



MM57136 RPN scientific calculator control ROM

general description

The MM57136 Control ROM is programmed to perform the functions described when used with the MM5782 Processor and RAM chip. Complete electrical specifications and application data may be found in the MM5781 and MM5782 data sheet.

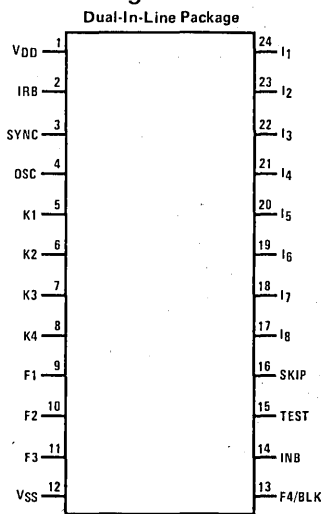
features

- Enters and displays $\pm 9.99999999 \times 10^{99}$ to $\pm 1 \times 10^{-99}$
- Calculates internally using 12 mantissa digits to insure all ten displayed digits are correct
- Left justified entry with trailing zero suppression
- Reverse Polish Notation (RPN)
- Arithmetic functions: +, -, X, \div , 1/X, \sqrt{x} , x^2
- Power function: Y^X
- Logarithmic functions: LN X, LOG X, e^X , 10^X
- Trigonometric functions: SIN, COS, TAN, SIN^{-1} , COS^{-1} , TAN^{-1}
- Compute in degrees, radians or gradian mode
- Rectangular/Polar conversions
- Degrees, minutes, seconds conversions
- 3 full-function, addressable memories
- 4-register working stack with ROLL, CLEAR and EXCHANGE capability
- Statistical functions: standard deviation and mean
- 4 display output modes: floating, scientific, fixed or engineering
- Factorial: n!
- Conversions: $^{\circ}F/^{\circ}C$, LB/KG, IN/CM and GAL/LITERS
- π , change sign and clear-all
- Percent and percent difference functions: %, $\Delta\%$
- Auto power-on clear
- Auto display cut-off for extended battery life

keyboard

F	SIN SIN ⁻¹	COS COS ⁻¹	TAN TAN ⁻¹	-D.MS -D
LN e ^x	LOG 10 ^x	1/X Y ^x	\sqrt{x} x ²	-P -R
M+ X!	$\Sigma+$ $\Sigma-$	% $\Delta\%$	X \cdot Y X \cdot M	ROLL π
MR SD	MS X	EE ENG	CS DSP	ENT CF
7 -KG	8 -CM	9 -LIT	*	M+
4 -LB	5 -IN	6 -GAL	X MX	
1 DEG	2 GRAD	3 RAD	-	M-
0 - ^o F	^o - ^o C	C CA	+	M+

connection diagram



Order Number MM57136N
See Package 22

Keyboard Matrix, Primary Functions

SWITCH INPUTS	DIGIT TIMING STATES									
	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14
K1		1	2	3	0	•	C	-	+	
K2		4	5	6	7	8	9	X	\div	
K3	MR	MS	EE	CS	$\Sigma+$	%	EXC	EN	ROLL	M+
K4	LN	LOG	1/X	\sqrt{x}	SIN	COS	TAN	R \rightarrow P	\rightarrow D.MS	F

functional description

REGISTER CONFIGURATION

The user has access to 7 registers designated X, Y, Z, T, M1, M2 and M3. X is the display and entry register and the bottom of an "operational" stack that includes Y, Z and T. M1, M2 and M3 are independent user-addressable memory registers that can be stored, recalled, added, multiplied, subtracted, divided or exchanged with X.

All registers contain 12 mantissa digits with sign and 2 exponent digits with sign.

DISPLAY CONFIGURATION

The X-register is always displayed and shown as 10 digits of mantissa with sign and 2 digits of exponent with sign. All internal calculations are done with 12 digits and rounded to ten; therefore, all displayed digits are accurate for all functions. Numbers are entered left justified with trailing zeros suppressed.

DISPLAY FORMAT

Floating point display output format is selected at power-on or by pressing "F", "DS", ".". If X is greater than 9999999999, or less than 0.1, the display is automatically in scientific notation.

