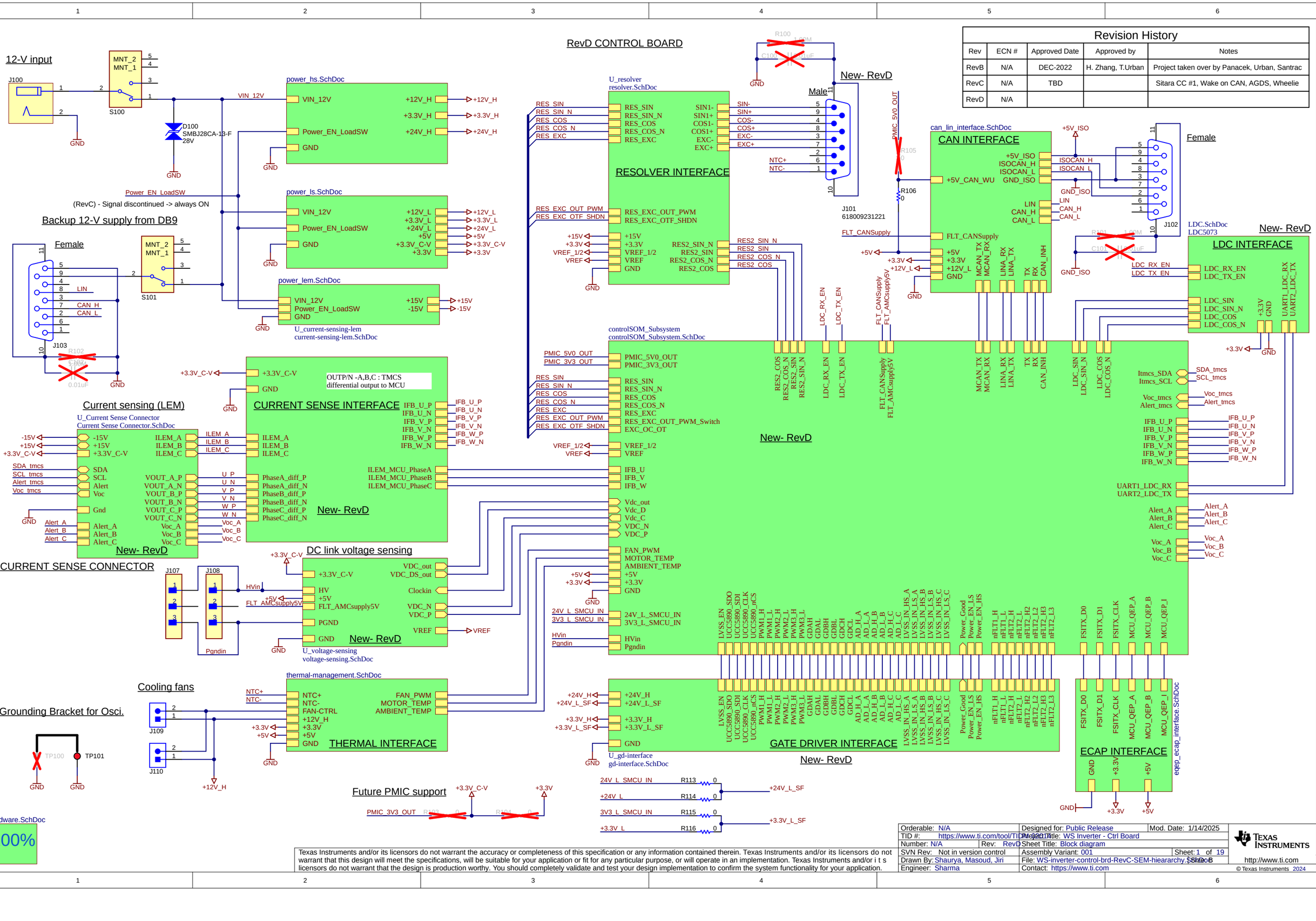
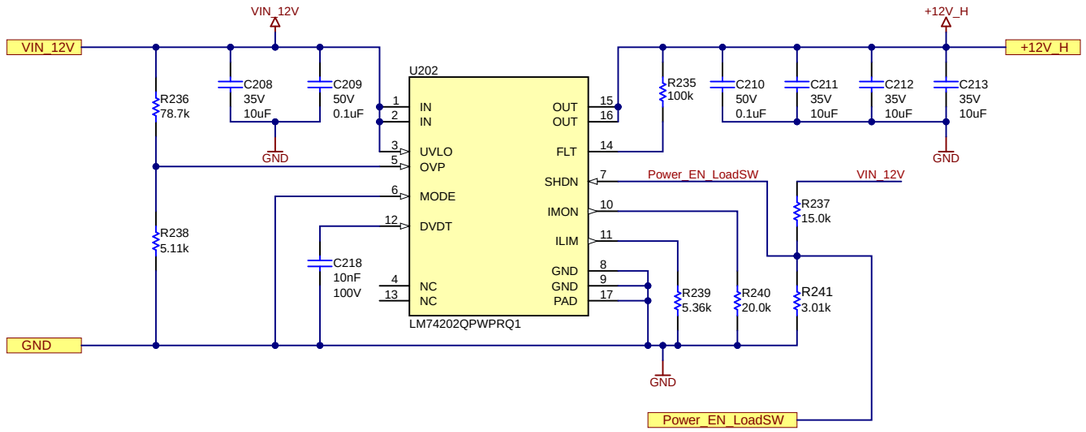


Revision History				
Rev	ECN #	Approved Date	Approved by	Notes
RevB	N/A	DEC-2022	H. Zhang, T.Urban	Project taken over by Panacek, Urban, Santrac
RevC	N/A	TBD		Sitara CC #1, Wake on CAN, AGDS, Wheelie
RevD	N/A			

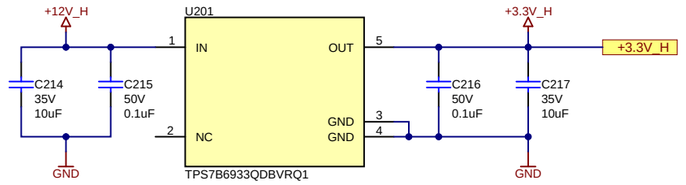
Orderable: N/A		Designed for: Public Release	Mod. Date: 1/14/2025
TID #:		Page Title: WS Inverter - Ctrl Board	
Number: N/A	Rev: RevD	Sheet Title: Block diagram	
SVN Rev: Not in version control		Assembly Variant: 001	Sheet: 1 of 19
Drawn By: Shaurya, Masoud, Jiri		File: WS-inverter-control-brd-RevC-SEM-hieararchy.SchDoc	
Engineer: Sharma		Contact: https://www.ti.com	

High Side Power Rail

Ideal diode with integrated overvoltage and overcurrent protection



High-side logic power supply



Magneto MV (UCC14240-Q1) pre-regulator

Orderable: N/A	Designed for: Public Release	Mod. Date: 1/14/2025
TID #: https://www.ti.com/tool/TIDA-010211	Project Title: WS Inverter - Ctrl Board	
Number: N/A Rev: RevD	Sheet Title: High-Side Power Rail	
SVN Rev: Not in version control	Assembly Variant: 001	Sheet: 2 of 19
Drawn By: Panacek	File: power_hs.SchDoc	Size: B
Engineer: Sharma	Contact: https://www.ti.com	

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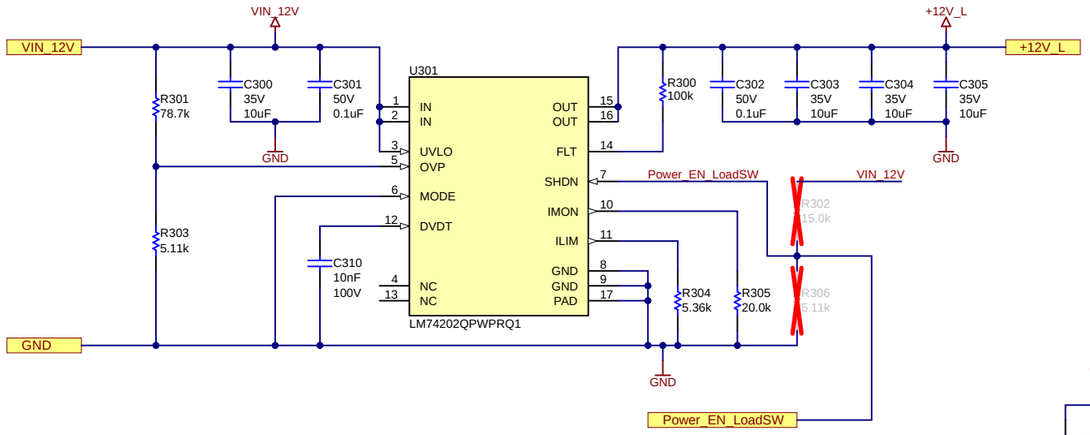
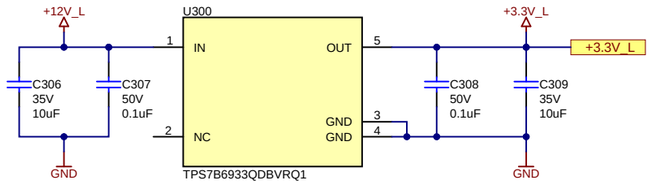
Low Side Power Rail

Ideal diode with integrated overvoltage and overcurrent protection

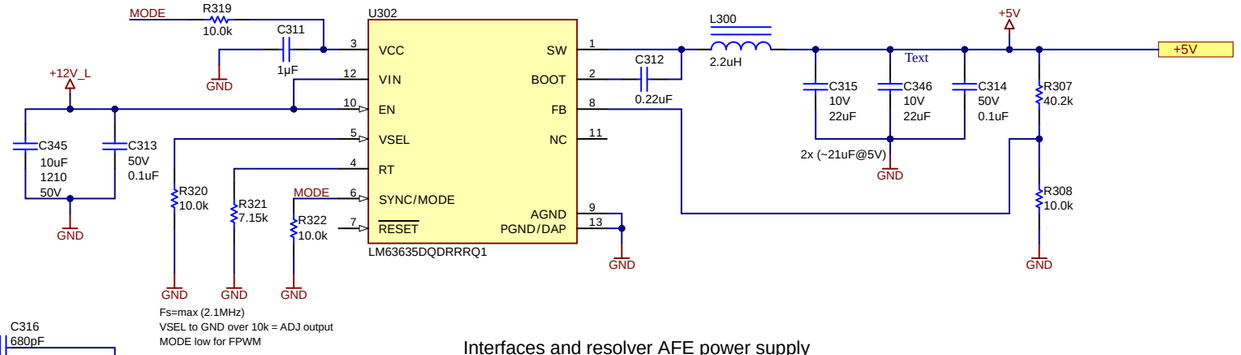


Low-side logic power supply



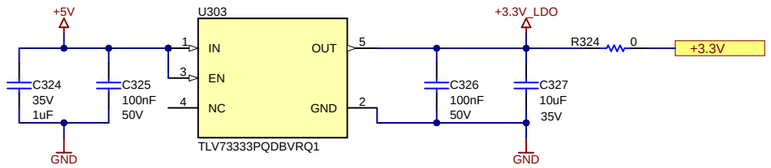
Controlcard and interfaces power supply

RevC Change: Swap from LMR50410Y5F (2.1MHz, Iout=1A, FPWM) to LM5365-Q1 (2MHz, Iout=3A, FPWM) - PMP30578
RevC Change: 5V has to be always available. Power_EN_LoadSW is now removed from the MCU and turns on load switches as soon as voltage reaches the threshold

