

MX-909 500 in 1

Book #1 HARDWARE- Entry Course

CONTENTS

1.	LIGHT-CONTROLLED BIRD	18
2.	A TRANSISTOR RADIO	19
3.	SOUND SCOOPER	20
4.	AMERICAN PATROL CAR SEREN	21
5.	DIGITAL ROULETTE	22
6.	IC ORGAN	22
2) Back to the Basics		
7.	LIGHT TELEGRAPH	23
8.	INTRODUCING THE RESISTOR	23
9.	PARALLEL RESISTOR	24
10.	MEET THE DIODE	24
11.	THE LED - A SPECIAL DIODE	25
12.	THE ELECTRONIC GAS TANK	25
13.	CAPACITORS IN SERIES AND PARALLEL	26
14.	MEET THE TRANSISTOR	27
14.	MEETTHE TRANSISTOR	27
15.	TRANSISTORS AS SWITCHES	28
16.	PNP TRANSISTOR SWITCH	28
17.	NPN TRANSISTOR SWITCH	29
18.	DELAYLIGHT	29
19.	NIGHT LIGHT	30
20.	ELECTRONIC TIMER	30
21.	CAPITAL LETTER DISPLAY	31
22.	SMALL LETTER DISPLAY	31
23.	NUMBER DISPLAY	32
3) Electronic Building Blocks		
24.	AN INVERTER CIRCUIT	32
25.	MEET THE OR GATE	33
26.	INTRODUCING THE AND GATE	33
27.	USING THE NOR GATE	34
28.	MEET THE NAND GATE	34
29.	HOWAMULTIVIBRATORWORKS	35
30.	A "ONE SHOT" MULTIVIBRATOR	35
31.	AN R-S FLIP-FLOP	36
32.	MEET~HEOSCILLATOR	36
33.	CHANGING OSCILLATION WITH CAPACITOR	37
34.	CHANGING OSCILLATION WITH FOREIGN SUBSTANCE	37
35.	MORE ABOUT OSCILLATOR	38
36.	A PUSH-PULL OSCILLATOR	38
37.	LOW DISTORTION SINEWAVE OSCILLATOR	39
4) Putting Electronics to Work		
38.	STROBE LIGHT	
39.	CdS-CONTROLLED OSCLLATOR	40
40.	FREQUENCY SHIFT CSCIL.LATOR	40
41.	ELECTRONIC GRANDFATHER CLOCK	41
42.	ELECTRONIC METRONOME	41

43.	MOTION DETECTOR	42
44.	DOOR ALARM	42
45.	RAPID LED DISPLAY SWITCHING	43
46.	CODE PRACTICE	43
47.	TWIN-T AUDIO OSCILLATOR	44
48.	CURRENT SWITCH	44
49.	SHOT IN THE DARK	45
50.	VARIABLE OSCILLATOR	45
51.	TWO-TONE BUZZER	46
52.	SAWTOOTH WAVE OSCILLATOR	46
53.	ASTABLE MULTIVIBRATOR	47
54.	MONOSTABLE MULTIVIBRATOR	47
55.	CODE PRACTICE UNIT	48
56.	THE NOISY LIGHT	48
57.	HEARING AID AMPLIFIER	49
58.	LIGHT/SOUND CODE PRACTICE UNIT	49
59.	LIGHT CONTROLLED BURGLAR ALARM	50
60.	DC-DC CONVERTER	50
61.	COUNT DOWN TIMER	51
5)	Radio Circuit	
62.	"CRYSTAL SET" RADIO	51
63.	"FUNNY TRANSISTOR" RADIO	52
64.	WIRELESS CODE TRANSMITTER	52
65.	REMOTE WATER LEVEL DETECTOR	53
66.	IC RADIO	53
6)	Sonic Zoo and Sound Factory	
67.	TWO-TONE PATROL CAR SIREN	54
68.	PLANT GROWTH STIMULATOR	54
69.	ELECTRONIC WOODPECKER	55
70.	FISH CALLER	55
71.	ELECTRONIC RAINDROPS	56
72.	PENCIL LEAD ORGAN	56
73.	ELECTRONIC MOTORCYCLE	57
74.	MACHINE GUN PULSE DETECTOR	57
75.	ELECTRONIC SIREN	58
76.	CHIRPING BIRD	58
77.	ELECTRONIC CAT	59
78.	ELECTRONIC BIRD	59
79.	"HORROR MOVIE" SOUND EFFECT	60
80.	ELECTRONIC ORGAN	60
81.	SOUNDMACHINE I	61
82.	SOUND MACHINE II	61
7)	Electronic Decision-Makers	
83.	MAJORITY LOGIC GATE	62
84.	ELECTRONIC COIN TOSS	62
85.	ELECTRONIC COIN TOSS II	63
86.	ELECTRONIC COIN TOSS III	63
87.	EVEN OR ODD	64
88.	QUICKDRAW GAME	64
89.	CLOSE-IN	65
90.	ESP TESTER	65
91.	THE LIGHT FANTASTIC	66
92.	SHOOTING GAME	66
93.	MARCHING LEDS	67

94.	ELECTRONIC DICE	68
95.	ELECTRONIC ROULETTE	68

8) Operational Amplifier IC Can Do Many Things

96.	MEET THE VCO	69
97.	SILICON DIODE SOLAR CELL	69
98.	INTEGRATING CIRCUIT	70
99.	ASTABLE MULTIVIBRATOR USING OP AMPLIFIER	70
100.	PULSE GENERATOR	71
101.	COMPARATOR	71
102.	EXPERIMENT OF COMPARATOR	72
103.	COMPARATOR WITH HYSTERESIS	72
104.	CONSTANT CURRENT SOURCE BY OP AMPLIFIER	73
105.	NON-INVERTING ADDER	73
106.	SCHMITT TRIGGER CIRCUIT	74
107.	DELAYEDTIMER	74
108.	PULSE FREQUENCY DOUBLER	75
109.	PITCH DOUBLING CIRCUIT	75
110.	PITCH DOUBLING CIRCUIT II	76
111.	TOUCH SWITCH USING OP AMPLIFIER	76
112.	EARLY BIRD	77
113.	DC-DC CONVERTER BY OP AMPLIFIER	77
114.	INVERTING AMPLIFIER	78
115.	NON-INVERTINGAMPLIFIE	78
116.	DIFFERENTIAL AMPLIFIER	79
117.	DIFFERENTIAL OUTPUT AMPLIFIER	79
118.	POWER AMPLIFIER USING OP AMPLIFIER	80
119.	BALANCEDTRANSFORMERLESSAMPLIFIER	80
120.	THREE-STAGE DIFFERENTIAL AMPLIFIER	81
121.	VCO USING OP AMPLIFIER	70

9) Introducing the Power Amplifier IC

122.	IC POWER AMPLIFIER	82
123.	IC POWER AMPLIFIER II	82
124.	OSCILLATOR USING POWER AMPLIFIER IC	83
125.	CdS CONTROLLED IC OSCILLATOR	83

10) A Trip to Digital Land

126.	SWIITCHING CIRCUIT	84.
127.	RTLINVERTER	84
128.	RTL BUFFER	85
129.	RTL OR GATE	85
130.	RTL AND GATE	86
131.	TRANSISTOR OR GATE	86
132.	TRANSISTOR AND GATE	87
133.	TRANSISTOR XOR GATE	87
134.	SPECIAL NAND GATE	88
135.	DTL OR GATE	88
136.	DTL AND GATE	89
137.	DTL NOR GATE	89
138.	DTL NAND GATE	90
139.	DTL EXCLUSIVE OR GATE	90
140.	C-MOS INVERTER	91
141.	C-MOS BUFFER	91
142.	C-MOS OR GATE	92
143.	C-MOS AND GATE	92
144.	C-MOS3-INPUTANDGATE	93

