# 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)
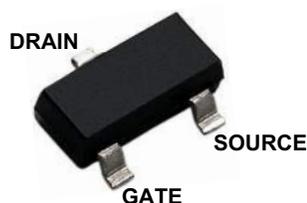
DRAIN

SOURCE

GATE

See Table 2-1 for pin information.

# TP5335

## 1.0 ELECTRICAL CHARACTERISTICS

### Absolute Maximum Ratings(†)

Drain-to-Source Voltage ................................................................................................................................. $BV_{DSS}$
Drain-to-Gate Voltage ................................................................................................................................... $BV_{DGS}$
Gate-to-Source Voltage.................................................................................................................................. ±20V
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 | $BV_{DSS}$ | −350 | — | — | V | $V_{GS} = 0V$, $I_D = −100$ µA |
| Gate Threshold Voltage | $V_{GS(th)}$ | −1 | — | −2.4 | V | $V_{DS} = V_{GS}$, $I_D = −1$ mA |
| Change in $V_{GS(th)}$ with Temperature | $\Delta V_{GS(th)}$ | — | — | 4.5 | mV/°C | $V_{DS} = V_{GS}$, $I_D = −1$ mA (**Note 1**) |
| Gate Body Leakage | $I_{GSS}$ | — | — | −100 | nA | $V_{GS} = ±20V$, $V_{DS} = 0V$ |
| Zero-Gate Voltage Drain Current | $I_{DSS}$ | — | — | −10 | µA | $V_{DS}$ = Maximum rating, $V_{GS} = 0V$ |
| | | — | — | −1 | mA | $V_{DS}$ = Maximum rating, $V_{GS} = 0V$, $T_A = 125°C$ (**Note 1**) |
| On-State Drain Current | $I_{D(ON)}$ | −200 | — | — | mA | $V_{GS} = −4.5V$, $V_{DS} = −25V$ |
| | | −400 | — | — | mA | $V_{GS} = −10V$, $V_{DS} = −25V$ |
| Static Drain-to-Source On-State Resistance | $R_{DS(ON)}$ | — | — | 75 | Ω | $V_{GS} = −4.5V$, $I_D = −150$ mA |
| | | — | — | 30 | Ω | $V_{GS} = −10V$, $I_D = −200$ mA |
| Change in $R_{DS(ON)}$ with Temperature | $\Delta_{RDS(ON)}$ | — | — | 1.7 | %/°C | $V_{GS} = −10V$, $I_D = −200$ mA (**Note 1**) |

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

## DC ELECTRICAL CHARACTERISTICS – AUTOMOTIVE

**Electrical Specifications: Boldface** specification limits apply over the full operating temperature range of $T_A = T_J = −55°C$, 25°C, and 150°C unless otherwise specified. Non-boldfaced specification limits apply only to $T_A = T_J = 25°C$ unless otherwise specified. All DC parameters are 100% tested at all three temperatures unless otherwise specified. (Pulse test: 300 µs pulse, 2% duty cycle.)

| Parameter | Sym. | Min. | Typ. | Max. | Unit | Conditions |
|---|---|---|---|---|---|---|
| Drain-to-Source Breakdown Voltage | $BV_{DSS}$ | **−350** | — | — | V | $V_{GS} = 0V$, $I_D = −100$ µA |
| Gate Threshold Voltage | $V_{GS(th)}$ | −1 | — | **−2.4** | V | $V_{DS} = V_{GS}$, $I_D = −1$ mA |
| Change in $V_{GS(th)}$ with Temperature | $\Delta V_{GS(th)}$ | — | 3.3 | — | mV/°C | $V_{DS} = V_{GS}$, $I_D = −1$ mA (**Note 1**) |
| Gate Body Leakage | $I_{GSS}$ | — | — | −100 | nA | $V_{GS} = ±20V$, $V_{DS} = 0V$ |
| | | — | — | **−220** | nA | $V_{GS} = ±20V$, $V_{DS} = 0V$ |

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

## DC ELECTRICAL CHARACTERISTICS – AUTOMOTIVE (CONTINUED)

**Electrical Specifications: Boldface** specification limits apply over the full operating temperature range of $T_A = T_J = -55°C$, 25°C, and 150°C unless otherwise specified. Non-boldfaced specification limits apply only to $T_A = T_J = 25°C$ unless otherwise specified. All DC parameters are 100% tested at all three temperatures unless otherwise specified. (Pulse test: 300 µs pulse, 2% duty cycle.)

