INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE SIU OVERCURRENT RELAY

Caution: It is recommended that the user of this equipment become thoroughly acquainted with the information in these instructions before energizing the relay. Failure to observe this precaution may result in damage to the equipment.

APPLICATION

The type SIU relay is an assembly of solid-state overcurrent units that produce a d-c output voltage when the input a-c current exceeds a given value. This output voltage is used as inputs to other devices that perform various functions in a protective relaying system.

The number of overcurrent functions will vary with the relaying system in which the relay is applied. Some of the typical overcurrent functions that can be supplied in a package are as follows:

Symbol	Function	Air Gap Design
I_O	SDGU-2 Ground Fault Detector	No
I_N	Zero Sequence Detector for Special Application such as Fault Reclose Block	No
I_{OS}	Carrier Start	No
I_{OH}	Ground Fault Detector for Direct Trip through SRU or SAR Devices	Yes
I_{BH}/I_{CH}	Phase Fault Detector for Direct Trip through SRU or SAR Devices	Yes
I_{A-OS}	Out-of-Step Supervision	No
I_A/I_C	Optional Fault Detector in Directional Comparison Scheme	No

CONSTRUCTION

The type SIU relay consists of printed circuit boards mounted in a standard 19-inch wide panel, 5 1/4 inches (3 rack units) high. Plug in modules are used to obtain a modular type design. In general, the number of modules will vary with the applications; however, each package will contain a voltage regulator module and one or more overcurrent modules. For some applications, additional logic modules are included in the package.

Each overcurrent function consists of an input transformer, an overcurrent module, and a resistor-Zener diode protective network. The overcurrent module can either be a single input module with one output or a dual input module with a single output.

Input Transformer - The input transformer is a two-winding type with a non-tapped primary winding and a tapped secondary winding. The secondary is connected to the overcurrent module and to the resistor-Zener diode protective network. The input transformer may either be an air-gap transformer or a non-air-gap transformer. An air-gap transformer is utilized where minimum transient over-reach is desired and a non-air-gap transformer is utilized in applications where a fast reset is desired.

Overcurrent Module - The overcurrent module consists of a setting circuit, phase splitter circuit, sensing circuit, amplifier circuit, feedback circuit and an output circuit. The location of components on the overcurrent board is shown in Fig. 3 and the schematic is shown in Fig. 4.

a. Setting Circuit - The setting circuit is connected across the secondary winding of the input transformer and consists of two branches, two resistors and a rheostat on the module connected in parallel with a resistor and Zener diode mounted off the board. This circuit loads the transformer and allows a secondary voltage to be produced that is proportional to the input current. The rheostat has a locking feature to minimize accidental change of current setting.

b. Phase Splitter Circuit - The phase splitter circuit consists of a capacitor, two resistors, a potentiometer and a three-phase rectifier bridge. This circuit converts the single-phase a.c. voltage from the output of the transformer to a three-phase voltage and rectifies this voltage to d.c.

c. Amplifier Circuit - The amplifier circuit consists of a transistor and associated resistors and capacitors. The transistor is normally not conducting.

d. Sensing Circuit - The sensing circuit consists of a resistor, Zener diode, and a transistor with associated components. This circuit is connected between the output of the phase splitter circuit and the amplifier circuit. In this circuit, the voltage from the phase splitter network must be high enough to break down the Zener diode to turn on the transistor.

e. Output Circuit - The output circuit consists of two resistors, a diode, and a Zener diode. This output can be measured from the front of the module by means of test points.

f. Feedback Circuit - The feedback circuit consists of a resistor, potentiometer, and diode. This circuit controls the dropout current of the overcurrent unit.

Voltage Regulator Module - The voltage regulator module consists of a transistor, and two Zener diodes. Two resistors mounted off of the module determine the rating of the power supply. The voltage output from the module is 20 volts with reference to negative of the station battery. The schematic of the module is shown in Fig. 5 and the location of components on the module is shown in Fig. 6.

OTHER MODULES - Other modules may be included in the SIU package. Among these are a timer module and two logic modules--a phase module and a ground module. These modules are utilized to perform functions other than an overcurrent function in the overall protective relay system.

1. Timer Module - This module is a transistor, Zener diode, capacitor and resistor type of timer. The module is used in conjunction with a high-set overcurrent unit to slow the tripping time of the overcurrent unit. The schematic of the timer module is shown in Fig. 7 and the location of components on the module is shown in Fig. 8.

2. Logic Modules - The logic modules contain various logic functions and are used to connect phase or ground relays into a protective relay system. The phase module is shown in Fig. 9 and the location of components is shown in Fig. 10. The ground module schematic is shown in Fig. 11 and the location of components is shown in Fig. 12.

OPERATION

The functions of the SIU relay are connected according to the logic diagram that applies to the particular relay. Typical logic diagrams are shown in Figures 13 and 14. With reference to the logic drawings and the schematic of the overcurrent unit of Fig. 4, transistors Q1 and Q2 are normally not conducting and no output is obtained from the overcurrent unit. When a.c. current is applied to the primary of the transformer of the overcurrent unit, a voltage is produced on the secondary side that is proportional to the amount of resistance in the rehostat (S_1). This single-phase voltage is applied to the phase splitter circuit where a three-phase voltage is produced, rectified, and applied to resistor R4 of the sensing circuit. If the voltage from the rectifier is greater than the voltage breakdown of the Zener diode (Z1), the Zener diode breaks down to allow base current to flow in transistor Q1. Q1 turns on to allow base current to flow in transistor Q2. When Q2 turns on, a voltage is obtained across R10 which is the output of the unit.

When Q2 turns on, positive voltage is applied to the feedback circuit such that a voltage is applied to Q1. By varying the magnitude of this voltage, the dropout of the relay can be set to values greater than 90% of pickup.

When large currents are applied to the primary of the input transformer, the Zener clipper on the secondary prevents the secondary voltage from becoming excessive.

CHARACTERISTICS

The SIU relay is available with the following ranges:

Air-Gap Design	Non Air-Gap Design
.5 - 2	.5 - 2
1 - 4	1 - 4
2 - 4	2 - 8
4 - 16	4 - 16
10 - 40	
20 - 80	

TABLE I

ENERGY REQUIREMENTS

Ampere Range	Setting	Volt Ampere at Setting	P.F.* Angle	Volt Amperes at 5 Amps.	P.F.* Angle
AIR-GAP TRANSFORMER DESIGN					
	0.50	0.10	48°	5.8	50
	0.75	0.12	50	5.8	50
	1.00	0.26	51	5.7	50
.5 - 2	1.25	0.38	55	5.7	50
	1.50	0.50	57	5.7	57
	1.75	0.67	58	5.5	57
	2.00	0.86	60	5.3	60
	1.0	0.1	46	2.1	42
	1.5	0.2	47	2.0	46
	2.0	0.3	48	1.8	47
1 - 4	2.5	0.4	48.5	1.7	49
	3.0	0.6	50	1.6	50
	3.5	0.8	52	1.6	54
	4.0	1.0	53	1.5	54
	2	0.1	39	0.71	38.5
	3	0.2	38	0.58	37.5
	4	0.35	38	0.53	37.5
2 - 8	5	0.5	39	0.5	38.5
	6	0.7	40	0.49	40
	7	0.9	41	0.47	40
	8	1.2	42	0.46	40
	4	0.16	32	0.26	31
	6	0.32	29	0.26	29
	8	0.57	29	0.21	29
4 - 16	10	0.80	28	0.21	29
	12	1.10	28	0.20	29
	14	1.87	28	0.20	29
	16	1.50	28	0.20	29
	10	0.40	13	0.10	13
	15	0.85	12	0.09	12.8
	20	1.50	11	0.09	12.5
10 - 40	25	2.25	11	0.09	12
	30	3.25	10	0.09	12
	35	4.60	10	0.09	12
	40	5.75	10	0.09	12

TABLE I (CONT'D.)

ENERGY REQUIREMENTS

Ampere Range	Setting	Volt Ampere at Setting	P.F.* Angle	Volt Amperes at 5 Amps.	P.F.* Angle
AIR-GAP TRANSFORMER DESIGN (CONT'D.)					
20 - 80	20	1.0	7	0.07	9
	30	2.5	6.5	0.07	8.5
	40	4.5	6.0	0.07	8.5
	50	7.0	5.0	0.07	7
	60	10.0	5.0	0.07	7
	70	16.8	5.0	0.07	7
	80	19.5	5.0	0.07	7
NON AIR-GAP TRANSFORMER DESIGN					
.5 - 2	0.50	0.06	11.5 ⌿	2.8	17.5
	0.75	0.09	2	2.7	15.8
	1.00	0.13	4	2.6	14.5
	2.25	0.17	8	2.5	14.5
	1.50	0.21	12	2.3	15.5
	1.75	0.26	14	2.1	16.5
	2.00	0.31	15	2.0	18.0
1 - 4	1.0	0.06	10.5 ⌿	1.3	4
	1.5	0.10	0.5	1.1	4
	2.0	0.15	5.5	0.9	5.8
	2.5	0.19	9.0	0.8	8
	3.0	0.25	11.0	0.7	11
	3.5	0.32	14.5	0.6	14
	4.0	0.37	16.5	0.6	16
2 - 8	2	0.07	8 ⌿	0.44	6 ⌿
	3	0.12	1.5	0.33	1.5
	4	0.18	5.5	0.28	5.5
	5	0.25	8.5	0.25	8.5
	6	0.35	10.5	0.23	10.5
	7	0.45	13	0.22	13
	8	0.50	14	0.2	13.5
4 - 16	4	0.10	6 ⌿	0.14	5.4 ⌿
	6	0.15	3	0.10	3
	8	0.25	5.5	0.10	6
	10	0.35	7.5	0.09	8
	12	0.50	9	0.08	9.5
	14	0.65	9.5	0.08	10.5
	16	0.8	10	0.08	11.5

* Current lagging voltage ⌿ Current leading voltage

The scale markings of the relay represent the a.c. current required to produce an output. These scale markings are accurate within 10% of the value specified on the scale plate. If a more accurate pickup or setting between the scale markings is desired, the current can be applied to the relay and the setting rheostat set at the specific current.

