EV6631H-L-00A

35V, 3A Peak Phase Current 3-Phase BLDC Motor Driver Evaluation Board

DESCRIPTION

The EV6631H-L-00A is an evaluation board designed for the MP6631H, a 3-phase brushless DC (BLDC) motor driver with integrated power MOSFETs. The MP6631H drives a 3-phase BLDC motor with 1 external Hall sensor or 3 external Hall sensors. The peak phase current is up to 3A across the 3.6V to 35V input voltage (V_{IN}) range.

The MP6631H controls the motor speed through the PWM signal, or it controls the DC signal on the PWM/DC pin. The device provides closed-/ open-loop control and a built-in, configurable speed curve function. The device also features sinusoid control methods for maximum torque while minimizing the low-speed ripple and noise across the entire speed range.

The MP6631H has a rotational speed detector feature. The rotational speed detector (the FG/RD pin) is an open-drain output. FG/RD outputs a high or low voltage relative to the Hall sensor comparator's output. In addition to rotational speed detection, the direction is controlled via the DIR pin's input.

Protections includes input over-voltage protection (OVP), under-voltage lockout (UVLO), locked-rotor protection, over-current protection (OCP), and thermal shutdown.

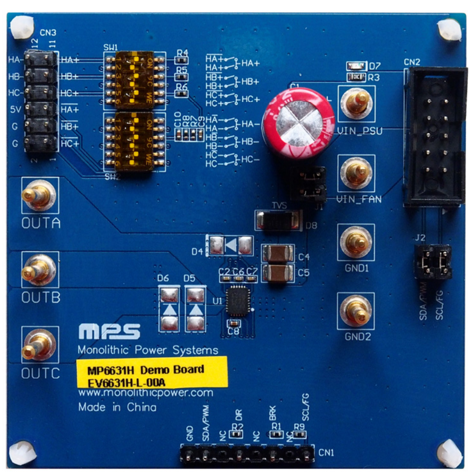
The MP6631H is available in a QFN-26 (3mmx4mm) package.

PERFORMANCE SUMMARY

Specifications are at T_A = 25°C, unless otherwise noted.

Parameters	Conditions	Value
Input voltage (V_{IN}) range		5V to 35V
Maximum output phase current (I_{OUT})	V_{IN} = 5V to 35V	3A
Input PWM frequency		1kHz to 100kHz
Switching frequency (f_{SW})		25kHz

EVALUATION BOARD



LxWxH (7cmx7cmx2.2cm)

Board Number	MPS IC Number
EV6631H-L-00A	MP6631HGL-0000

QUICK START GUIDE

Quick Start using the Communication Kit (MPS Fan Driver Communication Kit)

1. Preset the DC power supply, then turn the power supply off.
2. Connect the power supply outputs to VIN_PSU and GND (see Figure 1).
3. Connect the communication kit to the EV6631H-L-00A via CN2.
4. Connect the motor phase terminals to:
    a. Motor phase A: OUTA
    b. Motor phase B: OUTB
    c. Motor phase C: OUTC
5. Connect the motor's Hall sensor outputs to the corresponding connector.
6. Connect the communication kit to the computer.
7. Turn the power supply on.
8. Run the Windows application "MP6631H.exe".

    Figure 1 shows the equipment set-up with the communication kit.

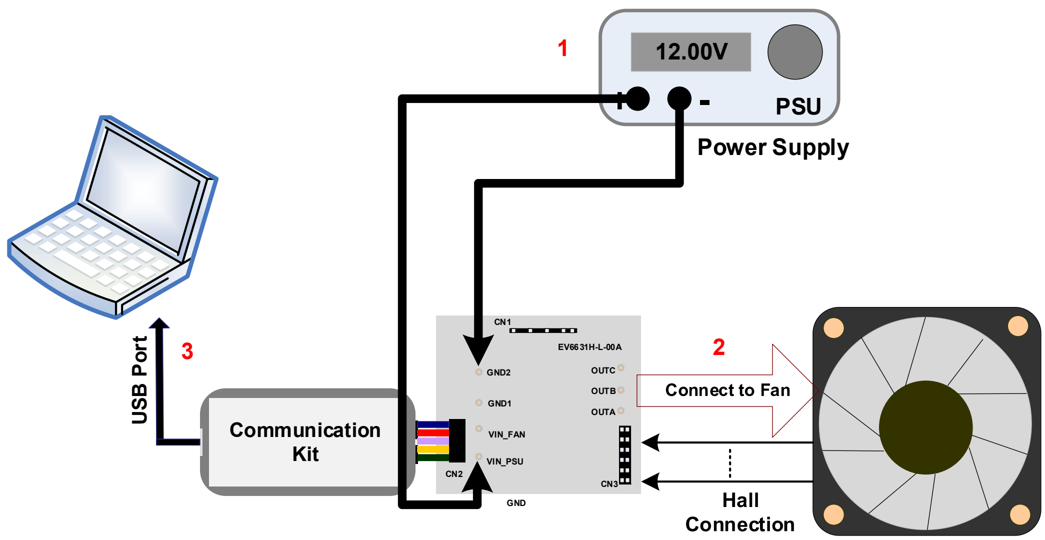


Figure 1: EVB Connection with the Communication Kit

Quick Start without the Communication Kit

1. Connect the power supply output terminals to VIN_FAN and GND.
2. Connect the motor phase terminals to:
    a. Motor phase A: OUTA
    b. Motor phase B: OUTB
    c. Motor phase C: OUTC
3. Connect the motor's Hall sensor outputs to the corresponding connector.
4. Turn the power supply on. The motor should begin working.
5. Set the function generator to pulse mode, such that the high level is 3.3V and the low level is 0V. Adjust the pulse duty cycle to adjust the motor's speed.

Figure 2 shows the equipment set-up without the communication kit.

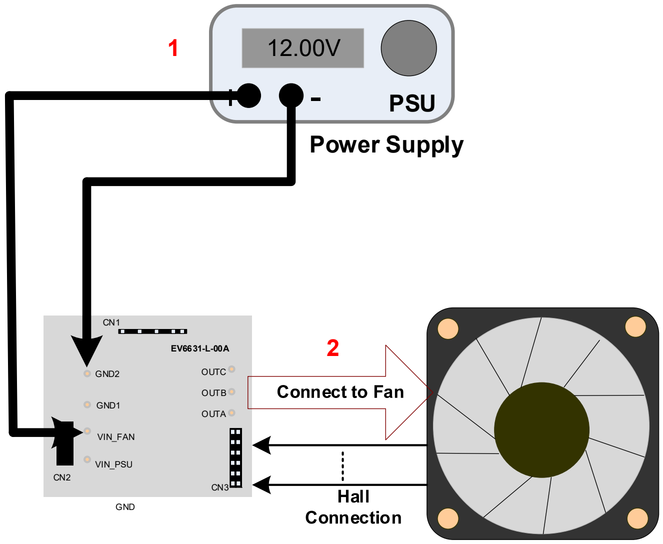


Figure 2: EVB Connection without the Communication Kit

The Hall Connection

The EV6631H-L-00A supports either a Hall IC (logic polarity input) or a Hall element (differential input) as the Hall input signal. Figure 3 shows the hall element that outputs the differential signal.

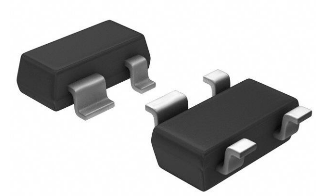


Figure 3: Hall Element (Outputs Differential Signal)

Figure 4 shows the Hall IC that outputs logic polarity signal.

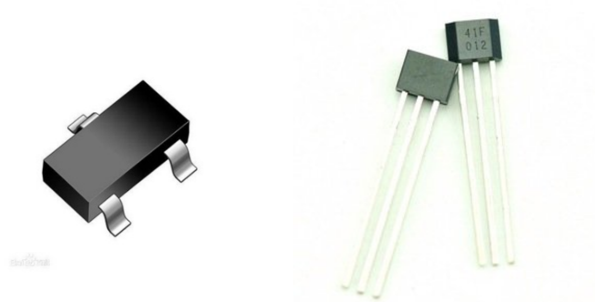


Figure 4: Hall IC (Output Logic Polarity Signal)

Hall Element Connection

1. Connect 5V to the Hall element's supply terminal.
2. Connect GND to the Hall element's ground.
3. Connect the CN3 terminals to:
   a. The Hall element's positive (+) output: HA+, HB+, and HC+
   b. The Hall element's negative (-) output: HA-, HB-, and HC-

   Use SW1 and SW2 to switch to the correct terminal (see Figure 5).