145.	C-MOSNORGATE	93
146.	C-MOS 4-INPUT NOR GATE	94
147.	C-MOS 4-INPUT NOR GATE II	94
148.	DEMORGANSTHEOREM	95
149.	EXPERIMENT OF THRESHOLD VOLTAGE	95
150.	NAND/NOR AND TRANSISTOR SWITCH	96
11) More Adventures in Digital Land		
151.	C-MOS XOR GATE	96
152.	C-MOS NAND ENABLE CIRCUIT	97
153.	C-MOS AND ENABLE CIRCUIT	97
154.	C-MOS OR ENABLE CIRCUIT	98
155.	A ONE-SHOT NAND GATE	98
156.	C-MOS LINE SELECTOR	99
157.	C-MOS DATA SELECTOR	99
158.	C-MOS R-S FLIP FLOP	100
159.	C~MOS R-S FLIP-FLOP II	100
160.	SET/RESET BUZZER	101
161.	SET/RESET BUZZERII	101
162.	SET/RESET BUZZER III	102
163.	TRANSISTORIZED TOGGLE FLIP-FLOP	102
164.	NAND TOGGLE FLIP-FLOP	103
165.	J-K TOGGLE FLIP-FLOP	103
166.	C-MOS ASTABLE MULTIVIBRATOR	104
167.	C-MOS J-K FLIP-FLOP	104
168.	C-MOS D FLIP-FLOP	105
169.	C-MOS D FLIP FLOP II	105
170.	R-S-T FLIP FLOP	106
171.	T TYPE FLIP-FLOP	106
172.	C-MOS LATCH	107
173.	SHIFT REGISTER	107
174.	TOUCH SWITCH USING NAND GATE	108
175.	HALF ADDER	108
176.	U-LATCH	109
177.	2-LINE TO 4-LINE DECODED	109
178.	MULTIPLIER	110
179.	DUAL 2-INPUT MULTIPLEXER	110
180.	TWO-STAGE FREQUENCY DIVIDER	111
12) Circuits That Counts		
181.	BASIC COUNTER	112
182.	SYNCHRONOUS COUNTER	112
183.	ASYNCHRONCUS COUNTER	113
184.	COUNTER WITH LINE DECODER	113
185..	DIVIDE BY 4 COUNTER	114
186.	DIVIDE BY 4 COUNTER WITH LINE DECODER	114
187.	HOW A DECODER WORKS	115
188.	MULPLE COUNTER	115
189.	BINARY COUNTER WITH DISPLAY	116
190.	DIVIDE BY 3 COUNTER WITH DISPLAY	116
190.	DIVIDE BY 4 COUNTER WITH DISPLAY	117
192	UP/DOWNCOUNTER	117
193.	DOWN COUNTER	118
194.	DECADE DOWN COUNTER	118
195.	DECADE DOWN COUNTER WITH DISPLAY	119
196.	PRESETTABLE COUNTER	119
197.	HEXADECIMAL COUNTER	120
198.	OCTAL COUNTER	120

199.	RANDOM ACCESS DISPLAY	121
200.	DECADE COUNTER	121
201.	BCD COUNTER WITH DISPLAY	122
202.	OCTAL COUNTER WITH LINE DECODER	122
203.	OCTAL COUNTER WITH DISPLAY	123
204.	DECADE COUNTER WITH DISPLAY	123
205.	DECADE COUNTER WITH DISPLAY II	124
206.	BCD TO 7-SEGMENT DECODER	124

13) Amusement in Digital Land

207.	VCO BY NOR GATE	125
208.	PULSE-DELAYED CIRCUIT	125
209.	NAND GATET ONE GENERATQR	126
210.	TRANSISTOR TIMER	126
211.	NOISE-SIGNAL DISCRIMINATOR	127
212.	PULSE STRETCHER	127
213.	BIDIRECTIONAL BUFFER	128
214.	VARIOUS INVERTERS	128
215.	ELECTRONIC SWITCH	129
216.	TONE BURST GENERATOR	129
217.	DIGITALTIMER	130
218.	DIGITAL TIMER II	130
219.	TEN COUNT BUZZER	131
220.	PRESS FIRST	131
221.	TARGETRANGE	132
222.	CATCH THE EIGHT	132
223.	SOS ALERT	133
224.	WHEEL OF FORTUNE	133
225.	LEAPIN LEDS	134

14) Surprise and Fun Revisited

226.	EXPERIMENT OF ELECTROMAGNETIC INDUCTION	134
227.	ELECTRONIC CANDLE	135
228.	CONSTANT CURRENT CIRCUIT	125
229.	A PHONY COUNTER	136
230.	ALPHABET FLASHER	136
231.	WINKING LEDS	137
233.	DELAYED TIMER II	137
234.	VOICE LEVEL METER	138
225.	CROSSING SIGNAL	139
236.	OCTAVE GENERATOR	139
237.	BUZZIN LED	140
238.	SON OF BUZZIN LED	140
239.	SOUND OUT TIMER	141
240.	SOUND STOP	141
241.	BIG MOUTH!	142
242.	LIGHT OR SOUND	142
243.	BE YOUR OWN MULTIVIBRATOR	143
244.	ANTICIPATION	143
245.	SET/RESET MATCH	144

15) Testing and Measuring Circuits

246.	CIRCUIT CONTINUITY CHECKER	144
247.	ACOUSTIC OHMMETER	145
248.	AUDIO SIGNALTRACER	145
249.	AUDIO SIGNAL GENERATOR	146
250.	METAL DETECTOR	146

251.	RAIN DETECTOR	147
252.	BURGLARALARM	147
253.	TEMPERATURE-SENSITIVE AUDIO AMPLIFIER	148
254.	WATER LEVEL DETECTOR	148

Book #2

HARDWARE - Advance Course

CONTENTS

1) Learn Basics More

255.	A BASIC OF CONTROL VOLUME	4
256.	EMITTER FOLLOWER	4
257.	BASIC OPERATION OF ZENER DIODE	5
258.	ZENER VOLTAGE CHECKER	5
259.	ZENER VOLTAGE CHECKERII	6
260.	BASIC PHOTO-TRANSISTOR OPERATION	6
261.	VOLTAGE DROP CIRCUIT BY MEANS OF DIODES	7
262.	EXPERIMENTATION OF CAPACITOR TEMPERATURE CHARACTERISTIC	7
263.	DARLINGTON CIRCUIT (TOUCH SENSOR)	8
264.	EDGE-TRIGGER CIRCUIT	8
265.	RC TYPE DIFFERENTIATING CIRCUIT	9
266.	SWITCH MATRIX CIRCUIT	9
267.	MEMORY BACKUP CIRCUIT	10
268.	POWER ON RESET CIRCUIT	10
269.	CONSTANT-VOLTAGE CIRCUIT (FIXED OUTPUT)	11
270.	CONSTANT-VOLTAGE CIRCUIT (VARIABLE OUTPUT)	11
271.	A RECTIFIER CIRCUIT BY DIODE BRIDGE	12
272.	AGC CIRCUIT USING A SINGLE TRANSISTOR	12
273.	UPPER/LOWER LIMITER CIRCUIT USING OP AMPLIFIER	13
274.	ABSOLUTE VALUE AMPLIFIER	13
275.	WINDOW COMPARATOR	14
276.	WINDOW COMPARATOR II	14

