actions are now performed by the User on the GUI, are recorded in the Python window
- The recording function is indicated by a window blinking in green, while the window is recording as shown below.

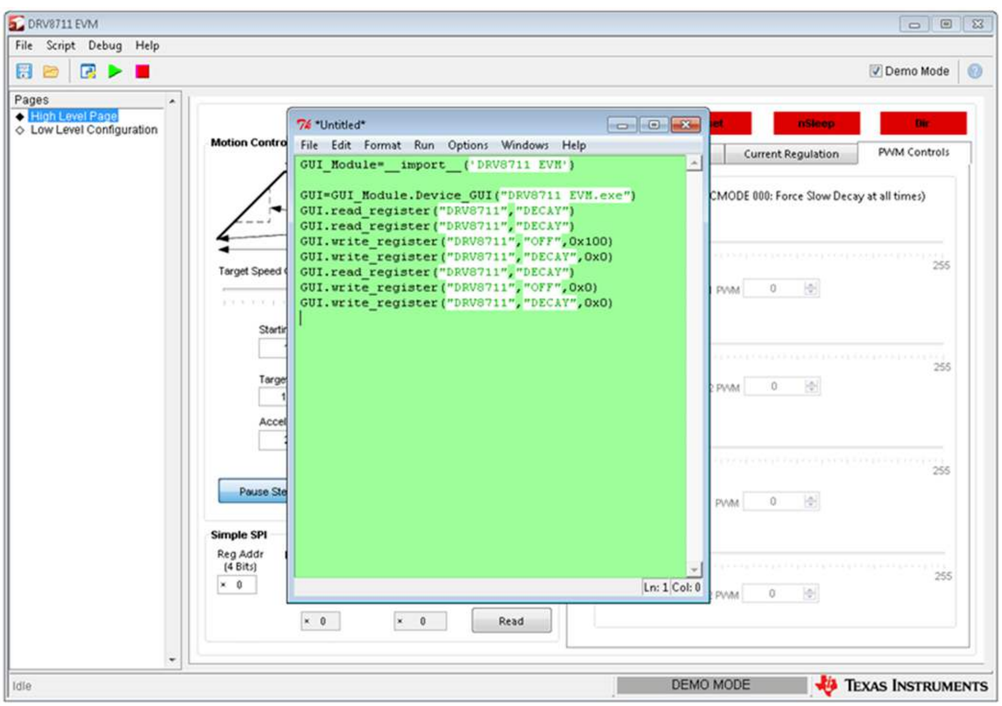


Figure 40. Start Recording

- Stop Recording- To stop recording
  - In GUI window, traverse to the Scripts -> Stop Recording option in the menu

- The Launch Window will still remain after the recording has been stopped as shown below. It can be closed with/without saving; else we can also continue recording.
- While saving, the window has to be saved with extension .py under script folder

