

Features

- Fast Read Access Time – 120 ns
- Automatic Page Write Operation
 - Internal Address and Data Latches for 128 Bytes
 - Internal Control Timer
- Fast Write Cycle Time
 - Page Write Cycle Time – 10 ms Maximum
 - 1 to 128-byte Page Write Operation
- Low Power Dissipation
 - 50 mA Active Current
 - 10 mA CMOS Standby Current
- Hardware and Software Data Protection
- DATA Polling for End of Write Detection
- High Reliability CMOS Technology
 - Endurance: $5 \cdot 10^4$ Read/Modify Write Cycles @ Ground Level
 - Data Retention: 10 Years
- Operating Range: 4.5V to 5.5V, -55 to +125°C
- CMOS and TTL Compatible Inputs and Outputs
- No Single Event Latch-up below a LET Threshold of 80 MeV/mg/cm²
- Tested up to a Total Dose of (according to MIL STD 883 Method 1019):
 - 10 kRads (Si) Read-only Mode when Biased
 - 30 kRads (Si) Read-only Mode when Unbiased
- JEDEC Approved byte-Wide Pinout
435 Mils Wide 32-Pin Flat Pack Package

Description

The AT28C010-12DK is a high-performance Electrically Erasable and Programmable Read-Only Memory. Its one megabit of memory is organized as 131,072 words by 8 bits. Manufactured with Atmel's advanced nonvolatile CMOS technology, the device offers access times to 120 ns with power dissipation of just 275 mW. When the device is deselected, the CMOS standby current is less than 10 mA.

The AT28C010-12DK is accessed like a Static RAM for the read or write cycle without the need for external components. The device contains a 128-byte page register to allow writing of up to 128 bytes simultaneously. During a write cycle, the address and 1 to 128 bytes of data are internally latched, freeing the address and data bus for other operations. Following the initiation of a write cycle, the device will automatically write the latched data using an internal control timer. The end of a write cycle can be detected by DATA POLLING of I/O7. Once the end of a write cycle has been detected a new access for a read or write can begin.

Atmel's 28C010 has additional features to ensure high quality in manufacturing. The device utilizes internal error correction for extended endurance and improved data retention characteristics. An optional software data protection mechanism is available to guard against inadvertent writes. The device also includes an extra 128 bytes of EEPROM for device identification or tracking.



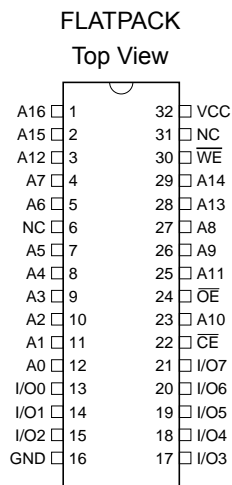
Space 1-MBit (128K x 8) Paged Parallel EEPROMs

AT28C010-12DK

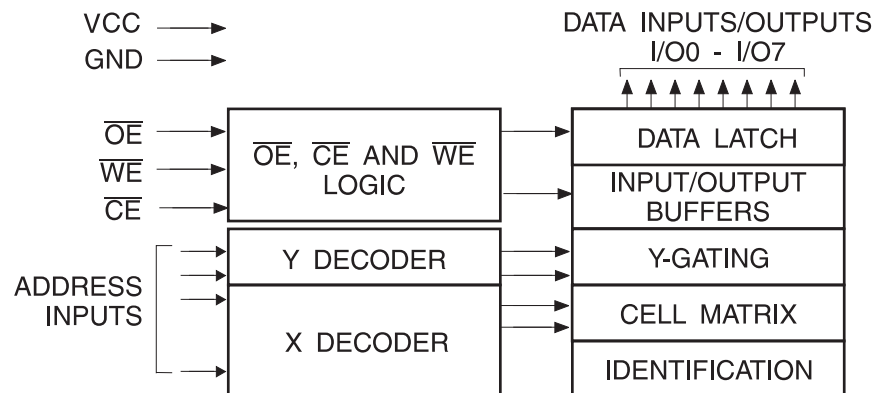


Pin Configuration

| Pin Name | Function |
|------------------------|---------------------|
| A0 - A16 | Addresses |
| $\overline{\text{CE}}$ | Chip Enable |
| $\overline{\text{OE}}$ | Output Enable |
| $\overline{\text{WE}}$ | Write Enable |
| I/O0 - I/O7 | Data Inputs/Outputs |
| NC | No Connect |