2) Amusement on Sound

277.	MULTI-TONE SIREN	15
278.	DIGITAL RHYTHM	16
279.	TWO-IC ELECTRIC ORGAN	16
280.	A WATER SERVICE PIPE SOUND	17
281.	ELECTRONIC KLAXON	17
262.	SOUNDMACHINE III	18
283.	SOUND WAVE VARYING WITH LIGHT INTENSITY	18
284.	PLAYER ORGAN	19
285.	SOUND OF PASSING SIREN	19
286.	LIGHT SOURCE SENSING CIRCUIT BY SOUND	20
287.	ELECTRONIC PIANO CIRCUIT	20
288.	WHISTLE GENERATING CIRCUIT	21
289.	SPACE GUN	21
290.	CAR HORN	22

3) More Radio Circuits

291.	MORSE CODE TRANSMITTER	22
292.	BROADCASTING ORGAN	23
293.	FM TRANSMITTER (FM WIRELESS MICROPHONE)	23

4) To the Game World

294.	QUIZ WINNER DETECTOR	24
295.	REFLEX NERVE TEST GAME	24
296.	SHOOTING GAME II	25
297.	SHOT IN THE DARK II	25
298.	SOUND QUIZ	26
299.	STOP THE SEVEN	26
300.	HIGH-POWER SWITCH	27
301.	“LOCKOUT MR. BLACKBEARD!” GAME	27
302.	RUSSIAN ROULEUE	28
303.	MOLE HITTING GAME	28
304.	“JANKEN” GAME	29
305.	PING-POND GAME	29

5) More Adventure in OP Amplifier Circuits

306.	VOLTAGE CONTROLLED AMPLIFIER	30
307.	V-F CONVERTER	30
308.	F-V CONVERTER	31
309.	F-V CONVERTER II	31
310.	WHITE NOISE GENERATOR	32
311.	SWEEP GENERATOR	32
312.	MULTIPLE FUNCTION IC PROJECT	33
313.	SOUND ALARM	33
314.	A SOUND OF RIPPLES	34
315.	PHOTO ORGAN	34
316.	VIBRATO ORGAN	35

6) More About Oscillation

317.	PHASE SHIFT OSCILLATOR	35
318.	WIDE RANGE AUDIO FREQUENCY OSCILLATOR	36
319.	SAWTOOTH WAVE OSCILLATOR II	36
320.	THREE PHASE OSCILLATOR	37
321.	WIEN-BRIDGE OSCILLATOR	37
322.	RAMP WAVE GENERATOR	38
323.	DIGITAL SINE WAVE GENERATOR	38
324.	FREQUENCY.VARIABLE SINE WAVE GENERATOR	39
325.	SINE WAVE OSCILLATOR USING D-A CONVERTER	39
326.	RC PHASE-SHIFT OSCILLATOR	40
327.	TWO SINE WAVES WITH DIFFERENT PHASES	40
328.	ONE-SHOT MULTIVIBRATOR USING IC 555	41
329.	ONE-SHOT MULTIVIBRATOR USING J-K FLIP-FLOP	41
330.	ONE-SHOT MULTIVIBRATOR USING OP AMPLIFIER	42

7) Shakehands of Analog and Digital

331.	PULSE NUMBER MODULATION LIGHT DIMMER	42
332.	PULSE WIDTH MODULATION LIGHT DIMMER	43
333.	DC-DC CONVERTER USING THE C-MOS OSCILLATOR	43
334.	DIGITAL LIGHT DIMMER	44
335.	A-D CONVERTER	44
336.	D-A CONVERTER	45
337.	PHOTOMETER WITH DIGITAL DISPLAY	45
338.	PULSE WIDTH MODULATION LIGHT DIMMER II	46
339.	VOLTMETER	46

8) Getting Closer to Computer

340.	FULL ADDER	47
------	------------	----

341.	DECIMAL TO BINARY ENCODER	47
342.	BINARY TO BCD	48
343.	OCTAL TO BCD	48
344.	HEXADECIMAL TO BCD	49
345.	3-SIT SHIFT REGISTER	49
346.	SOD-TO-DECIMAL DECODER	50

9) More Digital circuits

347.	4-INPUT DATA SELECTOR	51
348.	AND/OR CIRCUIT USING OP AMPLIFIER	51
349.	XOR USING OP AMPLIFIER	52
350.	TIME SHARING DISPLAY OF LEDES	52
351.	LED LIGHTING-DUTY VARYING CIRCUIT USING ONE-SHOT MULTIVIBRATOR	53
352.	LED BLINKING-CYCLE VARYING CIRCUIT USING ASTABLE MULTIVIBRATOR	53
353.	LCD STATIC DRIVE CIRCUIT	54
354.	LCD DYNAMIC DRIVE CIRCUIT	54
355.	TESTING LCD DISPLAY RESPONSE	55
356.	LED DRIVE BY 4 SWITCHES	55
357.	FLASHING LED BY PRESET NUMBER	56
358.	DIGITAL TIMER (1 TO 7 MINUTES)	56
359.	SOUND TIMER	57
360.	PROGRAMMABLE TIMER WITH DOWN COUNTER	57

10) Amusement in Electronic Circuits

361.	REVOLVING LIGHT	58
362.	PHOTO SWITCH	58
363.	DOOR CHIME	59
364.	VISITOR SENSING CHIME USING PHOTO-TRANSISTOR	59
365.	TOUCH VCO	60
366.	SOUND TUNING CIRCUIT	60
367.	CROSSING-BELL SOUND GENERATOR	61
368.	TURN INDICATOR	61
369.	STAIRCASE LIGHT SWITCHING CONTROL CIRCUIT	62
370.	PSEUDO CANDLE CIRCUIT	62
371.	LIE DETECTOR	63
372.	LIGHT SENSING CIRCUIT	63
373.	AUTOMATIC LIGHTING LED	64
374.	SOUND SENSING LED	64
375.	ILLUMINATION LAMP	65
376.	INTERCOM	65
377.	PIP SOUND INTERPHONE	66
378.	ELECTRONIC VOLUME	66
379.	PEDESTRIAN SIGNAL	67
380.	TIME COUNTER	67
381.	LED DISPLAY COUNTING UP/DOWN CIRCUIT	68
382.	AN ELECTRONIC PENDULUM	68
383.	STAIRCASE LIGHT SWITCHING CONTROL CIRCUIT-II	69
384.	LAMP BRIGHTNESS CONTROL CIRCUIT	69
385.	ILLUMINATION CIRCUIT WITH 4-LEDS	70
386.	A SIMULATED CAR WINKERS	70

11) Testing and Measuring Circuits

387.	BATTERY CHECKER	71
388.	CONDUCTIVITY TESTER	71
389.	IC OSCILLATOR/COMPONENT TESTER	72
390.	VOLTAGE DROP ALARM	72
391.	TRANSISTOR CHECKER	73
392.	CURRENT SHUT-DOWN CIRCUIT	73

393. LOGIC CHECKER	74
394. LOGIC CHECKER II	74
395. THREE-STEP WATER LEVEL INDICATOR	75
396. TEMPERATURE ALARM	75
397. FUNCTION GENERATOR	76
398. TACHOMETER	76
399. BATTERY CHECKER H	77
400. DIGITAL ILLUMINOMETER	77

