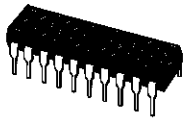
SGS-THOMSON MICROELECTRONICS

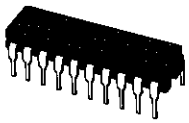
M54/74HC696/697
M54/74HC698/699

HC696/698 U/D DECADE COUNTER/REGISTER (3-STATE)
HC697/699 U/D 4 BIT BINARY COUNTER/REGISTER (3-STATE)

- HIGH SPEED
  f_{MAX} = 50 MHz (TYP.) AT V_{CC} = 5 V
- LOW POWER DISSIPATION
  I_{CC} = 4 µA (MAX.) AT T_A = 25 °C
- HIGH NOISE IMMUNITY
  $V_{NIH} = V_{NIL}$ = 28 % V_{CC} (MIN.)
- OUTPUT DRIVE CAPABILITY
  15 LSTTL LOADS (for Q_A to Q_D)
  10 LSTTL LOADS (for RCO)
- SYMMETRICAL OUTPUT IMPEDANCE
  $|I_{OH}| = I_{OL}$ = 6 mA (MIN.) FOR Q_A TO Q_D
  $|I_{OH}| = I_{OL}$ = 4 mA (MIN.) FOR RCO OUTPUT
- BALANCED PROPAGATION DELAYS
  $t_{PLH} = t_{PHL}$
- WIDE OPERATING VOLTAGE RANGE
  V_{CC} (OPR) = 2 V TO 6 V
- PIN AND FUNCTION COMPATIBLE
  WITH LSTTL 54/74LS696/697/698/699



B1R
(Plastic Package)



F1R
(Ceramic Package)

M1R
(Micro Package)

C1R
(Chip Carrier)

ORDER CODES :

M54HCXXXF1R M74HCXXXM1R
M74HCXXXB1R M74HCXXXC1R

DESCRIPTION

The HC696/697 are high speed CMOS up/down counters fabricated with silicon gate C^2MOS technology. They achieve the high speed operation similar to equivalent LSTTL while maintaining the CMOS low power dissipation. The HC696/698 are BCD DECADE COUNTER, and the HC697/699 are 4-BIT BINARY COUNTER. Both devices have register.

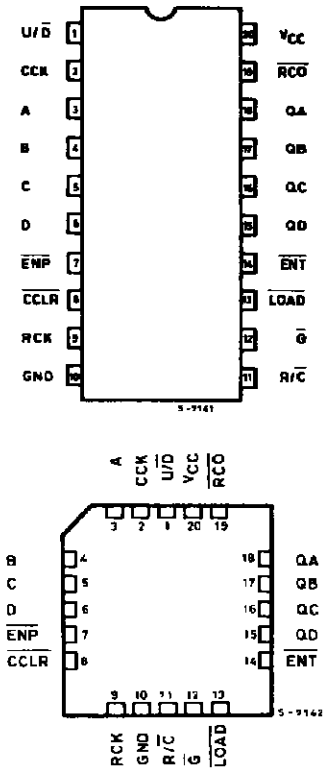
They count on the positive edge of the counter clock input (CCK) when selected by the "Counter Mode". If the input U/$\overline{D}$ is held "H", the internal counter counts up, and held "L", counts down. The internal counter's outputs are stored in the output register at the positive edge of register clock (RCK).

The counter features enable P and enable T and a ripple-carry output for easy expansion. the register/counter select input, R/C, selects the counter when low or the register when high for the three state outputs, QA, QB, Qc and QD.

Both the counter clock CCK and register clock RCK are positive-edge triggered. The counter clear CCLR is active low and is synchronous for HC698/699, and asynchronous for HC696/697.

All inputs are equipped with protection circuits against static discharge and transient excess voltage.

PIN CONNECTIONS (top view)

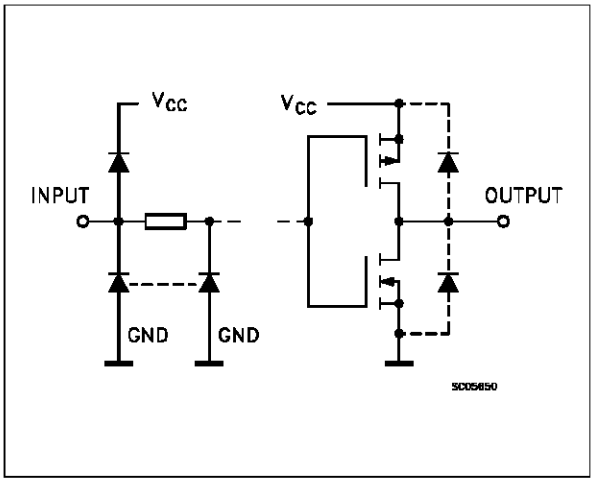


NC =
No Internal
Connection

PIN DESCRIPTION

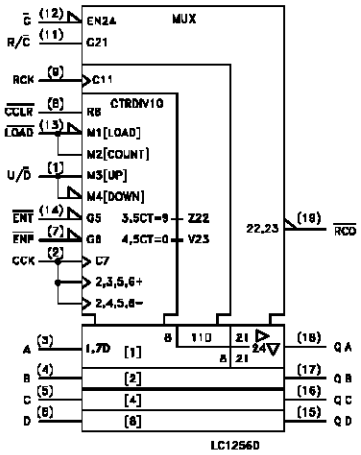
PIN No	SYMBOL	NAME AND FUNCTION
1	U/$\overline{D}$	Up Down Counter Selector
2	CCK	Counter Clock
3, 4, 5, 6	A to D	Data Inputs
7, 14	$\overline{EMP}$/$\overline{ENT}$	Enable $\overline{P}$ and $\overline{T}$
8	$\overline{CCLR}$	Counter Clear (Active LOW)
9	RCK	Register Clock
11	R/$\overline{C}$	Register Counter Selector
12	$\overline{G}$	Enable Input
13	LOAD	Load Counter (Active LOW)
15, 16, 17, 18	QA to QD	Data Outputs
19	$\overline{RCO}$	Load Counter (Active HIGH)
10	GND	Ground (0V)
20	V_{CC}	Positive Supply Voltage

