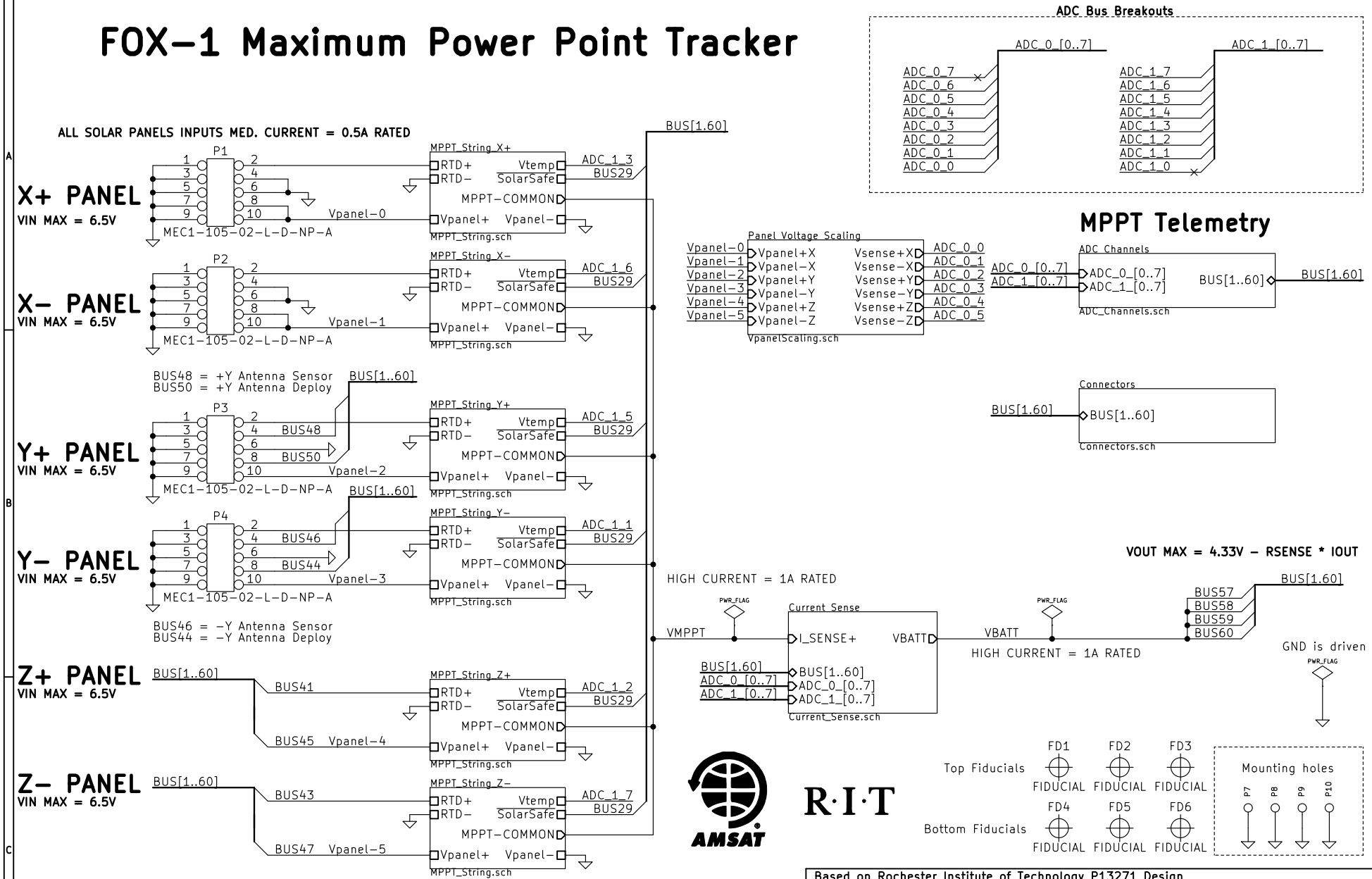
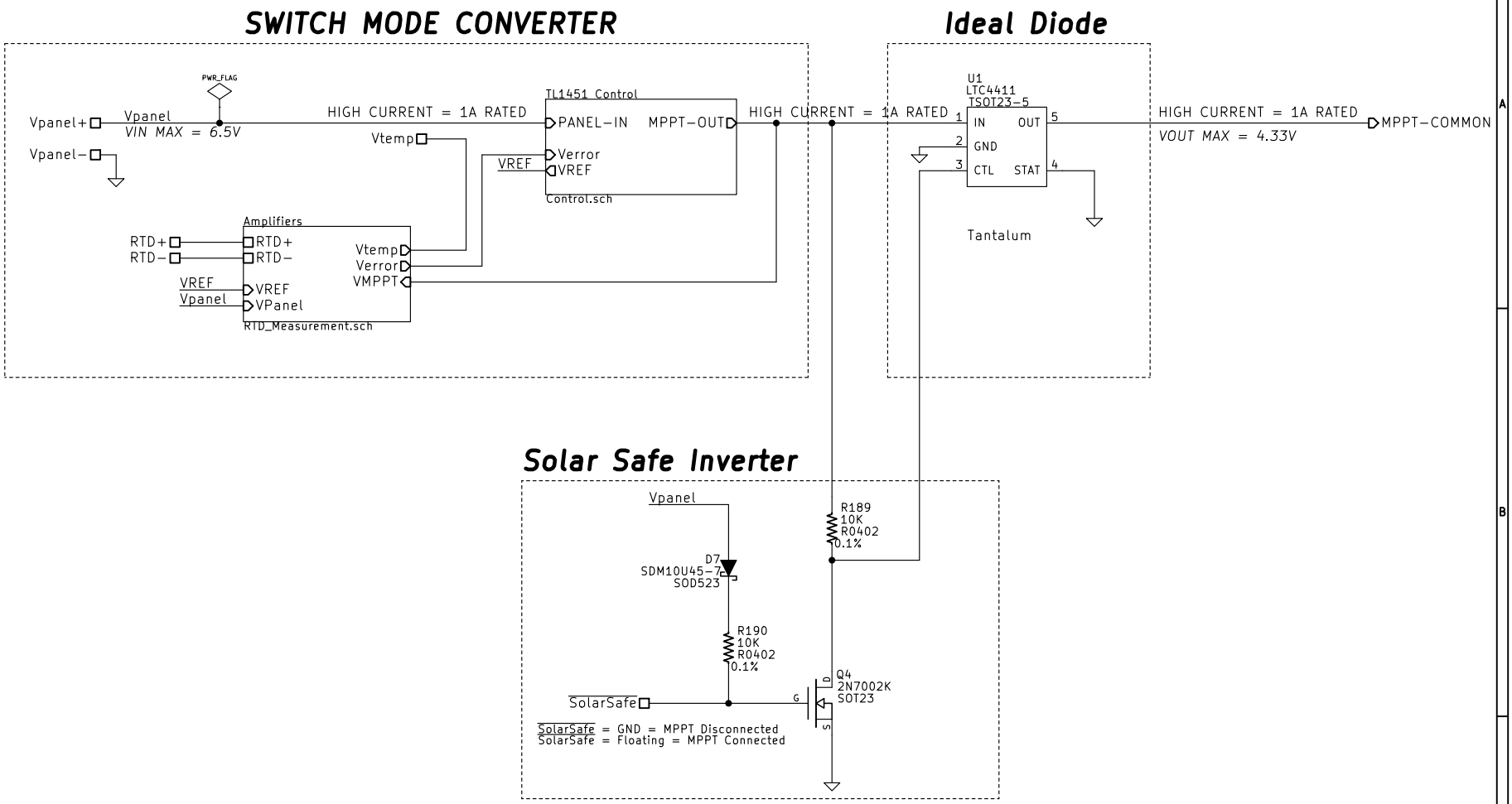
FOX-1 Maximum Power Point Tracker



NOTES

* This MPPT implements a set-point constant voltage tracking algorithm based on panel temperature.
* RIT MPPT Team: Brenton Salmi (KB1LQD), Bryce Salmi (KB1LQC), Ian MacKenzie (KB3OCF), Daniel Corriero.
* NASA derating taken into account, not gauranteed

Based on Rochester Institute of Technology P13271 Design	
Brent Salmi, KB1LQD	
Bryce Salmi, KB1LQC	
The Radio Amateur Satellite Corporation	
File: TL1451_MPPT_Flight_Rev1.sch	
Sheet: /	
Title: Fox-1 Maximum Power Point Tracker	
Size: USLetter *Date: 30 nov 2015*	*Rev: 2.0*
KiCad E.D.A.	Id: 1/37



NOTES

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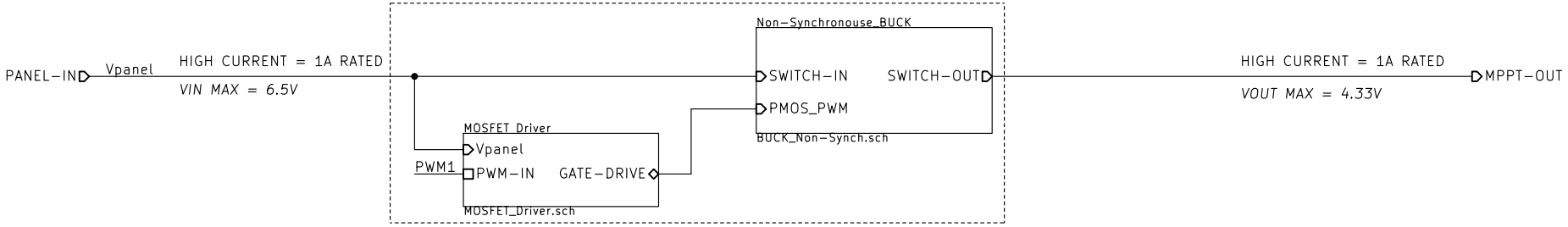
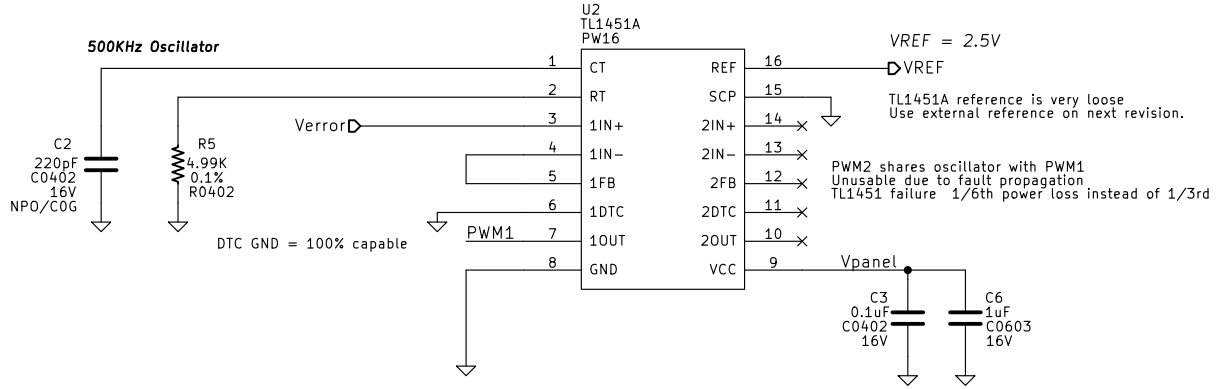
Based on Rochester Institute of Technology P13271 Design		
Brent Salmi, KB1LQD		
Bryce Salmi, KB1LQC		
The Radio Amateur Satellite Corporation		
File: MPPT_String.sch		
Sheet: /MPPT_String_X+/		
Title: Fox−1 Maximum Power Point Tracker		
Size: A	*Date: 30 nov 2015*	*Rev: 2.0*
KiCad E.D.A.		Id: 2/37

Switch Mode Converter





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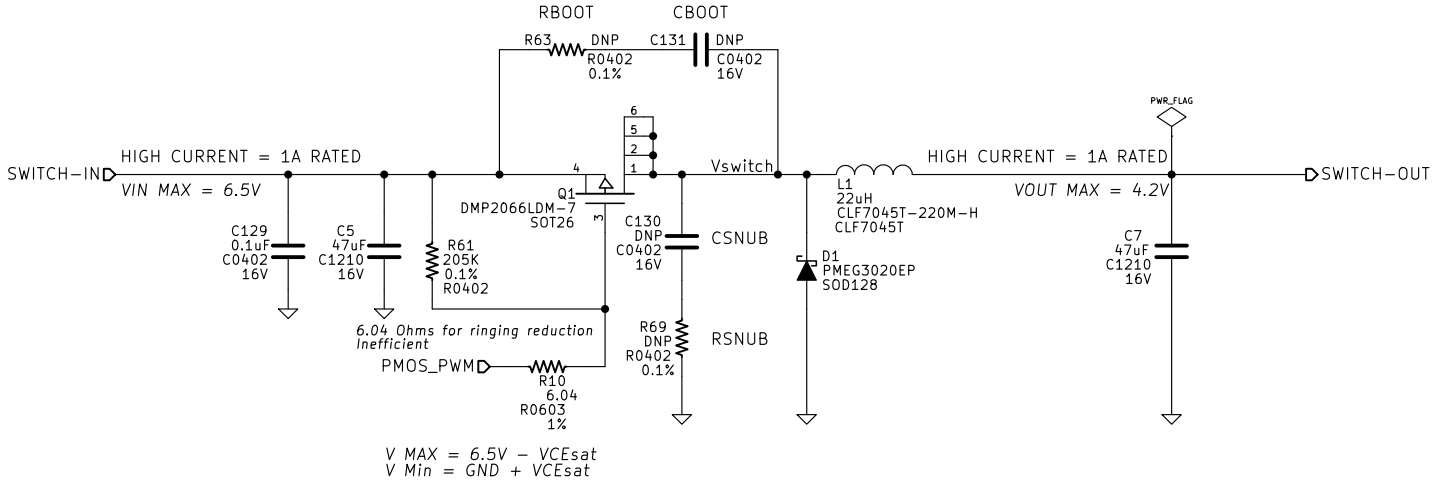
Based on Rochester Institute of Technology P13271 Design		
Brent Salmi, KB1LQD		
Bryce Salmi, KB1LQC		
The Radio Amateur Satellite Corporation		
File: Control.sch		
Sheet: /MPPT_String_X+/TL1451 Control/		
Title: Fox-1 Maximum Power Point Tracker		
Size: A4	*Date: 30 nov 2015*	*Rev: 2.0*
KiCad E.D.A.		Id: 3/37

500 KHz Step-Down Buck Converter



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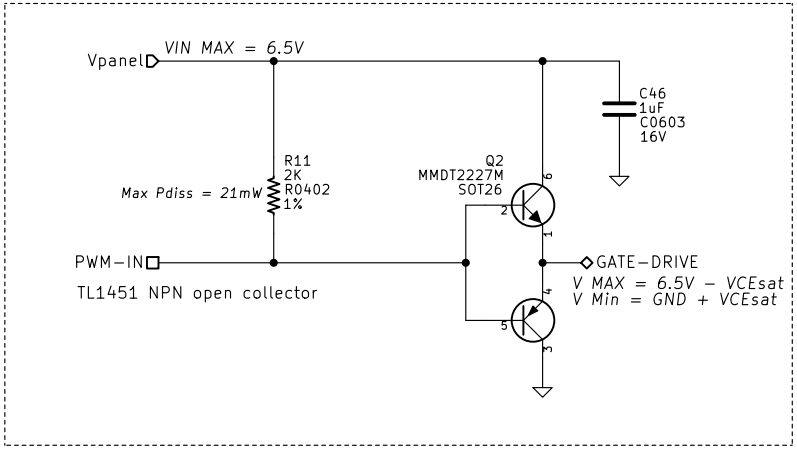
* Parts not yet NASA derated.

