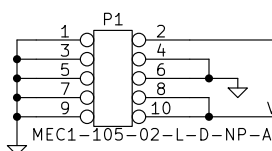


# FOX-1 Maximum Power Point Tracker

ALL SOLAR PANELS INPUTS MED. CURRENT = 0.5A RATED

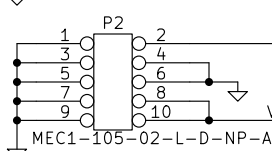
## X+ PANEL

VIN MAX = 6.5V



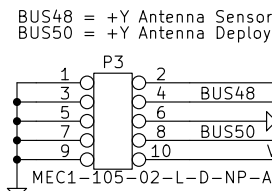
## X- PANEL

VIN MAX = 6.5V



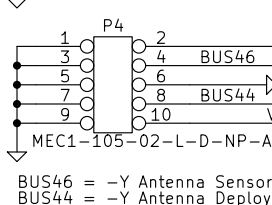
## Y+ PANEL

VIN MAX = 6.5V



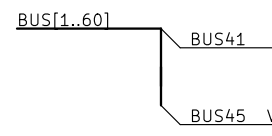
## Y- PANEL

VIN MAX = 6.5V



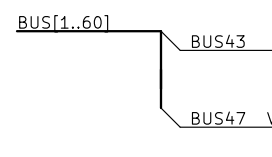
## Z+ PANEL

VIN MAX = 6.5V



## Z- PANEL

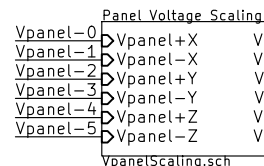
VIN MAX = 6.5V



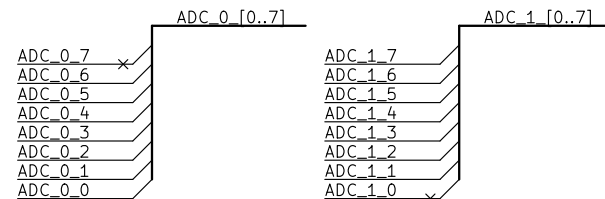
## NOTES

- \* 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

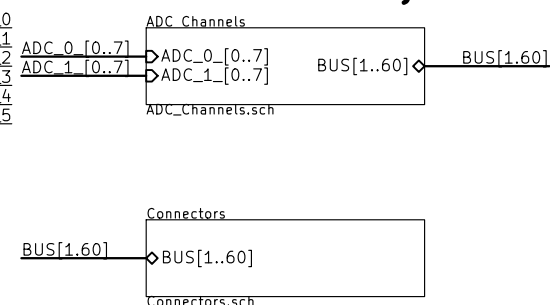
BUS[1..60]



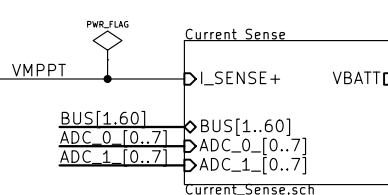
ADC\_Bus Breakouts



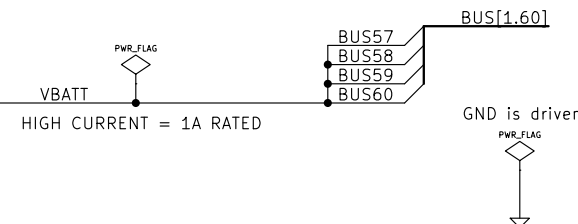
## MPPT Telemetry



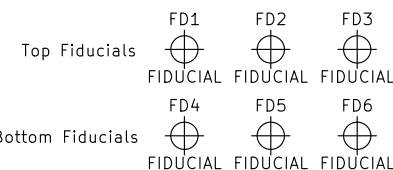
HIGH CURRENT = 1A RATED



VOUT MAX = 4.33V - RSENSE \* IOUT



R·I·T



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

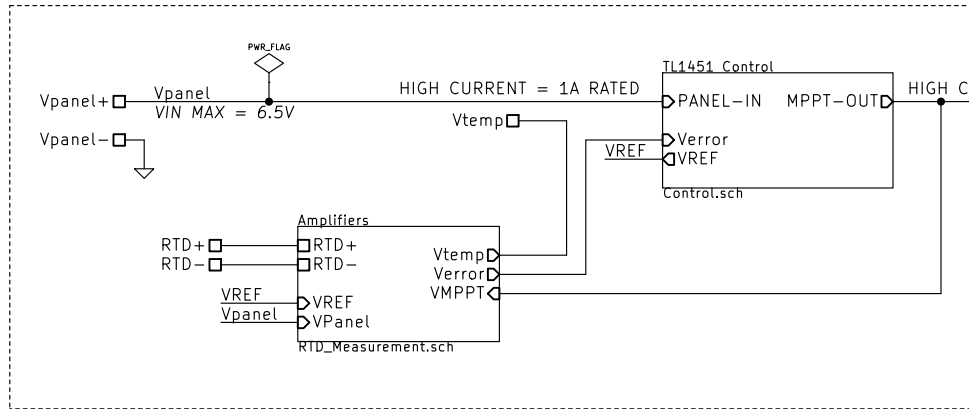
Size: USLetter Date: 3 sep 2016

KiCad E.D.A.

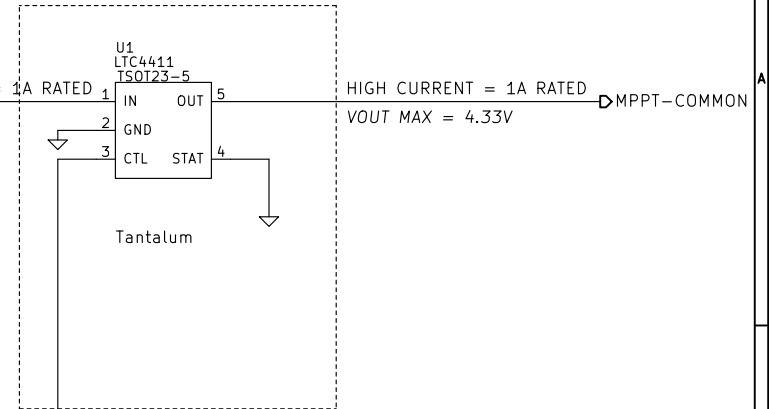
Rev: 2.0

Id: 1/37

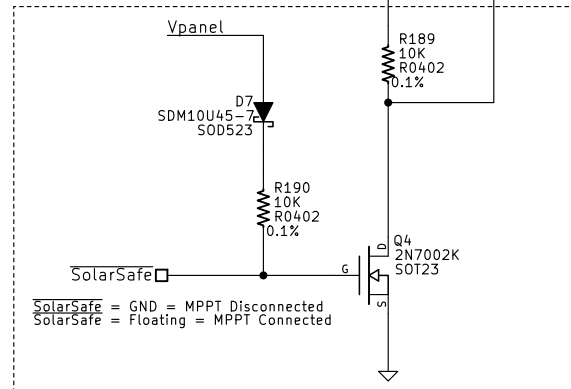
## SWITCH MODE CONVERTER



## 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

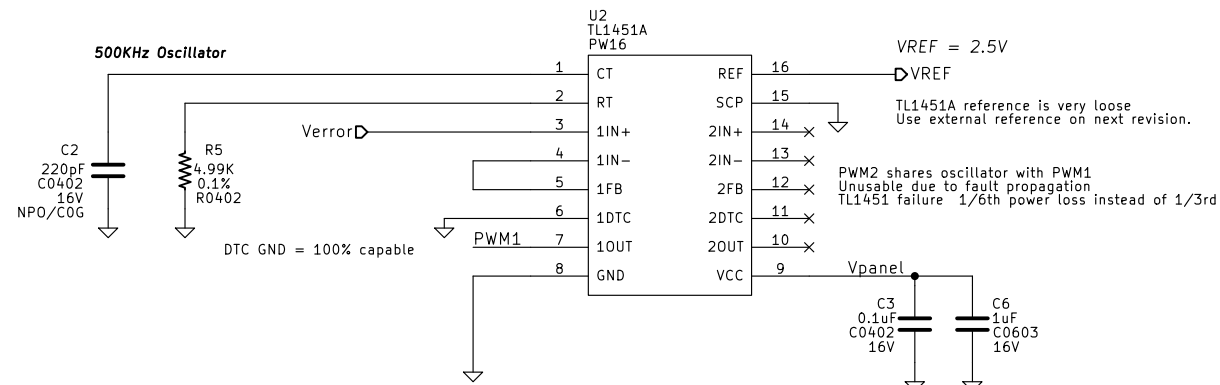
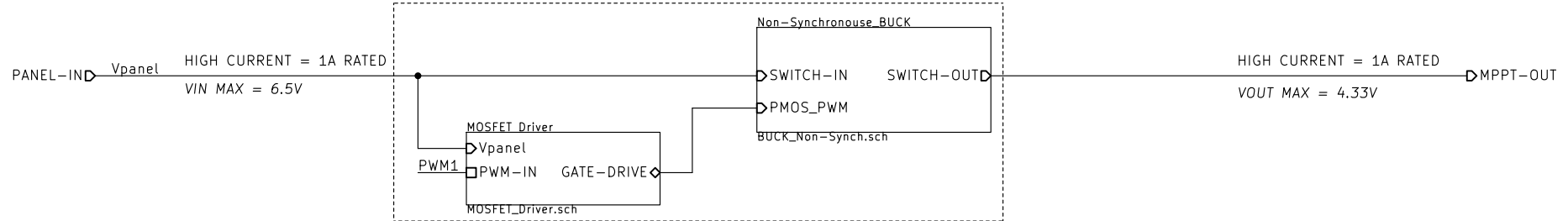
Date: 3 sep 2016

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 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

