MM5767 slide rule calculator*

general description

The single-chip MM5767 Slide Rule Calculator was developed with the primary objective of low end-product cost. A complete calculator as shown in *Figure 1* requires only the MM5767, a 20 or 22 key keyboard, DM8864 digit driver, NSA298 LED display and a 9V battery with appropriate hardware.

Keyboard decoding and key debounce circuitry, all clock and timing generation and 7-segment output display encoding are included on-chip and require no external components. Segments can usually be driven directly from the MM5767, as it typically sources about 8.5 mA of peak current. (Note: the typical duty cycle of each digit is 0.104; average LED segment current is therefore approximately 0.89 mA.) The left-most digit is used for the negative sign or the decimal point of a number less than unity.

An internal power-on clear circuit clears all registers, including the memory, when V_{DD} and V_{SS} are initially applied to the chip.

Trailing zero suppression allows convenient reading of the left justified display, and conserves power. The DM8864 digit driver is capable of sensing a low battery voltage and providing a signal during Digit 9 time that can be used to turn on one of the segments as an indicator.

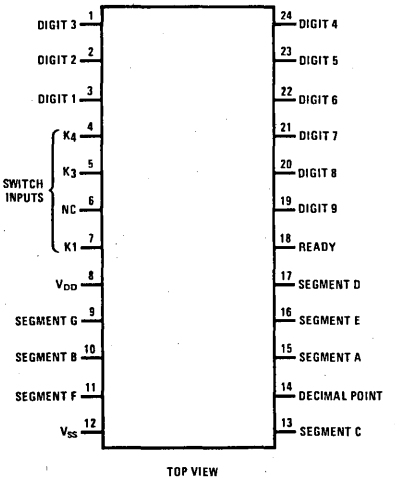
features

- 20 or 22 key keyboard
- Full 8-digit entry and display capacity
- Complete electronic slide rule capability
  - Arithmetic functions: +, −, x, ÷, $\sqrt{x}$, 1/x
  - Logarithmic functions: ln x, log x, e^x
  - Trigonometric functions: sin x, cos x, tan x, arc sin x, arc cos x, arc tan x
  - Other functions: Y^x, π, change sign, exchange, radians to degrees, degrees to radians
- Three-register operational stack
- Independent accumulating storage register with store, recall, memory plus and memory minus functions
- Floating point input and output
- Direct 9V battery compatibility; low power dissipation
- Power-on clear
- No external components required other than display digit driver, keyboard and LED display for complete calculator
- Error indication for over range, overflow and invalid operations
- Left justified entry and results with trailing zero suppression
- Automatic display cutoff
- Reverse polish notation

***Note:** For detailed information on electrical specifications and key operations please refer to the MM5760 data sheet.

connection diagram

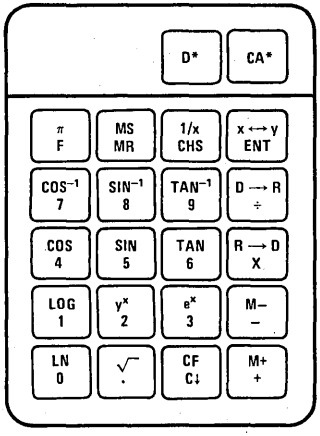
Dual-In-Line Package



TOP VIEW

Order Number MM5767N
See Package 22

keyboard outline

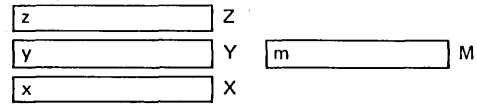


*Optional

Typical current drain of a complete calculator displaying five "5's" is 30 mA. Automatic display cutoff is included. If no key closure occurs for approximately 35 seconds, all numbers are blanked and all decimal points displayed.

The keys are arranged in a three-by-nine matrix *(Figure 2)*. In addition to seven arithmetic functions plus logarithmic, trigonometric and accumulating memory functions, the calculator is capable of calculating Y^X, automatically entering π and providing degrees/radian converions.

