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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-signals 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 bellow 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 L,P,H,A — 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 transfered 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-cristal 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

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ABSOLUTE MAXIMUM RATINGS

V_{DD}*	Supply voltage:	G and H types	-0.5 to	20	V
		E and F types	-0.5 to	18	V
V_I	Input voltage		-0.5 to	V_{DD}+0.5	V
I_I	DC input current (any one input)			±10	mA
P_{tot}	Total power dissipation (per package)			200	mW
	Dissipation per output transistor for T_A = full package-temperature range			100	mW
T_A	Operating temperature :	G and H types	-55 to	125	°C
		E and F types	-40 to	85	°C
T_{stg}	Storage temperature		-65 to	150	°C

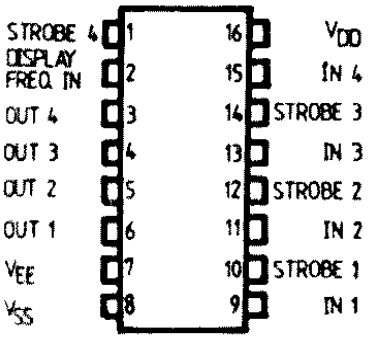
* All voltage values are referred to V_{SS} pin voltage

RECOMMENDED OPERATING CONDITIONS

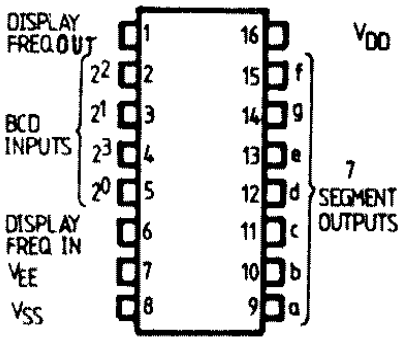
V_{DD}*	Supply voltage:	G and H types	3 to	18	V
		E and F types	3 to	15	V
V_I	Input voltage		0 to	V_{DD}	V
T_A	Operating temperature :	G and H types	-55 to	125	°C
		E and F types	-40 to	85	°C

