DEPARTMENT : INFORMATION SCIENCE AND ENGINEERING

STUDENT NAME : R·G· MANYITHA

STUDENT USN : 1RN19IS111

SEM : III

SEC : B

SUBJECT : Analog and Digital Electronics

Assignment - 1

1RN19IS111 R.G. Mauritha

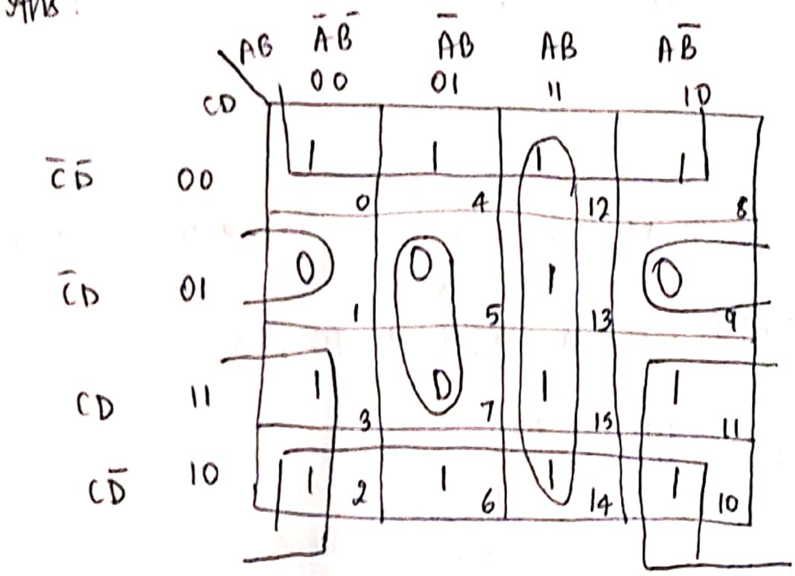
1> Plot the following function on a k-Map.

$F(A,B,C,D) = BD' + B'CD + ABC + ABC'D + BD'$

a> Find minimum SOP

b> Find minimum POS

Ans :



$Y = D' + AB + \bar{B}C$

$=$ minimum SOP

$Y = \bar{B}\bar{C}D + D\bar{A}B$

$Y' = (B+C+D')(A+B'+D')$

2> Find min sum of product expression for the following

a> $f(a,b,c,d) = \Sigma m(0,2,3,5,6,7,11,12,13)$

b> $f(a,b,c,d) = \Pi M(0,1,6,8,11,12)$

$* \Pi D(3,7,14,15)$

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a)

CD \ AB	$\bar{A}\bar{B}$ 00	$\bar{A}B$ 01	AB 11	$A\bar{B}$ 10
$\bar{C}\bar{D}$ 00	1 (0)	(4)	1 (12)	(8)
$\bar{C}D$ 01	(1)	1 (5)	1 (13)	(9)
CD 11	1 (3)	1 (7)	(15)	1 (11)
$C\bar{D}$ 10	1 (2)	1 (6)	(14)	(10)

$Y = \bar{A}C + \bar{B}CD + \bar{A}\bar{B}D + B\bar{C}D + AB\bar{C}$

b) $f(a,b,c,d) = \pi M(0,1,6,8,11,12) * \pi D(3,7,14,15)$

$\Sigma m(2, 3, 4, 5, 7, 9, 10, 13, 14, 15)$

CD \ AB	$\bar{A}\bar{B}$ 00	$\bar{A}B$ 01	AB 11	$A\bar{B}$ 10
$\bar{C}\bar{D}$ 00	(0)	1 (4)	(12)	(8)
$\bar{C}D$ 01	(1)	1 (5)	1 (13)	1 (9)
CD 11	X (3)	X (7)	X (15)	(11)
$C\bar{D}$ 10	1 (2)	(6)	X (14)	1 (10)

$Y = DB + A\bar{C}D + C\bar{D}\bar{B} + \bar{C}\bar{A}B$

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3> A switching circuit has 2 control inputs, two data inputs and one output the circuit performs one of the logic operation AND, OR, EQU or XOR on the two data inputs inputs, the function performed depends on control inputs

