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LV8961 start up setting for EVB and GUI

Sensor and Actuator ICs BU

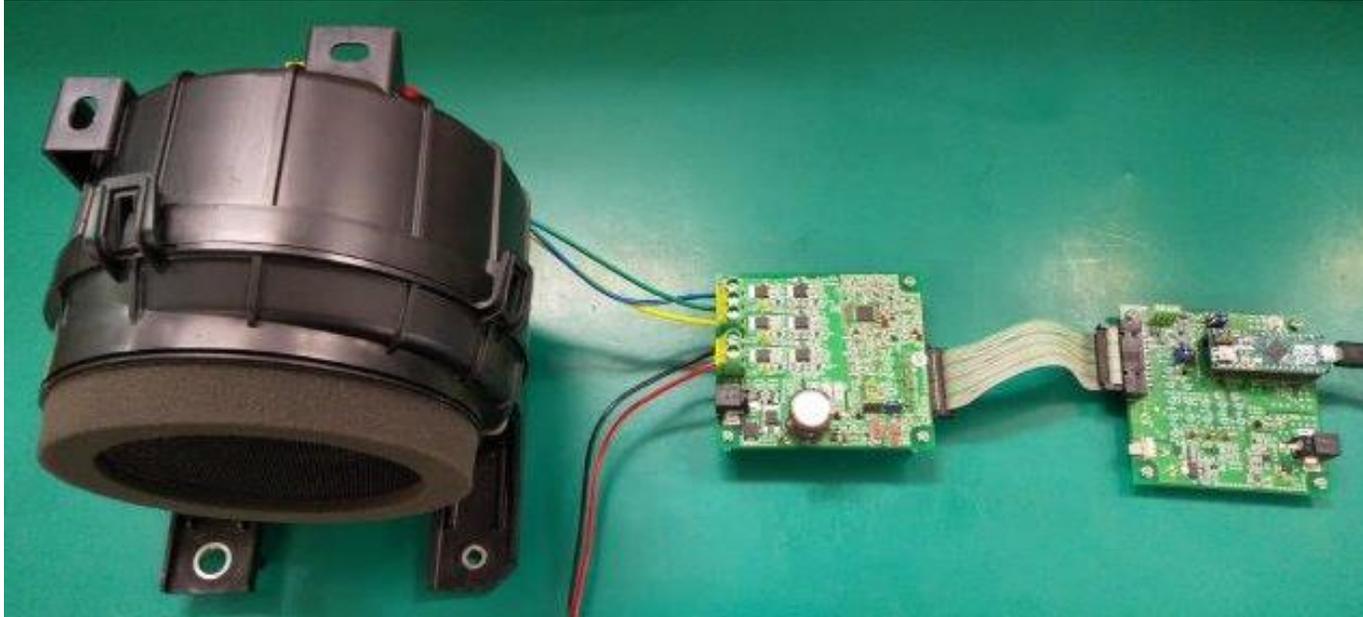
Feb, 2021

Public Information



LV8961 Evaluation board set up

This document presents a typical procedure for rotating the motor using the LV8961 GUI and the communication board. Minimum requirement of parameter tuning for a very first trial is assumed.



Left: Connect motors U, V, W to EVB's U, V, W. COM (black line) may not be connected

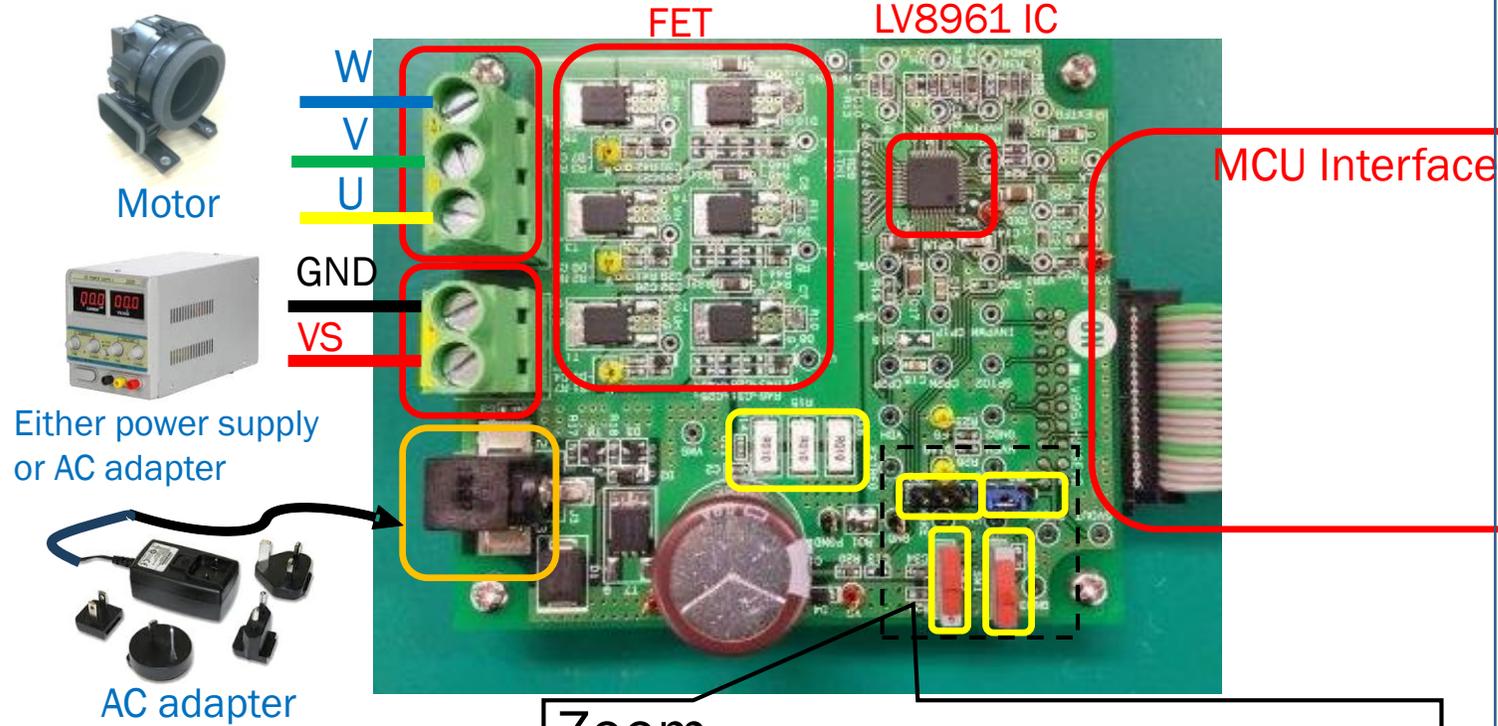
Center: Connect to power supply with VS-PGND. Apply 12V

Right: Communication board: Connect to PC via USB (USB-micro)

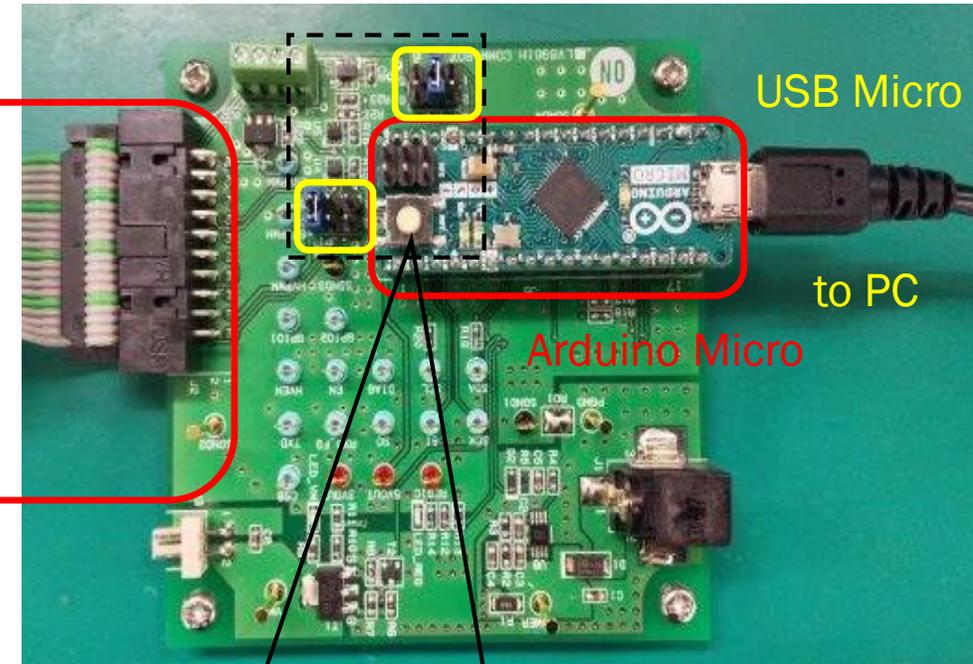
Connect the EVB and the communication board with the supplied connector cable.

LV8961 evaluation board and communication board

LV8961 evaluation board



Communication board (SPI - USB)



Zoom

SW1 set to L and SW2 set to H

JP1 is open

JP2 is short 2 to 3.

SW2:WAKE SW1:EN

Public Information

Zoom

JP2 is short 3 to 4.

JP1 is short 5 to 6.



Setting Motor parameter :Current Limit

Set the current limit according to the motor specifications and operating conditions.

The current limit is determined by the current sense resistors on the EVB: R14, R15, R16 and the internal register: CLSEL.

The current limit is given by the following equation.

$$I_{lim_1} = V_{CL} \times \frac{1}{R_{CS}}$$
$$R_{CS} = \frac{1}{\frac{1}{R14} + \frac{1}{R15} + \frac{1}{R16}}$$

$$CLSEL=1 \Rightarrow V_{CL} = 100mV$$

$$CLSEL=0 \Rightarrow V_{CL} = 50mV$$

It is set that current limit is 30A in this board.

Because 3 resistors of 10mohm connect to parallel.

Initial limit threshold voltage V_{CL} is 100mV.



R14,R15,R16

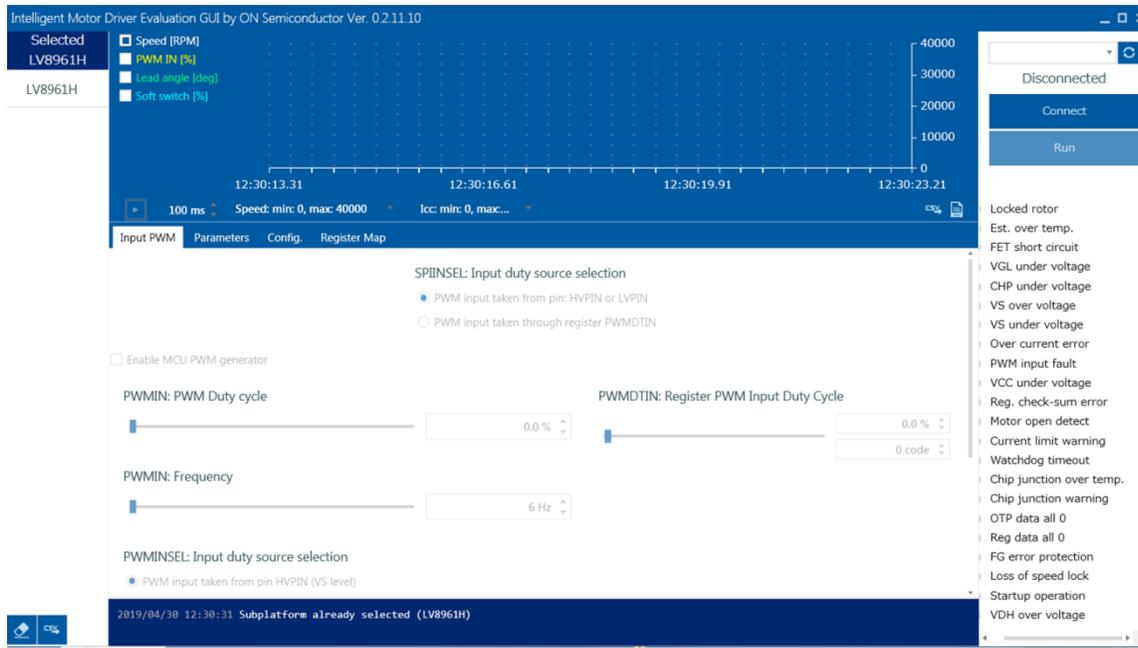
Set up GUI for LV8961 EVB

1. Install the GUI program

Install the LV8961H_GUI_0_2_11_16.zip

Please contact ONSEMI Sales for information on obtaining the GUI program.

Note: The file name may change.

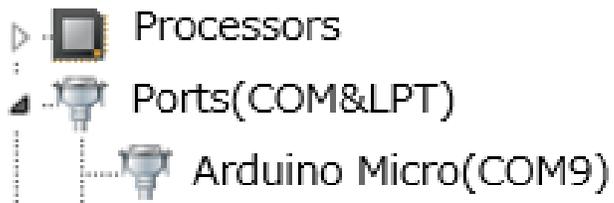


DEVICE DRIVER AND PROGRAM INSTALLATION

1. Obtain the GUI program(LV8961H_GUI_0_2_11_16.zip).
2. Unzip the program package
3. Confirm that the SW1 on the LV8961 EVB is L and SW2 is H.
4. Connect the power supply VS to the LV8961 EVB
5. Connect the Communication EVB to the PC using the USB micro cable.

Steps 4 to 12 show the driver installation procedure. It is required only for the first time when the LV8961 EVB is connected to the USB port.

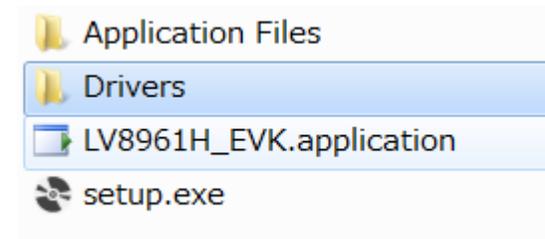
6. The Windows OS will try to install driver on its own. Wait for 5-10 minutes. Installation will fail.
7. Click on the Start Menu, and open the Control Panel.
8. Open the Device Manager.
9. Either under 'Ports (COM & LPT)' or 'Other Devices', you should see an open port named 'Arduino Micro'.



10. Right click on the 'Arduino Micro' port and choose the 'Update Driver Software' option. a. If the update driver software option is not available, then the Windows OS is still trying to install the driver on its own. Please wait till the OS finishes self-try.

11. Next, choose the "Browse my computer for Driver software" option.

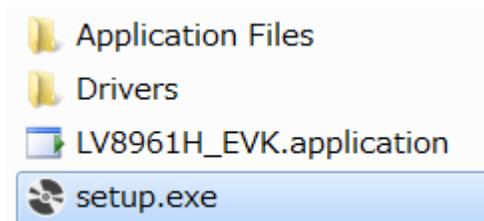
12. Finally, navigate to and select the driver file named 'arduino.inf', located in the 'Drivers' folder.



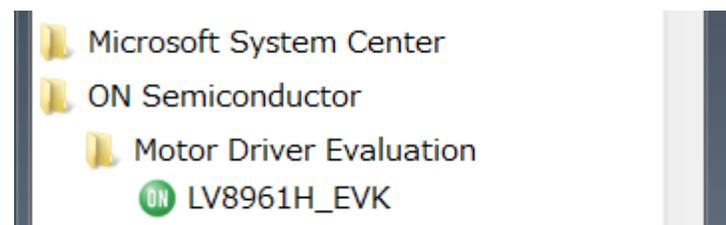
13. Windows will finish up the driver installation from there.

14. When the installation is successful, the recognized Arduino Micro port with the port number is shown in the Device Manager.

15. Run setup.exe of the installation package

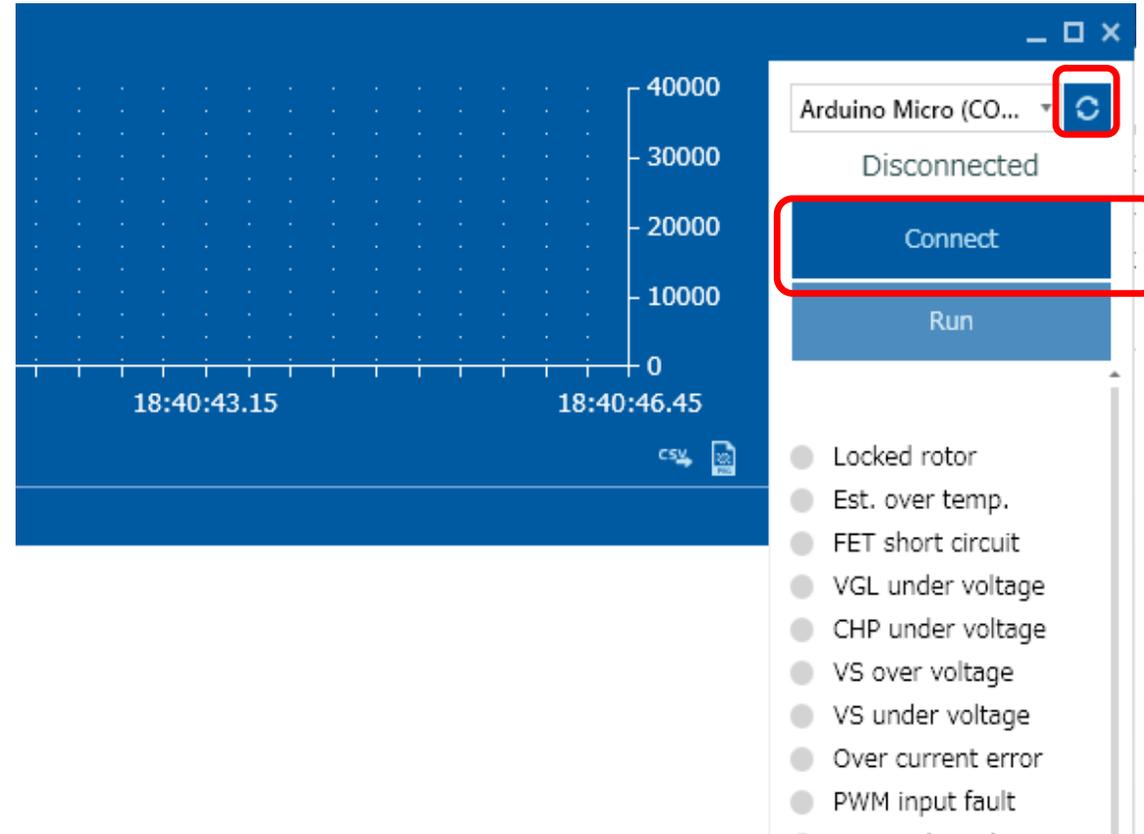


16. Launch the program



GUI for LV8961 EVB

1. Connect a USB cable to the microprocessor on the communication board
Click the  button
and “Connect” button on the upper right.
2. Supply a voltage(6V-28V) to VS of LV8961 evaluation board.



