

The Use of Zetex E-Line Transistors in DC-DC Converters

An Introduction and Typical Applications

David Bradbury

What Are DC-DC Converters?

DC-DC Converters are circuits designed to match loads to the power sources available. Generally, they accept power input at one voltage and supply one or more loads requiring power at different voltage levels. This description of converters is necessarily vague because of the extremely wide range of applications these circuits are used in.

Where Are They Used?

- In providing additional power supplies for applications such as computers, e.g. displays, memories, programmers, interfaces, etc.
- In matching power supplies to "difficult" loads such as capacitor charging in flash guns, pulsed laser drivers, ignition systems (spark generation), etc.
- In high efficiency voltage step down conversion.
- In safe high voltage power supplies.

Circuit Considerations and Device Characteristics

All the applications listed rely on the technique of using a switching circuit to turn the DC input into an AC signal, that can be conditioned using a transformer and rectifier to finally give the voltage and source characteristics required by the load. To obtain high efficiency, it is crucial that the transistor switch used to generate the AC signal gives very low losses. For low losses, the transistors must exhibit low conduction voltages and fast transition times. These must be achieved despite the high peak currents passed in most of the applications.

Size constraints are also very important. Unfortunately, small package size and high current handling are not characteristics that normally go together. A problem sometimes allied to size is operating temperatures. Circuits squeezed down to the limit may need to run at high temperatures, so this must be kept in mind when selecting a semiconductor switch.

Zetex offer a range of both bipolar and MOSFET transistors in the high reliability E-Line package with specifications that ideally suit many of the application areas listed previously.

This includes the Super E-Line range of NPN and PNP bipolar transistors with continuous current ratings up to 2A (6A peak) for 100V transistors and up to 0.5A continuous (1A peak) for a 300V device. Typical $V_{CE(sat)}$ voltages measure out at less than 250mV, even at these high continuous current levels. (**Important:** Please refer to **Note 1** on page AN7-5)

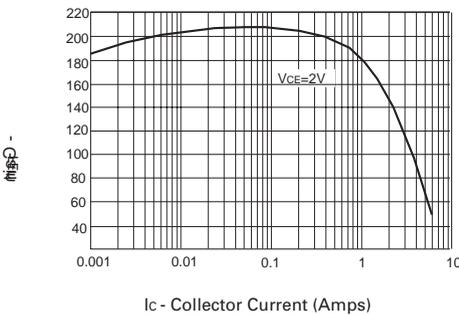


Figure 1
ZTX649 h_{FE} profile illustrating excellent gain holdup above 2A.

As an example, Figure 1 shows how the useful gain range of the 25V ZTX649 extends well beyond its 2A continuous rating. The bipolar E-Line 200°C maximum temperature rating and small package outline allows new converter designs to be more compact. Centre collector versions of the E-Line range can replace TO220 and SOT89 types presently used in many applications.

For circuits where very high speeds or ease of driving is important, Zetex also offer a useful range of MOSFET transistors encapsulated in the E-Line package.

N-Channel types available presently are rated from 60V through 450V, and continuous current ratings up to 1.1A. This voltage range is duplicated for P-Channel types though their resistance is higher. The output characteristics of the 60V ZVN4206A are shown in Figure 2 to illustrate the high current capabilities of the Zetex E-Line MOSFET range. All these devices share the small outline and proven reliability of the Zetex bipolar E-Line range, however chip constraints presently limit the maximum junction temperatures of the MOSFET devices to 150°C.

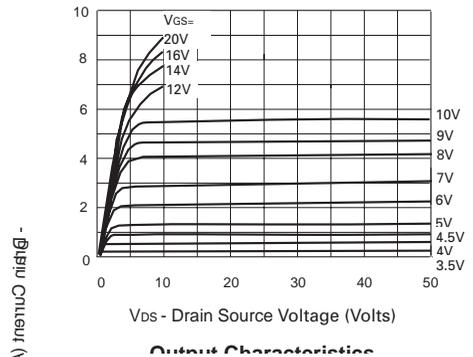


Figure 2
ZVN4206A Output Characteristics.