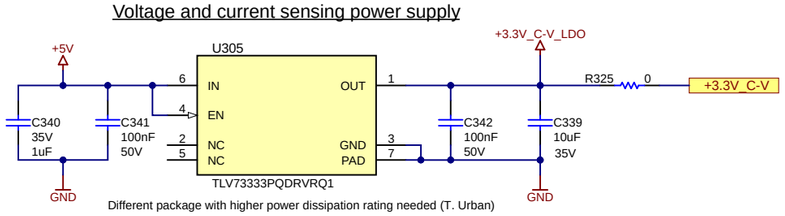


Magneto MV (UCC14240-Q1) pre-regulator

Interfaces and resolver AFE power supply



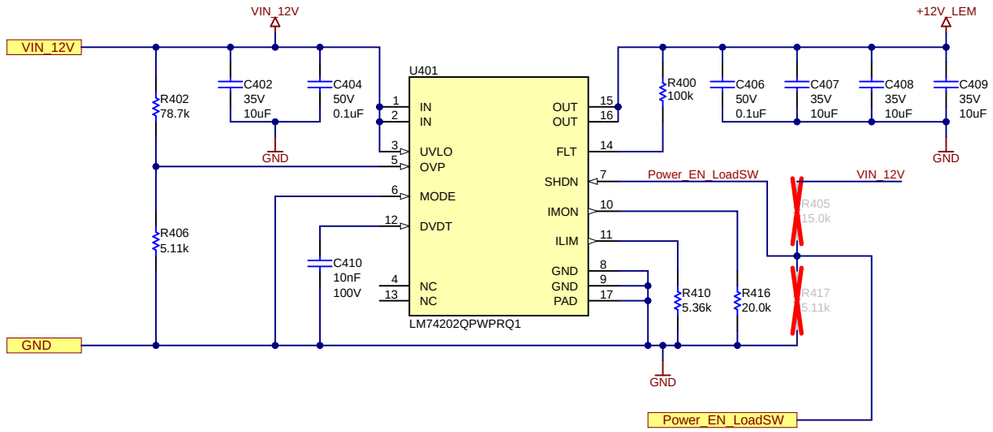
Voltage and current sensing power supply



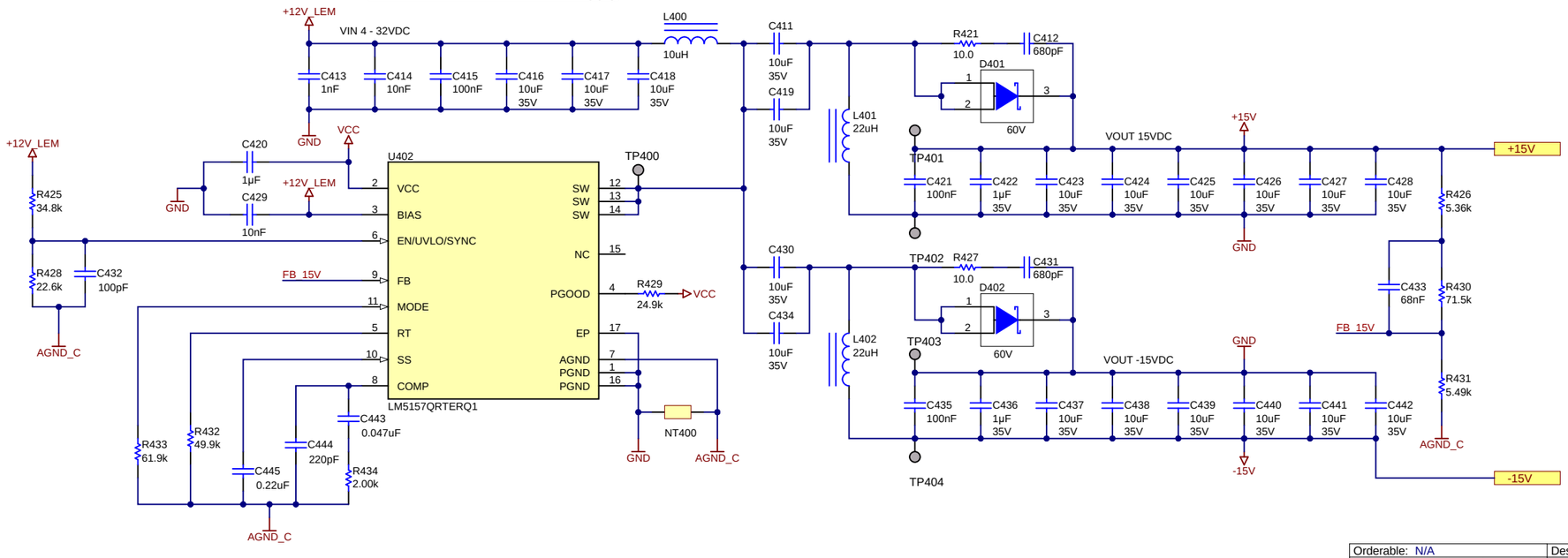
Different package with higher power dissipation rating needed (T. Urban)

Orderable: N/A		Designed for: Public Release	Mod. Date: 3/24/2025
TID #: https://www.ti.com/tool/TIDA-010170		Design Title: WS Inverter - Ctrl Board	
Number: N/A	Rev: RevD	Sheet Title: Low-Side Power Rail	
SVN Rev: Not in version control		Assembly Variant: 001	Sheet: 3 of 19
Drawn By: Panacek		File: power_ls.SchDoc	Size: B
Engineer: Sharma		Contact: https://www.ti.com	

Ideal diode with integrated overvoltage and overcurrent protection



LEM current sensor +/-15V supply

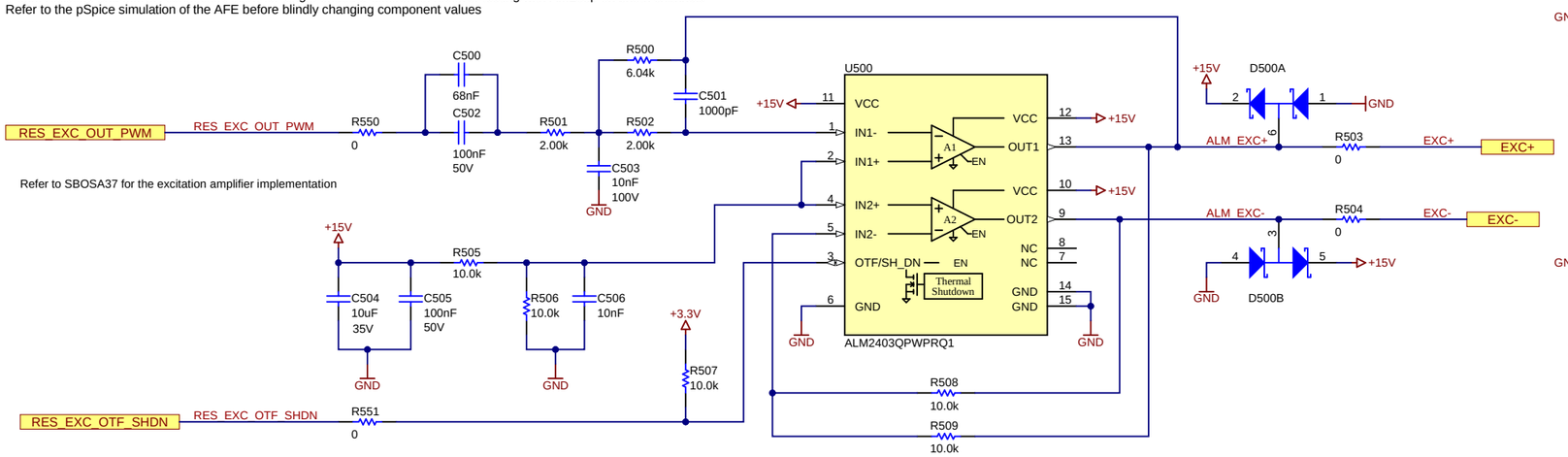


Orderable: N/A	Designed for: Public Release	Mod. Date: 1/14/2025
TID #: https://www.ti.com/tool/TIDA-010170	PCB Title: WS Inverter - Ctrl Board	
Number: N/A Rev: RevD	Sheet Title: LEM sensors power supply	
SVN Rev: Not in version control	Assembly Variant: 001	Sheet: 4 of 19
Drawn By: Panacek	File: power_lem.SchDoc	Size: B
Engineer: Sharma	Contact: https://www.ti.com	

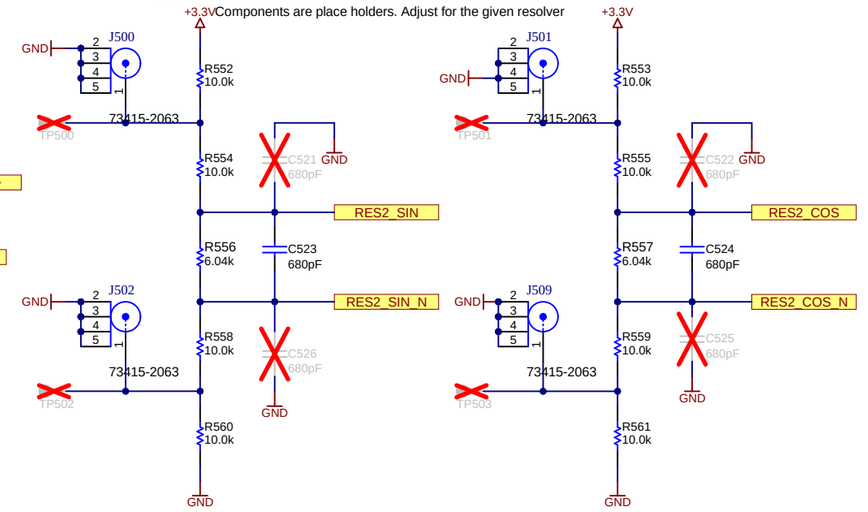
IMPORTANT NOTES:

Resolver sub-system optimized for 7-Vrms 10kHz resolvers
The current resolver sub-sustem does not support any additional diagnostic features
0-ohm resistors and MMCX connectors allow for single-ended & differential resolver testing with AM263p on bnoth channels
Refer to the pSpice simulation of the AFE before blindly changing component values

