8-DIGIT CALCULATOR

DESCRIPTION

The SC3423 is a single-chip LSI CMOS calculator with 8-digit four function arithmetic operations, single memory, extraction of square root and percentage calculation functions, leading zero and trailing zero suppression, chain calculations and internal debouncing and encoding of keyboard inputs. It is designed for LCD operation with 3.0V power supply (either from solar cell or battery), auto-power off, low power dissipation and single power supply making the SC3423 ideal for hand held calculators with low system cost.

FEATURES

* Number of digits - 8 digits (rough estimated calculation is possible).
* Calculations:
  - Standard four functions (+ , - , x , ÷).
  - Chain multiplication and division.
  - Auto-constant calculation (constant multiplicand, divisor, addend and subtrahend).
  - Square and reciprocal calculations.
  - Extraction of square root.
  - Percentage calculations.
  - Power calculations.
  - Rough estimate calculations.
  - Memory calculations.
* Decimal point system-complete floating decimal point system.
* Negative number indication: number + minus (-) sign.

SC3423 chip topography
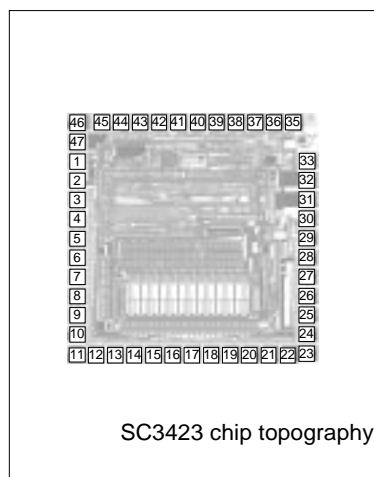
* Display format: 8 digits & sign (-, E & M) leading zero suppression   zero shift.
* Touch tone function and display.
* Punctuation comma display.
* Auto power off ability.

ORDERING INFORMATIOM

SC3423	Has on Chip Oscillator Resistor
SC3424	Pinning Mirrored Type of SC3423
SC3425	No Oscillator Resistor
SC3426	Pinning Mirrored Type of SC3425

ABSOLUTE MAXIMUM RATING

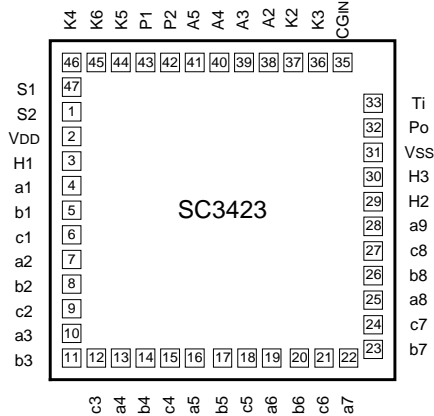| Characteristic	Symbol	Value	Unit
Supply Voltage	$V_{DD} - V_{SS}$	-0.3 ~ +3.5	V
Input Voltage (Note: 1)	V_{IN}	-0.3 ~ V_{DD} + 0.3	V
Resistance for CG (Note: 2)	Rf	560 ± 5%	KΩ
Storage temperature	T_{STG}	-55 ~ +125	°C
Operating Temperature	T_{OPT}	0 ~ + 50	°C

Note: 1.Maximum voltage on any pin with respect to the Vss.

   2.Resistor value for CG is varied according to the floating capacitance on a printed circuit board.

PAD ASSIGNMENT

Top pads: K4 K6 K5 P1 P2 A5 A4 A3 A2 K2 K3 CGIN

46 45 44 43 42 41 40 39 38 37 36 35

Left pads:
S1 — 47
S2 — 1
VDD — 2
H1 — 3
a1 — 4
b1 — 5
c1 — 6
a2 — 7
b2 — 8
c2 — 9
a3 — 10
b3 — 11

SC3423

Right pads:
33 — Ti
32 — Po
31 — Vss
30 — H3
29 — H2
28 — a9
27 — c8
26 — b8
25 — a8
24 — c7
23 — b7

Bottom pads: 11 12 13 14 15 16 17 18 19 20 21 22

c3 a4 b4 c4 a5 b5 c5 a6 b6 c6 a7

Note: The IC substrate should be connected to VDD in the PCB layout artwork.

