10 DIGITS SCIENTIFIC CALCULATOR CMOS

GENERAL DESCRIPTION

The TC1599C is the CMOS LSI for a 10-digit display and the complete single chip for scientific calculator with 56 programmed functions.

FUNCTION

(1) Six operations.
- Four operations（＋，－，×，÷）
- y^x
- $\sqrt{y}$
- Auto-constant
- Parenthesis
- Percentage

(2) Memory calculation
Independent single memory（X → M，RM，M＋）

(3) Four operations complex number calculation.

(4) 1-variable functions
- Trigonometirc and arctrigonometric function.
- Hyperbolic and archyperbolic function
- Factorial
- Reciprocal and square
- Square root and cube root
- Time conversions
- Angular mode conversion

(5) 2-variable functions
- Polar-rectangular coordinate conversion

(6) Statistics calculations
- Number of sample (n)
- Average (X)
- Total of all data (Σ X)
- Total of square of all data (Σ x^2)
- 2 kinds of the standard deviation (S， σ)

(7) Binary, octal, decimal and hexadecimal number calculations
- Mutual conversions and calculations of binary. octal, decimal, and hexadecimal numbers.

(8) Display conversion
- Conversion and setting of floating and engineering displays.

FEATURES

(1) Display

- 10 display digits plus negative code digit.
- Scientific and engineering displays.
- 8 mantissa digits plus 2 exponent digits plus 2 negative code digits.

(2) 14 kinds of special display

M	Memory	GRAD	Gradient
—	Minus	( )	Parenthesis
E	Error	BIN	Binary mode
2ndF	2nd Function	OCT	Octal mode
HYP	Hyperbolic	HEX	Hexadecimal mode
DEG	Degree	CPLX	Complex number mode
RAD	Radian	STAT	Statistic calculation mode

(3) The minus sign of the mantissa is floating minus.

(4) The arithmatic key operation has the same sequence as the mathematical equation, 6 pending operations are allowed and ( ) are up to continuous 15 levels.

(5) Mutual conversion and calculation in arithmetic among binary, octal, decimal, and hexadecimal numbers.

(6) One independent accumulating memory.

(7) It is possible to convert and fix the display number system by the F→E key.

(8) It is possible to specify decimal part digits by the TAB key.

(9) Direct drive for LCD (1/3 prebias，1/4 duty)

(10) Automatic power off (about 7.5 minutes)

(11) Low power consumption V_{DD} = 3.0V single power supply.

BASIC SPECIFICATIONS

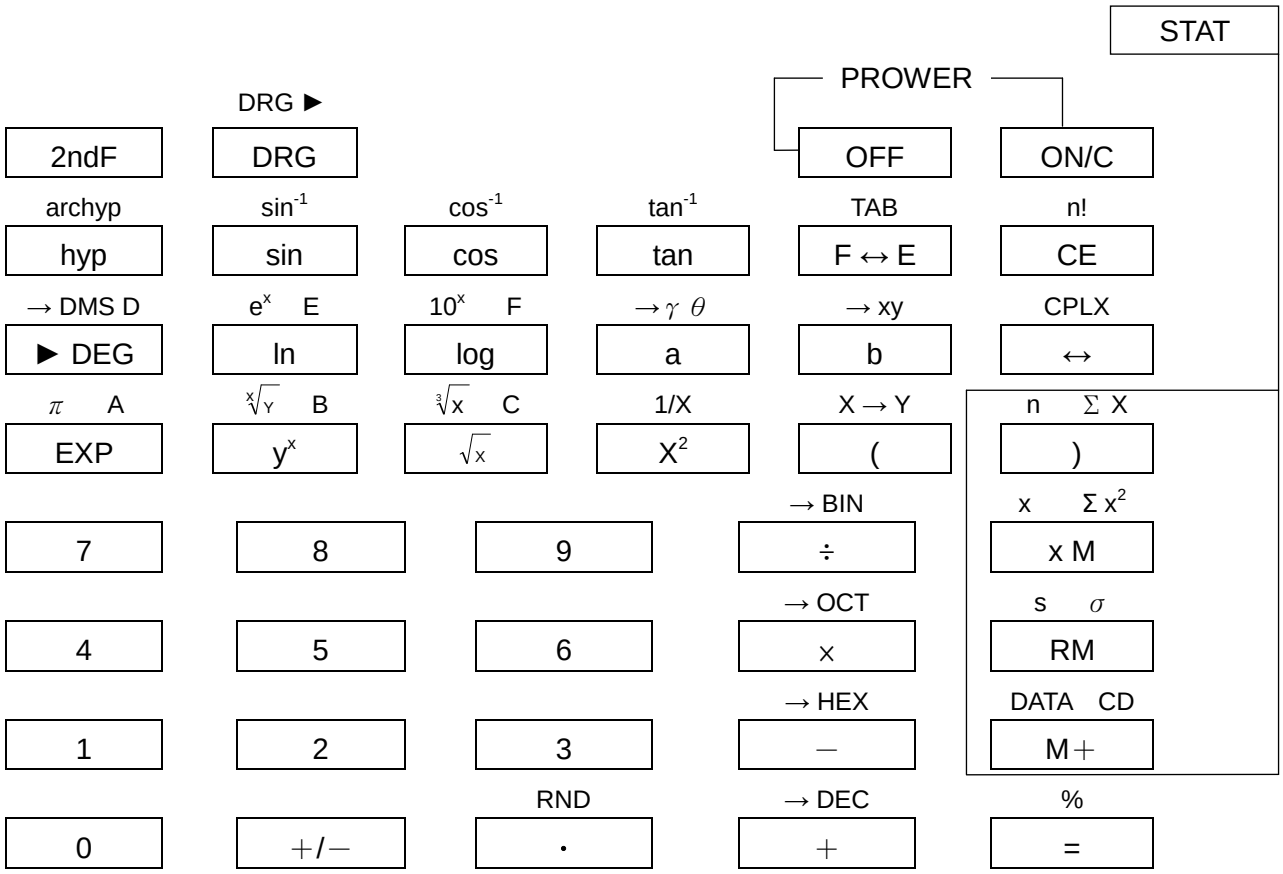
(1) Number of display digits

- 10-digit display and 14 kinds of special displays.
- Engineering display
- Max mantissa 8 digits plus exponent 2 digits plus each negative code digit.
- Normal display
  Max. 10 mantissa digits plus 1 negative code 6 digit.
  It is possible to specify the number of 0 to 9 digits below the decimal place by assignment of the decimal digit.

