TelCom Semiconductor, Inc.

TC652
TC653

Integrated Temperature Sensor and Brushless DC Fan Controller with Fan Fault Detect and Over Temperature Alert

FEATURES

- **Digital Temperature Sensing and Multi-Speed Fan Control**
- **FanSense™ Fan Fault Detect Circuitry**
- **Built in Over Temperature Alert ($\overline{\text{Tover}}$)**
- **Temperature Proportional Fan Speed Control for Acoustic Noise Reduction and Longer Fan Life**
- **Pulse Width Modulation Output Drive for Cost and Power Savings**
- **Solid State Temperature Sensing**
- **±1°C (Typical) Accuracy from 25°C to +70°C**
- **2.8 -5.5V Operating Range**
- **TC653 includes Auto Fan Shutdown**
- **Low Operating Power: 50µA (Typ)**

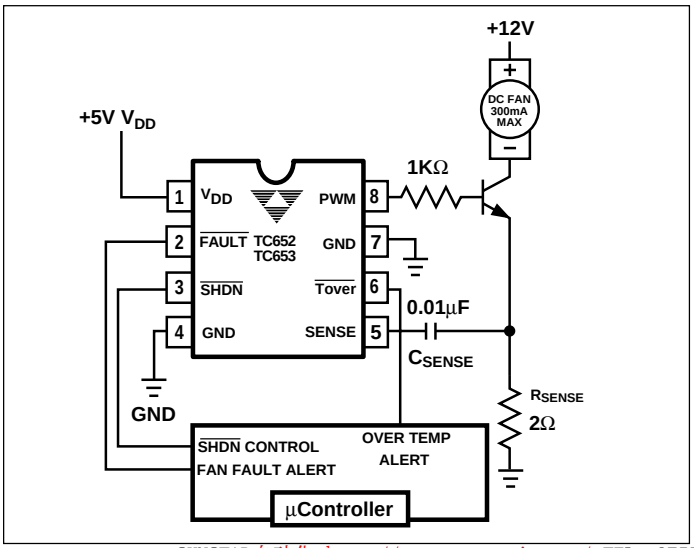
APPLICATIONS

- **Thermal Protection for Personal Computers**
- **Digital Set-Top Boxes**
- **Notebook Computers**
- **Data Communications**
- **Power Supplies**
- **Projectors**

RELATED LITERATURE

- **Application Note: 58**
- **Article: "An integrated fan speed control solution can lower system costs, reduce acoustic noise and power consumption and enhance system reliability"**

TYPICAL APPLICATION



GENERAL DESCRIPTION

The TC652/653 are integrated temperature sensors and brushless DC fan speed controllers with FanSense™ technology. The TC652/653 measure their junction temperature and control the speed of the fan based on that temperature, making them especially suited for applications in modern electronic equipment. The FanSense™ fan fault detect circuitry eliminates the need for a more expensive 3 wire fan.

Temperature data is converted from the on-chip thermal sensing element and translated into a fractional fan speed from 40% to 100%. A temperature selection guide in the data sheet is used to choose the low and high temperature limits to control the fan. The TC652/653 also include a single trip point over temperature alert ($\overline{\text{Tover}}$) that eliminates the need for additional temperature sensors. In addition the TC653 includes an auto fan shutdown function for additional power savings.

The TC652/653 are easy to use, require no software overhead, and are therefore the ideal choice for implementing thermal management in a variety of systems.

FanSense™ is a trademark of TelCom Semiconductor, Inc.

ORDERING INFORMATION

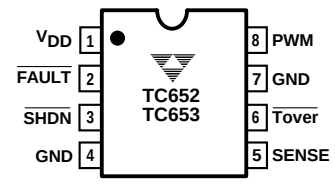
Part Number	Package	Operating Temp. Range
TC652XXVUA	8-Pin MSOP	–40°C to +125°C
TC653XXVUA	8-Pin MSOP	–40°C to +125°C

X (See Page 5)	Temperature
A	25
B	30
C	35
D	40
E	45
F	50
G	55

Notes: 1. The "X" denotes a suffix for temperature threshold settings.
2. Contact factory for other temperature ranges.

PIN CONFIGURATIONS

8-Pin MSOP



TelCom Semiconductor reserves the right to make changes in the circuitry and specifications of its devices.

