DS1825
Programmable Resolution 1-Wire Digital Thermometer With 4-Bit ID

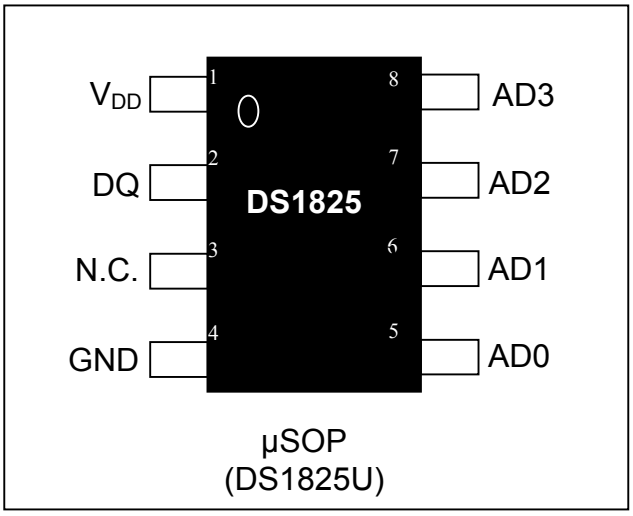
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FEATURES

- Unique 1-Wire® Interface Requires Only One Port Pin for Communication
- Each Device has a Unique 64-Bit Serial Code Stored in an On-Board ROM
- Multidrop Capability Simplifies Distributed Temperature-Sensing Applications
- 4 Pin-Programmable Bits to Uniquely Identify Up to 16 Sensor Locations on a Bus
- Requires No External Components
- Can be Powered from Data Line. Power Supply Range: 3.0V to 3.7V
- Measures Temperatures from -55°C to +125°C (-67°F to +257°F)
- ±0.5°C Accuracy from -10°C to +85°C
- Thermometer Resolution is User-Selectable from 9 to 12 Bits
- Converts Temperature to 12-Bit Digital Word in 750ms (max)
- User-Definable (NV) Alarm Settings
- Alarm Search Command Identifies and Addresses Devices Whose Temperature is Outside of Programmed Limits (Temperature Alarm Condition)
- Available in 8-Pin µSOP Package
- Software Compatible with the DS1822

1-Wire is a registered trademark of Dallas Semiconductor.

PIN ASSIGNMENT



µSOP
(DS1825U)

PIN DESCRIPTION

GND	- Ground
DQ	- Data In/Out
N.C.	- No Connect
V_{DD}	- Power Supply Voltage
AD0 to AD3	- Address Pins

APPLICATIONS

Thermostatic Controls
Industrial Systems
Consumer Products
Thermometers
Thermally-Sensitive Systems

DESCRIPTION

The DS1825 digital thermometer provides 9 to 12-bit centigrade temperature measurements and has an alarm function with NV user-programmable upper and lower trigger points. The DS1825 communicates over a 1-Wire bus that by definition requires only one data line (and ground) for communication with a central microprocessor. It has an operating temperature range of -55°C to +125°C and is accurate to ±0.5°C over the range of -10°C to +85°C. In addition, the DS1825 can derive power directly from the data line (“parasite power”), eliminating the need for an external power supply.

ORDERING INFORMATION

ORDERING NUMBER	PACKAGE MARKING	DESCRIPTION
DS1825U	1825	8-pin µSOP
DS1825U/T&R	1825	8-pin µSOP Tape-and-Reel
DS1825U+	1825 (See Note 1)	8-pin µSOP, Lead Free
DS1825U+T&R	1825 (See Note 1)	8-pin µSOP Tape-and-Reel, Lead Free

Note 1: Additionally, a "+" symbol will be marked on the package.

DESCRIPTION (cont.)

Each DS1825 has a unique 64-bit serial code, which allows multiple DS1825s to function on the same 1-Wire bus; thus, it is simple to use one microprocessor to control many DS1825s distributed over a large area. In addition, the 4-bit location address can be used to identify specific temperature sensors in the system without requiring a wide lookup table. Applications that can benefit from this feature include HVAC environmental controls, temperature monitoring systems inside buildings, equipment or machinery, and process monitoring and control systems.

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}= 3.0V to 3.7V)

PARAMETER	SYMBOL	CONDITION	MIN	TYP	MAX	UNITS	NOTES
Supply Voltage	V_{DD}	Local Power	+3.0		+3.7	V	1
Pullup Supply Voltage	V_{PU}	Parasite Power	+3.0		+3.7	V	1, 2
		Local Power	+3.0		V_{DD}		
Thermometer Error	t_{ERR}	-10°C to +85°C			±0.5	°C	3
		-55°C to +125°C			±2	°C	
Programming Resistor: AD0-AD3	R_{PGM}		0		10	kΩ	12
DQ Input Logic Low	$V_{IL(DQ)}$		-0.3		+0.7	V	1, 4, 5
DQ Input Logic High	$V_{IH(DQ)}$	Local Power	+2.2		The lower of 3.7 or V_{DD} + 0.3	V	1, 6
		Parasite Power	+3.0				
Sink Current	I_L	$V_{I/O}$ = 0.4V	4.0			mA	1
Standby Current	I_{DDS}			500	1000	nA	7, 8
Active Current	I_{DD}	V_{DD} = 3.7V		0.65	1.5	mA	9
DQ Input Current	I_{DQ}			5		µA	10
Drift				±0.2		°C	11

NOTES:

1. All voltages are referenced to ground.
2. The Pullup Supply Voltage specification assumes that the pullup device is ideal, and therefore the high level of the pullup is equal to V_{PU}. In order to meet the V_{IH} spec of the DS1825, the actual supply rail for the strong pullup transistor must include margin for the voltage drop across the transistor when it is turned on; thus: $V_{PU_ACTUAL} = V_{PU_IDEAL} + V_{TRANSISTOR}$.
3. See typical performance curve in Figure 18
4. Logic low voltages are specified at a sink current of 4mA.
5. To guarantee a presence pulse under low voltage parasite power conditions, V_{ILMAX} may have to be reduced to as low as 0.5V.
6. Logic high voltages are specified at a source current of 1mA.
7. Standby current specified up to 70°C. Standby current typically is 3µA at 125°C.
8. To minimize I_{DDS}, DQ should be within the following ranges: GND ≤ DQ ≤ GND + 0.3V or V_{DD} - 0.3V ≤ DQ ≤ V_{DD}.
9. Active current refers to supply current during active temperature conversions or EEPROM writes.
10. DQ line is high ("hi-Z" state).
11. Drift data is based on a 1000 hour stress test at 125°C.
12. Inputs AD0-AD3 must be tied either High or Low. A "Low" is a connection to the GND terminal. A "High" connection varies with usage of the DS1825. When connected as a parasite powered sensor, a connection to DQ is considered a High. When powered through the V_{DD} pin, a connection to V_{DD} is a High. If left floating, the input values are indeterminate and may be either logical "0" or logical "1." See Figures 20 and 21 for details. When optional programming resistors are used, their maximum values are 10,000Ω.

AC ELECTRICAL CHARACTERISTICS: NV MEMORY

(-55°C to +100°C; V_{DD} = 3.0V to 3.7V)

PARAMETER	SYMBOL	CONDITION	MIN	TYP	MAX	UNITS
NV Write Cycle Time	t_{wr}			2	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} = 3.0V to 3.7V)

PARAMETER	SYMBOL	CONDITION	MIN	TYP	MAX	UNITS	NOTES
Temperature Conversion Time	t_{CONV}	9-bit resolution			93.75	ms	1
		10-bit resolution			187.5	ms	1
		11-bit resolution			375	ms	1
		12-bit resolution			750	ms	1
Time to Strong Pullup On	t_{SPON}	Start Convert T Command Issued			10	µs	
Time Slot	t_{SLOT}		60		120	µs	1
Recovery Time	t_{REC}		1			µs	1
Write 0 Low Time	t_{LOW0}		60		120	µs	1
Write 1 Low Time	t_{LOW1}		1		15	µs	1
Read Data Valid	t_{RDV}				15	µs	1
Reset Time High	t_{RSTH}		480			µs	1
Reset Time Low	t_{RSTL}		480			µs	1, 2
Presence Detect High	t_{PDHIGH}		15		60	µs	1
Presence Detect Low	t_{PDLOW}		60		240	µs	1
Capacitance: DQ	$C_{IN/OUT}$				25	pF	
Capacitance: AD0-AD3	C_{IN_AD}				50	pF	

NOTES:

1. Refer to timing diagrams in Figure 18.
2. Under parasite power, if t_{RSTL} > 960µs, a power on reset may occur.

Table 1. DETAILED PIN DESCRIPTIONS

PIN	SYMBOL	DESCRIPTION
4	GND	**Ground.**
2	DQ	**Data Input/Output pin.** Open-drain 1-Wire interface pin. Also provides power to the device when used in parasite power mode (see *Parasite Power* section.)
1	V_{DD}	**Optional V_{DD} pin.** V_{DD} must be grounded for operation in parasite power mode.
5	AD0	**Location Address Input Pin LSB**
6	AD1	**Location Address Input Pin**
7	AD2	**Location Address Input Pin**
8	AD3	**Location Address Input Pin MSB**
3	N.C.	**No Connection**

