IS24C04-3

4,096-BIT SERIAL ELECTRICALLY ERASABLE PROM

PRELIMINARY
JANUARY 1998

FEATURES

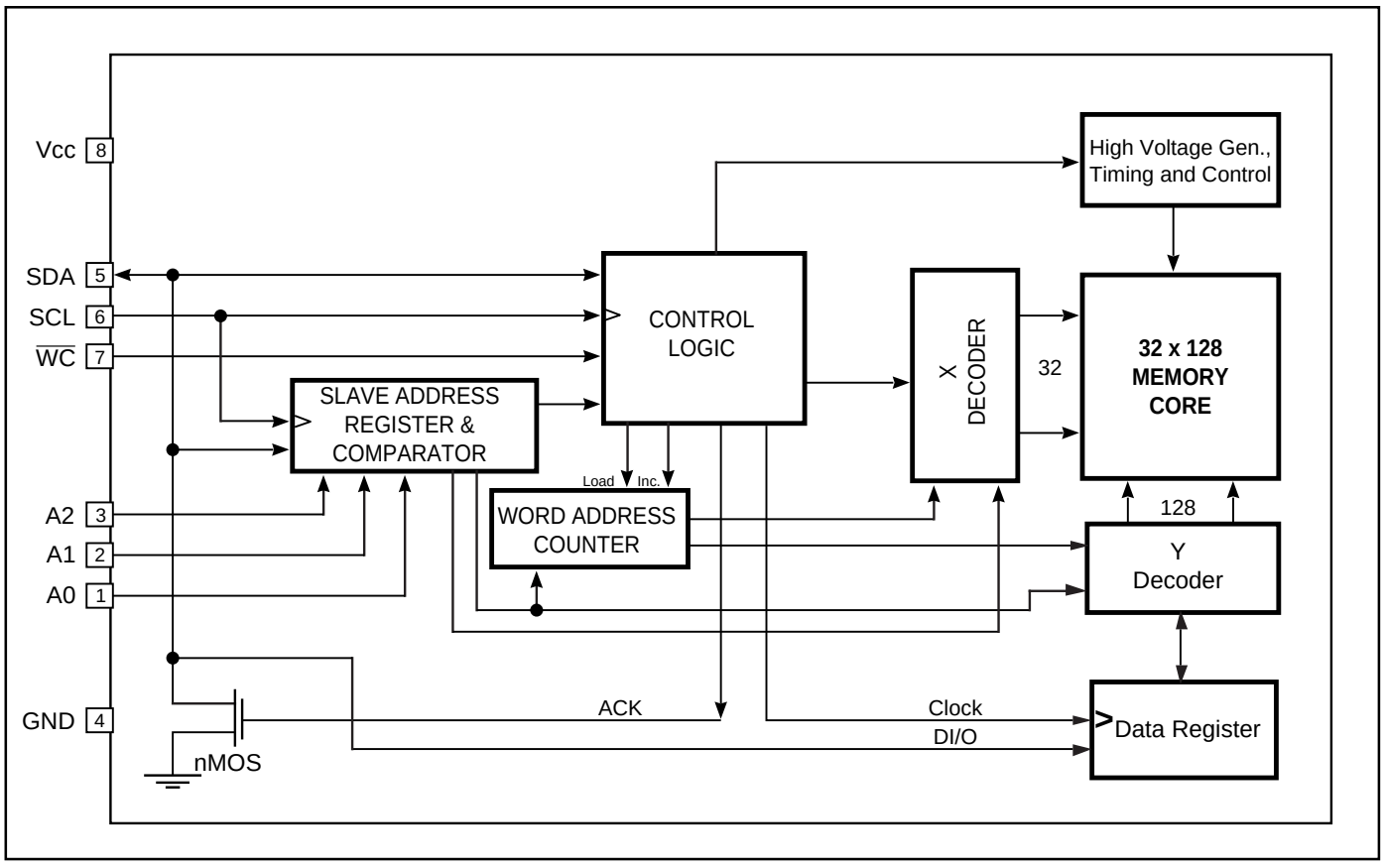
- Low power CMOS
  — Active current less than 2 mA
  — Standby current less than 8 μA
- Low voltage operation
  — 3.0V (Vcc = 2.7V to 5.5V)
- Hardware write protection
  — Write control pin
- Internally organized as 512 x 8
- Two-wire serial interface
  — Bidirectional data transfer protocol
- 16-Byte 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: 1,000,000 cycles per byte
- 8-pin PDIP or SOIC packages
- Filtered inputs for noise suppression