CONNECTION DIAGRAMS

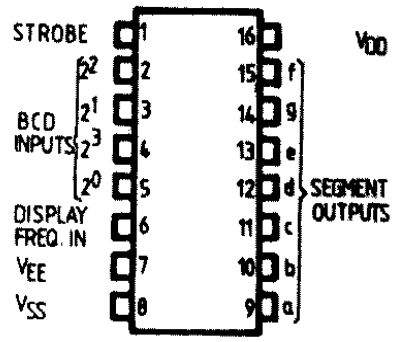
MMC 4054



MMC 4055

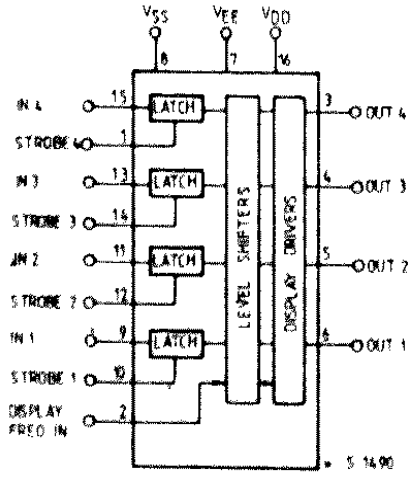


MMC 4056

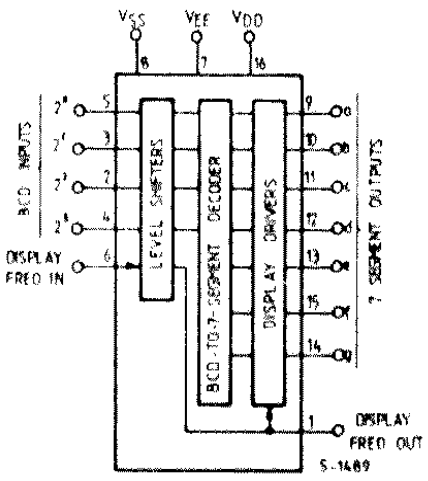


FUNCTIONAL DIAGRAMS

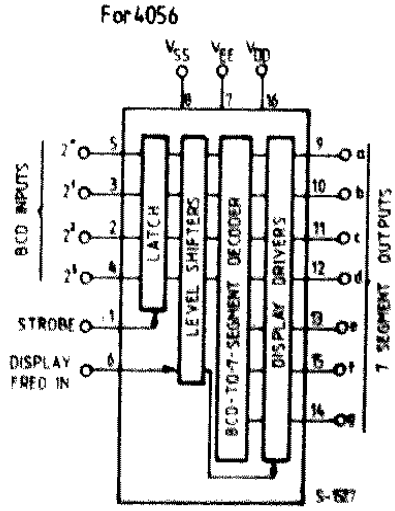
For 4054



For 4055



For 4056



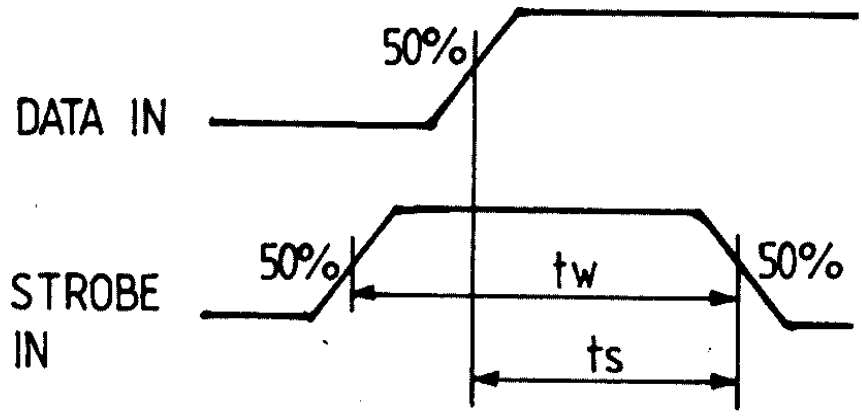
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TRUTH TABLE

For 4055 and 4056

INPUT CODE				OUTPUT STATE							DISPLAY CHARACTER
2^3	2^2	2^1	2^0	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	L
1	0	1	1	0	1	1	0	1	1	1	H
1	1	0	0	1	1	0	0	1	1	1	P
1	1	0	1	1	1	1	0	1	1	1	A
1	1	1	0	0	0	0	0	0	0	1	-
1	1	1	1	0	0	0	0	0	0	0	BLANK

Data setup time and strobe pulse duration



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STATIC ELECTRICAL CHARACTERISTICS

(under recommended operating conditions)

PARAMETER		TEST CONDITIONS					VALUES							UNIT
		V_{EE} (V)	V_I (V)	V_O (V)	V_{SS} (V)	V_{DD} (V)	T^*_{LOW} Min.	T^*_{LOW} Max.	25°C Min.	25°C Typ.	25°C Max.	T^*_{HIGH} Min.	T^*_{HIGH} Max.	
I_L Quiescent supply curent	Gand H types	−5	0/ 5		0	5		5		0.04	5		150	µA
		0	0/10		0	10		10		0.04	10		300	
		0	0/15		0	15		20		0.04	20		600	
		0	0/20		0	20		100		0.08	100		3000	
	Eand F types	−5	0/ 5		0	5		20		0.04	20		150	
		0	0/10		0	10		40		0.04	40		300	
		0	0/15		0	15		80		0.04	80		600	
V_{OH} 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_{OL} 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_{IH} 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_{IL} 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_{OH} 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_{OL} Output low current	Gand 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		
	Eand 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_{IH}, I_{IL} **Input leakage current	Gaud H types	0	0/18		0	18		±0.1		$±10^{-5}$	±0.1		±1	µA
	Eaud F types	0	0/15		0	15		±0.3		$±10^{-5}$	±0.3		±1	µA
C_I** Input capacitance										5	7.5			pF

* T_{LOW} = −55°C for Gaud H devices; −40°C for Eaud F devices

* T_{HIGH} = +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_{DD} = 5 V

2 V min. with V_{DD} = 10 V

2.5 V min. with V_{DD} = 15 V

** Any input

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DYNAMIC ELECTRICAL CHARACTERISTICS

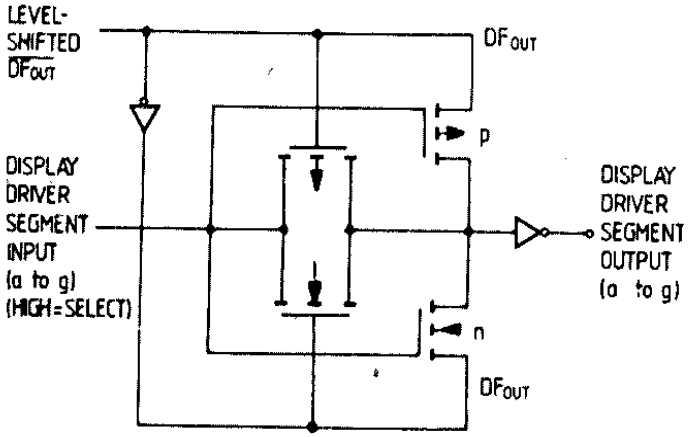
(T_{amb} = 25°C, C_L = 50 pF, R_L = 200 k typical temperature coefficient for all V_{DD} values is 0.3%/°C, all input rise and fall times = 20 ns)

