TP5335

P-Channel Enhancement-Mode Vertical DMOS FET

Features
• High Input Impedance and High Gain
• Low Power Drive Requirement
• Ease of Paralleling
• Low $C_{ISS}$ and Fast Switching Speeds
• Excellent Thermal Stability
• Integral Source-Drain Diode
• Free from Secondary Breakdown

Applications
• Logic-Level Interfaces (Ideal for TTL and CMOS)
• Solid-State Relays
• Analog Switches
• Power Management
• Telecommunication Switches

General Description
The TP5335 is a low-threshold, Enhancement-mode (normally-off) transistor that utilizes an advanced vertical DMOS structure and a well-proven silicon gate manufacturing process. This combination produces a device with the power handling capabilities of bipolar transistors and the high input impedance and positive temperature coefficient inherent in MOS devices. Characteristic of all MOS structures, this device is free from thermal runaway and thermally induced secondary breakdown.

Microchip’s vertical DMOS FETs are ideally suited to a wide range of switching and amplifying applications where high breakdown voltage, high input impedance, low input capacitance, and fast switching speeds are desired.

Package Type

3-lead SOT-23 (Top view)

DRAIN
SOURCE
GATE

See Table 2-1 for pin information.
## 1.0 ELECTRICAL CHARACTERISTICS

### Absolute Maximum Ratings†

- Drain-to-Source Voltage: \( V_{BVDSS} \)
- Drain-to-Gate Voltage: \( V_{BVDGS} \)
- Gate-to-Source Voltage: \( \pm 20 \, \text{V} \)
- Junction Temperature, \( T_J \): \(-55°C\) to \(+150°C\)
- Storage Temperature, \( T_S \): \(-55°C\) to \(+150°C\)

† Notice: Stresses above those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress rating only, and functional operation of the device at those or any other conditions above those indicated in the operational sections of this specification is not intended. Exposure to maximum rating conditions for extended periods may affect device reliability.

### DC ELECTRICAL CHARACTERISTICS – COMMERCIAL

**Electrical Specifications:** \( T_A = T_J = 25°C \) unless otherwise specified. All DC parameters are 100% tested at 25°C unless otherwise stated. (Pulse test: 300 µs pulse, 2% duty cycle.)

| Parameter                                                       | Sym.   | Min.   | Typ.   | Max.   | Unit            | Conditions                                      |
|                                                               |        |        |        |        |                 |                                                |
| Drain-to-Source Breakdown Voltage                             | \( V_{BVDSS} \) | –350   | —      | —      | V               | \( V_{GS} = 0 \, \text{V}, I_D = –100 \, \mu\text{A} \) |
| Gate Threshold Voltage                                        | \( V_{GS(th)} \) | –1     | —      | –2.4   | V               | \( V_{DS} = V_{GS}, I_D = –1 \, \text{mA} \) |
| Change in \( V_{GS(th)} \) with Temperature                  | \( \Delta V_{GS(th)} \) | —      | —      | 4.5    | mV/°C           | \( V_{DS} = V_{GS}, I_D = –1 \, \text{mA} \) (Note 1) |
| Gate Body Leakage                                             | \( I_{GSS} \) | —      | —      | –100   | nA              | \( V_{GS} = \pm 20 \, \text{V}, V_{DS} = 0 \, \text{V} \) |
| Zero-Gate Voltage Drain Current                               | \( I_{DSS} \) | —      | —      | –1     | μA              | \( V_{DS} = \text{Maximum rating}, V_{GS} = 0 \, \text{V} \) |
| On-State Drain Current                                        | \( I_{D(ON)} \) | –200   | —      | —      | mA              | \( V_{GS} = –4.5 \, \text{V}, V_{DS} = –25 \, \text{V} \) |
| Static Drain-to-Source On-State Resistance                    | \( R_{DS(ON)} \) | —      | —      | 75     | Ω               | \( V_{GS} = –4.5 \, \text{V}, I_D = –150 \, \text{mA} \) |
| Change in \( R_{DS(ON)} \) with Temperature                  | \( \Delta R_{DS(ON)} \) | —      | —      | 1.7    | %/°C            | \( V_{GS} = –10 \, \text{V}, I_D = –200 \, \text{mA} \) (Note 1) |

Note 1: Specification is obtained by characterization and is not 100% tested.

