CAT25320

32K-Bit SPI Serial CMOS EEPROM

FEATURES

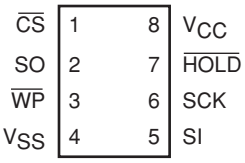
- 10 MHz SPI compatible
- 1.8 to 5.5 volt operation
- Hardware and software protection
- Low power CMOS technology
- SPI modes (0,0 &1,1)
- Industrial temperature range
- 1,000,000 program/erase cycles
- 100 year data tetention
- Self-timed write cycle
- *RoHS compliant "Green" & "Gold"*
  8-pin PDIP and 8-pin SOIC packages
- 64-Byte page write buffer
- Block write protection
  – Protect 1/4, 1/2 or all of EEPROM array

DESCRIPTION

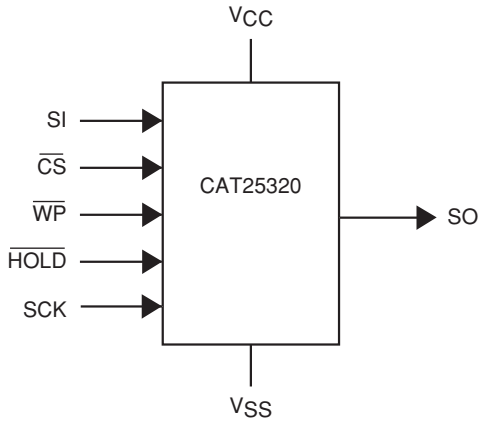
The CAT25320 is a 32K-Bit SPI Serial CMOS EEPROM internally organized as 4Kx8 bits. Catalyst's advanced CMOS Technology substantially reduces device power requirements. The CAT25320 features a 64-byte page write buffer. The device operates via the SPI bus serial interface and is enabled though a Chip Select ($\overline{CS}$). In addition to the Chip Select, the clock input (SCK), data in (SI) and data out (SO) are required to access the device. The $\overline{HOLD}$ pin may be used to suspend any serial communication without resetting the serial sequence. The CAT25320 is designed with software and hardware write protection features including Block write protection. The device is available in 8-pin DIP, SOIC and TSSOP packages.

PIN CONFIGURATION

PDIP (L)
SOIC (V)
TSSOP (Y)



FUNCTIONAL SYMBOL



PIN FUNCTIONS

Pin Name	Function
SO	Serial Data Output
SCK	Serial Clock
$\overline{WP}$	Write Protect
V_{CC}	+1.8V to +6.0V Power Supply
V_{SS}	Ground
$\overline{CS}$	Chip Select
SI	Serial Data Input
$\overline{HOLD}$	Suspends Serial Input

Doc. No. 1109, Rev. B

ABSOLUTE MAXIMUM RATINGS*

Storage Temperature	-65°C to +150°C
Voltage on Any Pin with Respect to Ground(1)	-0.5 V to +6.5 V

* Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions outside of those listed in the operational sections of this specification is not implied. Exposure to any absolute maximum rating for extended periods may affect device performance and reliability.

RELIABILITY CHARACTERISTICS(2)

Symbol	Parameter	Min	Units
N_{END}(*)	Endurance	1,000,000	Program/ Erase Cycles
T_{DR}	Data Retention	100	Years

(*) Page Mode, V_{CC} = 5 V, 25°C

D.C. OPERATING CHARACTERISTICS

V_{CC} = 1.8 V to 5.5 V, T_A = -40°C to 85°C, unless otherwise specified.

Symbol	Parameter	Test Conditions	Min	Max	Units
I_{CC}	Supply Current	Read, Write, V_{CC} = 5.0V, f_{SCK} = 10MHz, SO open		2	mA
I_{SB1}	Standby Current	V_{IN} = GND or V_{CC}, $\overline{CS}$ = V_{CC}, $\overline{WP}$ = V_{CC}, V_{CC} = 5V		2	µA
I_{SB2}	Standby Current	V_{IN} = GND or V_{CC}, $\overline{CS}$ = V_{CC}, $\overline{WP}$ = GND, V_{CC} = 5V		4	µA
I_L	Input Leakage Current	V_{IN} = GND or V_{CC}	-2	2	µA
I_{LO}	Output Leakage Current	$\overline{CS}$ = V_{CC}, V_{OUT} = GND or V_{CC}	-1	1	µA
V_{IL}(3)	Input Low Voltage		-0.5	$0.3V_{CC}$	V
V_{IH}(3)	Input High Voltage		$0.7V_{CC}$	V_{CC} + 0.5	V
V_{OL1}	Output Low Voltage	V_{CC} > 2.5V, I_{OL} = 3.0mA		0.4	V
V_{OH1}	Output High Voltage	V_{CC} > 2.5V, I_{OH} = -1.6mA	V_{CC} - 0.8V		V
V_{OL2}	Output Low Voltage	V_{CC} > 1.8V, I_{OL} = 150µA		0.2	V
V_{OH2}	Output High Voltage	V_{CC} > 1.8V, I_{OH} = -100µA	V_{CC} - 0.2V		V

PIN CAPACITANCE(2)

T_A = 25°C, f = 1 MHz, V_{CC} = 5V

Symbol	Test Conditions	Max	Units	Conditions
C_{OUT}	Output Capacitance (SO)	8	pF	V_{OUT} = 0 V
C_{IN}	Input Capacitance ($\overline{CS}$, SCK, SI, $\overline{WP}$, $\overline{HOLD}$)	6	pF	V_{IN} = 0 V

Note:

(1) The DC input voltage on any pin should not be lower than -0.5V or higher than V_{CC} + 0.5V. During transitions, the voltage on any pin may undershoot to no less than -1.5V or overshoot to no more than V_{CC} + 1.5V, for periods of less than 20ns.

(2) These parameters are tested initially and after a design or process change that affects the parameter according to appropriate AEC-Q100 and JEDEC test methods.

(3) V_{IL} and V_{IH} are reference values and are not tested.

