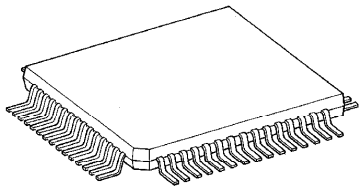
TOSHIBA CMOS DIGITAL INTEGRATED CIRCUIT SILICON MONOLITHIC

T9947S, JT9947X-AS

T9947S, JT9947X-AS CMOS SINGLE-CHIP LSI FOR LCD CALCULATOR

The T9947S, JT9947X-AS is a single-chip microcomputer for 10-digit 1-memory electronic calculator.
T9947S, JT9947X-AS can drive the liquid crystal display (LCD). Single power supply operation, low-power consumption make it suitable for solar battery or battery operated pocketable calculator.



LQFP60-P-1414-0.80

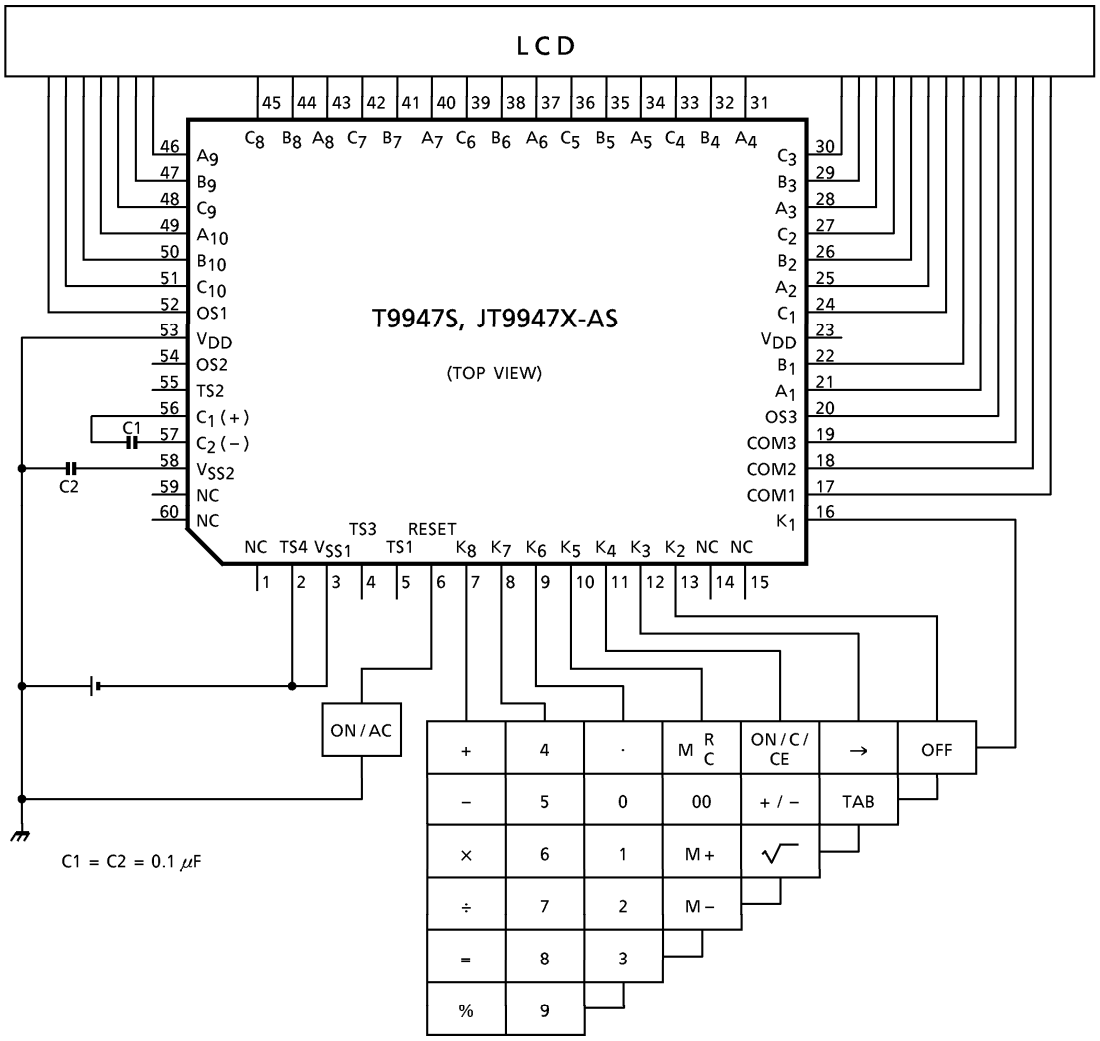
Weight : 0.66 g (Typ.)

FEATURES

- 10 digits of data and 1 symbol digit for calculator.
- Algebraic calculation mode.
- Punctuation.
- Standard 4 functions (+, −, ×, ÷), square root, 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 −3.0 V, 1 / 2 bias, 1 / 3 duty).
- Single power supply (−1.5 V typ.).
- Quad in line flat package (60 pin).
- Very low power consumption (3.0 μW typ. at wait).
- Very wide range of operating voltage (V_{SS1} = −1.2~−2.0 V).

