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N01S818HA

1 Mb Ultra-Low Power Serial SRAM

Standard SPI Interface and Multiplex DUAL and QUAD Interface

Overview

The ON Semiconductor serial SRAM family includes several integrated memory devices including this 1 Mb serially accessed Static Random Access Memory, internally organized as 128 K words by 8 bits. The devices are designed and fabricated using ON Semiconductor's advanced CMOS technology to provide both high-speed performance and low power. The devices operate with a single chip select (\overline{CS}) input and use a simple Serial Peripheral Interface (SPI) protocol. In SPI mode, a single data-in (SI) and data-out (SO) line is used along with the clock (SCK) to access data within the device. In DUAL mode, two multiplexed data-in/data-out (SIO0-SIO1) lines are used and in QUAD mode, four multiplexed data-in/data-out (SIO0-SIO3) lines are used with the clock to access the memory.

The devices can operate over a wide temperature range of -40°C to $+85^{\circ}\text{C}$ and are available in a 8-lead TSSOP package.

Features

- Power Supply Range: 1.7 to 2.2 V
- Very Low Typical Standby Current $< 1 \mu\text{A}$
- Very Low Operating Current $< 10 \text{ mA}$
- Simple Serial Interface
 - ◆ Single-bit SPI Access
 - ◆ DUAL-bit and QUAD-bit SPI-like Access
- Flexible Operating Modes
 - ◆ Word Mode
 - ◆ Page Mode
 - ◆ Burst Mode (Full Array)
- High Frequency Read and Write Operation
 - ◆ Clock Frequency 20 MHz
- Built-in Write Protection (\overline{CS} High)
- High Reliability
 - ◆ Unlimited Write Cycles
- These Devices are Pb-Free and are RoHS Compliant
 - ◆ Green TSSOP

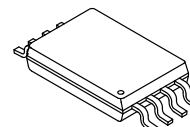
Table 1. DEVICE OPTIONS

| Device / Part Number | Power Supply | Speed | Package | Function |
|----------------------|---------------|--------|---------|----------|
| N01S818HAT22I | 1.7 V – 2.2 V | 20 MHz | TSSOP-8 | HOLD |



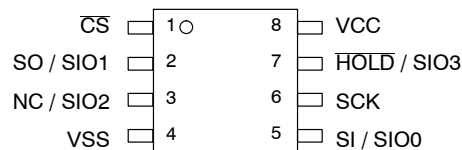
ON Semiconductor®

<http://onsemi.com>



TSSOP8 3x4.4
CASE 948BH

PACKAGE CONFIGURATION



ORDERING INFORMATION

| Device | Package | Shipping† |
|----------------|-------------------|--------------------|
| N01S818HAT22I | TSSOP-8 (Pb-Free) | 100 Units / Tube |
| N01S818HAT22IT | TSSOP-8 (Pb-Free) | 3000 / Tape & Reel |

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specification Brochure, BRD8011/D.

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Table 2. PIN NAMES

| Pin Name | Pin Function |
|--------------------------|--|
| \overline{CS} | Chip Select |
| SCK | Serial Clock |
| SI / SIO0 | Data Input – SPI mode Data Input/Output 0 – DUAL and QUAD mode |
| SO / SIO1 | Data Output – SPI mode Data Input/Output 1 – DUAL and QUAD mode |
| SC / SIO2 | No Connect – SPI and DUAL mode Data Input/Output 2 – QUAD mode |
| \overline{HOLD} / SIO3 | HOLD Input – SPI and DUAL mode Data Input/Output 3 – QUAD mode |
| V_{CC} | Power |
| V_{SS} | Ground |

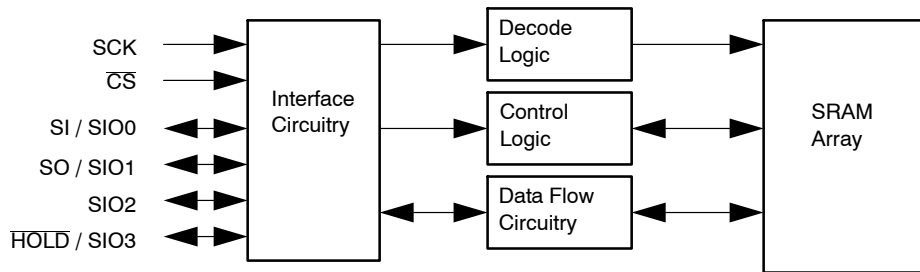


Figure 1. Functional Block Diagram

Table 3. CONTROL SIGNAL DESCRIPTIONS

| Signal | Mode Used | Name | Description |
|-------------------|--------------|----------------------------|--|
| \overline{CS} | All | Chip Select | A low level selects the device and a high level puts the device in standby mode. If \overline{CS} is brought high during a program cycle, the cycle will complete and then the device will enter standby mode. When \overline{CS} is high, SO is in high-Z. \overline{CS} must be driven low after power-up prior to any sequence being started. |
| SCK | All | Serial Clock | Synchronizes all activities between the memory and controller. All incoming addresses, data and instructions are latched on the rising edge of SCK. Data out is updated after the falling edge of SCK. |
| SI | SPI | Serial Data In | Receives instructions, addresses and data on the rising edge of SCK. |
| SO | SPI | Serial Data Out | Data is transferred out after the falling edge of SCK. |
| \overline{HOLD} | SPI and DUAL | Hold | A high level is required for normal operation. Once the device is selected and a serial sequence is started, this input may be taken low to pause serial communication without resetting the serial sequence. The pin must be brought low while SCK is low for immediate use. If SCK is not low, the HOLD function will not be invoked until the next SCK high to low transition. The device must remain selected during this sequence. SO is high-Z during the Hold time and SI and SCK are inputs are ignored. To resume operations, \overline{HOLD} must be pulled high while the SCK pin is low. Lowering the HOLD input at any time will take to SO output to High-Z. |
| SIO0 - 1 | DUAL | Serial Data Input / Output | Receives instructions, addresses and data on the rising edge of SCK. Data is transferred out after the falling edge of SCK. The instruction must be set after power-up to enable the DUAL access mode. |
| SIO0 - 3 | QUAD | Serial Data Input / Output | Receives instructions, addresses and data on the rising edge of SCK. Data is transferred out after the falling edge of SCK. The instruction must be set after power-up to enable the QUAD access mode. |

Basic Operation

The 1 Mb serial SRAM is designed to interface directly with a standard Serial Peripheral Interface (SPI) common on many standard micro-controllers in the default state. It may also interface with other non-SPI ports by programming discrete I/O lines to operate the device.

