GENERAL DESCRIPTION

The EM34001 is a single-chip LSI CMOS calculator 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 debuncing and encoding of keyboard inputs. It is designed for LCD operation with 1.5V power supply (either from solar cell or battery), auto-power off, low power dissipation and single power supply making the EM34001 ideal for hand held calculators with low system cost.

FEATURES

• Number of digits - 8 digits (rough estimated calculation is possible).
• Calculations :
 - Standard four functions (+ , - , x , ÷).
 - 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 calaulations.
 - Rough estimate calculations.
 - Memory calculations.
• Decimal point system- complete floating decimal point system.
• Display format : 8 digits + sign (- , E & M) leading zero suppression zero shift.
• Negative number indication : number + minus (-) sign.
• Auto power off ability.

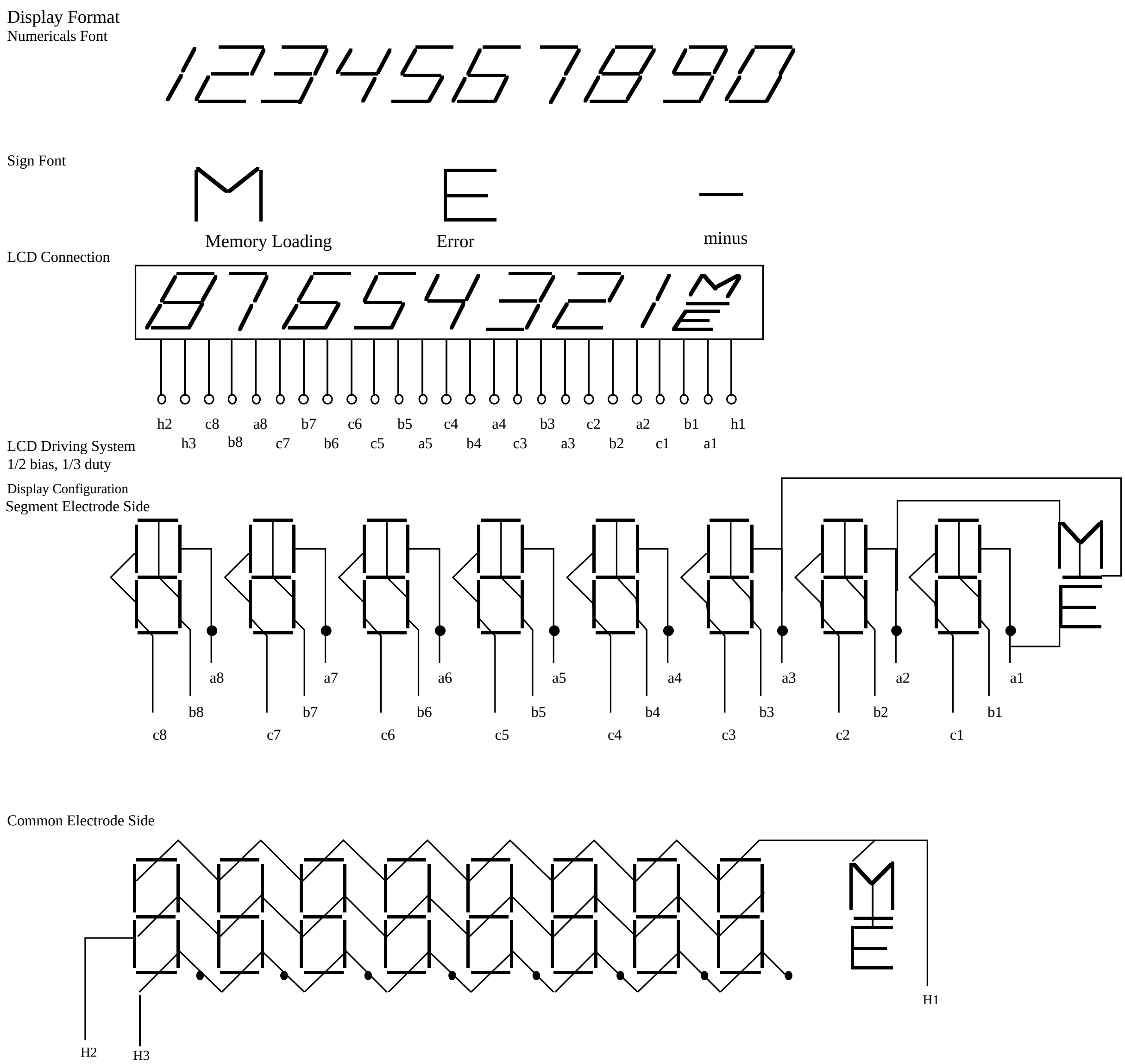
PIN DESCRIPTIONS

Symbol	I/O	Function
VSO	I	Voltage limiter option pad
APO	I	Auto power-off option pad
V_{DD}		Positive power supply
H1	O	O/P Signal to LCD (common)
a1	O	O/P Signal to LCD (segment)
b1	O	O/P Signal to LCD (segment)
c1	O	O/P Signal to LCD (segment)
