## ANALOG DEVICES

# 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.

### 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: <u>https://ez.analog.com/docs/DOC-11971</u>)
- Motor Control demo program executable and linker map file (also available here <a href="https://ez.analog.com/docs/DOC-11971">https://ez.analog.com/docs/DOC-11971</a>)

#### **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.

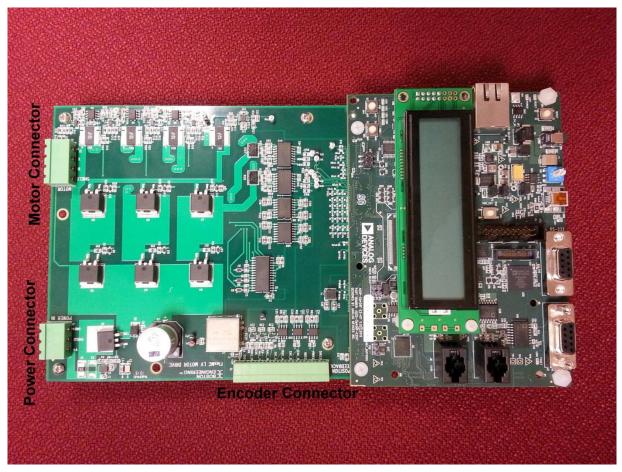


Figure 1 Low Voltage Power Board connected to CM408F EZ-kit.

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

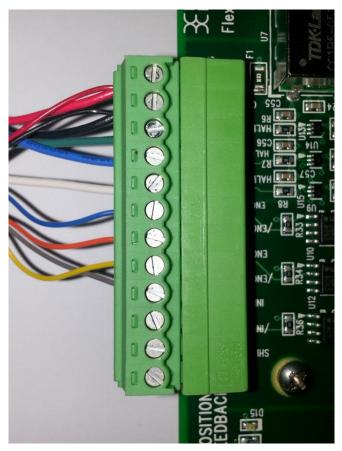


Figure 2 Wiring of Encoder Connector.

Pin	Color	Signal
1	Red	+5V
	(thick and thin wire)	
2	Black	GND
	(thick and thin wire)	
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*.

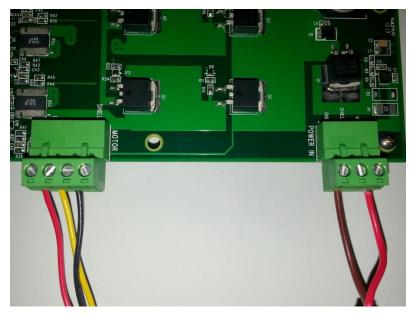


Figure 3 Wiring of Motor- and Power Connector.

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

Pin	Color	Signal
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.

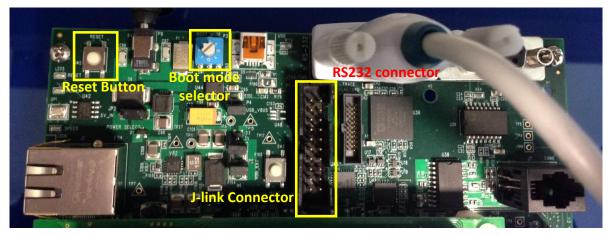
#### 5.1 Programming with Serial Downloader

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"

Windows Serial Downloader		
Second stage kernel		
C:\Analog Devices\ADSP-CM40x\CM40	3F_CM408F_EZ-KIT\tool\UARTFlash	Proc Browse
File to download		
C:\Users\DOSulli2\Documents\SVN\Pr	aiaat DM Matay EOC\ SW/ Taga\u020	LV E Browse
C. TOSERS (DOSUIIS (DOCUMERIS (SAM) Pr	UJEC PM MOULTPOC (SW Tags (V020_	
Target	Serial Port	Baudrate
ADSP-CM40x (flash)	COM3 (USB Serial Port) 📃 💌	115200 💌
Flash Action		
Program		
Frogram		
Status		
Sending second stage kernel. Read binary boot stream with 8756 byte		
Verified boot stream.	5.	
Autobaud succeeded.		
Downloaded 8756/8756 bytes. Download completed.		
Programming flash image.		
Read Intel HEX flash image with 35124 b Autobaud succeeded.	oytes.	
Erased 9/9 pages.		
Erase completed. Flashed 35124/35124 bytes.		
Flash completed.		
	Start Reset	Cancel

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.

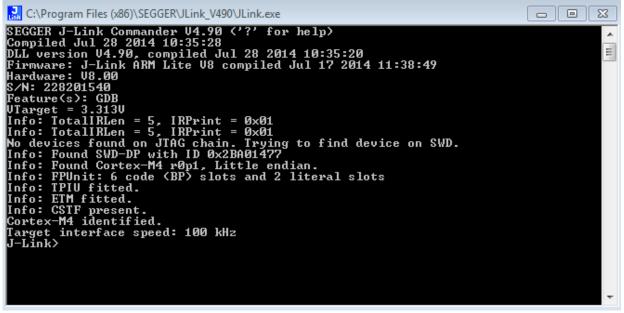
#### 5.2 Programming with Segger J-Link

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.

