# FSAE DC-DC

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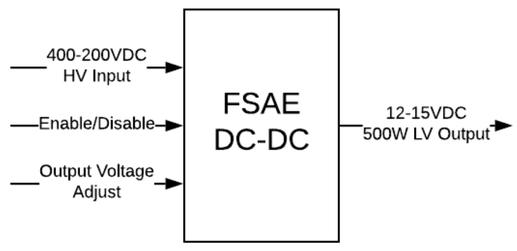
## Problem Overview

Cal Poly's Formula SAE club, Cal Poly Racing, needs a smaller, higher voltage rated DC-DC converter because their existing solution, the RSP-500-12, is only rated at 370 VDC, which a slight 0.4 V more than the expected maximum operating voltage of 369.6 VDC. The purpose of the DC-DC converter is to use the "high-voltage" 316 V battery pack, which is used to drive the electric motor, to power all of the low voltage electronics during vehicle operation.




## Requirements

- 200-400VDC input voltage range
- 12-15V adjustable output voltage
- 500W continuous output power rating
- Input/Output overcurrent/overvoltage/reverse voltage protection
- Isolated design
- Small, lightweight
- >90% Efficiency
- <5% Line and Load regulation

## Solution

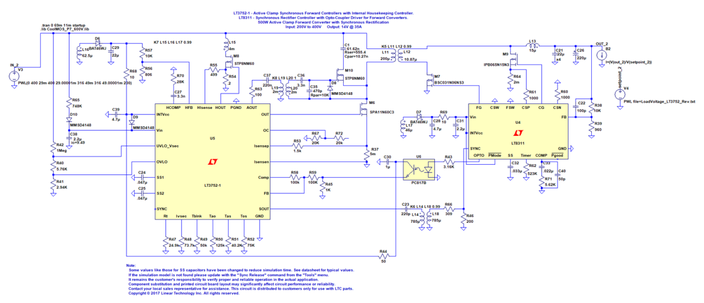
- LT3752-1/LT8311 Active Clamp Synchronous Forward Controllers
  - Active clamp reduces stress on switches and increases efficiency
  - Housekeeping supply improves efficiency and startup performance
  - Synchronous rectification for increased efficiency
  - Forced or discontinuous conduction mode for improved efficiency
  - Isolated topology
  - Balance between efficiency and number of switches
  - System input overvoltage, undervoltage, overcurrent protections

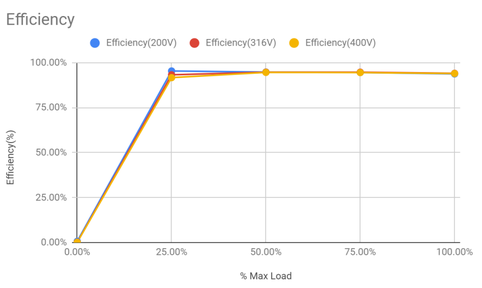
## Design and Simulation

| | |
|---|---|
| Vout (V) | 14 |
| Vin(Max) | 400 |
| Vin(Min) | 200 |
| Vin(nom) | 316 |
| Switching Frequency | |
| Desired Frequency (kHz) | 300 |
| Rt (kOhm) | 24.9 |
| Volt Second Clamp | |
| Max Allowed Duty Cycle (%) | 75.00% |
| UVLO Vsec (min) | 1.7425 |
| Rivsec(kOhm) | 73.69 |
| Clamp Capacitor | |
| Max Desired Duty Cycle | 0.3 |
| Turns Ratio(Np/Ns) | 4.285714286 |
| Coupling Coefficient (K) | 0.99 |
| Primary Inductance(uH) | 200 |
| Secondary Inductance (uH) | 10.88888889 |
| Magnetizing Inductance (uH) | 198 |

| | |
|---|---|
| Min Duty Cycle (%) | 15.00% |
| Max Duty Cycle (%) | 30.00% |
| Nom Duty Cycle (%) | 18.99% |
| Ccl(nF) | 10.26999932 |
| Csnub(nF) | 61.61999594 |
| Rsnub(Ohm) | 555.4019228 |
| Vccl | 85.71428571 |
| Rtimer | |
| Timeout | 0.000002 |
| Rtimer | 44.2 |
| Housekeeping Supply | |
| HVSide Voltage(Max) | 13.7 |
| HVSide Turns Ratio (Pri:Sec) | 8 |
| LVSide Voltage(Max) | 11 |
| LVside Turns Ratio (Pri:Sec) | 9.3 |
| Secondary Side HV Flyback | |
| Peak Reverse Voltage(V) | 63.7 |

| MOSFET Characteristics | FDP083N15A-F1 | FDH055N15A | SUG80050E-GE |
|---|---|---|---|
| Rds(on) | 0.0061 | 0.00475 | 0.005 |
| Qg | 0.0000000645 | 0.000000092 | 0.000000165 |
| R_(juction-case) (C/W) | 0.51 | 0.35 | 0.3 |
| R_(junction-ambient (C/W | 62.5 | 40 | 40 |
| Pirce | 3.61 | 6.12 | 5.7 |
| | | | |
| Pohmic | 6.706779547 | 5.22249227 | 5.497360284 |
| Pconverter | 0.20124 | 0.28704 | 0.5148 |
| | | | |
| Ptot | 6.908019547 | 5.50953227 | 6.012160284 |
| Tj(ambient only) (lower is | 471.7512217 | 260.3812908 | 280.4864114 |
| R_heatsink max (bigger i | 6.727964465 | 8.725180532 | 8.01647821 |






## Implementation