Based on Rochester Institute of Technology P13271 Design		
Brent Salmi, KB1LQD		
Bryce Salmi, KB1LQC		
The Radio Amateur Satellite Corporation		
File: BUCK_Non-Synch.sch		
Sheet: /MPPT_String_X+/TL1451 Control/Non-Synchronouse_BUCK/		
Title: Fox-1 Maximum Power Point Tracker		
Size: A4	*Date: 30 nov 2015*	*Rev: 2.0*
KiCad E.D.A.		Id: 4/37

TOTEM POLE MOSFET DRIVER



NOTES

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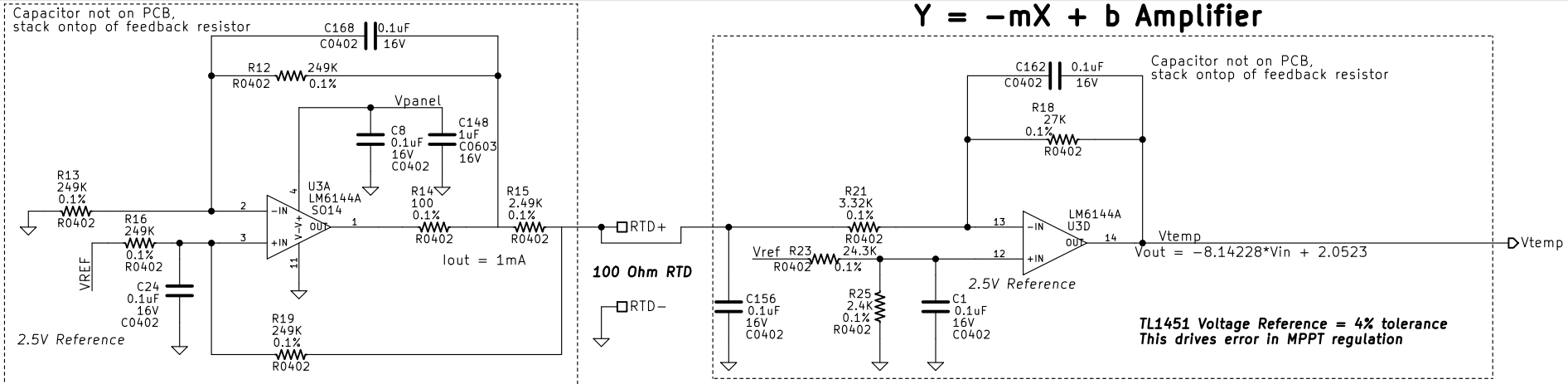
* Parts not yet NASA derated.

Based on Rochester Institute of Technology P13271 Design Brent Salmi, KB1LQD Bryce Salmi, KB1LQC *The Radio Amateur Satellite Corporation*		
File: MOSFET_Driver.sch Sheet: /MPPT_String_X+/TL1451 Control/MOSFET Driver/		
Title: Fox-1 Maximum Power Point Tracker		
Size: A4	*Date: 30 nov 2015*	*Rev: 2.0*
KiCad E.D.A.		Id: 5/37

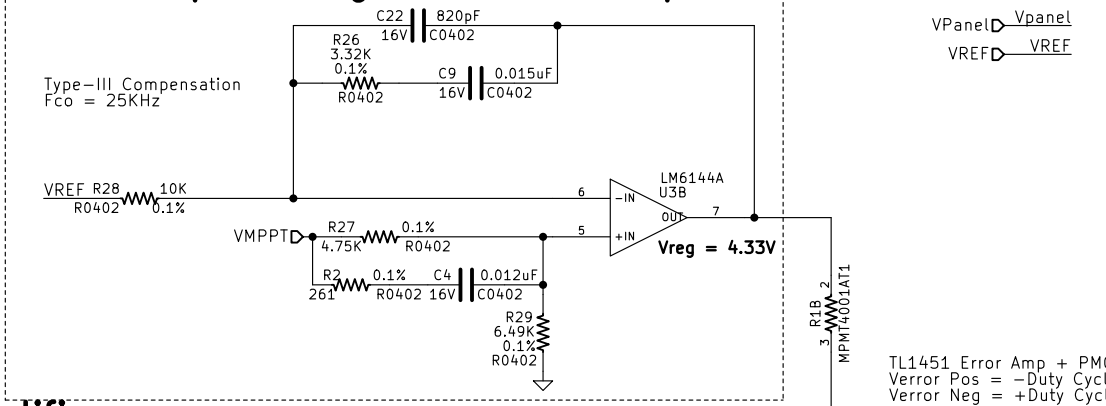


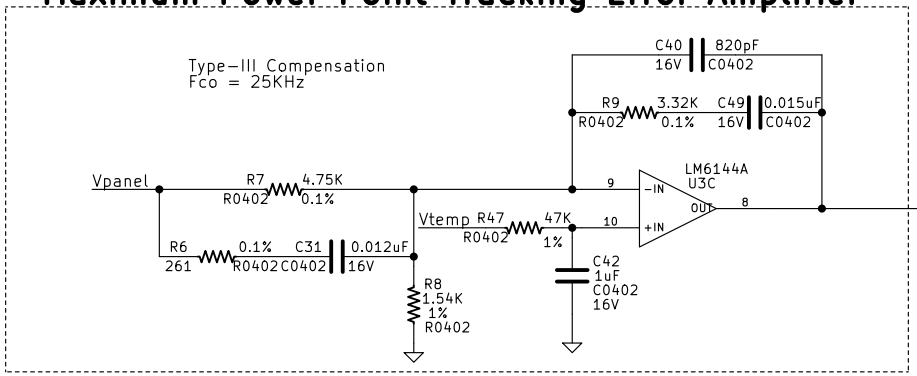
Constant 1mA Current Driver

Highest Voltage Wins = Lowest Duty Cycle Wins

MPPT = Vout 3.3V to 4.33V
VregError −> Increasing Duty Cycle = Decrease voltage

Regulation = Vout 4.33V, Vpanel increasing
Vmppt Error −> increases duty cycle (to load panel) so it looses





NOTES

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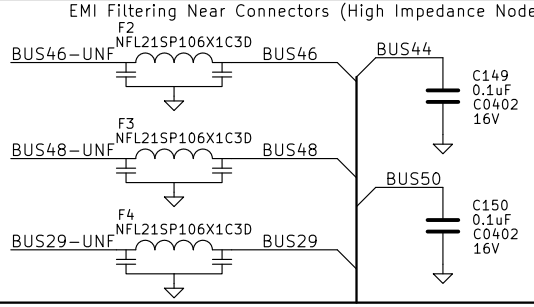
* NASA derating taken into account, not gauranteed

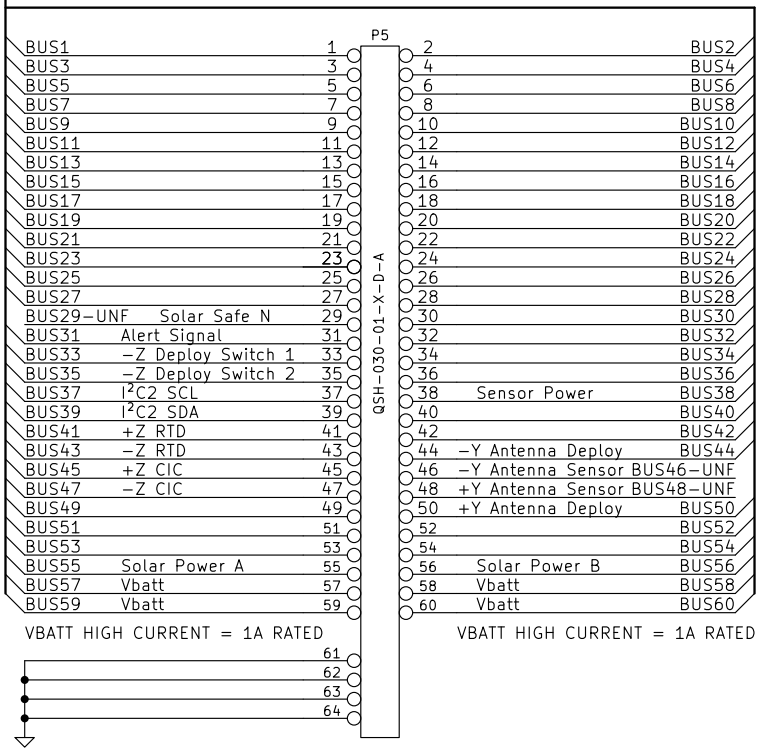
Based on Rochester Institute of Technology P13271 Design		
Brent Salmi, KB1LQD		
Bryce Salmi, KB1LQC		
The Radio Amateur Satellite Corporation		
File: RTD_Measurement.sch		
Sheet: /MPPT_String_X+/Amplifiers/		
Title: Fox−1 Maximum Power Point Tracker		
Size: A4	*Date: 30 nov 2015*	*Rev: 2.0*
KiCad E.D.A.		Id: 6/37

+Y Antenna Deploy & −Y Antenna Deploy
Deploy resistors = 6.98 Ohms
Imax = 4.2V/6.98V = 602mA
Pmax = 2.53W

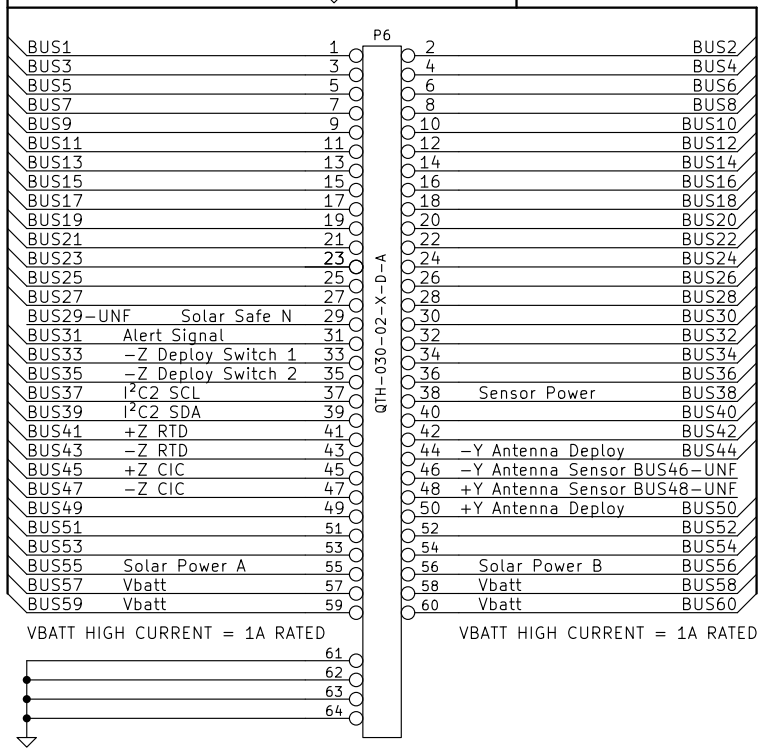
EMI Filtering Near Connectors (High Impedance Nodes)



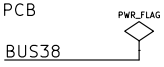
BUS[1..60]



BUS[1..60]



BUS38 Sensor Power is driven by the IHU PCB



NOTES

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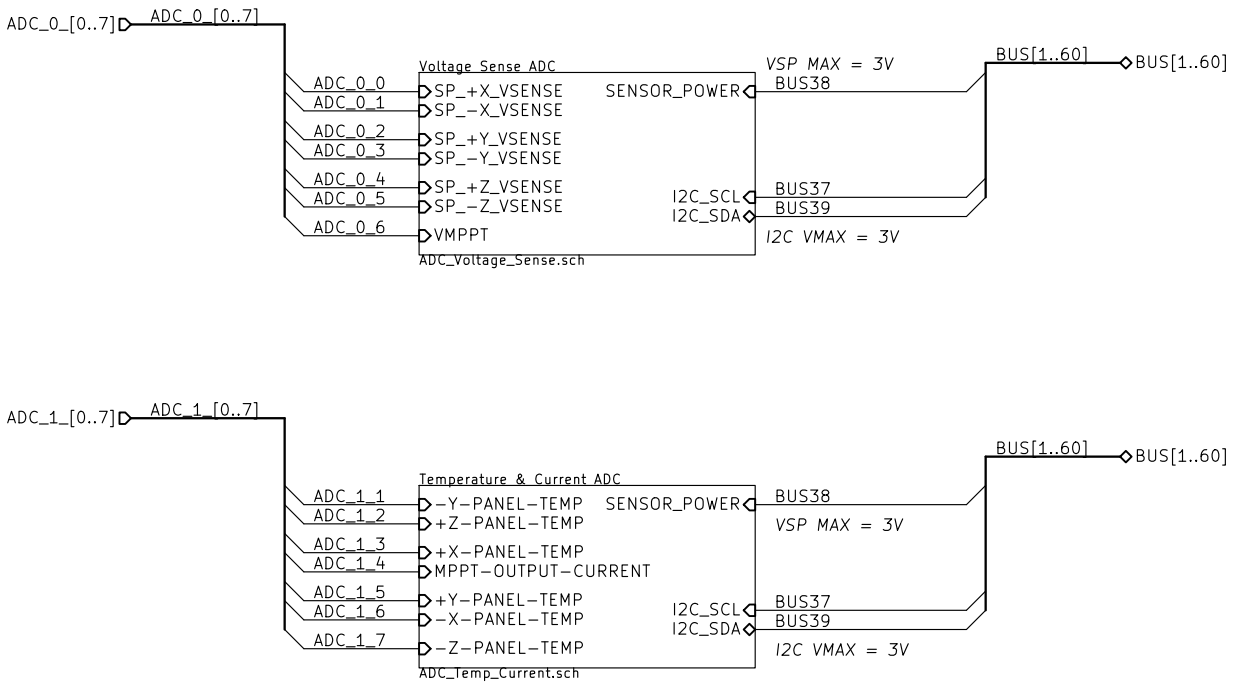
Based on Rochester Institute of Technology P13271 Design		
Brent Salmi, KB1LQD		
Bryce Salmi, KB1LQC		
The Radio Amateur Satellite Corporation		
File: Connectors.sch		
Sheet: /Connectors/		
Title: Fox−1 Maximum Power Point Tracker		
Size: A4	*Date: 30 nov 2015*	*Rev: 2.0*
KiCad E.D.A.		Id: 7/37



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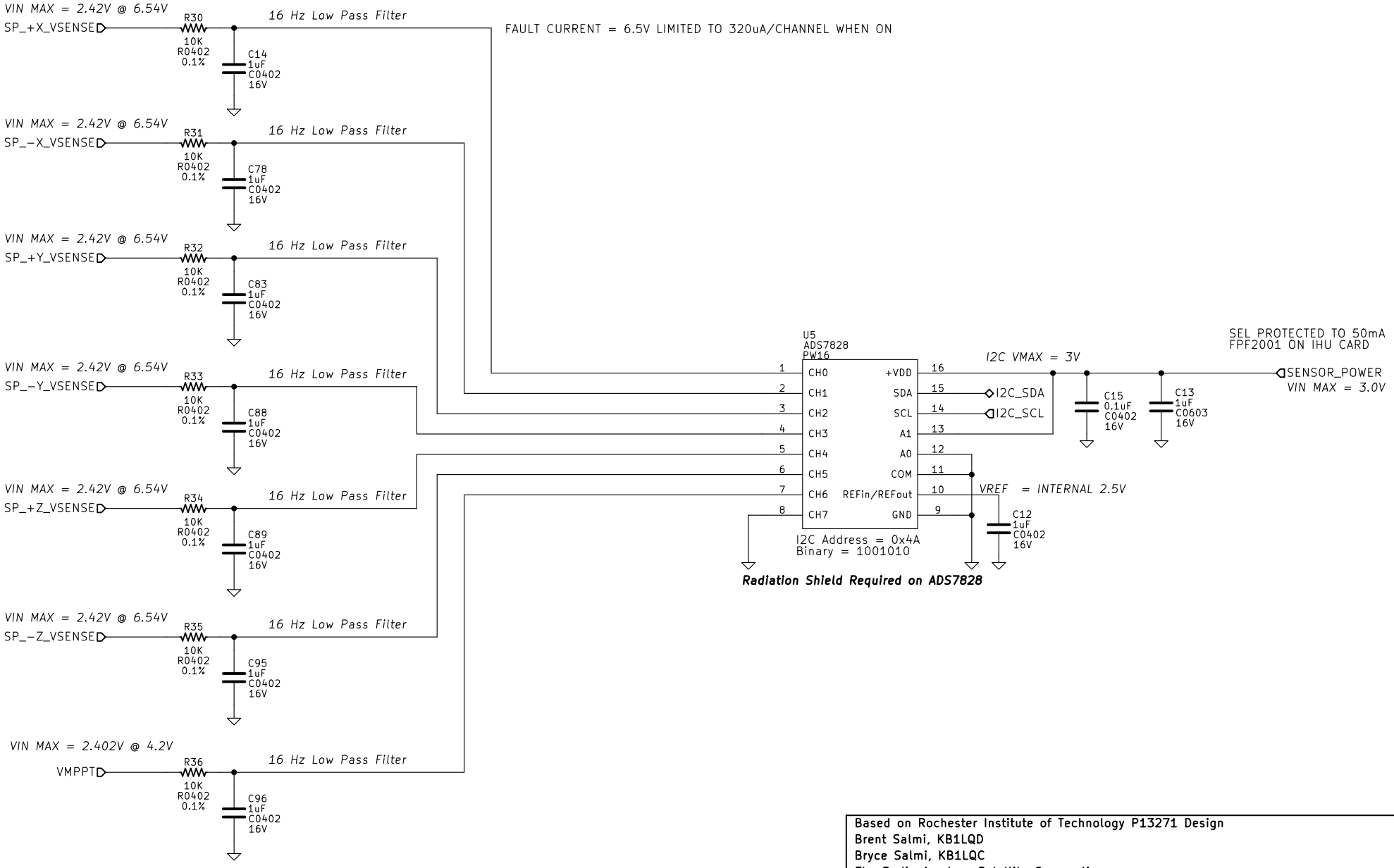
Based on Rochester Institute of Technology P13271 Design Brent Salmi, KB1LQD Bryce Salmi, KB1LQC *The Radio Amateur Satellite Corporation*		
File: ADC_Channels.sch Sheet: /ADC Channels/		
Title: Fox−1 Maximum Power Point Tracker		
Size: A4	*Date: 30 nov 2015*	*Rev: 2.0*
KiCad E.D.A.		Id: 8/37



