

# MC10E016, MC100E016

## 5.0 V ECL 8-Bit Synchronous Binary Up Counter

### Description

The MC10E/100E016 is a high-speed synchronous, presettable, cascadable 8-bit binary counter. Architecture and operation are the same as the MC10H016 in the MECL 10H™ family, extended to 8-bits, as shown in the logic symbol.

The counter features internal feedback of  $\overline{TC}$ , gated by the TCLD (terminal count load) pin. When TCLD is LOW (or left open, in which case it is pulled LOW by the internal pull-downs), the  $\overline{TC}$  feedback is disabled, and counting proceeds continuously, with  $\overline{TC}$  going LOW to indicate an all-one state. When TCLD is HIGH, the  $\overline{TC}$  feedback causes the counter to automatically reload upon  $\overline{TC} = \text{LOW}$ , thus functioning as a programmable counter. The  $Q_n$  outputs do not need to be terminated for the count function to operate properly. To minimize noise and power, unused Q outputs should be left unterminated.

The 100 series contains temperature compensation.

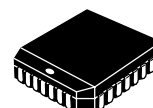
### Features

- 700 MHz Min. Count Frequency
- 1000 ps CLK to Q,  $\overline{TC}$
- Internal  $\overline{TC}$  Feedback (Gated)
- 8-Bit
- Fully Synchronous Counting and  $\overline{TC}$  Generation
- Asynchronous Master Reset
- PECL Mode Operating Range:  $V_{CC} = 4.2 \text{ V}$  to  $5.7 \text{ V}$  with  $V_{EE} = 0 \text{ V}$
- NECL Mode Operating Range:  $V_{CC} = 0 \text{ V}$  with  $V_{EE} = -4.2 \text{ V}$  to  $-5.7 \text{ V}$
- Pb-Free Packages are Available\*



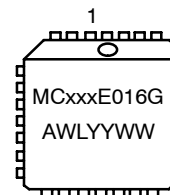
ON Semiconductor®

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PLCC-28  
FN SUFFIX  
CASE 776

### MARKING DIAGRAM\*



xxx	= 10 or 100
A	= Assembly Location
WL	= Wafer Lot
YY	= Year
WW	= Work Week
G	= Pb-Free Package

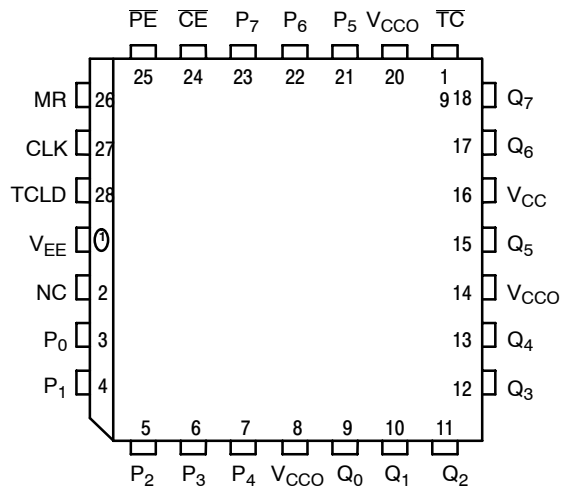
\*For additional marking information, refer to Application Note AND8002/D.

### ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 10 of this data sheet.

\*For additional information on our Pb-Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

