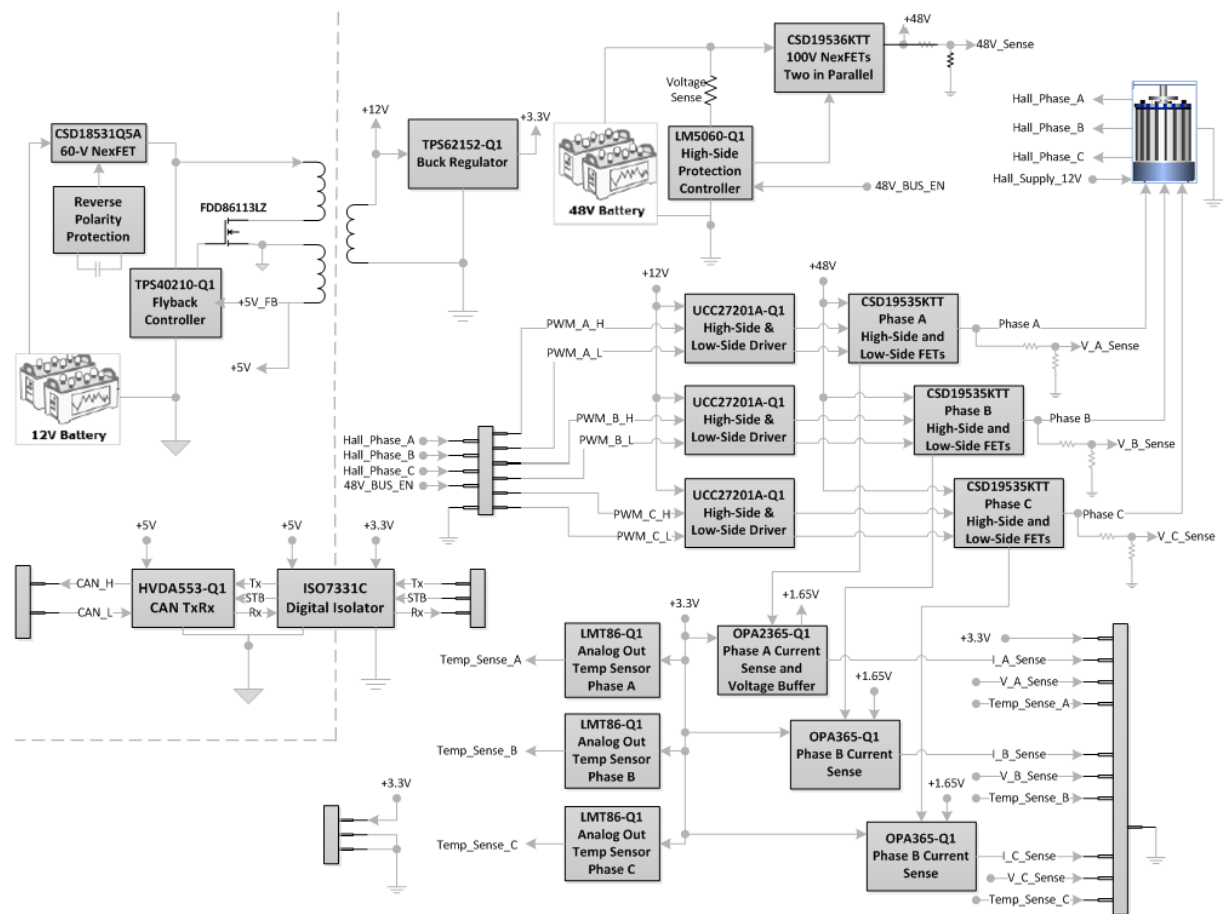


Revision History	
Revision	Notes
A	Change U2 timer cap, DNI current sense caps

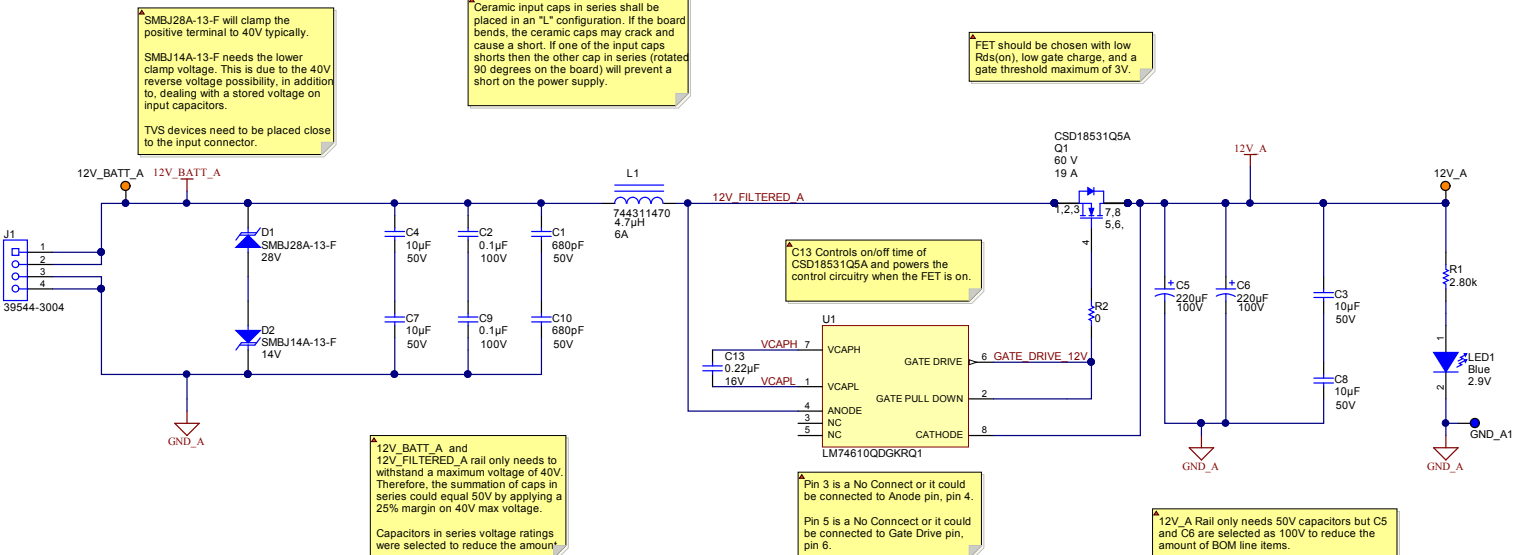


Orderable: N/A	Designed for: Public Release	Mod. Date: 6/8/2015
TID #: TIDA-00281	Project Title: Automotive 48V 1kW Motor Drive	
Number: TIDA-00281   Rev: E1	Sheet Title:	
Rev: Version control disabled	Assembly Variant [No Variations]	Sheet: 1 of 14
Drawn By:	File: COVER SHEET_REVA.SchDoc	Size: B
Engineer: Trenton J Reed	Contact: <a href="http://www.ti.com/support">http://www.ti.com/support</a>	

