ELEMENTS OF SWITCH MODE POWER SUPPLIES

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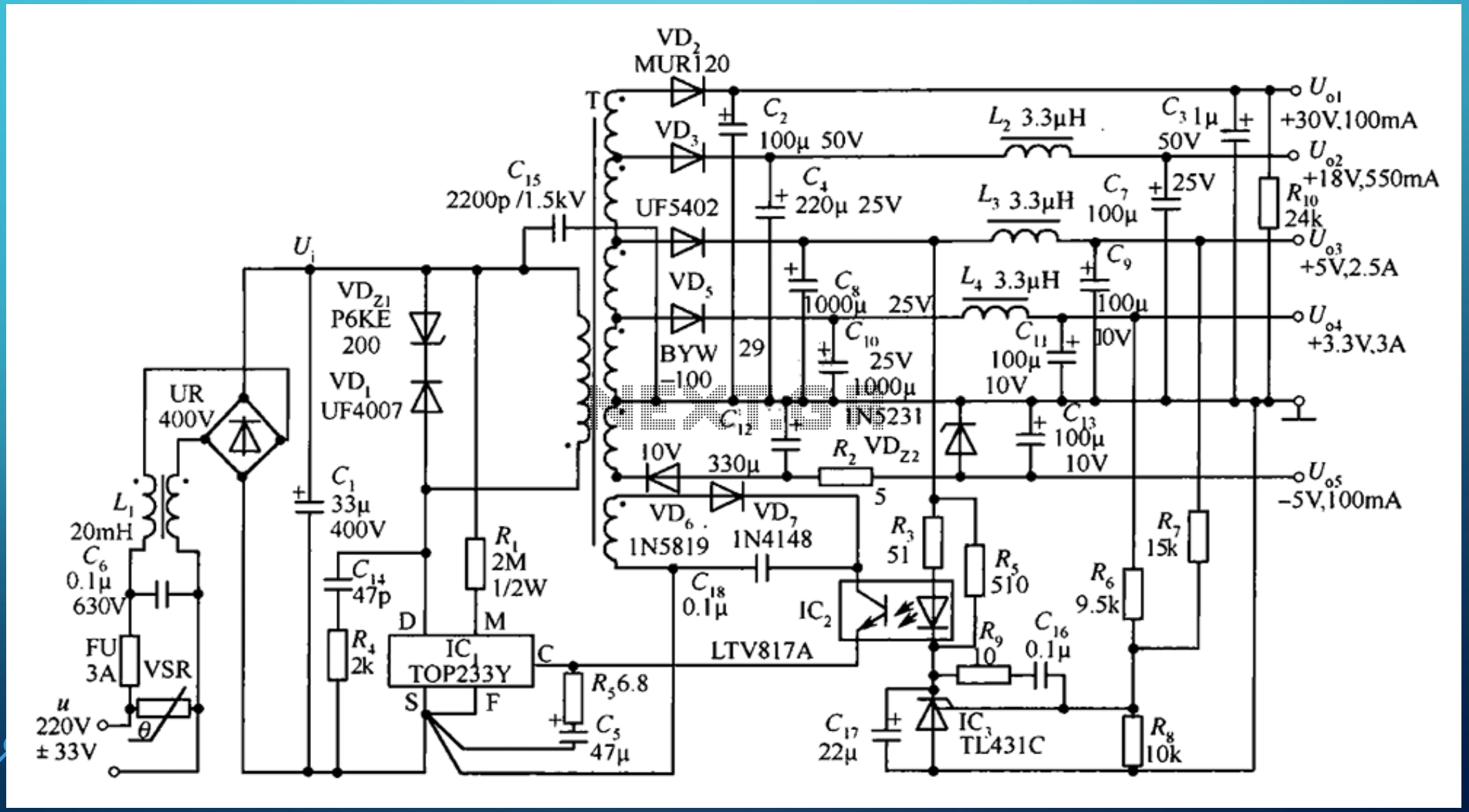
RALEIGH AMATUER RADIO SOCIETY

HIGH LEVEL VIEW OF AN OFF-LINE POWER SUPPLY



FUSES

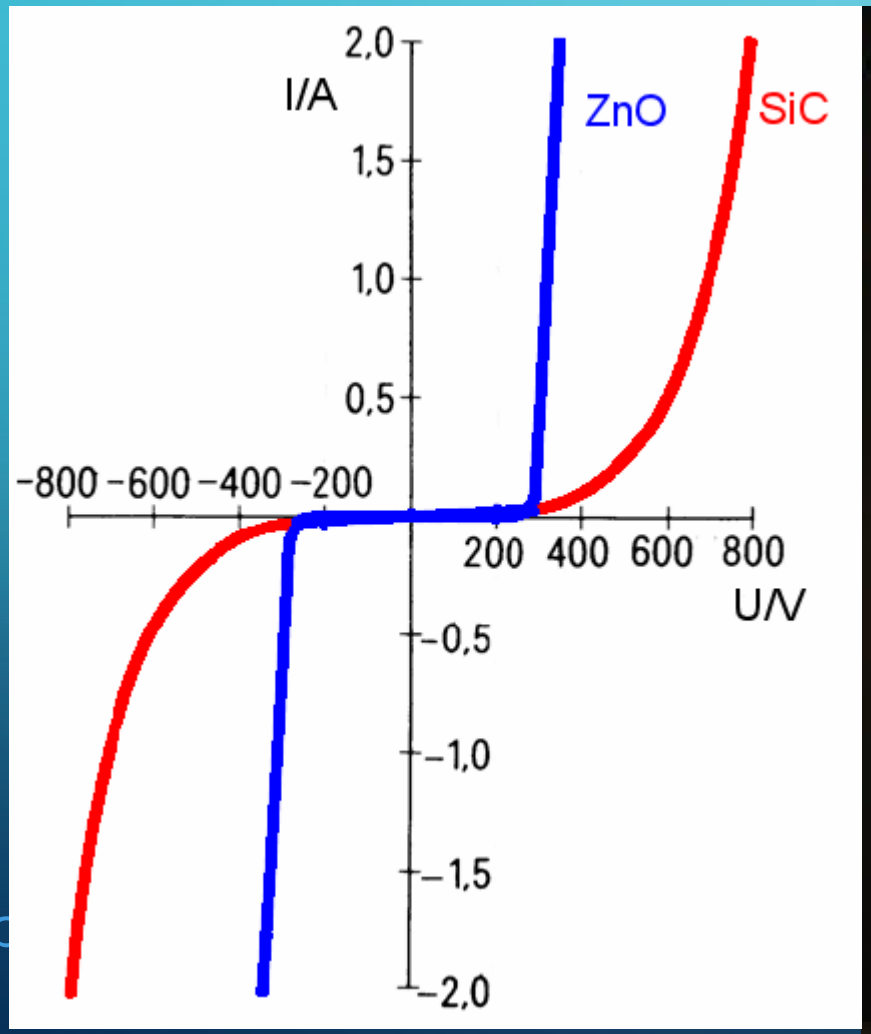
- Current rating
  - Fuses are rated in Amps
- Voltage rating
  - It is harder to break a high voltage arc and therefore fuses have a voltage rating
- Speed
  - Fuses have a current squared times time rating
- AC or DC
  - It is harder to break a DC arc and therefore DC fuses are special
- They are meant to burn open when their current rating is exceeded

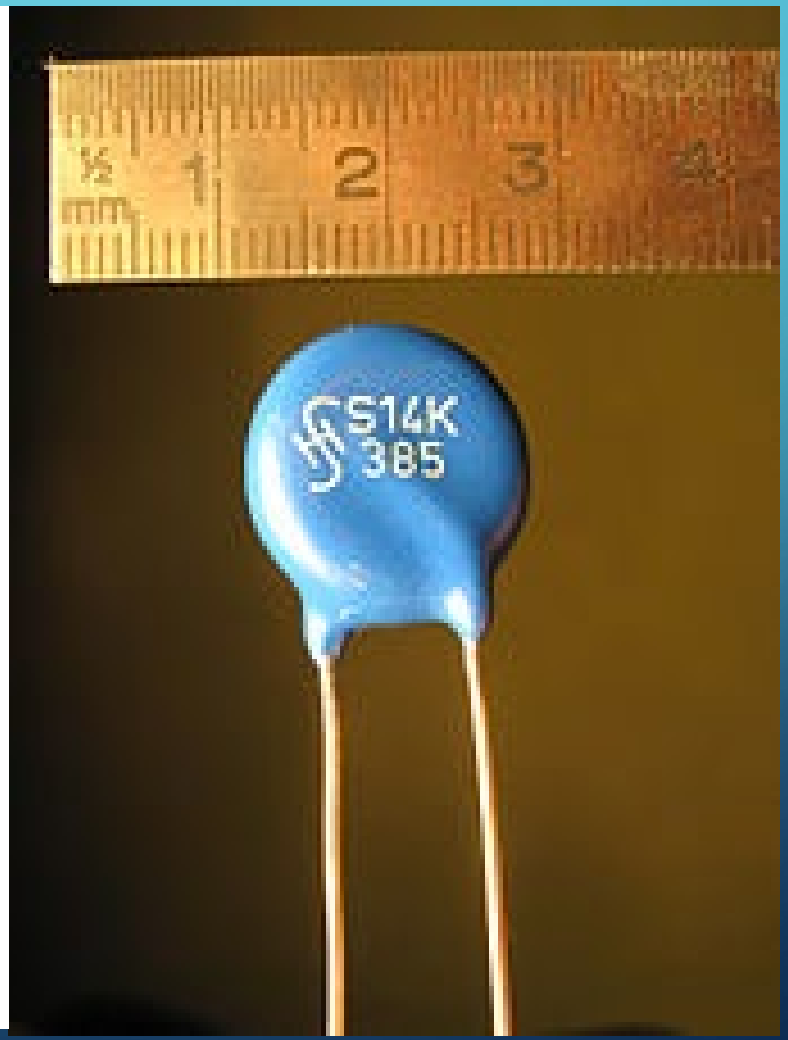
NEGATIVE TEMPERATURE COEFFICIENT (NTC) THERMISTORS

- They prevent excessive inrush current that could:
  - blow the system fuse
  - damage the capacitors
  - cause a power line disturbance to systems on the same power line
  - When cold they offer somewhat higher resistance

