DS1631
±0.5°C Accuracy Digital Thermometer and Thermostat

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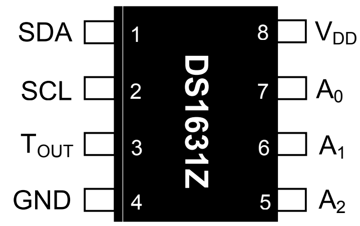
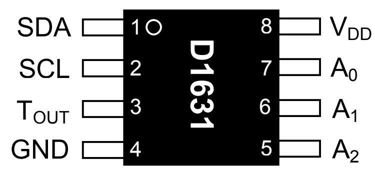
FEATURES

- Temperature measurements require no external components
- Measures temperatures from -55°C to +125°C (-67°F to +257°F)
- ±0.5°C accuracy over a range of 0°C to +70°C
- Output resolution is user-selectable to 9, 10, 11, or 12 bits
- Wide power-supply range (2.7V to 5.5V)
- Converts temperature to digital word in 750ms (max)
- Multidrop capability simplifies distributed temperature-sensing applications
- Thermostatic settings are user-definable and nonvolatile (NV)
- Data is read/written through a 2-wire serial interface (SDA and SCL pins)
- Applications include thermostatic controls, industrial systems, consumer products, thermometers, or any thermally sensitive system
- Available in 8-pin SO (150mil) and µSOP packages

PIN ASSIGNMENT



DS1631Z—8-pin SO (150mil)



DS1631U—µSOP

PIN DESCRIPTION

SDA	- Open-Drain Data I/O
SCL	- Clock Input
T_{OUT}	- Thermostat Output
GND	- Ground
V_{DD}	- Power Supply (2.7V to 5.5V)
A_0	- Address Input
A_1	- Address Input
A_2	- Address Input

DESCRIPTION

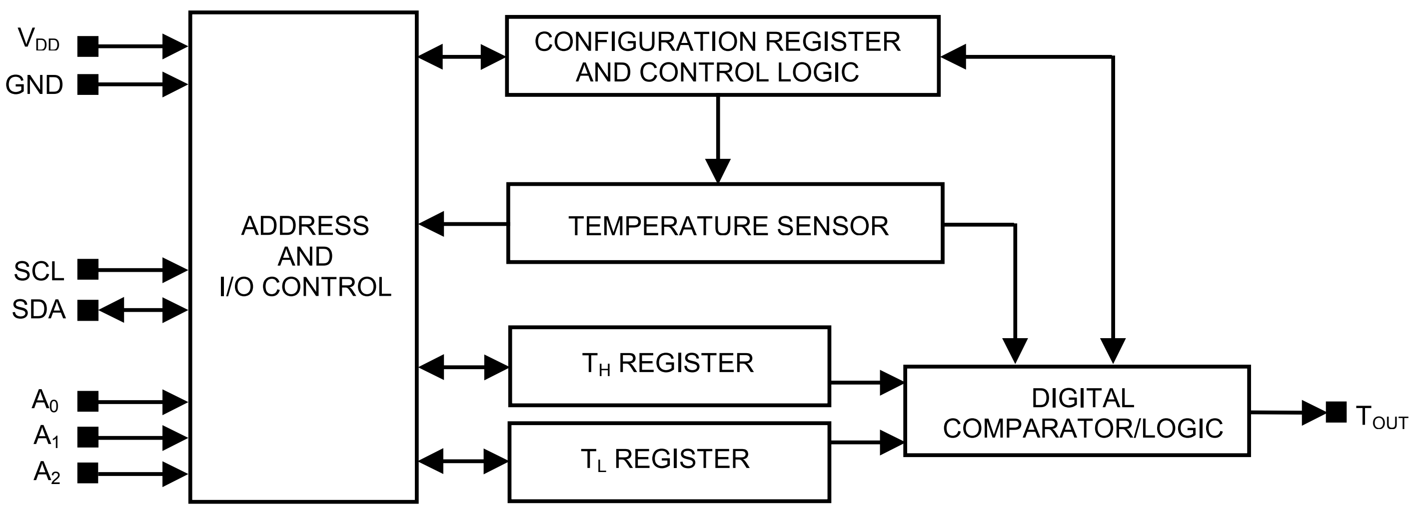
The DS1631 digital thermometer and thermostat provides 9-, 10-, 11-, or 12-bit digital temperature readings over a range of -55°C to +125°C. The thermometer accuracy is ±0.5°C from 0°C to +70°C with $3.0V \leq V_{DD} \leq 5.5V$. The thermostat provides custom hysteresis with user-defined trip points (T_H and T_L). The thermostat output (T_{OUT}) becomes active when the temperature of the device exceeds the upper thermostat trip point (T_H), and remains active until the temperature drops below the lower thermostat trip point (T_L).