C_1	C_2	Function performed by circuit
0	0	OR
0	1	XOR
1	0	AND
1	1	EQU

a> Find truth table for Z

b> Use K map to find

C_1	C_2	X_1	X_2	Z
0	0	0	0	0
0	0	0	1	1
0	0	1	0	1
0	0	1	1	1
0	1	0	0	0
0	1	0	1	1
0	1	1	0	1
0	1	1	1	0
1	0	0	0	0
1	0	0	1	0
1	0	1	0	0
1	0	1	1	1
1	1	0	0	1
1	1	0	1	0
1	1	1	0	0
1	1	1	1	1

$Y = \Sigma m(1, 2, 3, 5, 6, 11, 12, 15)$

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X_1X_2 \ C_1C_2	00 $\bar{C}_1\bar{C}_2$	01 $\bar{C}_1C_2$	11 C_1C_2	10 $C_1\bar{C}_2$
$\bar{X}_1\bar{X}_2$ 00	0	4	1 12	8
$\bar{X}_1X_2$ 01	1 1	1 5	13	9
X_1X_2 11	1 3	7	1 15	1 11
$X_1\bar{X}_2$ 10	1 2	1 6	14	10

$$Z = C_1C_2\bar{X}_1\bar{X}_2 + C_1X_1X_2 + X_1\bar{X}_2\bar{C}_1 + X_1\bar{C}_1\bar{C}_2$$
$$\bar{X}_1X_2\bar{C}_1$$

4> Define implicants, prime implicants and essential prime implicants.

Ans: A given function F of n variables, a product term P is an implicant of F.

A prime implicant of a function F is a product term implicant which is no longer an implicant if any literal is deleted from it.

If a minterm is covered by only prime implicants then that prime implicant is called an essential prime implicant.

5> Explain flowchart for determining min SOP using K-Map.

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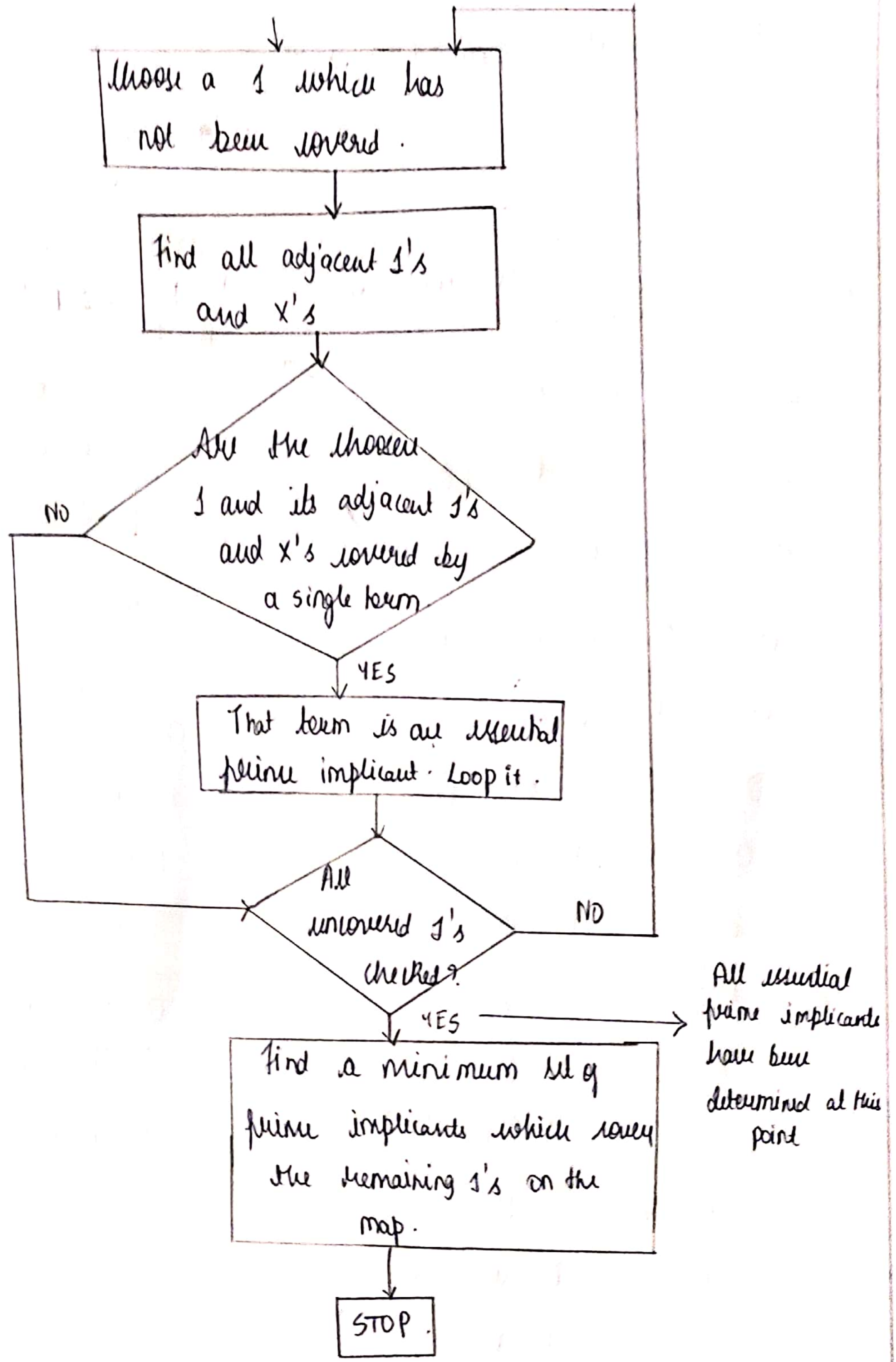

