National Semiconductor

MM54C922/MM74C922 16-Key Encoder
MM54C923/MM74C923 20-Key Encoder

General Description

These CMOS key encoders provide all the necessary logic to fully encode an array of SPST switches. The keyboard scan can be implemented by either an external clock or external capacitor. These encoders also have on-chip pull-up devices which permit switches with up to 50 kΩ on resistance to be used. No diodes in the switch array are needed to eliminate ghost switches. The internal debounce circuit needs only a single external capacitor and can be defeated by omitting the capacitor. A Data Available output goes to a high level when a valid keyboard entry has been made. The Data Available output returns to a low level when the entered key is released, even if another key is depressed. The Data Available will return high to indicate acceptance of the new key after a normal debounce period; this two key roll over is provided between any two switches.

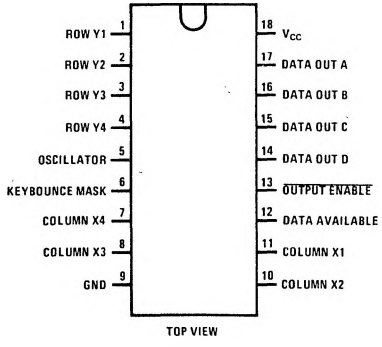
An internal register remembers the last key pressed even after the key is released. The TRI-STATE® outputs provide for easy expansion and bus operation and are LPTTL compatible.

Features

- 50 kΩ maximum switch on resistance
- On or off chip clock
- On chip row pull-up devices
- 2 key roll-over
- Keybounce elimination with single capacitor
- Last key register at outputs
- TRI-STATE outputs LPTTL compatible
- Wide supply range 3V to 15V
- Low power consumption

Connection Diagrams

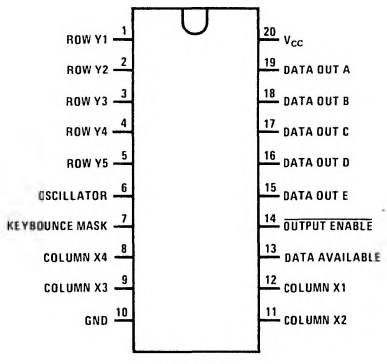
Dual-In-Line Package



Order Number MM54C922N
or MM74C922N
See Package 20

18A

Dual-In-Line Package



Order Number MM54C923N
or MM74C923N
See Package 20A

Absolute Maximum Ratings (Note 1)

Voltage at Any Pin	V_{CC} − 0.3V to V_{CC} + 0.3V	Package Dissipation	500 mW
Operating Temperature Range		Operating V_{CC} Range	3V to 15V
MM54C922, MM54C923	−55°C to +125°C	V_{CC}	18V
MM74C922, MM74C923	−40°C to +85°C	Lead Temperature (Soldering, 10 seconds)	300°C
Storage Temperature Range	−65°C to +150°C		

DC Electrical Characteristics Min/Max limits apply across temperature range unless otherwise specified.