The operating time of the relay is shown in Fig. 15. As shown in the figure, there is a maximum and minimum operating time for the relay for each multiple of pickup. This difference in time is due to the point on the current wave that the fault current is applied. Fig. 16 shows the operating times for different points on the fault wave for fault currents at twice pickup.

The reset time of the overcurrent unit is shown in Fig. 17. This reset time assumes that the fault current is interrupted at current zero. As shown in the figure, there is a difference between an air-gap design and a non-air-gap design. This difference is due to the time required for the flux to collapse in the iron of the air-gap design. Figure 18 is the maximum reset time of the over-current unit where the fault current is interrupted at any point on the current wave.

TABLE II
CURRENT RATINGS

Ratings of Overcurrent Units
Air-Gap and Non Air-Gap

Range	Continuous Rating (Amperes)	One Second Rating (Amperes)
.5 - 2	8	350
1 - 4	10	400
2 - 8	12	400
4 - 16	15	400
10 - 40	20	400
20 - 80	20	400

TABLE III
BATTERY DRAIN PER BOARD

Power Supply: 15 Milliampere 48 V d.c.
25 Milliampere 125 V d.c.
Max. allowable current: 100 Milliampere

Board	Non-Operate Condition	Operate Condition
Ground	8 Ma.	15 Ma.
Phase	4 Ma.	12 Ma.
Timer	4 Ma.	8 Ma.
I_{OH}	0	3 Ma.
I_{OS}	0	3 Ma.
I_O	0	3 Ma.
I_A/I_C	0	3 Ma.
$I_{A\text{-}OS}$	0	3 Ma.
I_{BH}/I_{CH}	0	3 Ma.
I_N	0	3 Ma.

TABLE IV

GENERAL CHARACTERISTICS

Maximum Number of Overcurrent Units Per Relay	8
Maximum Number of Air-Gap Units Per Relay	3
Adjustable Range of Timer Module	2 to 8 Milliseconds
Maximum Transient Overreach Air-Gap Design	17 Per Cent
Maximum Transient Overreach Non Air-Gap Design	85 Per Cent

SETTING

The pickup of each overcurrent function is made by adjusting the rheostat in the front of the function's module. Settings in between the scale marking can be made by applying the desired current and adjusting the rheostat until an output is obtained.

INSTALLATION

The SIU relay is supplied on a relay rack as a part of a complete relay system assembly. The location must be free from dust, excessive humidity, vibration, corrosive fumes heat. The maximum ambient temperature around the chassis must not exceed 55°C.

ADJUSTMENTS AND MAINTENANCE

The proper adjustments to insure correct operation of this relay have been made at the factory and should not be disturbed after receipt by the customer.

Acceptance Tests

The following check is recommended to insure that the relay is in proper working order. Refer to the logic diagram that applies to the relay and apply current to the proper terminals.

1. Minimum trip current - Check pickup at the minimum and maximum settings. This is accomplished by applying the specified current and checking that a voltage of approximately 20 volts appears across the output test points when the a.c. current is within 10% of the settings.
2. Dropout - After checking pickup, the dropout should be greater than 90% of the pickup as the current is gradually reduced.

Calibration

Use the following procedure for calibrating the overcurrent unit if the module adjustments have been disturbed. This procedure should not be used until it is apparent that the module is not in proper working order. A new scale plate may be necessary when parts are changed. On a dual input overcurrent module, the procedure has to be repeated for the second input.

Phase Splitter Adjustments

1. Turn rheostat on front of module to lowest setting.
2. Apply minimum setting current to the proper relay terminals.
3. Using a high resistance voltmeter (a.c.) adjust phase splitter potentiometer (R13) such that three voltages approximately equal to each other are obtained across TP1, printed circuit board terminal 9, and printed circuit board terminal 10. If a scope is available, adjust R13 such that the following waveform is obtained across TP2 and printed circuit board terminal 1.

Non Air-Gap Design

Peaks are in a sawtooth arrangement

Dial Calibration (S)

1. Apply the proper d.c. voltage to the relay.
2. Connect a high resistance d.c. voltmeter across the red and black Test Points.
3. Apply the desired S current to proper relay terminals.
4. Turn S rheostat until the relay operates as indicated by a sudden reading of approximately 20 volts d.c. on voltmeter.

Dropout (R12)

1. Set S on desired point and apply S amperes to proper relay terminals to make it operate.
2. Lower S amperes to desired dropout value and adjust R12 until voltmeter drops to approximately zero.
3. Verify dropout and pickup several times by raising a.c. current until unit operates and then lowering a.c. current until unit drops out.

TROUBLE SHOOTING PROCEDURE

Use the following procedure to locate the source of trouble if the SIU overcurrent module is not operating correctly.

1. Check voltages as listed on the electrical checkpoints.
2. Check resistance as listed on the internal schematic of the overcurrent module.
3. Inspect all wires and connections paying particular attention to printed circuit terminal.

ELECTRICAL CHECKPOINTS

The modules can be checked with reference to the following voltages. All voltage readings should be made with a high resistance voltmeter.

I. Overcurrent Module

a. No A.C. Current Input

All test point voltages should read approximately zero volts.

b. Minimum Trip A.C. Current Applied

Circuit	Terminals	Typical Voltage
Phase Splitter	TP1 to Board 10 TP1 to Board 9 Board 9 to Board 10	6.2 volts a.c. 6.2 volts a.c. 6.4 volts a.c.
Setting	Board 8 to Board 10	12.5 volts a.c.
Sensing	TP2 to Board 1 (Neg.)	7.5 volts d.c.
Amplifier	TP3 to Board 1 (Neg.) at twice pickup	0
Output	Red TP (pos.) to Black TP (Neg.)	20 volts d.c.

II. Ground Board

Voltage in D.C. Volts		
Terminal	No Input Condition	Input Condition
TP1 to Board 1 (Neg.)	13.5	0
TP2 to Board 1	0	16
TP3 to Board 1	20	0
TP4 to Board 1	0	20
TP5 to Board 1	16	0
TP6 to Board 1	16	0
TP7 to Board 1	0	20
TP8 to Board 1	20	0
TP9 to Board 1	0	20

III. Phase Board

Voltage in D.C. Volts		
Terminal	No Input Condition	Input Condition
TP1 to Board (Neg.)	16	0
TP2 to Board 1	20	0
TP3 to Board 1	0	20
TP4 to Board 1	16	0
TP5 to Board 1	0	16
Board 9 to Board 1	0	20

IV. Timer Board

Voltage in D.C. Volts		
Terminal	No Input Condition	Input Condition
TP1 to Board 1 (Neg.)	12.5	0
TP2 to Board 1	0	12 (Min. Set)-18 (Max.Set)
TP3 to Board 1	20	0
Red TP(pos.) to Black TP (Neg.)	0	20

RENEWAL PARTS

Repair work can be done most satisfactorily at the factory. However, interchangeable parts can be furnished to customers who are equipped for doing repair work. When ordering parts, always give the complete nameplate data.

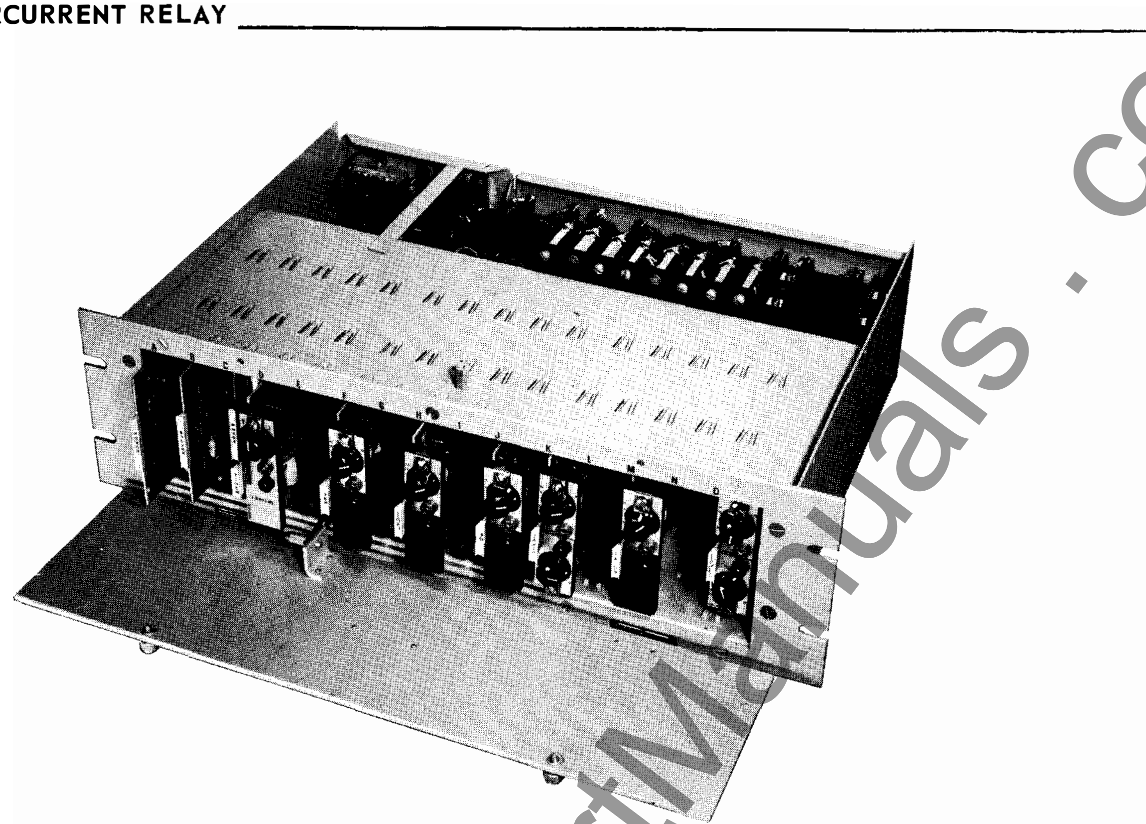


Fig. 1. Photograph (front view)

