19-2133; Rev 2; 11/02

MAXIM

Remote Temperature Switches with Integrated Fan Controller/Driver

General Description

The MAX6668/MAX6670 remote-junction thermal switches with an internal power transistor drive a cooling fan rated for supply voltages up to +12V and 250mA. These devices measure the temperature of an external P-N junction (typically a diode-connected transistor) and turn on the fan power switch when the remote temperature rises above a factory-programmed threshold. Self-contained and requiring no software development, the MAX6668/MAX6670 are simple "drop-in" fan-control solutions for a variety of systems.

The MAX6670 features an open-drain $\overline{WARN}$ output that goes active when the remote temperature exceeds the factory-programmed fan activation threshold by +15°C. The MAX6670 features an open-drain $\overline{OT}$ output that goes active when the remote temperature exceeds the factory-programmed threshold by +30°C. The MAX6668/MAX6670 provide a fan-control input, $\overline{FORCEON}$, that allows the fan to be driven externally, regardless of temperature.

Available temperature thresholds range from +40°C to +75°C in 5°C increments. Hysteresis is preset to 8°C on the MAX6668 or pin selectable to 4°C, 8°C, or 12°C using a three-level logic input on the MAX6670. Temperature threshold accuracy is ±1°C (typ) and ±2.2°C (max) for remote-junction temperatures from +40°C to +75°C.

The MAX6668/MAX6670 operate from a +3V to +3.6V power supply, and are specified over the automotive temperature range (-40°C to +125°C). The MAX6668 is offered in an 8-pin µMAX package and the MAX6670 is available in a space-saving 10-pin µMAX package.

Applications

Notebook and Desktop Computers

Network Switches

PC Power Supplies

Laboratory Instruments

Card Racks

Temperature Alarms

Fan Controls

Pin Configuration appears at end of data sheet.

Typical Operating Circuit appears at end of data sheet.

Features

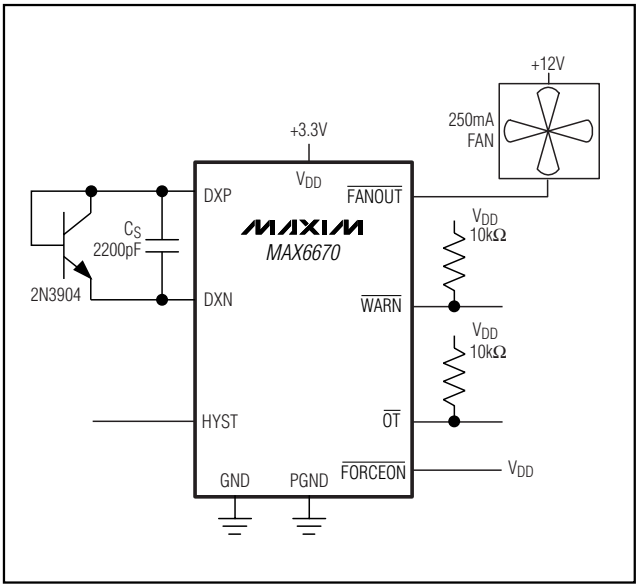
- **+12V, 250mA Integrated Fan Driver**
- **No Calibration Required**
- **Pin-Selectable 4°C, 8°C, or 12°C Hysteresis (MAX6670)**
- **Factory-Programmed Temperature Thresholds from +40°C to +75°C**
- **Overtemperature Warning Signals**
- **110µA (typ) Supply Current**
- **Space-Saving 8-Pin and 10-Pin µMAX Packages**

Ordering Information

PART	TEMP RANGE	PIN-PACKAGE	THRESHOLD (°C)
MAX6668AUA40	-40°C to +125°C	8 µMAX	40
MAX6668AUA45	-40°C to +125°C	8 µMAX	45
MAX6668AUA50	-40°C to +125°C	8 µMAX	50
MAX6668AUA60	-40°C to +125°C	8 µMAX	60
MAX6668AUA70	-40°C to +125°C	8 µMAX	70
MAX6668AUA75	-40°C to +125°C	8 µMAX	75

Ordering Information continued at end of data sheet.