Using Zetex E-Line devices, DC-DC converters up to 10W output can be easily made using a single switching transistor, even when supplying "difficult" loads. More typical loads will allow higher outputs to be achieved. Figure 3 shows the circuit of an 8W fluorescent lamp inverter (strictly a DC-AC converter). A fluorescent lamp is a particularly awkward load for a converter since it has a highly non-linear

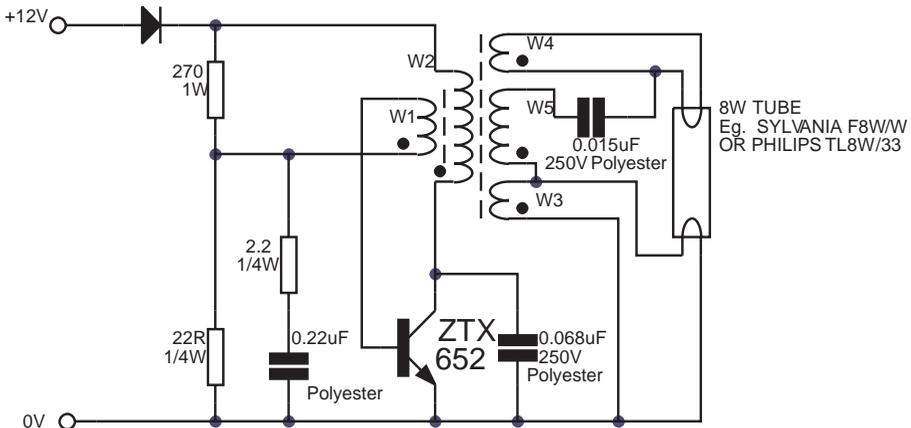


Figure 3
8W Output from a Single Switching Transistor.

impedance that varies greatly as the tube strikes and enters its normal operating condition. The converter must have a high output voltage capability for striking, yet also be capable of supplying the low impedance load the tube presents after it has struck. This leads to the specification of a high voltage transistor that can also pass high peak currents. These conflicting requirements lead many manufacturers to use a relatively expensive TO220 packaged device, but this application can be well served using a single Zetex E-Line ZTX652 transistor. Figure 4 shows the circuit waveforms obtained when using the ZTX652. Note how peak current levels approach 3A without high $V_{CE(sat)}$ voltages.

The low value of this input supply means that relatively high peak currents for a given output power and low values of $V_{CE(sat)}$ for good regulation are required. In this forward converter operating at

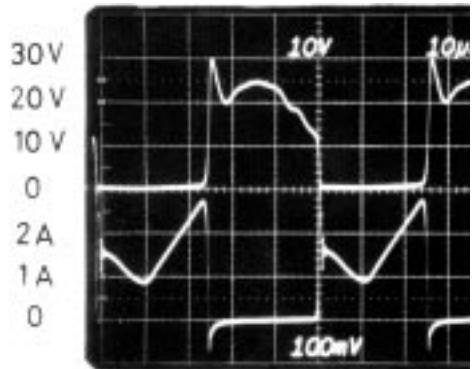


Figure 4
ZTX652 Switching waveforms for 8W Inverter.

Upper Trace - V_{CE} 10V/div
Lower Trace - I_E 1A/div

Figure 5 shows a very simple 5W converter intended to provide the +12V and -5V supplies often required in personal computers for memory, interface and display circuitry. Its power source is the standard 5V logic supply.

