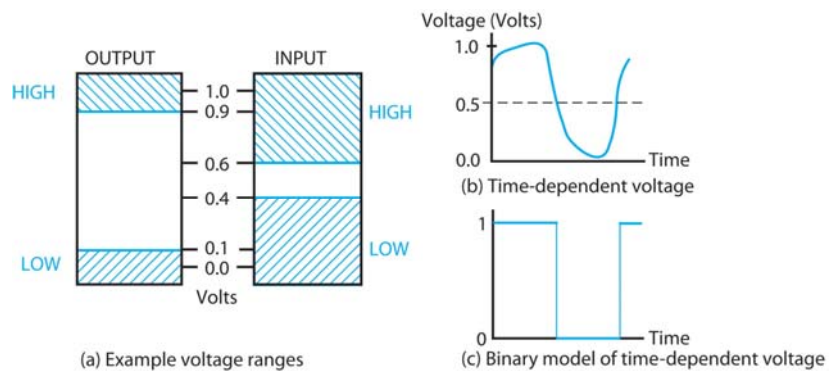


Boolean Functions



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Voltage ranges and waveform for Binary Signals



□ **TABLE 1-3**
Numbers with Different Bases

Decimal (base 10)	Binary (base 2)	Octal (base 8)	Hexadecimal (base 16)
00	0000	00	0
01	0001	01	1
02	0010	02	2
03	0011	03	3
04	0100	04	4
05	0101	05	5
06	0110	06	6
07	0111	07	7
08	1000	10	8
09	1001	11	9
10	1010	12	A
11	1011	13	B
12	1100	14	C
13	1101	15	D
14	1110	16	E
15	1111	17	F



□ **TABLE 1-4**
Binary-Coded Decimal (BCD)

Decimal Symbol	BCD Digit
0	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001



TABLE 1-5
American Standard Code for Information Interchange (ASCII)

$B_4B_3B_2B_1$	$B_7B_6B_5$							
	000	001	010	011	100	101	110	111
0000	NULL	DLE	SP	0	@	P	`	p
0001	SOH	DC1	!	1	A	Q	a	q
0010	STX	DC2	"	2	B	R	b	r
0011	ETX	DC3	#	3	C	S	c	s
0100	EOT	DC4	\$	4	D	T	d	t
0101	ENQ	NAK	%	5	E	U	e	u
0110	ACK	SYN	&	6	F	V	f	v
0111	BEL	ETB	'	7	G	W	g	w
1000	BS	CAN	(	8	H	X	h	x
1001	HT	EM	)	9	I	Y	i	y
1010	LF	SUB	*	:	J	Z	j	z
1011	VT	ESC	+	:	K	[	k	{
1100	FF	FS	,	<	L	\	l	|
1101	CR	GS	-	=	M	]	m	}
1110	SO	RS	.	>	N	^	n	~
1111	SI	US	/	?	O	_	o	DEL



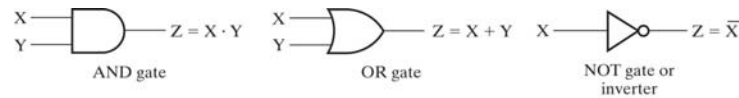
TABLE 1-5
American Standard Code for Information Interchange (ASCII)

$B_4B_3B_2B_1$	$B_7B_6B_5$							
	000	001	010	011	100	101	110	111
Control Characters								
NULL	NULL				DLE	Data link escape		
SOH	Start of heading				DC1	Device control 1		
STX	Start of text				DC2	Device control 2		
ETX	End of text				DC3	Device control 3		
EOT	End of transmission				DC4	Device control 4		
ENQ	Enquiry				NAK	Negative acknowledge		
ACK	Acknowledge				SYN	Synchronous idle		
BEL	Bell				ETB	End of transmission block		
BS	Backspace				CAN	Cancel		
HT	Horizontal tab				EM	End of medium		
LF	Line feed				SUB	Substitute		
VT	Vertical tab				ESC	Escape		
FF	Form feed				FS	File separator		
CR	Carriage return				GS	Group separator		
SO	Shift out				RS	Record separator		
SI	Shift in				US	Unit separator		
SP	Space				DEL	Delete		

