MM54C922,MM54C923,MM74C922,MM74C923

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

Literature Number: SNOS345A

National Semiconductor

July 1993

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 rollover is provided between any two switches.

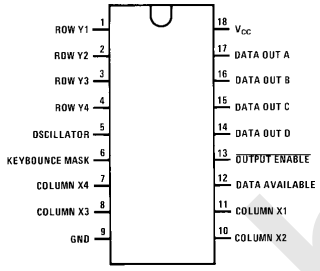
An internal register remembers the last key pressed even after the key is released. The TRI-STATE® outputs provide for easy expansion and bus operation and are LPTTL compatible.

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 outpust LPTTL compatible
- Wide supply range 3V to 15V
- Low power consumption

Connection Diagrams

Pin Assignment for Dual-In-Line Package

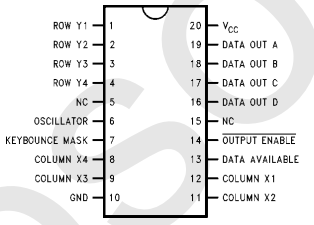


TL/F/6037–1

Top View

Order Number MM54C922 or MM74C922

Pin Assignment for SOIC

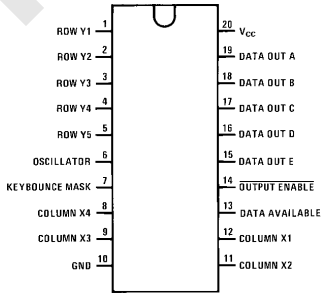


TL/F/6037–14

Top View

Order Number MM74C922

Pin Assignment for DIP and SOIC Package



TL/F/6037–2

Top View

Order Number MM54C923 or MM74C923

TRI-STATE® is a registered trademark of National Semiconductor Corporation.

Absolute Maximum Ratings (Note 1)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.

Voltage at Any Pin $V_{CC} - 0.3V$ to $V_{CC} + 0.3V$

Operating Temperature Range
- MM54C922, MM54C923 $-55°C$ to $+125°C$
- MM74C922, MM74C923 $-40°C$ to $+85°C$