GUI for LV8961 EVB

3. Register setting with external file

In this document, it is assumed that the configuration file prepared by ON Semiconductor will be imported first, which selects the driving mode of one BEMF detection window per electrical cycle. Please refer to the appendix for the details of the number of windows.

Select the Register Map tab and click "Import from file".

Name	7	6	5	4	3	2	1	0
- GSDAT	ORBEN	SACF	DIAGS	LATCH	OBSY		SMOD	
0x0000 MRACK0	0	1	0	1	0	1	0	1
0x0001 MRACK1	1	0	1	0	1	0	1	0
0x0002 MRSPCT0	0	0	CLSEL	CLDWNOFF		OCSEL		CLMSPD
0x0003 MRSPCT1	0	0				SSIT		
0x0004 MRSPCT2					STOSC			
0x0005 MRSPCT3	SLMD	0	0			LASET_L		
0x0006 MRSPCT4	0	0	0			LASET_H		
0x0007 MRSPCT5	0	0	0			LASET_LIM		
0x0008 MRSPCT6			MSKRST0_6				MSKRST1_6	

- VGL under voltage
- CHP under voltage
- VS over voltage
- VS under voltage
- Over current error
- PWM input fault
- VCC under voltage
- Reg. check-sum error
- Motor open detect
- Current limit warning
- Watchdog timeout
- Chip junction over temp.
- Chip junction warning
- OTP data all 0
- Prog data all 0

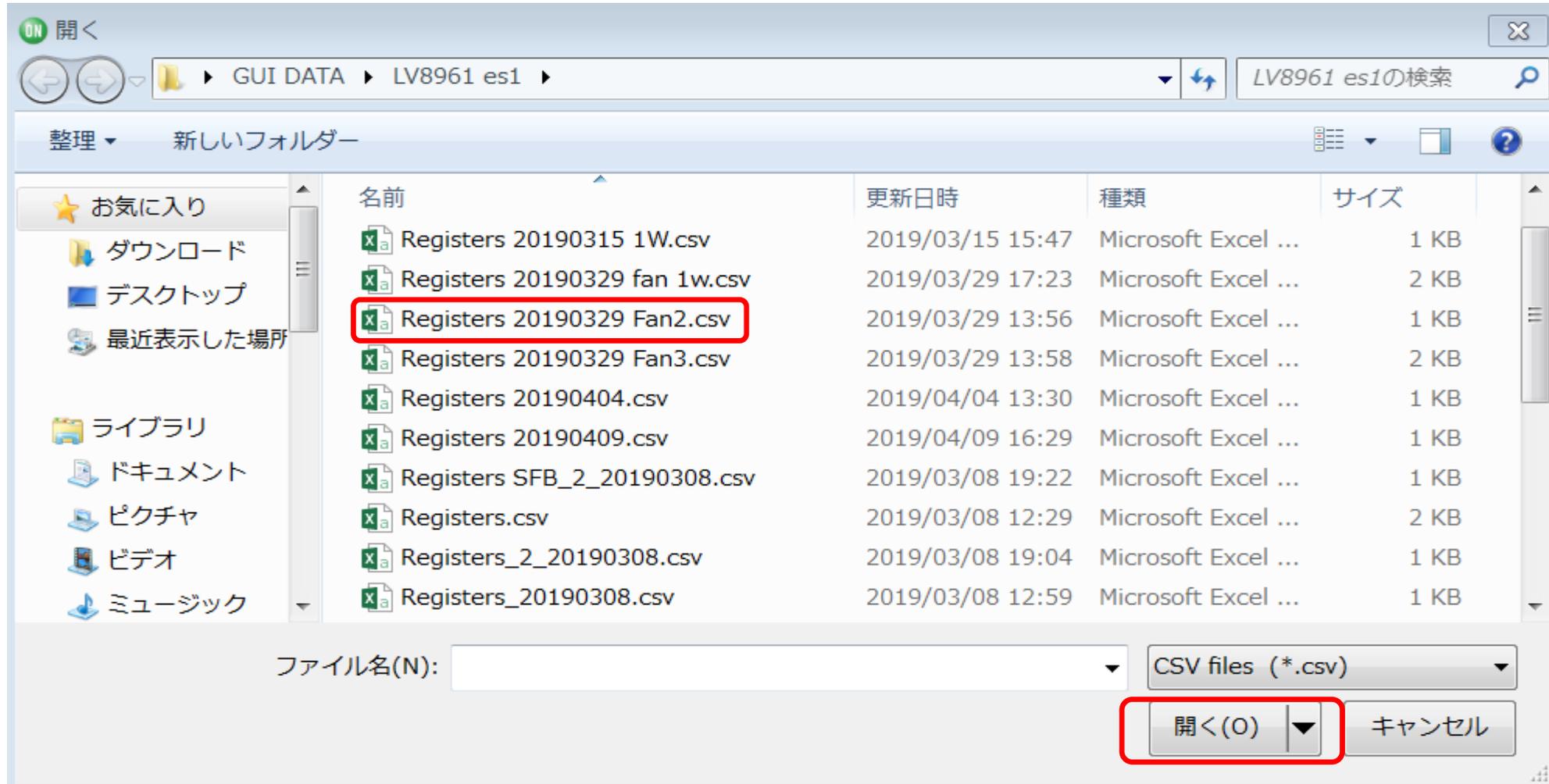
Each register can change in "Config tab" or "Resister Map".



GUI for LV8961 EVB

Note: The file name may be changed by case.

- a) Select External file
Select "Registers 20190329 Fan2.csv"
Click open(開く)



GUI for LV8961 EVB

3. By clicking the RECALC bit, the register value is reflected in the actual operation.

0x0010	MRSPECT14	0				TAG_L_1			
0x0011	MRSPECT15					TAG_H_0			
0x0012	MRSPECT16	0				TAG_H_1			
0x0013	MRSPECT17	0	0	0	0	0	0	0	RECALC
0x0015	MRSPECT19	0	0	0	0	0	0	0	WINDSEL
0x0016	MRSPECT20		MSKRSTNUM0_INI				MSKRSTNUM1_INI		
0x0017	MRSPECT21		MSKRSTNUM0_THR				MSKRSTNUM1_THR		
0x0018	MRSPECT22		MSKRSTNUM0_TWO				MSKRSTNUM1_TWO		
0x0019	MRSPECT23		MSKRSTNUM0_ONE				MSKRSTNUM1_ONE		

RECALC: Trigger for updating target speed setting

RECALC=0: No operation.

RECALC=1: Update latched values (SCEN, DUTY_L, DUTY_H, TAG_L and TAG_H) in the target speed calculation module and RECALC will be cleared automatically.

Please click RECALC when (SCEN, DUTY_L, DUTY_H, TAG_L and TAG_H) is changed.



Overall sequence of register setting tuning

1. Set motor parameters. Number of poles and the current sense resistance.
2. Set drive mode (sinusoidal or trapezoidal)
3. Set speed curve full span (output duty cycle 0 to 100% responding to 0 to 100% input, in open-loop linear control)
4. Set input PWM duty cycle 30% for the first try
5. Set the initial open-loop commutation frequency STOSC, 100ms interval
6. Set soft-start parameters: 2 seconds timeout, current ramp control, starting from 0%
7. Set the dead time FDTI, maximum (if the power FET and gate circuit is different from ON EVB.)
8. Run
9. Tune the mask width and delay from zero cross detection to commutation



1. Setting Motor parameter

Select “Parameters” tab.

1.Set number of poles for motor in “Number of poles”.

ex.10poles motor setting is 10.

2.Set current sense resistance(R_{CS}) on the board.

ex.3mohm resistance on the board sets 3mohm.

3.Click “update values”.

The screenshot shows a web-based configuration interface for a motor. At the top, there are four tabs: 'Input PWM', 'Parameters', 'Config.', and 'Register Map'. The 'Parameters' tab is active and highlighted with a red box. Below the tabs, there are several parameter settings, each with a text input field and a dropdown menu. The 'Number of poles' is set to 10, and 'Current sense resistance on the board' is set to 3 mΩ. Other parameters include '(RESERVED) Phase Resistance' (1 mΩ), '(RESERVED) Torque Constant' (1 Nm/A), and 'Timeout of USB communication: increase value for very slow PC' (7,000 ms). At the bottom right, there are three buttons: 'Save parameters' (with an 'Export' sub-button), 'Load parameters' (with an 'Import' sub-button), and 'Update values'. The 'Update values' button is highlighted with a red box.

2. Set Drive mode (Sinusoidal or trapezoidal)

Select “Config” tab. Click Edit mode.

The screenshot displays a configuration interface for a motor drive. At the top, there are four tabs: 'Input PWM', 'Parameters', 'Config.', and 'Register Map'. The 'Config.' tab is selected and highlighted with a red box. Below the tabs, the interface is divided into several sections for parameter adjustment:

- Input PWM:** A dropdown menu showing '75 mV' and a '0 code' spinner.
- STTT: Soft start time setting:** A slider and a spinner showing '3.366 s' and '32 code'.
- STOSC: Startup communication period:** A slider and a spinner showing '74.752 ms' and '72 code'.
- SLMD: Sinusoidal vs. trapezoidal drive mode:** Two radio buttons: 'Trapezoidal 120 degree' (unselected) and 'Sinusoidal w/6 windows w/ BEMF' (selected).
- LASET_L: lead angle at Output PWM 0%:** A slider and a spinner showing '0.0 deg' and '0 code'.
- LASET_H: lead angle at Output PWM 100%:** A spinner showing '0.0 deg'.
- LASET_LIM: lead angle max limit:** A spinner.

At the bottom right, there are two buttons: 'Write to NVM' and 'Edit mode'. The 'Edit mode' button is highlighted with a red box.

2. Set Drive mode (Sinusoidal or trapezoidal)

Select “Sinusoidal” Click “Update values.”

The screenshot shows a configuration window with four tabs: "Input PWM", "Parameters", "Config.", and "Register Map". The "Config." tab is active. The interface contains several parameter settings, each with a slider and two input fields (one for a numerical value and one for a code value). The "SLMD: Sinusoidal vs. trapezoidal drive mode" section is highlighted with a red box and contains two radio button options: "Trapezoidal 120 degree" (unselected) and "Sinusoidal w/6 windows w/ BEMF" (selected). Other parameters include SSTT (2.040 s, 19 code), STOSC (100.352 ms, 97 code), LASET_L (3.8 deg, 2 code), LASET_H (52.5 deg, 28 code), and LASET_LIM (52.5 deg, 28 code). At the bottom right, the "Update values" button is highlighted with a red box, and a "Cancel" button is also visible.

Parameter	Value	Code
SSTT: Soft start time setting	2.040 s	19 code
STOSC: Startup communication period	100.352 ms	97 code
SLMD: Sinusoidal vs. trapezoidal drive mode	Sinusoidal w/6 windows w/ BEMF	-
LASET_L: lead angle at Output PWM 0%	3.8 deg	2 code
LASET_H: lead angle at Output PWM 100%	52.5 deg	28 code
LASET_LIM: lead angle max limit	52.5 deg	28 code

3. Set speed curve full span

Select "Config" tab. Click Edit mode.

The screenshot shows a configuration interface with a top navigation bar containing 'Input PWM', 'Parameters', 'Config.', and 'Register Map'. The 'Config.' tab is highlighted with a red box. The main area is divided into four sections:

- DUTY_L: Input duty lower side**: A slider is positioned at the far left. To its right are two input fields: '0.098 %' and '0 code', both with up/down arrows.
- DUTY_H: Input duty upper side**: A slider is positioned at the far right. To its right are two input fields: '99.900 %' and '255 code', both with up/down arrows.
- TAG_L: minimum speed**: A slider is positioned at the far left. To its right are two input fields: '16 rpm' and '8 code', both with up/down arrows.
- TAG_H: maximum speed**: A slider is positioned in the middle. To its right are two input fields: '14,000 rpm' and '7,000 code', both with up/down arrows.

At the bottom, there are two radio button groups:

- FRMD: Motor rotation direction**: 'Forward' is selected with a blue dot, and 'Reverse' is unselected with a white dot.
- FRREN: Free-run detection enable**: 'Motor will start with a BEMF detection' is selected with a blue dot, and 'Motor will start open loop with startup parameters' is unselected with a white dot.

In the bottom right corner, there are two blue buttons: 'Write to NVM' and 'Edit mode'. The 'Edit mode' button is highlighted with a red box.



To simplify tuning, set Duty_L and Duty_H as follows. Later, it can be changed to proper values to match the target application. Minimize the Duty_L slider and maximize DUTY_H. Click “Update values”

The screenshot shows a configuration window with a dark blue header containing tabs: "Input PWM", "Parameters", "Config.", and "Register Map". The "Config." tab is active. The interface is divided into four main sections:

- DUTY_L: Input duty lower side:** A slider is positioned at the far left. A red arrow points from the left edge of the slider to the left, with a callout box labeled "minimam". To the right of the slider are two input fields: "0.098 %" and "0 code".
- DUTY_H: Input duty upper side:** A slider is positioned at the far right. A red arrow points from the right edge of the slider to the right, with a callout box labeled "maximum". To the right of the slider are two input fields: "99.900 %" and "255 code".
- TAG_L: minimum speed:** A slider is positioned at the far left. To the right are two input fields: "16 rpm" and "8 code".
- TAG_H: maximum speed:** A slider is positioned in the middle. To the right are two input fields: "14,000 rpm" and "7,000 code".

Below these sections are two radio button groups:

- FRMD: Motor rotation direction:** "Forward" is selected.
- FRREN: Free-run detection enable:** "Motor will start with a BEMF detection" is selected.

At the bottom right, there are two buttons: "Update values" (highlighted with a red box) and "Cancel". A status bar at the very bottom displays the text: "2019/07/02 12:46:55 Device online status changed to 'Online'".



4.PWM setting

Select "Input PWM" tab. Click Edit mode.

Input PWM Parameters Config. Register Map

SPIOINSEL: Input duty source selection

- PWM input taken from pin: HVPIN or LVPIN
- PWM input taken through register PWMDTIN

Enable MCU PWM generator

PWMIN: PWM Duty cycle

PWMDTIN: Register PWM Input Duty Cycle

PWMIN: Frequency

PWMINSEL: Input duty source selection

- PWM input taken from pin HVPIN (VS level)
- PWM input taken from pin LVPIN (logic level)

PWMON: PWM input signal level

Edit mode



Select PWM input taken from pin : HVPIN or LVPIN.

Click “Enable MCU PWM generator”.

Input Value of PWM duty cycle or Frequency.

Click Update values.

Input PWM Parameters Config. Register Map

Enable MCU PWM generator

PWMIN: PWM Duty cycle

PWMIN: Frequency

PWMDTIN: Register PWM Input Duty Cycle

PWMINSEL: Input duty source selection

PWMON: PWM input signal level

Update values Cancel

SPIINSEL: Input duty source selection

- PWM input taken from pin: HVPIN or LVPIN
- PWM input taken through register PWMDTIN

PWM Duty is recommended to start from about 30%.



5&6 Adjustment SSTT(soft start time) & STOSC(startup commutation frequency)

Adjust SSTT and STOSC in the case of a motor does not rotate with initial configuration file, or to adjust the start up time and inrush current.

“SSTT” is soft start time, “STOSC” is startup commutation period. They are set by internal registers. Select Config tab. Click Edit mode.

The screenshot shows a configuration interface with a top navigation bar containing 'Input PWM', 'Parameters', 'Config.', and 'Register Map'. The 'Config.' tab is highlighted with a red box. Below the navigation bar, there are six parameter settings, each with a slider and two input fields (one for a numerical value and one for a code value):

- SSTT: Soft start time setting**: Slider at approximately 25%. Input fields: 2.958 s and 28 code.
- STOSC: Startup communication period**: Slider at approximately 25%. Input fields: 100.352 ms and 97 code.
- SLMD: Sinusoidal vs. trapezoidal drive mode**: Radio buttons for 'Trapezoidal 120 degree' and 'Sinusoidal w/6 windows w/ BEMF' (selected).
- LASET_L: lead angle at Output PWM 0%**: Slider at approximately 10%. Input fields: 0.0 deg and 0 code.
- LASET_H: lead angle at Output PWM 100%**: Slider at approximately 75%. Input fields: 58.1 deg and 31 code.
- LASET_LIM: lead angle max limit**: Slider at approximately 75%. Input fields: 58.1 deg and 31 code.

At the bottom right, there are two buttons: 'Write to NVM' and 'Edit mode'. The 'Edit mode' button is highlighted with a red box.



Input Value of SSTT and STOSC. Click Update values.