Block Diagram



Device Operation

- **READ:** The AT28C010-12DK is accessed like a Static RAM. When \overline{CE} and \overline{OE} are low and \overline{WE} is high, the data stored at the memory location determined by the address pins is asserted on the outputs. The outputs are put in the high impedance state when either \overline{CE} or \overline{OE} is high. This dual-line control gives designers flexibility in preventing bus contention in their system.
- **BYTE WRITE:** A low pulse on the \overline{WE} or \overline{CE} input with \overline{CE} or \overline{WE} low (respectively) and \overline{OE} high initiates a write cycle. The address is latched on the falling edge of \overline{CE} or \overline{WE} , whichever occurs last. The data is latched by the first rising edge of \overline{CE} or \overline{WE} . Once a byte write has been started it will automatically time itself to completion. Once a programming operation has been initiated and for the duration of t_{WC} , a read operation will effectively be a polling operation.
- **PAGE WRITE:** The page write operation of the AT28C010-12DK allows 1 to 128 bytes of data to be written into the device during a single internal programming period. A page write operation is initiated in the same manner as a byte write; the first byte written can then be followed by 1 to 127 additional bytes. Each successive byte must be written within 150 μ s (t_{BLC}) of the previous byte. If the t_{BLC} limit is exceeded the AT28C010-12DK will cease accepting data and commence the internal programming operation. All bytes during a page write operation must reside on the same page as defined by the state of the A7 - A16 inputs. For each \overline{WE} high to low transition during the page write operation, A7 - A16 must be the same.
- The A0 to A6 inputs are used to specify which bytes within the page are to be written. The bytes may be loaded in any order and may be altered within the same load period. Only bytes which are specified for writing will be written; unnecessary cycling of other bytes within the page does not occur.
- **DATA POLLING:** The AT28C010-12DK features \overline{DATA} Polling to indicate the end of a write cycle. During a byte or page write cycle an attempted read of the last byte written will result in the complement of the written data to be presented on I/O7. Once the write cycle has been completed, true data is valid on all outputs, and the next write cycle may begin. \overline{DATA} Polling may begin at anytime during the write cycle.
- **TOGGLE BIT:** In addition to \overline{DATA} Polling the AT28C010-12DK provides another method for determining the end of a write cycle. During the write operation, successive attempts to read data from the device will result in I/O6 toggling between one and zero. Once the write has completed, I/O6 will stop toggling and valid data will be read. Reading the toggle bit may begin at any time during the write cycle.
- **DATA PROTECTION:** If precautions are not taken, inadvertent writes may occur during transitions of the host system power supply. Atmel has incorporated both hardware and software features that will protect the memory against inadvertent writes. For more information see the application note:
http://www.atmel.com/dyn/resources/prod_documents/DOC0544.PDF
- **HARDWARE PROTECTION:** Hardware features protect against inadvertent writes to the AT28C010-12DK in the following ways: (a) V_{DD} sense – if V_{DD} is below 3.8V (typical) the write function is inhibited; (b) V_{DD} power-on delay – once V_{DD} has reached 3.8V the device will automatically time out 5 ms (typical) before allowing a write; (c) write inhibit - holding any one of \overline{OE} low, \overline{CE} high or \overline{WE} high inhibits write cycles; (d) noise filter - pulses of less than 15 ns (typical) on the \overline{WE} or \overline{CE} inputs will not initiate a write cycle.
SOFTWARE DATA PROTECTION: A software controlled data protection feature has been implemented on the AT28C010-12DK. When enabled, the software data protection (SDP), will prevent inadvertent writes. The SDP feature may be enabled or disabled by the user; the AT28C010-12DK is shipped from Atmel with SDP disabled.
- SDP is enabled by the host system issuing a series of three write commands; three specific bytes of data are written to three specific addresses (refer to Software Data Protection



Algorithm). After writing the 3-byte command sequence and after t_{WC} the entire AT28C010-12DK will be protected against inadvertent write operations. It should be noted, that once protected the host may still perform a byte or page write to the AT28C010-12DK. This is done by preceding the data to be written by the same 3-byte command sequence used to enable SDP.

- Once set, SDP will remain active unless the disable command sequence is issued. Power transitions do not disable SDP and SDP will protect the AT28C010-12DK during power-up and power-down conditions. All command sequences must conform to the page write timing specifications. The data in the enable and disable command sequences is not written to the device and the memory addresses used in the sequence may be written with data in either a byte or page write operation.
- After setting SDP, any attempt to write to the device without the 3-byte command sequence will start the internal write timers. No data will be written to the device; however, for the duration of t_{WC} , read operations will effectively be polling operations.
- **DEVICE IDENTIFICATION:** An extra 128 bytes of EEPROM memory are available to the user for device identification. By raising A9 to $12V \pm 0.5V$ and using address locations 1FF80H to 1FFFFH the bytes may be written to or read from in the same manner as the regular memory array.
- **OPTIONAL CHIP ERASE MODE:** The entire device can be erased using a 6-byte software code. Please see Software Chip Erase application note for details.