ABSOLUTE MAXIMUM RATINGS*

Input Voltage (V_{DD} to GND) ..... +6V
Output Voltage (OUT to GND) 6V
Voltage On Any Pin ..... (GND – 0.3V) to (V_{DD} + 0.3V)
Package Thermal Resistance (θ_{JA}) ..... 250°C/W
Operating Temperature Range ..... –40°C to +125°C
Storage Temperature (unbiased) ..... –65°C to +150°C
Lead Temperature
(Soldering, 10sec duration) ..... +300°C

* This is a stress rating only and functional operation of the device at these or any other conditions above those indicated in the operation section of this specification is not implied. Exposure to absolute maximum ratings conditions for extended periods of time may affect reliability.

ELECTRICAL CHARACTERISTICS: V_{DD} = 2.8V to 5.5V, $\overline{SHDN}$ = V_{DD}, T_A = -40°C to 125°C unless otherwise specified.

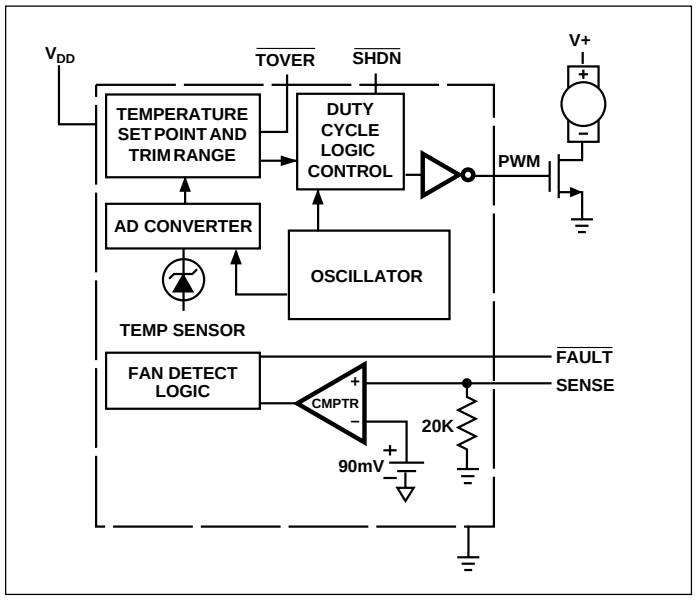
Symbol	Parameter	Test Conditions	Min	Typ	Max	Units
V_{DD}	Supply Voltage		2.8	—	5.5	V
I_{DD}	Supply Current	PWM, $\overline{FAULT}$, $\overline{Tover}$ are open	—	50	90	µA
$\overline{SHDN}$ Input						
V_{IH}	$\overline{SHDN}$ Input High Threshold		65	—	—	%V_{DD}
V_{IL}	SHDN Input Low Threshold		—	—	15	%V_{DD}
PWM Output						
V_{OL}	PWM Output Low Voltage	I_{SINK} = 1mA	—	—	0.3	V
V_{OH}	PWM Output High Voltage	I_{SOURCE} = 5mA	V_{DD} – 0.5	—	—	V
t_R	PWM Rise Time	I_{OH} = 5mA, 1nF from PWM to GND	—	10	—	µsec
t_F	PWM Fall Time	I_{OL} = 1mA, 1nF from PWM to GND	—	10	—	µsec
f_{OUT}	PWM Frequency		10	15	—	Hz
$t_{STARTUP}$	Startup Time	V_{DD} Rises from GND, or $\overline{SHDN}$ Released	—	32/f_{OUT}	—	sec
$V_{TH\ (sense)}$	Sense Input	Sense Input Threshold Voltage with Respect to Ground	—	70	—	mV
Temperature Accuracy						
$T_{H\ ACC}$	High Temp Accuracy	Note 1	T_H – 3	T_H	T_H + 3	°C
$(T_H–T_L)_{ACC}$	Temp Range Accuracy	$(T_H – T_L) \leq 20°C$	–1.0	—	+1.0	°C
		$(T_H – T_L) > 20°C$	–2.5	—	+2.5	
T_{HYST}	Auto Shutdown Hysteresis	TC653 Only	—	$(T_H – T_L)/5$	—	°C
$\overline{FAULT}$ Output						
V_{HIGH}	$\overline{FAULT}$ Output High Voltage	I_{SOURCE} = 1.2mA	V_{DD} – 0.5	—	—	V
V_{LOW}	$\overline{FAULT}$ Output Low Voltage	I_{SINK} = 2.5mA	—	—	0.4	V
tmp	Missing Pulse Detector Timeout		—	32/f_{OUT}	—	sec
$\overline{Tover}$ Output						
V_{HIGH}	$\overline{Tover}$ Output High Voltage	I_{SOURCE} = 1.2mA	V_{DD} – 0.5	—	—	V
V_{LOW}	$\overline{Tover}$ Output Low Voltage	I_{SINK} = 2.5mA	—	—	0.4	V
$\overline{Tover}_{ACC}$	Absolute Accuracy	At Trip Point	—	T_H + 10	—	°C
$\overline{Tover}_{HYST}$	Trip Point Hysteresis		—	5	—	°C

