ADT7604

20-Channel, Data Center Thermal Measurement and Leak Sensing System

FEATURES

- Directly Digitizes:
  - Copper Trace Temperature Sensors
  - Liquid Leakage Sensing
  - 2-, 3-, or 4-Wire RTDs
  - Thermistors
- Zero-Config Startup through On-Chip EEPROM
- Single 2.85V to 5.25V Supply
- No Negative Supply Required
- 20 Single-Ended/10 Differential Inputs Allow Interchanging Sensors
- Built-in Standard and User-Programmable Coefficients for RTDs and Thermistors
- Automatic Open-Circuit, Short-Circuit, and Fault Detection
- Buffered Inputs Allow External Filtering
- Simultaneous 50Hz/60Hz Rejection

APPLICATIONS

- AI/HPC Data Center Liquid Cooling Systems
- Server Rack Thermal Management
- Industrial Process Control and Monitoring
- CDU and Coolant Distribution Unit Monitoring

GENERAL DESCRIPTION

The ADT7604 measures a wide variety of temperature sensors and digitally outputs the result, in °C, °F, or Ω, with 0.1°C accuracy and 0.001°C resolution. The device measures temperature with standard 2-, 3-, or 4-wire RTDs and thermistors. It has 20 reconfigurable analog inputs enabling many sensor connections and configuration options. The ADT7604 includes excitation current sources and fault-detection circuitry appropriate for each type of temperature sensor, as well as an EEPROM for storing custom coefficients and channel configuration data.

The ADT7604 features accurate temperature measurement with copper trace sensors, which are thin copper traces integrated into PCBs or laminate substrates, and can be placed in mechanically hard-to-reach places to sense thermal hotspots. The ADT7604 also accurately measures resistive leak sensors for safety monitoring in liquid-handling systems.

The ADT7604 allows direct interfacing to ground-referenced sensors without the need for level shifters, negative supply voltages, or external amplifiers. All signals are buffered and simultaneously digitized with two high-accuracy, 24-bit Δ-∑ ADCs.

TYPICAL APPLICATION

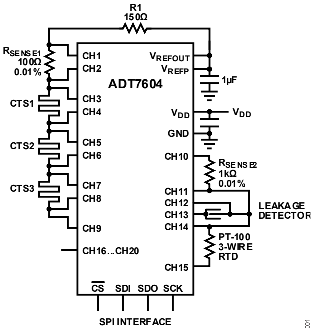

Figure 1. Copper Trace Temperature Measurement System with 3-Wire RTD Calibration Sensor

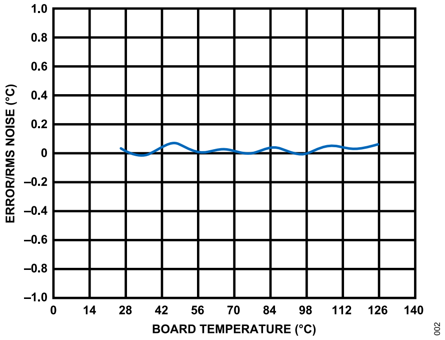

Figure 2. Typical Temperature Measurement Errors and Noise with 1Ω Copper Trace Resistor

Rev 0; 5/26

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TABLE OF CONTENTS

SPECIFICATIONS

Table 1. COMPLETE SYSTEM ELECTRICAL CHARACTERISTICS

(The * denotes the specifications that apply over the full operating temperature range. Otherwise, specifications are at $T_A = +25°C$.)

PARAMETER	CONDITIONS	COMMENTS	MIN	TYP	MAX	UNITS
Supply Voltage		*	2.85		5.25	V
Supply Current		*		15	20	mA
Sleep Current		*		25	60	µA
Input Range	All analog input channels	*	-0.05		$V_{DD} - 0.3$	V
Output Rate	Conversion cycle	*	150	164	170	ms
Input Common-Mode Rejection	50Hz/60Hz (4)	*	120			dB
Input Normal-Mode Rejection	60Hz (4,7)	*	120			dB
	50Hz (4,8)	*	120			dB
	50Hz/60Hz (4,6,9)	*	75			dB
Power-on Reset Threshold				2.25		V
Analog Power-up	(11)	*			100	ms
Digital Initialization	(12)	*			100	ms

Table 2. ADC ELECTRICAL CHARACTERISTICS

(The * denotes the specifications that apply over the full operating temperature range. Otherwise, specifications are at $T_A = +25°C$.)

PARAMETER	CONDITIONS	COMMENTS	MIN	TYP	MAX	UNITS
Resolution (No Missing Codes)	$-FS \le V_{IN} \le +FS$	*	24			bits
Integral Nonlinearity	$V_{IN(CM)} = 1.25V$ (15)	*		2	30	ppm of V_{REF}
Offset Error		*		0.5	2	µV
Offset Error Drift	(4)	*		10	20	nV/°C
Positive Full-Scale Error	(3,15)	*			100	ppm of V_{REF}
Positive Full-Scale Drift	(3,15)	*		0.1	0.5	ppm of V_{REF}/°C
Input Leakage	-40°C to +85°C	*			1	nA
	-40°C to +125°C				10	nA

(The * denotes the specifications that apply over the full operating temperature range. Otherwise, specifications are at T_A = +25°C.)

PARAMETER	CONDITIONS	COMMENTS	MIN	TYP	MAX	UNITS
Negative Full-Scale Error	(3,15)	*			100	ppm of V_{REF}
Negative Full-Scale Drift	(3,15)	*		0.1	0.5	ppm of V_{REF}/°C
Input Referred Noise	-40°C to +85°C	*		0.8	1.5	μV_{RMS}
	-40°C to +125°C				2.0	μV_{RMS}
Common-Mode Input Range		*	-0.05		V_{DD} – 0.3	V
RTD Excitation Current	(16)	*	-25	*Table 50*	+25	%
RTD Excitation Current Matching	Continuously calibrated	*		Error within noise level of ADC		
Thermistor Excitation Current	(16)	*	-37.5	*Table 74*	+37.5	%

Table 3. REFERENCE ELECTRICAL CHARACTERISTICS

(The * denotes the specifications that apply over the full operating temperature range. Otherwise, specifications are at T_A = +25°C.)

PARAMETER	CONDITIONS	COMMENTS	MIN	TYP	MAX	UNITS
Output Voltage	V_{REFOUT} (10)		2.49		2.51	V
Output Voltage Temperature Coefficient				10		ppm/°C
Line Regulation		*			10	ppm/V
Load Regulation	$I_{OUT(SOURCE)}$ = 100µA	*			5	mV/mA
	$I_{OUT(SINK)}$ = 100µA	*			5	mV/mA
Output Voltage Noise	0.1Hz ≤ f ≤ 10Hz			4		μV_{P-P}
	10Hz ≤ f ≤ 1kHz			4.5		μV_{P-P}
Output Short-Circuit Current	Short V_{REFOUT} to GND			40		mA
	Short V_{REFOUT} to V_{DD}			30		mA
Turn-on Time	0.1% setting, C_{LOAD} = 1µF			115		µs
Long-Term Drift of Output Voltage (13)				60		ppm/$\sqrt{khr}$

(The * denotes the specifications that apply over the full operating temperature range. Otherwise, specifications are at $T_A = +25°C$.)

PARAMETER	CONDITIONS	COMMENTS	MIN	TYP	MAX	UNITS
Hysteresis (14)	ΔT = 0°C to +125°C			30		ppm
	ΔT = -40°C to +85°C			70		ppm

Table 4. DIGITAL INPUTS AND DIGITAL OUTPUTS

(The * denotes the specifications that apply over the full operating temperature range. Otherwise, specifications are at $T_A = +25°C$.)

PARAMETER	SYMBOL	CONDITIONS	COMMENTS	MIN	TYP	MAX	UNITS
External SCK Frequency Range			*	0		2	MHz
External SCK Low Period			*	250			ns
External SCK High Period			*	250			ns
$\overline{CS}$↓ to SDO Valid	t_1		*	0		200	ns
$\overline{CS}$↑ to SDO High-Z	t_2		*	0		200	ns
$\overline{CS}$↓ to SCK↑	t_3		*	100			ns
SCK↓ to SDO Valid	t_4		*			225	ns
SDO Hold after SCK↓	t_5		*	10			ns
SDI Setup before SCK↑	t_6		*	100			ns
SDI Hold after SCK↑	t_7		*	100			ns
High-Level Input Voltage		$\overline{CS}$, SDI, SCK, $\overline{RESET}$	*	$V_{DD} - 0.5$			V
Low-Level Input Voltage		$\overline{CS}$, SDI, SCK, $\overline{RESET}$	*			0.5	V
Digital Input Current		$\overline{CS}$, SDI, SCK, $\overline{RESET}$	*	-10		+10	µA
Digital Input Capacitance		$\overline{CS}$, SDI, SCK, $\overline{RESET}$			10		pF
Low-Level Output Voltage (SDO, INTERRUPT)		$I_O = -800µA$	*			0.4	V
High-Level Output Voltage (SDO, INTERRUPT)		$I_O = 1.6mA$	*	$V_{DD} - 0.5$			V

(The * denotes the specifications that apply over the full operating temperature range. Otherwise, specifications are at T_A = +25°C.)

PARAMETER	SYMBOL	CONDITIONS	COMMENTS	MIN	TYP	MAX	UNITS
High-Z Output Leakage (SDO)			*	-10		10	µA

Table 5. EEPROM CHARACTERISTICS

(The * denotes the specifications that apply over the full operating temperature range. Otherwise, specifications are at T_A = +25°C.)

PARAMETER	SYMBOL	CONDITIONS	COMMENTS	MIN	TYP	MAX	UNITS
Retention		[17]	*	10			years
Endurance			*	10000			cycles
Programming Time		Complete transfer from RAM to EEPROM	*			2600	ms
Read Time		Complete transfer EEPROM to RAM	*			20	ms

[1] Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. Exposure to any Absolute Maximum Rating condition for extended periods may affect device reliability and lifetime.

[2] All voltage values are with respect to GND.

[3] Full-scale ADC error. Measurements do not include reference error.

[4] Guaranteed by design, not subject to test.

[5] The input referred noise includes the contribution of internal calibration operations.

[6] Mux configuration delay = default 1ms.

[7] Global configuration set to 60Hz rejection.

[8] Global configuration set to 50Hz rejection.

[9] Global configuration default 50Hz/60Hz rejection.

[10] The exact value of V_{REF} is stored in the ADT7604 and used for all measurement calculations. The temperature coefficient is measured by dividing the maximum change in output voltage by the specified temperature range.

[11] Analog power-up. The command status register is inaccessible during this time.

[12] Digital initialization. Begins at the conclusion of analog power-up. The command status register is 0×80 at the beginning of digital initialization and 0×40 at the conclusion.

[13] Long-term stability typically has a logarithmic characteristic and, therefore, changes after 1000 hours tend to be much smaller than before that time. Total drift in the second thousand hours is normally less than one third that of the first thousand hours with a continuing trend toward reduced drift with time. Long-term stability is also affected by differential stresses between the IC and the board material created during board assembly.

[14] Hysteresis in the output voltage is created by package stress that differs depending on whether the IC was previously at a higher or lower temperature. Output voltage is always measured at +25°C, but the IC is cycled to the hot or cold temperature limit before successive measurements. Hysteresis measures the maximum output change for the averages of three hot or cold temperature cycles. For instruments that are stored at well-controlled temperatures (within 20 or 30 degrees of operational temperature), it is usually not a dominant error source. Typical hysteresis is the worst-case of 25°C to cold to 25°C or 25°C to hot to 25°C, preconditioned by one thermal cycle.

[15] The differential input range is $\pm V_{REF}/2$.

[16] RTD and thermistor measurements are made ratiometrically. As a result, current source excitation variation does not affect absolute accuracy. Choose an excitation current such that the largest sensor or R_{SENSE} resistance value, when driven by the nominal excitation current, will drop 1V or less. The extended ADC input range accommodates variation in excitation current, and the ratiometric calculation negates the absolute value of the excitation current.

[17] 10-year data retention is guaranteed for up to 1000 program cycles.

[18] Do not apply voltage or current sources to these pins. They must be connected to capacitive loads only. Otherwise, permanent damage may occur.

[19] Input leakage is measured with V_{IN} = -10mV and V_{IN} = +2.5V.

ABSOLUTE MAXIMUM RATINGS

T_A = +25°C unless otherwise specified.

Table 6. Absolute Maximum Ratings

PARAMETER	RATING
Supply Voltage (V_{DD})	-0.3V to +6V
Analog Input Pins (CH1 to CH20, COM)	-0.3V to (V_{DD} + 0.3)V
Input Current (CH1 to CH20, COM)	±15mA
Digital Inputs ($\overline{CS}$, SDI, SCK, $\overline{RESET}$)	-0.3V to (V_{DD} + 0.3)V
Digital Outputs (SDO, INTERRUPT)	-0.3V to (V_{DD} + 0.3)V
V_{REFP}	-0.3V to +2.8V
Q1, Q2, Q3, LDO, V_{REFOUT}, V_{REF_BYP} (18) Reference Short-Circuit Duration	Indefinite
Operating Temperature Range	
ADT7604ASTZ	-40°C to +85°C
ADT7604BSTZ	0°C to +125°C
ADT7604CSTZ	–40°C to +125°C

Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. These are stress ratings only, functional operation of the product at these or any other conditions above those indicated in the operational section of this specification is not implied. Operation beyond the maximum operating conditions for extended periods may affect product reliability.

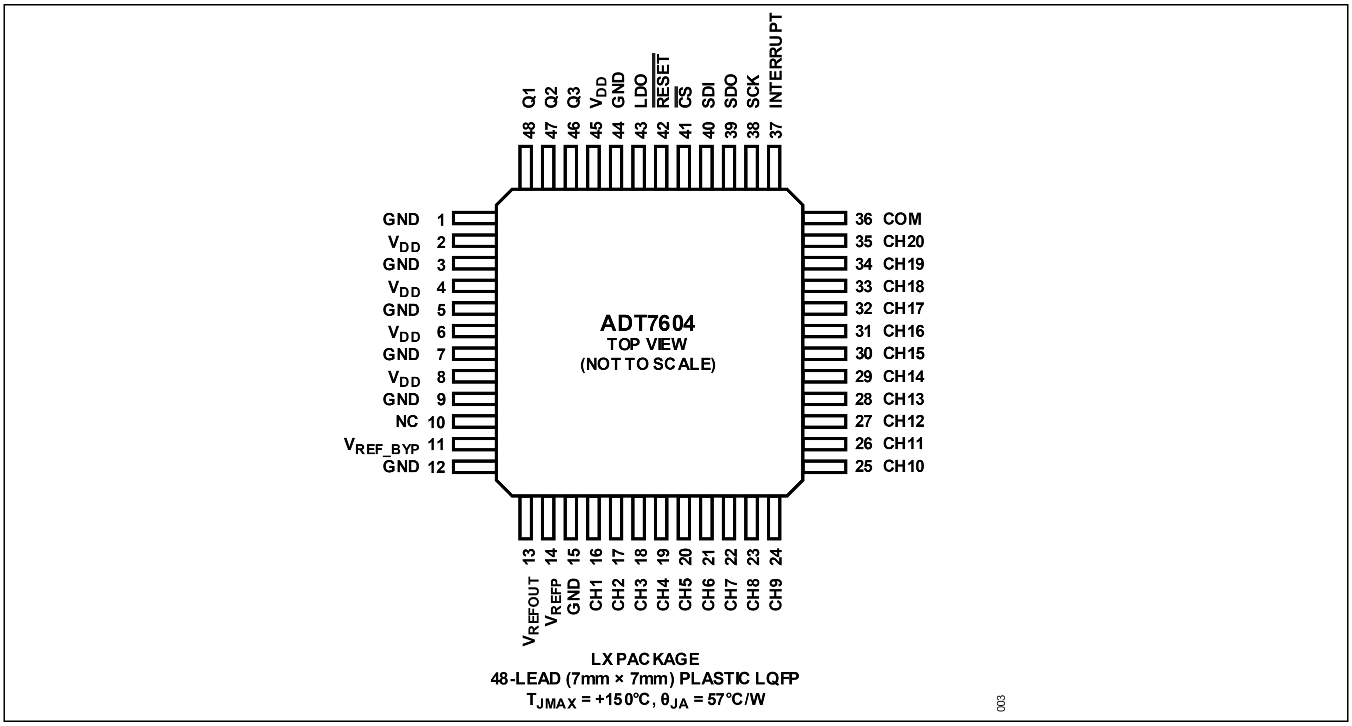
Thermal Resistance

Thermal performance is directly linked to PCB design and operating environment. Close attention to PCB thermal design is required.

ESD Caution

	**ESD (electrostatic discharge) sensitive device.** Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.

PIN CONFIGURATIONS AND FUNCTION DESCRIPTIONS



LX PACKAGE
48-LEAD (7mm × 7mm) PLASTIC LQFP
T_{JMAX} = +150°C, θ_{JA} = 57°C/W

Pin Descriptions

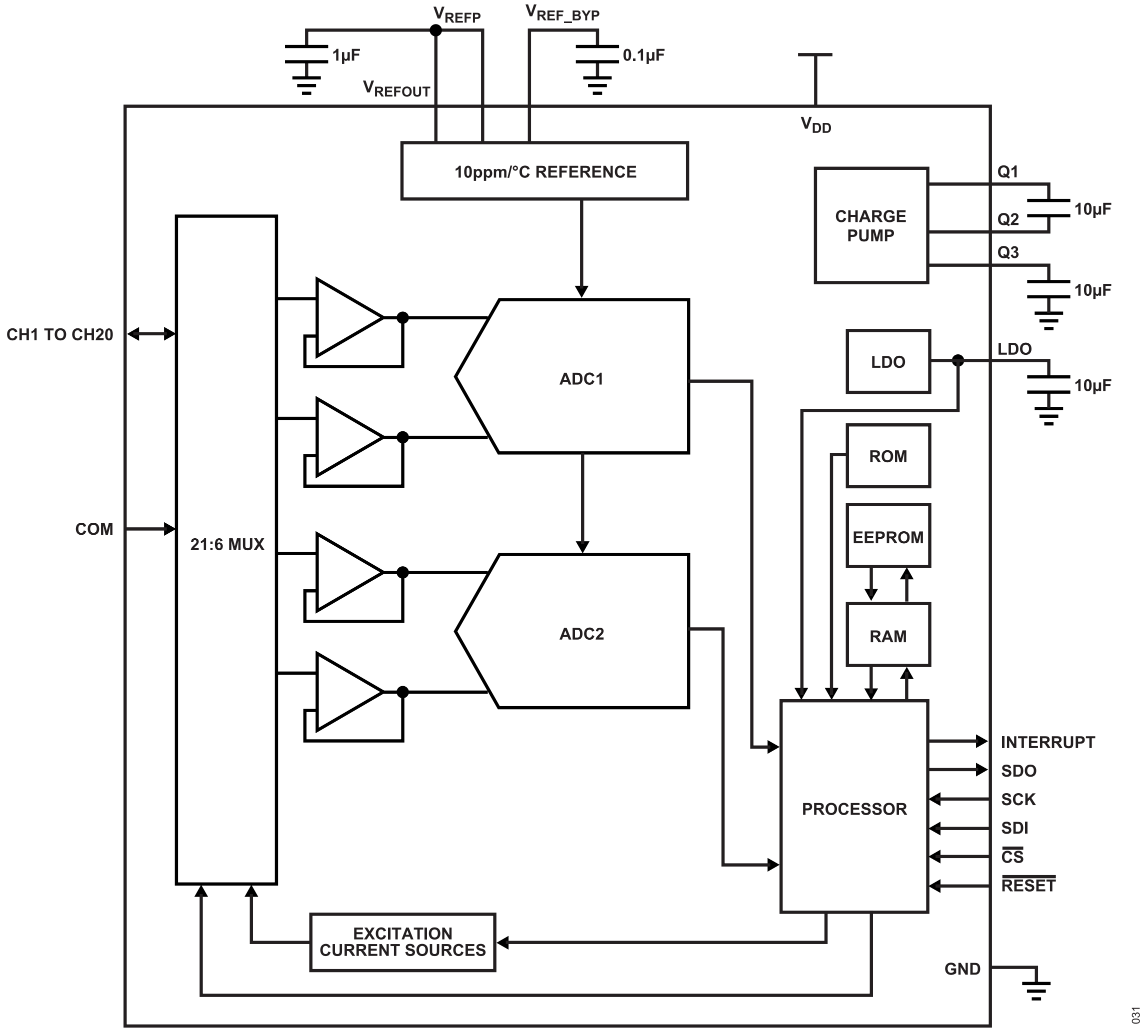
Table 7. Pin Descriptions

PIN	NAME	DESCRIPTION
1, 3, 5, 7, 9, 12, 15, 44	GND	Ground. Connect each of these pins to a common ground plane through a low-impedance connection. All eight pins must be grounded for proper operation.
2, 4, 6, 8, 45	V_{DD}	Analog Power Supply. Tie all five pins together and bypass as close as possible to the device to ground with a 0.1µF capacitor.
11	V_{REF_BYP}	Internal Reference Power. This is an internal supply pin; do not load this pin with external circuitry. Decouple with a 0.1µF capacitor to GND.
13	V_{REFOUT}	Reference Output Voltage. Short to V_{REFP}. A minimum 1µF capacitor to ground is required. Do not load this pin with external circuitry.

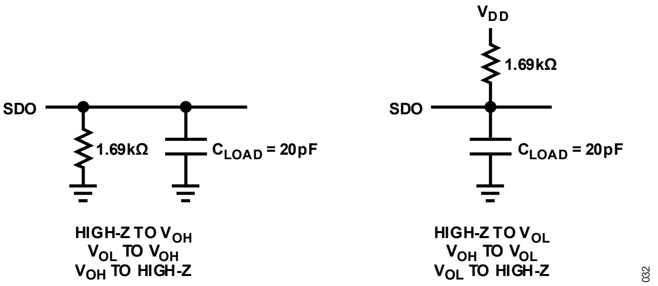
PIN	NAME	DESCRIPTION
14	V_{REFP}	Positive Reference Input. Tie to V_{REFOUT}.
16–35	CH1–CH20	Analog Inputs. May be programmed for single-ended, differential, or ratiometric operation. The voltage on these pins can have any value between GND – 50mV and V_{DD} – 0.3V. Unused pins can be grounded or left floating.
36	COM	Analog Input. The common negative input for all single-ended configurations. The voltage on this pin can have any value between GND – 50mV and V_{DD} – 0.3V. This pin is typically tied to ground for temperature measurements.
37	INTERRUPT	This pin outputs a low when the device is busy either during start-up or while a conversion cycle is in progress. This pin goes high at the conclusion of the start-up state or conversion cycle.
38	SCK	Serial Clock Pin. Data is shifted out of the device on the falling edge of SCK and latched by the device on the rising edge.
39	SDO	Serial Data Out. During the data output state, this pin is used as the serial data output. When the chip select pin is high, the SDO pin is in a high impedance state.
40	SDI	Serial Data Input. Used to program the device. Data is latched on the rising edge of SCK.
41	$\overline{\text{CS}}$	Active-Low Chip Select. A low on this pin enables the digital input/output. A high on this pin places the SDO in a high-impedance state. A falling edge on $\overline{\text{CS}}$ marks the beginning of an SPI transaction, and a rising edge marks the end.
42	$\overline{\text{RESET}}$	Active-Low Reset. While this pin is low, the device is forced into the

PIN	NAME	DESCRIPTION
		reset state. Once this pin is returned to high, the device initiates its start-up sequence.
43	LDO	2.5V LDO Output. Bypass with a 10µF capacitor to GND. This is an internal supply pin; do not load this pin with external circuitry other than what is recommended in this data sheet.
46, 47, 48	Q3, Q2, Q1	External Bypass Pins for –200mV Integrated Charge Pump. Tie a 10µF X7R capacitor between Q1 and Q2 close to each pin. Tie a 10µF X5R capacitor from Q3 to ground. These are internal supply pins; do not make additional connections.