A.C. CHARACTERISTICS

SYMBOL	PARAMETER	CAT250XX-1.8 1.8V-5.5V		CAT250XX 2.5V-5.5V		Test Conditions	UNITS
		Min.	Max.	Min.	Max.		
t_{SU}	Data Setup Time	30		20		C_L = 50pf	ns
t_H	Data Hold Time	30		20			ns
t_{WH}	SCK High Time	75		40			ns
t_{WL}	SCK Low Time	75		40			ns
f_{SCK}	Clock Frequency	DC	5	DC	10		MHz
t_{LZ}	$\overline{HOLD}$ to Output Low Z		50		50		ns
t_{RI}(1)	Input Rise Time		2		2		µs
t_{FI}(1)	Input Fall Time		2		2		µs
t_{HD}	$\overline{HOLD}$ Setup Time	0		0			ns
t_{CD}	$\overline{HOLD}$ Hold Time	10		10			ns
t_{WC}(4)	Write Cycle Time		5		5		ms
t_V	Output Valid from Clock Low		75		40		ns
t_{HO}	Output Hold Time	0		0			ns
t_{DIS}	Output Disable Time		50		20		ns
t_{HZ}	$\overline{HOLD}$ to Output High Z		100		25		ns
t_{CS}	$\overline{CS}$ High Time	50		15			ns
t_{CSS}	$\overline{CS}$ Setup Time	50		15			ns
t_{CSH}	$\overline{CS}$ Hold Time	50		15			ns
t_{WPS}	$\overline{WP}$ Setup Time	10		10			ns
t_{WPH}	$\overline{WP}$ Hold Time	10		10			ns

Power-Up Timing(1)(3)

Symbol	Parameter	Max.	Units
t_{PUR}	Power-up to Read Operation	1	ms
t_{PUW}	Power-up to Write Operation	1	ms

NOTE:
(1) This parameter is tested initially and after a design or process change that affects the parameter.
(2) AC Test Conditions:
Input Pulse Voltages: $0.3V_{CC}$ to $0.7V_{CC}$
Input rise and fall times: ≤10ns
Input and output reference voltages: $0.5V_{CC}$
Output load: current source IOL max/IOH max; C_L=50pF
(3) t_{PUR} and t_{PUW} are the delays required from the time V_{CC} is stable until the specified operation can be initiated.
(4) t_{WC} is the time from the rising edge of $\overline{CS}$ after a valid write sequence to the end of the internal write cycle.

FUNCTIONAL DESCRIPTION

The CAT25320 supports the SPI bus data transmission protocol. The synchronous Serial Peripheral Interface (SPI) helps the CAT25320 to interface directly with many of today's popular microcontrollers. The CAT25320 contains an 8-bit instruction register. (The instruction set and the operation codes are detailed in the instruction set table)

After the device is selected with $\overline{CS}$ going low, the first byte will be received. The part is accessed via the SI pin, with data being clocked in on the rising edge of SCK. The first byte contains one of the six op-codes that define the operation to be performed.

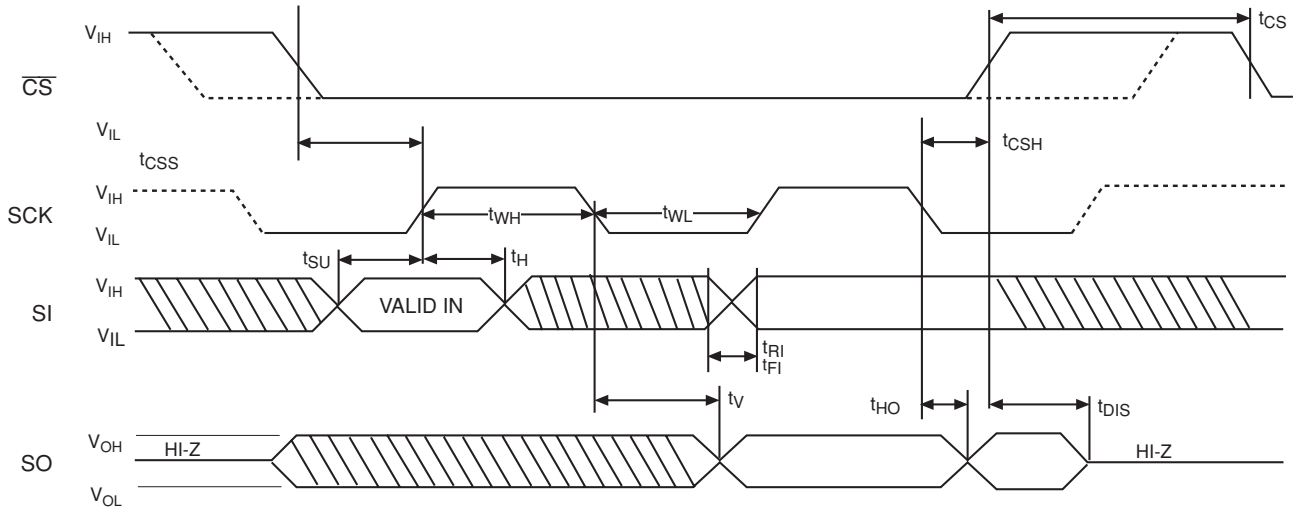
PIN DESCRIPTION

SI: Serial Input
SI is the serial data input pin. This pin is used to input all opcodes, byte addresses, and data to be written to the CAT25320. Input data is latched on the rising edge of the serial clock.

SO: Serial Output
SO is the serial data output pin. This pin is used to transfer data out of the CAT25320. During a read cycle, data is shifted out on the falling edge of the serial clock.

SCK: Serial Clock
SCK is the serial clock pin. This pin is used to synchronize

Figure 1. Sychronous Data Timing



Note: Dashed Line= mode (1, 1) — — — —

INSTRUCTION SET

Instruction	Opcode	Operation
WREN	0000 0110	Enable Write Operations
WRDI	0000 0100	Disable Write Operations
RDSR	0000 0101	Read Status Register
WRSR	0000 0001	Write Status Register
READ	0000 0011	Read Data from Memory
WRITE	0000 0010	Write Data to Memory

the communication between the microcontroller and the CAT25320. Opcodes, byte addresses, or data present on the SI pin are latched on the rising edge of the SCK. Data on the SO pin is updated on the falling edge of the SCK.

$\overline{CS}$: Chip Select

$\overline{CS}$ is the Chip select pin. $\overline{CS}$ low enables the CAT25320 and $\overline{CS}$ high disables the CAT25320. $\overline{CS}$ high takes the SO output pin to high impedance and forces the devices into a Standby Mode (unless an internal write operation is underway). A high to low transition on $\overline{CS}$ is required prior to any sequence being initiated. A low to high transition on $\overline{CS}$ after a valid write sequence is what initiates an internal write cycle.

$\overline{WP}$: Write Protect

$\overline{WP}$ is the Write Protect pin. The Write Protect pin will allow normal read/write operations when held high. When $\overline{WP}$ is tied low and the WPEN bit in the status register is set to "1", all write operations to the status register are inhibited. $\overline{WP}$ going low while $\overline{CS}$ is still low will interrupt a write to the status register. If the internal write cycle has already been initiated, $\overline{WP}$ going low will have no effect on any write operation to the status register. The $\overline{WP}$ pin function is blocked when the WPEN bit is set to 0. Figure 10 illustrates the $\overline{WP}$ timing sequence during a write operation.

$\overline{HOLD}$: Hold

The $\overline{HOLD}$ pin is used to pause transmission to the CAT25320 while in the middle of a serial sequence without having to re-transmit entire sequence at a later time. To pause, $\overline{HOLD}$ must be brought low while SCK is low. The SO pin is in a high impedance state during the time the part is paused, and transitions on the SI pins will be ignored. To resume communication, $\overline{HOLD}$ is brought high, while SCK is low. ($\overline{HOLD}$ should be held high any time this function is not being used.) $\overline{HOLD}$ may be tied high directly to V_{CC} or tied to V_{CC} through a resistor. Figure 9 illustrates hold timing sequence.

