APPLICATION FOCUS

Variable speed brushless DC motor pre-drivers

About Zetex

Zetex Semiconductors designs and manufactures high performance semiconductor solutions for analog signal processing and the management of power in automotive, communications, consumer and industrial electronics.

Meeting the demand for greater power economy, precision and speed in analog circuit design, the broad Zetex product range comprises application specific linear ICs and discrete semiconductor devices in multiple package configurations.

As a specialist in analog technology, Zetex offers a diverse series of ICs for motor control, lighting and DC-DC conversion as well as audio, video and linear applications. Its discrete component range features trench MOSFETs, IntelliFET™ smart MOSFETs and bipolar transistors.

Headquartered near Manchester in the UK, Zetex Semiconductors has manufacturing and sales operations in Asia, Europe and the USA and is supported by distributors in more than 45 countries.

For more information about Zetex, please visit www.zetex.com
www.zetex.cn

Zetex Semiconductors is committed to protecting the environment and compliance with all relevant national and international legislation. Zetex products are fully compliant with the European Union’s RoHS directive (2002/95/EC). For further information visit www.zetex.com/leadfree

Zetex products are distributed worldwide. For details, visit www.zetex.com/offices
The complete cooling solution

Fan assisted electronics cooling systems need to insure a lot more than just efficient air movement. They need to help minimize power consumption and keep noise – both audible and electrical – to the absolute minimum. The ZXBM series of dedicated motor pre-driver ICs achieves all of these goals and more.

Providing variable speed control for single and two-phase brushless DC fans and blowers up to 100W, the ZXBM motor pre-driver ICs provide designers with the flexibility to tailor a solution to fit the exact needs of an application. That is why the ZXBM series provides accurate variable motor speed control in response to PWM, Negative Temperature Coefficient (NTC) thermistor or voltage inputs. To drive the motor windings, there is also the Zetex range of market leading bipolar transistors and MOSFETs.

The Zetex pre-driver range continues to evolve to meet the exciting specifications of the world’s blue chip OEMs. Multiple fan cooling systems for high availability servers and mainframes demand even more stringent control of cooling, power and noise. The ZXBM series responds to this need by providing accurate variable motor speed control in response to PWM, Negative Temperature Coefficient (NTC) thermistor or voltage inputs.

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General features
- Supply voltage up to 18V
- Small outline surface mount packages
- Built-in Hall amplifier
- Built-in PWM oscillator
- Built-in lock detect function, rotational speed sensing and automatic recovery
- External driver transistors
- Optional speed control modes

Benefits
- Compact designs
- Suitable for 5V and 12V DC fans (24V and 48V with external pre-regulation)
- Suitable for full range of fans up to 100W
- Can be used for external PWM, thermal or voltage speed control

Applications
- Telecom mainframe fans and blowers
- Server and PC computer fans and blowers
- Industrial fans and blowers
- Automotive climate control
- Central heating blowers

Special features
- Current limit: In multi-fan systems it is important to safeguard the power supply from current surges. A current monitoring circuit enables supply current on start-up and stall to be kept permanently within OEM specifications.
- Tail-end current control: The current spike occurring at the end of a motor commutation cycle has an adverse effect on circuit efficiency, cost and audible noise. Tail-end current control completely removes the spike.
- Combined PWM and thermistor control: For multi-fan systems the simultaneous use of PWM and thermistor speed control inputs help avoid hotspots and insure more even temperature gradients.

Two-phase motor pre-driver ICs

<table>
<thead>
<tr>
<th>Part number</th>
<th>Supply voltage V</th>
<th>Min. quiescent current mA</th>
<th>Max. output V</th>
<th>Min. speed setting</th>
<th>Output flag format</th>
<th>Package</th>
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Single-phase motor pre-driver ICs

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</table>

The ZXBM series suits a variety of thermal control schemes.
The complete cooling solution

Fan assisted electronics cooling systems need to insure a lot more than just efficient air movement. They need to help minimize power consumption and keep noise – both audible and electrical – to the absolute minimum. The ZXBM series of dedicated motor pre-driver ICs achieves all of these goals and more.

Providing variable speed control for single and two-phase brushless DC fans and blowers up to 100W, the ZXBM motor pre-driver ICs provide designers with the flexibility to tailor a solution to fit the exact needs of an application.

