ABB

Effective: May 1979
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✪ Denotes Change Since Previous Issue.

Type SI-T Overcurrent Relay

CAUTION: Before putting relays into service, remove all blocking which may have been inserted for the purpose of securing the parts during shipment, make sure that all moving parts operate freely, inspect the contacts to see that they are clean and close properly, and operate the relay to check the settings and electrical connections.

APPLICATION

The SI-T relay is a high speed overcurrent device intended for use as a fault detector for distance relays, as a direct trip unit, in a breaker failure scheme or any similar application requiring an accurate current level detector. It contains three overcurrent units, each of which may be independently set and each of which may be used for a phase or ground relaying function.

The output unit is a telephone relay equipped with two independent contacts. The direct trip SI-T is further equipped with an ICS (indicating contactor switch) for each of the two trip circuits.

The SI-T can be used in applications requiring continuous energization above pickup level. Also, it has a dropout ratio of 88% or higher and a maximum transient overreach of 20%.

It is frequency compensated to prevent its operating on the high frequency current associated with line energization.

CONSTRUCTION

The type SI-T relay consists of three input current transformers, three resistor-zener diode protective networks, three setting circuits, three phase splitter circuits, an OR circuit, a sensing circuit, an amplifier circuit and a telephone relay. The relay for direct trip application also includes two indicating contactor switches.

The components are connected as shown in Figs. 3 and 4.

Input Transformer – The input transformer is a two-winding type with a tapped primary winding and a non-tapped secondary winding. The secondary is connected to the resistor-zener diode protective network on a small circuit board, to the setting circuit, and to the phase splitter circuit.

Setting Circuit – The setting circuit is connected across the secondary winding of the input transformer and consists of a rheostat on the front panel and a resistor on the main circuit board. It is in parallel with the resistor-zener diode protective network. 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.

Phase Splitter Circuit – The phase splitter circuit consists of two capacitors, three resistors, and a three-phase rectifier bridge. This circuit converts the single-phase ac voltage from the output of the transformer to three voltages 60° out of phase with each other and rectifies these voltages.

OR Circuit – Combining three three-phase rectifiers, the voltage across the resistor R20 will be the highest output voltage from these rectifiers.

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 OR circuit and the amplifier circuit. In this circuit, the voltage from the OR circuit must be high enough to break down the zener diode to turn on the transistor.

Amplifier Circuit – The amplifier circuit consists of a transistor and associated resistors and capacitor. The transistor is normally not conducting.

Feedback Circuit – The feedback circuit consists of a resistor and a diode. This circuit controls the dropout current of the overcurrent unit.

Output Circuit – The output circuit consists of a transistor driver, a telephone relay and several voltage dropping resistors. The transistor is normally not conducting and the two telephone relay contacts are open. For direct trip application there are two Indicating Contactor Switches.

Indicating Contactor Switches (ICS) – The indicating contactor switch is a small dc operated clapper type device. A magnetic armature, to which leaf-spring mounted contacts are attached, is attracted to the magentic core upon energization of the switch. When the switch closes the moving contacts bridge two stationary contacts, completing the trip circuit. Also during this operation, two fingers on the armature deflect a spring located on the front of the switch which allows the target to drop. The target is reset from the outside of the case by a push rod located at the bottom of the cover.

Power Supply – The power supply circuit consists of a zener diode, a capacitor and two resistors. It is rated for supply voltages of either 48 volts dc or 125 volts dc. The output from the zener diode is 20 volts dc. As an option, there are another zener diode and two voltage dropping resistors for rated supply voltage of 250 volts dc.

OPERATION

The logic diagram of the SI-T relay is shown in Figs. 1 and 2. With reference to the logic diagrams and the internal schematics Fig. 3 and Fig. 4, transistors, Q_1, Q_2 and Q_3 are normally not conducting and the contacts of the telephone relay are open. When ac current is applied to the primary of the transformer (T_1, T_2 or T_3), a voltage is produced on the secondary side that is proportional to the amount of resistance in the rheostat (R_1, R_2 or R_3). The single phase voltage is applied to the phase splitter circuit where three voltages 60° out of phase are produced, rectified, and applied to the resistor R20. If the voltage from rectifier is greater than the voltage breakdown of zener diode (Z4), the zener diode conducts to allow base current to flow in transistor Q_1. In turn, Q_2 and Q_3 are turned on to operate the telephone relay.

When Q_2 turns on, positive voltage is applied to the feedback circuit (R26) such that a voltage is applied to Q_1. The value of R26 controls the dropout ratio which is set above 88% of pickup.

When three ac input currents are applied simultaneously the sensing circuit operates on the voltage across R20, which is dependent on the maximum of the three bridge rectifier outputs.

