User's Guide
SLMU002–June 2011

DRV882x Evaluation Modules

This user guide is provided as a supplement to the DRV8828 and DRV8829 product data sheets. It details the hardware implementation of the CPG006_DRV882xEVM Customer Evaluation Module (EVM). This EVM is an evaluation board for the DRV8828 and DRV8829 motor controller devices.

This document covers the operation of the DRV8828EVM and the DRV8829EVM, collectively identified as *DRV882xEVM*. The EVM contains both a pair of DRV882x devices and a customer programming board (CPG006). Throughout this document, the abbreviations *CPG006*, *EVM*, and the term *evaluation module* are synonymous with the CPG006_DRV882xEVM. Unless otherwise indicated, all references to device operation apply to both devices.

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1 Introduction

The CPG006_DRV882xEVM is an evaluation platform populated with two DRV8828PWP or two DRV8829PWP single H-Bridge power stage controllers. These devices have been optimized to drive bipolar stepper motors; therefore, two devices are required.

The CPG006 also contains an MSP430 microcontroller and an USB interface chip. The USB chip allows for serial communications from a personal computer where a Microsoft® Windows®-based application is used to schedule serial commands. These commands can be used to control each signal of the devices individually, or to control both devices at the same time to drive a stepper motor.

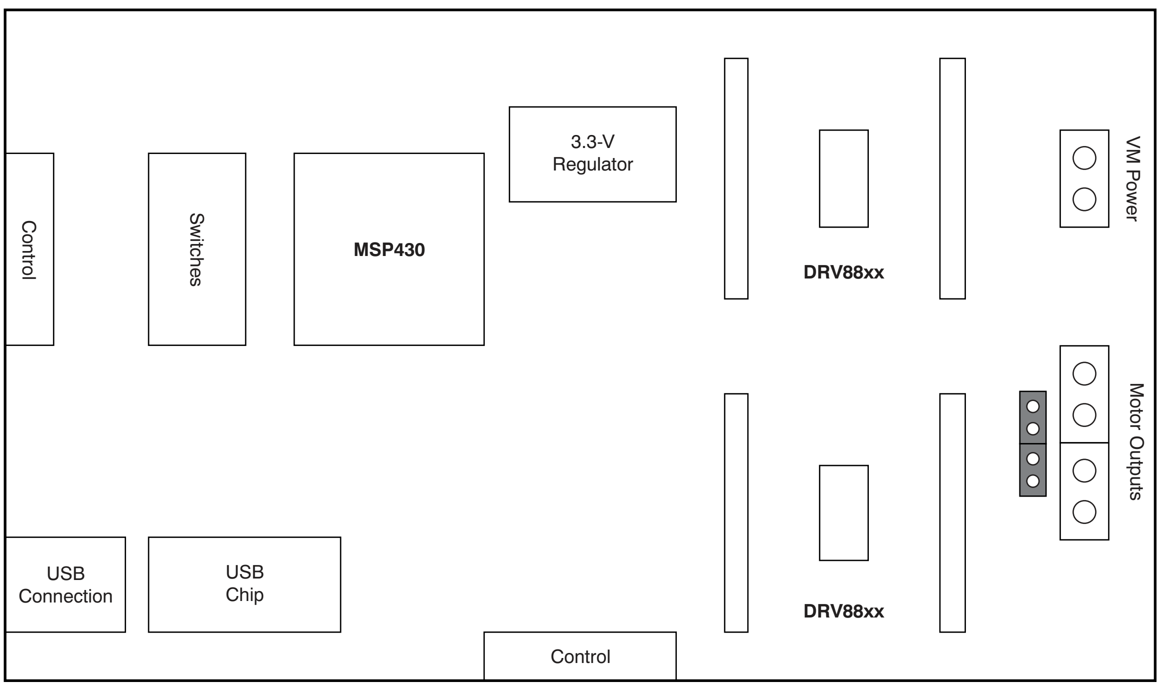
The microcontroller firmware operates in one of three modes. First, the microcontroller can be bypassed completely (that is, all GPIOs are 3-stated), in which case the user can connect his own application through the header connectors that provide access to each device control signal. The second operating mode configures the microcontroller as an STEP/DIRECTION interface and allows the user to drive a motor with up to 512 degrees of microstepping through STEP pulses and DIRECTION information.

The third operating mode allows full control of numerous functions through the computer and via the serial interface.

This user guide describes EVM operation in each of the three modes, as well as the hardware configurability of the CPG006 evaluation module itself.

2 Block Diagram

Figure 1 illustrates a block diagram of the DRV882xEVM.



NOTE: ***DRV882x*** indicates either the DRV8828 or the DRV8829 device.

Figure 1. DRV882xEVM Block Diagram

2.1 Power Connectors

The CPG006 offers access to the motor voltage (VM) power rail via terminal block J4. A set of test clips in parallel with the terminal block allows for the monitoring of the input power rail.

The user must apply VM power according to the recommended product data sheet parameters. For the DRV8828, the product data sheet is literature number SLVSA11. For the DRV8829, the product data sheet is SLVSA74. Both documents are available for download through the TI website (www.ti.com).

NOTE: VDD for logic and microcontroller supply is derived from an onboard 3.3-V regulator stepped down from the VM input voltage.

2.2 Test Stakes

Header connectors (100-mil, or 0.2,54-mm, pitch) provide access to all device signals. Both U2 and U3 have an identical structure; the respective header connectors follow the device pinout pattern, as shown in Figure 2.