INPUT AND OUTPUT EQUIVALENT CIRCUIT

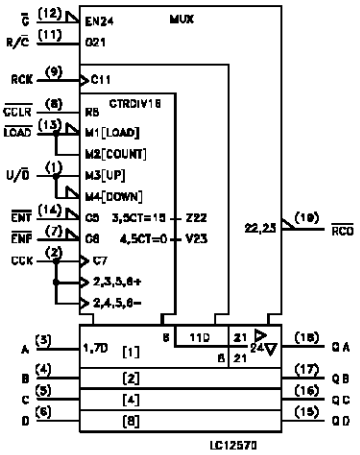


IEC LOGIC SYMBOL

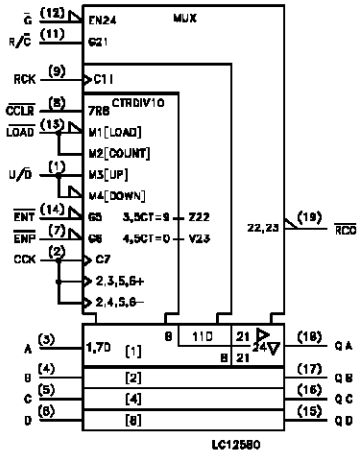
HC696



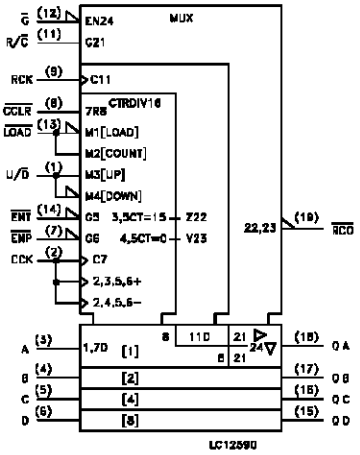
HC697



HC698



HC699



TRUTH TABLE

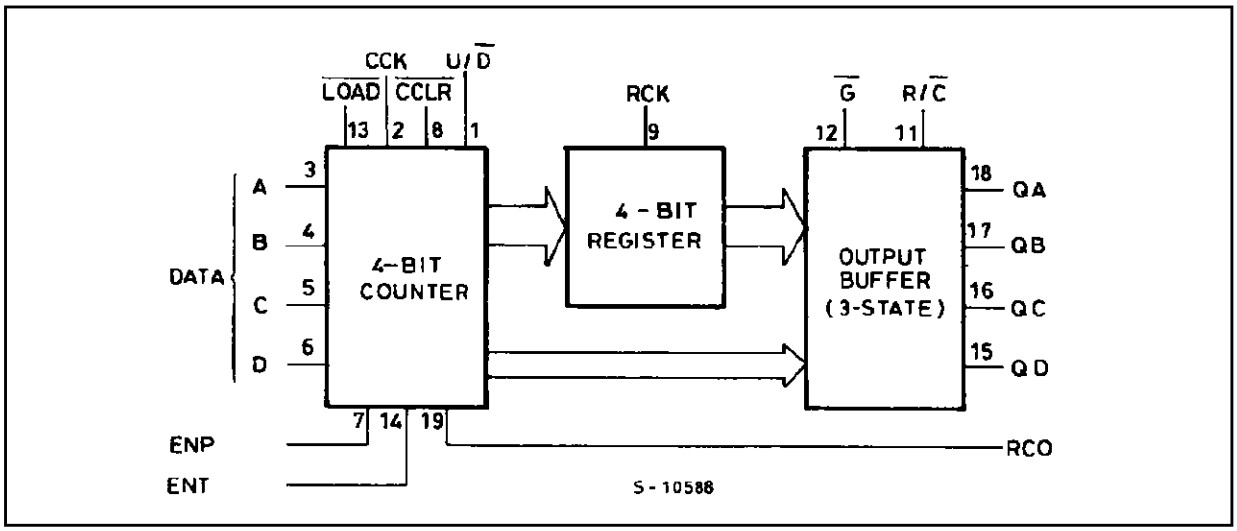
INPUTS									OUTPUTS				FUNCTION
$\overline{CCLR}$	$\overline{LOAD}$	$\overline{ENP}$	$\overline{ENT}$	CCK	U/$\overline{D}$	RCK	R/$\overline{C}$	$\overline{G}$	QA	QB	QC	QD	
X	X	X	X	X	X	X	X	H	Z	Z	Z	Z	HIGH IMPEDANCE
L	X	X	X	X (*)	X	X	L	L	L	L	L	L	CLEAR COUNTER
H	L	X	X	⎍	X	X	L	L	a	b	c	d	LOAD COUNTER
H	H	H	X	⎍	X	X	L	L	NO CHANGE				NO COUNT
H	H	X	H	⎍	X	X	L	L	NO CHANGE				NO COUNT
H	H	L	L	⎍	H	X	L	L	COUNT UP				COUNT UP
H	H	L	L	⎍	L	X	L	L	COUNT DOWN				COUNT DOWN
H	X	X	X	⎎	X	X	L	L	NO CHANGE				NO COUNT
X	X	X	X	X	X	⎍	H	L	a'	b'	c'	d'	LOAD REGISTER
X	X	X	X	X	X	⎎	H	L	NO CHANGE				NO LOAD

(*) : ⎍ For HC698/699
X : Don't care
Z : High impedance
a-d : The level of steady state input at inputs a through D respectively
a'-d' : The level of steady state outputs at internal counter outputs QA' through QD' respectively

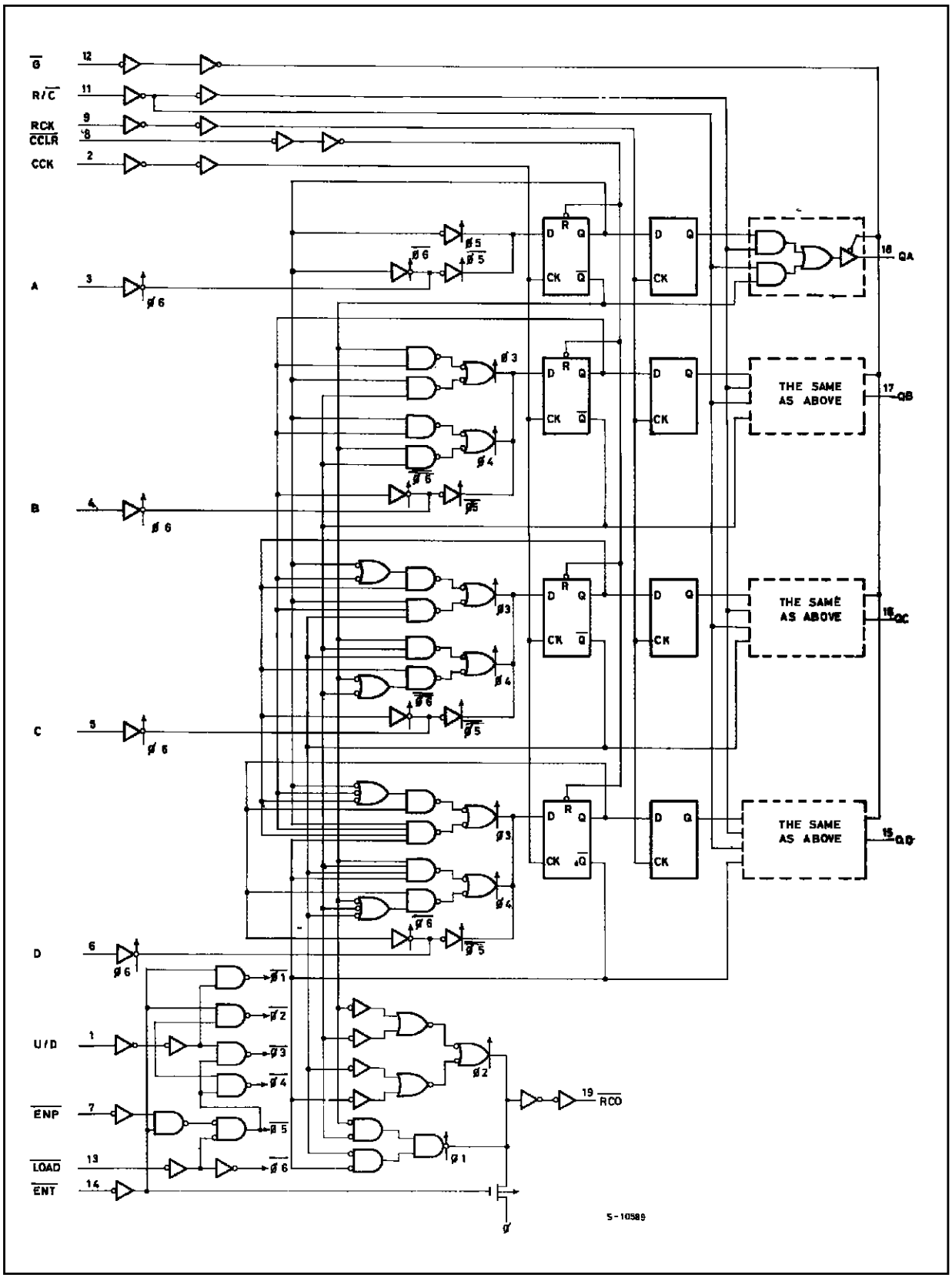
$\overline{RCO}$ function : HC696/8 - $\overline{RCO} = \overline{(UP \bullet QA \bullet QD \bullet ENT + \overline{UP} \bullet \overline{QA} \bullet \overline{QD} \bullet ENT)}$

HC697/9 - $\overline{RCO} = \overline{(UP \bullet QA \bullet QB \bullet QC \bullet QD \bullet ENT + \overline{UP} \bullet \overline{QA} \bullet \overline{QB} \bullet \overline{QC} \bullet \overline{QD} \bullet ENT)}$

