



## MM57135 scientific calculator ROM general description

The MM57135 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

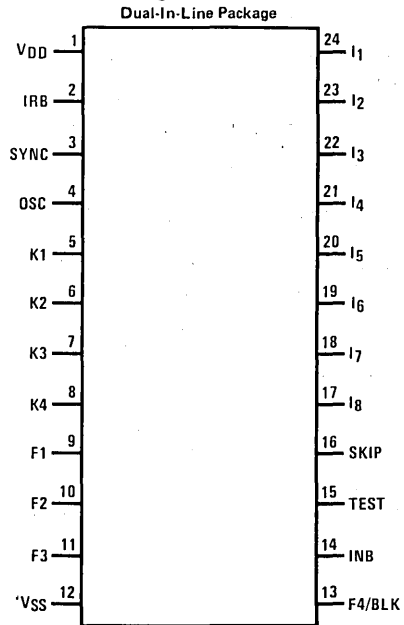
- Enters and displays  $\pm 9.99999999 \times 10^{99}$  to  $\pm 1 \times 10^{-99}$
- Calculates internally using 12 mantissa digits to insure all ten displayed digits are correct
- Left justified entry with trailing zero suppression
- Algebraic Notation with 2 levels of parentheses
- Arithmetic functions: +, -, X,  $\div$ , 1/X,  $\sqrt{X}$ ,  $X^2$
- Constant operations (second factor)

- 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
- Statistical functions: standard deviation and mean
- 2 display output modes: floating or scientific
- Factorial: n!
- Conversions:  $^{\circ}F/^{\circ}C$ , LB/KG, IN/CM and GAL/LITERS
- $\pi$ , change sign, clear-all and exchange
- Auto power-on clear

### keyboard

F	SIN SIN <sup>-1</sup>	COS COS <sup>-1</sup>	TAN TAN <sup>-1</sup>	→ D.MS → D
LN e <sup>X</sup>	LOG 10 <sup>X</sup>	Y <sup>X</sup> 1/X	$\sqrt{X^2}$	·P ·R
M+ X!	$\Sigma+$ $\Sigma-$	X ↔ Y X ↔ M	[( 2 $\pi$	)] $\pi$
MR SD	MS X	EE SCI	CS FLT	$\div$ M+
7 →KG	8 →CM	9 ·LIT	X MX	
4 →LB	5 →IN	6 ·GAL	- M-	
1 DEG	2 GRAD	3 RAD	+ M+	
0 →°F	· →°C	C CA	= CF	

### connection diagram



Order Number MM57135N  
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	
K3	MR	MS	EE	CS	$\Sigma+$	X ↔ Y	[(	$\div$	)]	M+
K4	LN	LOG	Y <sup>X</sup>	$\sqrt{X}$	SIN	COS	TAN	R → P	→ D.MS	F



## functional description

### REGISTER CONFIGURATION

The user has access to 7 registers designated X, Y, P1, P2, M1, M2 and M3. X is the display and entry register. Y is the constant register. M1, M2 and M3 are independent user-addressable memory registers that can be stored, recalled, added, multiplied, subtracted or divided with X. P1 and P2 are parentheses registers.

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 displayed 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", "FLT". If X is greater than 9999999999, or less than 0.000000001, the display is automatically in scientific notation.

By pressing "F", "EE" all results are displayed in scientific notation.

All results maintain 12 digits internally at all times.

### 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 show 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. All other registers and memories are protected. Any key depressed after an error will use  $X = 0$  for the next operator. Table I summarizes results and operations that will give an error indication.

### RANGE, ACCURACY AND SPEED

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

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.

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

Results $> 9.99999999 \times 10^{99}$
Results $< 1 \times 10^{-99}$
Division by 0
LOG, LN $\leq 0$
$Y^X$ for $Y \leq 0$
TAN, SIN, COS $\geq 25$ revolutions (9000°)
TAN of 90°, 270°, etc.
$\text{SIN}^{-1}$ , $\text{COS}^{-1} > 1$ or $\leq 10^{-50}$
$\sqrt{X} < 0$
DMS Conversion $\geq 10^{10}$
$X! < 0$ , or not an integer
More than two open parentheses
More closed parentheses than open parentheses

## functional description (con't)

### KEY OPERATIONS

#### Clear Key, "C"

- After number keys: copies Y to X
- After function key: clears all modes and X, Y, P1 and P2
- After "F": clears all modes and all registers