The T_H and T_L registers and thermometer configuration settings are stored in NV EEPROM so the DS1631 can be programmed prior to installation. Communication with the DS1631 is achieved through a standard 2-wire serial interface.

DETAILED PIN DESCRIPTION Table 1

PIN	SYMBOL	DESCRIPTION
1	SDA	**Data input/output pin** for 2-wire serial communication port. Open drain.
2	SCL	**Clock input pin** for 2-wire serial communication port.
3	T_{OUT}	**Thermostat output pin.** Push-pull.
4	GND	**Ground pin.**
5	A_2	**Address input pin.**
6	A_1	**Address input pin.**
7	A_0	**Address input pin.**
8	V_{DD}	**Supply Voltage.** 2.7V to 5.5V input power pin.

DS1631 FUNCTIONAL BLOCK DIAGRAM Figure 1



DS1631 REGISTER SUMMARY Table 2

REGISTER NAME	USER ACCESS	SIZE	MEMORY TYPE	REGISTER CONTENTS AND POWER-UP/POR STATE
Temperature	(Read Only)	2 bytes	SRAM	Measured temperature in two's complement format. Power-up/POR state: -60ºC (1100 0100 0000 0000)
T_H	(Read/ Write)	2 bytes	EEPROM	Upper alarm trip point in two's complement format. Power-up/POR state: user defined.
T_L	(Read/ Write)	2 bytes	EEPROM	Lower alarm trip point in two's complement format. Power-up/POR state: user defined.
Configuration	(Read/ Write, but some bits are Read Only—see Table 5)	1 byte	SRAM and EEPROM	Configuration and status information. Unsigned data. 6 MSbs = SRAM 2 LSbs (POL and 1SHOT bits) = EEPROM Power-up/POR state: 100011XX (XX = User defined)

OVERVIEW

The DS1631 measures temperature using a bandgap-based temperature sensor. A delta-sigma analog-to-digital converter (ADC) converts the measured temperature to a 9-, 10-, 11-, or 12-bit (user-selectable) digital value that is calibrated in degrees centigrade; for Fahrenheit applications a lookup table or conversion routine must be used. The DS1631 also provides thermostat capability with user-programmable NV trip-point registers. Communication with the DS1631 is achieved through a standard 2-wire serial interface.

Detailed DS1631 pin descriptions are provided in Table 1 and user-accessible registers are summarized in Table 2.

Note: The DS1631 is software- and pin-compatible with DS1621. This compatibility covers all functions/commands described in the DS1621 data sheet including access to the Count_Remain and Count_Per_C registers for high-resolution temperature calculations based on the legacy dual-oscillator architecture. Refer to *Application Note 176 Using the DS1631 in DS1621 Applications* for more information.

OPERATION—MEASURING TEMPERATURE

The DS1631 can be programmed to take continuous temperature measurements (continuous conversion mode) or to take single temperature measurements on command (one-shot mode). The measurement mode is programmed through the 1SHOT bit in the configuration register: 1SHOT = 1—one-shot mode; 1SHOT = 0—continuous conversion mode. The 1SHOT bit is stored in NV EEPROM, so it can be programmed prior to installation if desired. In continuous conversion mode, when a Start Convert T command is issued, the DS1631 will perform consecutive temperature measurements until a Stop Convert T command is issued. In one-shot mode, the Start Convert T command causes one temperature measurement to be taken, then the DS1631 returns to a low-power idle state. One-shot mode is recommended for use in power-sensitive applications.

The resolution of the DS1631 digital temperature data is user-configurable to 9, 10, 11, or 12 bits, corresponding to temperature increments of 0.5°C, 0.25°C, 0.125°C, and 0.0625°C, respectively. The default resolution at power-up is 12 bits, and it can be changed through the R0 and R1 bits in the configuration register as explained in the *CONFIGURATION REGISTER* section of this data sheet. Note that the conversion time doubles for each additional bit of resolution.

After each temperature measurement and analog-to-digital conversion, the DS1631 stores the temperature as a 16-bit two's complement number in the 2-byte temperature register (see Figure 2). The sign bit (S) indicates if the temperature is positive or negative: for positive numbers S = 0 and for negative numbers S = 1. The Read Temperature command provides user access to the temperature register.

Bits 3 through 0 of the temperature register are hardwired to 0. When the DS1631 is configured for 12-bit resolution, the 12 MSbs (bits 15 through 4) of the temperature register will contain temperature data. For 11-bit resolution, the 11 MSbs (bits 15 through 5) of the temperature register will contain data, and bit 4 will read out as 0. Likewise, for 10-bit resolution, the 10 MSbs (bits 15 through 6) will contain data, and for 9-bit the 9 MSbs (bits 15 through 7) will contain data, and all unused LSbs will contain 0s. Table 3 gives examples of 12-bit resolution digital output data and the corresponding temperatures.