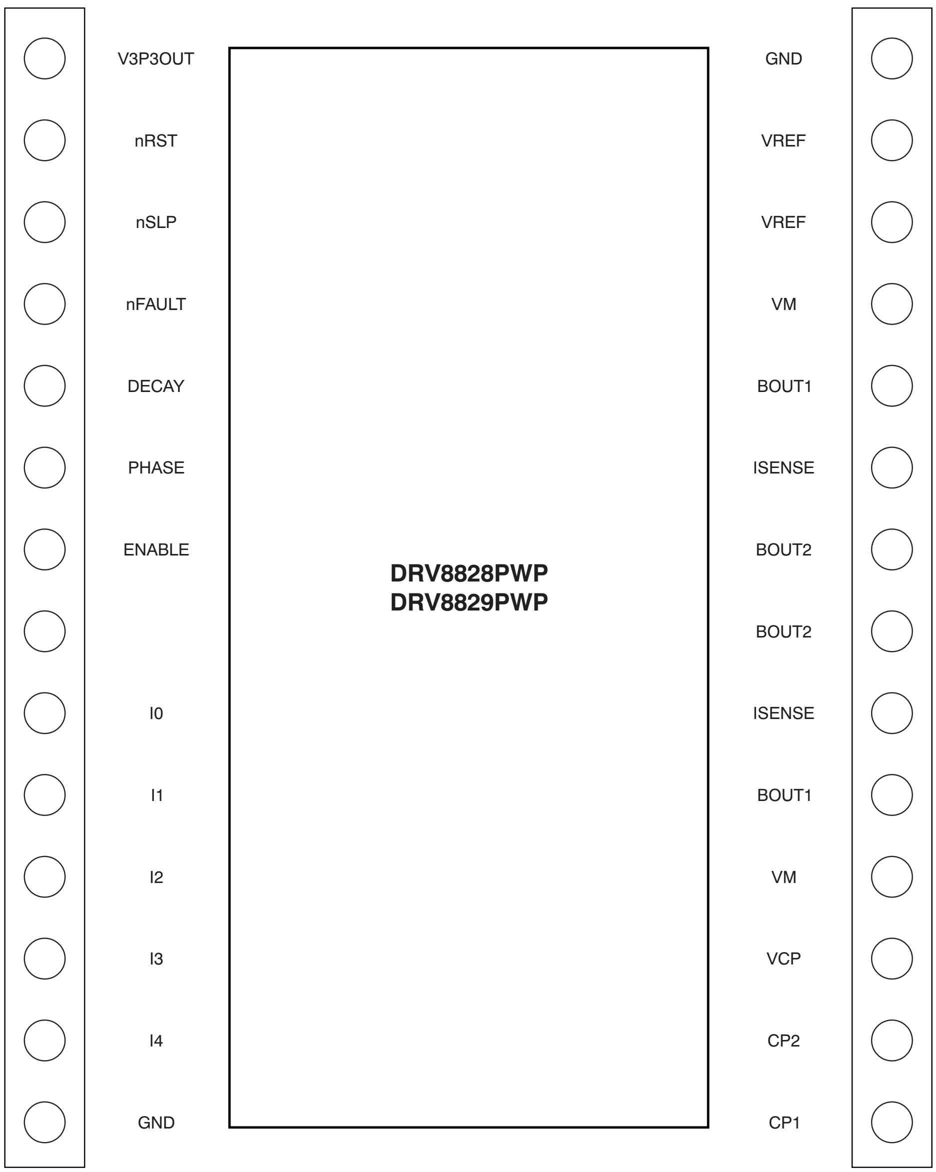


Figure 2. DRV882xEVM Pin Configuration

2.3 Jumpers

This EVM has no jumpers that must be configured by the user.

2.4 Switches

Switch S1 offers EVM configurability by moving each individual switch, as listed in Table 1.

Table 1. Switch S1 Configurations

Switch Position	Signal Name	HI	LO
1	USM0	Select Degrees of Microstepping (only available on Indexer Mode)	
2	USM1		
3	USM2		
4	Not Used	Not Used	
5	nRESET	DRV882x nRESET Pin (Reset Mode when LO)	
6	nSLEEP	DRV882x nSLEEP Pin (Sleep Mode when LO)	
7	MCU MODE	MCU Operational	MCU Hi-Z
8	SER MODE	Indexer Mode	Serial Mode

The USMx bits are only available when the board is configured as an internal indexer (S1:8 = HI). In this mode, the USMx bits select the microstepping rate according to Table 2.

Table 2. Microstepping Rate

USM2	USM1	USM2	MS Index	Microstepping Degrees
LO	LO	LO	0	512
LO	LO	HI	1	256
LO	HI	LO	2	128
LO	HI	HI	3	64
HI	LO	LO	4	32
HI	LO	HI	5	16
HI	HI	LO	6	8
HI	HI	HI	7	4

Changes made to the USMx, nRESET, and nSLEEP switches take effect immediately. Changes on the MCU_MODE or SER_MODE only take effect after a reset is issued. To reset the microcontroller, press the S2 switch or cycle the VM power rail.

2.5 Internal Indexer Mode Connectors

When operating in internal indexer mode (SER_MODE = HI or S1:8 = HI), the user must supply control signals through the J10 header connector. A second set of control signals are derived from the J11 connector, although these signals can be preselected through the S1 DIP switch. If the J11 connector is used, the respective switches should be positioned at the HI side so that inputs can be driven. If the switches are positioned at the LO side, input to the microcontroller will be LO.

[Figure 3](#) shows the two connectors and the respective signals for each.

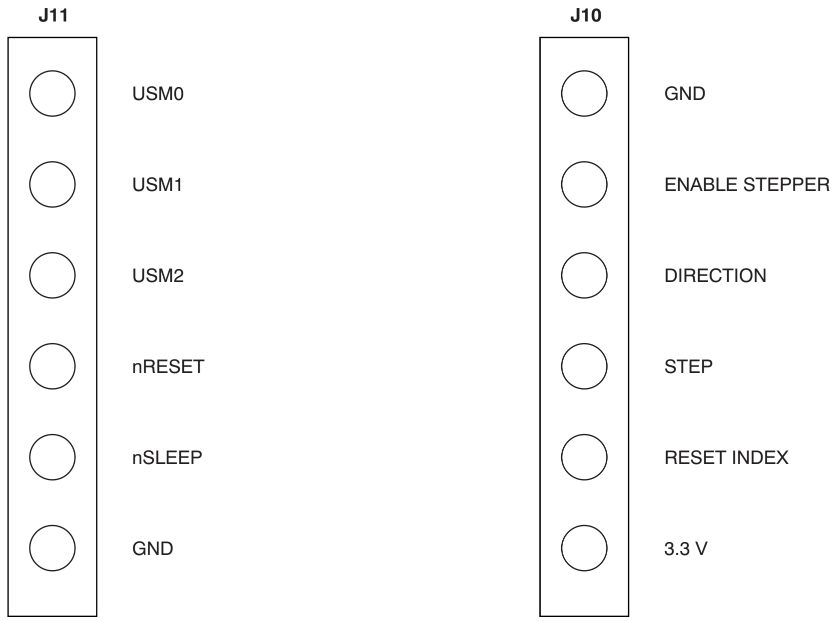


Figure 3. Connectors

USMx: Refer to Table 1 and Table 2 for details on operation.

nRESET: Same as nRESET on the DRV882x device. A LO on this signal places the device into reset with the H Bridges 3-stated. Refer to the respective device data sheet for further information about the nRESET signal.

nSLEEP: Same as nSLEEP on the DRV882x device. A LO on this signal places the device into low-power mode with the H Bridges 3-tated and all logic disabled. Refer to the respective device data sheet for further information about the nSLEEP signal.

ENABLE STEPPER: A transition from LO to HI commands the microcontroller to enable both DRV882x devices by asserting the respective ENABLE line for each device. A transition from HI to LO commands the microcontroller to disable both DRV882x devices by de-asserting the respective ENABLE line for each device.

DIRECTION: A transition from LO to HI commands the microcontroller to generate microsteps such that direction of rotation is in the clockwise (or forward) direction. A transition from HI to LO commands the microcontroller to generate microsteps such that direction of rotation is in the counter-clockwise (or reverse) direction. Note that stepper rotation is relative to the direction in which the motor is looked at (that is, from the front or the back of the motor), but also depends on how the motor was wired into the EVM. Reversing the motor leads often reverses the motor rotation direction.

STEP: A transition from LO to HI commands the microcontroller to generate the next step or microstep.

RESET_INDEX: A transition from LO to HI commands the microcontroller to enter the internal indexer reset. During reset, the DRV882x devices are disabled (ENABLE is LO). A transition from HI to LO commands the microcontroller to exit the internal indexer reset. At this point, the internal indexer index is set to zero, which is the same as angle 0 on the PHASE A sine wave output.

