+/-15V Boost Converter Board (BCB) Design and Performance

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Purpose of the board:

The purpose of the programmable +/-15V Boost Converter board is to drive temperature tuning ranges via a digital-to-analog converter on the LFDI Tuning Control Board. The TCB then uses these voltages to drive the LCVR.

Design:

Design Requirements:

The digital-to-analog converter must first receive 3.3V, then +15V, and finally -15V. This order must be achieved using 3.3V GPIO signals from the TCB to the Buck-Boost Converter to activate the +15V rail first and then the -15V rail. The 3.3V rail is sourced from the TCB itself.

Design Requirement	+15V Converter	-15V Converter

Voltage	+15V	-15V
Max Current Draw	LFDI TCB will draw ~40mA	LFDI TCB will draw ~40mA
Max Ripple Voltage	1.5Vpp	1.5Vpp
Input Voltage	3.3V	3.3V
TCB GND from 3.3V input	Yes	Yes
Circuit rails are at 0V if not enabled	TPS27081A load switch enabled by GPIO	TPS27081A load switch enabled by GPIO
Enabled from TCB	Yes	Yes
PC104 Form Factor	Same board	Same board
Input from TCB P9 Connector	Yes	Yes

Component Choice Considerations:

Two MC33063A ICs are used for the +15V and -15V topologies. The “MC3x063A 1.5A Peak Boost/Buck/Inverting Switching Regulators” datasheet was used to configure the Step-Up Converter application for +15V and the Voltage-Inverting Converter application for -15V. The recommended components for both topologies are as follows:

Voltage Setting Resistors:

R1 = 1 KOHM

R2 = 11 KOHM

Output Capacitor: C_O = 1000 uF

Timing Capacitor: C_T = 1500 pF

Schottky Diode: D = 1N5819

Input Capacitor: C_in = 100 uF

Inductor: L = 88 uH

Resistors:

R_sc = 0.24 OHM

(R = 180 OHM in Step-Up Converter from pin 8 to 7)

In order to execute proper power switching, two TPS27081A load switches are used. These allow for a complete shutdown of the MC33063A meaning its output rail will be at 0V until the TPS27081A receives a GPIO high signal from the LFDI Tuning Control Board. The recommended components for the TPS27081A are as follows:

Resistors:

R1 = 100 KOHM

R2 = 2 KOHM

Output Capacitor: C1 = 0.1 uF

Low ESR ceramic bypass capacitors of X5R or X7R dielectric rating:

