INTEGRATED FAN / MOTOR DRIVER

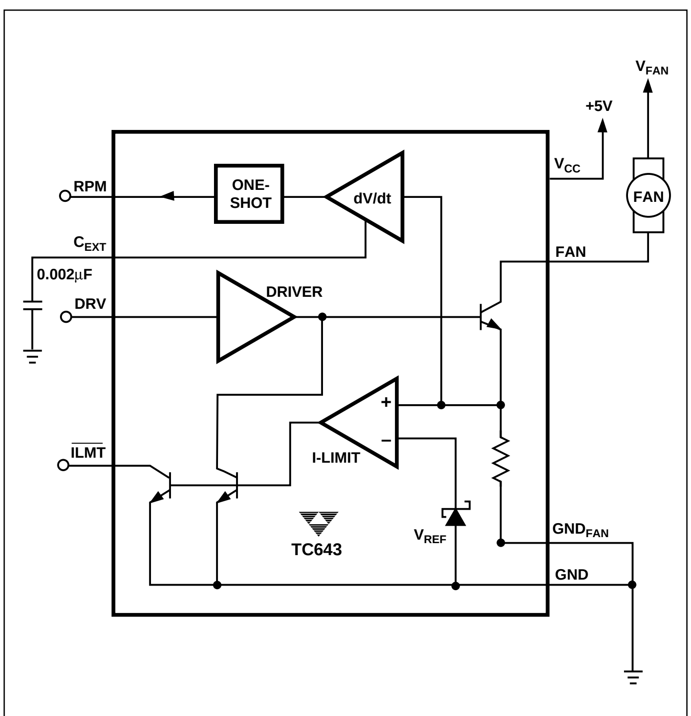
FEATURES

- **Integrates Current Limited Power Driver and Diagnostic/Monitoring Circuits in a Single IC**
- **Works with Standard DC Brushless Fans/Motors**
- **Supports Efficient PWM Drive with Logic-Level Input**
- **Supply Range .... 2.7V to 5.5V**
- **Motor Voltage Independent of TC643 Supply Voltage; Supports 3V-15V Fans!**
- **Logic-Level Output Provides RPM Data**
- **Optimized For Use as a Microcontroller Peripheral**
- **Eliminates Discrete Components and Analog Circuit Design Effort**
- **Internal Thermal Shutdown For Fail-safe Operation**
- **Available in 8-Pin PDIP, SOIC, and MSOP Packaging**

APPLICATIONS

- **General Purpose Fan or Motor Speed Control**
- **Power Supplies**
- **Portable and Desktop Computers**
- **Telecom Equipment, Servers**
- **UPS's, Power Amps, etc.**

FUNCTIONAL BLOCK DIAGRAM



GENERAL DESCRIPTION

The TC643 is a switchmode brushless DC fan/motor speed driver with diagnostic circuits. External components are kept to a minimum by integrating the power transistor on chip. Any logic-level signal can be used to drive the on-chip Power Driver. The output is current limited and a logic-level indication, $\overline{ILMT}$, is provided to indicate an over-current condition.

The RPM output gives an indication of motor RPM. Each time the motor current is interrupted by commutation, a logic pulse occurs on RPM. The fundamental frequency of the resulting square wave is (4 x rpm). See the *Applications* section for more information and system design guidelines.

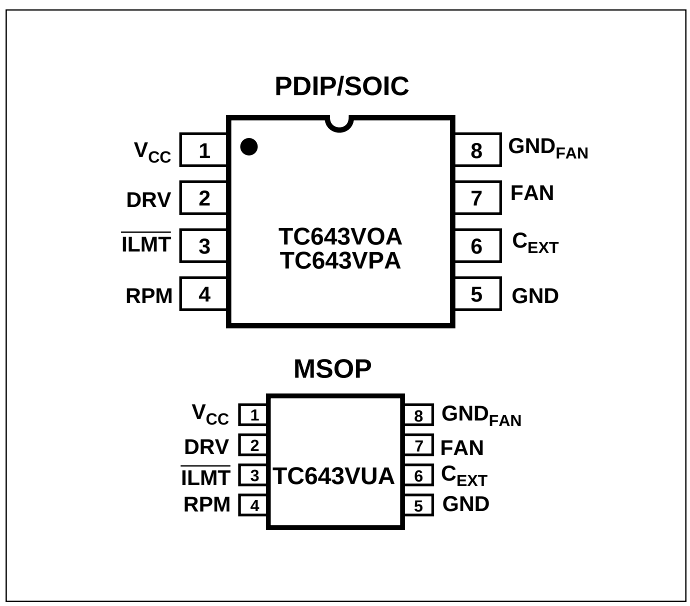
The TC643 mates easily with microcontrollers or other digital logic to form a complete motor or fan control and monitoring system, featuring: Variable Speed PWM Drive; RPM Indication; and Motor Open / Motor Shorted / Motor Locked Fault Detection.

