Switching Mode Power Supplies

By Shannon Strutz

Embedded Systems

-Any system that has a dedicated function.

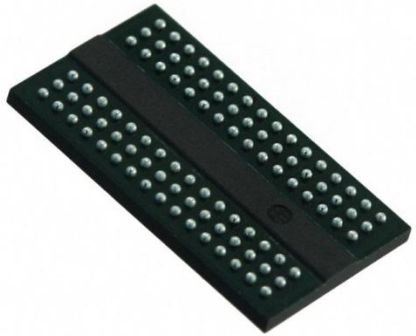
-Can be a part of a larger system

-Usually is made for a specific purpose unlike a PC

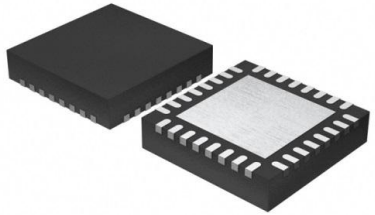
-Range from very simple, such as Cell Phones, up to very complex, such as a stealth fighters missile defense system.

Various Power Requirements

- CPU/FPGA Cores: ~1.0V / >8A
- On-board RAM (memory) ~1.35V / >4A
- I/O Logic ~3.3V
- USB peripherals 5V / >1A
- PLL (Phase-locked loop) ~2.5V / <1A



Intro to Power Supply



- Two kinds:
  - Linear Regulator such as an LDO (Low Dropout Regulator)
  - Switching Regulator, abbreviated SMPS (Switching Mode Power Supply)

- Type and amount vary by application

- Linear Regulators are quite inefficient, typically 30-40%
  Switching Mode can currently get up to 98% efficiency
  $(\text{Efficiency} = \frac{Power_{in}}{Power_{out}})$

Comparison

Linear:

1. Generally very small
2. Can require fewer than four components
3. Very straight forward and simple
4. Very inefficient

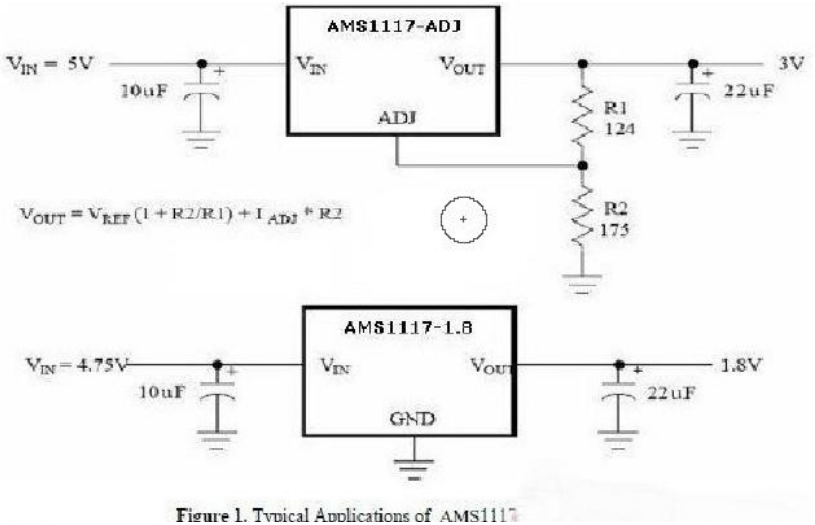
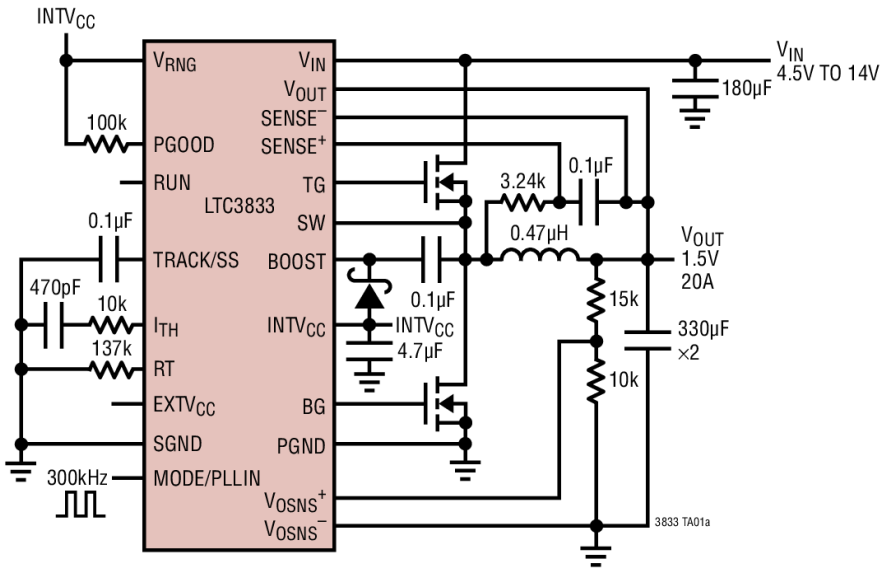