TEMPERATURE, T_H, and T_L REGISTER FORMAT Figure 2

	bit 15	bit 14	bit 13	bit 12	bit 11	bit 10	bit 9	bit 8
MS Byte	S	2^6	2^5	2^4	2^3	2^2	2^1	2^0

	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
LS Byte	2^{-1}	2^{-2}	2^{-3}	2^{-4}	0	0	0	0

12-BIT RESOLUTION TEMPERATURE/DATA RELATIONSHIP Table 3

TEMPERATURE (°C)	DIGITAL OUTPUT (BINARY)	DIGITAL OUTPUT (HEX)
+125	0111 1101 0000 0000	7D00h
+25.0625	0001 1001 0001 0000	1910h
+10.125	0000 1010 0010 0000	0A20h
+0.5	0000 0000 1000 0000	0080h
0	0000 0000 0000 0000	0000h
-0.5	1111 1111 1000 0000	FF80h
-10.125	1111 0101 1110 0000	F5E0h
-25.0625	1110 0110 1111 0000	E6F0h
-55	1100 1001 0000 0000	C900h

OPERATION—THERMOSTAT FUNCTION

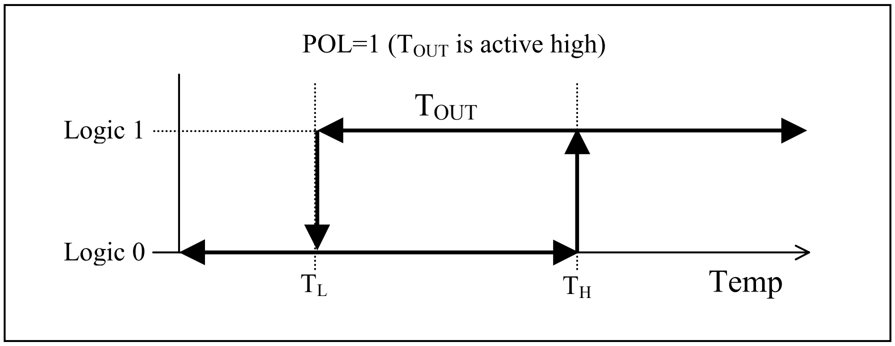
The DS1631 thermostat output (T_{OUT}) is updated after every temperature conversion, and remains at the updated value until the next conversion completes. T_{OUT} is activated and deactivated based on user-defined upper and lower trip points. When the measured temperature meets or exceeds the value stored in the upper trip-point register (T_H), T_{OUT} will become active and stay active until the temperature falls below the value stored in the lower trip-point register (T_L) (see Figure 3). This allows the user to program any amount of hysteresis into the output response. The active state of T_{OUT} is user-programmable through the polarity bit (POL) in the configuration register: POL = 1—T_{OUT} is active high; POL = 0—T_{OUT} is active low.

The user-defined values in the T_H and T_L registers (see Figure 2) must be in two's complement format with the MSb (bit 15) containing the sign bit (S). The resolution of the T_H and T_L values is determined by the R0 and R1 bits in the configuration register (see Table 4), so the T_H and T_L resolution will match the output temperature resolution. For example, for 10-bit resolution bits 5 through 0 of the T_H and T_L registers will read out as 0 (even if 1s are written to these bits), and the converted temperature will be compared to the 10 MSbs of T_H and T_L.

The T_H and T_L registers and the POL bit are stored in EEPROM; therefore, they are NV and can be programmed prior to installation of the DS1631. Writing to and reading from the T_H, T_L, and configuration registers is achieved using the Access TH, Access TL, and Access Config commands.

Another thermostat feature is the temperature high and low flags (THF and TLF) in the configuration register. These bits provide a record of whether the temperature has been greater than T_H or less than T_L at anytime since the DS1631 was powered up. If the temperature ever exceeds the T_H register value, the THF bit in the configuration register will be set to 1, and if the temperature ever falls below the T_L value, the TLF bit in the configuration register will be set to 1. Once THF and/or TLF has been set, it will remain set until over-written with a 0 by the user or until the power is cycled.

THERMOSTAT OUTPUT OPERATION Figure 3



CONFIGURATION REGISTER

The configuration register allows the user to program various DS1631 options such as conversion resolution, T_{OUT} polarity, and operating mode. It also provides information to the user about conversion status, EEPROM activity, and thermostat activity. The configuration register is arranged as shown in Figure 4 and detailed descriptions of each bit are provided in Table 5. This register can be read from and written to using the Access Config command. Note that the POL and 1SHOT bits are stored in EEPROM and all other configuration register bits are SRAM.

