Boost Converter Workshop Overview

Brady Salz
October 11, 2015

TECHNICAL ADVANCEMENT GROUP

Circuits

ieee@uiuc

ECE ILLINOIS

ILLINOIS

HIGH LEVEL

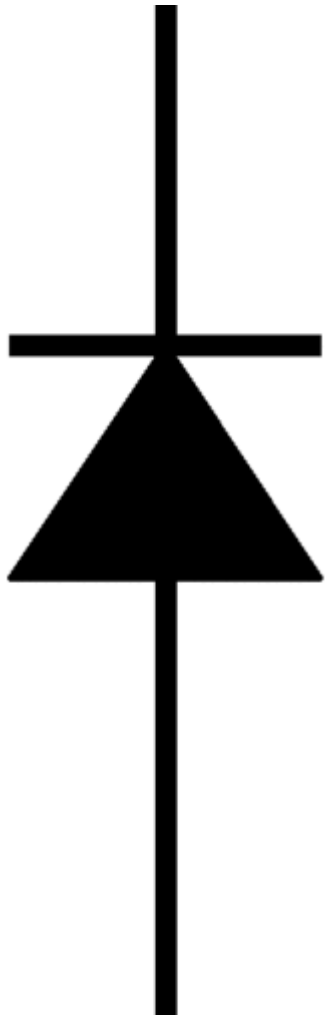
- Component Overview
- Ideal Converter
- Real Converter
- Implementation
- PCB

INDUCTOR

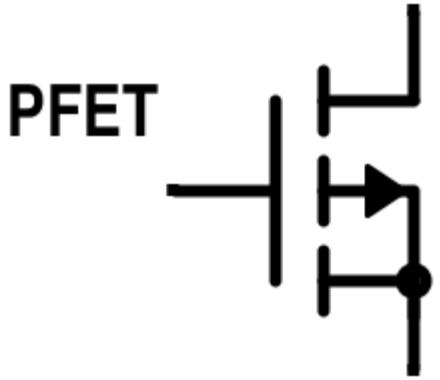
- E = LI or V = L dI/dt or Z = jwL
- AC “blocks”, DC “shorts”
- “Opposite” of a capacitor
- Easy to make, hard to make precise
- Often used in RF or Oscillator circuits for tuning

DIODE

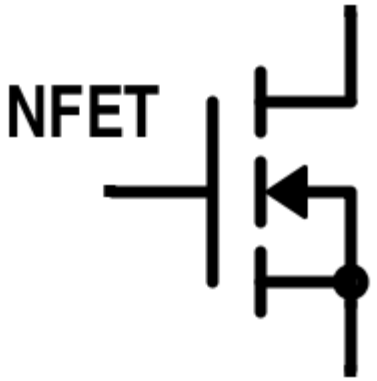
- Exponential IV curve
  – Can linearize to V > Vd, unlimited current, V < Vd,
- Negative/Low voltage “block”, else “short”
- Used for rectifiers, reverse polarity, voltage regulato
- Orientation matters!!
  – Does not behave the same both ways



MOSFET (PFET/NFET)

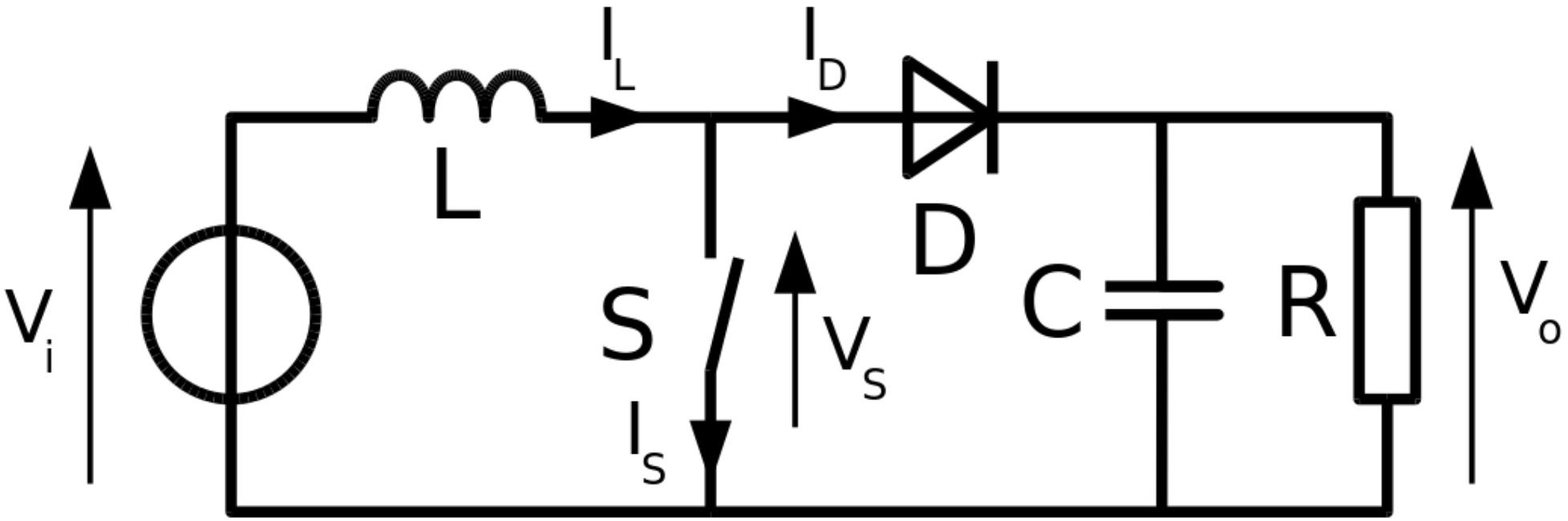


- Voltage-Controlled Current Source
- 3 Terminals – Drain Gate Source
- Two ways of viewing it (nFET):
  - Binary
    - Low voltage at gate, close up D-S connection (no curre
    - High voltage at gate, open up D-S connection (current
  - Continuous
    - Current through D-S is proportional to gate voltage
    - Has a min/max (off/saturated) point