Figure 1. Typical Applications of AMS1117

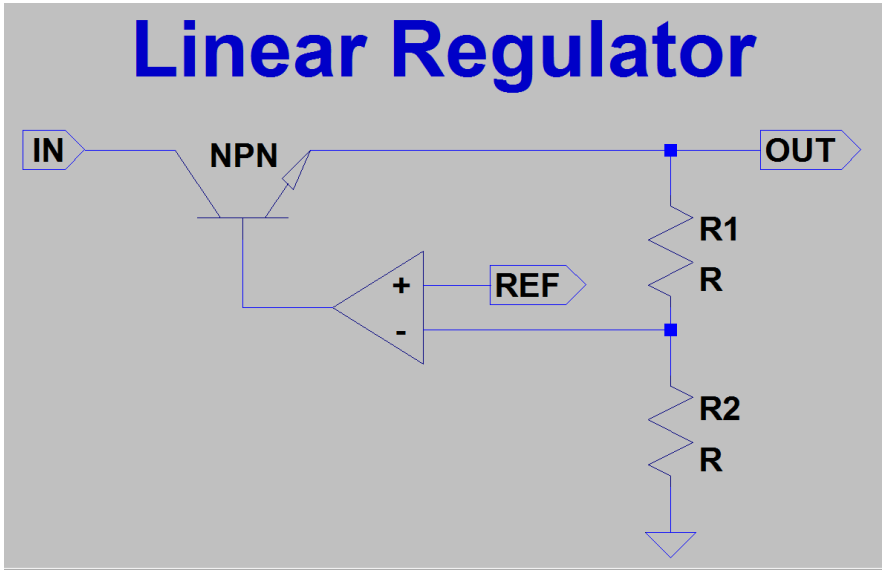
Switching:

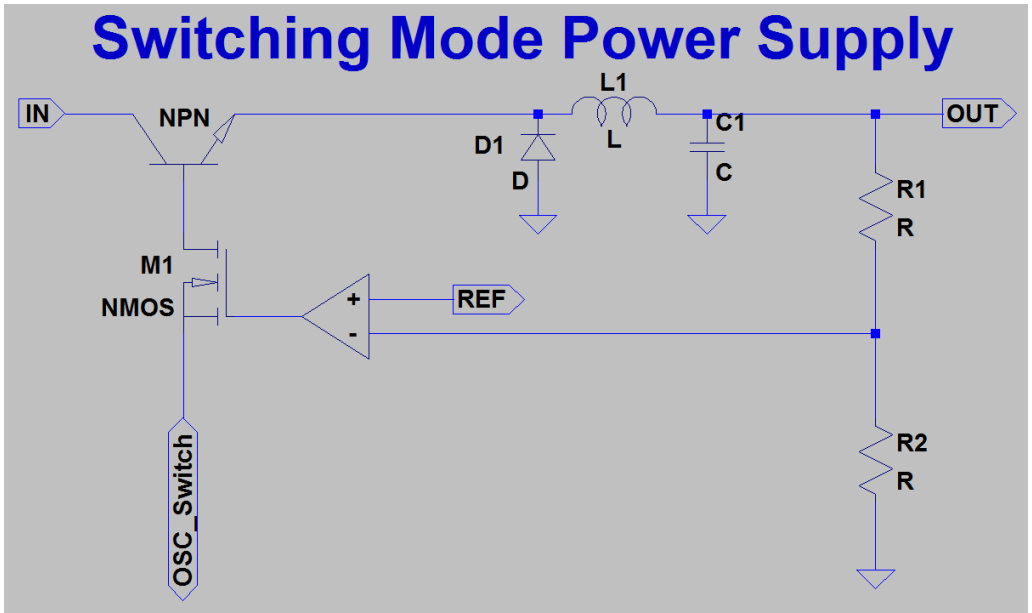
1. Sizes vary by complexity, generally around 32-QFN
2. Require many external components
3. Much more complex
4. Extremely efficient when designed properly



