STK22C48

2K x 8 *AutoStore*™ nvSRAM *QuantumTrap*™ CMOS Nonvolatile Static RAM

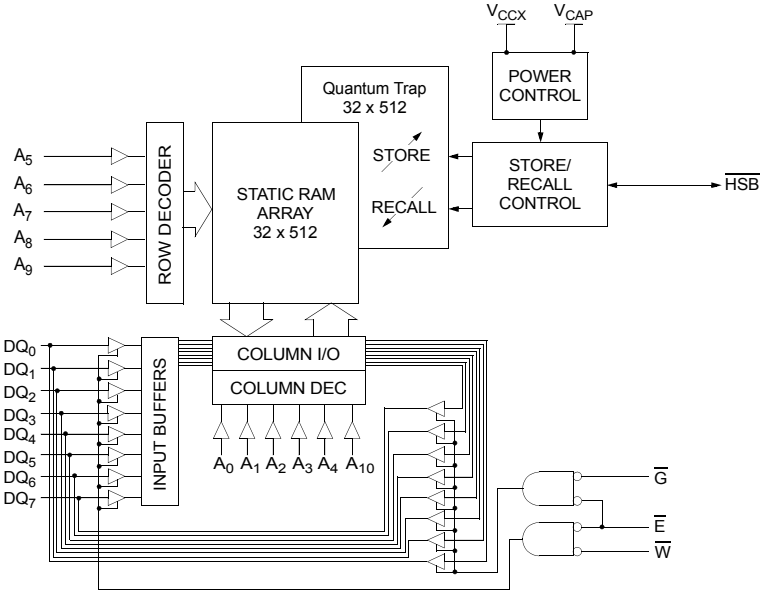
FEATURES

- **25ns, 35ns and 45ns Access Times**
- **"Hands-off" Automatic *STORE* with External 68μF Capacitor on Power Down**
- ***STORE* to Nonvolatile Elements Initiated by Hardware or *AutoStore*™ on Power Down**
- **Automatic *RECALL* on Power Up**
- **10mA Typical I_{cc} at 200ns Cycle Time**
- **Unlimited READ, WRITE and *RECALL* Cycles**
- **1,000,000 *STORE* Cycles to Nonvolatile Elements**
- **100-Year Data Retention in Nonvolatile Elements**
- **Single 5V ± 10% Operation**
- **Commercial and Industrial Temperatures**
- **28-Pin DIP and SOIC Packages**

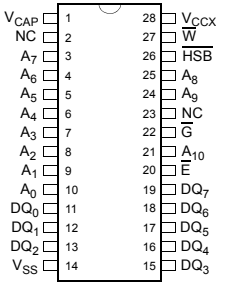
DESCRIPTION

The Simtek STK22C48 is a fast static RAM with a nonvolatile element incorporated in each static memory cell. The SRAM can be read and written an unlimited number of times, while independent, nonvolatile data resides in Nonvolatile Elements. Data transfers from the SRAM to the Nonvolatile Elements (the *STORE* operation) can take place automatically on power down. A 68μF or larger capacitor tied from V_{CAP} to ground guarantees the *STORE* operation, regardless of power-down slew rate or loss of power from "hot swapping". Transfers from the Nonvolatile Elements to the SRAM (the *RECALL* operation) take place automatically on restoration of power. A hardware *STORE* may be initiated with the HSB pin.

BLOCK DIAGRAM



PIN CONFIGURATIONS



28 - 300 PDIP
28 - 600 PDIP
28 - 300 SOIC
28 - 350 SOIC

PIN NAMES

A_0 - A_{10}	Address Inputs
DQ_0 -DQ_7	Data In/Out
$\overline{E}$	Chip Enable
$\overline{W}$	Write Enable
$\overline{G}$	Output Enable
$\overline{HSB}$	Hardware Store Busy (I/O)
V_{CCX}	Power (+ 5V)
V_{CAP}	Capacitor
V_{SS}	Ground

ABSOLUTE MAXIMUM RATINGS[a]

Voltage on Input Relative to Ground . . . . . –0.5V to 7.0V
Voltage on Input Relative to V_{SS} . . . . . –0.6V to (V_{CC} + 0.5V)
Voltage on DQ_{0-7} or $\overline{HSB}$ . . . . . –0.5V to (V_{CC} + 0.5V)
Temperature under Bias. . . . . –55°C to 125°C
Storage Temperature . . . . . –65°C to 150°C
Power Dissipation 1W
DC Output Current (1 output at a time, 1s duration) 15mA

Note a: Stresses 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 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.