DC and AC Operating Range

| | AT28C010-12DK-12 |
|------------------------------|-------------------------|
| Operating Temperature (Case) | -55°C to +125°C |
| V _{DD} Power Supply | 5V ± 10% |

Operating Modes

| Mode | \overline{CE} | \overline{OE} | \overline{WE} | I/O |
|-------------------------|-----------------|-----------------|-----------------|---------------------|
| Read | V_{IL} | V_{IL} | V_{IH} | D_{OUT} |
| Write ⁽¹⁾ | V_{IL} | V_{IH} | V_{IL} | D_{IN} |
| Standby | V_{IH} | X | X | High Z |
| Write Inhibit | X | X | V_{IH} | D_{OUT} or High Z |
| Write Inhibit | V_{IH} | X | X | High Z |
| Write Inhibit | X | V_{IL} | X | D_{OUT} or High Z |
| Write Inhibit | V_{IL} | V_{IL} | V_{IL} | No operation |
| Software Chip Clear | V_{IL} | V_{IH} | V_{IL} | D_{IN} |
| Software Write Protect | V_{IL} | V_{IH} | V_{IL} | D_{IN} |
| High Voltage Chip Clear | V_{IL} | V_H | V_{IL} | V_{IH} |
| Output Disable | X | V_{IH} | X | High Z |

V_{IH} = High Logic, "1" state, V_{IL} = Low Logic "0" state.

X = logic "don't care" state, High Z = high impedance state.

V_H = Chip clear voltage, D_{OUT} = Data out, and D_{IN} = Data in.

Notes: 1. Refer to AC Programming Waveforms



Electrical Characteristics

Absolute Maximum Ratings*

| | |
|---|--------------------------|
| Temperature Under Bias | -55°C to +125°C |
| Storage Temperature | -65°C to +150°C |
| All Input Voltages (including NC Pins) with Respect to Ground | -0.6V to +6.25V |
| All Output Voltages with Respect to Ground | -0.6V to $V_{DD} + 0.6V$ |
| Voltage on \overline{OE} and A9 with Respect to Ground | -0.6V to +13.5V |

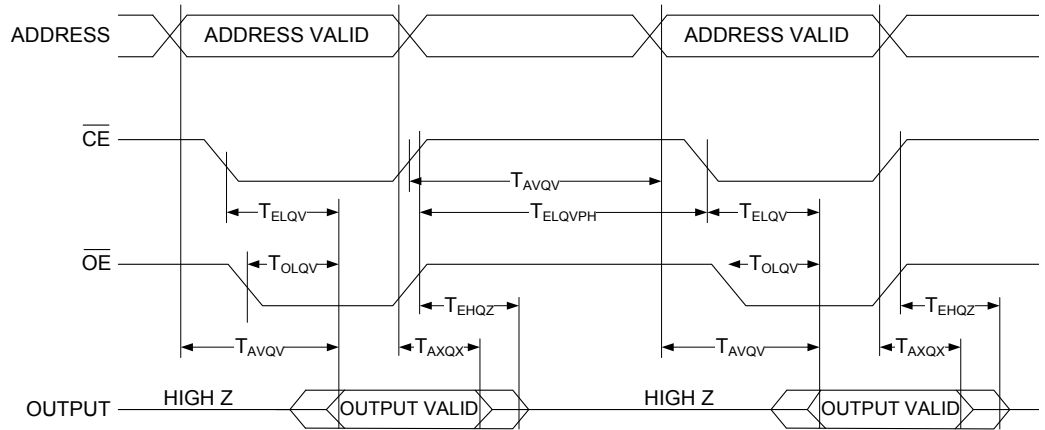
*NOTICE: Stresses beyond those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

DC Characteristics

| Symbol | Parameter | Condition | Min | Max | Units |
|--------------------|-------------------------------|--|-----|------|-------|
| I_{IL}, I_{IH} | Low Level Input Current | $V_{IN} = 0V$ to $V_{DD} + 1V$ | -10 | 10 | mA |
| I_{OZL}, I_{OZH} | Output Leakage Current | $V_{IO} = 0V$ to V_{DD} | -10 | 10 | mA |
| I_{CC3} | V_{DD} Standby Current CMOS | $\overline{CE} = V_{DD} - 0.3V$ to $V_{DD} + 1V$ | | 10 | mA |
| I_{CC2} | V_{DD} Standby Current TTL | $\overline{CE} = 2.0V$ to $V_{DD} + 1V$ | | 10 | mA |
| I_{CC1} | V_{DD} Active Current | $f = 5$ MHz; $I_{OUT} = 0$ mA | | 50 | mA |
| V_{IL} | Input Low Voltage | | | 0.8 | V |
| V_{IH} | Input High Voltage | | 2.0 | | V |
| V_{OL} | Output Low Voltage | $I_{OL} = 2.1$ mA | | 0.45 | V |
| V_{OH1} | Output High Voltage | $I_{OH} = -400$ mA | 2.4 | | V |
| V_{OH2} | Output High Voltage CMOS | $I_{OH} = -100$ mA; $V_{DD} = 4.5V$ | 4.2 | | V |

