User's Guide
SLAU643–July 2015

DRV10963 Evaluation Module

This document is provided with the DRV10963 customer evaluation module (EVM) as a supplement to the DRV10963 datasheet (SLAS955A). It details the hardware implementation of the EVM and gives a step-by-step introduction to the device operation and tuning process using DRV10963 GUI.

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1 DRV10963 EVM Kit Contents

The DRV10963 evaluation kit contains following:

1. DRV10963 motherboard circuit card
2. DRV10963 daughterboard circuit card
3. USB2ANY communication board for I2C GUI interaction
4. USB cable
5. 10-pin ribbon cable to connect USB2ANY and DRV10963 motherboard
6. DRV10963 EVM GUI

The DRV10963 EVM boards and GUI are designed to work together for tuning device to optimize the performance for a given application.

2 Introduction

The DRV10963 EVM is an evaluation platform for the DRV10963 5-V three phase sensor-less BLDC motor driver. The EVM is a combination of a motherboard and daughterboard. The motherboard includes a TLC555 timer configured to supply a PWM to the DRV10963 and a potentiometer to adjust the speed of the motor by varying the duty cycle of the PWM and has USB2ANY connector to communicate with DRV10963 GUI. The daughterboard contains a socket allowing the device to be programmed using the DRV10963 GUI via I^2C communication and it is mounted on top motherboard, as shown in Figure 1. The EVM set-up, together with DRV10963 GUI also provides means to program OTP (one time programmable) of DRV10963 blank version (un-programmed OTP) device for any custom motor solution.

The DRV10963 GUI is easy to use, requires only four simple steps to tune the motor for any end application and program the device OTP. The DRV10963 EVM comes with blank version device with un-programmed OTP bits. The DRV10963 device has configurable shadow registers corresponding to each OTP bit. Shadow registers provide ease-of-tuning to the user, as their values can be changed indefinitely during the course of tuning to arrive at the best optimized values. The DRV10963 also has an I^2C interface, this allows the user to program specific motor parameters in shadow registers, before deciding on final values to program OTP. Note that configurable shadow registers are volatile and lose their values in power off condition.

This document describes the kit details and explains the functions and locations of test points, jumpers, and connectors present on the kit. This document is also a quick start guide for using the GUI to tune a motor for an end application. For detailed information about the DRV10963, refer to the DRV10963 data sheet (SLAS955A).

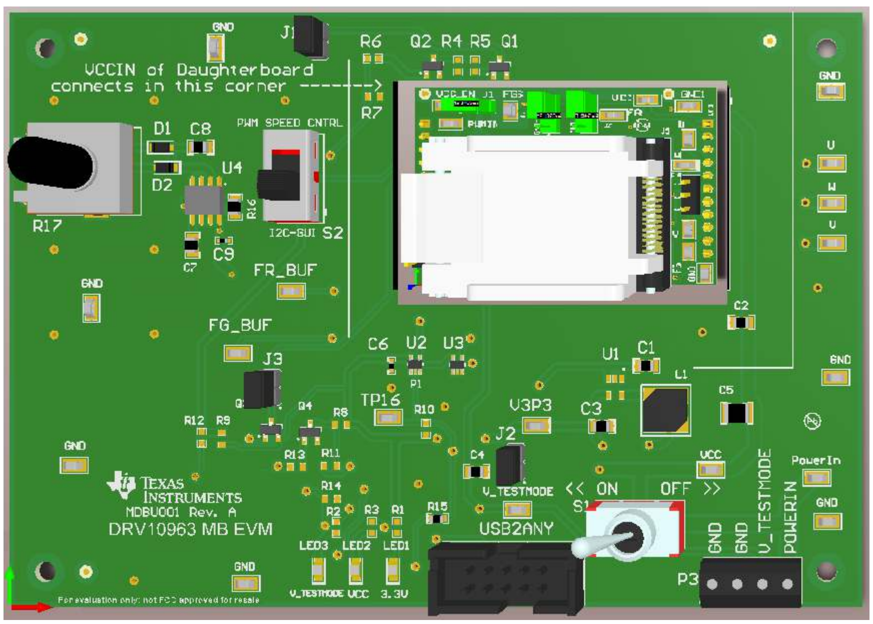

Figure 1. DRV10963 Motherboard with Socket Daughterboard Mounted on top

3 DRV10963 Motherboard Connectors

3.1 Power Input

The DRV 10963 requires two external power supply levels (6.2 V and 5 V) to operate the GUI via the I²C interface. Connector P3 provides the required interface for external power supply. The pin assignment of terminal P1 is as follows:

Pin	Description
1	GND
2	GND
3	Vtestmode-6.2 V to 7.2 V
3	Vpower-in-5.0 V to 6.0 V

3.2 Interface Connectors to Mount Daughterboard P1, P2

Connectors P1,P2 are used to interface the daughter socket board. The pin assignments are as follows:

Table 1. Connector P1: Daughterboard

Pin	Description
1, 2	NC
3	FR- Dual functionality: 1. Forward reverse for motor direction 2. Data signal for I²C
4	PWM, Dual functionality: 1. Motor speed control 2. Clock signal for I²C
5	FGS- Motor speed indicator selector
6	FG- Motor speed indicator output (open drain)
7	TOSC- To enable OTP programming
8, 9, 10, 11	NC

Table 2. Connector P2: Daughterboard

Pin	Description
1,2	VCC- 5-Volt power input
3	NC
4, 5	Phase-W
6, 7	Phase-U
8, 9	Phase-V
10, 11	GND

3.3 USB to Any Connector

The Connector USB2ANY is used for the I^2C interconnection with the GUI. The pin assignment is as follows:

Pin	Description
1, 2, 3, 4, 5	NC
6	GND
7	NC
8	FGS Control- For Internal Factory Testing
9	SCLK- Clock signal for I2C communication with GUI
10	SDATA- Data signal for I2C communication with GUI

4 DRV10963 Daughterboard Connectors

4.1 Motor Output Connector

The DRV10963 daughterboard provides the 3-terminal connector P3 to connect 3-phase BLDC motor. Pin assignment of terminal P3 is as follows:

Pin	Description
1	U
2	W
3	V

4.2 Interface Connectors to Motherboard P1, P2

Connectors P1,P2 are used to interface signals coming from the motherboard to the device via socket. The pin assignments are as follows:

Table 3. Connector P1: Motherboard

Pin	Description
1, 2	NC
3	FR- Dual functionality: 1. Forward reverse for motor direction 2. Data signal for I^2C
4	PWM, Dual functionality: 1. Motor speed control 2. Clock signal for I^2C
5	FGS- Motor speed indicator selector
6	FG- Motor speed indicator output (open drain)
7	TOSC- To enable OTP programming

Table 4. Connector P2: Motherboard

Pin	Description
1, 2	VCC- 5-Volt power input
3	NC
4, 5	Phase-W
6, 7	Phase-U
8, 9	Phase-V
10, 11	GND

5 Quick Start Guide

5.1 Installation of Software

If this your first encounter with the DRV10963, before proceeding to next step, install the following software packages to use the DRV10963 GUI for tuning the motor:

1. The DRV10963 EVM is provided with a GUI to configure the device and tune the application. Refer to DRV10963_2P0 User Manual.pdf present (C:\Program Files (x86)\Texas Instruments\DRV10963_2P0 EVM\Documents) in the GUI-installed directory for instructions to download and install the GUI application. Create a desktop shortcut with the name DRV10963_2P0 EVM, for future use.
2. Install the Run-Time Engine LabVIEW-2014 from the following link, for complete instructions, refer to http://www.ni.com/download/labview-run-time-engine-2014/4887/en

CAUTION

Do not apply power to board before you have verified settings mentioned in Section 5.2 and Section 5.3!

5.2 Initial Hardware Settings

The kit ships with the daughterboard already mounted on top of the motherboard. The daughter socket board also has a pre-inserted DRV0963 blank version device, however, ensure:

- The daughterboard is rigidly inserted on the motherboard without any loose connection. Check the orientation of the daughterboard with VCC_IN test-point connected to the right corner. Refer to Figure 2 for details and read instructions written on the motherboard for proper orientation.
- The DRV10963 device is properly inserted with right orientation at the socket in the daughter card as per Figure 3, referred to as U1.

