Design Guide: TIDA-020106

Electro-Mechanical Brake (EMB) Reference Design

Description

Electro-mechanical brake (EMB) is a new type of braking technology aimed at electrification and intelligence of automobiles, provides overall cost saving, faster response and more precise operation for advanced autonomous driving. This reference design shows a whole functional EMB design. The hardware, Software and function safety design are all illustrated in this guide. This reference design can also be referred for a electro power steering (EPS) since EPS has very similar key components as EMB.

Resources

TIDA-020106, C2000WARE-MOTORCONTROL-SDK	Design Folder
DRV3263-Q1, DRV3233-Q1	Product Folder
F29P32, TPS653860-Q1	Product Folder
DRV8263-Q1, DRV8243-Q1	Product Folder
LM68645-Q1, LM74930-Q1	Product Folder
TCAN1043H-Q1	Product Folder

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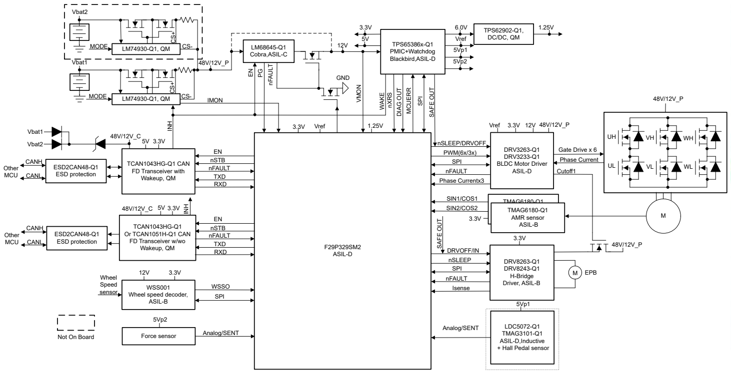
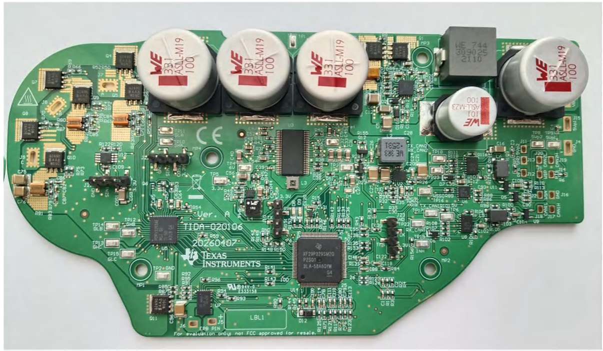
Features

- 48V/12V compatible design
- ASIL-D compatible design
- Flexible discrete components design
- <100uA standby power
- Electronic parking braking (EPB) supported
- Pedal and press sensors interface supported
- Up to 500W BLDC motor supported
- 158mm × 83mm x 20mm compact board size

Applications

- Electro-mechanical braking (EMB)
- Electric power steering (EPS)





1 System Description

Electro-mechanical brake (EMB) is a new type of braking technology aimed at electrification and intelligence of automobiles. Compared with the current mainstream electronic hydraulic brake (EHB), EMB achieves a 'dry' braking method which innovates in structure by eliminating brake fluid, hydraulic pipelines, vacuum boosters, and other related parts. The advantages include reducing vehicle weight, saving subsequent maintenance, and freeing up chassis space. Moreover, the response time is 80 to 100 milliseconds, which is about twice as fast as an EHB, and significantly shortens braking distance. The motor directly controls the EMB, providing more precise operation, which is also beneficial for the precise control required in advanced autonomous driving. This reference design shows a EMB design. The hardware, software and functional safety design are all illustrated in this guide.

1.1 Terminology

EMB	Electro-Mechanical Brake
BLDC	Brushless Direct Current
BEMF	Back Electromotive Force
PWM	Pulse Width Modulation
FET, MOSFET	Metal Oxide Semiconductor Field Effect Transistor
PLL	Phase Locked Loop
RMS	Root Mean Square
MTPA	Maximum Torque Per Ampere
FWC	Field Weakening Control
FOC	Field Oriented Control
CMPSS	Comparator Sub-System

1.2 Key System Specifications

The TIDA-020106 specifications are listed in Table 1-1.

Table 1-1. Key System Specifications

Parameters	TEST CONDITIONS	MIN	NOM	MAX	UNIT
	SYSTEM INPUT CHARACTERISTICS				
Input Voltage (V_{DC})	48V variant	32	48	60	VDC
Input Voltage (V_{DC})	12V variant	6	12	20	VDC
No Load Standby Power (P_{NL})	V_{DC} = 48V, I_{out} = 0A	–	1.5	–	W
Input Current (I_{IN})	V_{INDC} = 48V, P_{out} = P_{MAX}	–	12	–	A
	MOTOR INVERTER CHARACTERSITICS				
PWM switching frequency (f_{SW})	–	–	20		kHz
Rated output power (P_{OUT})	V_{INDC} = 48V	–	500		W
Output current (I_{RMS})	V_{INDC} = 48V	–	16	–	A
Inverter efficiency (Ƞ)	V_{INDC} = nom, P_{OUT} = nom	–	96	–	%
Motor electrical frequency (f)	V_{INAC} = min to max	20	200	1000	Hz
Fault protections	Overcurrent, stall with recovery, undervoltage, overvoltage				
Drive control method and features	FOC with position sensors				
Operating ambient	Open frame	–25	25	75	°C
Board size	Length × width × height	158mm × 83mm × 20mm			mm^3

WARNING

TI intends this reference design to be operated in a lab environment only and does not consider the device to be a finished product for general consumer use.

TI Intends this reference design to be used only by qualified engineers and technicians familiar with risks associated with handling high-voltage electrical and mechanical components, systems, and subsystems.

High voltage! There are accessible high voltages present on the board. The board operates at voltages and currents that can cause shock, fire, or injury if not properly handled or applied. Use the equipment with necessary caution and appropriate safeguards to avoid injuring yourself or damaging property.

Hot surface! Contact can cause burns. **Do not touch!** Some components can reach high temperatures >55°C when the board is powered on. The user must not touch the board at any point during operation or immediately after operating, as high temperatures can be present.

CAUTION

Do not leave the design powered when unattended.

2 System Overview

2.1 Block Diagram

Figure 2-1 shows the block diagram of this reference design.

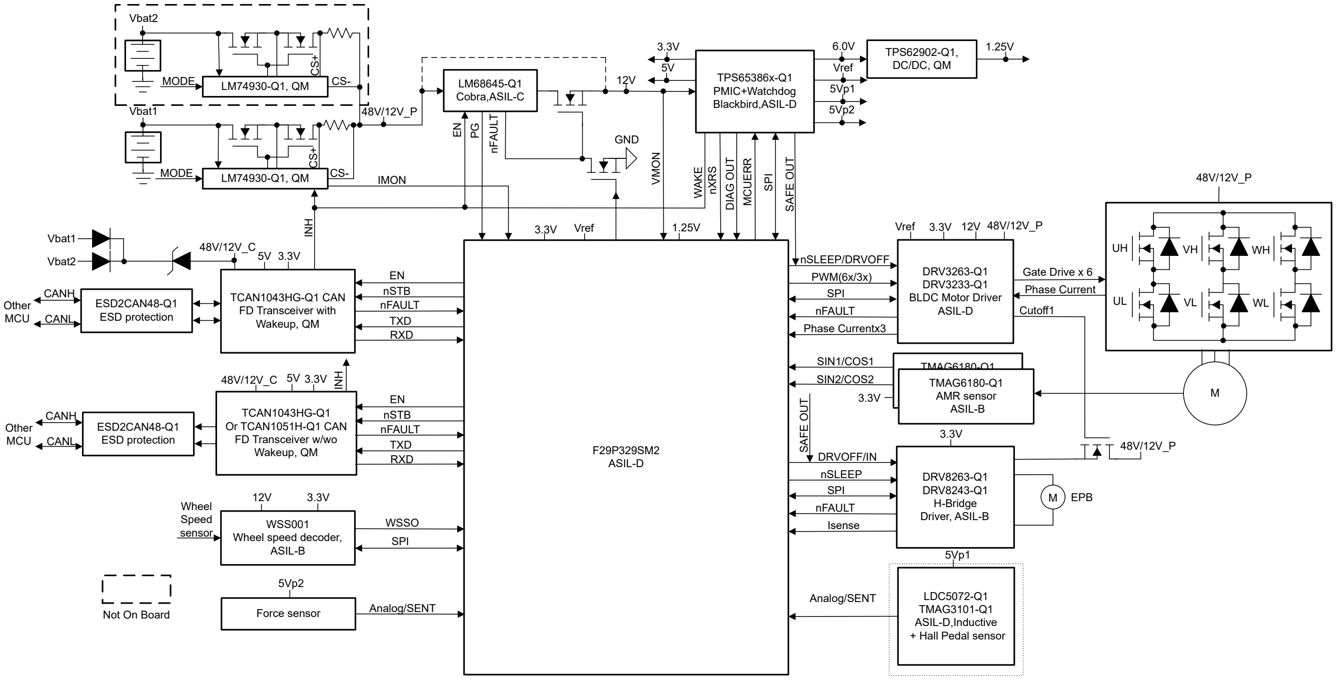


Figure 2-1. TIDA-020106 EMB Block Diagram

The entire system is represented in seven blocks:

- Ideal diodes
- 48V to 12V DC/DC
- PMIC
- BLDC motor driver
- EPB drive
- Wheel speed sensor decoder
- CAN transceivers
- F29P32 DSP
- Force sensor interface
- Pedal Sensor interface

2.2 Design Considerations

The design demos a completed EMB design, including power tree, DSP, motor drive, WSS decode, CAN transceivers and function safety. The hardware design files are available on ti.com.

2.3 Highlighted Products

The following highlighted products are used in this reference design. Key features for selecting the devices for this reference design are revealed in the following sections. Find more details of the highlighted devices in respective product data sheets.

2.3.1 F29P32X

The F29H85x, F29P58x, and F29P32x are members of the C2000™ real-time microcontroller family of scalable, ultra-low latency MCUs designed for efficiency in power electronics, motor control, and beyond, including but not limited to: high power density, high switching frequencies. The F29 product families feature the next-generation C29 CPU core, leading the industry with 2 times the performance from the previous-generation C28 CPU core. The C29 core also supports byte-addressing, with data types fully compatible with other popular CPU architectures, including the Arm™ architecture, enabling a smooth migration for customers looking to go to market quickly. For more information, see The C29 CPU – Unrivaled Real-Time Performance with Optimized Architecture on C2000 MCUs technical white paper.

2.3.2 LM74930-Q1

The LM74930-Q1 ideal diode controller drives and controls external back to back N-Channel MOSFETs to emulate an ideal diode rectifier and power path ON and OFF control with over current and overvoltage protection. The wide input supply of 4V to 65V allows protection and control of 12V and 24V automotive battery powered ECUs. The device can withstand and protect the loads from negative supply voltages down to –65V. An integrated high side gate control (HGATE) drives the first MOSFET in the power path. The device allows load disconnect (ON and OFF control) in case of overcurrent, overvoltage and undervoltage event using HGATE control while ideal diode controller (DGATE) drives a second MOSFET to replace a Schottky diode for input reverse polarity protection and output voltage holdup by blocking the reverse current from output to input. The device has integrated current sense amplifier which provides with an adjustable overcurrent and short circuit protection with circuit breaker functionality. The device features an adjustable overvoltage and undervoltage protection feature to protect against supply transients. LM74930-Q1 features MODE pin which can be used to selectively enable or disable reverse current blocking functionality.

2.3.3 WSS001

The WSS001 device is a single channel wheel-speed interface chip designed for use in harsh automotive environments requiring few external components. There is configurable wheel-speed sense input capable of handling active sensors. The device has five decoding modes to decode 2-Level, 3-Level AK protocol and 3-Level high-resolution AK protocol sensor. WSS001 outputs the sensor speed signal from WSSO output for MCU to measure the wheel speed and sensor signal decoded result is stored in internal register bits that can be accessed through SPI.

The WSS001 device uses 32-bit SPI protocol for communication. I/O pins accept 5V and 3.3V supply.

2.3.4 LM68645-Q1

The LM686x5-Q1 are a family of automotive buck converters designed for high efficiency, high-power density, and ultra-low electromagnetic interference (EMI). The converters operate over a wide input voltage range of 3V to 65V (70V transient < 100ms), reducing the need for external input surge protection. The LM686x5-Q1 comes with pin selectable fixed output voltages of 3.3V and 5V or in adjustable configuration. The low EMI operation is enabled with minimized loop inductance and optimized switch node slew rate. The current-mode control architecture with a 30ns typical minimum on-time allows high conversion ratios at high frequencies coupled with a fast transient response and excellent load and line regulation. Auto mode enables frequency foldback during light-load operation, allowing an unloaded current consumption as low as 2.5μA (typical) and high light-load efficiency, which extends operating runtime in battery-powered systems.

2.3.5 TPS653860-Q1

The TPS65386x-Q1 device is a multi-rail power supply designed to supply microcontrollers, sensors, transceivers and peripherals in safety relevant applications

2.3.6 DRV3263-Q1

The DRV3263-Q1 is an integrated smart gate driver for 48V automotive three-phase BLDC applications. The device provides three half-bridge gate drivers, each capable of driving high-side and low-side N-channel power MOSFETs. The DRV3263-Q1 generates the correct gate drive voltages using an external 12V supply and an integrated bootstrap diode for the high-side MOSFETs. A trickle charge pump allows for the gate drivers to support 100% PWM duty cycle control and provides overdrive gate drive voltage for driving external switches, which can be controlled through dedicated cutoff driver pins.

The DRV3263-Q1 provides low-side current sense amplifiers to support resistor based low-side current sensing. The low offset and low gain error of the amplifiers enable the system to obtain precise motor current measurements.

A wide range of diagnostics and protection features are integrated with the DRV3263-Q1, enabling a robust motor drive system design and reduce external components. The highly configurable device response allows the device to be integrated seamlessly into a variety of system designs.

2.3.7 DRV3233-Q1

The DRV3233-Q1 is an integrated smart gate driver for 12V and 24V automotive three-phase BLDC applications. The device provides three half-bridge gate drivers, each capable of driving high-side and low-side N-channel power MOSFETs. The DRV3233- Q1 generates the correct gate drive voltages using an integrated bootstrap diode and a GVDD charge pump. The Smart Gate Drive architecture supports configurable peak gate drive current from 0.8mA up to 1A source and 2A sink. The DRV3233-Q1 can operate from a single power supply with a wide input range from 4.5 to 60V. A trickle charge pump enables 100% PWM duty cycle control, and provides overdrive supply voltage for external switches.

The DRV3233-Q1 provides low-side current sense amplifiers to support resistor based low-side current sensing. The low offset of the amplifiers enables the system to obtain precise motor current measurement.

A wide range of diagnostics and protection features integrated in the DRV3233-Q1 enable a robust motor drive system design and help eliminate the needs of external components. The highly configurable device response allows the device to be integrated seamlessly into a variety of system designs.

2.3.8 DRV8263-Q1

The DRV8263-Q1 is a wide-voltage, high-power fully integrated H-bridge driver for 24V and 48V automotive applications. Designed in a BiCMOS high-power process technology node, this device in a power package offers excellent power handling and thermal capability while providing compact package size, ease of layout, EMI control, accurate current sense, robustness, and diagnostic capability.

The device integrates a N-channel H-bridge, charge pump, high-side current sensing with regulation, current proportional output, and protection circuitry. The integrated sensing uses a current mirror, removing the need for shunt resistors, saving board area, and reducing system cost. A low-power sleep mode is provided to achieve low quiescent current.

The device offers voltage monitoring and load diagnostics, as well as protection features against overcurrent and overtemperature. Fault conditions are indicated on the nFAULT pin. The device is available in two variants: HW interface and SPI. The SPI variant offers more flex

2.3.9 DRV8243-Q1

The DRV824x-Q1 family of devices is a fully integrated H-bridge driver intended for a wide range of automotive applications. The device can be configured as a single full-bridge driver or as two independent half-bridge drivers. Designed in a BiCMOS high power process technology node, this monolithic family of devices in a power package offer excellent power handling and thermal capability while providing compact package size, ease of layout, EMI control, accurate current sense, robustness, and diagnostic capability. This family provides an identical pin function with scalable RON (current capability) to support different loads

2.3.10 TMAG6180-Q1

The TMAG6180-Q1 is a high-precision angle sensor based on Anisotropic Magneto Resistive (AMR) technology. The device features integrated signal conditioning amplifiers and provides differential sine and cosine analog outputs related to the direction of the applied in-plane magnetic field. This device also features two independent Hall sensor outputs at X and Y axes that can be used to extend the angle range of the sensor to 360°.