Storage Temperature Range $-65°C$ to $+150°C$

Power Dissipation (P_D)
- Dual-In-Line 700 mW
- Small Outline 500 mW

Operating V_{CC} Range 3V to 15V

V_{CC} 18V

Lead Temperature (Soldering, 10 seconds) 260°C

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

Symbol	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 $V_{CC} = 10V$, $I_{IN} \geq 1.4$ mA $V_{CC} = 15V$, $I_{IN} \geq 2.1$ mA	3.0 6.0 9.0	3.6 6.8 10	4.3 8.6 12.9	V V V
V_{T-}	Negative-Going Threshold Voltage at Osc and KBM Inputs	$V_{CC} = 5V$, $I_{IN} \geq 0.7$ mA $V_{CC} = 10V$, $I_{IN} \geq 1.4$ mA $V_{CC} = 15V$, $I_{IN} \geq 2.1$ mA	0.7 1.4 2.1	1.4 3.2 5	2.0 4.0 6.0	V V V
$V_{IN(1)}$	Logical "1" Input Voltage, Except Osc and KBM Inputs	$V_{CC} = 5V$ $V_{CC} = 10V$ $V_{CC} = 15V$	3.5 8.0 12.5	4.5 9 13.5		V V V
$V_{IN(0)}$	Logical "0" Input Voltage, Except Osc and KBM Inputs	$V_{CC} = 5V$ $V_{CC} = 10V$ $V_{CC} = 15V$		0.5 1 1.5	1.5 2 2.5	V V V
I_{rp}	Row Pull-Up Current at Y1, Y2, Y3, Y4 and Y5 Inputs	$V_{CC} = 5V$, $V_{IN} = 0.1\ V_{CC}$ $V_{CC} = 10V$ $V_{CC} = 15V$		-2 -10 -22	-5 -20 -45	μA μA μA
$V_{OUT(1)}$	Logical "1" Output Voltage	$V_{CC} = 5V$, $I_O = -10\ \mu A$ $V_{CC} = 10V$, $I_O = -10\ \mu A$ $V_{CC} = 15V$, $I_O = -10\ \mu A$	4.5 9 13.5			V V V
$V_{OUT(0)}$	Logical "0" Output Voltage	$V_{CC} = 5V$, $I_O = 10\ \mu A$ $V_{CC} = 10V$, $I_O = 10\ \mu A$ $V_{CC} = 15V$, $I_O = 10\ \mu A$			0.5 1 1.5	V V V
R_{on}	Column "ON" Resistance at X1, X2, X3 and X4 Outputs	$V_{CC} = 5V$, $V_O = 0.5V$ $V_{CC} = 10V$, $V_O = 1V$ $V_{CC} = 15V$, $V_O = 1.5V$		500 300 200	1400 700 500	Ω Ω Ω
I_{CC}	Supply Current Osc at 0V, (one Y low)	$V_{CC} = 5V$ $V_{CC} = 10V$ $V_{CC} = 15V$		0.55 1.1 1.7	1.1 1.9 2.6	mA mA 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, $V_{CC} = 4.5V$ 74C, $V_{CC} = 4.75V$	$V_{CC} - 1.5$ $V_{CC} - 1.5$			V V
$V_{IN(0)}$	Logical "0" Input Voltage, Except Osc and KBM Inputs	54C, $V_{CC} = 4.5V$ 74C, $V_{CC} = 4.75V$			0.8 0.8	V V
$V_{OUT(1)}$	Logical "1" Output Voltage	54C, $V_{CC} = 4.5V$ $I_O = -360\ \mu A$ 74C, $V_{CC} = 4.75V$ $I_O = -360\ \mu A$	2.4 2.4			V V
$V_{OUT(0)}$	Logical "0" Output Voltage	54C, $V_{CC} = 4.5V$ $I_O = -360\ \mu A$ 74C, $V_{CC} = 4.75V$ $I_O = -360\ \mu A$			0.4 0.4	V V

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.

DC Electrical Characteristics

Min/Max limits apply across temperature range unless otherwise specified (Continued)

Symbol	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

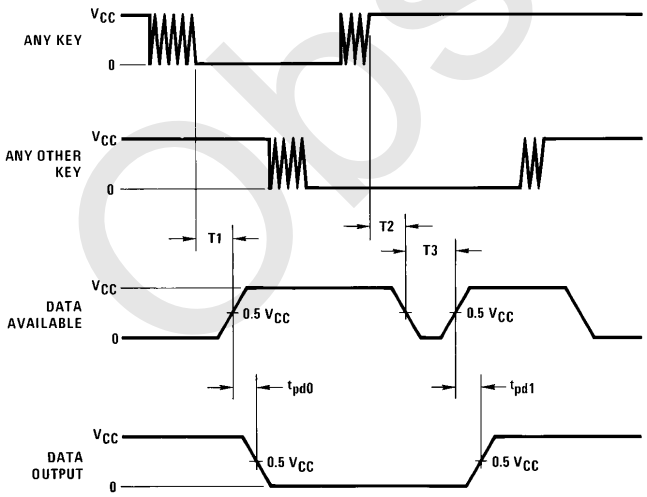
Symbol	Parameter	Conditions	Min	Typ	Max	Units
t_{pd0}, t_{pd1}	Propagation Delay Time to Logical "0" or Logical "1" from D.A.	$C_L = 50$ pF *(Figure 1)*				
		$V_{CC} = 5V$		60	150	ns
		$V_{CC} = 10V$		35	80	ns
		$V_{CC} = 15V$		25	60	ns
t_{0H}, t_{1H}	Propagation Delay Time from Logical "0" or Logical "1" into High Impedance State	$R_L = 10k$, $C_L = 10$ pF *(Figure 2)*				
		$V_{CC} = 5V$, $R_L = 10k$		80	200	ns
		$V_{CC} = 10V$, $C_L = 10$ pF		65	150	ns
		$V_{CC} = 15V$		50	110	ns
t_{H0}, t_{H1}	Propagation Delay Time from High Impedance State to a Logical "0" or Logical "1"	$R_L = 10k$, $C_L = 50$ pF *(Figure 2)*				
		$V_{CC} = 5V$, $R_L = 10k$		100	250	ns
		$V_{CC} = 10V$, $C_L = 50$ 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

