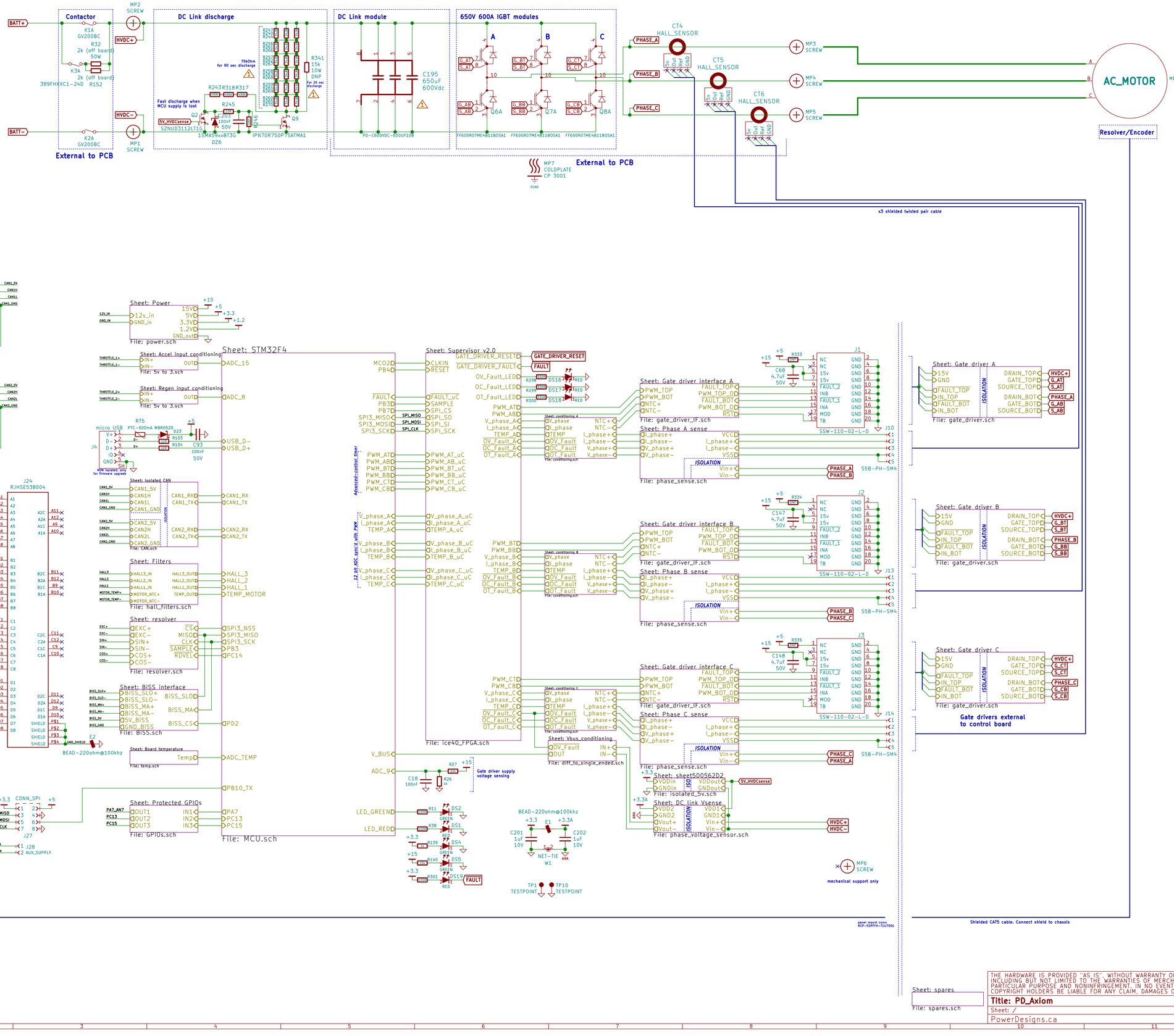
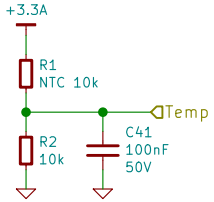
PD-Axiom Control Board



PCB temperature sensor



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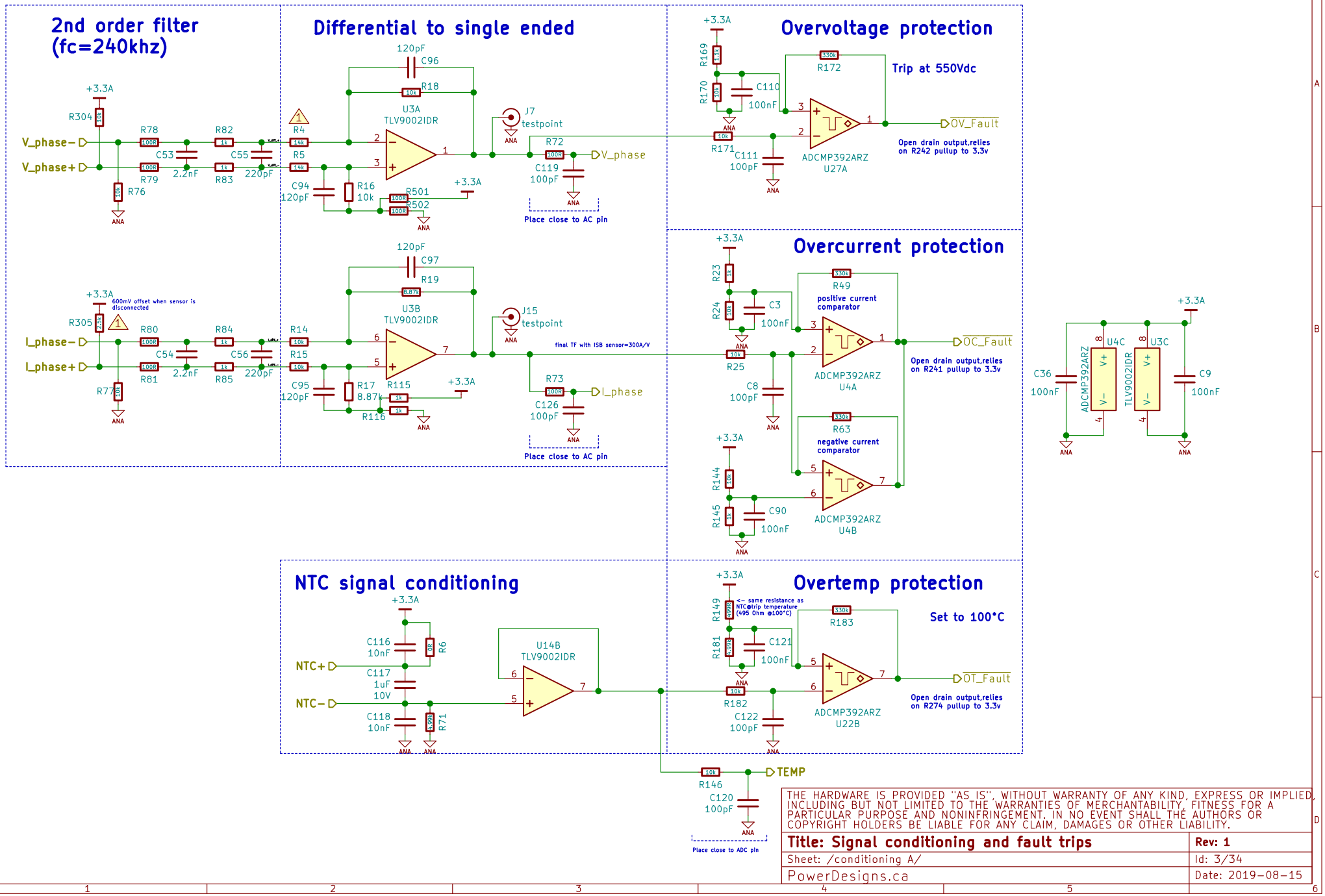
Title: Controller temperature sensing	**Rev: 1**
Sheet: /Board temperature/	Id: 2/34
PowerDesigns.ca	Date: 2019-08-15


2nd order filter
(fc=240khz)
Differential to single ended
Overvoltage protection
Trip at 550Vdc
Overcurrent protection
positive current comparator
negative current comparator
NTC signal conditioning
Overtemp protection
Set to 100°C
V_phase-
V_phase+
I_phase-
I_phase+
V_phase
I_phase
OV_Fault
OC_Fault
OT_Fault
TEMP
ADCMP392ARZ
TLV9002IDR
Open drain output,relies on R242 pullup to 3.3v
Open drain output,relies on R241 pullup to 3.3v
Open drain output,relies on R274 pullup to 3.3v
Place close to AC pin
Place close to ADC pin
final TF with ISB sensor=300A/V
600mV offset when sensor is disconnected
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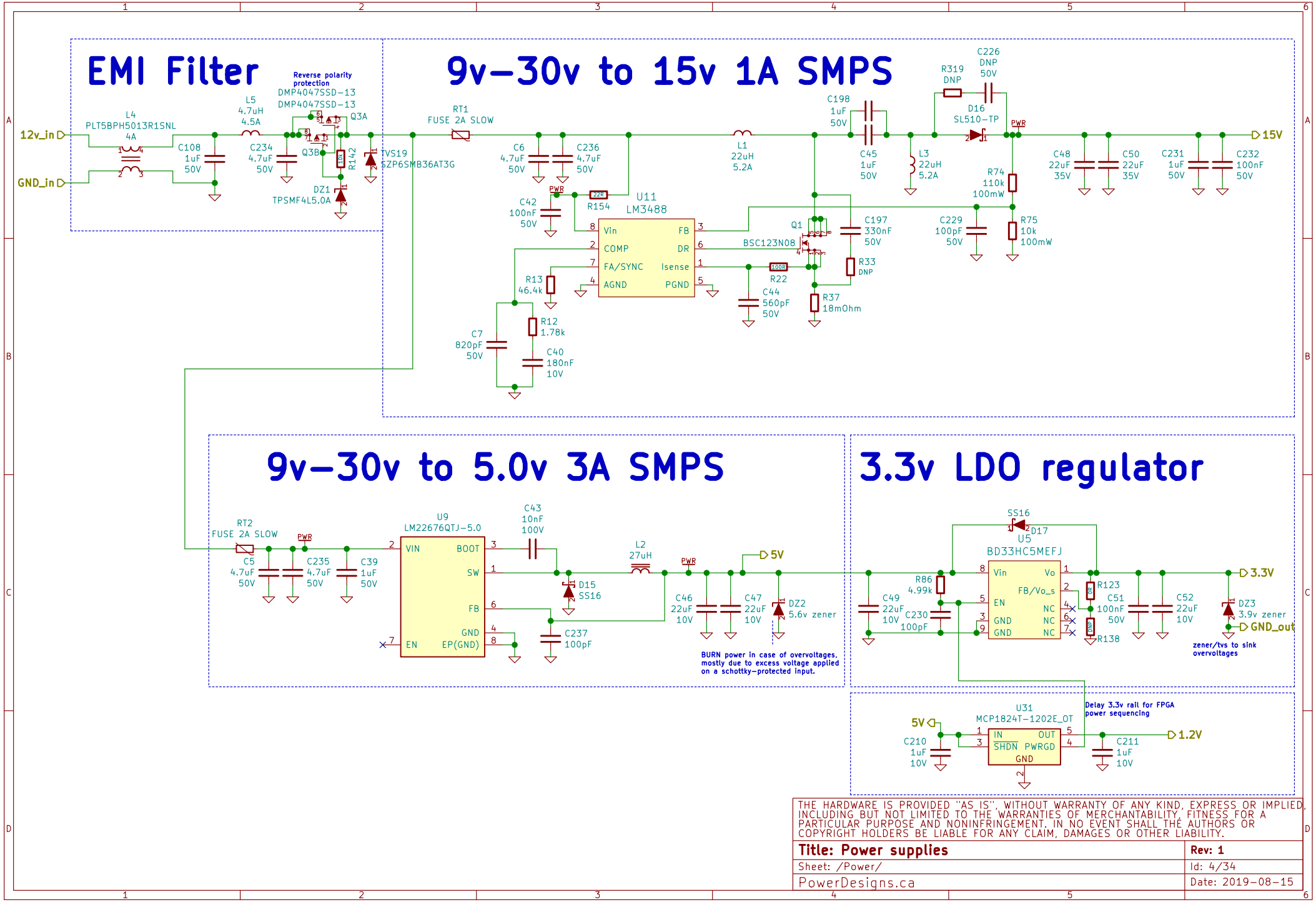
Title: Signal conditioning and fault trips
Rev: 1
Sheet: /conditioning A/
Id: 3/34
PowerDesigns.ca
Date: 2019-08-15