The user has access to four registers designated X, Y, Z and M. X is the display and entry register, and is the bottom of a "push-up" stack that also includes registers Y and Z:



Note: Lower case letters designate the data in the register identified by a capital letter.

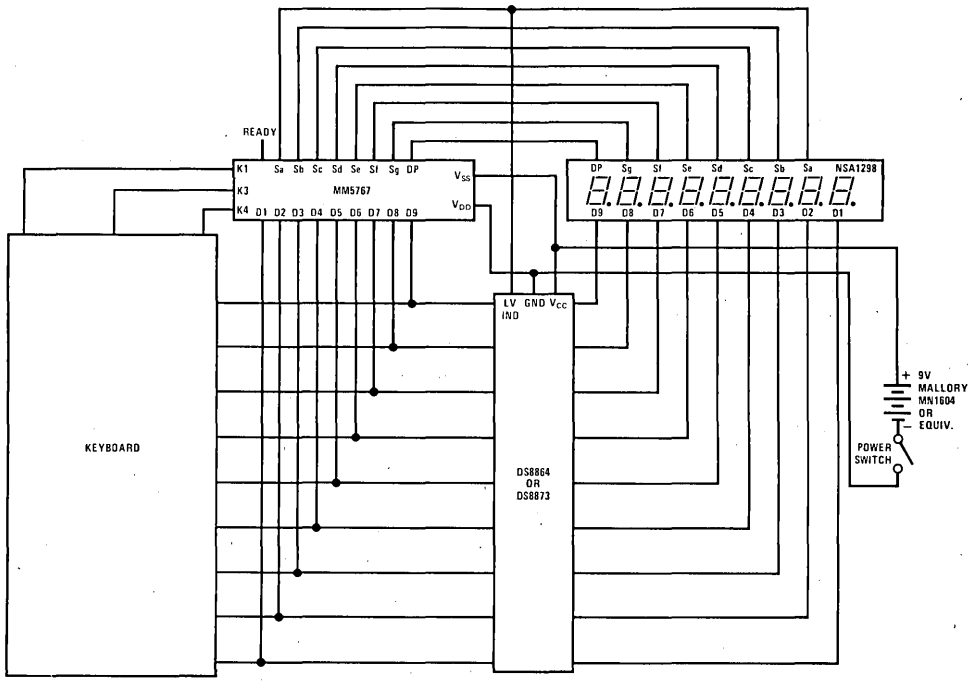


FIGURE 1. Complete Calculator Schematic

	K1	K3	K4
D9		TAN/6	
D8		$COS^{-1}/7$	π/F
D7	R → D/x	$SIN^{-1}/8$	D*
D6	D → R/÷	$TAN^{-1}/9$	LN/0
D5	M+/+	$\sqrt{\ }$ /·	Log/1
D4	M−/−	EXC/EN	$Y^X/2$
D3	CLF/CL	MS/MR	$e^x/3$
D2	CA*	1/x / CS	COS/4
D1			SIN/5

*Keys not included in 20 key version.

FIGURE 2. Keyboard Matrix

KEYBOARD BOUNCE AND NOISE REJECTION

The MM5767 is designed to interface with most low cost keyboards, which are often the least desirable from a false or multiple entry standpoint.

A key closure is sensed by the calculator chip when one of the key inputs, K1, K3 or K4 is forced more positive than the Logical High Level specified in the Electrical Specifications. An internal counter is started as a result of the closure. The key operation begins after nine word times if the key input is still at a Logical High Level. As long as the key is held down (and the key input remains high) no further entry is allowed. When the key input changes to a Logical Low Level, the internal counter starts a sixteen word time-out for key release. During both entry and release time-outs the key inputs are sampled approximately every other word time for valid levels. If they are found invalid, the counter is reset and the calculator assumes the last valid key input state.

One of the popular types of low-cost keyboards available, the elastomeric conductor type, has a key pressure versus contact resistance characteristic that can generate continuous noise during "teasing" or low pressure key depressions. The MM5767 recognizes a series contact resistance up to 50 kΩ as a valid key closure, assuring a reliable interface for that type of keyboard.

