LIQUID-CRYSTAL DISPLAY DRIVERS

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

- QUIESCENT CURRENT SPECIFIED TO 20V FOR HCC DEVICE
- OPERATION OF LIQUID CRYSTALS WITH COS/MOS 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 36V (p-p) 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 HCC DEVICE
- 100% TESTED FOR QUIESCENT CURRENT
- MEETS ALL REQUIREMENTS OF JEDEC TENTATIVE STANDARD NO. 13A, "STANDARD SPECIFICATIONS FOR DESCRIPTION OF "B" SERIES CMOS DEVICES"

The **HCC 4054B, HCC 4055B** and **HCC 4056B** (extended temperature range) and the **HCF 4054B, HCF 4055B** and **HCF 4056B** (intermediate temperature range) are monolithic integrated circuits available in 16-lead dual in-line plastic or ceramic package, ceramic flat package and plastic micropackage. The **HCC/HCF 4055B** and **HCC/HCF 4056B** 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 **HCC/HCF 4055B** provides a level-shifted high-amplitude DF output which is required for driving the common electrode in liquid-crystal displays. The **HCC/HCF 4056B** provides a strobed-latch function at the BCD inputs. Decoding of all input combinations on the **HCC/HCF 4055B** and **HCC/HCF 4056B** provides displays of 0 to 9 as well as L, P, H, A, −, and a blank position. (See typical application for other letters). The **HCC/HCF 4054B** provides level shifting similar to the **HCC/HCF 4055B** and **HCC/HCF 4056B** independently strobed latches, and common DF control on 4 signal lines. The **HCC/HCF 4054B** is intended to provide drive-signal compatibility with the **HCC/HCF 4055B** and **HCC/HCF 4056B** 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 **HCC/HCF 4054B** output line by connecting the corresponding input and strobe lines to a low and high level, respectively. The **HCC/HCF 4054B** 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 utput-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 **HCC/HCF 4054B** and **HCC/HCF 4056B**, 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 **HCC/HCF 4055B** can be used by itself to drive a liquid-crystal display (Fig. 10 and Fig. 12).

The **HCC/HCF 4056B**, however, must be used together with a **HCC/HCF 4054B** to provide the common DF output (Fig. 14). The capability of extending the voltage swing on the negative end (this voltage cannot be extended on the positive end) can be used to advantage in the setup of Fig. 11. Fig. 9 is common to all three types.

ABSOLUTE MAXIMUM RATINGS

V_{DD}*	Supply voltage: **HCC** types	-0.5 to 20	V
	HCF 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_{op} = full package-temperature range	100	mW
T_{op}	Operating temperature: **HCC** types	-55 to 125	°C
	HCF types	-40 to 85	°C
T_{stg}	Storage temperature	-65 to 150	°C

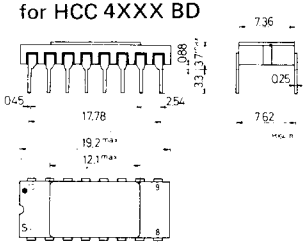
* All voltage values are referred to V_{SS} pin voltage

ORDERING NUMBERS:

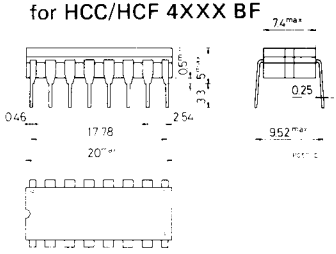
HCC 4XXX BD for dual in-line ceramic package
HCC 4XXX BF for dual in-line ceramic package, frit seal
HCC 4XXX BK for ceramic flat package
HCF 4XXX BE for dual in-line plastic package
HCF 4XXX BF for dual in-line ceramic package, frit seal
HCF 4XXX BM for plastic micropackage

MECHANICAL DATA (dimensions in mm)

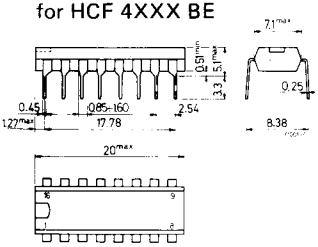
Dual in-line ceramic package for HCC 4XXX BD



