Automotive Alarm Siren Driver
2A DC Rated Super-ß Transistors Provide Reduced Component Count ‘H’ Bridge

Introduction
The majority of modern automotive alarm sirens employ a moving coil loudspeaker, that is driven by an ‘H’-bridge output stage. This output driver circuit is commonly effected with TO-126/TO-220 packaged power transistors, as the currents involved and the resulting power dissipation are both in excess of common smaller package products. Zetex Super E-Line (TO-92 style) transistors however, due to their superior device geometries and silicone packaging, can, and have been used in this application to provide a minimal drive circuitry topology, and a size, cost and performance advantage.

Background
The circuit diagrams presented in Figures 1 and 2, show two common methods of effecting a siren driver circuit. These circuits include collector-emitter (C-E) diodes to protect the transistor in the event of negative rail excursions, due to inductive load transients, and base-emitter (B-E) resistors to provide a path for any transistor leakage current. This latter point is an important consideration when using the usual TO-126/TO-220 power products, as their high VCE(sat) can lead to appreciable temperature rises.

Zetex E-Line transistors are optimised to possess a very low VCE(sat), and are therefore much more efficient in high current switching applications than conventional power products.

Some siren manufacturers use TO-220 packaged Darlington power transistors. While this can reduce the component count, (though can also increase the component cost), as the C-E diodes are sometimes integral to the Darlington, the intrinsic high on-state voltage of the Darlington configuration increases device dissipation. Consequently the circuit requires B-E resistors, and also reduces the power delivered to the load.

Circuit description
The circuit shown in Figure 3 has been devised using Zetex Super E-Line transistors. It is basically a modified version of figure 2. There are two important differences to note:

i) As the devices employ an efficient matrix die geometry, they produce low VCE(sat) values, this leads to very low device dissipation, and therefore low temperature rise. (Viz. ZTX690B: VCE(sat) = 0.3V at IC=2A, IB =20mA and ZTX790A: VCE(sat) = 0.4V at IC=2A, IB =50mA, please consult ZTX688B-ZTX696B and ZTX788B-ZTX796A series datasheets). This can be very important in automotive applications, where the operating environment can reach high ambient temperatures. It follows that in this case, the usual base-emitter resistors employed to aid turn-off, and to divert leakage currents at high junction temperature, are no longer required.

ii) The Zetex devices chosen, possess a reasonable hFE, (strictly termed hFC) when used in the inverted mode, Eg. with the collector/emitter terminals reversed. Typical peak values being 125 for the ZTX690B and 100 for the ZTX790A. This feature means that they are still capable of operating when subjected to reverse transients, such as when driving an inductive load, and therefore do not always require protection diodes. For the siren driver application, the C-E diodes may be confidently omitted.

Figure 1. Conventional Siren Driver Circuit using Separate Pre-driver Transistors.
Figure 2. Conventional Siren Driver Circuit using Cross-coupled Darlington Pre-driver Configuration.
Figure 3. ZETEX Reduced Component Count ‘H’-Bridge Circuit.
Automotive Alarm Siren Driver
2A DC Rated Super-ß Transistors Provide Reduced Component Count ‘H’ Bridge

Introduction
The majority of modern automotive alarm sirens employ a moving coil loudspeaker, that is driven by an ‘H’-bridge output stage. This output driver circuit is commonly effected with TO-126/TO-220 packaged power transistors, as the currents involved and the resulting power dissipation are both in excess of common smaller package products. Zetex Super E-Line (TO-92 style) transistors however, due to their superior device geometries and silicone packaging, can, and have been used in this application to provide a minimal drive circuitry topology, and a size, cost and performance advantage.

Background
The circuit diagrams presented in Figures 1 and 2, show two common methods of effecting a siren driver circuit. These circuits include collector-emitter (C-E) diodes to protect the transistor in the event of negative rail excursions, due to inductive load transients, and base-emitter (B-E) resistors to provide a path for any transistor leakage current. This latter point is an important consideration when using the usual TO-126/TO-220 power products, as their high V_CE(sat) can lead to appreciable temperature rises.

Circuit description
The circuit shown in Figure 3 has been devised using Zetex Super E-Line transistors. It is basically a modified version of figure 2. There are two important differences to note:

i) As the devices employ an efficient matrix die geometry, they produce low V_CE(sat) values, this leads to very low device dissipation, and therefore low temperature rise. (Viz. ZTX690B: V_CE(sat) = 0.3V at I_c=2A, I_b =20mA and ZTX90A: V_CE(sat) = 0.4V at I_c=2A, I_b =50mA, please consult ZTX688B-ZTX696B and ZTX788B-ZTX796A series datasheets). This can be very important in automotive applications, where the operating environment can reach high ambient temperatures. It follows that in this case, the usual base-emitter resistors employed to aid turn-off, and to divert leakage currents at high junction temperature, are no longer required.

ii) The Zetex devices chosen, possess a reasonable hFE, (strictly termed hFC) when used in the inverted mode, E.g. with the collector/emitter terminals reversed. Typical peak values being 125 for the ZTX690B and 100 for the ZTX790A. This feature means that they are still capable of operating when subjected to reverse transients, such as when driving an inductive load, and therefore do not always require protection diodes. For the siren driver application, the C-E diodes may be confidently omitted.
The modified "H"-bridge siren driver stage has been incorporated into a complete siren driver circuit, in order to demonstrate the capability of Zetex Super E-Line transistors. The demonstration circuit is shown in figure 4, and consists of two sections; the signal generation circuitry, and the 'H'-bridge output stage. The former comprises a slow running astable multivibrator to generate a ramp signal, that is then used to modulate a second multivibrator, causing it to sweep over a range of frequencies. This section drives the 'H'-bridge output stage described previously.

