National Semiconductor

January 1987

DM8898/DM8899 TRI-STATE® BCD to Binary/Binary to BCD Converters

General Description

These circuits are the TRI-STATE versions of the popular BCD to binary and binary to BCD converters, DM74184 and DM74185A respectively. They are derived from the 256-bit ROM, DM8598. Emitter connections are made to provide direct read out of converted codes at outputs Y8 through Y1, as shown in the truth tables. Both converters comprehend the fact that the least significant bits (LSB) of the binary and BCD codes are logically equal, and in each case the LSB bypasses the converter. Thus a 6-bit converter is produced in each case, and both devices are cascadable.

An overriding enable input is provided on each converter which, when taken high, inhibits the function, causing all outputs to go into the high-impedance state. For this reason, and to minimize power consumption, unused outputs Y7 and Y8 of the 185A and all ''don't care'' conditions of the 184 are programmed high.

DM8898 BCD-TO-BINARY CONVERTERS

The 6-bit BCD-to-binary function of the DM8898 is analogous to the algorithm:

a. Shift BCD number right one bit and examine each decade. Subtract three from each 4-bit decade containing a binary value greater than seven.

b. Shift right, examine, and correct after each shift until the least significant decade contains a number smaller than eight and all other converted decades contain zeros.

In addition to BCD-to-binary conversion, the DM8898 is programmed to generate BCD 9's complement or BCD 10's complement. In each case, one bit of the complement code is logically equal to one of the BCD bits; therefore, these complements can be produced on three lines. As outputs Y6, Y7 and Y8 are not required in the BCD-to-binary conversion, they are utilized to provide these complement codes as specified in the function table when the devices are connected as shown.

DM8899A BINARY-TO-BCD CONVERTERS

The function performed by these 6-bit binary-to-BCD converters is analogous to the algorithm:

a. Examine the three most significant bits. If the sum is greater than four, add three and shift left one bit.

b. Examine each BCD decade. If the sum is greater than four, add three and shift left one bit.

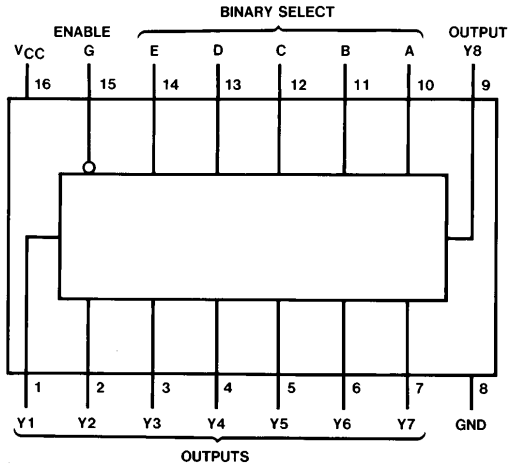
c. Repeat step b until the least-significant binary bit is in the least-significant BCD location.

Features

- TRI-STATE versions of DM74184, DM74185A
- Typical propagation delay 30 ns

Connection Diagram

Dual-In-Line Package



TL/F/6593–1

Order Number DM8898N or DM8899N
See NS Package Number N16A

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Absolute Maximum Ratings (Note)

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

Supply Voltage	7V
Input Voltage	5.5V
Operating Free Air Temperature Range	
DM88	0°C to +70°C
Storage Temperature Range	−65°C to +150°C

Note: *The "Absolute Maximum Ratings" are those values beyond which the safety of the device cannot be guaranteed. The device should not be operated at these limits. The parametric values defined in the "Electrical Characteristics" table are not guaranteed at the absolute maximum ratings. The "Recommended Operating Conditions" table will define the conditions for actual device operation.*

Recommended Operating Conditions

Symbol	Parameter	DM8898			Units
		Min	Nom	Max	
V_{CC}	Supply Voltage	4.75	5	5.25	V
V_{IH}	High Level Input Voltage	2			V
V_{IL}	Low Level Input Voltage			0.8	V
I_{OH}	High Level Output Current			−5.2	mA
I_{OL}	Low Level Output Current			12	mA
T_A	Free Air Operating Temperature	0		70	°C

DM8898 Electrical Characteristics

over recommended operating free air temperature range (unless otherwise noted)