BLOCK DIAGRAM

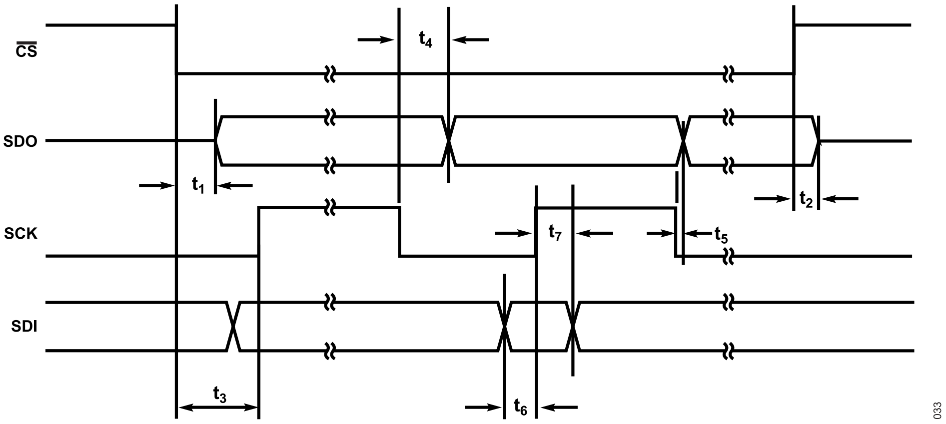


TEST CIRCUITS



TIMING DIAGRAM

SPI Timing Diagram



TYPICAL PERFORMANCE CHARACTERISTICS

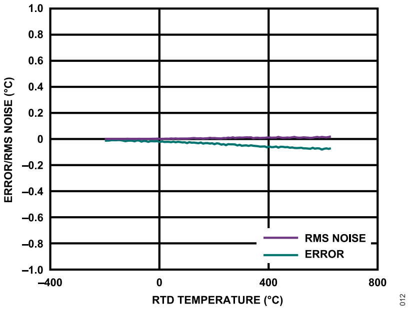


Figure 3. RTD PT-1000 Error and RMS Noise vs. Temperature

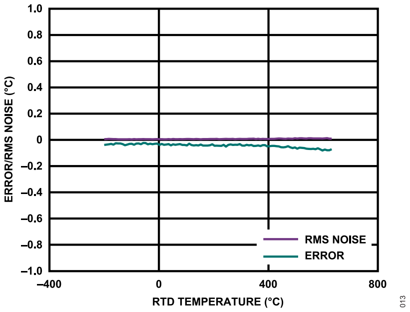


Figure 4. RTD PT-200 Error and RMS Noise vs. Temperature

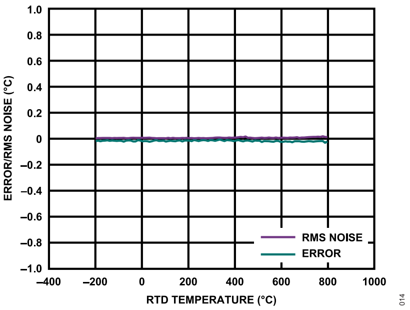


Figure 5. RTD PT-100 Error and RMS Noise vs. Temperature

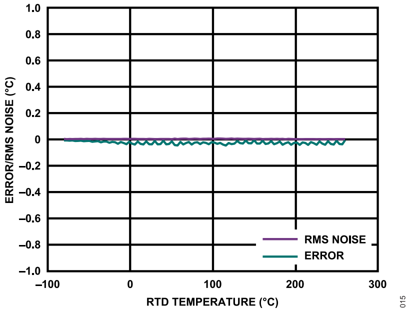


Figure 6. RTD NI-120 RTD Error and RMS Noise vs. Temperature

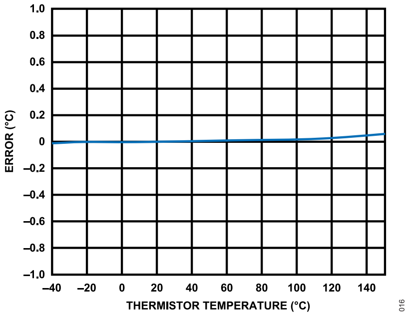


Figure 7. 2.252kΩ Thermistor Error vs. Temperature

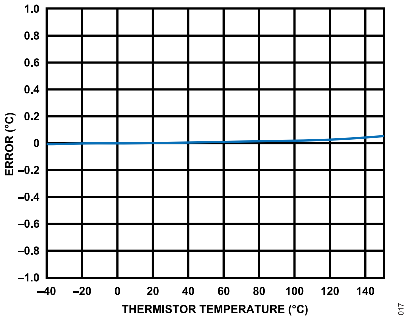


Figure 8. 3kΩ Thermistor Error vs. Temperature

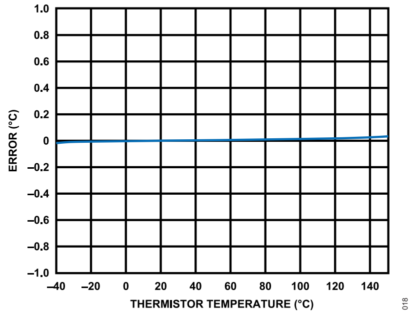


Figure 9. 5kΩ Thermistor Error vs. Temperature

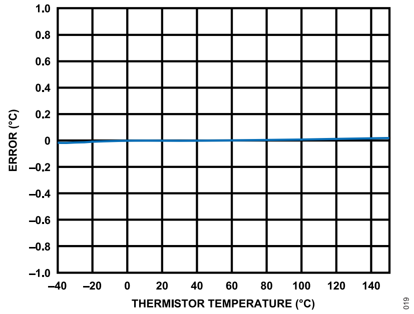


Figure 10.10kΩ Thermistor Error vs. Temperature

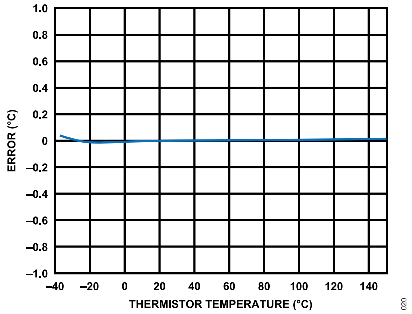


Figure 11.30kΩ Thermistor Error vs. Temperature

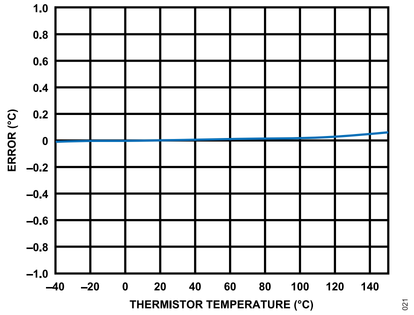


Figure 12.YSI-400 Thermistor Error vs. Temperature

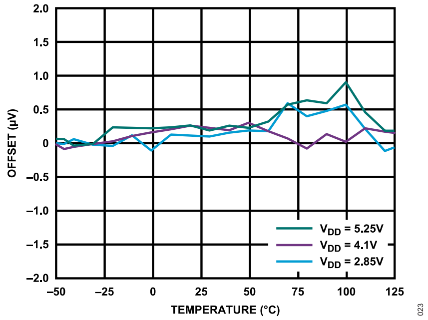


Figure 13.Offset vs. Temperature

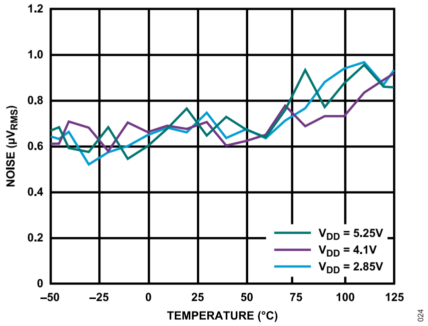


Figure 14.Noise vs. Temperature

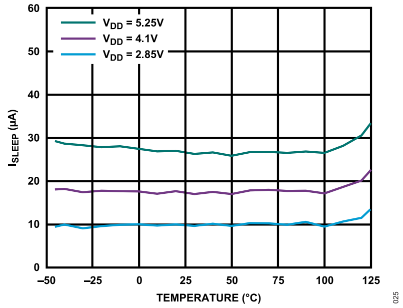


Figure 15.I_{SLEEP} vs. Temperature

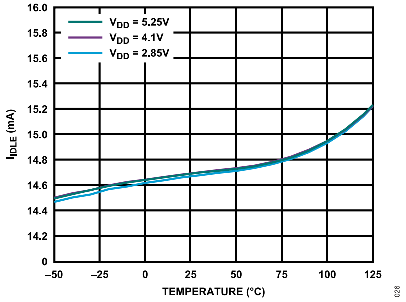


Figure 16.One-Shot Conversion Current vs. Temperature

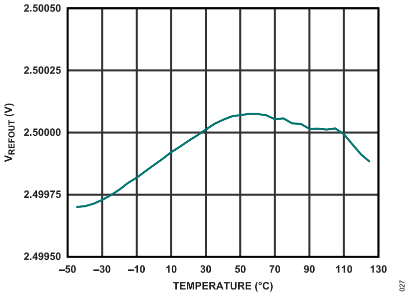


Figure 17.V_{REFOUT} vs. Temperature

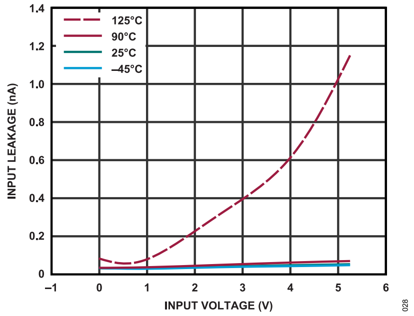


Figure 18.Channel Input Leakage Current vs. Temperature

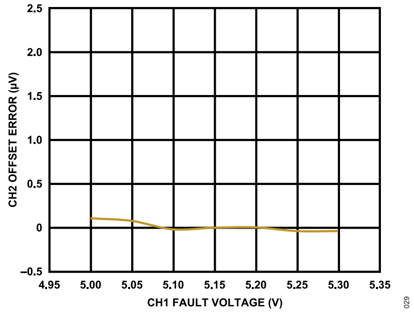


Figure 19.Adjacent Channel Offset Error vs. Input Fault Voltage (V_{DD} = 5V)

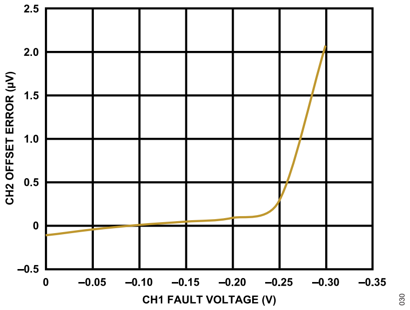


Figure 20.Adjacent Channel Offset Error vs. Input Fault Voltage

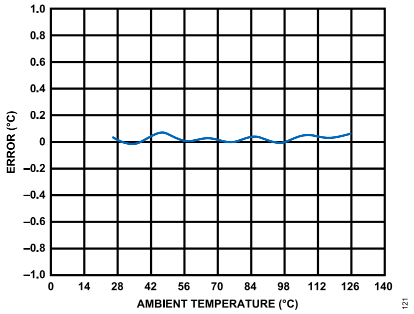


Figure 21. Copper Trace Sensor (0.25Ω, nom) Error vs. Temperature

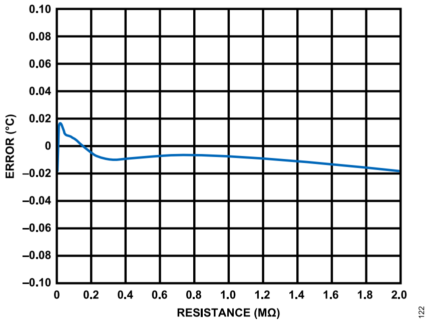


Figure 22. Measurement Resistance Accuracy

OVERVIEW

The ADT7604 measures temperature using common sensors (RTDs and thermistors). It includes all necessary active circuitry, switches, measurement algorithms, and mathematical conversions to determine the temperature for each sensor type. In addition to measuring RTDs and thermistors, the ADT7604 can directly measure copper trace resistors and resistive-based leak sensors.

RTDs and thermistors are resistors that change value as a function of temperature. RTDs can measure temperatures over a wide temperature range, from as low as –200°C to +850°C, while thermistors typically operate from –40°C to +150°C. In order to measure one of these devices, a precision sense resistor is tied in series with the sensor. An excitation current is applied to the network and a ratiometric measurement is made. The value (in Ω) of the RTD/thermistor can be determined from this ratio. This resistance is used to determine the temperature of the sensor element using a table lookup (RTDs) or solving Steinhart-Hart equations (thermistors). The ADT7604 automatically generates the excitation current, simultaneously measures the sense resistor and thermistor/RTD voltage, calculates the sensor resistance and reports the result in °C. The ADT7604 can digitize most RTD types (PT-10, PT-50, PT-100, PT-200, PT-500, PT-1000, and NI-120), has built-in coefficients for many curves (American, European, Japanese, and ITS-90), and accommodates 2-wire, 3-wire, and 4-wire configurations. It also includes coefficients for calculating the temperature of standard 2.252kΩ, 3kΩ, 5kΩ, 10kΩ, and 30kΩ thermistors. It can be configured to share one sense resistor among multiple RTDs/thermistors and to rotate excitation current sources to remove parasitic thermal effects. In addition to built-in linearization coefficients, the ADT7604 provides the means of inserting custom coefficients.

Table 8 shows the estimated system accuracy and noise associated with specific temperature sensing devices. System accuracy and peak-to-peak noise include the effects of the ADC, internal amplifiers, excitation current sources, and integrated reference. Accuracy and noise are the worst-case errors calculated from the guaranteed maximum ADC and reference specifications. Peak-to-peak noise values are calculated at 0°C.

Table 8. ADT7604 Error Contribution and Peak Noise Errors

SENSOR TYPE	TEMPERATURE RANGE	ERROR CONTRIBUTION	PEAK-TO-PEAK NOISE
Platinum RTD – PT-10, R_{SENSE} = 1kΩ	-200°C to +800°C	±0.1°C	±0.05°C
Platinum RTD – PT-100, R_{SENSE} = 2kΩ	-200°C to +800°C	±0.1°C	±0.05°C
Platinum RTD – PT-500, R_{SENSE} = 2kΩ	-200°C to +800°C	±0.1°C	±0.02°C
Platinum RTD – PT-1000, R_{SENSE} = 2kΩ	-200°C to +800°C	±0.1°C	±0.01°C
Thermistor, R_{SENSE} = 10kΩ	-40°C to +85°C	±0.1°C	±0.01°C
Copper Trace Sensor Nominal Value = 0.25Ω	0°C to +150°C	±0.2°C	0.5°C
Leak Sensor	1Ω to 2MΩ	±0.2%	0.001%–0.1%

Memory Map

The ADT7604 channel assignment, configuration, conversion start, and results are all accessible through the RAM (see *Table 9*). *Table 10* details the valid SPI instruction bytes for accessing memory. The channel conversion results are mapped into memory locations 0x010 to 0x05F and can be read using the SPI interface as shown in *Figure 23*. A read is initiated by sending the read instruction byte = 0x03 followed by the address and then data. Channel assignment data resides in memory locations 0x200 to 0x24F and can be programmed through the SPI interface as shown in *Figure 24*. A write is initiated by sending the write instruction byte = 0x02 followed by the address and then data. Conversions are initiated by writing the conversion control byte (see *Table 15*) into memory location 0x000 (command status register).

Table 9. Memory Map

ADT7604 MEMORY MAP				
SEGMENT	**START ADDRESS**	**END ADDRESS**	**SIZE (BYTES)**	**DESCRIPTION**
Command Status Register	0x000	0x0000	1	See *Table 14*, initiate conversion, sleep command
Reserved	0x001	0x000F	15	
Temperature Result Memory 20 Words – 80 Bytes	0x010	0x05F	80	See *Table 16*, *Table 17*, and *Table 18*, read result
Resistance Result Memory 20 Words – 80 Bytes	0x060	0x0AF	80	
EEPROM Key	0x0B0	0x0B3	4	See *Table 22*
Reserved	0x0B4	0x0CF	44	
EEPROM Read Result Code	0x0D0	0x0D0	1	See *Table 22*
Reserved	0x0D1	0x0EF	15	
Global Configuration Register	0x0F0	0x0F0	1	
Reserved	0x0F1	0x0F3	3	
Measure Multiple Channels Bit Mask	0x0F4	0x0F7	4	See *Table 87* and *Table 88*, run multiple conversions
Reserved	0x0F8	0x0F8	1	
EEPROM Status Register	0x0F9	0x0F9	1	See *Table 23*
Reserved	0x0FA	0x0FE	5	
Mux Configuration Delay	0x0FF	0x0FF	1	See the *Mux Configuration Delay* section
Reserved	0x100	0x1FF	256	
Channel Assignment Data	0x200	0x24F	80	See *Table 11* and *Table 12* (channel assignment tables)
Custom Sensor Table Data	0x250	0x3CF	384	
Reserved	0x3D0	0x3FF	48	

Table 10.SPI Instruction Byte

INSTRUCTION	SPI INSTRUCTION BYTE	DESCRIPTION
Read	0b00000011	See *Figure 23*
Write	0b00000010	See *Figure 24*

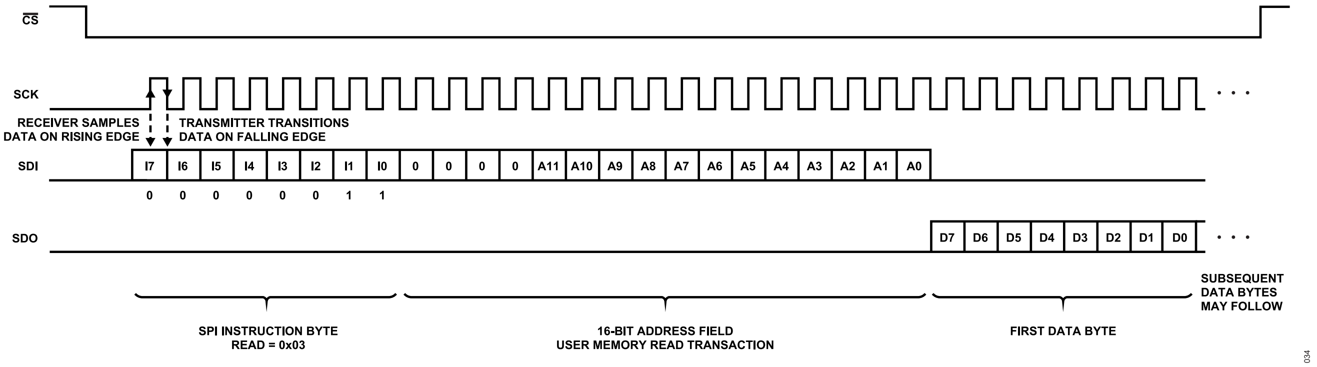


Figure 23. Memory Read Operation

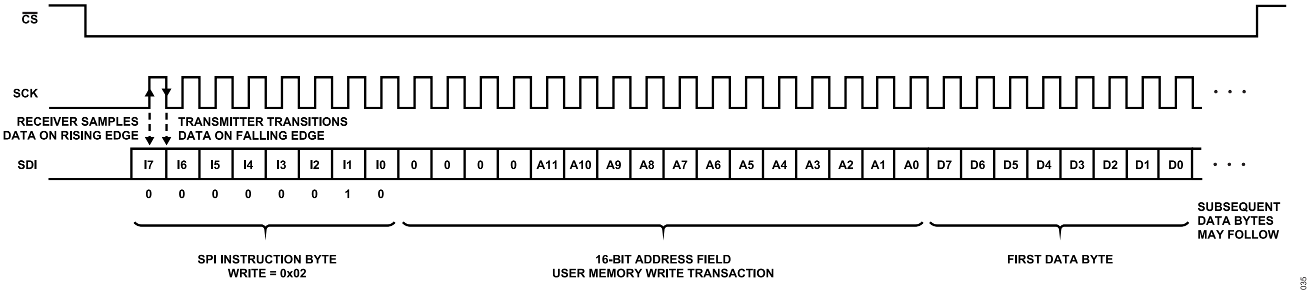


Figure 24. Memory Write Operation

APPLICATIONS INFORMATION

The ADT7604 combines high accuracy with ease of use. The basic operation is simple and is composed of five states (see *Figure 25*).

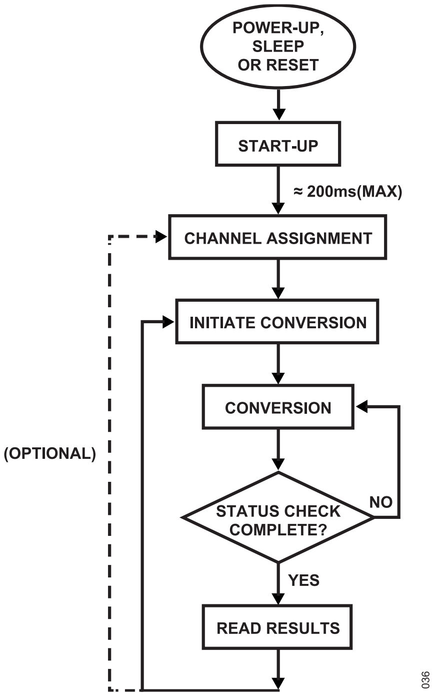


Figure 25. Basic Operation

Conversion States Overview

1. Startup. After power is applied to the ADT7604 (V_{DD} > 2.6V), there is a 200ms wake-up period. During this time, the LDO, charge pump, ADCs, and reference are powered up and the internal RAM is initialized. Once startup is complete, the INTERRUPT pin goes high and the command status register returns a value of 0x40 (Start bit = 0, Done bit = 1) when read.

2. Channel Assignment. The device automatically enters the channel assignment state after startup is complete. While in this state, the user writes sensor-specific data for each input channel into RAM or loads it from the EEPROM (see the *EEPROM Overview* section for more details). The assignment data contains information about the sensor type, pointers to sense resistors, and sensor-specific parameters.

3. Initiate Conversion. A conversion is initiated by writing a measurement command into RAM memory location 0x000. This command is a pointer to the channel in which the conversion will be performed.

4. Conversion. A new conversion begins automatically following an Initiate Conversion command. In this state, the ADC is running a conversion on the specified channel and associated R_{SENSE} channel (if applicable). The user is locked out of RAM access while in the state (except for reading status location 0x000). The end of conversion is indicated by both the INTERRUPT pin going high and a status register Start bit going low and Done bit going high.

5. Read Results. In this state, the user has access to RAM and can read the completed conversion results and fault status bits. It is also possible for the user to modify/append the channel assignment data during the read results state.

Conversion State Details State

State 1: Startup

The start-up state automatically occurs when power is applied to the ADT7604. If the power drops below a threshold of ≈2.6V and then returns to the normal operating voltage (2.85V to 5.25V), the ADT7604 resets and enters the power-up state. Note that the ADT7604 also enters the start-up state at the conclusion of the sleep state. Additionally, the start-up state can be entered at any time during normal operation by pulsing the $\overline{\text{RESET}}$ pin low.

In the first phase of the start-up state, all critical analog circuits are powered up. This includes the LDO, reference, charge pump, and ADCs. During this first phase, the command status register is inaccessible to the user. This phase takes a maximum of 100ms to complete. Once this phase completes, the command status register is accessible and returns a value of 0x80 until the ADT7604 is completely initialized. Once the ADT7604 is initialized and ready to use, the interrupt pin goes high, and the command status register returns a read value of 0x40 (Start bit = 0, Done bit = 1). At this point, the ADT7604 is fully initialized and ready to perform a conversion.

State 2: Channel Assignment

The ADT7604 RAM can be programmed with up to 20 sets of 32-bit (4-byte) channel-assignment data. These sets reside sequentially in RAM with a one-to-one correspondence to each of the 20 analog input channels (see *Table 11*). Channels that are not used should have their channel-assignment data set to all zeros (default at startup).

Table 11. Channel Assignment Memory Map

CHANNEL-ASSIGNMENT NUMBER	CONFIGURATION DATA START ADDRESS	CONFIGURATION DATA ADDRESS + 1	CONFIGURATION DATA ADDRESS + 2	CONFIGURATION DATA END ADDRESS + 3	SIZE (BYTES)
CH1	0x200	0x201	0x202	0x203	4
CH2	0x204	0x205	0x206	0x207	4
CH3	0x208	0x209	0x20A	0x20B	4
CH4	0x20C	0x20D	0x20E	0x20F	4
CH5	0x210	0x211	0x212	0x213	4
CH6	0x214	0x215	0x216	0x217	4
CH7	0x218	0x219	0x21A	0x21B	4
CH8	0x21C	0x21D	0x21E	0x21F	4
CH9	0x220	0x221	0x222	0x223	4
CH10	0x224	0x225	0x226	0x227	4
CH11	0x228	0x229	0x22A	0x22B	4
CH12	0x22C	0x22D	0x22E	0x22F	4
CH13	0x230	0x231	0x232	0x233	4
CH14	0x234	0x235	0x236	0x237	4
CH15	0x238	0x239	0x23A	0x23B	4
CH16	0x23C	0x23D	0x23E	0x23F	4
CH17	0x240	0x241	0x242	0x243	4
CH18	0x244	0x245	0x246	0x247	4
CH19	0x248	0x249	0x24A	0x24B	4
CH20	0x24C	0x24D	0x24E	0x24F	4

The channel-assignment data contains all of the necessary information associated with the specific sensor tied to that channel (see *Table 12*). The first 5 bits determine the sensor type (see *Table 13*). Associated with each sensor are sensor-specific configurations. These include pointers to sense resistor channels, pointers to memory locations of custom linearization data, and sense resistor values. Also included in this data are, if applicable, the excitation current level, single-ended/differential input mode, and sensor-specific controls. Separate detailed operation sections for RTDs, thermistors, and sense resistors describe the assignment data associated with each sensor type in more detail. The ADT7604 demonstration software includes a utility for checking configuration data and generating annotated C-code for programming the channel-assignment data.