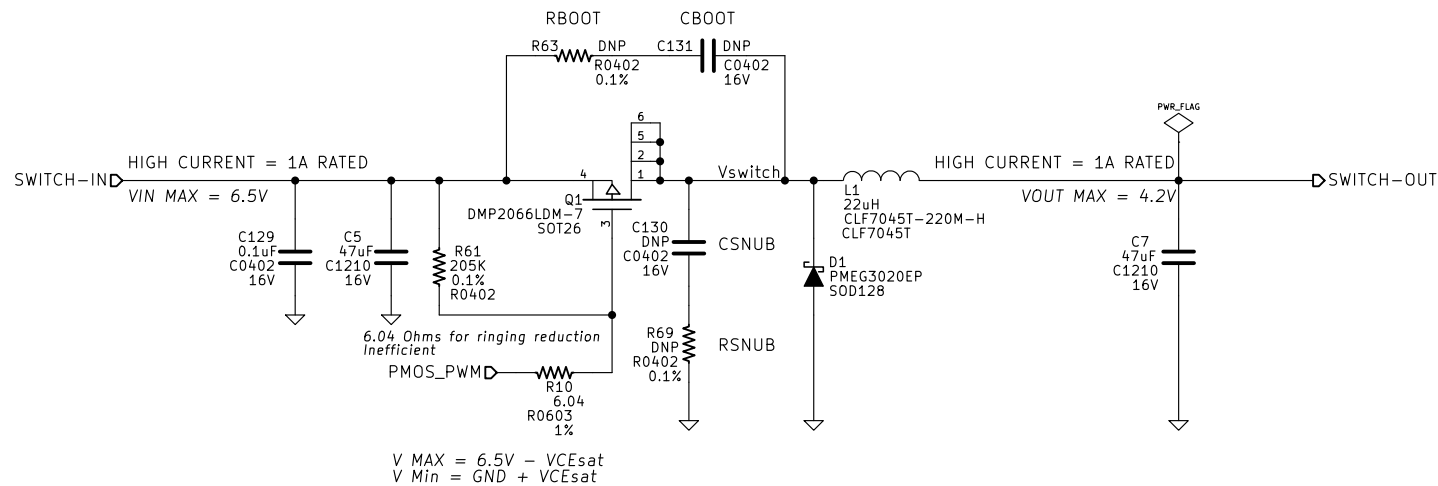
Date: 3 sep 2016

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

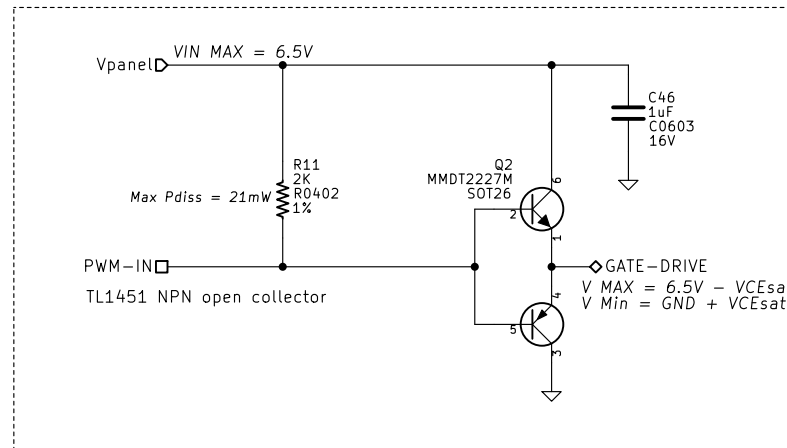
Date: 3 sep 2016

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

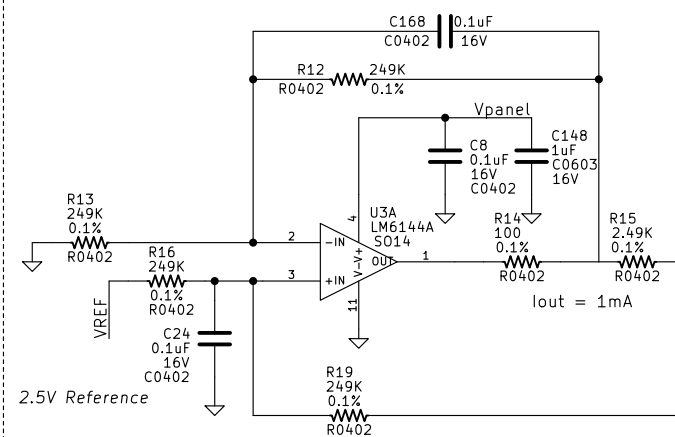
Size: A4

Date: 3 sep 2016

Rev: 2.0

KiCad E.D.A.

Id: 5/37



### Constant 1mA Current Driver

Highest Voltage Wins = Lowest Duty Cycle Wins

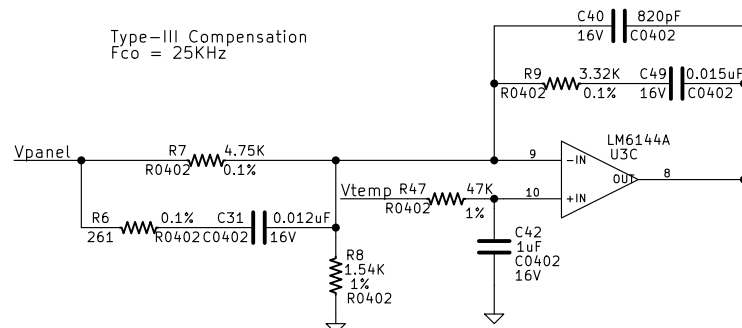
MPPT = Vout 3.3V to 4.33V

VregError -> Increasing Duty Cycle = Decrease voltage

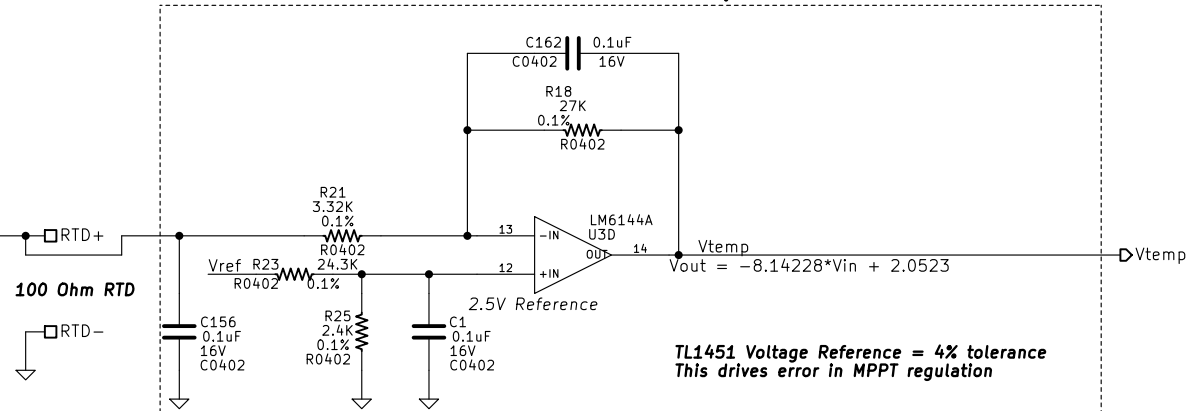
Regulation = Vout 4.33V, Vpanel increasing

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

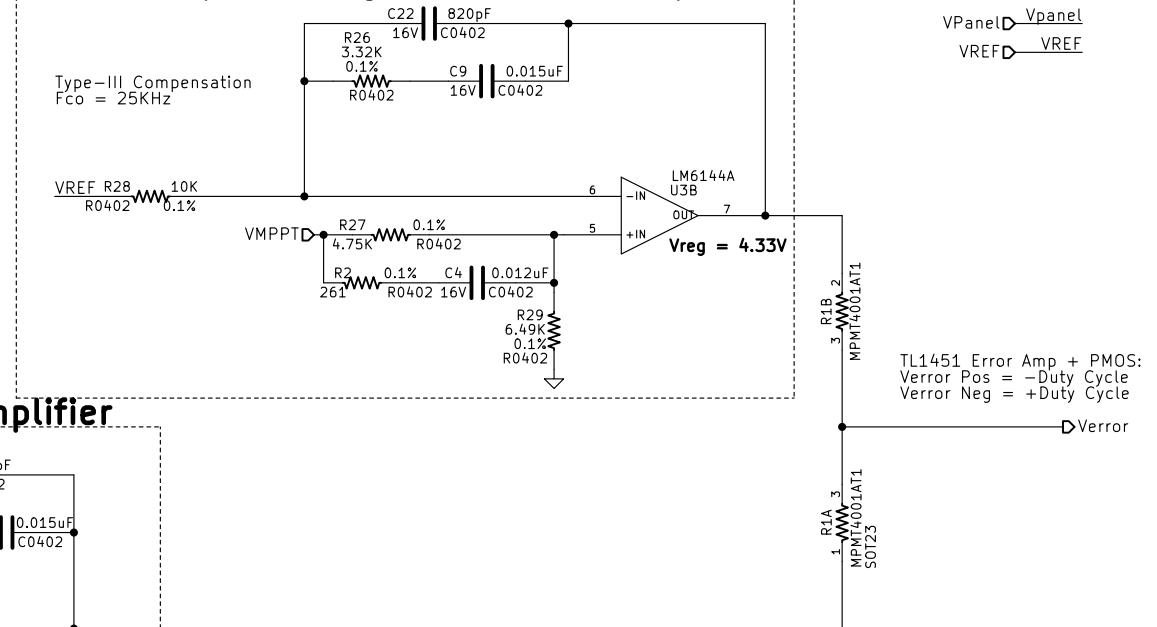
### Maximum Power Point Tracking Error Amplifier



### $Y = -mX + b$ Amplifier



### 4.33V Output Voltage Limit Error Amplifier



TL1451 Error Amp + PMOS:  
Verror Pos = -Duty Cycle  
Verror Neg = +Duty Cycle

### 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: 3 sep 2016

Rev: 2.0

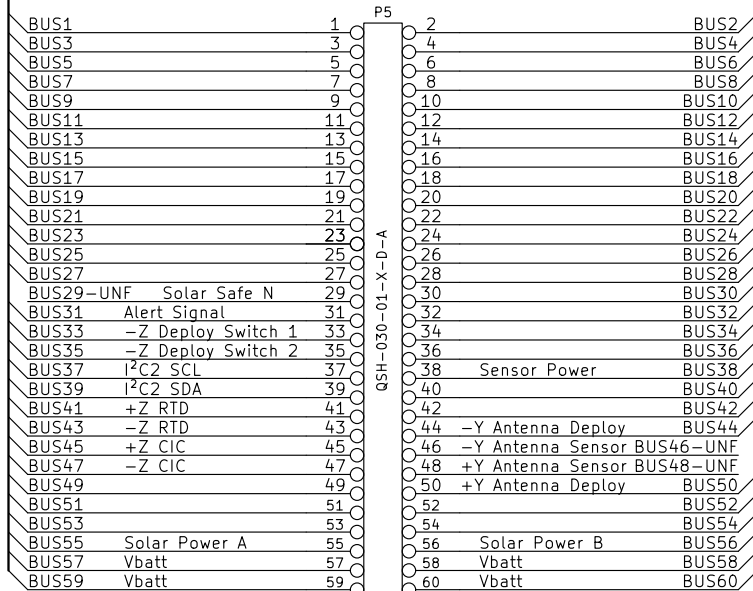
KiCad E.D.A.

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]

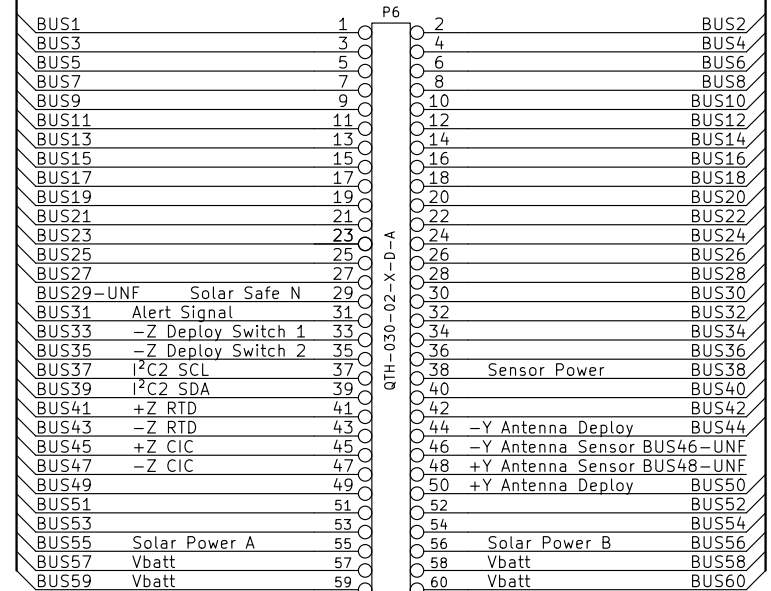
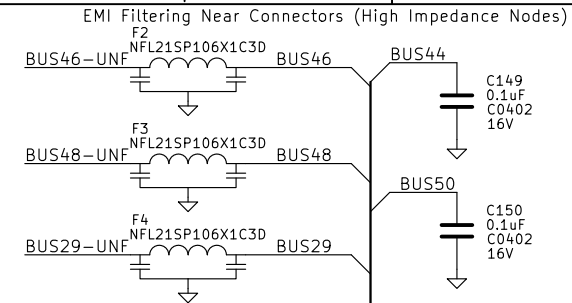
BUS[1..60]



VBATT HIGH CURRENT = 1A RATED

BUS38 Sensor Power is driven by the IHU PCB

BUS38



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

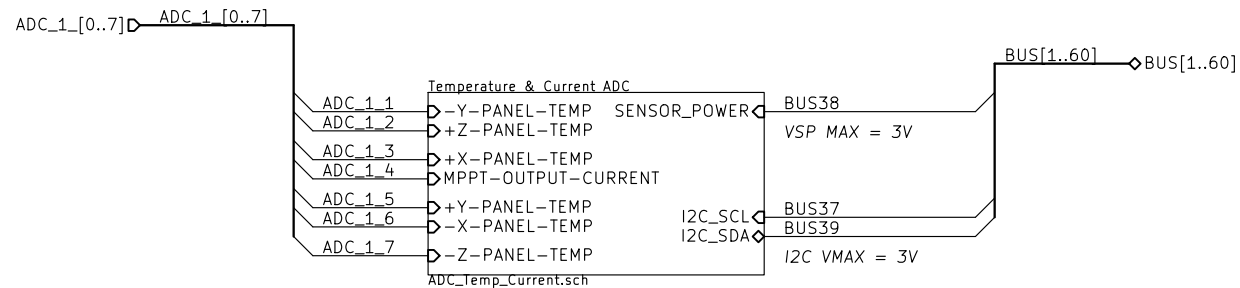
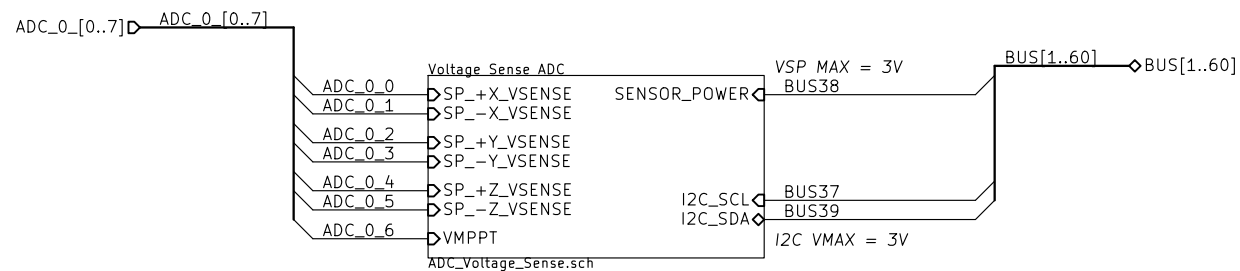
Size: A4

