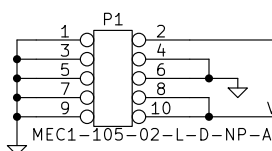


# FOX-1 Maximum Power Point Tracker

ALL SOLAR PANELS INPUTS MED. CURRENT = 0.5A RATED

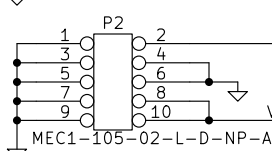
## X+ PANEL

VIN MAX = 6.5V



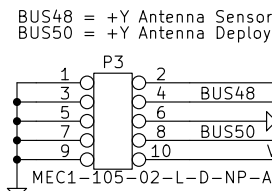
## X- PANEL

VIN MAX = 6.5V



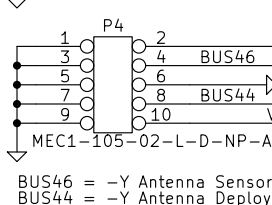
## Y+ PANEL

VIN MAX = 6.5V



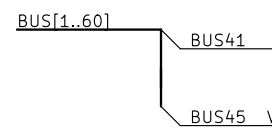
## Y- PANEL

VIN MAX = 6.5V



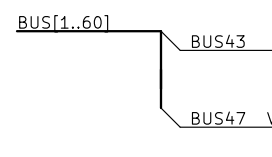
## Z+ PANEL

VIN MAX = 6.5V

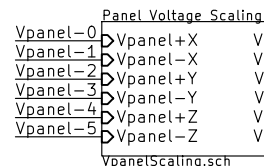


## Z- PANEL

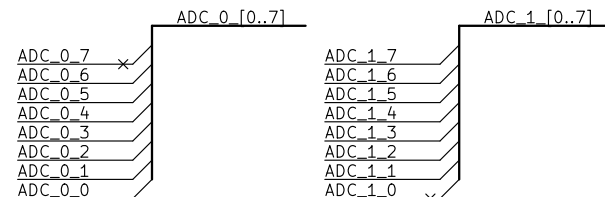
VIN MAX = 6.5V



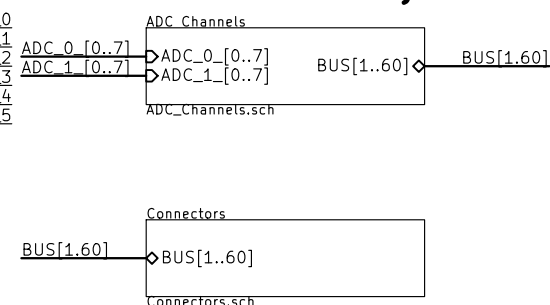
BUS[1..60]



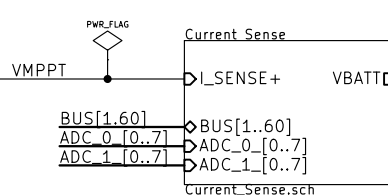
ADC\_Bus\_Breakouts



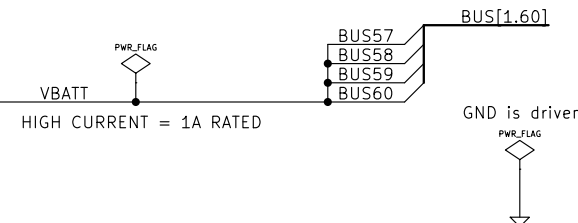
## MPPT Telemetry



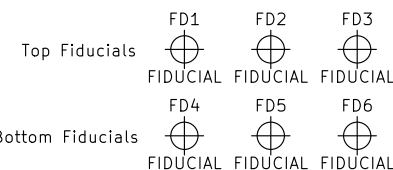
HIGH CURRENT = 1A RATED



VOUT MAX = 4.33V - RSENSE \* IOUT



R·I·T



## 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 guaranteed

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

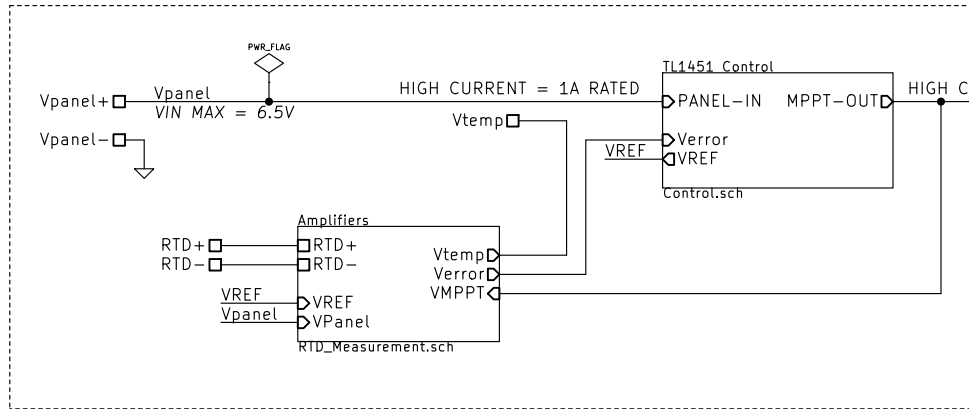
Size: USLetter Date: 30 nov 2015

Rev: 2.0

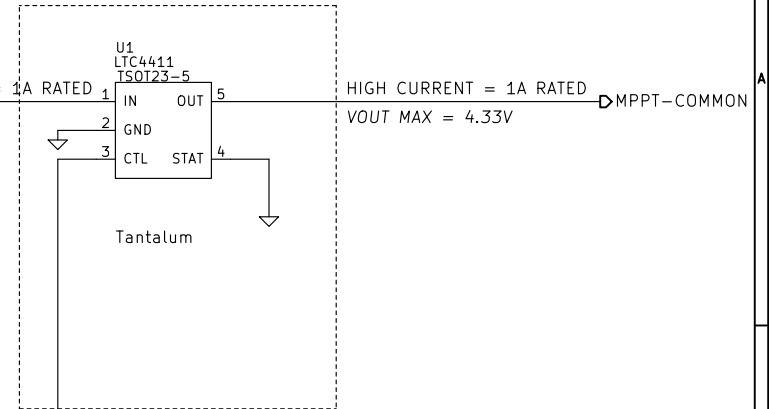
KiCad E.D.A.

Id: 1/37

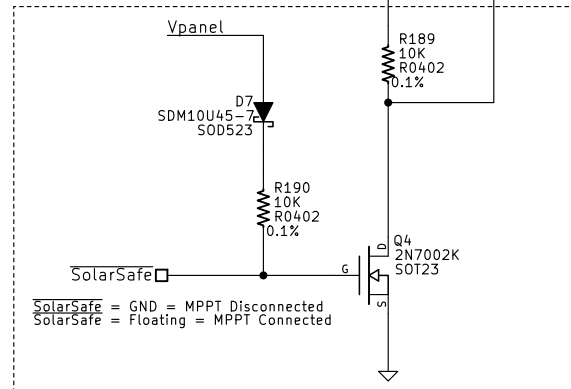
## SWITCH MODE CONVERTER



## Ideal Diode



## Solar Safe Inverter



## 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 Corrieo.
- \* 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: MPPT\_String.sch

Sheet: /MPPT\_String\_X+/

Title: Fox-1 Maximum Power Point Tracker

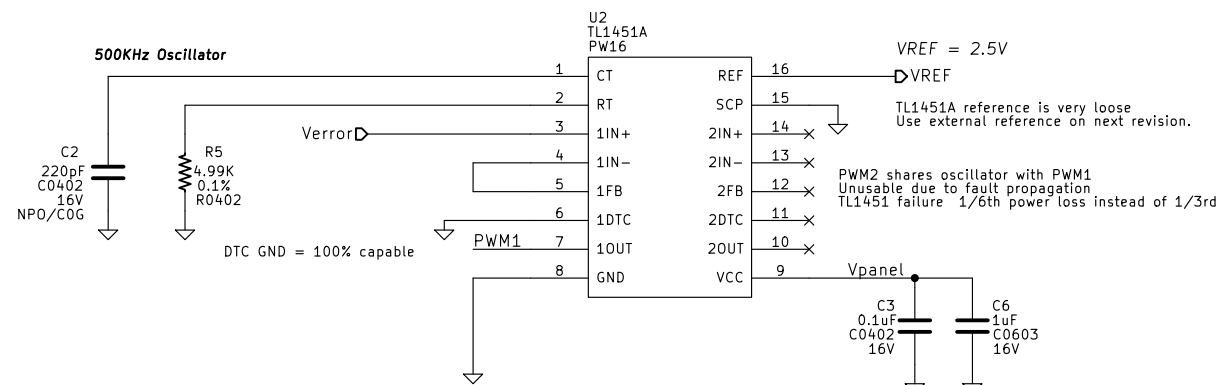
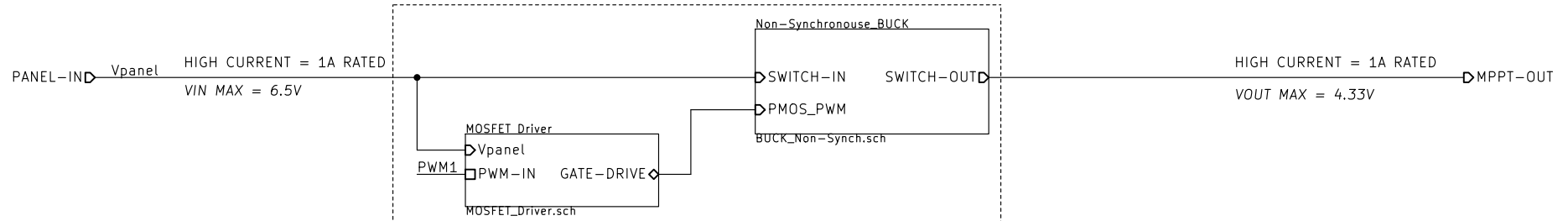
Size: A Date: 30 nov 2015

Rev: 2.0

KiCad E.D.A.

Id: 2/37

# Switch Mode Converter



## 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 guaranteed

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

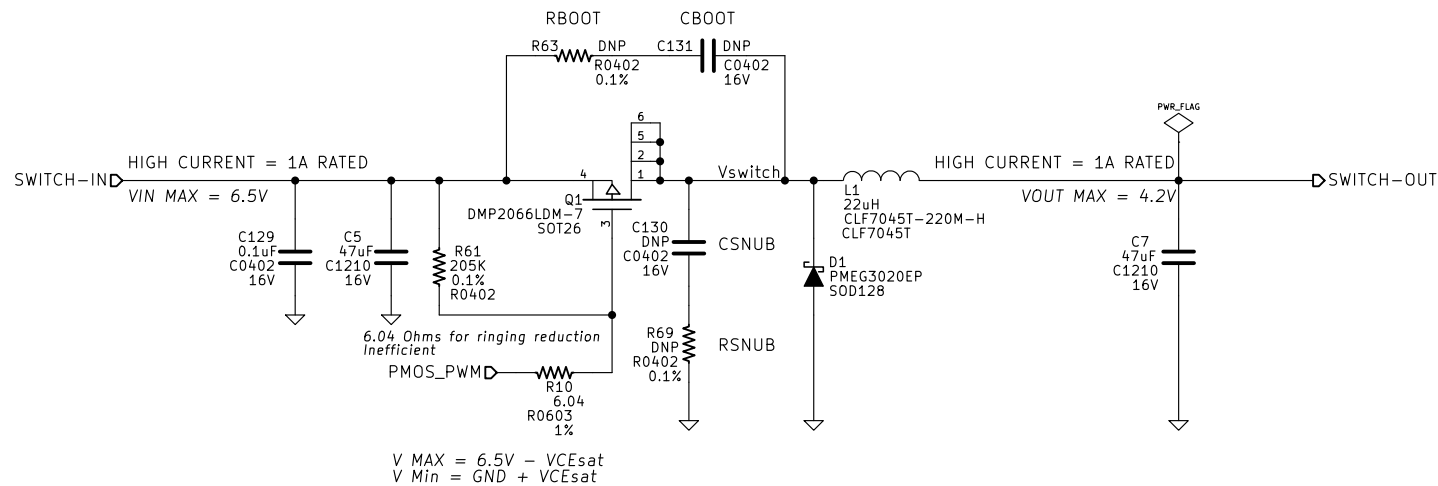
Date: 30 nov 2015

Rev: 2.0

KiCad E.D.A.

Id: 3/37

## 500 KHz Step-Down Buck Converter



### 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: BUCK\_Non-Synch.sch

Sheet: /MPPT\_String\_X+/TL1451 Control/Non-Synchronous\_BUCK/

Title: Fox-1 Maximum Power Point Tracker

Size: A4

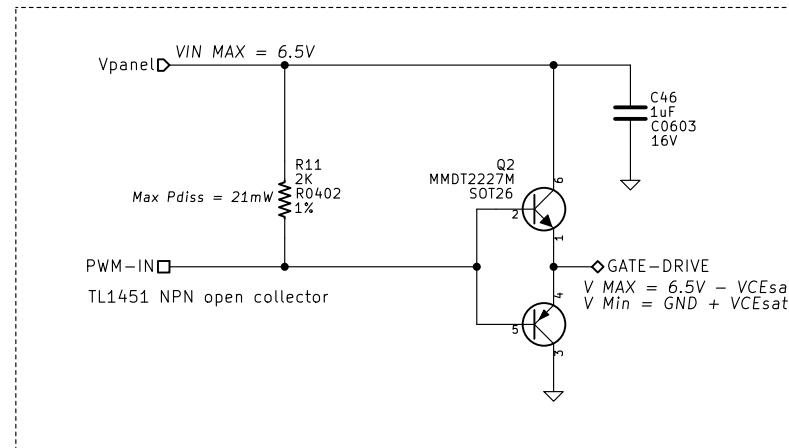
Date: 30 nov 2015

Rev: 2.0

KiCad E.D.A.