Typical Application Circuit



Remote Temperature Switches with Integrated Fan Controller/Driver

ABSOLUTE MAXIMUM RATINGS

V_{DD} to GND .....-0.3V to +6V
PGND to GND .....-0.3V to +0.3V
$\overline{FANOUT}$ to GND .....-0.3V to +15V
DXN to GND .....-0.3V to +0.8V
DXP, $\overline{WARN}$, HYST, $\overline{FORCEON}$, $\overline{OT}$.....-0.3V to (V_{DD} + 0.3V)
Current into V_{DD}, GND, DXP, DXN, $\overline{WARN}$, HYST, $\overline{FORCEON}$, $\overline{OT}$.....±20mA
Current into $\overline{FANOUT}$, PGND ..... ±300mA

Continuous Power Dissipation (T_A = +70°C)
8-Pin µMAX (derate 4.1mW/°C above +70°C).....333mW
10-Pin µMAX (derate 5.6mW/°C above +70°C).....444mW
Operating Temperature Range .....-40°C to +125°C
Storage Temperature Range .....-60°C to +150°C
Junction Temperature.....+150°C
Lead Temperature (soldering, 10s) .....+300°C

Stresses beyond 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 beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

ELECTRICAL CHARACTERISTICS

(V_{DD} = +3V to +3.6V, T_A = -40°C to +125°C, unless otherwise noted. Typical values are at V_{DD} = +3.3V and T_A = +25°C.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
POWER SUPPLY							
Power-Supply Range	V_{DD}			3		3.6	V
Average Supply Current	I_{DD}				110	200	µA
Operating Current		During sampling			400	650	µA
Power-On Reset (POR) Threshold	POR	V_{DD} falling edge		1	1.5	2.0	V
POR Threshold Hysteresis					50		mV
TEMPERATURE SENSOR							
$\overline{FANOUT}$ Temperature Threshold Accuracy	ΔT_{TH}	T_{RJ} = +40°C to +75°C (Note 1), T_A = 0°C to +85°C, V_{DD} = +3.3V			±1	±2.2	°C
		T_{RJ} = +40°C to +75°C (Note 1), T_A = -40°C to +125°C, V_{DD} = +3.3V			±1	±4	
$\overline{FANOUT}$ Temperature Threshold Hysteresis	T_{HYST}	MAX6670	HYST = GND		4		°C
			HYST = float		8		
			HYST = V_{DD}		12		
		MAX6668			8		
$\overline{WARN}$ Temperature Threshold (MAX6670 Only)		Relative to $\overline{FANOUT}$ temperature threshold			+15		°C
$\overline{OT}$ Temperature Threshold (MAX6670 Only)		Relative to $\overline{FANOUT}$ temperature threshold			+30		°C
Supply Sensitivity of Temperature Threshold					1	1.6	°C/V
Temperature Sample Frequency				3.3	4		Hz
FAN DRIVE OUTPUT							
$\overline{FANOUT}$ Output Voltage Low	V_{OL}	I_{SINK} = 250mA			0.5	1	V
Thermal Shutdown					170		°C
Thermal Shutdown Hysteresis					20		°C
LOGIC INPUT/OUTPUT							
$\overline{FORCEON}$ Input High Voltage	V_{IH}			0.8 x V_{DD}			V

ELECTRICAL CHARACTERISTICS (continued)

(V_{DD} = +3V to +3.6V, T_A = -40°C to +125°C, unless otherwise noted. Typical values are at V_{DD} = +3.3V and T_A = +25°C.)

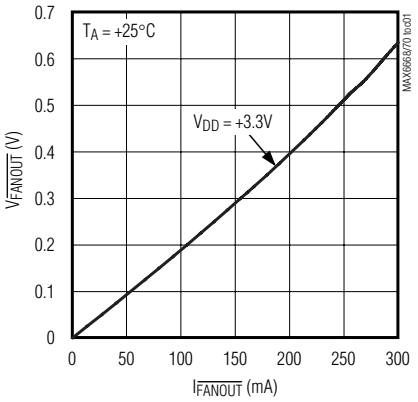
PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
$\overline{FORCEON}$ Input Low Voltage	V_{IL}				0.2 x V_{DD}	V
$\overline{FORCEON}$ Input Bias Current		$V_{\overline{FORCEON}}$ = V_{DD} or GND			1	µA
$\overline{WARN}$, $\overline{OT}$ Output Voltage Low	V_{OL}	I_{SINK} = 6mA			0.5	V
$\overline{WARN}$, $\overline{OT}$ Output High Leakage Current	I_{OH}	$V_{\overline{WARN}}$ or $V_{\overline{OT}}$ = +5.5V			1	µA

Note 1: T_{RJ} is the temperature of the remote P-N junction.