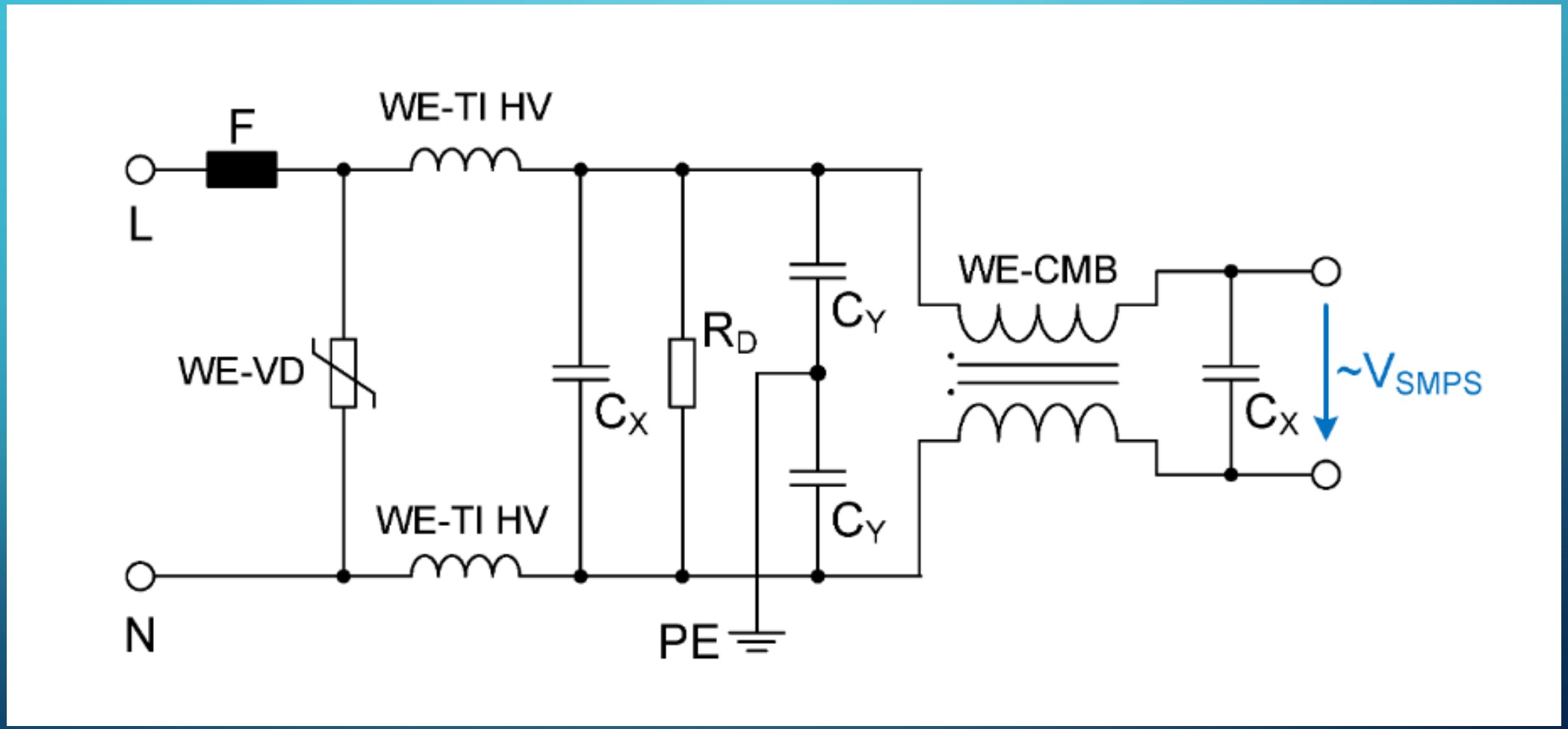
VARISTOR (TRANSORBS)

- Prevent excessive input voltage spikes that could damage the power supply

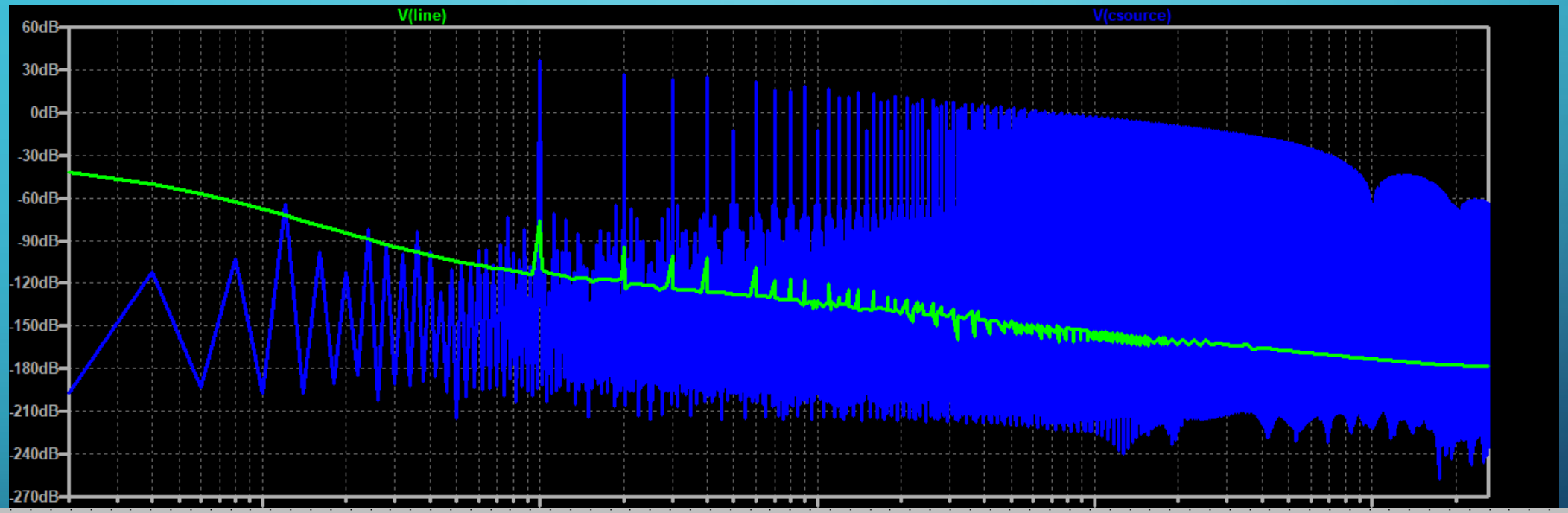


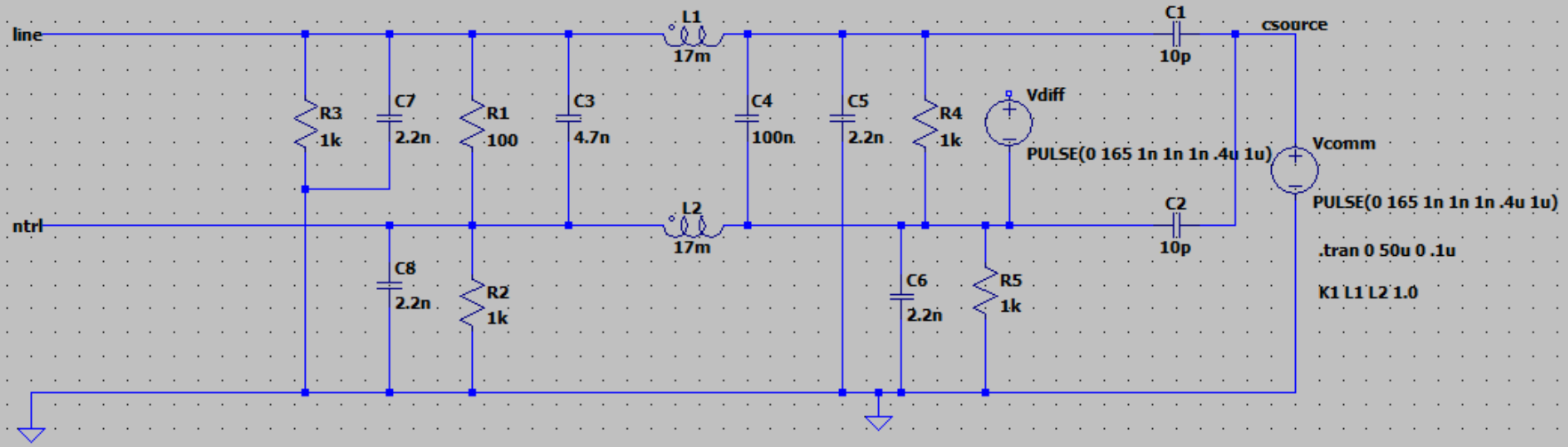


INPUT FILTER



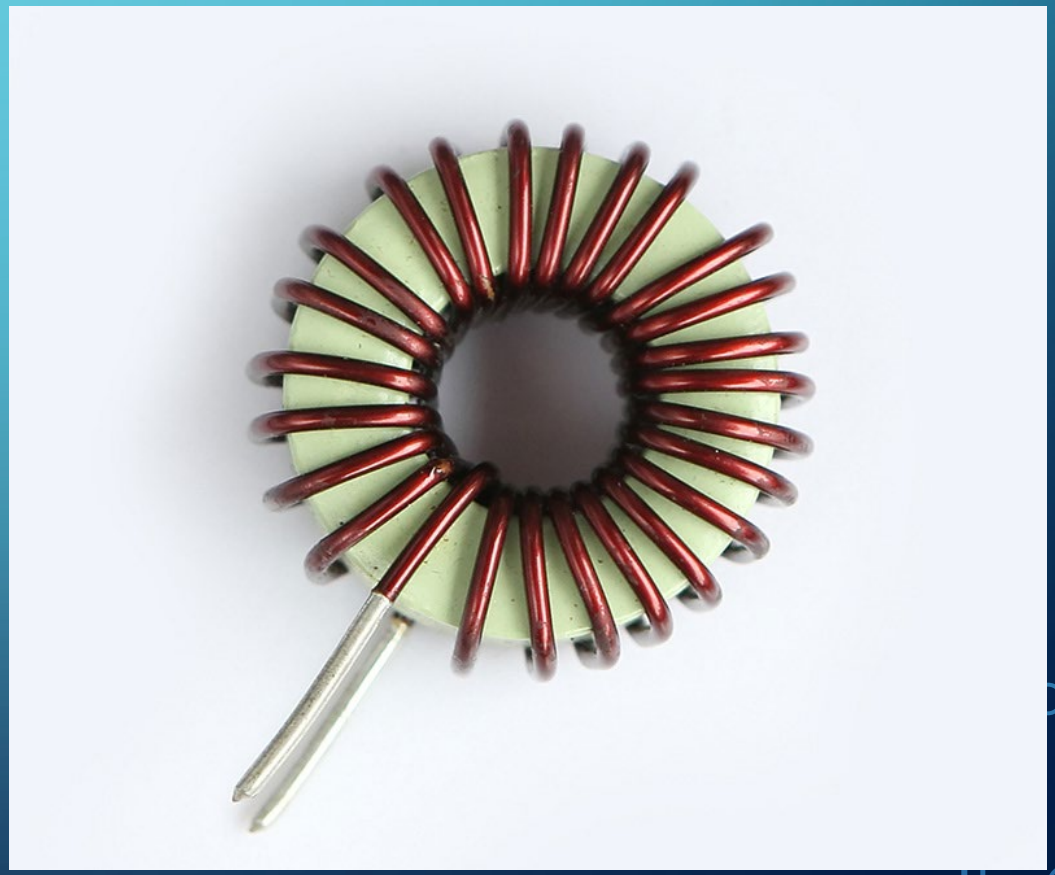
COMMON MODE INPUT FILTER RESPONSE, FFT





DIFFERENTIAL MODE INDUCTORS

- Cause an impedance (reluctance) to unwanted high frequency currents
  - They act on current flow from line to neutral
- Considerations:
  - Inductance value (uH)
  - Current rating



