CMOS 7-Stage Binary Counter

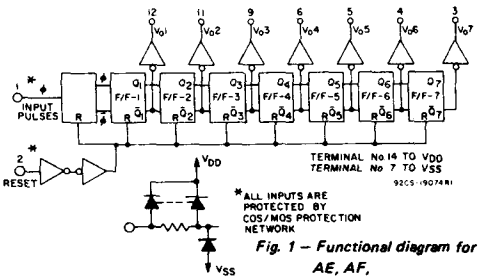
With Buffered Reset

The RCA-CD4024A consists of an INPUT PULSE shaping circuit, RESET line driver circuitry, and seven binary counter stages. The counter is reset to "zero" by a high level on the RESET input. Each counter stage is a static master-slave flip-flop. The counter state is advanced one count on the negative-going transition of each INPUT PULSE.

These types are supplied in 14-lead hermetic dual-in-line ceramic packages (D and F suffixes), 14-lead dual-in-line plastic package (E suffix), 12-lead hermetic TO-5-style package (T suffix) 14-lead ceramic flat packages (K suffix), and in chip form (H suffix).

Applications:

- **Frequency-dividing circuits**
- **Time-delay circuits**
- **Counter control**
- **D/A counter and switch on one chip**



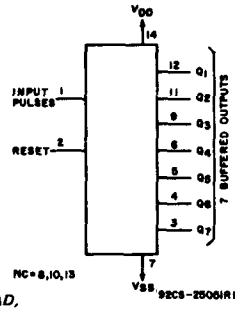
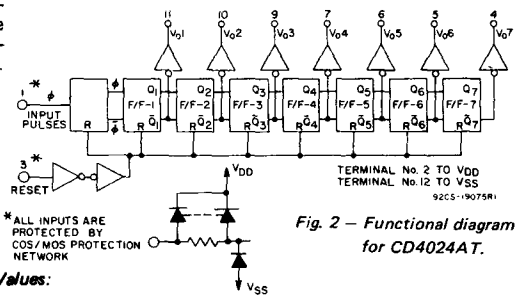


Fig. 1 – Functional diagram for CD4024AD, AE, AF,



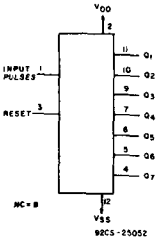


Fig. 2 – Functional diagram for CD4024AT.

MAXIMUM RATINGS, ***Absolute-Maximum Values:***

STORAGE-TEMPERATURE RANGE (T_{stg})	−65 to +150°C
OPERATING-TEMPERATURE RANGE (T_A):	
PACKAGE TYPES (D, F, K, T, H)	−55 to +125°C
PACKAGE TYPE E	−40 to +85°C
DC SUPPLY-VOLTAGE RANGE, (V_{DD})	
(Voltages referenced 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, T)	500 mW
FOR T_A = +100 to +125°C (PACKAGE TYPES D, F, K, T)	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 at T_A = 25°C, Except as Noted.
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, T, H Packages		*E Package*		
		Min.	Max.	Min.	Max.	
Supply-Voltage Range (For T_A = Full Package-Temperature Range)		3	12	3	12	V
Clock Pulse Width, t_W	5	330	–	500	–	ns
	10	125	–	165	–	
Clock Input Frequency, f_{CL}	5	dc	1.5	dc	1	MHz
	10	dc	4	dc	3	
Clock Rise or Fall Time, t_rCL, t_fCL	5	15	–	15	–	μs
	10	15	–	15	–	
Reset Pulse Width, t_W	5	500	–	600	–	ns
	10	300	–	350	–	

Features:

- **Medium-speed operation . . . . . 7-MHz (typ.) input pulse rate at $V_{DD} - V_{SS}$ = 10 V**
- **Low high-and-low level output impedance . . 700Ω and 500Ω (typ.), respectively at $V_{DD} - V_{SS}$ = 10 V**
- **Fully static operation**
- **Common reset**
- **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)**

