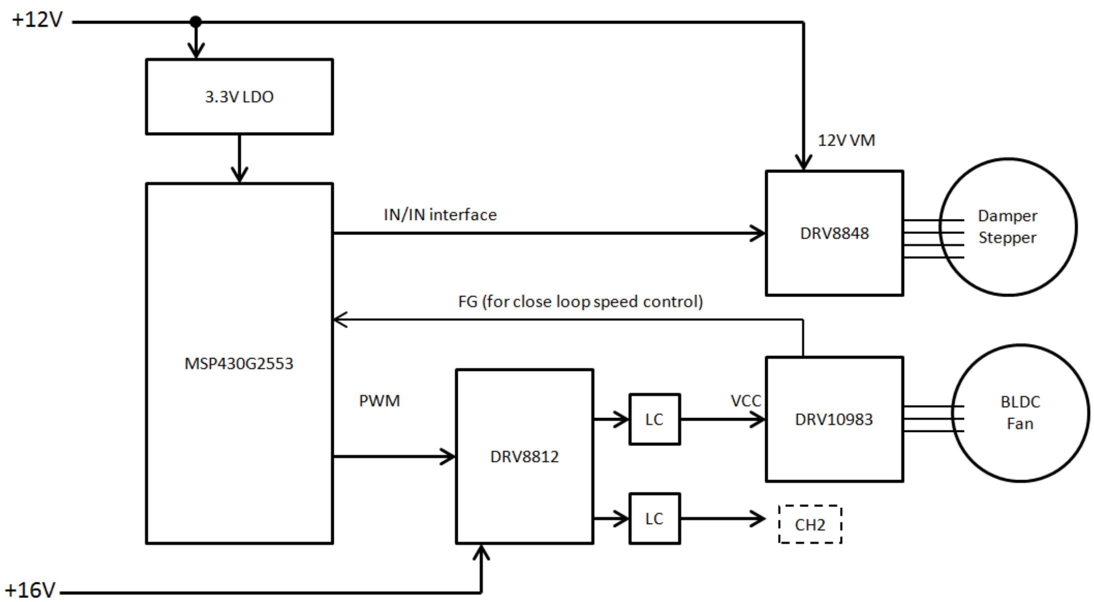
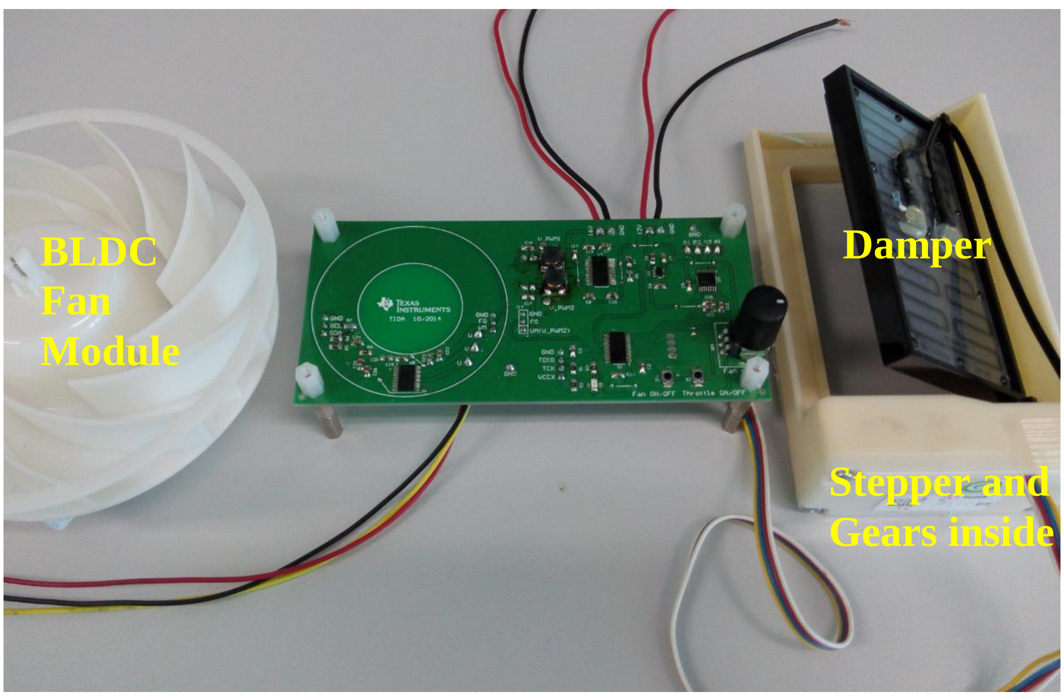
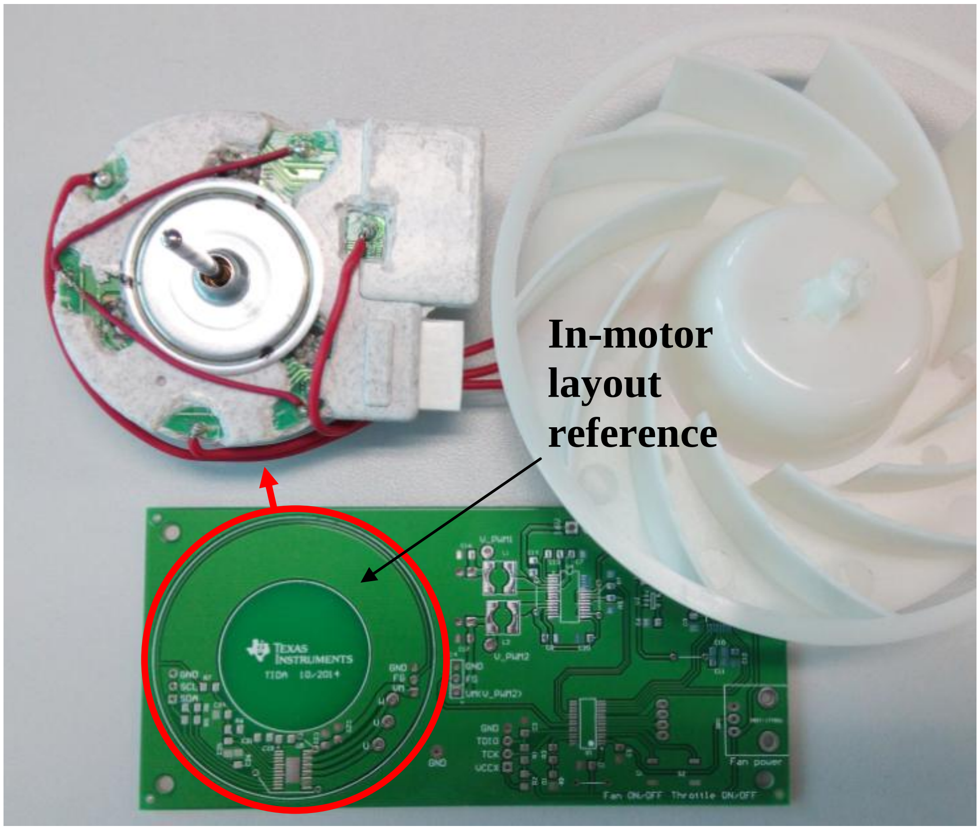
Refrigerator Damper and Fan Motor Control Solutions - Test Data

