MCP9804

±0.25°C Typical Accuracy Digital Temperature Sensor

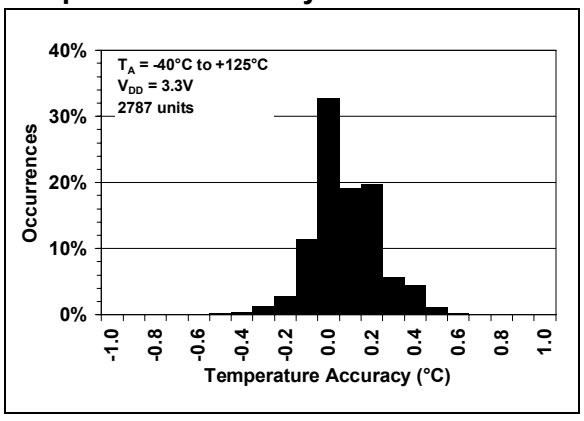
Features

- Accuracy:
  - ±0.25°C (typical) from -40°C to +125°C
  - ±1°C (maximum) from -40°C to +125°C
  - +0.05°C (typical) lifetime drift
  - ±0.0625°C or ±1 LSb (typical) repeatability
- User-Selectable Measurement Resolution:
  - +0.5°C, +0.25°C, +0.125°C, +0.0625°C
- User-Programmable Temperature Limits:
  - Temperature Window Limit
  - Critical Temperature Limit
- User-Programmable Temperature Alert Output
- Operating Voltage Range: 2.7V to 5.5V
- Operating Current: 200 µA (typical)
- Shutdown Current: 0.1 µA (typical)
- 2-wire Interface: I²C™/SMBus Compatible
- Available Packages: 2x3 DFN-8, MSOP-8

Typical Applications

- General Purpose
- Industrial Applications
- Industrial Freezers and Refrigerators
- Food Processing
- Personal Computers and Servers
- PC Peripherals
- Consumer Electronics
- Handheld/Portable Devices

Temperature Accuracy



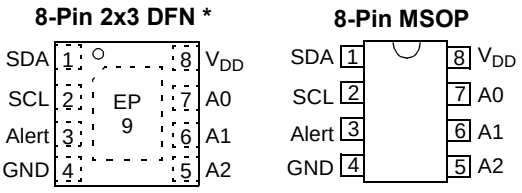
Description

Microchip Technology Inc.'s MCP9804 digital temperature sensor converts temperatures between -40°C and +125°C to a digital word with ±0.25°C/±1°C (typical/maximum) accuracy.

The MCP9804 comes with user-programmable registers that provide flexibility to temperature sensing applications. The registers allow user-selectable settings such as Shutdown or Low-Power modes and the specification of temperature Alert window limits and critical output limits. When the temperature changes beyond the specified boundary limits, the MCP9804 outputs an Alert signal. The user has the option of setting the Alert output signal polarity as an active-low or active-high comparator output for thermostat operation, or as a temperature Alert interrupt output for microprocessor-based systems. The Alert output can also be configured as a critical temperature output only.

This sensor has an industry standard 100 kHz, 2-wire, SMBus/I²C compatible serial interface, allowing up to eight or sixteen sensors to be controlled with a single serial bus (see Table 3-2 for available Address codes). These features make the MCP9804 ideal for sophisticated, multi-zone, temperature-monitoring applications.

Package Types



* Includes Exposed Thermal Pad (EP); see Table 3-1.