COMMON MODE INDUCTORS

Cause an impedance (reluctance) to unwanted high frequency currents

- They act on common current flow from line to neutral

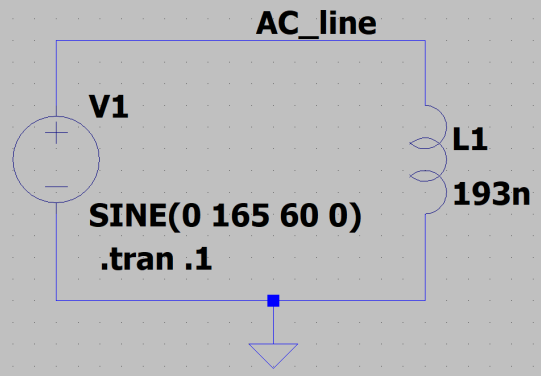
Considerations:

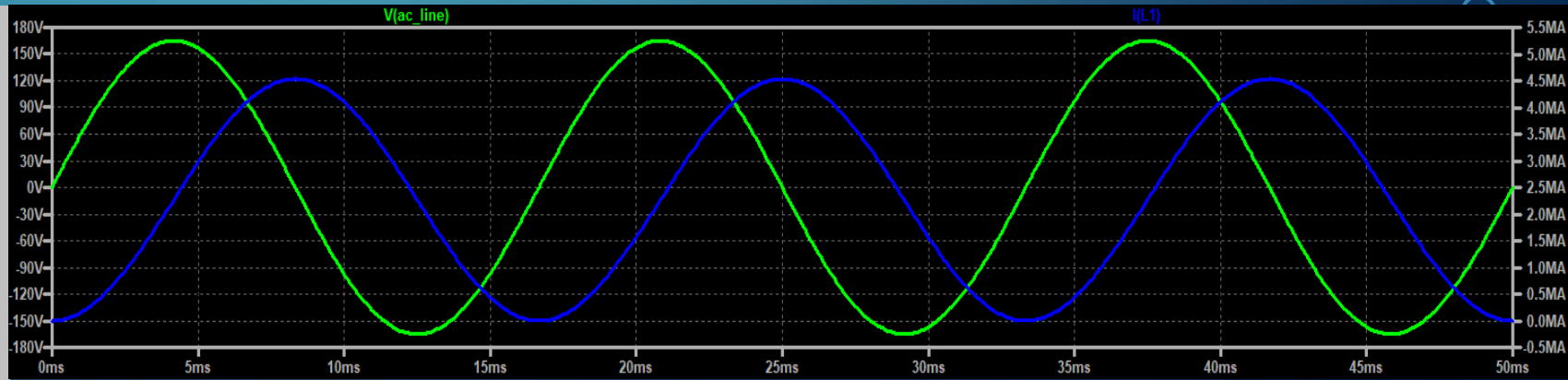
- Inductance value (uH)
- Current rating

TRANSFORMERS, MAGNETIZING INDUCTANCE

- Provide galvanic isolation, no direct contact with either side of the power line
- Consider the 10:1 transformer wound on a lifesaver candy
  - Why can it not be used to transform household 120 VAC to 12 VDC, just what we want!
  - b = 23.4 mm a = 7.1 mm H = 8.1 mm
  - 10 turns on a lifesaver candy yields an inductance of 193 nH

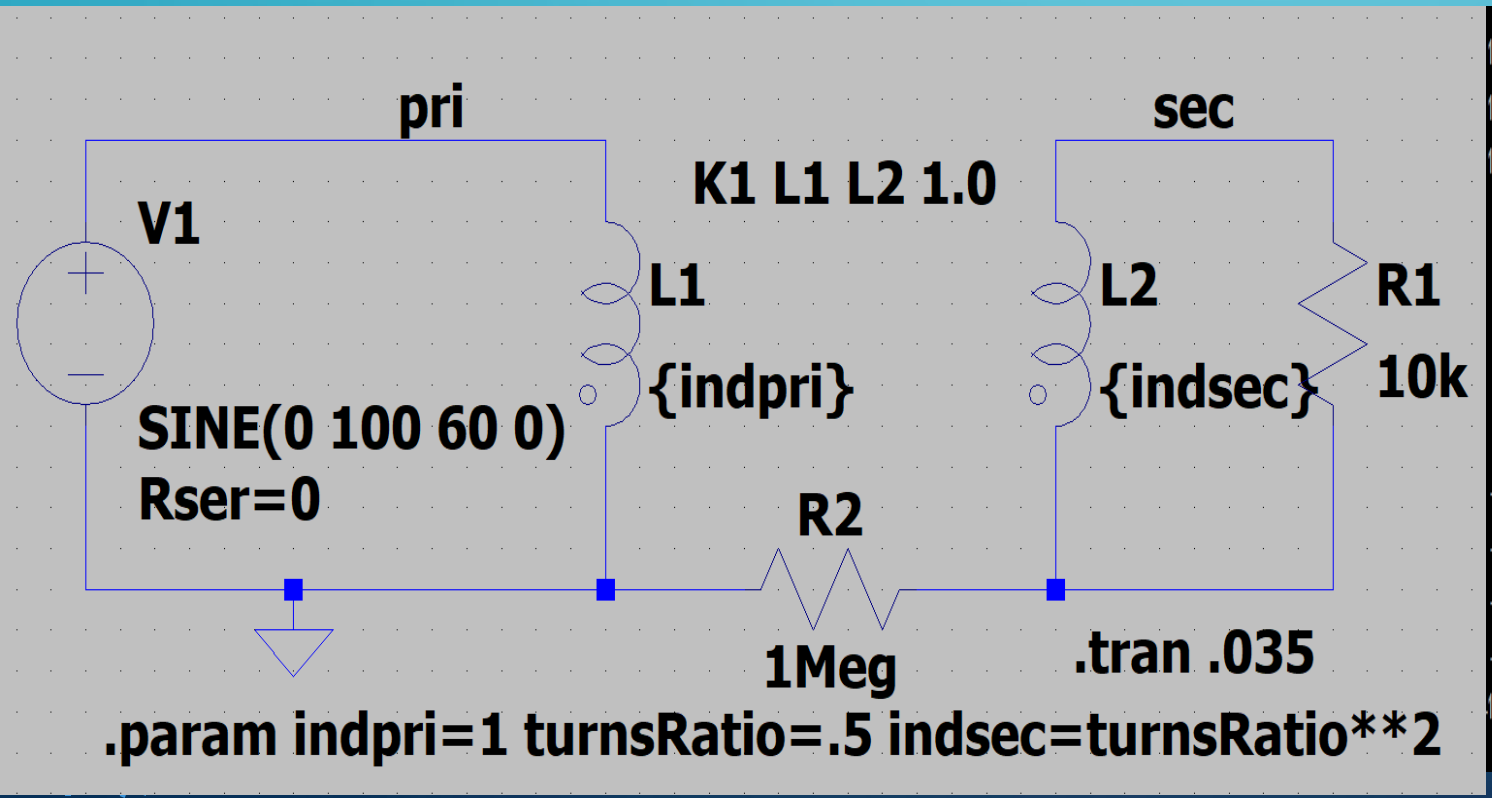
$$L = \frac{\mu_0 N^2 H \ln(b/a)}{2\pi}$$

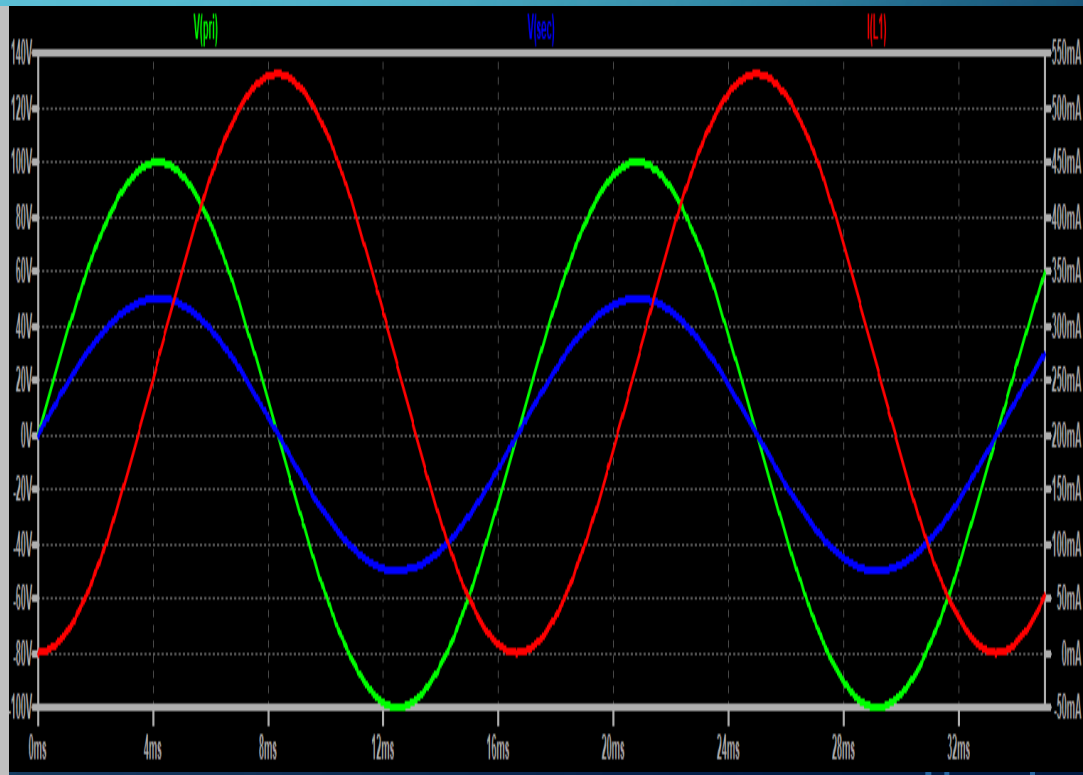




TRANSFORMERS, WITH SECONDARY

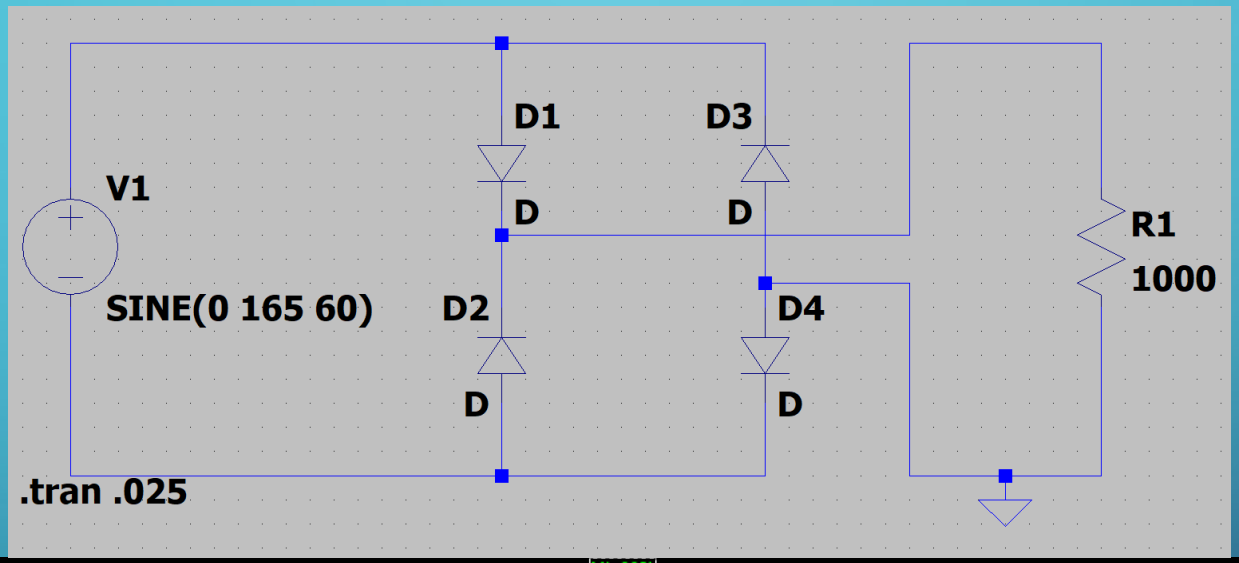
- Provide galvanic isolation from the power line
- Couples energy balance via a shared primary to secondary magnetic field
- Provides voltage step up or down based on primary to secondary turns ratio