Notes: 1. Transition from 90% to 100% Duty Cycle.

PIN DESCRIPTION

Pin No.	Symbol	Description
1	V_{DD}	Power Supply Input. May be independent of fan power supply.
2	$\overline{FAULT}$	Fan Fault Alert, Active-Low Output. Fault goes low to indicate a fan fault condition. When Fault ocurrs, the device is latched in shutdown mode with PWM low. Toggling the $\overline{SHDN}$ pin or cycling the V_{DD} will release the part and fan from shutdown. Fault will unconditionally remain high during shutdown.
3	$\overline{SHDN}$	Fan Shutdown, Active-Low Input. During shut down mode the chip still monitors temperature and $\overline{Tover}$ is low if temperature rises above factory setpoint.
4	GND	Ground return for all TC652/653 functions.
5	SENSE	Detect Fan Pulses Input. Pulses are detected at this pin as fan rotation chops the current through the sense resistor, Rsense. The absense of pulses indicates a fan fault.
6	Tover	Over-Temperature Alert, Active-Low Output.
7	GND	Ground.
8	PWM	PWM Fan Drive Output. Pulse width modulated rail-to-rail logic output. Nominal frequency is 15Hz.

FUNCTONAL BLOCK DIAGRAM



FUNCTIONAL DESCRIPTION

The TC652/653 acquire and convert their junction temperature (Tj), information from an on-chip solid state sensor with a typical accuracy of ±1°C (typical) . The temperature data is digitally stored in an internal register. The register is compared with pre-defined threshold values. The six threshold values are equally distributed over a pre-defined range of temperatures (See Table 1). The TC652/653 control the speed of a DC brushless fan using a fractional speed control scheme. The output stage requires only a 2N2222-type small-signal BJT for fans up to 300mA. For larger current fans (up to 1 Amp) a logic-level N-channel MOSFET may be used. In addition to controling the speed of the fan, the TC652/653 include an on-chip over-temperature alarm ($\overline{Tover}$) that gives a low-true signal when the temperature of the chip exceeds T_H by 10°C. This feature eliminates the need for a separate temperature sensor for over-temperature monitoring.

In normal fan operation, a pulse train is present at SENSE, pin 5. A missing-pulse detector monitors this pin during fan operation (FanSense™). A stalled, open, or unconnected fan causes the TC652/653 to trigger its startup timer once. If the fault persists, the $\overline{FAULT}$ output goes low, and the device is latched in its Shutdown Mode. To release the fan from shutdown, toggle the $\overline{SHDN}$ or V_{DD} Pin.

Table 1. Temperature Range Definition for TC652 (Minimum-Speed Mode)

Temperature (T=Tj)	PWM Duty Cycle
$T<T_L$	40%
$T_L<=T<T_1$	50%
$T_1<=T<T_2$	60%
$T_2<=T<T_3$	70%
$T_3<=T<T_4$	80%
$T_4<=T<T_H$	90%
$T_H<=T<T_{OV}$	100%
$T_{OV}<=T$	100% with over temp Alert ($\overline{Tover}$ = L)

Table 2. Temperature Range Definition for TC653 (Auto-Shutdown Mode)

Temperature (T=Tj)	PWM Duty Cycle
$T<T_L$	"OFF"
$T_L<=T<T_1$	50%
$T_1<=T<T_2$	60%
$T_2<=T<T_3$	70%
$T_3<=T<T_4$	80%
$T_4<=T<T_H$	90%
$T_H<=T<T_{OV}$	100%
$T_{OV}<=T$	100% with over temp Alert ($\overline{Tover}$ = L)

Note: The temperature regions defined by the six temperature thresholds are pre-defined in the TC652/653 by means of trimming. Once a T_L and T_H are programmed, the $T_1 - T_4$ thresholds are automatically equally spaced between T_L and T_H.