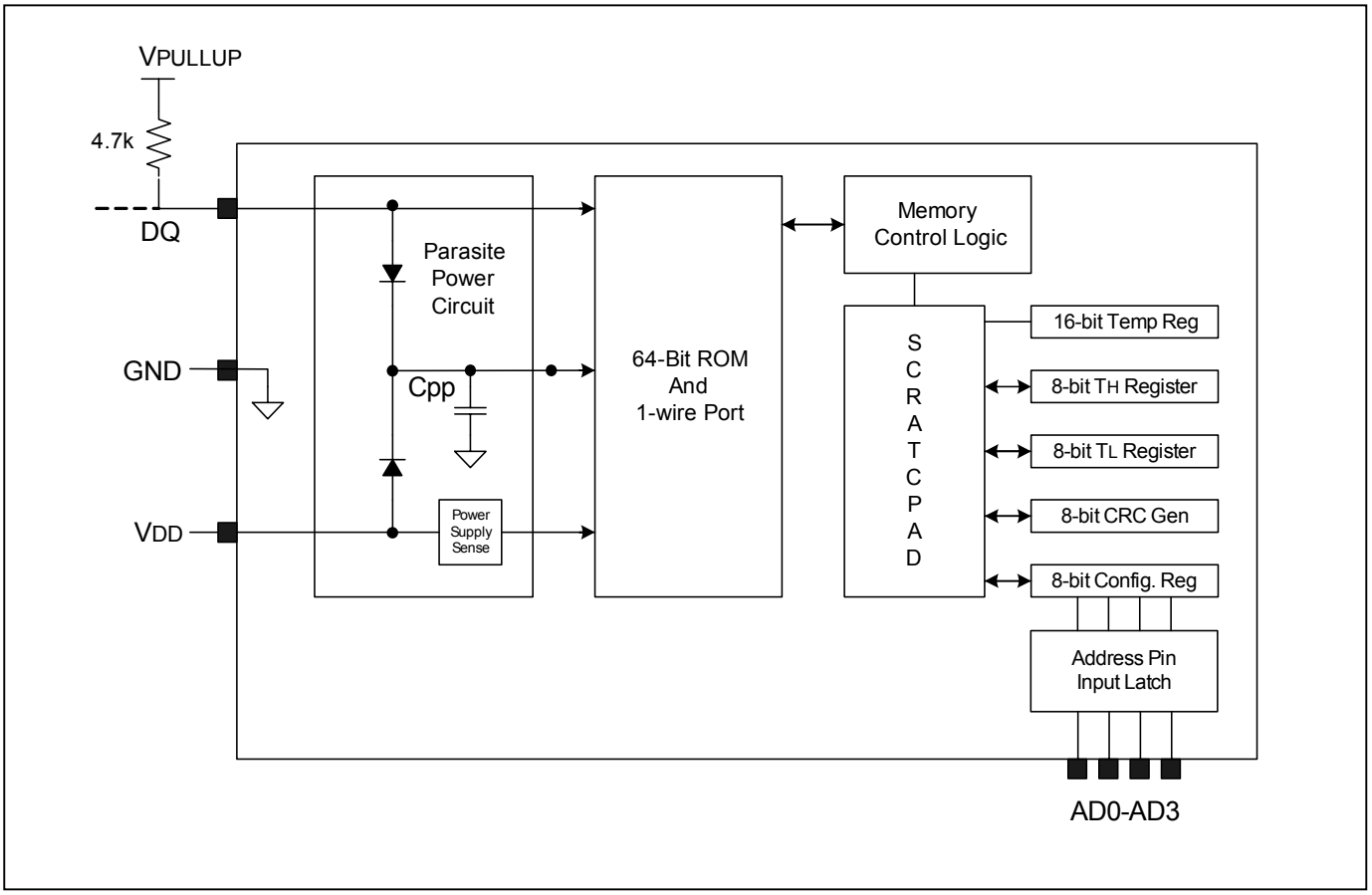
OVERVIEW

Figure 1 shows a block diagram of the DS1825, and pin descriptions are given in Table 1. The 64-bit ROM stores the device's unique serial code. The scratchpad memory contains the 2-byte temperature register that stores the digital output from the temperature sensor. In addition, the scratchpad provides access to the 1-byte upper and lower alarm trigger registers (T_H and T_L), and the 1-byte configuration register. The configuration register allows the user to set the resolution of the temperature-to-digital conversion to 9, 10, 11, or 12 bits. It is also used for the hard-wired address programmed by the AD0-AD3 pins. The T_H, T_L, and configuration registers are NV (EEPROM), so they will retain data when the device is powered down.

The DS1825 uses Dallas' exclusive 1-Wire bus protocol that implements bus communication using one control signal. The control line requires a weak pullup resistor since all devices are linked to the bus through a 3-state or open-drain port (the DQ pin in the case of the DS1825). In this bus system, the microprocessor (the master device) identifies and addresses devices on the bus using each device's unique 64-bit code. Because each device has a unique code, the number of devices that can be addressed on one bus is virtually unlimited. The 1-Wire bus protocol, including detailed explanations of the commands and "time slots," is covered in the *1-Wire BUS SYSTEM* section of this data sheet.

Another feature of the DS1825 is the ability to operate without an external power supply. Power is instead supplied through the 1-Wire pullup resistor through the DQ pin when the bus is high. The high bus signal also charges an internal capacitor (C_{PP}), which then supplies power to the device when the bus is low. This method of deriving power from the 1-Wire bus is referred to as "parasite power." As an alternative, the DS1825 can also be powered by an external supply on V_{DD}.

Figure 1. DS1825 BLOCK DIAGRAM



OPERATION—MEASURING TEMPERATURE

The core functionality of the DS1825 is its direct-to-digital temperature sensor. The resolution of the temperature sensor is user-configurable to 9, 10, 11, or 12 bits, corresponding to increments of 0.5°C, 0.25°C, 0.125°C, and 0.0625°C, respectively. The default resolution at power-up is 12-bit. The DS1825 powers-up in a low-power idle state; to initiate a temperature measurement and A-to-D conversion, the master must issue a Convert T [44h] command. Following the conversion, the resulting thermal data is stored in the 12-bit temperature register in the scratchpad memory and the DS1825 returns to its idle state. If the DS1825 is powered by an external supply, the master can issue "read time slots" (see the *1-Wire BUS SYSTEM* section) after the Convert T command and the DS1825 will respond by transmitting 0 while the temperature conversion is in progress and 1 when the conversion is done. If the DS1825 is powered with parasite power, this notification technique cannot be used since the bus must be pulled high by a strong pullup during the entire temperature conversion. The bus requirements for parasite power are explained in detail in the *POWERING THE DS1825* section of this data sheet.

The DS1825 output temperature data is calibrated in degrees centigrade; for Fahrenheit applications, a lookup table or conversion routine must be used. The temperature data is stored as a 16-bit sign-extended two's complement number in the temperature register (see Figure 2). The sign bits (S) indicate if the temperature is positive or negative: for positive numbers S = 0 and for negative numbers S = 1. If the DS1825 is configured for 12-bit resolution, all bits in the temperature register will contain valid data. For 11-bit resolution, bit 0 is undefined. For 10-bit resolution, bits 1 and 0 are undefined, and for 9-bit resolution bits 2, 1 and 0 are undefined. Table 3 gives examples of digital output data and the corresponding temperature reading for 12-bit resolution conversions.

Figure 2. TEMPERATURE REGISTER FORMAT

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

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

Table 3. TEMPERATURE/DATA RELATIONSHIP

TEMPERATURE	DIGITAL OUTPUT (Binary)	DIGITAL OUTPUT (Hex)
+125°C	0000 0111 1101 0000	07D0h
+85°C*	0000 0101 0101 0000	0550h
+25.0625°C	0000 0001 1001 0001	0191h
+10.125°C	0000 0000 1010 0010	00A2h
+0.5°C	0000 0000 0000 1000	0008h
0°C	0000 0000 0000 0000	0000h
-0.5°C	1111 1111 1111 1000	FFF8h
-10.125°C	1111 1111 0101 1110	FF5Eh
-25.0625°C	1111 1110 0110 1111	FE6Fh
-55°C	1111 1100 1001 0000	FC90h

*The power-on reset value of the temperature register is +85°C

OPERATION—ALARM SIGNALING

After the DS1825 performs a temperature conversion, the temperature value is compared to the user-defined two's complement alarm trigger values stored in the 1-byte T_H and T_L registers (see Figure 3). The sign bit (S) indicates if the value is positive or negative: for positive numbers S = 0 and for negative numbers S = 1. The T_H and T_L registers are NV (EEPROM) so they will retain data when the device is powered down. T_H and T_L can be accessed through bytes 2 and 3 of the scratchpad as explained in the *MEMORY* section of this data sheet.

Figure 3. T_H AND T_L REGISTER FORMAT

bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
S	2^6	2^5	2^5	2^5	2^2	2^1	2^0

Only bits 11 through 4 of the temperature register are used in the T_H and T_L comparison since T_H and T_L are 8-bit registers. If the measured temperature is lower than or equal to T_L or higher than or equal to T_H, an alarm condition exists and an alarm flag is set inside the DS1825. This flag is updated after every temperature measurement; therefore, if the alarm condition goes away, the flag will be turned off after the next temperature conversion.

The master device can check the alarm flag status of all DS1825s on the bus by issuing an Alarm Search [ECh] command. Any DS1825s with a set alarm flag will respond to the command, so the master can determine exactly which DS1825s have experienced an alarm condition. If an alarm condition exists and the T_H or T_L settings have changed, another temperature conversion should be done to validate the alarm condition.

POWERING THE DS1825

The DS1825 can be powered by an external supply on the V_{DD} pin, or it can operate in "parasite power" mode, which allows the DS1825 to function without a local external supply. Parasite power is very useful for applications that require remote temperature sensing or that are very space constrained. Figure 1 shows the DS1825's parasite-power control circuitry, which "steals" power from the 1-Wire bus through the DQ pin when the bus is high. The stolen charge powers the DS1825 while the bus is high, and some of the charge is stored on the parasite power capacitor (C_{PP}) to provide power when the bus is low. When the DS1825 is used in parasite power mode, the V_{DD} pin must be connected to ground.

In parasite power mode, the 1-Wire bus and C_{PP} can provide sufficient current to the DS1825 for most operations as long as the specified timing and voltage requirements are met (refer to the *DC ELECTRICAL CHARACTERISTICS* and the *AC ELECTRICAL CHARACTERISTICS* sections of this data sheet). However, when the DS1825 is performing temperature conversions or copying data from the scratchpad memory to EEPROM, the operating current can be as high as 1.5mA. This current can cause an unacceptable voltage drop across the weak 1-Wire pullup resistor and is more current than can be supplied by C_{PP}. To assure that the DS1825 has sufficient supply current, it is necessary to provide a strong pullup on the 1-Wire bus whenever temperature conversions are taking place or data is being copied from the scratchpad to EEPROM. This can be accomplished by using a MOSFET to pull the bus directly to the rail as shown in Figure 4. The 1-Wire bus must be switched to the strong pullup within 10μs (max) after a Convert T [44h] or Copy Scratchpad [48h] command is issued, and the bus must be held high by the pullup for the duration of the conversion (t_{conv}) or data transfer (t_{wr} = 10ms). No other activity can take place on the 1-Wire bus while the pullup is enabled.

The DS1825 can also be powered by the conventional method of connecting an external power supply to the V_{DD} pin, as shown in Figure 5. The advantage of this method is that the MOSFET pullup is not required, and the 1-Wire bus is free to carry other traffic during the temperature conversion time.

The use of parasite power is not recommended for temperatures above 100°C since the DS1825 may not be able to sustain communications due to the higher leakage currents that can exist at these temperatures. For applications in which such temperatures are likely, it is strongly recommended that the DS1825 be powered by an external power supply.

In some situations the bus master may not know whether the DS1825s on the bus are parasite powered or powered by external supplies. The master needs this information to determine if the strong bus pullup should be used during temperature conversions. To get this information, the master can issue a Skip ROM [CCh] command followed by a Read Power Supply [B4h] command followed by a "read time slot". During the read time slot, parasite powered DS1825s will pull the bus low, and externally powered DS1825s will let the bus remain high. If the bus is pulled low, the master knows that it must supply the strong pullup on the 1-Wire bus during temperature conversions.