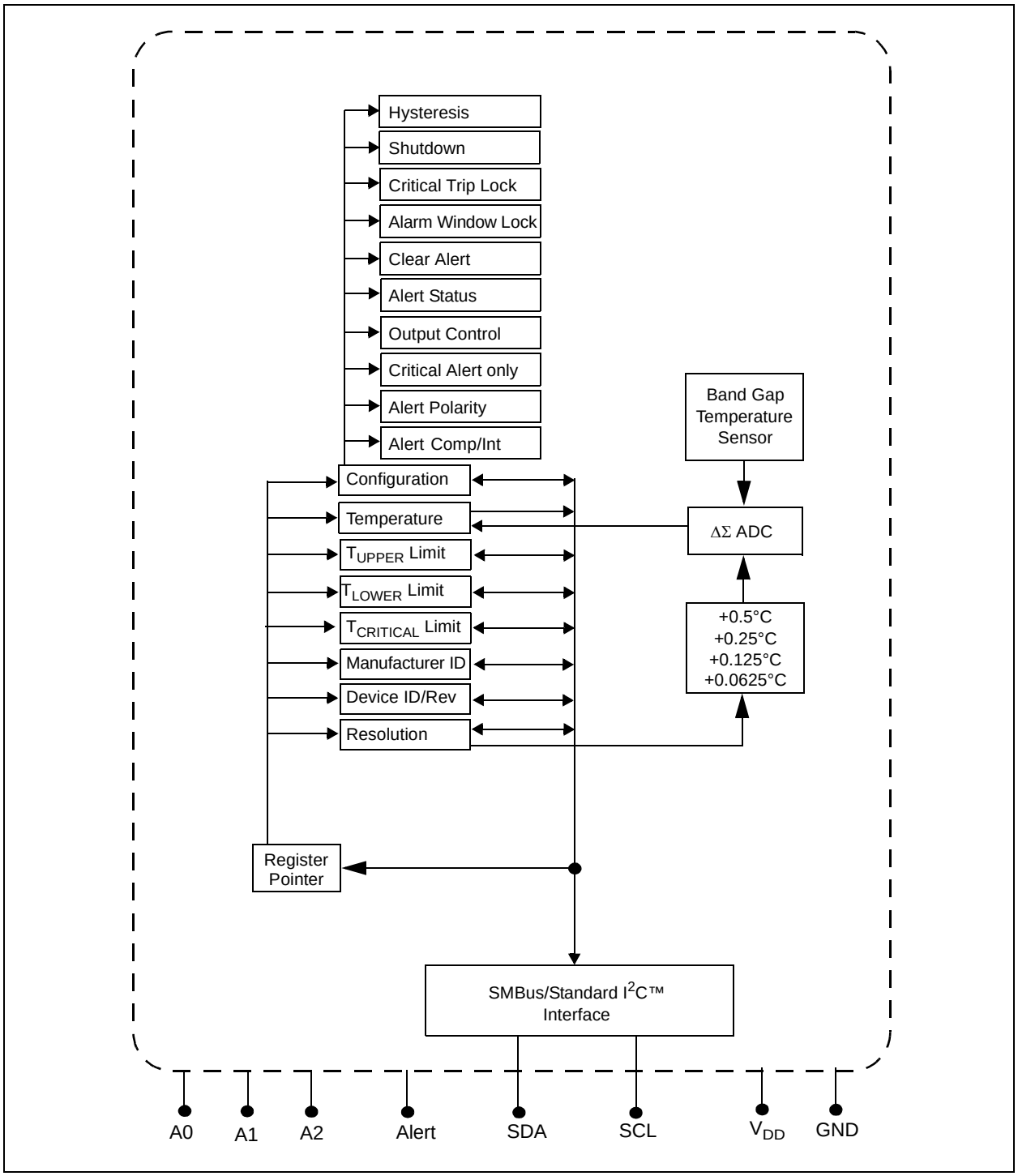


FIGURE 1: *Functional Block Diagram.*

1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings †

V_{DD}..... 6.0V
Voltage at All Input/Output Pins ..... GND – 0.3V to 6.0V
Storage Temperature .....-65°C to +150°C
Ambient Temperature with Power Applied ....-40°C to +125°C
Junction Temperature (T_J) .....+150°C
ESD Protection on All Pins (HBM:MM) ..... (4 kV:400V)
Latch-up Current at Each Pin (25°C) ..... ±200 mA

†Notice: Stresses above those listed under "Maximum ratings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device at those or any other conditions above those indicated in the operational listings of this specification is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.

TEMPERATURE SENSOR DC CHARACTERISTICS

Electrical Specifications: Unless otherwise indicated, V_{DD} = 2.7V to 5.5V, GND = Ground and T_A = -40°C to +125°C.