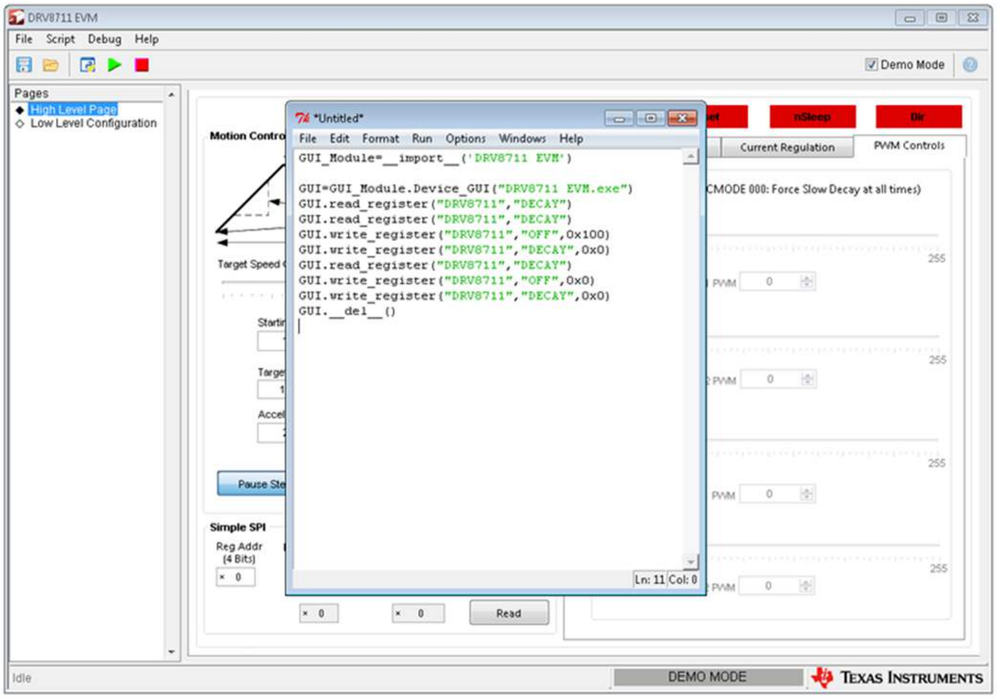


Figure 41. Stop Recording

4.3.3 Debug

The Debug option can be used for the following operations

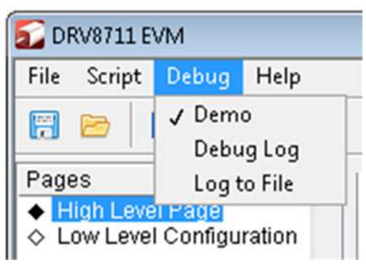


Figure 42. Debug Menu

- Demo
  - By selecting the Demo in the submenu, the GUI will run in simulation mode, and by unselecting it, the GUI will run in connected mode.
- Log to File
  - The log to file submenu is used to log the GUI activities to a log file that is specified.
- Debug Log
  - The Debug log option will enable to log all the activities of the user. If that is not selected, only the high-level operations will be logged.

4.3.4 Help

Clicking the user manual under Help option will open the User manual in the default browser.

- About
  – Clicking the user manual under Help option will open the User manual in the default browser.

Figure 43. About Page

5 Operating the EVM

1. This section acts as a quick start guide to allow the user to run the supplied motor.
2. Connect the black and green wires of the stepper motor to terminals A+ and A-, and the red and blue wires of the stepper motor to terminals B+ and B-.
3. Connect the VM power supply but do not apply power at this step.
4. Connect the USB between the PC and the EVM. Open the DRV8711EVM GUI located in the application folder of the downloadable DRV8711 product folder.
   a. Once the USB connection is established, the status light emitting diode (LED) begins blinking.
5. Apply 24 V to the VM+ and GND connections. The D2, FAULTn LED remains on until the part is taken out of sleep.

NOTE: If a battery is used as a power supply, it is possible that the FAULTn LED will not be enabled.

6. Open the Preset's configuration file (16-Step operation) from the following location as described in section 4.3.1
   1. Preset Configuration: C:\Program Files (x86)\Texas Instruments\DRV8711 EVM\Configurations\Preset Setting.cfg
7. Wake the device by clicking the nSleep button; it should turn green. The FAULTn LED D2 turns off.

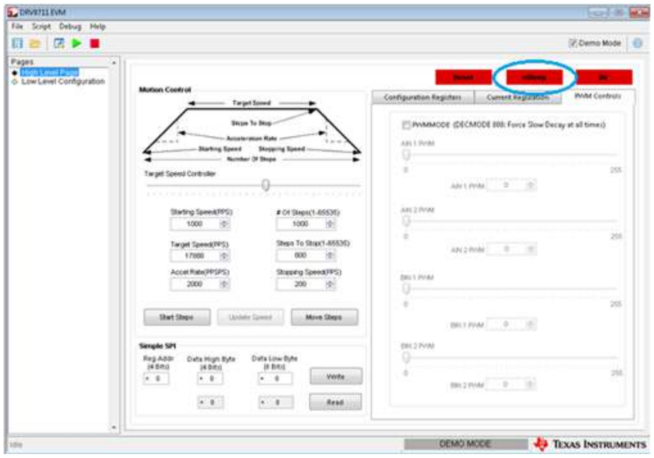


Figure 44. Wake the Device

8. The DRV8711 is now awake and can be commanded to turn the motor by either selecting Start Steps or Move Steps. If Start Steps is selected, the button changes to Pause Steps.