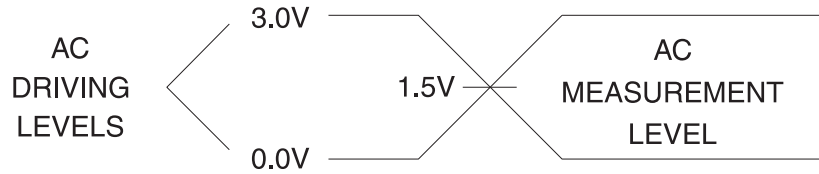
AC Read Characteristics

AC Read Waveforms⁽¹⁾⁽²⁾⁽³⁾⁽⁴⁾

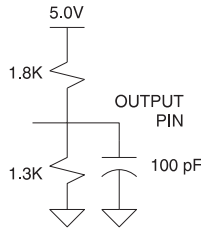


- Notes:
1. \overline{CE} may be delayed up to $T_{AVQV} - T_{ELQV}$ after the address transition without impact on T_{AVQV} .
 2. \overline{OE} may be delayed up to $T_{ELQV} - T_{OLQV}$ after the falling edge of \overline{CE} without impact on T_{ELQV} or by $T_{AVQV} - T_{OLQV}$ after an address change without impact in T_{AVQV} .
 3. T_{EHQZ} is specified from OE or CE whichever occurs first (CL = 5 pF).
 4. This parameter is characterized and is not 100% tested.
 5. If \overline{CE} is de-asserted, it must remain de-asserted for at least 50ns during read operations otherwise incorrect data may be read.

Input Test Waveforms and Measurement Level



Output Test Load



Pin Capacitance $f = 1 \text{ MHz}, T = 25^\circ\text{C}^{(1)}$

| Symbol | Typ | Max | Units | Conditions |
|-----------|-----|-----|-------|----------------|
| C_{IN} | 4 | 10 | pF | $V_{IN} = 0V$ |
| C_{OUT} | 8 | 12 | pF | $V_{OUT} = 0V$ |

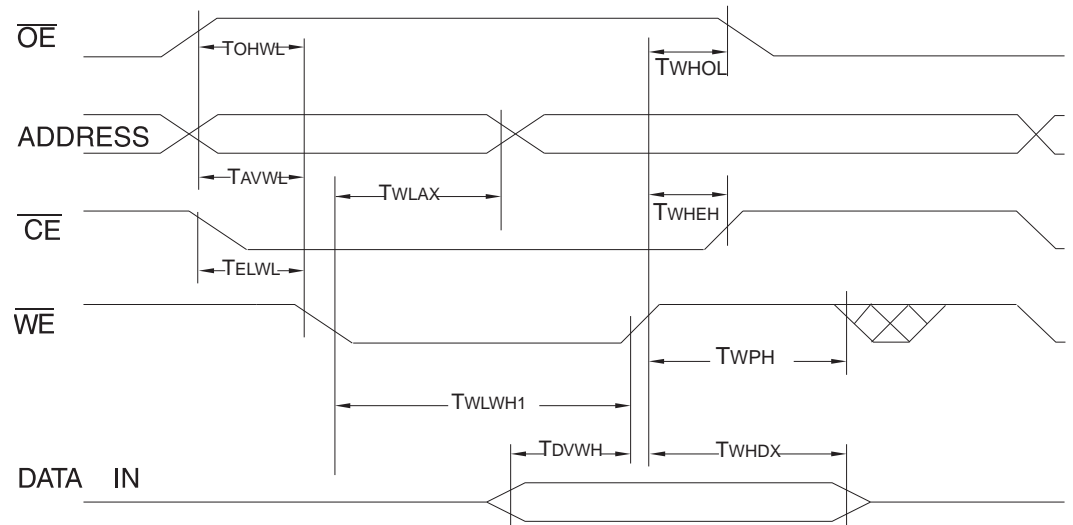
Note: 1. This parameter is 100% characterized and is not 100% tested.