Date: 3 sep 2016

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: 3 sep 2016	Rev: 2.0
KiCad E.D.A.		Id: 8/37

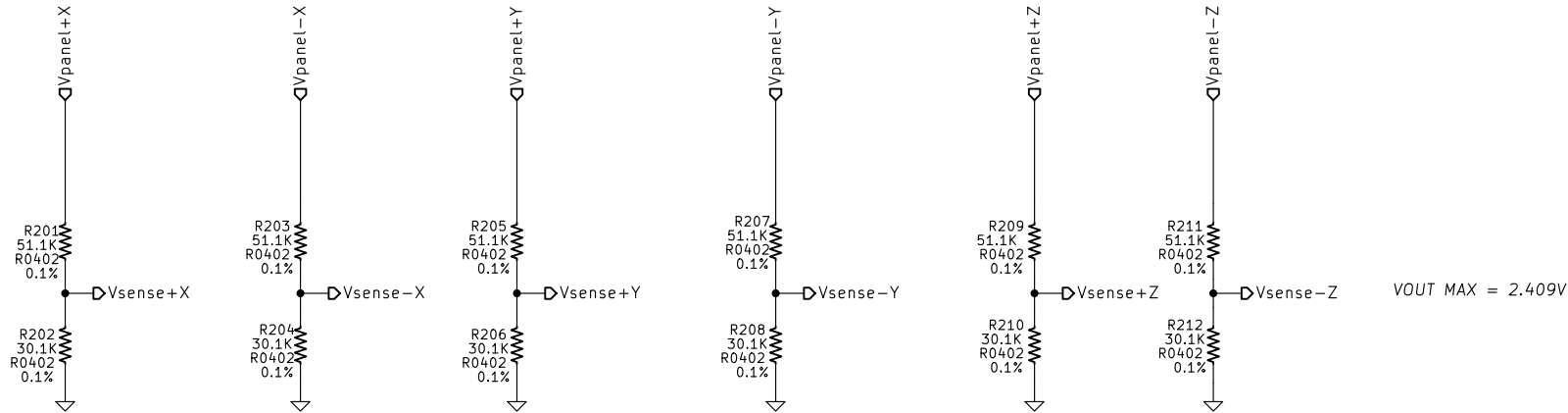






# PANEL VOLTAGE TELEMETRY ADC SCALING

VIN MAX = 6.5V



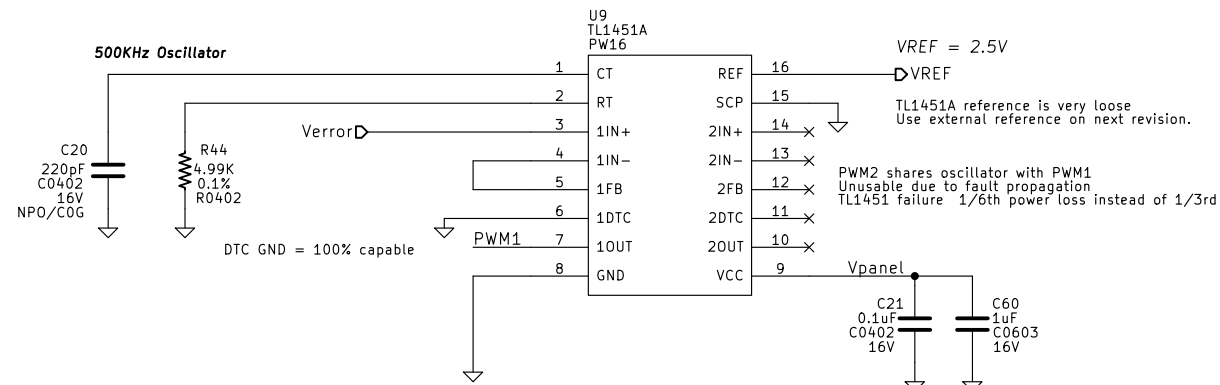
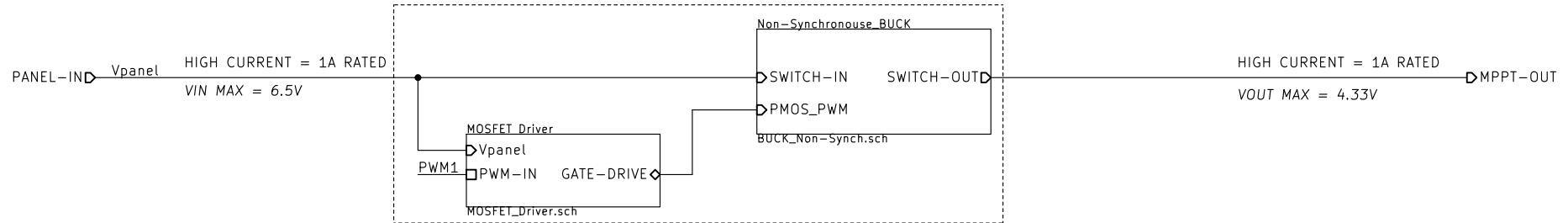
## NOTES

- \* 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: 3 sep 2016	Rev: 2.0
KiCad E.D.A.		Id: 11/37



## 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\_X-/TL1451 Control/

Title: Fox-1 Maximum Power Point Tracker

Size: A4

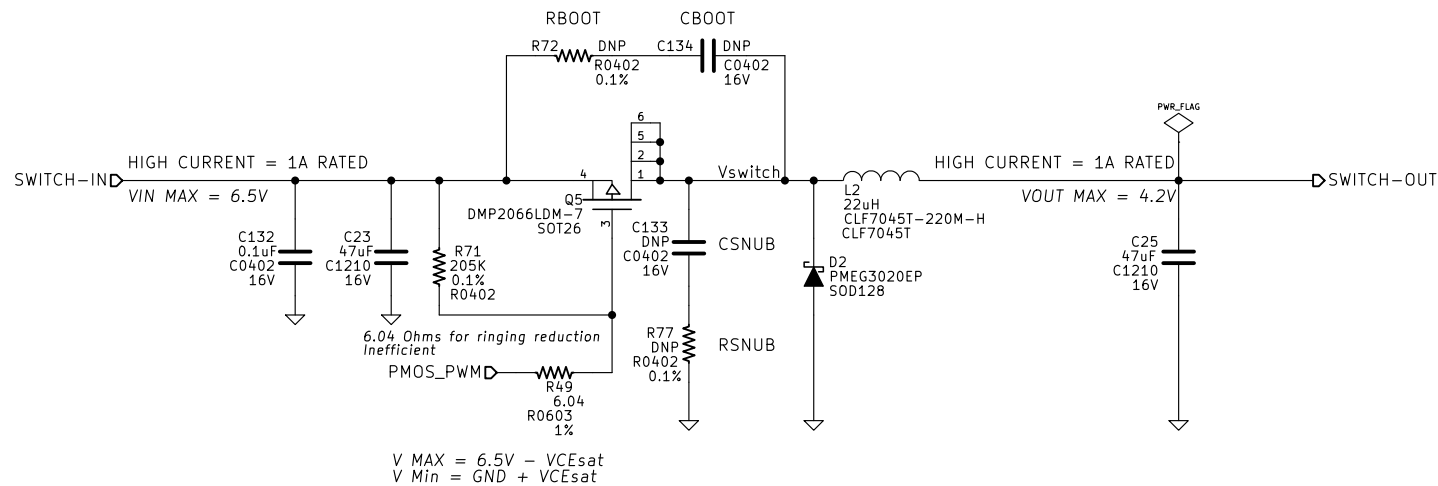
Date: 3 sep 2016

Rev: 2.0

KiCad E.D.A.

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

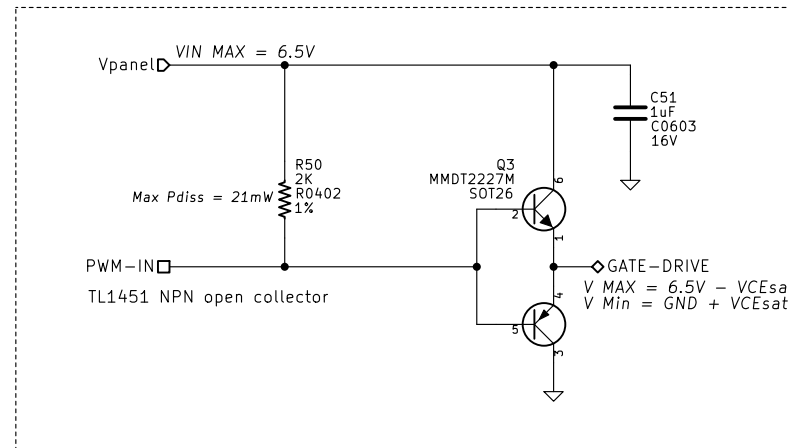
Date: 3 sep 2016

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

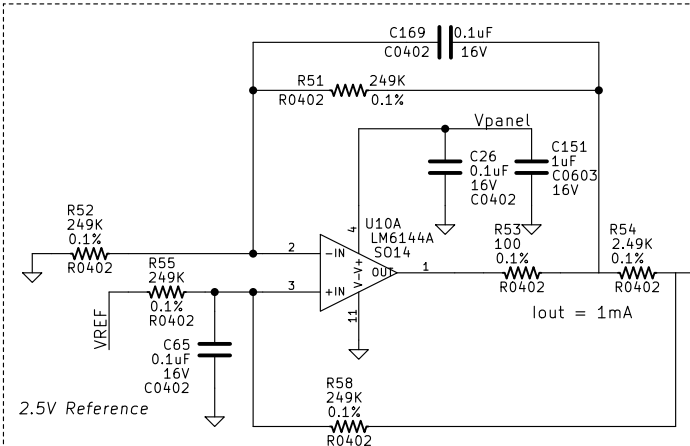
Size: A4

Date: 3 sep 2016

Rev: 2.0

KiCad E.D.A.

