



DC-DC Fundamentals

1.1 An Introduction

What is DC-DC converters?



**Power supply is needed everywhere
Almost all electronic systems need
constant voltage supply**



A DC-DC converter is the circuit to provide the DC power

industrial supply
solar cell
another converter
battery

Sources

DC-DC power
converters

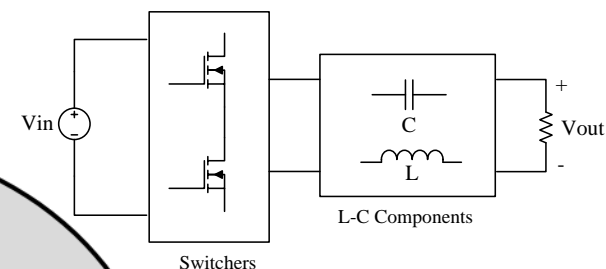
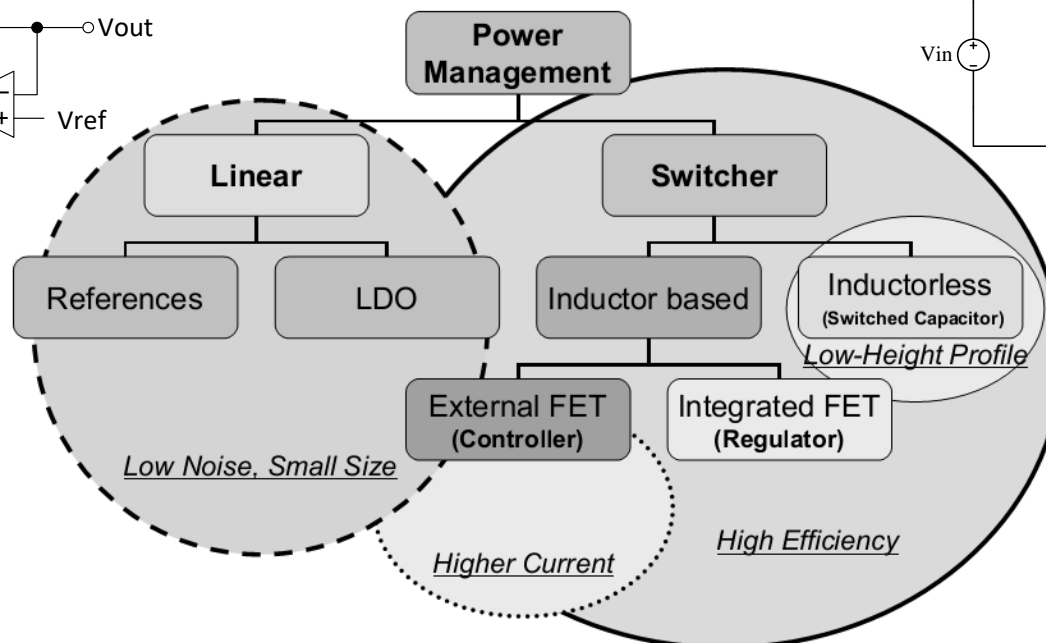
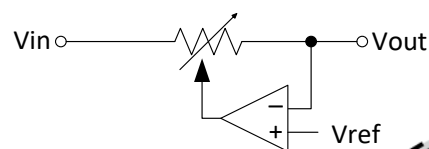
data converter
amplifier
microprocessor
resistor
another converter

Loads



Types of Converters

- Linear Type
 - The power delivery is continuous from source to load
 - The pass elements (which regulate the current flow from source to load) operate in the linear region
- Switcher Type
 - The power delivery is in bursts from source to load
 - The pass elements switch on and off by cycles



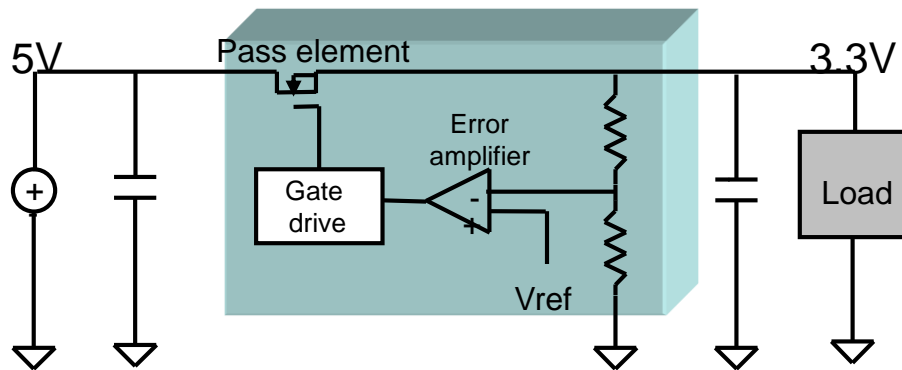


Converters Characteristics

- System requirements: output voltage, current rating, input voltage range
- Efficiency
- Steady state operation
- Transient response
- Size, Cost, ...



Linear Regulator



Applications

- Radio frequency or precise analog (measuring very small voltages) circuits that require extremely low ripple & noise
- Applications where $V_{IN} - V_{OUT}$ is very small.
- Applications that require a precisely regulated.
- FPGA or Multi-Core processors that require fast transient response due to fast changes in the load.

