TD24C16-R
16-Kbit I²C-Compatible Serial EEPROM

GENERAL DESCRIPTION

The TD24C16-R is a 16-Kbit I²C-compatible serial EEPROM device. The device is designed to operate in a supply voltage range of 1.7V to 5.5V, with a maximum of 1MHz transfer rate, over an operating temperature range of -40℃ to +125℃. The device incorporates a Write Protection pin used for Hardware Write Protection on the whole memory array. The device also offers a Software Write Protection feature for users to write protect the whole memory array.

The memory array is organized as 128 pages of 16 bytes each, totaling 2048 × 8 bits. The device offers an additional 16-byte Identification Page for users to store sensitive application parameters. This page can be permanently locked in Read-only mode after the data is written into the Identification Page. The device also offers a separate memory block (in Read-only mode) containing a factory programmed 128-bit Unique ID and can be accessed by sending a specific Read command.

The TD24C16-R is delivered in Lead-free green packages: SOIC-8, TSSOP-8, UTDFN-2×3-8AL, SOT-23-5 and MSOP-8.

FEATURES

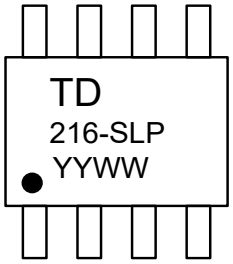
- **Supply Voltage Range: 1.7V to 5.5V**
- **2-Wire Serial Interface I²C Compatible**
  - **400kHz and High Speed 1MHz Transfer Rate Compatibility**
- **Byte and Page (up to 16 Bytes) Write Mode**
  - **Partial Page Write Allowed**
- **Self-timed Write Cycle (3ms MAX)**
- **Hardware and Software Write Protection on the Whole Memory Array**
- **Additional 16-byte Write Lockable Page and 128-bit Unique ID**
- **Schmitt Trigger, Filtered Inputs for Noise Suppression**
- **Low Operating Current**
  - **Write Current: 0.5mA (MAX)**
  - **Read Current: 0.5mA (MAX)**
  - **Standby Current: 1μA (MAX)**
- **High Reliability**
  - **Endurance: 1,000,000 Write Cycles at T_A = +25℃**
  - **Data Retention: 100 Years at T_A = +25℃**
  - **ESD Protection (HBM): 4000V**
- **Operating Temperature Range: -40℃ to +125℃**
- **RoHS Compliant and Halogen Free**
- **Available in Green SOIC-8, TSSOP-8, UTDFN-2×3-8AL, SOT-23-5 and MSOP-8 Packages**

PACKAGE/ORDERING INFORMATION

MODEL	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKING OPTION
TD24C16-R	SOIC-8	-40℃ to +125℃	TD24C16-SLPTR	TD 216-SLP YYWW	Tape and Reel, 4000
	TSSOP-8	-40℃ to +125℃	TD24C16-TLPTR	TD 216-TLP YYWW	Tape and Reel, 5000
	UTDFN-2×3-8AL	-40℃ to +125℃	TD24C16-ULPTR	TD216ULP YYWW	Tape and Reel, 3000
	SOT-23-5	-40℃ to +125℃	TD24C16-OLPTR	TD216 YYWW	Tape and Reel, 3000
	MSOP-8	-40℃ to +125℃	TD24C16-MLPTR	TD 216-MLP YYWW	Tape and Reel, 5000

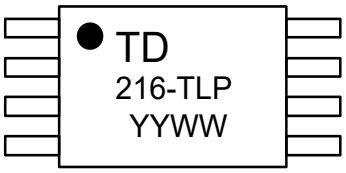
MARKING INFORMATION

SOIC-8



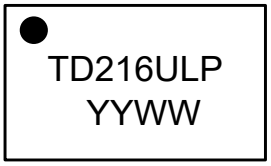
TD: SGMICRO Logo
216-SLP: TD24C16-SLP
YYWW: Date Code,
YY = year, WW = week
Example: 2040 = year 2020 and week 40

TSSOP-8



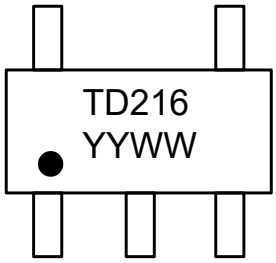
TD: SGMICRO Logo
216-TLP: TD24C16-TLP
YYWW: Date Code,
YY = year, WW = week
Example: 2040 = year 2020 and week 40

UTDFN-2×3-8AL



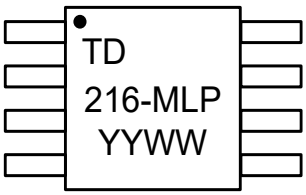
TD: SGMICRO Logo
216ULP: TD24C16-ULP
YYWW: Date Code,
YY = year, WW = week
Example: 2040 = year 2020 and week 40

SOT-23-5



TD: SGMICRO Logo
216: TD24C16-OLP
YYWW: Date Code,
YY = year, WW = week
Example: 2040 = year 2020 and week 40

MSOP-8



TD: SGMICRO Logo
216-MLP: TD24C16-MLP
YYWW: Date Code,
YY = year, WW = week
Example: 2040 = year 2020 and week 40

Green (RoHS & HSF): SG Micro Corp defines "Green" to mean Pb-Free (RoHS compatible) and free of halogen substances. If you have additional comments or questions, please contact your SGMICRO representative directly.

ABSOLUTE MAXIMUM RATINGS

Supply Voltage, V_{CC} ..... -0.5V to 6V
Voltage on Input Pins, V_{IN} ..... -0.5V to 6V
Ambient Temperature with Power Applied ... -55℃ to +130℃
Storage Temperature Range ..... -65℃ to +150℃
ESD Susceptibility
HBM 4000V

RECOMMENDED OPERATING CONDITIONS

Operating Ambient Temperature Range ..... -40℃ to +125℃

OVERSTRESS CAUTION

Stresses beyond those listed in Absolute Maximum Ratings may cause permanent damage to the device. Exposure to absolute maximum rating conditions for extended periods may affect reliability. Functional operation of the device at any conditions beyond those indicated in the Recommended Operating Conditions section is not implied.

ESD SENSITIVITY CAUTION

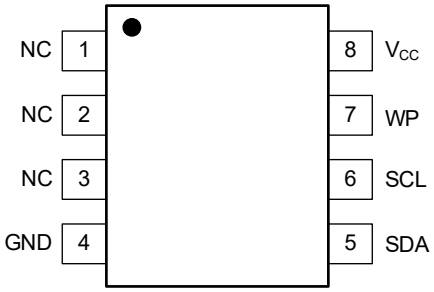
This integrated circuit can be damaged if ESD protections are not considered carefully. SGMICRO recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because even small parametric changes could cause the device not to meet the published specifications.

DISCLAIMER

SG Micro Corp reserves the right to make any change in circuit design, or specifications without prior notice.

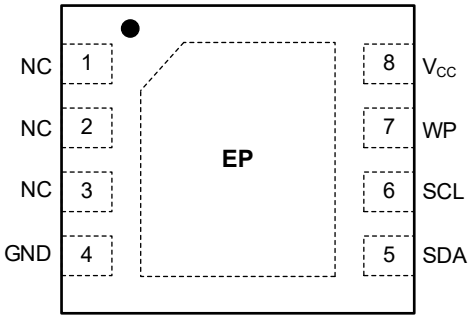
PIN CONFIGURATIONS

(TOP VIEW)



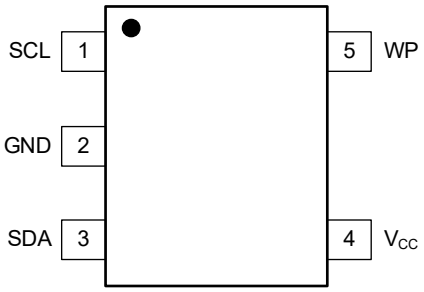
SOIC-8/TSSOP-8/MSOP-8

(TOP VIEW)



UTDFN-2×3-8AL

(TOP VIEW)



SOT-23-5

PIN DESCRIPTION

NAME	TYPE	FUNCTION
SDA	I/O	Serial Data. The SDA pin is an open-drain bidirectional input/output pin used to serially transfer data to and from the device.
SCL	I	Serial Clock. The SCL pin is used to provide a clock to the device and is used to control the flow of data to and from the device. Command and input data present on the SDA pin is always latched in on the rising edge of SCL, while output data on the SDA pin is always clocked out on the falling edge of SCL.
V_{CC}	P	Device Power Supply. The V_{CC} pin is used to supply the source voltage to the device. Operations at invalid V_{CC} voltages may produce spurious results and should not be attempted.
GND	P	Ground. The ground reference for the power supply. GND should be connected to the system ground.
WP	I	Write Protection. The WP pin is used to write protect the entire contents of the memory. When the WP pin is connected to Power Supply, the entire memory array becomes Write-protected, that is, the device becomes Read-only. When the WP pin is connected to GND, Write operations are enabled. If the pin is left floating, the WP pin will be internally pulled down to GND. When the WP pin is driven high, the device address byte and the word address bytes are acknowledged, data bytes are not acknowledged.

NOTE: I = input, I/O = input/output, P = power.

ELECTRICAL CHARACTERISTICS

DC Characteristics

(Operating range: T_A = -40℃ to +125℃, V_{CC} = 1.7V to 5.5V, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MIN	MAX	UNITS
Supply Voltage	V_{CC}		1.7	5.5	V
Supply Current (Read)	I_{CC1}	V_{CC} = 1.7V, Read at 1MHz		0.2	mA
		V_{CC} = 5.5V, Read at 400kHz		0.4	
		V_{CC} = 5.5V, Read at 1MHz		0.5	
Supply Current (Write)	I_{CC2}	V_{CC} = 1.7V, Write at 400kHz		0.2	mA
		V_{CC} = 5.5V, Write at 400kHz		0.5	
Standby Current	I_{SB}	V_{CC} = 1.7V, V_{IN} = V_{CC} or GND		0.5	μA
		V_{CC} = 5.5V, V_{IN} = V_{CC} or GND		1.0	
Input Leakage Current	I_{LI}	V_{IN} = V_{CC} or GND		1.0	μA
Output Leakage Current	I_{LO}	V_{OUT} = V_{CC} or GND		1.0	μA
Input Low-Level Voltage (SDA, SCL)	V_{IL}		-0.5	0.3 × V_{CC}	V
Input High-Level Voltage (SDA, SCL)	V_{IH}		0.7 × V_{CC}	V_{CC} + 0.5	V
Low-Level Output Voltage	V_{OL1}	V_{CC} > 2V, I_{OL} = 3mA		0.4	V
Low-Level Output Voltage	V_{OL2}	V_{CC} ≤ 2V, I_{OL} = 2mA		0.2	V

AC Characteristics

(Operating range: T_A = -40℃ to +125℃, V_{CC} = 1.7V to 5.5V, C_L = 100pF. Measurement conditions: input rise and fall time ≤ 50ns; input pulse voltages: 0.2 × V_{CC} to 0.8 × V_{CC}; input and output timing reference voltages: 0.3 × V_{CC} to 0.7 × V_{CC}; unless otherwise noted.)