Figure 4. SUPPLYING THE PARASITE-POWERED DS1825 DURING TEMPERATURE CONVERSIONS

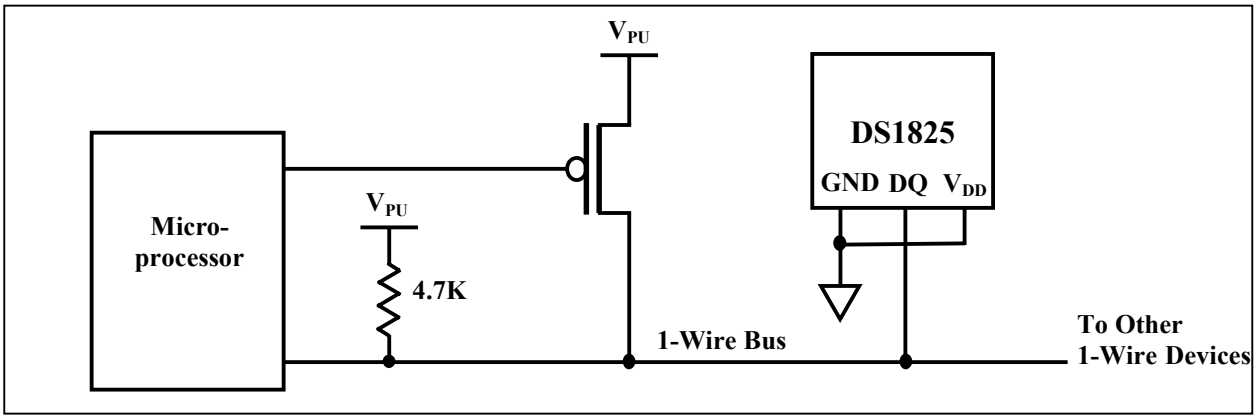
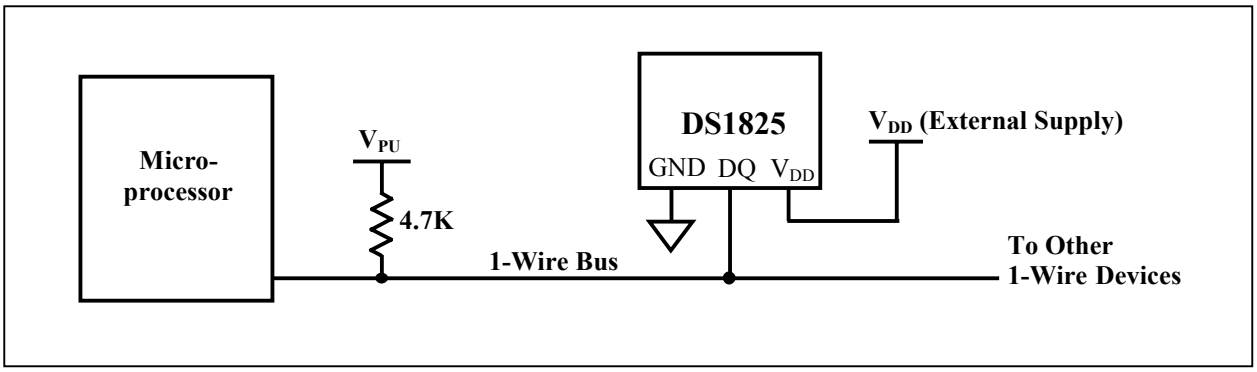


Figure 5. POWERING THE DS1825 WITH AN EXTERNAL SUPPLY



64-BIT LASERED ROM CODE

Each DS1825 contains a unique 64-bit code (see Figure 6) stored in ROM. The least significant 8 bits of the ROM code contain the DS1825's 1-Wire family code: 3Bh. The next 48 bits contain a unique serial number. The most significant 8 bits contain a cyclic redundancy check (CRC) byte that is calculated from the first 56 bits of the ROM code. A detailed explanation of the CRC bits is provided in the CRC GENERATION section. The 64-bit ROM code and associated ROM function control logic allow the DS1825 to operate as a 1-Wire device using the protocol detailed in the *1-Wire BUS SYSTEM* section of this data sheet.

Figure 6. 64-BIT LASERED ROM CODE

8-BIT CRC		48-BIT SERIAL NUMBER		8-BIT FAMILY CODE (3Bh)	
MSB	LSB	MSB	LSB	MSB	LSB

MEMORY

The DS1825's memory is organized as shown in Figure 7. The memory consists of an SRAM scratchpad with NV EEPROM storage for the high and low alarm trigger registers (T_H and T_L) and configuration register. Note that if the DS1825 alarm function is not used, the T_H and T_L registers can serve as general-purpose memory. All memory commands are described in detail in the *DS1825 FUNCTION COMMANDS* section.

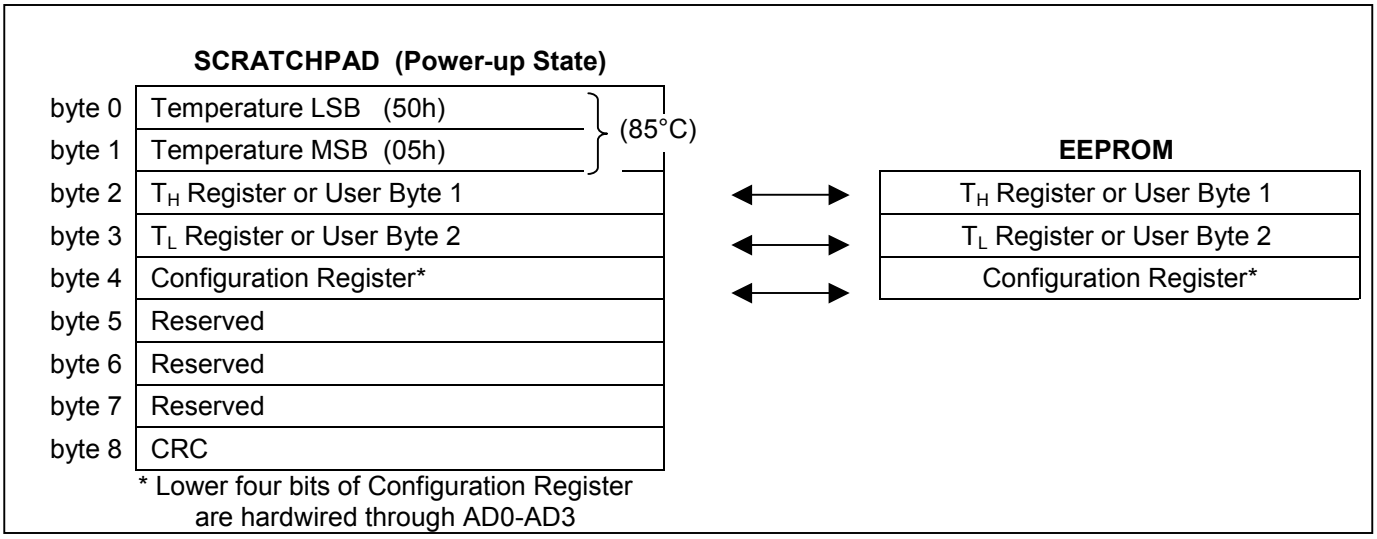
Byte 0 and byte 1 of the scratchpad contain the LSB and the MSB of the temperature register, respectively. These bytes are read-only. Bytes 2 and 3 provide access to T_H and T_L registers. Byte 4 contains the configuration register data, which is explained in detail in the *CONFIGURATION REGISTER* section of this data sheet. Bytes 5, 6, and 7 are reserved for internal use by the device and cannot be overwritten.

Byte 8 of the scratchpad is read-only and contains the cyclic redundancy check (CRC) code for bytes 0 through 7 of the scratchpad. The DS1825 generates this CRC using the method described in the *CRC GENERATION* section.

Data is written to bytes 2, 3, and 4 of the scratchpad using the Write Scratchpad [4Eh] command; the data must be transmitted to the DS1825 starting with the least significant bit of byte 2. To verify data integrity, the scratchpad can be read (using the Read Scratchpad [BEh] command) after the data is written. When reading the scratchpad, data is transferred over the 1-Wire bus starting with the least significant bit of byte 0. To transfer the T_H, T_L, and configuration data from the scratchpad to EEPROM, the master must issue the Copy Scratchpad [48h] command.

Data in the EEPROM registers is retained when the device is powered down; at power-up the EEPROM data (including the hard-wired address inputs AD0-AD3)is reloaded into the corresponding scratchpad locations. Data can also be reloaded from EEPROM to the scratchpad at any time using the Recall E^2 [B8h] command. The master can issue read time slots following the Recall E^2 command and the DS1825 will indicate the status of the recall by transmitting 0 while the recall is in progress and 1 when the recall is done.

Figure 7. DS1825 MEMORY MAP



CONFIGURATION REGISTER

Byte 4 of the scratchpad memory is the configuration register, as shown in Figure 8. The configuration register allows the user to set the conversion resolution using the R0 and R1 bits and read the programmed value of the address pins. The conversion resolution power-up default is R0 = 1 and R1 = 1 (12-bit resolution). Table 4 shows the resolution configuration settings and maximum conversion time. Note that there is a direct tradeoff between resolution and conversion time. AD0-AD3 bits report the pin programmed location information and are sampled at power-up. In Parasite Power mode, the address pins must be connected to DQ or GND and in V_{DD} powered mode, the address pins must be connected to V_{DD} or GND. Pins tied to DQ/V_{DD} are reported with a logical 1 and pins tied to GND are reported as a logical 0. Pins connected to DQ/ V_{DD} or GND through a resistor are valid logical 1s or logical 0s if the resistor is less than 10k. Floating or high impedance (>10kΩ) connections are indeterminate. Bit 7 and Bit 4 of the configuration register are reserved for internal use and cannot be overwritten.