Id: 4/37

## TOTEM POLE MOSFET DRIVER



## NOTES

- \* 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\_X+/TL1451 Control/MOSFET Driver/

Title: Fox-1 Maximum Power Point Tracker

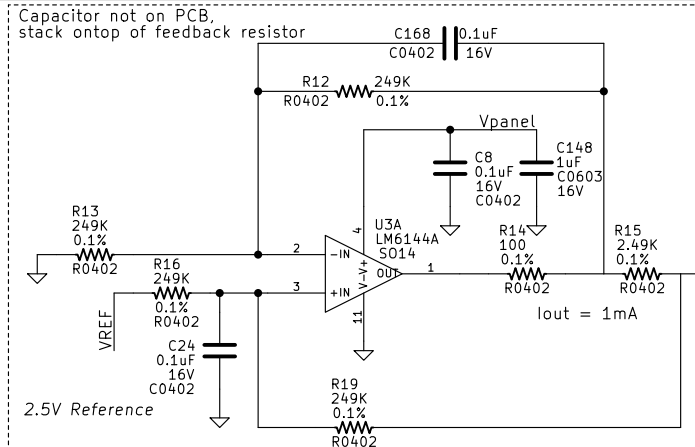
Size: A4

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

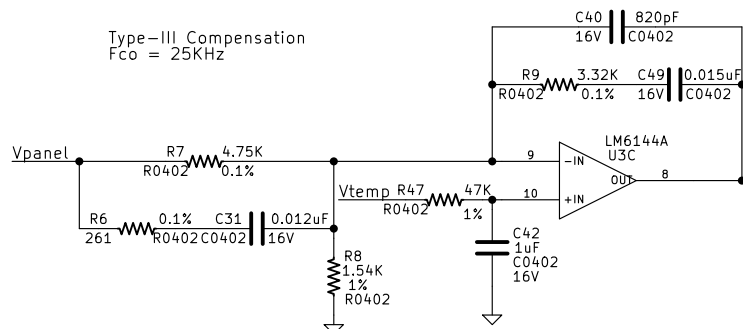
MPPT = Vout 3.3V to 4.33V

VregError -> Increasing Duty Cycle = Decrease voltage

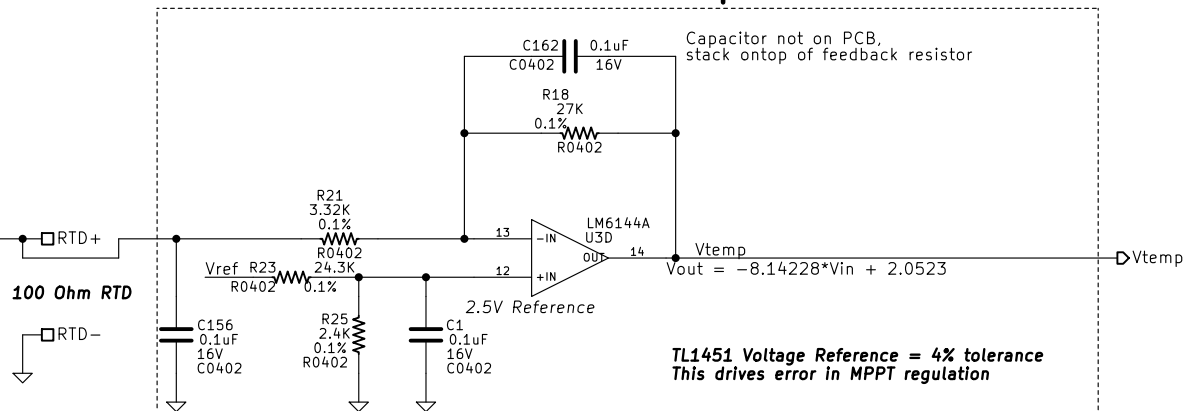
Regulation = Vout 4.33V, Vpanel increasing

Vmppt Error -> increases duty cycle (to load panel) so it looses

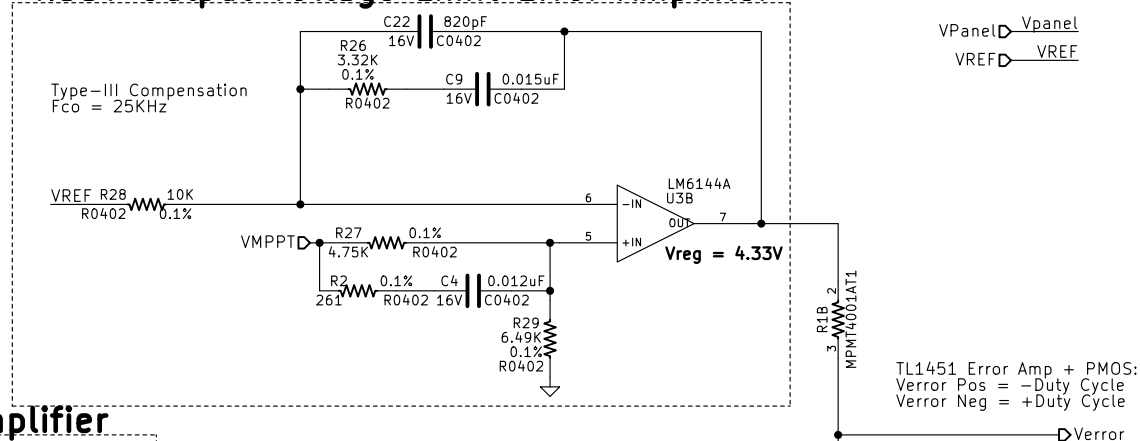
## Maximum Power Point Tracking Error Amplifier



## Y = -mX + b Amplifier



## 4.33V Output Voltage Limit Error Amplifier



## 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 guaranteed

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

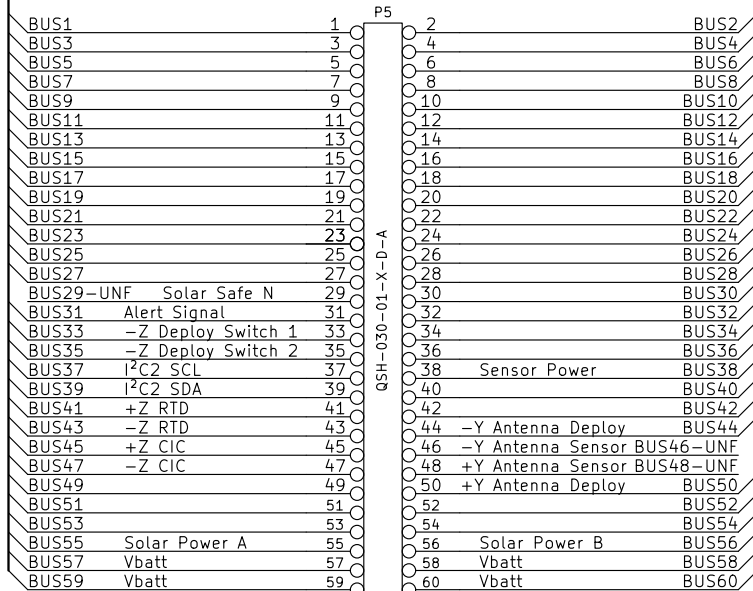
KiCad E.D.A.

Id: 6/37

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

BUS[1..60]

BUS[1..60]



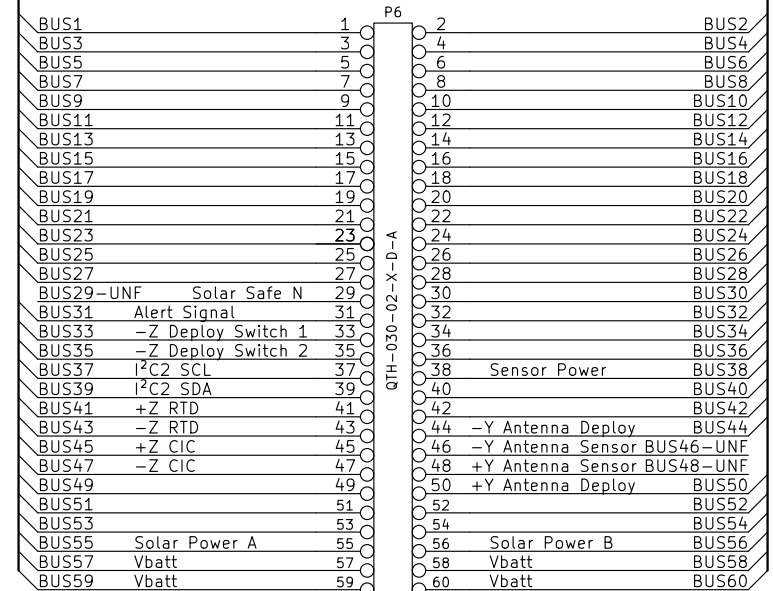
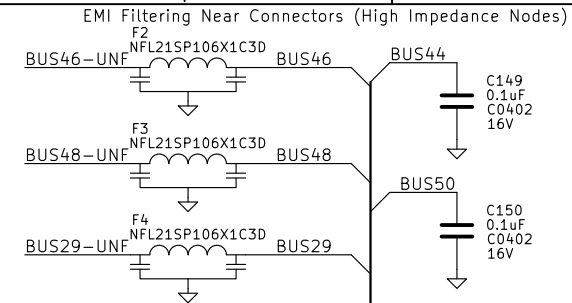
VBATT HIGH CURRENT = 1A RATED

VBATT HIGH CURRENT = 1A RATED

BUS38 Sensor Power is driven by the IHU PCB

BUS38

PWR\_FLAG



VBATT HIGH CURRENT = 1A RATED

VBATT HIGH CURRENT = 1A RATED

## 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: Connectors.sch

Sheet: /Connectors/

Title: Fox-1 Maximum Power Point Tracker

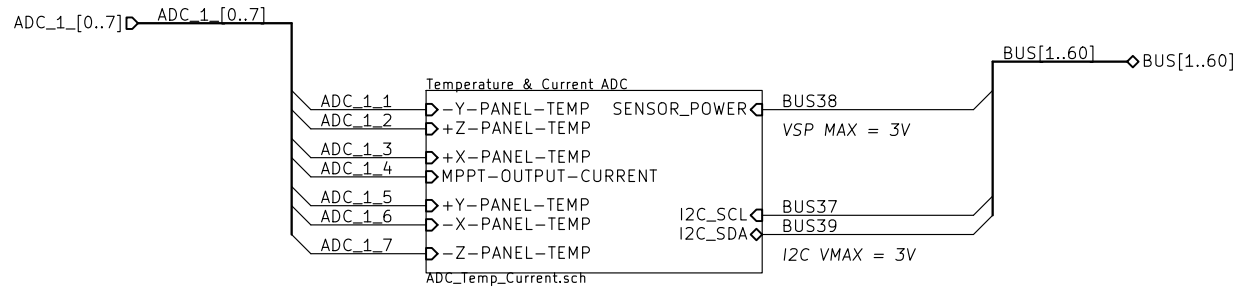
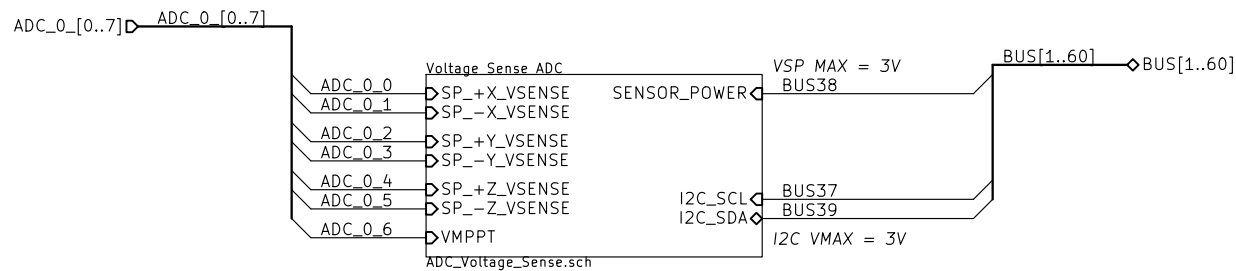
Size: A4

Date: 30 nov 2015

Rev: 2.0

KiCad E.D.A.