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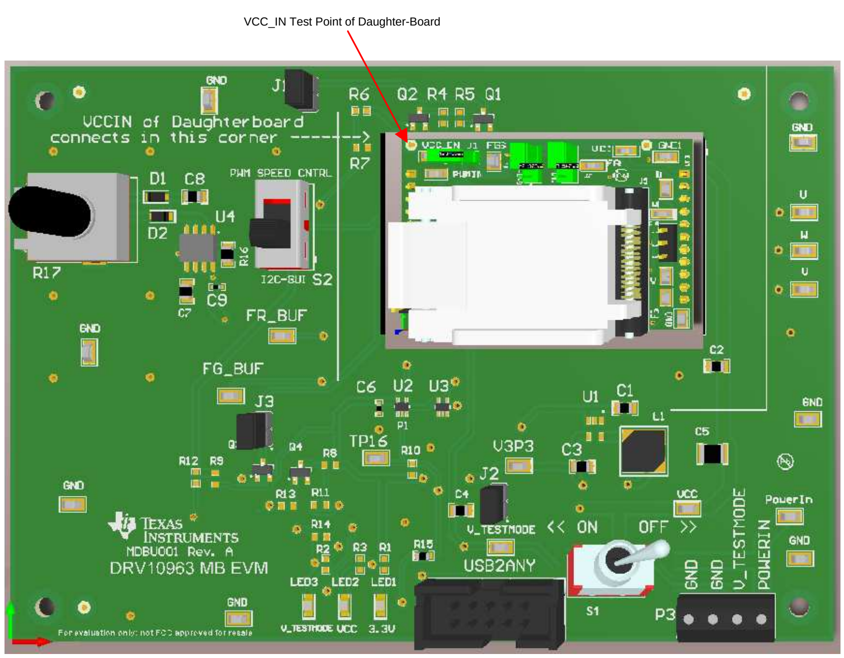

Figure 2. DRV10963 Daughterboard Mounting on Motherboard

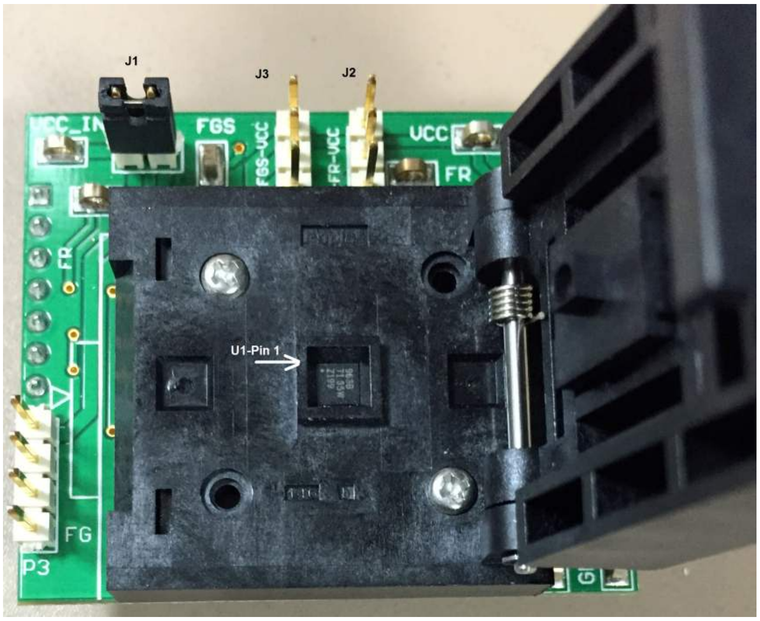

Figure 3. DRV10963 Orientation Inside Daughterboard Socket

5.3 Jumpers and Switch Setup Settings

On the daughterboard:

1. Make sure that only jumper J1 is populated, jumper J2 and J3 all 3-pins shall be open

On motherboard:

1. Make sure that all jumpers J1, J2, and J3 are populated
2. Switch S1 should be in the off position and switch S2 in the I2C-GUI position. DRV10963 PWM input pin has dual functionality, that is, it serves as speed control input as well as clock signal for I^2C. Switch S2 provides a means to configure the PWM input pin for speed control or I^2C clock.

5.4 Powering-Up EVM

DRV10963 EVM requires two power supply sources, that is, 5 V and 6.2 V to work with the GUI to enable I^2C interface for register configuration. Note that programmed device needs only one 5-V supply in the final end-application circuit. Use the following sequence to power-up the EVM and to establish a successful connection with the GUI:

1. Do not power up the power supply. First, connect the power supply ground to pin GND, the 6.2 V to pin V_Testmode, and 5 V to PowerIn on the motherboard at connector P3. At this point, make sure that switch S1 is in the turn-off position and the “USB2Any” board is not connected to the motherboard. If using a lab power supply, it is recommended to set the current limit of both power supplies to 1.5 A.
2. Turn the POT-R17 fully CCW (counter-clock wise). This keeps the speed PWM input to the minimum value.
3. Connect the 3-phase terminal of motor to connector P4 on the daughterboard. It is not important to observe the polarity as it only determines the direction of rotation.
4. Now power up the board and turn switch S1 to the “on” position. Check LED1, LED2, and LED3. All should turn green.
5. Connect USB2Any box first, via the supplied USB cable to the computer. Then connect the 10-pin ribbon cable to the USB2ANY connector on the motherboard.

5.5 Tuning GUI: to Configure Motor Parameter

Use the following steps to configure the motor parameters.

1. Now launch the DRV10963EVM GUI by double clicking the DRV10963_2P0 EVM shortcut on the desktop. If "Demo Mode" is selected, the screen shown in Figure 4 appears, deselect "Demo Mode" to go to the next step.

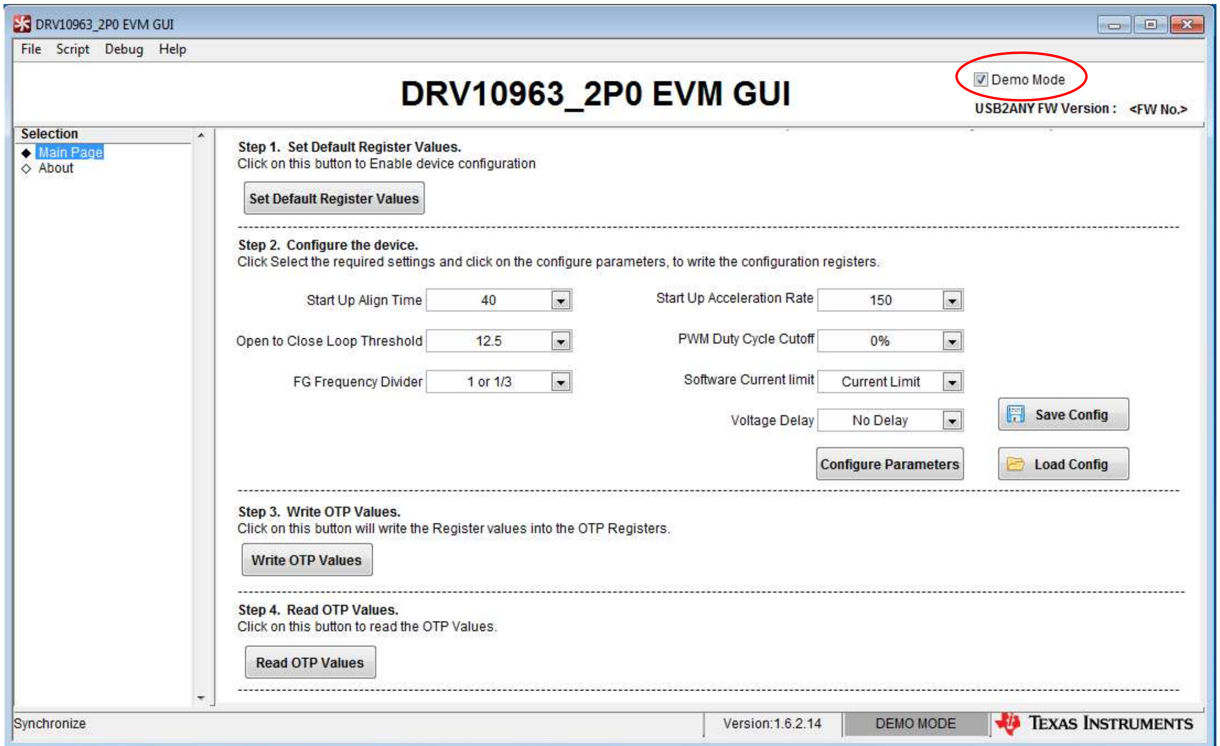

Figure 4. GUI Initial Screen With Demo Mode

2. If "Demo Mode" is not select previously, the screen shown in Figure 5 appears as soon as the GUI launches. The "CONNECTED" block should turn green indicating that the GUI is successfully connected to USB2ANY.