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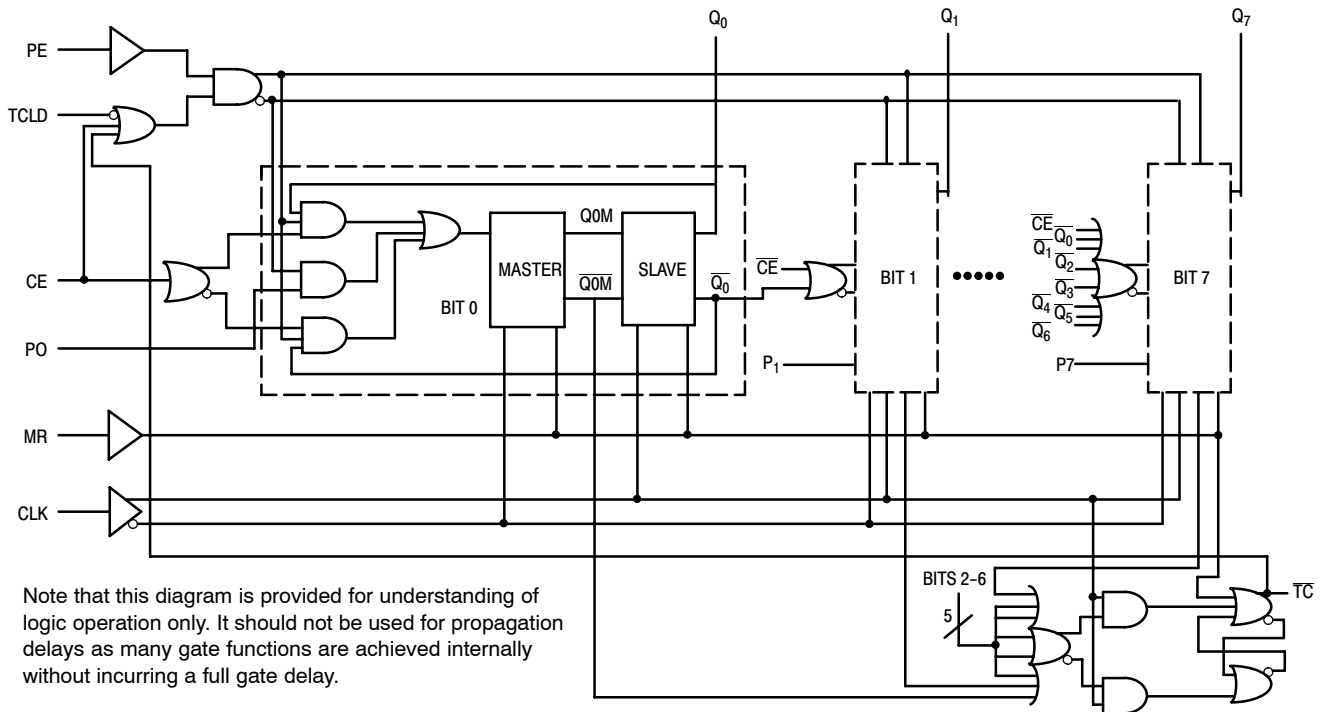


All  $V_{CC}$  and  $V_{CCO}$  pins are tied together on the die.  
Warning: All  $V_{CC}$ ,  $V_{CCO}$ , and  $V_{EE}$  pins must be externally connected to Power Supply to guarantee proper operation.

Figure 1. 28-Lead Pinout Assignment (Top View)

Table 1. PIN DESCRIPTION

PIN	FUNCTION
P0 – P7	ECL Parallel Data (Preset) Inputs
Q0 – Q7	ECL Data Outputs
CE	ECL Count Enable Control Input
PE	ECL Parallel Load Enable Control Input
MR	ECL Master Reset
CLK	ECL Clock
TC	ECL Terminal Count Output
TCLD	ECL TC–Load Control Input
NC	No Connect
$V_{CC}$ , $V_{CCO}$	Positive Supply
$V_{EE}$	Negative Supply



Note that this diagram is provided for understanding of logic operation only. It should not be used for propagation delays as many gate functions are achieved internally without incurring a full gate delay.

Figure 2. 8-Bit Binary Counter Logic Counter

Table 2. FUNCTION TABLE

FUNCTION	CE	PE	TCLD	MR	CLK
Load Parallel ( $P_n$ to $Q_n$ )	X	L	X	L	Z
Continuous Count	L	H	L	L	Z
Count; Load Parallel on $\overline{TC}$ = LOW	L	H	H	L	Z
Hold	H	H	X	L	Z
Masters Respond, Slaves Hold	X	X	X	L	ZZ
Reset ( $Q_n$ : = LOW, $\overline{TC}$ : = HIGH)	X	X	X	H	X

Z = clock pulse (low to high);  
ZZ = clock pulse (high to low)

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**Table 3. EXPANDED FUNCTION TABLE**

Function	PE	CE	MR	TCLD	CLK	P7-P4	P3	P2	P1	P0	Q7-Q4	Q3	Q2	Q1	Q0	TC
Load	L	X	L	X	Z	H	H	H	L	L	H	H	H	L	L	H
Count	H	L	L	L	Z	X	X	X	X	X	H	H	H	L	H	H
	H	L	L	L	Z	X	X	X	X	X	H	H	H	H	L	H
	H	L	L	L	Z	X	X	X	X	X	H	H	H	H	H	L
	H	L	L	L	Z	X	X	X	X	X	L	L	L	L	L	H
Load	L	X	L	X	Z	H	H	H	L	L	H	H	H	L	L	H
Hold	H	H	L	X	Z	X	X	X	X	X	H	H	H	L	L	H
	H	H	L	X	Z	X	X	X	X	X	H	H	H	L	L	H
Load On	H	L	L	H	Z	H	L	H	H	L	H	H	H	L	H	H
Terminal	H	L	L	H	Z	H	L	H	H	L	H	H	H	H	L	H
Count	H	L	L	H	Z	H	L	H	H	L	H	H	H	H	H	L
	H	L	L	H	Z	H	L	H	H	L	H	L	H	H	L	H
	H	L	L	H	Z	H	L	H	H	L	H	L	H	H	H	H
	H	L	L	H	Z	H	L	H	H	L	H	H	L	L	L	H
Reset	X	X	H	X	X	X	X	X	X	X	L	L	L	L	L	H

