

## 1 Basics

### 1.1 DC/DC voltage converters

A DC/DC converter (DC stands for Direct Current) converts an input DC voltage into a regulated or non-regulated DC output voltage which can be higher or lower, inverted or non-inverted and isolated or non-isolated.

DC/DC converters are added in the circuit where downstream electronic circuits/components require voltage levels that differ from the available voltage at the source.

For example, a 24 VDC truck battery cannot drive a radio or UHF transmitter in a car, as the voltage of 12 VDC is required in this case.

Today, DC/DC converters are part of almost all electronic products, such as phones, laptops, tablet computers, notebooks, routers, printers, TVs, lighting control devices etc.

For the developer, the specification and selection of a DC/DC converter is crucial prior to its use in order to ensure the correct operation of the product and to be sure that the final product does not constitute a hazard for the user.

Different applications call for different DC/DC converter requirements and therefore various converter topologies and controllers are necessary to cater the needs.

The basic function of a switching regulator can be described as “taking energy from the input source and passing it to the load, while maintaining the output voltage level appropriate for the load”. The input capacitor is charged up to the input voltage. An inductance is used as an energy storage element energy and to limit the current flow. The cycles are generated by an electronic switch which is periodically controlled with a square-wave signal. The ratio of the On and Off phases of the switch also determines the ratio of the input to the output voltage. The output voltage is present at the output capacitor and supplies the load. Depending on whether the inductance was implemented in the circuit (topology), the output voltage may be higher or lower than the input voltage.

Another simplified explanation of the function of a buck regulator is also applicable. An AC voltage is generated from the DC voltage at the input of a regulator by cycling. A filter (inductance + capacitance) then converts this back to a DC voltage with another amplitude.

The switching converters are broadly categorized as isolated and non-isolated converters. They are sub-categorized as follows:

### Square-wave signal

# 1 Basics

## 1.1 DC/DC voltage converters

Non-isolated DC/DC voltage converters:

- Buck (step-down) converters
- Boost (step-up) converters
- Buck/boost (step-up/step-down) converters
- Inverting converters
- SEPIC converters
- Switched-capacitor voltage converters

Isolated DC/DC voltage converters:

- Flyback converters
- Forward converters
- Push-pull converters
- Resonant converters
- Half-bridge converters
- Full-bridge converters

The non-isolated converters represent an inexpensive solution for many applications and are often used for small voltage conversions. However, they cannot offer much protection against high input voltages or transients. In contrast, the isolated DC/DC voltage converters have a high isolation voltage and can therefore be used for isolating floating ground connections between input and output. The isolated converters are more complex circuits and require a higher number of components and hence costly solutions.

In the case of a discrete switching regulator solution, the number of discrete components is higher and each discrete component needs to be selected wisely to meet the power requirement. The size of individual components has a direct implication on the overall converter size. In addition, the issues of EMC, heat management, as well as efficiency and temperature response of the circuit, have to be taken into consideration at the outset of design and this development depends more than ever on the user's expertise and time resources.

A power module represents an alternative to a discrete DC/DC voltage converter. All discrete components including controller IC, transistors, diodes, inductors and small capacitors are integrated in a package. The EMC, thermal and electrical performance are taken care of. In some cases, input and output capacitors are even integrated or capacitor selection recommendations are described in application notes.

Another advantage of the power modules is that it is in line with the ongoing trend of component miniaturization, because a power module needs a far smaller area on the circuit board than a discrete solution. Compliance with the respective norms and performance data are confirmed by the power module manufacturer in the datasheet and complex, cost-intensive tests and certifications for the assemblies can be significantly reduced.

One of the simplest components for DC voltage regulation is the linear voltage regulator, also known as series regulator. Series regulators are inexpensive, simple to use and to design-in, yet they have some significant drawbacks when compared with a power module, e.g. poorer efficiency and a higher power loss.

### 1.2 Linear regulators

Linear voltage regulators are used very often in electronic circuits to convert unregulated, fluctuating voltage to a constant voltage. The linear regulators (Fig. 1.1) are well suited for applications in which the available voltage is usually only slightly higher than the required voltage because minimizing the voltage difference between the input and output leads to a lower power loss. It can quickly compensate a load transient and also does not generate any interference radiation (EMI).

On account of their low space requirement (packages e.g. 78Lxx, 78Sxx and 78Hxx), linear regulators are preferred over switching regulators. 78xx series voltage regulators for positive and 79xx series for negative output voltages are probably the best known DC/DC converters. The xx in the type designation denotes the respective output voltage. A small number of passive components and therefore reasonable technical effort to design-in linear regulators makes them a very cost-effective variant for voltage regulation.



*Fig. 1.1: Typical series regulator package TO220*

Linear regulators are realized as integrated circuits that contain the control section (transistor) and a reference voltage. Linear voltage regulators come in two categories: fixed and with an adjustable output.

### Series regulator

### Linear regulators