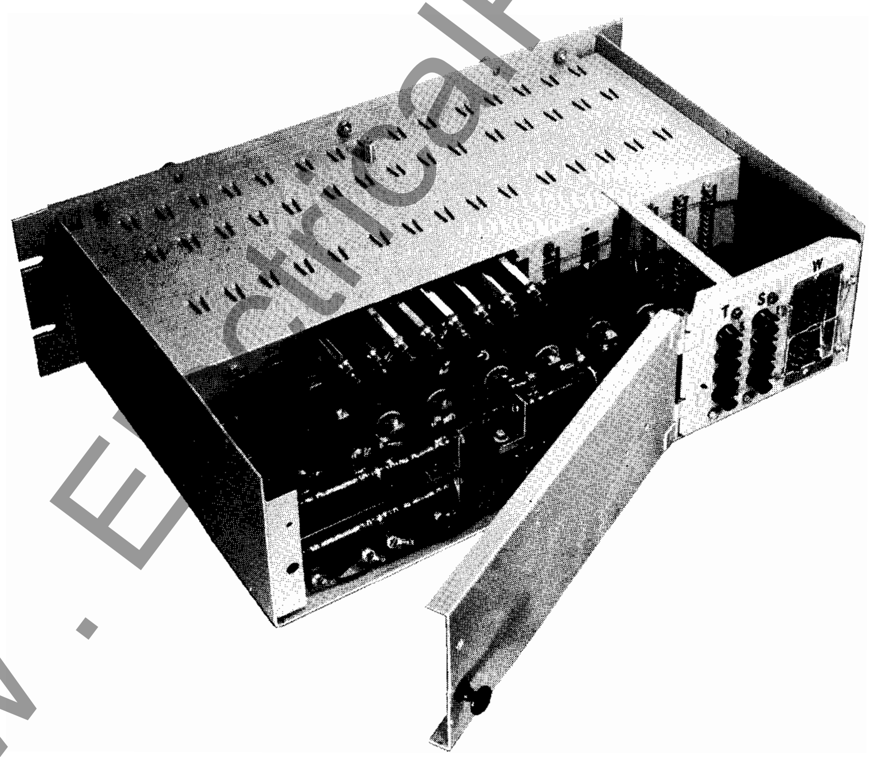


Fig. 2. Photograph (rear view with cover removed)