**Table 4. ATTRIBUTES**

Characteristics		Value	
Internal Input Pulldown Resistor		50 kΩ	
Internal Input Pullup Resistor		50 kΩ	
ESD Protection	Human Body Model Machine Model	> 2 kV > 200 V	
Moisture Sensitivity, Indefinite Time Out of Drypack (Note 1)		Pb Pkg	Pb-Free Pkg
PLCC-28		Level 1	Level 3
Flammability Rating	Oxygen Index: 28 to 34	UL 94 V-0 @ 0.125 in	
Transistor Count		592 Devices	
Meets or exceeds JEDEC Spec EIA/JESD78 IC Latchup Test			

1. For additional information, see Application Note AND8003/D.

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**Table 5. MAXIMUM RATINGS**

Symbol	Parameter	Condition 1	Condition 2	Rating	Unit
$V_{CC}$	PECL Mode Power Supply	$V_{EE} = 0\text{ V}$		8	V
$V_I$	PECL Mode Input Voltage NECL Mode Input Voltage	$V_{EE} = 0\text{ V}$ $V_{CC} = 0\text{ V}$	$V_I \leq V_{CC}$ $V_I \geq V_{EE}$	6 -6	V
$I_{out}$	Output Current	Continuous Surge		50 100	mA mA
$T_A$	Operating Temperature Range			0 to +85	°C
$T_{stg}$	Storage Temperature Range			-65 to +150	°C
$\theta_{JA}$	Thermal Resistance (Junction-to-Ambient)	0 lfpm 500 lfpm	PLCC-28 PLCC-28	63.5 43.5	°C/W °C/W
$\theta_{JC}$	Thermal Resistance (Junction-to-Case)	Standard Board	PLCC-28	22 to 26	°C/W
$T_{sol}$	Wave Solder Pb Pb-Free			265 265	°C

Maximum ratings are those values beyond which device damage can occur. Maximum ratings applied to the device are individual stress limit values (not normal operating conditions) and are not valid simultaneously. If these limits are exceeded, device functional operation is not implied, damage may occur and reliability may be affected.

**Table 6. 10E SERIES PECL DC CHARACTERISTICS**  $V_{CCx} = 5.0\text{ V}$ ;  $V_{EE} = 0.0\text{ V}$  (Note 1)

Symbol	Characteristic	0°C			25°C			85°C			Unit
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
$I_{EE}$	Power Supply Current		151	181		151	181		151	181	mA
$V_{OH}$	Output HIGH Voltage (Note 2)	3980	4070	4160	4020	4105	4190	4090	4185	4280	mV
$V_{OL}$	Output LOW Voltage (Note 2)	3050	3210	3370	3050	3210	3370	3050	3227	3405	mV
$V_{IH}$	Input HIGH Voltage	3830	3995	4160	3870	4030	4190	3940	4110	4280	mV
$V_{IL}$	Input LOW Voltage	3050	3285	3520	3050	3285	3520	3050	3302	3555	mV
$I_{IH}$	Input HIGH Current			150			150			150	μA
$I_{IL}$	Input LOW Current	0.5	0.3		0.5	0.25		0.3	0.2		μA

NOTE: Device will meet the specifications after thermal equilibrium has been established when mounted in a test socket or printed circuit board with maintained transverse airflow greater than 500 lfpm. Electrical parameters are guaranteed only over the declared operating temperature range. Functional operation of the device exceeding these conditions is not implied. Device specification limit values are applied individually under normal operating conditions and not valid simultaneously.

1. Input and output parameters vary 1:1 with  $V_{CC}$ .  $V_{EE}$  can vary -0.46 V / +0.06 V.
2. Outputs are terminated through a 50  $\Omega$  resistor to  $V_{CC} - 2.0\text{ V}$ .

