TOSHIBA CMOS DIGITAL INTEGRATED CIRCUIT SILICON MONOLITHIC

JT6A72-CS

JT6A72-CS CMOS SINGLE-CHIP LSI FOR LCD CALCULATOR

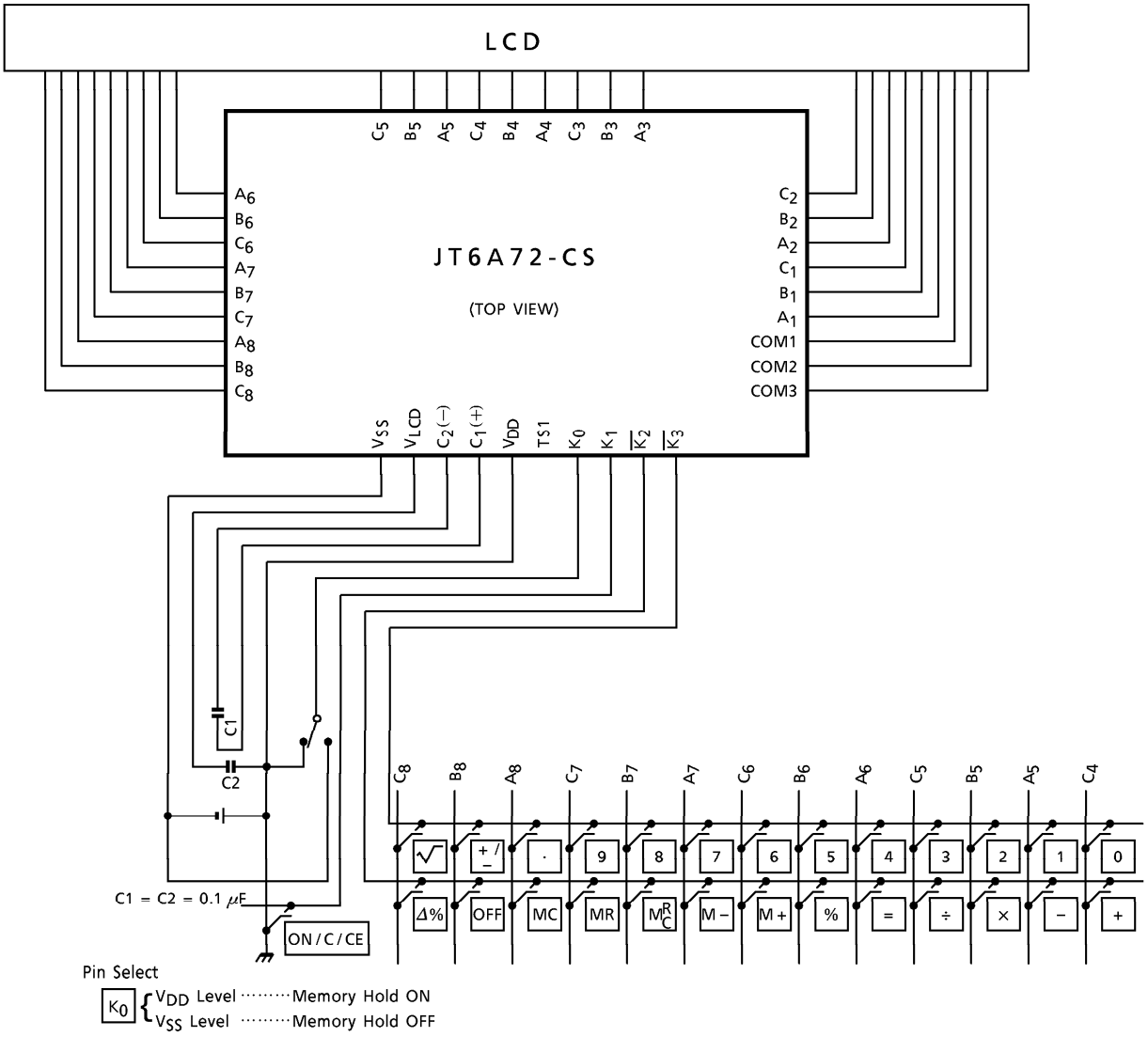
The JT6A72-CS is a single-chip microcomputer for 8-digit 1-memory calculator.
JT6A72-CS can drive the liquid crystal display (LCD). Single power supply operation, low-power consumption make it suitable for single battery operated pocketable calculator.

FEATURES

- 8 digits of data and 1 symbol digit for calculator.
- Algebraic calculation mode.
- Punctuation.
- Standard 4 functions (+, −, ×, ÷), mark up percent with automatic add-on / discount, automatic constant calculations, chain calculations, memory calculations with memory overflow protection.
- Internal keyboard decoding and denouncing.
- Complementary output buffer for direct driving of liquid crystal display (LCD : FEM type 3.0V, 1 / 2 bias, 1 / 3 duty).
- Single power supply (1.4 V typ.).
- Very low power consumption (2.66 μW typ. at wait).
- Very wide range of operating voltage (V_{DD} = 1.1~1.9 V).
- Automatic power off (A time for about 7 min.).