Book #3

SOFTWARE – Programming Course

CONTENTS

Welcome to the World of Computer!	5
Functions of Each Component	5
Memory	5
Accumulator and Registers	5
ALU (Arithmetic Logic Unit)	5
Keyboard and LCD Display	5
Input and Output Ports	5
Microprocessor's Instructions and Programming	5
Instruction Format	5
Outlook of the LCD Display	5
Line Number	6
Instruction	6
Operand(s)	6
Comments	6
Hexadecimal Numbering System	6
What is Flow-chart	7
How To Read Flow-chart	7
Keyboard and Operation	7
How To Run The Program	8
Initial Menu	8
Selecting a Mode of Operation	8
Program Mode (PGM)	8
To Enter An Instruction Code	8
Other Types of Move Instructions	9
Steps To Enter Type2/Type3 Instructions	9
Editing Instruction Lines	10
To Correct or Remove an Instruction Code	10
To Insert a New Instruction Code	10
Debug Mode	11
To Display the Contents of Zero-Flag and Carry-Flag	12
Game Mode	12

References:

Instructions Set	13
Carry-flag and Zero-flag	13
Input/Output Instructions	13
Move Instruction	14
Arithmetic Instructions	14
Shift Instructions	17
Increment/Decrement Instructions	18
Jump Instructions	19
Comparison Instruction	20
Beep Instructions	21

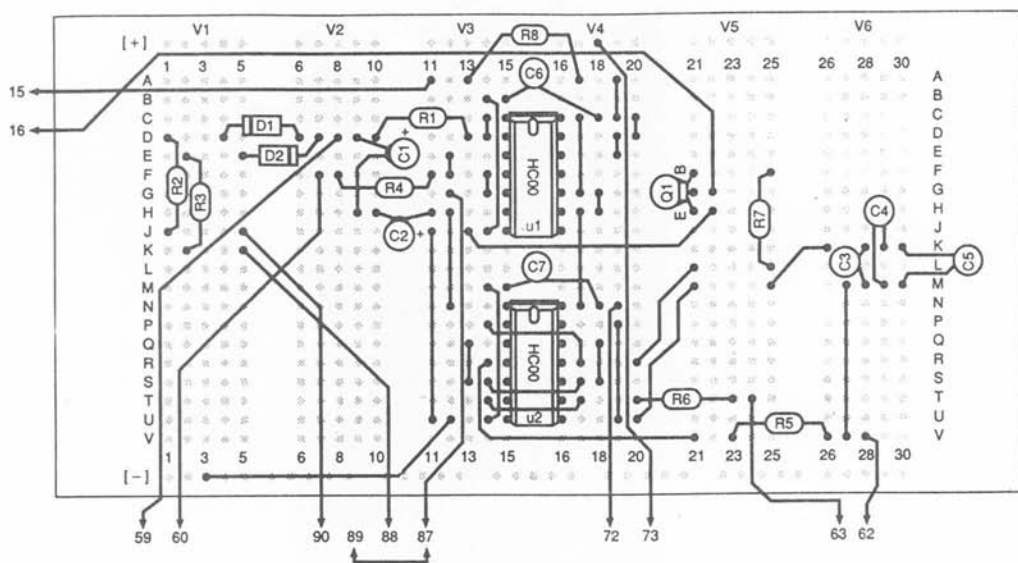
Time Control Instructions	22
Other Instructions	22
About Project-401 to Project-500	23

Software Projects

401	Light LEDs	24
402	Light On/Off LEDs	26
403.	A Binary Counter - Increment Value by ADD Instruction	27
404.	Binary Counter - Decrement Value by SUB Instruction	29
405.	LEDs Sequentially with AND Instruction	31
406.	Light LEDs Sequentially with OR Instruction	33
407.	Turn On and Off LEDs Sequentially with XOR Instruction	35
408.	Moving LEDs Light with AOL Instruction	37
409.	Moving LEDs Light with ROR instruction	38
410.	Night Riders LEDs with ROL/ROR Instructions (1)	39
411.	Night Riders LEDs with ROL/ROR Instructions (2)	40
412.	Binary Counter with INC Instruction	41
413.	Binary Counter with DEC Instruction	42
414.	Sound Do as Do, Re, Mi	43
415.	Sound a Series of Musical Scale	44
416.	Let's Input Data to Program	45
417.	Hidden Key Triggers Sound and Turns All LEDs On	46
418.	Stacked MOV Instructions	47
419.	Changing Order of LEDs by Switch	49
420.	A Musical Scale Sound by S1 Key	51
421.	Arithmetic addition of two binary values	52
422.	Arithmetic subtraction of two binary values	54
423.	Arithmetic Multiplication of Two Binary Values	55
424.	Arithmetic Division of Two Binary Values	57
425.	Displays Number 0 To 9 on 7-segment LED (1)	59
426.	Change Order of Numbers Display on 7-segment LED (2)	61
427.	Switches S1-S4 Light Hex Number On 7-Seg LED	62
428.	8-Key Organ	64
429.	Lighting Spade, Diamond, Heart, and Club on the LCDs Display (Basic)	65
430.	Lighting Spade/Heart and Diamond/Club on the LCDs Display	66
431.	Lighting Spade, Diamond, Heart, and Club by Static Drive Circuit	67
432.	Lighting Spade, Diamond, Heart, and Club by 1/2 Duty-1/2 Bias Circuit	69
433.	Lighting Spade/Diamond and Heart/Club by 1/2 Duty-1/2 Bias Circuit	71
434.	Lighting Spade/Diamond and Heart/Club Alternately by 1/2 Duty-1/2 Bias Circuit	73
435.	Lighting Spade, Diamond, Heart, and Club by 1/2 Duty-1/2 Bias Circuit	75
436.	Results of Logical Operations AND, NAND, OR, and NOR	76
437.	Results of Logical Operations XOR and XNOR	77
438.	Results of Logical Operations AND/NAND with 4-Switch Entry	78
439.	Results of Logical Operations OR/NOR with 4-Switch Entry	79
440.	Results of Logical Operations XOR/XNOR with 4-Switch Entry	80
441.	Logical AND/NAND Gate for Driving External Circuit	81
442.	Logical OR/NOR Gate for Driving External Circuit	82
443.	Logical XOR/XNOR Gate for Driving External Circuit	83
444.	Find a Leading Edge of Input Pulse	84
445.	Finding a trailing Edge of Input Pulse	85
446.	Finding a leading and trailing Edges of Input Pulse	86
447.	A Pulse Stretcher	87
448.	Starting a Delayed Pulse	88
449.	Pulse Stretcher By Counting a Clock	89
450.	Counting External Pulse To Advance Decimal Counter	90
451.	Displays Number 0 To 9 on 7-segment LED (1)	91
452.	Change Order of Numbers Display on 7-segment LED (2)	92

