TI Designs 00143 Automotive 60W Brushless DC Motor Drive

Abstract

This design implements a complete control and drive solution for 3-phase brushless DC motors up to about 90 Watts in power rating. The design includes analog circuits, digital processor, and software to spin BLDC motors without the need for position feedback from Hall effect sensors or quadrature encoder.

Equipment needed:

SAT0042 E4 Motor Drive board
3-phase Brushless DC (BLDC) motor
InstaSPIN-FOC software – InstaSPIN FOC Example GUI
Code Composer Studio V5.4
DC Power Supply
Coupling, cable, PC

Operational set-up

Power Connections

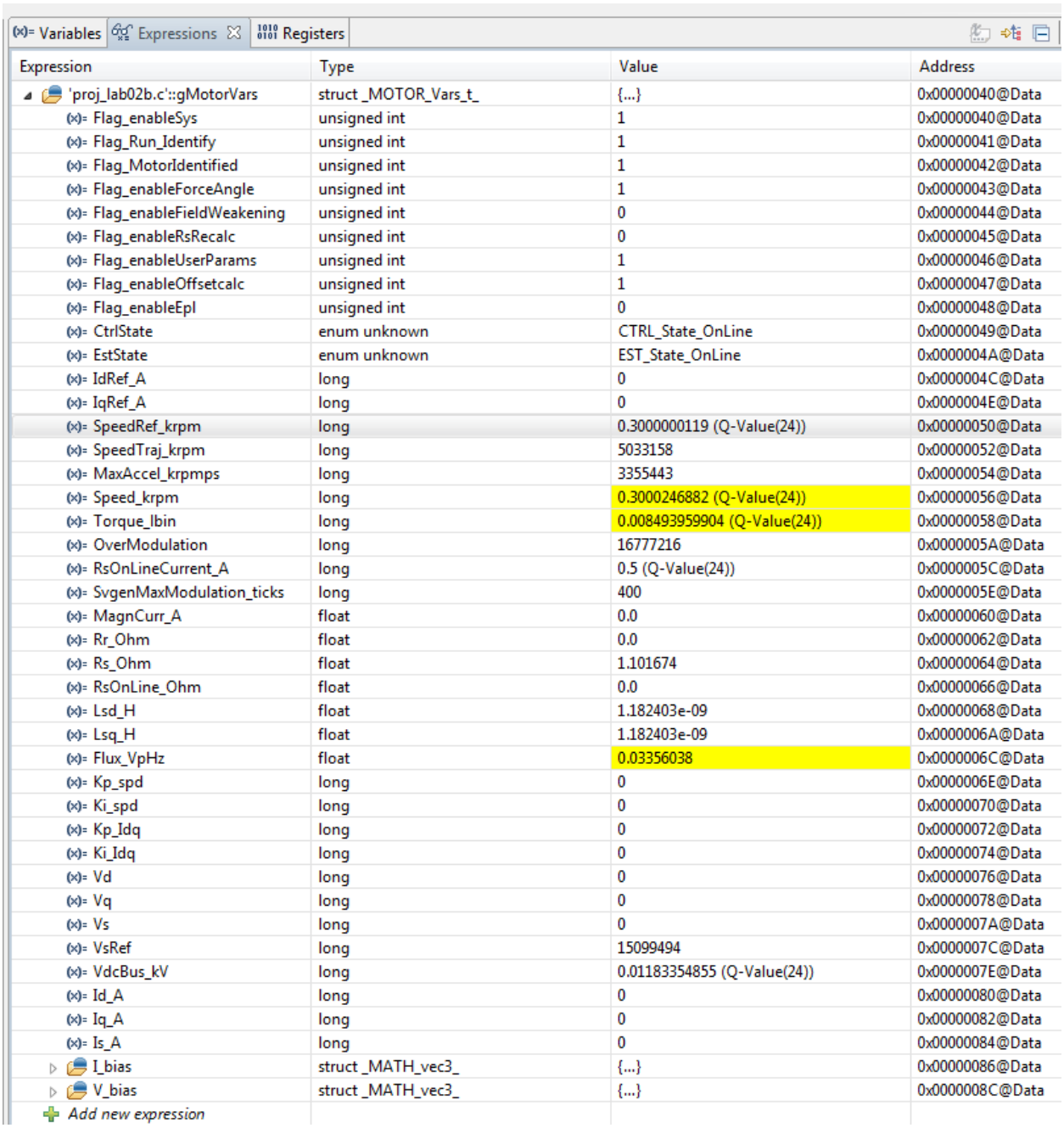
The board is capable of operation up to 7.5A Amps at 12V. Connect a suitable DC power supply to connector J1. When 12V power is applied, the green LED should illuminate on the board.

Motor to EVM board connections

Connect the 3 motor phases to connector J3. Note that the motor will operate with any assignment of the three motor phases to the three drive outputs on the board. There are 3 equivalent arrangements (A-B-C, B-C-A, C-A-B) which will cause clockwise motion, and 3 equivalent arrangements (C-B-A, B-A-C, A-C-B) which will cause counterclockwise motion. Either arrangement is valid as long as the user is satisfied with the polarity convention. If the user wishes to reverse the rotation for a given command, any two phases can be swapped.