PARAMETER		CONDITIONS	MIN	TYP	MAX	UNITS
CMOS TO CMOS						
V_{T+}	Positive-Going Threshold Voltage at Osc and KBM Inputs	V_{CC} = 5V, $I_{IN} \geq$ 0.7 mA	3	3.6	4.3	V
		V_{CC} = 10V, $I_{IN} \geq$ 1.4 mA	6	6.8	8.6	V
		V_{CC} = 15V, $I_{IN} \geq$ 2.1 mA	9	10	12.9	V
V_{T-}	Negative-Going Threshold Voltage at Osc and KBM Inputs	V_{CC} = 5V, $I_{IN} \geq$ 0.7 mA	0.7	1.4	2	V
		V_{CC} = 10V, $I_{IN} \geq$ 1.4 mA	1.4	3.2	4	V
		V_{CC} = 15V, $I_{IN} \geq$ 2.1 mA	2.1	5	6	V
$V_{IN(1)}$	Logical "1" Input Voltage, Except Osc and KBM Inputs	V_{CC} = 5V,	3.5	4.5		V
		V_{CC} = 10V,	8	9		V
		V_{CC} = 15V,	12.5	13.5		V
$V_{IN(0)}$	Logical "0" Input Voltage, Except Osc and KBM Inputs	V_{CC} = 5V,		0.5	1.5	V
		V_{CC} = 10V,		1	2	V
		V_{CC} = 15V,		1.5	2.5	V
I_{rp}	Row Pull-Up Current at Y1, Y2, Y3, Y4 and Y5 Inputs	V_{CC} = 5V, V_{IN} = 0.1 V_{CC}		−2	−5	μA
		V_{CC} = 10V		−10	−20	μA
		V_{CC} = 15V		−22	−45	μA
$V_{OUT(1)}$	Logical "1" Output Voltage	V_{CC} = 5V, I_O = −10μA	4.5			V
		V_{CC} = 10V, I_O = −10μA	9			V
		V_{CC} = 15V, I_O = −10μA	13.5			V
$V_{OUT(0)}$	Logical "0" Output Voltage	V_{CC} = 5V, I_O = 10μA			0.5	V
		V_{CC} = 10V, I_O = 10μA			1	V
		V_{CC} = 15V, I_O = 10μA			1.5	V
R_{on}	Column "ON" Resistance at X1, X2, X3 and X4 Outputs	V_{CC} = 5V, V_O = 0.5V		500	1400	Ω
		V_{CC} = 10V, V_O = 1V		300	700	Ω
		V_{CC} = 15V, V_O = 1.5V		200	500	Ω
I_{CC}	Supply Current	V_{CC} = 5V, Osc at 0V		0.55	1.1	mA
		V_{CC} = 10V		1.1	1.9	mA
		V_{CC} = 15V		1.7	2.6	mA
$I_{IN(1)}$	Logical "1" Input Current at $\overline{\text{Output Enable}}$	V_{CC} = 15V, V_{IN} = 15V		0.005	1.0	μA
$I_{IN(0)}$	Logical "0" Input Current at $\overline{\text{Output Enable}}$	V_{CC} = 15V, V_{IN} = 0V	−1.0	−0.005		μA
CMOS/LPTTL INTERFACE						
$V_{IN(1)}$	Logical "1" Input Voltage, Except Osc and KBM Inputs	54C, V_{CC} = 4.5V	V_{CC}−1.5			V
		74C, V_{CC} = 4.75V	V_{CC}−1.5			V
$V_{IN(0)}$	Logical "0" Input Voltage, Except Osc and KBM Inputs	54C, V_{CC} = 4.5V			0.8	V
		74C, V_{CC} = 4.75V			0.8	V
$V_{OUT(1)}$	Logical "1" Output Voltage	54C, V_{CC} = 4.5V, I_O = −360μA	2.4			V
		74C, V_{CC} = 4.75V, I_O = −360μA	2.4			V
$V_{OUT(0)}$	Logical "0" Output Voltage	54C, V_{CC} = 4.5V, I_O = −360μA			0.4	V
		74C, V_{CC} = 4.75V, I_O = −360μA			0.4	V

DC Electrical Characteristics (Cont'd.)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
OUTPUT DRIVE (See 54C/74C Family Characteristics Data Sheet) (Short Circuit Current)					
I_{SOURCE} Output Source Current (P-Channel)	V_{CC} = 5V, V_{OUT} = 0V, T_A = 25°C	−1.75	−3.3		mA
I_{SOURCE} Output Source Current (P-Channel)	V_{CC} = 10V, V_{OUT} = 0V, T_A = 25°C	−8	−15		mA
I_{SINK} Output Sink Current (N-Channel)	V_{CC} = 5V, V_{OUT} = V_{CC}, T_A = 25°C	1.75	3.6		mA
I_{SINK} Output Sink Current (N-Channel)	V_{CC} = 10V, V_{OUT} = V_{CC}, T_A = 25°C	8	16		mA

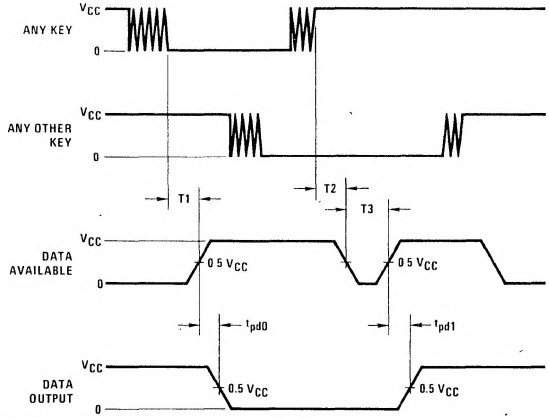
AC Electrical Characteristics T_A = 25°C, C_L = 50 pF, unless otherwise noted