2.6 Potentiometer R19

The microcontroller digital-to-analog converter (DAC) outputs are referenced from an external reference voltage that is derived from the internal 2.5-V reference voltage. A potentiometer (R19) is provided to scale the analog reference voltage to be used by the DAC12 module.

This voltage scaling offers a direct means to scale the microstepping current magnitude from 0 A to a 5-A sine wave peak, depending on the EVM module. The CPG006-001 contains a pair of DRV8828 devices and uses 200-mΩ SENSE resistors. The resulting programmable current ITRIP ranges from 0 A to 2.5 A. CPG006-002 contains a pair of DRV8829 devices and uses 100-mΩ SENSE resistors. The resulting programmable current ITRIP ranges from 0 A to 5 A.

2.7 Motor Outputs

There are two ways to connect the stepper motor into the CPG006: through a four-pin header (J7) or a four-position terminal block (J6).

3 Installing Drivers and Software

3.1 Installing the FTDI™ USB Driver

The USB driver can be easily installed on any PC with a Windows-based operating system (such as Windows XP, Windows Vista, or Windows 7) by double-clicking the *CDM20814_Setup.exe* file. This file is available for download from the FTDI website. The USB peripheral is the installed as a virtual COM port (PCO). The Windows-based applications then enumerate all available COM ports during installation and startup. At power-up, the applications attempt to communicate with the module. Once communications have been successfully established, the EVM is ready for operation.

3.2 Installing the CPG006_DRV882x Evaluation Board Windows-Based Application Software

Install the graphical user interface (GUI) software application by executing the *Setup.exe* file found in the CPG006_DRV88xx folder. This application software is also included on the CD image available for download from the CPG006 product folder.

3.3 Running the Windows Application Software

Start the application by clicking *Start→Programs* and then selecting the Texas Instruments, Inc folder.

4 UART Mode

The CPG006_DRV882xEVM application is the software counterpart for the CPG006_DRV882x EVM when the CPG006 is configured to operate in serial communications mode (nUART= LO or S1:8 = LO).It allows the PC to connect to the MSP430F2617 microcontroller though the onboard USB interface chip. Once the connection is established and commands are sent, the microcontroller configures the control signals and administers certain levels of automation, such as microstepping coordination, stepping rate acceleration and deceleration, ITrip configuration, and so forth.

The GUI has been designed to allow testing all of the DRV882x device functionality without having to configure with the hardware, except for adjusting the DAC reference voltage potentiometer (R19).

Figure 4 shows the CPG006_DRV88xxEVM GUI software startup screen.

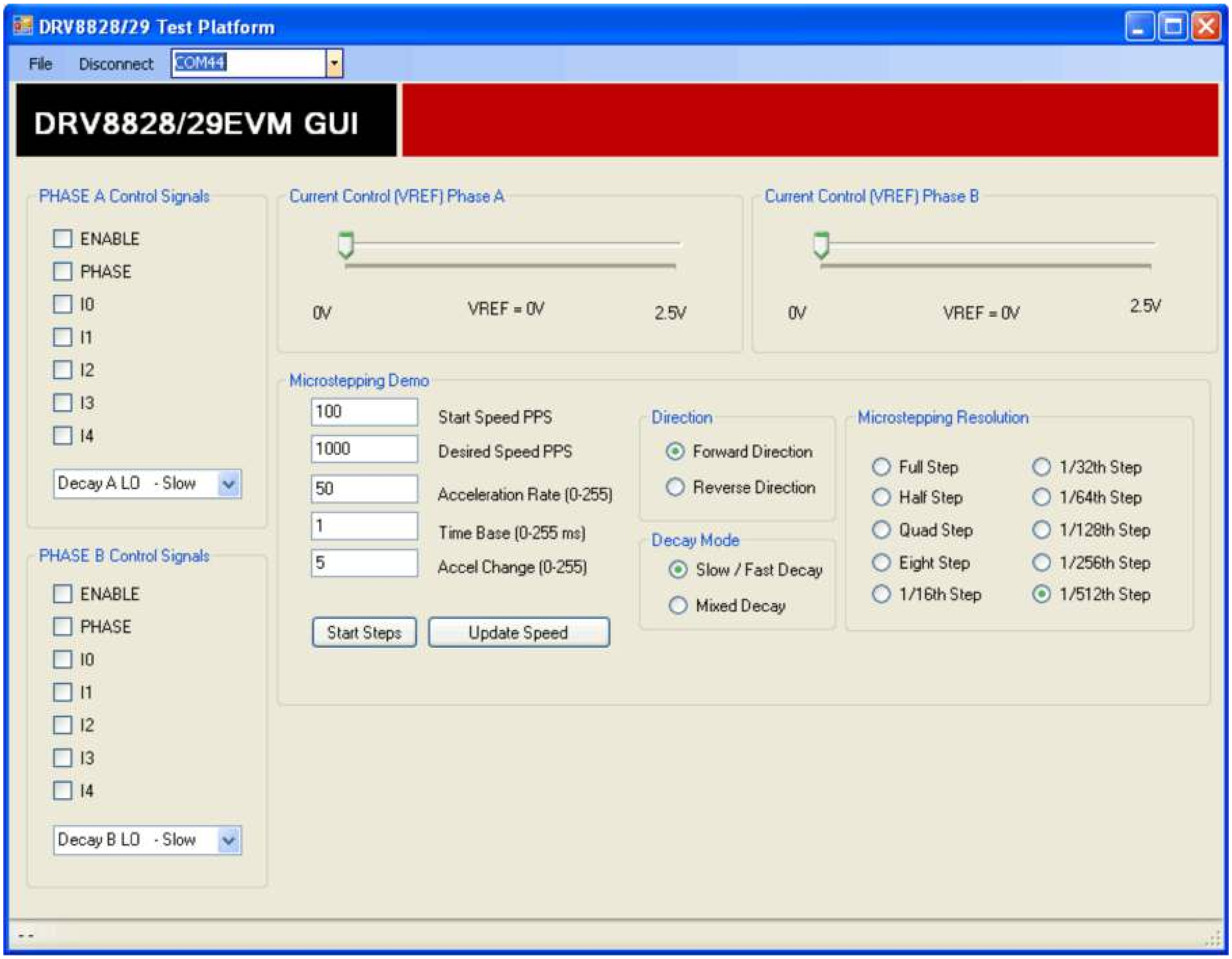


Figure 4. DRV882xEVM Software GUI: Startup Window

All the control signals required to control the motor enablement (ENABLE or INx), the direction of rotation (PHASE or the respective combination of the INx pins), current control (through VREF) and PWM control for both enablement and direction control signals are available.

Access to the DAC responsible for generating the VREF analog voltage is achieved by moving a simple slider (see Figure 6). A label offers information on what this reference voltage should be, on a scale ranging from 0 V to 2.5 V.

