

FM20

Low Voltage Ultra-Low-Power Temperature Sensor

General Description

The FM20 is a precision CMOS temperature sensor that provides a cost-effective solution for space-constrained applications.

The output voltage ramp of the FM20 has a negative slope of $-11.77\text{mV}/^\circ\text{C}$. With a supply voltage of 2.4V to 6V, the FM20 is typically accurate to $\pm 1^\circ\text{C}$ at 25°C , to $\pm 3^\circ\text{C}$ over the range of -55°C to 130°C . Reducing the supply voltage to 2.4V does not change the negative temperature extreme from -55°C , and the positive extreme also remains at $+130^\circ\text{C}$.

The FM20 does not require external calibration. Calibration of the FM20 is performed at the factory.

The FM20 is available in 5-pin SC70 and 3-pin SOT-23 surface mount packages.

Features

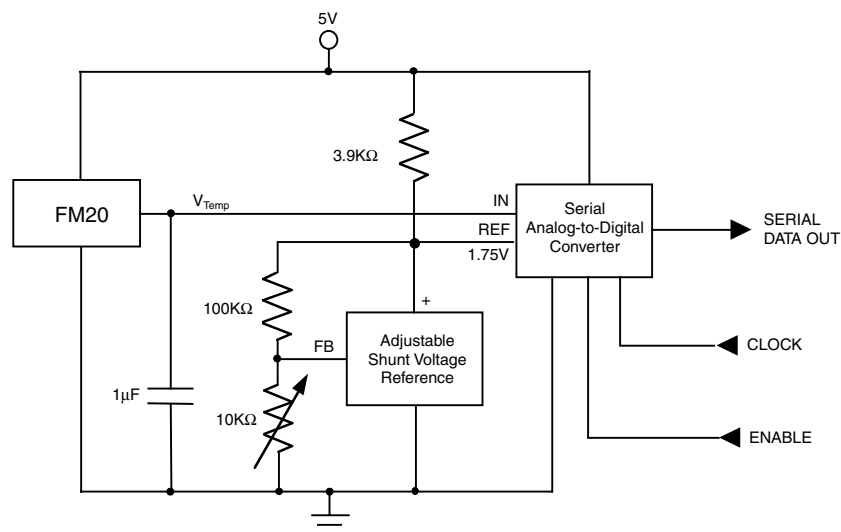
- Extremely Low Power
- Precision Calibrated to $\pm 1^\circ\text{C}$ (typical) at 25°C

- Temperature Range: -55°C to 130°C
- Linear Output Ramp ($-11.77\text{mV}/^\circ\text{C}$)
- Output Ramp is Calibrated to Degrees Celsius
- Low Self Heating (0.02°C max in still air)
- Uses a Single Positive Supply
- Operating Voltage Range: $+2.4\text{V}$ to $+6\text{V}$

Applications

- Cellular Telephones
- Computers
- Battery Management
- FAX Machines/Printers/Copiers
- Portable Medical Instruments
- HVAC
- Power Supply Modules
- Disk Drives
- Appliances