CVIN = 1 uF

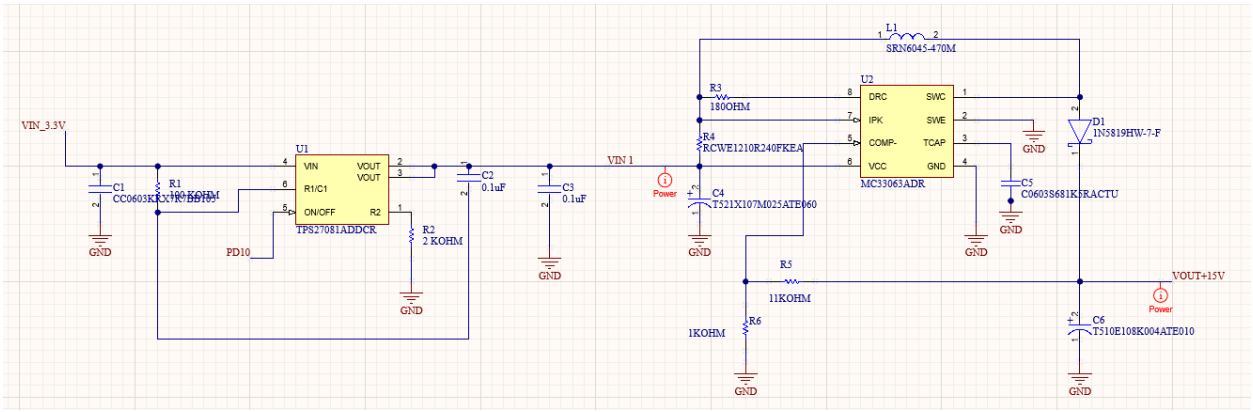
CVOUT = 0.1 uF

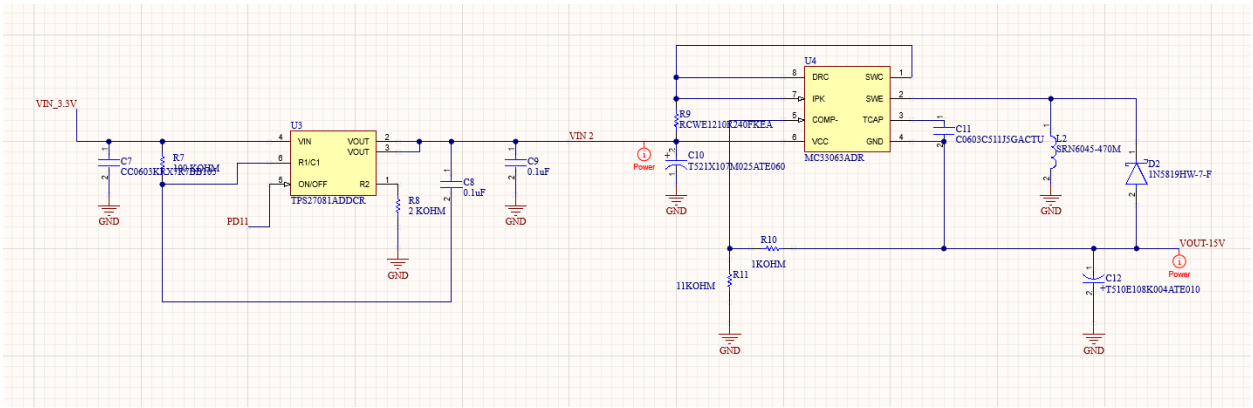
Vout + Vf – Vin

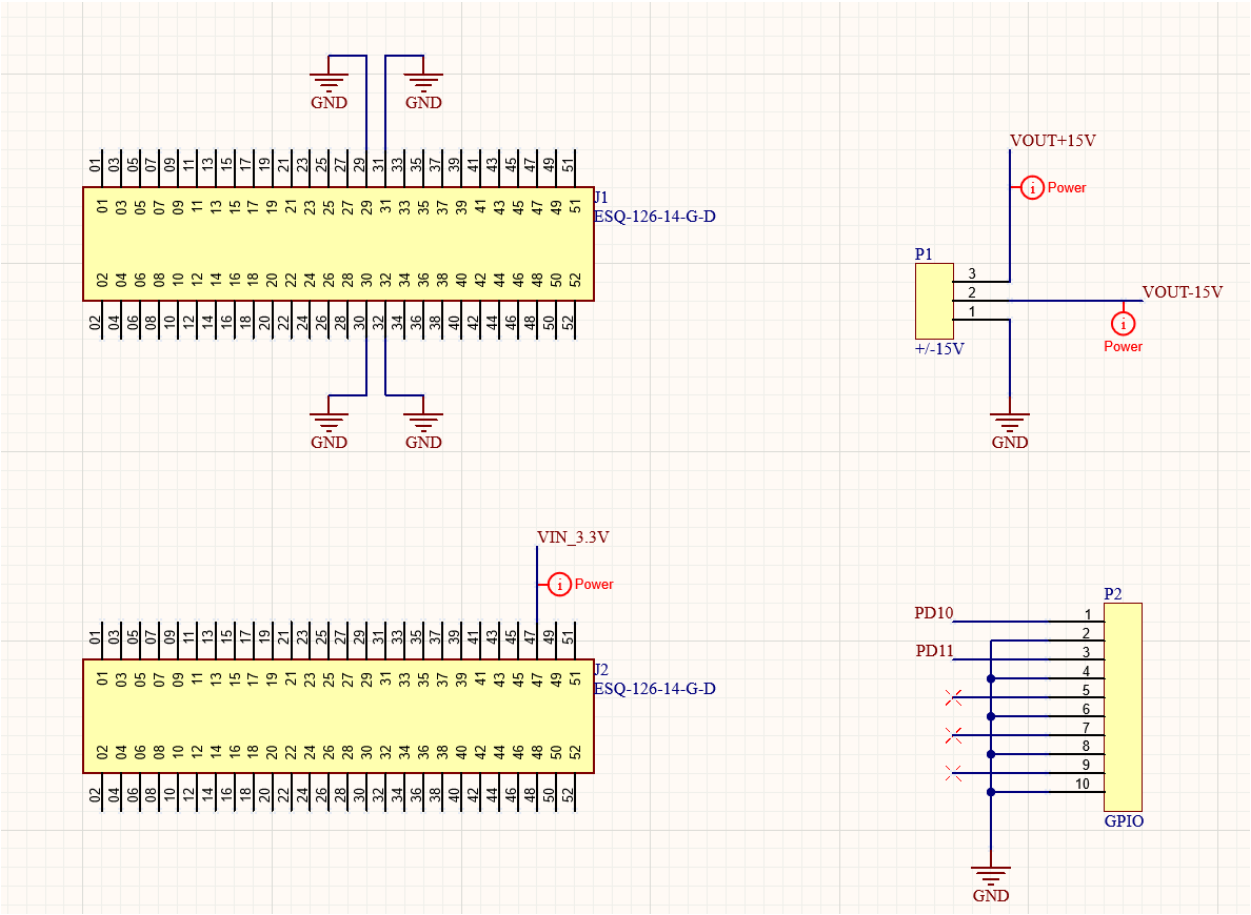
Implementation

Schematics

Below are the Schematics for the +15V Converter, The -15V converter and the Connectors.


VIN_3.3V
C1
CC0603KRX7R9BB105
R1
100 KOHM
U1
VIN
VOUT
VOUT
R1/C1
ON/OFF
R2
TPS27081ADDCR
PD10
R2
2 KOHM
C2
0.1uF
C3
0.1uF
VIN 1
L1
SRN6045-470M
R3
180OHM
U2
DRC
SWC
IPK
SWE
COMP-
TCAP
VCC
GND
MC33063ADR
R4
RCWE1210R240FKEA
C4
T521X107M025ATE060
C5
C0603S681K5RACTU
D1
1N5819HW-7-F
R5
11KOHM
R6
1KOHM
C6
T510E108K004ATE010
VOUT+15V
Power
GND


VIN_3.3V
C7
CC0603KRX7R9BB105
R7
100 KOHM
U3
VIN
VOUT
VOUT
R1/C1
ON/OFF
R2
TPS27081ADDCR
PD11
R8
2 KOHM
C8
0.1uF
C9
0.1uF
VIN 2
U4
DRC
SWC
IPK
SWE
COMP-
TCAP
VCC
GND
MC33063ADR
R9
RCWE1210R240FKEA
C10
T521X107M025ATE060
C11
C0603C511J5GACTU
L2
SRN6045-470M
D2
1N5819HW-7-F
R10
1KOHM
R11
11KOHM
C12
T510E108K004ATE010
VOUT-15V
Power
GND



PCB

PCB Implementation Considerations:

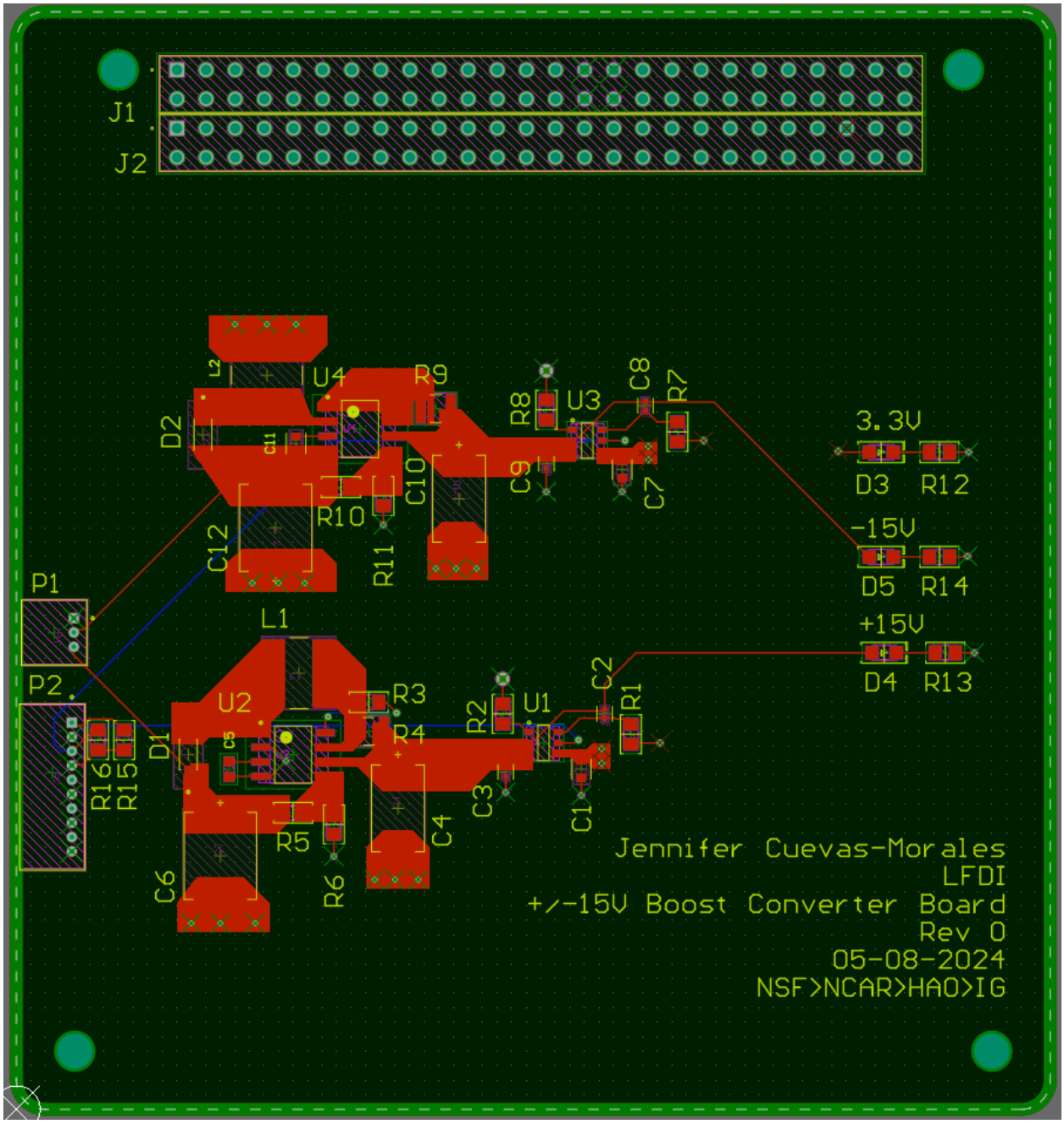
The +/-15V Boost Converter Board is of PC104 form factor to be able to stack with the LFDI Tuning Control Board. It receives its GND connection from header J1 and its 3.3V connection from header J2. It outputs +15V and -15V into connector P1 which interfaces with the LFDI Tuning Control Board's P9 connector. It receives GPIO signals from its P2 connector which interfaces with the TCB's P16 connector.

For the MC33063A ICs, it is important to keep the loop between the output capacitor, inductor, and diode as short as possible to reduce signal interference with the regulator's switching aspect. For the TPS27081A's, low ESR ceramic bypass capacitors are needed to decouple high-frequencies at the power supply inputs and outputs.

Power LEDs are included as visual indicators that the TPS27081A's are receiving a 3.3V input from J2.

PCB Design:

Below is a screen shot of the PCB Design of the Boost Converter Board.