The TMAG6180-Q1 features a wide operating magnetic field that enables flexible mechanical placements as well as low latency (1.6μs) outputs for high-speed applications like rotor position sensing. The device features ultra-low latency on the sine and cosine outputs to minimize latency related angle errors and is designed for high-speed applications like rotor position sensing up to 100krpm.

The TMAG6180-Q1 offers extensive diagnostics to support stringent functional safety automotive and industrial requirements. The device performs consistently across a wide ambient temperature range of –40°C to +150°C with minimal thermal drift and lifetime errors.

2.3.11 TCAN1043H-Q1

The TCAN1043H-Q1 meets the physical layer requirements of the ISO 11898–2 (2016) High Speed Controller Area Network (CAN) specification providing an interface between the CAN bus and the CAN protocol controller. These devices support both classical CAN and CAN FD up to 2 megabits per second (Mbps). Devices with part numbers that include the suffix “G” are designed for CAN FD data rates up to 5Mbps. The TCAN1043xx-Q1 allows for system-level reductions in battery current consumption by selectively enabling (via the INH output pin) the various power supplies that can be present on a node. This allows an ultra-low-current sleep state in which power is gated to all system components except for the TCAN1043xx-Q1, which remains in a low-power state monitoring the CAN bus.

When a wake-up pattern is detected on the bus or when a local wake-up is requested via the WAKE input, the TCAN1043xx-Q1 initiates node start-up by driving INH high. The TCAN1043xx-Q1 includes internal logic level translation via the VIO terminal to allow for interfacing directly to 3.3V or 5V controllers. The device includes many protection and diagnostic features including CAN bus line short-circuit detection and battery connection detection. The TCAN1043xxQ1 meets the ESD and EMC requirements of IEC 62228-3 and J2962-2 without the need for additional protection components.

2.3.12 TCAN1043-Q1

The TCAN104x-Q1 meets the physical layer requirements of the ISO 11898–2 (2016) High Speed Controller Area Network (CAN) specification providing an interface between the CAN bus and the CAN protocol controller. These devices support both classical CAN and CAN FD up to 2 megabits per second (Mbps). Devices with part numbers that include the suffix “G” are designed for CAN FD data rates up to 5Mbps. The TCAN1043xx-Q1 allows for system-level reductions in battery current consumption by selectively enabling (via the INH output pin) the various power supplies that can be present on a node. This allows an ultra-low-current sleep state in which power is gated to all system components except for the TCAN1043xx-Q1, which remains in a low-power state monitoring the CAN bus.

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2.3.13 LDC5072-Q1

The LDC5072-Q1 is an analog front-end for contact-less, inductive position sensors targeted for absolute rotary position in automotive and industrial applications. The LDC5072-Q1 excites a coil that is typically printed on a printed circuit board (PCB). The excitation is coupled back into two sets of receiver coils on the same PCB using a conductive target that is placed in close proximity of the PCB. The conductive target can also be a pattern printed on another PCB. The coil PCB stays stationary and the target moves with the motor, actuator, or valve. The excitation coil generates a secondary voltage on the receiver coils depending on the position of the target relative to the receiver coils. A signal representation of the position is obtained by reading in the voltages from the receiver coils, processing the voltages, and giving analog outputs representing the sine and cosine components of the position of the target.

2.4 System Design Theory

The main focus of this reference design is for EMB and EPS applications

2.4.1 Hardware Design

A typical motor control board has several blocks: auxiliary power supply, inverter, current and voltage sensing, protection circuit, and a microcontroller. These design concepts are explained in this section.

2.4.1.1 Power Tree Design

The power tree design includes the ideal diode controller LM74930-Q1, 48V to 12V DC/DC converter LM68645-Q1, and 12V PMIC TPS65386x-Q1 as shown Figure 2-2. LM74930-Q1 provides input over voltage, under voltage and over current protection, and allows reverse current to charge to the input power source. Because the

EMB motor can work under regeneration mode, the reverse current path can help to protect boards from over voltage breaking down.

12V is monitored by the internal CMPSS of F29P329SM2 to protect any shortage from 48V to 12V voltage rail due to any failure of LM68645-Q1. The CMPSS disables TCAN1043H-Q1 once the voltage is out of the setting range. Then, the INH of TCAN1043H-Q1 shuts down the ideal diode, DC/DC and PMIC. Because this design is for hardware protection and no software is needed, protection speed is fast.

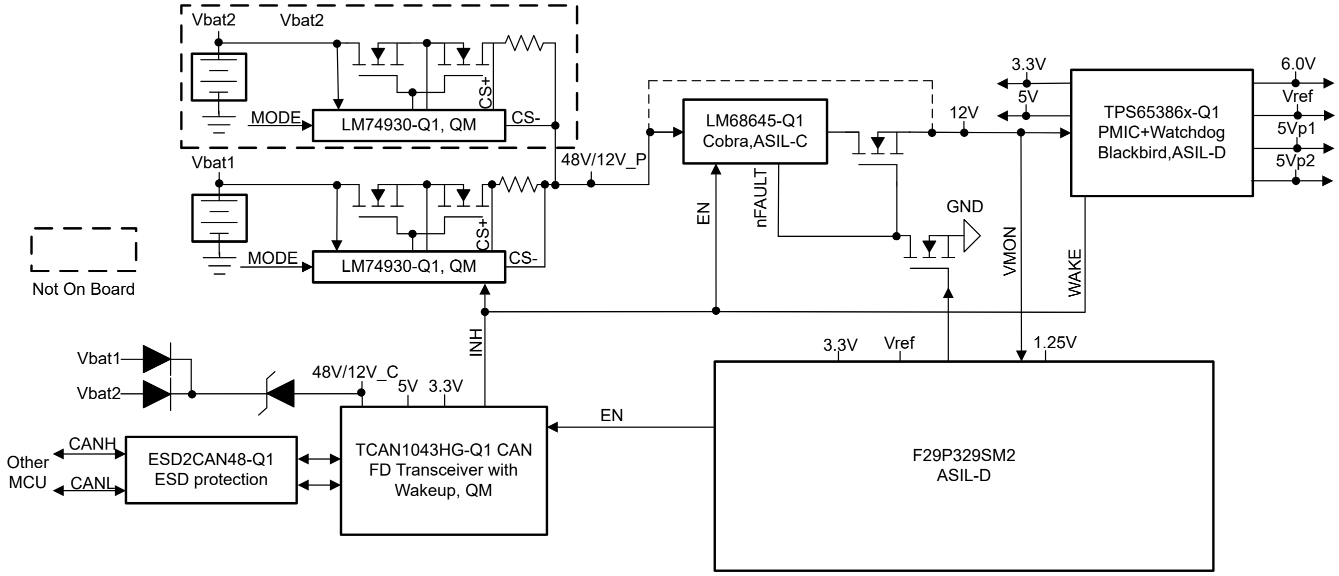


Figure 2-2. Power Tree Design

2.4.1.2 PMIC Design

TPS653860-Q1 is a 12V PMIC, on this reference design, three LDOs are used to create 3.3V for IO supply of F29, 3.3Vref for ADC reference voltage, and 5V for CAN transceiver. F29P32 core voltage is provided by a buck converter TPS62902-Q1. This PMIC also has two PLDOs to provide two protected 5V for off board sensors, such as force sensor and pedal sensors. Figure 2-3 shows the schematic.