DC CHARACTERISTICS

(V_{CC} = 5.0V ± 10%)[e]

SYMBOL	PARAMETER	COMMERCIAL		INDUSTRIAL		UNITS	NOTES
		MIN	MAX	MIN	MAX		
I_{CC_1}[b]	Average V_{CC} Current		85 75 65		90 75 65	mA mA mA	t_{AVAV} = 25ns t_{AVAV} = 35ns t_{AVAV} = 45ns
I_{CC_2}[c]	Average V_{CC} Current during *STORE*		3		3	mA	All Inputs Don't Care, V_{CC} = max
I_{CC_3}[b]	Average V_{CC} Current at t_{AVAV} = 200ns 5V, 25°C, Typical		10		10	mA	$\overline{W} \geq (V_{CC} - 0.2V)$ All Others Cycling, CMOS Levels
I_{CC_4}[c]	Average V_{CAP} Current during *AutoStore*™ Cycle		2		2	mA	All Inputs Don't Care
I_{SB_1}[d]	Average V_{CC} Current (Standby, Cycling TTL Input Levels)		25 21 18		26 22 19	mA mA mA	t_{AVAV} = 25ns, $\overline{E} \geq V_{IH}$ t_{AVAV} = 35ns, $\overline{E} \geq V_{IH}$ t_{AVAV} = 45ns, $\overline{E} \geq V_{IH}$
I_{SB_2}[d]	V_{CC} Standby Current (Standby, Stable CMOS Input Levels)		1.5		1.5	mA	$\overline{E} \geq (V_{CC} - 0.2V)$ All Others $V_{IN} \leq 0.2V$ or $\geq (V_{CC} - 0.2V)$
I_{ILK}	Input Leakage Current		±1		±1	µA	V_{CC} = max $V_{IN} = V_{SS}$ to V_{CC}
I_{OLK}	Off-State Output Leakage Current		±5		±5	µA	V_{CC} = max $V_{IN} = V_{SS}$ to V_{CC}, $\overline{E}$ or $\overline{G} \geq V_{IH}$
V_{IH}	Input Logic "1" Voltage	2.2	V_{CC} + .5	2.2	V_{CC} + .5	V	All Inputs
V_{IL}	Input Logic "0" Voltage	V_{SS} – .5	0.8	V_{SS} – .5	0.8	V	All Inputs
V_{OH}	Output Logic "1" Voltage	2.4		2.4		V	I_{OUT} = –4mA except $\overline{HSB}$
V_{OL}	Output Logic "0" Voltage		0.4		0.4	V	I_{OUT} = 8mA except $\overline{HSB}$
V_{BL}	Logic "0" Voltage on $\overline{HSB}$ Output		0.4		0.4	V	I_{OUT} = 3mA
T_A	Operating Temperature	0	70	–40	85	°C	

Note b: I_{CC_1} and I_{CC_3} are dependent on output loading and cycle rate. The specified values are obtained with outputs unloaded.
Note c: I_{CC_2} and I_{CC_4} are the average currents required for the duration of the respective *STORE* cycles (t_{STORE}).
Note d: $\overline{E} \geq V_{IH}$ will not produce standby current levels until any nonvolatile cycle in progress has timed out.
Note e: V_{CC} reference levels throughout this datasheet refer to V_{CCX} if that is where the power supply connection is made, or V_{CAP} if V_{CCX} is connected to ground.

AC TEST CONDITIONS

Input Pulse Levels . . . . . 0V to 3V
Input Rise and Fall Times. . . . . ≤ 5ns
Input and Output Timing Reference Levels 1.5V
Output Load . . . . . See Figure 1

CAPACITANCE[f] (T_A = 25°C, f = 1.0MHz)

SYMBOL	PARAMETER	MAX	UNITS	CONDITIONS
C_{IN}	Input Capacitance	8	pF	ΔV = 0 to 3V
C_{OUT}	Output Capacitance	7	pF	ΔV = 0 to 3V

Note f: These parameters are guaranteed but not tested.

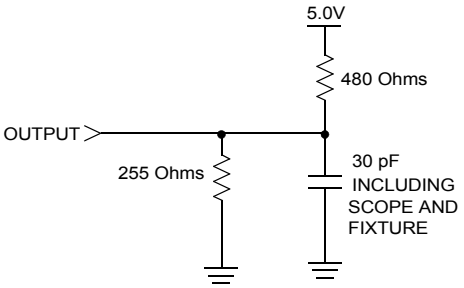


Figure 1: AC Output Loading

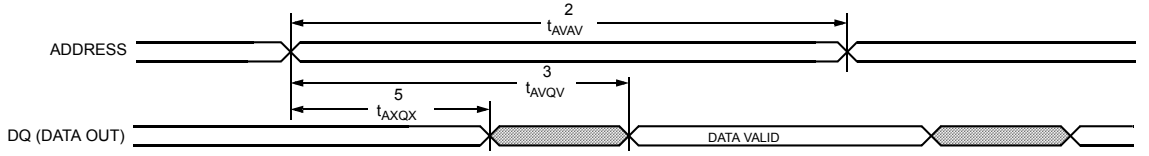
SRAM READ CYCLES #1 & #2

(V_{CC} = 5.0V ± 10%)[e]