Figure 8. CONFIGURATION REGISTER FORMAT

Note: Bit 0 through Bit 3 are programmed through the four Location Programming Address pins AD0-AD3. Reading the configuration register provides location information on up to 16 individual DS1825s.

bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
0	R1	R0	1	AD3	AD2	AD1	AD0

Table 4. THERMOMETER RESOLUTION CONFIGURATION

R1	R0	Resolution	Max Conversion Time	
0	0	9-bit	93.75ms	(t_{CONV}/8)
0	1	10-bit	187.5ms	(t_{CONV}/4)
1	0	11-bit	375ms	(t_{CONV}/2)
1	1	12-bit	750ms	(t_{CONV})

CRC GENERATION

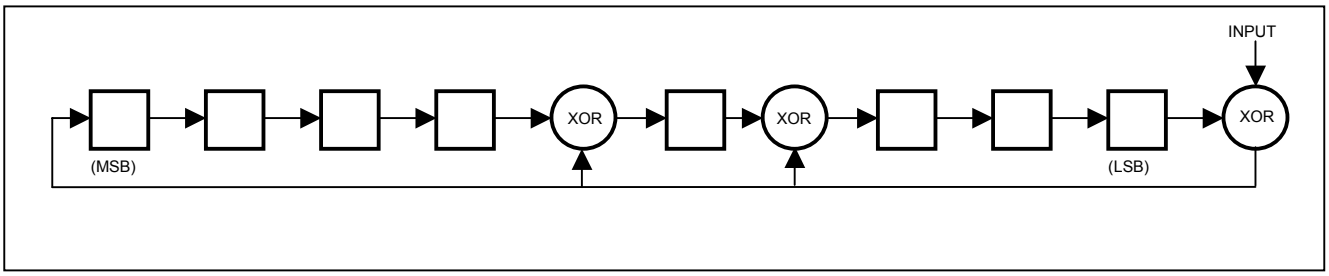
CRC bytes are provided as part of the DS1825's 64-bit ROM code and in the 9th byte of the scratchpad memory. The ROM code CRC is calculated from the first 56 bits of the ROM code and is contained in the most significant byte of the ROM. The scratchpad CRC is calculated from the data stored in the scratchpad, and therefore it changes when the data in the scratchpad changes. The CRCs provide the bus master with a method of data validation when data is read from the DS1825. To verify that data has been read correctly, the bus master must re-calculate the CRC from the received data and then compare this value to either the ROM code CRC (for ROM reads) or to the scratchpad CRC (for scratchpad reads). If the calculated CRC matches the read CRC, the data has been received error free. The comparison of CRC values and the decision to continue with an operation are determined entirely by the bus master. There is no circuitry inside the DS1825 that prevents a command sequence from proceeding if the DS1825 CRC (ROM or scratchpad) does not match the value generated by the bus master.

The equivalent polynomial function of the CRC (ROM or scratchpad) is:

$$CRC = X^8 + X^5 + X^4 + 1$$

The bus master can re-calculate the CRC and compare it to the CRC values from the DS1825 using the polynomial generator shown in Figure 9. This circuit consists of a shift register and XOR gates, and the shift register bits are initialized to 0. Starting with the least significant bit of the ROM code or the least significant bit of byte 0 in the scratchpad, one bit at a time should shifted into the shift register. After shifting in the 56th bit from the ROM or the most significant bit of byte 7 from the scratchpad, the polynomial generator will contain the re-calculated CRC. Next, the 8-bit ROM code or scratchpad CRC from the DS1825 must be shifted into the circuit. At this point, if the re-calculated CRC was correct, the shift register will contain all 0s. Additional information about the Dallas 1-Wire cyclic redundancy check is available in Application Note 27 entitled "Understanding and Using Cyclic Redundancy Checks with Dallas Semiconductor Touch Memory Products."

Figure 9. CRC GENERATOR



1-Wire BUS SYSTEM

The 1-Wire bus system uses a single bus master to control one or more slave devices. The DS1825 is always a slave. When there is only one slave on the bus, the system is referred to as a "single-drop" system; the system is "multidrop" if there are multiple slaves on the bus.

All data and commands are transmitted least significant bit first over the 1-Wire bus.

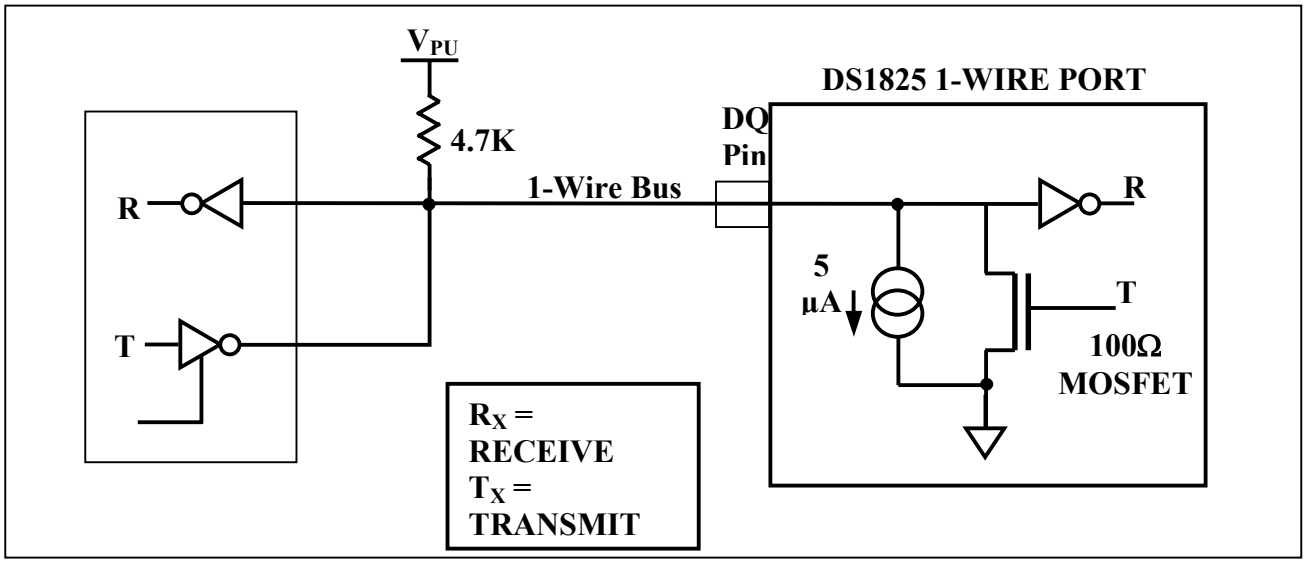
The following discussion of the 1-Wire bus system is broken down into three topics: hardware configuration, transaction sequence, and 1-Wire signaling (signal types and timing).

HARDWARE CONFIGURATION

The 1-Wire bus has by definition only a single data line. Each device (master or slave) interfaces to the data line through an open-drain or 3-state port. This allows each device to "release" the data line when the device is not transmitting data so the bus is available for use by another device. The 1-Wire port of the DS1825 (the DQ pin) is open drain with an internal circuit equivalent to that shown in Figure 10.

The 1-Wire bus requires an external pullup resistor of approximately 5kΩ; thus, the idle state for the 1-Wire bus is high. If for any reason a transaction needs to be suspended, the bus MUST be left in the idle state if the transaction is to resume. Infinite recovery time can occur between bits so long as the 1-Wire bus is in the inactive (high) state during the recovery period. If the bus is held low for more than 480μs, all components on the bus will be reset.

Figure 10. HARDWARE CONFIGURATION



TRANSACTION SEQUENCE

The transaction sequence for accessing the DS1825 is as follows:

Step 1. Initialization

Step 2. ROM Command (followed by any required data exchange)

Step 3. DS1825 Function Command (followed by any required data exchange)

It is very important to follow this sequence every time the DS1825 is accessed, as the DS1825 will not respond if any steps in the sequence are missing or out of order. Exceptions to this rule are the Search ROM [F0h] and Alarm Search [ECh] commands. After issuing either of these ROM commands, the master must return to Step 1 in the sequence.

INITIALIZATION

All transactions on the 1-Wire bus begin with an initialization sequence. The initialization sequence consists of a reset pulse transmitted by the bus master followed by presence pulse(s) transmitted by the slave(s). The presence pulse lets the bus master know that slave devices (such as the DS1825) are on the bus and are ready to operate. Timing for the reset and presence pulses is detailed in the *1-Wire SIGNALING* section.

ROM COMMANDS

After the bus master has detected a presence pulse, it can issue a ROM command. These commands operate on the unique 64-bit ROM codes of each slave device and allow the master to single out a specific device if many are present on the 1-Wire bus. These commands also allow the master to determine how many and what types of devices are present on the bus or if any device has experienced an alarm condition. There are five ROM commands, and each command is 8 bits long. The master device must issue an appropriate ROM command before issuing a DS1825 function command. A flowchart for operation of the ROM commands is shown in Figure 11.

SEARCH ROM [F0h]

When a system is initially powered up, the master must identify the ROM codes of all slave devices on the bus, which allows the master to determine the number of slaves and their device types. The master learns the ROM codes through a process of elimination that requires the master to perform a Search ROM cycle (i.e., Search ROM command followed by data exchange) as many times as necessary to identify all of the slave devices. If there is only one slave on the bus, the simpler Read ROM command (see below) can be used in place of the Search ROM process. For a detailed explanation of the Search ROM procedure, refer to the iButton® Book of Standards at www.ibutton.com/ibuttons/standard.pdf. After every Search ROM cycle, the bus master must return to Step 1 (Initialization) in the transaction sequence.

READ ROM [33h]

This command can only be used when there is one slave on the bus. It allows the bus master to read the slave's 64-bit ROM code without using the Search ROM procedure. If this command is used when there is more than one slave present on the bus, a data collision will occur when all the slaves attempt to respond at the same time.

MATCH ROM [55h]

The match ROM command followed by a 64-bit ROM code sequence allows the bus master to address a specific slave device on a multidrop or single-drop bus. Only the slave that exactly matches the 64-bit ROM code sequence will respond to the function command issued by the master; all other slaves on the bus will wait for a reset pulse.

SKIP ROM [CCh]

The master can use this command to address all devices on the bus simultaneously without sending out any ROM code information. For example, the master can make all DS1825s on the bus perform simultaneous temperature conversions by issuing a Skip ROM command followed by a Convert T [44h] command.

Note that the Read Scratchpad [BEh] command can follow the Skip ROM command only if there is a single slave device on the bus. In this case time is saved by allowing the master to read from the slave without sending the device's 64-bit ROM code. A Skip ROM command followed by a Read Scratchpad command will cause a data collision on the bus if there is more than one slave since multiple devices will attempt to transmit data simultaneously.

ALARM SEARCH [ECh]

The operation of this command is identical to the operation of the Search ROM command except that only slaves with a set alarm flag will respond. This command allows the master device to determine if any DS1825s experienced an alarm condition during the most recent temperature conversion. After every Alarm Search cycle (i.e., Alarm Search command followed by data exchange), the bus master must return to Step 1 (Initialization) in the transaction sequence. Refer to the *OPERATION—ALARM SIGNALING* section for an explanation of alarm flag operation.

DS1825 FUNCTION COMMANDS

After the bus master has used a ROM command to address the DS1825 with which it wishes to communicate, the master can issue one of the DS1825 function commands. These commands allow the master to write to and read from the DS1825's scratchpad memory, initiate temperature conversions and determine the power supply mode. The DS1825 function commands, which are described below, are summarized in Table 5 and illustrated by the flowchart in Figure 12.

CONVERT T [44h]

This command initiates a single temperature conversion. Following the conversion, the resulting thermal data is stored in the 2-byte temperature register in the scratchpad memory and the DS1825 returns to its low-power idle state. If the device is being used in parasite power mode, within 10μs (max) after this command is issued the master must enable a strong pullup on the 1-Wire bus for the duration of the conversion (t_{conv}) as described in the *POWERING THE DS1825* section. If the DS1825 is powered by an external supply, the master can issue read time slots after the Convert T command and the DS1825 will respond by transmitting 0 while the temperature conversion is in progress and 1 when the conversion is done. In parasite power mode this notification technique cannot be used since the bus is pulled high by the strong pullup during the conversion.

WRITE SCRATCHPAD [4Eh]

This command allows the master to write 3 bytes of data to the DS1825's scratchpad. The first data byte is written into the T_H register (byte 2 of the scratchpad), the second byte is written into the T_L register (byte 3), and the third byte is written into the configuration register (byte 4). Data must be transmitted least significant bit first. All three bytes MUST be written before the master issues a reset, or the data may be corrupted.

READ SCRATCHPAD [BEh]

This command allows the master to read the contents of the scratchpad. The data transfer starts with the least significant bit of byte 0 and continues through the scratchpad until the 9th byte (byte 8: CRC) is read. The master may issue a reset to terminate reading at any time if only part of the scratchpad data is needed.

COPY SCRATCHPAD [48h]

This command copies the contents of the scratchpad T_H, T_L and configuration registers (bytes 2, 3, and 4) to EEPROM. If the device is being used in parasite power mode, within 10μs (max) after this command is issued the master must enable a strong pullup on the 1-Wire bus for at least 10ms as described in the *POWERING THE DS1825* section.

RECALL E^2 [B8h]

This command recalls the alarm trigger values (T_H and T_L) and configuration data from EEPROM and places the data in bytes 2, 3, and 4, respectively, in the scratchpad memory. The master device can issue read time slots following the Recall E^2 command and the DS1825 will indicate the status of the recall by transmitting 0 while the recall is in progress and 1 when the recall is done. The recall operation happens automatically at power-up, so valid data is available in the scratchpad as soon as power is applied to the device.

READ POWER SUPPLY [B4h]

The master device issues this command followed by a read time slot to determine if any DS1825s on the bus are using parasite power. During the read time slot, parasite powered DS1825s will pull the bus low, and externally powered DS1825s will let the bus remain high. Refer to the *POWERING THE DS1825* section for usage information for this command.

Table 5. DS1825 FUNCTION COMMAND SET

Command	Description	Protocol	1-Wire Bus Activity After Command is Issued	Notes
TEMPERATURE CONVERSION COMMANDS				
Convert T	Initiates temperature conversion.	44h	DS1825 transmits conversion status to master (not applicable for parasite-powered DS1825s).	1
MEMORY COMMANDS				
Read Scratchpad	Reads the entire scratchpad including the CRC byte.	BEh	DS1825 transmits up to 9 data bytes to master.	2
Write Scratchpad	Writes data into scratchpad bytes 2, 3, and 4 (T_H, T_L, and configuration registers).	4Eh	Master transmits 3 data bytes to DS1825.	3
Copy Scratchpad	Copies T_H, T_L, and configuration register data from the scratchpad to EEPROM.	48h	None	1
Recall E^2	Recalls T_H, T_L, and configuration register data from EEPROM to the scratchpad.	B8h	DS1825 transmits recall status to master.	
Read Power Supply	Signals DS1825 power supply mode to the master.	B4h	DS1825 transmits supply status to master.	

NOTES:

1. For parasite-powered DS1825s, the master must enable a strong pullup on the 1-Wire bus during temperature conversions and copies from the scratchpad to EEPROM. No other bus activity may take place during this time.
2. The master can interrupt the transmission of data at any time by issuing a reset.
3. All three bytes must be written before a reset is issued.

Figure 11. ROM COMMANDS FLOW CHART

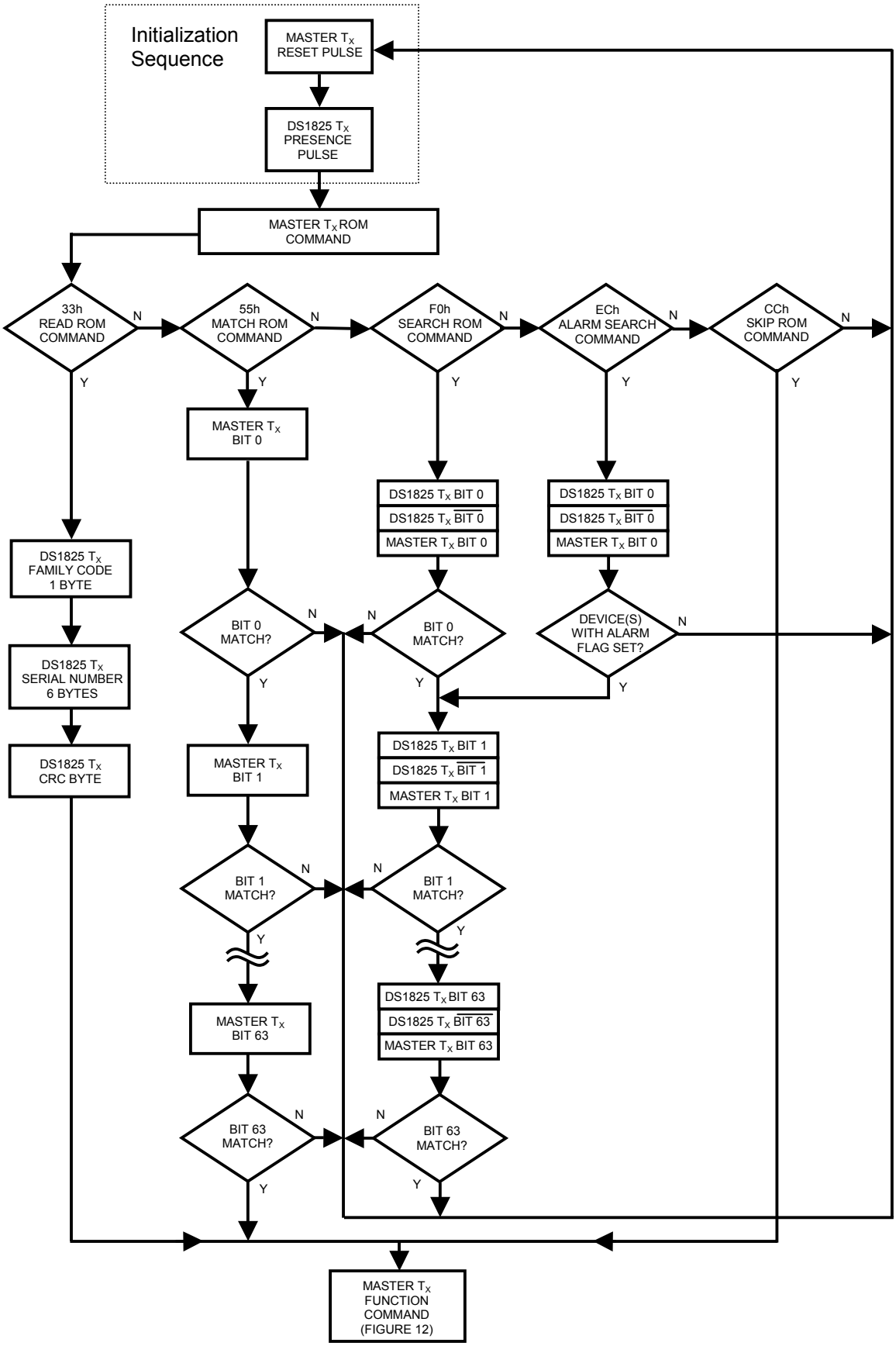
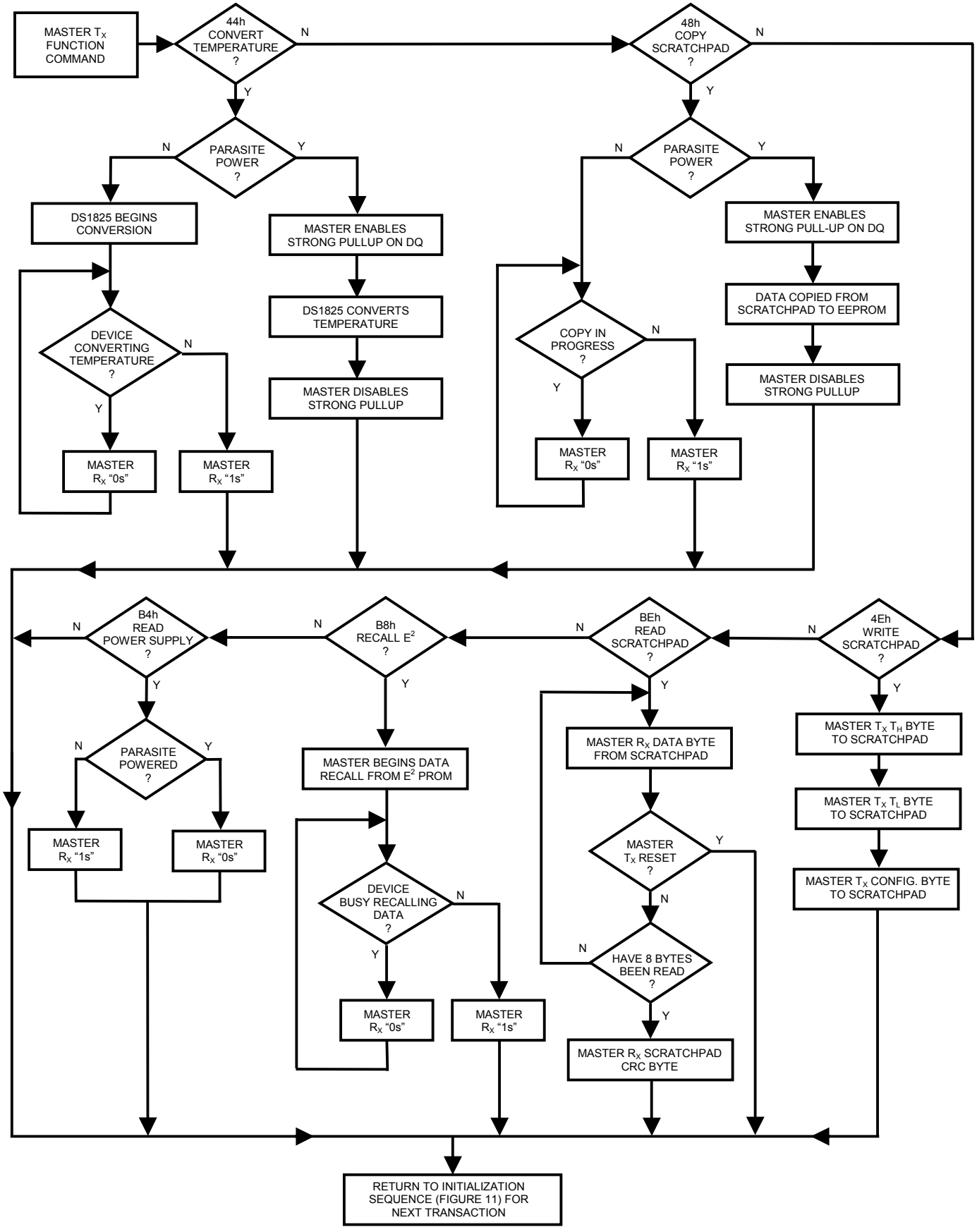


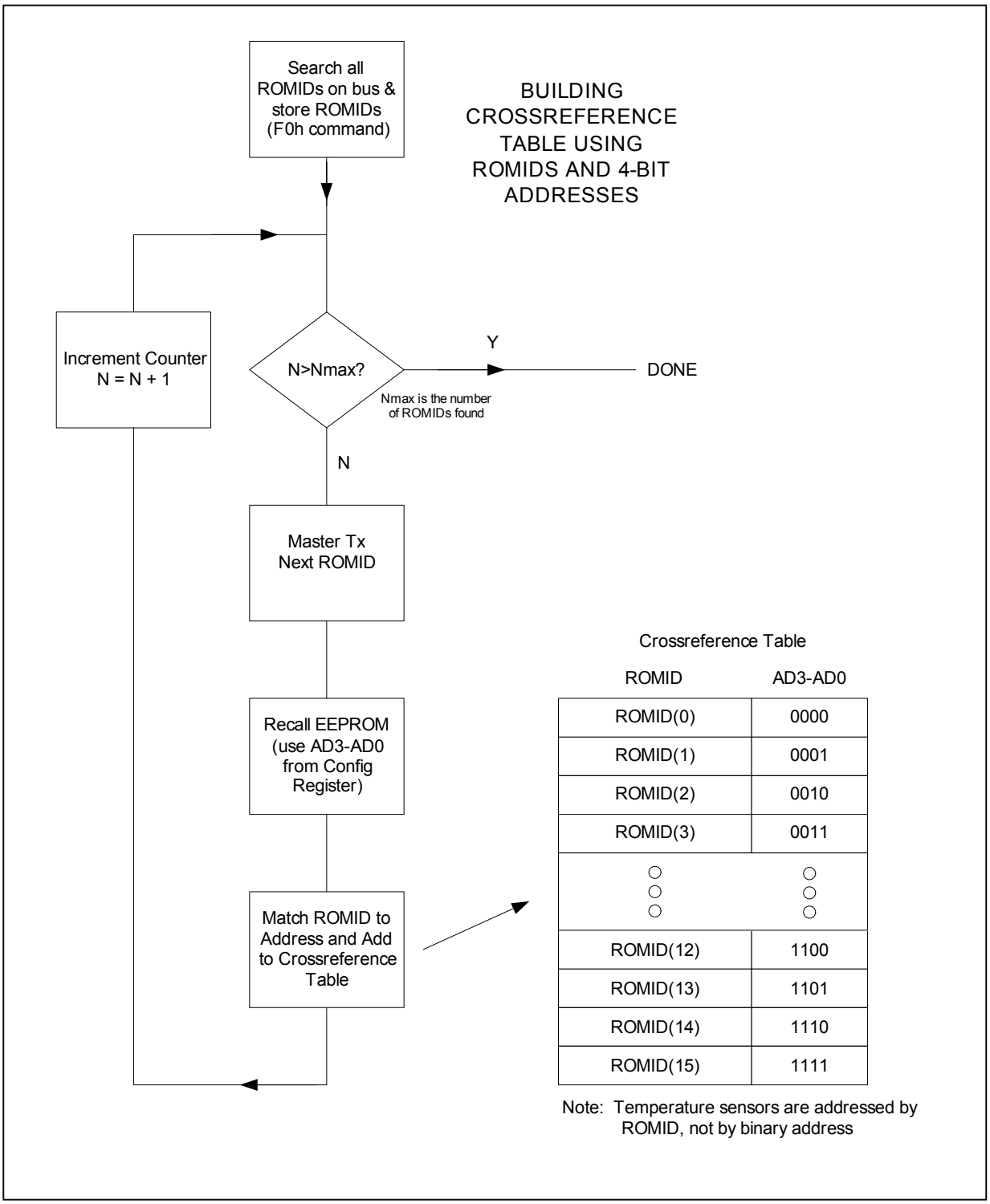
Figure 12. DS1825 FUNCTION COMMANDS FLOW CHART



SUGGESTED PROCEDURE FOR BUILDING CROSS-REFERENCE TABLE

This procedure uses the Search ROM command to find all DS1825s on the one-wire bus (16 maximum) and then reads each configuration register to match the ROMIDs to the hard-wired addresses.

Figure 13



1-Wire SIGNALING

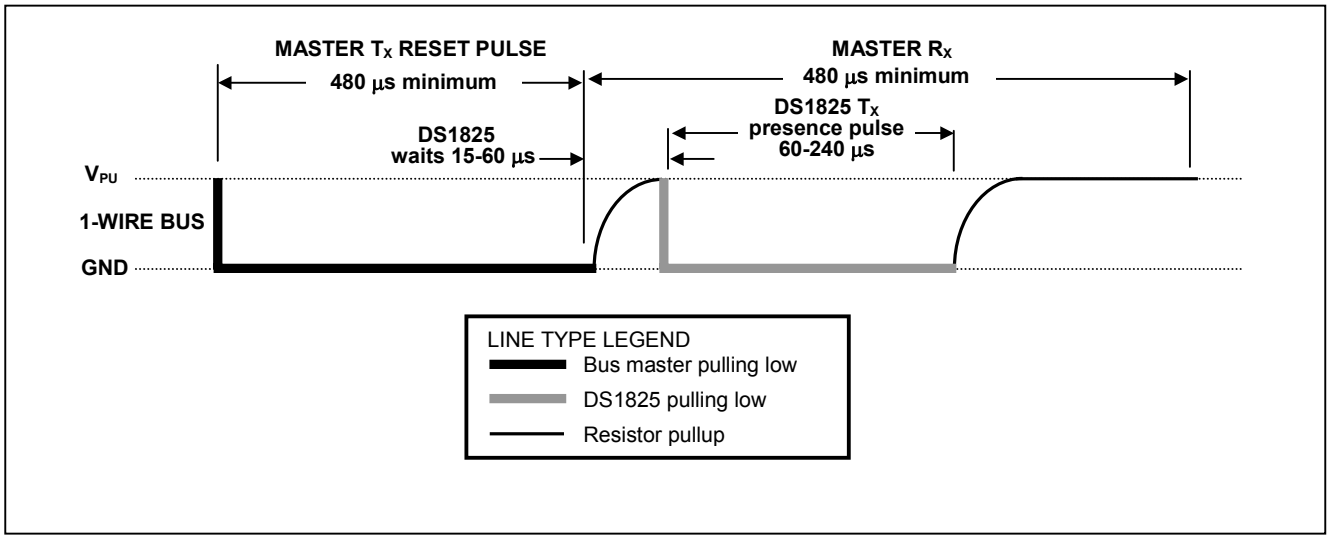
The DS1825 uses a strict 1-Wire communication protocol to insure data integrity. Several signal types are defined by this protocol: reset pulse, presence pulse, write 0, write 1, read 0, and read 1. All of these signals, with the exception of the presence pulse, are initiated by the bus master.

INITIALIZATION PROCEDURE: RESET AND PRESENCE PULSES

All communication with the DS1825 begins with an initialization sequence that consists of a reset pulse from the master followed by a presence pulse from the DS1825. This is illustrated in Figure 13. When the DS1825 sends the presence pulse in response to the reset, it is indicating to the master that it is on the bus and ready to operate.

During the initialization sequence the bus master transmits (T_X) the reset pulse by pulling the 1-Wire bus low for a minimum of 480μs. The bus master then releases the bus and goes into receive mode (R_X). When the bus is released, the 5k pullup resistor pulls the 1-Wire bus high. When the DS1825 detects this rising edge, it waits 15–60μs and then transmits a presence pulse by pulling the 1-Wire bus low for 60–240μs.

Figure 14. INITIALIZATION TIMING



READ/WRITE TIME SLOTS

The bus master writes data to the DS1825 during write time slots and reads data from the DS1825 during read time slots. One bit of data is transmitted over the 1-Wire bus per time slot.

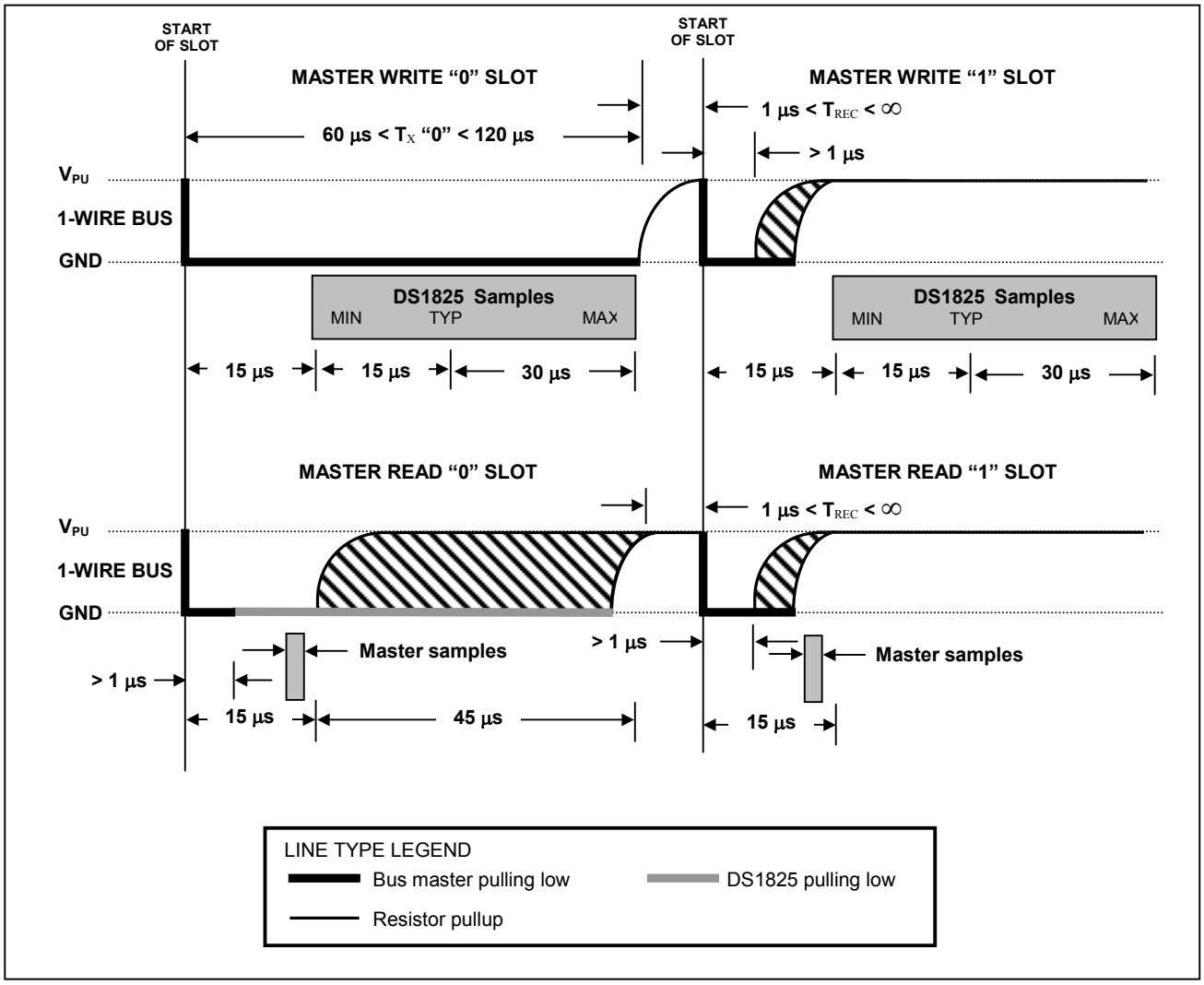
WRITE TIME SLOTS

There are two types of write time slots: “Write 1” time slots and “Write 0” time slots. The bus master uses a Write 1 time slot to write a logic 1 to the DS1825 and a Write 0 time slot to write a logic 0 to the DS1825. All write time slots must be a minimum of 60μs in duration with a minimum of a 1μs recovery time between individual write slots. Both types of write time slots are initiated by the master pulling the 1-Wire bus low (see Figure 14).

To generate a Write 1 time slot, after pulling the 1-Wire bus low, the bus master must release the 1-Wire bus within 15μs. When the bus is released, the 5k pullup resistor will pull the bus high. To generate a Write 0 time slot, after pulling the 1-Wire bus low, the bus master must continue to hold the bus low for the duration of the time slot (at least 60μs).

The DS1825 samples the 1-Wire bus during a window that lasts from 15μs to 60μs after the master initiates the write time slot. If the bus is high during the sampling window, a 1 is written to the DS1825. If the line is low, a 0 is written to the DS1825.

Figure 15. READ/WRITE TIME SLOT TIMING DIAGRAM



READ TIME SLOTS

The DS1825 can only transmit data to the master when the master issues read time slots. Therefore, the master must generate read time slots immediately after issuing a Read Scratchpad [BEh] or Read Power Supply [B4h] command, so that the DS1825 can provide the requested data. In addition, the master can generate read time slots after issuing Convert T [44h] or Recall E^2 [B8h] commands to find out the status of the operation as explained in the DS1825 FUNCTION COMMAND section.

All read time slots must be a minimum of 60µs in duration with a minimum of a 1µs recovery time between slots. A read time slot is initiated by the master device pulling the 1-Wire bus low for a minimum of 1µs and then releasing the bus (see Figure 14). After the master initiates the read time slot, the DS1825 will begin transmitting a 1 or 0 on bus. The DS1825 transmits a 1 by leaving the bus high and transmits a 0 by pulling the bus low. When transmitting a 0, the DS1825 will release the bus by the end of the time slot, and the bus will be pulled back to its high idle state by the pullup resister. Output data from the DS1825 is valid for 15µs after the falling edge that initiated the read time slot. Therefore, the master must release the bus and then sample the bus state within 15µs from the start of the slot.

Figure 15 illustrates that the sum of T_{INIT}, T_{RC}, and T_{SAMPLE} must be less than 15µs for a read time slot. Figure 16 shows that system timing margin is maximized by keeping T_{INIT} and T_{RC} as short as possible and by locating the master sample time during read time slots towards the end of the 15µs period.

Figure 16. DETAILED MASTER READ 1 TIMING

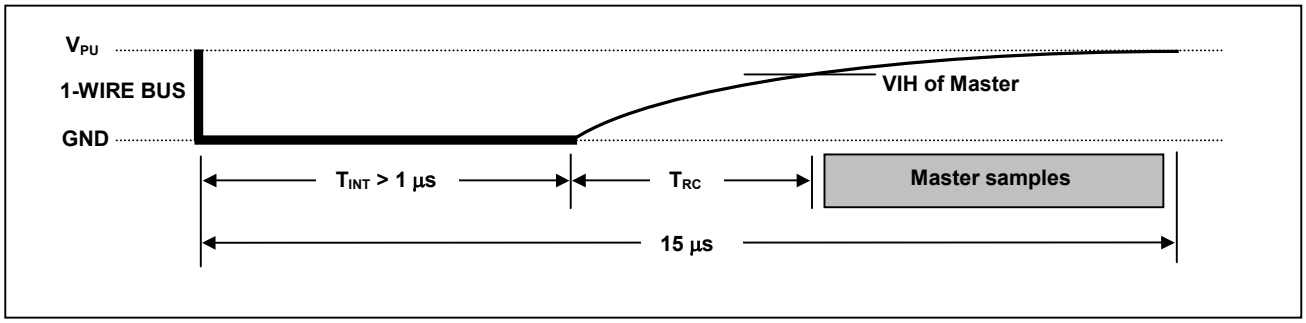
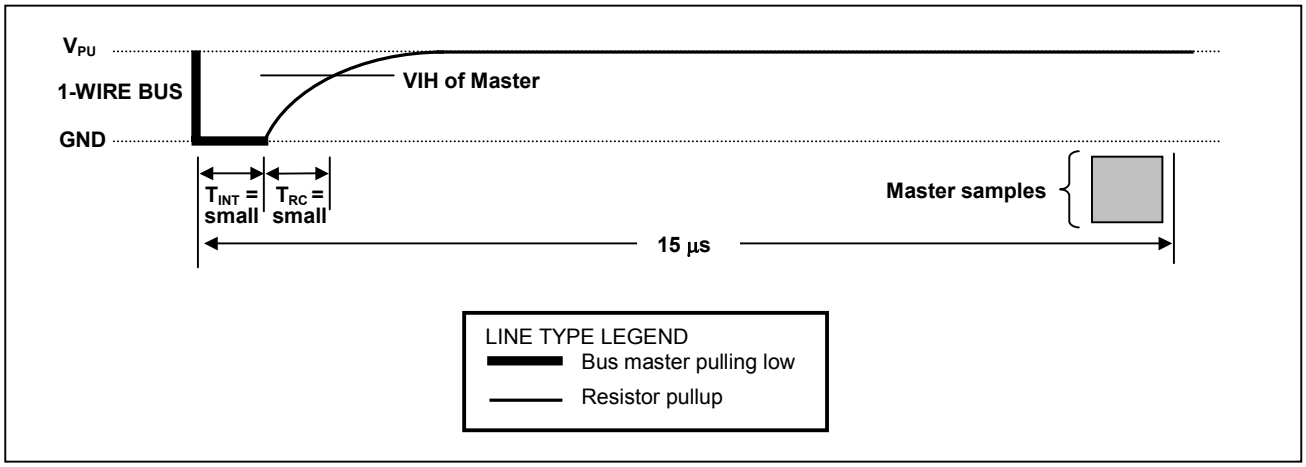


Figure 17. RECOMMENDED MASTER READ 1 TIMING



DS1825 OPERATION EXAMPLE

In this example there are multiple DS1825s on the bus and they are using parasite power. The bus master initiates a temperature conversion in a specific DS1825 and then reads its scratchpad and recalculates the CRC to verify the data.

MASTER MODE	DATA (LSB FIRST)	COMMENTS
TX	Reset	Master issues reset pulse.
RX	Presence	DS1825s respond with presence pulse.
TX	F0h	Master issues Search ROM command and builds Crossreference Table
TX	Reset	Master issues reset pulse.
RX	Presence	DS1825s respond with presence pulse.
TX	55h	Master issues Match ROM command for desired address
TX	64-bit ROM code	Master sends DS1825 ROM code.
TX	44h	Master issues Convert T command.
TX	DQ line held high by strong pullup	Master applies strong pullup to DQ for the duration of the conversion (t_{conv}).
TX	Reset	Master issues reset pulse.
RX	Presence	DS1825s respond with presence pulse.
TX	55h	Master issues Match ROM command.
TX	64-bit ROM code	Master sends DS1825 ROM code.
TX	BEh	Master issues Read Scratchpad command.
RX	9 data bytes	Master reads entire scratchpad including CRC. The master then recalculates the CRC of the first eight data bytes from the scratchpad and compares the calculated CRC with the read CRC (byte 9). If they match, the master continues; if not, the read operation is repeated.