STATUS REGISTER

7	6	5	4	3	2	1	0
WPEN	X	X	X	BP1	BP0	WEL	$\overline{RDY}$

BLOCK PROTECTION BITS

Status Register Bits		Array Address Protected	Protection
BP1	BP0		
0	0	None	No Protection
0	1	0C00-0FFF	Quarter Array Protection
1	0	800-0FFF	Half Array Protection
1	1	0000-0FFF	Full Array Protection

WPEN	$\overline{WP}$	WEL	Protected Blocks	Unprotected Blocks	Status Register
0	X	0	Protected	Protected	Protected
0	X	1	Protected	Writable	Writable
1	Low	0	Protected	Protected	Protected
1	Low	1	Protected	Writable	Protected
X	High	0	Protected	Protected	Protected
X	High	1	Protected	Writable	Writable

STATUS REGISTER

The Status Register indicates the status of the device.

The $\overline{RDY}$ (Ready) bit indicates whether the CAT25320 is busy with a write operation. When set to 1 a write cycle is in progress and when set to 0 the device indicates it is ready. This bit is read only.

The WEL (Write Enable) bit indicates the status of the write enable latch . When set to 1, the device is in a Write Enable state and when set to 0 the device is in a Write Disable state. The WEL bit can only be set by the WREN instruction and can be reset by the WRDI instruction.

The BP0 and BP1 (Block Protect) bits indicate which blocks are currently protected. These bits are set by the user issuing the WRSR instruction. The user is allowed to protect quarter of the memory, half of the memory or the entire memory by setting these bits. Once protected the user may only read from the protected portion of the array. These bits are non-volatile.

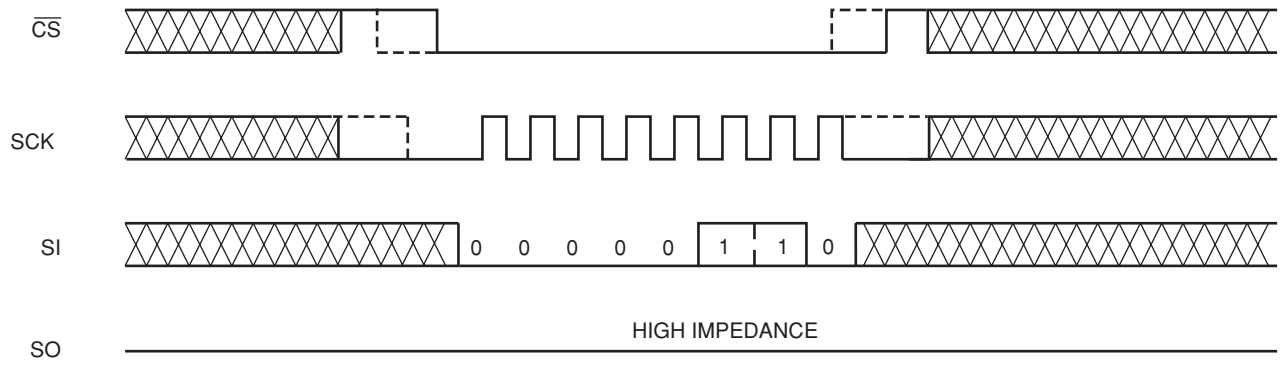
The WPEN (Write Protect Enable) is an enable bit for the $\overline{WP}$ pin. The $\overline{WP}$ pin and WPEN bit in the status register control the programmable hardware write protect feature. Hardware write protection is enabled when $\overline{WP}$ is low and WPEN bit is set to high. The user cannot write to the status register (including the block protect bits and the WPEN bit) and the block protected sections in the memory array when the chip is hardware write protected. Only the sections of the memory array that are not block protected can be written. Hardware write protection is disabled when either WP pin is high or the WPEN bit is zero.

DEVICE OPERATION

Write Enable and Disable

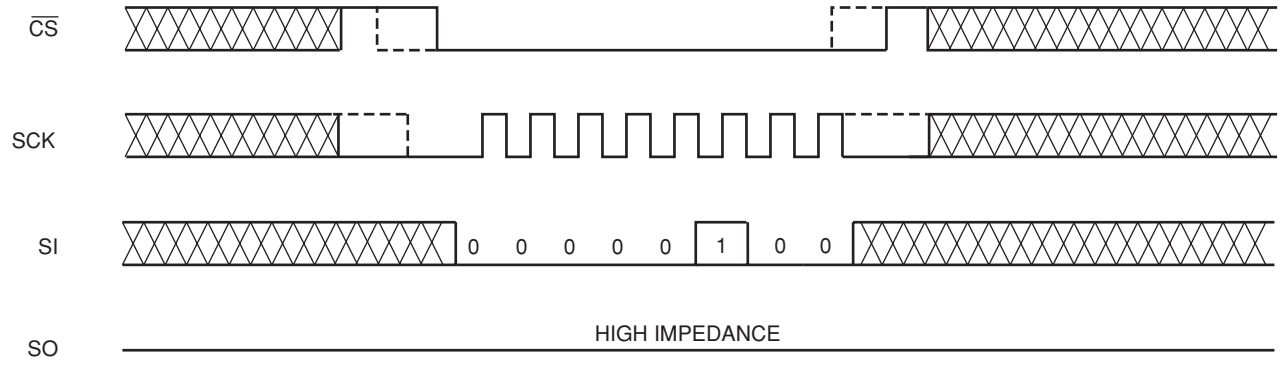
The CAT25320 contains a write enable latch. This latch must be set before any write operation. The device powers up in a write disable state when V_{CC} is applied. WREN instruction will enable writes (set the latch) to thedevice. WRDI instruction will disable writes (reset the latch) to the device. Disabling writes will protect the device against inadvertent writes.

Figure 2. WREN Instruction Timing



Note: Dashed Line = mode (1, 1) — — — —

Figure 3. WRDI Instruction Timing



Note: Dashed Line = mode (1, 1) — — — —

READ Sequence

The part is selected by pulling $\overline{CS}$ low. The 8-bit read instruction is transmitted to the CAT25320, followed by the 16-bit address (the four most significant bits are don't care).