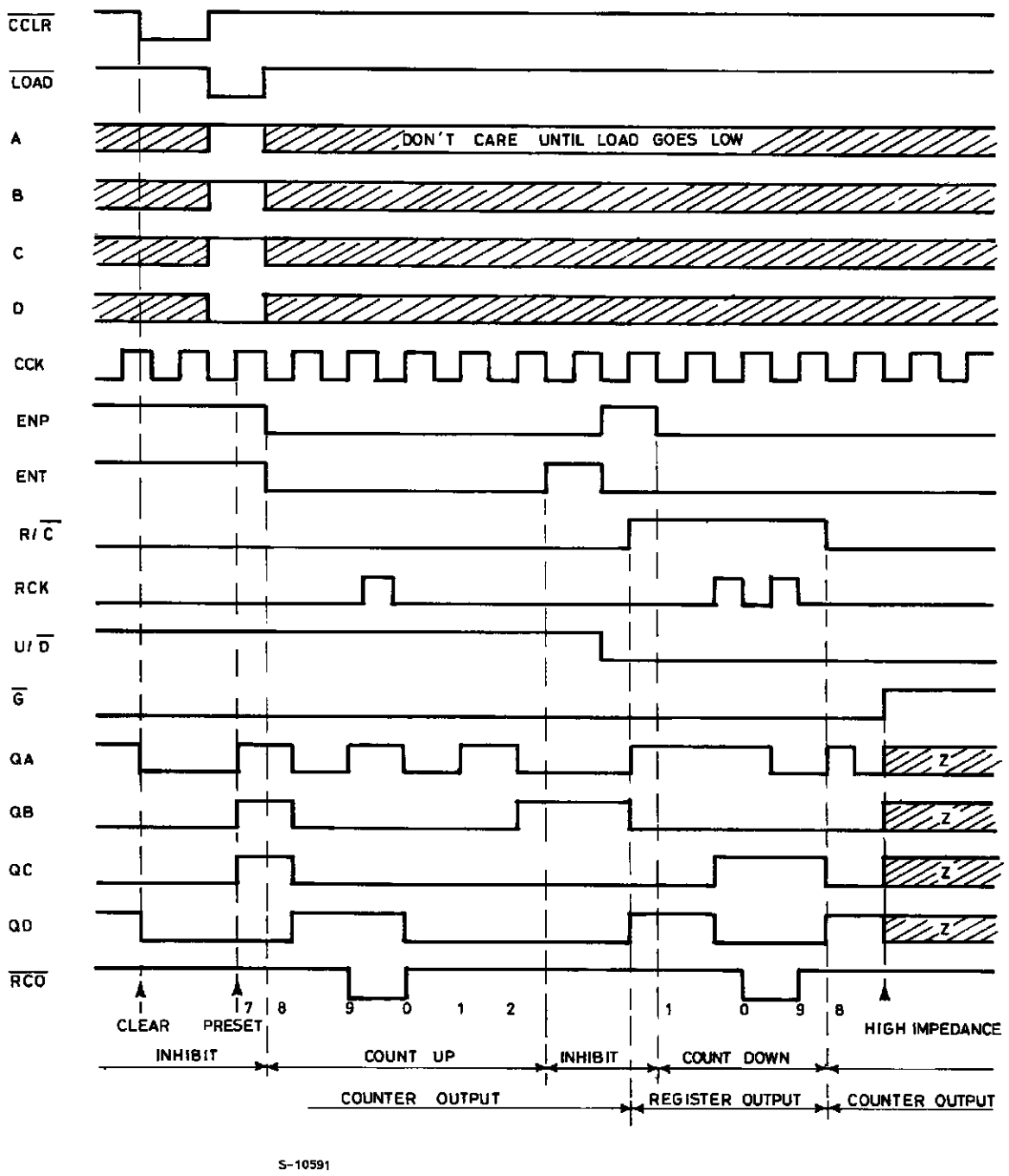
BLOCK DIAGRAM



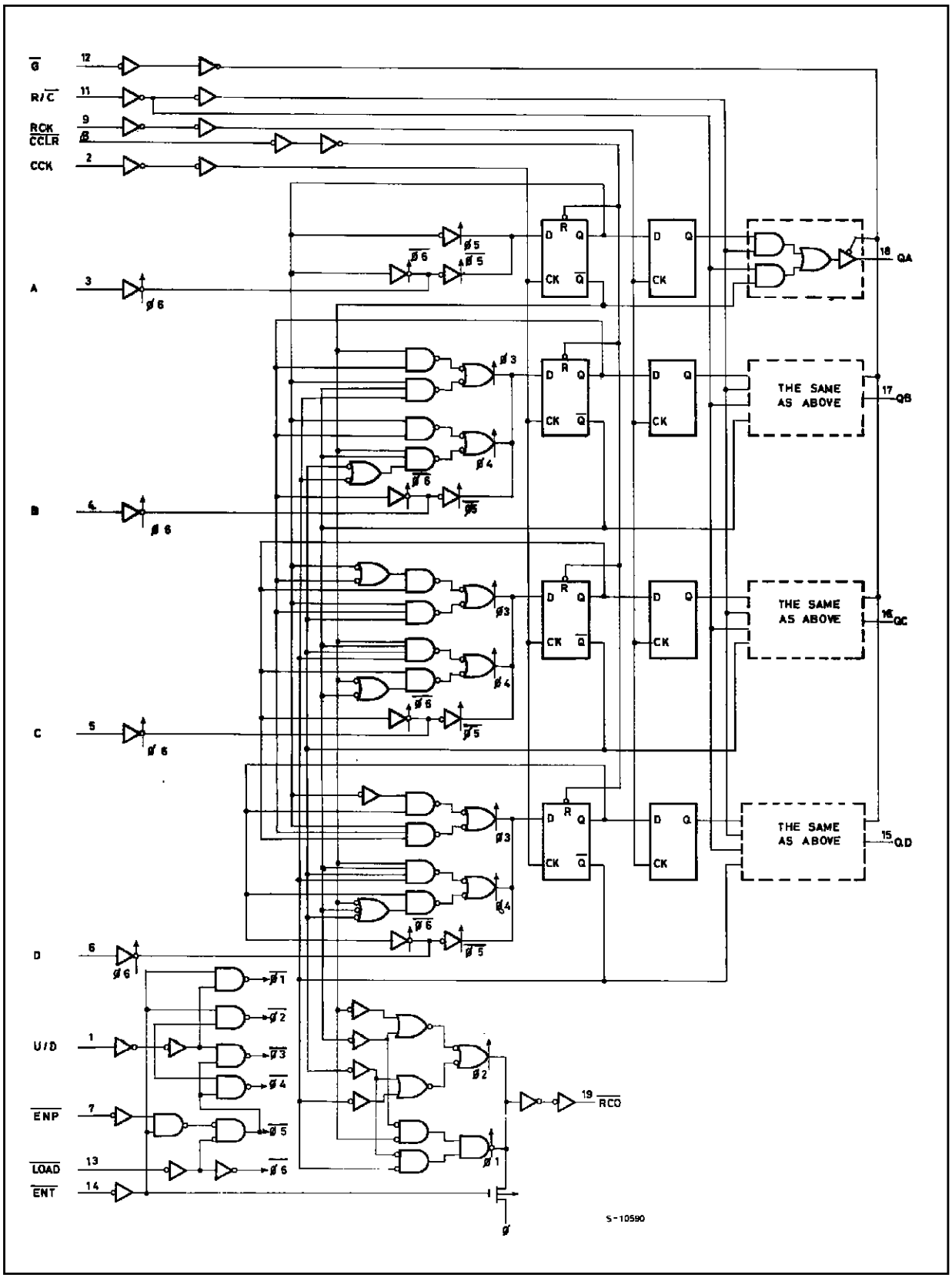
LOGIC DIAGRAM (HC696)



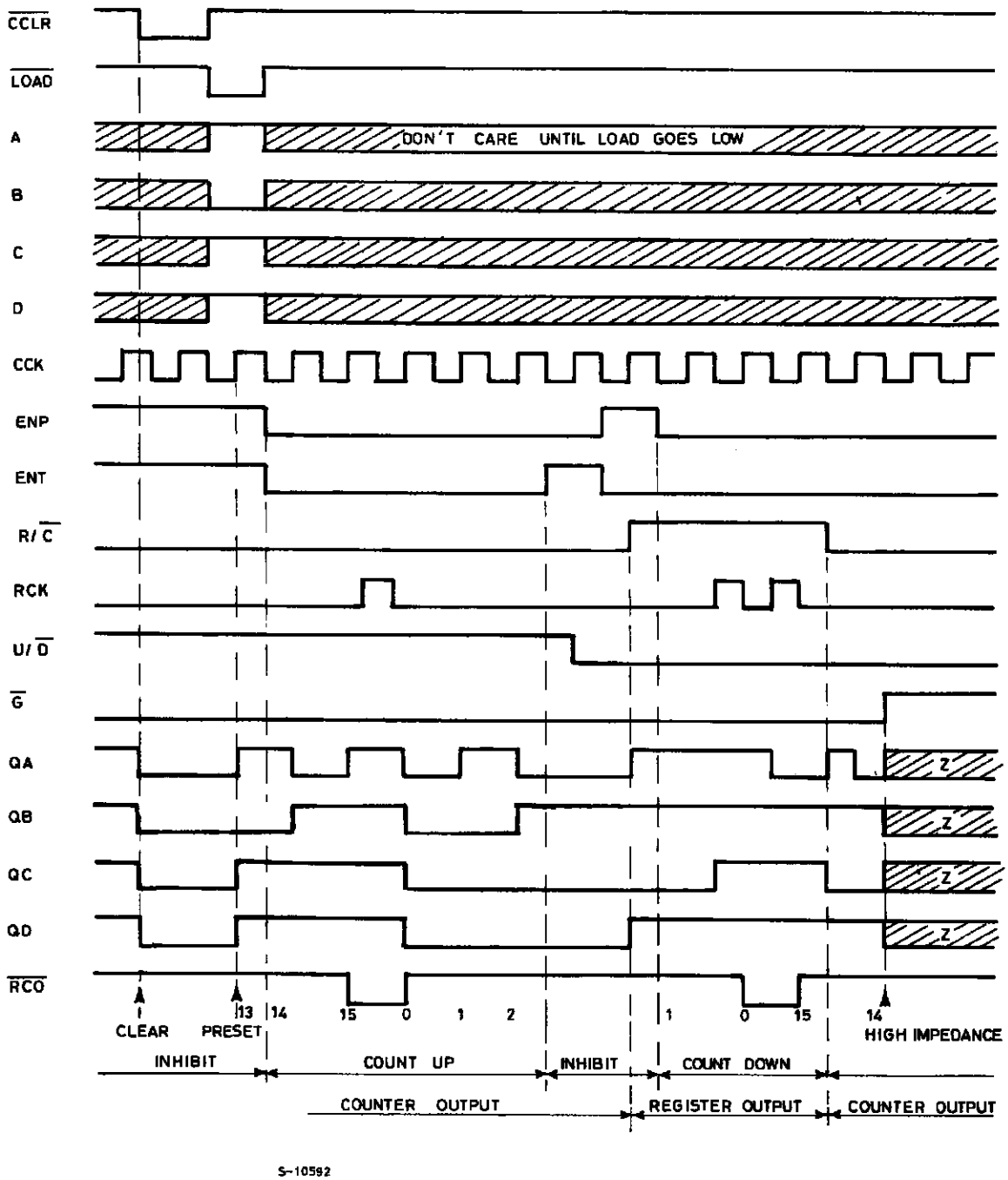
TIMING CHART (HC696)