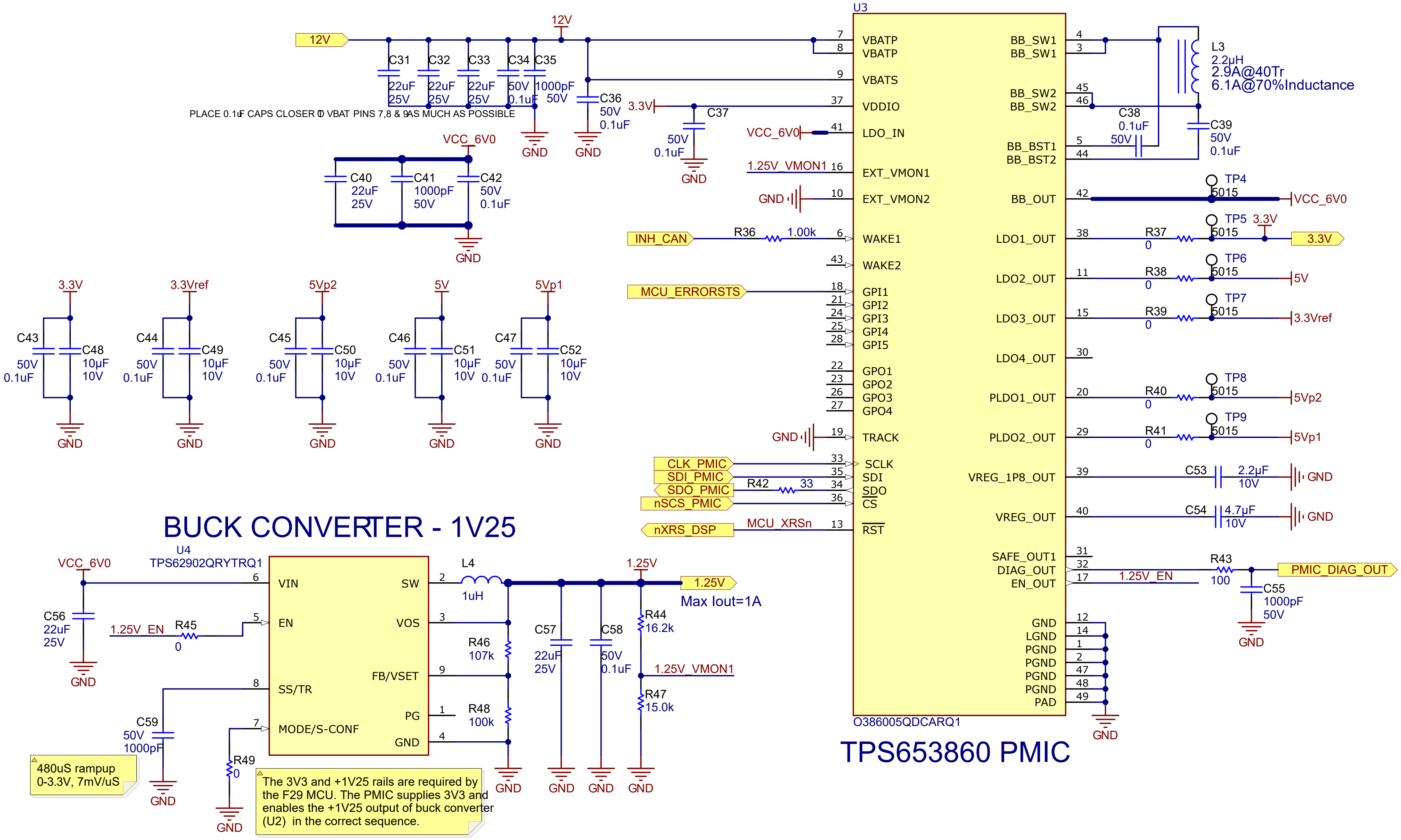
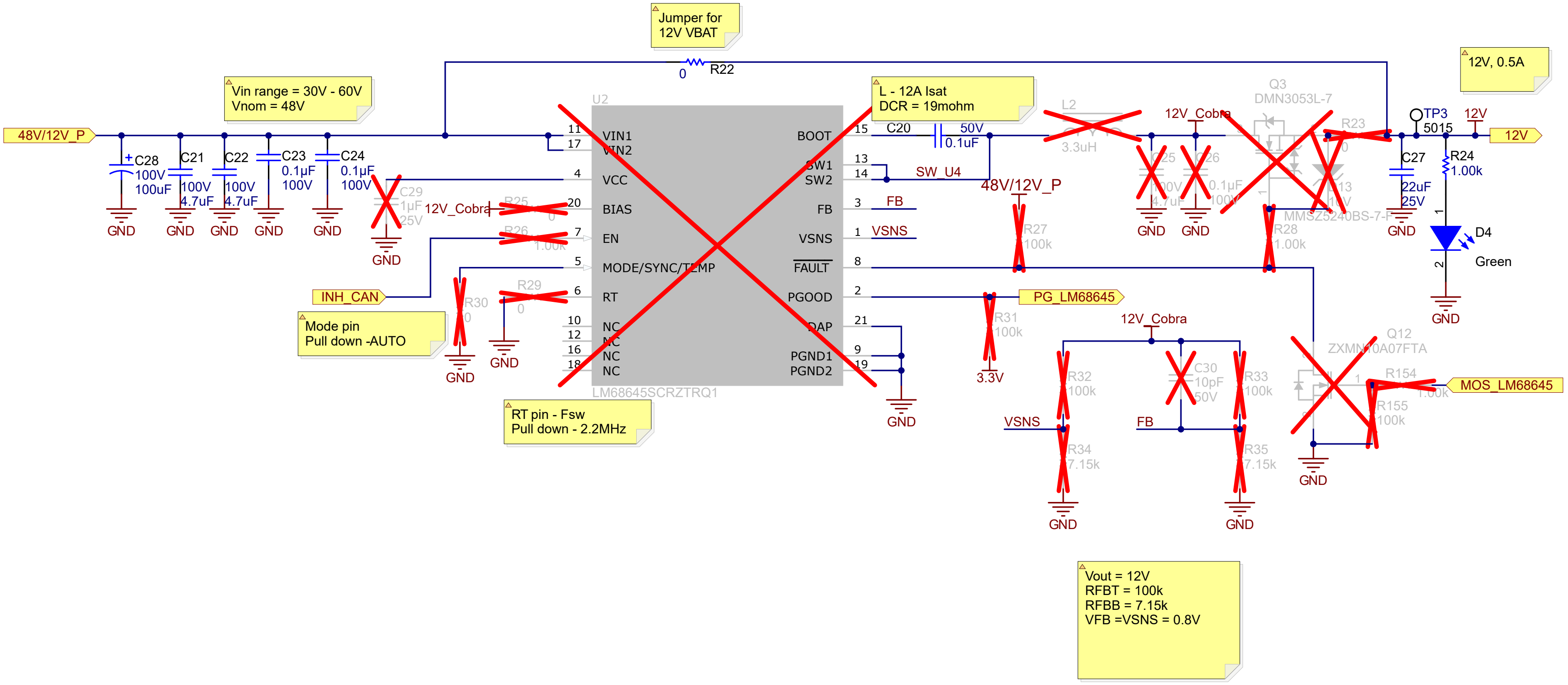


Figure 2-3. PMIC Design

2.4.1.3 DC/DC Converter Design

The DC/DC converter LM68645-Q1 is only needed for 48V variant, for 12V EMB variant, only R22 is needed as an jumper, all other DC/DC converter related components can be de-populated. See Figure 2-4 for the design.



Vout = 12V
RFBT = 100k
RFBB = 7.15k
VFB =VSNS = 0.8V

Figure 2-4. 48V to 12V DC/DC Converter

2.4.1.4 Motor Gate Driver Design

This EMB reference design supports both 48V and 12V motor gate driver DRV3263-Q1 and DRV3233-Q1. DRV3233-Q1 has two cutoffs which can be used to bus or motor phase cutoff, but DRV3233-Q1 has no cutoff, however VCP function can be used to provide a cutoff. Figure 2-5 shows the 48V gate drivers design.

