

## LIQUID-CRYSTAL DISPLAY DRIVERS

- 4054 - 4 SEGMENT DISPLAY DRIVER-STROBED LATCH FUNCTION**
- 4055 - BCD TO 7-SEGMENT DECODER/ DRIVER, WITH „DISPLAY-FREQUENCY“ OUTPUT**
- 4056 - BCD TO 7-SEGMENT DECODER/ DRIVER WITH STROBED LATCH FUNCTION**

### GENERAL DESCRIPTION

The MMC 4054, MMC 4055, MMC 4056 (G, H types extended temperature range and the E, F types intermediate temperature range) are monolithic integrated circuits available in 16-lead dual in-line plastic or ceramic package. The MMC 4055 and MMC 4056 types are single-digit BCD-to-7-segment decoder/driver circuits that provide level-shifting functions on the chip. This feature permits the BCD input-signal swings ( $V_{DD}$  to  $V_{SS}$ ) to be the same as or different from the 7-segment output-signal swings ( $V_{DD}$  to  $V_{EE}$ ). For example, the BCD input-signal swings ( $V_{DD}$  to  $V_{SS}$ ) may be as low as 0 to  $-3V$ , whereas the output-display drive-signal swing ( $V_{DD}$  to  $V_{EE}$ ) may be from 0 to  $-5V$ . If  $V_{DD}$  to  $V_{EE}$  exceeds 15V,  $V_{DD}$  to  $V_{SS}$  should be at least 4V. The 7-segment outputs are controlled by the DISPLAY-FREQUENCY (DF) input which causes the selected segment outputs to be low, high, or a square-wave output (for liquid-crystal displays).

When the DF input is low the output segments will be high when selected by the BCD inputs. When the DF input is high, the output segments will be low when selected by the BCD inputs. When a square-wave is present at the DF input, the selected segments will have a square-wave output that is 180° out of phase with the DF input. Those segments which are not selected will have a square-wave output that is in phase with the input. DF square-wave repetition rates for liquid-crystal displays usually range from 30 Hz (well above flicker rate) to 200 Hz (well below the upper limit of the liquid crystal frequency response). The MMC 4055 provides a level-shifted high-amplitude DF output which is required for driving the common electrode in liquid-crystal displays. The MMC 4056 provides a strobed latch function at the BCD inputs. Decoding of all input combinations on the MMC 4055 and MMC 4056 provides displays of 0 to 9 as well as LP,HA — and a blank position. The MMC 4054 provides level shifting similar to the MMC 4055 and MMC 4056 independently strobed latches, and common DF control on 4 signal lines. The MMC 4054 is intended to provide drive-signal compatibility with the MMC 4055 and MMC 4056 7-segment decoder types for the decimal point, colon, polarity, and similar display lines. A level-shifted high-amplitude DF output can be obtained from any MMC 4054 output line by connecting the corresponding input and strobe lines to a low and high level, respectively. The MMC 4054 may also be utilized for logic-level „up conversion“ or „down conversion“. For example, input-signal swings ( $V_{DD}$  to  $V_{SS}$ ) from +5 to 0V can be converted to output-signal swings ( $V_{DD}$  to  $V_{EE}$ ) of +5 to  $-5V$ . The

level shifted function on all three types permits the use of different input-and output-signal swings. The input swings from a low level of  $V_{SS}$  to a high level of  $V_{DD}$  while the output swings from a low level of  $V_{EE}$  to the same high level of  $V_{DD}$ . Thus, the input and output swings can be selected independently of each other over a 3-to 18V range.  $V_{SS}$  may be connected to  $V_{EE}$  when no level-shift function is required. For the MMC 4054 and the MMC 4056, data are transferred from input to output by placing a high voltage level at the strobe input. A low voltage level at the strobe input latches the data input and the corresponding output segments remain selected (or non-selected) while the strobe is low. Whenever the level-shifting function is required, the MMC 4055 can be used by itself to drive a liquid-crystal display. The MMC 4056, however, must be used together with a MMC 4054 to provide the common DF output.

