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## Quick Start Guide for EV-MCS-LVDRV-Z Motor Drive Evaluation Platform

*Rev. 0.1*

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## 2 Revision History

| Version | Modified By     | Date     | Comments            |
|---------|-----------------|----------|---------------------|
| 0.1     | Dara O'Sullivan | 1/6/2015 | Document finalized. |
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## 3 Overview

This document will give a high level introduction to the EV-MCS-LVDRV motor control development platform and will provide a step-by-step approach that will get a motor up running. Instructions are provided on hardware setup, executable download, and graphical user interface (GUI) operation.

### 3.1 System requirements

Before you start working on the motor control platform, please make sure you have the hardware and software listed below.

#### Required Hardware

- ADSP-CM408F EZ-KIT rev 0.2 (This is ordered separately from the EV-MCS-LVDRV-Z)
- EV-MCS-LVDRV-Z power board, including BLY171D-24V-6000 motor with encoder, power supply and USB to serial cable

#### Optional Hardware

- Segger J-Link Lite debugger (This comes with the ADSP-CM408F Ezkit and can be used for executable download, and code development, but is not necessary for basic setup)

#### Required Software

- ADSP-CM40x SW Enablement Package version 1.2.0 (available here : <http://sdk.analog.com/dw/sdks.aspx?file=ADUSC03> )
- ADIMonitor Graphical User Interface (available here: <https://ez.analog.com/docs/DOC-11971> )
- Motor Control demo program executable and linker map file (also available here <https://ez.analog.com/docs/DOC-11971> )

#### Optional Software

- IAR Embedded Workbench (for code development, version 6.6 or higher)
- Segger J-Link Lite driver software

## 4 Hardware Setup

This section will describe how to setup the hardware. This only has to be performed once, when bringing up a new platform.

### 4.1 Low Voltage Board

Connect the EZ-kit to the Power Board as shown in Figure 1. Make sure both Samtec connectors mate completely. Also, note the location of Encoder, Power and Motor connectors.

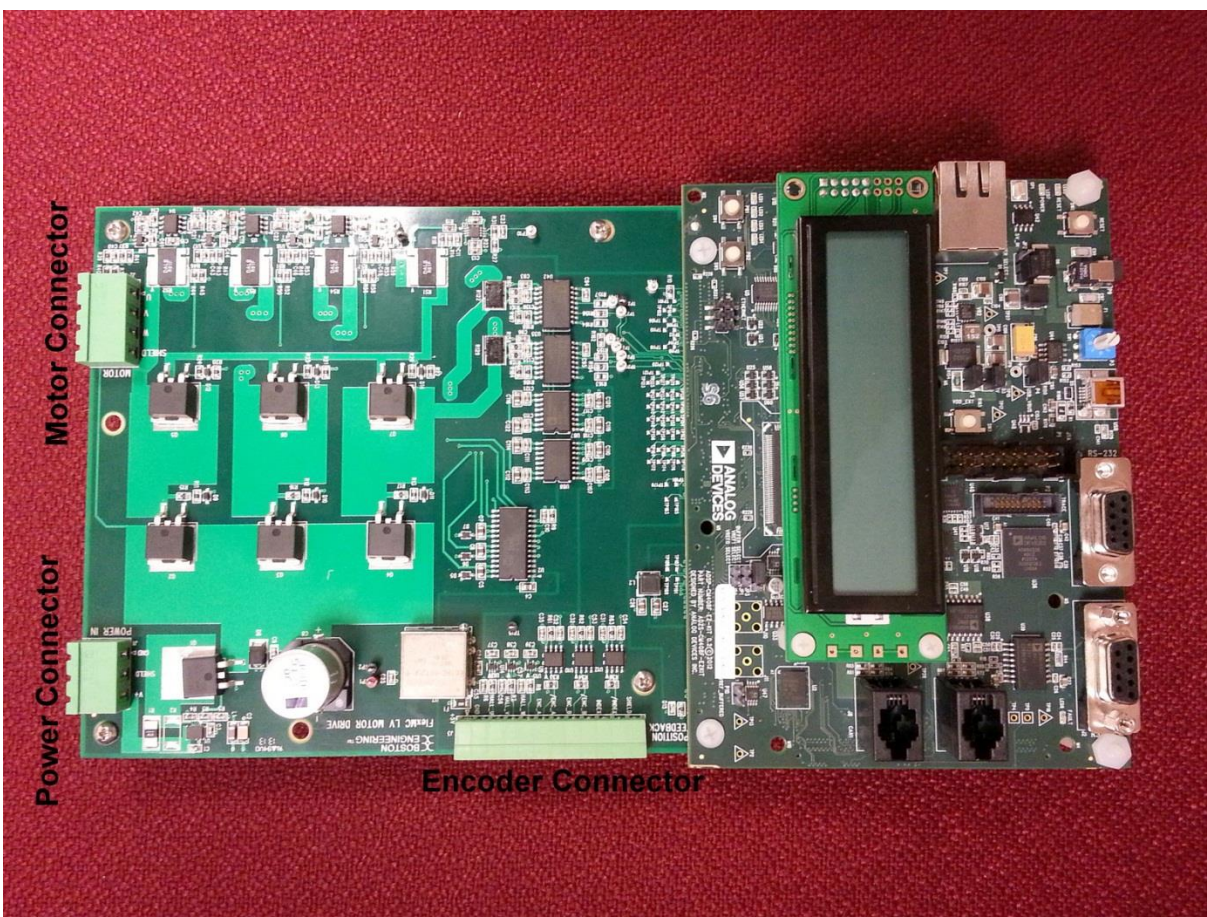


Figure 1 Low Voltage Power Board connected to CM408F EZ-kit.

Ensure that the Encoder connector is wired as shown in Figure 2 and Table 1.