Symbol	Parameter	Conditions	Min	Typ (Note 1)	Max	Units
V_I	Input Clamp Voltage	V_{CC} = Min, I_I = −12 mA			−1.5	V
V_{OH}	High Level Output Voltage	V_{CC} = Min, I_{OH} = Max V_{IL} = Max, V_{IH} = Min	2.4			V
V_{OL}	Low Level Output Voltage	V_{CC} = Min, I_{OL} = Max V_{IH} = Min, V_{IL} = Max			0.4	V
I_I	Input Current @ Max Input Voltage	V_{CC} = Max, V_I = 5.5V			1	mA
I_{IH}	High Level Input Current	V_{CC} = Max, V_I = 2.4V			40	μA
I_{IL}	Low Level Input Current	V_{CC} = Max, V_I = 0.4V			−1.6	mA
I_{OZH}	Off-State Output Current with High Level Output Voltage Applied	V_{CC} = Max, V_O = 2.4V V_{IH} = Min, V_{IL} = Max			40	μA
I_{OZL}	Off-State Output Current with Low Level Output Voltage Applied	V_{CC} = Max, V_O = 0.4V V_{IH} = Min, V_{IL} = Max			−40	μA
I_{OS}	Short Circuit Output Current	V_{CC} = Max (Note 2)	−20		−70	mA
I_{CC}	Supply Current	V_{CC} = Max		70	99	mA

Note 1: All typicals are at V_{CC} = 5V, T_A = 25°C.

Note 2: Not more than one output should be shorted at a time.

DM8898 Switching Characteristics

at $V_{CC} = 5V$ and $T_A = 25°C$ (See Section 1 for Test Waveforms and Output Load)

Symbol	Parameter	$R_L = 400\Omega$				Units
		$C_L = 5$ pF		$C_L = 50$ pF		
		Min	Max	Min	Max	
t_{PLH}	Propagation Delay Time Low to High Level Output				50	ns
t_{PHL}	Propagation Delay Time High to Low Level Output				50	ns
t_{PZH}	Output Enable Time to High Level Output				25	ns
t_{PZL}	Output Enable Time to Low Level Output				40	ns
t_{PHZ}	Output Disable Time from High Level Output		20			ns
t_{PLZ}	Output Disable Time from Low Level Output		36			ns

Recommended Operating Conditions

Symbol	Parameter	DM8899			Units
		Min	Nom	Max	
V_{CC}	Supply Voltage	4.75	5.0	5.25	V
V_{IH}	High Level Input Voltage	2			V
V_{IL}	Low Level Input Voltage			0.8	V
I_{OH}	High Level Output Current			−5.2	mA
I_{OL}	Low Level Output Current			12	mA
T_A	Free Air Operating Temperature	0		70	°C

DM8899 Electrical Characteristics

over recommended operating free air temperature range (unless otherwise noted)

Symbol	Parameter	Conditions	Min	Typ (Note 1)	Max	Units
V_I	Input Clamp Voltage	V_{CC} = Min, I_I = −12 mA			−1.5	V
V_{OH}	High Level Output Voltage	V_{CC} = Min, I_{OH} = Max V_{IL} = Max, V_{IH} = Min	2.4			V
V_{OL}	Low Level Output Voltage	V_{CC} = Min, I_{OL} = Max V_{IH} = Min, V_{IL} = Max			0.4	V
I_I	Input Current @ Max Input Voltage	V_{CC} = Max, V_I = 5.5V			1	mA
I_{IH}	High Level Input Current	V_{CC} = Max, V_I = 2.4V			40	μA
I_{IL}	Low Level Input Current	V_{CC} = Max, V_I = 0.4V			−1.6	mA
I_{OZH}	Off-State Output Current with High Level Output Voltage Applied	V_{CC} = Max, V_O = 2.4V V_{IH} = Min, V_{IL} = Max			40	μA
I_{OZL}	Off-State Output Current with Low Level Output Voltage Applied	V_{CC} = Max, V_O = 0.4V V_{IH} = Min, V_{IL} = Max			−40	μA
I_{OS}	Short Circuit Output Current	V_{CC} = Max (Note 2)	−20		−70	mA
I_{CC}	Supply Current	V_{CC} = Max		70	99	mA

DM8899 Switching Characteristics

at V_{CC} = 5V and T_A = 25°C (See Section 1 for Test Waveforms and Output Load)

Symbol	Parameter	R_L = 400Ω				Units
		C_L = 5 pF		C_L = 50 pF		
		Min	Max	Min	Max	
t_{PLH}	Propagation Delay Time Low to High Level Output				50	ns
t_{PHL}	Propagation Delay Time High to Low Level Output				50	ns
t_{PZH}	Output Enable Time to High Level Output				25	ns
t_{PZL}	Output Enable Time to Low Level Output				40	ns
t_{PHZ}	Output Disable Time from High Level Output		20			ns
t_{PLZ}	Output Disable Time from Low Level Output		36			ns

Note 1: All typicals are at V_{CC} = 5V, T_A = 25°C.