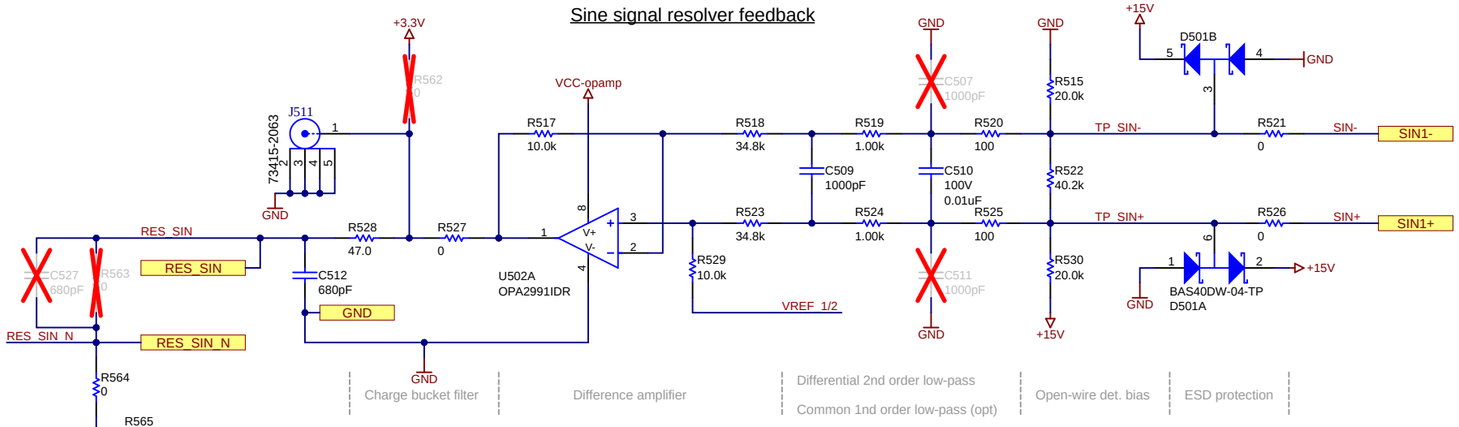
Excitation amplifier



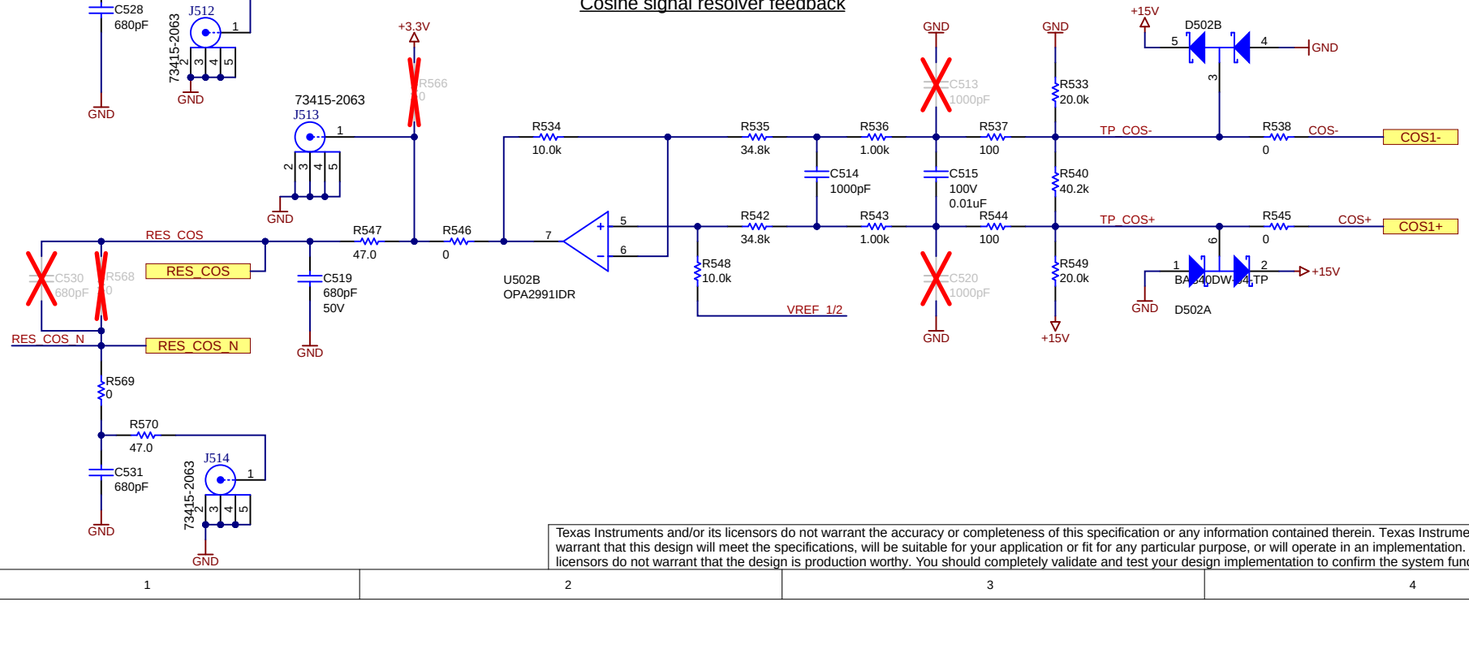
AM263P differential resolver2 AFE support



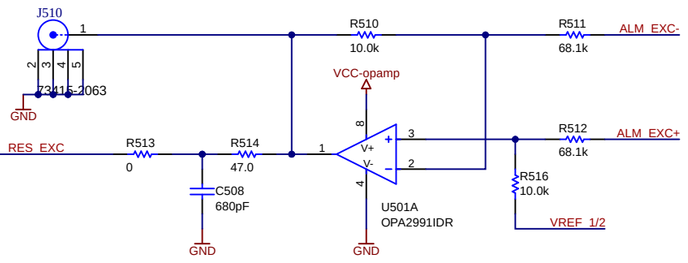
Sine signal resolver feedback



Cosine signal resolver feedback

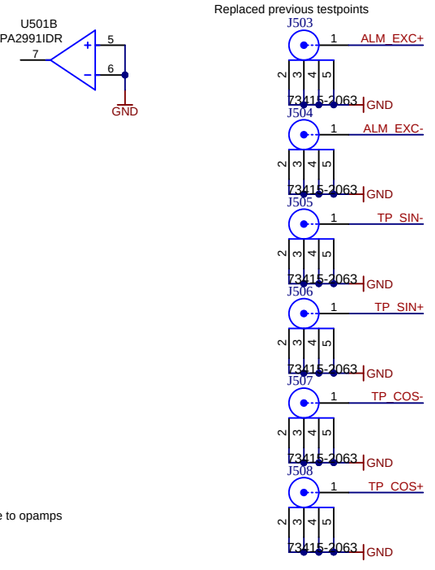


Excitation amplifier feedback sensing (optional)

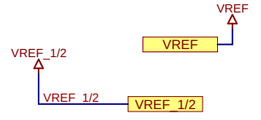


Test MMCX (rq. H. Zhang)

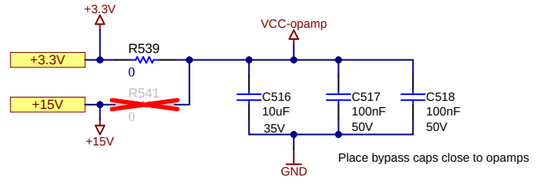
Replaced previous testpoints



DC offset (50% of the Vref)



AFE power supply selection (3.3V default)



Place bypass caps close to opamps

Orderable: N/A		Designed for: Public Release	Mod. Date: 1/14/2025
TID #: https://www.ti.com/tool/TIDM-02013		Project Title: WS Inverter - Ctrl Board	
Number: N/A	Rev: RevD	Sheet Title: Resolver Analog Front-End	
SVN Rev: Not in version control		Assembly Variant: 001	Sheet: 5 of 19
Drawn By: Panacek		File: resolver.SchDoc	Size: B
Engineer: Sharma		Contact: https://www.ti.com	

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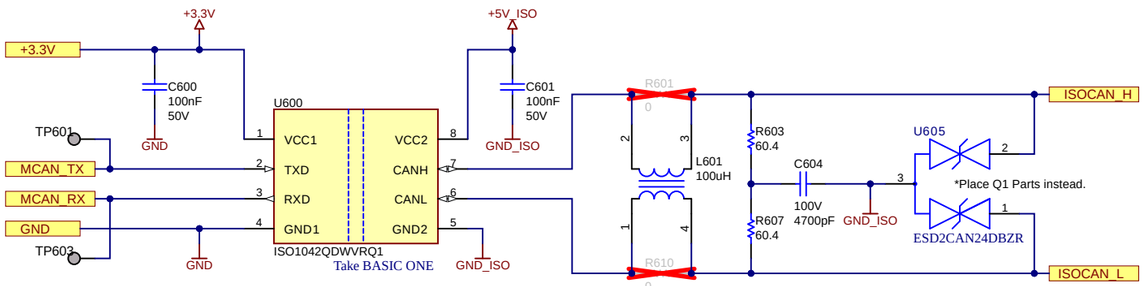
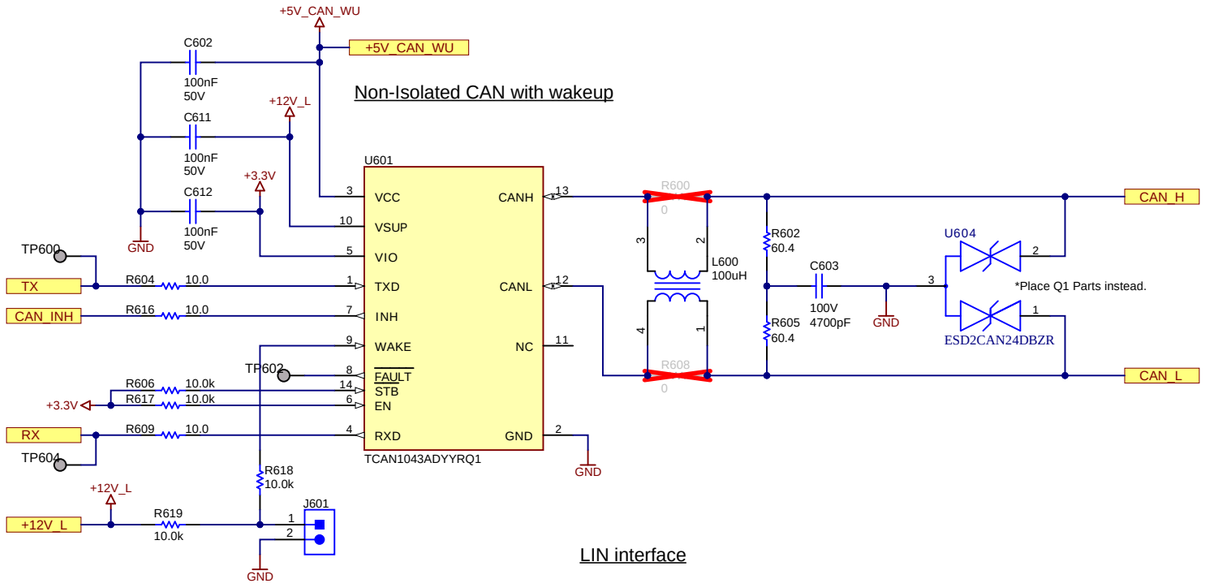
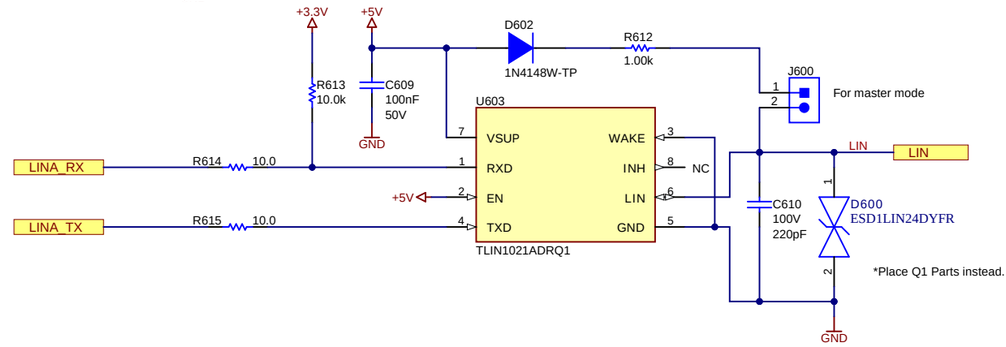
Isolated CAN

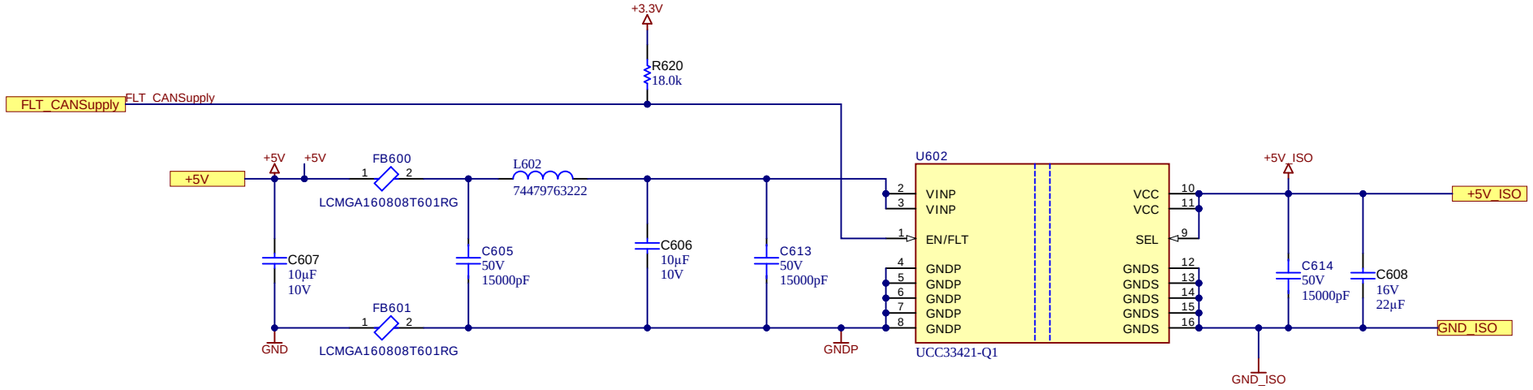


Non-Isolated CAN with wakeup



LIN interface





Orderable: N/A	Designed for: Public Release	Mod. Date: 1/14/2025
TID #: https://www.ti.com/tool/TIDM-02017	Project Title: WS Inverter - Ctrl Board	
Number: N/A Rev: RevD	Sheet Title: Communication Interfaces	
SVN Rev: Not in version control	Assembly Variant: 001	Sheet: 6 of 19
Drawn By: Panacek	File: can_lin_interface.SchDoc	Size: B
Engineer: Sharma	Contact: https://www.ti.com	