a2	O	O/P Signal to LCD (segment)
b2	O	O/P Signal to LCD (segment)
c2	O	O/P Signal to LCD (segment)
a3	O	O/P Signal to LCD (segment)
b3	O	O/P Signal to LCD (segment)
c3	O	O/P Signal to LCD (segment)
a4	O	O/P Signal to LCD (segment)
b4	O	O/P Signal to LCD (segment)
c4	O	O/P Signal to LCD (segment)
a5	O	O/P Signal to LCD (segment)
b5	O	O/P Signal to LCD (segment)
c5	O	O/P Signal to LCD (segment)
a6	O	O/P Signal to LCD (segment)
b6	O	O/P Signal to LCD (segment)
c6	O	O/P Signal to LCD (segment)
a7	O	O/P Signal to LCD (segment)
b7	O	O/P Signal to LCD (segment)
c7	O	O/P Signal to LCD (segment)
a8	O	O/P Signal to LCD (segment)
b8	O	O/P Signal to LCD (segment)
c8	O	O/P Signal to LCD (segment)
H2	O	O/P Signal to LCD (common)
H3	O	O/P Signal to LCD (common)
V_{SS}		Negative power supply
V_{EE}		Connected as voltage doubler
VA		Connected as voltage doubler
VB		Connected as voltage doubler
CG		Oscillator O/P
K3	I	Key I/P signal
K2	I	Key I/P signal
A2	O	O/P Strobe signal to key

Symbol	I/O	Function
A3	O	O/P Strobe signal to key
A4	O	O/P Strobe signal to key
A5	O	O/P Strobe signal to key
P2	O	O/P Strobe signal to key
P1	O	O/P Strobe signal to key
K5	I	Key I/P signal
K6	I	Key I/P signal
K4	I	Key I/P signal

