Synchronous Decade Counter

Students: Ilies Darius-Mihai, Lazar Razvan-Gabriel

Coordinator: Papazian Petru

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1. Block Diagrams Design

Synchronous Decade Counter, made with dedicated bistable, with decoded outputs and CC display. It will only use IC's from the HCT/HC series.Oscillator will have only one frequency of 1 Hz and a manual tick button.

1.1 Block Diagram

The block diagram contains the oscillator with the one frequency of 1Hz and manual clock, the synchronous counter made from 4 flip-flops, at whose outputs there are 4 LED's, the decoder 4/7 and the 7 segment display CC type. The diagram is shown below:

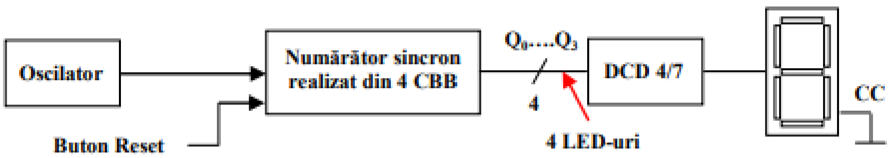

Figure 1. Block Diagram

1.2 Design of the power supply

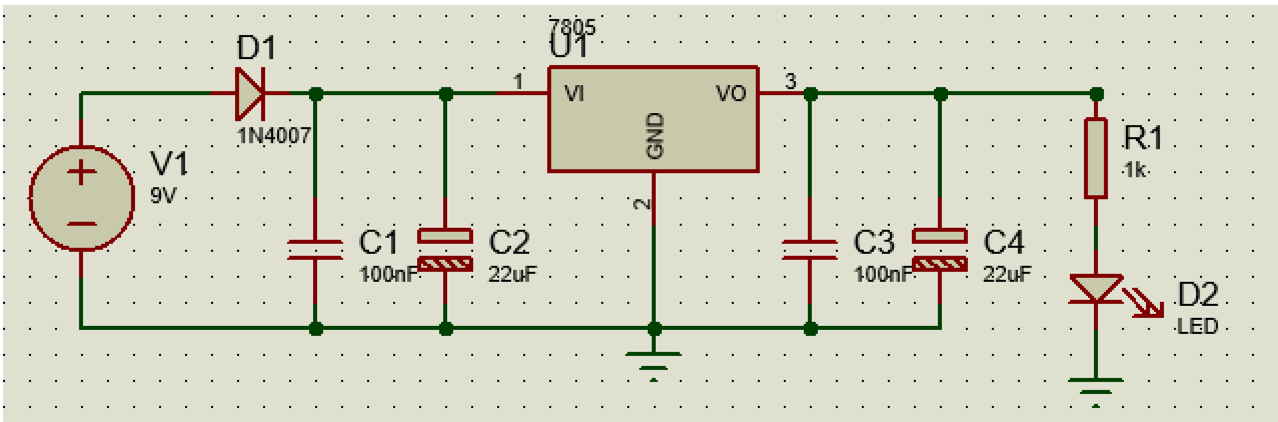

Figure 2. Power Supply Block Diagram

1.3 Design of the Oscillator

The clock signal (Figure 3) can be generated manually or automatically depending on the position of the switch.