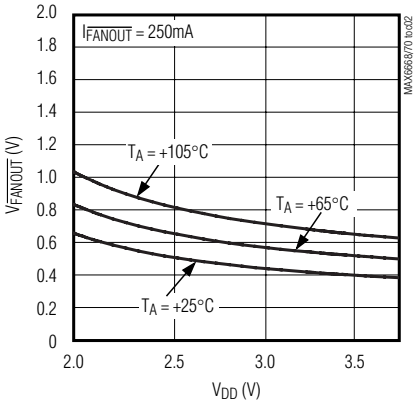
Typical Operating Characteristics

(T_A = +25°C, unless otherwise noted.)

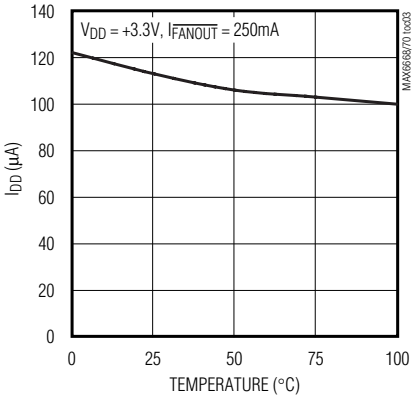
$\overline{FANOUT}$ CURRENT vs. $\overline{FANOUT}$ VOLTAGE



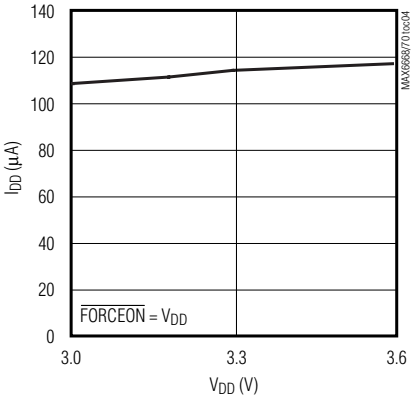
$\overline{FANOUT}$ VOLTAGE vs. SUPPLY VOLTAGE



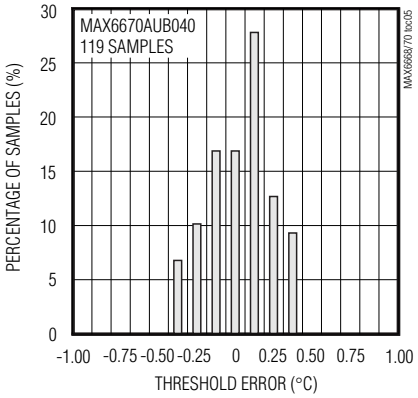
SUPPLY CURRENT vs. TEMPERATURE



SUPPLY CURRENT vs. SUPPLY VOLTAGE



TEMPERATURE THRESHOLD ERROR



Remote Temperature Switches with Integrated Fan Controller/Driver

Pin Description

PIN		NAME	FUNCTION
MAX6668	MAX6670		
1	1	PGND	Power Ground. PGND is the power ground for the $\overline{\text{FANOUT}}$ power MOSFET switch.
2	5	$\overline{\text{FORCEON}}$	Fan-Control Input. Drive $\overline{\text{FORCEON}}$ high for normal operation. Drive $\overline{\text{FORCEON}}$ low to force fan on.
3	3	DXP	Current Source Positive Input. Connect to the anode of the external diode-connected transistor. Do not leave DXP floating. Connect a 2200pF capacitor between DXP and DXN for noise filtering.
4	4	DXN	Current Sink Negative Input. Connect to the cathode of the external diode-connected transistor. DXN is internally biased to a diode voltage drop.
5, 7	7	GND	Ground
6	8	V_{DD}	Positive Power Supply
8	10	$\overline{\text{FANOUT}}$	Fan-Drive Output. $\overline{\text{FANOUT}}$ is an open-drain power MOSFET that sinks up to 250mA current to turn on the fan when the sensed temperature exceeds the fan trip threshold or the fan is forced on by driving $\overline{\text{FORCEON}}$ low.
—	2	$\overline{\text{WARN}}$	Temperature Warning Output. $\overline{\text{WARN}}$ is an open-drain output that goes low when the sensed junction temperature is 15°C higher than the fan trip threshold.
—	6	$\overline{\text{OT}}$	Overtemperature Output. $\overline{\text{OT}}$ is an open-drain output that goes low when the sensed junction temperature is 30°C higher than the fan trip threshold.
—	9	HYST	Hysteresis Control Input. HYST is a three-level logic input for controlling the fan-drive comparator's hysteresis. Connect HYST to GND for 4°C hysteresis, to V_{DD} for 12°C hysteresis, or leave floating for 8°C hysteresis.

