MC10E195, MC100E195

5V ECL Programmable Delay Chip

The MC10E/100E195 is a programmable delay chip (PDC) designed primarily for clock de-skewing and timing adjustment. It provides variable delay of a differential ECL input transition.

The delay section consists of a chain of gates organized as shown in the logic symbol. The first two delay elements feature gates that have been modified to have delays 1.25 and 1.5 times the basic gate delay of approximately 80 ps. These two elements provide the E195 with a digitally-selectable resolution of approximately 20 ps. The required device delay is selected by the seven address inputs D[0:6], which are latched on chip by a high signal on the latch enable (LEN) control.

Because the delay programmability of the E195 is achieved by purely differential ECL gate delays the device will operate at frequencies of > 1.0 GHz while maintaining over 600 mV of output swing.

The E195 thus offers very fine resolution, at very high frequencies, that is selectable entirely from a digital input allowing for very accurate system clock timing.

An eighth latched input, D7, is provided for cascading multiple PDC's for increased programmable range. The cascade logic allows full control of multiple PDC's, at the expense of only a single added line to the data bus for each additional PDC, without the need for any external gating.

The V_{BB} pin, an internally generated voltage supply, is available to this device only. For single-ended input conditions, the unused differential input is connected to V_{BB} as a switching reference voltage. V_{BB} may also rebias AC coupled inputs. When used, decouple V_{BB} and V_{CC} via a 0.01 µF capacitor and limit current sourcing or sinking to 0.5 mA. When not used, V_{BB} should be left open.

The 100 Series contains temperature compensation.

- 2.0 ns Worst Case Delay Range

- ≈20 ps/Delay Step Resolution

- >1.0 GHz Bandwidth

- On Chip Cascade Circuitry

- PECL Mode Operating Range: V_{CC} = 4.2 V to 5.7 V
  with V_{EE} = 0 V

- NECL Mode Operating Range: V_{CC} = 0 V
  with V_{EE} = –4.2 V to –5.7 V

- Internal Input 50 kΩ Pulldown Resistors

- ESD Protection: Human Body Model; > 2 kV,
  Machine Model; > 200 V

- Meets or Exceeds JEDEC Spec EIA/JESD78 IC Latchup Test

- Moisture Sensitivity Level 1
  For Additional Information, see Application Note AND8003/D

- Flammability Rating: UL 94 V–0 @ 0.125 in,
  Oxygen Index: 28 to 34

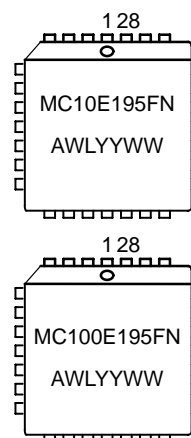- Transistor Count = 368 devices
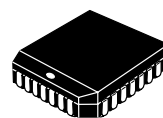
MARKING DIAGRAMS

PLCC–28
FN SUFFIX
CASE 776

1 28
MC10E195FN
AWLYYWW

1 28
MC100E195FN
AWLYYWW

A = Assembly Location
WL = Wafer Lot
YY = Year
WW = Work Week

MC10E195, MC100E195
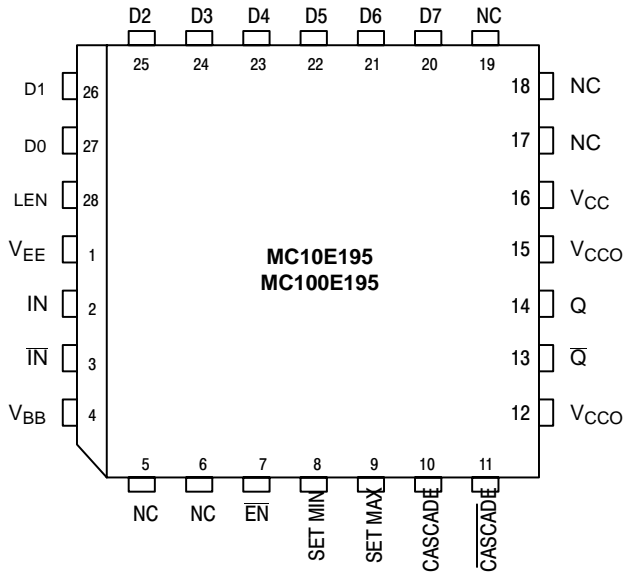
LOGIC DIAGRAM AND PINOUT ASSIGNMENT

Figure 1. Pinout:28-Lead PLCC
(Top View)

