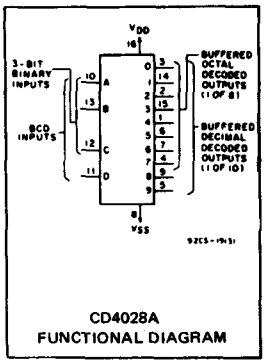
CMOS BCD-to-Decimal Decoder

The RCA-CD4028A types are BCD-to-decimal or binary-to-octal decoders consisting of pulse-shaping circuits on all 4 inputs, decoding-logic gates, and 10 output buffers. A BCD code applied to the four inputs, A to D, results in a high level at the selected one of 10 decimal decoded outputs. Similarly, a 3-bit binary code applied to inputs A through C is decoded in octal code at output 0 to 7. A high-level signal at the D input inhibits octal decoding and causes outputs 0 through 7 to go low. If unused, the D input must be connected to V_{SS}. High drive capability is provided at all outputs to enhance dc and dynamic performance in high fan-out applications.

These types are supplied in 16-lead hermetic dual-in-line ceramic packages (D and F suffixes), 16-lead dual-in-line plastic package (E suffix), 16-lead ceramic flat package (K suffix), and in chip form (H suffix).



CD4028A
FUNCTIONAL DIAGRAM

MAXIMUM RATINGS, *Absolute-Maximum Values:*

STORAGE-TEMPERATURE RANGE (T_{stg}) . . . . . −65 to +150°C

OPERATING-TEMPERATURE RANGE (T_A):

PACKAGE TYPES D, F, K, H . . . . . −65 to +125°C

PACKAGE TYPE E . . . . . −40 to +85°C

DC SUPPLY-VOLTAGE RANGE, (V_{DD})

(Voltages references to V_{SS} Terminal) . . . . . −0.5 to +15 V

POWER DISSIPATION PER PACKAGE (P_D):

FOR T_A = −40 to +60°C (PACKAGE TYPE E) . . . . . 500 mW

FOR T_A = +60 to +85°C (PACKAGE TYPE E) . . . . . Derate Linearly at 12 mW/°C to 200 mW

For T_A = −55 to +100°C (PACKAGE TYPES D, F, K) . . . . . 500 mW

For T_A = +100 to +125°C (PACKAGE TYPES D, F, K) . . . . Derate Linearly at 12 mW/°C to 200 mW

DEVICE DISSIPATION PER OUTPUT TRANSISTOR

FOR T_A = FULL PACKAGE-TEMPERATURE RANGE (ALL PACKAGE TYPES) . . . . . 100 mW

INPUT VOLTAGE RANGE, ALL INPUTS . . . . . −0.5 to V_{DD} +0.5 V

LEAD TEMPERATURE (DURING SOLDERING):

At distance 1/16 ± 1/32 inch (1.59 ± 0.79 mm) from case for 10 s max. . . . . +265°C

RECOMMENDED OPERATING CONDITIONS

For maximum reliability, nominal operating conditions should be selected so that operation is always within the following ranges:

CHARACTERISTIC	V_{DD} (V)	LIMITS				UNITS
		D, F, K, H PACKAGES		E PACKAGE		
		MIN.	MAX.	MIN.	MAX.	
Supply-Voltage Range (For T_A=Full Package-Temperature Range)		3	12	3	12	V

Features:

- **BCD-to-decimal decoding or binary-to-octal decoding**
- **High decoded output drive capability. . . . . 8 mA (typ.) sink or source**
- **"Positive logic" inputs and outputs. . . . . decoded outputs go high on selection**
- **Medium-speed operation . . . . t_{THL}, t_{TLH} = 30 ns (typ.) @ V_{DD} = 10 V**
- **Quiescent current specified to 15 V**
- **Maximum input leakage current of 1 μA at 15 V (full package-temperature range)**
- **1-V noise margin (full package-temperature range)**

Applications:

- **Code conversion**
- **Address decoding—memory selection control**
- **Indicator-tube decoder**

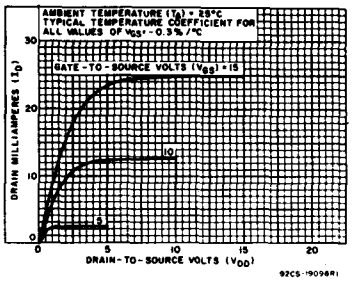


Fig. 1 — Typical output n-channel drain characteristics.