Note 2: Not more than one output should be shorted at a time.

Function Tables

BCD-to-Binary Converter

BCD Words		Inputs (See Note A)						Outputs (See Note B)				
		E	D	C	B	A	G	Y5	Y4	Y3	Y2	Y1
0	1	L	L	L	L	L	L	L	L	L	L	L
2	3	L	L	L	L	H	L	L	L	L	L	H
4	5	L	L	L	H	L	L	L	L	L	H	L
6	7	L	L	L	H	H	L	L	L	L	H	H
8	9	L	L	H	L	L	L	L	L	H	L	L
10	11	L	H	L	L	L	L	L	L	H	L	H
12	13	L	H	L	L	H	L	L	L	H	H	L
14	15	L	H	L	H	L	L	L	L	H	H	H
16	17	L	H	L	H	H	L	L	H	L	L	L
18	19	L	H	H	L	L	L	L	H	L	L	H
20	21	H	L	L	L	L	L	L	H	L	H	L
22	23	H	L	L	L	H	L	L	H	L	H	H
24	25	H	L	L	H	L	L	L	H	H	L	L
26	27	H	L	L	H	H	L	L	H	H	L	H
28	29	H	L	H	L	L	L	L	H	H	H	L
30	31	H	H	L	L	L	L	L	H	H	H	H
32	33	H	H	L	L	H	L	H	L	L	L	L
34	35	H	H	L	H	L	L	H	L	L	L	H
36	37	H	H	L	H	H	L	H	L	L	H	L
38	39	H	H	H	L	L	L	H	L	L	H	H
Any		X	X	X	X	X	H	Z	Z	Z	Z	Z

BCD 9's or BCD 10's Complement Converter

BCD Word	Inputs (See Note C)						Outputs (See Note D)		
	E†	D	C	B	A	G	Y8	Y7	Y6
0	L	L	L	L	L	L	H	L	H
1	L	L	L	L	H	L	H	L	L
2	L	L	L	H	L	L	L	H	H
3	L	L	L	H	H	L	L	H	L
4	L	L	H	L	L	L	L	H	H
5	L	L	H	L	H	L	L	H	L
6	L	L	H	H	L	L	L	L	H
7	L	L	H	H	H	L	L	L	L
8	L	H	L	L	L	L	L	L	H
9	L	H	L	L	H	L	L	L	L
0	H	L	L	L	L	L	L	L	L
1	H	L	L	L	H	L	H	L	L
2	H	L	L	H	L	L	H	L	L
3	H	L	L	H	H	L	L	H	H
4	H	L	H	L	L	L	L	H	H
5	H	L	H	L	H	L	L	H	L
6	H	L	H	H	L	L	L	H	L
7	H	L	H	H	H	L	L	L	H
8	H	H	L	L	L	L	L	L	H
9	H	H	L	L	H	L	L	L	L
Any	X	X	X	X	X	H	Z	Z	Z

H = High Level, L = Low Level, Z = High Impedance

Note A: Input conditions other than those shown produce highs at outputs Y1 through Y5.

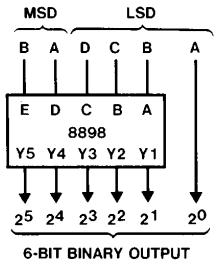
Note B: Outputs Y6, Y7, and Y8 are not used for BCD-to-binary conversion.

Note C: Input conditions other than those shown produce highs at outputs Y6, Y7, and Y8.

Note D: Outputs Y1 through Y5 are not used for BCD 9's or BCD 10's complement conversion.

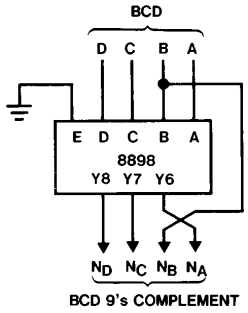
†When these devices are used as complement converters, input E is used as a mode control. With this input low, the BCD 9's complement is generated; when it is high, the BCD 10's complement is generated.