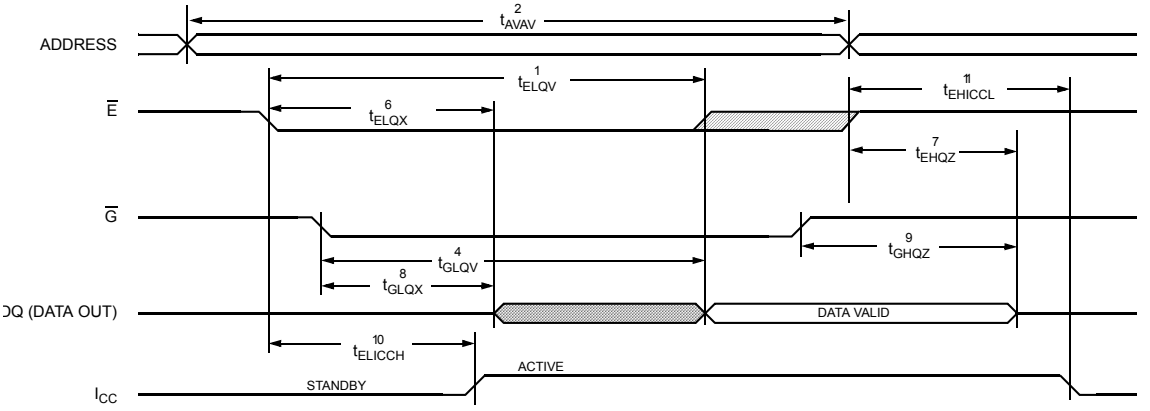
NO.	SYMBOLS		PARAMETER	STK22C48-25		STK22C48-35		STK22C48-45		UNITS
	#1, #2	Alt.		MIN	MAX	MIN	MAX	MIN	MAX	
1	t_{ELQV}	t_{ACS}	Chip Enable Access Time		25		35		45	ns
2	t_{AVAV}[g]	t_{RC}	Read Cycle Time	25		35		45		ns
3	t_{AVQV}[h]	t_{AA}	Address Access Time		25		35		45	ns
4	t_{GLQV}	t_{OE}	Output Enable to Data Valid		10		15		20	ns
5	t_{AXQX}[h]	t_{OH}	Output Hold after Address Change	5		5		5		ns
6	t_{ELQX}	t_{LZ}	Chip Enable to Output Active	5		5		5		ns
7	t_{EHQZ}[i]	t_{HZ}	Chip Disable to Output Inactive		10		13		15	ns
8	t_{GLQX}	t_{OLZ}	Output Enable to Output Active	0		0		0		ns
9	t_{GHQZ}[i]	t_{OHZ}	Output Disable to Output Inactive		10		13		15	ns
10	t_{ELICCH}[f]	t_{PA}	Chip Enable to Power Active	0		0		0		ns
11	t_{EHICCL}[f]	t_{PS}	Chip Disable to Power Standby		25		35		45	ns

Note g: $\overline{W}$ and $\overline{HSB}$ must be high during SRAM READ cycles.
Note h: Device is continuously selected with $\overline{E}$ and $\overline{G}$ both low.
Note i: Measured ± 200mV from steady state output voltage.

SRAM READ CYCLE #1: Address Controlled[g, h]



SRAM READ CYCLE #2: $\overline{E}$ Controlled[g]



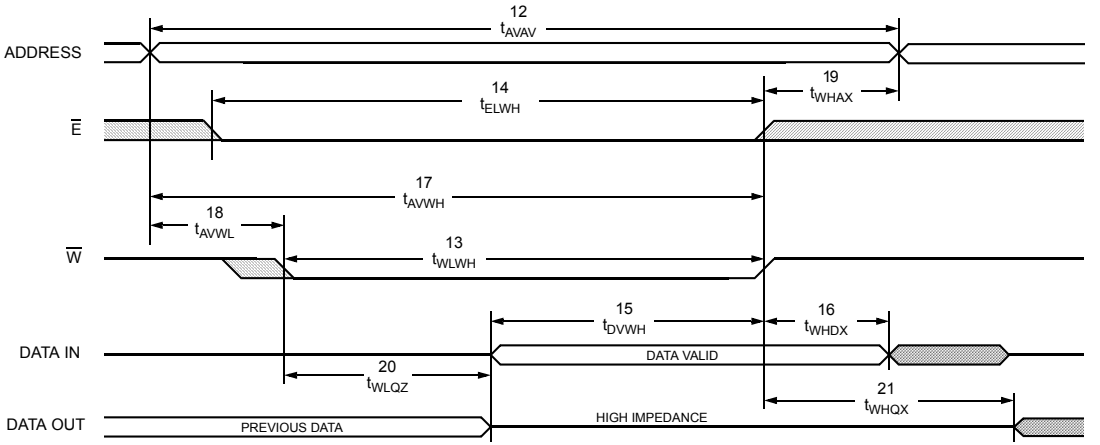
SRAM WRITE CYCLES #1 & #2

(V_{CC} = 5.0V ± 10%)[e]