OVERVIEW

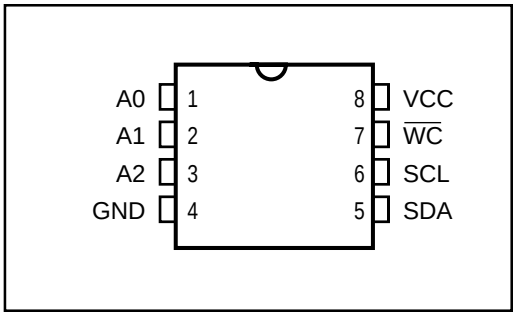
The IS24C04-3 is a low cost 4,096-bit serial EEPROM. It is fabricated using ***ISSI***'s advanced CMOS EEPROM technology and operates from a single supply.

The IS24C04-3 is internally organized as two 256 x 8 memory banks. The IS24C04-3 features a serial interface and software protocol allowing operation on a simple 2-wire bus. Up to eight IS24C04-3s may be connected to the 2-wire bus by programming the A0, A1, and A2 inputs.

FUNCTIONAL BLOCK DIAGRAM



PIN CONFIGURATION
8-Pin DIP and SOIC



PIN DESCRIPTIONS

A0-A2	Address Inputs
SDA	Serial Data I/O
SCL	Serial Clock Input
$\overline{WC}$	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.

Address (A0) - The A0 pin is not electrically connected to the IS24C04-3.

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 four IS24C04-3 devices to be connected together on the bus. An optional device will have these pins “don’t care.”

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 IS24C04-3 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 1,000,000 write cycles.

APPLICATIONS

The IS24C04-3 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 IS24C04-3 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 IS24C04-3 will be a slave device, since it never initiates any data transfers. Up to four IS24C04-3 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 transfered 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 IS24C04-3, this is fixed as 1010. The next three significant address bits (Bit 3 to Bit 1) address a particular device. Up to four IS24C04-3 devices can be connected on the bus. These four addresses are defined by the state of A1 and A2 inputs. The next bit of the serial stream (Bit 1) is the bank select bit. It is used by the host to toggle between the two 2K banks of memory. It is, in effect, the most significant bit of the word address, or A8. In order to access 512 bytes of data, nine address bits are required. A0 to A7 are transmitted in the word address. 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 IS24C04-3 requires another 8-bit data word address following the Device Addressing Byte and ACKnowledgement. The ninth address bit (A8) is provided by the bank select bit that is part of the device addressing byte. This data word address provides access to any one of the 512 data words of device's memory array.

Upon receipt of the data word address, the IS24C04-3 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 IS24C04-3 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 IS24C04-3 is capable of 16-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 transfered, the master device can transmit up to 15 more words. After the receipt of each data word, the IS24C04-3 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 16 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 IS24C04-3 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 representive of the operation desired. Only if the internal write cycle has been completed will the IS24C04-3 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 IS24C04-3 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 IS24C04-3 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 IS24C04-3.

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 IS24C04-3 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 IS24C04-3. The IS24C04-3 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 date 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 IS24C04-3 continues to output data for each ACKnowledge received. (Refer to Figure 9. Sequential Read Operation Starting with a Random Address READ Diagram.)

