

EVAL-6ED2742S01QM1 for Battery Powered Applications Evaluation Kit User Guide

Used for Consumer and Outdoor Power Tools, Robotics, Drones, Ebikes

About this document

Scope and purpose

The purpose of this document is to serve as an user guide for evaluating the new 160 V three phase gate driver from Infineon Technologies – [6ED2742S01Q](#). EVAL-6ED2742S01QM1 for Battery Powered Applications (BPA) evaluation kit consists of a three-phase inverter power board with the 160 V rated 6ED2742S01Q (in 5 x 5 QFN-32 package) three phase gate driver driving six 150 V rated OptiMOS™ MOSFETs BSC074N15NS5 (in 5 x 6 Super SO8 package). The power board has a M1 connector that is used to interface with iMotion™ [Modular Application Design Kit](#) (MADK) control card – [EVAL-M1-101T](#). This control card is powered by [IMC101T-T038 iMOTION™ Motor Control IC](#) featuring advanced Motor Control Engine (MCE), that enables state-of-the-art Sensorless Field Oriented Control (FOC) without need for any coding. IMC101T-T038 is a part of the iMOTION™ IMC100 series, which is the next generation of well established iMOTION™ motor control IC platform dedicated to field-oriented control of PMSM (BLDC) motors. The evaluation kit comes with both EVAL-6ED2742S01QM1 and EVAL-M1-101T including a USB connector to interface with a laptop having MCE Designer software.

Intended audience

Direct Current (DC) based Motor (BLDC, Servo, Stepper) control system engineers designing battery operated consumer power tools, outdoor power tools, robotics systems, drones, electric bikes and Small Home Appliances such as hair dryers, vacuum cleaners.

Evaluation Board

This board is to be used during the design-in process for evaluating and measuring characteristic curves, and for checking datasheet specifications. This board must be used in laboratory environment by trained power electronic engineers adhering to safety requirements.

Note: PCB and auxiliary circuits are NOT optimized for final customer design.

Note: Boards do not necessarily meet safety, EMI, quality standards (for example UL, CE) requirements.

Ordering information

Base part number	Package	Standard pack		Orderable part number
		Form	Quantity	
EVAL-6ED274201Q BPA EVAL Kit	MADK EVAL	Boxed	1	EVAL6ED2742S01Q
6ED2742S01Q	PG-VQFN-32	Tape and Reel	3000	6ED2742S01QPXUMA1
EVAL-M1-101T	MADK EVAL	Boxed	1	EVALM1101TTOBO2
BSC074N15NS5	PG-TSON-8	Tape and Reel	5000	BSC074N15NS5ATMA1
IFX25001 V33	PG-SOT223-4	Tape and Reel	1000	IFX25001 ME V33

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Important notice

Important notice

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Safety precautions

Note: Please note the following warnings regarding the hazards associated with development systems

Table 1 Safety precautions

	Warning: The DC link potential of this board is up to 160 VDC. When measuring voltage waveforms by oscilloscope, high voltage differential probes must be used. Failure to do so may result in personal injury or death.
	Warning: The evaluation or reference board contains DC bus capacitors which take time to discharge after removal of the main supply. Before working on the drive system, wait five minutes for capacitors to discharge to safe voltage levels. Failure to do so may result in personal injury or death. Darkened display LEDs are not an indication that capacitors have discharged to safe voltage levels.
	Warning: Remove or disconnect power from the drive before you disconnect or reconnect wires, or perform maintenance work. Wait five minutes after removing power to discharge the bus capacitors. Do not attempt to service the drive until the bus capacitors have discharged to zero. Failure to do so may result in personal injury or death.
	Caution: The heat sink and device surfaces of the evaluation or reference board may become hot during testing. Hence, necessary precautions are required while handling the board. Failure to comply may cause injury.
	Caution: Only personnel familiar with the drive, power electronics and associated machinery should plan, install, commission and subsequently service the system. Failure to comply may result in personal injury and/or equipment damage.
	Caution: The evaluation or reference board contains parts and assemblies sensitive to electrostatic discharge (ESD). Electrostatic control precautions are required when installing, testing, servicing or repairing the assembly. Component damage may result if ESD control procedures are not followed. If you are not familiar with electrostatic control procedures, refer to the applicable ESD protection handbooks and guidelines.
	Caution: A drive that is incorrectly applied or installed can lead to component damage or reduction in product lifetime. Wiring or application errors such as undersizing the motor, supplying an incorrect or inadequate AC supply, or excessive ambient temperatures may result in system malfunction.
	Caution: The evaluation or reference board is shipped with packing materials that need to be removed prior to installation. Failure to remove all packing materials that are unnecessary for system installation may result in overheating or abnormal operating conditions.

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The board at a glance

The functional blocks of EVAL-6ED2742S01QM1 BPA Evaluation Kit are presented in Figure 2

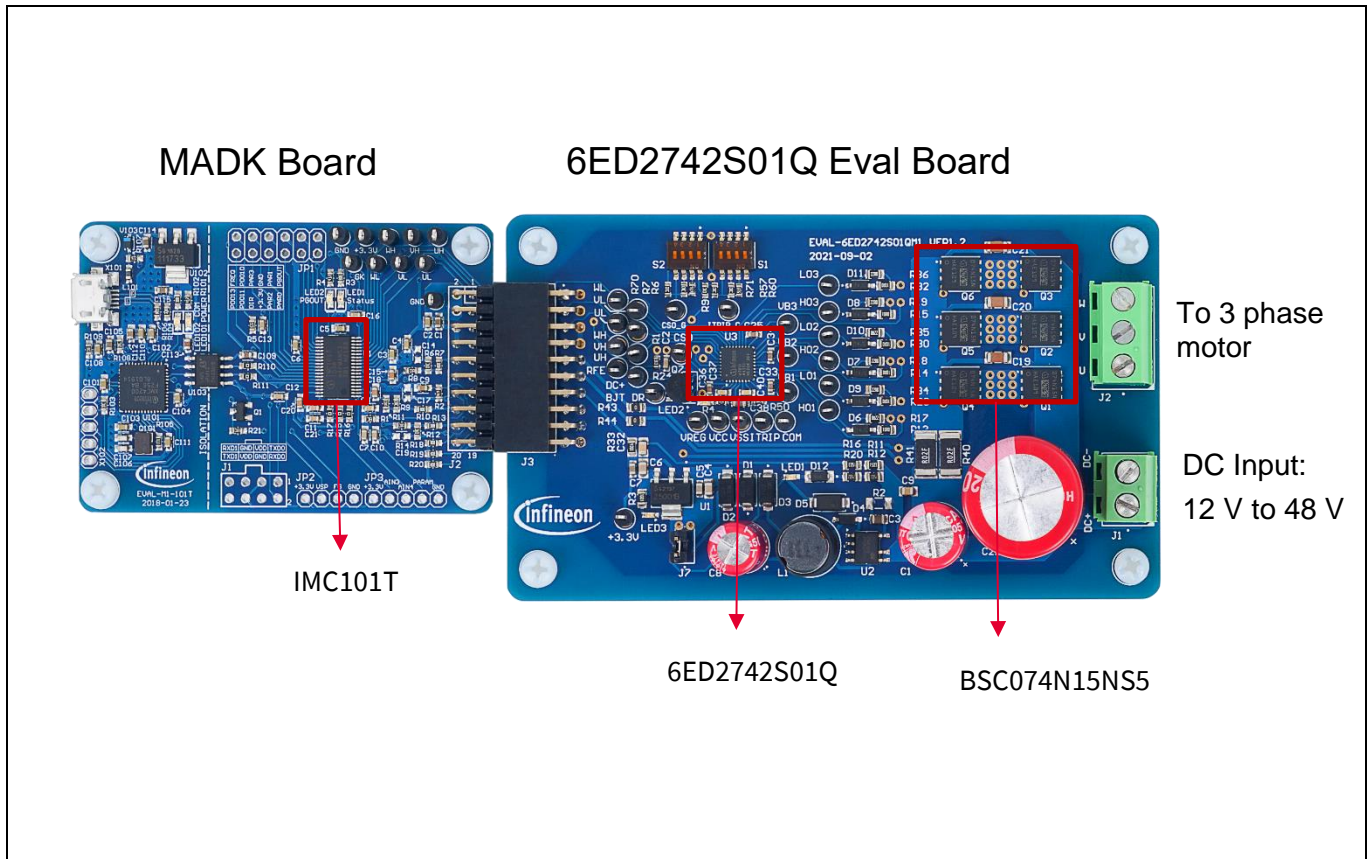


Figure 2 Functional blocks of EVAL-6ED2742S01QM1 BPA Evaluation Kit (top view)

1.3 Main features

The main features of EVAL-6ED2742S01QM1 include:

- Nominal DC input voltage of 24 V
- Design for maximum 250 W motor power output (500 W with added heatsink / forced air cooling)
- Single shunt for current sensing
- Sensing of DC-link voltage
- +12 V and +3.3 V auxiliary power supplies on the board
- M1 interface compatible with the iMOTION™ control board
- Integrated power management unit (PMU) inside 6ED2742S01Q with
 - Linear pre-regulator to enable wide input VIN range
 - Integrated charge pump for stable V_{CC}
- Integrated current sense amplifier (CSA) inside 6ED2742S01Q with selectable gain
- Integrated over-current protection inside 6ED2742S01Q with selectable V_{REF} threshold
- Integrated shoot-through protection with built-in dead time
- Multi-function RFE pin (Enable, Fault, and automatic Fault clear) to enable / disable motor drive
- Integrated short pulse / noise rejection input filter

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The board at a glance

1.4 Board parameters and technical data

The key specifications of EVAL-6ED2742S01QM1 are listed in Table 2.

Table 2 Specifications of EVAL-6ED2742S01QM1

Parameter	Symbol	Conditions	Value			Unit
			Min.	Nom.	Max.	
Input						
Input voltage	V _{IN}	DC voltage	10	24	48	V
Input current	I _{IN}	Input current	–	–	12	A
Output						
Output current	I _{OUT}	RMS phase-out current	–	–	10	A
Output power	P _{OUT}	Additional heat dissipation is needed (e.g. heat sink , forced air cooling)	150	250	500	W
Overcurrent protection	I _{OCP}	Peak phase-out current	–	–	11	A
Switching frequency						
Inverter carrier frequency	F _{SW}		–	23	–	kHz
Auxiliary power supply						
Fan power supply			–	12	–	V
Controller power supply			–	3.3	–	V
System environment						
Ambient temperature		With adequate cooling method	–	25	–	°C
PCB characteristics						
Dimensions	L	Length	–	120	–	mm
	W	Width	–	60	–	mm
	H	Height	–	25	–	mm
Layer			–	4	–	
PCB thickness			–	1.6	–	mm
Copper thickness			–	4	–	oz.
Material		FR-4, RoHS-compliant				

Note: The evaluation board is designed to evaluate the parameters of 6ED2742S01Q three phase gate driver IC. The board does not have over temperature protection and care should be taken to set the correct OCP – over current protection level with ITRIP config setting before starting the board test with a given BLDC motor. The board is design limits with and without heatsink are as below:

Table 3 EVAL-6ED2742S01QM1 board thermal / overcurrent limits:

With heatsink	With air cooling	Typical Speed	Board temperature after 15 minutes	Phase current
No	No	52 kRPM	80°C	8 A_{rms}, 16 A_{peak}
Yes	No	58 kRPM	75°C	10 A _{rms} , 20 A _{peak}
No	Yes	60 kRPM	75°C	11 A_{rms}, 21 A_{peak}
Yes	Yes	62 kRPM	82°C	12 A _{rms} , 22 A _{peak}

System and functional description

2 System and functional description

2.1 Getting started with EVAL-6ED2742S01QM1

To run the motor system, a combination of the power board EVAL-6ED2742S01QM1 and a matching iMOTION™ control board (e.g., EVAL-M1-101T) are required. This chapter explains how to set up the system and get started with the iMOTION™ development platform.

The power board EVAL-6ED2742S01QM1 can run a BLDC motor by connecting to the iMOTION™ 2.0 control board EVAL-M1-101T through an M1 interface. The system connection is shown in Figure 3, and the test results are listed in Section 4.1.

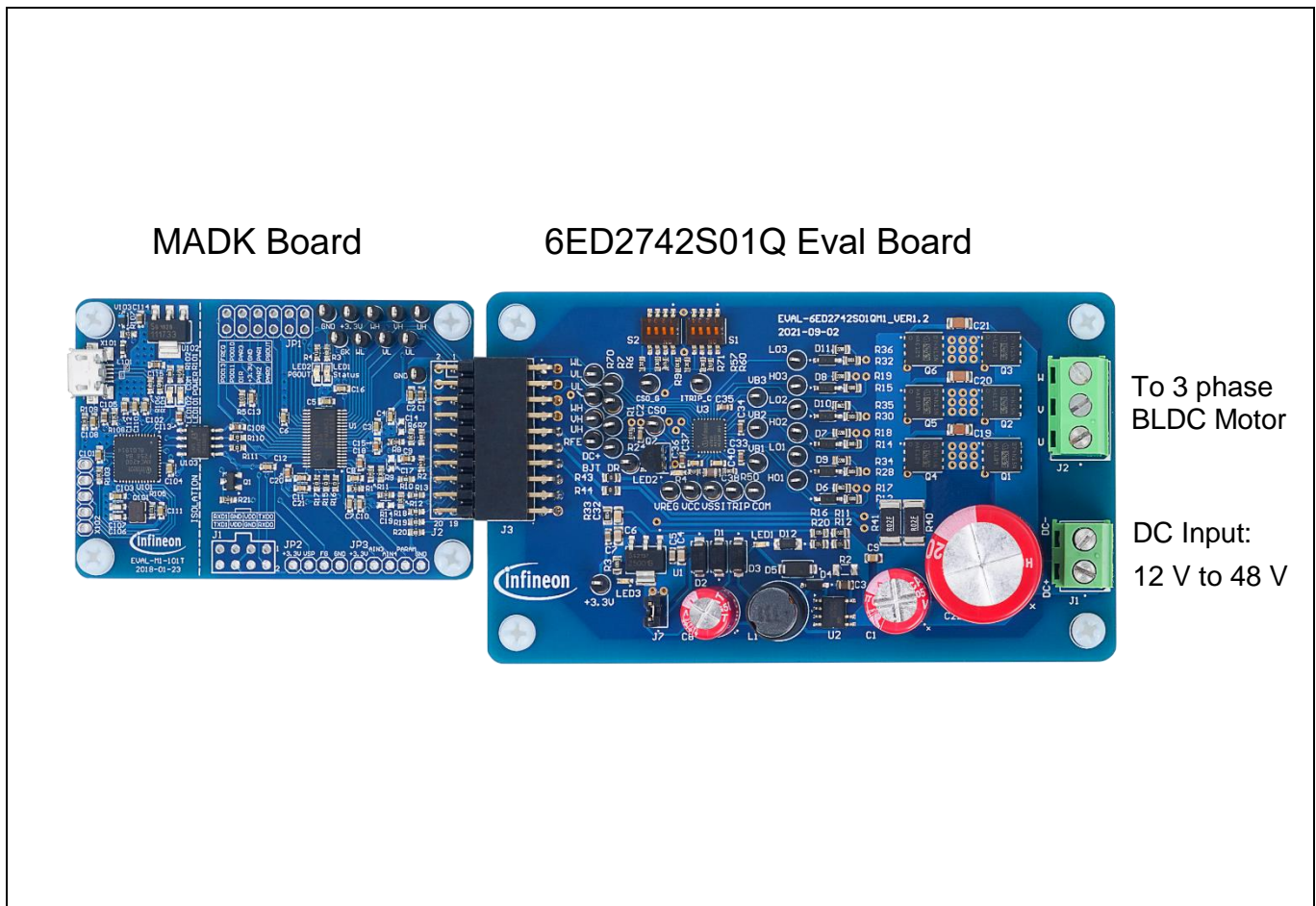


Figure 3 The system connection for running a BLDC motor.

2.1.1 The iMOTION™ control board

The latest IMC101T-T038 MCE software package can be downloaded from www.infineon.com/imotion-software.

With EVAL-M1-101T and the latest software, connect your PC to the control board via a USB cable to program and tune it.

1. Connect EVAL-M1-101T's M1 20-pin interface connector J2 to the EVAL-6ED2742S01QM1 board connector J3.
2. In the MCEWizard, enter the system and operating parameters of the target motor and the hardware parameters of the evaluation board. This data is used for calculating the digital parameter set of the controller, representing the complete motor drive system.

System and functional description

3. Go to the Verify & Save page and click **Calculate Parameters**. Then, save the drive parameter set into your project directory by clicking **Export to MCEDesigner file (.txt)** (see Figure 6). This saved drive system parameter file will be used later by the MCEDesigner. Refer to Section 2.1.4 or the MCEWizard user guide for more information.
4. Connect motor phase outputs (J2 on the EVAL-6ED2742S01QM1 board) to the motor.
5. Connect DC input to the power input connector (J1 on the EVAL-6ED2742S01QM1 board), then power on the system. Note the
6. Start the MCEDesigner tool.
7. Click **File > Open** to open the MCEDesigner default configuration file (.irc) for the IMC101T-T038 controller (IMC101T_Vxxx.irc). The IMC101T_Vxxx.irc file is included in the IMC101T-T038 MCE software package.
8. The MCEDesigner should automatically connect to the EVAL-M1-101T control board using the default COM port (indicated by a green circle next to the “COMx Up” status in the bottom frame of the MCEDesigner GUI). If the connection cannot be established, change the COM port as follows:
 - a) Open the System Page window.
 - b) Click **Preferences > Connection > Connect using**.
 - c) Choose one of the other available COM ports from the drop-down list.
9. Program the system parameters into the internal SRAM of the iMOTION™ IC using the following steps:
 - a. Click **Tools > Programmer** and select **Program Parameters**.
 - b. Browse and select the System Drive Parameters file created in step 3. See Section 2.1.4 for more information.
10. Start the motor by clicking the green traffic light button in the control bar. To stop the motor, click the red traffic light button in the control bar.

2.1.2 iMOTION™ development tools and software

The EVAL-6ED2742S01QM1 evaluation board can run a BLDC motor when connected to an external control board EVAL-M1-101T. Users must configure the iMOTION™ development tool and software according to the system and BLDC motor parameters.

The MCEDesigner and MCEWizard are based on MCEDesigner v2.3.1 and MCEWizard v2.3.1 and can be downloaded together with supported files from <http://www.infineon.com/imotion-software>.

A review of references [10] to [16], on [page 45](#) will provide a deeper understanding of the overall iMotion™ ecosystem.

2.1.3 MCEWizard setup overview

Use the MCEWizard to configure the parameters for the evaluation board or motor. Figure 4 shows the Welcome page of the MCEWizard. Here, users can select the control board or power board from a drop-down list. Infineon releases new control and power boards regularly. Therefore, it is possible that some of the latest power boards have not been pre-configured in the MCEWizard tool and cannot be selected from the drop-down menu. In that case, users can select another power board (as similar as possible) and follow the setup steps in the MCEWizard by entering parameters specific to the power board chosen. Please refer to the application note of the corresponding power board for additional information.

After selecting the modular application design kit (MADK) control board and the power board, click **Next** in the right-hand bottom corner of the Welcome page to start the MCEWizard system setup process.