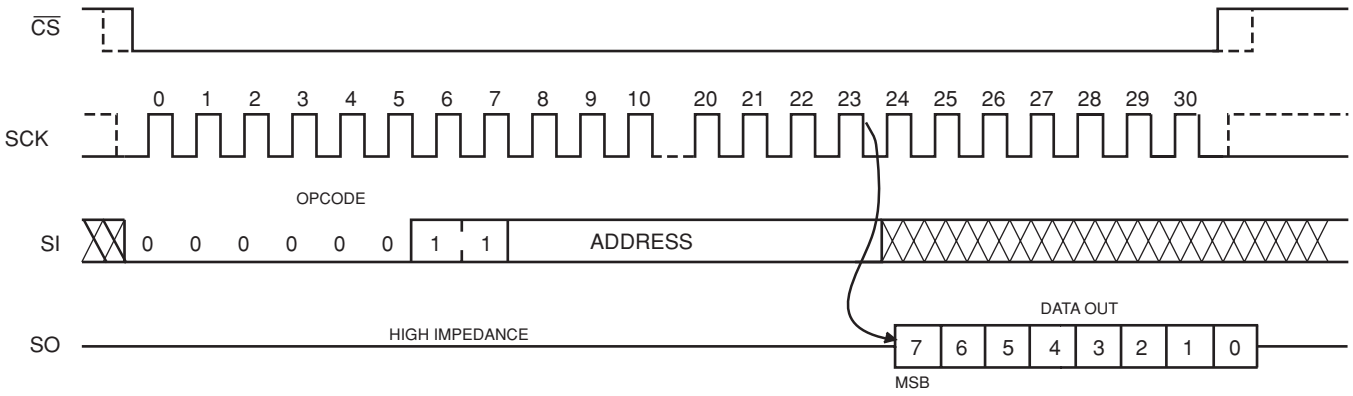
After the correct read instruction and address are sent, the data stored in the memory at the selected address is shifted out on the SO pin. The data stored in the memory at the next address can be read sequentially by continuing to provide clock pulses. The internal address pointer is automatically incremented to the next higher address after each byte of data is shifted out. When the highest address, FFFh is reached, the address counter rolls over to 0000h allowing the read cycle to be continued indefinitely. The read operation is terminated by pulling the $\overline{CS}$ high. Read sequece is illustrated in Figure 4.

To read the status register, RDSR instruction should be sent. The contents of the status register are shifted out on the SO line. The status register may be read at any time even during a write cycle. Reading status register is illustrated in Figure 5.

WRITE Sequence

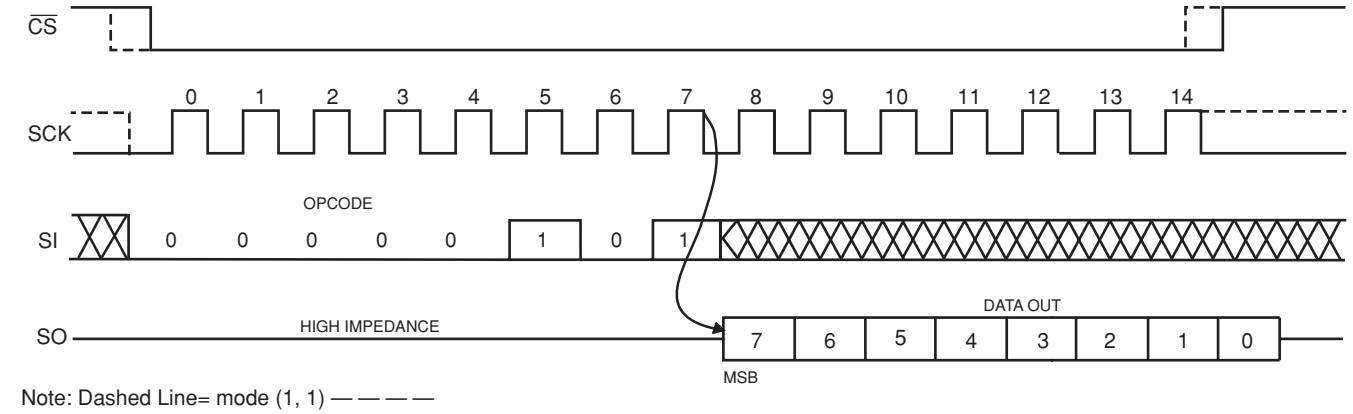
The CAT25320 powers up in a Write Disable state. Prior to any write instructions, the WREN instruction must be sent to CAT25320. The device goes into Write enable state by pulling the $\overline{CS}$ low and then clocking the WREN instruction into CAT25320. The $\overline{CS}$ must be brought high after the WREN instruction to enable writes to the device. If the write operation is initiated immediately after the WREN instruction without $\overline{CS}$ being brought high, the data will not be written to the array because the write enable latch will not have been properly set. Also, for a successful write operation the address of the memory location(s) to be programmed must be outside the protected address field location selected by the block protection level.

Figure 4. Read Instruction Timing



Note: Dashed Line= mode (1, 1) — — — —

Figure 5. RDSR Instruction Timing



Note: Dashed Line= mode (1, 1) — — — —

Byte Write

Once the device is in a Write Enable state, the user may proceed with a write sequence by setting the $\overline{CS}$ low, issuing a write instruction via the SI line, followed by the 16-bit address (four most significant bits are don't care), and then the data to be written. Programming will start after the $\overline{CS}$ is brought high. Figure 6 illustrates byte write sequence.

During an internal write cycle, all commands will be ignored except the RDSR (Read Status Register) instruction.

The Status Register can be read to determine if the write cycle is still in progress. If Bit 0 of the Status Register is set at 1, write cycle is in progress. If Bit 0 is set at 0, the device is ready for the next instruction.

Page Write

The CAT25320 features page write capability. After the first initial byte the host may continue to write up to 64 bytes of data to the CAT25320. After each byte of data is received, six lower order address bits are internally incremented by one; the high order bits of address will remain constant. The only restriction is that the 64 bytes must reside on the same page. If the address counter reaches the end of the page and clock continues, the counter will "roll over" to the first address of the page and overwrite any data that may have been written. The CAT25320 is automatically returned to the write disable state at the completion of the write cycle. Figure 8 illustrates the page write sequence.

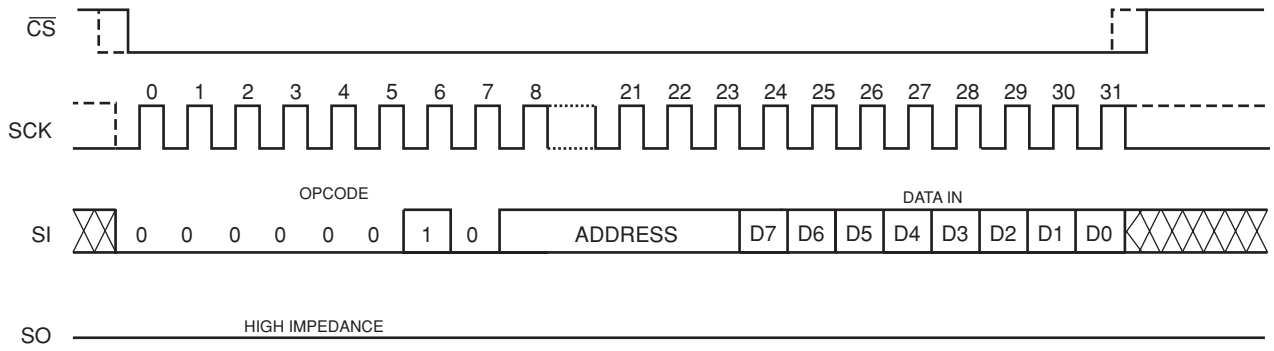
Status Register Write

To write to the status register, the WRSR instruction should be sent. Only Bit 2, Bit 3 and Bit 7 of the status register can be written using the WRSR instruction. Figure 7 illustrates the sequence of writing to status register.