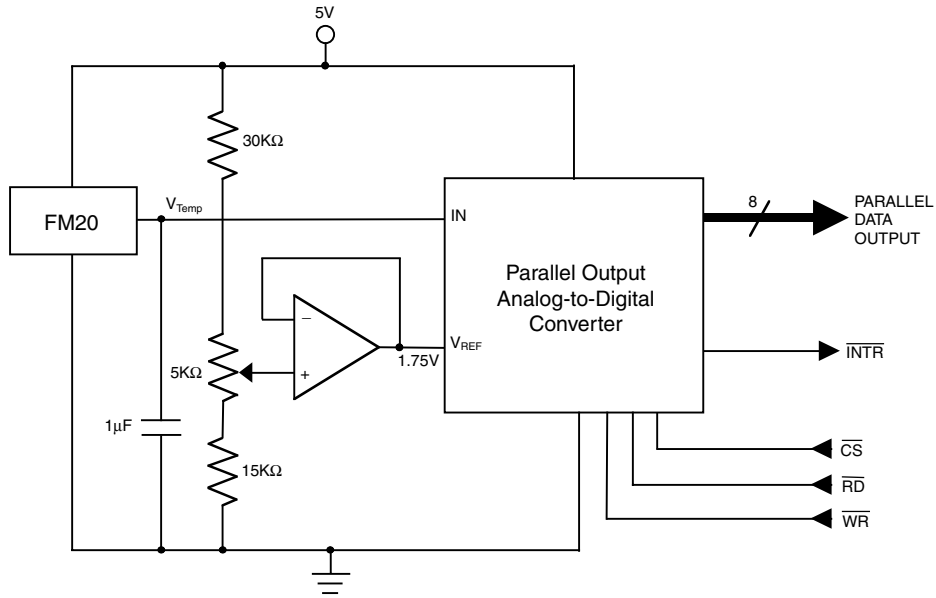
Typical Applications



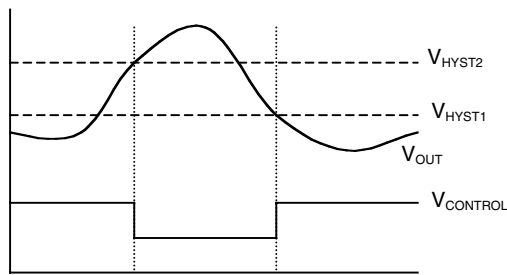
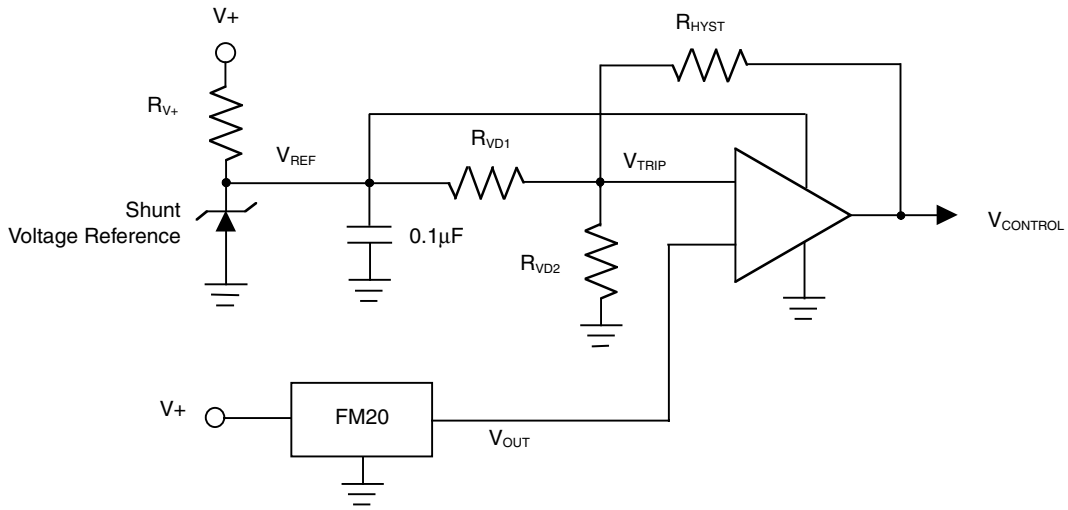
Serial Output Temperature to Digital Converter

(The full scale of the A-to-D Converter will typically be limited to $+125^\circ\text{C}$ simply by the number of bits available in the conversion. The FM20 would still be capable of its full output swing.)