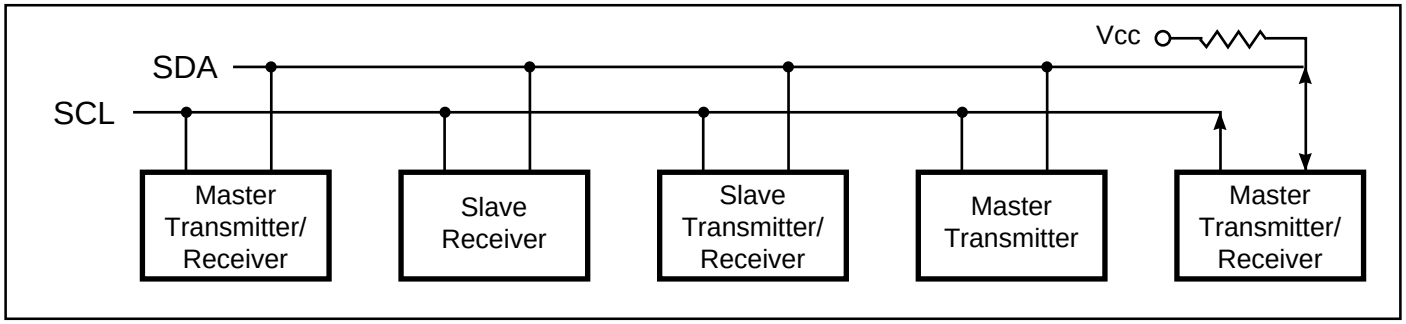


Figure 1. Typical System Bus Configuration

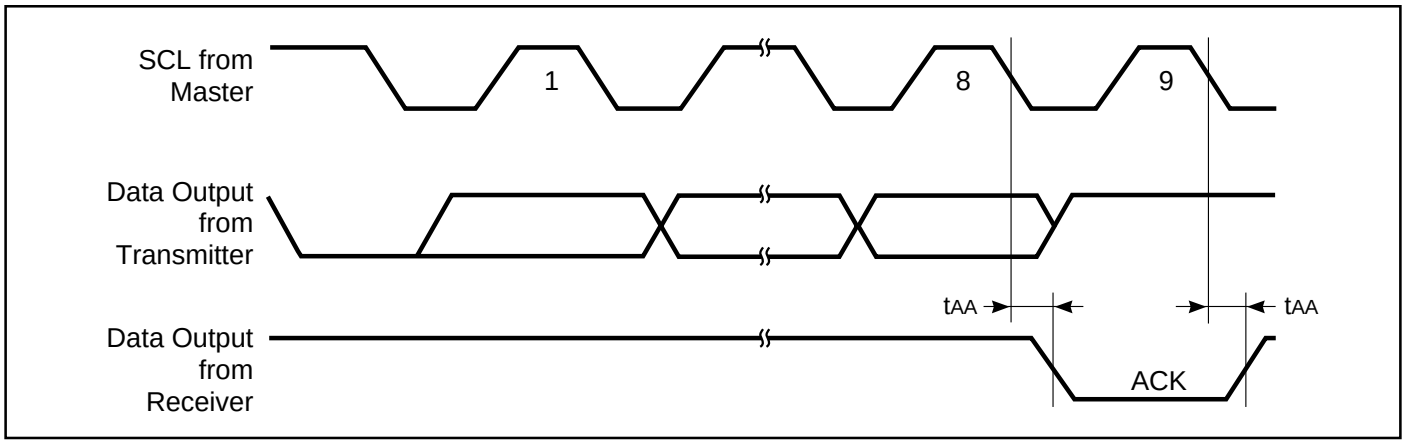


Figure 2. ACKnowledge Response from Receiver

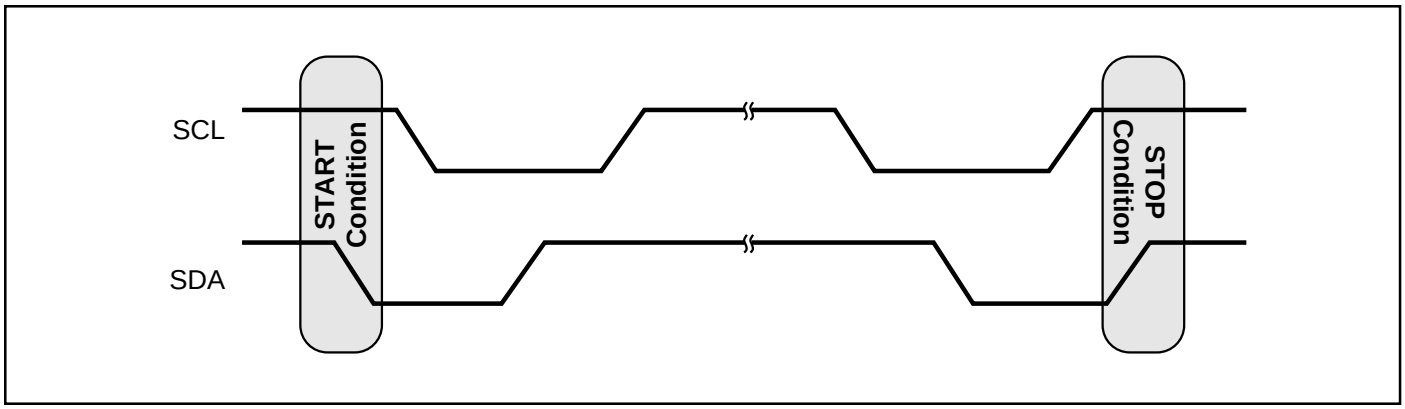