Parameters	Sym	Min	Typ	Max	Unit	Conditions
Temperature Sensor Accuracy						
-40°C < $T_A \leq$ +125°C	T_{ACY}	-1.0	±0.25	+1.0	°C	V_{DD} = 3.3V (**Note 1**)
Accuracy Drift	T_{DRIFT}	—	+0.05	—	°C	V_{DD} = 3.3V (**Note 2**)
Accuracy Repeatability	T_{REPEAT}	—	±0.0625	—	°C	48 hours at 55°C, V_{DD} = 3.3V
Temperature Conversion Time						
0.5°C/bit	t_{CONV}	—	30	—	ms	33s/sec (typical)
0.25°C/bit		—	65	—	ms	15s/sec (typical)
0.125°C/bit		—	130	—	ms	7s/sec (typical)
0.0625°C/bit		—	250	—	ms	4s/sec (typical)
Power Supply						
Operating Voltage Range	V_{DD}	2.7	—	5.5	V	
Operating Current	I_{DD}	—	200	400	µA	
Shutdown Current	I_{SHDN}	—	0.1	2	µA	
Power-on Reset (POR)	V_{POR}	—	2.2	—	V	Threshold for falling V_{DD}
Power Supply Rejection	$\Delta°C/\Delta V_{DD}$	—	-0.1	—	°C/V	V_{DD} = 2.7V to 5.5V, T_A = +25°C
Alert Output (open-drain output, external pull-up resistor required), see Section 5.2.3 "Alert Output Configuration"						
High-Level Current (leakage)	I_{OH}	—	—	1	µA	V_{OH} = V_{DD} (Active-Low, Pull-up Resistor)
Low-Level Voltage	V_{OL}	—	—	0.4	V	I_{OL}= 3 mA (Active-Low, Pull-up Resistor)
Thermal Response, from +25°C (air) to +125°C (oil bath)						
8L-DFN	t_{RES}	—	0.7	—	s	Time to 63% (+89°C)
8L-MSOP		—	1.4	—	s	

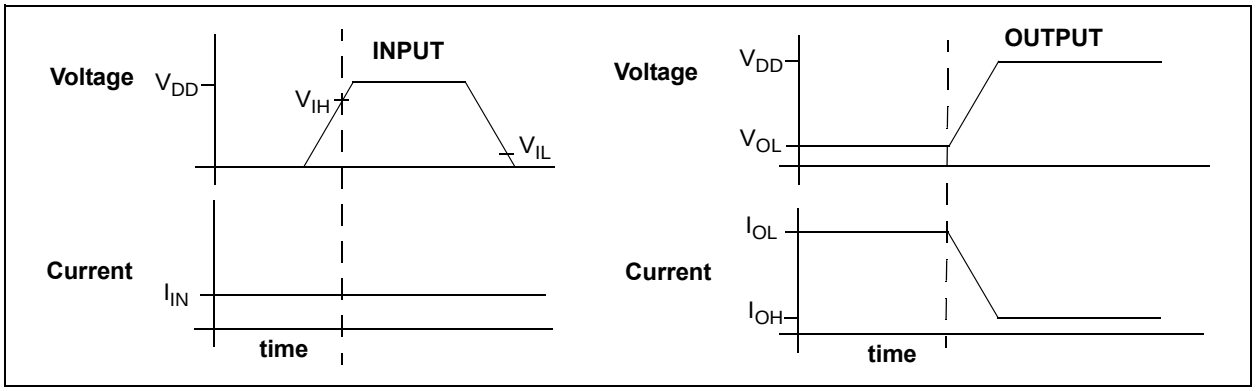
Note 1: Accuracy specification includes life time drift.
2: Using Accelerated Life Cycle, equivalent of 12 years of operation at 55°C.

DIGITAL INPUT/OUTPUT PIN CHARACTERISTICS

Electrical Specifications: Unless otherwise indicated, V_{DD} = 2.7V to 5.5V, GND = Ground and T_A = -40°C to +125°C.