Id: 7/37



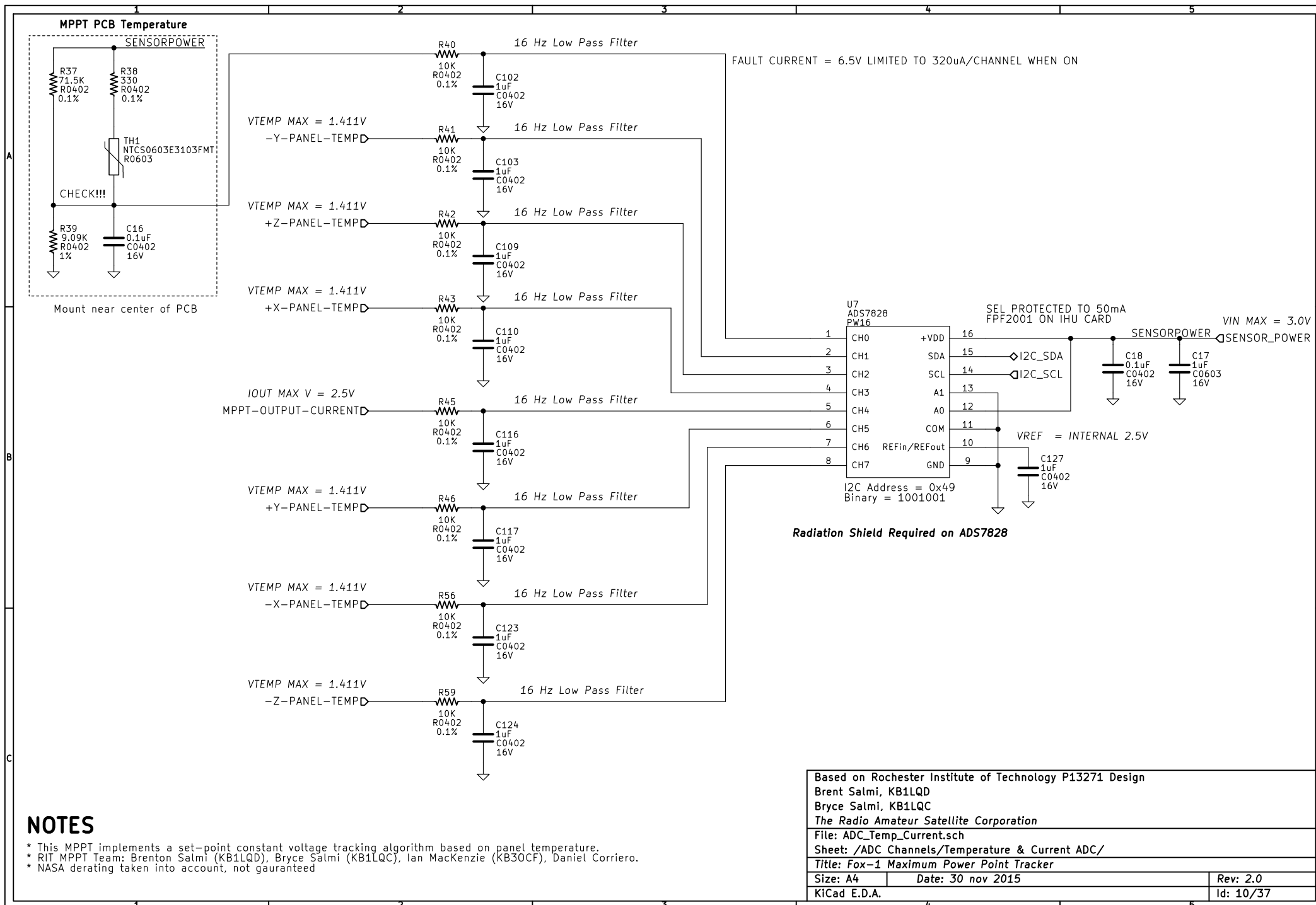
## NOTES

- \* 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: 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







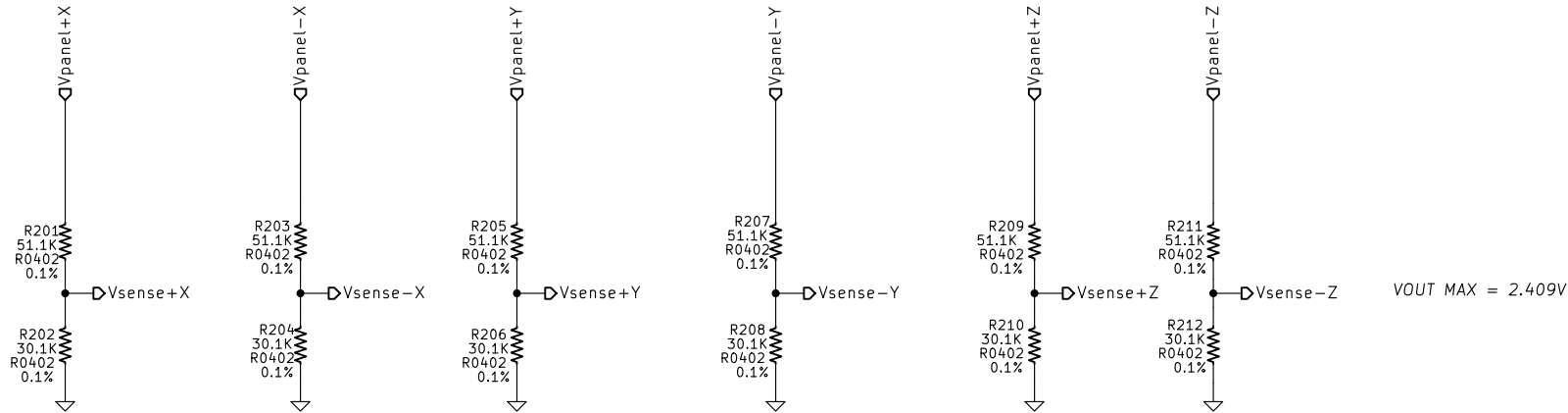
## NOTES

- \* 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: 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

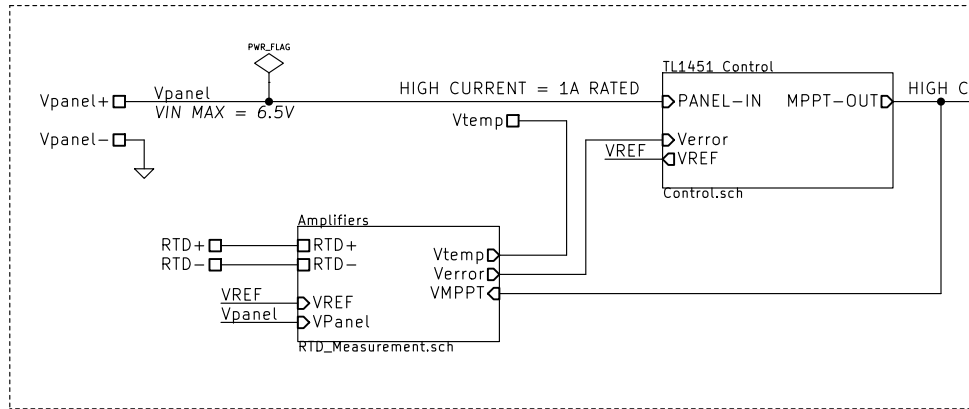


## NOTES

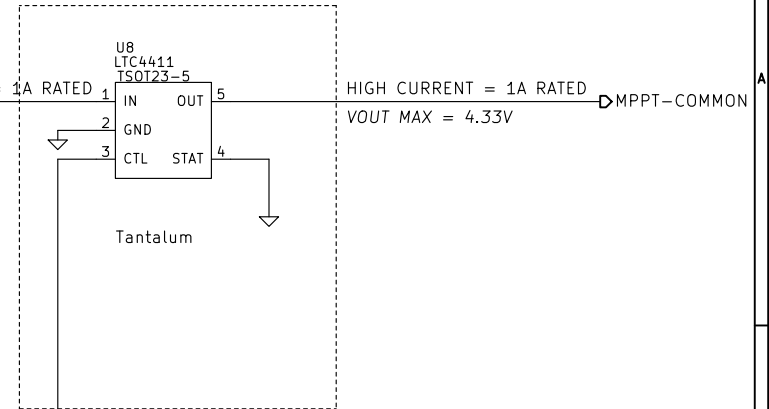
- \* This MPPT implements a set-point constant voltage tracking algorithm based on panel temperature.
- \* RIT MPPT Team: Brenton Salmi (KB1LQD), Bryce Salmi (KB1LQC), Ian MacKenzie (KB3OCF), Daniel Corriero.
- \* NASA derating taken into account, not gauranteed

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

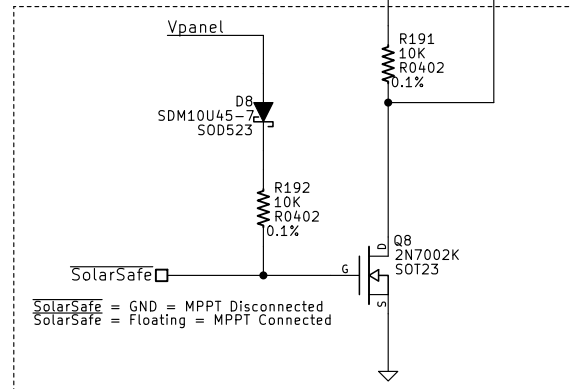
## SWITCH MODE CONVERTER



## Ideal Diode



## Solar Safe Inverter



## 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 Corrieo.
- \* 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: 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**

PANEL-IN  $V_{panel}$  HIGH CURRENT = 1A RATED  
VIN MAX = 6.5V

Non-Synchronous BUCK

SWITCH-IN SWITCH-OUT

PMOS\_PWM

BUCK\_Non-Synch.sch

MOSFET Driver

Vpanel

PWM1

PWM-IN GATE-DRIVE

MOSFET\_Driver.sch

HIGH CURRENT = 1A RATED  
VOUT MAX = 4.33V

MPPT-OUT

U9  
TL1451A  
PW16

500KHz Oscillator

C20  
220pF  
C0402  
16V  
NPO/COG

R44  
4.99K  
0.1%  
R0402

Verror

DTC GND = 100% capable

PWM1

VREF = 2.5V

VREF

TL1451A reference is very loose  
Use external reference on next revision.

PWM2 shares oscillator with PWM1  
Unusable due to fault propagation  
TL1451 failure 1/6th power loss instead of 1/3rd

C21  
0.1uF  
C0402  
16V

C60  
1uF  
C0603  
16V

Vpanel

CT REF 16

RT SCP 15

1IN+ 2IN+ 14

1IN- 2IN- 13

1FB 2FB 12

1DTC 2DTC 11

1OUT 2OUT 10

GND VCC 9

Vpanel

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: 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

- \* 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 guaranteed

File: Control.sch
Sheet: /MPPT_String_X-/TL1451 Control/
Title: Fox-1 Maximum Power Point Tracker

Size: A4	Date: 30 nov 2015
----------	-------------------

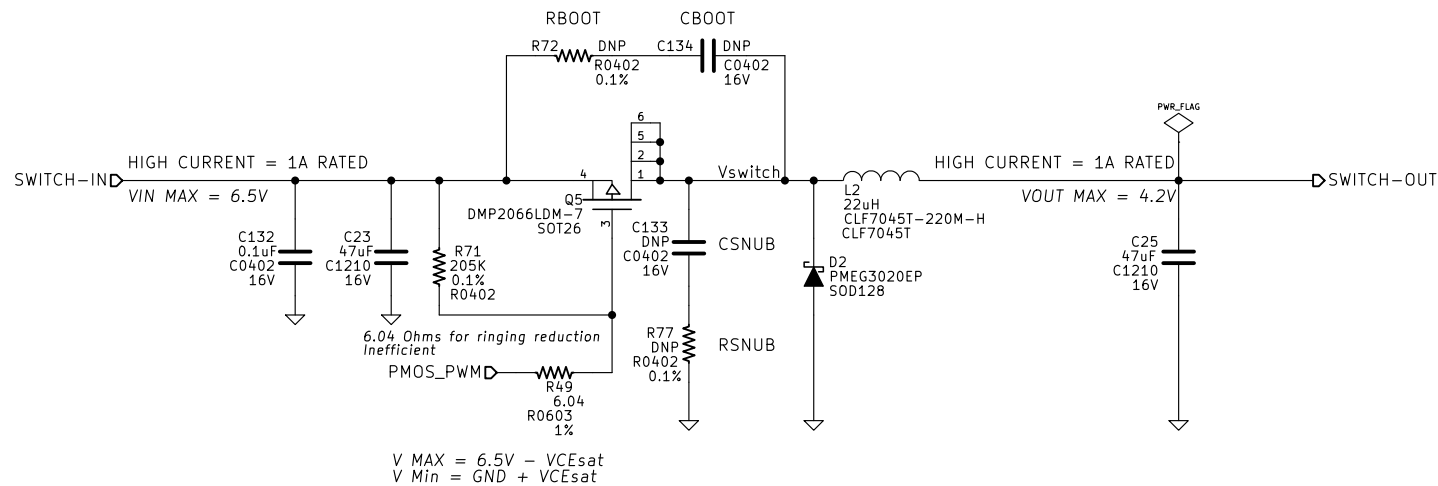
KiCad E.D.A.
--------------

Date: 30 nov 2015

Rev: 2.0

Id: 13/37

## 500 KHz Step-Down Buck Converter



### 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: BUCK\_Non-Synch.sch

Sheet: /MPPT\_String\_X-/TL1451 Control/Non-Synchronous\_BUCK/

Title: Fox-1 Maximum Power Point Tracker

Size: A4

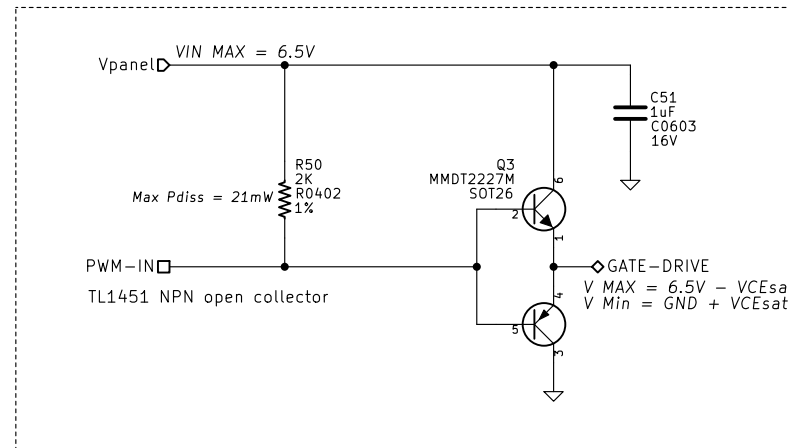
Date: 30 nov 2015

Rev: 2.0

KiCad E.D.A.