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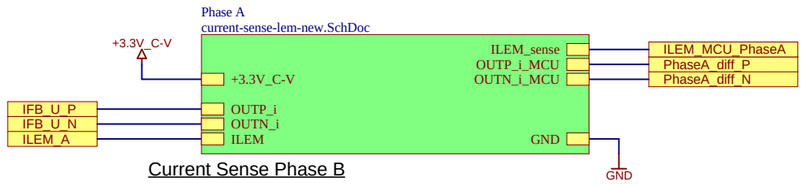
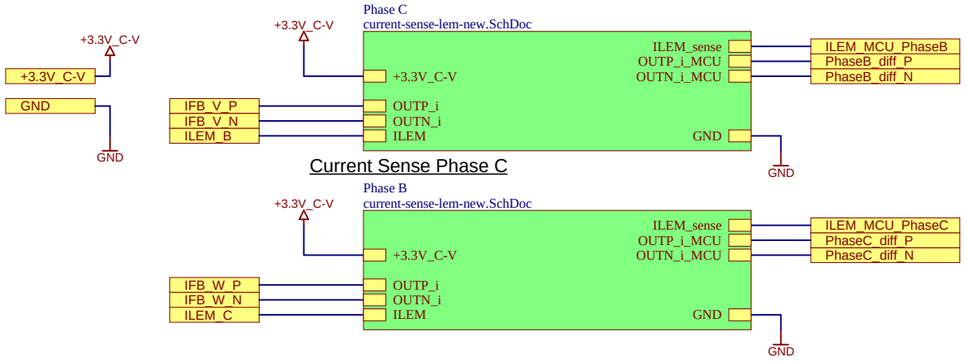
IMPORTANT NOTES:

This circuit re-uses the original Wolfspeed circuitry. It would be better to use a device such INA296A (soon Q1)

Current Sense Phase A



Current Sense Phase B



Current Sense Phase C

Orderable: N/A	Designed for: Public Release	Mod. Date: 1/14/2025
TID #: https://www.ti.com/tool/TIDM-02011	PWA Title: WS Inverter - Ctrl Board	
Number: N/A Rev: RevD	Sheet Title: Current Sensing Front-End	
SVN Rev: Not in version control	Assembly Variant: 001	Sheet: 7 of 19
Drawn By: Panacek	File: current-sensing-lem.SchDoc	Size: B
Engineer: Sharma	Contact: https://www.ti.com	

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LEM LF510 current output with G_th=0.2mA/A

Inverter output operating current I_out=360A RMS (509A peak)

LEM sensor current output I_lem_x=I_out*G_th=0.2e-3*509=+/- 0.1018A

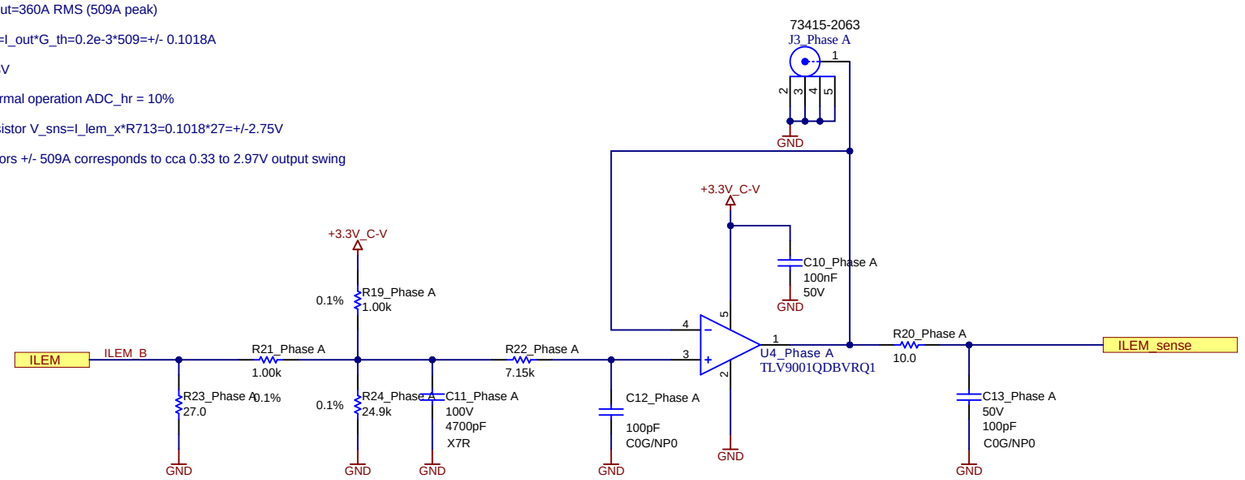
ADC input voltage range Vadc = 3.3V

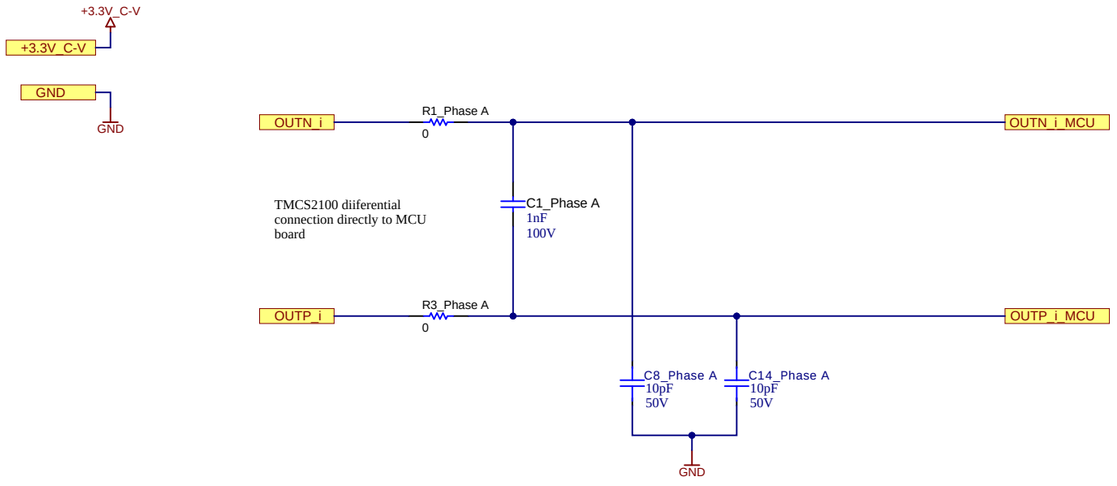
ADC headroom from rails during normal operation ADC_hr = 10%

Voltage drop across the sensing resistor V_sns=I_lem_x*R713=0.1018*27=+/-2.75V

With the given combination of resistors +/- 509A corresponds to cca 0.33 to 2.97V output swing

-3dB point fc=61.9kHz (simulated)





Orderable: N/A	Designed for: Public Release	Mod. Date: 1/14/2025
TID #: https://www.ti.com/tool/TIDA-020017	PCB Title: WS Inverter - Ctrl Board	
Number: N/A Rev: RevD	Sheet Title:	
SVN Rev: Not in version control	Assembly Variant: 001	Sheet: 8 of 19
Drawn By:	File: current-sense-lem-new.SchDoc	Size: B
Engineer: Sharma	Contact: https://www.ti.com	

LEM LF510 current output with G_th=0.2mA/A

Inverter output operating current I_out=360A RMS (509A peak)

LEM sensor current output I_lem_x=I_out*G_th=0.2e-3*509=+/- 0.1018A

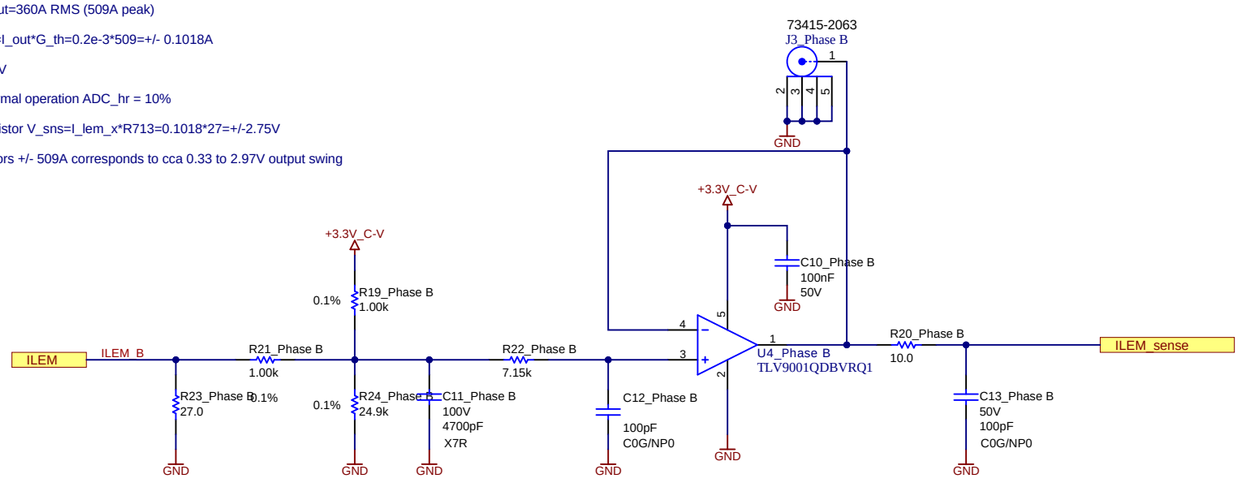
ADC input voltage range Vadc = 3.3V

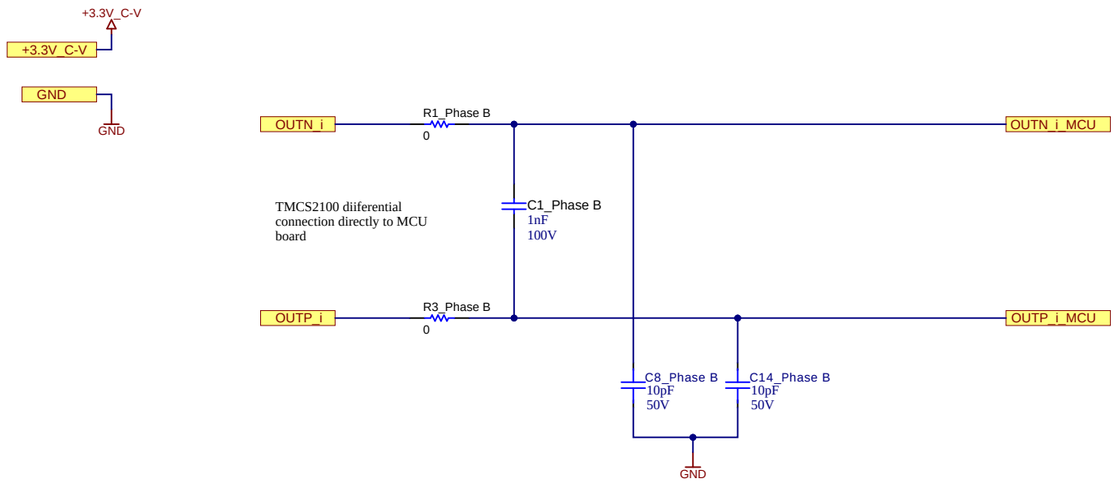
ADC headroom from rails during normal operation ADC_hr = 10%

Voltage drop across the sensing resistor V_sns=I_lem_x*R713=0.1018*27=+/-2.75V

With the given combination of resistors +/- 509A corresponds to cca 0.33 to 2.97V output swing

-3dB point fc=61.9kHz (simulated)





Orderable: N/A	Designed for: Public Release	Mod. Date: 1/14/2025
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Number: N/A Rev: RevD	Sheet Title:	
SVN Rev: Not in version control	Assembly Variant: 001	Sheet: 8 of 19
Drawn By:	File: current-sense-lem-new.SchDoc	Size: B
Engineer: Sharma	Contact: https://www.ti.com	

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LEM LF510 current output with G_th=0.2mA/A

Inverter output operating current I_out=360A RMS (509A peak)