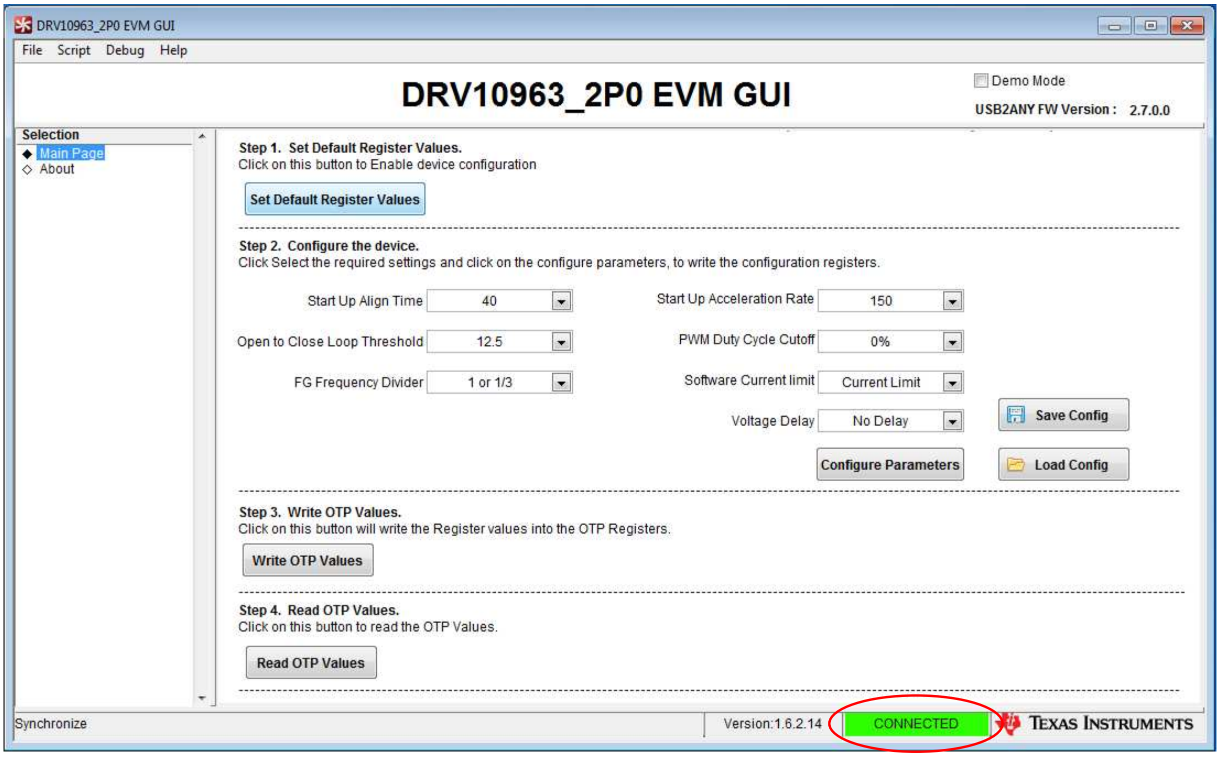

Figure 5. GUI Screen With Successful I2C Interface

3. Left-click on the step 1 button “Set Default Resister Values”. Step 1 is always mandatory before proceeding to step 2 to enable configuration of the device. This step programs the following parameters to the corresponding shadow register, as shown in Figure 6. These default values correspond to the factory programmed part DRV10963JJ. Refer to the DRV10963 datasheet for a detailed explanation of different versions of DRV10963 and descriptions of tunable parameters.
   - "Start Up Align Time" - 350 ms and "Start-up Acceleration Rate" - 80 Hz/s
   - "Open to Close Loop Threshold" - 100 Hz
   - "PWM Duty Cycle Cutoff" - 10%
   - "FG Frequency Divider" - 1 or 1/3
   - "Software Current limit" - 500 mA
   - "Voltage Delay" - 120 µs

   To enable motor spin with the above parameters, open the jumper J1 on the motherboard. There is a high probability that the motor will start rotating with previously shown default values. This state is equivalent to driving the motor at maximum speed with 100% duty cycle because PWM input being connected to the I^2C clock input continues to receive a high signal. Ensure that the parameters previously shown are optimized for their end application. Refer to Section 6 for guidelines to optimally determine and tune motor parameters using the GUI.

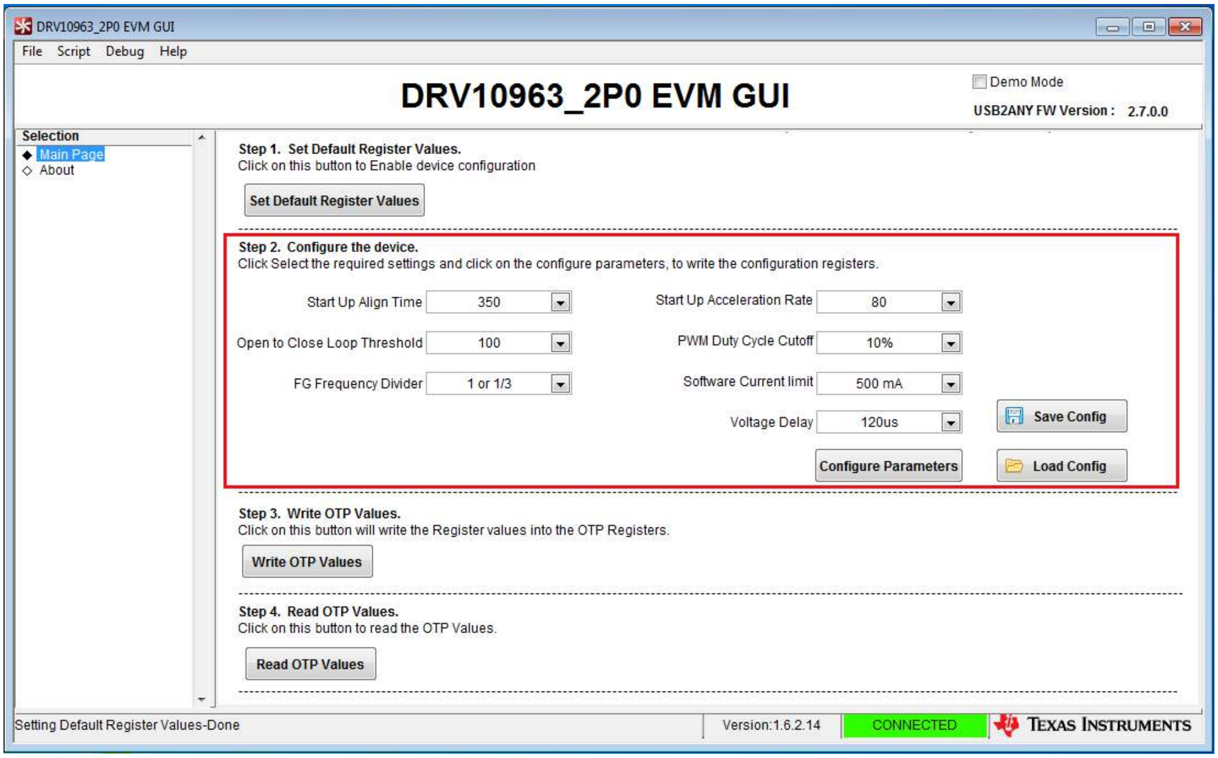

Figure 6. Default Configuration Parameters

4. To facilitate the tuning at different speeds or across a speed range, the EVM provides a TLC555 timer-based PWM generation circuit and potentiometer (R17) to adjust the duty cycle of PWM to control the speed of the motor. To enable speed control via POT-R17, change the switch S2 position to PWM Speed Control mode. Turn the POT-R17 clock-wise to increase the motor speed and counter-clockwise to reduce it.
5. In case motor performance is not satisfactory with default values or further optimization is desired, try three other factory-programmed device options before attempting to customize parameters. This would benefit in production phase because all versions of factory programmed devices can be easily procured and used directly without the burden to programming the OTP values. The GUI comes with three .txt files corresponding to the three remaining factory-programmed devices.
6. To test motor performance with the DRV10963JM version, short the jumper J1 back. This will stop the motor. Referring to Figure 7, left-click the “Load Config“ button, browse to the GUI installation directory for 3 .txt files in your PC and select DRV10963JM.txt.This will load the register with configuration parameters corresponding to DRV10963JM. Refer to Figure 8 to check configuration parameters corresponding to the DRV10963JM version. In same way, load and configure other versions of DRV10963 to test the performance. To enable motor spin, open the jumper J1 on the motherboard and use POT R-17 for speed control.