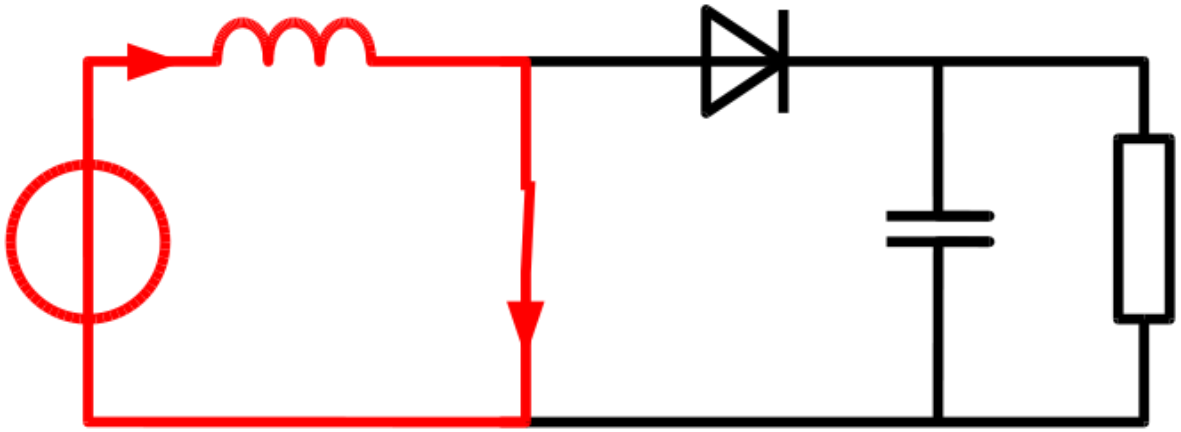
- pFET – same rules, just flip high flow (no current when high @ gate, etc)