The serial SRAM contains an 8-bit instruction register and is accessed via the SI pin. The \overline{CS} pin must be low and the \overline{HOLD} pin must be high for the entire operation. Data is sampled on the first rising edge of SCK after \overline{CS} goes low. If the clock line is shared, the user can assert the \overline{HOLD} input and place the device into a Hold mode. After releasing the \overline{HOLD} pin, the operation will resume from the point where it was held. The Hold operation is only supported in SPI and DUAL modes.

By programming the device through a command instruction, the dual and quad access modes may be initiated. In these modes, multiplexed I/O lines take the place of the SPI SI and SO pins and along with the \overline{CS} and SCK control the device in a SPI-like, two bit (DUAL) and four bit (QUAD) wide serial manner. Once the device is put into either the DUAL or QUAD mode, the device will remain operating in that mode until powered down or the Reset Mode operation is programmed.

The following table contains the possible instructions and formats. All instructions, addresses and data are transferred MSB first and LSB last.

Table 4. INSTRUCTION SET

| Instruction | Command | Description |
|-------------|---------|---|
| READ | 03h | Read data from memory starting at selected address |
| WRITE | 02h | Write (program) data to memory starting at selected address |
| EQIO | 38h | Enable QUAD I/O access |
| EDIO | 3Bh | Enable DUAL I/O access |
| RSTQIO | FFh | Reset from QUAD and DUAL to SPI I/O access |
| RDMR | 05h | Read mode register |
| WRMR | 01h | Write mode register |

DEVICE OPERATIONS

Read Operation

The serial SRAM Read operation is started by by enabling \overline{CS} low. First, the 8-bit Read instruction is transmitted to the device through the SI (or SIO0-3) pin(s) followed by the 24-bit address with the 7 MSBs of the address being “don’t care” bits and ignored. In SPI mode, after the READ instruction and address bits are sent, the data stored at that address in memory is shifted out on the SO pin after the output valid time. Additional “dummy” clock cycles (four in DUAL and two in QUAD) are required to follow the instruction and address inputs prior to the data being driven out on the SIO0-3 pins while operating in these two modes.

By continuing to provide clock cycles to the device, data can continue to be read out of the memory array in sequentially. The internal address pointer is automatically incremented to the next higher address after each byte of data is read out until the highest memory address is reached. When the highest memory address is reached, 1FFFFh, the address pointer wraps to the address 00000h. This allows the read cycles to be continued indefinitely. All Read operations are terminated by pulling \overline{CS} high.

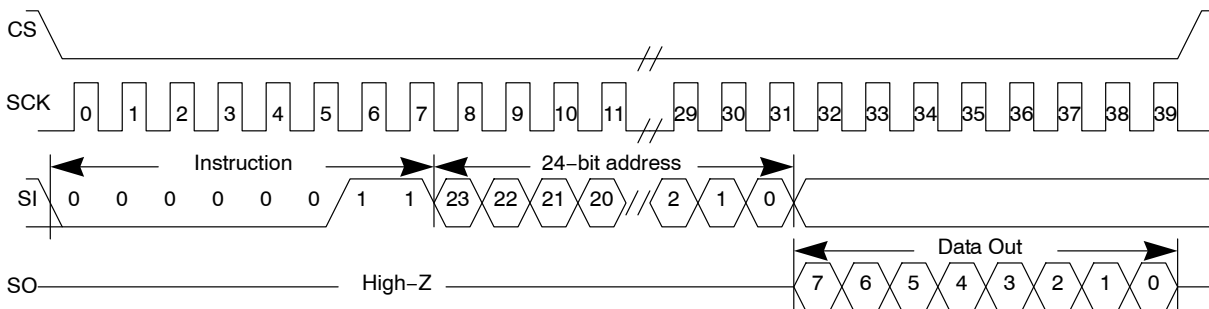


Figure 2. SPI Read Sequence (Single Byte)

