

# CAT93C86

## 16 Kb Microwire Serial EEPROM

### Description

The CAT93C86 is a 16 Kb Serial EEPROM memory device which is configured as either registers of 16 bits (ORG pin at V<sub>CC</sub>) or 8 bits (ORG pin at GND). Each register can be written (or read) serially by using the DI (or DO) pin. The CAT93C86 is manufactured using ON Semiconductor's advanced CMOS EEPROM floating gate technology. The device is designed to endure 1,000,000 program/erase cycles and has a data retention of 100 years. The device is available in 8-pin DIP and 8-pin SOIC packages.

### Features

- High Speed Operation: 3 MHz / V<sub>CC</sub> = 5 V
- Low Power CMOS Technology
- 1.8 V to 5.5 V Operation
- Selectable x8 or x16 Memory Organization
- Self-timed Write Cycle with Auto-clear
- Hardware and Software Write Protection
- Power-up Inadvertent Write Protection
- Sequential Read
- Program Enable (PE) Pin
- 1,000,000 Program/Erase Cycles
- 100 Year Data Retention
- Industrial and Extended Temperature Ranges
- 8-lead PDIP and SOIC Packages
- These Devices are Pb-Free, Halogen Free/BFR Free, and RoHS Compliant

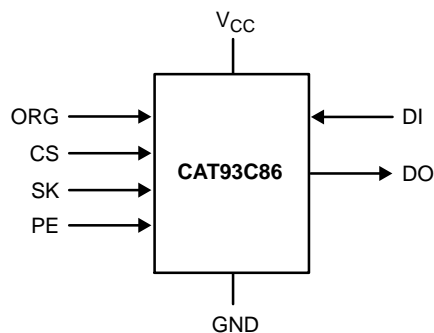


Figure 1. Functional Symbol

**Note:** When the ORG pin is connected to V<sub>CC</sub>, the x16 organization is selected. When it is connected to ground, the x8 pin is selected. If the ORG pin is left unconnected, then an internal pull-up device will select the x16 organization.

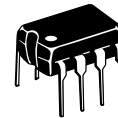


**ON Semiconductor®**

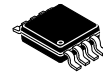
[www.onsemi.com](http://www.onsemi.com)



**SOIC-8**  
V, W SUFFIX  
CASE 751BD

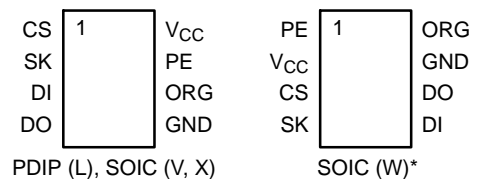


**PDIP-8**  
L SUFFIX  
CASE 646AA



**SOIC-8**  
X SUFFIX  
CASE 751BE

### PIN CONFIGURATION



### PIN FUNCTION

Pin Name	Function
CS	Chip Select
SK	Clock Input
DI	Serial Data Input
DO	Serial Data Output
V <sub>CC</sub>	Power Supply
GND	Ground
ORG	Memory Organization
PE	Program Enable

### ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 10 of this data sheet.

\* Not Recommended for New Designs

# CAT93C86

**Table 1. ABSOLUTE MAXIMUM RATINGS**

Parameters	Ratings	Units
Temperature Under Bias	-55 to +125	°C
Storage Temperature	-65 to +150	°C
Voltage on any Pin with Respect to Ground (Note 1)	-2.0 to +V <sub>CC</sub> +2.0	V
V <sub>CC</sub> with Respect to Ground	-2.0 to +7.0	V
Package Power Dissipation Capability (T <sub>A</sub> = 25°C)	1.0	W
Lead Soldering Temperature (10 seconds)	300	°C
Output Short Circuit Current (Note 2)	100	mA

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

- The minimum DC input voltage is -0.5 V. During transitions, inputs may undershoot to -2.0 V for periods of less than 20 ns. Maximum DC voltage on output pins is V<sub>CC</sub> +0.5 V, which may overshoot to V<sub>CC</sub> +2.0 V for periods of less than 20 ns.
- Output shorted for no more than one second. No more than one output shorted at a time.