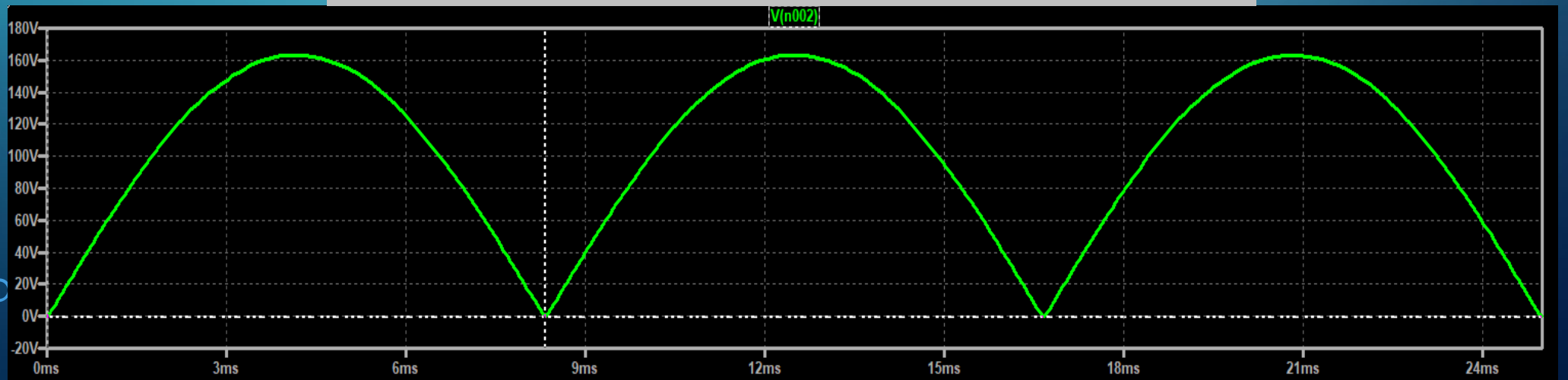




RECTIFIERS AND RECTIFIER BRIDGES

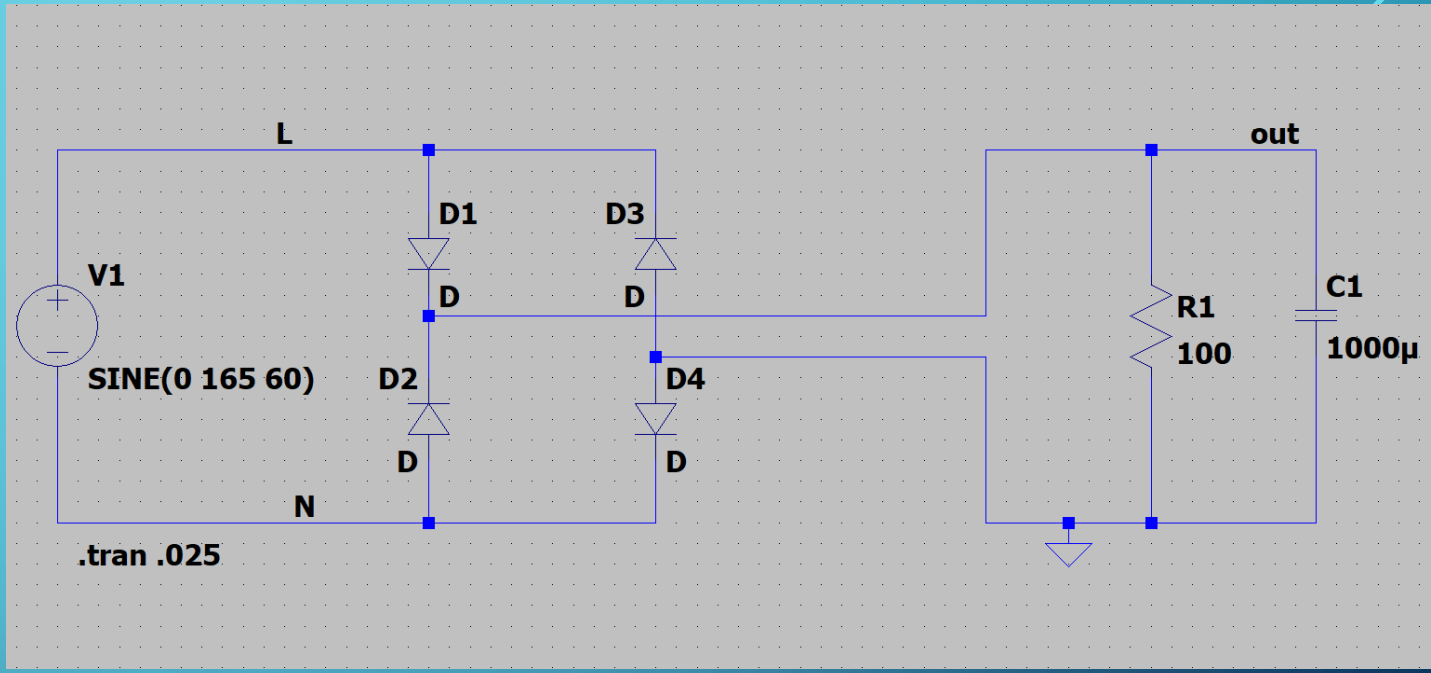
- Allow conventional current to flow in one direction only

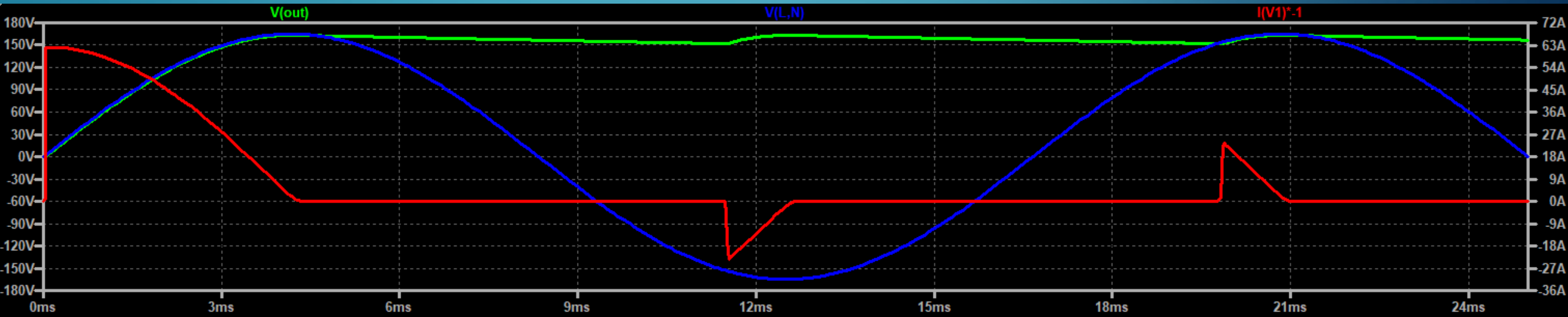




CAPACITORS

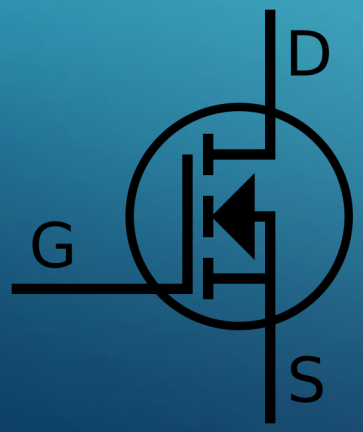
- Store energy in an electric field
- V = Q/C

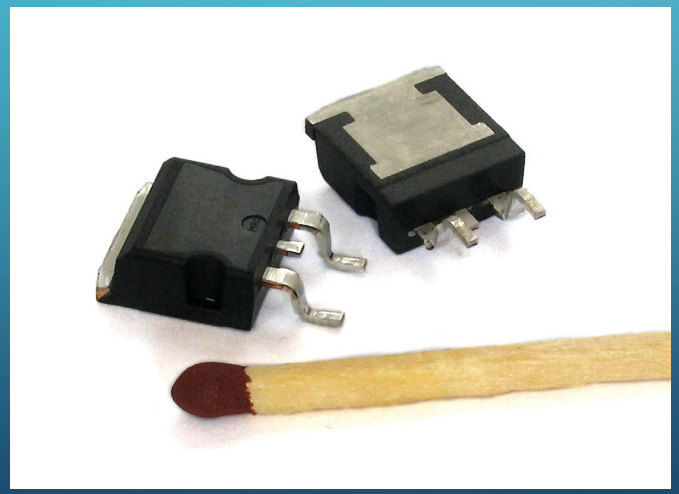




MOSFETS USED A SWITCHES

- Rated for voltage while off
- Current and channel resistance while on
- Threshold voltage (Vgs) to turn the device on or off





MOSFETS USED AS SWITCHES

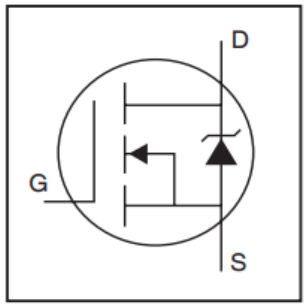
International
IOR Rectifier

PD - 95149

IRL2910S/LPbF

HEXFET® Power MOSFET

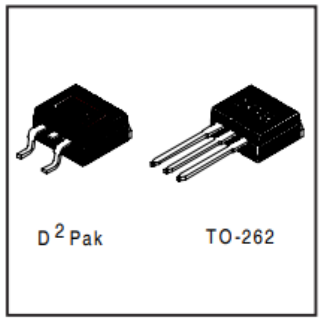
- Logic-Level Gate Drive
- Surface Mount
- Advanced Process Technology
- Ultra Low On-Resistance
- Dynamic dv/dt Rating
- Fast Switching
- Fully Avalanche Rated
- Lead-Free