DETAILED DESCRIPTION

PWM Output

The PWM pin is designed to drive a low-cost transistor or MOSFET as the low-side power-switching element in the system. Various examples of driver circuits will be shown below. This output has an asymmetric complementary drive and is optimized for driving NPN-transistors or N-channel MOSFETs. Since the system relies on PWM rather than linear power control, the dissipation in the power switch is kept to a minimum. Generally, very small devices (TO-92 or SOT packages) will suffice. The frequency of the PWM is about 15Hz. The PWM is also the timebase for the Start-up Timer (see paragraphs below). The PWM duty cycle has a range of 40% to 100% for the TC652 and 50% to 100% for the TC653.

Start-Up Timer

To ensure reliable fan start-up, the Start-up Timer turns PWM high for about 2 seconds whenever the fan is started from the off state. This occurs at power-up and when coming out of Shutdown Mode.

SENSE Input (FanSense™)

The SENSE input, pin 5, is connected to a low-value current sensing resistor in the ground return leg of the fan circuit. During normal fan operation, commutation occurs as each pole of the fan is energized. This causes brief interruptions in the fan current, seen as pulses across the sense resistor. If the device is not in Shutdown mode, and pulses are not appearing at the SENSE input, a fault exists. The short, rapid change in fan current (high di/dt) causes a corresponding dv/dt across the sense resistor, R_{SENSE}. The waveform on R_{SENSE} is differentiated and converted to a logic-level pulse train by C_{SENSE} and the internal signal processing circuitry. The presence and frequency of this pulse-train is a direct indication of fan operation.

$\overline{FAULT}$

This pin goes low to indicate a fan fault condition. Pulses appearing at SENSE pin due to the PWM turning on are blanked and the remaining pulses are filtered by a missing pulse detector. If consecutive pulses are not detected for 32 PWM cycles (about 2 sec), the PWM is Low and $\overline{FAULT}$ goes low. $\overline{FAULT}$ can be disabled by momentarily toggling $\overline{SHDN}$ or V_{DD} pin, or cycling system power. $\overline{FAULT}$ remains high during Shutdown Mode.

Over-Temperature Alert ($\overline{Tover}$)

This pin goes low when the T_H set point is exceeded by 10^oC. This indicates that the fan is at maximum drive, and the potential exists for system overheating: either heat dissipation in the system has gone beyond the cooling system's design limits, or some fault exists such as fan bearing failure or an airflow obstruction. This output may be treated as a "System Overheat" warning and used to trigger system shutdown, or bring other fans to full speed in the system. The fan will continue to run at 100% speed while Tover is asserted. Built-in hysteresis prevents $\overline{Tover}$ from "chattering" when measured temperature is at or near the $T_H + 10^oC$ trip point. As temperature falls through the $T_H + 10^oC$ trip point, hysteresis maintains the $\overline{Tover}$ output low until measured temperature is 5^oC above the trip point setting.

Shutdown ($\overline{SHDN}$)

The fan can be unconditionally shutdown by pulling low the $\overline{SHDN}$ pin. During shutdown $\overline{FAULT}$ output is high and PWM output is low. This is ideal for notebook computer and other portable applications when you need to change batteries and must not have the fan running at the time. Thermal monitoring and $\overline{Tover}$ are still in operation during shutdown. I_{DD} shutdown current is around 50µA.

Auto-Shutdown Mode

The TC653 has auto shutdown. If the temperature is below the factory set point at minimum speed (T_L), PWM is low and the fan is automatically shut off (Auto-Shutdown mode). This feature is ideal for notebook computers and other portable applications that need to conserve as much battery power as possible and thus run a fan when it is only absolutely needed. The TC653 will continue to be active so

as to monitor temperature for Tover. The TC653 exits Auto-Shutdown mode when the temperature rises above the factory set point (T_1).

Temperature Selection Guide (Minimum Fan Speed/Full Speed)

The five temperature regions defined by the six thresholds are defined in the TC652/653 by means of factory trimming. Once a T_L and T_H are set, the $T_1 - T_4$ thresholds are automatically equally spaced between T_L and T_H.

Temp Range (°C)	T_L (°C)	T_H (°C)	Part #
10	**25**	**35**	AC
	30	40	BD
	35	45	CE
15	25	40	AD
	30	**45**	BE
	35	50	CF
20	**25**	**45**	AE
	30	50	BF
	35	55	CG
30	**25**	**55**	AG

Note: The **Bold Type** temperature settings are available for ordering. Contact factory for other temperature selections.

