



Not Intended For New Designs
T-45-07

100181 4-Bit Binary/BCD Arithmetic Logic Unit

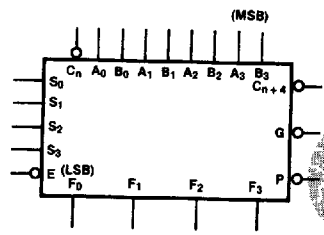
General Description

The 100181 performs eight logic operations and eight arithmetic operations on a pair of 4-bit words. The operating mode is determined by signals applied to the Select (S_n) inputs, as shown in the Function Select table. In addition to performing binary arithmetic, the circuit contains the necessary correction logic to perform BCD addition and subtraction. Output latches are provided to reduce overall package count and increase system operating speed. When the latches are not required, leaving the Enable (\bar{E}) input LOW makes the latches transparent.

The circuit uses internal lookahead carry to minimize delay to the F_n outputs and to the ripple Carry output, \bar{C}_{n+4} . Group Carry Lookahead Propagate (\bar{P}) and Generate (\bar{G}) outputs are also provided, which are independent of the Carry input \bar{C}_n . The \bar{P} output goes LOW when a plus operation produces fifteen (nine for BCD) or when a minus operation produces zero. Similarly, \bar{G} goes LOW when the sum of A and B is greater than fifteen (nine for BCD) in a plus mode, or when their difference is greater than zero in a minus mode. All inputs have 50 k Ω pull-down resistors.

Ordering Code: See Section 6

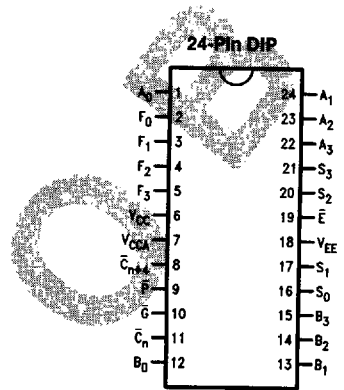
Logic Symbol



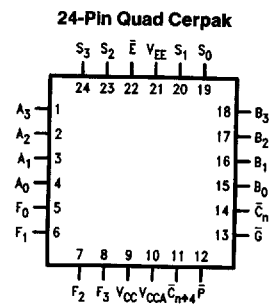
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| Pin Names | Description |
|-----------------|---|
| A_0-A_3 | Word A Operand Inputs |
| B_0-B_3 | Word B Operand Inputs |
| \bar{C}_n | Carry Input (Active LOW) |
| S_0-S_3 | Function Select Inputs |
| \bar{E} | Latch Enable Input (Active LOW) |
| \bar{P} | Carry Lookahead Propagate Output (Active LOW) |
| \bar{G} | Carry Lookahead Generate Output (Active LOW) |
| \bar{C}_{n+4} | Carry Output |
| F_0-F_3 | Function Outputs |

Connection Diagrams



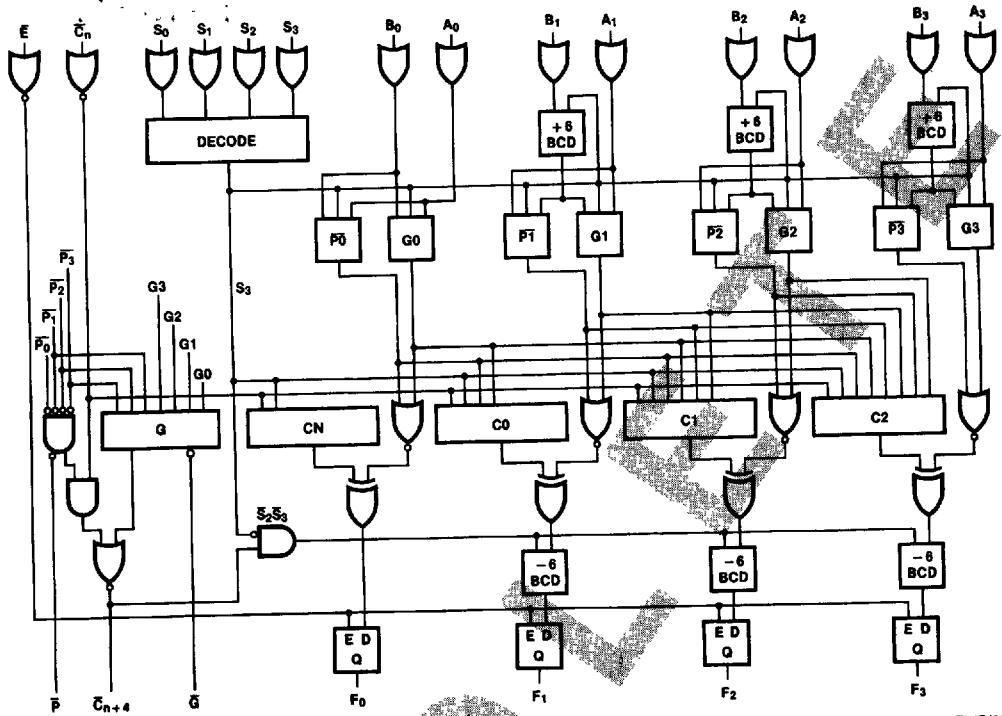
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TL/F/9873-2