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5V - 40V input  
12V Nominal



SMBJ28A-13-F will clamp the positive terminal to 40V typically. SMBJ14A-13-F needs the lower clamp voltage. This is due to the 40V reverse voltage possibility, in addition to, dealing with a stored voltage on input capacitors. TVS devices need to be placed close to the input connector.

Ceramic input caps in series shall be placed in an "L" configuration. If the board bends, the ceramic caps may crack and cause a short. If one of the input caps shorts then the other cap in series (rotated 90 degrees on the board) will prevent a short on the power supply.

FET should be chosen with low  $R_{ds(on)}$ , low gate charge, and a gate threshold maximum of 3V.

C13 Controls on/off time of CSD18531Q5A and powers the control circuitry when the FET is on.

12V\_BATT\_A and 12V\_FILTERED\_A rail only needs to withstand a maximum voltage of 40V. Therefore, the summation of caps in series could equal 50V by applying a 25% margin on 40V max voltage. Capacitors in series voltage ratings were selected to reduce the amount.

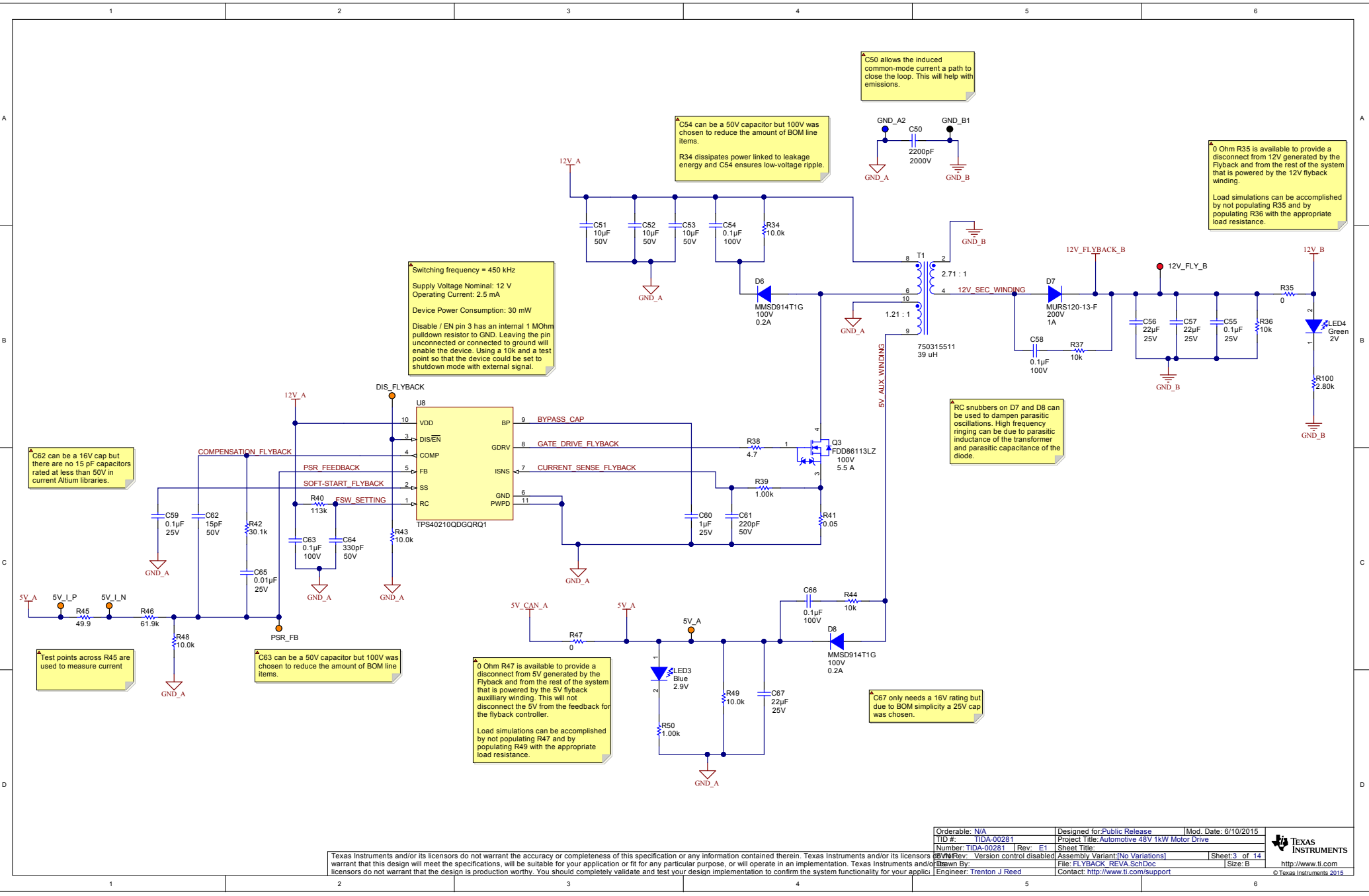
Pin 3 is a No Connect or it could be connected to Anode pin, pin 4. Pin 5 is a No Connect or it could be connected to Gate Drive pin, pin 6.

12V\_A Rail only needs 50V capacitors but C5 and C6 are selected as 100V to reduce the amount of BOM line items. According to EMI filter calculations the electrolytic capacitors need to be at least 4x total input capacitance for a switch-mode power supply. See Design Considerations for calculation.

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TID #: TIDA-00281	Project Title: Automotive 48V 1kW Motor Drive	
Number: TIDA-00281   Rev: E1	Sheet Title:	Sheet: 2 of 14
Rev: Version control disabled	Assembly Variant: [No Variations]	Size: B
Drawn By:	File: 12V_INPUT_REVA.SchDoc	http://www.ti.com
Engineer: Trenton J Reed	Contact: http://www.ti.com/support	© Texas Instruments 2015





C50 allows the induced common-mode current a path to close the loop. This will help with emissions.