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**Table 7. 10E SERIES NECL DC CHARACTERISTICS**  $V_{CCx} = 0.0\text{ V}$ ;  $V_{EE} = -5.0\text{ V}$  (Note 3)

Symbol	Characteristic	0°C			25°C			85°C			Unit
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
$I_{EE}$	Power Supply Current		151	181		151	181		151	181	mA
$V_{OH}$	Output HIGH Voltage (Note 4)	-1020	-930	-840	-980	-895	-810	-910	-815	-720	mV
$V_{OL}$	Output LOW Voltage (Note 4)	-1950	-1790	-1630	-1950	-1790	-1630	-1950	-1773	-1595	mV
$V_{IH}$	Input HIGH Voltage	-1170	-1005	-840	-1130	-970	-810	-1060	-890	-720	mV
$V_{IL}$	Input LOW Voltage	-1950	-1715	-1480	-1950	-1715	-1480	-1950	-1698	-1445	mV
$I_{IH}$	Input HIGH Current			150			150			150	μA
$I_{IL}$	Input LOW Current	0.5	0.3		0.5	0.065		0.3	0.2		μA

NOTE: Device will meet the specifications after thermal equilibrium has been established when mounted in a test socket or printed circuit board with maintained transverse airflow greater than 500 lfpm. Electrical parameters are guaranteed only over the declared operating temperature range. Functional operation of the device exceeding these conditions is not implied. Device specification limit values are applied individually under normal operating conditions and not valid simultaneously.

- Input and output parameters vary 1:1 with  $V_{CC}$ .  $V_{EE}$  can vary  $-0.46\text{ V} / +0.06\text{ V}$ .
- Outputs are terminated through a  $50\ \Omega$  resistor to  $V_{CC} - 2.0\text{ V}$ .

**Table 8. 100E SERIES PECL DC CHARACTERISTICS**  $V_{CCx} = 5.0\text{ V}$ ;  $V_{EE} = 0.0\text{ V}$  (Note 5)

Symbol	Characteristic	0°C			25°C			85°C			Unit
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
$I_{EE}$	Power Supply Current		151	181		151	181		174	208	mA
$V_{OH}$	Output HIGH Voltage (Note 6)	3975	4050	4120	3975	4050	4120	3975	4050	4120	mV
$V_{OL}$	Output LOW Voltage (Note 6)	3190	3295	3380	3190	3255	3380	3190	3260	3380	mV
$V_{IH}$	Input HIGH Voltage	3835	3975	4120	3835	3975	4120	3835	3975	4120	mV
$V_{IL}$	Input LOW Voltage	3190	3355	3525	3190	3355	3525	3190	3355	3525	mV
$I_{IH}$	Input HIGH Current			150			150			150	μA
$I_{IL}$	Input LOW Current	0.5	0.3		0.5	0.25		0.5	0.2		μA

NOTE: Device will meet the specifications after thermal equilibrium has been established when mounted in a test socket or printed circuit board with maintained transverse airflow greater than 500 lfpm. Electrical parameters are guaranteed only over the declared operating temperature range. Functional operation of the device exceeding these conditions is not implied. Device specification limit values are applied individually under normal operating conditions and not valid simultaneously.

- Input and output parameters vary 1:1 with  $V_{CC}$ .  $V_{EE}$  can vary  $-0.46\text{ V} / +0.8\text{ V}$ .
- Outputs are terminated through a  $50\ \Omega$  resistor to  $V_{CC} - 2.0\text{ V}$ .

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**Table 9. 100E SERIES NECL DC CHARACTERISTICS**  $V_{CCx} = 0.0 \text{ V}$ ;  $V_{EE} = -5.0 \text{ V}$  (Note 7)

Symbol	Characteristic	0°C			25°C			85°C			Unit
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
$I_{EE}$	Power Supply Current		151	181		151	181		174	208	mA
$V_{OH}$	Output HIGH Voltage (Note 8)	-1025	-950	-880	-1025	-950	-880	-1025	-950	-880	mV
$V_{OL}$	Output LOW Voltage (Note 8)	-1810	-1705	-1620	-1810	-1745	-1620	-1810	-1740	-1620	mV
$V_{IH}$	Input HIGH Voltage	-1165	-1025	-880	-1165	-1025	-880	-1165	-1025	-880	mV
$V_{IL}$	Input LOW Voltage	-1810	-1645	-1475	-1810	-1645	-1475	-1810	-1645	-1475	mV
$I_{IH}$	Input HIGH Current			150			150			150	$\mu\text{A}$
$I_{IL}$	Input LOW Current	0.5	0.3		0.5	0.25		0.5	0.2		$\mu\text{A}$

NOTE: Device will meet the specifications after thermal equilibrium has been established when mounted in a test socket or printed circuit board with maintained transverse airflow greater than 500 lfpm. Electrical parameters are guaranteed only over the declared operating temperature range. Functional operation of the device exceeding these conditions is not implied. Device specification limit values are applied individually under normal operating conditions and not valid simultaneously.

