MOTOROLA

Military 54LS161A

4-Bit Up/Down Counter (with Asynchronous Clear)

ELECTRICALLY TESTED PER:
MIL-M-38510/31504

The 'LS161A is a high-speed 4-bit synchronous counter. It is edge-triggered, synchronously presettable, and cascadable with MSI building blocks for counting, memory addressing, frequency division and other applications. The 'LS161A can count modulo 10 (BCD).

The 'LS161A has an asynchronous Master Reset (Clear) input that overrides, and is independent of the clock and all other control inputs.

- Synchronous Counting and Loading
- Two Count Enable Inputs For High-Speed Synchronous Expansion
- Terminal Count Fully Decoded
- Typical Count Rate of 35 MHz

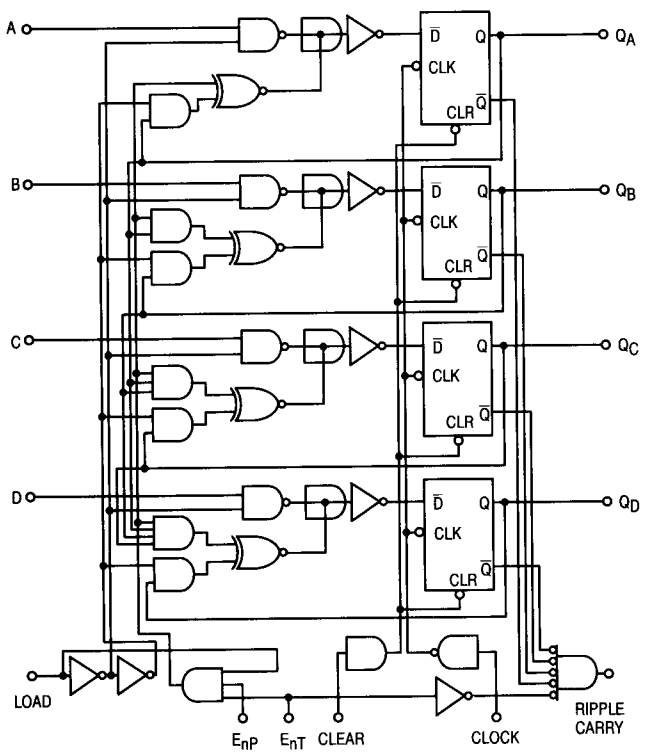
AVAILABLE AS:

1) JAN: JM38510/31504BXA
2) SMD: 7600801
3) 883: 54LS161A/BXAJC

X = CASE OUTLINE AS FOLLOWS:
PACKAGE: CERDIP: E
CERFLAT: F
LCC: 2

THE LETTER "M" APPEARS BEFORE THE / ON LCC.

LOGIC DIAGRAM



PIN ASSIGNMENTS

FUNCT.	DIL 620-09	FLATS 650-05	LCC 756A-02	BURN-IN (COND. A)
CLR	1	1	2	GND
CLK	2	2	3	V_{CC}
A	3	3	4	V_{CC}
B	4	4	5	V_{CC}
C	5	5	7	V_{CC}
D	6	6	8	V_{CC}
E_{nP}	7	7	9	V_{CC}
GND	8	8	10	GND
Ld	9	9	12	V_{CC}
E_{nT}	10	10	13	V_{CC}
Q_D	11	11	14	OPEN
Q_C	12	12	15	OPEN
Q_B	13	13	17	OPEN
Q_A	14	14	18	OPEN
RC	15	15	19	OPEN
V_{CC}	16	16	20	V_{CC}