### DC ELECTRICAL CHARACTERISTICS – AUTOMOTIVE

**Electrical Specifications:** \( T_A = T_J = (–55°C, 25°C, \) or \( 150°C \) unless otherwise specified. All DC parameters are 100% tested at all three temperatures unless otherwise stated. (Pulse test: 300 µs pulse, 2% duty cycle.)

| Parameter                                                       | Sym.   | Min.   | Typ.   | Max.   | Unit            | Conditions                                      |
|                                                               |        |        |        |        |                 |                                                |
| Drain-to-Source Breakdown Voltage                             | \( V_{BVDSS} \) | –350   | —      | —      | V               | \( V_{GS} = 0 \, \text{V}, I_D = –100 \, \mu\text{A} \) |
| Gate Threshold Voltage                                        | \( V_{GS(th)} \) | –1     | —      | –2.4   | V               | \( V_{DS} = V_{GS}, I_D = –1 \, \text{mA} \) |
| Change in \( V_{GS(th)} \) with Temperature                  | \( \Delta V_{GS(th)} \) | —      | —      | 3.3    | mV/°C           | \( V_{DS} = V_{GS}, I_D = –1 \, \text{mA} \) (Note 1) |
| Gate Body Leakage                                             | \( I_{GSS} \) | —      | —      | –100   | nA              | \( V_{GS} = \pm 20 \, \text{V}, V_{DS} = 0 \, \text{V} \) |

Note 1: Specification is obtained by characterization and is not 100% tested.
## DC ELECTRICAL CHARACTERISTICS – AUTOMOTIVE (CONTINUED)

**Electrical Specifications:** $T_A = T_J = (-55°C, 25°C, or 150°C)$ unless otherwise specified. All DC parameters are 100% tested at all three temperatures unless otherwise stated. (Pulse test: 300 µs pulse, 2% duty cycle.)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Sym.</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zero-Gate Voltage Drain Current</td>
<td>$I_{DSS}$</td>
<td>—</td>
<td>—</td>
<td>$-10$</td>
<td>µA</td>
<td>$V_{DS} =$ Maximum rating, $V_{GS} = 0V$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$V_{DS} =$ Maximum rating, $V_{GS} = 0V$, $T_A = 150°C$</td>
</tr>
<tr>
<td>On-State Drain Current</td>
<td>$I_{D(ON)}$</td>
<td>$-200$</td>
<td>—</td>
<td>—</td>
<td>mA</td>
<td>$V_{GS} = -4.5V, V_{DS} = -25V$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$V_{GS} = -10V, V_{DS} = -25V$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$V_{GS} = -10V, V_{DS} = -25V$, $T_A = 150°C$</td>
</tr>
<tr>
<td>Static Drain-to-Source On-State Resistance</td>
<td>$R_{DS(ON)}$</td>
<td>—</td>
<td>—</td>
<td>75</td>
<td>Ω</td>
<td>$V_{GS} = -4.5V, I_D = -150mA$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$V_{GS} = -10V, I_D = -200mA$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$V_{GS} = -10V, I_D = -200mA$, $T_A = 150°C$</td>
</tr>
<tr>
<td>Change in $R_{DS(ON)}$ with Temperature</td>
<td>$\Delta R_{DS(ON)}$</td>
<td>—</td>
<td>1</td>
<td>—</td>
<td>%/°C</td>
<td>$V_{GS} = -10V, I_D = -200mA$ (Note 1)</td>
</tr>
</tbody>
</table>