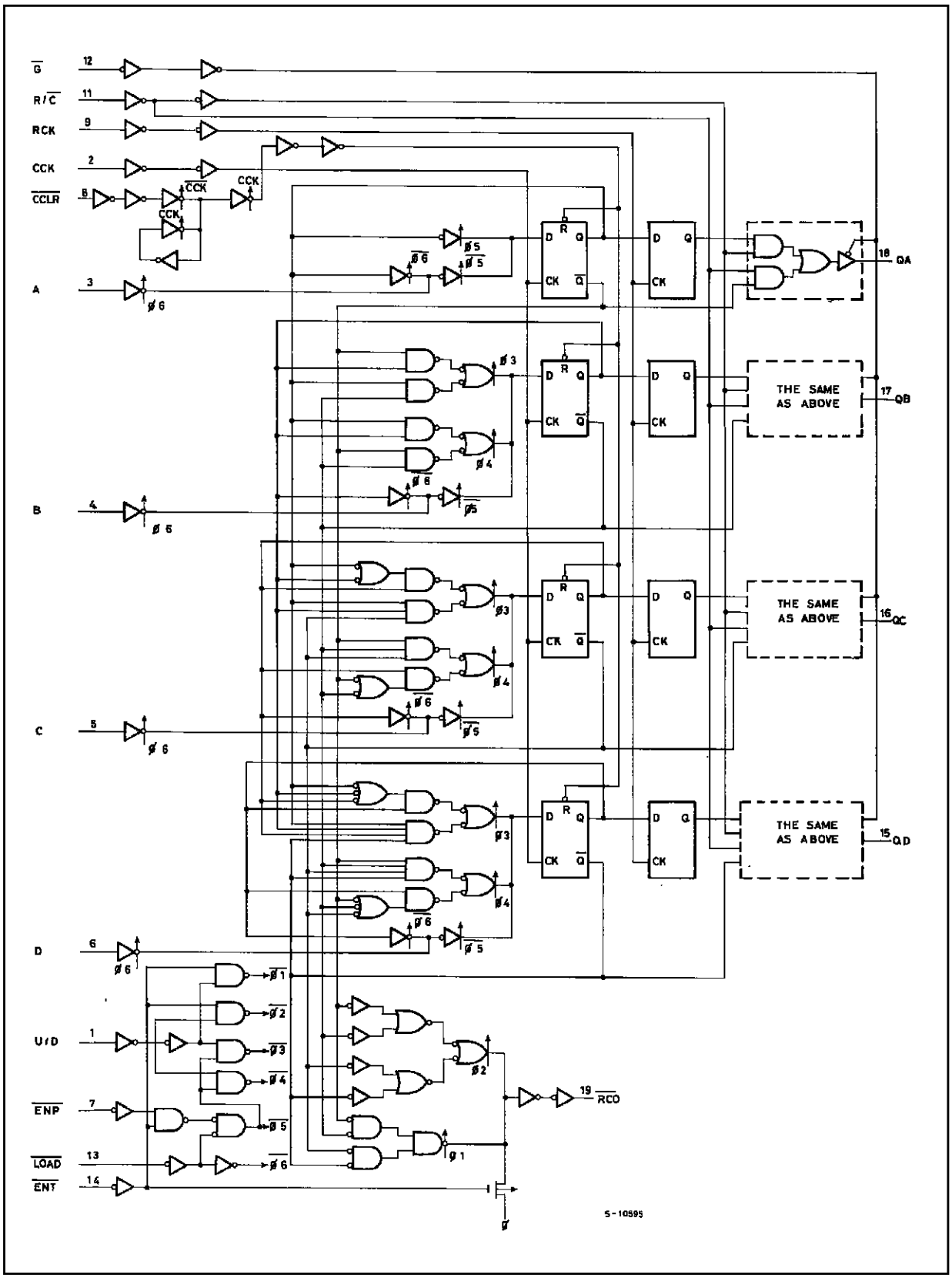
LOGIC DIAGRAM (HC697)



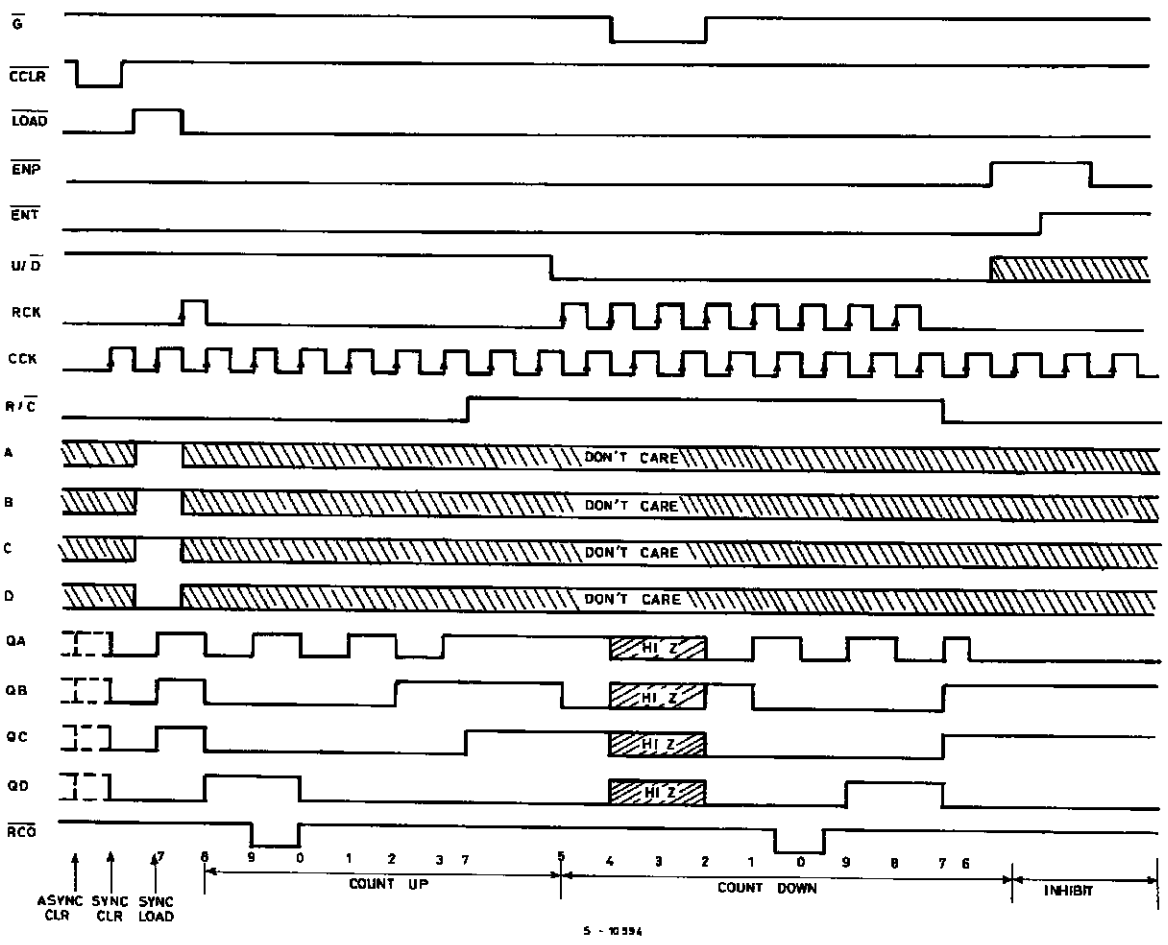
TIMING CHART (HC697)