Id: 15/37



**Constant 1mA Current Driver**

Highest Voltage Wins = Lowest Duty Cycle Wins

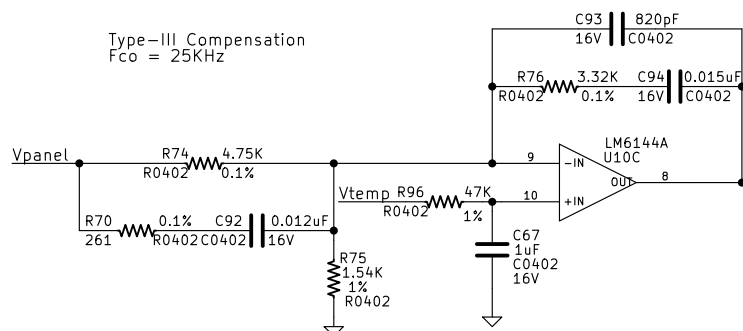
MPPT = Vout 3.3V to 4.33V

VregError -> Increasing Duty Cycle = Decrease voltage

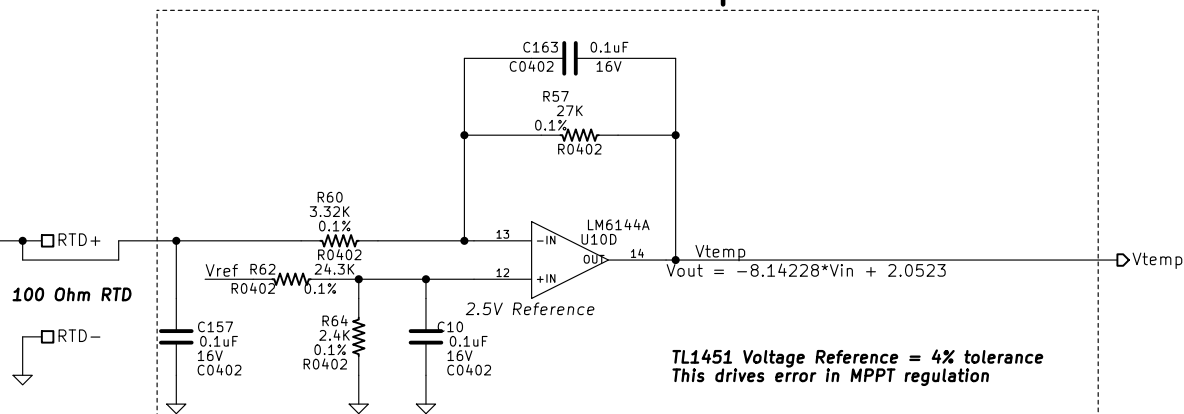
Regulation = Vout 4.33V, Vpanel increasing

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

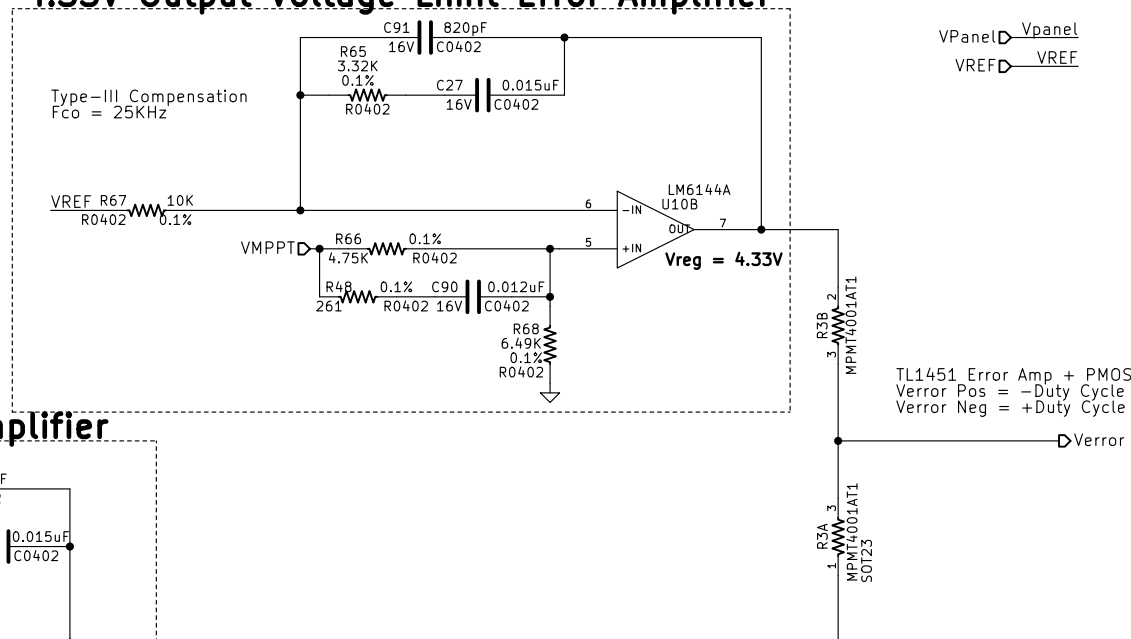
**Maximum Power Point Tracking Error Amplifier**



**Y = -mX + b Amplifier**



**4.33V Output Voltage Limit Error Amplifier**



TL1451 Error Amp + PMOS:  
Verror Pos = -Duty Cycle  
Verror Neg = +Duty Cycle

## 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: 3 sep 2016

Rev: 2.0

KiCad E.D.A.

Id: 16/37





**Switch Mode Converter**

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

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

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

HIGH CURRENT = 1A RATED  
VOUT MAX = 4.33V MPPT-OUT

**TL1451A Control Circuit**

U12 TL1451A PW16

500KHz Oscillator

C29 220pF C0402 16V NPO/COG

R73 4.99K 0.1% R0402

DTC GND = 100% capable

Verror

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

C30 0.1uF C0402 16V

C69 1uF C0603 16V

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 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: 3 sep 2016	Rev: 2.0
KiCad E.D.A.		Id: 18/37

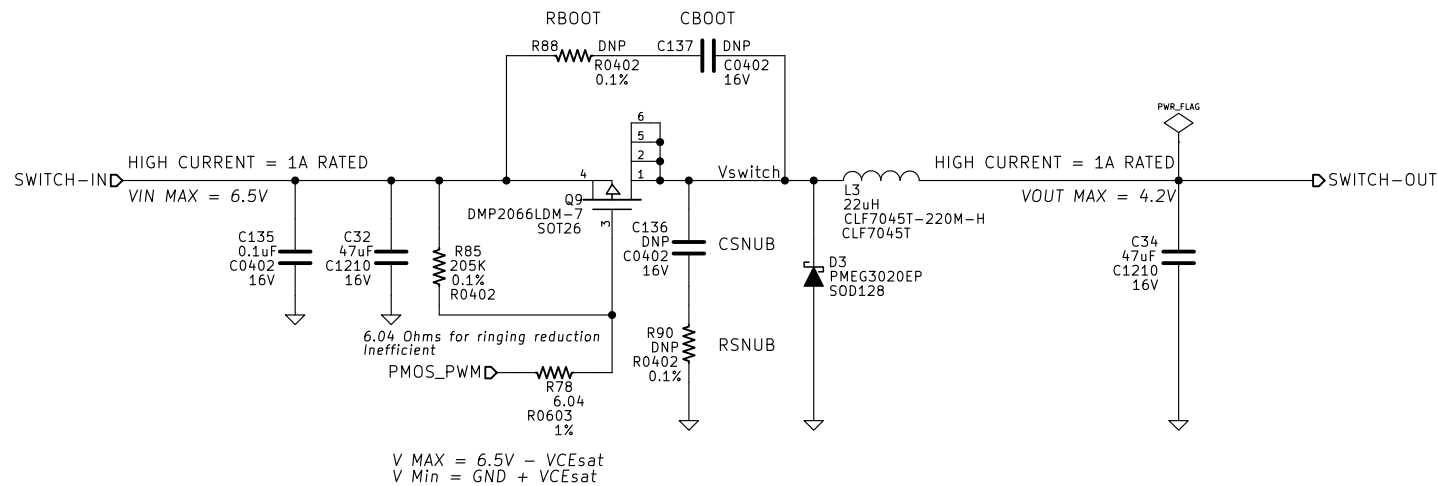
- \* This MPPT implements a set-point constant voltage tracking algorithm based on panel temperature.
- \* RIT MPPT Team: Brenton Salmi (KB1LQD), Bryce Salmi (KB1LQC), Ian MacKenzie (KB3OCF), Daniel Corriero.
- \* NASA derating taken into account, not guaranteed

File: Control.sch
Sheet: /MPPT_String_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

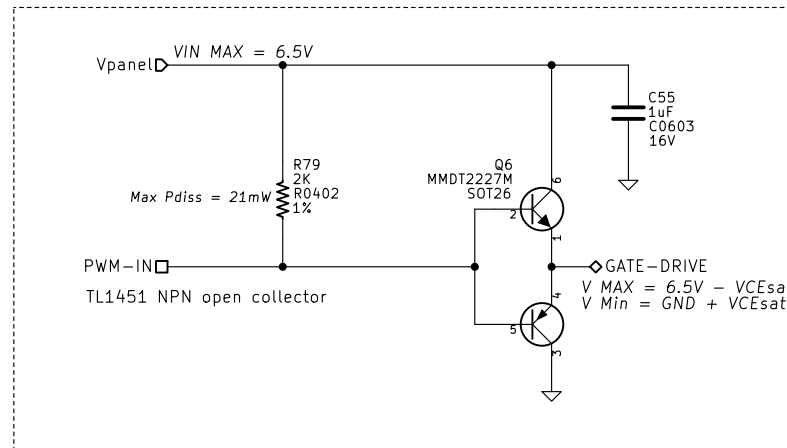
Date: 3 sep 2016

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

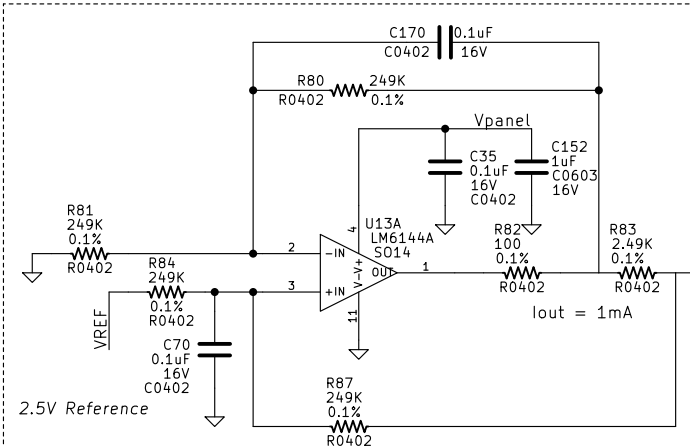
Size: A4

Date: 3 sep 2016

Rev: 2.0

KiCad E.D.A.

Id: 20/37



**Constant 1mA Current Driver**

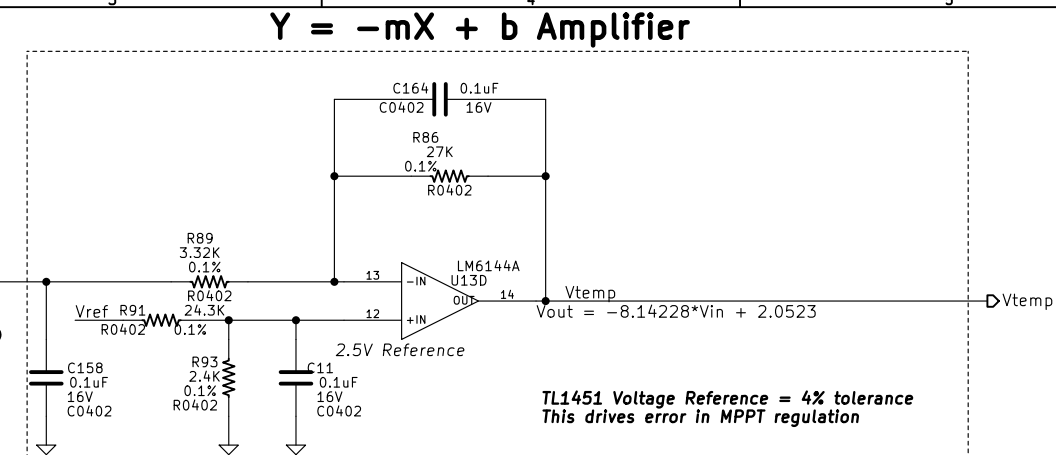
Highest Voltage Wins = Lowest Duty Cycle Wins