7. Input and output parameters vary 1:1 with  $V_{CC}$ .  $V_{EE}$  can vary  $-0.46 \text{ V} / +0.8 \text{ V}$ .

8. Outputs are terminated through a  $50 \Omega$  resistor to  $V_{CC} - 2.0 \text{ V}$ .

**Table 10. AC CHARACTERISTICS**  $V_{CCx} = 5.0 \text{ V}$ ;  $V_{EE} = 0.0 \text{ V}$  or  $V_{CCx} = 0.0 \text{ V}$ ;  $V_{EE} = -5.0 \text{ V}$  (Note 9)

Symbol	Characteristic	0°C			25°C			85°C			Unit
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
$f_{MAX}$	Maximum Toggle Frequency		700			700			700		MHz
$f_{COUNT}$	Maximum Count Frequency	700	900		700	900		700	900		MHz
$t_{PLH}, t_{PHL}$	Propagation Delay to Output										ps
	CLK to Q	500	725	900	500	725	900	500	725	900	
	MR to Q	500	775	900	500	775	900	500	775	900	
	CLK to $\overline{TC}$	500	775	900	500	775	900	500	775	900	
	MR to $\overline{TC}$	500	775	900	500	775	900	500	775	900	
$t_s$	Setup Time (to CLK +)										ps
	Pn	150	-30		150	-30		150	-30		
	$\overline{CE}$	600	400		600	400		600	400		
	$\overline{PE}$	600	400		600	400		600	400		
	TCLD	500	300		500	300		500	300		
$t_h$	Hold Time (to CLK +)										
	Pn	350	100		350	100		350	100		
	$\overline{CE}$	400	200		400	200		400	200		
	$\overline{PE}$	0	200		0	200		0	200		
	TCLD	100	-300		100	-300		100	-300		
$t_{RR}$	Reset Recovery Time	900	700		900	700		900	700		ps
$t_{PW}$	Minimum Pulse Width										ps
	CLK, MR	400			400			400			
$t_{JITTER}$	Random Clock Jitter (RMS)		< 1			< 1			< 1		ps
$t_r, t_f$	Rise/Fall Times (20 – 80%)	200	510	700	200	510	700	200	510	700	ps

NOTE: Device will meet the specifications after thermal equilibrium has been established when mounted in a test socket or printed circuit board with maintained transverse airflow greater than 500 lfpm. Electrical parameters are guaranteed only over the declared operating temperature range. Functional operation of the device exceeding these conditions is not implied. Device specification limit values are applied individually under normal operating conditions and not valid simultaneously.

9. 10 Series:  $V_{EE}$  can vary  $-0.46 \text{ V} / +0.06 \text{ V}$ .

100 Series:  $V_{EE}$  can vary  $-0.46 \text{ V} / +0.8 \text{ V}$ .

## APPLICATIONS INFORMATION

**Cascading Multiple E016 Devices**

For applications which call for larger than 8-bit counters multiple E016s can be tied together to achieve very wide bit width counters. The active low terminal count ( $\overline{TC}$ ) output and count enable input ( $\overline{CE}$ ) greatly facilitate the cascading of E016 devices. Two E016s can be cascaded without the need for external gating, however for counters wider than 16 bits external OR gates are necessary for cascade implementations.

Figure 3 below pictorially illustrates the cascading of 4 E016s to build a 32-bit high frequency counter. Note the E101 gates used to OR the terminal count outputs of the lower order E016s to control the counting operation of the higher order bits. When the terminal count of the preceding device (or devices) goes low (the counter reaches an all 1s state) the more significant E016 is set in its count mode and will count one binary digit upon the next positive clock transition. In addition, the preceding devices will also count one bit thus sending their terminal count outputs back to a high state disabling the count operation of the more significant counters and placing them back into hold modes.

Therefore, for an E016 in the chain to count, all of the lower order terminal count outputs must be in the low state. The bit width of the counter can be increased or decreased by simply adding or subtracting E016 devices from Figure 3 and maintaining the logic pattern illustrated in the same figure.

