

2,048-BIT SERIAL ELECTRICALLY ERASABLE PROM

PRELIMINARY
SEPTEMBER 1995

FEATURES

- Low power CMOS
 - Active current less than 2 mA
 - Standby current less than 8 μ A
- Hardware write protection
 - Write control pin
- Internally organized as 256 x 8
- Two-wire serial interface
 - Bidirectional data transfer protocol
- 8-Byte page-write mode
 - Minimized total write time per byte
- 100 KHz clock speed compatible
- Automatic word address incrementing
 - Sequential register read
- Self-timed write cycle
 - Maximum write cycle time of 10 ms
- Endurance: 100,000 cycles per byte
- 8-pin PDIP or SOIC packages
- Filtered inputs for noise suppression

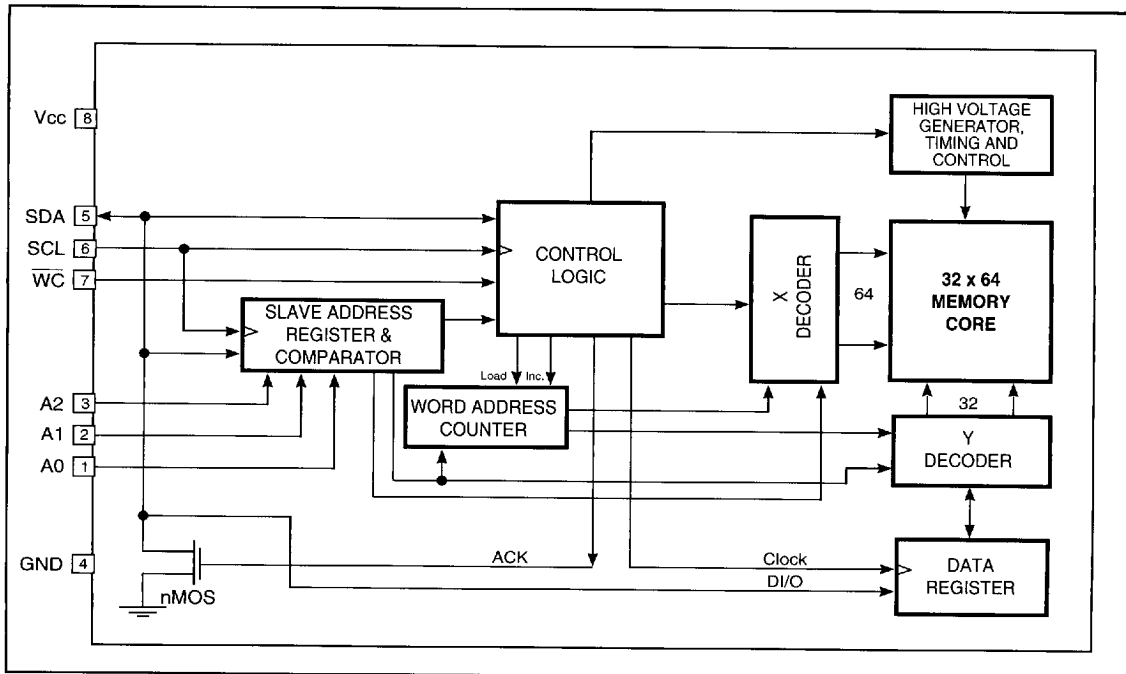
OVERVIEW

The IS24C02 is a low cost 2,048-bit serial EEPROM. It is fabricated using **ISSI's** advanced CMOS EEPROM technology and operates from a single supply.

The IS24C02 is internally organized as a 256 x 8 memory bank. The IS24C02 features a serial interface and software protocol allowing operation on a simple 2-wire bus. Up to eight IS24C02s may be connected to the 2-wire bus by programming the A0, A1, and A2 inputs.

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FUNCTIONAL BLOCK DIAGRAM



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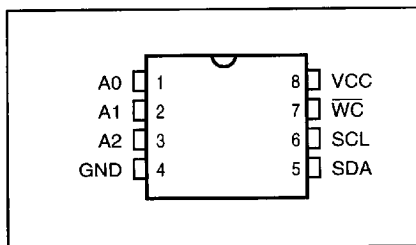
PRELIMINARY DATA Rev. A 0995
EP81995DS02

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4-1

PIN CONFIGURATION

8-Pin DIP and SOIC



PIN DESCRIPTIONS

| | |
|-------|---------------------|
| A0-A2 | Address Inputs |
| SDA | Serial Data I/O |
| SCL | Serial Clock Input |
| WC | Write Control Input |
| Vcc | Power |
| GND | Ground |

PIN DESCRIPTIONS

Serial Clock (SCL) - The SCL input is used to clock all data into and out of the device. In the WRITE mode, data must remain stable when SCL is HIGH. In the READ mode, data is clocked out on the falling edge of SCL.

Serial Data (SDA) - The SDA pin is a bidirectional pin used to transfer data into and out of the device. Data may change only when SCL is LOW. It is an open-drain output, and may be wire-ORed with any number of open-drain or open-collector outputs.

A0, A1, and A2 - The address inputs are used to set the least significant three bits of the slave address. These inputs may be tied HIGH or LOW, or they may be actively driven. These inputs allow up to eight IS24C02 devices to be connected together on the bus.

Write Control (\overline{WC}) - The Write Control input is used to disable any attempt to write to the memory. When HIGH, the memory is protected; when LOW, the write function is normal. The part can be read independent of the state of \overline{WC} pin. When not connected this pin will be pulled LOW.

ENDURANCE AND DATA RETENTION

The IS24C02 is designed for applications requiring high-endurance write cycles and unlimited read cycles. It provides 10 years of secure data retention, with or without power applied, after the execution of 100,000 write cycles.

APPLICATIONS

The IS24C02 is ideal for high volume applications requiring low power and low density storage. This device uses a low-cost, space-saving 8-pin plastic package. Candidate applications include robotics, alarm devices, electronic locks, meters and instrumentation.

GENERAL DESCRIPTION

The IS24C02 features a SERIAL communication, and supports bidirectional data transmission protocol allowing operation on a simple two-wire bus between the different devices connected somewhere on the system bus. The two-wire bus was defined as a serial data line (SDA), and a serial clock line (SCL). (Refer to Figure 1. Typical System Bus Configuration.)

The protocol defines any device that sends data onto the SDA bus as a transmitter, and the receiving device as a receiver. The device controlling the data transmission is named MASTER device, and the controlled device is named SLAVE device. In all cases, the IS24C02 will be a slave device, since it never initiates any data transfers. Up to eight IS24C02 can be connected to the bus. Device's physical address inputs A0-A2 must be connected to either Vcc or GND.

Following a START condition, the MASTER (transmitter) device must initiate the "Device Addressing Byte" including device type identifier, device address, and a read or write operation to select a slave device (receiver) connected to the system bus. The receiver will then respond with an ACKnowledge by pulled the SDA line LOW.

The ACKnowledge is used to indicate successful data transfers. The transmitting device will release the data bus (SDA goes HIGH) after transmitting eight bits (one data bit is transferred at the falling edge of each clock cycle). During the ninth clock cycle, the receiver will pull the SDA line LOW to ACKnowledge the transmitter that it received the eight bits of data. (Refer to Figure 2. ACKnowledge Response from Receiver Diagram.)

DEVICE OPERATION

START and STOP Conditions

Both SDA and SCL lines remain HIGH when the SDA bus is not busy. A HIGH-to-LOW transition of SDA line, while SCL is HIGH, is defined as the START condition. A LOW-to-High transition of SDA line, while SCL is HIGH, is defined as STOP condition. (Refer to Figure 3. Start and Stop Conditions.)

Data Validity Protocol

One data bit is transferred during each clock cycle. The data on the SDA line must remain stable during the HIGH period of the clock cycle, because changes on SDA line during the SCL HIGH period will be interpreted as START or STOP control signals. (Refer to Figure 4. Data Validity Protocol.)

Device Addressing Byte Definitions

The most significant four bits of Device Addressing Byte (Bit 7 to Bit 4) are defined as the device type identifier. For IS24C02, this is fixed as 1010. The next three significant address bits (Bit 3 to Bit 1) address a particular device. Up to eight IS24C02 devices can be connected on the bus. These eight addresses are defined by the state of the A0, A1, and A2 inputs. The last bit Bit 0 defines the write or read operation to be performed. When set to "1", a READ operation is selected; when set to "0" a WRITE operation is selected. (Refer to Figure 5. Device Addressing Byte Definitions.)

WRITE OPERATION

Byte Write

For a WRITE operation, the IS24C02 requires another 8-bit data word address following the Device Addressing Byte and ACKnowledgement. This data word address provides access to any one of the 256 data words of device's memory array.

Upon receipt of the data word address, the IS24C02 responds with an ACKnowledge on SDA, and waits for the next 8-bit data word, then again responding with an ACKnowledge. The master device terminates the Byte Write Operation by generating a STOP condition, afterward the IS24C02 begins the internal WRITE cycle to the nonvolatile memory array. Refer to Write Cycle Timing. All inputs are disabled during this write cycle and the device will not response to any requests from the master. (Refer to Figure 6. Write Operation for the Address, ACKnowledge, and Data Transfer Sequence.)

Page Write

The IS24C02 is capable of 8-byte page- WRITE operation. A page-WRITE is initiated in the same manner as a byte write, but instead of terminating the internal write cycle after the first data word is transferred, the master device can transmit up to 15 more words. After the receipt of each data word, the IS24C02 responds immediately with an ACKnowledge on SDA line, and the four lower order data word address bits are internally incremented by one while the four higher order bits of the data word address remain constant. If the master device should transmit more than 8 words, prior to issuing the STOP condition, the address counter will "roll over," and the previously written data will be overwritten. All inputs are disabled until completion of the internal WRITE cycle. (Refer to Figure 6. Write Operation for the Address, ACKnowledge, and Data Transfer Sequence.)

Acknowledge Polling

Once the internal write cycle has started and the IS24C02 inputs are disabled, acknowledge polling can be initiated. This involves sending a start condition followed by the Device Addressing Byte. The read/write bit is representative of the operation desired. Only if the internal write cycle has been completed will the IS24C02 respond with an acknowledge on the SDA bus allowing the read or write sequence to continue.

READ OPERATION

READ operations are initiated in the same manner as WRITE operations, except that the read/write bit of the device addressing byte is set to "1". There are three READ operation options: current address read, random address read and sequential read.

Current Address Read

The IS24C02 contains an internal address counter which maintains the address of the last data word accessed, incremented by one. For example, if the previous operation either a read or write operation addressed to the address location *n*, the internal address counter would address to address location *n*+1. When the IS24C02 receives the Device Addressing Byte with a READ operation (read/write bit set to "1"), it will respond an ACKnowledge and transmit the 8-bit data word stored at address location *n*+1. If the Current Address READ operation only accesses a single byte of data, the master device terminates the Current Address READ operation by pulling ACKnowledge HIGH (lack of ACKnowledge) indicating the last data word to be read, followed by a STOP condition. (Refer to Figure 7. Current Address Read Diagram.)

Random Access Read

Random Address READ operation allows the master device to access any memory location in a random fashion. This operation involves a two-step process. First, the master device generates a START condition and initiates Device Addressing Byte with a WRITE operation (read/write bit sets to "0"), followed by the address of the data word the master device is to READ. This procedure stores the desired address of data word to the internal address counter of the IS24C02.

After the data word address ACKnowledge is received by the master device, the master device now initiates a *CURRENT ADDRESS READ* by sending Device Addressing Byte with a READ operation (read/write bit sets to "1"). The IS24C02 responds with an ACKnowledge and transmits the eight data bits stored at the address location where the master device is to READ. At this point, the master device terminates the operation by pulling ACKnowledge HIGH (lack of ACKnowledge) indicating the last data word to be read, followed by a STOP condition. (Refer to Figure 8. Random Address Read Diagram.)

Sequential Read

Sequential Reads can be initiated as either a Current Address Read or Random Address Read. The first data word is transmitted as with the other byte read modes, the master device now responds with an ACKnowledge indicating that it requires additional data from the IS24C02. The IS24C02 continues to output data for each ACKnowledge received. the master device terminates the sequential READ operation by pulling ACKnowledge HIGH (lack of ACKnowledge) indicating the last data word to be read, followed by a STOP condition.

The data output is sequential, with the data from address n followed by the data from address $n+1$, ... etc. The address counter increments by one automatically, allowing the entire memory contents to be serially read during sequential read operation. When the memory address boundry (address 255) is reached, the address counter "rolls over" to address 0, and the IS24C02 continues to output data for each ACKnowledge received. (Refer to Figure 9. Sequential Read Operation Starting with a Random Address READ Diagram.)

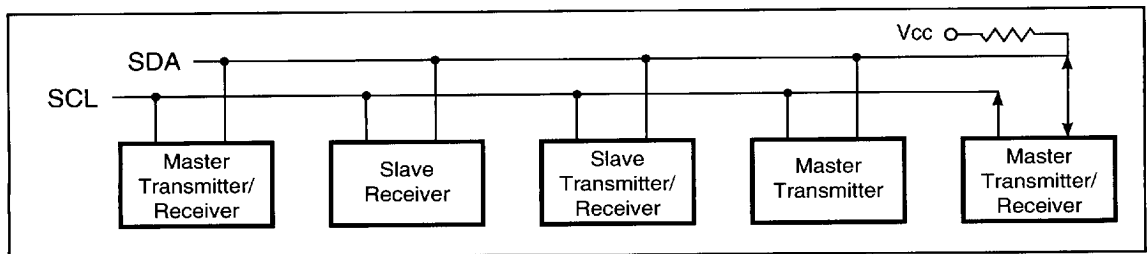


Figure 1. Typical System Bus Configuration

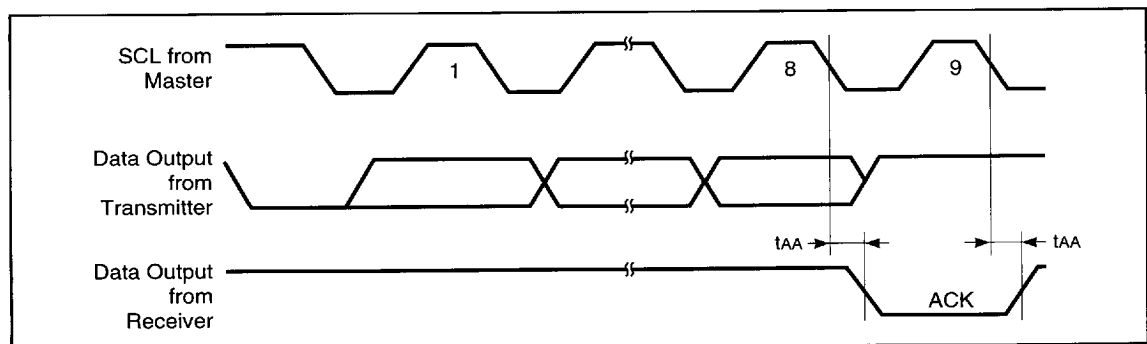


Figure 2. ACKnowledge Response from Receiver

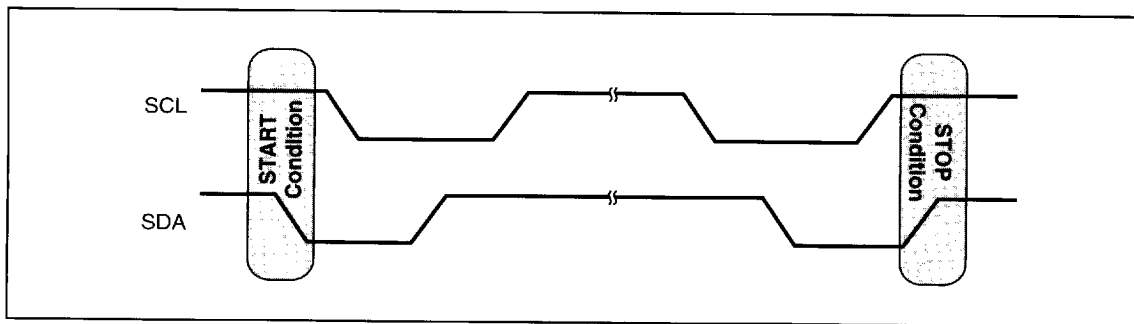


Figure 3. START and STOP Conditions

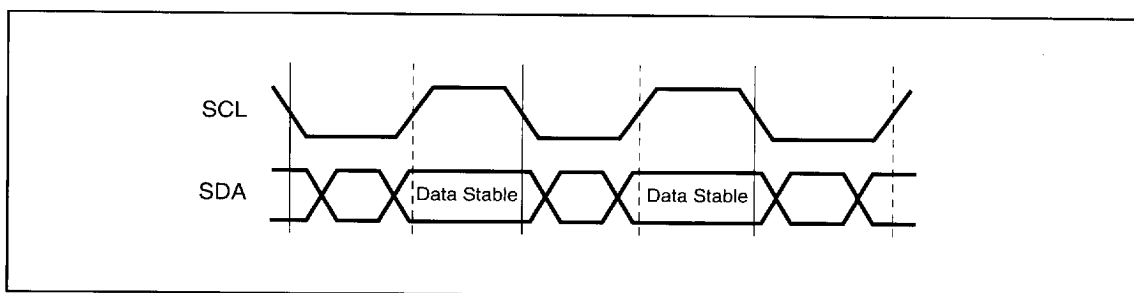


Figure 4. Data Validity Protocol

| BIT 7 | | BIT 4 | | BIT 3 | | BIT 1 | | BIT 0 |
|-------|---|-------|---|-------|---|-------|---|-------|
| 1 | 0 | 1 | 0 | A | 2 | A | 1 | R |
| | | | | | | | | W |

BIT 7 - BIT 4: Are defined as the Device Type Identifier.
For IS24C02, this is fixed as 1010.

BIT 3 - BIT 1: Address a particular device.

BIT 0: Defines the Write or Read Operation to be performed.
1: Read Operation
2: Write Operation

Figure 5. Device Addressing Byte Definitions

ABSOLUTE MAXIMUM RATINGS⁽¹⁾

| Symbol | Parameter | Value | Unit |
|-------------------|--|-------------------------------|------|
| V _S | Supply Voltage | 0 to +7.0 | V |
| V _P | Voltage on Any Pin | -0.5 to V _{CC} + 0.5 | V |
| T _{BIAS} | Temperature Under Bias | -40 to +85 | °C |
| T _{STG} | Storage Temperature | -65 to +150 | °C |
| T _{SOL} | Soldering Temperature (less than 10 sec) | 300 | °C |
| I _{OUT} | Output Current | 5 | mA |

Notes:

1. Stress greater than those listed under ABSOLUTE MAXIMUM RATINGS may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect reliability.

OPERATING RANGE

| Range | Ambient Temperature | V _{CC} |
|------------|---------------------|-----------------|
| Commercial | 0°C to +70°C | 5V ± 10% |
| Industrial | -40°C to +85°C | 5V ± 10% |

CAPACITANCE^(1,2)

| Symbol | Parameter | Conditions | Max. | Unit |
|------------------|--------------------|-----------------------|------|------|
| C _{IN} | Input Capacitance | V _{IN} = 0V | 5 | pF |
| C _{OUT} | Output Capacitance | V _{OUT} = 0V | 8 | pF |

Notes:

1. Tested initially and after any design or process changes that may affect these parameters.
2. Test conditions: T_A = 25°C, f = 1 MHz, V_{CC} = 5.0V.

DC ELECTRICAL CHARACTERISTICS

T_A = 0°C to +70°C for IS24C02 and -40°C to +85°C for IS24C02-I, V_{CC} = 4.5V to 5.5V.

| Symbol | Parameter | Test Conditions | Min. | Max. | Unit |
|------------------|----------------------------------|--|-----------------------|-----------------------|------|
| V _{OL} | Output LOW Voltage | V _{CC} = Min., I _{OL} = 3.0 mA | — | 0.4 | V |
| V _{IH} | Input HIGH Voltage | A1-A2, SCL, SDA | 0.7 x V _{CC} | — | V |
| V _{IL} | Input LOW Voltage ⁽¹⁾ | A1-A2, SCL, SDA | — | 0.3 x V _{CC} | V |
| I _{LI} | Input Leakage | V _{IN} = 0V to V _{CC} | — | 10 | μA |
| I _{LO} | Output Leakage | V _{OUT} = 0V to V _{CC} | — | 10 | μA |
| V _{HYS} | Input Hysteresis | SCL, SDA | — | 0.5 x V _{CC} | V |

POWER SUPPLY CHARACTERISTICS

T_A = 0°C to +70°C for IS24C02 and -40°C to +85°C for IS24C02-I, V_{CC} = 4.5V to 5.5V.

| Symbol | Parameter | Test Conditions | IS24C02 | | IS24C02-I | | Unit |
|------------------|--|---|---------|------|-----------|------|------|
| | | | Min. | Max. | Min. | Max. | |
| I _{CC1} | V _{CC} Operating Supply Current | SCL = CMOS Levels at 100 KHz SDA = Open All Other Inputs = GND or V _{CC} | — | 2 | — | 2 | mA |
| I _{SB1} | Standby Current CMOS | SCL = SDA = V _{CC} = 4.5V to 5.5V All Other Inputs = GND or V _{CC} | — | 8 | — | 8 | μA |

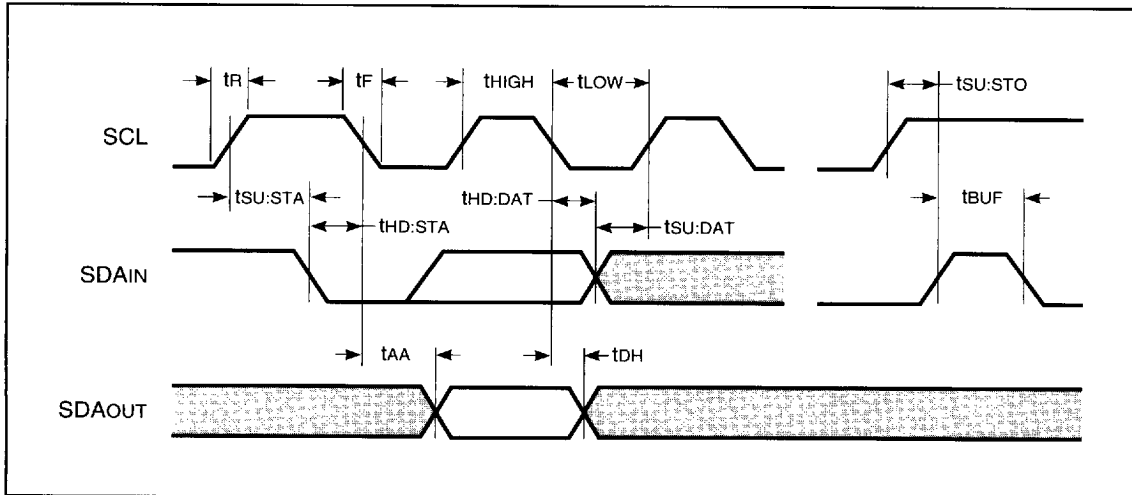
AC ELECTRICAL CHARACTERISTICS

T_A = 0°C to +70°C for IS24C02 and -40°C to +85°C for IS24C02-I, V_{CC} = 4.5V to 5.5V.

| Symbol | Parameter | Test Conditions | Min. | Max. | Unit |
|---------------------|----------------------------|----------------------------------|------|------|------|
| f _{SCL} | SCL Clock Frequency | | 0 | 100 | KHz |
| t _{LOW} | Clock LOW Period | | 4.7 | — | μs |
| t _{HIGH} | Clock HIGH Period | | 4 | — | μs |
| t _{BUF} | Bus Free Time | Before New Transmission | 4.7 | — | μs |
| t _{SU:STA} | Start Condition Setup Time | | 4.7 | — | μs |
| t _{SU:STO} | Stop Condition Setup Time | | 4.7 | — | μs |
| t _{HD:STA} | Start Condition Hold Time | | 4 | — | μs |
| t _{HD:STO} | Stop Condition Hold Time | | 4 | — | μs |
| t _{SU:DAT} | Data In Setup Time | | 250 | — | ns |
| t _{HD:DAT} | Data In Hold Time | | 0 | — | ns |
| t _{HD} | Data Out Hold Time | SCL LOW to SDA Data Out Change | 0 | — | ns |
| t _{AA} | Clock to Output | SCL LOW to SDA Data Out Valid | 0.3 | 3.5 | μs |
| t _R | SCL and SDA Rise Time | | — | 1 | μs |
| t _F | SCL and SDA Fall Time | | — | 300 | ns |
| t _{WR} | Write Cycle Time | | — | 10 | ms |
| t _I | Noise Spike Width | Time Constant at SCL, SDA Inputs | — | 100 | ns |

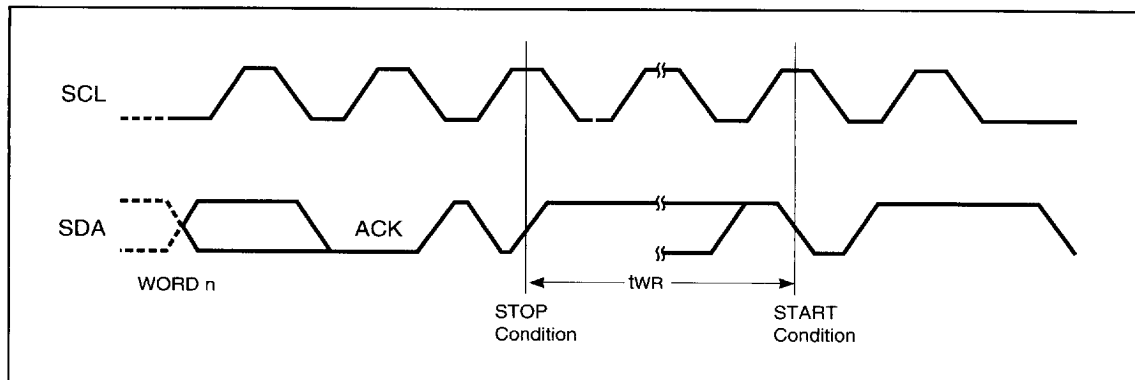
AC WAVEFORMS

BUS TIMING



4

WRITE CYCLE



ORDERING INFORMATION**Commercial Range: 0°C to +70°C**

| Frequency | Order Part Number | Package |
|-----------|-------------------|---------------------------|
| 100 KHz | IS24C02-P | 600-mil Plastic DIP |
| 100 KHz | IS24C02-G | Small Outline (JEDEC STD) |

ORDERING INFORMATION**Industrial Range: -40°C to +85°C**

| Frequency | Order Part Number | Package |
|-----------|-------------------|---------------------------|
| 100 KHz | IS24C02-PI | 600-mil Plastic DIP |
| 100 KHz | IS24C02-GI | Small Outline (JEDEC STD) |