BURN-IN CONDITIONS:
V_{CC} = 5.0 V MIN/6.0 V MAX

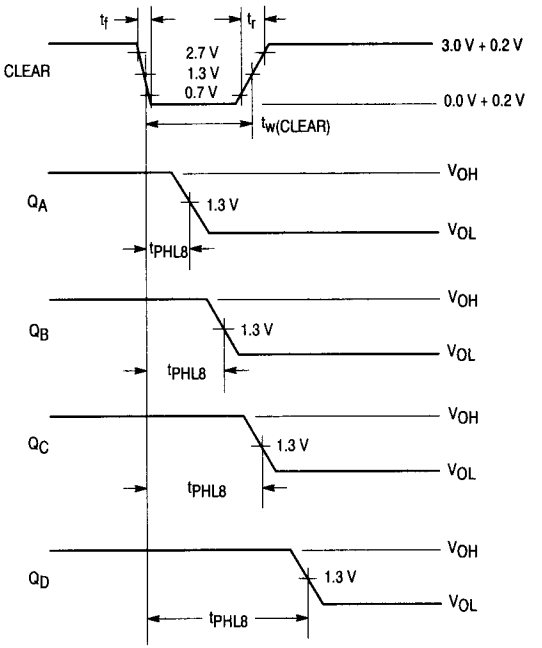
MODE SELECT TABLE

Ld	E_{nT}	E_{nP}	Action on the Rising Clock Edge (⌐)
X	X	X	Reset (Clear)
L	X	X	Load (D_n-Q_n)
H	H	H	Count (Increment)
H	L	X	No Change (Hold)
H	X	L	No Change (Hold)

H = HIGH Voltage Level
L = LOW Voltage Level
X = Don't Care

5

VOLTAGE WAVEFORM 1



NOTE:
The Clear pulse generator has the following characteristics:
V_{gen} = 3.0 V, $t_r \leq 15$ ns, $t_f \leq 6.0$ ns, $t_{w(Clear)}$ = 20 ns.

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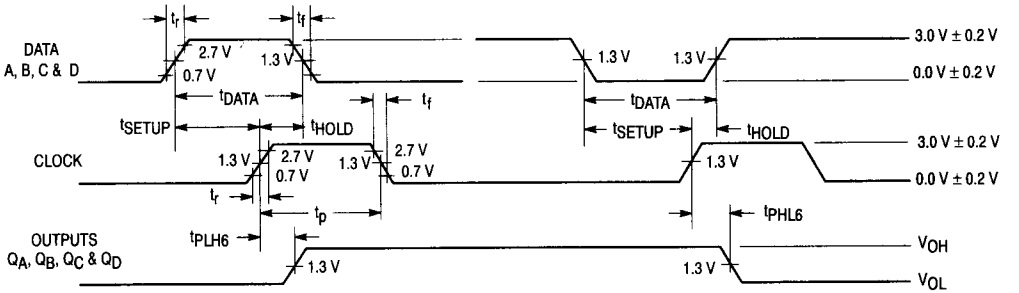
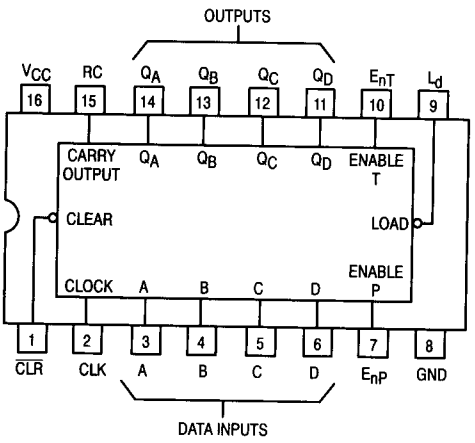
VOLTAGE WAVEFORM 2



NOTE:
The data pulse generator has the following characteristics:
V_{gen} = 3.0 V, $t_r \leq 15$ ns, $t_f \leq 6.0$ ns, t_{DATA} = 30 ns, t_{SETUP} = 20 ns,
t_{HOLD} = 10 ns.