	3001 (J-Link User Guide), <u>UM08003</u> (J-Flash User Guide), <u>UM08004</u> (RDI User Guide)
	for <u>J-Link DLL</u> , <u>J-Flash</u> , <u>J-Link RDI DLL</u> .
	ng sample projects for most popular eval boards. Support for ARM RDI standard. Makes J-Link compatible with RDI compliant debugger
↓ 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 .



- 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:

SEGGER J-Li	nk V4.90 - Flash download (2048 KB)	
Compare	90.6%	0.944s
Erase	0.0%	
Program	0.0%	
Verify	0.0%	
Cancel	Comparing range 0x181A0000 - 0x181BFFFF (2 Sectors, 128 KB)	0.944s

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 by es) Info: J-Link: Flash download: Total time needed: 6.429s (Prepare: 0.665s, Compar e: 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*.

TOURE CONTROL AND MONIT	TOR.			CONFIGURE CONTROL AND MONITO	R					
otor	Trigger	Downsampling		Motor	Trigger				Downsampl	ing
VF GAIN 7	Auto O Single Delay 100	1	1	VF GAIN 7	Auto	Serial Port C	onfiguration	8	1	
F MAX RATE 10	Address Address Prefix UID_ Filter	Butter		VF BOOST 0 VF MAX RATE 10	Address	Port	COM3	-	Buffer	
MAX 2 MAX RPM 2000	Plot # Name Address Type Plot	Count 0 Size 200	$\prec$	I MAX 2	Plot	Baud Rate	57600		Count	0
F CTRL 1				MAX RPM 2000		Data Bits Parity	8 None		Size	200
CCW Rotation				VF CTRL 1		Stop Bits	One	v		
	Load Map Clear Update Configuration		×	Configure		Handshake	None	·		
					Loa	Save		ancel		

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	Only used for open loop
	boost voltage representation	
VF_MAX_RATE	RPM change per 0.1 ms sample	Only used for open loop
I_MAX	Not used	Not used
MAX_RPM	M	ax 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	l 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.

tor		Trigger	Downsampling
'F GAIN	7	Auto O Single Delay 100	1
F BOOST	0		Buffer
F MAX RATE	10	Address Prefix UID_ Filter	Buffer
MAX	2	Plot # Name Address Type Plot	Count 0
IAX RPM	2000		Size 200
F CTRL	1		
	/ Rotation	Load Map Clear Update Configuration	n

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.

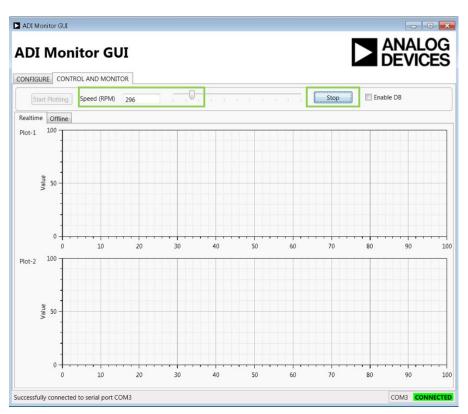


Figure 6: Motor Run Screen

# 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
Idc_LV	DC bus current in Amps	SINGLE
Idc_LV_adc	DC bus current – ADC value	UINT16
Vd	D-axis motor voltage per unit	SINGLE
Vdc_LV	DC bus voltage in Volts	SINGLE
Vdc_LV_adc	DC bus voltage – ADC value	UINT16
Vq	Q-axis motor voltage per unit	SINGLE
Vu_LV	U-phase motor voltage (filtered) in Volts	SINGLE
Vu_LV_adc	U-phase motor voltage (filtered) – ADC value	UINT16

	1	
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

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п	Organize 🔻 New	folder					0
DI	涬 Favorites 📃 Desktop	Subversi Exe	ion library			Arrange by:	Folder 🔻
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VF B	la Cadence						
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Figure 7: Load Map file for Data Visualization

Plot #	Name	Address	Туре	Min	Max
1	Idc_LV	0x20032be8	-71		42949672
1	Idc_LV_adc	0x20032d7a	UINT16	0	65536
1	Vd	0x20032ce0	SINGLE	0	42949672
1	Vdc_LV	0x20032be4	SINGLE	0	42949672
1	Vdc_LV_adc	0x20032d78	UINT16	0	65536
1	Vq	0x20032ce4	SINGLE	0	42949672 -
٠	1				•

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).
- 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 100µs, 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.