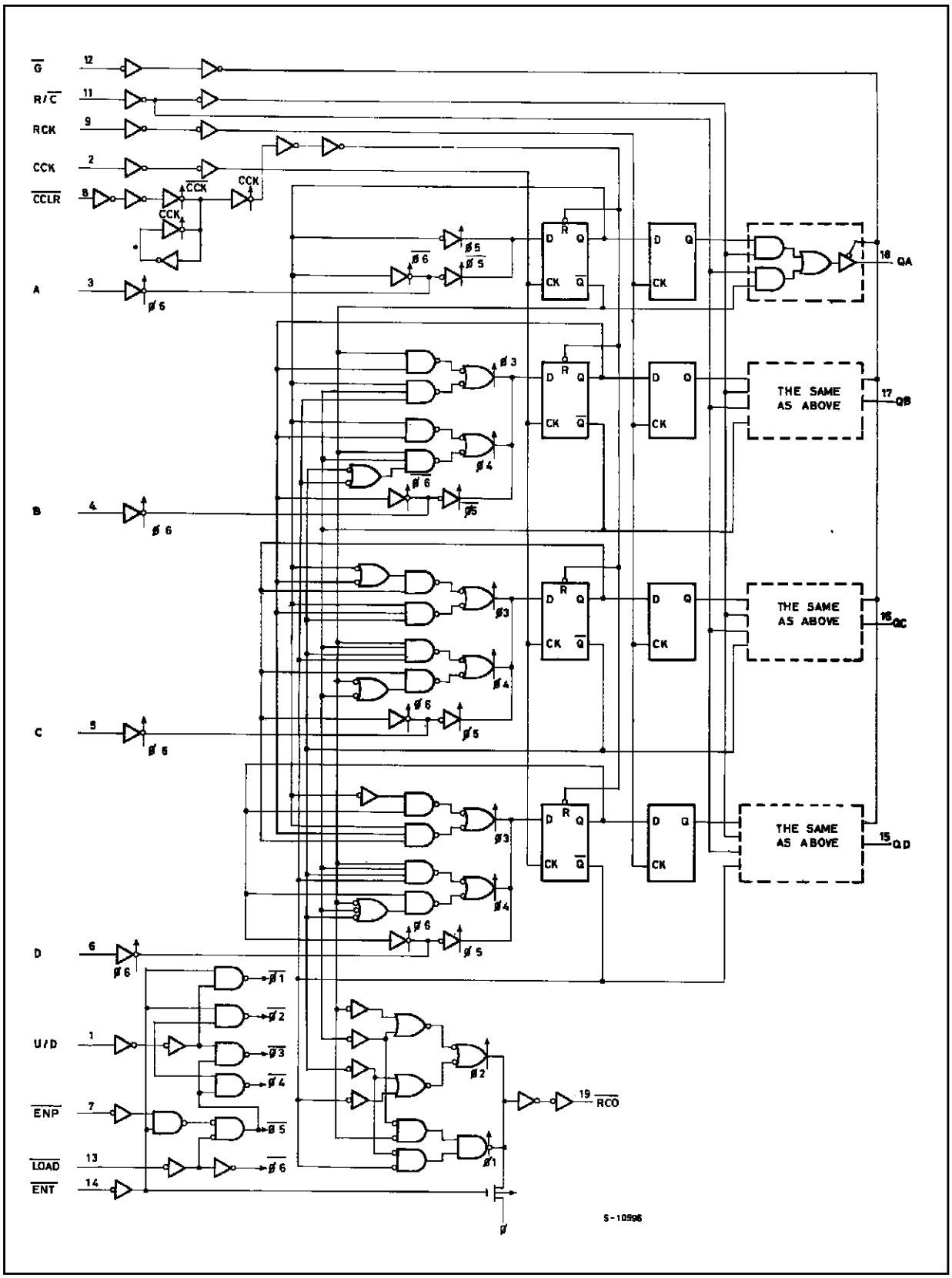
LOGIC DIAGRAM (HC698)



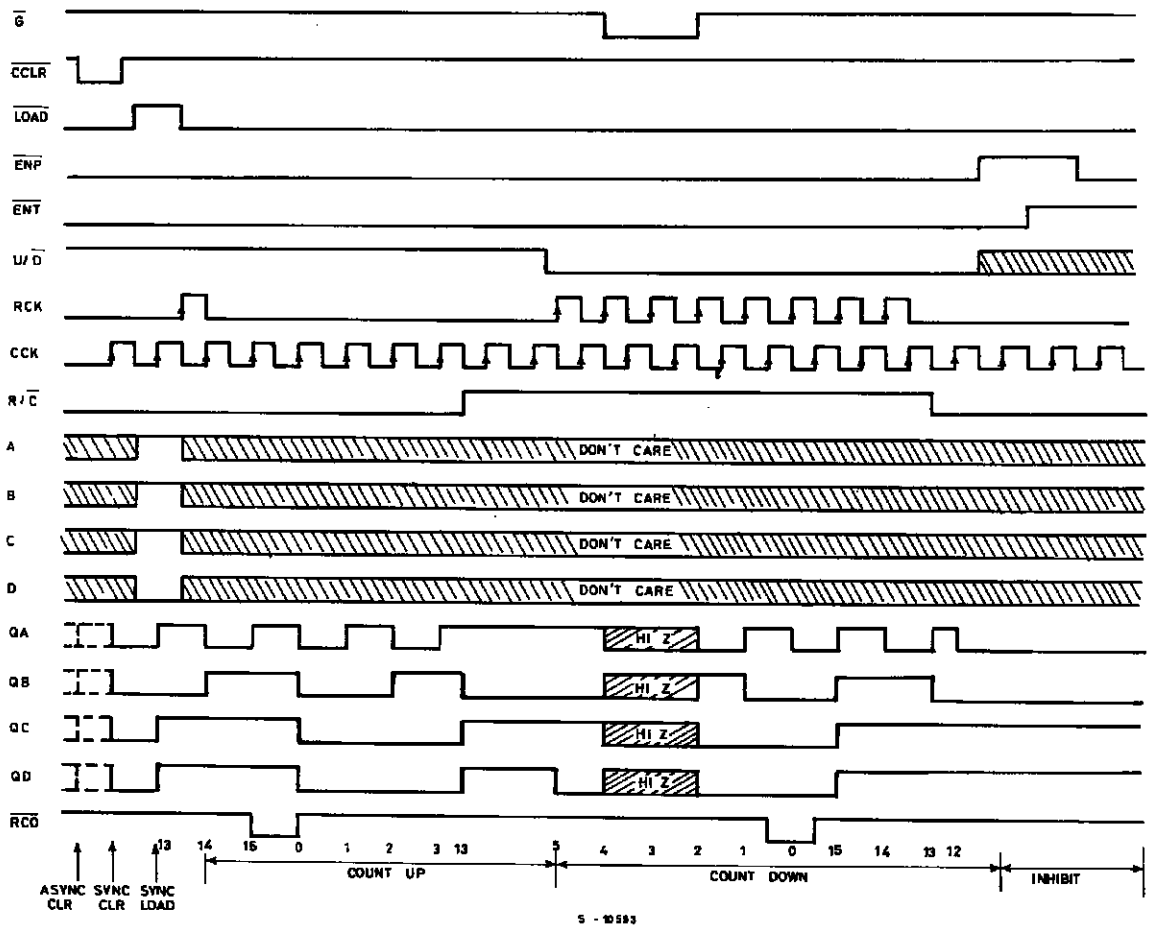
DECADE COUNTER, SYNCHRONOUS CLEAR (HC698)



LOGIC DIAGRAM (HC699)



BINARY COUNTER, SYNCHRONOUS CLEAR (HC699)



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{CC}	Supply Voltage	-0.5 to +7	V
V_I	DC Input Voltage	-0.5 to V_{CC} + 0.5	V
V_O	DC Output Voltage	-0.5 to V_{CC} + 0.5	V
I_{IK}	DC Input Diode Current	± 20	mA
I_{OK}	DC Output Diode Current	± 20	mA
I_O	DC Output Source Sink Current Per Output Pin (RCO) (QA to QD)	± 25 ± 35	mA
I_{CC} or I_{GND}	DC V_{CC} or Ground Current	± 70	mA
P_D	Power Dissipation	500 (*)	mW
T_{stg}	Storage Temperature	-65 to +150	°C
T_L	Lead Temperature (10 sec)	300	°C

Absolute Maximum Ratings are those values beyond which damage to the device may occur. Functional operation under these condition is not implied.
(*) 500 mW: ≅ 65 °C derate to 300 mW by 10mW/°C: 65 °C to 85 °C

RECOMMENDED OPERATING CONDITIONS

Symbol	Parameter		Value	Unit
V_{CC}	Supply Voltage		2 to 6	V
V_I	Input Voltage		0 to V_{CC}	V
V_O	Output Voltage		0 to V_{CC}	V
T_{op}	Operating Temperature: **M54HC** Series **M74HC** Series		-55 to +125 -40 to +85	°C °C
t_r, t_f	Input Rise and Fall Time	V_{CC} = 2 V	0 to 1000	ns
		V_{CC} = 4.5 V	0 to 500	
		V_{CC} = 6 V	0 to 400	