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System and functional description

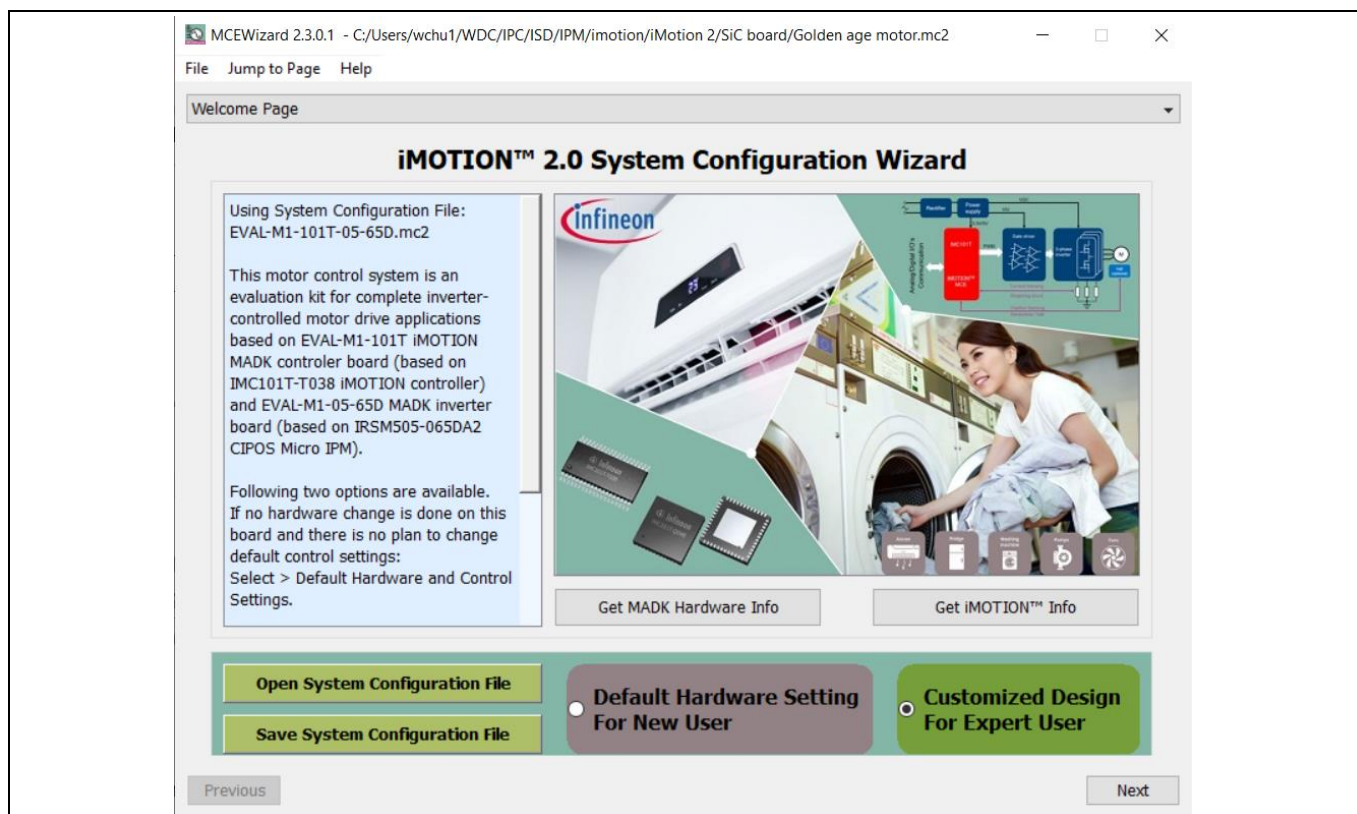


Figure 4 Welcome page of the MCEWizard

The iMOTION™ system enables users to easily test different combinations of control and power boards with their motors. Users should be familiar with system-level parameters related to the motor used. There are a limited number of parameters specific to the control board or power board hardware. Table 3 lists the hardware parameters specific to the EVAL-6ED2742S01QM1 power board for MCEWizard setup. Similar tables are available for each control board in its application note. A combination of data in this table and the corresponding table of the control board provides sufficient information to set up the motor drive system quickly.

Table 4 MCEWizard setup overview table

Parameter	Value
Control board selecting	EVAL-M1-101T for example
Motor 1 shunt configuration	Single shunt
Controller supply voltage	+3.3 V
Max DC bus voltage	36 V
DC bus sensing high resistor	300 kΩ
DC bus sensing low resistor	4.7 kΩ
NTC temperature shutdown value	Refer to the control board's application note [6]
Gate sense low-side devices	High is true
Gate sense high-side devices	High is true
Motor 1 current input scaling	Calculated in the corresponding section of the control board's application note [6]

After all the MCEWizard questions are answered, the Verify & Save page opens (see Figure 5.)

System and functional description

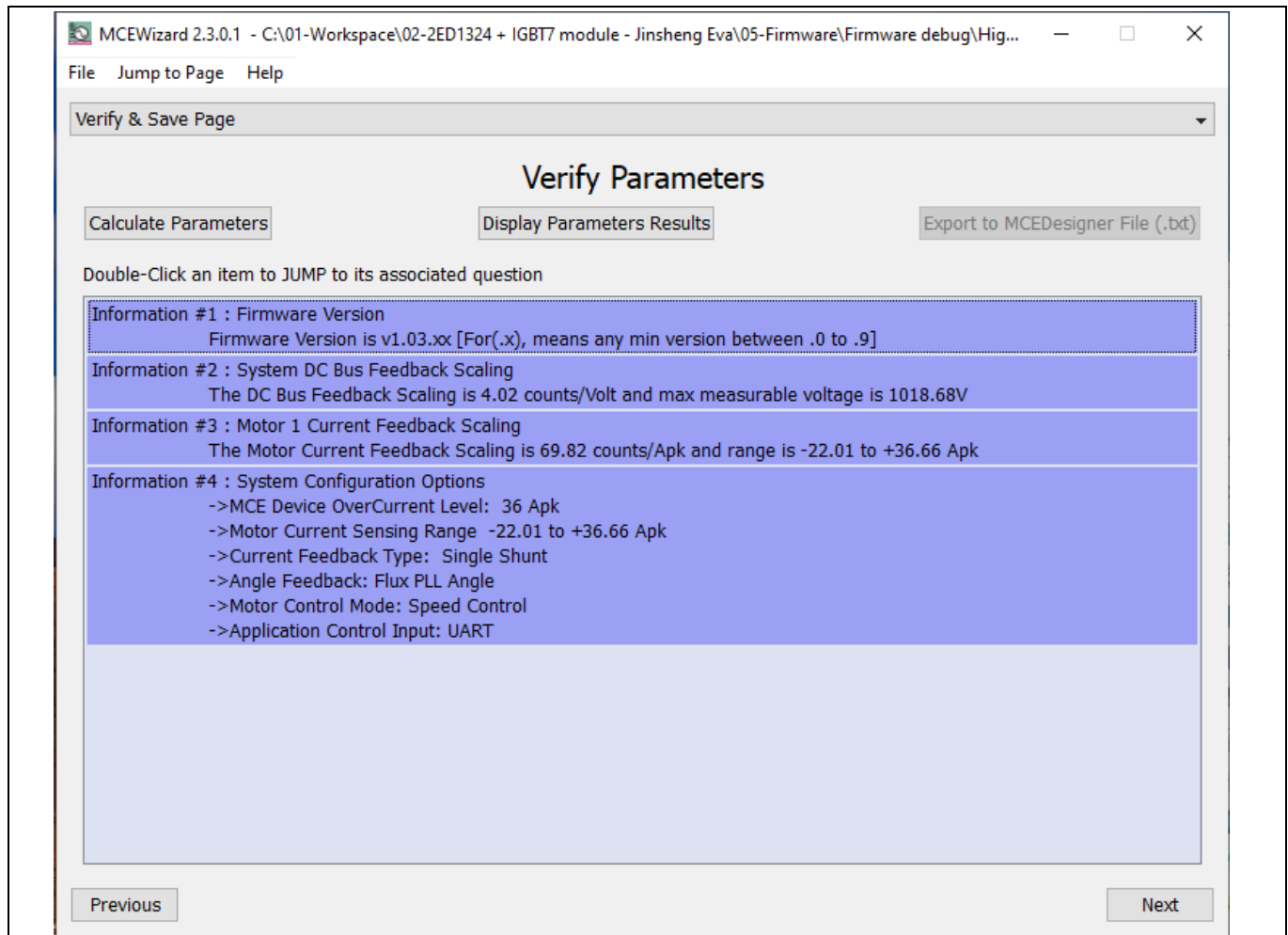


Figure 5 Verify & Save page of the MCEWizard.

Click **Calculate Parameters** and then **Export to MCEDesigner File (.txt)** to save the parameter file. This file will be used by the MCEDesigner in the next steps.

System and functional description

2.1.4 MCEDesigner setup overview

The MCEDesigner is a user interface to access or debug the control board. Open the MCEDesigner and then open the IMC101T_xx.irc file. The main display page for EVAL-M1-101T opens, as shown in Figure 6.

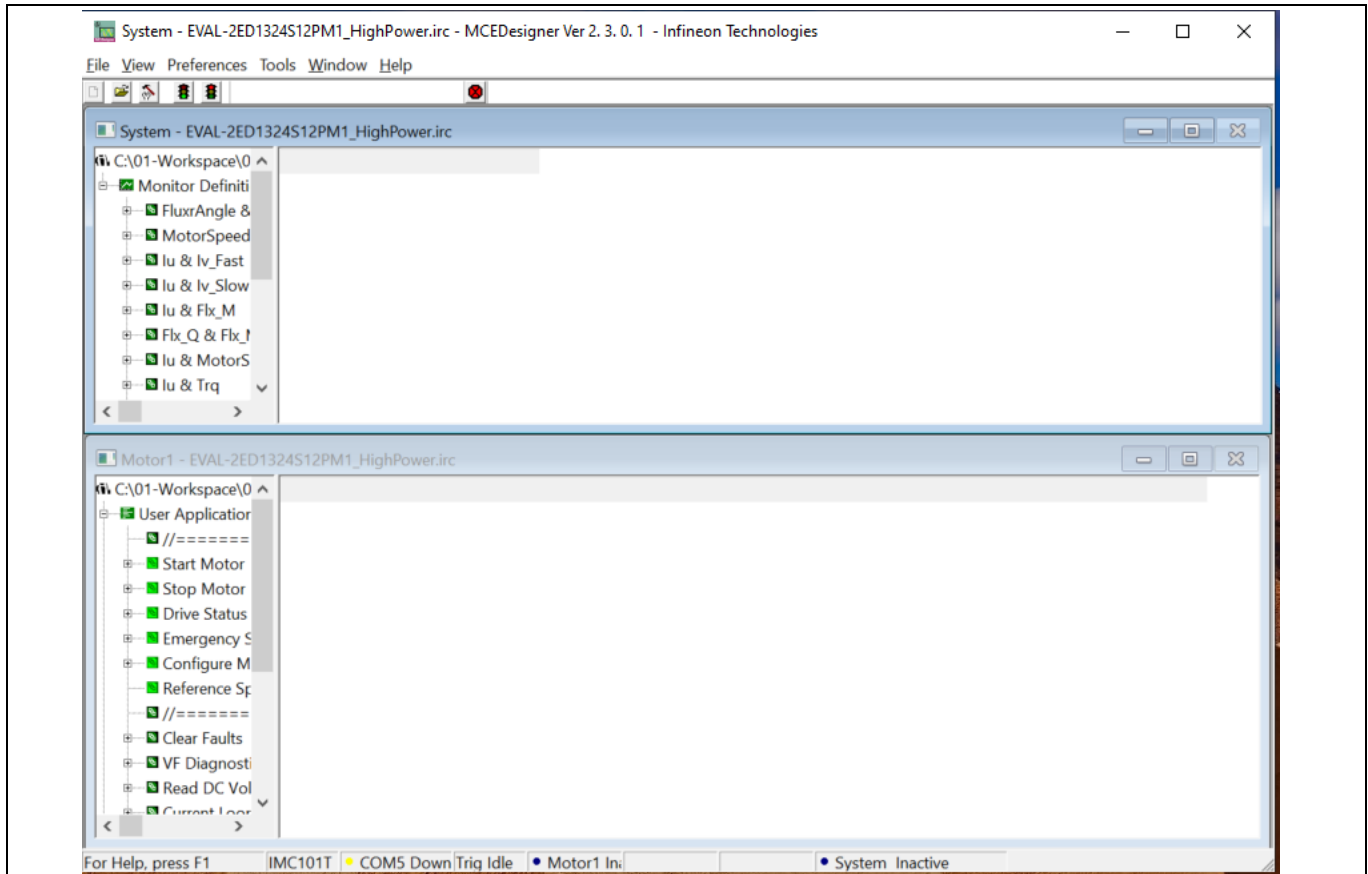


Figure 6 MCEDesigner's main display for EVAL-M1-101T

After the drive system parameter file has been programmed into the IMC101 controller, and the motor drive system powered, the MCEDesigner can be used to start/stop the motor, display motor current traces, change the motor speed, modify drive parameters, and perform many other functions. Please refer to the MCEDesigner documentation [8] for more details.

2.2 M1 Connector Pin details

In case the user prefers to use custom microcontroller, the pinout details of the 20 pin M1 connector used on the EVAL-6ED2742S01QM1 EVAL board is as shown in Table 5. The PWM signal output from the custom microcontroller can be fed to Pin 1, 2, 5, 7, 9, 11 and the single shunt current feedback is available on Pin 10 and Pin 12. Over current protection / RFE output from the 6ED2742S01Q is available on Pin 13. VCC of 3.3 V (Pin 6, 8) and GND (Pin 2, 4) is also available.

User can interface their microcontroller signals as per the pinout shown in Table 5 and evaluate with their existing code of different control schemes such as trapezoidal / block commutation and Sensorless Field Oriented Control (FOC).

User can also look at [EVAL-M1-101TF](#) control card (available to order separately), that comes with Hall Sensor Inputs to evaluate their existing code of Hall Sensor based FOC control.

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Table 5 20-pin M1 connector setup

Pin	Name	Pin Name Connectors
1	PWMUH	VDD compatible logic output for high side gate driver-Phase U
2	GND	Ground
3	PWMUL	VDD compatible logic output for low side gate driver-Phase U
4	GND	Ground
5	PWMVH	VDD compatible logic output for high side gate driver-Phase V
6	+3.3V	On board VDD supply
7	PWMVL	VDD compatible logic output for low side gate driver-Phase V
8	+3.3V	On board VDD supply
9	PWMWH	VDD compatible logic output for high side gate driver-Phase W
10	IU+	Shunt voltage phase U
11	PWMWL	VDD compatible logic output for low side gate driver-Phase W
12	IU-	Ground
13	GK	Gate kill signal – active low when over current is detected
14	DCBSENSE	DC bus positive voltage, scaled in 0 - VDD range by a voltage divider
15	VTH	Thermistor input
16	IV+	Shunt voltage phase V
17	IV-	Ground
18	IW+	Shunt voltage phase W
19	IW-	Ground
20	VCC	Defined for 15 V Power Supply (not used in this board)

2.3 Description of functional blocks

The motor inverter in EVAL-6ED2742S01QM1 hardware design is implemented by the new 160 V SOI three phase gate drivers 6ED2742S01Q and six OptiMOST™ 150 V N-Channel MOSFETs - BSC074N15NS5. The auxiliary power supply is derived from a high voltage DC-DC buck converter providing 12 V followed by a LDO providing the 3.3 V required to power the iMotion™ IMC101T microcontroller.

2.3.1 Overview of 6ED2742S01Q

Figure 7 shows the functional block diagram of 6ED2742S01Q. For more information such as static and dynamic electrical characteristics of the gate driver, please refer to the datasheet of 6ED2742S01Q.

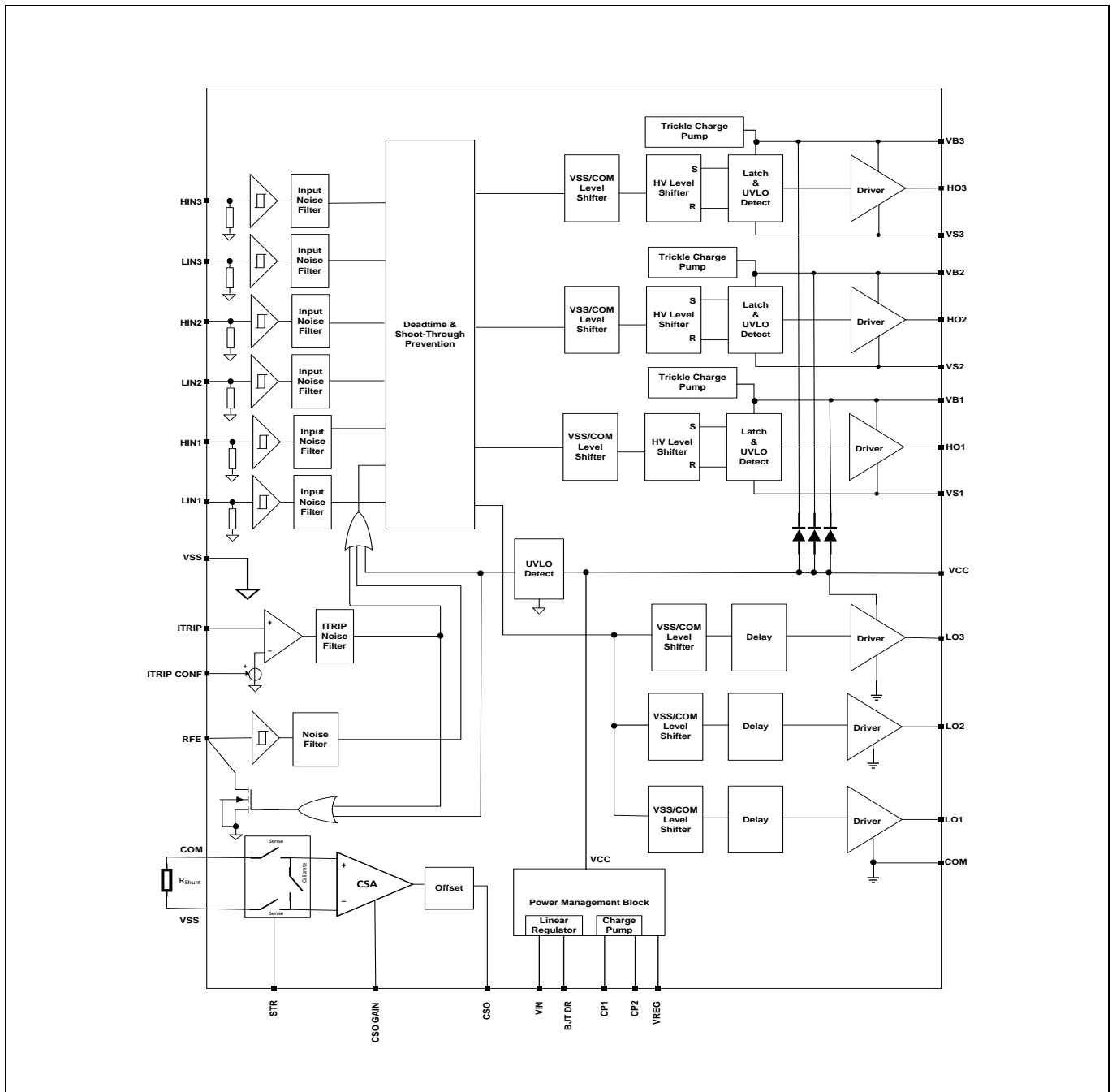


Figure 7 Functional block diagram of 6ED2742S01Q

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The main features of 6ED2742S01Q include:

- Bootstrap voltage (VB node) of +160 V
- Floating channel designed for bootstrap operation
- Integrated power management unit (PMU) with
 - Linear pre-regulator to enable wide input VIN range
 - Integrated charge pump for stable V_{CC}
- Integrated current sense amplifier (CSA) with selectable gain
- Integrated over-current protection with selectable V_{REF} threshold
- 100% duty cycle operation with trickle charge pump per high side
- Integrated low R_{ON}, ultra-fast bootstrap diodes
- Independent under voltage lockout for both high and low side
- Integrated shoot-through protection with built-in dead time
- Multi-function RFE pin (Enable, Fault, and automatic Fault clear)
- Integrated short pulse / noise rejection input filter
- Schmitt trigger inputs with hysteresis
- 3.3 V, 5 V input logic compatible, outputs in phase with inputs
- Available in small footprint QFN32 lead, 5x5 mm package
- 2kV HBM ESD, RoHS compliant in a 5 x 5 mm VQFN-32 package

Table 6 Absolute maximum ratings of 6ED2742S01Q

Symbol	Definition		Min.	Max.	Units
V _B	High-side floating well supply voltage (Note 1)		-0.3	160	V
V _{IN}	Input battery supply voltage		5	140	
V _S	High-side floating well supply return voltage		-0.3	140	
V _{BS}	Bootstrap supply range		-0.3	20	
V _{HO}	Floating gate drive output voltage		V _S - 0.3	V _B + 0.3	
V _{REG}	Charge pump input voltage		-0.3	20	
V _{CC}	Low side supply voltage		-0.3	20	
V _{LO}	Low-side output voltage		-0.3	V _{CC} + 0.3	
V _{LOGIC IN}	Logic input voltage (HIN, LIN)		-0.3	5	
BJTDR	Output signal for base drive of external NPN BJT		-0.3	20	
RFE	Enable, Fault and automatic fault clear pin		-0.3	5	
ITRIP	Over current protection input pin		-0.3	5	
ITRIP CONF	Over current protection threshold configuration pin		-0.3	5	
CSO	Current sense op amp output		-0.3	3.6	
CSO GAIN	Current sense op amp gain configuration pin		-0.3	5	
STR	Strobe signal for op amp offset compensation		-0.3	5	
CP1	Charge pump capacitor pin1		-0.3	20	
CP2	Charge pump capacitor pin2		-0.3	20	
COM	Low side power ground return		-5.0	+5.0	
dV _S /dt	Allowable V _S offset supply transient relative to COM		—	50	V / ns
P _D	Package power dissipation @ T _A ≤ +25°C	5 x 5mm QFN-32		3	W
R _{thJA}	Thermal resistance, junction to ambient	5 x 5mm QFN-32		41	°C/W
T _J	Junction temperature		—	150	°C

Note 1: There is an additional power dissipation in the internal bootstrap diode between pins VCC and VB for activated bootstrap diode in case VCC > VB

System and functional description

The 6ED2742S01Q internal Power Management Unit (PMU) can be configured to operate in four configurations. EVAL-6ED2742S01QM1 is designed to work in config #2 by default and can be configured to work in config #3 by removing R24 resistor on PCB board. Further information on operating the 6ED2742S01Q in config #1 and config #4 mode can be found in the device datasheet.