453.	Counts an External Clock (1)	93
454.	Counts an External Clock (2)	94
455.	Counts an External Clock (3)	95
456.	Counts an External Clock (4)	96
457.	Counts an External Clock (5)	97
458.	Counts an External Clock (6)	98
459.	3-Minute Timer	99
460.	Multi-Function Timer (1)	100
461.	15-Minute Timer with 7-segment Display	101
462.	Multi-Function Timer (2)	102
463.	Digital Organ with PHOTO-TRANSISTOR (1)	103
464.	Digital Organ with PHOTO-TRANSISTOR (2)	104
465.	Digital Volume Changer (1)	105
466.	Digital Volume Changer (2)	106
467.	Digital Volume Changer (3)	107
468.	Digital Volume Changer (4)	108
469.	Digital Volume Changer (5)	109
470.	Illumination Controlled by PHOTO-TRANSISTOR (1)	110
471.	Illumination Controlled by PHOTO-TRANSISTOR (2)	111
472.	Illumination Controlled by Oscillator and PHOTO-TRANSISTOR (1)	112
473.	Illumination Controlled by Oscillator and PHOTO-TRANSISTOR (2)	113
474.	Illumination with Speed Control (1)	114
475.	Illumination with Speed Control (2)	115
476.	Sawtooth Waveform Generator	116
477.	Triangular Pulse Generator	117
478.	Digital Level Indicator	118
479.	Digital Lux Meter (Display in Binary)	119
480.	4-Bit ND Converter (Display in Binary)	120
481.	4-Bit ND Converter (Display in Hexadecimal On 7-Segment LED)	121
482.	Digital Lux Meter (Display In Hexadecimal)	122
483.	Audio Level Meter	123
484.	Audio Level Meter With Peak-Holding Capability	124
485.	Lighting Sign Board	125
486.	Digital Dice	126
487.	Digital Roulette	127
488.	Digital Slot Machine	128
489.	Up/Down Counter	129
490.	Digital Metronome	130
491.	Frequency Counter	131
492.	Dynamic Lighting of 7-segment LED	132
493.	Lighting LED with Pulse Width Modulation	133
494.	Majority Logic Gate (2)	134
495.	Lighting LCD Segments by Static Drive	135
496.	Digital Buzzer	136
497.	Rhythm Box (1)	137
498.	Rhythm Box (2)	138
499.	Rhythm Box (3)	139
500.	Rhythm Box (3)	140

PROJECT 216. TONE BURST GENERATOR



U1	74HC00	R2	47K Ω	R6	33K Ω	C2	10 μ F	C6	0.1 μ F
U2	74HC00	R3	47K Ω	R7	10K Ω	C3	0.1 μ F	C7	0.1 μ F
Q1	NPN	R4	33K Ω	R8	470 Ω	C4	0.1 μ F	D1	Si
R1	220K Ω	R5	47K Ω	C1	10 μ F	C5	0.1 μ F	D2	Si

A tone generator is an oscillator that sends out signals repeated at regular intervals, as shown in Figure 1. As its name suggests, a speaker is usually used to let you hear the tone it makes. But in this project, we're going to use an LED to find out how it works.

You can see from the schematic, IC U2 is a tone generator whose frequency can be changed by 100K control volume. IC U1 is another generator which controls the start and stop of the tone generator. Its frequency can also be changed by turning 50K control volume, and its duty ratio can be adjusted using S1 and S2. Remember what the duty ratio is? Refer back to project 53. The duty ratio is about 24% when S1 is ON, and about 76% when S2 is ON. This project can be used as a logic circuit whose waveform ends in an integer cycle.

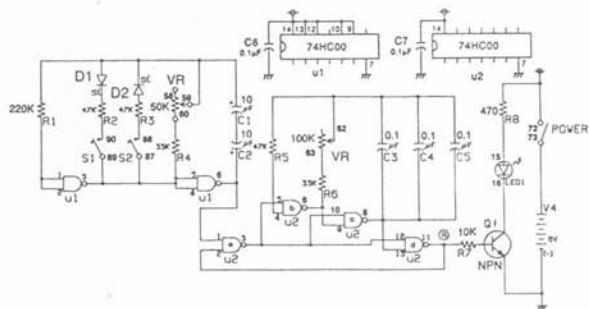
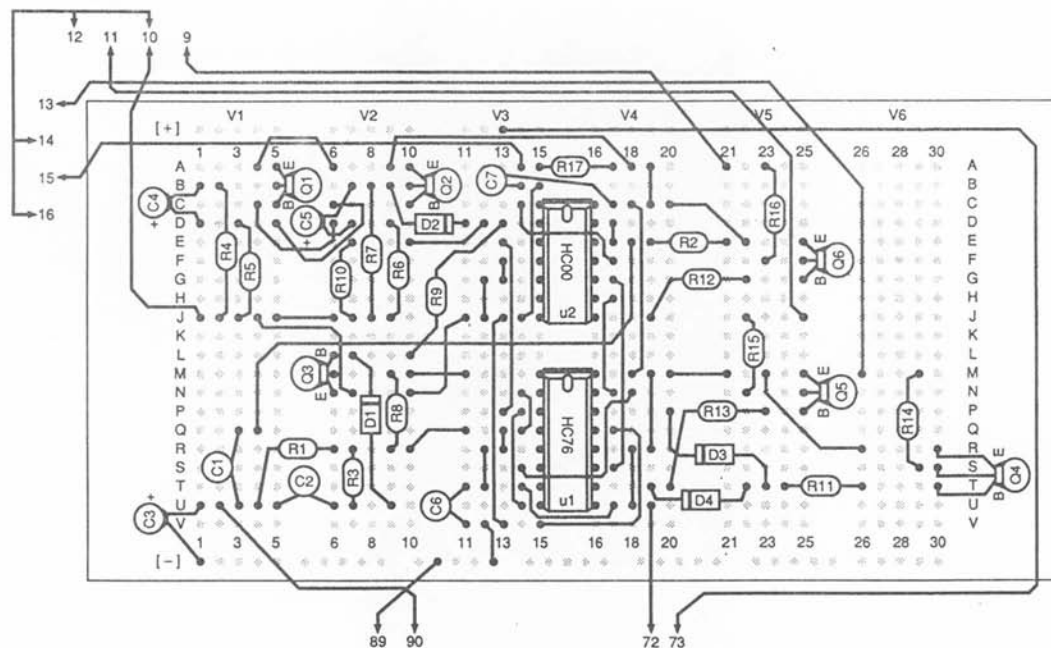


Figure 1

When you finish assembling the project, turn power ON and see what the LED is doing. Does it blink ON and OFF as shown in Figure 1? Then, turn 50K control volume and press S1 and S2, and see how the LED changes its blinking intervals.

PROJECT 225. LEAPIN' LEDS

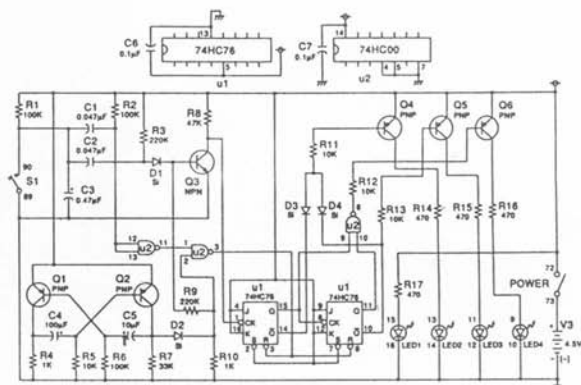


U1	74HC76	Q6	PNP	R7	33K Ω	R14	470 Ω	C4	100 μ F
U2	74HC00	R1	100K Ω	R8	47K Ω	R15	470 Ω	C5	10 μ F
Q1	PNP	R2	100K Ω	R9	220K Ω	R16	470 Ω	C6	0.1 μ F
Q2	PNP	R3	220K Ω	R10	1K Ω	R17	470 Ω	C7	0.1 μ F
Q3	NPN	R4	1K Ω	R11	10K Ω	C1	0.047 μ F	D1	Si
Q4	PNP	R5	10K Ω	R12	10K Ω	C2	0.047 μ F	D2	Si
Q5	PNP	R6	100K Ω	R13	10K Ω	C3	0.47 μ F	D3	Si
								D4	Si

