Centre Collector E-Line Applications

An Overview of Package Capability and Applications Advantages

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Introduction

This Application Note describes the product range, important package characteristics (including construction and thermal characteristics) and typical applications of the Zetex Semiconductors range of Centre Collector E-Line transistors.

Originally, the extensive range of ZETEX E-Line bipolar and MOSFET transistors was only available in the conventional edge collector (or drain) configuration. The high peak current, temperature and power capabilities exhibited by many of these devices allowed them to be used to replace higher power packages (TO126, TO202, TO220, TO237, SOT89, DPAK, etc.), which are mainly centre collector types. This fact, and second sourcing constraints, meant that circuit boards sometimes had to be laid out to accept both E-Line and larger centre collector power packages, wasting space and increasing costs. However, many of the high performance E-Line devices can now be supplied using centre collector/drain terminations, thus easing second sourcing problems for the designer.

Product Range

Design features of devices in the new Centre Collector E-Line range:

- NPN and PNP bipolar types up to 400V BV_{CEO}.
- NPN and PNP Darlingtons up to 160V BV_{CEO}.
- N and P channel MOSFET transistors up to 450V BV_{DSS}.
- High current gain.
- Super-β types available.
- High current handling capability - 10A peak, 3A continuous.
- Low saturation voltage.
- Fast switching and high F_T.
- T_j max up to 200°C.
- P_D up to 1W (this can be greater, and is very dependent on mounting method.)
- Small outline E-Line (TO92 style) package.
- Various through hole lead forms available as standard.
- Proven reliability and quality.

These features have been obtained by using advanced chip designs, the latest fabrication techniques and extensive modern production facilities, coupled with rigorous reliability and quality monitoring.

Further details of the product range can be found in the Zetex Semiconductor Data Book #1, Through Hole Components.

Package Construction and Reliability

The Centre Collector E-Line package is formed by transfer moulding a TO92 frame in a silicone plastic.

This plastic is specially selected to provide a rugged one-piece encapsulation resistant to severe environments, **and** allow the high junction temperatures normally associated with metal-can devices. The high glassing temperature and absence of ionic contaminants are two of the many features of the silicone encapsulant that allows chip operation up to 200°C without the risk of failure. The E-Line manufacturing process includes a resin backfill stage, involving vacuum impregnation of the moulded package with a silicone resin. This resin seals any voids which may exist between the lead frame and encapsulant, protecting the chip from exposure to corrosive agents and moisture, giving the package hermeticity properties approaching those of metal-can devices.

The resulting reliability given by these highly-developed packaging techniques and the use of well-passivated chips is routinely monitored. This monitoring covers tests such as high temperature reverse bias (HTRB), power cycling, temperature cycling and reliability in hazardous environments.

Power Rating

The Centre Collector TO92 lead frame was selected to allow a wide range of chip sizes and geometries, yet provide a low thermal resistance to the device. As can be expected, the thermal resistance offered by devices in the Centre Collector range depends on the chip size and, equally importantly, the mounting method. The centre collector range of devices was originally conceived to provide lead compatibility to allow drop in replacement of TO220 and TO126 packaged components, when these parts were being used for their high current capability rather than in a linear mode, (e.g. power dissipative). The thermal resistance presented by the E-Line will be higher than for a much larger packaged component, but this is often compensated for in most practical circumstances by the E-Line package's capability to be used with junction temperatures up to 200°C.

The thermal characteristics of the Centre Collector E-Line package is shown in Figure 1.

Figure 1 shows the power derating curves for an FXT651. For comparison purposes, the derating curves for free standing TO92, TO237 and TO220 types are also included in this diagram. Note that the E-Line package can provide excess power capability over TO92 and TO237 types at any temperature, and even over TO220 types at temperatures that occur in many "real" applications such as within automotive environments.

Full DC and transient thermal resistance data are available for all devices in the Centre Collector E-Line range.