That is why the ZXBM series provides accurate variable motor speed control in response to PWM, Negative Temperature Coefficient (NTC) thermistor or voltage inputs. To drive the motor windings, there is also the Zetex range of leading bipolar transistors and MOSFETs.

The Zetex pre-driver range continues to evolve to meet the exacting specifications of the world’s blue chip OEMs. Multiple fan cooling systems for high availability servers and mainframes demand even more stringent control of cooling, power and noise. The ZXBM series responds with added functionality: current limit, tail-end current control and combined PWM and thermistor control.

General features
- Supply voltage up to 18V
- Small outline surface mount packages
- Built in Hall amplifier
- Built in PWM oscillator
- Built in lock detect function, rotational speed sensing and automatic recovery
- External driver transistors
- Optional speed control modes

Benefits
- Compact designs
- Suitable for 5V and 12V DC fans (24V and 48V with external pre-regulation)
- Suitable for full range of fans up to 100W
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- Telecom mainframe fans and blowers
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- Industrial fans and blowers
- Automotive climate control
- Central heating blowers

Special features
- Current limit: In multi-fan systems it is important to safeguard the power supply from current surges. A current monitoring circuit enables supply current on start-up and stall to be kept permanently within OEM specifications.
- Tail-end current control: The current spike occurring at the end of a motor commutation cycle has an adverse effect on circuit efficiency, cost and audible noise. Tail-end current control completely removes the spike.
- Combined PWM and thermistor control: For multi-fan systems the simultaneous use of PWM and thermistor speed control inputs help avoid hotspots and insure more even temperature gradients.

The ZXBM series suits a variety of thermal control schemes.
To prevent a fan from running too slowly or stalling, the ZXBM1004 single-phase motor pre-driver and the ZXBM2004 two-phase motor pre-driver include a minimum speed setting. The ZXBM1004 has all the attributes of the ZXBM2004 plus additional outputs to drive an external H-bridge circuit. Variable speed control is achieved by driving the low-side of the H-bridge with a PWM signal, the duty cycle of which is controlled by a variable voltage, an NTC thermistor or PWM input.

Features
- Adjustable minimum speed setting
- Low noise
- Auto restart
- Integral Hall amplifier
- Locked rotor and speed output signals
- 4.7 to 18V supply voltage range (60V with external regulator)
- QSOP16 package

Basic variable speed control

The ZXBM2000 series of pre-driver ICs offers a complete variable speed control solution for two-phase DC brushless fan motors up to 100W. Speed control is implemented via the application of a variable voltage, an NTC thermistor or PWM input signal.

Features
- Built-in speed sensing, locked rotor detect and auto restart
- Integral Hall amplifier
- Combined rotor lock (RD) and speed (FG) signal - ZXBM2001
- Rotor lock output - ZXBM2002
- Speed (FG) pulse output - ZXBM2003
- 4.5 to 18V supply voltage range (60V with external regulator)
- MSOP10 package

Variable speed control circuit for a two-phase motor using the ZXBM2001 and an external PWM input.

Variable speed control with minimum speed setting

Variable speed control circuit for a single-phase motor using the ZXBM1004 and an external PWM input.

Variable speed control circuit for a two-phase motor using the ZXBM2001 and an external PWM input.
To prevent a fan from running too slowly or stalling, the ZXBM1004 single-phase motor pre-driver and the ZXBM2004 two-phase motor pre-driver include a minimum speed setting. The ZXBM1004 has all the attributes of the ZXBM2004 plus additional outputs to drive an external H-bridge circuit. Variable speed control is achieved by driving the low-side of the H-bridge with a PWM signal, the duty cycle of which is controlled by a variable voltage, an NTC thermistor or PWM input.

**Features**
- Adjustable minimum speed setting
- Low noise
- Auto restart
- Integral Hall amplifier
- Locked rotor and speed output signals
- 4.7 to 18V supply voltage range (60V with external regulator)
- QSOP16 package

Variable speed control with minimum speed setting

The ZXBM2000 series of pre-driver ICs offers a complete variable speed control solution for two-phase DC brushless fan motors up to 100W. Speed control is implemented via the application of a variable voltage, an NTC thermistor or PWM input signal.