*AC Parameters are guaranteed by DC correlated testing.

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.

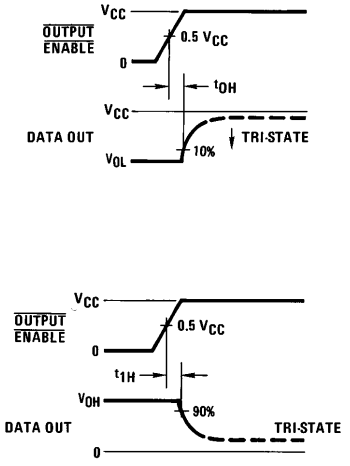
Switching Time Waveforms



TL/F/6037–3

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

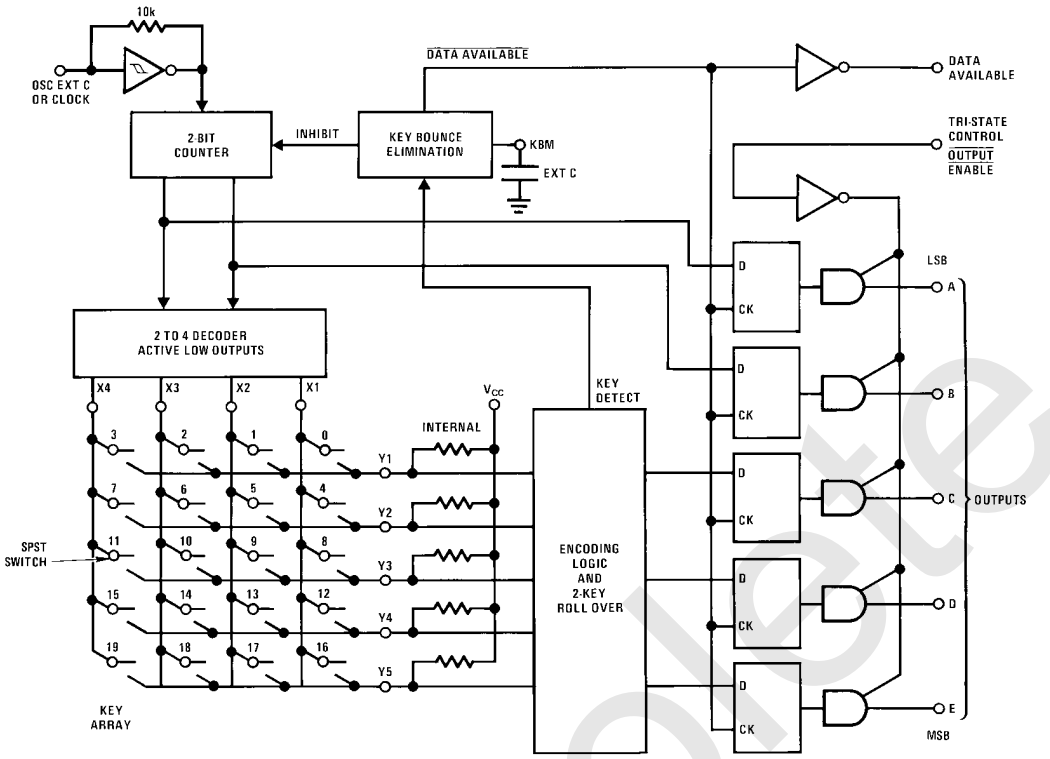
FIGURE 1



TL/F/6037–4

FIGURE 2

Block Diagram



TL/F/6037–5

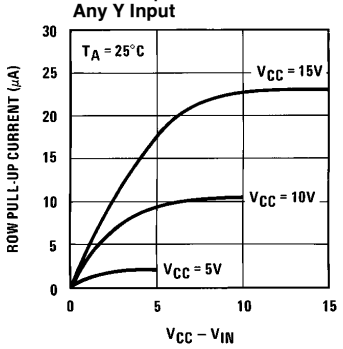
Truth Table

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
D																					
A	A	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1
T	B	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1
A	C	0	0	0	0	1	1	1	1	0	0	0	0	1	1	1	1	0	0	0	0
O	D	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0