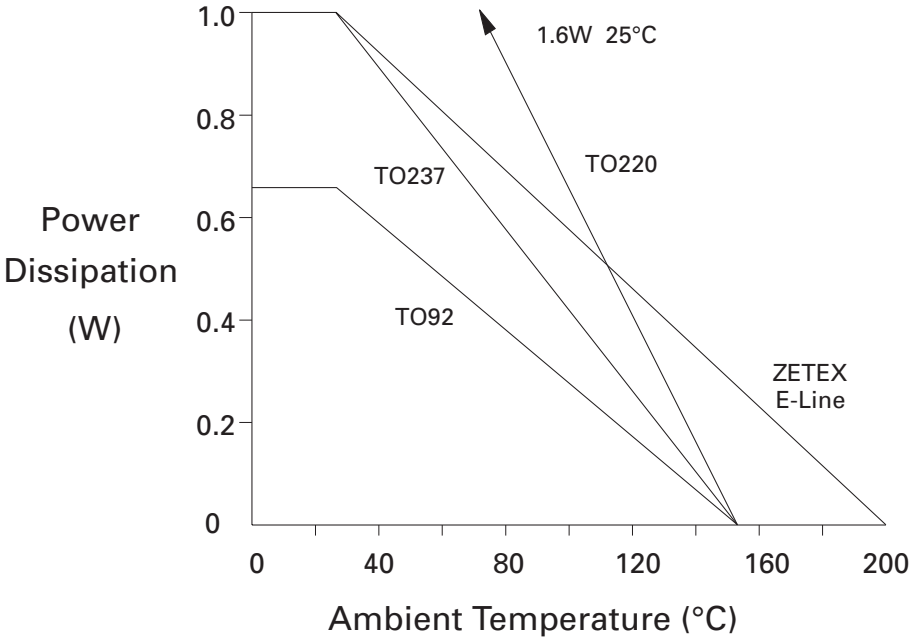

Figure 1
Power Derating Curves for Through Hole Mounted Free Standing Devices.

Applications

Some application areas that can take advantage of the E-Line Centre Collector package are listed below:

Automotive - Lamp and display drivers, Solenoid and relay drivers, Motor drivers.

Converters - Capacitor charging (Flash guns, Ignition units), Logic supplies, Isolated supplies, DC-AC supplies (Fluorescent lamps).

Computer Peripherals - Display and lamp drivers, Stepper Motor drivers (printers), Solenoid and relay drivers.

Telephones - Pulse code diallers, Earpiece muting, Hookswitches.

Miscellaneous - Low-level audio output stages, Low power RF transmitters, Frame drivers, Buzzers, Radio control, Warning lamps, Gaming machines.

Provided overleaf are some typical application examples mentioned in the above list.

Automotive

In automotive electronics, the devices face both mechanical and electrical hazards. The mechanical hazards centre on the extreme operating temperature range. The passenger compartment temperature can vary from -40°C to +85°C, with the engine compartment ambient reaching as high as 120°C. Consequently, metal can encapsulated devices or plastic types that are grossly overrated are normally required. However, Zetex manufacture a range of inexpensive medium-power transistors that are ideally suited to these severe operating conditions. With regard to the electrical hazards, automotive systems have to withstand a range of transients. More details regarding this can be found within application note AN5; Super E-Line Applications in Automotive Electronics.

It is common to see devices used to drive lamps, relays, etc., having a breakdown voltage in excess of 80V. Generally, high voltage transistors of a given chip size are not as good as their low voltage counterparts. (Eg. there is a significant compromise between high current gain hold-up and voltage rating). However as shown in Figure 2, the FXT653 (a 100V, 2A continuous rated device) replaces a similarly rated device in TO126 or TO220 package style. The FXT653 is used as a solenoid driver within a circuit that also includes a short-term current limit function to protect the output transistor.