LEM sensor current output I_lem_x=I_out*G_th=0.2e-3*509=+/- 0.1018A

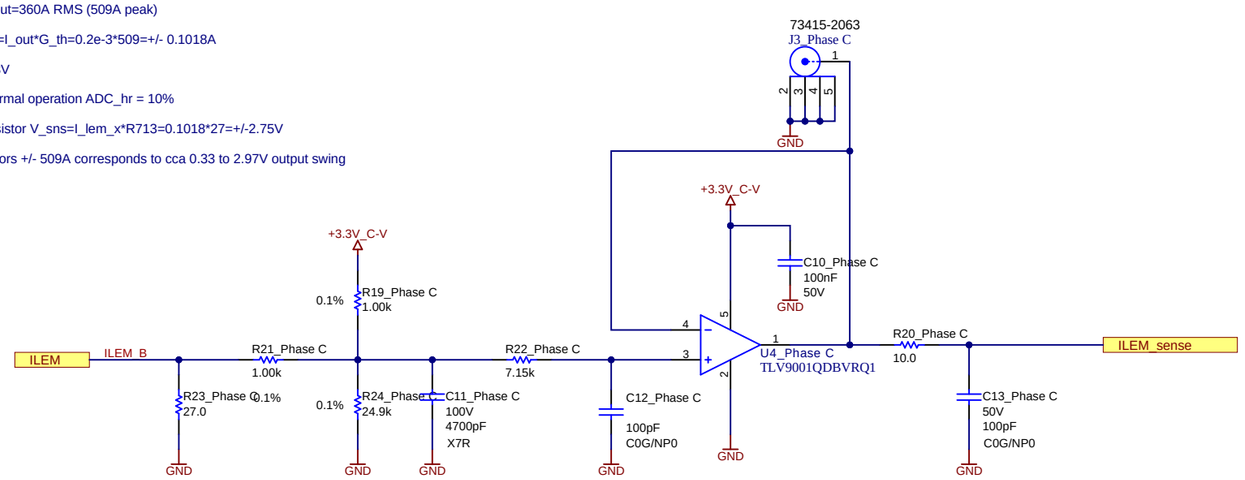
ADC input voltage range Vadc = 3.3V

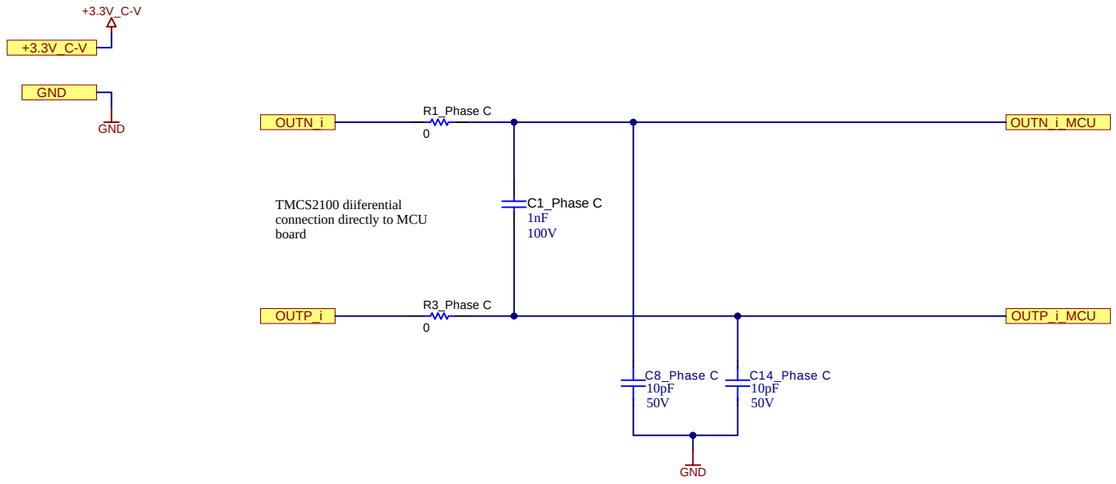
ADC headroom from rails during normal operation ADC_hr = 10%

Voltage drop across the sensing resistor V_sns=I_lem_x*R713=0.1018*27=+/-2.75V

With the given combination of resistors +/- 509A corresponds to cca 0.33 to 2.97V output swing

-3dB point fc=61.9kHz (simulated)





Orderable: N/A	Designed for: Public Release	Mod. Date: 1/14/2025
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Number: N/A Rev: RevD	Sheet Title:	
SVN Rev: Not in version control	Assembly Variant: 001	Sheet: 8 of 19
Drawn By:	File: current-sense-lem-new.SchDoc	Size: B
Engineer: Sharma	Contact: https://www.ti.com	

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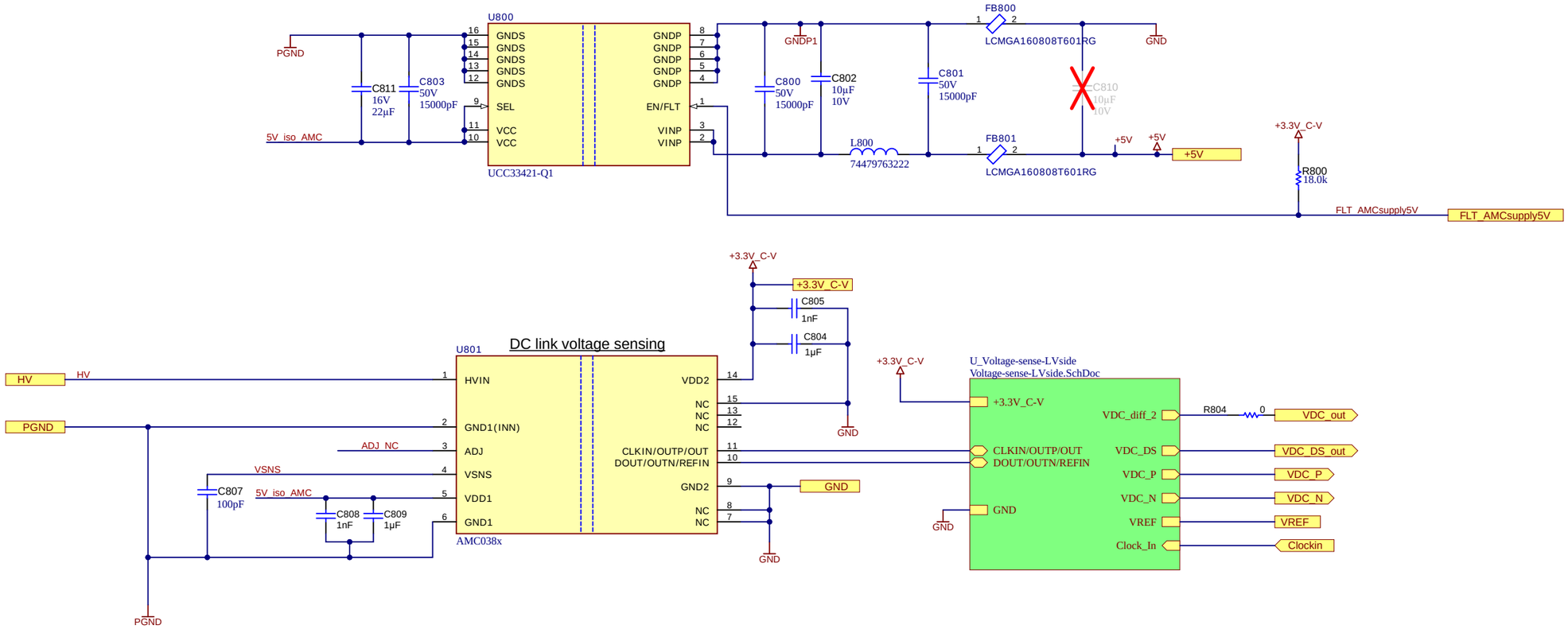
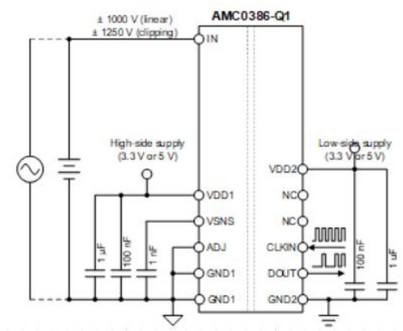
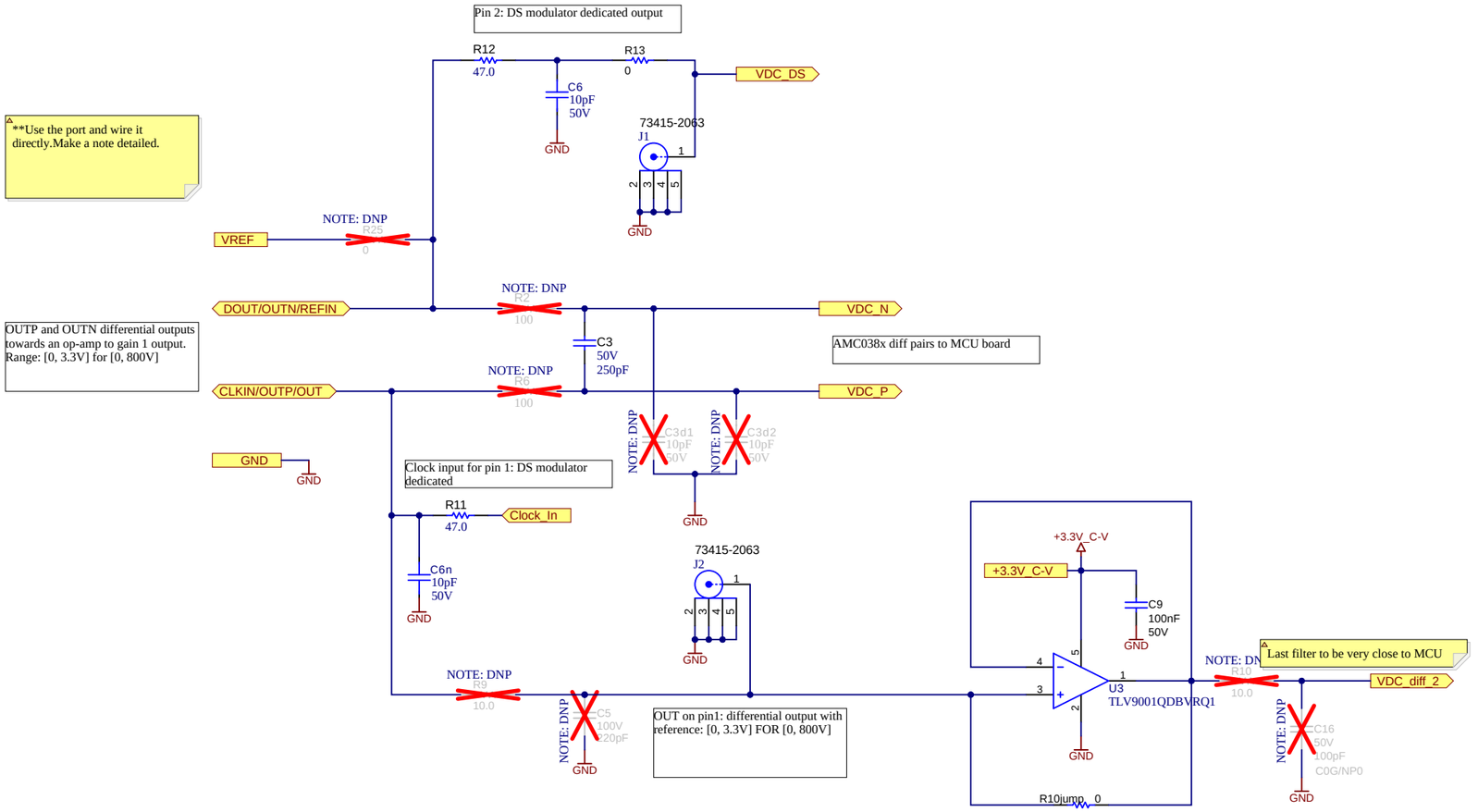


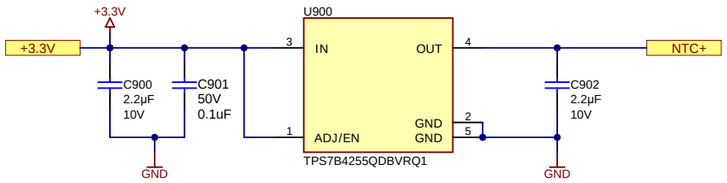


Orderable: N/A		Designed for: Public Release	Mod. Date: 4/17/2025
TID #: https://www.ti.com/tool/TIDA-020017		Project Title: WS Inverter - Ctrl Board	
Number: N/A	Rev: RevD	Sheet Title: HV Sensing	
SVN Rev: Not in version control		Assembly Variant: 001	Sheet: 9 of 19
Drawn By: Panacek		File: voltage-sensing.SchDoc	Size: B
Engineer: Sharma		Contact: https://www.ti.com	

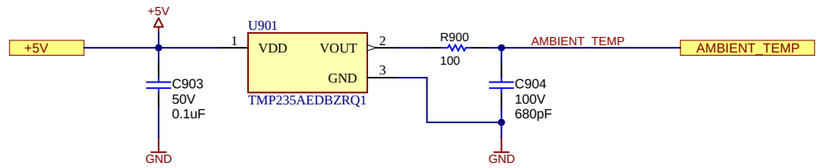


Orderable: N/A		Designed for: Public Release	Mod. Date: 1/14/2025
TID #: https://www.ti.com/tool/TIDA-010170		PWA#/Title: WS Inverter - Ctrl Board	
Number: N/A	Rev: RevD	Sheet Title:	
SVN Rev: Not in version control		Assembly Variant: 001	Sheet: 10 of 19
Drawn By:		File: Voltage-sense-LVside.SchDoc	Size: B
Engineer: Sharma		Contact: https://www.ti.com	