IDEAL SCHEMATIC

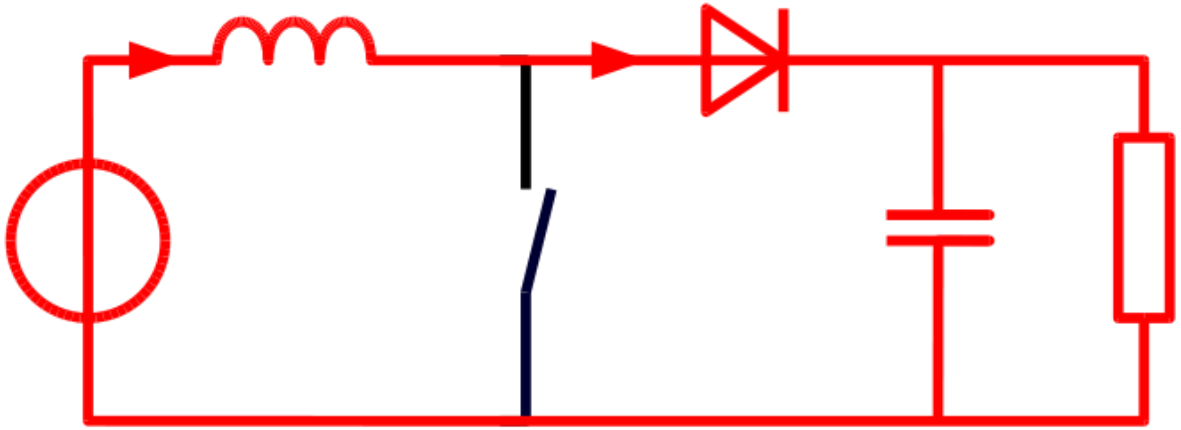


TWO STATES

ON STATE



OFF STATE



DERIVATION

This “should be” a DC circuit with constant output voltage

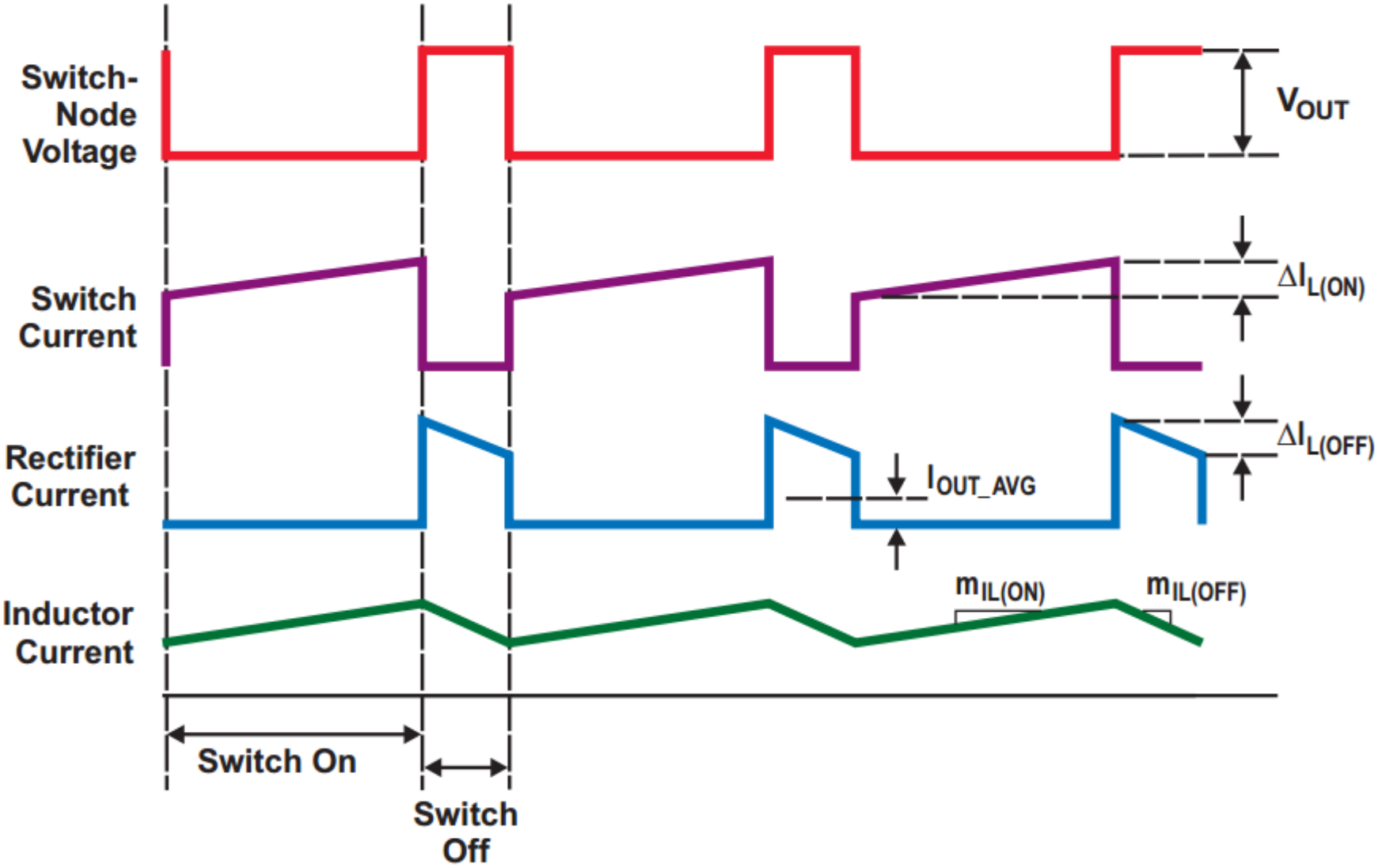
-> Implies DC current as well

-> DC current means no inductor voltage

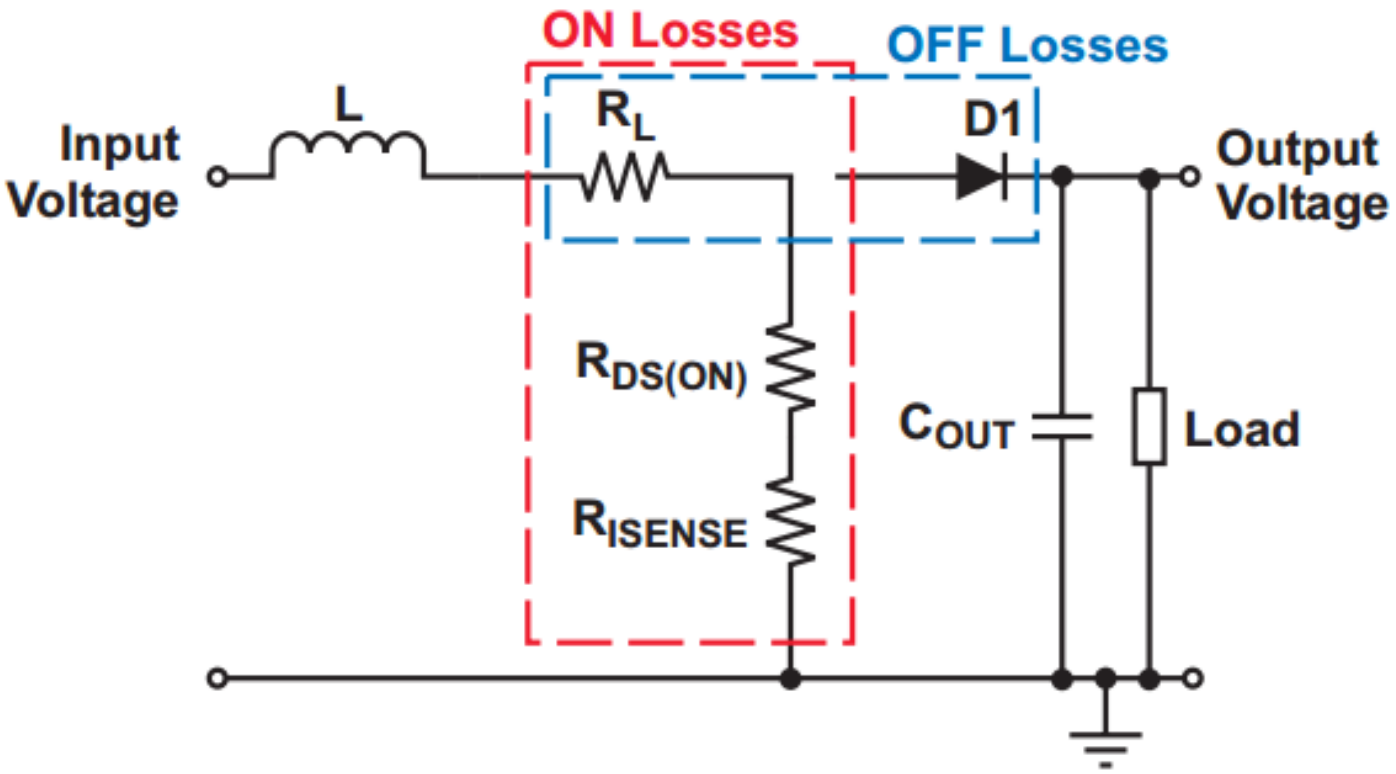
Assume driving switch with square wave

$$V_{L,\text{on}} + V_{L,\text{off}} = 0$$
$$T_{\text{on}}V_{\text{in}} + T_{\text{off}}(V_{\text{in}} - V_{\text{out}}) = 0$$
$$T_{period}\big(DV_{\text{in}} + (1-D)(V_{\text{in}} - V_{\text{out}})\big) = 0$$
$$DV_{in} + V_{in} - V_{out} - D_{vin} + D\,V_{out} = 0$$
$$V_{in} - (1-D)V_{out} = 0$$
$$V_{in} = (1-D)V_{out}$$
$$V_{out} = V_{in}\,/(1-D)$$