U	E*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1
T																					

*Omit for MM54C922/MM74C922

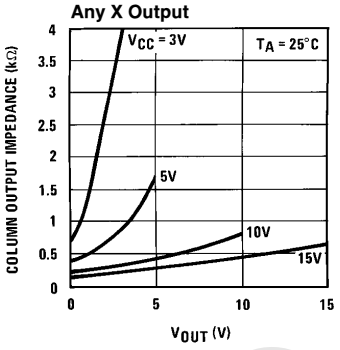
Typical Performance Characteristics

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



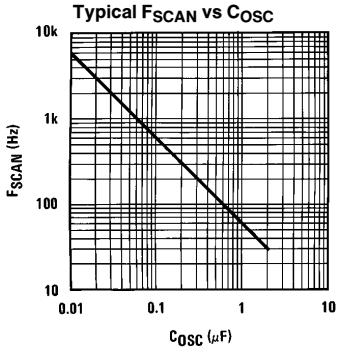
TL/F/6037–6

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



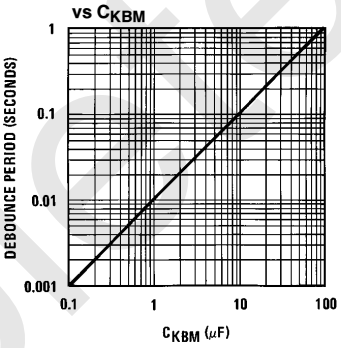
TL/F/6037–7

Typical F_{SCAN} vs C_{OSC}



TL/F/6037–8

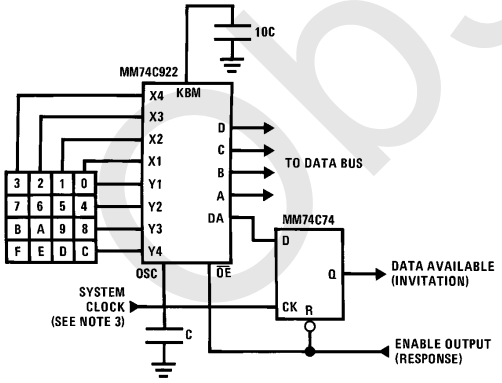
Typical Debounce Period vs C_{KBM}



TL/F/6037–9

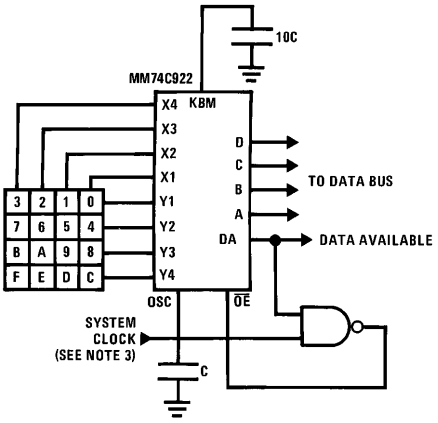
Typical Applications

Synchronous Handshake (MM74C922)



TL/F/6037–10

Synchronous Data Entry Onto Bus (MM74C922)