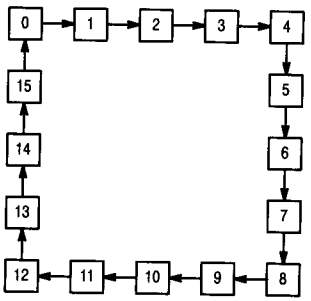
CONNECTION DIAGRAM



Pin Names		Loading (Note b)	
		HIGH	LOW
Load	Parallel Enable (Active LOW)	1.0 U.L.	0.5 U.L.
A-D	Parallel Inputs (Data Inputs)	0.5 U.L.	0.25 U.L.
E_{nP}	Count Enable Parallel Input	0.5 U.L.	0.25 U.L.
E_{nT}	Count Enable Trickle Input	1.0 U.L.	0.5 U.L.
CLK	Clock (Active HIGH Going Edge) Input	0.5 U.L.	0.25 U.L.
$\overline{CLR}$	Master Reset (Active LOW) Input	1.0 U.L.	0.25 U.L.
Q_A-Q_D	Parallel Outputs (Note b)	10 U.L.	5(2.5) U.L.
RC	Terminal Count (Ripple Carry) Output (Note b)	10 U.L.	5(2.5) U.L.

NOTES:
a. One TTL Unit Load (U.L.) = 40 µA HIGH/1.6 mA LOW.
b. The Output LOW drive factor is 2.5 U.L. for Military (54) Temperature Ranges.

STATE DIAGRAM



LOGIC EQUATIONS
Count Enable = $E_{nP} \bullet E_{nT} \bullet Ld$
RC for 'LS161A = $E_{nT} \bullet Q_A \bullet Q_B \bullet Q_C \bullet Q_D$
Preset = $\overline{Ld} \bullet$ CLK + (rising clock edge)
Reset = $\overline{CLR}$

5

FUNCTIONAL DESCRIPTION

The 'LS161A is a 4-bit synchronous counter with a synchronous Parallel Enable (Load) feature. The counter consists of four edge-triggered D flip-flops with the appropriate data routing networks feeding the D inputs. All changes of the Q outputs occur as a result of, and synchronous with, the LOW to HIGH transition of the Clock input (CLK). As long as the set-up time requirements are met, there are no special timing or activity constraints on any of the mode control or data inputs.

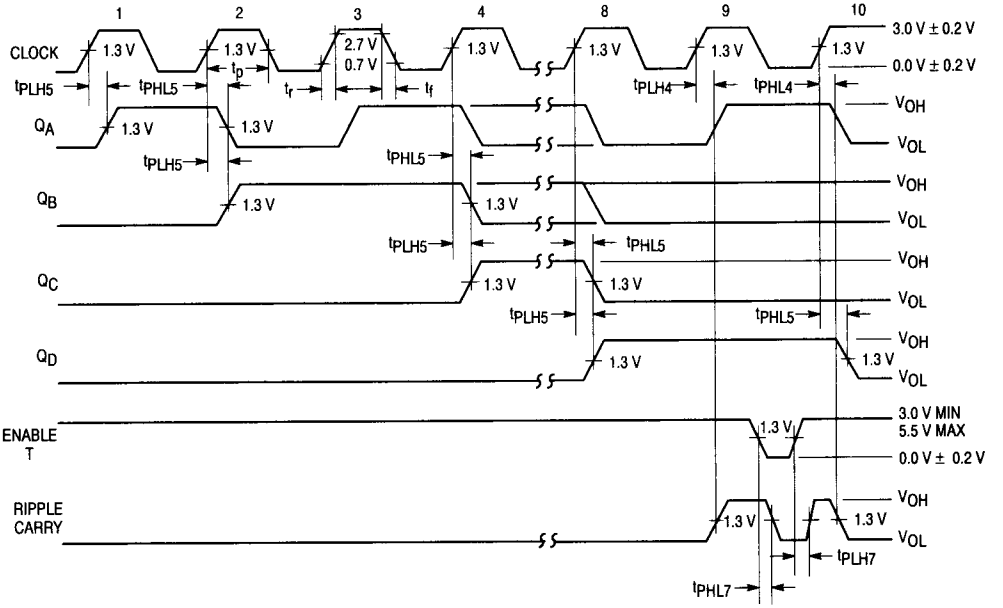
Three control inputs – Parallel Enable (Ld), Count Enable Parallel (E_{nP}) and Count Enable Trickle (E_{nT}) – select the mode of operation as shown in the table below. The Count Mode is enabled when the E_{nP}, E_{nT}, and $\overline{Ld}$ inputs are HIGH. When the $\overline{Ld}$ is LOW, the counters will synchronously load the data from the parallel inputs into the flip-flops on the LOW to HIGH transition of the clock. Either the E_{nP} or E_{nT} can be used to inhibit the count sequence. With the $\overline{Ld}$ held HIGH, a LOW on either the E_{nP} or E_{nT} inputs at least one set-up time prior to the LOW to HIGH clock transition will cause the existing output states to be retained. The AND feature of the two Count Enable inputs ($E_{nP} \bullet E_{nT}$) allows synchronous cascading without external gating and without delay accumulation over any practical number of bits or digits.