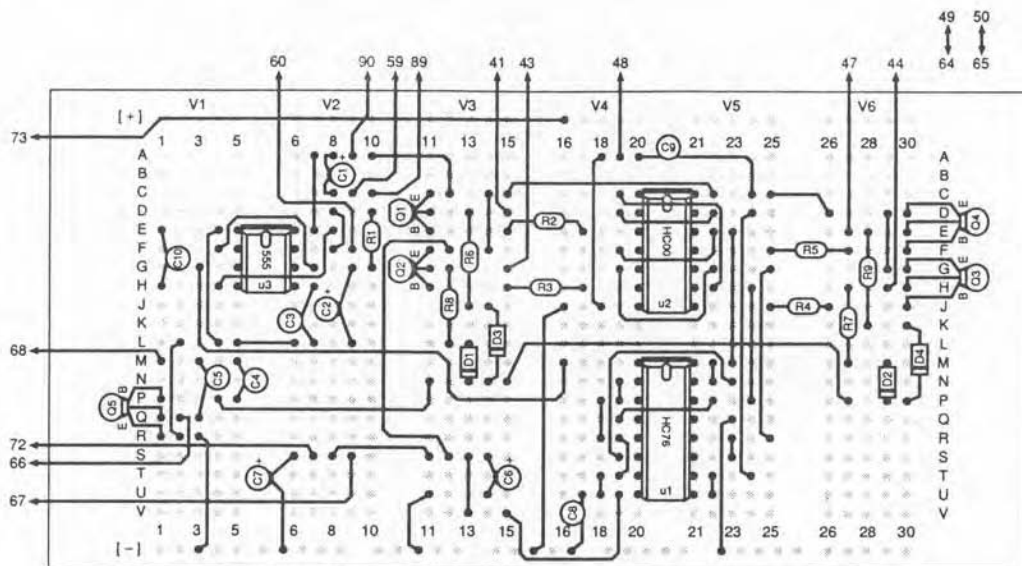
Here's game to see how fast you are on the trigger (or at least the key!). The object is to light **LEDs 1 through 4** as quickly as you are able or with as few presses of **S1** as you can.

To play, turn power ON. **LED 1** lights. Now press **S1** until **LED 2** lights. But, if you're not lucky, only **LED 1** lights. Continue to try to get all the **LEDs** to light up (**LED 1, 2, 3 and 4**).

The secret of this game is to press **S1** at exactly the right moment to light the **LED**. Timing's been an important part of all the digital circuits we've played with so far.



PROJECT 224. WHEEL OF FORTUNE



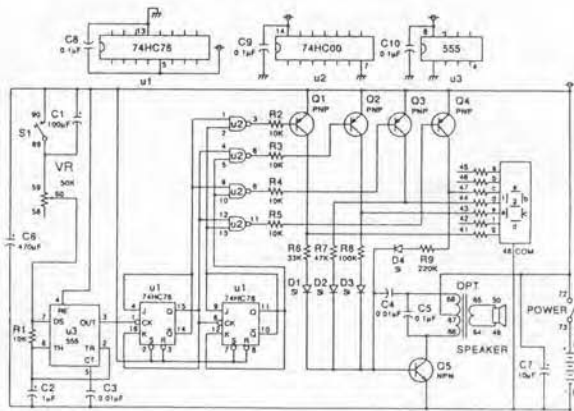
U1	74HC76	Q4	PNP	R5	10K Ω	C2	1 μ F	C8	0.1 μ F
U2	74HC00	Q5	NPN	R6	10K Ω	C3	0.01 μ F	C9	0.1 μ F
U3	555	R1	10K Ω	R7	47K Ω	C4	0.01 μ F	C10	0.1 μ F
Q1	PNP	R2	10K Ω	R8	100K Ω	C5	0.1 μ F	D1	Si
Q2	PNP	R3	10K Ω	R9	220K Ω	C6	470 μ F	D2	Si
Q3	PNP	R4	10K Ω	C1	100 μ F	C7	10 μ F	D3	Si
								D4	Si

You've probably seen a roulette wheel, or "wheel of fortune" type game in operation. You know how it works ... players try to guess where the wheel stops and they win if they guess right. We couldn't find room in this kit for the real thing, but we've included an electronic version!

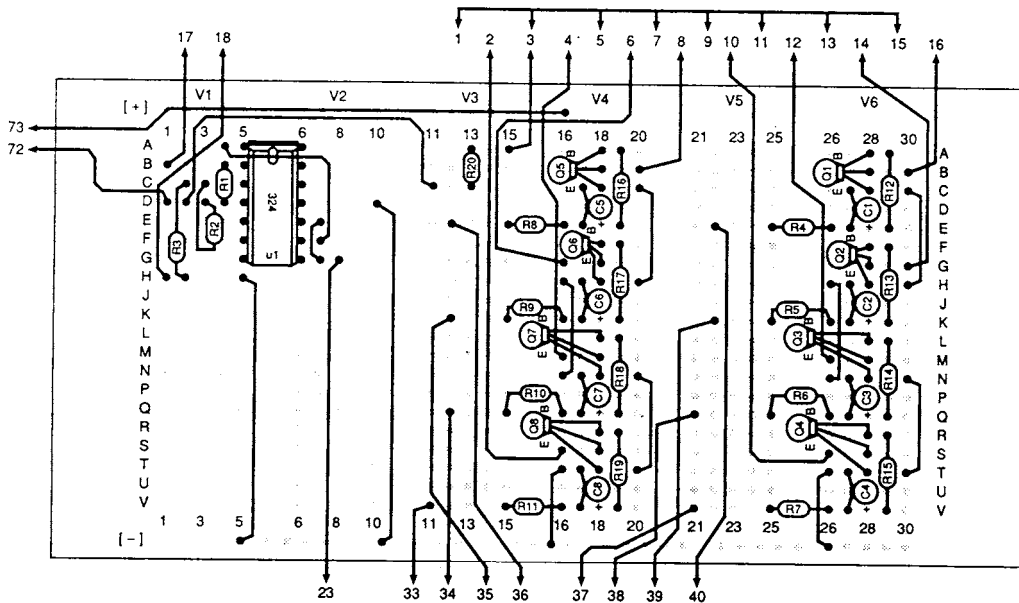
Using this electronic "wheel of fortune" is supersimple. Turn power ON and press **S1** down. You'll notice the lower half of the **LED display** lights up and seem to "spin" around. (It's not really spinning, of course - the different segments are just rapidly blinking on and off, one after the other.) During the "spinning" you'll hear a funny sound from the **speaker**. After a few moments both the "spinning" and sound slows down. Eventually, it stops with just one segment lit and a steady sound coming from the **speaker**.

You'll notice a couple of interesting things about this circuit. Each segment of the display has its own sound. And the speed at which the display "spins" depends upon the **control volume**. Try moving the **control volume** while the "wheel" is "spinning" ... notice how you can make it slow down or speed up.

You can use this project as a game by guessing which segment will be lit when the "wheel" finally stops "spinning." Or you can try to make the "wheel" stop at a certain segment by adjusting the **control volume** while it is still "spinning."