6) For the following function. Find all of prime implicants and min SOP Expression using Quine-McClusky method.

R.G Mauritha 1PN1918111

f(a,b,c,d) = Σm (1,3,4,5,6,7,10,12,13)
+ Σd (2,9,15)

A	B	C	D	
0	0	0	0	(0)
0	0	0	1	(1)
0	0	1	0	(2)
0	0	1	1	(3)
0	1	0	0	(4)
0	1	0	1	(5)
0	1	1	0	(6)
0	1	1	1	(7)
1	0	0	0	(8)
1	0	0	1	(9)
1	0	1	0	(10)
1	0	1	1	(11)
1	1	0	0	(12)
1	1	0	1	(13)
1	1	1	0	(14)
1	1	1	1	(15)

STAGE (1)

A	B	C	D	
0	0	0		(1)
0	0	1	0	(2)
0	1	0	0	(4)
0	0	1	1	(3)
0	1	0	1	(5)
0	1	1	0	(6)
1	0	0	1	(9)
1	0	1	0	(10)
1	1	0	0	(12)
0	1	1	1	(7)
1	1	0	1	(13)
1	1	1	1	(15)

Stage 2

00 - 1 (1,3)

0 - 0 1 (1,5)

- 0 0 1 (1,9)

0 0 1 - (2,3)

0 - 1 0 (2,6)

0 1 0 - (4,5)

- 0 1 0 (2,10)

0 1 - 0 (4,6)

- 1 0 0 (4,12)

---

0 - 1 1 (3,7)

0 1 - 1 (5,7)

- 1 0 1 (5,13)

0 1 1 - (6,7)

1 - 0 1 (9,13)

1 1 0 - (12,13)

- 1 1 1 (7,15)

1 1 - 1 (13,15)

Stage 3

0 - - 1 (1,3,5,7)

- - 0 1 (1,5,9,13)

0 - 1 - (2,3,6,7)

0 1 - - (4,5,6,7)

- 1 0 - (4,12,15,13)

- 1 - 1 (5,7,13,15)

	1	3	4	5	6	7	10	12	13
$\bar{A}D$ (1,3,5,7)	x	x		x		x			
$\bar{C}D$ (1,5,9,13)	x			x					x
$\bar{A}B$ (4,5,6,7)			x	x	x	x			
$\bar{A}C$ (2,3,6,7)		x			x	x			
$B\bar{C}$ (4,12,13,15)			x					x	x
$\bar{B}C\bar{D}$ (2,10)							x		

$Y = \bar{A}D + \bar{A}C + \bar{B}C\bar{D} + B\bar{C}$

7) Find all the prime implicants of the following function and then find all minimum solutions using Petrick's method.