Code Composer Studio

Code Composer Studio (CCS) is executed from the Start Programs menu, or from the desktop icon. Following the procedure indicated in the MotorWare labs, import the example project lab02b. Configure the target to TMS320F28027. Build the project, and start a Debug session.



Variables | Expressions | Registers

Expression	Type	Value	Address
'proj_lab02b.c'::gMotorVars	struct _MOTOR_Vars_t_	{...}	0x00000040@Data
Flag_enableSys	unsigned int	1	0x00000040@Data
Flag_Run_Identify	unsigned int	1	0x00000041@Data
Flag_MotorIdentified	unsigned int	1	0x00000042@Data
Flag_enableForceAngle	unsigned int	1	0x00000043@Data
Flag_enableFieldWeakening	unsigned int	0	0x00000044@Data
Flag_enableRsRecalc	unsigned int	0	0x00000045@Data
Flag_enableUserParams	unsigned int	1	0x00000046@Data
Flag_enableOffsetcalc	unsigned int	1	0x00000047@Data
Flag_enableEpl	unsigned int	0	0x00000048@Data
CtrlState	enum unknown	CTRL_State_OnLine	0x00000049@Data
EstState	enum unknown	EST_State_OnLine	0x0000004A@Data
IdRef_A	long	0	0x0000004C@Data
IqRef_A	long	0	0x0000004E@Data
SpeedRef_krpm	long	0.3000000119 (Q-Value(24))	0x00000050@Data
SpeedTraj_krpm	long	5033158	0x00000052@Data
MaxAccel_krpmps	long	3355443	0x00000054@Data
Speed_krpm	long	0.3000246882 (Q-Value(24))	0x00000056@Data
Torque_Ibin	long	0.008493959904 (Q-Value(24))	0x00000058@Data
OverModulation	long	16777216	0x0000005A@Data
RsOnLineCurrent_A	long	0.5 (Q-Value(24))	0x0000005C@Data
SvgenMaxModulation_ticks	long	400	0x0000005E@Data
MagnCurr_A	float	0.0	0x00000060@Data
Rr_Ohm	float	0.0	0x00000062@Data
Rs_Ohm	float	1.101674	0x00000064@Data
RsOnLine_Ohm	float	0.0	0x00000066@Data
Lsd_H	float	1.182403e-09	0x00000068@Data
Lsq_H	float	1.182403e-09	0x0000006A@Data
Flux_VpHz	float	0.03356038	0x0000006C@Data
Kp_spd	long	0	0x0000006E@Data
Ki_spd	long	0	0x00000070@Data
Kp_Idq	long	0	0x00000072@Data
Ki_Idq	long	0	0x00000074@Data
Vd	long	0	0x00000076@Data
Vq	long	0	0x00000078@Data
Vs	long	0	0x0000007A@Data
VsRef	long	15099494	0x0000007C@Data
VdcBus_kV	long	0.01183354855 (Q-Value(24))	0x0000007E@Data
Id_A	long	0	0x00000080@Data
Iq_A	long	0	0x00000082@Data
Is_A	long	0	0x00000084@Data
I_bias	struct _MATH_vec3_	{...}	0x00000086@Data
V_bias	struct _MATH_vec3_	{...}	0x0000008C@Data
Add new expression			

User Interface for Motor Variables to control BLDC

First set the Flag_enableSys value to 1.

Set the Flag_Run_Identify value to 1. The system will begin to excite the motor to determine the characteristics. This process will take a few minutes. When it is complete, the Flag_MotorIdentified will change from 0 to 1, and the Flag_Run_Identify will reset to a 0 value, and the motor will be idle.

At this point you can again set the Flag_Run_Identify to 1 to enable the motor drive, and change the SpeedRef_krpm value as desired to control the motor speed.