Project 470. Illumination Controlled by PHOTO-TRANSISTOR (1)



U1	324	Q8	NPN	R8	22K Ω	R16	4.7K Ω	C1	10 μ F
Q1	NPN	R1	2.7K Ω	R9	22K Ω	R17	4.7K Ω	C2	10 μ F
Q2	NPN	R2	100K Ω	R10	22K Ω	R18	4.7K Ω	C3	10 μ F
Q3	NPN	R3	47K Ω	R11	22K Ω	R19	4.7K Ω	C4	10 μ F
Q4	NPN	R4	22K Ω	R12	4.7K Ω	R20	270 Ω	C5	10 μ F
Q5	NPN	R5	22K Ω	R13	4.7K Ω			C6	10 μ F
Q6	NPN	R6	22K Ω	R14	4.7K Ω			C7	10 μ F
Q7	NPN	R7	22K Ω	R15	4.7K Ω			C8	10 μ F

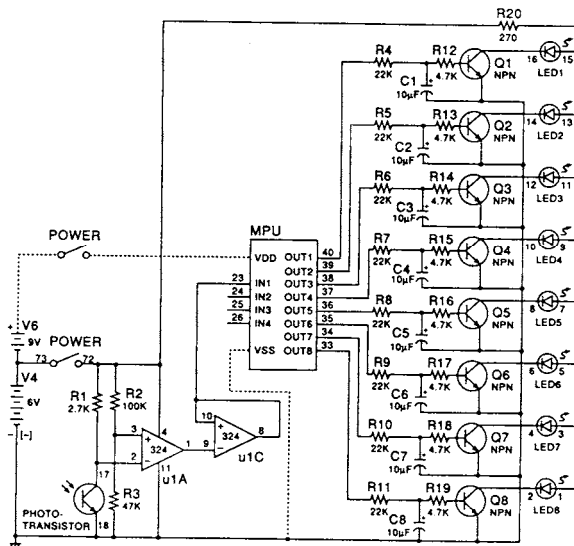
In this Project, we will make a program which starts illuminations on the LEDs by adjusting your finger position over the PHOTO-TRANSISTOR.

When the program is running, cover the PHOTO-TRANSISTOR with your finger tips for a moment and remove them. As you have waved a Checker Flag, it starts blinking of LEDs one by one from L1 thru L8.

Description:

When you look at the flow-chart, you can get it quite easily as its flow of control is relatively simple. Now, let's look into the program.

The key to understanding this program is how to start illumination by the movement of your finger tips over the PHOTO-TRANSISTOR. You can see one solution to that concern; the program code from #06 thru #08 and #09 thru #0B are what you have seen in several previous Projects. The code from #06 thru #08 captures the input data 01, that is, this short loop processing is over with your action of covering the PHOTO-TRANSISTOR with



your fingers. Then comes the 2nd gate, the #09 thru #0B, where the program waits for you to stop covering the PHOTO-TRANSISTOR with your fingers.

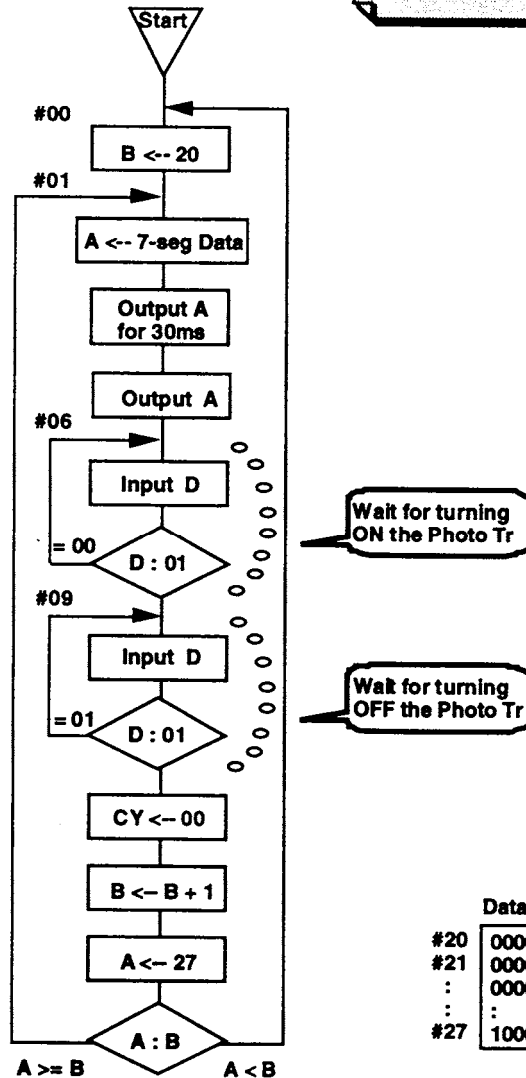
Program:

```

00 MOV B,#20H ; Get data table addr
01 MOV A,@B ; Get lighting data
02 OUT A ; Light LEDs
03 TM1 #03H ; for 30ms
04 MOV A,#00H ;
05 OUT A ; Turn OFF LEDs
06 IN D ; Get input
07 AND D,#01H ;
08 JZ L06H ; Wait for turning ON PTR
09 IN D ; Get input
0A AND D,#01H ;
0B JNZ L09H ; Wait for turning OFF PTR
0C CLC ; Clear carry-flag
0D INC B ; Increase table addr
0E MOV A,#27H ;
0F CMP A,B ;
10 JC L00H ; If end of table, return
11 JMP L01H ; In the mid of table; continue
12 NOP ;
:
20 HEX #01H ; (0000 0001)
21 HEX #02H ; (0000 0010)
22 HEX #04H ; (0000 0100)
23 HEX #08H ; (0000 1000)
24 HEX #10H ; (0001 0000)
25 HEX #20H ; (0010 0000)
26 HEX #40H ; (0100 0000)
27 HEX #80H ; (1000 0000)

```

Note: In the above program, NOP instructions in the lines #13 thru #1F are omitted. You are expected to enter these NOPs if you run the program.

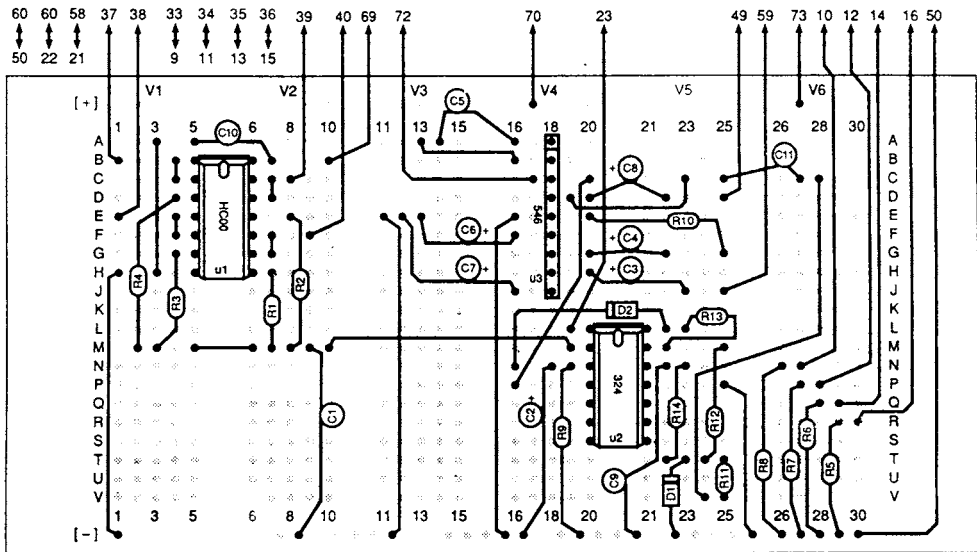


Data Table	
#20	0000 0001
#21	0000 0010
:	0000 0100
:	:
#27	1000 0000

Now, let's look the whole processing on the flow-chart. The program first gets the initial count value 20H at the #00. It then goes into a loop processing which includes the codes of sensing your finger action described above. This loop processing continue until its count becomes 28H. Since the initial count value is 20H, this loop repeats 8 times per one cycle. And this is also because that the output data table starting at address 20H contains 8 patterns of illumination.