Performance:

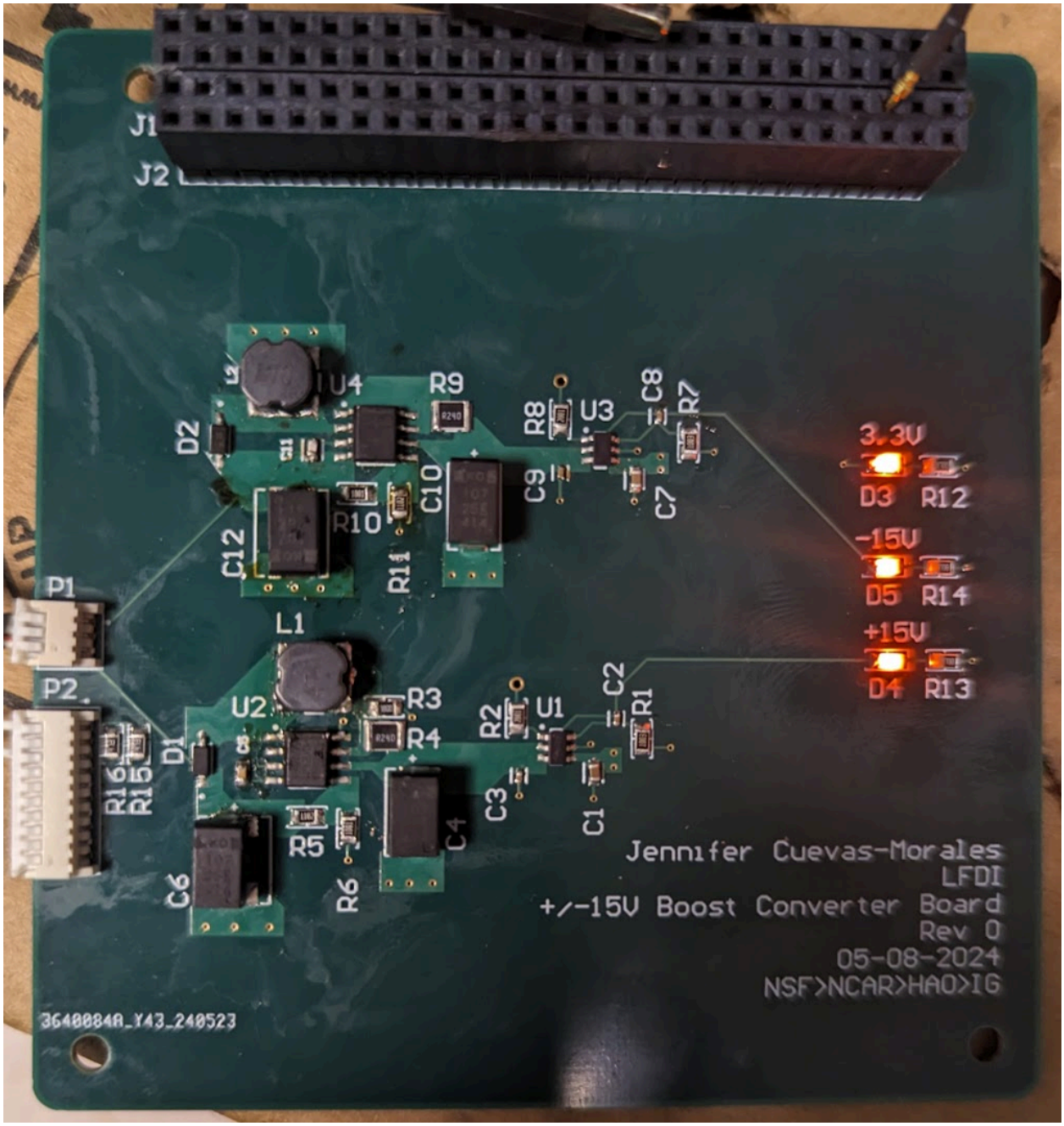
The +/-15V Boost Converter Board is fully compatible with the LFDI Tuning Control Board (TCB). The TCB supplies 3.3V first into J2, then outputs a GPIO high signal to start the +15V rail, and lastly outputs a different GPIO high signal to start the -15V rail.