DC SPECIFICATIONS

Symbol	Parameter	Test Conditions			Value							Unit
		V_{CC} (V)			T_A = 25 °C 54HC and 74HC			-40 to 85 °C 74HC		-55 to 125 °C 54HC		
					Min.	Typ.	Max.	Min.	Max.	Min.	Max.	
V_{IH}	High Level Input Voltage	2.0			1.5			1.5		1.5		V
		4.5			3.15			3.15		3.15		
		6.0			4.2			4.2		4.2		
V_{IL}	Low Level Input Voltage	2.0					0.5		0.5		0.5	V
		4.5					1.35		1.35		1.35	
		6.0					1.8		1.8		1.8	
V_{OH}	High Level Output Voltage (RCO)	2.0	V_I = V_{IH} or V_{IL}	I_O=-20 µA	1.9	2.0		1.9		1.9		V
		4.5			4.4	4.5		4.4		4.4		
		6.0			5.9	6.0		5.9		5.9		
		4.5		I_O=-4.0 mA	4.18	4.31		4.13		4.10		
		6.0		I_O=-5.2 mA	5.68	5.8		5.63		5.60		
V_{OH}	High Level Output Voltage (QA - QD)	2.0	V_I = V_{IH} or V_{IL}	I_O=-20 µA	1.9	2.0		1.9		1.9		V
		4.5			4.4	4.5		4.4		4.4		
		6.0			5.9	6.0		5.9		5.9		
		4.5		I_O=-6.0 mA	4.18	4.31		4.13		4.10		
		6.0		I_O=-7.8 mA	5.68	5.8		5.63		5.60		
V_{OL}	Low Level Output Voltage (RCO)	2.0	V_I = V_{IH} or V_{IL}	I_O= 20 µA		0.0	0.1		0.1		0.1	V
		4.5				0.0	0.1		0.1		0.1	
		6.0				0.0	0.1		0.1		0.1	
		4.5		I_O= 4.0 mA		0.17	0.26		0.33		0.40	
		6.0		I_O= 5.2 mA		0.18	0.26		0.33		0.40	
V_{OL}	Low Level Output Voltage (QA - QD)	2.0	V_I = V_{IH} or V_{IL}	I_O= 20 µA		0.0	0.1		0.1		0.1	V
		4.5				0.0	0.1		0.1		0.1	
		6.0				0.0	0.1		0.1		0.1	
		4.5		I_O= 6.0 mA		0.17	0.26		0.33		0.40	
		6.0		I_O= 7.8 mA		0.18	0.26		0.33		0.40	
I_I	Input Leakage Current	6.0	V_I = V_{CC} or GND				±0.1		±1		±1	µA
I_{OZ}	3 State Output Off State Current	6.0	V_I = V_{IH} or V_{IL} V_O = V_{CC} or GND				±0.5		±5		±10	µA
I_{CC}	Quiescent Supply Current	6.0	V_I = V_{CC} or GND				4		40		80	µA

AC ELECTRICAL CHARACTERISTICS (Input $t_r = t_f = 6$ ns)

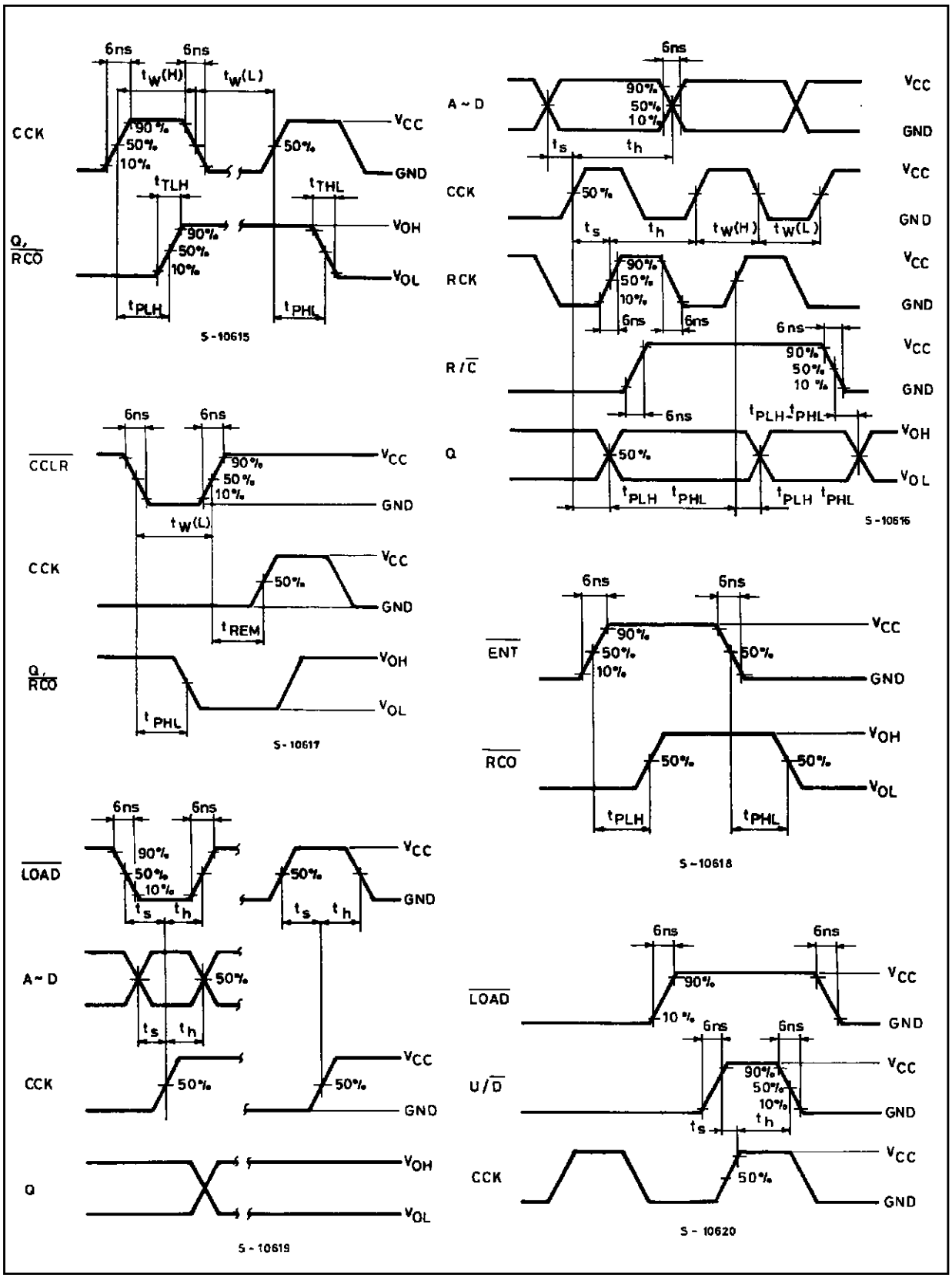
Symbol	Parameter	Test Conditions			Value							Unit
		V_{CC} (V)	C_L (pF)		T_A = 25 °C 54HC and 74HC			-40 to 85 °C 74HC		-55 to 125 °C 54HC		
					Min.	Typ.	Max.	Min.	Max.	Min.	Max.	
t_{TLH} t_{THL}	Output Transition Time (Qn)	2.0	50			25	60		75		90	ns
		4.5				7	12		19		18	
		6.0				6	10		13		15	
t_{TLH} t_{THL}	Output Transition Time ($\overline{RCO}$)	2.0	50			30	75		95		115	ns
		4.5				8	15		19		23	
		6.0				7	13		16		20	
t_{PLH} t_{PHL}	Propagation Delay Time (CCK - Q)	2.0	50			90	215		270		325	ns
		4.5				28	43		54		65	
		6.0				24	37		46		55	
		2.0	150			103	245		305		370	ns
		4.5				32	49		61		74	
		6.0				27	42		52		63	
t_{PLH} t_{PHL}	Propagation Delay Time (RCK - Q)	2.0	50			82	185		230		280	ns
		4.5				24	37		46		56	
		6.0				20	31		39		48	
		2.0	150			95	215		270		325	ns
		4.5				28	43		54		65	
		6.0				24	37		46		55	
t_{PLH} t_{PHL}	Propagation Delay Time (CCK - $\overline{RCO}$)	2.0	50			109	245		305		370	ns
		4.5				32	49		61		74	
		6.0				27	42		52		63	
t_{PLH} t_{PHL}	Propagation Delay Time (R/C - Q)	2.0	50			61	155		195		235	ns
		4.5				20	31		39		47	
		6.0				17	26		33		40	
		2.0	150			73	185		230		280	ns
		4.5				24	37		46		56	
		6.0				20	31		39		48	
t_{PLH} t_{PHL}	Propagation Delay Time (ENT - $\overline{RCO}$)	2.0	50			63	140		175		210	ns
		4.5				18	28		35		42	
		6.0				15	24		30		36	
t_{PLH} t_{PHL}	Propagation Delay Time (CCLR - Q)	2.0	50	for HC696 HC697		78	195		245		295	ns
		4.5				26	39		49		59	
		6.0				22	33		42		50	
		2.0	150			90	235		295		355	ns
		4.5				30	47		59		71	
		6.0				26	40		50		60	
t_{PLH} t_{PHL}	Propagation Delay Time ($\overline{CCLR}$ - $\overline{RCO}$)	2.0	50	for HC696 HC697		98	220		275		330	ns
		4.5				29	44		55		66	
		6.0				25	37		47		56	
f_{MAX}	Maximum Clock Frequency	2.0	50		5	12		4		3.4		MHz
		4.5			25	45		20		17		
		6.0			30	53		24		20		