Tracking LDO for protectiong the NTC excitation



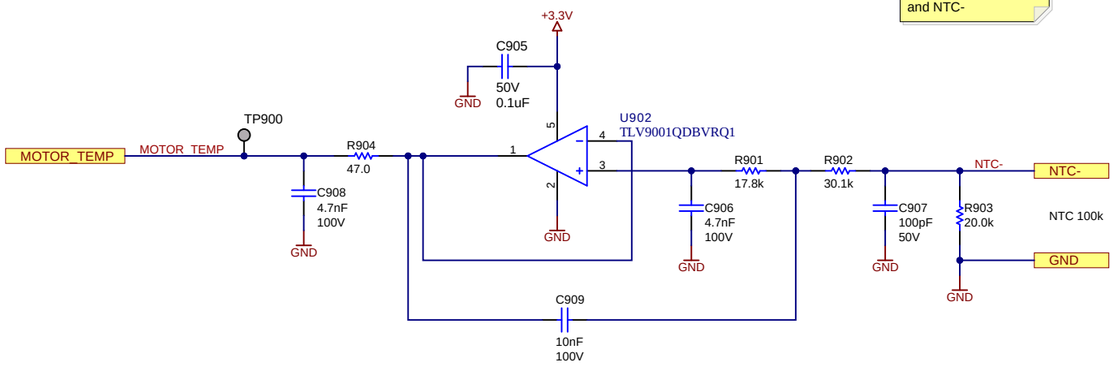
Ambient temperature sensing



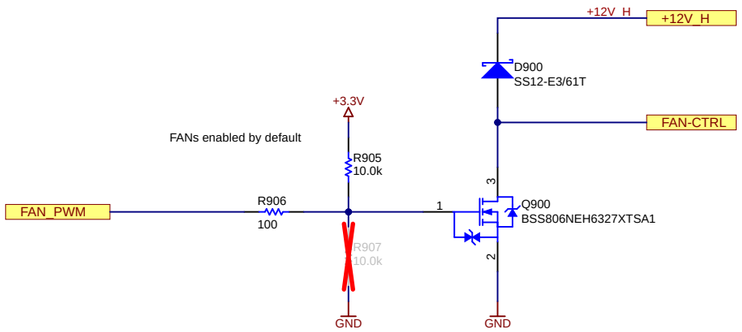
Motor temperature sensing

Do we need this? Not there on revC.

Add common mode choke for the NTC+ and NTC-



Cooling FANs speed control



Orderable: N/A		Designed for: Public Release	Mod. Date: 3/24/2025
TID #: https://www.ti.com/tool/TIDA-020017		Project Title: WS Inverter - Ctrl Board	
Number: N/A	Rev: RevD	Sheet Title: Thermal Management	
SVN Rev: Not in version control		Assembly Variant: 001	Sheet: 11 of 19
Drawn By: Panacek		File: thermal-management.SchDoc	Size: B
Engineer: Sharma		Contact: https://www.ti.com	

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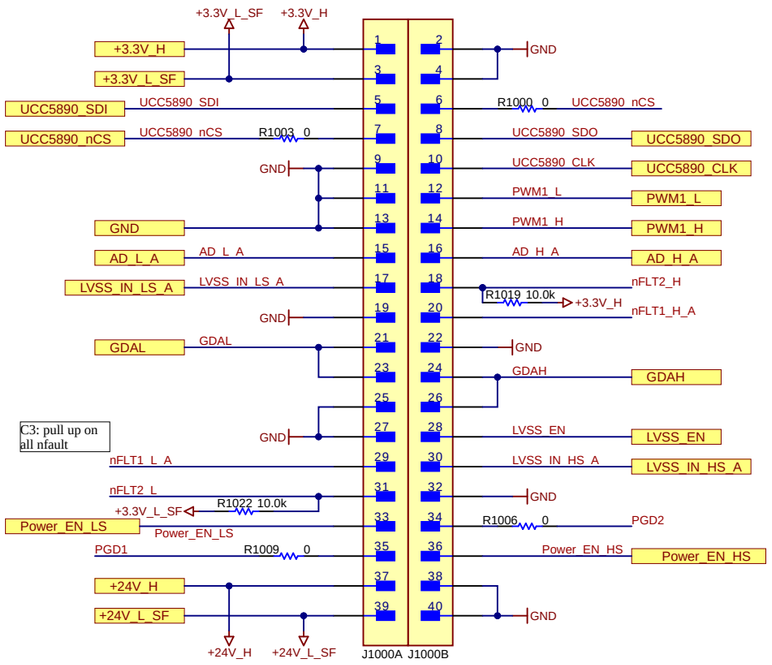
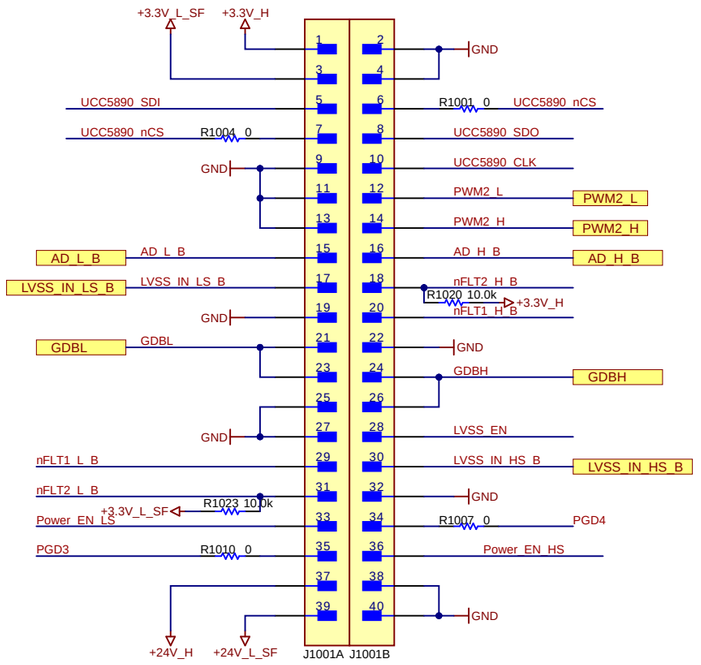
Interface to the GD board - PHASE A



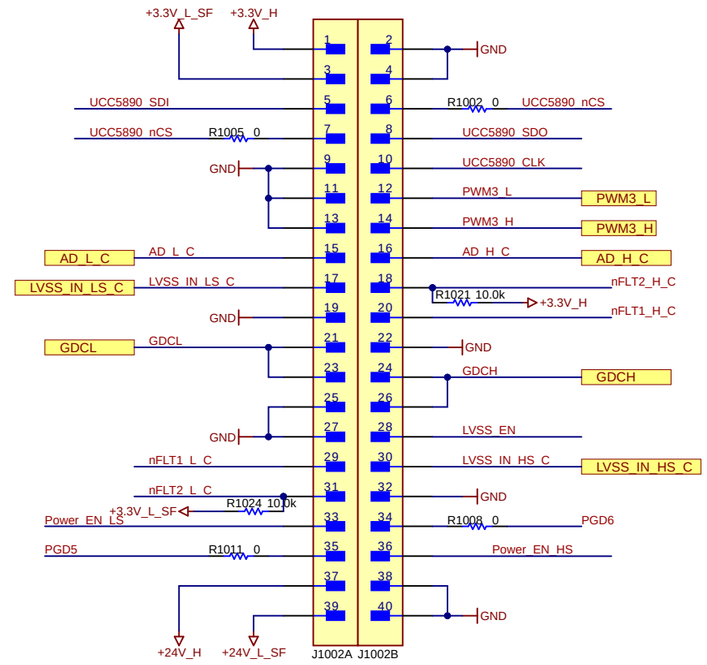
Cable: FFSD-20-D-02.00-01-N

Interface to the GD board - PHASE B



Cable: FFSD-20-D-02.00-01-N

Interface to the GD board - PHASE C



Cable: FFSD-20-D-02.00-01-N

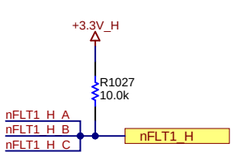
GDAL R1013 0 GDAH

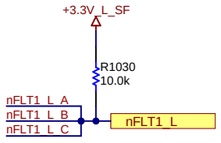
GDBL R1014 0 GDBH

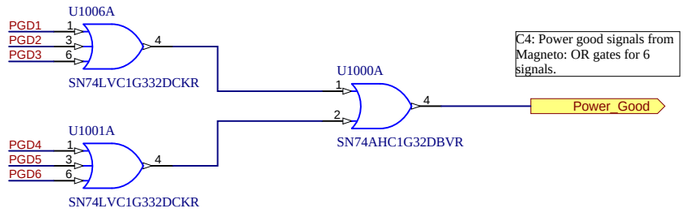
GDCL R1012 0 GDCH

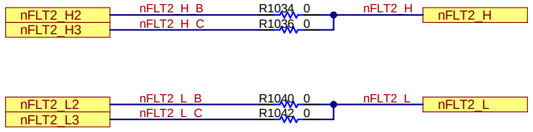
LVSS_IN_LS_A R1015 0 LVSS_IN_LS_B R1016 0 LVSS_IN_LS_C

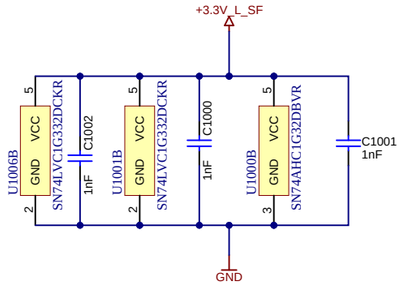
LVSS_IN_HS_A R1017 0 LVSS_IN_HS_B R1018 0 LVSS_IN_HS_C





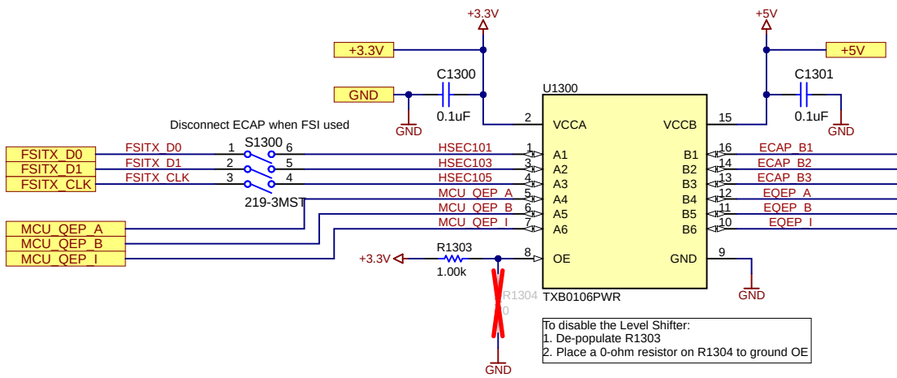




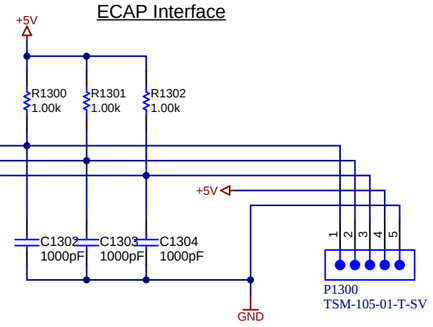


Orderable: N/A	Designed for: Public Release	Mod. Date: 1/14/2025
TID #: https://www.ti.com/tool/TIDM-02011	PCB Title: WS Inverter - Ctrl Board	
Number: N/A Rev: RevD	Sheet Title: GD Interface	
SVN Rev: Not in version control	Assembly Variant: 001	Sheet: 12 of 19
Drawn By: Panacek	File: gd-interface.SchDoc	Size: B
Engineer: Sharma	Contact: https://www.ti.com	