Detailed Description

The MAX6668/MAX6670 are simple fan controllers/drivers that turn on an internal power transistor when the sensed temperature of an external P-N junction exceeds a factory-set threshold. By connecting a small (up to +12V/250mA nominal) cooling fan to $\overline{\text{FANOUT}}$, a simple on/off fan-control system is created. Do not connect the fan to a power supply of higher than 12V nominal, 15V maximum.

$\overline{\text{FANOUT}}$ Driver and $\overline{\text{FORCEON}}$ Controller

$\overline{\text{FANOUT}}$ Fan-Driver Output

$\overline{\text{FANOUT}}$ is an open-drain output that sinks greater than 250mA of current to turn on the fan, either when the fan trip threshold is exceeded or the fan is forced on by driving $\overline{\text{FORCEON}}$ low.

$\overline{\text{FORCEON}}$ Fan-Control Input

Drive $\overline{\text{FORCEON}}$ low to turn on the fan when the MAX6670's remote-sensing junction temperature is less than the fan trip threshold temperature. This overrides the internal control circuitry and allows for an external device to activate the fan.

Overtemperature Alarm Outputs

$\overline{\text{WARN}}$ Output (MAX6670 Only)

$\overline{\text{WARN}}$ is an active-low, open-drain digital output that indicates when the external P-N junction's temperature exceeds 15°C above the fan trip threshold. The $\overline{\text{WARN}}$ output serves as a warning that the system temperature has continued to rise well above the fan activation temperature.

$\overline{\text{OT}}$ Output (MAX6670 Only)

$\overline{\text{OT}}$ is an active-low, open-drain digital output that indicates when the external P-N junction's temperature exceeds 30°C above the fan trip threshold. $\overline{\text{OT}}$ serves as a thermal shutdown output to the system in case of excessive temperature rise.

Hysteresis Input

The temperature comparator has hysteresis to prevent small temperature changes near the threshold temperature from causing the fan to turn on and off repeatedly over short periods of time. The $\overline{\text{FANOUT}}$ pin goes active and powers the fan when the external P-N junction's temperature exceeds the factory-programmed

trip temperature. As the cooling fan operates, the circuit board temperature should decrease, which causes the external P-N junction's temperature to decrease. When the P-N junction's temperature is equal to the trip threshold minus the hysteresis, the $\overline{FANOUT}$ pin turns the fan off, removing power from the fan. For the MAX6670, HYST is a three-level logic input for controlling the fan-drive comparator's hysteresis. Connect HYST to GND to select 4°C hysteresis, to V_{DD} to select 12°C hysteresis, or leave floating to select 8°C hysteresis. The MAX6668 has a built-in hysteresis of 8°C. This allows the amount of hysteresis to be matched to the cooling and noise requirements of the system. Figure 1 shows the temperature trip threshold hysteresis.

Applications Information

Remote-Diode Selection

The MAX6668/MAX6670 directly measure the die temperature of CPUs and other ICs that have on-board temperature-sensing diodes (see *Typical Operating Circuit*) or they can measure the temperature of a discrete diode-connected transistor. For best accuracy, the discrete transistor should be a small-signal device with its collector and base connected together. Several satisfactory discrete sensing transistors are shown in Table 1.

The sensing transistor must be a small-signal type with a relatively high forward voltage. Otherwise, the DXP input voltage range may be violated. The forward voltage at the highest expected temperature must be greater than 0.25V at 10µA, and at the lowest expected temperature, forward voltage must be less than 0.95V at 100µA. Do not use large power transistors. Also, ensure that the base resistance is less than 100Ω. Tight specifications for forward current gain ($50 < B_F < 150$, for example) indicate that the manufacturer has good process controls and that the transistors have consistent V_{BE} characteristics.

Noise-Filtering Capacitor

In noisy environments, high-frequency noise can be attenuated using an external 2200pF capacitor located at the DXP and DXN pins. Larger capacitor values may be used for additional filtering, but do not exceed 3300pF; excessive capacitance increases error. Figure 2 shows the recommended DXP/DXN PC traces.

Bypassing and Layout

The location of the remote-sensing junction in the system affects the MAX6668/MAX6670s' operation. When using a discrete temperature-sensing transistor, place the sensing junction close to major heat-generating components, such as a high-speed CPU or a power device.

