



F100136 4-Stage Counter/Shift Register

General Description

The F100136 operates as either a modulo-16 up/down counter or as a 4-bit bidirectional shift register. Three Select (S_n) inputs determine the mode of operation, as shown in the Function Select table. Two Count Enable (\overline{CEP} , \overline{CET}) inputs are provided for ease of cascading in multistage counters. One Count Enable (\overline{CET}) input also doubles as a Serial Data (D_0) input for shift-up operation. For shift-down operation, D_3 is the Serial Data input. In counting operations the Terminal Count (\overline{TC}) output goes LOW when the counter reaches 15 in the count/up mode or 0 (zero) in the count/down mode. In the shift modes, the \overline{TC} output repeats the Q_3 output. The dual nature of this \overline{TC}/Q_3 output and the D_0/\overline{CET} input means that one interconnection from one stage to the next higher stage serves as the link for

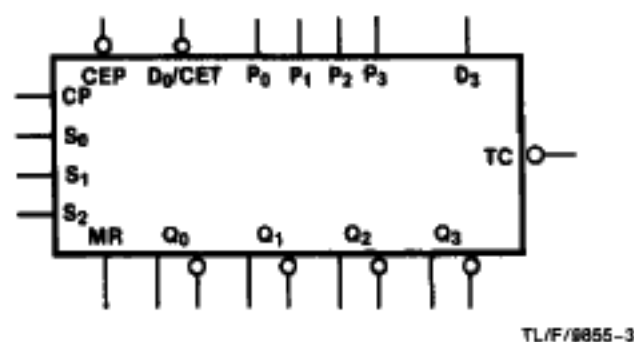
multistage counting or shift-up operation. The individual Pre-set (P_n) inputs are used to enter data in parallel or to preset the counter in programmable counter applications. A HIGH signal on the Master Reset (\overline{MR}) input overrides all other inputs and asynchronously clears the flip-flops. In addition, a synchronous clear is provided, as well as a complement function which synchronously inverts the contents of the flip-flops. All inputs have 50 k Ω pull-down resistors.

Refer to the F100336 datasheet for:

- PCC packaging
- Lower power
- Military versions
- Extended voltage specs (-4.2V to -5.7V)

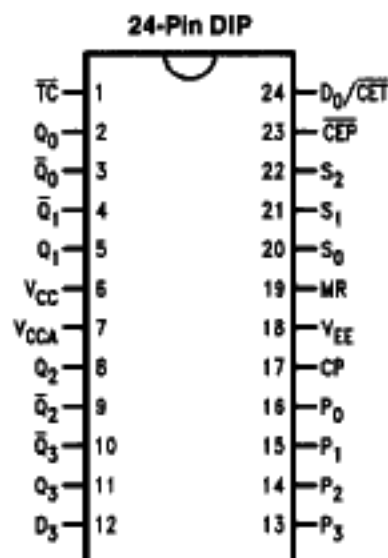
Ordering Code: See Section 8

Logic Symbol

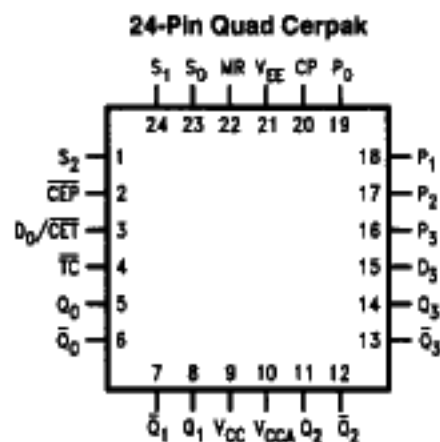


| Pin Names | Description |
|---------------------------------|---|
| CP | Clock Pulse Input |
| \overline{CEP} | Count Enable Parallel Input (Active LOW) |
| D_0/\overline{CET} | Serial Data Input/Count Enable Trickle Input (Active LOW) |
| S_0-S_2 | Select Inputs |
| \overline{MR} | Master Reset Input |
| P_0-P_3 | Preset Inputs |
| D_3 | Serial Data Input |
| \overline{TC} | Terminal Count Output |
| Q_0-Q_3 | Data Outputs |
| $\overline{Q}_0-\overline{Q}_3$ | Complementary Data Outputs |