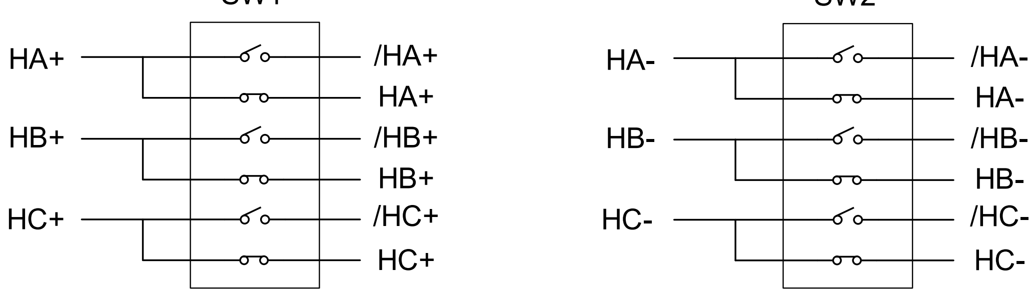


Figure 5: SW1 and SW2 with the Hall Element Connection

Hall IC Connection

1. Connect 5V to the Hall IC's supply terminal.
2. Connect GND to the Hall IC's ground.
3. Connect the CN3 terminals (HA+, HB+, and HC+) to their corresponding terminals in the Hall IC's output. Do not make connections for HA-, HB-, and HC-.

   Use SW1 and SW2 to switch to the correct terminal (see Figure 6).

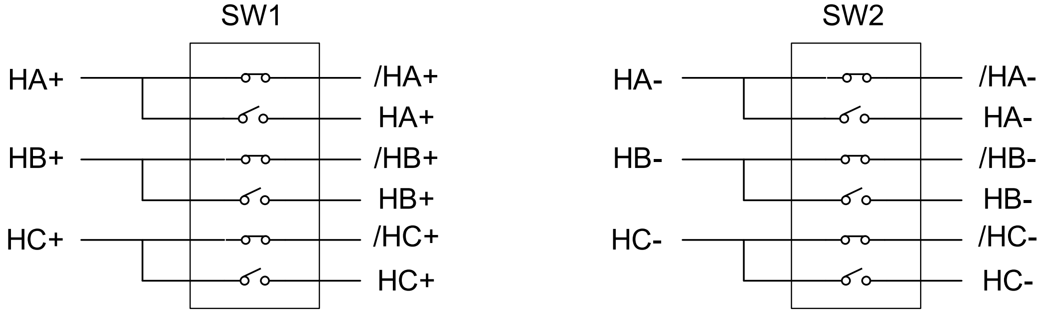


Figure 6: SW1 and SW2 with the Hall IC Connection

GUI Operation Guide

1. Double click "MP6631H.exe" to start the GUI. The first page of GUI should show the features and typical application circuit (see Figure 7).

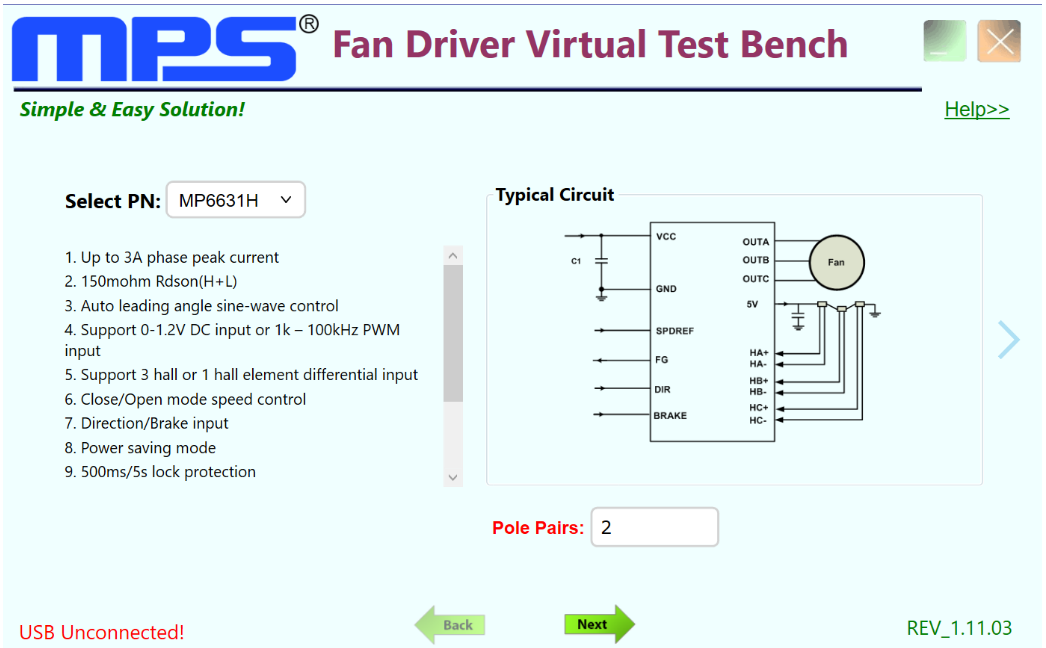


Figure 7: Fan Driver Virtual Test Bench

2. Insert the motor's pole pairs, then click "Next".

General Settings

There are a few general settings in the GUI, listed below.

1. Test Mode: Use test mode to begin a new design. When test mode is automatically selected, all internal register can be accessed.
2. Bench Verification: Automatically tests the RPM curve.
3. Reset Fan: Resets the hardware and the motor if a fault occurrs.
4. Programming: Use the programming feature to load code files and make configurations via the one-time programmable (OTP) memory.

   Figure 8 on page 6 shows the general settings page.

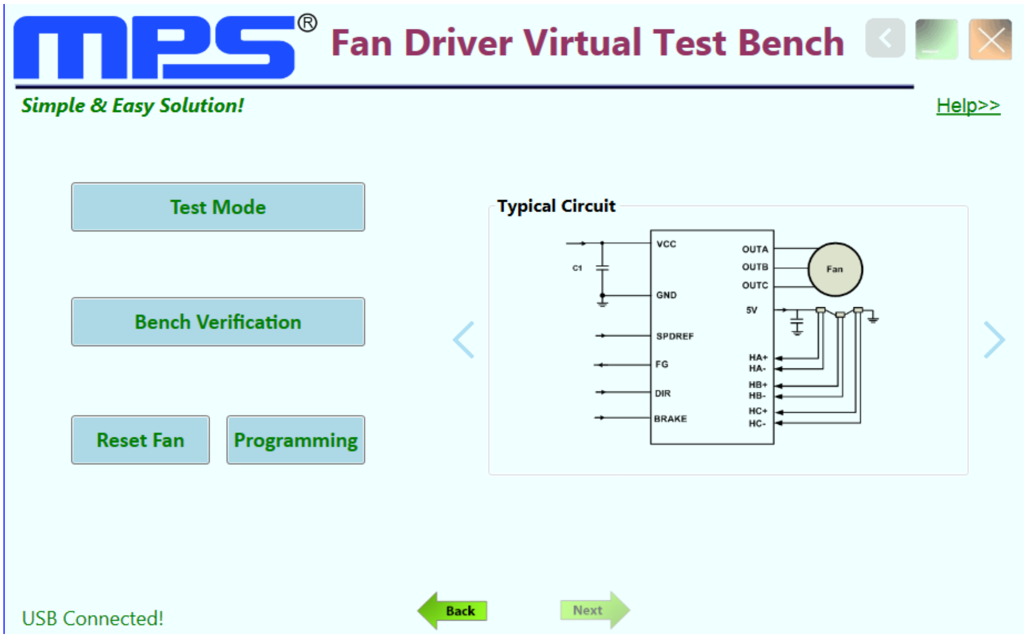


Figure 8: General Settings Page

Click "Test Mode". The GUI software should read back the MP6631H's register data and display the information (see Figure 9).

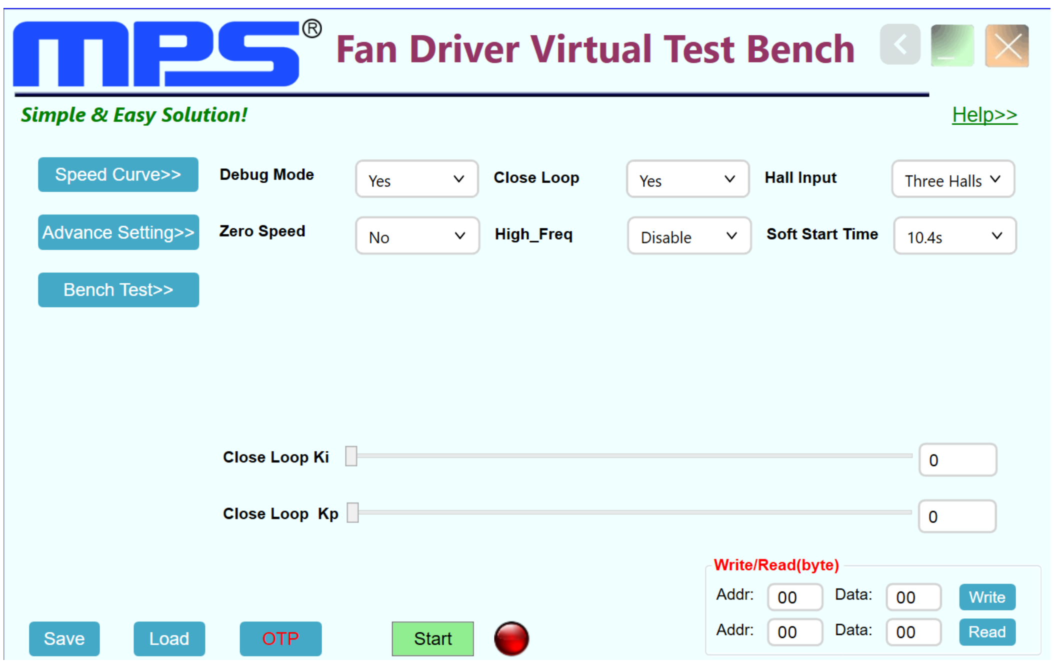


Figure 9: The MP6631H's Register Settings

The options for test mode are listed below.