Table 1. Remote-Sensor Transistor Manufacturers

MANUFACTURER	MODEL NO.
Central Semiconductor (USA)	CMPT3904
ON Semiconductor (USA)	2N3904, 2N3906
Rohm Semiconductor (USA)	SST3904
Samsung (Korea)	KST3904-TF
Siemens (Germany)	SMBT3904
Zetex (England)	FMMT3904CT-ND

To minimize noise and other errors, follow the guidelines below:

1) Place the MAX6668/MAX6670 as close as possible to the remote diode. In a noisy environment, such as a computer motherboard, this distance can be 10cm to 20cm (typ) or more as long as the worst noise sources (such as CRTs, clock generators, memory buses, and ISA/PCI buses) are avoided. In general, minimize the distance to the remote-sensing junction.
2) Do not route the DXP/DXN traces next to the deflection coils of a CRT. Also, do not route the traces across a fast memory bus, which can introduce +30°C error or more, even with good filtering.
3) Route the DXP and DXN traces in parallel and in close proximity to each other, away from any high-voltage traces, such as +12VDC. Avoid leakage currents from PC board contamination, since a 20MΩ leakage path from DXP to GND causes about +1°C error.
4) Connect guard traces to GND on either side of the DXP/DXN traces (Figure 2). With guard traces in place, routing near high-voltage traces is no longer an issue.
5) Route through as few vias and crossunders as possible to minimize copper/solder thermocouple effects.
6) Use wide traces where possible. Narrow traces are more inductive and tend to pick up radiated noise.
7) Do not use copper as an EMI shield. Only ferrous materials such as steel work well. Placing a copper ground plane between the DXP/DXN traces and other traces carrying high-frequency noise signals does not help reduce EMI.

The MAX6668/MAX6670s' PGND is the ground return for the fan driver. Bypass V_{DD} to GND with a 1µF capacitor located as close to V_{DD} as possible. Add additional bypass capacitors for long V_{DD} and GND lines.

Remote Temperature Switches with Integrated Fan Controller/Driver

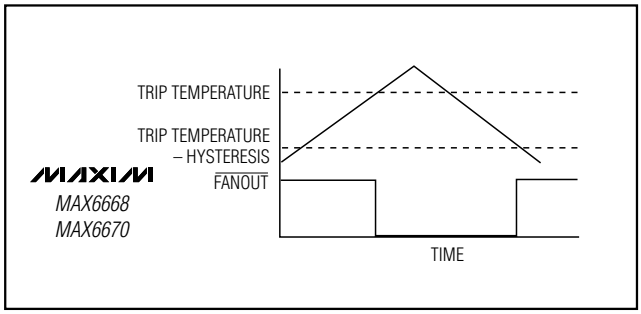


Figure 1. Temperature Trip Threshold Hysteresis

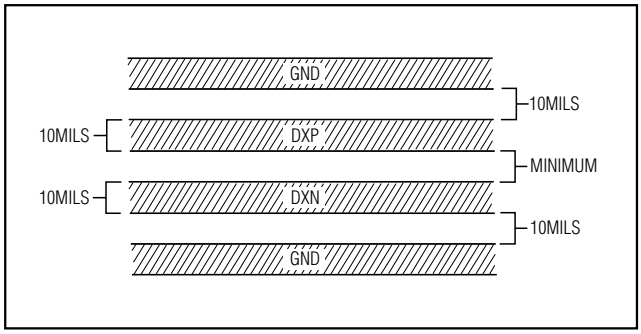
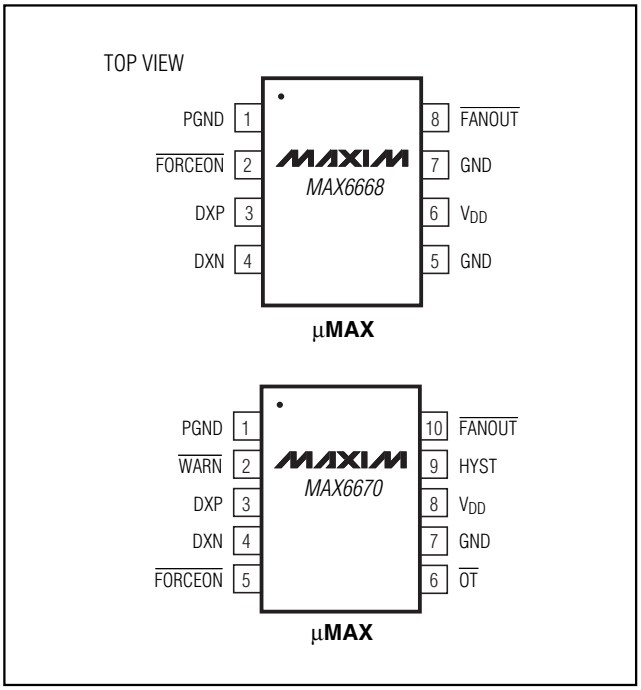
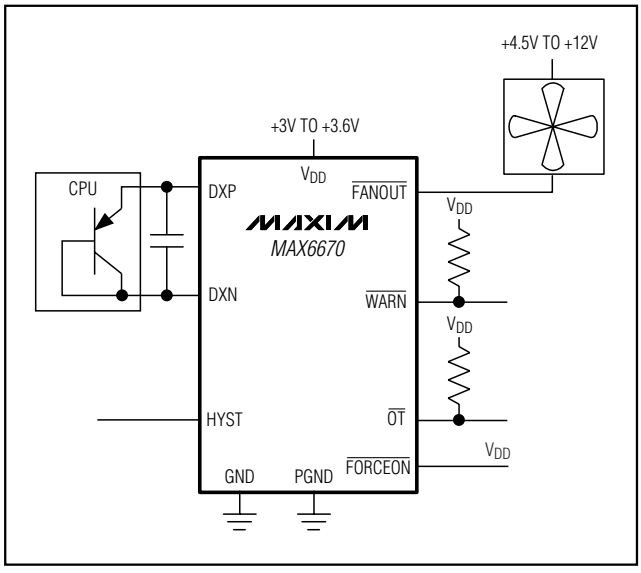