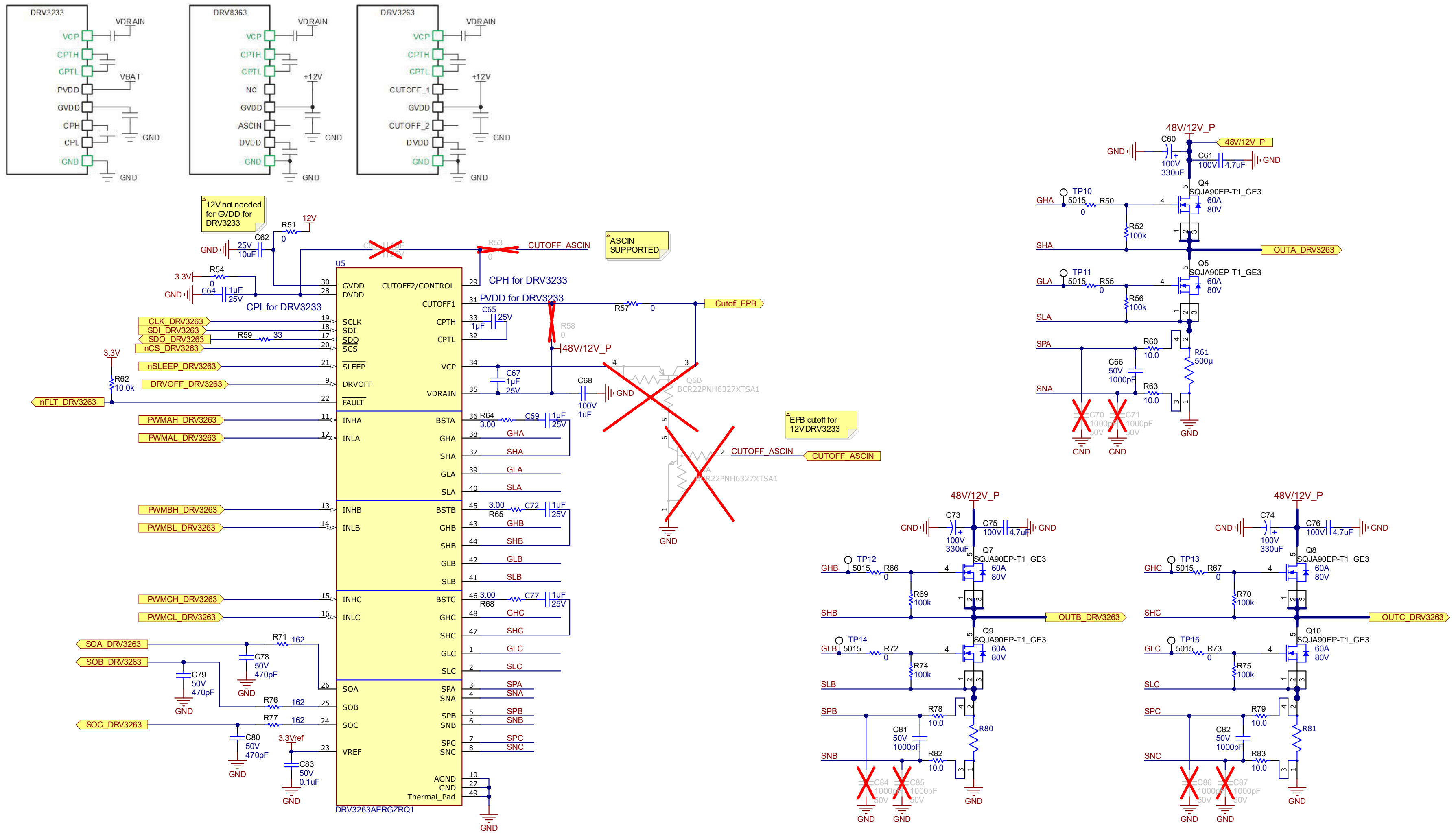


Figure 2-5. DRV3263 Motor Gate Driver for 48V EMB

Figure 2-6 shows the 12V gate drivers design.

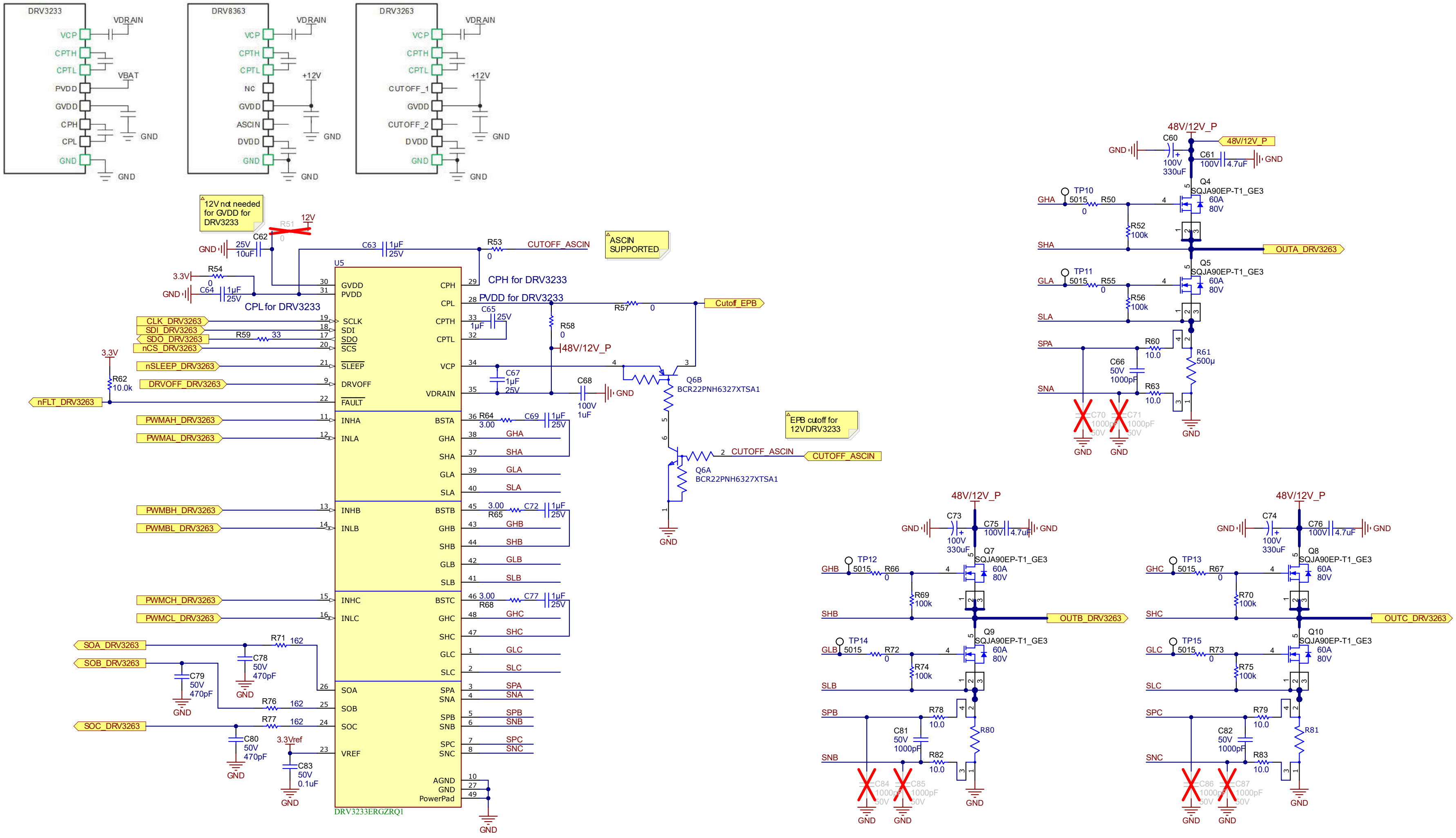


Figure 2-6. DRV3233 Motor Gate Driver for 12V EMB

2.4.1.5 Motor Phase Current Sensing

Both DRV3263-Q1 and DRV3233-Q1 supports low side shunt design with internal PGA.Figure 2-5 show the low side shunt design

2.4.1.6 Overcurrent Protection for F29P32

Besides over current protection of DRV3263-Q1 and DRV3233-Q1, F29P32 also has CMPSS to provide additional motor over current protection.

2.4.1.7 Motor Driver Protection by PMIC

In case the DSP F29P32 fails, the PMIC disables the BLDC motor driver and the EPB driver with a SAFE OUT. Figure 2-7 shows this protection logic.