The TC643 is available in a standard 8-pin plastic DIP, SOIC, and MSOP package.

ORDERING INFORMATION

Part No.	Package	Temp. Range
TC643VOA	8-Pin SOIC	0°C to +85°C
TC643VPA	8-Pin Plastic DIP	0°C to +85°C
TC643VUA	8-Pin MSOP	0°C to +85°C

PIN CONFIGURATIONS



TC643

ABSOLUTE MAXIMUM RATINGS*

Package Power Dissipation ($T_A \leq 70°C$)
- Plastic DIP 730mW
- Small Outline (SOIC) 470mW
- MSOP 320mW

Derating Factors .... 8mW/°C
Supply Voltage 6V
Input Voltage, Any Pin .... (GDN – 0.3V) to (V_{CC} + 0.3V)
Operating Temperature (Note 3) .... – 40°C to +125°C
Maximum Chip Temperature (Note 3) .... +150°C
Storage Temperature .... – 65°C to +150°C
Lead Temperature (Soldering, 10 sec) .... +300°C

*Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other conditions above those indicated in the operation sections of the specifications is not implied. Exposure to Absolute Maximum Rating conditions for extended periods may affect device reliability.

ELECTRICAL CHARACTERISTICS: Over Operating Temperature Range, V_{CC} = 3.0V to 5.5V ±10%, GND = GND_{FAN} = 0V, unless otherwise specified.

Symbol	Parameter	Test Conditions	Min	Typ	Max	Units
V_{CC}	Supply Voltage		2.7	5	5.5	V
I_{CC}	Supply Current, Operating	I_L = 300mA	—	16	24	mA
$I_{DD(SHDN)}$	Supply Current, Shutdown Mode	DRV < V_{IL}; $\overline{\text{ILMT}}$, RPM Open	—	.9	2	mA
I_{LIMIT}	Preset Current Limit		—	500	—	mA
C_{EXT}	Differentiator Capacitor	Note 1	—	0.002	—	µF
Power Driver						
V_{FAN}	Breakdown Voltage at Fan	DRV ≤ V_{IL}	15	—	—	V
$V_{CE(SAT)}$	Saturation Voltage (Voltage at FAN)	Duty Cycle = 90%; V_{FAN} = 12.0V I_{FAN} = 300mA DC I_{FAN} = 200mA DC I_{FAN} = 100mA DC	— 600	— 1200 800 400	— 1600 — —	— mV
I_{FAN}	Average Sink Current at FAN Output	DRV > V_{IH} Note 4	—	—	300	mA
t_R	FAN Rise Time	R_L = 120Ω to Fan Supply; C_L = 1pF to GND	—	80	—	µsec
t_F	FAN Fall Time	R_L = 120Ω to Fan Supply; C_L = 1pF to GND	—	80	—	µsec
I_{LEAK}	Leakage Current	R_L = 120Ω to Fan Supply; C_L = 1pF to GND	—	—	1	mA
DRV Input						
V_{IH}	Input High Voltage		2.0	—	—	V
V_{IL}	Input Low Voltage		—	—	0.8	V
I_L	Input Leakage		—	—	5	µA
$\overline{\text{ILMT}}$ Output						
V_{OL}	Output Low Voltage	I_{OL} = 2.5mA	—	—	0.3	V
t_{PROP}	Time Delay from $I_{FAN} > I_{LIMIT}$	V_{FAN} Connected to +12V	—	10	—	µsec
RPM Output						
V_{OH}	Output High Voltage	I_{OH} ≤ 100µA	V_{DD} – 0.3	—	—	V
V_{OL}	Output Low Voltage	R_L = 47kΩ to V_{DD}	—	—	0.3	V
t_R	Rise Time	RPM Output Open Circuited	—	50	—	nsec
t_F	Fall Time		—	50	—	nsec

ELECTRICAL CHARACTERISTICS: (Cont.) Over Operating Temperature Range, V_{CC} = 3.0V to 5.5V ±10%, GND = GND_{FAN} = 0V, unless otherwise specified.