Advantages

- Low O/P ripple & noise
- Fast transient response at V_{OUT} on large changes of the Load
- Low cost (for low power, at least)
- Few external components make the linear regulator easy to design
- Since linear regulators don't switch current into an inductor there is no EMI to worry about
- Easy to implement short circuit protection

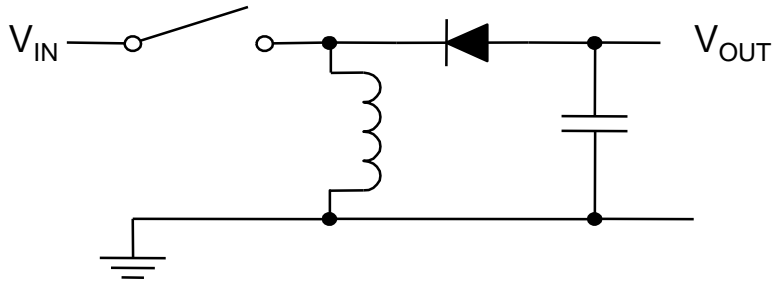
Disadvantages

- Low efficiency at $V_{IN} \gg V_{OUT}$ which requires a larger supply power source
- Power generated from the regulator ($V_{IN} - V_{OUT}$) * I_{OUT} is dissipated through the Regulator typically requiring a heat-sink
- V_{OUT} will always be less than V_{IN}

Inductive Switcher



Buck-Boost



Advantages

- Since regulation is done by dumping energy into and out of an inductor versus burning power through the regulator
 - Higher efficiencies can be obtained
 - Lower power dissipates through the regulator requiring a smaller heat sink.
 - Topologies of the switching power supply allow $V_{OUT} \gg \ll V_{IN}$
 - High Power Density (Watt/cm²)
 - Allows wider input voltage range
- Isolation possible (with transformer)
- Multiple O/Ps possible (with transformer)

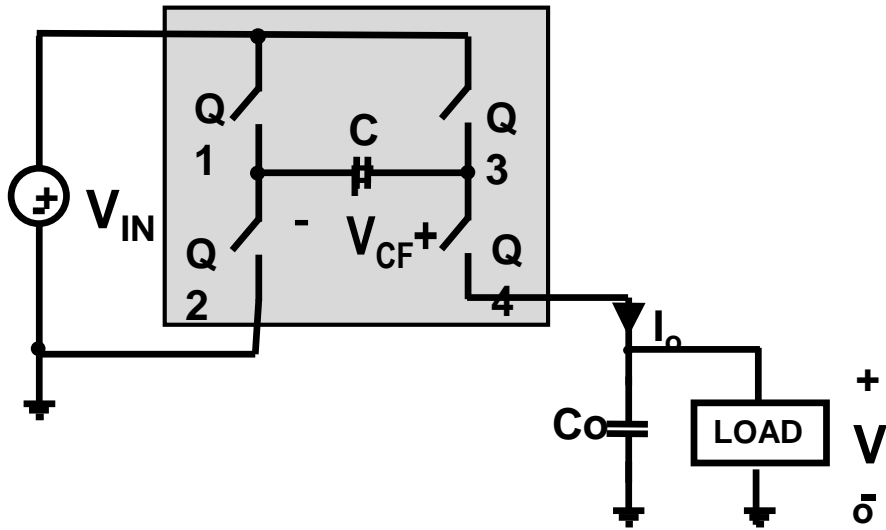
Applications

- Applications where high efficiency ($Power_{IN} - Power_{OUT}$ is very small)
- Applications with extremely high ambient temperatures such as Industrial or Automotive
- Applications where V_{IN} is much larger than V_{OUT}
- Applications where the power supply has space constraints (small area)
- Applications requiring High output power

Disadvantages

- Switching current into and out of an inductor:
 - Generates Electromagnetic Interference (EMI)
 - Causes the output to respond slower to transients in load
 - Produces higher output ripple & noise
- More external components and design variables make switching power supplies difficult to design

Charge Pump



Applications

- Applications requiring a low output current
- Applications with moderate input to output voltage difference
- Applications that have space constraints

Advantages

- Moderate Efficiency
- Since charge pumps switch voltages across capacitors in and out of the output:
 - No inductor is needed
 - $V_{OUT} \geq V_{IN}$
- Fewer components make the charge pump easier to design

Disadvantages

- Switching of the capacitor in and out of the circuit generates EMI
- Since the output of the charge pump is dependent on the charging and discharging of a capacitor, it has limited current capability

Converter Comparison



The choice of converter type depends on the power design priorities.

	Linear Regulator	Switching Regulator	
		Inductive	Charge Pump
Efficiency	20-60%	90-95%	75-90%
Ripple	Very low	Low	Moderate
EMI Noise	Very low	Moderate	Low
PCB Area	Very small	Largest	Medium
Cost	Lowest	Highest	Medium



Summary

- Types of DC-DC converter
- Basic characteristics of a converter
- Converter comparison



Thank you!