PARAMETER	SYMBOL	FAST MODE V_{CC} = 1.7V to 5.5V		HIGH SPEED MODE V_{CC} = 1.7V to 5.5V		UNITS
		MIN	MAX	MIN	MAX	
Clock Frequency, SCL	f_{SCL}		400		1000	kHz
Clock Pulse Width Low	t_{LOW}	1300		600		ns
Clock Pulse Width High	t_{HIGH}	600		260		ns
SDA Rise Time	t_R (1)		300		300	ns
SDA (Out) Fall Time	t_F (1)		300		100	ns
Start Hold Time	$t_{HD.STA}$	600		250		ns
Start Setup Time	$t_{SU.STA}$	600		250		ns
Stop Setup Time	$t_{SU.STO}$	600		250		ns
Bus Free Time between Stop and Next Start	t_{BUF}	1300		500		ns
Data In Hold Time	$t_{HD.DI}$	0.0		0.0		ns
Data In Setup Time	$t_{SU.DAT}$	100		50		ns
Data Out Hold Time	$t_{HD.DAT}$	50		50		ns
SCL Low to Data Out Valid	t_{AA}	100	900	50	500	ns
WP Pin Setup Time	$t_{SU.WP}$	1200		600		ns
WP Pin Hold Time	$t_{HD.WP}$	1200		600		ns
Write Cycle Time	t_{WR}		3		3	ms
Noise Suppression Time	t_I		50		50	ns

NOTE: 1. This parameter is ensured by characterization only.

ELECTRICAL CHARACTERISTICS (continued)

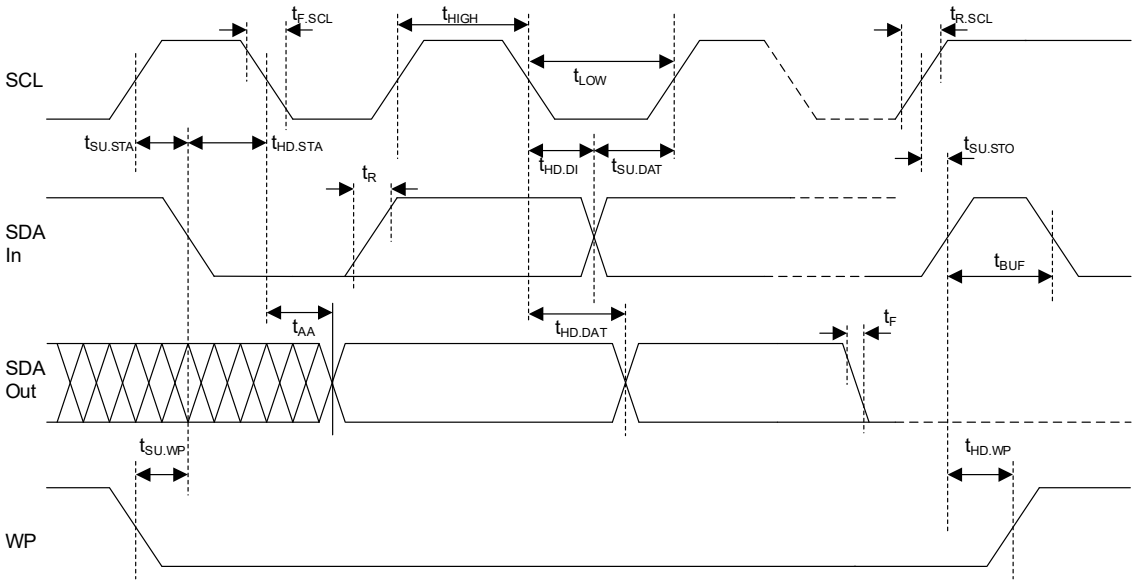


Figure 1. Bus Timing

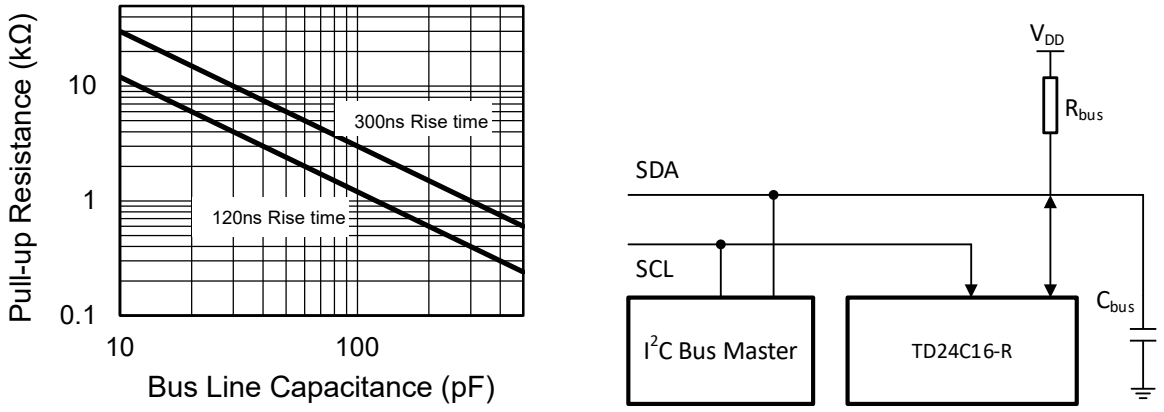


Figure 2. Maximum Pull-up Resistance vs. Bus Parasitic Capacitance

Pin Capacitance

PARAMETER (1)	SYMBOL	CONDITIONS	MAX	UNITS
Input/Output Capacitance (SDA)	$C_{I/O}$	$V_{I/O}$ = 0V	8	pF
Input Capacitance (Other Pins)	C_{IN}	V_{IN} = 0V	6	pF

NOTE: 1. These parameters are ensured by characterization only.

Reliability Characteristics

PARAMETER	SYMBOL	CONDITIONS	MIN	UNITS
Write Cycle Endurance	N_W	T_A = +25℃, Page mode	1×10^6	cycle
		T_A = +125℃, Page mode	1×10^5	
Data Retention	D_R	T_A = +25℃	100	year

FUNCTIONAL BLOCK DIAGRAM

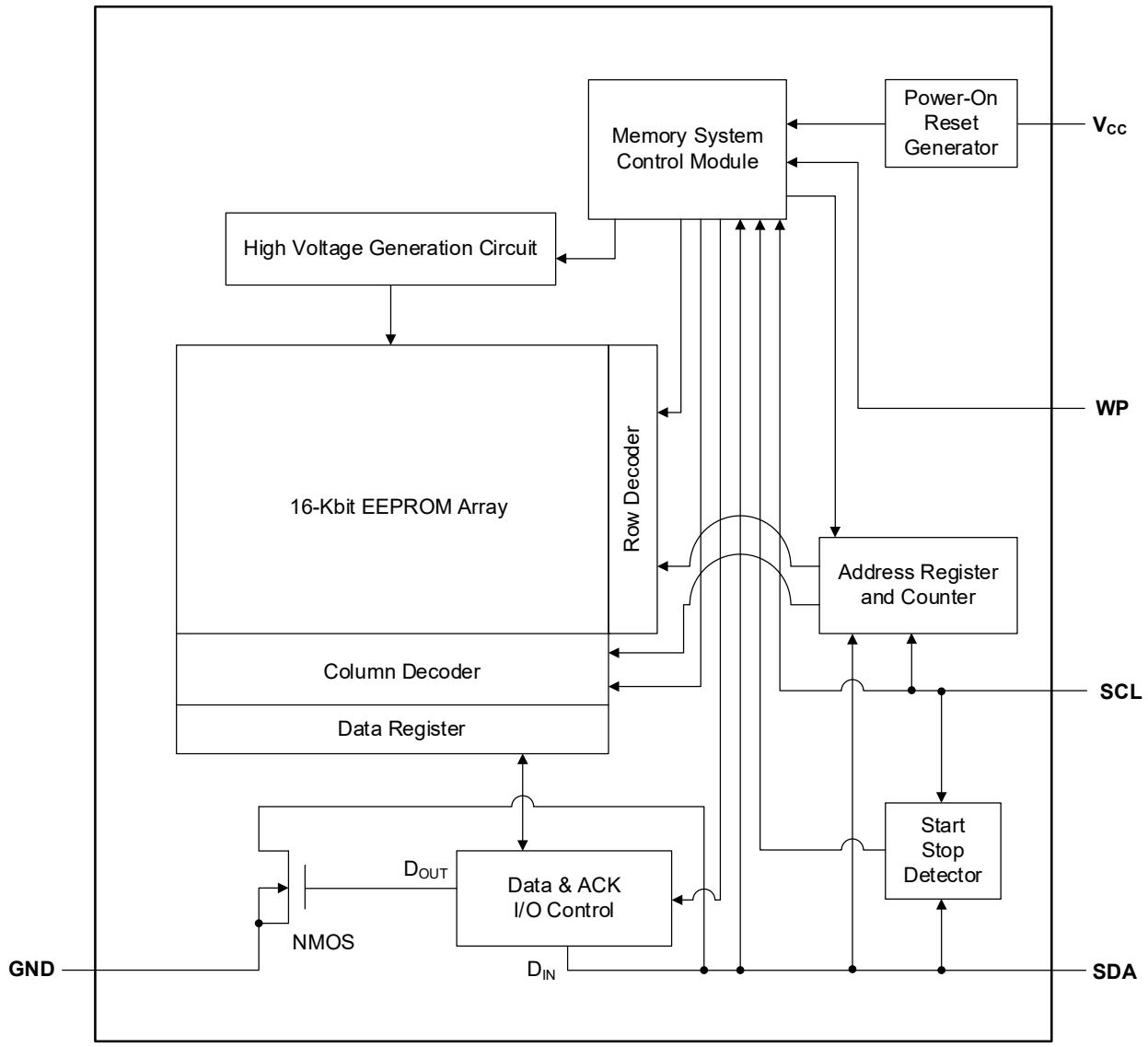


Figure 3. Block Diagram

DEVICE COMMUNICATION

The TD24C16-R operates as a slave device and utilizes a 2-wire serial interface to communicate with the Master. The Master initiates and controls all Read and Write operations to the slave devices on the serial bus, and both the Master and the slave devices can transmit and receive data on the bus.

The serial interface is comprised of just two signal lines: the Serial Clock (SCL) and the Serial Data (SDA). Data is always latched into the TD24C16-R on the rising edge of SCL and is always output from the device on the falling edge of SCL. Both the SCL pin and SDA pin incorporate integrated spike suppression filters and Schmitt Triggers to minimize the effects of input spikes and bus noise.

All command and data information is transferred with the Most Significant Bit (MSB) first. During the bus communication, one data bit is transmitted every clock cycle, and after eight bits of data has been transferred, the receiving device must respond with an acknowledge or a no-acknowledge response bit during a ninth clock cycle generated by the Master. Therefore, nine clock cycles are required for every one byte of data transferred. There is no unused clock cycle during any Read or Write operation, so there must not be any interruptions or breaks during the data stream.

During data transfers, data on the SDA pin must only change while SCL is low, and the data must remain stable while SCL is high. If data on the SDA pin changes while SCL is high, then either a Start or a Stop condition will occur. The number of data bytes transferred between a Start and a Stop condition is not limited and is determined by the Master.

Start Condition

A Start condition occurs when there is a high-to-low transition on the SDA pin while the SCL pin is stable in Logic 1 state. The Start condition must precede any command as the Master uses a Start condition to initiate any data transfer sequence (see Figure 4). The TD24C16-R will continuously monitor the SDA and SCL pins for a Start condition, and the device will not respond unless one is given.