| Parameter | Sym. | Min. | Typ. | Max. | Unit | Conditions |
|---|---|---|---|---|---|---|
| Zero-Gate Voltage Drain Current | $I_{DSS}$ | — | — | –10 | µA | $V_{DS}$ = Maximum rating, $V_{GS}$ = 0V |
| | | — | — | **–1** | mA | $V_{DS}$ = Maximum rating, $V_{GS}$ = 0V |
| On-State Drain Current | $I_{D(ON)}$ | **–200** | — | — | mA | $V_{GS}$ = –4.5V, $V_{DS}$ = –25V |
| | | **–400** | — | — | mA | $V_{GS}$ = –10V, $V_{DS}$ = –25V |
| | | **–375** | — | — | mA | $V_{GS}$ = –10V, $V_{DS}$ = –25V |
| Static Drain-to-Source On-State Resistance | $R_{DS(ON)}$ | — | — | **75** | Ω | $V_{GS}$ = –4.5V, $I_D$ = –150 mA |
| | | — | — | 30 | Ω | $V_{GS}$ = –10V, $I_D$ = –200 mA |
| | | — | — | **70** | Ω | $V_{GS}$ = –10V, $I_D$ = –200 mA |
| Change in $R_{DS(ON)}$ with Temperature | $\Delta_{RDS(ON)}$ | — | 1 | — | %/°C | $V_{GS}$ = –10V, $I_D$ = –200 mA (**Note 1**) |

**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.

| Parameter | Sym. | Min. | Typ. | Max. | Unit | Conditions |
|---|---|---|---|---|---|---|
| Forward Transconductance | $G_{FS}$ | 125 | — | — | mmho | $V_{DS}$ = –25V, $I_D$ = –200 mA |
| Input Capacitance | $C_{ISS}$ | — | — | 110 | pF | $V_{GS}$ = 0V, $V_{DS}$ = –25V, f = 1 MHz |
| Common Source Output Capacitance | $C_{OSS}$ | — | — | 60 | pF | |
| Reverse Transfer Capacitance | $C_{RSS}$ | — | — | 22 | pF | |
| Turn-On Delay Time | $t_{d(ON)}$ | — | — | 20 | ns | $V_{DD}$ = –25V, $I_D$ = –150 mA, $R_{GEN}$ = 25Ω |
| Rise Time | $t_r$ | — | — | 15 | ns | |
| Turn-Off Delay Time | $t_{d(OFF)}$ | — | — | 25 | ns | |
| Fall Time | $t_f$ | — | — | 25 | ns | |
| **DIODE PARAMETER** | | | | | | |
| Diode Forward Voltage Drop | $V_{SD}$ | — | — | –1.8 | V | $V_{GS}$ = 0V, $I_{SD}$ = –200 mA (**Note 1**) |
| Reverse Recovery Time | $t_{rr}$ | — | 800 | — | ns | $V_{GS}$ = 0V, $I_{SD}$ = –200 mA |

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

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## AC ELECTRICAL CHARACTERISTICS – AUTOMOTIVE

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

| Parameter | Sym. | Min. | Typ. | Max. | Unit | Conditions |
|---|---|---|---|---|---|---|
| Forward Transconductance | $G_{FS}$ | — | 285 | — | mmho | $V_{DS} = -25V$, $I_D = -200$ mA |
| Input Capacitance | $C_{ISS}$ | — | 80 | — | pF | $V_{GS} = 0V$, $V_{DS} = -25V$, f = 1 MHz |
| Common Source Output Capacitance | $C_{OSS}$ | — | 12 | — | pF | |
| Reverse Transfer Capacitance | $C_{RSS}$ | — | 2 | — | pF | |
| Turn-On Delay Time | $t_{d(ON)}$ | — | 7.6 | — | ns | $V_{DD} = -25V$, $I_D = -150$ mA, $R_{GEN} = 25\Omega$ |
| Rise Time | $t_r$ | — | 3 | — | ns | |
| Turn-Off Delay Time | $t_{d(OFF)}$ | — | 19 | — | ns | |
| Fall Time | $t_f$ | — | 10 | — | ns | |
| **DIODE PARAMETER** | | | | | | |
| Diode Forward Voltage Drop | $V_{SD}$ | — | — | –1.8 | V | $V_{GS} = 0V$, $I_{SD} = -200$ mA (**Note 1**) |
| Reverse Recovery Time | $t_{rr}$ | — | 450 | — | ns | $V_{GS} = 0V$, $I_{SD} = -200$ mA |