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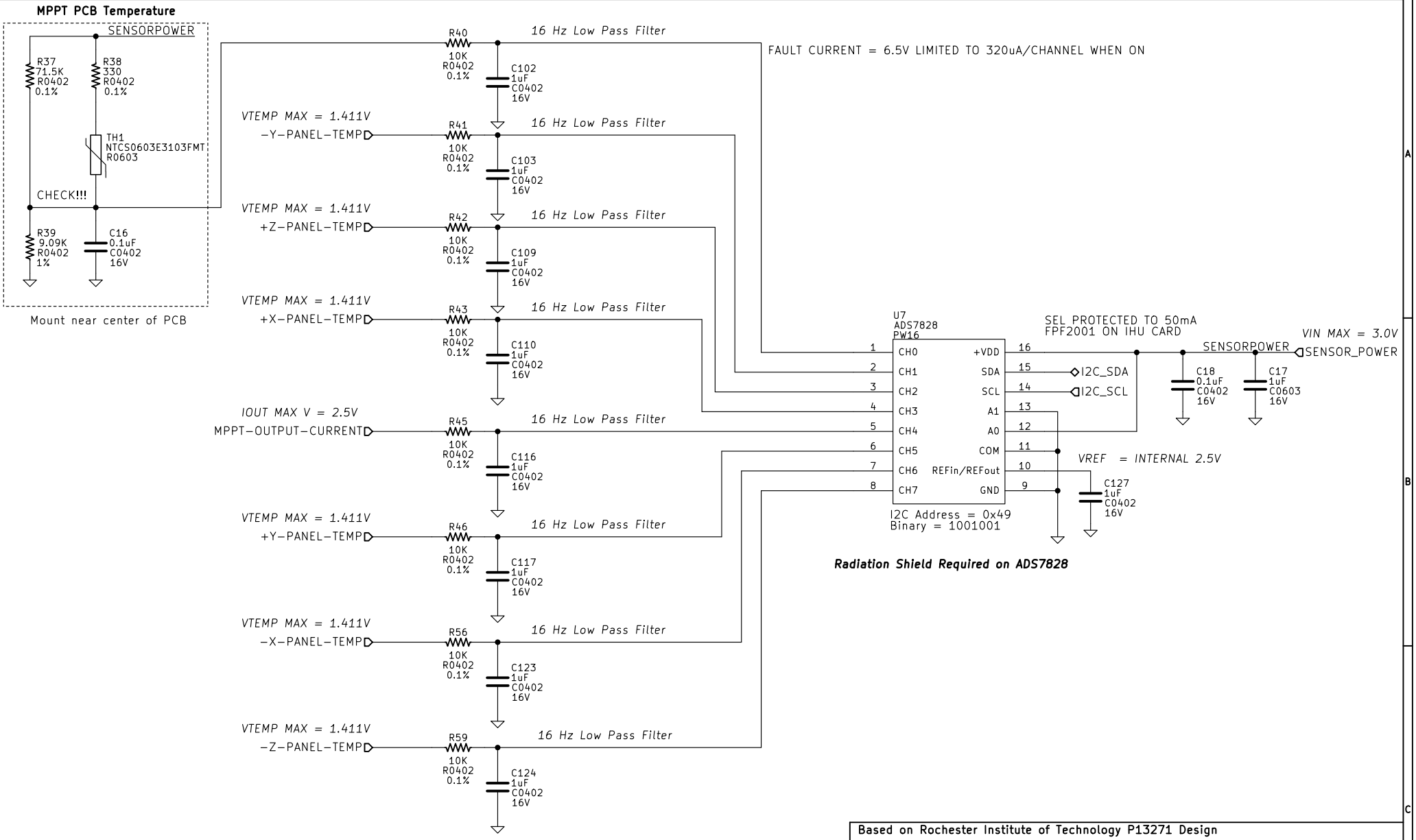
Based on Rochester Institute of Technology P13271 Design		
Brent Salmi, KB1LQD		
Bryce Salmi, KB1LQC		
The Radio Amateur Satellite Corporation		
File: ADC_Voltage_Sense.sch		
Sheet: /ADC Channels/Voltage Sense ADC/		
Title: Fox−1 Maximum Power Point Tracker		
Size: A4	*Date: 30 nov 2015*	*Rev: 2.0*
KiCad E.D.A.		Id: 9/37



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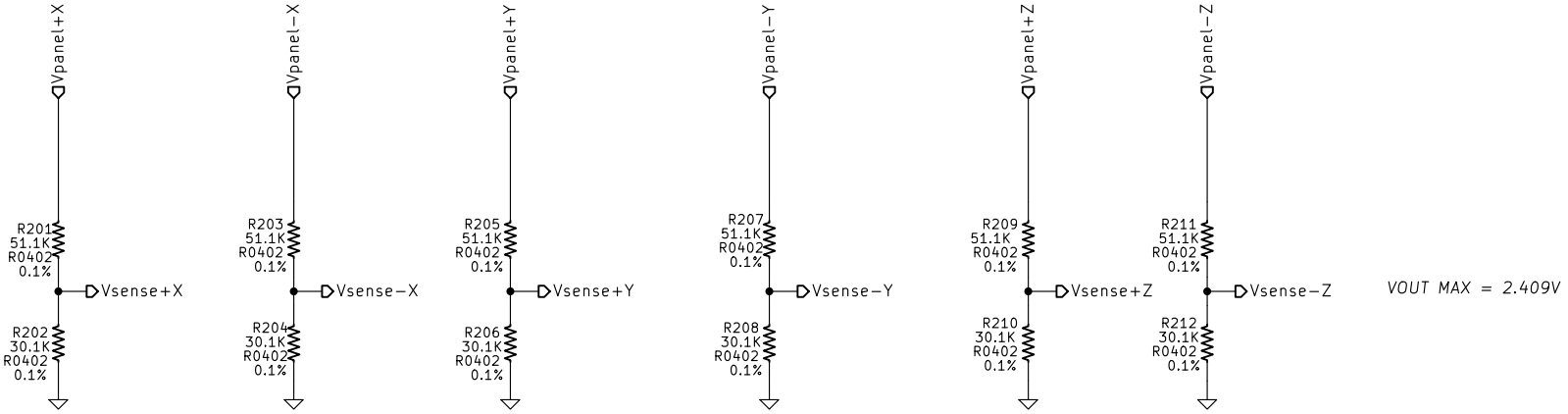
Based on Rochester Institute of Technology P13271 Design		
Brent Salmi, KB1LQD		
Bryce Salmi, KB1LQC		
The Radio Amateur Satellite Corporation		
File: ADC_Temp_Current.sch		
Sheet: /ADC Channels/Temperature & Current ADC/		
Title: Fox-1 Maximum Power Point Tracker		
Size: A4	*Date: 30 nov 2015*	*Rev: 2.0*
KiCad E.D.A.		Id: 10/37

PANEL VOLTAGE TELEMETRY ADC SCALING

VIN MAX = 6.5V



VOUT MAX = 2.409V

NOTES

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Based on Rochester Institute of Technology P13271 Design		
Brent Salmi, KB1LQD		
Bryce Salmi, KB1LQC		
The Radio Amateur Satellite Corporation		
File: VpanelScaling.sch		
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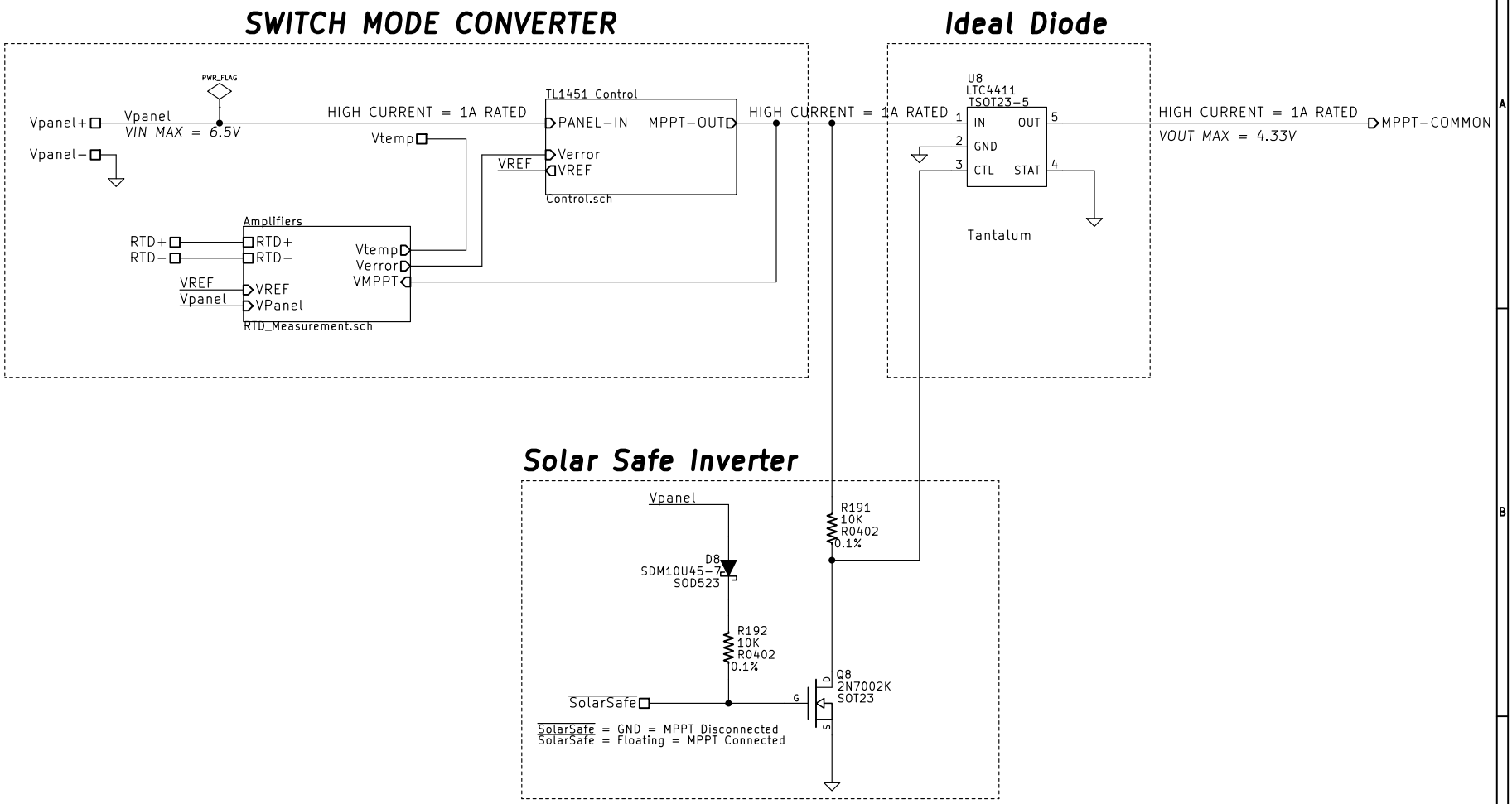
Title:		
Size: A4	*Date: 30 nov 2015*	*Rev: 2.0*
KiCad E.D.A.		Id: 11/37



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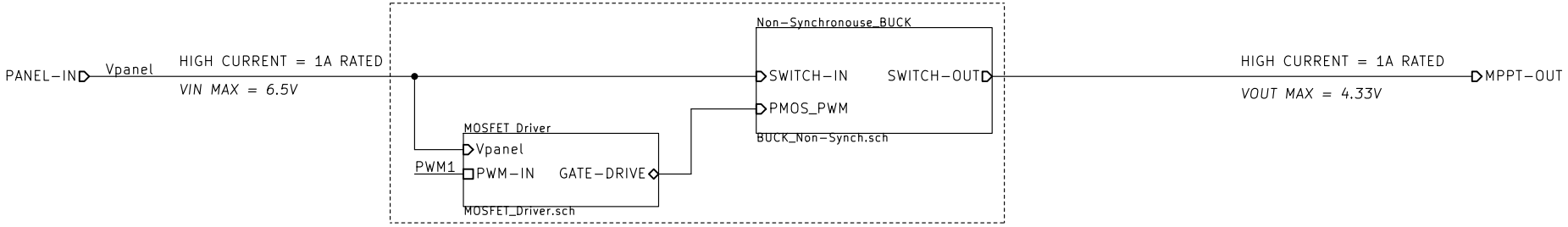
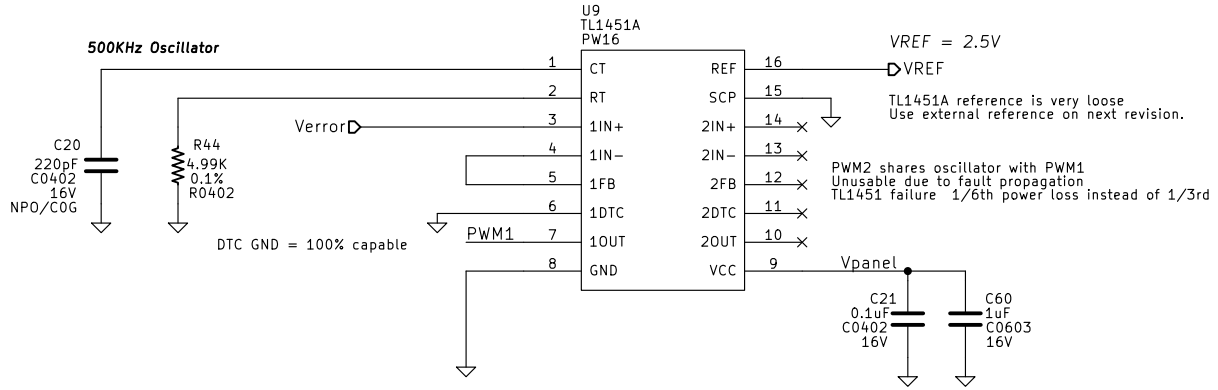
Based on Rochester Institute of Technology P13271 Design		
Brent Salmi, KB1LQD		
Bryce Salmi, KB1LQC		
The Radio Amateur Satellite Corporation		
File: MPPT_String.sch		
Sheet: /MPPT_String_X−/		
Title: Fox−1 Maximum Power Point Tracker		
Size: A	*Date: 30 nov 2015*	*Rev: 2.0*
KiCad E.D.A.		Id: 12/37