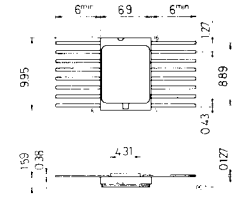
Dual in-line ceramic package for HCC/HCF 4XXX BF



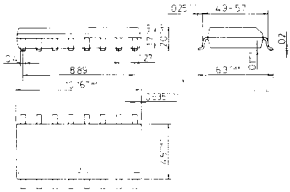
Dual in-line plastic package for HCF 4XXX BE



Ceramic flat package for HCC 4XXX BK

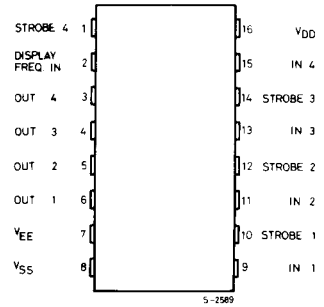


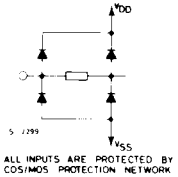
Plastic micropackage for HCF 4XXX BM



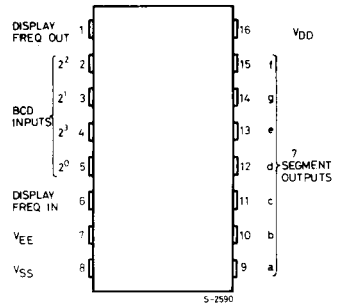
CONNECTION DIAGRAMS

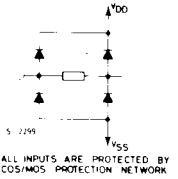
For 4054B



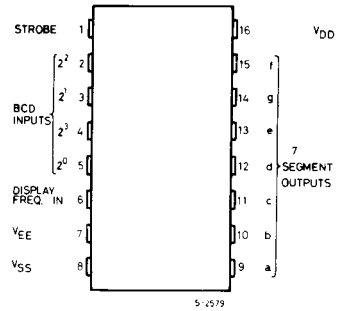


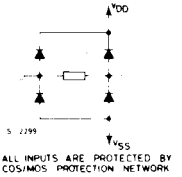
For 4055B





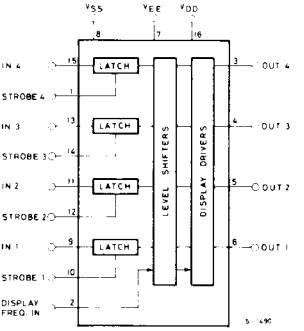
For 4056B



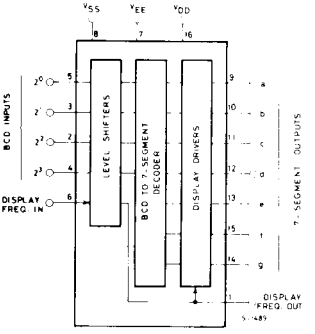


FUNCTIONAL DIAGRAMS

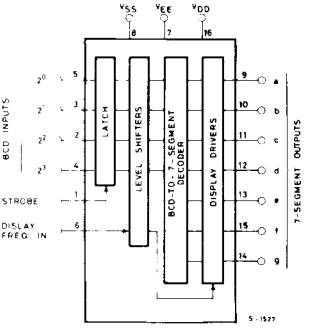
For 4054B



For 4055B



For 4056B



RECOMMENDED OPERATING CONDITIONS

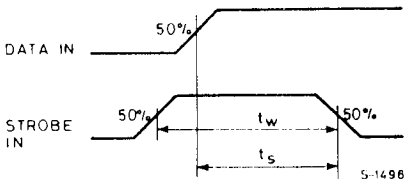
V_{DD}	Supply voltage: **HCC** types	3 to 18	V
	HCF types	3 to 15	V
V_I	Input voltage	0 to V_{DD}	V
T_{op}	Operating temperature: **HCC** types	-55 to 125	°C
	HCF types	-40 to 85	°C