The pattern of illumination is simple; it lights LEDs one by one from L1 to L8 repeatedly. You can change the data table values starting at #20 and get your own pattern.

Project 484. Audio Level Meter With Peak-Holding Capability



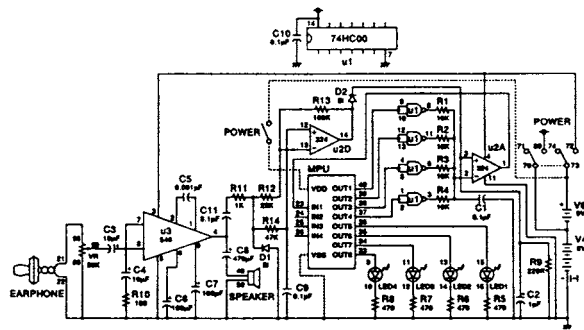
U1	74HC00	R4	10KΩ	R10	100Ω	C2	1μF	C8	470μF
U2	324	R5	470Ω	R11	1KΩ	C3	10μF	C9	0.1μF
U3	546	R6	470Ω	R12	22KΩ	C4	10μF	C10	0.1μF
R1	10KΩ	R7	470Ω	R13	100KΩ	C5	0.001μF	C11	0.1μF
R2	10KΩ	R8	470Ω	R14	47KΩ	C6	100μF	D1	Si
R3	10KΩ	R9	220KΩ	C1	0.1μF	C7	100μF	D2	Si

In this Project, the Audio Level Meter introduced by the Project-483 is enhanced so that it can capture the maximum input level and hold the data for a few second. This capability is convenient for checking the maximum sound signal level for example. You can change the holding period by altering the data value in register F.

Description:

The program works rather in a complicated way. The flow-chart will help you follow the move of program control. From the chart, you can find here again the inner loop processing; it starts from the #06 and ends at the #16. Let's trace the control of program by watching both the chart and the coding.

From the #06 thru #09, the program outputs the reference voltage data, wait for 40ms, and tries to get input data which is actually a single bit data from the comparator. If the input voltage to the IC2A exceeds the reference voltage, the comparator outputs high level of signal, and it is fed to the input port IN1 of the MPU. This is a 1-bit data from the comparator. If no data bit comes in, the control of program goes to the #11 at #0B. If 1-bit data comes in, the control of program goes forward to the #0C and the then-current reference voltage data in the



register C is saved to accumulator A.

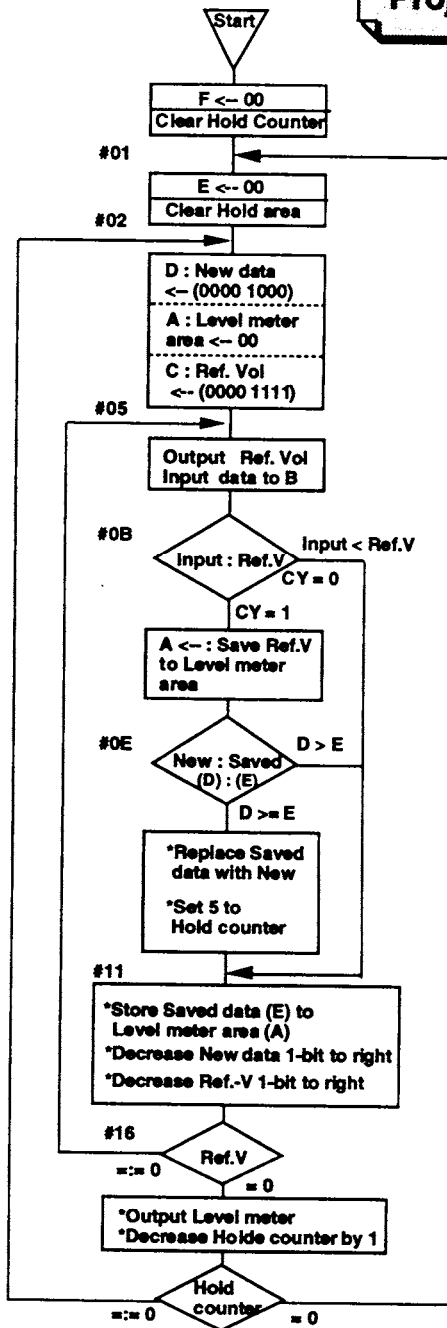
Then it comes to the #0D, where the Incoming data (register D) is compared with the Saved data (register E). If the Incoming data is less than the Saved data, the control of program goes to the #11. However, if the incoming data is greater than or equal to the Saved data, the program replaces the Saved data with the Incoming data at the #0F. After that, the Hold counter is set to 5 at the #10. And note that these two steps (#0F and #10) are performed only once within one Hold counter cycle! Let's prove it.

Program:

```

00 MOV F,#00H ; F = Hold counter
01 MOV E,#00H ; E = Hold-save area
02 MOV D,#08H ; D = Incoming data
03 MOV A,#00H ; A = Level meter data
04 MOV C,#0FH ; C = Reference voltage data
05 XOR C,#0FH ; Get lower 4-bit
06 OUT C ; Output reference voltage
07 XOR C,#0FH ; Restore C
08 TM1 #04H ; and wait for 40ms
09 IN B ; Get input from comparator
0A ROR B ; Move 1-bit data to carry FF
0B JNC L11H ; If input-V < ref-V; to #11
0C OR A,C ; Input-V > ref-V; save ref-V
0D CMP D,E ; (Incoming)-(Saved)
0E JC L11 ; If incoming < saved; to #11
0F MOV E,D ; Replace Saved with Incoming
10 MOV F,#05H ; Set hold counter to 5H
11 OR A,E ; Store Saved to M meter
12 CLC ; Clear carry FF
13 ROR D ; Decrease Incoming voltage
14 CLC ; Clear carry FF
15 ROR C ; Decrease ref-V
16 JNZ L05H ; If ref-V is not zero, to #05
17 CLC ; If ref-V is zero; clear FF
18 ROL A ; Move lower 4-bit left
19 ROL A ;
1A ROL A ;
1B ROL A ;
1C OUT A ; Output level meter data
1D TM1 #05H ; and wait for 50ms
1E DEC F ; Decrease Hold-counter by 1
1F JNZ L02H ; If not zero, go to 02#
20 JMP L01H ; If zero, go to #01
    
```

Project-484



Let's assume that the program is in the first pass of the first Hold counter cycle; therefore, the Incoming data (register D) is 08H (0000 1000) while the Saved data (register E) is 00H (0000 0000). This situation is possible only when the input voltage exceeds the reference voltage. Now, the control of program comes in the #0F, where the Saved data (register E) is replaced with the Incoming Data (register D). Because of this replacement of the data, these two steps can never be performed within the same Hold counter cycle. If the control returns to the same code at the #0D and #0E, the Incoming Data (register D) is ALWAYS smaller than the Saved data (register E) since the Incoming data is decreased by 1-bit shift to right at the #13 while the Saved data does not change. Remember that with these few steps, the largest Incoming data is captured within the Hold counter cycle.

Let's continue to trace the following codes. At the #11, the program stores the Saved data to the accumulator A as a level meter data, then it decreases the Incoming data at #13 and reference voltage data at #15 by shifting each register 1-bit to right.

The above inner loop processing continues until the reference voltage data becomes zero at the #16. Once this one cycle is over, the Level Meter data in the accumulator A is output and the Hold counter is decreased by 1. The program continues to perform these above processing until the Hold counter becomes zero.