The Terminal Count (RC) output is HIGH when the Counter Enable Trickle (E_{nT}) input is HIGH while the counter is in its maximum count state (HLLH for BCD counters, HHHH for Binary counters). Note that RC is fully decoded and will, therefore, be HIGH only for one count state.

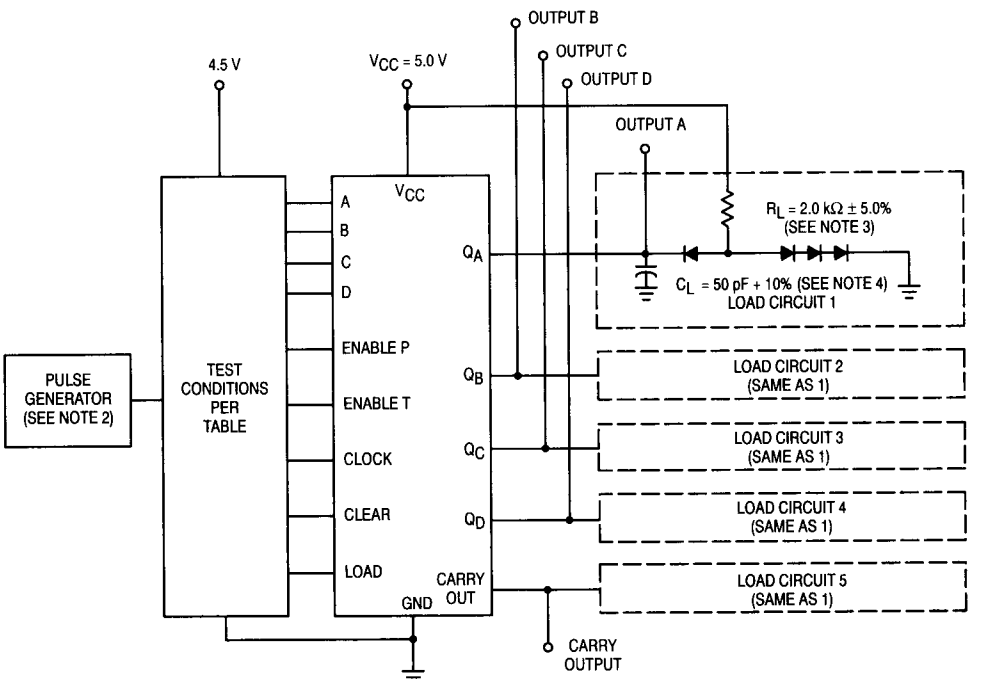
The 'LS161A can count modulo 16 following a binary sequence. It can generate an RC when the E_{nT} input is HIGH while the counter is in the state 15 (HHHH). From this state it can increment to state 0 (LLLL).

The Master Reset ($\overline{MR}$) of the 'LS161A is asynchronous. When the $\overline{MR}$ is LOW, it overrides all other input conditions and sets the outputs LOW. The $\overline{MR}$ pin shoud never be left open. If not used, the $\overline{MR}$ pin should be tied through a resistor to V_{CC} or to a gate output which is permanently set to a HIGH logic level.