Symbol	Parameter	Test Conditions	Min	Typ	Max	Units
t_{PW}	Pulse Width	Note 2	20	—	—	µsec
t_{SHDN}	Thermal Shutdown Temperature		—	150	—	°C

NOTES: 1. See the *Applications* section for specific capacitor recommendations and guidelines.
2. Refer to the *Applications* section for a detailed explanation.
3. Automatic thermal shutdown is activated at approximately 150°C junction temperature.
4. Maximum sink current in MSOP package is limited by power dissipation.

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PIN DESCRIPTION

Pin No. (DIP/SOIC/MSOP)	Symbol	Description
1	V_{CC}	Power Supply Input. The IC's supply voltage can be independent of the fan's supply voltage. See *Electrical Characteristics* section.
2	DRV	Digital input. This pin directly drives the internal power driver. The power driver is ON when this pin is HIGH, OFF when it is LOW. DRIVE is typically driven by a host microcontroller or other digital logic with a PWM signal to accomplish fan/motor speed control.
3	$\overline{ILMT}$	Digital (Open Collector) Output. If the output current, I_{FAN}, exceeds I_{LIMIT}, this output will go low. I_{FAN} will be clamped at I_{LIMIT}. This serves as an indication of a stalled or shorted motor, or other fault.
4	RPM	Digital Output. Each time the motor current is interrupted by a pole-crossing, a logic-level pulse occurs at this pin. Timing the fundamental frequency of the resulting waveform yields motor RPM. See the *Applications* Section for more details and example circuits.
5	GND	Ground Terminal. This is the ground terminal for the IC itself. A separate ground terminal, GND_{FAN}, is provided for the motor.
6	C_{EXT}	External Capacitor. A 0.002µF capacitor between this pin and ground is used to differentiate the fan's commutation pulses. This function is part of the internal signal conditioning circuitry that generates the RPM output.
7	FAN	Analog input. The negative terminal of the fan motor is connected to this terminal. This terminal is essentially the collector of an internal NPN transistor. It will be pulled to within $V_{CE(SAT)}$ of GND_{FAN} when the PWM is on. FAN will stand off 15V.
8	GND_{FAN}	Analog Output. This is a separate ground terminal for the fan motor return current. It is essentially the emitter of an NPN transistor. See the *Electrical Characteristics* section for more details.

DETAILED DESCRIPTION

The TC643 is the first IC which integrates all the power and analog signal-processing circuitry for fan management into a single, easy-to-use device. Only three logic signals interface the TC643 to its host. A number of value-added features can now be implemented by the system designer with minimal impact on cost, space, and design time. The advantages of a fan management system built around the TC643 may include:

(1) High Integration: higher reliability, lower cost, less design effort.
(2) PWM Speed Control: better efficiency, reduced operating temperatures, wide speed-control range, less acoustic noise, longer fan life, speed control of low-voltage fans without stalling.
(3) Fan Feedback and Diagnostics: system-level fault-tolerance, device-level fault protection, intelligent fault prediction, real-time fan performance characterization and trending.

Power Driver

The DRV input is a standard CMOS/TTL compatible logic input. The on-chip NPN power transistor is switched on when this input is high. The output features a high efficiency NPN power transistor (low $V_{CE(SAT)}$) for cooler operation. This permits driving even large motors with a DIP or SOIC packaged device. Normally, this input is driven with a digital PWM waveform to control fan speed. The FAN terminal will stand off 15V. The ground return for the power driver, GND_{FAN}, is separate from the IC's power supply return, GND, and the motor's power supply can be independent of the IC's. See the *Electrical Characteristics* section for more details.

$\overline{\text{ILMT}}$

The motor current through the TC643, I_{FAN}, is internally limited to a preset value, I_{LIMIT}. If I_{FAN} exceeds I_{LIMIT}, this open collector output will go low. I_{FAN} will be clamped at I_{LIMIT}. This serves as an indication of a stalled or shorted motor, or other fault. Typically this output is connected to an interrupt input of the host microcontroller. $\overline{\text{ILMT}}$ may go active momentarily during motor start-up. The digital control circuitry should ignore this indication until the motor has time to start. See the *Electrical Characteristics* and *Applications* sections for more details.

