Justin T

HV Board Flyback

1.0 Introduction

This design is to provide 5V to some ics in the high voltage side of the HV board.

2.0 Design

- Very difficult to find a high input (400V) and low output (5V) buck/switch mode converter.
- Take input from low voltage side (12V) and convert it to 5V
- Flyback design to provide isolation between the two grounds

3.0 Where to Find Calculations/Simulation

- Calculations can be found in PowerDistribution\HV_Board_Rev3\HV_Board_DC_Converter\LTSpice_Testing\lt3001
- Repo: PowerDistribution
- Branch: HVB-Rev3-lt3001
- Haven't merged with HVB-Rev3 as of 2022-03-16
- Equations can be found in https://www.analog.com/media/en/technical-documentation/data-sheets/LT3001.pdf

4.0 Results

4.1 Design Parameters

- vin_min = 8 // following design example
- vin = 12
- vin_max = 15 // following design example
- vout = 5
- iout = 0.2 // expected max output current
- vf_est = 0.1 // from parts selected
- vleak = 15 // following design example
- n = 0.85 // following design example

4.2 Design Results

Transformer

Turns ratio

$$N_{PS} < \frac{65V - V_{IN(MAX)} - V_{LEAKAGE}}{V_{OUT} + V_F}$$

- Nps < 6.8627

Primary Inductor current

$$L_{PRI} \geq \frac{t_{OFF(MIN)} \bullet N_{PS} \bullet (V_{OUT} + V_F)}{I_{SW(MIN)}}$$

$$L_{PRI} \geq \frac{t_{ON(MIN)} \bullet V_{IN(MAX)}}{I_{SW(MIN)}}$$

- Choose Lpri ~30% above calculated Lpri
- ~40uH

Chosen Transformer

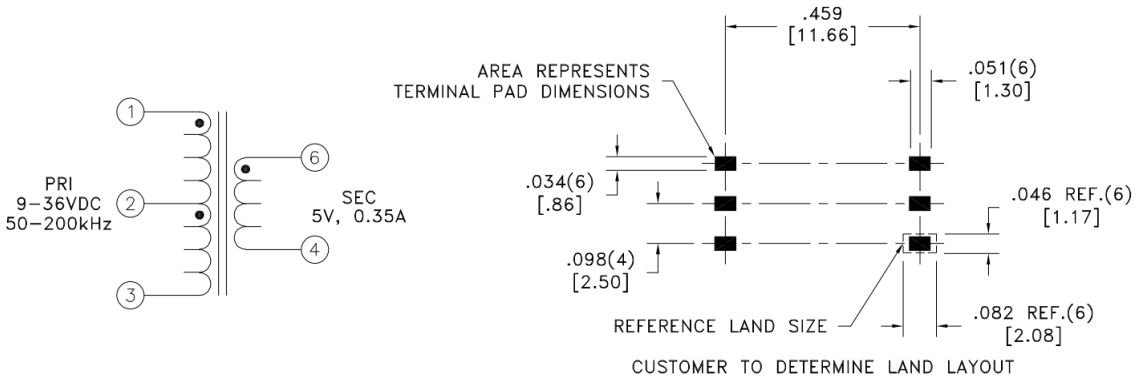
- Transformers are usually custom designed therefore you need to find a transformer that is close to what you spec
- 750315831
- https://www.digikey.ca/en/products/detail/w%C3%BCrth-elektronik/750315831/8594545
- Nps = 5
- Lpri = 150uH
- Lsec = Lpri/(Nps)^2
- 1500Vrms Isolation
- As Per rule EV.7.5.7

EV.7.5.7 If Tractive System and GLV are on the same circuit board:

a. They must be on separate, clearly defined and clearly marked areas of the board

b. Required spacing related to the spacing between traces / board areas are as follows:

Voltage	Over Surface	Thru Air (cut in board)	Under Conformal Coating
0-50 V DC	1.6 mm	1.6 mm	1 mm
50-150 V DC	6.4 mm	3.2 mm	2 mm
150-300 V DC	9.5 mm	6.4 mm	3 mm
300-600 V DC	12.7 mm	9.5 mm	4 mm



- Creepage between pads exceeds 12.7mm. Need to add a pcb slot under the transformer to meet the 9.5mm requirement.