CONFIGURATION REGISTER Figure 4

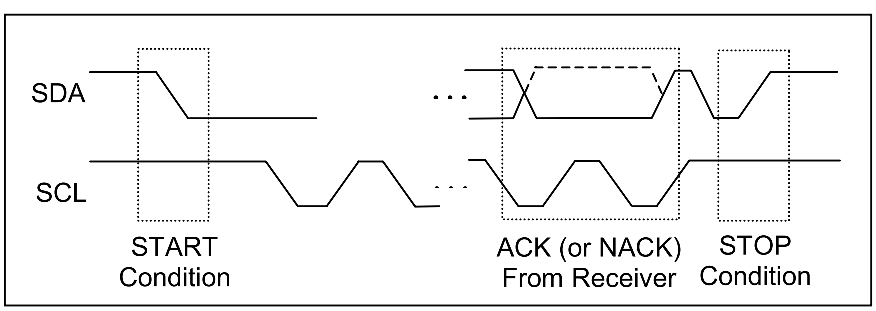
MSb	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	LSb
DONE	THF	TLF	NVB	R1	R0	POL*	1SHOT*

*NV (EEPROM)

RESOLUTION CONFIGURATION Table 4

R1	R0	RESOLUTION	CONVERSION TIME (MAX)
0	0	9-bit	93.75ms
0	1	10-bit	187.5ms
1	0	11-bit	375ms
1	1	12-bit	750ms

START, STOP, AND ACK SIGNALS Figure 5



CONFIGURATION REGISTER BIT DESCRIPTIONS Table 5

BIT NAME (USER ACCESS)	FUNCTIONAL DESCRIPTION
DONE—Temperature Conversion Done (Read Only)	Power-up/POR state = 1 DONE = 0—Temperature conversion is in progress. DONE = 1—Temperature conversion is complete.
THF—Temperature High Flag (Read/Write)	Power-up/POR state = 0. THF = 0—The measured temperature has not exceeded the value stored in the T_H register since power-up. THF = 1—At some point since power-up the measured temperature has been higher than the value stored in the T_H register. THF will remain a 1 until it is over-written with a 0 by the user or until the power is cycled.
TLF—Temperature Low Flag (Read/Write)	Power-up/POR state = 0 TLF = 0—The measured temperature has not been lower than the value stored in the T_L register since power-up. TLF = 1—At some point since power-up the measured temperature has been lower than the value stored in the T_L register. TLF will remain a 1 until it is over-written with a 0 by the user or until the power is cycled.
NVB—NV Memory Busy (Read Only)	Power-up/POR state = 0 NVB = 1—A write to EEPROM memory is in progress NVB = 0—NV memory is not busy.
R1—Resolution Bit 1 (Read/Write)	Power-up/POR state = 1 Used to set conversion, T_H, and T_L resolution (see Table 4)
R0—Resolution Bit 0 (Read/Write)	Power-up/POR state = 1 Used to set conversion, T_H, and T_L resolution (see Table 4)
POL*— T_{OUT} Polarity (Read/Write)	Power-up/POR state = last value written to this bit POL = 1—T_{OUT} is active high. POL = 0—T_{OUT} is active low.
1SHOT*— Conversion Mode (Read/Write)	Power-up/POR state = last value written to this bit 1SHOT = 1—One-shot mode. The Start Convert T command will cause a single temperature conversion and then the device will return to a low-power standby state. 1SHOT = 0—Continuous conversion mode. The Start Convert T command will initiate continuous temperature conversions.

*Stored in EEPROM

2-WIRE SERIAL DATA BUS

The DS1631 communicates over a standard bidirectional 2-wire serial data bus that consists of a serial clock (SCL) signal and serial data (SDA) signal. The DS1631 interfaces to the bus through the SCL input pin and open-drain SDA I/O pin.

The following terminology is used to describe 2-wire communication:

Master Device: Microprocessor/microcontroller that controls the slave devices on the bus. The master device generates the SCL signal and START and STOP conditions.

Slave: All devices on the bus other than the master. The DS1631 always functions as a slave.

Bus Idle or Not Busy: Both SDA and SCL remain high. SDA is held high by a pullup resistor when the bus is idle, and SCL must either be forced high by the master (if the SCL output is push-pull) or pulled high by a pullup resistor (if the SCL output is open-drain).

Transmitter: A device (master or slave) that is sending data on the bus.

Receiver: A device (master or slave) that is receiving data from the bus.

START Condition: Indicates the beginning of a data transfer to all devices on the bus. The master generates a START condition by pulling SDA from high to low while SCL is high (see Figure 5). A repeated START is sometimes used at the end of a data transfer (instead of a STOP) to indicate that the master will perform another operation.

STOP Condition: Indicates the end of a data transfer to all devices on the bus. The master generates a STOP condition by transitioning SDA from low to high while SCL is high (see Figure 5). After the STOP is issued, the master releases the bus to its idle state.