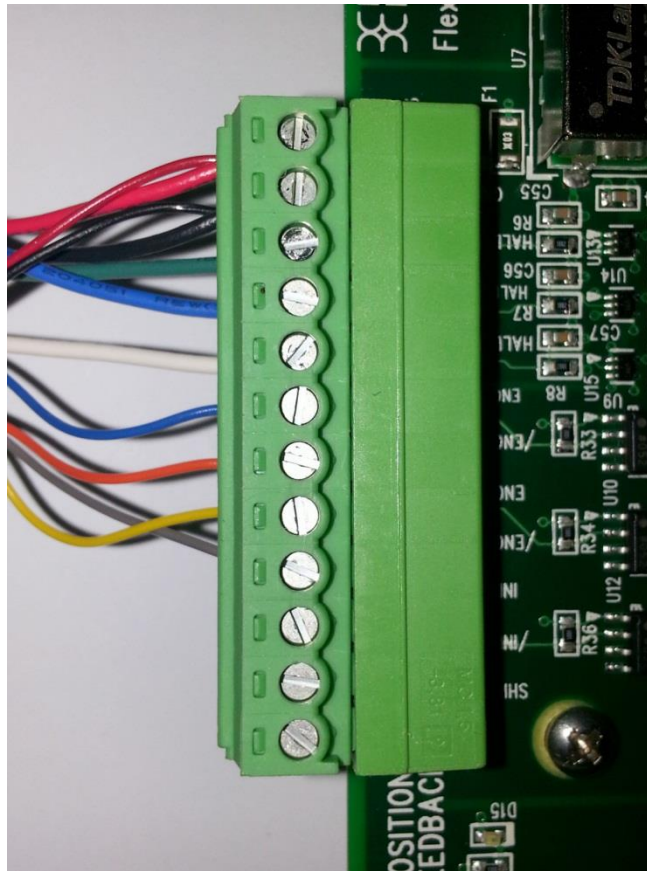


Figure 2 Wiring of Encoder Connector.

| Pin | Color                          | Signal |
|-----|--------------------------------|--------|
| 1   | Red<br>(thick and thin wire)   | +5V    |
| 2   | Black<br>(thick and thin wire) | GND    |
| 3   | Green                          | HALL_U |
| 4   | Blue (thick)                   | HALL_V |
| 5   | White                          | HALL_W |
| 6   | Blue (thin)                    | ENC_A+ |
| 7   | Orange                         | ENC_A- |
| 8   | Yellow                         | ENC_B+ |

|    |      |        |
|----|------|--------|
| 9  | Grey | ENC_B- |
| 10 | NC   | INDEX+ |
| 11 | NC   | INDEX- |
| 12 | NC   | Shield |

Table 1 Encoder Connector

Ensure that the Motor and Power Connectors are wired as shown in Figure 3, Table 2 and Table 3.

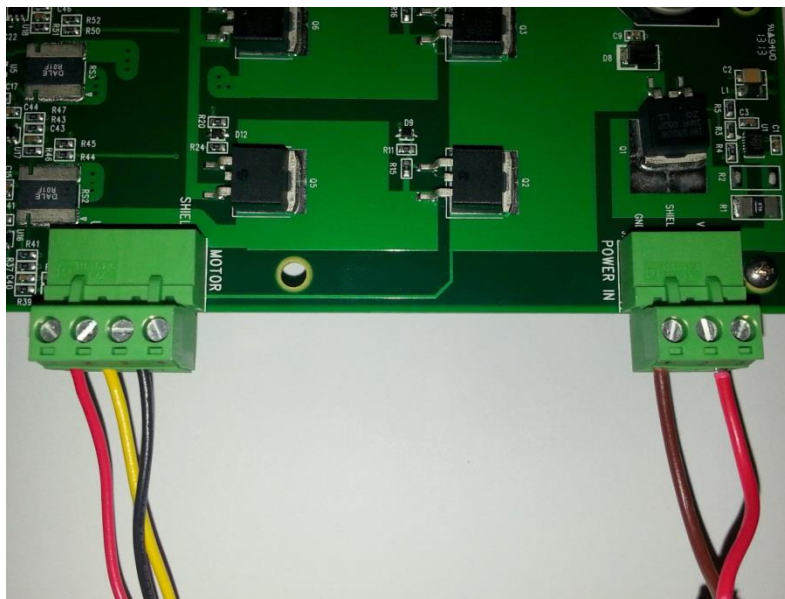


Figure 3 Wiring of Motor- and Power Connector.

| Pin | Color  | Signal        |
|-----|--------|---------------|
| 1   | Red    | Motor phase U |
| 2   | Yellow | Motor phase V |
| 3   | Black  | Motor phase W |
| 4   | NC     | Shield        |

Table 2 Motor Connector

| <i>Pin</i> | <i>Color</i> | <i>Signal</i> |
|------------|--------------|---------------|
| 1          | Brown        | GND           |
| 2          | NC           | Shield        |
| 3          | Red          | +24V          |

Table 3 Power Connector

## 5 Software Setup

The software setup steps are as follows:

1. Download and install the ADSP-CM40x SW Enablement Package version 1.2.0 from the link shown previously in “SW Requirements”. This includes the serial boot-loader which is needed for download of the executable to the processor.
2. Download and install the GUI from the Engineer Zone link provided in “SW Requirements”. This requires the .NET framework to be on the PC and it will prompt the user to download this if it is not detected.
3. Download the motor control demo executable program from the Engineer Zone link provided in “SW Requirements” and program this to the processor board (ADSP-CM408 EZkit).

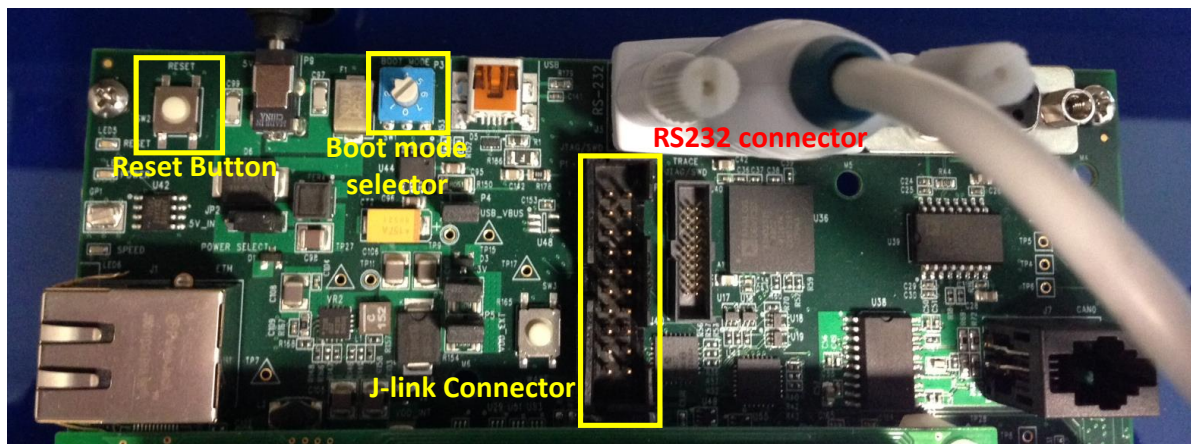
The first two steps are fairly self-explanatory. The third step – programming of the executable to the processor – can be carried out in two alternate ways. These are detailed in this section.