$F(A,B,C,D) = \Sigma m(7,12,14,15) + d(1,3,5,8,10,11,13)$

R G Manvitha 1RN11IS111

Stage 1

A	B	C	D	
0	0	0	1	(1)
1	0	0	0	(8)
0	0	1	1	(3)
0	1	0	1	(5)
1	0	1	0	(10)
1	1	0	0	(12)
0	1	1	1	(7)
1	0	1	1	(11)
1	1	0	1	(13)
1	1	1	0	(14)
1	1	1	1	(15)

Stage 2

A	B	C	D	
0	0	-	1	(1,3)
0	-	0	1	(1,5)
1	0	-	0	(8,10)
1	-	0	0	(8,12)
0	-	1	1	(3,7)
-	0	1	1	(3,11)
-	1	0	1	(5,13)
1	1	-	0	(12,14)
-	1	1	1	(7,15)
1	-	1	1	(11,15)
1	1	-	1	(13,15)
1	1	1	-	(14,15)

Stage 3

A	B	C	D	
0	-	-	1	(1,5,3,7)
1	-	-	0	(8,10,12,14)
-	-	1	1	(3,7,11,15)
-	1	-	1	(5,13,7,15)
1	1	-	-	(12,13,14,15)
1	-	1	-	(10,11,14,15)

		7	12	14	15
$\bar{A}D$	P_1 (1,5,9,7)	X			
$A\bar{D}$	P_2 (8,10,12,14)		X	X	
CD	P_3 (3,7,11,15)	X			X
BD	P_4 (5,13,7,15)	X			X
AB	P_5 (12,14,13,15)		X	X	X
AC	P_6 (10,11,14,15)			X	X

$1 = (P_1+P_3+P_4)(P_2+P_5)(P_1+P_5+P_6)(P_3+P_4+P_6+P_5)$

$= (P_1P_2 + P_1P_5 + P_1P_3 + P_3P_5 + P_2P_4 + P_5P_4)$

$(P_2P_3 + P_2P_4 + \cancel{P_2P_5} + \cancel{P_2P_6} + \cancel{P_5P_3} + \cancel{P_4P_5} + P_5 +$

$\cancel{P_5P_6} + \cancel{P_6P_3} + \cancel{P_6P_4} + \cancel{P_6P_5} + P_6)$

$\Rightarrow (P_1P_2 + P_1P_5 + P_2P_3 + P_3P_5 + P_2P_4 + P_5P_4)(P_2P_3 + P_2P_4 + P_5 + P_6)$

$\Rightarrow P_1P_2\cancel{P_3} + P_1\cancel{P_2}P_4 + P_1\cancel{P_2}P_5 + P_1P_2P_6$

$P_1P_5\cancel{P_2}P_3 + P_1P_5\cancel{P_2}P_4 + \underline{P_1P_5} + P_1\cancel{P_6}P_5$

$\underline{P_2P_3} + P_2P_3\cancel{P_4} + P_2\cancel{P_3}P_5 + P_2\cancel{P_3}P_6$

$P_2P_3\cancel{P_5} + P_2P_3\cancel{P_4P_5} + \underline{P_3P_6} + P_3\cancel{P_5}P_6$

$P_2P_3\cancel{P_4} + \underline{P_2P_4} + P_2P_4\cancel{P_5} + P_2\cancel{P_4}P_6$

$P_2P_4P_3\cancel{P_5} + P_2P_4\cancel{P_5} + \underline{P_5P_4} + P_4\cancel{P_5}P_6$