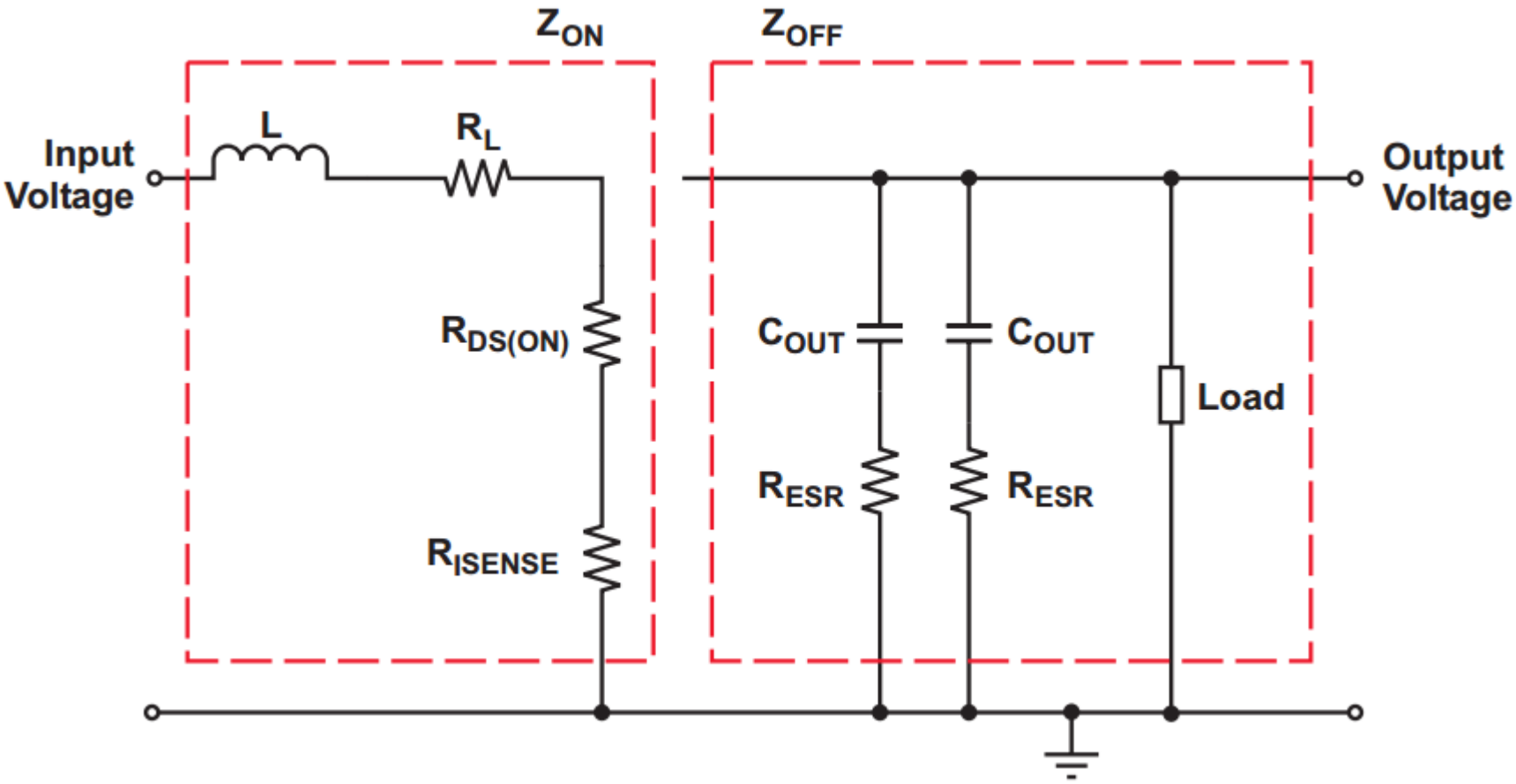
WAVEFORMS


Switch-
Node
Voltage
Switch
Current
Rectifier
Current
Inductor
Current
V_{OUT}
$\Delta I_{L(ON)}$
$\Delta I_{L(OFF)}$
I_{OUT_AVG}
$m_{IL(ON)}$
$m_{IL(OFF)}$
Switch On
Switch
Off