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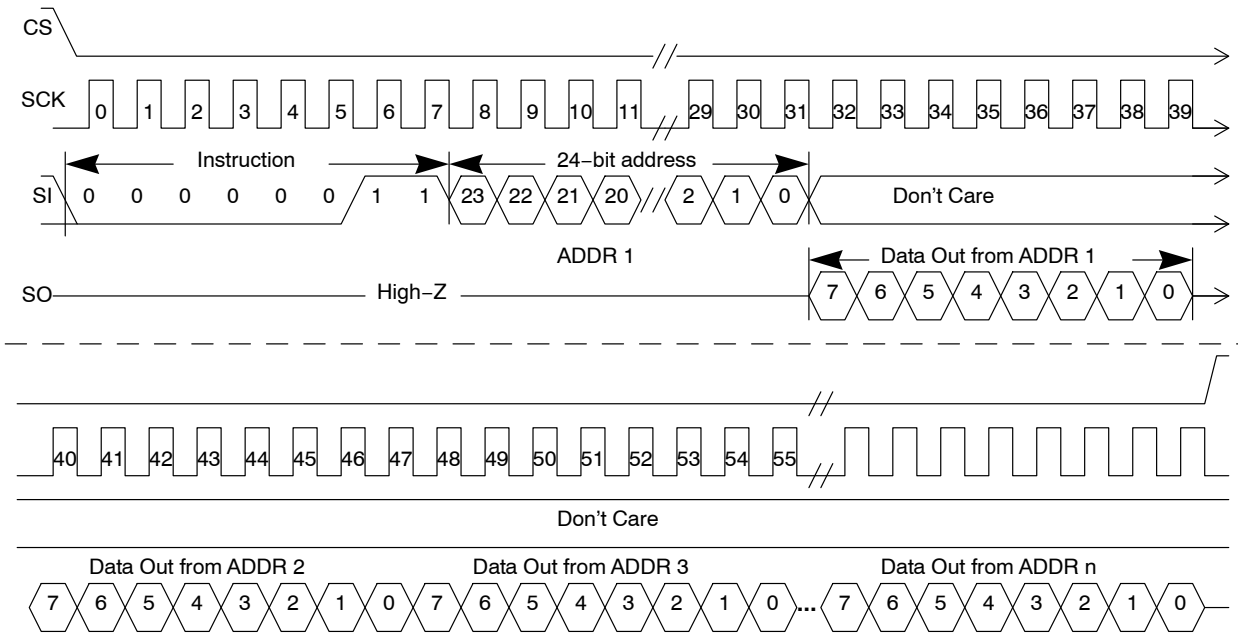
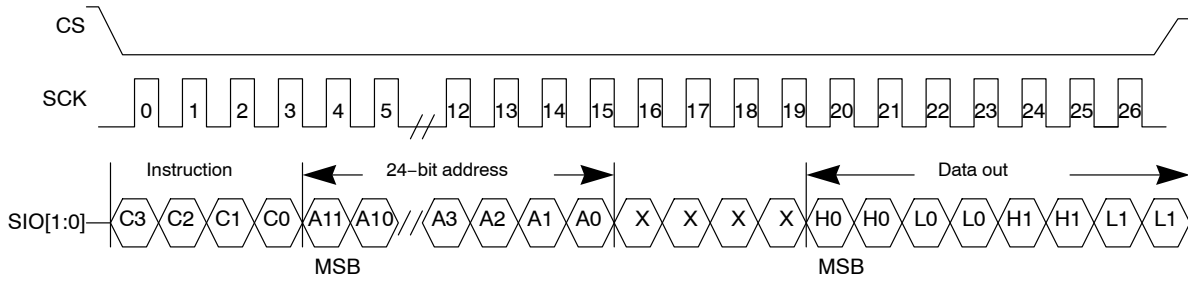
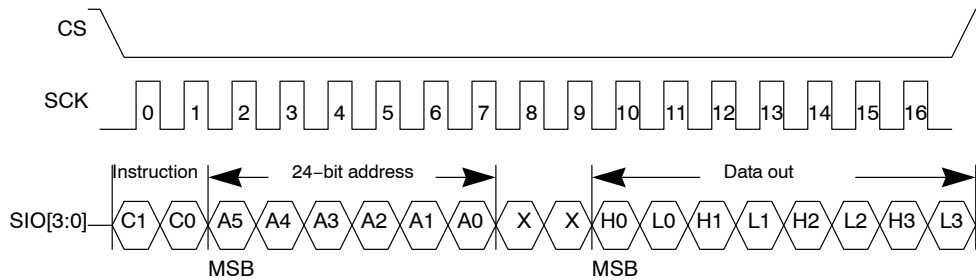


Figure 3. SPI Read Sequence (Sequential Bytes)



Notes: C[3:0] = 03h
 H0 = 2 high order bits of data byte 0
 L0 = 2 low order bits of data byte 0
 H1 = 2 high order bits of data byte 1
 L1 = 2 low order bits of data byte 1

Figure 4. DUAL Read Sequence



Notes: C[1:0] = 03h
 H0 = 4 high order bits of data byte 0
 L0 = 4 low order bits of data byte 0
 H1 = 4 high order bits of data byte 1
 L1 = 4 low order bits of data byte 1

Figure 5. QUAD Read Sequence

Write Operation

The serial SRAM WRITE is selected by enabling \overline{CS} low. First, the 8-bit WRITE instruction is transmitted to the device followed by the 24-bit address with the 7 MSBs being don't care. After the WRITE instruction and addresses are sent, the data to be stored in memory is shifted in on the SI pin.

If operating in page mode, after the initial word of data is shifted in, additional data words can be written as long as the address requested is sequential on the same page. Simply write the data on SI pin and continue to provide clock pulses. The internal address pointer is automatically incremented to the next higher address on the page after each word of data is written in. This can be continued for the entire page length of 32 words long. At the end of the page, the addresses pointer will be wrapped to the 0 word address within the

page and the operation can be continuously looped over the 32 words of the same page. The new data will replace data already stored in the memory locations.

If operating in burst mode, after the initial word of data is shifted in, additional data words can be written to the next sequential memory locations by continuing to provide clock pulses. The internal address pointer is automatically incremented to the next higher address after each word of data is read out. This can be continued for the entire array and when the highest address is reached, 1FFFFh, the address counter wraps to the address 00000h. This allows the burst write cycle to be continued indefinitely. Again, the new data will replace data already stored in the memory locations.

All WRITE operations are terminated by pulling \overline{CS} high.