Id: 14/37

## TOTEM POLE MOSFET DRIVER



## 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\_X-/TL1451 Control/MOSFET Driver/

Title: Fox-1 Maximum Power Point Tracker

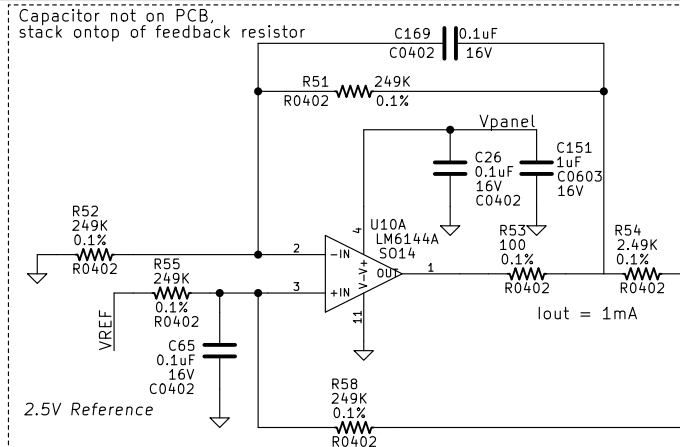
Size: A4

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

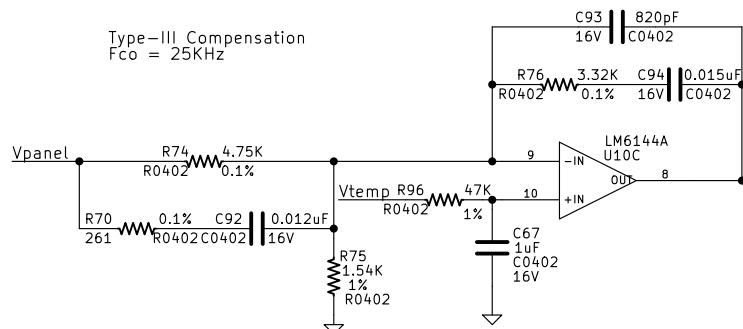
MPPT = Vout 3.3V to 4.33V

VregError -> Increasing Duty Cycle = Decrease voltage

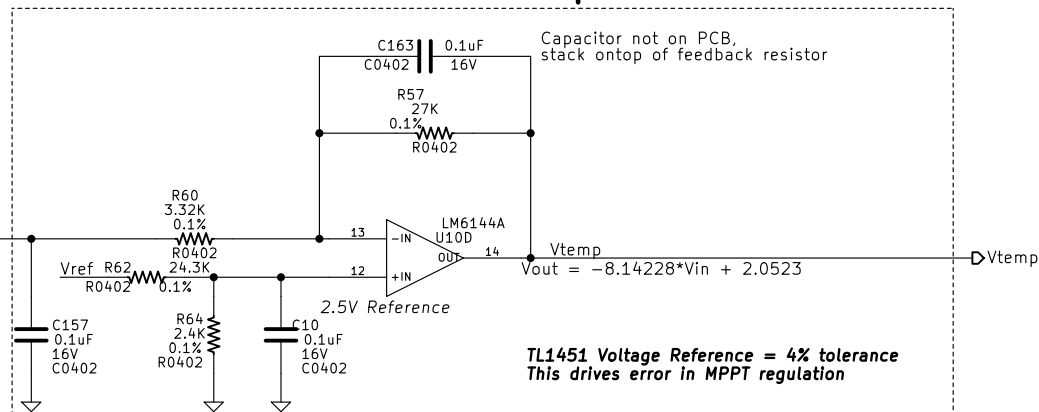
Regulation = Vout 4.33V, Vpanel increasing

Vmppt Error -> increases duty cycle (to load panel) so it looses

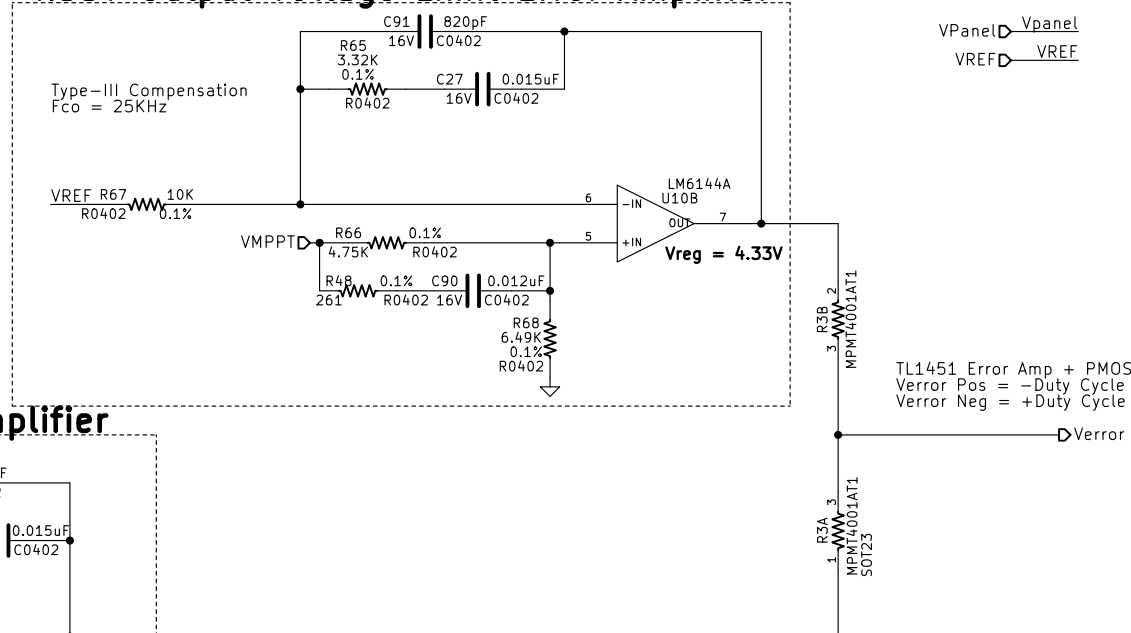
## Maximum Power Point Tracking Error Amplifier



## Y = -mX + b Amplifier



## 4.33V Output Voltage Limit Error Amplifier



## 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 guaranteed

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

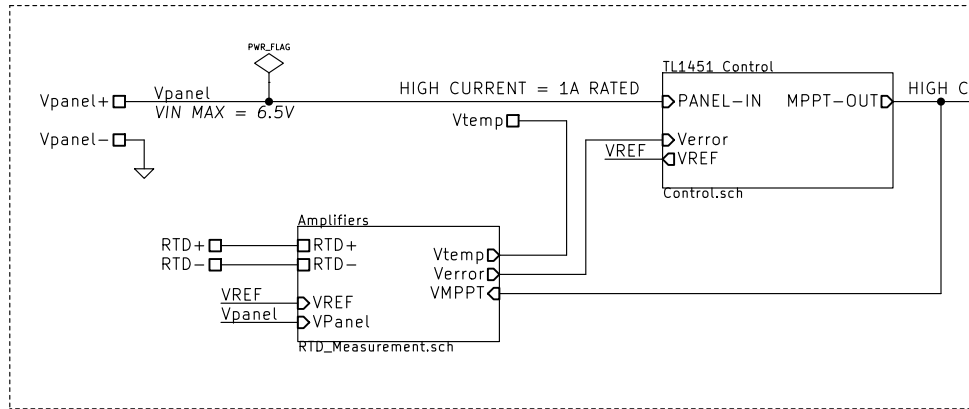
Rev: 2.0

KiCad E.D.A.

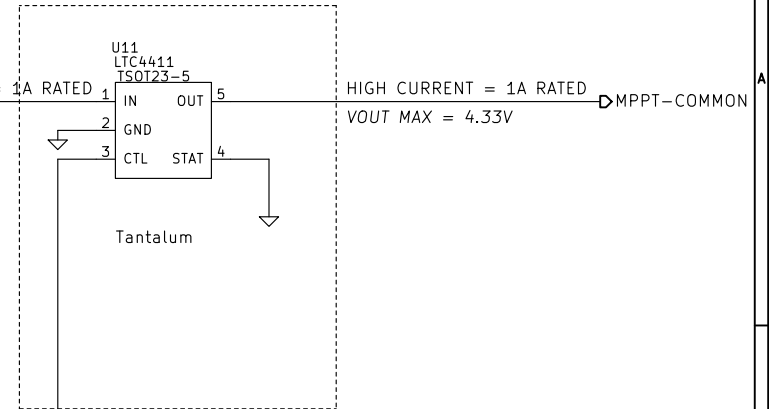
Id: 16/37



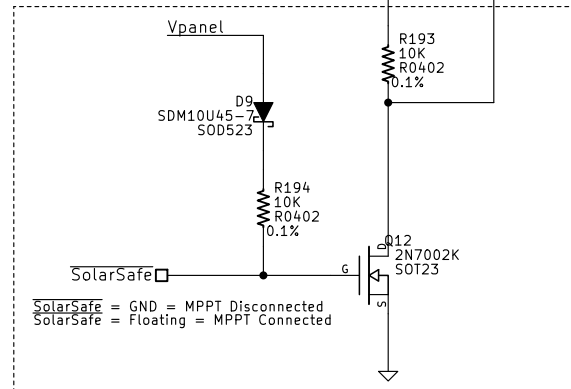
## SWITCH MODE CONVERTER



## Ideal Diode



## Solar Safe Inverter



## 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 Corrieo.
- \* 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: 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

1 2 3 4 5

A

B

C

Switch Mode Converter

Non-Synchronous BUCK

PANEL-IN  $V_{panel}$  HIGH CURRENT = 1A RATED  
 $V_{IN} \text{ MAX} = 6.5V$

SWITCH-IN SWITCH-OUT  
PMOS\_PWM  
BUCK\_Non-Synch.sch

MPPT-OUT HIGH CURRENT = 1A RATED  
 $V_{OUT} \text{ MAX} = 4.33V$

MOSFET Driver  
 $V_{panel}$   
PWM1 PWM-IN GATE-DRIVE  
MOSFET\_Driver.sch

U12  
TL1451A  
PW16

500KHz Oscillator

C29  
220pF  
C0402  
16V  
NPO/COG

R73  
4.99K  
0.1%  
R0402

Verror

DTC GND = 100% capable

PWM1

CT REF 16  
RT SCP 15  
1IN+ 2IN+ 14  
1IN- 2IN- 13  
1FB 2FB 12  
1DTC 2DTC 11  
1OUT 2OUT 10  
GND VCC 9

VREF = 2.5V  
VREF

TL1451A reference is very loose  
Use external reference on next revision.

PWM2 shares oscillator with PWM1  
Unusable due to fault propagation  
TL1451 failure 1/6th power loss instead of 1/3rd

C30  
0.1uF  
C0402  
16V

C69  
1uF  
C0603  
16V

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 guaranteed

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

1 2 3 4 5

A

B

C

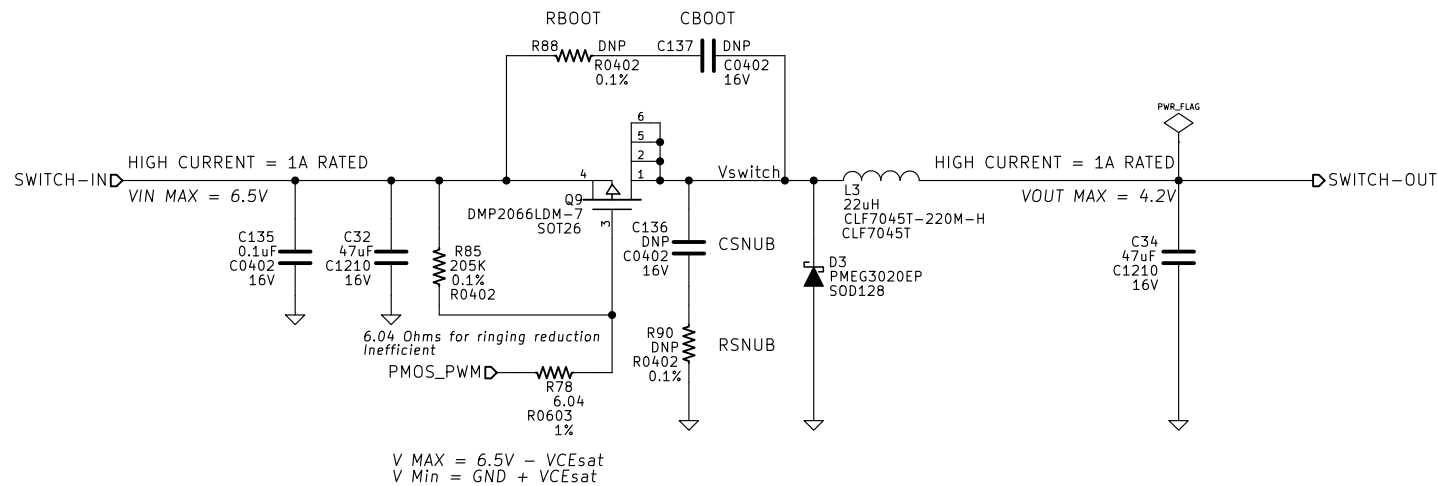
- \* This MPPT implements a set-point constant voltage tracking algorithm based on panel temperature.
- \* RIT MPPT Team: Brenton Salmi (KB1LQD), Bryce Salmi (KB1LQC), Ian MacKenzie (KB3OCF), Daniel Corriero.
- \* NASA derating taken into account, not guaranteed

File: Control.sch
Sheet: /MPPT_String_Y+/TL1451 Control/
Title: Fox-1 Maximum Power Point Tracker