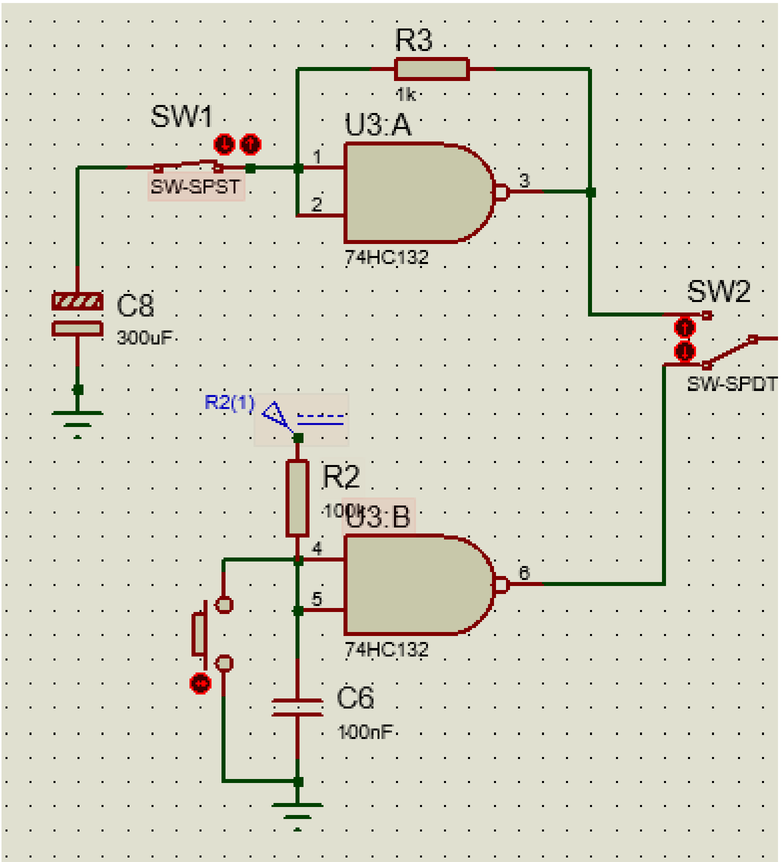

Figure 3. Oscillator Block Diagram

For a 74HCT132 gate we will have: V1 = 1,5V; V2 = 0,9V; VOL = 0V; VOH = 5V; IILR = 0V.
After using the formulas and calculating we see that T1=0,51RC and T2=0,15RC.
So f=1/0.66RC.
And since we need to get the f=1Hz we can make the following calculations:
1 = 1/0.66RC
0,66*R*C=1
R*C=1.515
then we can take the values for the resistor and capacitor as R=100k and C=15.15uF and R=1k and C=1.515mF or 1515uf.