C54 can be a 50V capacitor but 100V was chosen to reduce the amount of BOM line items.  
R34 dissipates power linked to leakage energy and C54 ensures low-voltage ripple.

0 Ohm R35 is available to provide a disconnect from 12V generated by the Flyback and from the rest of the system that is powered by the 12V flyback winding.  
Load simulations can be accomplished by not populating R35 and by populating R36 with the appropriate load resistance.

Switching frequency = 450 kHz  
Supply Voltage Nominal: 12 V  
Operating Current: 2.5 mA  
Device Power Consumption: 30 mW  
Disable / EN pin 3 has an internal 1 MOhm pull-down resistor to GND. Leaving the pin unconnected or connected to ground will enable the device. Using a 10k and a test point so that the device could be set to shutdown mode with external signal.

RC snubbers on D7 and D8 can be used to dampen parasitic oscillations. High frequency ringing can be due to parasitic inductance of the transformer and parasitic capacitance of the diode.

C62 can be a 16V cap but there are no 15 pF capacitors rated at less than 50V in current Altium libraries.

Test points across R45 are used to measure current

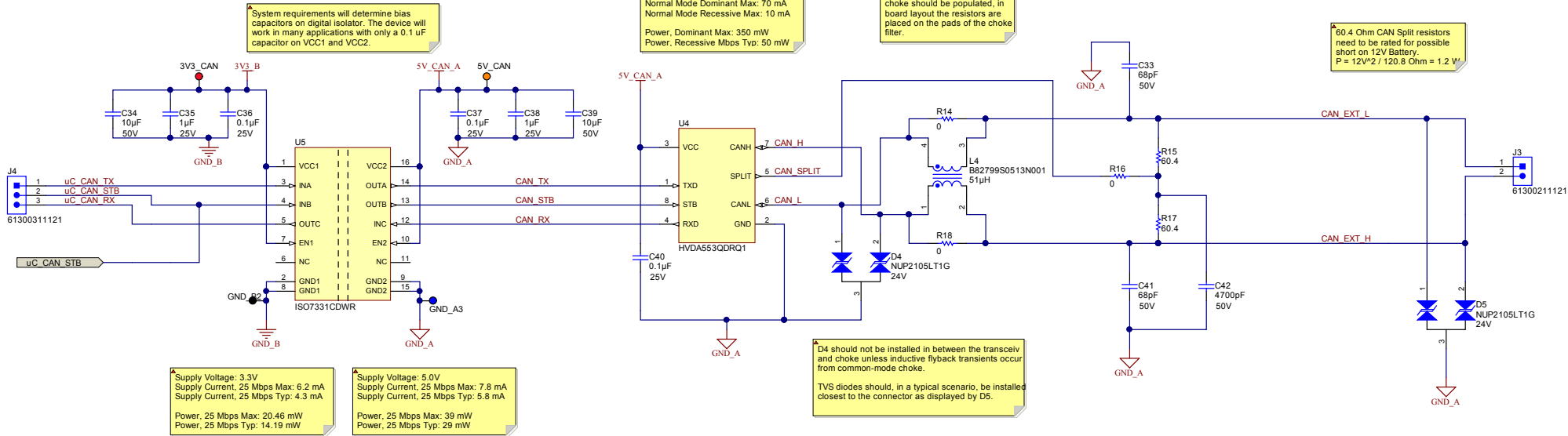
C63 can be a 50V capacitor but 100V was chosen to reduce the amount of BOM line items.

0 Ohm R47 is available to provide a disconnect from 5V generated by the Flyback and from the rest of the system that is powered by the 5V flyback auxiliary winding. This will not disconnect the 5V from the feedback for the flyback controller.  
Load simulations can be accomplished by not populating R47 and by populating R49 with the appropriate load resistance.

C67 only needs a 16V rating but due to BOM simplicity a 25V cap was chosen.

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TID #: TIDA-00281	Project Title: Automotive 48V 1kW Motor Drive	
Number: TIDA-00281   Rev: E1	Sheet Title:	
BOM Rev: Version control disabled	Assembly Variant [No Variations]	Sheet: 3 of 14
Drawn By:	File: FLYBACK_REVA_SchDoc	Size: B
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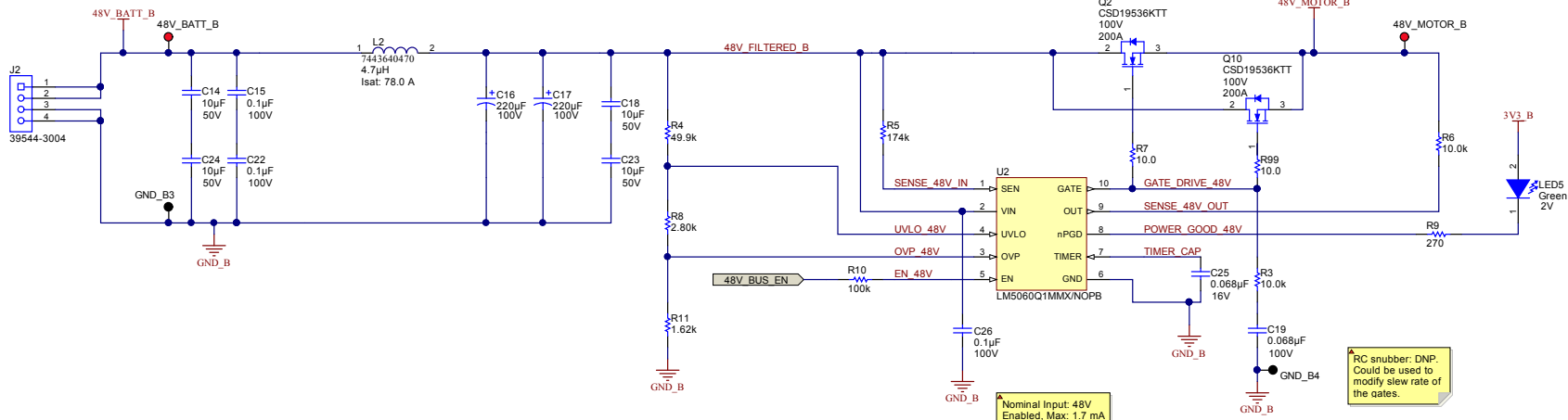
Orderable: N/A	Designed for: Public Release	Mod. Date: 6/10/2015
TID #: TIDA-00281	Project Title: Automotive 48V 1kW Motor Drive	
Number: TIDA-00281   Rev: E1	Sheet Title:	
Rev: Version control disabled	Assembly Variant: [No Variations]	Sheet: 4 of 14
Drawn By:	File: CAN & DIGITAL_ISO_REVA.SchDoc	Size: B
Engineer: Trenton J Reed	Contact: <a href="http://www.ti.com/support">http://www.ti.com/support</a>	