**Features**
- Built-in speed sensing, locked rotor detect and auto restart
- Integral Hall amplifier
- Combined rotor lock (RD) and speed (FG) signal - ZXBM2001
- Rotor lock output - ZXBM2002
- Speed (FG) pulse output - ZXBM2003
- 4.5 to 18V supply voltage range (60V with external regulator)
- MSOP10 package

**Basic variable speed control**

The ZXBM2000 series of pre-driver ICs offers a complete variable speed control solution for two-phase DC brushless fan motors up to 100W. Speed control is implemented via the application of a variable voltage, an NTC thermistor or PWM input signal.

**Features**
- Adjustable minimum speed setting
- Low noise
- Auto restart
- Integral Hall amplifier
- Locked rotor and speed output signals
- 4.7 to 18V supply voltage range (60V with external regulator)
- QSOP16 package
**Variable speed control with minimum speed setting and current limit**

In multi-fan systems it is important to safeguard the power supply from current surges. The ZXBM1015 and ZXBM1017 single-phase motor pre-drivers therefore include a current monitoring circuit that enables supply current on start-up and stall to be kept permanently within OEM specifications. The ICs also offer a configurable phase commutation delay, which allows OEMs to accurately meet the requirements of different motor sizes and so further optimise efficiency. The ZXBM1015 has a 3V reference which is suitable for desktop and server requirements whereas the ZXBM1017 has a 5V reference for more specific OEM and 48V requirements. Speed control is via variable voltage, NTC thermistor or PWM input.

**Features**
- Variable commutation delay
- Hall bias output
- Current limit
- Adjustable minimum speed setting
- Low noise
- Auto restart
- Integral Hall amplifier
- Locked rotor and speed output signals
- 4.7 to 18V supply voltage range (60V with external regulator)
- TSSOP20 package

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**Variable speed control with minimum speed setting, current limit and tail-end current control**

For single and two-phase brushless DC motors, the current spike occurring at the end of the commutation cycle has an adverse effect on circuit efficiency, cost and audible noise. The tail-end current control feature of the ZXBM1016 single-phase motor pre-driver completely removes the spike. Besides improving overall circuit efficiency, it enables the use of lower rated, lower cost power switching devices and bridge capacitors. The stress on motor core plates is also reduced therefore removing audible ‘clicks’. Speed control is via variable voltage, NTC thermistor or PWM input.

**Features**
- High efficiency
- Current limit
- Adjustable minimum speed setting
- Low noise
- Auto restart
- Integral Hall amplifier
- Locked rotor and speed output signals
- 6.7 to 18V supply voltage range (60V with external regulator)
- TSSOP20 package
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**Features**
- High efficiency
- Current limit
- Adjustable minimum speed setting
- Low noise
- Auto restart
- Integral Hall amplifier
- Locked rotor and speed output signals
- 6.7 to 18V supply voltage range (60V with external regulator)
- TSSOP20 package

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Variable speed control with minimum speed setting and current limit

In multi-fan systems it is important to safeguard the power supply from current surges. The ZXBM1015 and ZXBM1017 single-phase motor pre-drivers therefore include a current monitoring circuit that enables supply current on start-up and stall to be kept permanently within OEM specifications. The ICs also offer a configurable phase commutation delay, which allows OEMs to accurately meet the requirements of different motor sizes and so further optimize efficiency. The ZXBM1015 has a 3V reference which is suitable for desktop and server requirements whereas the ZXBM1017 has a 5V reference for more specific OEM and 48V requirements. Speed control is via variable voltage, NTC thermistor or PWM input.

**Features**
- Variable commutation delay
- Hall bias output
- Current limit
- Adjustable minimum speed setting
- Low noise
- Auto restart
- Integral Hall amplifier
- Locked rotor and speed output signals
- 4.7 to 18V supply voltage range (60V with external regulator)
- TSSOP20 package

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Variable speed control circuit using an external voltage. The ZXBM1016 includes integrated tail-end current control.
Variable speed control with minimum speed setting, current limit and combined PWM and thermistor inputs

Intel specifications for multi-fan systems require the simultaneous use of PWM and thermistor speed control inputs in order to avoid hotspots and to ensure more even temperature gradients. The ZXBM1016 single-phase fan motor pre-driver therefore offers both inputs, which can either be used together or in isolation.

