

T7988, JT7988Y-AS

T7988, JT7988Y-AS SINGLE-CHIP CMOS LSI FOR LCD CALCULATORS

The T7988, JT7988Y-AS is single-chip microcomputer for 10-digit + 2-digit scientific calculator.

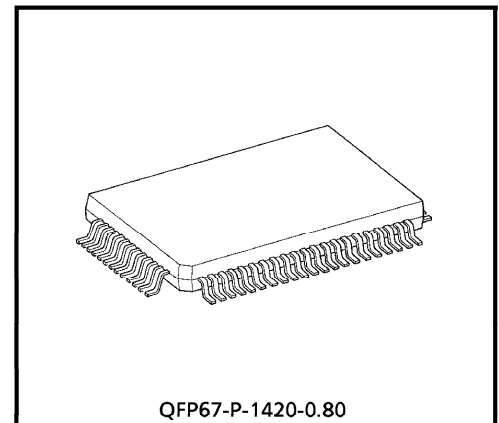
T7988, JT7988Y-AS is the complete single-chip CMOS LSI for electronic calculator with 10 digits, 67 functions, 3 expression and hexadecimal, octal and binary, statistic calculation, fractional number calculation, and logic operation with the following features.

FEATURES

- 12-digit display plus 2-digit code at the right margin.
 - Scientific and engineering display.
Mantissa 10 digits plus exponent 2 digits plus negative code 2 digits.
 - Other than above
Mantissa 10 digits plus negative code 1 digit.
- 13 kinds of special display

M	Memory	HEX	Hexadecimal mode
-	Mantissa and exponent Minus	SD	Statistic calculation mode
E	Error	DEG	Degree
INV	Inverse	RAD	Radian
HYP	Hyperbolic	GRAD	Gradian
BIN	Binary mode	()	Parenthesis calculation
OCT	Octal mode		

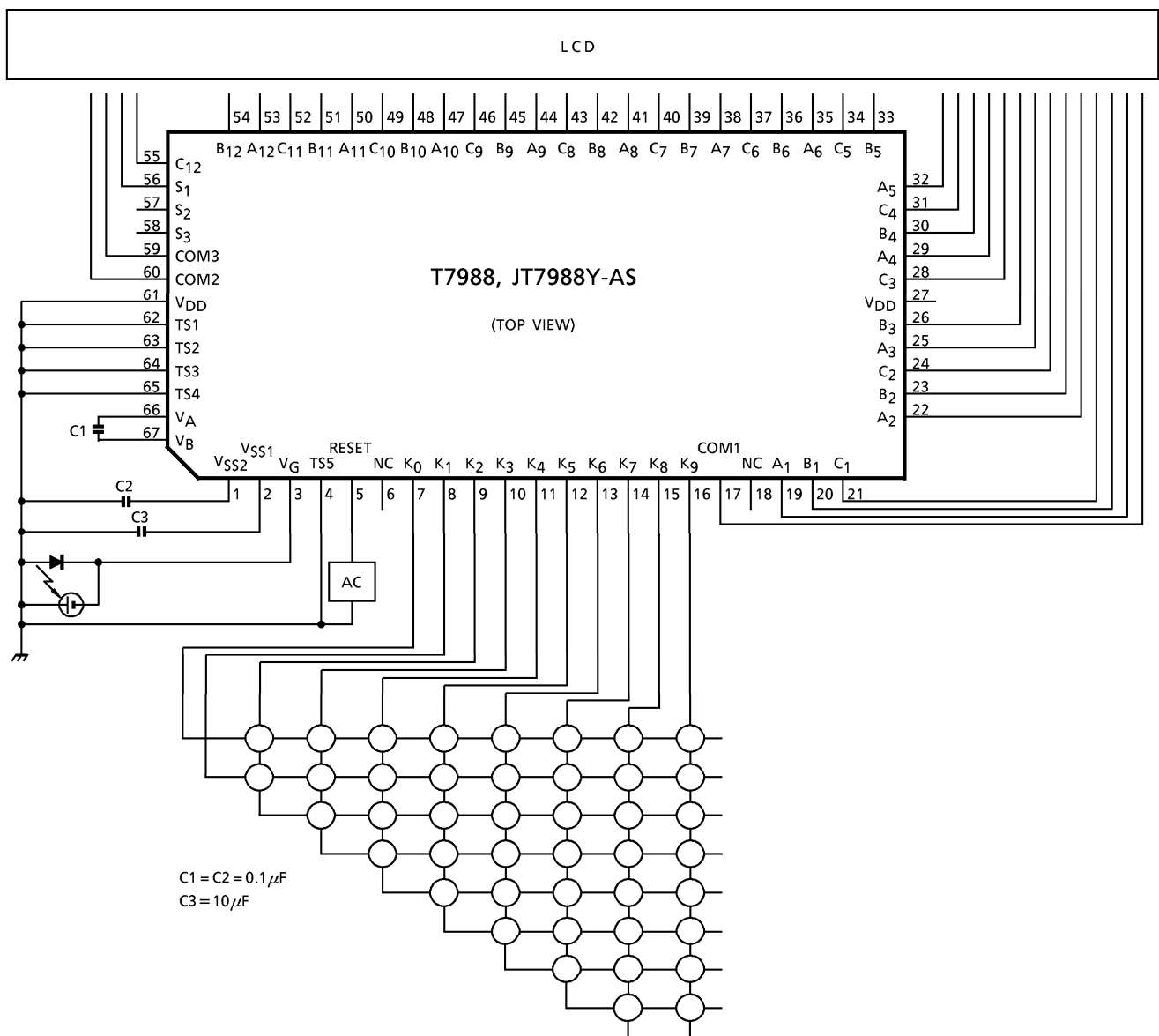
- The minus sign of the mantissa is floating minus.
- The arithmetic key operation in clouding Y^x or $^x\sqrt{Y}$ has same sequence as mathematical equation. 6 pending operations are allowed and () are up to continuous 15 levels.
- Fractional number calculation.
- It is possible to convert mutually between decimal, binary, octal and hexadecimal, and the 4 operations in arithmetic in binary, octal and hexadecimal.



