Sharif University of Technology

DC/DC Converters

Mehdi Ghasemzadeh

Spring 2021

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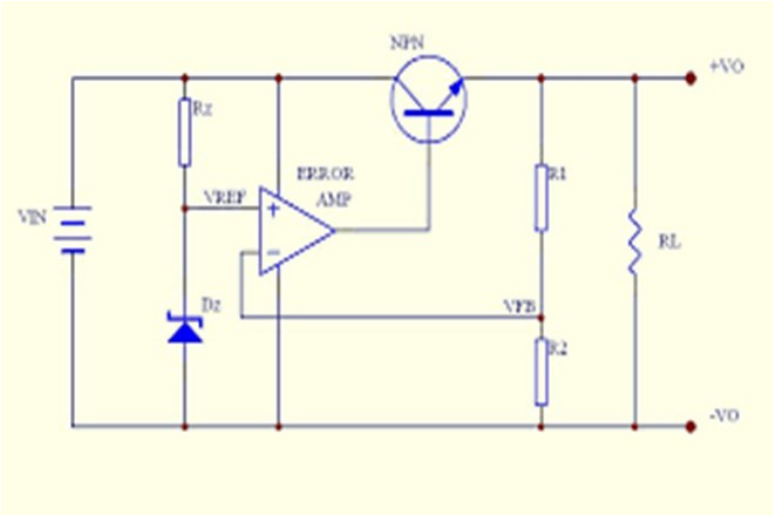
Introduction

Linear regulators : Linear regulators use linear, non-switching techniques to regulate the voltage output from the power supply. The regulator's resistance varies according to the load and results in a constant output voltage.



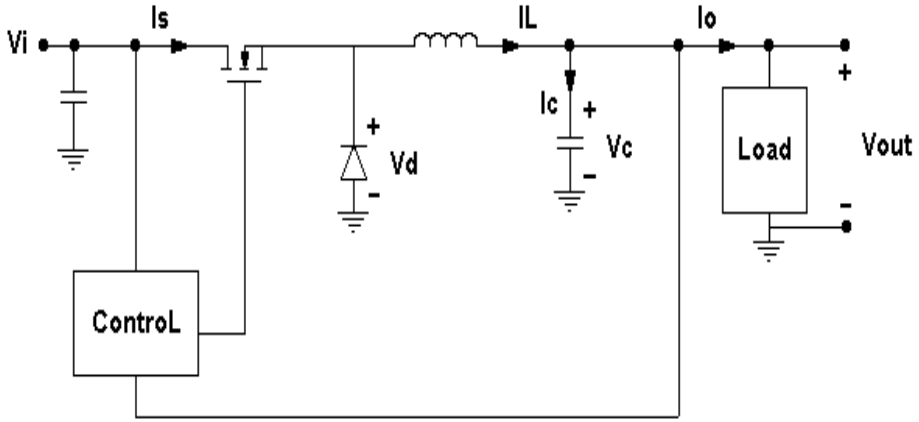
Advantages	Disadvantages
✓ Simplicity of design	✓ Low efficiency if input-output difference is large
✓ Lower parts count	✓ Low efficiency = significant heat dissipation
✓ Space savings (unless a heat sink is used)	✓ May require a heat sink
✓ Low noise	✓ Capable exclusively of step-down operations
✓ Fast transient response	
✓ Low cost	

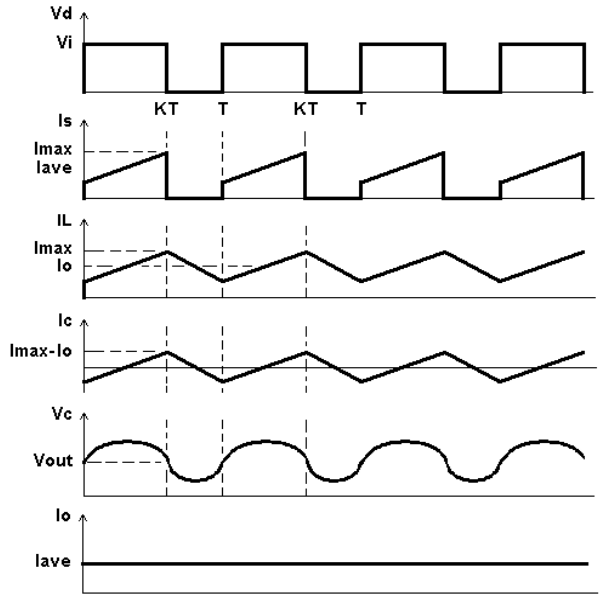
Switching regulators : Switching regulators convert one voltage to another by temporarily storing energy and then releasing that stored energy to the output at a different voltage.