Single       Delay       100         Address Prefix       UIDFilter         # Name       Address       Type         ic_sinc_hdr       0x20032494       SINGLE         ic_sinc_raw_HDR       0x200325a0       UINT16         qep_cnt_monitor       0x200325ac       UINT16         speed_fil       0x200324a4       SINGLE         speed_ref       0x200324a8       SINGLE         theta_enc       0x20032498       SINGLE	BOOST 0 MAX RATE 10 MAX RATE 10 MAX RATE 10 MAX RATE 10 MAX RATE 10 MAX RATE 10 MAX 2 Address Prefix UID_ Plot # Name Address Type Plot 1 ic_sinc_hdr 0x20032494 SINGLE 1 ic_sinc_raw_HDR 0x200325a0 UINT16 1 gep_cnt_monitor 0x200325aC UINT16 1 gep_cnt_monitor 0x200325aC UINT16 1 speed_fil 1 speed_raw 0x20032444 SINGLE
Address Prefix UID_ Filter  Name Address Type Plot  ic_sinc_hdr 0x20032494 SINGLE  ic_sinc_raw_HDR 0x200325a0 UINT16  gep_cnt_monitor 0x200325ac UINT16  speed_fil 0x200324a0 SINGLE  speed_raw 0x200324a4 SINGLE  speed_ref 0x200324a8 SINGLE	MAX RATE       10       Address       Filter       Buffer         MAX RATE       1       ic_sinc_hdr       0x20032494       SINGLE       Count       8         MAX RPM       2000       1       ic_sinc_hdr       0x200325a0       UINT16       1       Size       150         CTRL       1       speed_fil       0x20032448       SINGLE       Image: Count in the speed_file       Image: Count i
Address Prefix UID_ Filter  Name Address Type Plot  ic_sinc_hdr 0x20032494 SINGLE  ic_sinc_raw_HDR 0x200325a0 UINT16  gep_cnt_monitor 0x200325ac UINT16  speed_fil 0x200324a0 SINGLE  speed_raw 0x200324a4 SINGLE  speed_ref 0x200324a8 SINGLE	MAX RATE       10       Address Prefix       UID_       Filter         IAX       2       Plot # Name       Address       Type       Plot       8         I       ic_sinc_hdr       0x20032494       SINGLE       5       5       5         I       ic_sinc_naw_HDR       0x200325a0       UINT16       5
Name       Address       Type       Piot         ic_sinc_hdr       0x20032494       SINGLE	AX       2       Plot in Name       Address       Type       Plot         I       ic_sinc_hdr       0x20032494       SINGLE       Image: Size       Size         I       ic_sinc_raw_HDR       0x200325a0       UINT16       Image: Size       Size       150         CTRL       I       speed_fil       0x200324a0       SINGLE       Image: Size       Image: Size       150         CCW Rotation       I       speed_raw       0x200324a8       SINGLE       Image: Size
ic_sinc_raw_HDR         0x200325a0         UINT16         Size         150           qep_cnt_monitor         0x200325ac         UINT16           5000000000000000000000000000000000000	AX RPM         2000         1         ic_sinc_raw_HDR         0x200325a0         UINT16         1         150           CTRL         1         qep_cnt_monitor         0x200325ac         UINT16         1         150           CCW Rotation         1         speed_raw         0x200324a0         SINGLE         1         150           Configure         1         speed_ref         0x200324a8         SINGLE         1         1
IC_SINC_TAW_HDR     0x200325a0     OINT16     Image: Constraint of the second	1       IC_SINE_TAW_HDR       0x200325a0       OIN116       130         CTRL       1       qep_cnt_monitor       0x200325ac       UIN116       130         CTRL       1       speed_fil       0x200324a0       SINGLE       Image: Comparison of the speed_raw       0x200324a4       SINGLE       Image: Comparison of the speed_raw       0x200324a8       SINGLE       Image: Comparison of the speed_raw       Image: Comparison of
speed_fil         0x200324a0         SINGLE         Image: Comparison of the system           speed_raw         0x200324a4         SINGLE         Image: Comparison of the system         Image: Comparison of the system           speed_ref         0x200324a8         SINGLE         Image: Comparison of the system         Image: Comparison of the system	CTRL       1       speed_fil       0x200324a0       SINGLE       Image: Configure         CCW Rotation       2       speed_raw       0x200324a4       SINGLE       Image: Configure         Configure       1       theta_enc       0x200324a8       SINGLE       Image: Configure
speed_raw 0x200324a4 SINGLE speed_ref 0x200324a8 SINGLE	CCW Rotation       1       speed_raw       0x200324a4       SINGLE
	2     speed_ref     0x200324a8     SINGLE       1     theta_enc     0x20032498     SINGLE
theta_enc 0x20032498 SINGLE	
	Load Map Clear Update Configuration
Map Clear Update Configuration	
Map Clear Update Configuration	

Figure 9: Setup of Variables for Plotting

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