Parameters	Sym	Min	Typ	Max	Units	Conditions
Serial Input/Output (SCL, SDA, A0, A1, A2)						
Input						
High-Level Voltage	V_{IH}	0.7 V_{DD}	—	—	V	
Low-Level Voltage	V_{IL}	—	—	0.3 V_{DD}	V	
Input Current	I_{IN}	—	—	±5	µA	
Output (SDA)						
Low-Level Voltage	V_{OL}	—	—	0.4	V	I_{OL}= 3 mA
High-Level Current (leakage)	I_{OH}	—	—	1	µA	V_{OH} = 5.5V
Low-Level Current	I_{OL}	6	—	—	mA	V_{OL} = 0.6V
SDA and SCL Inputs						
Hysteresis	V_{HYST}	—	0.05 V_{DD}	—	V	
Spike Suppression	t_{SP}	—	—	50	ns	
Capacitance	C_{IN}	—	5	—	pF	

GRAPHICAL SYMBOL DESCRIPTION



TEMPERATURE CHARACTERISTICS

Electrical Specifications: Unless otherwise indicated, V_{DD} = 2.7V to 5.5V and GND = Ground.

Parameters	Sym	Min	Typ	Max	Units	Conditions
Temperature Ranges						
Specified Temperature Range	T_A	-40	—	+125	°C	**(Note 1)**
Operating Temperature Range	T_A	-40	—	+125	°C	
Storage Temperature Range	T_A	-65	—	+150	°C	
Thermal Package Resistances						
Thermal Resistance, 8L-DFN	θ_{JA}	—	41	—	°C/W	
Thermal Resistance, 8L-MSOP	θ_{JA}	—	206	—	°C/W	

Note 1: Operation in this range must not cause T_J to exceed Maximum Junction Temperature (+150°C).

SENSOR SERIAL INTERFACE TIMING SPECIFICATIONS

Electrical Specifications: Unless otherwise indicated, V_{DD}= 2.7V to 5.5V, T_A = -40°C to +125°C, GND = Ground and C_L = 80 pF **(Note 1)**.

				(Note 6)			
Parameters	**Sym**	**Min**	**Max**	**Min**	**Max**	**Units**	**Conditions**
2-Wire SMBus/I²C Interface							
Serial port frequency	f_{SCL}	0	100	0	400	kHz	(Note 2, Note 4)
Low Clock	t_{LOW}	4700	—	1300	—	ns	(Note 2)
High Clock	t_{HIGH}	4000	—	600	—	ns	(Note 2)
Rise Time	t_R	—	1000	20	300	ns	
Fall Time	t_F	20	300	20	300	ns	
Data in Setup Time	t_{SU-DI}	250	—	100	—	ns	(Note 3)
Data in Hold Time	t_{HD-DI}	0	—	0	—	ns	**(Note 5)**
Data out Hold Time	t_{HD-DO}	300	—	200	900	ns	**(Note 4)**
Start Condition Setup Time	$t_{SU-START}$	4700	—	600	—	ns	
Start Condition Hold Time	$t_{HD-START}$	4000	—	600	—	ns	
Stop Condition Setup Time	$t_{SU-STOP}$	4000	—	600	—	ns	
Bus Free	t_{B-FREE}	4700	—	1300	—	ns	
Time-out	t_{OUT}	25	50	25	50	ms	
Bus Capacitive load	C_b	—	—	—	400	pf	

Note 1: All values referred to $V_{IL\ MAX}$ and $V_{IH\ MIN}$ levels.

2: If $t_{LOW} > t_{OUT}$ or $t_{HIGH} > t_{OUT}$, the temperature sensor I²C interface will time-out. A Repeat Start command is required for communication.