Connection Diagrams

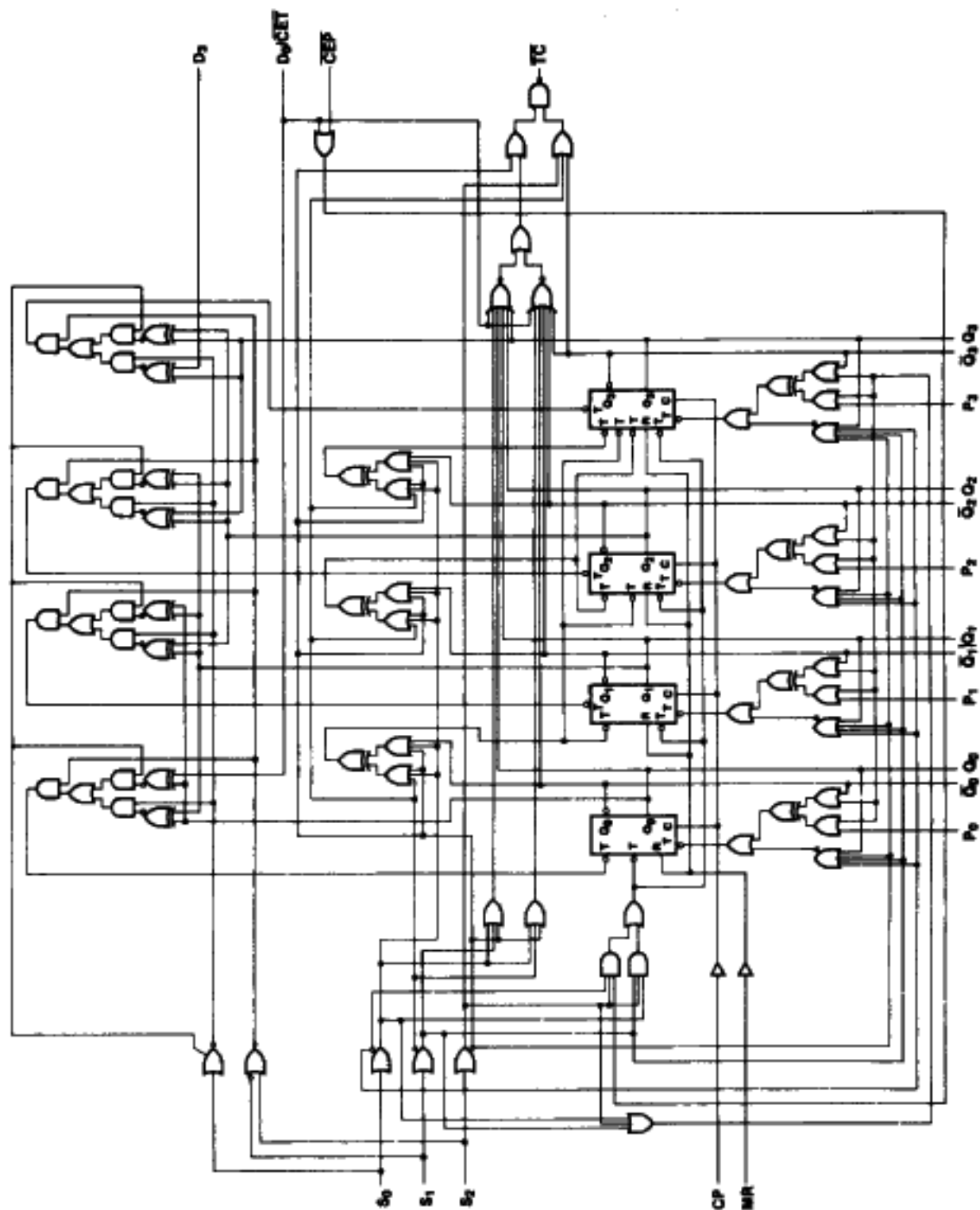


TL/F/9855-1



TL/F/9855-2

Logic Diagram



TL/F/8655-5

Function Select Table

| S ₂ | S ₁ | S ₀ | Function |
|----------------|----------------|----------------|---------------|
| L | L | L | Parallel Load |
| L | L | H | Complement |
| L | H | L | Shift Left |
| L | H | H | Shift Right |
| H | L | L | Count Down |
| H | L | H | Clear |
| H | H | L | Count Up |
| H | H | H | Hold |