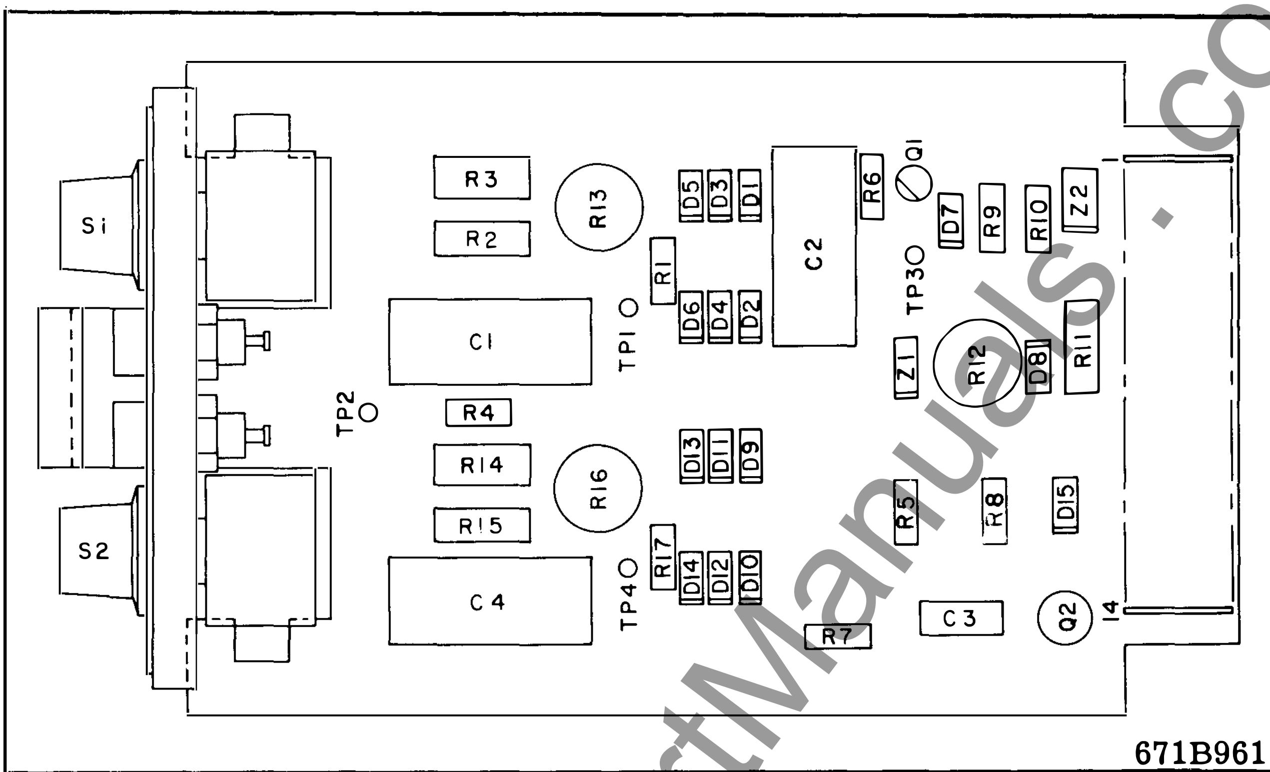


Fig. 3. Location of Components on Overcurrent Module

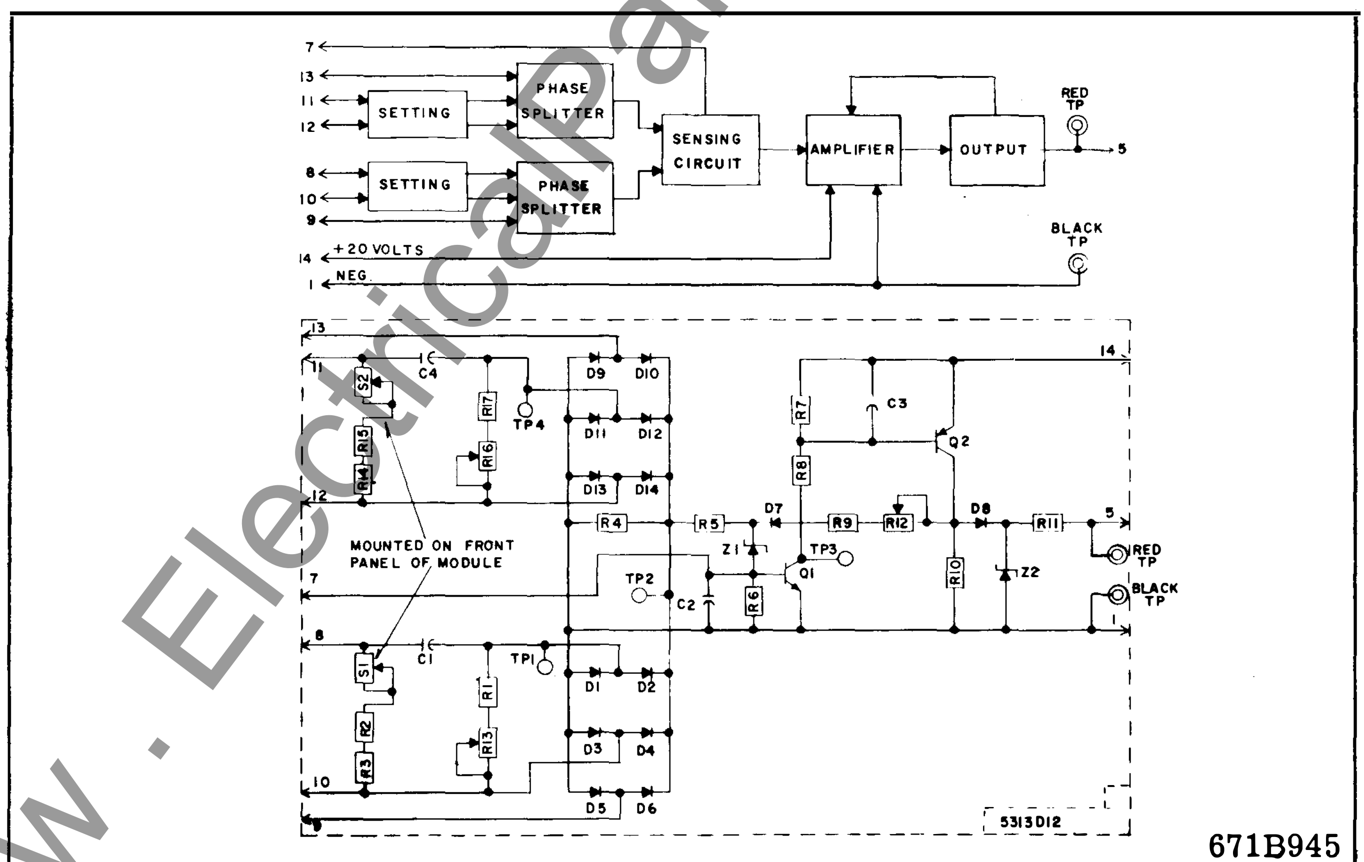


Fig. 4. Schematic of Overcurrent Module

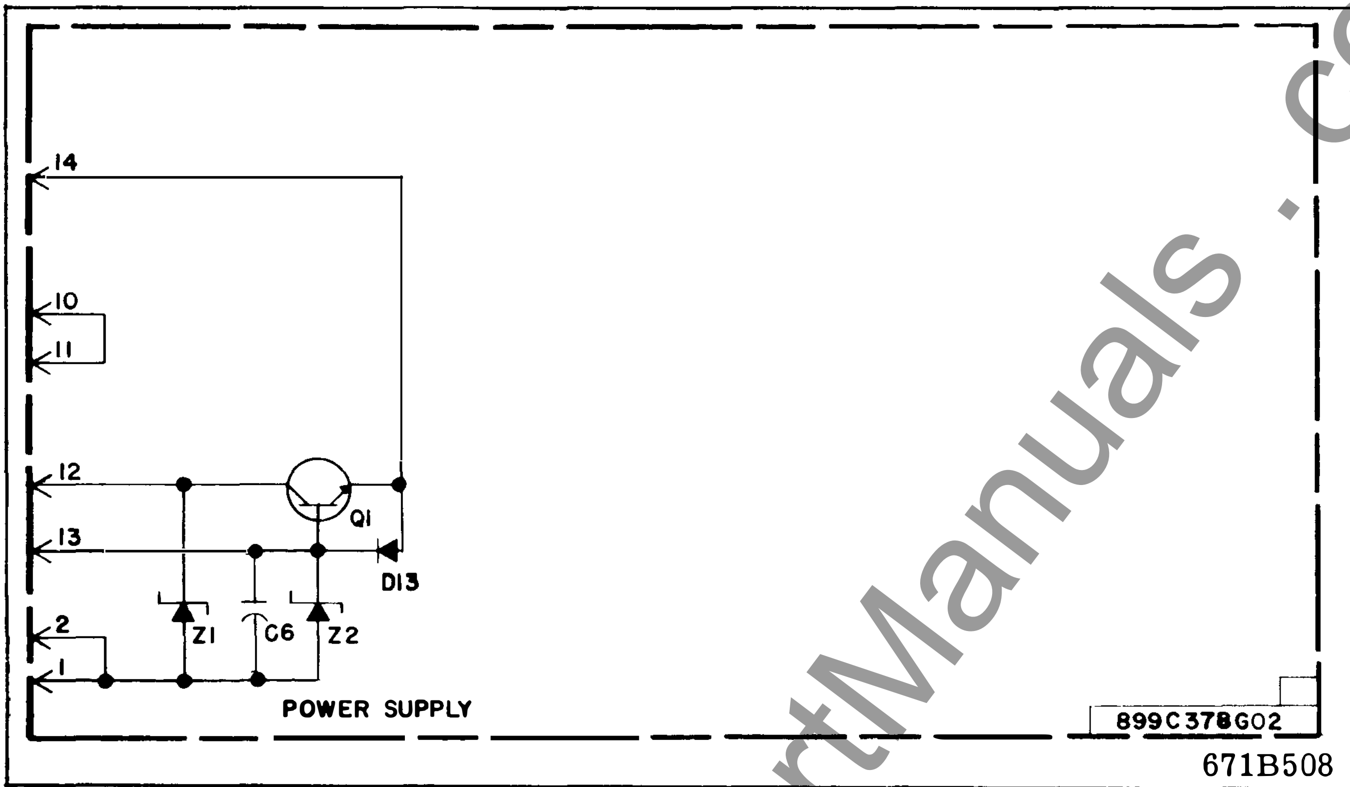