Switching Regulators

Buck converter

- Output voltage always lower than input voltage
- Filter capacitor is very large to ensure constant output voltage
- Non-isolated



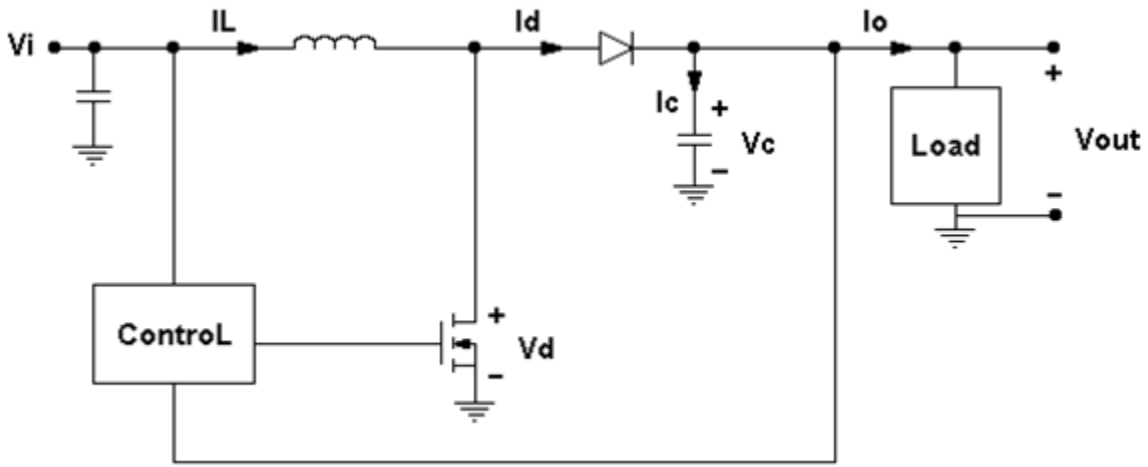


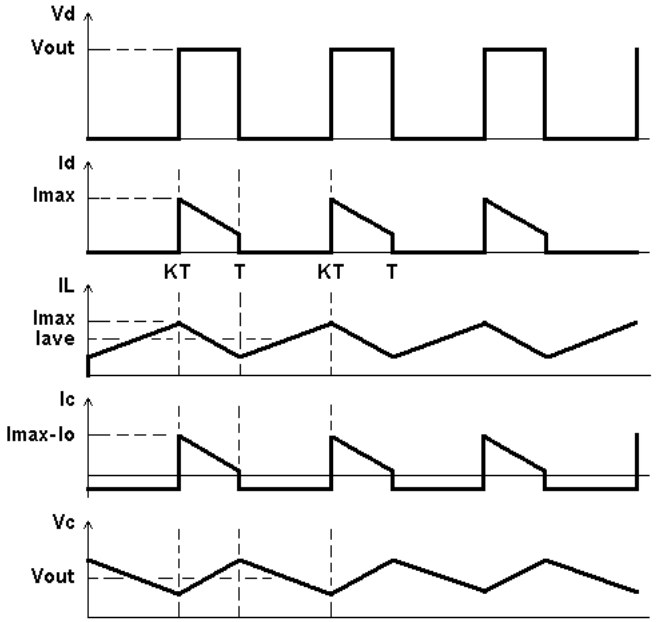
$$Vout = D \times Vin$$

Switching Regulators

Boost converter

- Output voltage always higher than input voltage
- Filter capacitor is very large to ensure constant output voltage
- Non-isolated