### FEATURES

- Operation of liquid crystals with CMOS circuits provides ultra low-power displays
- Equivalent AC output drive for liquid-crystal displays-no external capacitor required
- Voltage doubling across display ( $V_{DD} - V_{EE} = 18V$  results in effective 36 V (pp) drive across selected display segments)
- Low-or high-output level DC drive for other types of displays
- On chip logic-level conversion for different input and output-level swings
- Full decoding of all input combinations: "0-9,L,H,P, A" and blank positions
- Input current of 100 nA at 18V and 25°C for MMC device G, H types
- 100% tested for quiescent current

**ABSOLUTE MAXIMUM RATINGS**

$V_{DD}^*$	Supply voltage: G and H types E and F types	-0.5 to -0.5 to	20 18	V V
$V_i$	Input voltage	-0.5 to	$V_{DD}+0.5$	V
$I_i$	DC input current (any one input)		$\pm 10$	mA
$P_{tot}$	Total power dissipation (per package) Dissipation per output transistor for $T_A$ = full package-temperature range		200	mW
$T_A$	Operating temperature : G and H types E and F types	-55 to -40 to	125 85	$^{\circ}C$ $^{\circ}C$
$T_{stg}$	Storage temperature	-65 to	150	$^{\circ}C$

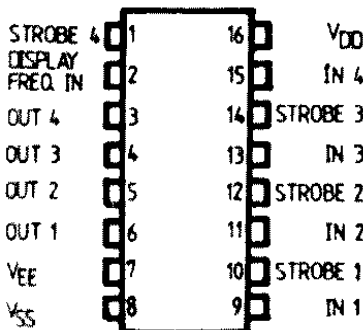
\* All voltage values are referred to  $V_{SS}$  pin voltage

**RECOMMENDED OPERATING CONDITIONS**

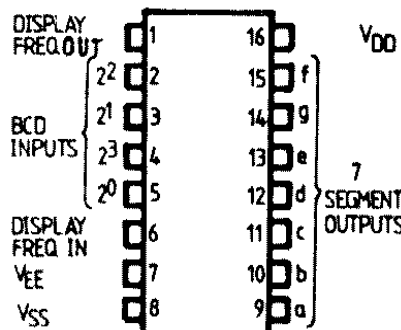
$V_{DD}^*$	Supply voltage: G and H types E and F types	3 to 3 to	18 15	V V
$V_i$	Input voltage	0 to	$V_{DD}$	V
$T_A$	Operating temperature : G and H types E and F types	-55 to -40 to	125 85	$^{\circ}C$ $^{\circ}C$