The number of decimal places displayed can be selected by pressing "F", "DSP" and a number key (0-9). The display is rounded to the selected decimal position. A result too large or small to show with the selected position is displayed in scientific notation.

By pressing "F", "ENG" all results are displayed in modified scientific notation with exponents of 10 that are multiples of 3.

All results maintain 12 digits internally at all times. Only the display is affected when "DS" is used to reduce the number of decimal positions. The unrounded result may be viewed by returning to the floating point mode.

DISPLAY CUT-OFF

If no key is depressed for approximately 32 seconds, an internal display cut-off circuit will turn off the entire display except for segments C, D, E and G of the left-most digit. Depression of any key will restore the display. Input INB of the MM5781 must be wired to VDD to enable the display cut-off feature. If INB is left floating, no display cut-off will occur.

BATTERY LOW INDICATION

The DS8664 digit driver can sense a low battery voltage condition and send a signal to input IRB of the MM5781, which causes the display to flash an "L" in the left-most sign position.

READY SIGNAL OPERATION

Output FIP of the MM5781 can be used as a "ready signal" to indicate calculator status. It can be useful in providing synchronization information during testing and if used with other logic.

When the calculator is in the "idle state" and ready to accept a key, FIP is high (near V_{SS}). It remains high until a key is depressed and accepted, then goes low. It stays low until the calculation is complete, then returns to a high state which signifies a new key may be entered.

KEYBOUNCE AND NOISE REJECTION

When a key is depressed, a time-out is started. A key is accepted as valid if it remains depressed for approximately 12 ms. The key must be released for at least 12 ms before a new key can be entered.

ERROR CONDITIONS AND INDICATION

In the event of an illegal operation, the calculator will display "Error" and X will be cleared. The other registers in the stack and all memories are protected. Any key depressed after an error will use $X = 0$ for the next operator. Table 2 summarizes results and operations that will give an error indication.

TABLE II. Results and Operations that Result in an Error Indication

Results $> 9.999999999 \times 10^{99}$
 Results $< 1 \times 10^{-99}$
 Division by 0
 $\text{LOG}, \text{LN} \leq 0$
 Y^X for $Y \leq 0$
 $\text{TAN}, \text{SIN}, \text{COS} > 25$ revolutions (9000°)
 TAN of angles at or near $\pm\infty$ asymptotes
 $\text{SIN}^{-1}, \text{COS}^{-1} > 1$ or $\leq 10^{-50}$
 $\sqrt{x} < 0$
 $\text{DMS Conversion} \geq 10^{10}$
 $X! < 0$, not an integer, or > 69

RANGE, ACCURACY AND SPEED

All functions work over the mathematically allowable range defined by Table II.

Transcendental functions give 10 digits of accuracy except near normal limits and all other functions are internally accurate to 12 digits.

The calculation time of all transcendental functions takes less than a second; all other functions, with the exception of factorial computations, are executed in less than 1/3 second. Factorial of 69, the longest calculation possible, takes less than 3 seconds.

functional description (con't)

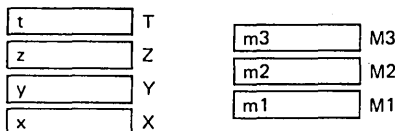


FIGURE 1. User Register Configuration

KEY OPERATIONS

Clear Key, "C"

- Pushes down stack and clears T. Four "C" depressions will clear a completely full stack
- After "F": Clears all registers including the memories

Number Keys, "0" ~ "9," "."

- After any function key except "EN": pushes up stack, clears X and enters number left justified to X
- After any number key: enters next number. All entries after tenth are ignored
- After "EE": enters number to exponent. Last two entries are used
- After "EN": clears X and enters number in X
- After "DS": load decimal select position for fixed decimal output mode
- After "F":

($\rightarrow^{\circ}\text{C}$) "°C" Converts X in $^{\circ}\text{F}$ to $^{\circ}\text{C}$
 $(^{\circ}\text{C} = (^{\circ}\text{F} - 32)/1.8)$