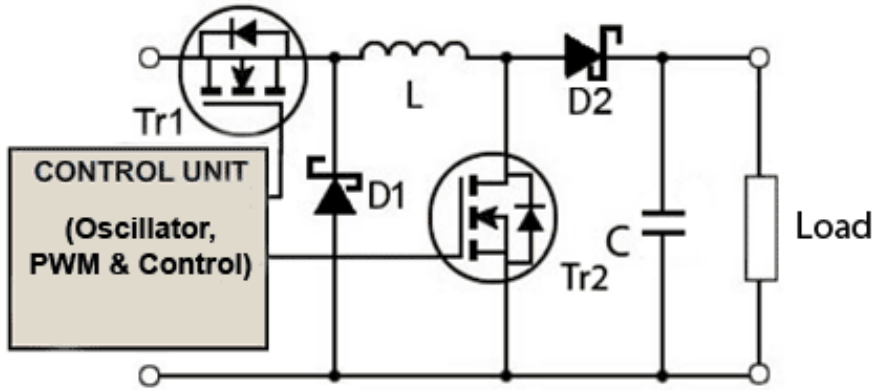
$$V_l = L \times \frac{di}{dt} = L \times \frac{\Delta i}{\Delta t}$$

$$Vout = \frac{1}{1-D} \times Vin$$

Switching Regulators

Buck – Boost converter

- Output voltage can be either higher or lower than the input voltage
- Non-isolated



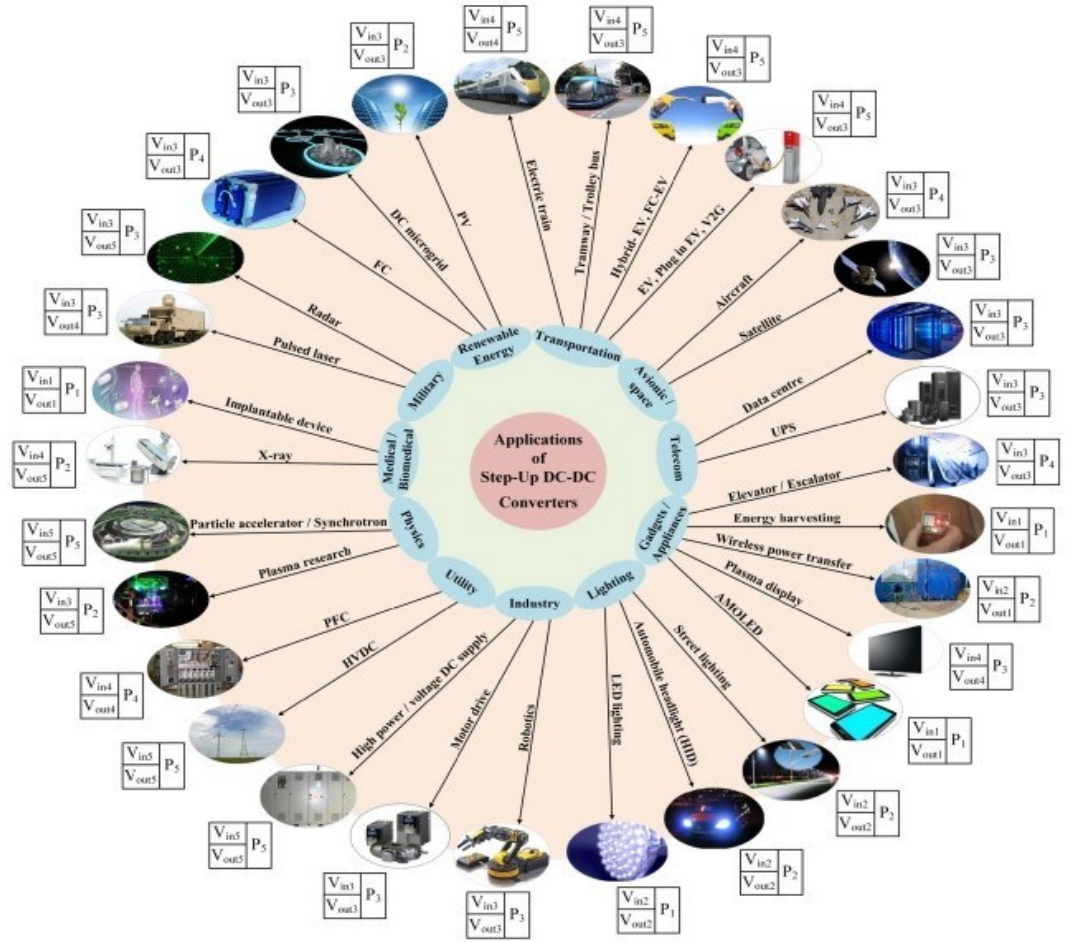
Advantages

- ✓ Capable of Boost, Buck, Inverting and Buck/Boost
- ✓ High efficiency
- ✓ Low thermal dissipation
- ✓ Can handle a large output current

