

92D 00715 D T-49-13-02



8-Digit Single-Chip CMOS Calculator

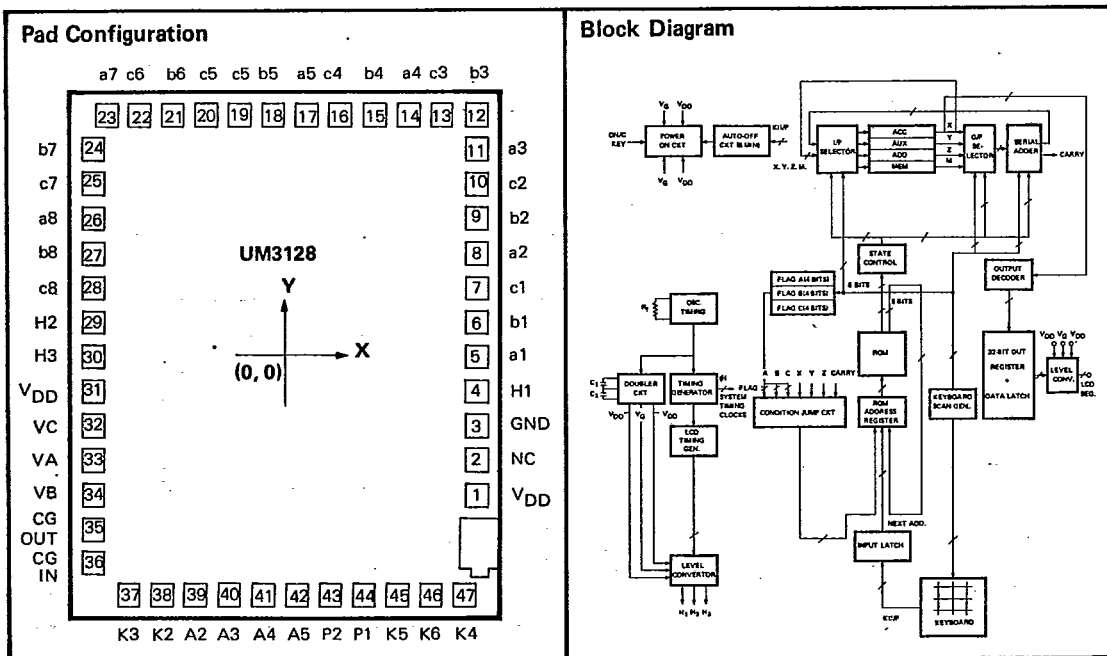
Features

- Number of digits
 - 8 digits (rough estimate calculation possible)
- Calculations
 - Standard four functions (+, −, ×, ÷)
 - Chain multiplication and division
 - Auto-constant calculation (constant multiplicand, divisor, addend and subtrahend)
 - Square and reciprocal calculations
 - Mark-up and mark-down calculations
 - Extraction of square root
 - Percentage calculations
 - Power calculations
 - Rough estimate calculations
 - Memory calculations
- Decimal point system
 - Complete floating decimal point system.
- Display format
 - 8 digits + sign (−, E, and M) leading zero suppression zero shift
- Negative number indication
 - Number + minus (−) sign.

General Description

The UM3128 is a single-chip CMOS calculator LSI 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 1.5V power supply, auto-power-off, low power dissipation and single power supply making the UM3128 ideal for battery or solar cell operated, hand-held calculators with low system cost.



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UM3128

Absolute Maximum Ratings*

Terminal Voltage, V_{DD} $-0.3 \sim +2.3V$ *
 Terminal Voltage $-0.3 \sim V_{DD} + 0.3V$ *
 Operating Temperature $0 \sim +50^{\circ}C$
 Storage Temperature $-20 \sim +70^{\circ}C$
 Supply Voltage $V_{DD} + 1.3 \sim 1.7V$
 Resistance for C_G : $R_f = 470K\Omega \pm 5\%$ *
 Operating Temperature $0^{\circ} \sim +50^{\circ}C$

- * Maximum voltage on any pin with respect to GND.
- * The floating capacitances of CG_{IN} and CG_{OUT} terminals shall be minimized. (i.e. the stray capacitance of PCB layout C_{stray} should be less than 5PF).

***Comments**

Stress above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only. Functional operation of this device at these or any other conditions above those indicated in the operational sections of this specification is not implied and exposure to absolute maximum rating conditions for extended periods may affect device reliability.