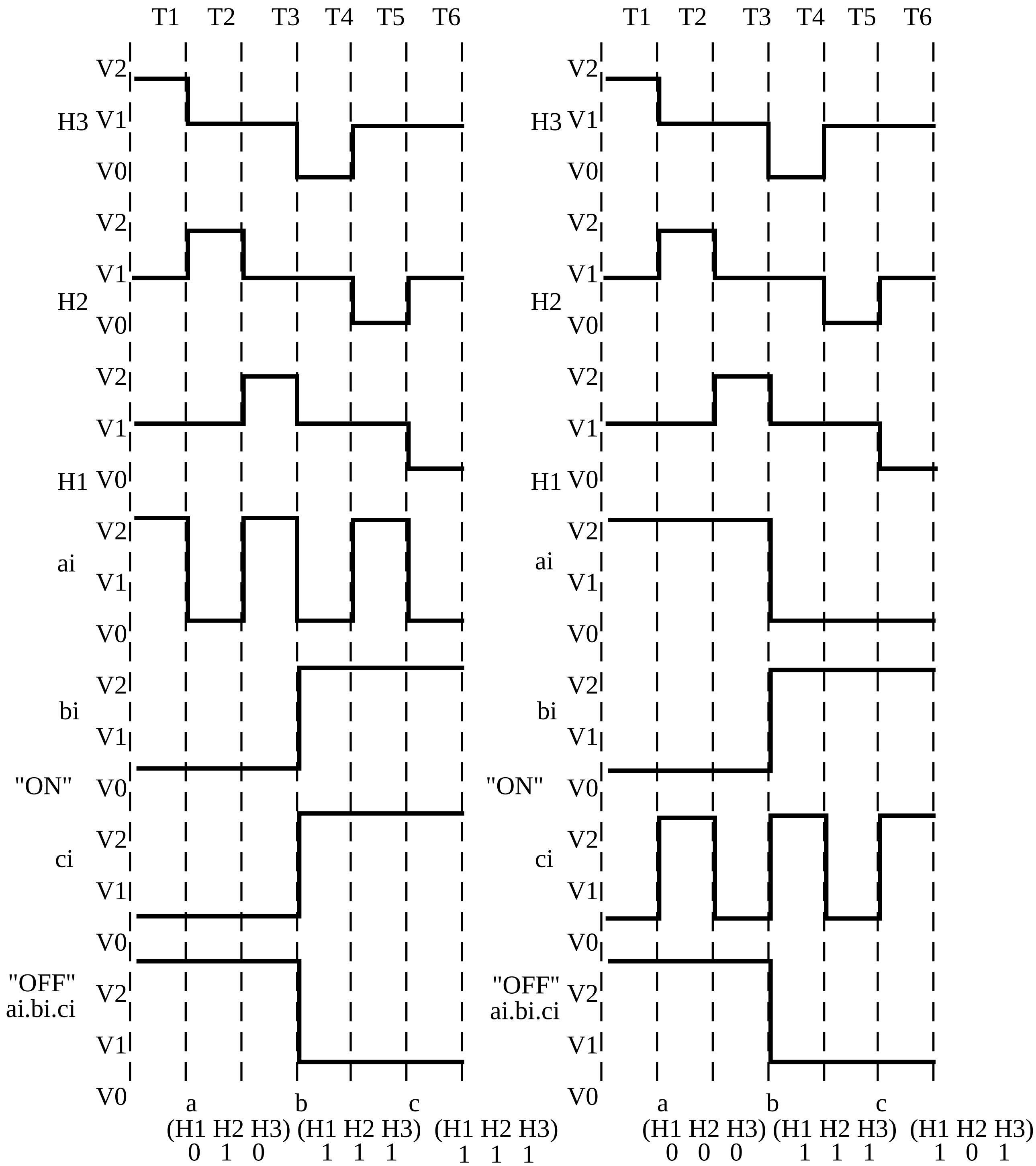
FUNCTION DESCRIPTIONS

A). LCD Display



Display Example

No. "8" ON OR OFF WAVEFORM   No. "5" ON OR OFF WAVEFORM



B). Keyboard descriptions

a) Equal Key (=)
- i) Performs Keyed-in operation and maintains that operation for possible use.
- ii) Establishes power/reciprocation calculation.

b) Multiplication Key (x)
- i) Enters multiplicand.
- ii) Performs previous operation and displays result.

c) Division Key (÷)
- i) Enters dividend.
- ii) Performs previous operation and displays result.

d) Addition Key (+)
- i) Conditions machine for an addition.
- ii) Performs previous operation and displays result.

e) Subtraction Key (-)
- i) Conditions machine for a subtraction.
- ii) Performs previous operation and displays result.

f) Percent Key (%)

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

g) Change Sign Key (+/-)

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

h) Power On/All Clear Key (ON/AC)
- i) First push power-on displays "0".
- ii) In the middle of a digit entry, a second push will clear all registers and memory.

i) Clear Entry/Clear Key (CE/C)
- i) During the digit entry, the first depression will clear the entry register. And display the previous enter number again.
- ii) The second push will clear all registers except memory.

j) Clear Entry Key (CE)

During the digit entry will clear the entry register and display number "0".