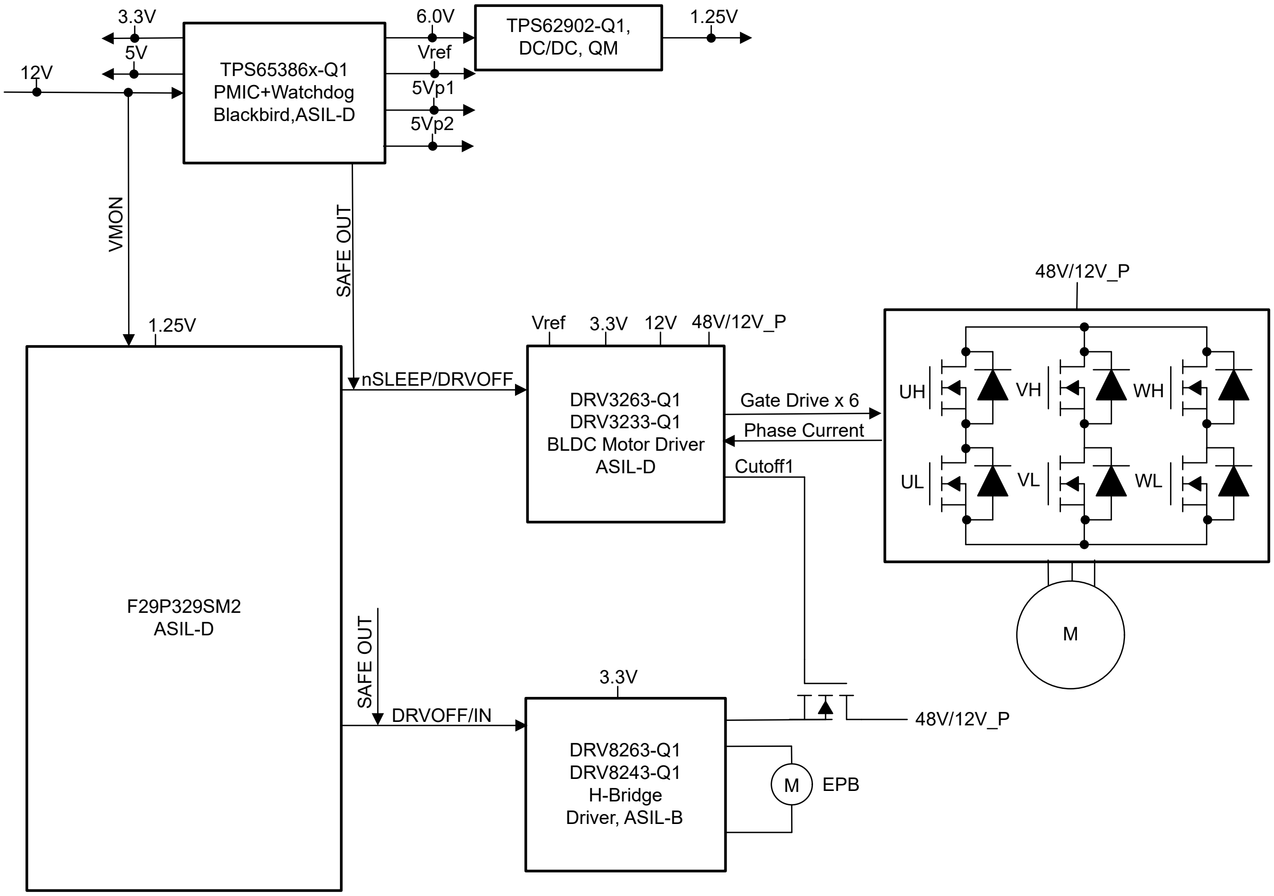


Figure 2-7. Motor Driver Protection by PMIC

2.4.1.8 CAN Transceiver Design

As 48V can transceivers is not so popular, this reference design applow to use both 12V or 48V CAN transceiver, to use 12V can transceiver, populate R97, but R99 for 48V CAN transceiver. Figure 2-8 has the details for motor phase current sensing design.

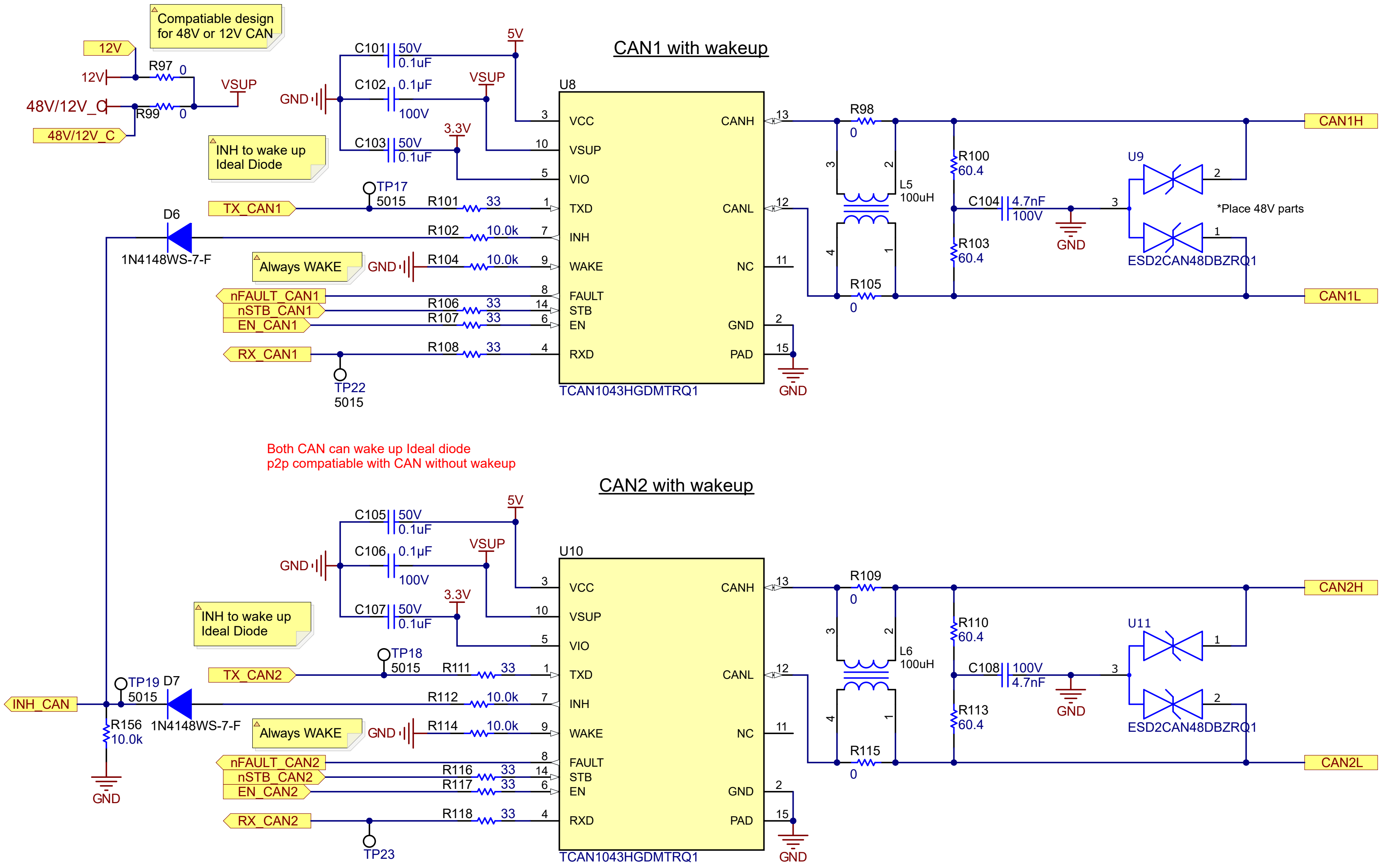


Figure 2-8. CAN Transceiver Design

3 Hardware, Software, Testing Requirements, and Test Results

3.1 Getting Started Hardware

This section details the necessary equipments, test setups, and procedure instructions for the reference design board and software testing and validation.

3.1.1 Board Power On Sequence

Figure 3-1 shows power tree design of this reference design.