VOLTAGE WAVEFORM 3



TEST CIRCUIT



REFERENCE NOTES ON PAGE 5-186

Symbol	Parameter	Limits						Unit	Test Condition (Unless Otherwise Specified)
	Static Parameters:	+ 25°C		+ 125°C		− 55°C			
		Subgroup 1		Subgroup 2		Subgroup 3			
		Min	Max	Min	Max	Min	Max		
V_{OH}	Logical "1" Output Voltage	2.5		2.5		2.5		V	V_{CC} = 4.5 V, I_{OH} = −0.4 mA, CR = 4.5 V, E_{nP} = open, CLK = (See Note 7), V_{IH} = 2.0 V, E_{nT} = 2.0 V, Ld = GND.
V_{OL}	Logical "0" Output Voltage		0.4		0.4		0.4	V	V_{CC} = 4.5 V, I_{OL} = 4.0 mA, V_{IL} = 0.7 V, Ld = GND, CLK = (See Note 7), CR = 4.5 V, E_{nP} = open, E_{nT} = 0.7 V.
V_{IC}	Input Clamping Voltage		−1.5					V	V_{CC} = 4.5 V, I_{IN} = −18 mA, other inputs are open.
I_{IH}	Logical "1" Input Current		20		20		20	µA	V_{CC} = 5.5 V, V_{IH} = 2.7 V, (other inputs are open).
I_{IH}	Logical "1" Input Current		40		40		40	µA	V_{CC} = 5.5 V, V_{IH} = 2.7 V (other inputs are open), (CLK, E_{nT} & Ld) are open.
I_{IHH}	Logical "1" Input Current		100		100		100	µA	V_{CC} = 5.5 V, V_{IHH} = 5.5 V (other inputs are open), (CLK, E_{nT} & Ld) are open.
I_{IHH}	Logical "1" Input Current		200		200		200	µA	V_{CC} = 5.5 V, V_{IHH} = 5.5 V (other inputs are open).
I_{IL}	Logical "0" Input Current	−150	−380	−150	−380	−150	−380	µA	V_{CC} = 5.5 V, V_{IN} = 0.4 V, Ld/E_{nT} = 4.5 V (other inputs are open).
I_{ILL}	Logical "0" Input Current	0	−100	0	−100	0	−100	µA	V_{CC} = 5.5 V, V_{IN} = 0.4 V (other inputs are open), Ld = GND or open.
I_{IL}	Logical "0" Input Current	−160	−400	−160	−400	−160	−400	µA	V_{CC} = 5.5 V, V_{IN} = 0.4 V (other inputs are open), E_{nP}/E_{nT} = 4.5 V.
I_{ILL}	Logical "0" Input Current	−300	−760	−300	−760	−300	−760	µA	V_{CC} = 5.5 V, V_{IN} = 0.4 V, Ld & E_{nP} = 4.5 V, other inputs are open.
I_{OS}	Output Short Circuit Current	−15	−100	−15	−100	−15	−100	mA	V_{CC} = 5.5 V, V_{IN} = 4.5 V (other inputs are open), Ld = GND, V_{OUT} = GND, CLK = (See Note 7), CR = 4.5 V, $E_{nT/P}$ = open.
I_{CCH}	Power Supply Current Off		31		31		31	mA	V_{CC} = 5.5 V, V_{IN} = 5.5 V (all inputs), Ld = 5.5 V or GND.
I_{CCL}	Power Supply Current Off		32		32		32	mA	V_{CC} = 5.5 V, V_{IN} = GND (all inputs), CLK = GND or 5.5 V.
V_{IH}	Logical "1" Input Voltage	2.0		2.0		2.0		V	V_{CC} = 4.5 V.
V_{IL}	Logical "0" Input Voltage		0.7		0.7		0.7	V	V_{CC} = 4.5 V.
	Functional Tests	Subgroup 7		Subgroup 8A		Subgroup 8B			per Truth Table with V_{CC} = 5.0 V, V_{INL} = 0.4 V, and V_{INH} = 2.5 V.