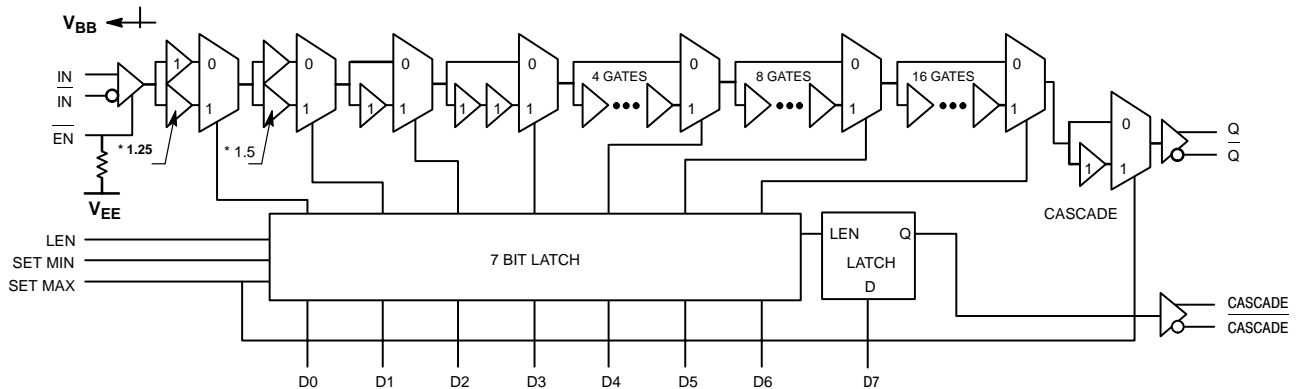*All V_{CC} and V_{CCO} pins are tied together on the die.

Warning: All V_{CC}, V_{CCO}, and V_{EE} pins must be externally connected to Power Supply to guarantee proper operation.

Table 1. PIN DESCRIPTION

PIN	FUNCTION
IN/$\overline{\text{IN}}$	ECL Signal Input
$\overline{\text{EN}}$	ECL Input Enable
D[0:7]	ECL MUX Select Inputs
Q/$\overline{\text{Q}}$	ECL Signal Output
LEN	ECL Latch Enable
SET MIN	ECL Min Delay Set
SET MAX	ECL Max Delay Set
CASCADE, $\overline{\text{CASCADE}}$	ECL Cascade Signal
V_{BB}	Reference Voltage Output
V_{CC}, V_{CCO}	Positive Supply
V_{EE}	Negative Supply
NC	No Connect

Table 2. TRUTH TABLE

$\overline{\text{EN}}$	L	Q = IN
$\overline{\text{EN}}$	H	Q Logic Low
LEN	L	Pass Through D[0:10]
LEN	H	Latch D[0:10]
SETMIN	L	Normal Mode
SETMIN	H	Min Delay Path
SETMAX	L	Normal Mode
SETMAX	H	Max Delay Path

* delays are 25% or 50% longer than standard (standard ≈ 80 ps)

Figure 2. Logic Diagram – Simplified

Table 3. MAXIMUM RATINGS

Symbol	Parameter	Condition 1	Condition 2	Rating	Unit
V_{CC}	PECL Mode Power Supply	$V_{EE} = 0$ V		8	V
V_{EE}	NECL Mode Power Supply	$V_{CC} = 0$ V		−8	V
V_I	PECL Mode Input Voltage NECL Mode Input Voltage	$V_{EE} = 0$ V $V_{CC} = 0$ V	$V_I \leq V_{CC}$ $V_I \geq V_{EE}$	6 −6	V V
I_{out}	Output Current	Continuous Surge		50 100	mA mA
I_{BB}	V_{BB} Sink/Source			± 0.5	mA
T_A	Operating Temperature Range			0 to +85	°C
T_{stg}	Storage Temperature Range			−65 to +150	°C
θ_{JA}	Thermal Resistance (Junction–to–Ambient)	0 lfpm 500 lfpm	PLCC−28 PLCC−28	63.5 43.5	°C/W °C/W
θ_{JC}	Thermal Resistance (Junction–to–Case)	Standard Board	PLCC−28	22 to 26	°C/W
V_{EE}	PECL Operating Range NECL Operating Range			4.2 to 5.7 −5.7 to −4.2	V V
T_{sol}	Wave Solder	< 2 to 3 sec @ 248°C		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 4. 10E SERIES PECL DC CHARACTERISTICS V_{CCx}= 5.0 V; V_{EE}= 0.0 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		130	156		130	156		130	156	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 (Single−Ended)	3830	3995	4160	3870	4030	4190	3940	4110	4280	mV
V_{IL}	Input LOW Voltage (Single−Ended)	3050	3285	3520	3050	3285	3520	3050	3302	3555	mV
V_{BB}	Output Voltage Reference	3.62		3.74	3.65		3.75	3.69		3.81	V
V_{IHCMR}	Input HIGH Voltage Common Mode Range (Differential Configuration) (Note 3)	2.2		4.6	2.2		4.6	2.2		4.6	V
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 Ω resistor to V_{CC} − 2.0 V.
3. V_{IHCMR} min varies 1:1 with V_{EE}, max varies 1:1 with V_{CC}.