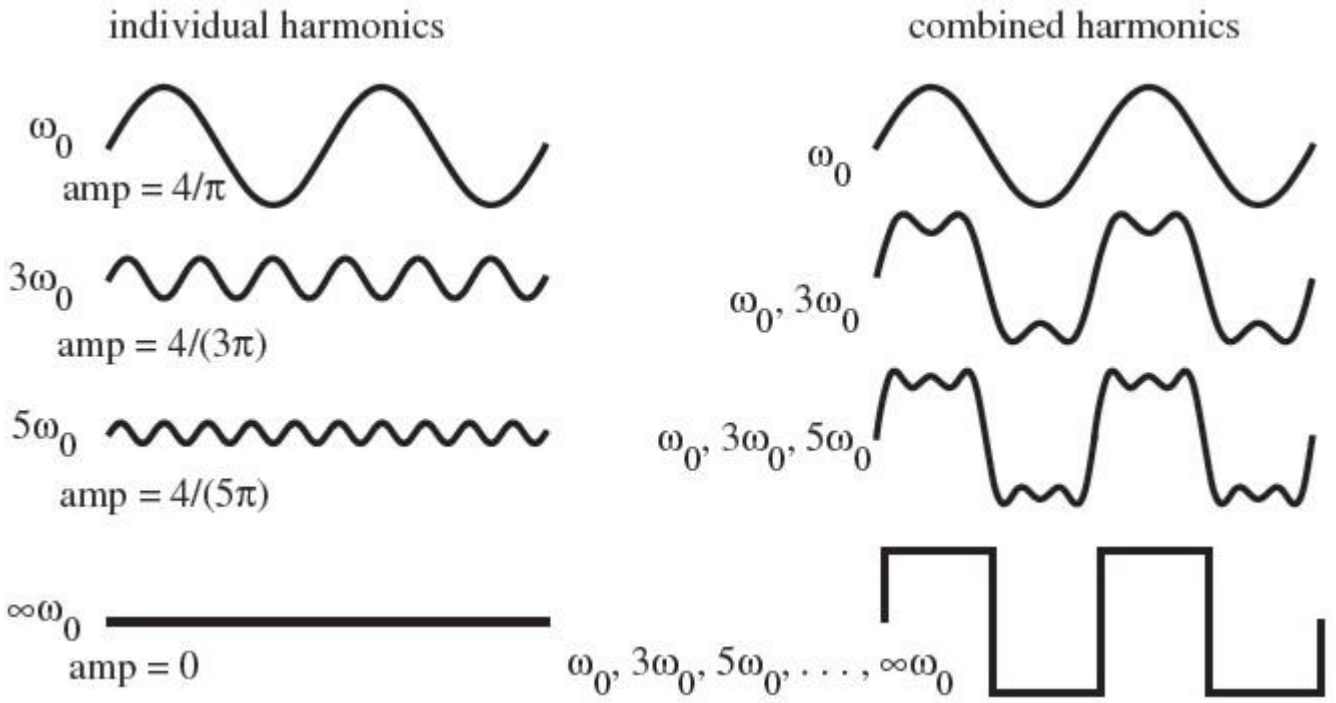
BASIC NON-IDEALITIES



MORE NON-IDEALITIES



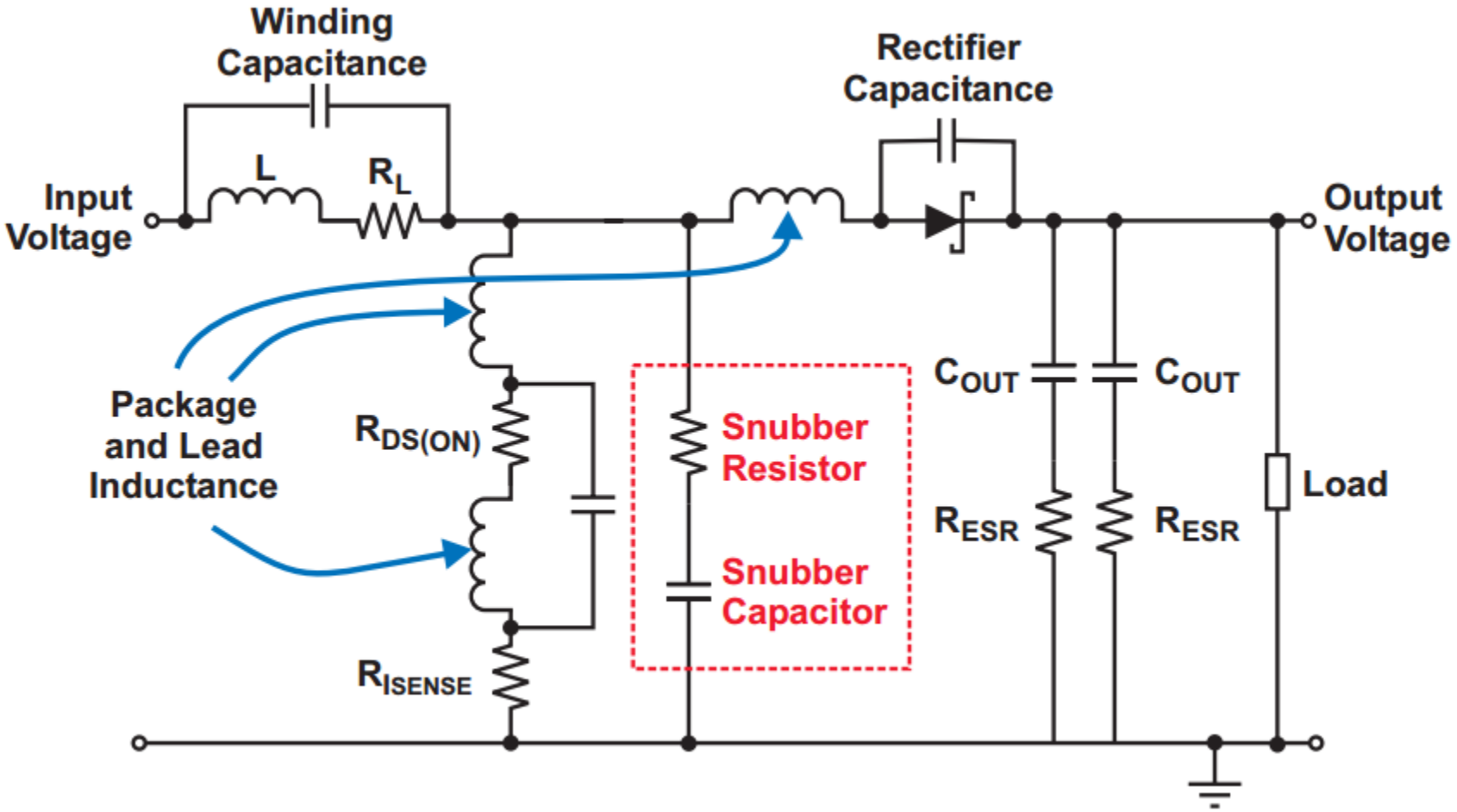
FOURIER SERIES



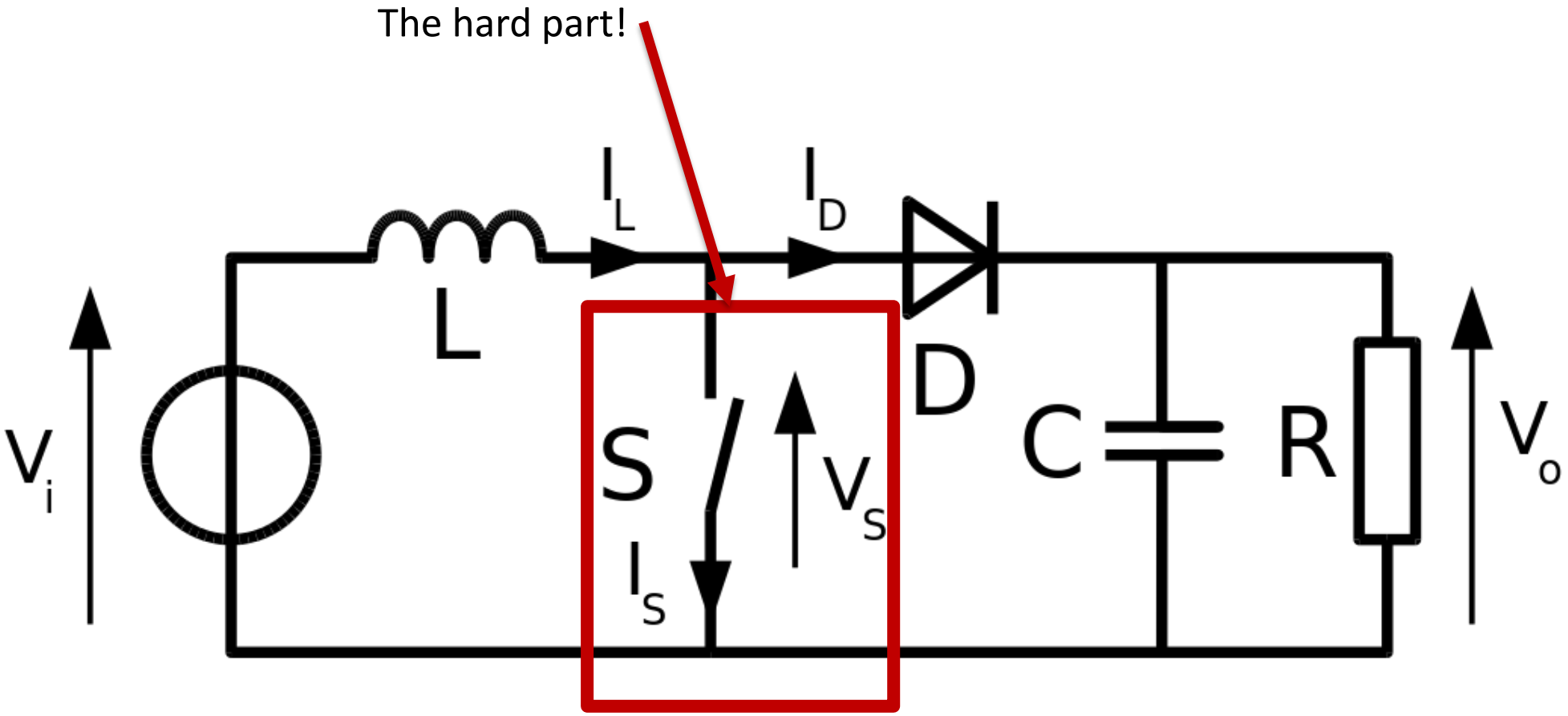
Problem?