20V - 70V input (Following LV148)  
48V Nominal up to 30A

48V\_BATT\_B and 48V\_FILTERED\_B rails need to withstand a maximum voltage of 70V (per LV148). Therefore, the summation of caps in series could equal 87.5V by applying a 25% margin on 70V max voltage. Series capacitors voltage ratings were selected to reduce the amount of BOM line items.

Due to the max current of 30A and worst case  $R_{ds(on)}$  of a single FET the power dissipation would cause the temperature rise to be too significant. By adding a FET in parallel, the  $R_{ds(on)}$  will be cut in half which will reduce the power dissipation and, in turn, reduce the temperature rise.

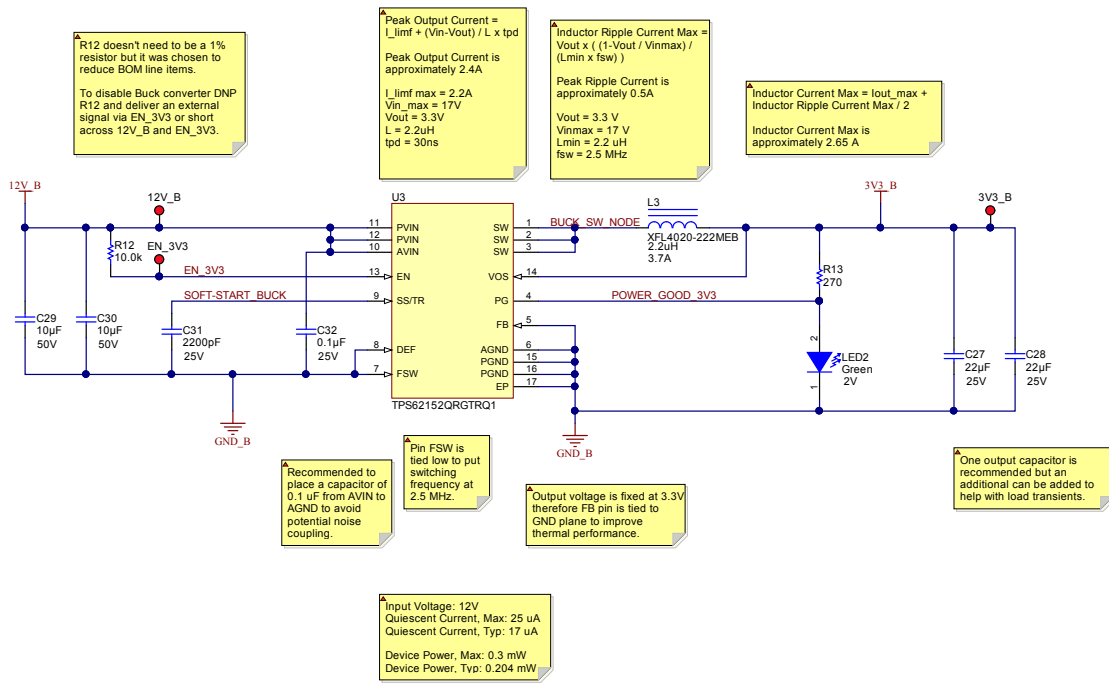


Nominal Input: 48V  
Enabled, Max: 1.7 mA  
Enabled, Typ: 1.4 mA  
Power, Max: 81.6 mW  
Power, Typ: 67.2 mW

RC snubber: DNP.  
Could be used to modify slew rate of the gates.

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TID #: TIDA-00281	Project Title: Automotive 48V 1kW Motor Drive	
Number: TIDA-00281   Rev: E1	Sheet Title:	Sheet: 5 of 14
Rev: Version control disabled	Assembly Variant: [No Variations]	File: 48V_INPUT_REVA_SchDoc
Drawn By:	Engineer: Trenton J Reed	Contact: <a href="http://www.ti.com/support">http://www.ti.com/support</a>

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R12 doesn't need to be a 1% resistor but it was chosen to reduce BOM line items.  
To disable Buck converter DNP R12 and deliver an external signal via EN\_3V3 or short across 12V\_B and EN\_3V3.

Peak Output Current =  $I_{lim} + (V_{in} - V_{out}) / L \times t_{pd}$   
Peak Output Current is approximately 2.4A  
 $I_{lim\ max} = 2.2A$   
 $V_{in\ max} = 17V$   
 $V_{out} = 3.3V$   
 $L = 2.2\ \mu H$   
 $t_{pd} = 30ns$

Inductor Ripple Current Max =  $V_{out} \times (1 - V_{out} / V_{in\ max}) / (L_{min} \times f_{sw})$   
Peak Ripple Current is approximately 0.5A  
 $V_{out} = 3.3V$   
 $V_{in\ max} = 17V$   
 $L_{min} = 2.2\ \mu H$   
 $f_{sw} = 2.5\ MHz$

Inductor Current Max =  $I_{out\ max} + \text{Inductor Ripple Current Max} / 2$   
Inductor Current Max is approximately 2.65 A

One 10 uF input Capacitor is recommended. However, additional capacitance can be added to reduce input current ripple further.  
Only 25V caps are needed but 50V was chosen to reduce the amount of BOM line items.