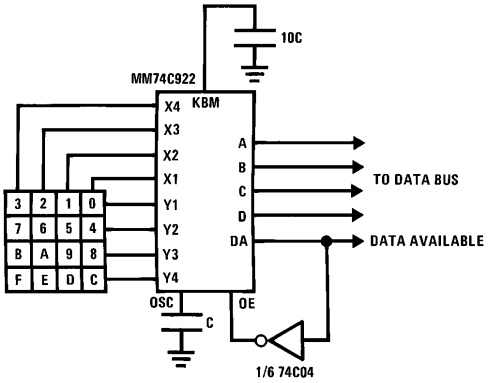
TL/F/6037–11

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

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 Applications (Continued)

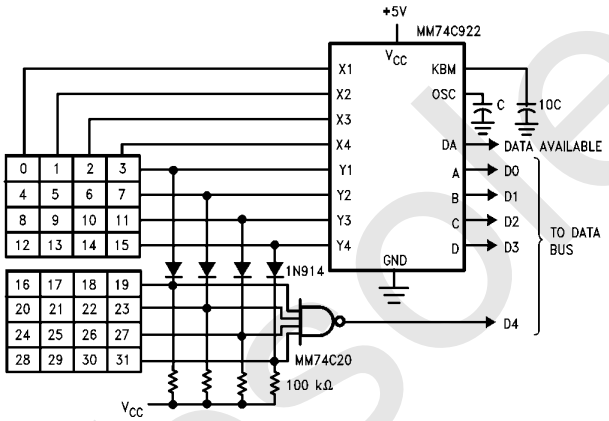
Asynchronous Data Entry Onto Bus (MM74C922)



TL/F/6037–12

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

Expansion to 32 Key Encoder (MM74C922)



TL/F/6037–13

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/MM74C923'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 output 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.

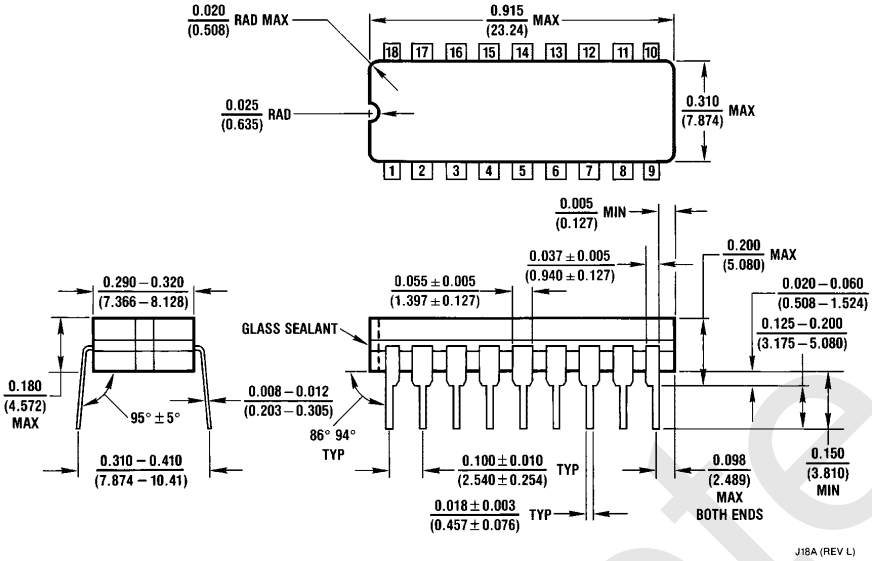
If, during the key closure the switch bounces, Y1 input will go high again, restarting the scan and resetting the key bounce circuitry. The key may bounce several times, but as soon as the switch stays low for a debounce period, the closure is assumed valid and the data is latched.

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.