Internals

- Both have NPN series transistor, op-amp with reference voltage, and sampling resistor divider.
- Some linear regulators will have the resistors outside the supply
- Basically all switching supplies have the resistors external



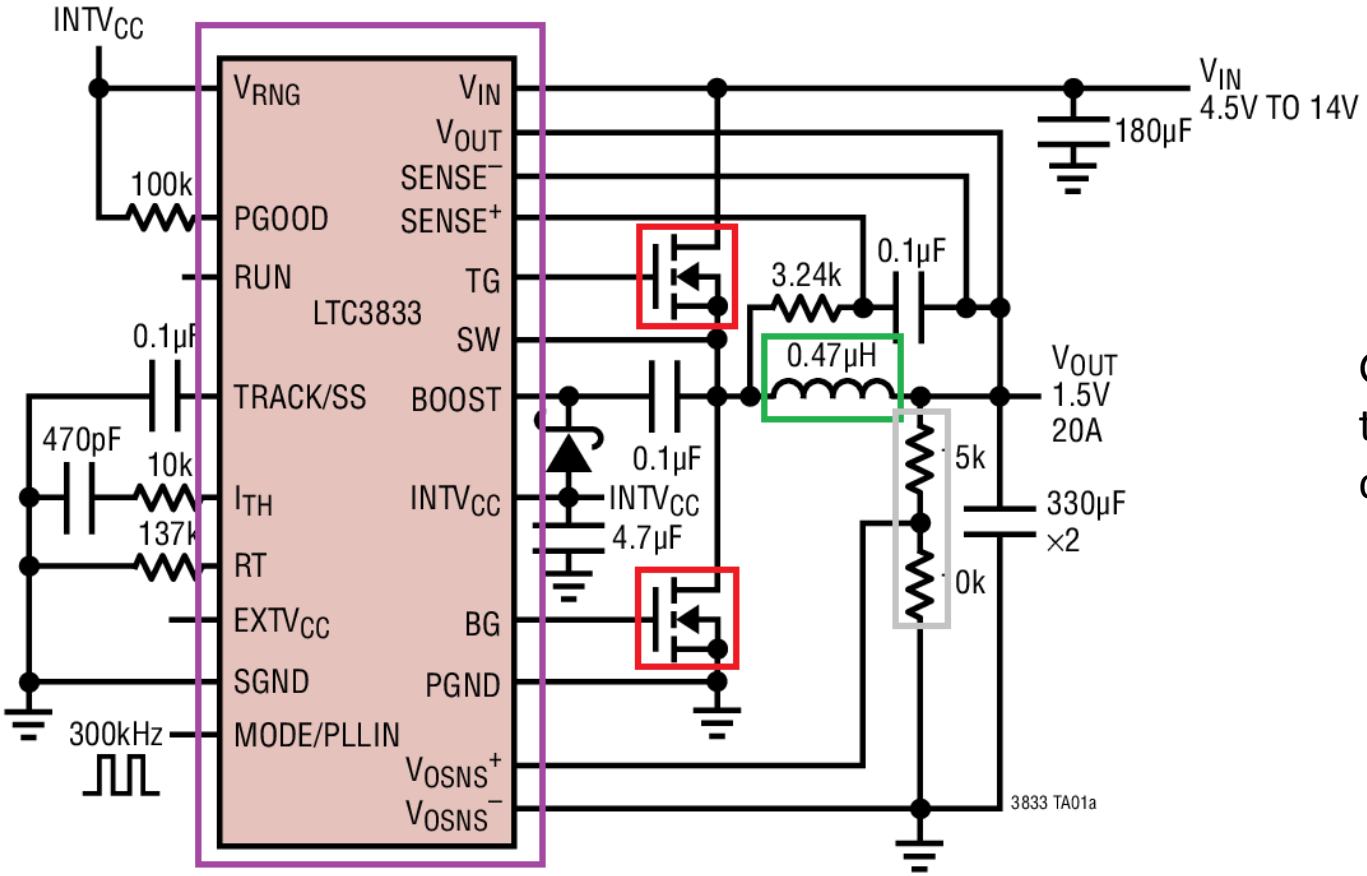


Types of SMPS

- Buck – Higher voltage to target lower voltage
  The most common type of switching P.S.