Fig. 5. Schematic of Power Supply Module

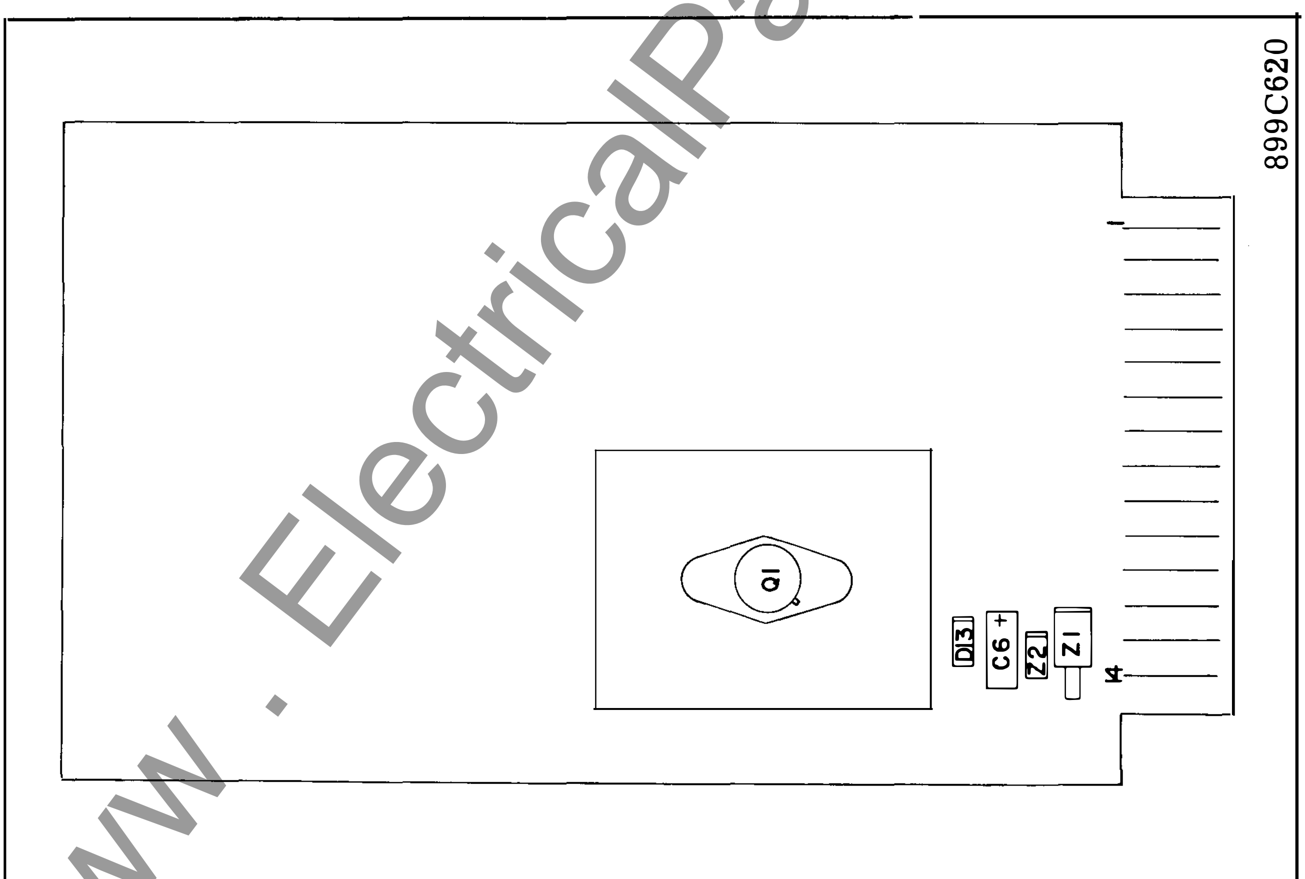


Fig. 6. Location of Components on Power Supply Module

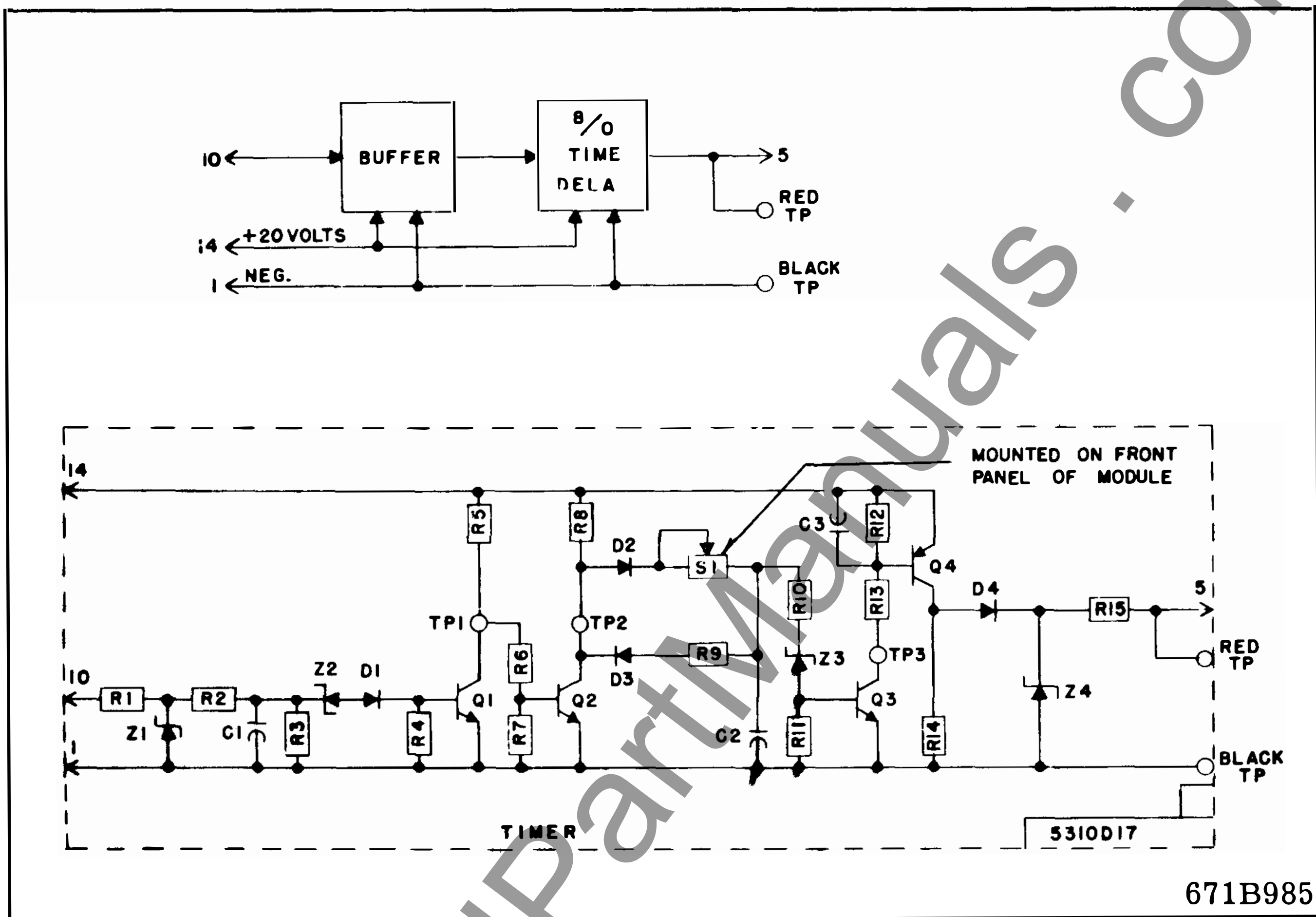


Fig. 7. Schematic of Timer Module