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

CHARACTERISTICS

The SI-T relay is available with the following ranges of overcurrent functions:

0.25 to 8 amps

0.5 to 16 amps

2 to 64 amps

The range of the overcurrent unit is obatined in two ways:

1. - A 1 to 4 range by means of the rheostat on the front panel.
2. - Transformer taps which multiply the rheostat setting by one of the following: 1, 4, or 8.

The scale markings of the relay represent the ac current required to operate the output telephone relay. 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 rheostat set at the desired point.

The operating time of the relay is shown in Fig. 7. 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.

The reset time curve is shown in Fig. 8. It is taken at the condition of the current interrupted at current zero and maintained at zero.

The transient overreach is a maximum of 20%.

The frequency response of the relay is shown in Fig. 9. It shows that the maximum sensitivity is occured at 60 Hz.

Battery Current Drain: 33 milliamperes (max.) for 48, 125 and 250 volts dc.

Energy Requirements: (Table I)

Transformer Current Ratings: (Table II)

TRIP CIRCUIT (FOR RELAYS WITH ICS UNIT)

The main contacts will safely close 30 amperes at 250 volts d-c and the seal-in contacts of the indicating contactor switch will safely carry this current long enough to trip a circuit breaker.

The indicating contactor switch has two taps that provide a pickup setting of 0.2 or 2 amperes. To change taps requires connecting the lead locating in front of the tap block to the desired setting by means of a screw connection.

TRIP CIRCUITS CONSTANTS (FOR RELAYS WITH ICS UNIT)

Contactor Switch –

0.2 ampere tap .... 6.5 ohms d-c resistance

2.0 ampere tap .... 0.15 ohms d-c resistance

SETTINGS

The relay must be set for the desired levels of current and where equipped with an ICS unit, a tap must be selected depending on the device being operated.

1. **Fault Detector** – where the SI-T is used as a fault detector, its principal function is to add to the security of the system for circumstances such as loss of potential on distance relays. This requires a setting above the maximum load current and below the minimum fault current for which it must respond.

2. **Direct Trip** – these applications require that differences in fault current be sufficient to distinguish location. The setting should be 125% of the maximum symmetrical fault current for which operation is not desired. For applications involving direct energization of a breaker trip coil, the ICS 2.0 ampere tap should be used. For energization of lockout relays (such as the WL) that produce high speed coil cutoff by their own contact action, the 0.2 ampere tap of the ICS should be chosen.

3. **Breaker Failure** – Trip coil energization that does not cause the cessation of current flow in the breaker after adequate passage of time is identified as breaker failure and appropriate clearing action is initiated. The SI-T can be used to sense this breaker current flow. A pickup setting below maximum load current is permissable from the relay viewpoint. A setting above maximum load current is more secure, but the settings must be below minimum phase and ground fault. levels. An allowance must be made in the setting of the separate breaker failure timer to accomodate the reset time of the SI-T relay as shown in Figure. 8.

The pickup of the relay is made by adjusting the rheostat and the setting of the multiplier of the tap plate in the front of the relay. Setting in between the scale marking can be made by applying the desired current and adjusting the rheostat until the telephone relay operates.

INDICATING CONTACTOR SWITCH (ICS)

The only setting required on the ICS unit is the selection of the 0.2 or 2.0 ampere tap setting. This selection is made by connecting the lead located in front of the tap block to the desired setting by means of the connecting screw.

INSTALLATION

The relays should be mounted on switchboard panels or their equivalent in a location free from moisture. Mount the relay vertically by means of the four mounting holes on the flange for semi-flush mounting or by means of the rear mounting stud or studs for projection mounting. Either a mounting stud or the mounting screws may be utilized for grounding the relay. The electrical connections may be made directly to the terminals by means of screws for steel-panel mounting or to the terminal studs furnished with the relay for thick panel mounting. The terminal studs may be easily removed or inserted by locking two nuts on the stud and then turning the proper nut with a wrench.

For detailed FT case information, refer to I.L. 41-076.

ADJUSTMENTS AND MAINTENANCE

The proper adjustments to insure correct operation of this relay have been made at the factory and should not be distrubed 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 internal schematics 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 the pickup of the output telephone relay when the ac current is within 10% of the settings.

2. **Dropout** – After checking pickup, the dropout should be greater than 88% of the pickup as the current is gradually reduced.

INDICATING CONTACTOR SWITCH (ICS)

Close the main relay contacts and pass sufficient d-c current through the trip circuit to close the contacts of the ICS. This value of current should be not greater than the particular ICS tap setting being used. The operation indicator target should drop freely.

The contact gap should be approximately .047" between the bridging moving contact and the adjustable stationary contacts. The bridging moving contact should touch both stationary contacts simultaneously.

ROUTINE MAINTENANCE

All relays should be checked at least once every year or at such other time intervals as may be dictated by experience to be suitable to the particular application.