Input PWM Parameters Config. Register Map

SSTT: Soft start time setting

Slider: [Position] | Input: 2.040 s | Code: 19 code

STOSC: Startup communication period

Slider: [Position] | Input: 100.352 ms | Code: 97 code

SLMD: Sinusoidal vs. trapezoidal drive mode

Trapezoidal 120 degree

Sinusoidal w/6 windows w/ BEMF

LASET_L: lead angle at Output PWM 0%

Slider: [Position] | Input: 3.8 deg | Code: 2 code

LASET_H: lead angle at Output PWM 100%

Slider: [Position] | Input: 52.5 deg | Code: 28 code

LASET_LIM: lead angle max limit

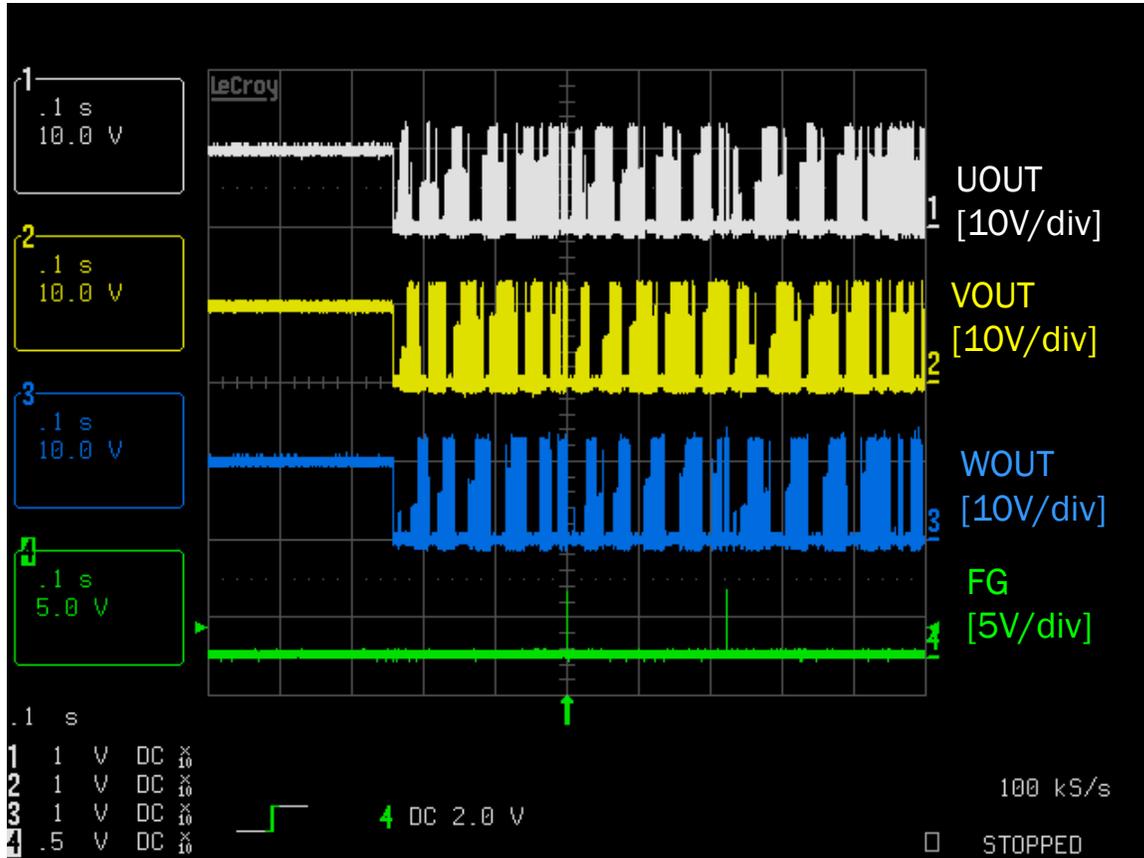
Slider: [Position] | Input: 52.5 deg | Code: 28 code

Update values Cancel

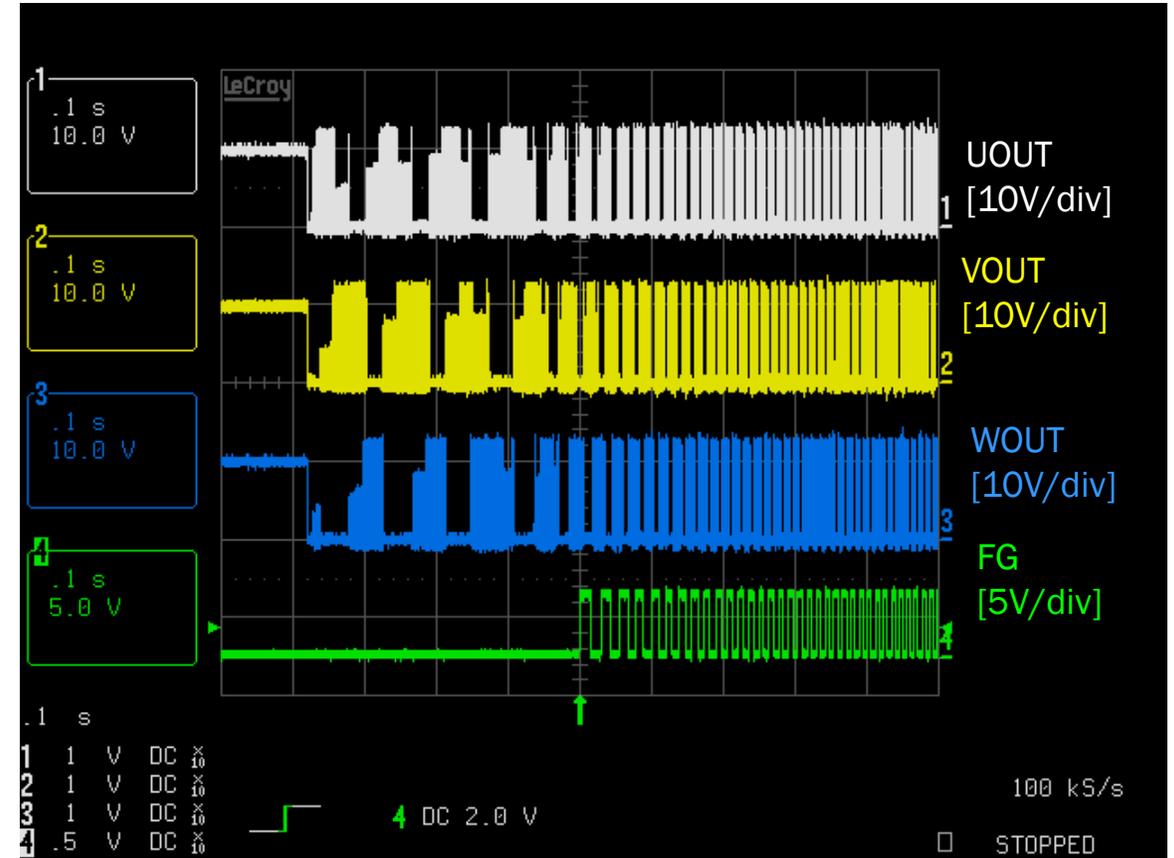


STOSC(Startup commutation period)

When “STOSC” is small, the waveform at start up become as the left figure, and the motor does not rotate normally. In this case, increase “STOSC” until motor to rotate normally.



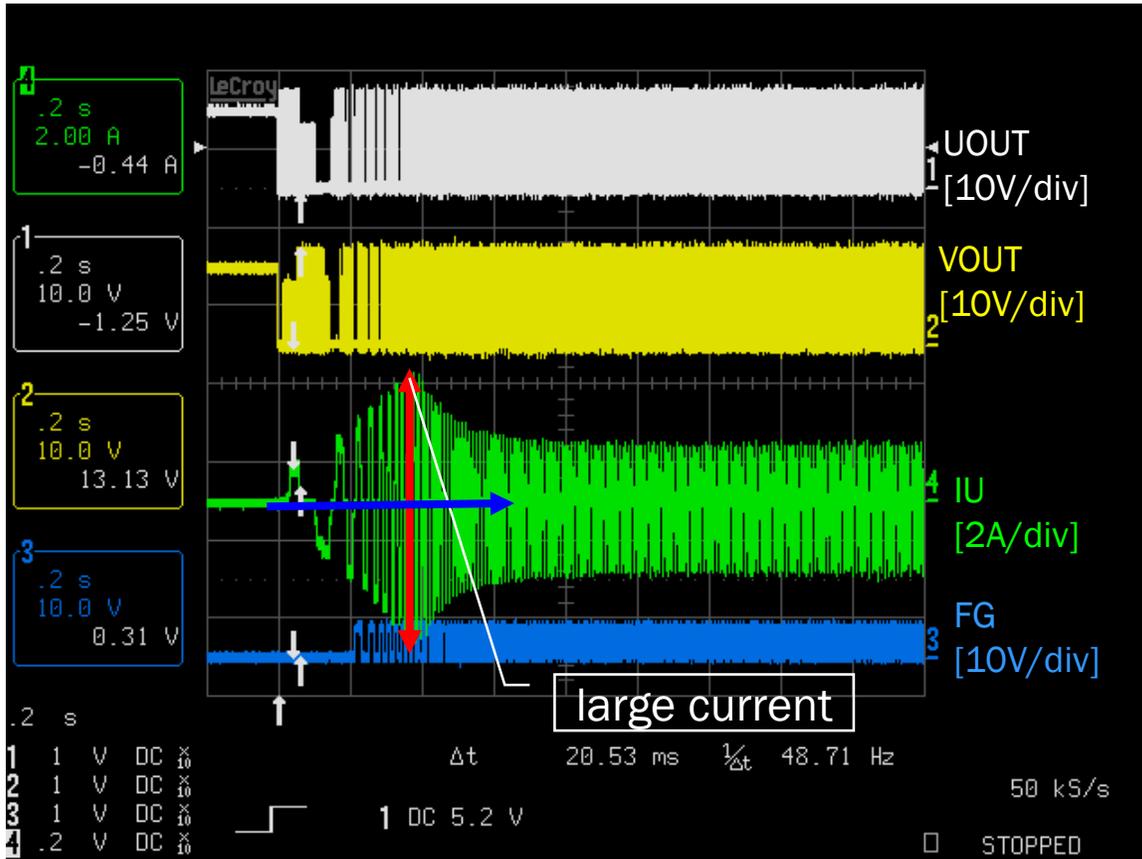
Startup failed because STOSC is too small.



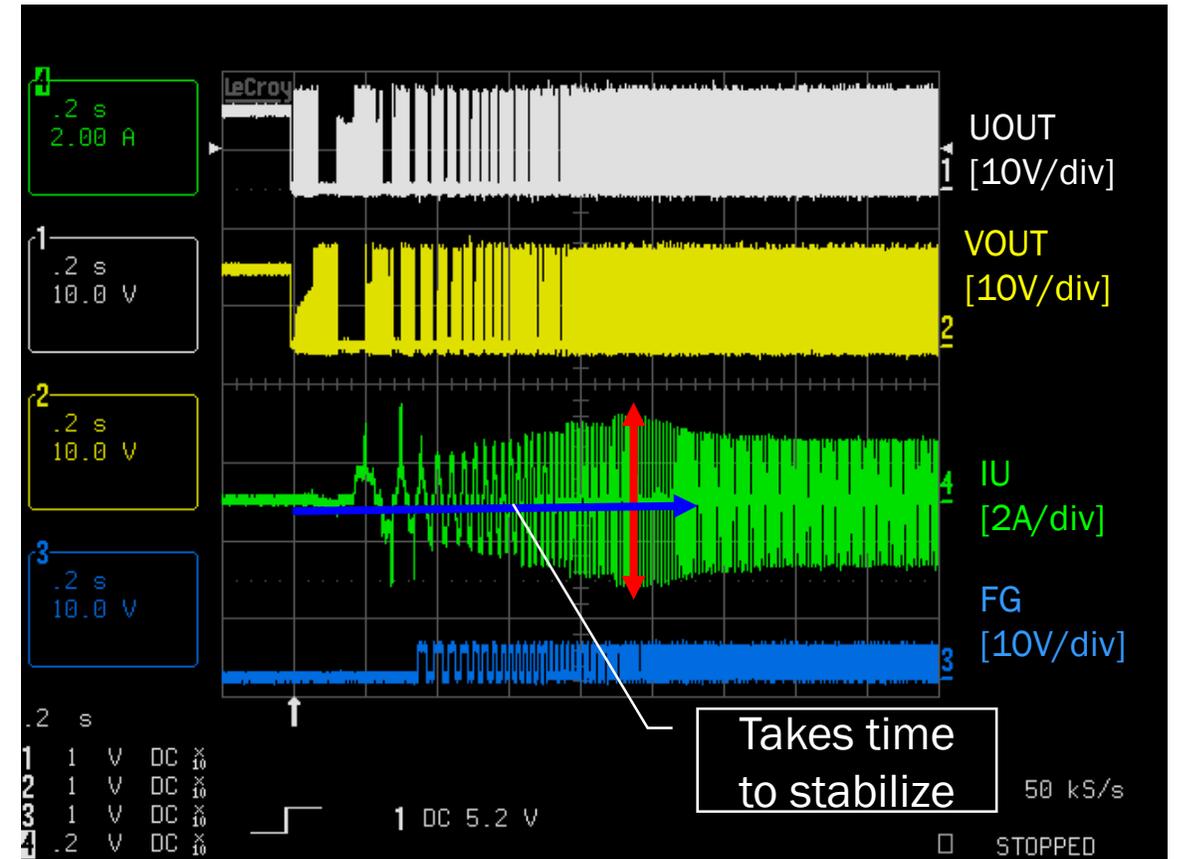
Startup success by increasing STOSC

SSTT(Soft start time)

When “SSTT” is a small value (left waveform), stable operation starts in a short time, but inrush current gets larger.
If “SSTT” is increased(right waveform), the time until to get stable operation is longer, but the inrush current gets smaller.



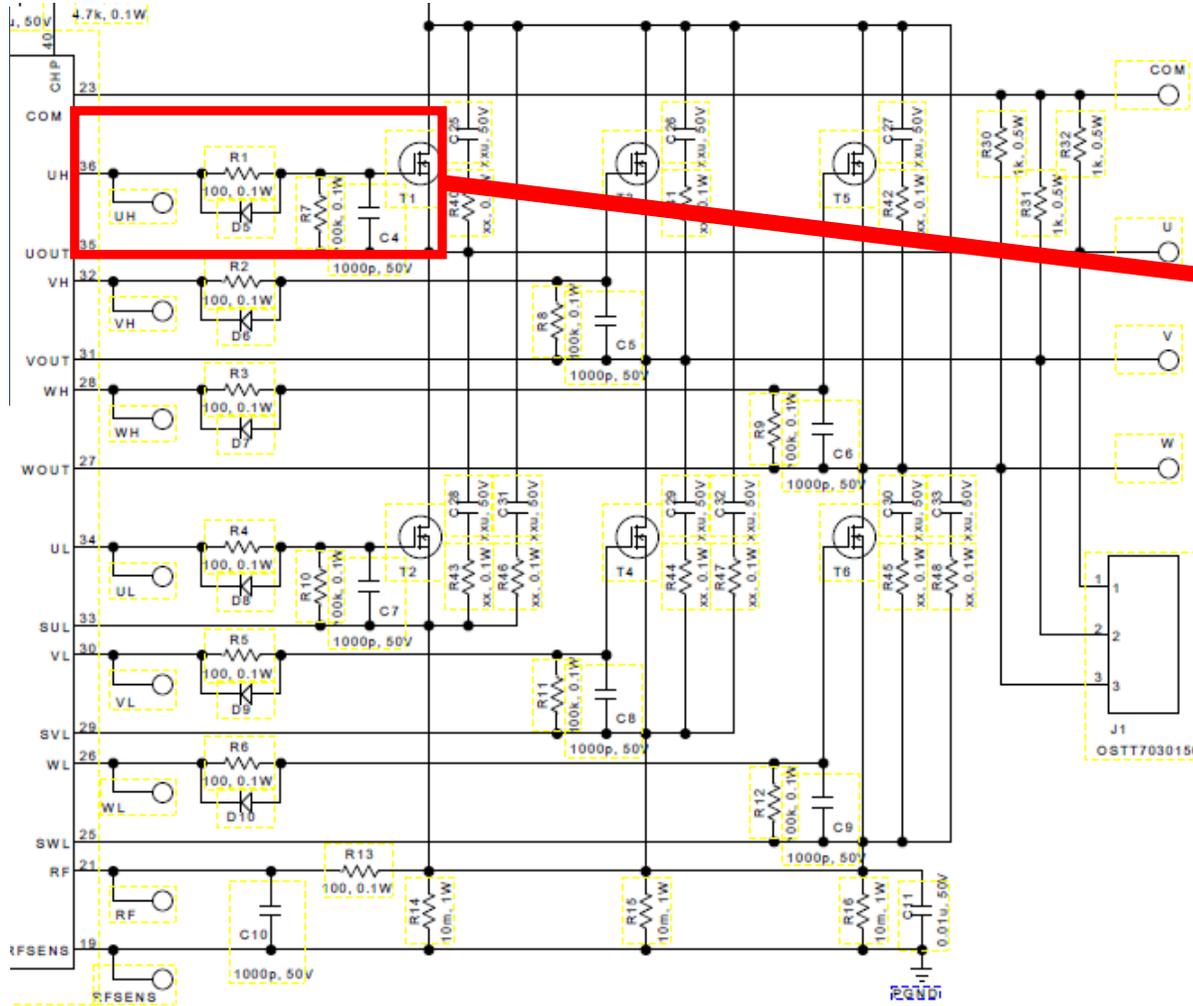
SSTT:small Immediately stabilizes, but the current is large



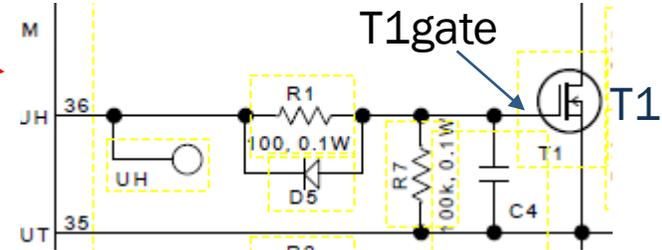
SSTT:large It takes time to stabilize but the current is small

7. Dead-Time setting

Output stage circuit block(LV8961EVB)



With diode



Select Input Config tab. Click Edit mode.

The screenshot displays the 'Input PWM' configuration interface. At the top, there are four tabs: 'Input PWM', 'Parameters', 'Config.', and 'Register Map'. The 'Config.' tab is selected and highlighted with a red box. Below the tabs, the interface is divided into several sections for configuring different parameters:

- PDTC: Fast startup operation mode**: Two radio buttons, 'Off' (selected) and 'Driven with the duty-cycle defined by PDTSEL'.
- FGOF: FG output setting (measured motor speed)**: A dropdown menu set to 'One pulse per electrical' and a numeric input field set to '2 code'.
- CLMASK: Current limit mask time setting**: A dropdown menu set to '1.8' and a numeric input field set to '8 code'.
- FGSTBLMD: 6 windos stable mode**: Two radio buttons, 'Disable' (selected) and 'Enable'.
- FDTI: Dead time selection**: A slider control with a value of '0.8 us' and a numeric input field set to '28 code'.
- OCMASK: Over-current detection Mask time setting**: A dropdown menu set to '1.8' and a numeric input field set to '8 code'.