Weight : 1.20g (Typ.)

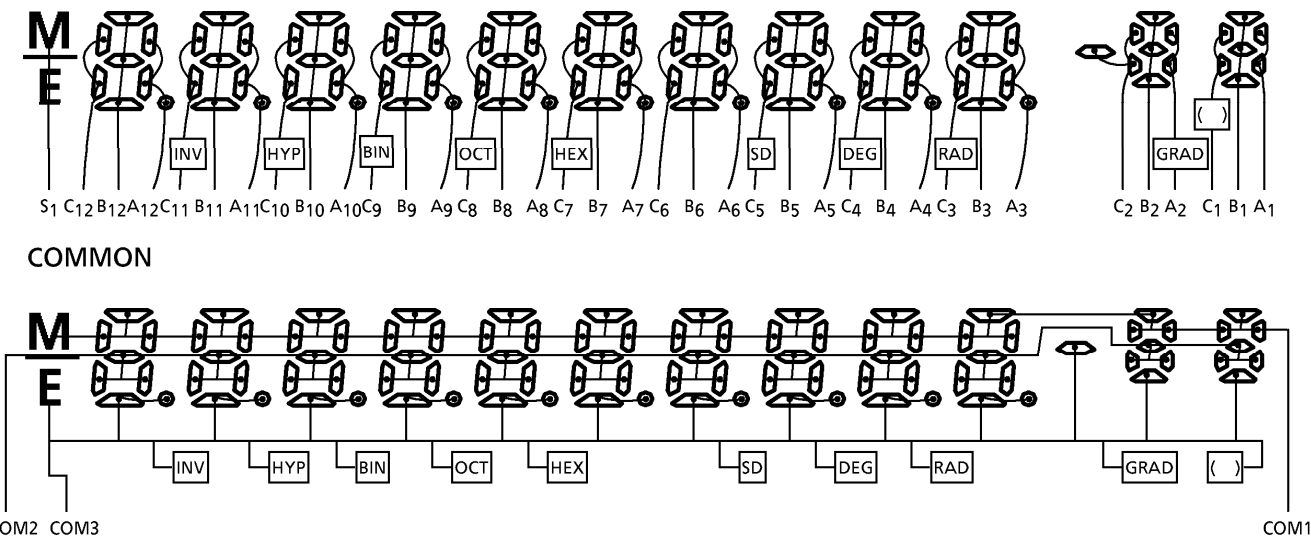
- One independent accumulating memory.
- It is possible to convert or fix the display number system by FLO (Floating) , SCI (Scientific) or ENG (Engineering) key.
- It is possible to specify decimal part digits (0~9) by FIX key.
- Direct drive for FEM LCD (1/2 prebias, 1/3 duty) .
- Automatic power on clear.
- Low-power consumption. $V_G = -1.5V$ single power supply.
- The 67-pin flat package is used.

