Batt to 12V Buck Calculations

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Design Requirements for Buck Selection

V_{in}: 24V-60V
- 24V is what the eCVT motors run off of
- 60V is V_{max} according to Baja SAE rules

V_{out}: 12V
- 12V is what we send around the car and what we cascade off of for 3V3 and 5V

I_{load}: 8.4A nominal, 12A for FOS of 1.43
- Calculated in Power draw section

Efficiency: > 90%

Fsw: 500 kHz
- Better efficiency
- Cleaner output ripple

Operating temperature range: -40C to 100C

Output ripple: 10%

Power Draw of the entire system

Components	Power Draw (W)	Operating Voltage (V)	Current Draw (A)
Electronics System run off of battery	327.364	24.00	13.64
Electronics system run off of 12v buck	100.844	12.00	8.40
Motherboard	317.38	24.00	13.22
eCVT	1.78	3.30	0.19
SAS	0.70	3.30	0.21
TL	0.70	3.30	0.21
DAQ	0.57	3.30	0.17
Radio	1.31	12.00	0.62
IMU/GPS	1.02	12.00	0.53
Front Breakout	1.26	12.00	0.64
Rear Breakout	1.03	12.00	0.59
Dashboard	0.89	12.00	0.50

12A/8.40A = 1.43 FOS

Electrons System Calculator (Last Year's System)

Inductor Selection

Ripple current

$$\Delta I_L = 0.3 \cdot I_{L max}$$

$$\Delta I_L = 0.3 \cdot 12$$

$$\Delta I_L = 3.6A$$

Inductor

$$L = \frac{V_{out}\left(1 - \frac{V_{out}}{V_{in}}\right)}{\Delta I_L \cdot f_{sw}}$$

$$L = \frac{12V\left(1 - \frac{12V}{60V}\right)}{3.6A \cdot 500kHz}$$

$$L = \frac{12V(1-0.2)}{3.6A \cdot 500kHz}$$

$$L = \frac{9.6}{1800000}$$

$$L = 5.3\ mH$$

[SRP1040VA-5R6M]

Mosfet Selection

- V_{DS} = 60V
- I_D = 48A
- $V_{GateSource}$ = -4 to 6V
- Q_G = 5nC
- R_{DS} = 2.6 mOhms

EPC2031

C_{in} Selection

Duty cycle

$$\frac{V_{out}}{V_{in}}$$

$$\frac{12}{60}$$

$$D = 0.2$$

Cin

$$C_{in} \geq \frac{D(1-D) \cdot I_{out}}{\Delta V_{in_{pp}} \cdot f_{sw}}$$

$$C_{in} \geq \frac{0.2(1-0.2) \cdot 12A}{60V \cdot 500kHz}$$

$$\geq \frac{0.2(0.8) \cdot 12}{30000000}$$

$$\geq \frac{1.92}{30000000}$$

$$C_{in} \geq 0.64 nF$$

C_{out} Selection

Cout

$$C_o = \frac{(1-D)}{\frac{\Delta V_o}{V_o} 8Lf^2}$$

$$= \frac{(1-0.2)}{\frac{12.08V}{12V} \cdot 8(5.6\mu H)(500kHz)^2}$$

$$= \frac{0.8}{1.0006 \cdot 8(1400000)}$$

$$= \frac{0.8}{11274666.67}$$

$$C_o \geq 0.7nF$$

R_{sense} Selection

Rsense

$$R_{sense} = \frac{V_{sense(max)}}{I_{L(max)} + \frac{\Delta IL}{2}}$$

$$R_{sense} = \frac{50mV}{12A + \frac{3.6A}{2}}$$

$$R_{sense} = \frac{50mV}{13.8}$$

$$R_{sense} = 3.6m\Omega$$

Frequency Resistor Selection

Operating Frequency

$$R_{freq} = \frac{37\,MHz}{500\,KHz}$$

$$R_{freq} = 74\,K\Omega$$

$$73.2\,K\Omega$$

V_{fb} Selection

Output voltage

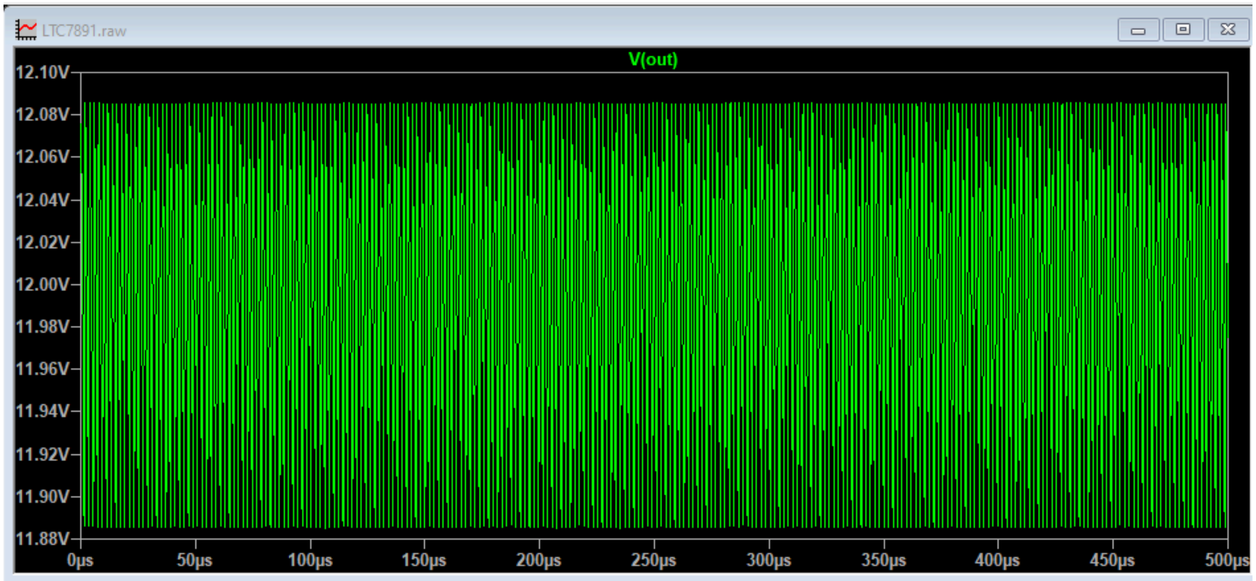
$$V_{out} = 0.8V\left(1 + \frac{R_B}{R_A}\right)$$