- Boost – Lower voltage to target higher voltage
- Buck-Boost – Higher or lower to a target voltage
- Split-π – Boost followed by buck
- SEPIC – Anything to a target voltage

Main SMPS Components

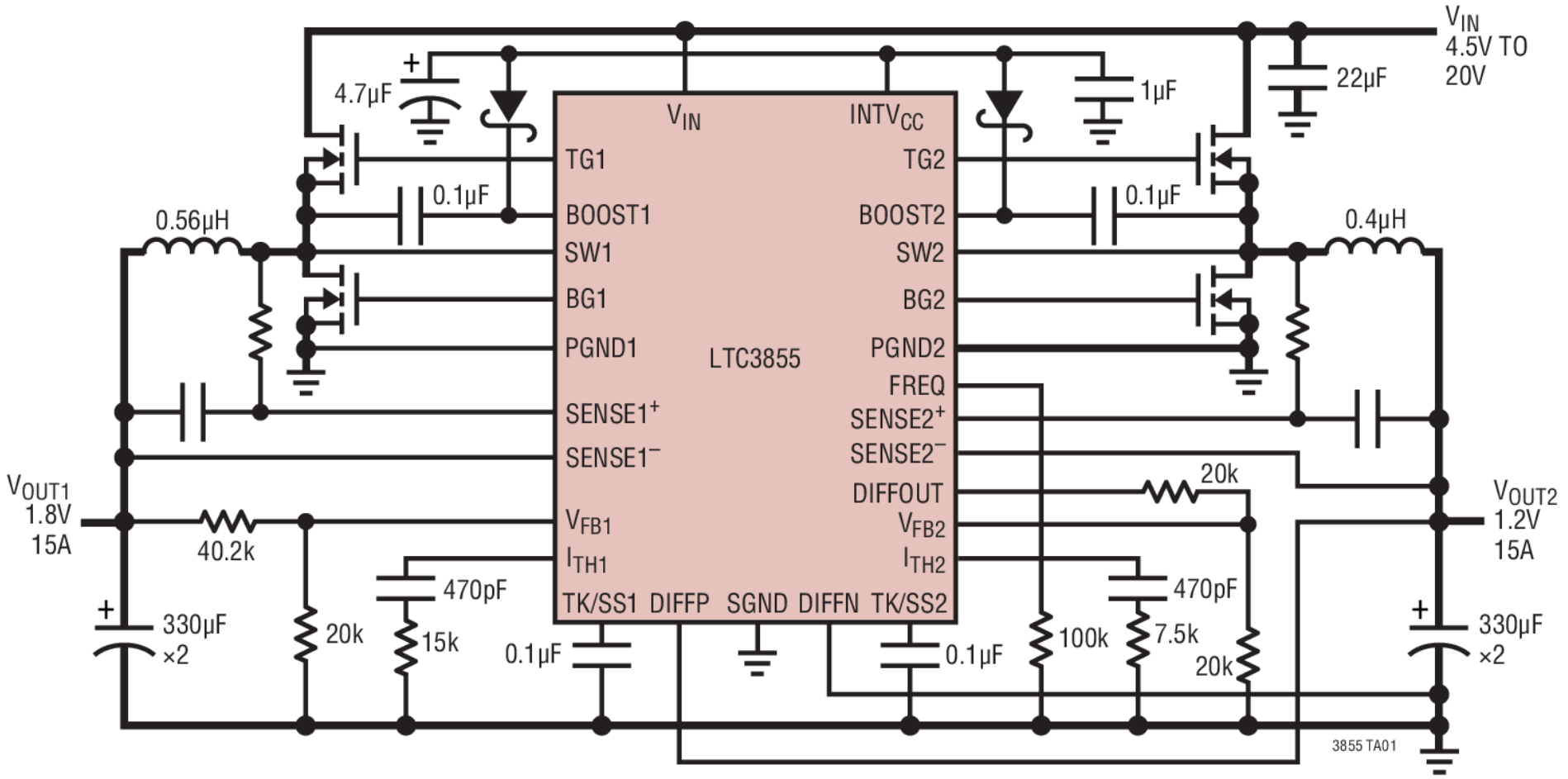
- Controller
- Top MOSFET
- Bottom MOSFET / Diode
- Output Inductor
- Feedback Resistors
- Output Capacitors