**Note 1:** Specification is obtained by characterization and is not 100% tested.

## AC ELECTRICAL CHARACTERISTICS – COMMERCIAL

**Electrical Specifications:** $T_A = T_J = 25°C$ unless otherwise specified. Specification is obtained by characterization and is not 100% tested.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Sym.</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forward Transconductance</td>
<td>$G_{FS}$</td>
<td>125</td>
<td>—</td>
<td>—</td>
<td>mmho</td>
<td>$V_{DS} = -25V, I_D = -200mA$</td>
</tr>
<tr>
<td>Input Capacitance</td>
<td>$C_{ISS}$</td>
<td>—</td>
<td>—</td>
<td>110</td>
<td>pF</td>
<td></td>
</tr>
<tr>
<td>Common Source Output Capacitance</td>
<td>$C_{OSS}$</td>
<td>—</td>
<td>—</td>
<td>60</td>
<td>pF</td>
<td>$V_{GS} = 0V, V_{DS} = -25V$, $f = 1$ MHz</td>
</tr>
<tr>
<td>Reverse Transfer Capacitance</td>
<td>$C_{RSS}$</td>
<td>—</td>
<td>—</td>
<td>22</td>
<td>pF</td>
<td></td>
</tr>
<tr>
<td>Turn-On Delay Time</td>
<td>$t_{d(ON)}$</td>
<td>—</td>
<td>—</td>
<td>20</td>
<td>ns</td>
<td>$V_{DD} = -25V, I_D = -150mA$, $R_{GEN} = 25Ω$</td>
</tr>
<tr>
<td>Rise Time</td>
<td>$t_r$</td>
<td>—</td>
<td>—</td>
<td>15</td>
<td>ns</td>
<td></td>
</tr>
<tr>
<td>Turn-Off Delay Time</td>
<td>$t_{d(OFF)}$</td>
<td>—</td>
<td>—</td>
<td>25</td>
<td>ns</td>
<td></td>
</tr>
<tr>
<td>Fall Time</td>
<td>$t_f$</td>
<td>—</td>
<td>—</td>
<td>25</td>
<td>ns</td>
<td></td>
</tr>
</tbody>
</table>

### DIODE PARAMETER

| Parameter                                      | $V_{SD}$ | —    | —    | $-1.8$ | V    | $V_{GS} = 0V, I_{SD} = -200mA$ (Note 1) |
| Reverse Recovery Time                          | $t_{rr}$ | —    | 800  | —      | ns   | $V_{GS} = 0V, I_{SD} = -200mA$ |

**Note 1:** All DC parameters are 100% tested at 25°C unless otherwise stated. (Pulse test: 300 µs pulse, 2% duty cycle.)
# AC ELECTRICAL CHARACTERISTICS – AUTOMOTIVE

**Electrical Specifications:** $T_A = T_J = 25^\circ\text{C}$ unless otherwise specified. Specification is obtained by characterization and is not 100% tested.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Sym.</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forward Transconductance</td>
<td>$G_{FS}$</td>
<td>—</td>
<td>285</td>
<td>—</td>
<td>$\text{mmho}$</td>
<td>$V_{DS} = -25\text{V}, I_D = -200\text{ mA}$</td>
</tr>
<tr>
<td>Input Capacitance</td>
<td>$C_{ISS}$</td>
<td>—</td>
<td>80</td>
<td>—</td>
<td>$\text{pF}$</td>
<td>$V_{GS} = 0\text{V}, V_{DS} = -25\text{V}, f = 1\text{ MHz}$</td>
</tr>
<tr>
<td>Common Source Output Capacitance</td>
<td>$C_{OSS}$</td>
<td>—</td>
<td>12</td>
<td>—</td>
<td>$\text{pF}$</td>
<td>$V_{DD} = -25\text{V}, I_D = -150\text{ mA}, R_{GEN} = 25\Omega$</td>
</tr>
<tr>
<td>Reverse Transfer Capacitance</td>
<td>$C_{RSS}$</td>
<td>—</td>
<td>2</td>
<td>—</td>
<td>$\text{pF}$</td>
<td>$V_{GS} = 0\text{V}, I_{SD} = -200\text{ mA}$ (Note 1)</td>
</tr>
<tr>
<td>Turn-On Delay Time</td>
<td>$t_d(\text{ON})$</td>
<td>—</td>
<td>7.6</td>
<td>—</td>
<td>$\text{ns}$</td>
<td>$V_{DD} = -25\text{V}, I_D = -150\text{ mA}, R_{GEN} = 25\Omega$</td>
</tr>
<tr>
<td>Rise Time</td>
<td>$t_r$</td>
<td>—</td>
<td>3</td>
<td>—</td>
<td>$\text{ns}$</td>
<td>$V_{GS} = 0\text{V}, I_{SD} = -200\text{ mA}$ (Note 1)</td>
</tr>
<tr>
<td>Turn-Off Delay Time</td>
<td>$t_d(\text{OFF})$</td>
<td>—</td>
<td>19</td>
<td>—</td>
<td>$\text{ns}$</td>
<td>$V_{GS} = 0\text{V}, I_{SD} = -200\text{ mA}$ (Note 1)</td>
</tr>
<tr>
<td>Fall Time</td>
<td>$t_f$</td>
<td>—</td>
<td>10</td>
<td>—</td>
<td>$\text{ns}$</td>
<td>$V_{GS} = 0\text{V}, I_{SD} = -200\text{ mA}$ (Note 1)</td>
</tr>
</tbody>
</table>