-> Switching at 3*f

SNUB IT OUT

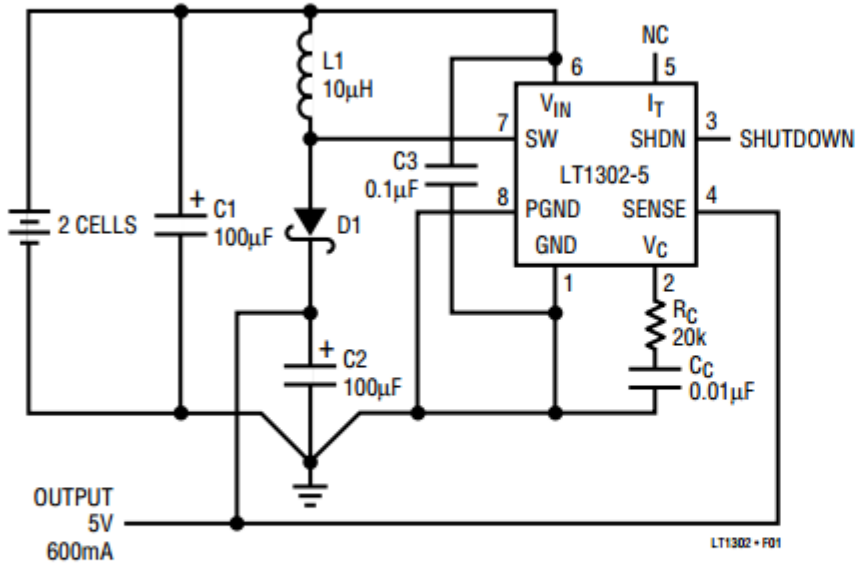

Winding
Capacitance
L
R_L
Input
Voltage
Rectifier
Capacitance
Output
Voltage
Package
and Lead
Inductance
$R_{DS(ON)}$
Snubber
Resistor
Snubber
Capacitor
C_{OUT}
C_{OUT}
R_{ESR}
R_{ESR}
Load
R_{ISENSE}