Switch Mode Converter





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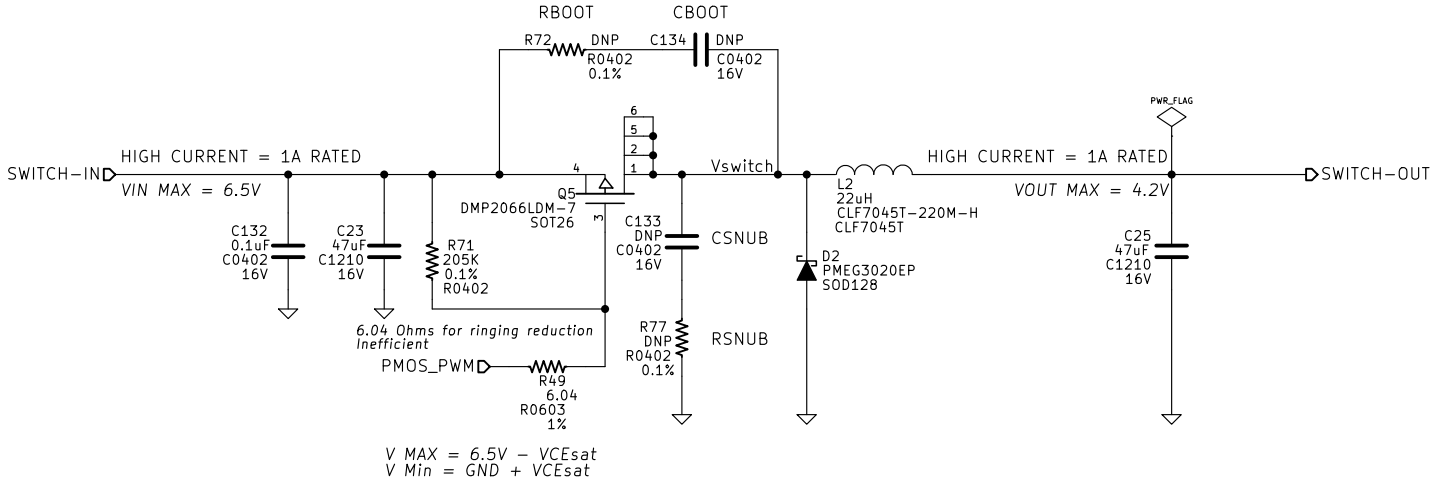
Based on Rochester Institute of Technology P13271 Design		
Brent Salmi, KB1LQD		
Bryce Salmi, KB1LQC		
The Radio Amateur Satellite Corporation		
File: Control.sch		
Sheet: /MPPT_String_X-/TL1451 Control/		
Title: Fox-1 Maximum Power Point Tracker		
Size: A4	*Date: 30 nov 2015*	*Rev: 2.0*
KiCad E.D.A.		Id: 13/37

500 KHz Step-Down Buck Converter



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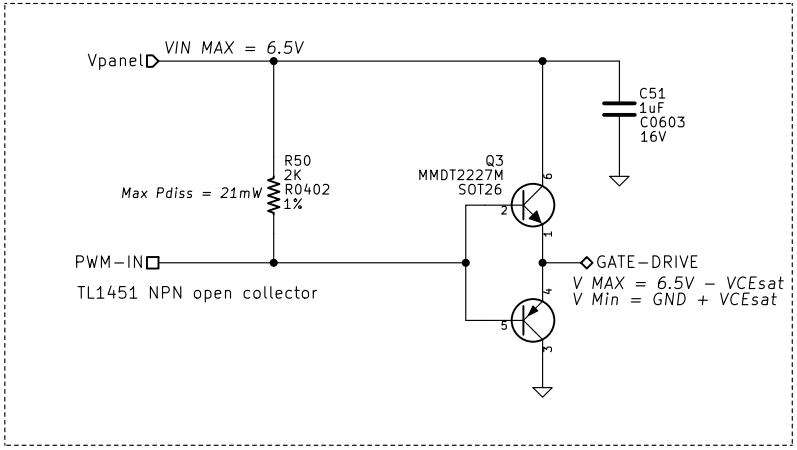
Based on Rochester Institute of Technology P13271 Design		
Brent Salmi, KB1LQD		
Bryce Salmi, KB1LQC		
The Radio Amateur Satellite Corporation		
File: BUCK_Non-Synch.sch		
Sheet: /MPPT_String_X-/TL1451 Control/Non-Synchronouse_BUCK/		
Title: Fox-1 Maximum Power Point Tracker		
Size: A4	*Date: 30 nov 2015*	*Rev: 2.0*
KiCad E.D.A.		Id: 14/37

TOTEM POLE MOSFET DRIVER



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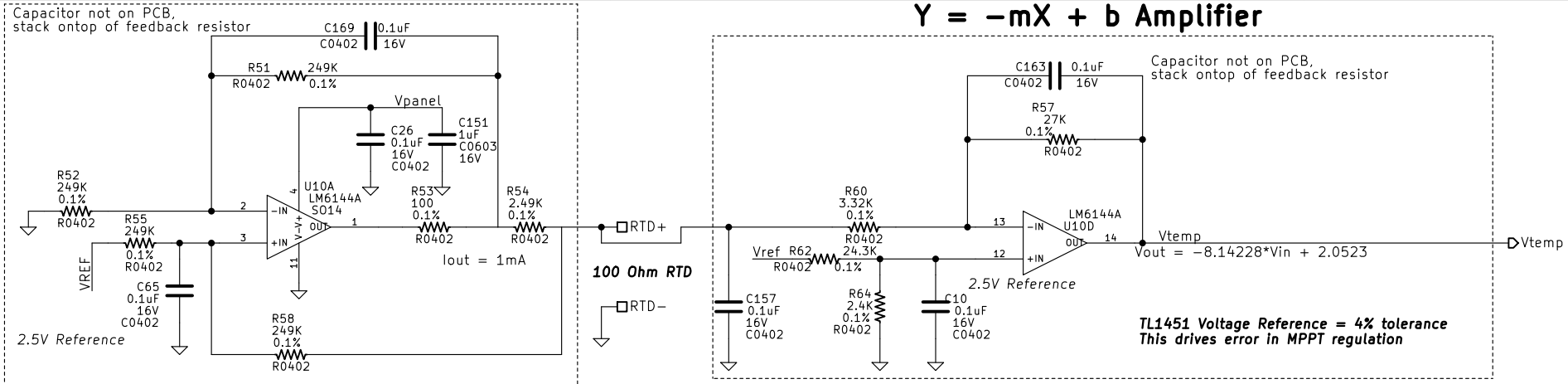
Based on Rochester Institute of Technology P13271 Design Brent Salmi, KB1LQD Bryce Salmi, KB1LQC *The Radio Amateur Satellite Corporation*		
File: MOSFET_Driver.sch Sheet: /MPPT_String_X-/TL1451 Control/MOSFET Driver/		
Title: Fox-1 Maximum Power Point Tracker		
Size: A4	*Date: 30 nov 2015*	*Rev: 2.0*
KiCad E.D.A.		Id: 15/37

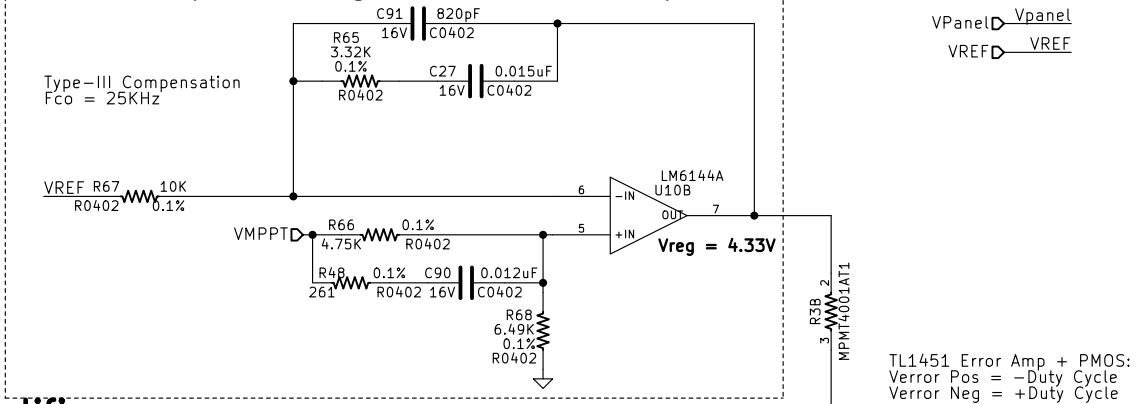


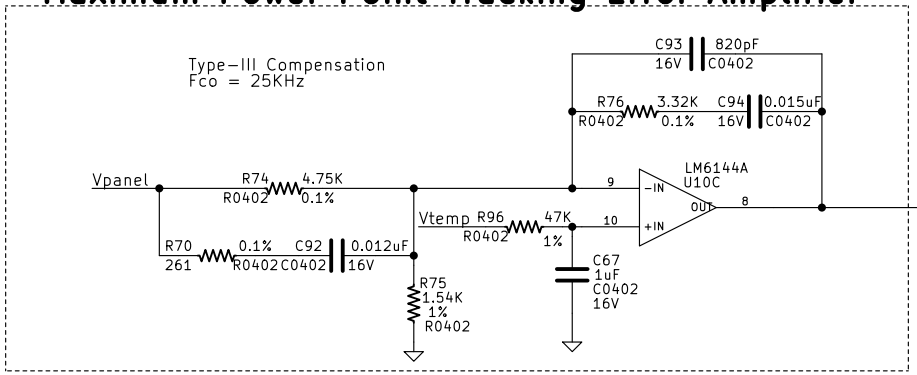
Constant 1mA Current Driver

Highest Voltage Wins = Lowest Duty Cycle Wins

MPPT = Vout 3.3V to 4.33V
VregError −> Increasing Duty Cycle = Decrease voltage

Regulation = Vout 4.33V, Vpanel increasing
Vmppt Error −> increases duty cycle (to load panel) so it looses





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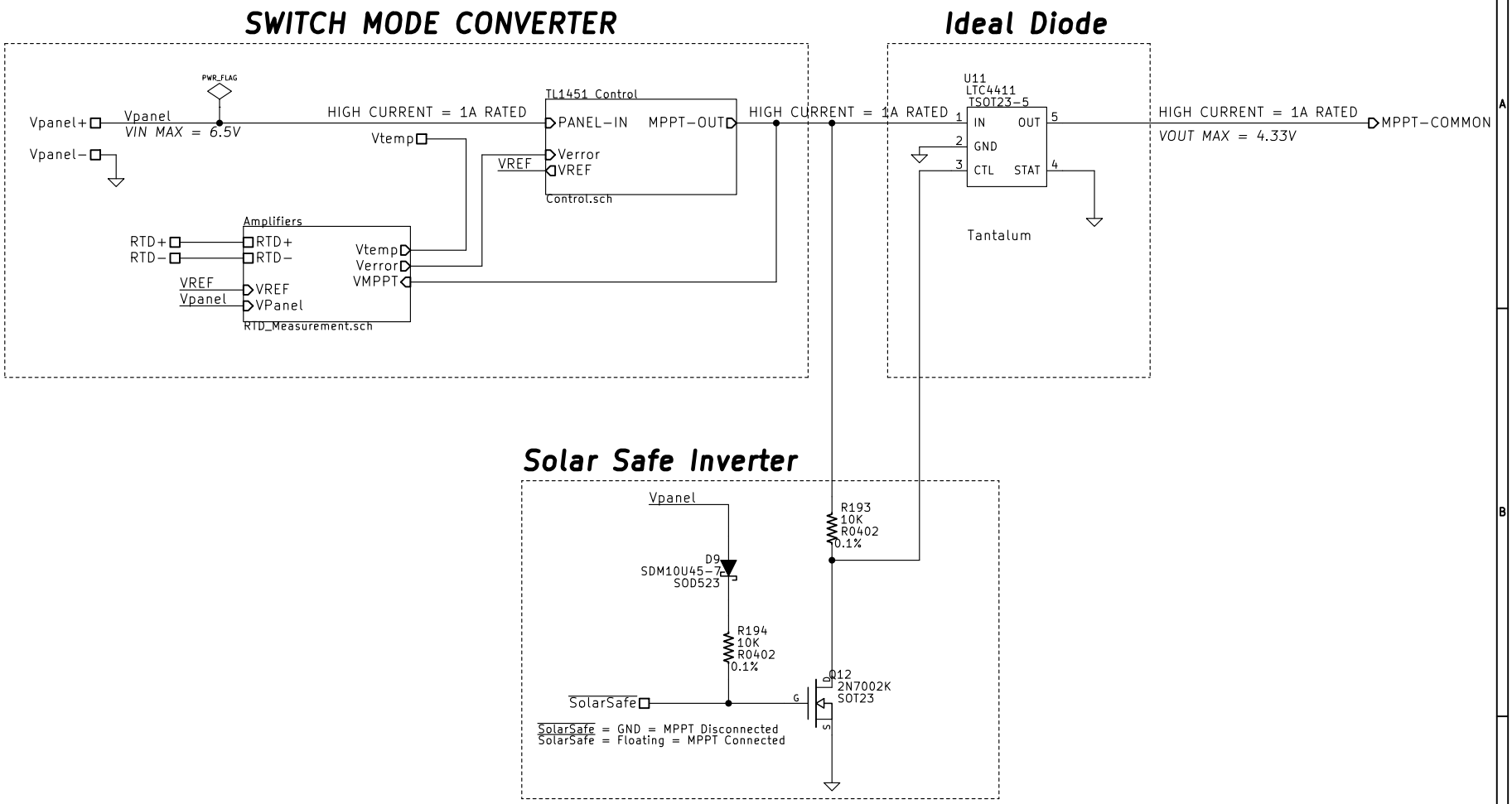
Based on Rochester Institute of Technology P13271 Design		
Brent Salmi, KB1LQD		
Bryce Salmi, KB1LQC		
The Radio Amateur Satellite Corporation		
File: RTD_Measurement.sch		
Sheet: /MPPT_String_X−/Amplifiers/		
Title: Fox−1 Maximum Power Point Tracker		
Size: A4	*Date: 30 nov 2015*	*Rev: 2.0*
KiCad E.D.A.		Id: 16/37



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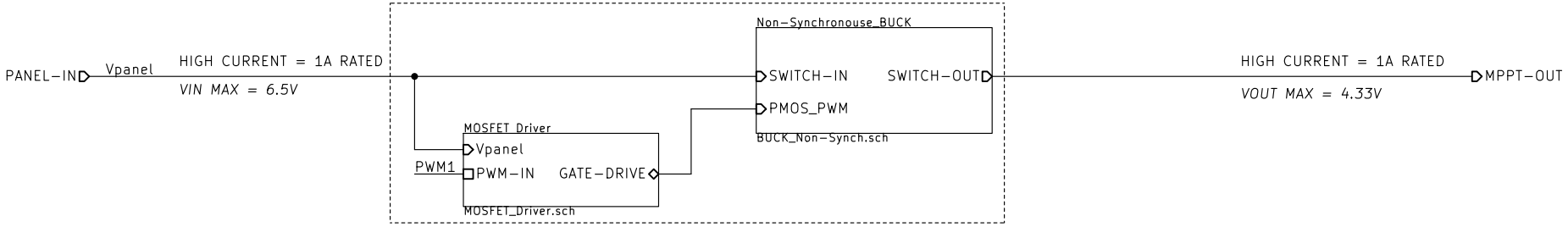
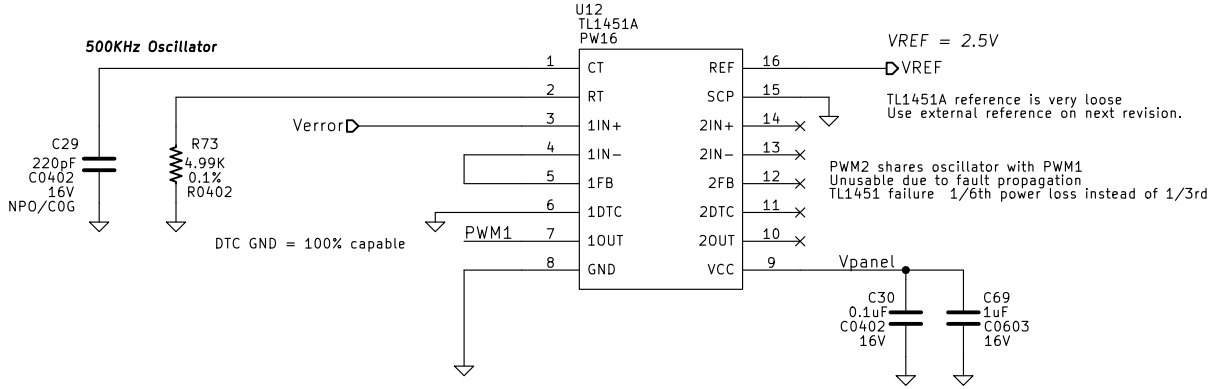
Based on Rochester Institute of Technology P13271 Design		
Brent Salmi, KB1LQD		
Bryce Salmi, KB1LQC		
The Radio Amateur Satellite Corporation		
File: MPPT_String.sch		
Sheet: /MPPT_String_Y+/		
Title: Fox−1 Maximum Power Point Tracker		
Size: A	*Date: 30 nov 2015*	*Rev: 2.0*
KiCad E.D.A.		Id: 17/37