2.3.2 6ED2742S01Q PMU in Config #2 - Pre-regulator / charge pump: V_{BATT} connected to VIN

Configuration #2 provides wider input voltage flexibility with the smallest form factor since an external BJT is not used. Typical input voltage range operation up to 96 V is possible.

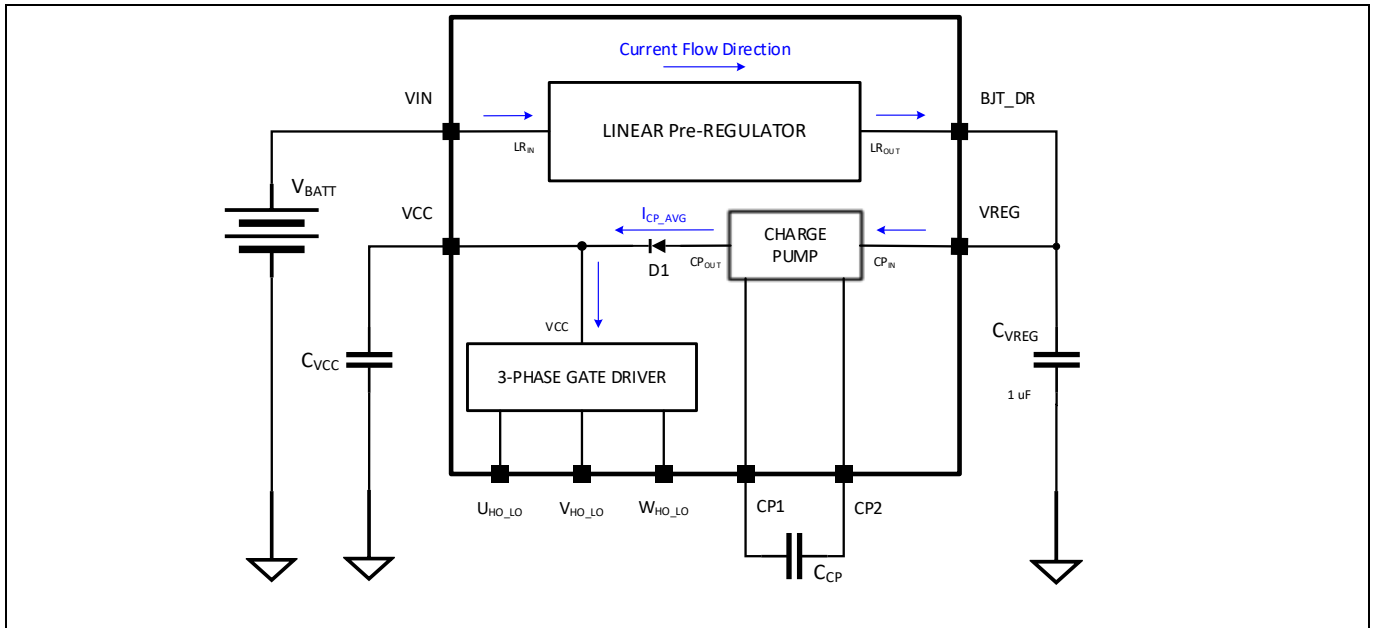


Figure 8 Typical configuration for 12 V to 90 V applications

Table 7 Charge pump only operating conditions (typical)

$V_{BATT} = VIN$ (V)	BJT_DR = VREG (V)	VCC (V)
90	15.5	12
72		
60		
48		
36		
24		
12	10.5	12
9	7.5	

2.3.3 6ED2742S01Q PMU in Config #3: V_{BATT} connected to VIN and external BJT

Configuration #3 provides the widest input voltage range with the addition of an external NPN BJT to share the power dissipation between the internal PMU blocks and BJT.

The schematic diagram illustrates the internal architecture of a power management IC (PMIC) and its connection to external components. The IC is represented by a large rectangle containing several functional blocks:

- LINEAR Pre-REGULATOR:** Receives input current I_{RIN} from the VIN pin and provides output current I_{ROUT} to the BJT_DR pin.
- CHARGE PUMP:** Receives input current I_{CP_AVG} from the VCC pin and provides output current I_{CPIN} to the $CPIN$ pin. It is connected to a capacitor C_{CP} between pins $CP1$ and $CP2$.
- 3-PHASE GATE DRIVER:** Receives input current I_{CP_AVG} from the VCC pin and provides output currents I_{HO_LO} , I_{VO_LO} , and I_{WO_LO} to pins U_{HO_LO} , V_{HO_LO} , and W_{HO_LO} respectively.

External components and connections include:

- BATT:** A battery symbol connected to the VIN pin.
- C_{VCC}:** A capacitor connected between the VCC pin and ground.
- BJT_DR:** A BJT symbol connected to the $VREG$ pin.
- C_{VREG} 10 uF:** A capacitor connected between the $VREG$ pin and ground.

Current flow directions are indicated by blue arrows: I_{RIN} into the linear pre-regulator, I_{ROUT} out of it, I_{CP_AVG} into the charge pump and gate driver, I_{CPIN} into the charge pump, and I_{HO_LO} , I_{VO_LO} , and I_{WO_LO} out of the gate driver.

VIN (V)	BJT_DR (V)	VREG (V)	VCC (V)
120	16.5	15.5	12
90			
80			
36			
24			
18		14.5	
12	10.5	9.5	
8	6.7	5.7	10

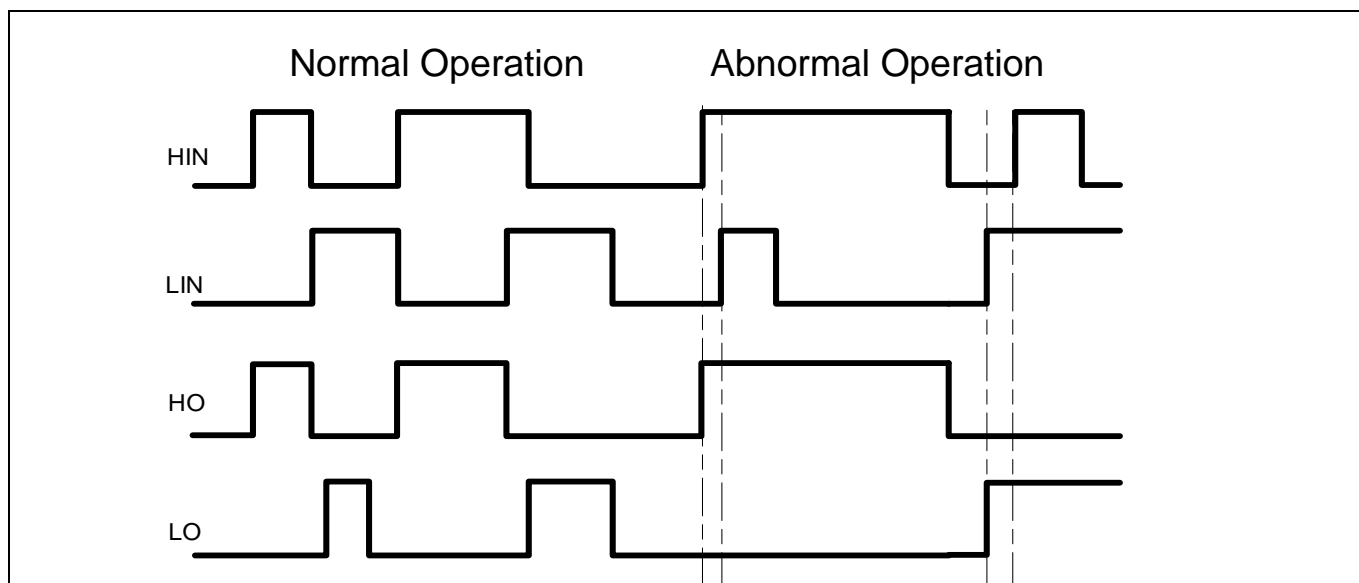


Figure 10 Illustration of shoot-through protection circuitry

2.5 Enable, Fault reporting and programmable fault clear timer

The 6ED2742S01Q provides an enable functionality that allows it to shutdown or enable the HVIC and also provides an integrated fault reporting output along with an adjustable fault clear timer. There are two situations that would cause the IC to report a fault via the RFE pin. The first is an undervoltage condition of VCC and the second is if the over-current feature has recognized a fault. Once the fault condition occurs, the RFE pin is internally pulled to VSS and the fault clear timer is activated. The RFE output stays in the low state until the fault condition has been removed and the fault clear timer expires; once the fault clear timer expires, the voltage on the RFE pin will return to its external pull-up voltage.

The length of the fault clear time period (t_{FLTCLR}) is determined by exponential charging characteristics of the capacitor where the time constant is set by R_{RFE} and C_{RFE} . Figure 15 shows that R_{RFE} is connected between the external supply (V_{DD}) and the RFE pin, while C_{RFE} is placed between the RFE and VSS pins.

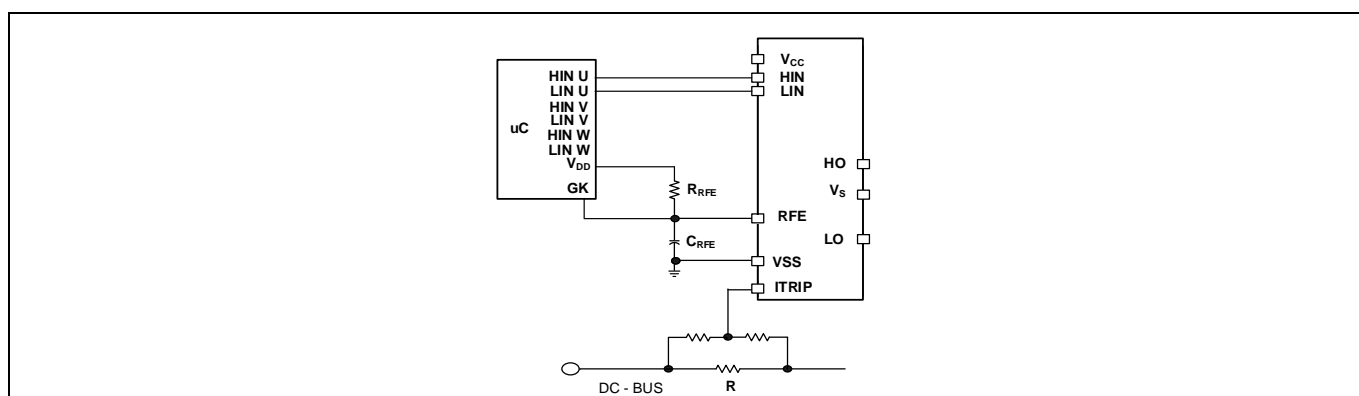


Figure 11 Programming the fault clear timer

The design guidelines for this network are shown in Table 7

System and functional description

Table 9 Fault clear timer design guidelines

C_{RFE}	$\leq 1 \text{ nF}$
	Ceramic
R_{RFE}	$0.5 \text{ M}\Omega$ to $2 \text{ M}\Omega$
	$\gg R_{ON}, R_{CIN}$

The length of the fault clear time period can be determined by using the formula below.

$$v_c(t) = V_f(1 - e^{-t/RC})$$

$$t_{FLTCLR} = -(R_{RFE} \cdot C_{RFE}) \cdot \ln(1 - V_{RFE+}/V_{DD}) + 100\text{ns}$$

The voltage on the RFE pin should not exceed the VDD of the uC power supply.

The EVAL-6ED2742S01QM1 board has C_{RFE} of 1 nF and R_{RFE} of 1 M Ω .

2.6 Over-current protection

The 6ED2742S01Q is equipped with an over-current feature in addition to the stand-alone Current Sense Amplifier (CSA). This functionality can sense over-current events in the DC- bus. Once the IC detects an over-current event, the outputs are shutdown, and RFE is pulled to VSS.

The level of current at which the over-current protection (OCP) is initiated is determined by the shunt resistor connected between COM pin and VSS pin as shown in Figure 12, and by the threshold configured by ITRIP CONF pin (V_{ITRIP+}). The circuit designer will need to determine the maximum allowable level of current in the DC- bus and select R_0 and V_{ITRIP+} .

$$V_{ITRIP+} = R_0 \times I_{DC-}$$

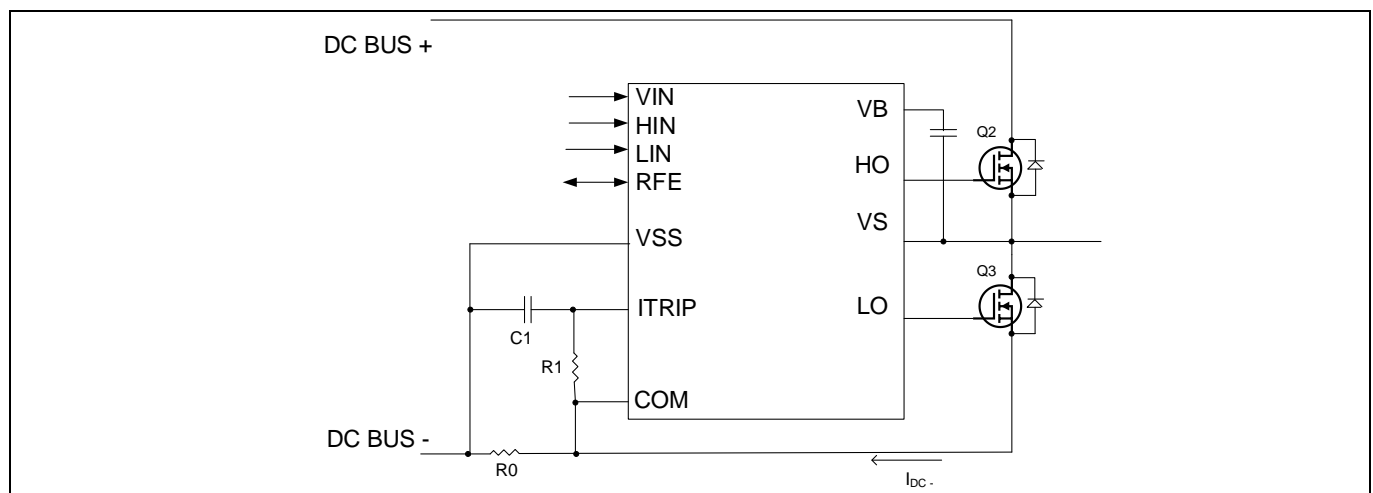


Figure 12 Programming the over-current protection

For example, a typical value for resistor R_0 could be 10 m Ω as with EVAL-6ED2742S01QM1 board providing the over-current protection on the ITRIP as 25 A with a ITRIP config threshold set to 0.25 V. See figure 14 to enable the correct switch position for this configuration on board.

System and functional description

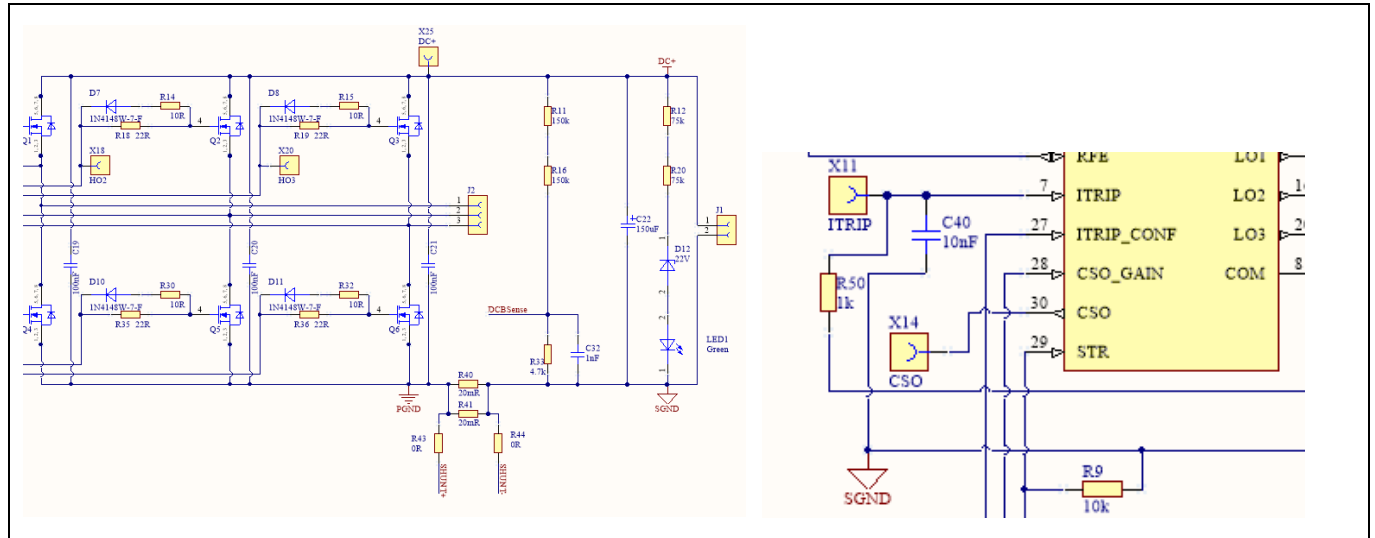


Figure 13 Over current protection section of EVAL-6ED2742S01QM1 board

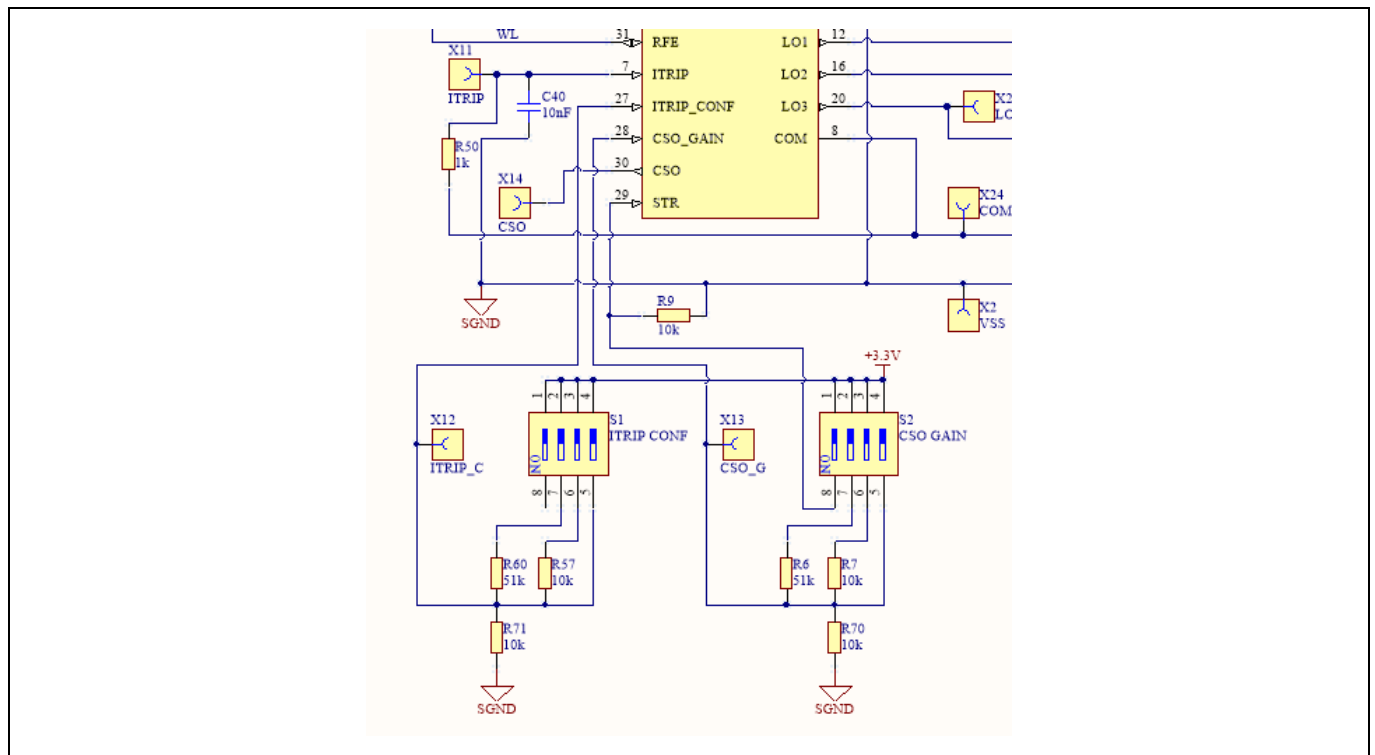


Figure 14 Over current protection ITRIP-Config section of EVAL-6ED2742S01QM1 board. Slide switch on position 2 to set 0.25 V ITRIP threshold.