Table 12. Channel Assignment Data

<table>
<tr><td></td><td colspan="5">SENSOR TYPE</td><td colspan="27">SENSOR-SPECIFIC CONFIGURATION</td></tr>
<tr><td>CHANNEL ASSIGNMENT MEMORY LOCATION</td><td colspan="8">CONFIGURATION DATA START ADDRESS</td><td colspan="8">CONFIGURATION DATA START ADDRESS + 1</td><td colspan="8">CONFIGURATION DATA START ADDRESS + 2</td><td colspan="8">CONFIGURATION DATA START ADDRESS + 3</td></tr>
<tr><td></td><td>31</td><td>30</td><td>29</td><td>28</td><td>27</td><td>26</td><td>25</td><td>24</td><td>23</td><td>22</td><td>21</td><td>20</td><td>19</td><td>18</td><td>17</td><td>16</td><td>15</td><td>14</td><td>13</td><td>12</td><td>11</td><td>10</td><td>9</td><td>8</td><td>7</td><td>6</td><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td><td>0</td></tr>
<tr><td>Unassigned
(Default)</td><td colspan="5">Type = 0</td><td colspan="27">Channel Disabled</td></tr>
</table>

<table>
<tr><td>RTD</td><td>Type = 10 to 17</td><td>R_{SENSE} Channel Assignment [4:0]</td><td colspan="2">2-, 3-, 4-Wire</td><td colspan="2">Excitation Mode</td><td colspan="2">Excitation Current [3:0]</td><td colspan="2">Curve [1:0]</td><td colspan="2">Not used</td></tr>
<tr><td>Copper Trace Sensor</td><td>Type = 18</td><td>R_{SENSE} Channel Assignment [4:0]</td><td colspan="4">Sensor Configuration 0b1001</td><td colspan="6">Not used</td></tr>
<tr><td>Thermistor</td><td>Type = 19 to 26</td><td>R_{SENSE} Channel Assignment [4:0]</td><td>SGL=1
DIFF=0</td><td colspan="2">Excitation Mode</td><td colspan="2">Excitation Current [3:0]</td><td>0</td><td>0</td><td>0</td><td>Custom Address [5:0]</td><td>Custom Length - 1 [5:0]</td></tr>
<tr><td>Leak Sensor</td><td>Type = 27</td><td>R_{SENSE} Channel Assignment [4:0]</td><td colspan="3">Sensor Configuration 0b001</td><td colspan="2">Excitation Current [3:0]</td><td>0</td><td>0</td><td>0</td><td>Custom Address [5:0]</td><td>Custom Length - 1 [5:0]</td></tr>
<tr><td>Sense Resistor</td><td>Type = 29</td><td colspan="11">Sense Resistor Value (17, 10) up to 131,072Ω with 1/1024Ω Resolution</td></tr>
<tr><td>Reserved</td><td>Type = 31</td><td colspan="11">Not Used</td></tr>
</table>

Table 13.Sensor Type Selection

31	30	29	28	27	SENSOR TYPE
0	0	0	0	0	Unassigned
0	1	0	1	0	RTD PT-10
0	1	0	1	1	RTD PT-50
0	1	1	0	0	RTD PT-100
0	1	1	0	1	RTD PT-200
0	1	1	1	0	RTD PT-500
0	1	1	1	1	RTD PT-1000
1	0	0	0	0	RTD 1000 (0.00375)
1	0	0	0	1	RTD NI-120
1	0	0	1	0	Copper Trace Sensor
1	0	0	1	1	Thermistor 44004/44033 2.252kΩ at 25°C
1	0	1	0	0	Thermistor 44005/44030 3kΩ at 25°C
1	0	1	0	1	Thermistor 44007/44034 5kΩ at 25°C
1	0	1	1	0	Thermistor 44006/44031 10kΩ at 25°C
1	0	1	1	1	Thermistor 44008/44032 30kΩ at 25°C
1	1	0	0	0	Thermistor YSI 400 2.252kΩ at 25°C
1	1	0	0	1	Thermistor Spectrum 1003k 1kΩ
1	1	0	1	0	Thermistor Custom Steinhart-Hart
1	1	0	1	1	Leak Sensor
1	1	1	0	1	Sense Resistor
1	1	1	1	1	Reserved

State 3: Initiate Conversion

Once the channel assignment is complete, the device is ready to begin a conversion. A conversion is initiated by writing Start (B7 = 1) and Done (B6 = 0) followed by the desired input channel (B4–B0) into RAM memory location

0x000 (see *Table 14* and *Table 15*). It is possible to initiate a measurement cycle on multiple channels by setting the channel-selection bits (B4 to B0) to 00000 (see the *Running Conversions Consecutively on Multiple Channels* section).

Table 14.Command Status Register

B7	B6	B5	B4	B3	B2	B1	B0	
Start = 1	Done = 0	0	EEPROM Command and Channel Selection 1 to 20					Start Conversion
1	0	0	1	0	1	1	1	Initiate Sleep

Table 15.Input Channel Mapping

B7	B6	B5	B4	B3	B2	B1	B0	CHANNEL SELECTED
1	0	0	0	0	0	0	0	Multiple Channels
1	0	0	0	0	0	0	1	CH1
1	0	0	0	0	0	1	0	CH2
1	0	0	0	0	0	1	1	CH3
1	0	0	0	0	1	0	0	CH4
1	0	0	0	0	1	0	1	CH5
1	0	0	0	0	1	1	0	CH6
1	0	0	0	0	1	1	1	CH7
1	0	0	0	1	0	0	0	CH8
1	0	0	0	1	0	0	1	CH9
1	0	0	0	1	0	1	0	CH10
1	0	0	0	1	0	1	1	CH11
1	0	0	0	1	1	0	0	CH12
1	0	0	0	1	1	0	1	CH13
1	0	0	0	1	1	1	0	CH14
1	0	0	0	1	1	1	1	CH15
1	0	0	1	0	0	0	0	CH16
1	0	0	1	0	0	0	1	CH17
1	0	0	1	0	0	1	0	CH18
1	0	0	1	0	0	1	1	CH19
1	0	0	1	0	1	0	0	CH20
1	0	0	1	0	1	1	1	Sleep
All Other Combinations								Reserved

Bits B4 to B0 determine which input channel the conversion is performed upon and are simply the binary equivalent of the channel number (see *Table 15*). These bits are also used for EEPROM read and write operations (see *Table 25*).

Bit B5 should be set to 0.

Bits B7 and B6 serve as Start/Done bits. In order to start a conversion, these bits must be set to 10 (B7 = 1 and B6 = 0). When the conversion begins, the INTERRUPT pin goes low. Once the conversion is complete, bits B7 and B6 toggles to 01 (B7 = 0 and B6 = 1) (Address = 0x000) and the INTERRUPT pin goes high, indicating the conversion is complete and the result is available.

State 4: Conversion

The measurement cycle starts after the Initiate Conversion command is written into RAM location 0x000 (*Table 14*). The ADT7604 simultaneously measures the selected input sensor and sense resistors (RTDs and thermistors).

Once the conversion is started, the user is locked out of the RAM, with the exception of the reading status data that is stored in RAM memory location 0x000.

Once the conversion is started, the INTERRUPT pin goes low. Two 82ms cycles are required per temperature result. This corresponds to a conversion time of 167ms.

The end of the conversion can be monitored either through the interrupt pin (low-to-high transition), or by reading the Command Status register in RAM memory location 0x000 (Start bit B7 toggles from 1 to 0, and Done bit B6 toggles from 0 to 1).

State 5: Read Results

Once the conversion is complete, the conversion results or resistance value can be read from RAM memory locations corresponding to the input channel (see *Table 16*).

The temperature conversion result is 32 bits long and contains both the sensor temperature (D23 to D0) and sensor fault data (D31 to D24) (see *Table 17* and *Table 18*).

The temperature result is reported in °C for all temperature sensors with a range of -273.16°C to +8192°C and 1/1024°C resolution or in °F with a range of -459.67°F to +8192°F with 1/1024°F resolution. Included with the conversion result are 7 sensor fault bits and a valid bit. These bits are set to a 1 if there was a problem associated with the corresponding conversion result (see *Table 21*). Two types of errors are reported: hard errors and soft errors. Hard errors indicate the reading is invalid and the resulting temperature reported is -999°C or °F. Soft errors indicate operation beyond the normal temperature range of the sensor or the input range of the ADC. In this case, the calculated temperature is reported, but the accuracy may be compromised. Details relating to each fault type are sensor specific and are described in detail in the sensor-specific sections of this data sheet. Bit D24 is the valid bit and is set to a 1 for valid data.

The resistance result for copper trace sensors is reported in mΩ with a range of 0Ω to 2,097,151mΩ and a resolution of 0.001mΩ in Resistance Result memory starting at address 0x060 (see *Table 19*). The actual value of the resistance in mΩ is calculated by dividing the reported result by 1024 (see *Table 20*).

The resistance result for leakage sensing circuits is reported in Ω with a range of 0Ω to 2,097,151Ω and a resolution of 0.001Ω, in Resistance Result Memory starting at address 0x060 (see *Table 19*). The actual value of the resistance in Ω is calculated by dividing the reported result by 1024 (see *Table 20*).

Once the data read is complete, the device is ready for a new initiate conversion command. In cases where new channel-configuration data is required, the user has access to the RAM in order to modify existing channel-assignment data.

Table 16.Temperature Result Memory Map

CONVERSION CHANNEL	START ADDRESS	END ADDRESS	SIZE (BYTES)
CH1	0x010	0x013	4
CH2	0x014	0x017	4
CH3	0x018	0x01B	4
CH4	0x01C	0x01F	4
CH5	0x020	0x023	4
CH6	0x024	0x027	4
CH7	0x028	0x02B	4
CH8	0x02C	0x02F	4
CH9	0x030	0x033	4
CH10	0x034	0x037	4
CH11	0x038	0x03B	4
CH12	0x03C	0x03F	4
CH13	0x040	0x043	4
CH14	0x044	0x047	4
CH15	0x048	0x04B	4
CH16	0x04C	0x04F	4
CH17	0x050	0x053	4
CH18	0x054	0x057	4
CH19	0x058	0x05B	4
CH20	0x05C	0x05F	4

Table 17.Example Data Output Words (°C)

	START ADDRESS								START ADDRESS + 1								START ADDRESS + 2								START ADDRESS + 3 (END ADDRESS)							
	D31	**D30**	**D29**	**D28**	**D27**	**D26**	**D25**	**D24**	**D23**	**D22**	**D21**	**D20**	**D19**	**D18**	**D17**	**D16**	**D15**	**D14**	**D13**	**D12**	**D11**	**D10**	**D9**	**D8**	**D7**	**D6**	**D5**	**D4**	**D3**	**D2**	**D1**	**DO**
	Fault Data								SIGN MSB																							LSB
Temperature	Sensor Hard Fault	ADC Hard Fault			Sensor Over Range Fault	Sensor Under Range Fault	ADC Out of Range Fault	Valid If 1		4096°C												1°C										1/1024°C
8191.999°C								1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1024°C								1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1°C								1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
1/1024°C								1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
0°C								1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-1/1024°C								1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
-1°C								1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0
-273.15°C								1	1	1	1	1	1	0	1	1	1	0	1	1	1	0	1	1	0	1	1	0	0	1	1	1

Table 18.Example Data Output Words (°F)

	START ADDRESS								START ADDRESS + 1								START ADDRESS + 2								START ADDRESS + 3 (END ADDRESS)							
	D31	D30	D29	D28	D27	D26	D25	D24	D23	D22	D21	D20	D19	D18	D17	D16	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
	Fault Data								SIGN	MSB																						LSB
Temperature	Sensor Hard Fault	ADC Hard Fault			Sensor Over Range Fault	Sensor Under Range Fault	ADC Out of Range Fault	Valid If 1		4096°F												1°F										1/1024°F
8191.999°F								1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1024°F								1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1°F								1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
1/1024°F								1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
0°F								1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-1/1024°F								1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
-1°F								1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0
-459.67°F								1	1	1	1	1	1	0	0	0	1	1	0	1	0	0	0	1	0	1	0	1	0	0	1	0

Table 19. Resistance Result Memory Map

CONVERSION CHANNEL	START ADDRESS	END ADDRESS	SIZE (BYTES)
CH1	0x060	0x063	4
CH2	0x064	0x067	4
CH3	0x068	0x06B	4
CH4	0x06C	0x06F	4
CH5	0x070	0x073	4
CH6	0x074	0x077	4
CH7	0x078	0x07B	4
CH8	0x07C	0x07F	4
CH9	0x080	0x083	4
CH10	0x084	0x087	4
CH11	0x088	0x08B	4
CH12	0x08C	0x08F	4
CH13	0x090	0x093	4
CH14	0x094	0x097	4
CH15	0x098	0x09B	4
CH16	0x09C	0x09F	4
CH17	0x0A0	0x0A3	4
CH18	0x0A4	0x0A7	4
CH19	0x0A8	0x0AB	4
CH20	0x0AC	0x0AF	4

Table 20.Data Output Words for Resistance Sensors: Copper Trace Sensors and Leak Sensors

	START ADDRESS								START ADDRESS + 1								START ADDRESS + 2								START ADDRESS + 3 (END ADDRESS)							
	D31	D30	D29	D28	D27	D26	D25	D24	D23	D22	D21	D20	D19	D18	D17	D16	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
	0	MSB																														LSB
Copper Trace	0	1048576mΩ																				1mΩ							0.001mΩ			
Leak Sensor	0	1048576Ω																				1Ω							0.001Ω			

Table 21.Sensor Fault Reporting

BIT	FAULT	ERROR TYPE	DESCRIPTION	OUTPUT RESULT
D31	Sensor Hard Fault	Hard	Bad sensor reading	-999°C or °F
D30	Hard ADC-Out-of-Range	Hard	Bad ADC reading (could be large external noise event)	-999°C or °F
D27	Sensor Over Range	Soft	Sensor reading is above normal range	Suspect reading
D26	Sensor Under Range	Soft	Sensor reading is below normal range	Suspect reading
D25	ADC Out-of-Range	Soft	ADC absolute input voltage is beyond ±1.125 x $V_{REF}/2$	Suspect reading
D24	Valid	NA	Result valid (should be 1) discard results if 0	Suspect reading

EEPROM Overview

The ADT7604 contains 512 bytes of EEPROM, which shadow the upper sensor configuration segment of USER RAM (locations 0x200–0x3CF, see *Figure 26*). Prior to initial usage, the user programs the USER RAM with all channel-assignment and custom sensor data. Once the USER RAM has been programmed, the user can save this segment of memory into the EEPROM. After subsequent power-down or sleep cycles, the user can reload the USER RAM with this stored EEPROM data, bypassing the channel assignment and custom sensor programming that is typically required.

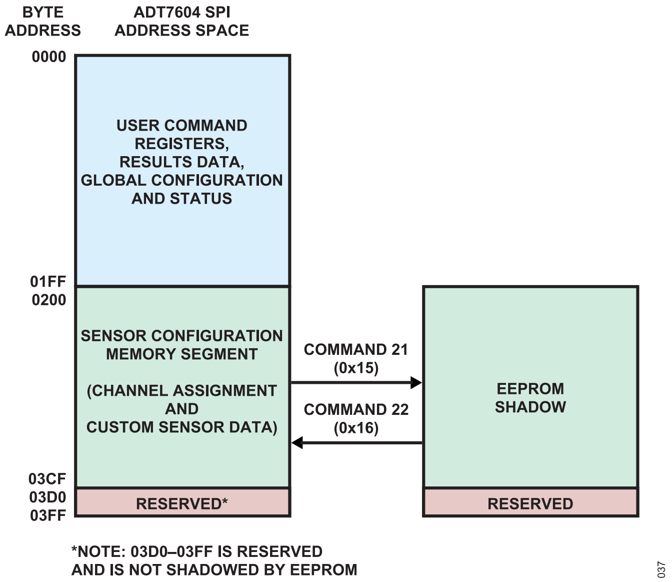


Figure 26.Shadow EEPROM Memory Map

EEPROM Read/Write Validation

Access to the EEPROM is key-protected to prevent inadvertent access. The EEPROM also has two levels of data integrity protection. The first level is implemented using an error correcting code (ECC) on each 32-bit word of data in the EEPROM. The ECC is capable of correcting any single-bit error per word and detecting 2-bit errors per word. The second level of protection is implemented using a 32-bit checksum, which covers the entire contents of user EEPROM. Status bits are available to the user for reporting ECC status and checksum error conditions.

EEPROM Write Operation

The EEPROM write operation requires five steps (see *Figure 27*).

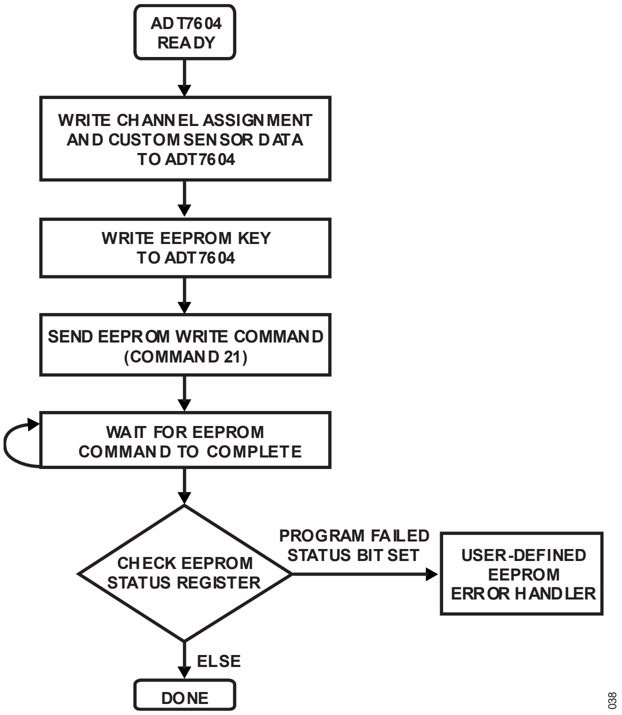


Figure 27. Write Operation

1. Sensor-Configuration. Write all desired channel-assignment and custom sensor data to the ADT7604 USER RAM.

2. Set EEPROM Key. Write the EEPROM key (0xA53C0F5A) to the key register space of the ADT7604 USER RAM (Address range 0x0B0–0x0B3, see *Table 13*, *Table 15*, and *Table 22*). Note that the key is written MSB first.

3. Send EEPROM Write Command. Write the EEPROM write command (0x15) and start bit (0x80) to the ADT7604 command register (Address 0x000). The command plus start bit is 0x80 + 0x15 = 0x95 (see *Table 23*).

4. Wait for EEPROM Command to Complete. Completion of the write operation is indicated by both the interrupt pin going high and the status register Start bit going low and Done bit going high.

5. Check EEPROM Status Register. Read EEPROM Status register (Address 0x0F9) and check the Program-Failed status bit (Bit 2) to determine whether the EEPROM write operation was successful (see *Table 24*). The Program-Failed status bit being set indicates that the write operation failed.

Upon successful completion of steps 1–5, the EEPROM contains the image that was present in USER RAM locations 0x200–0x3CF.

EEPROM Read Operation

The ADT7604 EEPROM read operation is comprised of four steps (see *Figure 28*).

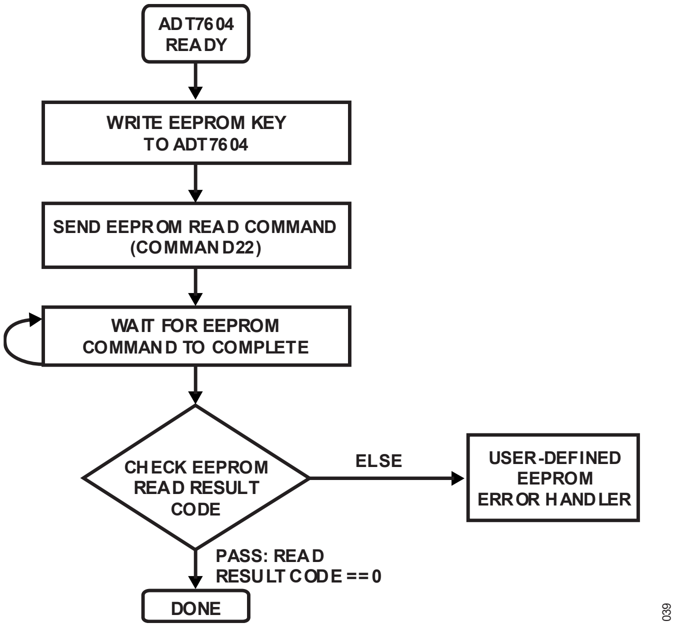


Figure 28.Read Operation

1. Set EEPROM Key. Write the EEPROM key (0xA53C0F5A) to the key register space of the ADT7604 USER RAM (Address range 0x0B0–0x0B3, see *Table 13*, *Table 15*, and *Table 22*). Note that the key is written MSB first.

2. Send EEPROM Read Command. Write the EEPROM read command (0x16) and Start bit (0x80) to the ADT7604 command register (Address 0x000). The command plus Start bit would be 0x80 + 0x16 = 0x96 (see *Table 23*).

3. Wait for EEPROM Command to Complete. Completion of the read operation is indicated by both the interrupt pin going high and the status register Start bit going low and Done bit going high.

4. Check EEPROM Read Result Code. Read the EEPROM read result code register address (0x0D0) to determine the pass/fail status of the read operation. A value of 0 indicates that the command completed successfully and a nonzero value indicates that an error has occurred. Additional read operation status bits are also available in the EEPROM status register (see *Table 24* and *Table 25*).

Upon successful completion of steps 1–4, USER RAM locations 0x200–0x3CF contain the data that was stored in the ADT7604's shadow EEPROM.

Table 22.ADT7604 EEPROM Related Registers

ADDRESS	REGISTER NAME	DESCRIPTION
0x0B0	EEPROM key [3] (MSB)	EEPROM key byte 3 – Set to 0xA5
0x0B1	EEPROM key [2]	EEPROM key byte 2 – Set to 0x3C
0x0B2	EEPROM key [1]	EEPROM key byte 1 – Set to 0x0F
0x0B3	EEPROM key [0] (LSB)	EEPROM key byte 0 – Set to 0x5A
0x0D0	EEPROM Read Result code	This register indicates the Pass/Fail status of the most recent EEPROM read operation. 0x00 = PASS 0xFF = FAIL
0x0F9	EEPROM status register	See ADT7604 EEPROM status register *Table 23* and *Table 24*.

Table 23.ADT7604 EEPROM-Related Commands and Status

B7	B6	B5	B4	B3	B2	B1	B0	DESCRIPTION
1	0	0	1	0	1	0	1	**EEPROM Write Command –** Transfer the contents of user memory locations 0x200–0x3CF to the on-chip shadow EEPROM.
1	0	0	1	0	1	1	0	**EEPROM Read Command –** Transfer the contents of the on-chip shadow EEPROM to user memory locations 0x200–0x3CF.

Table 24.EEPROM Status Bits

EEPROM STATUS BIT	DESCRIPTION
ECC Used	Error Correcting Code Used – This bit indicates that ECC was used to correct data on one or more locations during the EEPROM read process (Note 1).
ECC Failure	Error Correcting Code Failure – This bit indicates that ECC failed to correct data on one or more locations during the EEPROM read process. If this bit is set one or more locations has invalid data (Note 1).
Program Failure	Program Failure – This bit indicates that a write data error occurred on one or more locations during the EEPROM programming process (Note 1).
Checksum Error	Checksum Error – This bit indicates that a checksum error occurred during the EEPROM read process (Note 1).

Note 1: *Once the bits in the EEPROM status register are set, they will remain set until cleared by the user. The EEPROM status register bits are cleared by writing 0x00 to address 0x0F9. These bits are also cleared on reset and after exiting sleep mode.*

Table 25.ADT7604 EEPROM Status Register (Address 0x0F9)

7	6	5	4	3	2	1	0
—	—	—	—	Checksum Error	Program Failure	ECC Failure	ECC Used

Copper Trace Sensors

Channel Assignment – Copper Trace Sensors

For each copper trace sensor tied to the ADT7604, a 32-bit channel-assignment word is programmed into a memory location corresponding to the channel sensor it is tied to (see *Table 26*). This data includes (1) copper trace sensor type, (2) sense resistor channel pointer, and (3) sensor configuration.

Table 26.Channel-Assignment Data for Copper Trace Resistors

	(1) COPPER TRACE SENSOR TYPE	(2) SENSE RESISTOR CHANNEL POINTER	(3) SENSOR CONFIGURATION	NOT USED
Measurement Class	31 30 29 28 27	26 25 24 23 22	21 20 19 18	17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0
Copper Trace Sensor	0b10010	R_{SENSE} channel assignment [4:0]	0b1001	0b000000000000000000

(1) Copper Trace Sensor Type

The copper trace sensor type is determined by the first 5 bits (B31 to B27) as shown in *Table 26*. These bits are always 0b10010 for this sensor type.

(2) Sense Resistor Channel Pointer

Copper trace sensor measurements are performed ratiometrically relative to a known R_{SENSE} resistor. The sensor resistor channel pointer field indicates the differential channel that the sensor resistor is tied to (see *Table 27*). For most applications, a single sense resistor can be shared with all copper trace sensors. The sense resistor for copper trace sensors should be a low drift (10ppm/°C) high accuracy (0.1%) 100Ω resistor. In *Table 28*, this sense resistor should be stored in mΩ.

