National Semiconductor

54AC/74AC191
Up/Down Counter with Preset and Ripple Clock

General Description

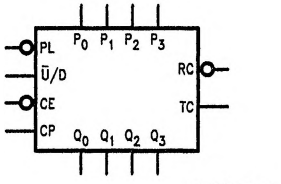
The 'AC191 is a reversible modulo 16 binary counter. It features synchronous counting and asynchronous presetting. The preset feature allows the 'AC191 to be used in programmable dividers. The Count Enable input, the Terminal Count output and the Ripple Clock output make possible a variety of methods of implementing multistage counters. In the counting modes, state changes are initiated by the rising edge of the clock.

Features

- High speed—133 MHz typical count frequency
- Synchronous counting
- Asynchronous parallel load
- Cascadable
- Outputs source/sink 24 mA

Ordering Code: See Section 8

Logic Symbols



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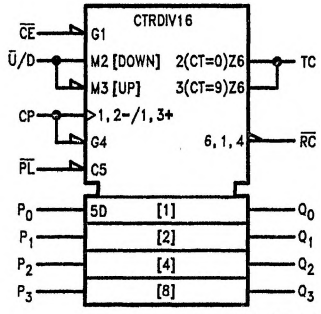
IEEE/IEC



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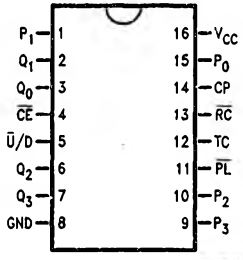
Pin Names	Description
$\overline{CE}$	Count Enable Input
CP	Clock Pulse Input
P_0–P_3	Parallel Data Inputs
$\overline{PL}$	Asynchronous Parallel Load Input
$\overline{U}$/D	Up/Down Count Control Input
Q_0–Q_3	Flip-Flop Outputs
$\overline{RC}$	Ripple Clock Output
TC	Terminal Count Output

Connection Diagrams

Pin Assignment for DIP, Flatpak and SOIC



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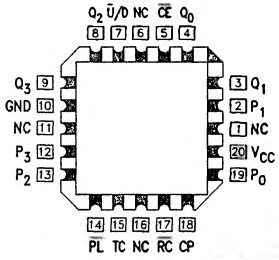
Pin Assignment for LCC



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Functional Description

The 'AC191 is a synchronous up/down counter. The 'AC191 is organized as a 4-bit binary counter. It contains four edge-triggered flip-flops with internal gating and steering logic to provide individual preset, count-up and count-down operations.

Each circuit has an asynchronous parallel load capability permitting the counter to be preset to any desired number. When the Parallel Load ($\overline{PL}$) input is LOW, information present on the Parallel Load inputs (P_0–P_3) is loaded into the counter and appears on the Q outputs. This operation overrides the counting functions, as indicated in the Mode Select Table.

A HIGH signal on the $\overline{CE}$ input inhibits counting. When $\overline{CE}$ is LOW, internal state changes are initiated synchronously by the LOW-to-HIGH transition of the clock input. The direction of counting is determined by the $\overline{U}$/D input signal, as indicated in the Mode Select Table. $\overline{CE}$ and $\overline{U}$/D can be changed with the clock in either state, provided only that the recommended setup and hold times are observed.

Two types of outputs are provided as overflow/underflow indicators. The terminal count (TC) output is normally LOW. It goes HIGH when the circuits reach zero in the count down mode or 15 in the count up mode. The TC output will then remain HIGH until a state change occurs, whether by counting or presetting or until $\overline{U}$/D is changed. The TC output should not be used as a clock signal because it is subject to decoding spikes.