Acknowledge (ACK): When a device (either master or slave) is acting as a receiver, it must generate an acknowledge (ACK) on the SDA line after receiving every byte of data. The receiving device performs an ACK by pulling the SDA line low for an entire SCL period (see Figure 5). During the ACK clock cycle, the transmitting device must release SDA. A variation on the ACK signal is the "not acknowledge" (NACK). When the master device is acting as a receiver, it uses a NACK instead of an ACK after the last data byte to indicate that it is finished receiving data. The master indicates a NACK by leaving the SDA line high during the ACK clock cycle.

Slave Address: Every slave device on the bus must have a unique 7-bit address that allows the master to access that device. The DS1631's 7-bit bus address is as follows:

bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
1	0	0	1	A_2	A_1	A_0

where bits 2, 1, and 0 are user selectable through the A_2, A_1, and A_0 pins. The three user-selectable address bits allow up to eight DS1631s to be multi-dropped on the same bus.

Control Byte: The control byte is transmitted by the master and consists of the 7-bit slave address plus a read/write ($R/\overline{W}$) bit. If the master is going to read data from the slave device then $R/\overline{W} = 1$, and if the master is going to write data to the slave device then $R/\overline{W} = 0$.

Command Byte: The command byte can be any of the command protocols described in the *DS1631 COMMAND SET* section of this data sheet.

GENERAL 2-WIRE INFORMATION

- All data is transmitted MSb first over the 2-wire bus.
- A pullup resistor is required on the SDA line and, when the bus is idle, both SDA and SCL must remain in a logic-high state.
- All bus communication must be initiated with a START condition and terminated with a STOP condition. During a START or STOP is the only time SDA is allowed to change states while SCL is high. At all other times, changes on the SDA line can only occur when SCL is low: SDA must remain stable when SCL is high.
- One bit of data is transmitted on the 2-wire bus each SCL period.
- After every 8-bit (1-byte) transfer, the receiving device must answer with an ACK (or NACK), which takes one SCL period. Therefore, nine clocks are required for every one byte data transfer.

INITIATING COMMUNICATION WITH THE DS1631

To initiate communication with the DS1631, the master must generate a START followed by a control byte containing the DS1631 bus address. The $R/\overline{W}$ bit of the control byte must be a 0 ("write") since the master must next write a command byte to the DS1631. The DS1631 will respond with an ACK after receiving the control byte. This must be followed by a command byte from the master, which tells the DS1631 what type of operation is to be performed. The DS1631 will again respond with an ACK after receiving the command byte.

If the command byte is a Start Convert T or Stop Convert T command (see Figure 6a), the transaction is finished, and the master must issue a STOP to signal the end of the communication sequence. If the command byte indicates a write or read operation, additional actions must occur as explained in the following sections.