**Table 2. RELIABILITY CHARACTERISTICS**

Symbol	Parameter	Reference Test Method	Min	Units
N <sub>END</sub> (Note 3)	Endurance	MIL-STD-883, Test Method 1033	1,000,000	Cycles/Byte
T <sub>DR</sub> (Note 3)	Data Retention	MIL-STD-883, Test Method 1008	100	Years
V <sub>ZAP</sub> (Note 3)	ESD Susceptibility	MIL-STD-883, Test Method 3015	2000	V
I <sub>LTH</sub> (Notes 3, 4)	Latch-Up	JEDEC Standard 17	100	mA

- These parameters are tested initially and after a design or process change that affects the parameter.
- Latch-up protection is provided for stresses up to 100 mA on address and data pins from -1 V to V<sub>CC</sub> +1 V.

**Table 3. D.C. OPERATING CHARACTERISTICS** (V<sub>CC</sub> = +1.8 V to +5.5 V unless otherwise specified.)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Units
I <sub>CC1</sub>	Power Supply Current (Write)	f <sub>SK</sub> = 1 MHz; V <sub>CC</sub> = 5.0 V			3	mA
I <sub>CC2</sub>	Power Supply Current (Read)	f <sub>SK</sub> = 1 MHz; V <sub>CC</sub> = 5.0 V			500	μA
I <sub>SB1</sub>	Power Supply Current (Standby) (x8 Mode)	CS = 0 V ORG = GND			10	μA
I <sub>SB2</sub>	Power Supply Current (Standby) (x16 Mode)	CS = 0 V ORG = Float or V <sub>CC</sub>		0	10	μA
I <sub>LI</sub>	Input Leakage Current	V <sub>IN</sub> = 0 V to V <sub>CC</sub>			1	μA
I <sub>LO</sub>	Output Leakage Current (Including ORG pin)	V <sub>OUT</sub> = 0 V to V <sub>CC</sub> ; CS = 0 V			1	μA
V <sub>IL1</sub>	Input Low Voltage	4.5 V ≤ V <sub>CC</sub> < 5.5 V	-0.1		0.8	V
V <sub>IH1</sub>	Input High Voltage	4.5 V ≤ V <sub>CC</sub> < 5.5 V	2		V <sub>CC</sub> + 1	V
V <sub>IL2</sub>	Input Low Voltage	1.8 V ≤ V <sub>CC</sub> < 4.5 V	0		V <sub>CC</sub> x 0.2	V
V <sub>IH2</sub>	Input High Voltage	1.8 V ≤ V <sub>CC</sub> < 4.5 V	V <sub>CC</sub> x 0.7		V <sub>CC</sub> + 1	V
V <sub>OL1</sub>	Output Low Voltage	4.5 V ≤ V <sub>CC</sub> < 5.5 V; I <sub>OL</sub> = 2.1 mA			0.4	V
V <sub>OH1</sub>	Output High Voltage	4.5 V ≤ V <sub>CC</sub> < 5.5 V; I <sub>OH</sub> = -400 μA	2.4			V
V <sub>OL2</sub>	Output Low Voltage	1.8 V ≤ V <sub>CC</sub> < 4.5 V; I <sub>OL</sub> = 1 mA			0.2	V
V <sub>OH2</sub>	Output High Voltage	1.8 V ≤ V <sub>CC</sub> < 4.5 V; I <sub>OH</sub> = -100 μA	V <sub>CC</sub> - 0.2			V

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

# CAT93C86

**Table 4. PIN CAPACITANCE** (Note 5)

Symbol	Test	Conditions	Min	Typ	Max	Units
C <sub>OUT</sub>	Output Capacitance (DO)	V <sub>OUT</sub> = 0 V			5	pF
C <sub>IN</sub>	Input Capacitance (CS, SK, DI, ORG)	V <sub>IN</sub> = 0 V			5	pF

**Table 5. POWER-UP TIMING** (Notes 5, 6)

Symbol	Parameter	Max	Units
t <sub>PUR</sub>	Power-up to Read Operation	1	ms
t <sub>PUW</sub>	Power-up to Write Operation	1	ms

**Table 6. A.C. TEST CONDITIONS**

Input Rise and Fall Times	≤ 50 ns	
Input Pulse Voltages	0.4 V to 2.4 V	4.5 V ≤ V <sub>CC</sub> ≤ 5.5 V
Timing Reference Voltages	0.8 V, 2.0 V	4.5 V ≤ V <sub>CC</sub> ≤ 5.5 V
Input Pulse Voltages	0.2 x V <sub>CC</sub> to 0.7 x V <sub>CC</sub>	1.8 V ≤ V <sub>CC</sub> ≤ 4.5 V
Timing Reference Voltages	0.5 x V <sub>CC</sub>	1.8 V ≤ V <sub>CC</sub> ≤ 4.5 V