**DIODE PARAMETER**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Sym.</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diode Forward Voltage Drop</td>
<td>$V_{SD}$</td>
<td>—</td>
<td>—</td>
<td>—1.8</td>
<td>$\text{V}$</td>
<td>$V_{GS} = 0\text{V}, I_{SD} = -200\text{ mA}$ (Note 1)</td>
</tr>
<tr>
<td>Reverse Recovery Time</td>
<td>$t_{rr}$</td>
<td>—</td>
<td>450</td>
<td>—</td>
<td>$\text{ns}$</td>
<td>$V_{GS} = 0\text{V}, I_{SD} = -200\text{ mA}$ (Note 1)</td>
</tr>
</tbody>
</table>

*Note 1:* 100% Production Tested at $T_A = T_J = (-55^\circ\text{C}, 25^\circ\text{C},$ and $150^\circ\text{C}$).

## TEMPERATURE SPECIFICATIONS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Sym.</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TEMPERATURE RANGE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating Junction Temperature</td>
<td>$T_J$</td>
<td>−55</td>
<td>—</td>
<td>+150</td>
<td>$^\circ\text{C}$</td>
<td>$V_{GS} = 0\text{V}, I_{SD} = -200\text{ mA}$ (Note 1)</td>
</tr>
<tr>
<td>Storage Temperature</td>
<td>$T_S$</td>
<td>−55</td>
<td>—</td>
<td>+150</td>
<td>$^\circ\text{C}$</td>
<td></td>
</tr>
</tbody>
</table>

**PACKAGE THERMAL RESISTANCE**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Sym.</th>
<th>Min.</th>
<th>Typ.</th>
<th>Unit</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-lead SOT-23</td>
<td>$\theta_{JA}$</td>
<td>—</td>
<td>203</td>
<td>$^\circ\text{C}/\text{W}$</td>
<td>$V_{GS} = 0\text{V}, I_{SD} = -200\text{ mA}$ (Note 1)</td>
</tr>
</tbody>
</table>

## THERMAL CHARACTERISTICS

<table>
<thead>
<tr>
<th>Package</th>
<th>$I_D$ (Note 1) (Continuous) (mA)</th>
<th>$I_D$ (Pulsed) (mA)</th>
<th>Power Dissipation at $T_A = 25^\circ\text{C}$ (W)</th>
<th>$I_{DR}$ (Note 1) (mA)</th>
<th>$I_{DRM}$ (mA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-lead SOT-23</td>
<td>−85</td>
<td>−400</td>
<td>0.36</td>
<td>−85</td>
<td>−400</td>
</tr>
</tbody>
</table>

*Note 1:* $I_D$ (continuous) is limited by maximum $T_J$. 
2.0 PIN DESCRIPTION

Table 2-1 shows the description of pins in TP5335 SOT-23. Refer to Package Type for the location of pins.

<table>
<thead>
<tr>
<th>Pin Number</th>
<th>Pin Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Gate</td>
<td>Gate</td>
</tr>
<tr>
<td>2</td>
<td>Source</td>
<td>Source</td>
</tr>
<tr>
<td>3</td>
<td>Drain</td>
<td>Drain</td>
</tr>
</tbody>
</table>
3.0 FUNCTIONAL DESCRIPTION

Figure 3-1 illustrates the switching waveforms and test circuit for TP5335.

TABLE 3-1: PRODUCT SUMMARY

<table>
<thead>
<tr>
<th>$BV_{DSS}/BV_{DGS}$ (V)</th>
<th>$R_{DS(ON)}$ (Maximum) (Ω)</th>
<th>$V_{GS(th)}$ (Maximum) (V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>~350</td>
<td>30</td>
<td>~2.4</td>
</tr>
</tbody>
</table>
4.0 PACKAGING INFORMATION

4.1 Package Marking Information

Legend:
- XX...X  Product Code or Customer-specific information
- Y      Year code (last digit of calendar year)
- YY     Year code (last 2 digits of calendar year)
- WW     Week code (week of January 1 is week ‘01’)
- NNN    Alphanumeric traceability code
- e3     Pb-free JEDEC® designator for Matte Tin (Sn)
*        This package is Pb-free. The Pb-free JEDEC designator (e3) can be found on the outer packaging for this package.