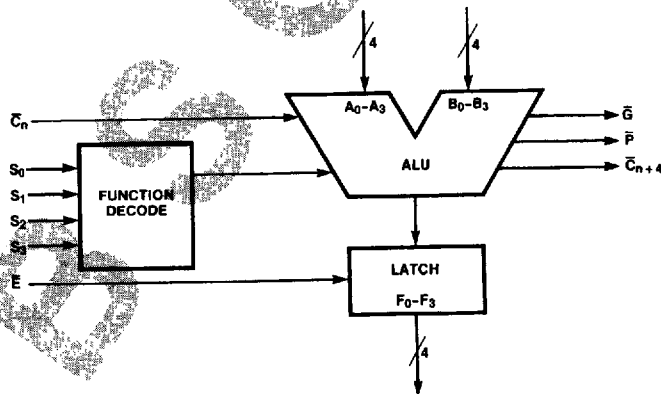
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Logic Diagram



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Block Diagram



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Functional Description

There are two modes of operation: Arithmetic and Logic. The S_3 input controls these two modes:

$S_3 = \text{LOW}$ for Arithmetic mode

$S_3 = \text{HIGH}$ for Logic mode

The arithmetic mode includes decimal and binary arithmetic operations. S_2 is the control input: with $S_3 = \text{LOW}$,

$S_2 = \text{LOW}$ for Decimal Arithmetic (BCD)

$S_2 = \text{HIGH}$ for Binary Arithmetic

DECIMAL ARITHMETIC OPERATION

Addition

$F = A$ plus B plus C_n . Arguments A and B are directly applied to the inputs. The circuit automatically performs the "+6" and "-6" logic correction internally.

Subtraction

$F = A$ minus B plus C_n . Arguments A and B are directly applied to the inputs. The circuit automatically takes the nines complement of B and adds "+6". A "-6" adjustment is made if the subtraction algorithm calls for it. If there is a carry out, the result is a positive number. With no carry out, the result is a negative number expressed in its nines complement form. Therefore, to perform a subtraction with

results in the tens complement form, an initial carry should be forced into the lowest order bit, i.e., set $C_n = \text{LOW}$.

(tens complement of B) = (nines complement of B) + 1

$F = B$ minus A plus C_n . Operation is similar to and results are the same as $F = A$ minus B plus C_n .

BINARY ARITHMETIC OPERATION

Addition

$F = A$ minus B plus C_n . Arguments A and B are directly applied to the inputs.

Subtraction

$F = A$ minus B plus C_n . Arguments A and B are directly applied to the inputs. The circuit automatically takes the ones complement of B (by inverting B internally). If there is a carry out the result is a positive number. With no carry out, the result is a negative number expressed in its ones complement form. Therefore, to perform a subtraction with results in the twos complement form, an initial carry should be forced into the lowest order bit, i.e., set $C_n = \text{LOW}$.

(twos complement of B) = (ones complement of B) + 1

$F = B$ minus A plus C_n . Operation is similar and results are the same as $F = A$ minus B plus C_n .