Disadvantages

- ✓ Complicated design
- ✓ High parts count
- ✓ Switching noise and ripple exist
- ✓ Cost factor

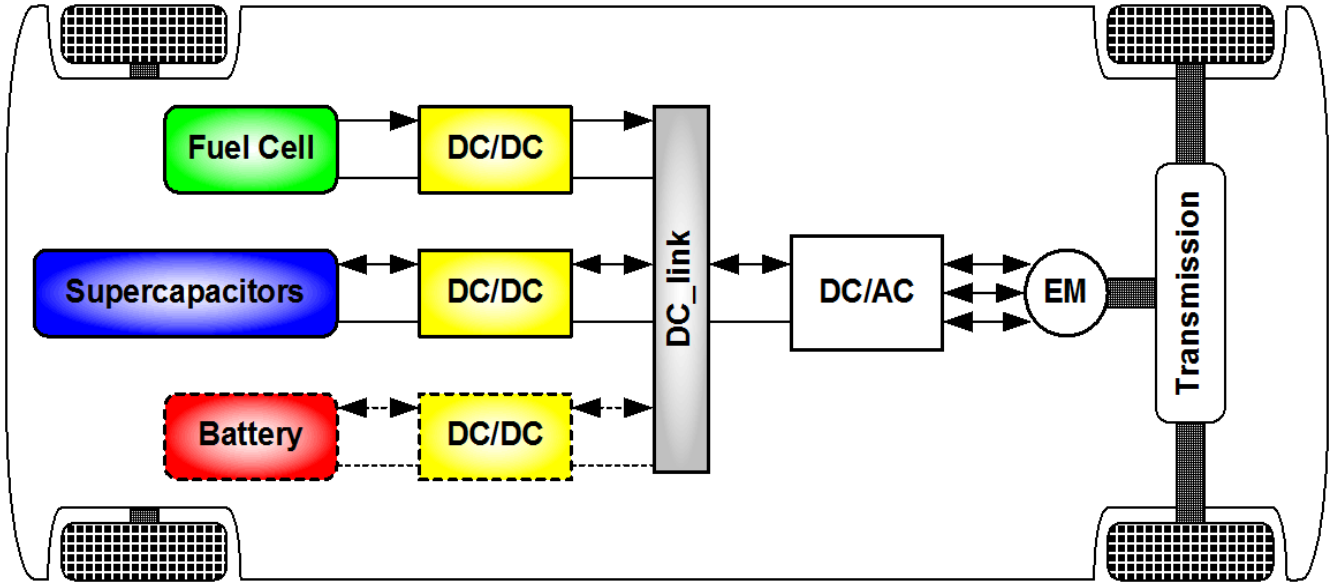
Applications of DC/DC converters



	V_{in1}	V_{in2}	V_{in3}	V_{in4}	V_{in5}		V_{out1}	V_{out2}	V_{out3}	V_{out4}	V_{out5}		P_1	P_2	P_3	P_4	P_5
V_{in}	<5V	<20V	<200V	<600V	>600V	V_{out}	<20V	<100V	<750V	<2 kV	>2 kV	P	<10W	<200W	<1kW	<20kW	>20kW

DC/DC Converters for Electric Vehicles

a comparative study on three DC/DC converters topologies (Conventional step-up dc-dc converter, interleaved 4-channels step-up dc-dc converter with independent inductors and Full-Bridge step-up dc-dc converter) is carried out. The modeling and the control of each topology are presented. Simulations of 30KW DC/DC converter are carried out for each topology. This study takes into account the weight, volume, current and the efficiency of each converter topology.