TRUTH TABLE

For **4055B** and **4056B**

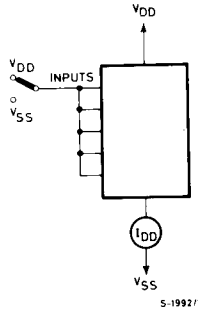
INPUT CODE				OUTPUT STATE							DISPLAY CHARACTER
2^3	2^2	2^1	2^0	a	b	c	d	e	f	g	
0	0	0	0	1	1	1	1	1	1	0	0
0	0	0	1	0	1	1	0	0	0	0	1
0	0	1	0	1	1	0	1	1	0	1	2
0	0	1	1	1	1	1	1	0	0	1	3
0	1	0	0	0	1	1	0	0	1	1	4
0	1	0	1	1	0	1	1	0	1	1	5
0	1	1	0	1	0	1	1	1	1	1	6
0	1	1	1	1	1	1	0	0	0	0	7
1	0	0	0	1	1	1	1	1	1	1	8
1	0	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	U
1	1	0	0	1	1	0	0	1	1	1	P
1	1	0	1	1	1	1	0	1	1	1	P
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

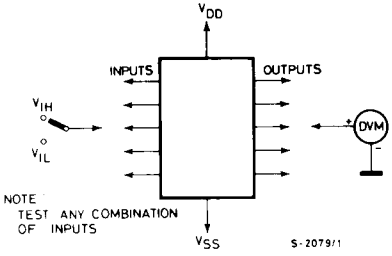


TEST CIRCUITS

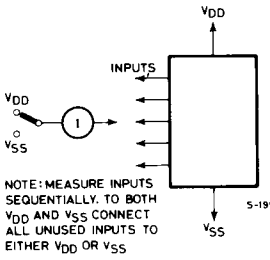
Quiescent device current



Input voltage



Input leakage current



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 current	HCC 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	
		HCF 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		0.5/4.5	0	5		1.5			1.5		1.5	V
			0		9/1	0	10		3			3		3	
			0		1.5/13.5	0	15		4			4		4	
I_{OH}	Output high current	HCC types	-5	0/ 5	4.5	0	5	-0.6		-0.45	-0.9		-0.3		mA
			0	0/10	9.5	0	10	-0.6		-0.45	-0.9		-0.3		
			0	0/15	13.5	0	15	-1.9		-1.5	-3		-1.1		
		HCF 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	HCC 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		
		HCF 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		0.82		
			0	0/15	1.5	0	15	3.62		2.9	6.8		2.17		
I_{IH},I_{IL}**	Input leakage current	HCC types	0	0/18		0	18		+0.1		$\pm 10^{-5}$	±0.1		± 1	μA
		HCF types	0	0/15		0	15		±0.3		$\pm 10^{-5}$	±0.3		± 1	μA
C_I**	Input capacitance										5	7.5			pF

* T_{Low} = - 55°C for **HCC** device; -40°C for **HCF** device.
* T_{High} = +125°C for **HCC** device: +85°C for **HCF** device.
The Noise Margin for both "1" and "0" level is: 1V min. with V_{DD} = 5V
2V min. with V_{DD} = 10V
2.5V min. with V_{DD} = 15V

** Any input

12R

DYNAMIC ELECTRICAL CHARACTERISTICS (T_{amb}= 25°C, C_L= 50 pF, R_L= 200 kΩ, typical temperature coefficient for all V_{DD} values is 0,3%/°C, all input rise and fall times = 20 ns)

Parameter	Test conditions			Types						Unit
	V_{EE} (V)	V_{SS} (V)	V_{DD} (V)	4054B			4055B, 4056B			
				Min.	Typ.	Max.	Min.	Typ.	Max.	
t_{PHL}, t_{PLH} Propagation delay time (Any Input 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_{setup}* 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		

* HCC/HCF 4054B and HCC/HCF 4056B only.