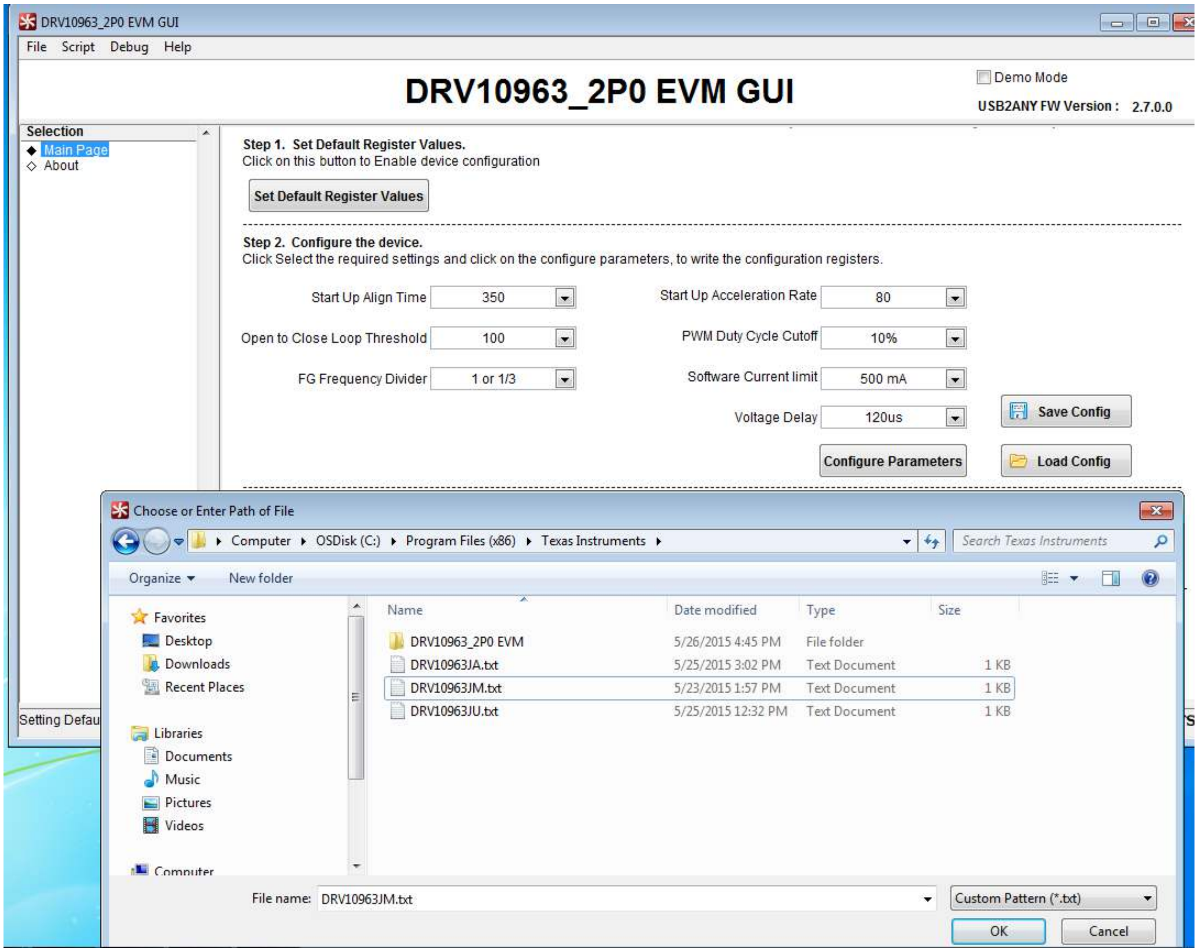

Figure 7. Loading DRV10963JM Configuration Parameter to Device

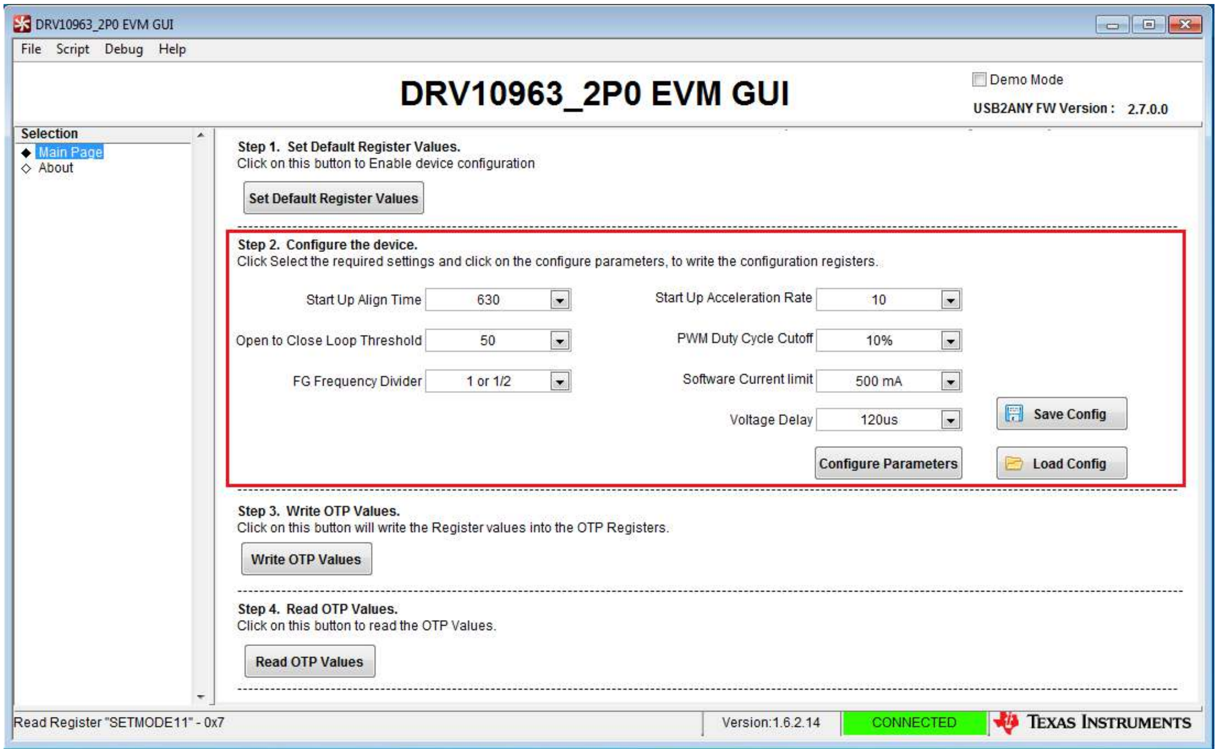

Figure 8. DRV10963JM Configuration Parameter

7. After trying DRV10963JM, the next file to load is the DRV10963JU configuration followed by loading the DRV10963JA.
8. If only one of the preloaded configurations spins the motor, then obviously that is the part number to order to control the motor. However, if two or more spin the motor, then refer to Figure 9.

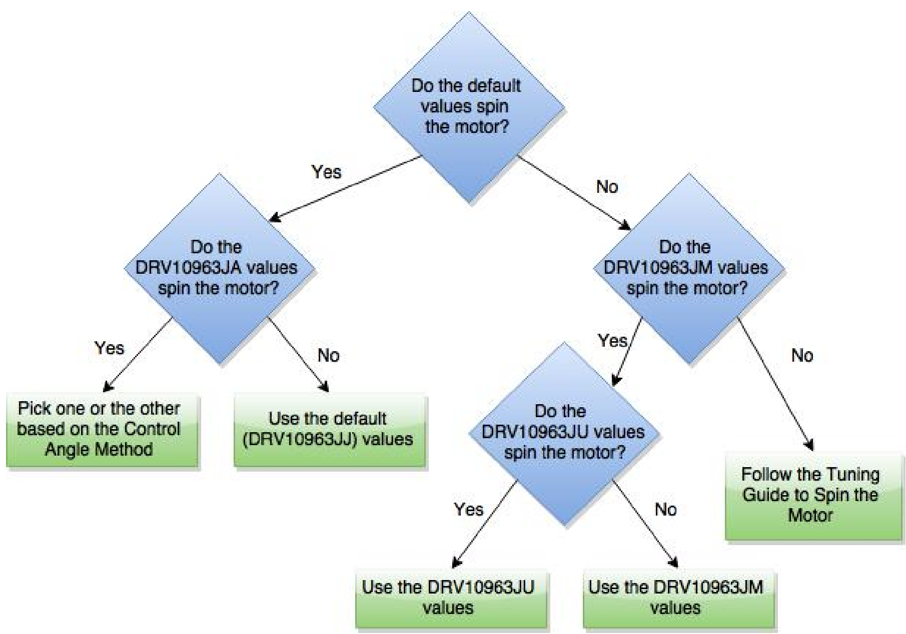

Figure 9. Initial Tuning Flow Chart

9. Even if one of the four factory-programmed settings do spin the motor, it may not be optimized for that motor. Using whichever DRV10963xx file as a starting point, then run through the tuning guide in Section 6 to create the best settings. However, for convenience it would be easier to just order a factory-programmed part. The "Control Advance Angle Method is described in Section 6.1.6.

6 Tuning Guide

If all four of the given factory-programmed settings have been tried (3 .txt files and the default values) and the motor still will not spin or you would like to further optimize your motor then you can try the following steps to custom tune the DRV10963 for your motor.

6.1 Configuring the Device

Leave the device connected to the motor and the computer. Next, make sure that the DRV10963EVM is powered up in test mode and the GUI is open. If an error message like the one in Figure 10 is returned, just close the GUI and reopen it and make sure that it reconnects to the device.

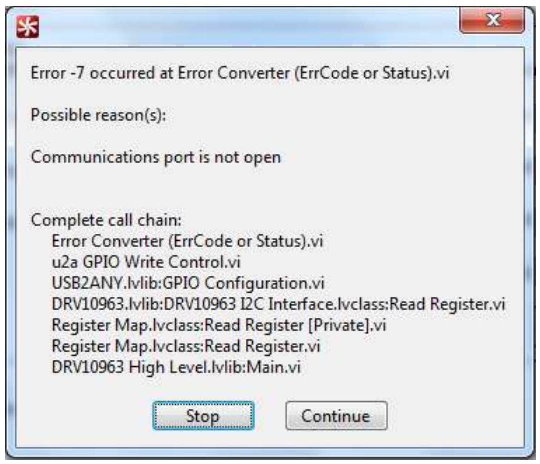

Figure 10. Error Message

Each one of the parameters that you can configure with the GUI will change how your motor reacts to the DRV10963 device. Read the description of each one of the parameters below and then choose if you would like to make the changes suggested. Be sure to connect a current probe to phase V to observe the phase current during tuning.

6.1.1 Start UP Align Time and Start Up Acceleration Rate

Start-up align time and acceleration rate determines how fast the motor can reach a particular set speed from standstill, so these values should be chosen to get the fastest possible start-up time. Note that too aggressive values of acceleration rate can cause higher inrush current in starting and may hit overcurrent protection, in which case the motor may not be able to start successfully. It is better to start with slower values and gradually increases to get the fastest possible start-up time based on the application. In the DRV10963 device, both the values are dependent on each other. They can only be configured as a dependent pair. The values tunable from the GUI of align time is in ms and acceleration rate is in Hz/sec.