System and functional description

2.7 Integrated Current Sense Operational amplifier – unused in current EVAL-6ED2742S01QM1 board

A current sense operational amplifier (CSA) with configurable gain is integrated in the gate driver sensing the voltage between VSS and COM pins. The amplifier has a strobe input signal. When strobe signal is LOW the operational amplifier output signal CSO is following the VSS-COM voltage multiplied by a certain gain, when strobe signal is HIGH CSO signal is reporting the op amp offset. CSO output has an offset added above VSS of 150 mV. This offset ensures the measured current remains positive and does not go negative in any regular operating conditions.

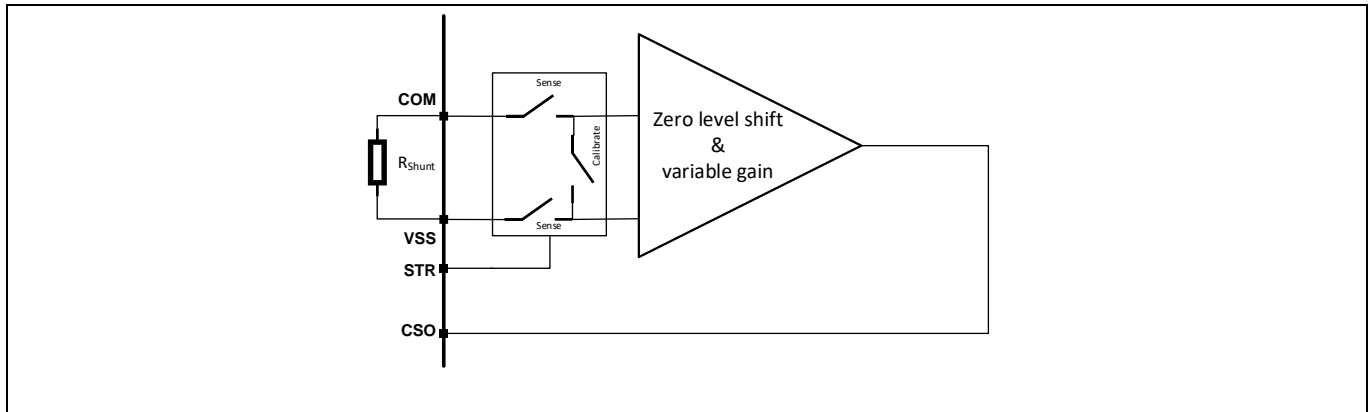


Figure 15 Current sense operational amplifier

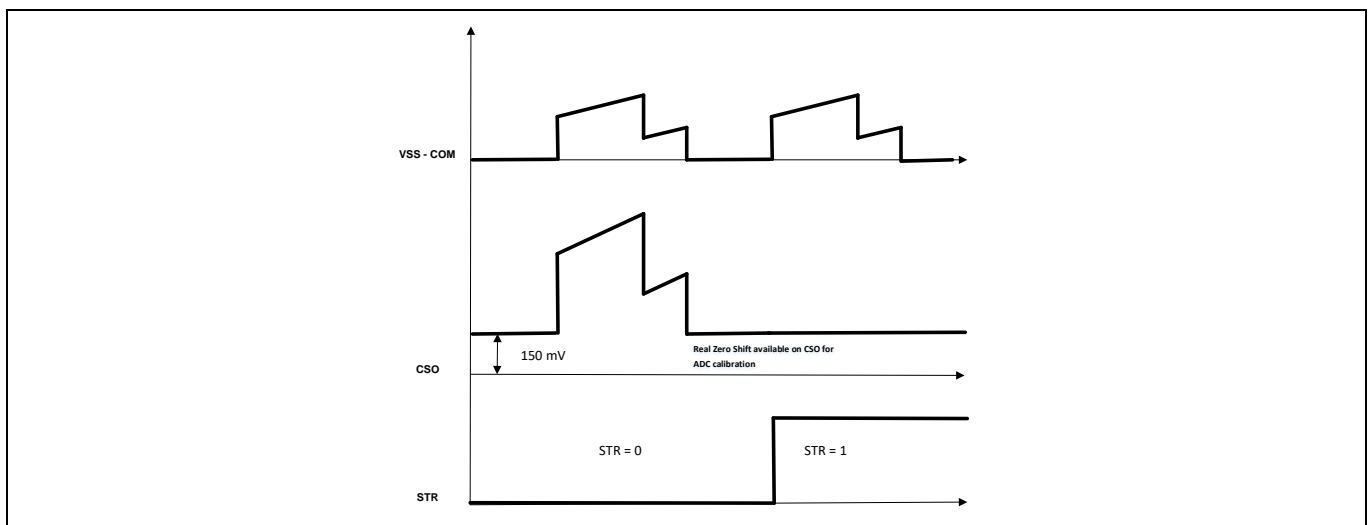


Figure 16 Current sense operational amplifier timing diagram

This section is not enabled in the EVAL-6ED2742S01QM1 board. Pages 42 and 43 in the current document show the simulated performance of the above integrated current sense amplifier.

User can tap the CSO output at test pin X14 on the EVAL-6ED2742S10Q board to verify the linearity and slew rate of the amplifier. A new EVAL-6ED2742S01QM1 Multifold Control board will demonstrate the performance of this amplifier along with XMC1302 microcontroller based MADK control card.

System and functional description

2.8 Gain settings for the over current protection (ITRIP_Conf) and current sense operational amplifier (CSO)

The gain for the over current protection via ITRIP and current sense operation amplifier output can be set using a simple potential divider network as shown in below figure 17.

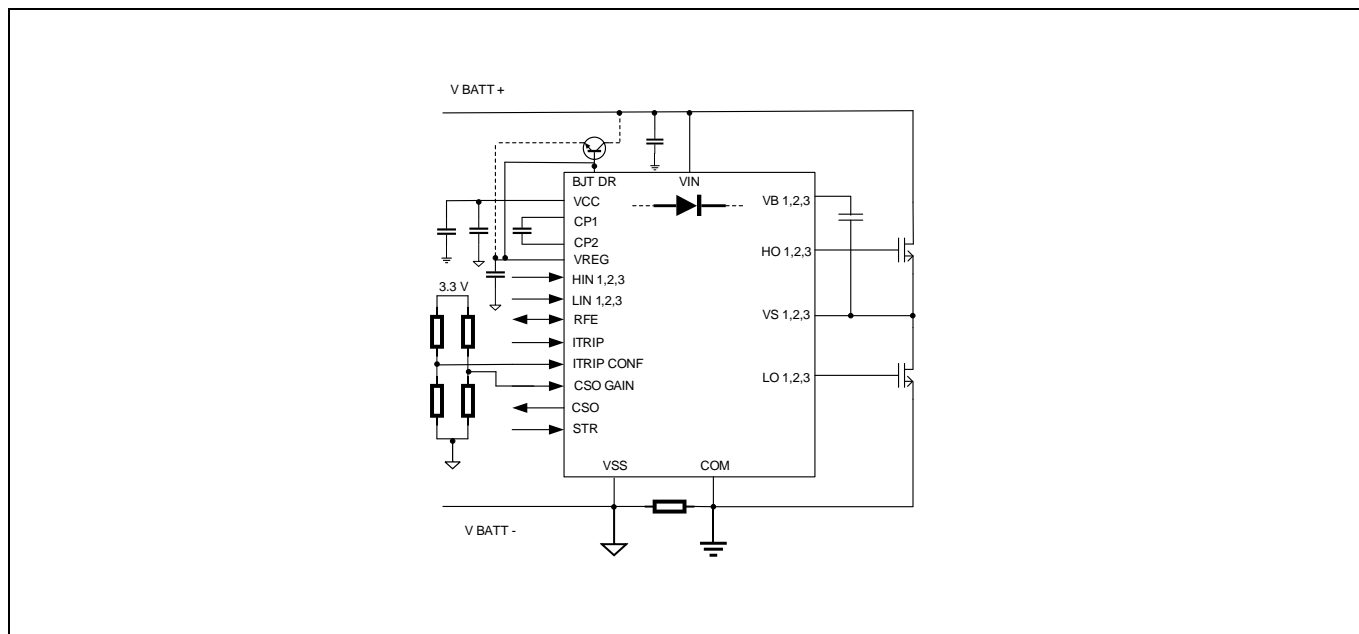


Figure 17 Setting over current protection (ITRIP) gain and current sense operational amplifier gain via the resistor divider

The voltage of the potential divider network can be scaled down from an external 3.3 V. It should be noted that when powering from external 3.3 V the supply sequencing should be such that the 6ED2742 is first powered up via VIN before applying the 3.3 V to the Gain / Config pins. Two use cases are shown in figure 20. Figure “a” shows the option where the 3.3 V input is either ramped up after or along with VIN / VCC. RFE gets asserted (IC gets enabled) after the UVLO of VCC is crossed and V_{RFE+} threshold is crossed. Figure” b” shows use case when the 3.3 V input is already available before VIN / VCC arrive. In this case, RFE gets asserted when the UVLO of VCC is crossed. It is good to note that the RFE pin is held low under two conditions:

Under Voltage Lock Out (UVLO) of VCC / V_{RFE}

ITRIP threshold as set by ITRIP Config is crossed

In case the 3.3 V arrives before VCC toggling (pulling down and the pulling up) the RFE will re-read the values of ITRIP config and CSO Gain.

System and functional description

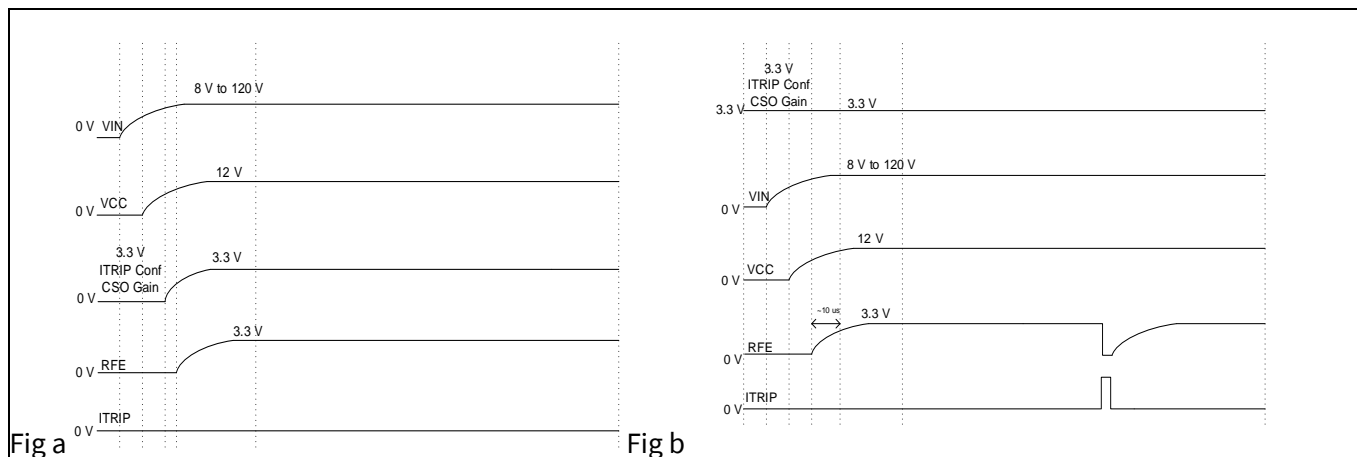


Figure 18 Input voltage sequencing for setting up different gain and ITRIP config

The voltage limits for different gains are as shown in the electrical characteristics table 3 in page 6 and 7. They are summarized as below in Table 8 and 9

Table 10 ITRIP Config pin voltage settings for different overcurrent threshold voltages

V_{ITRIP}	Over current threshold voltage	950	1000	1050	mV	ITRIP Conf > 3 V
		475	500	525		1.5V < ITRIP Conf < 2V
		225	250	275		0.5V < ITRIP Conf < 1V
		110	130	150		ITRIP Conf < 0.25V

Table 11 CSO gain pin voltage settings for different gain of CSO output

G_{CSO}	Current sense amplifier gain	36	40	41	V/V	CSO gain > 3 V
		18	20	21		1.5V < CSO gain < 2V
		9	10	11		0.5V < CSO gain < 1V
		4	5	6		CSO gain < 0.25V

System and functional description

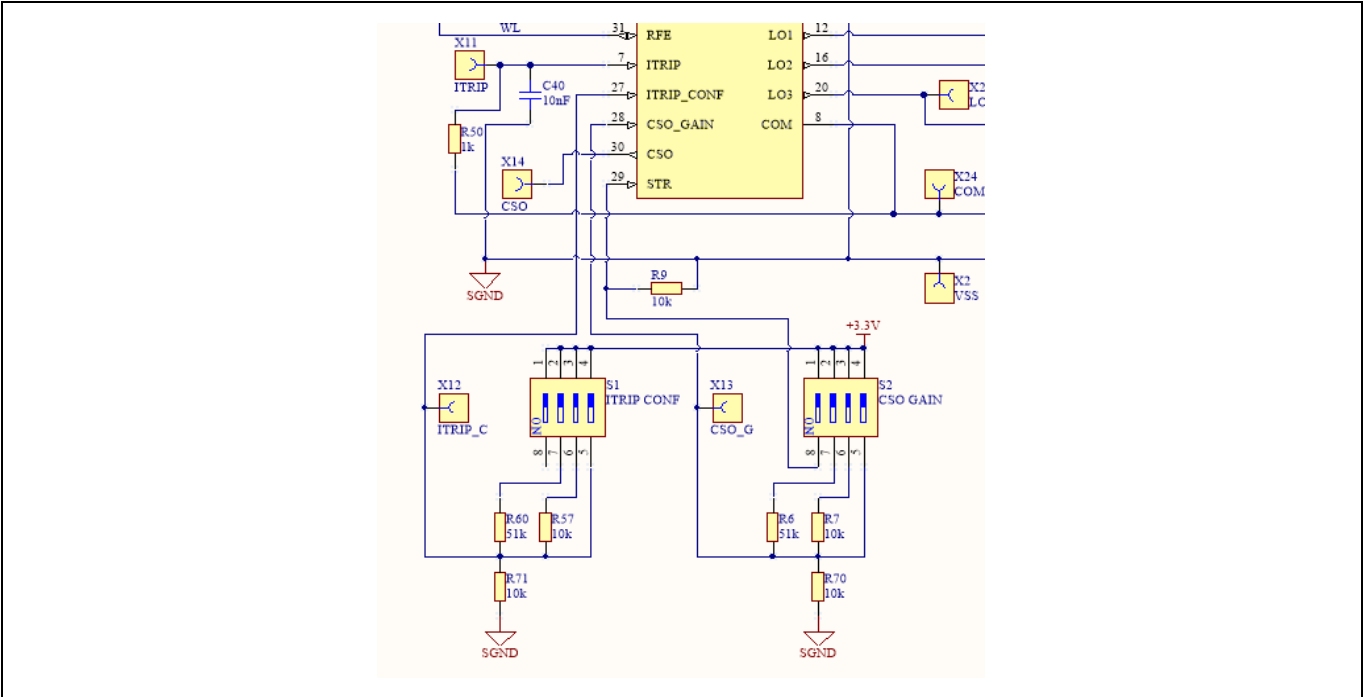


Figure 19 EVAL-6ED2742S01QM1 provides switch configurations to test different gain and threshold levels

2.9 Advanced input filter

The advanced input filter allows an improvement in the input/output pulse symmetry of the HVIC and helps to reject noise spikes and short pulses. This input filter has been applied to the HIN and LIN inputs.

Figure 19 shows a typical input filter and the asymmetry of the input and output. The upper pair of waveforms (Example 1) show an input signal with a duration much longer then $t_{FIL,IN}$; the resulting output is approximately the difference between the input signal and $t_{FIL,IN}$. The lower pair of waveforms (Example 2) show an input signal with a duration slightly longer then $t_{FIL,IN}$; the resulting output is approximately the difference between the input signal and $t_{FIL,IN}$.

Figure 22 shows the advanced input filter and the symmetry between the input and output. The upper pair of waveforms (Example 1) show an input signal with a duration much longer then $t_{FIL,IN}$; the resulting output is approximately the same duration as the input signal. The lower pair of waveforms (Example 2) show an input signal with a duration slightly longer then $t_{FIL,IN}$; the resulting output is approximately the same duration as the input signal.