**Table 7. A.C. CHARACTERISTICS**

Symbol	Parameter	Test Conditions	V <sub>CC</sub> = 1.8 V – 5.5 V		V <sub>CC</sub> = 2.5 V – 5.5 V		V <sub>CC</sub> = 4.5 V – 5.5 V		Units
			Min	Max	Min	Max	Min	Max	
t <sub>CSS</sub>	CS Setup Time		200		100		50		ns
t <sub>CSH</sub>	CS Hold Time		0		0		0		ns
t <sub>DIS</sub>	DI Setup Time		200		100		50		ns
t <sub>DIH</sub>	DI Hold Time		200		100		50		ns
t <sub>PD1</sub>	Output Delay to 1			1		0.5		0.15	μs
t <sub>PD0</sub>	Output Delay to 0	C <sub>L</sub> = 100 pF (Note 7)		1		0.5		0.15	μs
t <sub>HZ</sub> (Note 5)	Output Delay to High-Z			400		200		100	ns
t <sub>EW</sub>	Program/Erase Pulse Width			5		5		5	ms
t <sub>CSMIN</sub>	Minimum CS Low Time		1		0.5		0.15		μs
t <sub>SKHI</sub>	Minimum SK High Time		1		0.5		0.15		μs
t <sub>SKLOW</sub>	Minimum SK Low Time		1		0.5		0.15		μs
t <sub>SV</sub>	Output Delay to Status Valid			1		0.5		0.1	μs
SK <sub>MAX</sub>	Maximum Clock Frequency		DC	500	DC	1000	DC	3000	kHz

5. These parameters are tested initially and after a design or process change that affects the parameter.
6. t<sub>PUR</sub> and t<sub>PUW</sub> are the delays required from the time V<sub>CC</sub> is stable until the specified operation can be initiated.
7. The input levels and timing reference points are shown in the "A.C. Test Conditions" table.

# CAT93C86

**Table 8. INSTRUCTION SET**

Instruction	Start Bit	Opcode	Address		Data		Comments
			x8	x16	x8	x16	
READ	1	10	A10–A0	A9–A0			Read Address AN– A0
ERASE	1	11	A10–A0	A9–A0			Clear Address AN– A0
WRITE	1	01	A10–A0	A9–A0	D7–D0	D15–D0	Write Address AN– A0
EWEN	1	00	11XXXXXXXXXX	11XXXXXXXXXX			Write Enable
EWDS	1	00	00XXXXXXXXXX	00XXXXXXXXXX			Write Disable
ERAL	1	00	10XXXXXXXXXX	10XXXXXXXXXX			Clear All Addresses
WRAL	1	00	01XXXXXXXXXX	01XXXXXXXXXX	D7–D0	D15–D0	Write All Addresses

## Device Operation

The CAT93C86 is a 16,384-bit nonvolatile memory intended for use with industry standard microprocessors. The CAT93C86 can be organized as either registers of 16 bits or 8 bits. When organized as X16, seven 13-bit instructions control the reading, writing and erase operations of the device. When organized as X8, seven 14-bit instructions control the reading, writing and erase operations of the device. The CAT93C86 operates on a single power supply and will generate on chip, the high voltage required during any write operation.

Instructions, addresses, and write data are clocked into the DI pin on the rising edge of the clock (SK). The DO pin is normally in a high impedance state except when reading data from the device, or when checking the ready/busy status after a write operation.

The ready/busy status can be determined after the start of a write operation by selecting the device (CS high) and polling the DO pin; DO low indicates that the write operation is not completed, while DO high indicates that the device is ready for the next instruction. If necessary, the DO pin may be placed back into a high impedance state during chip select by shifting a dummy “1” into the DI pin. The DO pin will enter the high impedance state on the falling edge of the clock (SK). Placing the DO pin into the high impedance state is recommended in applications where the DI pin and the DO pin are to be tied together to form a common DI/O pin.

The format for all instructions sent to the device is a logical “1” start bit, a 2-bit (or 4-bit) opcode, 10-bit address (an additional bit when organized X8) and for write operations a 16-bit data field (8-bit for X8 organizations).

**Note:** The Write, Erase, Write all and Erase all instructions require PE = 1. If PE is left floating, 93C86 is in Program Enabled mode. For Write Enable and Write Disable instruction PE = don't care.

## Read

Upon receiving a READ command and an address (clocked into the DI pin), the DO pin of the CAT93C86 will come out of the high impedance state and, after sending an initial dummy zero bit, will begin shifting out the data addressed (MSB first). The output data bits will toggle on the rising edge of the SK clock and are stable after the specified time delay ( $t_{PD0}$  or  $t_{PD1}$ ).

After the initial data word has been shifted out and CS remains asserted with the SK clock continuing to toggle, the device will automatically increment to the next address and shift out the next data word in a sequential READ mode. As long as CS is continuously asserted and SK continues to toggle, the device will keep incrementing to the next address automatically until it reaches to the end of the address space, then loops back to address 0. In the sequential READ mode, only the initial data word is preceeded by a dummy zero bit. All subsequent data words will follow without a dummy zero bit.

## Write

After receiving a WRITE command, address and the data, the CS (Chip Select) pin must be deselected for a minimum of  $t_{CSMIN}$ . The falling edge of CS will start the self clocking clear and data store cycle of the memory location specified in the instruction. The clocking of the SK pin is not necessary after the device has entered the self clocking mode. The ready/busy status of the CAT93C86 can be determined by selecting the device and polling the DO pin. Since this device features Auto-Clear before write, it is NOT necessary to erase a memory location before it is written into.

# CAT93C86

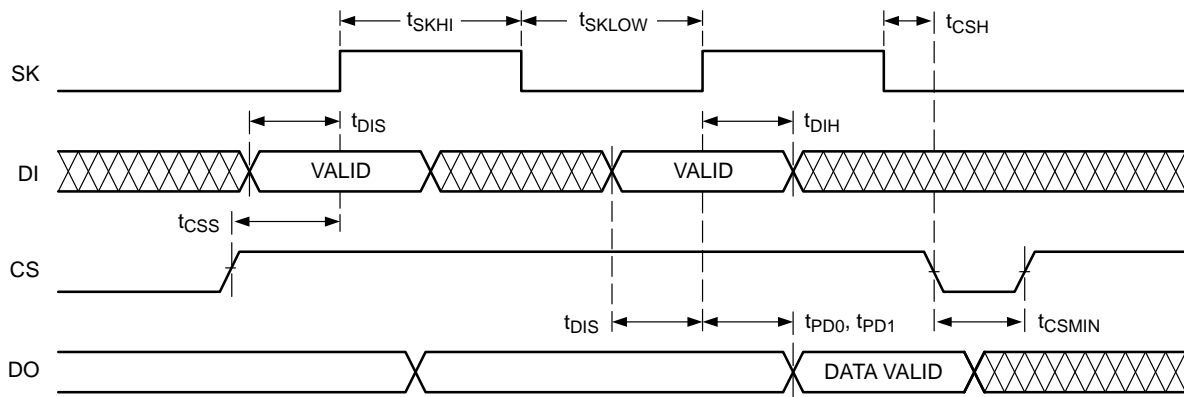


Figure 2. Synchronous Data Timing

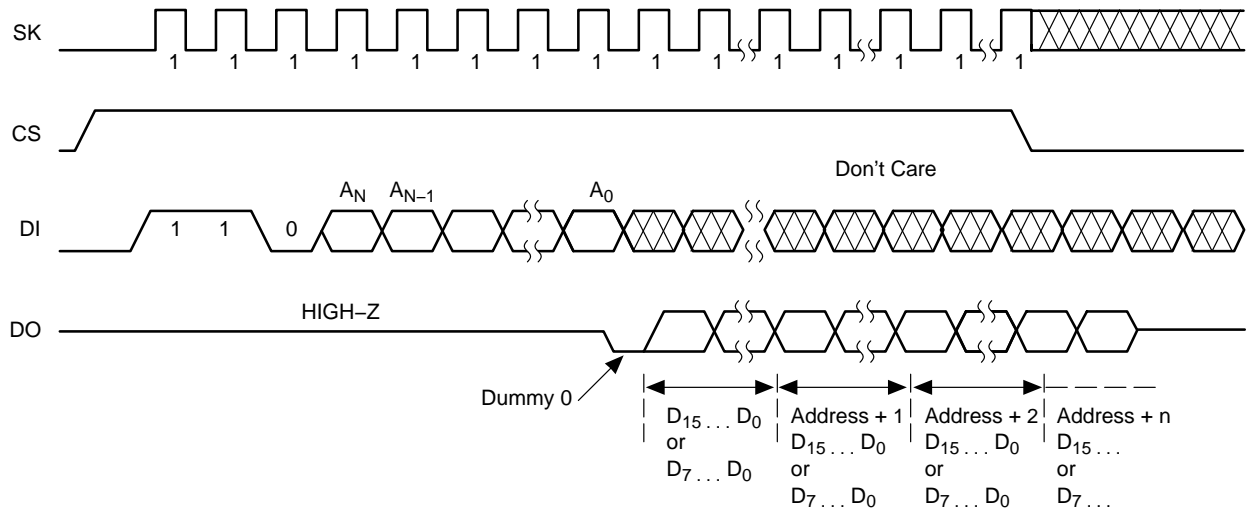


Figure 3. Read Instruction Timing

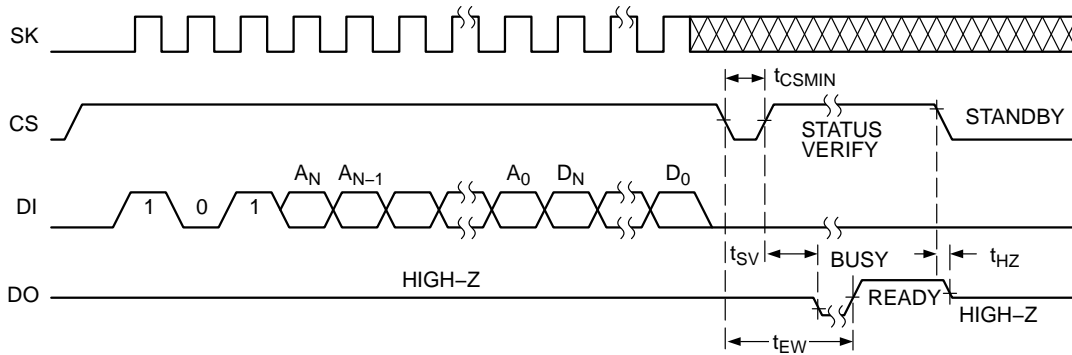


Figure 4. Write Instruction Timing

# CAT93C86

## Erase

Upon receiving an ERASE command and address, the CS (Chip Select) pin must be deasserted for a minimum of  $t_{CSMIN}$ . The falling edge of CS will start the self clocking clear cycle of the selected memory location. The clocking of the SK pin is not necessary after the device has entered the self clocking mode. The ready/busy status of the CAT93C86 can be determined by selecting the device and polling the DO pin. Once cleared, the content of a cleared location returns to a logical “1” state.

## Erase/Write Enable and Disable

The CAT93C86 powers up in the write disable state. Any writing after power-up or after an EWDS (write disable) instruction must first be preceded by the EWEN (write enable) instruction. Once the write instruction is enabled, it will remain enabled until power to the device is removed, or the EWDS instruction is sent. The EWDS instruction can be used to disable all CAT93C86 write and clear instructions, and will prevent any accidental writing or clearing of the device. Data can be read normally from the device regardless of the write enable/disable status.

## Erase All

Upon receiving an ERAL command, the CS (Chip Select) pin must be deselected for a minimum of  $t_{CSMIN}$ . The falling edge of CS will start the self clocking clear cycle of all memory locations in the device. The clocking of the SK pin is not necessary after the device has entered the self clocking mode. The ready/busy status of the CAT93C86 can be determined by selecting the device and polling the DO pin. Once cleared, the contents of all memory bits return to a logical “1” state.

## Write All

Upon receiving a WRAL command and data, the CS (Chip Select) pin must be deselected for a minimum of  $t_{CSMIN}$ . The falling edge of CS will start the self clocking data write to all memory locations in the device. The clocking of the SK pin is not necessary after the device has entered the self clocking mode. The ready/busy status of the CAT93C86 can be determined by selecting the device and polling the DO pin. It is not necessary for all memory locations to be cleared before the WRAL command is executed.

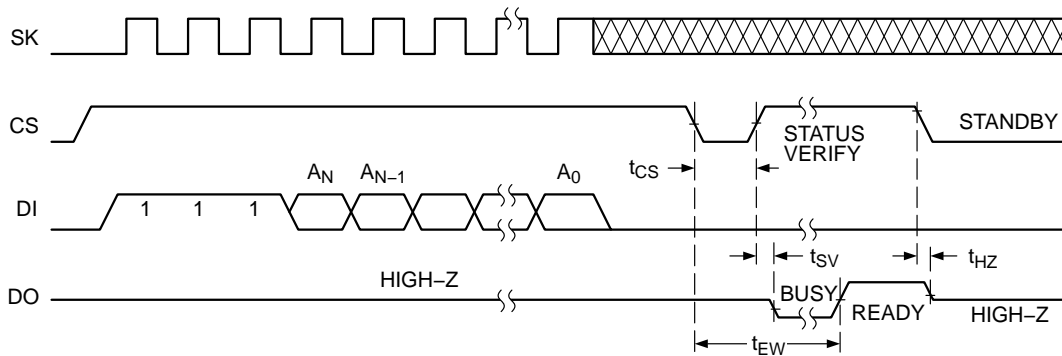
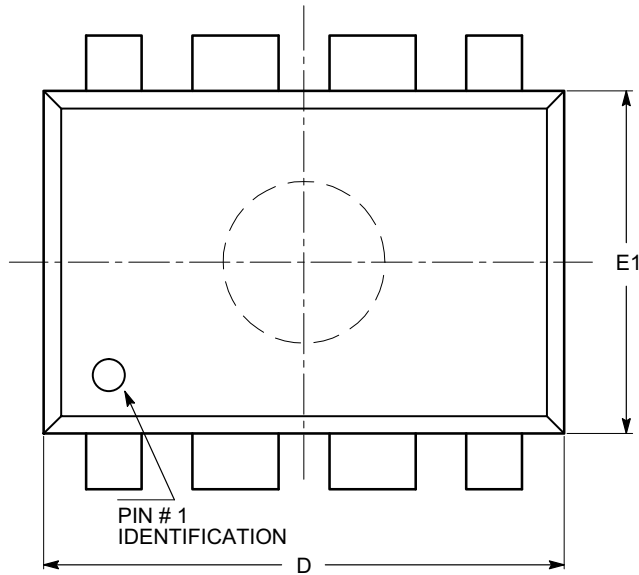


Figure 5. Erase Instruction Timing

# CAT93C86

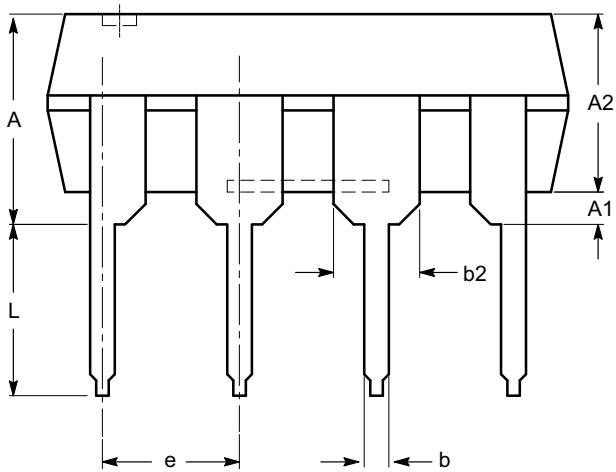
## PACKAGE DIMENSIONS

PDIP-8, 300 mils  
CASE 646AA-01  
ISSUE A

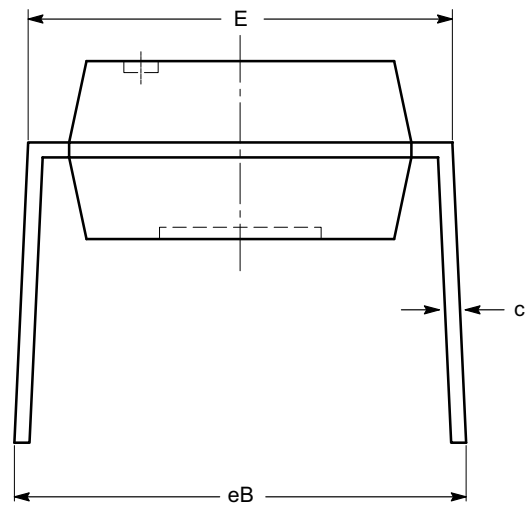


SYMBOL	MIN	NOM	MAX
A			5.33
A1	0.38		
A2	2.92	3.30	4.95
b	0.36	0.46	0.56
b2	1.14	1.52	1.78
c	0.20	0.25	0.36
D	9.02	9.27	10.16
E	7.62	7.87	8.25
E1	6.10	6.35	7.11
e	2.54 BSC		
eB	7.87		10.92
L	2.92	3.30	3.80