(TIDA-00297)

1. System Diagram and Picture





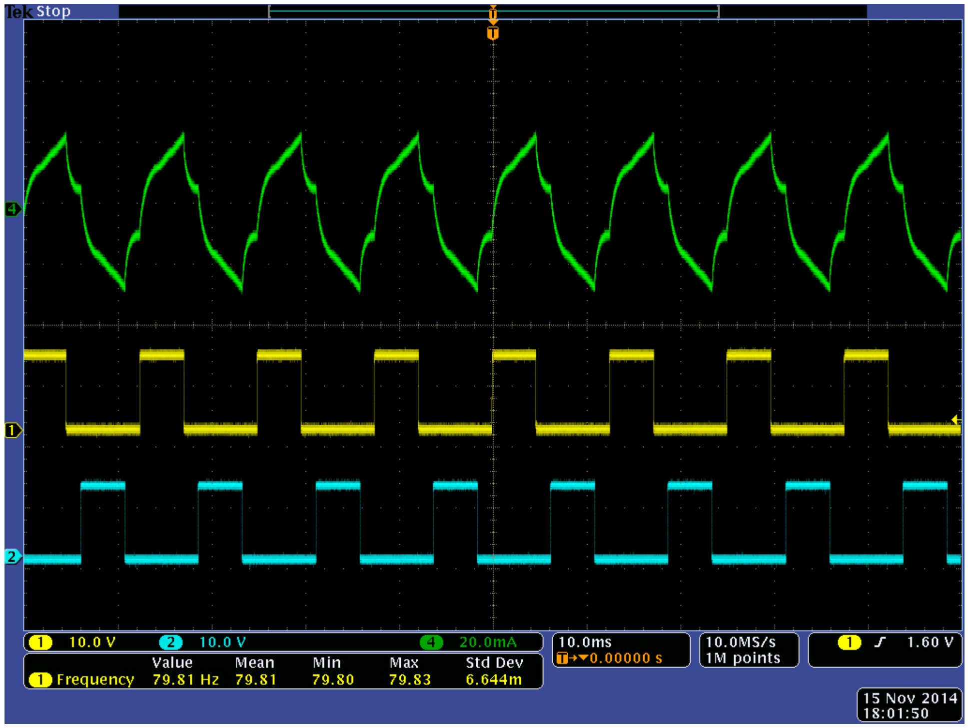


2. Damper Stepper Parameters and Test Data

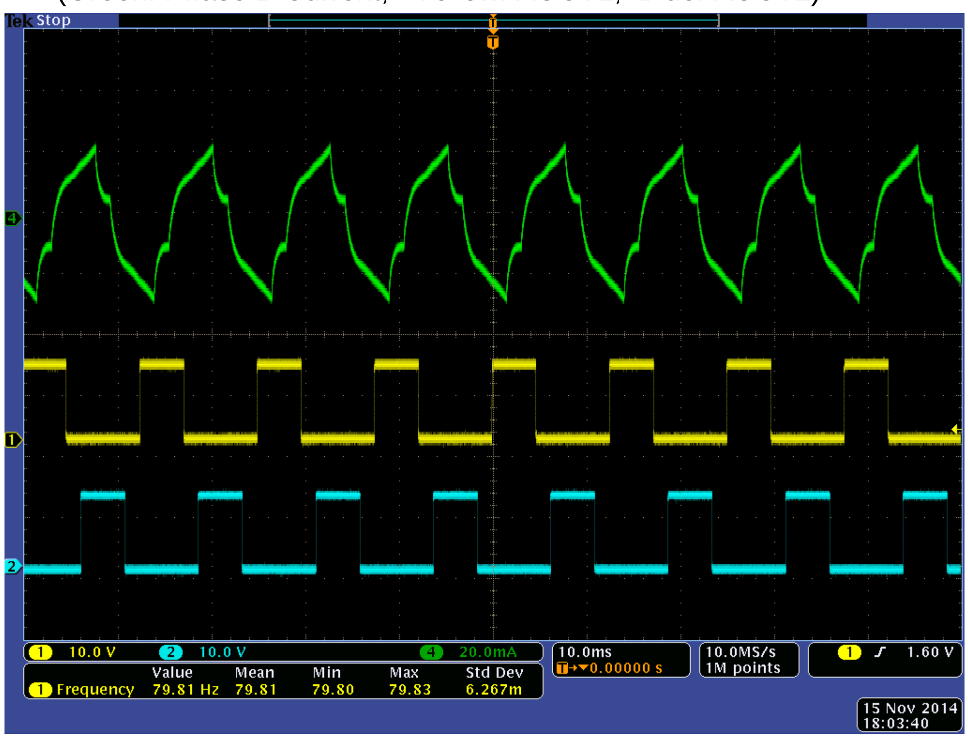
- **Stepper type**
  Permanent Magnet Stepper motor
  Phase A DC resistor: 409 ohm
  Phase B DC resistor: 406 ohm
  Phase inductance: ~130mH@1kHz
  Voltage: 12 V
  Current: 30 mA
  Mechanical step angle: 18°/full step