V_{DSS} = 100V

$R_{DS(on)}$ = 0.026Ω

I_D = 55A



Description

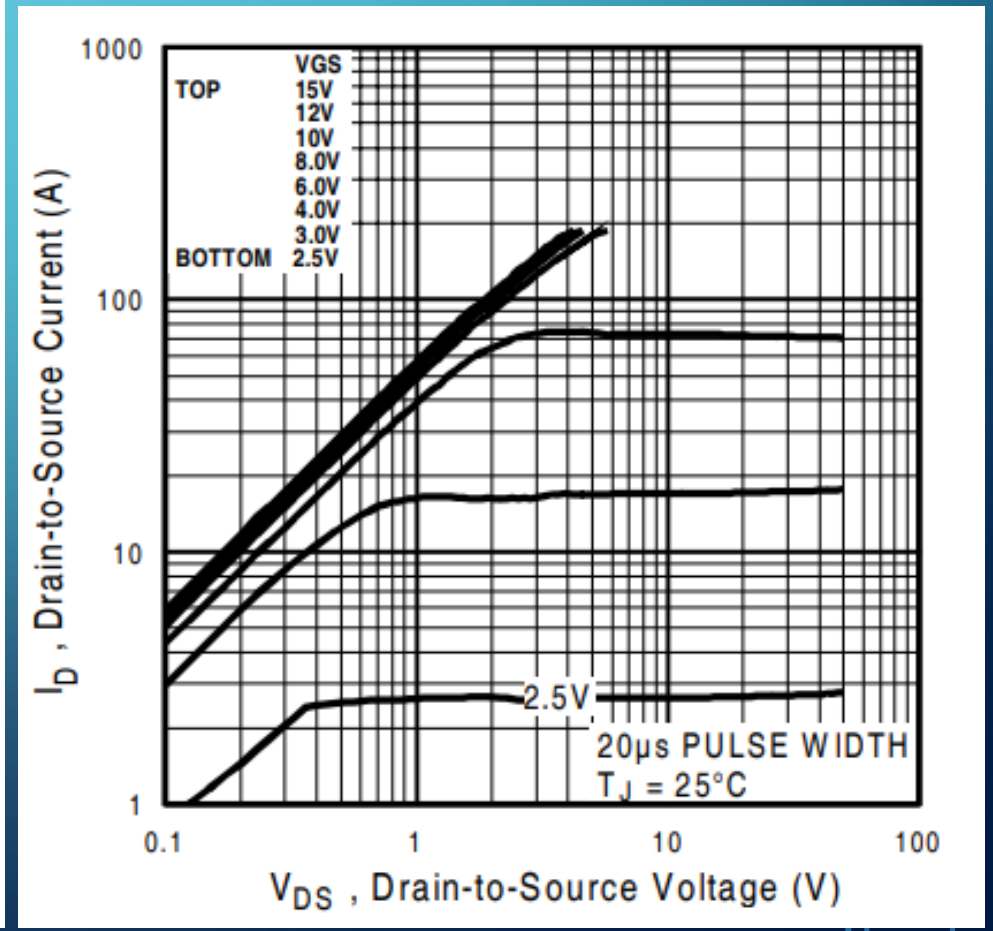
Fifth Generation HEXFETs from International Rectifier utilize advanced processing techniques to achieve extremely low on-resistance per silicon area. This benefit, combined with the fast switching speed and ruggedized device design that HEXFET Power MOSFETs are well known for, provides the designer with an extremely efficient and reliable device for use in a wide variety of applications.

The D²Pak is a surface mount power package capable of accommodating die sizes up to HEX-4. It provides the highest power capability and the lowest possible on-resistance in any existing surface mount package. The D²Pak is suitable for high current applications because of its low internal connection resistance and can dissipate up to 2.0W in a typical surface mount application.

The through-hole version (IRL2910L) is available for low-profile applications.

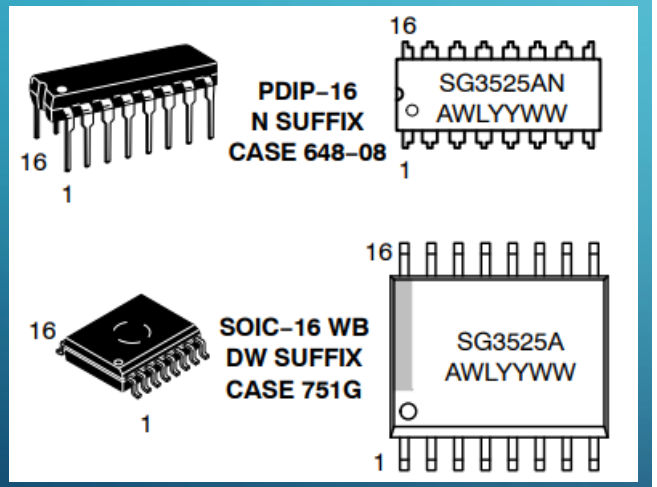
Absolute Maximum Ratings

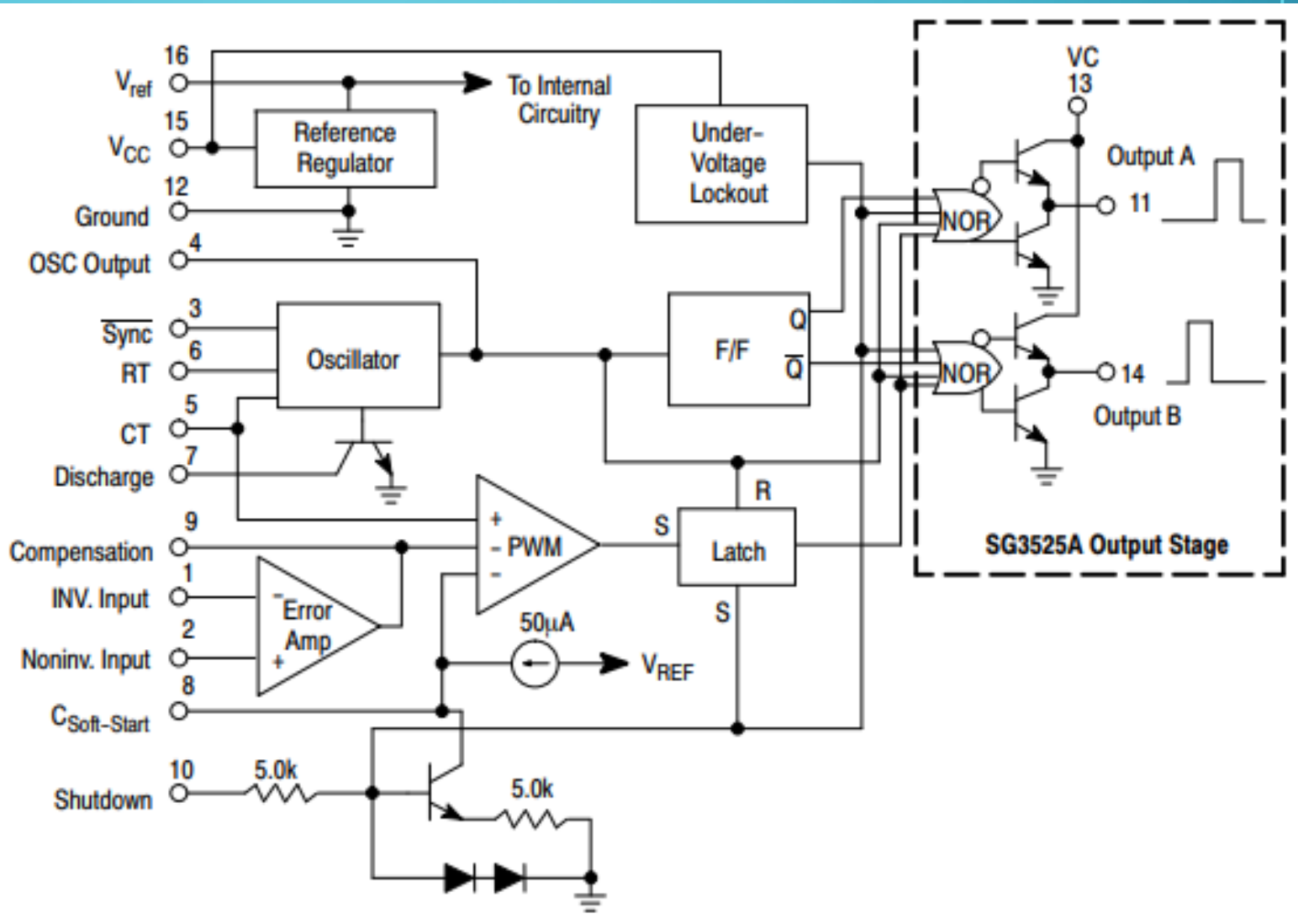
	Parameter	Max.	Units
I_D @ T_C = 25°C	Continuous Drain Current, V_{GS} @ 10V⑤	55	A
I_D @ T_C = 100°C	Continuous Drain Current, V_{GS} @ 10V⑤	39	
I_{DM}	Pulsed Drain Current ①⑤	190	



PULSE WIDTH MODULATORS (PWM)