T_L and T_H can be selected in 5°C increments. T_H must be chosen at least 10°C higher than T_L. T_L can range from 25°C to 35°C.

As an example, suppose you wanted the fan to **run at 40% speed at 25°C** or less and go to **full speed at 45°C.** You would order the part number TC652AEVUA.

As another example, suppose you wanted the fan to **turn on at 30°C** and go to **full speed at 45°C.** You would order the part number TC653BEVUA.

APPLICATIONS INFORMATION

Reducing Switching Noise

For fans consuming more than 300mA, a slowdown capacitor (C_{SLOW}) is recommended for reducing switching PWM induced noise (see Figure 1). The value of this capacitor should be 4.7µF to 47µF, depending on the fan current consumption. Please see Application Note 38 for more information.

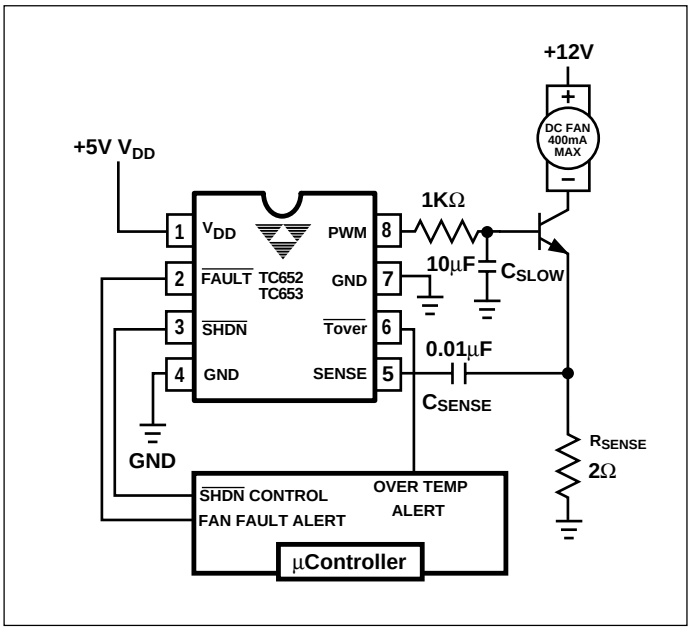
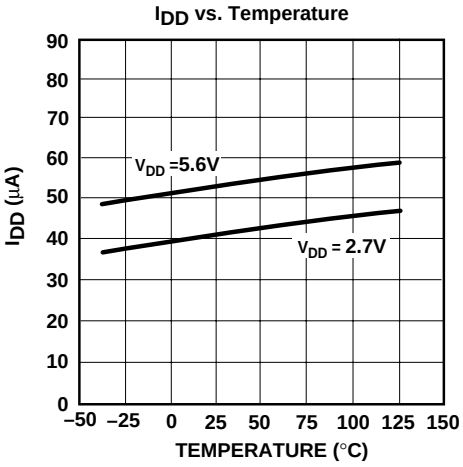
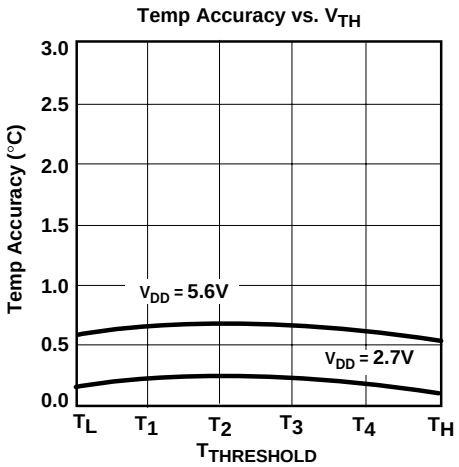
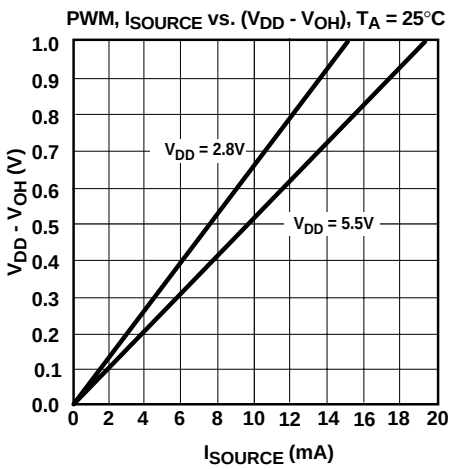