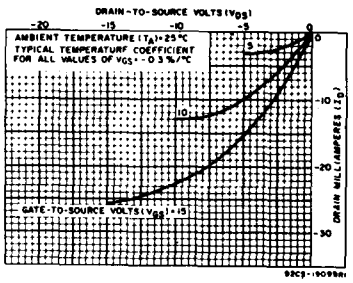


Fig. 2 — Typical output p-channel drain characteristics.

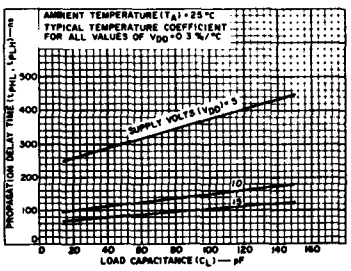


Fig. 3 — Typical propagation delay time vs. C_L.

CD4028A Types

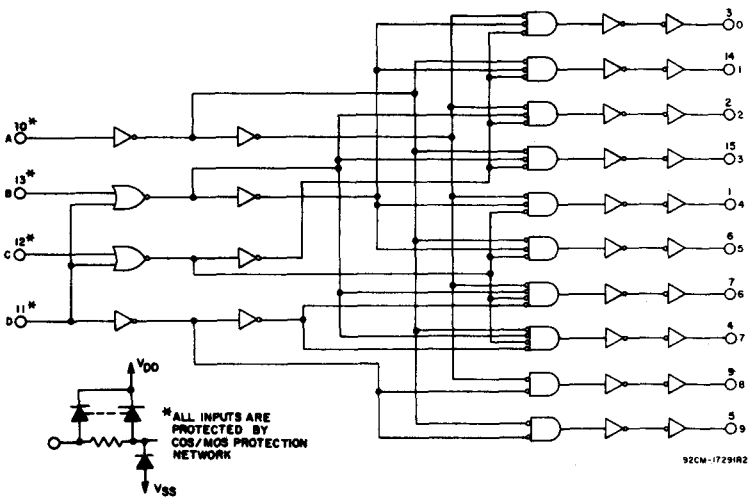


Fig. 4 — Logic diagram.

TABLE I — TRUTH TABLE

D	C	B	A	0	1	2	3	4	5	6	7	8	9	
0	0	0	0	1	0	0	0	0	0	0	0	0	0	*
0	0	0	1	0	1	0	0	0	0	0	0	0	0	
0	0	1	0	0	0	1	0	0	0	0	0	0	0	
0	0	1	1	0	0	0	1	0	0	0	0	0	0	
0	1	0	0	0	0	0	0	1	0	0	0	0	0	
0	1	0	1	0	0	0	0	0	1	0	0	0	0	
0	1	1	0	0	0	0	0	0	0	1	0	0	0	
0	1	1	1	0	0	0	0	0	0	0	1	0	0	
1	0	0	0	0	0	0	0	0	0	0	0	1	0	
1	0	0	1	0	0	0	0	0	0	0	0	0	1	
1	0	1	0	0	0	0	0	0	0	0	0	1	0	**
1	0	1	1	0	0	0	0	0	0	0	0	0	1	
1	1	0	0	0	0	0	0	0	0	0	0	1	0	
1	1	0	1	0	0	0	0	0	0	0	0	0	1	
1	1	1	0	0	0	0	0	0	0	0	0	1	0	
1	1	1	1	0	0	0	0	0	0	0	0	0	1	

* WHERE 1 = HIGH LEVEL
0 = LOW LEVEL

** EXTRAORDINARY STATES

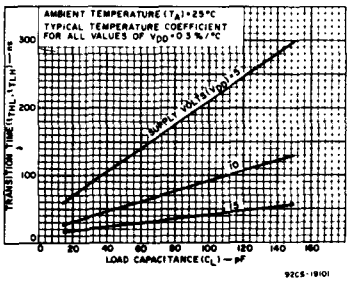


Fig. 5 — Typical transition time vs. C_L.