AC Write Characteristics

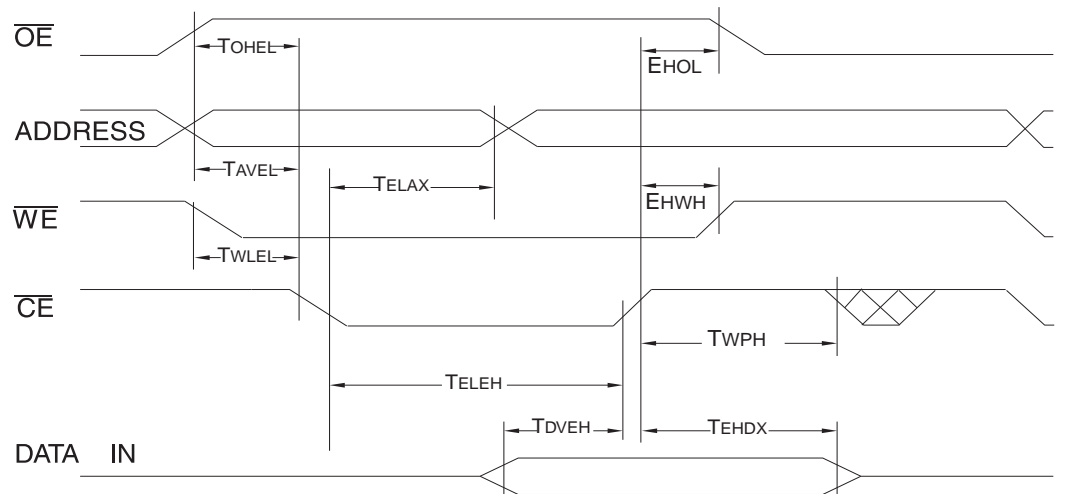
| Symbol | Parameter | Min | Max | Units |
|--|--|-----|-----|-------|
| $T_{AVEL}, T_{AVWL}, T_{OHWL}, T_{OHEL}$ | Address, \overline{OE} Set-up Time | 0 | | ns |
| T_{ELAX}, T_{WLAX} | Address Hold Time | 50 | | ns |
| T_{WLEL}, T_{ELWL} | Chip Select Set-up Time | 0 | | ns |
| T_{EHWL}, T_{WHEH} | Chip Select Hold Time | 0 | | ns |
| T_{ELEH}, T_{WLWHI} | Write Pulse Width (\overline{WE} or \overline{CE}) | 100 | | ns |
| T_{DVEH}, T_{DVWH} | Data Set-up Time | 50 | | ns |
| $T_{EHDX}, T_{WHDX}, T_{WHOL}, T_{EHOL}$ | Data, \overline{OE} Hold Time | 0 | | ns |
| T_{WPH} | Write Pulse Width High | 50 | | ns |

AC Write
Waveforms

$\overline{\text{WE}}$ Controlled



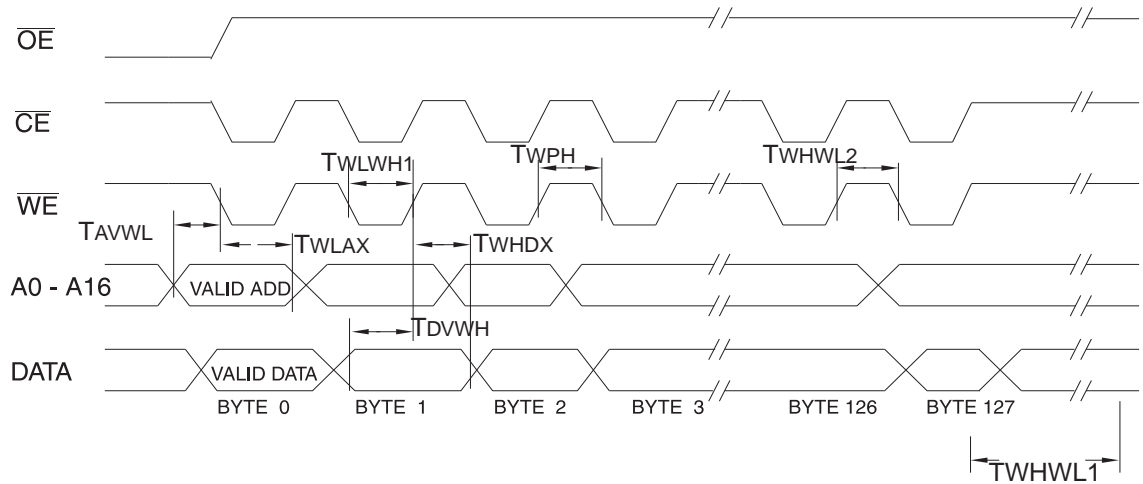
$\overline{\text{CE}}$ Controlled



Page Mode Characteristics

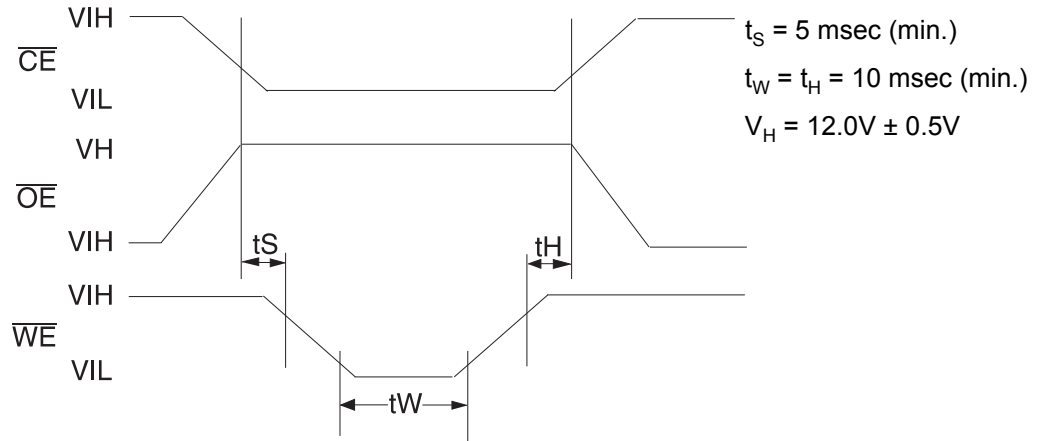
| Symbol | Parameter | Min | Max | Units |
|----------------------|--|-----|-----|-------|
| T_{WHWL1} | Write Cycle Time | | 10 | ms |
| T_{AVWL}, T_{OHWL} | Address Set-up Time, \overline{OE} Set up time | 0 | | ns |
| T_{WLAX} | Address Hold Time | 50 | | ns |
| T_{DVWH} | Data Set-up Time | 50 | | ns |
| T_{WHDX}, T_{WHOL} | Data Hold Time, \overline{OE} Hold time | 0 | | ns |
| T_{WLWH1} | Write Pulse Width | 100 | | ns |
| T_{WHWL2} | Byte Load Cycle Time | | 150 | ms |
| T_{WPH} | Write Pulse Width High | 50 | | ns |

