DC to DC converters explained

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This article explains how a dc/dc converter works. These are the latest highly efficient regulators used in all modern electronics including everything battery powered

If you have any suggestions for improving this application note, please drop us a line at: enquiries@electronworks.co.uk

Introduction

In many applications in electronics the designer needs to convert one voltage to another. In a car, the battery voltage is typically 12V while most of the electronics runs at 5V or lower. A method of converting one voltage to another is needed.

Voltage Regulator Techniques

A simple way of converting from a higher voltage to a lower voltage is to 'throw away' the spare voltage in the form of heat. These devices are called linear regulators and represent a low cost method of regulating a voltage. However heat can cause damage to components, shorten their lifetime and is wasteful. To dissipate the heat, a heatsink is often needed which makes the circuit bulky. This is not too important in a car as there is lots of power available from the battery. However in a mobile phone where battery life equates to talk time, converting from a high voltage to a lower voltage in an efficient way is very important. This is where 'switched mode' power supplies are needed. A switched mode power supply (or dc to dc converter) uses a switch to regulate the voltage.

A device dissipates heat if it has current flowing through it at the same time as it has a voltage across it.

Consider a resistor of 1 Ohm with a voltage applied to it of 1 volt. It will develop a current through it of 1A (from V = I x R). The resistor will dissipate power (heat) according to:

$$P = IxV$$

Where P is the power (in Watts), I is the current in Amps and V is the voltage across it in Volts. In our case, the resistor will dissipate 1W of power (heat).

With a car battery, if you have a circuit requiring 5V with a current of 0.5A (like a car stereo or a satellite navigator) and you are powering this from the 12V battery, the voltage across the regulator is 7V and the current flowing through it is 0.5A, implying a heat dissipation of 3.5W. This is a lot of heat to get rid of and would normally be achieved by using a heat sink which is big and bulky and will get hot.

Now, consider the operation of a switch. When it is closed, a switch has a current flowing through it but with no voltage across it. When it is open it has a voltage across it, but with no current flowing through it. In both cases the product of (current x voltage) is zero, so the heat dissipation is zero. This is the basic principle of operation of a switched mode power supply.

Thus a circuit in FIG 1 can be considered.

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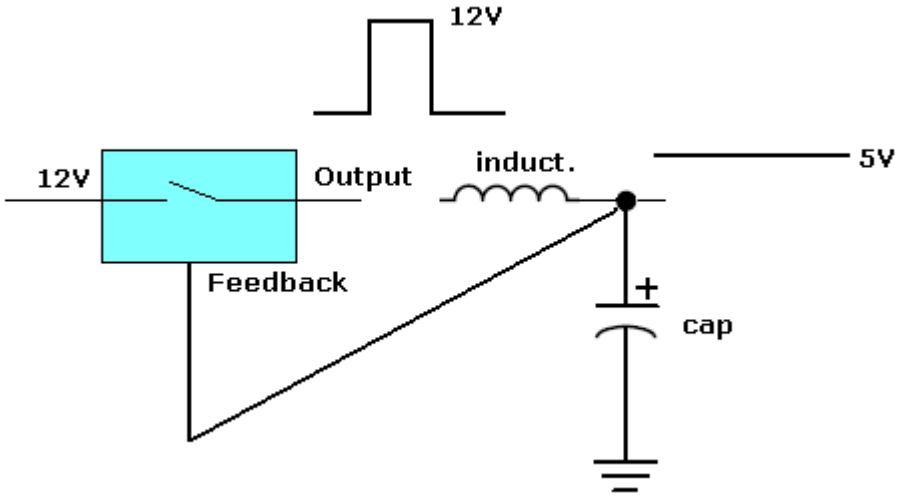

FIG 1

To smooth the current and voltage in a switched mode circuit, inductors and capacitors are used.

This is a standard 'step down' regulator that produces a lower output voltage from a higher input voltage.

When the switch closes, the input voltage is connected to the inductor. The current in the inductor ramps up thus storing energy. When the switch is opened, the energy in the inductor discharges into the capacitor and the capacitor charges up slightly. As this process is repeated, the capacitor charges more and more until the desired output voltage is reached. If the capacitor voltage is connected back to the component that controls the switch, the switch oscillation can be stopped, thus regulating the output voltage at any desired level (as long as it is less than the input).

With a circuit similar to that in if FIG 1, we can regulate the 12V to 5V with very little heat dissipation hence no heat sink and thus design a smaller, more efficient, more elegant circuit.

The following kit is very similar to the circuit above. It regulates a car battery voltage down to 2 preset levels (either 3.8V or 5V) to enable pretty much any portable electronics to be powered from a car battery

http://www.electronworks.co.uk/ck10.htm

For a more detailed insight to the operation of dc/dc converters, please see: 'More Detailed Operation of dc/dc Converters.'

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