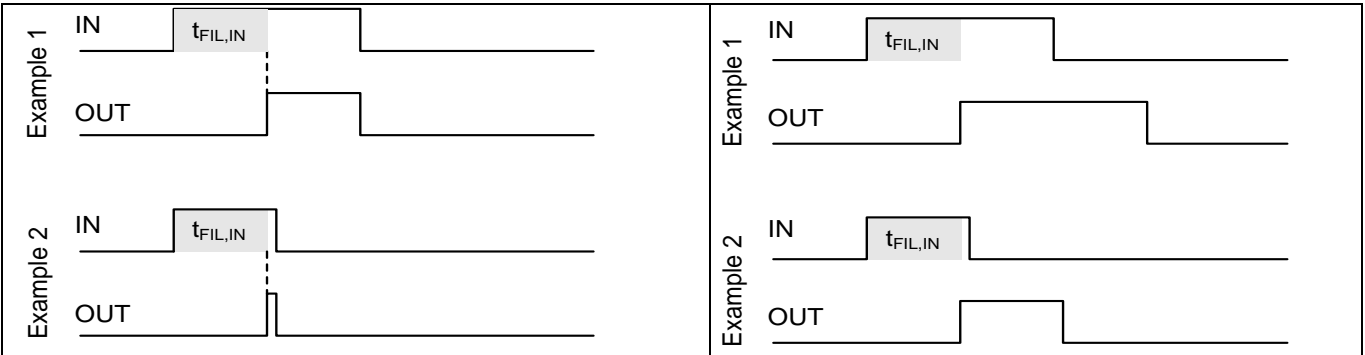


Figure 19 Typical input filter

Figure 20 Advanced input filter

2.10 Short-Pulse / Noise rejection filters

This device's input filter provides protection against short pulses (e.g., noise) on the input lines. If the duration of the input signal is less than $t_{FIL,IN}$, the output will not change states. Example 1 of Figure 21 shows the input and output in the low state with positive noise spikes of durations less than $t_{FIL,IN}$; the output does not change states. Example 2 of Figure 21 shows the input and output in the high state with negative noise spikes of durations less than $t_{FIL,IN}$; the output does not change states.

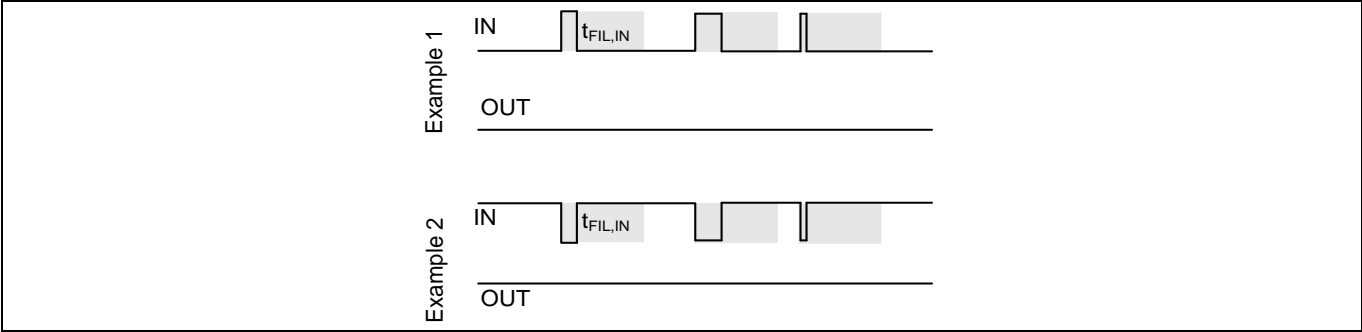


Figure 21 Noise Rejecting Input Filters

2.10.1 Overview of BSC074N15NS5

The BSC074N15NS5 is a 150 V rated N-Channel OptiMOS™ 5 power MOSFET. It was mainly chosen for its 5 x 6 Super SO8 package and its excellent gate charge x $R_{DS(on)}$ product Figure of Merit (FOM).

Figure 22 shows the key features of BSC074N15NS5. For more information about the MOSFET, please refer to the datasheet of BSC074N15NS5.

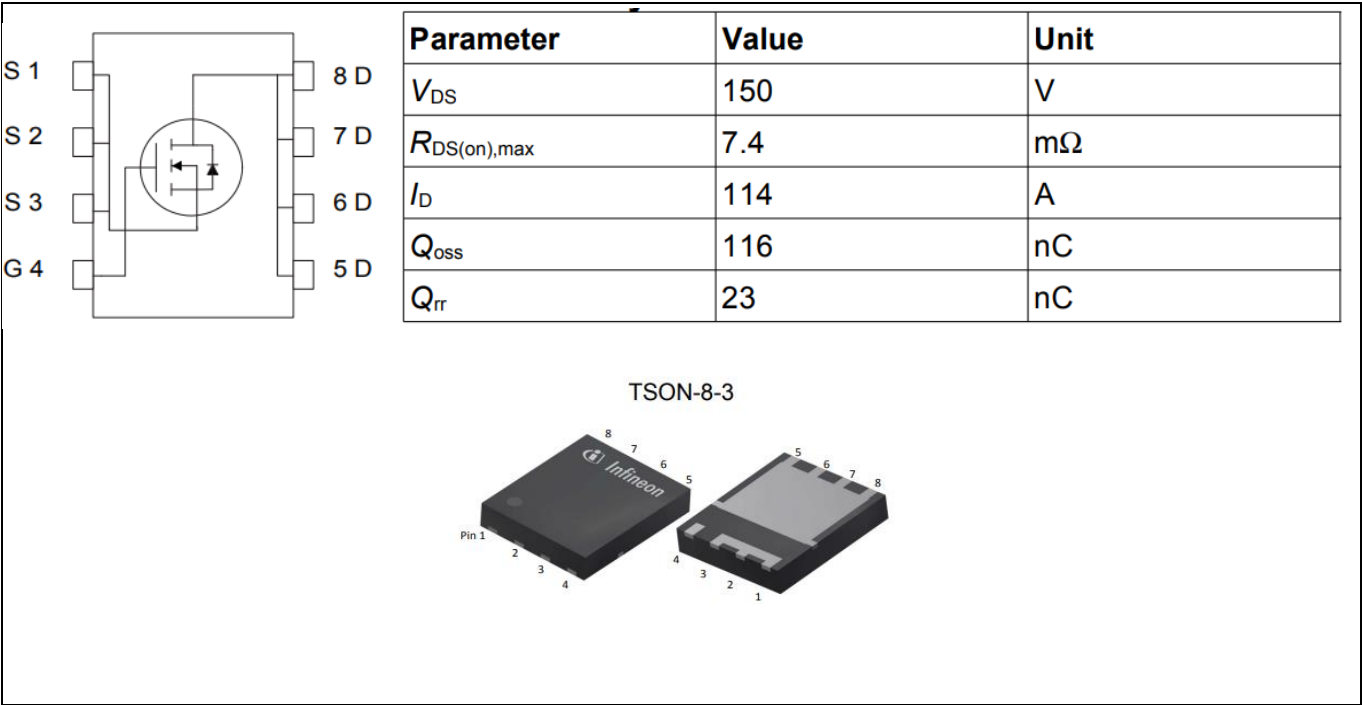


Figure 22 Key features of BSC074N15NS5

System and functional description

The typical gate charge characteristics and typical capacitances of BSC074N15NS5 are shown in Figure 23.

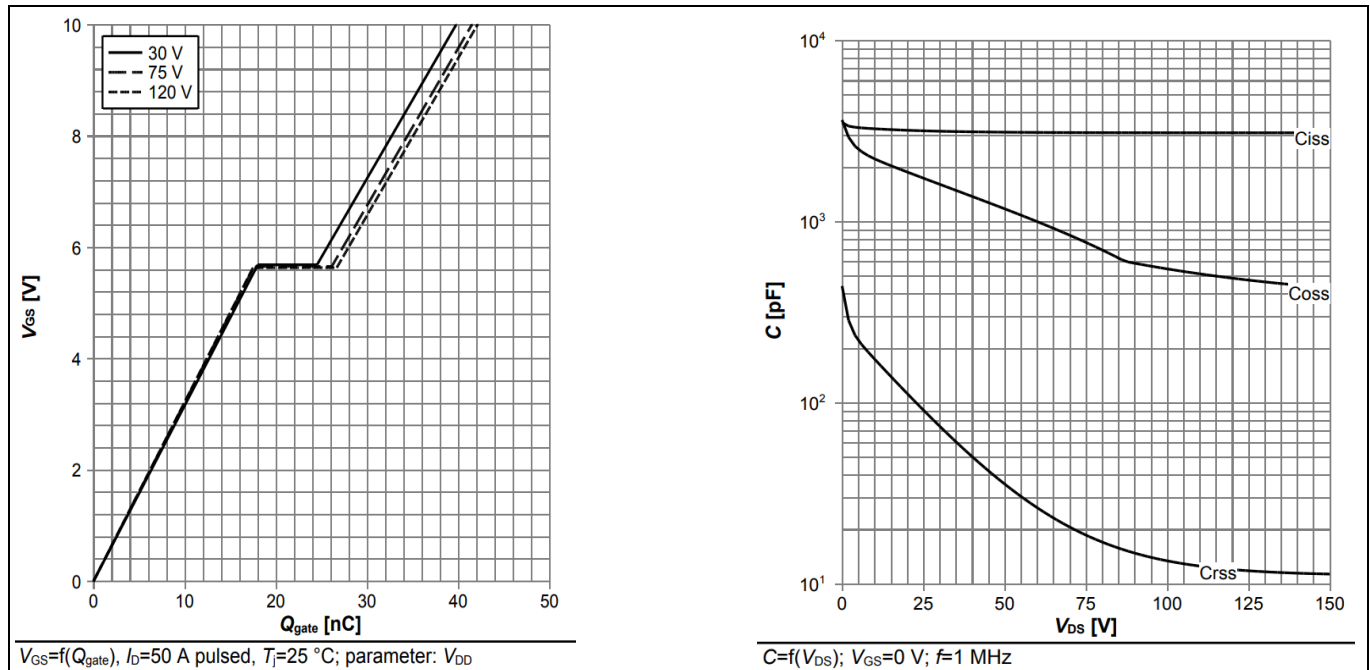


Figure 23 BSC074N15NS5 typical characteristics

A review of references [8] and [9], on [page 45](#) will provide a deeper understanding of the features of OptiMOS™ 5 technology and its benefits in low voltage high power motor drive applications.

3 System design

This chapter covers the hardware design of EVAL-6ED2742S01QM1 in detail. Users can modify the circuit or re-select the component values based on DC bus voltage, motor type.

3.1.1 DC-link voltage measurement and inrush current limiter

Bus capacitors should be large enough to stabilize the bus voltage.

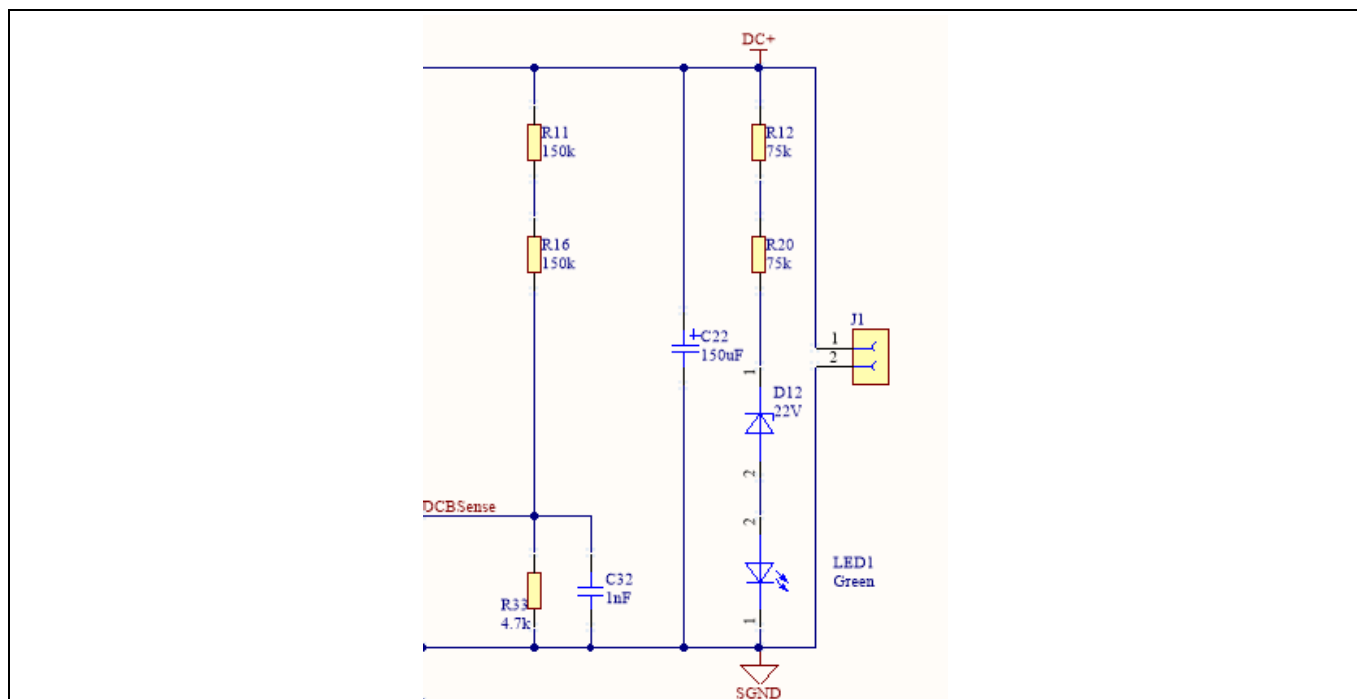


Figure 24 Bus capacitor configuration and DC bus sensing

3.1.2 Inverter section using OptiMOS™ 5 BSC074N15NS5

The inverter section is implemented using BSC074N15NS5 as shown in Figure 25. It is a three-phase inverter bridge section with Infineon's OptiMOS™ 5 N-channel MOSFETs. R40/ R41 (in parallel) are single shunt for current sensing.

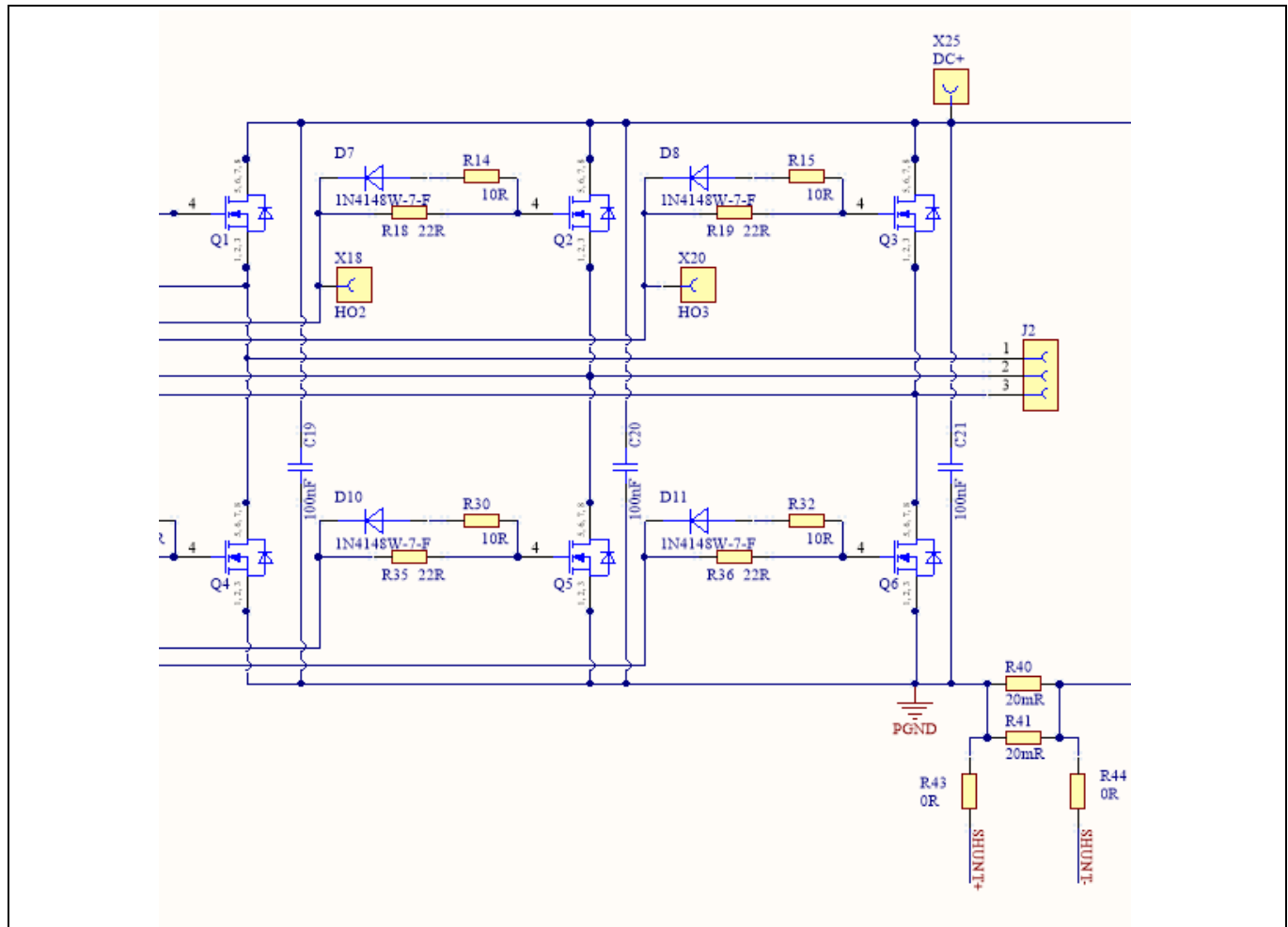


Figure 25 The diagram of the BSC074N15NS5 based inverter section with single shunt current sense

3.1.3 Drive circuit with 6ED2742S01Q

The configuration of 6ED2742S01Q is shown in Figure 26.

The capacitor C33 (C34, C35) is used as bootstrap capacitor to provide the necessary floating supply voltage VBS. Thanks to the bootstrap diode integration in 6ED2742S01Q, an external bootstrap diode is not needed.

6ED2742S01Q is equipped with ITRIP input pin. This functionality can be used to detect overcurrent events in the DC bus. When the gate driver IC detects an overcurrent event through the ITRIP pin for one of the three phases, the output is shut down and the RFE is pulled to VSS to report the fault condition. The outputs of the other two phases are also shut down because of the daisy chain connection with the RFE pins. The RFE can also be used as the enable input pin and fault-clear time programmable pin.

The fault-clear time setup is based on the datasheet of 6ED2742S01Q. The main feature of 6ED2742S01Q designed with Infineon's SOI technology is its tolerance in terms of negative transient voltage in inductive load applications. 6ED2742S01Q can tolerate repetitive negative transient voltage of up to 15 V (pulse width up to 100 ns).