$\Rightarrow P_1P_2P_6 + P_1P_5 + P_2P_3 + P_3P_5 + P_2P_4$

P_5P_4

$Y = \bar{A}D + AB$ or $Y = A\bar{D} + CD$ or

$Y = AB + CD$ or $Y = A\bar{D} + BD$ or

$Y = BD + AB$

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8) Using Method of MEV use 4-variable maps to find min SOP expression.

$$Z(A,B,C,D,E,F) = \Sigma m(2,5,6,9) + d(1,3,4,13,14) + E(m_{11} + m_{12}) + F(m_{10})$$

E = 0 F = 0

CD \ AB	$\bar{A}\bar{B}$ 00	$\bar{A}B$ 01	AB 11	$A\bar{B}$ 10
$\bar{C}\bar{D}$ 00	0	X 4	E 12	8
$\bar{C}D$ 01	X 1	1 5	X 13	1 9
CD 11	X 3	7	15	E 11
$C\bar{D}$ 10	1 2	1 6	X 14	F 10

$Y = \bar{C}D + \bar{A}C\bar{D}$

CD \ AB	$\bar{A}\bar{B}$ 00	$\bar{A}B$ 01	AB 11	$A\bar{B}$ 10
$\bar{C}\bar{D}$ 00	0	X 4	1 12	8
$\bar{C}D$ 01	X 1	1 5	X 13	1 9
CD 11	X 3	7	15	1 11
$C\bar{D}$ 10	1 2	1 6	X 14	0 10

E = 1 F = 0

$Y = AB\bar{C}E + \bar{C}D + A\bar{B}DE + \bar{A}C\bar{D}$

E = 0 F = 1

CD \ AB	00	01	11	10
$\bar{C}\bar{D}$ 00	0	X 4	12	8
$\bar{C}D$ 01	X 1	1 5	X 13	1 9
CD 11	X 3	7	15	11
$C\bar{D}$ 10	1 2	1 6	X 14	1 10

$Y = \bar{C}D + C\bar{D}F$

$$Y = \bar{C}D + \bar{A}C\bar{D} + AB\bar{C}E + A\bar{B}DE + \bar{A}C\bar{D} + C\bar{D}F$$

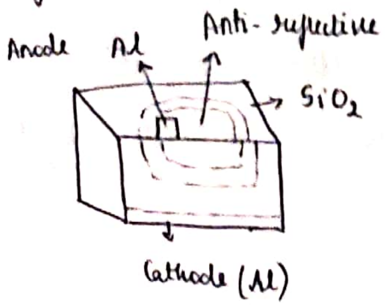
R. G. Mauritha 1RN19IS111

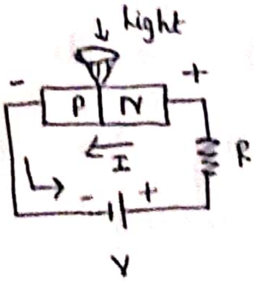
Q9> Explain construction and working of photodiode.

Ans: <u>Construction</u>: Typical construction of a photodiode is in the figure, this example uses a construction technique called ion implanatation where the surface of a layer of N-type is bombarded with P-type silicon ions to produce a P-type layer about 1 μm (micrometre) thick.

During the formation of the diode, excess electrons move from n-type towards p-type and excess holes move from p-type towards n-type this process is called diffusion resulting in the removal of free charge carriers close to the PN junction, so creating a depletion layer.

The (light-facing) top of the diode is protected by a layer of Silicon-Dioxide (SiO_2) in which there is a window for light to shine on the semi-conductor. This window is coated with a thin anti-reflective layer of SiN to allow maximum absorption of light and an anode connection of Al is provided to the P-type layer. Beneath the N type layer is a more heavily doped N+ layer to provide a low-resistance connection to the cathode.





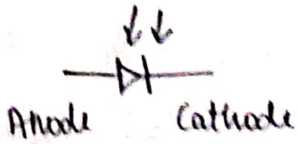


Photo-diode in reverse bias

Working Principle when the conventional diode is reverse biased, the depletion region starts expanding and the current starts flowing due to minority charge carriers. With the increase of reverse voltage, the reverse current also starts increasing. The same condition can be obtained in Photodiode without applying reverse voltage.