MPPT = Vout 3.3V to 4.33V

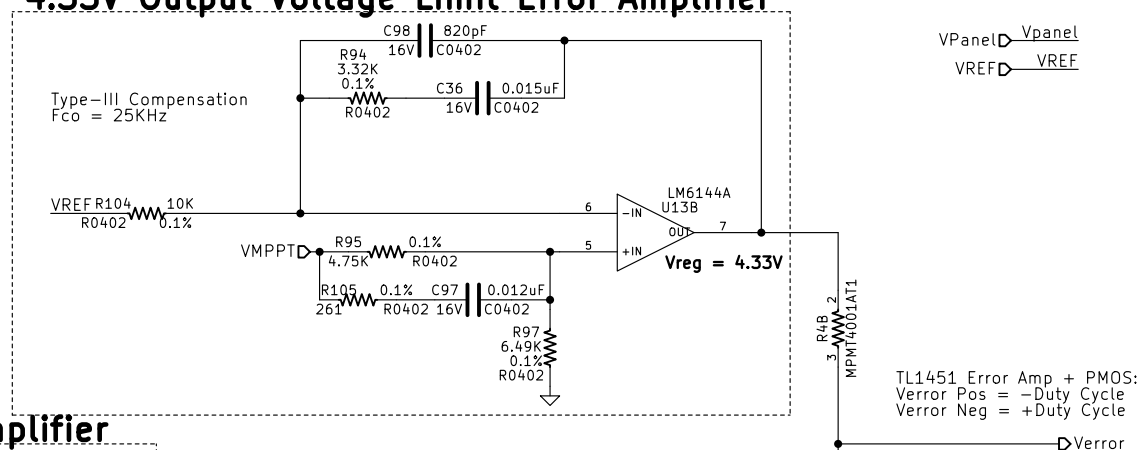
VregError -> Increasing Duty Cycle = Decrease voltage

Regulation = Vout 4.33V, Vpanel increasing

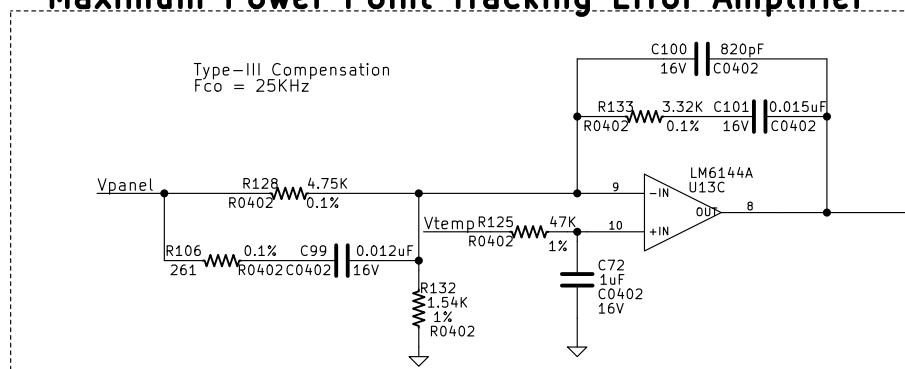
Vmppt Error -> increases duty cycle (to load panel) so it looses



**4.33V Output Voltage Limit Error Amplifier**



**Maximum Power Point Tracking 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

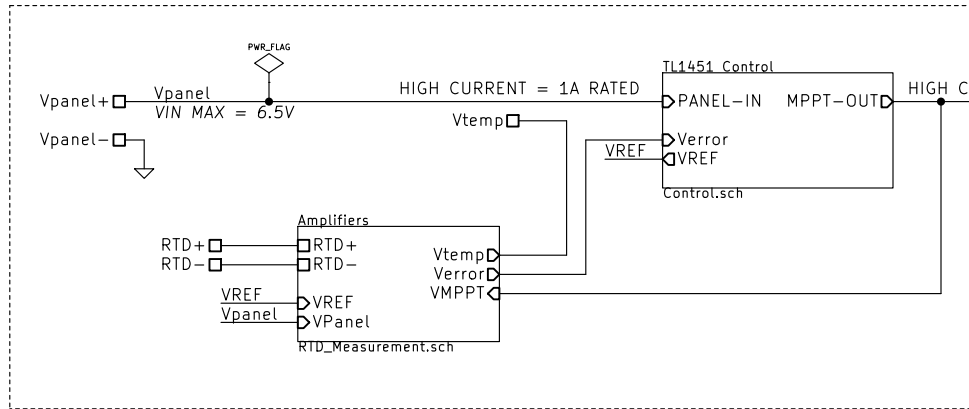
Date: 3 sep 2016

Rev: 2.0

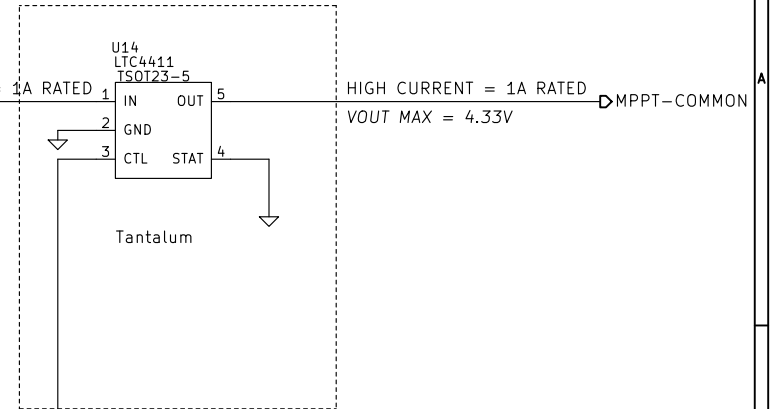
KiCad E.D.A.

Id: 21/37

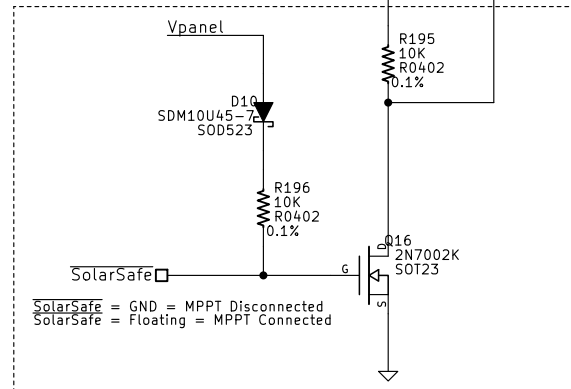
## SWITCH MODE CONVERTER



## 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 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

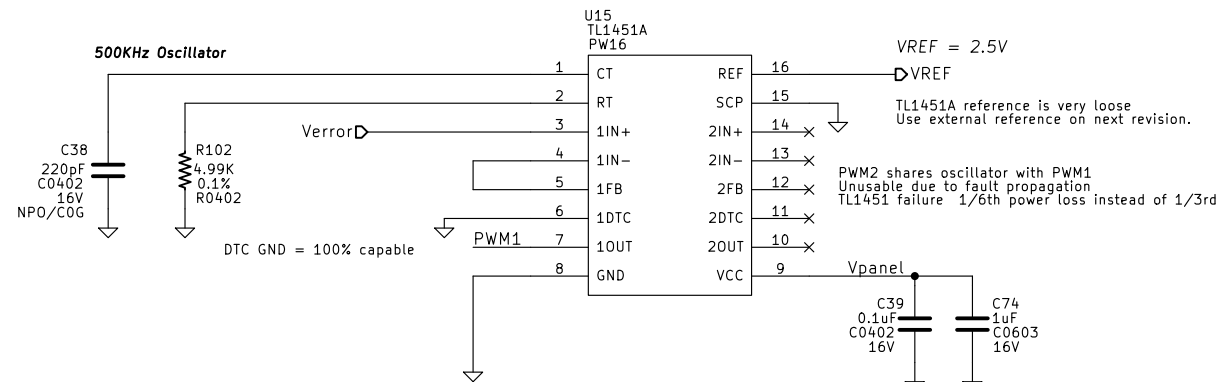
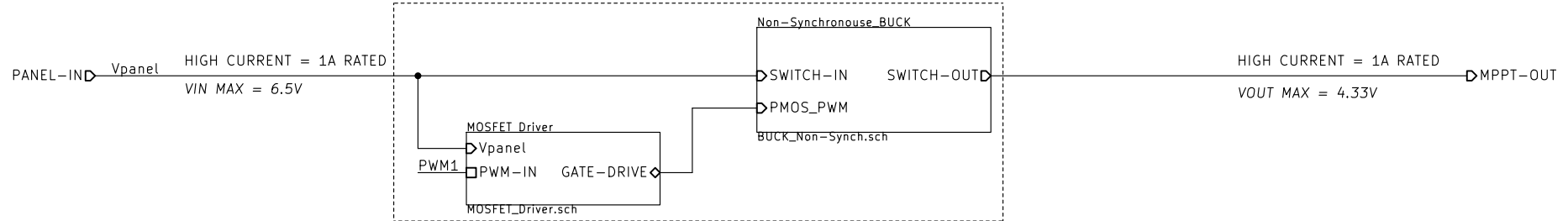
Date: 3 sep 2016

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

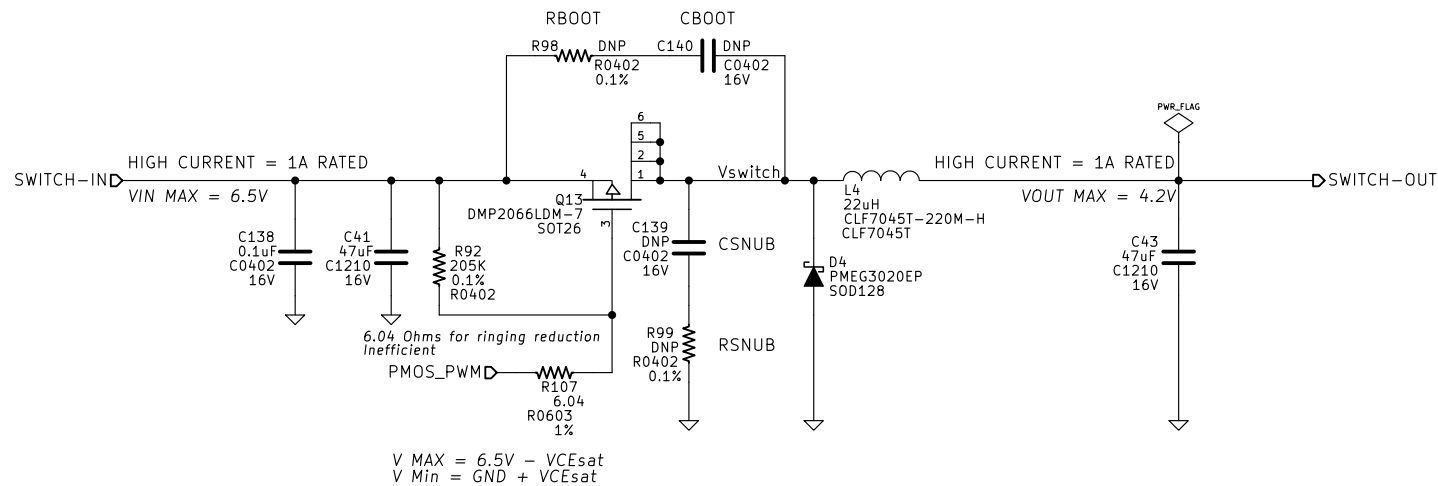
Date: 3 sep 2016

Rev: 2.0

KiCad E.D.A.

Id: 23/37

## 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: 3 sep 2016

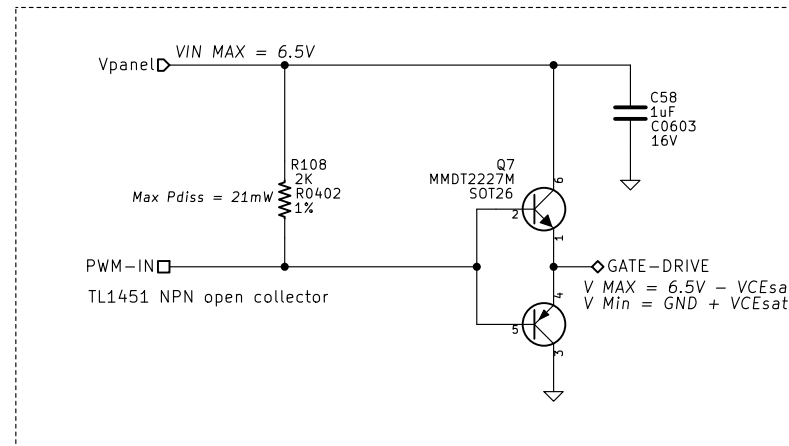
Rev: 2.0

KiCad E.D.A.