### 5.1 Programming with Serial Downloader

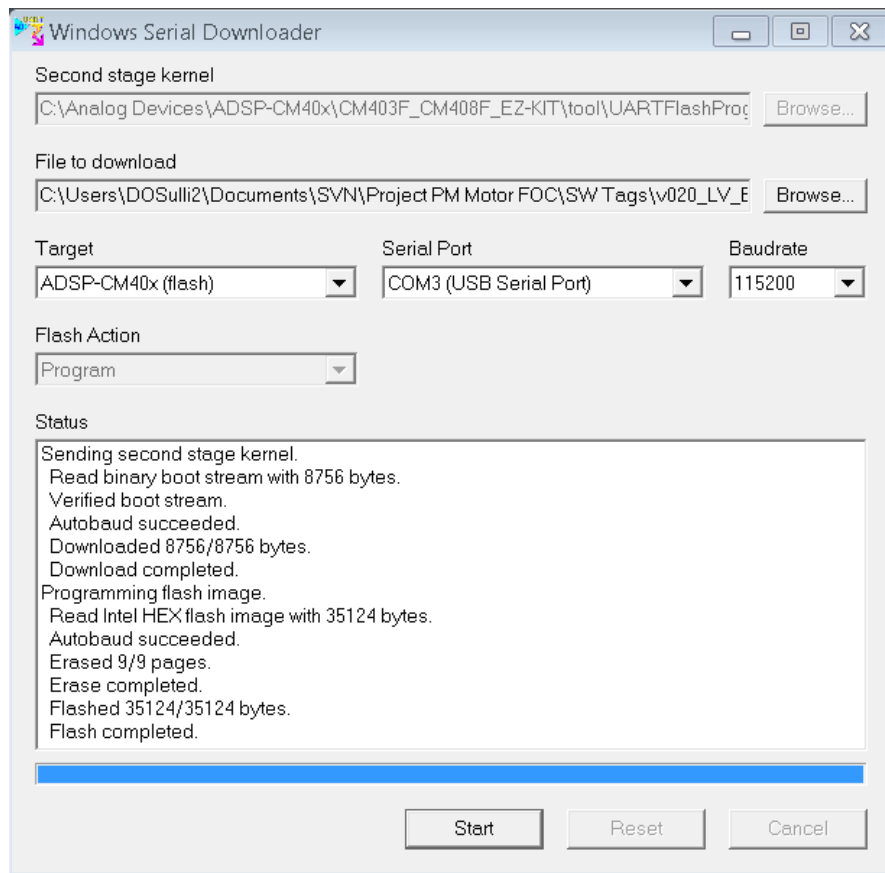
The serial downloader (“wsd.exe”) is provided as part of the ADSP-CM408 SW Enablement Package and once this has been installed, assuming default installation directory structures, the downloader is found in C:\Analog Devices\ADSP-CM40x\CM403F\_CM408F\_EZ-KIT\tool\UARTFlashProgrammer. This method uses the **MC\_Demo.hex** executable provided at the Engineer Zone link.

Steps:

1. Connect the EZ-kit to the PC using the USB-UART cable: UART (RS-232) connector on the EZkit, USB on the PC
2. Select Boot Mode 3 (UART Boot) on the EZkit using the selector switch P3 (adjacent to the power connector)



3. Power up the EZkit
4. Open the Windows Serial Downloader (wsd.exe) and select the appropriate options:
  - Target: ADSP-CM40x (flash)
  - Serial Port: Select the COM port to which the USB-serial cable is connected (if in doubt, check under 'Device Manager->Ports')
  - Baudrate: 115200
5. Click "Browse" under "File to download" and navigate to the provided executable "MC\_demo.hex"
6. Select "Start"



7. Once the operation completes, select Boot Mode 1 (SPI Flash Boot) on the EZkit, using the selector switch P3 (adjacent to the power connector)

8. Reset the EZkit (SW2 adjacent to power connector)

At this point the application should now be executing or loaded from flash, and the GUI can be connected to run the motor.

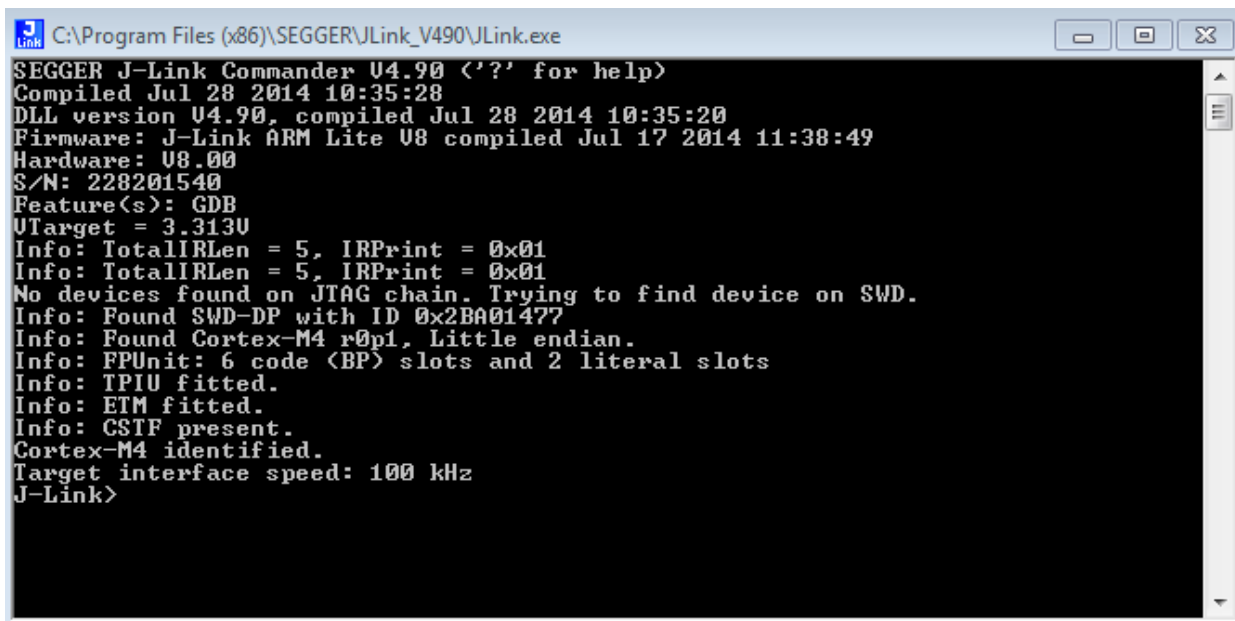
## 5.2 Programming with Segger J-Link

This method uses the JLink software and the debugger provided with the EZkit to program the processor flash memory.

1. Download and install Segger JLink Software ( <http://www.segger.com/jlink-software.html> )
2. Click the blue download button under Windows. The version number may be different from the one shown below.