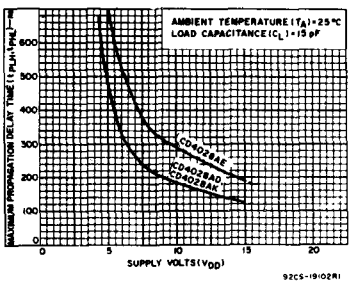


Fig. 6 — Maximum propagation delay time vs. V_{DD}.

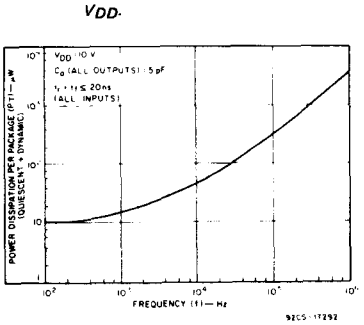


Fig. 7 — Dissipation vs. input frequency.

STATIC ELECTRICAL CHARACTERISTICS

CHARACTERISTIC	CONDITIONS			LIMITS AT INDICATED TEMPERATURES (°C)								UNITS
				D, F, K, H PACKAGES				E PACKAGE				
	V_O (V)	V_{IN} (V)	V_{DD} (V)	−55	+25 TYP.	+25 LIMIT	+125	−40	+25 TYP.	+25 LIMIT	+85	
Quiescent Device Current, I_L Max.	–	–	5	5	0.5	5	300	50	5	50	700	µA
	–	–	10	10	1	10	600	100	10	100	1400	
	–	–	15	50	1	50	2000	500	10	500	5000	
Output Voltage: Low-Level, V_{OL}	–	5	5	0 Typ.; 0.05 Max.								V
	–	10	10	0 Typ.; 0.05 Max.								
High Level V_{OH}	–	0	5	4.95 Min.; 5 Typ.								
	–	0	10	9.95 Min.; 10 Typ.								
Noise Immunity: Inputs Low, V_{NL}	4.2	–	5	1.5 Min.; 2.25 Typ.								V
	9	–	10	3 Min.; 4.5 Typ.								
Inputs High V_{NH}	0.8	–	5	1.5 Min.; 2.25 Typ.								
	1	–	10	3 Min.; 4.5 Typ.								
Noise Margin: Inputs Low, V_{NML}	4.5	–	5	1 Min.								V
	9	–	10	1 Min.								
Inputs High, V_{NMH}	0.5	–	5	1 Min.								
	1	–	10	1 Min.								
Output Drive Current N-Channel (Sink), I_{DN} Min.	0.5	–	5	0.75	1.2	0.6	0.45	0.35	1.2	0.3	0.25	mA
	0.5	–	10	1.5	2.4	1.2	0.9	0.7	2.4	0.6	0.5	
P-Channel (Source), I_DP Min.	4.5	–	5	−0.7	−0.9	−0.45	−0.32	−0.32	−0.9	−0.22	−0.18	
	9	–	10	−1.4	−1.9	−0.95	−0.65	−0.65	−1.9	−0.48	−0.4	
Input Leakage Current, I_{IL}, I_{IH}	Any Input											µA
	–	–	15	$\pm 10^{-5}$ Typ., ±1 Max.								