RPM

During normal fan operation, commutation occurs as each pole of the fan is energized. This causes brief interruptions in the fan current (See Figure 1). The TC643 detects these perturbations in fan current by monitoring the current through the on-chip drive transistor. Internal signal conditioning circuitry derives a pulse-train representing the fan-pole crossings. RPM outputs a high-going pulse each time a fan pole-crossing is detected. See the *Electrical Characteristics* section for detailed timing information. The host microcontroller or digital control logic can derive the motor rpm by timing the period of the waveform present on RPM. If commutation occurs while the power driver is off, a pulse will not be detected. A careful study of the motor rpm range and PWM frequency of interest is called for when designing with the TC643. See the *Applications* section for more details.

C_{EXT}

A 0.002µF (typical) capacitor between this pin and ground serves as part of the signal conditioning circuitry which derives the RPM output. It is effectively part of a differentiator designed to sense the commutation of the fan. These commutation pulses are translated to logic-level and squared-up to produce the RPM signal. The characteristics of this capacitor are not particularly critical. A 0.002µF, 5.0V ceramic type is suggested.

APPLICATIONS INFORMATION

Designing with the TC643 involves a number of issues. This section provides simple methodologies and guidelines to deal with each one. With reasonable care and thoughtfulness, it is a straightforward procedure to design a complete fan management system that is efficient, reliable, and "feature-rich".

Applying the TC643 generally involves . . .

(1) Matching a fan (or motor) with the desired performance to the TC643.

(2) Selecting a PWM frequency and duty-cycle range and considering its impact on RPM determination.

(3) Architecting the microcontroller hardware and software (or other control scheme) to drive the TC643 and take full advantage of its fan management capabilities.

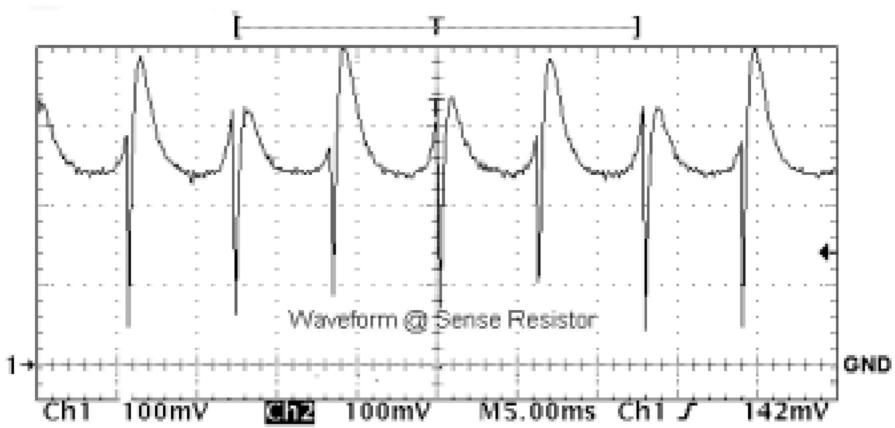


Figure 1.