4.1 Menu

The menu at the top of the GUI application offers a series of options for how the COM port should behave:

- **File:**
  - Exit: Terminates the application
- **Connect:**
  - Opens the serial port. When this menu item is pressed, its caption changes to **Disconnect**.
- **Disconnect:**
  - Opens the serial port. When this menu item is pressed, its caption changes to **Connect**.

Once the application has initialized and started up, the order of events should be:

- Press **Connect**.

  If COM ports are available, the application searches for the EVM. If no EVM is found, an error message notifies the user. If the port is available and communications are successful, the menu item changes from **Connect** to **Disconnect**. Press **Disconnect** if you want to disable serial communications.
- Verify successful communication.

  After any command button is pressed, *<1><0><0>* should be displayed on the bottom status bar as an acknowledgement that proper communication has occurred with the board.

The application is now ready for use.

Closing down the application (through the **X** in the upper-right corner or the *File→Exit* option) closes the serial port connection; it is not necessary to press **Disconnect** before shutting down the application.

4.2 DRV882x GPIO Control Signals

Once the application is communicating with the interface board, actuate the control signals by checking or unchecking a series of check boxes in the Control Signals frame, as shown in Figure 5.

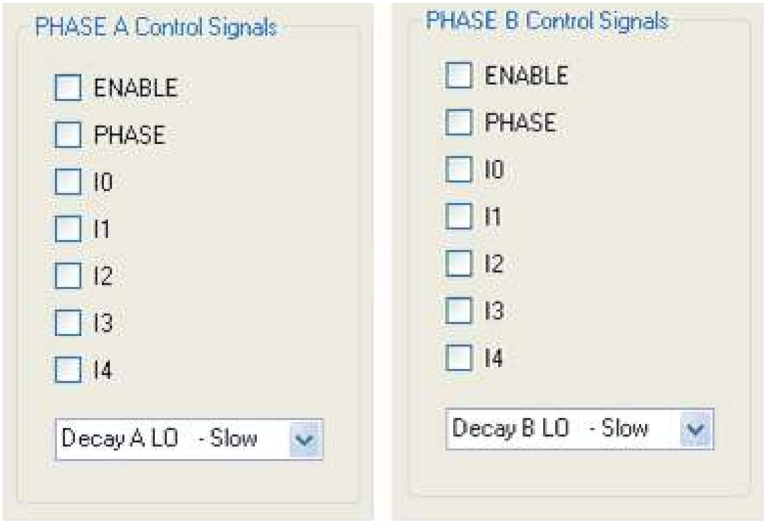


Figure 5. Control Signals

Control signal functionality follows this protocol:. Un-checked checkboxes

- A marked checkbox translates to a *hi* level on the respective control signal
- An empty checkbox translates to a *low* level on the respective control signals

The DECAY signal uses a dropdown box with three options, because the signal can be configured as *LO*, *HI*, or *HI-Z*, as shown in Figure 5.

4.3 Updating DAC Output for Current Control (VREF)

During evaluation, the user may want to study the operation of the ITRIP regulation scheme. Both MSP430F2617 MCU DAC channels can be controlled through the provided sliders, shown in Figure 6. Moving these sliders produces the effect of having the regulated current be directly proportional to the slider position.

It must be noted, however, that during stepper actuation the DAC channels are solely controlled by the microstepping application.

Figure 6. Current Regulation Control

The 12-bit DAC channels 0/1 are connected to the DRV882x VREF analog inputs VREF. Changing the DAC digital value from 0 to 4095 changes the analog voltage at the respective VREF pin from 0 V to 2.5 V respectively, as modeled by Equation 1.

$$VREF = DAC\_VALUE \bullet \frac{eVREF}{4095} \quad (1)$$

Where:

- VREF is the MCU DAC output voltage into the DRV882x device.
- DAC_VALUE is a number from 0 to 4095; in this case, it is specified by the slider position.
- eVREF is the R19 potentiometer output, or external reference voltage into the MCU DAC module.

Note that the GUI software is not aware of the setting for the MSP430 eVREF. Slider position to analog output voltage transformations are made on the assumption that R19 has been set so that eVREF = 2.5 V.

4.4 Stepper Control

Figure 7 illustrates the stepper control frame of the CPG006 GUI software.

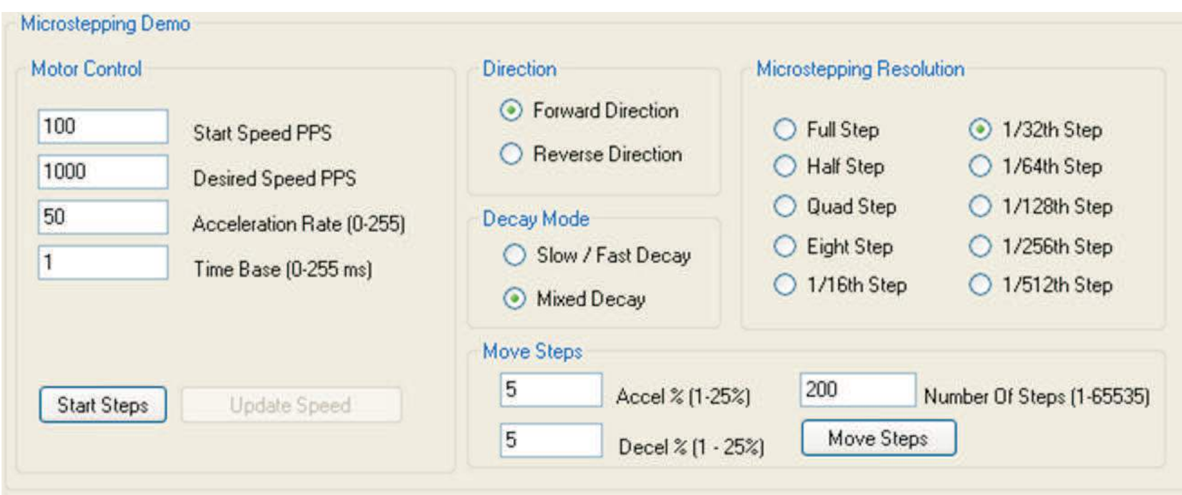


Figure 7. Stepper Control Screen

This screen is an area that offers access to a series of simple stepper control algorithms. The user can control motor enablement, rotation rate, direction of rotation, current decay mode during microstepping, microstepping resolution (from full step to 512 degrees of microstepping), and the number of steps the motor should move.

Motor motion can only occur by using an acceleration profile. A detailed explanation of each stepper control section is presented in the following subsections.

4.4.1 Motor Control Frame

This frame allows the configuration and operation of the stepper with the direction as specified under the *Direction* frame, with the current decay mode as specified under the *Decay Mode* frame and the microstepping resolution as specified under the *Microstepping Resolution* frame.

The Motor Control frame gathers user information about the stepping rate, or motor speed. An acceleration profile is employed to start at a programmable speed and increase the stepping rate until the programmable desired speed is reached.

An internal 4-MHz timer is used to measure time and generate the steps in a timely manner. The application software transforms the entered number of pulses per second (PPS) into clock cycles by following the formula in Equation 2.

$$\#\text{Clk Cycles} = \frac{\text{4E6 Hz}}{\#\text{PPS}} \tag{2}$$

The acceleration profile is coded into the microcontroller to accept both *Start Speed PPS* and *Desired Speed PPS* as clock cycle numbers. When the *Start Steps* command is issued (by pressing the **Start Steps** button), an interrupt service routine (ISR) generates steps at the rate specified by the Start Speed PPS parameter.