At the bottom right, there are two buttons: 'Write to NVM' and 'Edit mode'. The 'Edit mode' button is highlighted with a red box. To the right of the configuration area is a vertical list of status indicators, each with a colored circle:

- Est. over temp. (grey)
- FET short circuit (grey)
- VGL under voltage (grey)
- CHP under voltage (grey)
- VS over voltage (grey)
- VS under voltage (grey)
- Over current error (grey)
- PWM input fault (grey)
- VCC under voltage (grey)
- Reg. check-sum error (grey)
- Motor open detect (grey)
- Current limit warning (grey)
- Watchdog timeout (grey)
- Chip junction over tem (grey)
- Chip junction warning (grey)
- OTP data all 0 (red)
- Reg data all 0 (red)
- FG error protection (grey)
- Loss of speed lock (grey)
- Startun operation (red)



Input Value of the Dead time(0.2us-6.4us,0.2us/step).
Click the Update button and finally the Run button.

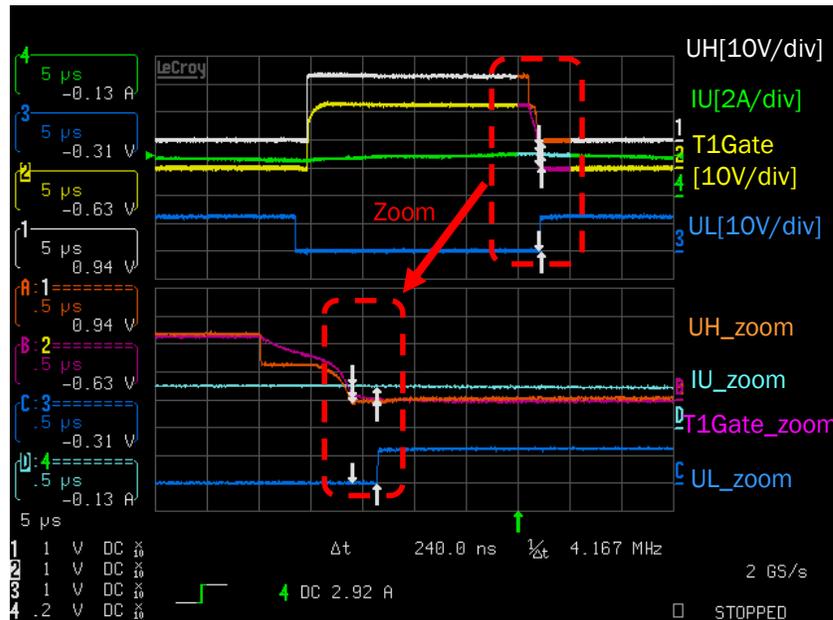
The screenshot displays a software interface for motor control configuration. At the top, there is a graph area with a blue background and a grid. Below the graph, a control bar includes a play button, a 100 ms scale, and various parameter labels like 'Speed: min: 0, max: 40000' and 'Icc: min: 0, max:...'. Below this, there are tabs for 'Input PWM', 'Parameters', 'Config.', and 'Register Map'. The 'Config.' tab is active, showing several configuration sections: 'PDTC: Fast startup operation mode' with 'Off' selected; 'FGOF: FG output setting (measured motor speed)' with 'One pulse per electrical' and '2 code'; 'CLMASK: Current limit mask time setting' with '1.8' and '8 code'; 'FGSTBLMD: F window stable mode' with 'Disable' selected; 'FDTI: Dead time selection' with a slider and a value of '3.2 us' (circled in red) and '16 code'; and 'OCMASK: Over-current detection Mask time setting' with '1.8' and '8 code'. At the bottom right, there are 'Update values' and 'Cancel' buttons, with 'Update values' circled in red. On the right side, there is a 'Disconnect' button (circled in red) and a 'Run' button (circled in red). Below these buttons is a list of status indicators, including 'SMOD: Standby mode' and various fault codes like 'Locked rotor', 'Est. over temp.', 'FET short circuit', etc. A blue callout box with white text is overlaid on the 'FDTI' section, stating: 'Dead Time is recommended to start from about 3.2us for safe.'



Through Current at the Dead Time setting

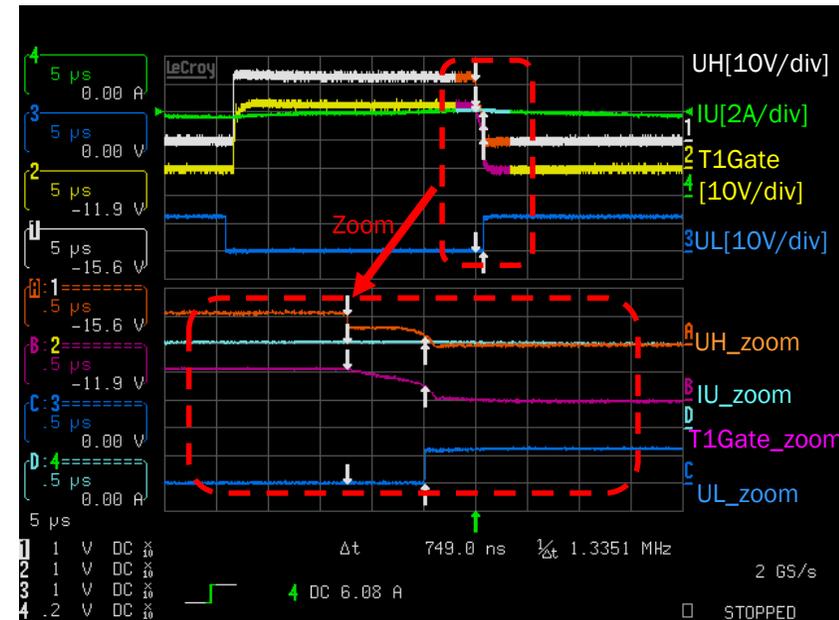
The most important thing is through current at the Dead Time setting. As the Dead Time is reduced, timing occurs that UH and UL overlap, V phase and W phase are the same. These conditions causes a through current to occur when the external FET is turned on simultaneously. In the waveform on the left, UL goes high after UH goes low, so there is no problem. In the right waveform, UL becomes Hi during UH falls to Low, and there is a risk of through current flow. It is important to set Dead Time not to occur through current.

Normal wave @Dead Time:Large



This is OK because Hi of UH and UL are not overlapped.

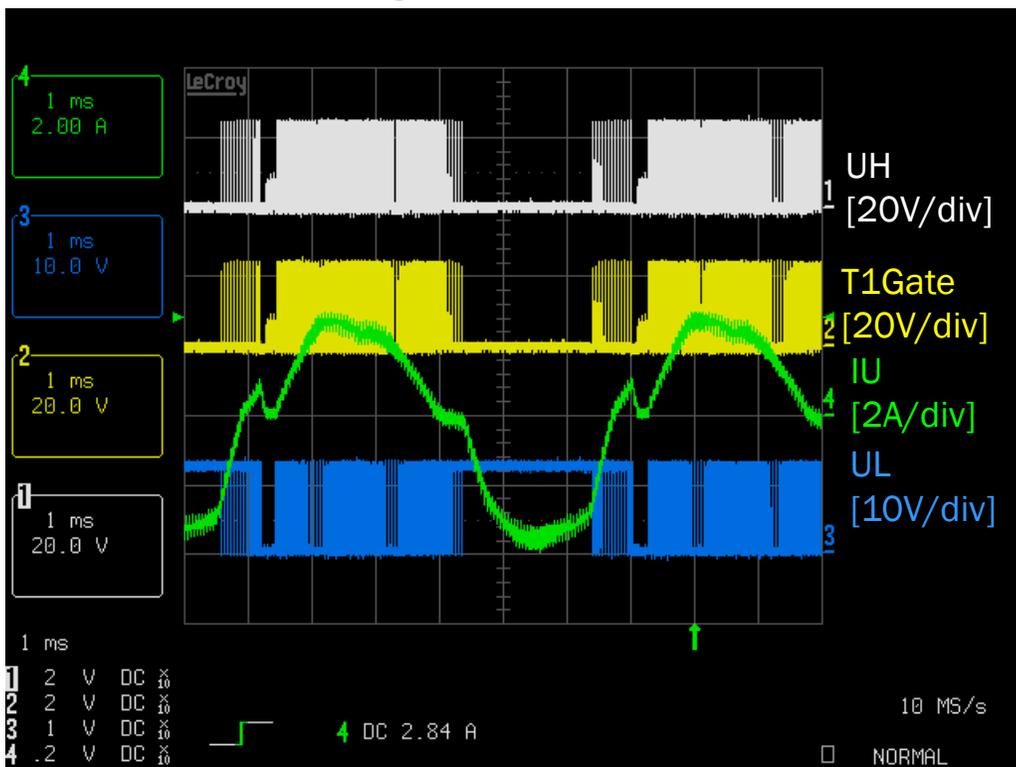
Normal wave @Dead Time:too Small



This is not suitable, because Hi of UH and UL are overlapped.

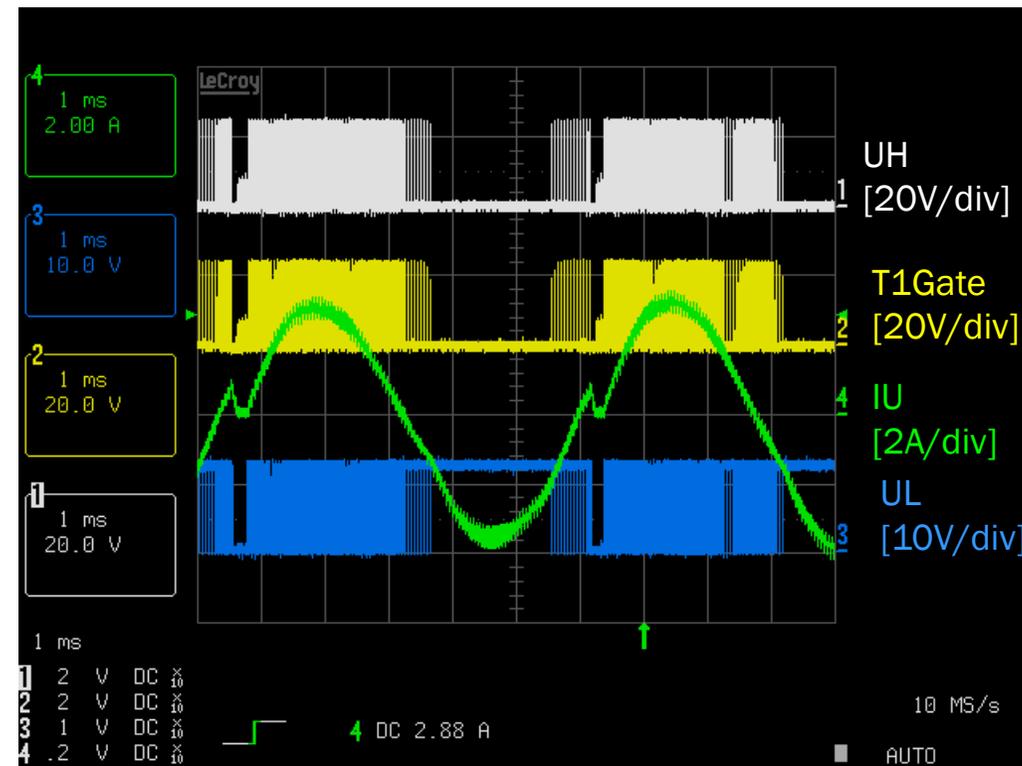
Set the “Dead Time” as short as possible without through current.
 First, set the “Dead Time” parameter, then confirm current wave form.
 The wave forms in two “Dead Time” settings are shown below.
 In these cases, the setting of Dead Time = 3.2us where the IU waveform is distorted is not suitable value, and the Dead Time=0.6us is not distorted.

Abnormal wave @Dead Time=3.2us



Dead time = 3.2us is not suitable, because the IU waveform is distorted.

Normal wave @Dead Time=0.6us



This is OK, because IU waveform is not distorted.

Export to file

Save the setting.

Select "Register Map" tab and Click the"Export to file"

Name		7	6	5	4	3	2	1	0
-	GSDAT	ORBEN	SACF	DIAGS	LATCH	OBSY		SMOD	
0x0000	MRACK0	0	1	0	1	0	1	0	1
0x0001	MRACK1	1	0	1	0	1	0	1	0
0x0002	MRSPT0	0	0	CLSEL	CLDWNOFF		OCSEL		CLMSPD
0x0003	MRSPT1	0	0				SSTT		
0x0004	MRSPT2					STCSC			
0x0005	MRSPT3	SLMD	0	0			LASET_L		
0x0006	MRSPT4	0	0	0			LASET_H		

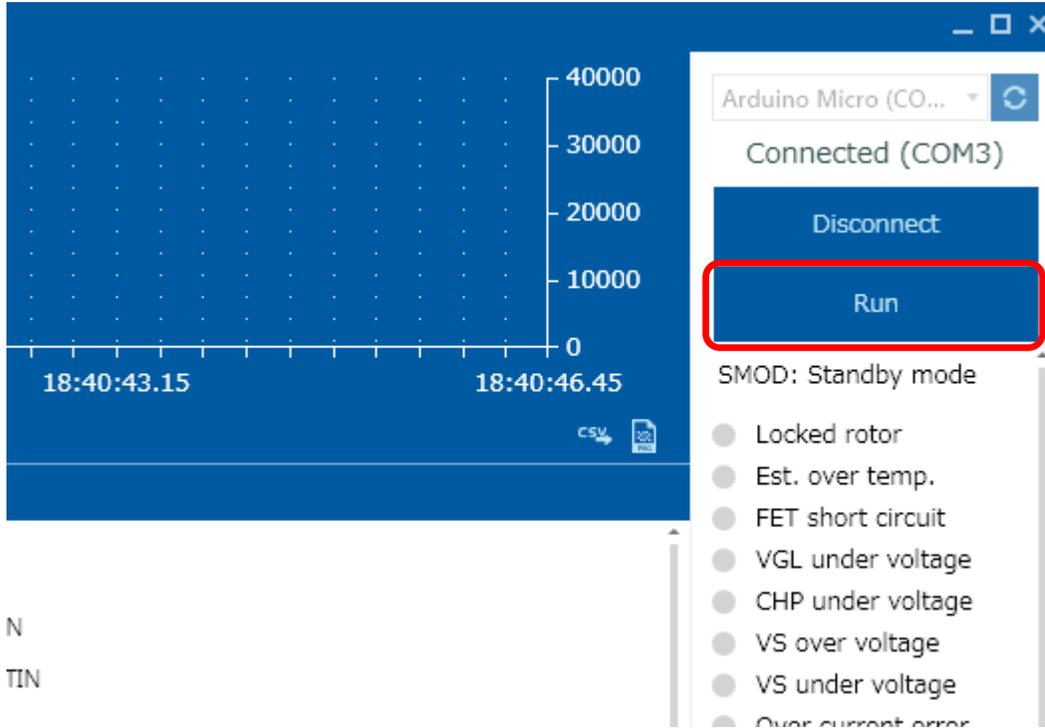
Buttons: Show values, Comment, Save register map, **Export to file**, Load register map, Import from file

It is recommended to save an edited register setting to a file before running trial and power-off at the end of tuning. File name should be changed from the name provided by ON Semiconductor.



8.Run

Click the Run button and start rotating the mortar



The screenshot shows a software interface with a blue background. On the left is a graph with a vertical axis from 0 to 40000 and a horizontal axis with timestamps 18:40:43.15 and 18:40:46.45. On the right is a control panel for an 'Arduino Micro (CO...)' connected to 'COM3'. The panel includes a 'Disconnect' button and a 'Run' button, which is highlighted with a red rectangle. Below the 'Run' button is a list of status indicators, including 'SMOD: Standby mode' and several error types like 'Locked rotor', 'Est. over temp.', 'FET short circuit', 'VGL under voltage', 'CHP under voltage', 'VS over voltage', 'VS under voltage', and 'Over current error'.

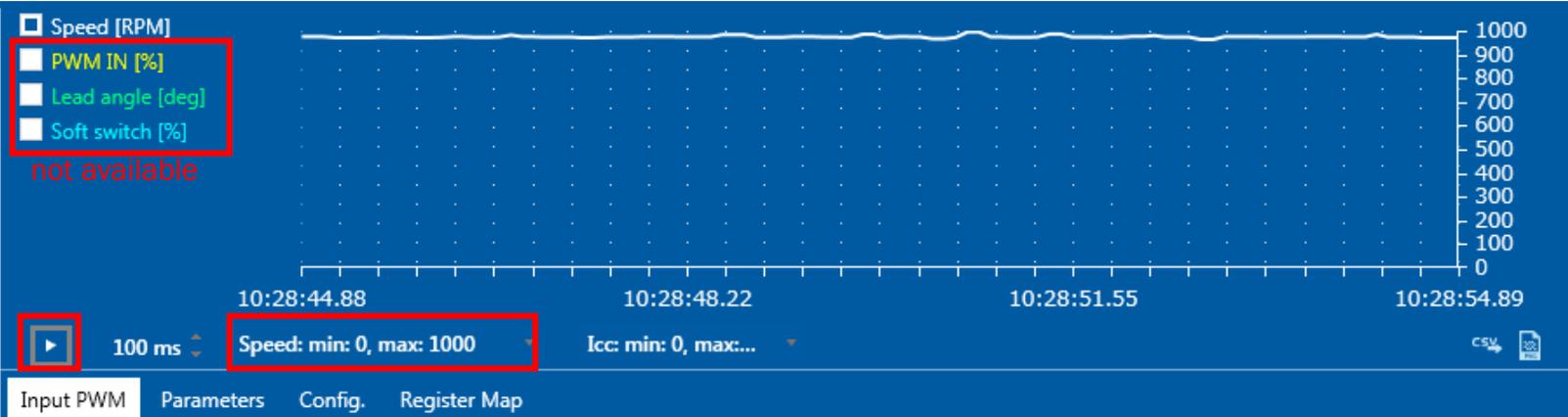
N
TIN

Confirmation of Rotations of Motor

It can confirm Rotations of Motor on GUI.

The rotation speed is displayed on the graph when  is pressed.

Press Speed: min ... to change the scale of the Y axis.



Note: PWM, Lead angle, and soft switch are not available with this version.



9. Lead angle & Mask width tuning

At first it set initial setting data. And tunes the Lead angle (LASET_H and LASET_LIM) and the Mask width (MSKRSTNUM0 / 1_ONE). Actually select "Register Map" tab, it set value as following data.

Select "Register Map" tab. Set the following.