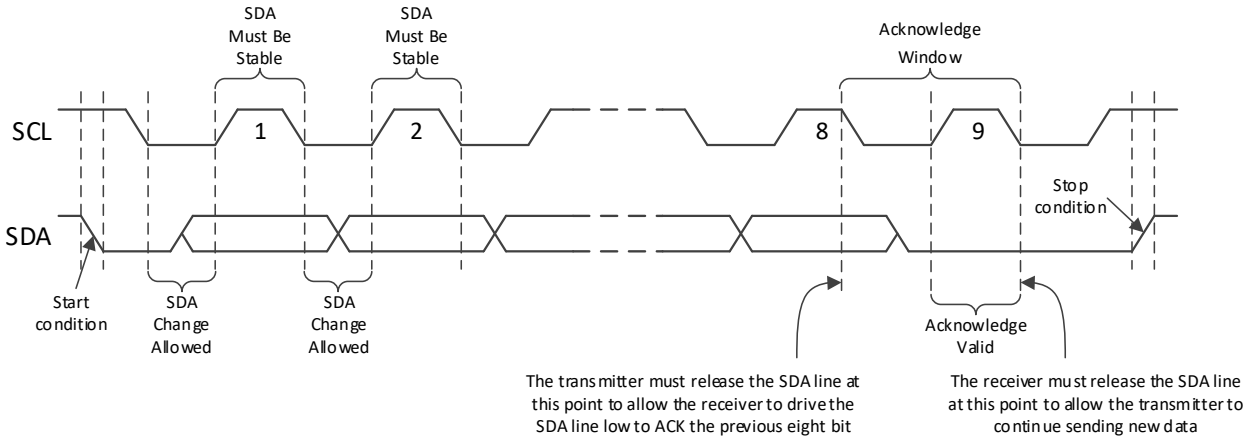


Figure 4. Start, Stop, and ACK

Stop Condition

A Stop condition occurs when there is a low-to-high transition on the SDA pin while the SCL pin is stable in Logic 1 state (see Figure 4). A stop condition terminates communication between the device and the Master. A Stop condition at the end of a Write command triggers the EEPROM internal write cycle. Otherwise, the device subsequently returns to Standby mode after receiving a Stop condition.

Acknowledge (ACK)

After each byte of data is received, the TD24C16-R should acknowledge to the Master that it has received the data byte successfully. This is accomplished by the Master first releasing the SDA line and providing the ACK/NACK clock cycle (a ninth clock cycle for every byte). During the ACK/NACK clock cycle, the device must output Logic 0 as ACK for the entire clock cycle so that the SDA line must be stable in Logic 0 state during the entire high period of the clock cycle (see Figure 4).

DEVICE COMMUNICATION (continued)

Standby Mode

The TD24C16-R features a low-power Standby mode which is enabled:

(1) Upon power-up;

(2) After the receipt of a Stop condition in Read operation;

(3) The completion of any internal operations.

Software Reset

After an interruption in protocol, power loss, or system reset, any 2-wire part can be reset by following these steps: (1) Create a Start condition; (2) Clock nine cycles; (3) Create another Start condition followed by a Stop condition (see Figure 5).

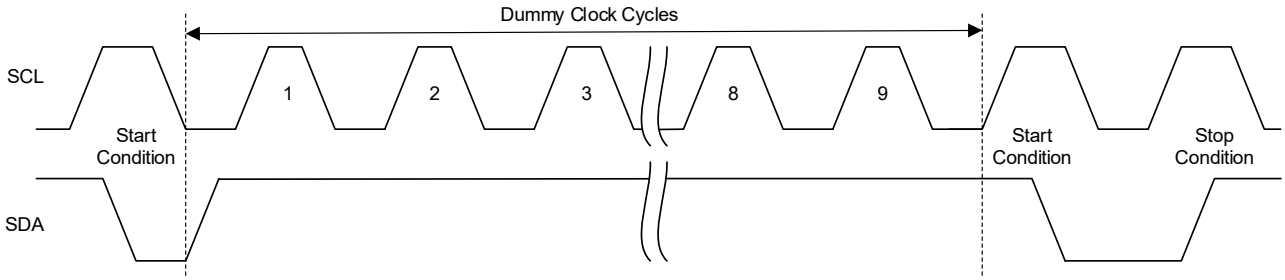


Figure 5. 2-Wire Software Reset

Device Reset and Initialization

The TD24C16-R incorporates a Power-On Reset (POR) circuit to prevent inadvertent operations during power-up. On a cold power-up, the device does not respond to any instructions until the supply voltage reaches the internal power-on reset threshold voltage (V_{POR}). The supply voltage must rise continuously between V_{POR} and minimum V_{CC} without any ring back to ensure a proper power-up. Once the supply voltage passes V_{POR}, the device is reset and enters Standby mode. However, no protocol should be issued to the device until a valid and stable supply voltage is applied. The supply voltage must remain stable and valid until the end of the protocol transmission, and for a Write instruction, until the end of the internal write cycle.

This POR behavior is bi-directional. It protects the TD24C16-R against brown-out failure caused by a temporary loss of power. In a similar way, as soon as the supply voltage drops below the internal brown-out reset threshold voltage (V_{BOR}), the device is reset and stops responding to any instructions.

Data Security

The TD24C16-R incorporates a hardware data protection feature that allows the user to write protect the whole memory array (and Identification Page) when the WP pin is connected directly to V_{CC}.

The TD24C16-R also offers a Software Write Protection (SWP) feature that allows the user to write protect the whole memory array (and Identification Page) when the internal non-volatile SWP bit is set to Logic 1 (see ***Software Write Protection (SWP)*** section for details).

DEVICE ADDRESSING

The TD24C16-R requires a 7-bit device address and a Read/Write select bit following a Start condition from the Master to initiate communication with the serial EEPROM. The device address byte is comprised of a 4-bit device type identifier followed by 3 device address bits and a R/$\overline{W}$ select bit, and is clocked by the Master on the SDA pin with the most significant bit (MSB, bit 7) first.

The device will respond to two unique device type identifiers. The device type identifier of '1010' is necessary to select the device memory for normal Read or Write operation. The device type identifier of '1011' is used (1) to select the Identification Page for Read or Write/Lock operation; (2) to select the Software Write Protection bit for Read or Write operation; (3) for Read Unique ID (see Table 1).

The 8th bit of the address byte is the R/$\overline{W}$ operation selection bit. A Read operation is selected if this bit is Logic 1, and a Write operation is selected if this bit is Logic 0. Upon a compare of the device address byte, the TD24C16-R outputs an ACK or an NACK during the 9th clock cycle if the compare is true or not true, respectively. The device will return to the low-power Standby mode after an NACK.

Table 1. TD24C16-R Device Address Byte

FUNCTION	DEVICE TYPE IDENTIFIER				DEVICE ADDRESS			READ/WRITE
	BIT 7	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1	BIT 0
When accessing the 16-Kbit memory array	1	0	1	0	A10 (1)	A9	A8	R/W
When accessing the Identification Page	1	0	1	1	X (2)	X	X	R/W
When accessing the Lock Identification Page bit	1	0	1	1	X	X	X	0
When accessing the Software Write Protection bit	1	0	1	1	X	X	X	R/W
When accessing the Unique ID	1	0	1	1	X	X	X	1

NOTES:

1. A = Significant address bit.
2. X = Bit is Don't Care.

Once the TD24C16-R has acknowledged the device address byte, the device waits for the Master to send the word address byte for a certain Read or Write instruction according to Table 2. The device should respond to the word address byte with an ACK.

Table 2. TD24C16-R Word Address Bits

FUNCTION	MSB WORD ADDRESS BITS			WORD ADDRESS BYTE							
	BIT 3 (1)	BIT 2 (1)	BIT 1 (1)	BIT 7	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1	BIT 0
Random Read	A10 (2)	A9	A8	A7	A6	A5	A4	A3	A2	A1	A0
Byte/Page Write	A10	A9	A8	A7	A6	A5	A4	A3	A2	A1	A0
Read/Write Identification Page	X (3)	X	X	0	0	X	X	A3	A2	A1	A0
Lock Identification Page	X	X	X	0	1	X	X	X	X	X	X
Read Lock Status	X	X	X	0	0	X	X	X	X	X	X
Read/Write SWP Bit	X	X	X	1	1	X	X	X	X	X	X
Read Unique ID	X	X	X	1	0	X	X	A3	A2	A1	A0

NOTES:

1. Address bits defined inside the Device Address Byte (see Table 1).
2. A = Significant address bit.
3. X = Bit is Don't Care.

READ AND WRITE OPERATIONS

Write Operations

Byte Write

For a Byte Write operation, the Master sends a Start condition followed by the device type identifier of '1010', the device address bits and the R/$\overline{W}$ select bit set to Logic 0. The TD24C16-R responds with an ACK during the ninth clock cycle and waits for the Master to send one word address byte. Then the device responds to the word address byte with an ACK. After receiving ACK from the TD24C16-R, the Master transmits one data byte. If the addressed location has been Write-protected, by the WP pin connected to V_{CC} or the SWP bit set to Logic 1, the device responds with an NACK, and the location is not modified. If the addressed location is not Write-protected, by the WP pin set to GND and the SWP bit set to Logic 0, the device will respond with an ACK (see Figure 6 and Figure 7). The Master ends the Byte Write sequence with a Stop condition during the 10th clock cycle to initiate the internally self-timed write cycle. A Stop condition issued during any other clock cycle during the Write operation will not trigger the internal write cycle.

Once the write cycle begins, the preloaded data word will be programmed in the amount of time not to exceed the t_{WR} specification (see Figure 10). During the time, the Master should wait a fixed time by the t_{WR} specification, or for time sensitive applications, an ACK polling routine can be implemented. All inputs are ignored by the device during the write cycle and the device will not respond until the write cycle is completed. The serial EEPROM will increment its internal address counter each time a byte is written.

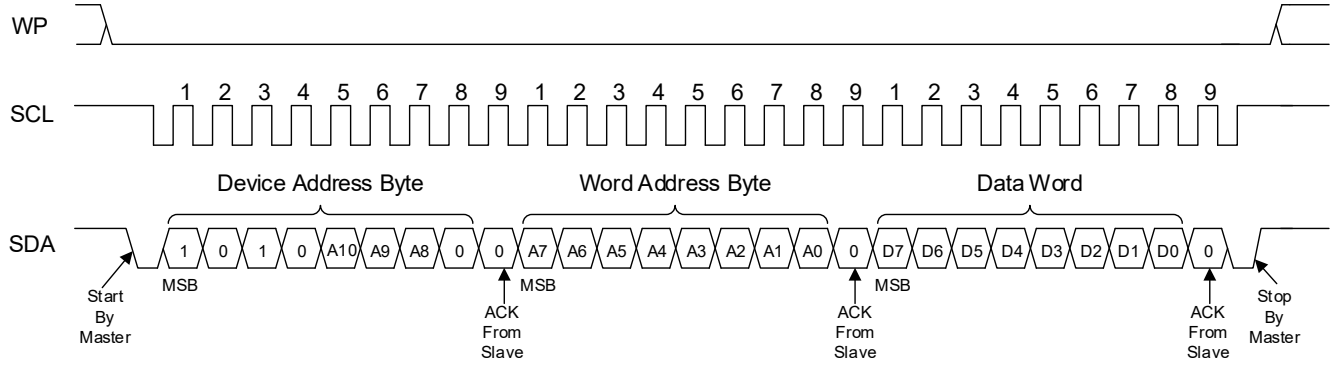


Figure 6. Byte Write Operation with Write Protection Pin Set to Low (and SWP bit = 0)