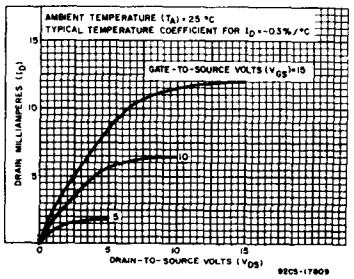
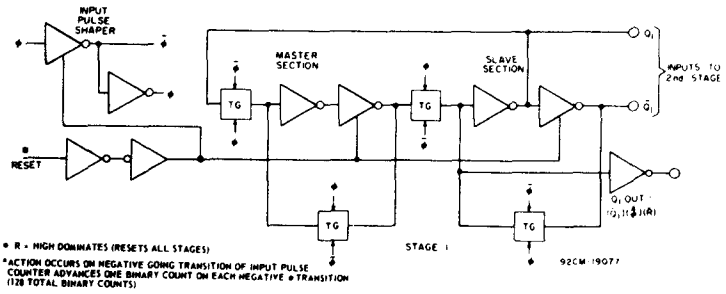


Fig. 3 – Typical output n-channel drain characteristics.

CD4024A Types

STATIC ELECTRICAL CHARACTERISTICS

Characteristic	Conditions			Limits at Indicated Temperatures (°C)								Units
				D, F, K, T, H Packages				E Package				
				−55	+25		+125	−40	+25		+85	
	V_O (V)	V_{IN} (V)	V_{DD} (V)		Typ.	Limit			Typ.	Limit		
Quiescent Device Current, I_L Max.	–	–	5	5	0.3	5	300	50	0.5	50	700	μA
	–	–	10	10	0.5	10	600	100	1	100	1400	
	–	–	15	50	1	50	2000	500	5	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	0.31	0.5	0.25	0.175	0.15	0.5	0.12	0.095	mA
	0.5	–	10	0.62	1	0.5	0.35	0.31	1	0.25	0.2	
p-Channel (Source) I_DP Min.	4.5	–	5	-0.19	-0.3	-0.15	-0.105	-0.145	-0.3	-0.12	-0.095	
	9.5	–	10	-0.45	-0.7	-0.35	-0.25	-0.31	-0.7	-0.25	-0.2	
Input Leakage Current, I_{IL}, I_{IH}	Any Input	–	15	$\pm 10^{-5}$ Typ.; ±1 Max.								μA



* R = HIGH DOMINATES (RESETS ALL STAGES)
*ACTION OCCURS ON NEGATIVE GOING TRANSITION OF INPUT PULSE
COUNTER ADVANCES ONE BINARY COUNT ON EACH NEGATIVE Φ TRANSITION
(128 TOTAL BINARY COUNTS)

EQUATIONS FOR STAGES 2 TO 7

$Q_{2OUT} = (\bar{Q}_2)(Q_1)(\overset{\Phi}{\blacklozenge})(R)$ $\quad Q_{5OUT} = (\bar{Q}_5)(Q_1)(Q_2)(Q_3)(Q_4)(\overset{\Phi}{\blacklozenge})(\bar{R})$

$Q_{3OUT} = (\bar{Q}_3)(Q_1)(Q_2)(\overset{\Phi}{\blacklozenge})(\bar{R})$ $\quad Q_{6OUT} = (\bar{Q}_6)(Q_1)(Q_2)(Q_3)(Q_4)(Q_5)(\overset{\Phi}{\blacklozenge})(\bar{R})$

$Q_{4OUT} = (\bar{Q}_4)(Q_1)(Q_2)(Q_3)(\overset{\Phi}{\blacklozenge})(\bar{R})$ $\quad Q_{7OUT} = (\bar{Q}_7)(Q_1)(Q_2)(Q_3)(Q_4)(Q_5)(Q_6)(\overset{\Phi}{\blacklozenge})(\bar{R})$

Fig. 7 — Logic block diagram (pulse shaper and 1 binary stage).

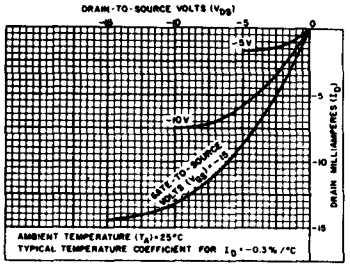


Fig. 4 — Typical output p-channel drain characteristics.

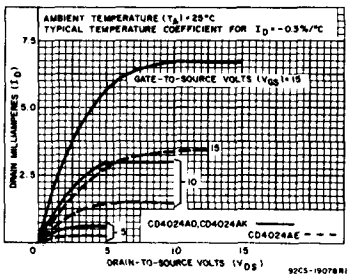


Fig. 5 — Minimum output n-channel drain characteristics.