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

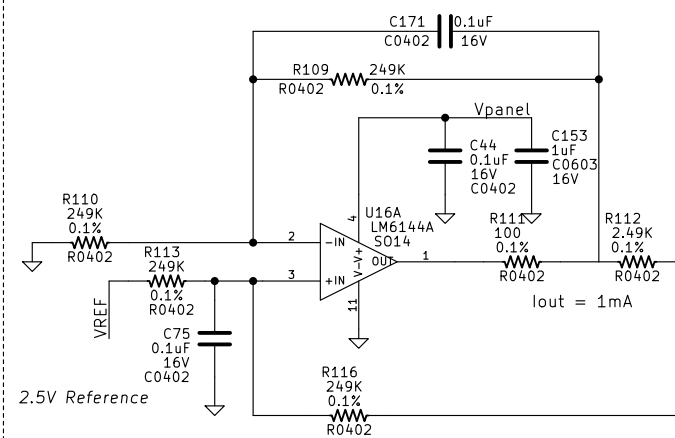
Size: A4

Date: 3 sep 2016

Rev: 2.0

KiCad E.D.A.

Id: 25/37



**Constant 1mA Current Driver**

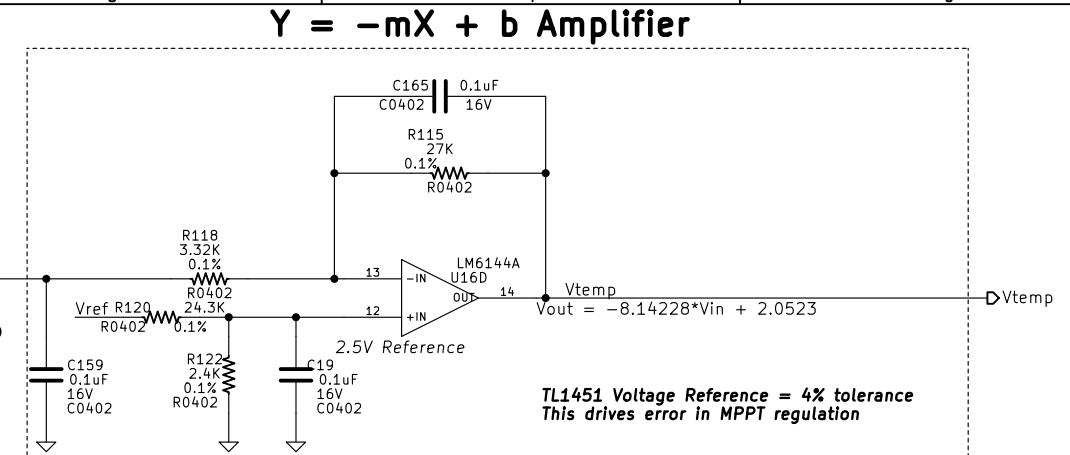
Highest Voltage Wins = Lowest Duty Cycle Wins

MPPT = Vout 3.3V to 4.33V

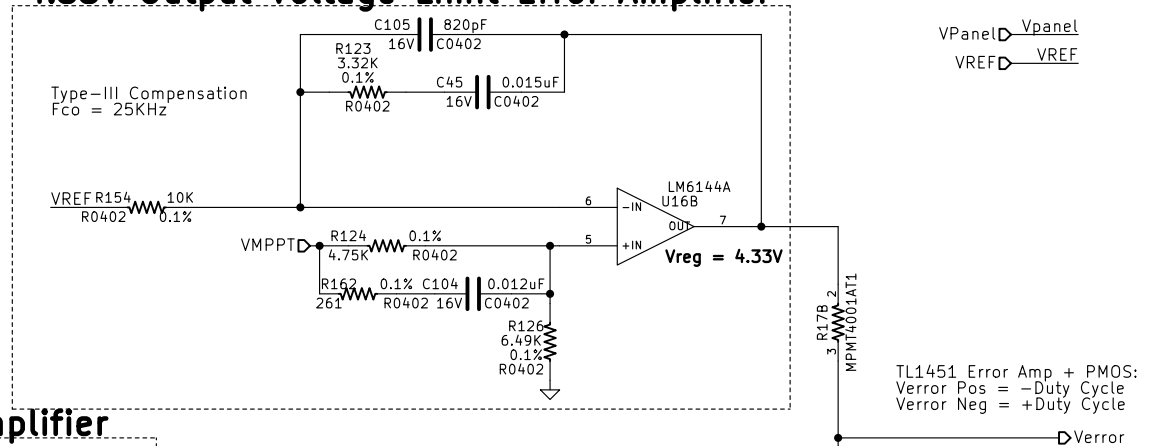
VregError -> Increasing Duty Cycle = Decrease voltage

Regulation = Vout 4.33V, Vpanel increasing

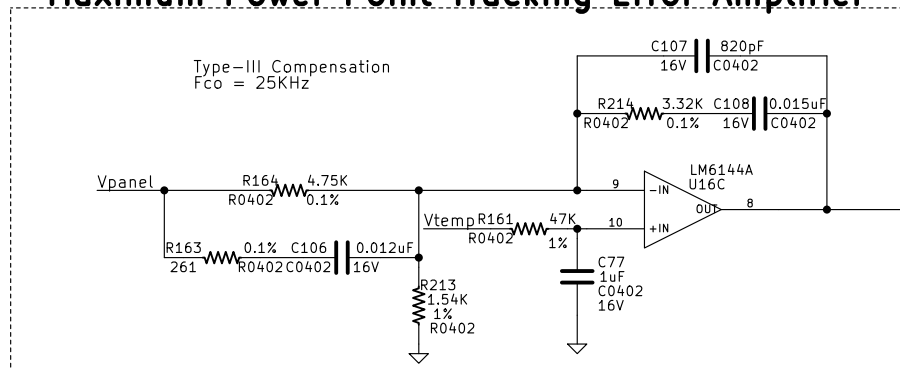
Vmppt Error -> increases duty cycle (to load panel) so it looses



**4.33V Output Voltage Limit Error Amplifier**



**Maximum Power Point Tracking 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

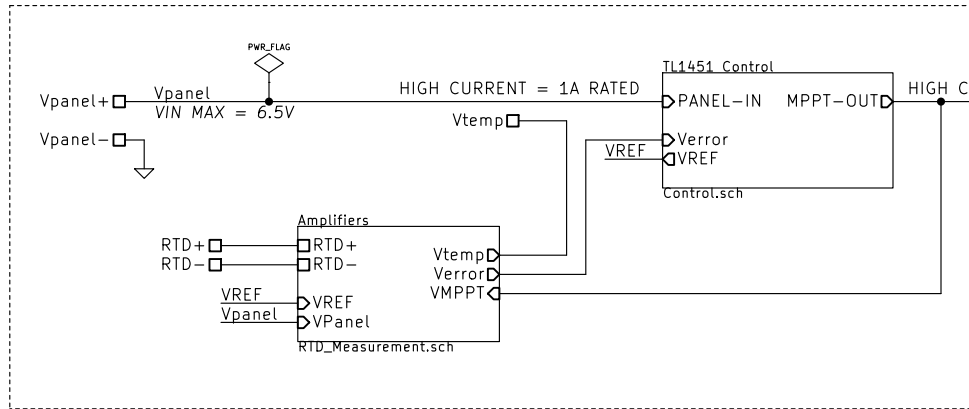
Date: 3 sep 2016

Rev: 2.0

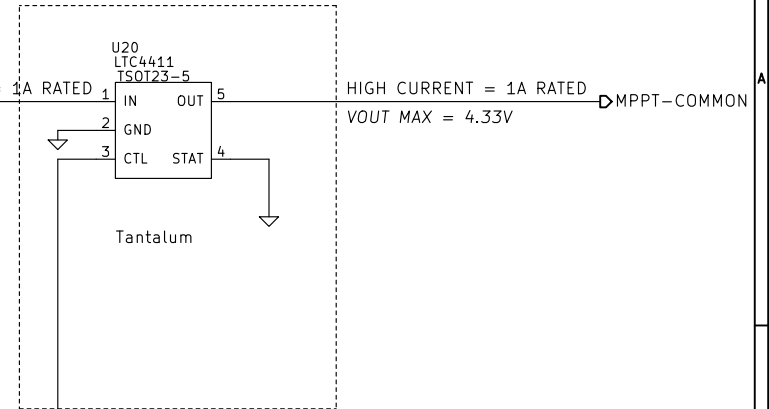
KiCad E.D.A.

Id: 26/37

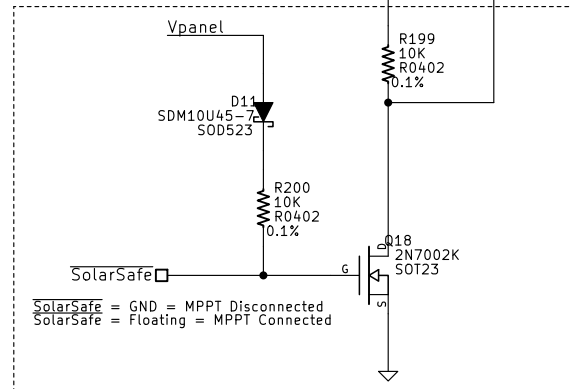
## SWITCH MODE CONVERTER



## 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

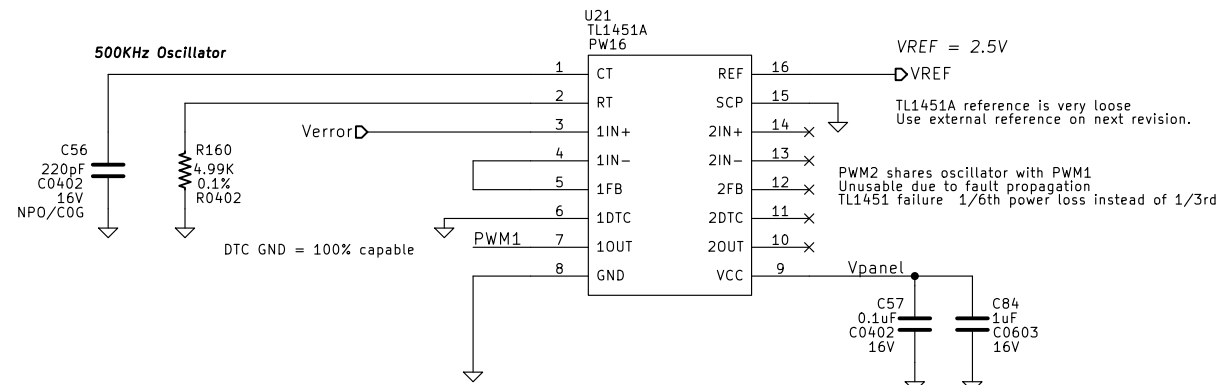
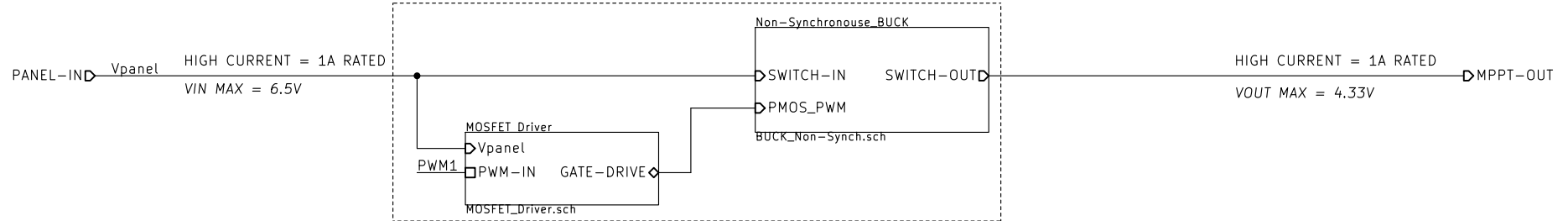
Size: A Date: 3 sep 2016

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 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