- **Half step driving waveform**
  Running at F=79.81Hz
  (RPM=F*4*18/360=16.0RPM; The damper takes about 1840 Full steps to fully open or close, so the total time of the opening or closing will be 1840/4/F = 5.76s at this speed)

(Green: Phase B Current;   Yellow: BOUT1; Blue: BOUT2)



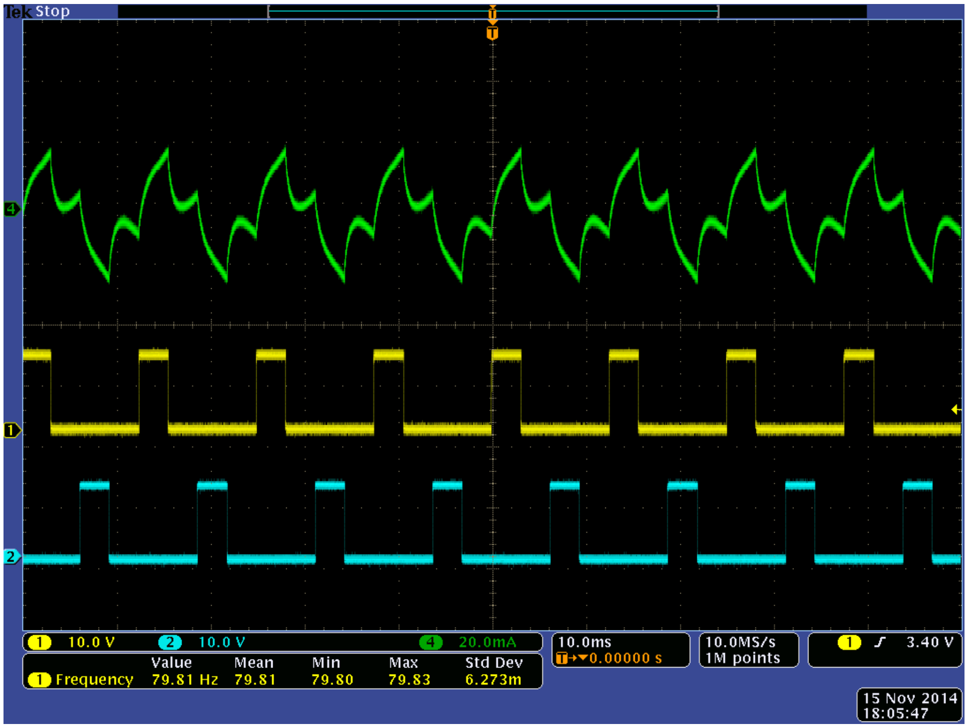
(Green: Phase B Current;   Yellow: AOUT1; Blue: AOUT2)