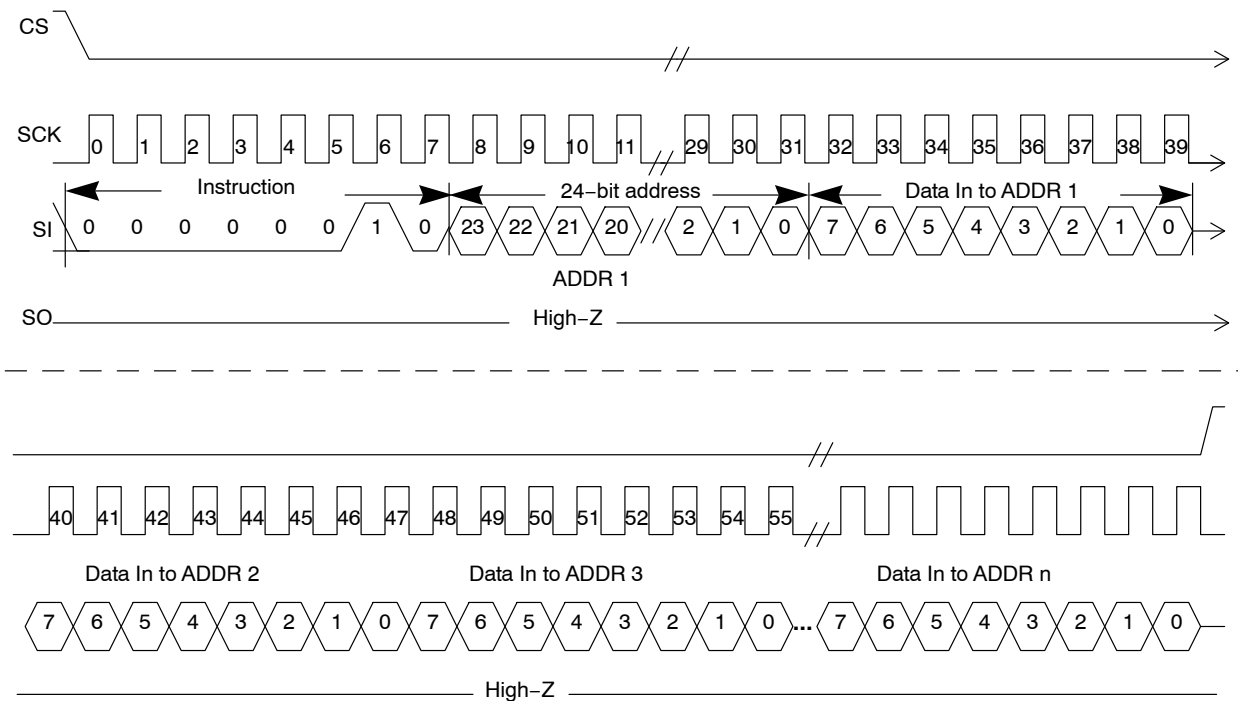
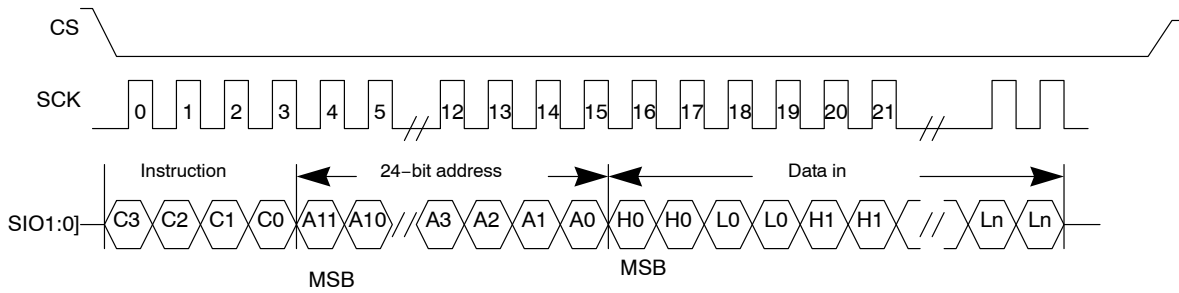


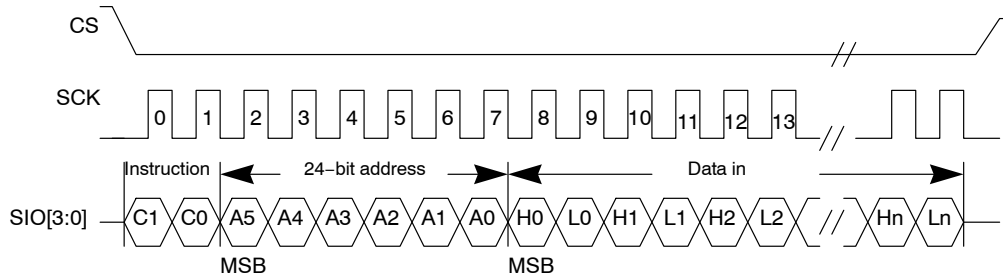
Figure 6. SPI Write Sequence

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- Notes:**
- C[3:0] = 02h
 - H0 = 2 high order bits of data byte 0
 - L0 = 2 low order bits of data byte 0
 - H1 = 2 high order bits of data byte 1
 - L1 = 2 low order bits of data byte 1

Figure 7. DUAL Write Sequence



- Notes:**
- C[1:0] = 02h
 - H0 = 4 high order bits of data byte 0
 - L0 = 4 low order bits of data byte 0
 - H1 = 4 high order bits of data byte 1
 - L1 = 4 low order bits of data byte 1

Figure 8. QUAD Write Sequence

READ Mode Register (RDMR)

This instruction provides the ability to read the mode register. The register may be read at any time including during a Write operation. The Read Mode Register operation is executed by driving \overline{CS} low, then sending the

RDMR instruction to the device. Immediately after the instruction, the device outputs data on the SO (SIO0-3) pin(s). To complete the operation, drive \overline{CS} high to terminate the register read.

