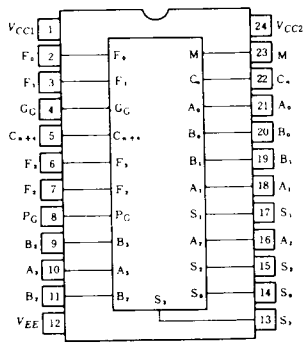
4-bit Arithmetic Logic Unit/Function Generator

The HD10181 is a high-speed arithmetic logic unit capable of performing 16 logic operations and 16 arithmetic operations on two four-bit words. Full internal carry is incorporated for ripple through operation. Arithmetic logic operations are selected by applying the appropriate binary word to the select inputs (S0 through S3) as indicated in the table of arithmetic/logic functions. Group carry propagate (P_G) and carry generate (G_G) are provided to allow fast operations on very long words using a second order look-ahead. The internal carry is enabled by applying a low level voltage to the mode control input (M).

■ PIN ARRANGEMENT



(Top View)

■ FUNCTIONS OF PIN NUMBER

Pin No.	Function
A_3, A_2, A_1, A_0	Word A Inputs
B_3, B_2, B_1, B_0	Word B Inputs
S_3, S_2, S_1, S_0	Function-Select Inputs
C_n	Ripple-Carry Input
M	Mode Control Input
F_3, F_2, F_1, F_0	Function Outputs
P_G	Carry Propagate Output
C_{n+4}	Ripple-Carry Output
G_G	Carry-Generate Output