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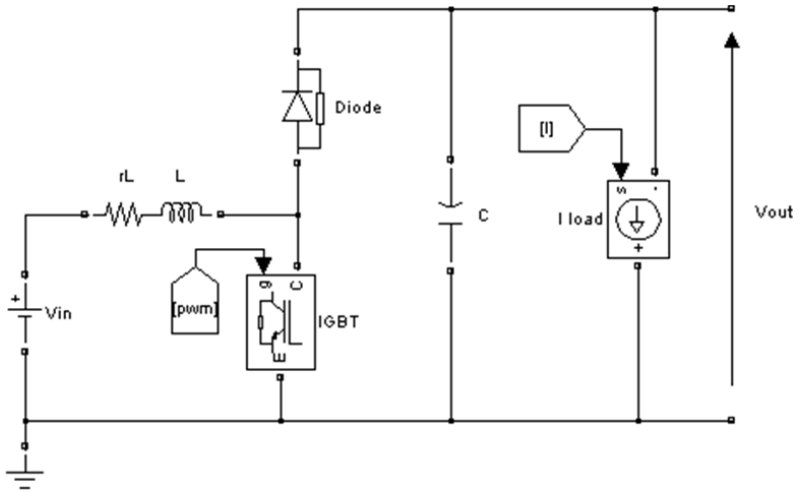
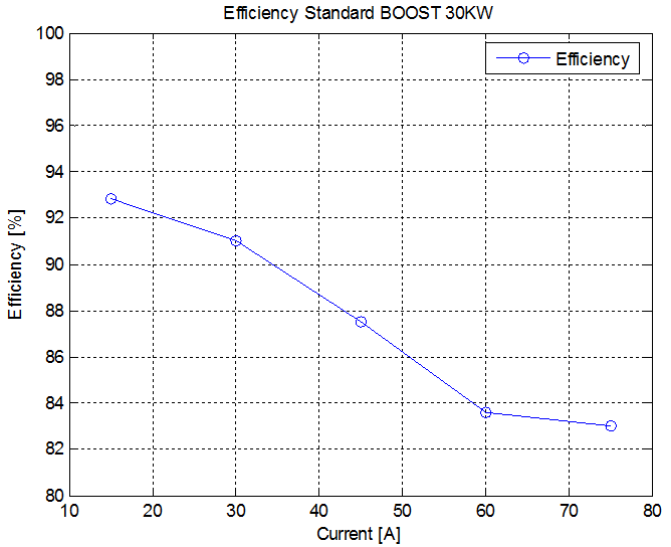
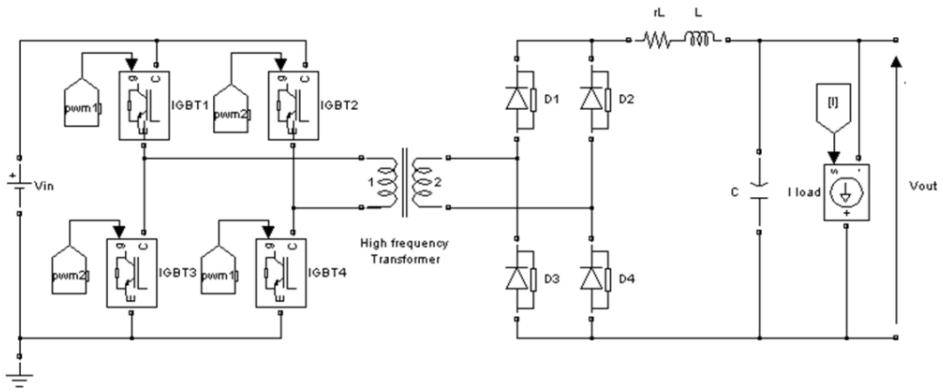
DC/DC Converters for Electric Vehicles