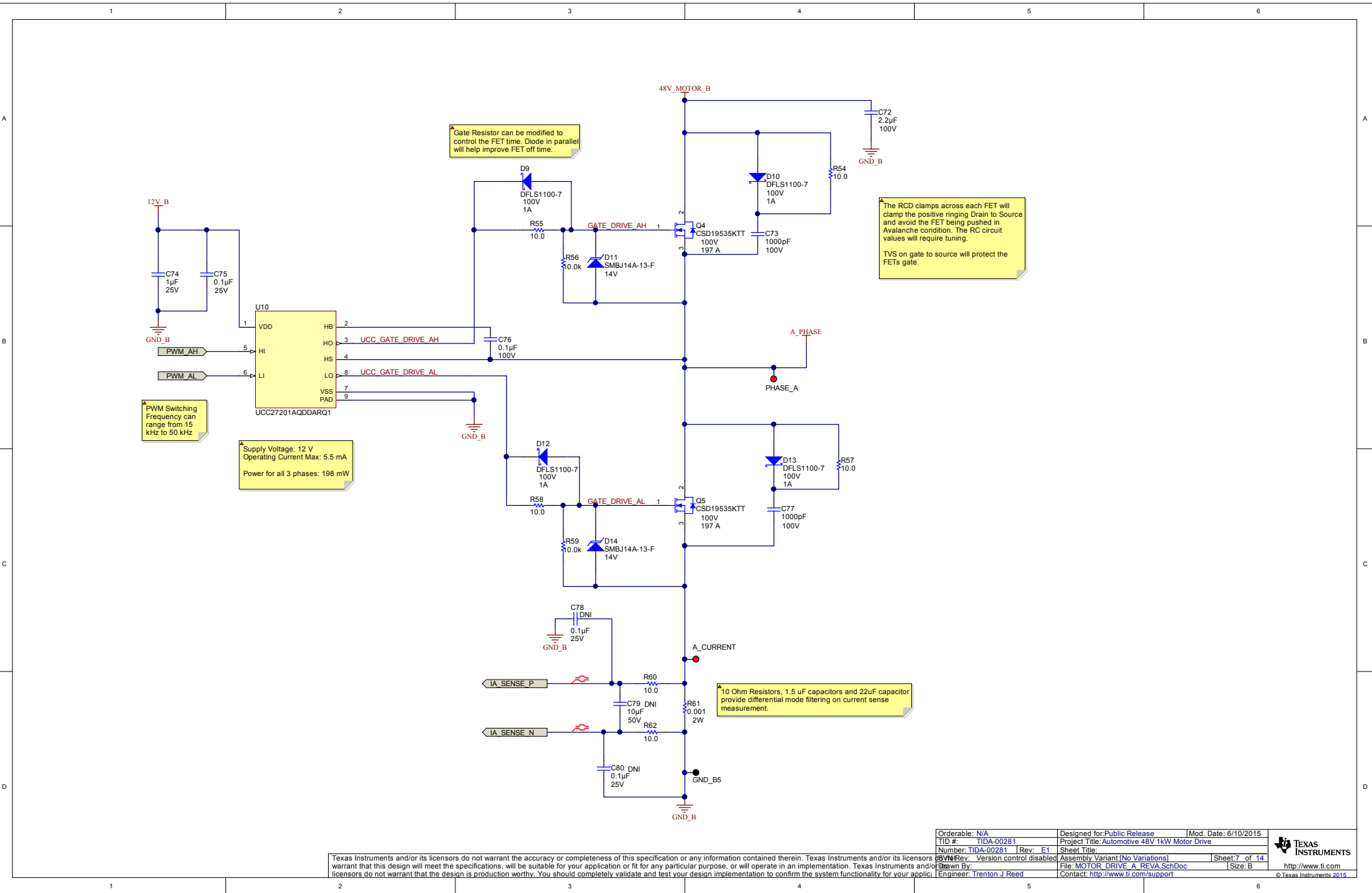
Recommended to place a capacitor of 0.1 uF from AVIN to AGND to avoid potential noise coupling.

Pin FSW is tied low to put switching frequency at 2.5 MHz.

Output voltage is fixed at 3.3V therefore FB pin is tied to GND plane to improve thermal performance.

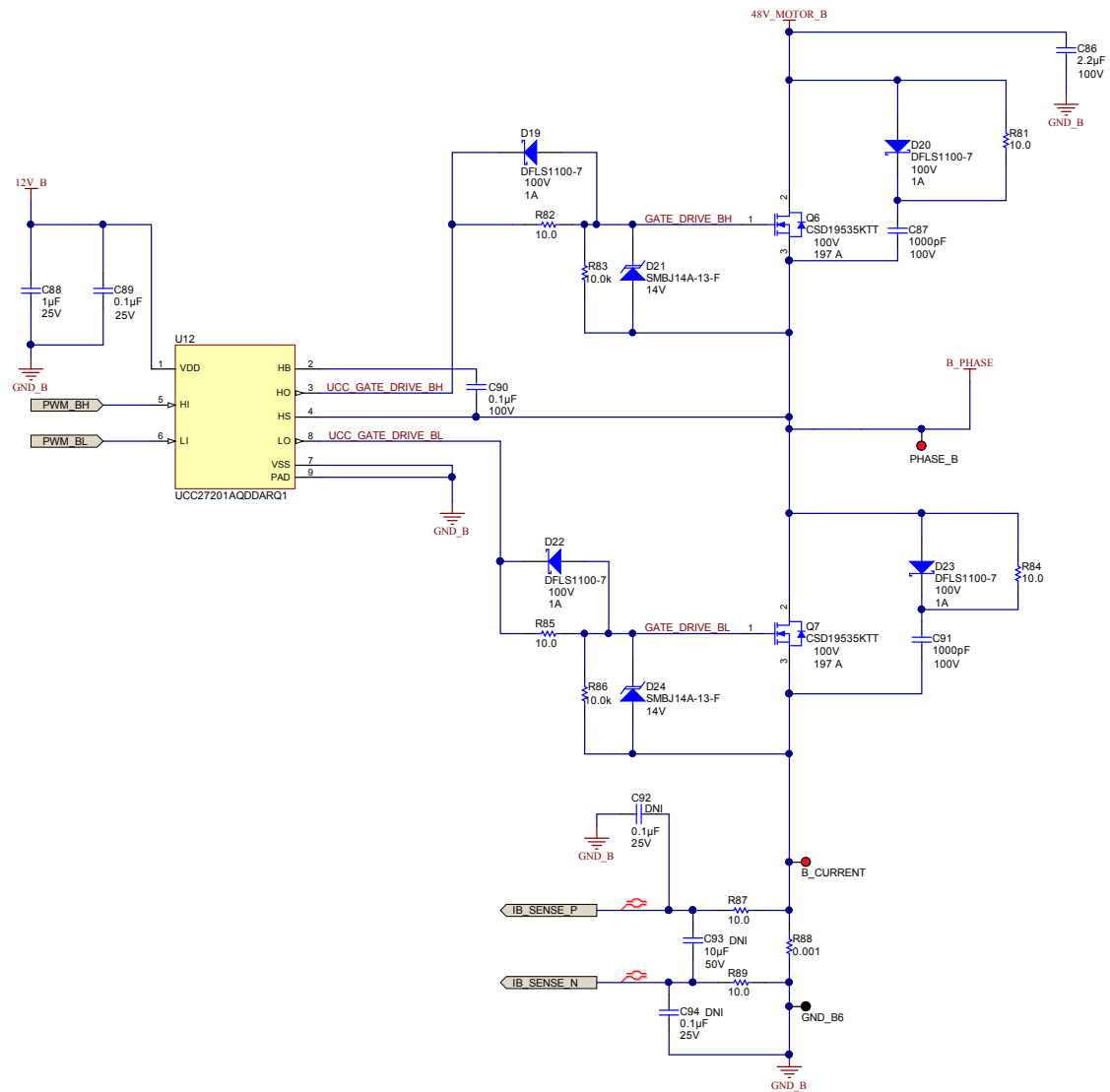
One output capacitor is recommended but an additional can be added to help with load transients.