Typical Applications (continued)



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



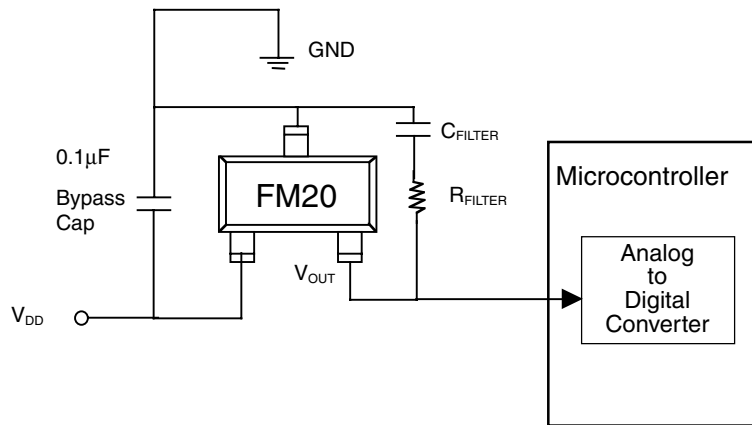
$$V_{HYST2} = \frac{(V_{REF}) \cdot (R_{VD2})}{R_{VD1} + \frac{(R_{VD2}) \cdot (R_{HYST})}{R_{HYST} + R_{VD2}}}$$

$$V_{HYST1} = \frac{(V_{REF}) \cdot (R_{VD2})}{R_{VD2} + \frac{(R_{VD1}) \cdot (R_{HYST})}{R_{HYST} + R_{VD1}}}$$

V_{REF} is set by the Shunt Voltage Reference. $V_{CONTROL}$ high is an alarm state or control for activating cooling/fan.

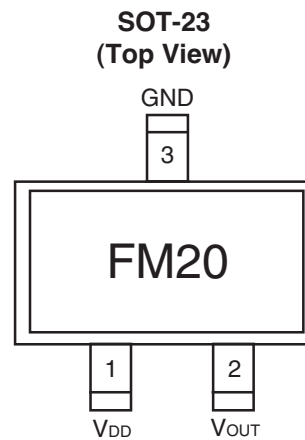
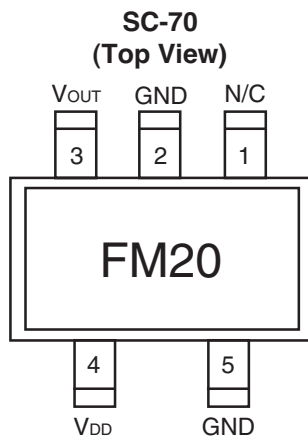
Thermostat/ Fan Controller

Typical Applications (continued)



Digital Temperature Output Through a Microcontroller

Pin Configuration



Ordering Information

Part Number	Package	Temperature Range	How Supplied
FM20P5x	5-Pin SC70	-55°C to +130°C	3000 units on T&R
FM20S3x	3-Pin SOT-23	-55°C to +130°C	3000 units on T&R

Absolute Maximum Ratings (Note 1)

Parameter	Rating	Storage Temperature Range	-60°C to +150°C
Supply Voltage	+7V	Lead Soldering Temperature	220°C
Output Voltage	$V_{DD} + 0.5V$	ESD ²	
Output Current	-20/+1μA	Human Body Model	2000V
		Machine Model	250V

Notes:

- Absolute maximum ratings are limits beyond which operation may cause permanent damage to the device. These are stress ratings only; functional operation at or above these limits is not implied.
- Human Body Model: 100pF capacitor discharged through a 1.5kΩ resistor into each pin. Machine Model: 200pF capacitor discharged directly into each pin.