[Download](#)
**Software and documentation pack for Windows V4.90 [20,125 kb]**  
 md5 checksum: 8c3335d09848ef8fdc66cec27d60b1a3

3. Enter your Segger JLink Lite serial number in the next box. This number is printed on the microcontroller on the debugger board.
4. Click the confirmation box on the next screen, download the software and install (default location is C:\Program Files(x86)\Segger)
5. Connect the JLink to the PC USB port and the other end to the 20 pin connector on the CM40x board.
6. The PC will start automatically start installing drivers for your Jlink . Let it complete and turn on power to the EZkit.
7. Turn on power to the CM408x board.
8. Go to the location where Segger was installed and click on JLink .exe. In this case it is in: C:\Program Files (x86)\SEGGER\JLink\_V490 (The version number and folder name may be different to the one in this example.)
9. The following should be displayed in the Jlink window. It should identify that a Cortex-M4 is connected to the Jlink .

A screenshot of the SEGGER J-Link Commander V4.90 application window. The title bar shows the file path: C:\Program Files (x86)\SEGGER\JLink\_V490\JLink.exe. The main window has a black background with white text. The text displays various system information: 'SEGGER J-Link Commander V4.90 ("?" for help)', 'Compiled Jul 28 2014 10:35:28', 'DLL version V4.90, compiled Jul 28 2014 10:35:20', 'Firmware: J-Link ARM Lite V8 compiled Jul 17 2014 11:38:49', 'Hardware: V8.00', 'S/N: 228201540', 'Feature(s): GDB', 'VTarget = 3.313V', 'Info: TotalIRLen = 5, IRPrint = 0x01', 'Info: TotalIRLen = 5, IRPrint = 0x01', 'No devices found on JTAG chain. Trying to find device on SWD.', 'Info: Found SWD-DP with ID 0x2BA01477', 'Info: Found Cortex-M4 r0p1, Little endian.', 'Info: FPUUnit: 6 code <BP> slots and 2 literal slots', 'Info: TPIU fitted.', 'Info: ETM fitted.', 'Info: CSTF present.', 'Cortex-M4 identified.', 'Target interface speed: 100 kHz', and 'J-Link>'.

```
SEGGER J-Link Commander V4.90 ("?" for help)
Compiled Jul 28 2014 10:35:28
DLL version V4.90, compiled Jul 28 2014 10:35:20
Firmware: J-Link ARM Lite V8 compiled Jul 17 2014 11:38:49
Hardware: V8.00
S/N: 228201540
Feature(s): GDB
VTarget = 3.313V
Info: TotalIRLen = 5, IRPrint = 0x01
Info: TotalIRLen = 5, IRPrint = 0x01
No devices found on JTAG chain. Trying to find device on SWD.
Info: Found SWD-DP with ID 0x2BA01477
Info: Found Cortex-M4 r0p1, Little endian.
Info: FPUUnit: 6 code <BP> slots and 2 literal slots
Info: TPIU fitted.
Info: ETM fitted.
Info: CSTF present.
Cortex-M4 identified.
Target interface speed: 100 kHz
J-Link>
```

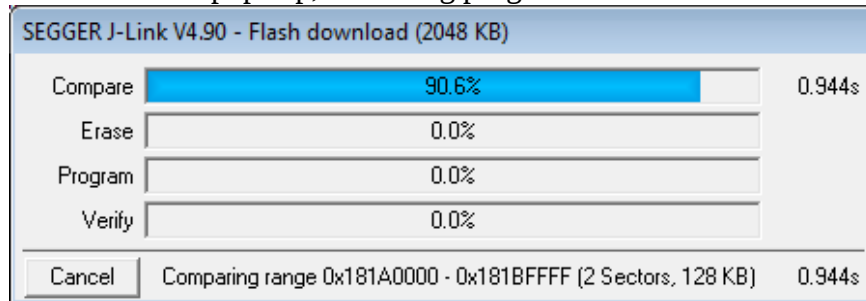
1. Enter the following at the prompt:  
exec device = ADSP-CM408BSWZ-BF  
The following will be displayed indicating that the chip has been identified correctly:  
**J-Link>exec device = ADSP-CM408BSWZ-BF**  
**Info: Device "ADSP-CM408BSWZ-BF" selected (2048 KB flash, 64 KB RAM).**
2. Copy the binary file you need to load into the CM40x in a known location. For this example, we will be placing the file **MC\_demo.bin** in C:\temp

3. In the JLink window, type the following to load the binary code at address 0x1800 0000, which is the start of flash.

```
loadbin c:\temp\MC_demo.bin, 0x18000000
```

```
J-Link>exec device= ADSP-CM408BSWZ-BF
Info: Device "ADSP-CM408BSWZ-BF" selected (2048 KB flash, 64 KB RAM).
J-Link>loadbin c:\temp\MC_demo.bin, 0x18000000
```

A new window pops up, indicating progress:



The JLink window will also show information about the flash procedure.

```
J-Link>loadbin c:\temp\MC_demo.bin, 0x18000000
Halting CPU for downloading file.
Downloading file... [c:\temp\MC_demo.bin]
Info: J-Link: Flash download: Flash programming performed for 1 range (65536 bytes)
Info: J-Link: Flash download: Total time needed: 6.429s (Prepare: 0.665s, Compare: 0.009s, Erase: 0.712s, Program: 4.971s, Verify: 0.015s, Restore: 0.055s)
J-Link>
```

4. Reset the EZkit (SW2 adjacent to power connector)

At this point the application should now be executing or loaded from flash, and the GUI can be connected to run the motor.

## 6 GUI Configuration

Once the installation zip file is extracted, the GUI application is loaded by running the installer executable "ADIMonitorGUI.exe". This GUI requires the .NET framework and this will be downloaded if it is not already on the PC. The first step is to set up the serial port (having connected the USB-serial converter to the EZkit RS232 port). This is accomplished by right-clicking the bottom right-hand corner of the GUI and selecting *Connect*. The program should automatically select the correct COM port, but if several options are available, right-click *Configure* and select the correct one. Once this is selected press, *Save* and then *Connect*.