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

- After any function key: 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 "F":
  - ( $\rightarrow^{\circ}\text{C}$ ) ". ." Converts X in  $^{\circ}\text{F}$  to  $^{\circ}\text{C}$   
( $^{\circ}\text{C} = (^{\circ}\text{F} - 32)/1.8$ )
  - ( $\rightarrow^{\circ}\text{F}$ ) "0" 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
  - ( $\rightarrow$  LB) "4" Replace X with  $X \div 0.4535924$
  - ( $\rightarrow$  IN) "5" Replace X with  $X \div 2.54$
  - ( $\rightarrow$  GAL) "6" Replace X with  $X \div 3.785412$
  - ( $\rightarrow$  KG) "7" Replace X with  $X \cdot 0.4535924$
  - ( $\rightarrow$  CM) "8" Replace X with  $X \cdot 2.54$
  - ( $\rightarrow$  LIT) "9" Replace X with  $X \cdot 3.785412$

- 1, 2, 3 after:

"MR"	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 · X to selected memory
"M÷ mode"	M ÷ X to selected memory
"MEXC mode"	X is exchanged with selected memory

#### Change Sign Key, "CS"

- After "EE": change sign of exponent of X
- After "F": (FLT) set calc to Floating Point 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 ( $\Sigma x$ )
  - Sums  $X^2$  to M2 ( $\Sigma x^2$ )
  - Adds 1 to M3 (N)
- After "F": ( $\Sigma -$ ) 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 ↔ P"

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

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

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

- After "F": (P → R) converts contents of X and Y in polar coordinates to rectangular coordinates: resets calculator mode:
  - Y SIN X → Y
  - Y COS X → X

Note: R ↔ P works in all four quadrants

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

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

#### Second Function Key, "F"

Sets F mode

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

- Sets memory store mode
- After "F": ( $\bar{X}$ ) 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:

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

$\Sigma X$ ,  $\Sigma X^2$  and N may be recovered from M1, M2 and M3

#### Enter Exponent Key, "EE/SCI"

- Sets enter exponent mode, displaying 00 in exponent position
- After F: (SCI) sets the calculator to display using scientific notation

#### Common Log Key, "LOG/10 $X^x$ "

- 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

## functional description (con't)

### Decimal to Degrees Conversion Key, "D.MS"

- Replaces the decimal angle in X with its degrees (or hours), minutes and seconds conversion
- 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

### Power/Reciprocal Key, "Y<sup>X</sup>/1/X"

- If not in chain mode: copy X to Y set Y<sup>X</sup> chain mode
- After "+, -, X, ÷, Y<sup>X</sup> key: copy X to Y, set Y<sup>X</sup> chain mode
- In chain mode: perform the specified function of X and Y putting the result to X and Y, set Y<sup>X</sup> chain mode
- After "F": reciprocal of non-zero value of X to X

### The Four Function Keys, "+, -, X, ÷"

- If not in chain mode: copy X to Y, set the specified chain mode
- After "+, -, X, ÷, Y<sup>X</sup> " key: copy X to Y, set chain mode
- In chain mode: perform the specified function of X and Y putting the result to X and Y, set the specified chain mode
- After "F," "MS" or "MR": set the appropriate memory mode (M+, M-, MX, M÷)

### Equal Key, "="

- In chain mode: perform the specified function of X and Y, putting the result to X and save the last number displayed in Y, set the constant mode
- In constant mode: perform the specified function of X, Y putting the result in X
- After "F": (CF) reset F mode

### Exchange Key, "X ↔ Y/X ↔ M"

- Exchange X and Y
- After "MS," "MR" or "F": (X ↔ M) sets calculator to MEXC mode

### Open Parentheses, "{(/2π"

- Copy P1 to P2, copy Y to P1. Copy P1 mode to P2 mode, copy the calculator mode to P1 mode, reset calculator mode
- After "F": (2π) enter 2 Pi to X (6.283185307)

### Close Parentheses/Pi Key, ")/π"

- In chain mode: perform the specified function of X, Y putting the result to X. Copy P1 to Y, copy P2 to P1, clear P2. Copy P2 mode to P1 mode, copy P1 mode to the calculator mode, reset P2 mode
- Not in chain mode: P1 to Y, P2 to P1, clear P2, P1 mode to calculator mode, P2 mode to P1 mode, reset P2 mode
- After "F": (π) enter Pi to X (3.14159765359)

TABLE II. Example Showing Parentheses Registers and Modes

$$6 \times (2(8-5) + 2)$$

	X	Y MODE	P1 MODE	P2 MODE
6	6			
X	6	6 X		
(	6	6	6 X	
2	2	6	6 X	
Y <sup>X</sup>	2	2 Y <sup>X</sup>	6 X	
(	2	2	2 Y <sup>X</sup>	6 X
8	8	2	2 Y <sup>X</sup>	6 X
-	8	8 -	2 Y <sup>X</sup>	6 X
5	5	8 -	2 Y <sup>X</sup>	6 X
)	3	2 Y <sup>X</sup>	6 X	
+	8	8 +	6 X	
2	2	8 +	6 X	
)	10	6 X		
=	60	10 X (const)		

10 is constant multiplier