Truth Table

Q₀ = LSB

| Inputs | | | | | | | | Outputs | | | | | Mode |
|--------|----------------|----------------|----------------|-------------------------|---------------------|----------------|------------|-----------------------------|-------------------------|-------------------------|-------------------------|------------------------|--|
| MR | S ₂ | S ₁ | S ₀ | $\overline{\text{CEP}}$ | D ₀ /CET | D ₃ | CP | Q ₃ | Q ₂ | Q ₁ | Q ₀ | $\overline{\text{TC}}$ | |
| L | L | L | L | X | X | X | \nearrow | P ₃ | P ₂ | P ₁ | P ₀ | L | Preset (Parallel Load) |
| L | L | L | H | X | X | X | \nearrow | $\overline{\text{Q}}_3$ | $\overline{\text{Q}}_2$ | $\overline{\text{Q}}_1$ | $\overline{\text{Q}}_0$ | L | Invert |
| L | L | H | L | X | X | X | \nearrow | D ₃ | Q ₃ | Q ₂ | D ₁ | D ₃ | Shift Left |
| L | L | H | H | X | X | X | \nearrow | Q ₂ | Q ₁ | Q ₀ | D ₀ | Q ₃ * | Shift Right |
| L | H | L | L | L | L | X | \nearrow | (Q ₀₋₃) minus 1 | | | | ⊖ | Count Down |
| L | H | L | L | H | L | X | X | Q ₃ | Q ₂ | Q ₁ | Q ₀ | ⊖ | Count Down with $\overline{\text{CEP}}$ not active |
| L | H | L | L | X | H | X | X | Q ₃ | Q ₂ | Q ₁ | Q ₀ | H | Count Down with $\overline{\text{CET}}$ not active |
| L | H | L | H | X | X | X | \nearrow | L | L | L | L | H | Clear |
| L | H | H | L | L | L | X | \nearrow | (Q ₀₋₃) plus 1 | | | | ⊕ | Count Up |
| L | H | H | L | H | L | X | X | Q ₃ | Q ₂ | Q ₁ | Q ₀ | ⊕ | Count Up with $\overline{\text{CEP}}$ not active |
| L | H | H | L | X | H | X | X | Q ₃ | Q ₂ | Q ₁ | Q ₀ | H | Count Up with $\overline{\text{CET}}$ not active |
| L | H | H | H | X | X | X | X | Q ₃ | Q ₂ | Q ₁ | Q ₀ | H | Hold |
| H | L | L | L | X | X | X | X | L | L | L | L | L | Asynchronous Master Reset |
| H | L | L | H | X | X | X | X | L | L | L | L | L | |
| H | L | H | L | X | X | X | X | L | L | L | L | L | |
| H | L | H | H | X | X | X | X | L | L | L | L | L | |
| H | H | L | L | X | L | X | X | L | L | L | L | L | |
| H | H | L | H | X | H | X | X | L | L | L | L | H | |
| H | H | L | H | X | X | X | X | L | L | L | L | H | |
| H | H | H | L | X | X | X | X | L | L | L | L | H | |
| H | H | H | H | X | X | X | X | L | L | L | L | H | |

⊖ = L if Q₀-Q₃ = LLLLH if Q₀-Q₃ ≠ LLLL⊕ = L if Q₀-Q₃ = HHHHH if Q₀-Q₃ ≠ HHHH

H = HIGH Voltage Level

L = LOW Voltage Level

X = Don't Care

 \nearrow = LOW-to-HIGH Transition*Before the clock, $\overline{\text{TC}}$ is Q₃After the clock, $\overline{\text{TC}}$ is Q₂

Absolute Maximum Ratings

Above which the useful life may be impaired. (Note 1)

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

Storage Temperature -65°C to $+150^{\circ}\text{C}$
 Maximum Junction Temperature (T_J) $+150^{\circ}\text{C}$

Case Temperature under Bias (T_C) 0°C to $+85^{\circ}\text{C}$
 V_{EE} Pin Potential to Ground Pin -7.0V to $+0.5\text{V}$
 Input Voltage (DC) V_{EE} to $+0.5\text{V}$
 Output Current (DC Output HIGH) -50 mA
 Operating Range (Note 2) -5.7V to -4.2V