1. "LASET_L" and "LASET_H" set to 00000b, and "LASET_LIM" set to 11111b
2. "MSKRSTNUM0_ONE" set to 0000b, and "MSKRSTNUM1_ONE" set to 0011b
3. "DDUTYSEL" set to 111b
4. "SCEN" set to 1

Green :1
White :0

Input PWM	Parameters	Config.	Register Map																	
0x0005	MRSPT3	SLMD	0	0								LASET_L								
0x0006	MRSPT4	0	0	0								LASET_H								
0x0007	MRSPT5	0	0	0								LASET_LIM								
0x0008	MRSPT6				MSKRST0_6															
0x0009	MRSPT7	0				PX														
0x000A	MRSPT8																			
0x000B	MRSPT9	0	0																	
0x000C	MRSPT10	0																		
0x000D	MRSPT11																			
0x0013	MRSPT17	0	0	0																
0x0015	MRSPT19	0	0	0	0	0	0	0	0	0	0									
0x0019	MRSPT23																			
0x001A	MRSPT24	0	0	0	0	0	0	0	0	0	0									
0x0100	MRCONF0	FRMD	FRREN																	

LASET_L, LASET_H = 00000
LASET_LIM = 11111

DDUTYSEL = 111

WINDSEL = 111

SCEN = 1

MSKRSTNUM0_ONE = 0000

MSKRSTNUM1_ONE = 0011



Select “Input PWM” tab. Click Edit mode.

Input PWM Parameters Config. Register Map

SPIINSEL: Input duty source selection

- PWM input taken from pin: HVPIN or LVPIN
- PWM input taken through register PWMDTIN

Enable MCU PWM generator

PWMIN: PWM Duty cycle 0.0 %

PWMDTIN: Register PWM Input Duty Cycle 0.0 %
 0 code

PWMIN: Frequency 6 Hz

PWMINSEL: Input duty source selection

- PWM input taken from pin HVPIN (VS level)
- PWM input taken from pin LVPIN (logic level)

PWMON: PWM input signal level

Edit mode



Click “Enable MCU PWM generator”.
Input Value of “PWM duty cycle” and “Frequency”.
Click “Update values” and “Run” .

Speed [RPM]
PWM IN [%]
Lead angle [deg]
Soft switch [%]

14:55:55.57 14:55:58.91 14:56:02.25 14:56:05.59

100 ms Speed: min: 0, max: 2000 Icc: min: 0, max:...

Input PWM Parameters Config. Register Map

Enable MCU PWM generator

PWMIN: PWM Duty cycle 30.0 %

PWMIN: Frequency 100 Hz

PWMDTIN: Register PWM Input Duty Cycle 0.0 %

0 code

PWM Duty is recommended to start from about 30%.

Update values Cancel

Arduino Micro (CO...)
Connected (COM9)
Disconnect
Run

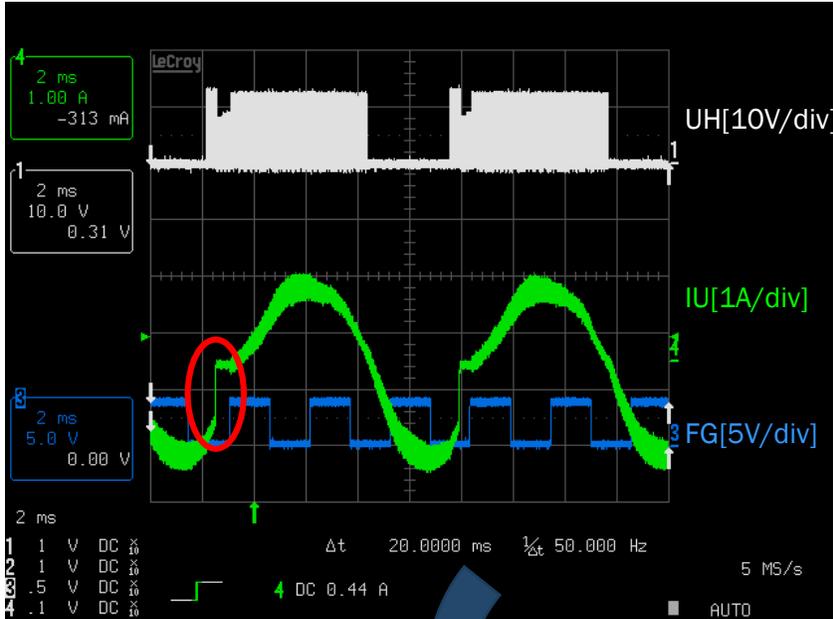
SMOD: Standby mode

- Locked rotor
- Est. over temp.
- FET short circuit
- VGL under voltage
- CHP under voltage
- VS over voltage
- VS under voltage
- Over current error
- PWM input fault
- VCC under voltage
- Reg. check-sum error
- Motor open detect
- Current limit warning
- Watchdog timeout

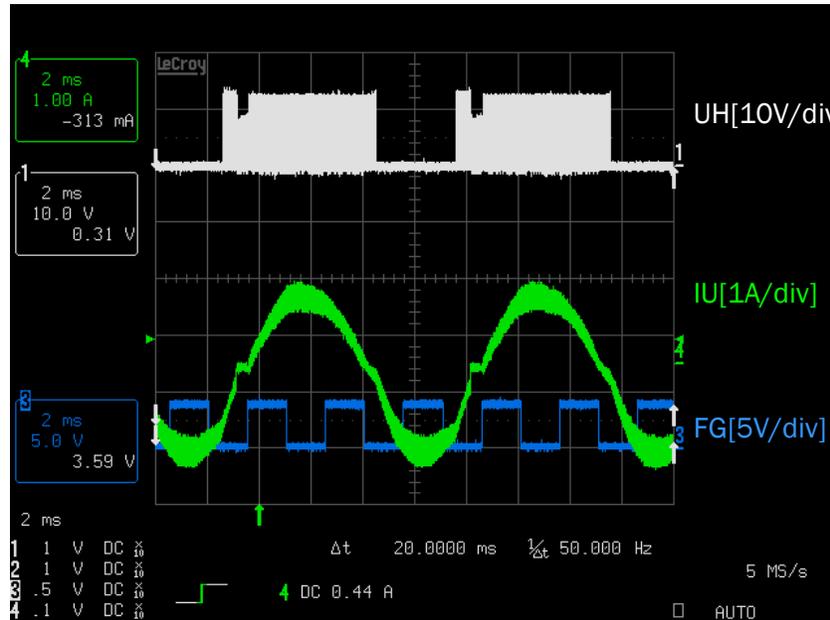


Lead angle tuning

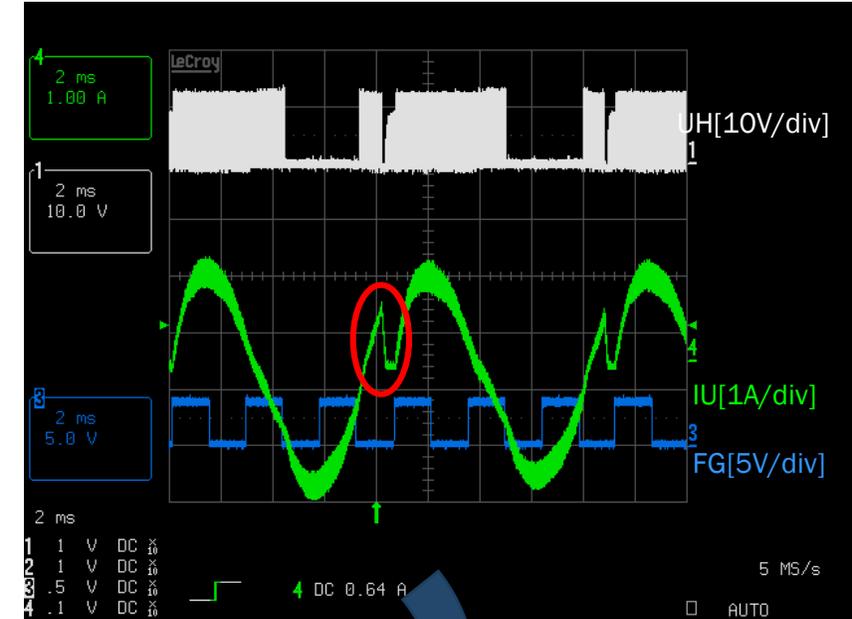
Confirm U phase and IU current. If the wave form is distorted as the left or the right figure, change “mask width” and “lead angle” to decrease distortion as the center figure.



Tuning



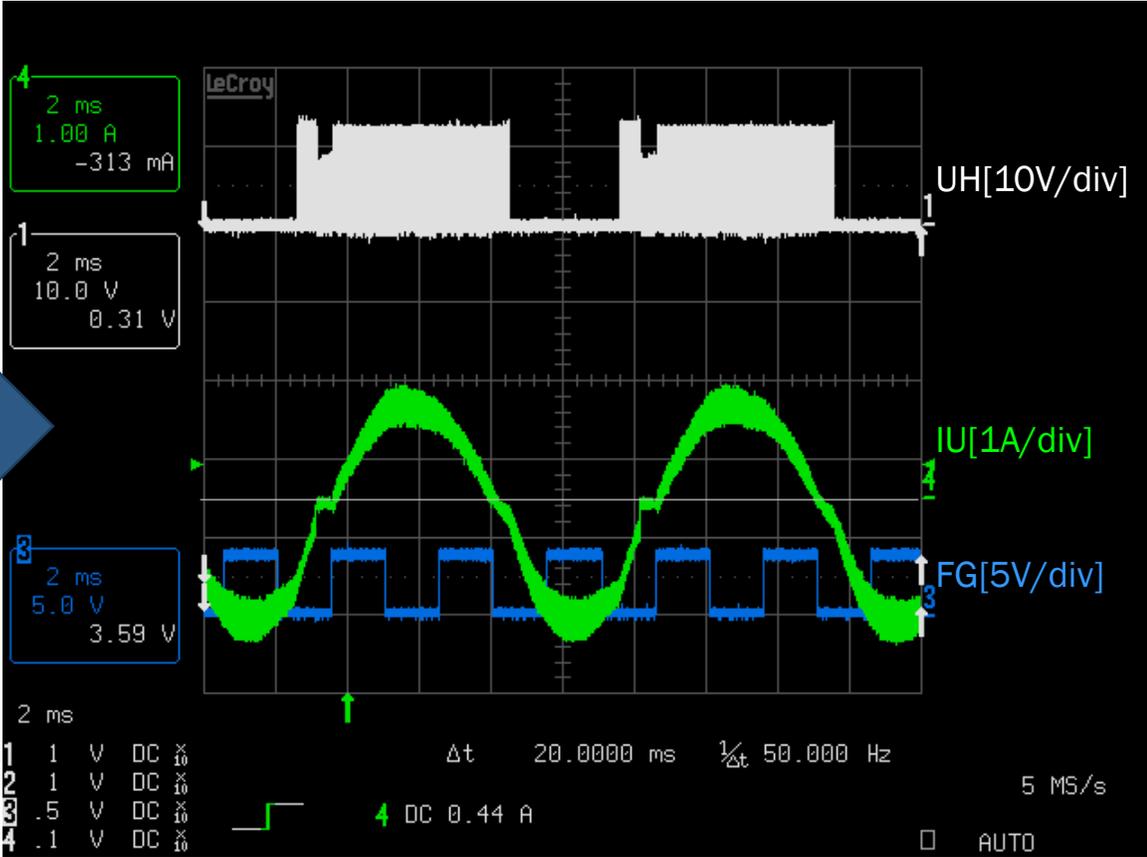
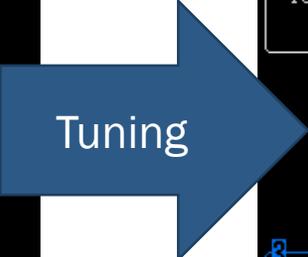
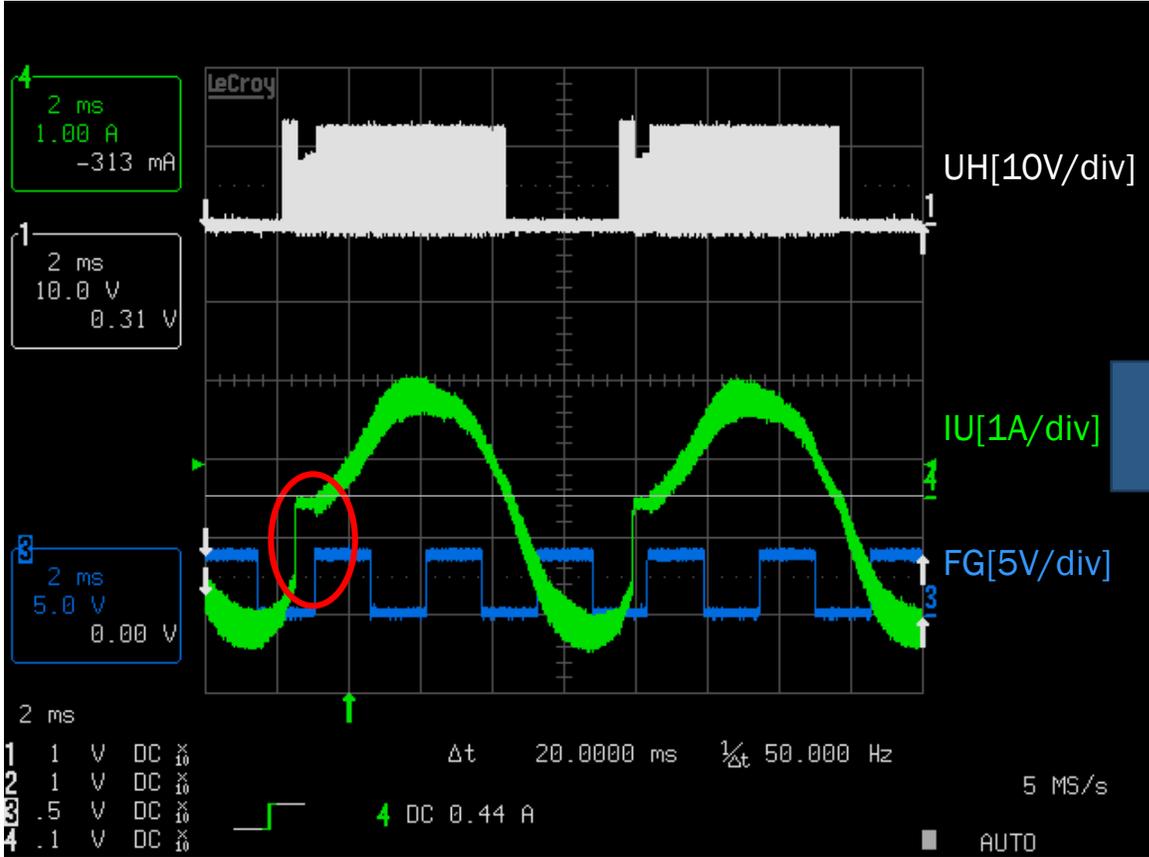
Public Information



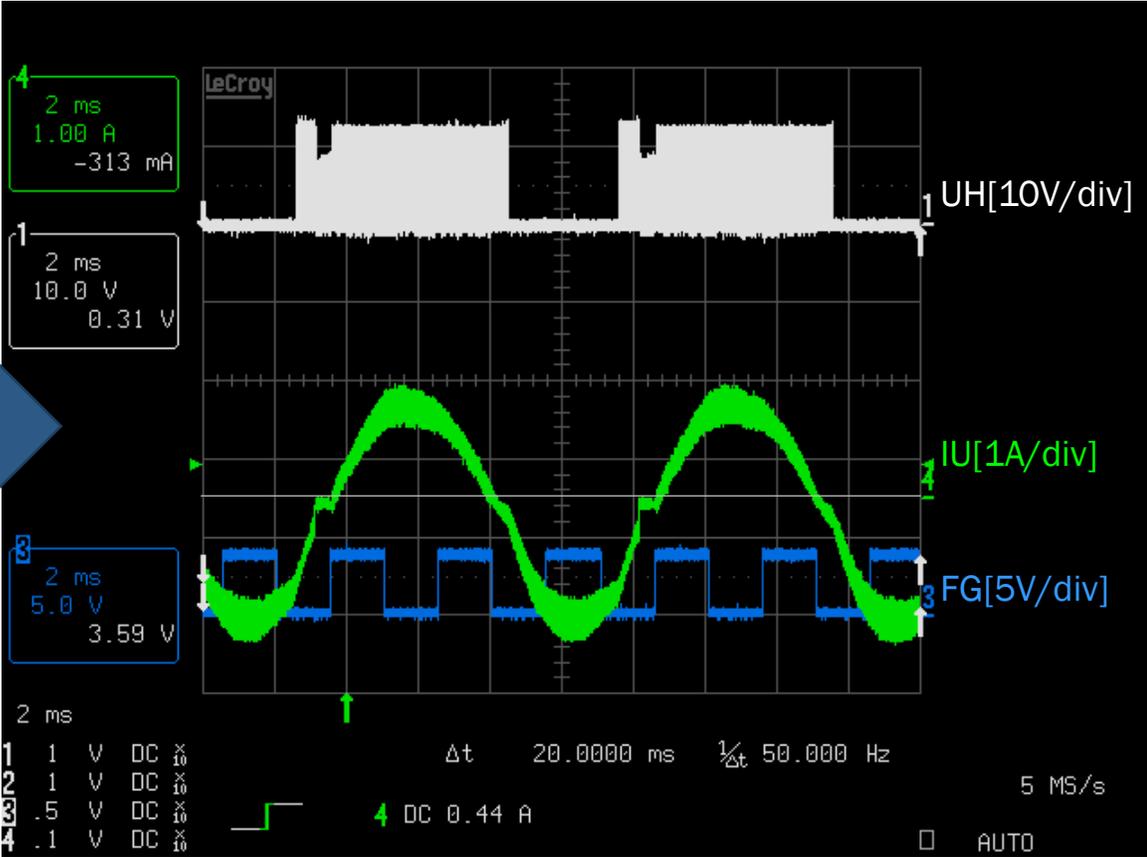
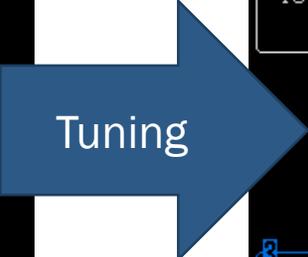
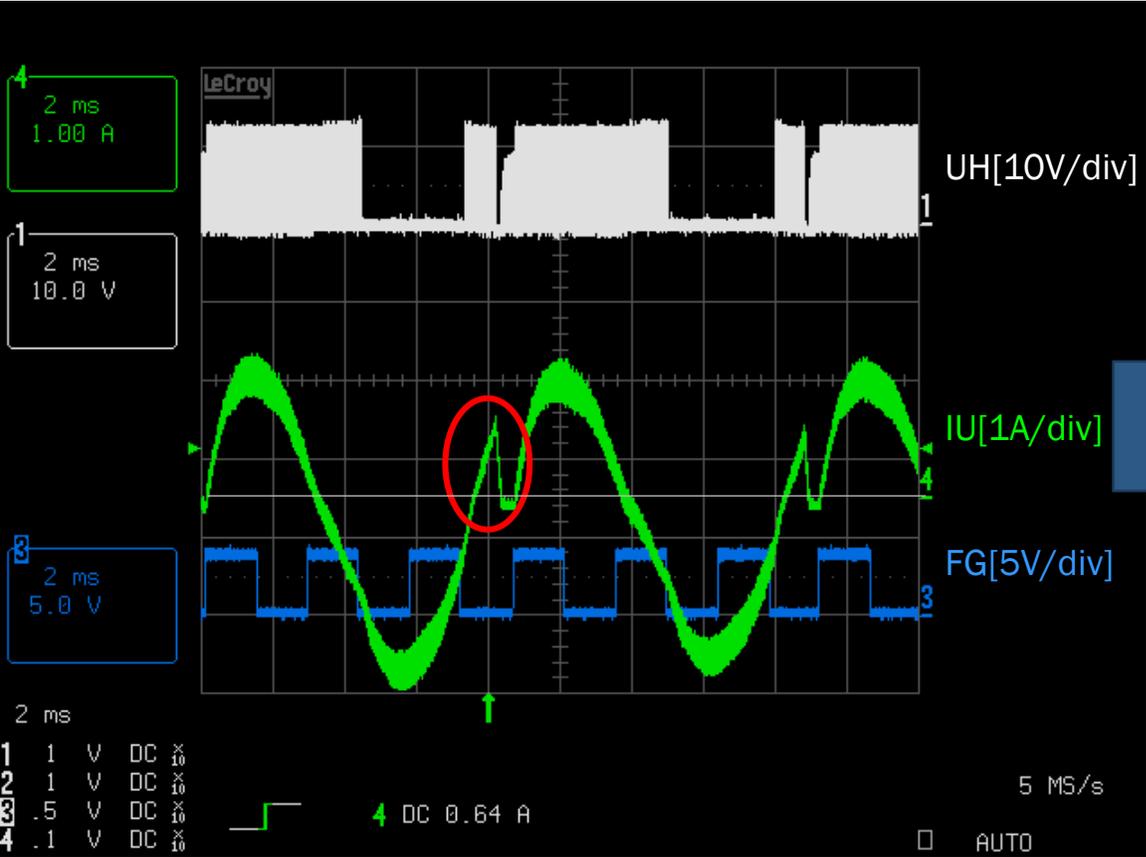
Tuning