SYSTEM BLOCK DIAGRAM

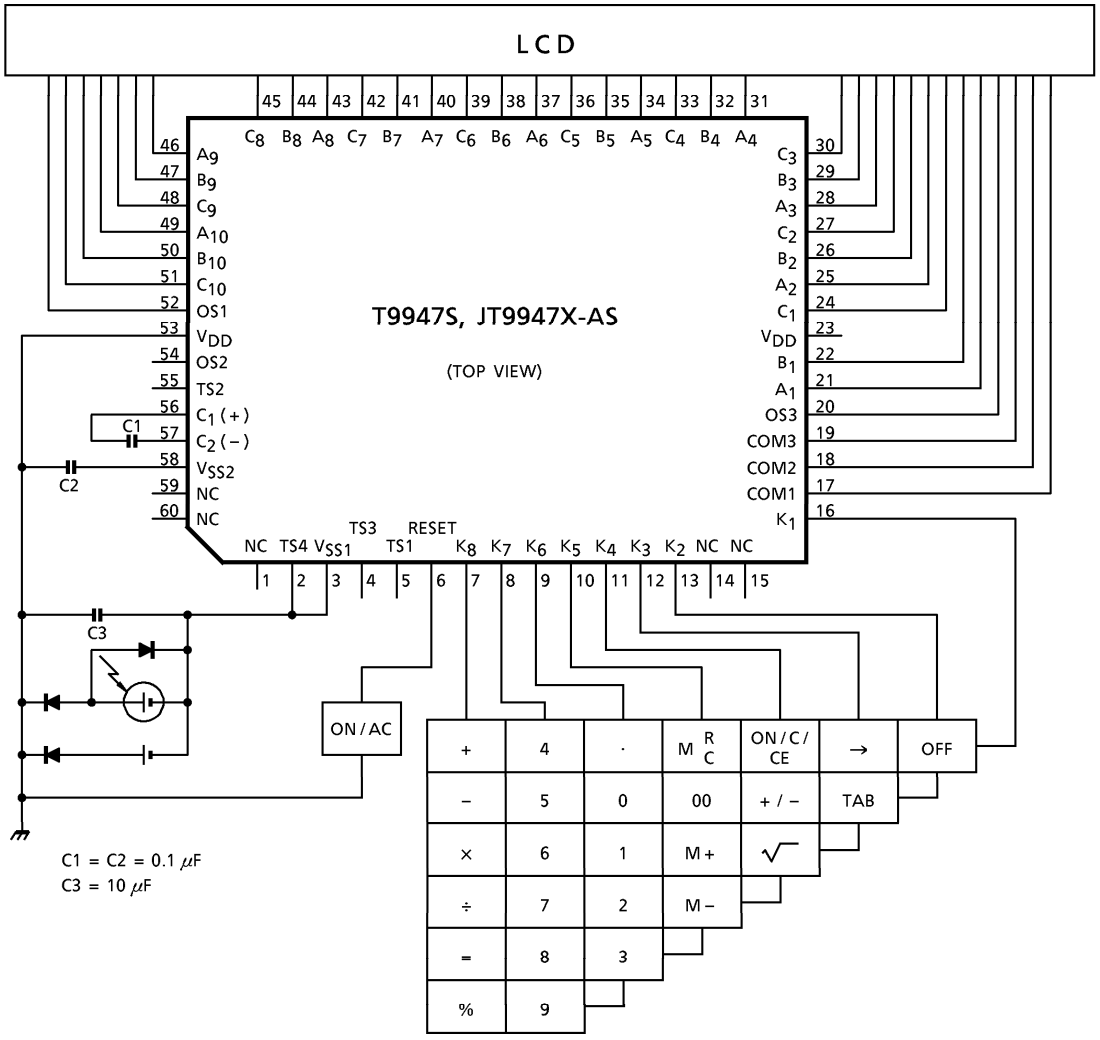
Battery Type



(Note) : TS4 { V_{DD} ……OFF MODE DISABLE
V_{SS1} ……OFF MODE ENABLE

Solar Capacitor C3 ≦ 10 μF
Rkey ≦ 20 kΩ (– 1.2 V)
≦ 135 kΩ (– 1.5 V)