TABLE I
ENERGY REQUIREMENTS

AMPERE RANGE	RHEOSTAT SETTING	MULTIP.	PCIKUP AMPS	OHMS AT PICKUP	P.F. ANGLE	OHMS AT 5 AMPS.	P.F. ANGLE
	.250	1	.250	1.70	21.0	1.3	15
	.375		.375	1.5	19.0	1.3	15
	.500		.500	1.4	18.0	1.3	15
	.625		.625	1.3	17.5	1.3	15
	.750		.750	1.3	17.0	1.2	15
	.875		.875	1.2	16.0	1.2	15
	1.000		1.000	1.2	15.5	1.2	15
	.250	4	1.0	0.190	9.5	0.190	8.5
	.375		1.5	0.180	8.5	0.180	8.0
	.500		2.0	0.170	7.0	0.170	7.5
.25-8	.625		2.5	0.170	6.5	0.170	7.0
	.750		3.0	0.165	6.0	0.165	6.5
	.875		3.5	0.160	6.0	0.160	6.5
	1.000		4.0	0.160	6.0	0.160	6.0
	.250	8	2.0	0.082	5.5	0.082	5.5
	.375		3.0	0.080	5.0	0.080	5.0
	.500		4.0	0.078	4.0	0.078	4.0
	.625		5.0	0.077	4.0	0.077	4.0
	.750		6.0	0.076	4.0	0.076	4.0
	.875		7.0	0.075	4.0	0.075	4.0
	1.000		8.0	0.075	3.5	0.075	3.5
	.50	1	.50	0.42	20.0	0.35	15.0
	.75		.75	0.37	18.0	0.35	15.0
	1.00		1.00	0.34	16.0	0.34	15.0
	1.25		1.25	0.33	15.0	0.33	15.0
	1.50		1.50	0.32	14.5	0.32	14.5
	1.75		1.75	0.31	14.0	0.31	14.0
	2.00		2.00	0.31	13.5	0.31	13.5
	.50	4	2.0	0.055	6.5	0.055	6.5
	.75		3.0	0.052	6.0	0.052	6.0
	1.00		4.0	0.051	5.5	0.051	5.5
.5-16	1.25		5.0	0.050	5.0	0.050	5.0
	1.50		6.0	0.049	4.5	0.049	4.5
	1.75		7.0	0.048	4.5	0.048	4.5
	2.00		8.0	0.048	4.5	0.048	4.5
	.50	8	4.0	0.029	4.0	0.028	4.0
	.75		6.0	0.028	4.0	0.028	4.0
	1.00		8.0	0.027	3.5	0.027	3.5
	1.25		10.0	0.027	3.5	0.027	3.5
	1.50		12.0	0.027	3.5	0.027	3.5
	1.75		14.0	0.027	3.5	0.027	3.5
	2.00		16.0	0.027	3.5	0.027	3.5
	2.00	1	2.00	0.040	8.0	0.040	8.0
	3.00		3.00	0.037	7.5	0.037	7.5
	4.00		4.00	0.035	7.0	0.035	7.0
	5.00		5.00	0.034	6.5	0.034	6.5
	6.00		6.00	0.033	6.5	0.033	6.5
	7.00		7.00	0.033	6.5	0.033	6.5
	8.00		8.00	0.032	6.5	0.032	6.5
	2.00	4	8.00	0.015	2.5	0.015	2.5
	3.00		12.00	0.015	2.5	0.015	2.5
	4.00		16.00	0.015	2.5	0.015	2.5
2-64	5.00		20.00	0.015	2.5	0.015	2.5
	6.00		24.00	0.015	2.5	0.015	2.5
	7.00		28.00	0.015	2.5	0.015	2.5
	8.00		32.00	0.015	2.5	0.015	2.5

TABLE I
ENERGY REQUIREMENTS (Continued)

AMPERE RANGE	RHEOSTAT SETTING	MULTIP.	PCIKUP AMPS	OHMS AT PICKUP	P.F. ANGLE	OHMS AT 5 AMPS.	P.F. ANGLE
	2.00	8	16.00	0.014	2.5	0.014	1.5
	3.00		24.00	0.014	2.5	0.014	1.5
	4.00		32.00	0.014	2.5	0.014	1.5
	5.00		40.00	0.014	2.5	0.014	1.5
	6.00		48.00	0.014	2.5	0.014	1.5
	7.00		56.00	0.014	2.5	0.014	1.5
	8.00		64.00	0.014	2.5	0.014	1.5

TABLE II
CURRENT RATINGS

RHEOSTAT RANGE	MULTIP.	CONTINUOUS RATING AMPERES	ONE SECOND RATING AMPERES
.25-1	1	3.5	88
	4	9.0	80
	8	12.0	88
.5-2	1	7	185
	4	15	185
	8	24	185
2-8	1	24	400
	4	24	400
	8	24	400

CALIBRATION

Use the following procedure for calibrating the relay, if the relay adjustments have been disturbed. This procedure should not be used until it is apparent that the relay is not in proper working order. A new scale plate may be necessary when parts are changed. This procedure must be repeated for the other two inputs.