Table 5. 10E SERIES NECL DC CHARACTERISTICS V_{CCx}= 0.0 V; V_{EE}= −5.0 V (Note 4)

Symbol	Characteristic	0°C			25°C			85°C			Unit
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
I_{EE}	Power Supply Current		130	156		130	156		130	156	mA
V_{OH}	Output HIGH Voltage (Note 5)	−1020	−930	−840	−980	−895	−810	−910	−815	−720	mV
V_{OL}	Output LOW Voltage (Note 5)	−1950	−1790	−1630	−1950	−1790	−1630	−1950	−1773	−1595	mV
V_{IH}	Input HIGH Voltage (Single−Ended)	−1170	−1005	−840	−1130	−970	−810	−1060	−890	−720	mV
V_{IL}	Input LOW Voltage (Single−Ended)	−1950	−1715	−1480	−1950	−1715	−1480	−1950	−1698	−1445	mV
V_{BB}	Output Voltage Reference	−1.38		−1.27	−1.35		−1.25	−1.31		−1.19	V
V_{IHCMR}	Input HIGH Voltage Common Mode Range (Differential Configuration) (Note 6)	−2.8		−0.4	−2.8		−0.4	−2.8		−0.4	V
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.

4. Input and output parameters vary 1:1 with V_{CC}. V_{EE} can vary −0.46 V / +0.06 V.
5. Outputs are terminated through a 50 Ω resistor to V_{CC} − 2.0 V.
6. V_{IHCMR} min varies 1:1 with V_{EE}, max varies 1:1 with V_{CC}.

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Table 6. 100E SERIES PECL DC CHARACTERISTICS V_{CCx}= 5.0 V; V_{EE}= 0.0 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		130	156		130	156		150	179	mA
V_{OH}	Output HIGH Voltage (Note 8)	3975	4050	4120	3975	4050	4120	3975	4050	4120	mV
V_{OL}	Output LOW Voltage (Note 8)	3190	3295	3380	3190	3255	3380	3190	3260	3380	mV
V_{IH}	Input HIGH Voltage (Single−Ended)	3835	3975	4120	3835	3975	4120	3835	3975	4120	mV
V_{IL}	Input LOW Voltage (Single−Ended)	3190	3355	3525	3190	3355	3525	3190	3355	3525	mV
V_{BB}	Output Voltage Reference	3.62		3.74	3.62		3.74	3.62		3.74	V
V_{IHCMR}	Input HIGH Voltage Common Mode Range (Differential Configuration) (Note 9)	2.2		4.6	2.2		4.6	2.2		4.6	V
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.

7. Input and output parameters vary 1:1 with V_{CC}. V_{EE} can vary −0.46 V / +0.8 V.
8. Outputs are terminated through a 50 Ω resistor to V_{CC} − 2.0 V.
9. V_{IHCMR} min varies 1:1 with V_{EE}, max varies 1:1 with V_{CC}.

Table 7. 100E SERIES NECL DC CHARACTERISTICS V_{CCx}= 0.0 V; V_{EE}= −5.0 V (Note 10)

Symbol	Characteristic	0°C			25°C			85°C			Unit
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
I_{EE}	Power Supply Current		130	156		130	156		150	179	mA
V_{OH}	Output HIGH Voltage (Note 11)	−1025	−950	−880	−1025	−950	−880	−1025	−950	−880	mV
V_{OL}	Output LOW Voltage (Note 11)	−1810	−1705	−1620	−1810	−1745	−1620	−1810	−1740	−1620	mV
V_{IH}	Input HIGH Voltage (Single−Ended)	−1165	−1025	−880	−1165	−1025	−880	−1165	−1025	−880	mV
V_{IL}	Input LOW Voltage (Single−Ended)	−1810	−1645	−1475	−1810	−1645	−1475	−1810	−1645	−1475	mV
V_{BB}	Output Voltage Reference	−1.38		−1.26	−1.38		−1.26	−1.38		−1.26	V
V_{IHCMR}	Input HIGH Voltage Common Mode Range (Differential Configuration) (Note 12)	−2.8		−0.4	−2.8		−0.4	−2.8		−0.4	V
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.

10. Input and output parameters vary 1:1 with V_{CC}. V_{EE} can vary −0.46 V / +0.8 V.
11. Outputs are terminated through a 50 Ω resistor to V_{CC} − 2.0 V.
12. V_{IHCMR} min varies 1:1 with V_{EE}, max varies 1:1 with V_{CC}.