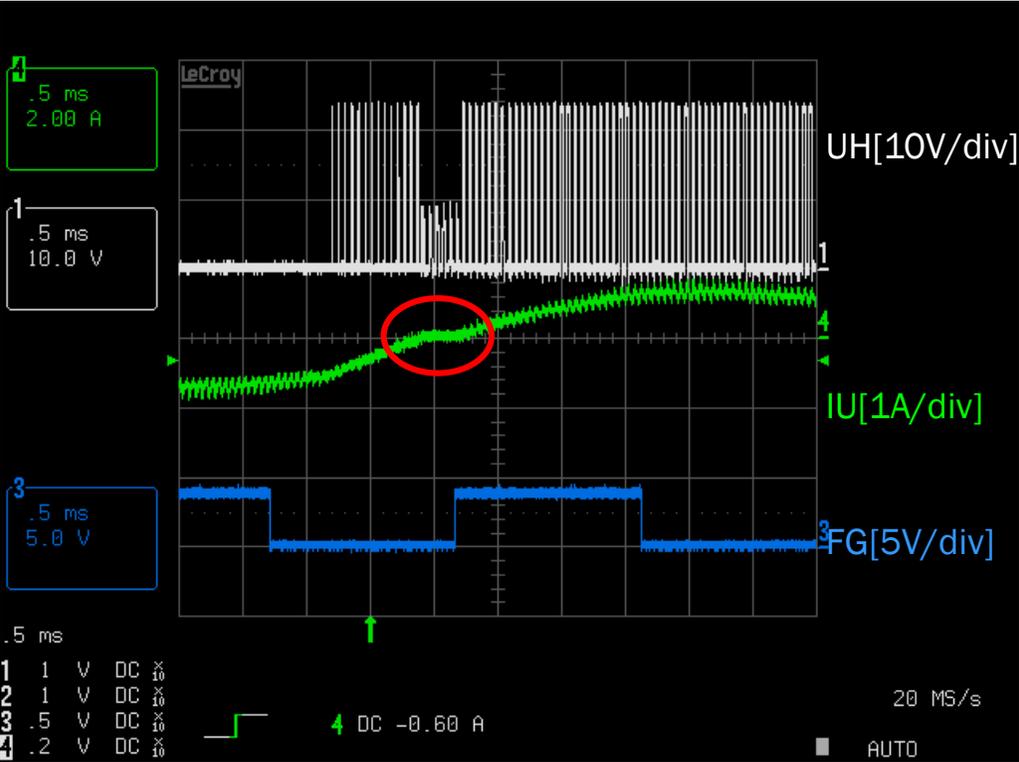
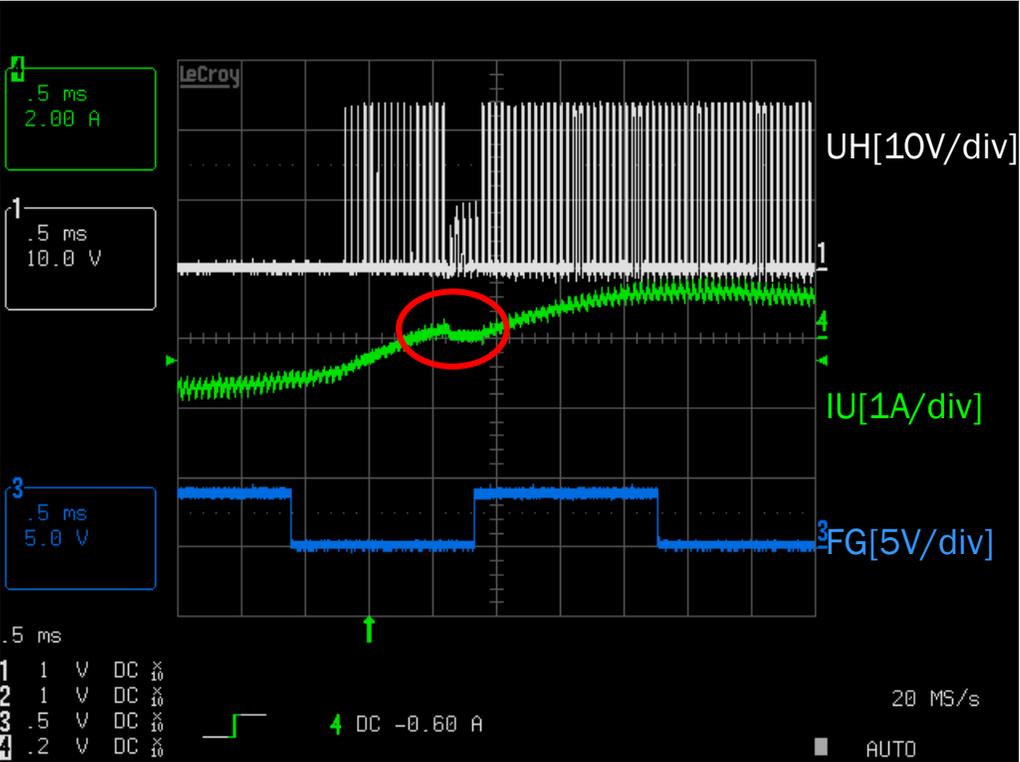
In the case of left figure which having distortion before zero cross, the value of “Lead angle” is too small. Decrease distortion as right figure by to change Lead angle(LASET_L, LASET_H). LASET_L and LASET_H are needed to be same value. Increasing “Lead angle”, distortion of wave form to get smaller.



In the case of left figure which having distortion after zero cross, the value of “Lead angle” is too large. Decrease distortion as right figure by to change Lead angle(LASET_L, LASET_H). LASET_L and LASET_H are needed to be same value. Decreasing “Lead angle”, distortion of wave form to get smaller.



After adjusting the Lead angle and correcting the rough distortion, adjust the Lead angle by expanding the area near the zero cross. Even if it looks like a proper Lead angle in the long time axis, there is still possibility for adjustment when it is enlarged.



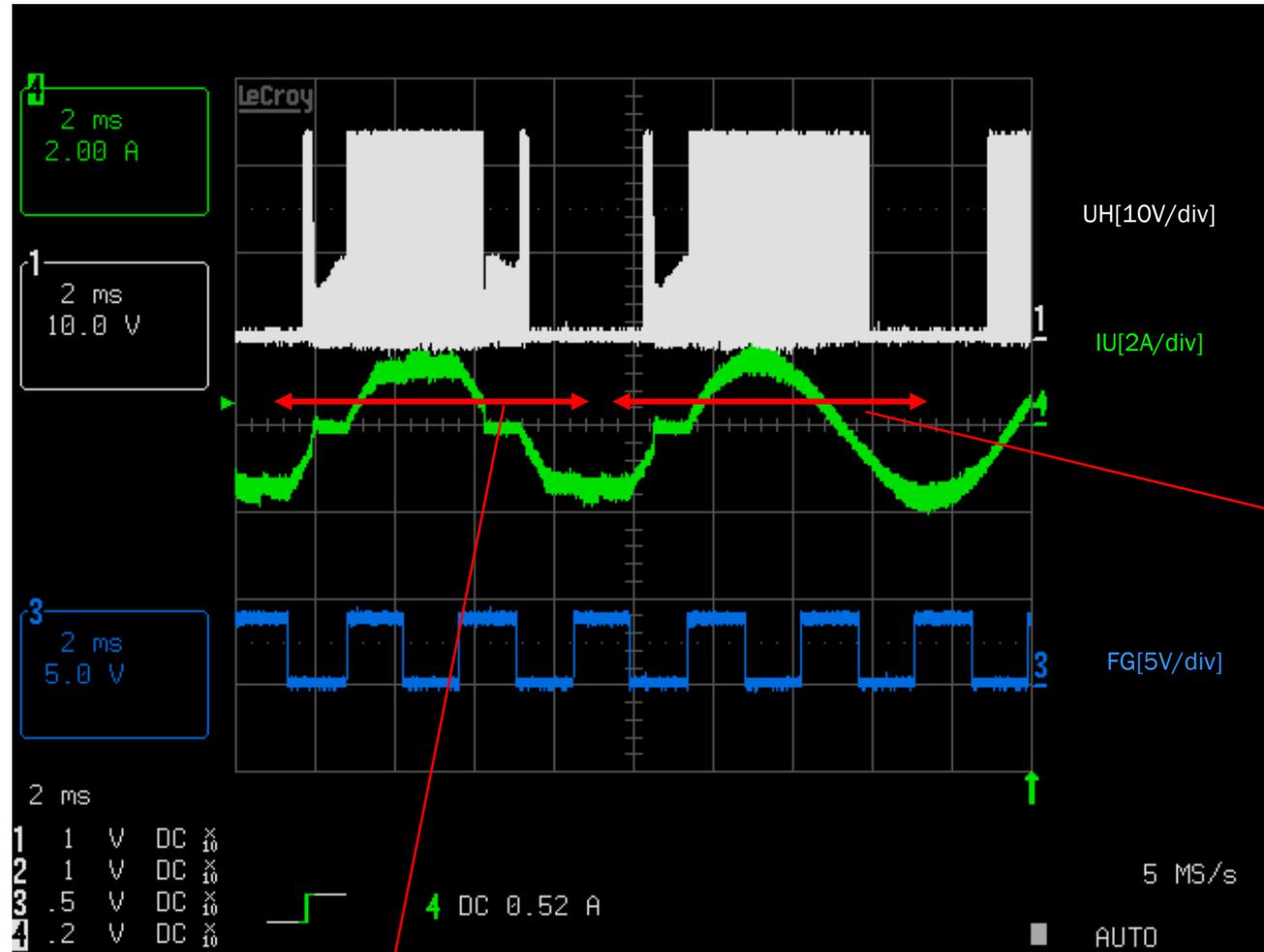
Lead angle
Tuning



It change Mask width.

If window time is narrowed, IU is unstable as below figure.

Therefore, adjusting of Mask width should be in range of normal IU wave.



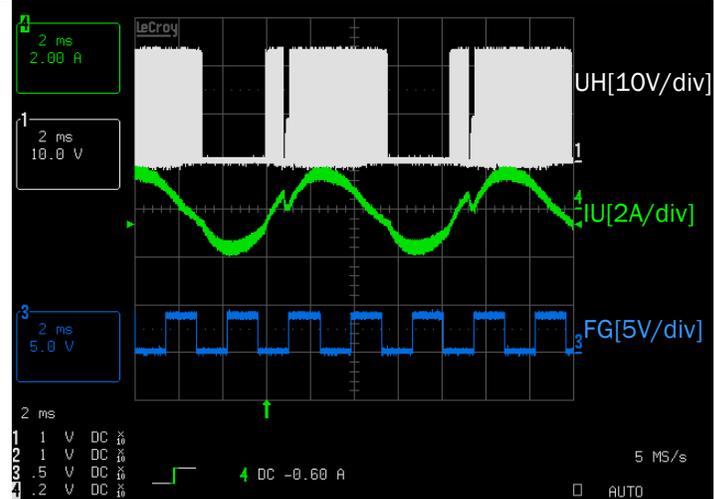
Next, while rotating the motor at PWM Duty 30%, increase the value of Lead angle by 2 (in this case, 7 + 2 = 9), and then set PWM Duty to 40%.

From the state as PWM Duty30%,

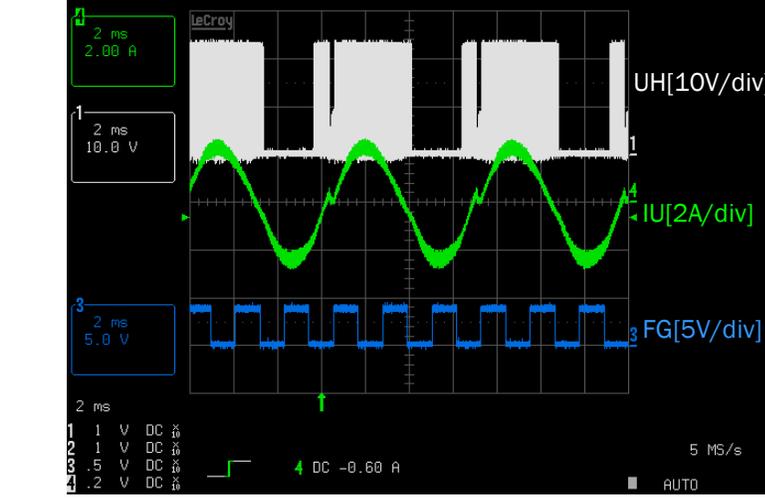
1. Adjust the Lead angle (LASET_L, LASET_H), and adjust the current waveform without distortion
 2. Narrow the Mask width(MSK0,MSK1).
 3. Readjust Lead angle(LASET_L,LASET_H),it takes note PWM Duty, motor speed, Lead angle , andMSK0,MSK1.
- Repeat 1-3 to fill the table up to 100%.

PWM Duty[%]	Lead Angle =LASET_L =LASET_H	MSK0	MSK1	rpm
30	7	11	2	1400
40	8	11	3	1780

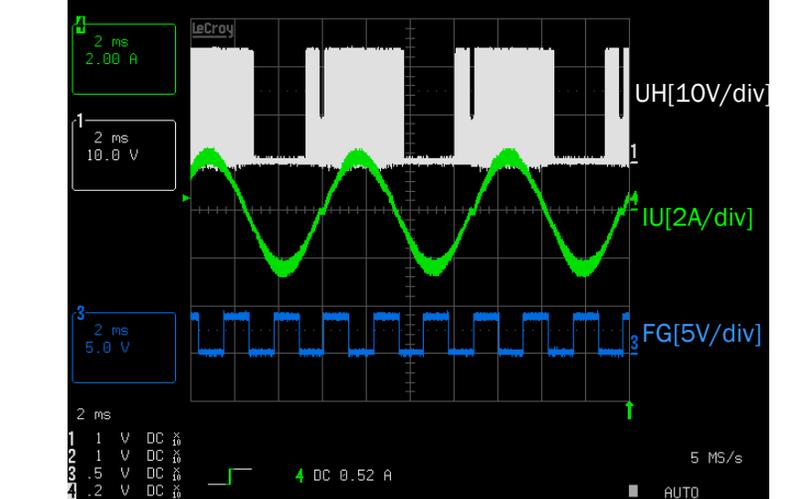
PWM Duty=30% Lead angle=9 MSK0=11 MSK1=2