PHASE SPLITTER CHECK

1. Turn rheostat on front of relay to lowest setting.

2. Apply minimum setting current to the proper relay terminals.

3. Connect scope across output of phase splitter (TP1). Set scope for ac deflection and the following waveform should be observed.

DIAL CALIBRATION

1. Apply the proper dc voltage between terminals 20 and 5. Terminal 20 is positive.
2. Connect a dc voltmeter across TP2 and terminal 5.
3. Apply the desired current to proper relay terminals.
4. Turn rheostat on front of relay clockwise from extreme counter-clockwise position unitl the relay operates as indicated by a sudden reading of approximately 20 volts dc on meter.

INDICATOR CONTACTOR SWITCH (ICS)

Close the main relay contacts and pass sufficient d-c current through the trip circuit to close the contacts of the ICS. This value of current should be not greater than the particular ICS tap setting being used. The operation indicator target should drop freely.

TROUBLE SHOOTING PROCEDURE

Use the following procedures to locate the source of trouble if the relay is not operating correctly.

1. Check voltage as listed on the electrical checkpoints.
2. Check resistance as listed on the internal schematic of the relay.
3. Inspect all wires and connections, paying particular attention to printed circuit terminals.

ELECTRICAL CHECKPOINTS

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

1. No AC Current Input (for 48 volts dc)

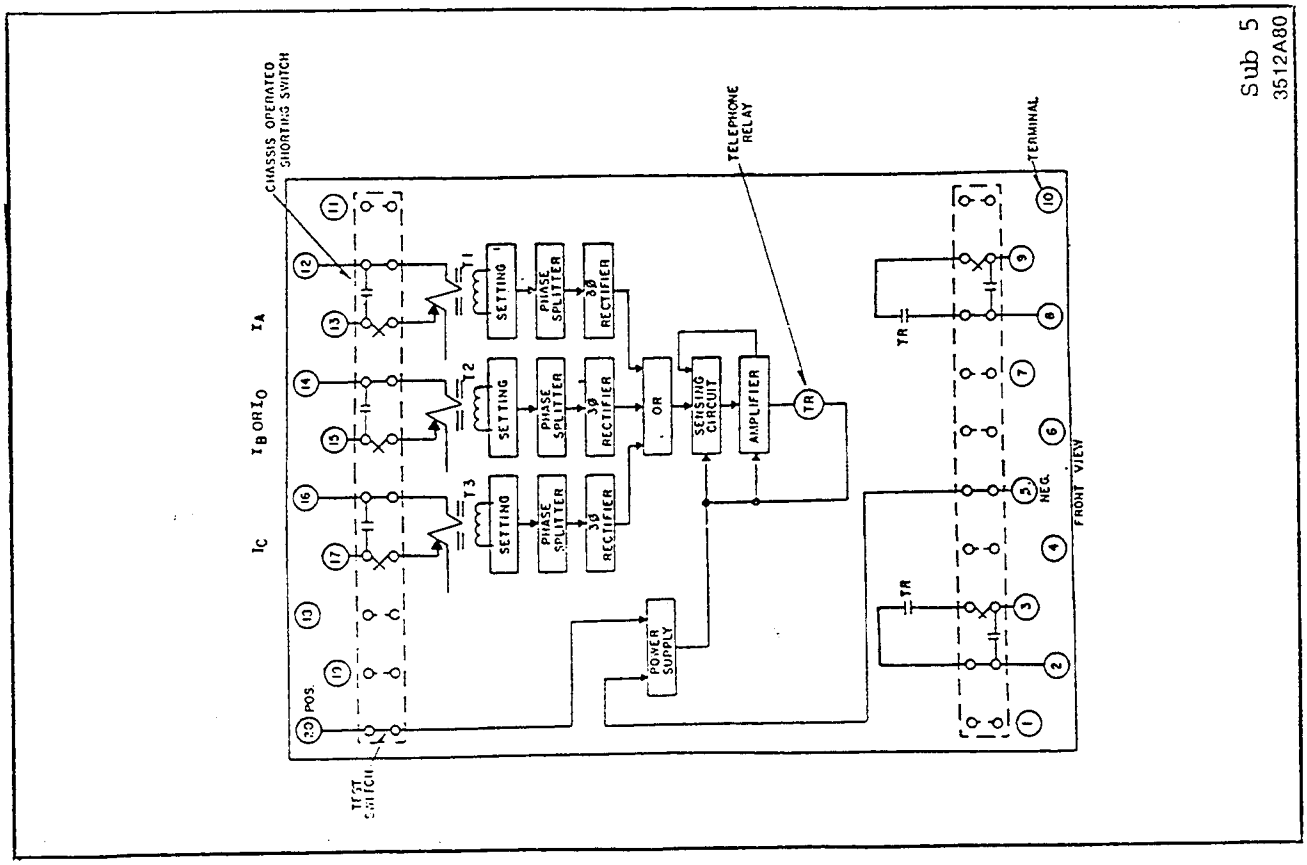
Test Terminal	Typical Voltage
TP1	less than 0.6 volts
TP2	less than 0.6 volts
TP3	48 volts
TP4	20 volts