ELECTRICAL CHARACTERISTICS (Ta=25°C, VDD =3.0V,Unless otherwise specified)

Parameter	Symbol	Test conditions		Min	Typ	Max	Unit
Input Voltage 1 (Note: 3)	V_{IH1}			V_{DD}-0.4	--	--	V
	V_{IL1}			--	--	0.4	
Input Voltage 2 (Note: 4)	V_{IH2}			V_{DD}-0.4	--	--	V
	V_{IL2}			--	--	0.2	
Input Current 1 (Note: 5)	I_{IH1}	V_{IN}=V_{DD}		--	--	1	μA
	I_{IL1}	V_{IN}=0V		--	5.5	10	
Input Current 2 (Note: 6)	I_{IH2}	V_{IN}=V_{DD}		--	--	1	μA
	I_{IL2}	V_{IN}=0V		--	--	1	
Input Current 3 (Note: 4)	I_{IH3}	V_{IN}=V_{DD}	S2=V_{SS}	--	--	1	μA
	I_{IL3}	V_{IN}=0V		5	10	15	
Input Current 3 (Note: 4)	I_{IH3}	V_{IN}=V_{DD}	S2= V_{DD}	20	30	40	μA
	I_{IL3}	V_{IN}=0V		--	--	1	
Output Voltage 1 (Note: 7)	V_{OH1}	without load		V_{DD} – 0.15	--	--	V
	V_{OL1}	I_{OUT}=15μA		--	--	0.15	
Output Voltage 2 (Note: 8)	V_{OA}	without load		2.80	2.95	--	V
	V_{OB}	without load		1.30	1.50	1.70	
	V_{OC}	without load		--	0	0.20	
Display Frequency (Note: 8)	F_D	V_{DD}=3V, display on, Rf=560k		50	75	--	Hz
Touch Tone Output Drive Current (Note: 11)	I_{OL}	V_{DD}=3V, V_{OL}=0.5V,TI=3V		1.0	1.5	--	mA
	I_{OH}	V_{DD}=3V, V_{OH}=2.5V,TI=0V		1.0	1.3	--	
Dissipation Current	I_{DD}	Display off, (Note: 9)		--	--	0.1	μA
	V_{DD1}	V_{DD}=3V, display on, (Note: 10)		--	20	30	

Note: 3. Applies to Pins K2 – K6, TI and S2.
    4. Applies to Pin S1.
    5. Applies to Pins K2 ~ K6 and TI.
    6. Applies to Pin S2.
    7. Applies to P1, P2, A2 ~ A5.
    8. Applies to H1 ~ H3, a1 ~ a9, b1 ~ b8, c1 ~ c8.
    9. Measured by the next test circuit after powe
       supply automatically yurns off.
   10. Measured by the next test circuit while "0" is
       being displayed after auto-clear operation
       and while key is not being depressed.
   11. Applies to PO
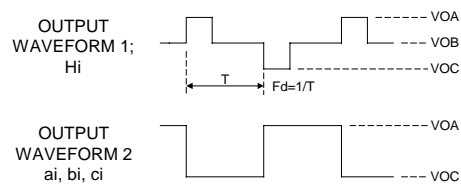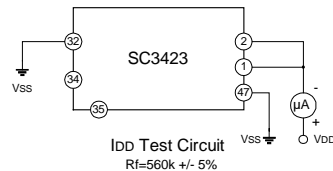
PIN DESCRIPTION