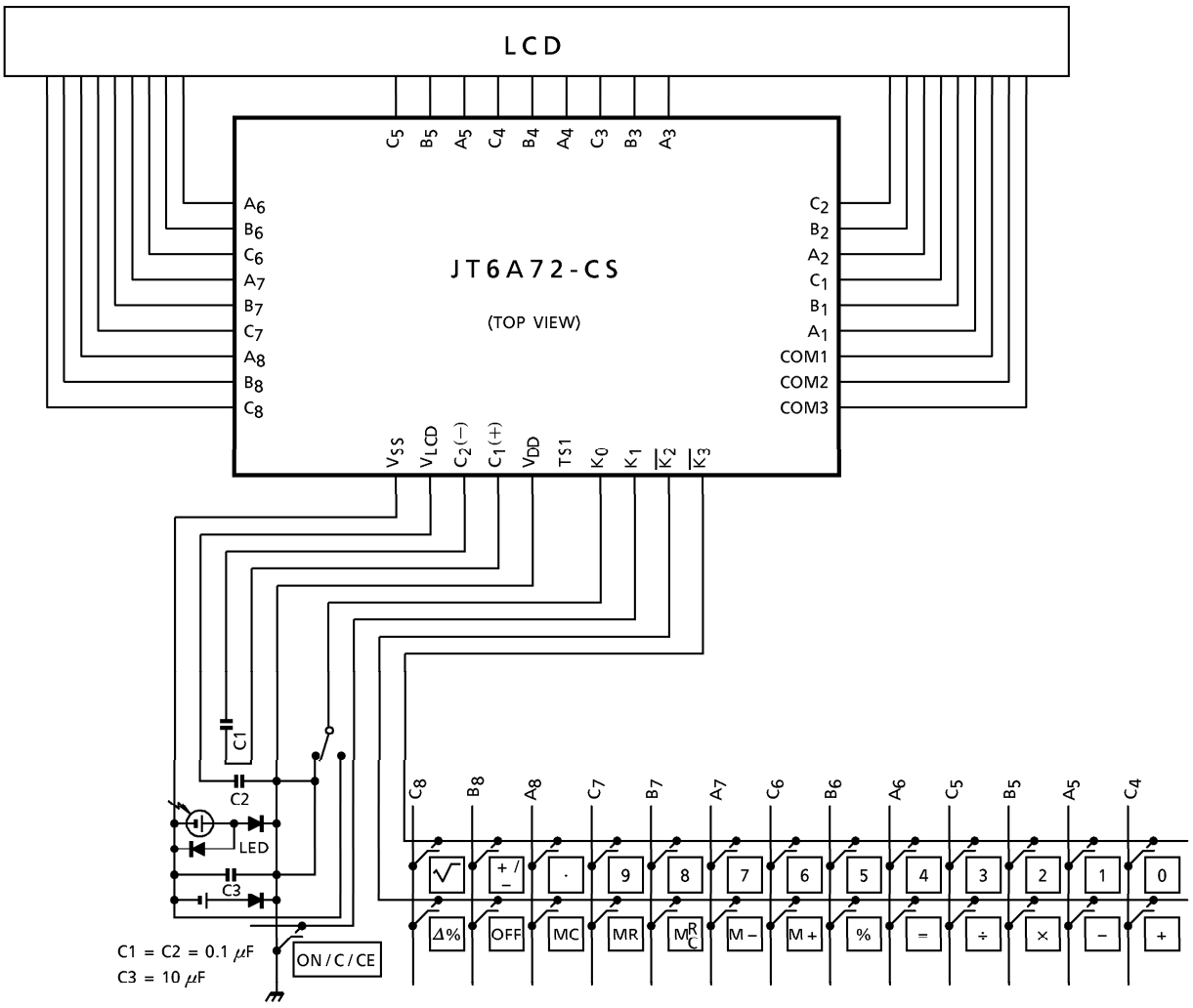
SYSTEM BLOCK DIAGRAM

Battery Type



(Note) : INPUT capacity ⩽ 400 (pF) at V_{DD} = 1.4 (V)
Key resistance ⩽ 10 (kΩ) at V_{DD} = 1.4 (V)

Dual Type

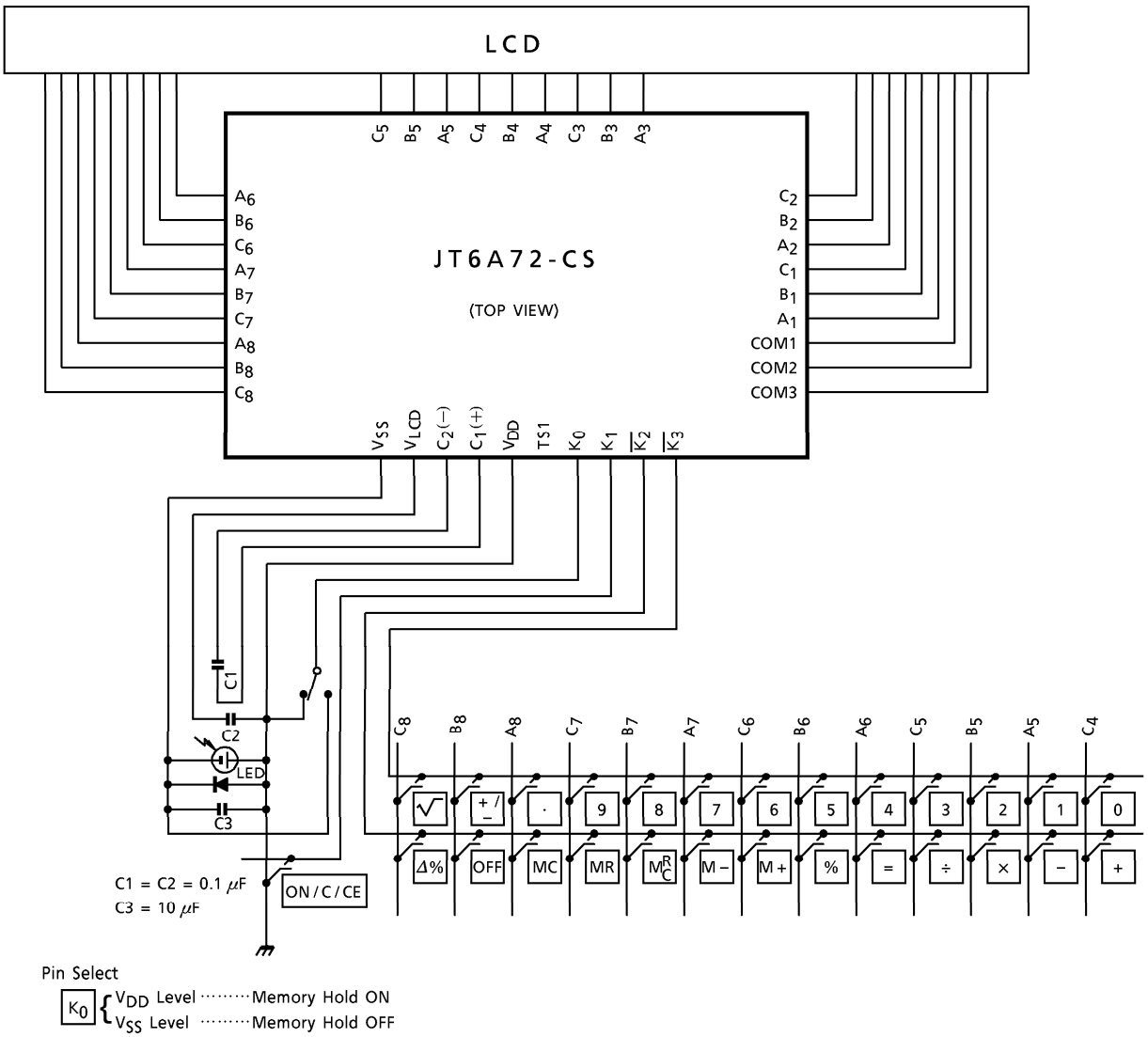


Pin Select

K_0 { V_{DD} Level ·····Memory Hold ON
V_{SS} Level ·····Memory Hold OFF

(Note) : INPUT capacity ⩽ 400 (pF) at V_{DD} = 1.4 (V)
Key resistance ⩽ 10 (kΩ) at V_{DD} = 1.4 (V)

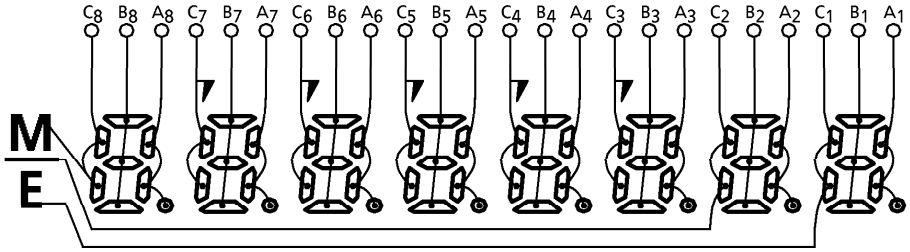
Solar Type



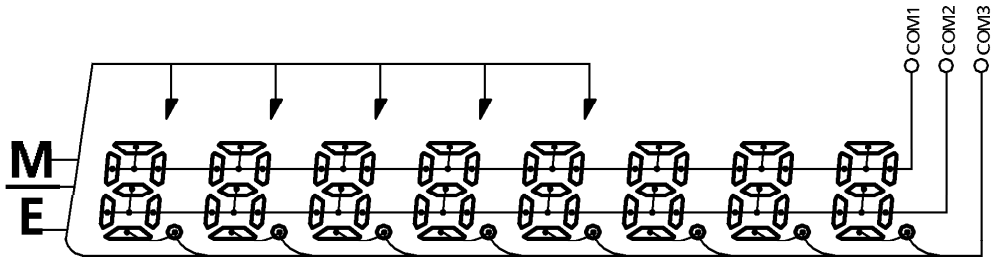
(Note) : INPUT capacity $\leqslant$ 400 (pF) at V_{DD} = 1.4 (V)
Key resistance $\leqslant$ 10 (kΩ) at V_{DD} = 1.4 (V)

CONNECTION OF LCD

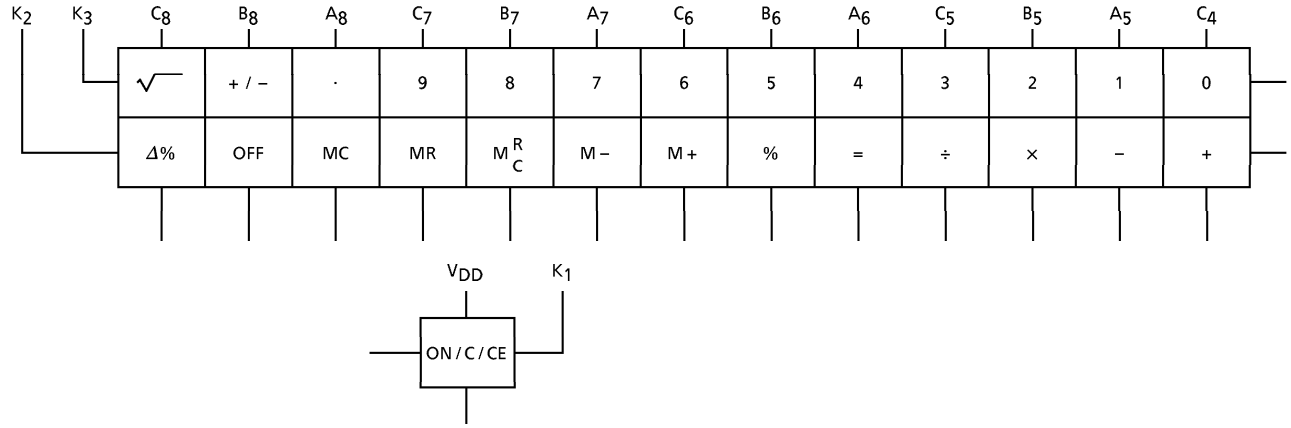
SEGMENT



COMMON



KEY CONNECTION



SPECIFICATION OF CALCULATOR

Operational Features

(1) 8 digits of data and 1 symbol digit.

(2) Algebraic mode.

(3) Full floating point.

(4) Standard 4 functions +, −, ×, ÷.

(5) Memory calculation and memory hold.

(6) Delta Percent, mark-up and mark-down functions.

(7) Percent with automatic add-on and discount.

(8) Constant calculation (Automatic constant).

(9) Chain calculation.

(10) Leading zero suppression.

(11) Trailing zero suppression.

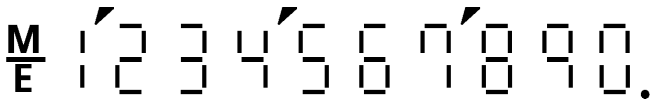
(12) Square root.

(13) Change sign.

Capacity of Calculation

(1)	Numeral entry	8 digits
(2)	Addition / Subtraction	8 digits + (−) 8 digits = 8 digits
(3)	Multiplication / Division	8 digits × (÷) 8 digits = 8 digits
(4)	Memory calculation	8 digits + (−) 8 digits = 8 digits

Display Font



Overflow Condition

(1) When division by zero is attempted, an overflow condition will result, and error symbol "E" and a zero are displayed.

(2) When the integer part of result exceeds 8 digits, the display will shown 8 most significant digits of result divided by 10^{+8} and "E".

(3) When the integer part of result exceeds 15 digits, display will show a zero and "E".

(4) When the integer part of result in memory register exceeds 8 digits at memory calculation, display will show a zero and "E", and previous data will be kept in memory register.

(5) When an overflow occurs on the way of add-on / discount calculation, display will show a zero and "E".

(6) In overflow condition, any operation or numeral entry will be inhibited.

Clearing Overflow Condition

(1) The resulting overflow condition can be cleared by depressing [ON / C / CE] .

(2) At memory overflow condition, depression of [MR] or [M^{R}_{C}] after [ON / C / CE] will recall the previous memory data.

(3) At the condition of exceeding capacity overflow occurred in chain calculation, depression of [ON / C / CE] will reset the error symbol "E", and you can continue the calculation using the displayed data.

Speed of Calculation

(1)	Numeral entry				56.0～59.3 ms
(2)	Addition	11111111	+	11111111 =	102.6～105.9 ms
(3)	Multiplication	1	×	99999999 =	258.6～261.9 ms
(4)	Division	99999999	÷	1 =	294.6～297.9 ms
(5)	Memory Calculation	99999999	÷	1 M+	345.3～348.6 ms
(6)	Percentage calculation	1	+	99999999 %	287.9～291.2 ms
(7)	Square root			99999999 √	259.9～263.2 ms

Arithmetic Operations

1. Addition

Key Op.	Display
A	A
+	A
B	B
+	A + B
C	C
=	A + B + C
D	D
+	D
E	E
+	D + E
=	D + E

2. Subtraction

	Key Op.	Display
(1)	A	A
	−	A
	B	B
	−	A − B
	C	C
	=	A − B − C
	−	A − B − C
	D	D

		Key Op.	Display
		[+ / −]	− D
		[−]	A − B − C + D
		[=]	− (A − B − C + D)

3. Multiplication

	(1)	A	A
		[×]	A
		B	B
		[=]	A·B
		[+]	A·B
		C	C
		[=]	A·B + C
	(2)	[−]	0.
		A	A
		[×]	− A
		B	B
		[=]	− A·B

4. Division

	(1)	A	A
		[÷]	A
		B	B
		[=]	A / B
	(2)	[−]	0.
		A	A.
		[÷]	− A
		B	B
		[=]	− A / B

5. Power calculation

	(1)	A	A
		[×]	A

	Key Op.	Display
	[=]	A^2
	[=]	A^3
(2)	A	A
	[÷]	A
	[=]	1 / A
	[=]	$1 / A^2$
(3)	[−]	0.
	A	A
	[×]	− A
	[=]	A^2
	[=]	$-A^3$
(4)	[−]	0.
	A	A
	[÷]	− A
	[=]	− 1 / A
	[=]	$1 / A^2$
(5)	A	A
	[×]	A
	[=]	A^2
	[×]	A^2
	[=]	A^4

6. Mixed calculation

(1)	A	A
	[×]	A
	B	B
	[+]	A·B
	C	C
	[÷]	A·B + C
	D	D

		Key Op.	Display
		[−]	$\frac{A \cdot B + C}{D}$
		E	E
		[=]	$\frac{A \cdot B + C}{D} - E$

7. Constant calculation

	(1)	A	A
		[×]	A
		B	B
		[=]	A·B
		C	C
		[=]	A·C
	(2)	[−]	0.
		A	A
		[×]	− A
		B	B
		[=]	− A·B
		C	C
		[=]	− A·C
	(3)	A	A
		[÷]	A
		B	B
		[=]	A / B
		C	C
		[=]	C / B
		D	D
		[×]	D
		[=]	D^2
	(4)	A	A
		[+]	A
		B	B

	Key Op.	Display
	[=]	A + B
	C	C
	[=]	C + B
(5)	A	A
	[−]	A
	B	B
	[=]	A − B
	C	C
	[=]	C − B
(6)	A	A
	[×]	A
	B	B
	[=]	A·B
	C	C
	[×]	C
	D	D
	[=]	C·D
	E	E
	[=]	C·E
	[×]	C·E
	F	F
	[=]	C·E·F
	G	G
	[÷]	G
	H	H
	[=]	G / H
	I	I
	[=]	I / H

	Key Op.	Display
(7)	A	A
	×	A
	B	B
	%	A·B / 100
	C	C
	%	A·C / 100
	D	D
	÷	D
	E	E
	%	100·D / E
	F	F
	%	100·F / E

8. Mark-up / Discount calculator

(1)	A	A
	×	A
	B	B
	+	A·B
	=	A + A·B
(2)	A	A
	×	A
	B	B
	−	A·B
	=	A − A·B
(3)	A	A
	×	A
	B	B
	%	A·B / 100
	+	A·B / 100
	=	A + A·B / 100

	Key Op.	Display
(4)	A	A
	[×]	A
	B	B
	[%]	A·B / 100
	[−]	A·B / 100
	[=]	A − A·B / 100
(5)	A	A
	[+]	A
	B	B
	[%]	A + AB / 100
(6)	A	A
	[−]	A
	B	B
	[%]	A − AB / 100

9. Memory calculation

Key Op.	Display	Memory
A	A	0.
[M+]	A (M)	A
B	B (M)	A
[M+]	B (M)	A + B
C	C (M)	A + B
[M−]	C (M)	A + B − C
D	D (M)	A + B − C
[MRC] or [MR]	A + B − C (M)	A + B − C
[MRC] or [MC]	A + B − C	0.
(2) A	A	0.
[+]	A	0.
B	B	0.
[M+]	A + B (M)	A + B

	Key Op.	Display	Memory
	[+]	A + B (M)	A + B
	[M+]	A + B (M)	2 (A + B)
	C	C (M)	2 (A + B)
	[M−]	C (M)	2 (A + B) − C
(3)	A	A	0.
	[×]	A	0.
	B	B	0.
	[M+]	A·B (M)	A·B
	C	C (M)	A·B
	[×]	C (M)	A·B
	D	D (M)	A·B
	[M−]	C·D (M)	AB − CD
	[MRC] or [MR]	A·B − C·D (M)	AB − CD
	[M−]	A·B − C·D	0.
(4)	A	A	0.
	[×]	A	0.
	B	B	0.
	[=]	A·B	0.
	C	C	0.
	[M+]	C (M)	C
	[=]	A·C (M)	C
	D	D (M)	C
	[M−]	D (M)	C − D
	[=]	A·D (M)	C − D
(5)	A	A	0.
	[M+]	A (M)	A
	B	B (M)	A
	[M+]	B (M)	A + B
	[MRC] or [MR]	A + B (M)	A + B

	Key Op.	Display	Memory
	[×]	A + B (M)	A + B
	[MRC] or [MR]	A + B (M)	A + B
	[+]	$(A + B)^2$ (M)	A + B
	C	C (M)	A + B
	[=]	$(A + B)^2 + C$ (M)	A + B
(6)	1.0000001	1.0000001	0.
	[M+]	1.0000001 (M)	1.0000001
	99999999	99999999. (M)	1.0000001
	[M+]	0. ($_{E}^{M}$)	1.0000001
	[ON/C/CE]	0. (M)	1.0000001
	[MRC] or [MR]	1.0000001 (M)	1.0000001

10. Square root

(1)	A	A
	[√]	$\sqrt{A}$
	B	B
(2)	A	A
	[×]	A
	B	B
	[√]	$\sqrt{B}$
	[=]	$A\sqrt{B}$
(3)	A	A
	[×]	A
	[√]	$\sqrt{A}$
	B	B
	[=]	A·B
(4)	[−]	0.
	A	A
	[=]	− A
	[√]	$\sqrt{A}$ (E)

	Key Op.	Display	Memory
(5)	A	A	0.
	[M+]	A (M)	A
	[MRC] or [MR]	A (M)	A
	[÷]	A (M)	A
	B	B (M)	A
	[+/−]	−B (M)	A
	[√]	$\sqrt{B}$ ($\frac{M}{E}$)	A
	[ON/C/CE]	0. (M)	A

11. Percentage calculation

(1)	A	A
	[×]	A
	B	B
	[%]	A·B / 100
	C	C
	[%]	A·C / 100
	D	D
	[%]	A·D / 100
(2)	A	A
	[%]	A
	B	B
	[%]	B
	C	C
	[%]	C
(3)	A	A
	[−]	A
	B	B
	[%]	A − A·B / 100
	[−]	A − A·B / 100
	[+]	A − A·B / 100

	Key Op.	Display	Memory
	C	C	
	%	$\left(A - \frac{A \cdot B}{100}\right) + \frac{\left(A - \frac{A \cdot B}{100}\right) \cdot C}{100}$	

12. Key correction

(1)	A	A	0.
	×	A	0.
	÷	A	0.
	−	A	0.
	+	A	0.
	√	$\sqrt{A}$	0.
	M+	$A + \sqrt{A}$ (M)	$A + \sqrt{A}$
	+/−	$-(A + \sqrt{A})$ (M)	$A + \sqrt{A}$
	MRC or MR	$A + \sqrt{A}$ (M)	$A + \sqrt{A}$
	MRC or MR	$A + \sqrt{A}$	0.
	B	B	0.
	+	B	0.
	−	B	0.
	×	B	0.
	÷	B	0.
	=	1 / B	0.

13. Others

(1)	A	A
	+	A
	=	A
(2)	A	A
	×	A
	÷	A
	=	1 / A
(3)	A	A
	÷	A

	Key Op.	Display	Memory
	[+]	A	
	[=]	A	
(4)	A	A	
	[×]	A	
	[−]	A	
	[=]	−A	
(5)	A	A	
	[÷]	A	
	[−]	A	
	[=]	−A	
(6)	A	A	
	[×]	A	
	[ON / C / CE]	0.	
	B	B	
	[=]	B	
(7)	A	A	
	[×]	A	
	B	B	
	[ON / C / CE]	0.	
	C	C	
	[=]	A·C	

14. Delta Percentage key function

(1)	A	A	
	[+]	A	
	B	B	
	[Δ%]	(A + B) / B·100	
(2)	A	A	
	[÷]	A	
	B	B	

	Key Op.	Display	Memory
	[Δ%]	A / (1 − B / 100)	
	[Δ%]	|A / (1 − B / 100) − A|	
(3)	A	A	
	[×]	A	
	B	B	
	[Δ%]	A (1 + B / 100)	
(4)	A	A	
	[×]	A	
	B	B	
	[+ / −]	− B	
	[Δ%]	A (1 − B / 100)	

Key Chattering Protection

(1) At time of key on : about 6.2~9.5 ms, after key input (fϕ typ.)

(2) At time of key off : about 30.8 ms, after completion of the operation (fϕ typ.)

(3) Simultaneous keying protection.

If 2 or more keys are pressed simultaneously, any key input is not accepted.

MAXIMUM RATINGS

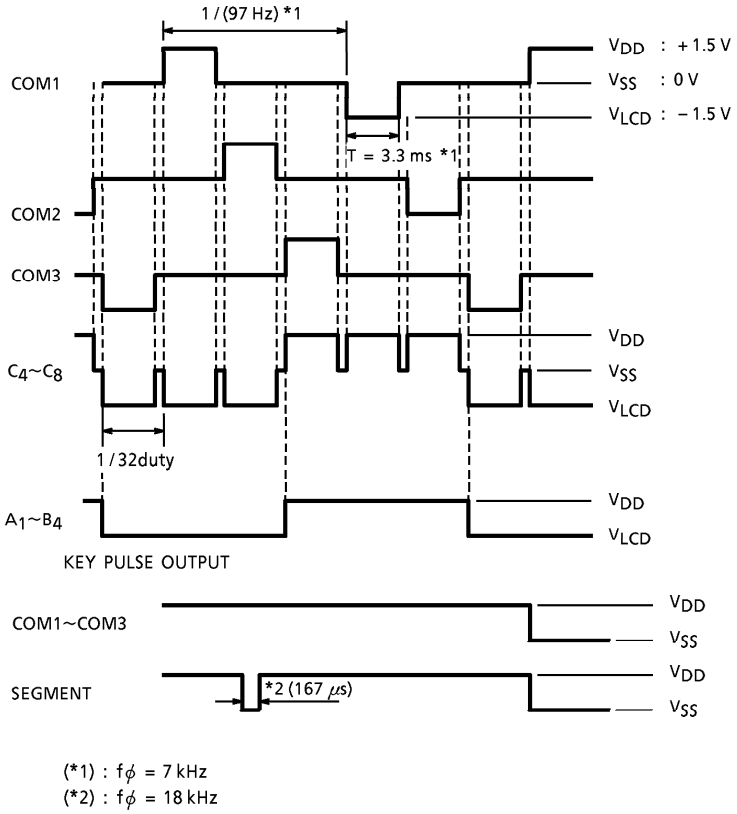
CHARACTERISTICS	SYMBOL	RATING	UNIT
Supply Voltage	V_{DD}	−0.3~+2.1	V
Input Voltage	V_{IN}	−0.3~V_{DD} + 0.3	V
Operating Temperature	T_{opr}	0~40	°C
Storage Temperature	T_{stg}	−55~125	°C

ELECTRICAL CHARACTERISTICS (V_{DD} = 1.4 V ± 0.2 V, V_{SS} = 0 V, Ta = 25°C)

CHARACTERISTICS		SYMBOL	TEST CIR-CUIT	PIN NAME	TEST CONDITION	MIN	TYP.	MAX	UNIT
Operating Voltage		V_{DD}	—	—	—	1.1	1.4	1.9	V
"1" Input Voltage		V_{IH}	—	K_1~$\overline{K_3}$	—	V_{DD} −0.4	—	V_{DD}	V
"0" Input Voltage		V_{IL}	—	K_1~$\overline{K_3}$	—	0	—	0.4	V
"1" Output Voltage		V_{OH}	—	Segment Common	—	V_{DD} −0.2	—	V_{DD}	V
"0" Output Voltage		V_{OL}	—	Segment Common	—	V_{DD} +0.2	—	−V_{DD}	V
"1" Output Voltage		V_{OH}	—	$\overline{K_2}$~$\overline{K_3}$	—	V_{DD} −0.2	—	V_{DD}	V
"0" Output Voltage		V_{OL}	—	K_1	—	0	—	0.2	V
"M" Output Voltage		V_{OM}	—	Common	—	V_{SS} +0.2	—	V_{SS} −0.2	V
Output Resistance	"1"	R_{OH}	—	Segment	V_{OUT} = V_{DD} − 0.5 V Key Strobe	—	—	70	kΩ
	"0"	R_{OL}	—	Segment	V_{OUT} = V_{LCD} + 0.5 V	—	—	70	
	"1"	R_{OH}	—	Common	V_{OUT} = V_{DD} − 0.5 V	—	—	70	
	"0"	R_{OL}	—	Common	V_{OUT} = V_{LCD} + 0.5 V	—	—	70	
Output Resistance	"M"	R_{OM}	—	Common	V_{OUT} = V_{SS} + 0.5 V	—	—	10	kΩ
Key Pull Down Resistance		R pull down	—	K_1	V_{OUT} = V_{DD}	45	80	240	kΩ
Key Pull up Resistance		R pull up	—	$\overline{K_2}$~$\overline{K_3}$	V_{OUT} = 0V	45	80	240	kΩ
"0" Output Resistance		R_{KEY}	—	Segment	V_{OUT} = V_{SS} + 0.5 V Key Strobe	—	—	10	kΩ
Input Leakage Current		I_{IL}	—	K_0	0 ≦ V_{IN} ≦ V_{DD}	—	—	±1.0	μA
Current Consumption (Wait)		I_{DD1}	—	—	V_{DD} = 1.4 V (Key Open)	—	1.9	3.3	μA
Current Consumption (OP)		I_{DD2}	—	—	V_{DD} = 1.1 V (ALL 9 $\sqrt{\ }$ Peak)	—	3.0	4.0	μA
Current Consumption (OFF)		I_{DD} OFF	—	—	V_{DD} = 1.4 V	—	—	1.0	μA
Oscillating Frequency		f_ϕ (Wait)	—	—	V_{DD} = 1.4 V, f_ϕ (Typ.) = Wait	4.2	7	9.8	kHz
		f_ϕ (OP)			V_{DD} = 1.4 V, f_ϕ (Typ.) = Operate	10.8	18	25.2	
Frame Frequency		f_F	—	—	V_{DD} = 1.4 V (Wait)	58	97	136	Hz
Power off Timer		Timer	—	—	V_{DD} = 1.4 V	300	420	700	s

WAVEFORMS FOR DISPLAY

Display Device : FEM type LCD 3.0 V, 1/2 bias, 1/3 duty dynamic system

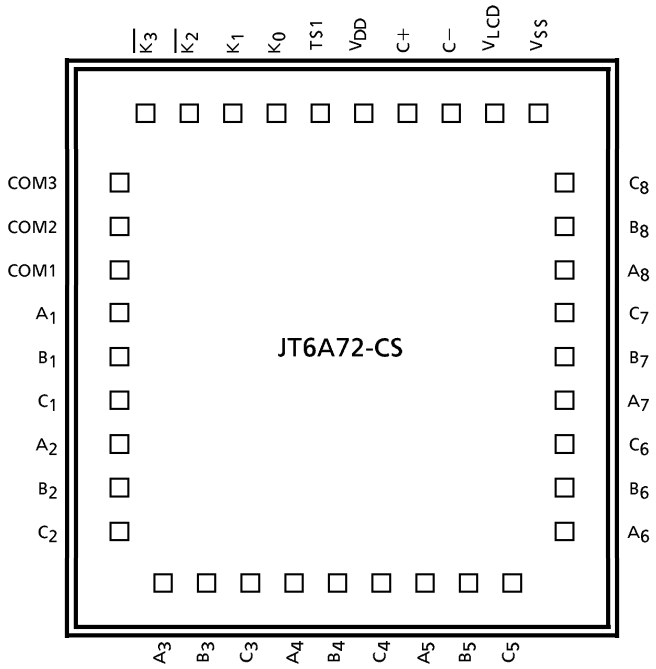


(*1) : fϕ = 7 kHz
(*2) : fϕ = 18 kHz

PAD LOCATION TABLE (μm)

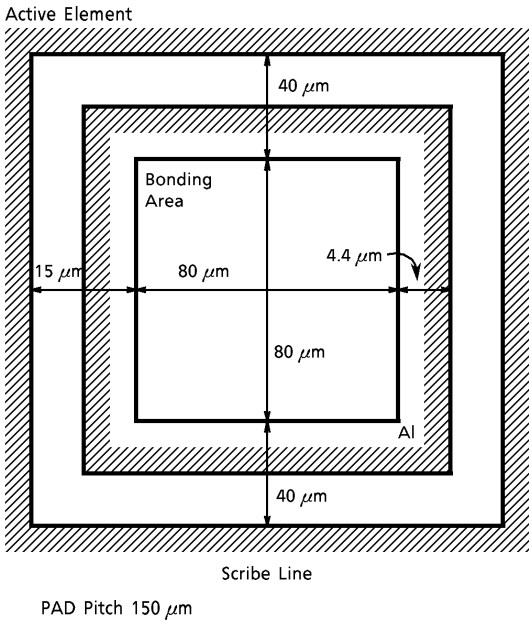
NAME	X POINT	Y POINT
C_2	– 1049	– 697
B_2	– 1049	– 515
A_2	– 1049	– 353
C_1	– 1049	– 172
B_1	– 1049	– 10
A_1	– 1049	171
COM1	– 1049	362
COM2	– 1049	549
COM3	– 1049	713
$\overline{K_3}$	– 809	879
$\overline{K_2}$	– 627	879
K_1	– 466	879
K_0	– 284	879
TS1	– 123	879
V_{DD}	45	879
C +	229	879
C –	464	879
V_{LCD}	736	879
V_{SS}	910	879
C_8	1049	703
B_8	1049	516
A_8	1049	351
C_7	1049	164
B_7	1049	– 1
A_7	1049	– 188
C_6	1049	– 353
B_6	1049	– 540
A_6	1049	– 705
C_5	721	– 879
B_5	555	– 879
A_5	369	– 879
C_4	203	– 879
B_4	– 110	– 879
A_4	– 263	– 879
C_3	– 444	– 879
B_3	– 606	– 879
A_3	– 788	– 879

CHIP LAYOUT



Chip size : 2.34 × 2.00 (mm)
Chip thickness : 200 ± 30 (μm)
Substrate : V_{SS}

PAD LAYOUT



PAD Pitch 150 μm