(2) Classification of operation mode.
The following 6 types of operation mode are set by the 2ndF key and below keys:

2ndF	STAT	:	Statistic calculation mode set
2ndF	CPLX	:	Complex number calculation mode set
2ndF	-BIN	:	Binary mode set
2ndF	-OCT	:	Octal mode set
2ndF	-HEN	:	Hexadecimal mode set
2ndF	-DEC	:	Decimal mode set

(3) Kinds of keys and classification of the multi-functions for all 42 touch keys.



(4) The condition during calculation.
No key input is allowed and no data is displayed during calculation.

(5) Display method.

a. Set number and result of operation are displayed in the right margin, minus floating.

b. Display of decimal number operation results.
Display is made according to the display format that has been set by the F ↔ E key.

・Floating mode

$10^{10} \leqq | \times | \leqq 10^{100}$: Exponent display.

$10^{-99} \leqq | \times | \leqq 10^{-9}$: Exponent display.

0 and $10^{-9} \leqq | \times | \leqq 10^{10}$: Floating display.

・Engineering mode

0 and $10^{-99} \leqq | \times | \leqq 10^{100}$ (all ranges) ;Exponent display.

The F ↔ E key also converts the display format of a displayed numerical value simultaneously with the display format setting.

At the same time, the number of digits below the decimal point of the above modes follows the display format assigned by the 2ndF and F ↔ E keys.

Further, in the same manner as the F ↔ E key, the conversion is also takes place simultaneously with the display format setting.

When the number of digits is specified, the last digit displayed is a rounded number, and when there is no specification of

Example:

2	÷	7	=	0.285714285	F ↔ E			2.857-01

	TAB					TAB		
2ndF	F ↔ E	3	0.286	2ndF	F ↔ E	・	2.8571428-01

c. Negative numbers are not displayed with the minus symbol "—" but are displayed in hexadecimal, octal, and binary two's complements.

d. Display style and special display

・Display style.

・Special display

e. Examples of display

・Floating of -6000 1 /x;TAB = 7

・Same as above, engineering display

・Error display

(6) Protection

a. Memory overflow protection
If the overflow occurs in the memory calculation, the data before the calculation is retained.

b. Statistical overflow protection
If the overflow occurs in the statistical calculation, the data before the calculation is retained.

(7) The number of digits of the internal retained data.
The number of digits of the mantissa of the displayed data is a maximum of 10 digits, but the available data for successive calculations is the internally retained data.
The number of digits of the mantissa of internally retained data is as follows:

a. Data input	Maximum	10 digits
b. Arithmetic	Maximum	10 digits
c. Engineering function		
d. Statistical function		
e. Complex number function		
f. Memory calculation		
g. Number of random	Maximum	3 digits

(8) Auto clear
When the power supply is suddenly turned on an auto clear routine is executed to initialize as DEC mode, no TAB, floating, and DEG modes.

(9) Power off function

a. Auto power off

About 7.5 minutes after operation is ended by pressing the key, the power supply is turned off.

b. OFF

Pressing this key will stop the oscillator. (Memory safe guard)

c. ON

Pressing this key will wake the oscillator and initialize.

OPERATION MODE

(1) Operation mode

Operation \ Mode		DEC	BIN	OCT	HEX	STAT	CPLX
6 Operation	4 Operation ＋，－，×，÷，=	○	○	○	○	○	○
	Power y^x, $\sqrt[x]{Y}$	○	×	×	×	○	×
	Parenthesis ( )	○	○	○	○	×	×
	Constant calculation	○	○	○	○	○	×
	Percentage calculation	○	×	×	×	○	×
STAT	Statistical calculation	×	×	×	×	○	×
CPLX	CPLX calculation	×	×	×	×	×	○
	Input a, b	○	×	×	×	×	○
DATA setting	Numeric input 0, 1	○	○	○	○	○	○
	Numeric input (2-7)	○	×	○	○	○	○
	Numeric input 8, 9	○	×	×	○	○	○
	Hex input A-F	×	×	×	○	×	×
	・, Exp	○	×	×	×	○	○
	＋/－	○	○	○	○	○	○
	Shift key	○	○	○	○	○	○
CE		○	○	○	○	○	○
Memory.	Memory calculation	○	○	○	○	○	○
Display conversion	F ← E, TAB	○	×	×	×	×	×
P-R conversion	P → R R → P	○	×	×	×	×	○
Random	RND	○	×	×	×	○	○
Function	1 variable function	○	×	×	×	○	○
Augular conversion	DRG DRG ►	○	×	×	×	○	○

(2) The calculation is always shifted to a specified mode by mode keys
A Mode B Mode

A / B	DEC	BIN	OCT	HEX	STAT	CPLX
DEC	NOP	DEC Conversion	DEC Conversion	DEC Conversion	DEC Conversion State clear	DEC Conversion State clear
BIN	BIN Conversion	NOP	BIN Conversion	BIN Conversion	BIN Conversion State clear	BIN Conversion State clear
OCT	OCT Conversion	OCT Conversion	NOP	OCT Conversion	OCT Conversion State clear	OCT Conversion State clear
HEX	HEX Conversion	HEX Conversion	HEX Conversion	NOP	HEX Conversion State clear	HEX Conversion State clear
STAT	Display Clear	Display Clear	Display Clear	Display Clear	NOP	Display Clear
CPLX	Display Clear	Display Clear	Display Clear	Display Clear	Display Clear State clear	NOP

NOP:NO operation.

KEY DEFINITIONS

(1) 2ndF
This is the key for specifying the second function.
When this key is pressed, the special display "2ndF" lights. When this key is pressed twice the second function mode is released.

(2) DRG DRG ►

a. Pressing this key will change the mode of angle sequencially
DEG → RAD → GRAD and display it.

b. Pressing this key after 2ndF key will change the mode of the angle and will convert the displayed data.

DEC → RAD : $RAD = DEG \times \frac{\pi}{180}$

RAD → GRAD : $GRAD = RAD \times \frac{200}{\pi}$

GRAD → DEG : $DEG = GRAD \times 0.9$

(3) 0-9

a. In setting data in the mantissa section, it is set at the right margin, and the data in more than 11 digits cannot be input.

b. At the data input against the exponent, the last two numbers are efficients.

(4) ・RND

a. The position first pressed has preference, and no input is made to data set in the exponent section.

b. When pressed as the first set number, it is regarded as 0 and ・keys are pressed.

c. Random as a 2ndF
Pressing this key shall display the random numbers.
The range of random numbers is 0.0000-0.999.