An FXT601, a 160V medium-power Darlington, has been used as a lamp driver in Figure 3, to replace an alternative in the TO220 package. This circuit holds on the internal light for approximately one minute after the car doors are closed.

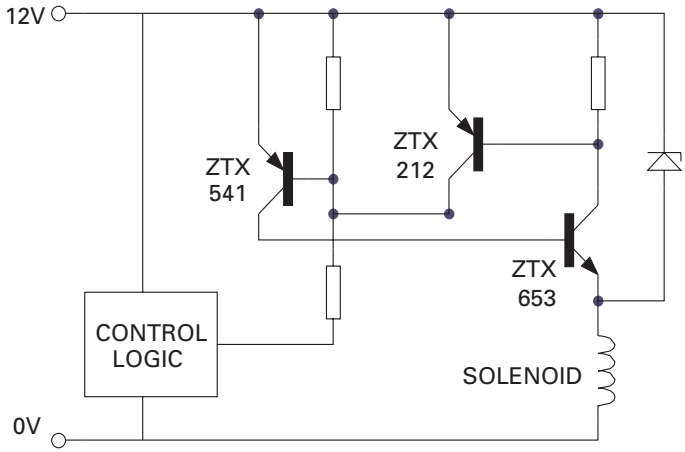

Figure 2
Automotive Systems Relay Driver using Centre Collector E-Line.

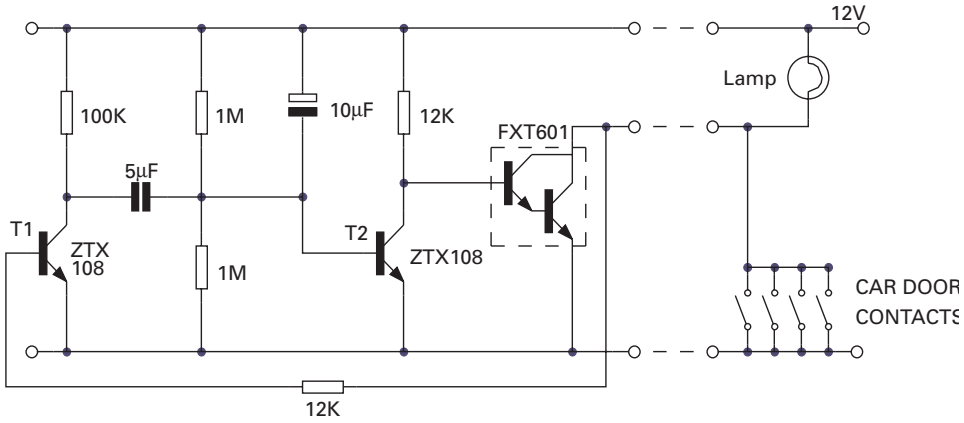

Figure 3
Automotive System Courtesy Lamp Driver using a Centre Collector Darlington Transistor.

Converters

Figure 4 shows a circuit diagram for a portable, low-power beacon used for distress signalling systems. A 3 Volt D.C. supply is converted to 350 Volt D.C.

The original unit employed a TO220 package device which gave a poor conversion efficiency. The superior characteristics of the Centre Collector E-Line transistor, FXT653, allowed the unit to be operated at a higher frequency, thus reducing the size of the magnetics. The end result was a circuit with high efficiency, smaller size and a significant cost saving.