**CONNECTION DIAGRAMS**

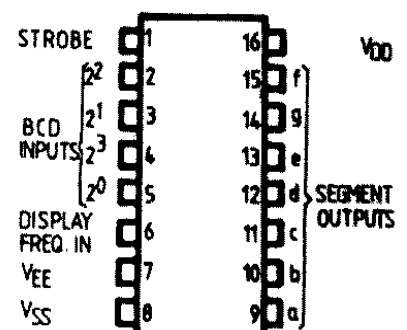
MMC 4054



MMC 4055

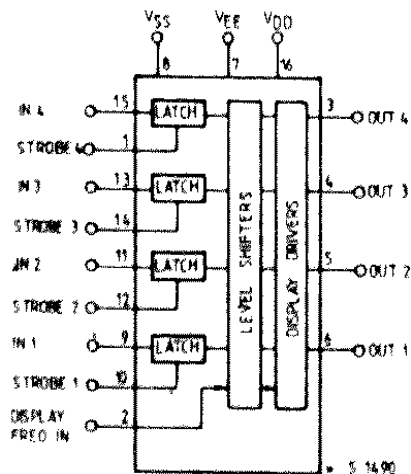


MMC 4056

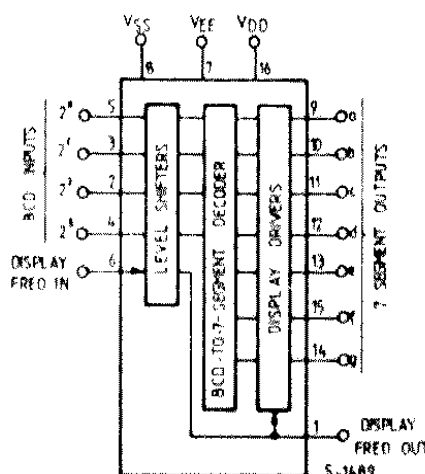


**FUNCTIONAL DIAGRAMS**

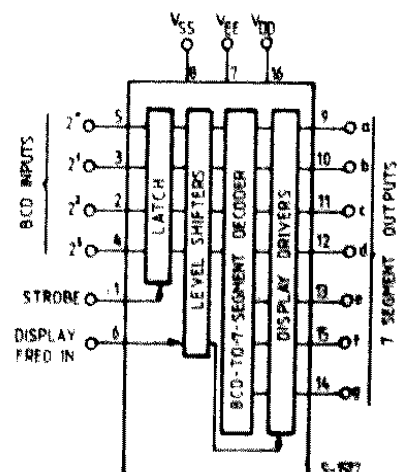
For 4054



For 4055



For 4056

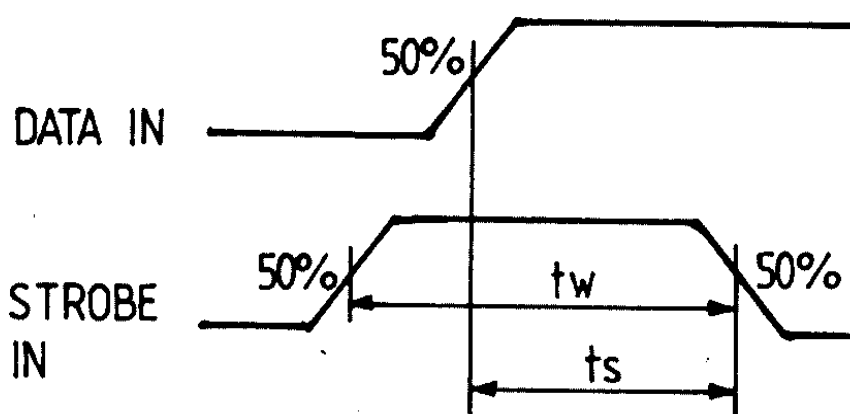


**TRUTH TABLE**

For 4055 and 4056

INPUT CODE				OUTPUT STATE							DISPLAY CHARACTER
2 <sup>3</sup>	2 <sup>2</sup>	2 <sup>1</sup>	2 <sup>0</sup>	a	b	c	d	e	f	g	
0	0	0	0	1	1	1	1	1	1	0	0
0	0	0	1	0	1	1	0	0	0	0	1
0	0	1	0	1	1	0	1	1	0	1	2
0	0	1	1	1	1	1	1	0	0	1	3
0	1	0	0	0	1	1	0	0	1	1	4
0	1	0	1	1	0	1	1	0	1	1	5
0	1	1	0	1	0	1	1	1	1	1	6
0	1	1	1	1	1	1	0	0	0	0	7
1	0	0	0	1	1	1	1	1	1	1	8
1	0	0	1	1	1	1	1	0	1	1	9
1	0	1	0	0	0	0	1	1	1	0	A
1	0	1	1	0	1	1	0	1	1	1	B
1	1	0	0	1	1	0	0	1	1	1	C
1	1	0	1	1	1	1	0	1	1	1	D
1	1	1	0	0	0	0	0	0	0	1	E
1	1	1	1	0	0	0	0	0	0	0	BLANK

Data setup time and strobe pulse duration



## STATIC ELECTRICAL CHARACTERISTICS

(under recommended operating conditions)