DESIGN CONSIDERATIONS

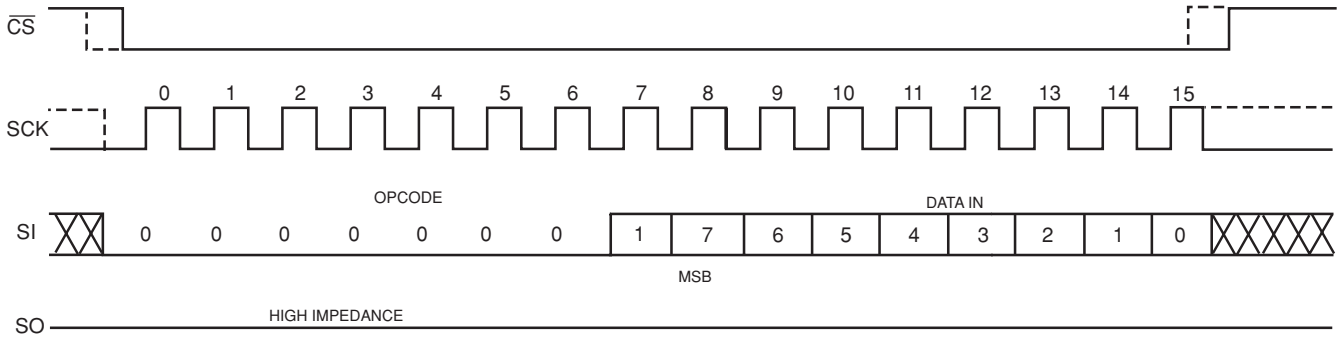
The CAT25320 powers up in a write disable state and in a low power standby mode. A WREN instruction must be issued to perform any writes to the device after power up. After power up $\overline{CS}$ must be brought low to enter a ready state and receive an instruction. After a successful byte/page write or status register write the CAT25320 goes into

Figure 6. Write Instruction Timing



Note: Dashed Line = mode (1, 1) — — — —

Figure 7. WRSR Instruction Timing

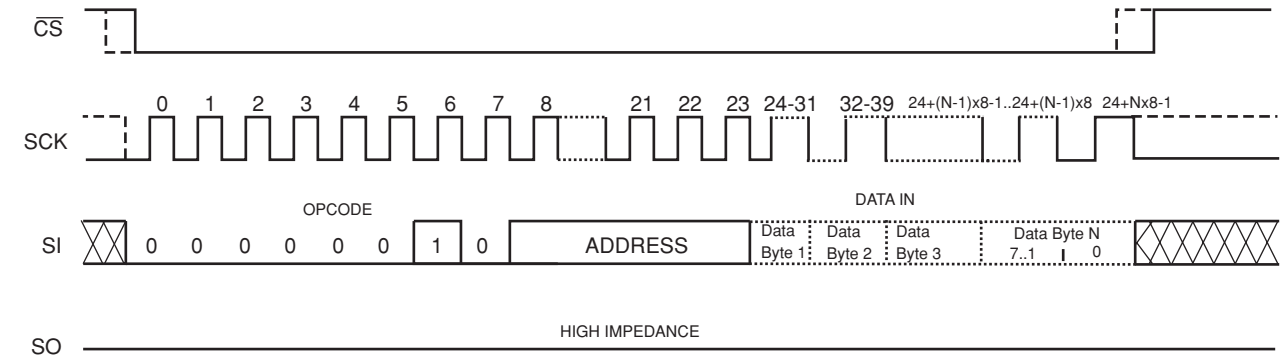


Note: Dashed Line = mode (1, 1) — — — —

a write disable mode. $\overline{CS}$ must be set high after the proper number of clock cycles to start an internal write cycle. Access to the array during an internal write cycle is ignored and programming is continued. On power up, SO is in a high impedance.

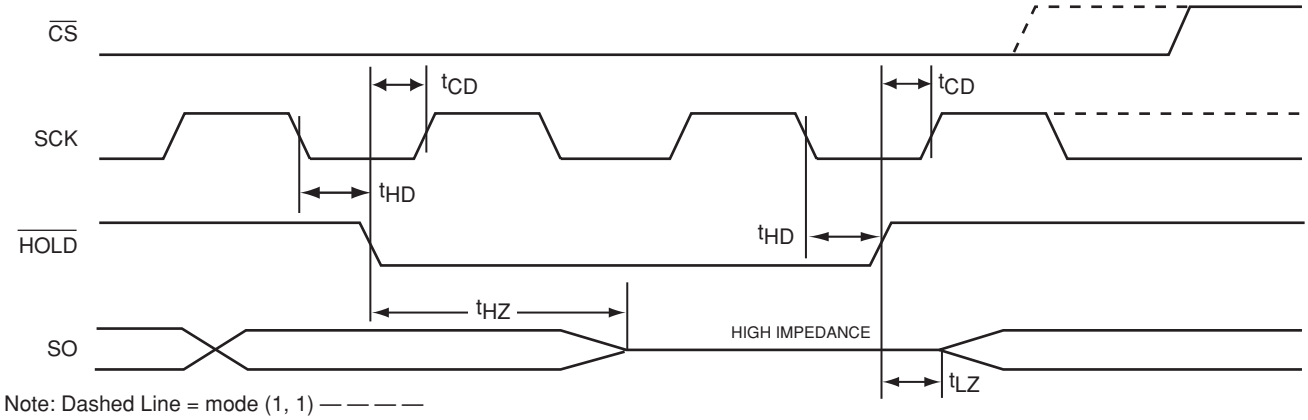
If an invalid code is received, no data will be shifted into the CAT25320 and the serial output pin (SO) will remain in a high impedance state until the falling edge of $\overline{CS}$ is detected again.