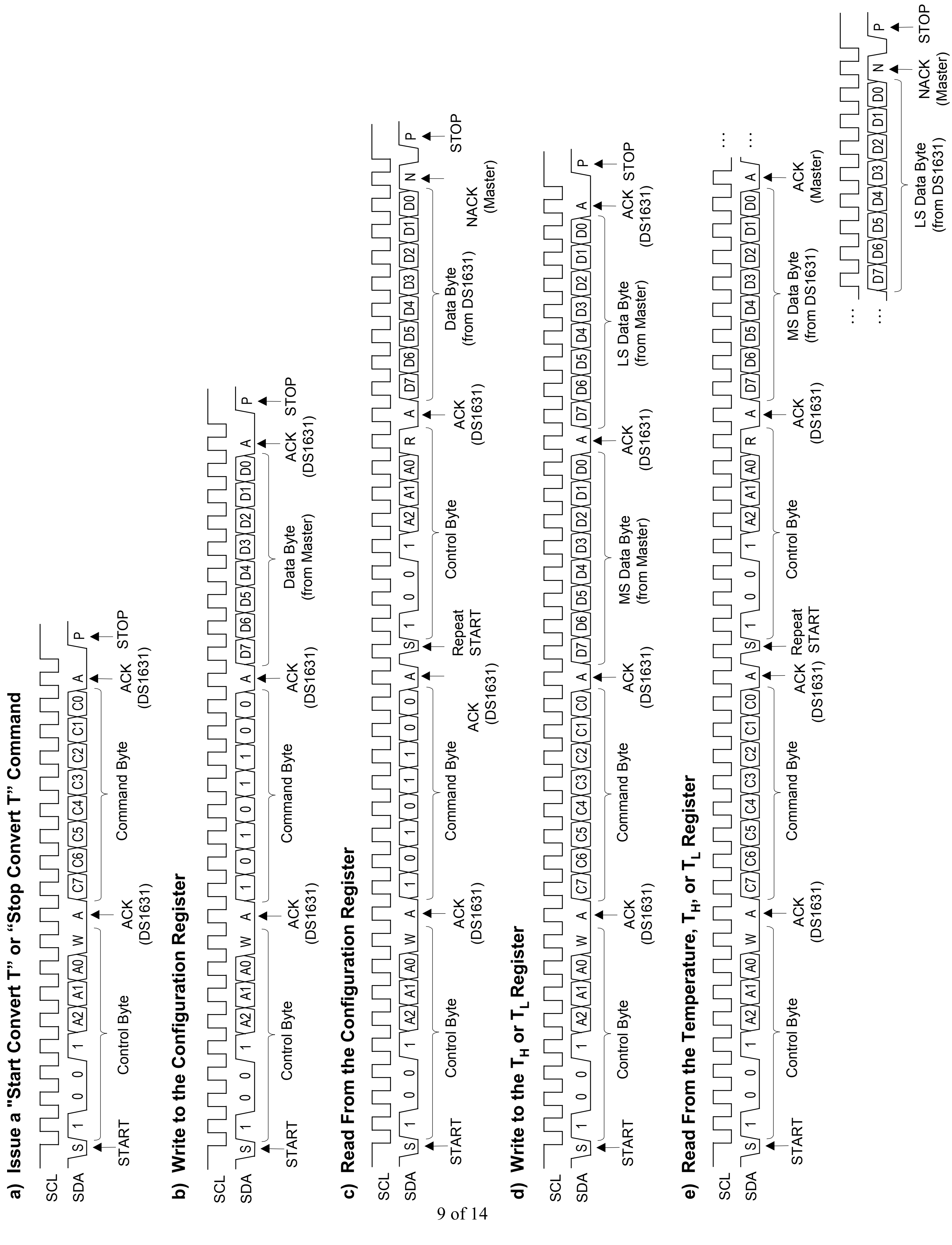
2-WIRE WRITES

The master can write data to the DS1631 by issuing an Access Config, Access TH, or Access TL command following the control byte (see Figures 6b and 6d). Since the $R/\overline{W}$ bit in the control byte was a 0 ("write"), the DS1631 is already prepared to receive data. Therefore, after the DS1631 sends an ACK in response to the command byte, the master device can immediately begin transmitting data to the DS1631. When writing to the configuration register, the master must send one byte of data, and when writing to the T_H or T_L registers the master must send two bytes of data. After receiving each data byte, the DS1631 will respond with an ACK, and the transaction is finished with a STOP from the master.

2-WIRE READS

The master can read data from the DS1631 by issuing an Access Config, Access TH, Access TL, or Read Temperature command following the control byte (see Figures 6c and 6e). After the DS1631 sends an ACK in response to the command, the master must generate a repeated START followed by a control byte with the same DS1631 address as the first control byte. However, this time the $R/\overline{W}$ bit must be a 1, which tells the DS1631 that a "read" is being performed. After the DS1631 sends an ACK in response to the control byte, it will begin transmitting the requested data on the next clock cycle, provided the master continues to generate the clock signal on SCL. When reading from the configuration register, the DS1631 will transmit one byte of data, after which the master must respond with a NACK followed by a STOP. For two-byte reads (i.e., from the temperature, T_H or T_L, register), the master must respond to the first data byte with an ACK and to the second byte with a NACK, followed by a STOP. If only one byte of temperature data is needed, the master can issue a NACK followed by a STOP after reading the first data byte, and the DS1631 will quit transmitting data.

2-WIRE INTERFACE TIMING Figure 6



DS1631 COMMAND SET

The DS1631 command set is detailed below and is summarized in Table 6.

Start Convert T [51h]

Initiates temperature conversions. If the part is in one-shot mode (1SHOT = 1), only one conversion will be performed. In continuous mode (1SHOT = 0), continuous temperature conversions will be performed until a Stop Convert T command is issued.

Stop Convert T [22h]

Stops temperature conversions when the device is in continuous conversion mode (1SHOT = 0).

Read Temperature [AAh]

Reads last converted temperature value from the 2-byte temperature register.

Access TH [A1h]

Reads or writes the 2-byte T_H register.

Access TL [A2h]

Reads or writes the 2-byte T_L register.

Access Config [ACh]

Reads or writes the 1-byte configuration register.

Software POR [54h]

Initiates a software power-on reset (POR).

DS1631 COMMAND SET Table 6

Command	Description	Protocol	2-Wire Bus Activity After Command is Issued	Notes
TEMPERATURE				
Start Convert T	Initiates temperature conversions.	51h	Idle	
Stop Convert T	Halts temperature conversions.	22h	Idle	
Read Temperature	Reads last converted temperature value from temperature register.	AAh	Two data bytes are transmitted by the DS1631.	1
THERMOSTAT				
Access TH	Reads or writes the T_H register.	A1h	Two data bytes are transmitted.	2, 3
Access TL	Reads or writes the T_L register.	A2h	Two data bytes are transmitted.	2, 3
Access Config	Reads or writes the configuration register.	ACh	One data byte is transmitted.	2, 3
OTHER				
Software POR	Initiates a software power-on reset.	54h	Idle	

NOTES:

1) If only one byte of temperature data is needed, the master can issue a NACK followed by a STOP after reading the first data byte, and the DS1631 will quit transmitting data.
2) After issuing a write command, no further writes should be requested for at least 10ms due to the EEPROM write cycle time.
3) Data direction depends upon $R/\overline{W}$ bit in the 2-wire control byte.