DC Electrical Characteristics

$V_{EE} = -4.5\text{V}$, $V_{CC} = V_{CCA} = \text{GND}$, $T_C = 0^{\circ}\text{C}$ to $+85^{\circ}\text{C}$ (Note 3)

| Symbol | Parameter | Min | Typ | Max | Units | Conditions (Note 4) | |
|-----------|---------------------|-------|-------|-------|---------------|--|--|
| V_{OH} | Output HIGH Voltage | -1025 | -955 | -880 | mV | $V_{IN} = V_{IH}(\text{Max})$ or $V_{IL}(\text{Min})$ | Loading with 50Ω to -2.0V |
| V_{OL} | Output LOW Voltage | -1810 | -1705 | -1620 | | | |
| V_{OHC} | Output HIGH Voltage | -1035 | | | mV | $V_{IN} = V_{IH}(\text{Min})$ or $V_{IL}(\text{Max})$ | Loading with 50Ω to -2.0V |
| V_{OLC} | Output LOW Voltage | | | -1610 | | | |
| V_{IH} | Input HIGH Voltage | -1165 | | -880 | mV | Guaranteed HIGH Signal for All Inputs | |
| V_{IL} | Input LOW Voltage | -1810 | | -1475 | mV | Guaranteed LOW Signal for All Inputs | |
| I_{IL} | Input LOW Current | 0.50 | | | μA | $V_{IN} = V_{IL}(\text{Min})$ | |

DC Electrical Characteristics

$V_{EE} = -4.2\text{V}$, $V_{CC} = V_{CCA} = \text{GND}$, $T_C = 0^{\circ}\text{C}$ to $+85^{\circ}\text{C}$ (Note 3)

| Symbol | Parameter | Min | Typ | Max | Units | Conditions (Note 4) | |
|-----------|---------------------|-------|-----|-------|---------------|--|--|
| V_{OH} | Output HIGH Voltage | -1020 | | -870 | mV | $V_{IN} = V_{IH}(\text{Max})$ or $V_{IL}(\text{Min})$ | Loading with 50Ω to -2.0V |
| V_{OL} | Output LOW Voltage | -1810 | | -1605 | | | |
| V_{OHC} | Output HIGH Voltage | -1030 | | | mV | $V_{IN} = V_{IH}(\text{Min})$ or $V_{IL}(\text{Max})$ | Loading with 50Ω to -2.0V |
| V_{OLC} | Output LOW Voltage | | | -1595 | | | |
| V_{IH} | Input HIGH Voltage | -1150 | | -870 | mV | Guaranteed HIGH Signal for All Inputs | |
| V_{IL} | Input LOW Voltage | -1810 | | -1475 | mV | Guaranteed LOW Signal for All Inputs | |
| I_{IL} | Input LOW Current | 0.50 | | | μA | $V_{IN} = V_{IL}(\text{Min})$ | |

DC Electrical Characteristics

$V_{EE} = -4.8\text{V}$, $V_{CC} = V_{CCA} = \text{GND}$, $T_C = 0^{\circ}\text{C}$ to $+85^{\circ}\text{C}$ (Note 3)

| Symbol | Parameter | Min | Typ | Max | Units | Conditions (Note 4) | |
|-----------|---------------------|-------|-----|-------|---------------|--|--|
| V_{OH} | Output HIGH Voltage | -1035 | | -880 | mV | $V_{IN} = V_{IH}(\text{Max})$ or $V_{IL}(\text{Min})$ | Loading with 50Ω to -2.0V |
| V_{OL} | Output LOW Voltage | -1830 | | -1620 | | | |
| V_{OHC} | Output HIGH Voltage | -1045 | | | mV | $V_{IN} = V_{IH}(\text{Min})$ or $V_{IL}(\text{Max})$ | Loading with 50Ω to -2.0V |
| V_{OLC} | Output LOW Voltage | | | -1610 | | | |
| V_{IH} | Input HIGH Voltage | -1165 | | -880 | mV | Guaranteed HIGH Signal for All Inputs | |
| V_{IL} | Input LOW Voltage | -1830 | | -1490 | mV | Guaranteed LOW Signal for All Inputs | |
| I_{IL} | Input LOW Current | 0.50 | | | μA | $V_{IN} = V_{IL}(\text{Min})$ | |

Note 1: Absolute maximum ratings are those values beyond which the device may be damaged or have its useful life impaired. Functional operation under these conditions is not implied.

Note 2: Parametric values specified at -4.2V to -4.8V .

Note 3: The specified limits represent the "worst case" value for the parameter. Since these "worst case" values normally occur at the temperature extremes, additional noise immunity and guard banding can be achieved by decreasing the allowable system operating ranges.

Note 4: Conditions for testing shown in the tables are chosen to guarantee operation under "worst case" conditions.