Switch Mode Converter





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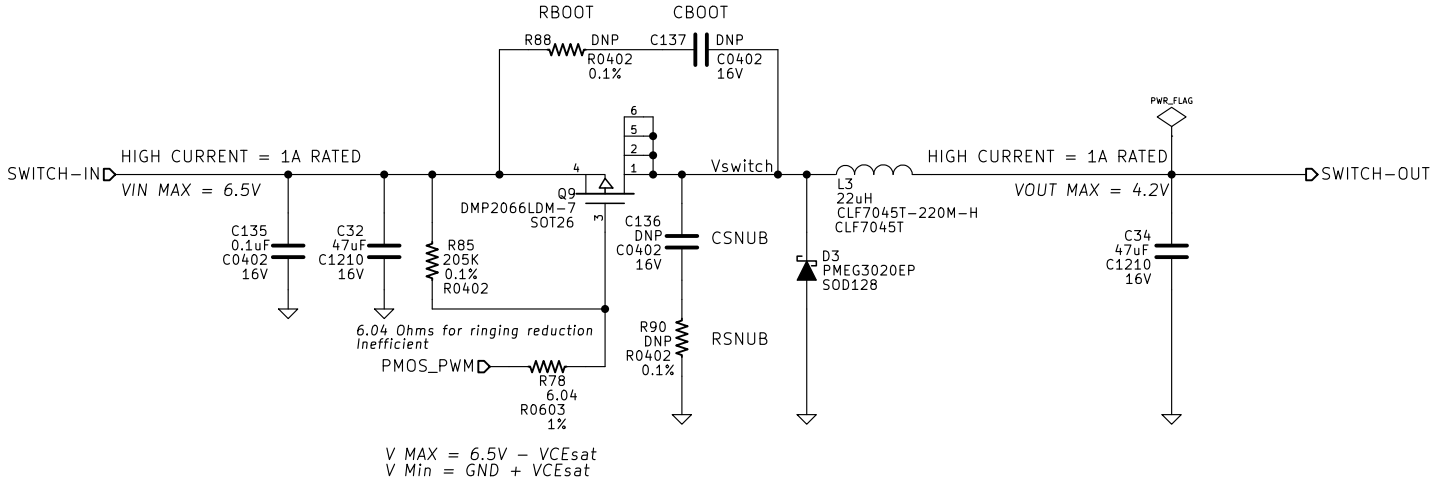
Based on Rochester Institute of Technology P13271 Design		
Brent Salmi, KB1LQD		
Bryce Salmi, KB1LQC		
The Radio Amateur Satellite Corporation		
File: Control.sch		
Sheet: /MPPT_String_Y+/TL1451 Control/		
Title: Fox-1 Maximum Power Point Tracker		
Size: A4	*Date: 30 nov 2015*	*Rev: 2.0*
KiCad E.D.A.		Id: 18/37

500 KHz Step-Down Buck Converter



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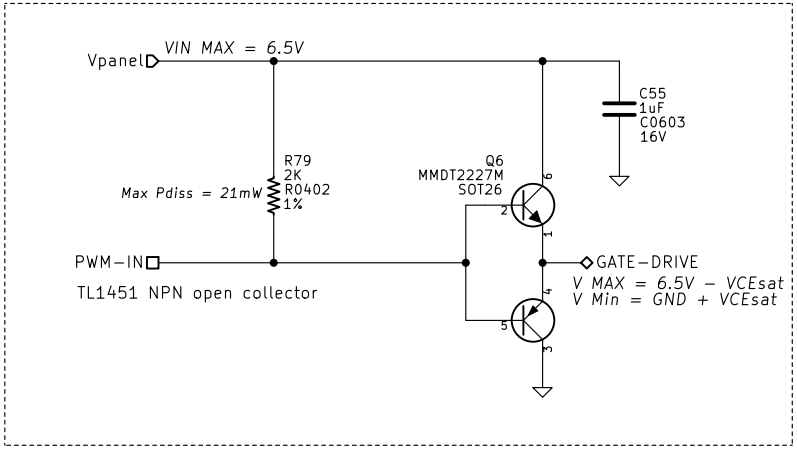
* Parts not yet NASA derated.

Based on Rochester Institute of Technology P13271 Design		
Brent Salmi, KB1LQD		
Bryce Salmi, KB1LQC		
The Radio Amateur Satellite Corporation		
File: BUCK_Non-Synch.sch		
Sheet: /MPPT_String_Y+/TL1451 Control/Non-Synchronouse_BUCK/		
Title: Fox-1 Maximum Power Point Tracker		
Size: A4	*Date: 30 nov 2015*	*Rev: 2.0*
KiCad E.D.A.		Id: 19/37

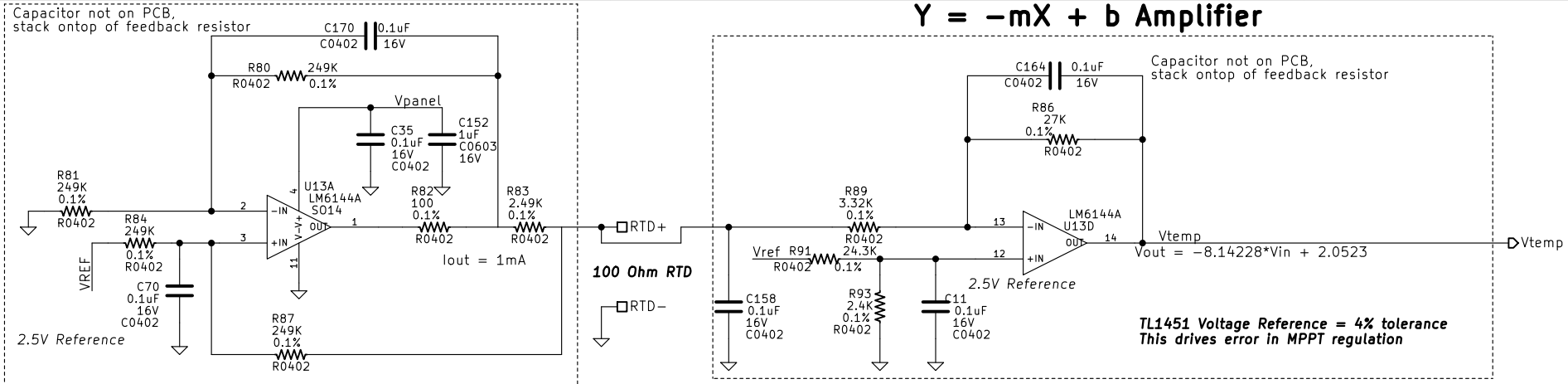
TOTEM POLE MOSFET DRIVER



NOTES

* This MPPT implements a set-point constant voltage tracking algorithm based on panel temperature.
* RIT MPPT Team: Brenton Salmi (KB1LQD), Bryce Salmi (KB1LQC), Ian MacKenzie (KB3OCF), Daniel Corriero.
* Parts not yet NASA derated.

Based on Rochester Institute of Technology P13271 Design Brent Salmi, KB1LQD Bryce Salmi, KB1LQC *The Radio Amateur Satellite Corporation*		
File: MOSFET_Driver.sch Sheet: /MPPT_String_Y+/TL1451 Control/MOSFET Driver/		
Title: Fox-1 Maximum Power Point Tracker		
Size: A4	*Date: 30 nov 2015*	*Rev: 2.0*
KiCad E.D.A.		Id: 20/37

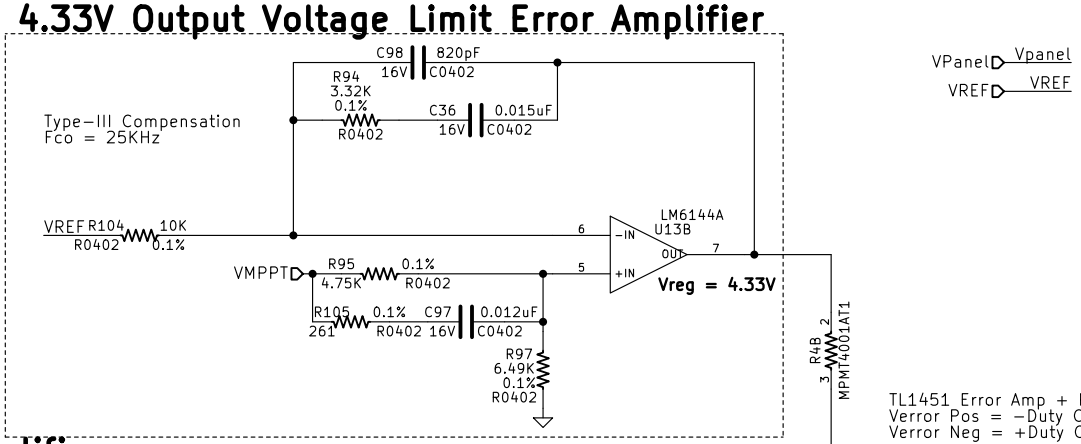


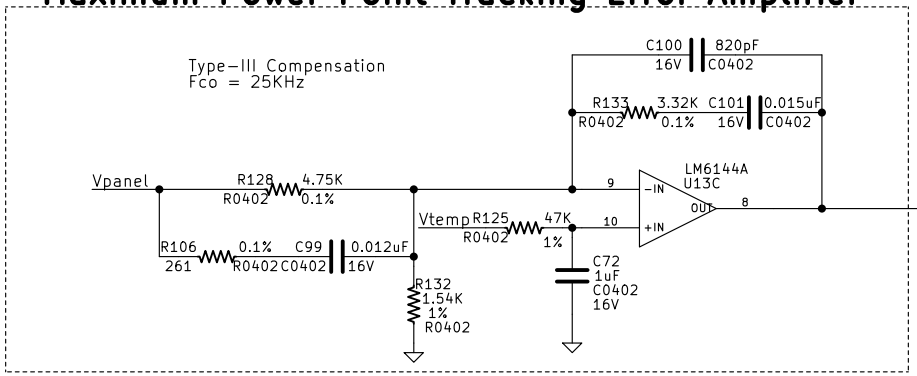
Constant 1mA Current Driver

Highest Voltage Wins = Lowest Duty Cycle Wins

MPPT = Vout 3.3V to 4.33V
VregError −> Increasing Duty Cycle = Decrease voltage

Regulation = Vout 4.33V, Vpanel increasing
Vmppt Error −> increases duty cycle (to load panel) so it looses





NOTES

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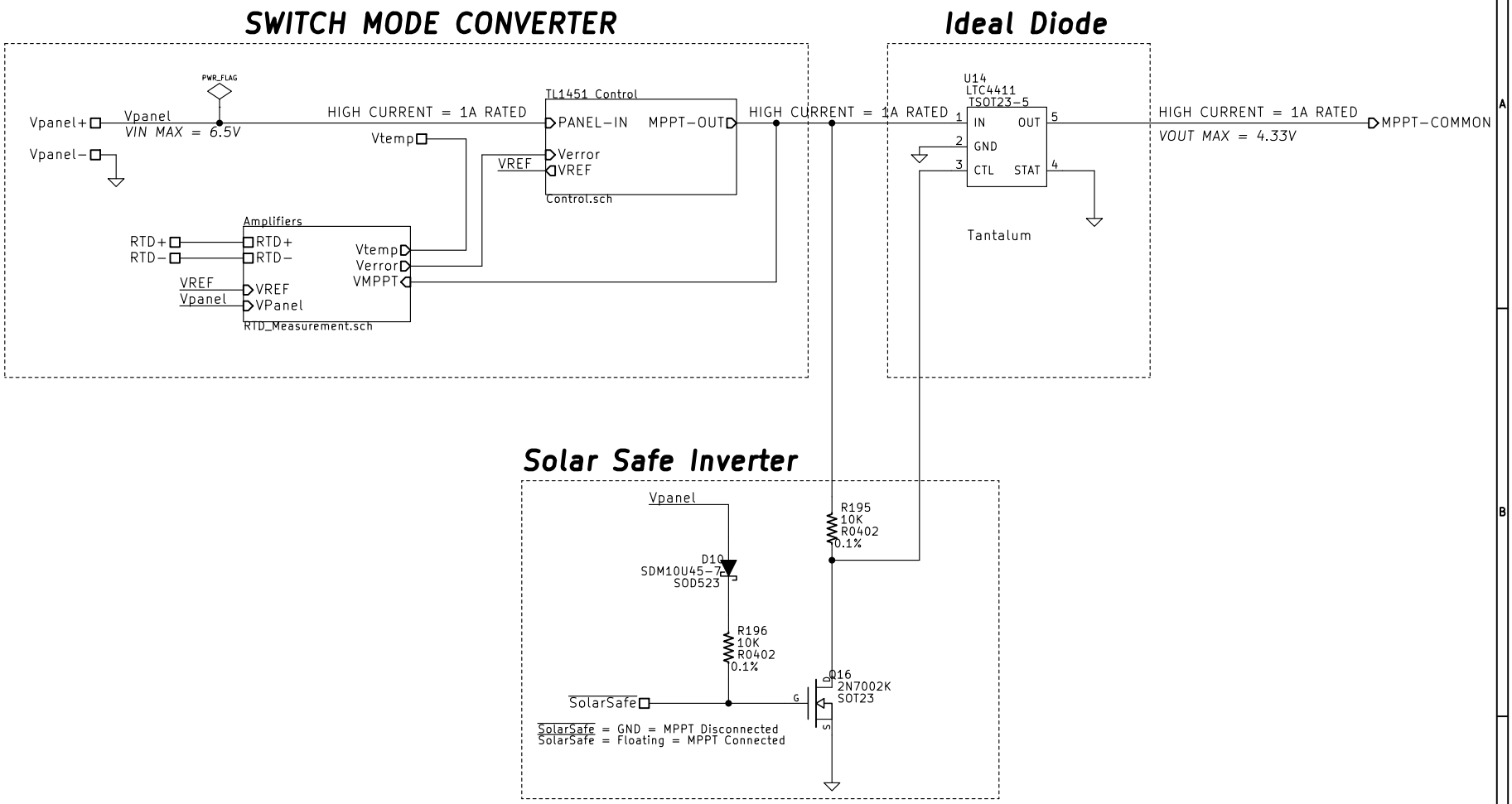
* NASA derating taken into account, not gauranteed

Based on Rochester Institute of Technology P13271 Design		
Brent Salmi, KB1LQD		
Bryce Salmi, KB1LQC		
The Radio Amateur Satellite Corporation		
File: RTD_Measurement.sch		
Sheet: /MPPT_String_Y+/Amplifiers/		
Title: Fox−1 Maximum Power Point Tracker		
Size: A4	*Date: 30 nov 2015*	*Rev: 2.0*
KiCad E.D.A.		Id: 21/37



NOTES

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* RIT MPPT Team: Brenton Salmi (KB1LQD), Bryce Salmi (KB1LQC), Ian MacKenzie (KB3OCF), Daniel Corriero.
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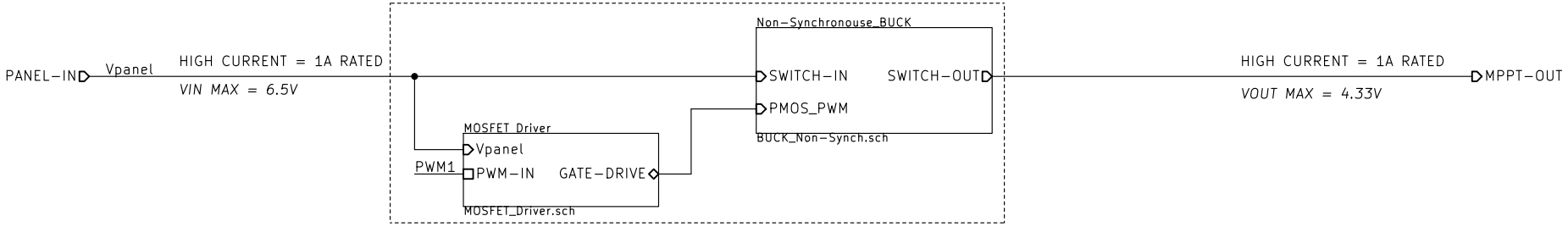
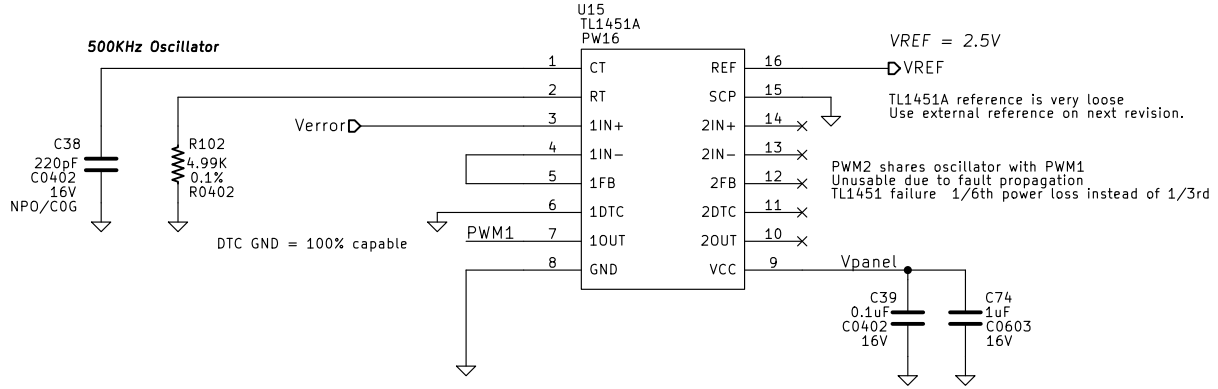
Based on Rochester Institute of Technology P13271 Design		
Brent Salmi, KB1LQD		
Bryce Salmi, KB1LQC		
The Radio Amateur Satellite Corporation		
File: MPPT_String.sch		
Sheet: /MPPT_String_Y−/		
Title: Fox−1 Maximum Power Point Tracker		
Size: A	*Date: 30 nov 2015*	*Rev: 2.0*
KiCad E.D.A.		Id: 22/37