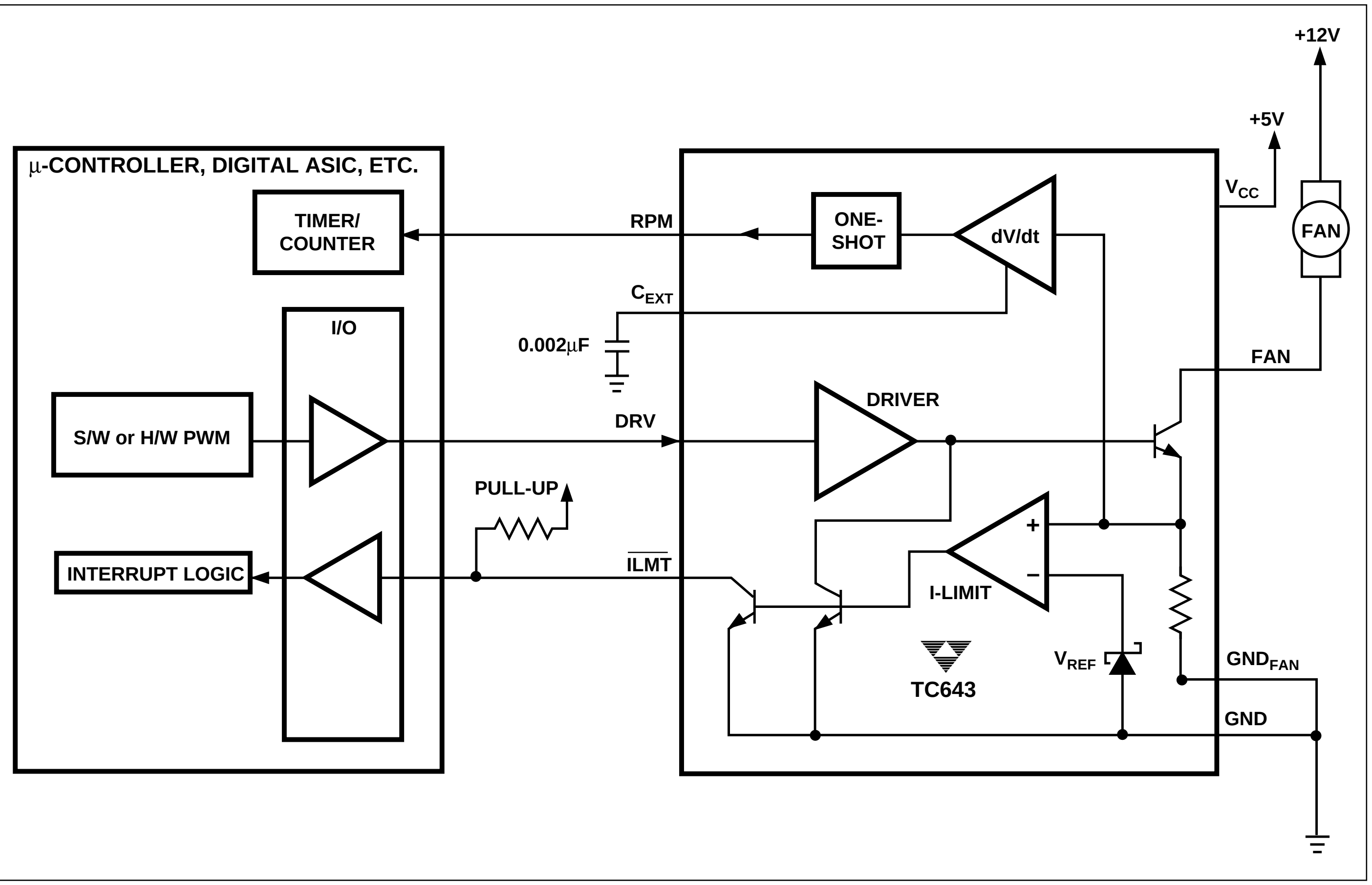
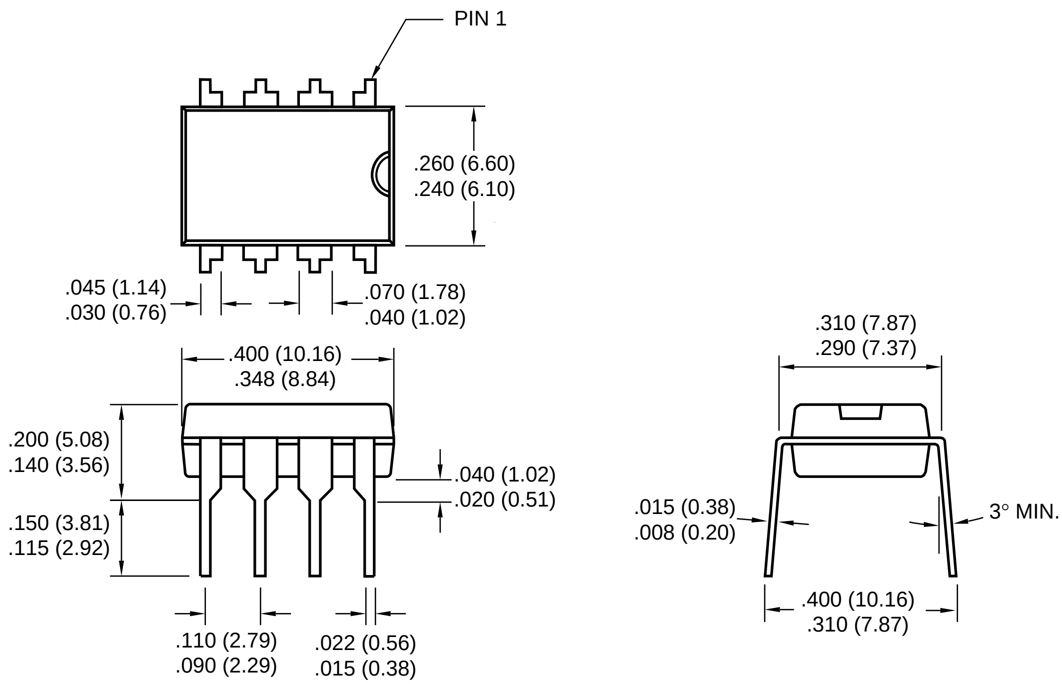