The TC signal is also used internally to enable the Ripple Clock ($\overline{RC}$) output. The $\overline{RC}$ output is normally HIGH. When $\overline{CE}$ is LOW and TC is HIGH, $\overline{RC}$ output wil go LOW when the clock next goes LOW and will stay LOW until the clock goes HIGH again. This feature simplifies the design of multistage counters, as indicated in *Figures A* and *B*. In *Figure A*, each $\overline{RC}$ output is used as the clock input for the next higher stage. This configuration is particularly advantageous when the clock source has a limited drive capability, since it drives only the first stage. To prevent counting in all stages it is only necessary to inhibit the first stage, since a HIGH signal on $\overline{CE}$ inhibits the $\overline{RC}$ output pulse, as indicated in the $\overline{RC}$ Truth Table. A disadvantage of this configuration, in some applications, is the timing skew between state changes in the first and last stages. This represents the cumulative delay of the clock as it ripples through the preceding stages.

A method of causing state changes to occur simultaneously in all stages is shown in *Figure B*. All clock inputs are driven in parallel and the $\overline{RC}$ outputs propagate the carry/borrow signals in ripple fashion. In this configuration the LOW state duration of the clock must be long enough to allow the negative-going edge of the carry/borrow signal to ripple through to the last stage before the clock goes HIGH. There is no such restriction on the HIGH state duration of the clock, since the $\overline{RC}$ output of any device goes HIGH shortly after its CP input goes HIGH.

The configuration shown in *Figure C* avoids ripple delays and their associated restrictions. The $\overline{CE}$ input for a given stage is formed by combining the TC signals from all the preceding stages. Note that in order to inhibit counting an enable signal must be included in each carry gate. The simple inhibit scheme of *Figures A* and *B* doesn't apply, because the TC output of a given stage is not affected by its own $\overline{CE}$.

Mode Select Table

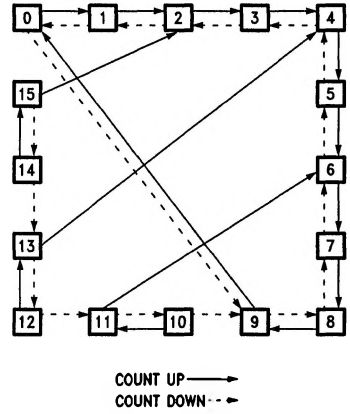
Inputs				Mode
$\overline{PL}$	$\overline{CE}$	$\overline{U}$/D	CP	
H	L	L	↗	Count Up
H	L	H	↗	Count Down
L	X	X	X	Preset (Asyn.)
H	H	X	X	No Change (Hold)

$\overline{RC}$ Truth Table

Inputs				Outputs
$\overline{PL}$	$\overline{CE}$	TC*	CP	$\overline{RC}$
H	L	H	⊓	⊓
H	H	X	X	H
H	X	L	X	H
L	X	X	X	H

*TC is generated internally
H = HIGH Voltage Level
L = LOW Voltage Level
X = Immaterial
↗ = LOW-to-HIGH Transition

State Diagram



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Functional Description (Continued)

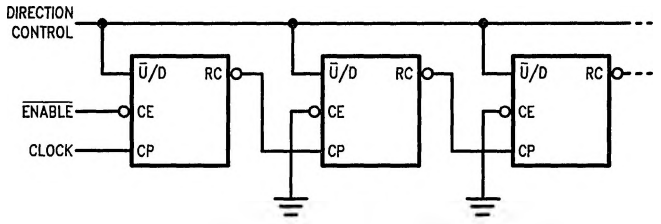

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FIGURE A. N-Stage Counter Using Ripple Clock

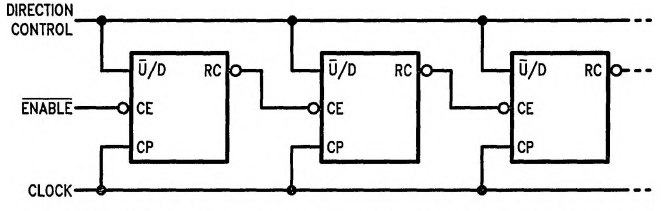

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FIGURE B. Synchronous N-Stage Counter Using Ripple Carry/Borrow