Metrics

Device State	Power Draw
Armed (+/-15V Boost Converters Off)	0mW
+15V Boost Converters Powered (no load)	66mW
-15V Boost Converter Powered (no load)	330 mW
+/-15V Boost Converters On (no load)	363mW
Total System (TCB + BCB)	924mW

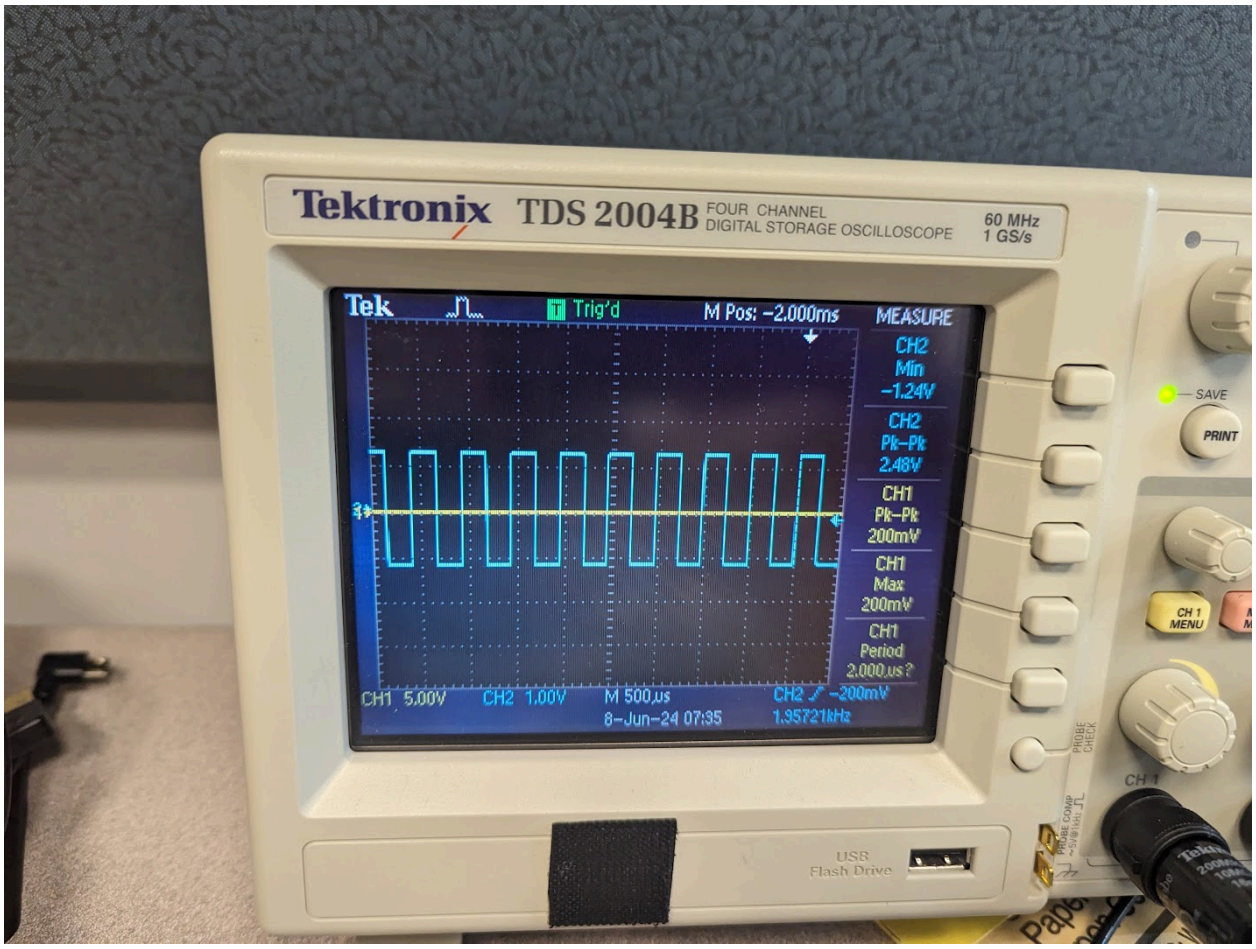
Parameter	+15V Boost Converter	-15V Boost Converter
Voltage	+15.2V	-15.1V
Voltage Ripple	<60mV	<60mV