DC Electrical Characteristics
 $V_{EE} = -4.2V$ to $-4.8V$ unless otherwise specified, $V_{CC} = V_{CCA} = GND$, $T_C = 0^\circ C$ to $+85^\circ C$

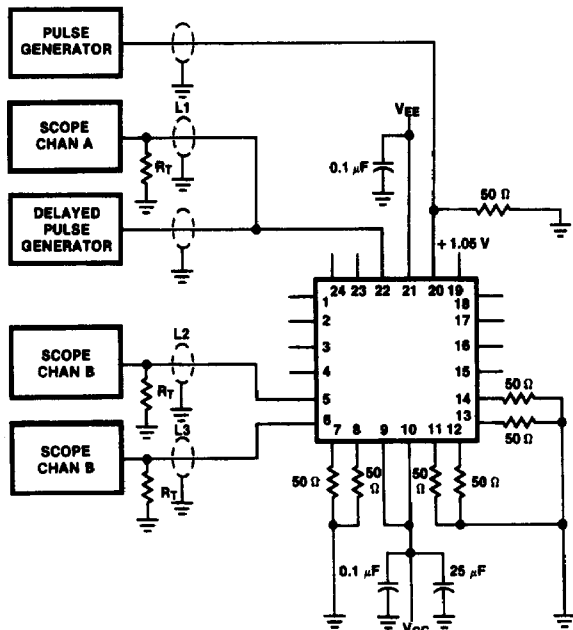
| Symbol | Parameter | Min | Typ | Max | Units | Conditions |
|----------------------|----------------------|------|------|------|---------|-------------------------|
| I_{IH} | Input HIGH Current | | | | | $V_{IN} = V_{IH} (Max)$ |
| | P_n, S_n | | | 180 | μA | |
| | \overline{CEP} | | | 200 | | |
| | MR | | | 240 | | |
| | D_3 | | | 280 | | |
| | CP | | | 390 | | |
| D_0/\overline{CET} | | | 530 | | | |
| I_{EE} | Power Supply Current | -283 | -195 | -136 | mA | Inputs Open |

Ceramic Dual-In-Line Package AC Characteristics
 $V_{EE} = -4.2V$ to $-4.8V$, $V_{CC} = V_{CCA} = GND$

| Symbol | Parameter | $T_C = 0^\circ C$ | | $T_C = +25^\circ C$ | | $T_C = +85^\circ C$ | | Units | Conditions |
|------------------------|--|-------------------|------|---------------------|------|---------------------|------|-------|-----------------|
| | | Min | Max | Min | Max | Min | Max | | |
| f_{shift} | Shift Frequency | 250 | | 250 | | 250 | | MHz | Figures 2 and 3 |
| t_{PLH} t_{PHL} | Propagation Delay CP to Q_n, \overline{Q}_n | 0.85 | 2.10 | 0.85 | 2.10 | 0.85 | 2.25 | ns | Figures 1 and 3 |
| t_{PLH} t_{PHL} | Propagation Delay CP to \overline{TC} | 1.90 | 4.80 | 1.90 | 4.60 | 1.90 | 5.20 | ns | |
| t_{PLH} t_{PHL} | Propagation Delay MR to Q_n, \overline{Q}_n | 1.20 | 2.95 | 1.35 | 2.95 | 1.20 | 3.10 | ns | Figures 1 and 4 |
| t_{PLH} t_{PHL} | Propagation Delay MR to TC | 2.20 | 4.80 | 2.20 | 4.80 | 2.20 | 5.30 | ns | |
| t_{PLH} t_{PHL} | Propagation Delay D_0/\overline{CET} to \overline{TC} | 1.40 | 3.20 | 1.40 | 3.20 | 1.40 | 3.50 | ns | Figures 1 and 5 |
| t_{PLH} t_{PHL} | Propagation Delay S_n to \overline{TC} | 0.90 | 3.80 | 1.00 | 3.80 | 1.00 | 4.30 | ns | |
| t_{TLH} t_{THL} | Transition Time 20% to 80%, 80% to 20% | 0.45 | 1.80 | 0.45 | 1.80 | 0.45 | 1.80 | ns | Figures 1 and 3 |
| t_s | Setup Time | | | | | | | ns | Figure 6 |
| | D_3 | 1.20 | | 1.20 | | 1.20 | | | |
| | P_n | 1.70 | | 1.70 | | 1.70 | | | |
| | $D_0/\overline{CET}, \overline{CEP}$ | 1.45 | | 1.45 | | 1.45 | | | |
| | S_n | 3.30 | | 3.30 | | 3.30 | | | |
| | MR (Release Time) | 2.60 | | 2.60 | | 2.60 | | | |
| t_h | Hold Time | | | | | | | ns | Figure 6 |
| | D_3 | 0.20 | | 0.20 | | 0.20 | | | |
| | P_n | 0.10 | | 0.10 | | 0.10 | | | |
| | $D_0/\overline{CET}, \overline{CEP}$ | 0.20 | | 0.20 | | 0.20 | | | |
| | S_n | -0.90 | | -0.90 | | -0.90 | | | |
| $t_{pw(H)}$ | Pulse Width HIGH CP, MR | 2.00 | | 2.00 | | 2.00 | | ns | Figures 3 and 4 |