Dual Type



(Note) : TS4 { V_{DD} ……OFF MODE DISABLE
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Solar Capacitor C3 ≦ 10 μF
Rkey ≦ 20 kΩ (– 1.2 V)
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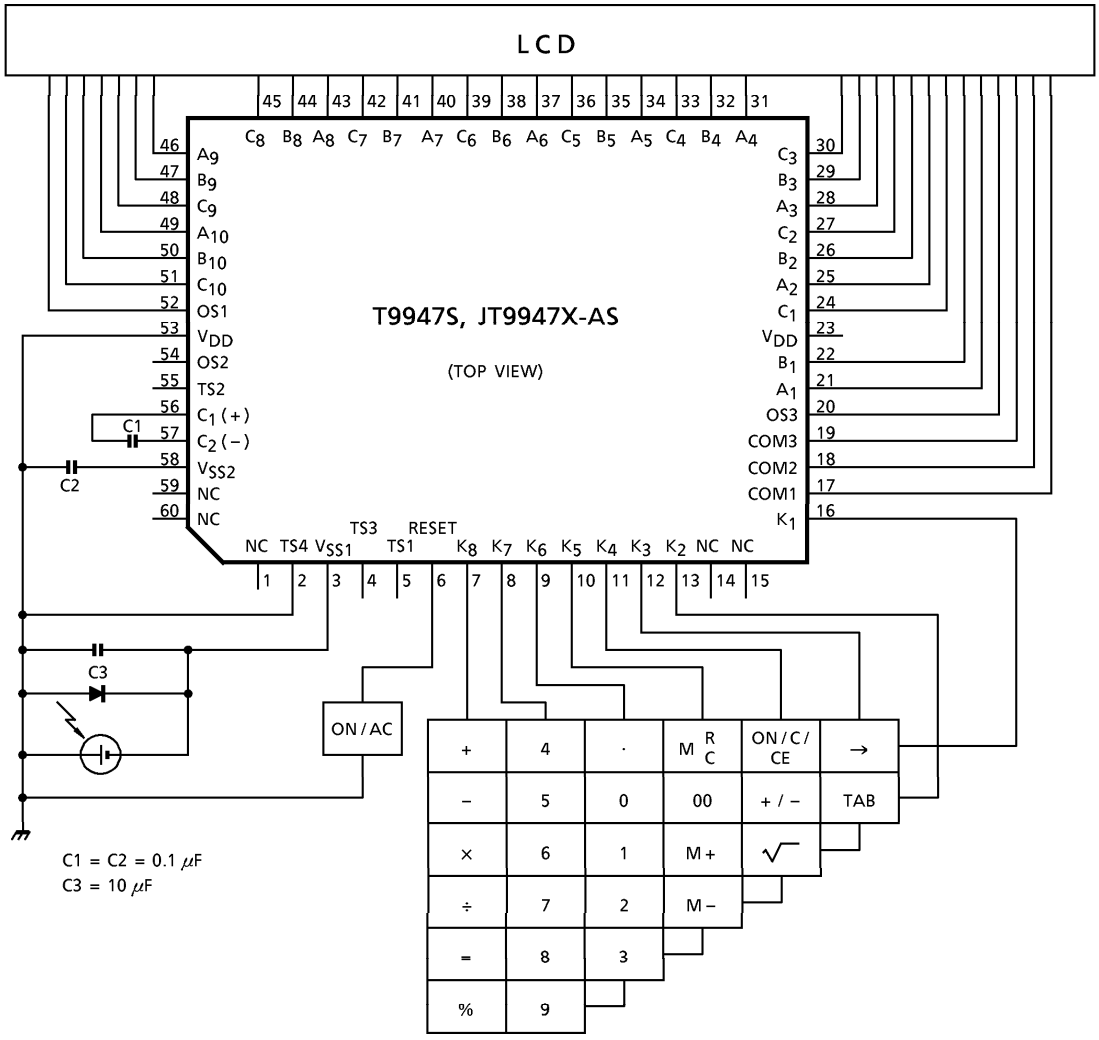
Solar Type

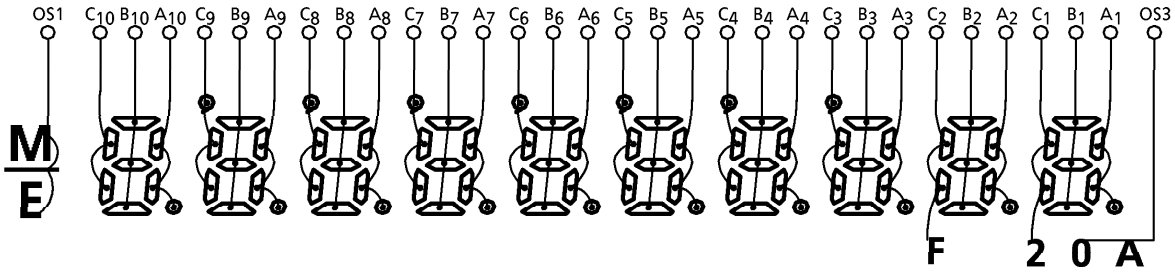


(Note) : TS4 { V_{DD} ……OFF MODE DISABLE
V_{SS1} ……OFF MODE ENABLE

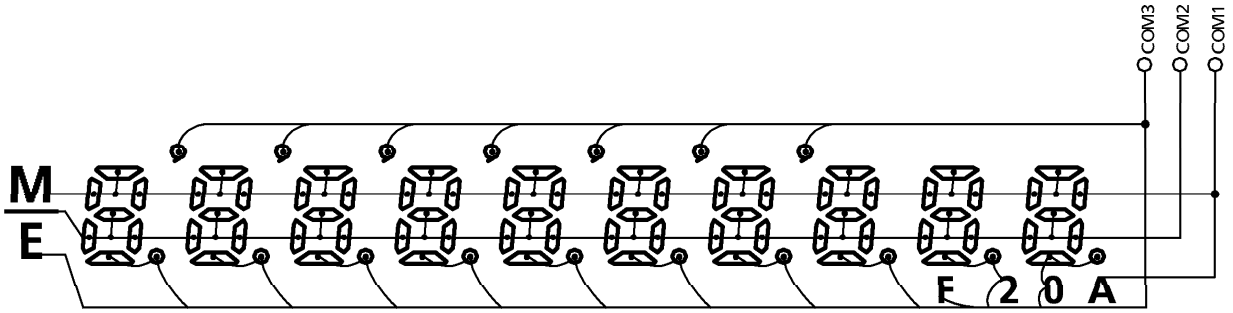
Solar Capacitor C3 ≦ 10 μF
Rkey ≦ 20 kΩ (– 1.2 V)
≦ 135 kΩ (– 1.5 V)