Generally referred to as “Power Stage” components

Higher Current SMPS Controllers

- Make use of multiple phases to achieve current output



Challenges

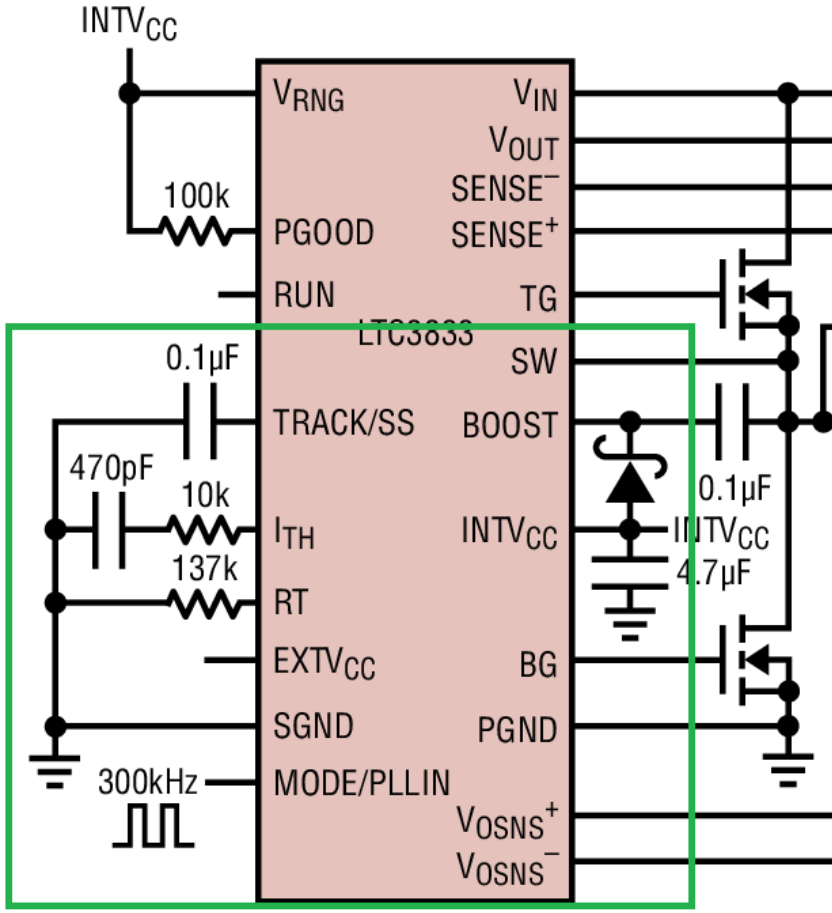
•Proper small-signal components

•Adjusting components to real-world environments from ideal environments.