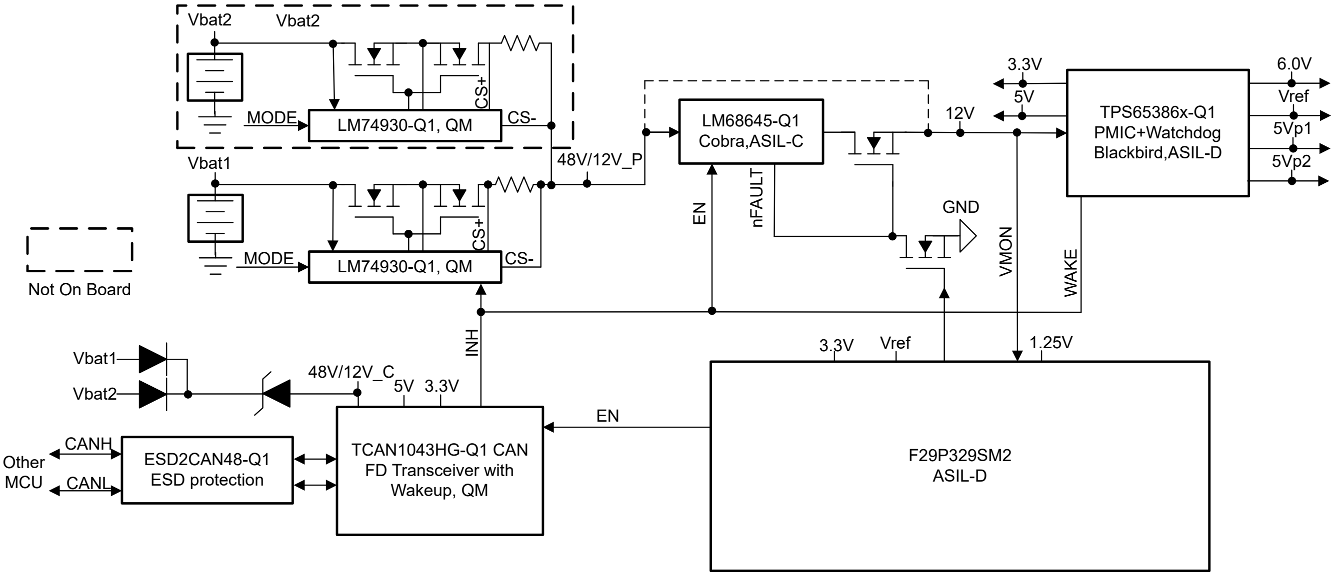


Figure 3-1. Power Tree design

48V/12V_IN_FILTERED is monitored and controlled by the ideal diode controller LM74930-Q1, during powering on, INH of CAN transceiver TCAN1043H will stay high for about 300mS, LM68645-Q1, TPS653860-Q1 and F29P32 starts up within this 300mS time, and F29P32 sets nSTB_CANx ans EN_CANx to be high level to make sure CAN transceiver is enabled and INH is still high after this 300mS startup time. After power on, PMIC outputs:

- 3.3V at LDO1
- 5V at LDO2
- 3.3V at LDO3

Buck converter TTPS62902-Q1 will create 1.25V for F29P32 core voltage supply.

TI recommends taking the following precautions when using the board:

WARNING

- Do not touch any part of the board or components connected to the board when the board is energized.

3.1.2 Test Conditions

Observe the following for testing the reference design software:

- For input, the power supply source must range from 36VDC to 58VDC if using the DC source. Set the input current limit of input DC source to 3A, but start with a lower current limit during initial board bring up.
- For the output, use a 3-phase PMSM with dynamo meters.

3.1.3 Test Equipment Required for Board Validation

The designer must use the following equipment for board validation:

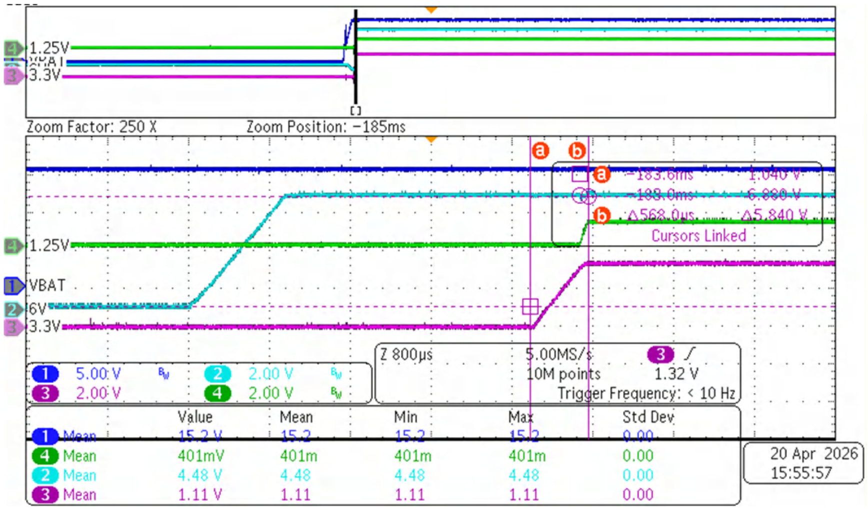
- Isolated DC source
- Three-phase power analyzer
- Digital oscilloscope
- Multimeters
- DC power supply
- 500W, 3-phase PM synchronous motors
- Dynamo meter

3.2 Test Results

The following sections show the test data from characterizing the design. The test results are divided in multiple sections that cover the steady-state performance and data, functional performance waveforms, and transient performance waveforms of the fan and compressor motor.

3.2.1 Power on Sequence of PMIC

Figure 3-2 shows the power on sequence of PMIC and 1.25V DC/DC converter.

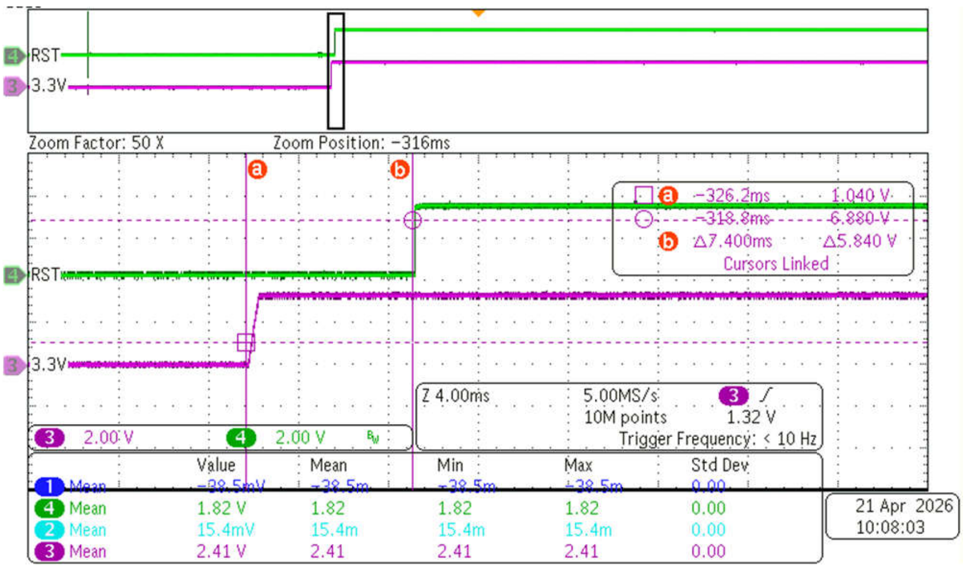


	Value	Mean	Min	Max	Std Dev
1 Mean	15.2 V	15.2	15.2	15.2	0.00
4 Mean	401mV	401m	401m	401m	0.00
2 Mean	4.48 V	4.48	4.48	4.48	0.00
3 Mean	1.11 V	1.11	1.11	1.11	0.00

Figure 3-2. Power on Sequence of PMIC

3.2.2 F29P32 Reset Sequence

Figure 3-3 shows a 7.4mS reset time after 3.3V for F29P32.