Input Voltage: 12V  
Quiescent Current, Max: 25 uA  
Quiescent Current, Typ: 17 uA  
Device Power, Max: 0.3 mW  
Device Power, Typ: 0.204 mW



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TID #: TIDA-00281	Project Title: Automotive 48V 1kW Motor Drive	Sheet: 7 of 14	
Number: TIDA-00281   Rev: E1	Assembly Variant: [No Variations]	File: MOTOR_DRIVE_A_REVA.SchDoc	Size: B
Drawn By: [Redacted]	Engineer: Trenton J Reed	Contact: <a href="http://www.ti.com/support">http://www.ti.com/support</a>	<a href="http://www.ti.com">http://www.ti.com</a>

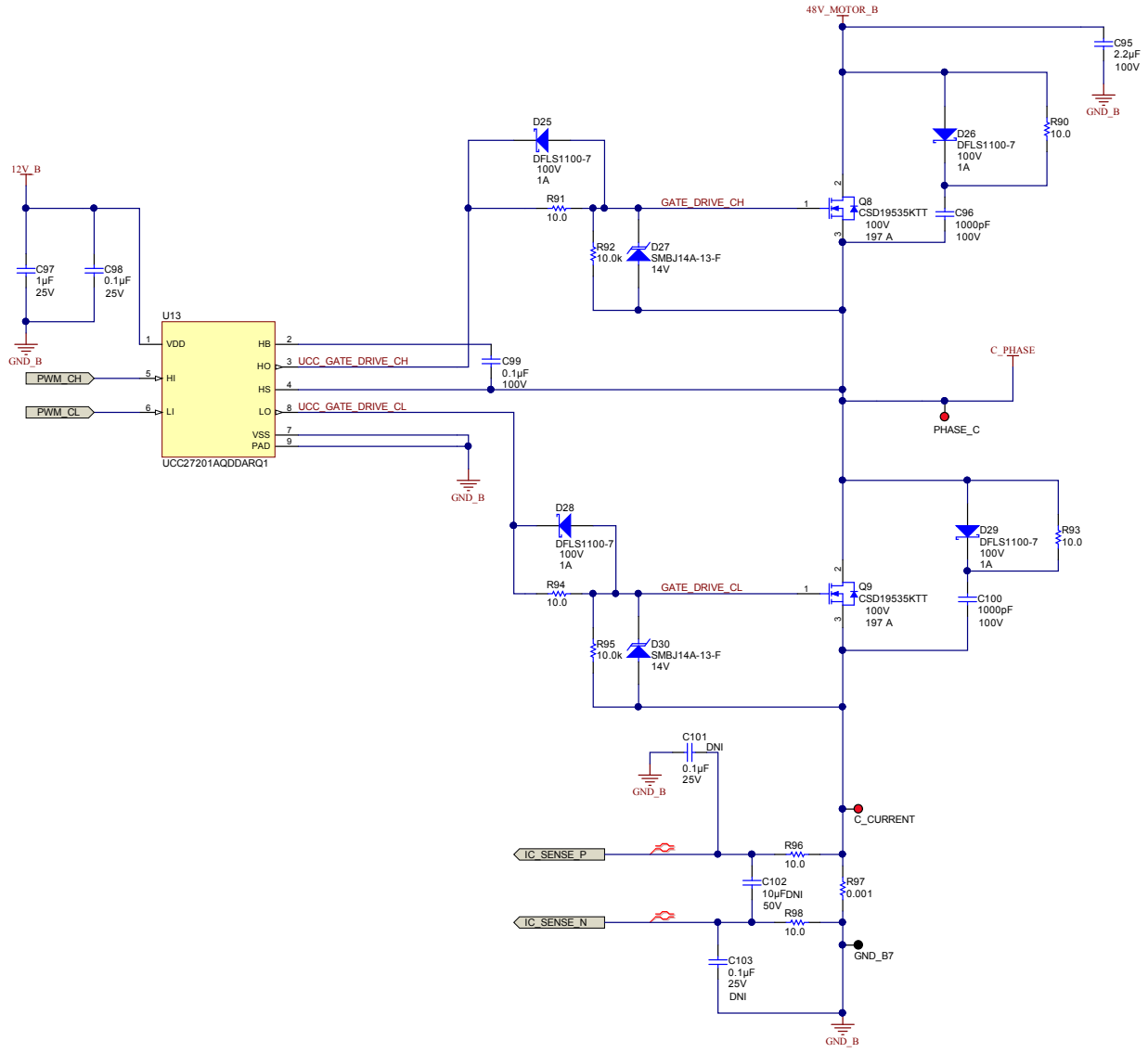


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TID #: TIDA-00281	Project Title: Automotive 48V 1kW Motor Drive	
Number: TIDA-00281   Rev: E1	Sheet Title:	Sheet: 8 of 14
Rev. Version control disabled	Assembly Variant: [No Variations]	File: MOTOR_DRIVE_B_REVA.SchDoc
Drawn By:	Engineer: Trenton J Reed	Contact: <a href="http://www.ti.com/support">http://www.ti.com/support</a>