1.4 Counter Design

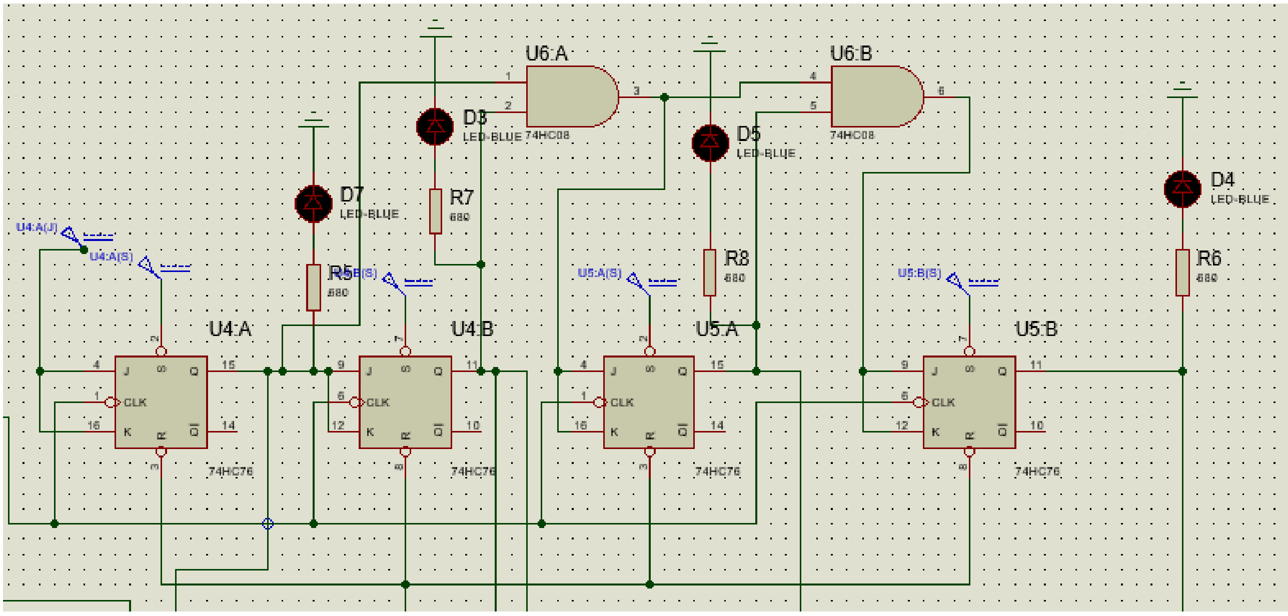

Figure 4. Counter Block Diagram

1.5 7 Segment Display Design

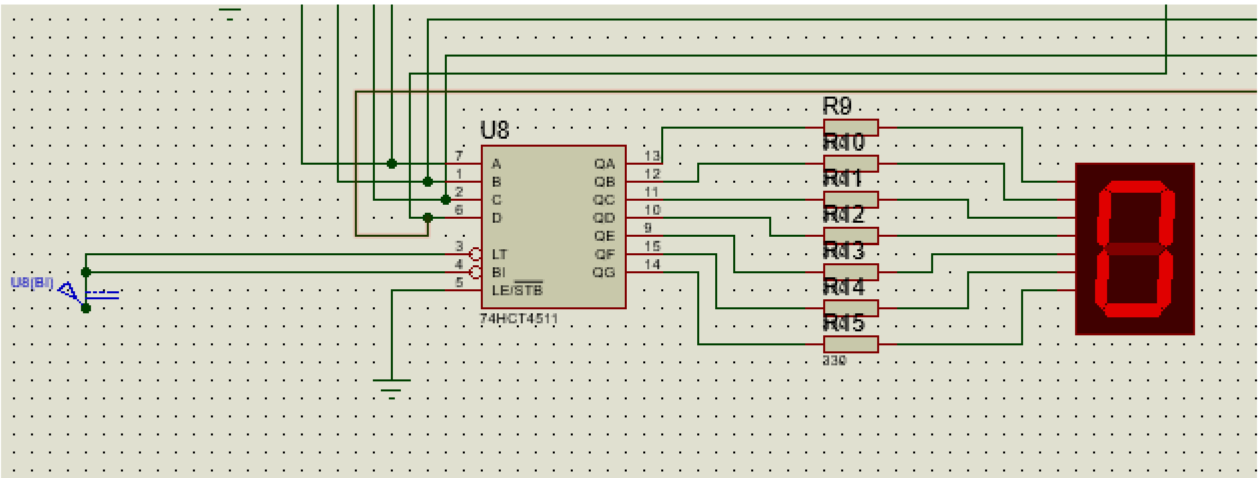

Figure 5. CC Display Block Diagram

1.6 Reset Button Design

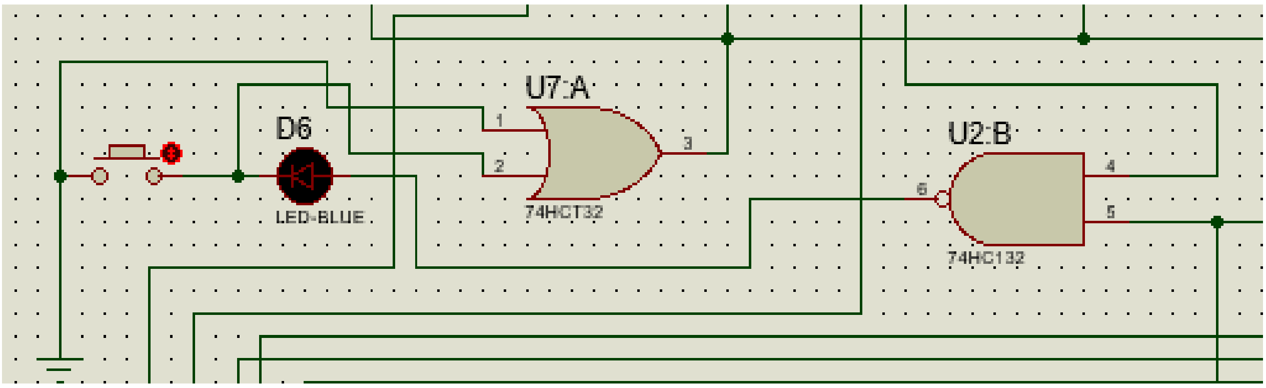