AUTOMATIC DISPLAY CUTOFF

If no key is depressed for approximately 35 seconds, an internal automatic display cutoff circuit will blank all segments and display nine decimal points. Any key depression will restore the display; to restore the display without modifying the status of the calculator, use two change sign, "CS," depressions.

READY SIGNAL OPERATION

The Ready signal indicates calculator status. When the calculator is in an "idle" state the output is at a Logical High Level (near V_{SS}). When a key is closed, the internal key entry timer is started. Ready remains high until the time-out is completed and the key entry is accepted as valid, then goes low as indicated in *Figures 3 and 4*. It remains at a Logical Low Level until the function initiated by the key is completed and the key is released. The low to high transition indicates the calculator has returned to an idle state and a new key can be entered.

ERROR INDICATION

In the event of an operating error, the MM5767 will display all zeros and all decimal points. In addition to normal calculator overflow situations which occur as a result of adding, subtracting, multiplying or dividing and including division by zero, the error indication is displayed for any other calculation where the result is $|R| > 99999999$ or $|R| \leq 0.00000001$.

For error conditions the Z-register is automatically cleared and the Y- and M-registers are saved. An error condition is cleared by depressing any key except "1/X," "÷," "LOG X" or "LN X." Operation on the X register with an error displayed will be performed as if X contained a zero.

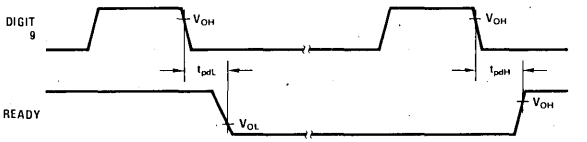


FIGURE 3. Ready Timing

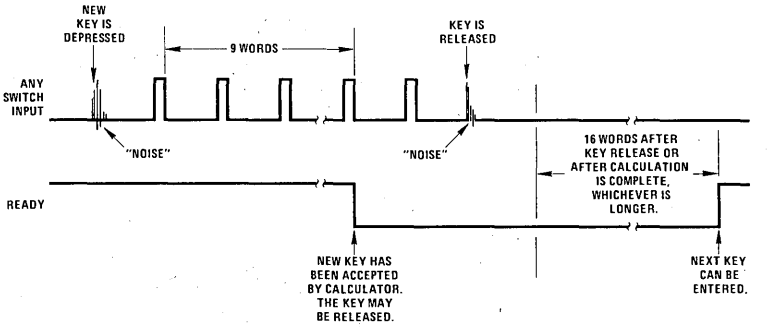


FIGURE 4. Functional Description of Ready Signal and Key Entry

RANGE AND ACCURACY OF FUNCTIONS

The smallest magnitude that can be displayed is ±0.00000001 and the total range is from −99999999 to +99999999. The arithmetic functions (+, −, x, ÷, 1/X, $\sqrt{X}$) have eight digit accuracy. All results are truncated. Table I summarizes range and accuracy of the other functions. Arithmetic calculations will be completed in less than 0.5 second; all others except Y^x in less than 2.5 seconds and Y^x in less than 5 seconds.

TABLE I. Digit Accuracy for Various Functions

FUNCTION	RANGE	APPROXIMATE ACCURACY (Note 1)
SIN, COS, TAN	$\sim -90^\circ$ to $\sim 90^\circ$ $\sim -360^\circ$ to $\sim 360^\circ$	7 Digits 6 Digits
ARC SIN and ARC COS	~ -1 to $\sim +1$	6 Digits
ARC TAN	−99999999 to 99999999	6 Digits
LOG	$X \geq 0$	6 Digits
e^X	$-28 \leq X \leq \ell n\ 99999999$	6 Digits
LN	$X \geq 0$	6 Digits
$\sqrt{X}$	$X \geq 0$	8 Digits
Y^X	$Y > 0$ $X\ \ell n\ Y \leq \ell n\ 99999999$	5 Digits

Note 1: Six digit accuracy, as an example, would be:

1 2 3 4 5 6 X X
↑
└ ±1

n digit accuracy has the n^{th} digit from the MSD being displayed accurate within ±1.