DS1631 OPERATION EXAMPLE

In this example, the master configures the DS1631 ($A_1A_2A_3$ = 000) for continuous conversions and thermostatic function.

MASTER MODE	DS1631 MODE	DATA (MSb first)	COMMENTS
TX	RX	START	Master issues a START condition.
TX	RX	90h	Master sends control byte with $R/\overline{W}$ = 0.
RX	TX	ACK	DS1631 generates acknowledge bit.
TX	RX	ACh	Master sends Access Config command.
RX	TX	ACK	DS1631 generates acknowledge bit.
TX	RX	02h	Master writes a data byte to the configuration register to put the DS1631 in continuous conversion mode and set the T_{OUT} polarity to active high.
RX	TX	ACK	DS1631 generates acknowledge bit.
TX	RX	START	Master generates a repeated START condition.
TX	RX	90h	Master sends control byte with $R/\overline{W}$ = 0.
RX	TX	ACK	DS1631 generates acknowledge bit.
TX	RX	A1h	Master sends Access TH command.
RX	TX	ACK	DS1631 generates acknowledge bit.
TX	RX	28h	Master sends most significant data byte for T_H = +40°C.
RX	TX	ACK	DS1631 generates acknowledge bit.
TX	RX	00h	Master sends least significant data byte for T_H = +40°C.
RX	TX	ACK	DS1631 generates acknowledge bit.
TX	RX	START	Master generates a repeated START condition.
TX	RX	90h	Master sends control byte with $R/\overline{W}$ = 0.
RX	TX	ACK	DS1631 generates acknowledge bit.
TX	RX	A2h	Master sends Access TL command.
RX	TX	ACK	DS1631 generates acknowledge bit.
TX	RX	0Ah	Master sends most significant data byte for T_L = +10°C.
RX	TX	ACK	DS1631 generates acknowledge bit.
TX	RX	00h	Master sends least significant data byte for T_L = +10°C.
RX	TX	ACK	DS1631 generates acknowledge bit.
TX	RX	START	Master generates a repeated START condition.
TX	RX	90h	Master sends control byte with $R/\overline{W}$ = 0.
RX	TX	ACK	DS1631 generates acknowledge bit.
TX	RX	51h	Master sends Start Convert T command.
RX	TX	ACK	DS1631 generates acknowledge bit.
TX	RX	STOP	Master issues a STOP condition.

ABSOLUTE MAXIMUM RATINGS*

Voltage on any Pin Relative to Ground	-0.5V to +6.0V
Operating Temperature Range	-55°C to +125°C
Storage Temperature Range	-55°C to +125°C
Solder Dip Temperature (10s)	+260°C
Reflow Oven Temperature	+220°C

* These are stress ratings only and functional operation of the device at these or any other conditions above those indicated in the operation sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods of time may affect reliability.

DC ELECTRICAL CHARACTERISTICS (-55°C to +125°C; V_{DD} = 2.7V to 5.5V)

PARAMETER	SYMBOL	CONDITIONS	MIN	MAX	UNITS	NOTES
Supply Voltage	V_{DD}		2.7	5.5	V	1
Thermometer Error	T_{ERR}	0°C to +70°C 3.0V ≤ V_{DD} ≤ 5.5V		±½	°C	2
		0°C to +70°C 2.7V ≤ V_{DD} < 3.0V		±1		
		-55°C to +125°C		±2		
Low-Level Input Voltage	V_{IL}		-0.5	0.3V_{DD}	V	
High-Level Input Voltage	V_{IH}		0.7V_{DD}	V_{DD} + 0.3	V	
SDA Low-Level Output Voltage	V_{OL1}	3mA sink current	0	0.4	V	
	V_{OL2}	6mA sink current	0	0.6	V	
Input Current each I/O pin		0.4 < $V_{I/O}$ < 0.9V_{DD}	-10	+10	µA	
Active Supply Current	I_{DD}	Temperature conversion -55°C to +85°C		1	mA	3
		Temperature conversion +85°C to +125°C		1.25	mA	
		E^2 Write		400	µA	
		Communication only		110	µA	
Standby Supply Current	I_{STBY}	0°C to +70°C		800	nA	4
T_{OUT} Output Logic Voltage	V_{OH}	1mA source current	2.4		V	1
	V_{OL}	4mA sink current		0.4	V	1

NOTES:

1) All voltages are referenced to ground.
2) See Typical Curve (Figure 7).
3) Specified with T_{OUT} pin open; V_{DD} = 5V; A_0, A_1, A_2 = 0 or V_{DD}; and $f_{SCL} \geq$ 2Hz.
4) Specified with temperature conversions stopped; T_{OUT} pin open; V_{DD} = 5V; SDA = V_{DD}; SCL = V_{DD}; and A_0, A_1, A_2 = 0 or V_{DD}.