The maximum frequency of operation for the cascaded counter chain is set by the propagation delay of the  $\overline{TC}$  output and the necessary setup time of the  $\overline{CE}$  input and the propagation delay through the OR gate controlling it (for 16-bit counters the limitation is only the  $\overline{TC}$  propagation delay and the  $\overline{CE}$  setup time). Figure 3 shows EL01 gates used to control the count enable inputs, however, if the frequency of operation is lower a slower, ECL OR gate can be used. Using the worst case guarantees for these parameters from the ECLinPS data book, the maximum count frequency for a greater than 16-bit counter is 500 MHz and that for a 16-bit counter is 625 MHz.

Note that this assumes the trace delay between the  $\overline{TC}$  outputs and the  $\overline{CE}$  inputs are negligible. If this is not the case estimates of these delays need to be added to the calculations.

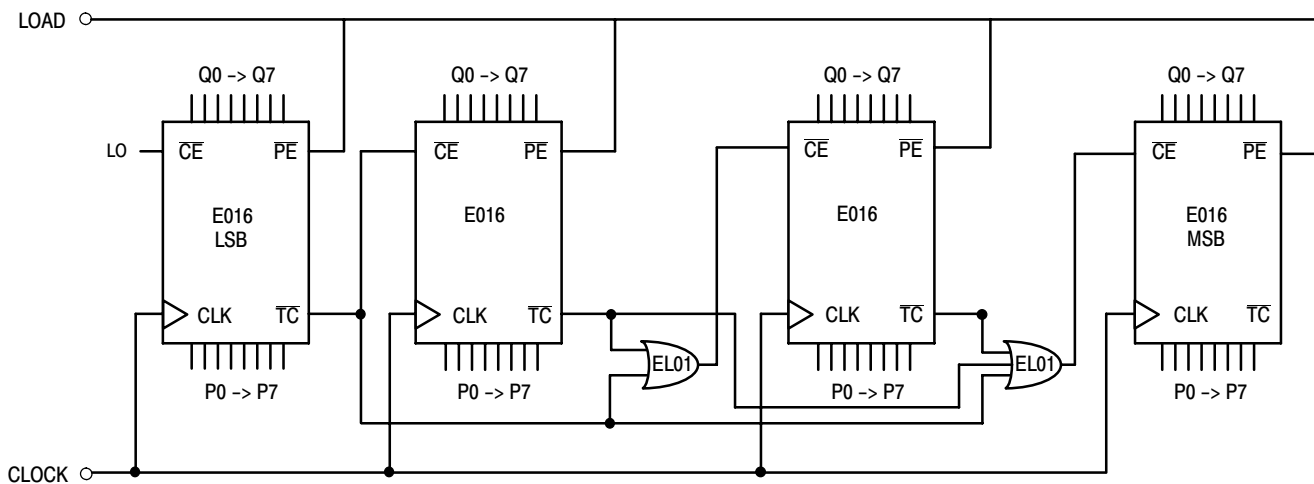


Figure 3. 32-Bit Cascaded E016 Counter

## APPLICATIONS INFORMATION (continued)

**Programmable Divider**

The E016 has been designed with a control pin which makes it ideal for use as an 8-bit programmable divider. The TCLD pin (load on terminal count) when asserted reloads the data present at the parallel input pin (Pn's) upon reaching terminal count (an all 1s state on the outputs). Because this feedback is built internal to the chip, the programmable division operation will run at very nearly the same frequency as the maximum counting frequency of the device. Figure 4 below illustrates the input conditions necessary for utilizing the E016 as a programmable divider set up to divide by 113.

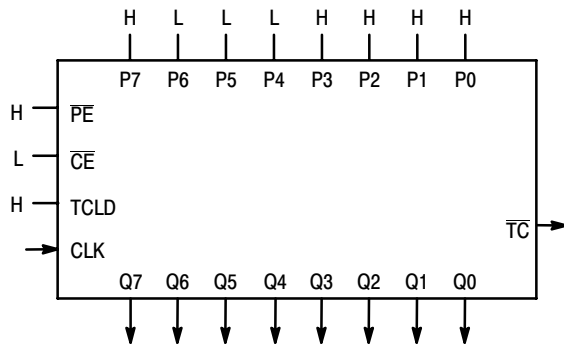


Figure 4. Mod 2 to 256 Programmable Divider

To determine what value to load into the device to accomplish the desired division, the designer simply subtracts the binary equivalent of the desired divide ratio from the binary value for 256. As an example for a divide ratio of 113:

$$Pn's = 256 - 113 = 8F_{16} = 1000\ 1111$$

where:

P0 = LSB and P7 = MSB

Forcing this input condition as per the setup in Figure 4 will result in the waveforms of Figure 5. Note that the  $\overline{TC}$  output is used as the divide output and the pulse duration is

equal to a full clock period. For even divide ratios, twice the desired divide ratio can be loaded into the E016 and the  $\overline{TC}$  output can feed the clock input of a toggle flip flop to create a signal divided as desired with a 50% duty cycle.