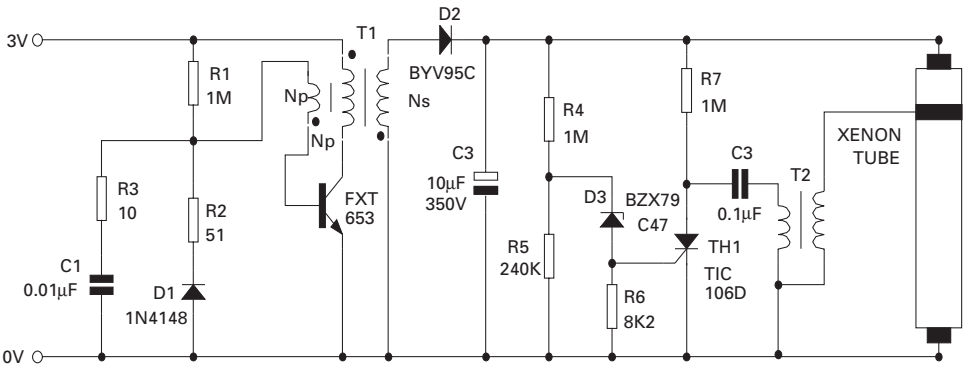

Figure 4
Low Power Xenon Beacon employing an FXT653 in a 3V DC to 350V DC Converter.

The circuit shown in Figure 5 has been designed to drive an 8 watt fluorescent lamp from a 12 volt source using an inverter based on an inexpensive Centre Collector E-Line, FXT653, transistor. It replaced a 2N3055 in TO220 plastic package style transistor. The inverter was designed to operate from supplies in the range of 10 to 16.5 Volts.

Computer Peripherals

The majority of modern printers use stepper motors and solenoids for driving various transport and print mechanisms. For ease of driving and circuit simplicity, expensively packaged Darlingtons with integral collector-emitter diodes are used.

The diodes are required to protect the Darlingtons from negative current pulses caused by the inductive loading.

The stepper motor driver circuit shown in Figure 6 uses Centre Collector E-Line MOSFET transistors which are electrically compatible in a smaller package, at much reduced cost. Due to the inherent nature of MOSFET technology, the required protection diode already exists. The circuit interfaces directly with standard TTL.

To keep the power losses in the motor low during periods of low speed operation, a logic controlled positive line switch is required. The FXT704 PNP Darlington transistor can easily be used

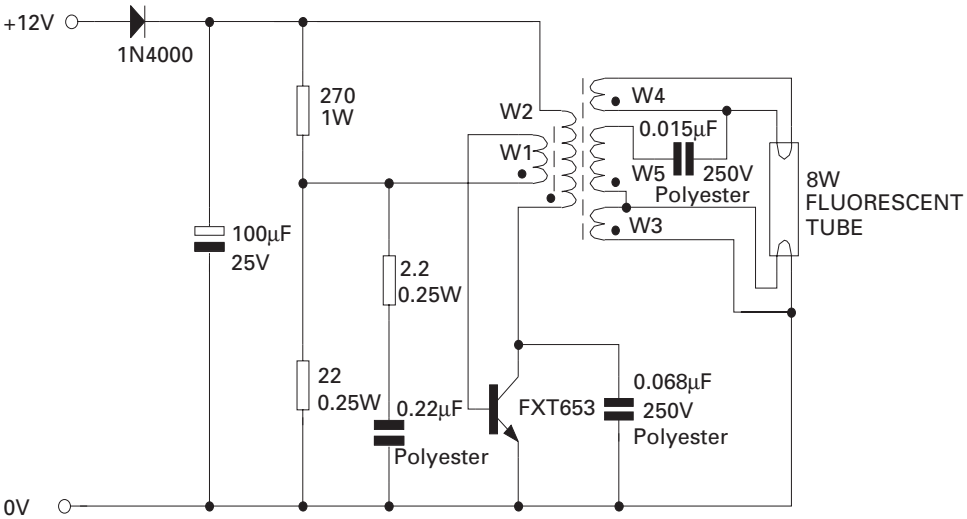

Figure 5
8W Fluorescent Lamp Inverter.