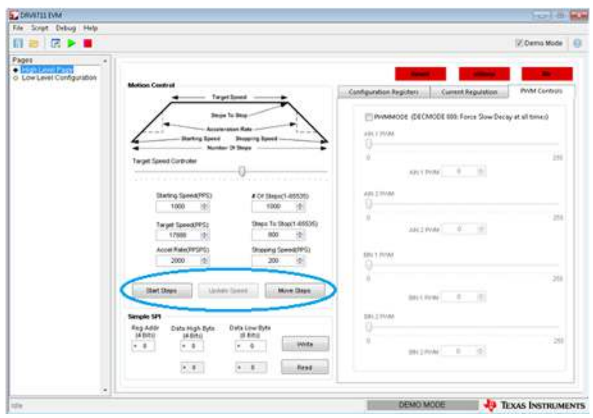


Figure 45. Turn the Motor

9. When stopping the motor, select Pause Steps.

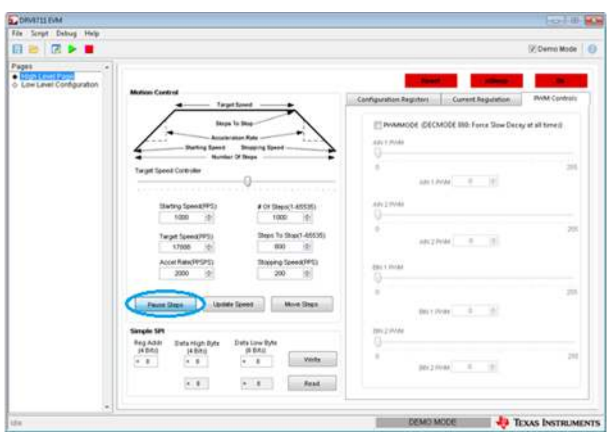
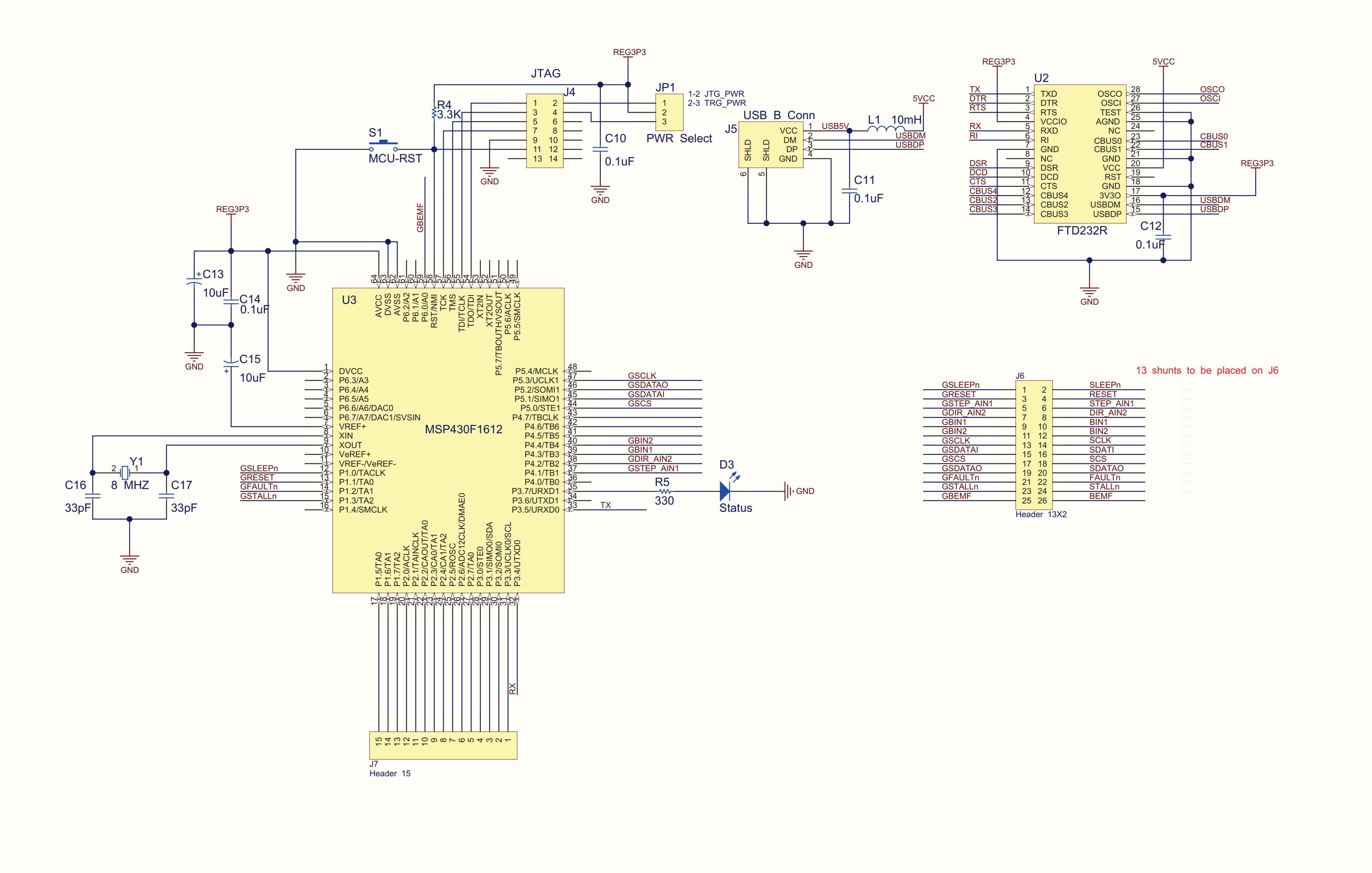
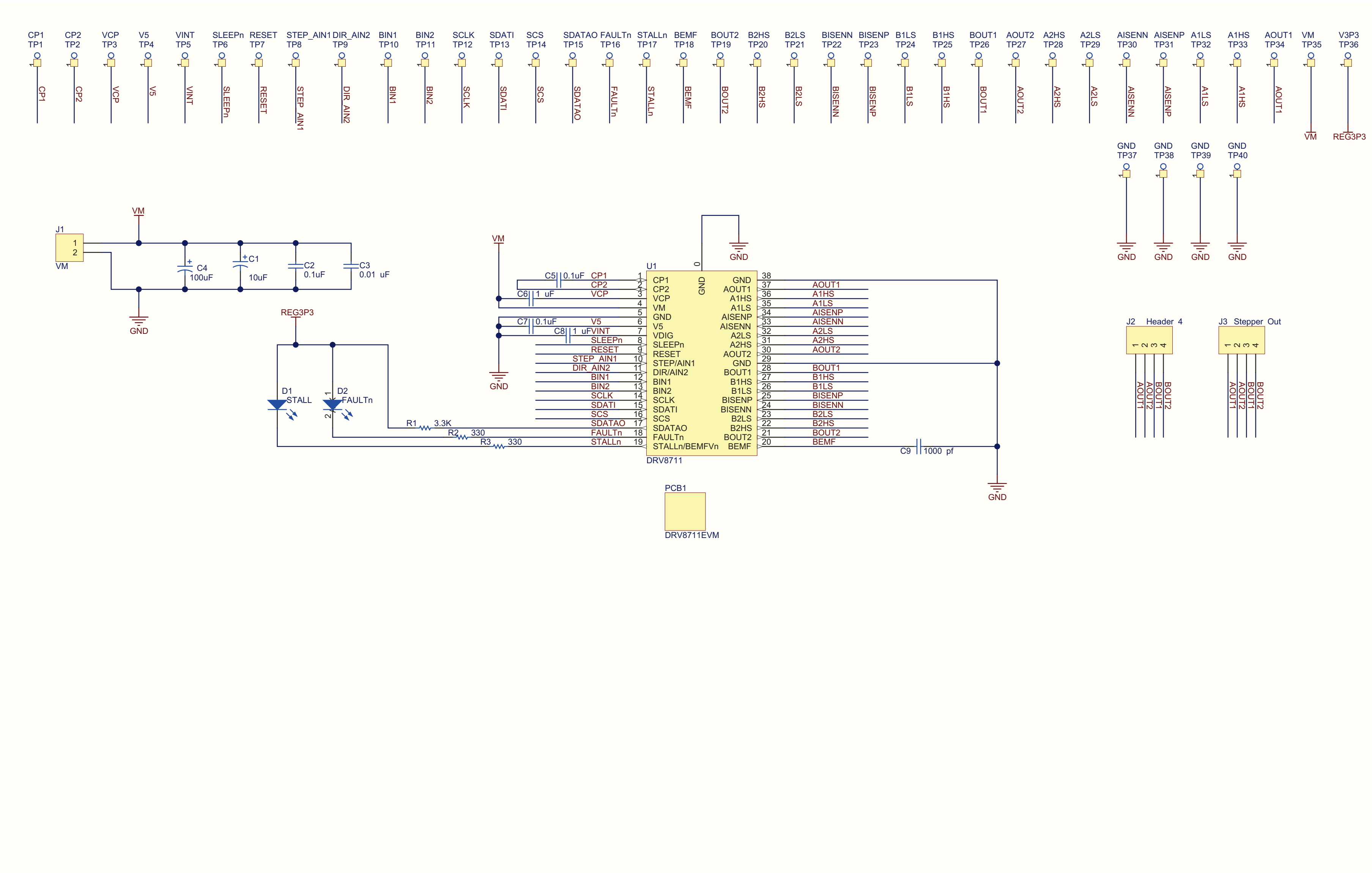