Output Diode

$$I_{DIODE(MAX)} = I_{SW(MAX)} \bullet N_{PS}$$

$$V_{REVERSE} = V_{OUT} + \frac{V_{IN(MAX)}}{N_{PS}}$$

I_diode_max = 5.5A
V_reverse = 8.750V

Chosen Diode

- SK64L-TP
- https://www.digikey.ca/en/products/detail/micro-commercial-co/SK64L-TP/10054698
- Vrev = 40V
- Io = 6A

Output Capacitor

$$C_{OUT} = \frac{L_{PRI} \bullet I_{SW}^2}{2 \bullet V_{OUT} \bullet \Delta V_{OUT}}$$

Cout = 7.758527795404752e-06 F

- Based on simulations kinda low
- Going to select multiple capacitors to range a larger frequency range

DZ Snubber

$$V_{ZENER(MAX)} \leq 65V - V_{IN(MAX)}$$

Choose a diode that is fast and has sufficient reverse voltage breakdown:

$$V_{REVERSE} > V_{SW(MAX)}$$

$$V_{SW(MAX)} = V_{IN(MAX)} + V_{ZENER(MAX)}$$

Chosen Zener

Vzener = 50V
CMDZ5250B TR PBFREE
https://www.digikey.ca/en/products/detail/central-semiconductor-corp/CMDZ5250B-TR-PBFREE/5211260

Chosen Diode

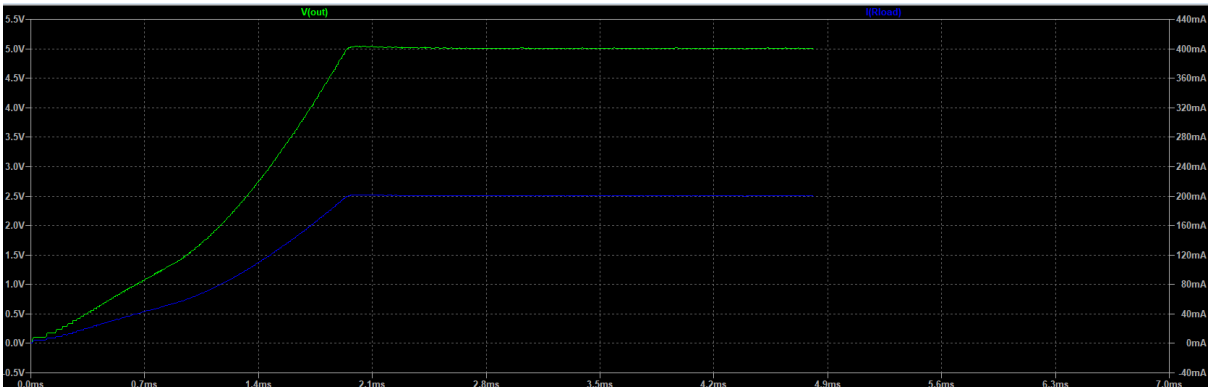
1N4148WTR
V_rev = 75V
250mA
https://www.digikey.ca/en/products/detail/smc-diode-solutions/1N4148WTR/6022450

Feedback Resistor

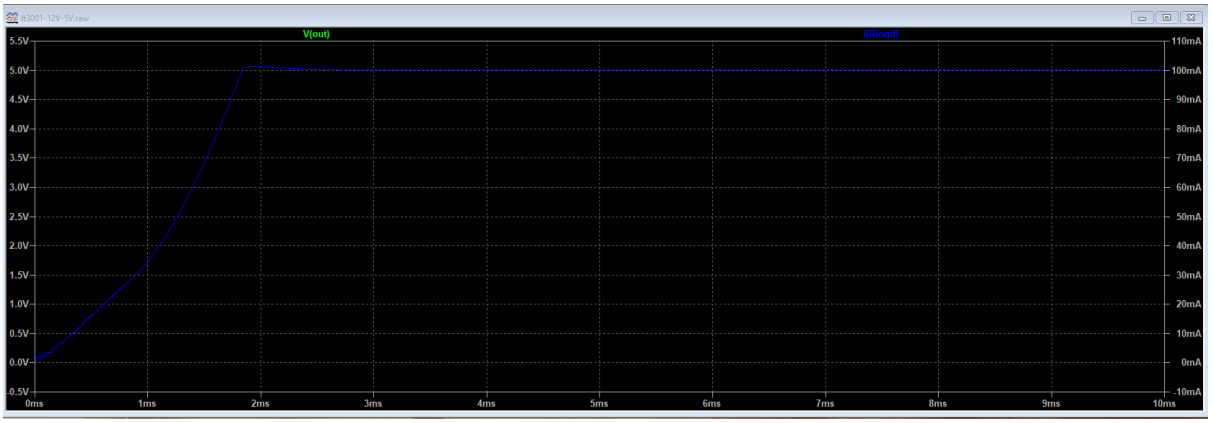
$$R_{FB} = \frac{N_{PS} \cdot (V_{OUT} + V_F)}{100\mu A}$$

Calculated to 204k
Rounded to 205k
RC0603FR-07205KL
https://www.digikey.ca/en/products/detail/yageo/RC0603FR-07205KL/727046

LTSpice Waveforms



Output with 25 ohm load



Output with 50 ohm load

Schematic Design