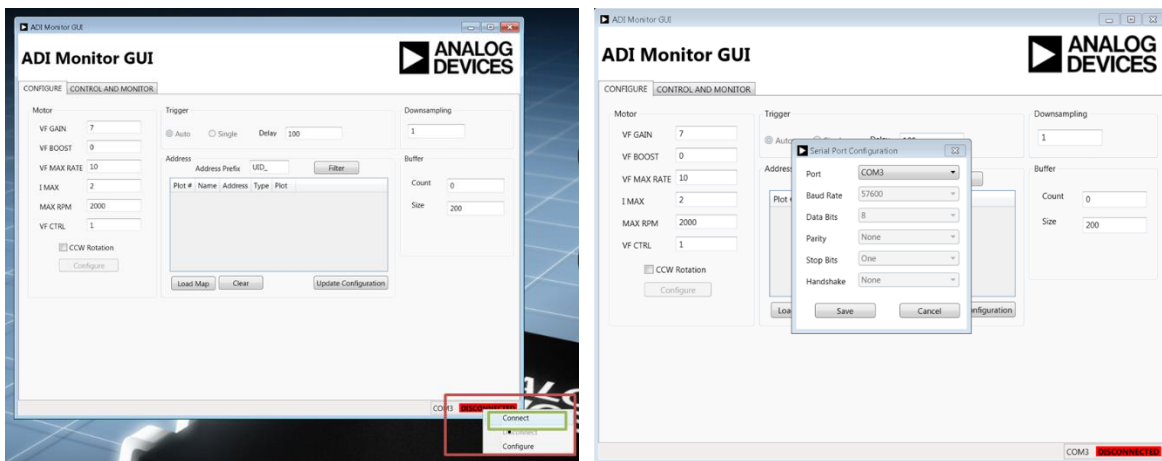


Figure 4: Serial Port Setup

The next step is to configure the motor control settings. These are listed in *Table 4*, along with an explanation of their relevance. The default settings are for open loop Volts/Hz control. Closed loop field-oriented control (FOC) can also be selected by changing the setting for VF\_CTRL. (The executable provided will run in either mode; however, sample C code is only provided and supported for open loop mode).

| Parameter       | Open Loop V/f control                                                                  | Closed loop FOC              |
|-----------------|----------------------------------------------------------------------------------------|------------------------------|
| VF_GAIN         | Volts per Hz representation                                                            | Only used for open loop      |
| VF_BOOST        | Low speed boost voltage representation                                                 | Only used for open loop      |
| VF_MAX_RATE     | RPM change per 0.1 ms sample                                                           | Only used for open loop      |
| I_MAX           | Not used                                                                               | Not used                     |
| MAX_RPM         | Max rpm                                                                                |                              |
| VF_CTRL         | Set to 1 for open loop V/f                                                             | Set to 0 for closed loop FOC |
| CCW rotation    | Check for CCW rotation. Uncheck for CW rotation. When looking into shaft end of motor. |                              |
| Speed reference | Speed reference                                                                        |                              |

Table 4: Motor Control Settings

Once the configuration settings have been entered, press *Configure*. Typical settings for open loop control are depicted in *Figure 5*. Please note that the VF\_GAIN and VF\_BOOST settings do not directly refer to volts/Hz or volts quantities. Care should be taken when setting the VF\_GAIN quantity. If it is set too high, the motor will draw large currents and an overcurrent trip may occur. Also if the VF\_MAX\_RATE is set too high, the applied motor voltage and frequency will ramp too quickly – especially if a large step change in speed reference occurs – potentially causing an overcurrent trip. If an overcurrent or PWM trip occurs, set the GUI start/stop command to *Stop* and reset the EZkit using the reset switch. Reduce VF\_GAIN or VF\_MAX\_RATE to limit the steady state and transient current amplitudes.

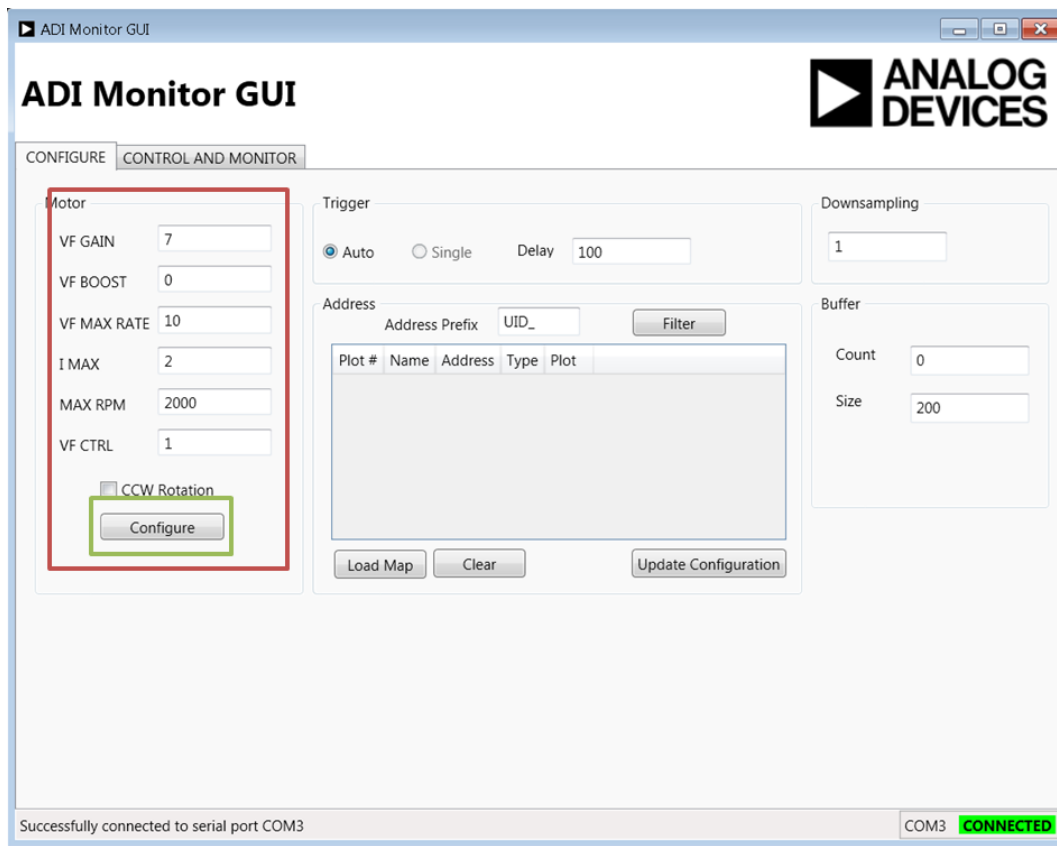


Figure 5: Motor Control Configuration – Typical open loop settings.

## 7 Running the Motor

In order to control the motor, navigate to the *Control and Monitor* tab. From here, the motor can be started by pressing the *Start* button, and the speed varied by moving the slider or entering a speed in the numeric box. This is illustrated in Figure 6.