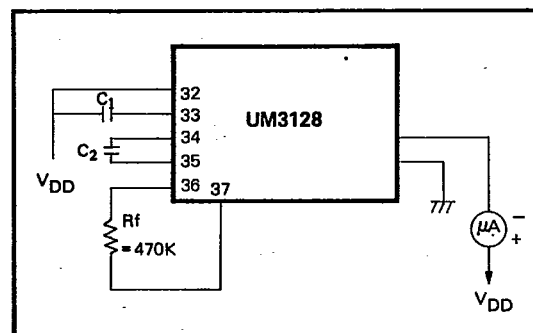
Electrical Characteristics

($V_{DD} = 1.5V$, $T_A = 25^{\circ}C$, unless otherwise specified.)

Parameter	Symbol	Test Conditions	Rating			Unit
			Min.	Typ.	Max.	
Input Voltage	V_{IL1}				0.4	V
	V_{IH1}		$V_{DD} - 0.4$			V
Input Current	I_{IH1}	$V_{IN} = V_{DD}$	0.3	1.0	3	μA
	I_{IL1}	$V_{IN} = 0V$			1	μA
Output Voltage	V_{OH2}	No load	$V_{DD} - 0.15$			V
	V_{OL2}	$I_{OUT} = 15\mu A$			0.15	V
	V_{OA3}		1.3	1.5		V
	V_{OB3}		-0.2	0.0	0.2	V
	V_{OC3}			-1.5	-1.3	V
Display Frequency	f_{d13}	$V_{DD} = 1.5V$ While display is on	70	100	120	Hz
Dissipation Current	I_{DD4}	Display is off			0.8	μA
	I_{DD15}	$V_{DD} = 1.5V$ While display is on		6	8	μA

Notes:

- 1 Applies to terminals K2 — K6
- 2 Applies to terminals P1, P2 and A2 — A5
- 3 Applies to terminals H_i ($i = 1 - 3$), a_i , b_i and c_i ($i = 1 - 8$)
- 4 Measured by the following test circuit after power supply automatically turns off.
- 5 Measured by the above test circuit while "0" is being displayed after auto-clear operation and while no key is being depressed.



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Pad Description

Pad No.	Designation	Description
1	V _{DD}	Power Supply Terminal
2	NC	Non - Contact
3	GND	Ground
4	H1	H1 O/P Signal to LCD (Common)
5	a1	a1 O/P Signal to LCD (Segment)
6	b1	b1 O/P Signal to LCD (Segment)
7	NC	Non - contact
8	c1	c1 O/P Signal to LCD (Segment)
9	a2	a2 O/P Signal to LCD (Segment)
10	b2	b2 O/P Signal to LCD (Segment)
11	c2	c2 O/P Signal to LCD (Segment)
12	a3	a3 O/P Signal to LCD (Segment)
13	b3	b3 O/P Signal to LCD (Segment)
14	c3	c3 O/P Signal to LCD (Segment)
15	a4	a4 O/P Signal to LCD (Segment)
16	b4	b4 O/P Signal to LCD (Segment)
17	c4	c4 O/P Signal to LCD (Segment)
18	a5	a5 O/P Signal to LCD (Segment)
19	b5	b5 O/P Signal to LCD (Segment)
20	c5	c5 O/P Signal to LCD (Segment)
21	a6	a6 O/P Signal to LCD (Segment)
22	b6	b6 O/P Signal to LCD (Segment)
23	c6	c6 O/P Signal to LCD (Segment)
24	a7	a7 O/P Signal to LCD (Segment)
25	b7	b7 O/P Signal to LCD (Segment)
26	c7	c7 O/P Signal to LCD (Segment)
27	a8	a8 O/P Signal to LCD (Segment)
28	b8	b8 O/P Signal to LCD (Segment)
29	c8	c8 O/P Signal to LCD (Segment)
30	H2	H2 O/P Signal to LCD (Segment)
31	H3	H3 O/P Signal to LCD (Segment)
32	V _{DD}	Power Supply Terminal
33	V _C	Connected As Voltage Doubler
34	V _A	
35	V _B	
36	CG _{OUT}	Connected As An RC Oscillator
37	CG _{IN}	
38	K3	Key I/P Signal
39	K2	Key I/P Signal
40	A2	A2 O/P Strobe Signal To Key
41	A3	A3 O/P Strobe Signal To Key
42	A4	A4 O/P Strobe Signal To Key
43	A5	A5 O/P Strobe Signal To Key
44	P2	P2 O/P Strobe Signal To Key
45	P1	P1 O/P Strobe Signal To Key
46	K5	Key I/P Signal
47	K6	Key I/P Signal
48	K4	Key I/P Signal

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Display Format

Numericals Font

1 2 3 4 5 6 7 8 9 0

Sign Font

M

MEMORY LOADING

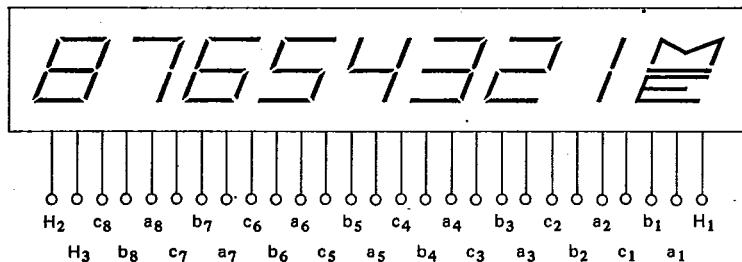
E

ERROR

—

MINUS

LCD Connection

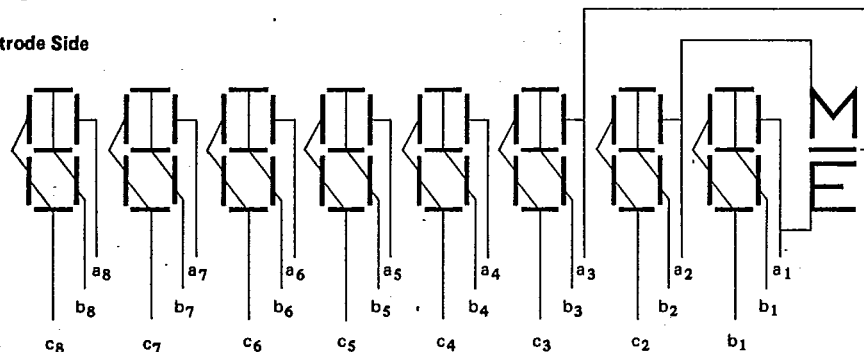


LCD Driving System

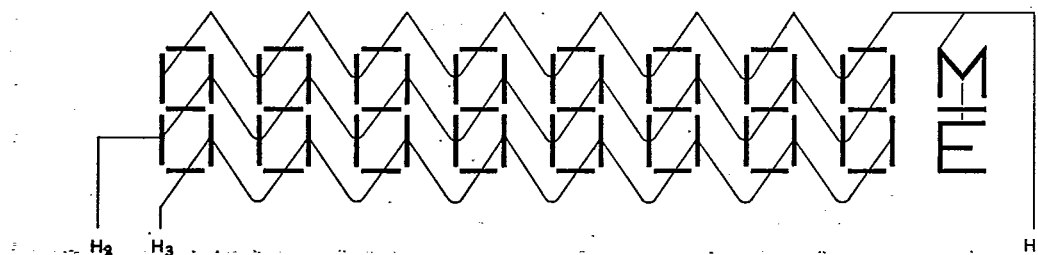
1/2 bias, 1/3 duty

Display Configuration

Segment Electrode Side



Common Electrode Side



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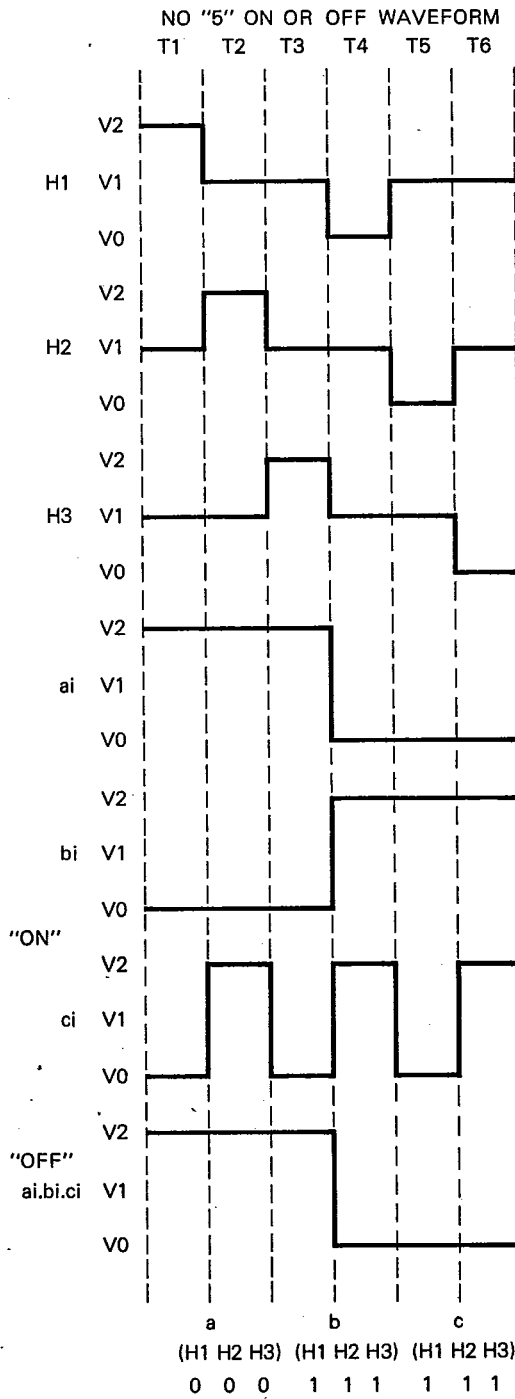
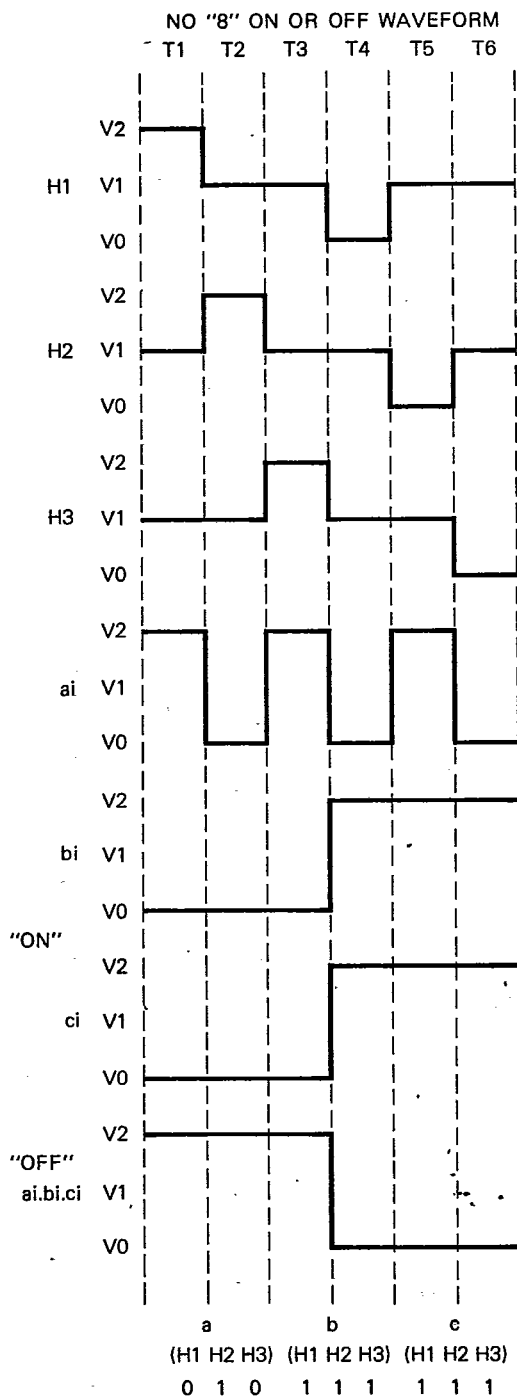
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Display Example



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**UM3128****Keyboard Description****Equals Key (=)**

Performs keyed-in operation and maintains that operation for possible use. Establishes power/reciprocal calculation.

Multiplication Key (x)

Enters multiplicand
Performs previous operation and displays result.

Division Key (÷)

Enters dividend
Performs previous operation and displays result.

Addition Key (+)

Performs previous operation and displays result.
Conditions machine for an addition.

Subtraction Key (—)

Performs previous operation and displays result.
Conditions machine for a subtraction.

Percent Key (%)

The purpose of the percent key is to allow for calculation of add-on and discount. Determination 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 be principal.

Change Sign Key (+/—)

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

Power On/All Clear Key (ON/AC)

First push power-on displays "0"
In the middle of a digit entry, a second push will clear all registers and memory.

Clear Entry/Clear Key (CE/C)

During digit entry, the first depression will clear the entry

register, and the second push will clear all registers except memory.

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

The square root key extracts the square root of a positive number displayed in the entry register.

Memory Plus Key "M+"

Adds the current display to the contents of memory.
M+ will terminate a number entry.

Memory Minus Key "M—"

Subtracts current display from the contents of memory.
M— will terminate a number entry.

Memory Recall and Clear Key ($\frac{R}{C}$ M)

First push, as RM key, transfers the contents of the memory register into the display register. Second push, as CM key, clears the memory.

Number, Decimal Key (0 — 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 enter data in the display register. The first decimal point entered is effective. An attempted entry of more than 8 digits or 7 decimal places will be ignored.

Error Conditions**Error Detection**

System errors occur when:

- The integral part of any calculation result exceeds 16-digit.
- 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.
- The integral part of a mark-up and mark-down calculation result exceeds 8-digit.
- A division by zero is attempted.
- 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.

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Error Indication

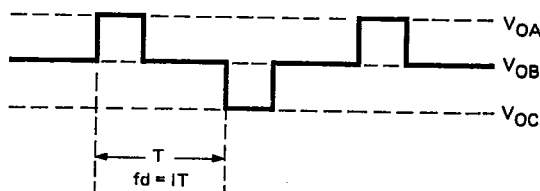
System error:

"0" is indicated in the first-digit position and "E" in the sign-digit position.

Rough estimate calculation result:

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 10^{-8} , and no zero shift is performed.

Output waveform example



Error Release

System error:

A system error can be released by depressing ON/AC key.

Rough estimate calculation result:

A rough estimate calculation error can be released by depressing the ON/AC or CE/C key. A calculation result is not cleared by CE/C key but is retained.

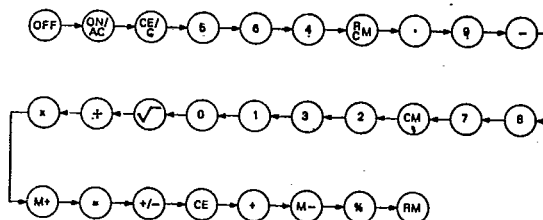
Double Key Depression

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

Operation Characteristics

Constant Operation

The UM3128 has an implied constant mode on +, -, x, /, and % operations. The constant calculation is performed automatically by the = key, % key, or % = keys without a constant switch. The second operand is treated as the constant for addition, subtraction and division, while the first operand is the constant for multiplication.



Number Entry

Numericals can be entered up to 8-digit. Numerical entries equal to 9-digit or more are ignored.

Memory Protection

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

Memory Indication

If the memory contents are a number other than zero. "M" is indicated in the sign-digit position.

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 (Approx. 7 minutes and 12 seconds at $f_d = 100$ Hz, the display time of a word being equal to 3.3 mS when $f_d = 100$ Hz)

When the OFF and ON/C keys are depressed simultaneously, the OFF key is given priority.

Key Bounce Protection

- * Front edge: Down to 1 word and up to about 3 words.
 - * Back edge: 12 words
- The display time of a word is equal to 3.3mS when display frequency $f_d = 100$ Hz

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**UM3128****Arithmetic Operations**

	Key Operation	Display
Entry	1 2 3 4 5 6 7 8 9 0	12345678.
Four Fundamental Arithmetic Calculations	$a \div b =$ $a - b =$ $a \times b =$ $a \div b =$	$a + b$ $a - b$ $a \cdot b$ $a \div b$
Square Root Calculations	$a \sqrt{\quad}$ $a \div \sqrt{\quad}$ ON/AC $a \times b \sqrt{\quad}$ $=$	$\sqrt{a}$ OE O $\sqrt{b}$ $a \cdot \sqrt{b}$
Percent Calculations	$a \times b \%$ $\div =$ $a \times b \%$ $- =$ $a \div b \%$ $\div =$ $a \div b \%$ $- =$	$a \cdot b/100$ $a + (a \cdot b/100)$ $a \cdot b/100$ $a - (a \cdot b/100)$ $100 \cdot a/b$ $a + (a \cdot b/100)$ $a - (a \cdot b/100)$
Constant Calculations	$k \times b =$ $c =$ $a \div k =$ $c =$ $k \times b \%$ $c \%$ $a \div k \%$ $c \%$ $a + k =$ $b =$ $a - k =$ $b =$	$k \cdot b$ $k \cdot c$ a/k c/k $k \cdot b/100$ $k \cdot c/100$ $100 \cdot a/k$ $100 \cdot c/k$ $a + k$ $b + k$ $a - k$ $b - k$

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	Key Operation	Display	Memory
Repeated Calculations	a $\boxed{+}$ b $\boxed{=}$ $\boxed{=}$	a + 2b	
	a $\boxed{-}$ b $\boxed{=}$ $\boxed{=}$	a - 2b	
	a $\boxed{\div}$ b $\boxed{=}$ $\boxed{=}$	(a/b)/b	
	a $\boxed{\times}$ b $\boxed{=}$ $\boxed{=}$	(a * b) * a	
Power Calculations	a $\boxed{\times}$ $\boxed{=}$	a ²	
	$\boxed{\times}$ $\boxed{=}$	a ⁴	
	a $\boxed{\times}$ $\boxed{=}$ $\boxed{=}$	a ³	
	a $\boxed{\div}$ $\boxed{=}$	1/a	
	a $\boxed{\div}$ $\boxed{=}$ $\boxed{=}$	1/a ²	
Mixed Calculations	a $\boxed{+}$ b $\boxed{\times}$ c $\boxed{\div}$ d $\boxed{=}$	(a+b) * c/d	
	at $\boxed{+}$ [(a+b) * c/d] * e $\boxed{>10^8}$	((a+b) * c/d) * e/10 ⁸ E	
	$\boxed{\times}$ e $\boxed{=}$	((a+b) * c/d) * e/10 ⁸	
Memory Calculations	$\boxed{CE}$		
	a $\boxed{M+}$	a M	a
	a $\boxed{M-}$	b M	a - b
	$\boxed{RM}$	a - b M	a - b
	$\boxed{CM}$	a - b	0
	a $\boxed{+}$ b $\boxed{M+}$	a + b M	a + b
	c $\boxed{\times}$ d $\boxed{M+}$	c * d M	a + b + c * d
	$\boxed{RM}$	a + b + c * d M	a + b + c * d
	at $\boxed{+}$ [a + b + c * d + e] $\boxed{>10^8}$	0 ^M _E	a + b + c * d
	$\boxed{CE/C}$	0M	a + b + c * d
	$\boxed{RM}$	a + b + c * d M	a + b + c * d

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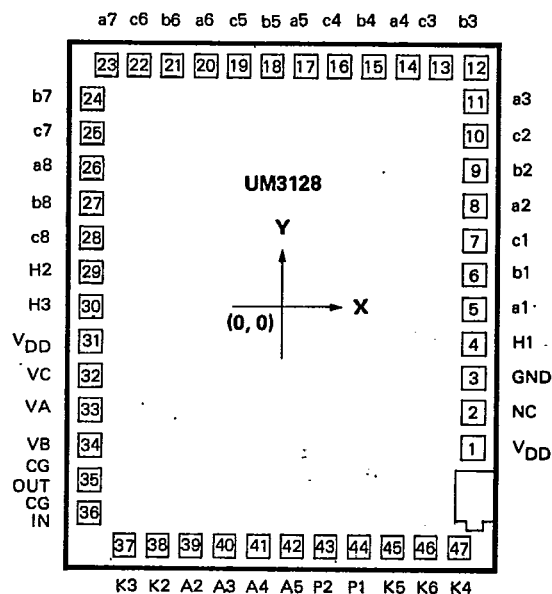
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Bonding Diagram

unit: μm

Pad No.	Designation	X	Y	Pad No.	Designation	X	Y
1	V _{DD}	1055.11	- 888.49	25	c7	- 1055.11	945.38
2	NC	1055.11	- 707.39	26	a8	- 1055.11	760.47
3	GND	1055.11	- 349.50	27	b8	- 1055.11	575.56
4	H1	1055.11	- 164.59	28	c8	- 1055.11	390.39
5	a1	1055.11	20.57	29	H2	- 1055.11	205.48
6	b1	1055.11	205.48	30	H3	- 1055.11	20.57
7	c1	1055.11	390.39	31	V _{DD}	- 1055.11	- 164.59
8	a2	1055.11	575.56	32	V _C	- 1055.11	- 349.50
9	b2	1055.11	760.47	33	V _A	- 1055.11	- 534.41
10	c2	1055.11	945.38	34	V _B	- 1055.11	- 719.58
11	a3	1055.11	1130.55	35	CG OUT	- 1055.11	- 904.49
12	b3	1055.11	1318.00	36	CG IN	- 1055.11	- 1089.40
13	c3	869.95	1318.00	37	K3	- 869.95	- 1318.51
14	a4	685.03	1318.00	38	K2	- 685.03	- 1318.51
15	b4	500.12	1318.00	39	A2	- 500.126	- 1318.51
16	c4	314.96	1318.00	40	A3	- 314.96	- 1318.51
17	a5	130.04	1318.00	41	A4	- 130.04	- 1318.51
18	b5	- 55.11	1318.00	42	A5	55.11	- 1318.51
19	c5	- 240.03	1318.00	43	P2	240.03	- 1318.51
20	a6	- 423.92	1318.00	44	P1	424.94	- 1318.51
21	b6	- 610.10	1318.00	45	K5	605.02	- 1318.51
22	c6	- 795.02	1318.00	46	K6	789.94	- 1318.51
23	a7	- 979.93	1318.00	47	K4	975.10	- 1318.51
24	b7	- 1055.11	1135.63				

Note: All positions corresponding to pad central position

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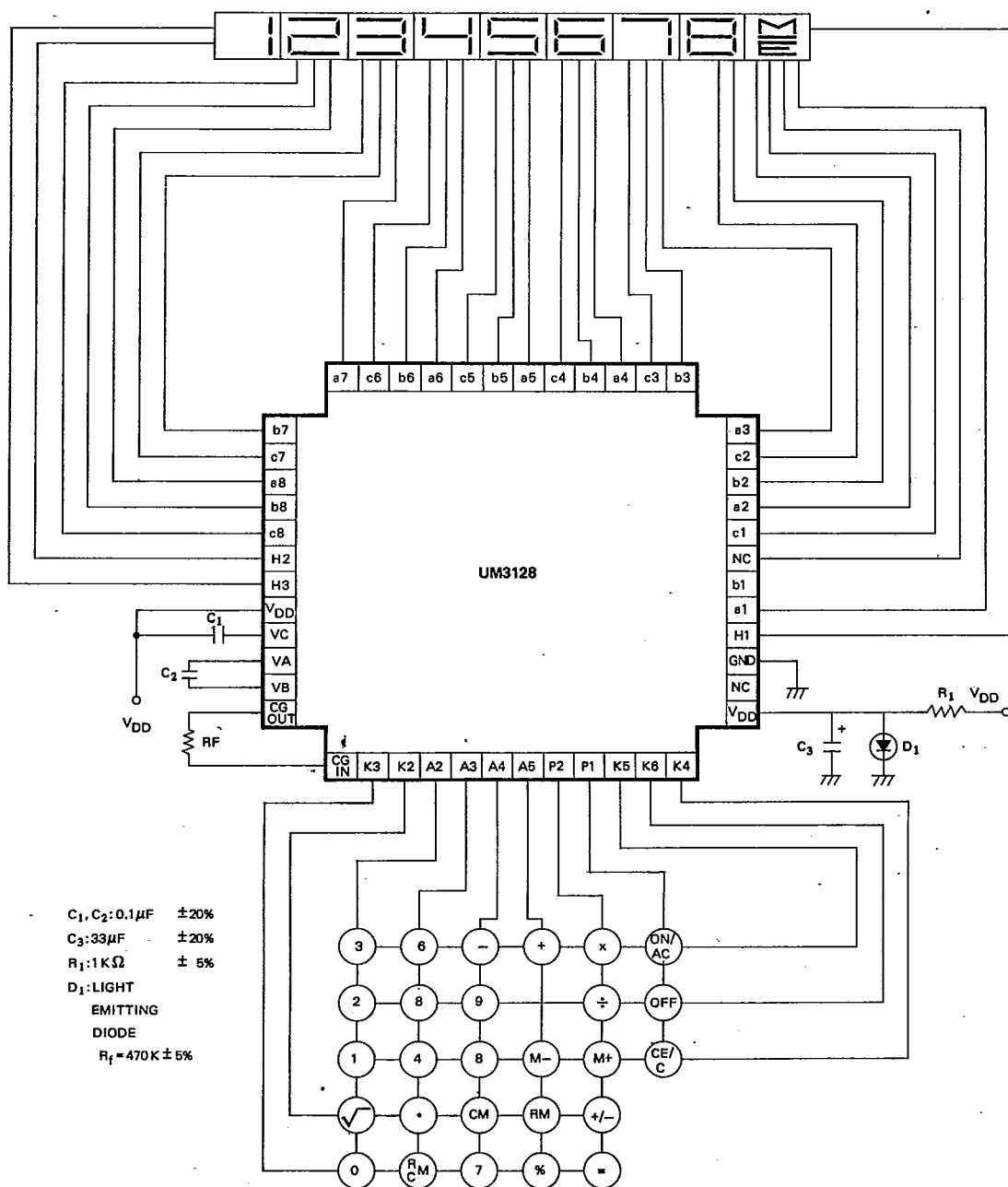
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Typical Applications

SOLAR POWERED CALCULATOR



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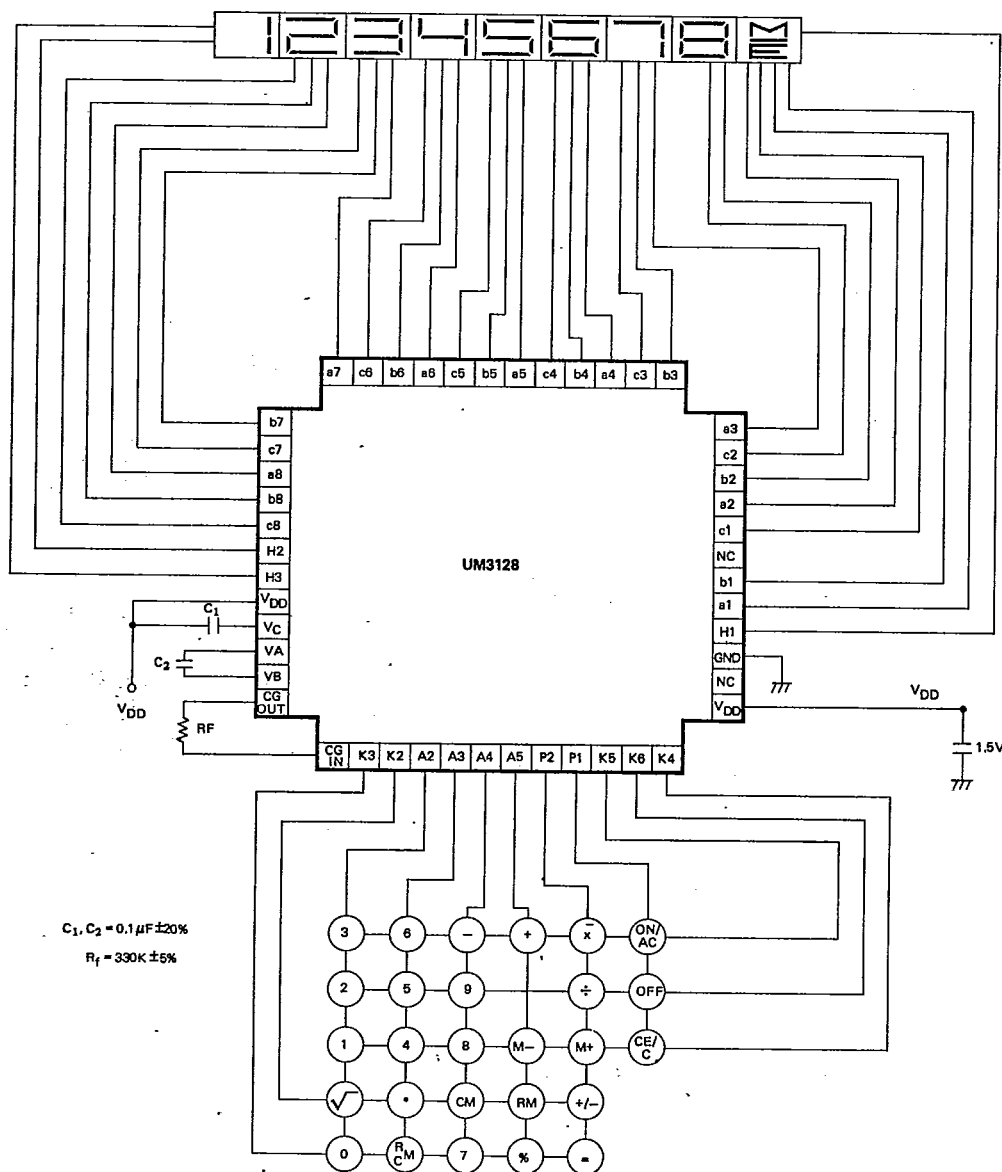
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UM3128

BATTERY POWERED CALCULATOR



Ordering Information

Part No.	Package	Mask Type
UM3128F	48 Pin Flat Package	Normal
UM3128H	Chip	Normal
UM3128MH	Chip	Mirror