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

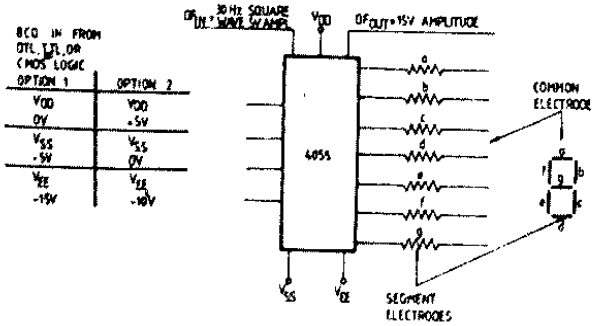
* MMC 4055 and 4056 only

TYPICAL APPLICATIONS

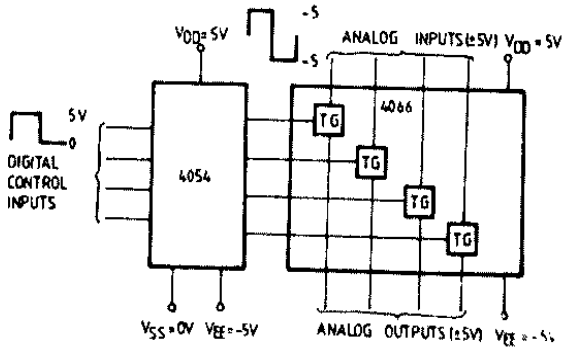
Display-driver circuit for one segment line



Single-digit liquid crystal display

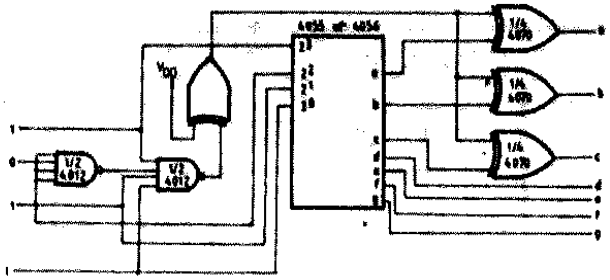


Digital (0 to +5 to −5V) to bidirectional analog control (+5 to −5V) level shifter

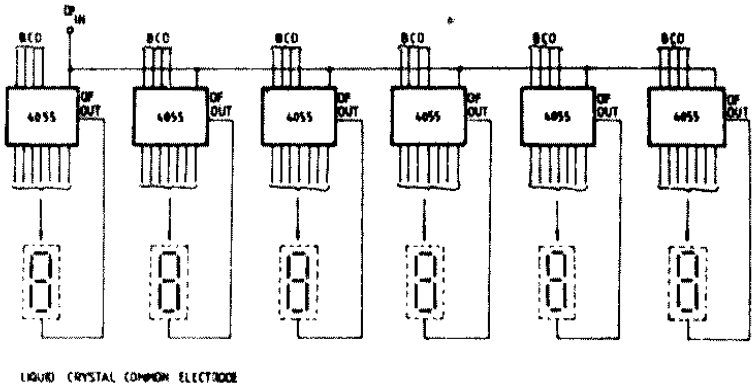


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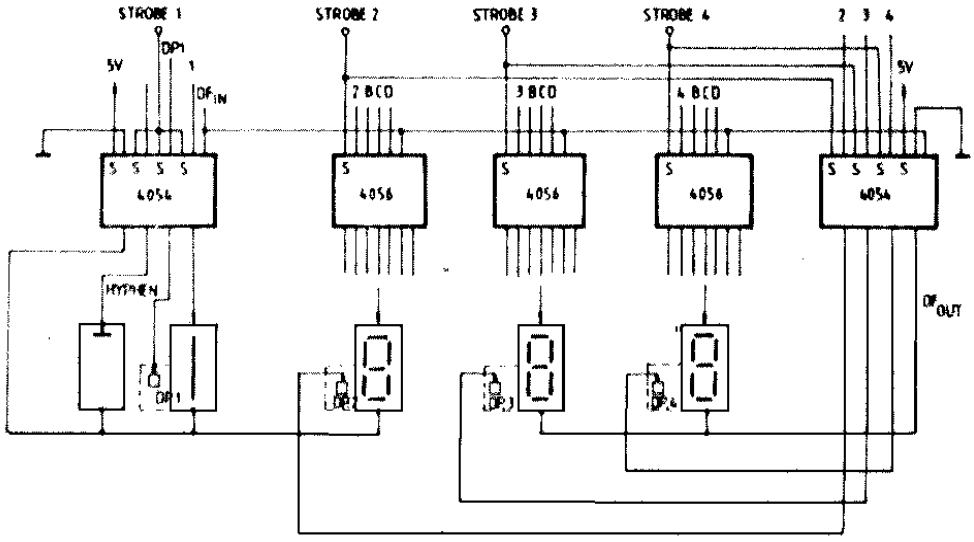
Conversion of "H" display to "F" display



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 bellow 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 appropiate 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.