•Cooling of the power-stage components

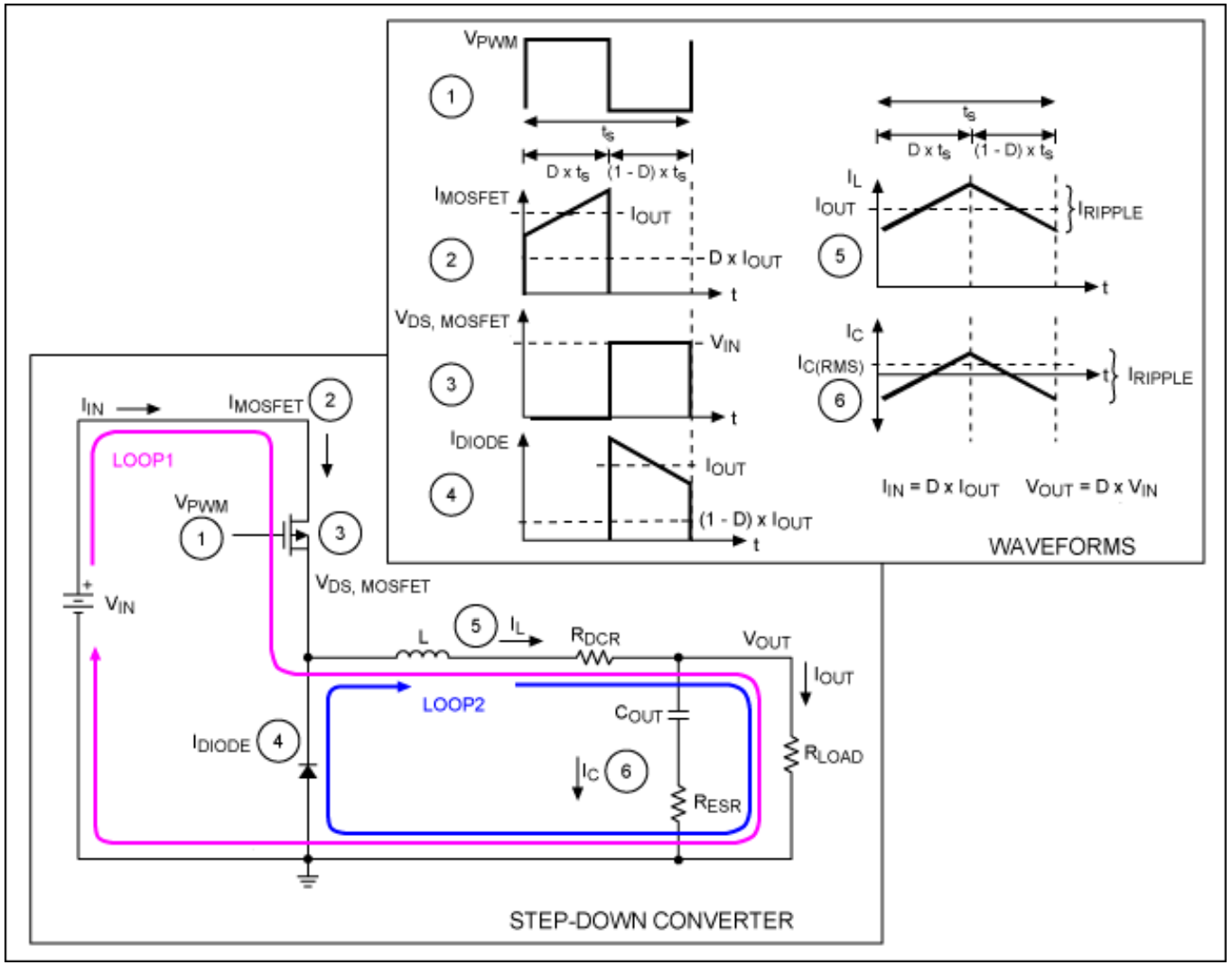
•Finding proper components for the different parts of the supply

•Maintaining Overall Stability



These challenges are overcome by a combination of methods such as:
•Proper simulation (LTspice, iSimPE)
•De-rating of components for head-room
•Proper testing of previously design power supplies