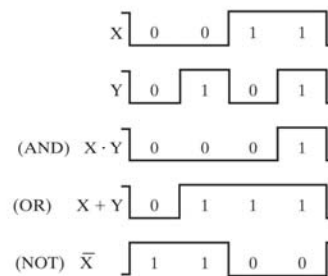


TABLE 2-1
Truth Tables for the Three Basic Logical Operations

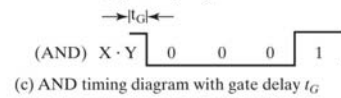
AND			OR			NOT	
X	Y	Z = X · Y	X	Y	Z = X + Y	X	Z = \bar{X}
0	0	0	0	0	0	0	1
0	1	0	0	1	1	1	0
1	0	0	1	0	1		
1	1	1	1	1	1		



(a) Graphic symbols



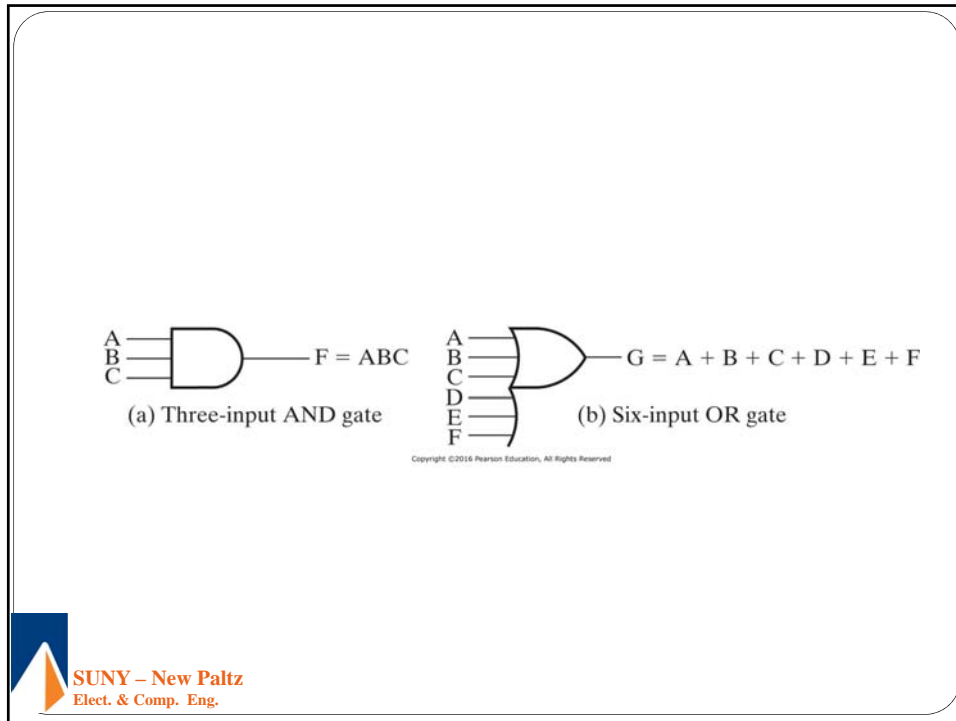
(b) Timing diagram



(c) AND timing diagram with gate delay t_G

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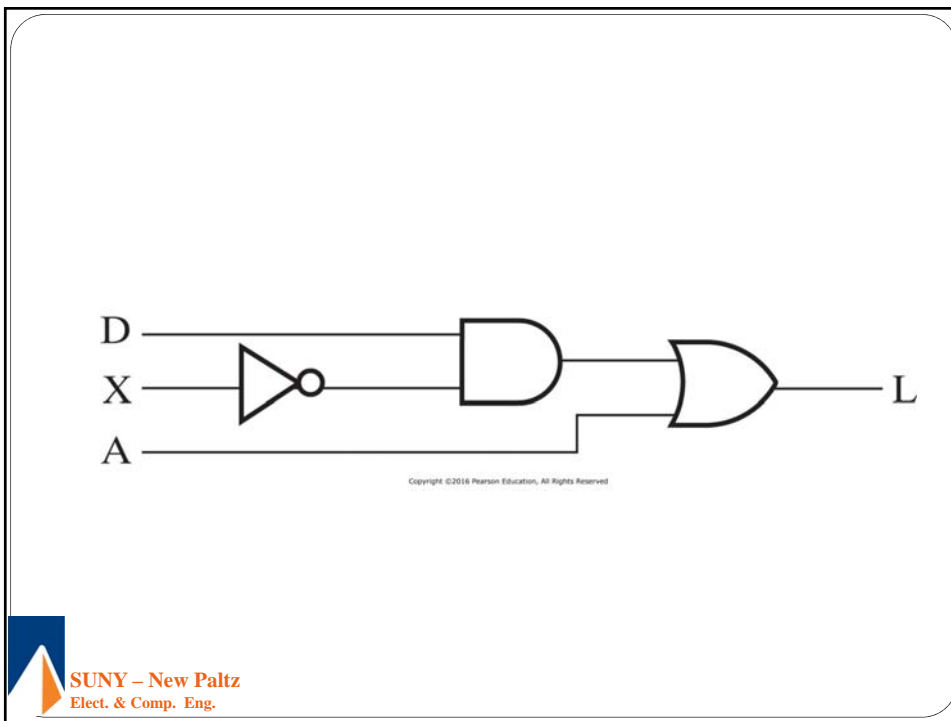
Name	Distinctive-Shape Graphics Symbol	Algebraic Equation	Truth Table															
AND		$F = XY$	<table border="1"> <thead> <tr><th>X</th><th>Y</th><th>F</th></tr> </thead> <tbody> <tr><td>0</td><td>0</td><td>0</td></tr> <tr><td>0</td><td>1</td><td>0</td></tr> <tr><td>1</td><td>0</td><td>0</td></tr> <tr><td>1</td><td>1</td><td>1</td></tr> </tbody> </table>	X	Y	F	0	0	0	0	1	0	1	0	0	1	1	1
X	Y	F																
0	0	0																
0	1	0																
1	0	0																
1	1	1																
OR		$F = X + Y$	<table border="1"> <thead> <tr><th>X</th><th>Y</th><th>F</th></tr> </thead> <tbody> <tr><td>0</td><td>0</td><td>0</td></tr> <tr><td>0</td><td>1</td><td>1</td></tr> <tr><td>1</td><td>0</td><td>1</td></tr> <tr><td>1</td><td>1</td><td>1</td></tr> </tbody> </table>	X	Y	F	0	0	0	0	1	1	1	0	1	1	1	1
X	Y	F																
0	0	0																
0	1	1																
1	0	1																
1	1	1																
NOT (inverter)		$F = \bar{X}$	<table border="1"> <thead> <tr><th>X</th><th>F</th></tr> </thead> <tbody> <tr><td>0</td><td>1</td></tr> <tr><td>1</td><td>0</td></tr> </tbody> </table>	X	F	0	1	1	0									
X	F																	
0	1																	
1	0																	