PARAMETER	TEST CONDITIONS					VALUES						UNIT		
	V <sub>EE</sub> (V)	V <sub>I</sub> (V)	V <sub>O</sub> (V)	V <sub>SS</sub> (V)	V <sub>DD</sub> (V)	T <sub>LOW</sub>		25°C			T <sub>HIGH</sub>			
						Min.	Max.	Min.	Typ.	Max.	Min.		Max.	
I <sub>L</sub> Quiescent supply current	Gaud H types	-5	0/5		0	5		5		0.04	5		150	
		0	0/10		0	10		10		0.04	10		300	
		0	0/15		0	15		20		0.04	20		600	
	Eaud F types	0	0/20		0	20		100		0.08	100		3000	
		-5	0/5		0	5		20		0.04	20		150	
		0	0/10		0	10		40		0.04	40		300	
V <sub>OH</sub> Output high voltage	0	0/5		0	5	4.95		4.95			4.95		V	
	0	0/10		0	10	9.95		9.95			9.95			
	0	0/15		0	15	14.95		14.95			14.95			
V <sub>OL</sub> Output low voltage	0	5/0		0	5		0.05			0.05		0.05	V	
	0	10/0		0	10		0.05			0.05		0.05		
	0	15/0		0	15		0.05			0.05		0.05		
V <sub>IH</sub> Input high voltage	-5		0.5/4.5	0	5	3.5		3.5			3.5		V	
	0		1/9	0	10	7		7			7			
	0		1.5/13.5	0	15	11		11			11			
V <sub>IL</sub> Input low voltage	5		4.5/0.5	0	5		1.5			1.5		1.5	V	
	0		9/1	0	10		3			3		3		
	0		13.5/1.5	0	15		4			4		4		
I <sub>OH</sub> Output high current	Gaud H types	-5	0/5	4.5	0	5	-0.6		-0.45	-0.9		-0.3	mA	
		0	0/10	9.5	0	5	-0.6		-0.45	-0.9		-0.3		
		0	0/15	13.5	0	15	-1.9		-1.5	-3		-1.1		
	Eaud F types	-5	0/5	4.5	0	5	-0.47		-0.38	-0.9		-0.28		
		0	0/10	9.5	0	10	-0.47		-0.38	-0.9		-0.28		
		0	0/15	13.5	0	15	-1.58		-1.27	-3		-0.95		
I <sub>OL</sub> Output low current	Gaud H types	-5	0/5	0.4	0	5	1.6		1.3	2.6		0.9	mA	
		0	0/10	0.5	0	10	1.6		1.3	2.6		0.9		
		0	0/15	1.5	0	15	4.2		3.4	6.8		2.4		
	Eaud F types	-5	0/5	0.4	0	5	1.37		1.1	2.6		0.82		
		0	0/10	0.5	0	10	1.37		1.1	2.6		0.9		
		0	0/15	1.5	0	15	3.62		2.9	6.8		2.17		
I <sub>IH</sub> Input leakage current	Gaud H types	0	0/18		0	18		±0.1		±10 <sup>-5</sup>	±0.1		±1	μA
	Eaud F types	0	0/15		0	15		±0.3		±10 <sup>-5</sup>	±0.3		±1	μA
C <sub>I</sub> **	Input capacitance								5	7.5			pF	

\* T<sub>LOW</sub> = -55°C for Gaud H devices; -40°C for Eaud F devices\* T<sub>HIGH</sub> = +125°C for Gaud H devices; +85°C for Eaud F devices

The Noise Margin for both "1" and "0" level is:

1 V min. with V<sub>DD</sub> = 5 V2 V min. with V<sub>DD</sub> = 10 V2.5 V min. with V<sub>DD</sub> = 15 V

\*\* Any input.