An internal task running at 1 kHz modifies the stepping rate by subtracting the Acceleration Rate parameter until the actual stepping rate equals or is larger than the Desired Speed PPS parameter.

The internal task in charge of coordinating stepping rate coordination can be slowed down so that the further increase in stepping rate is achieved at a slower rate than its inherent 1-ms period. This is done by increasing the Time Base parameter. The Time Base parameter is zero based, so if a 1-ms period is desired (the fastest acceleration time rate possible), a zero must be programmed in place.

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

Whether the motor is disabled or allowed to maintain a holding torque (windings are energized), will depend on the Disable Stepper checkbox. Its default is asserted, in which case the motor will become de-energized after motor is commanded to stop.

Figure 8 shows the acceleration profile and the role each parameter plays during speed computation.

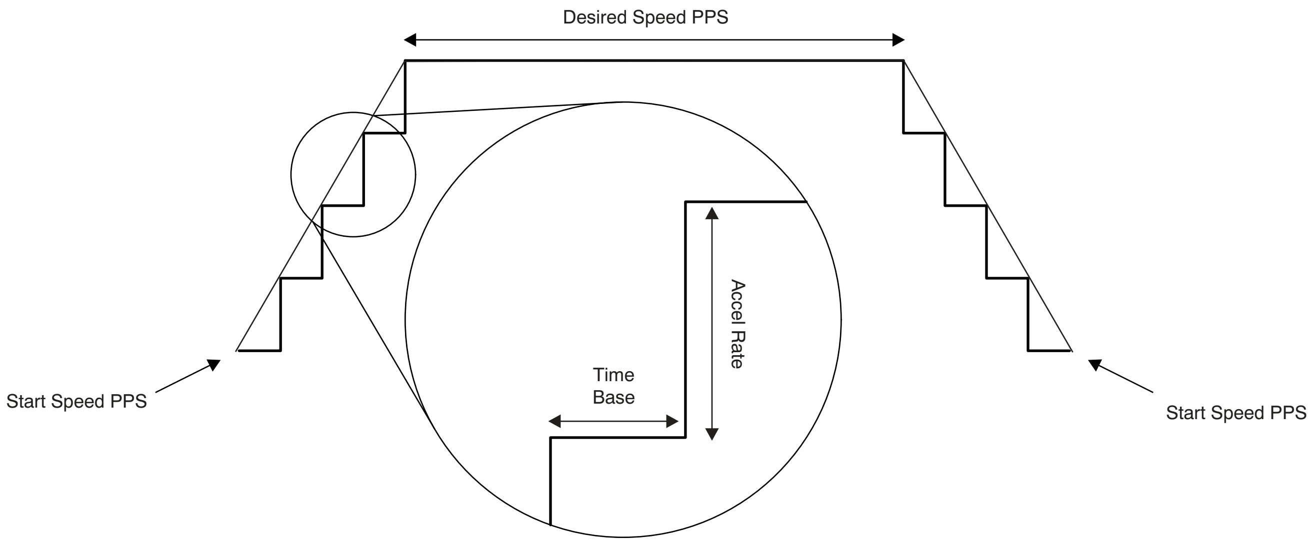


Figure 8. Acceleration Profile

The following controls are available within the Motor Control Frame:

Start Speed PPS: Number of pulses per second (or Full Steps Per Second) at which the motor will rotate at the beginning of operation. The SW will only allow a number as small as 61 PPS and can be taken to a number as large as 65535 PPS.

Desired Speed PPS: Number of pulses per second (or Full Steps Per Second) at which we want the motor to operate. The acceleration profile will start from the Start Speed PPS and increase stepping rate until reaching the Desired Speed PPS. The SW will only allow a number as small as 61 PPS and can be taken to a number as large as 65535 PPS.

Acceleration Rate (0-255): A number from 0 to 255 which acts as a stepping rate modifier to increase the Start Speed PPS up to Desired Speed PPS. Each unit on the Acceleration Rate is equal to 250 µs on the internal timer clock.

Time Base (0-255 ms): Defines the amount of time in between stepping rate changes. The lower this parameter, the faster the motor accelerates toward Desired Speed PPS stepping rate. Time Base is zero based, so a value of 0 actually means 1-ms delay between stepping rate updates.

4.4.2 Direction Frame

Stepper motor direction of rotation can be controlled by specifying the desired direction on this frame. Actual stepper rotation may be different depending on how the motor was wired to the EVM. If the opposite direction is observed, simply reverse the motor connections and the motor should reverse the direction of rotation as well.

Stepper direction of rotation is defined by selecting one of the radial buttons. Only one can be selected at any given time. If the motor is not moving, changing the selection only applies to the next time the motor starts moving. If the motor is rotating, change of direction will be observed instantaneously.

4.4.3 Decay Mode Frame

Current decay is of the utmost importantance especially during microstepping. Which decay mode is used will play a vital role on the waveform generation due to two facts:

1. Slow decay is much more efficient than fast decay as the current ripple is minimized and average current is higher. This allows for motor torque on a per step basis to be higher.
2. Slow decay does not allow the current to discharge the winding as fast as it charges it.

As a result, we will want to use slow decay during most of the time, with the exception being those periods of the microstepping cycle in which waveform generation is compromised. This translates to the usage of slow decay mode while the winding current is charging (Quadrants 1 and 3 as seen in Figure 9) and fast decay mode during while the winding current is discharging (Quadrants 2 and 4 as seen in Figure 9).

The microcontroller firmware is in charge of modulating the Decay pin HI or LO depending on sine wave quadrant generation. The decay information is stored inside the same lookup table which holds the sine wave magnitude and phase information.