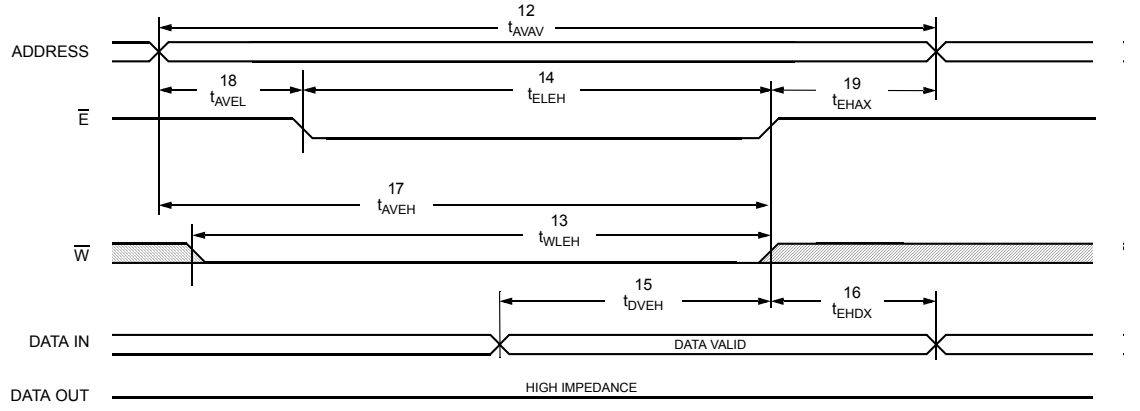
NO.	SYMBOLS			PARAMETER	STK22C48-25		STK22C48-35		STK22C48-45		UNITS
	#1	#2	Alt.		MIN	MAX	MIN	MAX	MIN	MAX	
12	t_{AVAV}	t_{AVAV}	t_{WC}	Write Cycle Time	25		35		45		ns
13	t_{WLWH}	t_{WLEH}	t_{WP}	Write Pulse Width	20		25		30		ns
14	t_{ELWH}	t_{ELEH}	t_{CW}	Chip Enable to End of Write	20		25		30		ns
15	t_{DVWH}	t_{DVEH}	t_{DW}	Data Set-up to End of Write	10		12		15		ns
16	t_{WHDX}	t_{EHDX}	t_{DH}	Data Hold after End of Write	0		0		0		ns
17	t_{AVWH}	t_{AVEH}	t_{AW}	Address Set-up to End of Write	20		25		30		ns
18	t_{AVWL}	t_{AVEL}	t_{AS}	Address Set-up to Start of Write	0		0		0		ns
19	t_{WHAX}	t_{EHAX}	t_{WR}	Address Hold after End of Write	0		0		0		ns
20	t_{WLQZ} [i, j]		t_{WZ}	Write Enable to Output Disable		10		13		15	ns
21	t_{WHQX}		t_{OW}	Output Active after End of Write	5		5		5		ns

Note j: If $\overline{W}$ is low when $\overline{E}$ goes low, the outputs remain in the high-impedance state.
Note k: $\overline{E}$ or $\overline{W}$ must be ≥ V_{IH} during address transitions.
Note l: $\overline{HSB}$ must be high during SRAM WRITE cycles.

SRAM WRITE CYCLE #1: $\overline{W}$ Controlled[k, l]



SRAM WRITE CYCLE #2: $\overline{E}$ Controlled[k, l]



HARDWARE MODE SELECTION

$\overline{E}$	$\overline{W}$	$\overline{HSB}$	A_{12} - A_0 (hex)	MODE	I/O	POWER	NOTES
H	X	H	X	Not Selected	Output High Z	Standby	
L	H	H	X	Read SRAM	Output Data	Active	n
L	L	H	X	Write SRAM	Input Data	Active	
X	X	L	X	Nonvolatile *STORE*	Output High Z	I_{CC_2}	m

Note m: $\overline{HSB}$ *STORE* operation occurs only if an SRAM write has been done since the last nonvolatile cycle. After the *STORE* (if any) completes, the part will go into standby mode, inhibiting all operations until $\overline{HSB}$ rises.
Note n: I/O state assumes $\overline{G} \leq V_{IL}$. Activation of nonvolatile cycles does not depend on state of $\overline{G}$.