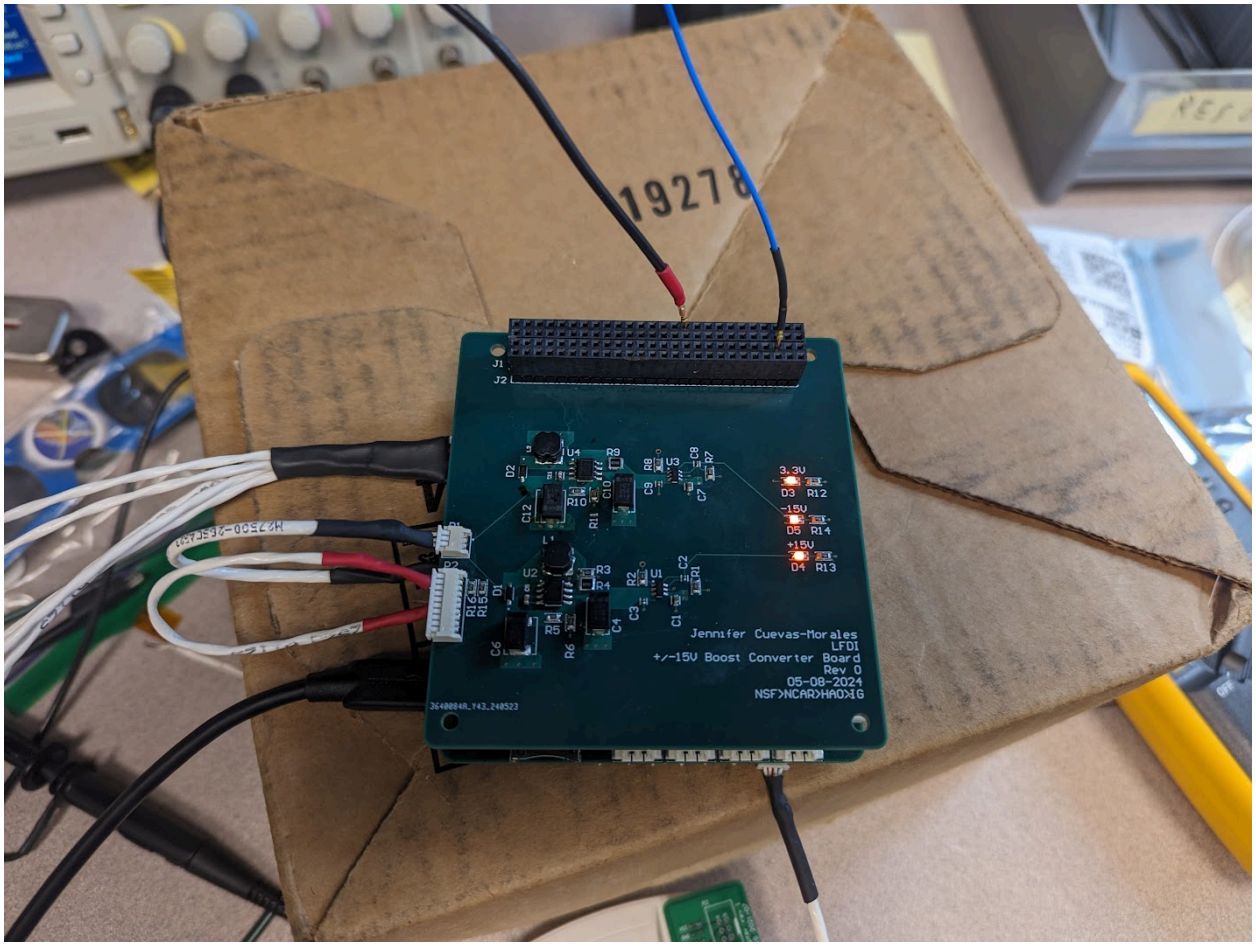
PCB Pictures



Compatibility:

With minor Updates to the Tuning Control board software at bootup the TCB is able to enable the positive and negative rails of the Boost Converter board.
After enabling both rails the TCB performs as expected.
Below is a picture of the TCB generating a squarewave to control a single stage using the rails from the Boost Converter Board and the Boost Converter Board Fully integrated with Tuning Control board




J1
J2
3.3V
D3 R12
-15V
D5 R14
+15V
D4 R13
Jennifer Cuevas-Morales
LFDI
+/-15V Boost Converter Board
Rev 0
05-08-2024
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