Recommended Operating Ratings

Symbol	Parameter	Min	Max	Units
V_{DD}	Supply Voltage	+2.4	+6	V
V_{OUT}	Output Voltage	0	V_{DD}	V
T_A	Operating Temperature Range	-55	+130	°C

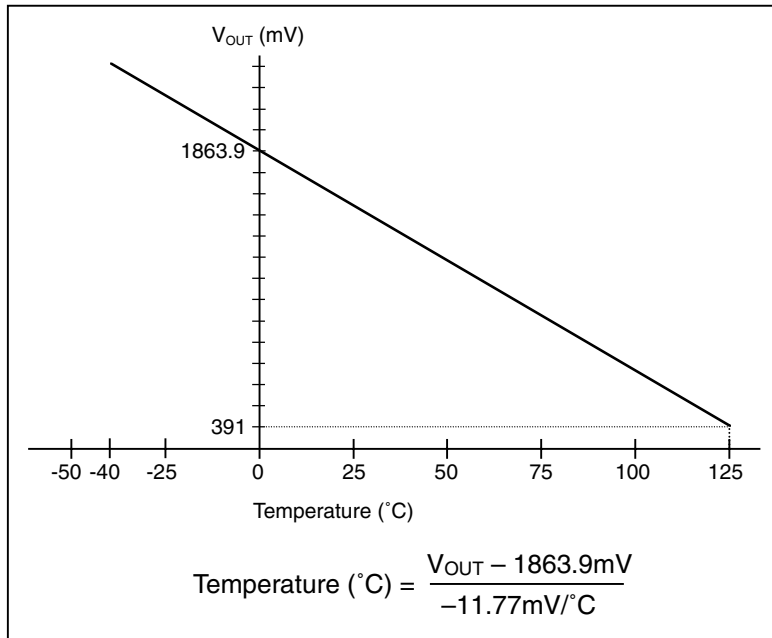
Electrical Characteristics⁴

Limits apply for $-55^{\circ}\text{C} \leq T_A \leq +130^{\circ}\text{C}$ and $V_{DD} = +5.0\text{V}$ unless otherwise noted.

Parameter	Symbol	Conditions	Min	Typ	Max	Units
Accuracy ⁴		$T_A = +25^{\circ}\text{C}$ $T_A = -55^{\circ}\text{C} (T_{MIN})$ $T_A = +130^{\circ}\text{C} (T_{MAX})$	-2 -3 -5	± 1 ± 2 ± 2	+2 +3 +5	°C °C °C
Non-linearity ⁵			-5		+2	°C
Quiescent Supply Current Output Floating	I_{DD}	$T_A = +25^{\circ}\text{C}$ $-55^{\circ}\text{C} \leq T_A \leq +130^{\circ}\text{C}$	7.5 5	9 9	10.5 12	μA μA
Output Sink Capability ⁶	I_{OL}	$V_{DD} = +5\text{V}$		20		μA
Output Source Capability ⁶	I_{OH}	$V_{DD} = +5\text{V}$		1		μA
Average Output Slope (Sensor Gain)	A_{OUT}			-11.77		mV/°C
Output Voltage	V_{OUT}	$T_A = 0^{\circ}\text{C}$		+1863.9		mV
Capacitive Load ⁷	C_L		0		1000	pF
Self Heating		SOT-23 SC70			0.02016 0.02082	°C °C

Notes:

- These specifications are guaranteed only for the test conditions listed.
- Accuracy (expressed in °C) = Difference between calculated output voltage and measured output voltage. Calculated output voltage = $-11.77\text{mV}/^{\circ}\text{C}$ multiplied by device's case temperature at specified conditions of temperature, voltage and power supply plus an offset of 1863.9 mV at 0°C.
- Non-linearity is defined as the deviation of the output-voltage-versus-temperature curve from the best-fit straight line, over the device's rated temperature range.
- Lowest output current should be targeted; higher currents result in more self-heating of the device.
- High capacitive loads may be driven by the output in a static mode, but it may require a delay time before initial read at power up to allow for the RC time constant of the charging capacitor.



FM20 Output Voltage vs. Temperature

Mounting

The FM20 can be easily mounted by gluing or cementing it to a surface. In this case, its temperature will be within about 0.2 $^{\circ}C$ of the temperature of the surface it is attached to 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 FM20 die will be at an intermediate temperature between the surface temperature and the air temperature.