6-Bit Converter



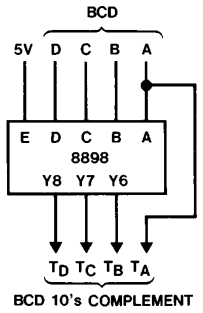
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BCD 9's Complement Converter



TL/F/6593–3

BCD 10's Complement Converter



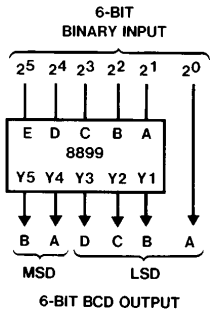
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Function Tables (Continued)

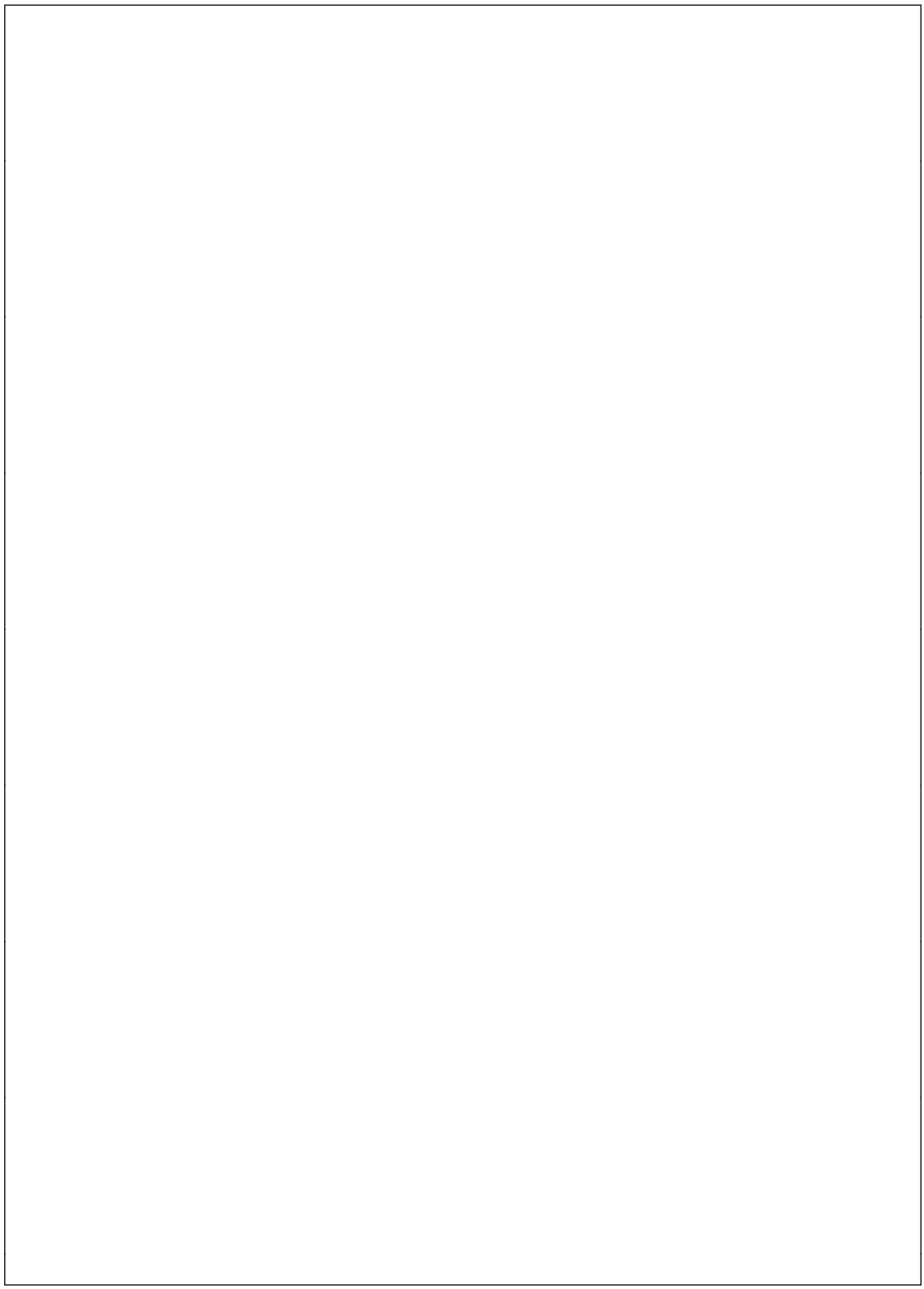
Binary Words		Inputs						Outputs							
		Binary Select					Enable								
		E	D	C	B	A	G	Y8	Y7	Y6	Y5	Y4	Y3	Y2	Y1
0	1	L	L	L	L	L	L	H	H	L	L	L	L	L	L
2	3	L	L	L	L	H	L	H	H	L	L	L	L	L	H
4	5	L	L	L	H	L	L	H	H	L	L	L	L	H	L
6	7	L	L	L	H	H	L	H	H	L	L	L	L	H	H
8	9	L	L	H	L	L	L	H	H	L	L	L	H	L	L
10	11	L	L	H	L	H	L	H	H	L	L	H	L	L	L
12	13	L	L	H	H	L	L	H	H	L	L	H	L	L	H
14	15	L	L	H	H	H	L	H	H	L	L	H	L	H	L
16	17	L	H	L	L	L	L	H	H	L	L	H	L	H	H
18	19	L	H	L	L	H	L	H	H	L	L	H	H	L	L
20	21	L	H	L	H	L	L	H	H	L	H	L	L	L	L
22	23	L	H	L	H	H	L	H	H	L	H	L	L	L	H
24	25	L	H	H	L	L	L	H	H	L	H	L	L	H	L
26	27	L	H	H	L	H	L	H	H	L	H	L	L	H	H
28	29	L	H	H	H	L	L	H	H	L	H	L	H	L	L
30	31	L	H	H	H	H	L	H	H	L	H	H	L	L	L
32	33	H	L	L	L	L	L	H	H	L	H	H	L	L	H
34	35	H	L	L	L	H	L	H	H	L	H	H	L	H	L
36	37	H	L	L	H	L	L	H	H	L	H	H	L	H	H
38	39	H	L	L	H	H	L	H	H	L	H	H	H	L	L
40	41	H	L	H	L	L	L	H	H	H	L	L	L	L	L
42	43	H	L	H	L	H	L	H	H	H	L	L	L	L	H
44	45	H	L	H	H	L	L	H	H	H	L	L	L	H	L
46	47	H	L	H	H	H	L	H	H	H	L	L	L	H	H
48	49	H	H	L	L	L	L	H	H	H	L	L	H	L	L
50	51	H	H	L	L	H	L	H	H	H	L	H	L	L	L
52	53	H	H	L	H	L	L	H	H	H	L	H	L	L	H
54	55	H	H	L	H	H	L	H	H	H	L	H	L	H	L
56	57	H	H	H	L	L	L	H	H	H	L	H	L	H	H
58	59	H	H	H	L	H	L	H	H	H	L	H	H	L	L
60	61	H	H	H	H	L	L	H	H	H	H	L	L	L	L
62	63	H	H	H	H	H	L	H	H	H	H	L	L	L	H
All		X	X	X	X	X	H	Z	Z	Z	Z	Z	Z	Z	Z