NAND		$F = \overline{X \cdot Y}$	<table border="1"> <thead> <tr><th>X</th><th>Y</th><th>F</th></tr> </thead> <tbody> <tr><td>0</td><td>0</td><td>1</td></tr> <tr><td>0</td><td>1</td><td>1</td></tr> <tr><td>1</td><td>0</td><td>1</td></tr> <tr><td>1</td><td>1</td><td>0</td></tr> </tbody> </table>	X	Y	F	0	0	1	0	1	1	1	0	1	1	1	0
X	Y	F																
0	0	1																
0	1	1																
1	0	1																
1	1	0																
NOR		$F = \overline{X + Y}$	<table border="1"> <thead> <tr><th>X</th><th>Y</th><th>F</th></tr> </thead> <tbody> <tr><td>0</td><td>0</td><td>1</td></tr> <tr><td>0</td><td>1</td><td>0</td></tr> <tr><td>1</td><td>0</td><td>0</td></tr> <tr><td>1</td><td>1</td><td>0</td></tr> </tbody> </table>	X	Y	F	0	0	1	0	1	0	1	0	0	1	1	0
X	Y	F																
0	0	1																
0	1	0																
1	0	0																
1	1	0																
Exclusive-OR (XOR)		$F = X\bar{Y} + \bar{X}Y$ $= X \oplus Y$	<table border="1"> <thead> <tr><th>X</th><th>Y</th><th>F</th></tr> </thead> <tbody> <tr><td>0</td><td>0</td><td>0</td></tr> <tr><td>0</td><td>1</td><td>1</td></tr> <tr><td>1</td><td>0</td><td>1</td></tr> <tr><td>1</td><td>1</td><td>0</td></tr> </tbody> </table>	X	Y	F	0	0	0	0	1	1	1	0	1	1	1	0
X	Y	F																
0	0	0																
0	1	1																
1	0	1																
1	1	0																
Exclusive-NOR (XNOR)		$F = XY + \bar{X}\bar{Y}$ $= X \odot Y$	<table border="1"> <thead> <tr><th>X</th><th>Y</th><th>F</th></tr> </thead> <tbody> <tr><td>0</td><td>0</td><td>1</td></tr> <tr><td>0</td><td>1</td><td>0</td></tr> <tr><td>1</td><td>0</td><td>0</td></tr> <tr><td>1</td><td>1</td><td>1</td></tr> </tbody> </table>	X	Y	F	0	0	1	0	1	0	1	0	0	1	1	1
X	Y	F																
0	0	1																
0	1	0																
1	0	0																
1	1	1																