While the multivibrator method is valid, (some manufacturers use a similar circuit, while others favour op-amp derived circuits, or even small micro-controllers - see Note 2), there can be a problem with cross-conduction, Eg. Simultaneous conduction by both NPN and PNP devices during switch-over, thus leading to excessive power dissipation. To prevent this, the output stage on the demonstration circuit has two additional signal diodes, D3 and D4. These components inhibit the driver transistors Q5 and Q6, until the opposing half of the 'H'-bridge has started to switch off. More elaborate signal generators incorporate delays between changes of output state, (using an extra gate or software) so would not require these extra diodes.

The circuit has been designed assuming a load impedance of 6 Ohms; a common value for the drive units used. Lower loads can be driven but may require either a change to the bias resistors, R13/14, to provide sufficient base current, or for very low impedance loads, a change of output transistors:- the ZTX851/ZTX951 with a continuous current rating of 5 Amps and 4 Amps respectively are eminently suitable.

**Example Circuit Specification**

- **Supply Voltage Range**: 2 – 25V
- **Output Stage Efficiency**: 98.5%
  - Load dependent; 14.2V nominal
  - Average $V_{CE(sat)} = 0.1V$
  - $V_{supply} = 14.2V$
  - $I_{(dc)} = 1.2A$
- **Output Stage Efficiency**: 91.5%
  - 6 Ohm Resistive load
  - Average $V_{CE(sat)} = 0.55V$
  - $V_{supply} = 14.2V$
  - $I_{(dc)} = 2.12A$
- **Junction Temperature Rise**: 19°C
  - 6 Ohm moving coil load
  - $V_{supply} = 14.2V$
- **Control ramp**: 1 to 9V, 4Hz
- **Swept frequency range**: 870Hz – 1.9kHz
  - $V_{supply} = 14.2V$

**Note 1:**
D3 and D4 are not required for signal generation circuits possessing output/output deadtime.

**Note 2:**
ZETEX now offer an IC solution for the signal generation circuitry - namely the ZSD100.
The modified 'H'-bridge siren driver stage has been incorporated into a complete siren driver circuit, in order to demonstrate the capability of Zetex Super E-Line transistors. The demonstration circuit is shown in figure 4, and consists of two sections; the signal generation circuitry, and the 'H'-bridge output stage. The former comprises a slow running astable multivibrator to generate a ramp signal, that is then used to modulate a second multivibrator, causing it to sweep over a range of frequencies. This section drives the 'H'-bridge output stage described previously.

While the multivibrator method is valid, (some manufacturers use a similar circuit, while others favour op-amp derived circuits, or even small micro-controllers - see Note 2), there can be a problem with cross-conduction, Eg. Simultaneous conduction by both NPN and PNP devices during switch-over, thus leading to excessive power dissipation. To prevent this, the output stage on the demonstration circuit has two additional signal diodes, D3 and D4. These components inhibit the driver transistors Q5 and Q6, until the opposing half of the 'H'-bridge has started to switch off. More elaborate signal generators incorporate delays between changes of output state, (using an extra gate or software) so would not require these extra diodes.

The circuit has been designed assuming a load impedance of 6 Ohms; a common value for the drive units used. Lower loads can be driven but may require either a change to the bias resistors, R13/14, to provide sufficient base current, or for very low impedance loads, a change of output transistors:- the ZTX851/ZTX951 with a continuous current rating of 5 Amps and 4 Amps respectively are eminently suitable.

Note 1:
D3 and D4 are not required for signal generation circuits possessing output/output deadtime.

Note 2:
ZETEX now offer an IC solution for the signal generation circuitry - namely the ZSD100.

Example Circuit Specification

Supply Voltage Range 2 – 25V
Load dependent; 14.2V nominal
Output Stage Efficiency 98.5%
Average VCE(sat) = 0.1V
Vsupply = 14.2V
I_(dc) = 1.2A

Output Stage Efficiency 91.5%
6 Ohm Resistive load
Average VCE(sat) = 0.55V
Vsupply = 14.2V
I_(dc) = 2.12A

Junction Temperature Rise 19°C
6 Ohm moving coil load
Vsupply = 14.2V

Control ramp 1 to 9V, 4Hz
Vsupply = 14.2V

Swept frequency range 870Hz – 1.9kHz
Vsupply = 14.2V

Example Circuit (Note 1).

Figure 4.