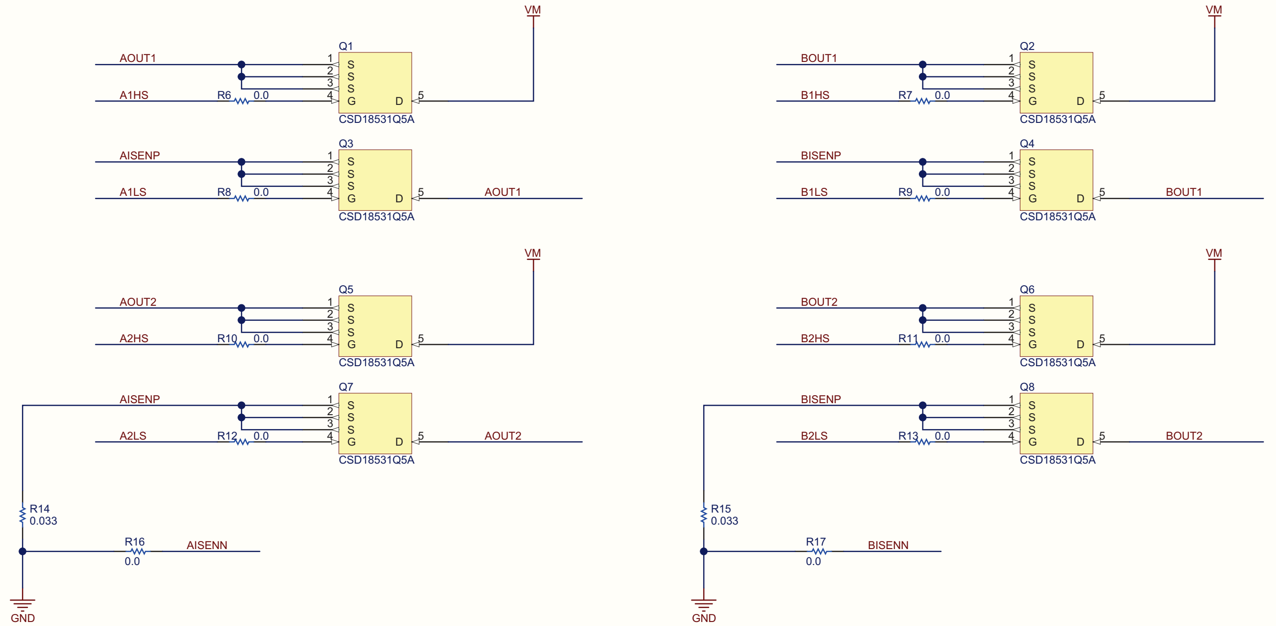
Figure 46. Stop the Motor

5.1 Schematic

See the following pages for the schematics. The PDFs of these schematics are also available for download as part of the zipped software package in the DRV8711EVM product folder.




U1
DRV8711
J1
VM
J2 Header 4
J3 Stepper Out
PCB1
DRV8711EVM
C4 100uF
C1 10uF
C2 0.1uF
C3 0.01 uF
C5 0.1uF
C6 1 uF
C7 0.1uF
C8 1 uF
C9 1000 pf
R1 3.3K
R2 330
R3 330
D1 STALL
D2 FAULTn
REG3P3
GND


VM
Q1
AOUT1
A1HS
R6
0.0
CSD18531Q5A
Q3
AISENP
A1LS
R8
0.0
AOUT1
CSD18531Q5A
VM
Q5
AOUT2
A2HS
R10
0.0
CSD18531Q5A
Q7
AISENP
A2LS
R12
0.0
AOUT2
CSD18531Q5A
R14
0.033
R16
0.0
AISENN
GND
VM
Q2
BOUT1
B1HS
R7
0.0
CSD18531Q5A
Q4
BISENP
B1LS
R9
0.0
BOUT1
CSD18531Q5A
VM
Q6
BOUT2
B2HS
R11
0.0
CSD18531Q5A
Q8
BISENP
B2LS
R13
0.0
BOUT2
CSD18531Q5A
R15
0.033
R17
0.0
BISENN
GND