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

## TEMPERATURE SPECIFICATIONS

| Parameter | Sym. | Min. | Typ. | Max. | Unit | Conditions |
|---|---|---|---|---|---|---|
| **TEMPERATURE RANGE** | | | | | | |
| Operating Junction Temperature | $T_J$ | –55 | — | +150 | °C | |
| Storage Temperature | $T_S$ | –55 | — | +150 | °C | |
| **PACKAGE THERMAL RESISTANCE** | | | | | | |
| 3-lead SOT-23 | $\theta_{JA}$ | — | 203 | — | °C/W | |

## THERMAL CHARACTERISTICS

| Package | $I_D$ (**Note 1**) (Continuous) (mA) | $I_D$ (Pulsed) (mA) | Power Dissipation at $T_A = 25°C$ (W) | $I_{DR}$ (**Note 1**) (mA) | $I_{DRM}$ (mA) |
|---|---|---|---|---|---|
| 3-lead SOT-23 | –85 | –400 | 0.36 | –85 | –400 |

**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 2-1:      PIN FUNCTION TABLE**

| Pin Number | Pin Name | Description |
|:---:|:---:|:---|
| 1 | Gate | Gate |
| 2 | Source | Source |
| 3 | Drain | Drain |

## 3.0 FUNCTIONAL DESCRIPTION

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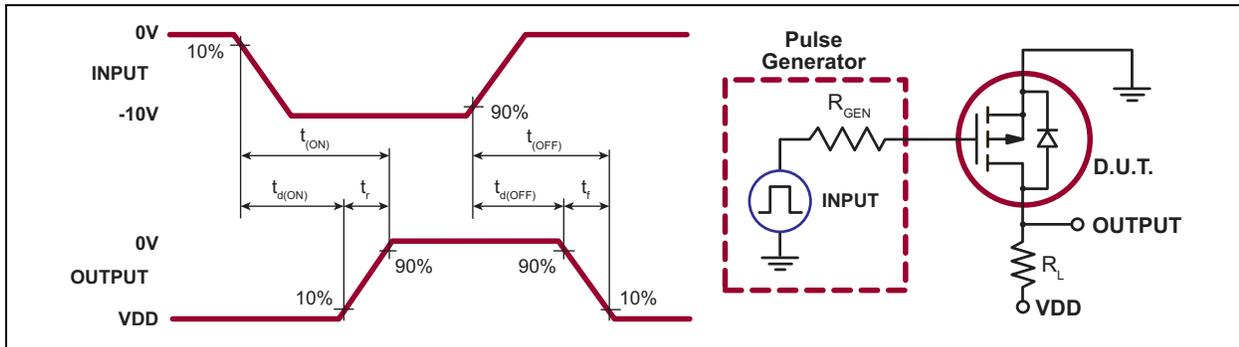


**FIGURE 3-1:** *Switching Waveforms and Test Circuit.*

**TABLE 3-1: PRODUCT SUMMARY**

| $BV_{DSS}/BV_{DGS}$ (V) | $R_{DS(ON)}$ (Maximum) ($\Omega$) | $V_{GS(th)}$ (Maximum) (V) |
|---|---|---|
| −350 | 30 | −2.4 |

## 4.0 PACKAGING INFORMATION

### 4.1 Package Marking Information

3-Lead SOT-23
(2.90 mm X 1.30 mm)

Example

XXXNNN

P3S256
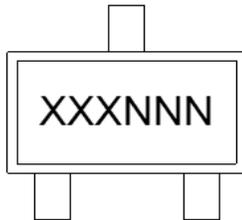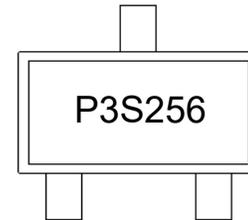
| **Legend:** | XX...X | Product Code or Customer-specific information |
|---|---|---|
| | Y | Year code (last digit of calendar year) |
| | YY | Year code (last 2 digits of calendar year) |
| | WW | Week code (week of January 1 is week '01') |
| | NNN | Alphanumeric traceability code |
| | (e3) | Pb-free 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 customer-specific information. Package may or not include the corporate logo.