Function Table

| S_3 | S_2 | S_1 | S_0 | F_n Function | G_n ($n = 0$ to 3) | P_n ($n = 0$ to 3) | Outputs | | |
|-------|-------|-------|-------|---|--------------------------|--------------------------|-----------|-------------|-----------|
| | | | | | | | C_{n+4} | \bar{G} | \bar{P} |
| L | L | L | L | $F_n = A$ plus B plus C_n (BCD) | $A_n D_n$ | $A_n + D_n$ | C_{n+4} | \bar{G} | \bar{P} |
| L | L | L | H | $F_n = A$ minus B plus C_n (BCD) | $A_n \bar{B}_n$ | $A_n + \bar{B}_n$ | C_{n+4} | \bar{G} | \bar{P} |
| L | L | H | L | $F_n = B$ minus A plus C_n (BCD) | $\bar{A}_n B_n$ | $\bar{A}_n + B_n$ | C_{n+4} | \bar{G} | \bar{P} |
| L | L | H | H | $F_n = 0$ minus B plus C_n (BCD) | L | B_n | C_{n+4} | H | \bar{P} |
| L | H | L | L | $F_n = A$ plus B plus C_n (Binary) | $A_n B_n$ | $A_n + B_n$ | C_{n+4} | \bar{G} | \bar{P} |
| L | H | L | H | $F_n = A$ minus B plus C_n (Binary) | $A_n \bar{B}_n$ | $A_n + \bar{B}_n$ | C_{n+4} | \bar{G} | \bar{P} |
| L | H | H | L | $F_n = B$ minus A plus C_n (Binary) | $\bar{A}_n B_n$ | $\bar{A}_n + B_n$ | C_{n+4} | \bar{G} | \bar{P} |
| L | H | H | H | $F_n = 0$ minus B plus C_n (Binary) | L | B_n | C_{n+4} | H | \bar{P} |
| H | L | L | L | $F_n = A_n B_n + \bar{A}_n \bar{B}_n$ | $A_n B_n$ | $A_n + B_n$ | C_{n+4} | \bar{G} | \bar{P} |
| H | L | L | H | $F_n = A_n \bar{B}_n + \bar{A}_n B_n$ | $A_n \bar{B}_n$ | $A_n + \bar{B}_n$ | C_{n+4} | \bar{G} | \bar{P} |
| H | L | H | L | $F_n = A_n + B_n$ | A_n | B_n | C_{n+4} | \bar{G}_x | \bar{P} |
| H | L | H | H | $F_n = \bar{A}_n$ | \bar{A}_n | H | C_{n+4} | \bar{G} | L |
| H | H | L | L | $F_n = \bar{B}_n$ | L | B_n | C_{n+4} | H | \bar{P} |
| H | H | L | H | $F_n = B_n$ | L | \bar{B}_n | C_{n+4} | H | \bar{P} |
| H | H | H | L | $F_n = A_n B_n$ | L | $\bar{A}_n + \bar{B}_n$ | C_{n+4} | H | \bar{P} |
| H | H | H | H | $F_n = \text{LOW}$ | L | H | C_n | H | L |

H = HIGH Voltage Level

L = LOW Voltage Level

$$\bar{P} = \bar{P}_0 + \bar{P}_1 + \bar{P}_2 + \bar{P}_3$$

$$\bar{G} = \bar{G}_3 + P_3 G_2 + P_3 P_2 G_1 + P_3 P_2 P_1 G_0$$

$$C_{n+4} = \bar{G} \cdot (\bar{P} + C_n)$$

Arithmetic Operations

$$F_n = G_n + \bar{P}_n \oplus C_i, \quad i = 0 \text{ to } 3$$

Logic Operations

$$F_n = G_n + \bar{P}_n$$

Internal Equations for Carry Lookahead

($i = 0, 1, 2, 3$)

$$C_0 = C_n + S_3$$

$$C_1 = G_0 + P_0 C_n + S_3$$

$$C_2 = G_1 + P_1 G_0 + P_1 P_0 C_n + S_3$$

$$C_3 = G_2 + P_2 G_1 + P_2 P_1 G_0 + P_2 P_1 P_0 C_n + S_3$$

Internal Equations for +6 Logic

$$D_0 = B_0$$

$$D_1 = \bar{B}_1$$

$$D_2 = B_1 B_2 + \bar{B}_1 \bar{B}_2$$

$$D_3 = B_1 + B_2 + B_3$$

$$\bar{G}_x = \bar{G}_3 P_3 + P_3 G_2 + P_3 P_2 G_1 + P_3 P_2 P_1 G_0$$

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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°C
 Maximum Junction Temperature (T_J) +150°C