($\rightarrow^{\circ}\text{F}$) "°F" Converts X in $^{\circ}\text{C}$ to $^{\circ}\text{F}$
 $(^{\circ}\text{F} = 1.8^{\circ}\text{C} + 32)$

(DEG) "1" Set calc to degrees mode

(GRAD) "2" Set calc to gradians mode

(RAD) "3" Set calc to radians mode

($\rightarrow\text{LB}$) "4" Replace X with $X \div 0.4535924$

($\rightarrow\text{IN}$) "5" Replace X with $X \div 2.54$

($\rightarrow\text{GAL}$) "6" Replace X with $X \div 3.785412$

($\rightarrow\text{KG}$) "7" Replace X with $X \cdot 0.4535924$

($\rightarrow\text{CM}$) "8" Replace X with $X \cdot 2.54$

($\rightarrow\text{LIT}$) "9" Replace X with $X \cdot 3.785412$

- 1, 2, 3 after:

"MR" Push up stack, recall selected memory to X

"MS" X to selected memory

"M+ mode" M + X to selected memory

"M- mode" M - X to selected memory

"MX mode" M \cdot X to selected memory

"M \div mode" M \div X to selected memory

"MEXC mode" X is exchanged with selected memory

Change Sign Key, "CS/DS"

- After "EE": change sign of exponent of X
- After "F": (DS) set calc to Decimal Select mode
- After any other key: changes sign of X mantissa

Positive/Negative Summing Key, " Σ +/ Σ -"

- Used to enter data points for computation of mean and standard deviation:
 Sums X to M1 (ΣX)
 Sums X^2 to M2 (ΣX^2)
 Adds 1 to M3 (N)
- After "F": (Σ -) used to delete data points:
 Subtracts X from M1
 Subtracts X^2 from M2
 Subtracts 1 from M3

Accumulative/Factorial Key, "M+/X!"

- Sums X to M1
- After "F": (X!) replaces X with X-factorial

Coordinate Conversion Key, "R \leftrightarrow P"

- Converts contents of X and Y in rectangular coordinates to polar coordinates:

$$\sqrt{X^2 + Y^2} \text{ to } Y$$

$$\text{TAN}^{-1} Y/X \text{ to } X$$

- After "F": (P \rightarrow R) converts contents of X and Y in polar coordinates to rectangular coordinates:

$$Y \text{ SIN } X \rightarrow Y$$

$$Y \text{ COS } X \rightarrow X$$

Note: R \leftrightarrow P works in all four quadrants

Square Root/Square Key, " \sqrt{X}/X^2 "

- Square root of positive value of X to X
- After "F": (X^2) X-squared to X

functional description (con't)

Reciprocal/Power Key, "1/X/Y^x"

- Reciprocal of non-zero value of X to X
- After "F": (Y^X) computes power, pushes down stack, clears T

Enter Key, "ENT/CF"

- Pushes up stack, retains X
- After F: (CF) resets F mode

Second Function Key, "F"

Sets F mode

Memory Store/Mean Key, "MS/ \bar{X} "

- Sets memory store mode
- After "F": (X) divides M1 by M3 and puts result in X, this gives mean of data summed using $\Sigma+$ key

Memory Recall/Standard Deviation Key, "MR/SD"

- Sets Memory Recall mode
- After F: (S.D.) computes standard deviation of data entered with the $\Sigma+$ key using the relationship:

$$SD = \sqrt{\frac{\Sigma X^2 - \frac{(\Sigma X)^2}{N}}{N - 1}} \equiv \sqrt{\frac{M2 - \frac{(M1)^2}{M3}}{M3 - 1}} \rightarrow X$$

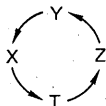
ΣX , ΣX^2 and N may be recovered from M1, M2 and M3

Enter Exponent Key, "EE/ENG"

- Sets enter exponent mode, displaying 00 in exponent position
- After F: (ENG) sets the calculator to the engineering mode, which displays all numbers with an exponent in multiples of 3.