Using the motor inertia from the motor parameters previously determined, estimate the align time. If you do not know, just input the highest possible align time which will correspond to the lowest possible acceleration rate. Then, after tuning the rest of the parameters is complete, come back to align time and step it down one-by-one until the fan will not spin. Then you know the best align time is the value just before the one where the fan stopped.

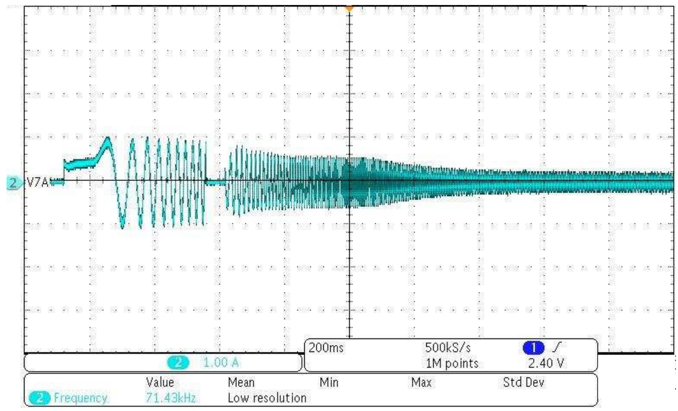

Figure 11. Correct Align Time and Acceleration Rate

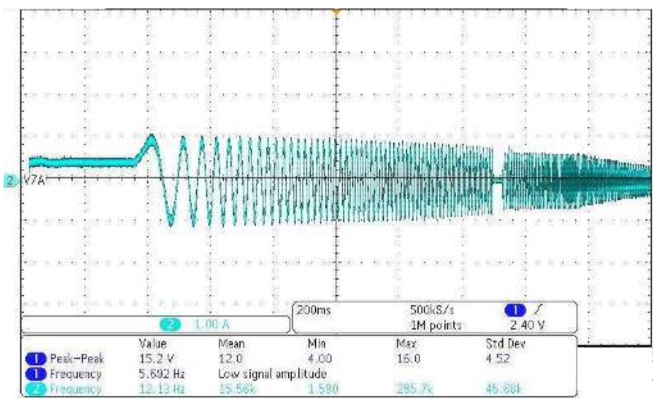

Figure 12. Align Time Too Long

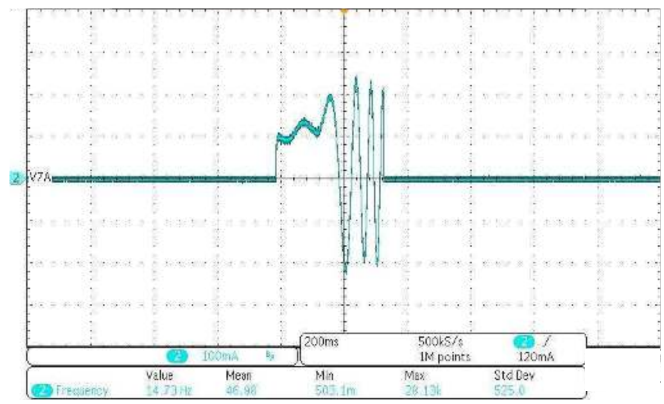

Figure 13. Align Time Too Short

6.1.2 Open to Close Loop Threshold

Open to close loop threshold determines the threshold frequency at which the controller goes from open-loop commutation to closed-loop, back-emf, zero-crossing-based commutation. For best performance to get stability during dynamic load/speed changing conditions and for maximum possible speed range, the motor should run in closed-loop commutation mode, therefore, the threshold frequency should be chosen as low as possible. However, too low values will cause an issue with sensor-less control because back-emf will not be sufficient to allow closed loop operation. Typically this threshold should be 10% to 25% of the speed desired to run the motor. The values tunable via GUI are in units of Hz. Normally, higher-speed motors (maximum speed) require a higher handoff threshold because higher speed motors have lower Kt, and as a result, lower BEMF.

In other words, if your desired RPM is 3000, then the open to close loop threshold should be 1/4 × (500 rpm) = 125 Hz. Therefore, the open to close loop threshold should be around 50≈125 Hz.

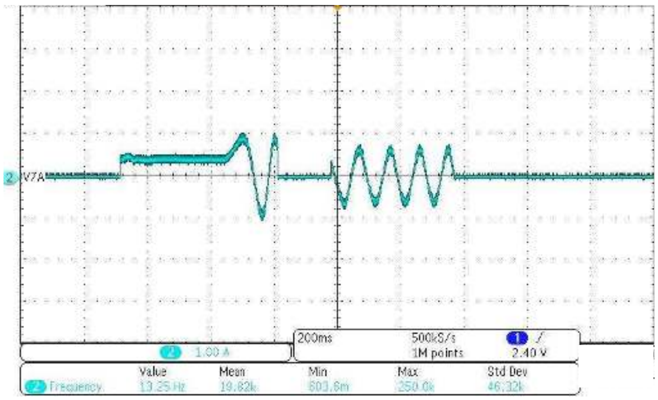

Figure 14. Open to Close Loop Threshold Too Low

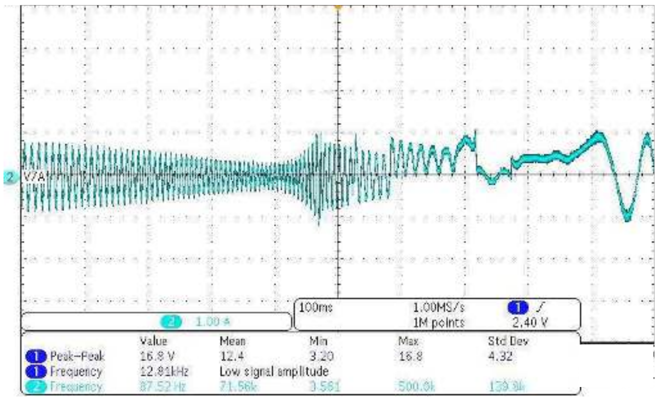

Figure 15. Open to Close Loop Threshold Too High

6.1.3 PWM Duty Cycle Cutoff

PWM duty cycle cutoff decides the minimum operating duty cycle; this can be chosen to meet minimum speed requirements. Refer to the DRV10963 datasheet for more information about the different minimum duty cycles.

6.1.4 FG Frequency Divider

The FG pin provides an indication of the speed of the motor. There are two options, 1 or 1/2 toggles FG once every 2 electrical cycles and 1 or 1/3, toggles FG once every 3 electrical cycles. This signal can be used to get the motor speed feedback information. In order to see this relationship off of the FG pin on the daughterboard, the device must be taken out of test mode by opening the jumper J1 on the motherboard, using the POT R-17 for speed control, and the FGS pin must be driven low. For more information about this, refer to the DRV10963 datasheet.

6.1.5 Software Current Limit

The software current limit function is only available in closed loop commutation mode. It works more like an active current or better as torque limit, and does not cause overcurrent trip. This value can tune to get a particular speed at a given motor loading condition. For example, increasing its value increases the motor-applied torque and thus the speed, however, ensure that the value is not exuberantly high to prevent motor heating. A lower value will prevent the motor from reaching a higher speed.

Start out at 0.125 A to make sure that your motor will spin and then slowly start to increase the current limit until it fails, then use the current limit right before.

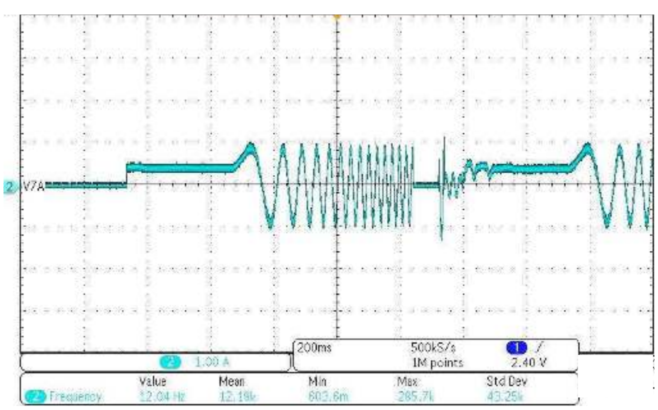

Figure 16. Current Limit Too High

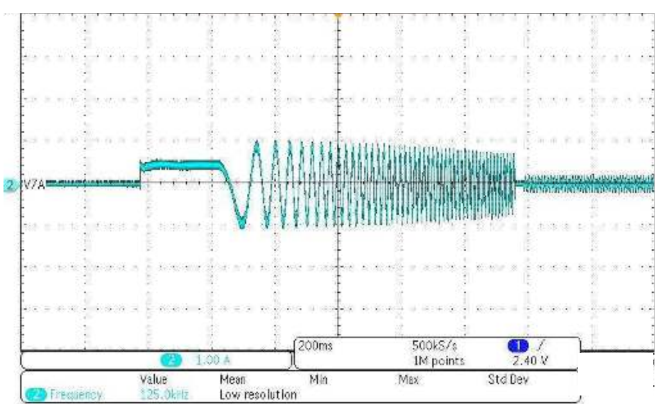

Figure 17. Current Limit Very Small

6.1.6 Control Advance Angle Method a.k.a Voltage Delay

Voltage delay represents lagging phase angle (in unit of time) of back-emf with respect to applied voltage. As explained in the datasheet, for efficient operation, applied voltage must lead the back-emf to force the motor-current in phase with back-emf for constant air-gap BLDC moor without saliency. For salient pole motors back-emf and phase current may have phase angle difference for efficient operation depending upon motor parameters. Both types of motor can be tuned efficiently via the GUI using voltage delay. In the GUI, zero delay setting forces the applied voltage in phase with back-emf and increasing its value, make the applied voltage to lead with respect to back-emf. To determine the optimized value, run the motor at rated speed as per end-application requirement and adjust the value to draw minimum current from the power supply.