Switch Mode Converter





NOTES

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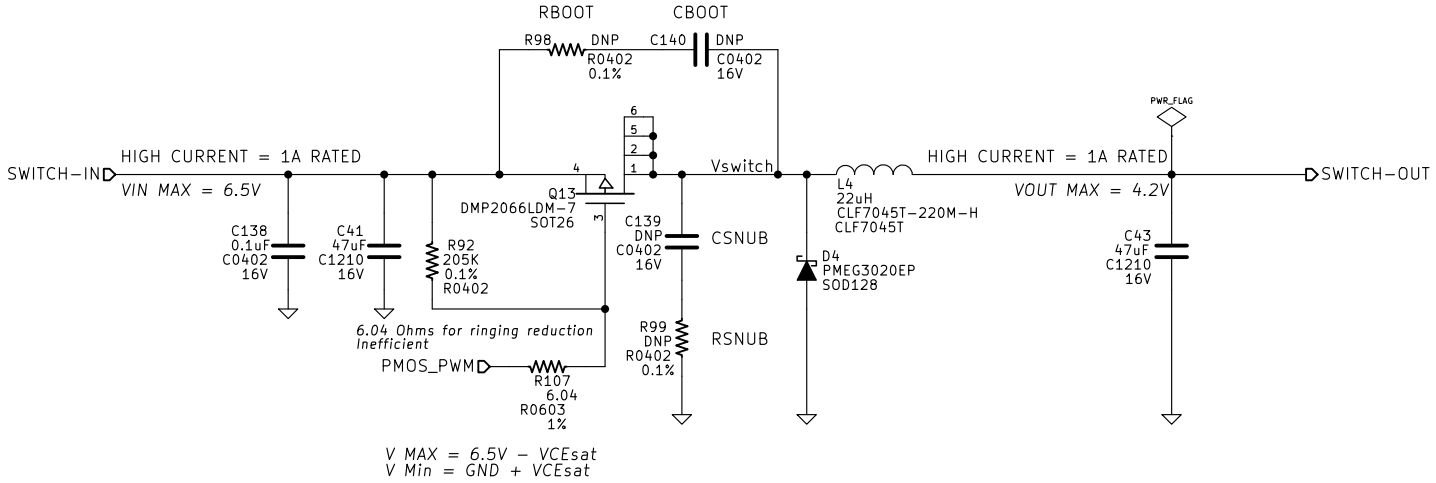
* NASA derating taken into account, not gauranteed

Based on Rochester Institute of Technology P13271 Design		
Brent Salmi, KB1LQD		
Bryce Salmi, KB1LQC		
The Radio Amateur Satellite Corporation		
File: Control.sch		
Sheet: /MPPT_String_Y-/TL1451 Control/		
Title: Fox-1 Maximum Power Point Tracker		
Size: A4	*Date: 30 nov 2015*	*Rev: 2.0*
KiCad E.D.A.		Id: 23/37

500 KHz Step-Down Buck Converter



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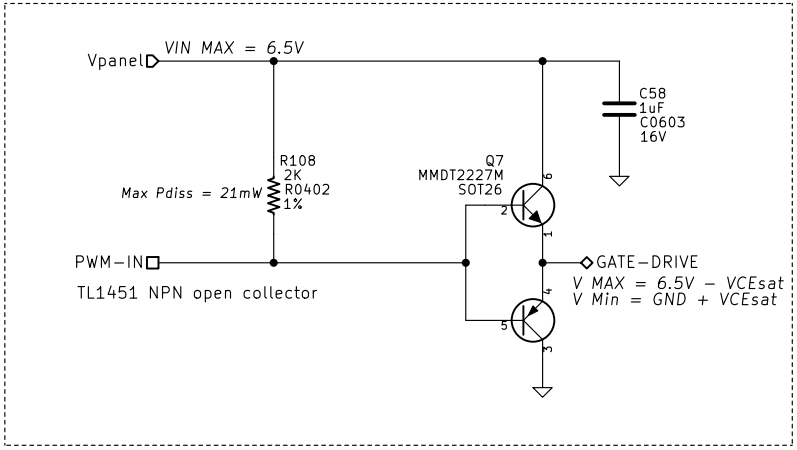
* RIT MPPT Team: Brenton Salmi (KB1LQD), Bryce Salmi (KB1LQC), Ian MacKenzie (KB3OCF), Daniel Corriero.
* Parts not yet NASA derated.

Based on Rochester Institute of Technology P13271 Design		
Brent Salmi, KB1LQD		
Bryce Salmi, KB1LQC		
The Radio Amateur Satellite Corporation		
File: BUCK_Non-Synch.sch		
Sheet: /MPPT_String_Y-/TL1451 Control/Non-Synchronouse_BUCK/		
Title: Fox-1 Maximum Power Point Tracker		
Size: A4	*Date: 30 nov 2015*	*Rev: 2.0*
KiCad E.D.A.		Id: 24/37

TOTEM POLE MOSFET DRIVER



NOTES

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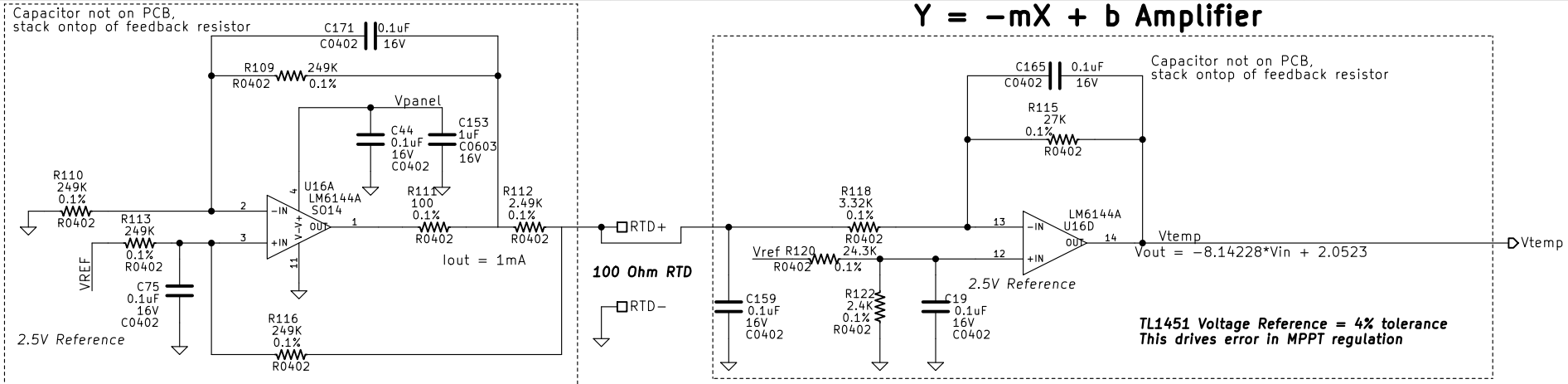
* Parts not yet NASA derated.

Based on Rochester Institute of Technology P13271 Design Brent Salmi, KB1LQD Bryce Salmi, KB1LQC *The Radio Amateur Satellite Corporation*		
File: MOSFET_Driver.sch Sheet: /MPPT_String_Y-/TL1451 Control/MOSFET Driver/		
Title: Fox-1 Maximum Power Point Tracker		
Size: A4	*Date: 30 nov 2015*	*Rev: 2.0*
KiCad E.D.A.		Id: 25/37

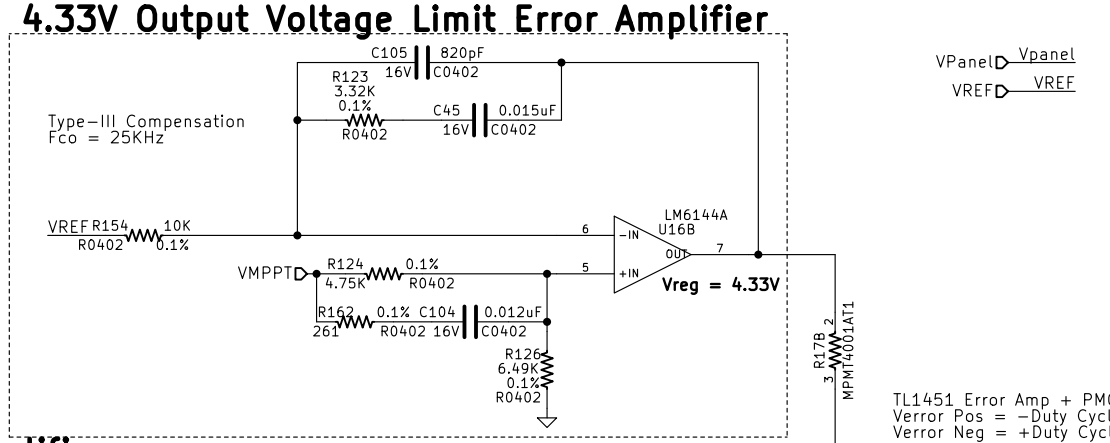


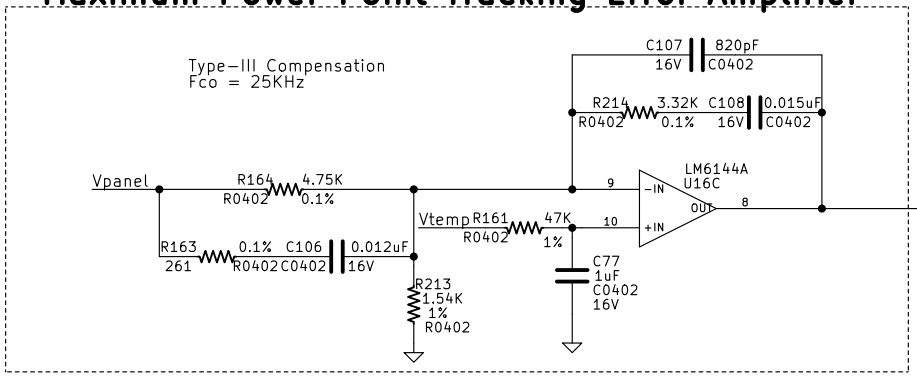
Constant 1mA Current Driver

Highest Voltage Wins = Lowest Duty Cycle Wins

MPPT = Vout 3.3V to 4.33V
VregError −> Increasing Duty Cycle = Decrease voltage

Regulation = Vout 4.33V, Vpanel increasing
Vmppt Error −> increases duty cycle (to load panel) so it looses





NOTES

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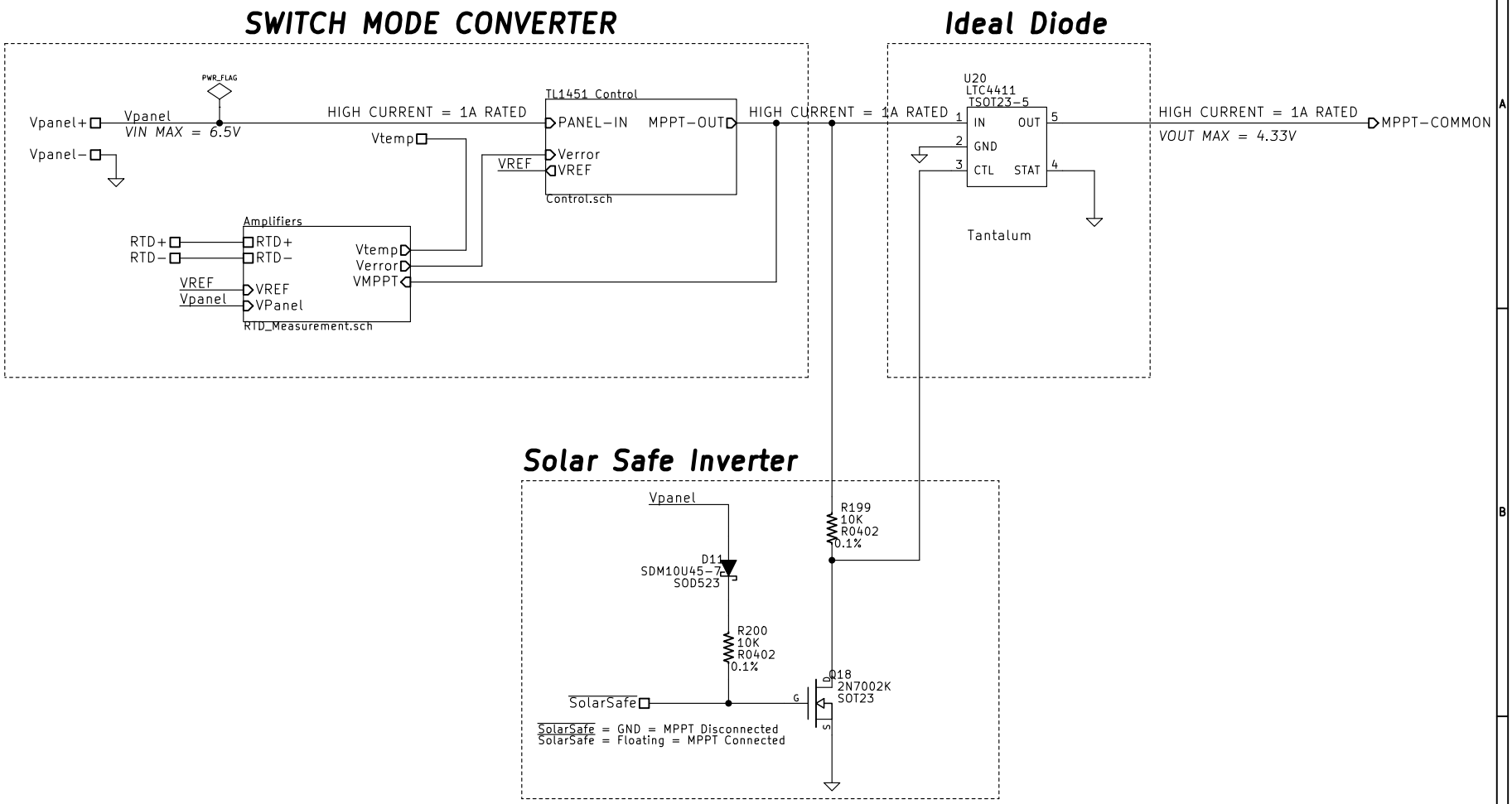
* RIT MPPT Team: Brenton Salmi (KB1LQD), Bryce Salmi (KB1LQC), Ian MacKenzie (KB3OCF), Daniel Corriero.
* NASA derating taken into account, not gauranteed

Based on Rochester Institute of Technology P13271 Design		
Brent Salmi, KB1LQD		
Bryce Salmi, KB1LQC		
The Radio Amateur Satellite Corporation		
File: RTD_Measurement.sch		
Sheet: /MPPT_String_Y−/Amplifiers/		
Title: Fox−1 Maximum Power Point Tracker		
Size: A4	*Date: 30 nov 2015*	*Rev: 2.0*
KiCad E.D.A.		Id: 26/37



