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FAIRCHILD SEMICONDUCTOR®

April 2008

FM50 — Analog Temperature Sensor

Features

- Analog Output: 10mV/°C
- Range: -40 to 125°C Range
- Accuracy: ±2°C at 25°C
- Supply Current: 170µA Maximum
- Output Drive: 25µA
- Self-heating: <0.1°C
- Operating Voltage: +2.4V to +6V

Applications

- Mobile Phones
- Computers
- Battery Management
- Office Equipment
- HVAC
- Power Supply Modules
- Disk Drives
- Automotive

Description

As a precision CMOS temperature sensor, the FM50 is cost effective for accurate, low-power, temperature-monitoring applications. Output voltage versus temperature is extremely linear. With no load, the supply current is typically 130µA. For normal operation, the load on V_{OUT} should be 100KΩ or less.

In a typical application, a remotely mounted FM50 is monitored by a microcontroller with an analog A/D converter input. Alternatively, the FM50 can drive a comparator with a high-impedance input.

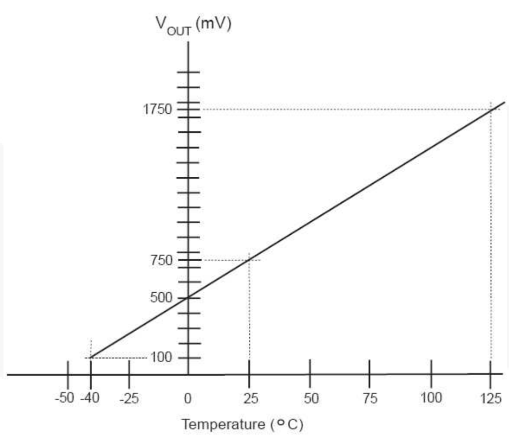
Accuracy is typically ±0.5°C at room temperature, and better than ±2°C from 0 to 75°C.

FM50 is available in a 3-pin SOT-23 package.

Ordering Information

Part Number	Operating Temperature Range	Package	Packing Method
FM50S3X	-40 to +125°C	3-Pin SOT-23	3000 Units, Tape and Reel

All packages are lead free per JEDEC: J-STD-020B standard.



$$\text{Temperature } (°C) = \frac{V_{OUT} - 500 \text{ mV}}{10 \text{ mV}/°C}$$

Figure 1. Output Voltage vs. Temperature

Pin Configuration

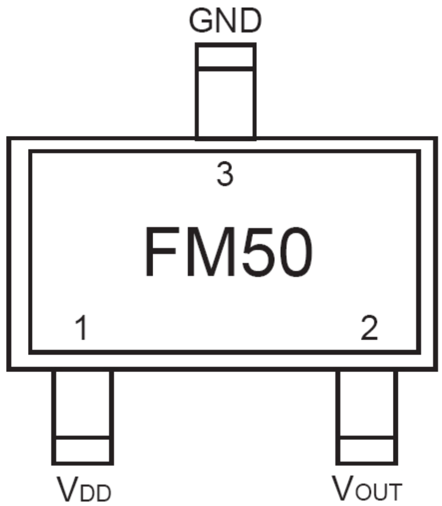


Figure 2. Pin Configuration

Pin Definitions

Pin #	Name	Type	Description
1	V_{DD}	Power	**Power Supply**. 2.4 to 6.0V.
2	V_{OUT}	Analog Output	**Temperature Sensor**. Analog output voltage indicating temperature. V_{OUT} = 500+10T(°C) mV.
3	GND	Power	**Ground**.

Absolute Maximum Ratings

Stresses exceeding the absolute maximum ratings may damage the device. The device may not function or be operable above the recommended operating conditions and stressing the parts to these levels is not recommended. In addition, extended exposure to stresses above the recommended operating conditions may affect device reliability. The absolute maximum ratings are stress ratings only.

Symbol	Parameter	Min.	Max.	Unit
V_{DD}	Supply Voltage		+7	V
V_{OUT}	Output Voltage		V_{DD}+0.5	V
I_{OUT}	Output Current		10	µA
T_J	Operating Temperature Range	-50	+150	°C
T_{STG}	Storage Temperature Range	-60	+150	°C
T_L	Lead Soldering Temperature		+220	°C
ESD	Human Body Model, JESD22-A114(1)		2000	V
	Machine Model, JESD22-A115(2)		250	

Notes:
1. Human body model: 100pF capacitor discharged through a t 1.5kW resister into each pin.
2. Machine model: 200pF capacitor discharged directly into each pin.