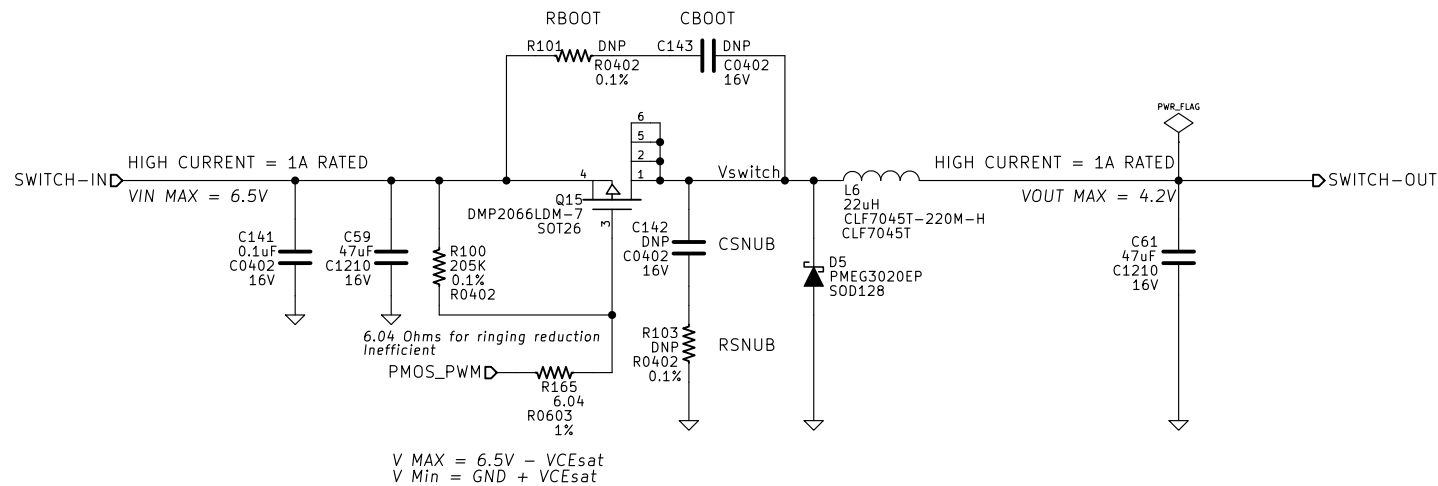
Date: 3 sep 2016

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

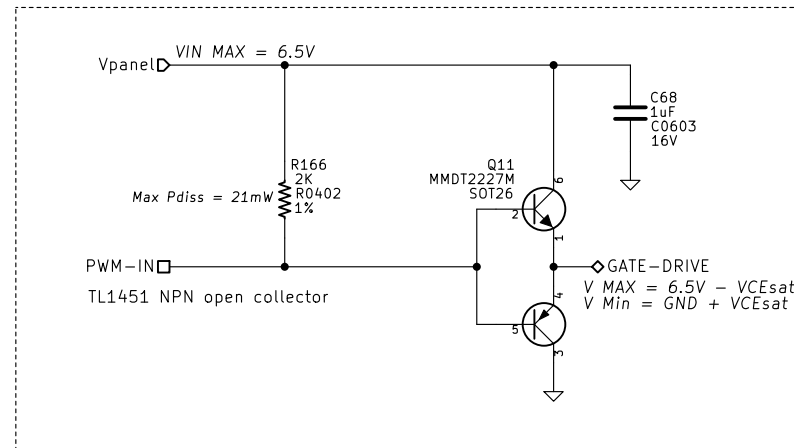
Date: 3 sep 2016

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

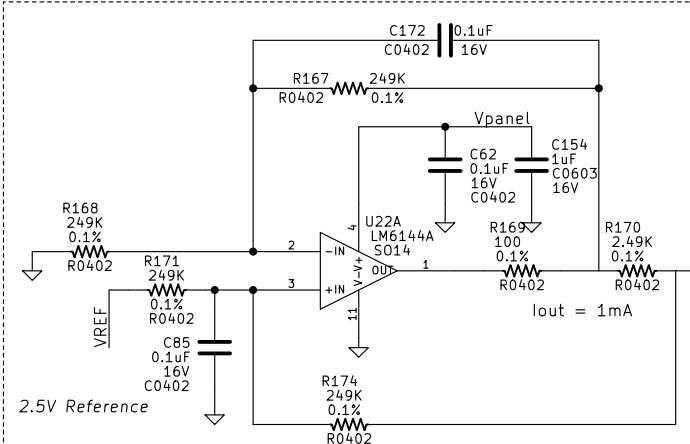
Size: A4

Date: 3 sep 2016

Rev: 2.0

KiCad E.D.A.

Id: 30/37



**Constant 1mA Current Driver**

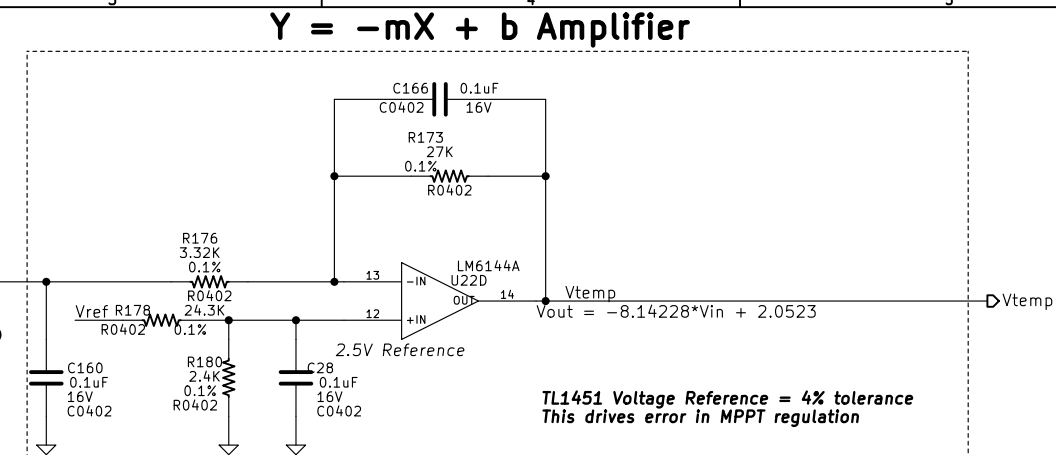
Highest Voltage Wins = Lowest Duty Cycle Wins

MPPT = Vout 3.3V to 4.33V

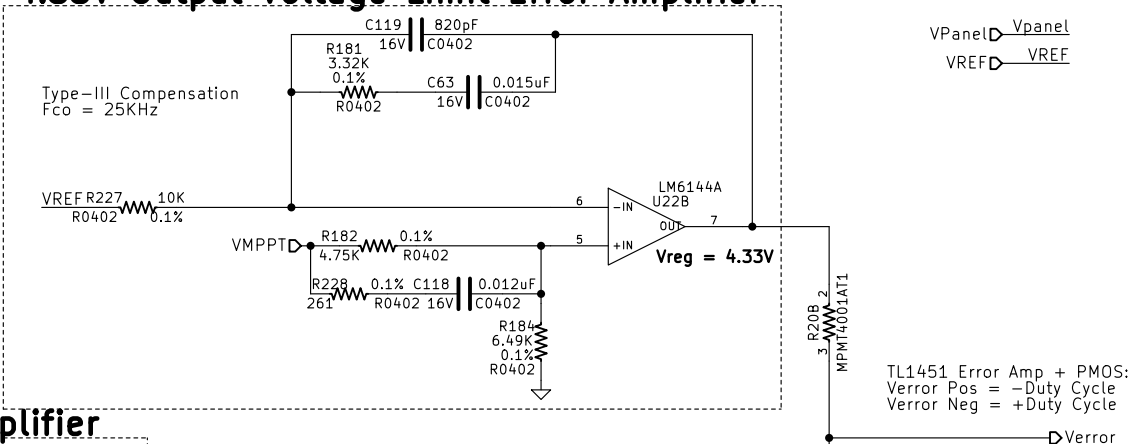
VregError -> Increasing Duty Cycle = Decrease voltage

Regulation = Vout 4.33V, Vpanel increasing

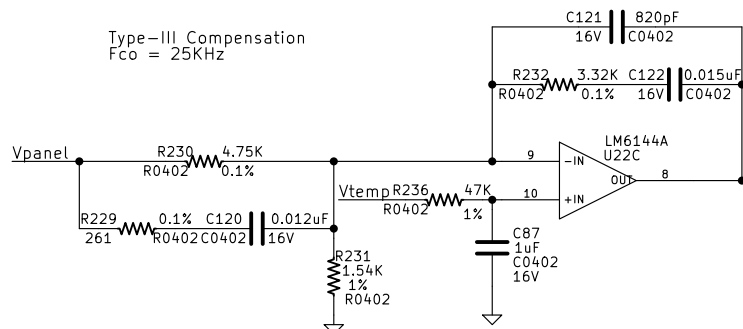
Vmppt Error -> increases duty cycle (to load panel) so it looses



**4.33V Output Voltage Limit Error Amplifier**



**Maximum Power Point Tracking 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

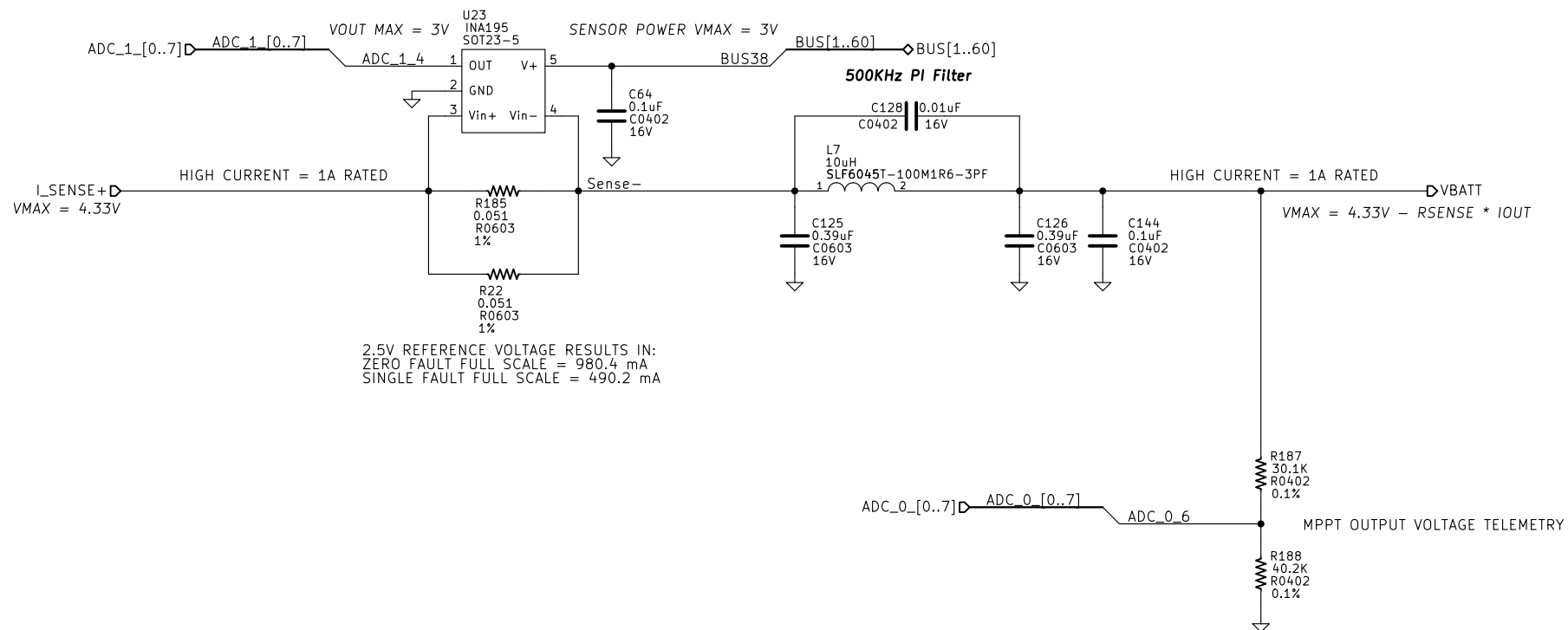
Size: A4

Date: 3 sep 2016

Rev: 2.0

KiCad E.D.A.

Id: 31/37



## 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: Current\_Sense.sch

Sheet: /Current Sense/

Title: Fox-1 Maximum Power Point Tracker

Size: A4

Date: 3 sep 2016

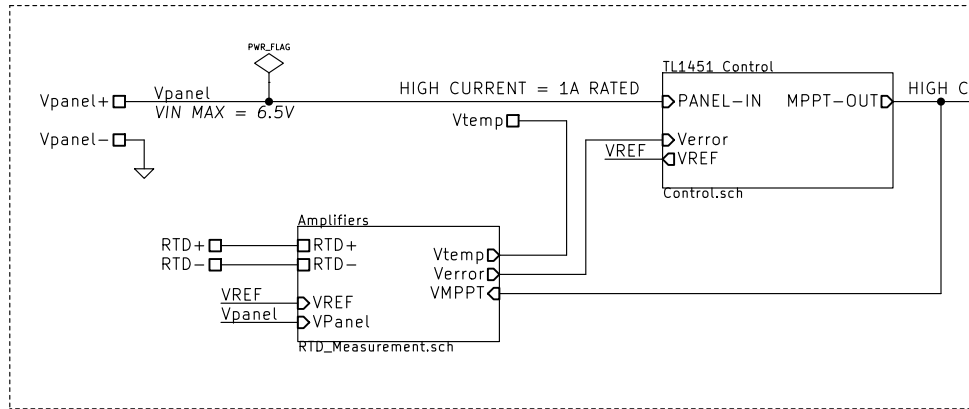
Rev: 2.0

KiCad E.D.A.