Table 8. AC CHARACTERISTICS V_{CCx}= 5.0 V; V_{EE}= 0.0 V or V_{CCx}= 0.0 V; V_{EE}= −5.0 V (Note 13)

Symbol	Characteristic	0°C			25°C			85°C			Unit
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
f_{MAX}	Maximum Toggle Frequency					> 1.0					GHz
t_{PLH} t_{PHL}	Propagation Delay										ps
	IN to Q; Tap = 0	1210	1360	1510	1240	1390	1540	1440	1590	1765	
	IN to Q; Tap = 127	3200	3570	3970	3270	3630	4030	3885	4270	4710	
	$\overline{EN}$ to Q; Tap = 0	1250	1450	1650	1275	1475	1675	1350	1650	1950	
	D7 to CASCADE	300	450	700	300	450	700	300	450	700	
t_{RANGE}	Programmable Range t_{PD} (max) − t_{PD} (min)	2000	2175		2050	2240		2375	2580		ps
Δt	Step Delay (Note 19)										ps
	D0 High		17			17.5			21		
	D1 High		34			35			42		
	D2 High	55	68	105	55	70	105	65	84	120	
	D3 High	115	136	180	115	140	180	140	168	205	
	D4 High	250	272	325	250	280	325	305	336	380	
	D5 High	505	544	620	515	560	620	620	672	740	
	D6 High	1000	1088	1190	1030	1120	1220	1240	1344	1450	
L_{in}	Linearity (Note 20)	D1	D0		D1	D0		D1	D0		
t_{SKEW}	Duty Cycle Skew t_{PHL}−t_{PLH} (Note 14)		±30			±30			±30		ps
t_{JITTER}	Random Clock Jitter (RMS)		< 5			< 5			< 5		ps
t_s	Setup Time										ps
	D to LEN	200	0		200	0		200	0		
	D to IN (Note 15)	800			800			800			
	$\overline{EN}$ to IN (Note 16)	200			200			200			
t_h	Hold Time										ps
	LEN to D	500	250		500	250		500	250		
	IN to $\overline{EN}$ (Note 17)	0			0			0			
t_R	Release Time										ps
	$\overline{EN}$ to IN (Note 18)	300			300			300			
	SET MAX to LEN	800			800			800			
	SET MIN to LEN	800			800			800			
t_{jit}	Jitter		< 5			< 5			< 5		ps
t_r t_f	Output Rise/Fall Time										ps
	20–80% (Q)	125	225	325	125	225	325	125	225	325	
	20–80% (CASCADE)	300	450	650	300	450	650	300	450	650	

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.

13. 10 Series: V_{EE} can vary −0.46 V / +0.06 V.
    100 Series: V_{EE} can vary −0.46 V / +0.8 V.
14. Duty cycle skew guaranteed only for differential operation measured from the cross point of the input to the cross point of the output.
15. This setup time defines the amount of time prior to the input signal the delay tap of the device must be set.
16. This setup time is the minimum time that $\overline{EN}$ must be asserted prior to the next transition of IN/$\overline{IN}$ to prevent an output response greater than ±75 mV to that IN/$\overline{IN}$ transition.
17. This hold time is the minimum time that $\overline{EN}$ must remain asserted after a negative going IN or positive going $\overline{IN}$ to prevent an output response greater than ±75 mV to that IN/IN transition.
18. This release time is the minimum time that $\overline{EN}$ must be deasserted prior to the next IN/$\overline{IN}$ transition to ensure an output response that meets the specified IN to Q propagation delay and transition times.
19. Specification limits represent the amount of delay added with the assertion of each individual delay control pin. The various combinations of asserted delay control inputs will typically realize D0 resolution steps across the specified programmable range.
20. The linearity specification guarantees to which delay control input the programmable steps will be monotonic (i.e. increasing delay steps for increasing binary counts on the control inputs Dn). Typically the device will be monotonic to the D0 input, however under worst case conditions and process variation, delays could decrease slightly with increasing binary counts when the D0 input is the LSB. With the D1 input as the Least Significant Bit (LSB), the device is guaranteed to be monotonic over all specified environmental conditions and process variation.
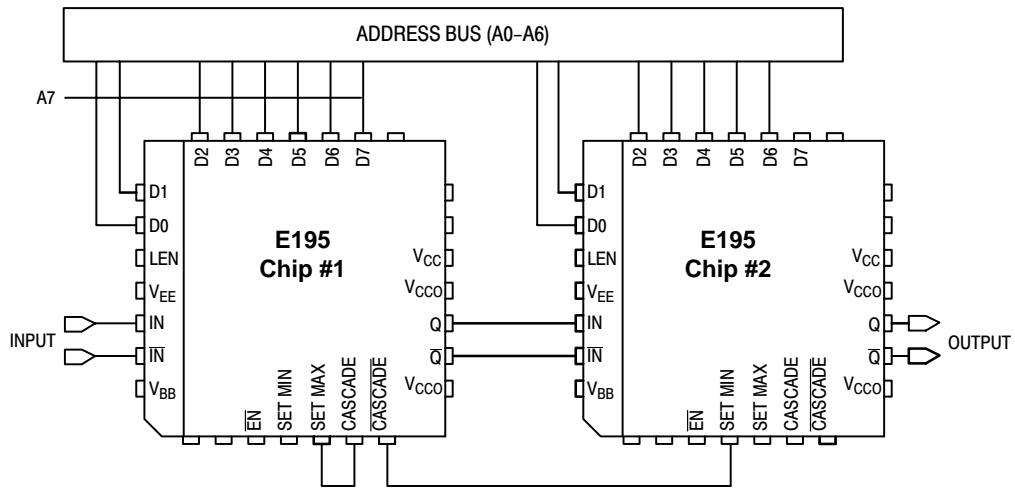
Figure 3. Cascading Interconnect Architecture