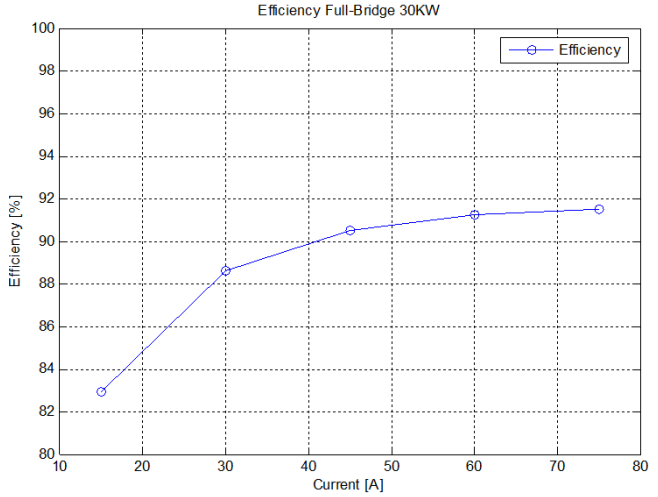
Boost DC/DC converter





Full-bridge DC/DC converter





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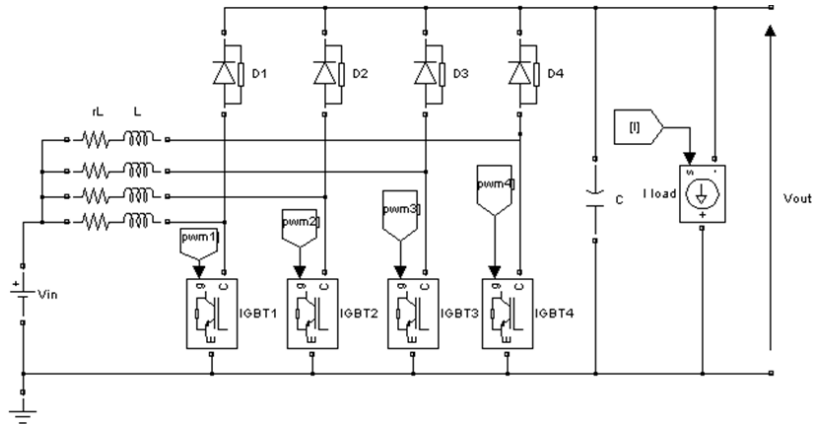
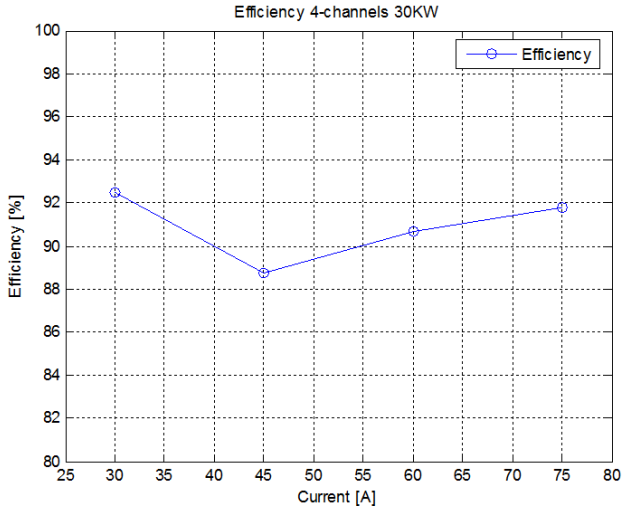
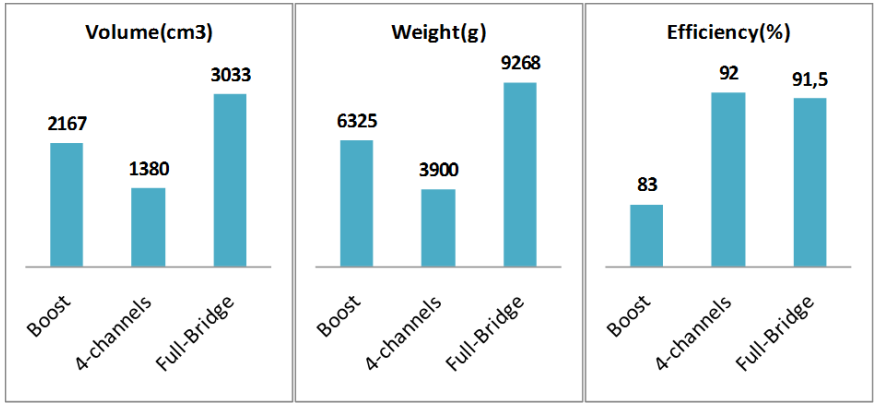
DC/DC Converters for Electric Vehicles

Interleaved 4-channel DC/DC converter





Results



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Conclusion

- When power efficiency is not a concern, or when the input voltage is only slightly higher than the output voltage, the best choice is usually a linear regulator. Linear regulators are typically cheaper, less complex, and require fewer components. If a really clean, ripple-free output voltage is required then a linear regulator is also the best choice.
- Some of the key requirements of today's power management solutions include less power consumption under various load conditions, less space, high reliability and wide input voltage. These requirements are driving the need for highly efficient, wide V_{IN}, low quiescent current (IQ) switching regulators in a broad range of applications.
- As with all aspects of engineering there are always trade-offs between various solutions. Many times the best solution is a switching regulator followed by a linear regulator. This way you get the best of both worlds: efficiency and a super clean output voltage.

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