Fig. 1 - Typical output low (sink) current characteristics

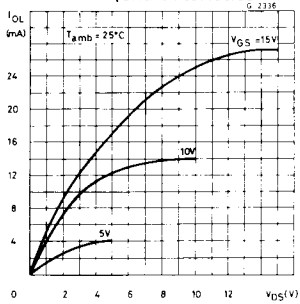


Fig. 2 - Minimum output low (sink) current characteristics

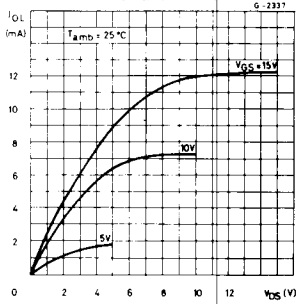


Fig. 3 - Typical output high (source) current characteristics

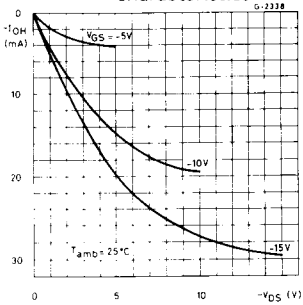


Fig. 4 - Minimum output (source) current characteristics

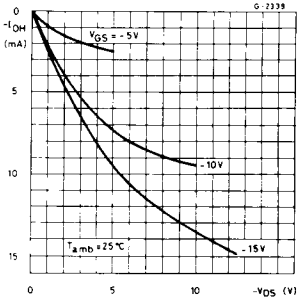


Fig. 5 - Typical propagation delay time vs. load capacitance (for 4054B)

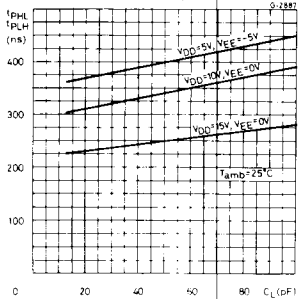


Fig. 6 - Typical propagation delay time vs. load capacitance for 4055B and 4056B)

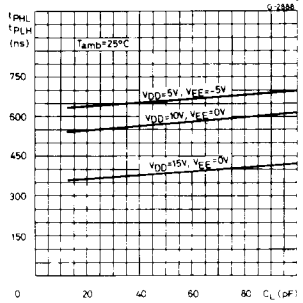


Fig. 7 - Typical transition time vs. load capacitance

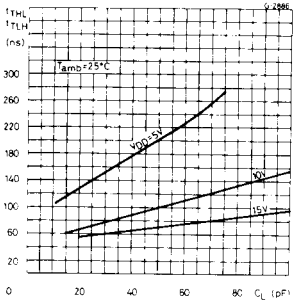
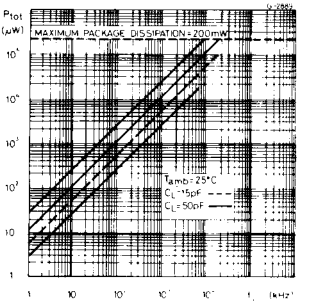


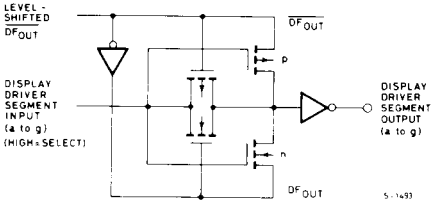
Fig. 8 - Typical dynamic power dissipation vs. frequency



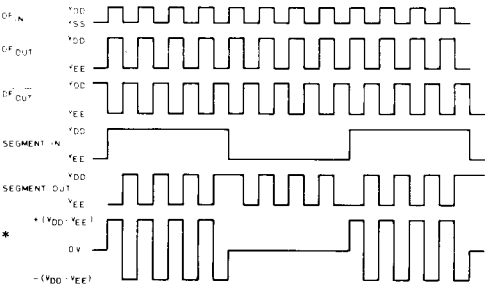
TYPICAL APPLICATIONS

Fig. 9 - Display-driver circuit for one segment line and waveforms

(a)



(b)