5

Symbol	Parameter	Limits						Unit	Test Condition (Unless Otherwise Specified)
	Switching Parameters:	+ 25°C		+ 125°C		− 55°C			
		Subgroup 9		Subgroup 10		Subgroup 11			
		Min	Max	Min	Max	Min	Max		
t_{PHL4} t_{PHL4}	Propagation Delay /Data-Output Clock to Carry Out	3.0 —	40 35	3.0 —	56 51	3.0 —	56 51	ns	V_{CC} = 5.0 V, C_L = 50 pF, R_L = 2.0 kΩ. V_{CC} = 5.0 V, C_L = 15 pF.
t_{PLH4} t_{PLH4}	Propagation Delay /Data-Output Clock to Carry Out	3.0 —	40 35	3.0 —	56 51	3.0 —	56 51	ns	V_{CC} = 5.0 V, C_L = 50 pF, R_L = 2.0 kΩ. V_{CC} = 5.0 V, C_L = 15 pF.
t_{PHL5} t_{PHL5}	Propagation Delay /Data-Output Clock to Q_n	3.0 —	32 27	3.0 —	45 40	3.0 —	45 40	ns	V_{CC} = 5.0 V, C_L = 50 pF, R_L = 2.0 kΩ. V_{CC} = 5.0 V, C_L = 15 pF.
t_{PLH5} t_{PLH5}	Propagation Delay /Data-Output Clock to Q_n	3.0 —	29 24	3.0 —	41 36	3.0 —	41 36	ns	V_{CC} = 5.0 V, C_L = 50 pF, R_L = 2.0 kΩ. V_{CC} = 5.0 V, C_L = 15 pF.
t_{PHL6} t_{PHL6}	Propagation Delay /Data-Output Clock to Q_n	3.0 —	32 27	3.0 —	48 43	3.0 —	48 43	ns	V_{CC} = 5.0 V, C_L = 50 pF, R_L = 2.0 kΩ. V_{CC} = 5.0 V, C_L = 15 pF.
t_{PLH6} t_{PLH6}	Propagation Delay /Data-Output Clock to Q_n	3.0 —	29 24	3.0 —	42 37	3.0 —	42 37	ns	V_{CC} = 5.0 V, C_L = 50 pF, R_L = 2.0 kΩ. V_{CC} = 5.0 V, C_L = 15 pF.
t_{PHL7} t_{PHL7}	Propagation Delay /Data-Output E_{nT} to Carry Out	3.0 —	19 14	3.0 —	28 23	3.0 —	28 23	ns	V_{CC} = 5.0 V, C_L = 50 pF, R_L = 2.0 kΩ. V_{CC} = 5.0 V, C_L = 15 pF.
t_{PLH7} t_{PLH7}	Propagation Delay /Data-Output E_{nT} to Carry Out	3.0 —	19 14	3.0 —	28 23	3.0 —	28 23	ns	V_{CC} = 5.0 V, C_L = 50 pF, R_L = 2.0 kΩ. V_{CC} = 5.0 V, C_L = 15 pF.
t_{PHL8} t_{PHL8}	Propagation Delay /Data-Output Clear to Q_n	3.0 —	33 28	3.0 —	46 41	3.0 —	46 41	ns	V_{CC} = 5.0 V, C_L = 50 pF, R_L = 2.0 kΩ. V_{CC} = 5.0 V, C_L = 15 pF.
f_{MAX} f_{MAX}	Maximum Clock Frequency	22 25		22		22		MHz	V_{CC} = 5.0 V, C_L = 50 pF, R_L = 2.0 kΩ. V_{CC} = 5.0 V, C_L = 15 pF.

5

NOTES:

1. Voltage measurements are made with respect to ground terminal.
2. The pulse generator has the following characteristics:
   V_{GEN} = 3.0 V, t_r = 6.0 ns, t_f = 6.0 ns, t_p = 0.5 µs, PRR ≤ 1.0 MHz, Z_{OUT} ≈ 50 Ω.
3. All diodes are 1N3064 or equivalent.
4. C_L = 50 pF ± 10%, including scope probe and jig capacitance.
5. f_{MAX}: $t_r = t_f \leq 6.0$ ns.
6. The limits specified for C_L = 15 pF are guaranteed but not tested.
7. Apply one pulse prior to measurement as follows: