

\* ADD4.ABL 13-Oct-83

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module ADD4;

title

'4-bit ripple adder

Michael Holley Date I/O Redmond WA 6-Oct-83'

U1 device '16L8';

\* Equations for an n-bit ripple adder

\*  $S_n = A_n \text{ xor } B_n \text{ xor } C_n$

\*  $C_{n+1} = A_n B_n \text{ | } (A_n \text{ | } B_n) \ \& \ C_n$

\* Macro to generate carry signal from adding 2 signals.

\* Create the text:  $(A_n \ \& \ B_n \ \text{ | } (A_n \ \text{ | } B_n) \ \& \ C_n)$

carry macro (A,B,n) ((?A?n & ?B?n | (?A?n | ?B?n) & C?n));

AB,A1,A2,A3 pin 1,2,3,4;

BB,B1,B2,B3 pin 5,6,7,8;

SB,S1,S2,S3 pin 14,15,16,17;

\* Use macros to fake some pins:

CB macro ( B );

C1 macro ( carry(A,B,B) );

C2 pin 13;

C3 pin 18;

C4 pin 19;

equations

C2 = carry(A,B,1);

C3 = carry(A,B,2);

C4 = carry(A,B,3);

SB = AB \$ BB \$ CB;

S1 = A1 \$ B1 \$ C1;

S2 = A2 \$ B2 \$ C2;

S3 = A3 \$ B3 \$ C3;

function\_table ([[A3,A2,A1,AB],[B3,B2,B1,BB]] -> [C4,S3,S2,S1,SB])

A + B = S

[ 0, 0 ] -> 0 + 0;

[ 5, 4 ] -> 5 + 4;

[ 10, 7 ] -> 10 + 7;

[ 12, 15 ] -> 12 + 15;

[ 0, 5 ] -> 0 + 5;

[ 3, 10 ] -> 3 + 10;

end ADD4;

4-bit ripple adder

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Constants & Pin list for Module ADD4

Device U1:

Pin 1 : A0	Pin 20: Vcc
Pin 2 : A1	Pin 19: C4
Pin 3 : A2	Pin 18: C3
Pin 4 : A3	Pin 17: S3
Pin 5 : B0	Pin 16: S2
Pin 6 : B1	Pin 15: S1
Pin 7 : B2	Pin 14: S0
Pin 8 : B3	Pin 13: C2
Pin 9 :	Pin 12:
Pin 10: GND	Pin 11:

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Equations for Module ADD4

Device U1:

Original Equations:

$$C2 = (A1 \& B1 \mid (A1 \mid B1) \& (A0 \& B0 \mid (A0 \mid B0) \& 0))$$

$$C3 = (A2 \& B2 \mid (A2 \mid B2) \& C2)$$

$$C4 = (A3 \& B3 \mid (A3 \mid B3) \& C3)$$

$$S0 = A0 \oplus B0 \oplus 0$$

$$S1 = A1 \oplus B1 \oplus (A0 \& B0 \mid (A0 \mid B0) \& 0)$$

$$S2 = A2 \oplus B2 \oplus C2$$

$$S3 = A3 \oplus B3 \oplus C3$$

Expanded Equations:

$$S3 = (A3 \oplus (B3 \oplus C3))$$

$$S2 = (A2 \oplus (B2 \oplus C2))$$

$$S1 = (A1 \oplus (B1 \oplus (A0 \& B0)))$$

$$S0 = (A0 \oplus B0)$$

$$C4 = (A3 \& B3 \mid (A3 \mid B3) \& C3)$$

$$C3 = (A2 \& B2 \mid (A2 \mid B2) \& C2)$$

$$C2 = (A1 \& B1 \mid (A1 \mid B1) \& (A0 \& B0))$$

Reduced Equations:

