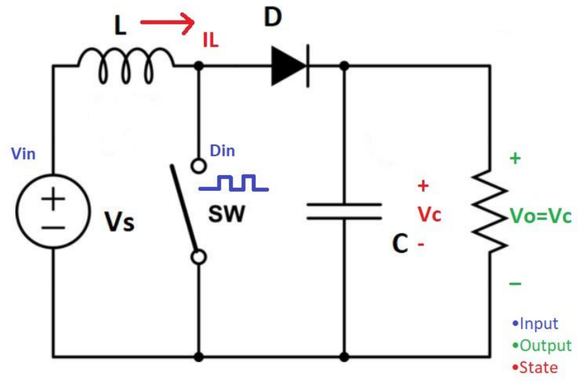
Boost Converter State-space Modelling



- Multi-Input single Output (MISO)
- Two operating modes:
  1. SW ON
  2. SW OFF
- Combine modes to create ***weighted-average*** model
- Linearization necessary to create ***small-signal*** model around EQM
- **GOAL:** regulate output voltage Vo using duty cycle (Din) with
  1. 15V output
  2. 0.5W rated power

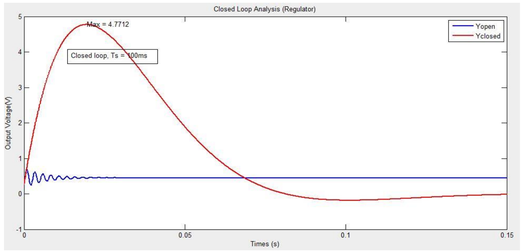
Linearized State EQTs:

$$\begin{bmatrix} \dot{X1}_\delta \\ \dot{X2}_\delta \end{bmatrix} = \begin{bmatrix} 0 & \frac{-(1-D)}{L} \\ \frac{1-D}{C} & \frac{-1}{RC} \end{bmatrix} * \begin{bmatrix} X1_\delta \\ X2_\delta \end{bmatrix} + \begin{bmatrix} \frac{1}{L} & \frac{\widehat{X1}}{L} \\ 0 & \frac{-\widehat{X2}}{L} \end{bmatrix} \begin{bmatrix} U1 \\ U2 \end{bmatrix}$$

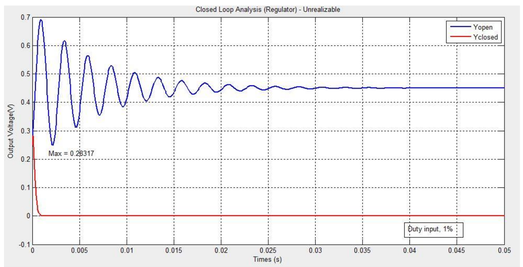
$$H(s) = C(SI - A)^{-1}B$$

$$H(s)_{1x2} = \frac{1}{s^2 + \frac{s}{RC} + \frac{(1-D)^2}{LC}} * \begin{bmatrix} \frac{(1-D)}{LC} & \frac{(1-D) * \widehat{V_c} - \widehat{I_L} Ls}{LC} \end{bmatrix}$$

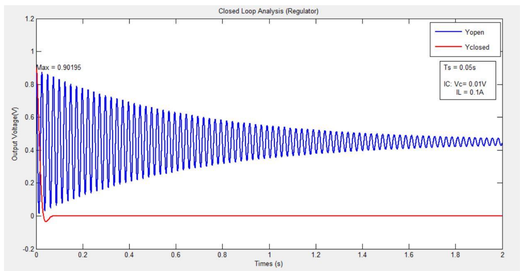
System Dynamics




```
OPoles =

   1.0e+03 *

  -0.1500 + 2.5310i
  -0.1500 - 2.5310i


K =

   -0.4297   -6.1278
```

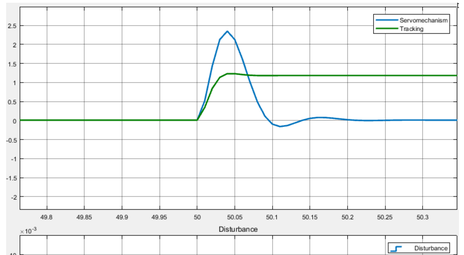



```
desP =

   1.0e+03 *

  -8.0000 - 0.0385i
  -8.0000 + 0.0385i


K =

   30.6641   54.9058
```