Figure 18. TYPICAL PERFORMANCE CURVE

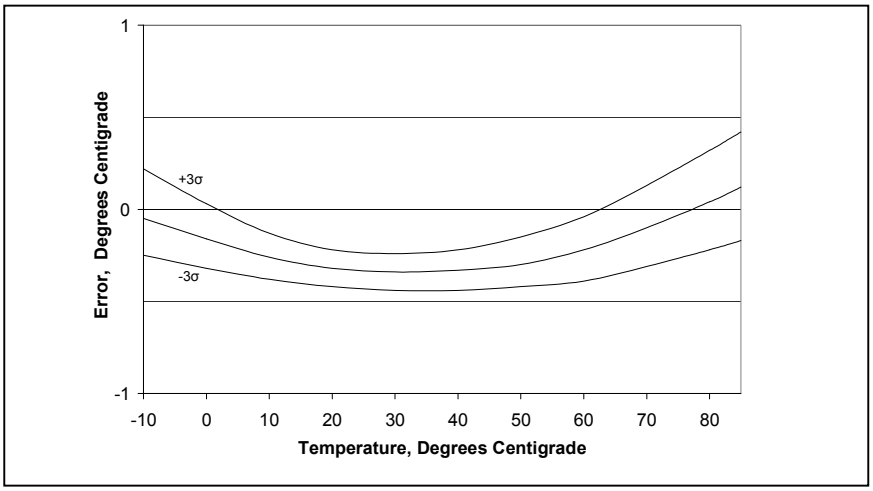


Figure 19. TIMING DIAGRAMS

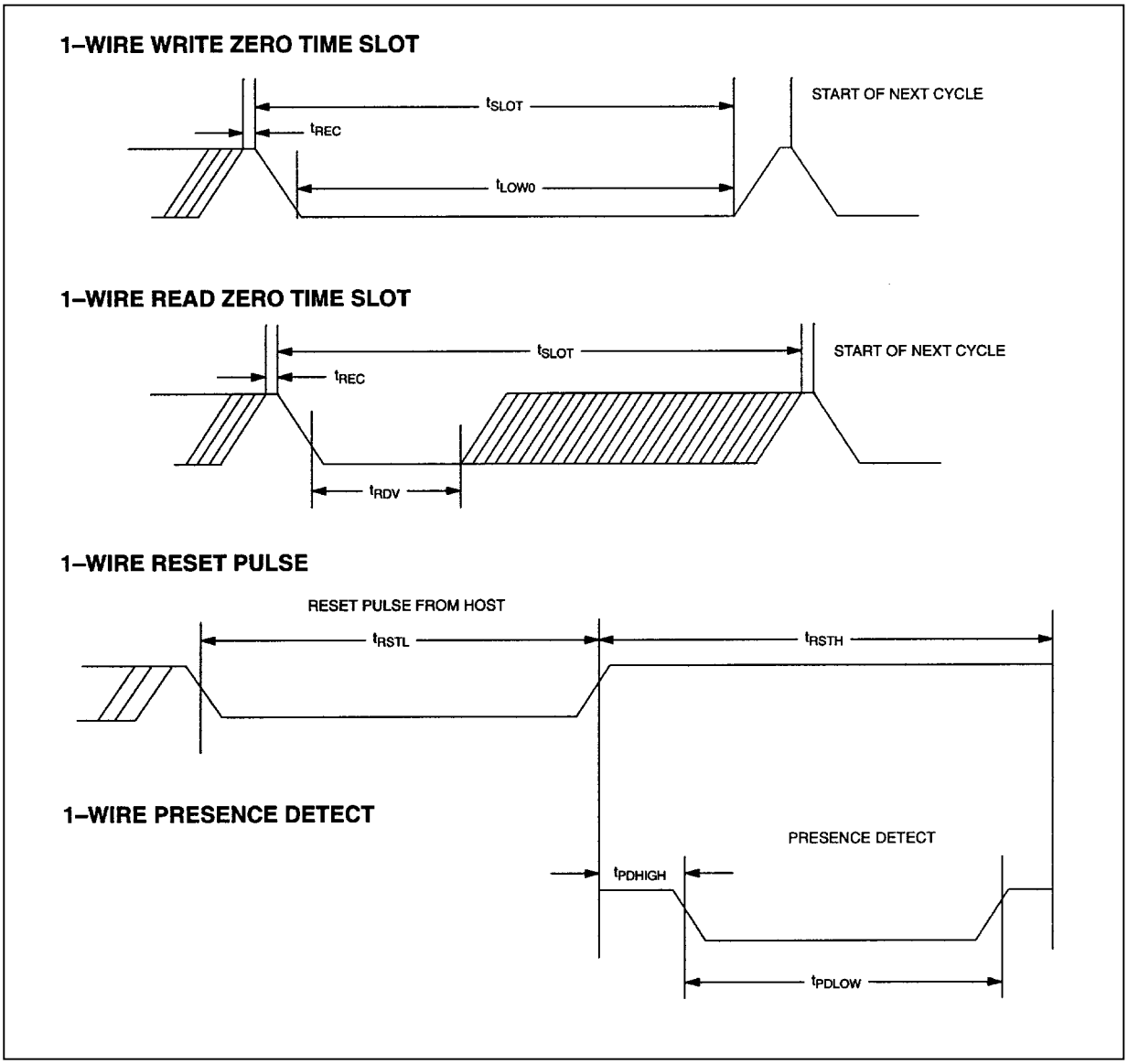
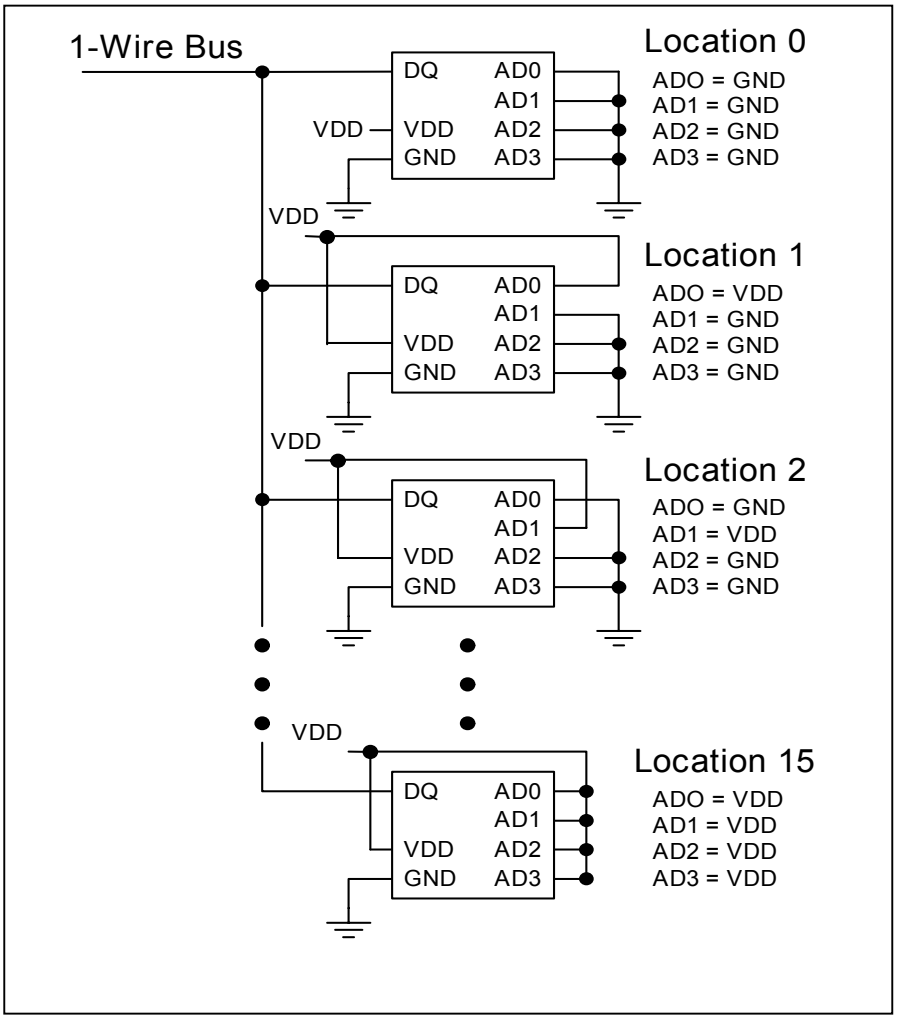
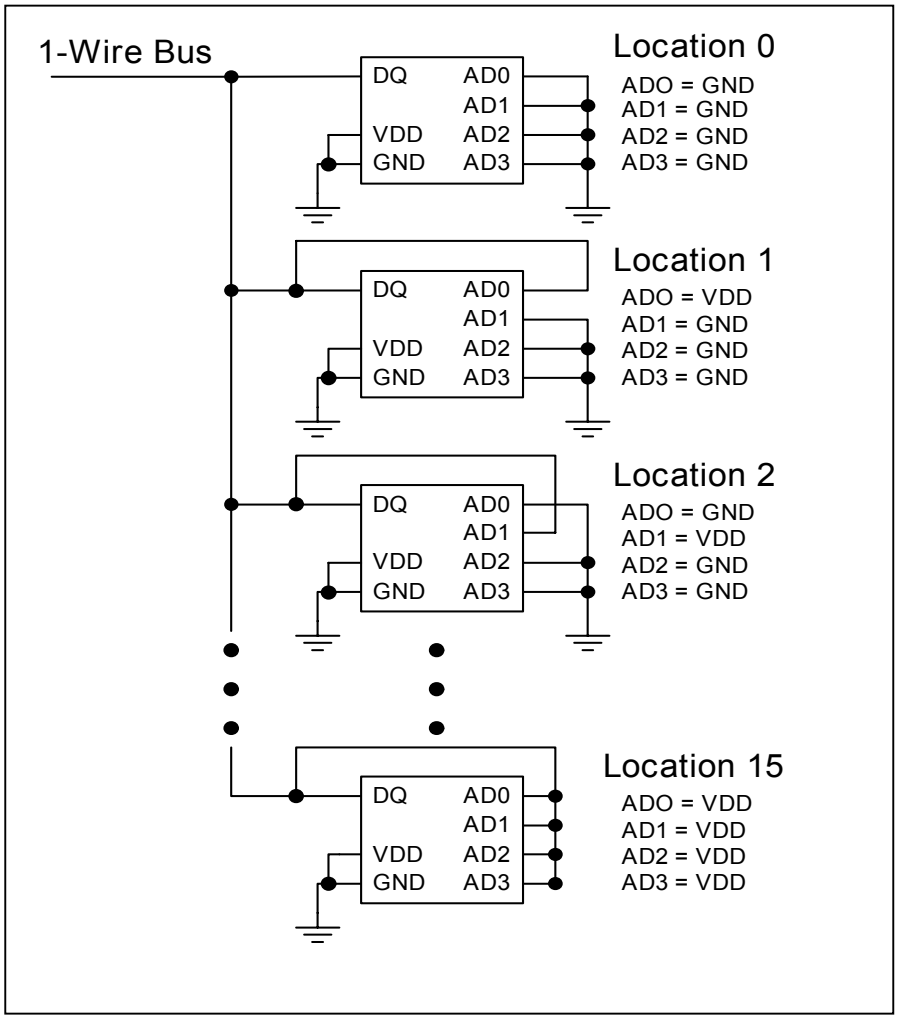


Figure 20. ADDRESS PROGRAMMING DIAGRAM, V_{DD} POWERED



Note: AD0-AD3 cannot float, each pin must be tied to either V_{DD} or GND.

Figure 21. ADDRESS PROGRAMMING DIAGRAM, PARASITE POWERED



Note: AD0-AD3 cannot float, each pin must be tied to either V_{DD} or GND.

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