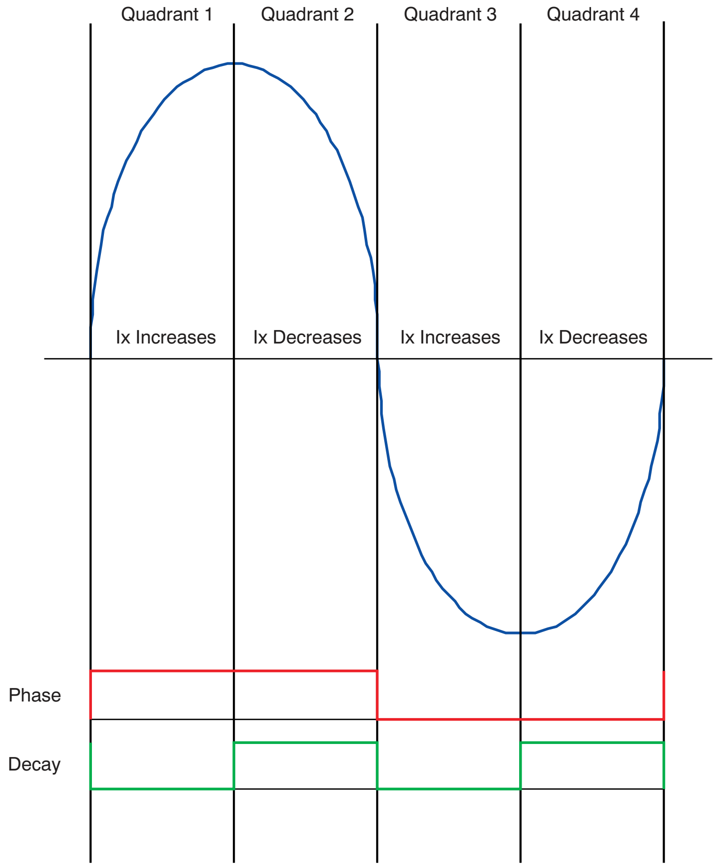


Figure 9. Decay Mode

Another option is to use mixed decay mode. Because mixed decay mode is a current decay rate which is in between fast and slow, it uses the best of both scenarios and gives us a reasonable current regulation rate (low current ripple and good enough average current) while allowing us to discharge the winding and preserve sine wave shape.

When using mixed decay mode, there is no need to switch between slow and mixed or mixed and fast during sine wave generation, although each application is unique and exploring these options is recommended.

The decay mode frame allows the user to select between the slow/fast decay mode or mixed decay mode of sine wave generation. Only one option can be selected at any given time. Selection can be done prior to motor enablement or during normal motor run time.

4.4.4 Microstepping Resolution

Segmenting a full step into microsteps can be achieved by how many times we can divide the current regulation magnitude. Because the VREF input on the DRV8828 or DRV8829 devices is an analog input, we could in essence generate an infinite amount of microsteps. Our analog voltage generator, however, is not an infinitesimally divisible analog function and can only give us up to 4096 different voltage outputs, which is more than plenty to generate any useful amount of microsteps.

Since in a previous application note (SLVA416) we implemented 256 degrees for a microstepping engine, we can take this design one step further. The DRV8828EVM and DRV8829EVM have been programmed to divide a full step to up to 512 degrees of microstepping.

The microstepping resolution frame gives the user the option to change the full step divider factor so that microsteps from half step to 512 degrees of microstepping are obtained. Selection is done by pressing one of the radial boxes. Only one option can be made at any given time. If the motor is not moving, changing the selection only applies to the next time the motor starts moving. If the motor is rotating, change of direction will be observed instantaneously.

4.5 Move Steps Frame

If the user desires to move the stepper a certain number of steps, this can be easily accomplished by using the move steps function. Parameters from the other frames are reused and its utilization is as explained previously. Three new parameters have been added to properly control the limited number of steps actuation.

Number Of Steps: How many steps/microsteps the controller will issue.

Accel % or Acceleration Percentage: A percentage from the total number of steps which will be used to accelerate the motor stepping rate. The result is a number of steps which will be allocated to the acceleration portion of the motor actuation.

$$\#Accel\_Steps = \frac{Number\_of\_Steps \times AccelerationPercentage}{100} \quad (3)$$

Decel % or Deceleration Percentage: A percentage from the total number of steps which will be used to decal the motor stepping rate. The result is a number of steps which will be allocated to the deceleration portion of the motor actuation.

$$\#Deceleration\_Steps = \frac{Number\_of\_Steps \times DecelerationPercentage}{100} \quad (4)$$

In move steps mode we specify a total number steps which we want the motor to move so that a pre-determined distance is achieved. However, depending on the desired speed, it may be imperative to accelerate and decelerate the stepping rate, or errors in motion may occur. Since the total number of steps is in itself a variable, how much we want to use for acceleration and deceleration must also vary accordingly.

The microcontroller firmware gathers the parameters and computes a portion of steps from the total amount, which will be utilized for the acceleration portion of the profile and the deceleration portion of the profile. The remaining steps are used to move the step at the reached speed, which (depending on how parameters were chosen) could or could not be the desired speed.

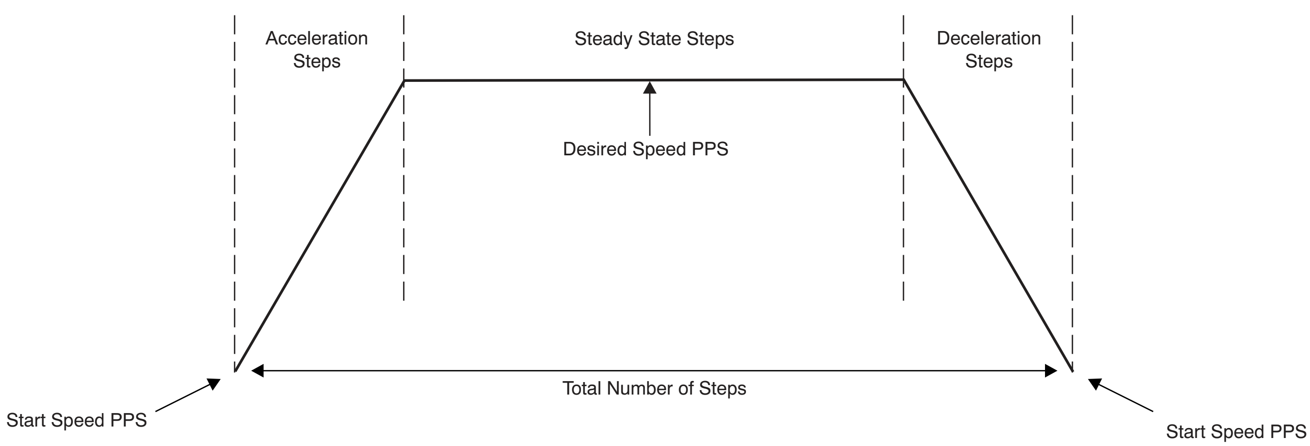


Figure 10. Move Steps

On the CPG006 board, the algorithm to compute acceleration, steady state, and deceleration is an hybrid of two functions: How fast we are modifying the stepping rate so that a desired speed is reached and how many steps we have allocated to modify said rate. This translates to two mechanisms on terminating the acceleration profile. Either acceleration/deceleration culminates as we reach the desired/start speed, or as the allocated number of steps elapses.

It is important to understand these two clauses are mutually exclusive; depending on which one is reached first, the other one will be affected.

For example, if the acceleration percentage is too small, the acceleration profile will be capped by the available number of steps, in which case the desired speed will most likely not be reached.

If the acceleration percentage is too high, then the desired speed will finish the acceleration profile and whatever steps are left on the acceleration profile will be assigned to the steady state portion.