Rev: 2.0

Id: 18/37

## 500 KHz Step-Down Buck Converter



### 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: BUCK\_Non-Synch.sch

Sheet: /MPPT\_String\_Y+/TL1451 Control/Non-Synchronous\_BUCK/

Title: Fox-1 Maximum Power Point Tracker

Size: A4

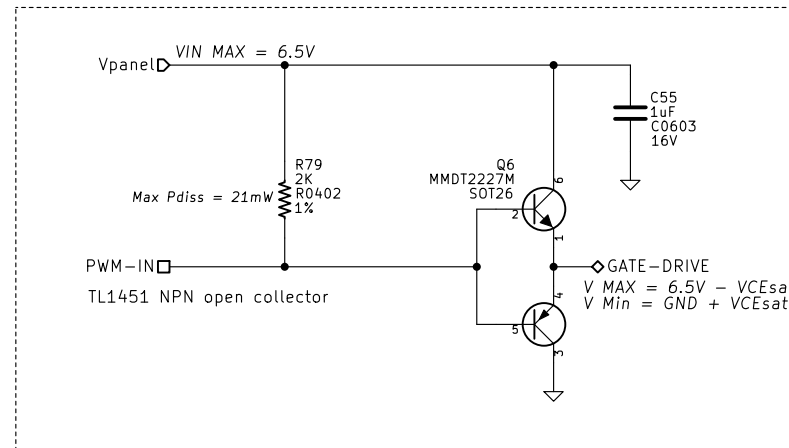
Date: 30 nov 2015

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

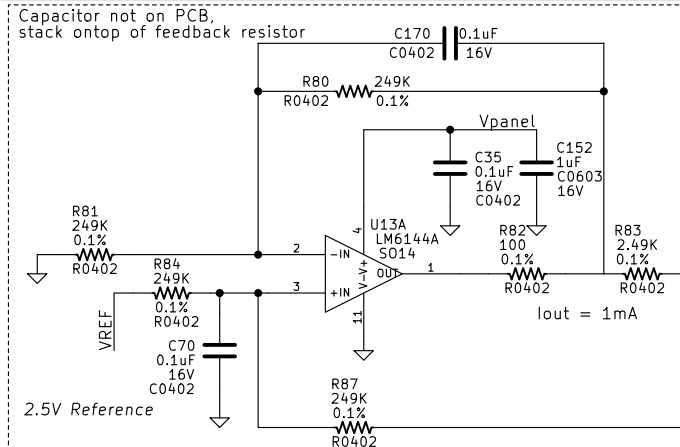
Size: A4

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

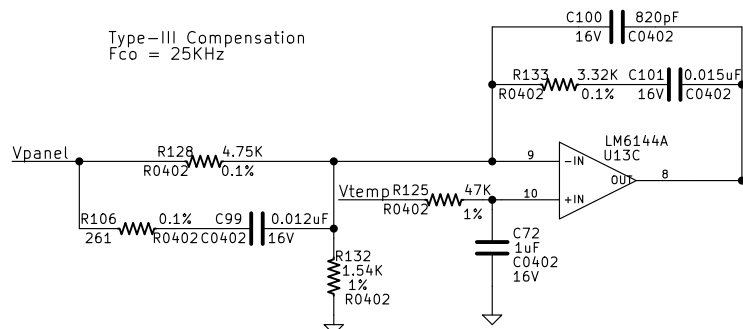
MPPT = Vout 3.3V to 4.33V

VregError -> Increasing Duty Cycle = Decrease voltage

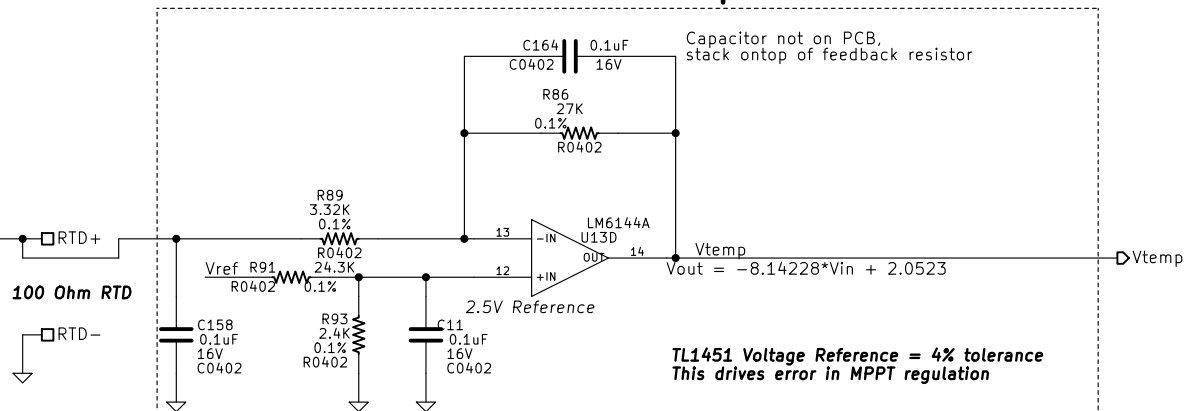
Regulation = Vout 4.33V, Vpanel increasing

Vmppt Error -> increases duty cycle (to load panel) so it looses

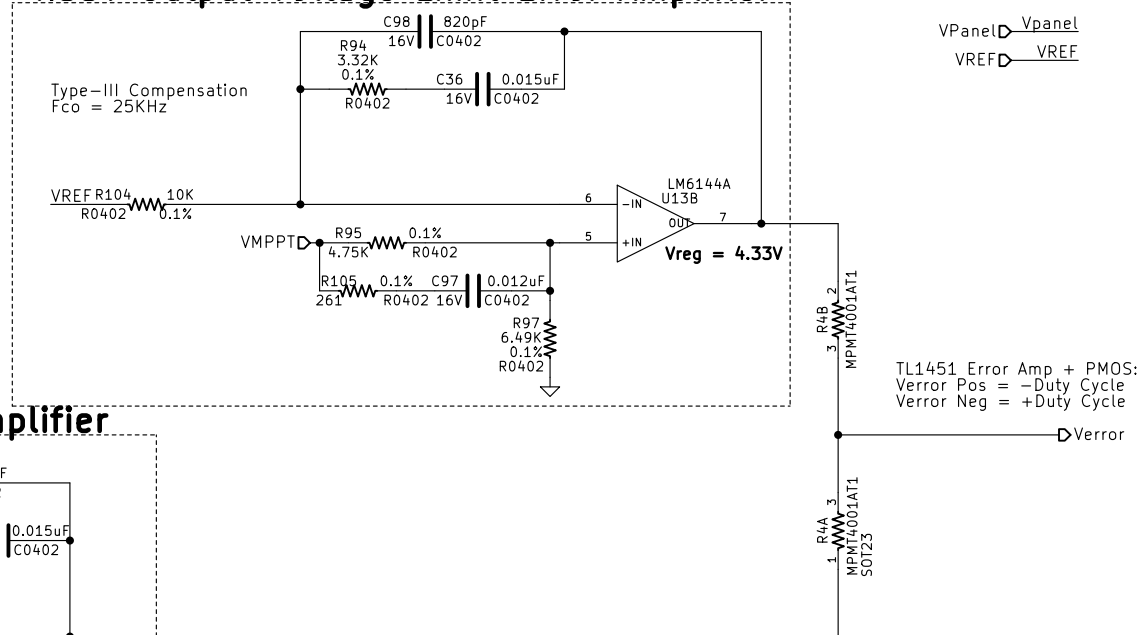
## Maximum Power Point Tracking Error Amplifier



## Y = -mX + b Amplifier



## 4.33V Output Voltage Limit Error Amplifier



## 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 guaranteed

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

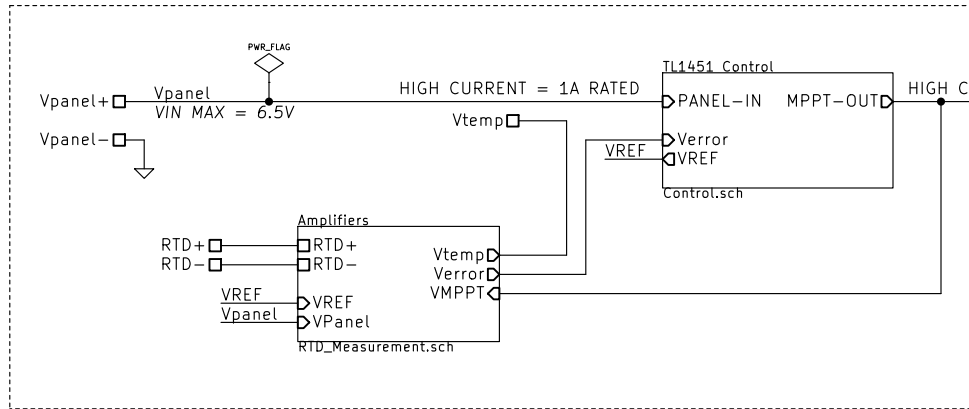
Date: 30 nov 2015

Rev: 2.0

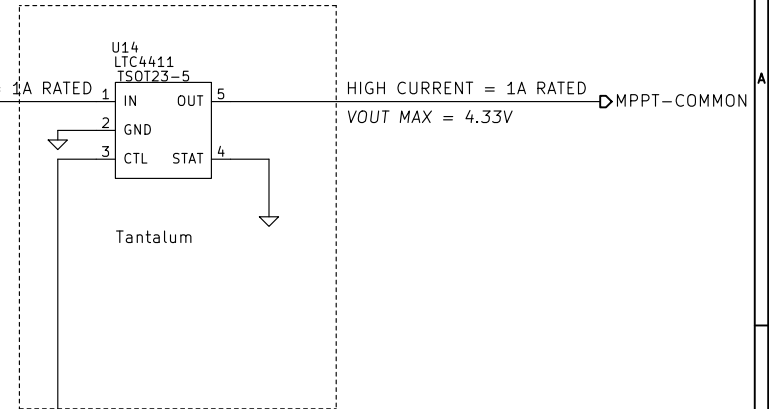
KiCad E.D.A.

Id: 21/37

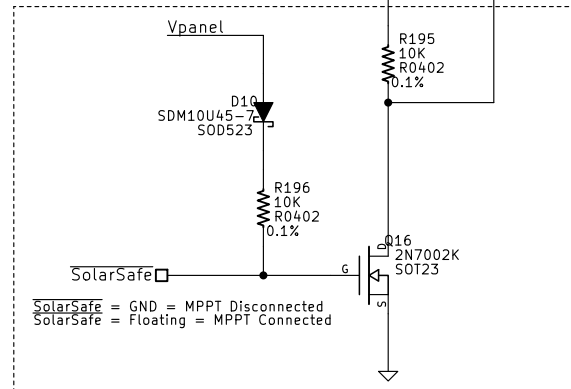
## SWITCH MODE CONVERTER



## Ideal Diode



## Solar Safe Inverter



## 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 Corriere.
- \* 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: MPPT\_String.sch

Sheet: /MPPT\_String\_Y-/

Title: Fox-1 Maximum Power Point Tracker

Size: A

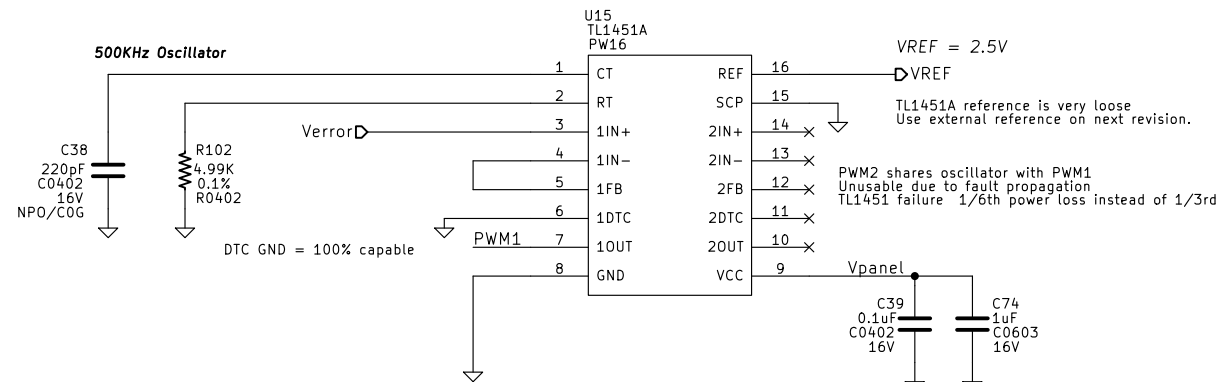
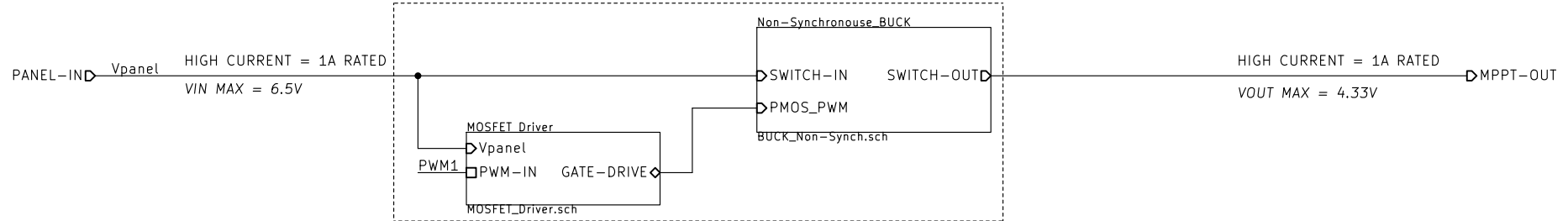
Date: 30 nov 2015

Rev: 2.0

KiCad E.D.A.

Id: 22/37

## Switch Mode Converter



## NOTES

- \* 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: 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

The circuit diagram shows a step-down buck converter. The input is labeled "SWITCH-IND" and "VIN MAX = 6.5V". It includes two parallel capacitors: C138 (0.1uF, C0402, 16V) and C41 (47uF, C1210, 16V). A resistor R92 (205K, 0.1%, R0402) is connected between the input and the gate of the MOSFET Q13 (DMP2066LDM-7, SOT26). A note indicates "6.04 Ohms for ringing reduction Inefficient". The MOSFET's source is grounded through a resistor R107 (6.04, R0603, 1%). Its drain is connected to the output filter network, which consists of an inductor L4 (22uH, CLF7045T-220M-H, CLF7045T) and a capacitor C139 (DNP, C0402, 16V). A snubber network with CSNUB (C139) and RSNUB (R99, DNP, R0402, 0.1%) is also shown. A diode D4 (PMEG3020EP, SOD128) is connected from the output filter to ground. The output is labeled "SWITCH-OUT" and "VOUT MAX = 4.2V". It includes a capacitor C43 (47uF, C1210, 16V) and a PWR\_FLAG signal. A bootstrap network with RBOOT (R98, DNP, R0402, 0.1%) and CBOOT (C140, DNP, C0402, 16V) is connected to the MOSFET's gate. A PMOS\_PWM signal is connected to the MOSFET's gate.