Electrical Characteristics

Limits apply for -40°C ≤ T_A ≤ +125°C and V_{DD}=+5.0V unless otherwise noted. These specifications are guaranteed only for the test conditions listed.

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Units
Transfer Characteristics						
A_{OUT}	Sensitivity		9.7	10.0	10.3	mV/°C
	Output at 25°C		740	750	760	mV
	Accuracy(3)	T_A=+25°C	-2.0	±0.5	+2.0	°C
		T_A=-40°C (T_{MIN})	-3.5	±1.0	+3.5	
		T_A=+125°C (T_{MAX})	-3	±1	+3	
T_A	Temperature Range		-40		+125	°C
	Non-Linearity(4)		-0.8		+0.8	°C
Output						
V_{OUT}	Output Voltage Range		100		1750	mV
I_{ONSN}	Output Current Source	Sensing		25		µA
I_{ONSG}		Surge				mA
I_{OL}	Output Current Sink			50		µA
R_{OUT}	Output Resistance	100kΩ Load at 25°C	1		10	kΩ
R_{LOAD}	Load Regulation					mV/mA
Power						
V_{DD}	Supply Voltage		2.4		6.0	V
I_Q	Quiescent Current	No Output Load			170	µA
Package						
Θ_{JA}	Thermal Resistance			260		°C/W

Notes:
3. Accuracy (expressed in °C)= difference between calculated output voltage and measured output voltage. Calculated output voltage =10m/V°C multiplied by the device’s case temperature at specific conditions of temperature, voltage and power supply, added to 500mV.
4. Non-linearity is defined as the deviation of the output voltage vs. temperature curve from the best fit straight line over the rated temperature range.