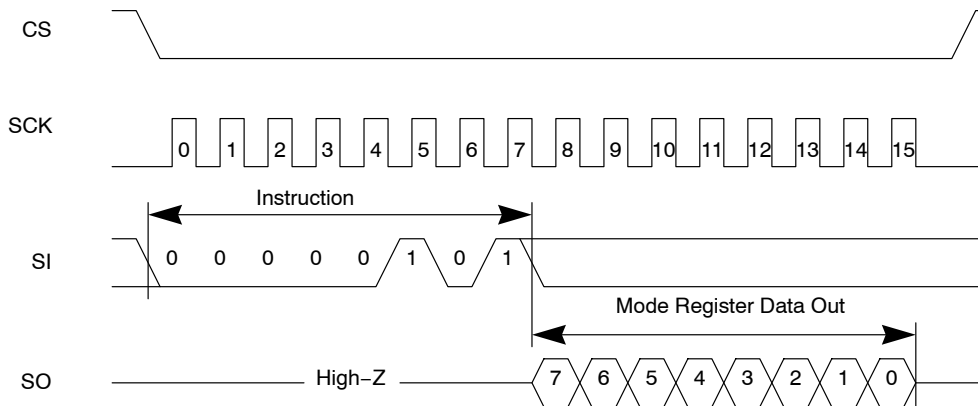


Figure 9. SPI Read Mode Register Sequence (RDMR)

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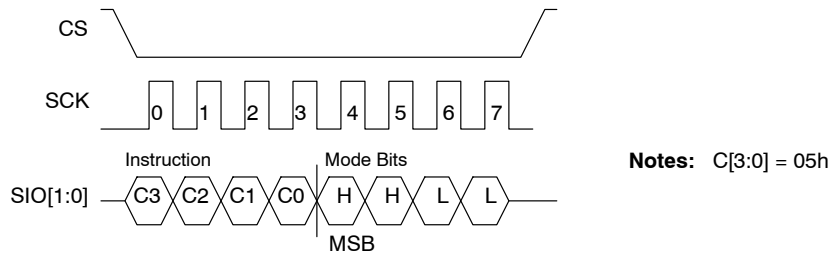


Figure 10. DUAL Read Mode Register Sequence (RD MR)

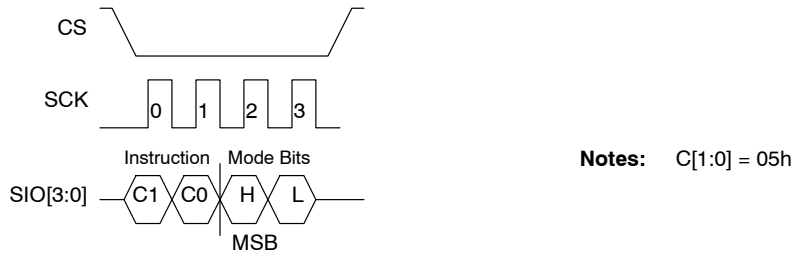


Figure 11. QUAD Read Mode Register Sequence (RD MR)

Write Mode Register (WRMR)

This instruction provides the ability to write the mode register. The Write Mode Register operation is executed by driving \overline{CS} low, then sending the WRMR instruction to the

device. Immediately after the instruction, the data is driven to the device on the SO (SIO0-3) pin(s). To complete the operation, drive \overline{CS} high to terminate the register write.

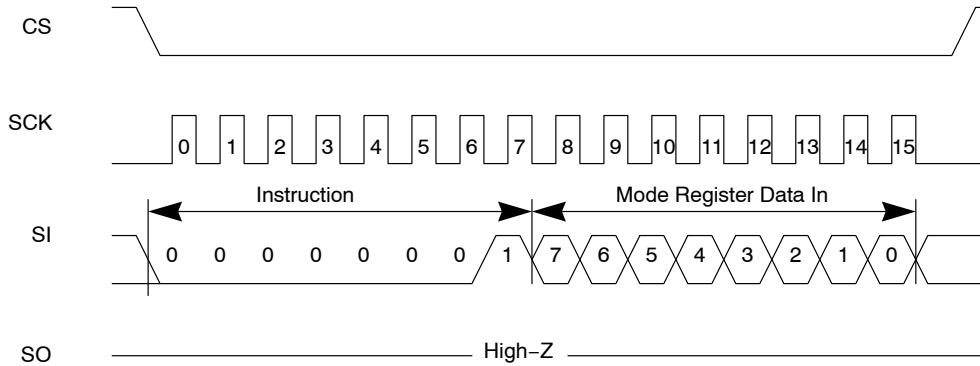


Figure 12. SPI Write Mode Register Sequence

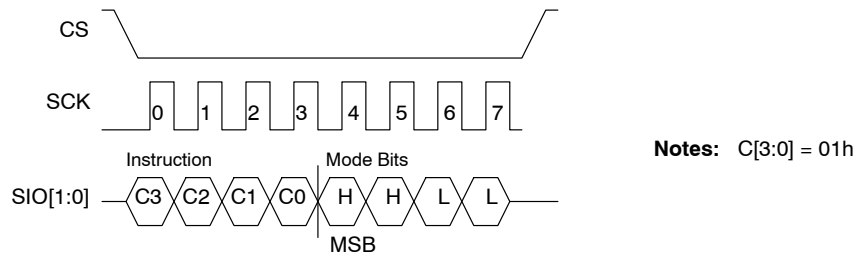


Figure 13. DUAL Write Mode Register Sequence

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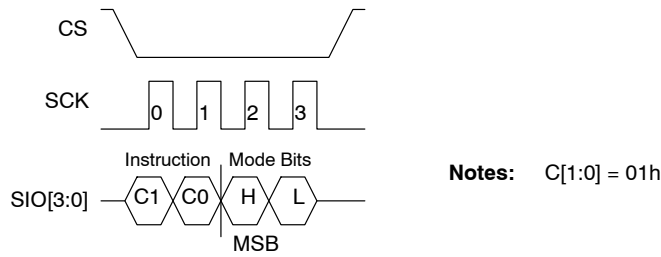