PARAMETER		CONDITIONS	MIN	TYP	MAX	UNITS
t_{pd0},t_{pd1}	Propagation Delay Time to	C_L = 50 pF, *(Figure 1)*				
	Logical "0" or Logical "1"	V_{CC} = 5V		60	150	ns
	from D.A.	V_{CC} = 10V		35	80	ns
		V_{CC} = 15V		25	60	ns
t_{0H},t_{1H}	Propagation Delay Time from	R_L = 10k, C_L = 10pF *(Figure 2)*				
	Logical "0" or Logical "1"	V_{CC} = 5V R_L = 10k		80	200	ns
	into High Impedance State	V_{CC} = 10V C_L = 10 pF		65	150	ns
		V_{CC} = 15V		50	110	ns
t_{H0},t_{H1}	Propagation Delay Time from	R_L = 10k, C_L = 50 pF, *(Figure 2)*				
	High Impedance State to a	V_{CC} = 5V R_L = 10k		100	250	ns
	Logical "0" or Logical "1"	V_{CC} = 10V C_L = 50 pF		55	125	ns
		V_{CC} = 15V		40	90	ns
C_{IN}	Input Capacitance	Any Input, (Note 2)		5	7.5	pF
C_{OUT}	TRI-STATE Output Capacitance	Any Output, (Note 2)		10		pF

Note 1: "Absolute Maximum Ratings" are those values beyond which the safety of the device cannot be guaranteed. Except for "Operating Temperature Range" they are not meant to imply that the devices should be operated at these limits. The table of "Electrical Characteristics" provides conditions for actual device operation.

Note 2: Capacitance is guaranteed by periodic testing.

Switching Time Waveforms



T1 ≃ T2 ≈ RC, T3 ≈ 0.7 RC where R ≃ 10k and C is external capacitor at KBM input.

FIGURE 1

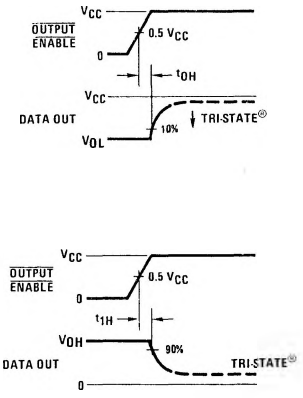
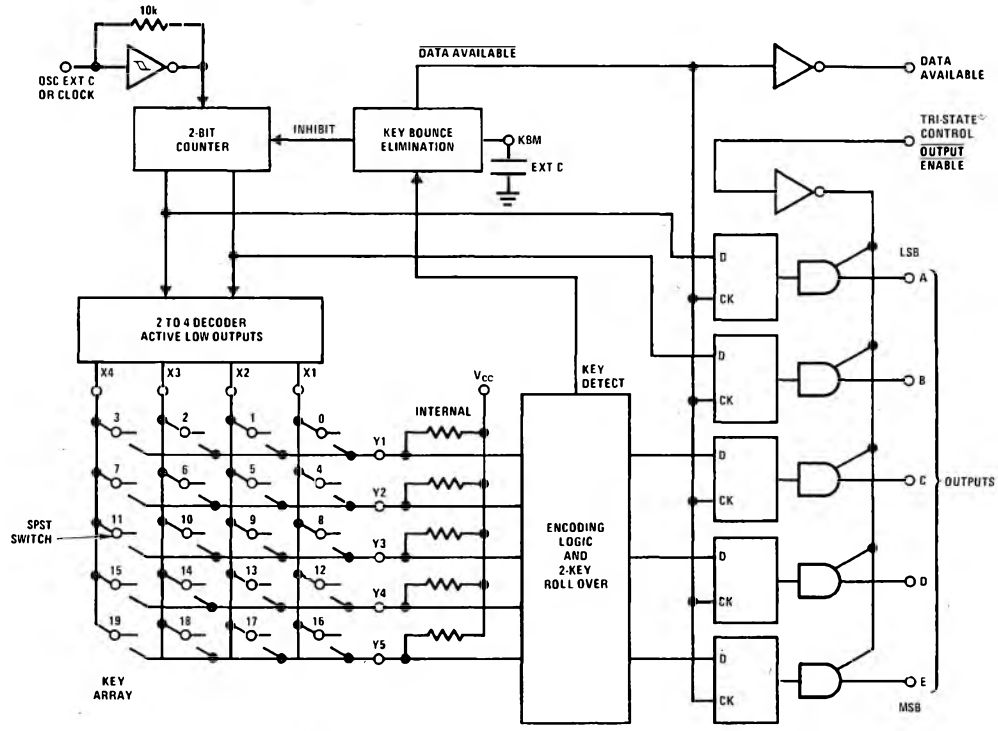