Cascading Multiple E195's

To increase the programmable range of the E195 internal cascade circuitry has been included. This circuitry allows for the cascading of multiple E195's without the need for any external gating. Furthermore this capability requires only one more address line per added E195. Obviously cascading multiple PDC's will result in a larger programmable range however this increase is at the expense of a longer minimum delay.

Figure 3 illustrates the interconnect scheme for cascading two E195's. As can be seen, this scheme can easily be expanded for larger E195 chains. The D7 input of the E195 is the cascade control pin. With the interconnect scheme of Figure 3 when D7 is asserted it signals the need for a larger programmable range than is achievable with a single device.

An expansion of the latch section of the block diagram is pictured below. Use of this diagram will simplify the explanation of how the cascade circuitry works. When D7 of chip #1 above is low the cascade output will also be low while the cascade bar output will be a logical high. In this condition the SET MIN pin of chip #2 will be asserted and thus all of the latches of chip #2 will be reset and the device will be set at its minimum delay. Since the RESET and SET inputs of the latches are overriding any changes on the A0–A6 address bus will not affect the operation of chip #2.

Chip #1 on the other hand will have both SET MIN and SET MAX de-asserted so that its delay will be controlled entirely by the address bus A0–A6. If the delay needed is greater than can be achieved with 31.75 gate delays (1111111 on the A0–A6 address bus) D7 will be asserted to signal the need to cascade the delay to the next E195 device. When D7 is asserted the SET MIN pin of chip #2 will be de-asserted and the delay will be controlled by the A0–A6 address bus. Chip #1 on the other hand will have its SET MAX pin asserted resulting in the device delay to be independent of the A0–A6 address bus.

When the SET MAX pin of chip #1 is asserted the D0 and D1 latches will be reset while the rest of the latches will be set. In addition, to maintain monotonicity an additional gate delay is selected in the cascade circuitry. As a result when D7 of chip #1 is asserted the delay increases from 31.75 gates to 32 gates. A 32 gate delay is the maximum delay setting for the E195.