*RESULTANT LIQUID-CRYSTAL SEGMENT WAVEFORM IF DFOUT IS APPLIED TO LIQUID-CRYSTAL COMMON LINE
DFIN = DISPLAY-FREQUENCY INPUT
DFOUT = LEVEL-SHIFTED DISPLAY-FREQUENCY OUTPUT

Fig. 10 - Clock display

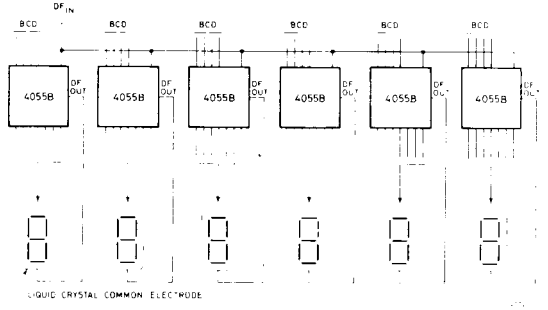
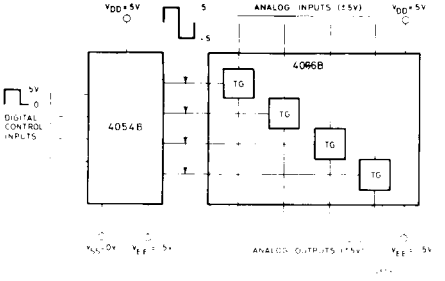


Fig. 11 - Digital (0 to +5V) to bidirectional analog control (+5 to -5V) level shifter



V_{DD}= 0V, V_{SS}= -5V, V_{EE}= -15V DF_{IN}= 30 Hz square wave.

TYPICAL APPLICATIONS (continued)

Fig. 12 - Single-digit liquid crystal display

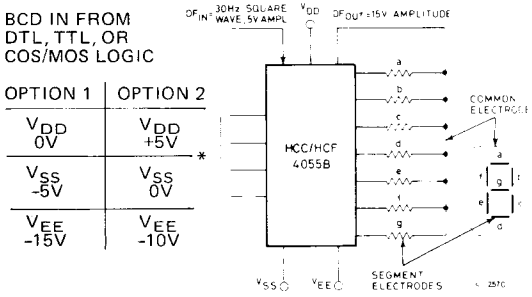


Fig. 13 - Conversion of "H" display to "F" display

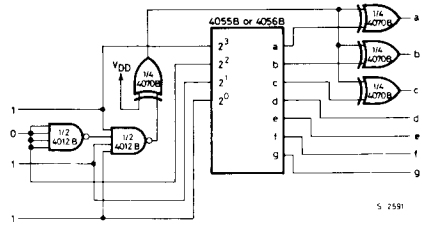
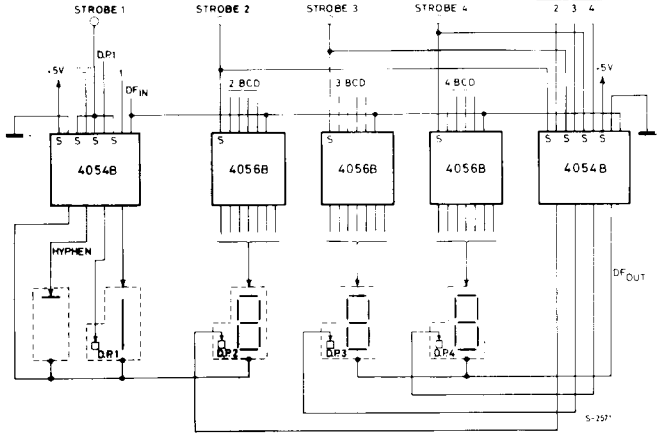


Fig. 14 - Typical 3½-digit liquid-crystal display: (V_{DD}=+5V, V_{SS}=0V, V_{EE}=-10V, DF_N=30Hz square wave)



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 **HCC/HCF 4055B** or **HCC/HCF 4056B** devices. Fig. 13 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 **HCC/HCF 4054B** 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.