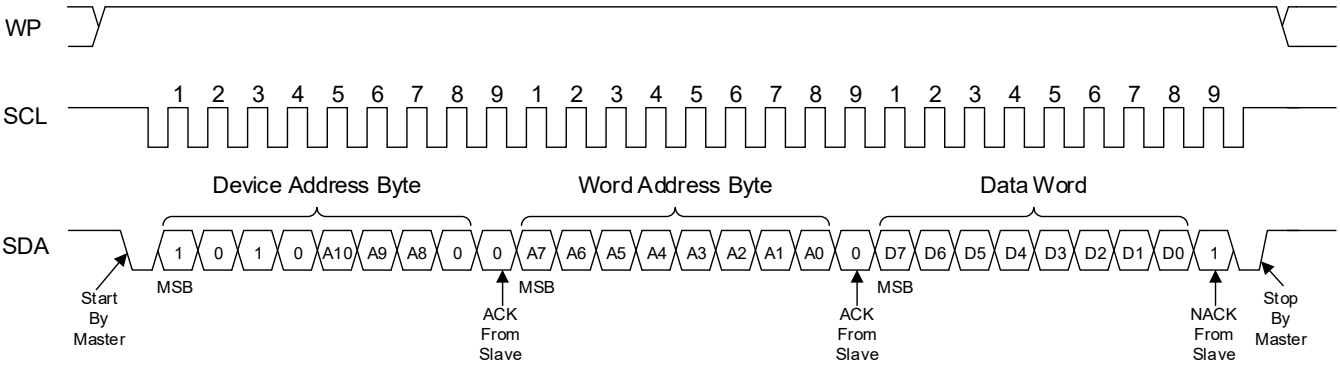


Figure 7. Byte Write Operation with Write Protection Pin Set to High (or SWP bit = 1)

READ AND WRITE OPERATIONS (continued)

Page Write

The 16-Kbit serial EEPROM is capable of writing up to 16 data bytes at a time by executing the Page Write protocol sequence. A partial or full Page Write operation is initiated the same as a Byte Write operation except that the Master does not send a Stop condition after the first data word is clocked in. Instead, after the device has acknowledged to the first data word, the Master can transmit up to 15 more data words. The device responds with an ACK after each data word is received if the WP pin is set to GND and the SWP bit set to Logic 0, while the device is not acknowledged to each data word and the addressed locations are not modified if the WP pin is connected to V_{CC} or the SWP bit set to Logic 1 (see Figure 8 and Figure 9). After the device acknowledges to the last data word, the Master should terminate the Page Write sequence with a Stop condition to start the internal write cycle. A Stop condition issued at any other clock cycle will not initiate the internally self-timed write cycle and the Write sequence will have to be repeated again. Once the write cycle begins, the data words should be programmed in the amount of time not exceeding the t_{WR} specification (see Figure 10). During this time, the Master should wait a fixed time by the specified t_{WR} parameter, or for time sensitive applications, an ACK polling routine can be implemented.

The lower 4 bits of the word address are internally incremented following the receipt of each data word. The higher word address bits are not incremented, retaining the memory page row location. When the internally generated word address reaches the page boundary, then the following data word is placed at the beginning of the same page. If more than 16 data words are transmitted to the device, the data word address will roll over and the previous data will be overwritten. The address roll-over during a Write sequence is from the last byte of the current page to the first byte of the same page.

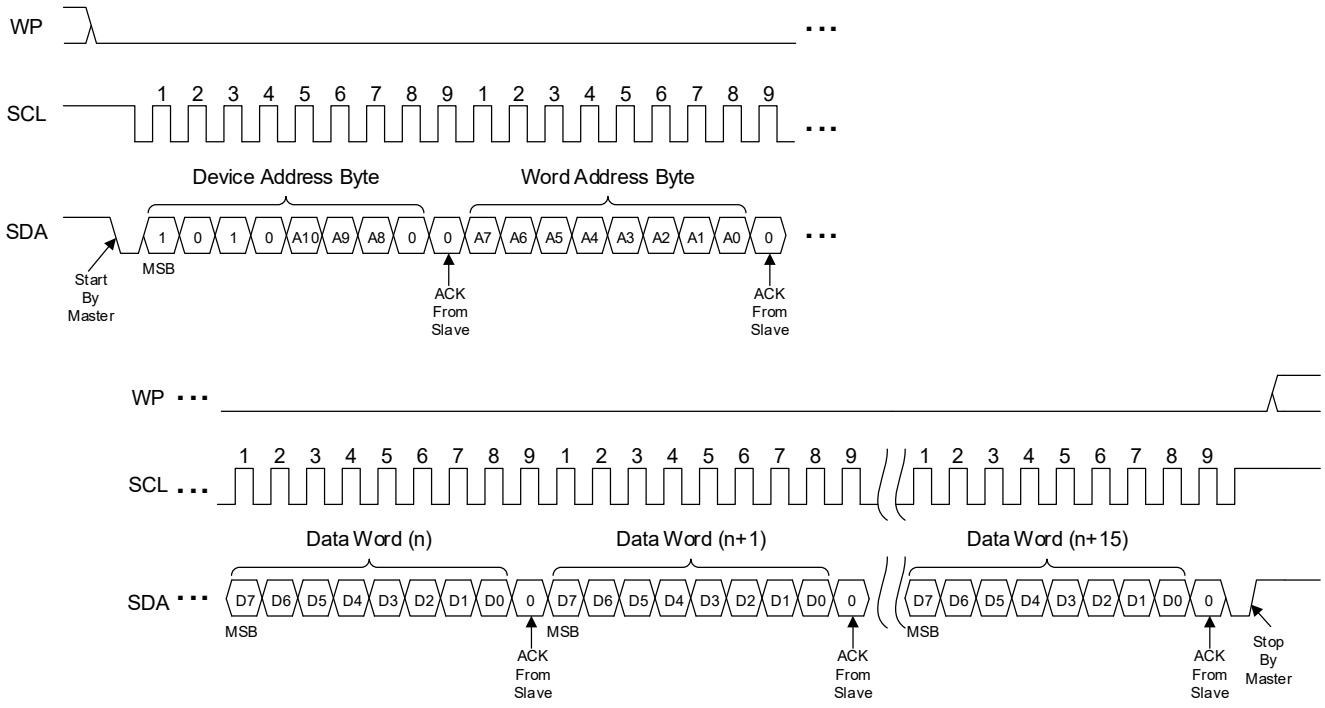


Figure 8. Page Write Operation with Write Protection Pin Set to Low (and SWP bit = 0)

READ AND WRITE OPERATIONS (continued)

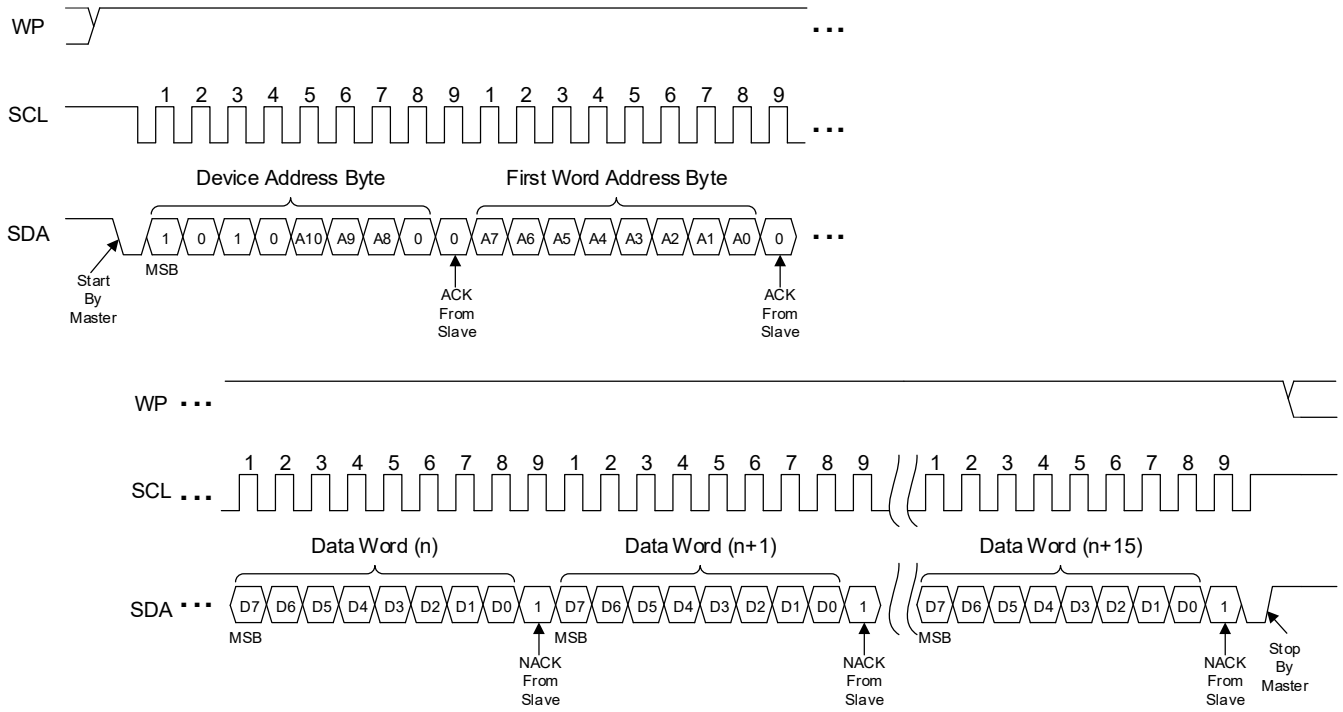


Figure 9. Page Write Operation with Write Protection Pin Set to High (or SWP bit = 1)

Write Cycle Timing

The length of the self-timed write cycle, or t_{WR}, is defined as the amount of time from a valid Stop condition that begins the internal write sequence to the Start condition of the first device address byte sent to the TD24C16-R that it subsequently responds to with an ACK (see Figure 10).

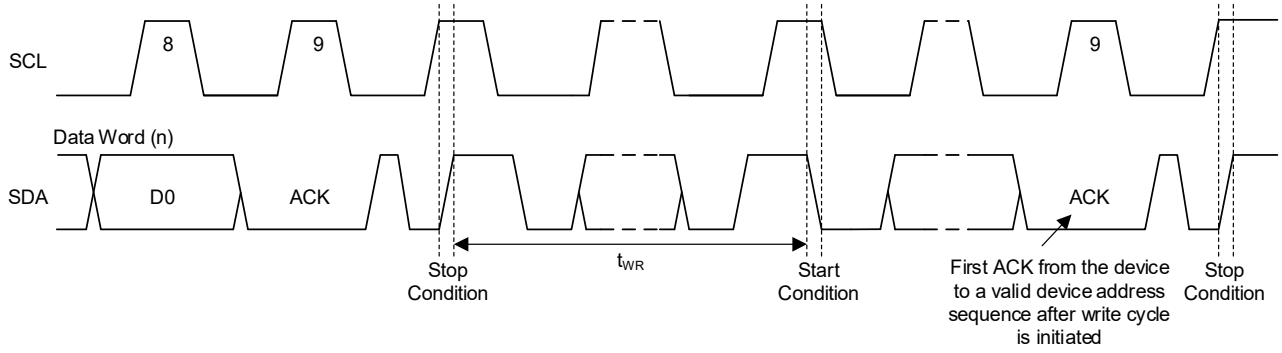


Figure 10. Write Cycle Timing

READ AND WRITE OPERATIONS (continued)

Acknowledge (ACK) Polling

An ACK polling routine can be implemented to optimize time sensitive applications that would not prefer to wait the fixed maximum write cycle time but would prefer to know immediately when the serial EEPROM write cycle has completed to start a subsequent operation. Once the internally self-timed write cycle has started, the device inputs are disabled and ACK polling can be initiated. An ACK polling routine involves sending a valid Start condition followed by the device address byte. While the write cycle is in progress, the device will not respond with an ACK, indicating the device is busy writing data. Once completed, the device returns an ACK and the next device operation can be started (see Figure 11).