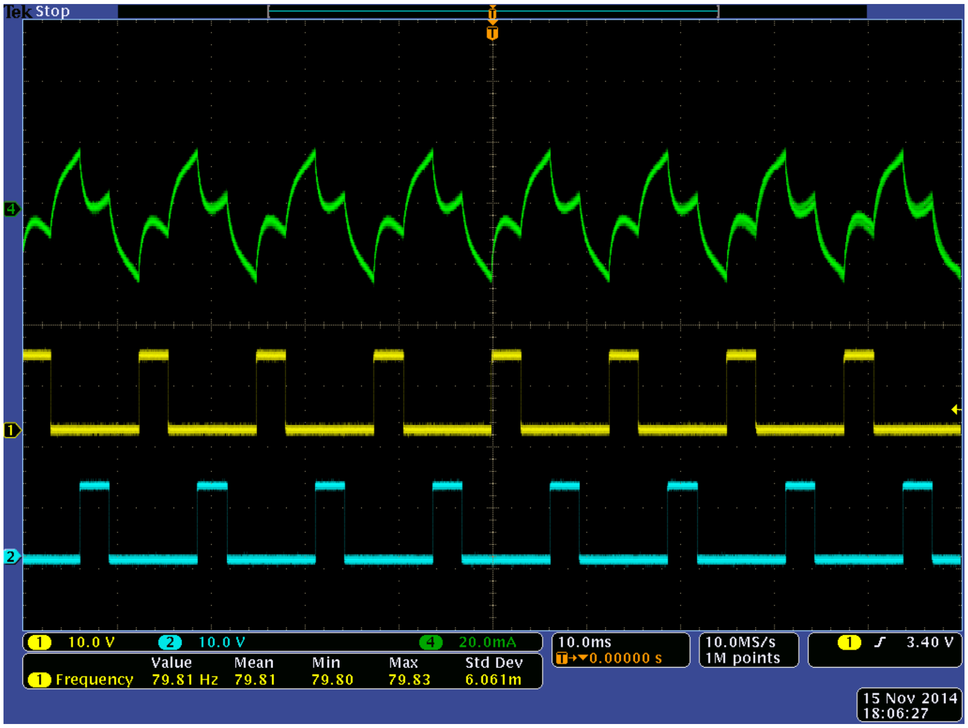
- **Full step driving waveform**

Running at 79.81Hz (16.0 RPM; 5.76s fully opening or closing time)

(Green: Phase B Current; Yellow: BOUT1; Blue: BOUT2)

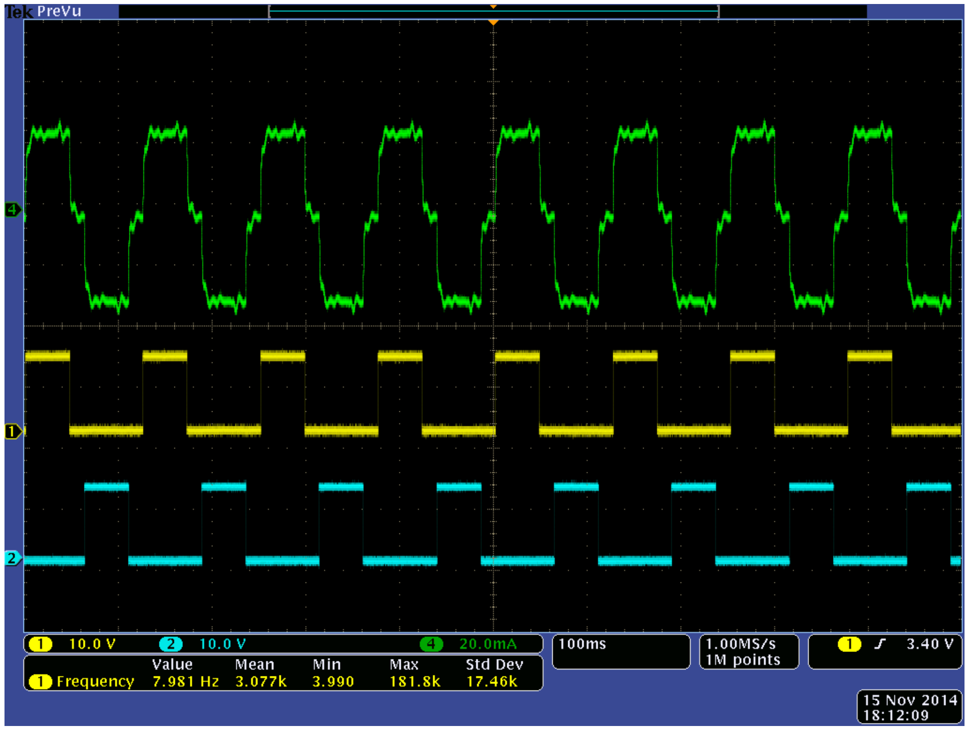


(Green: Phase B Current; Yellow: AOUT1; Blue: AOUT2)