1. Speed Curve: Edits and simulates the motor's speed curve.
2. Advance Setting: Configures the MP6631H's pre-start time and brake settings.
3. Bench Test: Tests the motor speed with different input PWM duty cycles.
4. Save: Reads back all registers from the MP6631H and saves the information to a .txt file.
5. Load: Loads a .txt file and writes all the configurations to the MP6631H.

6. OTP: Configures the MP6631H. do 1 time OTP
7. Start: Starts or stops the motor.
8. Write: Writes values to a particular address.
9. Read: Reads register values from a particular address.

Note that if the mouse cursor hovers over a menu item, the related design notes pop up. In addition, a longer soft-start time helps the PWM output change smoothly to avoid a reverse current charge back.

Speed Curve Settings

Click "Speed Curve" to edit the RPM vs. PWM Duty Cycle curve with the latest registers settings (see Figure 10).

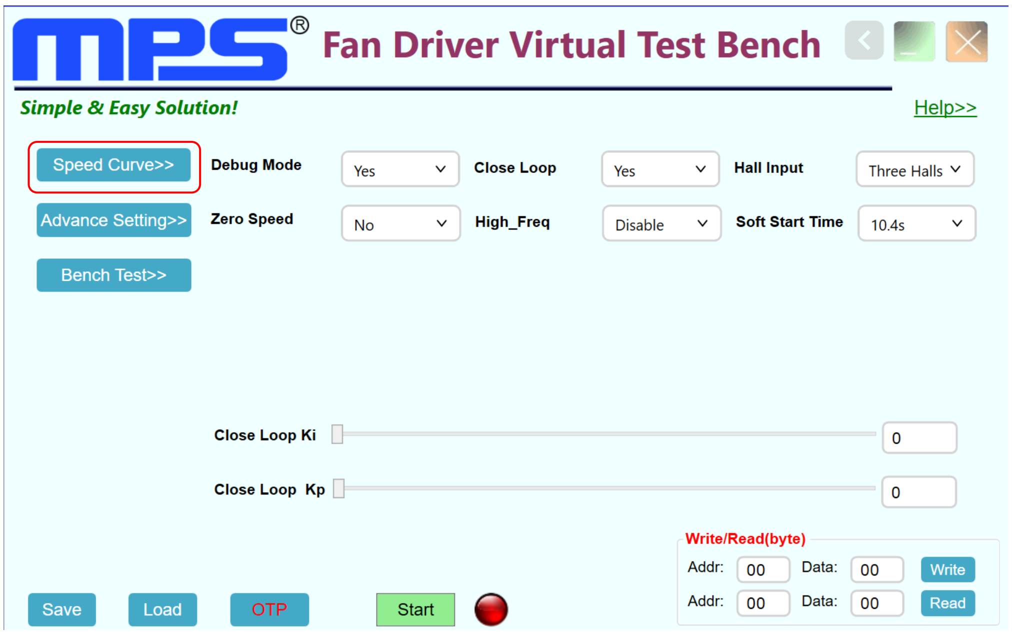


Figure 10: Speed Curve Settings

Figure 11 shows how to adjust the speed curve.

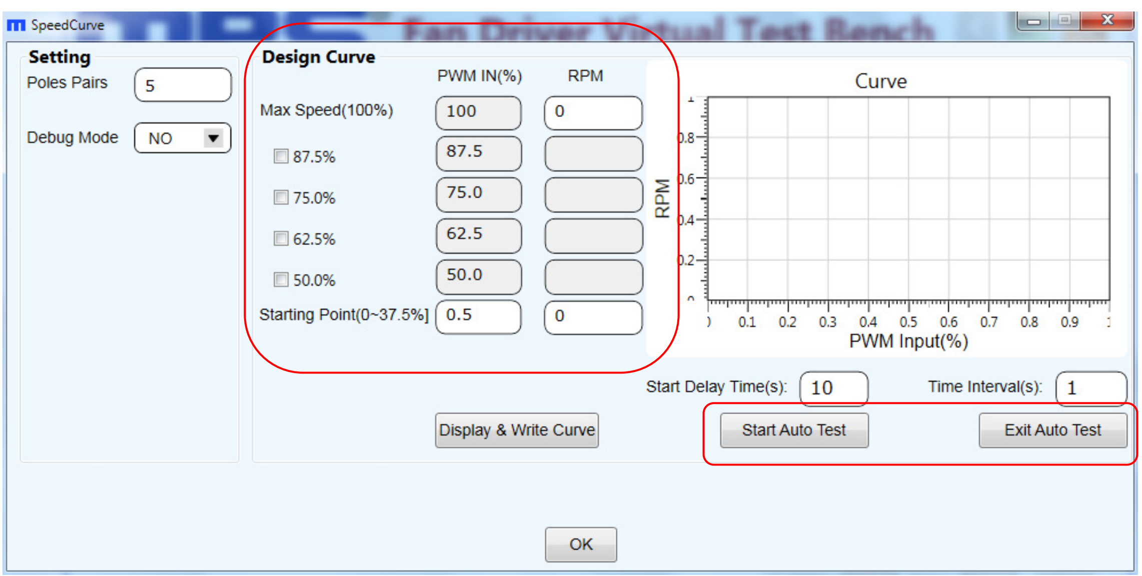


Figure 11: Adjusting the Speed Curve

The options to set the speed curve are described below.

1. Display & Write Curve: Input a valid curve and click this button to write the curve to the MP6631H.
2. Start Auto Test: Write a valid curve to the MP6631H then click this button to simulate an RPM vs. PWM duty cycle curve.
3. Exit Auto Test: Exit the simulator for the RPM vs. PWM duty cycle curve.

Advanced Settings

Click "Advance Setting" to modify some advanced settings (see Figure 12).

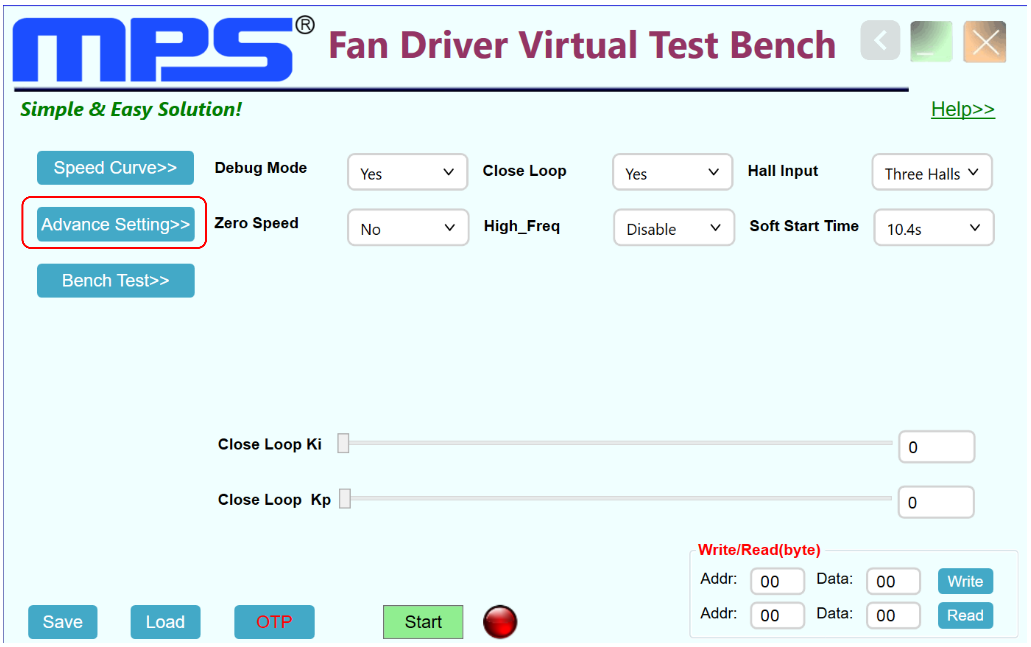


Figure 12: Advanced Settings

Figure 13 shows the advanced settings that can be configured.

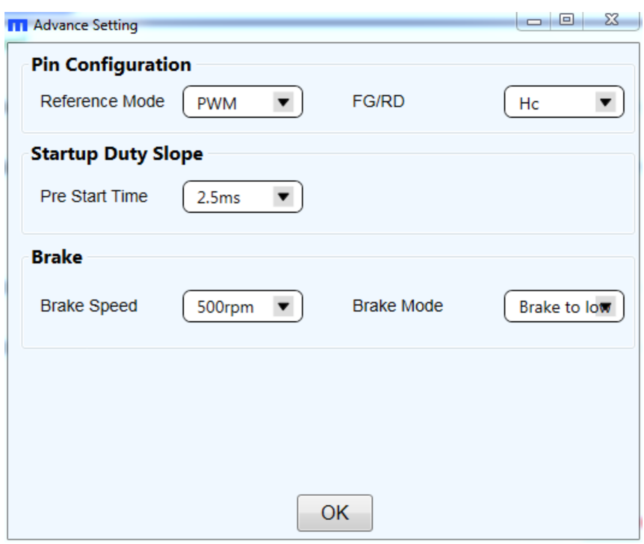


Figure 13: Configurable Advanced Settings

Note that for the pre-start time, a lower value results in a higher start-up torque but can cause a higher current overshoot.

Bench Test

Click “Bench Test” to test the motor speed with different input PWM duty cycles (see Figure 14).

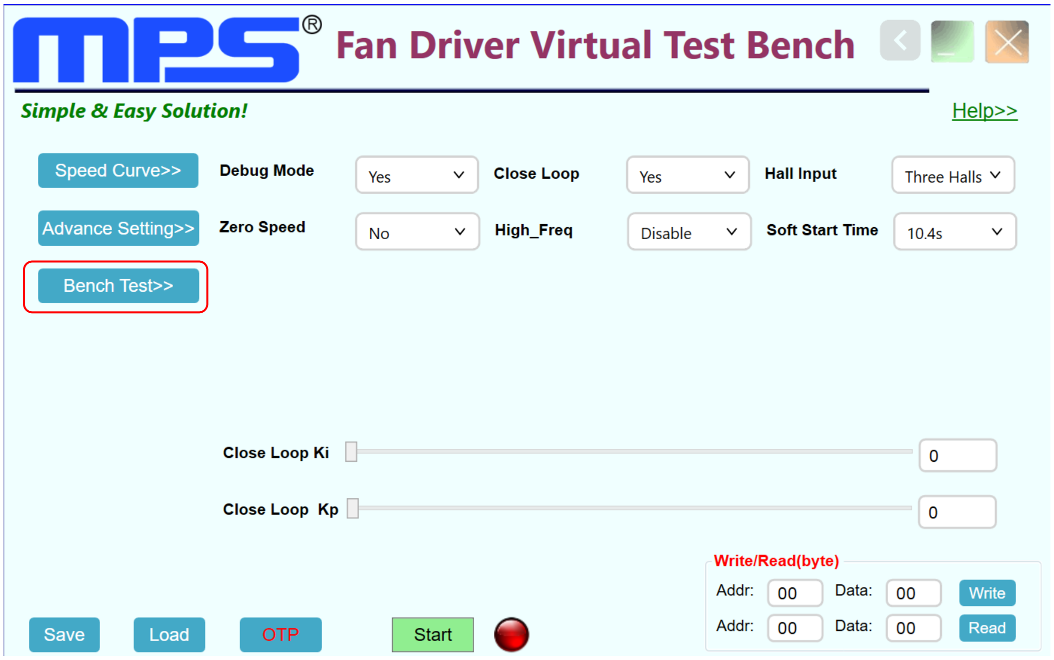


Figure 14: Bench Test Settings

Figure 15 shows how to adjust the PWM duty cycle. On this page, the GUI and communication kit provide the PWM signal and obtain the speed from the FG pin.

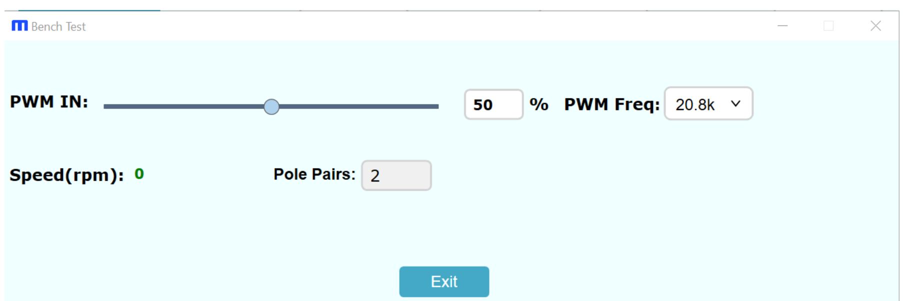


Figure 15: Adjusting the PWM Duty Cycle

Bench Verification

Click “Bench Verification” in the general setting page to run the bench verification (see Figure 16 on page 10). This mode can accomplish the following:

- The GUI and communication kit provide a PWM signal to the motor.
- The FG signal is obtained to calculate and plot the speed curve.

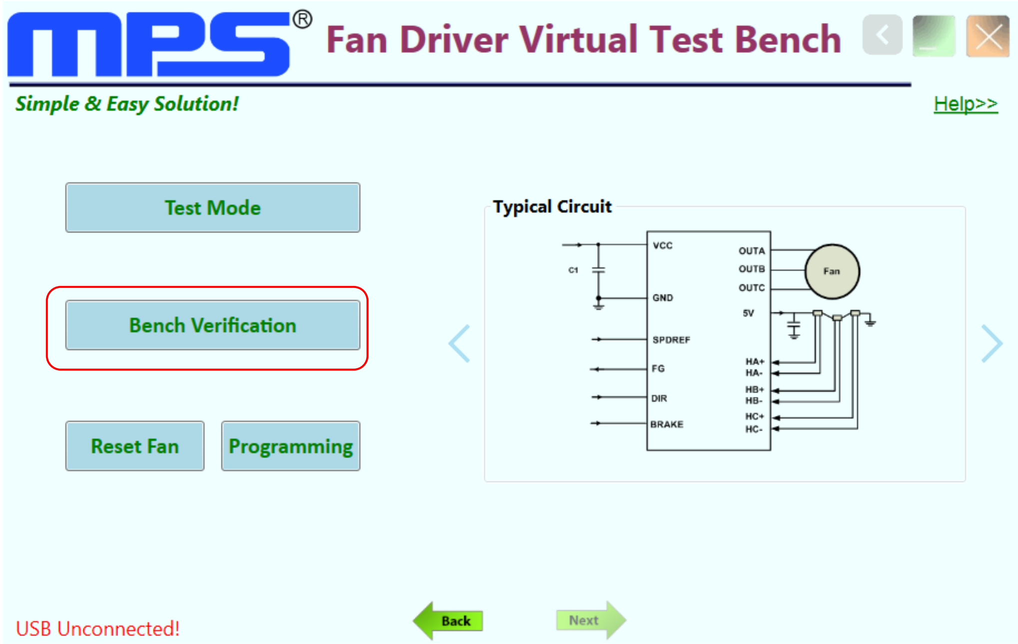


Figure 16: Selecting Bench Verification

Change the PWM duty cycle, then check the speed and current (see Figure 17).

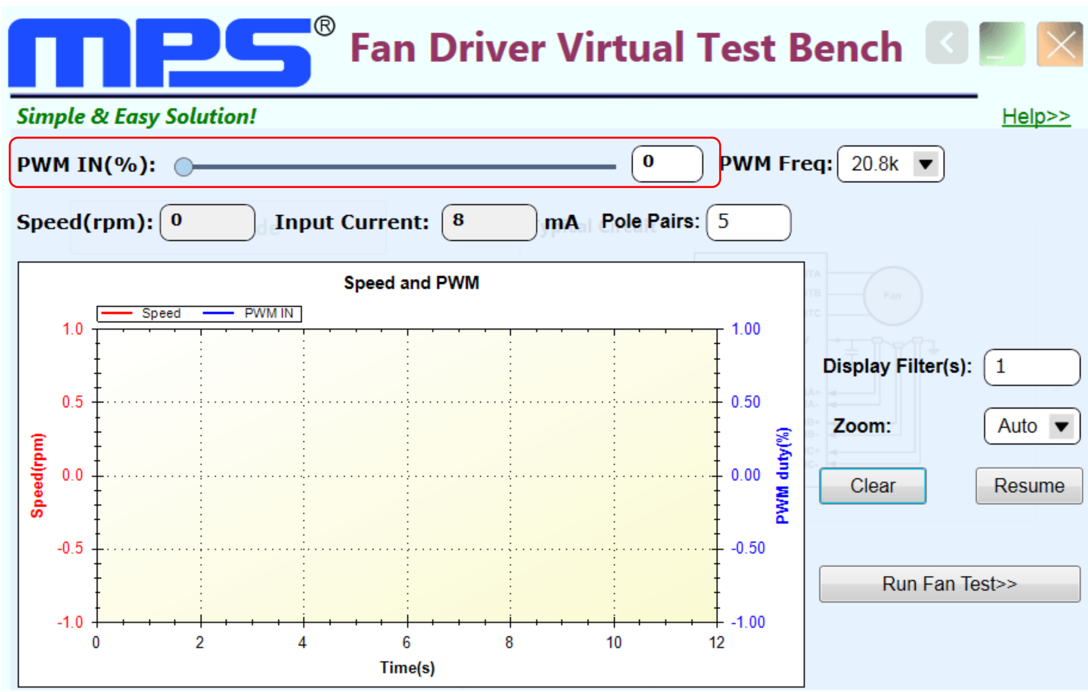


Figure 17: Adjusting the PWM Duty Cycle

The options to adjust the PWM duty cycle are listed below.

1. Clear: Clear the speed and PWM lines, which are displayed on the left window.
2. Pause/Resume: Pause and resume speed curve test, the refreshed speed and PWM line may be displayed on the left window.
3. Run Fan Test: The GUI generates a PWM signal from 100% to 0%, calculates the motor speed, and plots the speed curve in real time.

4. Display Filter: Shows the filter coefficient for the delayed motor speed on the left window.

Click "Run Fan Test". Load a MP6631H register configuration .txt file to initiate a motor speed curve test (see Figure 18).

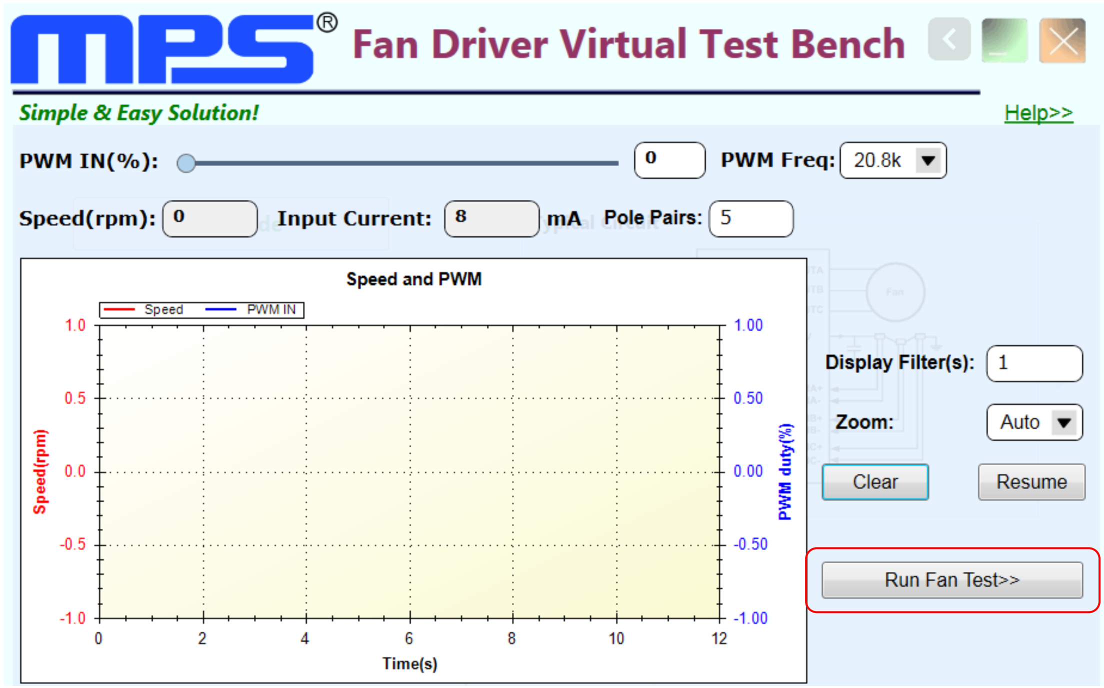


Figure 18: Fan Speed Curve Test

Figure 19 on page 11 shows loading a .txt register configuration file for the speed curve test.

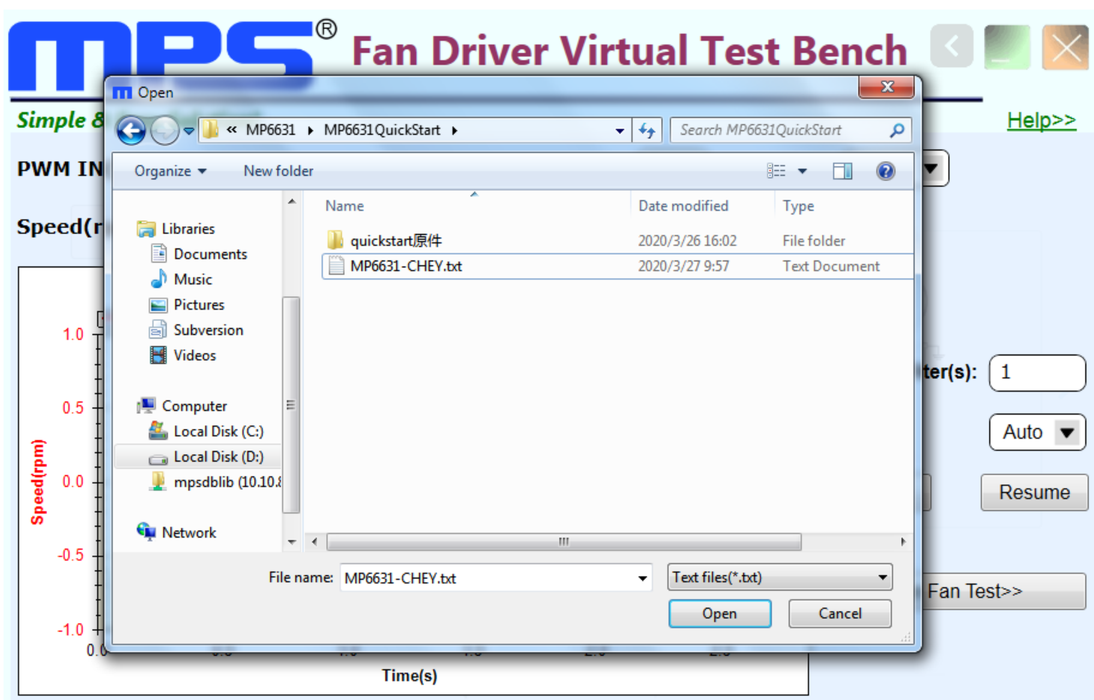


Figure 19: Load a .txt Register Configuration File for Speed Curve Test

Click "Start" to run a motor test (see Figure 20 on page 12).

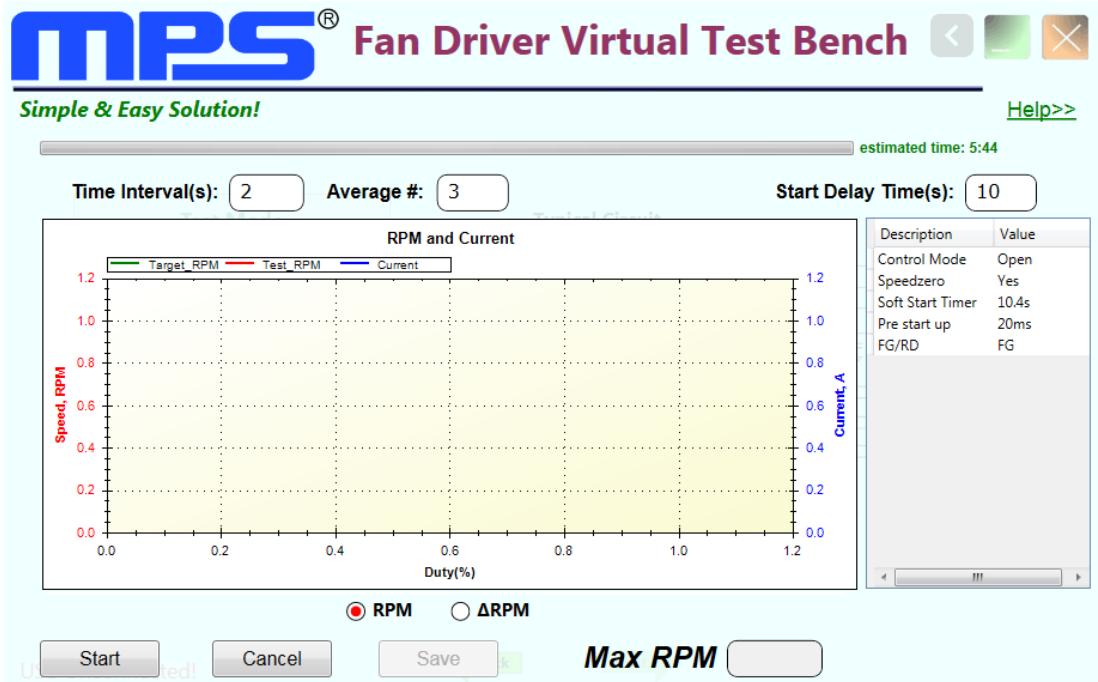


Figure 20: Starting a Motor Speed Test

The options to adjust this test are listed below.

1. Start: Start the test, change the PWM duty from 100% to 0%, then the information should be displayed on the speed and current window.
2. Pause/Resume: Pauses or resumes the test.
3. Cancel: Cancels the test and sends the user to the last window.
4. Save: Saves the speed and current data from a 100% to 0% duty cycle after the test is complete.
5. Time Interval: Sets the interval time between each data point. Additional time intervals can achieve a more stable speed. The default value 2 seconds.
6. Average #: Each data point is the average of three data points. A higher average number provides speed data stability. The default average number is 3.
7. Start Delay Times #: Sets the motor speed-up time to reach the maximum speed. The default value is 10 seconds.

EVALUATION BOARD SCHEMATIC

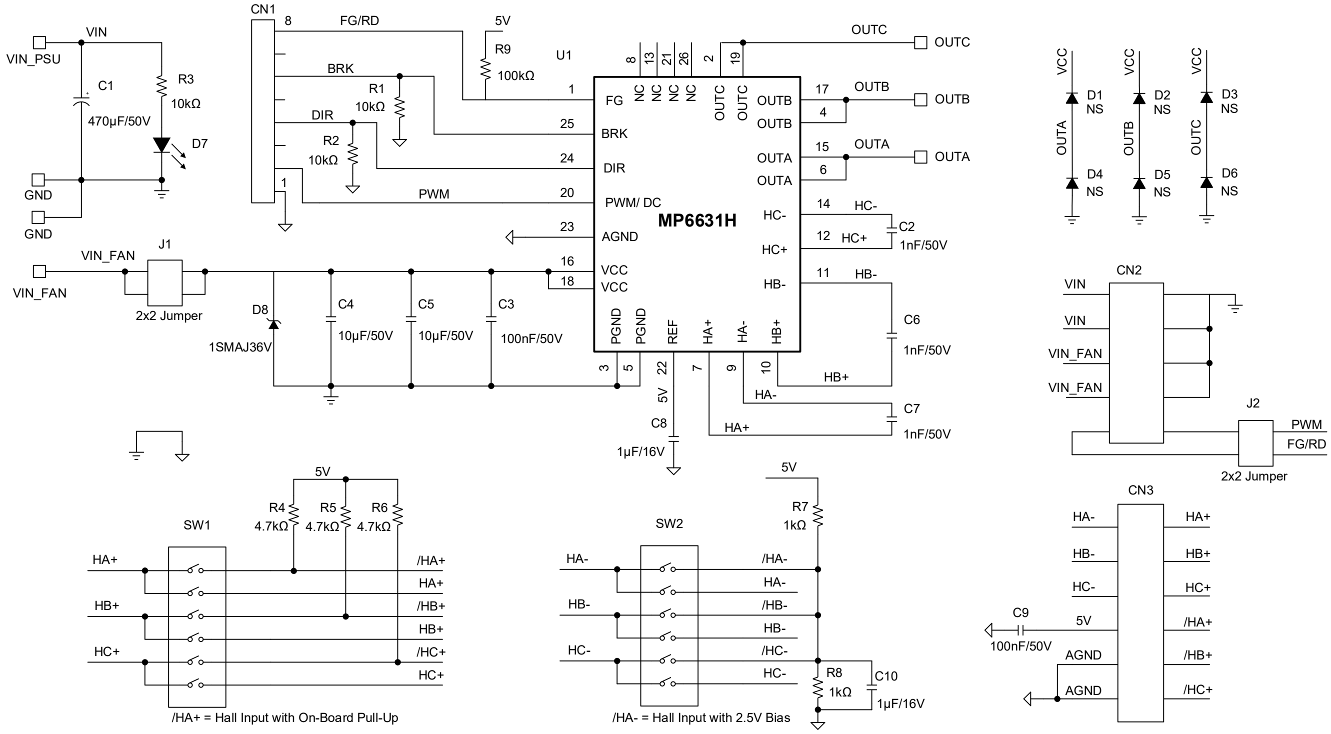


Figure 21: Evaluation Board Schematic

EV6631H-L-00A BILL OF MATERIALS

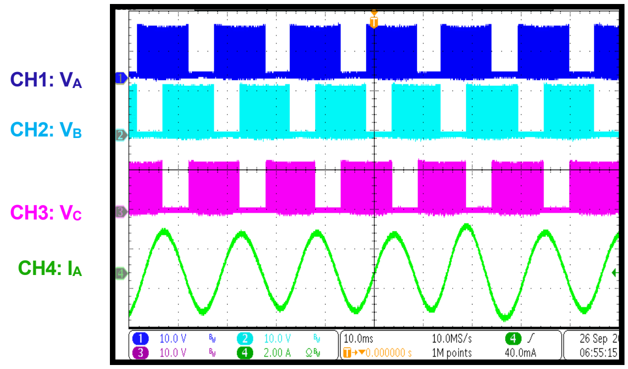
Qty	Ref	Value	Description	Package	Manufacturer	Manufacturer PN
1	C1	470µF, 50V	Electrolytic capacitor, 50V, 470µF	DIP	Wurth	860020675022
3	C2, C6, C7	1nF, 50V	Ceramic capacitor, 50V, X7R	0402	Murata	GCM155R71H102KA37D
2	C3, C9	100nF, 50V	Ceramic capacitor, 50V, X7R	0402	Murata	GRM155R71H104KE14D
2	C4, C5	10µF, 50V	Ceramic capacitor, 50V, X7R	1210	Murata	GRM32ER71H106KA12L
2	C8, C10	1µF, 16V	Ceramic capacitor, 16V, X6S	0402	Murata	GRM155C81C105KE11D
2	R1, R2	10kΩ	Film resistor, 1%	0402	Yageo	RC0402FR-0710KL
1	R3	10kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-0710KL
3	R4, R5, R6	4.7kΩ	Film resistor, 1%	0402	Yageo	RC0402FR-074K7L
2	R7, R8	1kΩ	Film resistor, 1%	0402	Yageo	RC0402FR-071KL
1	R9	100kΩ	Film resistor, 1%	0402	Yageo	RC0402FR-07100KL
6	D1, D2, D3, D4, D5, D6	NC				
1	D7	Red	Red LED	0603	Bright LED	BL-HUE36A-AV-TRB
1	D8	36V, 6.9A	TVS diode	SMA	Semtech	1SMA36A
7	GND1, GND2, VIN_FAN, VIN_PSU, OUTA, OUTB, OUTC	2mm connector	2mm connector	DIP	Any	
1	CN1	8-pin	Connector, header, 1x8-pin, 2.54mm	DIP	Any	
1	CN2	5-pin	Header, 5-pin, dual-row, with frame	DIP	Any	
1	CN3	6-pin	Connector, 2x6-pin, 2.54mm	DIP	Any	
2	J1, J2	2-pin	Connector, jumper, 2x2-pin, 2.54mm	DIP	Any	
2	SW1, SW2	1.27mm	6 positions, 1.27mm pitch switch	SMD	Wurth	416131160806
1	U1	MP6631H	3-phase motor driver with Hall input	QFN-26 (3mmx 4mm)	MPS	MP6631HGL

EVB TEST RESULTS

Performance curves and waveforms are tested on the evaluation board, V_{IN} = 12V, PWM frequency = 20kHz, with 1 external Hall sensor or 3 external Hall sensors, unless otherwise noted.