a	−326.2ms	1.040 V
	−318.8ms	6.880 V
b	Δ7.400ms	Δ5.840 V
Cursors Linked		

Z 4.00ms 5.00MS/s 10M points
3 1.32 V
Trigger Frequency: < 10 Hz

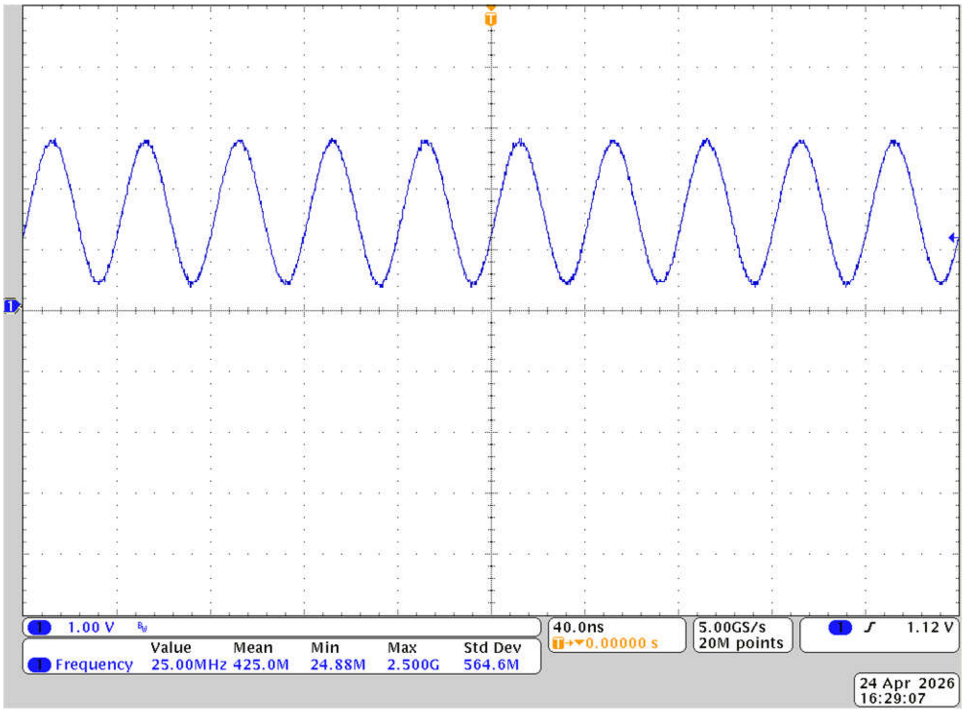
	Value	Mean	Min	Max	Std Dev
1 Mean	−38.5mV	−38.5m	−38.5m	−38.5m	0.00
4 Mean	1.82 V	1.82	1.82	1.82	0.00
2 Mean	15.4mV	15.4m	15.4m	15.4m	0.00
3 Mean	2.41 V	2.41	2.41	2.41	0.00

21 Apr 2026
10:08:03

Figure 3-3. F29P32 Reset Sequence

3.2.3 25MHz Clock

Figure 3-4 shows the 25MHz clock generated by CDC6C025000.



40.0ns
T→▼0.00000 s
5.00GS/s
20M points
1 1.12 V

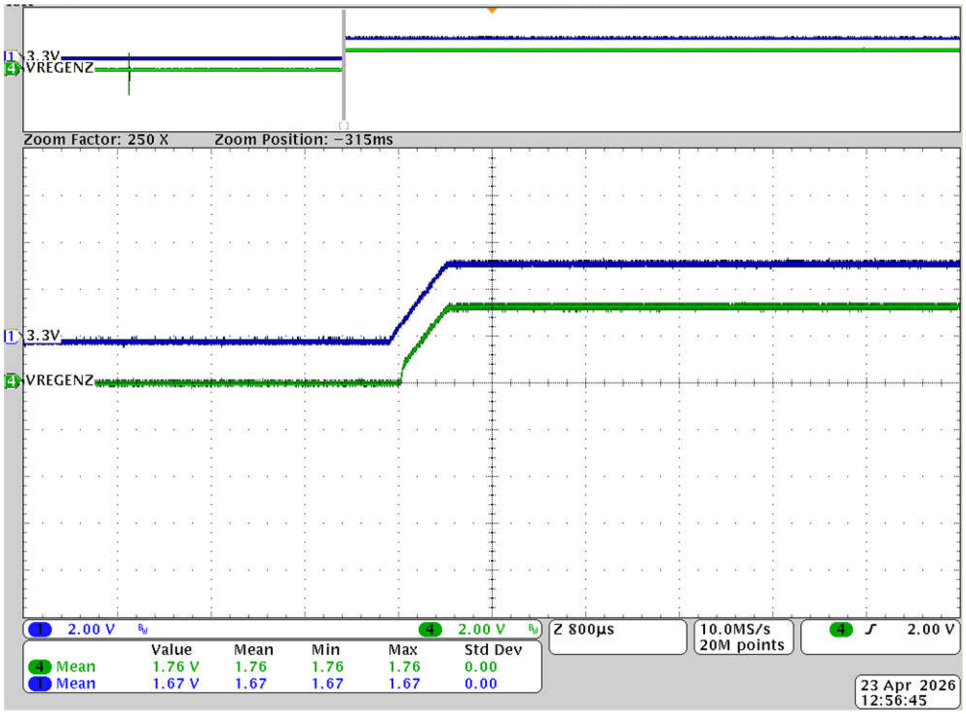
	Value	Mean	Min	Max	Std Dev
1 Frequency	25.00MHz	425.0M	24.88M	2.500G	564.6M

24 Apr 2026
16:29:07

Figure 3-4. 25MHz Clock

3.2.4 Sequence to Use External 1.25V

VREGENZ is a signal for F29 to determine to use internal or external 1.25V power supply, Figure 3-5 shows the sequence of VREGENZ, this signal rise up together with 3.3V, so the external 1.25V power supply is chosen.



	Value	Mean	Min	Max	Std Dev
4 Mean	1.76 V	1.76	1.76	1.76	0.00
1 Mean	1.67 V	1.67	1.67	1.67	0.00

Figure 3-5. VREGENZ Power on Sequence

3.3 Getting Started F29P32 Firmware

Contact the local TI sales representative for F29P32 firmware.

4 Design and Documentation Support

4.1 Design Files

4.1.1 Schematics

To download the schematics, see the design files at TIDA-020106.

4.1.2 Bill of Materials

To download the bill of materials (BOM), see the design files at TIDA-020106.

4.1.3 PCB Layout Recommendations

This reference design is implemented using a PCB with two-layer, 2oz copper with the bottom-side SMD component placement to save cost and board area. There are several important aspects to remember while designing the PCB. In the following bullets, system-level placement and layout of each block is explained.

- Separate components (or singles) into high and low voltage, high and low current, high and low independence groups. Place and route low-voltage and high-impedance components and signals together, such as microcontroller-related signals and the input side of IPM. Use a whole copper pour to provide an integrated GND plane for these area. AC input, filter, and rectifiers and IPM output sides are high-voltage, high-current and low-impedance parts and signals, route them with wider traces or copper pours to provide high-current paths, and also separate them from above low voltage and high-impedance signals to reduce interference.
- Components in the high power path are kept on the outer edges of the PCB with the minimum distance possible. The microcontroller is placed at the center considering the optimum distance from all the power blocks that need to be controlled. Pin assignment is set to minimize the control signal or feedback signal trace distance and the crossing between analog and digital signals.
- AC Line Protection and EMI Filter
  - AC line protection components are closely placed within the minimum distance to the connection path. Earth connection guarding is provided around protection and EMI filter circuit.
- Motor Drive
  - For the high ripple requirement, the motor drive is placed as close as possible to the film capacitor and DC bus capacitor bank.
  - The low-side shunt resistor method with four-wire sensing is implemented for current sensing. A differential pair with impedance matching resistor is used to connect the sensing signal from the shunt resistors to the op-amp circuit. Shunt resistors are placed near the module with an immediate ground copper plane connection.
- Auxiliary Power Supply
  - The GND of the auxiliary power supply connects the DC bus capacitor bank directly and independently to separate low current from high current and high frequency GND trace for the inverter.

4.1.4 Altium Project

To download the Altium project files, see the design files at TIDA-020106.

4.1.5 Gerber Files

To download the Gerber files, see the design files at TIDA-020106.

4.2 Software Files

CCSTUDIO	Code Composer Studio Integrated Development Environment
F29-SDK	F29 DSP SDK

4.3 Documentation Support

1. Texas Instruments, *C2000 64 bit MCU with C29x 200MHz Microcontrollers* datasheet
2. Texas Instruments, *F29 Real-Time Microcontrollers* technical reference manual

4.4 Support Resources

TI E2E™ support forums are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

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5 About the Author

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