Figure 6. Reset Button Block Diagram

1.7 Complete Electronic Schematic Design

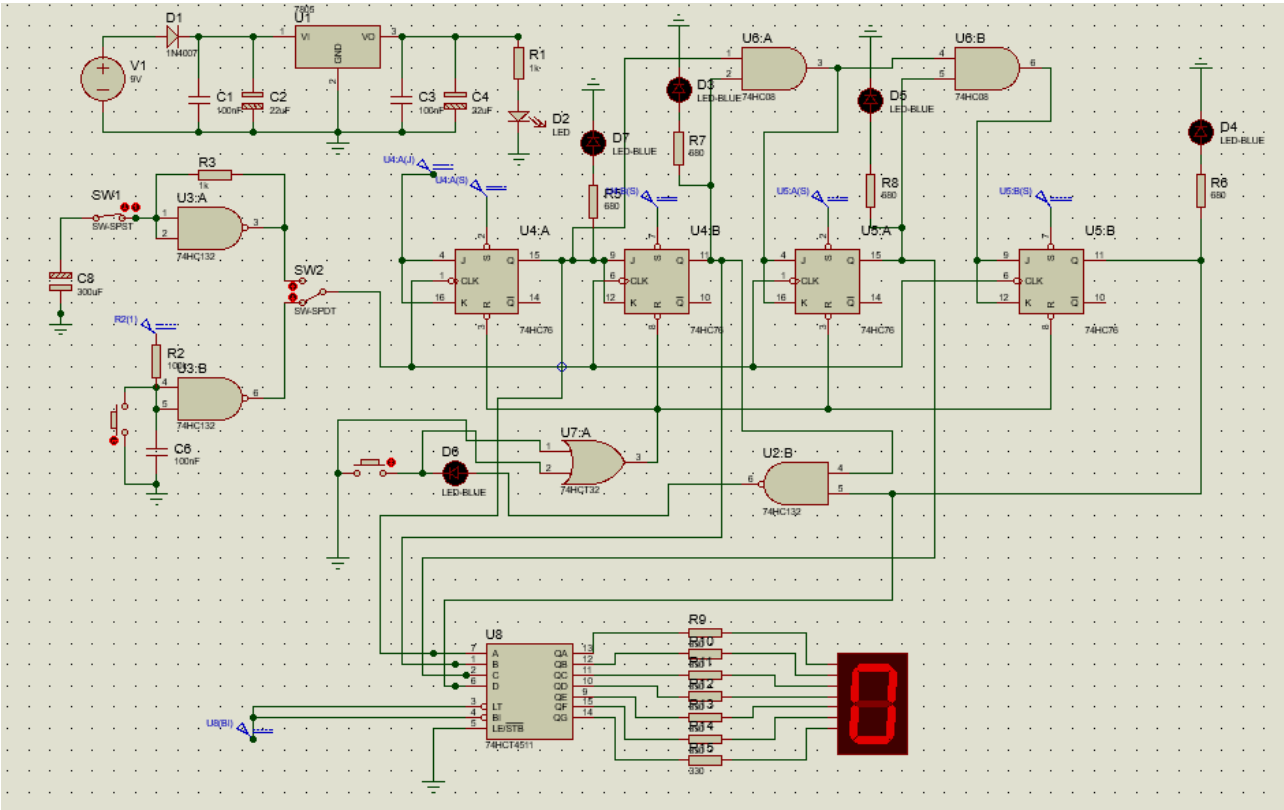

Figure 7. Complete Schematic Block Diagram

2. Simulation

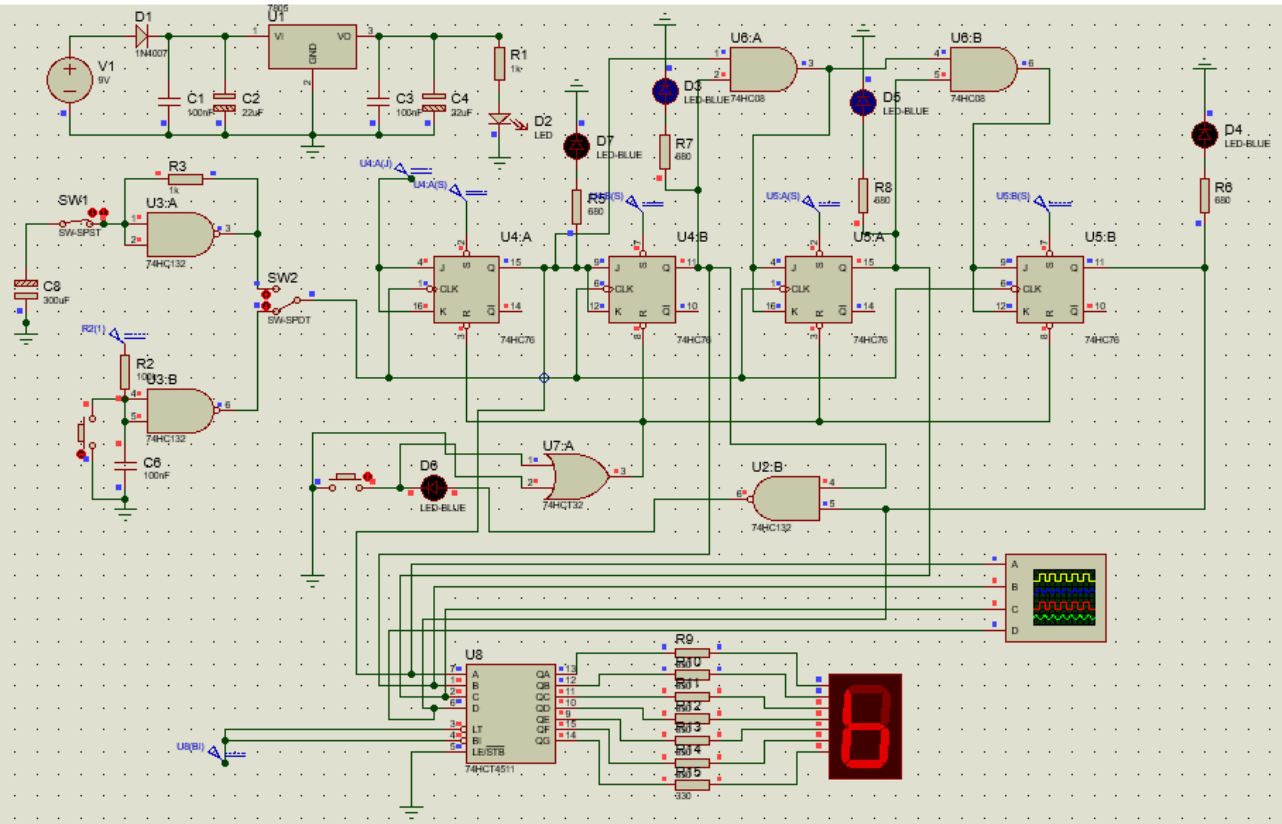

Figure 8. Simulation in Proteus

3. General Considerations

3.1 Calculation of Power Dissipation

In the schematic we have 4 integrated circuits for which the power dissipation value can be found in the datasheet, the 5 LEDs, the 7 segment display and a voltage regulation. Power dissipation calculation for the integrated circuit $U2$, based on the datasheet:

$$PU2 = Vcc \cdot Icc = 5[V] \cdot 50[mA] = 250\ [mW]$$

Power dissipation calculation for the integrated circuit $U3$, $U4$ based on the datasheet:

$$PU3 = PU4 = Vcc \cdot Icc = 5[V] \cdot 50[mA] = 250\ [mW]$$

Power dissipation calculation for the integrated circuit $U5$, based on the datasheet:

$$PU5 = Vcc \cdot Icc = 5[V] \cdot 50[mA] = 250\ [mW]$$

Power dissipation calculation for the 7 segment display $U6$, based on the datasheet:

$$PU6 = Vcc \cdot IF = 5[V] \cdot 25[mA] = 125\ [mW]$$

The calculation of power dissipation of the voltage regulator $U1$:

$$IOUT = 4 \cdot Icc + IF = 200[mA] + 25[mA]$$

$$PU1 = (VIN - VOUT) \cdot IOUT = (9 - 5)[V] \cdot 225[mA] = 900[mW] = 0.9[W]$$

Also in the schematic we have 4 LEDs, one for the power supply and four for the outputs of the counter:

$$ILED = (VDD - VD)/R = (5 - 2)/1000 = 3[mA]$$
$$PLED = VR \cdot ILED = 3[V] \cdot 3[mA] = 9[mW]$$
$$PtLED = 5 \cdot 9[mW] = 45[mW]$$

The total power dissipated in the designed schematic is the sum of the power dissipated by the integrated circuits, the voltage regulator and the power dissipated by the 4 LEDs and the 7 segment display.

$$PDtotal = PU1 + PU2 + PU3 + PU4 + PU5 + PU6 + PtLED$$
$$PDtotal = 900 + 250 + 250 + 250 + 250 + 45 = 1945[mW]$$
$$PDtotal = 1.945[W]$$

3.2 BOM (Bill Of Materials) - table with components

Reference Designation	Logic Type	PartType
C1	CAP	CAP-ELECTAA
C2	CAP	CAP-ELECTAA
C3	CAP	CAP-ELECTAA
C4	CAP	CAP-AE4
C5	CAP	CAP-AE4
C6	CAP	CAP-ELECTAA
D1	DIO	LED
D2	DIO	LED-1
D3	DIO	LED-1
D4	DIO	LED-1
D6	DIO	LED
D7	DIO	LED
D8	DIO	LED
H1	RES	SIP-1P
H2	RES	SIP-1P

R17	RES	RES-1/8W
R18	RES	RES-1/8W
S1	SWI	SW-NKK-JF15
S2	SWI	SW-COBA-MT1100
U1	TTL	74HC08
U2	TTL	74HC132
U3	TTL	74HCT832
U4	CMO	74HCT4511
U5	TTL	74HC76
U6	TTL	74HC76
U7	ANA	MC7805ACT
U8	TTL	74HC132
U9	TTL	74HC76
U10	TTL	74HC76
U11	TTL	74HC132
U12	TTL	74HC08

H2	RES	SIP-1P
H3	RES	SIP-1P
H4	RES	SIP-1P
J1	CON	CON-SIP-2P
R1	RES	RES-1/8W
R2	RES	RES-1/8W
R3	RES	RES-1/8W
R4	RES	RES-1/8W
R5	RES	RES-1/8W
R6	RES	RES-1/8W
R7	RES	RES-1/8W
R8	RES	RES-1/8W
R9	RES	RES-1/8W
R10	RES	RES-1/8W
R11	RES	RES-1/8W
R16	RES	RES-1/8W
R17	RES	RES-1/8W
R18	RES	RES-1/8W