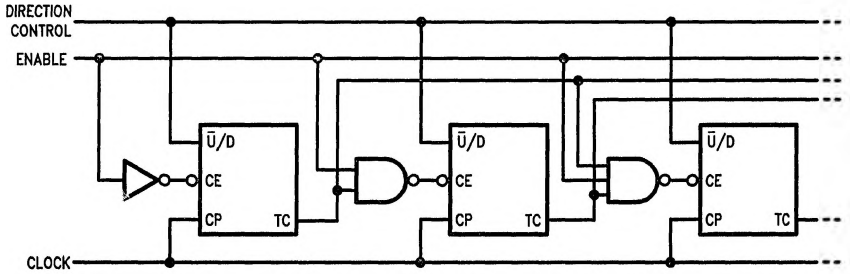

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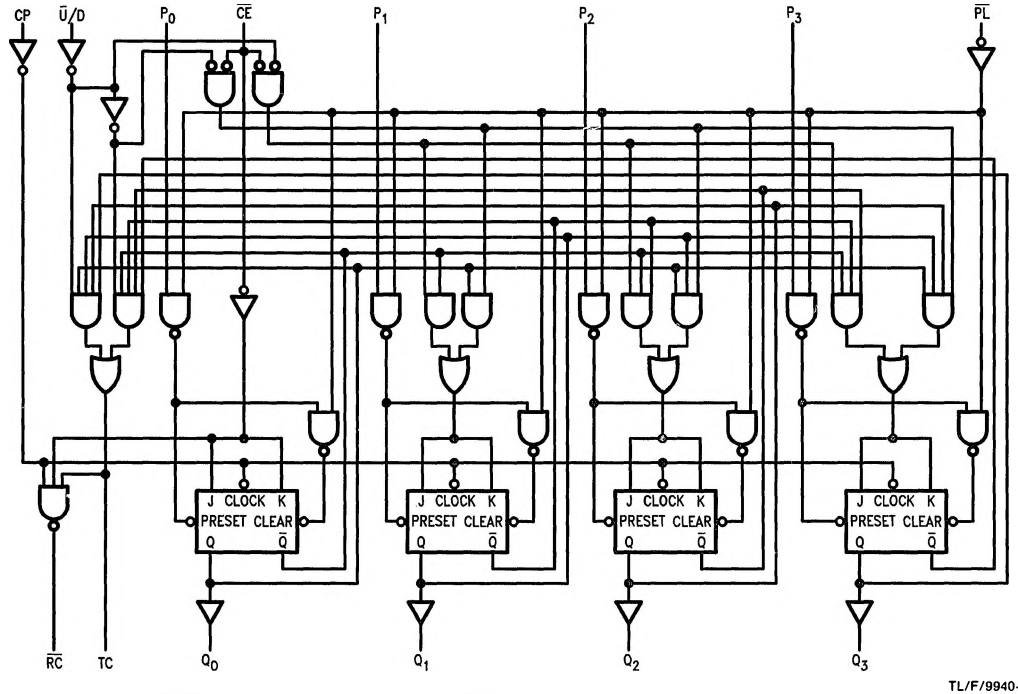
FIGURE C. Synchronous N-Stage Counter with Parallel Gated Carry/Borrow

Logic Diagram



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Please note that this diagram is provided only for the understanding of logic operations and should not be used to estimate propagation delays.

Absolute Maximum Ratings (Note 1)

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

Supply Voltage (V_{CC})	−0.5V to +7.0V
DC Input Diode Current (I_{IK})	
V_I = −0.5V	−20 mA
V_I = V_{CC} + 0.5V	+20 mA
DC Input Voltage (V_I)	−0.5V to V_{CC} + 0.5V
DC Output Diode Current (I_{OK})	
V_O = −0.5V	−20 mA
V_O = V_{CC} + 0.5V	+20 mA
DC Output Voltage (V_O)	−0.5V to V_{CC} + 0.5V
DC Output Source or Sink Current (I_O)	±50 mA
DC V_{CC} or Ground Current per Output Pin (I_{CC} or I_{GND})	±50 mA
Storage Temperature (T_{STG})	−65°C to +150°C
Junction Temperature (T_J)	
CDIP	175°C
PDIP	140°C

Note 1: Absolute maximum ratings are those values beyond which damage to the device may occur. The databook specifications should be met, without exception, to ensure that the system design is reliable over its power supply, temperature, output/input loading variables. National does not recommend operation of FACT™ circuits outside databook specifications.