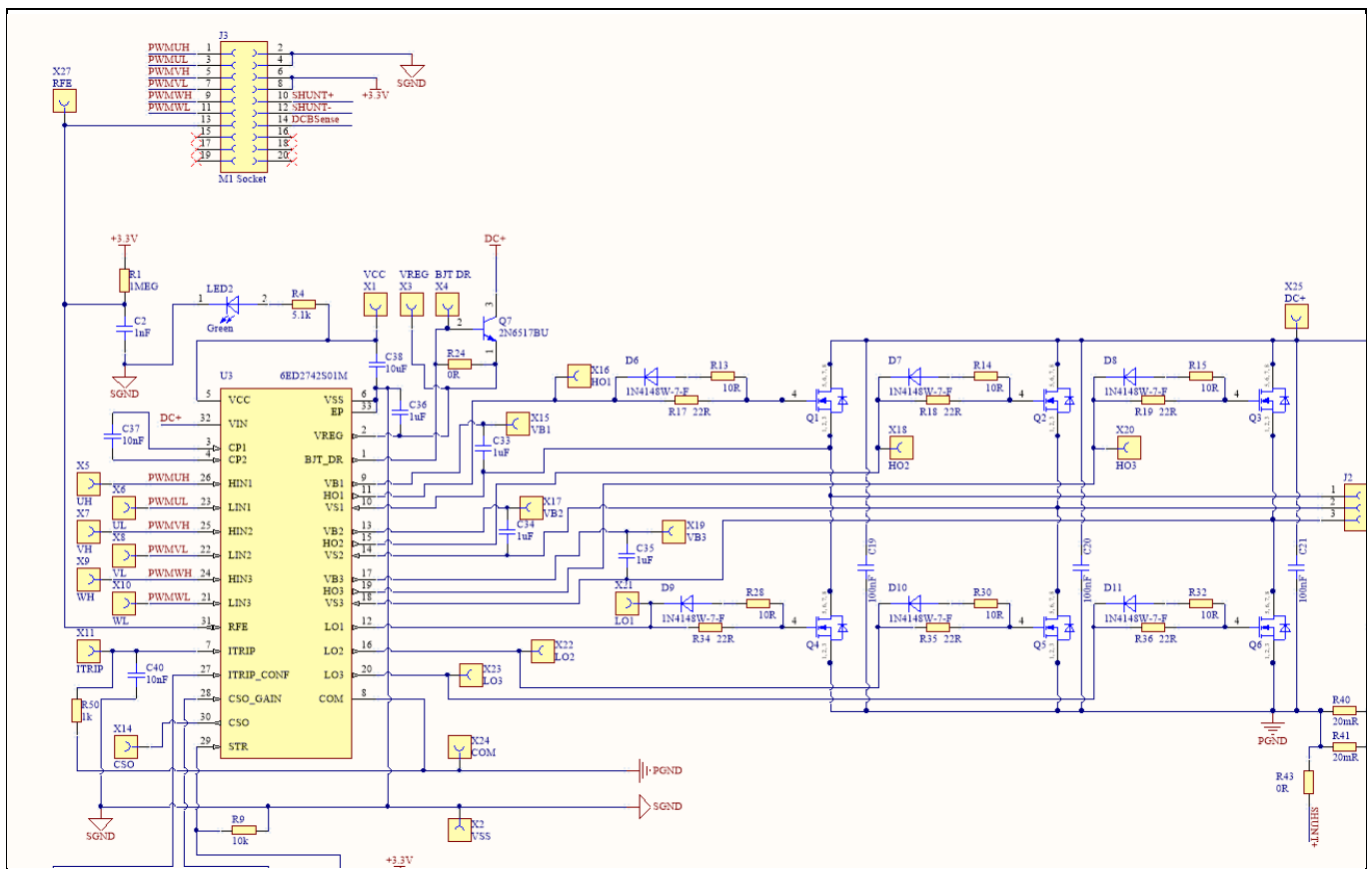


Figure 26 Drive circuit design with 6ED2742S01Q

3.1.4 Overcurrent protection

The overcurrent circuit is shown in Figure 25. To save power loss of the shunt resistor, the R_{shunt} value is set as 10 mΩ by using two 20 mΩ / 2 W surface-mounted devices (SMD) resistors (R40/R41) and low equivalent series inductance (ESL) in parallel. In the design, the target current for overcurrent protection (I_{OC}) is 25 A. The overcurrent threshold of the ITRIP pin is 0.54 V. An additional 0.19 V DC-bias voltage is needed at the ITRIP pin to meet the target current of 25 A. This is achieved by using resistor dividers R19 and R20 with 3.3 V supply.

The I_{OC} is calculated using:

$$I_{ocp} = \frac{(V_{ITRIP+} - \frac{R_{19}}{R_{19} + R_{20}} * 3.3V) * (R_{19} + R_{20})}{R_{20} * R_{shunt}}$$

$$= 24.93 \text{ A}$$

Here, V_{ITRIP+} is the positive-going threshold for ITRIP and its typical value is 0.44 V, $R_{19} = 100 \Omega$, and $R_{20} = 1 \text{ k}\Omega$.

Note: If EVAL-M1-101T is not used as the controller board, an offset circuit needs to be added.

3.1.5 Auxiliary power supply

The auxiliary power supply is derived from BM0650HV based DC-DC buck converter. The 12 V DC can be connected an external Fan (not provided with the Eval board) for forced air cooling during prolonged testing. The 3.3 V power supply required for the IMC101T based MADK control card is derived from the 12 V DC using the linear regulator IFX25001ME V33. This 3.3 V power supply is also used to bias different circuitry on board such as the ITRIP config and CSO config. The auxiliary supply stage is as shown in the schematic in figure 27.

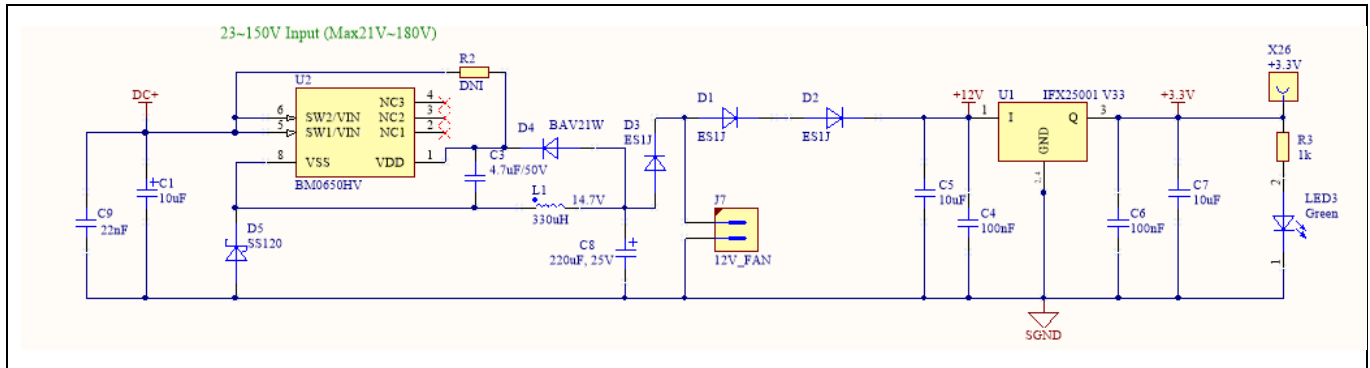


Figure 27 A high voltage DC-DC buck converter provides 12 V followed by a 3.3 V generated from a linear regulator

System design

3.2 Schematics

The schematics of EVAL-6ED2742S01QM1 are shown in Figure 28

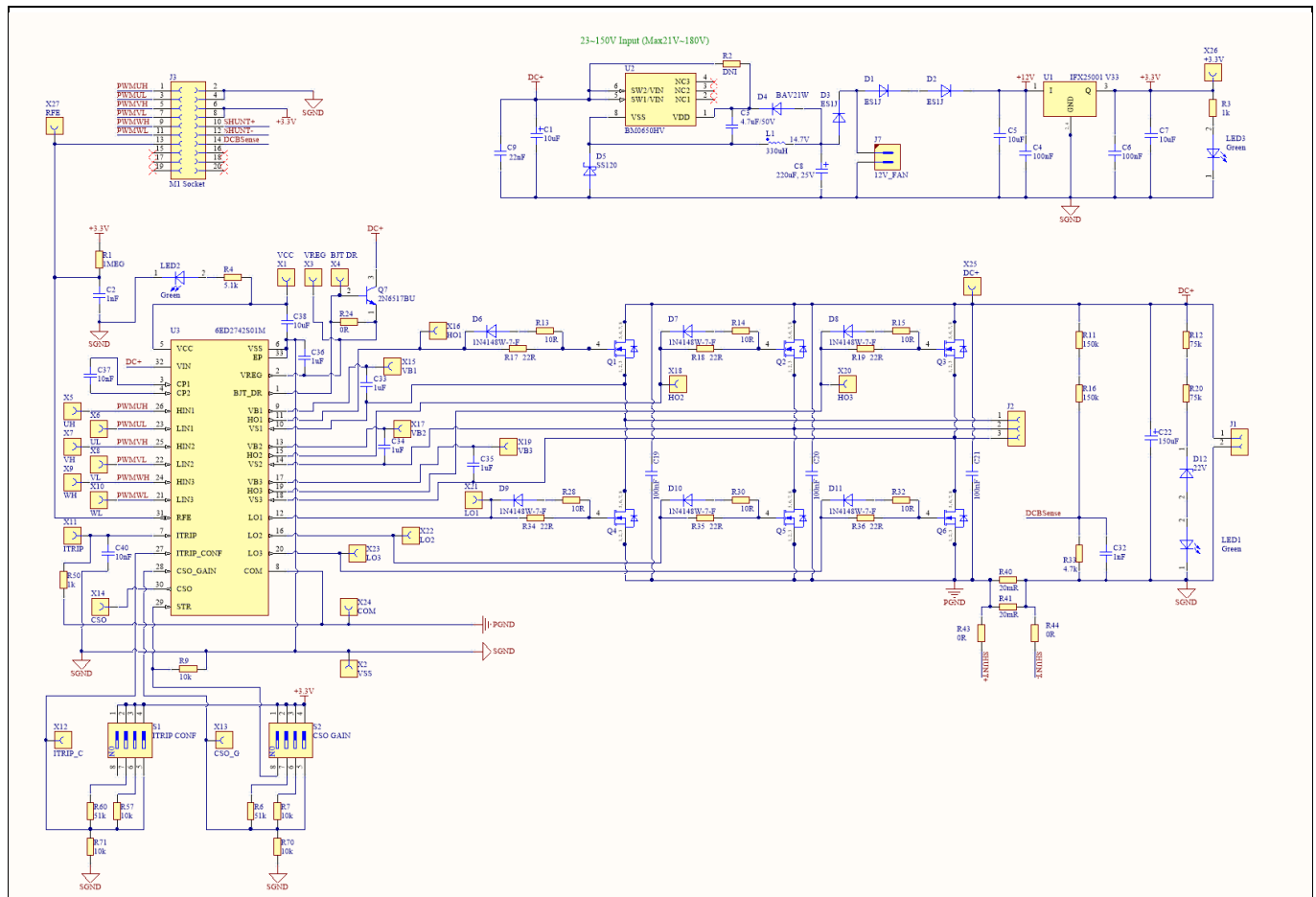


Figure 28 Circuitry of the power inverter board (main board)

3.3 Layout

3.3.1 Layout details

Detailed layouts of the main inverter board are shown in Figure 29 to Figure 32.

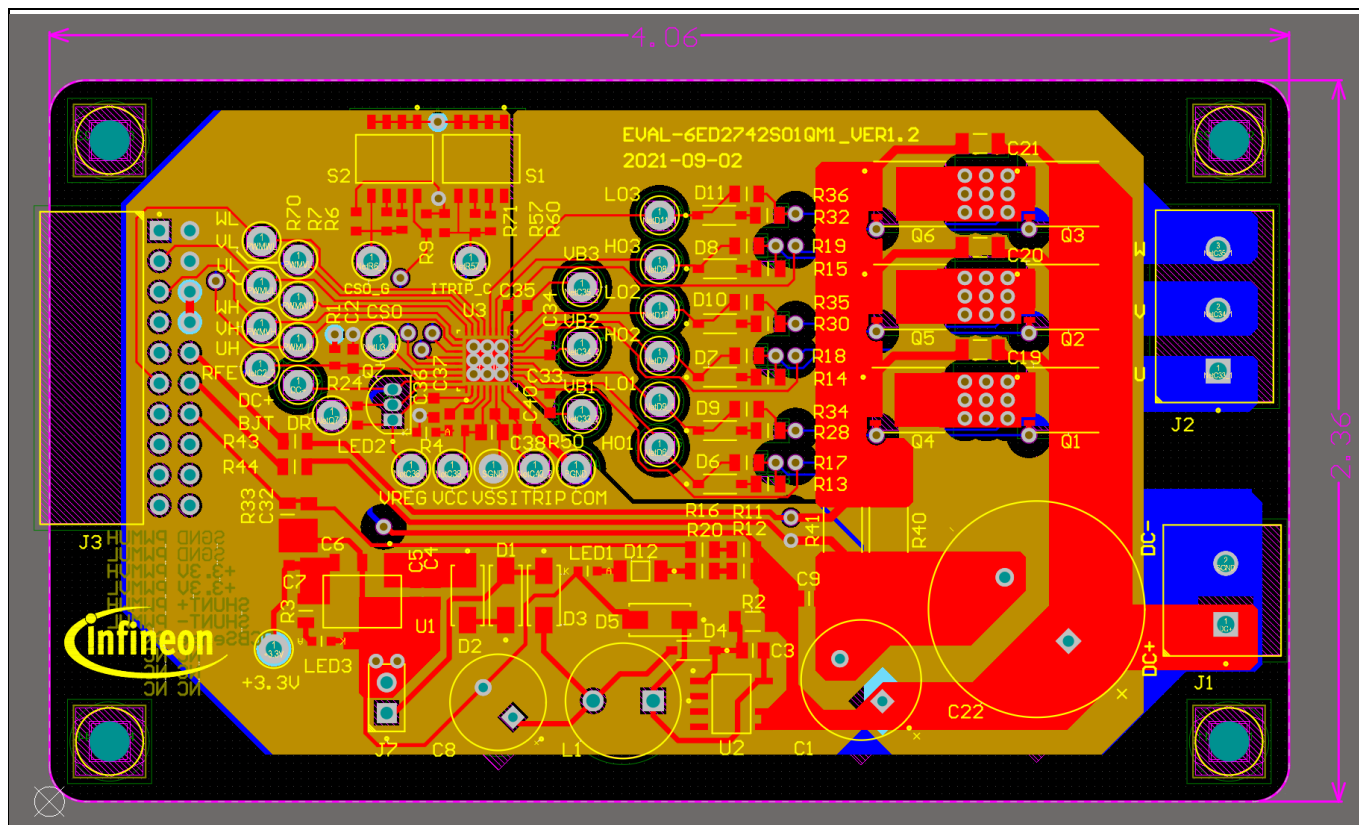


Figure 29 Power inverter board layout (top view)

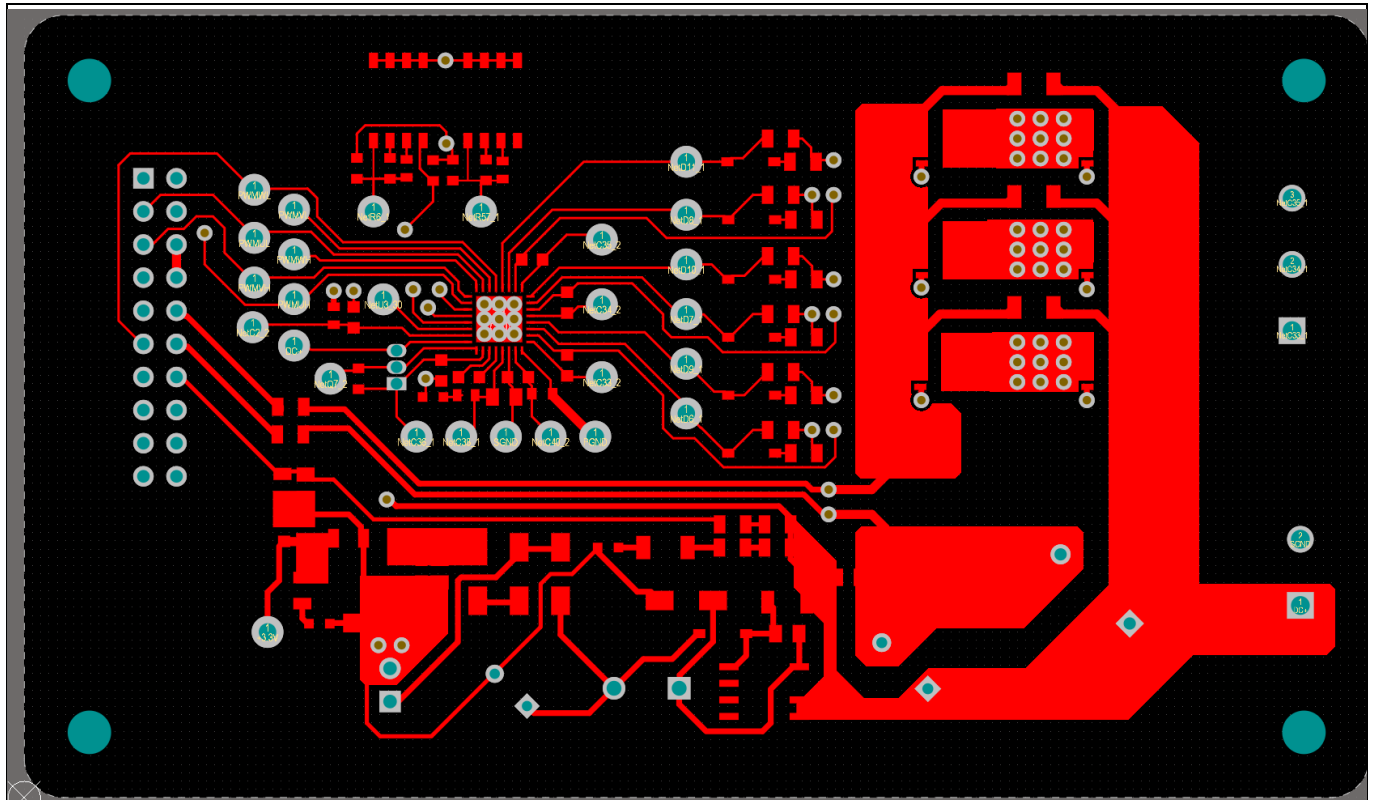


Figure 30 Power inverter board layout (bottom view)

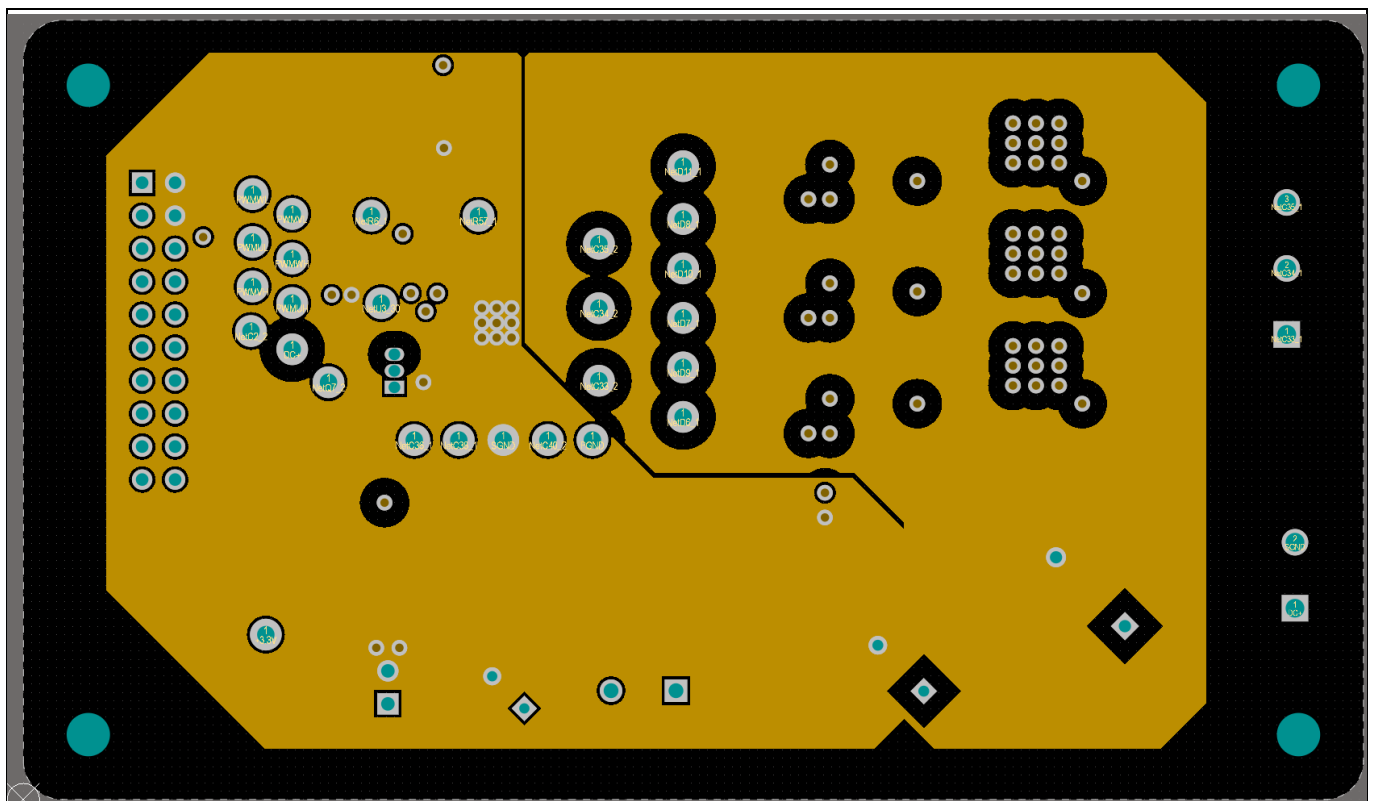


Figure 31 Drive circuitry layout of the daughter board (top view)