Pin No.	Symbol	I/O	Description	Pin No.	Symbol	I/O	Description
1	S2	I	APO(Auto Power Off) input	25	a8	O	Display Output (Common)
2	VDD	--	Power Supply	26	b8	O	Display Output (Segment)
3	H1	O	Display Output (Common)	27	c8	O	Display Output (Segment)
4	a1	O	Display Output (Segment)	28	a9	O	Display Output (Segment)
5	b1	O	Display Output (Segment)	29	H2	O	Display Output (Common)
6	c1	O	Display Output (Segment)	30	H3	O	Display Output (Common)
7	a2	O	Display Output (Segment)	31	VSS	--	Ground
8	b2	O	Display Output (Segment)	32	Po	O	Piezo Output
9	c2	O	Display Output (Segment)	33	Ti	I	Test Input
10	a3	O	Display Output (Segment)	34	CGout	O	Resistor terminal for CG
11	b3	O	Display Output (Segment)	35	CGin	I	Resistor terminal for CG
12	c3	O	Display Output (Segment)	36	K3	I	Key input
13	a4	O	Display Output (Segment)	37	K2	I	Key input
14	b4	O	Display Output (Segment)	38	A2	O	Strobe output
15	c4	O	Display Output (Segment)	39	A3	O	Strobe output
16	a5	O	Display Output (Segment)	40	A4	O	Strobe output
17	b5	O	Display Output (Segment)	41	A5	O	Strobe output
18	c5	O	Display Output (Segment)	42	P2	O	Strobe output
19	a6	O	Display Output (Segment)	43	P1	O	Strobe output
20	b6	O	Display Output (Segment)	44	K5	I	Key input
21	c6	O	Display Output (Segment)	45	K6	I	Key input
22	a7	O	Display Output (Segment)	46	K4	I	Key input
23	b7	O	Display Output (Segment)	47	S1	I	
24	c7	O	Display Output (Segment)				

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FUNCTIONAL DESCRIPTION

1. LCD DISPLAY

Display Format
Numericals Font

Sign Font

Memory   Error

minus   Punctuation   Touch tone indicator

LCD Connection

H2 H3 a9 c8 b8 a8 c7 b7 a7 c6 b6 a6 c5 b5 a5 c4 b4 a4 c3 b3 a3 c2 b2 a2 c1 b1 a1 H1
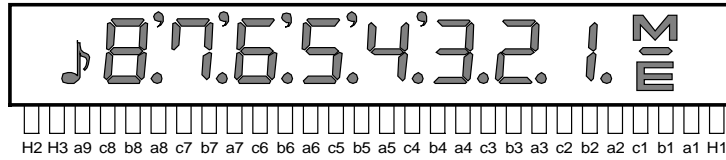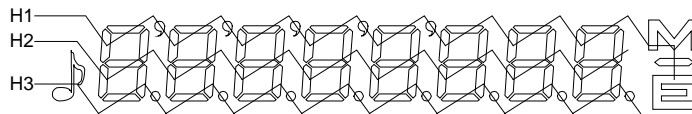
LCD Driving System
1/2 bias, 1/3 duty
Display Configuration
Segment Electrode Side

a9   a8   a7   a6   a5   a4   a3   a2   a1
    b8   b7   b6   b5   b4   b3   b2   b1
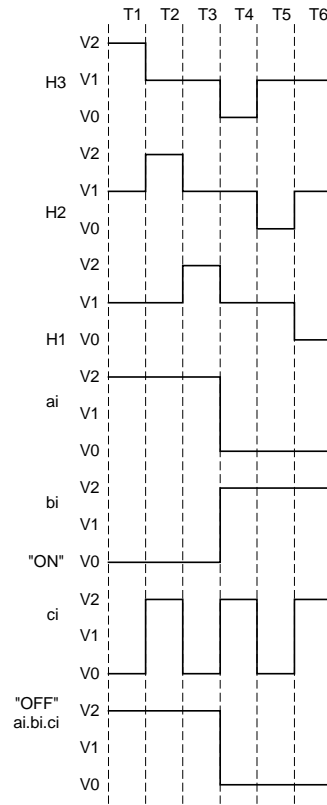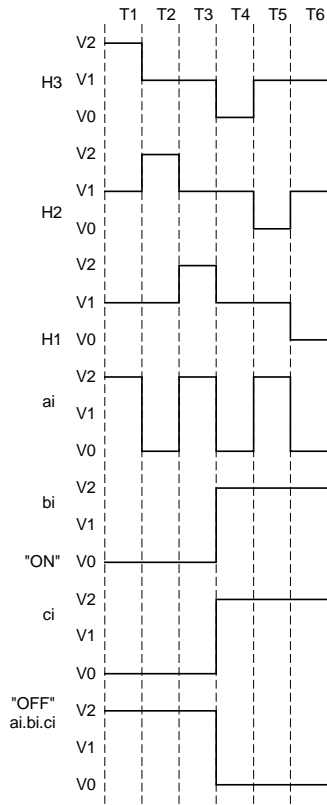   c8   c7   c6   c5   c4   c3   c2   c1
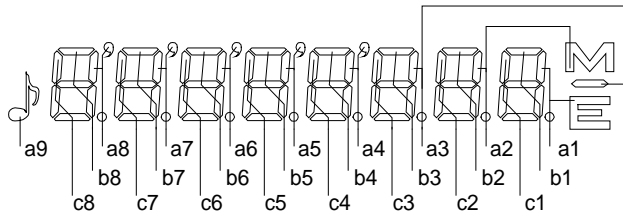
Common Electrode Side