Figure 8. Page Write Instruction Timing



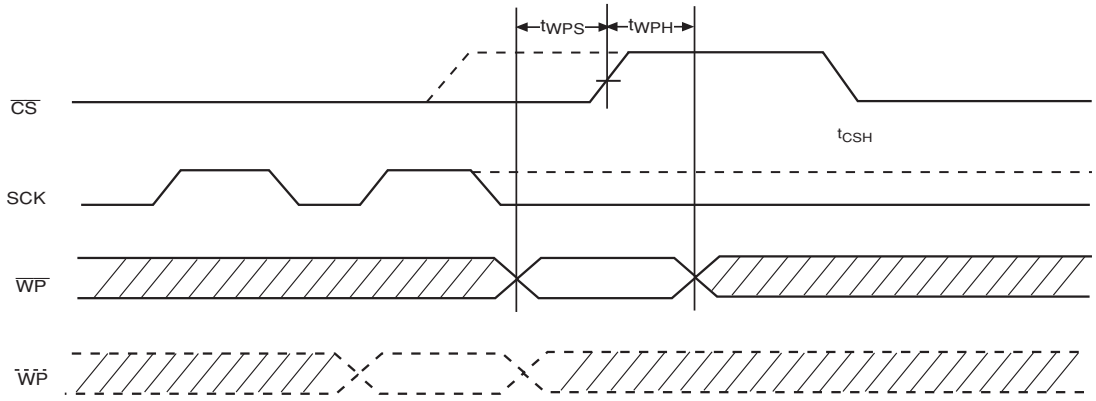
Note: Dashed Line = mode (1, 1) — — — —

Figure 9. $\overline{HOLD}$ Timing

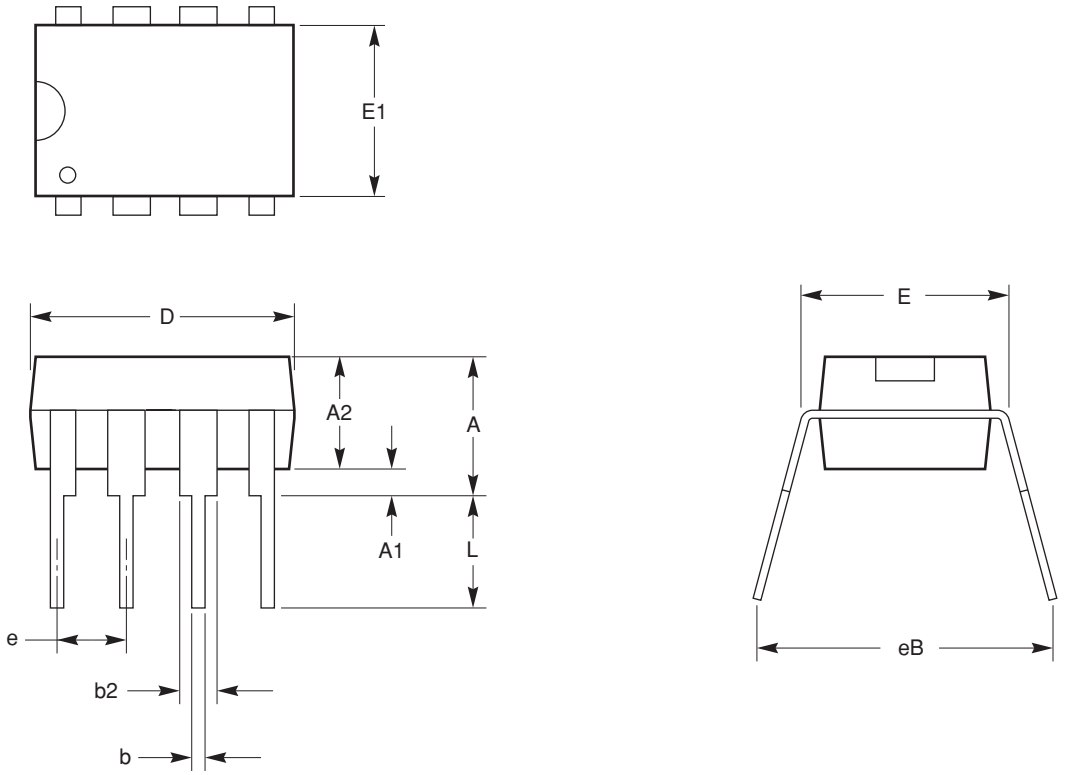


Note: Dashed Line = mode (1, 1) — — — —

Figure 10. $\overline{WP}$ Timing



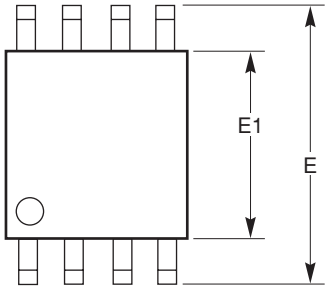
8-LEAD 300 MIL WIDE PLASTIC DIP (L)

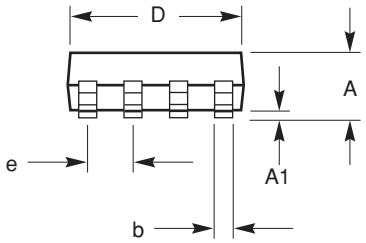


SYMBOL	MIN	NOM	MAX
A	0.120		0.210
A1	0.015		
A2	0.115	0.130	0.195
b	0.014	0.018	0.022
b2	0.045	0.060	0.070
D	0.355	0.365	0.400
D2	0.300		0.325
E	0.300	0.310	0.325
E1	0.240	0.250	0.280
e		0.100 BSC	
eB			0.430
L	0.115	0.130	0.150

Notes:
1. Complies with JEDEC Standard MS001.
2. All dimensions are in inches.
3. Dimensioning and tolerancing per ANSI Y14.5M-1982

8-LEAD 150 MIL WIDE SOIC (V)