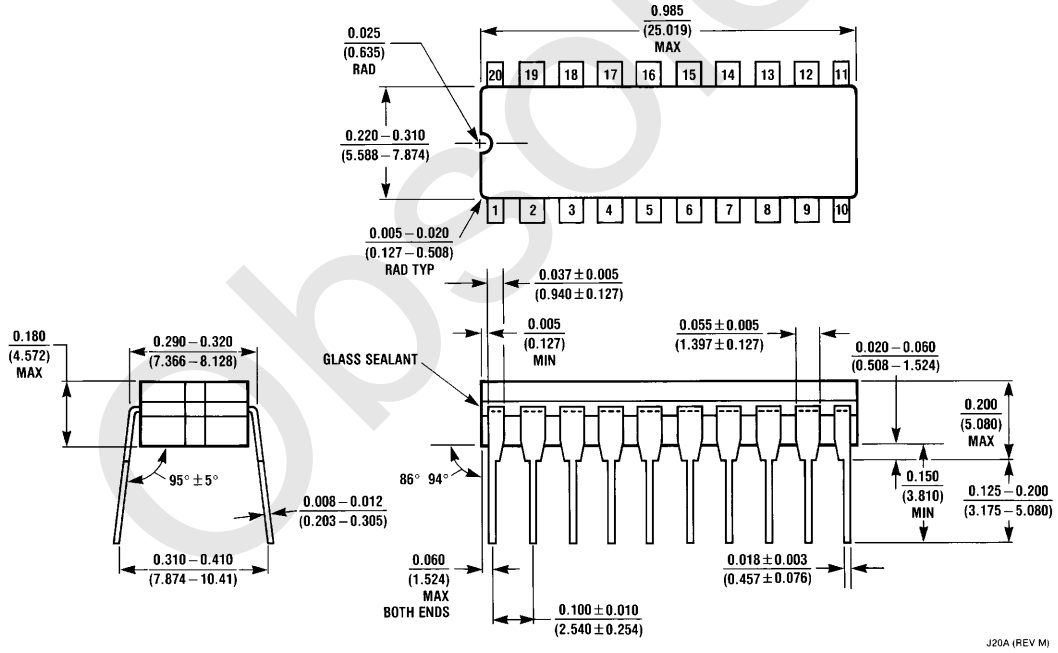
The two-key roll-over feature can be illustrated by assuming a key is depressed, and then a second key is depressed. Since all scanning has stopped, and all other Y inputs are disabled, the second key is not recognized until the first key is lifted and the key bounce circuitry has reset.

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

Physical Dimensions inches (millimeters)