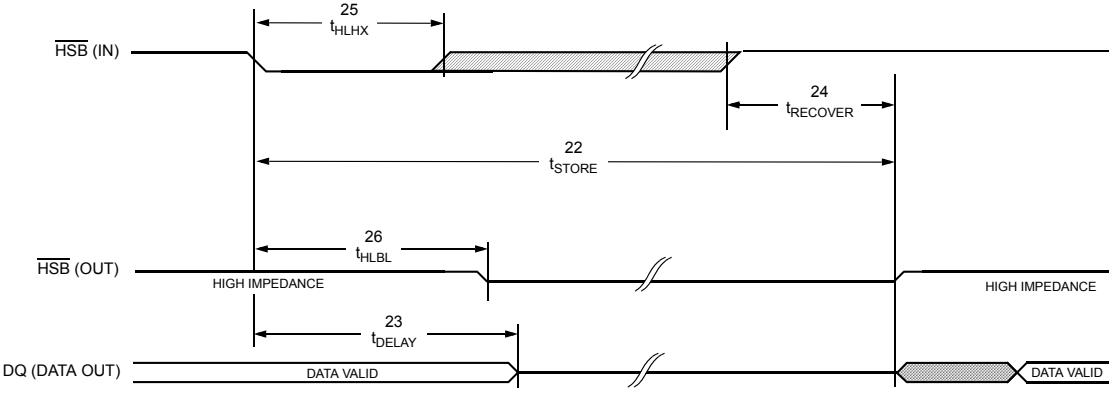
HARDWARE *STORE* CYCLE

(V_{CC} = 5.0V ± 10%)[e]

NO.	SYMBOLS		PARAMETER	STK22C48		UNITS	NOTES
	Standard	Alternate		MIN	MAX		
22	t_{STORE}	t_{HLHZ}	*STORE* Cycle Duration		10	ms	i, o
23	t_{DELAY}	t_{HLQZ}	Time Allowed to Complete SRAM Cycle	1		µs	i, p
24	$t_{RECOVER}$	t_{HHQX}	Hardware *STORE* High to Inhibit Off		700	ns	o, q
25	t_{HLHX}		Hardware *STORE* Pulse Width	15		ns	
26	t_{HLBL}		Hardware *STORE* Low to Store Busy		300	ns	

Note o: $\overline{E}$ and $\overline{G}$ low for output behavior.
Note p: $\overline{E}$ and $\overline{G}$ low and $\overline{W}$ high for output behavior.
Note q: $t_{RECOVER}$ is only applicable after t_{STORE} is complete.

HARDWARE *STORE* CYCLE



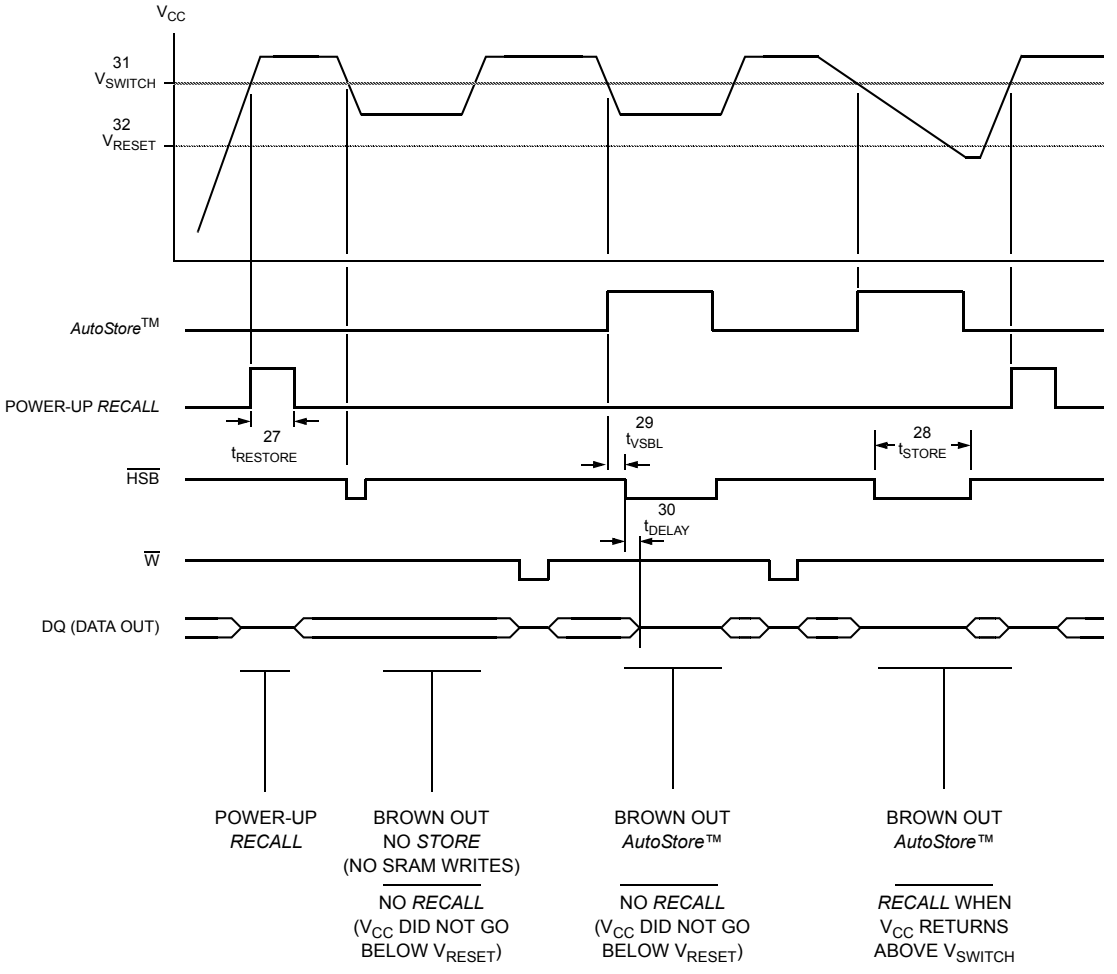
AutoStore™ / POWER-UP *RECALL*

(V_{CC} = 5.0V ± 10%)[e]