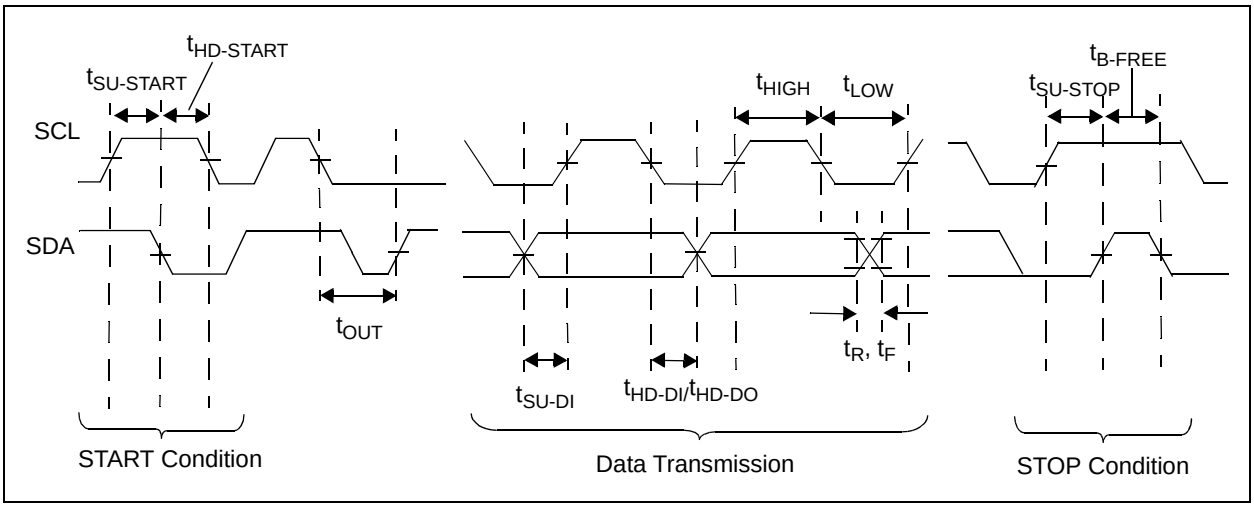
3: This device can be used in a Standard-mode I²C-bus system, but the requirement $t_{SU:DI\ MIN}$ must be met. This device does not stretch SCL Low time.

4: As a transmitter, the device provides internal minimum delay time $t_{HD:DO\ MIN}$, to bridge the undefined region of the falling edge of SCL $t_{F\ MAX}$ to avoid unintended generation of Start or Stop conditions.

5: As a receiver, SDA should not be sampled at the falling edge of SCL. SDA can transition $t_{HD:DI}$ after SCL toggles Low.

6: The I²C Fast Mode specification, or timing for bus frequency up to 400KHz, applies to devices starting with date code of 1145.

TIMING DIAGRAM



NOTES:

2.0 TYPICAL PERFORMANCE CURVES

Note: The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only. The performance characteristics listed herein are not tested or guaranteed. In some graphs or tables, the data presented may be outside the specified operating range (e.g., outside specified power supply range) and therefore outside the warranted range.

Note: Unless otherwise indicated, V_{DD} = 2.7V to 5.5V, GND = Ground, SDA/SCL pulled-up to V_{DD} and T_A = -40°C to +125°C.