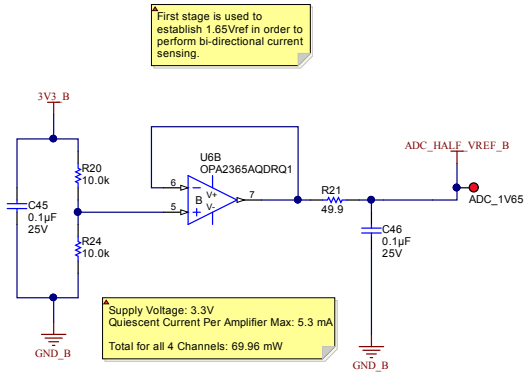






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TID #: TIDA-00281	Project Title: Automotive 48V 1kW Motor Drive	
Number: TIDA-00281   Rev: E1	Sheet Title:	
Rev: Version control disabled	Assembly Variant: [No Variations]	Sheet: 9 of 14
Drawn By:	File: MOTOR_DRIVE_C_REVA.SchDoc	Size: B
Engineer: Trenton J Reed	Contact: <a href="http://www.ti.com/support">http://www.ti.com/support</a>	

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First stage is used to establish 1.65Vref in order to perform bi-directional current sensing.

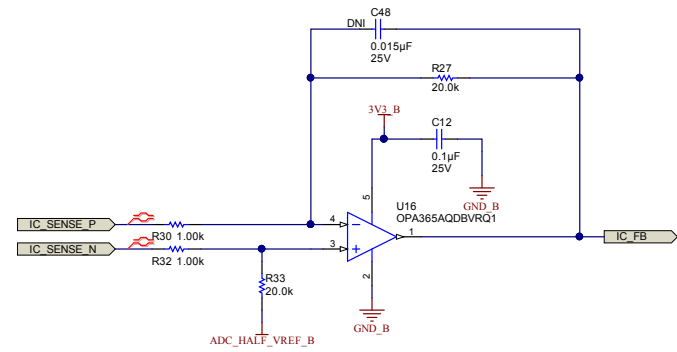
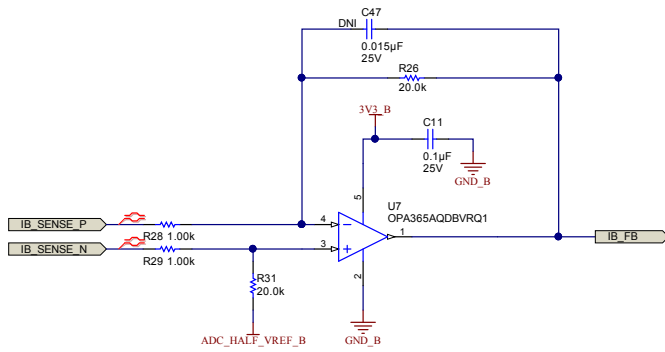
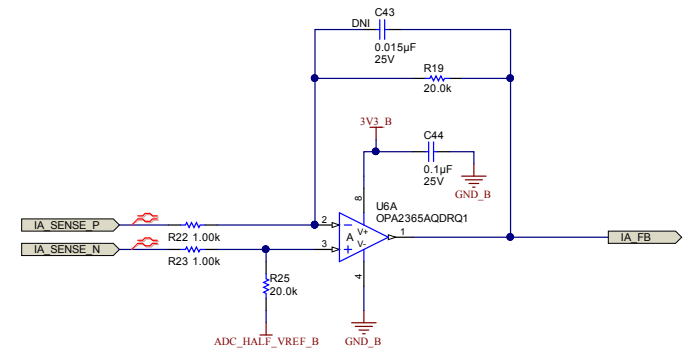
Supply Voltage: 3.3V  
Quiescent Current Per Amplifier Max: 5.3 mA  
Total for all 4 Channels: 69.96 mW

All 0.1µF caps on this page have a 25V cap rating. This was selected for BOM reduction but a 6.3V or higher will work.

0.1 µF bypass capacitors must be connected between each supply pin and ground as close to the device as possible.

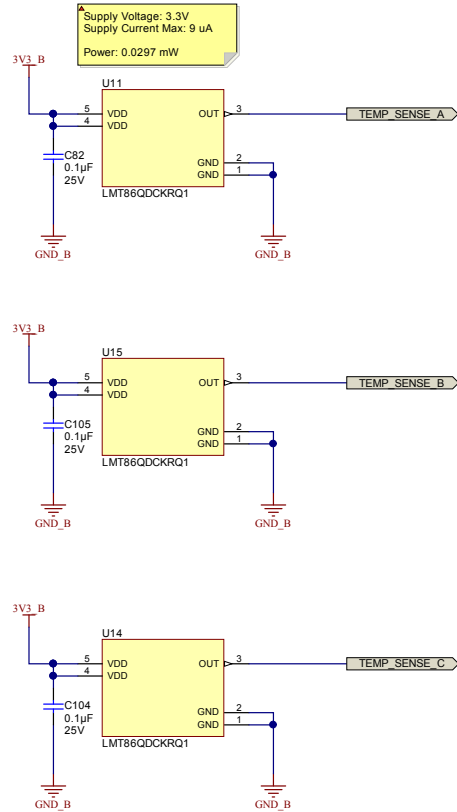
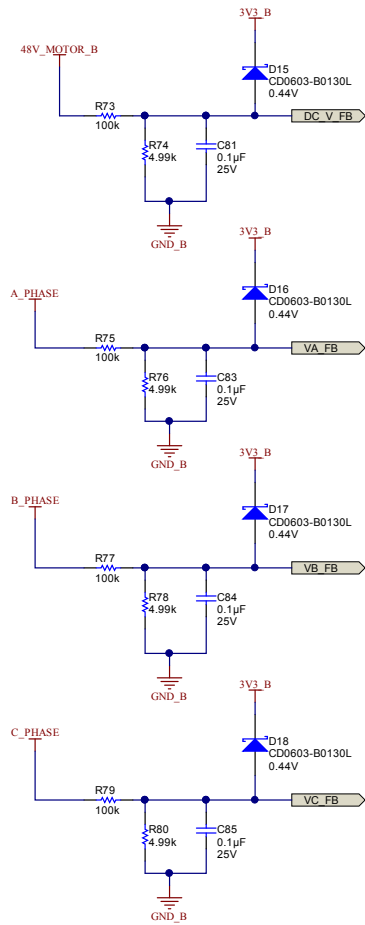
Gain can be adjusted by increasing/decreasing the value of feedback resistor.