PWM Duty=40% Lead angle=9 MSK0=11MSK1=2



PWM Duty=40% Lead angle=8 MSK0=11 MSK1=3



PWM Duty:30%→40%

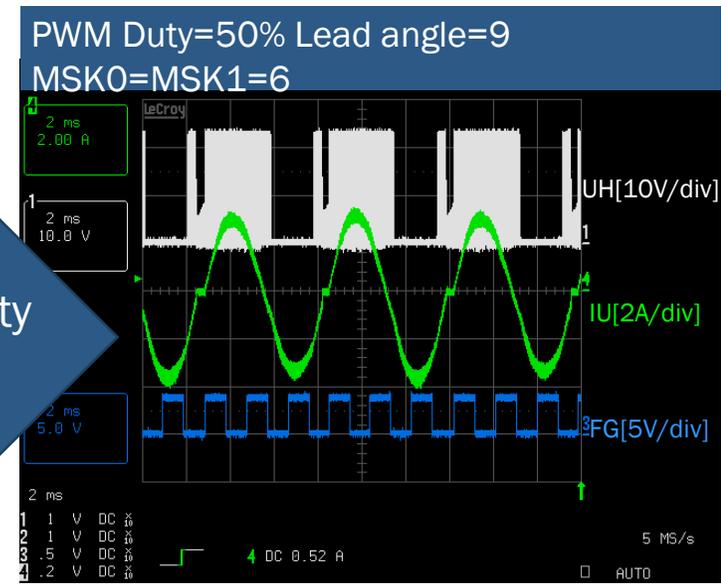
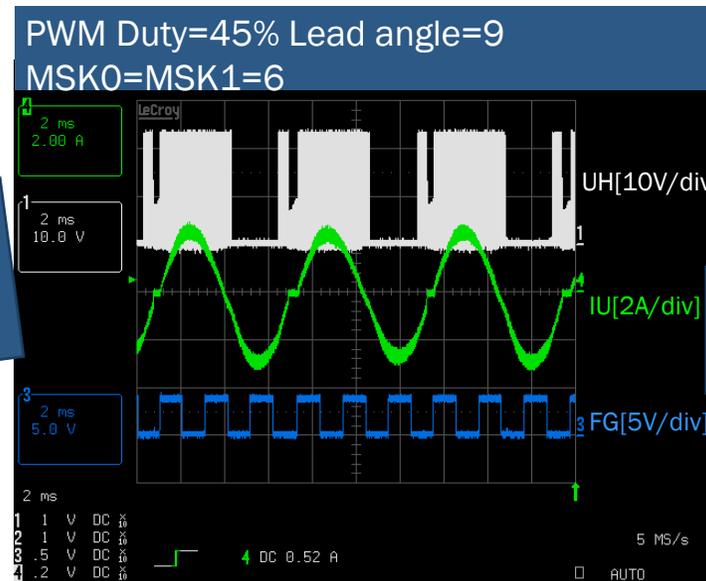
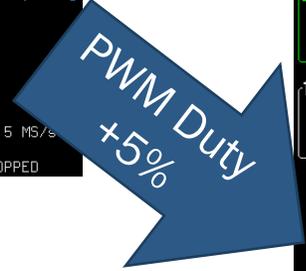
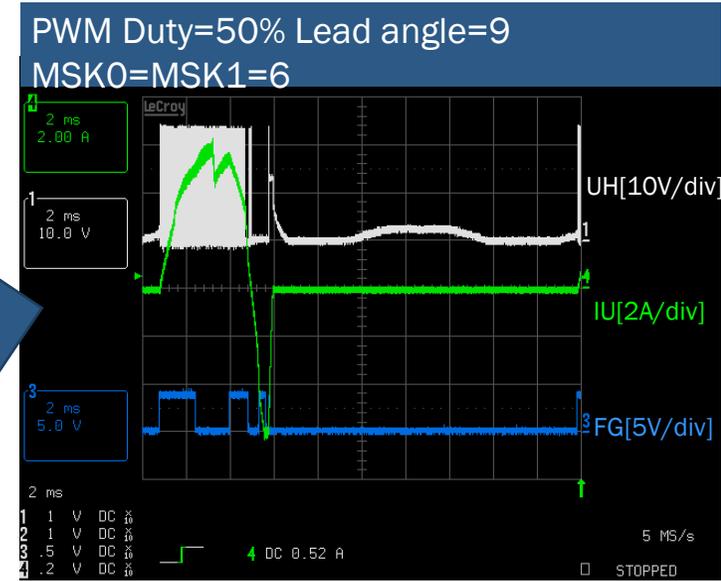
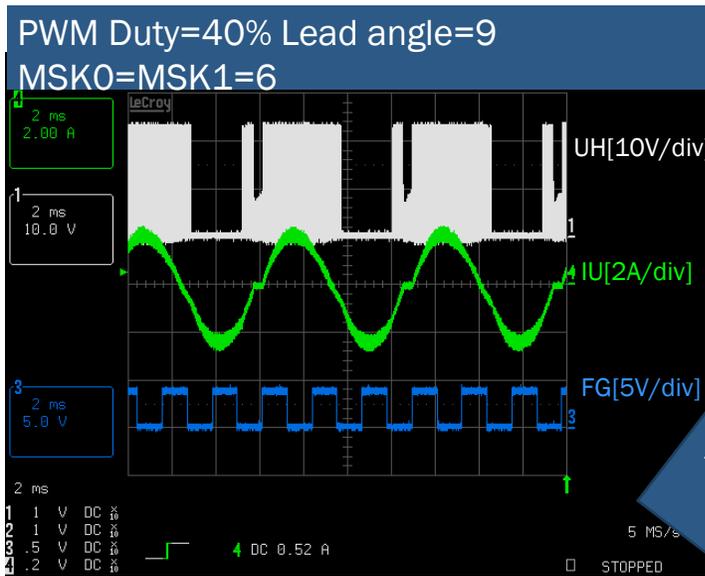
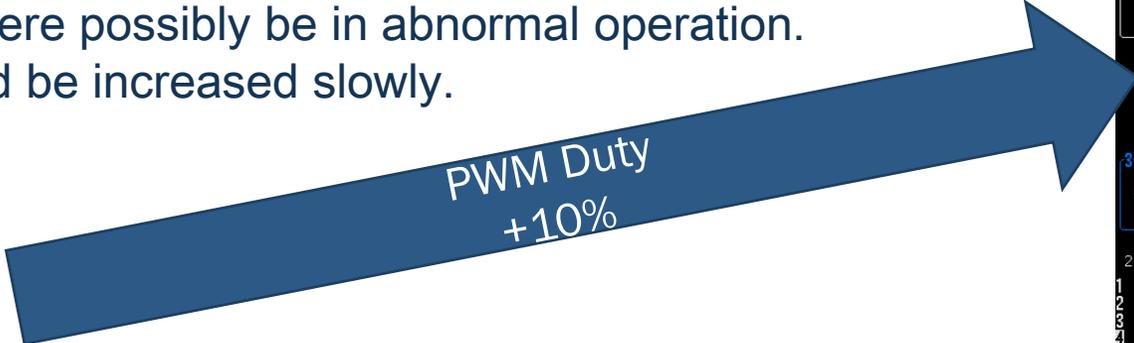
Lead angle & Mask Time Tuning



As a technique to increase PWM Duty at the time of tuning, for example, when changing from 40% to 50%, it should be increased in small steps from 40% to 45% to 50%.

When changing PWM Duty 40% → 50% in one step, it looks like the upper right waveform. Even if the motor does not rotate normally, increasing the PWM duty in 5% steps. It rotates normally like the lower right waveform.

(Note) If it starts with high duty, there possibly be in abnormal operation. Therefore, the duty should be increased slowly.



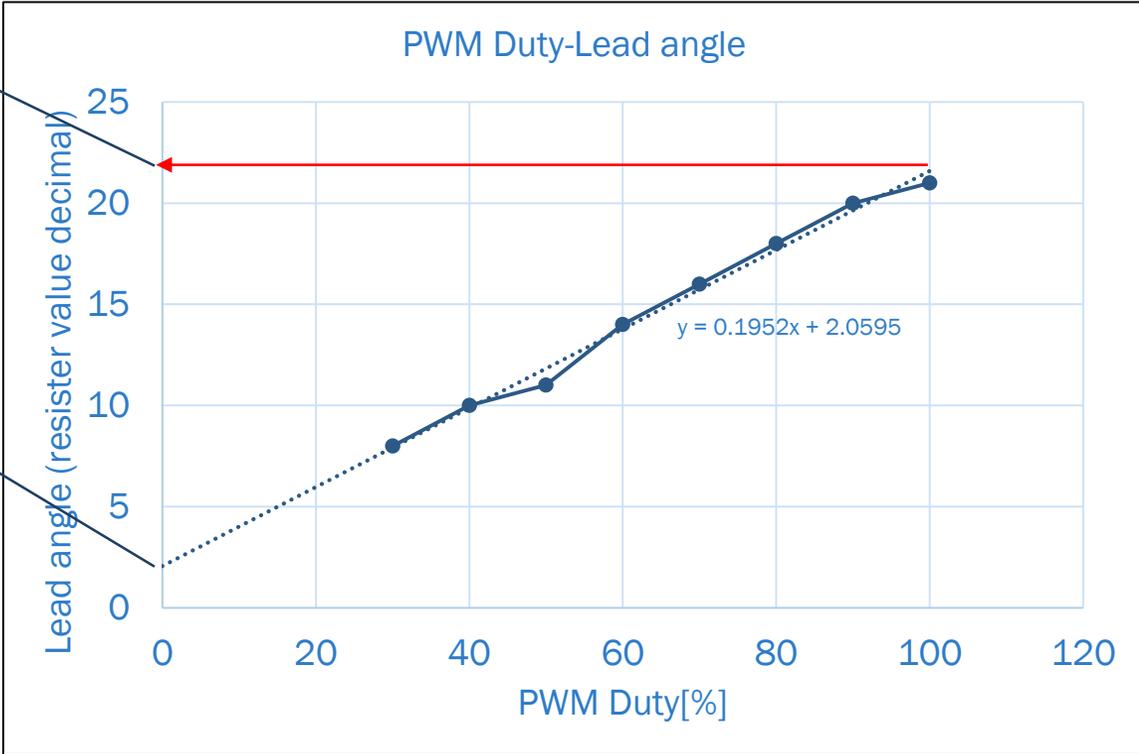
After it filled the table to 100% and search the widest mask setting. In the example below, it becomes MSK0 = 7 and MSK1 = 4. It set these value in MASK0 and MASK1, and it determine the Lead angle again. This time, Mask width (MSK0 = 7, MSK1 = 4) is fixed. It graphed these data (X-axis: PWM Duty, Y-axis Lead angle), it determine Lead angle at PWM Duty = 0% and 100% from the linear approximation formula. In the example below, Lead angle = 2 at PWM Duty = 0%, Lead angle = 22 at PWM Duty = 100%.

PWM Duty[%]	Lead Angle =LASET_L =LASET_H	MSK0	MSK1	rpm
30	7	11	2	1400
40	8	11	3	1780
50	10	9	3	2200
60	12	8	3	2450
70	16	7	4	2750
80	18	7	4	2950
90	20	7	4	3150
100	21	7	4	3350

Lead angle(LASET_H) is 22
at PWM Duty 100%

PWM Duty[%]	Lead Angle =LASET_L =LASET_H	MSK0	MSK1	rpm
30	8	7	4	1400
40	10	7	4	1780
50	11	7	4	2200
60	14	7	4	2450
70	16	7	4	2750
80	18	7	4	2950
90	20	7	4	3150
100	21	7	4	3350

Lead angle(LASET_L) is 2
at PWM Duty 0%



Enter Lead angle =(2d)= (00010b) with PWM Duty = 0% in LASET_L. Enter Lead angle =22d= (10110b) with PWM Duty = 100% in LASET_H. Check if stable operation is performed under the conditions from the minimum rotation speed to the maximum rotation speed used under this condition.

Input PWM	Parameters	Config.	Register Map					
0x0005	MRSPCT3	SLMD	0	0			LASET_L	
0x0006	MRSPCT4	0	0	0			LASET_H	
0x0007	MRSPCT5	0	0	0			LASET_LIM	
0x0008	MRSPCT6		MSKRST0_6			MSKRST1_6		
0x0009	MRSPCT7	0		PX	0		PG	
0x000A	MRSPCT8			DC	0		IG	
0x000B	MRSPCT9	0	0		TX	0		TG
0x000C	MRSPCT10	0		DDUTYSEL		USTEPSEL		DSTEPSEL
0x000D	MRSPCT11					DUTY_L		

LASET_L=00010

LASET_H=10110

Show values

Comment

Save register map

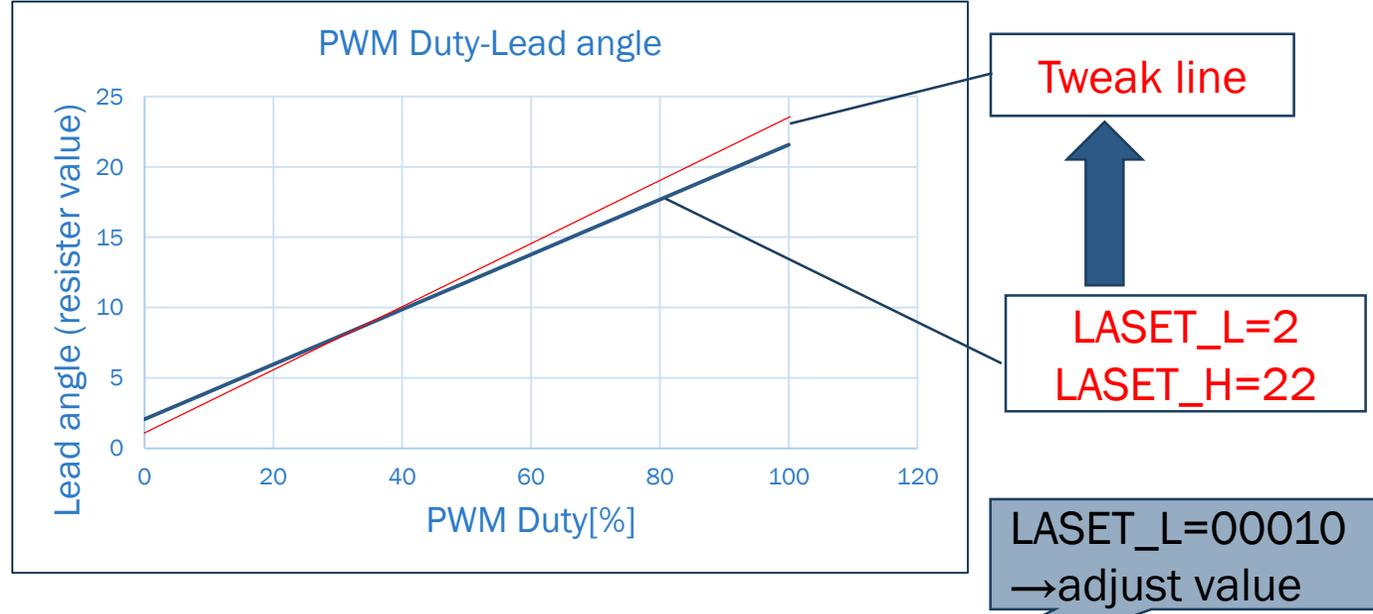
Export to file

Load register map

Import from file



If the motor did not rotate with the settings on the previous page, finely adjust the Lead angle settings (LASET_L, LASET_H) based on the inclination at LASET_L = 2, LASET_H = 22 . And check the motor stability again.



Input PWM	Parameters	Config.	Register Map			
0x0005	MRSPECT3	SLMD	0	0	LASET_L	
0x0006	MRSPECT4	0	0	0	LASET_H	
0x0007	MRSPECT5	0	0	0	LASET_LIM	
0x0008	MRSPECT6		MSKRST0_6		MSKRST1_6	
0x0009	MRSPECT7	0		PX	0	PG
0x000A	MRSPECT8		DX		0	IG
0x000B	MRSPECT9	0	0	TX	0	TG
0x000C	MRSPECT10	0		DDUTYSEL	USTEPSEL	DSTEPSEL
0x000D	MRSPECT11				DUTY_L	

Show values

Comment

Save register map

Export to file

Load register map

Import from file

LASET_H=10110
->adjust value



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LV8961 N-window mode Timing chart

May 30th, 2019

iPS BU, Motor Control Solutions

Application team

Public Information



LV8961 N-window mode Timing Chart

LV8961H is a three-phase sensorless pre-driver with sinusoidal two-phase drive (space vector modulation).

This two-phase driver always activates all three driver outputs. To detect rotor position, this device monitors the BEMF zero cross timing. It is required to have the driver output floating timing; so called window.

The four selectable numbers of the detection window per electrical cycle.

6: all zero cross for all three phases

3: one rising zero cross for each phase

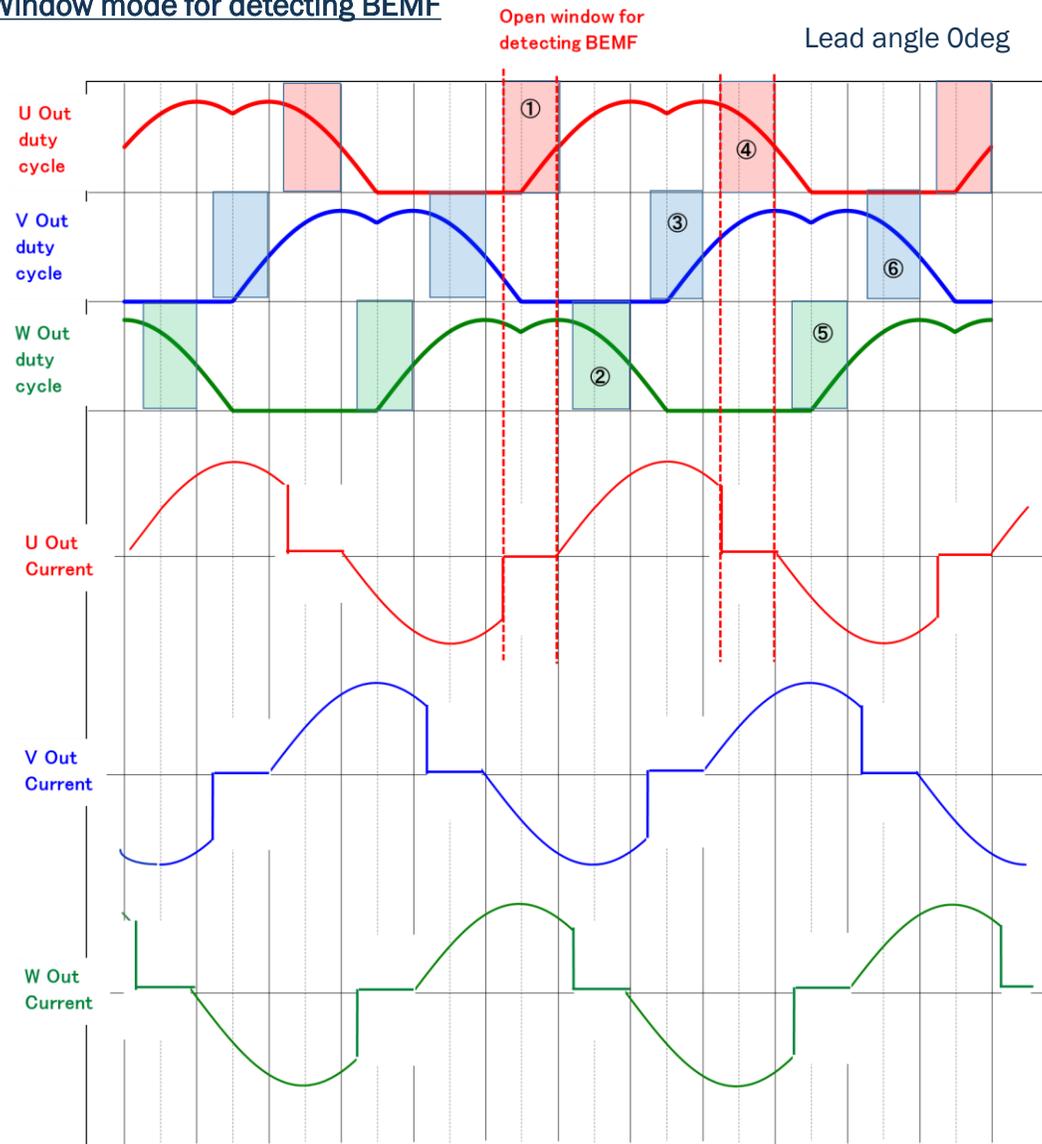
2: rising and falling zero crosses of the phase U

1: one rising zero cross of the phase U

Timing charts of these zero cross detection modes will be shown in the following slides.