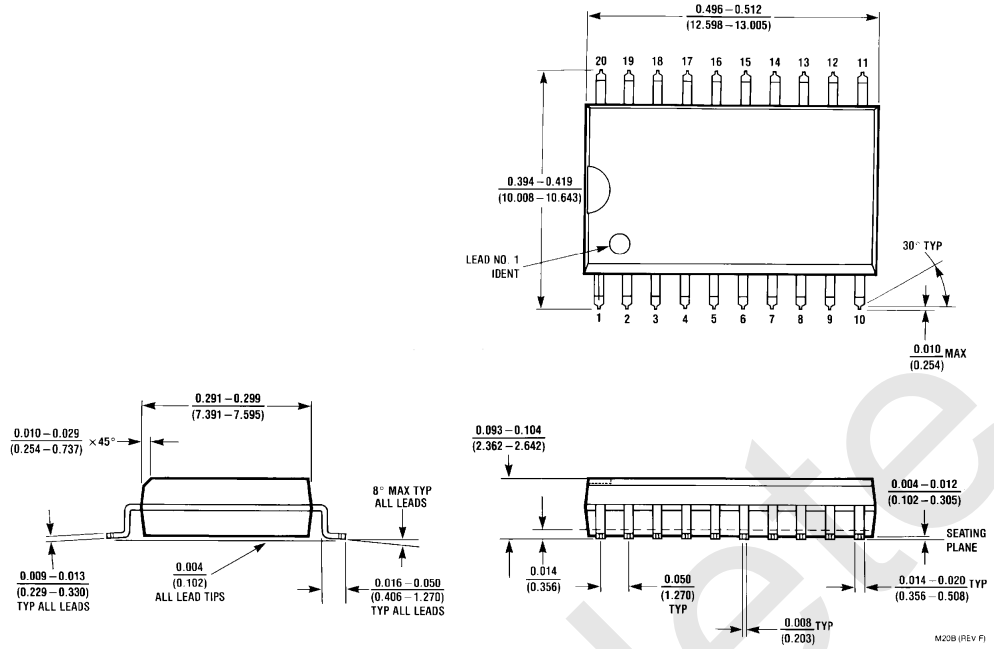


Ceramic Dual-In-Line Package (J)
Order Number MM54C922J or MM74C922J
NS Package Number J18A



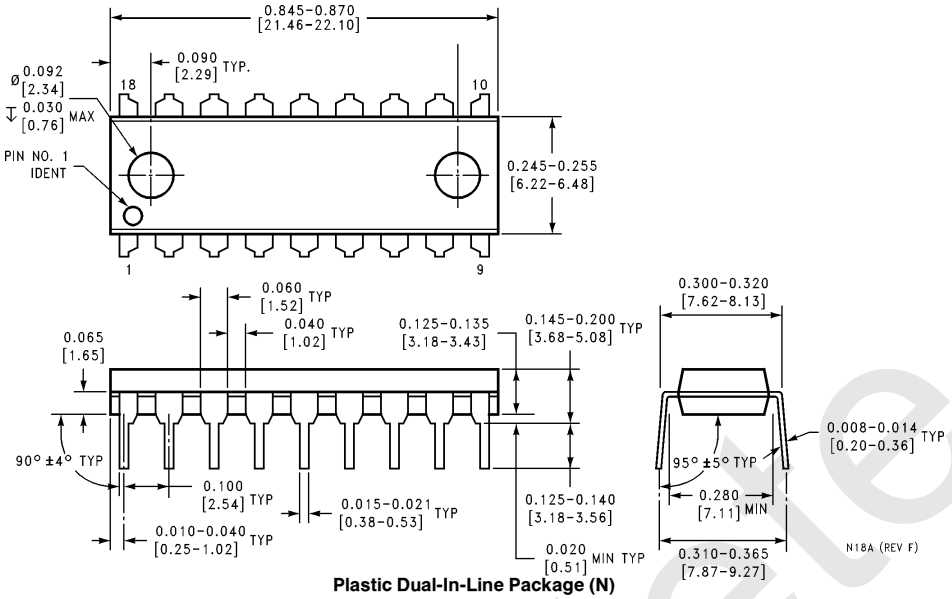
Ceramic Dual-In-Line Package (J)
Order Number MM54C923J or MM74C923J
NS Package Number J20A

Physical Dimensions inches (millimeters) (Continued)



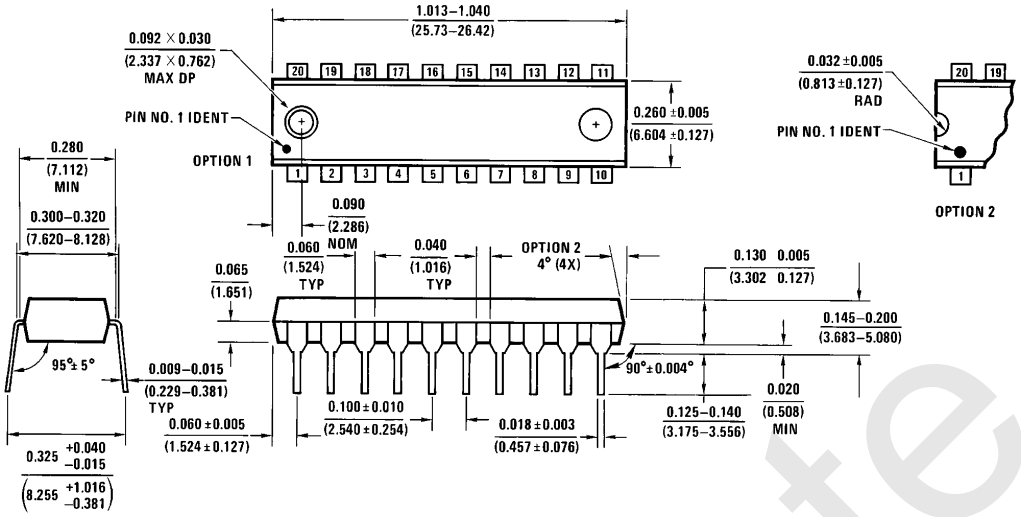
Plastic Small Outline I.C. Package (M)
Order Number MM74C922M or MM74C923M
NS Package Number M20B