To expand this cascading scheme to more devices one simply needs to connect the D7 input and CASCADE outputs of the current most significant E195 to the new most significant E195 in the same manner as pictured in Figure 3. The only addition to the logic is the increase of one line to the address bus for cascade control of the second PDC.
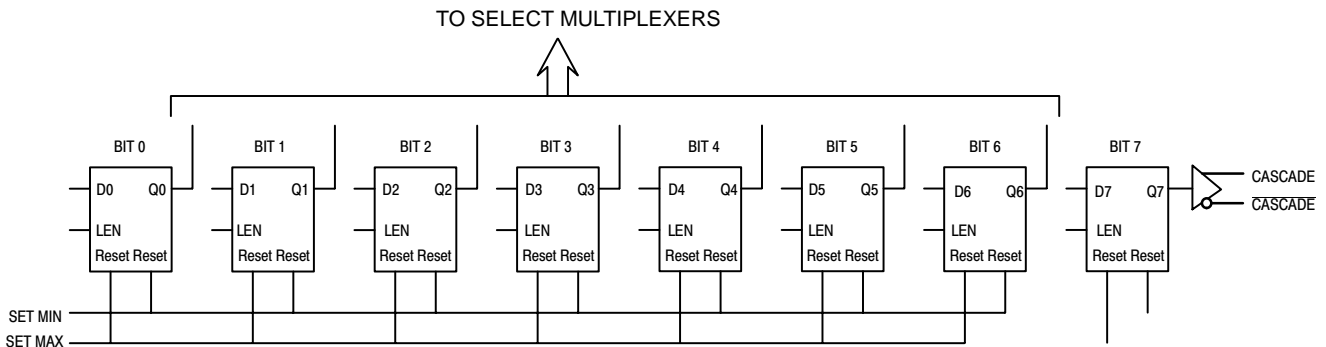
Figure 4. Expansion of the Latch Section of the E195 Block Diagram
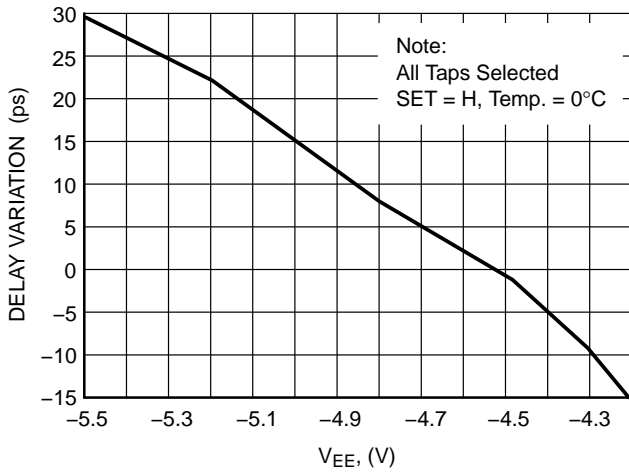
Figure 5. Change in Delay vs. Change in Supply Voltage
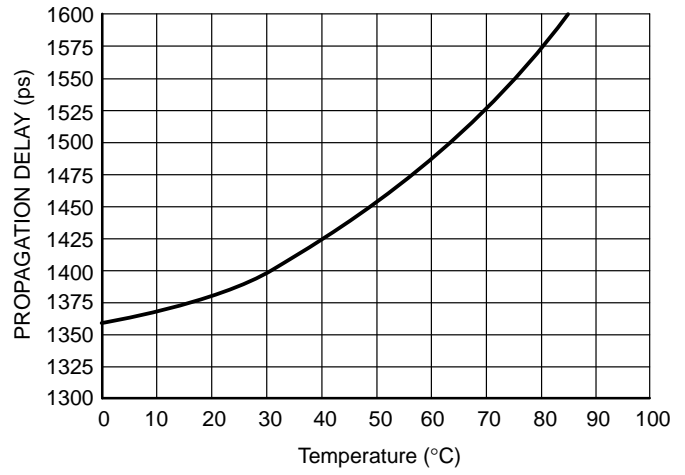
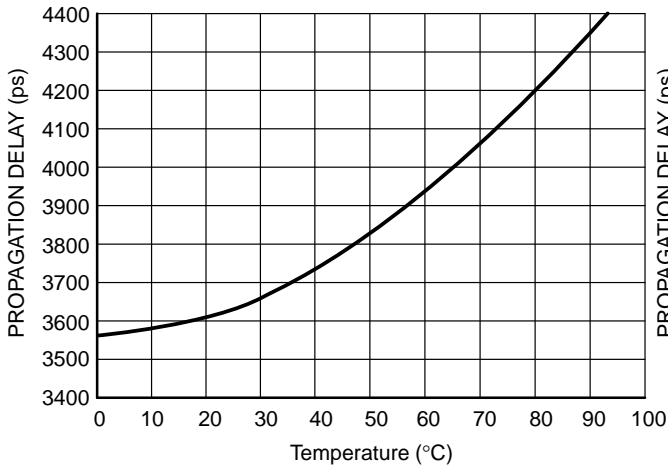**Figure 6. Delay vs. Temperature (Fixed Path)**

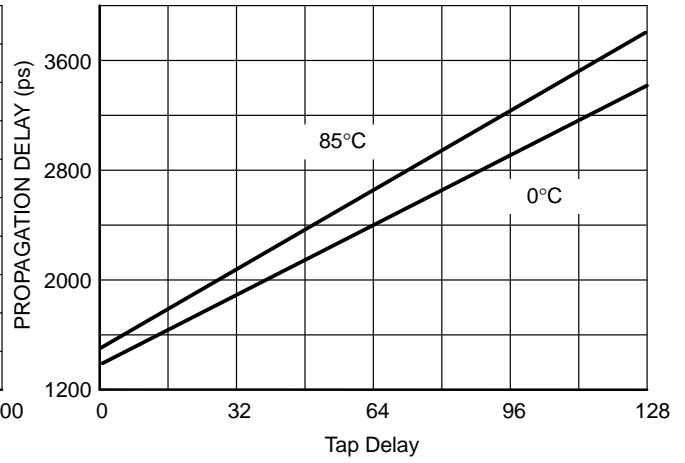**Figure 7. Delay vs. Temperature (Max. Delay).**