DYNAMIC ELECTRICAL CHARACTERISTICS

at T_A = 25°C, Input t_r, t_f = 20 ns, C_L = 15 pF, R_L = 200 kΩ

CHARACTERISTIC	TEST CONDITIONS		LIMITS						UNITS
			D, F, K, H PACKAGES			E PACKAGE			
		V_{DD} (V)	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	
Propagation Delay Time; t_{PLH}, t_{PHL}		5	–	250	480	–	250	700	ns
		10	–	100	180	–	100	290	
Transition Time; t_{THL}, t_{TLH}		5	–	60	150	–	60	300	ns
		10	–	30	75	–	30	150	
Average Input Capacitance, C_I	Any Input		–	5	–	–	5	–	pF

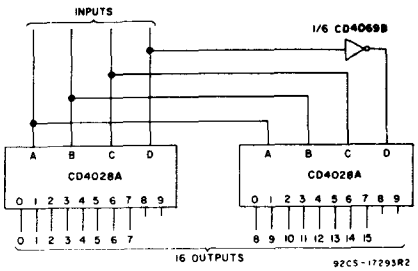
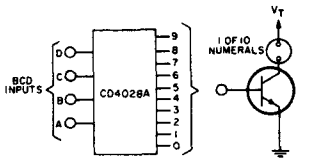


Fig. 8 – Code conversion circuit.

The circuit shown in Fig. 9 converts any 4-bit code to a decimal or hexadecimal code. Table 2 shows a number of codes and the decimal or hexadecimal number in these codes which must be applied to the input terminals of the CD4028A to select a particular output. For example: in order to get a high on output No. 8 the input must be either an 8 expressed in 4-Bit Binary code, a 15 expressed in 4-Bit Gray code, or a 5 expressed in Excess-3 code.



▲ (Trademark) Burroughs Corp.

TUBE REQUIREMENTS

Type	V_T (Vdc)	mA/numeral
Burroughs B4081	170	1.4
B4336/7/8	170	2
B4032	170	1.4
B4021	120	1.4

TRANSISTOR CHARACTERISTICS

Leakage with transistor cutoff ≤ 0.05mA

$V_{(BR)CEO}$ ≥ 70V

Fig. 9 – Neon readout (Nixie Tube▲) display application.

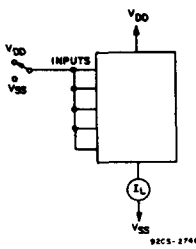


Fig. 10 – Quiescent-device-current test circuit.

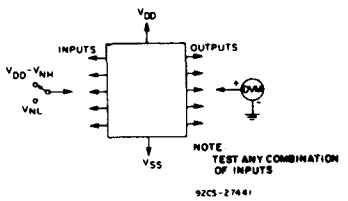


Fig. 11 – Noise-immunity test circuit.

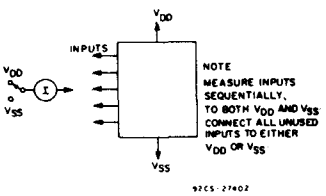


Fig. 12 – Input-leakage-current test circuit.

TABLE II – CODE CONVERSION CHART

INPUTS				INPUT CODES					OUTPUT NUMBER																	
				Hexa – Decimal	Decimal																					
D	C	B	A	4-BIT BINARY	4-BIT GRAY	EXCESS-3	EXCESS-3 GRAY	AIKEN	4-2-2-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	0	0	0	0			0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	1	1	1			1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	1	0	2	3		0	2	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	1	1	3	2	0	3	3		0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
0	1	0	0	4	7	1	4	4		0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
0	1	0	1	5	6	2			3	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
0	1	1	0	6	4	3	1		4	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
0	1	1	1	7	5	4	2			0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
1	0	0	0	8	15	5				0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
1	0	0	1	9	14	6			5	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
1	0	1	0	10	12	7	9		6	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
1	0	1	1	11	13	8		5		0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
1	1	0	0	12	8	9	5	6		0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
1	1	0	1	13	9		6	7	7	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
1	1	1	0	14	11		8	8	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
1	1	1	1	15	10		7	9	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1