Solutions

to Lab Manual to accompany

Industrial Automated Systems:

Instrumentation and Motion Control

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Experiment 1

Operational Amplifiers

Experiment Questions

1. analog
2. linear
3. greater
4. 6, –
5. –5V

INPUTS		
V_1	V_2	V_{OUT} (V)
+4	+1	–5
+2	+3	+5
+1	0	–5
+4	+4	0
0	+1	+5
+3	+2	–5

Figure 1-2 b

V_{IN} (V)	V_{OUT} (V)
+0.2	–1
–0.4	+2
0	0
+0.32	–1.6

Figure 1-3 b

V_{IN} (V)	V_{OUT} (V)
+0.3	–0.75
–0.15	+0.38
–2.0	–5
+0.4	–1

Figure 1-3 c

Input Voltage			Output Voltage	
V_1	V_2	V_3	Measured	Calculated
+1	+1	+1	–3	–3
+1	–1	–1	+1	+1
+2	–1	–1	0	0
–3	–1	+3	+1	+1
+1	+2	–1	–2	–2

Figure 1-4 b

Experiment 2

Schmitt Trigger

Procedure Question Answer

1. No. Because the 7476 J-K flip-flop is negative-edge triggered, and reacts only to positive-to-negative–going signals that change abruptly. The rectified sine wave does not change fast enough.

Step 5

Point 1
V_{th} − = .9 VDC
V_{th} + = 1.7 VDC

Table 2-1

Step 7

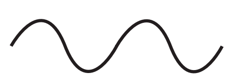
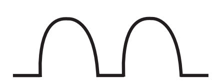
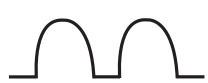
Waveform	At Point 1	At Point 2	Is the Flip-Flop Toggling (Yes, No)
Circuit (a)			NO
Circuit (b)			YES

Table 2-2

Experiment Questions

1. - Convert electronic signals to square waves.
   - Perform NAND gate and Inverter logic functions.
2. D
3. edge
4. Low, High
5. hysteresis
6. Because when sine waves are counted, they must be converted to square waves before being applied to a flip-flop.

Experiment
3

Magnitude Comparator

Procedure Question Answer

1. If the high-order bits are equal, then the output state is determined by comparing the low-order bits.

Step 2A

Input B				Input A				Outputs		
B_3	B_2	B_1	B_0	A_3	A_2	A_1	A_0	A<B	A=B	A>B
0	0	0	0	0	0	0	0	0	1	0
0	1	0	0	0	0	0	1	1	0	0
1	0	0	1	1	0	0	0	1	0	0
0	0	1	1	0	1	0	0	0	0	1
0	0	0	1	1	0	0	1	0	0	1

Table 3-2

Step 3B

Input B				Input A				Expansion Inputs			Outputs		
B_3	B_2	B_1	B_0	A_3	A_2	A_1	A_0	I_A<B	I_A=B	I_A>B	A<B	A=B	A>B
0	0	0	0	1	1	1	1	1	0	0	0	0	1
0	0	0	1	0	0	0	1	0	0	1	0	0	1
0	1	1	0	0	1	1	0	0	1	0	0	1	0
1	1	1	0	1	1	0	1	0	0	1	1	0	0
0	1	0	1	1	1	1	0	0	1	0	0	0	1

Table 3-4

Experiment Questions

1. 1111
2. Yes. By connecting a Low to the MSB of inputs A and B, and applying the three binary bits to the remaining inputs.
3. $I_A > B = 0$
   $I_A = B = 0$
   $I_A < B = 1$
4. 4
5. When A is greater than B, or B is greater than A, the circuit would operate normally. When A is equal to B, however, output A<B would incorrectly go High—instead of output A=B.