The junction of photodiode is illuminated by the light source, the photons strike the junction surface. The photons impart their energy in the form of light to the junction. Due to which electrons from valence band get the energy to jump into the conduction band. This leaves positively charged holes in the valence band, so producing 'electrons/hole pairs' in the deplementation layer.

Some electron hole pairs are also produced in the P and N layers, but apart from those produced in the diffusion region N layers, most will be re-absorbed within the P and N materials as heat. The electrons in the depletion layer are then swept towards the positive potential on the cathode, and the holes swept towards the negative potential on the anode, so creating a photo-current. In this way the photodiode converts light energy into electrical energy.

R.G. Maurittra 1RN19IS111

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Explain construction and working and application optocouplers.

Construction: All optocouplers consist of two elements: a light source which is almost always a light-emitting diode (LED) and photosensor typically a photoresistor, photodiode, phototransistor, silicon-controlled rectifier (SCR) or triac. Both of these elements are separated by a dielectric (non-conducting) barrier.

Working Principle: When input current is applied to the LED, it switches ON and emits infrared light; the photosensor then detects this light and allows current to flow through the output side of the circuit.

Conversely, when the LED is off, no current will flow through the photosensors. By this method, the two flowing currents are electrically isolated. It consists of LED and photo-diode where the circuits are isolated electrically. In LED is forward biased, photo-diode is reverse biased and output exists across R_2. When current is not being applied via Pin 1, the LED is off, and the circuit connected to Pin 4 and 5 is experiencing no current flow.

When power is applied to the input circuit, the LED switches on, the sensor detects

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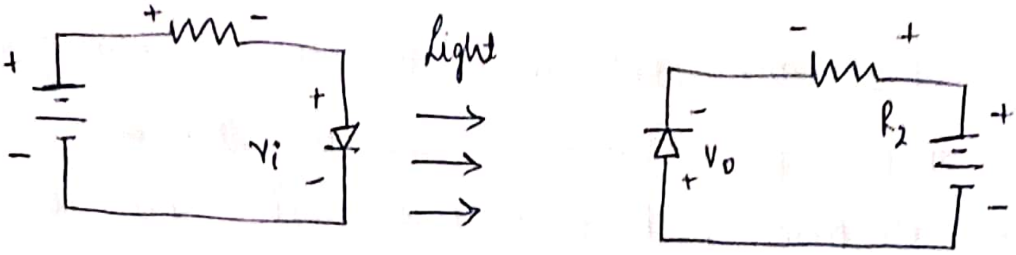
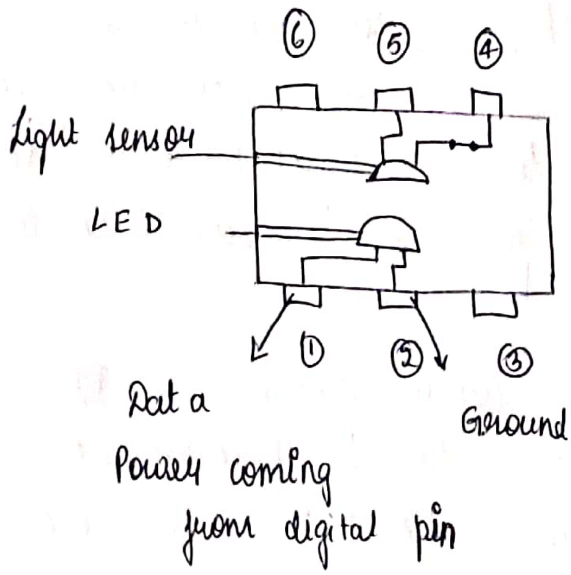
the light, closes the switch and initiates current flow in the output circuit.





Photocoupler operation.

Applications :

→ Signal isolation

→ Power isolation

→ PC / modem communications

→ switch - mode power supplies

→ Input - output switching, especially in electronically noisy environments.

→ controlling transistors and triacs.