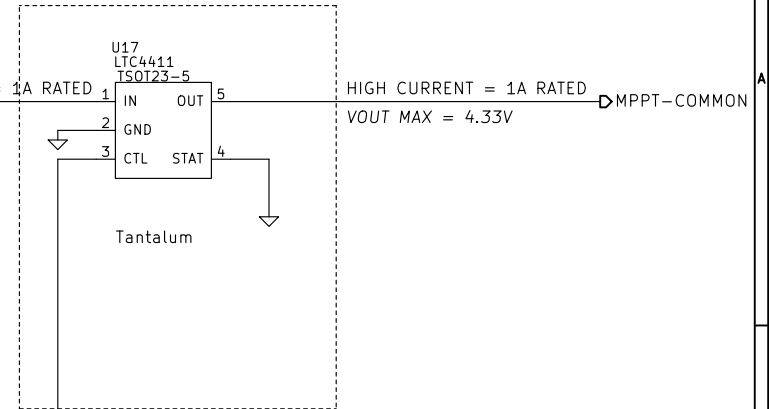
Id: 32/37



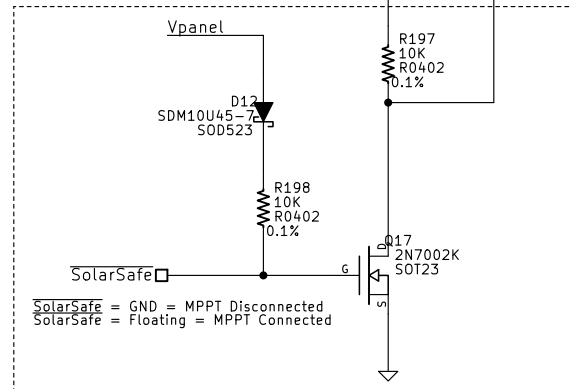
## SWITCH MODE CONVERTER



## 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

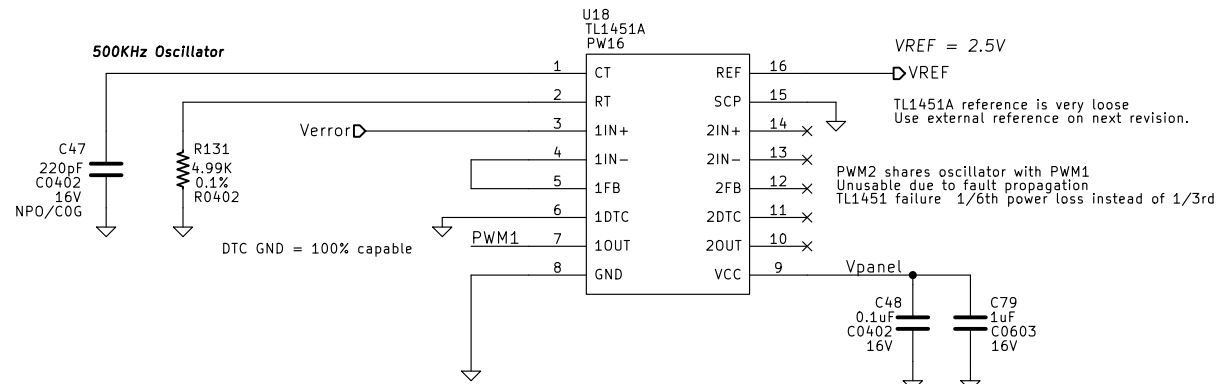
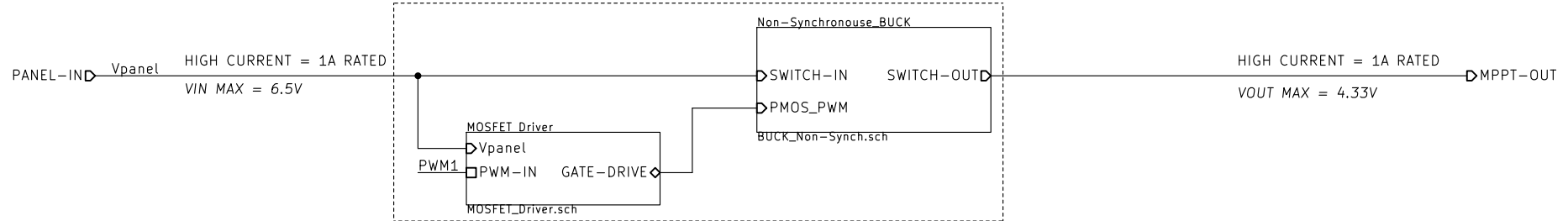
Date: 3 sep 2016

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: 3 sep 2016

Rev: 2.0

KiCad E.D.A.

Id: 34/37

### 500 KHz Step-Down Buck Converter

SWITCH-IND HIGH CURRENT = 1A RATED  
VIN MAX = 6.5V

SWITCH-OUT HIGH CURRENT = 1A RATED  
VOUT MAX = 4.2V

Q14 DMP2066LDM-7 SOT26

PMOS\_PWM

R136 6.04 1%

R0603 1%

V MAX = 6.5V - VCESat  
V Min = GND + VCESat

6.04 Ohms for ringing reduction  
Inefficient

R114 205K 0.1% R0402

R117 DNP R0402 0.1%

CBOOT C147 DNP C0402 16V

Vswitch

C146 DNP C0402 16V

CSNUB

R119 DNP R0402 0.1%

RSNUB

L5 22uH CLF7045T-220M-H CLF7045T

D6 PMEG3020EP SOD128

C145 0.1uF C0402 16V

C50 47uF C1210 16V

C52 47uF C1210 16V

PWR\_FLAG

#### 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: 3 sep 2016	Rev: 2.0
KiCad E.D.A.		Id: 35/37

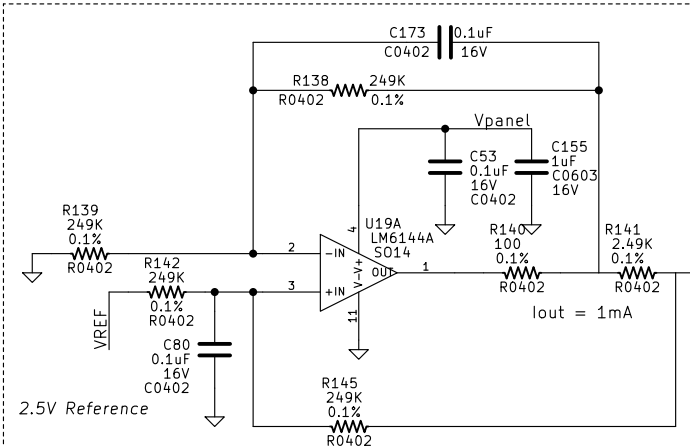
- \* This MPPT implements a set-point constant voltage tracking algorithm based on panel temperature.
- \* RIT MPPT Team: Brenton Salmi (KB1LQD), Bryce Salmi (KB1LQC), Ian MacKenzie (KB30CF), Daniel Corriero.
- \* Parts not yet NASA derated.

Id: 35/37

[illegible]

- \* 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: 36/37



**Constant 1mA Current Driver**

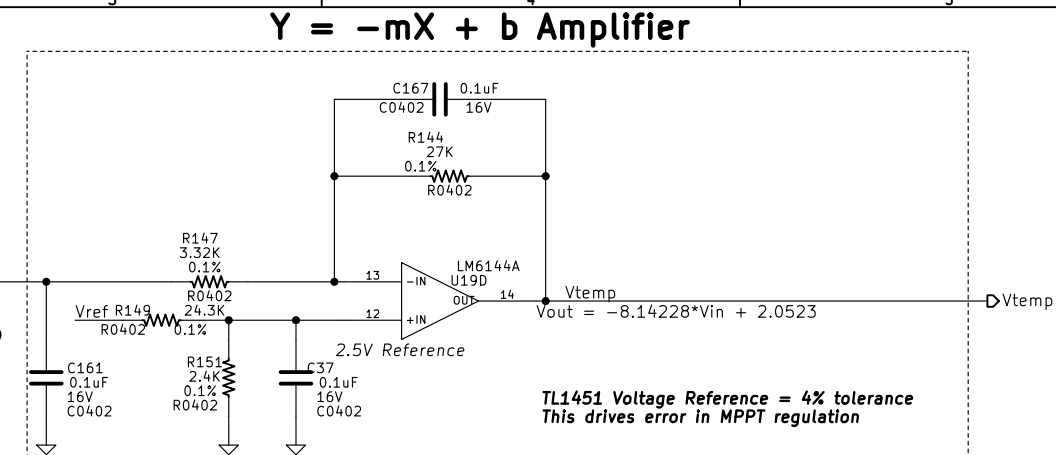
Highest Voltage Wins = Lowest Duty Cycle Wins

MPPT = Vout 3.3V to 4.33V

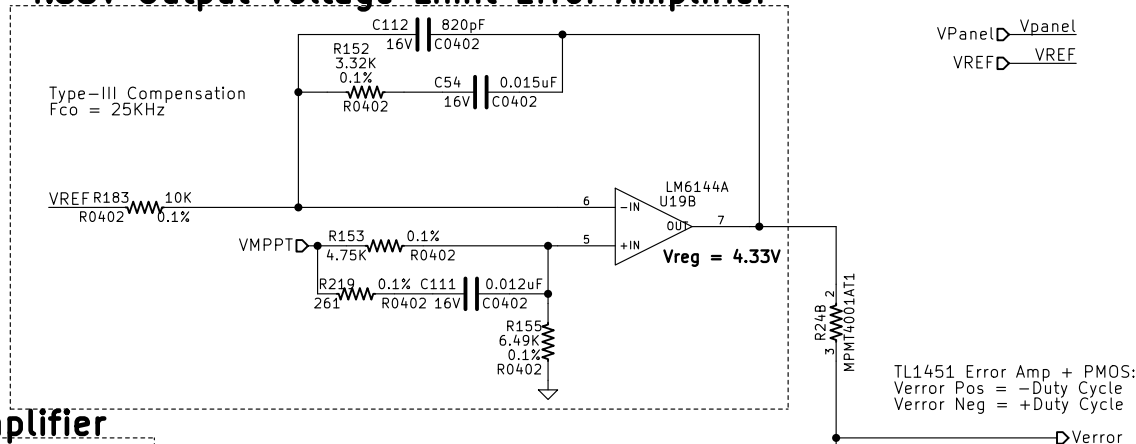
VregError -> Increasing Duty Cycle = Decrease voltage

Regulation = Vout 4.33V, Vpanel increasing

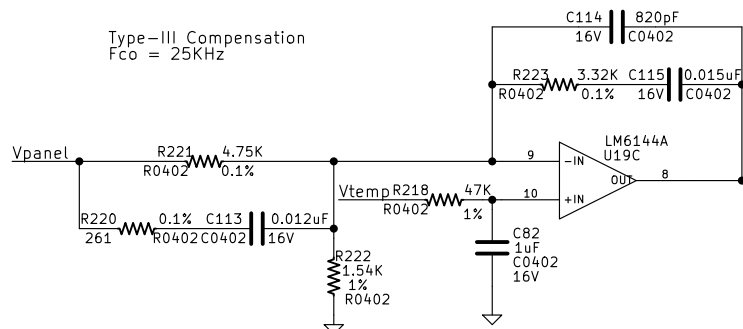
Vmppt Error -> increases duty cycle (to load panel) so it looses



**4.33V Output Voltage Limit Error Amplifier**



**Maximum Power Point Tracking 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: 3 sep 2016

Rev: 2.0

KiCad E.D.A.

Id: 37/37