Cerpak AC Electrical Characteristics $V_{EE} = -4.2V$ to $-4.8V$, $V_{CC} = V_{CCA} = GND$

| Symbol | Parameter | $T_C = 0^\circ C$ | | $T_C = +25^\circ C$ | | $T_C = +85^\circ C$ | | Units | Conditions |
|------------------------|---|--------------------------------------|------|--------------------------------------|------|--------------------------------------|------|-------|-----------------|
| | | Min | Max | Min | Max | Min | Max | | |
| f_{shift} | Shift Frequency | 250 | | 250 | | 250 | | MHz | Figures 2 and 3 |
| t_{PLH} t_{PHL} | Propagation Delay CP to Q_n , \overline{Q}_n | 0.85 | 1.90 | 0.85 | 1.90 | 0.85 | 2.05 | ns | Figures 1 and 3 |
| t_{PLH} t_{PHL} | Propagation Delay CP to \overline{TC} | 1.90 | 4.60 | 1.90 | 4.40 | 1.90 | 5.00 | ns | |
| t_{PLH} t_{PHL} | Propagation Delay MR to Q_n , \overline{Q}_n | 1.20 | 2.75 | 1.35 | 2.75 | 1.20 | 2.90 | ns | Figures 1 and 4 |
| t_{PLH} t_{PHL} | Propagation Delay MR to \overline{TC} | 2.20 | 4.60 | 2.20 | 4.60 | 2.20 | 5.10 | ns | |
| t_{PLH} t_{PHL} | Propagation Delay D_0/\overline{CET} to \overline{TC} | 1.40 | 3.00 | 1.40 | 3.00 | 1.40 | 3.30 | ns | Figures 1 and 5 |
| t_{PLH} t_{PHL} | Propagation Delay S_n to \overline{TC} | 0.90 | 3.60 | 1.00 | 3.60 | 1.00 | 4.10 | ns | |
| t_{TLH} t_{THL} | Transition Time 20% to 80%, 80% to 20% | 0.45 | 1.70 | 0.45 | 1.70 | 0.45 | 1.70 | ns | Figures 1 and 3 |
| t_s | Setup Time D_3 P_n D_0/\overline{CET} , \overline{CEP} S_n MR (Release Time) | 1.10 1.60 1.35 3.20 2.50 | | 1.10 1.60 1.35 3.20 2.50 | | 1.10 1.60 1.35 3.20 2.50 | | ns | Figure 6 |
| t_h | Hold Time D_3 P_n D_0/\overline{CET} , \overline{CEP} S_n | 0.10 0 0.10 -1.00 | | 0.10 0 0.10 -1.00 | | 0.10 0 0.10 -1.00 | | ns | Figure 6 |
| $t_{pw}(H)$ | Pulse Width HIGH CP, MR | 2.00 | | 2.00 | | 2.00 | | ns | Figures 3 and 4 |



Notes:
 $V_{CC}, V_{CCA} = +2V, V_{EE} = -2.5V$
 $L1, L2$ and $L3 =$ equal length 50Ω impedance lines
 $R_T = 50\Omega$ terminator internal to scope
 Decoupling $0.1 \mu F$ from GND to V_{CC} and V_{EE}
 All unused outputs are loaded with 50Ω to GND
 $C_L =$ Fixture and stray capacitance $\leq 3 pF$
 Pin numbers shown are for flatpak;
 for DIP see logic symbol