H1
H2
H3

Display Example

No. "8" ON OR OFF WAVEFORM   No. "5" ON OR OFF WAVEFORM

	(H1 H2 H3)	(H1 H2 H3)	(H1 H2 H3)		(H1 H2 H3)	(H1 H2

H3) (H1 H2 H3)

			0		1		0	
0	0	0	1	1	1	1	0	1

2. KEYBOARD DESCRIPTIONS

a)   Equal Key (=)

   i) Performs Keyed-in operation and maintains that operation for possible use.

   ii) Establishes power/reciprocation calculation.

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b) Multiplication Key (x)

  i) Enters multiplicand.

  ii) Performs previous operation and displays result.

c) Division Key (÷)

  i) Enters dividend.

  ii) Performs previous operation and displays result.

d) Addition Key (+)

  i) Conditions machine for an addition.

  ii) Performs previous operation and displays result.

e) Subtraction Key (-)

  i) Conditions machine for a subtraction.

  ii) Performs previous operation and displays result.

f) Percent Key (%)

  The purpose of the percent key is to allow for calculation of add-on and discount. Deter mination of add-on requires the principal amount to be the first entry followed by the "+" or "x" key, with the percentage being the second entry. Depression of the percent key yields the amount to add on, such as tax or interest. Depression of the "=" key adds this amount to the principal.

g) Change Sign Key (+/-)

  Pushing the "+/-" key twice in succession causes the corresponding sign to appear and disappear. During digit entry; this function changes the sign of the entered factor.

h) Power On/All Clear Key (ON/AC)

  i) First push power-on displays "0".

  ii) In the middle of a digit entry, a second push will clear all registers and memory.

i) Clear Entry/Clear Key (CE/C)

  i) During the digit entry, the first depression will clear the entry register. And display the previous enter number again.

  ii) The second push will clear all registers except memory.

j) Clear Entry Key (CE)

  During the digit entry will clear the entry register and display number "0".

k) Square Root Key ($\sqrt{\ }$)

  Extracts the square root of a positive number displayed in the entry register.

l) Memory Plus Key (M+)

  i) Adds the current display to the contents of memory.

  ii) It will terminate a number entry.

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m) Memory Minus Key (M-)

   i) Subtracts the current display from the contents of memory

   ii) It will terminate a number entry.

n) Memory Recall and Clear Key (RCM)

   i) First push, as RM key, transfers the contents of the memory register into the display register.

   ii) Second push, as CM key, clears the memory.

o) Number, Decimal Key ("O - 9", "•")

   The First number key in a sequence will clear the display and enter the digit in the display. Successive entries will shift the display left and enters the data in display register. The first decimal point entered is effective. An attempted entry of more than 8 digits or 7 decimal places will be ignored.

p) Touch Tone (♪) Key

   i) When power is ON, the touchtone function is enable and the beep sound is generated output during 125ms and ♪ **sign is displayed on LCD.**

   ii) Selection of touchtone function is toggled by touchtone key.

   iii) Output waveform.

$f_T = 2kHz$

VOA

VOC

125ms
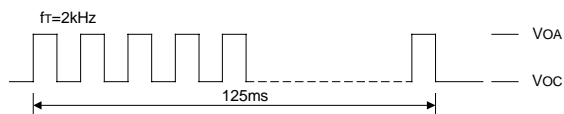
3. ERROR CONDITIONS

  a). Error Detection

   System errors occur when:

   i) The integral part of any calculation result exceeds 16 digits.

   ii) The integral part of any memory calculation result exceeds 8-digit or when the integral part of any addend or subtrahend to memory exceeds 8-digit.

   iii) The integral part of a mark-up and markdown calculation result exceeds 8-digit.

   iv) A division by zero is attempted.

   v) An extraction of the square root of a negative number is attempted.