IMPLEMENTATION



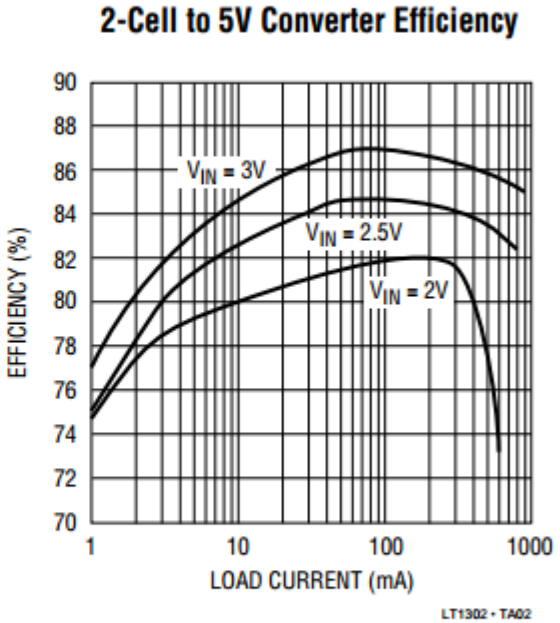
LET SOMEONE ELSE HANDLE IT

TYPICAL APPLICATION

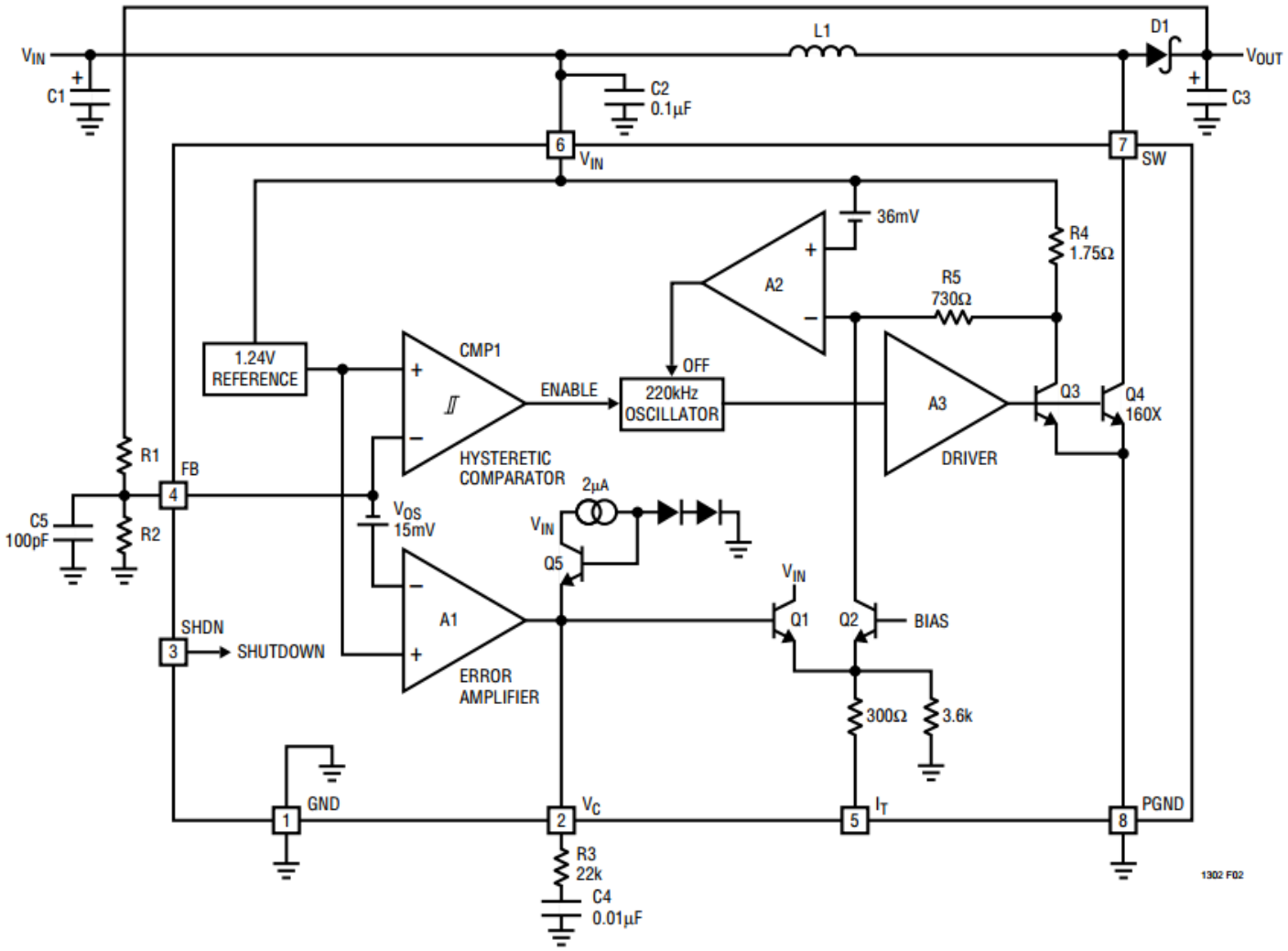


C1 = C2 = SANYO OS-CON D1 = MOTOROLA MBRS130LT3
L1 = COILTRONICS CTX10-3
COILCRAFT DO3316-103

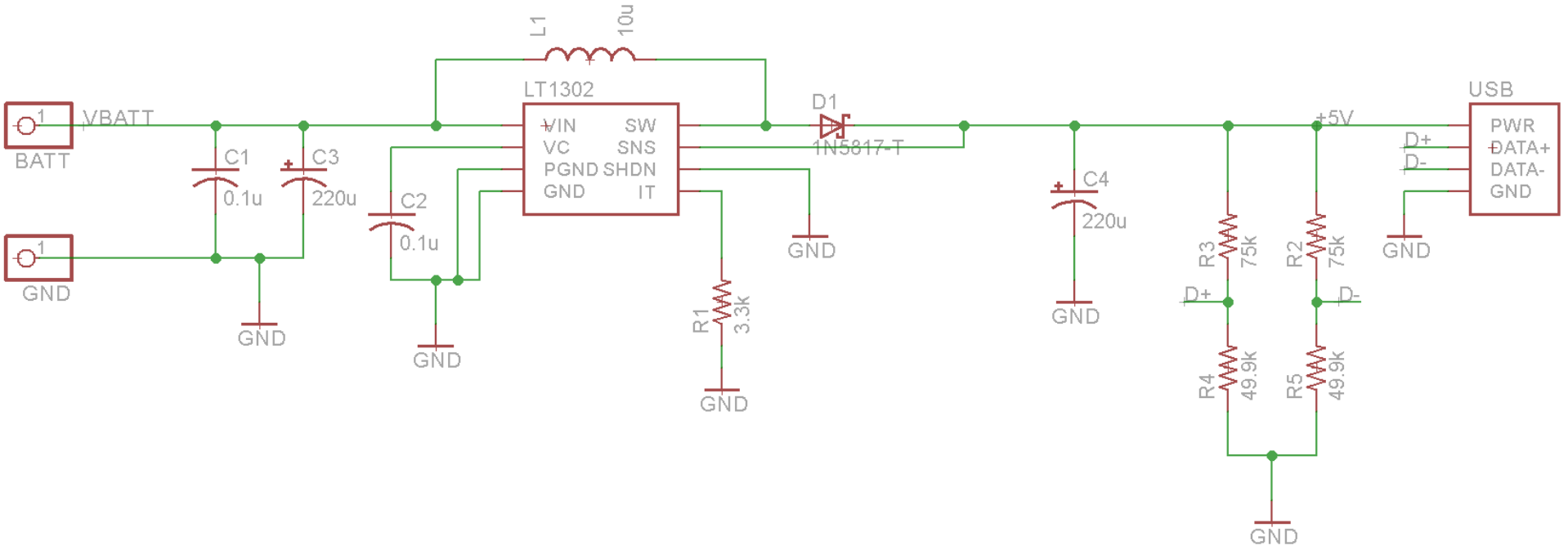
Figure 1. 2-Cell to 5V/600mA DC/DC Converter



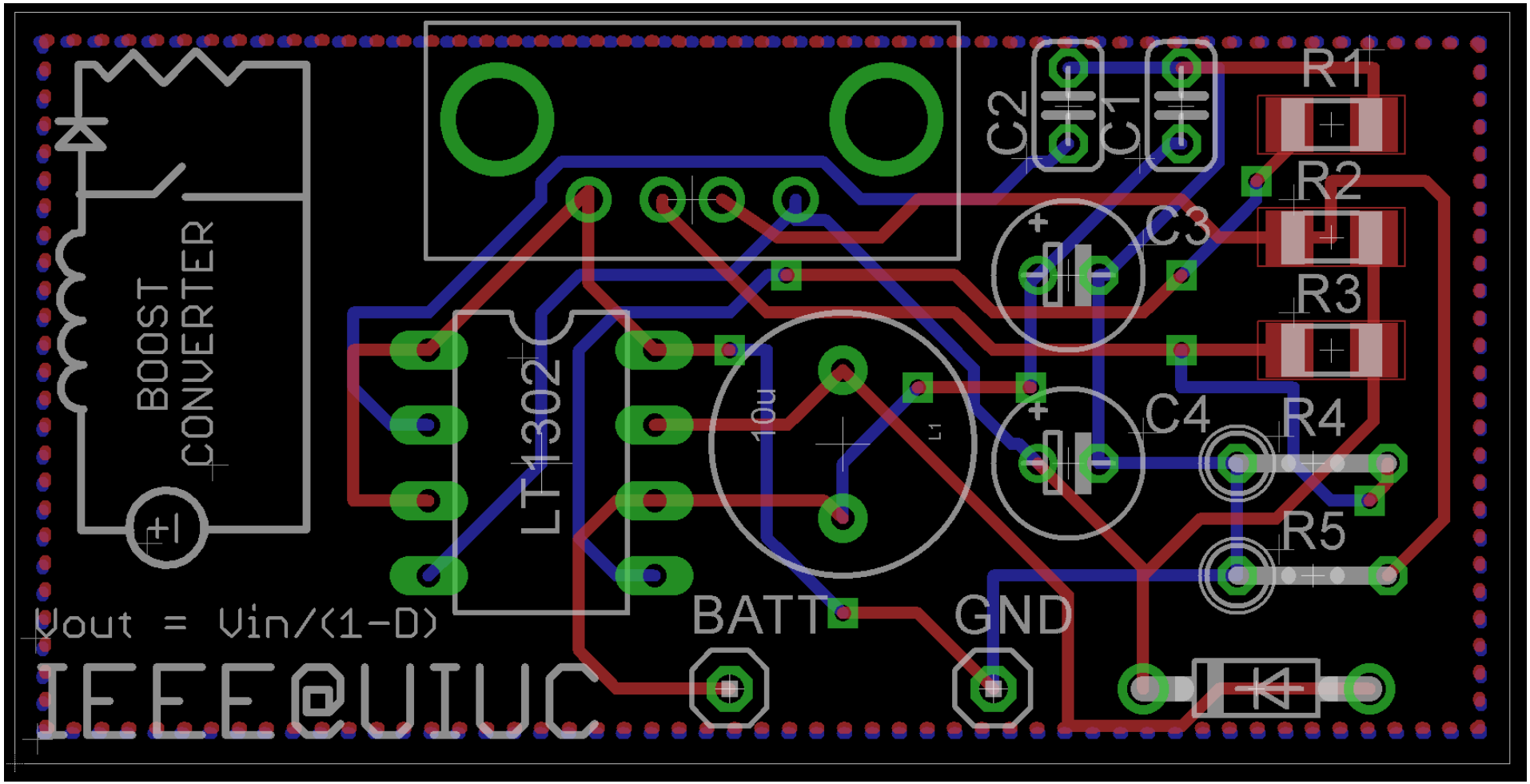
WHAT'S INSIDE?