FIGURE 1. AC Test Circuit

TL/F/9855-6

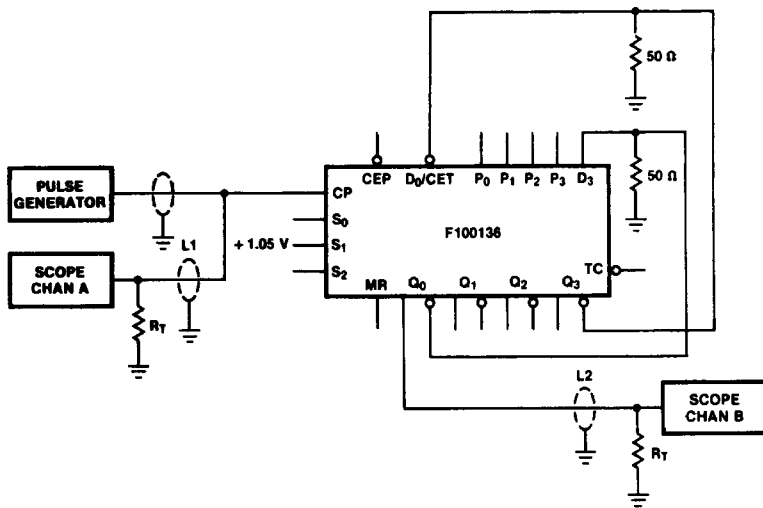


FIGURE 2. Shift Frequency Test Circuit (Shift Left)

TL/F/9855-7

Notes:
 For shift right mode, $+1.05V$ is applied at S_0 .
 The feedback path from output to input should be as short as possible.

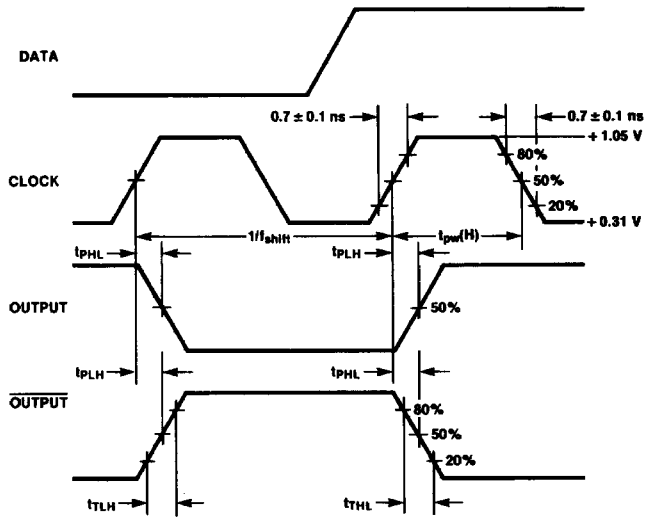


FIGURE 3. Propagation Delay (Clock) and Transition Times

TL/F/9855-8

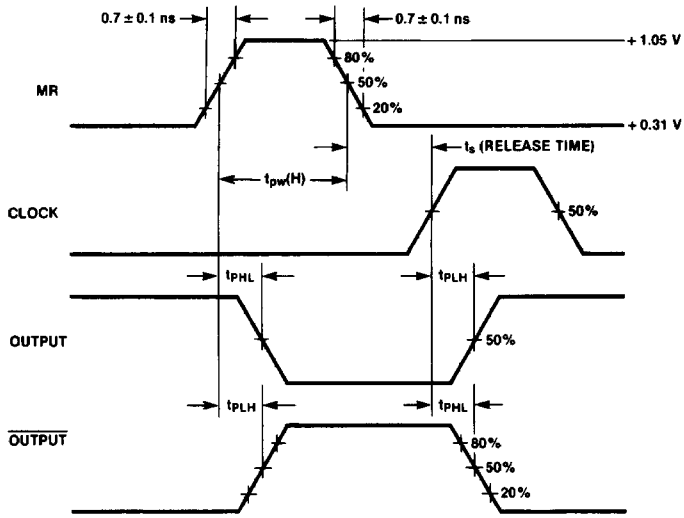


FIGURE 4. Propagation Delay (Reset)