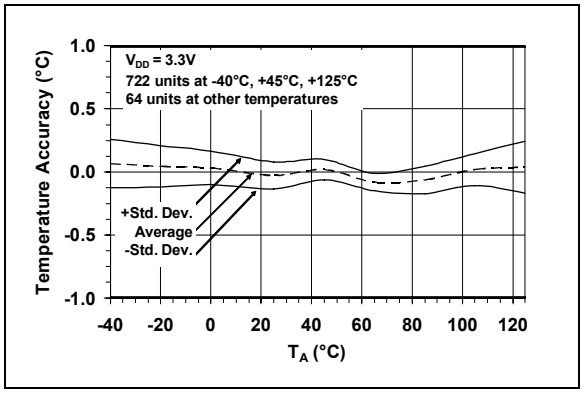


FIGURE 2-1: *Temperature Accuracy.*

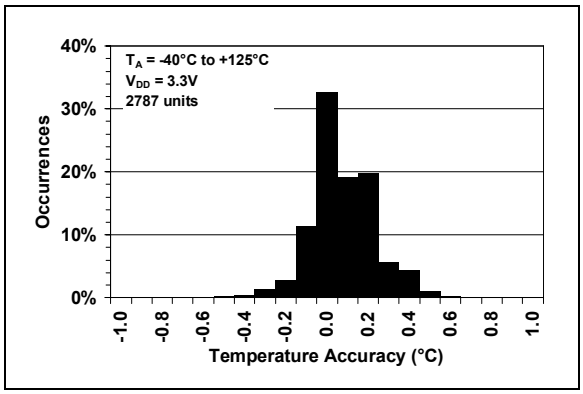


FIGURE 2-2: *Temperature Accuracy Histogram, T_A = -40°C to +125°C.*

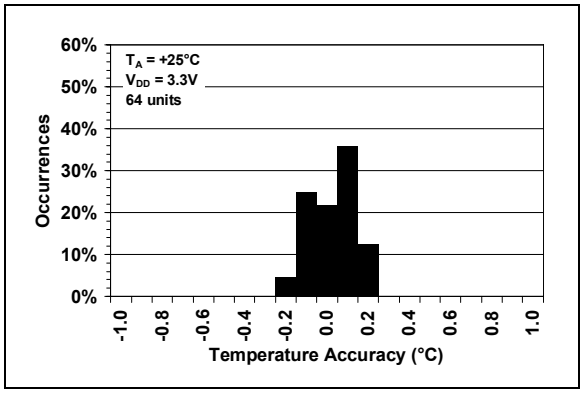


FIGURE 2-3: *Temperature Accuracy Histogram, T_A = +25°C.*

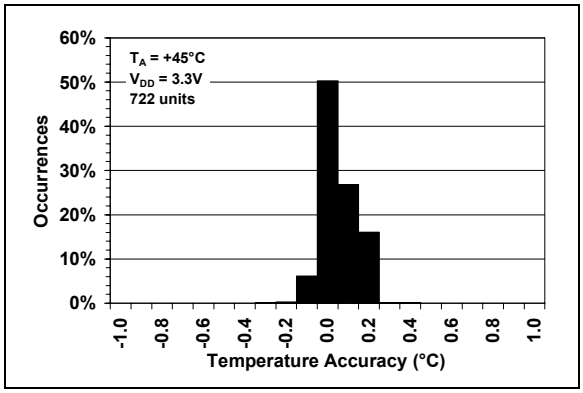


FIGURE 2-4: *Temperature Accuracy Histogram, T_A = +45°C.*

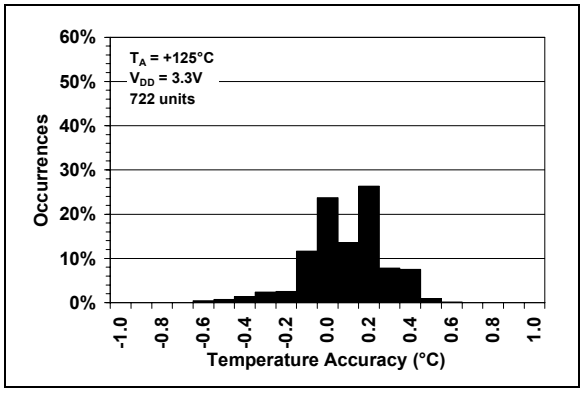


FIGURE 2-5: *Temperature Accuracy Histogram, T_A = +125°C.*

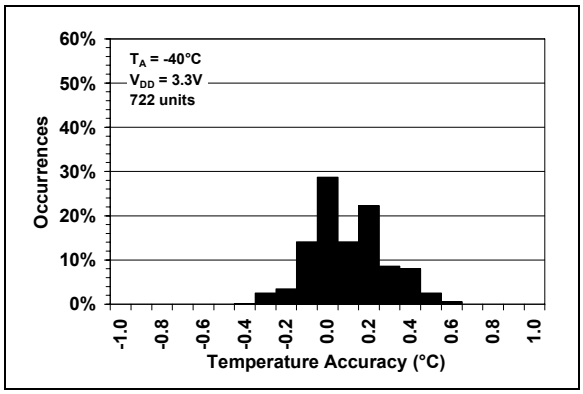


FIGURE 2-6: *Temperature Accuracy Histogram, T_A = -40°C.*

Note: Unless otherwise indicated, V_{DD} = 2.7V to 5.5V, GND = Ground, SDA/SCL pulled-up to V_{DD} and T_A = -40°C to +125°C.