Table 27. Sense Resistor Channel Pointer

(2) SENSE RESISTOR CHANNEL POINTER					SENSE RESISTOR CHANNEL
B26	B25	B24	B23	B22	
0	0	0	0	0	Invalid
0	0	0	0	1	Invalid
0	0	0	1	0	CH2-CH1
0	0	0	1	1	CH3-CH2
0	0	1	0	0	CH4-CH3
0	0	1	0	1	CH5-CH4
0	0	1	1	0	CH6-CH5
0	0	1	1	1	CH7-CH6
0	1	0	0	0	CH8-CH7
0	1	0	0	1	CH9-CH8

0	1	0	1	0	CH10-CH9
0	1	0	1	1	CH11-CH10
0	1	1	0	0	CH12-CH11
0	1	1	0	1	CH13-CH12
0	1	1	1	0	CH14-CH13
0	1	1	1	1	CH15-CH14
1	0	0	0	0	CH16-CH15
1	0	0	0	1	CH17-CH16
1	0	0	1	0	CH18-CH17
1	0	0	1	1	CH19-CH18
1	0	1	0	0	CH20-CH19
All Other Combinations					Invalid

(3) Sensor Configuration

The sensor configuration field is used to define the copper trace sensor. This should always be set to 0b1001.

The remaining 18 bits are not used and should be set to 0.

Conversion Result

The ADT7604 reports the resistance value of the copper trace sensor in mΩ. This value can be used to calculate the temperature. Each channel assigned a copper trace sensor includes a unique address containing the last resistance value measured for that channel. *Table 19* shows the memory locations corresponding to each resistance result.

Using Copper Trace Sensors

For good accuracy, design each copper trace sensor with resistance of at least 0.25Ω at room temperature. The ADT7604 can precisely measure the resistance of copper traces with a precision of 1mΩ. A copper trace with resistance of 0.25Ω increases its resistance by 1mΩ/°C. Utilizing the ADT7604 as a resistance measurement device allows pinpoint temperature measurement on PCBs and laminates using tiny parasitic copper traces. Any set of input channels can be configured to measure copper trace resistors. *Figure 29* shows an example using three sensors.

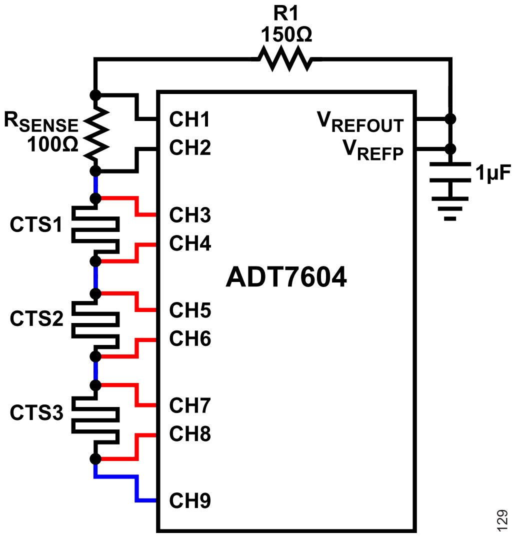


Figure 29. 3-Channel Copper Trace Sensor Measurement

For copper trace sensor resistors, the recommended value for R_{SENSE} is 100Ω; this should be a 0.1% accurate resistor with 10ppm/°C drift specification for optimal accuracy. In addition to the R_{SENSE} resistor, a second 1% low-precision resistor is required between R_{SENSE} and V_{REF}.

The copper trace sensors can be placed anywhere on the PCB; the ADT7604 automatically cancels the parasitic interconnect resistances. The copper trace sensors (CTS1, CTS2, and CTS3) are all connected in series from the sense resistor back to the ADT7604, see the blue interconnects in *Figure 29*. One additional channel (CH9) is required for this return in order to provide complete cancellation of parasitic resistances. Separate lines (see the red interconnects in *Figure 29*) are Kelvin-connected to each sensor. All parasitic resistances due to the red/blue lines are cancelled. The ADT7604 has 20 input channels, and it is possible to measure up to 8 copper trace sensors. Alternatively, the remaining channels can be used for other sensors (i.e., RTDs, thermistors, or leakage-sensing circuits).

Table 28 shows the channel-assignment data for the 100Ω sense resistor.

Note: For copper trace sensors, the value of the sense resistor is entered as mΩ. Therefore, the value for R_{SENSE} entered here is 100,000.

Table 28.Channel Assignment for Sense Resistor

DESCRIPTION	# OF BITS	BINARY DATA	MEMORY ADDRESS 0x204								MEMORY ADDRESS 0x205								MEMORY ADDRESS 0x206								MEMORY ADDRESS 0x207							
Sense Resistor	5	11101	1	1	1	0	1																											
100,000mΩ	27	110000110100000000000000000						1	1	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 29 shows the channel assignment data for the copper trace sensor tied to CH3-CH4, CTS1. The remaining copper trace resistors (CTS2 and CTS3) use the same channel-assignment data written into the address corresponding to CH6 and CH8.

Table 29. Channel Assignment for Copper Trace Sensor Tied to CH4

CONFIGURATION FIELD	DESCRIPTION	# OF BITS	BINARY DATA	MEMORY ADDRESS 0x20C								MEMORY ADDRESS 0x20D								MEMORY ADDRESS 0x20E								MEMORY ADDRESS 0x20F							
(1) Sensor Type	Copper Trace Sensor	5	10010	1	0	0	1	0																											
(2) Sense Resistor Channel Pointer	CH2	5	00010						0	0	0	1	0																						
(3) Sensor Configuration		4	1001											1	0	0	1																		
Not Used	N/A	18	000000000000000000															0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Ambient Calibration

In order to achieve the highest accuracy, a one-time 1-point calibration at room temperature is required to remove errors associated with the ultra-small copper sensors resistance. In a temperature-stable environment (with a known ambient temperature, T_0), measure each of the copper trace sensor resistance values (R_0). These values can be stored in the EEPROM user space and used for calculations of external resistance to temperature. It is achieved by saving the values into the Custom Sensor Table Data registers in RAM (0x250 to 0x3xF), then writing to EEPROM.

The optimal way to store this data is by using 32-bit floating point values. The first 4 bytes stored in memory are the ambient temperature used to measure each nominal resistance value of the copper trace sensor (see *Table 30*). The second 4 bytes are the temperature coefficient of the copper used in the PCB manufacturing process (typically 0.00393Ω/°C). The next 1-8 bytes contain the floating point resistance value of each copper trace sensor at the known ambient temperature.

Table 30 specifies memory location as offsets. The base address is configurable and could be a valid address within the range 0x250–0x3CF, as long as there is no data overflow or overlap. The absolute address for each field is calculated as:

Absolute Address = Base Address + Offset

For example, if the base address is 0x00C (also the CH1 ambient temperature start address), then the CH4 ambient temperature start absolute address is: 0x00C+0x024 = 0x030.

Table 30. Calibration Data Memory Map

CHANNEL	AMBIENT TEMPERATURE START ADDRESS	RESISTANCE START ADDRESS	TEMPCO START ADDRESS
CH1	0x000	0x004	0x008
CH2	0x00C	0x010	0x014
CH3	0x018	0x01C	0x020
CH4	0x024	0x028	0x02C
CH5	0x030	0x034	0x038
CH6	0x03C	0x040	0x044
CH7	0x048	0x04C	0x050
CH8	0x054	0x058	0x05C
CH9	0x060	0x064	0x068
CH10	0x06C	0x070	0x074
CH11	0x078	0x07C	0x080
CH12	0x084	0x088	0x08C

CH13	0x090	0x094	0x098
CH14	0x09C	0x0A0	0x0A4
CH15	0x0A8	0x0AC	0x0B0
CH16	0x0B4	0x0B8	0x0BC
CH17	0x0C0	0x0C4	0x0C8
CH18	0x0CC	0x0D0	0x0D4
CH19	0x0D8	0x0DC	0x0E0
CH20	0x0E4	0x0E8	0x0EC

It is possible to use the ADT7604 to measure the ambient temperature by adding an RTD to the copper trace sensor string (see *Figure 30*).

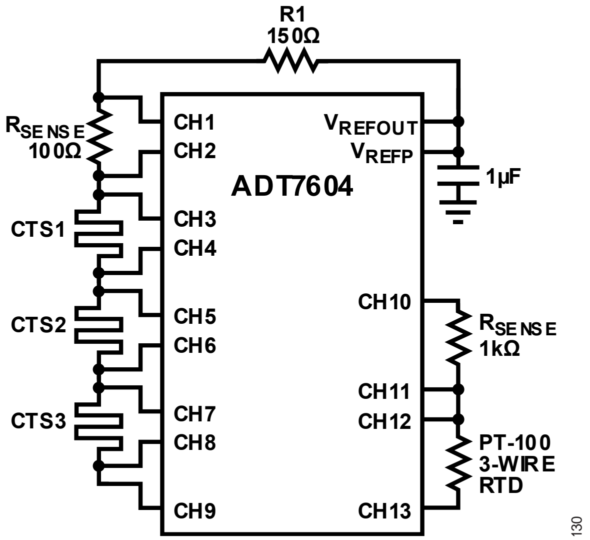


Figure 30. Adding a PT-100 RTD to Measure Ambient Temperature

Temperature Calculation

The ADT7604 reports the resistance in mΩ of the copper trace sensors; the actual temperature requires a simple calculation by an external microcontroller. In order to calculate the temperature of the copper trace sensor, the calibration data corresponding to that particular sensor is required. This data is the calibration ambient temperature (T_0), the measured resistance at that temperature (R_0), and the copper temperature coefficient (T_C, typically 0.00393). For a measured resistance (R_M), the corresponding temperature can be calculated using the following equation:

$$T_M = \frac{R_M - R_0}{T_C \cdot R_0} + T_0$$

Copper Trace Resistors ≥ 1Ω

For a copper trace sensor ≥ 1Ω tied to ADT7604, a 32-bit channel assignment word is programmed into the memory location corresponding to the channel sensor it is tied to (see *Table 31*). This data includes a (1) copper trace sensor type, (2) sense resistor channel pointer, (3) sensor configuration, (4) excitation current, and (5) custom sensor data pointer.

Table 31. Channel Assignment Data for Copper Trace Sensor ≥ 1Ω

	(1) COPPER TRACE SENSOR TYPE	**(2) SENSE RESISTOR CHANNEL POINTER**	**(3) SENSOR CONFIGURATION**	**(4) EXCITATION CURRENT**	**NOT USED**	**(5) CUSTOM SENSOR DATA POINTER**	
Measurement Class	31 30 29 28 27	26 25 24 23 22	21 20 19 18	17 16 15 14	13 12	11 10 9 8 7 6	5 4 3 2 1 0
Copper Trace Sensor ≥ 1Ω	0b10010	R_{SENSE} Channel Assignment [4:0]	0b1001	Excitation Current [3:0]	0 0	Custom Address [5:0]	Custom Length-1 [5:0]

The (1) copper trace sensor type, (2) sense resistor channel pointer, and (3) sensor configuration are the same as the copper trace sensor ≤ 1Ω.

(4) Excitation Current

The next field in the channel-assignment word (B17–B14) controls the magnitude of the excitation current applied to the sensor (see *Table 32*). The current selected is the total current flowing through the sensor independent of the wiring configuration.

It is recommended to use largest current option (1mA) since the copper trace sensors typically have small resistance. The maximum voltage that the ADT7604 can measure on a single sensor is 1.25V.

Table 32. Total Excitation Current for Copper Trace Sensors

(4) EXCITATION CURRENT				
B17	**B16**	**B15**	**B14**	**CURRENT**
0	0	0	0	Reserved
0	0	0	1	5µA
0	0	1	0	10µA
0	0	1	1	25µA
0	1	0	0	50µA
0	1	0	1	100µA
0	1	1	0	250µA
0	1	1	1	500µA
1	0	0	0	1mA

(5) Custom Sensor Data Pointer

The ADT7604 can be configured to report not only resistance, but also the temperature of a copper trace sensor ≥ 1Ω. Users can import custom sensor data, which is a table of resistance (mΩ) vs. temperature (K), to ADT7604's custom sensor table data registers, starting from address 0x250 (see *Table 9*). The ADT7604 automatically converts resistance results into temperature results and saves them in the Temperature Result memory starting from address 0x010.

B11–B6 is for the Custom Table Start Address, and B5–B0 is for the table length. See the *Copper Trace Sensor ≥ 1Ω Example* section for detailed instructions.

Use of a Copper Trace Sensor ≥ 1Ω

For a copper trace sensor that has a resistance of ≥1Ω, the user can remove the R1 150Ω (shown in *Figure 29* and *Figure 30*) and use internal excitation current because a resistance ≥1Ω is large enough for the internal excitation current to generate proper voltage across the copper trace sensor for measurements. See *Table 32* for setting the excitation current properly.

Custom sensor data (minimum of 3, maximum of 64 pairs) reside sequentially in memory and are arranged in blocks of six bytes of monotonically increasing tabular data Ω vs. temperature (see *Table 33*).

Table 33. Custom Copper Trace Sensor Tabular Data Format

ADDRESS	BYTE 0 BYTE 1 BYTE 2	BYTE 3 BYTE 4 BYTE 5
0x250 + 6 x Start Address	Table Entry #1 (mΩ)	Table Entry #1 (Kelvin)
0x250 + 6 x Start Address + 6	Table Entry #2 (mΩ)	Table Entry #2 (Kelvin)
0x250 + 6 x Start Address + 12	Table Entry #3 (mΩ)	Table Entry #3 (Kelvin)
•	•	•
•	•	•
•	•	•
Max Address = 0x3CA	Table Entry #64 (mΩ)	Table Entry #64 (Kelvin)

Copper Trace Sensor ≥ 1Ω Example

In the *Figure 31* example, a copper trace sensor curve is implemented. Points P1–P9 represent the normal operating range of the copper trace sensor. Resistance readings above point P9 result in a soft fault, and the reported temperature is a linear extrapolation using a slope determined by points P8 and P9 (the final two table entries). Resistance readings below point P1 are also reported as soft faults. The temperature reported is the extrapolation between point P1 and P0, where P0 is the sensor output temperature at 0Ω. (This point should be 0Ω for proper interpolation below point P1.)

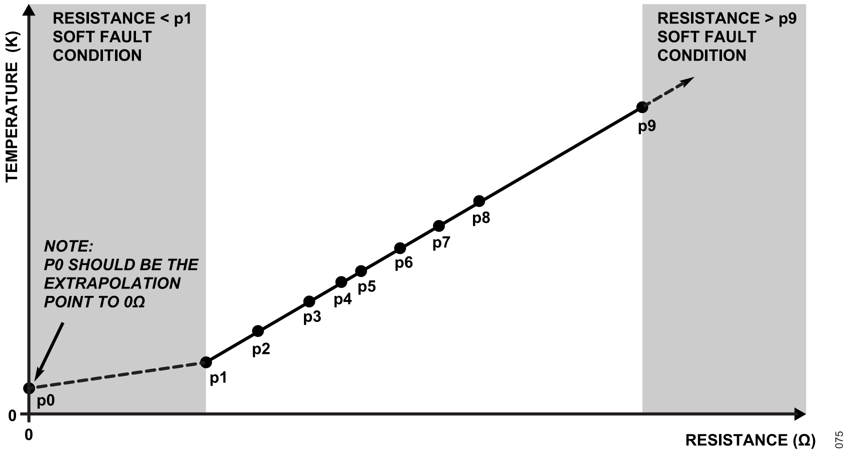


Figure 31. Copper Trace Sensor ≥ 1Ω Example

The copper trace sensor data table is formatted in mΩ vs. Kelvin (see *Table 34*). Each table entry pair spans 6 bytes. The first set of data can begin at any memory location greater than or equal to 0x250 and end at or below 0x3CF.

In order to program the ADT7604 with the copper trace sensor data table, both the resistance data and the Kelvin data are converted to 24-bit binary values. The sensor output resistance (units = mΩ) follows the convention shown in *Table 35*, where the first 13 bits are the integer part and the remaining 11 bits are the fractional part.

In order to simplify the temperature field, temperature values are input in Kelvin as an unsigned value, but the final temperatures reported by the ADT7604 are reported in °C or °F. The sensor temperature (Kelvin) follows the convention shown in *Table 36*, where the first 14 bits are the integer part and the remaining 10 bits are the fractional part.

Table 34.Example Sensor Resistance vs. Kelvin Data Memory Map

POINT	SENSOR OUTPUT RESISTANCE (mΩ)	TEMPERATURE (K)	START ADDRESS	STOP ADDRESS	BYTE 1	BYTE 2	BYTE 3	BYTE 1	BYTE 2	BYTE 3
P0	0	0	0x28C	0x291	Resistance Data (mΩ)			Temperature Data		
P1	25.36	50	0x292	0x297						
P2	221.88	100	0x298	0x29D						
P3	418.36	150	0x29E	0x2A3						
P4	607	198	0x2A4	0x2A9						
P5	803.52	248	0x2AA	0x2AF						
P6	1000	298	0x2B0	0x2B5						
P7	1204.36	350	0x2B6	0x2BB						
P8	1400.88	400	0x2BC	0x2C1						
P9	1687.76	473	0x2C2	0x2C7						

Table 35.Example Sensor Resistance Values

	BYTE 1								BYTE 2								BYTE 3							
	B23	**B22**	**B21**	**B20**	**B19**	**B18**	**B17**	**B16**	**B15**	**B14**	**B13**	**B12**	**B11**	**B10**	**B9**	**B8**	**B7**	**B6**	**B5**	**B4**	**B3**	**B2**	**B1**	**B0**
Resistance (mΩ)	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	2^{-1}	2^{-2}	2^{-3}	2^{-4}	2^{-5}	2^{-6}	2^{-7}	2^{-8}	2^{-9}	2^{-10}	2^{-11}
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25.36	0	0	0	0	0	0	0	0	1	1	0	0	1	0	1	0	1	1	1	0	0	0	0	1
221.88	0	0	0	0	0	1	1	0	1	1	1	0	1	1	1	1	0	0	0	0	1	0	1	0
418.36	0	0	0	0	1	1	0	1	0	0	0	1	0	0	1	0	1	1	1	0	0	0	0	1
607	0	0	0	1	0	0	1	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0
803.52	0	0	0	1	1	0	0	1	0	0	0	1	1	1	0	0	0	0	1	0	1	0	0	1
1000	0	0	0	1	1	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1204.36	0	0	1	0	0	1	0	1	1	0	1	0	0	0	1	0	1	1	1	0	0	0	0	1
1400.88	0	0	1	0	1	0	1	1	1	1	0	0	0	1	1	1	0	0	0	0	1	0	1	0
1687.76	0	0	1	1	0	1	0	0	1	0	1	1	1	1	1	0	0	0	0	1	0	1	0	0

Table 36.Example Sensor Temperature Values

	BYTE 1								BYTE 2								BYTE 3							
	B23	**B22**	**B21**	**B20**	**B19**	**B18**	**B17**	**B16**	**B15**	**B14**	**B13**	**B12**	**B11**	**B10**	**B9**	**B8**	**B7**	**B6**	**B5**	**B4**	**B3**	**B2**	**B1**	**B0**
Temperature (K)	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	2^{-1}	2^{-2}	2^{-3}	2^{-4}	2^{-5}	2^{-6}	2^{-7}	2^{-8}	2^{-9}	2^{-10}
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0
100	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
150	0	0	0	0	0	0	1	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0
198	0	0	0	0	0	0	1	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0
248	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
298	0	0	0	0	0	1	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0
350	0	0	0	0	0	1	0	1	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0
400	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
473	0	0	0	0	0	1	1	1	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0

In this example, a copper trace sensor tied to CH2/CH3, with a sense resistor on CH1/2, is programmed with the channel assignment data shown in *Table 37*. In this case, the custom data begins at memory location 0x28C (starting address is 10). The starting address (offset from 0x250) is entered in the sensor data pointer field of the channel assignment data. The table data length –1 (9 in this case) is entered into the sensor data length field of the channel assignment word. See *Table 33* where the total number of paired entries is 10.

Table 37. Copper Trace Sensor Channel Assignment Data

CONFIGURATION FIELD	DESCRIPTION	# OF BITS	BINARY DATA	MEMORY ADDRESS 230								MEMORY ADDRESS 231								MEMORY ADDRESS 232								MEMORY ADDRESS 233							
(1) Sensor Type	Copper Trace Sensor	5	10010	1	0	0	1	0																											
(2) Sense Resistor Channel Pointer	CH2	5	00010						0	0	0	1	0																						
(3) Sensor Configuration		4	1001											1	0	0	0																		
(4) Excitation Current	1mA	4	1000															1	0	0	0														
Not Used		2	00																			0	0												
(5) Custom Data Pointer	Start Address = 10	6	001010																					0	0	1	0	1	0						
(5) Custom Data Length -1	Data Length -1 = 9 10 Paired	6	001001																											0	0	1	0	0	1

Leak Sensors

Channel Assignment – Leakage Sensing

For each leak sensor tied to the ADT7604, a 32-bit channel assignment word is programmed into a memory location corresponding to the channel that the sensor is tied to (see *Table 38*).

Table 38.Channel Assignment Data for Leak Sensor

	(1) LEAK SENSOR TYPE	(2) SENSE RESISTOR CHANNEL POINTER	(3) SENSOR CONFIGURATION	(4) EXCITATION CURRENT	NOT USED	(5) CUSTOM SENSOR DATA POINTER	
Measurement Class	31 30 29 28 27	26 25 24 23 22	21 20 19	18 17 16 15	14 13 12	11 10 9 8 7 6	5 4 3 2 1 0
Leak Sensor	0b11011	R_{SENSE} Channel Assignment [4:0]	0b001	Excitation Current [3:0]	Not Used 0 0 0	Custom Address [5:0]	Custom Length -1 [5:0]

(1) Leak Sensor Type

The leak sensor type is determined by the first 5 bits (B31–B27) as shown in *Table 38*. These bits are always 0b11011 for this sensor type.

(2) Sense Resistor Channel Pointer

Leakage sensing measurements are performed ratiometrically relative to a known R_{SENSE} resistor. The sensor resistor channel pointer field indicates the differential channel that the sensor is tied to (see *Table 27*). For most applications, a single sense resistor can be shared with all leak sensors. This sense resistor should be a low-drift (10ppm/°C), high-accuracy (0.1%), 1kΩ to 10kΩ resistor.

(3) Sensor Configuration

The sensor configuration field is used to define the leak sensor; this should always be set to 0b001.

(4) Excitation Current

The next field in the channel assignment word (B18–B15) controls the magnitude of the excitation current applied to the leak sensor. Properly select this value based on liquid electrical characteristics for accurate measurement (see *Table 39*). The recommended excitation current is 10µA (0b0101) for PG25.

Table 39. Excitation Current for Leak Sensors

(4) EXCITATION CURRENT				CURRENT
B18	B17	B16	B15	
0	0	0	0	Reserved
0	0	0	1	250nA
0	0	1	0	500nA
0	0	1	1	1µA
0	1	0	0	5µA
0	1	0	1	10µA
0	1	1	0	25µA
0	1	1	1	50µA
1	0	0	0	100µA
1	0	0	1	250µA
1	0	1	0	500µA
1	0	1	1	1mA
1	1	0	1	Invalid
1	1	1	0	Invalid
1	1	1	1	Reserved

(5) Custom Sensor Data Pointer

It is possible to configure the leak sensor to report not only the resistance value, but also percent liquid coverage of a sensor. This is achieved by importing a table containing information about resistance vs. percentage of coverage into the ADT7604's custom sensor table data registers, starting from address 0x250 (see *Table 9*). The ADT7604 will convert the resistance results into the percentage of coverage and save it in the Temperature Result memory starting from address 0x010. Data read from the Temperature Result memory is the % number.

B11–B6 is for the custom sensor data table Start address, and B5–B0 is for the table length. If the percentage of coverage is not needed, set this field to all 0's.

Custom Sensor Data Table

Characterize the leak sensor by reading the resistance at different coverage from 0 to 100%. Then convert the percentage number into coverage data that can be saved in the ADT7604 using the following equation.

Note: In the global configuration register, the ADT7604 must be set to report the temperature in °C. If Fahrenheit mode is set, the coverage data output is incorrect.

Coverage data = P + 273.15

where P means P% of liquid coverage of the leak sensor.

Table 40 shows an example of leak sensor data.

Table 40. Leak Sensor Data Example

RESISTANCE (Ω)	COVERAGE DATA
1000000	273.15 (0%)
800	298.15 (25%)
400	323.15 (50%)
267	348.15 (75%)
200	372.15 (99%)
0	373.15 (100%)

Save the columns “Resistance” and “Coverage Data” into the ADT7604. The more test points that are taken, the more accurate the reading will be.