FIGURE 2

Block Diagram



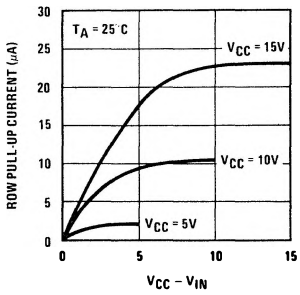
Truth Table

SWITCH POSITION		0 Y1,X1	1 Y1,X2	2 Y1,X3	3 Y1,X4	4 Y2,X1	5 Y2,X2	6 Y2,X3	7 Y2,X4	8 Y3,X1	9 Y3,X2	10 Y3,X3	11 Y3,X4	12 Y4,X1	13 Y4,X2	14 Y4,X3	15 Y4,X4	16 Y5*,X1	17 Y5*,X2	18 Y5*,X3	19 Y5*,X4
DATA OUT	A	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1
	B	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1
	C	0	0	0	0	1	1	1	1	0	0	0	0	1	1	1	1	0	0	0	0
	D	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0
	E*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1

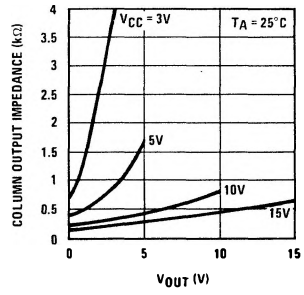
*Omit for MM54C922/MM74C922

Typical Performance Characteristics

Typical I_{rp} vs V_{IN} at Any Y Input

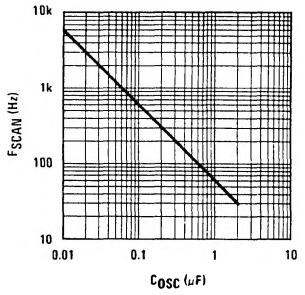


Typical R_{on} vs V_{OUT} at Any X Output

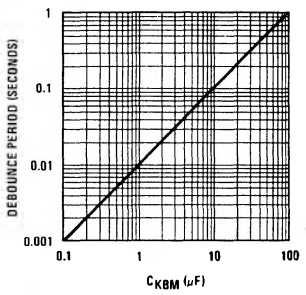


Typical Performance Characteristics (Cont'd.)

Typical F_{SCAN} vs C_{OSC}

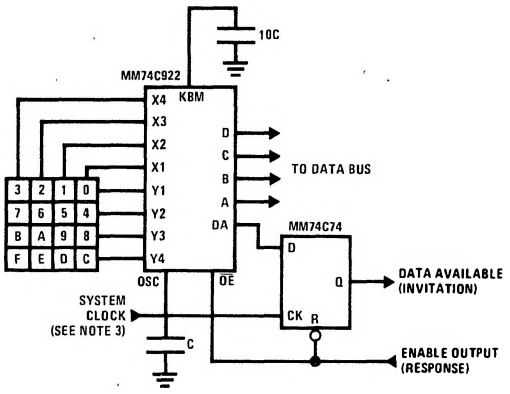


Typical Debounce Period vs C_{KBM}

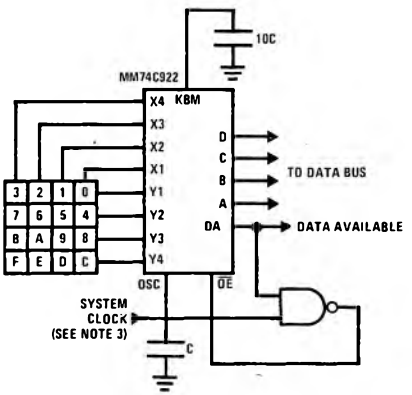


Typical Applications

Synchronous Handshake (MM74C922)

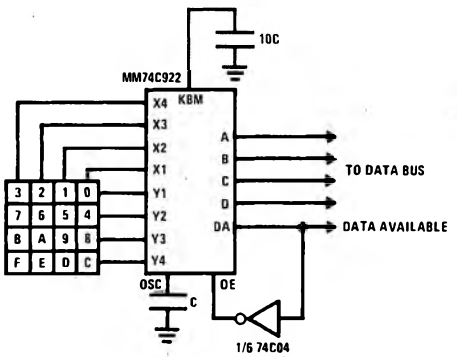


Synchronous Data Entry Onto Bus (MM74C922)



Outputs are enabled when valid entry is made and go into TRI-STATE when key is released.