NOTES

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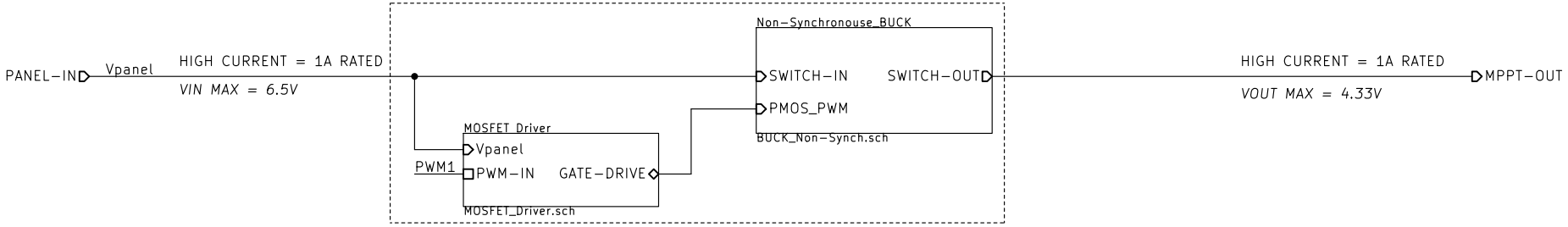
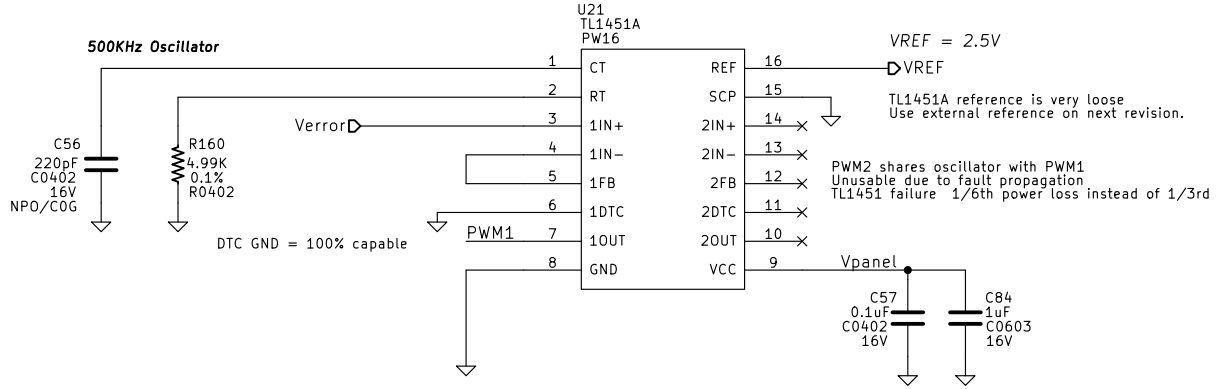
Based on Rochester Institute of Technology P13271 Design		
Brent Salmi, KB1LQD		
Bryce Salmi, KB1LQC		
The Radio Amateur Satellite Corporation		
File: MPPT_String.sch		
Sheet: /MPPT_String_Z−/		
Title: Fox−1 Maximum Power Point Tracker		
Size: A	*Date: 30 nov 2015*	*Rev: 2.0*
KiCad E.D.A.		Id: 27/37

Switch Mode Converter





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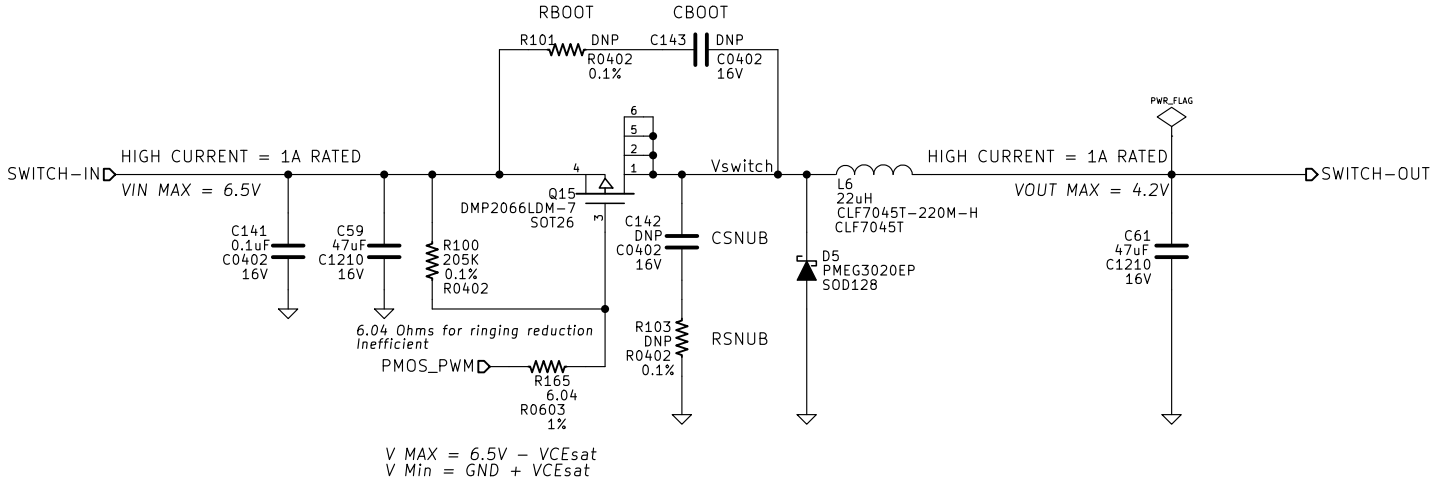
Based on Rochester Institute of Technology P13271 Design		
Brent Salmi, KB1LQD		
Bryce Salmi, KB1LQC		
The Radio Amateur Satellite Corporation		
File: Control.sch		
Sheet: /MPPT_String_Z-/TL1451 Control/		
Title: Fox-1 Maximum Power Point Tracker		
Size: A4	*Date: 30 nov 2015*	*Rev: 2.0*
KiCad E.D.A.		Id: 28/37

500 KHz Step-Down Buck Converter



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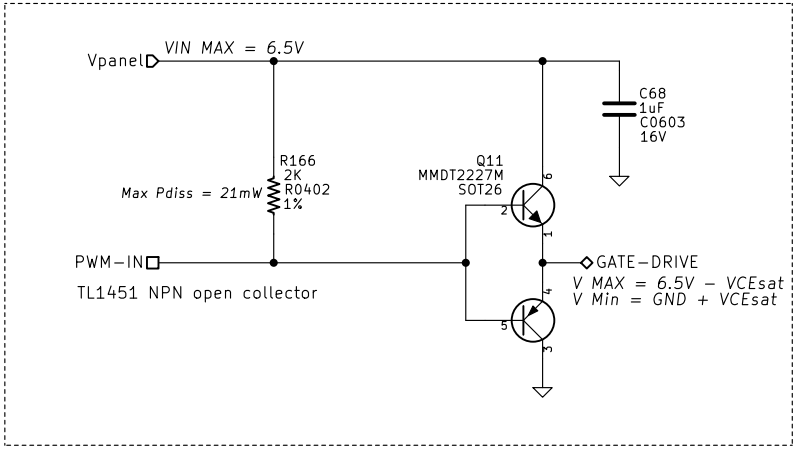
Based on Rochester Institute of Technology P13271 Design		
Brent Salmi, KB1LQD		
Bryce Salmi, KB1LQC		
The Radio Amateur Satellite Corporation		
File: BUCK_Non-Synch.sch		
Sheet: /MPPT_String_Z-/TL1451 Control/Non-Synchronouse_BUCK/		
Title: Fox-1 Maximum Power Point Tracker		
Size: A4	*Date: 30 nov 2015*	*Rev: 2.0*
KiCad E.D.A.		Id: 29/37

TOTEM POLE MOSFET DRIVER



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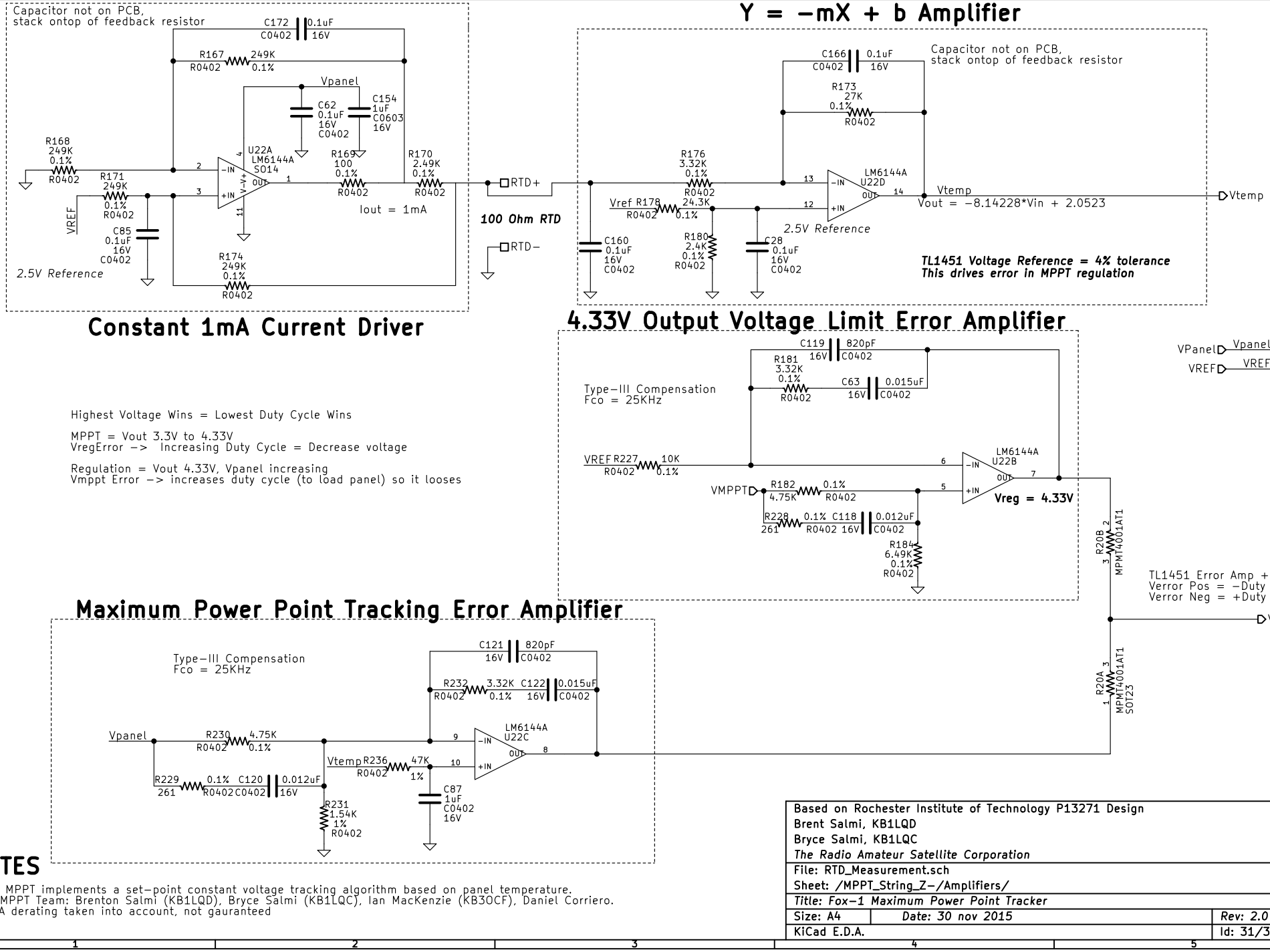
Based on Rochester Institute of Technology P13271 Design Brent Salmi, KB1LQD Bryce Salmi, KB1LQC *The Radio Amateur Satellite Corporation*		
File: MOSFET_Driver.sch Sheet: /MPPT_String_Z-/TL1451 Control/MOSFET Driver/		
Title: Fox-1 Maximum Power Point Tracker		
Size: A4	*Date: 30 nov 2015*	*Rev: 2.0*
KiCad E.D.A.		Id: 30/37



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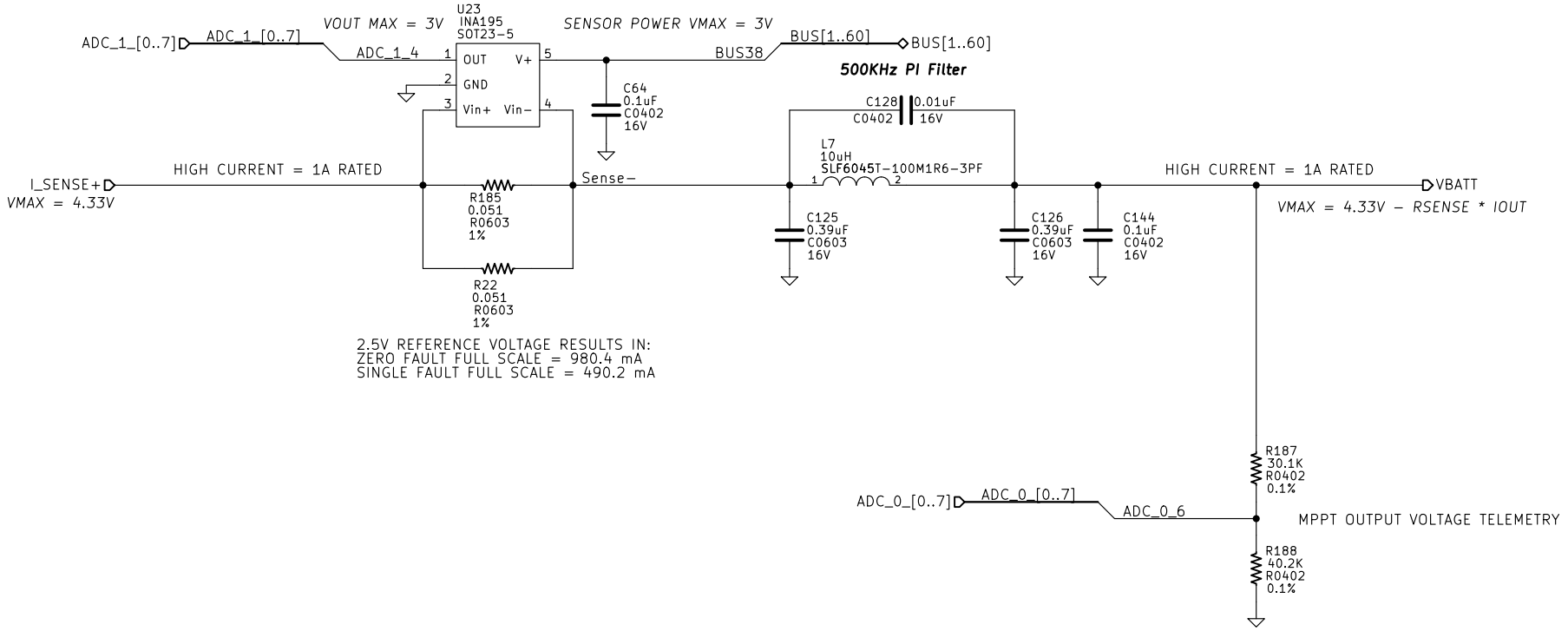
Based on Rochester Institute of Technology P13271 Design		
Brent Salmi, KB1LQD		
Bryce Salmi, KB1LQC		
The Radio Amateur Satellite Corporation		
File: RTD_Measurement.sch		
Sheet: /MPPT_String_Z−/Amplifiers/		
Title: Fox−1 Maximum Power Point Tracker		
Size: A4	*Date: 30 nov 2015*	*Rev: 2.0*
KiCad E.D.A.		Id: 31/37