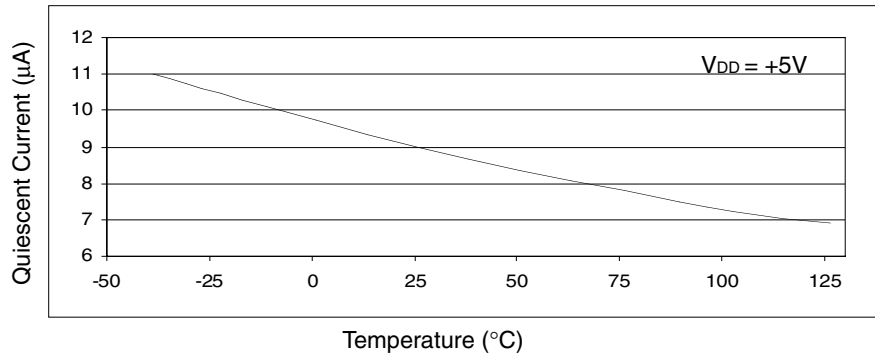
To ensure good thermal conductivity, the backside of the FM20 die is directly attached to the GND pin. The lands and traces to the FM20 will, of course, be part of the printed circuit board, which is the object whose temperature is being measured. These printed

circuit board lands and traces will not cause the FM20's temperature to deviate from the desired temperature.

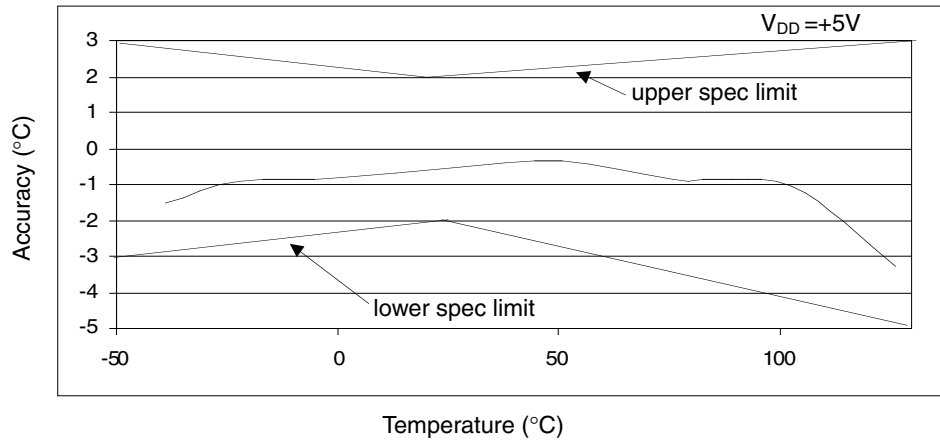
Alternatively, the FM20 can be mounted inside a sealed-end metal tube, and can then be dipped into a bath or screwed into a threaded hole in a tank. As with any IC, the FM20 and accompanying wiring and circuits must be kept insulated and dry to avoid leakage and corrosion. This is especially true if 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 FM20 or its connections.

Typical Performance Characteristics

Quiescent Current vs. Temperature



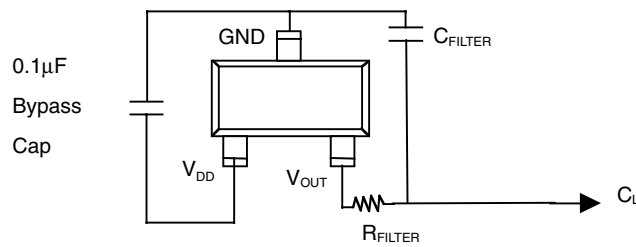
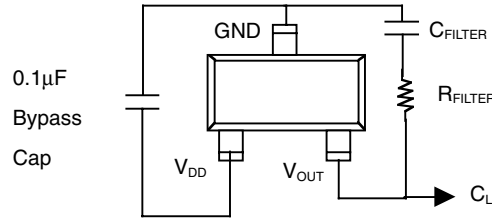
Accuracy vs. Temperature