Figure 8. 100E195 Temperature Effects on Delay.
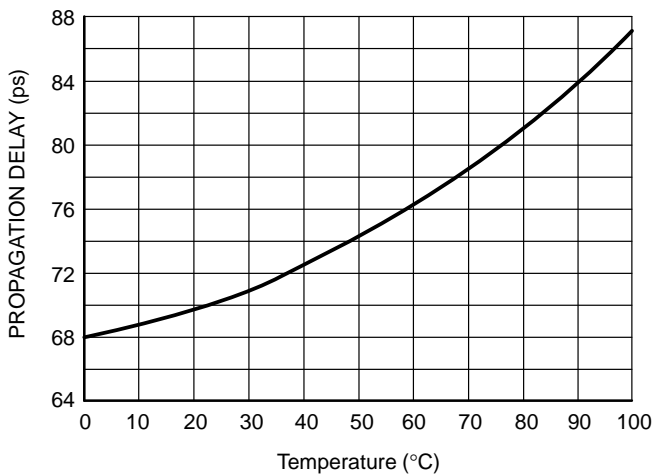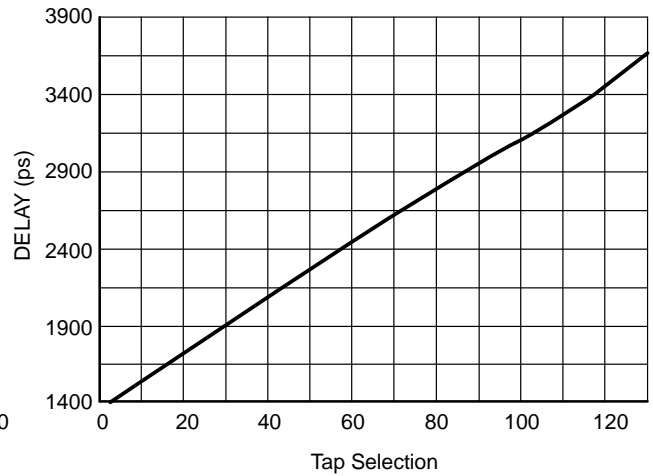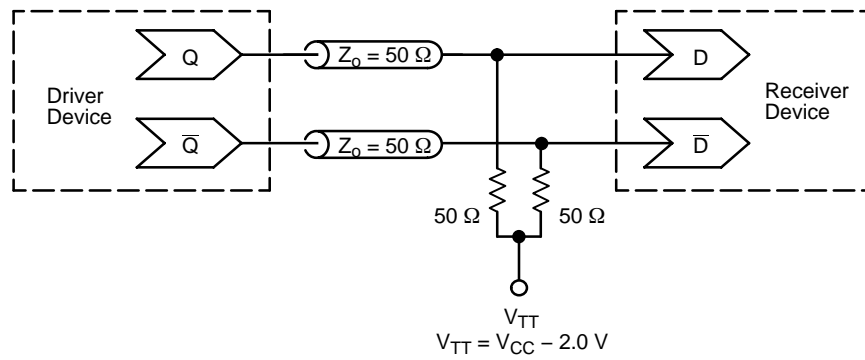

Figure 9. Delay vs. Temperature (Per Gate).

Figure 10. E195 Delay Linearity.

**Figure 11. Typical Termination for Output Driver and Device Evaluation
(See Application Note AND8020/D – Termination of ECL Logic Devices.)**

ORDERING INFORMATION

Device	Package	Shipping[†]
MC10E195FN	PLCC–28	37 Units / Rail
MC10E195FNR2	PLCC–28	500 / Tape & Reel
MC100E195FN	PLCC–28	37 Units / Rail
MC100E195FNR2	PLCC–28	500 / Tape & Reel

†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.

Resource Reference of Application Notes

AN1405/D – ECL Clock Distribution Techniques

AN1406/D – Designing with PECL (ECL at +5.0 V)