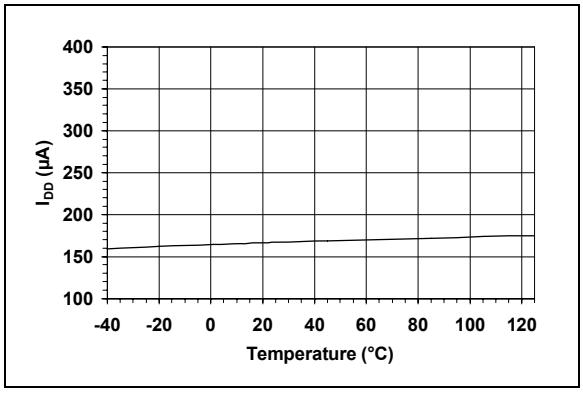


FIGURE 2-7: *Supply Current vs. Temperature.*

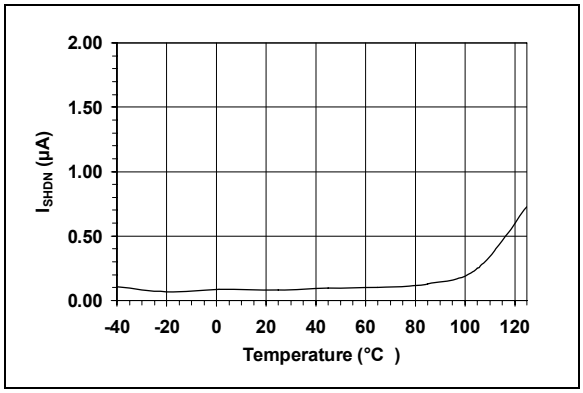


FIGURE 2-8: *Shutdown Current vs. Temperature.*

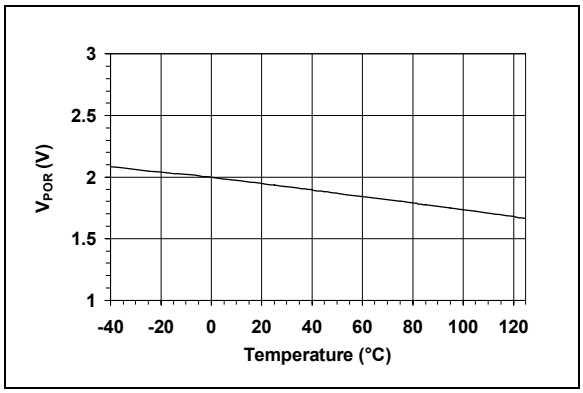


FIGURE 2-9: *Power-on Reset Threshold Voltage vs. Temperature.*

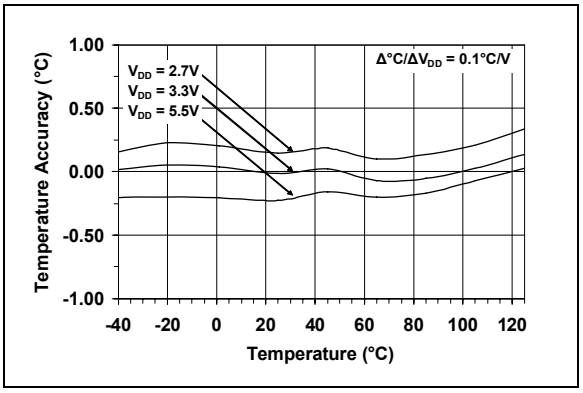


FIGURE 2-10: *Temperature Accuracy vs. Supply Voltage.*

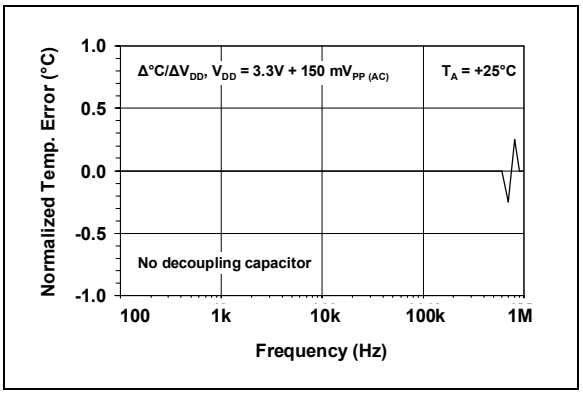


FIGURE 2-11: *Power Supply Rejection vs. Frequency.*

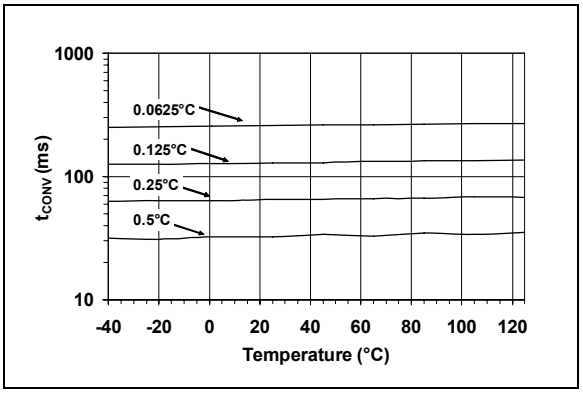