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

DC Electrical Characteristics

V_{EE} = -4.5V, V_{CC} = V_{CCA} = GND, T_C = 0°C to +85°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} (Max) or V _{IL} (Min) | Loading with 50Ω to -2.0V |
| V _{OL} | Output LOW Voltage | -1810 | -1705 | -1620 | | | |
| V _{OH} C | Output HIGH Voltage | -1035 | | | mV | V _{IN} = V _{IH} (Min) or V _{IL} (Max) | Loading with 50Ω to -2.0V |
| V _{OL} C | 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} (Min) | |

DC Electrical Characteristics

V_{EE} = -4.2V, V_{CC} = V_{CCA} = GND, T_C = 0°C to +85°C (Note 3)

| Symbol | Parameter | Min | Typ | Max | Units | Conditions (Note 4) | |
|-------------------|---------------------|-------|-----|-------|-------|--|---------------------------|
| V _{OH} | Output HIGH Voltage | -1020 | | -870 | mV | V _{IN} = V _{IH} (Max) or V _{IL} (Min) | Loading with 50Ω to -2.0V |
| V _{OL} | Output LOW Voltage | -1810 | | -1605 | | | |
| V _{OH} C | Output HIGH Voltage | -1030 | | | mV | V _{IN} = V _{IH} (Min) or V _{IL} (Max) | Loading with 50Ω to -2.0V |
| V _{OL} C | 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} (Min) | |

DC Electrical Characteristics

V_{EE} = -4.8V, V_{CC} = V_{CCA} = GND, T_C = 0°C to +85°C (Note 3)

| Symbol | Parameter | Min | Typ | Max | Units | Conditions (Note 4) | |
|-------------------|---------------------|-------|-----|-------|-------|--|---------------------------|
| V _{OH} | Output HIGH Voltage | -1035 | | -880 | mV | V _{IN} = V _{IH} (Max) or V _{IL} (Min) | Loading with 50Ω to -2.0V |
| V _{OL} | Output LOW Voltage | -1830 | | -1620 | | | |
| V _{OH} C | Output HIGH Voltage | -1045 | | | mV | V _{IN} = V _{IH} (Min) or V _{IL} (Max) | Loading with 50Ω to -2.0V |
| V _{OL} C | 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} (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 S_n, \bar{E} All Others | | | 350 250 | μA | $V_{IN} = V_{IH} (Max)$ |
| I_{EE} | Power Supply Current | -300 | -210 | -130 | mA | Inputs Open |

Ceramic Dual-In-Line Package 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 | | |
| t_{PLH} t_{PHL} | Propagation Delay A_n, B_n to F_n | 2.00 | 6.90 | 2.10 | 6.80 | 2.30 | 7.40 | ns | Figures 1 and 2 |
| t_{PLH} t_{PHL} | Propagation Delay A_n, B_n to \bar{P}, \bar{G} | 1.40 | 4.70 | 1.40 | 4.40 | 1.40 | 4.70 | ns | |
| t_{PLH} t_{PHL} | Propagation Delay A_n, B_n to \bar{C}_{n+4} | 2.00 | 6.50 | 2.00 | 6.50 | 2.10 | 6.80 | ns | |
| t_{PLH} t_{PHL} | Propagation Delay \bar{C}_n to F_n | 1.60 | 5.10 | 1.60 | 5.20 | 1.60 | 5.50 | ns | Figures 1 and 2 |
| t_{PLH} t_{PHL} | Propagation Delay \bar{C}_n to \bar{C}_{n+4} | 1.30 | 3.00 | 1.40 | 3.00 | 1.40 | 3.10 | ns | |
| t_{PLH} t_{PHL} | Propagation Delay S_n to F_n | 1.40 | 8.80 | 1.50 | 8.60 | 1.50 | 9.00 | ns | Figures 1 and 2 |
| t_{PLH} t_{PHL} | Propagation Delay S_n to \bar{P}, \bar{G} | 1.70 | 7.40 | 2.00 | 5.90 | 2.00 | 6.50 | ns | |
| t_{PLH} t_{PHL} | Propagation Delay S_n to \bar{C}_{n+4} | 2.70 | 10.10 | 2.80 | 8.50 | 2.90 | 8.70 | ns | |
| t_{PLH} t_{PHL} | Propagation Delay \bar{E} to F_n | 1.00 | 3.40 | 0.90 | 3.60 | 1.10 | 3.80 | ns | Figures 1 and 2 |
| t_{TLH} t_{THL} | Transition Time 20% to 80%, 80% to 20% | 0.45 | 2.70 | 0.45 | 2.60 | 0.45 | 2.70 | ns | Figures 1 and 2 |
| t_s | Setup Time A_n, B_n S_n \bar{C}_n | 7.60 8.70 4.80 | | 7.60 8.50 5.00 | | 8.10 9.60 5.30 | | ns | Figure 3 |
| t_h | Hold Time A_n, B_n S_n \bar{C}_n | 0.10 0.60 0.60 | | 0.10 0.60 0.60 | | 0.10 0.60 0.60 | | ns | |
| $t_{pw(L)}$ | Pulse Width LOW E | 2.00 | | 2.00 | | 2.00 | | ns | |