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.

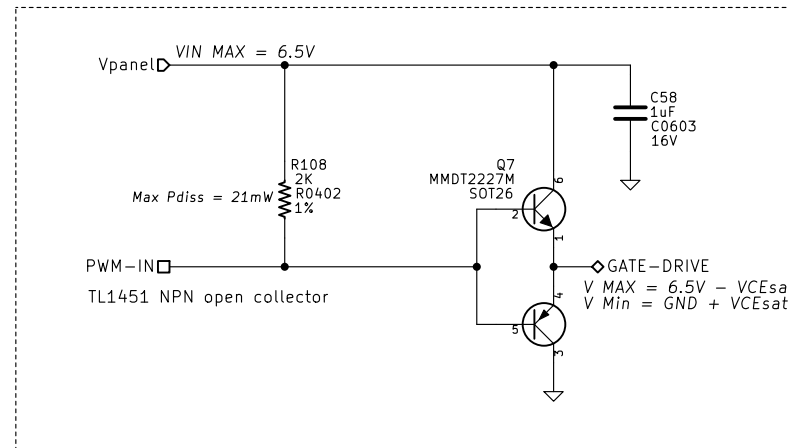
Based on Rochester Institute of Technology P13271 Design Brent Salmi, KB1LQD Bryce Salmi, KB1LQC The Radio Amateur Satellite Corporation		
File: BUCK_Non-Synch.sch		
Sheet: /MPPT_String_Y-/TL1451 Control/Non-Synchroneuse_BUCK/		
Title: Fox-1 Maximum Power Point Tracker		
Size: A4	Date: 30 nov 2015	Rev: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

- \* 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.

Id: 24/37



## 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

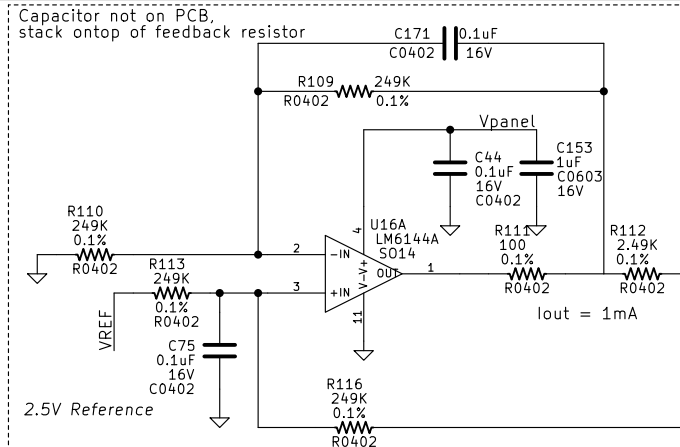
Size: A4

Date: 30 nov 2015

Rev: 2.0

KiCad E.D.A.

Id: 25/37



## Constant 1mA Current Driver

Highest Voltage Wins = Lowest Duty Cycle Wins

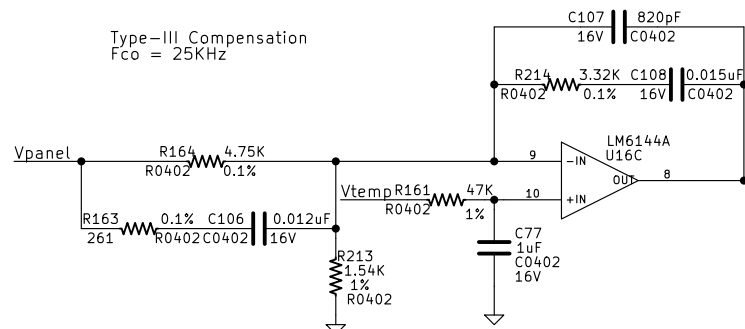
MPPT = Vout 3.3V to 4.33V

VregError -> Increasing Duty Cycle = Decrease voltage

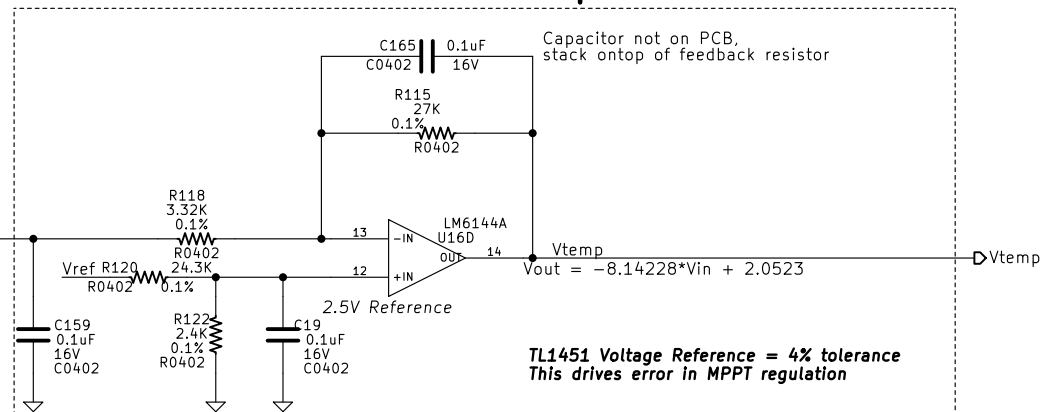
Regulation = Vout 4.33V, Vpanel increasing

Vmppt Error -> increases duty cycle (to load panel) so it looses

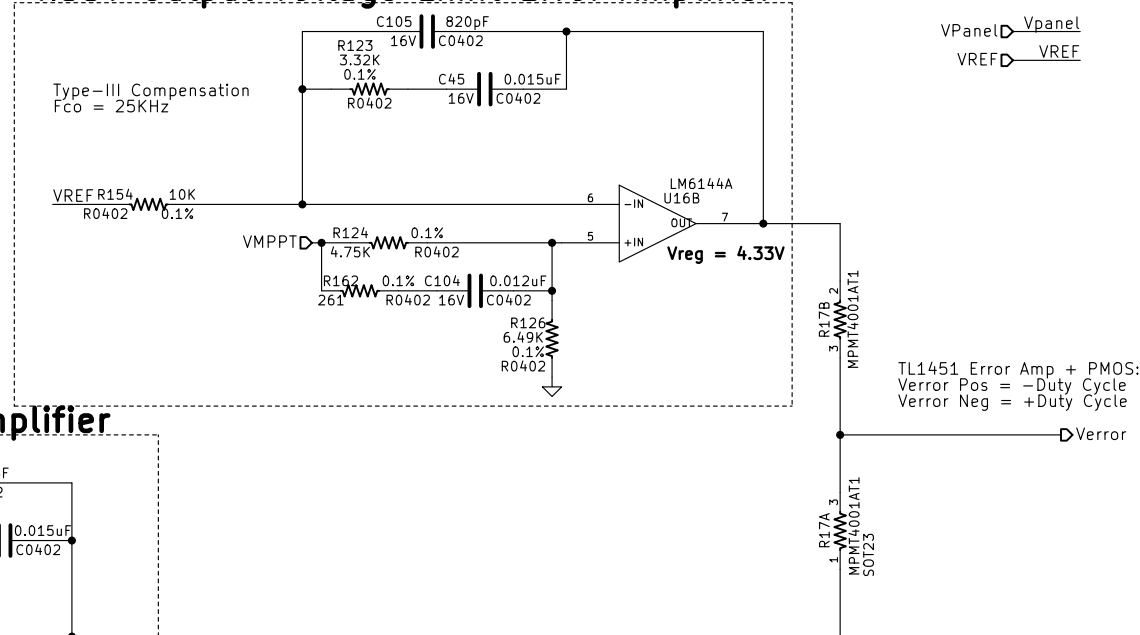
## Maximum Power Point Tracking Error Amplifier



## Y = -mX + b Amplifier



## 4.33V Output Voltage Limit Error Amplifier



## 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: RTD\_Measurement.sch

Sheet: /MPPT\_String\_Y-/Amplifiers/

Title: Fox-1 Maximum Power Point Tracker

Size: A4

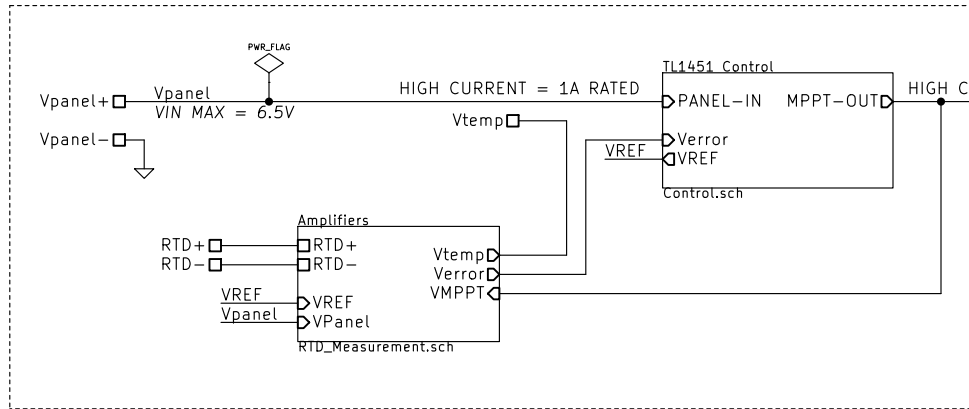
Date: 30 nov 2015

Rev: 2.0

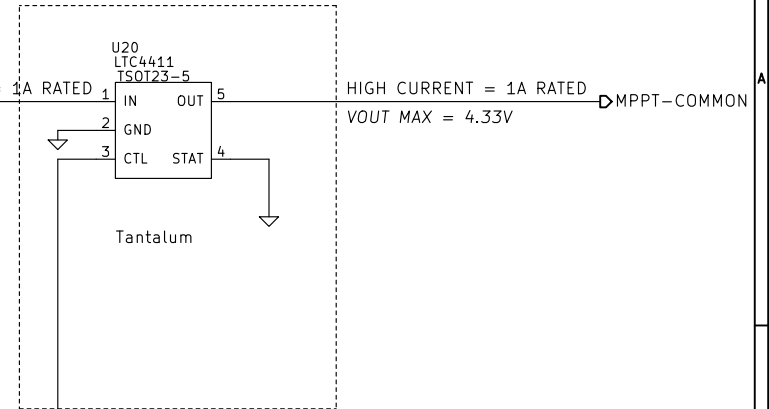
KiCad E.D.A.

Id: 26/37

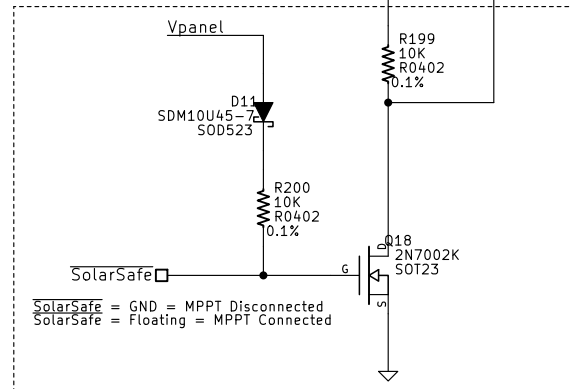
## SWITCH MODE CONVERTER



## Ideal Diode



## Solar Safe Inverter



## 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 Corrieo.
- \* 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: MPPT\_String.sch

Sheet: /MPPT\_String\_Z-/

Title: Fox-1 Maximum Power Point Tracker

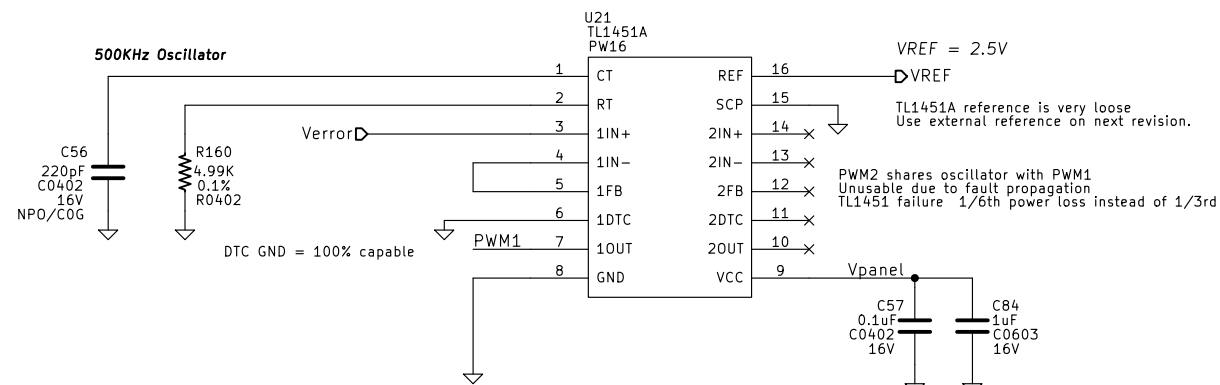
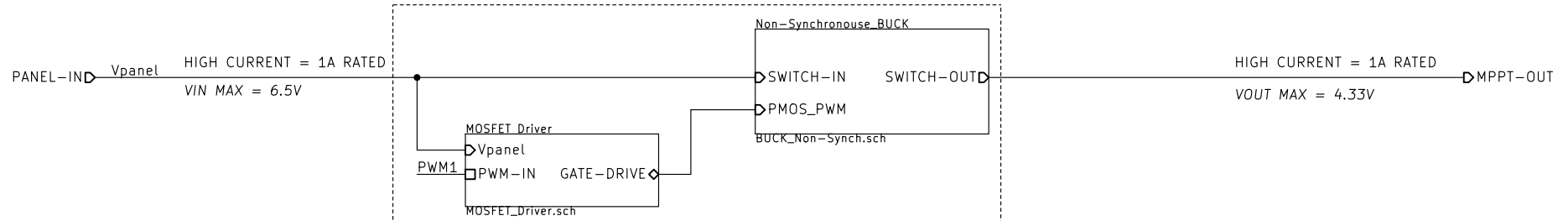
Size: A Date: 30 nov 2015

Rev: 2.0

KiCad E.D.A.