Table 11. Preset Values for Various Divide Ratios

Divide Ratio	Preset Data Inputs							
	P7	P6	P5	P4	P3	P2	P1	P0
2	H	H	H	H	H	H	H	L
3	H	H	H	H	H	H	L	H
4	H	H	H	H	H	H	L	L
5	H	H	H	H	H	L	H	H
w	w	•	•	•	•	•	•	•
w	•	•	•	•	•	•	•	•
112	H	L	L	H	L	L	L	L
113	H	L	L	L	H	H	H	H
114	H	L	L	L	H	H	H	L
•	•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•	•
254	L	L	L	L	L	L	H	L
255	L	L	L	L	L	L	L	H
256	L	L	L	L	L	L	L	L

A single E016 can be used to divide by any ratio from 2 to 256 inclusive. If divide ratios of greater than 256 are needed multiple E016s can be cascaded in a manner similar to that already discussed. When E016s are cascaded to build larger dividers the TCLD pin will no longer provide a means for loading on terminal count. Because one does not want to reload the counters until all of the devices in the chain have reached terminal count, external gating of the  $\overline{TC}$  pins must be used for multiple E016 divider chains.

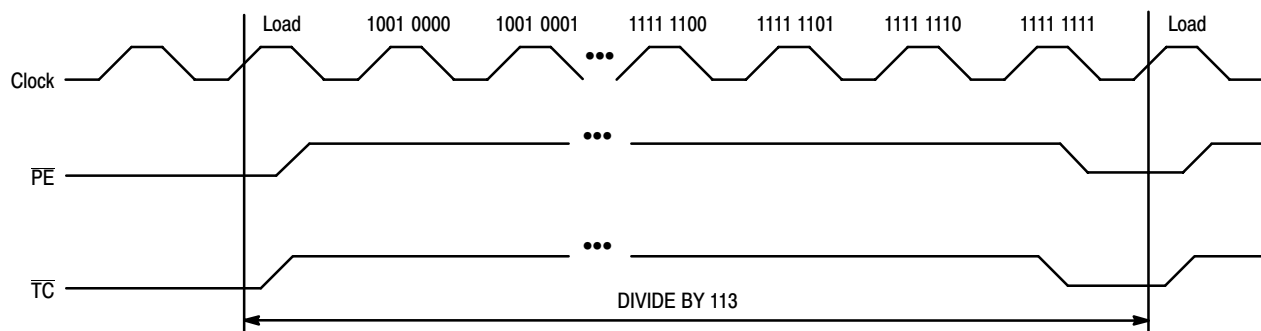


Figure 5. Divide by 113 E016 Programmable Divider Waveforms

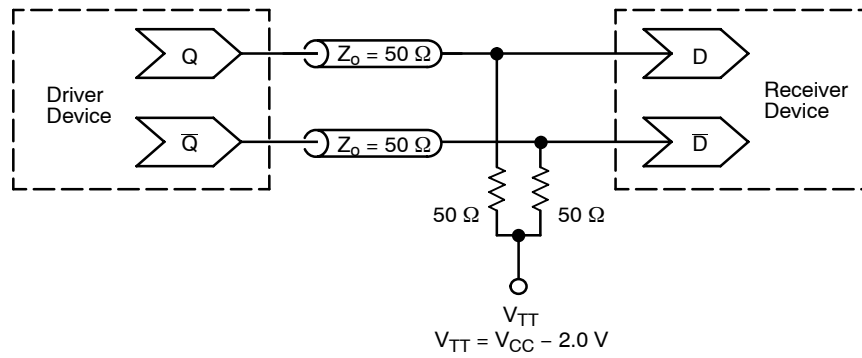




## Maximizing E016 Count Frequency

The E016 device produces 9 fast transitioning single-ended outputs, thus  $V_{CC}$  noise can become significant in situations where all of the outputs switch simultaneously in the same direction. This  $V_{CC}$  noise can negatively impact the maximum frequency of operation of the device. Since the device does not need to have the Q outputs terminated to count properly, it is recommended that if the outputs are not going to be used in the rest of the system they should be left unterminated. In addition, if only a subset of the Q outputs are used in the system only those outputs should be terminated. Not terminating the unused outputs will not only cut down the  $V_{CC}$  noise generated but will also save in total system power dissipation. Following these guidelines will allow designers to either be more aggressive in their designs or provide them with an extra margin to the published data book specifications.