Features
- Current limit
- Adjustable minimum speed setting
- Low noise
- Auto restart
- Integral Hall and thermistor amplifiers
- Speed output signals
- 7 to 18V supply voltage range (60V with external
- TSSOP20 package

Transistors for single-phase fan motor driving

To interface the ZXBM motor pre-driver ICs with single-phase motor windings, Zetex offers a wide range of suitable bipolar transistor and MOSFET packages:

**MOSFET H-bridges**

<table>
<thead>
<tr>
<th>Part number</th>
<th>Polarity</th>
<th>VDS max</th>
<th>Id</th>
<th>Ion</th>
<th>Vgs(th)</th>
<th>Vgs(th) max</th>
<th>Package</th>
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**N and P-channel MOSFETs**

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**Low-side N-channel MOSFET switches**

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Variable speed control circuit using combined PWM and thermistor inputs.
Variable speed control with minimum speed setting, current limit and combined PWM and thermistor inputs

Intel specifications for multi-fan systems require the simultaneous use of PWM and thermistor speed control inputs in order to avoid hotspots and to ensure more even temperature gradients. The ZXBM1016 single-phase fan motor pre-driver therefore offers both inputs, which can either be used together or in isolation.

Features
- Current limit
- Adjustable minimum speed setting
- Low noise
- Auto restart
- Integral Hall and thermistor amplifiers
- Speed output signals
- 7 to 18V supply voltage range (60V with external regulator)
- TSSOP20 package

Transistors for single-phase fan motor driving

To interface the ZXBM motor pre-driver ICs with single-phase motor windings, ZexeX offers a wide range of suitable bipolar transistor and MOSFET packages:

### MOSFET H-bridges

<table>
<thead>
<tr>
<th>Part number</th>
<th>Polarity</th>
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### N and P-channel MOSFETs

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### Low-side N-channel MOSFET switches

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<td>N</td>
<td>-30</td>
<td>7.7</td>
<td>7.7</td>
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<td>38</td>
<td>95</td>
<td>DPAK</td>
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<td>N</td>
<td>-30</td>
<td>7.7</td>
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<td>7.7</td>
<td>38</td>
<td>95</td>
<td>DPAK</td>
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<tr>
<td>ZXMB1024N8K</td>
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<td>-30</td>
<td>7.7</td>
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<td>38</td>
<td>95</td>
<td>DPAK</td>
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<td>ZXMB1024N8K</td>
<td>N</td>
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<td>38</td>
<td>95</td>
<td>DPAK</td>
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### High-side PNP bipolar switches

<table>
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<tr>
<th>Part number</th>
<th>Polarity</th>
<th>( V_{\text{CEO}} ) (V)</th>
<th>( I_{\text{CBO}} ) (A)</th>
<th>( I_{\text{CEO}} ) (A)</th>
<th>( I_{\text{fmax}} ) (mA)</th>
<th>( T_{\text{thmax}} ) (°C)</th>
<th>Package</th>
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</thead>
<tbody>
<tr>
<td>ZXT790AK</td>
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<td>ZXT791AK</td>
<td>PNP</td>
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<td>-6</td>
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<td>-185</td>
<td>95</td>
<td>DPAK</td>
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<td>ZXT792AK</td>
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<td>-10</td>
<td>-10</td>
<td>-175</td>
<td>95</td>
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</table>

Variable speed control circuit using combined PWM and thermistor inputs.
Transistors for two-phase fan motor driving

To interface the ZXBM motor pre-driver ICs with two-phase motor windings, Zetex offers a wide range of suitable bipolar transistor and MOSFET packages:

### NPN bipolar transistors

<table>
<thead>
<tr>
<th>Part number</th>
<th>Polarity</th>
<th>VCEO</th>
<th>IC</th>
<th>Max</th>
<th>IB</th>
<th>VCEO</th>
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<tr>
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<td>ZX1053D</td>
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<tr>
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<td>N</td>
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<td>100</td>
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<td>10</td>
<td>SO189</td>
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<tr>
<td>XMN6A13K</td>
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<td>220</td>
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<td>50</td>
<td>SO189</td>
</tr>
<tr>
<td>XMN6A124</td>
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<td>125</td>
<td>1</td>
<td>250</td>
<td>5</td>
<td>10</td>
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</tr>
<tr>
<td>ZX185S</td>
<td>NPN</td>
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<td>355</td>
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<td>SO189</td>
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<tr>
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<td>6</td>
<td>70</td>
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<td>50</td>
<td>SOT223</td>
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<tr>
<td>ZET21011G</td>
<td>NPN</td>
<td>100</td>
<td>6</td>
<td>220</td>
<td>5</td>
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<td>SOT223</td>
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### 60V N-channel MOSFETs