6 Bill of Materials

Description	Designator	Digikey Part Number	Quantity
SHUNT JUMPER, .1 in., BLACK GOLD	SHNT2, SHNT3, SHNT4, SHNT5, SHNT6, SHNT7, SHNT8, SHNT9, SHNT10, SHNT11, SHNT12, SHNT13, SHNT14	3M9580-ND	13
FERRITE, 1.5 A, 40 Ω, 0805, SMD	L1	240-2389-1-ND	1
IC, MCU, 16 BIT, 92 K, FLASH, 64-LQFP	U3	296-22695-6-ND	1
RES, 330 Ω, 1/8 W, 5%, 0805, SMD, Resistor	R2, R3, R5	311-330GRCT-ND	3
Capacitor	C9	311-1342-1-ND	1
CAP, .10 µF, 50 V, CERAMIC, X7R, 0805, Capacitor	C7, C10, C11, C12, C14	311-1343-1-ND	5
Capacitor	C3	445-1304-1-ND	1
Capacitor	C8	445-1328-1-ND	1
Capacitor	C6	445-1423-1-ND	1
Capacitor	C2, C5	445-5202-1-ND	2
CAP, CERAMIC, 33 PF, 50 V, NP0, 0805	C16, C17	478-6211-1-ND	2
CAP, ALUM, 10 µF, 25 V, 20%, RADIAL	C13, C15	493-1057-ND	2
CAP, ALUM, 10 µF, 100 V, 20%, RADIAL	C1	493-6066-ND	1
IC, USB, FS, SERIAL, UART, 28 SSOP	U2	768-1007-1-ND	1
TEST POINT PC COMPACT .063 in. D RED	TP35, TP36	5005K-ND	2
TEST POINT PC COMPACT .063 in. D BLK	TP37, TP38, TP39, TP40	5006K-ND	4
TEST POINT PC COMPACT .063 in. D WHT	TP1, TP2, TP3, TP4, TP5, TP6, TP7, TP8, TP9, TP10, TP11, TP12, TP13, TP14, TP15, TP16, TP17, TP18, TP19, TP20, TP21, TP22, TP23, TP24, TP25, TP26, TP27, TP28, TP29, TP30, TP31, TP32, TP33, TP34	5007K-ND	34
CONN HEADER, .100 SNGL, STR, 3POS	JP1	929647-09-03-ND	1
CONN HEADER, .100 SNGL, STR, 4POS	J3	929647-09-04-ND	1
CONN HEADER, .100 DUAL, STR, 14POS	J4	929665-09-07-ND	1
CONN HEADER, .100 DUAL, STR, 26POS	J6	929665-09-13-ND	1
MOSFET N-CH, 60-V, 8 SON	Q1, Q2, Q3, Q4, Q5, Q6, Q7, Q8	CSD18531Q5A	8
TERM BLOCK, 5.08 mm, VERT, 2 POS PCB	J1	ED2580-ND	1
TERM BLOCK, 5.08 mm, VERT, 4 POS PCB	J2	ED2582-ND	1
Pre Driver Stepper Motor Controller	U1	N/A	1
RES, 0 Ω, 1/10 W, 0603, SMD	R6, R7, R8, R9, R10, R11, R12, R13, R16, R17	P0.0GCT-ND	10
RES, 3.3 kΩ, 1/10 W, 5%, 0603, SMD	R1, R4	P3.3KGCT-ND	2
CAP, ALUM, 100 µF, 100 V, 20%, RADIAL	C4	P5313-ND	1
SWITCH TACTILE SPST-NO, 0.02 A, 15 V	S1	P8070SCT-ND	1
LED, RED, FACE UP, 1206	D1, D2, D3	P11532CT-ND	3
CONN, USB, RT ANG, RECPT, TYPE B, BLK	J5	WM17113-ND	1
Resistor	R14, R15	WSHA-.033CT-ND	2
CRYSTAL, 8 MHz, 20 PF, 49 µs	Y1	X165-ND	1

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