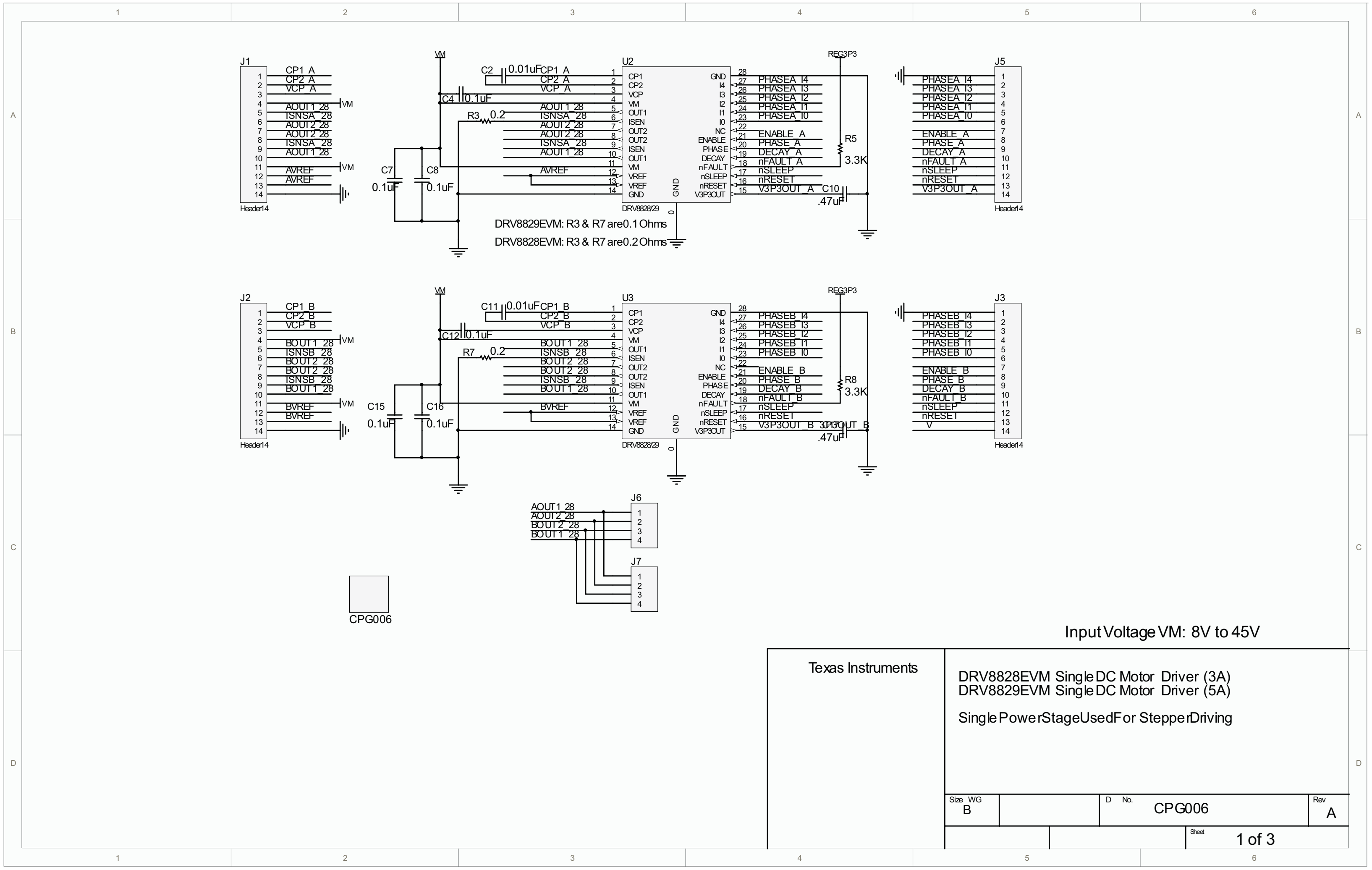
The user will find many different behaviors that are too numerous to mention and beyond the scope of this guide. Experimentation will show all the possibilities present within this acceleration algorithm.

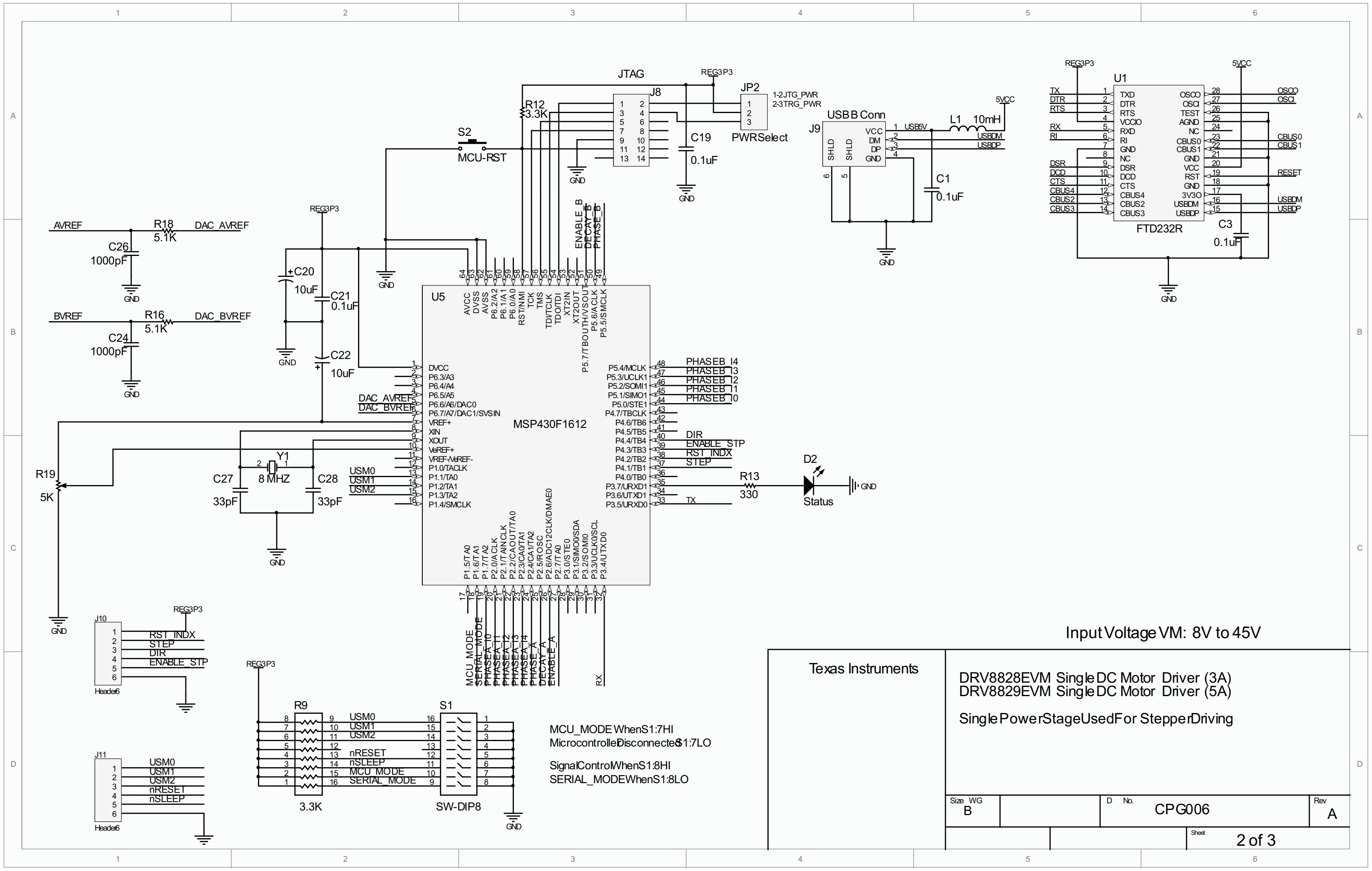
5 Internal Indexer Mode

When the SER_MODE (S1:8) signal is made HI, the microcontroller is configured to operate as an internal indexer. In this mode, the serial communications channel is disabled and connection from a PC is not necessary. User will operate the stepper driver by issuing their own signals through connectors J10 and J11 as described in section 2.5 of this guide.