(5) ＋/－

a. In setting data in the mantissa section, this key reverses the code in the mantissa section. Similarly, for the exponent section, it reverses the code in the exponent section.

b. For the operation result, this key reverse codes in the mantissa section.

(6) ＋ － × ÷ ＝ ( )

a. When the key operations are performed by these keys according to a numerical expression, a result of the operation is obtained according to mathematical priorities. discriminated are:

1) 1 Variable function

2) Expression in ( ): (The most inner expression has priority in case of multiple parentheses)

3) y^x, $\sqrt[x]{y}$

4) ×，÷

5) ＋，－

b. Whenever the key is operated, the calculator discriminates the above priorities and holds the data and operation keys pending as required.
This pending action is possible up to 6 times and 7 or more pending become error.

c. (Key in accepted only immediately after CE，＋，－，×，÷ y3x，$\sqrt[x]{y}$ ，=，(Keys and not accepted in all other cases.
When this key is accepted, the displayed data is cleared to 0.
When (key is first accepted, the special display "( )" illuminates.
When a parenthesis expression is completed) and = keys or when it is cleared by the ON/C key ,etc, or when errors are generated, the special display "( )" goes out.

d. If it is within the allowable range of pending.(can be input into any place in an expression as many times as desired.
However, if the key is pressed continuously 16 times or more, it be comes error.

e. From a viewpoint of numerical expression, even when the corresponding C key is not pressed, the operation is not executed if the ") " key is pressed. On the other hand, when the " (" key is pressed and the "=" key is pressed without pressing the corresponding ") " key, the operation is also completed according to the priority.

(7) Memory calculation (x → M，RM，M＋)

a. The memory register "M" used by these keys is a completely independent single memory.

b. Display data is added to "M" (memory register) by M＋key.
If data overflows at this time, the proceeding data is held.

c. Display data is stored in "M" by x → M key.

d. Contents of "M" is displayed by MR key.

e. When any data except for 0 is stored in "M" ,the special display "M" illuminates.

(8) π

a. This key displays a rounded value (3.141592654) of a 12-digit value (3.14159265359) according to the set display format.

b. A value that is used in a subsequent operation is the above the 12-digit value.

c. The display is cleared by the following 1 st numeric key and new data is set.

(9) % Calculation

a. When any arithmetic functions or constant mode has/not been set, the displayed number is converted from a percentage to a decimal.
Example) 61.5%

	Display
6 1. 5 %	0.615

b. When = key is pressed after % with any arithmetic function

· Add-on

$a + b \quad \% \quad = \quad \rightarrow a + \frac{a \times b}{100}$

· y^x , $\sqrt[x]{y}$

$a\ y^x\ b \quad \% \quad = \quad \rightarrow a^t \left(t = \frac{b}{100} \right)$

· Discount

$a - b \quad \% \quad = \quad \rightarrow a - \frac{a \times b}{100}$

$a\ \sqrt[x]{y}\ b \quad \% \quad = \quad \rightarrow \sqrt[t]{a} \left(t = \frac{b}{100} \right)$

· Percentage

$a \times b \quad \% \quad = \quad \rightarrow \frac{a \times b}{100}$

$a \div b \quad \% \quad = \quad \rightarrow \frac{a}{b} \times 100$

(10) Trigonometric and arctrigonometric functions (1 Variable)
(sin cos tan $\sin^{-1}$ $\cos^{-1}$ $\tan^{-1}$)
These functions are calculated according to respective defined areas and accuracy show in (6) ,and displayed result of operation can become operators.

(11) Hyperbolic and archyperbolic function.
(hyp → sin cos tan, archyp → sin cos tan)
Same as trigonometric function.

(12) Exponential and logarithmic functions.
(e^x 10^x In log)
Same sa trigonometric functions.

(13) Reciprocal, square, square root and cube root.
(1/x x^2 $\sqrt{}$ $\sqrt[3]{}$)
Same as trigonometric functions.

(14) Factorial function (n!)
$n! = n \times (n-1) \times (n-2) \times .....\times 2 \times 1$
Same as trigonometric functions.

(15) → DEG → DMS

a. These keys convert degrees, minutes and seconds into decimal degrees and decimal degrees into degree minutes and seconds.

b. On the DMS format, the integer part of display data is regarded as degrees, 2 digits below the decimal point as minutes and the 3rd digit and below as seconds.

1.999999999	-DMS	1 degree	59 minute	5999 second

(16) Coordinate conversion (a b → r θ → xy)

a. These keys convert the rectangular coordinates into the polar coordinates and the polar coordinates into the rectangular coordinates. The angle units that have been set by the DRG key follows.

b. Respective defined areas and accuracy are as shown ic (6), however, the range of θ obtained by R → P in degree is as follows:

1st	Quadrant	$0^\circ \leqq \theta \leqq$	90°
2nd	Quadrant	$90^\circ \leqq \theta \leqq$	180°
3rd	Quadrant	$-180^\circ \leqq \theta \leqq$	-90°
4th	Quadrant	$-90^\circ \leqq \theta \leqq$	0°

c. Input of 2 variables is performed by setting
X or r by pressing a key and
Y or θ by pressing b key.

d. The operation result of X or R is obtained in the display register or by pressing a key and Y or θ by pressing b key.

	Input Data		Result	
	a	**b**	**a**	**b**
R → P (Rectangular → Polar)	X	Y	r	θ
P → R (Polar → Rectangular)	r	θ	X	Y

(→ r, θ) r = $\sqrt{x^2 + y^2}$, θ = $\tan^{-1}$ y/x

(→ x,y) x = rcos θ , y = rsin θ

e. (R → P Conversion) ([x,y] → [r, θ])

Key operation	Display
x	x
a	x
y	y
b	y
→ r θ	r
b	θ

f. (P → R Conversion) ([r, θ] → [x,y])

θ	θ
b	θ
r	r
a	r
→xy	x
b	y

(17) Binary mode (2ndF, → BIN, 0,1)

a. Data input and output are both binary integers in a maximum of 10 digits.

b. A negative number is expressed in binary number of two's complement.

c. The range of internal operation is as shown below and if the result of the operation exceed the range, it becomes an error (overflow)

	Binary Number	Decimal Number
Outside the operation range	—	512 ≦ DATA
Binary Positive Integer	1 1 1 1 1 1 1 1 1	511
	1 1 1 1 1 1 1 1 0	510
	1 1 1 1 1 1 1 0 1	509
	:	:
	:	:
	1 0	2
	1	1
	0	0
Binary Positive Integer (Complement)	1 1 1 1 1 1 1 1 1	-1
	1 1 1 1 1 1 1 1 0	-2
	1 1 1 1 1 1 1 0 1	-3
	: :	:
	: :	:
	1 0 0 0 0 0 0 0 0 1	-511
	1 0 0 0 0 0 0 0 0 0	-512
Outside the operation range		-512 ≧ DATA

(18) Octal mode (2ndF, → OCT, 0-7)

a. Data input and output are both octal integers with a maximum of 10 digits.

b. A negative number is expressed in the octal number display of two's complement.

c. The range of internal operation is as shown below and if the result of the operation exceeds the range, it becomes an error(overflow)

	Octal Number	Decimal Number
Outside the operation range	—	5 3 6 8 7 0 9 1 2 ≦ DATA
Binary Positive Integer	3 7 7 7 7 7 7 7 7 7 3 7 7 7 7 7 7 7 7 6 : : 1 0	5 3 6 8 7 0 9 1 1 5 3 6 8 7 0 9 1 0 : : 1 0
Octal Negative Integer (Complement)	7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 6 1 1 1 1 1 1 1 0 1 : : : : 4 0 0 0 0 0 0 0 0 1 4 0 0 0 0 0 0 0 0 0	-1 -2 : : - 5 3 6 8 7 0 9 1 1 - 5 3 6 8 7 0 9 1 2
Outside the operation range		-5 3 6 8 7 0 9 1 3 ≧ DATA

(19) Hexadecimal Mode (2ndF, → HEX, 0 - 9, A-F)

a. Data input and output are both hexadecimal integers with a maximum of 10 digits.

b. A negative number is expressed in a hexadecimal number of two's complement.

c. The range of internal operation is as shown below and if the result of operation exceeds the range, it becomes an error (overflow)

	Hexadecimal Number	Decimal Number
Outside the operation range	—	$1 \times 10^{10} \leqq$ DATA
Hexadecimal Positive Integer	2 5 4 0 B E 3 F F 2 5 4 0 B E 3 F E : : 1 0	9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 8 : : 1 0
Hexadecimal Negative Integer (Complement)	F F F F F F F F F F F F F F F F F E : : F D A B F 4 1 C 0 2 F D A B F 4 1 C 0 1	-1 -2 : : - 9 9 9 9 9 9 9 9 8 - 9 9 9 9 9 9 9 9 9
Outside the operation range		$-1 \times 10^{10} \geqq$ DATA

(20) Complex number mode (2ndF , CPLX)

a. Pressing these keys shall set the complex number mode.

b. Input of 2 parts is performed by setting the real part (× ; Pressing a key) and the imaginary part (Y ; pressing b key)

c. The operation result of the real part is obtained by pressing = or a key and the imaginary part by pressing b key.

Item	Input Data 1		Function	Input Data 2		Result	
	Real	Imaginary		Real	Imaginary	Real	Imaginary
	a	b		a	b	a	b
Addition	X1	Y1	+	X2	Y2	X1 + X2	Y1 + Y2
Subtraction	X1	Y1	–	X2	Y2	X1 – X2	Y1 – Y2
Multiplication	X1	Y1	×	X2	Y2	X1X2 – Y1Y2	Y1X2 + X1Y2
Division	X1	Y1	÷	X2	Y2	$\frac{X1X2 + Y1Y2}{X2^2 + Y2^2}$	$\frac{Y1X2 + X1Y2}{X2^2 + Y2^2}$

(21) Static calculation mode (2ndF , STAT)

a. Pressing these keys shall set the static calculation mode.

b. The available number of data is a positive integer, such as $0 \leqq n \leqq 9999999999$, and when the number of data exceeds this integer, it becomes an error.

c. The input range of the data is as follows: $0 \leqq |\text{ data }| \leqq 1 \times 10^{50}$

d. n ΣX ΣX^2

These keys display the number of data (sample) , each sum total of x and sum total of x^2

· Average;$x = \frac{\sum_{i=1}^{n} xi}{n} = \frac{\Sigma x}{n}$

· The standard deviation of the sample

$$S = \sqrt{\frac{\sum_{i=1}^{n} (xi - x)^2}{n-1}} = \sqrt{\frac{\Sigma x^2 - (\Sigma x)^2 / n}{n-1}}$$

The standard deviation of the population

$$\sigma = \sqrt{\frac{\sum_{i=1}^{n} (xi - x)^2}{n}} = \sqrt{\frac{\Sigma x^2 - (\Sigma x)^2 / n}{n}}$$

ERROR CONDITIONS

(1) The result of operation in exponent parts exceed ＋99

(2) Entering more then the calculation range (6) of each function.

(3) Dividing by zero.

(4) In statistical calculation.

a. x, s, σ when n=0

b. s when n=1

(5) The number of pending operations exceeds 3

(6) The number of the parenthesis in the one level exceeds 15.

OPERATION RANGE AND ACCURACY.

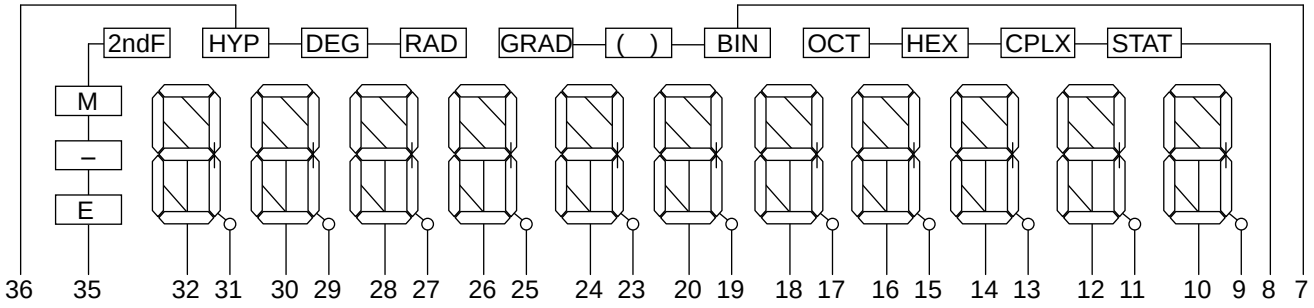
Function	Angle Unit	Opreation Range	Under Flow Area	Normal Accuracy
sin x	DEG	$0 \leqq \lvert X \rvert \leqq 4.499999999 \times 10^{10}$	$0 \leqq \lvert X \rvert \leqq 5.729577951 \times 10^{-98}$	10 digits ± 1
	RAD	$0 \leqq \lvert X \rvert \leqq 7853981633$	—	
	GRAD	$0 \leqq \lvert X \rvert \leqq 4.999999999 \times 10^{10}$	$0 \leqq \lvert X \rvert \leqq 6.366197723 \times 10^{-98}$	
cos x	DEG	$0 \leqq \lvert X \rvert \leqq 4.500000008 \times 10^{10}$	—	
	RAD	$0 \leqq \lvert X \rvert \leqq 7853981649$	—	
	GRAD	$0 \leqq \lvert X \rvert \leqq 5.000000009 \times 10^{10}$	—	
tan x	DEG	Same as sin x	Same as sin x	
	RAD	Same as sin x	Same as sin x	
	GRAD	Same as sin x	Same as sin x	
$\sin^{-1}$ x	DEG	$0 \leqq \lvert X \rvert \leqq 1$	$0 \leqq \lvert X \rvert \leqq 1.570796326 \times 10^{-99}$	
	RAD	$0 \leqq \lvert X \rvert \leqq 1$	—	
	GRAD	$0 \leqq \lvert X \rvert \leqq 1$	$0 \leqq \lvert X \rvert \leqq 1.570796326 \times 10^{-99}$	
$\cos^{-1}$ x	DEG	Same as $\sin^{-1}$ x	—	
	RAD	Same as $\sin^{-1}$ x	—	
	GRAD	Same as $\sin^{-1}$ x	—	
$\tan^{-1}$ x	DEG	$0 \leqq \lvert X \rvert \leqq 9.999999999 \times 10^{99}$	Same as $\sin^{-1}$ x	
	RAD	$0 \leqq \lvert X \rvert \leqq 9.999999999 \times 10^{99}$	—	
	GRAD	$0 \leqq \lvert X \rvert \leqq 9.999999999 \times 10^{99}$	Same as $\sin^{-1}$ x	
ln x		$0 \leqq X$	—	
logx		$0 \leqq X$	—	
e^x		$-9.999999999 \times 10^{99} \leqq X \leqq 230.2585092$	$-9.999999999 \times 10^{99} \leqq X \leqq -227.9559243$	
10^x		$-9.999999999 \times 10^{99} \leqq X \leqq 99.99999999$	$-9.999999999 \times 10^{99} \leqq X \leqq -99.00000001$	10 digits ± 1
x!		$0 \leqq X \leqq 69$ (integer)	—	
$\frac{1}{x}$		$1 \times 10^{-99} \leqq \lvert X \rvert \leqq 9.999999999 \times 10^{99}$	$1.000000001 \times 10^{99} \leqq \lvert X \rvert \leqq 9.999999999 \times 10^{99}$	
x^2		$0 \leqq \lvert X \rvert \leqq 9.999999999 \times 10^{49}$	$0 \leqq \lvert X \rvert \leqq 3.162277660 \times 10^{-50}$	
$\sqrt{x}$		$0 \leqq \lvert X \rvert \leqq 9.999999999 \times 10^{99}$	—	
$\sqrt[3]{x}$		$0 \leqq \lvert X \rvert \leqq 9.999999999 \times 10^{99}$	—	
DMS → DEG		$0 \leqq \lvert X \rvert \leqq 9.999999999 \times 10^{9}$	—	
DEG → DMS		$0 \leqq \lvert X \rvert \leqq 9.999999999 \times 10^{9}$	$0 \leqq \lvert X \rvert \leqq 2.777777777 \times 10^{-99}$	
sinh x		$0 \leqq \lvert X \rvert \leqq 230.2585092$	—	
cosh x		$0 \leqq \lvert X \rvert \leqq 230.2585092$	—	
tanh x		$0 \leqq \lvert X \rvert \leqq 9.999999999 \times 10^{99}$	—	
sinh-1 x		$0 \leqq \lvert X \rvert \leqq 4.999999999 \times 10^{99}$	—	
cosh-1 x		$1 \leqq \lvert X \rvert \leqq 4.999999999 \times 10^{99}$	—	
tanh-1 x		$0 \leqq \lvert X \rvert \leqq 9.9999999999 \times 10^{-1}$	—	
R → P(x,y)(r, θ)		$\lvert X \rvert, \lvert Y \rvert \leqq 9.999999999 \times 10^{49}$ $(x^2+y^2) \leqq 9.999999999 \times 10^{99}$	correspond to the under flow area of tan x	
P → R(r, θ) (x,y)		$0 \leqq r \leqq 9.999999999 \times 10^{99}$ θ correspond to the operation range of sin x, cos x	θ correspond to the under flow area of sin x, cos x	
DEG → RAD		$0 \leqq \lvert X \rvert \leqq 9.999999999 \times 10^{99}$	$0 \leqq \lvert X \rvert \leqq 5.729577951 \times 10^{98}$	
RAD → GARD		$0 \leqq \lvert X \rvert \leqq 1.570796326 \times 10^{98}$	—	
GARD → DEG		$0 \leqq \lvert X \rvert \leqq 9.999999999 \times 10^{99}$	$0 \leqq \lvert X \rvert \leqq 9.999999999 \times 10^{99}$	

OPERATION RANGE AND ACCURACY.(Continuer)