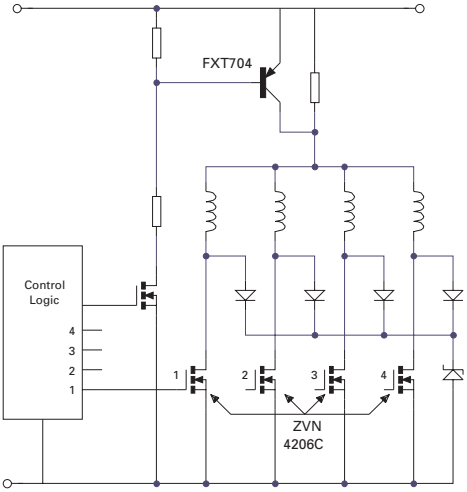

Figure 6
Centre Drain MOSFETs utilised within a Stepper-Motor Module.

in this application for motor currents to 4A peak. The motor circuit shown interfaces directly with standard TTL.

Figure 7 shows the typical voltage and current waveform of a MOSFET used in the motor drive.

Telephones

High breakdown voltage, high current handling capability, high gate input impedance, low on-resistance and low cost make Centre Collector E-Line MOSFETs an ideal choice for use as dial-pulse and muting switches in a dialler circuit. Figure 8 shows the use of high voltage Centre Collector E-Line bipolar and MOSFETs in a typical telephone instrument.

The Centre Collector E-Line package used in this application replaces commonly-used TO237 plastic package.

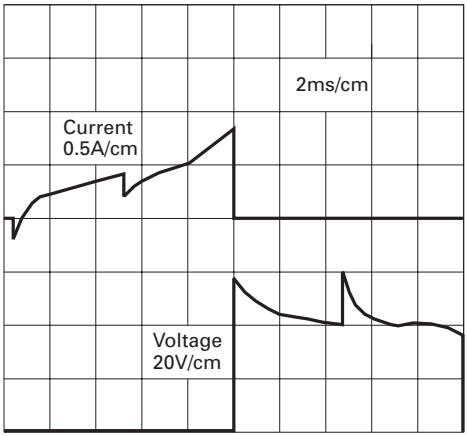

Figure 7
Stepper Motor Drive Circuit - Source Current and Drain-source Voltage of ZVN4206C During Drive Cycle.

Summary

The Zetex E-Line package has built its reputation on reliability and advanced design. Extensive reliability tests have been performed on the packaging and die geometries that enables the Zetex E-Line range, confirming both power ratings and quality. Highly developed packaging techniques have allowed Zetex to produce the Centre Collector range of E-Line devices to give improved thermal and electrical characteristics. This allows them to be used to replace higher power packages such as TO202, TO220, TO126, TO225, TO237, SOT89 and DPAK.

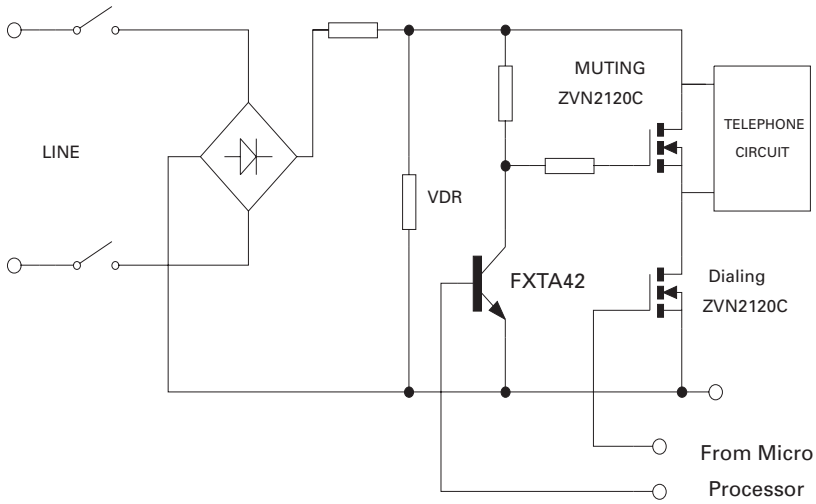

Figure 8
Centre Collector High Voltage MOSFETs and Bipolar transistors within a Telephone.