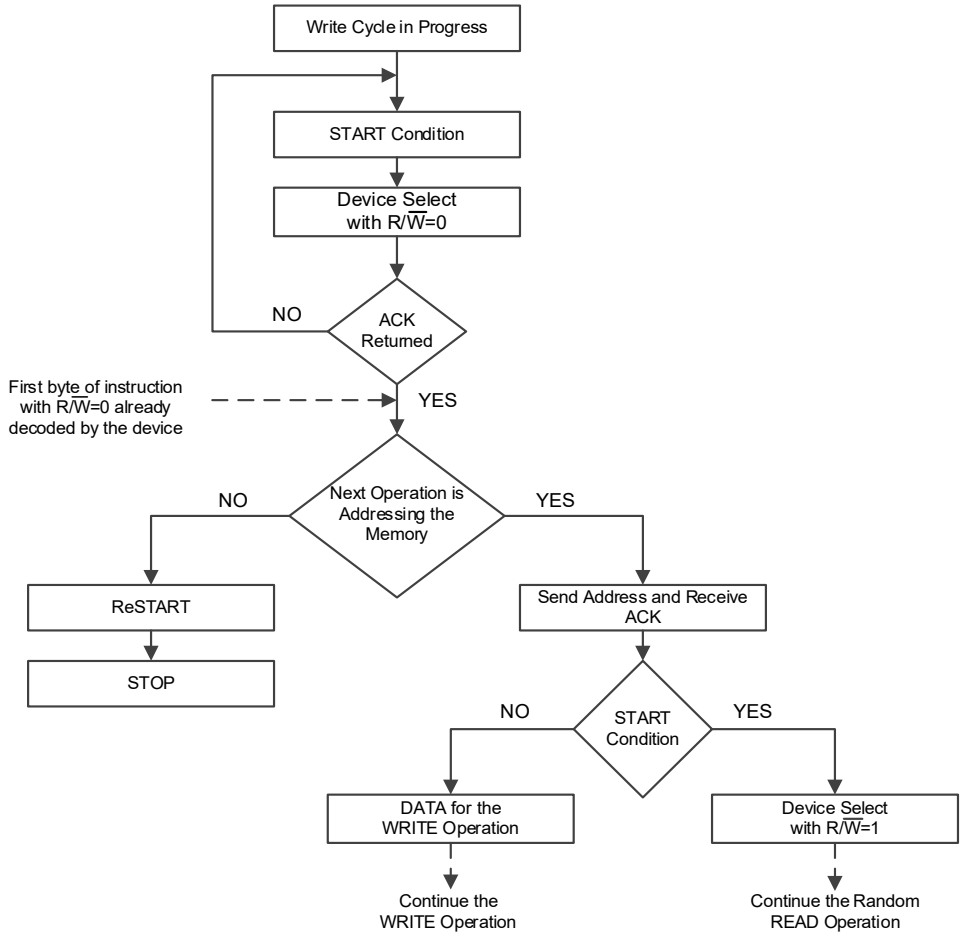


Figure 11. Acknowledge Polling Flow Chart

READ AND WRITE OPERATIONS (continued)

Write Identification Page

The device offers a 16-byte Identification Page (ID Page) in addition to the 16-Kbit memory array for storage of specific application data. This Identification Page can be written and permanently locked in Read-only mode after the data is written into this Page. The Identification Page is written by issuing the Write Identification Page instruction (see Figure 12), which is similar to Page Write, except that:

- The device type identifier is defined as '1011';
- The word address bits A7:A6 must be '00', bits A5:A4 are Don't Care;
- The word address bits A3:A0 define the byte locations inside the ID Page (see Table 2).

If the Identification Page has been locked, the data bytes transferred during the Write Identification Page instruction will not be acknowledged.

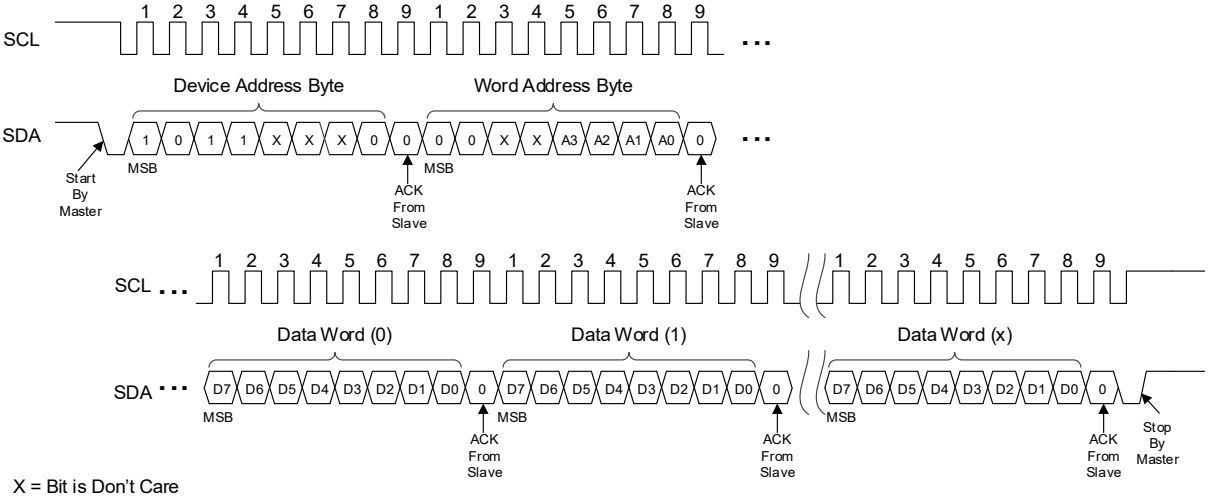


Figure 12. Write Identification Page

Lock Identification Page

The Lock Identification Page (Lock ID) instruction permanently locks the Identification Page in Read-only mode. The Lock ID instruction is similar to Byte Write, except the following specific conditions:

- The device type identifier is defined as '1011';
- The word address bits A7:A6 must be '01' and other word address bits are Don't Care;
- The data byte must be equal to the binary value xxxx_xx1x, where x is Don't Care (see Figure 13).

Once a valid Lock ID instruction has been executed, if another Lock ID instruction is issued, the device will respond with an NACK to the data byte.

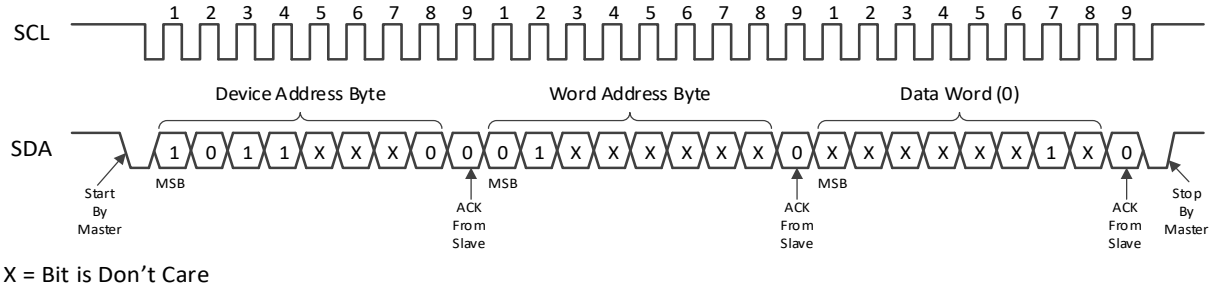


Figure 13. Lock Identification Page

READ AND WRITE OPERATIONS (continued)

Software Write Protection (SWP)

In order to prevent unwanted Write sequence, the TD24C16-R offers an internal non-volatile SWP bit, which makes it possible to protect the content in the whole memory array (and Identification Page). Updating the SWP bit to a new value is a reversible action by performing the Write SWP Bit instruction. This instruction is similar to Byte Write, except that:

- The device type identifier is defined as '1011';
- The word address bits A7:A6 must be '11' and other word address bits are Don't Care;
- The higher seven bits of the data word byte are Don't Care and bit 0 (D0) configures the SWP bit (see Figure 14). The SWP bit can be updated from Logic 0 to 1 and from Logic 1 to 0. Write operations are disabled (Read-only) when the SWP bit is set to Logic 1, while Write operations are enabled when the SWP bit is set to Logic 0.

Writing more than one byte will discard the write cycle and the value of SWP bit will not be changed.

Note that the device also incorporates a Write Protection pin used for Hardware Write Protection. Either connecting the WP pin directly to V_{CC} or setting the SWP bit to Logic 1 will write protect the whole memory array (and Identification Page). Writing the SWP bit is performed independently of the state of the WP pin connection. Upon a certain instruction send by the Master, the device will automatically load the last configuration of the SWP bit.

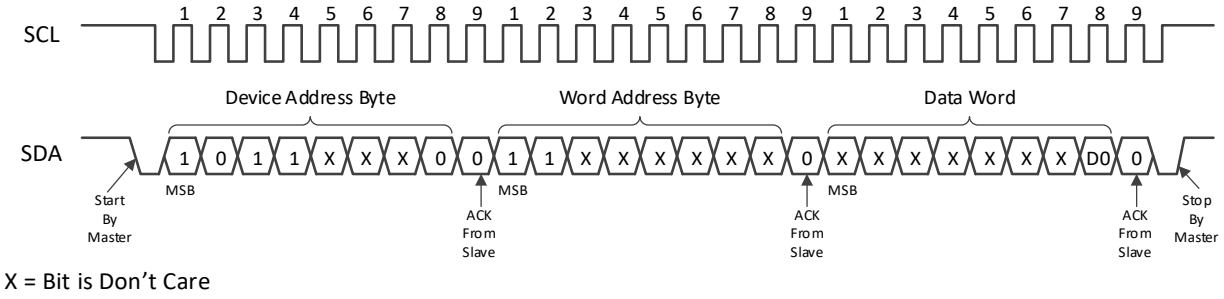


Figure 14. Write SWP Bit

Read Operations

All Read operations are initiated by the Master transmitting a Start condition, a device type identifier of '1010' or '1011', three software device address bits and the R/W select bit with Logic 1 state. In the following clock cycle, the TD24C16-R should respond with an ACK. The subsequent protocol depends on the type of Read operation desired. There are three Read operations for memory array: Current Address Read, Random Address Read, and Sequential Read with the device type identifier of '1010'; four Read operations for Identification Page, SWP bit and Unique ID: Read Identification Page, Read the Lock Status, Read SWP Bit and Read Unique ID with the device type identifier of '1011'. Read operations are performed independently of the state of the WP pin connection and the value of SWP bit.

READ AND WRITE OPERATIONS (continued)

Current Address Read

For a Current Address Read operation, the Master sends a Start condition followed by transmitting the device address byte with the R/W bit set to Logic 1 (see Figure 15). The TD24C16-R should respond with an ACK and then serially transmits the data word addressed by the internal address counter. This address maintained by the internal address counter is the last address accessed during the last Read or Write operation. The counter is then incremented by one and the address will stay valid between operations as long as power to the device is supplied. The address roll-over during a Read operation is from the last byte of the last page to the first byte of the first page. To end the command, the Master responds with an NACK followed by a Stop condition.

Note that the internal address counter value is defined by instructions accessing the 16-Kbit memory or the Identification Page or the Unique ID. For example, when accessing the ID Page, the counter value is loaded with the byte location in the ID Page. Therefore the next Current Address Read in the memory uses this new address counter value. When accessing the memory, it is recommended to always use Random Read instruction (see ***Random Read***) instead of Current Address Read instruction.

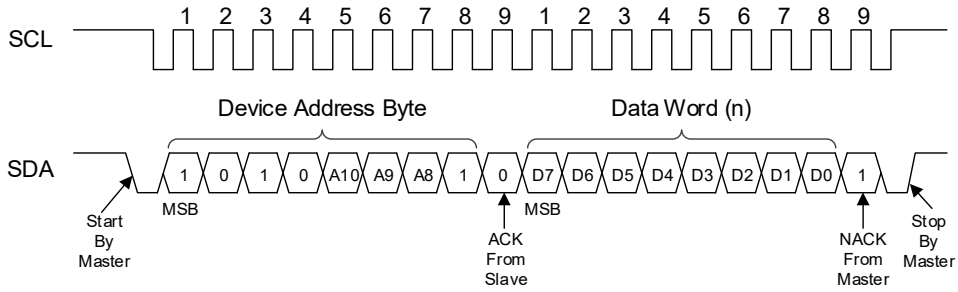


Figure 15. Current Address Read

Random Read

A Random Read operation allows the Master to access any memory location in a random manner and requires a dummy write sequence to preload the starting data word address. To perform a Random Read, the device address byte and the word address bytes are transmitted to the TD24C16-R as part of the dummy write sequence (see Figure 16). Once the device address byte and word address bytes are clocked in and acknowledged by the TD24C16-R, the Master must generate another Start condition. The Master initiates a Current Address Read by sending another device address byte with the R/W bit set to Logic 1. The TD24C16-R responds with an ACK to the device address byte and serially clocks out the first data word and increments its internal address counter. The device will continue to transmit sequential data words as long as the Master continues to acknowledge each data word. To end the sequence, the Master responds with an NACK followed by a Stop condition.

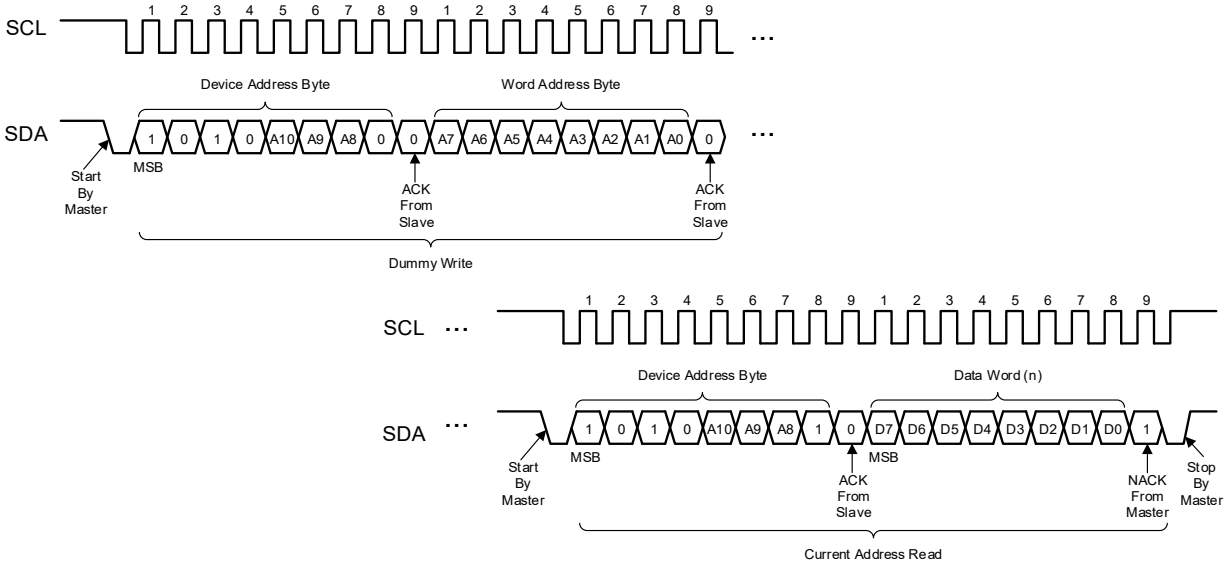


Figure 16. Random Read

READ AND WRITE OPERATIONS (continued)

Sequential Read

A Sequential Read operation is initiated in the same way as either a Current Address Read or a Random Read, except that after the TD24C16-R transmitting the first data word, the Master responds with an ACK instead of an NACK. As long as the TD24C16-R receives an ACK, it will continue to increment the data word address and serially clock out the sequential data words (see Figure 17). When the internal address counter is at the last byte of the last page, the word address will roll over to the beginning of the memory array and the Sequential Read operation will continue. The Sequential Read operation is terminated by the Master responding with an NACK followed by a Stop condition.

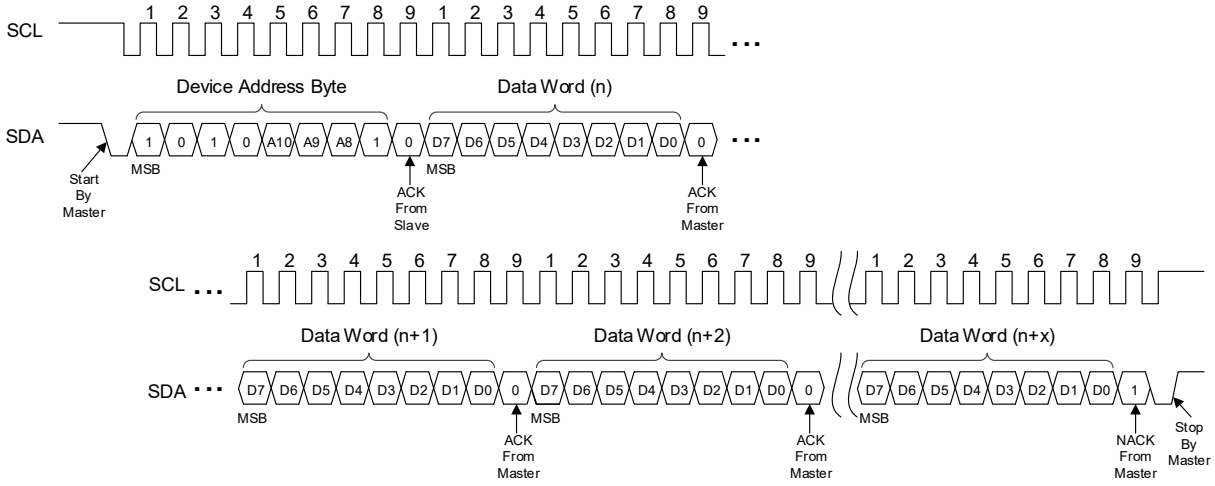


Figure 17. Sequential Read

Read Identification Page

The Identification Page can be read by issuing a Read Identification Page instruction. This instruction uses the same protocol and format as Random Read, except that:

- The device type identifier is defined as ‘1011’;
- The word address bits A7:A6 must be ‘00’, bits A5:A4 are Don't Care;
- The word address bits A3:A0 define the byte locations inside the ID Page (see Table 2).

When the end of Identification Page is reached, the word address will roll over to the beginning of the Identification Page. The Read Identification Page operation is terminated by the Master responding with an NACK followed by a Stop condition (see Figure 18).

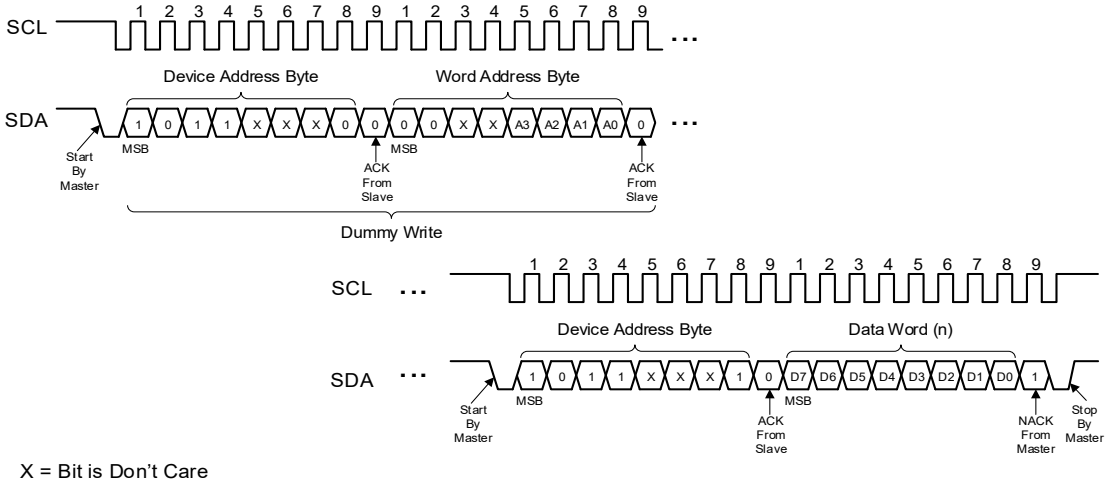
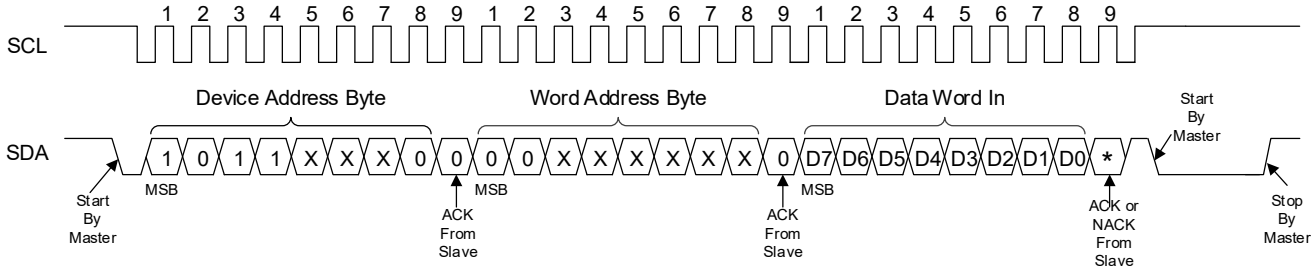


Figure 18. Read Identification Page

READ AND WRITE OPERATIONS (continued)

Read Lock Status

The locked/unlocked status of the Identification Page can be checked by transmitting a specific truncated command, Write Identification Page instruction and one data byte to the device. The device responds with an ACK to the data byte if the Identification Page is unlocked, or responds with an NACK if the Identification Page has been locked. Right after this, it is recommended to transmit a Start condition to the device followed by a Stop condition (see Figure 19), so that the truncated Write command will not be executed because the Start condition resets the device internal logic, and the device is then set back into Standby mode by the Stop condition.



X = Bit is Don't Care

Bit * = 0, ACK after one data byte indicates the Identification Page is unlocked.

Bit * = 1, NACK after one data byte indicates the Identification Page is locked.

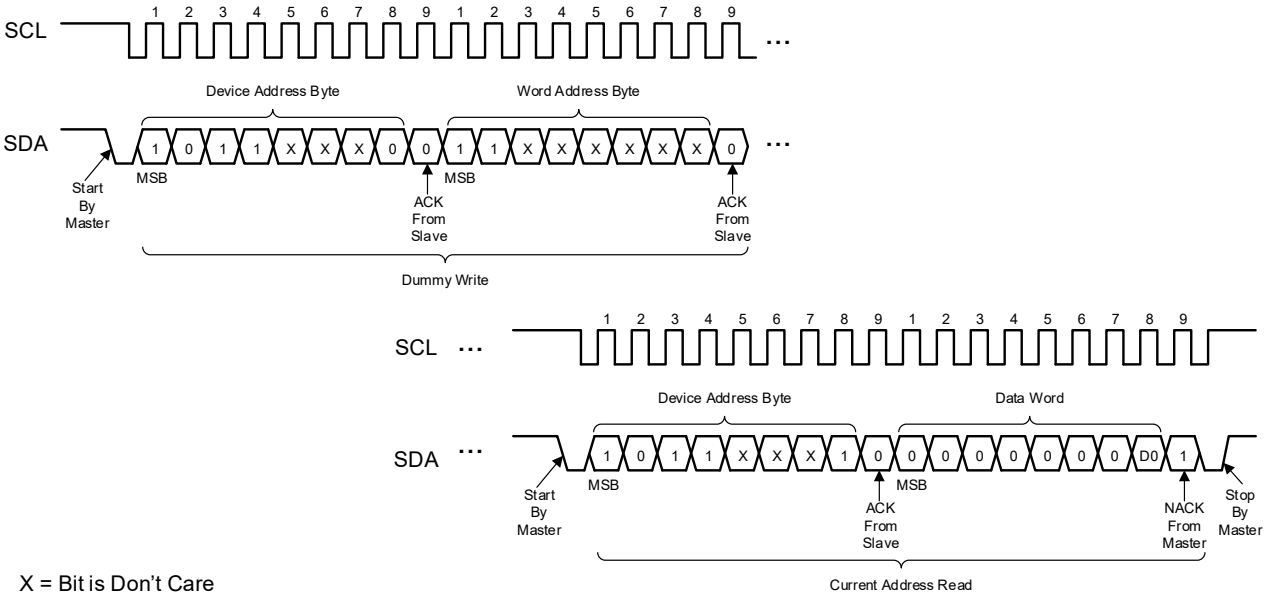
Figure 19. Read Lock Status

Read SWP Bit

Reading the Software Write Protection bit is performed with a Read SWP Bit instruction, which is similar to Random Read except that:

- The device type identifier is defined as '1011';
- The word address bits A7:A6 must be '11' and other word address bits are Don't Care;
- The higher seven bits of the data word byte are read as '0000000' and the bit 0 (D0) is the value of SWP bit (see Figure 20).

Reading more than one byte will loop on reading the SWP bit value.



X = Bit is Don't Care

Figure 20. Read SWP Bit

READ AND WRITE OPERATIONS (continued)

Read Unique ID

The TD24C16-R offers a separate memory block containing a factory programmed 128-bit Unique ID (UID), or Serial Number. Reading the Serial Number is similar to Sequential Read, except that:

- The device type identifier is defined as ‘1011’;
- The word address bits A7:A6 must be ‘10’, bits A5:A4 are Don't Care;
- The word address bits A3:A0 define the byte locations inside the Unique ID (see Table 2).

In order to guarantee a unique number, the entire 128-bit value must be read from the starting address of the Serial Number block. Reading from a location other than the first address of the block will not result in a unique Serial Number. To read the first byte of the Serial Number, the word address bits A3:A0 need to be ‘0000’. Writing or altering the 128-bit Unique ID is not allowed. When the end of the 128-bit UID block is reached (16 bytes of data), the word address will roll over to the beginning of the 128-bit UID block. The Read Unique ID operation is terminated when the Master responds with an NACK to the data byte followed by a Stop condition (see Figure 21).

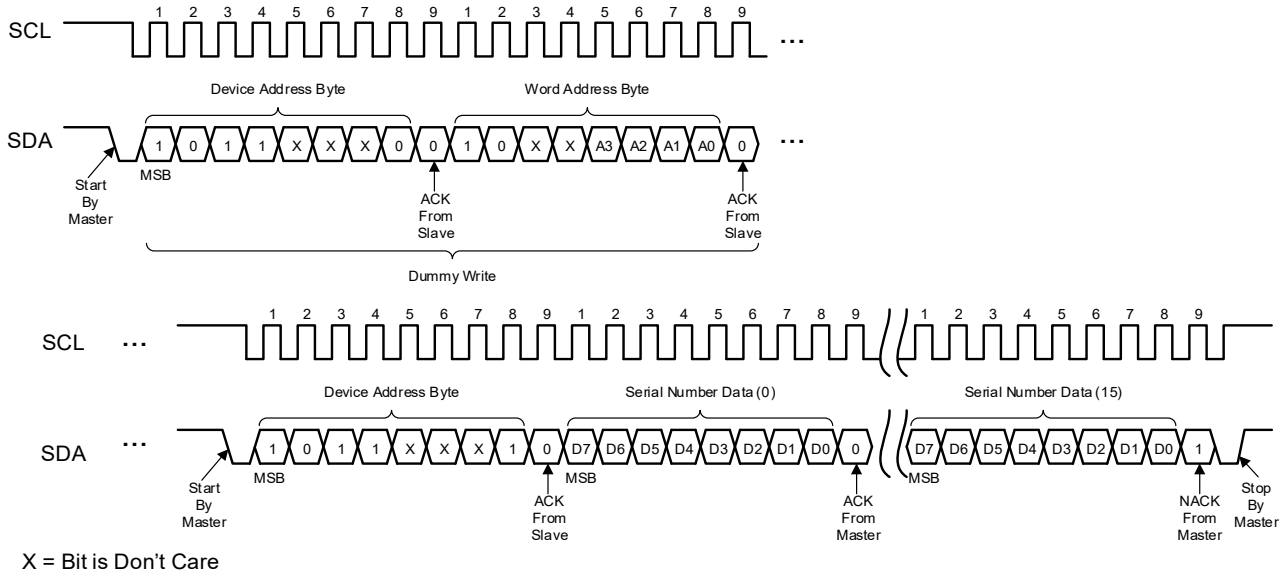


Figure 21. Read Unique ID

INITIAL DELIVERY STATE

The TD24C16-R serial EEPROM is delivered as follows:

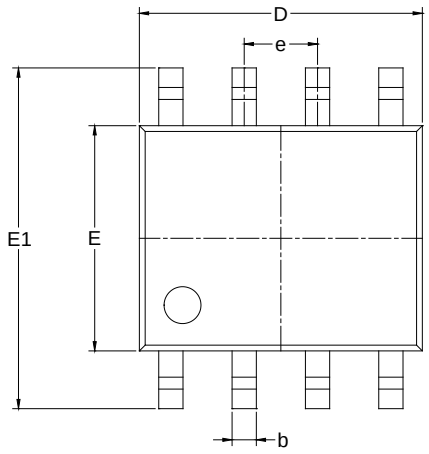
- All bits in the memory array are set to ‘1’ (each byte contains FFh).
- All bits in the Identification Page are set to ‘1’ (each byte contains FFh).
- The Software Write Protection bit is set to ‘0’.

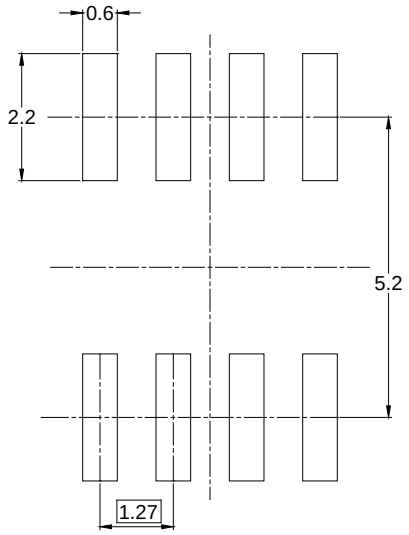
REVISION HISTORY

REVISION	DATE	COMMENTS
REV.A	Nov. 2020	Initial version A release
REV.A.1	Jun. 2021	Updated: — *Features* Section — Figure 7, Figure 13 and Figure 21 — I_{CC2} value in *DC Characteristics* table
REV.A.2	Oct. 2026	Updated: — Operating Temperature Range — Package Outline Dimensions Added: — N_W at T_A = +125℃, Page mode — MSOP-8 Package — Tape and Reel Information

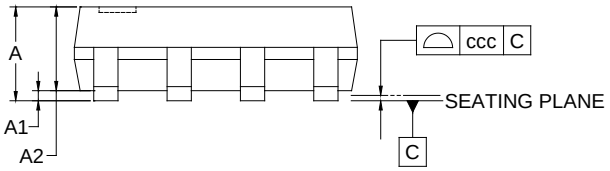
PACKAGE OUTLINE DIMENSIONS

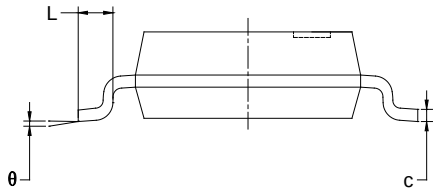
SOIC-8





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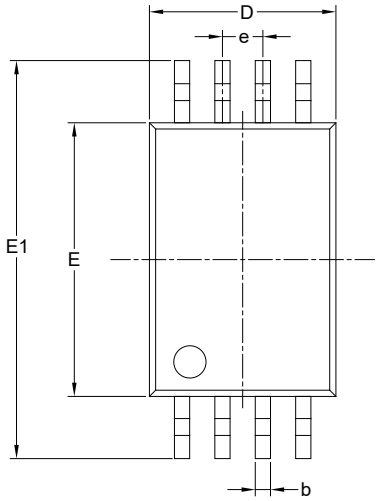


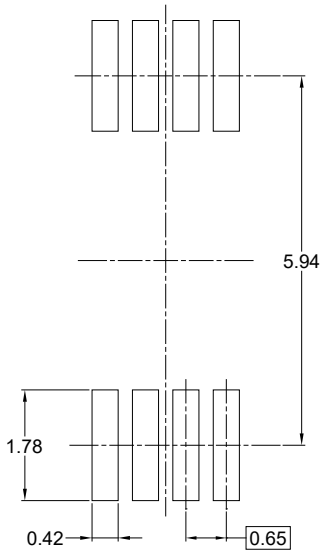
Symbol	Dimensions In Millimeters		
	MIN	NOM	MAX
A	1.350	-	1.750
A1	0.100	-	0.250
A2	1.350	-	1.550
b	0.330	-	0.510
c	0.170	-	0.250
D	4.700	-	5.100
E	3.800	-	4.000
E1	5.800	-	6.200
e	1.270 BSC		
L	0.400	-	1.270
θ	0°	-	8°
ccc	0.100		

NOTES:
1. This drawing is subject to change without notice.
2. This dimension does not include mold flash, protrusions or gate burrs. Mold flash, protrusions or gate burrs shall not exceed 0.15mm per side.
3. Reference JEDEC MS-012.

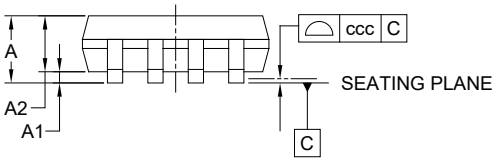
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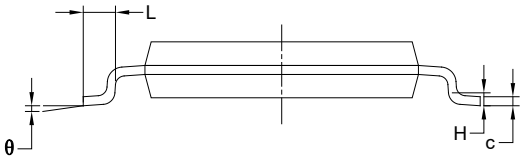
TSSOP-8





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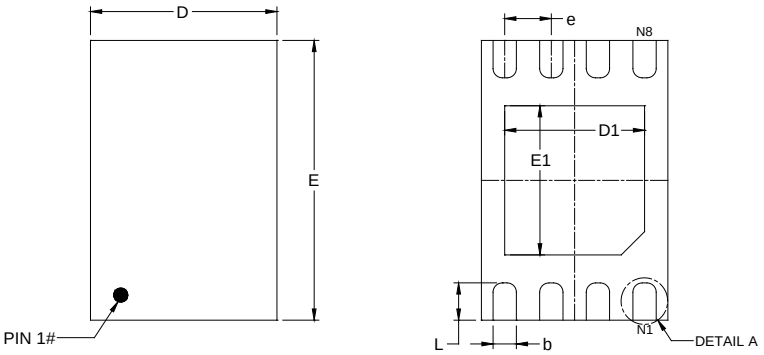


Symbol	Dimensions In Millimeters		
	MIN	NOM	MAX
A	-	-	1.200
A1	0.050	-	0.150
A2	0.800	-	1.050
b	0.190	-	0.300
c	0.090	-	0.200
D	2.900	-	3.100
E	4.300	-	4.500
E1	6.200	-	6.600
e	0.650 BSC		
L	0.450	-	0.750
H	0.250 TYP		
θ	0°	-	8°
ccc	0.100		

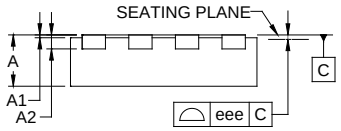
NOTES:
1. This drawing is subject to change without notice.
2. The dimensions do not include mold flashes, protrusions or gate burrs.
3. Reference JEDEC MO-153.

PACKAGE OUTLINE DIMENSIONS

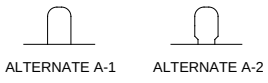
UTDFN-2×3-8AL



TOP VIEW **BOTTOM VIEW**

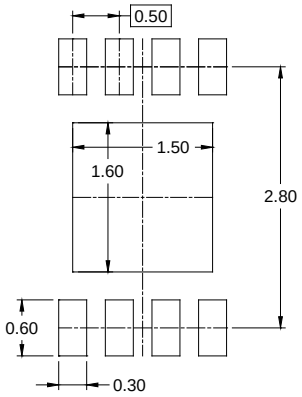


SIDE VIEW



DETAIL A

ALTERNATE TERMINAL CONSTRUCTION



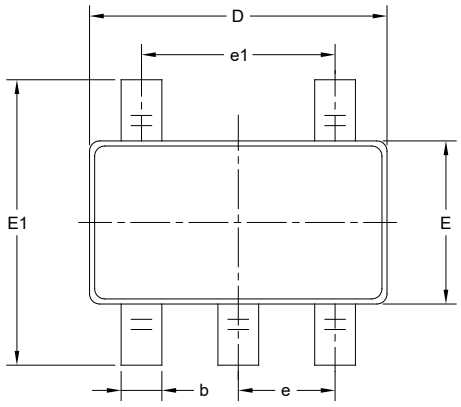
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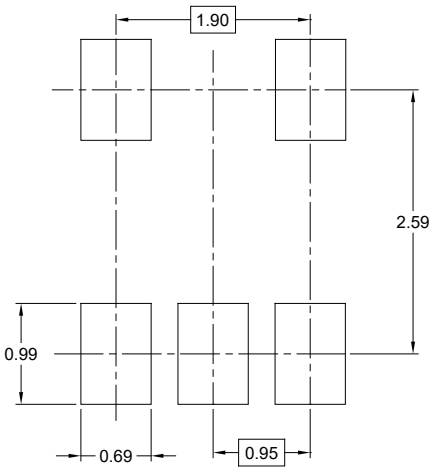
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A1	0.000	-	0.050
A2	0.150 REF		
b	0.180	-	0.300
D	1.900	-	2.100
D1	1.400	-	1.600
E	2.900	-	3.100
E1	1.500	-	1.700
e	0.500 BSC		
L	0.300	-	0.500
eee	0.080		

NOTE: This drawing is subject to change without notice.

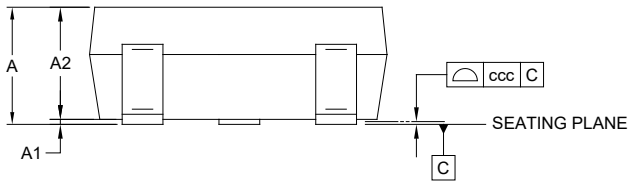
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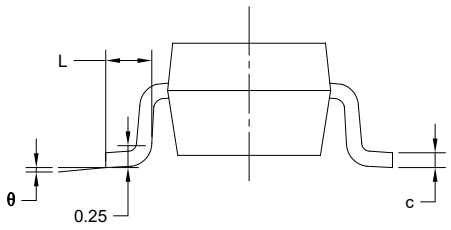
SOT-23-5





RECOMMENDED LAND PATTERN (Unit: mm)



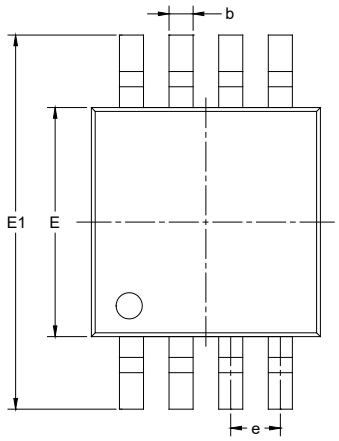


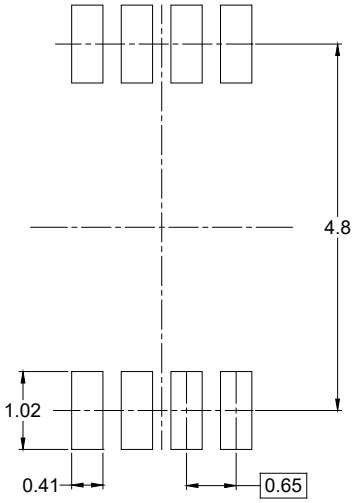
Symbol	Dimensions In Millimeters		
	MIN	NOM	MAX
A	-	-	1.450
A1	0.000	-	0.150
A2	0.900	-	1.300
b	0.300	-	0.500
c	0.080	-	0.220
D	2.750	-	3.050
E	1.450	-	1.750
E1	2.600	-	3.000
e	0.950 BSC		
e1	1.900 BSC		
L	0.300	-	0.600
θ	0°	-	8°
ccc	0.100		

NOTES:
1. This drawing is subject to change without notice.
2. The dimensions do not include mold flashes, protrusions or gate burrs.
3. Reference JEDEC MO-178.

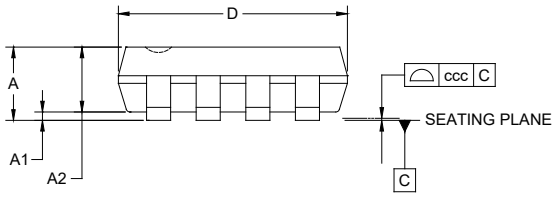
PACKAGE OUTLINE DIMENSIONS

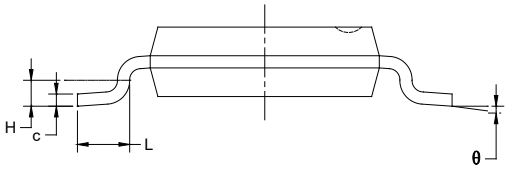
MSOP-8





RECOMMENDED LAND PATTERN (Unit: mm)



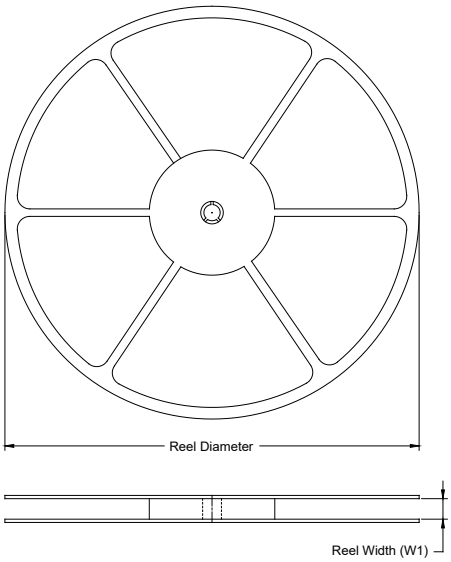


Symbol	Dimensions In Millimeters		
	MIN	NOM	MAX
A	-	-	1.100
A1	0.000	-	0.150
A2	0.750	-	0.950
b	0.220	-	0.380
c	0.080	-	0.230
D	2.800	-	3.200
E	2.800	-	3.200
E1	4.650	-	5.150
e	0.650 BSC		
L	0.400	-	0.800
H	0.250 TYP		
θ	0°	-	8°
ccc	0.100		

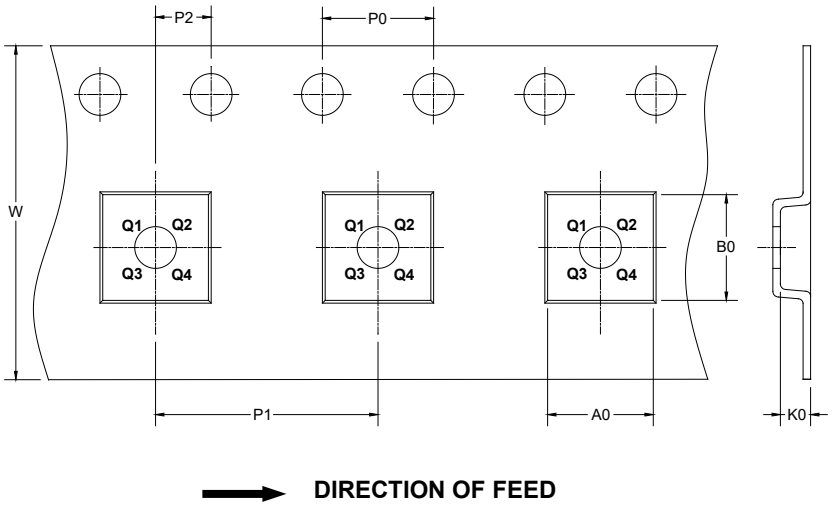
NOTES:
1. This drawing is subject to change without notice.
2. The dimensions do not include mold flashes, protrusions or gate burrs.
3. Reference JEDEC MO-187.

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



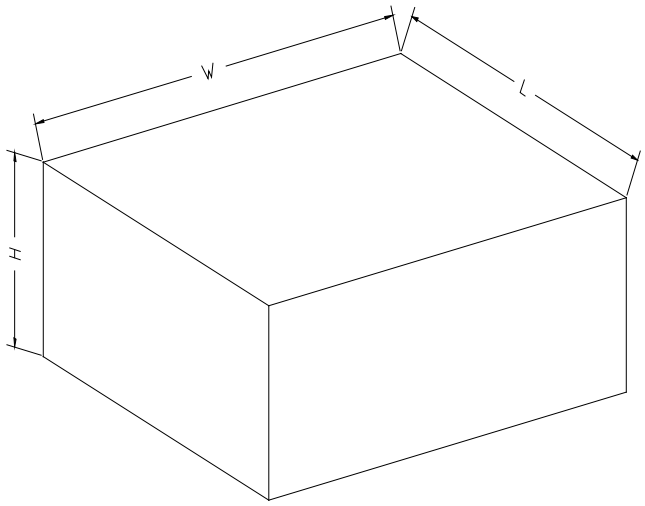
NOTE: The picture is only for reference. Please make the object as the standard.

KEY PARAMETER LIST OF TAPE AND REEL

Package Type	Reel Diameter	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	P1 (mm)	P2 (mm)	W (mm)	Pin1 Quadrant
SOIC-8	13"	12.4	6.60	5.30	1.90	4.0	8.0	2.0	12.0	Q1
TSSOP-8	13"	12.4	6.90	3.40	1.60	4.0	8.0	2.0	12.0	Q1
UTDFN-2×3-8AL	7"	8.6	2.30	3.30	0.95	4.0	4.0	2.0	8.0	Q2
SOT-23-5	7"	8.6	3.26	3.30	1.40	4.0	4.0	2.0	8.0	Q3
MSOP-8	13"	12.4	5.20	3.30	1.50	4.0	8.0	2.0	12.0	Q1

DD0001

CARTON BOX DIMENSIONS



NOTE: The picture is only for reference. Please make the object as the standard.

KEY PARAMETER LIST OF CARTON BOX

Reel Type	Length (mm)	Width (mm)	Height (mm)	Pizza/Carton
7″ (Option)	368	227	224	8
7″	442	410	224	18
13″	386	280	370	5

DD0002