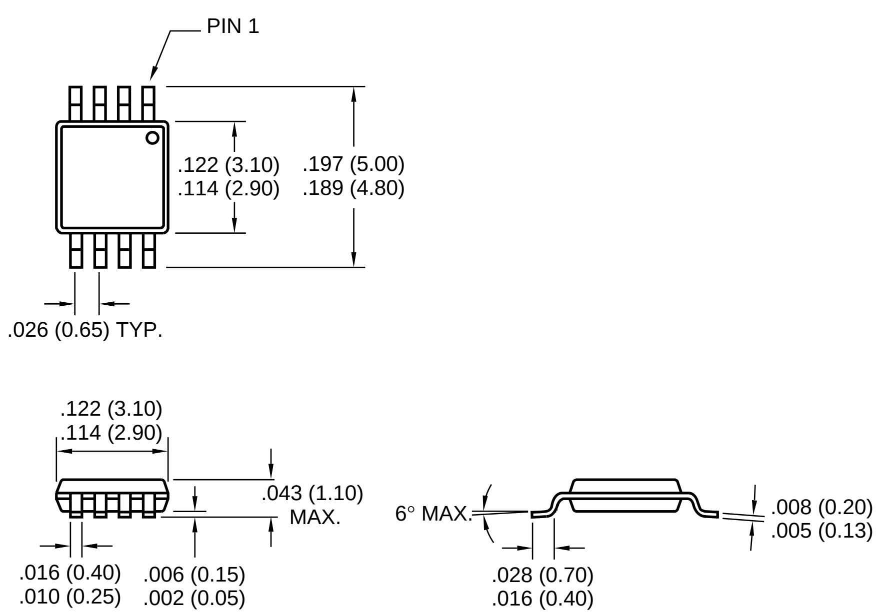
Figure 2. Typical Application Circuit

PACKAGE DIMENSIONS

8-Pin Plastic DIP

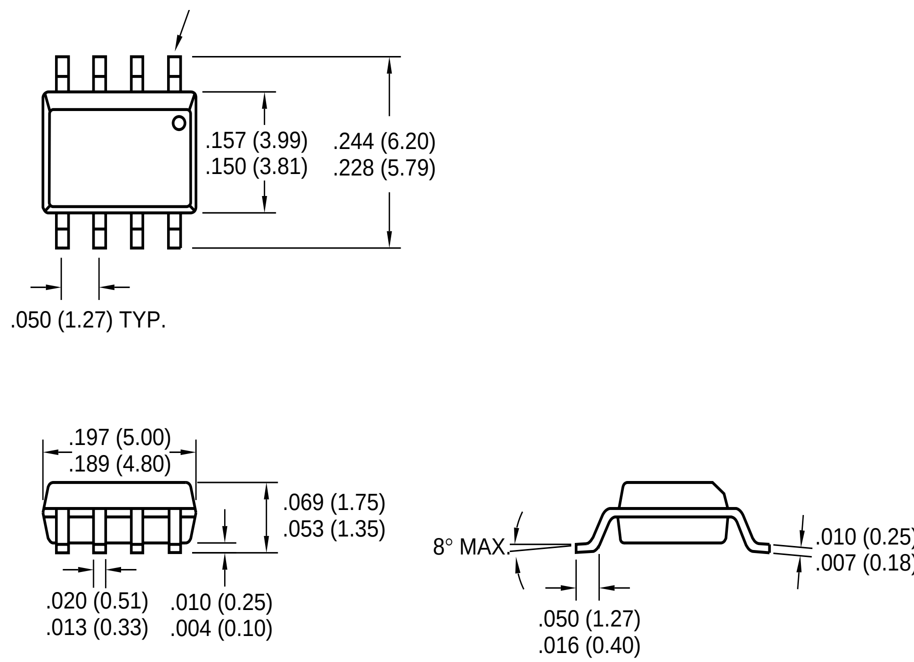


8-Pin MSOP



Dimensions: inches (mm)

8-Pin SOIC



Dimensions: inches (mm)

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