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

Extracts the square root of a positive number displayed in the entry register.

l) Memory Plus Key (M+)
- i) Adds the current display to the contents of memory.

ii) It will terminate a number entry.

m) Memory Minus Key (M-)

i) Subtracts the current display from the contents of memory

ii) It will terminate a number entry.

n) Memory Recall and Clear Key (RCM)

i) First push, as RM key, transfers the contents of the memory register into the display register.

ii) Second push, as CM key, clears the memory.

o) 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 enters the data in display register. The first decimal point entered is effective. An attempted entry of more than 8 digits or 7 decimal places will be ignored.

C). Error Conditions

a). Error Detection

System errors occur when :

i) The integral part of any calculation result exceeds 16 digits.

ii) 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.

iii) The integral part of a mark-up and mark-down calculation result exceeds 8-digit.

iv) A division by zero is attempted.

v) 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.

b). Error Indication

i) System error :
"0" is indicated in the first-digit position and "E" in the sign-digit position.

ii) 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 le-8, and no zero shift is performed.

c). Error Release

i) System error :
A system error can be released by depressing ON/AC key.

ii) Rough Estimate Calculation result :
A rough estimate calculation error can be released by depressing the ON/AC or CE/C key. However the calculation result is not cleared by CE/C key but is retained.

D). Operation Characteristics

a) Constant Operation

The EM34001 has implied constant mode on +, -, x, ÷, &, % operations. The constant is performed automatically by the "=" key, "%" key, or "%" key without a constant for addition, subtraction and division while the first operand is the constant for multiplication.

b) Number Entry

Numbericals can be entered up to 8-digit. Entries equal to 9-digit or more are ignored.

c) Memory Protection

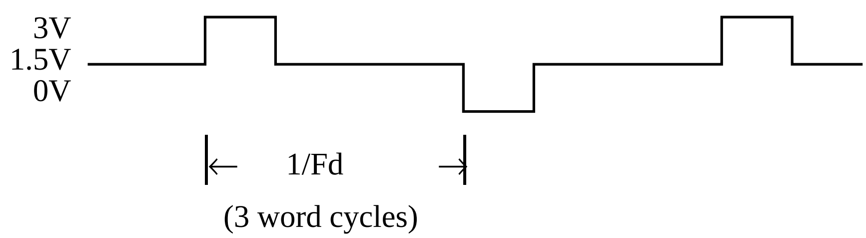
In any error detection, the memory contents present before the error detection are protected.

d) Memory Indication

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

e) 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 (Approximately equal to 14 minutes and 24 seconds at Fd= 52 Hz, the display time of a word being equal to 6 ms when Fd= 52 Hz).



Output waveform example

f) Double Key Depression

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

OFF -> ON/AC -> CE/C -> 5 -> 6 -> 4 -> ROM -> • -> 9
x <- ÷ <- √ <- 0 <- 1 <- 3 <- 2 <- CM <- 7 <- 8 <- - <
> M+ -> = -> +/- -> CE -> + -> M- -> % -> RM

g) Key Bounce Protection

- Font edge : Down to 1 word and up to about 3 words.
- Back edge : 14 words.

E). Arithmetic Operations

Entry	Key Operation	Display
	1 2 3 4 5 6 7 8 9 0	12345678.
Four Fundamental Arithmetic Calculations	a [+] b [=]	a + b
	a [-] b [=]	a - b
	a [x] b [=]	a • b
	a [÷] b [=]	a ÷ b
Square Root Calculations	a [√]	√a
	a [+/-] [√]	0E
	[ON/AC]	0
	a [x] b [√]	√b
	[=]	a • √b
Percent Calculations	a [x] b [%]	a • b/100
	[+] [=]	a + (a•b/100)
	a [x] b [%]	a • b/100
	[-] [=]	a - (a•b/100)
	a [÷] b [%]	100 • a/b
	a [+] b [%]	a + (a • b/100)
	a [-] b [%]	a - (a • b/100)
Constant Calculations	k [x] b [=]	k • b
	c [=]	k • c
	a [÷] k [=]	a /k
	c [=]	c/k
	k [x] b [%]	k • b/100
	c [%]	k • c/100
	a [÷] k [%]	100 • a/k
	c [%]	100 • c/k
	a [+] k [=]	a + k
	b [=]	b + k
	a [-] k [=]	a - k
	b [=]	b - k