Page Mode Write Waveforms ⁽¹⁾⁽²⁾



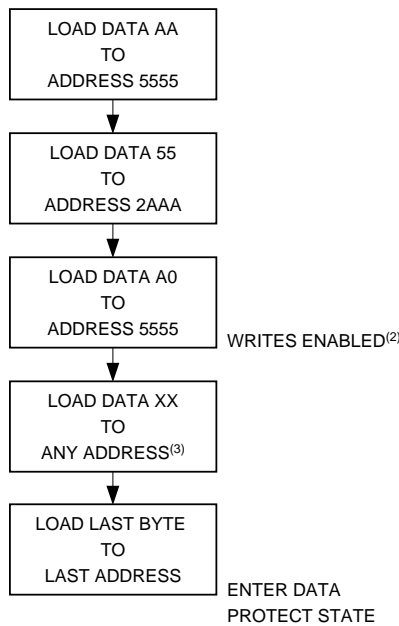
- Notes:
1. A7 through A16 must specify the page address during each high to low transition of \overline{WE} (or \overline{CE}).
 2. \overline{OE} must be high only when \overline{WE} and \overline{CE} are both low.

Chip Erase Waveforms



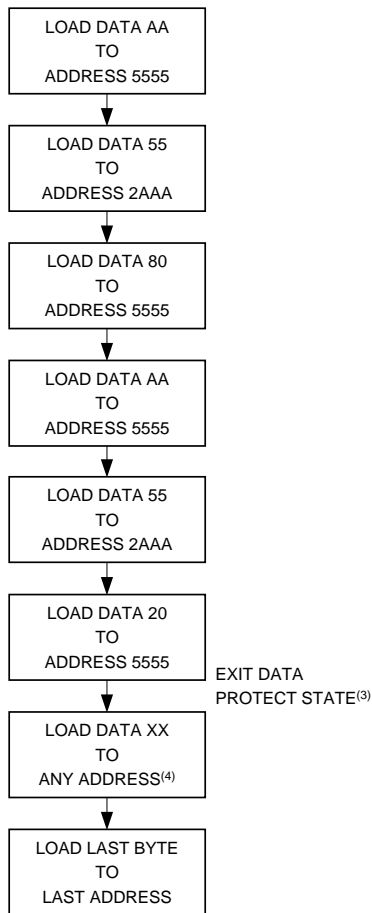
Software Data

Figure 1. Protection Enable Algorithm⁽¹⁾



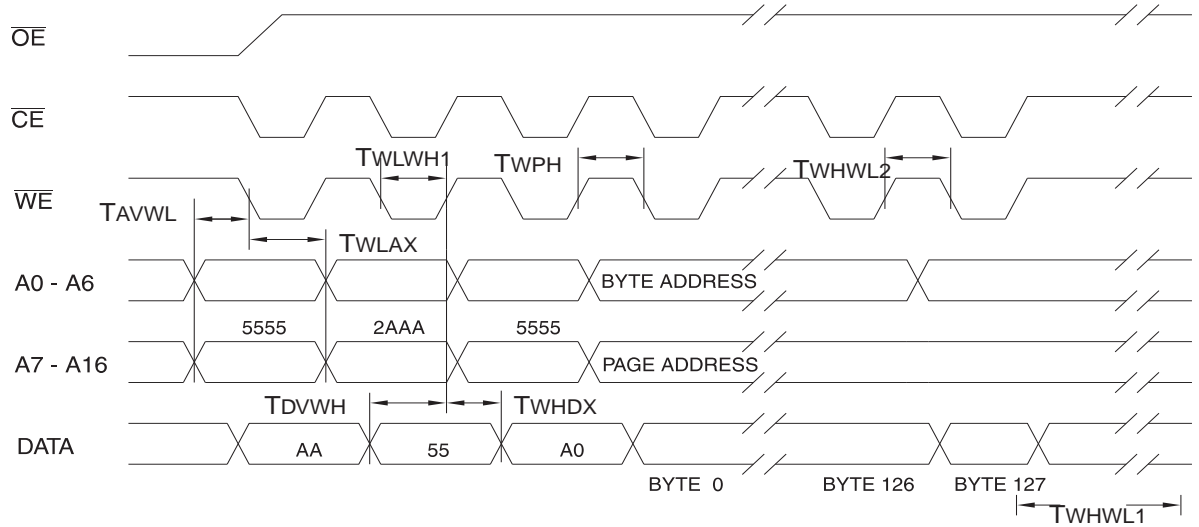
- Notes:
1. Data Format: I/O7 - I/O0 (Hex); Address Format: A14 - A0 (Hex).
 2. Write Protect state will be activated at end of write even if no other data is loaded.
 3. 1 to 128 bytes of data are loaded.

Figure 2. Protection Disable Algorithm⁽¹⁾



- Notes:
1. Data Format: I/O7 - I/O0 (Hex);
Address Format: A14 - A0 (Hex).
 2. Write Protect state will be activated at end of write even if no other data is loaded.
 3. Write Protect state will be deactivated at end of write period even if no other data if loaded.
 4. 1 to 128 bytes of data are loaded.

Software Protected Program Cycle Waveform⁽¹⁾⁽²⁾⁽³⁾



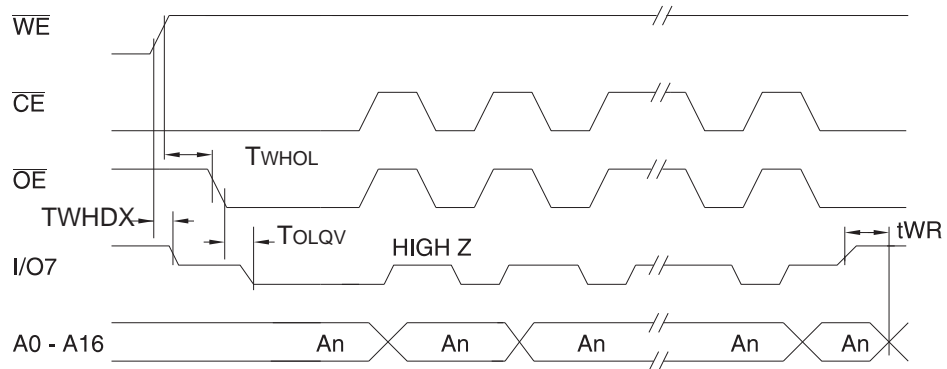
- Notes:
1. A0 - A14 must conform to the addressing sequence for the first 3 bytes as shown above.
 2. After the command sequence has been issued and a page write operation follows, the page address inputs (A7 - A16) must be the same for each high to low transition of \overline{WE} (or \overline{CE}).
 3. \overline{OE} must be high only when \overline{WE} and \overline{CE} are both low.

Data Polling Characteristics⁽¹⁾

| Symbol | Parameter | Min | Typ | Max | Units |
|------------|--|-----|-----|-----|-------|
| T_{WHDX} | Data Hold Time | 10 | | | ns |
| T_{WHOL} | \overline{OE} Hold Time | 10 | | | ns |
| T_{OLQV} | \overline{OE} Access Time ⁽²⁾ | | | | ns |
| t_{WR} | Write Recovery Time | 0 | | | ns |

Notes: 1. These parameters are characterized and not 100% tested.
 2. See AC Read Characteristics.

Data Polling Waveforms

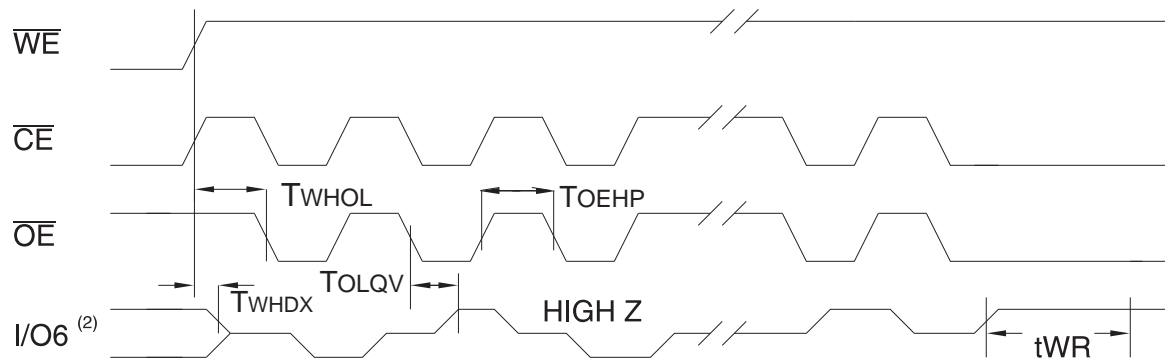


Toggle Bit Characteristics⁽¹⁾

| Symbol | Parameter | Min | Typ | Max | Units |
|------------|--|-----|-----|-----|-------|
| T_{WHDX} | Data Hold Time | 10 | | | ns |
| T_{WHOL} | \overline{OE} Hold Time | 10 | | | ns |
| T_{OLQV} | \overline{OE} Access Time ⁽²⁾ | | | | ns |
| T_{OEHP} | \overline{OE} High Pulse | 150 | | | ns |
| T_{WR} | Write Recovery Time | 0 | | | ns |

- Notes: 1. These parameters are characterized and not 100% tested.
 2. See AC Read Characteristics.