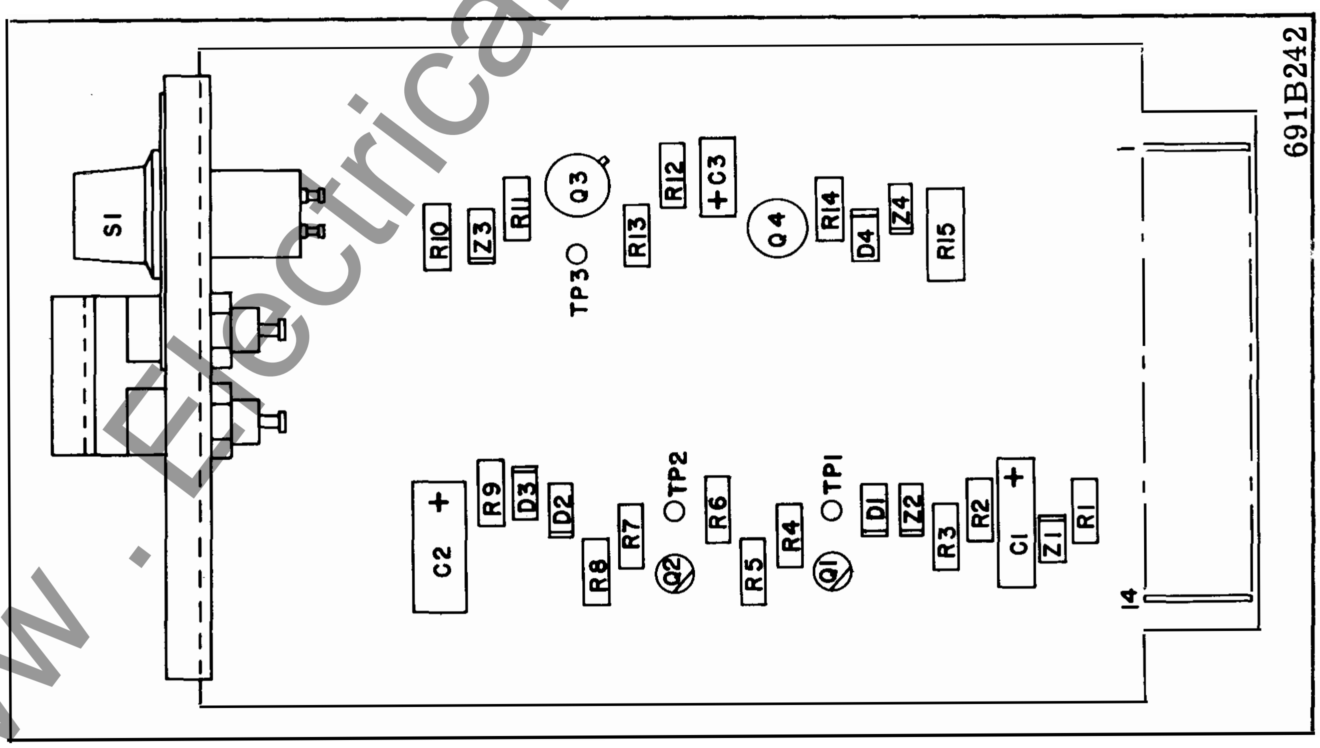


Fig. 8. Location of Components on Timer Module

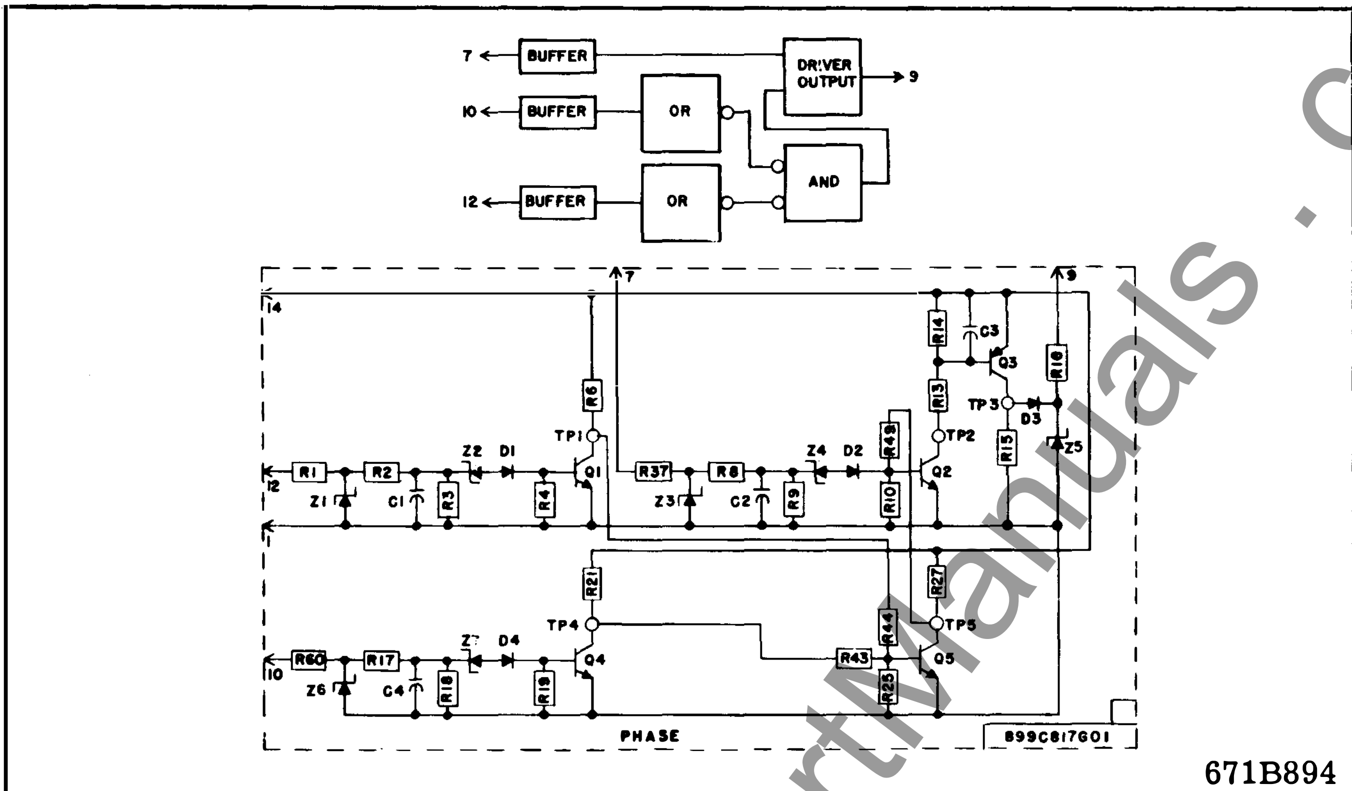


Fig. 9. Schematic of Timer Module

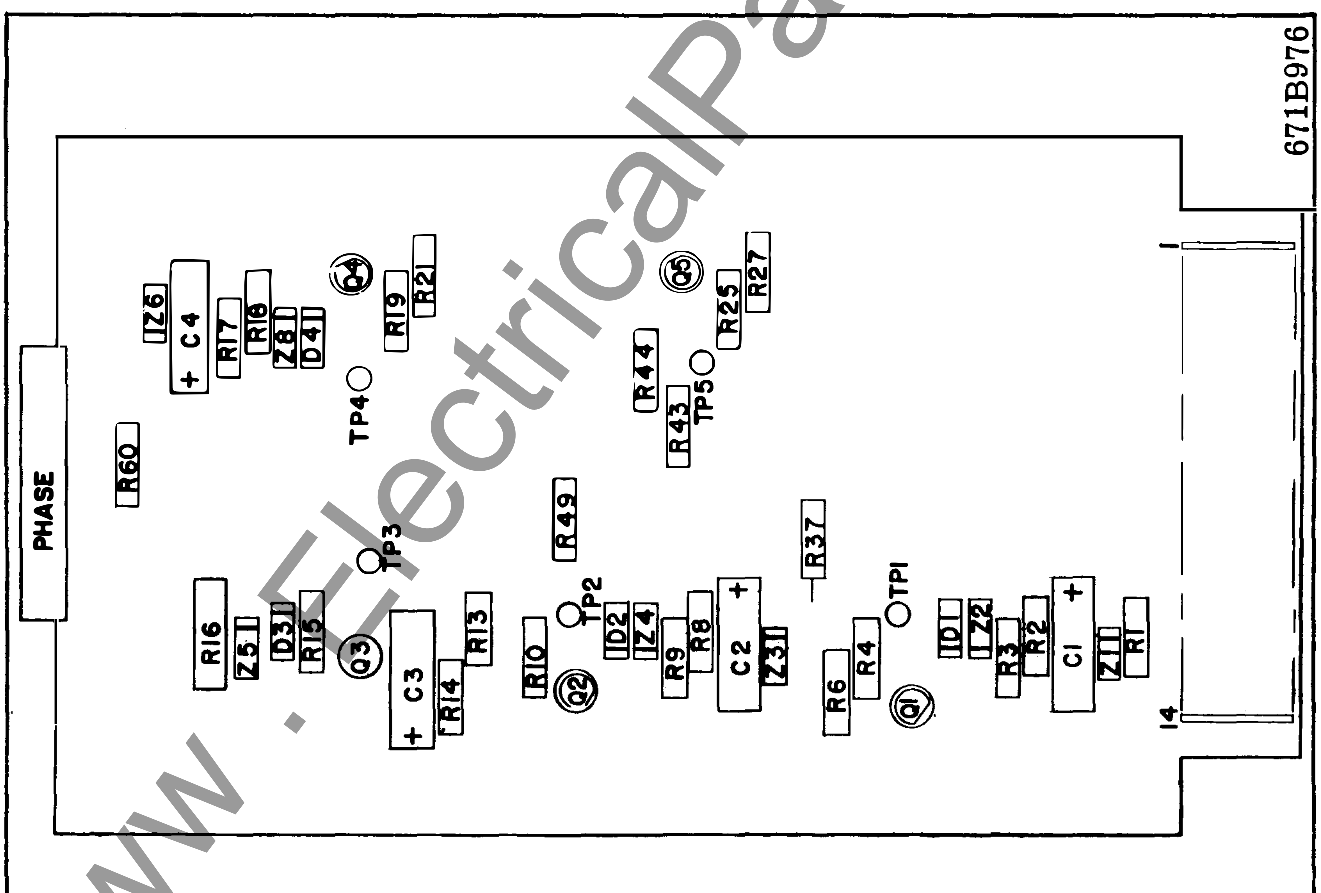
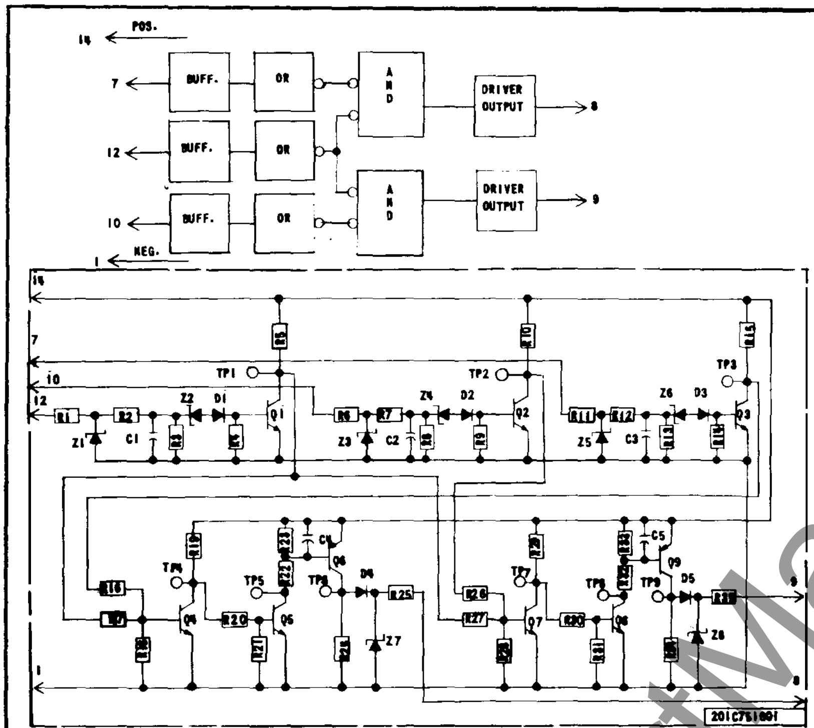