   Rough Estimate Calculation results occur when:

   The integral part of the result of any one of the standard four functions, percentage, square, reciprocal, and power calculations exceeds 8-digit and is equal to 16-digit or less.

  b). Error Indication

   i) System error: "0" is indicated in the first-digit position and "E" in the sign-digit position.

   ii) Rough Estimate Calculation result:

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The high-order 8-digit of a calculation result is indicated together with "E". The location of the decimal point corresponds to the result of calculation times le-8, and no zero shift is performed.

c). Error Release

   i) System error: A system error can be released by depressing ON/AC key.

   ii) Rough Estimate Calculation result: A rough estimate calculation error can be released by depressing the ON/AC or CE/C key. However the calculation result is not cleared by CE/C key but is retained.

4. OPERATION CHARACTERISTICS

a) Constant Operation

The SC3423 has implied constant mode on +, -, x, ÷, &, % operations. The constant is performed automatically by the "=" key, "%" key, or "%" key without a constant for addition, subtraction and division while the first operand is the constant for multiplication.

b) Number Entry

Numbericals can be entered up to 8-digit. Entries equal to 9-digit or more are ignored.

c) Memory Protection

In any error detection, the memory contents present before the error detection are protected.

d) Memory Indication

If the memory contents are a number other than zero, "M" is indicated in the sign-digit position.
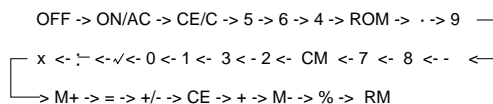
e) Auto Power Off

If no key is depressed for a specific period of time, the power supply will automatically turn off. This time interval up to power-off is 131,072 words (Approximately equal to 14 minutes and 24 seconds at Fd= 52 Hz, the display time of a word being equal to 6ms when Fd= 52 Hz).

```
3V
1.5V
0V
         |<-- 1/Fd -->|
         (3 Word cycles)
```
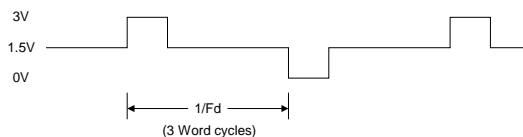
Output waveform example

f) Double Key Depression

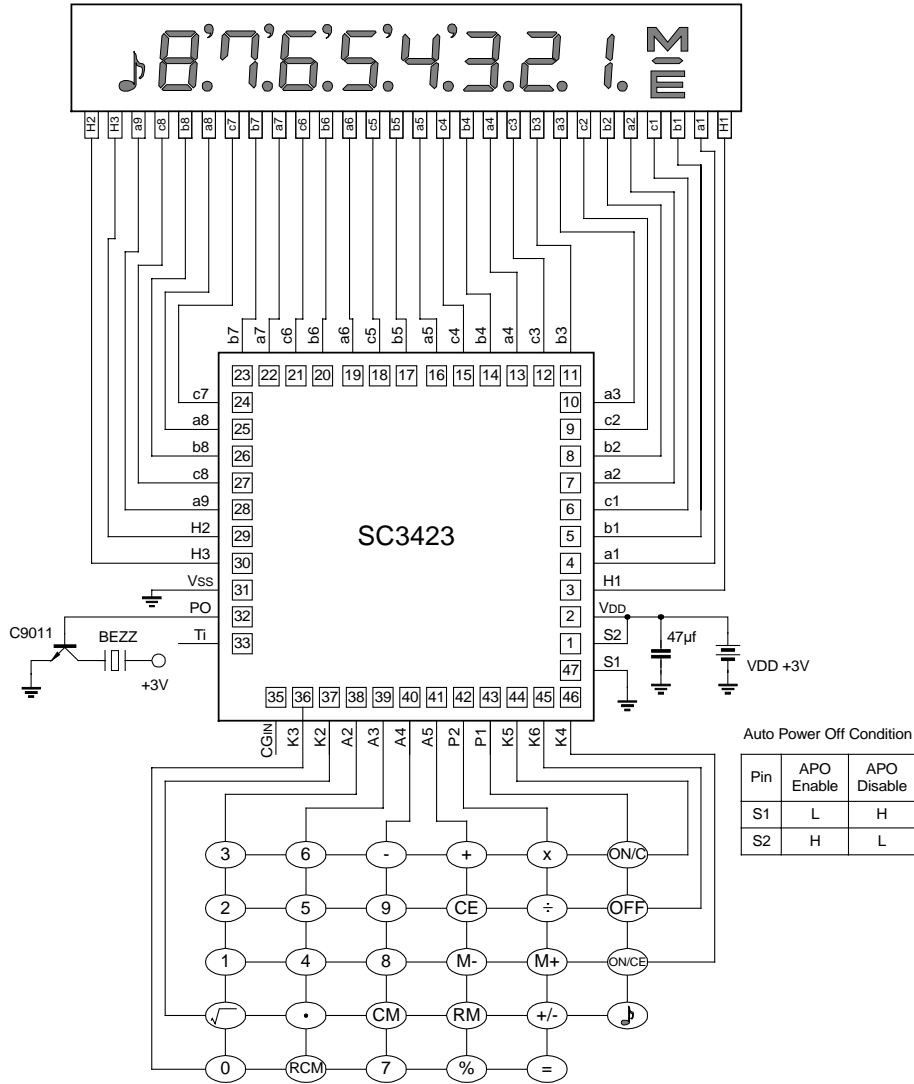The order of priority, when two keys are depressed simultaneously is as follows :

```
OFF -> ON/AC -> CE/C -> 5 -> 6 -> 4 -> ROM -> · -> 9 ┐
┌ x <- ·- <-√<- 0 <- 1 <- 3 <- 2 <- CM <- 7 <- 8 <- - <-┘
└-> M+ -> = -> +/- -> CE -> + -> M- -> % -> RM
```