$$C2 = (B0 \& B1 \& A0 \mid (B0 \& A0 \& A1 \mid B1 \& A1))$$

$$C3 = (B2 \& C2 \mid (C2 \& A2 \mid B2 \& A2))$$

$$C4 = (B3 \& C3 \mid (C3 \& A3 \mid B3 \& A3))$$

$$S0 = (B0 \& !A0 \mid !B0 \& A0)$$

$$S1 = (B0 \& !B1 \& A0 \& !A1 \mid (B0 \& B1 \& A0 \& A1 \mid (!B0 \& B1 \& !A1 \mid (B1 \& !A0 \& !A1 \mid (!B0 \& !B1 \& A1 \mid !B1 \& !A0 \& A1))))))$$

$$S2 = (!B2 \& C2 \& !A2 \mid (B2 \& !C2 \& !A2 \mid (B2 \& C2 \& A2 \mid !B2 \& !C2 \& A2)))$$

$$S3 = (!B3 \& C3 \& !A3 \mid (B3 \& !C3 \& !A3 \mid (B3 \& C3 \& A3 \mid !B3 \& !C3 \& A3)))$$

4-bit ripple adder

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Fuse Map for Module ADD4

Device U1:

	0	10	20	30
0:	-----	-----	-----	---
32:	-----X---	-----	-----X---	---
64:	-----X-X-	-----	-----	---
96:	-----X-	-----	-----X---	---
128:	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	XX
160:	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	XX
192:	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	XX
224:	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	XX
256:	-----	-----	-----	---
288:	-----	-----	X-----X---	---
320:	----X-----	-----	-----X---	---
352:	----X-----	-----	X-----	---
384:	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	XX
416:	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	XX
448:	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	XX
480:	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	XX
512:	-----	-----	-----	---
544:	-----X-X-	-----	-----X---	---
576:	-----X-X-	-----	-----X---	---
608:	-----X-X-	-----	-----X---	---
640:	-----XX-	-----	-----X---	---
672:	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	XX
704:	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	XX
736:	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	XX
768:	-----	-----	-----	---
800:	-----X---	-----	-X-----X---	---
832:	-----X---	-----	X-----X---	---
864:	----X-----	-----	X-----X---	---
896:	----X-----	-----	-X-----X---	---
928:	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	XX
960:	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	XX
992:	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	XX
1024:	-----	-----	-----	---
1056:	-XX-----	--X--X-	-----	---
1088:	X-X-----	--X--X-	-----	---
1120:	-X-----	--X--X-	-----	---
1152:	-X-X-----	-----X-	-----	---
1184:	X-----	--X--X-	-----	---
1216:	X--X-----	-----X-	-----	---
1248:	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	XX

4-bit ripple adder

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Fuse Map for Module ADD4

Device U1:

```

1280: -----
1312: ---X----- --X-----
1344: --X----- --X-----
1376: XXXXXXXXXXXX XXXXXXXXXXXX XXXXXXXXXXXX XX
1408: XXXXXXXXXXXX XXXXXXXXXXXX XXXXXXXXXXXX XX
1440: XXXXXXXXXXXX XXXXXXXXXXXX XXXXXXXXXXXX XX
1472: XXXXXXXXXXXX XXXXXXXXXXXX XXXXXXXXXXXX XX
1504: XXXXXXXXXXXX XXXXXXXXXXXX XXXXXXXXXXXX XX
1536: -----
1568: --X----- --X--X---
1600: X-X----- --X-----
1632: X----- --X-----
1664: XXXXXXXXXXXX XXXXXXXXXXXX XXXXXXXXXXXX XX
1696: XXXXXXXXXXXX XXXXXXXXXXXX XXXXXXXXXXXX XX
1728: XXXXXXXXXXXX XXXXXXXXXXXX XXXXXXXXXXXX XX
1760: XXXXXXXXXXXX XXXXXXXXXXXX XXXXXXXXXXXX XX
1792: XXXXXXXXXXXX XXXXXXXXXXXX XXXXXXXXXXXX XX
1824: XXXXXXXXXXXX XXXXXXXXXXXX XXXXXXXXXXXX XX
1856: XXXXXXXXXXXX XXXXXXXXXXXX XXXXXXXXXXXX XX
1888: XXXXXXXXXXXX XXXXXXXXXXXX XXXXXXXXXXXX XX
1920: XXXXXXXXXXXX XXXXXXXXXXXX XXXXXXXXXXXX XX
1952: XXXXXXXXXXXX XXXXXXXXXXXX XXXXXXXXXXXX XX
1984: XXXXXXXXXXXX XXXXXXXXXXXX XXXXXXXXXXXX XX
2016: XXXXXXXXXXXX XXXXXXXXXXXX XXXXXXXXXXXX XX