CONNECTION OF LCD

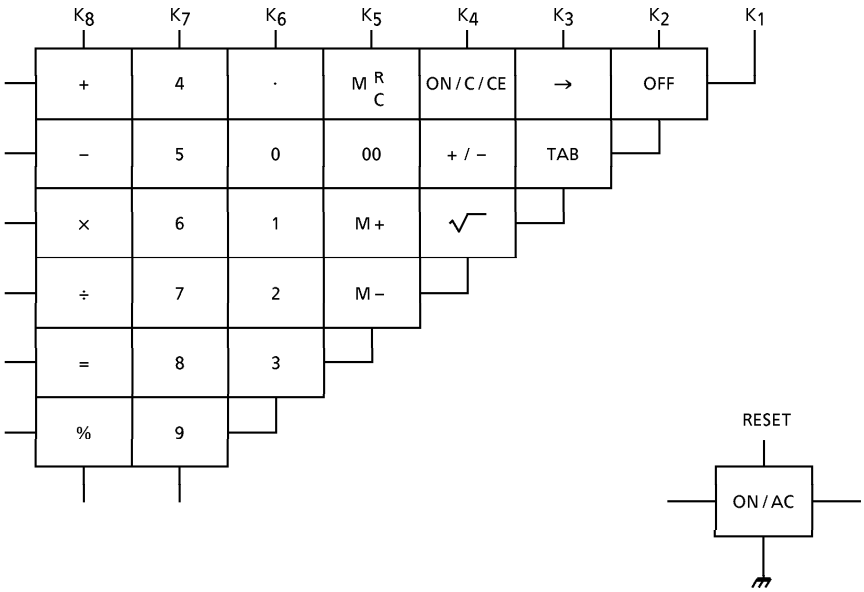
SEGMENT



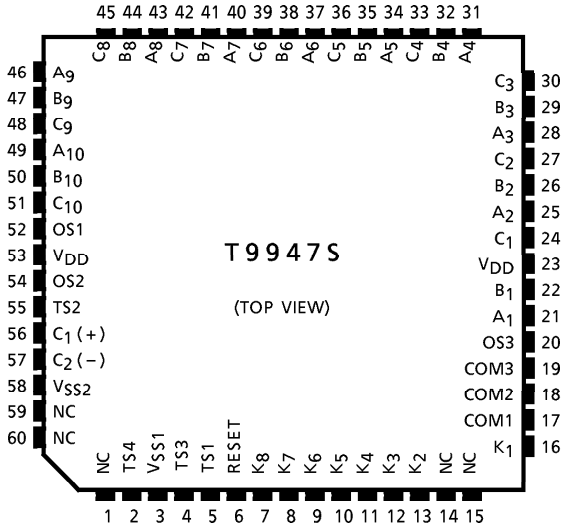
COMMON



KEY CONNECTION



PIN ASSIGNMENT



SPECIFICATION OF CALCULATOR

Operational Features

(1) 10 digits of data and 1 symbol digit.

(2) Algebraic mode.

(3) Full floating point.

(4) Standard 4 functions +, −, ×, ÷.

(5) Memory calculation.

(6) Square root.

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

(8) Constant calculation (Automatic constant).

(9) Chain calculation.

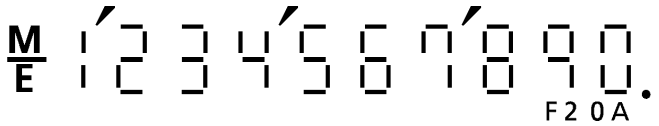
(10) Leading zero suppression.

(11) Trailing zero suppression.

Capacity of Calculation

(1)	Numeral entry	10 digits
(2)	Addition / Subtraction	10 digits + (−) 10 digits = 10 digits
(3)	Multiplication / Division	10 digits × (÷) 10 digits = 10 digits
(4)	Memory calculation	10 digits + (−) 10 digits = 10 digits
(5)	Square root	$\sqrt{10}$ digits = 10 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 10 digits, the display will show 10 most significant digits of result divided by 10^{+10} and "E".

(3) When the integer part of result exceeds 19 digits, display will show a zero and "E".

(4) When the integer part of result in memory register exceeds 10 digits at memory calculation, display will show a zero and "E", and previous data will be kept in memory resister.

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

(6) When square root of any negative number is attempted, "E" and square root of absolute value are displayed.

(7) 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 [MRC] 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					74.4 ms
(2)	Addition	1111111111	+	1111111111	=	102.7 ms
(3)	Multiplication	1	×	9999999999	=	394.7 ms
(4)	Division	9999999999	÷	1	=	394.7 ms
(5)	Memory calculation	9999999999	÷	1	M+	482.7 ms
(6)	Percentage calculation	1	+	9999999999	%	378.7 ms
(7)	Square root			9999999999	√	326.7 ms

Keys for Calculator

(1) Data Keys

The data keys consist of numeral keys 0 , 00 through 9 and a decimal point key · . The first of a sequence of data keys will clear the contents of display register before being entered. The decimal point key will be accepted the first time it is depressed during calculations.