Leak Sensor Table Example

In the *Figure 32* example, a leak sensor curve is implemented. Points P1–P9 represent the normal operating range of the leak sensor. Resistance readings above P9 result in a soft fault, and the reported temperature is a linear extrapolation using a slope determined by P8 and P9 (the final two table entries). The resistance readings below P1 are also reported as soft faults. The temperature reported is the extrapolation between P1 and P0, where P0 is the sensor output temperature at 0Ω. (This point must be 0Ω for proper interpolation below point P1.)

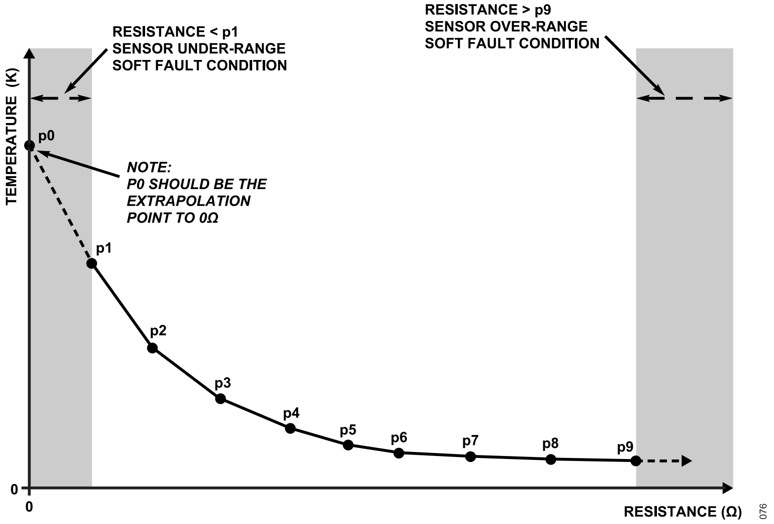


Figure 32. Leak Sensor Data Example

The leak sensor table data is formatted in Ω (sensor output resistance) vs. coverage data (see *Table 41*). Each table entry pair spans 6 bytes. The first set of data can begin at any memory location greater than or equal to 0x250 and end below 0x3CF.

In order to program the ADT7604 with the leak sensor table, both the resistance data and the coverage data are converted to 24-bit binary values. The sensor output resistance (units = Ω) follows the convention shown in *Table 42*, where the first 20 bits are the integer part and the remaining 4 bits are the fractional part.

In order to simplify the coverage data field, values are input as an unsigned value. The sensor coverage data follows the convention shown in *Table 43*, where the first 14 bits are the integer part and the remaining 10 bits are the fractional part.

Table 41. Leak Sensor Example Resistance vs. Coverage Information Data Memory Map

POINT	SENSOR OUTPUT RESISTANCE(Ω)	COVERAGE DATA	START ADDRESS	STOP ADDRESS	BYTE 1	BYTE 2	BYTE 3	BYTE 1	BYTE 2	BYTE 3
P0	0.00	373.15	0x2C8	0x2CD	Resistance Data			Coverage Info Data		
P1	202.02	372.15	0x2CE	0x2D3						
P2	285.71	343.15	0x2D4	0x2D9						
P3	333.33	333.15	0x2DA	0x2DF						
P4	400.00	323.15	0x2E0	0x2E5						
P5	500.00	313.15	0x2E6	0x2EB						
P6	666.67	303.15	0x2EC	0x2F1						
P7	1000.00	293.15	0x2F2	0x2F7						
P8	2000.00	283.15	0x2F8	0x2FD						
P9	1000000.00	273.15	0x2FE	0x303						

Table 42. Example Leak Sensor Resistance Values

	BYTE 1								BYTE 2								BYTE 3							
	B23	**B22**	**B21**	**B20**	**B19**	**B18**	**B17**	**B16**	**B15**	**B14**	**B13**	**B12**	**B11**	**B10**	**B9**	**B8**	**B7**	**B6**	**B5**	**B4**	**B3**	**B2**	**B1**	**B0**
Resistance	2^{19}	2^{18}	2^{17}	2^{16}	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	2^{-1}	2^{-2}	2^{-3}	2^{-4}
0.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
202.02	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	1	0	0	0	0	0
285.71	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	1	1	0	1	1
333.33	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1	1	0	1	0	1	0	1
400.00	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0
500.00	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	1	0	0	0	0	0	0
666.67	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1	1	0	1	0	1	0	1	1
1000.00	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	1	0	0	0	0	0	0	0
2000.00	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	1	0	0	0	0	0	0	0	0
1000000.00	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Table 43. Example Leak Sensor Coverage Data Values

	BYTE 1								BYTE 2								BYTE 3							
	B23	**B22**	**B21**	**B20**	**B19**	**B18**	**B17**	**B16**	**B15**	**B14**	**B13**	**B12**	**B11**	**B10**	**B9**	**B8**	**B7**	**B6**	**B5**	**B4**	**B3**	**B2**	**B1**	**B0**
Temperature	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	2^{-1}	2^{-2}	2^{-3}	2^{-4}	2^{-5}	2^{-6}	2^{-7}	2^{-8}	2^{-9}	2^{-10}
373.15	0	0	0	0	0	1	0	1	1	1	0	1	0	1	0	0	1	0	0	1	1	0	1	0
372.15	0	0	0	0	0	1	0	1	1	1	0	1	0	0	0	0	1	0	0	1	1	0	1	0
343.15	0	0	0	0	0	1	0	1	0	1	0	1	1	1	0	0	1	0	0	1	1	0	1	0
333.15	0	0	0	0	0	1	0	1	0	0	1	1	0	1	0	0	1	0	0	1	1	0	1	0
323.15	0	0	0	0	0	1	0	1	0	0	0	0	1	1	0	0	1	0	0	1	1	0	1	0
313.15	0	0	0	0	0	1	0	0	1	1	1	0	0	1	0	0	1	0	0	1	1	0	1	0
303.15	0	0	0	0	0	1	0	0	1	0	1	1	1	1	0	0	1	0	0	1	1	0	1	0
293.15	0	0	0	0	0	1	0	0	1	0	0	1	0	1	0	0	1	0	0	1	1	0	1	0
283.15	0	0	0	0	0	1	0	0	0	1	1	0	1	1	0	0	1	0	0	1	1	0	1	0
273.15	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	1	0	0	1	1	0	1	0

Using Leak Sensors

The leakage-sensing circuit can be any type of resistive leakage-sensing circuits, such as rope and PCB traces. Refer to the EVAL-AD7604-AZ board design for an example of a leak sensor. The ADT7604 reports the resistance value of the leakage-sensing circuit (see *Table 19* and *Table 20*). If custom sensor data is provided, the ADT7604 can provide a percentage of coverage. The ADT7604 is capable of measuring resistance up to 2MΩ. A leak sensor without the presence of leakage can have a resistance that is significantly greater than 2MΩ; in this case, the reported resistance will be 0b01111111111111111111111111111111, indicating an open circuit.

Figure 33 shows an example using three leak sensors. For leak sensors, the recommended value R_{SENSE} is 10kΩ. In applications where precise leakage impedance is required, this should be a 0.1% accurate resistor with 10ppm/°C drift. Each leak sensor requires two input channels and a shared sense resistor; up to nine leakage sensors can be used with each ADT7604.

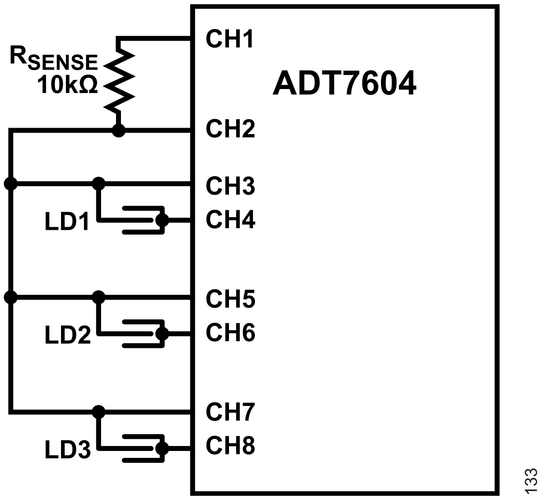


Figure 33. Leakage-Sensing Example Circuit

Table 44 shows the channel assignment data for the 10kΩ sense resistor that is tied to CH1/CH2.

Table 44.Channel Assignment for Sensor Resistor

CONFIGURATION FIELD	DESCRIPTION	# OF BITS	BINARY DATA	MEMORY ADDRESS 0x204								MEMORY ADDRESS 0x205								MEMORY ADDRESS 0x206								MEMORY ADDRESS 0x207							
(1) Sensor Type	Sense Resistor	5	11101	1	1	1	0	1																											
(2) Sense Resistor Value	10kΩ	27	00010011100010000 0000000000						0	0	0	1	0	0	1	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 45 shows the channel assignment data for the leak sensor that is tied to CH3/CH4. The remaining leak sensors (LD2 and LD3) use the same channel assignment data written into the addresses corresponding to CH6 and CH8. The custom sensor data begins at memory location 0x2C8 (the starting address is 20). The starting address (offset from 0x250) is entered in the sensor data pointer field of the channel assignment data. The table data length –1 (9, in this case) is entered into the sensor data length field of the channel assignment data.

Table 45.Channel Assignment for Leak Sensor Tied to CH4

CONFIGURATION FIELD	DESCRIPTION	# OF BITS	BINARY DATA	MEMORY ADDRESS 0x20C								MEMORY ADDRESS 0x20D								MEMORY ADDRESS 0x20E								MEMORY ADDRESS 0x20F							
(1)Sensor Type	Leak Sensor	5	11011	1	1	0	1	1																											
(2)Sense Resistor Channel Pointer	CH2	5	00010						0	0	0	1	0																						
(3)Sensor Configuration		3	001											0	0	1																			
(4) Excitation Current	10µA	4	0101														0	1	0	1															
Not Used	N/A	3	000																		0	0	0												
(5) Custom Data Pointer	Start Address = 20	6	010100																					0	1	0	1	0	0						
(5) Custom Length -1	Length -1 = 9	6	001001																											0	0	1	0	0	1

RTD Measurements

Channel Assignment – RTD

For each RTD tied to the ADT7604, a 32-bit channel-assignment word is programmed into a memory location corresponding to the channel that the sensor is tied to (see *Table 46*). This word includes the (1) RTD type, (2) sense resistor channel pointer, (3) sensor configuration, (4) excitation current, and (5) RTD curve.

(1) RTD Type

The RTD type is determined by the first 5 input bits B31–B27 as shown in *Table 47*. Linearization coefficients for RTD types PT-10, PT-50, PT-100, PT-200, PT-500, PT-1000, and NI-120 with selectable common curves (α = 0.003850, α = 0.003911, α = 0.003916, and α = 0.003926) are built into the device.

(2) Sense Resistor Channel Pointer

RTD measurements are performed ratiometrically relative to a known R_{SENSE} resistor. The sense resistor channel pointer field indicates the differential channel that the sense resistor is tied to for the RTD (see *Table 48*). Sense resistors are always measured differentially.

(3) Sensor Configuration

The sensor configuration field is used to define the various RTD properties. Configuration bits B20 and B21 determine if the RTD is a 2-, 3-, or 4-wire type (see *Table 49*).

The simplest configuration is the 2-wire configuration. While this setup is simple, parasitic errors due to IR drops in the leads result in systematic temperature errors. The 3-wire configuration cancels RTD lead resistance errors (if the lines are equal resistance) by applying two matched current sources to the RTD, one per lead. Mismatches in the two current sources are removed through transparent background calibration. 4-wire RTDs remove unbalanced RTD lead resistance by measuring directly across the sensor using high-impedance Kelvin sensing. 4-wire measurements with Kelvin R_{SENSE} are useful in applications where sense resistor wiring parasitics can lead to errors; this is especially useful for low-resistance PT-10 RTDs. In this case, both the RTD and sense resistor have Kelvin-sensing connections.

The next sensor configuration bits (B18 and B19) determine the excitation current mode. These bits are used to enable R_{SENSE} sharing, where one sense resistor is used for multiple 2-, 3-, or 4-wire RTDs. In this case, the RTD ground connection is internal and each RTD points to the same R_{SENSE} channel.

Table 46.RTD Channel Assignment Word

	(1) RTD TYPE	(2) SENSE RESISTOR CHANNEL POINTER	(3) SENSOR CONFIGURATION		(4) EXCITATION CURRENT	(5) RTD CURVE	NOT USED
	Table 47	Table 48	Table 49		Table 50	Table 51	
Measurement Class	31 30 29 28 27	26 25 24 23 22	21 20	1918	17 16 15 14	13 12	11 10 9 8 7 6 5 4 3 2 1 0
RTD	Type = 10 to 17	R_{SENSE} Channel Assignment [4:0]	2, 3, 4 Wire	Excitation Mode	Excitation Current [3:0]	Curve [1:0]	0b000000000000

Table 47.RTD Type

(1) RTD TYPE					RTD TYPE
B31	B30	B29	B28	B27	
0	1	0	1	0	RTD PT-10
0	1	0	1	1	RTD PT-50
0	1	1	0	0	RTD PT-100
0	1	1	0	1	RTD PT-200
0	1	1	1	0	RTD PT-500
0	1	1	1	1	RTD PT-1000

1	0	0	0	0	RTD 1000 (α = 0.00375)
1	0	0	0	1	RTD NI-120

Table 48.Sense Resistor Channel Pointer

(2) SENSE RESISTOR CHANNEL POINTER					SENSE RESISTOR CHANNEL
B26	B25	B24	B23	B22	
0	0	0	0	0	Invalid
0	0	0	0	1	Invalid
0	0	0	1	0	CH2-CH1
0	0	0	1	1	CH3-CH2
0	0	1	0	0	CH4-CH3
0	0	1	0	1	CH5-CH4
0	0	1	1	0	CH6-CH5
0	0	1	1	1	CH7-CH6
0	1	0	0	0	CH8-CH7
0	1	0	0	1	CH9-CH8
0	1	0	1	0	CH10-CH9
0	1	0	1	1	CH11-CH10
0	1	1	0	0	CH12-CH11
0	1	1	0	1	CH13-CH12
0	1	1	1	0	CH14-CH13
0	1	1	1	1	CH15-CH14
1	0	0	0	0	CH16-CH15
1	0	0	0	1	CH17-CH16
1	0	0	1	0	CH18-CH17
1	0	0	1	1	CH19-CH18
1	0	1	0	0	CH20-CH19
All Other Combinations					Invalid

Table 49.RTD Sensor Configuration Selection

(3) SENSE CONFIGURATION				MEASUREMENT MODE					BENEFITS			
NUMBER OF WIRES		EXCITATION MODE		NUMBER OF WIRES	GROUND CONNECTION	CURRENT SOURCE ROTATION	SENSE RESISTOR SHARING	RTDs POSSIBLE PER DEVICE	CANCELS RTD MATCHED LEAD RESISTANCE	CANCELS RTD MISMATCH LEAD RESISTANCE	CANCELS PARASITIC THERMOCOUPLE EFFECTS	CANCELS R_{SENSE} LEAD RESISTANCE
B21	B20	B19	B18									
0	0	0	0	2-Wire	External	No	No	5				
0	0	0	1	2-Wire	Internal	No	Yes	9				
0	1	0	0	3-Wire	External	No	No	5	•			
0	1	0	1	3-Wire	Internal	No	Yes	9	•			
0	1	1	X	Reserved								
1	0	0	0	4-Wire	External	No	No	4	•	•		
1	0	0	1	4-Wire	Internal	No	Yes	6	•	•		
1	0	1	0	4-Wire	Internal	Yes	Yes	6	•	•	•	
1	0	1	1	Reserved								

1	1	0	0	4-Wire, Kelvin R_{SENSE}	External	No	No	4	•	•		•
1	1	0	1	4-Wire, Kelvin R_{SENSE}	Internal	No	Yes	5	•	•		•
1	1	1	0	4-Wire, Kelvin R_{SENSE}	Internal	Yes	Yes	5	•	•	•	•
1	1	1	1	Reserved								

Bits B18 and B19 are also used to enable excitation current rotation to automatically remove parasitic thermocouple effects. Parasitic thermocouple effects may arise from the physical connection between the RTD and the measurement instrument. This mode is available for all 4-wire configurations using internal current source excitation.

(4) Excitation Current

The next field in the channel assignment word (B17 to B14) controls the magnitude of the excitation current applied to the RTD (see *Table 50*). The current selected is the total current flowing through the RTD independent of the wiring configuration. The R_{SENSE} current is 2x the sensor excitation current for 3-wire RTDs.

In order to prevent soft or hard faults, select a current such that the maximum voltage drop across the sensor or sense resistor is nominally 1.0V. For example, if R_{SENSE} is 10kΩ and the RTD is a PT-100, select an excitation current of 100µA for 2-wire and 4-wire RTDs, and select 50µA for a 3-wire RTD. Alternatively, using a 1kΩ sense resistor with a PT-100 RTD allows 500µA excitation for any wiring configuration.

Table 50.Total Excitation Current for All RTD Wire Types

(4) EXCITATION CURRENT				
B17	**B16**	**B15**	**B14**	**CURRENT**
0	0	0	0	Reserved
0	0	0	1	5µA
0	0	1	0	10µA
0	0	1	1	25µA
0	1	0	0	50µA
0	1	0	1	100µA
0	1	1	0	250µA
0	1	1	1	500µA
1	0	0	0	1mA

(5) RTD Curve

Bits B13 and B12 set the RTD curve used and the corresponding Callendar-Van Dusen constants (shown in *Table 51*).

Table 51.RTD Curves: RT = R0 x (1 + a x T + b x T^2 + (T – 100°C) x c x T^3) for T < 0°C, RT = R0 x (1 + a x T + b x T^2) for T > 0°C

(5) RTD CURVE						
B13	**B12**	**CURVE**	**ALPHA**	**a**	**b**	**c**
0	0	European Curve	0.00385	3.908300E-03	-5.775000E-07	-4.183000E-12
0	1	American	0.003911	3.969200E-03	-5.849500E-07	-4.232500E-12
1	0	Japanese	0.003916	3.973900E-03	-5.870000E-07	-4.400000E-12
1	1	ITS-90	0.003926	3.984800E-03	-5.870000E-07	-4.000000E-12
X	X	RTD1000-375	0.00375	3.810200E-03	-6.018880E-07	-6.000000E-12
X	X	*NI-120	N/A	N/A	N/A	N/A

**NI-120 uses table-based data.*

Fault Reporting – RTD

Each sensor type has unique fault-reporting mechanism indicated in the most significant byte of the data output word. *Table 52* shows the faults reported in the measurement of RTDs.

Bit D31 indicates the RTD or R_{SENSE} is open, shorted, or not plugged in. This is a hard fault and -999°C or °F is reported. Bit D30 indicates a bad ADC reading. This can be a result of either a broken (open) sensor or an excessive noise event (ESD or static discharge into the sensor path). This is a hard error and -999°C or °F is reported. In the case of an excessive noise event, the device should recover and the following conversions will be valid if the noise was a random infrequent event. Bits D29 and D28 are not used for RTDs. Bits D27 and D26 indicate over or under temperature limits (see *Table 53*). The calculated temperature is reported, but the accuracy may be compromised. Bit D25 indicates the absolute voltage measured by the ADC is beyond its normal operating range.

Table 52.RTD Fault Reporting

BIT	FAULT	ERROR TYPE	DESCRIPTION	OUTPUT RESULT
D31	Sensor Hard Fault	Hard	Open or short RTD or R_{SENSE}	-999°C or °F
D30	Hard ADC-out-of-Range	Hard	Bad ADC reading (could be large external noise event)	-999°C or °F
D29	Not Used for RTDs	N/A	Always 0	Valid reading
D28	Not Used for RTDs	N/A	Always 0	Valid reading
D27	Sensor over Range	Soft	T > high temp limit (see *Table 53*)	Suspect reading
D26	Sensor under Range	Soft	T < low temp limit (see *Table 53*)	Suspect reading
D25	ADC out-of-Range	Soft	ADC absolute input voltage is beyond ±1.125 x V_{REF}/2	Suspect reading
D24	Valid	N/A	Result valid (should be 1) discard results if 0	Valid reading

Table 53.Voltage and Resistance Ranges

RTD TYPE	MIN (Ω)	MAX (Ω)	LOW TEMP LIMIT (°C)	HIGH TEMP LIMIT (°C)
PT-10	1.95	34.5	-200	850
PT-50	9.75	172.5	-200	850
PT-100	19.5	345	-200	850
PT-200	39	690	-200	850
PT-500	97.5	1725	-200	850
PT-1000	195	3450	-200	850
NI-120	66.6	380.3	-80	260

Table 54.Sense Resistor Channel Assignment Word

	(1) SENSOR TYPE					(2) SENSE RESISTOR VALUE (Q)																										
	Table 55					*Table 56*																										
Measurement Class	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Sense Resistor	Type = 29					Sense resistor value (17, 10) up to ~ 131,072Ω with 1/1024Ω resolution																										

Sense Resistor

Channel Assignment

For each sense resistor tied to the ADT7604, a 32-bit channel assignment word is programmed into a memory location corresponding to the channel the sensor is tied to (see *Table 54*). This word includes (1) sense resistor selection and (2) sense resistor value.

(1) Sensor Type

The sense resistor is selected by setting the first 5 input bits, B31 to B27, to 11101 (see *Table 55*).

Table 55.Sense Resistor Selection

(1) SENSOR TYPE					SENSOR TYPE
B31	B30	B29	B28	B27	
1	1	1	0	1	Sense resistor

(2) Sense Resistor Value

The last field in the channel assignment word (B26 to B0) sets the value of the sense resistor within the range 0 to 131,072Ω with 1/1024Ω precision (see *Table 56*). The top 17 bits (B26 to B10) create the integer and bits B9 to B0 create the fraction of the sense resistor value.

Example: 2-Wire RTD

The simplest RTD configuration is the 2-wire configuration; 2-wire RTDs follow the general convention shown in *Figure 34*. They require only two connections per RTD and can be tied directly to 2-lead RTD elements. The disadvantages of this topology are errors due to parasitic lead resistance. If sharing is not selected (1 R_{SENSE} per RTD), then CH_{RTD} should be grounded. The ground connection should be removed if sharing is enabled (1 R_{SENSE} for multiple RTDs).

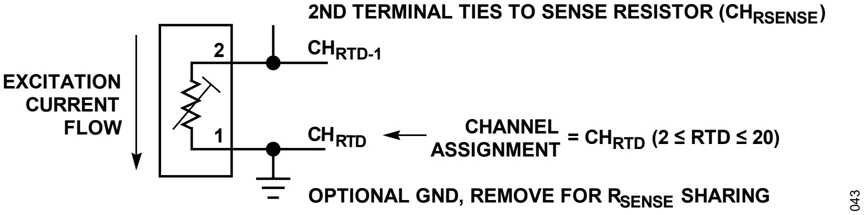


Figure 34.2-Wire RTD Channel Assignment Convention

Table 56.Example Sense Resistor Values

	(2) SENSE RESISTOR VALUE (Ω)																										
	B26	B25	B24	B23	B22	B21	B20	B19	B18	B17	B16	B15	B14	B13	B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0
Example R	2^{16}	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	2^{-1}	2^{-2}	2^{-3}	2^{-4}	2^{-5}	2^{-6}	2^{-7}	2^{-8}	2^{-9}	2^{-10}
10,000.2Ω	0	0	0	1	0	0	1	1	1	0	0	0	1	0	0	0	0	0	0	1	1	0	0	1	1	0	1
99.99521kΩ	1	1	0	0	0	0	1	1	0	1	0	0	1	1	0	1	1	0	0	1	1	0	1	0	1	1	1
1.0023kΩ	0	0	0	0	0	0	0	1	1	1	1	1	0	1	0	1	0	0	1	0	0	1	1	0	0	1	1

Sense resistor channel assignments follow the general convention shown in *Figure 35*. The sense resistor is tied between CH_{RSENSE} and $CH_{RSENSE-1}$, and CH_{RSENSE} is tied to the 2nd terminal of the RTD. Channel assignment data (see *Table 54*) is mapped into a memory location corresponding to CH_{RSENSE}.

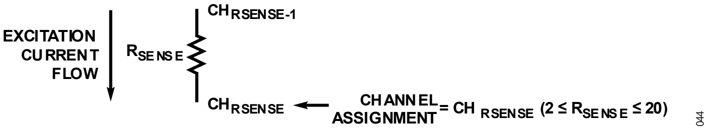


Figure 35.Sense Resistor Channel Assignment Convention for 2-Wire RTDs

Example: 2-Wire RTDs with Shared R_{SENSE}

Figure 36 shows a typical temperature measurement system using multiple 2-wire RTDs. In this example, a PT-1000 RTD ties to CH17 and CH18 and an NI-120 RTD ties to CH19 and CH20. Using this configuration, the ADT7604 can digitize up to nine 2-wire RTDs with a single sense resistor.

The RTD #1 sensor type and configuration data are assigned to CH18; 32 bits of binary configuration data are mapped directly into memory locations 0x244 to 0x247 (see *Table 57*). The RTD #2 sensor type and configuration data are assigned to CH20; 32-bits of binary configuration data are mapped directly into memory locations 0x24C to 0x24F (see *Table 58*). The sense resistor is assigned to CH16. The user-programmable value of this resistor is 5001.5Ω; 32 bits of binary configuration data are mapped directly into memory locations 0x23C to 0x23F (see *Table 59*).