2. Minimum Trip AC Current Applied

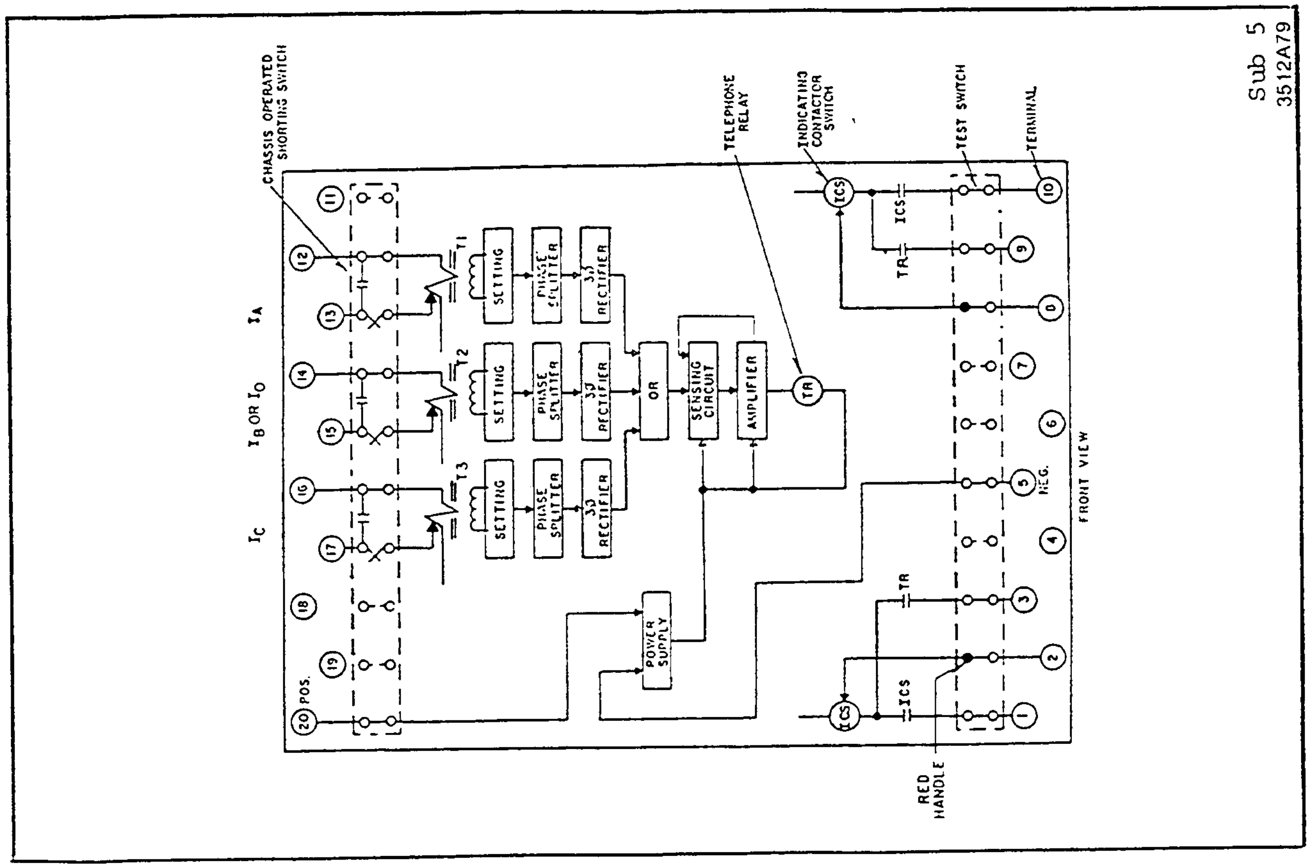
Test Terminal	Typical Voltage
TP1	7.5 volts
TP2	20 volts
TP3	less than 0.6 volts
TP4	20 volts

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. 2. Block Diagram of the Type SI-T Relay in FT-22 Case (without ICS).



✪ Fig. 1. Block Diagram of the Type SI-T Relay in FT-22 Case (with ICS).

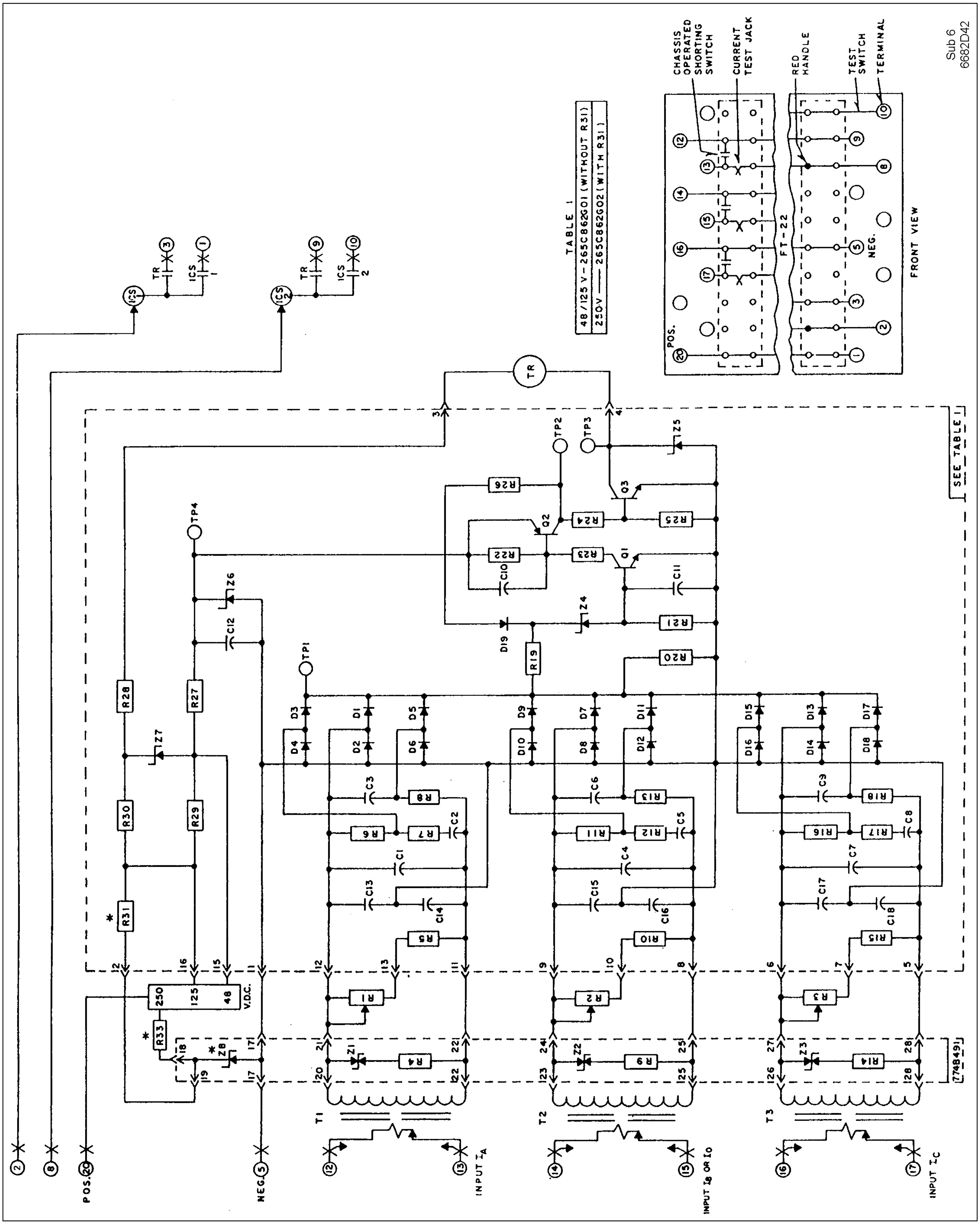


Fig. 3. Internal Schematic for the Type SI-T Relay with ICS Output.

CAPACITOR	STYLE NO.	REQ.	REF.
C1 - C4 - C7 - C12	188A669H03	4	0.1 MFD.
C2 - C5 - C8	188A669H01	3	0.47 MFD.
C3 - C6 - C9	876A409H15	3	0.22 MFD.
C10	187A508H09	1	1.5 MFD.
C11	187A508H05	1	0.47 MFD.
C13 TO C18	762A680H02	6	0.001 MFD.
DIODE			
D1 TO D19	184A855H07	19	1N457A
POTENTIOMETER			
R1 - R2 - R3	836A635H07	3	5K - 12 1/2 W
⊖ RESISTOR			
R4 - R9 - R14	185A209H06	3	50Ω - 5W
R5 - R10 - R15	763A129H03	3	500Ω - 5W
R6-R8-R11-R13-R16-R18	629A531H58	6	12 K
R7 - R12 - R17	629A531H49	3	5.1 K
R19-R21-R22-R24-R25	629A531H56	5	10 K
R20	629A531H73	1	51 K
R23	629A531H52	1	6.8 K
R26	184A763H79	1	150K-1/2W-±5%
R27	763A127H03	1	2K - 3W
R28	185A207H31	1	1.5K - 2W
R29	184A636H10	1	6K - 5W
R30	763A129H01	1	5K - 5W
* R31	762A679H01	1	150Ω - 3W
* R33	763A098H25	1	4K - 12W
TRANSFORMER			
T1 - T2 - T3	774B484G02	3	.5 - 16 A.
TRANSISTOR			
Q1	848A851H02	1	2N3417
Q2	849A441H01	1	2N3645
Q3	837A617H01	1	2N3589
ZENER DIODE			
Z1 - Z2 - Z3	184A617H06	3	1N1832C
Z4	186A797H06	1	1N957B
Z5	187A936H17	1	1N3050B
Z6	849A487H01	1	1N4747A
Z7	629A369H01	1	1R200
* Z8	762A631H11	1	1N3011B
TELEPHONE RELAY			
TR	541D514H24	1	1,500Ω - 24V.

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

* = FOR 250 V. ONLY.

Fig.3a Parts List for SI-T Relay

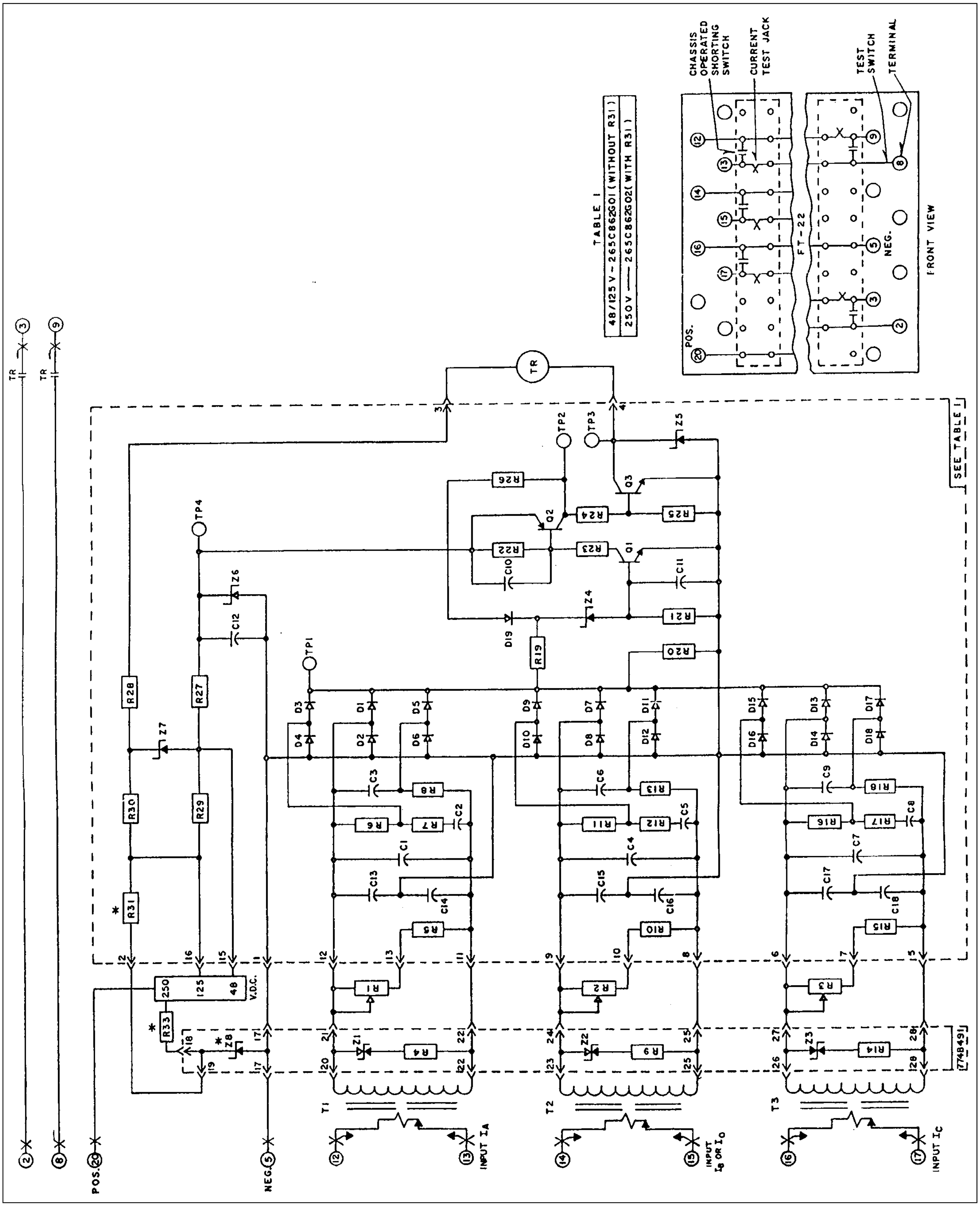

Fig. 4. Internal Schematic for the Type SI-T Relay without ICS Output.