- **Half stepping at low speed**

(7.98Hz; 1.6RPM; 57.6s fully opening or closing time)



- **Full stepping at low speed**

(7.98Hz; 1.6RPM; 57.6s fully opening or closing time)

- **MAX speed versus stepping mode**

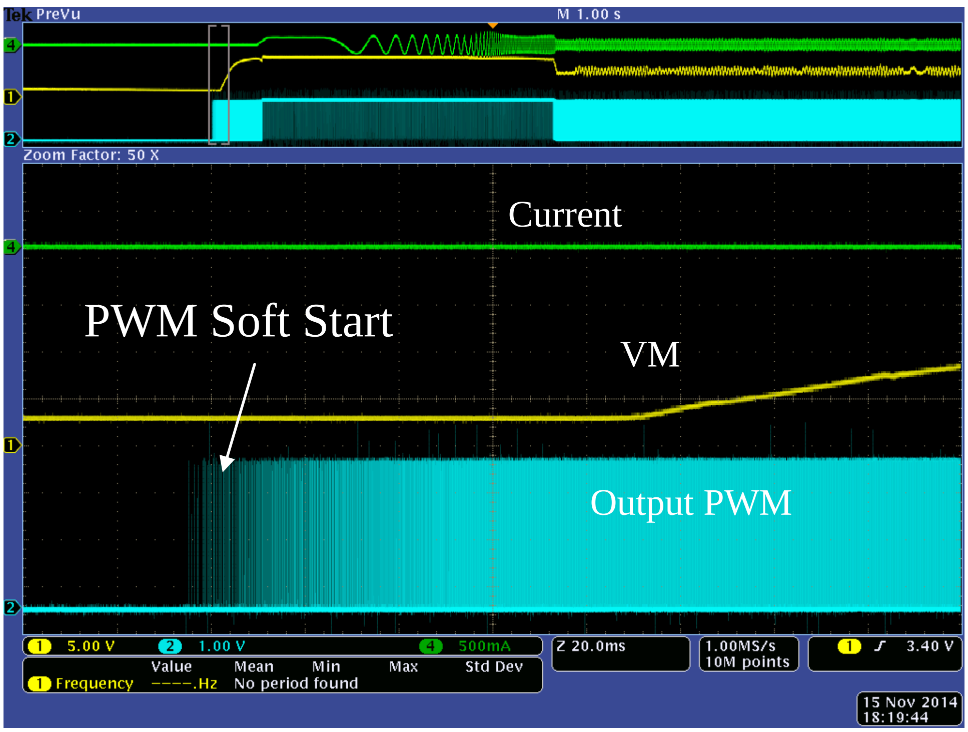
  Using half step driving can achieve higher torque and higher MAX speed.

Stepping mode	MAX speed	Average Current @12V
Half	~130Hz (26RPM; 3.5s)	43mA
Full	~100Hz (20RPM; 4.6s)	30mA