AN1503/D – ECLinPS™ I/O SPiCE Modeling Kit

AN1504/D – Metastability and the ECLinPS Family

AN1568/D – Interfacing Between LVDS and ECL

AN1642/D – The ECL Translator Guide

AND8001/D – Odd Number Counters Design

AND8002/D – Marking and Date Codes

AND8020/D – Termination of ECL Logic Devices

AND8066/D – Interfacing with ECLinPS

AND8090/D – AC Characteristics of ECL Devices

PACKAGE DIMENSIONS

PLCC–28
FN SUFFIX
PLASTIC PLCC PACKAGE
CASE 776–02
ISSUE E
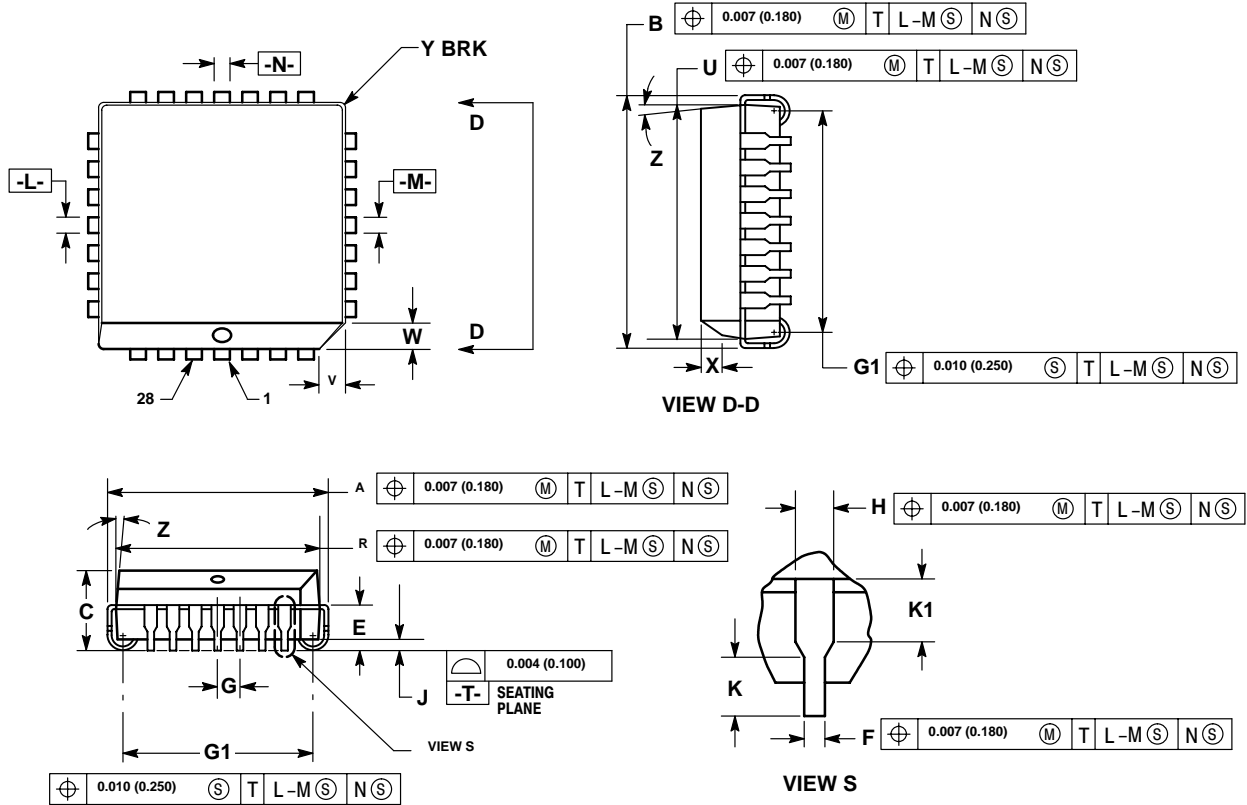
NOTES:
1. DATUMS -L-, -M-, AND -N- DETERMINED WHERE TOP OF LEAD SHOULDER EXITS PLASTIC BODY AT MOLD PARTING LINE.
2. DIM G1, TRUE POSITION TO BE MEASURED AT DATUM -T-, SEATING PLANE.
3. DIM R AND U DO NOT INCLUDE MOLD FLASH. ALLOWABLE MOLD FLASH IS 0.010 (0.250) PER SIDE.
4. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
5. CONTROLLING DIMENSION: INCH.
6. THE PACKAGE TOP MAY BE SMALLER THAN THE PACKAGE BOTTOM BY UP TO 0.012 (0.300). DIMENSIONS R AND U ARE DETERMINED AT THE OUTERMOST EXTREMES OF THE PLASTIC BODY EXCLUSIVE OF MOLD FLASH, TIE BAR BURRS, GATE BURRS AND INTERLEAD FLASH, BUT INCLUDING ANY MISMATCH BETWEEN THE TOP AND BOTTOM OF THE PLASTIC BODY.
7. DIMENSION H DOES NOT INCLUDE DAMBAR PROTRUSION OR INTRUSION. THE DAMBAR PROTRUSION(S) SHALL NOT CAUSE THE H DIMENSION TO BE GREATER THAN 0.037 (0.940). THE DAMBAR INTRUSION(S) SHALL NOT CAUSE THE H DIMENSION TO BE SMALLER THAN 0.025 (0.635).

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.485	0.495	12.32	12.57
B	0.485	0.495	12.32	12.57
C	0.165	0.180	4.20	4.57
E	0.090	0.110	2.29	2.79
F	0.013	0.019	0.33	0.48
G	0.050 BSC		1.27 BSC	
H	0.026	0.032	0.66	0.81
J	0.020	—	0.51	—
K	0.025	—	0.64	—
R	0.450	0.456	11.43	11.58
U	0.450	0.456	11.43	11.58
V	0.042	0.048	1.07	1.21
W	0.042	0.048	1.07	1.21
X	0.042	0.056	1.07	1.42
Y	—	0.020	—	0.50
Z	2°	10°	2°	10°
G1	0.410	0.430	10.42	10.92
K1	0.040	—	1.02	—

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