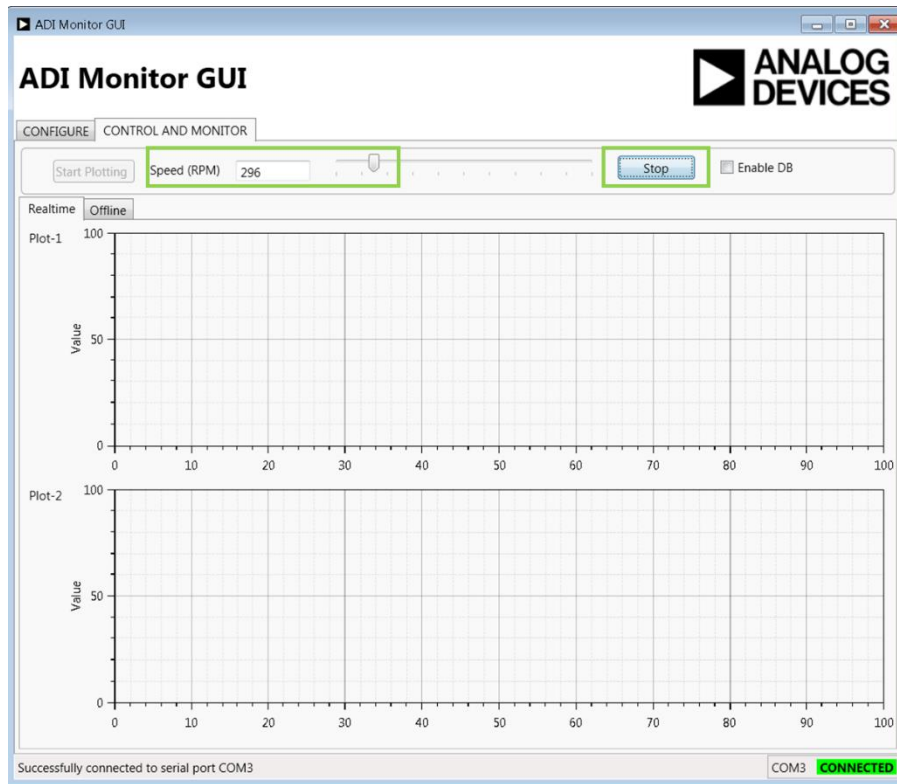


Figure 6: Motor Run Screen

## 8 Data Visualization

In order to import visualization data into the GUI, the linker map file (**MC\_demo.map**) provided with the demo C code or executable must be loaded. This is selected from the *Configure* tab as illustrated in Figure 7 with the resultant variable list shown in Figure 8. The variables provided by default have a `UID_` prefix in the map file and are listed in the Table below, along with their data types. It should be noted that the GUI cannot determine from the map file if a variable has signed or unsigned type, so if a variable is of signed type (e.g. `duty_a`) it is necessary to manually change the Type from `UINT16` to `SINT16` in the relevant column of Figure 8.

| Variable Name           | Variable                                     | Data Type |
|-------------------------|----------------------------------------------|-----------|
| <code>Idc_LV</code>     | DC bus current in Amps                       | SINGLE    |
| <code>Idc_LV_adc</code> | DC bus current – ADC value                   | UINT16    |
| <code>Vd</code>         | D-axis motor voltage per unit                | SINGLE    |
| <code>Vdc_LV</code>     | DC bus voltage in Volts                      | SINGLE    |
| <code>Vdc_LV_adc</code> | DC bus voltage – ADC value                   | UINT16    |
| <code>Vq</code>         | Q-axis motor voltage per unit                | SINGLE    |
| <code>Vu_LV</code>      | U-phase motor voltage (filtered) in Volts    | SINGLE    |
| <code>Vu_LV_adc</code>  | U-phase motor voltage (filtered) – ADC value | UINT16    |

|                    |                                              |        |
|--------------------|----------------------------------------------|--------|
| Vv_LV              | V-phase motor voltage (filtered) in Volts    | SINGLE |
| Vv_LV_adc          | V-phase motor voltage (filtered) – ADC value | UINT16 |
| Vw_LV              | W-phase motor voltage (filtered) in Volts    | SINGLE |
| Vw_LV_adc          | W-phase motor voltage (filtered) – ADC value | UINT16 |
| duty_a             | A phase duty cycle counter                   | SINT16 |
| duty_b             | B phase duty cycle counter                   | SINT16 |
| duty_c             | C phase duty cycle counter                   | SINT16 |
| hall_state_monitor | Hall signals code                            | UINT16 |
| ia_adc             | U phase current – SAR ADC value              | UINT16 |
| ia_sar             | U phase current – SAR Amps value             | SINGLE |
| ia_sinc            | U phase current – SINC Amps value            | SINGLE |
| ib_adc             | V phase current – SAR ADC value              | UINT16 |
| ib_sar             | V phase current – SAR Amps value             | SINGLE |
| ib_sinc            | V phase current – SINC Amps value            | SINGLE |
| ib_sinc_raw        | V phase current – SINC ADC value             | SINT16 |
| ic_adc             | W phase current – SAR ADC value              | UINT16 |
| ic_sar             | W phase current – SAR Amps value             | SINGLE |
| ic_sinc            | W phase current – SINC Amps value            | SINGLE |
| ic_sinc_raw        | W phase current – SINC ADC value             | SINT16 |
| qep_cnt_monitor    | Quadrature encoder count                     | UINT16 |
| speed_fil          | Speed in rpm (filtered)                      | SINGLE |
| speed_raw          | Speed in rpm (unfiltered)                    | SINGLE |
| theta_enc          | Electrical angle from encoder                | SINGLE |
| theta_vf           | Open loop electrical angle                   | SINGLE |