H = High Level, L = Low Level, X = Don't Care, Z = High Impedance

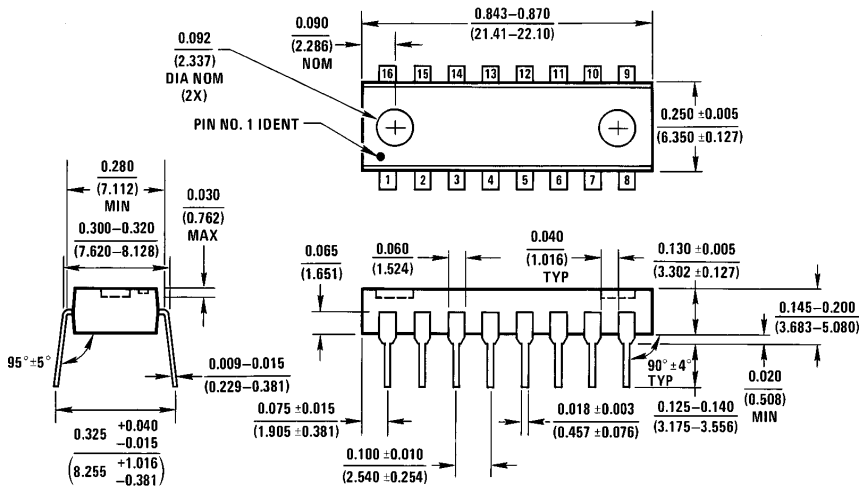
6-Bit Converter



TL/F/6593–5



Physical Dimensions inches (millimeters)



N16A (REV E)

Molded Dual-In-Line Package (N)
Order Number DM8898N or DM8899AN
NS Package Number N16A

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