Recommended Operating Conditions

Supply Voltage (V_{CC})	2.0V to 6.0V
Input Voltage (V_I)	0V to V_{CC}
Output Voltage (V_O)	0V to V_{CC}
Operating Temperature (T_A)	
74AC/ACT	−40°C to +85°C
54AC/ACT	−55°C to +125°C
Minimum Input Edge Rate ($\Delta V/\Delta t$)	
'AC Devices	
V_{IN} from 30% to 70% of V_{CC}	
V_{CC} @ 3.3V 4.5V, 5.5V	125 mV/ns
Minimum Input Edge Rate ($\Delta V/\Delta t$)	
'ACT Devices	
V_{IN} from 0.8V to 2.0V	
V_{CC} @ 4.5V, 5.5V	125 mV/ns

DC Characteristics for 'AC Family Devices

Symbol	Parameter	V_{CC} (V)	74AC T_A = +25°C		54AC T_A = −55°C to +125°C	74AC T_A = −40°C to +85°C	Units	Conditions
			Typ	Guaranteed Limits				
V_{IH}	Minimum High Level Input Voltage	3.0	1.5	2.1	2.1	2.1	V	V_{OUT} = 0.1V or V_{CC} − 0.1V
		4.5	2.25	3.15	3.15	3.15		
		5.5	2.75	3.85	3.85	3.85		
V_{IL}	Maximum Low Level Input Voltage	3.0	1.5	0.9	0.9	0.9	V	V_{OUT} = 0.1V or V_{CC} − 0.1V
		4.5	2.25	1.35	1.35	1.35		
		5.5	2.75	1.65	1.65	1.65		
V_{OH}	Minimum High Level Output Voltage	3.0	2.99	2.9	2.9	2.9	V	I_{OUT} = −50 μA
		4.5	4.49	4.4	4.4	4.4		
		5.5	5.49	5.4	5.4	5.4		
								*V_{IN} = V_{IL} or V_{IH}
		3.0		2.56	2.4	2.46		−12 mA
		4.5		3.86	3.7	3.76		I_{OH} −24 mA
		5.5		4.86	4.7	4.76		−24 mA
V_{OL}	Maximum Low Level Output Voltage	3.0	0.002	0.1	0.1	0.1	V	I_{OUT} = 50 μA
		4.5	0.001	0.1	0.1	0.1		
		5.5	0.001	0.1	0.1	0.1		
								*V_{IN} = V_{IL} or V_{IH}
		3.0		0.36	0.50	0.44		12 mA
		4.5		0.36	0.50	0.44		I_{OL} 24 mA
		5.5		0.36	0.50	0.44		24 mA
I_{IN}	Maximum Input Leakage Current	5.5		±0.1	±1.0	±1.0	μA	V_I = V_{CC}, GND

*All outputs loaded; thresholds on input associated with output under test.

†Maximum test duration 2.0 ms, one output loaded at a time.

DC Characteristics for 'AC Family Devices (Continued)

Symbol	Parameter	V_{CC} (V)	74AC $T_A = +25°C$		54AC $T_A = -55°C$ to $+125°C$	74AC $T_A = -40°C$ to $+85°C$	Units	Conditions
			Typ	Guaranteed Limits				
I_{OLD}	†Minimum Dynamic Output Current	5.5			50	75	mA	V_{OLD} = 1.65V Max
I_{OHD}		5.5			−50	−75	mA	V_{OHD} = 3.85V Min
I_{CC}	Maximum Quiescent Supply Current	5.5		8.0	160.0	80.0	μA	$V_{IN} = V_{CC}$ or GND

*All outputs loaded; thresholds on input associated with output under test.

†Maximum test duration 2.0 ms, one output loaded at a time.

Note: I_{IN} and I_{CC} @ 3.0V are guaranteed to be less than or equal to the respective limit @ 5.5V V_{CC}.
I_{CC} for 54AC @ 25°C is identical to 74AC @ 25°C.