Figure 3. START and STOP Conditions

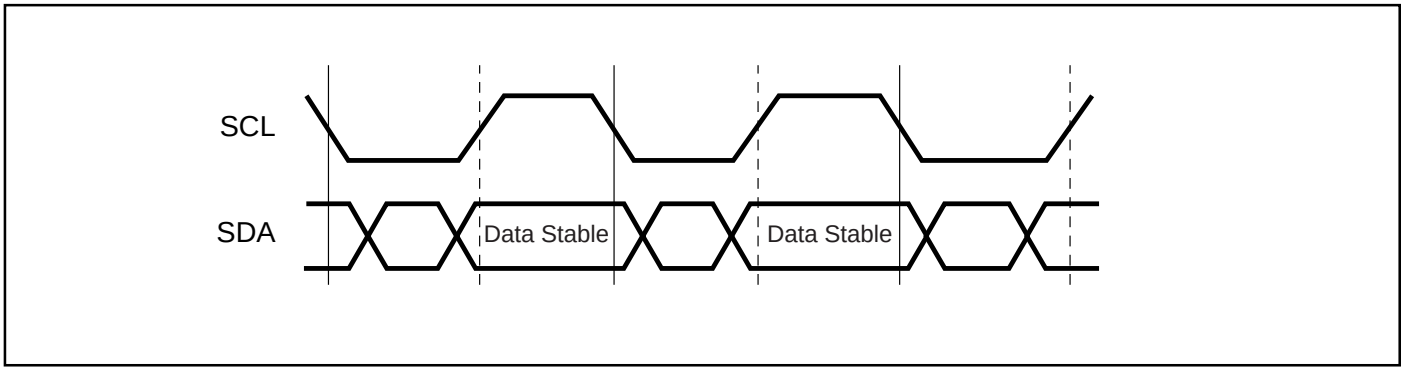


Figure 4. Data Validity Protocol

DEVICE TYPE IDENTIFIER				DEVICE ADDRESS		BANK SELECT	READ/ WRITE
SLAVE ADDRESS							
1	0	1	0	A2	A1	BS (A8)	READ = 1 WRITE = 0