- Usually packaged as
- an integrated circuit

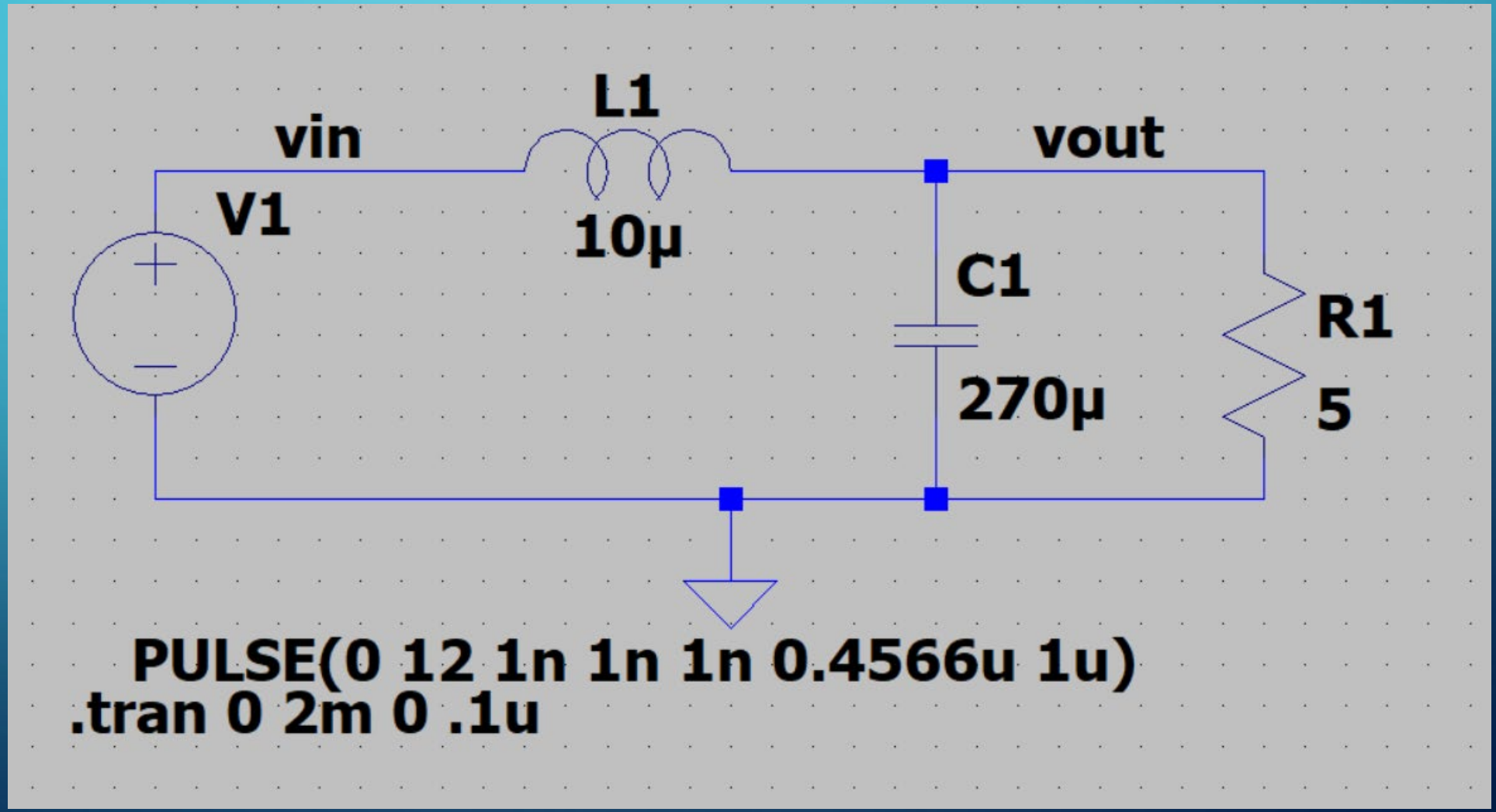




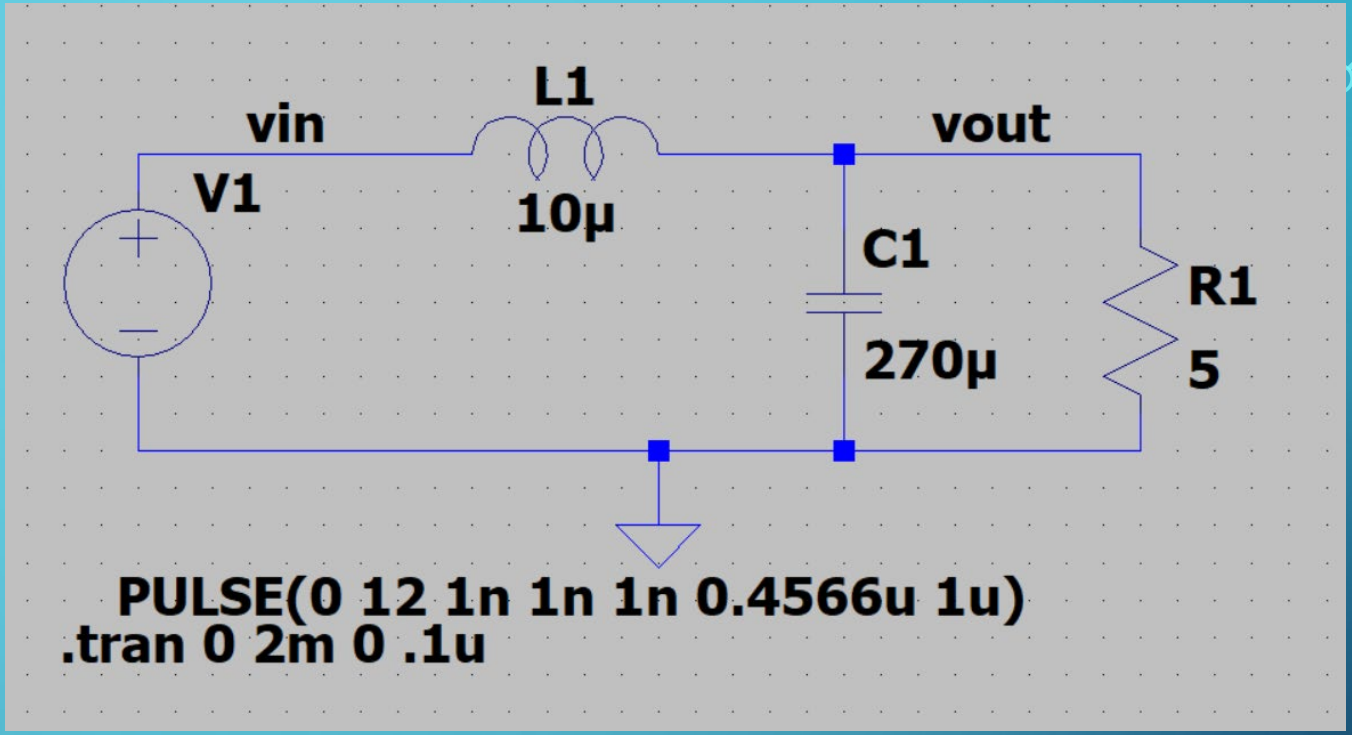
POWER PROCESSOR TOPOLOGIES

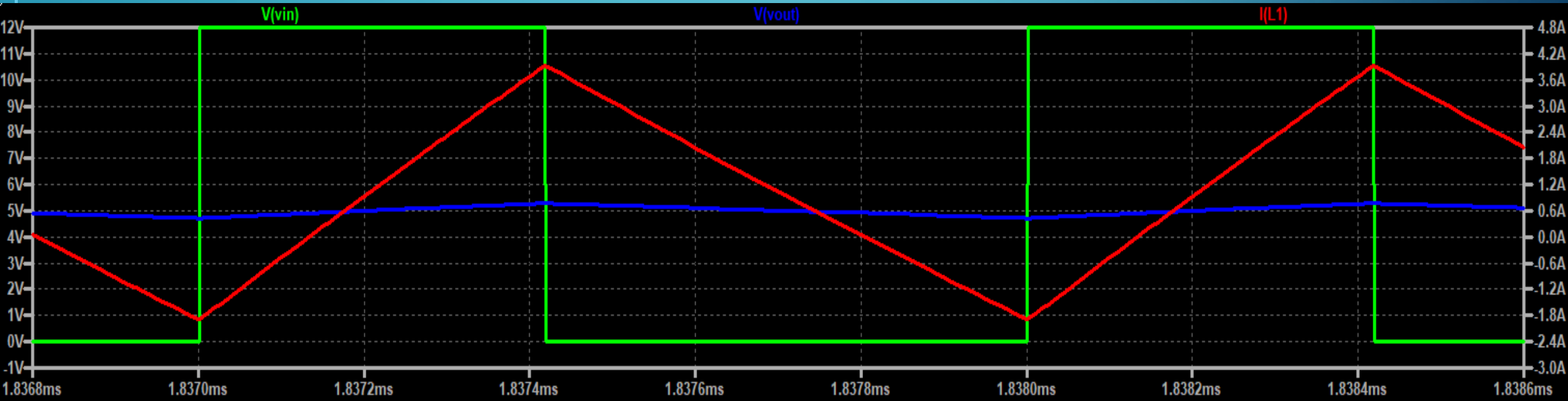
- Buck derived
- Boost power factor correction, followed by isolation
- Flyback inherently economical but limited to low power