<table>
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<th>Part number</th>
<th>Polarity</th>
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<th>ID</th>
<th>IR</th>
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<td>11.2</td>
<td>0.45</td>
<td>DPAK</td>
<td></td>
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<td>ZXMN6A1242</td>
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<td>0.18</td>
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<tr>
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### 100V N-channel MOSFETs

<table>
<thead>
<tr>
<th>Part number</th>
<th>Polarity</th>
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<th>Package</th>
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</table>

Application notes

The following application notes for the ZXBM1004 and ZXBM2004 can be found at www.zetex.com/motorapplications

- AN41 - Fan motor speed control using PWM input
- AN42 - Fan motor speed control using PWM input
- AN43 - Interfacing to the motor windings

For further motor control application information visit www.zetex.com/motorapplications

Demonstration boards

Subject to availability and qualification procedures, demonstration boards can be made available to customers for many of the ZXBM series motor pre-driver ICs. Boards can also be modified or designed for specific customer applications.

To request a demonstration board contact your local Zetex office:

- asia.sales@zetex.com
- europe.sales@zetex.com
- usa.sales@zetex.com
Transistors for two-phase fan motor driving

To interface the ZXBM motor pre-driver ICs with two-phase motor windings, Zetex offers a wide range of suitable bipolar transistor and MOSFET packages:

### NPN bipolar transistors

| Part number | Polarity | \(V_{CEO}\) | \(I_C\) | \(\beta\) | \(R_{EB(OFF)}\) | \(V_{CEO} \times \beta\) | Package |
|-------------|----------|-------------|--------|---------|----------------|----------------|
| ZXMN6A07Z  | NPN      | 75          | 3      |         |                |                | SOT89    |
| ZXMN6A09K  | NPN      | 100         | 1      | 100     | 0.6           | 60             | DPAK     |
| ZXMN6A11G  | NPN      | 30          | 3      | 25      | 0.1           | 10              | SOT89    |
| ZXMN10A07Z | NPN      | 100         | 1      | 100     | 0.5           | 50              | SOT89    |
| ZXMN10A09K | NPN      | 70          | 2      | 20      | 0.2           | 10              | SOT123   |
| ZXMN10A11G | NPN      | 125         | 1      | 250     | 1             | 50              | SOT123   |
| ZXMN125A07 | NPN      | 60          | 6      | 35      | 0.5           | 30              | SOT223   |
| ZXMN125A09 | NPN      | 100         | 6      | 100     | 1             | 50              | SOT223   |

### 60V N-channel MOSFETs

<table>
<thead>
<tr>
<th>Part number</th>
<th>Polarity</th>
<th>(V_{DSS})</th>
<th>(I_D)</th>
<th>(r_{on})</th>
<th>(\bar{R}_D)</th>
<th>Package</th>
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<td>4.7</td>
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<td>0.095</td>
<td>SO8</td>
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</table>

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<table>
<thead>
<tr>
<th>Part number</th>
<th>Polarity</th>
<th>(V_{DSS})</th>
<th>(I_D)</th>
<th>(r_{on})</th>
<th>(\bar{R}_D)</th>
<th>Package</th>
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<tr>
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<td>100</td>
<td>2.4</td>
<td></td>
<td>0.35</td>
<td>SOT223</td>
</tr>
</tbody>
</table>

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- usa.sales@zetex.com

For an example of a demonstration board, refer to the image provided.
APPLICATION FOCUS

Variable speed brushless DC motor pre-drivers

About Zetex

Zetex Semiconductors designs and manufactures high performance semiconductor solutions for analog signal processing and the management of power in automotive, communications, consumer and industrial electronics.

Meeting the demand for greater power economy, precision and speed in analog circuit design, the broad Zetex product range comprises application specific linear ICs and discrete semiconductor devices in multiple package configurations.

As a specialist in analog technology, Zetex offers a diverse series of ICs for motor control, lighting and DC-DC conversion as well as audio, video and linear applications. Its discrete component range features trench MOSFETs, IntelliFET™ smart MOSFETs and bipolar transistors.

Headquartered near Manchester in the UK, Zetex Semiconductors has manufacturing and sales operations in Asia, Europe and the USA and is supported by distributors in more than 45 countries.

For more information about Zetex, please visit
www.zetex.com
www.zetex.cn

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