Typical Performance Characteristics

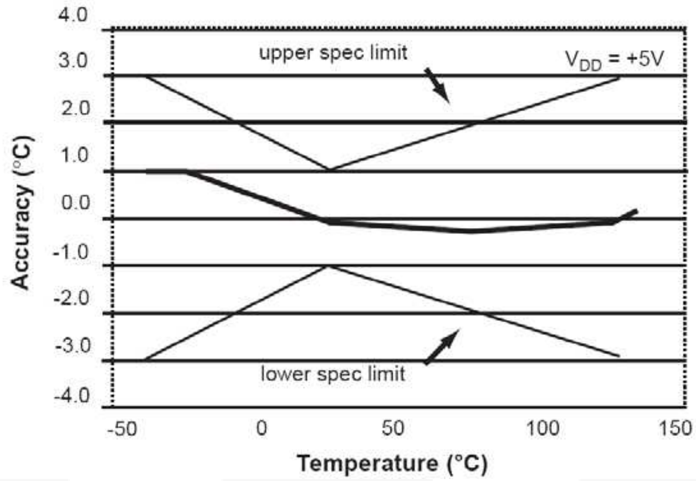


Figure 3. Accuracy vs. Temperature

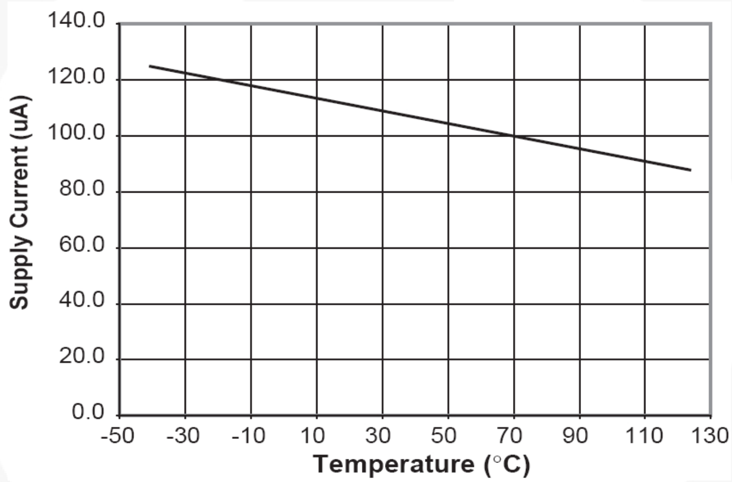


Figure 4. Typical I_{DD} vs. Temperature

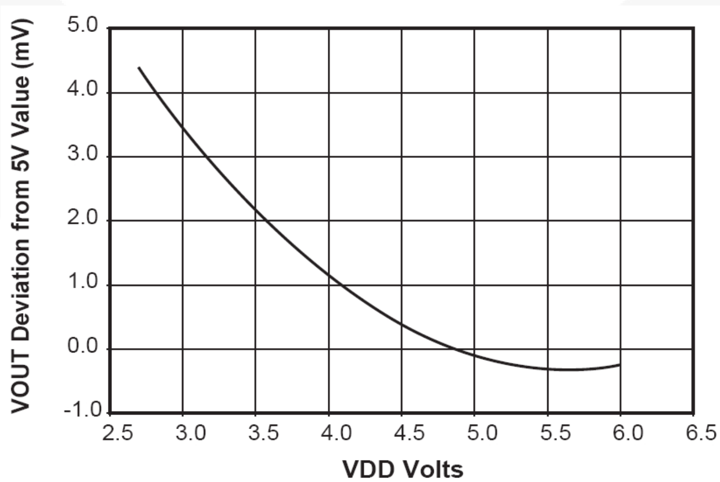


Figure 5. Typical Sensitivity to Supply Voltage

Functional Description

The FM50 contains a thermal diode, calibration circuits, and amplifiers. Since the FM50 is calibrated at 33°C, the nominal output in mV is:

$$V_{OUT} = 830 + 10 \cdot (T-33) \quad (1)$$

where T is the thermal junction temperature expressed in °C.

At 33°C, the tolerances are:

- Offset is ±3mV.
- Slope is ±0.3mV/°C.

These values accommodate the specified accuracies at -40, +25, and +125°C.

Output structure is an N-channel CMOS transistor driving a P-channel load. Available current is typically 50µA to ground. Series resistance is typically 7kΩ, charging and 2kΩ, discharging through a capacitor connected from V_{OUT} to ground.

Following application of power to V_{DD}, V_{OUT} is accurate after a delay of approximately 80ms.

Application Information

Although the FM50 is a simple device, care must be taken to ensure that temperature is measured accurately. The major sources of errors are:

- Voltage Errors
- Thermal Delay Errors
- Location Errors

Voltage Errors

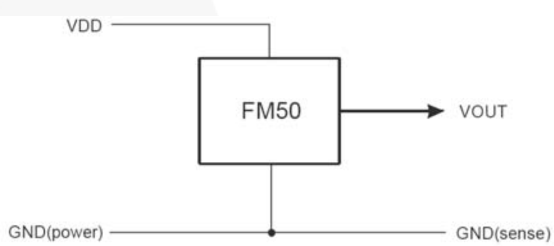


Figure 6. Recommended Electrical Connections

A Kelvin connection is recommended to avoid errors due to voltage drops in the ground connections. Although the typical 130µA supply current draw only causes a 130µV error; if the series resistance is 1Ω, a 100mA current supply to adjacent circuits can cause a 10mV drop across 100mΩ (10mΩ is a typical value for soldered joints or contact resistance), leading to a 1°C error. For this reason, the FM50 should be Kelvin connected, as shown in Figure 6.

Thermal Delay Errors

For measurement accuracy of the order of tenths of 1°C, adequate settling time must be allowed. For a typical circuit board installation, 15 minutes should be allowed to elapse after reading temperature within 1~2°C of the expected final value. Once V_{OUT} has ceased to slew and is stable (with or without about ±0.1°C noise) for about five minutes, temperature can be calculated.

Location Errors

Position is source of error. Even within a controlled thermal environment, changing location by a few inches can lead to errors of several tenths of 1°C.

Mounting

The FM50 can be easily mounted by gluing or cementing it to a surface. In this case, its temperature will be within about 0.2°C of the temperature of the surface to which it is attached if the ambient air temperature is almost the same as the surface temperature. If the air temperature is much higher or lower than the surface temperature, the actual temperature of the die will be at an intermediate temperature between the surface temperature and the air temperature.

To ensure good thermal conductivity, the backside of the die is directly attached to the GND pin. The lands and traces to the FM50 are part of the printed circuit board, for which the temperature is being measured. These printed circuit board lands and traces do not cause the FM50's temperature to deviate from the desired temperature.

Alternatively, the FM50 can be mounted inside a sealed-end metal tube and can be dipped into a bath or screwed into a threaded hole in a tank. As with any IC, the FM50 and accompanying wiring and circuits must be kept insulated and dry to avoid leakage and corrosion. This is especially true if the circuit may operate at cold temperatures where condensation can occur. Printed-circuit coatings and varnishes, such as Humiseal and epoxy paint or dips, can be used to ensure that moisture cannot corrode the FM50 or it connections.