Asynchronous Data Entry Onto Bus (MM74C922)



Outputs are in TRI-STATE until key is pressed, then data is placed on bus. When key is released, outputs return to TRI-STATE.

Keyboard Suppliers

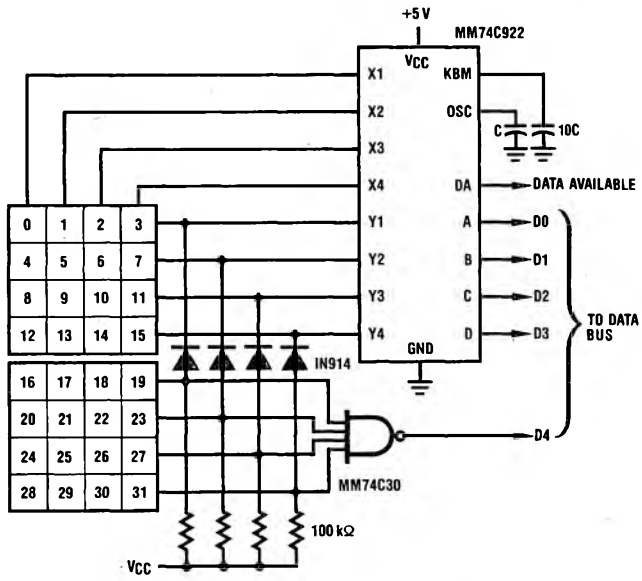
Mini Key Series KL
Digitran Company
Pasadena, California

Computronics Engineering
7235 Hollywood Blvd
Hollywood, California 90046

Note 3: The keyboard may be synchronously scanned by omitting the capacitor at osc. and driving osc. directly if the system clock rate is lower than 10 kHz.

Typical Application (Cont'd.)

Expansion to 32 Key Encoder (MM74C922)



Theory of Operation

The MM74C922/MM74C923 Keyboard Encoders implement all the logic necessary to interface a 16 or 20 SPST key switch matrix to a digital system. The encoder will convert a key switch closer to a 4(MM74C922) or 5(MM74C923) bit nibble. The designer can control both the keyboard scan rate and the key debounce period by altering the oscillator capacitor, C_{OSE}, and the key bounce mask capacitor, C_{MSK}. Thus, the MM74C922/MM47C923's performance can be optimized for many keyboards.

The keyboard encoders connect to a switch matrix that is 4 rows by 4 columns (MM74C922) or 5 rows by 4 columns (MM74C923). When no keys are depressed, the row inputs are pulled high by internal pull-ups and the column outputs sequentially output a logic "0". These outputs are open drain and are therefore low for 25% of the time and otherwise off. The column scan rate is controlled by the oscillator input, which consists of a Schmitt trigger oscillator, a 2-bit counter, and a 2-4-bit decoder.

When a key is depressed, key 0, for example, nothing will happen when the X1 input is off, since Y1 will remain high. When the X1 column is scanned, X1 goes low and Y1 will go low. This disables the counter and keeps X1 low. Y1 going low also initiates the key bounce circuit timing and locks out the other Y inputs. The key code to be outputted is a combination of the frozen counter value and the decoded Y inputs. Once the key bounce circuit times out, the data is latched, and the Data Available (DAV) output goes high.

If, during the key closure the switch bounces, Y1 input will go high again, restarting the scan and resetting the key bounce circuitry. The key may bounce several times, but as soon as the switch stays low for a debounce period, the closure is assumed valid and the data is latched.

A key may also bounce when it is released. To ensure that the encoder does not recognize this bounce as another key closure, the debounce circuit must time out before another closure is recognized.

The two key roll over feature can be illustrated by assuming a key is depressed, and then a second key is depressed. Since all scanning has stopped, and all other Y inputs are disabled, the second key is not recognized until the first key is lifted and the key bounce circuitry has reset.

The output latches feed TRI-STATE®, which are enabled when the Output Enable ($\overline{OE}$) input is taken low.