■ FUNCTION TABLE

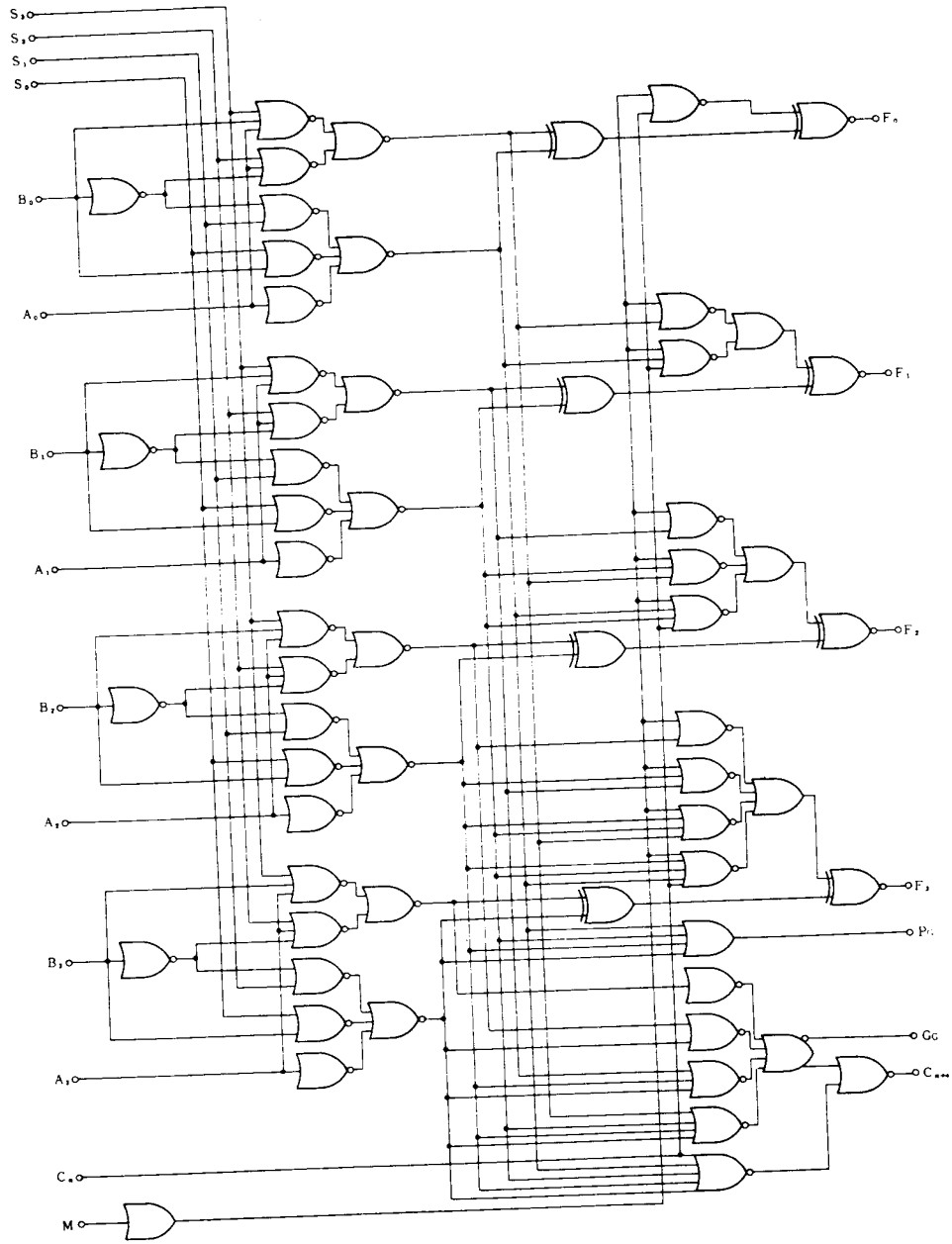
1. Positive Logic

Function Select				Logic Function (M = "H")	Arithmetic Operation (M = "L", Cn = "L")
S_3	S_2	S_1	S_0	F	F
L	L	L	L	$F = \overline{A}$	$F = A + 0$
L	L	L	H	$F = \overline{A} + \overline{B}$	$F = A + (A \cdot \overline{B})$
L	L	H	L	$F = \overline{A} + B$	$F = A + (A \cdot B)$
L	L	H	H	F = "H"	$F = A \times 2$
L	H	L	L	$F = \overline{A \cdot \overline{B}}$	$F = (A + B) + 0$
L	H	L	H	$F = \overline{B}$	$F = (A + B) + (A \cdot \overline{B})$
L	H	H	L	$F = \overline{A \oplus B}$	$F = A + B$
L	H	H	H	$F = A + \overline{B}$	$F = A + (A + B)$
H	L	L	L	$F = \overline{A} \cdot B$	$F = (A + \overline{B}) + 0$
H	L	L	H	$F = A + B$	$F = A - B - 1$
H	L	H	L	$F = B$	$F = (A + \overline{B}) + (A \cdot B)$
H	L	H	H	$F = A + B$	$F = (A + \overline{B}) + A$
H	H	L	L	F = "L"	F = −1 (two's complement)
H	H	L	H	$F = A \cdot \overline{B}$	$F = (A \cdot \overline{B}) - 1$
H	H	H	L	$F = A \cdot B$	$F = (A \cdot B) - 1$
H	H	H	H	$F = A$	$F = A - 1$

2. Negative Logic

Function Select				Logic Function (M = "H")	Arithmetic Operation (M = "L", Cn = "H")
S_3	S_2	S_1	S_0	F	F
L	L	L	L	$F = \overline{A}$	$F = A - 1$
L	L	L	H	$F = \overline{A + \overline{B}}$	$F = A + (A + \overline{B})$
L	L	H	L	$F = \overline{A} \cdot B$	$F = A + (A + B)$
L	L	H	H	F = "L"	$F = A \times 2$
L	H	L	L	$F = \overline{A \cdot \overline{B}}$	$F = (A \cdot B) - 1$
L	H	L	H	$F = \overline{B}$	$F = (A \cdot B) + (A + \overline{B})$
L	H	H	L	$F = A \oplus B$	$F = A + B$
L	H	H	H	$F = A \cdot \overline{B}$	$F = A + (A \cdot B)$
H	L	L	L	$F = \overline{A} + B$	$F = (A \cdot \overline{B}) - 0$
H	L	L	H	$F = \overline{A \oplus B}$	$F = A - B - 1$
H	L	H	L	$F = B$	$F = (A \cdot \overline{B}) + (A + B)$
H	L	H	H	$F = A \cdot B$	$F = (A \cdot \overline{B}) + A$
H	H	L	L	F = "H"	F = −1 (two's complement)
H	H	L	H	$F = A + \overline{B}$	$F = (A + \overline{B}) + 0$
H	H	H	L	$F = A + B$	$F = (A + B) + 0$
H	H	H	H	$F = A$	$F = A + 0$