Note: In the event the full Microchip part number cannot be marked on one line, it will be carried over to the next line, thus limiting the number of available characters for product code or customer-specific information. Package may or not include the corporate logo.
3-Lead TO-236AB (SOT-23) Package Outline (K1/T)
2.90x1.30mm body, 1.12mm height (max), 1.90mm pitch

Note: For the most current package drawings, see the Microchip Packaging Specification at www.microchip.com/packaging.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>A</th>
<th>A1</th>
<th>A2</th>
<th>b</th>
<th>D</th>
<th>E</th>
<th>E1</th>
<th>e</th>
<th>e1</th>
<th>L</th>
<th>L1</th>
<th>θ</th>
</tr>
</thead>
<tbody>
<tr>
<td>MIN</td>
<td>0.89</td>
<td>0.01</td>
<td>0.88</td>
<td>0.30</td>
<td>2.80</td>
<td>2.10</td>
<td>1.20</td>
<td>0.95</td>
<td>BSC</td>
<td>0.20°</td>
<td>0.54</td>
<td>0°</td>
</tr>
<tr>
<td>NOM</td>
<td>-</td>
<td>-</td>
<td>0.95</td>
<td>-</td>
<td>2.90</td>
<td>-</td>
<td>1.30</td>
<td>-</td>
<td>BSC</td>
<td>-</td>
<td>0.60</td>
<td>-</td>
</tr>
<tr>
<td>MAX</td>
<td>1.12</td>
<td>0.10</td>
<td>1.02</td>
<td>0.50</td>
<td>3.04</td>
<td>2.64</td>
<td>1.40</td>
<td>-</td>
<td>BSC</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

† This dimension differs from the JEDEC drawing.

Drawings not to scale.
APPENDIX A: REVISION HISTORY

Revision A (December 2018)

• Converted Supertex Doc# DSFP-TP5335 to Microchip DS20005704A
• Made minor text changes throughout the document

Revision B (February 2020)

• Revised the order of pins in the Pin Function Table
• Revised the Electrical Specifications and included notes in the DC Electrical Characteristics and AC Electrical Characteristics tables
• Made minor text changes throughout the document

Revision C (June 2020)

• Added automotive specifications to the Electrical Characteristics section
• Added automotive specifications to the Product Identification System section
• Made minor text changes throughout the document
## PRODUCT IDENTIFICATION SYSTEM

To order or obtain information, e.g., on pricing or delivery, contact your local Microchip representative or sales office.

<table>
<thead>
<tr>
<th>PART NO.</th>
<th>XX</th>
<th>Package Options</th>
<th>X</th>
<th>Environmental</th>
<th>X</th>
<th>Media Type</th>
<th>Option</th>
</tr>
</thead>
</table>

| Device: | TP5335 = P-Channel Enhancement-Mode Vertical DMOS FET |
| Package: | K1 = 3-lead SOT-23 |
| Environmental: | G = Lead (Pb)-free/RoHS-compliant Package |
| Media Type: | (blank) = 3000/Reel for a K1 Package |
| Option: | VAO = Automotive Grade |

**Example:**

a) TP5335K1-G: P-Channel Enhancement-Mode Vertical DMOS FET, 3-lead SOT-23, 3000/Reel

b) TP5335K1-G-VAO: P-Channel Enhancement-Mode Vertical DMOS FET, Automotive Grade, 3-lead SOT-23, 3000/Reel
Note the following details of the code protection feature on Microchip devices:

- Microchip products meet the specification contained in their particular Microchip Data Sheet.
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- There are dishonest and possibly illegal methods used to breach the code protection feature. All of these methods, to our knowledge, require using the Microchip products in a manner outside the operating specifications contained in Microchip’s Data Sheets. Most likely, the person doing so is engaged in theft of intellectual property.
- Microchip is willing to work with the customer who is concerned about the integrity of their code.
- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of their code. Code protection does not mean that we are guaranteeing the product as “unbreakable.”

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