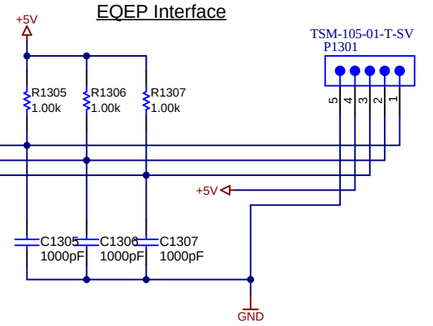
EQEP/ECAP Level Shifter



ECAP Interface



EQEP Interface



Orderable: N/A	Designed for: Public Release	Mod. Date: 1/14/2025
TID #: https://www.ti.com/tool/TIDM-02017	PCB Title: WS Inverter - Ctrl Board	
Number: N/A Rev: RevD	Sheet Title: EQEO/ECAP Inaterface	
SVN Rev: Not in version control	Assembly Variant: 001	Sheet: 13 of 19
Drawn By: Panacek	File: eqep_ecap_interface.SchDoc	Size: B
Engineer: Sharma	Contact: https://www.ti.com	

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LOGO1200

DANGER HIGH VOLTAGE

FID1200 Fiducial

FID1201 Fiducial

FID1202 Fiducial

FID1203 Fiducial

FID1204 Fiducial

FID1205 Fiducial

PCB
LOGO
FCC disclaimer

PCB
LOGO
Texas Instruments

LBL1200

PCB Label

THT-14-423-10
Size: 0.65" x 0.20 "

PCB Number: N/A
PCB Rev: RevD

PCB
LOGO
WEEE logo

Orderable: N/A	Designed for: Public Release	Mod. Date: 4/17/2025
TID #: https://www.ti.com/tool/TIDM-02013	Project Title: WS Inverter - Ctrl Board	
Number: N/A Rev: RevD	Sheet Title: Hardaware / Mechanical	
SVN Rev: Not in version control	Assembly Variant: 001	Sheet: 14 of 19
Drawn By: Panacek	File: hardware.SchDoc	Size: B
Engineer: Sharma	Contact: https://www.ti.com	

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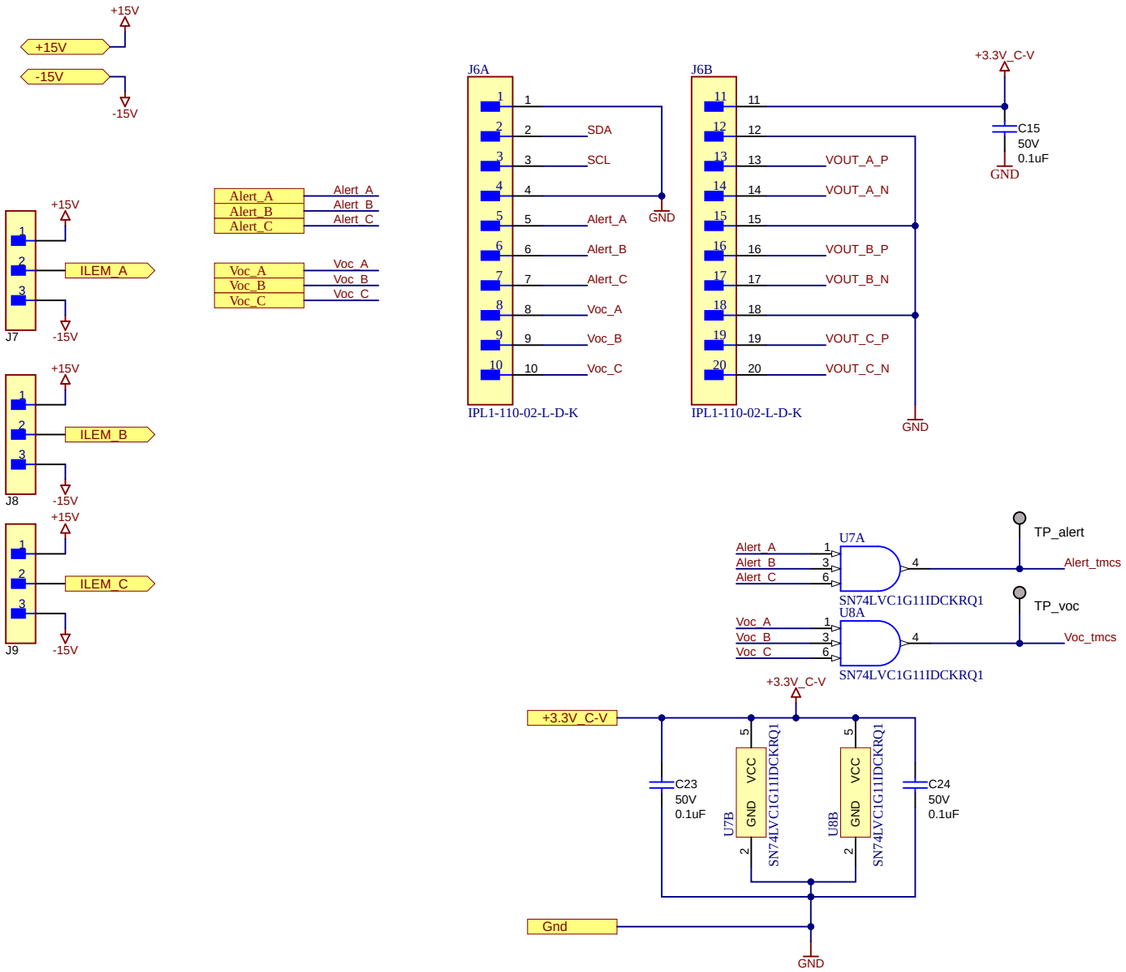

Orderable: N/A	Designed for: Public Release	Mod. Date: 1/14/2025
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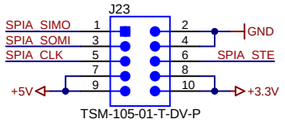
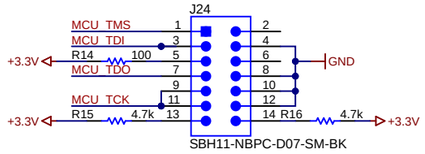
Number: N/A Rev: RevD	Sheet Title:	
SVN Rev: Not in version control	Assembly Variant: 001	Sheet: 15 of 19
Drawn By:	File: Current Sense Connector.SchDoc	Size: B
Engineer: Sharma	Contact: https://www.ti.com	

http://www.ti.com

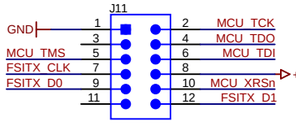
SPI (Debug only)



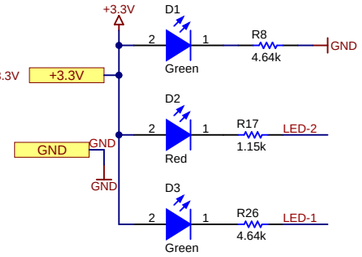
JTAG (Optional)



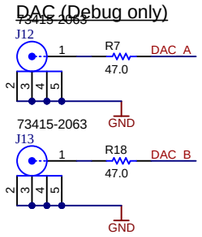
ETAS



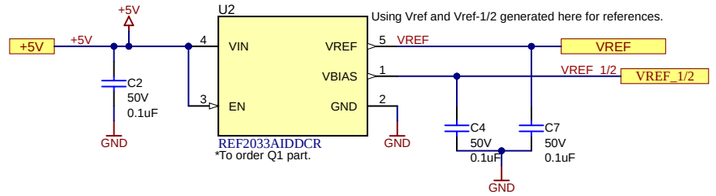
PWR & DEBUG LEDs



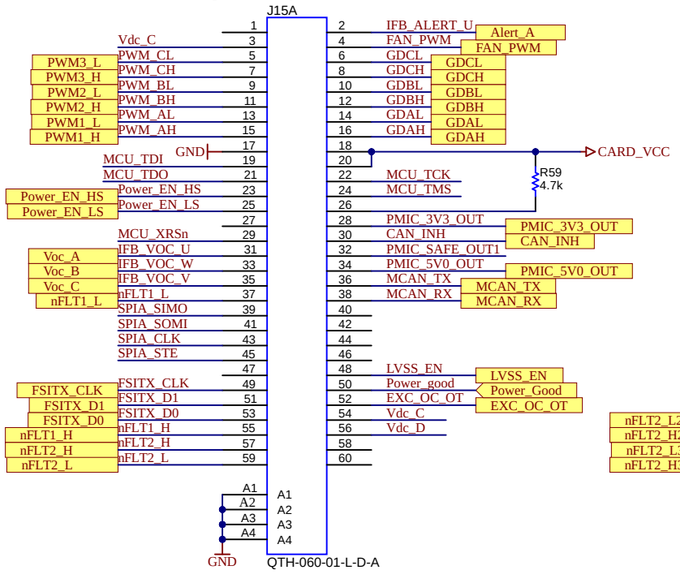
DAC (Debug only)



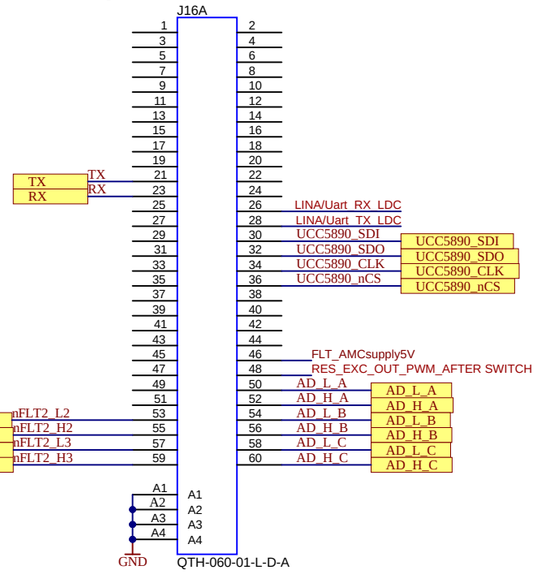
External voltage reference



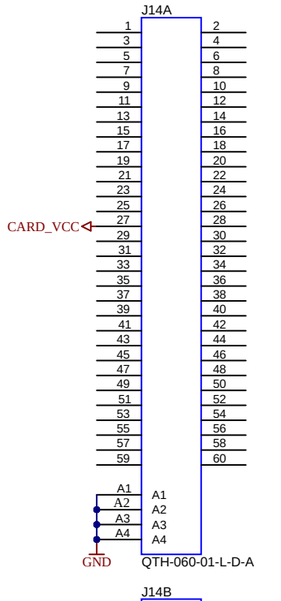
High Density Connector 1



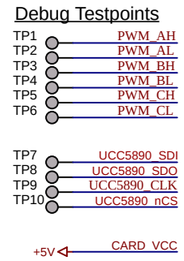
High Density Connector 2



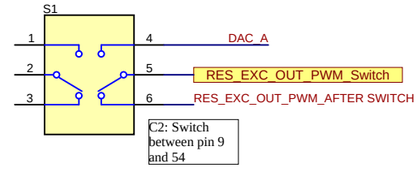
High Density Connector 3



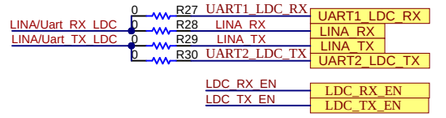
Debug Testpoints



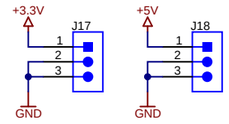
S1



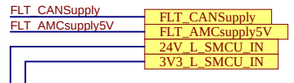
LINA/Uart_RX_LDC / LINA/Uart_TX_LDC



AUX power

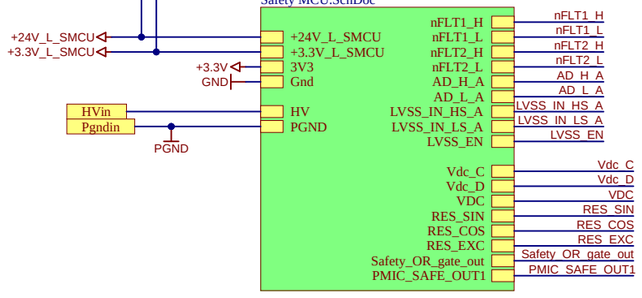


FLT_CANSupply / FLT_AMCsupply5V



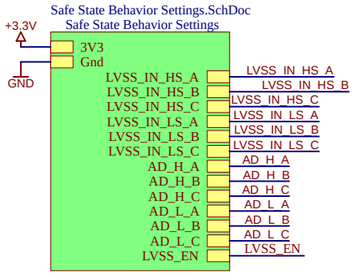
Safety MCU

Safety MCU.SchDoc

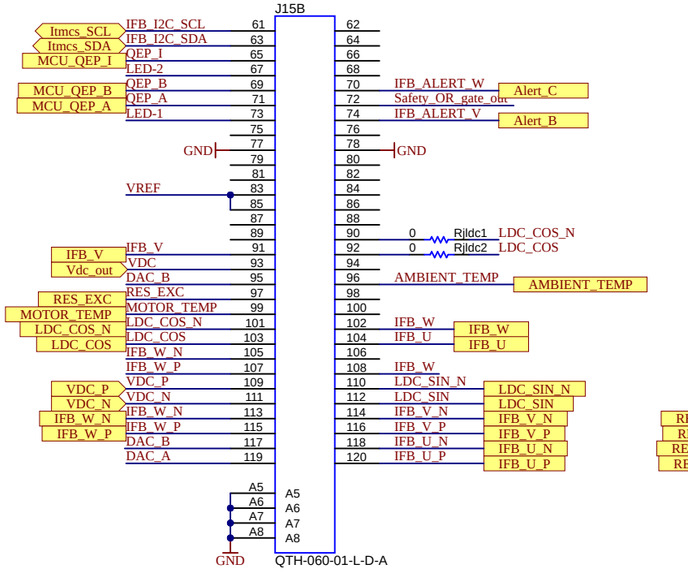


Safe State Behavior Settings

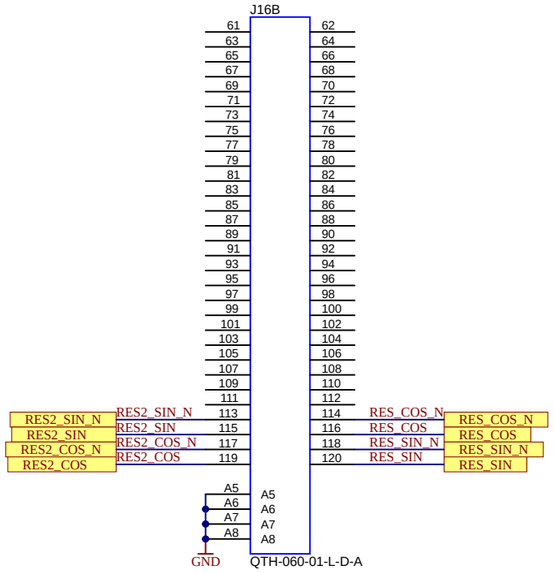
Safe State Behavior Settings.SchDoc



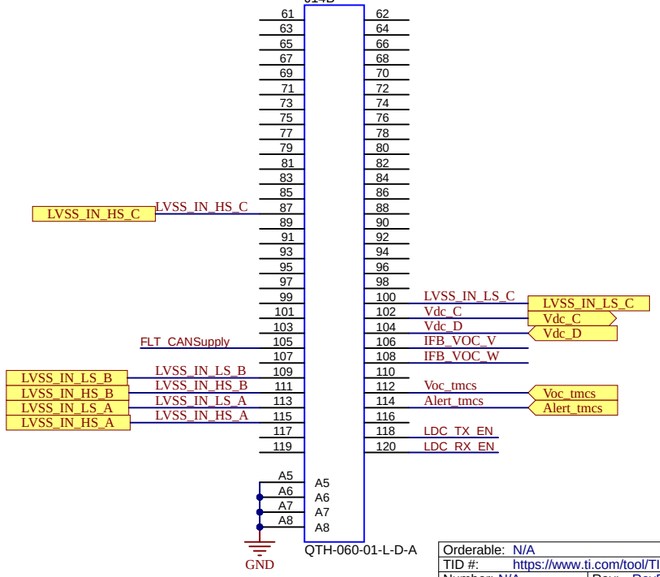
High Density Connector 1 (lower)



High Density Connector 2 (lower)

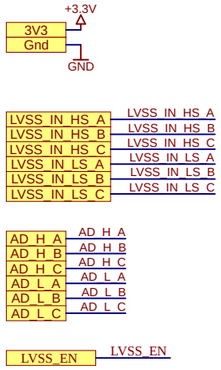


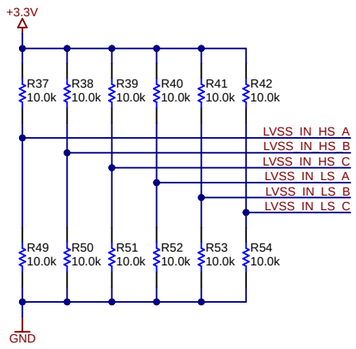
High Density Connector 3 (lower)

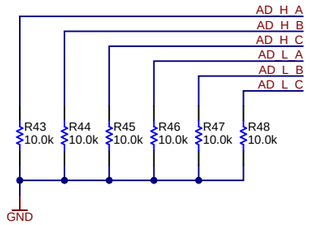


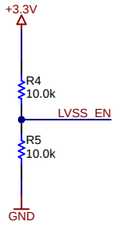
Orderable: N/A	Designed for: Public Release	Mod. Date: 3/24/2025
TID #: https://www.ti.com/tool/TIDM-02011	Project Title: WS Inverter - Ctrl Board	
Number: N/A Rev: RevD	Sheet Title:	
SVN Rev: Not in version control	Assembly Variant: 001	Sheet: 16 of 19
Drawn By:	File: controlSOM_Subsystem.SchDoc	Size: B
Engineer: Sharma	Contact: https://www.ti.com	

http://www.ti.com









Orderable: N/A	Designed for: Public Release	Mod. Date: 1/14/2025
TID #: https://www.ti.com/tool/TIDM-02013	PMP Title: WS Inverter - Ctrl Board	
Number: N/A Rev: RevD	Sheet Title:	
SVN Rev: Not in version control	Assembly Variant: 001	Sheet: 17 of 19
Drawn By:	File: Safe State Behavior Settings.SchDoc	Size: B
Engineer: Sharma	Contact: https://www.ti.com	

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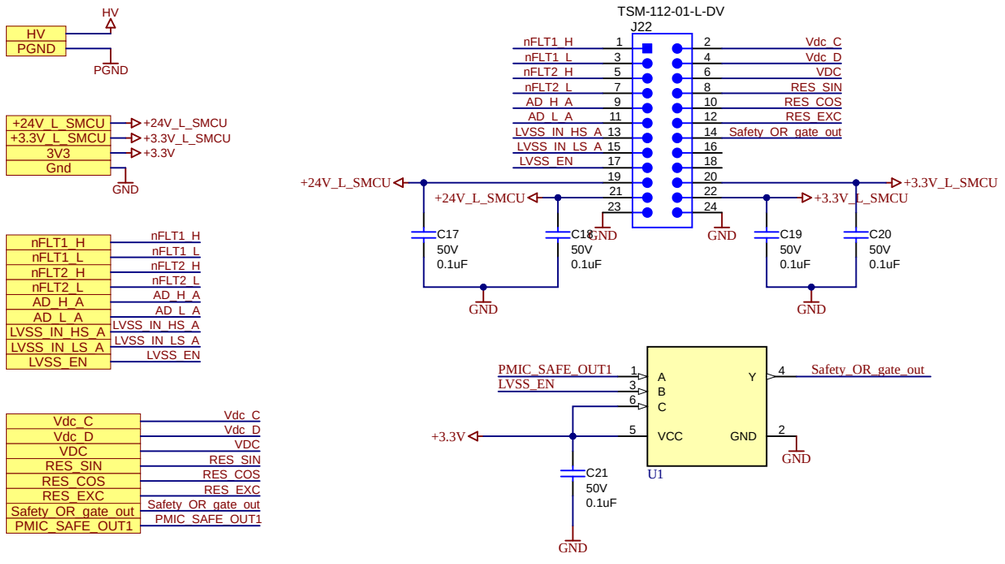
MCU2 --> LVSS_AD H/L (phase A)
MCU1 --> LVSS_AD H/L (phase B and C)

Power tree:
Flyback from HV DC:
1- MCU2
2- Low side drivers
KL30:
1- MCU1
2- High side drivers

Safety_OR_gate_out:
PMIC_SAFE_OUT1 OR LVSS_EN



Orderable: N/A	Designed for: Public Release	Mod. Date: 1/14/2025
TID #: https://www.ti.com/tool/TIDA-010170	Page Title: WS Inverter - Ctrl Board	
Number: N/A Rev: RevD	Sheet Title:	
SVN Rev: Not in version control	Assembly Variant: 001	Sheet: 18 of 19
Drawn By:	File: Safety MCU.SchDoc	Size: B
Engineer: Sharma	Contact: https://www.ti.com	

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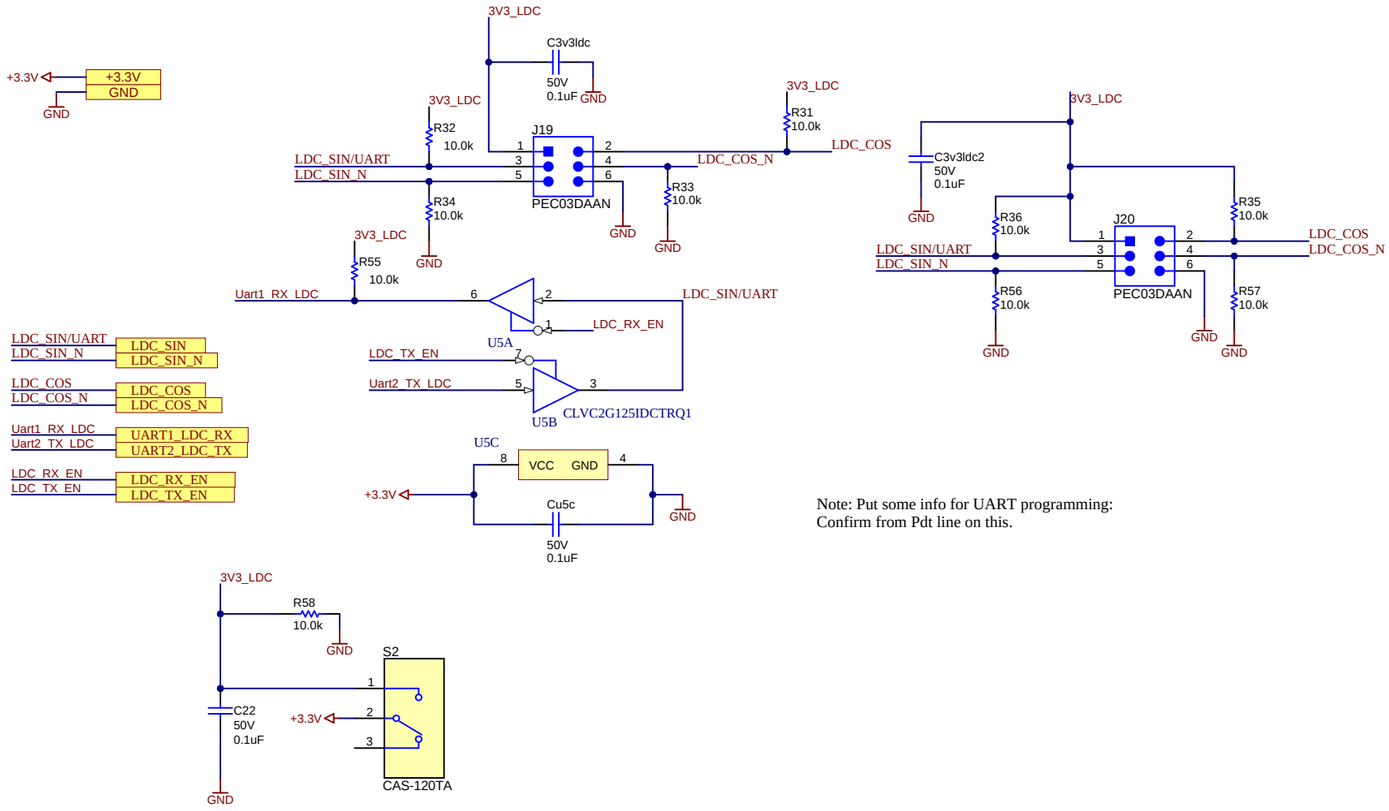

Note: Put some info for UART programming:
Confirm from Pdt line on this.

Orderable: N/A		Designed for: Public Release	Mod. Date: 3/24/2025
TID #: https://www.ti.com/tool/TIDA-020017		Project Title: WS Inverter - Ctrl Board	
Number: N/A	Rev: RevD	Sheet Title: Resolver Analog Front-End	
SVN Rev: Not in version control		Assembly Variant: 001	Sheet: 19 of 19
Drawn By: Panacek		File: LDC.SchDoc	Size: B
Engineer: Sharma		Contact: https://www.ti.com	

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