■ BLOCK DIAGRAM



HITACHI

■DC CHARACTERISTICS ($V_{EE}=-5.2V$, $Ta=-30\sim+85°C$)

Item	Symbol	Test Condition			min	typ	max	Unit
Supply Current	I_{EE}			25°C	—	—	145	mA
Input Current	I_{IH}	$V_{IH}=-0.810V$	B_0, B_1, B_2, B_3	25°C	—	—	245	μA
			A_0, A_1, A_2, A_3		—	—	220	
			S_3, M		—	—	200	
			S_0, S_1, S_2		—	—	265	
			C_n		—	—	290	
	I_{IL}	$V_{IL}=-1.850V$		25°C	0.5	—	—	μA
Output Voltage	V_{OH}	$V_{IH}=-0.890V$, $V_{IL}=-1.890V$		−30°C	−1.060	—	−0.890	V
		$V_{IH}=-0.810V$, $V_{IL}=-1.850V$		25°C	−0.960	—	−0.810	
		$V_{IH}=-0.700V$, $V_{IL}=-1.825V$		85°C	−0.890	—	−0.700	
	V_{OL}	$V_{IH}=-0.890V$, $V_{IL}=-1.890V$		−30°C	−2.000	—	−1.675	V
		$V_{IH}=-0.810V$, $V_{IL}=-1.850V$		25°C	−1.990	—	−1.650	
		$V_{IH}=-0.700V$, $V_{IL}=-1.825V$		85°C	−1.920	—	−1.615	
Output Threshold Voltage	V_{OHA}	$V_{IHA}=-1.205V$, $V_{ILA}=-1.500V$		−30°C	−1.080	—	—	V
		$V_{IHA}=-1.105V$, $V_{ILA}=-1.475V$		25°C	−0.980	—	—	
		$V_{IHA}=-1.035V$, $V_{ILA}=-1.440V$		85°C	−0.910	—	—	
	V_{OLA}	$V_{IHA}=-1.205V$, $V_{ILA}=-1.500V$		−30°C	—	—	−1.655	V
		$V_{IHA}=-1.105V$, $V_{ILA}=-1.475V$		25°C	—	—	−1.630	
		$V_{IHA}=-1.035V$, $V_{ILA}=-1.440V$		85°C	—	—	−1.595	

■AC CHARACTERISTICS ($V_{EE}=-3.2V$, $V_{CC}=+2.0V$, $Ta=-30\sim+85°C$, $R_L=50\Omega$)

Item	Symbol	Input	Output	High level input*	Ta	min	typ	max	Unit
Propagation Delay Time	t_{PLH}	C_n	C_{n+1}	A_0, A_1, A_2, A_3	−30°C	1.0	—	5.1	ns
					25°C	1.1	3.1	5.0	
					85°C	1.1	—	5.4	
	t_{PHL}				−30°C	1.0	—	5.1	
					25°C	1.1	3.1	5.0	
					85°C	1.1	—	5.4	
Rise Time	t_{TLH}				−30°C	1.0	—	3.2	
					25°C	1.0	2.0	3.0	
					85°C	1.0	—	3.2	
Fall Time	t_{THL}				−30°C	1.0	—	3.2	
					25°C	1.0	2.0	3.0	
					85°C	1.0	—	3.2	
Propagation Delay Time	t_{PLH}	C_n	F_1	A_0	−30°C	1.7	—	7.2	
					25°C	2.0	4.5	7.0	
					85°C	2.0	—	7.5	
	t_{PHL}				−30°C	1.7	—	7.2	
					25°C	2.0	4.5	7.0	
					85°C	2.0	—	7.5	
Rise Time	t_{TLH}				−30°C	1.3	—	5.3	
					25°C	1.5	3.0	5.0	
					85°C	1.5	—	5.3	
Fall Time	t_{THL}				−30°C	1.3	—	5.3	
					25°C	1.5	3.0	5.0	
					85°C	1.5	—	5.3	