AC Electrical Characteristics: See Section 2 for waveforms

Symbol	Parameter	V_{CC}* (V)	74AC $T_A = +25°C$, $C_L = 50$ pF			54AC $T_A = -55°C$ to $+125°C$, $C_L = 50$ pF		74AC $T_A = -40°C$ to $+85°C$, $C_L = 50$ pF		Units	Fig. No.
			Min	Typ	Max	Min	Max	Min	Max		
f_{max}	Maximum Count Frequency	3.3	70	105		55		65		MHz	
		5.0	90	133		80		85			
t_{PLH}	Propagation Delay CP to Q_n	3.3	2.0	8.5	15.0	1.0	16.5	1.5	16.0	ns	2-3,4
		5.0	1.5	6.0	11.0	1.0	12.0	1.5	12.0		
t_{PHL}	Propagation Delay CP to Q_n	3.3	2.5	8.5	14.5	1.0	16.0	2.0	16.0	ns	2-3,4
		5.0	1.5	6.0	10.5	1.0	12.0	1.5	11.5		
t_{PLH}	Propagation Delay CP to TC	3.3	3.5	10.5	18.0	1.0	19.5	2.5	20.0	ns	2-3,4
		5.0	2.5	7.5	12.0	1.0	14.0	1.5	14.0		
t_{PHL}	Propagation Delay CP to TC	3.3	4.0	10.5	17.5	1.0	19.0	3.0	19.0	ns	2-3,4
		5.0	2.5	7.5	12.5	1.0	14.5	2.0	13.5		
t_{PLH}	Propagation Delay CP to $\overline{RC}$	3.3	2.5	7.5	12.0	1.0	14.0	2.0	13.5	ns	2-3,4
		5.0	2.0	5.5	9.5	1.0	10.5	1.0	10.5		
t_{PHL}	Propagation Delay CP to $\overline{RC}$	3.3	2.5	7.0	11.5	1.0	12.5	2.0	12.5	ns	2-3,4
		5.0	1.5	5.0	8.5	1.0	9.5	1.0	9.5		
t_{PLH}	Propagation Delay $\overline{CE}$ to $\overline{RC}$	3.3	2.5	7.0	12.0	1.0	14.0	1.5	13.5	ns	2-3,4
		5.0	1.5	5.0	8.5	1.0	10.0	1.0	9.5		
t_{PHL}	Propagation Delay $\overline{CE}$ to $\overline{RC}$	3.3	2.0	6.5	11.0	1.0	12.5	1.5	12.5	ns	2-3,4
		5.0	1.5	5.0	8.0	1.0	9.5	1.0	9.0		
t_{PLH}	Propagation Delay $\overline{U}/D$ to $\overline{RC}$	3.3	2.5	6.5	12.5	1.0	14.5	2.0	14.5	ns	2-3,4
		5.0	1.5	5.0	9.0	1.0	11.0	1.0	10.0		
t_{PHL}	Propagation Delay $\overline{U}/D$ to $\overline{RC}$	3.3	2.5	7.0	12.0	1.0	15.0	2.0	13.5	ns	2-3,4
		5.0	1.5	5.0	8.5	1.0	11.0	1.0	10.0		
t_{PLH}	Propagation Delay $\overline{U}/D$ to TC	3.3	2.0	7.0	11.5	1.0	14.0	1.5	13.5	ns	2-3,4
		5.0	1.5	5.0	8.5	1.0	13.5	1.0	9.5		
t_{PHL}	Propagation Delay $\overline{U}/D$ to TC	3.3	2.0	6.5	11.0	1.0	13.5	1.5	12.5	ns	2-3,4
		5.0	1.5	5.0	8.5	1.0	10.0	1.0	9.5		
t_{PLH}	Propagation Delay P_n to Q_n	3.3	2.5	8.0	13.5	1.0	16.5	2.0	15.5	ns	2-3,4
		5.0	2.0	5.5	9.5	1.0	11.5	1.0	10.5		