Figure 14. QUAD Write Mode Register Sequence

Table 5. MODE REGISTER

| Bit | Function |
|-----|--|
| 0 | Hold Function 1 = Hold function disabled 0 = Hold function enabled (Default) |
| 1 | Reserved |
| 2 | Reserved |
| 3 | Reserved |
| 4 | Reserved |
| 5 | Reserved |

| | | |
|---|----------------|--------------------------|
| 6 | Operating Mode | |
| | Bit 7 | Bit 6 |
| | 0 | 0 = Word Mode |
| 7 | 1 | 0 = Page Mode |
| | 0 | 1 = Burst Mode (Default) |
| | 1 | 1 = Reserved |

Power-Up State

The serial SRAM enters a know state at power-up time. The device is in low-power standby state with $\overline{CS} = 1$. A low level on \overline{CS} is required to enter a active state.

Table 6. ABSOLUTE MAXIMUM RATINGS

| Item | Symbol | Rating | Units |
|---|--------------|------------------------|-------|
| Voltage on any pin relative to V_{SS} | $V_{IN,OUT}$ | -0.3 to $V_{CC} + 0.3$ | V |
| Voltage on V_{CC} Supply Relative to V_{SS} | V_{CC} | -0.3 to 5.5 | V |
| Power Dissipation | P_D | 500 | mW |
| Storage Temperature | T_{STG} | -40 to 125 | °C |
| Operating Temperature | T_A | -40 to +85 | °C |
| Soldering Temperature and Time | T_{SOLDER} | 260°C, 10 sec | °C |

Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

Table 7. OPERATING CHARACTERISTICS (OVER SPECIFIED TEMPERATURE RANGE)

| Item | Symbol | Test Conditions | Min | Typ (Note 1) | Max | Units |
|---------------------------------|----------|--|----------------|--------------|----------------|---------------|
| Supply Voltage | V_{CC} | | 1.7 | | 2.2 | V |
| Data Retention Voltage (Note 2) | V_{DR} | | | 1.0 | | V |
| Input High Voltage | V_{IH} | | $0.7 V_{CC}$ | | $V_{CC} + 0.3$ | |
| Input Low Voltage | V_{IL} | | -0.3 | | $0.2 V_{CC}$ | V |
| Output High Voltage | V_{OH} | $I_{OH} = -0.4 \text{ mA}$ | $V_{CC} - 0.2$ | | | V |
| Output Low Voltage | V_{OL} | $I_{OL} = 1 \text{ mA}$ | | | 0.2 | V |
| Input Leakage Current | I_{LI} | $\overline{CS} = V_{CC}, V_{IN} = 0 \text{ to } V_{CC}$ | | | 1.0 | μA |
| Output Leakage Current | I_{LO} | $\overline{CS} = V_{CC}, V_{OUT} = 0 \text{ to } V_{CC}$ | | | 1.0 | μA |
| Operating Current | I_{CC} | $f = 20 \text{ MHz}, I_{OUT} = 0, \text{ SPI / DUAL}$ | | | 10 | mA |
| | | $f = 20 \text{ MHz}, I_{OUT} = 0, \text{ QUAD}$ | | | 10 | |
| Standby Current | I_{SB} | $\overline{CS} = V_{CC}, V_{IN} = V_{SS} \text{ or } V_{CC}$ | | 1 | 5 | μA |

1. Typical values are measured at $V_{CC} = V_{CC \text{ Typ.}}$, $T_A = 25^\circ\text{C}$ and are not 100% tested.
2. Typical lower limit of VCC when data will be retained in the memory array, not 100% tested.

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Table 8. CAPACITANCE (Note 3)

| Item | Symbol | Test Conditions | Min | Max | Units |
|-------------------|-----------|---|-----|-----|-------|
| Input Capacitance | C_{IN} | $V_{IN} = 0\text{ V}, f = 1\text{ MHz}, T_A = 25^\circ\text{C}$ | | 7 | pF |
| I/O Capacitance | $C_{I/O}$ | $V_{IN} = 0\text{ V}, f = 1\text{ MHz}, T_A = 25^\circ\text{C}$ | | 7 | pF |

3. These parameters are verified in device characterization and are not 100% tested.

Table 9. TIMING TEST CONDITIONS

| Item | Value |
|--|------------------------------|
| Input Pulse Level | $0.1 V_{CC}$ to $0.9 V_{CC}$ |
| Input Rise and Fall Time | 5 ns |
| Input and Output Timing Reference Levels | $0.5 V_{CC}$ |
| Output Load | $CL = 30\text{ pF}$ |
| Operating Temperature | -40 to $+85^\circ\text{C}$ |

Table 10. TIMING

| Item | Symbol | Min | Max | Units |
|------------------------------|-----------|-----|-----|-------|
| Clock Frequency | f_{CLK} | | 20 | MHz |
| Clock Period | t_{CLK} | 50 | | ns |
| Clock Rise Time | t_R | | 20 | ns |
| Clock Fall Time | t_F | | 20 | ns |
| Clock High Time | t_{HI} | 25 | | ns |
| Clock Low Time | t_{LO} | 25 | | ns |
| Clock Delay Time | t_{CLD} | 25 | | ns |
| \overline{CS} Setup Time | t_{CSS} | 25 | | ns |
| \overline{CS} Hold Time | t_{CSH} | 50 | | ns |
| \overline{CS} Disable Time | t_{CSD} | 25 | | ns |
| SCK to \overline{CS} | t_{SCS} | 5 | | ns |
| Data Setup Time | t_{SU} | 10 | | ns |
| Data Hold Time | t_{HD} | 10 | | ns |
| Output Valid From Clock Low | t_V | | 25 | ns |
| Output Hold Time | t_{HO} | 0 | | ns |
| Output Disable Time | t_{DIS} | | 20 | ns |
| HOLD Setup Time | t_{HS} | 10 | | ns |
| HOLD Hold Time | t_{HH} | 10 | | ns |
| HOLD Low to Output High-Z | t_{HZ} | 10 | | ns |
| HOLD High to Output Valid | t_{HV} | | 50 | ns |

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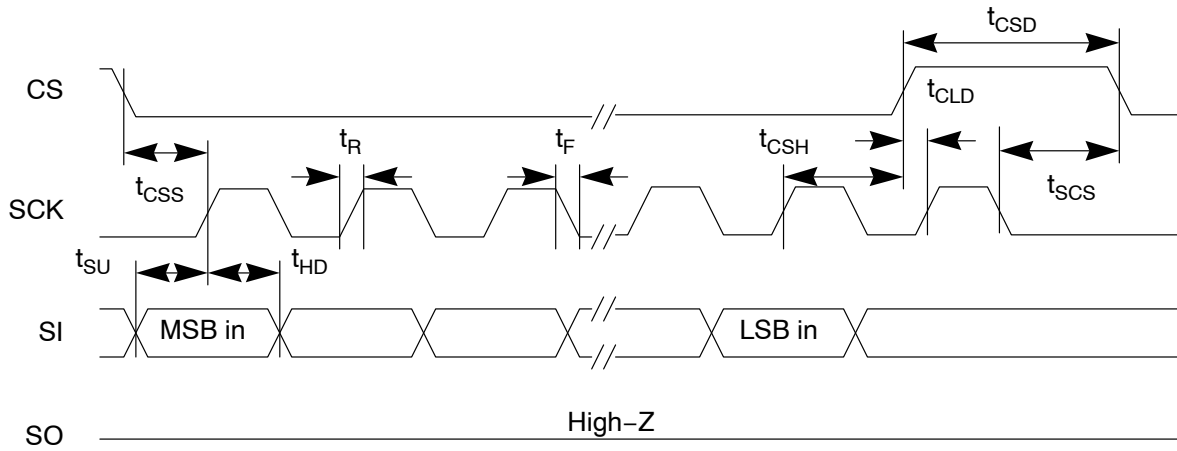


Figure 15. SPI Input Timing

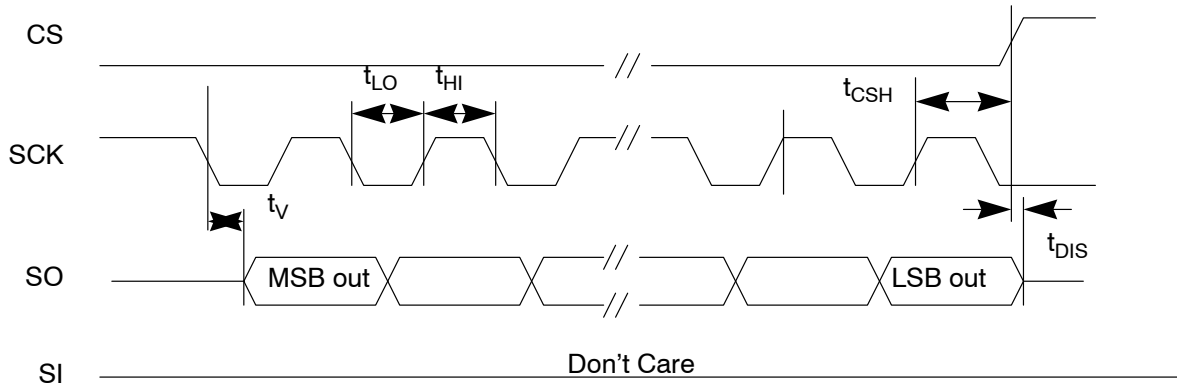


Figure 16. SPI Output Timing

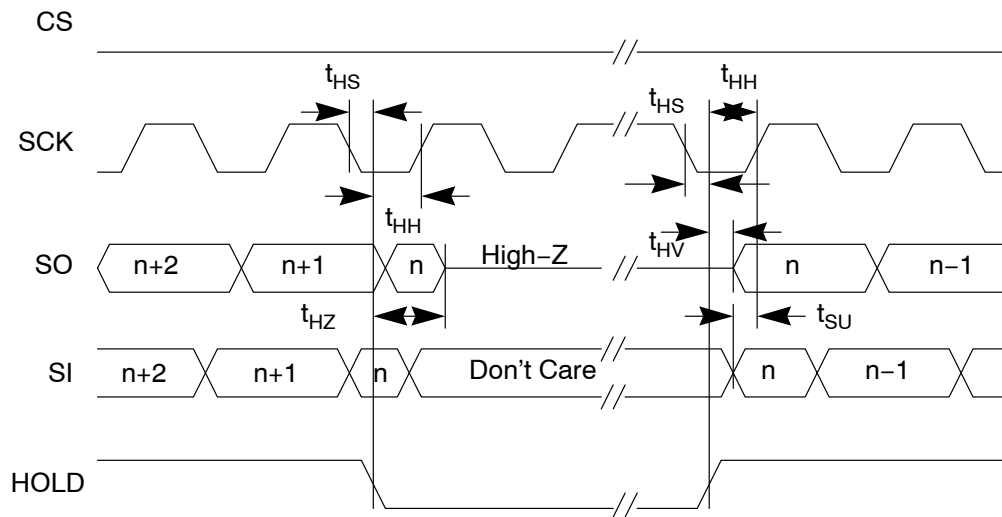


Figure 17. SPI Hold Timing

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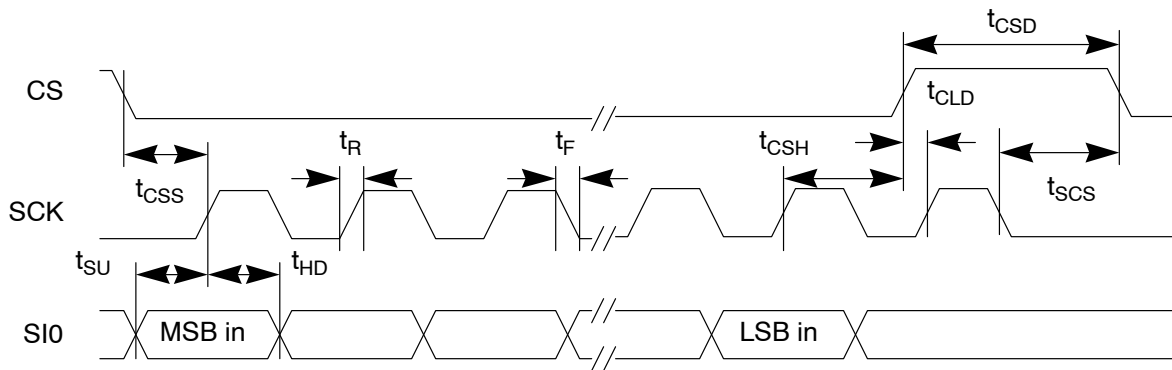


Figure 18. QUAD Input Timing

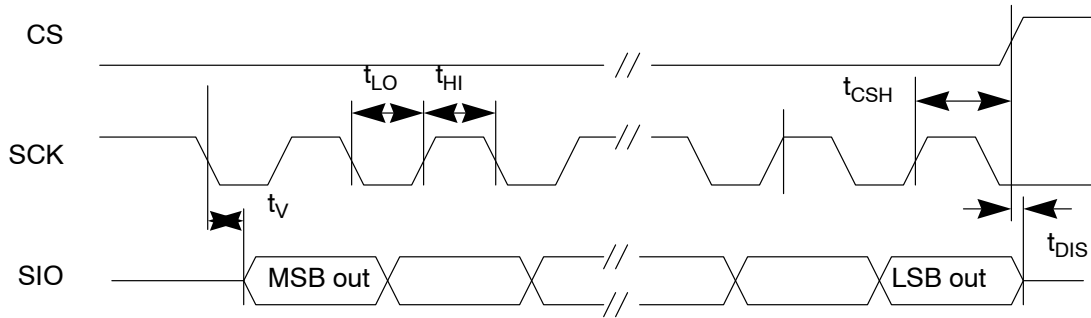
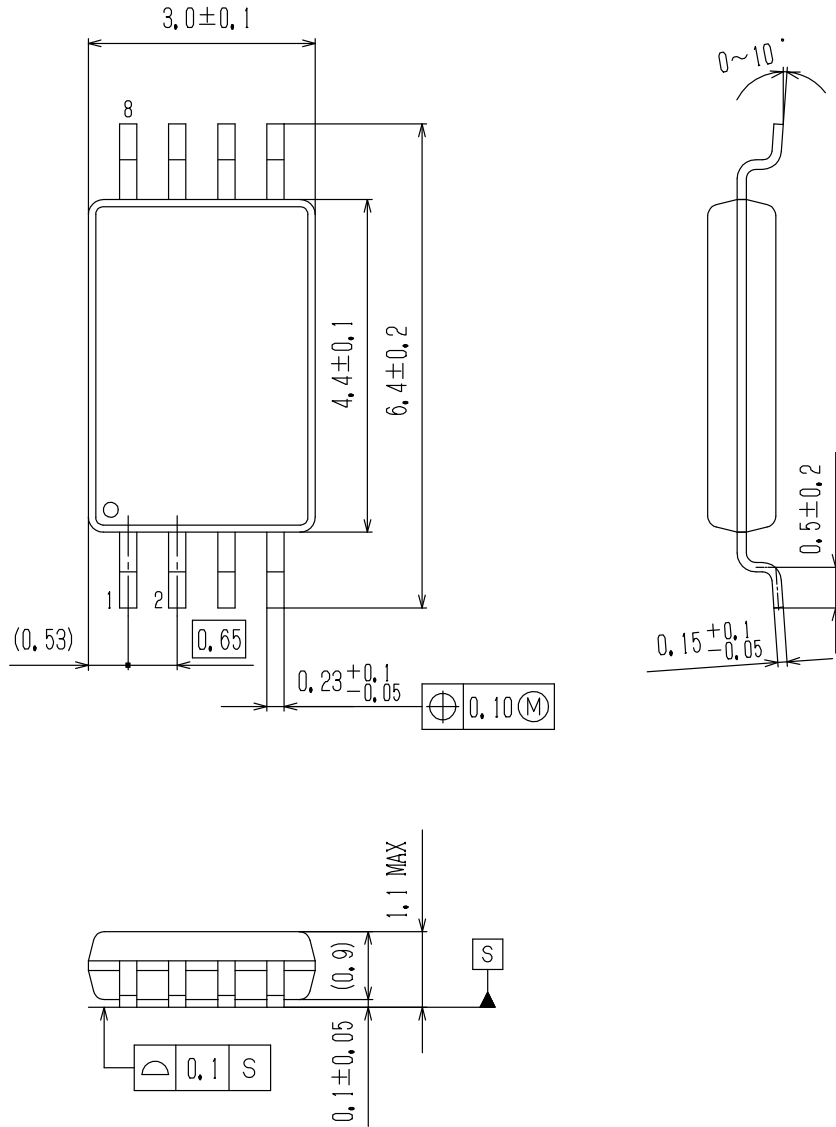



Figure 19. QUAD Output Timing

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PACKAGE DIMENSIONS

TSSOP8 3x4.4 / TSSOP8 (225 mil)
CASE 948BH
ISSUE O



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