(to be continued)

■AC CHARACTERISTICS (V_{EE} = −3.2V, V_{CC} = +2.0V, Ta = −30 ~ +85°C, R_L = 50Ω)

Item	Symbol	Input	Output	High level input*	Ta	min	typ	max	Unit
Propagation Delay Time	t_{PLH}	A_1	F_1	—	−30°C	2.6	—	10.4	ns
					25°C	3.0	6.5	10.0	
					85°C	3.0	—	10.8	
	t_{PHL}				−30°C	2.6	—	10.4	
					25°C	3.0	6.5	10.0	
					85°C	3.0	—	10.8	
Rise Time	t_{TLH}				−30°C	1.3	—	5.4	
					25°C	1.5	3.0	5.0	
					85°C	1.5	—	5.3	
Fall Time	t_{THL}				−30°C	1.3	—	5.4	
					25°C	1.5	3.0	5.0	
					85°C	1.5	—	5.3	
Propagation Delay Time	t_{PLH}	A_1	P_G	S_0, S_3	−30°C	1.6	—	7.0	
					25°C	2.0	5.0	6.5	
					85°C	2.0	—	7.0	
	t_{PHL}				−30°C	1.6	—	7.0	
					25°C	2.0	5.0	6.5	
					85°C	2.0	—	7.0	
Rise Time	t_{TLH}				−30°C	0.8	—	3.7	
					25°C	1.1	2.0	3.5	
					85°C	1.1	—	3.8	
Fall Time	t_{THL}				−30°C	0.8	—	3.7	
					25°C	1.1	2.0	3.5	
					85°C	1.1	—	3.8	
Propagation Delay Time	t_{PLH}	A_1	G_G	A_0, A_2, A_3, C_n	−30°C	1.1	—	7.4	
					25°C	2.0	4.5	7.0	
					85°C	1.3	—	7.7	
	t_{PHL}				−30°C	1.1	—	7.4	
					25°C	2.0	4.5	7.0	
					85°C	1.3	—	7.7	
Rise Time	t_{TLH}				−30°C	1.2	—	5.1	
					25°C	1.5	4.0	5.0	
					85°C	1.2	—	5.3	
Fall Time	t_{THL}				−30°C	1.2	—	5.1	
					25°C	1.5	4.0	5.0	
					85°C	1.2	—	5.3	
Propagation Delay Time	t_{PLH}	A_1	C_{n+4}	A_0, A_2, A_3, C_n	−30°C	1.7	—	7.3	
					25°C	2.0	5.0	7.0	
					85°C	2.0	—	7.8	
	t_{PHL}				−30°C	1.7	—	7.3	
					25°C	2.0	5.0	7.0	
					85°C	2.0	—	7.8	
Rise Time	t_{TLH}				−30°C	1.0	—	3.1	
					25°C	1.0	2.0	3.0	
					85°C	1.0	—	3.2	
Fall Time	t_{THL}				−30°C	1.0	—	3.1	
					25°C	1.0	2.0	3.0	
					85°C	1.0	—	3.2	

(to be continued)

■AC CHARACTERISTICS ($V_{EE}=-3.2V$, $V_{CC}=+2.0V$, $Ta=-30\sim+85°C$, $R_L=50\,\Omega$)