Typical Application Circuits

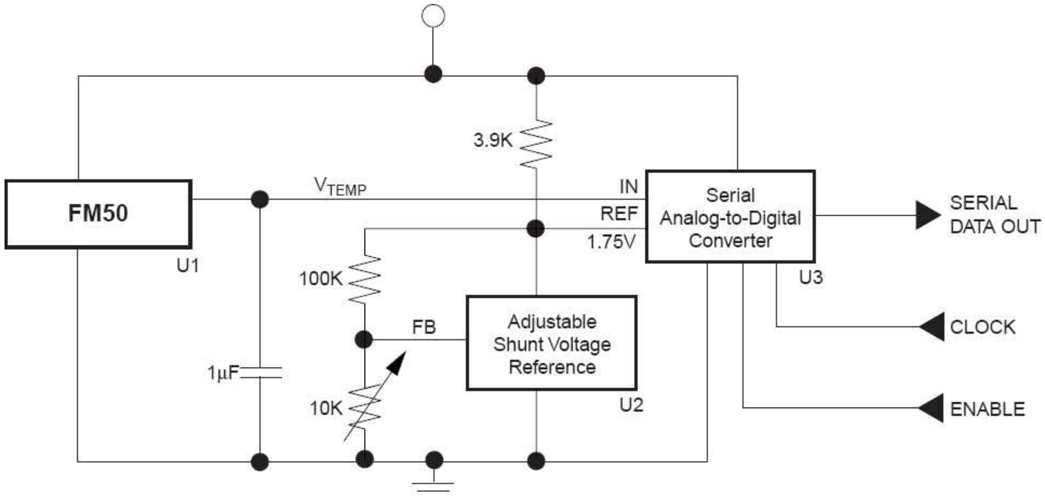


Figure 7. Serial Output Temperature to Digital Converter (Full Scale = +125°C)

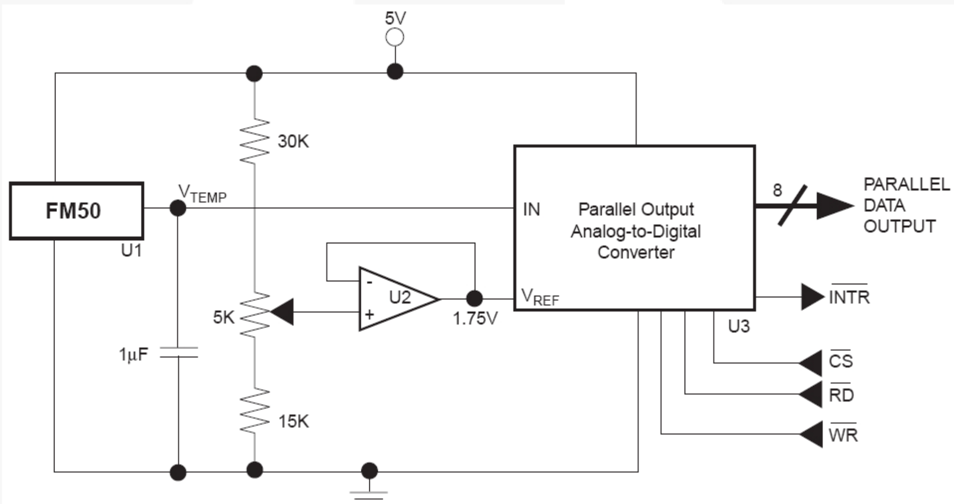


Figure 8. Parallel Output Temperature to Digital Converter (Full Scale = +125°C)