3. PWM Power Module Test

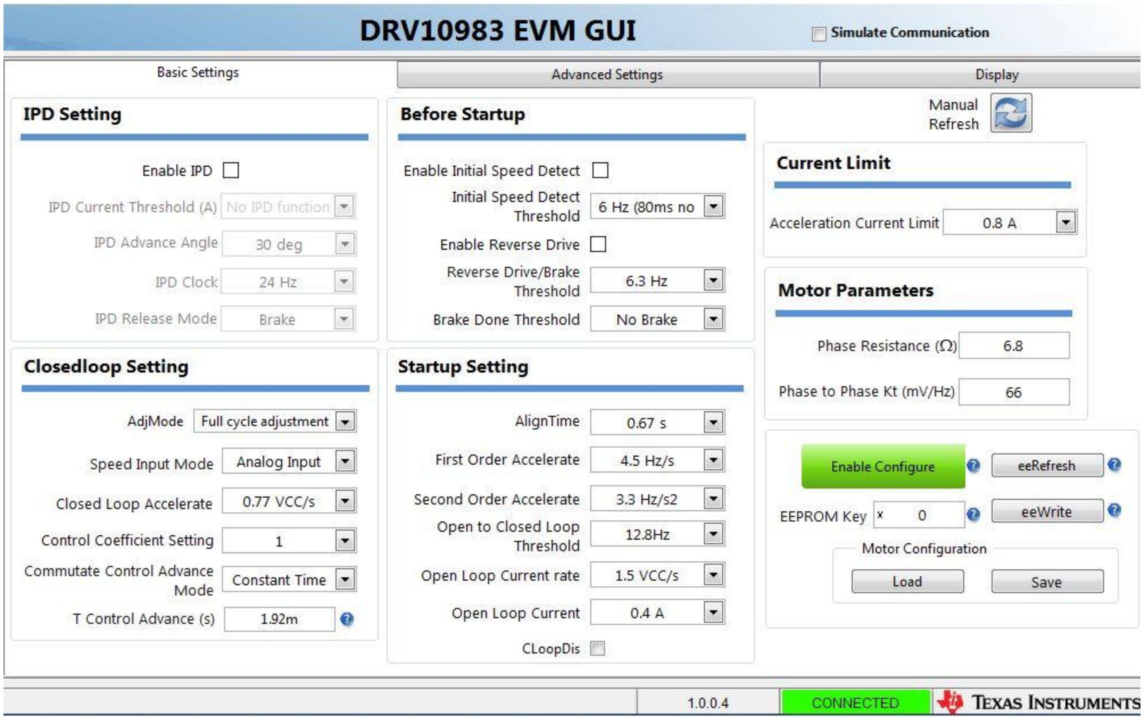
- **Soft startup**

  Soft startup means the PWM duty cycle increasing from 0 to desired value gradually when enable the PWM power stage of DRV8812. This is an important method to avoid OCP event caused by the inrush charging current to the LC output filter when DRV8812 is just enabled. The test results show that output pulse width >= 10µs at the startup of DRV8812 may cause the OCP event. This design includes the adjustable PWM duty ramping up function in the demo code, beginning with PWM pulse width < 1us.