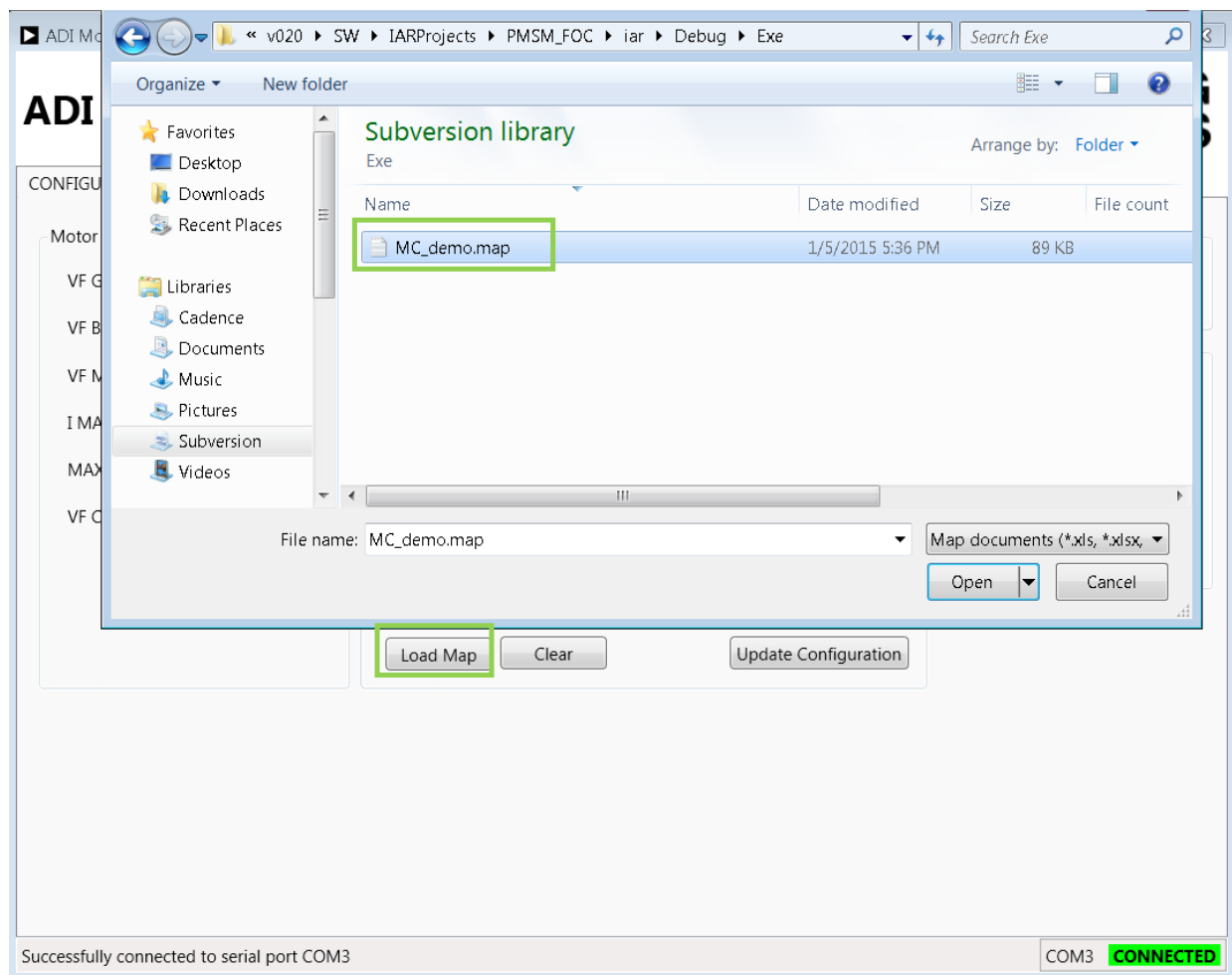


Figure 7: Load Map file for Data Visualization

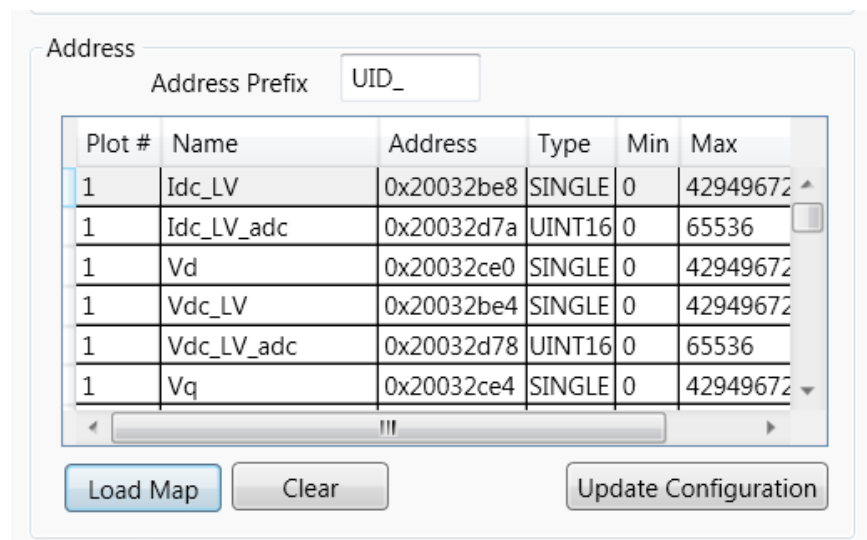


Figure 8: Visualization Variables

In order to select a variable for plotting, selection is by means of the check-box in the Plot column. The

variable can be plotted in Plot 1 or Plot 2 (see Figure 6). There are certain constraints on the number of bytes and buffers that can be streamed using the GUI. The program will limit the total buffer size to 1.7k bytes. The number of variables plotted can be increased by reducing the buffer size, which is maximum 200, although a total maximum selected variable size of 8 bytes is allowed (e.g. 2xSINGLE or 4xINT16, or 1xSINGLE+2xINT16 etc).

The steps to prepare for plotting of variables are (refer to Figure 9):

1. Select all of the variables to be plotted and whether each one is to be on Plot 1 or Plot 2, bearing in mind the maximum buffer memory size (1.7k) and the maximum byte count per buffer (8).
2. Down Sampling factor – the buffer time slice length equals the PWM switching period x Down Sampling ratio, so for a down sampling ratio of 1, the sampling period will be 100 $\mu$ s, and with a buffer length of 200, the plot time slices will be of 20ms length. To look at longer time slices, increase the down sampling factor.
3. Press *Update Configuration*
4. On the *Control and Monitor* tab, press *Start Plotting*.
5. If the variables are to be changed, press *Stop Plotting* and return to the *Configure* tab to change the configured variables.