# TP5335

## 3-Lead TO-236AB (SOT-23) Package Outline (K1/T)
### *2.90x1.30mm body, 1.12mm height (max), 1.90mm pitch*



**Top View**

**View B**

**Side View**

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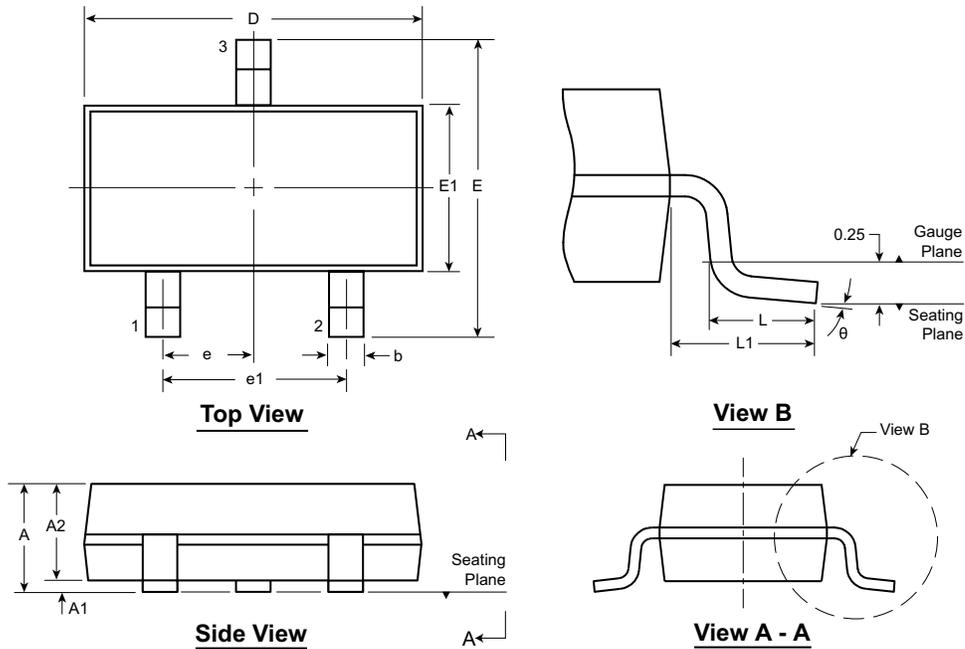
Note: For the most current package drawings, see the Microchip Packaging Specification at www.microchip.com/packaging.

| Symbol | | A | A1 | A2 | b | D | E | E1 | e | e1 | L | L1 | θ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dimension (mm) | MIN | 0.89 | 0.01 | 0.88 | 0.30 | 2.80 | 2.10 | 1.20 | 0.95 BSC | 1.90 BSC | 0.20† | 0.54 REF | 0° |
| | NOM | - | - | 0.95 | - | 2.90 | - | 1.30 | | | 0.50 | | - |
| | MAX | 1.12 | 0.10 | 1.02 | 0.50 | 3.04 | 2.64 | 1.40 | | | 0.60 | | 8° |

*JEDEC Registration TO-236, Variation AB, Issue H, Jan. 1999.*
*† This dimension differs from the JEDEC drawing.*
***Drawings not to scale.***

## APPENDIX A: REVISION HISTORY

### Revision D (March 2022)

• Updated tables DC Electrical Characteristics – Automotive and AC Electrical Characteristics – Automotive.
• Updated Section 4.1 "Package Marking Information".
• Updated Product Identification System format.
• Updated legal and contact information.

### 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.

### 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 A (December 2018)

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

# 2N7000

**NOTES:**

# TP5335

## PRODUCT IDENTIFICATION SYSTEM

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

| PART NO. | XX | -X | -XXX |
|---|---|---|---|
| Device | Package | Environmental | Qualification |

| | | |
|---|---|---|
| **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 |
| **Qualification:** | (Blank) VAO | = Standard Part = Automotive AEC-Q100 Qualified |

**Examples:**

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, Automotive Grade

**NOTES:**

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