A conversion is initiated on CH18 by writing 10010010 into memory location 0x000. Once the conversion is complete, the INTERRUPT pin goes high and memory location 0x000 becomes 01010010. The resulting temperature in °C can be read from memory locations 0x054 to 0x057 (corresponding to CH18). A conversion can be initiated and read from CH20 in a similar fashion.

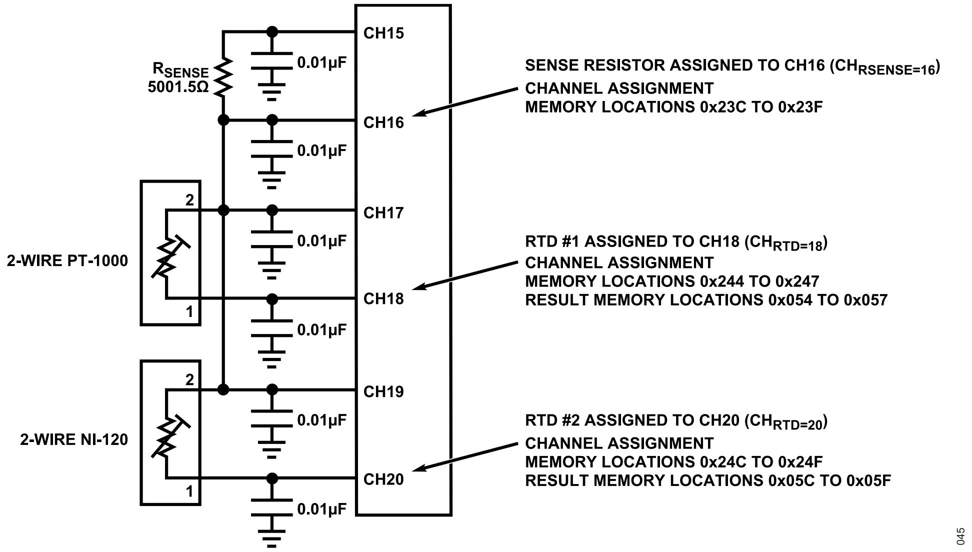


Figure 36. Shared 2-Wire RTD Example

Table 57. Channel Assignment Data for 2-Wire RTD #1 (PT-1000, R_{SENSE} on CH16, 2-Wire, Shared R_{SENSE}, 10µA Excitation Current, α = 0.003916 Curve)

CONFIGURATION FIELD	DESCRIPTION	# OF BITS	BINARY DATA	MEMORY ADDRESS 0x244								MEMORY ADDRESS 0x245								MEMORY ADDRESS 0x246								MEMORY ADDRESS 0x247							
(1) RTD TYPE	PT-1000	5	01111	0	1	1	1	1																											
(2) Sense Resistor Channel Pointer	CH16	5	10000						1	0	0	0	0																						
(3) Sensor Configuration	2-Wire with Shared R_{SENSE}	4	0001											0	0	0	1																		
(4) Excitation Current	10µA	4	0010															0	0	1	0														
(5) Curve	Japanese, α = 0.003916	2	10																			1	0												
Not Used		12	000000000000																					0	0	0	0	0	0	0	0	0	0	0	0

Table 58. Channel Assignment Data for 2-Wire RTD #2 (NI-120, R_{SENSE} on CH16, 2-Wire, Shared R_{SENSE}, 100µA Excitation Current

CONFIGURATION FIELD	DESCRIPTION	# OF BITS	BINARY DATA	MEMORY ADDRESS 0x24C								MEMORY ADDRESS 0x24D								MEMORY ADDRESS 0x24E								MEMORY ADDRESS 0x24F							
(1) RTD TYPE	NI-120	5	10001	1	0	0	0	1																											
(2) Sense Resistor Channel Pointer	CH16	5	10000						1	0	0	0	0																						
(3) Sensor Configuration	2-Wire with Shared R_{SENSE}	4	0001											0	0	0	1																		
(4) Excitation Current	100µA	4	0101															0	1	0	1														
(5) Curve	European α = 0.00385	2	00																			0	0												
Not Used		12	000000000000																					0	0	0	0	0	0	0	0	0	0	0	0

Table 59. Channel Assignment Data for Sense Resistor (Value = 5001.5Ω)

CONFIGURATION FIELD	DESCRIPTION	# OF BITS	BINARY DATA	MEMORY ADDRESS 0x23C								MEMORY ADDRESS 0x23D								MEMORY ADDRESS 0x23E								MEMORY ADDRESS 0x23F							
(1) Sensor Type	Sense Resistor	5	11101	1	1	1	0	1																											
(2) Sense Resistor Value	5001.5Ω	27	000010011100010011000000000						0	0	0	0	1	0	0	1	1	1	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0

Example: 3-Wire RTD

3-wire RTD channel assignments follow the general convention shown in *Figure 37*. Terminals 1 and 2 tie to the input/excitation current sources, and terminal 3 connects to the sense resistor. Channel assignment data is mapped to memory locations corresponding to CH_{RTD}.

Sense resistor channel assignments follow the general convention shown in *Figure 38*. The sense resistor is tied between CH_{RSENSE} and $CH_{RSENSE-1}$, where CH_{RSENSE} is tied to the 3rd terminal of the RTD and $CH_{RSENSE-1}$ is tied to ground (or left floating for R_{SENSE} sharing). Channel assignment data (see *Table 54*) is mapped into the memory location corresponding to CH_{RSENSE}.

Figure 39 shows a typical temperature measurement system using a 3-wire RTD. In this example, a 3-wire RTD's terminals tie to CH9, CH8, and CH7. The sense resistor ties to CH7 and CH6. The sense resistor and RTD connect together at CH7.

The 3-wire RTD reduces the errors associated with parasitic lead resistance by applying excitation current to each RTD input. This first-order cancellation removes matched lead resistance errors. This cancellation does not remove errors due to thermocouple effects or mismatched lead resistances. The RTD sensor type and configuration data are assigned to CH9; 32 bits of binary configuration data are mapped directly into memory locations 0x220 to 0x223 (see *Table 60*). The sense resistor is assigned to CH7. The user-programmable value of this resistor is 12150.39Ω; 32 bits of binary configuration data are mapped directly into memory locations 0x218 to 0x21B (see *Table 61*).

A conversion is initiated on CH9 by writing 10001001 into memory location 0x000 . Once the conversion is complete, the INTERRUPT pin goes high and memory location 0x000 becomes 01001001. The resulting temperature in °C can be read from memory locations 0x030 to 0x033 (corresponding to CH9).

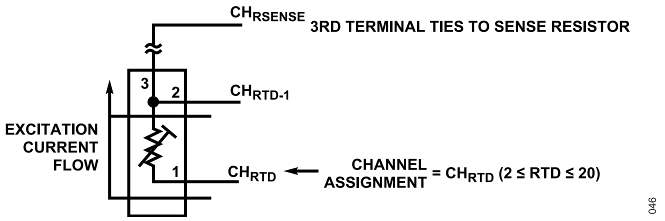


Figure 37.3-Wire RTD Channel Assignment Convention

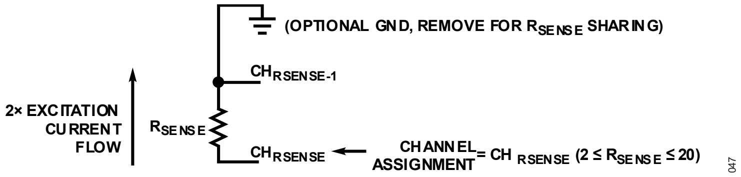


Figure 38.3-Wire Sense Resistor Channel Assignment Convention for 3-Wire RTDs

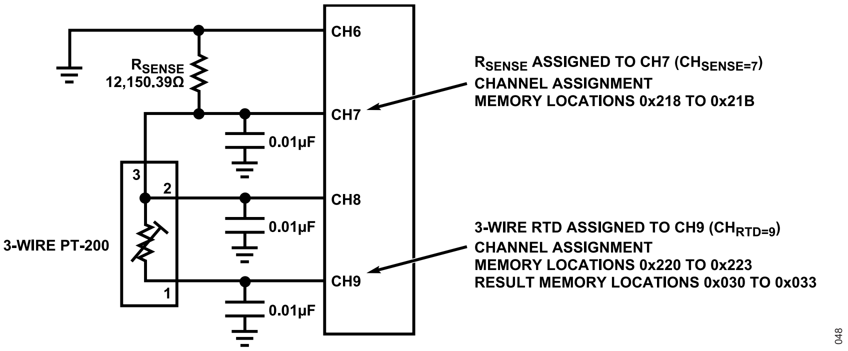


Figure 39.3-Wire RTD Example

Table 60.Channel Assignment Data for 3-Wire RTD (PT-200, R_{SENSE} on CH7, 3-Wire, 50µA Excitation Current, α = 0.003911 Curve)

CONFIGURATION FIELD	DESCRIPTION	# OF BITS	BINARY DATA	MEMORY ADDRESS 0x230								MEMORY ADDRESS 0x231								MEMORY ADDRESS 0x232								MEMORY ADDRESS 0x233							
(1) RTD TYPE	PT-200	5	01101	0	1	1	0	1																											
(2) Sense Resistor Channel Pointer	CH7	5	00111						0	0	1	1	1																						
(3) Sensor Configuration	3-Wire	4	0100											0	1	0	0																		
(4) Excitation Current	50µA	4	0100															0	1	0	0														
(5) Curve	American, α = 0.003911	2	01																			0	1												
Not Used		12	000000000000																					0	0	0	0	0	0	0	0	0	0	0	0

Table 61.Channel Assignment Data for Sense Resistor (Value = 12150.39Ω)

CONFIGURATION FIELD	DESCRIPTION	# OF BITS	BINARY DATA	MEMORY ADDRESS 0x218								MEMORY ADDRESS 0x219								MEMORY ADDRESS 0x21A								MEMORY ADDRESS 0x21B						
(1) Sensor Type	Sense Resistor	5	11101	1	1	0	1																											
(2) Sense Resistor Value	12150.39Ω	27	000101111011101100110001111					0	0	0	1	0	1	1	1	1	0	1	1	1	0	1	1	0	0	1	1	0	0	0	1	1	1	0

Example: Standard 4-Wire RTD (No Rotation or R_{SENSE} Sharing)

Standard 4-wire RTD channel assignments follow the general convention shown in *Figure 40*. Terminal 1 is tied to ground, terminals 2 and 3 (Kelvin-sensed signal) tie to CH_{RTD} and CH_{RTD-1}, and the 4th terminal ties to the sense resistor. Channel assignment data (see *Table 46*) is mapped to memory locations corresponding to CH_{RTD}.

Sense resistor channel assignments follow the general convention shown in *Figure 41*. The sense resistor is tied between CH_{RSENSE} and $CH_{SENSE-1}$, where CH_{RSENSE} is tied to the 4th terminal of the RTD. Channel assignment data (see *Table 54*) is mapped into a memory location corresponding to CH_{RSENSE}.

Figure 42 shows a typical temperature measurement system using a 4-wire RTD. In this example, a 4-wire RTD's terminals tie to GND, CH13, CH12, and CH11. The sense resistor ties to CH11 and CH10. The sense resistor and RTD share a common connection at CH11. The RTD sensor type and configuration data are assigned to CH13; 32 bits of binary configuration data are mapped directly into memory locations 0x230 to 0x233 (see *Table 62*). The sense resistor is assigned to CH11. The user-programmable value of this resistor is 5000.2Ω; 32 bits of binary configuration data are mapped directly into memory locations 0x228 to 0x22B (see *Table 63*).

A conversion is initiated on CH13 by writing 10001101 into the data byte at memory location 0x000. Once the conversion is complete, the INTERRUPT pin goes high and memory location 0x000 becomes 01001101. The resulting temperature in °C can be read from memory locations 0x040 to 0x043 (corresponding to CH13).

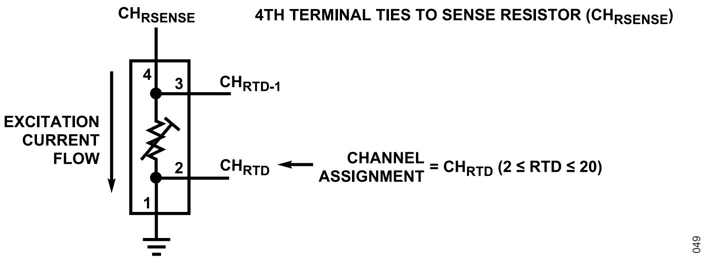


Figure 40.4-Wire RTD Channel Assignment Convention

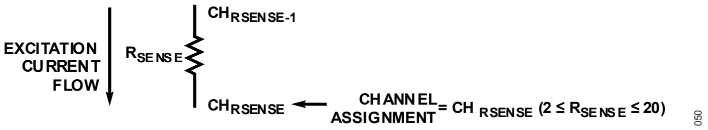


Figure 41.Sense Resistor Channel Assignment Convention for 4-Wire RTDs

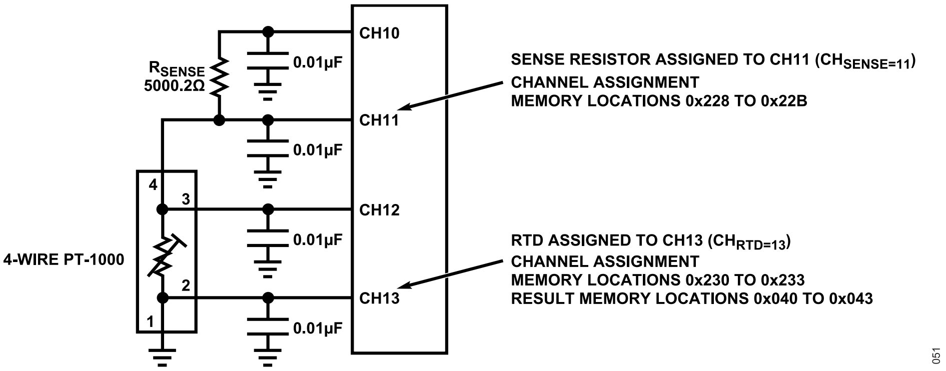


Figure 42.Standard 4-Wire RTD Example

Table 62.Channel Assignment Data for 4-Wire RTD (PT-1000, R_{SENSE} on CH11, Standard 4-Wire, 25µA Excitation Current, α = 0.00385 Curve)

CONFIGURATION FIELD	DESCRIPTION	# OF BITS	BINARY DATA	MEMORY ADDRESS 0x230								MEMORY ADDRESS 0x231								MEMORY ADDRESS 0x232								MEMORY ADDRESS 0x233							
(1) RTD TYPE	PT-1000	5	01111	0	1	1	1	1																											
(2) Sense Resistor Channel Pointer	CH11	5	01011						0	1	0	1	1																						
(3) Sensor Configuration	4-Wire, No Rotate, No Share	4	1000											1	0	0	0																		
(4) Excitation Current	25µA	4	0011															0	0	1	1														
(5) Curve	European, α = 0.00385	2	00																			0	0												
Not Used		12	000000000000																					0	0	0	0	0	0	0	0	0	0	0	0

Table 63.Channel Assignment Data for Sense Resistor (Value = 5000.2Ω)

CONFIGURATION FIELD	DESCRIPTION	# OF BITS	BINARY DATA	MEMORY ADDRESS 0x228								MEMORY ADDRESS 0x229								MEMORY ADDRESS 0x22A								MEMORY ADDRESS 0x22B							
(1) Sensor Type	Sense Resistor	5	11101	1	1	1	0	1																											
(2) Sense Resistor Value	5000.2Ω	27	000010011100010000011001100						0	0	0	0	1	0	0	1	1	1	0	0	0	1	0	0	0	0	0	1	1	0	0	1	1	0	0

Example: 4-Wire RTD with Rotation

One method to improve the accuracy of an RTD over the standard 4-wire implementation is by rotating the excitation current source. Parasitic thermocouple effects are automatically removed through autorotation. In order to perform autorotation, the 1st terminal of the RTD ties to CH_{RTD+1} instead of GND, as in the standard case. This allows the ADT7604 to automatically change the direction of the current source without the need for additional external components.

The 4-wire RTD with rotation channel assignments follows the general convention shown in *Figure 43*. Terminal 1 is tied to CH_{RTD+1}, terminals 2 and 3 (Kelvin-sensed signal) tie to CH_{RTD} and CH_{RTD-1}, and the 4th terminal ties to the sense resistor. Channel assignment data (see *Table 46*) is mapped to memory locations corresponding to CH_{RTD}.

Sense resistor channel assignments follow the general convention shown in *Figure 44*. The sense resistor is tied between CH_{RSENSE} and $CH_{RSENSE-1}$, where CH_{RSENSE} is tied to the 4th terminal of the RTD. Channel assignment data is mapped into a memory location corresponding to CH_{RSENSE}.

Figure 45 shows a typical temperature measurement system using a rotating 4-wire RTD. In this example a 4-wire RTD's terminals tie to CH17, CH16, CH15, and CH6. The sense resistor is tied to CH6 and CH5. The sense resistor and RTD connect together at CH6. The RTD sensor type and configuration data are assigned to CH16. 32 bits of binary configuration data are mapped directly into memory locations 0x23C to 0x23F (see *Table 64*). The sense resistor is assigned to CH6. The user programmable value of this resistor is 10.0102kΩ; 32 bits of binary configuration data are mapped directly into memory locations 0x214 to 0x217 (see *Table 65*).

A conversion is initiated on CH16 by writing 10010000 into memory location 0x000. Once the conversion is complete, the INTERRUPT pin goes high and memory location 0x000 becomes 01010000. The resulting temperature in °C can be read from memory locations 0x04C to 0x04F (corresponding to CH16).

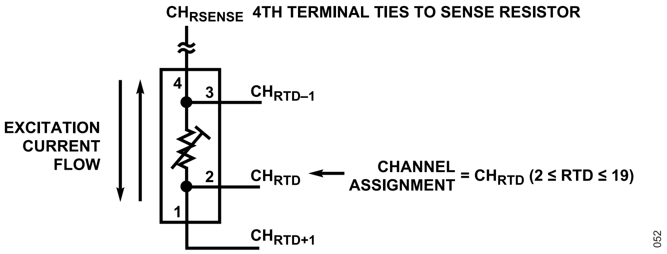


Figure 43.4-Wire RTD Channel Assignment Convention

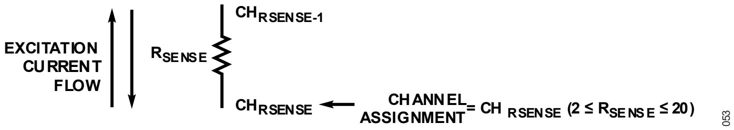


Figure 44.Sense Resistor Channel Assignment Convention for 4-Wire RTDs with Rotation

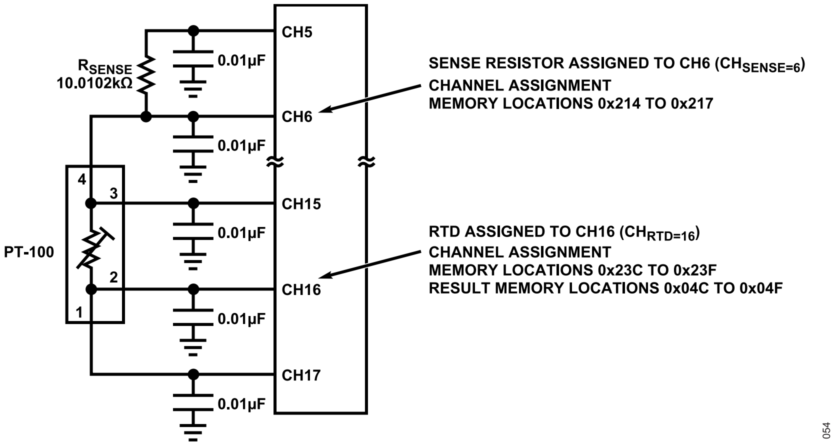


Figure 45.Rotating 4-Wire RTD Example

Table 64. Channel Assignment Data for Rotating 4-Wire RTD (PT-100, R_{SENSE} on CH6, Rotating 4-Wire, 100µA Excitation Current, α = 0.003911 Curve)

CONFIGURATION FIELD	DESCRIPTION	# OF BITS	BINARY DATA	MEMORY ADDRESS 0x23C								MEMORY ADDRESS 0x23D								MEMORY ADDRESS 0x23E								MEMORY ADDRESS 0x23F							
(1) RTD TYPE	PT-100	5	01100	0	1	1	0	0																											
(2) Sense Resistor Channel Pointer	CH6	5	00110						0	0	1	1	0																						
(3) Sensor Configuration	4-Wire with Rotation	4	1010											1	0	1	0																		
(4) Excitation Current	100µA	4	0101															0	1	0	1														
(5) Curve	American, α = 0.003911	2	01																			0	1												
Not Used		12	000000000000																					0	0	0	0	0	0	0	0	0	0	0	0

Table 65. Channel Assignment Data for Sense Resistor (Value = 10.0102kΩ)

CONFIGURATION FIELD	DESCRIPTION	# OF BITS	BINARY DATA	MEMORY ADDRESS 0x214								MEMORY ADDRESS 0x215								MEMORY ADDRESS 0x216								MEMORY ADDRESS 0x217							
(1) Sensor Type	Sense Resistor	5	11101	1	1	1	0	1																											
(2) Sense Resistor Value	10.0102kΩ	27	000100111000110100011001100						0	0	0	1	0	0	1	1	1	0	0	0	1	1	0	1	0	0	0	1	1	0	0	1	1	0	0

Example: Multiple 4-Wire RTDs with Shared R_{SENSE}

Figure 46 shows a typical temperature measurement system using two 4-wire RTDs with a shared R_{SENSE}. The ADT7604 can support up to six 4-wire RTDs with a single sense resistor. In this example, the first 4-wire RTD's terminals tie to CH17, CH16, CH15, and CH6, and the 2nd ties to CH20, CH19, CH18, and CH6. The sense resistor ties to CH5 and CH6. The sense resistor and both RTDs connect together at CH6. This channel assignment convention is identical to that of the rotating RTD. This topology supports both rotated and non-rotated RTD excitations. Channel assignment data for each sensor is shown in *Table 66*, *Table 67*, and *Table 68*.

A conversion is initiated on CH16 by writing 10010000 into memory location 0x000. Once the conversion is complete, the INTERRUPT pin goes high and memory location 0x000 becomes 01010000. The resulting temperature in °C can be read from memory locations 0x04C to 0x04F (corresponding to CH16). A conversion can be initiated and read from CH19 in a similar fashion.