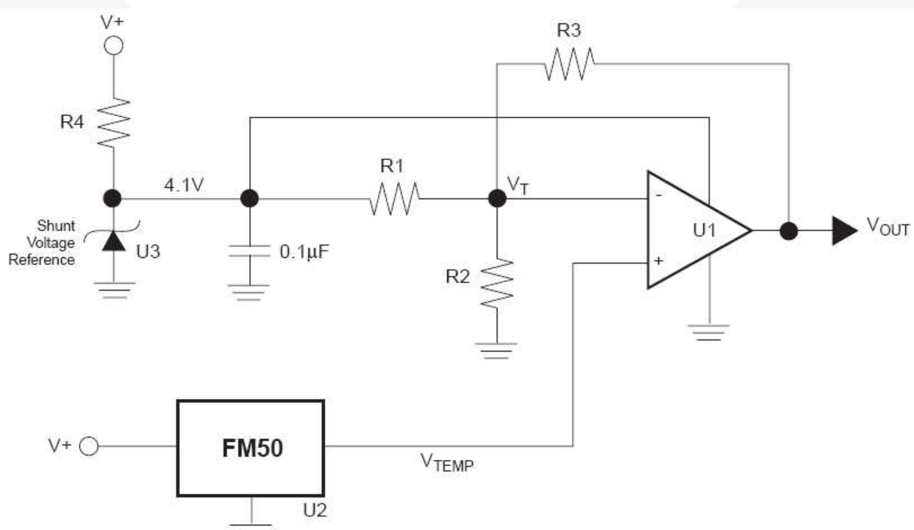


Figure 9. Thermostat / Fan Controller

Physical Dimensions

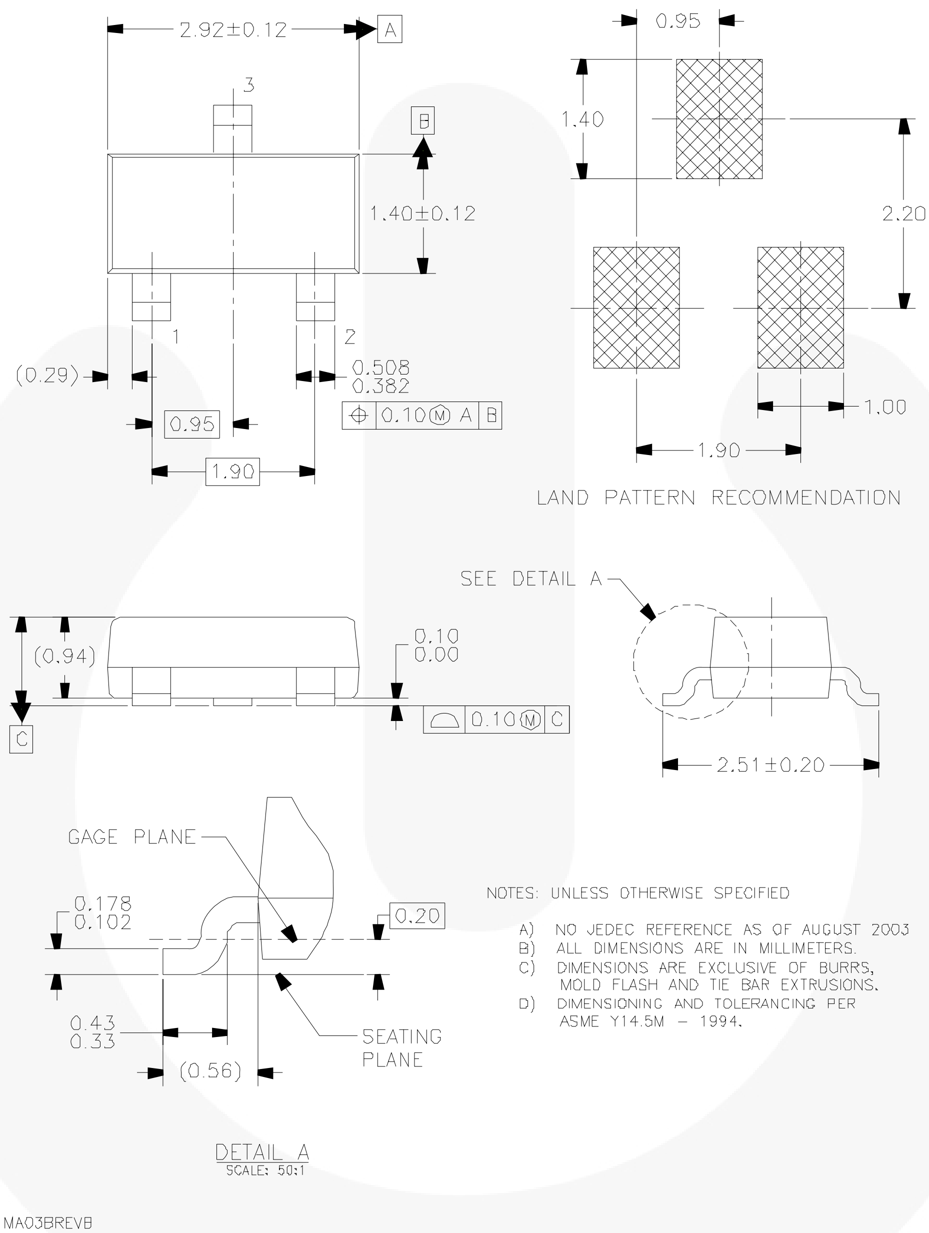


Figure 10. 3-Pin SOT Package

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