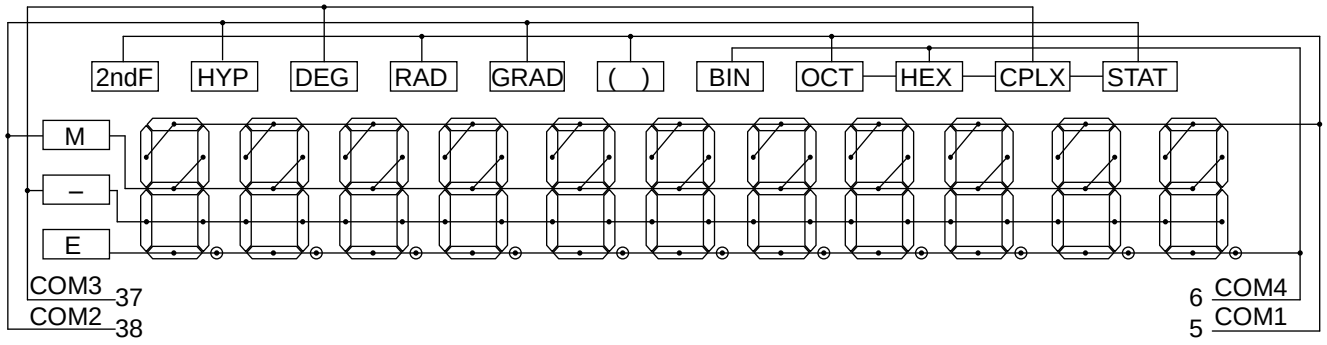
Function	Operation Range	Under Flow Area	Normal Accuracy
y^x	$-9.999999999 \times 10^{99} \leqq x.\ln \lvert y \rvert \leqq 230.2585092$	$-9.999999999 \times 10^{99} \leqq x.\ln \lvert y \rvert \leqq -227.9559243$	10 digits ± 1
	i) y > 0; The above — mentioned operation renge ii) y < 0; x (integer) or 1/x (x = odd, x = 0) The above — mentioned operation range iii) y = 0; x > 0		
$\sqrt[x]{y}$	$-9.999999999 \times 10 \leqq 1/x.\ln \lvert y \rvert \leqq 230.2585092$	$-9.999999999 \times 10 \leqq 1/x.\ln \lvert y \rvert \leqq -227.9559243$	
	i) y > 0; The above — mentioned operation renge ii) y < 0; x (odd) or 1/x (integer, x ≠ 0) The above — mentioned operation range iii) y = 0; x > 0		
→ DEC	The following operation range after the conversion. $0 \leqq \lvert X \rvert \leqq 9999999999$		—
→ BIN	The following operation range after the conversion. $1000000000 \leqq X \leqq 1111111111, 0 \leqq X \leqq 1111111111$		—
→ OCT	The following operation range after the conversion. $4000000000 \leqq X \leqq 777777777, 0 \leqq X \leqq 3777777777$		—
→ HEX	The following operation range after the conversion. $FDABF41C01 \leqq X \leqq FFFFFFFFFF, 0 \leqq X \leqq 2540BE3FF$		—
Complex number calculation	(X1+Y1i) ＋, －, ×, ÷ (X2+Y2i) i) Addition and subtraction $\lvert X1+X2 \rvert \leqq 9.999999999999 \times 10^{99}$ $\lvert Y1+Y2 \rvert \leqq 9.999999999999 \times 10^{99}$ ii) Multiplication $\lvert X1X2-Y1Y2 \rvert \leqq 9.999999999999 \times 10^{99}$ $\lvert Y1X2-X1Y2 \rvert \leqq 9.999999999999 \times 10^{99}$ $\lvert X1X2 \rvert, \lvert Y1,Y2 \rvert, \lvert Y1X2 \rvert, \lvert X1Y2 \rvert \leqq 9.999999999999 \times 10^{99}$ iii) Division $\left\lvert \frac{X1X2 + Y1Y2}{X2^2 + Y2^2} \right\rvert, \left\lvert \frac{Y1X2 + X1Y2}{X2^2 + Y2^2} \right\rvert \leqq 9.999999999 \times 10^{99}$ $\lvert X2^2+Y2^2 \rvert, \lvert X2^2 \rvert, \lvert Y2^2 \rvert, \lvert X1X2+Y1Y2 \rvert, \lvert Y1X2+X1Y2 \rvert$ $\lvert X1X2 \rvert, \lvert Y1Y2 \rvert, \lvert Y1X2 \rvert, \lvert X1Y2 \rvert \leqq 9.9999999999 \times 10^{99}$		10 digits ± 1
Statistical calculation	i) Data; $\lvert X \rvert \leqq 9.9999999999 \times 10$ ii) $\lvert \Sigma X \rvert \leqq 9.9999999999 \times 10$ iii) $\lvert \Sigma X^2 \rvert \leqq 9.9999999999 \times 10$ iv) x; n=0 v) s; n=1 n=0 $0 \leqq \frac{\Sigma x^2 - (\Sigma x)^2 / n}{n-1} \leqq 9.9999999999 \times 10$ vi) σ ; n=0 $0 \leqq \frac{\Sigma x^2 - (\Sigma x)^2 / n}{n} \leqq 9.9999999999 \times 10$		10 digits ± 1