Id: 27/37

# Switch Mode Converter



## 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 guaranteed

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

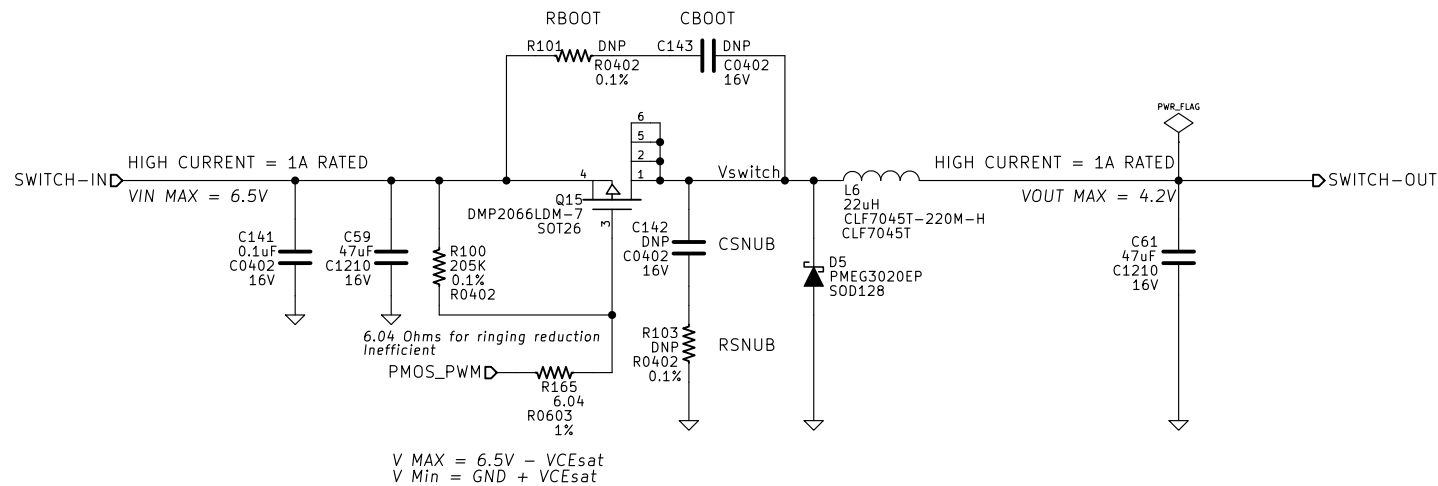
Date: 30 nov 2015

Rev: 2.0

KiCad E.D.A.

Id: 28/37

## 500 KHz Step-Down Buck Converter



### 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: BUCK\_Non-Synch.sch

Sheet: /MPPT\_String\_Z-/TL1451 Control/Non-Synchronous\_BUCK/

Title: Fox-1 Maximum Power Point Tracker

Size: A4

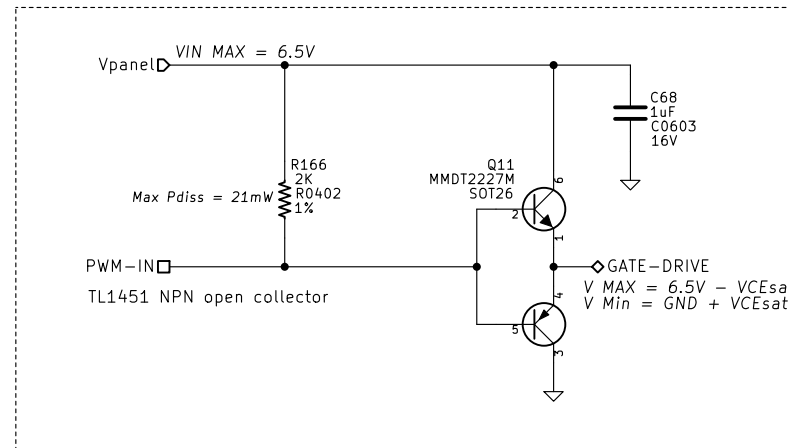
Date: 30 nov 2015

Rev: 2.0

KiCad E.D.A.

Id: 29/37

## TOTEM POLE MOSFET DRIVER



## 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\_Z-/TL1451 Control/MOSFET Driver/

Title: Fox-1 Maximum Power Point Tracker

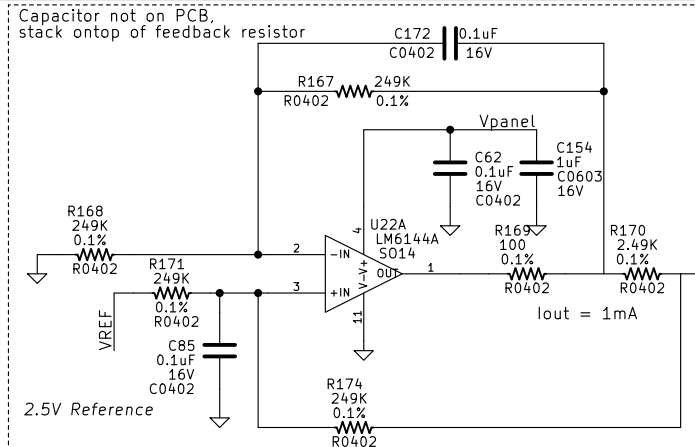
Size: A4

Date: 30 nov 2015

Rev: 2.0

KiCad E.D.A.

Id: 30/37



## Constant 1mA Current Driver

Highest Voltage Wins = Lowest Duty Cycle Wins

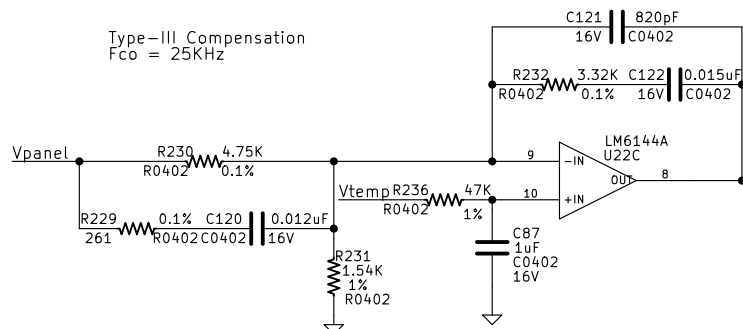
MPPT = Vout 3.3V to 4.33V

VregError -> Increasing Duty Cycle = Decrease voltage

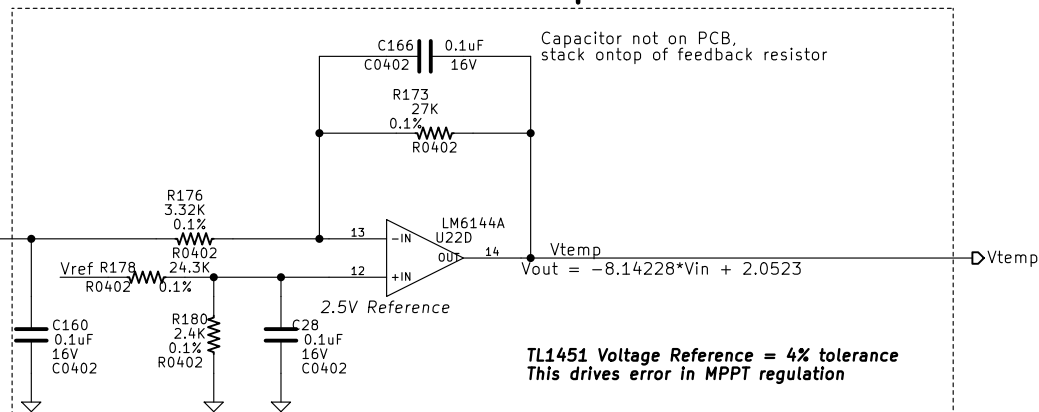
Regulation = Vout 4.33V, Vpanel increasing

Vmppt Error -> increases duty cycle (to load panel) so it looses

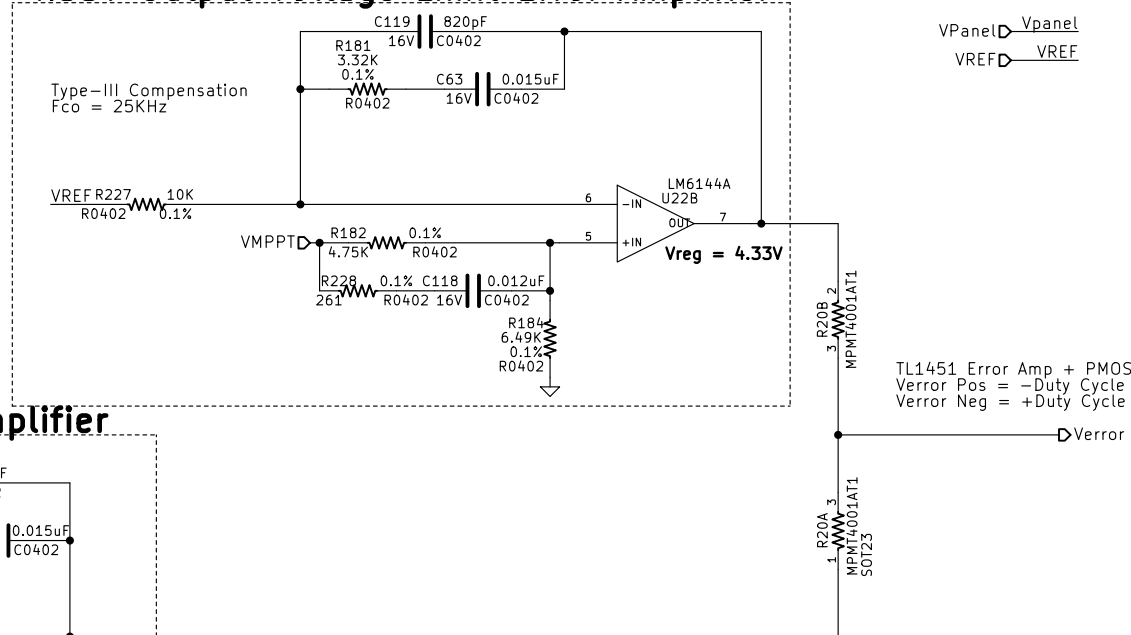
## Maximum Power Point Tracking Error Amplifier



## Y = -mX + b Amplifier



## 4.33V Output Voltage Limit Error Amplifier



## 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 guaranteed

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

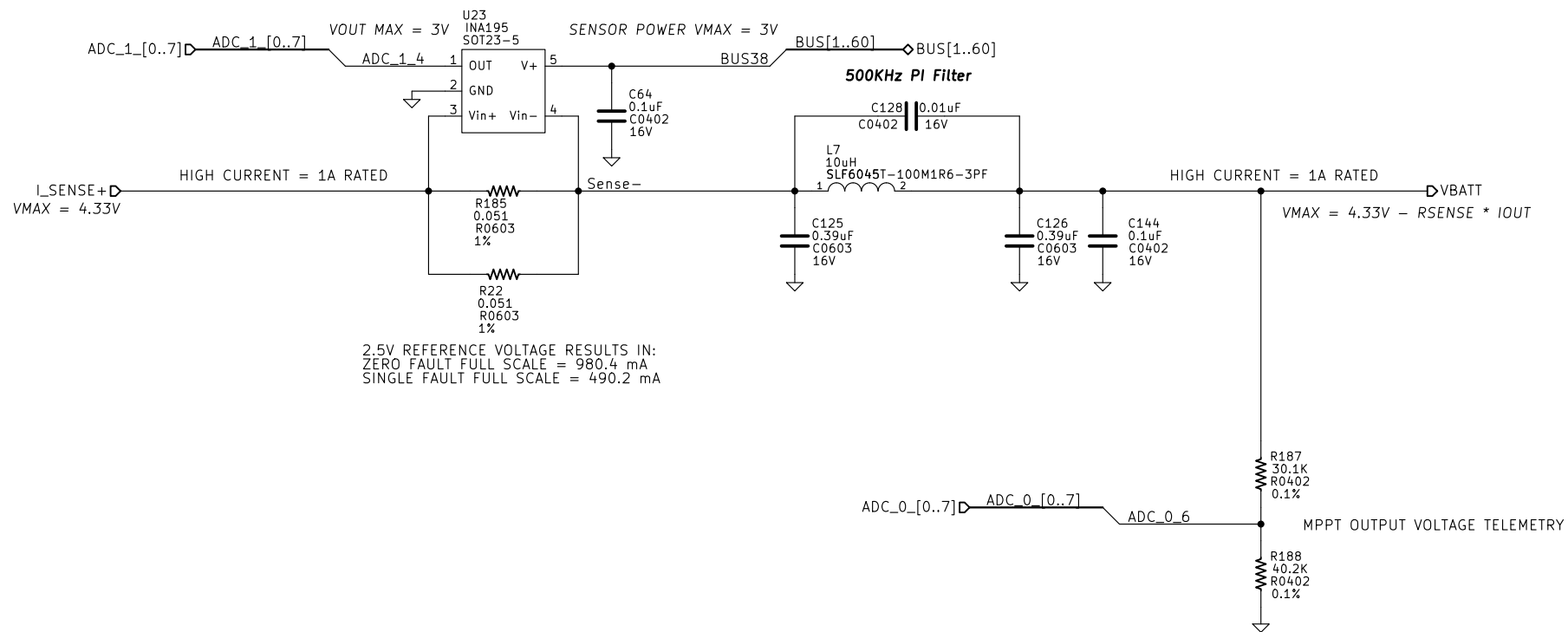
Size: A4

Date: 30 nov 2015

Rev: 2.0

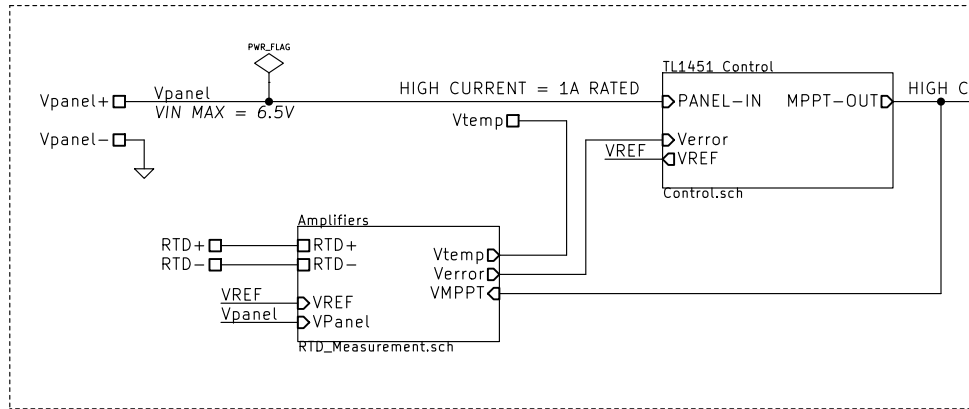
KiCad E.D.A.