SCHEMATIC


L1
10u
LT1302
VIN
VC
PGND
GND
SW
SNS
SHDN
IT
D1
1N5817-T
VBATT
BATT
GND
C1
0.1u
C3
220u
C2
0.1u
R1
3.3k
C4
220u
R3
75k
R2
75k
R4
49.9k
R5
49.9k
+5V
USB
PWR
DATA+
DATA-
GND
D+
D-

PCB


BOOST
CONVERTER
LT1302
10u
L1
C1
C2
C3
C4
R1
R2
R3
R4
R5
BATT
GND
Vout = Vin/(1-D)
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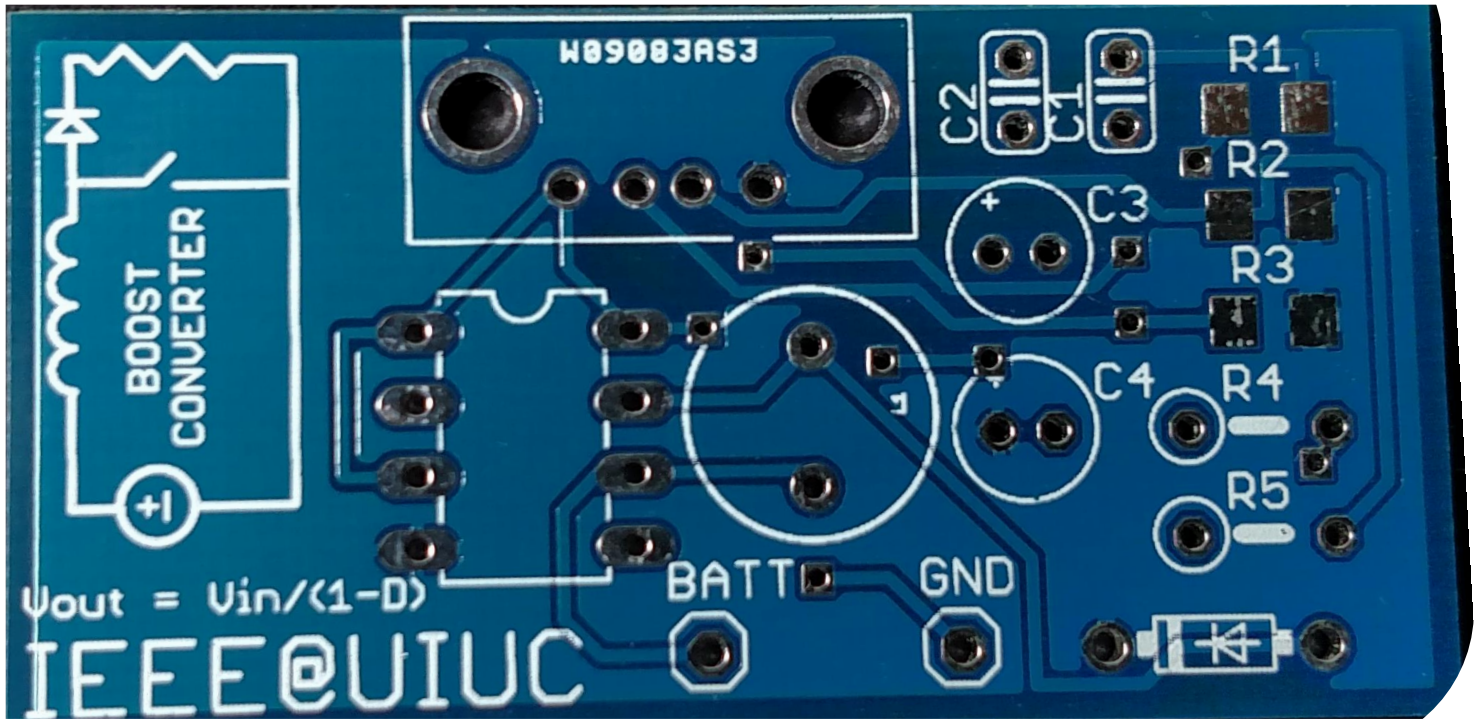
BOARD


W09003AS3
C2
C1
R1
R2
C3
R3
C4
R4
R5
BOOST
CONVERTER
Vout = Vin/(1-D)
BATT
GND
IEEE@UIUC

CITATIONS

- "Under the Hood of a DC/DC Boost Converter" by Brian Lynch http://www.ti.com/download/trng/docs/seminar/Topic_3_Lynch.pdf
- "Boost Converter" – Wikipedia https://en.wikipedia.org/wiki/Boost_converter
- LT1302 Datasheet http://www.linear.com/product/LT1302
- "MintyBoost Documentation" – Adafruit https://learn.adafruit.com/minty-boost/