6 Schematics

A complete schematic for the DRV882xEVM is appended to this user's guide. It is also available in the form of a PDF file (*CPG006_Schematic.pdf*) in the *EVM Related* folder in the product folder for the downloadable EVM software package.


DRV8829EVM: R3 & R7 are 0.1 Ohms
DRV8828EVM: R3 & R7 are 0.2 Ohms
CPG006
Input Voltage VM: 8V to 45V
Texas Instruments
DRV8828EVM Single DC Motor Driver (3A)
DRV8829EVM Single DC Motor Driver (5A)
Single Power Stage Used For Stepper Driving
Size WG
B
Doc No.
CPG006
Rev
A
Sheet
1 of 3



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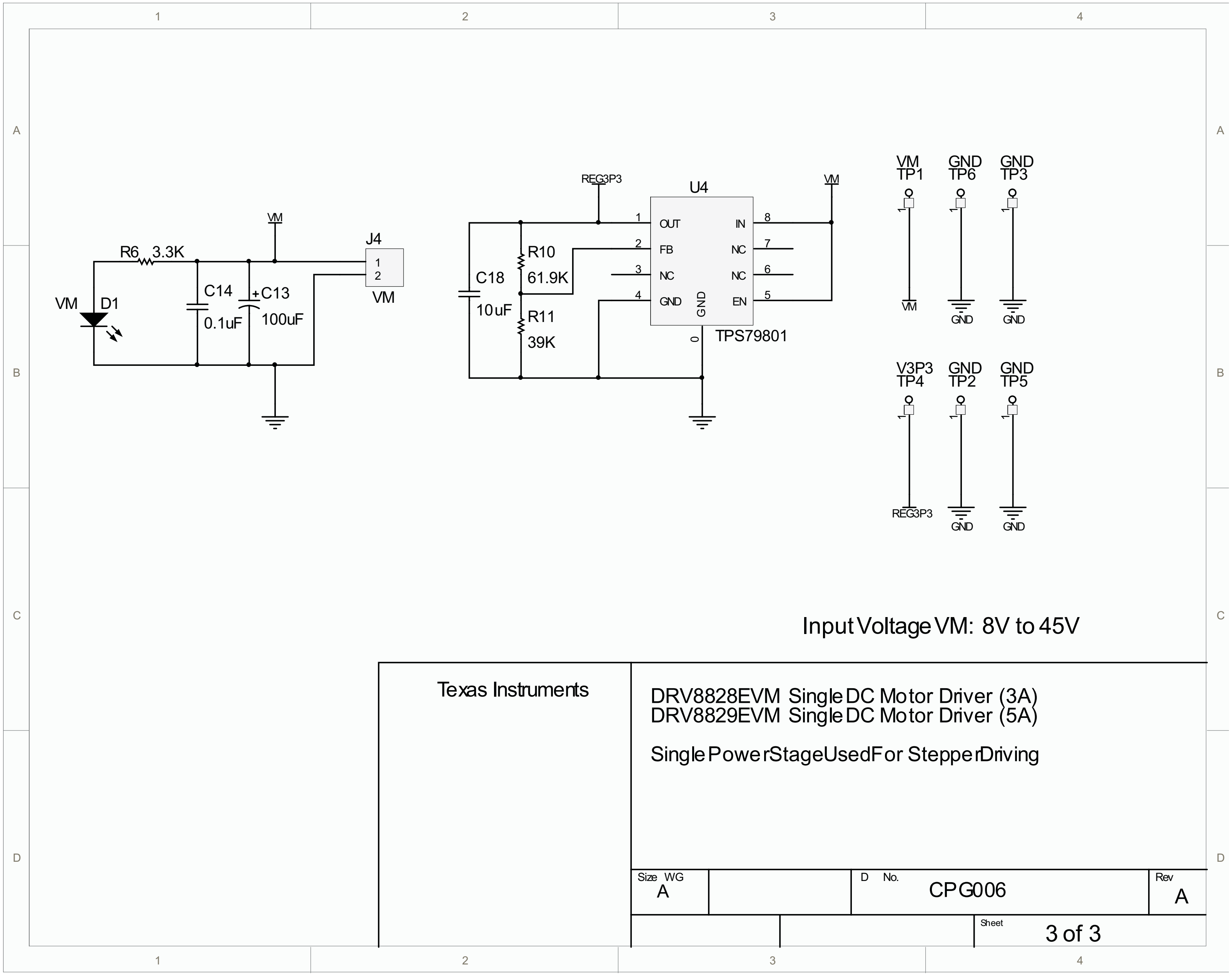
R6 3.3K
VM
D1
C14
0.1uF
+C13
100uF
J4
1
2
VM
REG3P3
U4
C18
10uF
R10
61.9K
R11
39K
OUT
FB
NC
GND
IN
NC
NC
EN
GND
TPS79801
VM TP1
GND TP6
GND TP3
V3P3 TP4
GND TP2
GND TP5
REG3P3
GND
Input Voltage VM: 8V to 45V
Texas Instruments
DRV8828EVM Single DC Motor Driver (3A)
DRV8829EVM Single DC Motor Driver (5A)
Single Power Stage Used For Stepper Driving
Size WG
A
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CPG006
Rev
A
Sheet
3 of 3

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FCC Warning

This evaluation board/kit is intended for use for **ENGINEERING DEVELOPMENT, DEMONSTRATION, OR EVALUATION PURPOSES ONLY** and is not considered by TI to be a finished end-product fit for general consumer use. It generates, uses, and can radiate radio frequency energy and has not been tested for compliance with the limits of computing devices pursuant to part 15 of FCC rules, which are designed to provide reasonable protection against radio frequency interference. Operation of this equipment in other environments may cause interference with radio communications, in which case the user at his own expense will be required to take whatever measures may be required to correct this interference.

EVM Warnings and Restrictions

It is important to operate this EVM within the input voltage range of 8.2 V to 45 V and the output voltage range of 8.2 V to 45 V.

Exceeding the specified input range may cause unexpected operation and/or irreversible damage to the EVM. If there are questions concerning the input range, please contact a TI field representative prior to connecting the input power.

Applying loads outside of the specified output range may result in unintended operation and/or possible permanent damage to the EVM. Please consult the EVM User's Guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative.

During normal operation, some circuit components may have case temperatures greater than +130°C. The EVM is designed to operate properly with certain components above +85°C as long as the input and output ranges are maintained. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors. These types of devices can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during operation, please be aware that these devices may be very warm to the touch.

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

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