g) Key Bounce Protection

   - Font edge: Down to l word and up to about 3 words.

   - Back edge: 14 words.

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5. ARITHMETIC OPERATIONS

| Entry	Key Operation	Display
	1 2 3 4 5 6 7 8 9 0	12345678.
Four Fundamental Arithmetic Calculations	a + b =	a + b
	a - b =	a - b
	a x b =	a • b
	a ÷ b =	**a ÷ b**
Square Root Calculations	a √	√a
	a +/- √	0E
	ON/AC	0
	a x b √	√b
	=	a • √b
Percent Calculations	a x b %	a • b/100
	+ =	a + (a•b/100)
	a x b =	a • b/100
	- =	a - (a•b/100)
	a ÷ b %	100 • a/b
	a + b %	a + (a•b/100)
	a - b %	a - (a•b/100)
Constant Calculations	k x b =	k • b
	c =	k • c
	a ÷ k =	a/k
	c =	c/k
	k x b %	k • b/100
	c %	k • c/100
	a ÷ k %	100 • a/k
	c %	100 • c/k
	a + k =	a + k
	c =	b + k
	a - k =	a - k
	c =	b - k

	Key Operation	Display	Memory
Repeated Calculations	a $+$ b $=$ $=$	a + 2b	
	a $-$ b $=$ $=$	a - 2b	
	a $\div$ b $=$ $=$	(a/b)/b	
	a $\times$ b $=$ $=$	(a·b)·b	
Power Calculations	a $\times$ $=$	a^2	
	$\times$ $=$	a^4	
	a $\times$ $=$ $=$	a^3	
	a $\times$ b $=$ $=$	(a·b)·b	
	a $\div$ $=$	1/a	
	a $\div$ $=$ $=$	$1/a^2$	
Mixed Calculations	a $+$ b $\times$ c $\div$ d $=$	(a+b) · c/d	
at $\lvert(a+b) \cdot (c/d) \cdot e\rvert > 10^8$	$\times$ e $=$	((a+b) · c/d) ·e/10^8E	
	CE/C	((a+b) · c/d) ·e/10^8	
Memory Calculations	a M+	aM	a
at $\lvert(a+b) \cdot (c/d) \cdot e\rvert > 10^8$	b M-	bM	a - b
	RM	a - bM	a - b
	CM	a - b	0
	a $+$ b M+	a + bM	a + b
	c $\times$ d M+	c · dM	a+b+c · d
	RM	a+b+c · dM	a+b+c · d
	e M+	0^M_E	a+b+c · d
	CE/E	0M	a+b+c · d
	RM	a+b+c · dM	a+b+c · d

APPLICATION CIRCUITS

Auto Power Off Condition		
Pin	APO Enable	APO Disable
S1	L	H
S2	H	L

Note: 1. The Pad 34 (CGout) is deleted in SC3423 die.