SMPS theory of operation

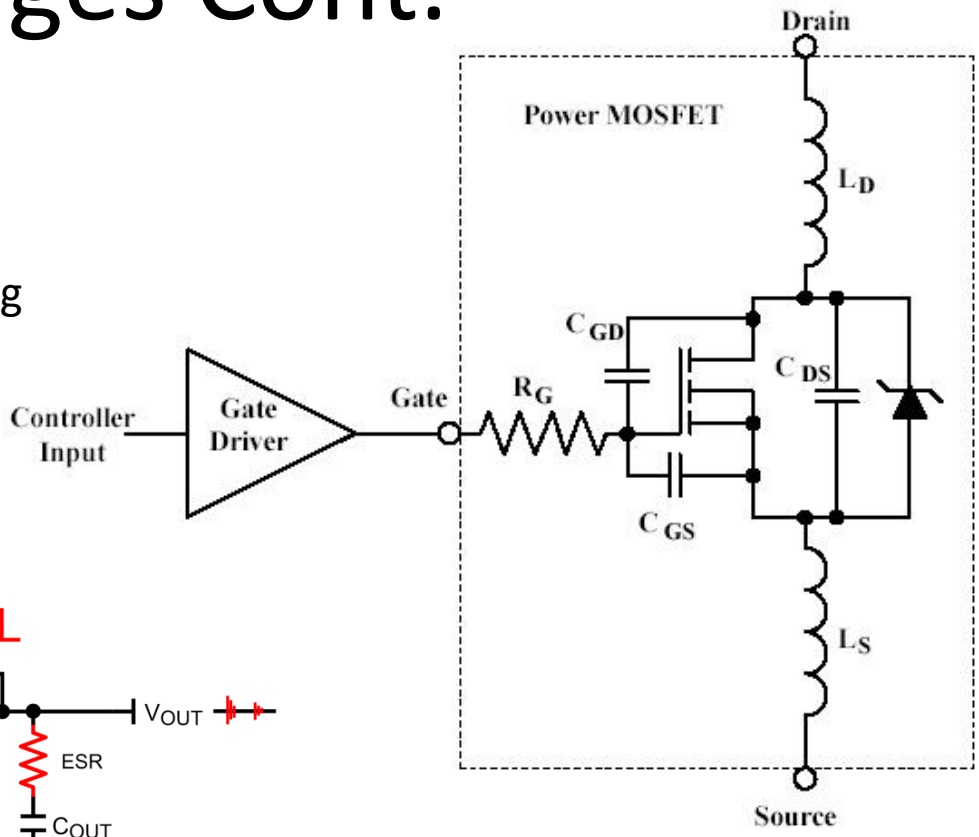


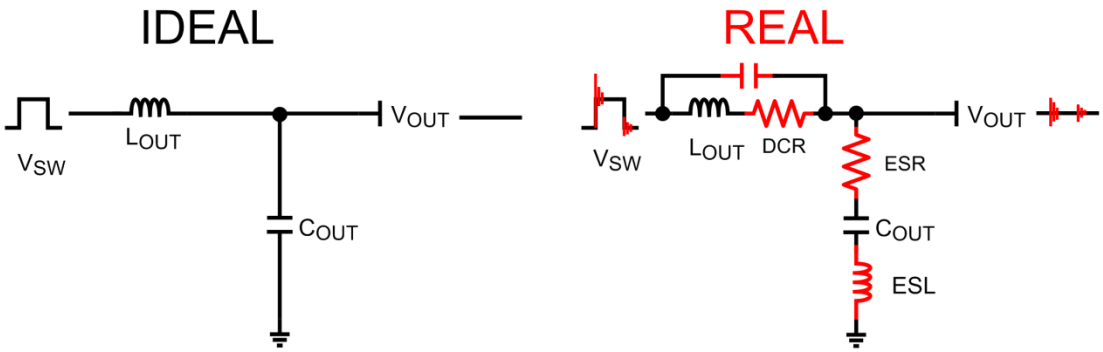
Challenges Cont.

- Playing the “Efficiency Game”

  Parasitics play a large role in designing power supplies.

  Generally parasitics are a problem, but can also be beneficial.





Different kinds of controllers

- **Poly-phase** – Basically the controller is daisychain-able and will communicate with more of the same IC
- **VID Controlled** – Regulates the voltage to what is designated at simple digital input/output pins
- **Multi-phase** – Has multiple parallel power-stage circuits to achieve higher output current
- **Multi-output** – Can regulate two separate output lines at different voltages as if they were separate