TOP VIEW



SIDE VIEW



END VIEW

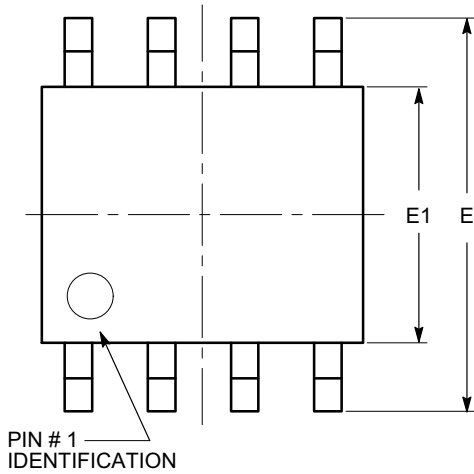
**Notes:**

- (1) All dimensions are in millimeters.
- (2) Complies with JEDEC MS-001.

# CAT93C86

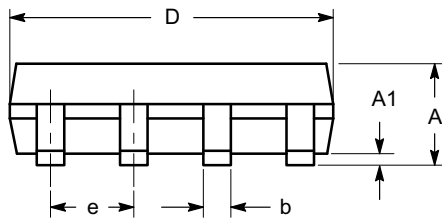
## PACKAGE DIMENSIONS

SOIC 8, 150 mils  
CASE 751BD-01  
ISSUE O

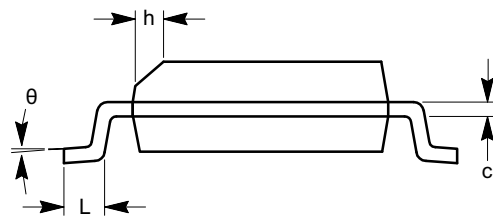


TOP VIEW

SYMBOL	MIN	NOM	MAX
A	1.35		1.75
A1	0.10		0.25
b	0.33		0.51
c	0.19		0.25
D	4.80		5.00
E	5.80		6.20
E1	3.80		4.00
e	1.27 BSC		
h	0.25		0.50
L	0.40		1.27
$\theta$	0°		8°



SIDE VIEW



END VIEW

**Notes:**

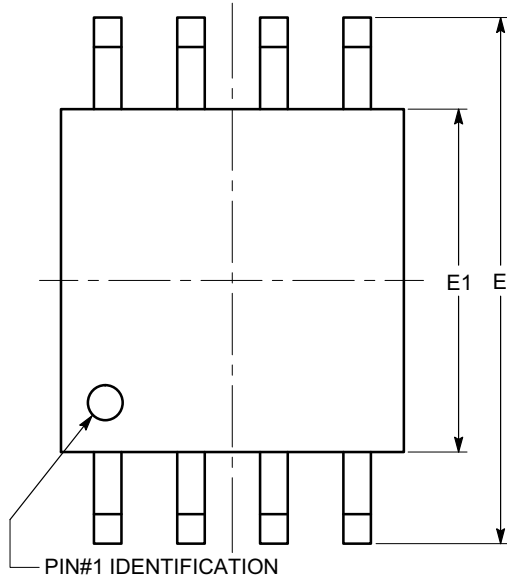
- (1) All dimensions are in millimeters. Angles in degrees.
- (2) Complies with JEDEC MS-012.



# CAT93C86

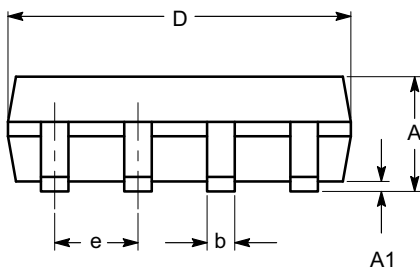
## PACKAGE DIMENSIONS

SOIC-8, 208 mils  
CASE 751BE-01  
ISSUE O

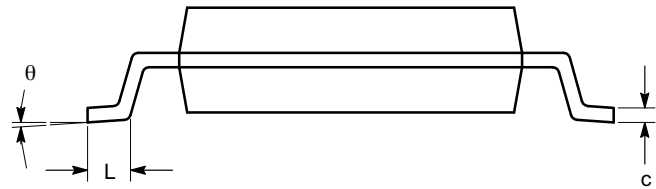


TOP VIEW

SYMBOL	MIN	NOM	MAX
A			2.03
A1	0.05		0.25
b	0.36		0.48
c	0.19		0.25
D	5.13		5.33
E	7.75		8.26
E1	5.13		5.38
e	1.27 BSC		
L	0.51		0.76
$\theta$	0°		8°



SIDE VIEW



END VIEW

**Notes:**

- (1) All dimensions are in millimeters. Angles in degrees.
- (2) Complies with EIAJ EDR-7320.