LV8961 6-window mode Timing Chart

6-Window mode for detecting BEMF



6-window mode

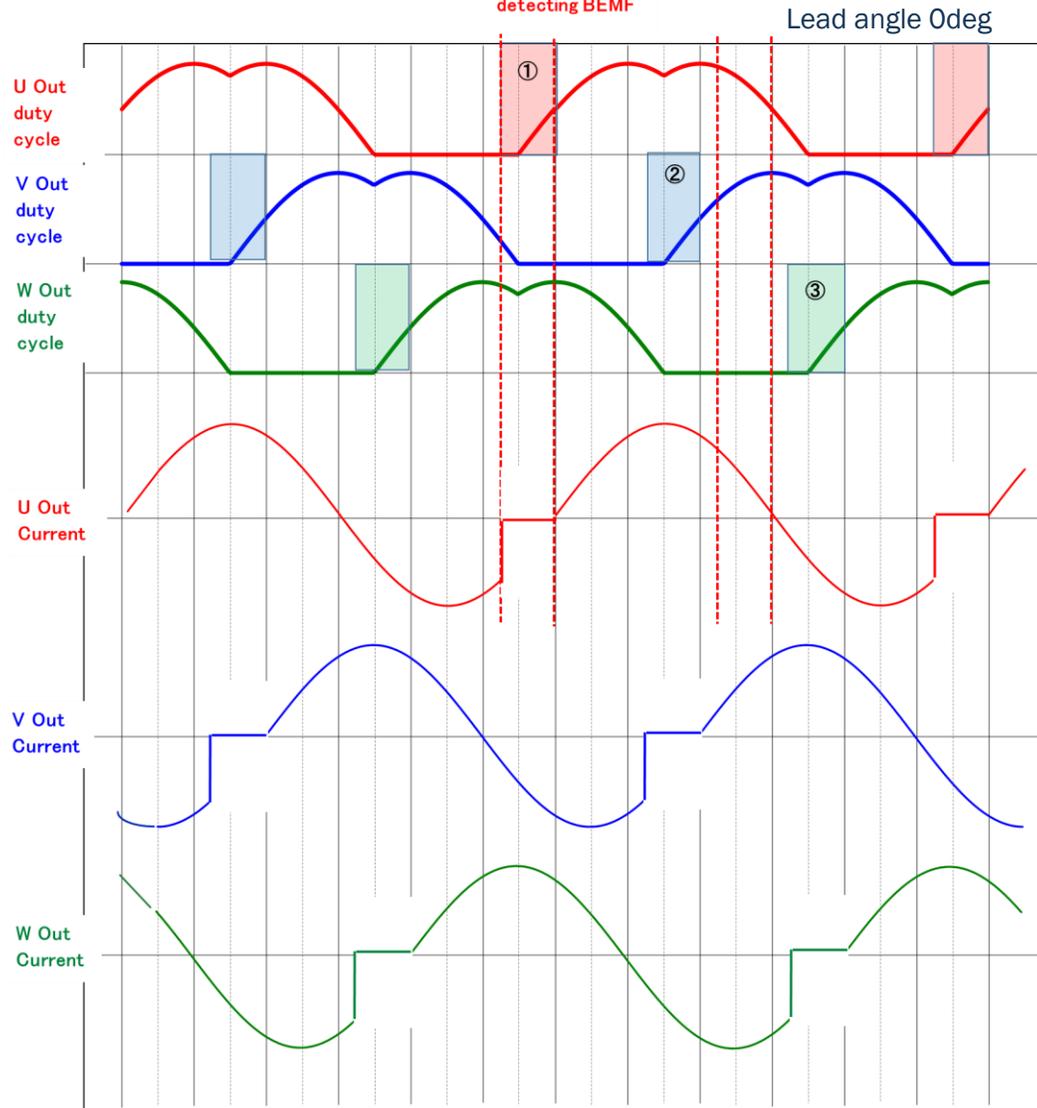
All zero cross (rising and falling) for all three phases will be detected by opening 6 windows per electrical cycle. The shaded period in the left chart, is the window i.e. floating output.

It gives best robustness to secure the all zero cross detection. However, the current waveform distortion will be higher. Even though, other window number (1, 2, or 3) is selected, 6-window mode is automatically selected at the initial motor start-up.



LV8961 3-window mode Timing Chart

3-Window mode for detecting BEMF



3-window mode

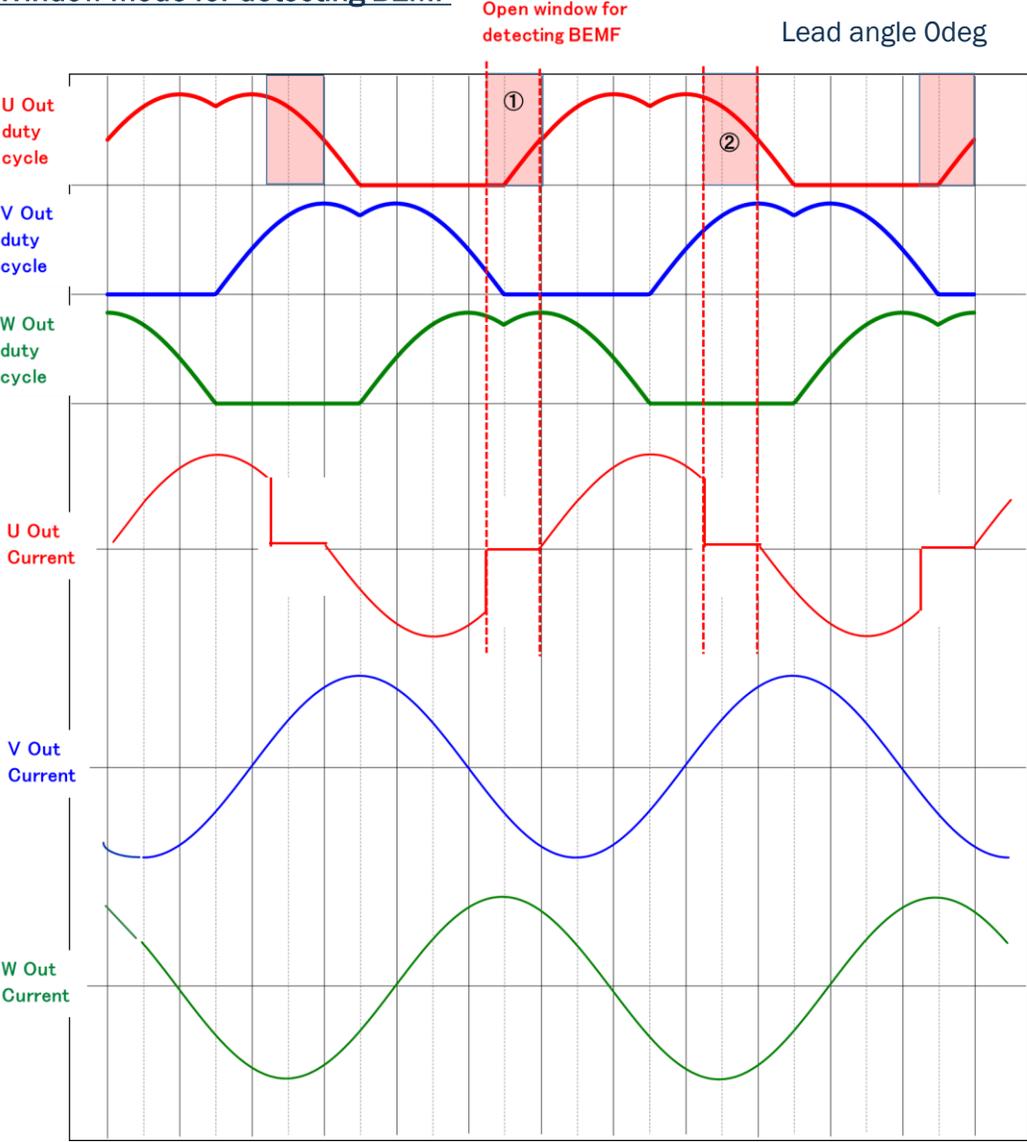
One rising zero cross for each phase will be detected by opening 3 windows per electrical cycle. The shaded period in the left chart, is the window i.e. floating output.

Balanced (or same) waveform is applied among three phases.



LV8961 2-window mode Timing Chart

2-Window mode for detecting BEMF



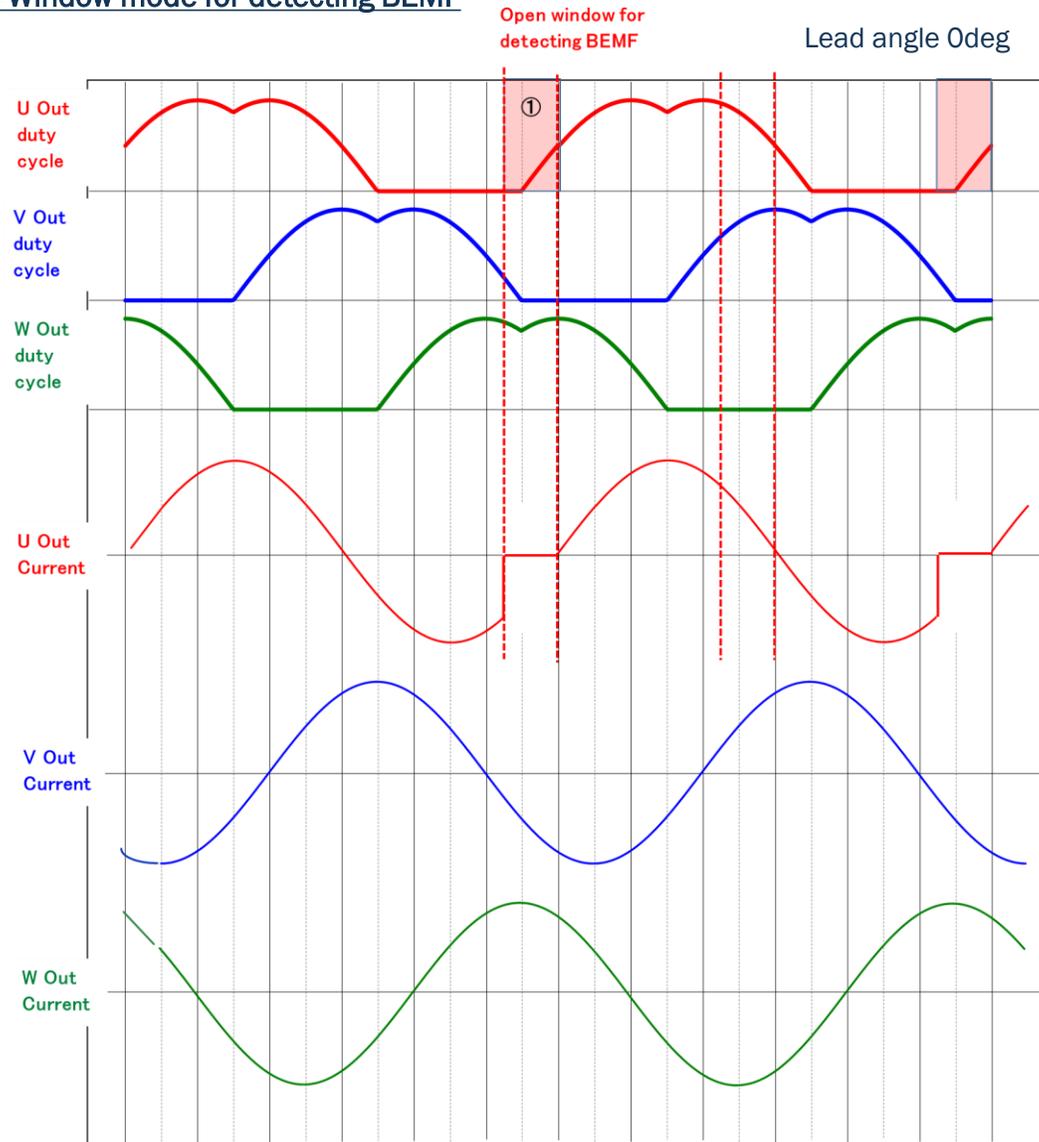
2-window mode

Rising and falling zero crosses of the phase U will be detected by opening two windows per electrical cycle. The shaded period in the left chart, is the window i.e. floating output. Only phase U has the windows, and the others (V and W) doesn't. Therefore, the current waveform distortion will be reduced.



LV8961 1-window mode Timing Chart

1-Window mode for detecting BEMF



1-window mode

Rising zero crosses of the phase U will be detected by opening one window per electrical cycle. The shaded period in the left chart, is the window i.e. floating output.

Only phase U has the window, and the others (V and W) doesn't. Therefore, the current waveform distortion will be minimized in the those four window modes.

LV8961 Register for window

Register Description

Speed Control Register Overview

ADDR	ADDR	Data Name	D[7]	D[6]	D[5]	D[4]	D[3]	D[2]	D[1]	D[0]
MSAENB=L	0015h	MRSPCT19	0	0	0	0	0	0	WINDSEL[1:0]	
	0016h	MRSPCT20	MSKRSTNUM0_INI[3:0]				MSKRSTNUM1_INI[3:0]			
	0017h	MRSPCT21	MSKRSTNUM0_THR[3:0]				MSKRSTNUM1_THR[3:0]			
	0018h	MRSPCT22	MSKRSTNUM0_TWO[3:0]				MSKRSTNUM1_TWO[3:0]			
	0019h	MRSPCT23	MSKRSTNUM0_ONE[3:0]				MSKRSTNUM1_ONE[3:0]			



LV8961 Register for window

MRSPCT19 (Default: 00h)

ADDR	Data Name	D[7]	D[6]	D[5]	D[4]	D[3]	D[2]	D[1]	D[0]
0015h	MRSPCT19	0	0	0	0	0	0	WINDSEL	

WINDSEL[1:0]: selects the number of BEMF zero cross detection window per electrical cycle

WINDSEL[1:0]=0h: 6-window

WINDSEL[1:0]=2h: 2-window

WINDSEL[1:0]=1h: 3-window

WINDSEL[1:0]=3h: 1-window

MRSPCT20 (Default: 00h)

ADDR	Data Name	D[7]	D[6]	D[5]	D[4]	D[3]	D[2]	D[1]	D[0]
0016h	MRSPCT20	MSKRSTNUM0_INI[3:0]				MSKRSTNUM1_INI[3:0]			

MSKRSTNUM0_INI[3:0]: Energization width setting from BEMF zero-cross to Hiz window start point, for 6-window initial mode

MSKRSTNUM1_INI[3:0]: Mask-period setting for detecting BEMF zero-cross from Hiz window start point, for 6-window initial mode

MSKRSTNUM0_INI[3:0]=x:

($x < 8$) -> $(15 + x * 3.75)$ deg.

($x \geq 8$) -> $(41.25 + (x - 7) * 1.875)$ deg.

MSKRSTNUM1_INI[3:0]=x: $((x + 1) * 1.875)$ deg.



LV8961 Register for window

MRSPCT21 (Default: 00h)

ADDR	Data Name	D[7]	D[6]	D[5]	D[4]	D[3]	D[2]	D[1]	D[0]
0017h	MRSPCT21	MSKRSTNUM0_THR[3:0]				MSKRSTNUM1_THR[3:0]			

MSKRSTNUM0_THR[3:0]: Energization width setting from BEMF zero-cross to Hiz window start point, for 3-window mode

MSKRSTNUM0_THR[3:0]=x:

$(x < 8) \rightarrow (15 + x * 3.75) \text{ deg.}$

$(x \geq 8) \rightarrow (41.25 + (x - 7) * 1.875) \text{ deg.}$

MSKRSTNUM1_THR[3:0]: Mask-period setting for detecting BEMF zero-cross from Hiz window start point, for 3-window mode

MSKRSTNUM1_THR[3:0]=x: $((x + 1) * 1.875) \text{ deg.}$

LV8961 Register for window

MRSPCT22 (Default: 00h)

ADDR	Data Name	D[7]	D[6]	D[5]	D[4]	D[3]	D[2]	D[1]	D[0]
0018h	MRSPCT22	MSKRSTNUM0_TWO[3:0]				MSKRSTNUM1_TWO[3:0]			

MSKRSTNUM0_TWO[3:0]: Energization width setting from BEMF zero-cross to Hiz window start point, for 2-window mode

MSKRSTNUM0_TWO[3:0]=x:

$(x < 8) \rightarrow (15 + x * 3.75) \text{ deg.}$

$(x \geq 8) \rightarrow (41.25 + (x - 7) * 1.875) \text{ deg.}$

MSKRSTNUM1_TWO[3:0]: Mask-period setting for detecting BEMF zero-cross from Hiz window start point, for 2-window mode

MSKRSTNUM1_TWO[3:0]=x: $((x + 1) * 1.875) \text{ deg.}$

LV8961 Register for window

MRSPCT23 (Default: 00h)

ADDR	Data Name	D[7]	D[6]	D[5]	D[4]	D[3]	D[2]	D[1]	D[0]
0019h	MRSPCT23	MSKRSTNUM0_ONE[3:0]				MSKRSTNUM1_ONE[3:0]			

MSKRSTNUM1_ONE[3:0]: Mask-period setting for detecting BEMF zero-cross from Hiz window start point, for 1-window mode

MSKRSTNUM1_ONE[3:0]=x: $((x + 1) * 1.875)$ deg.

MSKRSTNUM1_ONE[3:0]: Mask-period setting for detecting BEMF zero-cross from Hiz window start point, for 1-window mode

MSKRSTNUM1_ONE[3:0]=x: $((x + 1) * 1.875)$ deg.