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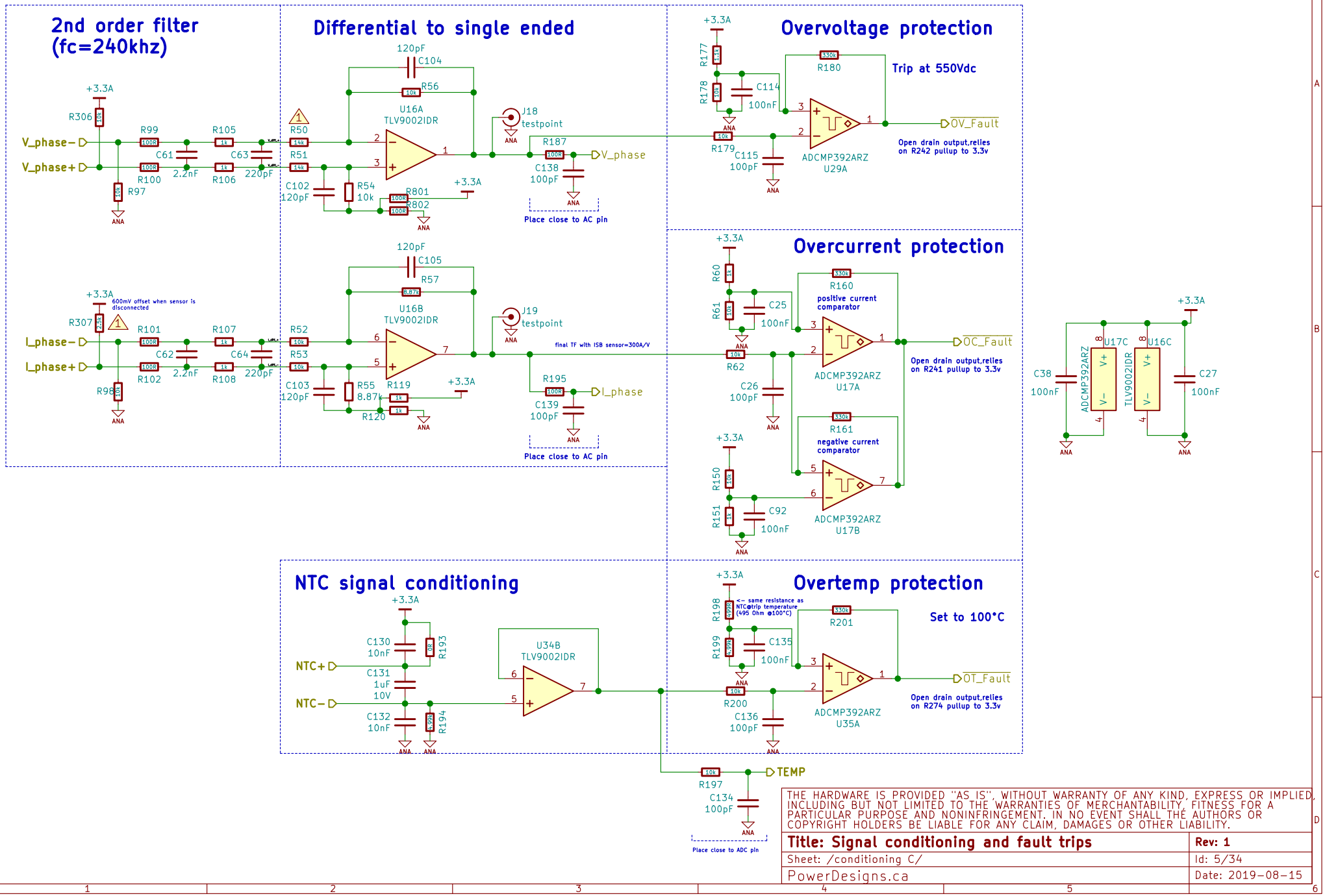
Title: Power supplies	**Rev: 1**
Sheet: /Power/	Id: 4/34
PowerDesigns.ca	Date: 2019-08-15



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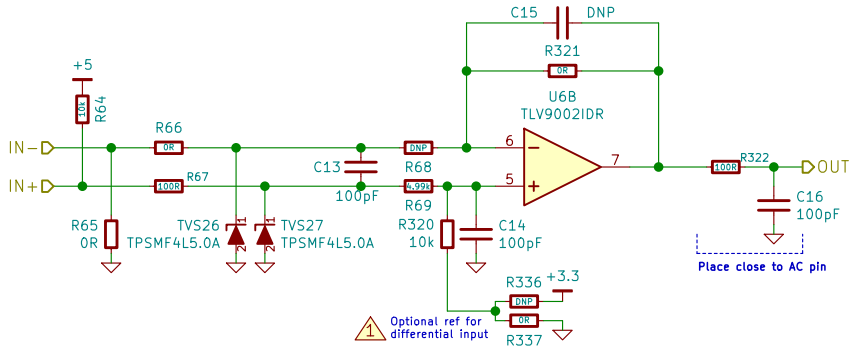
Title: Signal conditioning and fault trips	**Rev: 1**
Sheet: /conditioning C/	Id: 5/34
PowerDesigns.ca	Date: 2019-08-15

5v to 3.3v with overvoltage protection and filtering



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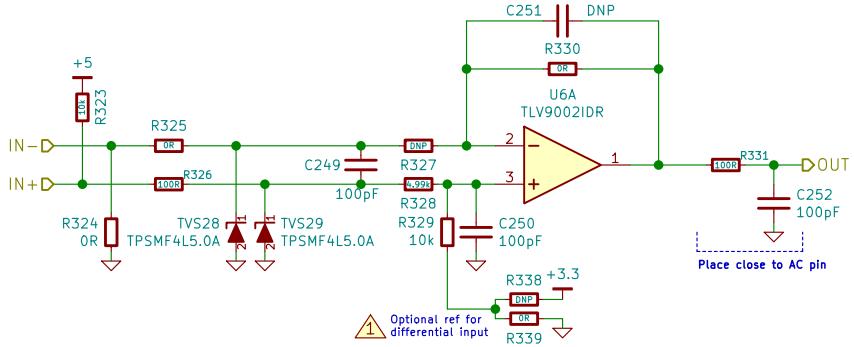
Title: 5v to 3.3v conditioning	**Rev: 1**
Sheet: /Accel input conditioning/	Id: 6/34
PowerDesigns.ca	Date: 2019-08-15

5v to 3.3v with overvoltage protection and filtering



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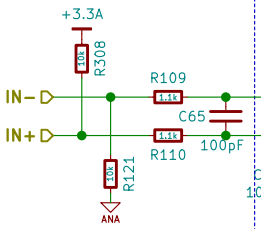
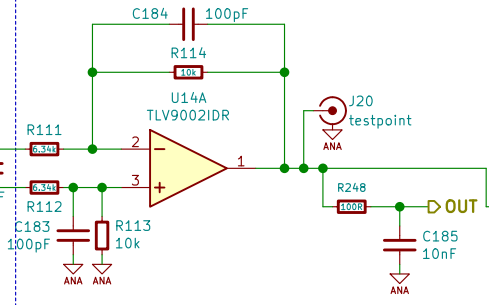
Title: 5v to 3.3v conditioning	**Rev: 1**
Sheet: /Regen input conditioning/	Id: 7/34
PowerDesigns.ca	Date: 2019-08-15

1st order filter

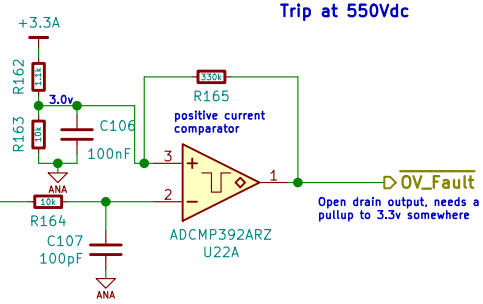


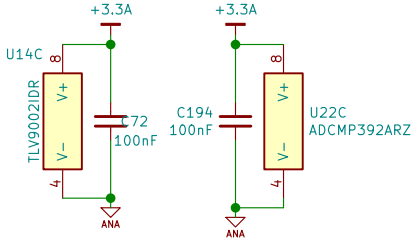
Differential to single ended

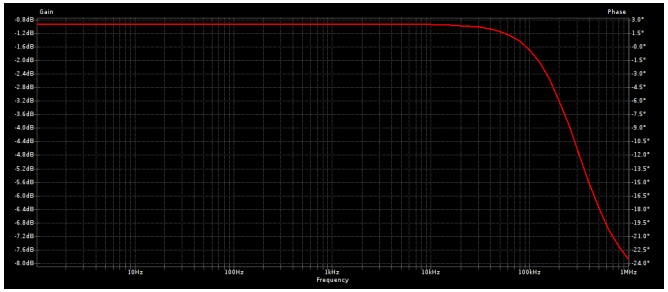


Overvoltage Protection

Trip at 550Vdc







fc = 170khz

see simulation projects in /simulation/ folder

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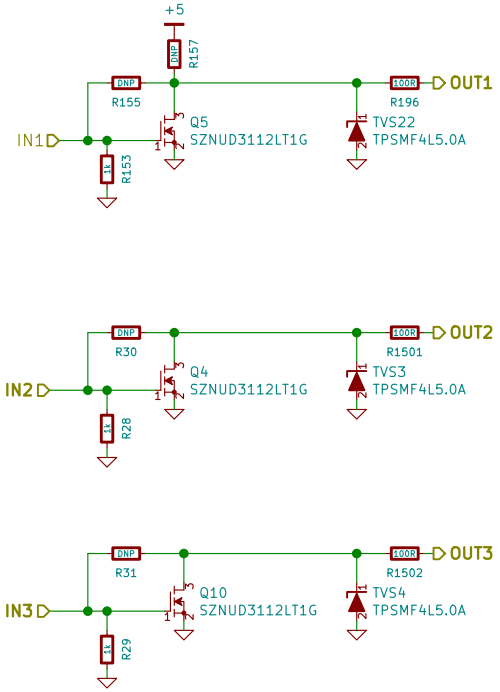
Title: Differential to single ended	**Rev: 1**
Sheet: /Vbus_conditioning/	Id: 8/34
PowerDesigns.ca	Date: 2019-08-15

Protected, 1A Open drain outputs



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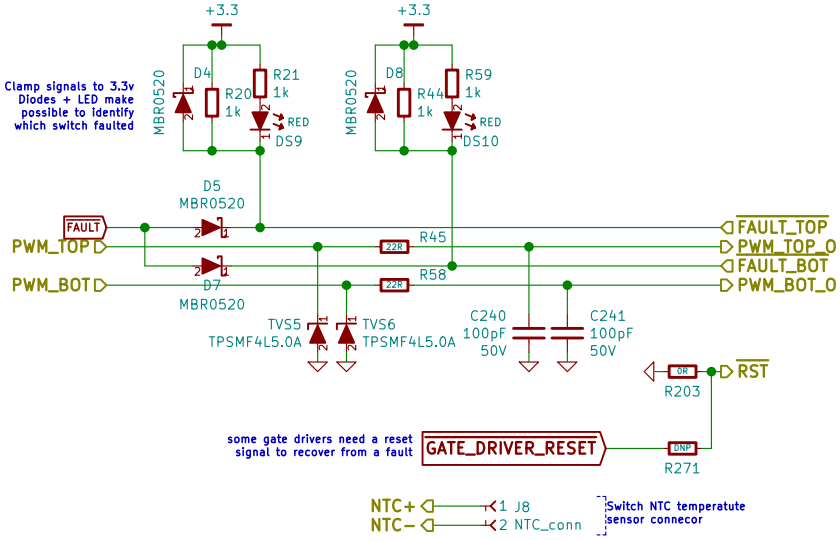
Title: Protected outputs	**Rev: 1**
Sheet: /Protected GPIOs/	Id: 9/34
PowerDesigns.ca	Date: 2019-08-15