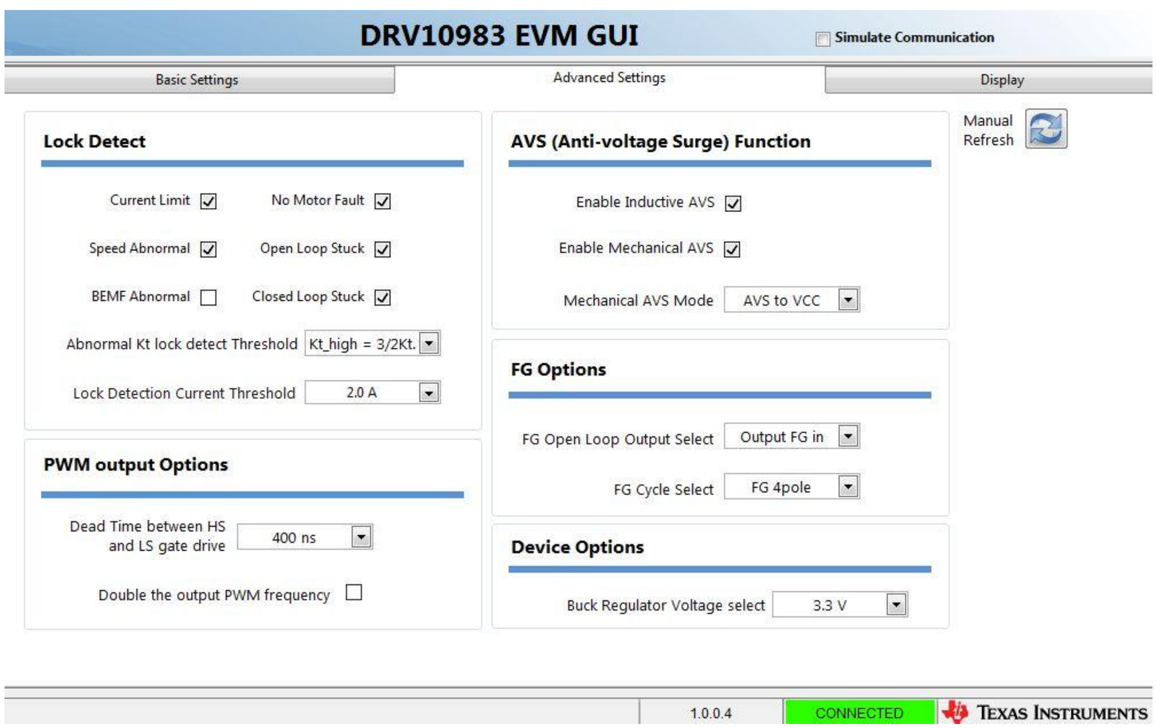


5. Fan module

- Motor Parameters and DRV10983 configuration data

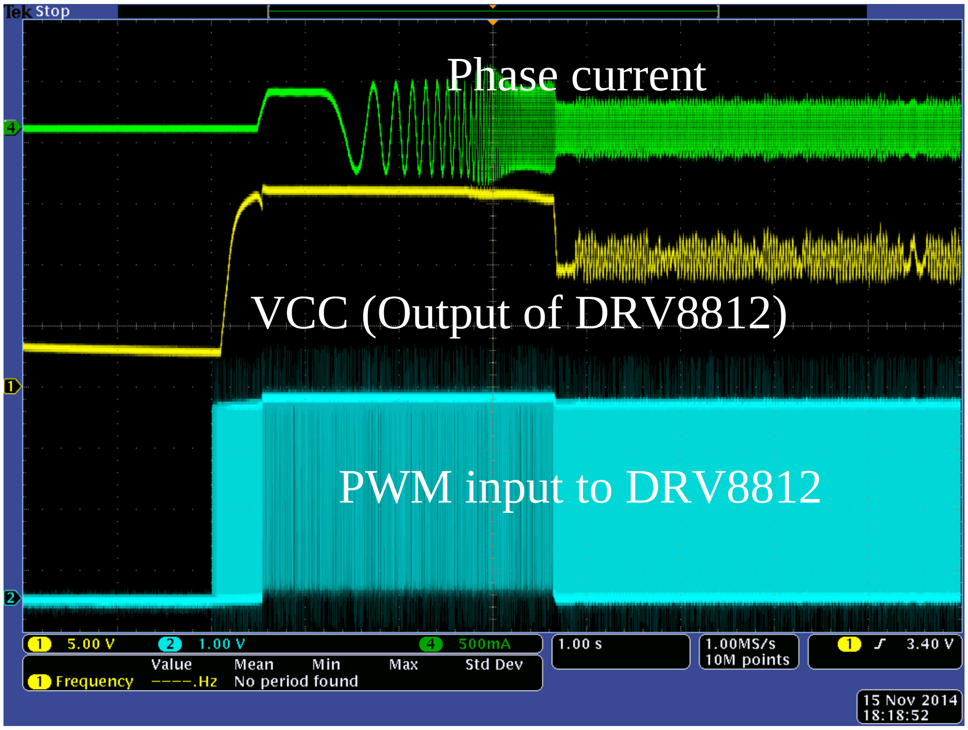

DRV10983 EVM GUI
Simulate Communication
Basic Settings
Advanced Settings
Display
IPD Setting
Enable IPD
IPD Current Threshold (A) No IPD function
IPD Advance Angle 30 deg
IPD Clock 24 Hz
IPD Release Mode Brake
Before Startup
Enable Initial Speed Detect
Initial Speed Detect Threshold 6 Hz (80ms no
Enable Reverse Drive
Reverse Drive/Brake Threshold 6.3 Hz
Brake Done Threshold No Brake
Manual Refresh
Current Limit
Acceleration Current Limit 0.8 A
Motor Parameters
Phase Resistance (Ω) 6.8
Phase to Phase Kt (mV/Hz) 66
Closedloop Setting
AdjMode Full cycle adjustment
Speed Input Mode Analog Input
Closed Loop Accelerate 0.77 VCC/s
Control Coefficient Setting 1
Commutate Control Advance Mode Constant Time
T Control Advance (s) 1.92m
Startup Setting
AlignTime 0.67 s
First Order Accelerate 4.5 Hz/s
Second Order Accelerate 3.3 Hz/s2
Open to Closed Loop Threshold 12.8Hz
Open Loop Current rate 1.5 VCC/s
Open Loop Current 0.4 A
CLoopDis
Enable Configure
eeRefresh
EEPROM Key x 0
eeWrite
Motor Configuration
Load
Save
1.0.0.4
CONNECTED
TEXAS INSTRUMENTS