Loading

The FM20 will handle sizable capacitive loads up to 300pF without any special considerations. In an extremely noisy environment it may be advisable to add some filtering to minimize noise in the output voltage. It is also recommended that a 0.1μF bypass capacitor be added between the supply voltage and ground. This is due to the instant current demand caused by switching CMOS transistors. Normally it is inadvisable to put a sufficiently large supply (particularly in portable electronics) to be able to handle the dynamic currents of CMOS transistors. It is a much simpler solution to use a bypass capacitor to sustain the supply voltage during this short demand period.

In environments that are particularly noisy it may be necessary to add a low-pass filter network to the output of the device. As shown below, a 1μF capacitor in addition to the output impedance of the device and a 200Ω series resistor for a low-pass filter that will pass the slow thermal time constant of the FM20, while filtering the higher frequency noise. The response time of the FM20 can be affected by this filter network, therefore values for $C_{\text{FILTER}} < 1500\text{pF}$ are recommended.

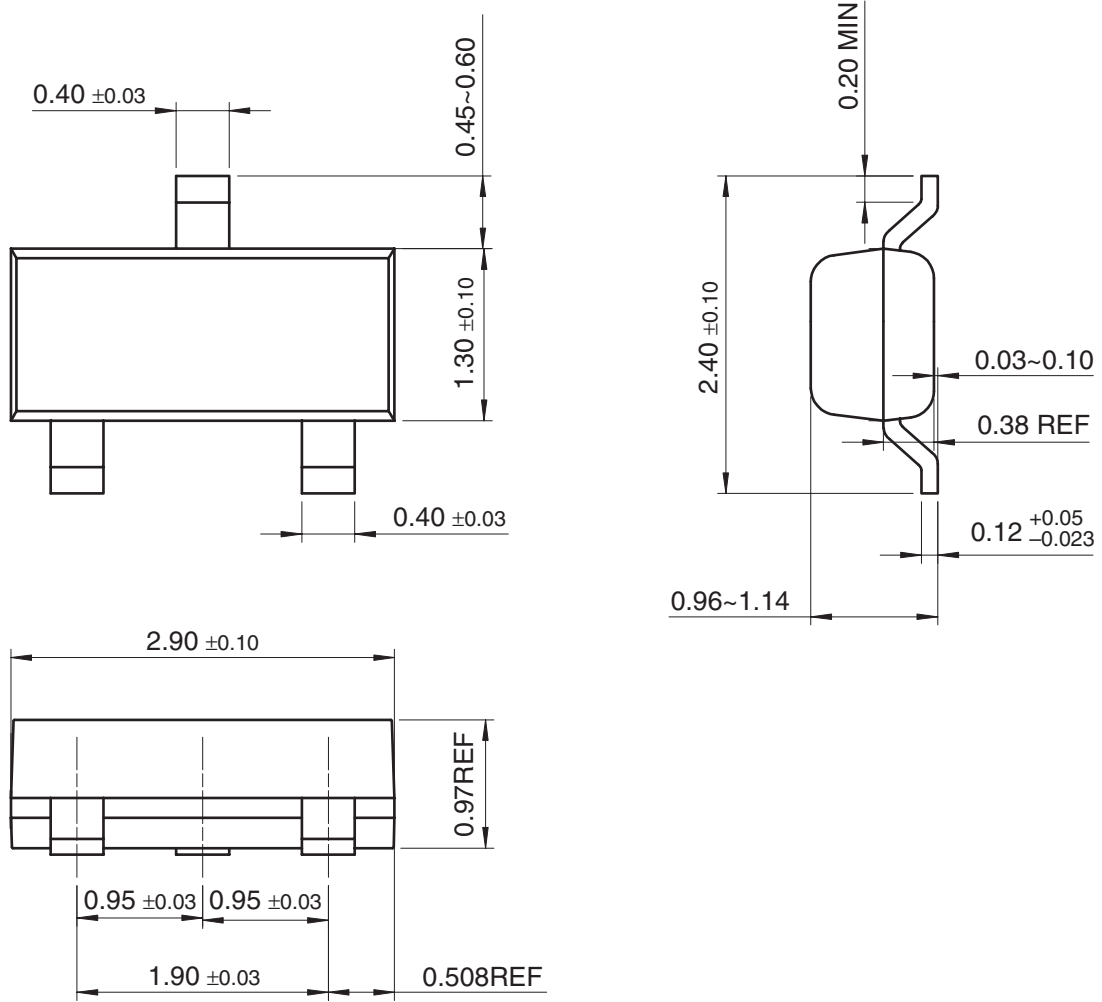


FM20 with Filter Network for Noisy Environments or for Capacitive Loads Greater than 300pF

Resistor/Capacitor Combinations for Filter Network

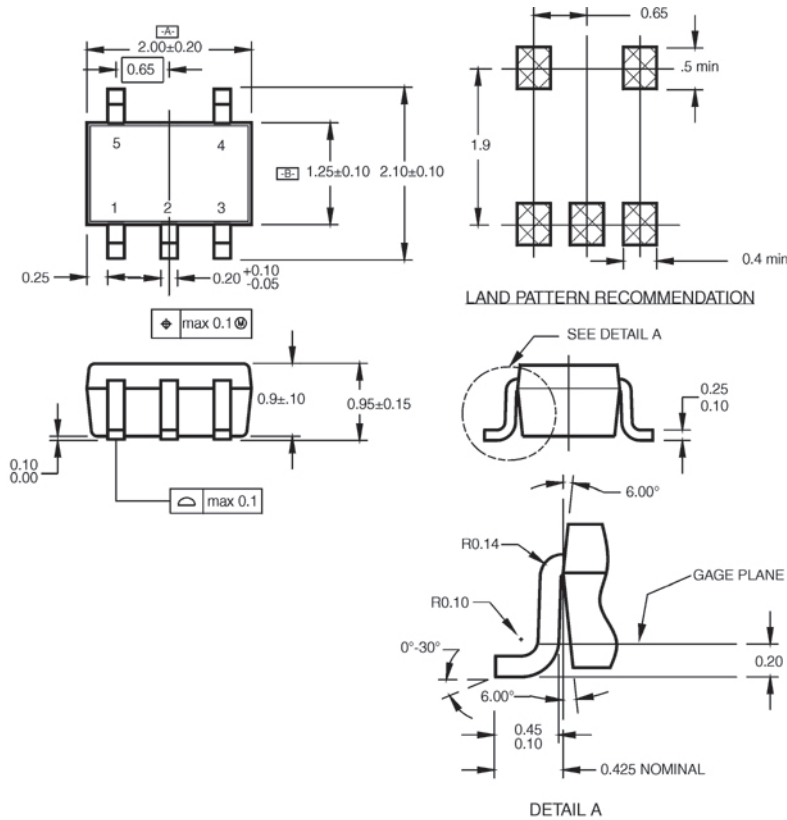
R_{FILTER}	C_{FILTER}
200Ω	1μF
470Ω	0.1μF
680Ω	0.01μF
1000Ω	1000pF
10kΩ	100pF
100kΩ	10pF

Physical Dimensions inches (millimeters) unless otherwise noted



**SOT-23 Package Dimensions
FS Package Code MA03A**

Physical Dimensions inches (millimeters) unless otherwise noted



NOTES:
 A. CONFORMS TO EIAJ REGISTERED OUTLINE DRAWING SC88A.
 B. DIMENSIONS DO NOT INCLUDE BURRS OR MOLD FLASH.
 C. DIMENSIONS ARE IN MILLIMETERS.

MAA05ARevC

**SC70 5-pin Package Dimensions
 FS Package Code MAA05A**

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