BUCK


L1
vin
vout
V1
10µ
C1
R1
270µ
5
PULSE(0 12 1n 1n 1n 0.4566u 1u)
.tran 0 2m 0 .1u

BUCK CONTINUED

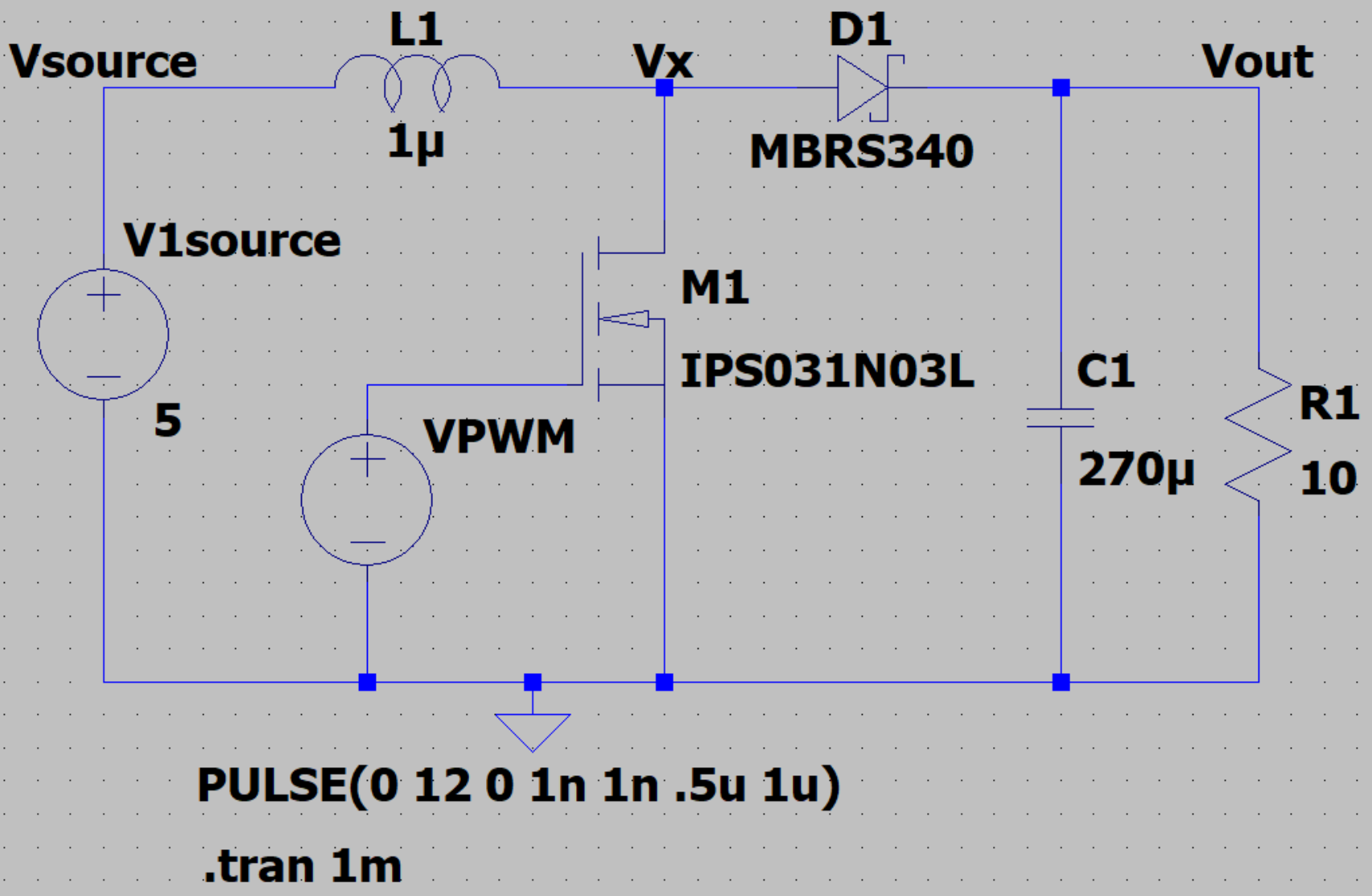




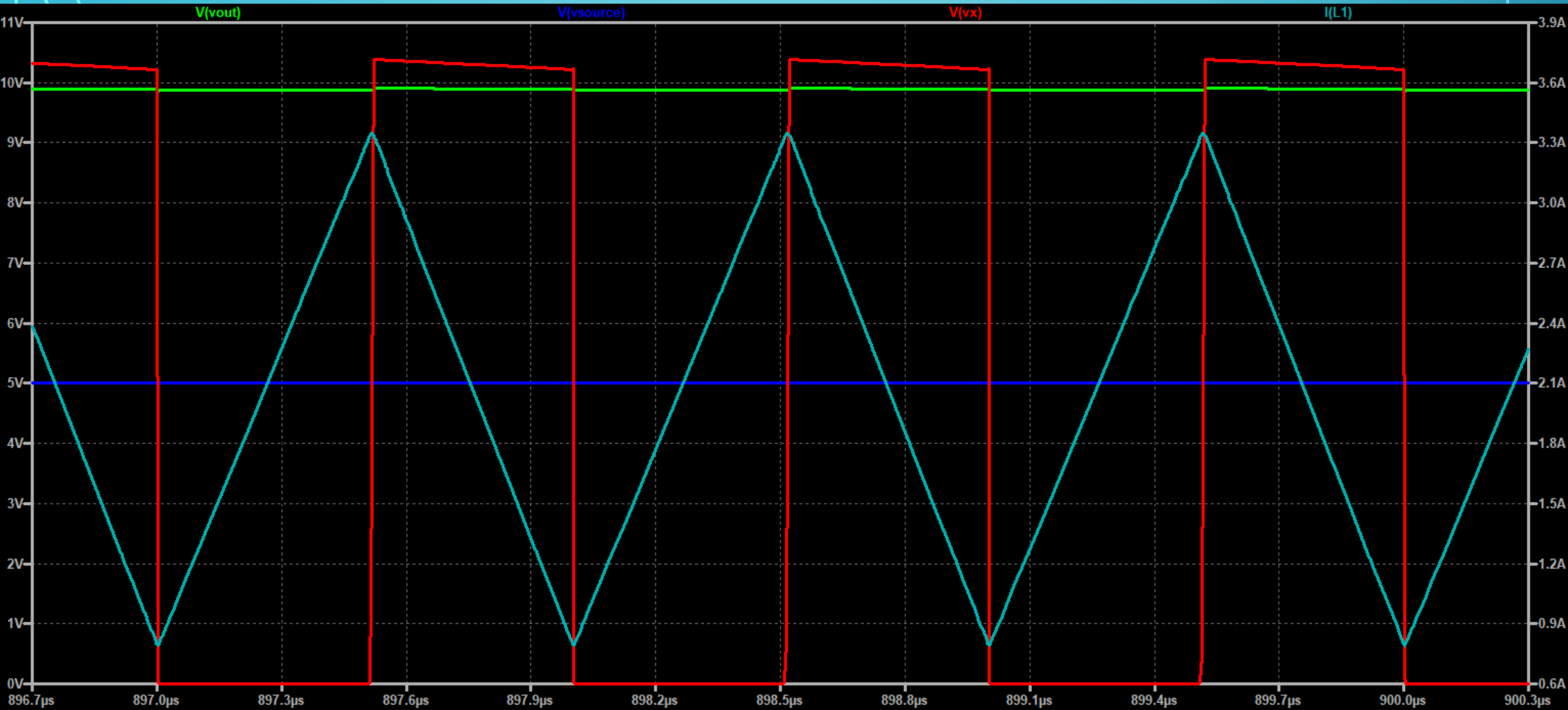
BOOST (AND POWER FACTOR CORRECTION)

- Usually preceded by a diode bridge without a large filter capacitor
- Input current is continuous
- Can only boost the instantaneous input voltage
- Imagine that the input current is controlled with a replica of the input voltage

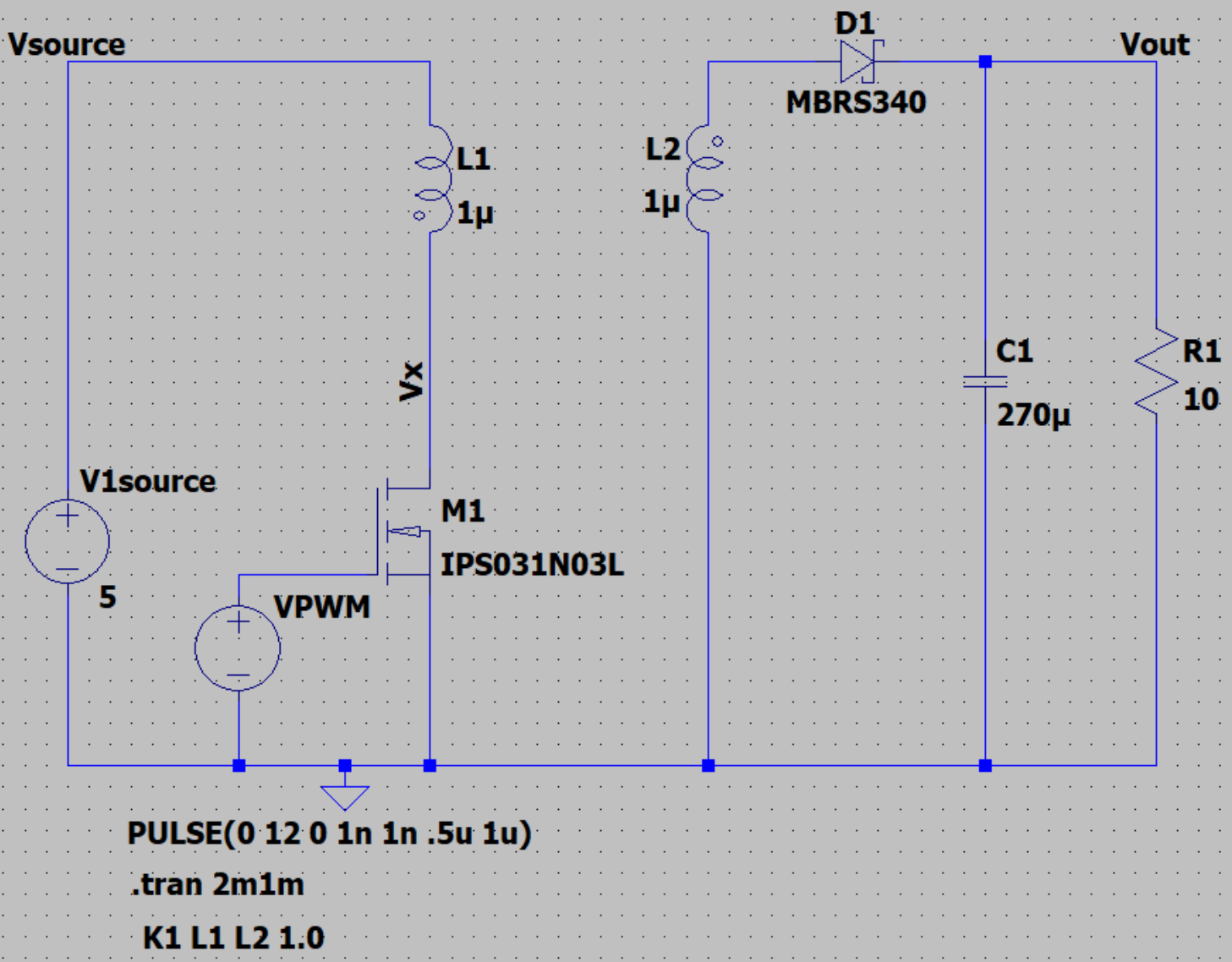
BOOST CONT.


Vsource
L1
1µ
Vx
D1
MBRS340
Vout
V1source
5
M1
IPS031N03L
VPWM
C1
270µ
R1
10
PULSE(0 12 0 1n 1n .5u 1u)
.tran 1m

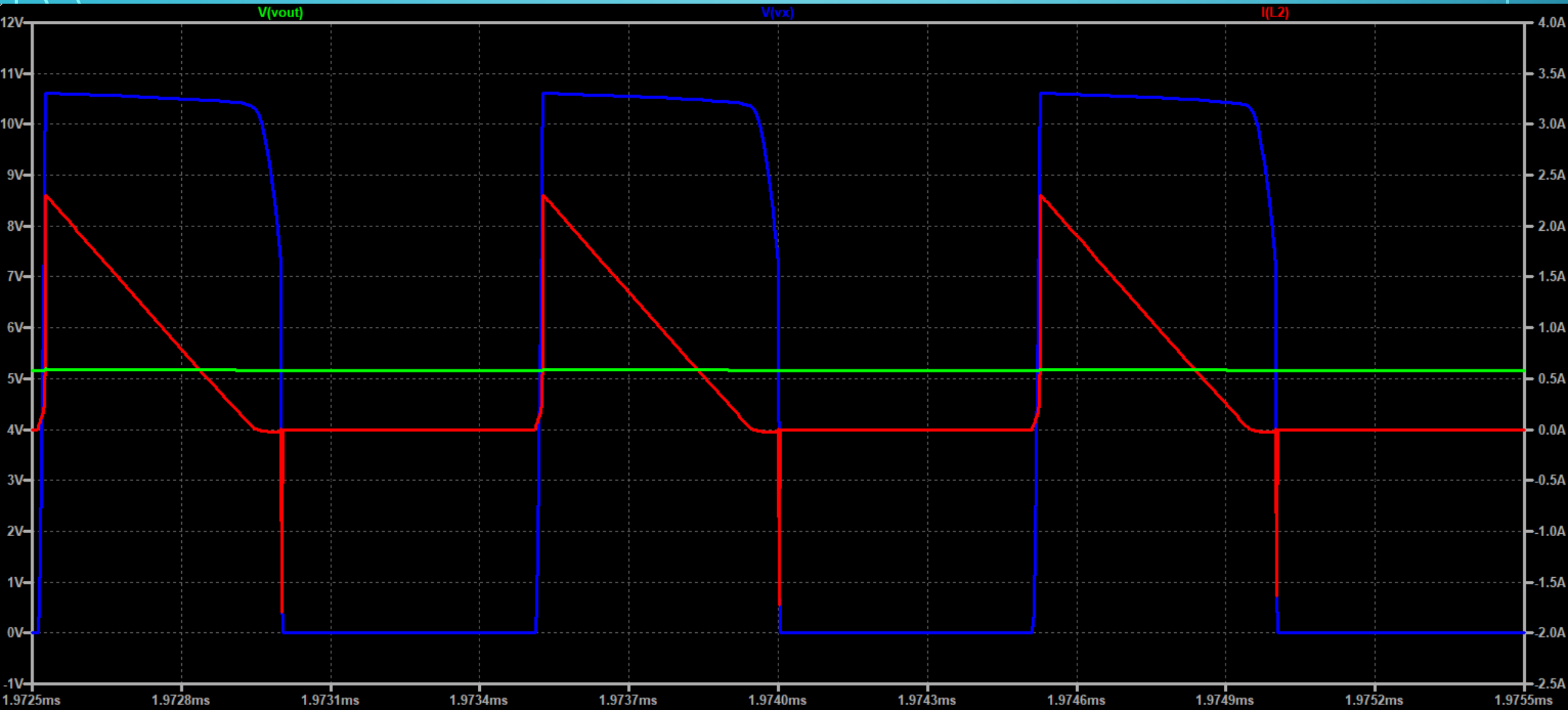
BOOST CONT.