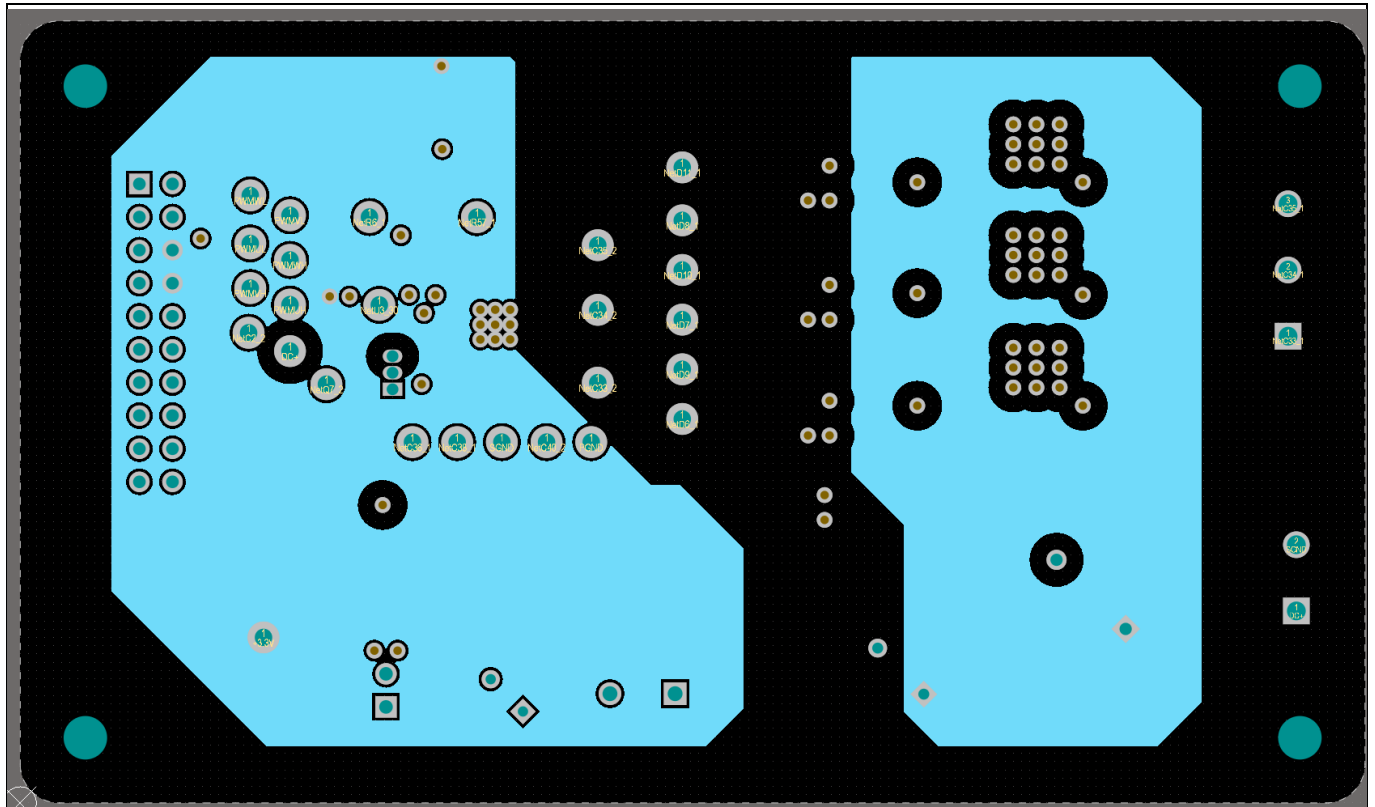


Figure 32 Drive circuitry layout of the daughter board (bottom view)

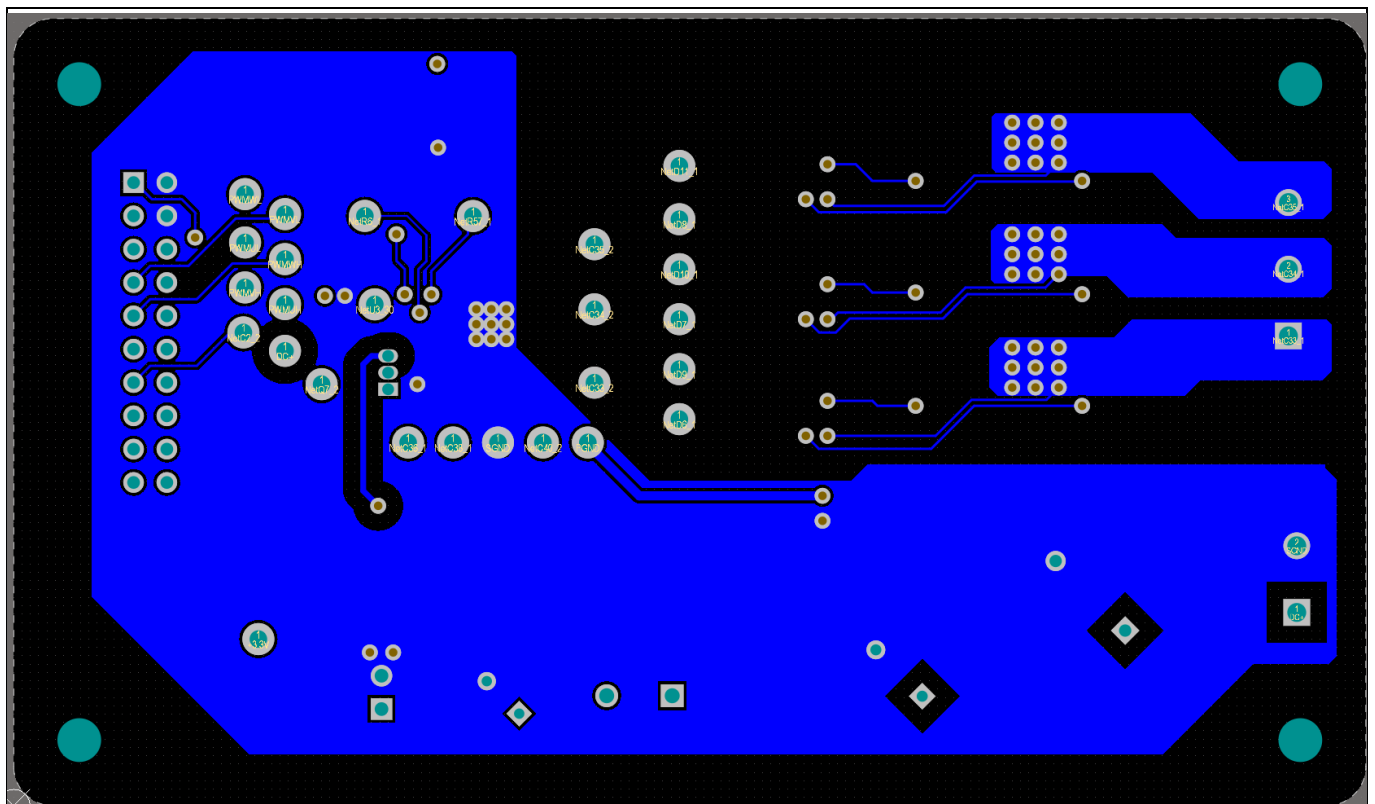


Figure 33 Drive circuitry layout of the daughter board (bottom view)

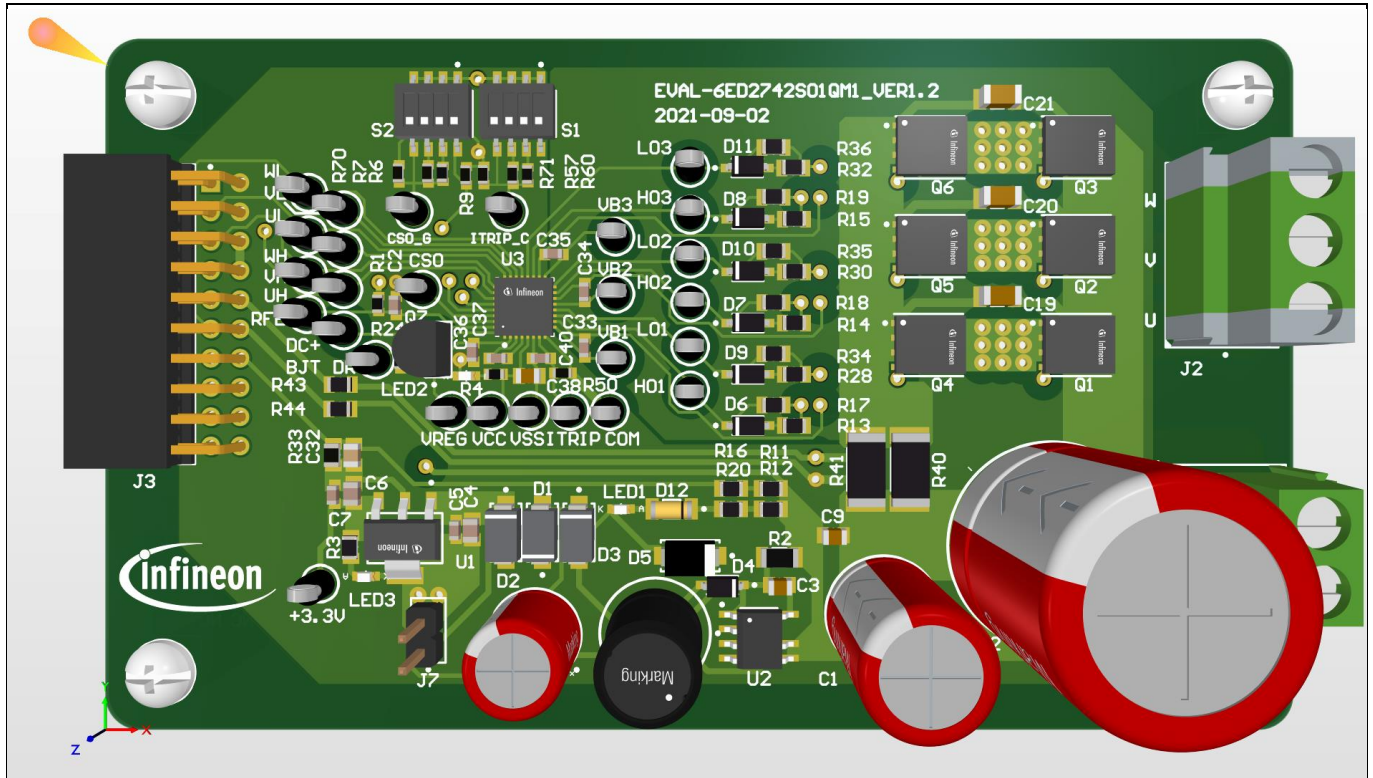


Figure 34 Drive circuitry layout of the daughter board (bottom view)

Both the schematic and layout files in Altium are provided on the 6ED2742S01Q webpage online. Users can download the same by logging in with their infineon.com credentials.

3.3.2 Layout guidelines

Some basic layout guidelines are as follows:

- The V_{CC} and V_{BS} bypass capacitors should be close to the IC
- The drive loop should be as small as possible
- The loop of VSS and COM should be made as small as possible by connecting the VSS and COM directly at the shunt-resistor terminals
- The two current-sensing traces should be started from the shunt terminals and placed close to each other

See pages 30 and 31 of 6ED2742S01Q datasheet for further layout guidelines.

3.4 Bill of material

The complete bill of material (BOM) is available in the Downloads section of Infineon's homepage. A login is required to download this material.

Table 12 lists the important components used in EVAL-6ED2742S01QM1.

Table 12 BOM with Infineon components in Bold

Designator	Component Value	Description	Quantity
C1	10uF	CAP / ELCO / 10uF / 200V / 20% / Aluminium electrolytic	1
C2	1nF	CAP / - / 1nF / 25V / 10% / X7R (EIA)	1
C3	4.7uF/50V	Chip Monolithic Ceramic Capacitor	1
C4, C6	100nF	Surface Mount Ceramic Capacitor 0.1uF 25V X7R 10%	2
C5, C7	10uF	Chip Monolithic Ceramic Capacitor	2
C8	220uF, 25V	CAP / ELCO / 220uF / 25V / 20% / Aluminium electrolytic	1
C9	22nF	CAP / - / 22nF / 250V / 10% / X7R (EIA)	1
C19, C20, C21	100nF	Ceramic Capacitor 0.1uF 250V X7R 10% SMD 1206	3
C22	150uF	CAP / ELCO / 150uF / 200V / 20% / Aluminium electrolytic	1
C32	1nF	Surface Mount Multilayer Ceramic Chip Capacitor	1
C33, C34, C35, C36	1uF	CAP / - / 1uF / 25V / 10% / X7R (EIA)	4
C37, C40	10nF	CAP / - / 10nF / 25V / 5% / X7R (EIA)	2
C38	10uF	Chip Monolithic Ceramic Capacitor	1
D1, D2, D3	ES1J	1.0A Ultra Fast Recovery Rectifier	3
D4	BAV21W	Surface Mount Fast Switching Diode	1
D5	SS120	Surface Mount Schottky Barrier Rectifier, 20V	1
D6, D7, D8, D9, D10, D11	1N4148W-7-F	Surface Mount Fast Switching Diode	6
D12	22V	Zener Diode, 5% 22V	1
L1	330uH	IND / STD / 330uH / 1.1A / 10% / 470mR / Radial / Inductor, Radial;	1
LED1, LED2, LED3	Green	WL-SMCW SMT Mono-color Chip LED Waterclear, Green, 515nm	3
Q1, Q2, Q3, Q4, Q5, Q6	BSC074N15NS5	OptiMOS 5 Power-Transistor, 150 V, N-channel	6
Q7	2N6517BU	NPN Epitaxial Silicon Transistor, High Voltage Transistor	1
R1	1MEG	RES / STD / 1MEG / 100mW / 1% / 100ppm/K	1
R2	DNI	Standard Thick Film Chip Resistor	1
R3	1k	Standard Thick Film Chip Resistor	1
R4	5.1k	RES / STD / 5.1k / 100mW / 1% / 100ppm/K	1
R6, R60	51k	RES / STD / 51k / 100mW / 1% / 100ppm/K	2
R7, R9, R57, R70, R71	10k	RES / STD / 10k / 100mW / 1% / 100ppm/K	5
R11, R16	150k	Standard Thick Film Chip Resistor	2
R12, R20	75k	Standard Thick Film Chip Resistor	2

EVAL-6ED2742S01Q for Battery Powered Applications Evaluation Kit

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System design

R13, R14, R15, R28, R30, R32	10R	Standard Thick Film Chip Resistor	6
R17, R18, R19, R34, R35, R36	22R	Standard Thick Film Chip Resistor	6
R24	0R	RES / STD / 0R / 100mW / 0R / 0ppm/K	1
R33	4.7k	4.7k/150V/1%	1
R40, R41	20mR	Low Value Power Metal Strip Resistor	2
R43, R44	0R	Standard Thick Film Chip Resistor	2
R50	1k	RES / STD / 1k / 100mW / 1% / 100ppm/K	1
S1	ITRIP CONF	Slide DIP Switch with seal tape	1
S2	CSO GAIN	Slide DIP Switch with seal tape	1
U1	IFX25001 V33	Low Dropout Voltage Regulator, 3.3V Output	1
U2	BM0650HV	PFM Controller and 200 V Smart power with high avalanche capability MOSFET	1
U3	6ED2742S01Q	160 V pre-regulated three phase SOI gate driver	1

3.5 Connector details

Table 13 Connectors

PIN	Label	Function
Various signal input / output	X1 – X27	Test points for various onboard signals
DC+, DC-	J1	DC power supply input
U/V/W	J2	Three phase-outs (U/V/W) to the motor
M1 connector	J3	M1 Socket - iMOTION™ MADK-M1 20-pin interface connector
12 V Aux output	J7	12V_FAN Header

System performance

4 System performance

4.1 System setup for running a BLDC motor

EVAL-6ED2742S01QM1 is tested while running a custom BLDC motor in the setup shown in Figure 35.

Test conditions:

- Input: $V_{IN} = 24 \text{ Vdc}$
- Phase-out current: $I_{PHASE} = 8 \text{ A}_{rms}$,
- Room temperature
- BLDC motor: Custom, $I_{PHASE} = 10 \text{ A}$, test at speed = 52000 r/min