AC ELECTRICAL CHARACTERISTICS (Continued)

Symbol	Parameter	Test Conditions			Value							Unit
		V_{CC} (V)	C_L (pF)		T_A = 25 °C 54HC and 74HC			-40 to 85 °C 74HC		-55 to 125 °C 54HC		
					Min.	Typ.	Max.	Min.	Max.	Min.	Max.	
t_{PZL} t_{PZH}	Output Enable Time	2.0	50	R_L = 1KΩ		45	120		150		180	ns
		4.5				15	24		30		36	
		6.0				13	20		26		31	
		2.0	150	R_L = 1KΩ		57	150		190		225	ns
		4.5				19	30		38		45	
		6.0				16	26		32		38	
t_{PLZ} t_{PHZ}	Output Disable Time	2.0	50	R_L = 1KΩ		32	115		145		175	ns
		4.5				17	23		29		35	
		6.0				14	20		25		30	
$t_{W(H)}$ $t_{W(L)}$	Minimum Pulse Width (CCK, RCK)	2.0	50			40	75		95		110	ns
		4.5				8	15		19		22	
		6.0				7	13		16		19	
$t_{W(L)}$	Minimum Pulse Width $\overline{(CCLR)}$	2.0	50	for HC696 HC697		40	75		95		110	ns
		4.5				8	15		19		22	
		6.0				7	13		16		19	
t_s	Minimum Set-up Time $\overline{(CCLR)}$	2.0	50	for HC698 HC699		16	50		65		75	ns
		4.5				4	10		13		15	
		6.0				3	9		11		13	
t_s	Minimum Set-up Time (LOAD, ENT, ENP)	2.0	50			64	150		190		220	ns
		4.5				16	30		38		44	
		6.0				14	26		32		37	
t_s	Minimum Set-up Time (A, B, C, D)	2.0	50			16	50		65		75	ns
		4.5				4	10		13		15	
		6.0				3	9		11		13	
t_s	Minimum Set-up Time (CCK, RCK)	2.0	50			44	100		125		150	ns
		4.5				11	20		25		30	
		6.0				9	17		21		26	
t_s	Minimum Set-up Time $\overline{(U/D)}$	2.0	50			44	100		125		145	ns
		4.5				11	20		25		29	
		6.0				9	17		21		25	
t_h	Minimum Hold Time	2.0	50				5		5		5	ns
		4.5					5		5		5	
		6.0					5		5		5	
t_{REM}	Minimum Removal Time	2.0	50	for HC696 HC697			5		5		5	ns
		4.5					5		5		5	
		6.0					5		5		5	
C_{IN}	Input Capacitance					5	10		10		10	pF
C_{PD} (*)	Power Dissipation Capacitance		HC696/697/699 HC698			71 77						pF

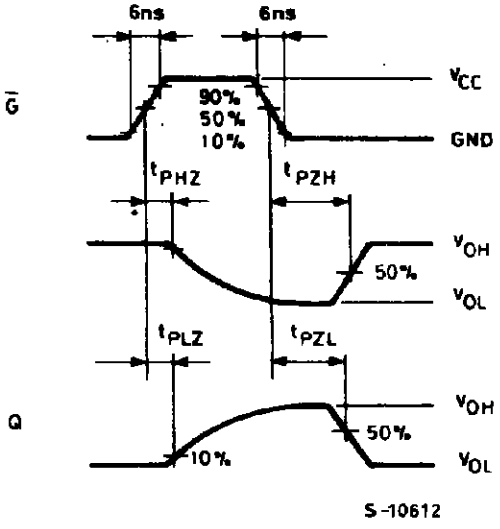
(*) C_{PD} is defined as the value of the IC's internal equivalent capacitance which is calculated from the operating current consumption without load. (Refer to Test Circuit). Average operting current can be obtained by the following equation. $I_{CC}(opr) = C_{PD} \bullet V_{CC} \bullet f_{IN} + I_{CC}/2$ (per circuit)

SWITCHING CHARACTERISTICS TEST WAVEFORM (HC696/697)

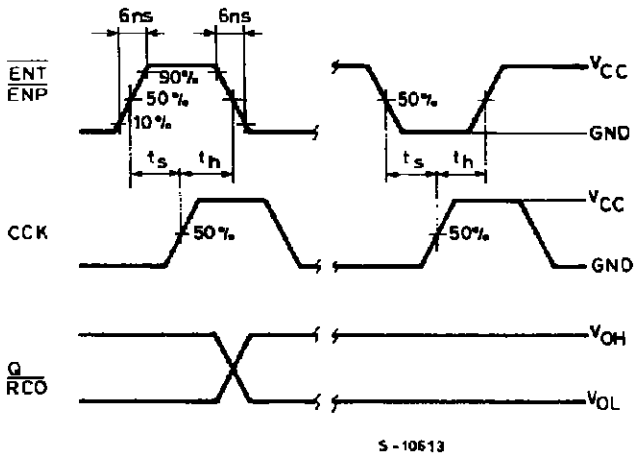


SWITCHING CHARACTERISTICS TEST WAVEFORM (continued)

OUTPUT DISABLE, ENABLE

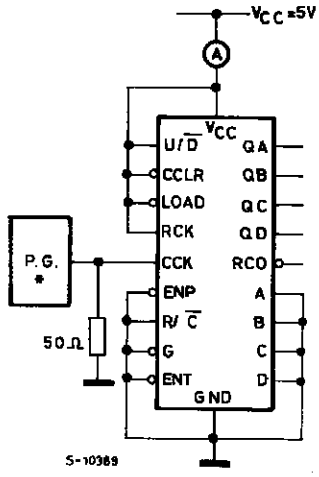


S-10612



S-10613

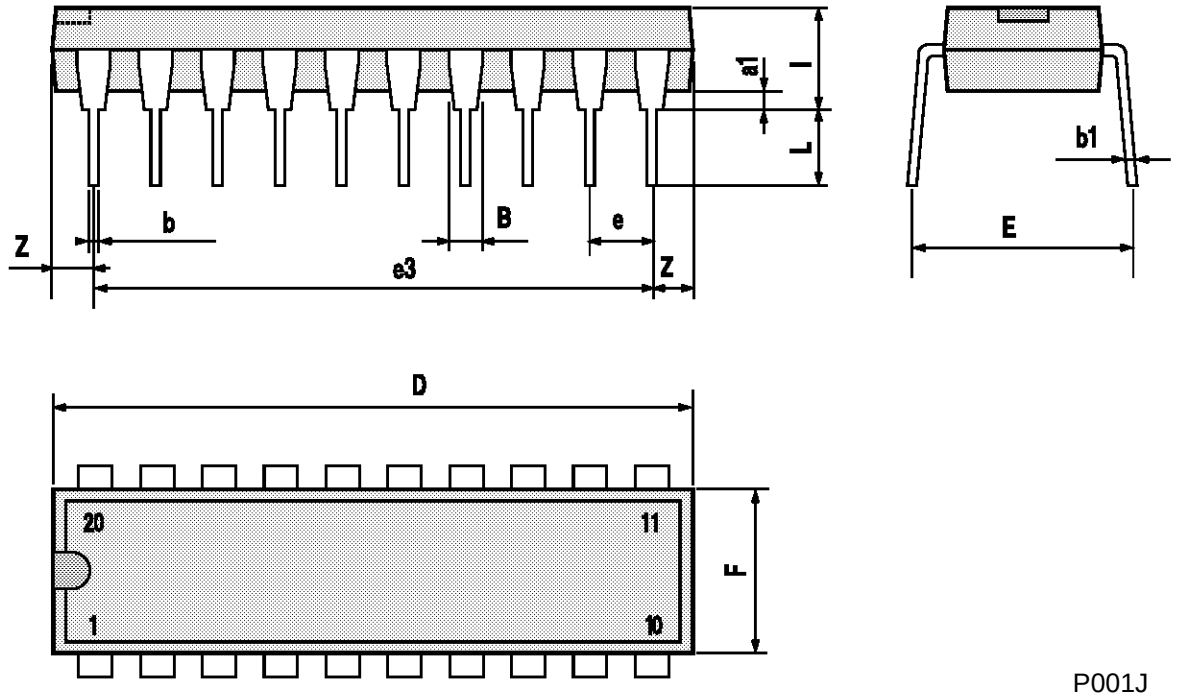
TEST CIRCUIT I_{CC} (Opr.)