Stack Rotate/Pi Key, "ROLL/ π "

- Rolls stack down



- After F: (π) pushes up stack and enters π , 3.14159265359 to X

Exchange Key "X \leftrightarrow Y/X \leftrightarrow M"

- Exchanges X and Y
- After MS, MR or F: (X \leftrightarrow M) sets calculator to MEXC mode

Percent/Delta Percent Key, "%/ Δ %"

- Calculates percent by:

$$\frac{X \cdot Y}{100} \rightarrow X$$

- After F:(Δ %) percent change between X and Y to X, and difference to Y:

$$\frac{Y - X}{X} \cdot 100 \rightarrow X, \text{ and } Y - X \rightarrow Y$$

Common Log Key, "LOG/ 10^x "

- Common logarithm of X to X (base 10)
- After "F": (10^X) 10^X to X

Natural Log Key, "Ln/ e^x "

- Natural logarithm of X to X (base e)
- After "F": (e^X) e^X to X

Decimal to Degrees Conversion Key, "D.MS"

- Replaces the decimal angle in X with its degrees (or hours), minutes and seconds conversion and sets the decimal select to four.
- After "F": (DMS) degrees (or hours), minutes and seconds in X is converted to decimal angle

Trigonometric Keys, "SIN, COS, TAN"

- Replaces the decimal angle in X with the indicated trigonometric function
- After F: replaces X with the decimal angle of the indicated inverse trigonometric function

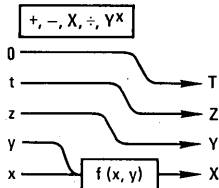
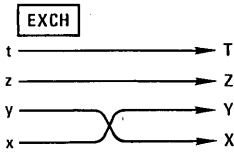
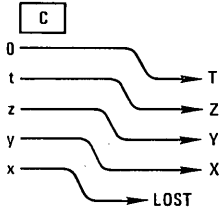
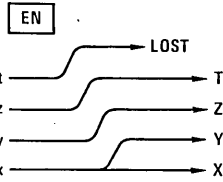
The Four Function Keys, "+, -, x, \div "

- | | |
|---|--|
| Add key: Y + X \rightarrow X | } Then push down stack and clear T:
0 \rightarrow T \rightarrow Z \rightarrow Y |
| Subtract key: Y - X \rightarrow X | |
| Multiply key: Y \cdot X \rightarrow X | |
| Divide key: Y \div X \rightarrow X | |
- After MS, MR or F:
 - "+" Sets M+ mode
 - "-" Sets M- mode
 - "X" Sets Mx mode
 - " \div " Sets M \div mode

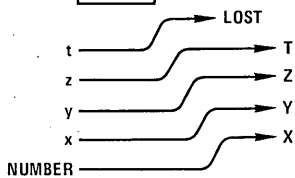
summary

Summary of Stack Operations

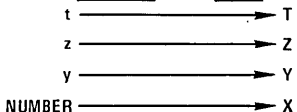
(M1, M2, M3 UNCHANGED)



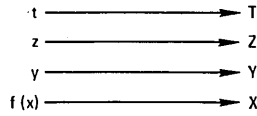
FIRST
0 ~ 9 , . AFTER FUNCTION KEY



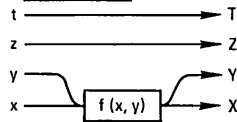
0 ~ 9 , . AFTER **EN** OR **0 ~ 9 , .**



SIN, COS, TAN, SIN⁻¹, COS⁻¹, TAN⁻¹, CS, LN, LOG, 10^x, e^x, 1/X, √X, X², X!, SD., X̄, KG, CM, LT, LB, IN, GAL, °F, °C, DMS→, →DMS, %



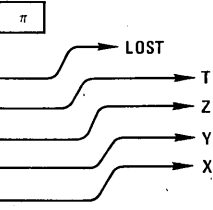
R → P, Δ%



ROLL

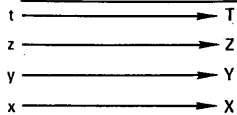


EE AFTER FUNCTION KEY OR

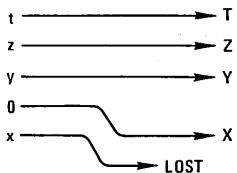


EE AFTER NUMBER KEY OR

DS, DEG, RAD, GRAD, ENG, CF, F



ERROR



summary (con't)

Summary of Operations Using Memory(s)