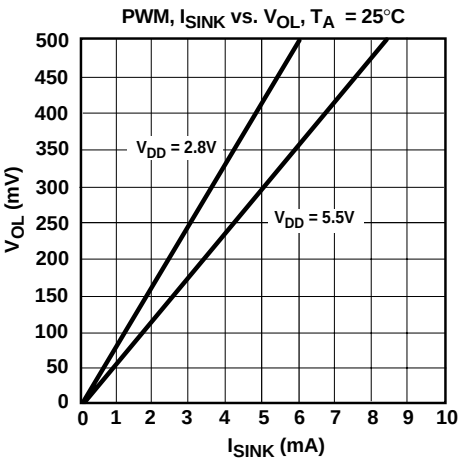
Figure 1. Reducing Switching Noise

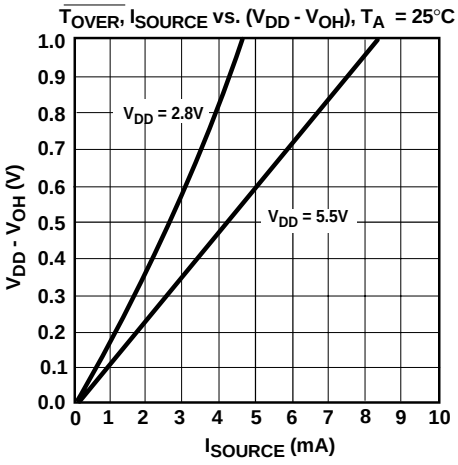
TYPICAL CHARACTERISTIC CURVES

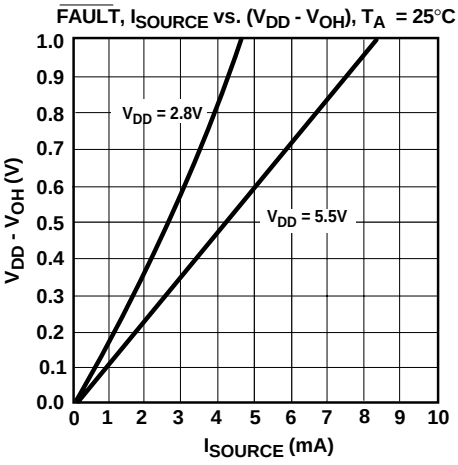


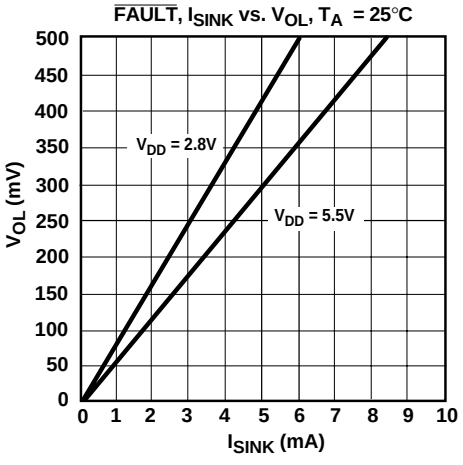


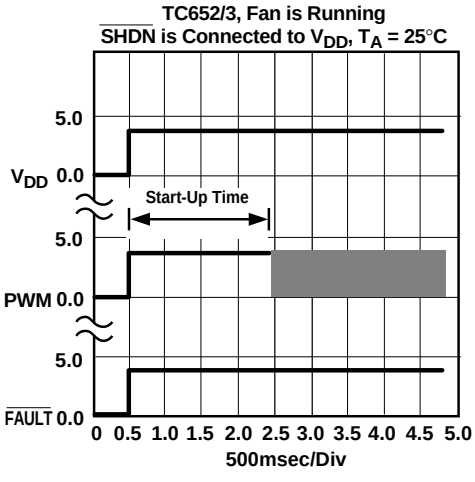


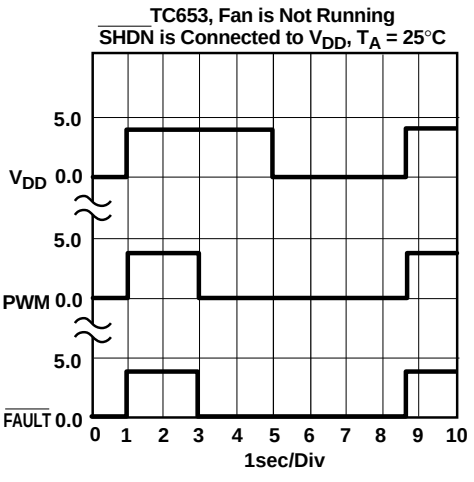