NO.	SYMBOLS		PARAMETER	STK22C48		UNITS	NOTES
	Standard	Alternate		MIN	MAX		
27	$t_{RESTORE}$		Power-up *RECALL* Duration		550	µs	r
28	t_{STORE}	t_{HLHZ}	*STORE* Cycle Duration		10	ms	p, s
29	t_{VSBL}		Low Voltage Trigger (V_{SWITCH}) to $\overline{HSB}$ Low		300	ns	l
30	t_{DELAY}	t_{BLQZ}	Time Allowed to Complete SRAM Cycle	1		µs	o
31	V_{SWITCH}		Low Voltage Trigger Level	4.0	4.5	V	
32	V_{RESET}		Low Voltage Reset Level		3.6	V	

Note r: $t_{RESTORE}$ starts from the time V_{CC} rises above V_{SWITCH}.
Note s: $\overline{HSB}$ is asserted low for 1µs when V_{CAP} drops through V_{SWITCH}. If an SRAM write has not taken place since the last nonvolatile cycle, $\overline{HSB}$ will be released and no *STORE* will take place.

AutoStore™ / POWER-UP *RECALL*



DEVICE OPERATION

The STK22C48 has two separate modes of operation: SRAM mode and nonvolatile mode. In SRAM mode, the memory operates as a standard fast static RAM. In nonvolatile mode, data is transferred from SRAM to Nonvolatile Elements (the *STORE* operation) or from Nonvolatile Elements to SRAM (the *RECALL* operation). In this mode SRAM functions are disabled.

NOISE CONSIDERATIONS

The STK22C48 is a high-speed memory and so must have a high-frequency bypass capacitor of approximately 0.1µF connected between V_{CAP} and V_{SS}, using leads and traces that are as short as possible. As with all high-speed CMOS ICs, normal careful routing of power, ground and signals will help prevent noise problems.

SRAM READ

The STK22C48 performs a READ cycle whenever $\overline{E}$ and $\overline{G}$ are low and $\overline{W}$ and $\overline{HSB}$ are high. The address specified on pins A_{0-10} determines which of the 2,048 data bytes will be accessed. When the READ is initiated by an address transition, the outputs will be valid after a delay of t_{AVQV} (READ cycle #1). If the READ is initiated by $\overline{E}$ or $\overline{G}$, the outputs will be valid at t_{ELQV} or at t_{GLQV}, whichever is later (READ cycle #2). The data outputs will repeatedly respond to address changes within the t_{AVQV} access time without the need for transitions on any control input pins, and will remain valid until another address change or until $\overline{E}$ or $\overline{G}$ is brought high, or $\overline{W}$ or $\overline{HSB}$ is brought low.

SRAM WRITE

A WRITE cycle is performed whenever $\overline{E}$ and $\overline{W}$ are low and $\overline{HSB}$ is high. The address inputs must be stable prior to entering the WRITE cycle and must remain stable until either $\overline{E}$ or $\overline{W}$ goes high at the end of the cycle. The data on the common I/O pins DQ_{0-7} will be written into the memory if it is valid t_{DVWH} before the end of a $\overline{W}$ controlled WRITE or t_{DVEH} before the end of an $\overline{E}$ controlled WRITE.

It is recommended that $\overline{G}$ be kept high during the entire WRITE cycle to avoid data bus contention on common I/O lines. If $\overline{G}$ is left low, internal circuitry will turn off the output buffers t_{WLQZ} after $\overline{W}$ goes low.

POWER-UP *RECALL*

During power up, or after any low-power condition (V_{CAP} < V_{RESET}), an internal *RECALL* request will be latched. When V_{CAP} once again exceeds the sense voltage of V_{SWITCH}, a *RECALL* cycle will automatically be initiated and will take $t_{RESTORE}$ to complete.

If the STK22C48 is in a WRITE state at the end of power-up *RECALL*, the SRAM data will be corrupted. To help avoid this situation, a 10K Ohm resistor should be connected either between $\overline{W}$ and system V_{CC} or between $\overline{E}$ and system V_{CC}.

AutoStore™ OPERATION

The STK22C48 can be powered in one of three modes.

During normal *AutoStore*™ operation, the STK22C48 will draw current from V_{CCX} to charge a capacitor connected to the V_{CAP} pin. This stored charge will be used by the chip to perform a single *STORE* operation. After power up, when the voltage on the V_{CAP} pin drops below V_{SWITCH}, the part will automatically disconnect the V_{CAP} pin from V_{CCX} and initiate a *STORE* operation.