V(vout)
V(vsource)
V(vx)
I(L1)
11V
10V
9V
8V
7V
6V
5V
4V
3V
2V
1V
0V
3.9A
3.6A
3.3A
3.0A
2.7A
2.4A
2.1A
1.8A
1.5A
1.2A
0.9A
0.6A
896.7µs
897.0µs
897.3µs
897.6µs
897.9µs
898.2µs
898.5µs
898.8µs
899.1µs
899.4µs
899.7µs
900.0µs
900.3µs

FLYBACK

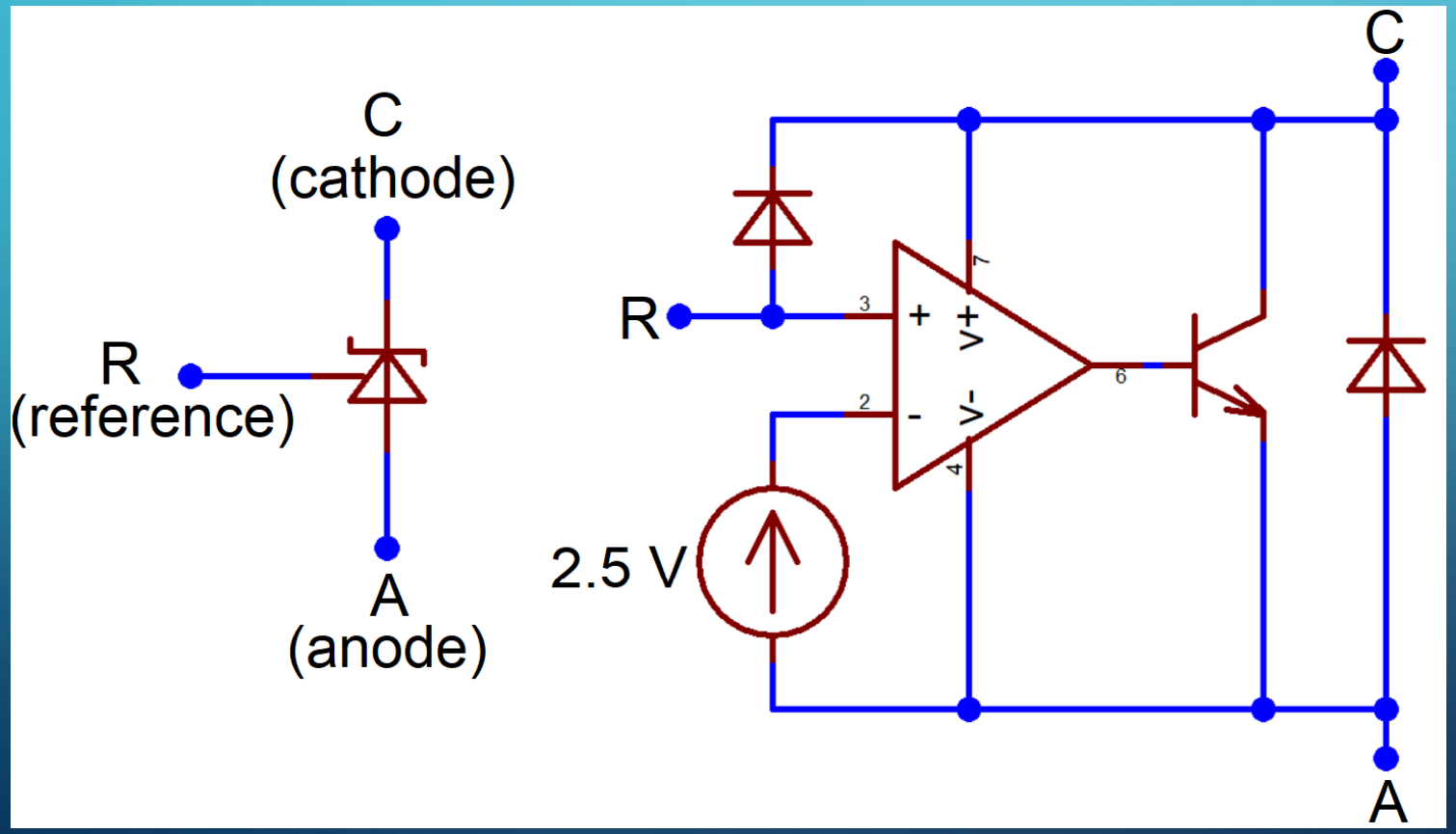

Vsource
L1
1µ
D1
MBRS340
Vout
L2
1µ
Vx
C1
270µ
R1
10
V1source
5
M1
IPS031N03L
VPWM
PULSE(0 12 0 1n 1n .5u 1u)
.tran 2m1m
K1 L1 L2 1.0

FLYBACK


V(vout)
V(vx)
I(L2)
12V
11V
10V
9V
8V
7V
6V
5V
4V
3V
2V
1V
0V
-1V
4.0A
3.5A
3.0A
2.5A
2.0A
1.5A
1.0A
0.5A
0.0A
-0.5A
-1.0A
-1.5A
-2.0A
-2.5A
1.9725ms
1.9728ms
1.9731ms
1.9734ms
1.9737ms
1.9740ms
1.9743ms
1.9746ms
1.9749ms
1.9752ms
1.9755ms

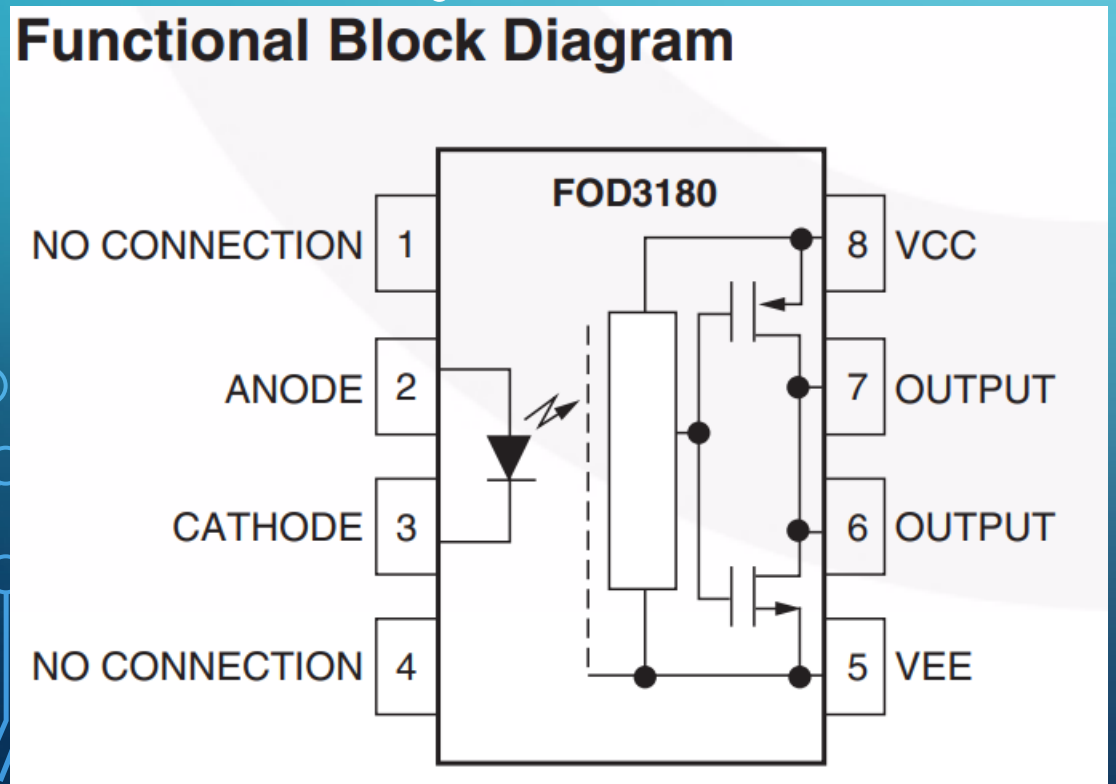
VOLTAGE REFERENCES

- Usually located on the output side of the isolation boundary
- Need to be stable over line, load, temperature, and ageing (TL431)

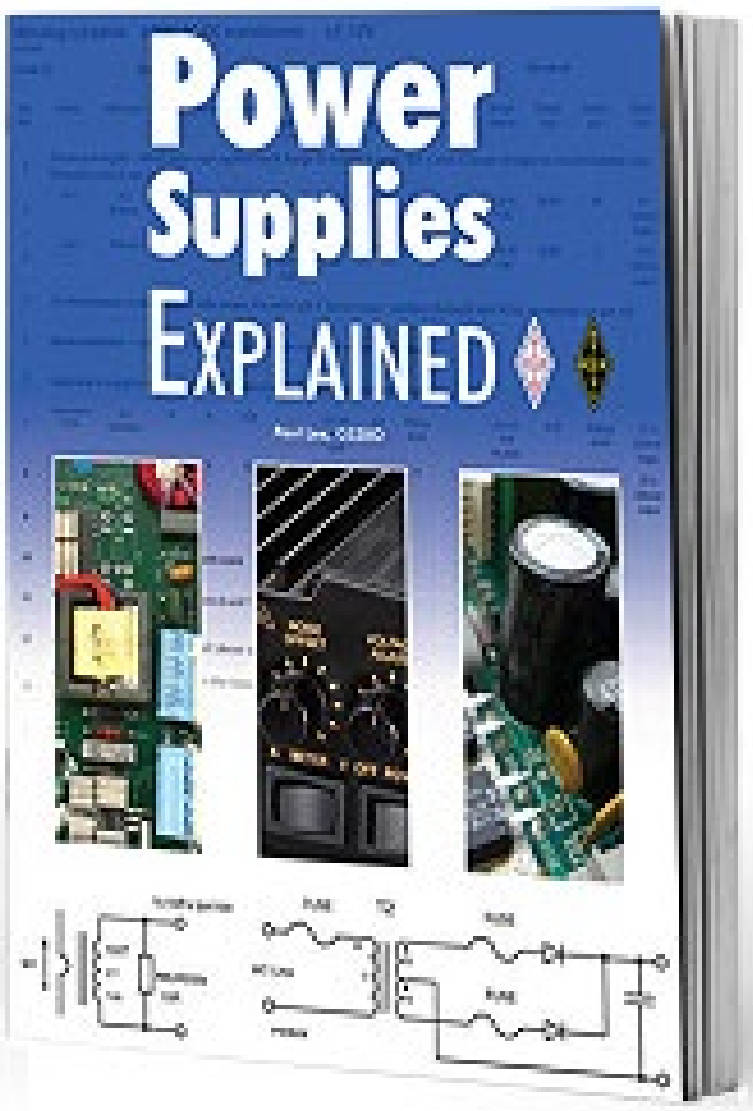


OPTICAL COUPLERS

- These contain an LED on their input and a transistor on their output
- Light from the LED input shines on the base of the output transistor
  - Light shining on the base of the output transistor knocks electrons loose in the junction and is analogous to base current



ARRL “POWER SUPPLIES EXPLAINED”



POWER SUPPLIES EXPLAINED (RSGB)

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