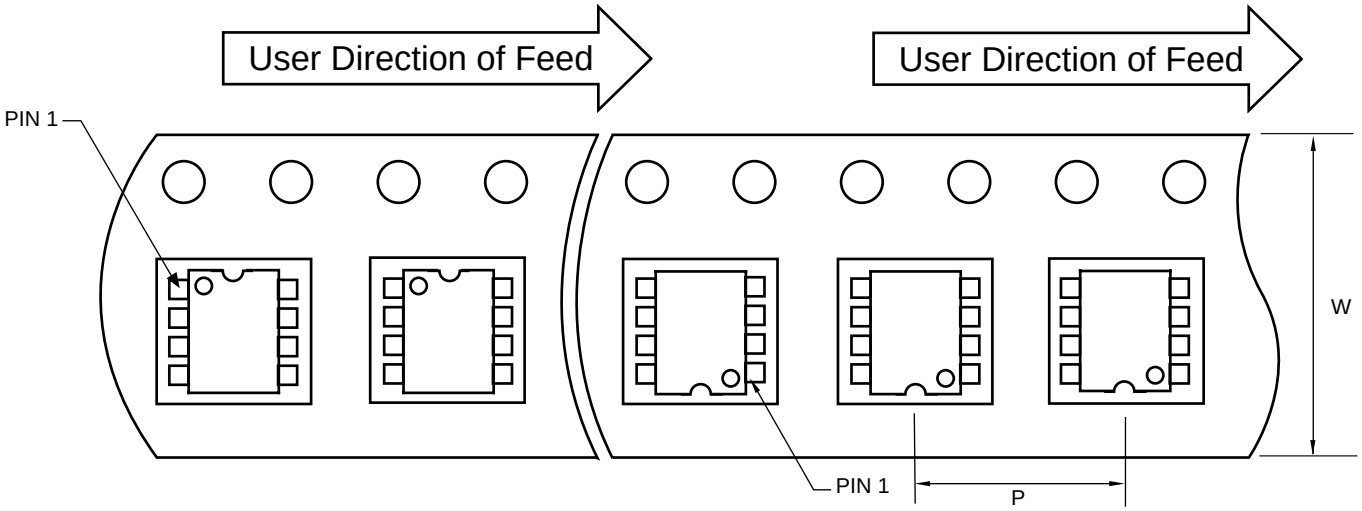






TAPE AND REEL DIAGRAM

Component Taping Orientation for 8-Pin MSOP Devices



Standard Reel Component Orientation for TR Suffix Device

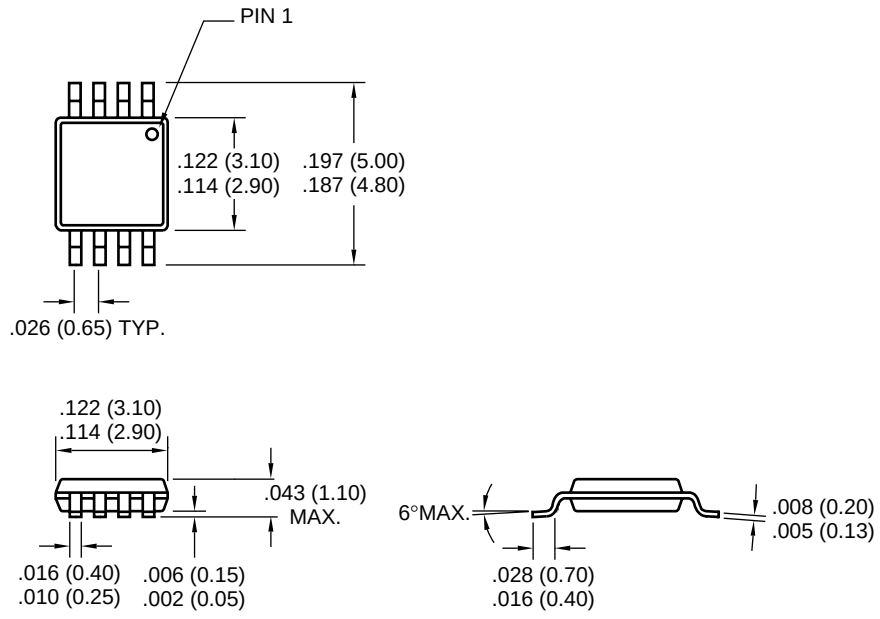
Reverse Reel Component Orientation for RT Suffix Device

Carrier Tape, Number of Components Per Reel and Reel Size

Package	Carrier Width (W)	Pitch (P)	Part Per Full Reel	Reel Size
8-Pin MSOP	12 mm	8 mm	2500	13 in

PACKAGE DIMENSIONS

8-Pin MSOP



Dimensions: inches (mm)

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SUNSTAR商斯达实业集团是集研发、生产、工程、销售、代理经销 、技术咨询、信息服务等为一体的高科技企业，是专业高科技电子产品生产厂家，是具有 10 多年历史的专业电子元器件供应商，是中国最早和最大的仓储式连锁规模经营大型综合电子零部件代理分销商之一,是一家专业代理和分銷世界各大品牌IC芯片和電子元器件的连锁经营綜合性国际公司。在香港、北京、深圳、上海、西安、成都等全国主要电子市场设有直属分公司和产品展示展销窗口门市部专卖店及代理分销商，已在全国范围内建成强大统一的供货和代理分销网络。 我们专业代理经销、开发生产电子元器件、集成电路、传感器、微波光电元器件、工控机/DOC/DOM电子盘、专用电路、单片机开发、MCU/DSP/ARM/FPGA软件硬件、二极管、三极管、模块等，是您可靠的一站式现货配套供应商、方案提供商、部件功能模块开发配套商。**专业以现代信息产业（计算机、通讯及传感器）三大支柱之一的传感器为主营业务，专业经营各类传感器的代理、销售生产、网络信息、科技图书资料及配套产品设计、工程开发。我们的专业网站——中国传感器科技信息网（全球传感器数据库） www.SENSOR-IC.COM 服务于全球高科技生产商及贸易商，为企业科技产品开发提供技术交流平台。欢迎各厂商互通有无、交换信息、交换链接、发布寻求代理信息。欢迎国外高科技传感器、变送器、执行器、自动控制产品厂商介绍产品到 中国，共同开拓市场。**本网站是关于各种传感器-变送器-仪器仪表及工业自动化大型专业网站,深入到工业控制、系统工程计 测计量、自动化、安防报警、消费电子等众多领域，把最新的传感器-变送器-仪器仪表买卖信息,最新技术供求,最新采购商,行业动态，发展方向，最新的技术应用和市场资讯及时的传递给广大科技开发、科学研究、产品设计人员。本网站已成功为石油、化工、电力、医药、生物、航空、航天、国防、能源、冶金、电子、工业、农业、交通、汽车、矿山、煤炭、纺织、信息、通信、IT、安防、环保、印刷、科研、气象、仪器仪表等领域从事科学研究、产品设计、开发、生产制造的科技人员、管理人员 、和采购人员提供满意服务。 **我公司专业开发生产、代理、经销、**销售各种传感器、变送器、敏感元器件、开关、执行器、仪器仪表、自动化控制系统： 专门从事设计、生产、销售各种传感器、变送器、各种测控仪表、热工仪表、现场控制器、计算机控制系统、数据采集系统、各类环境监控系统、专用控制系统应用软件以及嵌入式系统开发及应用等工作。如热敏电阻、压敏电阻、温度传感器、温度变送器、湿度传感器、 湿度变送器、气体传感器、 气体变送器、压力传感器、 压力变送、称重传感器、物（液）位传感器、物（液）位变送器、流量传感器、 流量变送器、电流（压）传感器、溶氧传感器、霍尔传感器 、图像传感器、超声波传感器、位移传感器、速度传感器、加速度传感器、扭距传感器、红外传感器、紫外传感器、 火焰传感器、激光传感器、振动传感器、轴角传感器、光电传感器、接近传感器、干簧管传感器、继电器传感器、微型电泵、磁敏（阻）传感器 、压力开关、接近开关、光电开关、色标传感器、光纤传感器、齿轮测速传感器、 时间继电器、计数器、计米器、温控仪、固态继电器、调压模块、电磁铁、电压表、电流表等特殊传感器 。 同时承接传感器应用电路、产品设计和自动化工程项目。

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