Item	Symbol	Input	Output	High level input*	Ta	min	typ	max	Unit
Propagation Delay Time	t_{PLH}	B_1	F_1	S_3, C_n	−30°C	2.7	—	11.3	ns
					25°C	3.0	8.0	11.0	
					85°C	3.0	—	11.9	
Rise Time	t_{TLH}				−30°C	1.2	—	5.3	
					25°C	1.5	3.5	5.0	
					85°C	1.5	—	5.3	
Fall Time	t_{THL}				−30°C	1.2	—	5.3	
					25°C	1.5	3.5	5.0	
					85°C	1.5	—	5.3	
Propagation Delay Time	t_{PLH}	B_1	P_G	S_0, S_3	−30°C	1.6	—	7.7	
					25°C	2.0	6.0	7.5	
					85°C	2.0	—	8.0	
	t_{PHL}				−30°C	1.6	—	7.7	
					25°C	2.0	6.0	7.5	
					85°C	2.0	—	8.0	
Rise Time	t_{TLH}				−30°C	1.0	—	3.6	
					25°C	1.1	2.0	3.5	
					85°C	1.1	—	3.9	
Fall Time	t_{THL}				−30°C	1.0	—	3.6	
					25°C	1.1	2.0	3.5	
					85°C	1.1	—	3.9	
Propagation Delay Time	t_{PLH}	B_1	G_G	S_1, C_n	−30°C	1.7	—	8.2	
					25°C	2.0	6.0	8.0	
					85°C	2.0	—	8.6	
	t_{PHL}				−30°C	1.7	—	8.2	
					25°C	2.0	6.0	8.0	
					85°C	2.0	—	8.6	
Rise Time	t_{TLH}				−30°C	1.4	—	5.2	
					25°C	1.5	3.0	5.0	
					85°C	1.2	—	5.4	
Fall Time	t_{THL}				−30°C	1.4	—	5.2	
					25°C	1.5	3.0	5.0	
					85°C	1.2	—	5.4	
Propagation Delay Time	t_{PLH}	B_1	C_{n+1}	S_3, C_n	−30°C	1.8	—	8.2	
					25°C	2.0	6.0	8.0	
					85°C	2.0	—	8.7	
	t_{PHL}				−30°C	1.8	—	8.2	
					25°C	2.0	6.0	8.0	
					85°C	2.0	—	8.7	
Rise Time	t_{TLH}				−30°C	0.9	—	3.1	
					25°C	1.0	2.0	3.0	
					85°C	1.0	—	3.2	
Fall Time	t_{THL}				−30°C	0.9	—	3.1	
					25°C	1.0	2.0	3.0	
					85°C	1.0	—	3.2	

(to be continued)

■AC CHARACTERISTICS ($V_{EE}=-3.2V$, $V_{CC}=+2.0V$, $Ta=-30\sim+85°C$, $R_L=50\Omega$)

Item	Symbol	Input	Output	High level input*	Ta	min	typ	max	Unit
Propagation Delay Time	t_{PLH}	M	F_1	—	−30°C	2.4	—	10.3	ns
					25°C	3.0	6.5	10.0	
					85°C	3.0	—	10.8	
	t_{PHL}				−30°C	2.4	—	10.3	
					25°C	3.0	6.5	10.0	
					85°C	3.0	—	10.8	
Rise Time	t_{TLH}				−30°C	1.1	—	5.1	
					25°C	1.5	4.0	5.0	
					85°C	1.5	—	5.3	
Fall Time	t_{THL}				−30°C	1.1	—	5.1	
					25°C	1.5	4.0	5.0	
					85°C	1.5	—	5.3	
Propagation Delay Time	t_{PLH}	S_1	F_1	A_1, B_1	−30°C	2.5	—	10.7	
					25°C	3.0	6.5	10.0	
					85°C	3.0	—	10.8	
	t_{PHL}				−30°C	2.5	—	10.7	
					25°C	3.0	6.5	10.0	
					85°C	3.0	—	10.8	
Rise Time	t_{TLH}				−30°C	1.0	—	5.4	
					25°C	1.5	3.0	5.0	
					85°C	1.5	—	5.4	
Fall Time	t_{THL}				−30°C	1.0	—	5.4	
					25°C	1.5	3.0	5.0	
					85°C	1.5	—	5.4	
Propagation Delay Time	t_{PLH}	S_1	P_0	A_3, B_3	−30°C	1.7	—	8.3	
					25°C	2.0	6.0	8.0	
					85°C	2.0	—	8.4	
	t_{PHL}				−30°C	1.7	—	8.3	
					25°C	2.0	6.0	8.0	
					85°C	2.0	—	8.4	
Rise Time	t_{TLH}				−30°C	0.8	—	5.1	
					25°C	1.1	3.0	5.0	
					85°C	1.1	—	5.2	
Fall Time	t_{THL}				−30°C	0.8	—	5.1	
					25°C	1.1	3.0	5.0	
					85°C	1.1	—	5.2	
Propagation Delay Time	t_{PLH}	S_1	C_{0-4}	A_3, B_3	−30°C	1.6	—	9.3	
					25°C	2.0	6.0	9.0	
					85°C	2.0	—	9.9	
	t_{PHL}				−30°C	1.6	—	9.3	
					25°C	2.0	6.0	9.0	
					85°C	2.0	—	9.9	
Rise Time	t_{TLH}				−30°C	0.9	—	5.3	
					25°C	1.1	3.0	5.0	
					85°C	1.0	—	5.2	
Fall Time	t_{THL}				−30°C	0.9	—	5.3	
					25°C	1.1	3.0	5.0	
					85°C	1.0	—	5.2	