**DYNAMIC ELECTRICAL CHARACTERISTICS**

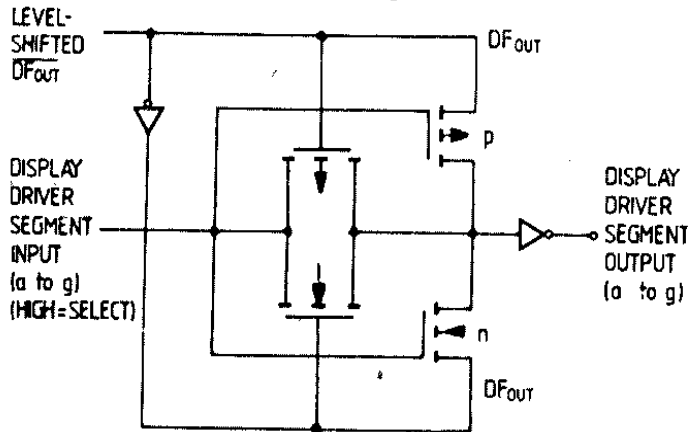
( $T_{amb} = 25^{\circ}C$ ,  $C_L = 50$  pF,  $R_L = 200$  k typical temperature coefficient for all  $V_{DD}$  values is  $0.3\%/^{\circ}C$ , all input rise and fall times = 20 ns)

PARAMETER	TEST CONDITIONS			TYPES						UNIT	
	$V_{EE}$ (V)	$V_{SS}$ (V)	$V_{DD}$ (V)	4054			4055 and 4056				
				Min.	Typ.	Max.	Min.	Typ.	Max.		
$t_{PHL}$ $t_{PLH}$	Propagat ion delay time (Any time to Any output)	-5 0 0	0 0 0	5 10 15		400 340 250	800 680 500		650 575 375	1300 1150 750	ns
$t_{THL}$ $t_{TLH}$	Transit ion time (Any output)	-5 0 0	0 0 0	5 10 15		100 100 75	200 200 150		100 100 75	200 200 150	ns
$t_{Set\ up}^*$	Data setup time	-5 0 0	0 0 0	5 10 15	220 100 70	110 50 35		220 100 70	110 50 35		ns
$t_w^*$	Strobe pulse width	-5 0 0	0 0 0	5 10 15	220 100 70	110 50 35		220 100 70	110 50 35		ns

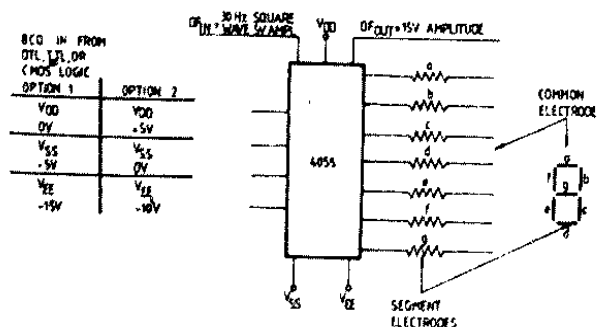
\* MMC 4055 and 4056 only

**TYPICAL APPLICATIONS**

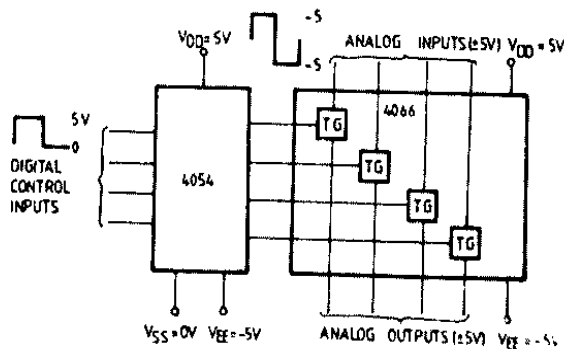
Display-driver circuit for one segment line