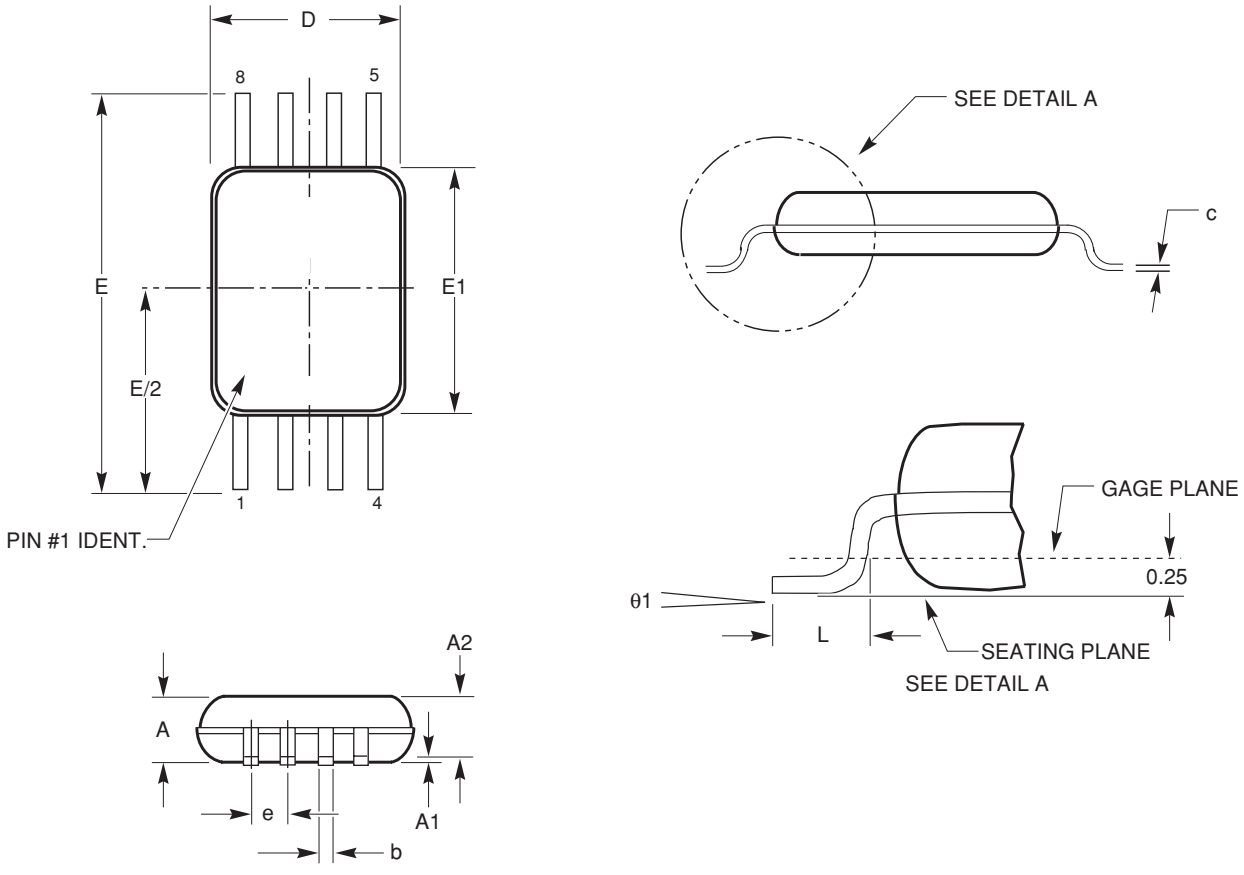




SYMBOL	MIN	NOM	MAX
A1	0.0040		0.0098
A2	0.0532		0.0688
b	0.013		0.020
C	0.0075		0.0098
D	0.1890		0.1968
E	02284		0.2440
E1	0.149		0.1574
e		0.050 BSC	
f	0.0099		0.0196
θ1	0°		8°

Notes:
1. Complies with JEDEC specification MS-012 dimensions.
2. All linear dimensions in millimeters.

8-LEAD TSSOP (Y)

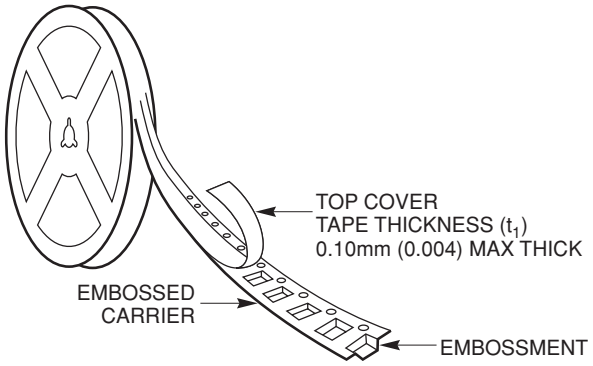


SYMBOL	MIN	NOM	MAX
A			1.20
A1	0.05		0.15
A2	0.80	0.90	1.05
b	0.19		0.30
c	0.09		0.20
D	2.90	3.00	3.10
E	6.30	6.4	6.50
E1	4.30	4.40	4.50
e		0.65 BSC	
L	0.50	0.60	0.75
θ1	0.00		8.00

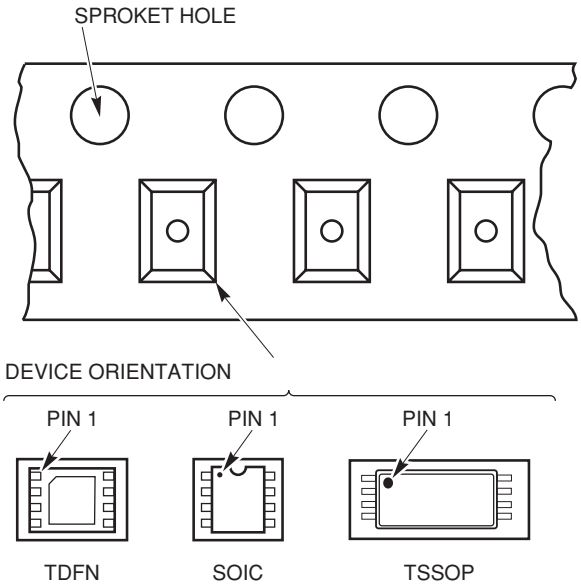
Notes:
1. All dimensions in millimeters.

TAPE AND REEL

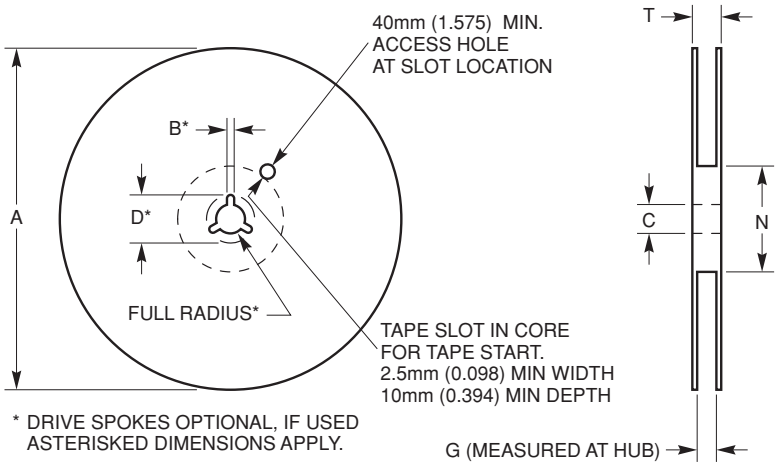
Direction of Feed



Device Orientation



Reel Dimensions(1)