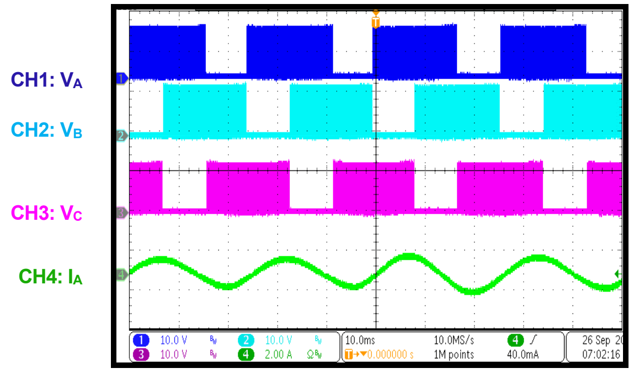
Steady State

PWM duty cycle = 100%, DIR = low, counterclockwise



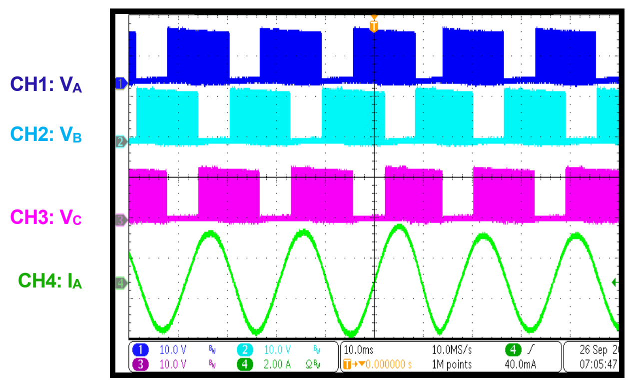
Steady State

PWM duty cycle = 50%, DIR = low, counterclockwise



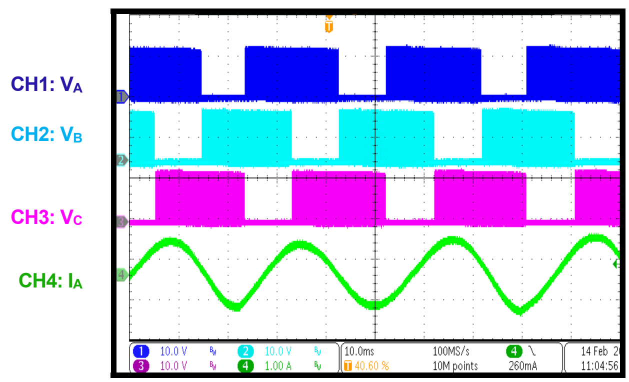
Steady State

PWM duty cycle = 100%, DIR = high, clockwise



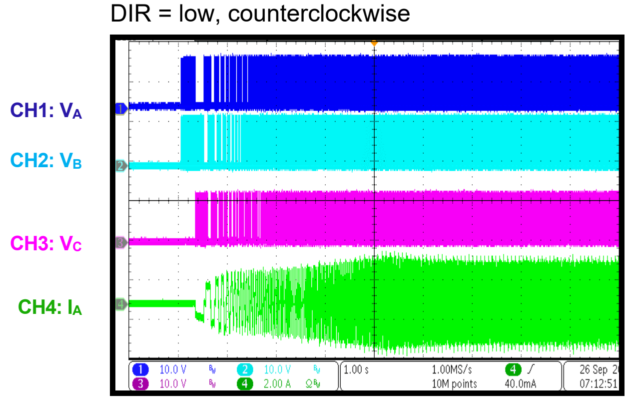
Steady State

PWM duty cycle = 50%, DIR = high, clockwise



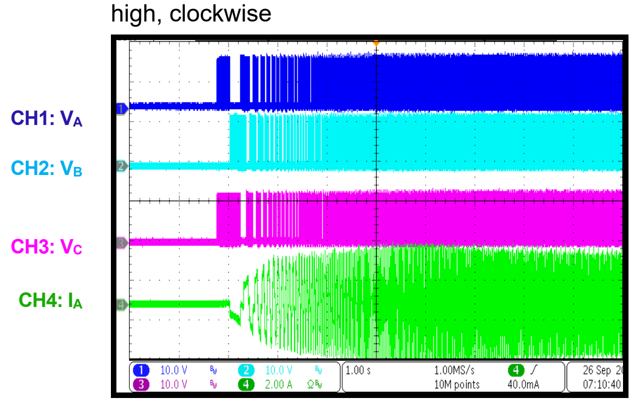
PWM On

PWM duty cycle = 0% to 100%, 3 Hall sensors, DIR = low, counterclockwise



PWM On

PWM duty = 0% to 100%, 3 Hall sensors, DIR = high, clockwise

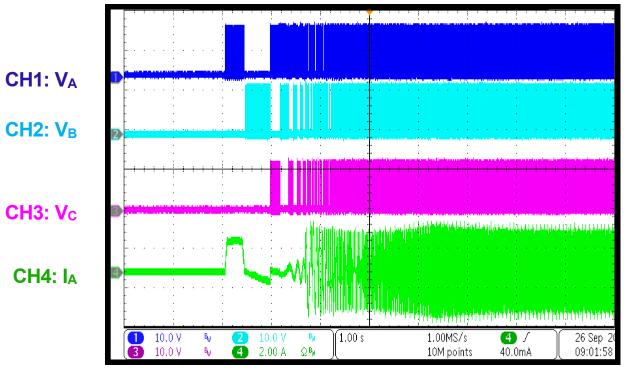


EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board, V_{IN} = 12V, PWM frequency = 20kHz, with 1 external Hall sensor or 3 external Hall sensors, unless otherwise noted.

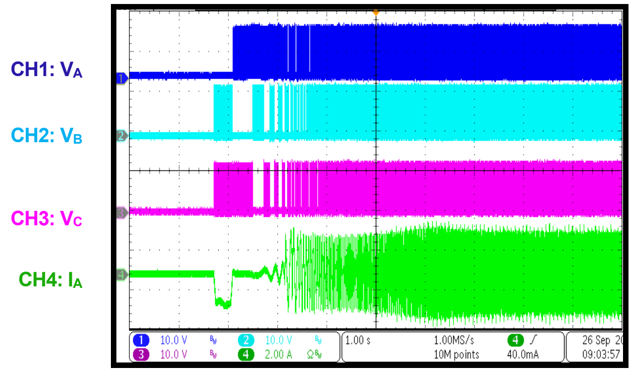
PWM On

PWM duty cycle = 0% to 100%, 1 Hall sensor, DIR = low, counterclockwise



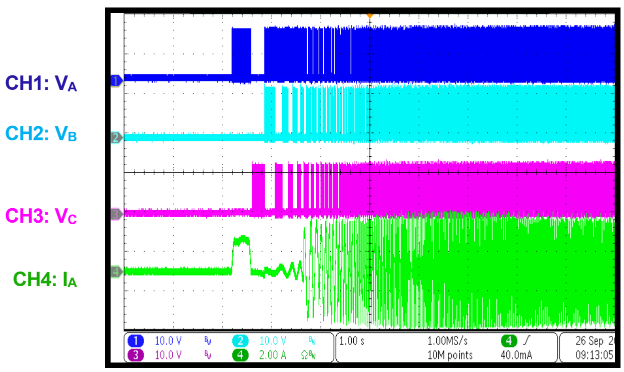
PWM On

PWM duty = 0% to 100%, 1 Hall sensor, DIR = low, counterclockwise



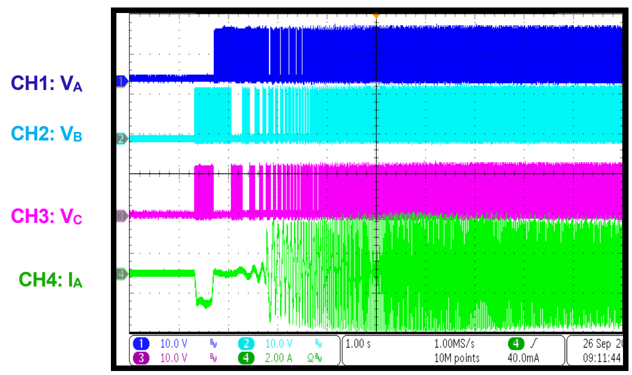
PWM On

PWM duty cycle = 0% to 100%, 1 Hall sensor, DIR = high, clockwise



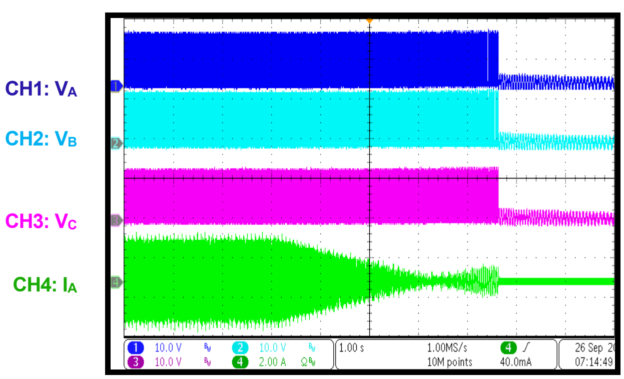
PWM On

PWM duty cycle = 0% to 100%, 1 Hall sensor, DIR = high, clockwise



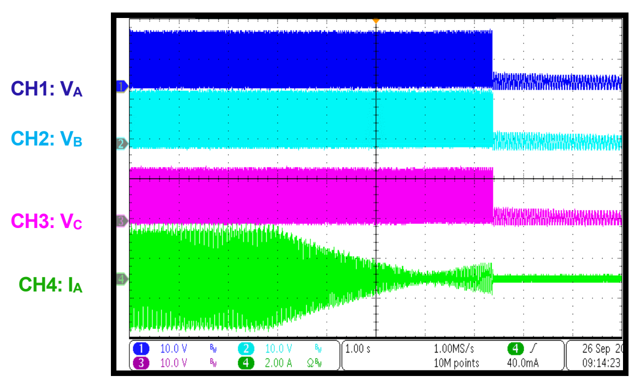
PWM Off

PWM duty cycle = 100% to 0%, DIR = low, counterclockwise



PWM Off

PWM duty cycle = 100% to 0%, DIR = high, clockwise

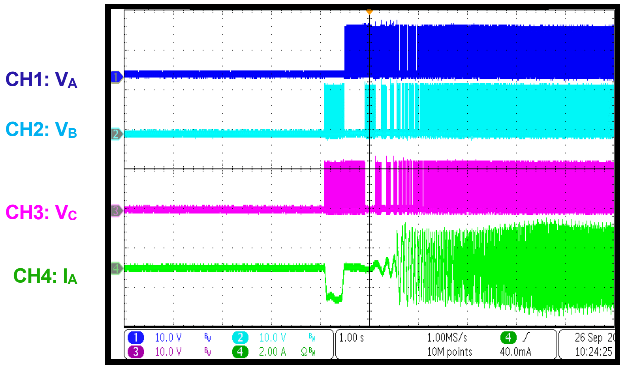


EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board, V_{IN} = 12V, PWM frequency = 20kHz, with 1 external Hall sensor or 3 external Hall sensors, unless otherwise noted.