LCD CONNECTION

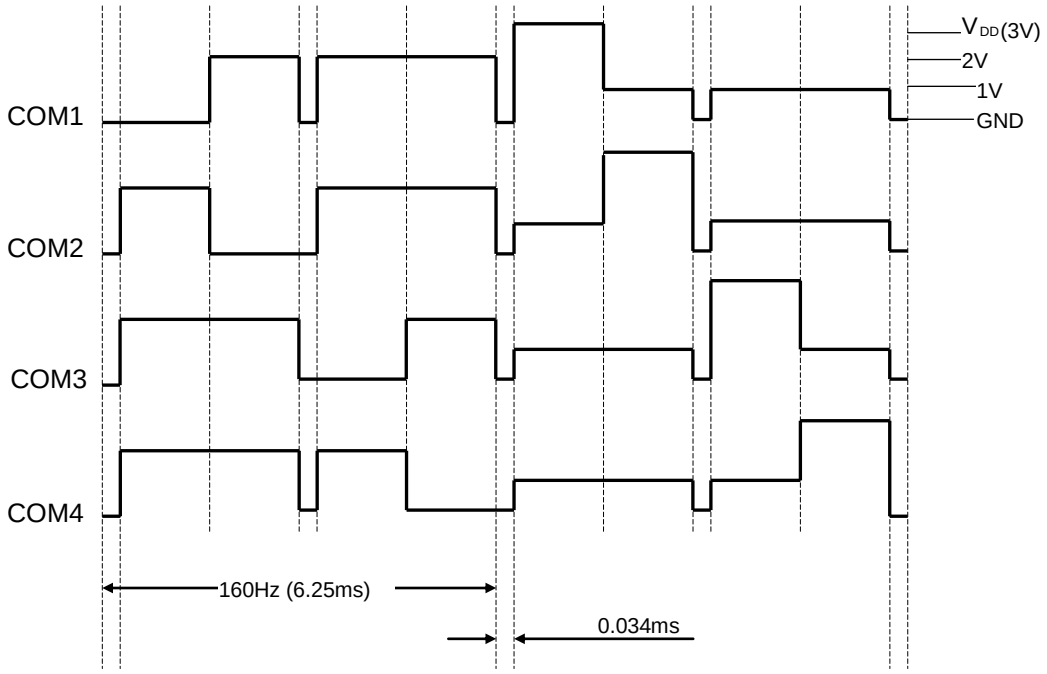
(1) Segment



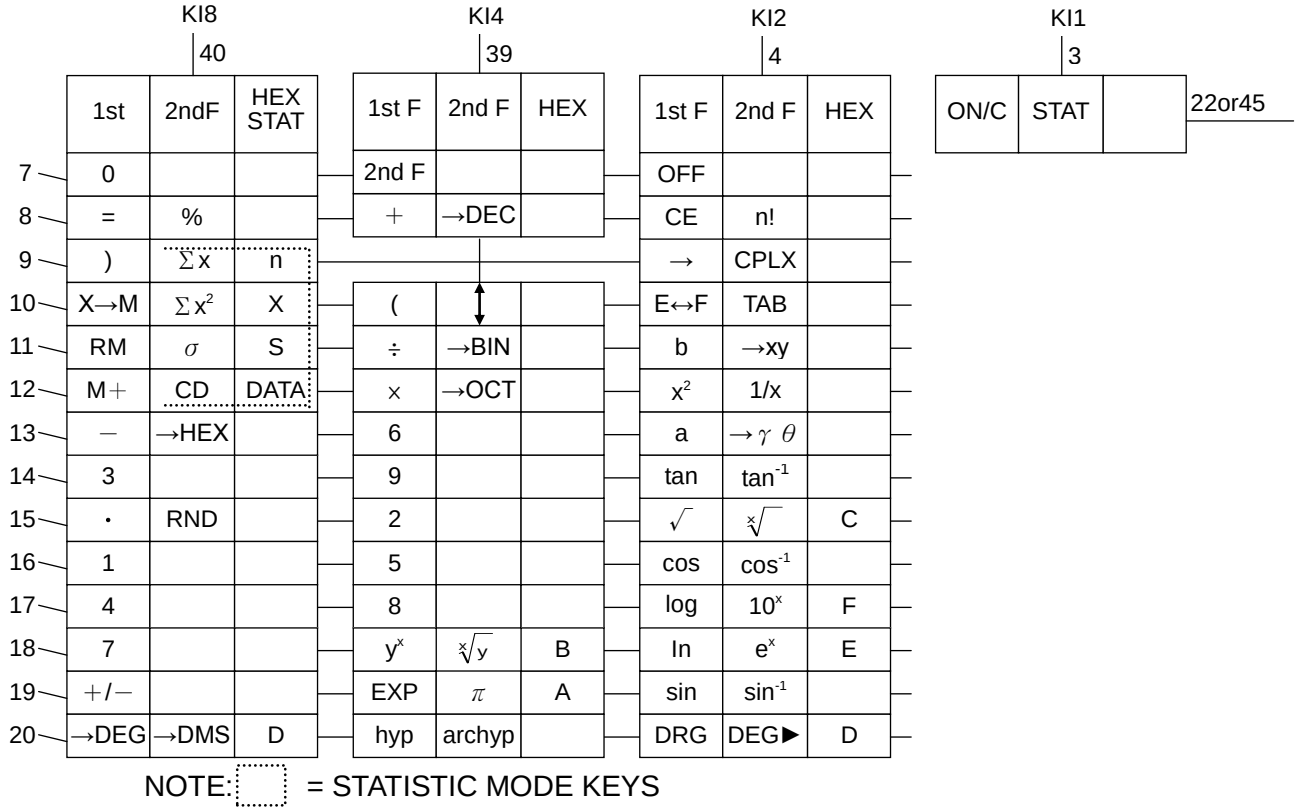
(2) Common



WAVEFORM OF COM



KEY CONNECTIONS



ELECTRICAL CHARACTERISTICS

(1) Absolute Maximum Rating.

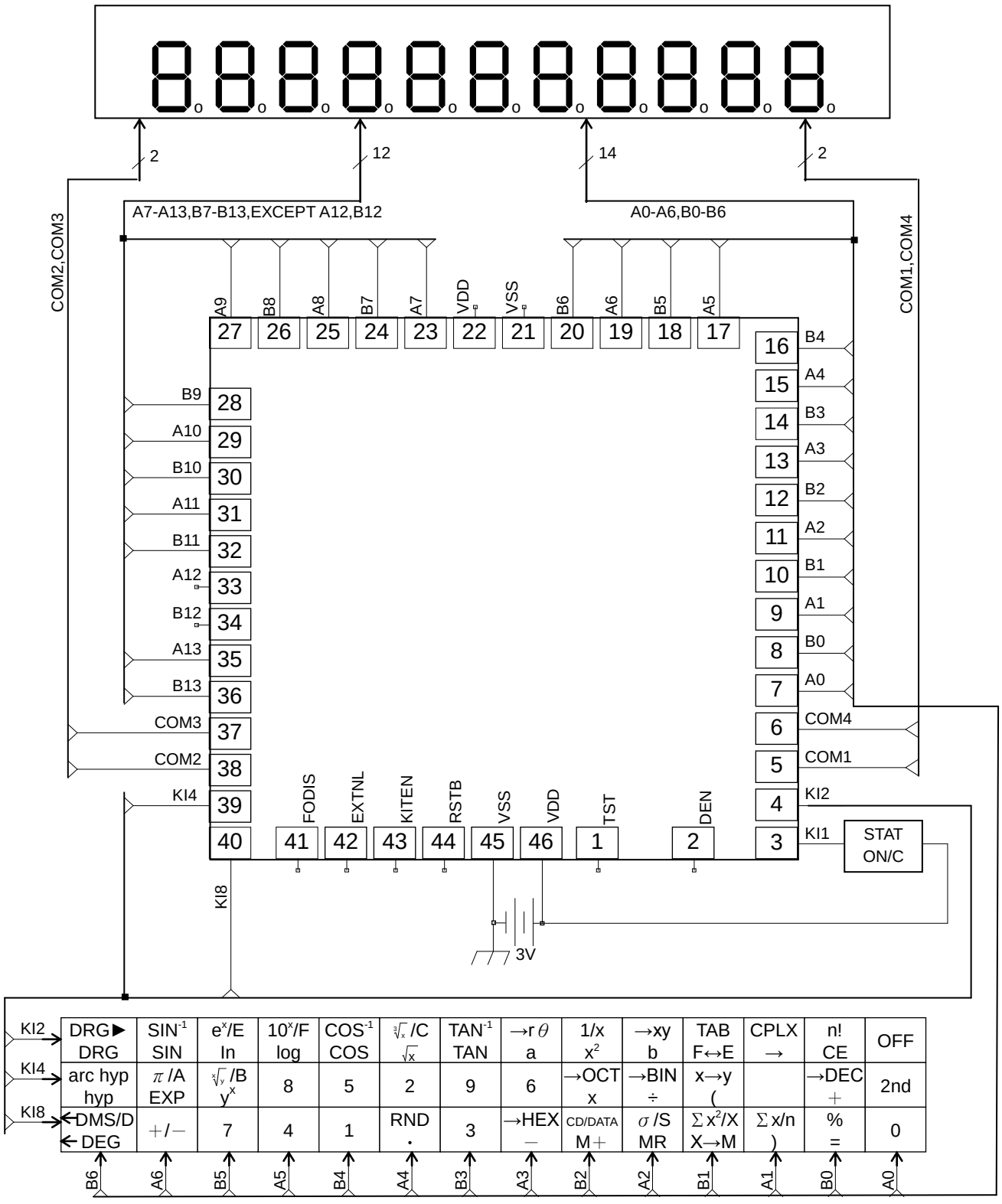
Item	Symbol	Rating	Unit
Terminal Voltage	V_{DD}	- 0.3 ~ +3.3	V
	V_{IN}	- 0.3 ~ V_{DD} + 0.3	V
Operating temperature	Topr	0 ~ + 40	℃
Storage temperature	Tstg	- 55 ~ + 125	℃

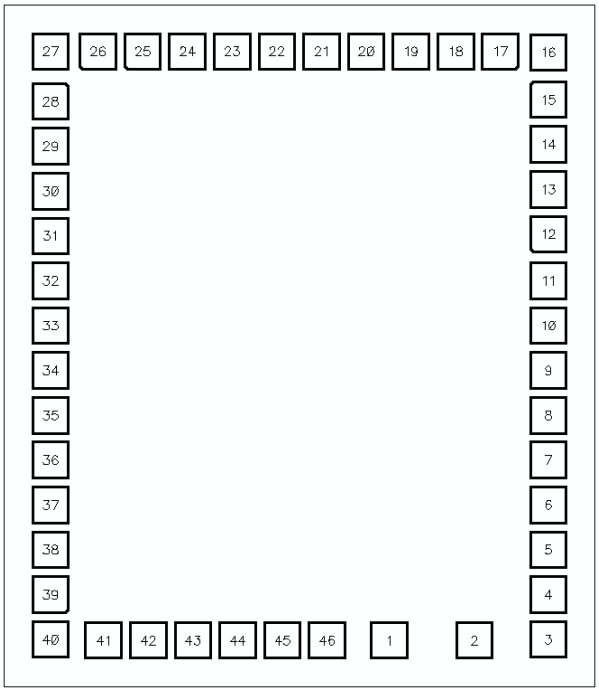
・Voltage greater than above may damage the circuit.

(2) Electrical Characteristics. [V_{DD} = + 3.0V ± 0.2V , V_{SS} = 0V , Ta = 25℃]

Item	Pin Name	Symbol	Condition	Min	Typ	Max	Unit
Operating voltage	—	—	—	2.5	3	3.4	V
Supply current	—	Idis	V_{DD}=3V,Stand by		20	35	uA
	—	Iopr	V_{DD}=3V,Operating		70	120	uA
	—	Ioff	V_{DD}=3V,Off		1	3	uA
Osc frequency	—	Fdis	V_{DD}=3V,Stand by	30	45		KHz
	—	Fopr	V_{DD}=3V,Operating		200	280	KHz
Frame frequency	—	Ff	V_{DD}=3V,Stand by	110	180		Hz
Auto power off	—	Tapo	V_{DD}=3V	300	430	600	Sec
High input voltage	KI8 ~ KI1	V_{IH}	—	V_{DD}-0.5		V_{DD}	V
Low input voltage	KI8 ~ KI1	V_{IL}	—	V_{SS}		V_{SS}+0.5	V
High output voltage	KI8,KI4,KI2	V_{OH}	—	V_{DD}-0.2	V_{DD}	V_{DD}	V
Low output voltage	KI1	V_{OL}	—	V_{SS}	V_{SS}	+0.2	V
Key pull down resistance	KI1	Rpd	Vout=3V	40	60	80	KΩ
Key pull up resistance	KI8,KI4,KI2	R_{PU}	Vout=V_{DD}	40	60	80	KΩ
High output voltage	LCD,COM	V_{OH}	—	V_{DD}-0.2	V_{DD}	V_{DD}	V
"M" output voltage	LCD,COM	V_{OM}	—	2/3V_{DD}-0.2	2/3V_{DD}	2/3V_{DD}+0.2	V
"M" output voltage	LCD,COM	V_{OM}	—	1/3V_{DD}-0.2	1/3V_{DD}	1/3V_{DD}+0.2	V
Low output voltage	LCD,COM	V_{OL}	—	V_{SS}	V_{SS}	V_{SS}+0.2	V

Application circuit





PAD'S COORDINATE
PAD

NAME	NO.	X	Y	NAME	NO.	X	Y
TST	1	200.650	-656.650	B7	24	-250.750	656.650
DEN	2	391.200	-656.650	A8	25	-350.750	656.650
KI1	3	556.650	-654.650	B8	26	-450.750	656.650
KI2	4	556.650	-554.650	A9	27	-556.650	656.650
COM1	5	556.650	-454.650	B9	28	-556.650	545.350
COM4	6	556.650	-354.650	A10	29	-556.650	445.350
A0	7	556.650	-254.650	B10	30	-556.650	345.350
B0	8	556.650	-154.650	A11	31	-556.650	245.350
A1	9	556.650	-54.650	B11	32	-556.650	145.350
B1	10	556.650	45.350	A12	33	-556.650	45.350
A2	11	556.650	145.350	B12	34	-556.650	-54.650
B2	12	556.650	249.350	A13	35	-556.650	-154.650
A3	13	556.650	349.350	B13	36	-556.650	-254.650
B3	14	556.650	449.350	COM3	37	-556.650	-354.650
A4	15	556.650	549.350	COM2	38	-556.650	-454.650
B4	16	556.650	654.650	KI4	39	-556.650	-554.650
A5	17	449.250	656.650	KI8	40	-556.650	-654.650
B5	18	349.250	656.650	FODIS	41	-438.150	-656.650
A6	19	249.250	656.650	EXTNL	42	-338.150	-656.650
B6	20	149.250	656.650	KITEN	43	-238.150	-656.650
VSS	21	49.250	656.650	RSTB	44	-138.150	-656.650
VDD	22	-50.750	656.650	VSS	45	-38.150	-656.650
A7	23	-150.750	656.650	VDD	46	61.850	-656.650

CHIP SIZE = 1405um X 1605um

IC Substrate can not connect to VDD or VSS.

Ordering Information

TC1599C

Package Type	Chip Type	Wafer Type
-----	**TC1599C**	-----

Revision History

1. 2014/7/24 - The original version：V_1.0
2. 2017/2/7- Chip Size Correction : V_1.1