Embossed Carrier Dimensions

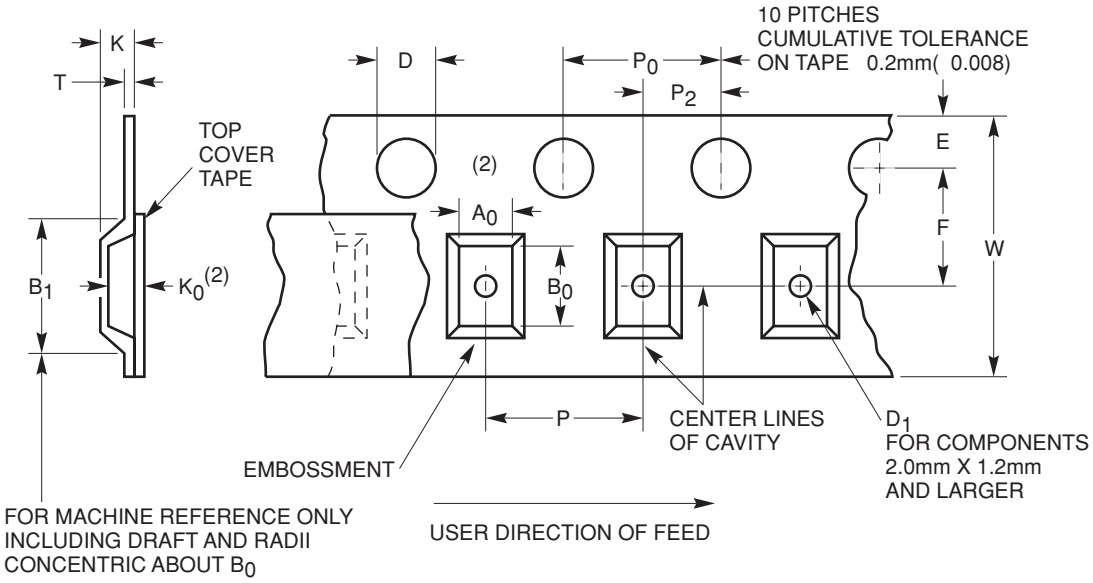
TAPE SIZE	A		B MIN	C	D* MIN	N MIN	G	T MAX
	MAX	QTY/REEL						
12MM	330 (13.00)	3000	1.5 (0.059)	12.80 (0.504) 13.20 (0.5200)	20.2 (0.795)	50 (1.969)	12.4 (0.488) 14.4 (0.558)	18.4 (0.724)

Component/Tape Size Cross-Reference

Component	Package Type	Tape Size (W)	Part Pitch (P)
8L SOIC, TSSOP	V, Y	12mm	8mm

Notes:
(1) Metric dimensions will govern; English measurements rounded, for reference only and in parentheses.

Embossed Carrier Dimensions (12 Pape Only)



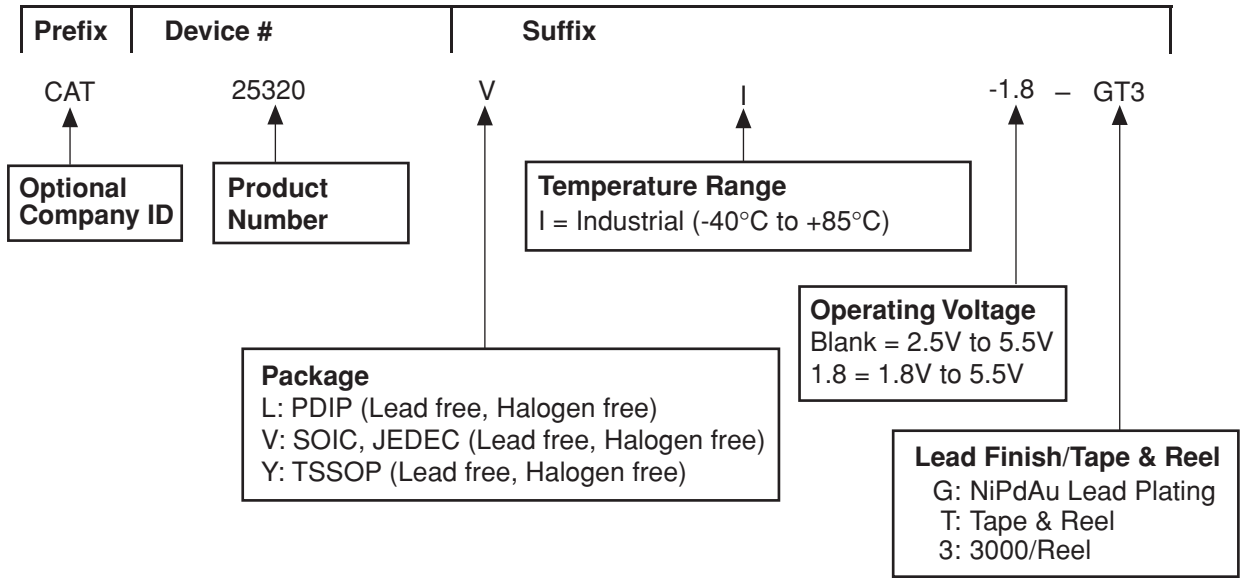
Embossed Tape—Constant Dimensions(1)

Tape Sizes	D	E	P_0	T Max.	D1 Min.	A_0 B_0 K_0(2)
12mm	1.5 (0.059) 1.6 (0.063)	1.65 (0.065) 1.85 (0.073)	3.9 (0.153) 4.1 (0.161)	400 (0.016)	1.5 (0.059)	

Embossed Tape—Variable Dimensions(1)

Tape Sizes	B_1 Max.	F	K Max.	P_2	R Min.	W	P
12mm	8.2 (0.0323)	5.45 (0.0215) 5.55 (0.0219)	4.5 (0.177)	1.95 (0.077) 2.05 (0.081)	30 (1.181)	11.7 (0.460) 12.3 (0.484)	7.9 (0.275) 8.1 (0.355)

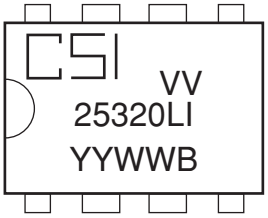
Note:
(1) Metric dimensions will govern; English measurements rounded, for reference only and in parentheses.
(2) A_0 B_0 K_0 are determined by component size. The clearance between the component and the cavity must be within 0.05 (0.002) min. to 0.65 (0.026) max. for 12mm tape, 0.05 (0.002) min. to 0.90 (0.035) max. for 16mm tape, and 0.05 (0.002) min. to 1.00 (0.039) max. for 24mm tape and larger. The component cannot rotate more than 20° within the determined cavity, see Component Rotation.



Notes:
(1) The device used in the above example is a CAT25320VI-1.8GT3 (SOIC, Industrial Temperature, 1.8 Volt to 5.5 Volt Operating Voltage, Tape & Reel)

PACKAGE MARKING

8-Lead PDIP

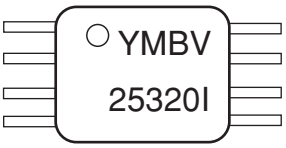


CSI = Catalyst Semiconductor, Inc.
VV = Voltage Range
1.8V - 5.5V = 18
2.5V - 5.5V = Blank
25320L = Device Code
I = Temperature Range
YY = Production Year
WW = Production Week
B = Product Revision

8-Lead SOIC

CSI = Catalyst Semiconductor, Inc.
VV = Voltage Range
1.8V - 5.5V = 18
2.5V - 5.5V = Blank
25320V = Device Code
I = Temperature Range
YY = Production Year
WW = Production Week
B = Product Revision

8-Lead TSSOP



Y = Production Year
M = Production Month
B = Die Revision
25320 = Device Code
I = Industrial Temperature Range
V = Voltage Range
1.8V - 5.5V = 8
2.5V - 5.5V = Blank

REVISION HISTORY

Date	Rev.	Reason
12/20/05	A	Initial Issue
03/21/06	B	Update D.C. Operating Characteristics Update A.C. Characteristics Update Pin Description

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