Figure 2. Recommended DXP/DXN PC Traces

Pin Configurations



Typical Operating Circuit



Chip Information

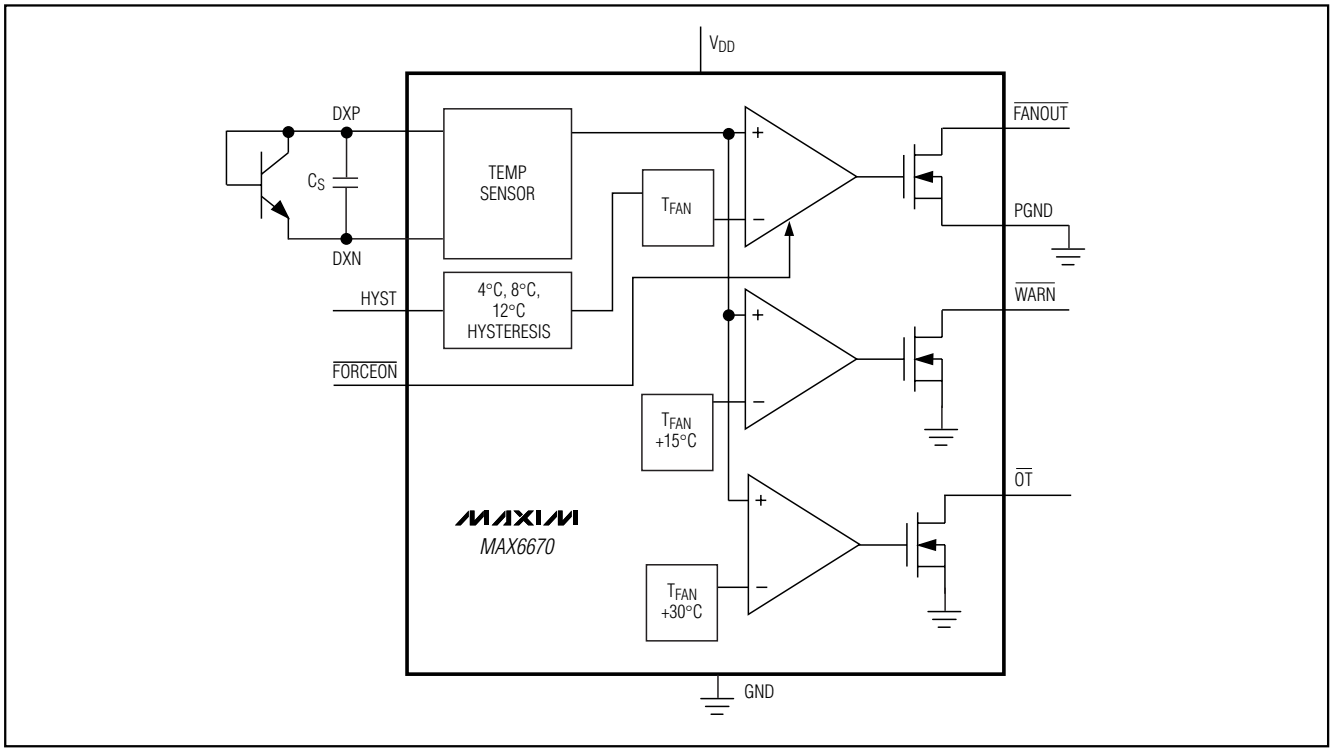
TRANSISTOR COUNT: 8113

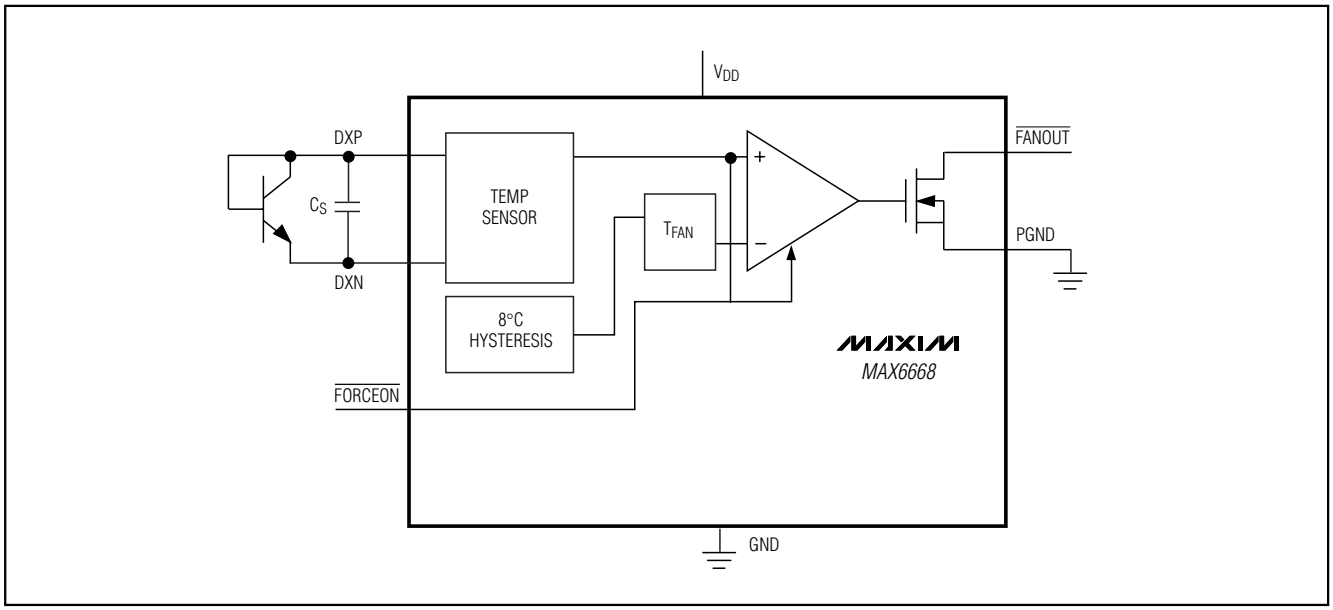
PROCESS: BiCMOS

Ordering Information

PART	TEMP RANGE	PIN-PACKAGE	THRESH-OLD (°C)
MAX6670AUB40	-40°C to +125°C	10 µMAX	40
MAX6670AUB45	-40°C to +125°C	10 µMAX	45
MAX6670AUB50	-40°C to +125°C	10 µMAX	50
MAX6670AUB55	-40°C to +125°C	10 µMAX	55
MAX6670AUB60	-40°C to +125°C	10 µMAX	60
MAX6670AUB65	-40°C to +125°C	10 µMAX	65
MAX6670AUB70	-40°C to +125°C	10 µMAX	70
MAX6670AUB75	-40°C to +125°C	10 µMAX	75