Id: 31/37

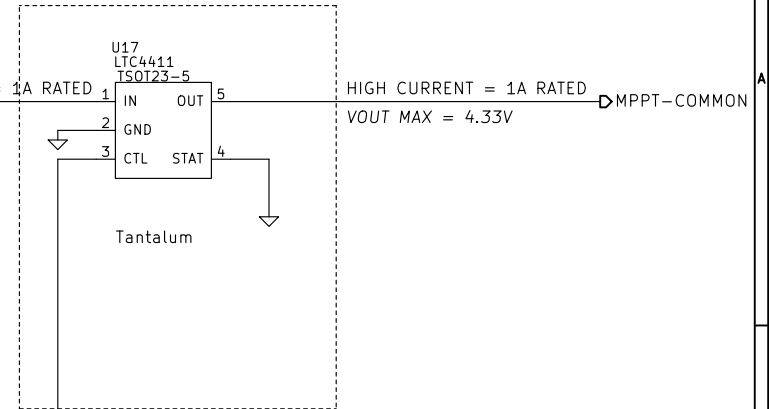




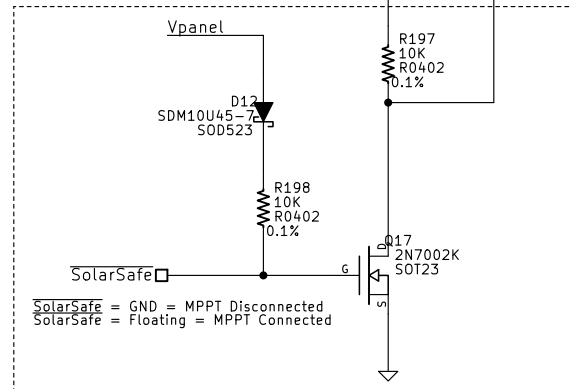
## SWITCH MODE CONVERTER



## Ideal Diode



## Solar Safe Inverter



## 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 Corrieo.
- \* 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: MPPT\_String.sch

Sheet: /MPPT\_String\_Z+ /

Title: Fox-1 Maximum Power Point Tracker

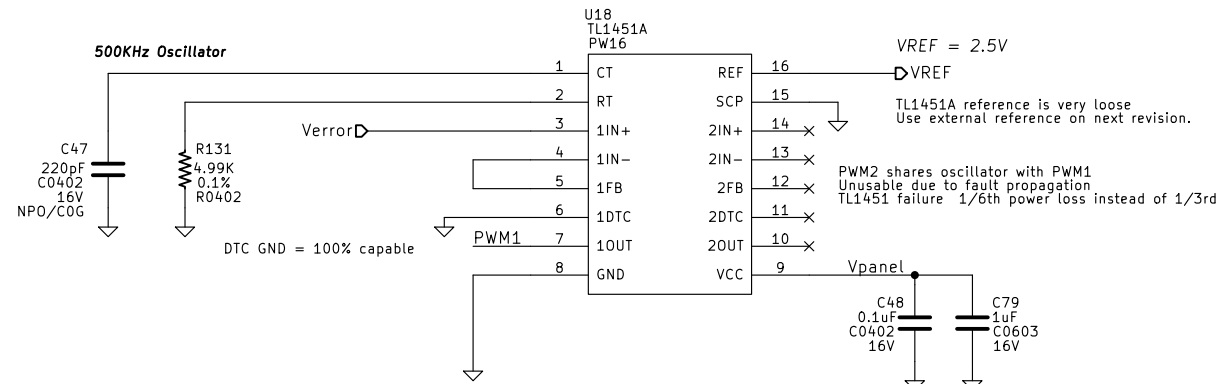
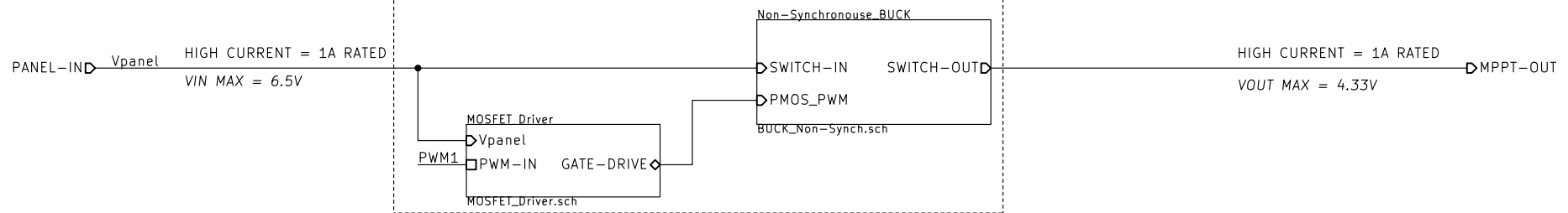
Size: A Date: 30 nov 2015

Rev: 2.0

KiCad E.D.A.

Id: 33/37

## Switch Mode Converter



## 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: 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**

**NOTES**

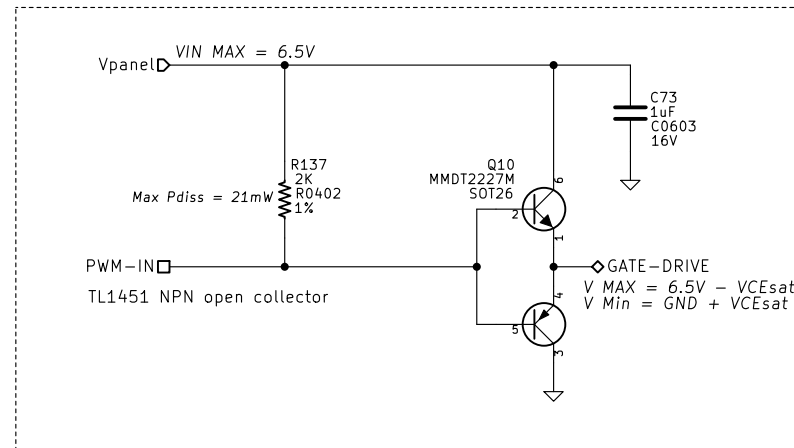
- \* This MPPT implements a set-point constant voltage tracking algorithm based on panel temperature.
- \* RIT MPPT Team: Brenton Salmi (KB1LQD), Bryce Salmi (KB1LQC), Ian MacKenzie (KB3OCF), Daniel Corriero.
- \* Parts not yet NASA derated.

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

- \* 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.

Id: 35/37

## 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\_Z+/TL1451 Control/MOSFET Driver/

Title: Fox-1 Maximum Power Point Tracker

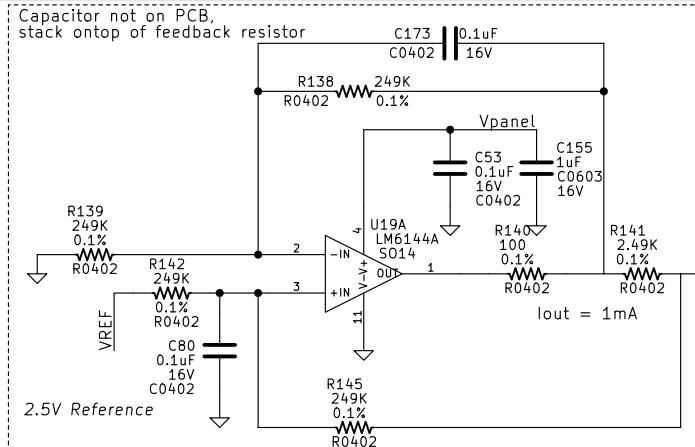
Size: A4

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

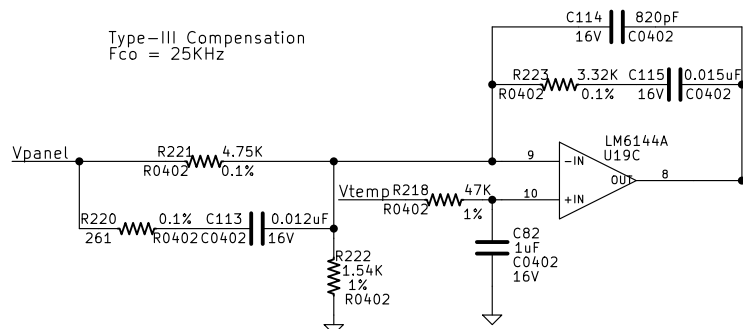
MPPT = Vout 3.3V to 4.33V

VregError -> Increasing Duty Cycle = Decrease voltage

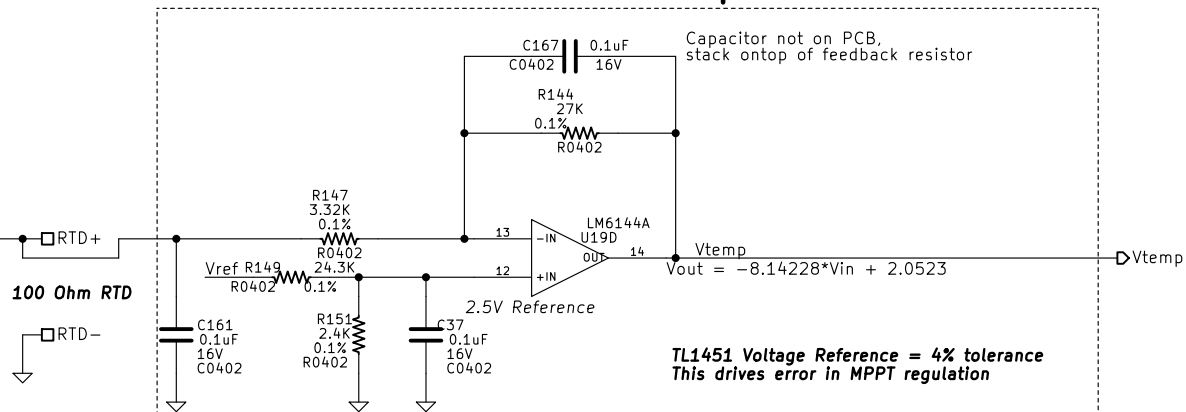
Regulation = Vout 4.33V, Vpanel increasing

Vmppt Error -> increases duty cycle (to load panel) so it looses

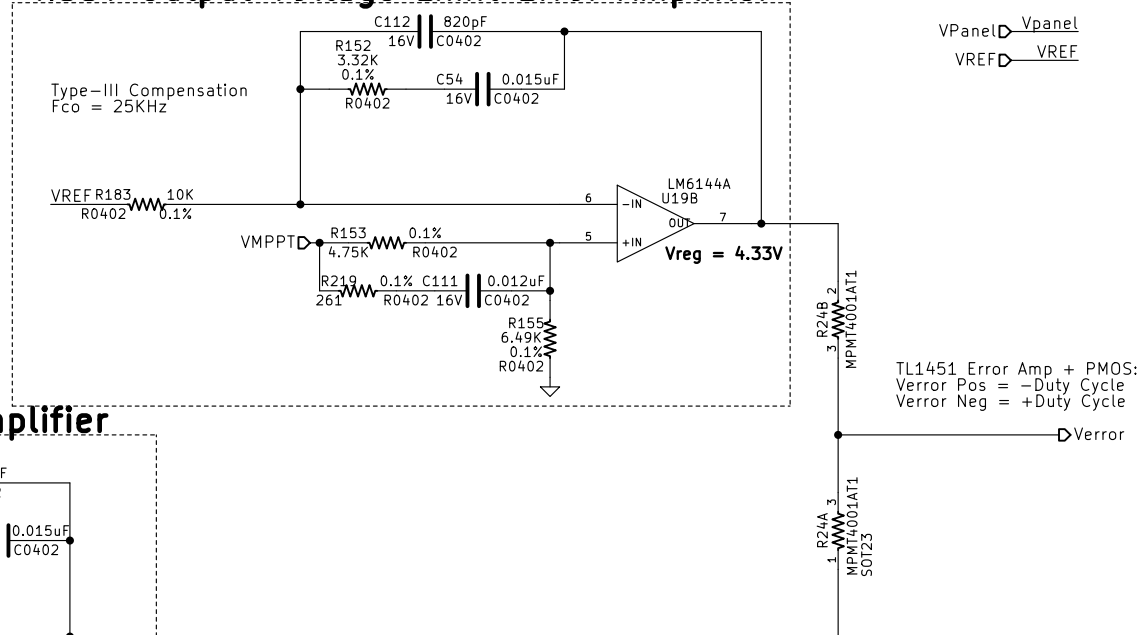
## Maximum Power Point Tracking Error Amplifier



## Y = -mX + b Amplifier



## 4.33V Output Voltage Limit Error Amplifier



## 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 guaranteed

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