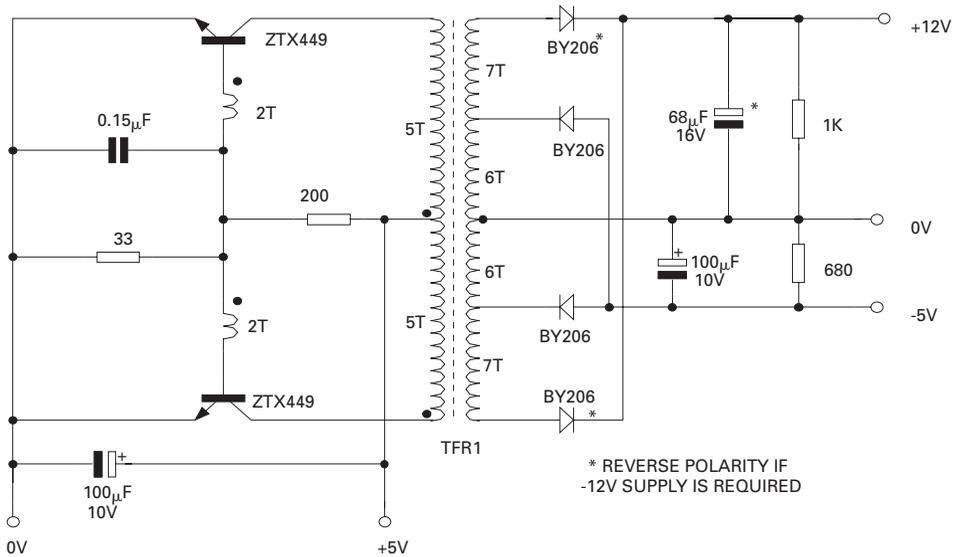


Figure 5
Simple 5W Inverter to Provide +12V and -5V.

25kHz, two Zetex ZTX449 E-Line transistors alternately pass currents up to 1.5A. The 250mV $V_{CE(sat)}$ typically given by these devices gives this simple circuit its high efficiency and good regulation. For even higher output powers, ZTX649 transistors could be substituted.

Capacitor charging is a common application for DC-DC converters. This type of converter appears in flash guns, ignition units, etc. Capacitors are awkward components to charge efficiently because the voltage across them varies greatly during the charging cycle (0 to 400V in a typical flash gun). Flyback converters are particularly suited to this task since they isolate the characteristics of the load from the

converter switching element.

However, for a given power output, the peak switching current required in a flyback converter is generally greater than that for a forward converter. So the high current ratings and low saturation voltages of the Zetex E-Line products can be even more important. Figure 6 shows a simple Xenon tube flash circuit based on a flyback converter. The circuit includes a special shut-down sensor which both ensures that the output capacitor is not overcharged and also increases battery life.

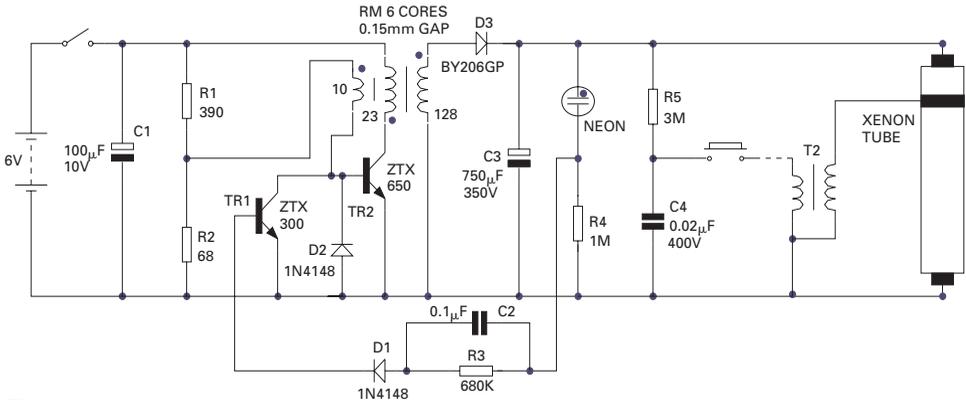


Figure 6
Xenon Tube Flash Circuit with Shut Down to Increase Battery Life.

Summary

DC-DC converters are to be found in a very wide range of electronic products. The type of circuits used varies greatly to suit each application area. All these circuits require switching devices, and the better the switch, the more efficient and smaller the converter can be. Devices possessing fast switching characteristics, require low drive power (high gain), exhibit low voltage drops and can handle high peak currents are ideal for these applications. Modern chip designs and superior packaging allow the Zetex E-Line range of bipolar and MOSFET transistors to meet these requirements for most applications up to 10W. **Please refer to Note 1 below.**

For more detailed information regarding the Zetex transistors featured in this Application Note, please refer to the following publications:

Semiconductor Data Book

Book 1 Through Hole Components

Note 1:

Since the original issue of this application note, Zetex have introduced many new transistor ranges including the ZTX850 NPN series rated to 5A DC, and the complementary ZTX 950 series. These ranges represent the highest current capability of any E-Line /TO92 transistor. High gain or Super- β parts are also available which allow extremely high conversion efficiencies due to very low on-state loss and drive power requirements.

These ranges are detailed in later application notes.