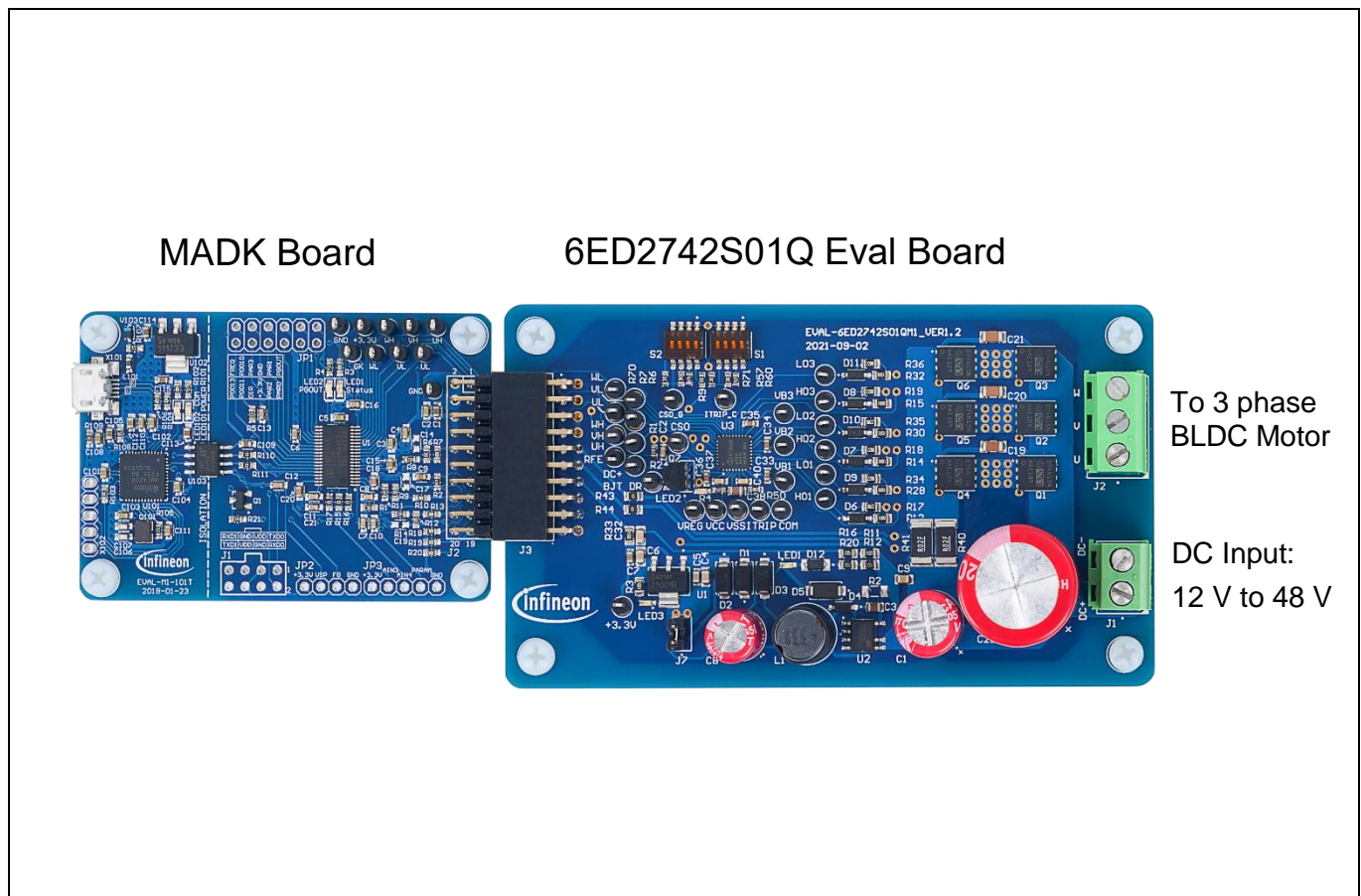


Figure 35 System setup for running a BLDC motor

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System performance

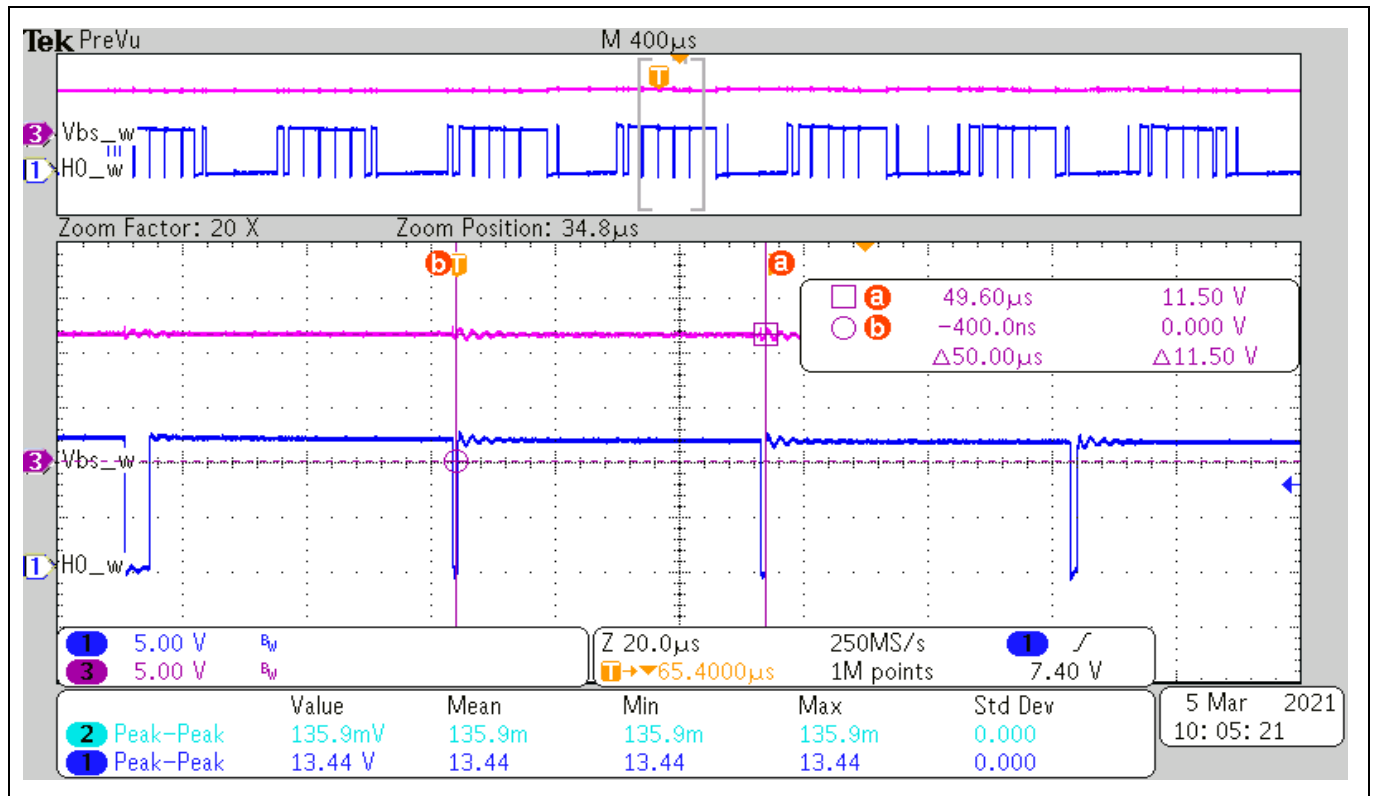


Figure 36 Trickle Charge Pump operation for large duty cycle (> 90 %) operation

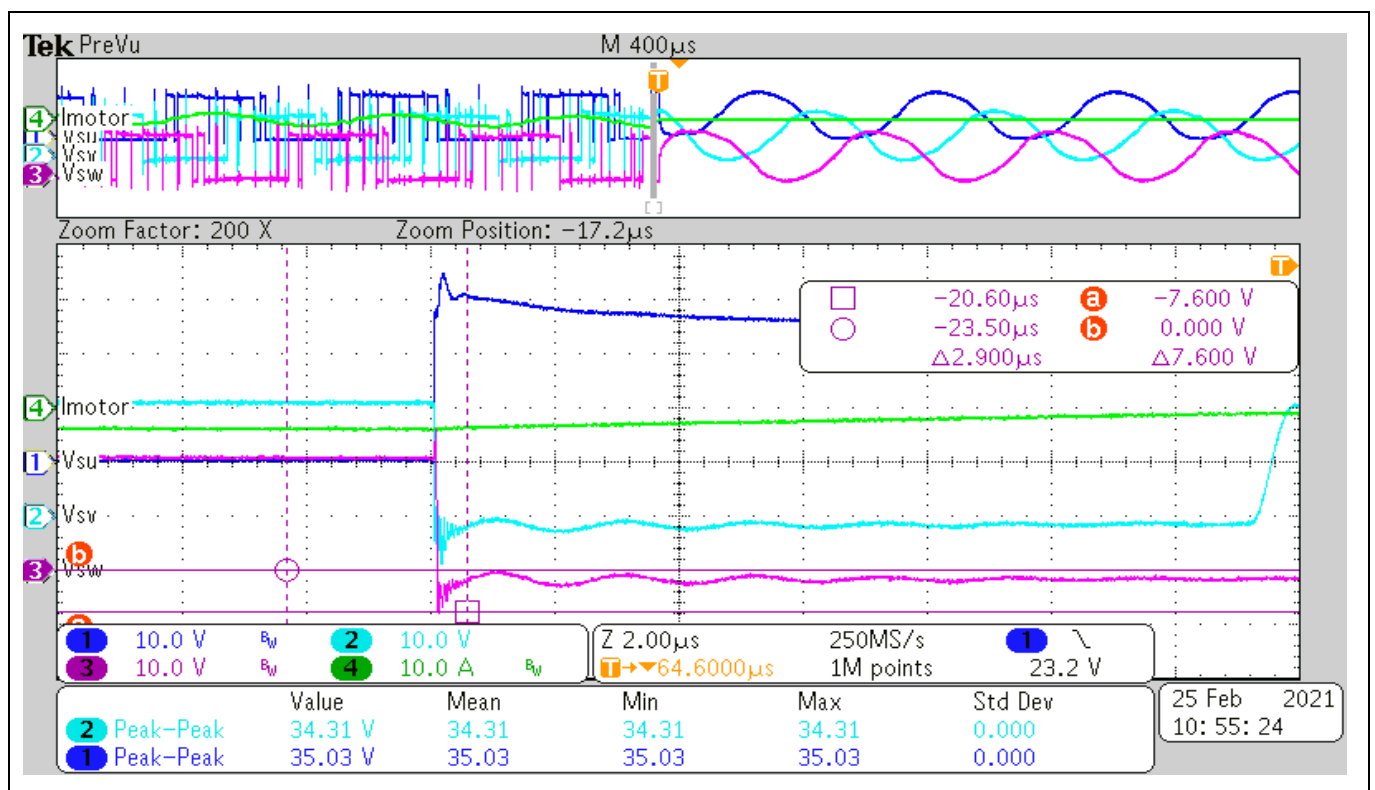


Figure 37 Motor Over Current protection

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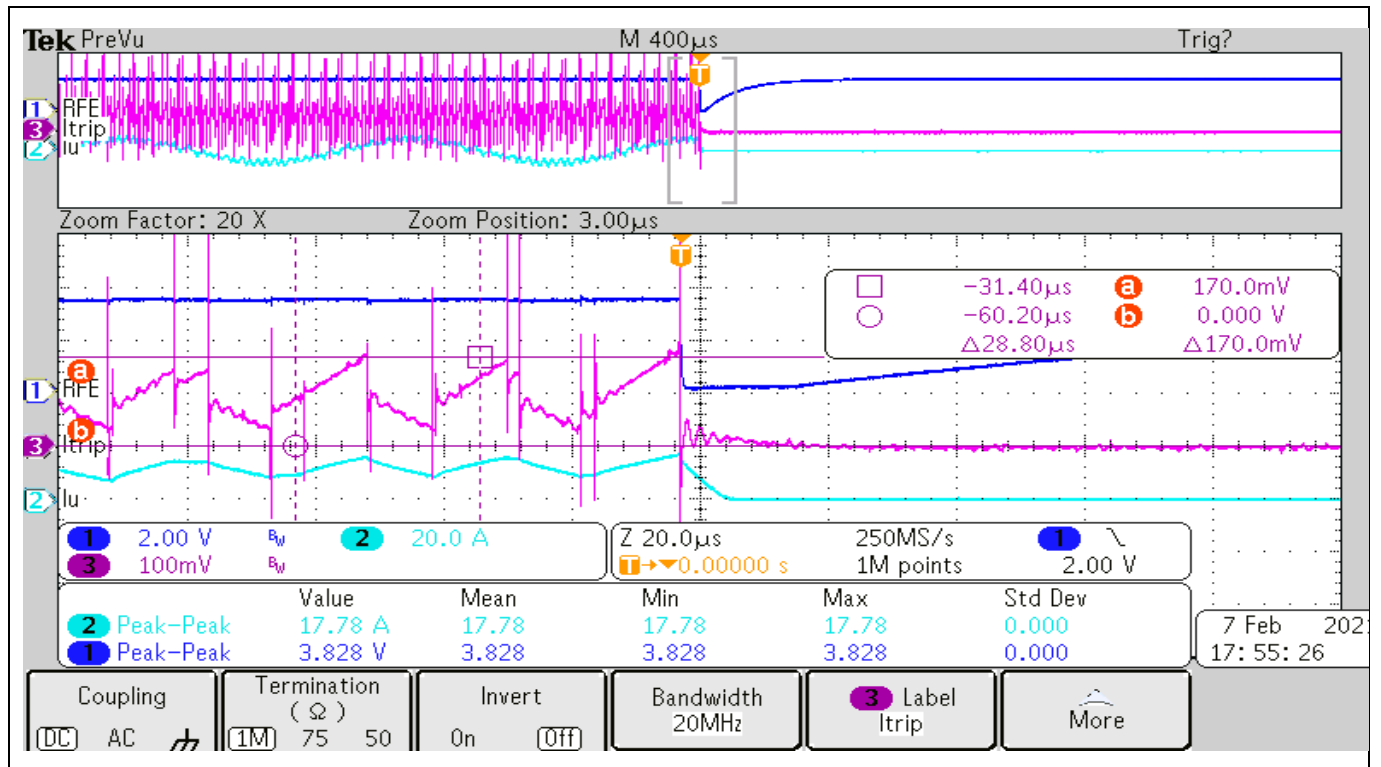
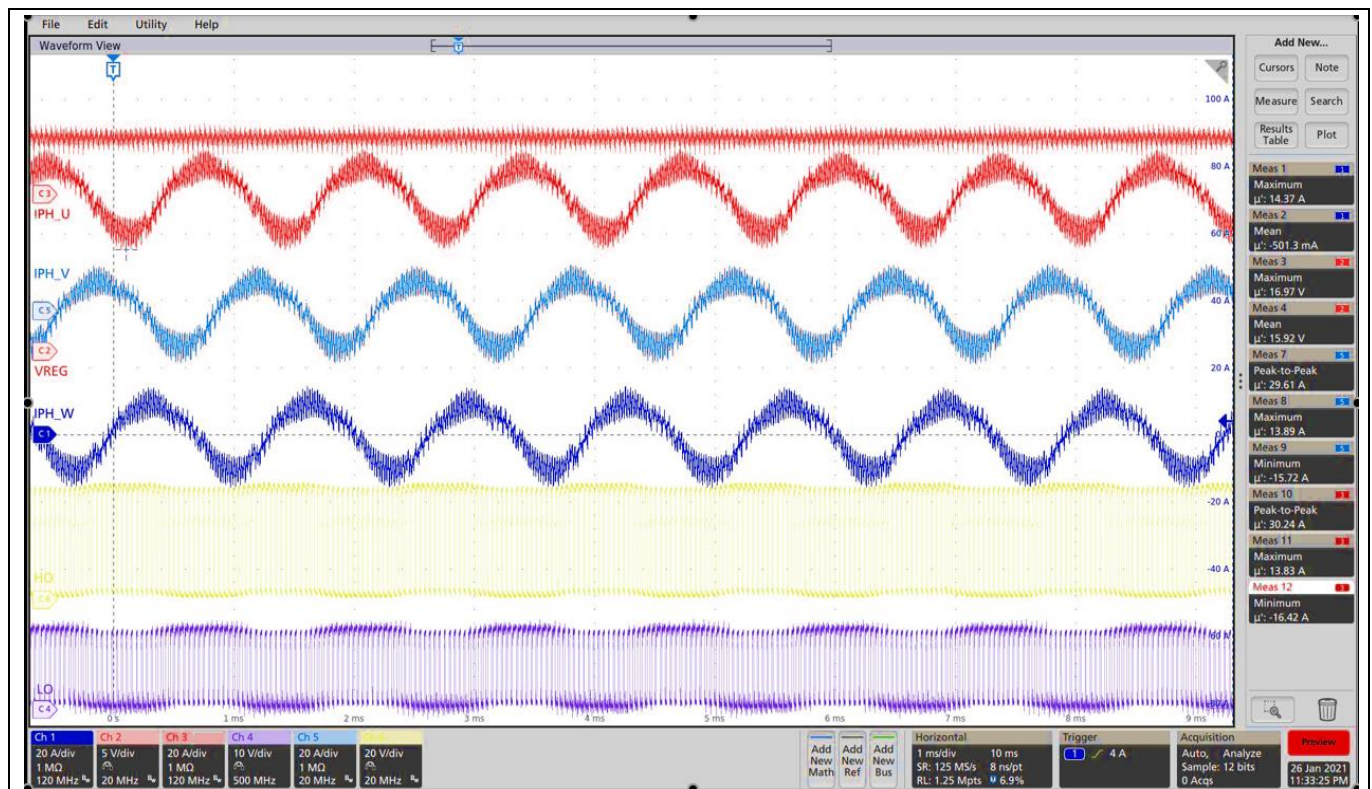


Figure 38 RFE pin in over current protection mode

4.2 The output phase current

Figure 39 shows the waveform when running a BLDC motor.

Figure 39 EVAL-6ED2742S01QM1 board test results showing three phase output currents at $F_{sw} = 20$ kHz

System performance

4.3 Test result for overcurrent protection

Error! Reference source not found. shows the overcurrent detection function of EVAL-6ED2742S01QM1 by ITRIP input of 6ED2742S01Q. Overcurrent detection shuts down the outputs of the gate driver if the ITRIP pin input is over 440 mV and lasts longer than 500 nanoseconds. In that case, the overcurrent protection starts when the peak current is around 24.93 A.

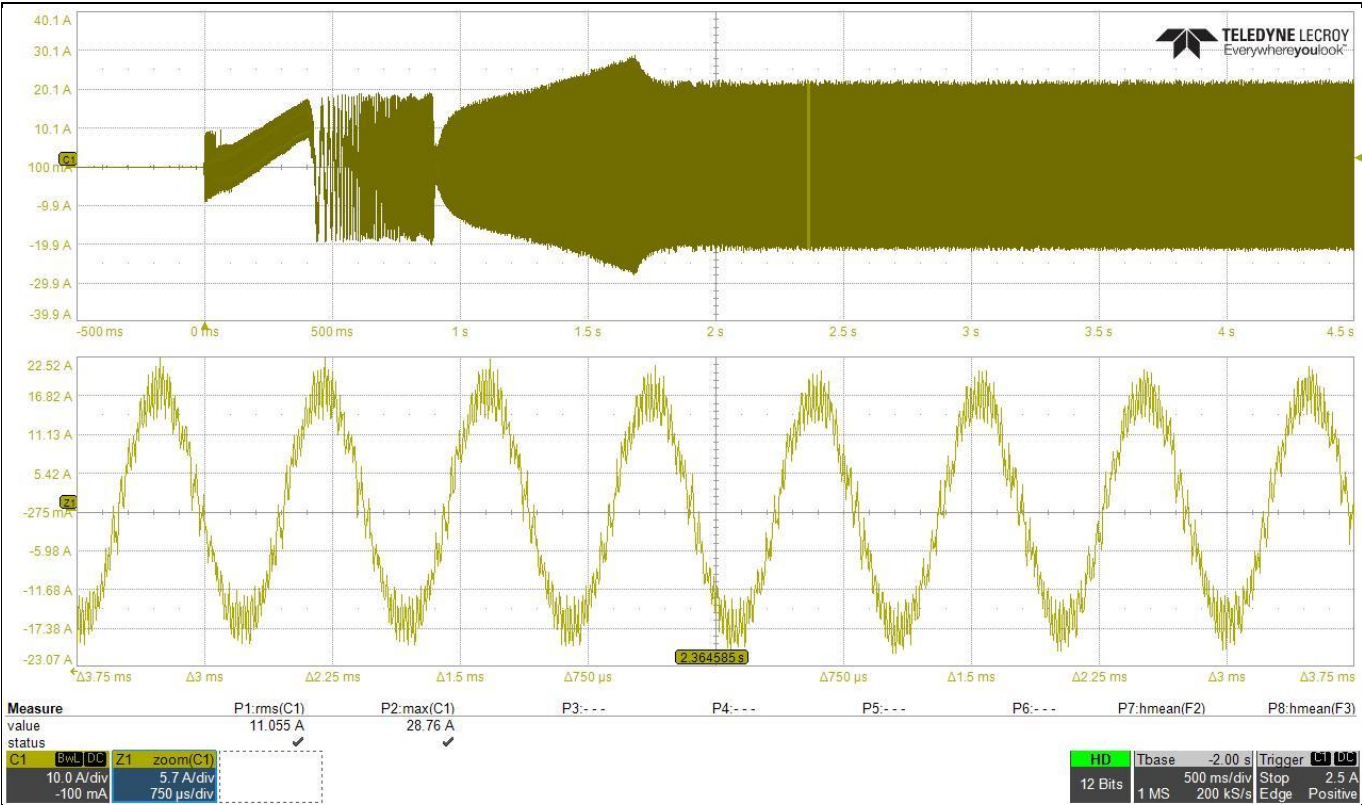


Figure 40 Typical drive characteristics at switching frequency of 23kHz, parking time = 0.4s, startup time = 0.93s

For the EVAL-6ED2742S01QM1 to run for 30 minutes at the rated speed without exceeding temperatures above 85°C (and damaging the board) a heat sink was glued with Thermal Glue onto the OptiMOS™ inverter stage.

5 References and appendices

5.1 Abbreviations and definitions

Table 14 Abbreviations

Abbreviation	Meaning
IC	Integrated circuit
MOSFET	Metal Oxide Semiconductor Field Effect Transistor
DC	Direct Current
BLDC	Brushless Direct Current
PWM	Pulse Width Modulation
EVAL	Evaluation board
PCB	Printed Circuit Board
SOI	Silicon on Insulator

5.2 References

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- [3] Infineon Technologies AG. Simulation mode of [6ED2742S01Q](#)
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- [16] Infineon Technologies AG. Application note: [Handling multiple motor parameters with iMOTION™2.0](#)

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