Figure 2 shows the proper connection of capacitors for automatic store operation. A charge storage capacitor having a capacity of between 68µF and 220µF (± 20%) rated at 6V should be provided.

In system power mode (Figure 3), both V_{CCX} and V_{CAP} are connected to the + 5V power supply without the 68µF capacitor. In this mode the *AutoStore*™ function of the STK22C48 will operate on the stored system charge as power goes down. The user must, however, guarantee that V_{CCX} does not drop below 3.6V during the 10ms *STORE* cycle.

If an automatic *STORE* on power loss is not required, then V_{CCX} can be tied to ground and + 5V applied to V_{CAP} (Figure 4). This is the *AutoStore*™ Inhibit mode, in which the *AutoStore*™ function is disabled. If the STK22C48 is operated in this configuration, references to V_{CCX} should be changed to V_{CAP} throughout this data sheet. In this mode, *STORE* operations may be triggered with the $\overline{HSB}$ pin. It is not permissable to change between these three options “on the fly”.

In order to prevent unneeded *STORE* operations, automatic *STORE*s as well as those initiated by externally driving $\overline{HSB}$ low will be ignored unless at least one WRITE operation has taken place since the most recent *STORE* or *RECALL* cycle. An optional pull-up resistor is shown connected to $\overline{HSB}$. This can be used to signal the system that the *AutoStore*™ cycle is in progress.

$\overline{HSB}$ OPERATION

The STK22C48 provides the $\overline{HSB}$ pin for controlling and acknowledging the *STORE* operations. The $\overline{HSB}$ pin is used to request a hardware *STORE* cycle. When the $\overline{HSB}$ pin is driven low, the STK22C48 will conditionally initiate a *STORE* operation after t_{DELAY}; an actual *STORE* cycle will only begin if a WRITE to the SRAM took place since the last *STORE* or *RECALL* cycle. The $\overline{HSB}$ pin acts as an open drain driver that is internally driven low to indicate a busy condition while the *STORE* (initiated by any means) is in progress.

SRAM READ and WRITE operations that are in progress when $\overline{HSB}$ is driven low by any means are given time to complete before the *STORE* operation is initiated. After $\overline{HSB}$ goes low, the STK22C48 will continue SRAM operations for t_{DELAY}. During t_{DELAY}, multiple SRAM READ operations may take place. If a WRITE is in progress when $\overline{HSB}$ is pulled low it will be allowed a time, t_{DELAY}, to complete. However, any SRAM WRITE cycles requested after $\overline{HSB}$ goes low will be inhibited until $\overline{HSB}$ returns high.

The $\overline{HSB}$ pin can be used to synchronize multiple STK22C48s while using a single larger capacitor. To operate in this mode the $\overline{HSB}$ pin should be connected together to the $\overline{HSB}$ pins from the other STK22C48s. An external pull-up resistor to + 5V is required since $\overline{HSB}$ acts as an open drain pull down. The V_{CAP} pins from the other STK22C48 parts can be tied together and share a single capacitor. The capacitor size must be scaled by the number of devices connected to it. When any one of the STK22C48s detects a power loss and asserts $\overline{HSB}$, the common $\overline{HSB}$ pin will cause all parts to request a *STORE* cycle (a *STORE* will take place in those STK22C48s that have been written since the last nonvolatile cycle).

During any *STORE* operation, regardless of how it was initiated, the STK22C48 will continue to drive the $\overline{HSB}$ pin low, releasing it only when the *STORE* is complete. Upon completion of the *STORE* operation the STK22C48 will remain disabled until the $\overline{HSB}$ pin returns high.

If $\overline{HSB}$ is not used, it should be left unconnected.

PREVENTING STORES

The *STORE* function can be disabled on the fly by holding $\overline{HSB}$ high with a driver capable of sourcing 30mA at a VOH of at least 2.2V, as it will have to overpower the internal pull-down device that drives $\overline{HSB}$ low for 20µs at the onset of a *STORE*. When the STK22C48 is connected for *AutoStore*™ operation (system V_{CC} connected to V_{CCX} and a 68µF capacitor on V_{CAP}) and V_{CC} crosses V_{SWITCH} on the way down, the STK22C48 will attempt to pull $\overline{HSB}$ low; if $\overline{HSB}$ doesn't actually get below V_{IL}, the part