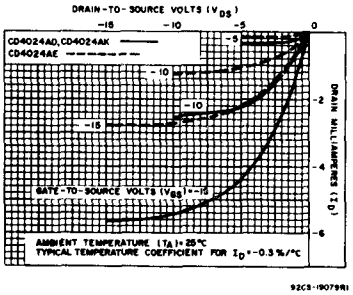


Fig. 6 — Minimum output p-channel drain characteristics.

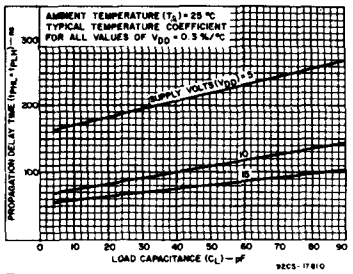


Fig. 8 — Typical propagation delay time vs. C_L.

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, T, H Packages			E Package			
	V_{DD} (V)	Min.	Typ.	Max.	Min.	Typ.	Max.	
ϕ INPUT OPERATION								
Propagation Delay Time;* t_{PLH}, t_{PHL}	5	–	175	350	–	175	400	ns
	10	–	80	125	–	80	150	
Transition Time; t_{THL}, t_{TLH}	5	–	175	225	–	175	250	ns
	10	–	80	125	–	80	150	
Maximum Pulse Input Frequency, f_ϕ	5	1.5	2.5	–	1	2.5	–	MHz
	10	4	7	–	3	7	–	
Minimum Input Pulse Width, t_W	5	–	200	330	–	200	500	ns
	10	–	140	125	–	140	165	
Input Pulse Rise & Fall Time, $t_{r\phi}$, $t_{f\phi}$	5	–	–	15	–	–	15	μs
	10	–	–	10	–	–	10	
Average Input Capacitance, C_I	Any Input	–	5	–	–	5	–	pF
RESET OPERATION								
Propagation Delay Time; T_{PLH}, T_{PHL}	5	–	500	700	–	500	800	ns
	10	–	250	350	–	250	400	
Minimum Reset Pulse Width; t_W	5	–	375	500	–	375	600	ns
	10	–	200	300	–	200	350	

* Propagation delay time is from input pulse to Q_1 output.

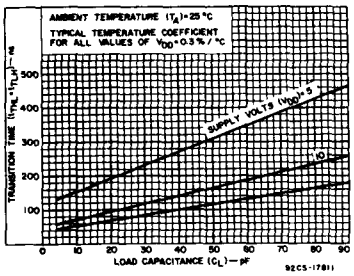


Fig. 9 — Typical transition time vs. C_L.

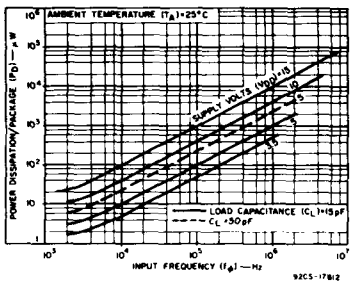


Fig. 10 — Typical dissipation characteristics.

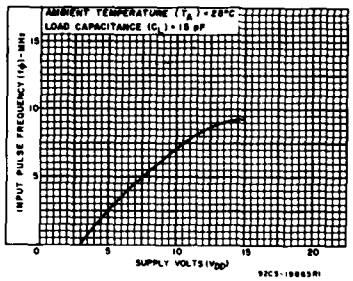


Fig. 11 — Typical input pulse frequency vs. V_{DD}.

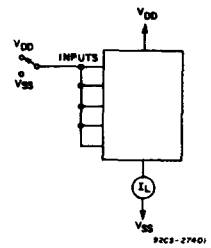


Fig. 12 — Quiescent-device-current test circuit.

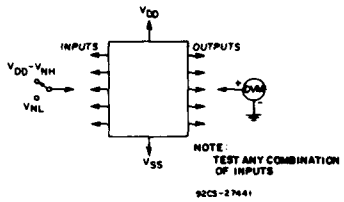


Fig. 13 — Noise-immunity test circuit.

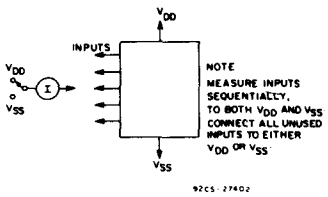


Fig. 14 — Input-leakage-current test circuit.

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