Physical Dimensions inches (millimeters) (Continued)



Plastic Dual-In-Line Package (N)
Order Number MM54C922N or MM74C922N
NS Package Number N18A

Physical Dimensions inches (millimeters) (Continued)



Plastic Dual-In-Line Package (N)
Order Number MM54C923N or MM74C923N
NS Package Number N20A

LIFE SUPPORT POLICY

NATIONAL'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF THE PRESIDENT OF NATIONAL SEMICONDUCTOR CORPORATION. As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, and whose failure to perform, when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury to the user.
2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

National Semiconductor Corporation
1111 West Bardin Road
Arlington, TX 76017
Tel: 1(800) 272-9959
Fax: 1(800) 737-7018

National Semiconductor Europe
Fax: (+49) 0-180-530 85 86
Email: cnjwge@tevm2.nsc.com
Deutsch Tel: (+49) 0-180-530 85 85
English Tel: (+49) 0-180-532 78 32
Français Tel: (+49) 0-180-532 93 58
Italiano Tel: (+49) 0-180-534 16 80

National Semiconductor Hong Kong Ltd.
13th Floor, Straight Block,
Ocean Centre, 5 Canton Rd.
Tsimshatsui, Kowloon
Hong Kong
Tel: (852) 2737-1600
Fax: (852) 2736-9960

National Semiconductor Japan Ltd.
Tel: 81-043-299-2309
Fax: 81-043-299-2408

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

TI products are not authorized for use in safety-critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of TI products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by TI. Further, Buyers must fully indemnify TI and its representatives against any damages arising out of the use of TI products in such safety-critical applications.

TI products are neither designed nor intended for use in military/aerospace applications or environments unless the TI products are specifically designated by TI as military-grade or "enhanced plastic." Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are designated by TI as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, TI will not be responsible for any failure to meet such requirements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

Products		**Applications**	
Audio	www.ti.com/audio	Communications and Telecom	www.ti.com/communications
Amplifiers	amplifier.ti.com	Computers and Peripherals	www.ti.com/computers
Data Converters	dataconverter.ti.com	Consumer Electronics	www.ti.com/consumer-apps
DLP® Products	www.dlp.com	Energy and Lighting	www.ti.com/energy
DSP	dsp.ti.com	Industrial	www.ti.com/industrial
Clocks and Timers	www.ti.com/clocks	Medical	www.ti.com/medical
Interface	interface.ti.com	Security	www.ti.com/security
Logic	logic.ti.com	Space, Avionics and Defense	www.ti.com/space-avionics-defense
Power Mgmt	power.ti.com	Transportation and Automotive	www.ti.com/automotive
Microcontrollers	microcontroller.ti.com	Video and Imaging	www.ti.com/video
RFID	www.ti-rfid.com		
OMAP Mobile Processors	www.ti.com/omap		
Wireless Connectivity	www.ti.com/wirelessconnectivity		
	TI E2E Community Home Page		e2e.ti.com

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265