Functional Diagrams

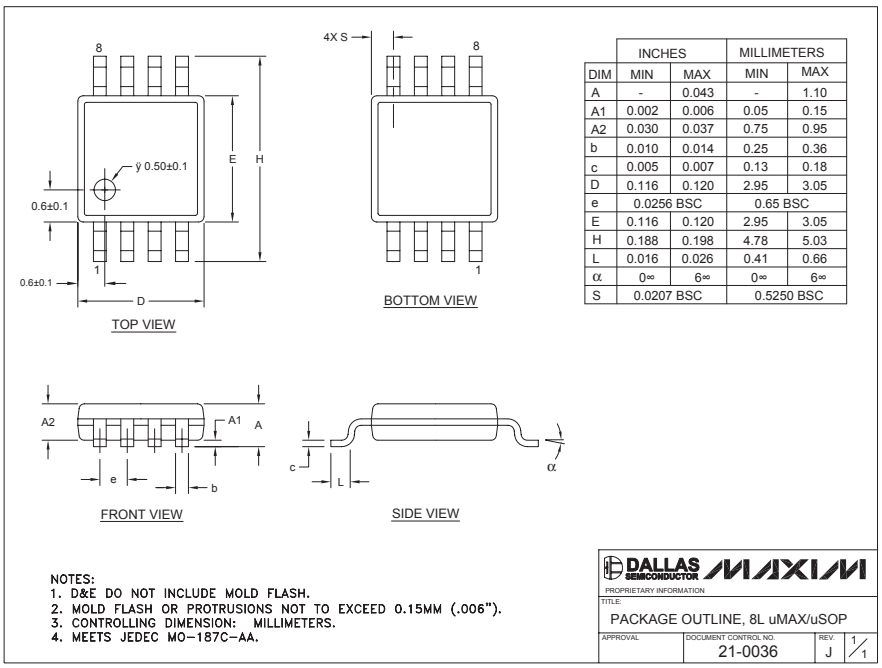




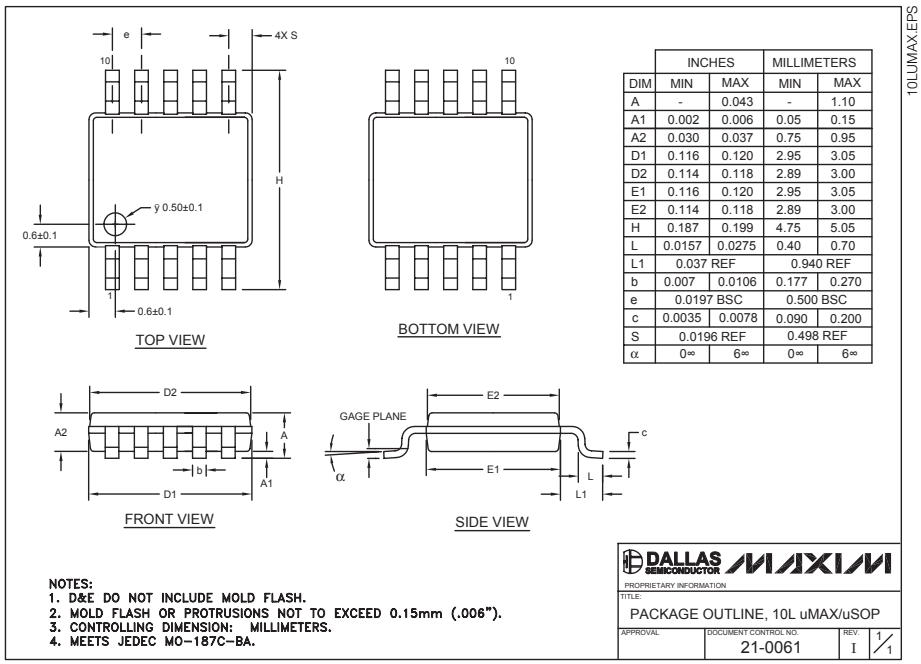
Remote Temperature Switches with Integrated Fan Controller/Driver

Package Information

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information, go to **www.maxim-ic.com/packages**.)



DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	-	0.043	-	1.10
A1	0.002	0.006	0.05	0.15
A2	0.030	0.037	0.75	0.95
b	0.010	0.014	0.25	0.36
c	0.005	0.007	0.13	0.18
D	0.116	0.120	2.95	3.05
e	0.0256 BSC		0.65 BSC	
E	0.116	0.120	2.95	3.05
H	0.188	0.198	4.78	5.03
L	0.016	0.026	0.41	0.66
α	0∞	6∞	0∞	6∞
S	0.0207 BSC		0.5250 BSC	



DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	-	0.043	-	1.10
A1	0.002	0.006	0.05	0.15
A2	0.030	0.037	0.75	0.95
D1	0.116	0.120	2.95	3.05
D2	0.114	0.118	2.89	3.00
E1	0.116	0.120	2.95	3.05
E2	0.114	0.118	2.89	3.00
H	0.187	0.199	4.75	5.05
L	0.0157	0.0275	0.40	0.70
L1	0.037 REF		0.940 REF	
b	0.007	0.0106	0.177	0.270
e	0.0197 BSC		0.500 BSC	
c	0.0035	0.0078	0.090	0.200
S	0.0196 REF		0.498 REF	
α	0∞	6∞	0∞	6∞