```

4-bit ripple adder

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Test Vectors for Module ADD4

Device U1:

```
[0000 0000 ---- ---- ---- ] -> [---- ---- ---- -LLL L-L- ]  
[1010 0010 ---- ---- ---- ] -> [---- ---- ---- -HLL H-L- ]  
[0101 1110 ---- ---- ---- ] -> [---- ---- ---- -HLL L-H- ]  
[0011 1111 ---- ---- ---- ] -> [---- ---- ---- -HHL H-H- ]  
[0000 1010 ---- ---- ---- ] -> [---- ---- ---- -HLH L-L- ]  
[1100 0101 ---- ---- ---- ] -> [---- ---- ---- -HLH H-L- ]
```

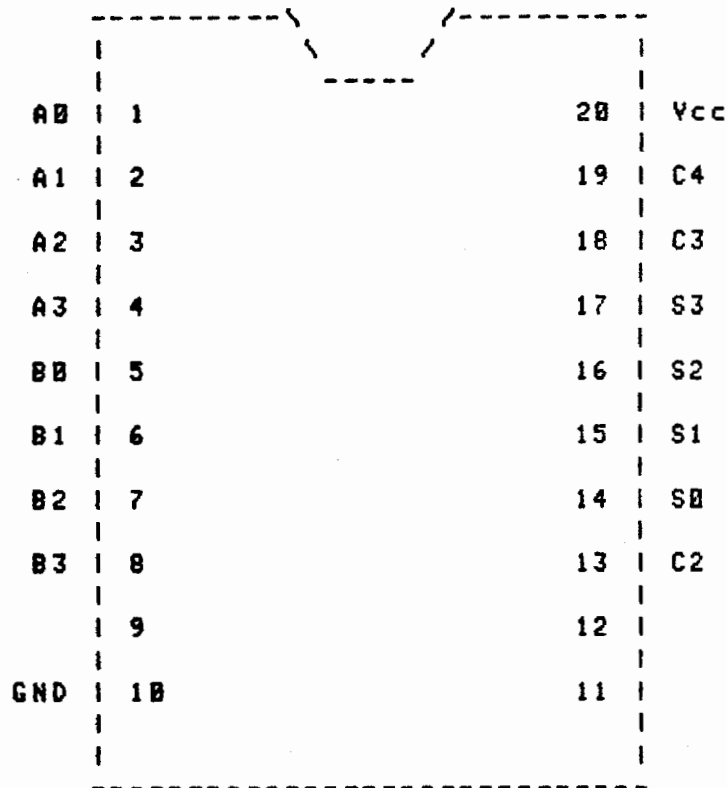
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Chip diagram for Module ADD4

Device U1:

PAL16L8



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Test Vectors for Module ADD4

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```
[0000 0000 ---- ---- ---- ] -> [---- ---- ---- -LLL L-L- ]  
[1010 0010 ---- ---- ---- ] -> [---- ---- ---- -HLL H-L- ]  
[0101 1110 ---- ---- ---- ] -> [---- ---- ---- -HLL L-H- ]  
[0011 1111 ---- ---- ---- ] -> [---- ---- ---- -HHL H-H- ]  
[0000 1010 ---- ---- ---- ] -> [---- ---- ---- -HLH L-L- ]  
[1100 0101 ---- ---- ---- ] -> [---- ---- ---- -HLH H-L- ]
```