# CAT93C86

## ORDERING INFORMATION

OPN	Specific Device Marking*	Pkg Type	Temperature Range	Lead Finish	Shipping
CAT93C86LI-G	93C86D	PDIP-8	I = Industrial (-40°C to +85°C)	NiPdAu	Tube, 50 Units / Tube
CAT93C86VI-G	93C86D	SOIC-8, JEDEC	I = Industrial (-40°C to +85°C)	NiPdAu	Tube, 100 Units / Tube
CAT93C86VI-GT3	93C86D	SOIC-8, JEDEC	I = Industrial (-40°C to +85°C)	NiPdAu	Tape & Reel, 3000 Units / Reel
CAT93C86WI-GT3 (Note 10)	93C86D	SOIC-8, JEDEC	I = Industrial (-40°C to +85°C)	NiPdAu	Tape & Reel, 3000 Units / Reel
CAT93C86XI-T2	93C86D	SOIC-8, EIAJ	I = Industrial (-40°C to +85°C)	Matte-Tin	Tape & Reel, 2000 Units / Reel

\*Marking for new product Revision D.

8. All packages are RoHS-compliant (Lead-free, Halogen-free).


9. The standard lead finish is NiPdAu.

10. Not recommended for new designs.

11. For additional package and temperature options, please contact your nearest ON Semiconductor Sales office.

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

13. For detailed information and a breakdown of device nomenclature and numbering systems, please see the ON Semiconductor Device Nomenclature document, TND310/D, available at [www.onsemi.com](http://www.onsemi.com)

ON Semiconductor and the  are registered trademarks of Semiconductor Components Industries, LLC (SCILLC) or its subsidiaries in the United States and/or other countries. SCILLC owns the rights to a number of patents, trademarks, copyrights, trade secrets, and other intellectual property. A listing of SCILLC's product/patent coverage may be accessed at [www.onsemi.com/site/pdf/Patent-Marking.pdf](http://www.onsemi.com/site/pdf/Patent-Marking.pdf). SCILLC reserves the right to make changes without further notice to any products herein. SCILLC makes no warranty, representation or guarantee regarding the suitability of its products for any particular purpose, nor does SCILLC assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation special, consequential or incidental damages. "Typical" parameters which may be provided in SCILLC data sheets and/or specifications can and do vary in different applications and actual performance may vary over time. All operating parameters, including "Typicals" must be validated for each customer application by customer's technical experts. SCILLC does not convey any license under its patent rights nor the rights of others. SCILLC products are not designed, intended, or authorized for use as components in systems intended for surgical implant into the body, or other applications intended to support or sustain life, or for any other application in which the failure of the SCILLC product could create a situation where personal injury or death may occur. Should Buyer purchase or use SCILLC products for any such unintended or unauthorized application, Buyer shall indemnify and hold SCILLC and its officers, employees, subsidiaries, affiliates, and distributors harmless against all claims, costs, damages, and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if such claim alleges that SCILLC was negligent regarding the design or manufacture of the part. SCILLC is an Equal Opportunity/Affirmative Action Employer. This literature is subject to all applicable copyright laws and is not for resale in any manner.

## PUBLICATION ORDERING INFORMATION

### LITERATURE FULFILLMENT:

Literature Distribution Center for ON Semiconductor  
P.O. Box 5163, Denver, Colorado 80217 USA  
Phone: 303-675-2175 or 800-344-3860 Toll Free USA/Canada  
Fax: 303-675-2176 or 800-344-3867 Toll Free USA/Canada  
Email: [orderlit@onsemi.com](mailto:orderlit@onsemi.com)

**N. American Technical Support:** 800-282-9855 Toll Free  
USA/Canada  
**Europe, Middle East and Africa Technical Support:**  
Phone: 421 33 790 2910  
**Japan Customer Focus Center**  
Phone: 81-3-5817-1050

**ON Semiconductor Website:** [www.onsemi.com](http://www.onsemi.com)

**Order Literature:** <http://www.onsemi.com/orderlit>

For additional information, please contact your local Sales Representative