EEPROM AC ELECTRICAL CHARACTERISTICS

(-55°C to +100°C; V_{DD} = 2.7V to 5.5V)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
EEPROM Write Cycle Time	t_{wr}			4	10	ms
EEPROM Writes	N_{EEWR}	-55°C to +55°C	50k			writes
EEPROM Data Retention	t_{EEDR}	-55°C to +55°C	10			years

AC ELECTRICAL CHARACTERISTICS (-55°C to +125°C; V_{DD} = 2.7V to 5.5V)

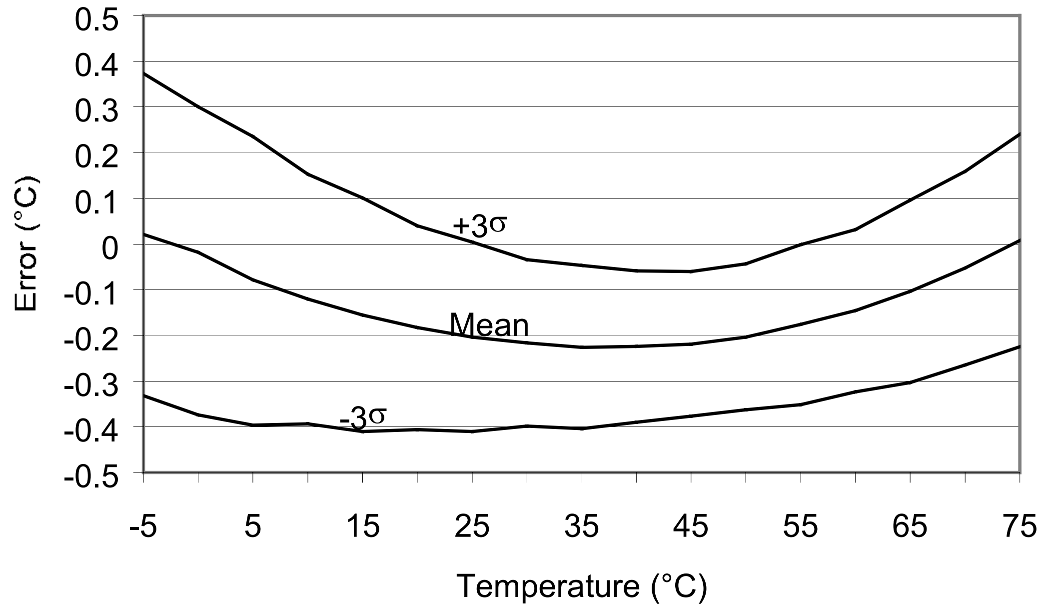
PARAMETER	SYMBOL	CONDITION	MIN	TYP	MAX	UNITS	NOTES
Temperature Conversion Time	t_{TC}	9-bit resolution			93.75	ms	
		10-bit resolution			187.5		
		11-bit resolution			375		
		12-bit resolution			750		
SCL Frequency	f_{SCL}		0		400	kHz	
Bus Free Time Between a STOP and START Condition	t_{BUF}		1.3			µs	1
START and Repeated START Hold Time from Falling SCL	$t_{HD:STA}$		0.6			µs	1, 2
Low Period of SCL	t_{LOW}		1.3			µs	1
High Period of SCL	t_{HIGH}		0.6			µs	1
Repeated START Condition Setup Time to Rising SCL	$t_{SU:STA}$		0.6			µs	1
Data-Out Hold Time from Falling SCL	$t_{HD:DAT}$		0		0.9	µs	1
Data-In Setup Time to Rising SCL	$t_{SU:DAT}$		100			ns	1
Rise Time of SDA and SCL	t_R		20 + $0.1C_B$		1000	ns	1, 3
Fall time of SDA and SCL	t_F		20 + $0.1C_B$		300	ns	1, 3
STOP Setup Time to Rising SCL	$t_{SU:STO}$		0.6			µs	1
Capacitive Load for each Bus Line	C_B				400	pF	
I/O Capacitance	$C_{I/O}$			10		pF	
Input Capacitance	C_I			5		pF	
Spike Pulse Width that can be Suppressed by Input Filter	t_{SP}		0		50	ns	

All values referenced to V_{IH} = 0.9 V_{DD} and V_{IL} = 0.1 V_{DD}.

NOTES:

1) See timing diagram in Figure 8.
2) After this period the first clock pulse is generated.
3) For example, if C_B = 300pF, then t_R[min] = t_F[min] = 50ns.

TYPICAL PERFORMANCE CURVE Figure 7



TIMING DIAGRAM Figure 8