Experiment 4

SCR Phase Control Circuit

Step 3 169 volts, yes

Step 4 15 volts, yes

Experiment Questions

1. D
2. B
3. 169–15 = 154
4. A
5. B
6. B

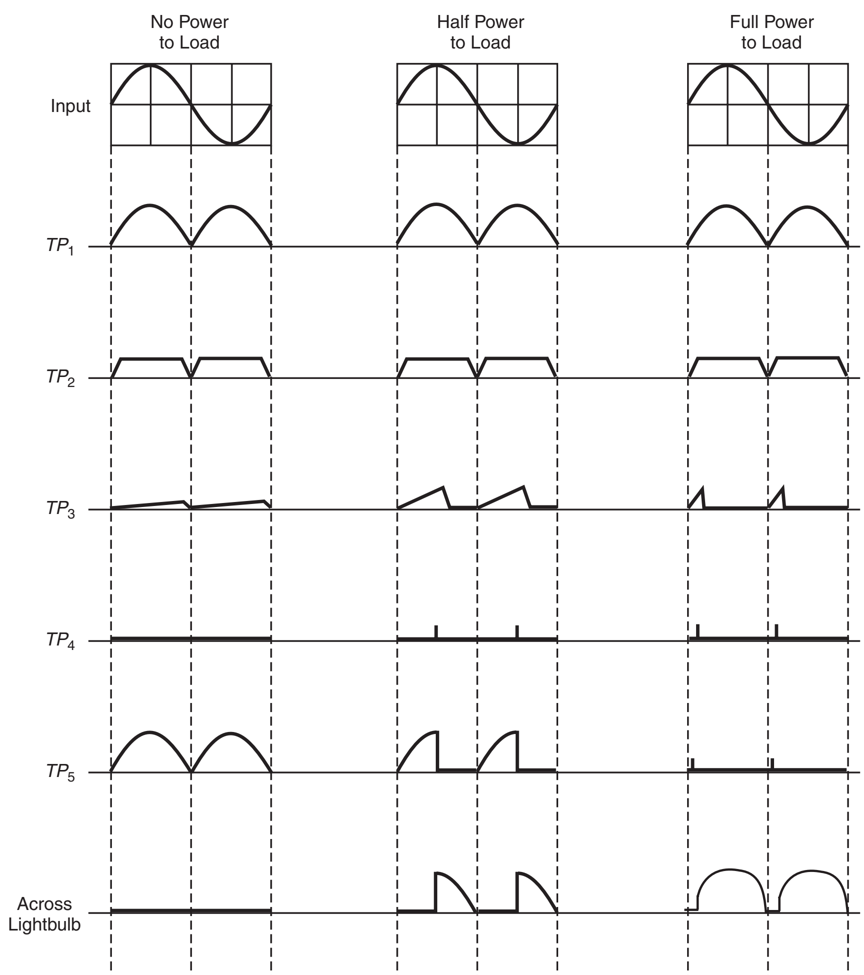


Figure 4-1

Experiment 5

Photoresistor

Step 1 Dark resistance = 40KΩ

Step 3 Ambient light voltage = –8V
Dark voltage = +7V

Design Question

Switch the position of R_1 with that of the photoresistor.

Experiment Questions

1. A
2. B
3. B
4. B
5. A

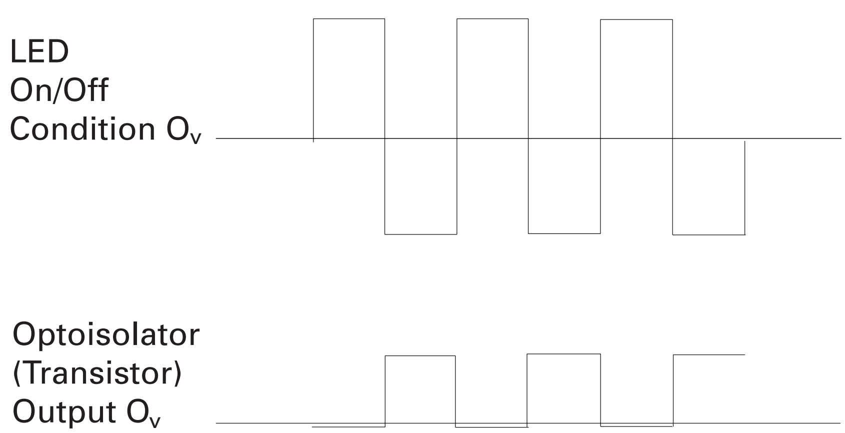
Experiment 6

Optocoupler

Step 1 1 Meg ohm

Step 2 150 ohms

Step 4



Step 5 B

Step 6 25KHz

Step 7 I_C = 3.5mA
I_f = 16mA
CTR 22%

Experiment Questions

1. True
2. A
3. A
4. 25%
5. C

Experiment
7

Digital-to-Analog Converter

Procedure Question Answers

1. A
2. A
3. 16 (2^4)
4. 1
5. Eight different voltage levels. When an open is at the LSB input, a binary 1 is always applied to the LSB digital input lead of the D/A converter. This causes the D/A converter to produce the following counts:

Desired Count	Count with Pin 12 Open
0	1
1	1
2	3
3	3
4	5
5	5
6	7
7	7
8	9
9	9
10	11
11	11
12	13
13	13
14	15
15	15

6. 32
   The number of outputs is determined by multiplying 2 by the power of the number of inputs applied to the digital input of the D/A converter (2^5).

Experiment Questions

1. 256
2. 1
3. - Change V_{REF} applied to pin 14.
   - Change the resistor value connected to pin 14.
   - Change the R_F resistor connected to pin 4.