S-10389

Plastic DIP20 (0.25) MECHANICAL DATA

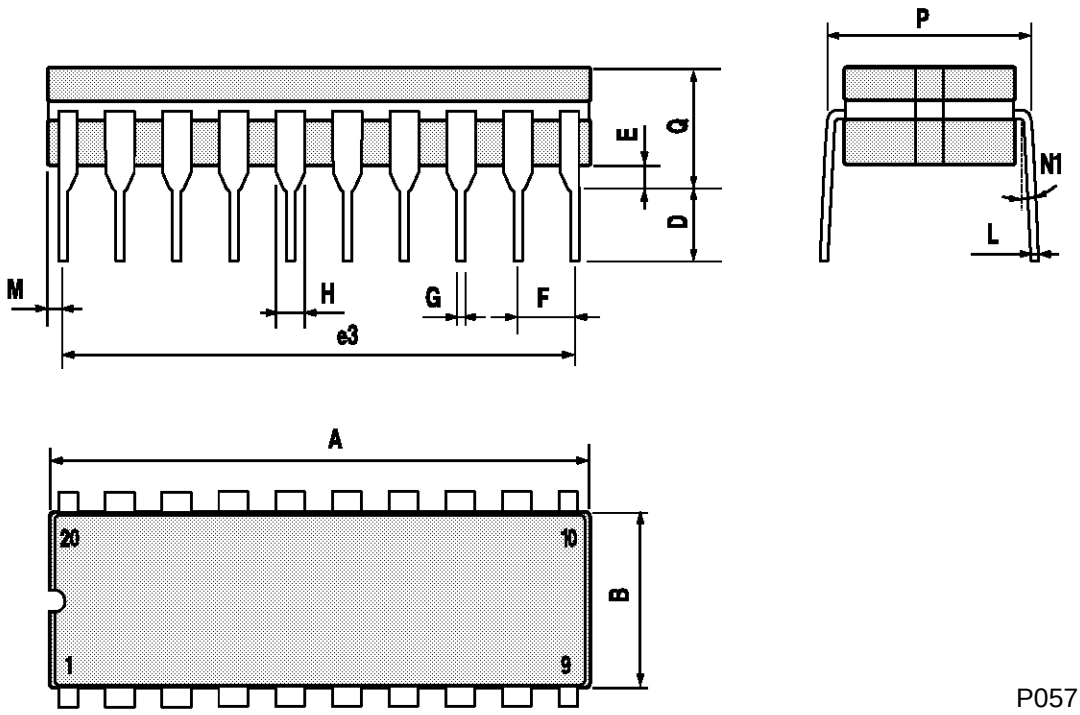
DIM.	mm			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
a1	0.254			0.010		
B	1.39		1.65	0.055		0.065
b		0.45			0.018	
b1		0.25			0.010	
D			25.4			1.000
E		8.5			0.335	
e		2.54			0.100	
e3		22.86			0.900	
F			7.1			0.280
I			3.93			0.155
L		3.3			0.130	
Z			1.34			0.053



P001J

Ceramic DIP20 MECHANICAL DATA

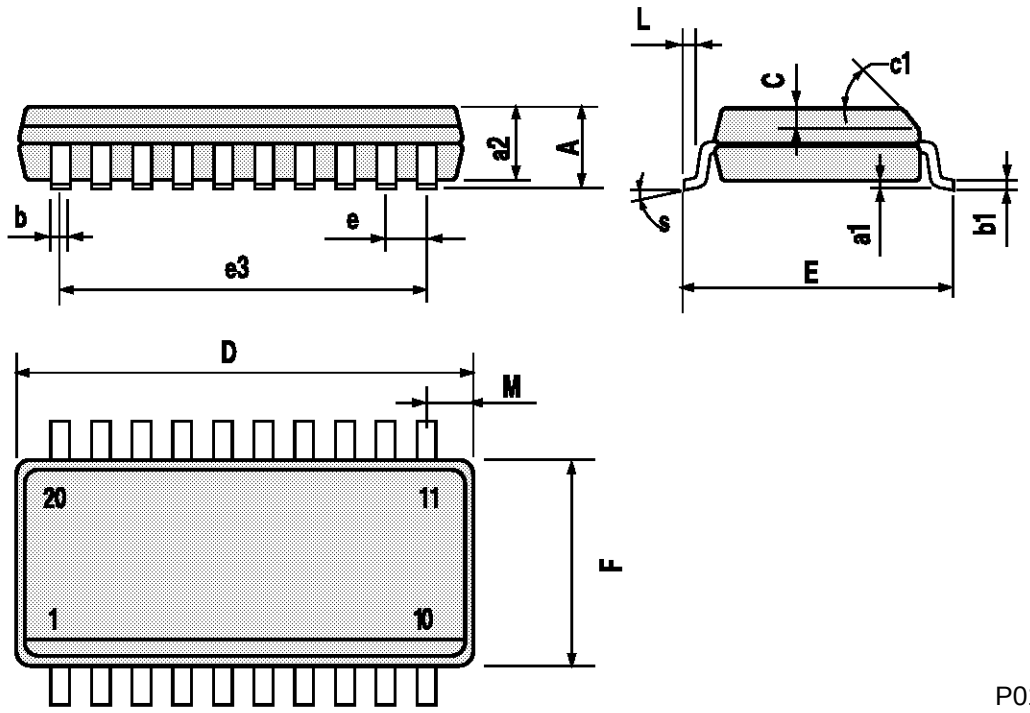
DIM.	mm			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A			25			0.984
B			7.8			0.307
D		3.3			0.130	
E	0.5		1.78	0.020		0.070
e3		22.86			0.900	
F	2.29		2.79	0.090		0.110
G	0.4		0.55	0.016		0.022
I	1.27		1.52	0.050		0.060
L	0.22		0.31	0.009		0.012
M	0.51		1.27	0.020		0.050
N1	4° (min.), 15° (max.)					
P	7.9		8.13	0.311		0.320
Q			5.71			0.225



P057H

SO20 MECHANICAL DATA

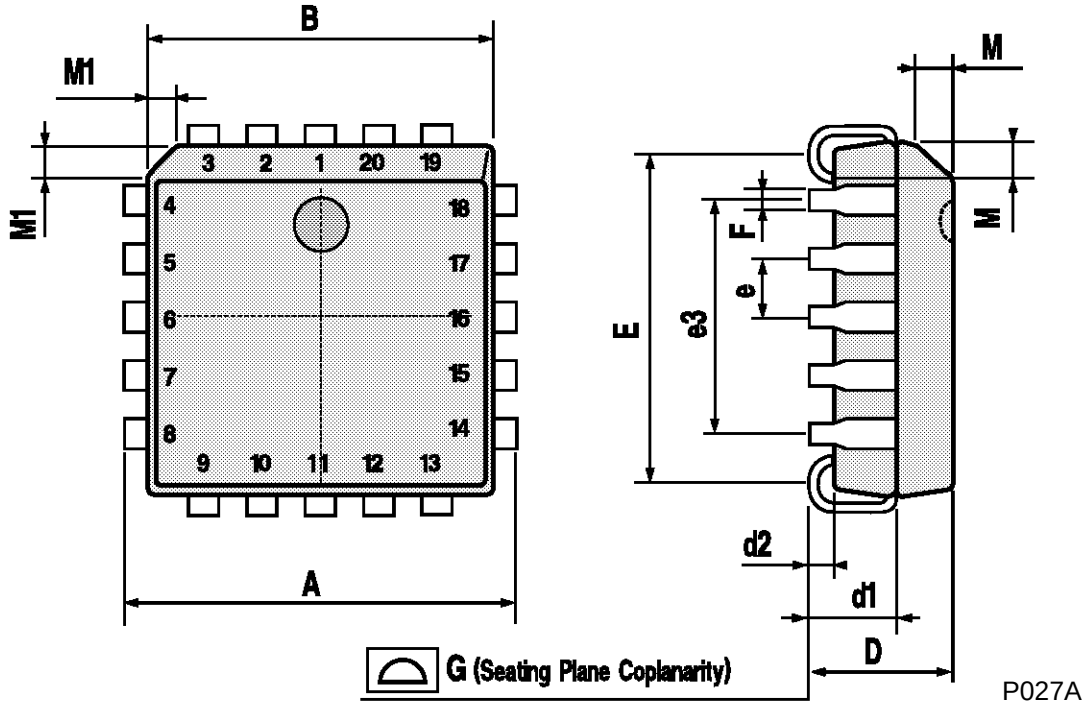
DIM.	mm			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A			2.65			0.104
a1	0.10		0.20	0.004		0.007
a2			2.45			0.096
b	0.35		0.49	0.013		0.019
b1	0.23		0.32	0.009		0.012
C		0.50			0.020	
c1	45° (typ.)					
D	12.60		13.00	0.496		0.512
E	10.00		10.65	0.393		0.419
e		1.27			0.050	
e3		11.43			0.450	
F	7.40		7.60	0.291		0.299
L	0.50		1.27	0.19		0.050
M			0.75			0.029
S	8° (max.)					



P013L

PLCC20 MECHANICAL DATA

DIM.	mm			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A	9.78		10.03	0.385		0.395
B	8.89		9.04	0.350		0.356
D	4.2		4.57	0.165		0.180
d1		2.54			0.100	
d2		0.56			0.022	
E	7.37		8.38	0.290		0.330
e		1.27			0.050	
e3		5.08			0.200	
F		0.38			0.015	
G			0.101			0.004
M		1.27			0.050	
M1		1.14			0.045	



P027A