Pole of LPF can be adjusted by modifying feedback capacitor.

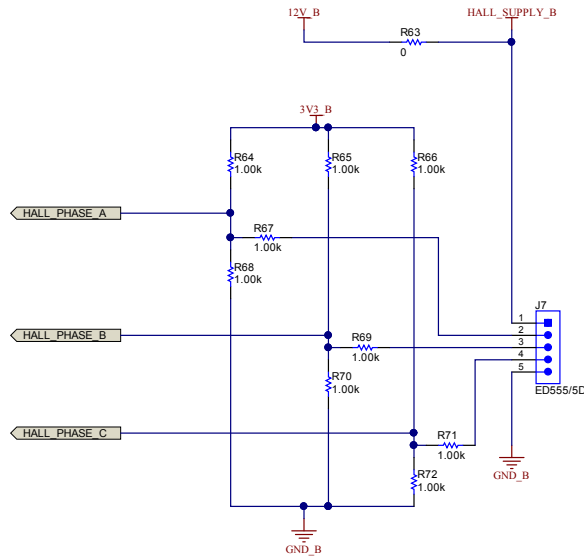
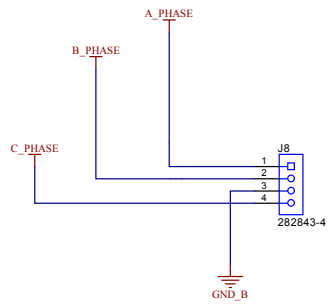


Voltage divider to scale the maximum input voltage of 70V (per LV148) into the LAUNCHXL-F28027F's ADC range of 0 V - 3.3 V.  
LPF with -3dB at approximately 333 Hz

All 0.1µF caps on this page have a 25V cap rating. This was selected for BOM reduction but a 6.3V or higher will work.

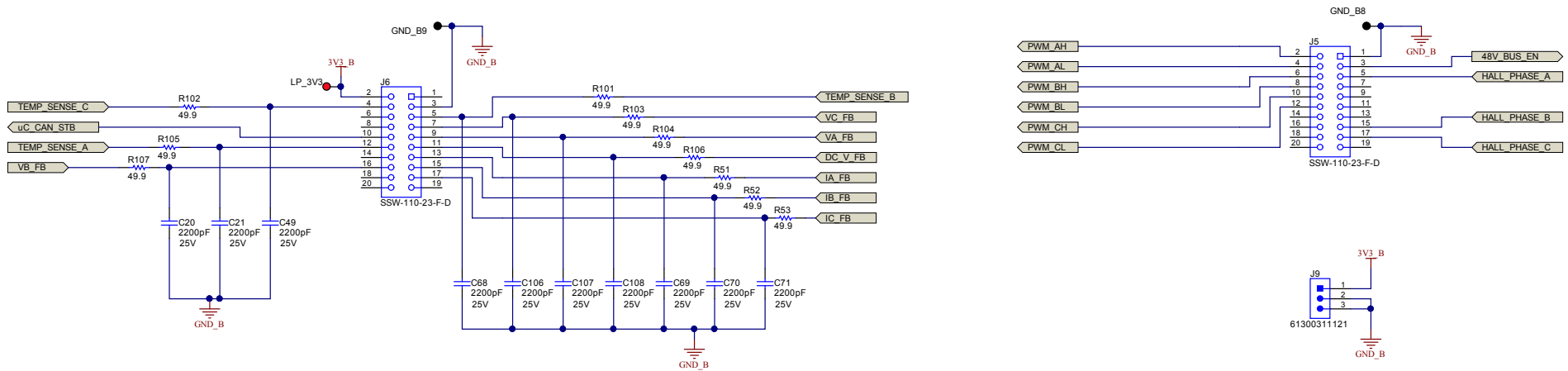


U11 should be placed underneath High-Side and Low-Side FETs of Phase A  
U15 should be placed underneath High-Side and Low-Side FETs of Phase B  
U14 should be placed underneath High-Side and Low-Side FETs of Phase C



Populate resistors based upon hall sensor input signals and supply from motor.

Max Launchpad Power Consumption: 2.5 W



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TID #: TIDA-00281	Project Title: Automotive 48V 1kW Motor Drive	
Number: TIDA-00281   Rev: E1	Sheet Title:	
Rev: Version control disabled	Assembly Variant: [No Variations]	Sheet: 13 of 14
Drawn By:	File: LAUNCHPAD INTERFACE REVA SchDoc	Size: B
Engineer: Trenton J Reed	Contact: <a href="http://www.ti.com/support">http://www.ti.com/support</a>	

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H1 NY PMS 440 0025 PH H2 NY PMS 440 0025 PH H3 NY PMS 440 0025 PH H4 NY PMS 440 0025 PH

H5 1902E H6 1902E H7 1902E H8 1902E

FID1 FID2 FID3

PCB Number: TIDA-00281  
PCB Rev: E1

PCB LOGO Pb-Free Symbol  
PCB LOGO Texas Instruments

Label Table	
Variant	Label Text
001	DNP components used for lab tuning or specific scenarios as noted in the schematics

ZZ1  
Assembly Note  
These assemblies are ESD sensitive, ESD precautions shall be observed.

ZZ2  
Assembly Note  
These assemblies must be clean and free from flux and all contaminants. Use of no clean flux is not acceptable.

ZZ3  
Assembly Note  
These assemblies must comply with workmanship standards IPC-A-610 Class 2, unless otherwise specified.

ZZ4  
Assembly Note  
J5 and J6, SSW-110-23-F-D, connectors are to be installed on the bottom of the PCB. This means the male leads of J5 and J6 will be visible from the top and the female from the bottom.

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TID #: TIDA-00281	Project Title: Automotive 48V 1kW Motor Drive	
Number: TIDA-00281   Rev: E1	Sheet Title:	Sheet: 14 of 14
Drawn By: <del>BYN</del> Rev: Version control disabled	Assembled Variant: [No Variations]	Size: B
Engineer: Trenton J Reed	File: TID_HARDWARE_REVA_SchDoc	Contact: <a href="http://www.ti.com/support">http://www.ti.com/support</a>

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