2. While using SC3425, please connect a 560k Ω $\pm$5% resistor between Pad 34 and Pad 35.

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Rev: 1.0   2000.12.31

CHIP TOPOGRAPHY
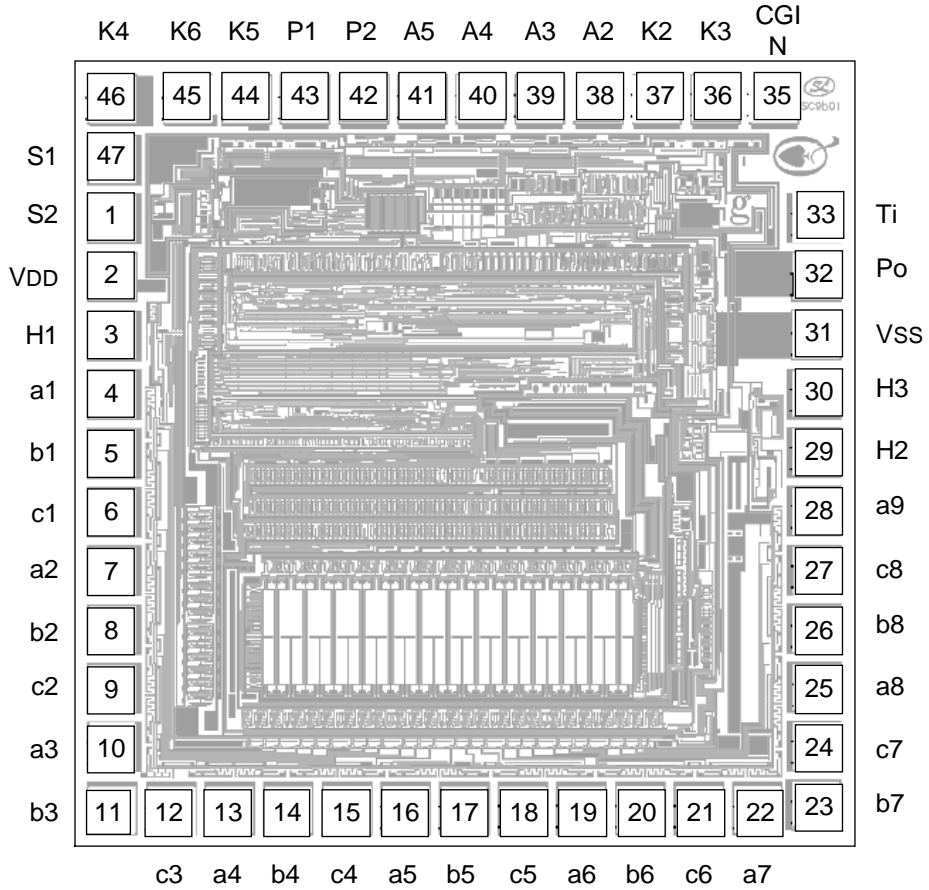
Chip Size : 1.630 x 1.640 (mm^2)

PAD COORDINATES (Unit: μm)

(SC3423)

Pin No.	Symbol	X	Y	Pin No.	Symbol	X	Y
1	S2	-755	505	25	a8	755	-500
2	VDD	-755	380	26	b8	755	-375
3	H1	-755	255	27	c8	755	-250
4	a1	-755	130	28	a9	755	-120
5	b1	-755	0	29	H2	755	5
6	c1	-755	-125	30	H3	755	130
7	a2	-755	-250	31	VSS	755	255
8	b2	-755	-375	32	Po	755	380
9	c2	-755	-500	33	Ti	755	510
10	a3	-755	-630	34	CGout		
11	b3	-755	-765	35	CGin	665	760
12	c3	-630	-765	36	K3	540	760
13	a4	-505	-765	37	K2	415	760
14	b4	-380	-765	38	A2	285	760
15	c4	-255	-765	39	A3	160	760
16	a5	-125	-765	40	A4	35	760
17	b5	-0	-765	41	A5	-90	760
18	c5	125	-765	42	P2	-215	760
19	a6	250	-765	43	P1	-340	760
20	b6	375	-765	44	K5	-470	760
21	c6	505	-765	45	K6	-595	760
22	a7	630	-765	46	K4	-755	760
23	b7	755	-755	47	S1	-755	630
24	c7	755	-625				

Note: The original point of the coordinate is the die center.