Fig. 10. Location of Components on Phase Module



CAPACITORS	STYLE	REQ.	REF.
C1 - C2 - C3	848A437H04	3	.047 MFD.
C4 - C5	[illegible]	2	.27 MFD.
DIODE			
D1-D2-D3-D4-D5	837A692H03	5	1N645A
RESISTOR *			
R1-R2-R6-R7-R11-R12	629A531H48	6	4.7K
[illegible]	629A531H52	7	6.8K
R4-R9-R14-R18-R21-R23-R28-R31-R33	629A531H56	8	10K
R16-R17-R20-R26-R27-R30	629A531H66	6	27K
R3-R8-R13-R24-R34	629A531H78	5	82K
R25 - R35	762A679H01	2	150 3W
TRANSISTOR			
Q1 TO Q5-Q7-Q8	848A851H02	7	2N3417
Q6 - Q9	849A441H01	2	2N3645
ZENER DIODES			
Z1 - Z3 - Z5	185A212H06	3	[illegible]
Z2 - Z4 - Z6	186A797H06	3	1N957B
Z7 - Z8	862A288H01	2	[illegible]

* = RESISTORS TO BE 1/2W ± 2% UNLESS OTHERWISE SPECIFIED.

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Fig. 11. Schematic of Ground Module

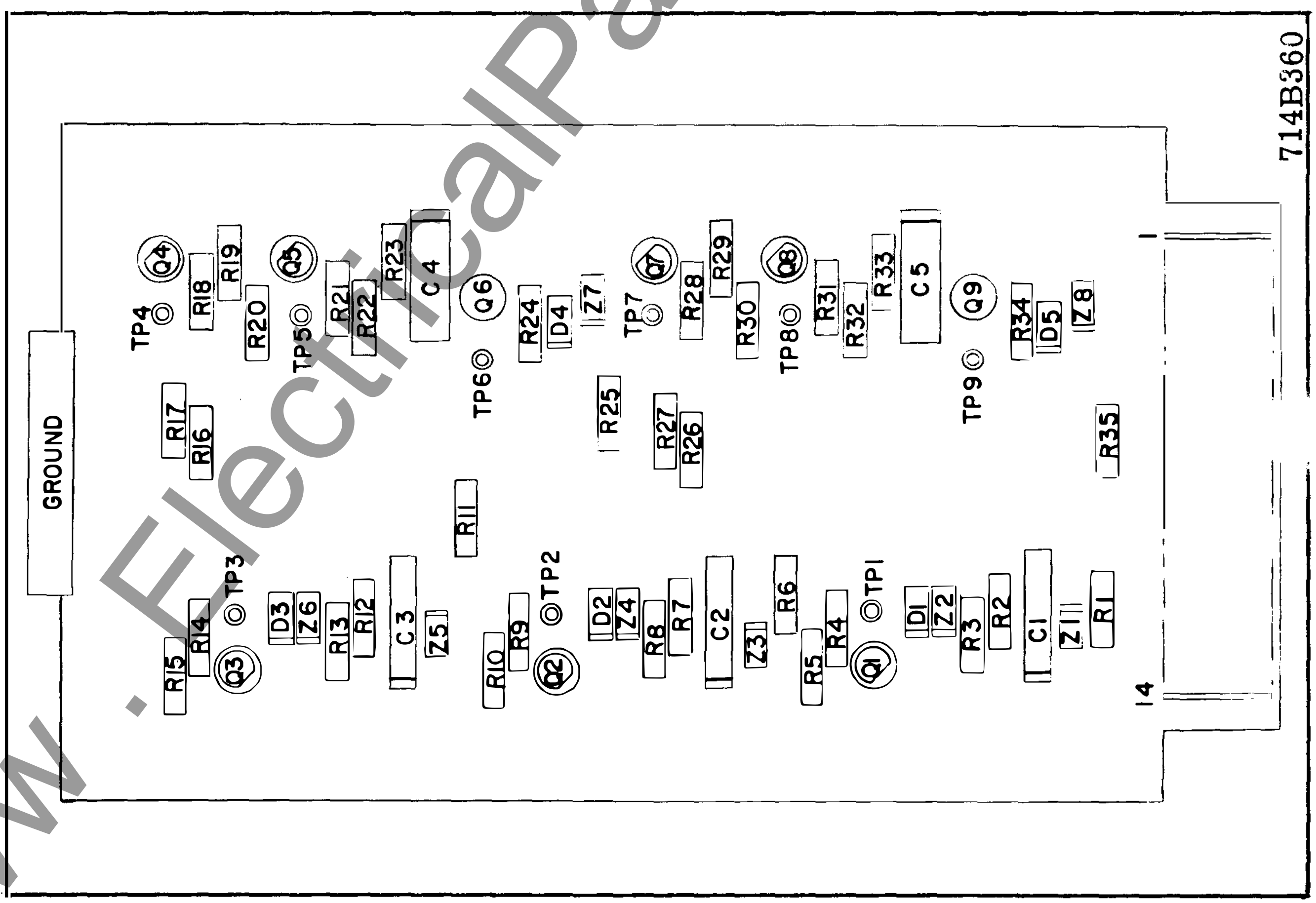

Fig. 12. Location of Compo… …s on Ground Module

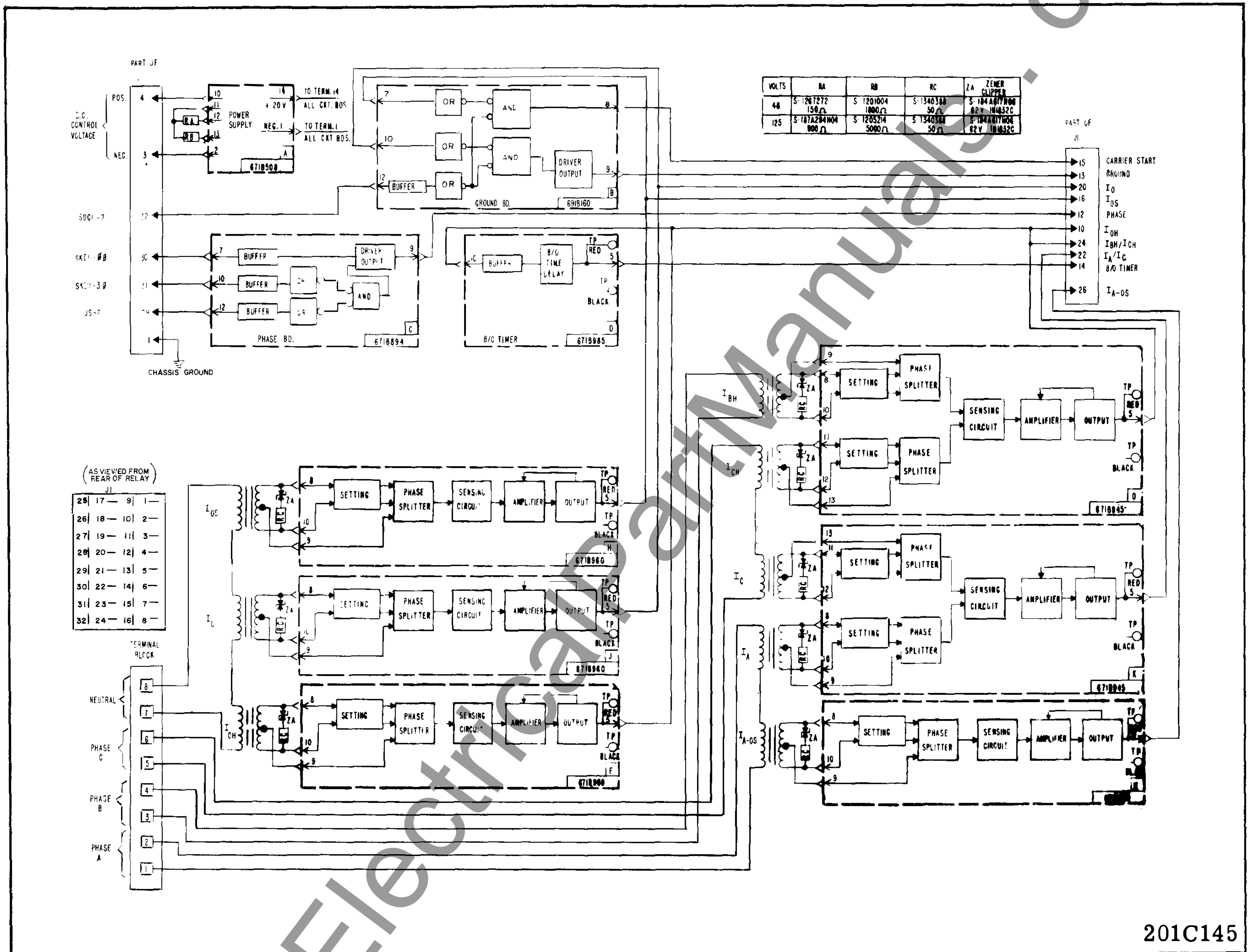

Fig. 13. Typical Logic Diagram of SIU Relay

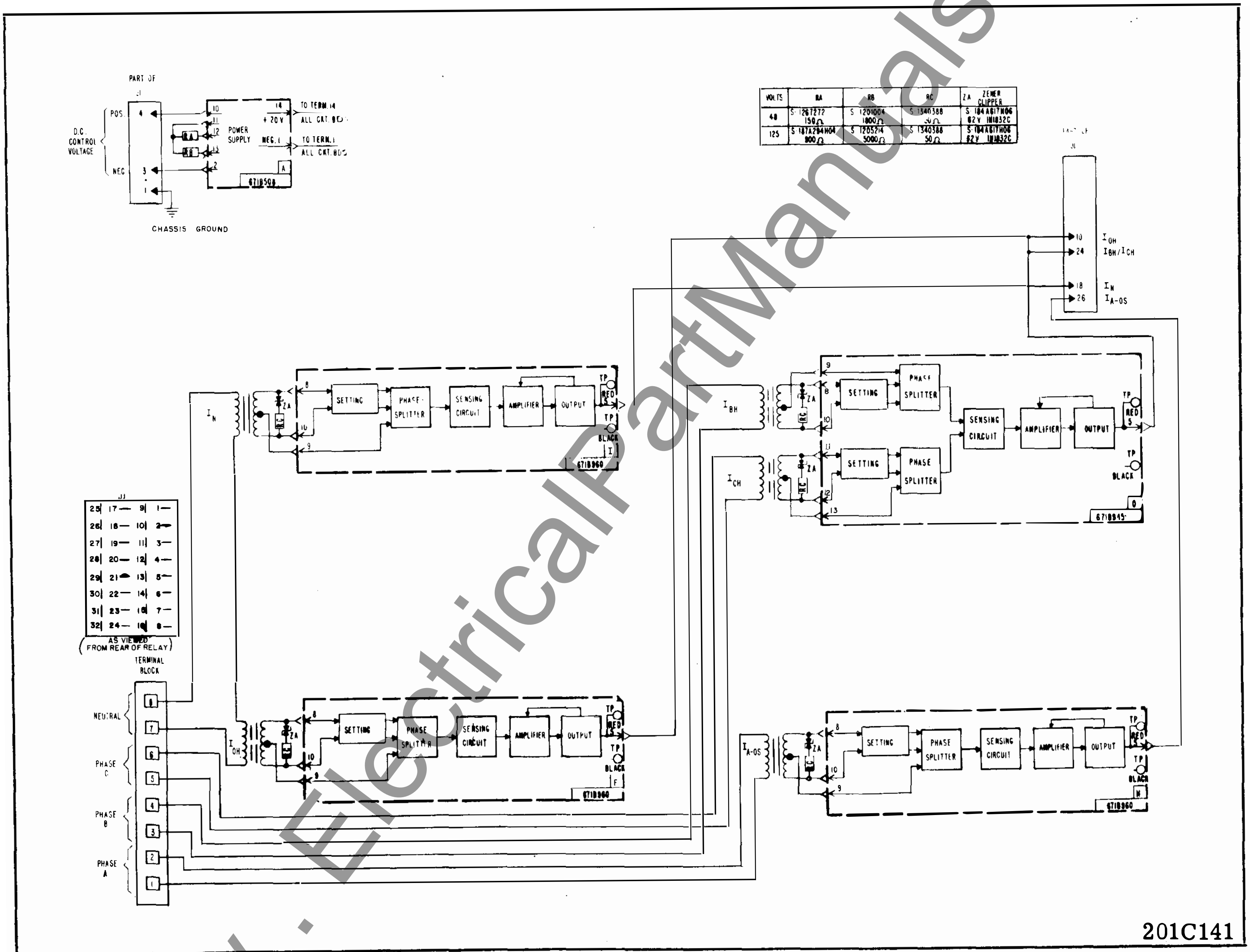

Fig. 14. Typical Logic Diagram of SIU Relay

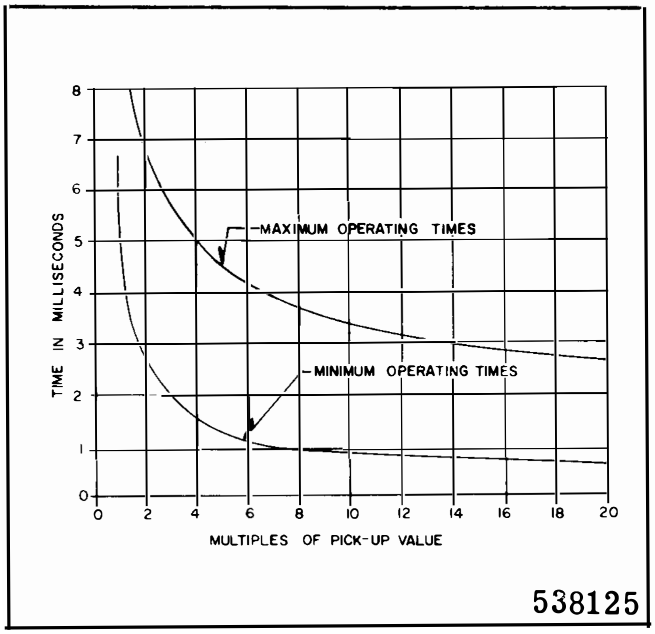

Fig. 15. Operating Time of Overcurrent Module of SIU Relay

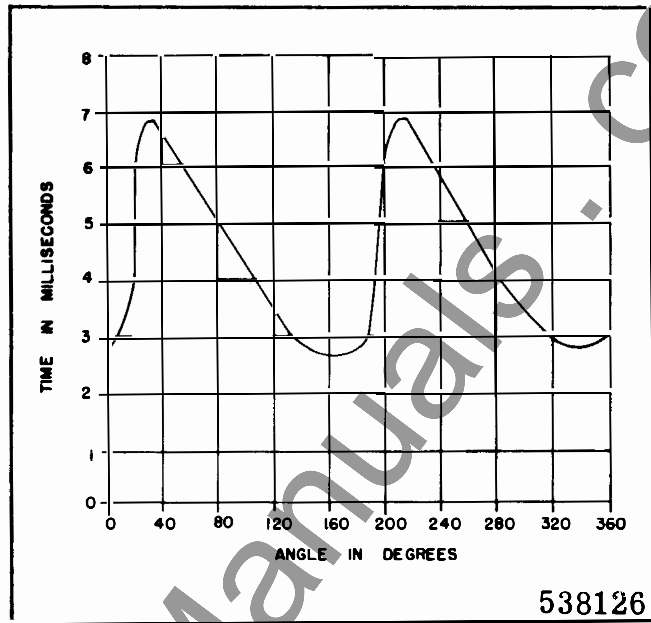

Fig. 16. Operating Time for the Type SIU Relay Overcurrent Module as a Function of Fault Incidence Angle At Twice Minimum Trip