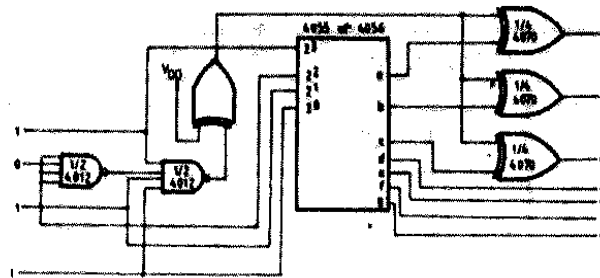
Single-digit liquid crystal display



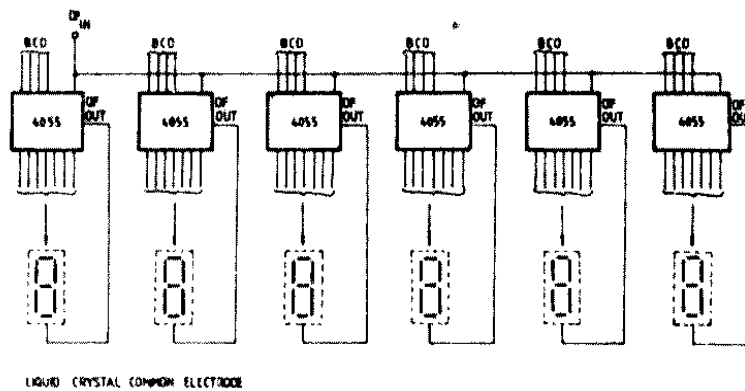
Digital (0 to +5 to -5V) to bidirectional analog control (+5 to -5V) level shifter



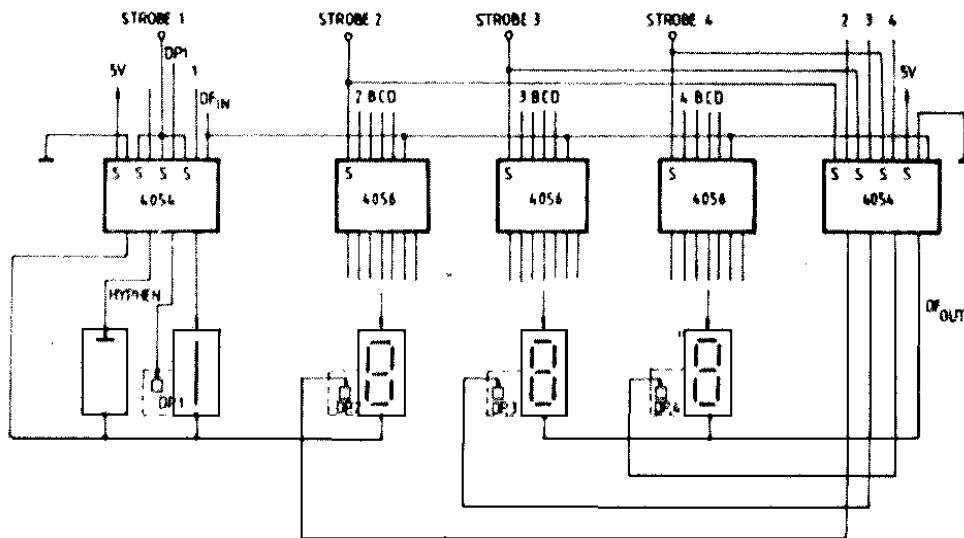
Conversion of "H" display to "F" display



Clock display



Typical 3 1/2-digit liquid crystal display: ( $V_{DD} = +5V$ ,  $V_{SS} = 0V$ ,  $V_{EE} = -10V$ ,  $DF_N = 30$  Hz square wave)



In addition to the letters L, H, P and A, five other letters can be displayed through the use of simple logic circuits preceding and following the 4055 or 4056 devices. Figure below is an example of a circuit that converts an "H" display, (code 1011) to an "F" display. One condition that must be met is that  $V_{EE} - V_{SS}$ . If  $V_{EE} \neq V_{SS}$ , the 4054 must be used to level shift in the appropriate places. In a similar manner the letters C, E, J and U can be displayed. These circuits can also be used to drive LED displays provided the exclusive-OR gates have sufficient output-current drive. The letters B, D, G, I, O and S may be represented by the codes for numbers 8, 0, 6, 1, 0 and 5 respectively, when there is preknowledge that only letters are to be displayed.