1. Configure the motor using the Tuning Guide up to this point and make sure it can spin in closed loop control (after the current flat lines on startup and then keeps oscillating). Switch S2 to the PWM so it can receive a PWM signal. Have a current probe on one of the phases of the motor and a voltage probe on the FG pin of the daughterboard. Also make sure that the input voltage V_{IN} is run through a multimeter so that you can know the exact output current at all times.
2. Change the Voltage Delay to “No Delay” and click ‘Configure Parameters’.
3. Next, the device must be taken out of test mode. Disconnect the USB2ANY from the EVM board. Turn off the output of 6.2 V. Disconnect the J2 jumper from the motherboard.
4. Connect a function generator to the PWM in the pin located on the daughterboard. The function generator is outputting 50 kHz square wave at 5 V_{pp} with 2.5 V DC offset and in High Z. Using this signal, adjust the duty cycle to reach the RPM that is desired for your application. The RPM can be obtained using Equation 1. The frequency of the FG pin corresponds to the electrical frequency.

$$\text{RPM} = \frac{f_{\text{elec}}}{\#\ \text{of poles}} \times 60 \quad (1)$$

5. Take the current measure from the multimeter.
6. Once you have those taken down, turn off the output of the function generator and do the steps in reverse order to put the device back into test mode. Connect J2 and the USB2ANY and then turn on the 6.2-V supply.
7. Reopen the GUI, connect to the device and set the default register values like in the tuning guide. Next, configure all other values to what they were when the motor was spinning in closed loop.
8. Repeat Steps 2-7 several times changing the "Voltage Delay" each time to get a few reference points.
9. The "Voltage Delay" value that has the smallest current off of the multimeter is the current that is most in phase with the BEMF.

If you are deciding between the JA and the JJ models, just do Steps 4 and 5 for both parts and pick the one with the minimum current between the two.

6.2 Writing to the OTP Registers

Each time when writing to the OTP registers, always ensure:

Jumper J1 on motherboard remains:	Shorted to enable I^2C and configuration via GUI Open to enable motor spin after any configuration
Switch S2 on motherboard remains:	I2C-GUI to enable I^2C and configuration via GUI "Speed Control" mode to enable PWM to device

1. The EVM provides means to program the OTPs of a blank part. To enable OTP programming of any new blank device:
   - Disconnect the motor from EVM
   - Start with initial condition of jumpers/switches mentioned in Section 5.3 and follow-up power on EVM steps of Section 5.4.
2. As a first step to program the OTP, launch the GUI and left click "Set Default Register Value", that is, step 1. Load the custom configuration as shown in Figure 18 from the stored directory on your PC.

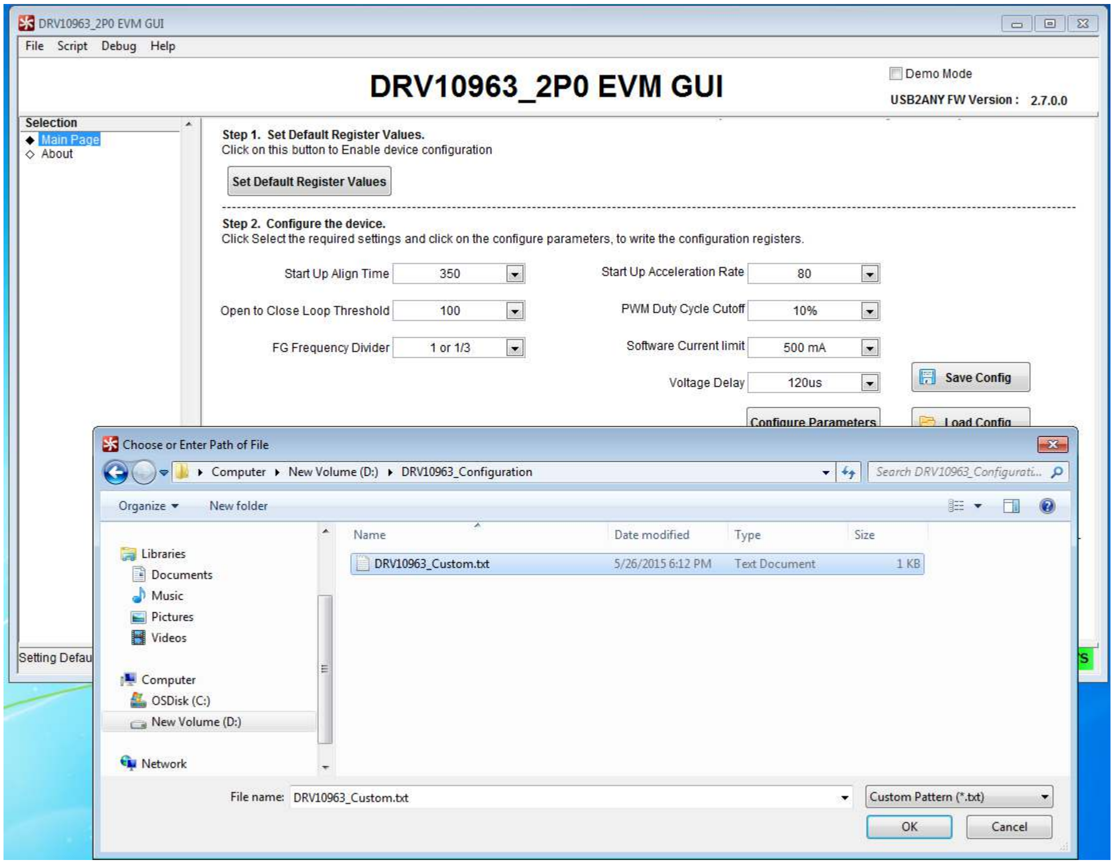

Figure 18. Load Custom Configurations to GUI

3. Increase the V_Testmode voltage level to 7.4 V and Vpower_in to 6.2 V. Now, left click “Write OTP Values” from the GUI. This will program the OTP bits of a blank device with user-configured values.

CAUTION

Never exceed Vpower_in beyond 6.5 V in any circumstances to prevent damaging the EVM.

4. In order to ensure that OTP are programmed properly, step 4 provides a means for read-back option. To enable read-back, first reduce the V_Testmode voltage level back to 6.2 V and Vpower_in to 5.0 V and left click “Read OTP Values”. If the GUI does not give any error message, it ensures the correct OTP programming. This means the device is ready to be used in stand-alone mode at the end-application circuit.
5. The final test to ensure proper OTP programming, power down both power supplies, disconnect the USB2ANY. Reconnect the motor to EVM and reapply 6.2 V and 5.0 V, don’t connect USB2ANY and open the jumper J1 on motherboard. The motor will start rotating confirming that the OTP are programmed and device is ready to use.

NOTE: The DRV10963 blank version is not available off-the-shelf for direct purchase, contact TI sales or distributors for further details if custom settings for production with a blank version is desired.

6.3 Reading the OTP Values

After writing the values from the shadow register to the OTP, complete step four on the GUI and read back the OTP values to make sure they are correct.

6.4 Notes

There are several issues that may occur when tuning the DRV1093 to your motor. The following sections details several common issues that could happen and how to fix them.

6.4.1 Hitting Current Limit

If the beginning of the current waveform looks like Figure 19, there might be a problem with the current limitation of the chip itself. If the align time is small, the current limit of the chip is reached and the chip turns itself off, waits for a set amount of time then tries again. If you see a waveform like the one below either add a 1-Ω resistor to each one of the 3 phases or lower the V_{IN} to around 4.8 V.

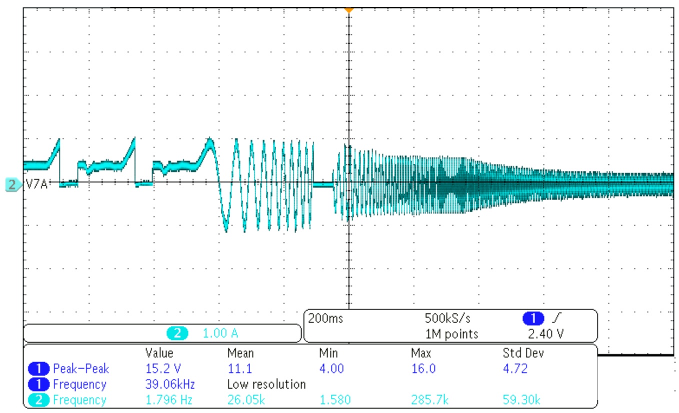

Figure 19. Motor Hitting Current Limit and Trying Again

6.4.2 Open to Close Loop Threshold High

Sometimes even though the motor will go into closed loop at a certain threshold does not mean that it is optimized. If the current waveform resembles the one shown in Figure 20 before it goes into closed loop (it goes into closed loop after the flat line in the middle where the GUI is measuring the BEMF) then it means that the Open to Closed Loop Threshold is high. This is an inefficient way to start up the motor because it is dangerously close to hitting a current limit and stopping the motor waiting and trying again. The optimized performance would be to make the current funnel down until it hits closed loop control.