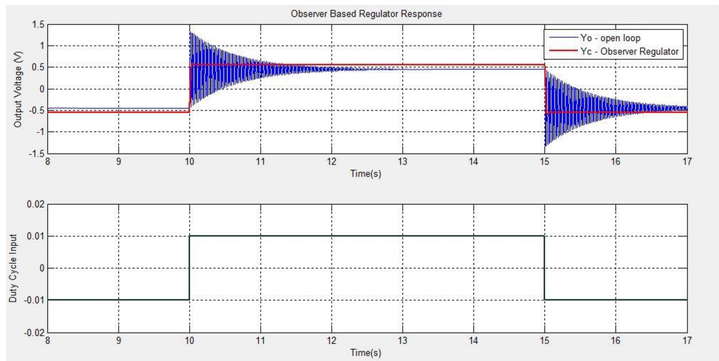



```
open_poles =

   1.0e+02 *

  -0.0150 + 2.5354i
  -0.0150 - 2.5354i


desP =

  -80.0000 -77.0214i
  -80.0000 +77.0214i


K =

    1.2266   -1.5855
```

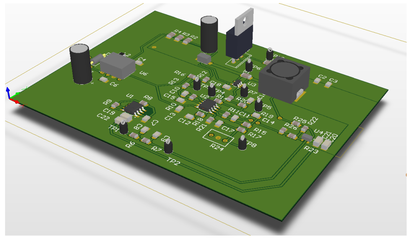
Controller Performance

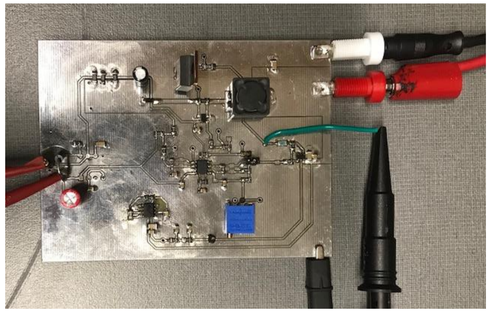


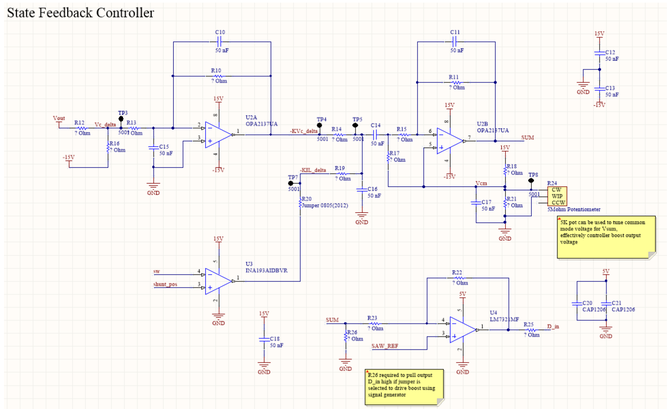

```
desP =

  -80.0000 -77.0214i
  -80.0000 +77.0214i


K =

    1.2266   -1.5855


Gc =

    0.0043


ITAE_poles =

  -26.0475 +53.4051i
  -26.0475 -53.4051i
  -35.4050 + 0.0000i


Ksrv =

    0.6602   -1.7976   -0.0432
```

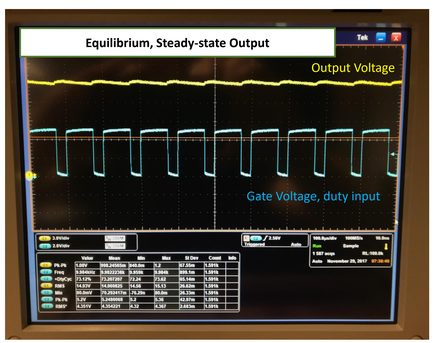


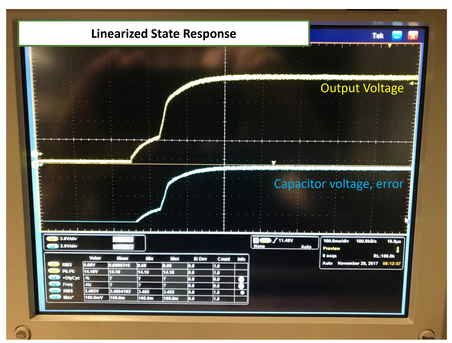
Hardware Prototyping











- Due to power constraints, R is very large, C & L are small (large open-loop poles)
- For small %OS, closed loop poles must be left of open loop
- For desired performance, unrealizable K is required
- Compromise: increase capacitance, lower K, O-poles further right

- Measuring inductor current is costly and inconvenient
- Implementing an observer allows direct control over output voltage using only capacitor voltage state
- Observer based regulator provides suitable performance, easier implementation in hardware as less computation required (can be achieved as analog)

Mitchell Johnston