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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 | | |
| t_{PLH} t_{PHL} | Propagation Delay A_n, B_n to F_n | 2.00 | 6.70 | 2.10 | 6.60 | 2.30 | 7.20 | ns | Figures 1 and 2 |
| t_{PLH} t_{PHL} | Propagation Delay A_n, B_n to \bar{F}, \bar{G} | 1.40 | 4.50 | 1.40 | 4.20 | 1.40 | 4.50 | ns | |
| t_{PLH} t_{PHL} | Propagation Delay A_n, B_n to \bar{C}_{n+4} | 2.00 | 6.30 | 2.00 | 6.30 | 2.10 | 6.60 | ns | Figures 1 and 2 |
| t_{PLH} t_{PHL} | Propagation Delay \bar{C}_n to F_n | 1.60 | 4.90 | 1.60 | 5.00 | 1.60 | 5.30 | ns | |
| t_{PLH} t_{PHL} | Propagation Delay \bar{C}_n to \bar{C}_{n+4} | 1.30 | 2.80 | 1.40 | 2.80 | 1.40 | 2.90 | ns | Figures 1 and 2 |
| t_{PLH} t_{PHL} | Propagation Delay S_n to F_n | 1.40 | 8.60 | 1.50 | 8.40 | 1.50 | 8.80 | ns | |
| t_{PLH} t_{PHL} | Propagation Delay S_n to \bar{F}, \bar{G} | 1.70 | 7.20 | 2.00 | 5.70 | 2.00 | 6.30 | ns | Figures 1 and 2 |
| t_{PLH} t_{PHL} | Propagation Delay S_n to \bar{C}_{n+4} | 2.70 | 9.90 | 2.80 | 8.30 | 2.90 | 8.50 | ns | |
| t_{PLH} t_{PHL} | Propagation Delay E to F_n | 1.00 | 3.20 | 0.90 | 3.40 | 1.10 | 3.60 | ns | Figures 1 and 2 |
| t_{TLH} t_{THL} | Transition Time 20% to 80%, 80% to 20% | 0.45 | 2.60 | 0.45 | 2.50 | 0.45 | 2.60 | ns | Figures 1 and 2 |
| t_s | Setup Time A_n, B_n S_n \bar{C}_n | 7.50 | | 7.50 | | 8.00 | | ns | Figure 3 |
| | | 8.60 | | 8.40 | | 9.50 | | | |
| | | 4.70 | | 4.90 | | 5.20 | | | |
| t_h | Hold Time A_n, B_n S_n \bar{C}_n | 0 | | 0 | | 0 | | ns | |
| | | 0.50 | | 0.50 | | 0.50 | | | |
| | | 0.50 | | 0.50 | | 0.50 | | | |
| $t_{pw(L)}$ | Pulse Width LOW E | 2.00 | | 2.00 | | 2.00 | | ns | Figure 2 |