Toggle Bit Waveforms⁽¹⁾⁽²⁾⁽³⁾



- Notes: 1. Toggling either \overline{OE} or \overline{CE} or both \overline{OE} and \overline{CE} will operate toggle bit.
 2. Beginning and ending state of I/O6 will vary.
 3. Any address location may be used but the address should not vary.

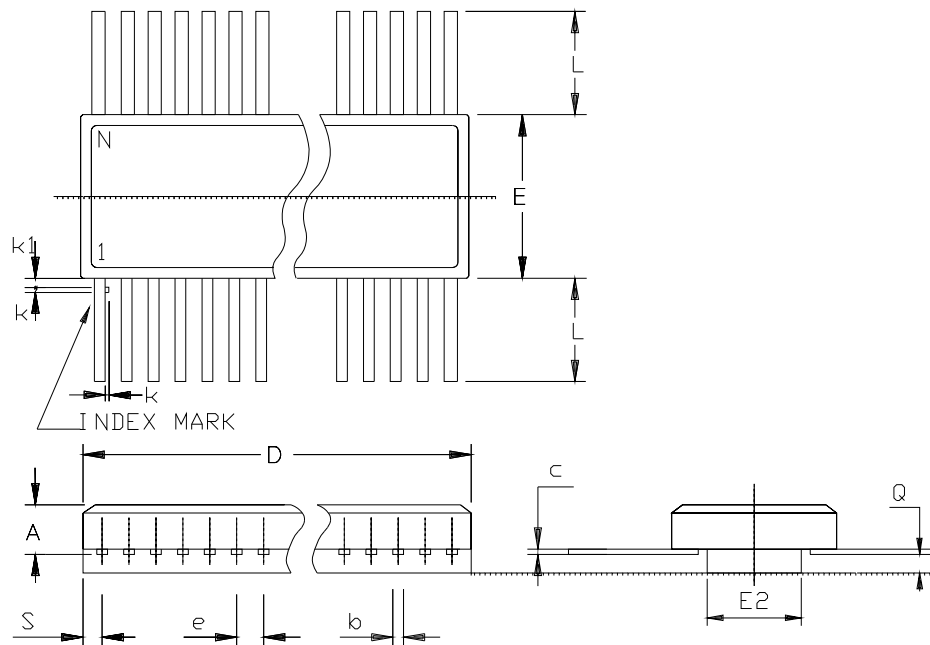
Ordering Information

| t_{ACC} (ns) | I_{CC} (mA) | | Ordering Code | Package | Packing |
|----------------|---------------|---------|------------------|---------|---------------------|
| | Active | Standby | | | |
| 120 | 50 | 10 | AT28C010-12DK-E | FP32.4 | Engineering Samples |
| | | | AT28C010-12DK-MQ | | Military Level B |
| | | | AT28C010-12DK-SV | | Space Level B |

Packaging Information

FP32.435

32F, 32-Lead, Non-Windowed, Ceramic Bottom
 Brazed Flat Package (Flatpack)
 Dimensions in Inches and Millimeters
 MIL-STD-1835 F-18 CONFIG B
 JEDEC OUTLINE MO-115



| | MM | | INCH | |
|----|----------|-------|----------|------|
| | Min | Max | Min | Max |
| A | 1.78 | 2.72 | .070 | .107 |
| b | 0.38 | 0.48 | .015 | .019 |
| c | 0.076 | 0.15 | .003 | .007 |
| D | 20.62 | 21.03 | .812 | .828 |
| E | 10.92 | 11.18 | .430 | .440 |
| E2 | 8.46 | 8.82 | .333 | .347 |
| k | 0.20 | 0.38 | .008 | .015 |
| k1 | 0.63 BSC | | .025 BSC | |
| e | 1.27 BSC | | .050 BSC | |
| L | 6.65 | 8.20 | .262 | .323 |
| Q | 0.66 | ---- | .026 | ---- |
| S | 0.13 | ---- | .005 | .045 |
| N | 32 | | 32 | |

Document Revision History

Changes from Rev. C to Rev. D

Page 7 : updated to be in compliance with military version of the datasheet which implements a condition on the CE Pulse High Time to avoid bad output data when a very fast read enable is used by application.

Changes from Rev. D to Rev. E

Page 1 :

- “Preliminary” status suppressed
- Endurance : Read Cycles replaced by Read/Modify Write Cycles @ Ground Level



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