(2) Arithmetic Operation Keys

The arithmetic operation keys include the plus + , minus − , multiply × , divide ÷ , equal = , percent % , square root √ , memory add M+ , memory subtract M− , sign change +/− , data shift →.

+ Depression of this key conditions the calculator for addition of display register to upper register.
If the calculator was previously conditioned for add, subtract, multiply or device, those operation would be performed with the resultant intermediate sum, difference, product or quotient displayed and previous modes and reset, and calculator stores add command.
In the successive depressions of this key, the first will perform the previously enabled mode and more than twice depressions will be ignored.

− Depression of this key performs the same function as the + key with the exception that calculator stores subtract mode.

× Depression of this key conditions the calculator for multiplication of upper register and display register.
If the calculator was previously conditioned for add, subtract multiply or divide, those operation would be performed with the resultant intermediate sum, difference, product or quotient displayed.
And then set the multiply mode.

M – Depression of this key will perform the same function as the M + with the exception that the calculator result or displayed number is subtracted from the memory register.

= Depression of this key following numeral entry will perform the previously enabled mode.
If no number has been entered, the displayed number will be used to perform the previously enabled mode. If no mode are enabled, this key will be ignored. If multiplication or division are enabled, constant mode operations are performed by termination a sequence of operations with the = key, entering a new number and depressing the = key.
Any key sequence terminated with, = key will not require the use of ON / C / CE key before a new operation sequence can be initiated.

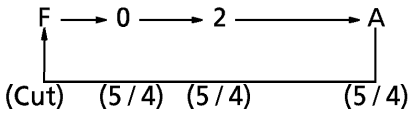
% If the calculator was previously conditioned for addition, or subtraction or multiplication or divination, % calculations would be performed as follows.

a + b % a + a·b / 100
a – b % a – a·b / 100
a × b % a·b / 100
a ÷ b % 100 a / b

If no mode are enabled, this key will be ignored. If multiplication or division are enabled, constant mode operations are performed by terminating a sequence of operation with the % key, entering new number and depressing the % key.

M + Depression of this key will perform the previously enabled mode and add the result to memory register and leave the result in the display register.
If no modes are enabled, the displayed number is added to memory register by this key.
Any key sequence terminated with M + will not require the use of the ON·/ C / CE key before a new operation sequence can be initiated.

TAB "TAB" fixed point mode selectable



÷ Depression of this key performs a similar function as the × key except that division of upper register by display register is either set up or performed and the divide mode is activated.

[√] Depression of this key calculated the square root of number displayed without changing modes of operation.
Depression of this key following [+], [−], [×], or [÷] keys will transfer the contents of display register to upper register and calculate the square root of number displayed.
The entry of a new number following this key clear the previous display.

[+ / −] Depression of this key will change the sign of display register.

[→] Depression of this key will shift the right data of display register.

(3) Command Function Keys

The command function keys include the clear entry / clear all [ON / C / CE], recall / clear memory [MRC]

[MRC] Depression of this key following [+], [−], [×] or [÷] will transfer the contents of display register to upper register and recall the contents of memory register to display register.
[MRC] key following [=], [%], [M+], [M−] or any number key will recall the contents of memory register to the display register without affecting any other operations in progress.
Successive depressions of [MRC] key will clear the memory register.

[ON / C / CE] Depression of this key after [MRC], [√], [·], or numeral keys will clear the display register.
You can reset the error symbol "E" if you depress [ON / C / CE] at the condition of exceeding capacity error.

[OFF] Depression of this key will off the LSI.

Arithmetic Operations

1. Addition

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

	Key Op.	Display
	[+]	D + E
	[=]	D + E

2. Subtraction

(1)	A	A
	[−]	A
	B	B
	[−]	A − B
	C	C
	[=]	A − B − C
	[−]	A − B − C
	D	D
	[+ / −]	− D
	[−]	A − B − D + 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

		Key Op.	Display
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
		[=]	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
		[=]	$1 / A^2$

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

	Key Op.	Display
	[=]	– 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
	[=]	A + B
	C	C
	[=]	C
(5)	A	A
	[−]	A
	B	B
	[=]	A – B
	C	C
	[=]	C
(6)	A	A
	[×]	A
	B	B
	[=]	A·B
	C	C
	[×]	C
	D	D

	Key Op.	Display
	[=]	C·D
	E	E
	[=]	C·E
	[×]	C·E
	F	F
	[=]	C·E·F
	G	G
	[÷]	G
	H	H
	[=]	G / H
	I	I
	[=]	I / H
(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

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

9. Memory calculation

	Key Op.	Display	Memory
(1)	A	A	0.
	M +	A (M)	A
	B	B (M)	A

	Key Op.	Display	Memory
	[M+]	B (M)	A + B
	C	C (M)	APB
	[M−]	C (M)	A + B − C
	D	D (M)	A + B − C
	[MRC]	A + B − C (M)	A + B − C
	MRC	A + B − C	0.
(2)	A	A	0.
	[+]	A	0.
	B	B	0.
	[M+]	A + B (M)	A + B
	[+]	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)	A·B − C·D
	[MRC]	A·B − D·D (M)	A·B − C·D
	[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