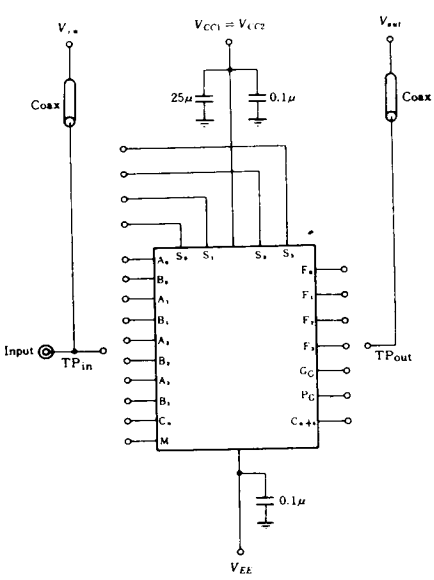
(to be continued)

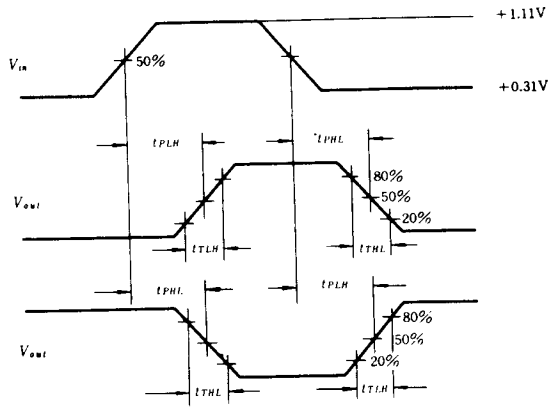
■AC CHARACTERISTICS ($V_{EE}=-3.2V$, $V_{CC}=+2.0V$, $Ta=-30\sim+85°C$, $R_L=50\Omega$)

Item	Symbol	Input	Output	High level input*	Ta	min	typ	max	Unit
Propagation Delay Time	t_{PLH}	S_1	G_G	A_3, B_3	−30°C	1.5	—	9.6	ns
					25°C	2.0	6.0	9.0	
					85°C	1.9	—	9.7	
	t_{PHL}				−30°C	1.5	—	9.6	
					25°C	2.0	6.0	9.0	
					85°C	1.9	—	9.7	
Rise Time	t_{TLH}				−30°C	0.8	—	6.2	
					25°C	0.8	3.0	6.0	
					85°C	0.8	—	6.5	
Fall Time	t_{THL}				−30°C	0.8	—	6.2	
					25°C	0.8	3.0	6.0	
					85°C	0.8	—	6.5	

Note) * : Other inputs are open, or connected to +0.31V.

■SWITCHING TIME TEST CIRCUIT





Notes)
1. 50Ω termination to ground located in each scope channel input. All input and output cables to the scope are equal lengths of 50Ω coaxial cable.
2. Wire length should be <6.35mm (1/4 inch) from TPin to input pin and TPout to output pin.
3. Unused outputs connected to a 50Ω resistor to ground.