	Key Operation	Display	Memory
Repeated Calculations	a [+] b [=] [=]	a + 2b	
	a [-] b [=] [=]	a - 2b	
	a [÷] b [=] [=]	(a/b)/b	
	a [x] b [=] [=]	(a•b)•a	
Power Calculations	a [x] [=]	a^2	
	[x] [=]	a^4	
	a [x] [=] [=]	a^3	
	a [÷] [=]	1/a	
	a [÷] [=] [=]	$1/a^2$	
Mixed Calculations at | (a + b) • c/d) • e|>10^8	a [+] b [x] c [÷] d [=]	(a+b) • c/d	
	[x] e [=]	((a+b)•c/d) • e/10^8 E	
	[CE/C]	((a+b)•c/d) • e/10^8	
Memory Calculations	a [M+]	a M	a
	b [M -]	b M	a - b
	[RM]	a - b M	a - b
	[CM]	a - b	0
	a [+] b [M+]	a + b M	a + b
	c [x] d [M+]	c • d M	a+b+c • d
	[RM]	a+b+c • d M	a+b+c • d
at | a + b + c • d + e|>10^8	e [M+]	0 M E	a+b+c • d
	[CE/C]	0 M	a+b+c • d
	[RM]	a+b+c • d M	a+b+c • d

ABSOLUTE MAXIMUM RATINGS

Items	Sym.	Min.	Max.	Unit
Supply Voltage	V_{DD} -V_{SS}	-0.3	2.0	V
Input Voltage	Vin	-0.3	V_{DD}+0.3	V
Operating Temperature	Top	0	+50	°C
Storage Temperature	Tstg	-20	+70	°C

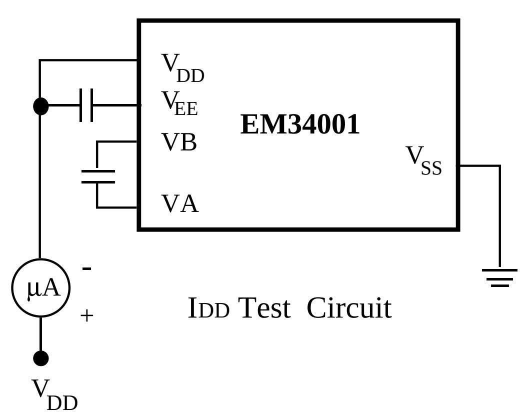
ELECTRICAL CHARACTERISTICS

(V_{DD}=1.5V, T_A=25°C, Unless otherwise specified)

Parameter	Sym.	Min.	Typ.	Max.	Unit	Condition
Supply Voltage	V_{DD}	1.1	1.3	1.8	V	
Input Voltage	V_{IL}	-	-	0.4	V	Note 1
	V_{IH}	V_{DD}-0.4	-	-	V	Note 1
Input Current	I_{IH}	0.3	1	3	μA	V_{IN}=V_{DD}, Note 1
	I_{IL}	-	-	1	μA	V_{IN}=0V, Note 1
Output Voltage	V_{OH}	V_{DD}-0.15	-	-	V	No load, Note 2
	V_{OL}	-	-	0.15	V	I_{OUT}=15μA, Note 2
	V_{OA}	2.8	3		V	Note 3
	V_{OB}	1.3	1.5	1.7	V	Note 3
	V_{OC}	-	0	0.2	V	Note 3
Display Frequency	Fd	50	65	-	Hz	V_{DD}=1.3V While display is on
Dissipation Current	I_{DD}			0.1	μA	Display is off, Note 4
	V_{DD1}	-	2.5	3.5	μA	V_{DD}=1.3V , Note 5 While display is on

Note :