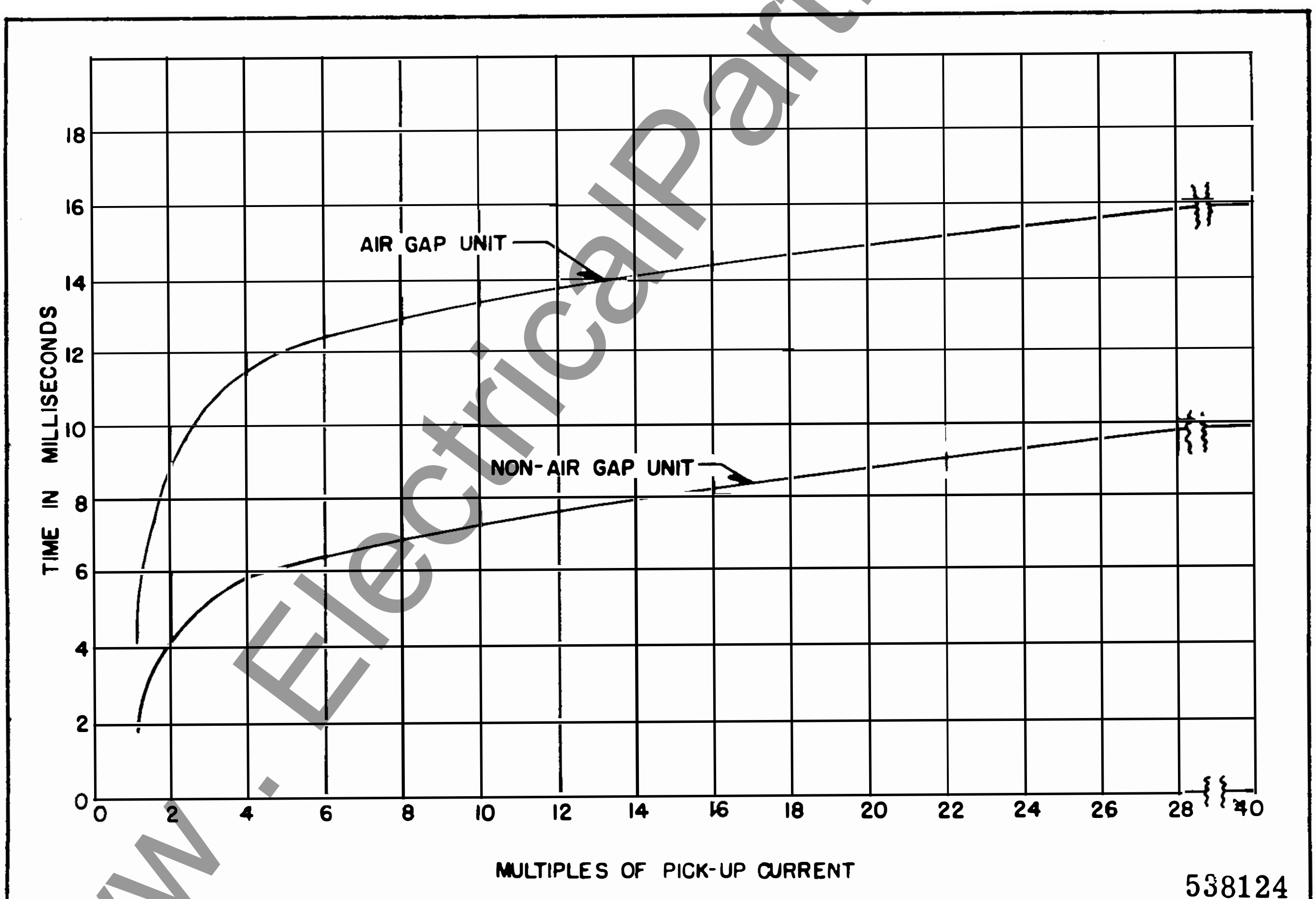

Fig. 17. Reset Time of the Overcurrent Module of the Type SIU Relay. Current interrupted at Current Zero.

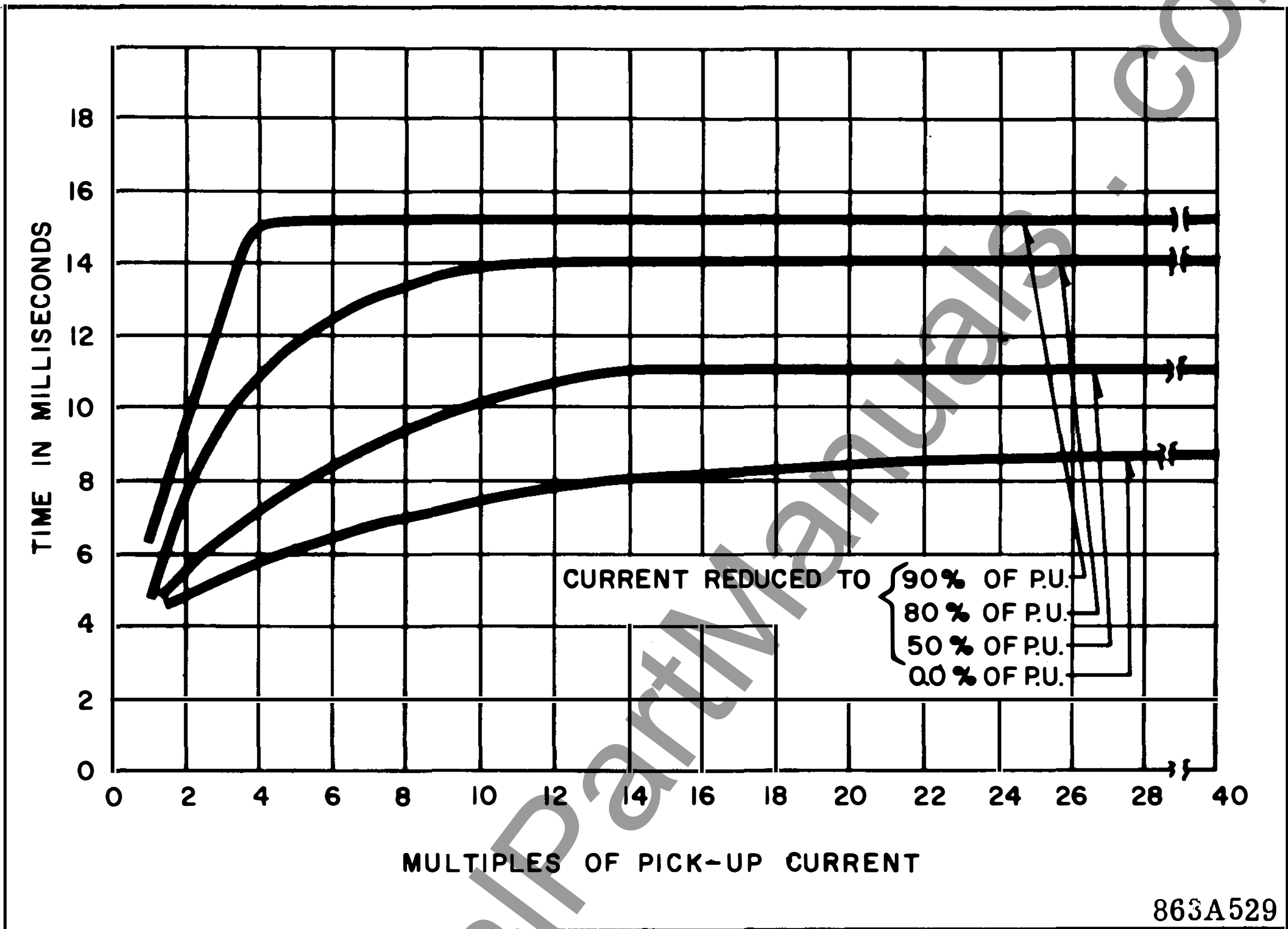

Fig. 18. Maximum Reset Time of the Overcurrent Unit of the SIU Relay

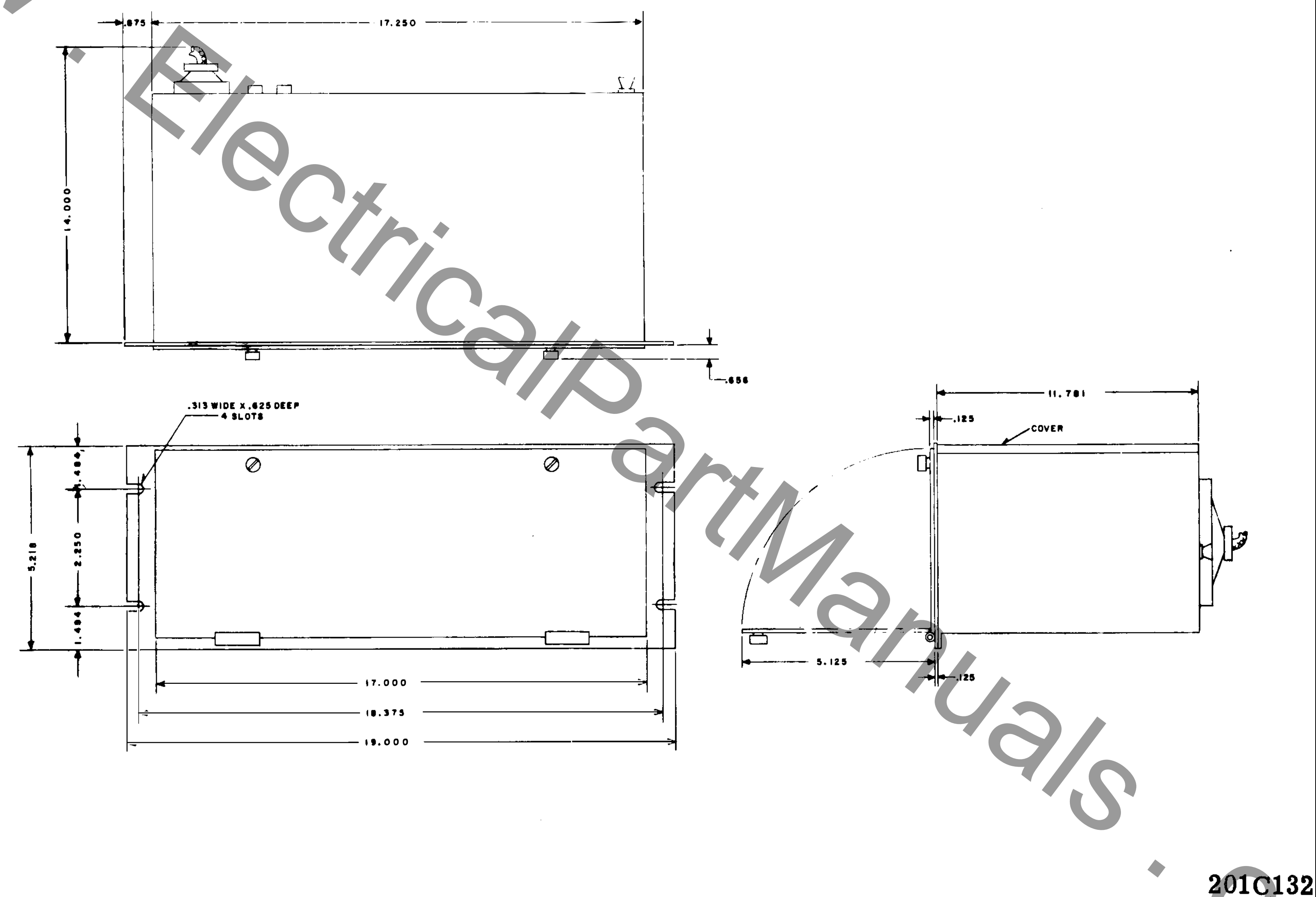

Fig. 19. Outline and Drilling Plan for the Type SIU Relay

WESTINGHOUSE ELECTRIC CORPORATION
RELAY-INSTRUMENT DIVISION **NEWARK, N. J.**
Printed in U.S.A.