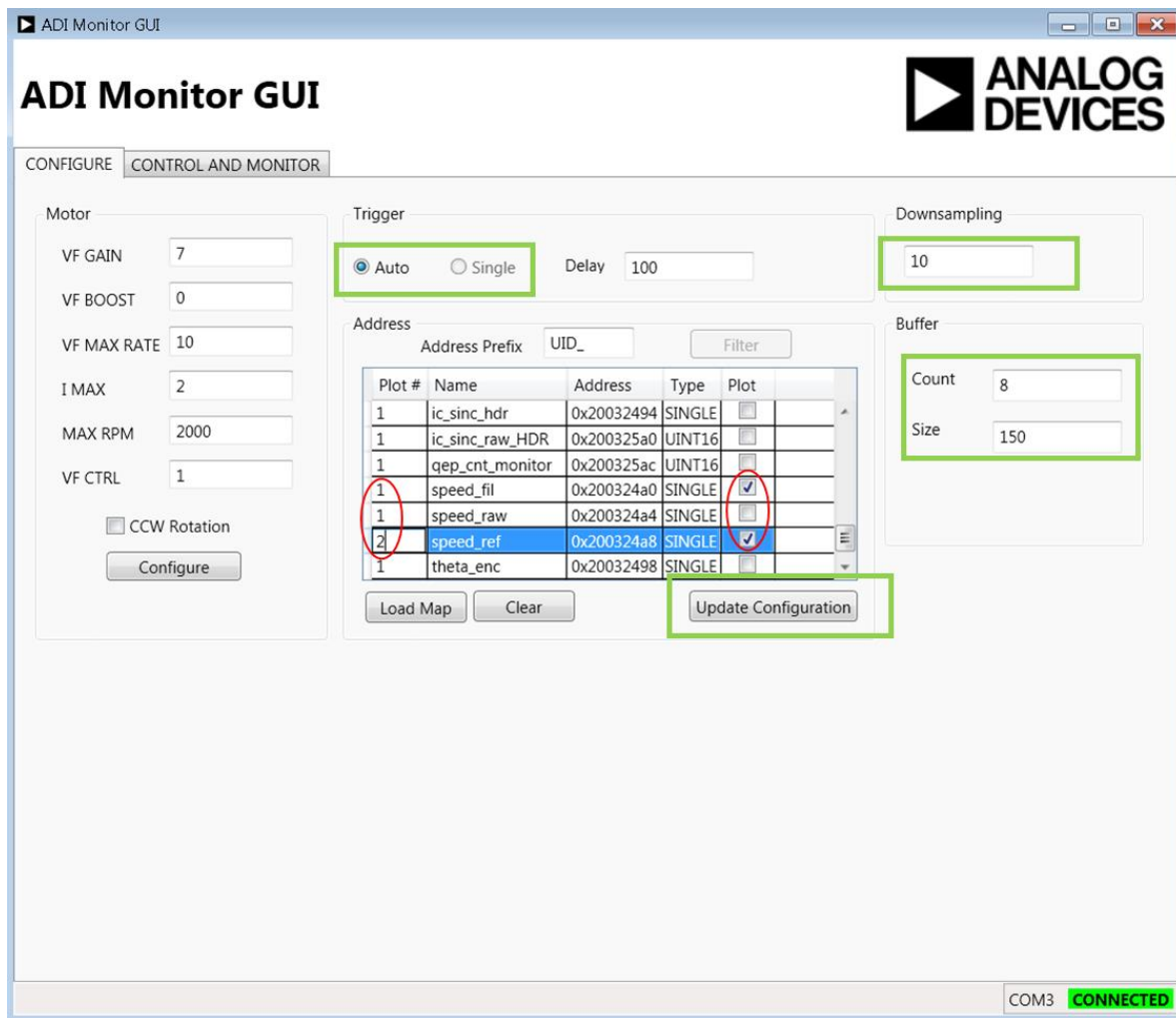


Figure 9: Setup of Variables for Plotting

The variables will start to plot in the *Control and Monitor* tab as illustrated in Figure 10.

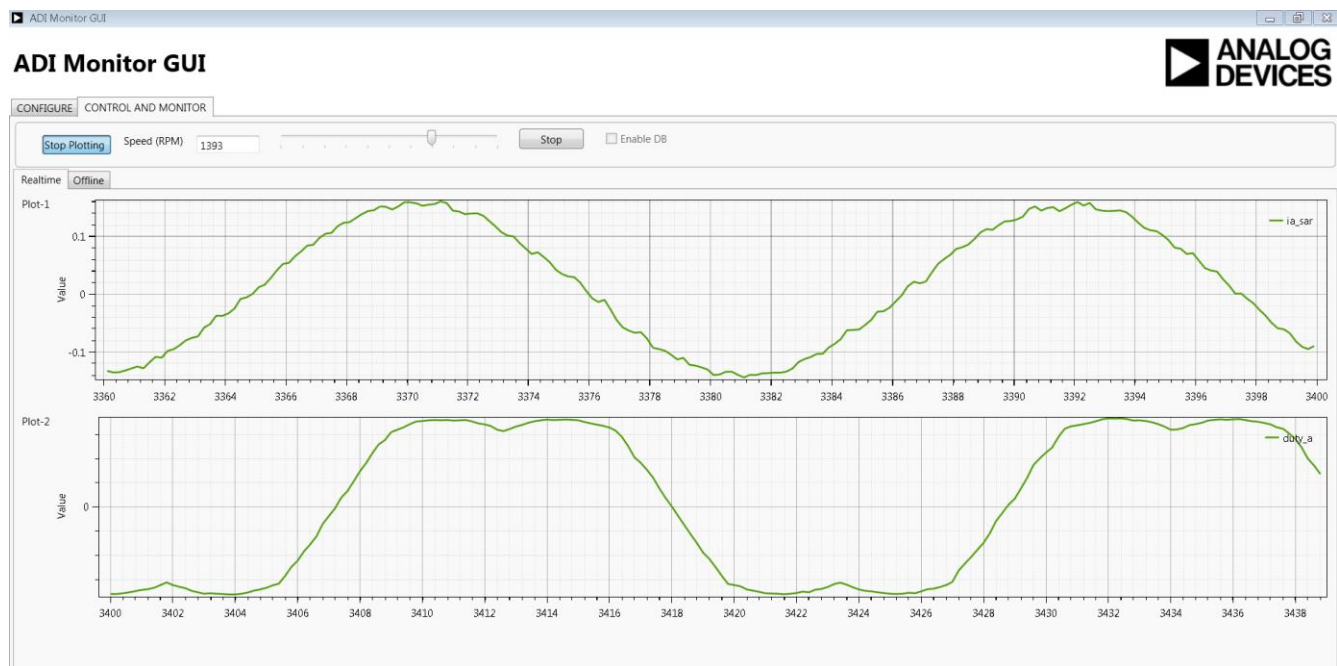


Figure 10: Variable plotting

## 9 Support

For support issues on setup and operation of the EV-MCS-LVDRV-Z platform, please visit the Engineer Zone support site at <https://ez.analog.com/community/motor-control-hardware-platforms2>.

For other support issues:

- Visit the Technical Support web site at <http://www.analog.com/support>
- For processor and processor tools specific questions, visit <https://ez.analog.com/community/dsp> or email [processor.tools.support@analog.com](mailto:processor.tools.support@analog.com)
- E-mail processor questions to [processor.support@analog.com](mailto:processor.support@analog.com) [processor.china@analog.com](mailto:processor.china@analog.com) (China and Taiwan only)
- Phone questions to 1-800-ANALOGD
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