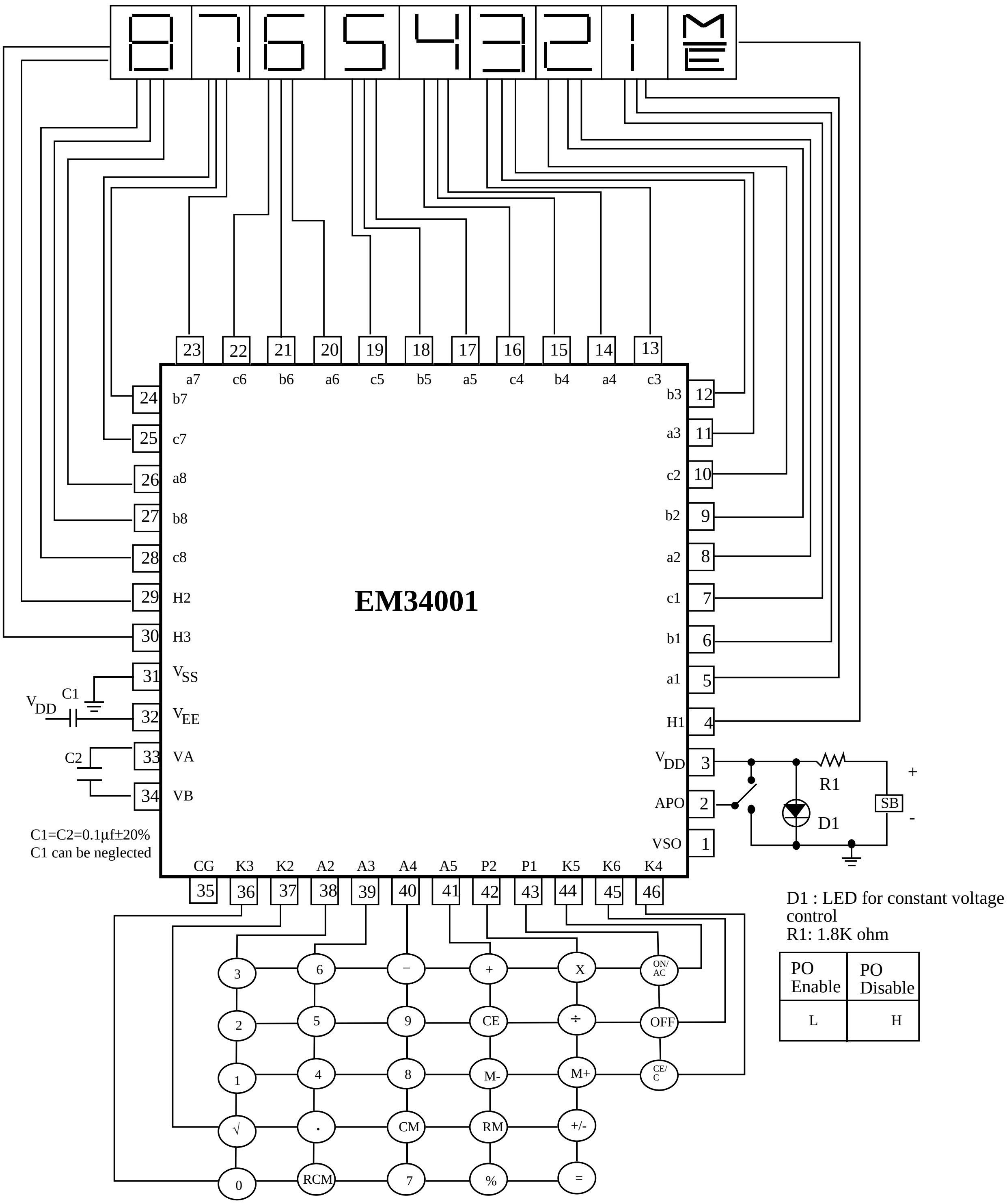
1. Applies to terminals K2 - K6
2. Applies to terminals P1 , P2 and A2 - A5
3. Applies to terminals Hi(i=1 - 3),ai,bi and ci(i=1 - 8)
4. Measured by the following test circuit after power supply automatically turns off. .
5. Measured by the above test circuit while "0" is being dis played after auto-clear and while no key is being depressed.