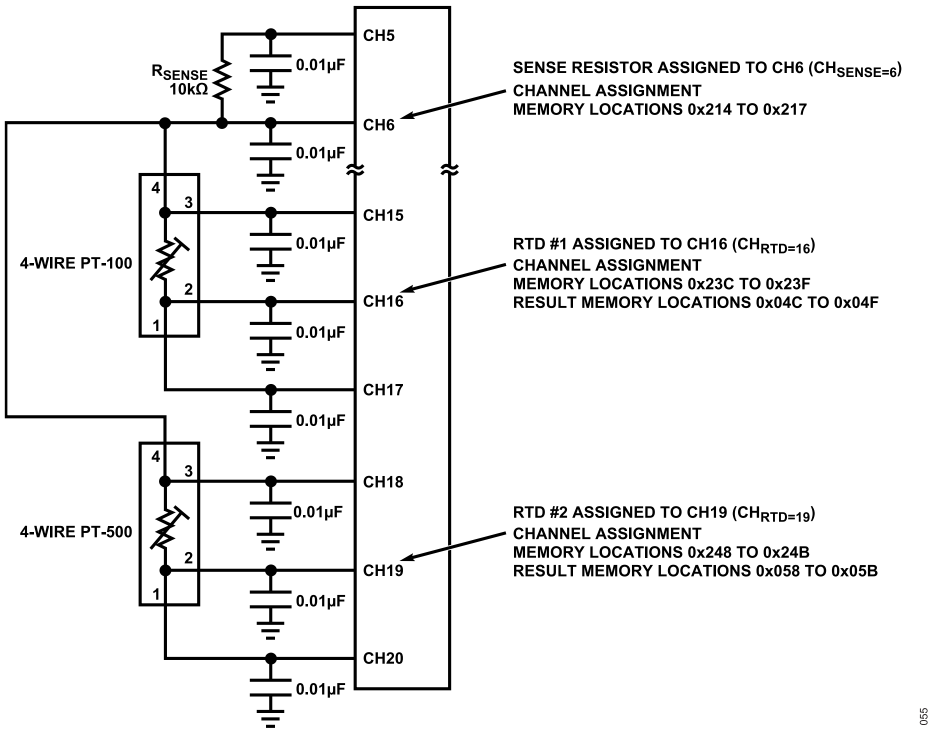


Figure 46.Shared R_{SENSE} 4-Wire RTD Example

Table 66.Channel Assignment Data for 4-Wire RTD #1 (PT-100, R_{SENSE} on CH6, 4-Wire, Shared R_{SENSE}, Rotated 100µA Excitation Current, α = 0.003926 Curve)

CONFIGURATION FIELD	DESCRIPTION	# OF BITS	BINARY DATA	MEMORY ADDRESS 0x23C								MEMORY ADDRESS 0x23D								MEMORY ADDRESS 0x23E								MEMORY ADDRESS 0x23F							
(1) RTD TYPE	PT-100	5	01100	0	1	1	0	0																											
(2) Sense Resistor Channel Pointer	CH6	5	00110						0	0	1	1	0																						
(3) Sensor Configuration	4-Wire Rotated	4	1010											1	0	1	0																		
(4) Excitation Current	100µA	4	0101															0	1	0	1														
(5) Curve	ITS-90, α = 0.003926	2	11																			1	1												
Not Used		12	000000000000																					0	0	0	0	0	0	0	0	0	0	0	0

Table 67.Channel Assignment Data for 4-Wire RTD #2 (PT-500, R_{SENSE} on CH6, 4-Wire, Rotated 50µA Excitation Current, α = 0.003911 Curve)

CONFIGURATION FIELD	DESCRIPTION	# OF BITS	BINARY DATA	MEMORY ADDRESS 0x248								MEMORY ADDRESS 0x249								MEMORY ADDRESS 0x24A								MEMORY ADDRESS 0x24B							
(1) RTD TYPE	PT-500	5	01110	0	1	1	1	0																											
(2) Sense Resistor Channel Pointer	CH6	5	00110						0	0	1	1	0																						

(3) Sensor Configuration	4-Wire Shared, No Rotation	4	1001											1	0	0	1																		
(4) Excitation Current	50µA	4	0100															0	1	0	0														
(5) Curve	American, α = 0.003911	2	01																			0	1												
Not Used		12	000000000000																					0	0	0	0	0	0	0	0	0	0	0	0

Table 68.Channel Assignment Data for Sense Resistor (Value = 10.000kΩ)

CONFIGURATION FIELD	DESCRIPTION	# OF BITS	BINARY DATA	MEMORY ADDRESS 0x214								MEMORY ADDRESS 0x215								MEMORY ADDRESS 0x216								MEMORY ADDRESS 0x217							
(1) Sensor Type	Sense	5	11101	1	1	1	0	1																											
(2) Sense Resistor Value	10.000kΩ	27	000100111000100000000000000						0	0	0	1	0	0	1	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Example: 4-Wire RTD with Kelvin R_{SENSE}

It is possible to cancel the parasitic lead resistance in the sense resistors by configuring the 4-wire RTD with a 4-wire (Kelvin-connected) sense resistor. This is useful when using a PT-10 or PT-50 with a small valued R_{SENSE} or when the sense resistor is remotely located or in applications requiring extreme precision.

The 4-wire RTD channel assignments follow the general conventions previously defined (*Figure 41* and *Figure 43*) for a standard 4-wire RTD. The sense resistor follows the convention shown in *Figure 47*.

Figure 48 shows a typical temperature measurement system using a 4-wire RTD with a Kelvin-connected R_{SENSE}. In this example, the 4-wire RTD's terminals tie to CH17, CH16, CH15, and CH6. The sense resistor ties to CH6, CH5, and CH4 and excitation current is applied to CH4 and CH17. The sense resistor's nominal value is 1kΩ in order to accommodate a 1mA excitation current. The sense resistor and RTD connect together at CH6. This topology supports both rotated, shared, and standard 4-wire RTD topologies. If rotated or shared configuration are not used, then terminal 1 of the RTD is tied to ground instead of CH17, freeing up one input channel. Channel assignment data is shown in *Table 69* and *Table 70*.

A conversion is initiated on CH16 by writing 10010000 into memory location 0x000. Once the conversion is complete, the INTERRUPT pin goes high and memory location 0x000 becomes 01010000 (see *Table 14*). The resulting temperature in °C can be read from memory locations 0x04C to 0x04F (corresponding to CH16).

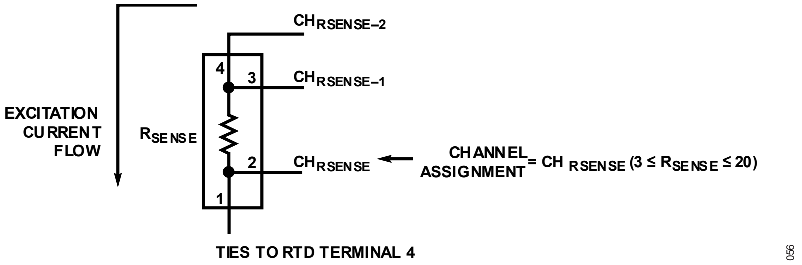


Figure 47.Sense Resistor with Kelvin Connections Channel Assignment Convention

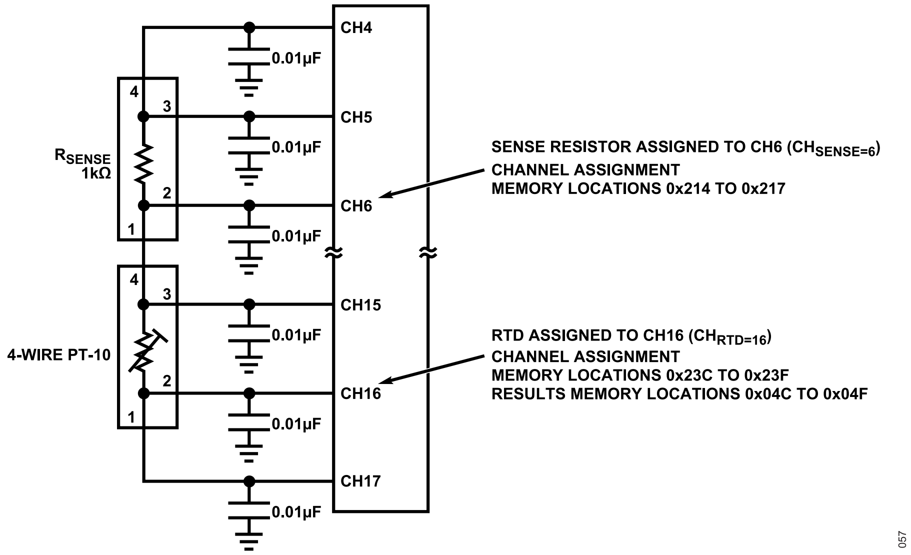


Figure 48. Sense Resistor with Kelvin Connections Example

Table 69. Channel Assignment Data for 4-Wire RTD with Kelvin Connected R_{SENSE} (PT-10, R_{SENSE} on CH6, 4-Wire, Kelvin R_{SENSE} with Rotated 1mA Excitation Current, α = 0.003916 Curve)

CONFIGURATION FIELD	DESCRIPTION	# OF BITS	BINARY DATA	MEMORY ADDRESS 0x23C								MEMORY ADDRESS 0x23D								MEMORY ADDRESS 0x23E								MEMORY ADDRESS 0x23F							
(1) RTD TYPE	PT-10	5	01010	0	1	0	1	0																											
(2) Sense Resistor Channel Pointer	CH6	5	00110						0	0	1	1	0																						
(3) Sensor Configuration	4-Wire Kelvin R_{SENSE} and Rotation	4	1110											1	1	1	0																		
(4) Excitation Current	1mA	4	1000															1	0	0	0														
(5) Curve	Japanese, α = 0.003916	2	10																			1	0												
Not Used		12	000000000000																					0	0	0	0	0	0	0	0	0	0	0	0

Table 70. Channel Assignment Data for Sense Resistor (Value = 1000Ω)

CONFIGURATION FIELD	DESCRIPTION	# OF BITS	BINARY DATA	MEMORY ADDRESS 0x214								MEMORY ADDRESS 0x215								MEMORY ADDRESS 0x216								MEMORY ADDRESS 0x217							
(1) Sensor Type	Sense Resistor	5	11101	1	1	1	0	1																											
(2) Sense Resistor Value	1000ft	27	000000011111010000000000000						0	0	0	0	0	0	0	1	1	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0

Thermistor Measurements

Channel Assignment – Thermistor

For each thermistor tied to the ADT7604, a 32-bit channel assignment word is programmed into a memory location corresponding to the channel the sensor is tied to (see *Table 71*). This data includes (1) thermistor type, (2) sense resistor channel pointer, (3) sensor configuration, (4) excitation current, and (5) custom Steinhart-Hart address pointer.

(1) Thermistor Type

The thermistor type is determined by the first 5 input bits (B31 to B27) as shown in *Table 72*. Linearization coefficients based on the Steinhart-Hart equation for commonly used thermistor types 44004/44033, 44005/44030, 44006/44031, 44007/44034, 44008/44032, and YSI-400 are built into the device. Besides built-in thermistor types, thermistor custom Steinhart-Hart (temperature vs. resistance) can be selected. In this case, user-specific data can be stored in the on-chip RAM starting at the address defined in thermistor custom Steinhart-Hart address pointers.

(2) Sense Resistor Channel Pointer

Thermistor measurements are performed ratiometrically relative to a known R_{SENSE} resistor. The sense resistor channel pointer field indicates the differential channel the sense resistor is tied to for the current thermistor (see *Table 48*).

Table 71.Thermistor Channel Assignment Word

	(1) THERMISTOR TYPE					(2) SENSE RESISTOR					(3) SENSOR CONFIGURATION			(4) EXCITATION CURRENT				NOT USED			(5) CUSTOM STEINHART-HART ADDRESS POINTER											
	Table 72					*Table 48*					*Table 73*			*Table 74*							***Table 84*, *Table 85***											
Measurement Class	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Thermistor	Type = 19 to 26					R_{SENSE} Channel Pointer [4:0]					SGL = 1 DIFF = 0	Excitation Mode		Excitation Current [3:0]				Not Used 0 0 0			Custom Address [5:0]						Custom Length -1 [5:0]					

Table 72.Thermistor Type: $1/T = A + B \times \ln(R) + C \times \ln(R)^2 + D \times \ln(R)^3 + E \times \ln(R)^4 + F \times \ln(R)^5$

B31	B30	B29	B28	B27	THERMISTOR TYPE	A	B	C	D	E	F
1	0	0	1	1	Thermistor 44004/44033 2.252kΩ at 25°C	1.46800E-03	2.38300E-04	0	1.00700E-07	0	0
1	0	1	0	0	Thermistor 44005/44030 3kΩ at 25°C	1.40300E-03	2.37300E-04	0	9.82700E-08	0	0
1	0	1	0	1	Thermistor 44007/44034 5kΩ at 25°C	1.28500E-03	2.36200E-04	0	9.28500E-08	0	0
1	0	1	1	0	Thermistor 44006/44031 10kΩ at 25°C	1.03200E-03	2.38700E-04	0	1.58000E-07	0	0
1	0	1	1	1	Thermistor 44008/44032 30kΩ at 25°C	9.37600E-04	2.20800E-04	0	1.27600E-07	0	0
1	1	0	0	0	Thermistor YSI-400 2.252kΩ at 25°C	1.47134E-03	2.37624E-04	0	1.05034E-07	0	0

1	1	0	0	1	Spectrum 1003k 1kΩ at 25°C	1.445904E-3	2.68399E-04	0	1.64066E-07	0	0
1	1	0	1	0	Thermistor Custom Steinhart-Hart	User input	User input	User input	User input	User input	User input

(3) Sensor Configuration

The sensor configuration field is used to define various thermistor properties. Configuration bit B21 is set high for single-ended (measurement relative to COM) and low for differential (see *Table 73*).

Table 73.Sensor Configuration Data

(3) SENSOR CONFIGURATION			SINGLE-ENDED/DIFFERENTIAL	SHARE R_{SENSE}	ROTATE
SGL	EXCITATION MODE				
B21	B20	B19			
0	0	0	Differential	No	No
0	0	1	Differential	Yes	Yes
0	1	0	Differential	Yes	No
0	1	1		Reserved	
1	0	0	Single-Ended	No	No
1	0	1		Reserved	
1	1	0		Reserved	
1	1	1		Reserved	

The next sensor configuration bits (B19 and B20) determine the excitation current mode. These bits are used to enable R_{SENSE} sharing, where one sense resistor is used for multiple thermistors. In this case, the thermistor ground connection is internal and each thermistor points to the same R_{SENSE} channel.

Bits B19 and B20 are also used to enable excitation current rotation to automatically remove parasitic thermocouple effects. Parasitic thermocouple effects may arise from the physical connection between the thermistor and the measurement instrument. This mode is available for differential thermistor configurations using the internal current source excitation.

(4) Excitation Current

The next field in the channel assignment word (B18 to B15) controls the magnitude of the excitation current applied to the thermistor (see *Table 74*). In order to prevent hard or soft faults, select a current such that the maximum voltage drop across the sensor or sense resistor is nominally 1.0V. The ADT7604 has no special requirements related to the ratio between the voltage drop across the sense resistor and the sensor. Consequently, it is possible to have a sense resistor that is several orders of magnitude smaller than the maximum sensor value. For optimal performance over the full thermistor temperature range, auto-ranged current can be selected. In this case, the ADT7604 conversion is performed in three cycles (instead of the standard two cycles). The first cycle determines the optimal excitation current for the sensor resistance value and R_{SENSE} value. The following two cycles use that current to measure the thermistor temperature.

(5) Steinhart-Hart Address

See the*Thermistor Custom Steinhart-Hart* section for more information.

Table 74.Excitation Current for Thermistors

(4) EXCITATION CURRENT				CURRENT
B18	**B17**	**B16**	**B15**	
0	0	0	0	Reserved
0	0	0	1	250nA
0	0	1	0	500nA
0	0	1	1	1µA
0	1	0	0	5µA
0	1	0	1	10µA
0	1	1	0	25µA
0	1	1	1	50µA
1	0	0	0	100µA
1	0	0	1	250µA
1	0	1	0	500µA
1	0	1	1	1mA
1	1	0	0	Auto-range*
1	1	0	1	Invalid
1	1	1	0	Invalid
1	1	1	1	Reserved

**Auto-range not allowed for custom sensors.*

**Additional circuitry required for auto-range; see Figure 54.*

Fault Reporting – Thermistor

Each sensor type has unique fault reporting mechanism indicated in the upper byte of the data output word. *Table 75* shows faults reported during the measurement of thermistors.

Bit D31 indicates the thermistor or R_{SENSE} is open, shorted, or not plugged in. This is a hard fault and -999°C is reported. Bit D30 indicates a bad ADC reading. This could be a result of either a broken (open) sensor or an excessive noise event (ESD or static discharge into the sensor path).

This is a hard error and -999°C is output. In the case of an excessive noise event, the device should recover and the following conversions will be valid if the noise event was a random infrequent event. Bits D29 and D28 are not used for thermistors. Bits D27 and D26 indicate the reading is over or under temperature limits (see *Table 76*). The calculated temperature is reported, but the accuracy may be compromised. Bit D25 indicates that the absolute voltage measured by the ADC is beyond its normal operating range.

Table 75. Thermistor Fault Reporting

BIT	FAULT	ERROR TYPE	DESCRIPTION	OUTPUT RESULT
D31	Sensor Hard Fault	Hard	Open or short thermistor or R_{SENSE}	-999°C
D30	Hard ADC-Out-of-Range	Hard	Bad ADC reading (could be large external noise event)	-999°C
D29	Not Used for Thermistors	N/A	Always 0	Valid reading
D28	Not Used for Thermistors	N/A	Always 0	Valid reading
D27	Sensor Over Range*	Soft	T > high temp limit	Suspect reading
D26	Sensor Under Range*	Soft	T < low temp limit	Suspect reading
D25	ADC Out-of-Range	Soft	ADC absolute input voltage is beyond ±1.125 x $V_{REF}/2$	Suspect reading
D24	Valid	N/A	Result valid (should be 1) discard results if 0	Valid reading

**Do not apply to custom Steinhart-Hart sensor type. Custom table thermistor over/under range is determined by the resistor table values; see custom Steinhart-Hart thermistor table example for details.*

Table 76. Thermistor Temperature/Resistance Range

THERMISTOR TYPE	MIN (Ω)	MAX (Ω)	LOW TEMP LIMIT (°C)	HIGH TEMP LIMIT (°C)
Thermistor 44004/44033 2.252kΩ at 25°C	41.9	75.79k	-40	+150
Thermistor 44005/44030 3kΩ at 25°C	55.6	101.0k	-40	+150
Thermistor 44007/44034 5kΩ at 25°C	92.7	168.3k	-40	+150
Thermistor 44006/44031 10kΩ at 25°C	237.0	239.8k	-40	+150
Thermistor 44008/44032 30kΩ at 25°C	550.2	884.6k	-40	+150
Thermistor YSI 400 2.252kΩ at 25°C	6.4	1.66M	-80	+250
Spectrum 1003K 1kΩ at 25°C	51.1	39.51k	-50	+125
Thermistor Custom Steinhart-Hart	N/A	N/A	N/A	N/A

Example: Single-Ended Thermistor

The simplest thermistor configuration is the single-ended configuration. Thermistors using this configuration share a common ground (COM) between all sensors and are each tied to a unique sense resistor. (R_{SENSE} sharing is not allowed for single-ended thermistors.) Single-ended thermistors follow the convention shown in *Figure 49*. Terminal 1 ties to ground (COM) and terminal 2 ties to CH_{THERM} and the sense resistor. Channel assignment data (see *Table 71*) is mapped to memory locations corresponding to CH_{THERM}.

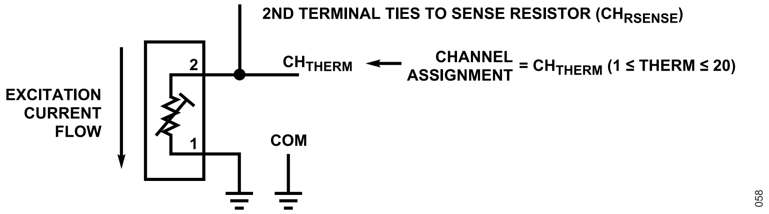


Figure 49. Single-Ended Thermistor Channel Assignment Convention

Sense resistor channel assignments follow the general convention shown in *Figure 50*. The sense resistor is tied between CH_{RSENSE} and $CH_{RSENSE-1}$, where CH_{RSENSE} is tied to the 2nd terminal of the thermistor. Channel assignment data (see *Table 54*) is mapped into the memory location corresponding to CH_{RSENSE}.

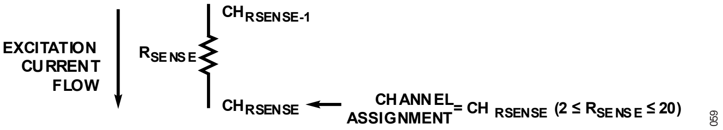


Figure 50.Sense Resistor Channel Assignment Convention

Figure 51 shows a typical temperature measurement system using a single-ended thermistor. In this example, a 10kΩ (44031 type) thermistor is tied to a 10.1kΩ sense resistor. The thermistor is assigned channel CH5 (memory locations 0x210 to 0x213), and the sense resistor is assigned CH4 (memory locations 0x20C to 0x20F). Channel assignment data is shown in *Table 77* and *Table 78*.

A conversion is initiated on CH5 by writing 10000101 into memory location 0x000. Once the conversion is complete, the INTERRUPT pin goes high and memory location 0x000 becomes 01000101. The resulting temperature in °C can be read from memory locations 0x020 to 0x023 (corresponding to CH5).

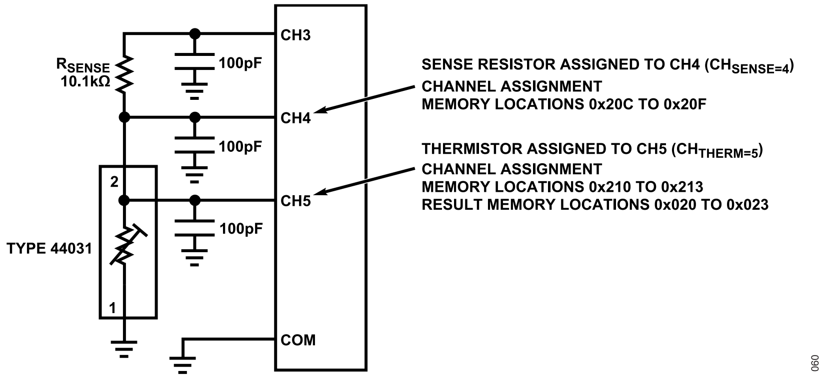


Figure 51.Single-Ended Thermistor Example

Table 77.Channel Assignment Data for Single-Ended Thermistor (44006/44031 10kΩ at 25°C Type Thermistor, Single-Ended Configuration, R_{SENSE} on CH4, 1µA Excitation Current)

CONFIGURATION FIELD	DESCRIPTION	# OF BITS	BINARY DATA	MEMORY ADDRESS 0x210								MEMORY ADDRESS 0x211								MEMORY ADDRESS 0x212								MEMORY ADDRESS 0x213							
(1) Thermistor Type	44006/44031 10kΩ at 25°C	5	10110	1	0	1	1	0																											
(2) Sense Resistor Channel Pointer	CH4	5	00100						0	0	1	0	0																						
(3) Sensor Configuration	Single-Ended	3	100											1	0	0																			
(4) Excitation Current	1µA	4	0011														0	0	1	1															
Not Used	Set These Bits to 0	3	000																		0	0	0												
(5) Custom Data Pointer	Not Custom	12	000000000000																					0	0	0	0	0	0	0	0	0	0	0	0

Table 78.Channel Assignment Data for Sense Resistor (Value = 10.1kΩ)

CONFIGURATION FIELD	DESCRIPTION	# OF BITS	BINARY DATA	MEMORY ADDRESS 0x228								MEMORY ADDRESS 0x229								MEMORY ADDRESS 0x22A								MEMORY ADDRESS 0x22B							
(1) Sensor Type	Sense Resistor	5	11101	1	1	1	0	1																											
(2) Sense Resistor Value	10.1kΩ	27	000100111011101000000000000						0	0	0	1	0	0	1	1	1	0	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0

Example: Differential Thermistor

The differential thermistor configuration allows separate ground sensing for each sensor. In this standard differential configuration, one sense resistor is used for each thermistor. Differential thermistors follow the convention shown in *Figure 52*. Terminal 1 ties to CH_{THERM} and is shorted to ground, and terminal 2 ties $\text{CH}_{\text{THERM-1}}$ to the sense resistor. Channel assignment data (see *Table 71*) is mapped to memory locations corresponding to CH_{THERM}.

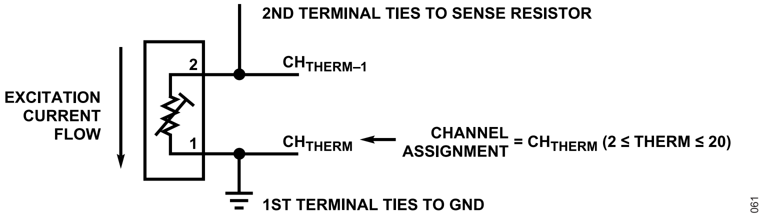


Figure 52.Differential Thermistor Channel Assignment Convention

Sense resistor channel assignments follow the general convention shown in *Figure 53*. The sense resistor is tied between $\text{CH}_{\text{RSENSE}}$ and $\text{CH}_{\text{RSENSE-1}}$, and $\text{CH}_{\text{RSENSE}}$ is tied to the 2nd terminal of the thermistor. Channel assignment data (see *Table 54*) is mapped into a memory location corresponding to $\text{CH}_{\text{RSENSE}}$.

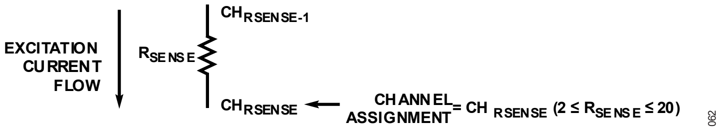


Figure 53.Sense Resistor Channel Assignment Convention

Figure 54 shows a typical temperature measurement system using a differential thermistor. In this example, a 30kΩ (44032 type) thermistor is tied to a 9.99kΩ sense resistor. The thermistor is assigned channel CH13 (memory locations 0x230 to 0x233), and the sense resistor is assigned CH11 (memory locations 0x228 to 0x22B). Channel assignment data is shown in *Table 79* and *Table 80*).

A conversion is initiated on CH13 by writing 10001101 into memory location 0x000. Once the conversion is complete, the INTERRUPT pin goes high and memory location 0x000 becomes 01001101. The resulting temperature in °C can be read from memory locations 0x040 to 0x043 (corresponding to CH13).