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□ **TABLE 2-5**
Truth Table for the Function $L = D\bar{X} + A$

D	X	A	L
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	1
1	0	0	1
1	0	1	1
1	1	0	0
1	1	1	1



□ **TABLE 2-2**
Verilog Primitives for Combinational Logic Gates

Gate primitive	Example instance
and	and (F, X, Y);
or	or (F, X, Y);
not	not (F, Y);
nand	nand (F, X, Y);
nor	nor (F, X, Y);
xor	xor (F, X, Y);
xnor	xnor (F, X, Y);



```
module fig2_5 (L, D, X, A);  
    input D, X, A;  
    output L;  
    wire X_n, t2;  
  
    not (X_n, X);  
    and (t2, D, X_n);  
    or (L, t2, A);  
endmodule
```

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TABLE 2-6
Basic Identities of Boolean Algebra

1. $X + 0 = X$	2. $X \cdot 1 = X$	
3. $X + 1 = 1$	4. $X \cdot 0 = 0$	
5. $X + X = X$	6. $X \cdot X = X$	
7. $X + \bar{X} = 1$	8. $X \cdot \bar{X} = 0$	
9. $\overline{\bar{X}} = X$		
10. $X + Y = Y + X$	11. $XY = YX$	Commutative
12. $X + (Y + Z) = (X + Y) + Z$	13. $X(YZ) = (XY)Z$	Associative
14. $X(Y + Z) = XY + XZ$	15. $X + YZ = (X + Y)(X + Z)$	Distributive
16. $\overline{X + Y} = \bar{X} \cdot \bar{Y}$	17. $\overline{X \cdot Y} = \bar{X} + \bar{Y}$	DeMorgan's



TABLE 2-7
Truth Tables to Verify DeMorgan's Theorem

(a) X	Y	$X + Y$	$\overline{X + Y}$	(b) X	Y	\bar{X}	\bar{Y}	$\bar{X} \cdot \bar{Y}$
0	0	0	1	0	0	1	1	1
0	1	1	0	0	1	1	0	0
1	0	1	0	1	0	0	1	0
1	1	1	0	1	1	0	0	0