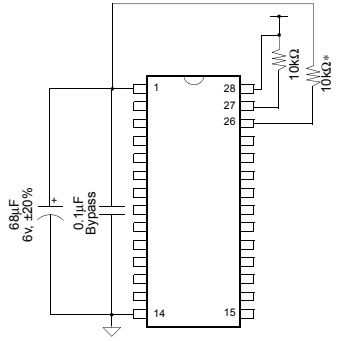


Figure 2: *AutoStore*™ Mode

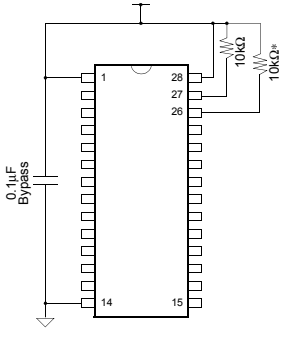


Figure 3: System Power Mode

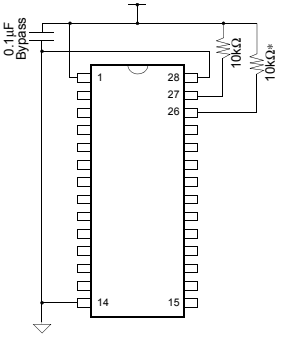


Figure 4: *AutoStore*™ Inhibit Mode

*If $\overline{HSB}$ is not used, it should be left unconnected.

will stop trying to pull $\overline{HSB}$ low and abort the *STORE* attempt.

HARDWARE PROTECT

The STK22C48 offers hardware protection against inadvertent *STORE* operation and SRAM WRITEs during low-voltage conditions. When $V_{CAP} < V_{SWITCH}$, all externally initiated *STORE* operations and SRAM WRITEs are inhibited.

AutoStore™ can be completely disabled by tying V_{CCX} to ground and applying + 5V to V_{CAP} . This is the *AutoStore*™ Inhibit mode; in this mode *STORE*s are only initiated by explicit request using the $\overline{HSB}$ pin.

LOW AVERAGE ACTIVE POWER

The STK22C48 draws significantly less current when it is cycled at times longer than 50ns. Figure 5 shows the relationship between I_{CC} and READ cycle time. Worst-case current consumption is shown for both CMOS and TTL input levels (commercial temperature range, V_{CC} = 5.5V, 100% duty cycle on chip enable). Figure 6 shows the same relationship for WRITE cycles. If the chip enable duty cycle is less than 100%, only standby current is drawn when the chip is disabled. The overall average current drawn by the STK22C48 depends on the following items: 1) CMOS vs. TTL input levels; 2) the duty cycle of chip enable; 3) the overall cycle rate for accesses; 4) the ratio of READs to WRITEs; 5) the operating temperature; 6) the V_{cc} level; and 7) I/O loading.

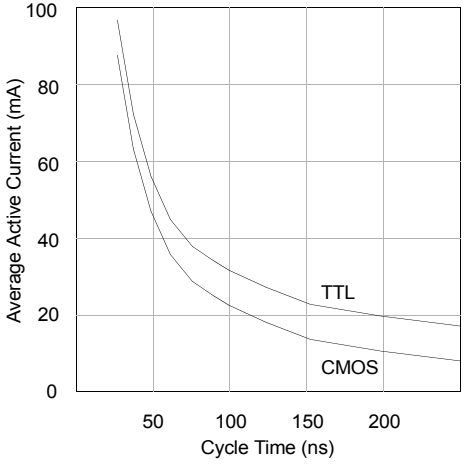


Figure 5: I_{cc} (max) Reads

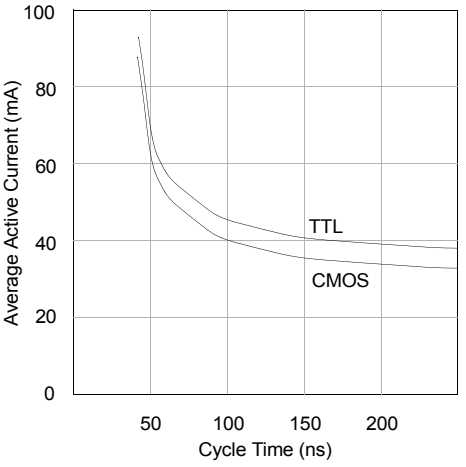
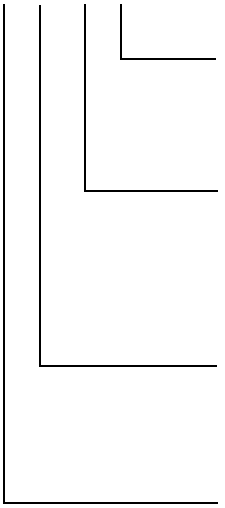


Figure 6: I_{cc} (max) Writes

ORDERING INFORMATION

STK22C48 - P F 45 I



Temperature Range
- Blank = Commercial (0 to 70°C)
- I = Industrial (-40 to 85°C)

Access Time
- 25 = 25ns
- 35 = 35ns
- 45 = 45ns

Lead Finish
- Blank = 85%Sn/15%Pb
- F = 100% Sn (Matte Tin)

Package
- P = Plastic 28-pin 300 mil DIP
- W = Plastic 28-pin 600 mil DIP
- N = Plastic 28-pin 300 mil SOIC
- S = Plastic 28-pin 350 mil SIOC

Document Revision History

Revision	Date	Summary
0.0	December 2002	Removed 20 nsec device.
0.1	September 2003	Added lead-free lead finish