Figure 5. Device Addressing Byte Definitions

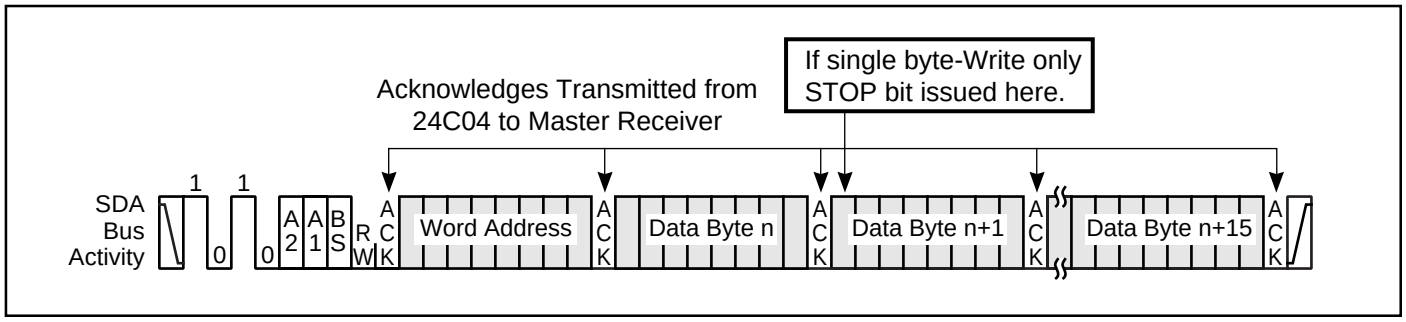


Figure 6. Write Operation

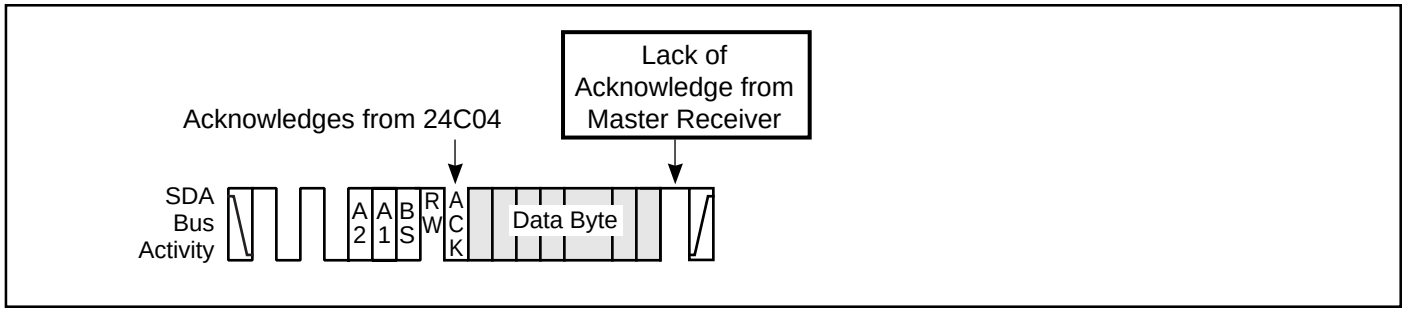


Figure 7. Current Address Read

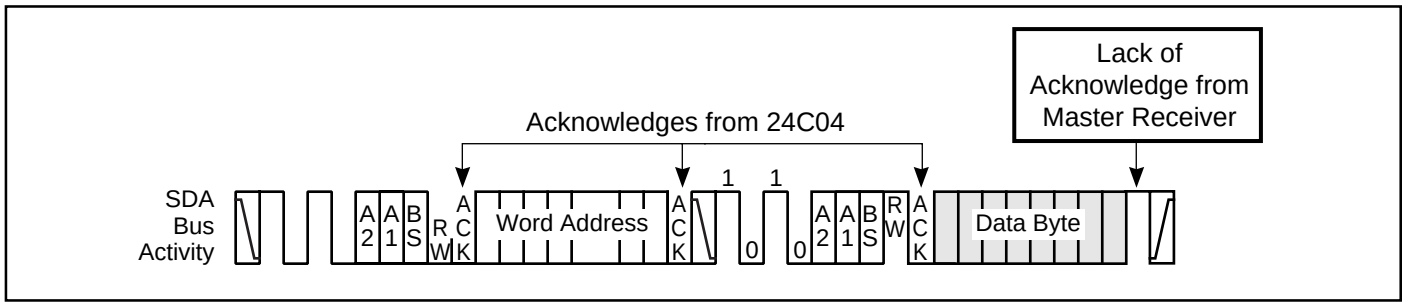


Figure 8. Random Access Read

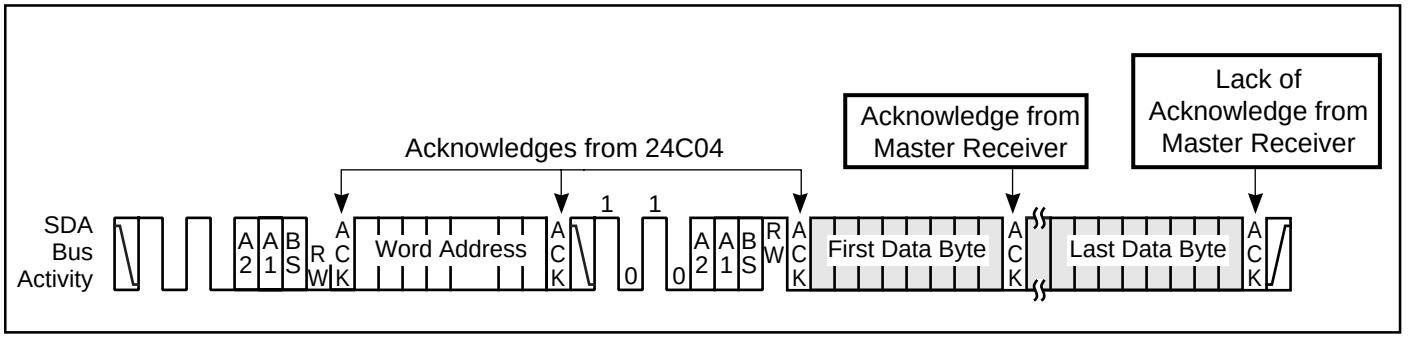


Figure 9. Sequential Read

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 Vcc + 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	Vcc
Commercial	0°C to +70°C	2.7V to 5.5V
Industrial	–40°C to +85°C	2.7V to 5.5V

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, Vcc = 5.0V.

DC ELECTRICAL CHARACTERISTICS

T_A = 0°C to +70°C for IS24C04-3 and –40°C to +85°C for IS24C04-3I, Vcc = 2.7V 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 IS24C04-3 and –40°C to +85°C for IS24C04-3I, Vcc = 2.7V to 5.5V.

Symbol	Parameter	Test Conditions	Min.	Max.	Unit
I_{CC1}	Vcc Operating Supply Current	SCL = CMOS Levels at 100 KHz SDA = Open All Other Inputs = GND or Vcc	—	2	mA
I_{SB1}	Standby Current CMOS	SCL = SDA = V_{CC} = 2.7V to 5.5V All Other Inputs = GND or Vcc	—	8	µA

AC ELECTRICAL CHARACTERISTICS

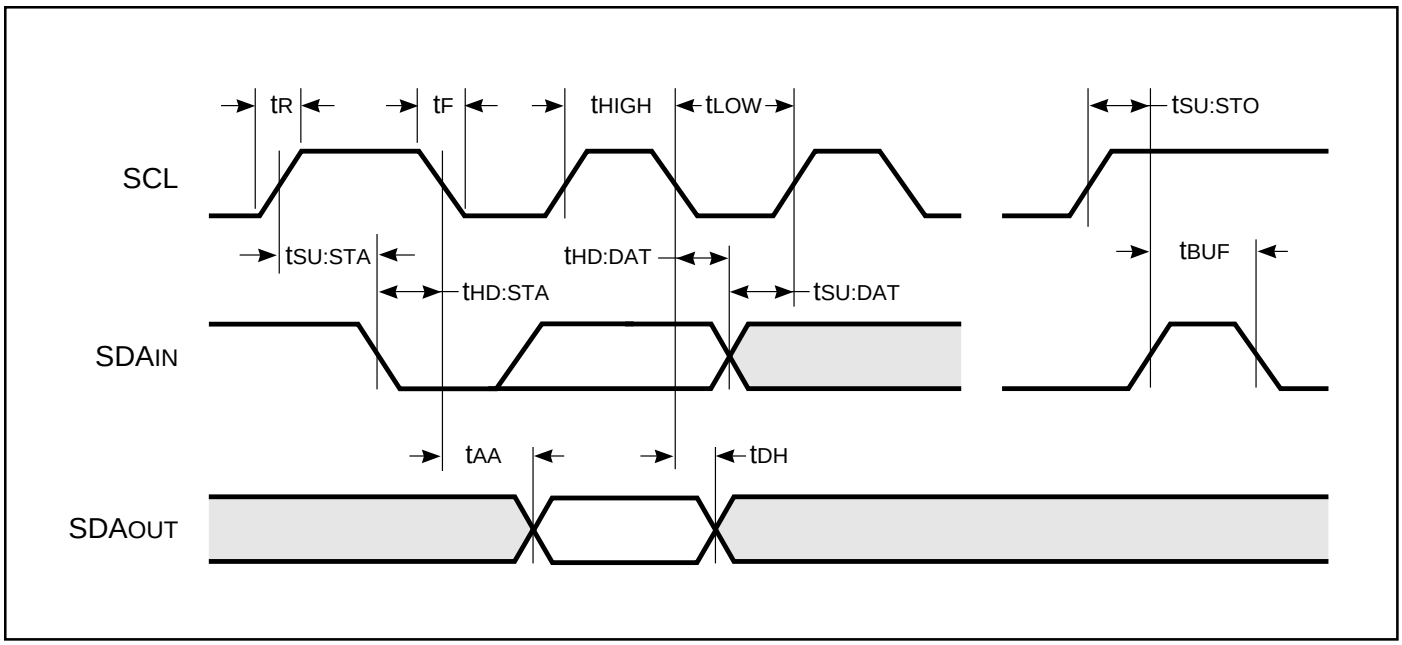
T_A = 0°C to +70°C for IS24C04-3 and –40°C to +85°C for IS24C04-3I, Vcc = 2.7V to 5.5V.

Symbol	Parameter	Test Conditions	Min.	Max.	Unit
f_{SCL}	SCL Clock Frequency(1)		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(2)	Time Constant at SCL, SDA Inputs	—	100	ns

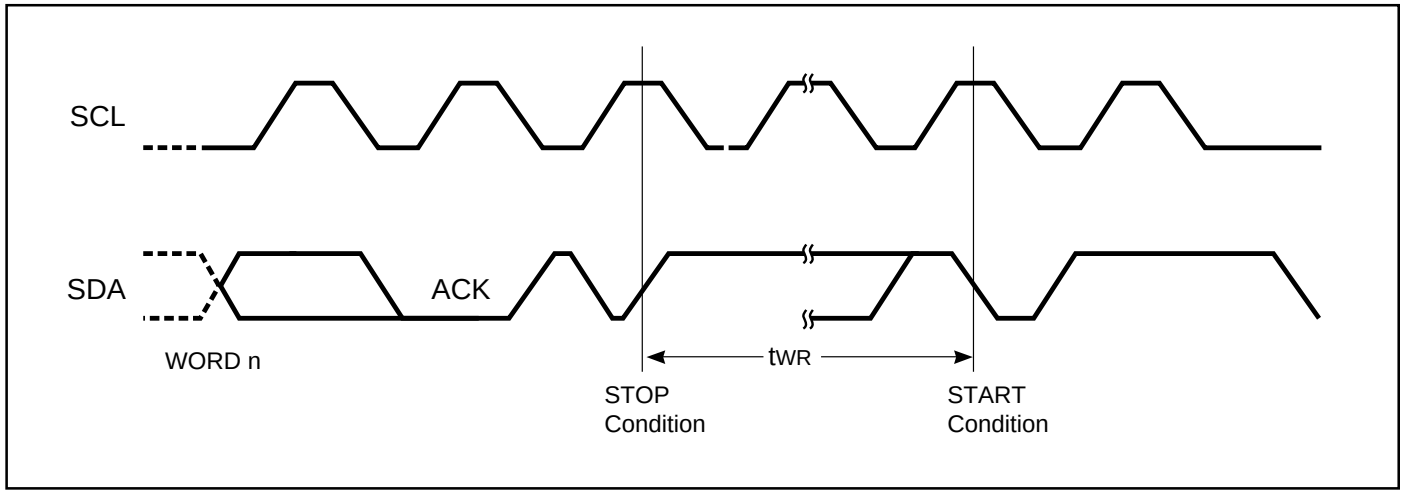
Notes:
1. This parameter is sampled and not 100% tested.

AC WAVEFORMS

BUS TIMING



WRITE CYCLE



ORDERING INFORMATION

Commercial Range: 0°C to +70°C

Frequency	Order Part Number	Package
100 KHz	IS24C04-3-P	300-mil Plastic DIP
	IS24C04-3-G	Small Outline (JEDEC STD)

ORDERING INFORMATION

Industrial Range: –40°C to +85°C

Frequency	Order Part Number	Package
100 KHz	IS24C04-3PI	300-mil Plastic DIP
	IS24C04-3GI	Small Outline (JEDEC STD)

Integrated Silicon Solution, Inc.
2231 Lawson Lane
Santa Clara, CA 95054
Fax: (408) 588-0806
Toll Free: 1-800-379-4774
e-mail: sales@issiusa.com
http://www.issiusa.com