	Key Op.	Display	Memory
	[=]	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]	A + B (M)	A + B
	×	A + B (M)	A + B
	[MRC]	A + B (M)	A + B
	[+]	$(A + B)^2$ (M)	A + B
	C	C (M)	A + B
	[=]	$(A + B)^2 + C$ (M)	A + B
(6)	1.000000001	1.000000001	0.
	M+	1.000000001 (M)	1.000000001
	9999999999	9999999999. (M)	1.000000001
	[M+]	0. ($_{E}^{M}$)	1.000000001
	[ON/C/CE]	0. (M)	1.000000001
	[MRC]	1.000000001 (M)	1.000000001

10.Square root

(1)	A	A
	[√]	$\sqrt{A}$
	B	B
(2)	A	A
	[×]	A
	B	B
	[√]	$\sqrt{B}$
	[=]	$A\sqrt{B}$

	Key Op.	Display	Memory
(3)	A	A	
	×	A	
	√	$\sqrt{A}$	
	B	B	
	=	A·B	
(4)	−	0.	
	A	A	
	=	− A	
	√	$\sqrt{A}$ (E)	
(5)	A	A	0.
	M+	A (M)	A
	MRC	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	

	Key Op.	Display	Memory
	[%]	B	
	C	C	
	[%]	C	
(3)	A	A	
	[−]	A	
	B	B	
	[%]	A − A·B / 100	
	[−]	A − A·B / 100	
	[+]	A − A·B / 100	
	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]	A + $\sqrt{A}$ (M)	A + $\sqrt{A}$
	[MRC]	A + $\sqrt{A}$	0.
	B	B	0.
	[+]	B	0.
	[−]	B	0.
	[×]	B	0.
	[÷]	B	0.
	[=]	1 / B	0.

13. Others		Key Op.	Display	Memory
	(1)	A	A	
		[+]	A	
		[=]	A	
	(2)	A	A	
		[×]	A	
		[÷]	A	
		[=]	1 / A	
	(3)	A	A	
		[%]	A	
		[+]	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	

Key Chattering Protection

(1) At time of key on : about 18.0 ms, after key input. ($f\phi$ typ.)

(2) At time of key off : about 17.0 ms, after completion of the operation ($f\phi$ typ.)

(3) Simultaneous Keying protection

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

MAXIMUM RATINGS

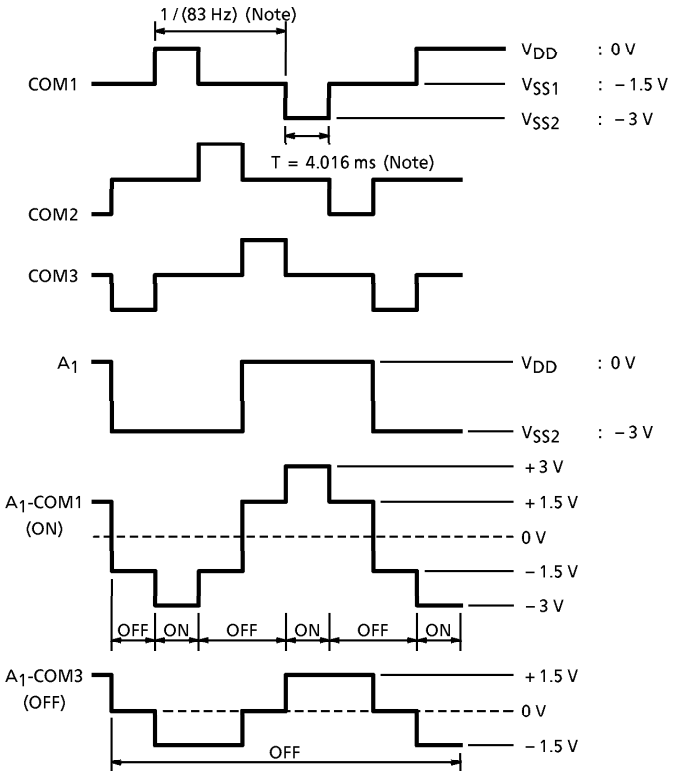
CHARACTERISTICS	SYMBOL	RATING	UNIT
Supply Voltage	V_{SS1}	+0.3~−2.2	V
Input Voltage	V_{IN}	+0.3~V_{DD1} − 0.3	V
Operating Temperature	T_{opr}	+0.0~40	°C
Storage Temperature	T_{stg}	−55~125	°C

ELECTRICAL CHARACTERISTICS (V_{SS1} = −1.5 V ± 0.2 V, V_{SS2} = −3.0 V ± 4.0 V, V_{DD} = 0 V, Ta = 25°C)

CHARACTERISTICS		SYMBOL	TEST CIR-CUIT	PIN NAME	TEST CONDITION	MIN	TYP.	MAX	UNIT
Supply Voltage		V_{SS1}	—	—	—	−1.2	−1.5	−2.0	V
VOLTAGE	Input "1"	V_{IH}	—	K_2~K_8, RESET	—	V_{SS1} +0.4	—	V_{SS1}	V
	Input "0"	V_{IL}	—	K_2~K_8, RESET	—	0	—	−0.4	V
	Output "1"	V_{OH}	—	Segment, Common	—	V_{SS2} +0.2	—	V_{SS2}	V
	Output "0"	V_{OL}	—	Segment, Common	—	0	—	−0.2	V
	Output "1"	V_{OH}	—	K_1~K_8, RESET	—	V_{SS1} +0.2	—	V_{SS1}	V
	Output "0"	V_{OL}	—	K_1~K_6, RESET	—	0	—	−0.2	V
Resistance	Output "1"	R_{OH}	—	Segment	V_{OUT} = V_{SS2} + 0.5 V	—	—	70	kΩ
	Output "0"	R_{OL}	—	Segment	V_{OUT} = −0.5 V	—	—	70	kΩ
	Output "1"	R_{OH}	—	Common	V_{OUT} = V_{SS2} + 0.5 V	—	—	70	kΩ
	Output "0"	R_{OL}	—	Common	V_{OUT} = −0.5 V	—	—	70	kΩ
	Pull Up	R_{KH}	—	K_1~K_8	V_{OUT} = 0 V	60	400	1500	kΩ
		RESET	—	RESET	V_{OUT} = 0 V	180	300	420	kΩ
	Output "0"	R_{OL}	—	K_1~K_6	V_{OUT} = −0.5 V	—	—	10	kΩ
Supply Current 1 (On Display)		I_{DD1}	—	—	V_{SS1} = −1.5 V (No Keys)	—	−2.2	−3.6	μA
Supply Current 2 (Operation)		I_{DD2}	—	—	V_{SS1} = −1.2 V (Peak OF A11 9√‾)	—	−4.4	−6.6	μA
Supply Current 3 (Off)		I_{DD3}	—	—	V_{SS1} = −1.5 V (Off Status)	—	−0.5	−2.0	μA
Oscillating Frequency		f_{osc} (WAIT)	—	—	V_{SS1} = −1.5 V, On Display	5.4	9	12.6	kHz
		f_{osc} (OP)			V_{SS1} = −1.5 V, On Operating	10.8	18	25.2	kHz
Frame Frequency		f_F	—	—	V_{SS1} = −1.5 V (Wait)	50	83	117	Hz

WAVEFORMS FOR DISPLAY

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



(Note) : $f\phi$ = 9 kHz

OTHERS

- AUTO POWER OFF (Typ.) = 7 MIN
- RESET Key

  i) After releasing this key, the cpu is reset and display "0".

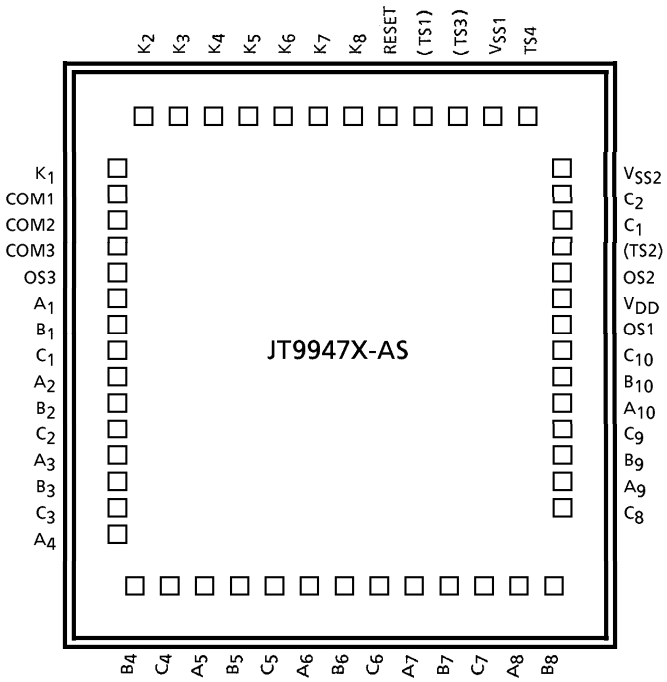
PAD LOCATION TABLE (μm)

NAME	X POINT	Y POINT
K_1	– 1291	1093
COM1	– 1291	896
COM2	– 1291	744
COM3	– 1291	592
OS3	– 1291	441
A_1	– 1291	289
B_1	– 1291	137
C_1	– 1291	– 14
A_2	– 1291	– 166
B_2	– 1291	– 318
C_2	– 1291	– 470
A_3	– 1291	– 621
B_3	– 1291	– 773
C_3	– 1291	– 925
A_4	– 1291	– 1076
B_4	– 927	– 1249
C_4	– 776	– 1249
A_5	– 624	– 1249
B_5	– 472	– 1249
C_5	– 320	– 1249
A_6	– 169	– 1249
B_6	– 17	– 1249
C_6	135	– 1249
A_7	286	– 1249
B_7	438	– 1249
C_7	590	– 1249
A_8	741	– 1249
B_8	893	– 1249
C_8	1254	– 1077

NAME	X POINT	Y POINT
A_9	1254	– 925
B_9	1254	– 774
C_9	1254	– 622
A_{10}	1254	– 470
B_{10}	1254	– 319
C_{10}	1254	– 167
OS1	1254	– 15
V_{DD}	1254	137
OS2	1254	288
(TS2)	1254	489
C_1	1254	697
C_2	1254	898
V_{SS2}	1254	1100
TS4	949	1249
V_{SS1}	798	1249
(TS3)	646	1249
(TS1)	494	1249
RESET	343	1249
K_8	191	1249
K_7	39	1249
K_6	– 112	1249
K_5	– 264	1249
K_4	– 416	1249
K_3	– 568	1249
K_2	– 719	1249

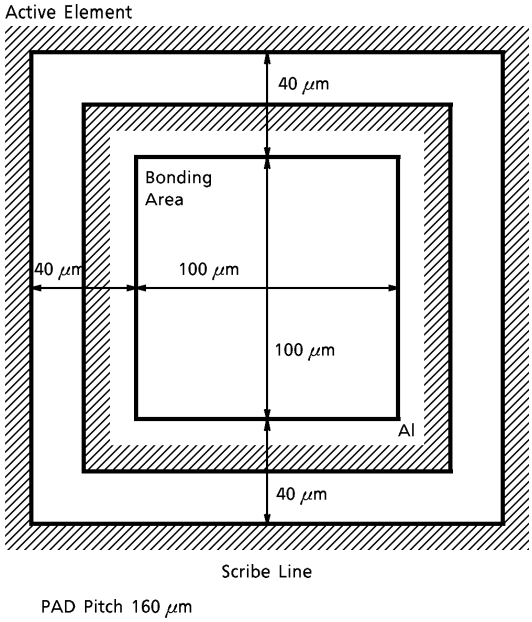
(Note) : ( ) Do not connect.

CHIP LAYOUT



Chip size : 3.04 × 3.02 [mm]
Chip thickness : 290 ± 20 [μm]
Substrate : V_{DD}

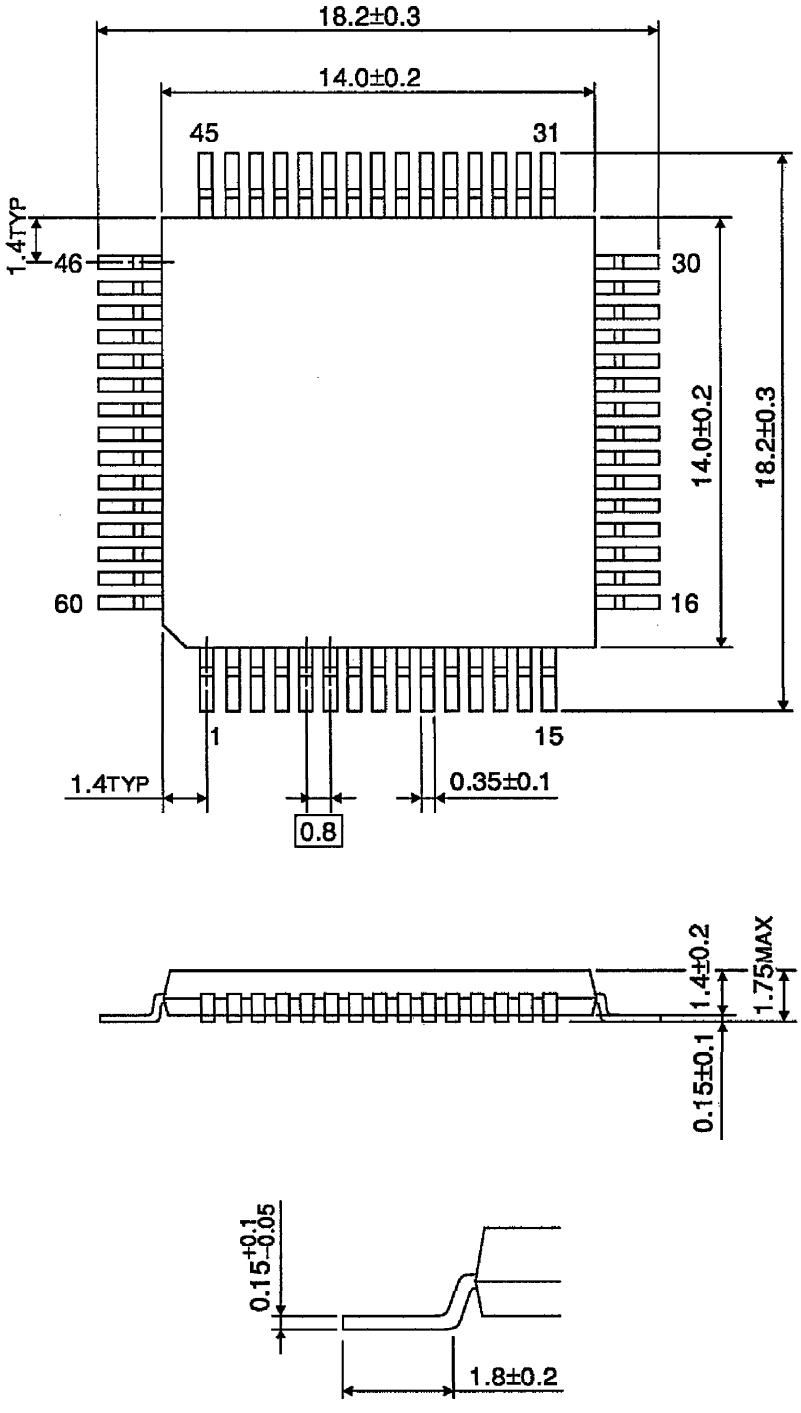
PAD LAYOUT



PAD Pitch 160 μm

PACKAGE DIMENSIONS

LQFP60-P-1414-0.80 Unit : mm



Weight : 0.66 g (Typ.)

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