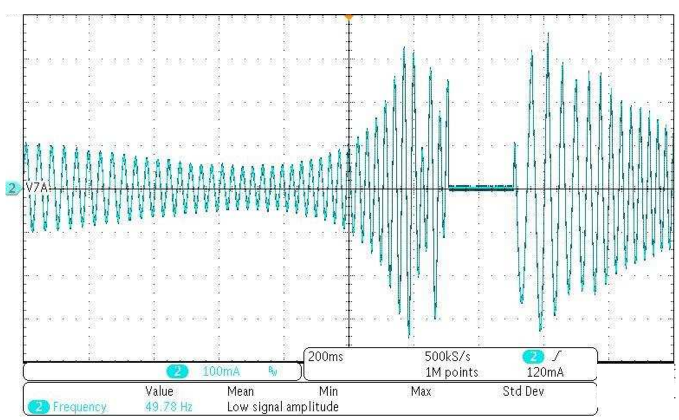

Figure 20. OTC Threshold not Optimized

6.4.3 Cannot Read Registers GUI Error

Sometimes when trying to "Set Default Register Values", the GUI will try to read the registers off of the device and cannot do so. The GUI will then throw this error message.

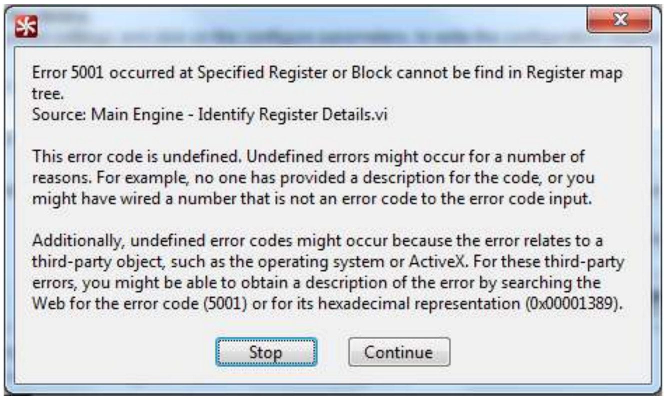

Figure 21. Register Error Message

Click continue and try again to "Set Default Register Values". It should work the second time, if all of the connections are correct from the Quick Start Guide in Section 5. If not, just power cycle the EVM and restart the GUI.

7 Schematic and Bill of Materials

This section contains the DRV10983 schematic and bill of materials (BOM).

7.1 Schematic

Figure 22 shows the DRV10963 motherboard schematic.

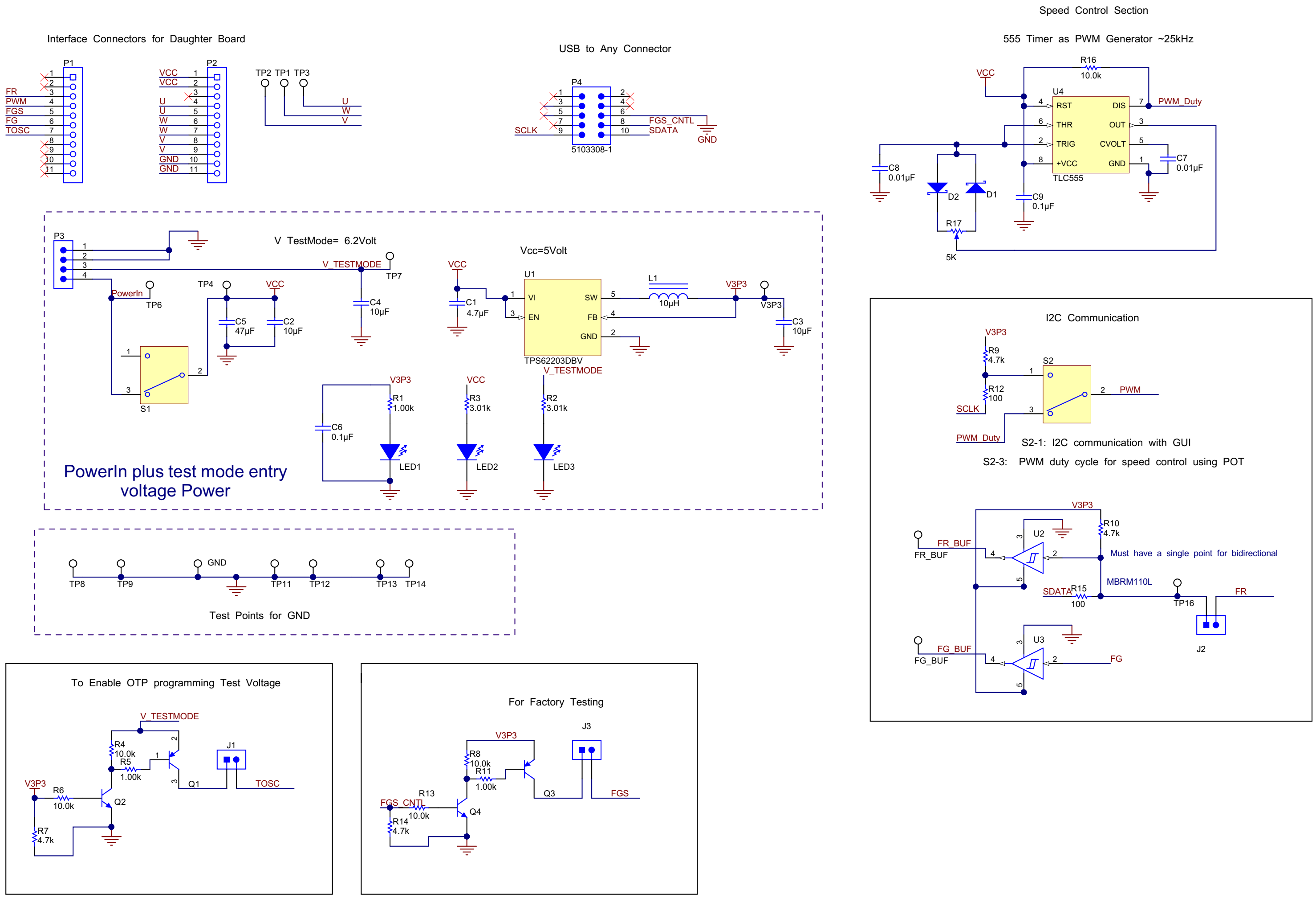

Figure 22. DRV10963 Motherboard Schematic

Figure 23 shows the DRV10963 daughterboard schematic.

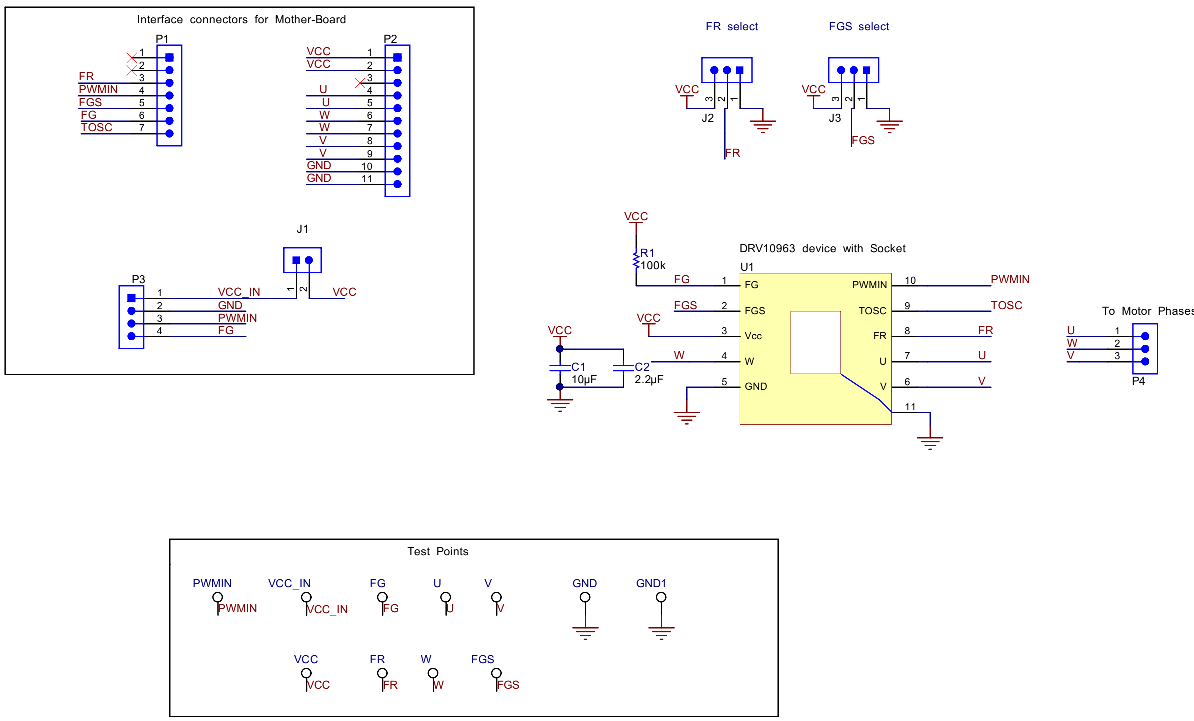

Figure 23. DRV10963 Daughterboard Schematic

7.2 Bill of Materials (BOM)

Table 5 lists the DRV10963 motherboard bill of materials.