## MC10E016, MC100E016



**Figure 7. Typical Termination for Output Driver and Device Evaluation**  
**(See Application Note AND8020/D – Termination of ECL Logic Devices.)**

### ORDERING INFORMATION

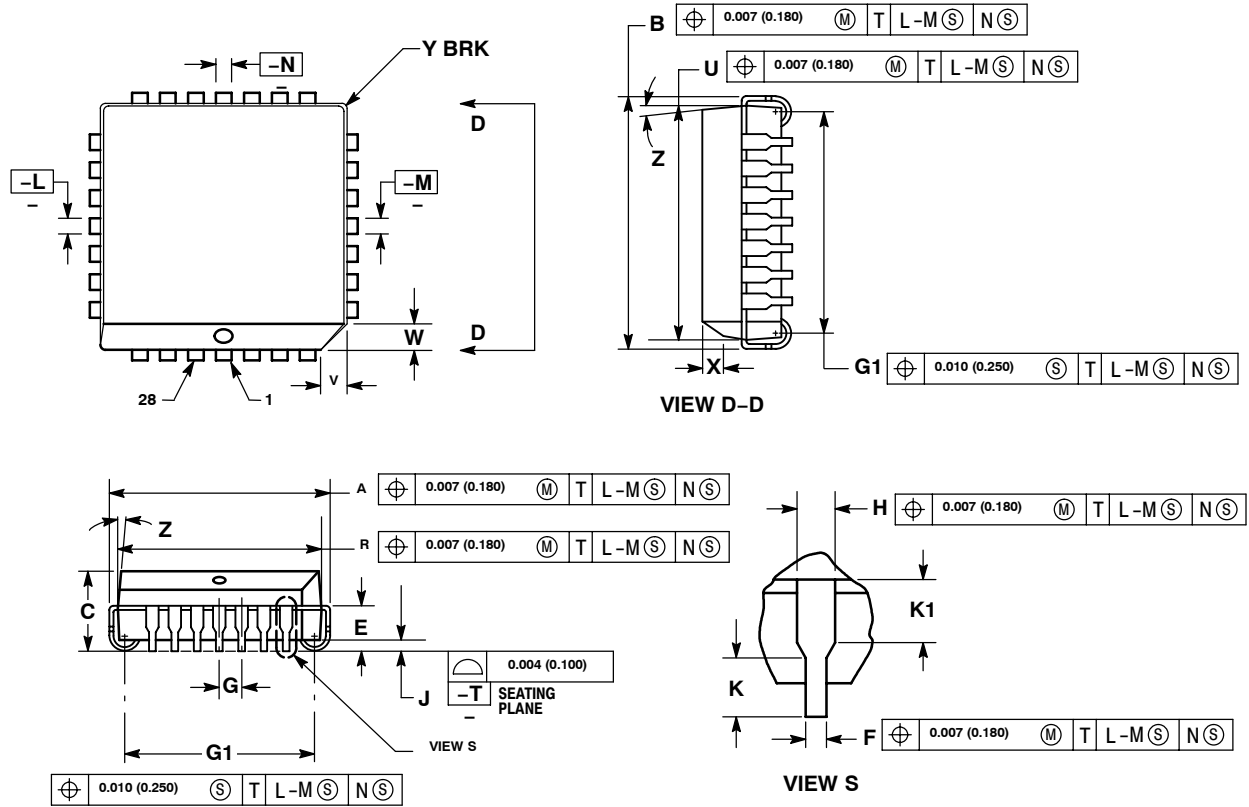
Device	Package Type	Shipping <sup>†</sup>
MC10E016FN	PLCC-28	37 Units/Rail
MC10E016FNG	PLCC-28 (Pb-Free)	37 Units/Rail
MC10E016FNR2	PLCC-28	500 Units/Reel
MC10E016FNR2G	PLCC-28 (Pb-Free)	500 Units/Reel
MC100E016FN	PLCC-28	37 Units/Rail
MC100E016FNG	PLCC-28 (Pb-Free)	37 Units/Rail
MC100E016FNR2	PLCC-28	500 Units/Reel
MC100E016FNR2G	PLCC-28 (Pb-Free)	500 Units/Reel

<sup>†</sup>For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

# MC10E016, MC100E016


## PACKAGE DIMENSIONS

PLCC-28  
FN SUFFIX  
PLASTIC PLCC PACKAGE  
CASE 776-02  
ISSUE E



# MC10E016, MC100E016

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