SYSTEM BLOCK DIAGRAM

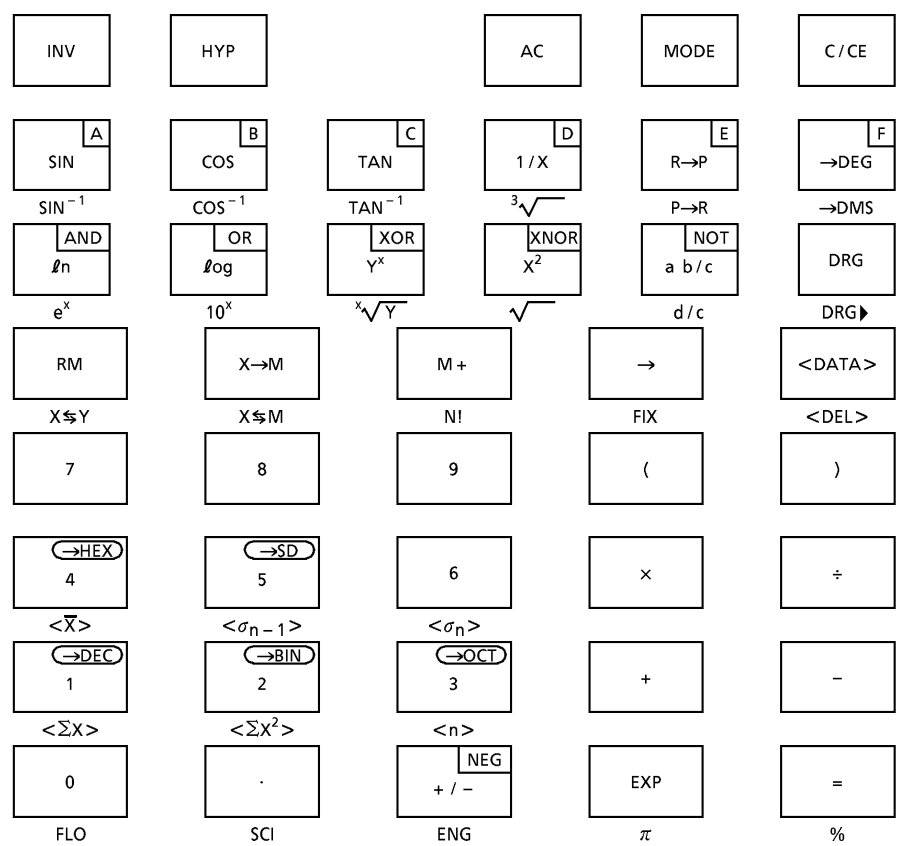


CONNECTION OF LCD

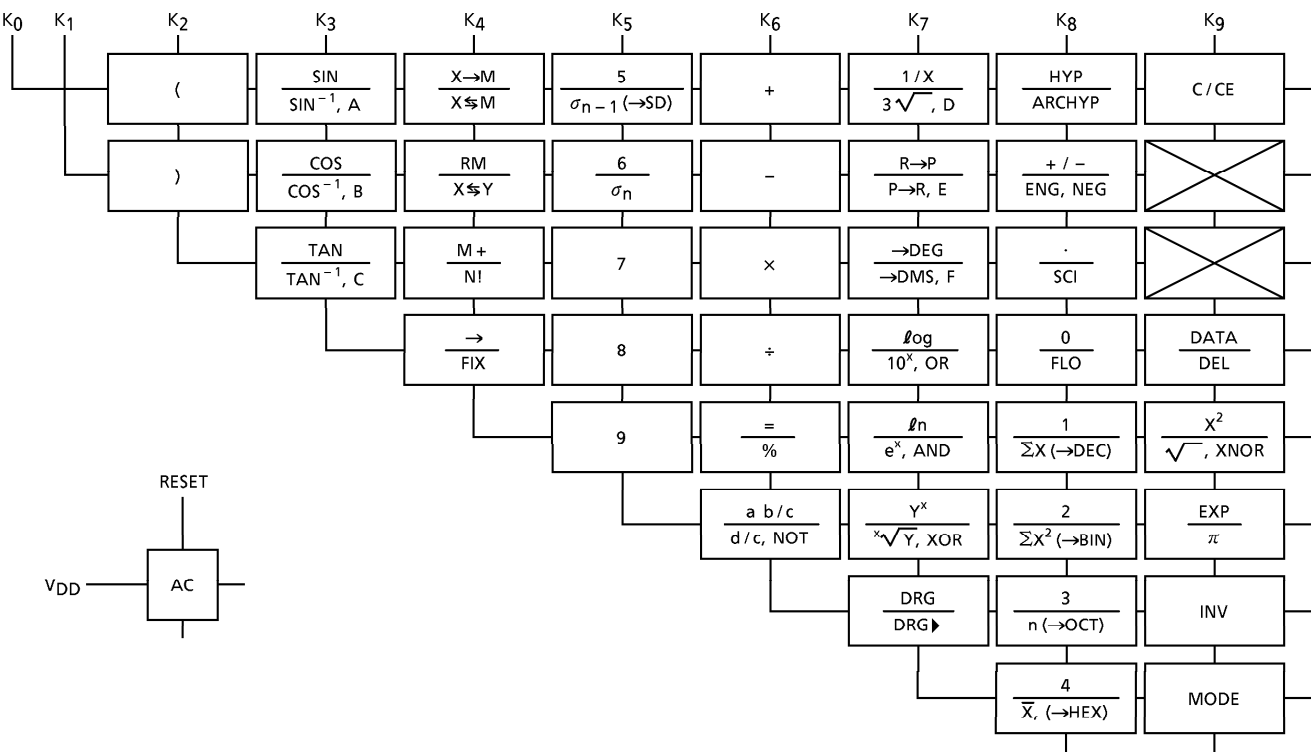
SEGMENT



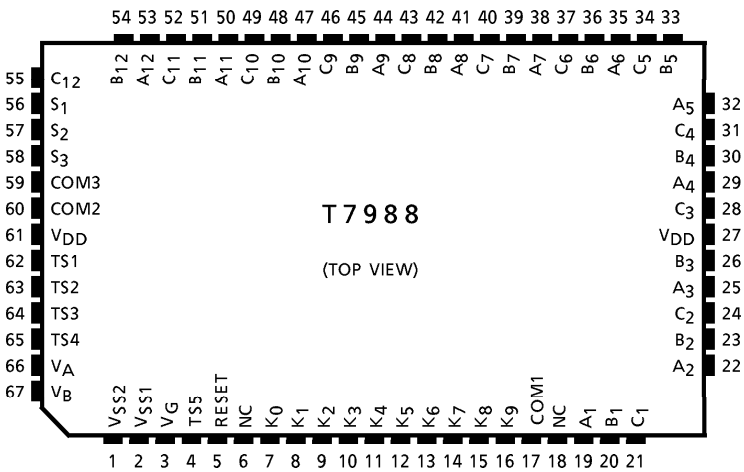
SET KEY LAYOUT (Example)



KEY CONNECTION



PIN ASSIGNMENT



SPECIFICATION OF CALCULATOR

Speed of calculation

Key on 10ms

Key off 33.8ms

 $f_{\phi} \text{ WAIT} = 9\text{kHz}$, $f_{\phi} \text{ op} = 24\text{kHz}$

The calculation speed doesn't include the key on or off time.

ITEM	OPERATION			CALCULATION SPEED (ms)
Number	DEC		5	26
		5	5	25
	HEX		A	26
		A	A	25
Function	DEC	5	+	69
		5	$\times$	73
	HEX	A	-	172
		A	$\div$	176
4 operation	DEC	1 + 2	+	97
		1 0 0 0 0 0 0 0 0 - 1	-	104
		5 $\times$ 9	$\times$	104
		5 5 5 5 5 $\times$ 9 9 9 9 9	$\times$	120
		5 $\div$ 9	$\div$	157
		5 5 5 5 5 $\div$ 9 9 9 9 9	$\div$	193
	HEX	A B C + D E F	+	291
		A B C - D E F	-	479
		A B C $\times$ D E F	$\times$	334
		A B C $\div$ D E F	$\div$	324
Y^X , $X\sqrt{Y}$	3 Y^X 4			= 842
	3 $X\sqrt{Y}$ 4			= 872
SIN	DEG	3 0	SIN	798
	RAD	$\pi \div 6 =$	SIN	764
	GRAD	1 0 0 $\div$ 3 =	SIN	1161
COS	DEG	6 0	COS	809
	RAD	$\pi \div 3 =$	COS	1031
	GRAD	200 $\div$ 3 =	COS	1176
TAN	DEG	4 5	TAN	386
	RAD	$\pi \div 4 =$	TAN	143
	GRAD	5 0	TAN	154
SIN^{-1}	DEG	0. 5	SIN^{-1}	836
	RAD	0. 5	SIN^{-1}	653
	GRAD	0. 5	SIN^{-1}	825
COS^{-1}	DEG	0. 5	COS^{-1}	1069
	RAD	0. 5	COS^{-1}	762
	GRAD	0. 5	COS^{-1}	1057
TAN^{-1}	DEG	1	TAN^{-1}	237
	RAD	1	TAN^{-1}	147
	GRAD	1	TAN^{-1}	236
Ln	2 0			ln 160
Log	2 0			log 332

ITEM	OPERATION			CALCULATION SPEED (ms)
e^x		2 0	e^x	315
10^x		1. 2 3	10^x	380
		1 0	10^x	137
$X!$		6 9	$N!$	970
HYP		3 hyp	SIN	623
		3 hyp	COS	627
		3 hyp	TAN	766
ARC HYP		3 hyp ⁻¹	SIN	607
		3 hyp ⁻¹	COS	677
		0.5 hyp ⁻¹	TAN	574
X^2		2 0	X^2	64
$\sqrt{\quad}$		2 0	$\sqrt{\quad}$	217
$1/X$		2 0	$1/X$	80
$\sqrt[3]{\quad}$		2 0	$\sqrt[3]{\quad}$	604
Mutual Conversion	DEC	1 2 3	→BIN	118
		1 2 3 4 5	→OCT	134
		1 2 3 4 5	→HEX	120
	BIN	1 0 1 0 1	→DEC	93
	OCT	1 2 3 4 5	→DEC	112
	HEX	A B C D E	→DEC	181
→DEG		1.2 3 4 5	→DEG	265
→DMS		1.2 3 4 5	→DMS	304
R→P	DEG	$\sqrt[3]{\quad} X \leftrightarrow Y$ 1	R→P	920
	RAD	$\sqrt[3]{\quad} X \leftrightarrow Y$ 1	R→P	723
	GRAD	$\sqrt[3]{\quad} X \leftrightarrow Y$ 1	R→P	919
P→R	DEG	2 $X \leftrightarrow Y$ 3 0	P→R	1543
	RAD	2 $X \leftrightarrow Y$ 30 DRG▶	P→R	1461
	GRAD	2 $X \leftrightarrow Y$ 30 DRG▶ DRG▶	P→R	2089
→RAD	DEG	3 6 0	DRG▶	147
→GRAD	RAD	2 $\times \pi =$	DRG▶	100
→DEG	GRAD	4 0 0	DRG▶	71
Memory		1 2 3	$X \rightarrow M$	47
		1 2 3 $X \rightarrow M$	$M +$	65
		1 2 3 $X \rightarrow M$	RM	41
		1 2 3 $X \rightarrow M$	$X \leftrightarrow M$	54
%		1 2 3 + 4 5 6	%	86
		1 2 3 - 4 5 6	%	86
		1 2 3 $\times$ 4 5 6	%	56
		1 2 3 $\div$ 4 5 6	%	56
Exchange		1 2 3 + 4 5 6	$X \leftrightarrow Y$	52
Shift		1 2 3	→	27

ITEM	OPERATION						CALCULATION SPEED (ms)
Statistic Calculation	1 DATA	2 DATA	3 DATA		8 DATA	9 DATA	125
							n
							$\bar{X}$
							ΣX
							ΣX^2
							σ_{n-1}
							σ_n
Logic operation	HEX	A B C AND D E F				=	603
		A B C OR D E F				=	650
		A B C XOR D E F				=	568
		A B C XNOR D E F				=	961
						A B C NOT	394
NEG	HEX					A B C NEG	375
Fractional number calculation	Function	2 ab/c 3 6 ab/c 2 3 4				—	249
		2 ab/c 3 6 ab/c 2 3 4				÷	253
	4-operation	2 $\frac{\quad}{\quad}$ 36 J 234 + 3 $\frac{\quad}{\quad}$ 45 J 345				=	536
		2 $\frac{\quad}{\quad}$ 36 J 234 - 3 $\frac{\quad}{\quad}$ 45 J 345				=	512
		2 $\frac{\quad}{\quad}$ 36 J 234 × 3 $\frac{\quad}{\quad}$ 45 J 345				=	498
		2 $\frac{\quad}{\quad}$ 36 J 234 ÷ 3 $\frac{\quad}{\quad}$ 45 J 345				=	562

OPERATION RANGE AND ACCURACY

FUNCTION	ANGLE UNIT	OPERATION RANGE	UNDER FLOW AREA	NORMAL ACCURACY
SIN X	DEG	$0 \leq X \leq 4.499999999 \times 10^{10}$	$0 \leq X \leq 5.729577951 \times 10^{-98}$	± 1 in 10th significant digit
	RAD	$0 \leq X \leq 785398163.3$	—	
	GRAD	$0 \leq X \leq 4.999999999 \times 10^{10}$	$0 \leq X \leq 6.366197723 \times 10^{-98}$	
COS X	DEG	$0 \leq X \leq 4.500000008 \times 10^{10}$	—	
	RAD	$0 \leq X \leq 785398164.9$	—	
	GRAD	$0 \leq X \leq 5.000000009 \times 10^{10}$	—	
TAN X	DEG	SAME AS SINX except for $ X = (2n - 1) \cdot 90$	SAME AS SINX	
	RAD	SAME AS SINX except for $ X = (2n - 1) \cdot \pi / 2$	SAME AS SINX	
	GRAD	SAME AS SINX except for $ X = (2n - 1) \cdot 100$	SAME AS SINX	
$\text{SIN}^{-1}X$	DEG	$0 \leq X \leq 1$	$0 \leq X \leq 1.570796326 \times 10^{-99}$	
	RAD	$0 \leq X \leq 1$	—	
	GRAD	$0 \leq X \leq 1$	$0 \leq X \leq 1.570796326 \times 10^{-99}$	
$\text{COS}^{-1}X$	DEG	SAME AS $\text{SIN}^{-1}X$	—	
	RAD	SAME AS $\text{SIN}^{-1}X$	—	
	GRAD	SAME AS $\text{SIN}^{-1}X$	—	
$\text{TAN}^{-1}X$	DEG	$0 \leq X \leq 9.999999999 \times 10^{99}$	SAME AS $\text{SIN}^{-1}X$	
	RAD	$0 \leq X \leq 9.999999999 \times 10^{99}$	—	
	GRAD	$0 \leq X \leq 9.999999999 \times 10^{99}$	SAME AS $\text{SIN}^{-1}X$	

FUNCTION	OPERATION RANGE	UNDER FLOW AREA	NORMAL ACCURACY
LN X	$0 < X$	—	± 1 in 10th significant digit
LOG X	$0 < X$	—	
e^x	$-9.99999999 \times 10^{99} \leq X \leq 230.2585092$	$-9.99999999 \times 10^{99} \leq X \leq -227.9559243$	
10^x	$-9.99999999 \times 10^{99} \leq X \leq 99.99999999$	$-9.99999999 \times 10^{99} \leq X \leq -99.00000001$	
X!	$0 \leq X \leq 69$ (INTEGER)	—	
$\frac{1}{X}$	$1 \times 10^{-99} \leq X \leq 9.99999999 \times 10^{99}$	$1.000000001 \times 10^{99} \leq X \leq 9.99999999 \times 10^{99}$	
X^2	$0 \leq X \leq 9.99999999 \times 10^{49}$	$\leq X \leq 3.162277660 \times 10^{-50}$	
$\sqrt{X}$	$0 \leq X \leq 9.99999999 \times 10^{99}$	—	
$\sqrt[3]{X}$	$0 \leq X \leq 9.99999999 \times 10^{99}$	—	
DMS→DEG	$0 \leq X \leq 9.99999999 \times 10^9$	—	± 1 in least significant digit
DEG→DMS	$0 \leq X \leq 9999999.999$	$0 \leq X \leq 1.388888888 \times 10^{-6}$	
SINH X	$0 \leq X \leq 230.2585092$	—	± 1 in 10th significant digit
COSH X	$0 \leq X \leq 230.2585092$	—	
TANH X	$0 \leq X \leq 9.99999999 \times 10^{99}$	—	
$\sinh^{-1}X$	$0 \leq X \leq 4.99999999 \times 10^{99}$	—	
$\cosh^{-1}X$	$1 \leq X \leq 4.99999999 \times 10^{99}$	—	
$\tanh^{-1}X$	$0 \leq X \leq 9.99999999 \times 10^{-1}$	—	
R→P ($xy \rightarrow \gamma\theta$)	$ x , y \leq 9.99999999 \times 10^{49}$ $(x^2 + y^2) \leq 9.99999999 \times 10^{99}$ $\frac{Y}{X}$; SAME AS $\tan^{-1}X$	$\frac{Y}{X}$; SAME AS $\tan^{-1}X$	
P→R ($\gamma\theta \rightarrow xy$)	$0 \leq \gamma \leq 9.99999999 \times 10^{99}$ θ ; SAME AS SIN X, COS X	θ ; SAME AS SIN X, COS X	
DEG→RAD	$0 \leq X \leq 9.99999999 \times 10^{99}$	$0 \leq X \leq 5.729577951 \times 10^{-98}$	
RAD→GRAD	$0 \leq X \leq 1.570796326 \times 10^{98}$	—	± 1 in 10th significant digit
GRAD→DEG	$0 \leq X \leq 9.99999999 \times 10^{99}$	$0 \leq X \leq 1.111111111 \times 10^{-99}$	
γ^x	$-9.99999999 \times 10^{99} \leq X \cdot \ln Y \leq 230.2585092$ (1) $Y > 0$...The above-mentioned operation range. (2) $Y < 0$...X (Integer) or, $1/X$ (Odd, $X \neq 0$)...The above-mentioned operation range. (3) $Y = 0$... $0 < X$	$-9.99999999 \times 10^{99} \leq X \cdot \ln Y \leq -227.9559243$	

FUNCTION	OPERATION RANGE	UNDER FLOW AREA	NORMAL ACCURACY
$\sqrt[n]{Y}$	$-9.999999999 \times 10^{99}$	$-9.999999999 \times 10^{99}$	± 1 in 10th significant digit
	$\leq \frac{1}{X} \cdot \text{LN } Y \leq 230.2585092$	$\leq \frac{1}{X} \cdot \text{LN } Y \leq -227.95593243$	
	(1) $Y > 0 \cdots$ The above-mentioned operation range. (2) $Y < 0 \cdots X$ (Odd) or $1/X$ (Integer, $X \neq 0$) $\cdots$ The above-mentioned operation range. (3) $Y = 0 \cdots 0 < X$		
$\rightarrow \text{DEC}$	Operation range		—
	The following operation range after the conversion. $0 \leq X \leq 9999999999$		
$\rightarrow \text{BIN}$	The following operation range after the conversion. $1000000000 \leq X \leq 1111111111$ $0 \leq X \leq 1111111111$		—
$\rightarrow \text{OCT}$	The following operation range after the conversion. $4000000000 \leq X \leq 7777777777$ $0 \leq X \leq 3777777777$		—
$\rightarrow \text{HEX}$	The following operation range after the conversion. $\text{FDABF41CO1} \leq X \leq \text{FFFFFFFF}$ $0 \leq X \leq 2540\text{BE3FF}$		—
AND OR XOR XNOR	BIN ; $1000000000 \leq X \leq 1111111111$ $0 \leq X \leq 1111111111$ OCT ; $4000000000 \leq X \leq 7777777777$ $0 \leq X \leq 3777777777$ HEX ; The following operation range after the operation. $\text{FDABF41CO1} \leq X \leq \text{FFFFFFFF}$ $0 \leq X \leq 2540\text{BE3FF}$		—
NOT	BIN ; SAME AS AND OCT ; SAME AS AND HEX ; $\text{FDABF41CO1} \leq X \leq \text{FFFFFFFF}$ $0 \leq X \leq 2540\text{BE3FE}$		—
NEG	BIN ; $1000000001 \leq X \leq 1111111111$ $0 \leq X \leq 1111111111$ OCT ; $4000000001 \leq X \leq 7777777777$ $0 \leq X \leq 3777777777$ HEX ; $\text{FDABF41CO1} \leq X \leq \text{FFFFFFFF}$ $0 \leq X \leq 2540\text{BE3FF}$		—

FUNCTION		OPERATION RANGE	NORMAL ACCURACY
Statistic	DATA DEL	$ x \leq 9.999999999 \times 10^{49}$ $ \sum x \leq 9.999999999 \times 10^{99}$ $\sum x^2 \leq 9.999999999 \times 10^{99}$ $0 \leq n \leq 9999999999$. n = Integer	± 1 in 10th significant digit
	$\bar{x}$	$n \neq 0$	
	σ_{n-1}	$n \neq 1, n \neq 0$ $0 \leq \frac{\sum X^2 - \{(\sum X)^2 / n\}}{n-1} \leq 9.999999999 \times 10^{99}$	
	σ_n	$n \neq 0$ $0 \leq \frac{\sum X^2 - \{(\sum X)^2 / n\}}{n} \leq 9.999999999 \times 10^{99}$	

MAXIMUM RATINGS (Ta = 25°C)

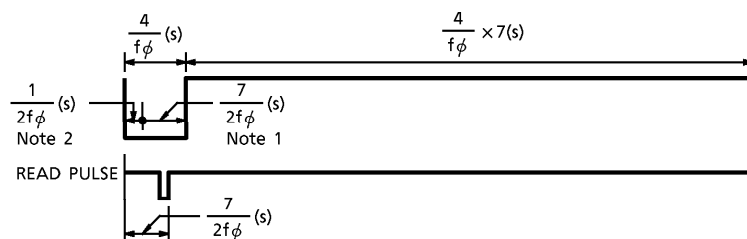
CHARACTERISTICS	SYMBOL	RATING	UNIT
Supply Voltage	V _G	+0.3 ~ -2.2	V
Input Voltage	V _{IN}	+0.3 ~ V _G - 0.3	V
Operating Temperature	T _{opr}	0 ~ 40	°C
Storage Temperature	T _{stg}	-55 ~ 125	°C

ELECTRICAL CHARACTERISTICS (V_G = -1.5V ± 0.2V, V_{SS2} = -3.0 ± 0.4V, V_{DD} = 0V, Ta = 25°C)

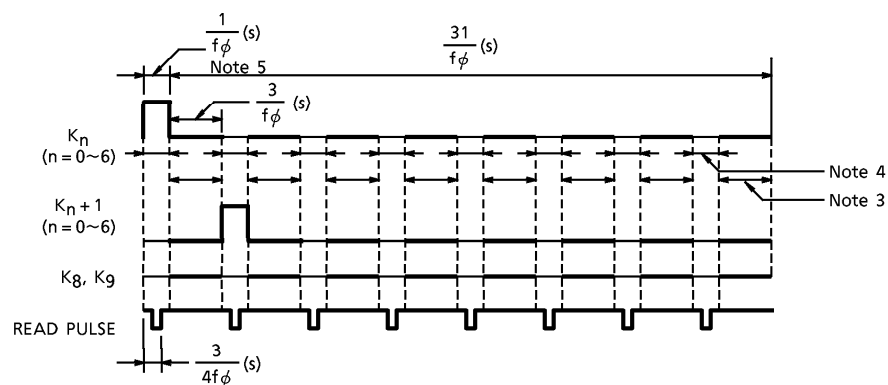
CHARACTERISTICS	SYMBOL	TEST CIR-CUIT	PIN NAME	TEST CONDITION	MIN	TYP.	MAX	UNIT
Operating Voltage	V _G	—	—	—	-1.2	-1.5	-2.0	V
Supply Current (I)	I _{DD} WAIT	—	—	V _G = -1.5V, wait	—	2.0	3.0	μA
Supply Current (II)	I _{DD} OP	—	—	V _G = -1.2V, operate	—	4.5	7.0	μA
Oscillating Frequency (I)	F _φ WAIT	—	—	V _G = -1.5V, wait	5.4	9.0	12.6	kHz
Oscillating Frequency (II)	F _φ OP	—	—	V _G = -1.5V, operate	14.4	24.0	33.6	kHz
Frame Frequency	f _F	—	—	V _G = -1.5V, wait	56.3	93.8	131.3	Hz
"1" Input Voltage	V _{IH}	—	K ₂ ~K ₉ RESET	—	V _G + 0.4	—	V _G	V
"0" Input Voltage	V _{IL}	—	K ₂ ~K ₉ RESET	—	V _{DD}	—	-0.4	V
"1" Output Voltage	V _{OH} (I)	—	SEGMENT COM1~3	—	V _{SS2} + 0.2	—	V _{SS2}	V
"0" Output Voltage	V _{OL} (I)	—	SEGMENT COM1~3	—	V _{DD}	—	-0.2	V

CHARACTERISTICS	SYMBOL	TEST CIRCUIT	PIN NAME	TEST CONDITION	MIN	TYP.	MAX	UNIT
"M" Output Voltage	V_{OM}	—	COM1~3	—	$V_{SS1} + 0.2$	—	$V_{SS1} - 0.2$	V
"1" Output Voltage	$V_{OH} (II)$	—	$K_0 \sim K_9$ RESET	—	$V_{SS1} + 0.2$	—	V_{SS1}	V
"0" Output Voltage	$V_{OL} (II)$	—	$K_0 \sim K_9$ RESET	—	V_{DD}	—	-0.2	V
"1" Output Resistance	R_{OH}	—	SEGMENT COM1~3	$V_{OUT} = V_{SS2} + 0.5V$	—	—	70	$k\Omega$
"0" Output Resistance	R_{OL}	—	SEGMENT COM1~3	$V_{OUT} = -0.5V$	—	—	70	$k\Omega$
RESET Pull Up Resistance (I)	$R_{RESETH} (I)$	—	RESET	$V_{OUT} = 0V$ (Note 1)	156	260	364	$k\Omega$
RESET Pull Up Resistance (II)	$R_{RESETH} (II)$	—	RESET	$V_{OUT} = 0V$ (Note 2)	18	75	300	$k\Omega$
Key Pull Up Resistance (I)	$R_{KEYH} (I)$	—	$K_0 \sim K_9$	$V_{OUT} = V_G + 0.5V$ (Note 3)	—	—	500	$k\Omega$
Key Pull Up Resistance (II)	R_{KEYH}	—	$K_0 \sim K_9$	$V_{OUT} = 0V$ (Note 4)	60	300	1500	$k\Omega$
Key RESET Pull Down Resistance	$R_{KEYL} RESETL$	—	$K_0 \sim K_9$ RESET	$V_{OUT} = -0.5V$ (Note 5)	—	—	25	$k\Omega$

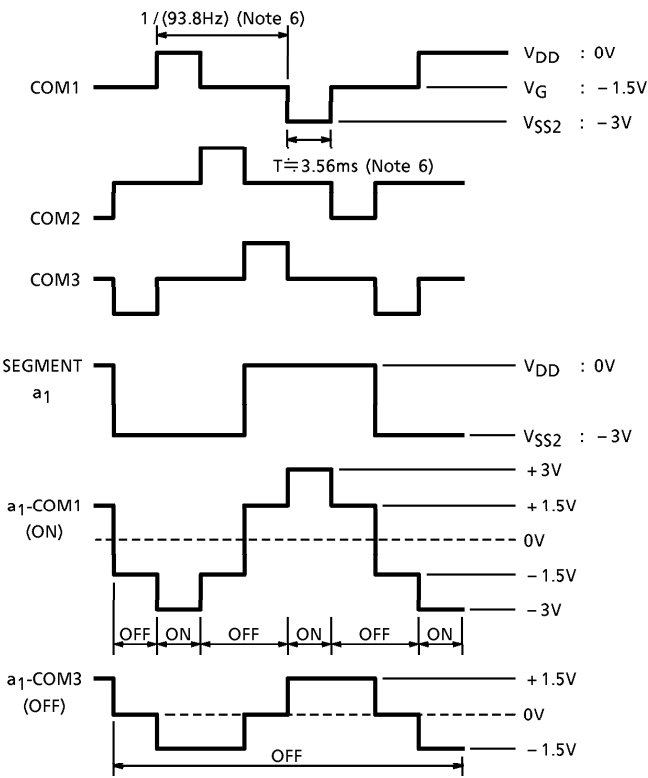
(Note 1, 2, 5) RESET Waveform, 1-cycle



(Note 3, 4, 5) KEY Waveform, 1-cycle



WAVEFORMS FOR DISPLAY



(Note 6) : $F_{\phi} \text{ WAIT} = 9\text{kHz}$

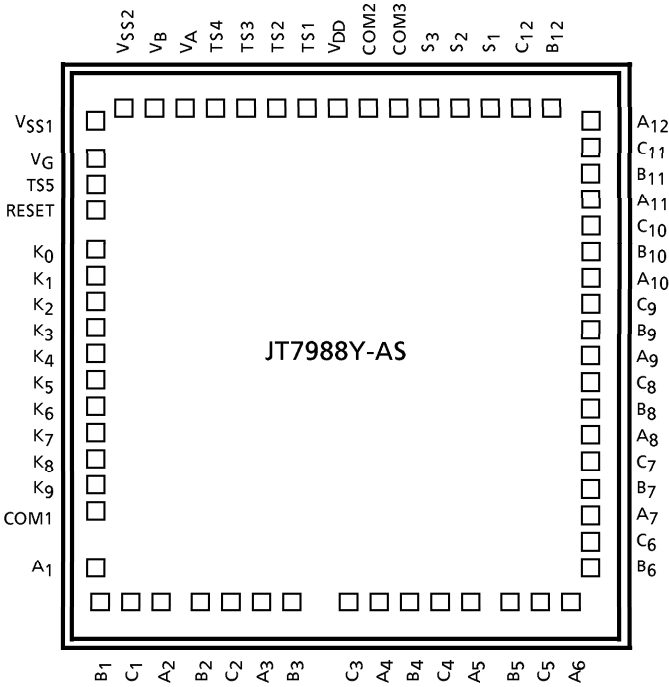
PAD LOCATION TABLE

NAME	X POINT	Y POINT
V _{SS2}	– 1215	1536
V _{SS1}	– 1404	1494
VG	– 1404	1260
TS5	– 1404	1059
RESET	– 1404	873
K ₀	– 1404	612
K ₁	– 1404	450
K ₂	– 1404	288
K ₃	– 1404	126
K ₄	– 1404	– 36
K ₅	– 1404	– 198
K ₆	– 1404	– 360
K ₇	– 1404	– 522
K ₈	– 1404	– 684
K ₉	– 1404	– 846
COM1	– 1404	– 1008
A ₁	– 1404	– 1377
B ₁	– 1326	– 1539
C ₁	– 1164	– 1539
A ₂	– 1002	– 1539
B ₂	– 758	– 1539
C ₂	– 596	– 1539
A ₃	– 434	– 1539
B ₃	– 272	– 1539
C ₃	127	– 1539
A ₄	289	– 1539
B ₄	451	– 1539
C ₄	613	– 1539
A ₅	775	– 1539
B ₅	1002	– 1539
C ₅	1164	– 1539
A ₆	1326	– 1539

(μm)

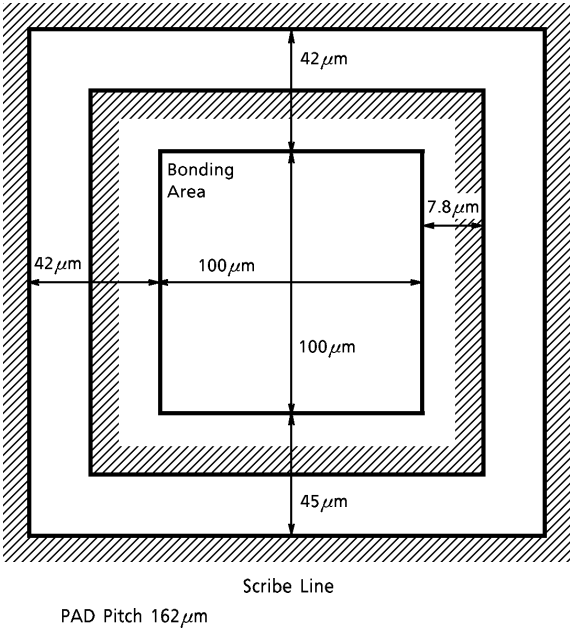
NAME	X POINT	Y POINT
B ₆	1404	– 1377
C ₆	1404	– 1170
A ₇	1404	– 1008
B ₇	1404	– 846
C ₇	1404	– 684
A ₈	1404	– 522
B ₈	1404	– 360
C ₈	1404	– 198
A ₉	1404	– 36
B ₉	1404	126
C ₉	1404	288
A ₁₀	1404	450
B ₁₀	1404	612
C ₁₀	1404	774
A ₁₁	1404	936
B ₁₁	1404	1098
C ₁₁	1404	1260
A ₁₂	1404	1494
B ₁₂	1215	1536
C ₁₂	1053	1536
S ₁	869	1536
S ₂	707	1536
S ₃	545	1536
COM3	383	1536
COM2	218	1536
V _{DD}	0	1536
TS1	– 218	1536
TS2	– 380	1536
TS3	– 542	1536
TS4	– 729	1536
VA	– 891	1536
VB	– 1053	1536

CHIP LAYOUT



Chip size : 3.08×3.41 [mm]
Chip thickness : 450 ± 20 [μm]
Substrate : VDD

PAD LAYOUT



QFP67-P-1420-0.80

Technical drawing of a rectangular PCB layout. The overall dimensions are 24.1±0.4 (width) and 18.1±0.4 (height). The inner dimensions are 20.0±0.2 (width) and 14.0±0.2 (height). The layout includes several rows of component footprints, labeled with numbers: 54, 33, 55, 67, 32, 22, 1, 21, and 20. Dimensions for the footprints and spacing are provided, including 2.0TYP, 1.2TYP, 2.2TYP, 3.8TYP, 2.2TYP, 2.0TYP, 0.3±0.1, 0.8, 0.15±0.1, 1.85±0.2, 2.25MAX, 0.2+0.1/-0.05, and 1.35±0.2.

2001-06-27

RESTRICTIONS ON PRODUCT USE

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