*Voltage Range 3.3 is 3.3V ±0.3V
Voltage Range 5.0 is 5.0V ±0.5V

AC Electrical Characteristics: See Section 2 for waveforms (Continued)

Symbol	Parameter	V_{CC}* (V)	74AC $T_A = +25°C$, $C_L = 50$ pF			54AC $T_A = -55°C$ to $+125°C$, $C_L = 50$ pF		74AC $T_A = -40°C$ to $+85°C$, $C_L = 50$ pF		Units	Fig. No.
			Min	Typ	Max	Min	Max	Min	Max		
t_{PHL}	Propagation Delay P_n to Q_n	3.3	2.5	7.5	13.0	1.0	15.5	1.5	14.5	ns	2-3,4
		5.0	1.5	5.5	9.5	1.0	10.5	1.0	10.5		
t_{PLH}	Propagation Delay $\overline{PL}$ to Q_n	3.3	3.5	9.5	14.5	1.0	18.0	2.5	17.5	ns	2-3,4
		5.0	2.0	5.5	9.5	1.0	12.5	1.0	10.5		
t_{PHL}	Propagation Delay $\overline{PL}$ to Q_n	3.3	3.0	8.0	13.5	1.0	15.5	2.0	15.5	ns	2-3,4
		5.0	2.0	6.0	10.0	1.0	11.5	1.5	11.0		

*Voltage Range 3.3 is 3.3V ±0.3V
Voltage Range 5.0 is 5.0V ±0.5V

AC Operating Requirements: See Section 2 for waveforms

Symbol	Parameter	V_{CC}* (V)	74AC $T_A = +25°C$, $C_L = 50$ pF		54AC $T_A = -55°C$ to $+125°C$, $C_L = 50$ pF	74AC $T_A = -40°C$ to $+85°C$, $C_L = 50$ pF	Units	Fig. No.
			Typ	Guaranteed Minimum				
t_s	Setup Time, HIGH or LOW P_n to $\overline{PL}$	3.3	1.0	3.0	4.0	3.0	ns	2-7
		5.0	0.5	2.0	3.0	2.5		
t_h	Hold Time, HIGH or LOW P_n to $\overline{PL}$	3.3	−1.5	0.5	1.5	1.0	ns	2-7
		5.0	−0.5	1.0	2.0	1.0		
t_s	Setup Time, LOW $\overline{CE}$ to CP	3.3	3.0	6.0	9.0	7.0	ns	2-7
		5.0	1.5	4.0	6.0	4.5		
t_h	Hold Time, LOW $\overline{CE}$ to CP	3.3	−4.0	−0.5	0	−0.5	ns	2-7
		5.0	−2.5	0	0.5	0		
t_s	Setup Time, HIGH or LOW $\overline{U}/D$ to CP	3.3	4.0	8.0	10.5	9.0	ns	2-7
		5.0	2.5	5.5	7.5	6.5		
t_h	Hold Time, HIGH or LOW $\overline{U}/D$ to CP	3.3	−5.0	0	0	0	ns	2-7
		5.0	−3.0	0.5	1.0	0.5		
t_w	$\overline{PL}$ Pulse Width, LOW	3.3	2.0	3.5	5.0	4.0	ns	2-3
		5.0	1.0	1.0	5.0	1.0		
t_w	CP Pulse Width, LOW	3.3	2.0	3.5	6.0	4.0	ns	2-3
		5.0	2.0	3.0	6.0	4.0		
t_{rec}	Recovery Time $\overline{PL}$ to CP	3.3	−0.5	0	1.5	0	ns	2-3,7
		5.0	−1.0	0	1.0	0		

*Voltage Range 3.3 is 3.3V ±0.3V
Voltage Range 5.0 is 5.0V ±0.5V

Capacitance

Symbol	Parameter	Typ	Units	Conditions
C_{IN}	Input Capacitance	4.5	pF	$V_{CC} = 5.0V$
C_{PD}	Power Dissipation Capacitance	75.0	pF	$V_{CC} = 5.0V$