IDD Test Circuit

APPLICATIONS CIRCUITS

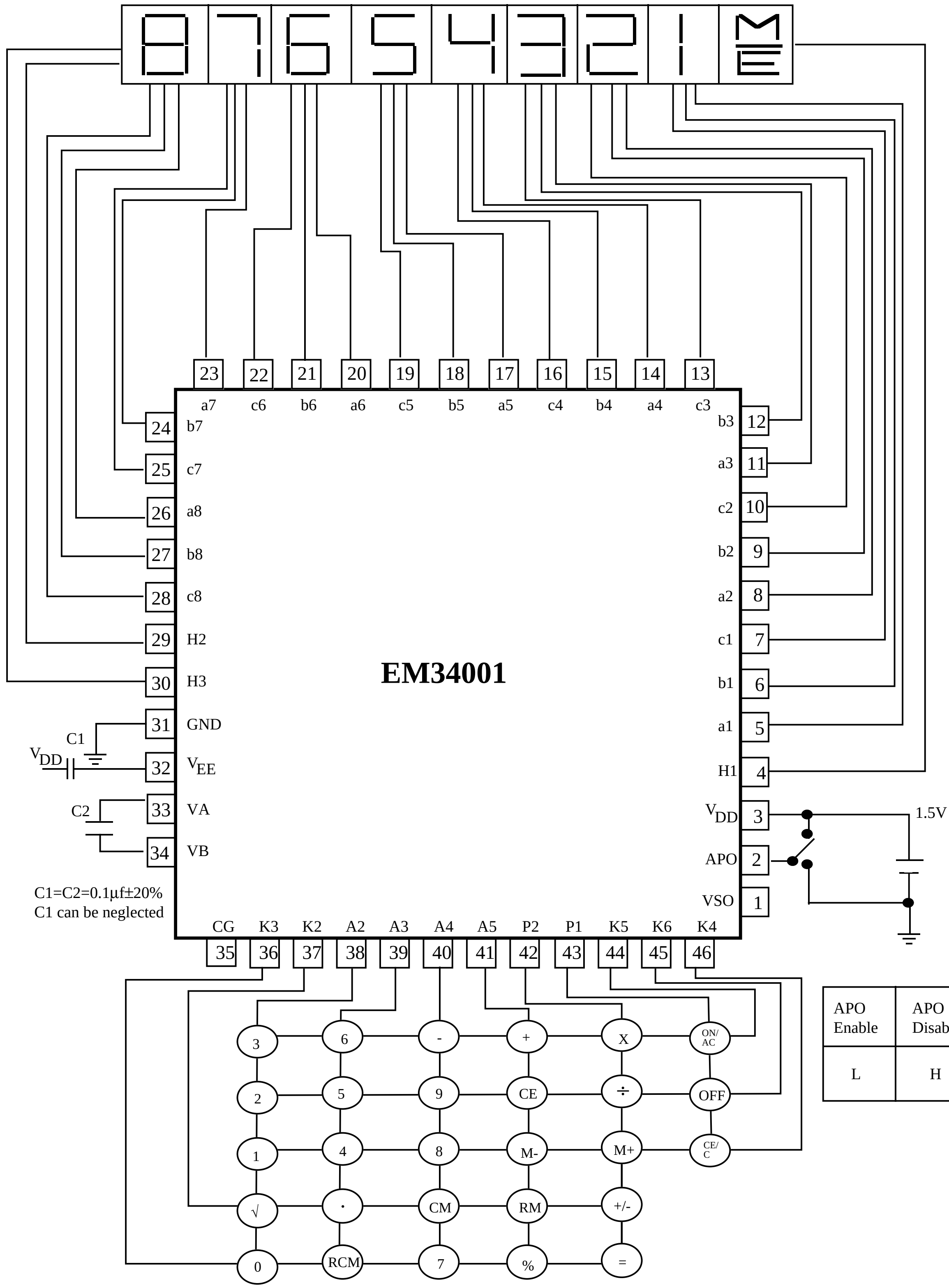
A). Solar Powered Calculator



D1 : LED for constant voltage control
R1: 1.8K ohm

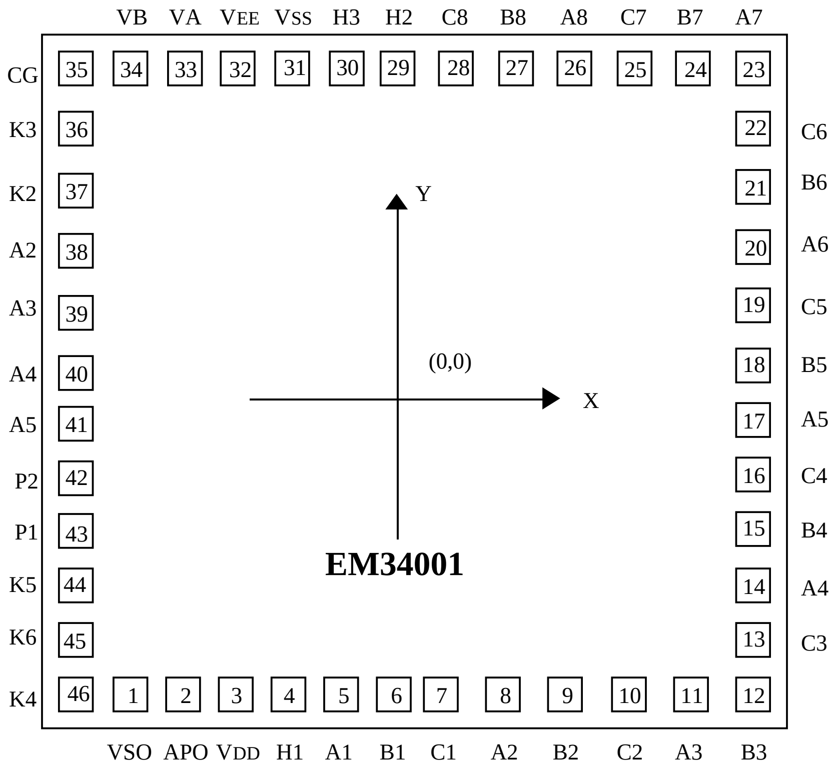
PO Enable	PO Disable
L	H

B). Battery Powered Calculator



APO Enable	APO Disable
L	H

PAD DIAGRAM



Pad No.	Symbol	X	Y
1	VSO	-690.0	-769.0
2	APO	-552.0	-769.0
3	V_{DD}	-414.0	-769.0
4	H1	-276.0	-769.0
5	a1	-138.0	-769.0
6	b1	0.0	-769.0
7	c1	138.0	-769.0
8	a2	276.0	-769.0
9	b2	414.0	-769.0
10	c2	552.0	-769.0
11	a3	690.0	-769.0
12	b3	834.2	-756.6
13	c3	834.2	-618.6
14	a4	834.2	-480.6
15	b4	834.2	-342.6
16	c4	834.2	-204.6
17	s5	834.2	-66.6
18	b5	834.2	71.4
19	c5	834.2	209.4
20	a6	834.2	347.4
21	b6	834.2	485.4
22	c6	834.2	623.4
23	a7	833.4	768.8

Pad No.	Symbol	X	Y
24	b7	695.4	768.8
25	c7	557.4	768.8
26	a8	417.3	768.8
27	b8	279.3	768.8
28	c8	141.3	768.8
29	H2	3.3	768.8
30	H3	-134.7	768.8
31	V_{SS}	-272.7	768.8
32	V_{EE}	-410.7	768.8
33	VA	-556.2	768.8
34	VB	-694.2	768.8
35	CG	-834.0	749.0
36	K3	-834.0	611.0
37	K2	-834.0	473.0
38	A2	-834.0	335.0
39	A3	-834.0	197.0
40	A4	-834.0	59.0
41	A5	-834.0	-79.0
42	P2	-834.0	-217.0
43	P1	-834.0	-355.0
44	K5	-834.0	-493.0
45	K6	-834.0	-631.0
46	K4	-834.0	-769.0

Chip Size : 1960x 1830 µm