Page 1

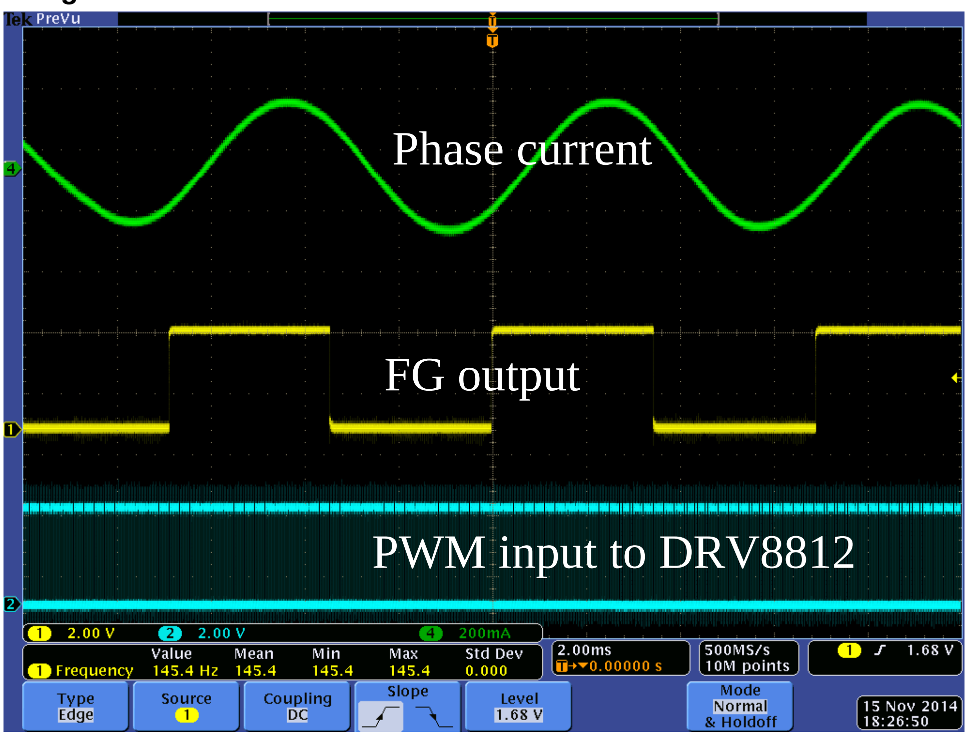

DRV10983 EVM GUI
Simulate Communication
Basic Settings
Advanced Settings
Display
Lock Detect
Current Limit
No Motor Fault
Speed Abnormal
Open Loop Stuck
BEMF Abnormal
Closed Loop Stuck
Abnormal Kt lock detect Threshold Kt_high = 3/2Kt.
Lock Detection Current Threshold 2.0 A
AVS (Anti-voltage Surge) Function
Enable Inductive AVS
Enable Mechanical AVS
Mechanical AVS Mode AVS to VCC
Manual Refresh
PWM output Options
Dead Time between HS and LS gate drive 400 ns
Double the output PWM frequency
FG Options
FG Open Loop Output Select Output FG in
FG Cycle Select FG 4pole
Device Options
Buck Regulator Voltage select 3.3 V
1.0.0.4
CONNECTED
TEXAS INSTRUMENTS

Page 2

- **Startup waveform**



- **Normal running waveform**



- **Speed change with VM in close-loop control**

  This design has closed-loop speed control with minimum hardware change of existing solution, using an MSP430G2553 and the DRV8812 for a PWM-based power supply. The following benefits can be gained from close-loop speed control.

  - The fan speed can be set to any value and stay steady easily. Sometimes we need to set the speed point to reduce the acoustic running noise which may be resonated higher at certain speed.
  - The fan speed can be remained constantly regardless of the temperature, power supply changes and manufacture variations of the motor parameters.
  - Constant speed can be achieved within the whole product life cycle. So the system performance can be constant as well regardless of the mechanical wear and electronic drifting.

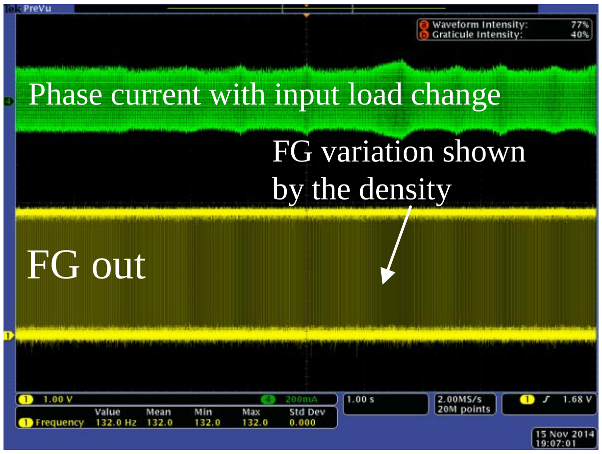
VM (J3) to DRV8812 /v	FG out /Hz(Command = 140Hz)	Error / %
11	139.3	-0.5
11.5	138.4	-1.1
12	141.0	0.7
12.5	141.7	1.2
13	138.7	-0.9
13.5	138.6	-1
14	140.3	0.2
14.5	138.9	-0.8
15	138.5	-1.1
15.5	139.4	-0.4
16	140.4	0.3

- **Speed change with external load**

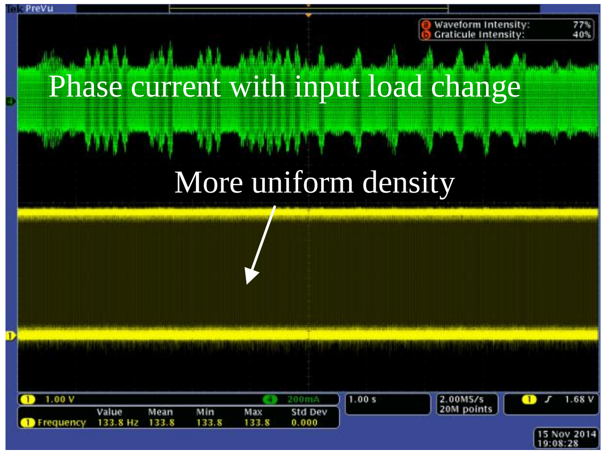
  Without close-loop control, the speed of BLDC fan will be changed abruptly according to the external load change.

  In the test, extra friction was generated by touching blades of the BLDC fan. With similar touching pressure, with or without the speed close-loop control, the speed drops are about 5% versus 20%.

  The variation of FG (out of DRV10983) which represents the speed, at the input load changing condition, can be shown as the density change on the following FG waveform.



Without close-loop speed control



With close-loop speed control