Part Type	Description				
74HC08					
	U1	U12			
74HC76					
	U5	U6	U9	U10	
74HC132					
	U2	U8	U11		
74HCT832					
	U3				
74HCT4511					
	U4				
CAP-AE4					
	C4	C5			
CAP-ELECTAA					
	C1	C2	C3	C6	
CON-SIP-2P					
	J1				
LED					
	D1	D6	D7	D8	
LED-1					
	D2	D3	D4		
MC7805ACT					
	U7				
RES-1/8W					
	R1	R2	R3	R4	R5
	R6	R7	R8	R9	R10
	R11	R16	R17	R18	
SIP-1P					
	H1	H2	H3	H4	
SW-COBA-MT1100					
	S2				
SW-NKK-JF15					
	S1				

Figure 9. List of the components

4. PCB Design

4.1 Component Placement Drawing

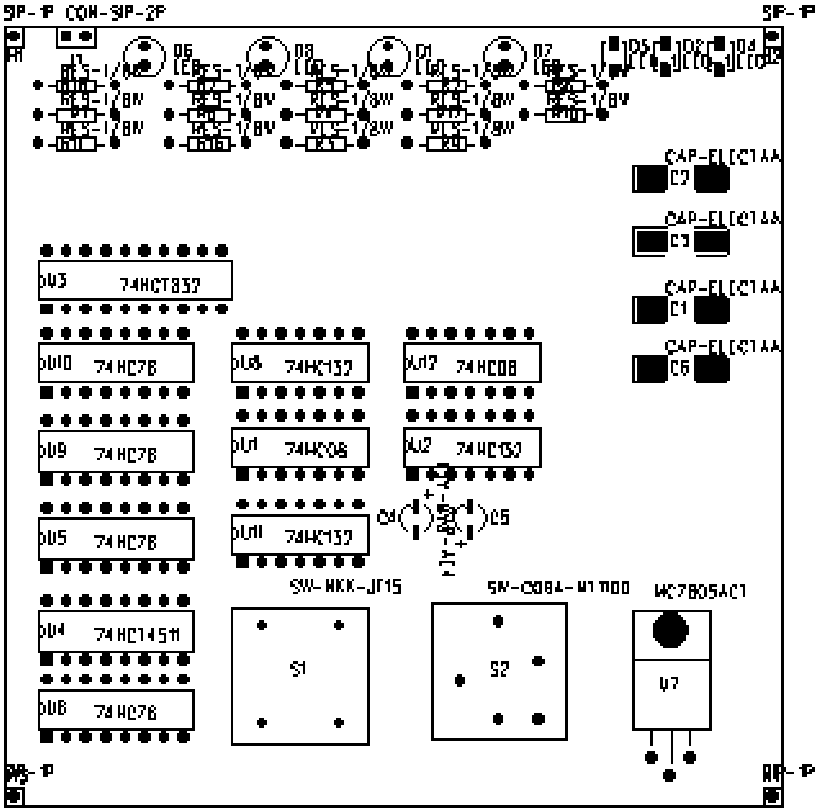

Figure 10. Component Placing Drawing

4.2 Top Layer Drawing

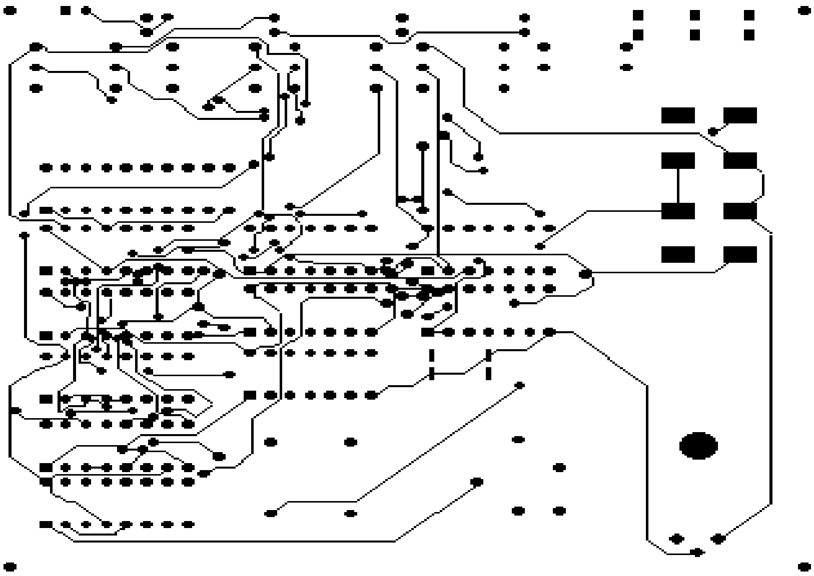

Figure 11. Top Layer Drawing

4.3 Bottom Layer Drawing

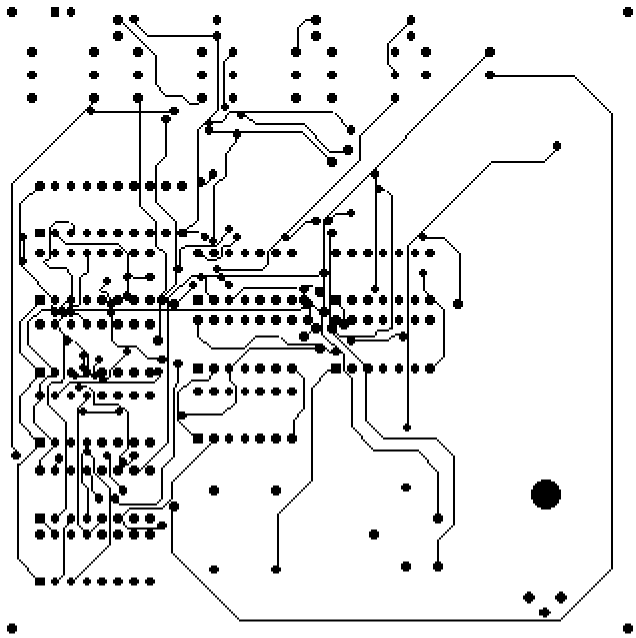

Figure 12. Bottom Layer Drawing

4.4 Assembly Drawing (Top Layer + Bottom Layer + Components)

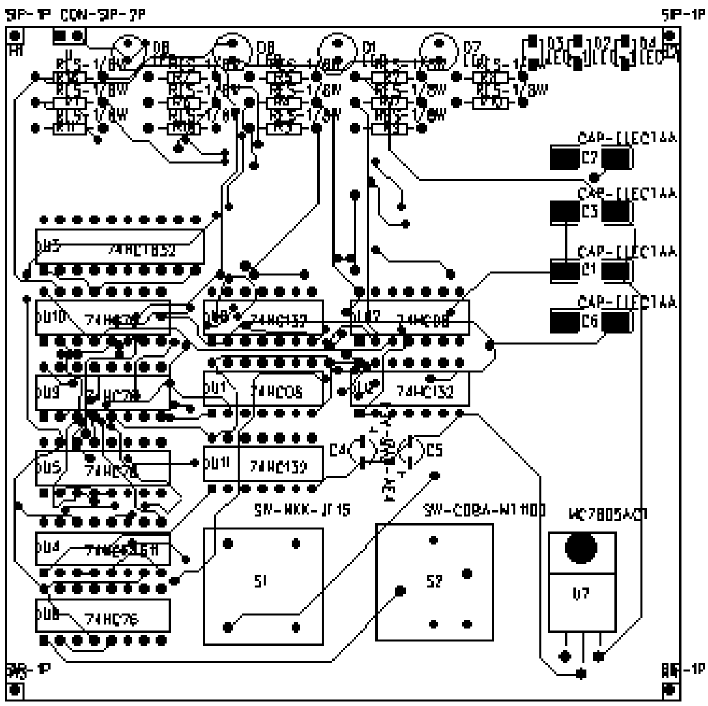

Figure 13. Assembly Drawing