Table 5. DRV10963 Motherboard Bill of Materials

Item #	Designator	Qty	Value	PartNumber	Manufacturer	Description	PackageReference
1	!PCB	1		MDBU001	Any	Printed Circuit Board	
2	C1	1	4.7uF	GRM21BR61C475KA88L	Murata	CAP, CERM, 4.7uF, 16V, +/-10%, X5R, 0805	0805
3	C2, C3, C4	3	10uF	GRM21BR61C106KE15L	Murata	CAP, CERM, 10uF, 16V, +/-10%, X5R, 0805	0805
4	C5	1	47uF	GRM32ER61C476KE15L	Murata	CAP, CERM, 47uF, 16V, +/-10%, X5R, 1210	1210
5	C6, C9	2	0.1uF	GRM155R71A104KA01D	Murata	CAP, CERM, 0.1uF, 10V, +/-10%, X7R, 0402	0402
6	C7, C8	2	0.01uF	C0805C103K1RACTU	Kemet	CAP, CERM, 0.01 µF, 100 V, +/- 10%, X7R, 0805	0805
7	D1, D2	2	40V	MSS1P4-M3/89A	Vishay-Siliconix	Diode, Schottky, 40 V, 1 A, MicroSMP	MicroSMP
8	FG_BUF, FR_BUF, GND, TP1, TP2, TP3, TP4, TP6, TP7, TP8, TP9, TP11, TP12, TP13, TP14, TP16, V3P3	17	SMT	5015	Keystone	Test Point, Miniature, SMT	Testpoint_Keystone_Miniature
9	FID1, FID2, FID3	3		N/A	N/A	Fiducial mark. There is nothing to buy or mount.	Fiducial
10	H1, H2, H3, H4	4		SJ-5303 (CLEAR)	3M	Bumpon, Hemisphere, 0.44 X 0.20, Clear	Transparent Bumpon
11	J1, J2, J3	3		PBC02SAAN	Sullins Connector Solutions	Header, 100mil, 2x1, Gold, TH	Sullins 100mil, 1x2, 230 mil above insulator
12	L1	1	10uH	CDRH5D18NP-100NC	Sumida	Inductor, Shielded Drum Core, Ferrite, 10uH, 1.2A, 0.124 ohm, SMD	CDRH5D18
13	LED1, LED2, LED3	3		LTST-C171GKT	Lite-On	LED, Green, SMD	LED_0805
14	P1, P2	2		BCS-111-L-S-PE	Samtec	Receptacle, 2.54mm, 11x1, Gold, TH	Receptacle, 2.54mm, 11x1, TH
15	P3	1		ED555/4DS	On-Shore Technology	Terminal Block, 6A, 3.5mm Pitch, 4-Pos, TH	14x8.2x6.5mm
16	P4	1		5103308-1	TE Connectivity	Header (shrouded), 100mil, 5x2, Gold, TH	5x2 Shrouded header
17	PCB2	1		Used in BOM report	Used in BOM report	Will add component to BOM. Useful for cables, nuts, etc. not in libraries	Used in PnP output and some BOM reports
18	Q1, Q3	2	0.25V	MMBT3906	Fairchild Semiconductor	Transistor, PNP, 40V, 0.2A, SOT-23	SOT-23
19	Q2, Q4	2	0.2V	MMBT3904	Fairchild Semiconductor	Transistor, NPN, 40V, 0.2A, SOT-23	SOT-23
20	R1, R5, R11	3	1.00k	CRCW06031K00FKEA	Vishay-Dale	RES, 1.00k ohm, 1%, 0.1W, 0603	0603
21	R2, R3	2	3.01k	CRCW06033K01FKEA	Vishay-Dale	RES, 3.01k ohm, 1%, 0.1W, 0603	0603
22	R4, R6, R8, R13	4	10.0k	CRCW060310K0FKEA	Vishay-Dale	RES, 10.0k ohm, 1%, 0.1W, 0603	0603
23	R7, R9, R10, R14	4	4.7k	CRCW06034K70JNEA	Vishay-Dale	RES, 4.7k ohm, 5%, 0.1W, 0603	0603
24	R12, R15	2	100	RC0603FR-07100RL	Yageo America	RES, 100 ohm, 1%, 0.1W, 0603	0603
25	R16	1	10.0k	CRCW080510K0FKEA	Vishay-Dale	RES, 10.0 k, 1%, 0.125 W, 0805	0805
26	R17	1	5K	296UD502B1N	CTS Electrocomponents	Trimmer, 5K Ohms, 0.15 W, TH	TH, 3-Leads, Body 12.5x12.8mm, Height 23.2mm
27	S1	1		100SP1T1B4M2QE	E-Switch	Switch, SPDT, On-On, 2 Pos, TH	12.7x6.86mm
28	S2	1		500SSP1S2M2QEA	E-Switch	Switch, SPDT, Slide, On-On, 2 Pos, TH	12.85x6.6mm

Table 5. DRV10963 Motherboard Bill of Materials (continued)

Item #	Designator	Qty	Value	PartNumber	Manufacturer	Description	PackageReference
29	SH-J1, SH-J2, SH-J3	3	1x2	SPC02SYAN	Sullins Connector Solutions	Shunt, 100mil, Flash Gold, Black	Closed Top 100mil Shunt
30	U1	1		TPS62203DBVR	Texas Instruments	HIGH-EFFICIENCY, STEP-DOWN, DC-DC CONVERTER, DBV0005A	DBV0005A
31	U2, U3	2		SN74LVC1G17DCKR	Texas Instruments	SINGLE SCHMITT-TRIGGER BUFFER, DCK0005A	DCK0005A
32	U4	1		TLC555CDR	Texas Instruments	Timer, 8-pin Narrow SOIC	M08A

Table 6 lists the DRV10963 daughterboard bill of materials.

Table 6. DRV10963 Daughterboard Bill of Materials

Item #	Designator	Qty	Value	PartNumber	Manufacturer	Description	PackageReference
1	!PCB	1		MDBU002	Any	Printed Circuit Board	
2	C1	1	10uF	GRM21BR61C106KE15L	Murata	CAP, CERM, 10uF, 16V, +/-10%, X5R, 0805	0805
3	C2	1	2.2uF	GRM188R61C225KE15D	Murata	CAP, CERM, 2.2uF, 16V, +/-10%, X5R, 0603	0603
4	FG, FGS, FR, GND, GND1, PWMIN, U, V, VCC, VCC_IN, W	11	SMT	5015	Keystone	Test Point, Miniature, SMT	Testpoint_Keystone_Miniature
5	FID1, FID2, FID3, FID4, FID5, FID6	6		N/A	N/A	Fiducial mark. There is nothing to buy or mount.	Fiducial
6	J1	1		PBC02SAAN	Sullins Connector Solutions	Header, 100mil, 2x1, Gold, TH	Sullins 100mil, 1x2, 230 mil above insulator
7	J2, J3	2		PEC03SAAN	Sullins Connector Solutions	Header, 100mil, 3x1, Tin, TH	Header, 3 PIN, 100mil, Tin
8	P1	1		PBC07SAAN	Sullins Connector Solutions	Header, 2.54 mm, 7x1, Gold, TH	Header, 2.54 mm, 7x1, TH
9	P2	1		PBC11SAAN	Sullins Connector Solutions	Header, 2.54 mm, 11x1, Gold, TH	Header, 2.54 mm, 11x1, TH
10	P3	1		PBC04SAAN	Sullins Connector Solutions	Header, 2.54 mm, 4x1, Gold, TH	Header, 2.54 mm, 4x1, TH
11	P4	1	1x3	PBC03SAAN	Sullins Connector Solutions	Header, 100mil, 3x1, Gold, TH	PBC03SAAN
12	R1	1	100k	RC0603FR-07100KL	Yageo America	RES, 100k ohm, 1%, 0.1W, 0603	0603
13	SH-J1, SH-J2, SH-J3	3	1x2	SPC02SYAN	Sullins Connector Solutions	Shunt, 100mil, Flash Gold, Black	Closed Top 100mil Shunt
14	U1	1		QFN-10(20)B-0.5-02	Enplas Tech Solutions	Socket, QFN-10, 0.5mm pitch, TH	Socket, QFN-10, 0.5mm Pitch

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   CAUTION

   This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

   Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

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FCC Interference Statement for Class B EVM devices

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- *Reorient or relocate the receiving antenna.*
- *Increase the separation between the equipment and receiver.*
- *Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.*
- *Consult the dealer or an experienced radio/TV technician for help.*

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This device complies with Industry Canada license-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

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Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Concerning EVMs Including Detachable Antennas:

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication. This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Concernant les EVMs avec antennes détachables

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante. Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d’usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur

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2. Use EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or
3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

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