GATE DRIVER INTERFACE



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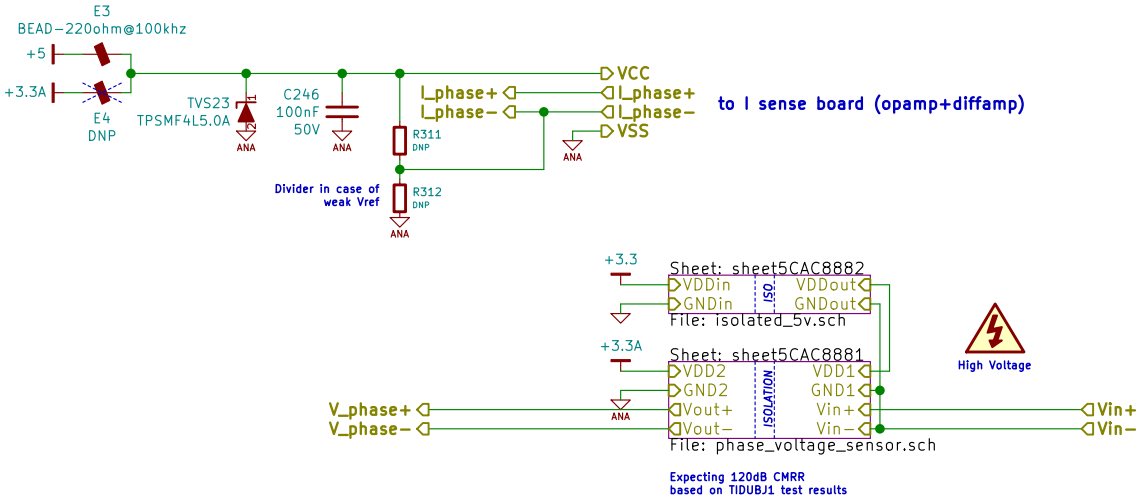
Title: Gate Driver Interface	**Rev: 1**
Sheet: /Gate driver interface A/	Id: 10/34
PowerDesigns.ca	Date: 2019-08-15



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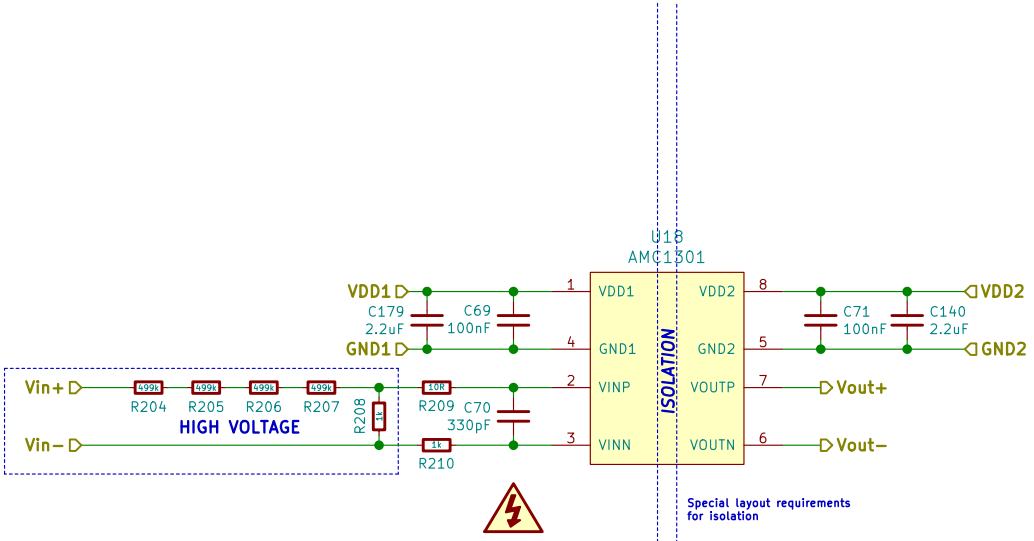
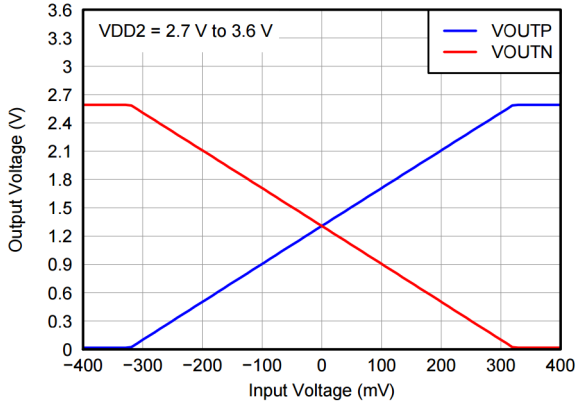
Title: High Voltage sensing and current sensor input	**Rev: 1**
Sheet: /Phase A sense/	Id: 11/34
PowerDesigns.ca	Date: 2019-08-15

0–650V phase voltage measurement using isolation amplifier

1 Features

- ±250-mV Input Voltage Range Optimized for Shunt Resistors
- Very Low Nonlinearity: 0.075% Maximum at 5 V
- Low Offset Error: 1.5 mV Maximum
- Low Noise: 3.1 mV_{RMS} Typical
- Low High-Side Supply Current: 8 mA Maximum at 5 V
- Input Bandwidth: 60 kHz Minimum
- Fixed Gain: 8 (0.5% accuracy)
- High Common Mode Rejection Ratio: 108 dB
- 3.3-V Operation on Low-Side
- Certified Galvanic Isolation:
  - UL1577 and VDE V 0884-10 Approved
  - Isolation Voltage: 4250 V_{PEAK} (AMC1200B)
  - Working Voltage: 1200 V_{PEAK}
  - Transient Immunity: 10 kV/µs Minimum
- Typical 10-Year Lifespan at Rated Working Voltage (see Application Report SLLA197)
- Fully Specified Over the Extended Industrial Temperature Range





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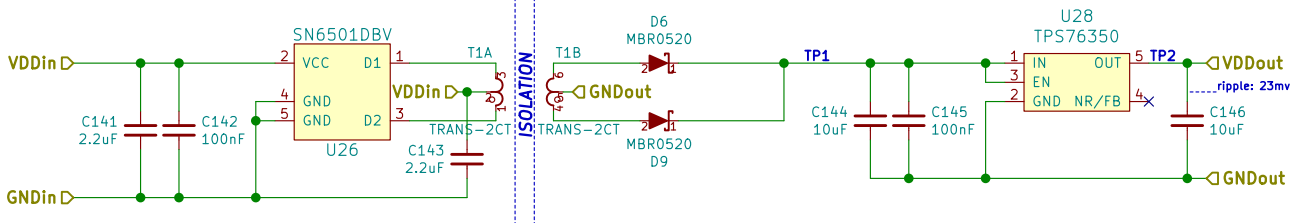
Title: High Voltage sensing	Rev: 1
Sheet: /Phase A sense/sheet5CAC8881/	Id: 12/34
PowerDesigns.ca	Date: 2019-08-15

ISOLATED POWER SUPPLY



Special layout requirements for isolation

Transformer selection:
2500Vrms Isolation 3 -> 5v (LDO) 760390015
5000Vrms Isolation 3 -> 5v (LDO) 750313626 (higher CMRR?)

Figure 9. Output Voltage vs Load Current

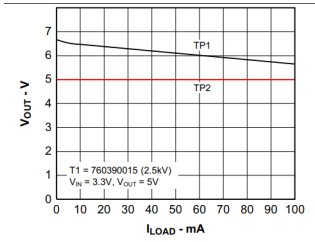
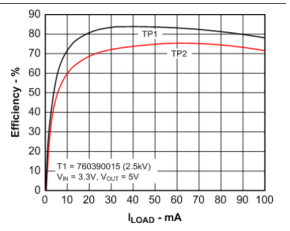


Figure 10. Efficiency vs Load Current



TP1: rectified node
TP2: LDO output

11.2 Layout Example

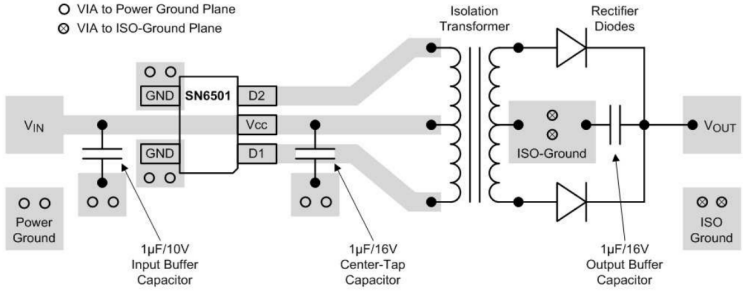


Figure 57. Layout Example of a 2-Layer Board (SN6501)

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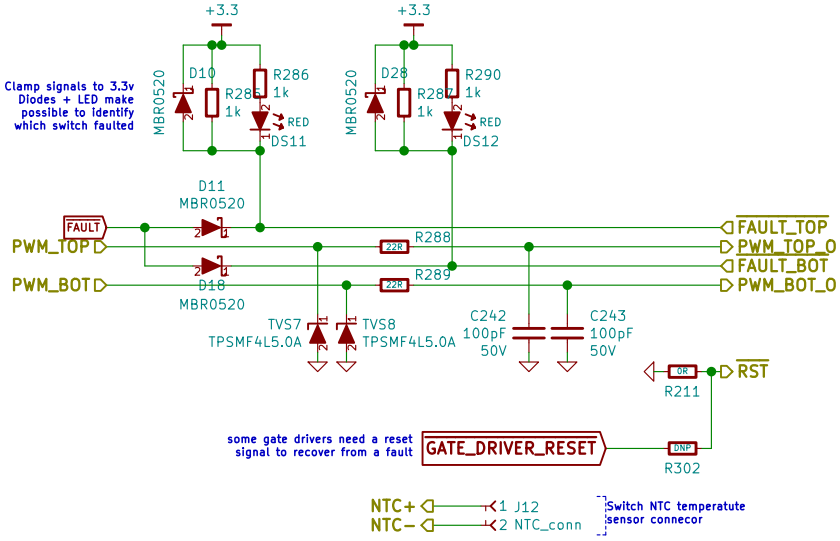
Title: Isolated DC/DC supply	Rev: 1
Sheet: /Phase A sense/sheet5CAC8882/	Id: 13/34
PowerDesigns.ca	Date: 2019-08-15

GATE DRIVER INTERFACE



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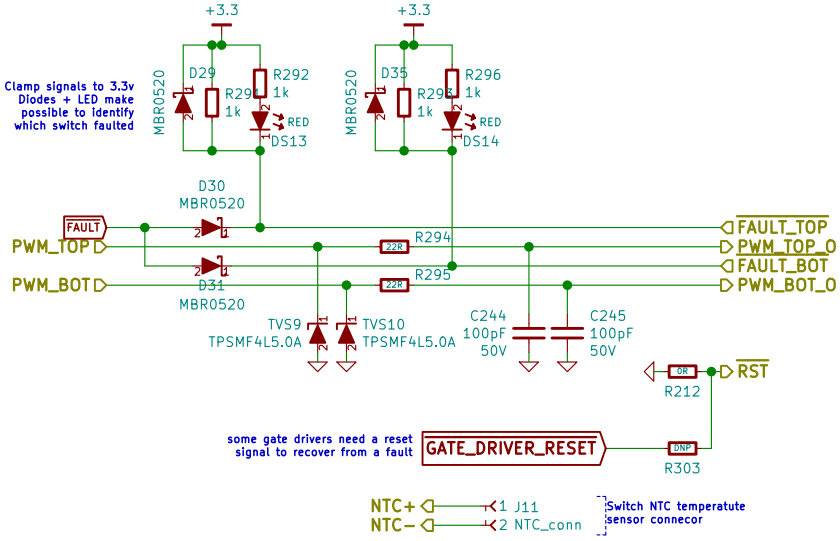
Title: Gate Driver Interface	**Rev: 1**
Sheet: /Gate driver interface B/	Id: 14/34
PowerDesigns.ca	Date: 2019-08-15

GATE DRIVER INTERFACE



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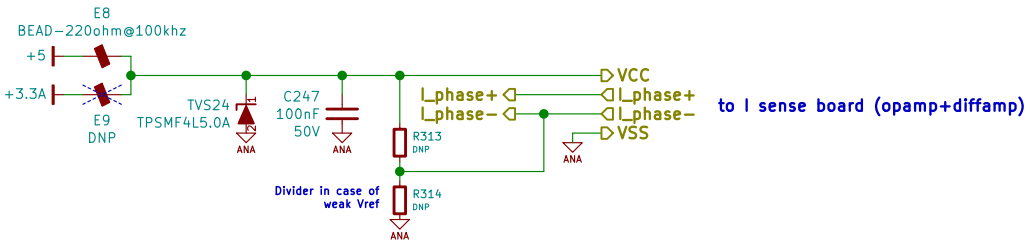
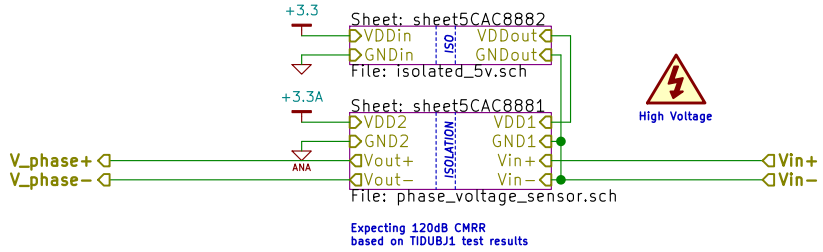
Title: Gate Driver Interface	**Rev: 1**
Sheet: /Gate driver interface C/	Id: 15/34
PowerDesigns.ca	Date: 2019-08-15





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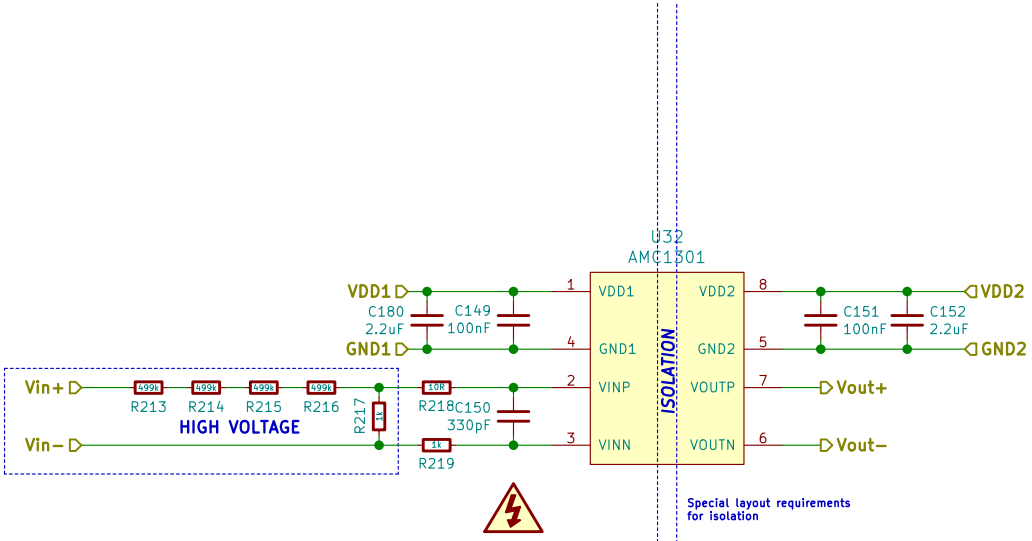
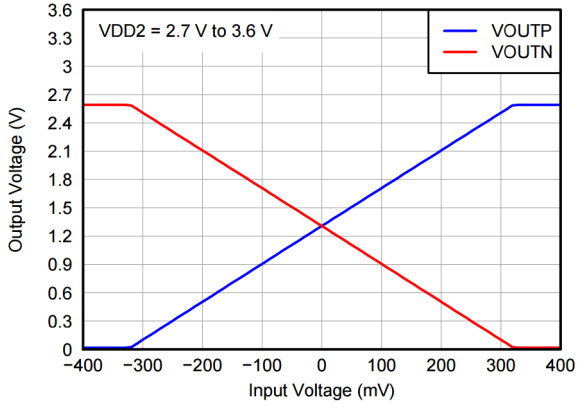
Title: High Voltage sensing and current sensor input	**Rev: 1**
Sheet: /Phase B sense/	Id: 16/34
PowerDesigns.ca	Date: 2019-08-15

0–650V phase voltage measurement using isolation amplifier

1 Features

- ±250-mV Input Voltage Range Optimized for Shunt Resistors
- Very Low Nonlinearity: 0.075% Maximum at 5 V
- Low Offset Error: 1.5 mV Maximum
- Low Noise: 3.1 mV_{RMS} Typical
- Low High-Side Supply Current: 8 mA Maximum at 5 V
- Input Bandwidth: 60 kHz Minimum
- Fixed Gain: 8 (0.5% accuracy)
- High Common Mode Rejection Ratio: 108 dB
- 3.3-V Operation on Low-Side
- Certified Galvanic Isolation:
  - UL1577 and VDE V 0884-10 Approved
  - Isolation Voltage: 4250 V_{PEAK} (AMC1200B)
  - Working Voltage: 1200 V_{PEAK}
  - Transient Immunity: 10 kV/µs Minimum
- Typical 10-Year Lifespan at Rated Working Voltage (see Application Report SLLA197)
- Fully Specified Over the Extended Industrial Temperature Range





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Title: High Voltage sensing	Rev: 1
Sheet: /Phase B sense/sheet5CAC8881/	Id: 17/34
PowerDesigns.ca	Date: 2019-08-15

ISOLATED POWER SUPPLY

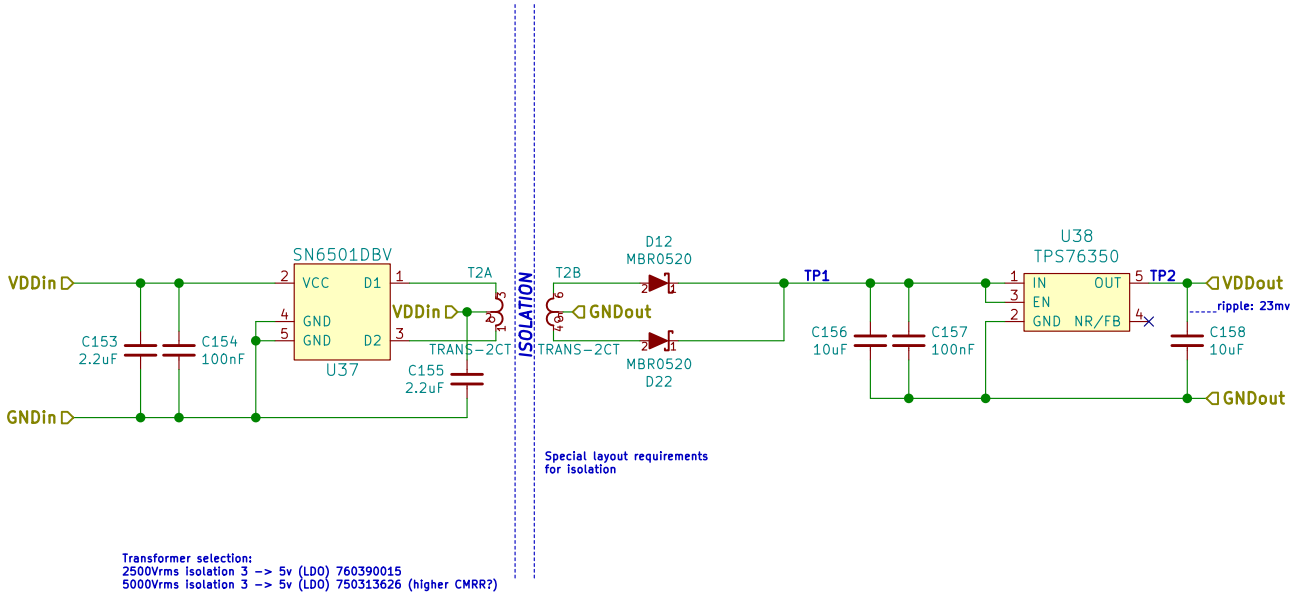


Figure 9. Output Voltage vs Load Current

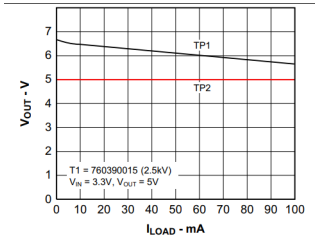
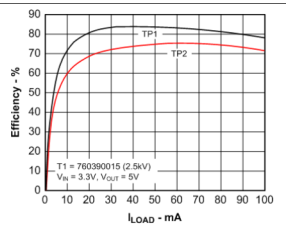


Figure 10. Efficiency vs Load Current



TP1: rectified node
TP2: LDO output

11.2 Layout Example

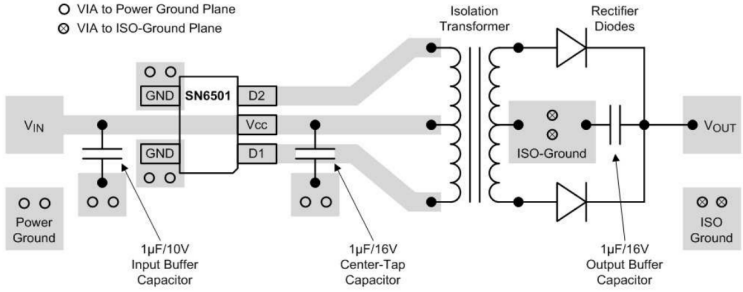


Figure 57. Layout Example of a 2-Layer Board (SN6501)

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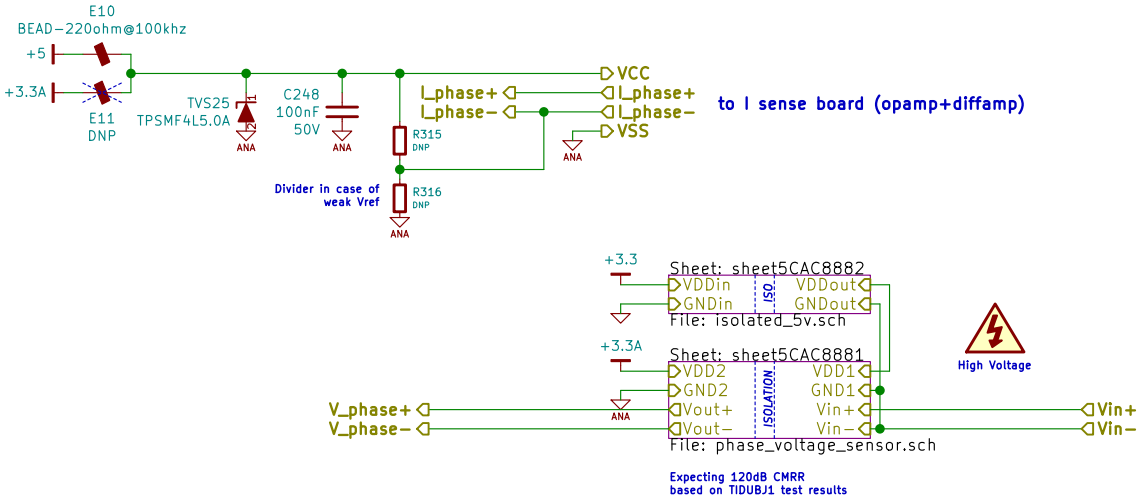
Title: Isolated DC/DC supply	Rev: 1
Sheet: /Phase B sense/sheet5CAC8882/	Id: 18/34
PowerDesigns.ca	Date: 2019-08-15



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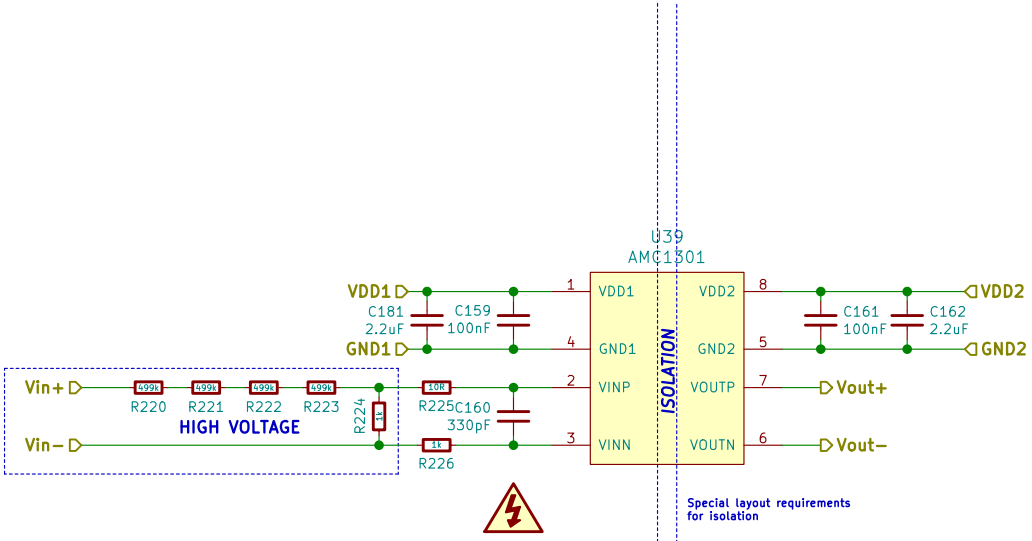
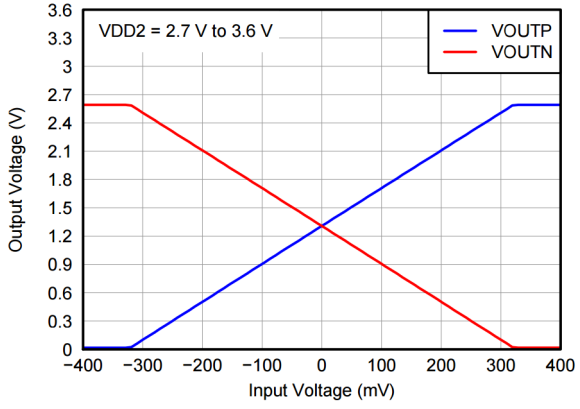
Title: High Voltage sensing and current sensor input	**Rev: 1**
Sheet: /Phase C sense/	Id: 19/34
PowerDesigns.ca	Date: 2019-08-15

0–650V phase voltage measurement using isolation amplifier

1 Features

- ±250-mV Input Voltage Range Optimized for Shunt Resistors
- Very Low Nonlinearity: 0.075% Maximum at 5 V
- Low Offset Error: 1.5 mV Maximum
- Low Noise: 3.1 mV_{RMS} Typical
- Low High-Side Supply Current: 8 mA Maximum at 5 V
- Input Bandwidth: 60 kHz Minimum
- Fixed Gain: 8 (0.5% accuracy)
- High Common Mode Rejection Ratio: 108 dB
- 3.3-V Operation on Low-Side
- Certified Galvanic Isolation:
  - UL1577 and VDE V 0884-10 Approved
  - Isolation Voltage: 4250 V_{PEAK} (AMC1200B)
  - Working Voltage: 1200 V_{PEAK}
  - Transient Immunity: 10 kV/µs Minimum
- Typical 10-Year Lifespan at Rated Working Voltage (see Application Report SLLA197)
- Fully Specified Over the Extended Industrial Temperature Range





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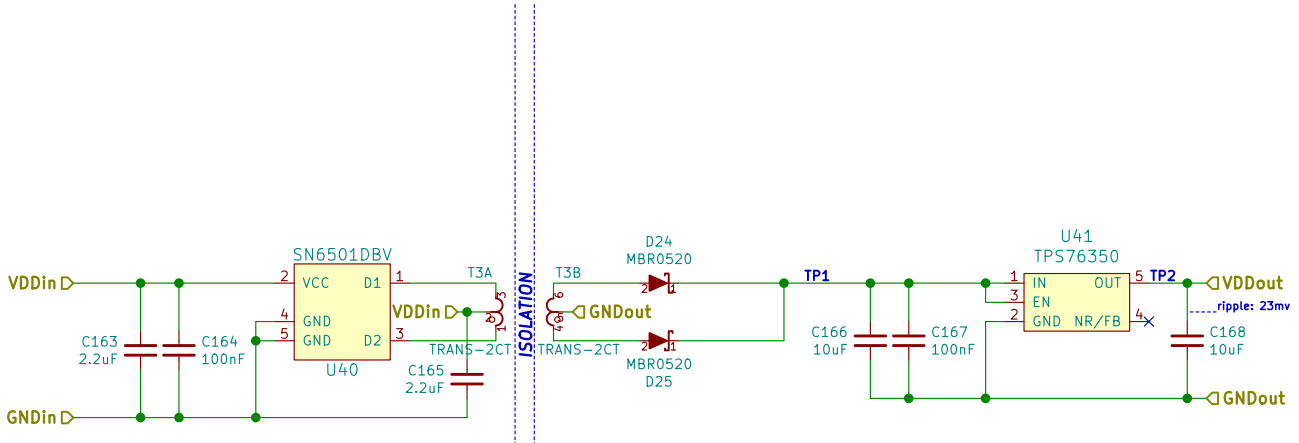
Title: High Voltage sensing	Rev: 1
Sheet: /Phase C sense/sheet5CAC8881/	Id: 20/34
PowerDesigns.ca	Date: 2019-08-15

ISOLATED POWER SUPPLY



Transformer selection:
2500Vrms Isolation 3 -> 5v (LDO) 760390015
5000Vrms Isolation 3 -> 5v (LDO) 750313626 (higher CMRR?)

Figure 9. Output Voltage vs Load Current

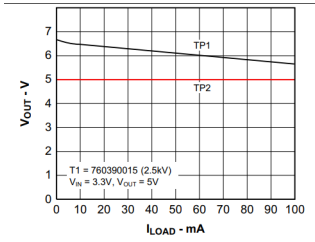
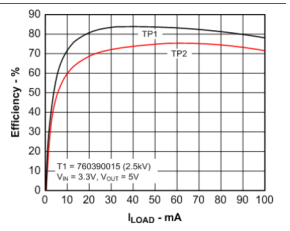


Figure 10. Efficiency vs Load Current



TP1: rectified node
TP2: LDO output

11.2 Layout Example

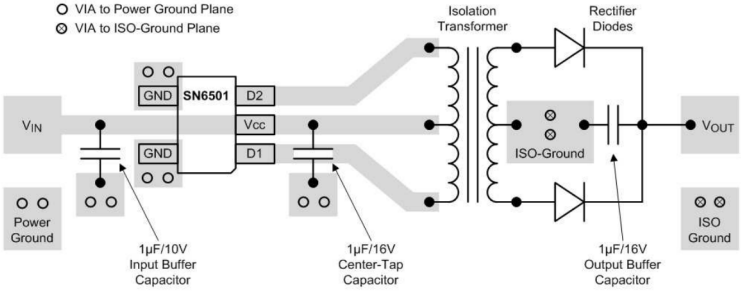


Figure 57. Layout Example of a 2-Layer Board (SN6501)

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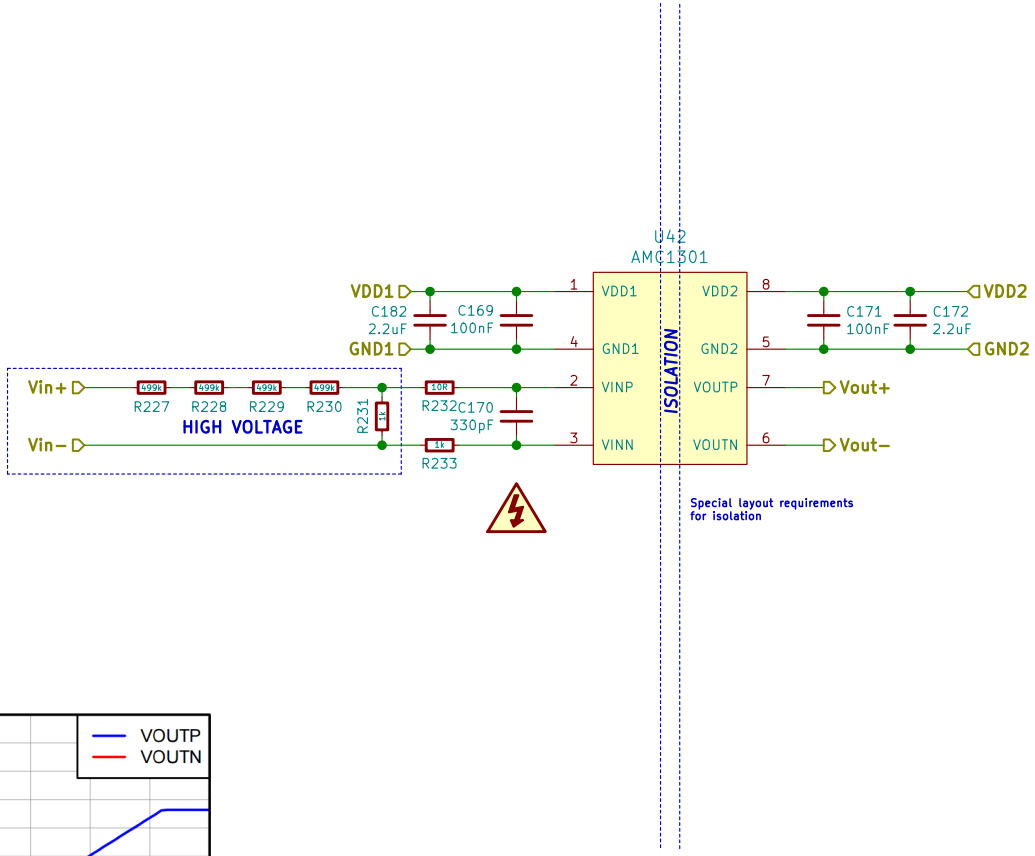
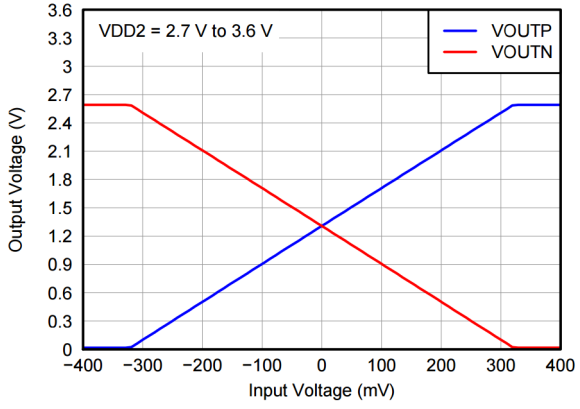
Title: Isolated DC/DC supply	Rev: 1
Sheet: /Phase C sense/sheet5CAC8882/	Id: 21/34
PowerDesigns.ca	Date: 2019-08-15

0–650V phase voltage measurement using isolation amplifier

1 Features

- ±250-mV Input Voltage Range Optimized for Shunt Resistors
- Very Low Nonlinearity: 0.075% Maximum at 5 V
- Low Offset Error: 1.5 mV Maximum
- Low Noise: 3.1 mV_{RMS} Typical
- Low High-Side Supply Current: 8 mA Maximum at 5 V
- Input Bandwidth: 60 kHz Minimum
- Fixed Gain: 8 (0.5% accuracy)
- High Common Mode Rejection Ratio: 108 dB
- 3.3-V Operation on Low-Side
- Certified Galvanic Isolation:
  - UL1577 and VDE V 0884-10 Approved
  - Isolation Voltage: 4250 V_{PEAK} (AMC1200B)
  - Working Voltage: 1200 V_{PEAK}
  - Transient Immunity: 10 kV/µs Minimum
- Typical 10-Year Lifespan at Rated Working Voltage (see Application Report SLLA197)
- Fully Specified Over the Extended Industrial Temperature Range





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Title: High Voltage sensing	Rev: 1
Sheet: /DC link Vsense/	Id: 22/34
PowerDesigns.ca	Date: 2019-08-15

ISOLATED POWER SUPPLY

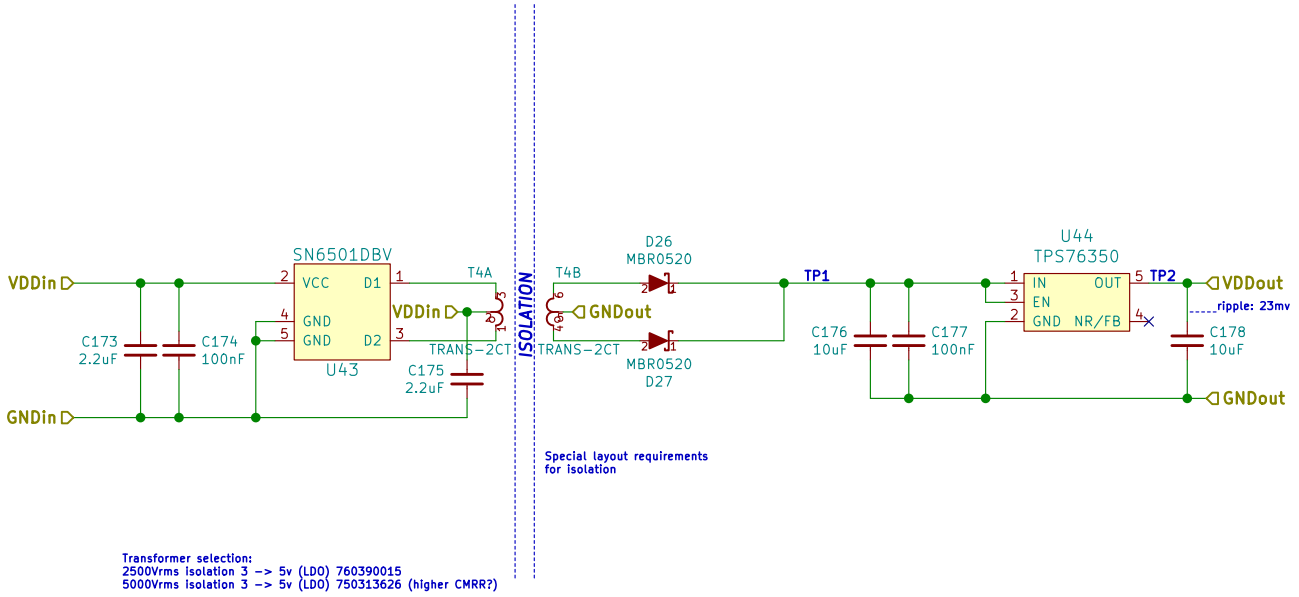


Figure 9. Output Voltage vs Load Current

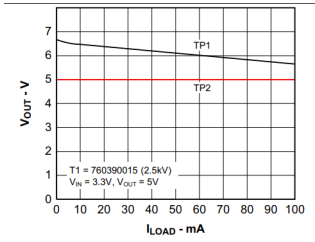
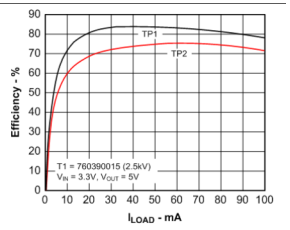


Figure 10. Efficiency vs Load Current



TP1: rectified node
TP2: LDO output

11.2 Layout Example

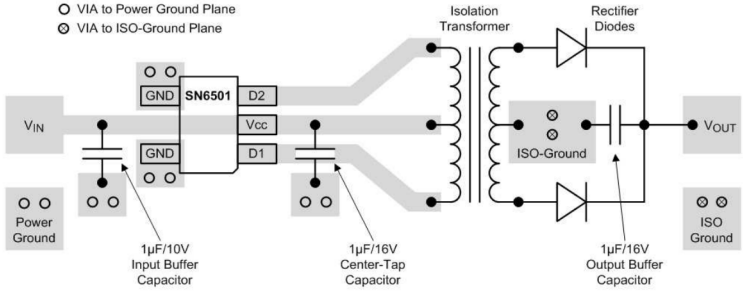


Figure 57. Layout Example of a 2-Layer Board (SN6501)

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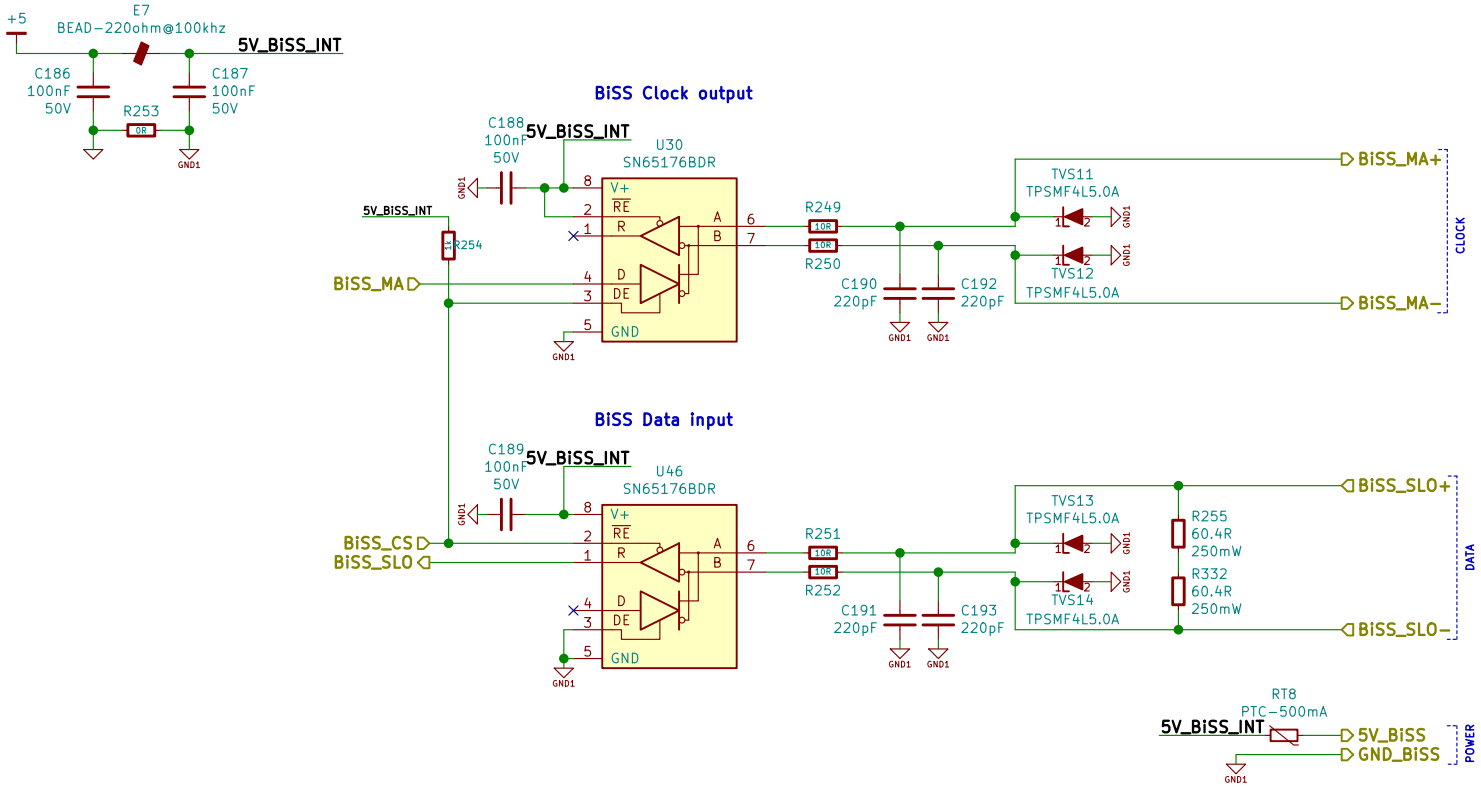
Title: Isolated DC/DC supply	Rev: 1
Sheet: /sheet5D0562D2/	Id: 23/34
PowerDesigns.ca	Date: 2019-08-15

BiSS absolute encoder PHY



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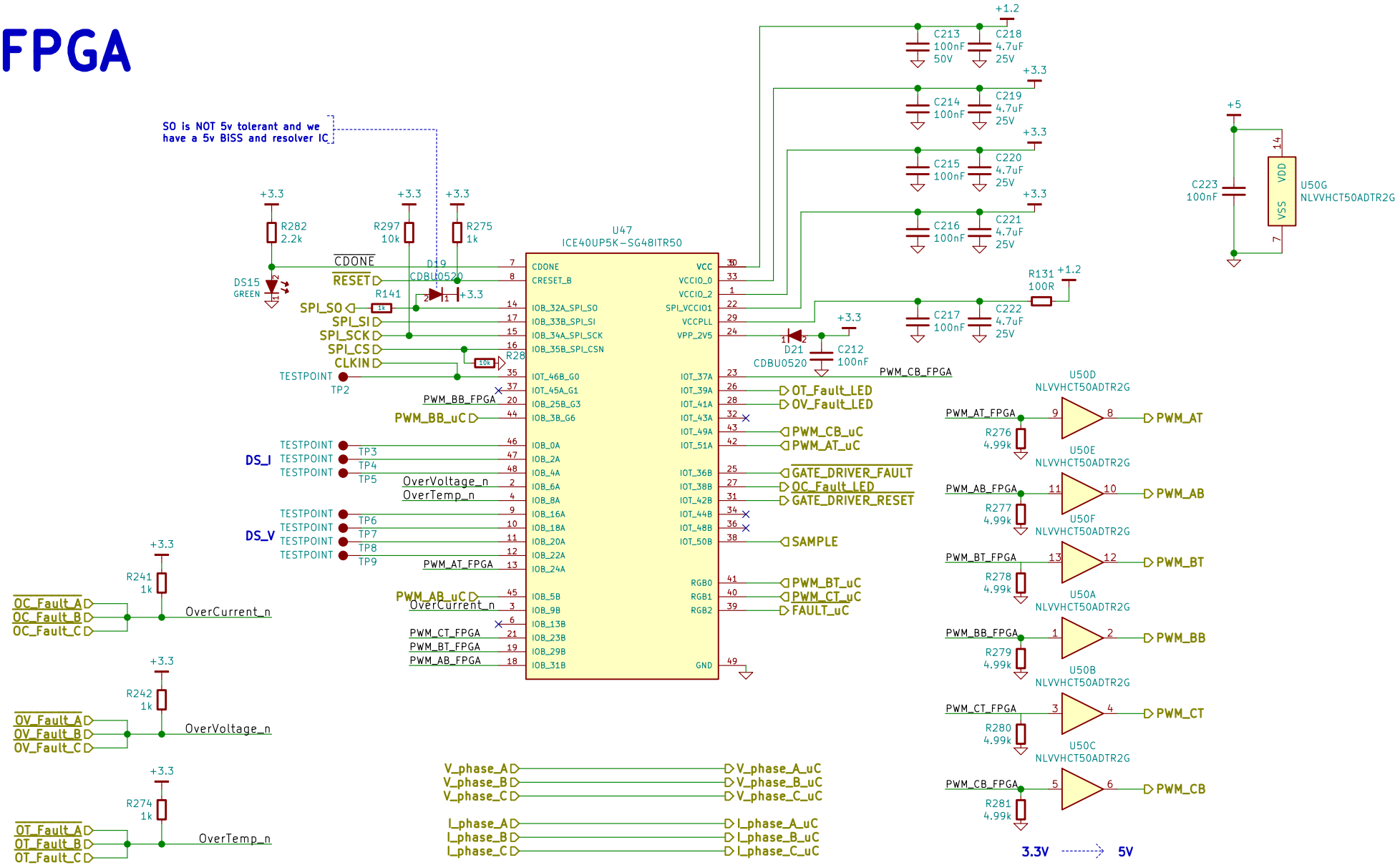
Title: BiSS PHY	**Rev: 1**
Sheet: /BiSS interface/	Id: 24/34
PowerDesigns.ca	Date: 2019-08-15

FPGA

SO is NOT 5v tolerant and we have a 5v BISS and resolver IC



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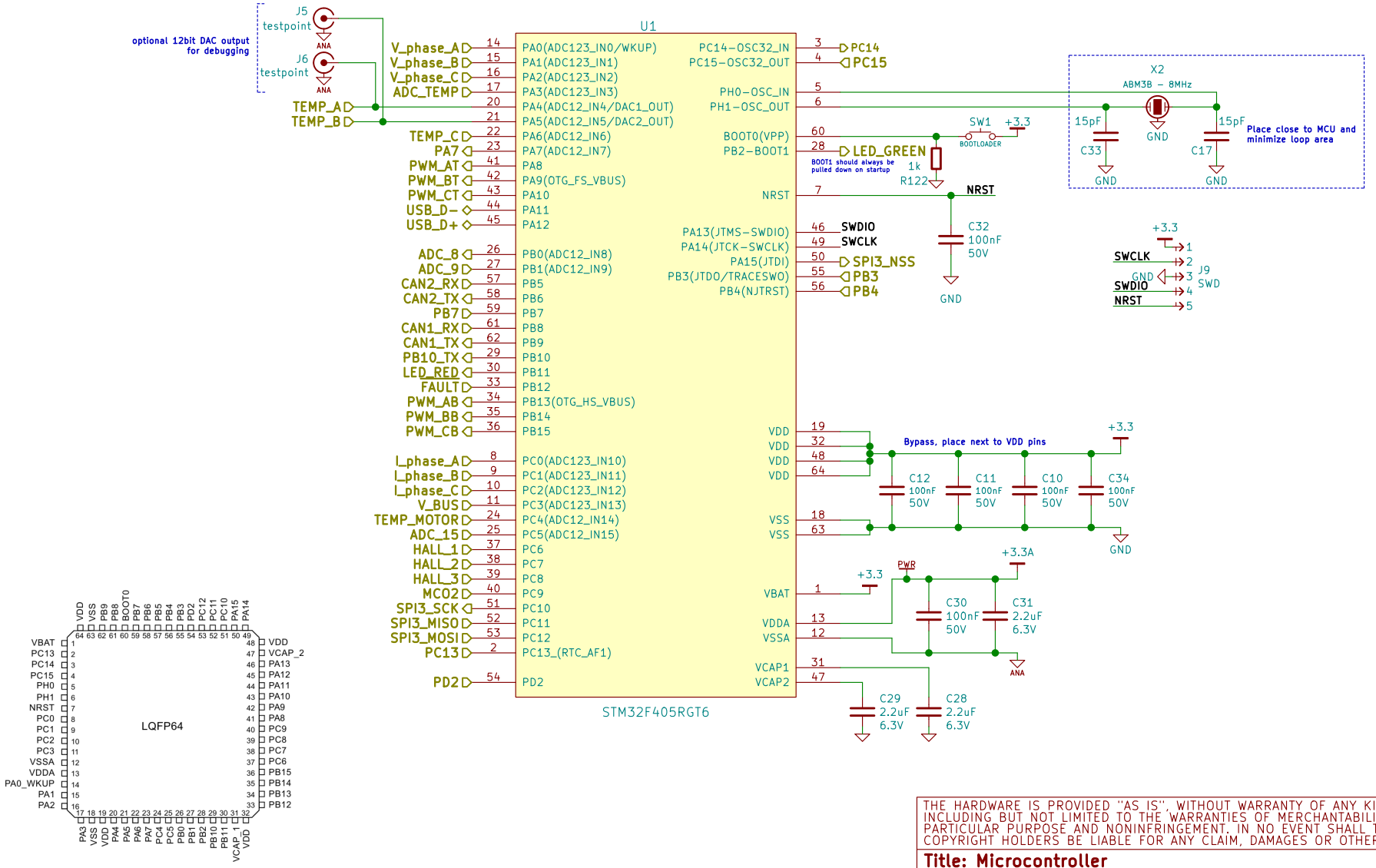
Title: FPGA supervisor	**Rev: 1**
Sheet: /Supervisor v2.0/	Id: 25/34
PowerDesigns.ca	Date: 2019-08-15

STM32F405 MCU



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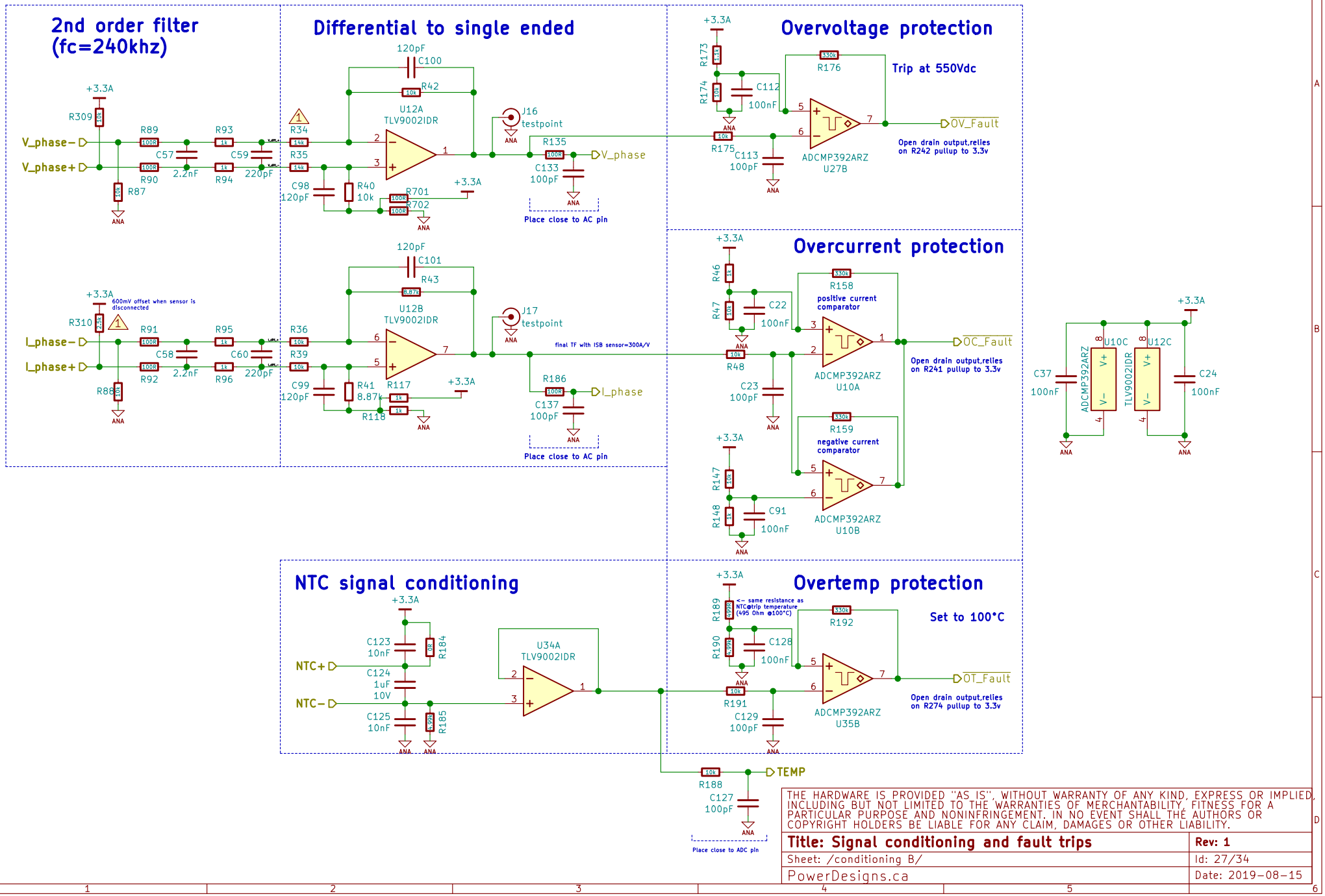
Title: Microcontroller	**Rev: 1**
Sheet: /STM32F4/	Id: 26/34
PowerDesigns.ca	Date: 2019-08-15



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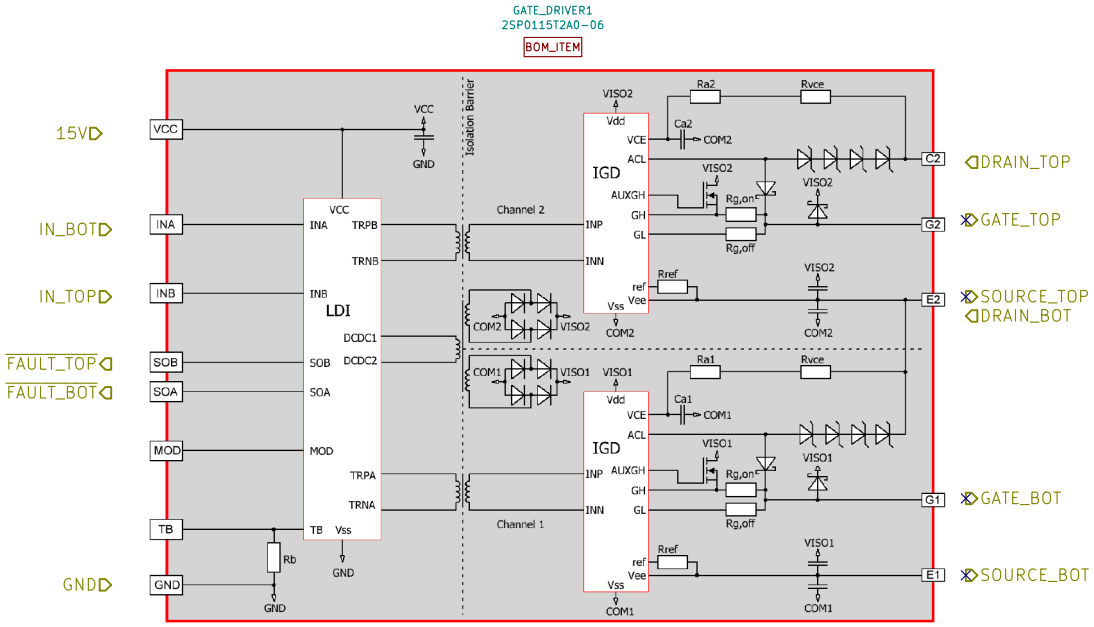
Title: Signal conditioning and fault trips	**Rev: 1**
Sheet: /conditioning B/	Id: 27/34
PowerDesigns.ca	Date: 2019-08-15

GATE DRIVER



External to control board

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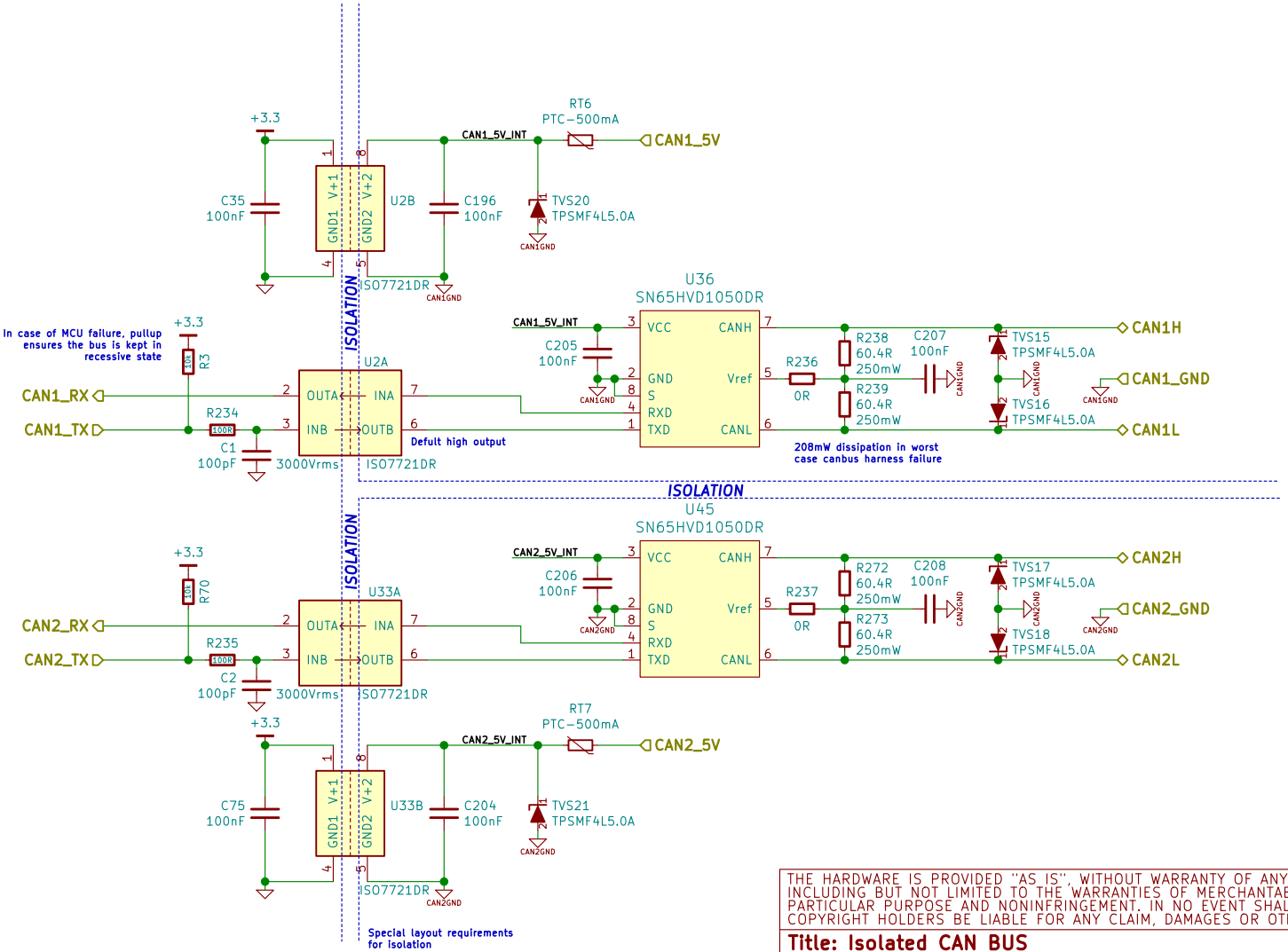
Title: Gate driver	**Rev: 1**
Sheet: /Gate driver A/	Id: 28/34
PowerDesigns.ca	Date: 2019-08-15

REDUNDANT ISOLATED CAN BUS TRANSCEIVER



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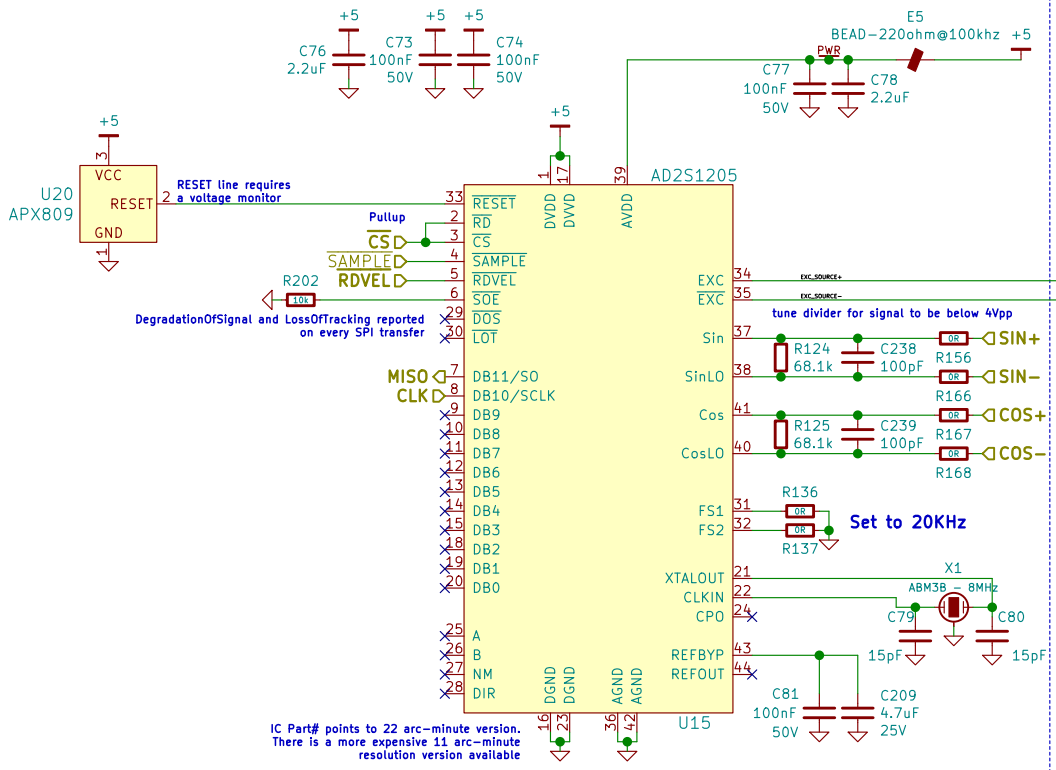
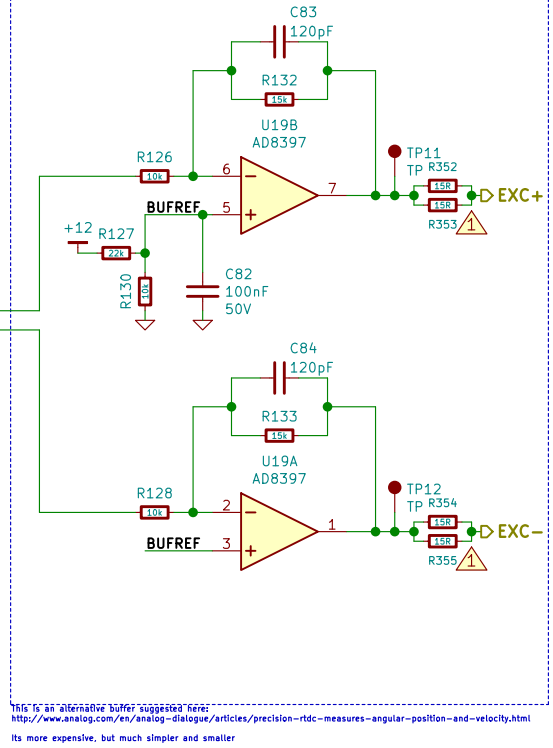
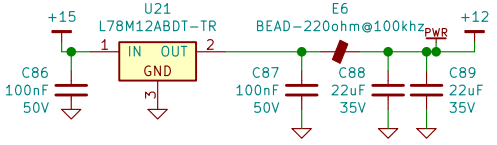
Title: Isolated CAN BUS	**Rev: 1**
Sheet: /Isolated CAN/	Id: 29/34
PowerDesigns.ca	Date: 2019-08-15

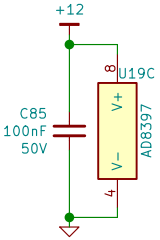
Resolver interface



Buffer







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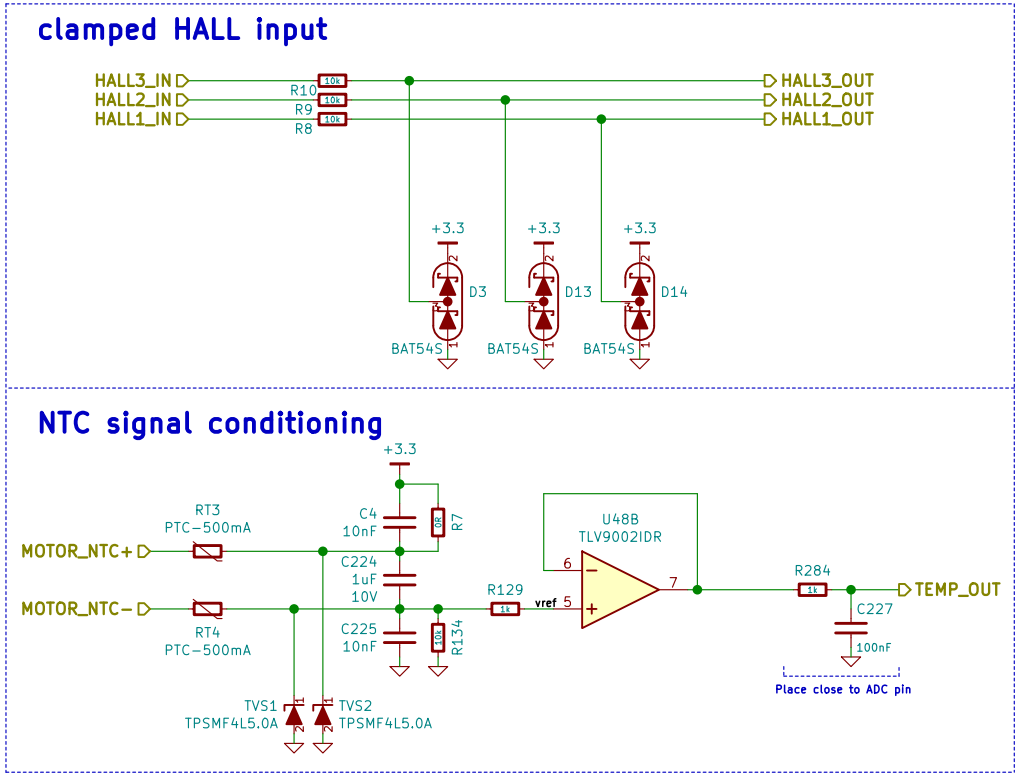
Title: Resolver	**Rev: 1**
Sheet: /resolver/	Id: 30/34
PowerDesigns.ca	Date: 2019-08-15

HALL position input and motor temp sensor



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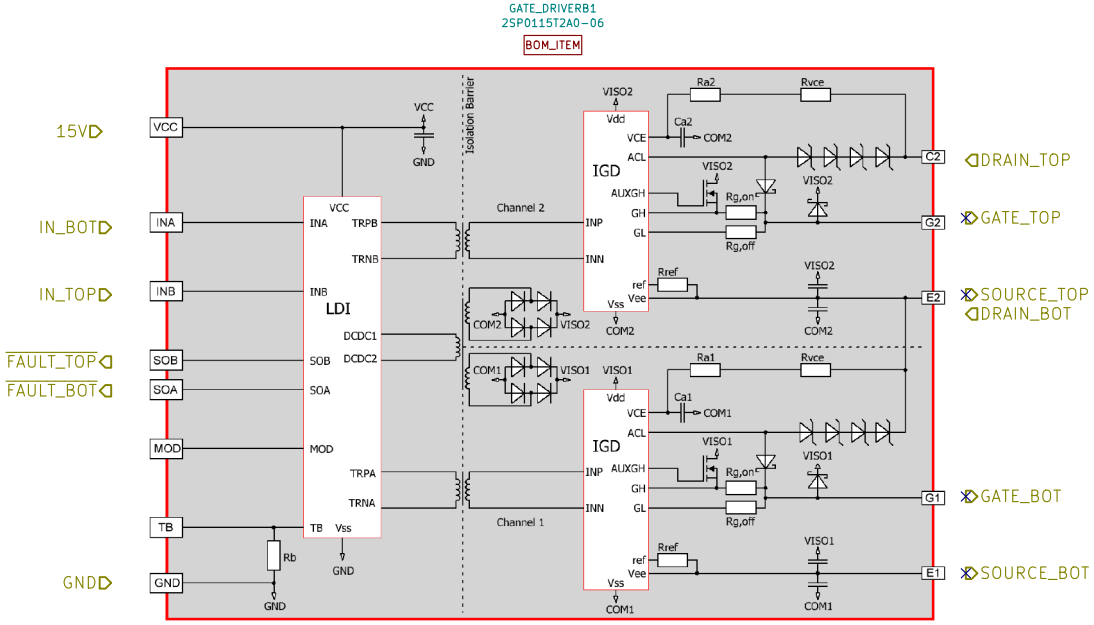
Title: Hall sensor and motor temperature	**Rev: 1**
Sheet: /Filters/	Id: 31/34
PowerDesigns.ca	Date: 2019-08-15

GATE DRIVER



External to control board

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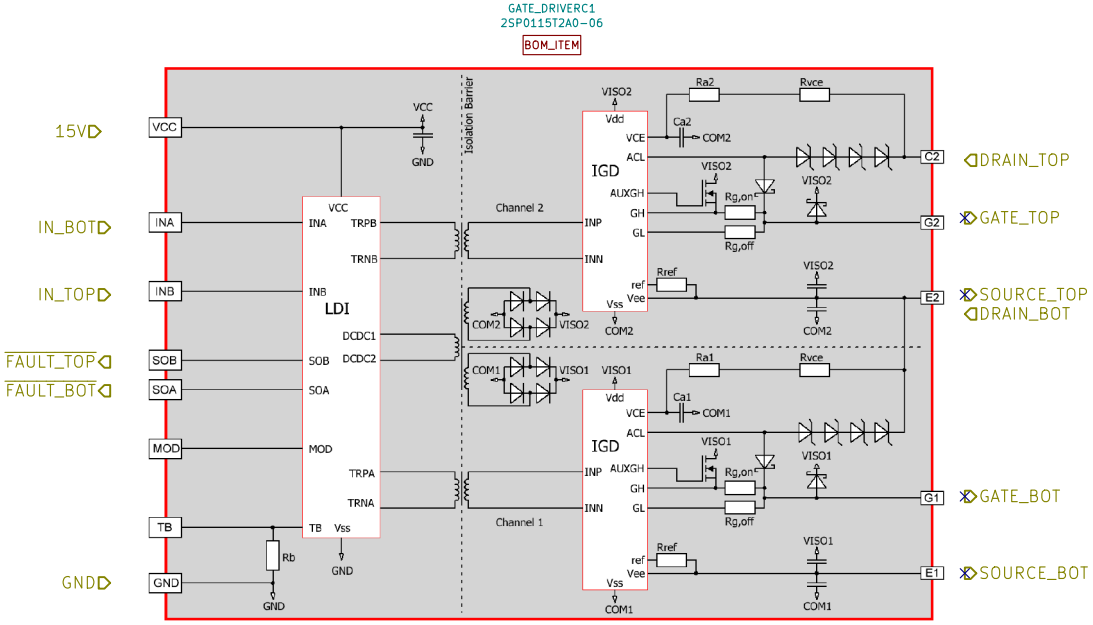
Title: Gate driver	Rev: 1
Sheet: /Gate driver B/	Id: 32/34
PowerDesigns.ca	Date: 2019-08-15

GATE DRIVER



External to control board

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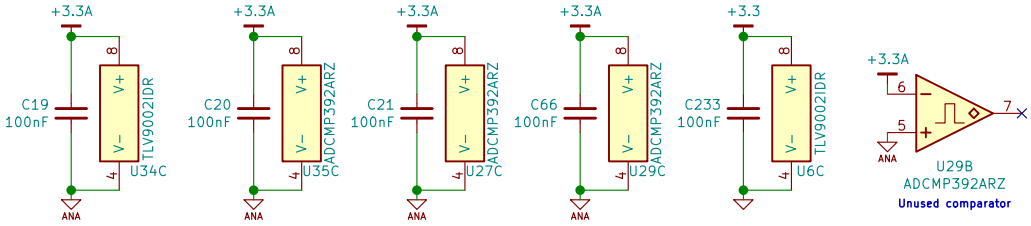
Title: Gate driver	**Rev: 1**
Sheet: /Gate driver C/	Id: 33/34
PowerDesigns.ca	Date: 2019-08-15



opamp and comparators scattered throughout the schematic without their supply pins in order to be shared across different sheets

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Title: Spares	**Rev: 1**
Sheet: /spares/	Id: 34/34
PowerDesigns.ca	Date: 2019-08-15