$$R_B = 10K\left(\frac{12V}{0.8V} - 1\right)$$

$$R_B = 10K(14)$$

$$R_B = 140K$$

Voltage Output Ripple Simulation



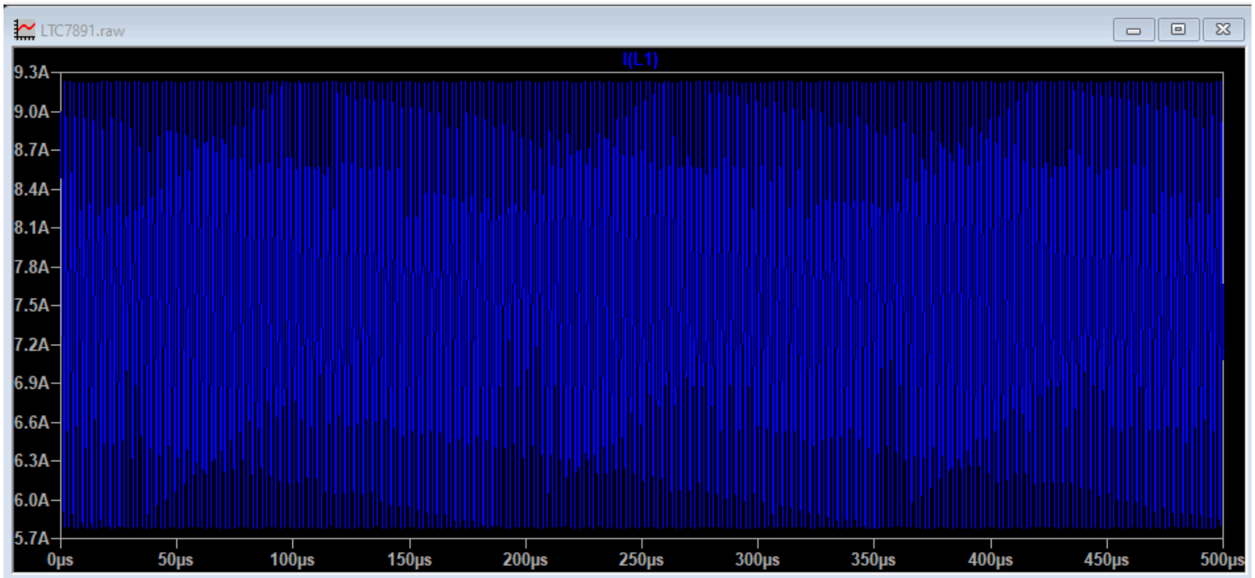
Voltage output Ripple

12.09V − 11.88V

$$= \frac{0.21V}{12V}$$

$$= 1.7\%$$

Current through the Inductor Simulation



Test Points

- Vin
- Vout
- Switching node

Questions

1.

1	PLLIN/SPREAD	External Synchronization Input to Phase Detector/Spread Spectrum Enable. When an external clock is applied to PLLIN/SPREAD, the phase-locked loop forces the rising TGxx signal to synchronize with the rising edge of the external clock. When not synchronizing to an external clock, tie this input to $INTV_{CC}$ to enable spread spectrum dithering of the oscillator, or to GND to disable spread spectrum dithering.

   a. Tie to ground right?

2.

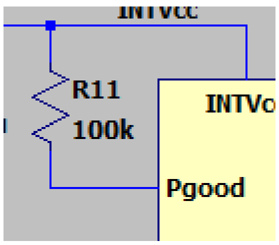
6	VPRG	Output Voltage Control Pin. VPRG sets the adjustable output mode using external feedback resistors or the fixed 12 V or 5 V output mode. Floating VPRG programs the output from 0.8 V to 60 V with an external resistor divider, regulating V_{FB} to 0.8 V. Connect VPRG to $INTV_{CC}$ or GND to program the output to 12 V or 5 V, respectively, through an internal resistor divider on V_{FB}.

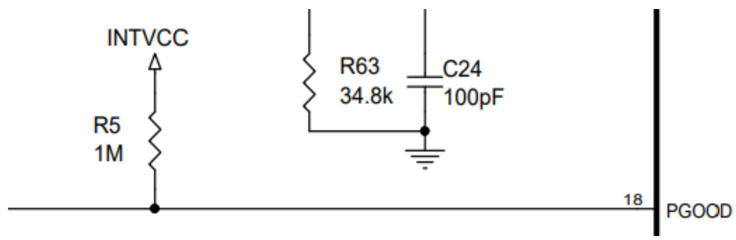
   a. Leave floating right?

3.

9	$BSTV_{CC}$	Bootstrap Diode Anode Connection Pin. Place an optional external Schottky diode between the $BSTV_{CC}$ and BOOST pins to bypass most of the 7 Ω switch resistance between DRV_{CC} and BOOST.

   a. Leave floating?

4. 



   a. 100k or 1M res?

5. Cout and Cin caps