TL/F/9855-9

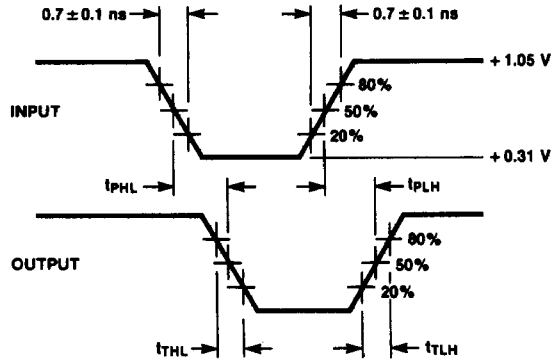
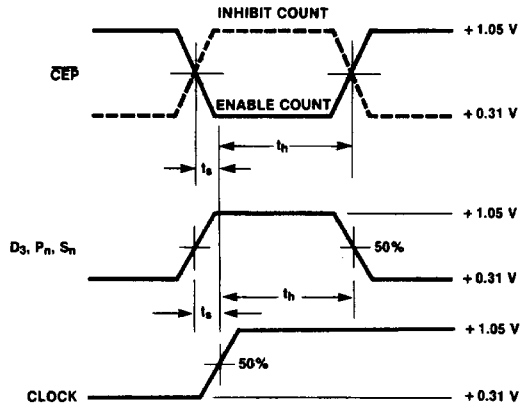


FIGURE 5. Propagation Delay (Serial Data, Selects)

TL/F/9855-10



TL/F/9855-11

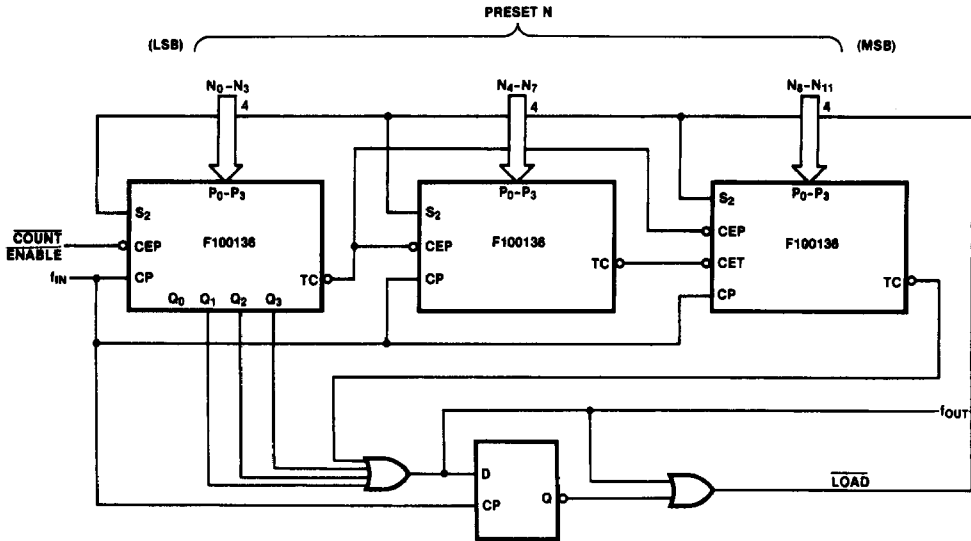
Notes:

- t_s is the minimum time before the transition of the clock that information must be present at the data input.
- t_h is the minimum time after the transition of the clock that information must remain unchanged at the data input.

FIGURE 6. Setup and Hold Time

Applications

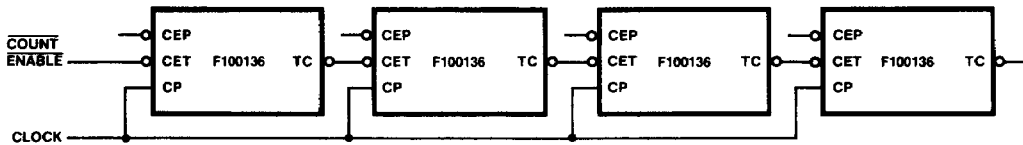
3-Stage Divider, Preset Count Down Mode



Note: If $S_0 = S_1 = S_2 = \text{LOW}$, then $T_C = \text{LOW}$

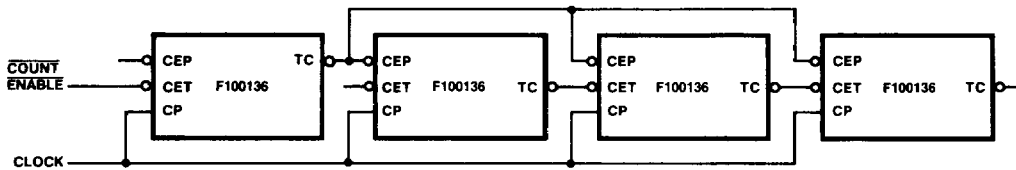
TL/F/9855-12

Slow Expansion Scheme



TL/F/9855-13

Fast Expansion Scheme



TL/F/9855-15