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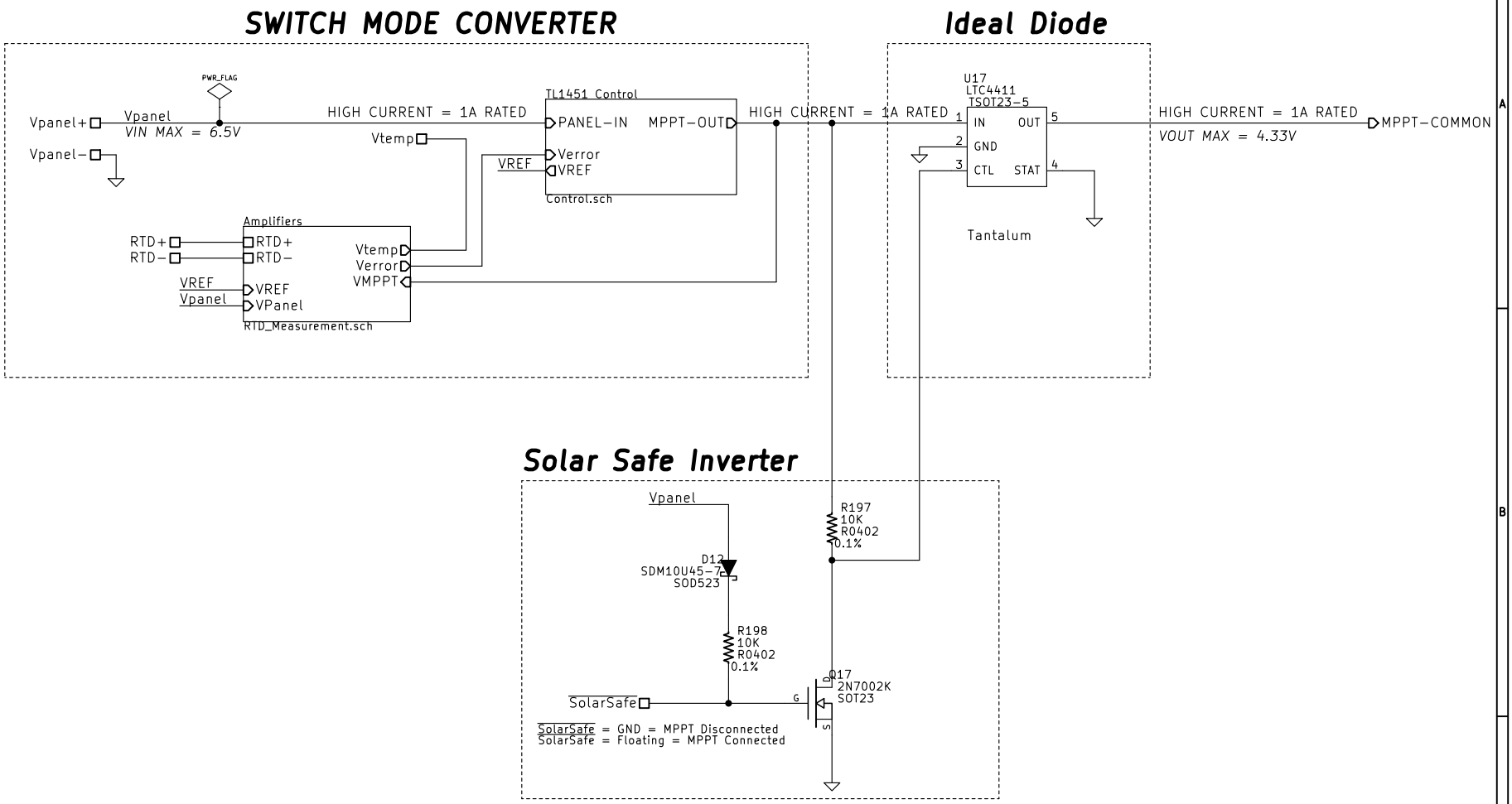
Based on Rochester Institute of Technology P13271 Design		
Brent Salmi, KB1LQD		
Bryce Salmi, KB1LQC		
The Radio Amateur Satellite Corporation		
File: Current_Sense.sch		
Sheet: /Current Sense/		
Title: Fox-1 Maximum Power Point Tracker		
Size: A4	*Date: 30 nov 2015*	*Rev: 2.0*
KiCad E.D.A.		Id: 32/37



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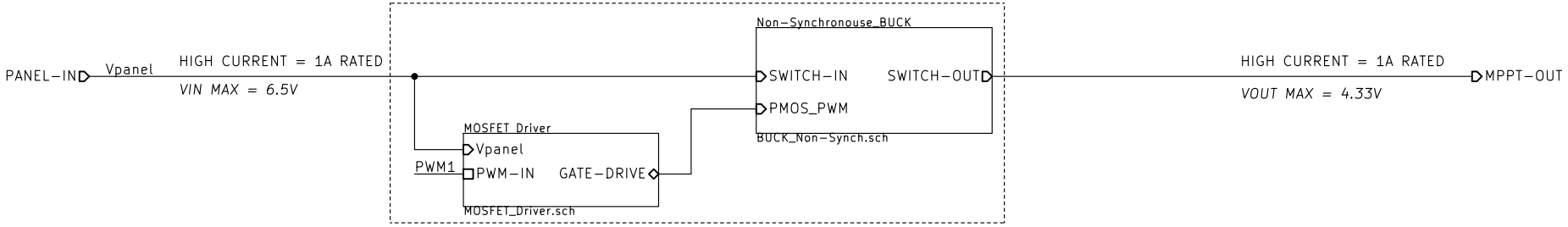
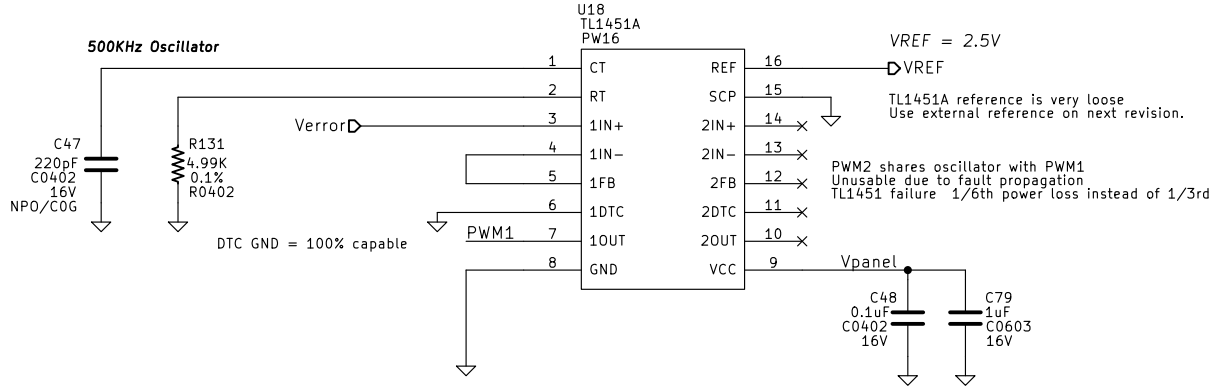
Based on Rochester Institute of Technology P13271 Design		
Brent Salmi, KB1LQD		
Bryce Salmi, KB1LQC		
The Radio Amateur Satellite Corporation		
File: MPPT_String.sch		
Sheet: /MPPT_String_Z+/		
Title: Fox−1 Maximum Power Point Tracker		
Size: A	*Date: 30 nov 2015*	*Rev: 2.0*
KiCad E.D.A.		Id: 33/37

Switch Mode Converter





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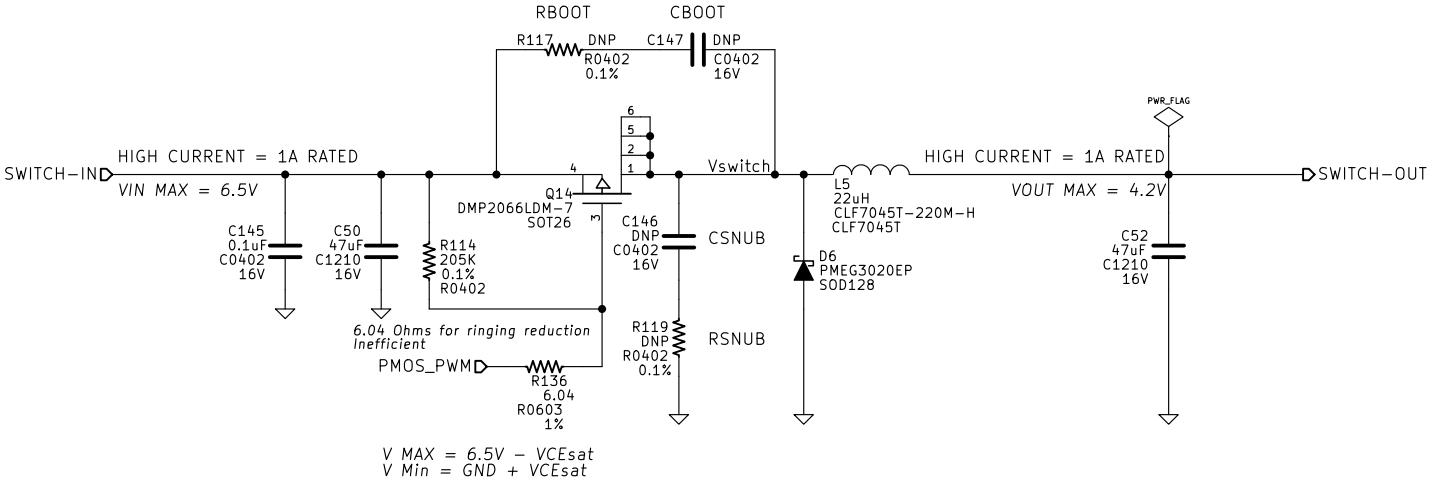
Based on Rochester Institute of Technology P13271 Design		
Brent Salmi, KB1LQD		
Bryce Salmi, KB1LQC		
The Radio Amateur Satellite Corporation		
File: Control.sch		
Sheet: /MPPT_String_Z+/TL1451 Control/		
Title: Fox-1 Maximum Power Point Tracker		
Size: A4	*Date: 30 nov 2015*	*Rev: 2.0*
KiCad E.D.A.		Id: 34/37

500 KHz Step-Down Buck Converter



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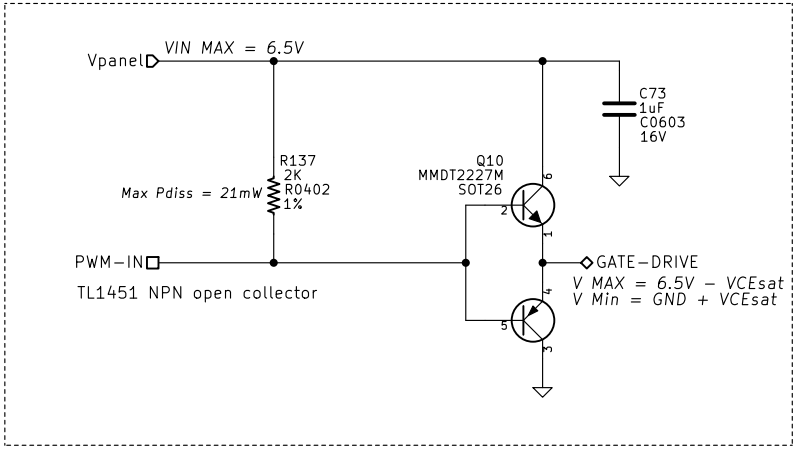
Based on Rochester Institute of Technology P13271 Design		
Brent Salmi, KB1LQD		
Bryce Salmi, KB1LQC		
The Radio Amateur Satellite Corporation		
File: BUCK_Non-Synch.sch		
Sheet: /MPPT_String_Z+/TL1451 Control/Non-Synchronouse_BUCK/		
Title: Fox-1 Maximum Power Point Tracker		
Size: A4	*Date: 30 nov 2015*	*Rev: 2.0*
KiCad E.D.A.		Id: 35/37

TOTEM POLE MOSFET DRIVER



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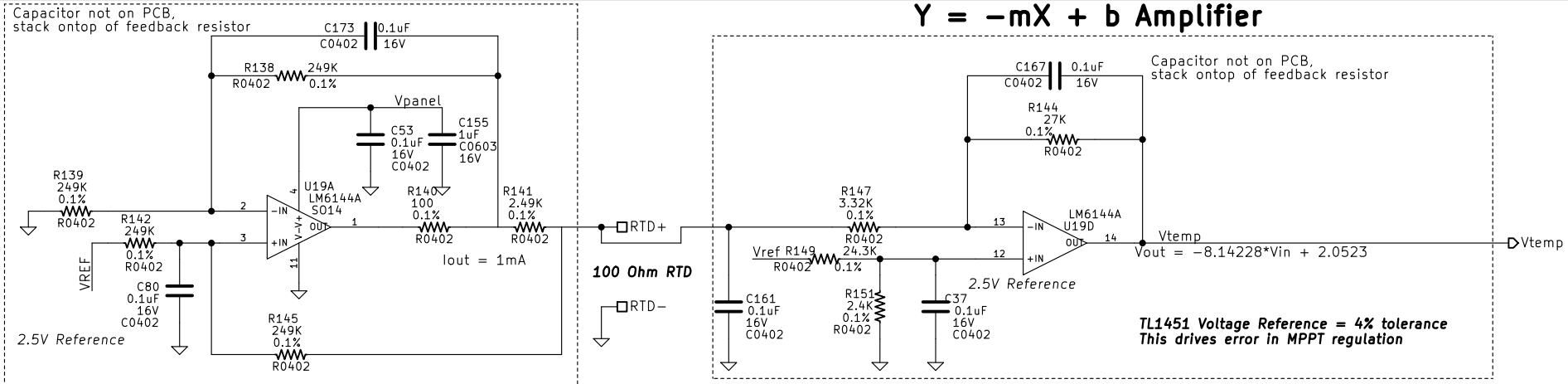
Based on Rochester Institute of Technology P13271 Design Brent Salmi, KB1LQD Bryce Salmi, KB1LQC *The Radio Amateur Satellite Corporation*		
File: MOSFET_Driver.sch Sheet: /MPPT_String_Z+/TL1451 Control/MOSFET Driver/		
Title: Fox-1 Maximum Power Point Tracker		
Size: A4	*Date: 30 nov 2015*	*Rev: 2.0*
KiCad E.D.A.		Id: 36/37

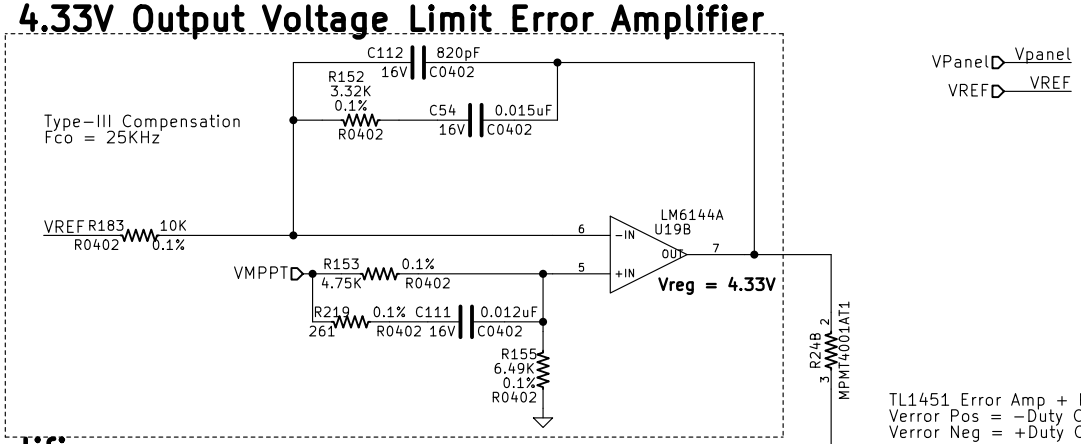


Constant 1mA Current Driver

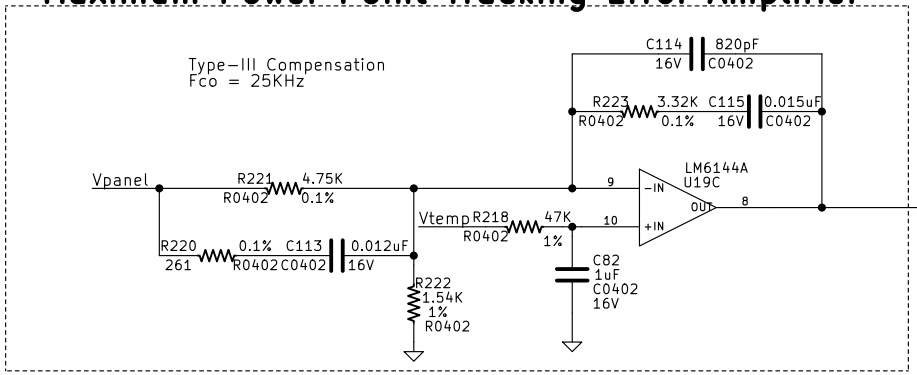
Highest Voltage Wins = Lowest Duty Cycle Wins

MPPT = Vout 3.3V to 4.33V
VregError −> Increasing Duty Cycle = Decrease voltage

Regulation = Vout 4.33V, Vpanel increasing
Vmppt Error −> increases duty cycle (to load panel) so it looses



Maximum Power Point Tracking Error Amplifier



NOTES

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Based on Rochester Institute of Technology P13271 Design		
Brent Salmi, KB1LQD		
Bryce Salmi, KB1LQC		
The Radio Amateur Satellite Corporation		
File: RTD_Measurement.sch		
Sheet: /MPPT_String_Z+/Amplifiers/		
Title: Fox−1 Maximum Power Point Tracker		
Size: A4	*Date: 30 nov 2015*	*Rev: 2.0*
KiCad E.D.A.		Id: 37/37