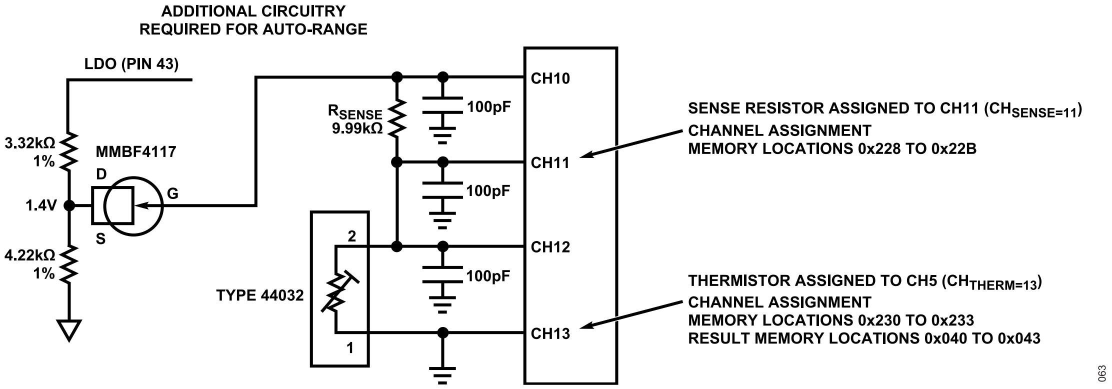


Figure 54.Differential Thermistor Example

Table 79.Channel Assignment Data for Differential Thermistor (44008/44032 30kΩ at 25°C Type Thermistor, Differential Configuration, R_{SENSE} on CH11, Auto-Range Excitation)

CONFIGURATION FIELD	DESCRIPTION	# OF BITS	BINARY DATA	MEMORY ADDRESS 0x230	MEMORY ADDRESS 0x231	MEMORY ADDRESS 0x232	MEMORY ADDRESS 0x233
(1) Thermistor Type	44008/44032 30kΩ at 25°C	5	10111	1 0 1 1 1			
(2) Sense Resistor Channel Pointer	CH11	5	01011	0 1 0	1 1		
(3) Sensor Configuration	Differential, No Share, No Rotate	3	000		0 0 0		
(4) Excitation Current	Auto Range See Note 1	4	1100		1 1 0	0	
Not Used	Set These Bits to 0	2	000			0 0 0	
(5) Custom Data Pointer	Not Custom	12	000000000000			0 0 0 0	0 0 0 0 0 0 0 0

***Note 1:** Additional circuitry required for thermistors using auto-range. See Figure 54.*

Table 80.Channel Assignment Data for Sense Resistor (Value = 9.99kΩ)

CONFIGURATION FIELD	DESCRIPTION	# OF BITS	BINARY DATA	MEMORY ADDRESS 0x228	MEMORY ADDRESS 0x229	MEMORY ADDRESS 0x22A	MEMORY ADDRESS 0x22B
(1) Sensor Type	Sense Resistor	5	11101	1 1 1 0 1			
(2) Sense Resistor Value	9.99kΩ	27	000100111000001100000000000	0 0 0	1 0 0 1 1 1 0 0	0 0 0 1 1 0 0 0	0 0 0 0 0 0 0 0

Example: Shared/Rotated Differential Thermistor

The differential thermistor configuration allows separate internal ground sensing for each sensor. In this configuration, one sense resistor can be used for multiple thermistors. Differential thermistors follow the convention shown in *Figure 55*. Terminal 1 ties to C_{HTHERM}, and terminal 2 ties to $C_{HTHERM-1}$ and the sense resistor. Channel assignment data (see *Table 71*) is mapped to memory locations corresponding to C_{HTHERM}.

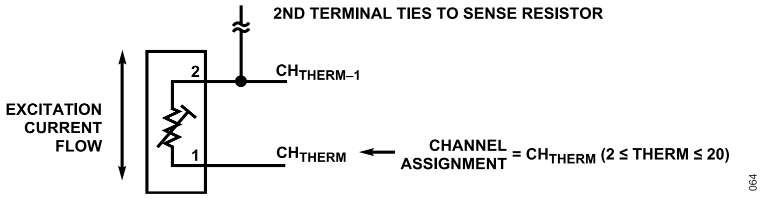


Figure 55. Thermistor with Shared RSENSE Channel Assignment Convention

Sense resistor channel assignments follow the general convention shown in *Figure 56*. The sense resistor is tied between $C_{HRSENSE}$ and $C_{HRSENSE-1}$, and C_{HSENSE} is tied to the 2nd terminal of the thermistor. Channel assignment data (see *Table 54*) is mapped into a memory location corresponding to C_{HSENSE}.

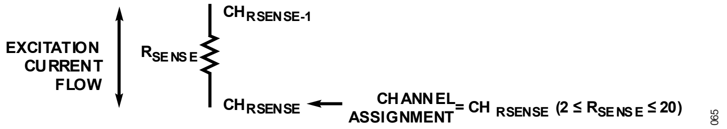


Figure 56. Sense Resistor Channel Assignment Convention for Thermistors

Figure 57 shows a typical temperature measurement system using a shared sense resistor and one rotated/one non-rotated differential thermistors. In this example, a 30kΩ (44032 type) thermistor is tied to a 10.0kΩ sense resistor and configured as rotated/shared. The second thermistor a 2.25kΩ (44004 type) is configured as a non-rotated/shared. Channel assignment data are shown in *Table 81*, *Table 82*, and *Table 83*.

A conversion is initiated on CH18 by writing 10010010 into memory location 0x000. Once the conversion is complete, the INTERRUPT pin goes high and memory location 0x000 becomes 01010010. The resulting temperature in °C can be read from memory locations 0x054 to 0x057 (corresponding to CH16). A conversion can be initiated and read from CH20 in a similar fashion.

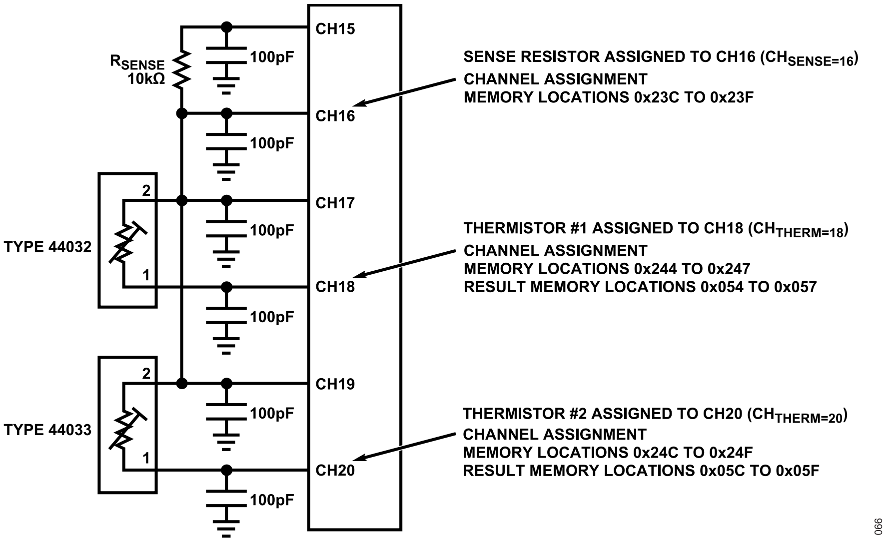


Figure 57. Rotated and Shared Thermistor Example

Table 81. Channel Assignment Data Differential Thermistor (44008/44032 30kΩ at 25°C Type Thermistor, Differential Configuration with Sharing and Rotation, R_{SENSE} on CH16, 250nA Excitation Current)

CONFIGURATION FIELD	DESCRIPTION	# OF BITS	BINARY DATA	MEMORY ADDRESS 0x244								MEMORY ADDRESS 0x245								MEMORY ADDRESS 0x246								MEMORY ADDRESS 0x247							
(1) Thermistor Type	44008/44032 30kΩ at 25°C	5	10111	1	0	1	1	1																											
(2) Sense Resistor Channel Pointer	CH16	5	10000						1	0	0	0	0																						
(3) Sensor Configuration	Differential, Rotate and Shared	3	001											0	0	1																			
(4) Excitation Current	250nA Excitation Current	4	0001														0	0	0	1															
Not Used	Set These Bits to 0	3	000																		0	0	0												
(5) Custom Data Pointer	Not Custom	12	000000000000																					0	0	0	0	0	0	0	0	0	0	0	0

Table 82. Channel Assignment Data Differential Thermistor (44004/44033 2.252kΩ at 25°C Type Thermistor, Differential Configuration with Sharing and No Rotation, R_{SENSE} on CH16, 10µA Excitation Current)

CONFIGURATION FIELD	DESCRIPTION	# OF BITS	BINARY DATA	MEMORY ADDRESS 0x24C								MEMORY ADDRESS 0x24D								MEMORY ADDRESS 0x24E								MEMORY ADDRESS 0x24F							
(1) Thermistor Type	44004/440332.252kΩ at 25°C	5	10011	1	0	0	1	1																											
(2) Sense Resistor Channel Pointer	CH16	5	10000						1	0	0	0	0																						
(3) Sensor Configuration	Differential, No Rotate and Shared	3	010											0	1	0																			
(4) Excitation Current	10µA Excitation Current	4	0101														0	1	0	1															
Not Used	Set These Bits to 0	3	000																		0	0	0												
(5) Custom Data Pointer	Not Custom	12	000000000000																					0	0	0	0	0	0	0	0	0	0	0	0

Table 83. Channel Assignment Data for Sense Resistor (Value = 10.0kΩ)

CONFIGURATION FIELD	DESCRIPTION	# OF BITS	BINARY DATA	MEMORY ADDRESS 0x23C								MEMORY ADDRESS 0x23D								MEMORY ADDRESS 0x23E								MEMORY ADDRESS 0x23F							
(1) Sensor Type	Sense Resistor	5	11101	1	1	1	0	1																											
(2) Sense Resistor Value	10.0kΩ	27	000100111000100000000000000						0	0	0	1	0	0	1	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Thermistor Custom Steinhart-Hart

In addition to custom table-driven thermistors, it is also possible to directly input Steinhart-Hart coefficients into the ADT7604 (thermistor type 11010, see *Table 71*). Steinhart-Hart coefficients are commonly specified parameters provided by thermistor manufacturers. The Steinhart-Hart equation is:

$$\frac{1}{T} = A + B \times \ln(R) + C \times \text{In}(R)^2 + D \times \text{In}(R)^3 + E \times \text{In}(R)^4 + F \times \text{In}(R)^5$$

Steinhart-Hart data is stored sequentially in any memory location greater than or equal to 0x250 and below 0x3CF. Each coefficient is represented by a standard, single-precision, IEEE 754 32-bit value (see *Table 84*).

Table 84.Steinhart-Hart Custom Thermistor Data Format

ADDRESS	COEFFICIENT	VALUE
0x250 + 4 x Start Address	A	32-Bit Single-Precision Floating Point Format
0x250 + 4 x Start Address + 4	B	32-Bit Single-Precision Floating Point Format
0x250 + 4 x Start Address + 8	C	32-Bit Single-Precision Floating Point Format
0x250 + 4 x Start Address + 12	D	32-Bit Single-Precision Floating Point Format
0x250 + 4 x Start Address + 16	E	32-Bit Single-Precision Floating Point Format
0x250 + 4 x Start Address + 20	F	32-Bit Single-Precision Floating Point Format

Example Custom Steinhart-Hart Thermistor

In this example, a Steinhart-Hart equation is entered into memory starting at location 0x300 (see *Table 85*).

Table 85.Custom Steinhart-Hart Data Example

COEFFICIENT	VALUE	START ADDRESS	SIGN	EXPONENT																				MANTISSA										
				MSB							LSB	MSB																						LSB
A	1.45E-03	0x300	0	0	1	1	1	0	1	0	1	0	1	1	1	1	1	0	0	0	0	0	1	1	0	1	1	1	1	0	1	1	0	1
B	2.68E-04	0x304	0	0	1	1	1	0	0	1	1	0	0	0	1	1	0	0	1	0	0	0	0	0	1	0	0	1	0	1	1	0	1	0
C	0	0x308	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
D	1.64E-07	0x30C	0	0	1	1	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0	1	0	1	1	1	1	1	1	1	1	0	1	0
E	0	0x310	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F	0	0x314	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

A custom thermistor tied to CH5 with a sense resistor on CH3/4 is programmed with the channel assignment data shown in *Table 86* (see *Figure 51* for a similar format). In this case, the custom data begins at memory location 0x26E (the starting address is 30). The starting address (offset from 0x250) is entered in the custom thermistor data pointer field of the channel assignment data. The data length (set to 0) is always six 32-bit floating point words.

Table 86.Custom Steinhart-Hart Channel Assignment Data

CONFIGURATION FIELD	DESCRIPTION	# OF BITS	BINARY DATA	MEMORY ADDRESS 210								MEMORY ADDRESS 211								MEMORY ADDRESS 212								MEMORY ADDRESS 213							
(1) Thermistor Type	Custom Steinhart-Hart	5	11010	1	1	0	1	0																											
(2) Sense Resistor Channel Pointer	CH4	5	00100						0	0	1	0	0																						
(3) Sensor Configuration	Single-Ended	3	100											1	0	0																			
(4) Excitation Current	1µA	4	0011														0	0	1	1															
Not Used	Set These Bits to 0	3	000																		0	0	0												
(5) Custom Data Pointer	Start Address = 30	6	011110																					0	1	1	1	1	0						
(5) Custom Steinhart- Hart Length Always Set to 0	Fixed at Six 32-Bit Words	6	000000																											0	0	0	0	0	0

SUPPLEMENTAL INFORMATION

Fault Protection and Anti-Aliasing

The ADT7604 analog input channels draw a maximum of 1nA DC. As a result, it is possible to add anti-aliasing and fault-protection circuitry directly to the input of the ADT7604. The most common input circuitry is a low-pass filter with 1kΩ to 10kΩ resistance (limited by excitation current for RTDs and thermistors) and a capacitor with 100pF – 0.1µF capacitance. This circuit can be placed directly between the 4-wire RTDs and the ADT7604. In the case of 3-wire RTDs, mismatch errors between the protection resistors can degrade the performance. Thermistors requiring input projection should be tied to the ADT7604 through a Kelvin-type connection in order to avoid errors due to the fault-protection resistors.

Running Conversions Consecutively on Multiple Channels

Generally, during the Initiate Conversion state, a conversion measurement is started on a single-input channel determined by the channel number (bits B[4:0] = 00001 to 10100) written into memory location 0x000. Multiple consecutive conversions can be initiated by writing bits B[4:0] = 00000 into memory location 0. Conversions will be initiated on each channel selected in the mask register (see *Table 87*).

For example, using the mask data shown in *Table 88*, after 1000000 is written into memory location 0, conversions are initiated consecutively on CH20, CH19, CH16, and CH1. Once the conversions begin, the INTERRUPT pin goes low and remains low until all conversions are complete. If the mask register is set for a channel that has no assignment data, that conversion step is skipped. All the results are stored in the conversion result memory locations and can be read at the conclusion of the measurement cycle.

Table 87.Multiple Conversion Mask Register

MEMORY LOCATION	B7	B6	B5	B4	B3	B2	B1	B0
0x0F4		Reserved						
0x0F5					CH20	CH19	CH18	CH17
0x0F6	CH16	CH15	CH14	CH13	CH12	CH11	CH10	CH9
0x0F7	CH8	CH7	CH6	CH5	CH4	CH3	CH2	CH1

Table 88.Example Mask Register Select CH20, CH19, CH16, and CH1

MEMORY LOCATION	B7	B6	B5	B4	B3	B2	B1	B0
0x0F4		Reserved						
0x0F5					1	1	0	0
0x0F6	1	0	0	0	0	0	0	0
0x0F7	0	0	0	0	0	0	0	1

Entering/Exiting Sleep Mode

The ADT7604 can be placed into sleep mode by writing 0x97 to memory location 0x000. On the rising edge of $\overline{\text{CS}}$ following the memory write (see *Figure 24*), the device enters the low-power sleep state. It remains in this state until $\overline{\text{CS}}$ is brought low or $\overline{\text{RESET}}$ is asserted. Once one of these two signals is asserted, the ADT7604 begins its start-up cycle as described in the *State 1: Startup* section.

Mux Configuration Delay

The ADT7604 performs two or three internal conversion cycles per temperature result. Each conversion cycle is performed with different excitation and input multiplexer configurations. Prior to each conversion, these excitation circuits and input switch configurations are changed and an internal 1ms (typ) delay ensures settling prior to the conversion cycle in most cases.

If excessive RC time constants are present in external sensor circuits (large bypass capacitors used for thermistors or RTDs), it is possible to increase the settling time between current source excitation and mux switching. The extra delay is determined by the value written into the mux configuration delay register (memory location 0x0FF). The value written into this memory location is multiplied by 100µs; therefore, the maximum extra mux delay is 25.5ms (i.e., 0x0FF = 255 x 100µs).

Global Configuration Register

The ADT7604 includes a global configuration register (memory location 0x0F0, see *Figure 58*). This register is used to set the notch frequency of the digital filter and temperature results format (°C or °F). The default setting is simultaneous 50Hz/60Hz rejection (75dB rejection with 1ms mux delay). If higher 60Hz rejection is required (120dB rejection), write 0x01 into memory location 0x0F0; if higher 50Hz rejection is required (120dB rejection) write 0x02 into memory location 0x0F0.

The default temperature units reported by the ADT7604 are °C. The reported temperature can also be output in °F by setting bit 3 of memory location 0x0F0 to 1. All other global configuration bits should be set to 0.

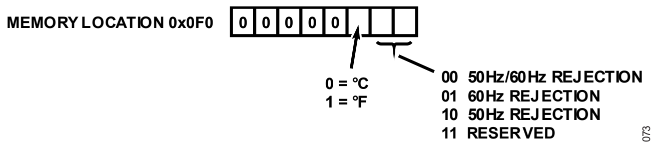


Figure 58.Global Configuration Register

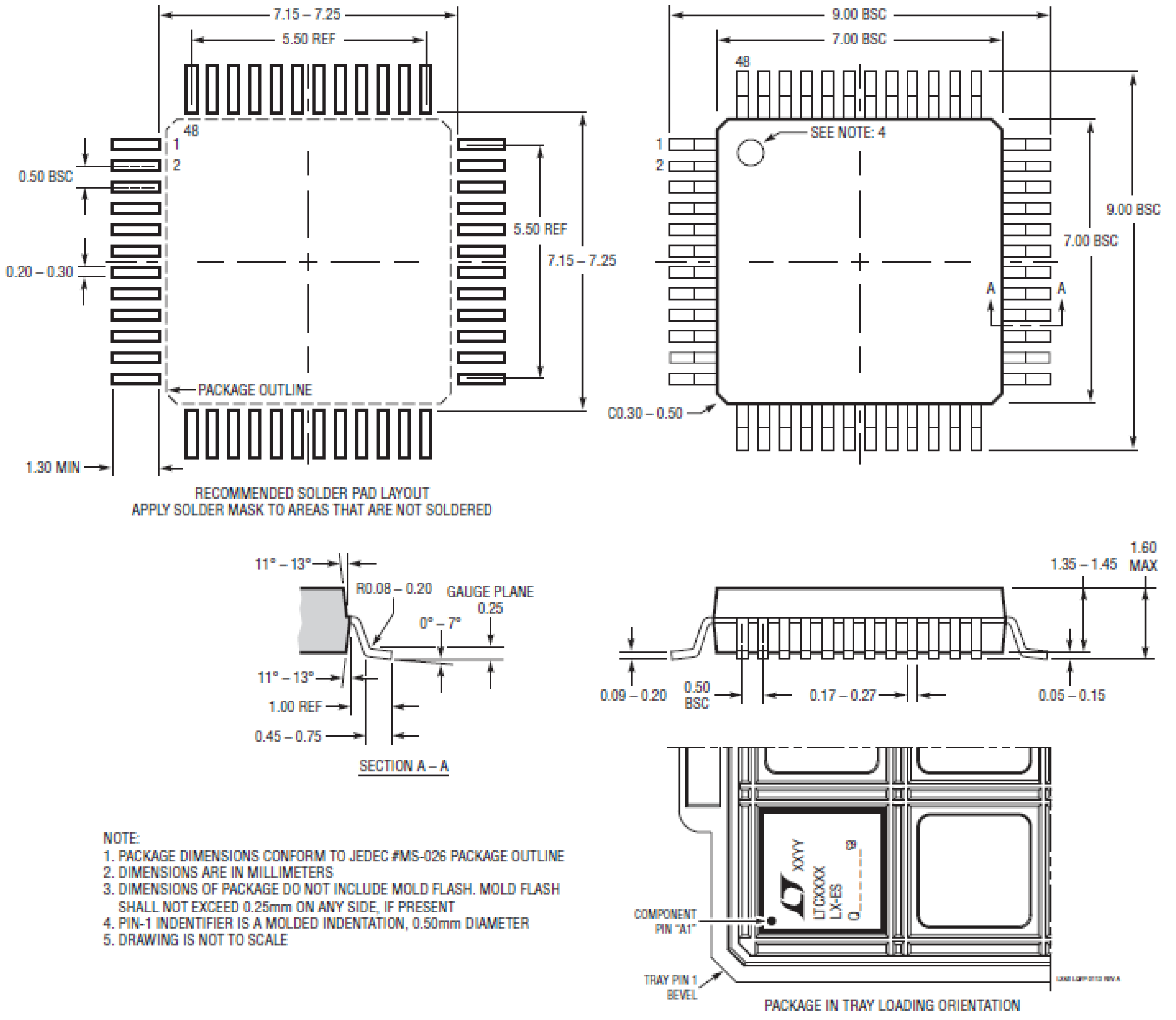
Reference Considerations

The mechanical stress of soldering the ADT7604 to a PC board can cause the output voltage reference to shift and temperature coefficient to change. These two changes are not correlated. For example, the voltage may shift but the temperature coefficient may not. To reduce the effects of stress-related shifts, mount the reference near the short edge of the PC board or in a corner.

PACKAGE DESCRIPTION

Please refer to *www.analog.com/en/resources/packaging-quality-symbols-footprints/package-index.html* for the most recent package drawings.

LX Package
48-Lead Plastic LQFP (7mm × 7mm)
(Reference LTC DWG # 05-08-1760 Rev A)



NOTE:
1. PACKAGE DIMENSIONS CONFORM TO JEDEC #MS-026 PACKAGE OUTLINE
2. DIMENSIONS ARE IN MILLIMETERS
3. DIMENSIONS OF PACKAGE DO NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED 0.25mm ON ANY SIDE, IF PRESENT
4. PIN-1 INDENTIFIER IS A MOLDED INDENTATION, 0.50mm DIAMETER
5. DRAWING IS NOT TO SCALE

ORDERING GUIDE

Table 89.Ordering Guide

LEAD-FREE FINISH	TAPE AND REEL	PART MARKING	PACKAGE DESCRIPTION	TEMPERATURE RANGE
ADT7604ASTZ	ADT7604ASTZ-RL	ADT7604ASTZ	48-lead (7mm × 7mm) LQFP	-40°C to +85°C
ADT7604BSTZ	ADT7604BSTZ-RL	ADT7604BSTZ	48-lead (7mm × 7mm) LQFP	0°C to +125°C
ADT7604CSTZ	ADT7604CSTZ-RL	ADT7604CSTZ	48-lead (7mm × 7mm) LQFP	-40°C to +125°C

For more information on lead-free part marking, go to: ***www.analog.com/en/support/quality-and-reliability/product-stewardship/material-declarations.html***.

TYPICAL APPLICATION

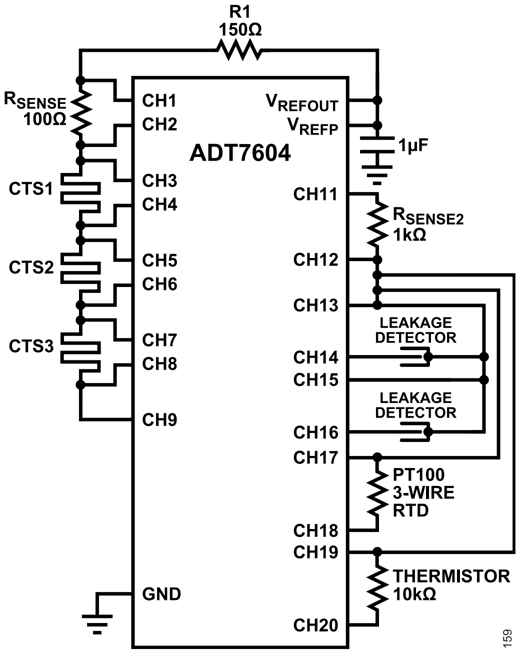


Figure 59.Universal Temperature and Leakage Measurement System for AI Data Center

RELATED PARTS

Table 90.Related Parts

PART NUMBER	DESCRIPTION	COMMENTS
MAX31732	Four-Channel Remote Temperature Sensor	Measures diode temperature on CPU/GPU/TPU. Wide ideality factor programming includes black box fault NVM memory.
MAX31760	Precision Fan-Speed Controller with Nonvolatile Lookup Table	Single PWM dual tach inputs. Nonvolatile memory, watchdog for hung BMC/I^{2}C bus.
MAX31790	6-Channel PWM-Output Fan RPM Controller	6 PWM outputs, up to 12 tach inputs for dual-rotor operation. Watchdog for hung BMC/I^{2}C bus.
MAX31889	±0.25°C Accurate I^{2}C Temperature Sensor	High-precision I^{2}C temperature sensor

REVISION HISTORY

Table 91.Revision History

REV	DATE	DESCRIPTION	PAGE NUMBER
0	5/26	Initial release	—