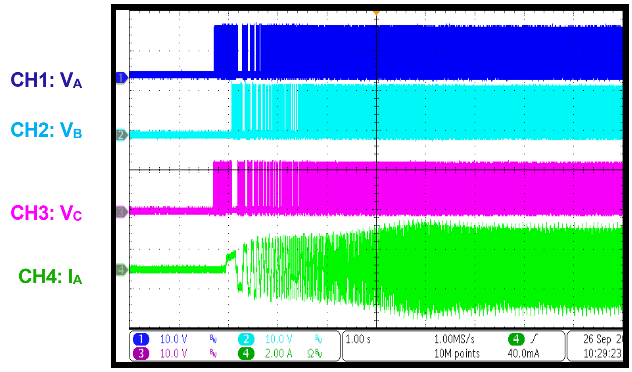
Start-Up through VCC

V_{CC} = 0V to 12V, PWM duty cycle = 100%, 1 Hall sensor, DIR = low, counterclockwise



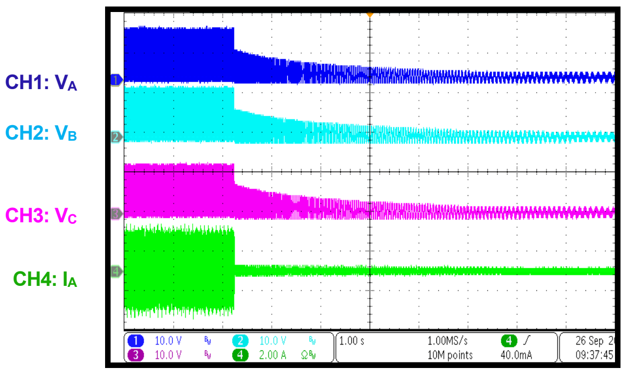
Start-Up through VCC

V_{CC} = 0V to 12V, PWM duty cycle = 100%, 3 Hall sensor, DIR = low, counterclockwise



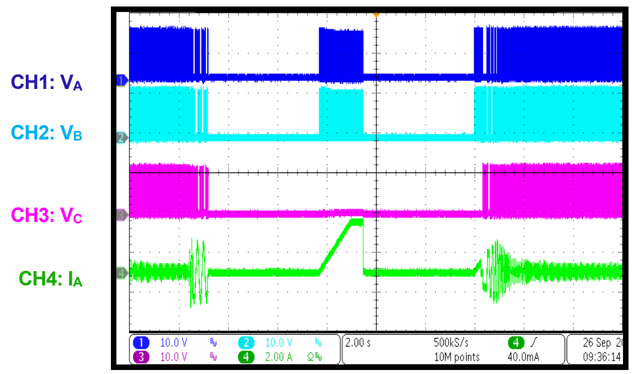
Shutdown through VCC

V_{CC} = 12V to 0V, PWM duty cycle= 100%, DIR = low, counterclockwise



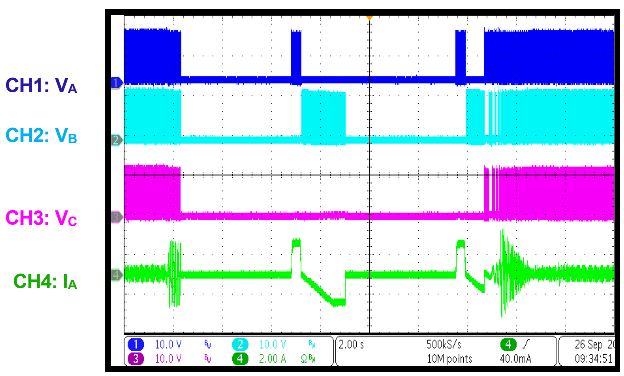
Lock and Retry

PWM duty cycle = 25%, 3 Hall sensors, lock rotor then release



Lock and Retry

PWM duty cycle = 25%, 1 Hall sensor, lock rotor then release



PCB LAYOUT

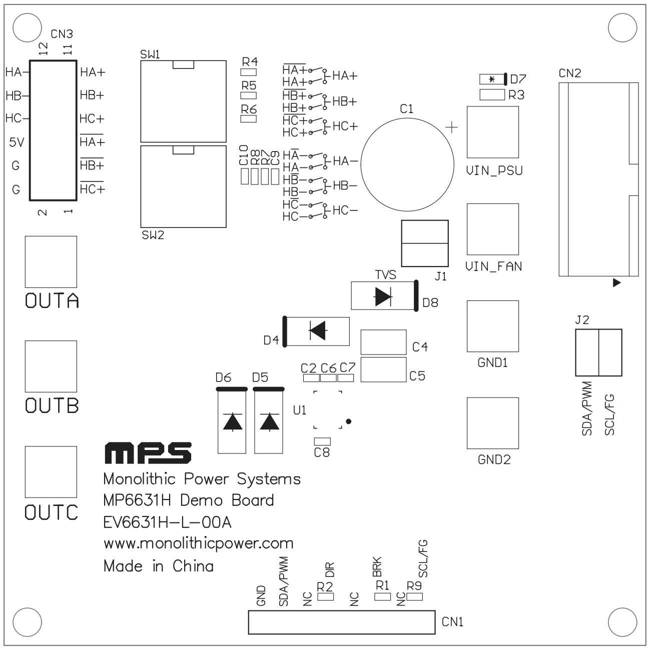


Figure 22: Top Silk

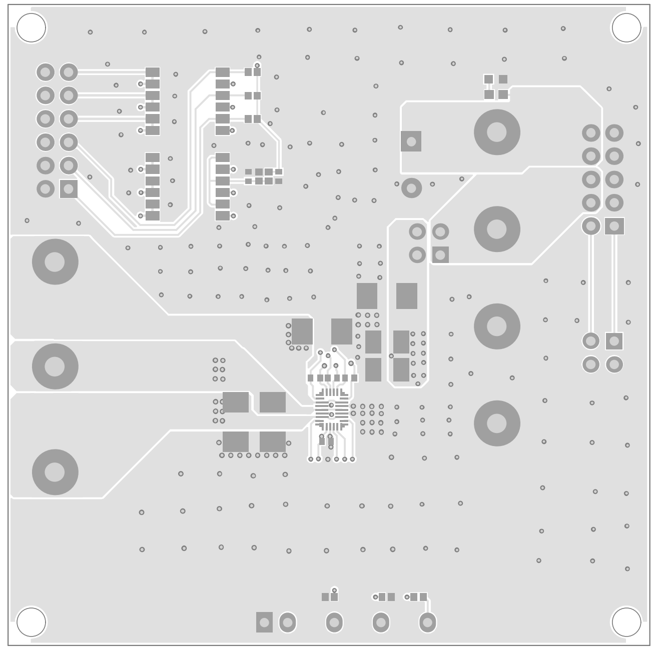


Figure 23: Top Layer

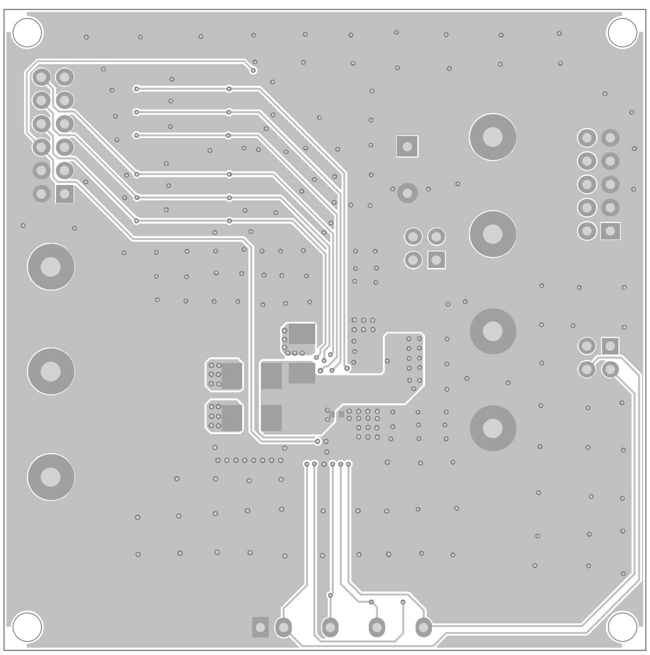


Figure 24: Bottom Layer

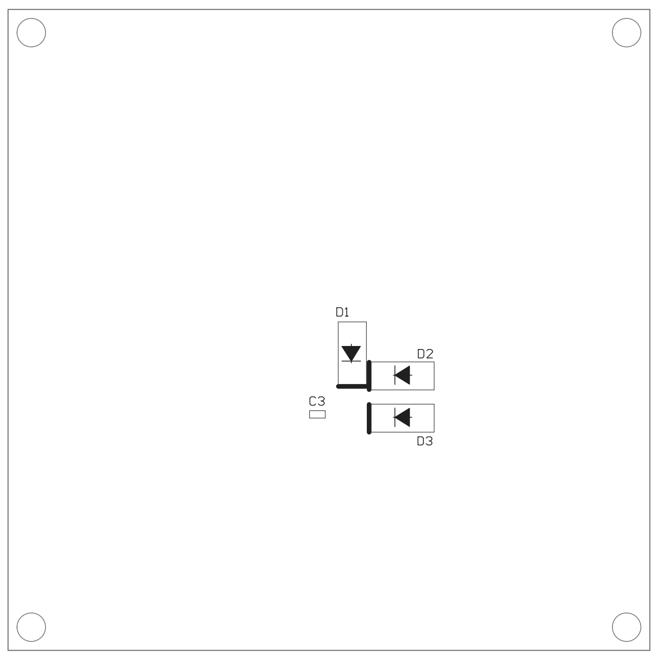


Figure 25: Bottom Silk

REVISION HISTORY

Revision #	Revision Date	Description	Pages Updated
1.0	2/22/2022	Initial Release	-