FIGURE 2-12: *Temperature Conversion Time vs. Temperature.*

Note: Unless otherwise indicated, V_{DD} = 2.7V to 5.5V, GND = Ground, SDA/SCL pulled-up to V_{DD} and T_A = -40°C to +125°C.

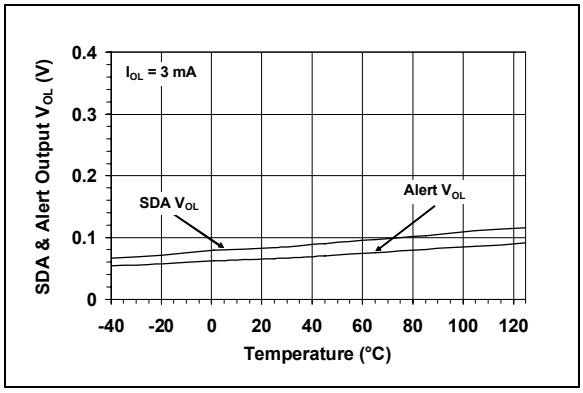


FIGURE 2-13: *SDA and Alert Output V_{OL} vs. Temperature.*

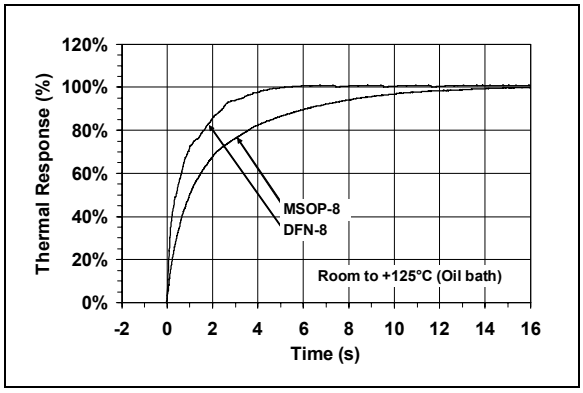


FIGURE 2-15: *Package Thermal Response.*

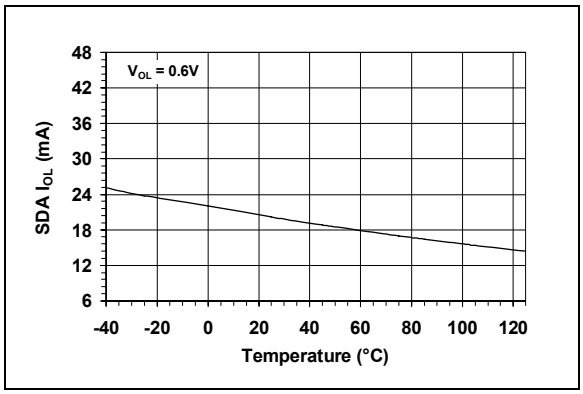


FIGURE 2-14: *SDA I_{OL} vs. Temperature.*

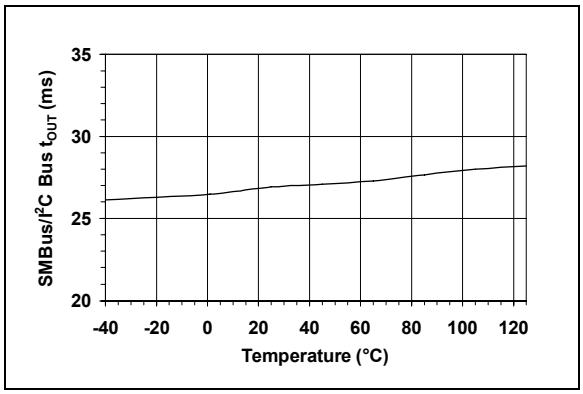


FIGURE 2-16: *SMBus Time-out vs. Temperature.*