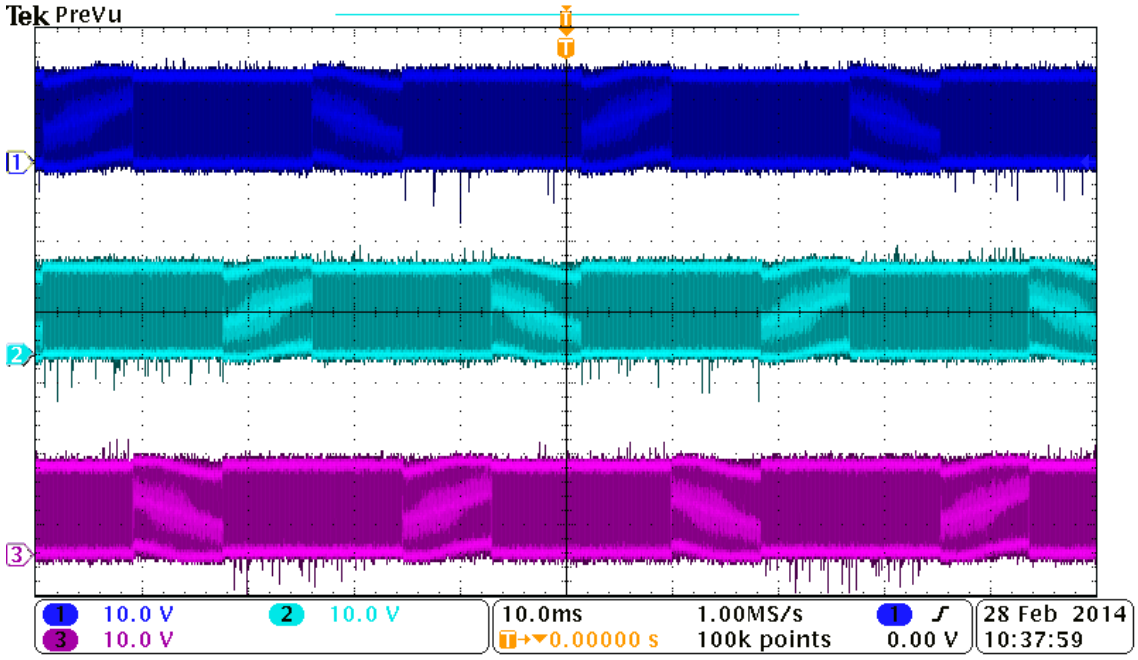


Figure 1 Motor phase voltages (A,B,C) during operation

Figure 1 shows the motor voltages as oscilloscope traces as the motor rotates. Channel 1 is measuring output A, channel 2 is measuring output B, and channel 3 is measuring output C. Note that the traces do not show the details of the pulse-width modulated (PWM) outputs, but the general characteristics of the waveforms can be seen.

IMPORTANT NOTICE FOR TI REFERENCE DESIGNS

Texas Instruments Incorporated ("TI") reference designs are solely intended to assist designers (“Buyers”) who are developing systems that incorporate TI semiconductor products (also referred to herein as “components”). Buyer understands and agrees that Buyer remains responsible for using its independent analysis, evaluation and judgment in designing Buyer’s systems and products.

TI reference designs have been created using standard laboratory conditions and engineering practices. **TI has not conducted any testing other than that specifically described in the published documentation for a particular reference design.** TI may make corrections, enhancements, improvements and other changes to its reference designs.

Buyers are authorized to use TI reference designs with the TI component(s) identified in each particular reference design and to modify the reference design in the development of their end products. HOWEVER, NO OTHER LICENSE, EXPRESS OR IMPLIED, BY ESTOPPEL OR OTHERWISE TO ANY OTHER TI INTELLECTUAL PROPERTY RIGHT, AND NO LICENSE TO ANY THIRD PARTY TECHNOLOGY OR INTELLECTUAL PROPERTY RIGHT, IS GRANTED HEREIN, including but not limited to any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license to use such products or services, or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

TI REFERENCE DESIGNS ARE PROVIDED "AS IS". TI MAKES NO WARRANTIES OR REPRESENTATIONS WITH REGARD TO THE REFERENCE DESIGNS OR USE OF THE REFERENCE DESIGNS, EXPRESS, IMPLIED OR STATUTORY, INCLUDING ACCURACY OR COMPLETENESS. TI DISCLAIMS ANY WARRANTY OF TITLE AND ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, QUIET ENJOYMENT, QUIET POSSESSION, AND NON-INFRINGEMENT OF ANY THIRD PARTY INTELLECTUAL PROPERTY RIGHTS WITH REGARD TO TI REFERENCE DESIGNS OR USE THEREOF. TI SHALL NOT BE LIABLE FOR AND SHALL NOT DEFEND OR INDEMNIFY BUYERS AGAINST ANY THIRD PARTY INFRINGEMENT CLAIM THAT RELATES TO OR IS BASED ON A COMBINATION OF COMPONENTS PROVIDED IN A TI REFERENCE DESIGN. IN NO EVENT SHALL TI BE LIABLE FOR ANY ACTUAL, SPECIAL, INCIDENTAL, CONSEQUENTIAL OR INDIRECT DAMAGES, HOWEVER CAUSED, ON ANY THEORY OF LIABILITY AND WHETHER OR NOT TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES, ARISING IN ANY WAY OUT OF TI REFERENCE DESIGNS OR BUYER’S USE OF TI REFERENCE DESIGNS.

TI reserves the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products are sold subject to TI’s terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI’s terms and conditions of sale of semiconductor products. Testing and other quality control techniques for TI components are used to the extent TI deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

TI assumes no liability for applications assistance or the design of Buyers’ products. Buyers are responsible for their products and applications using TI components. To minimize the risks associated with Buyers’ products and applications, Buyers should provide adequate design and operating safeguards.

Reproduction of significant portions of TI information in TI data books, data sheets or reference designs is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards that anticipate dangerous failures, monitor failures and their consequences, lessen the likelihood of dangerous failures and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in Buyer’s safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI’s goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed an agreement specifically governing such use.

Only those TI components that TI has specifically designated as military grade or “enhanced plastic” are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components that have ***not*** been so designated is solely at Buyer's risk, and Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265