CAPACITOR	STYLE NO.	REQ.	REF.
C1 - C4 - C7 - C12	188A669H03	4	0.1 MFD.
C2 - C5 - C8	188A669H01	3	0.47 MFD.
C3 - C6 - C9	876A409H15	3	0.22 MFD.
C10	187A508H09	1	1.5 MFD.
C11	187A508H05	1	0.47 MFD.
C13 TO C18	762A680H02	6	0.001 MFD.
DIODE			
D1 TO D19	184A855H07	19	1N457A
POTENTIOMETER			
R1 - R2 - R3	836A635H07	3	5K - 12 1/2 W
-θ- RESISTOR			
R4 - R9 - R14	185A209H06	3	50Ω - 5W
R5 - R10 - R15	763A129H03	3	500Ω - 5W
R6-R8-R11-R13-R16-R18	629A531H58	6	12 K
R7 - R12 - R17	629A531H49	3	5.1K
R19-R21-R22-R24-R25	629A531H56	5	10 K
R20	629A531H73	1	51 K
R23	629A531H52	1	6.8 K
R26	184A763H79	1	150K-1/2W-±5%
R27	763A127H03	1	2K - 3W
R28	185A207H31	1	1.5K - 2W
R29	184A636H10	1	6K - 5W
R30	763A129H01	1	5K - 5W
* R31	762A679H01	1	150Ω - 3W
* R33	763A098H25	1	4K - 12W
TRANSFORMER			
T1 - T2 - T3	774B484G02	3	.5 - 16 A.
TRANSISTOR			
Q1	848A851H02	1	2N3417
Q2	849A441H01	1	2N3645
Q3	837A617H01	1	2N3589
ZENER DIODE			
Z1 - Z2 - Z3	184A617H06	3	1N1832C
Z4	186A797H06	1	1N957B
Z5	187A936H17	1	1N3050B
Z6	849A487H01	1	1N4747A
Z7	629A369H01	1	1R200
* Z8	762A631H11	1	1N3011B
TELEPHONE RELAY			
TR	541D514H24	1	1,500Ω - 24 V.

-θ- • RESISTORS TO BE 1/2W ±2% UNLESS OTHERWISE SPECIFIED.
* • FOR 250 V. ONLY.

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Fig.4a Parts List for SI-T Relay

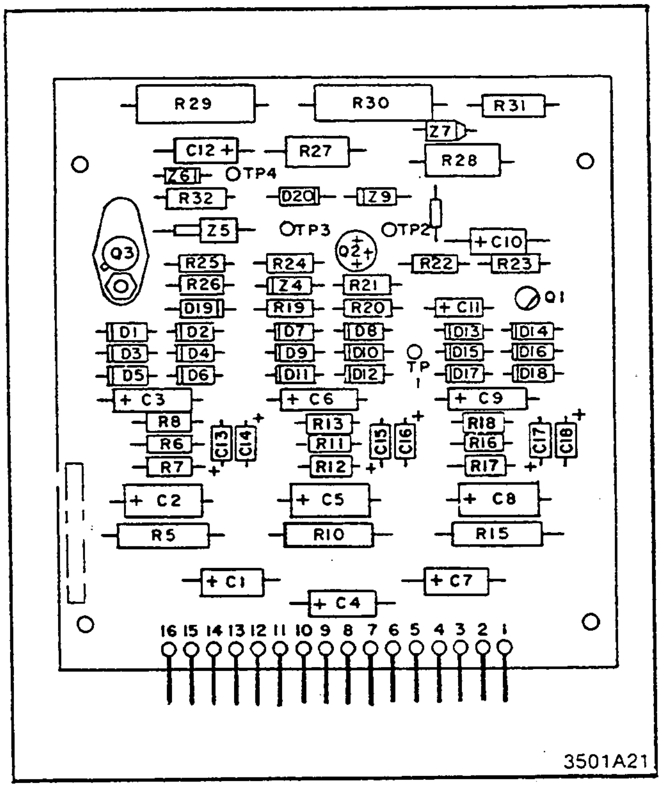


Fig. 5. Component Location on Overcurrent Module.

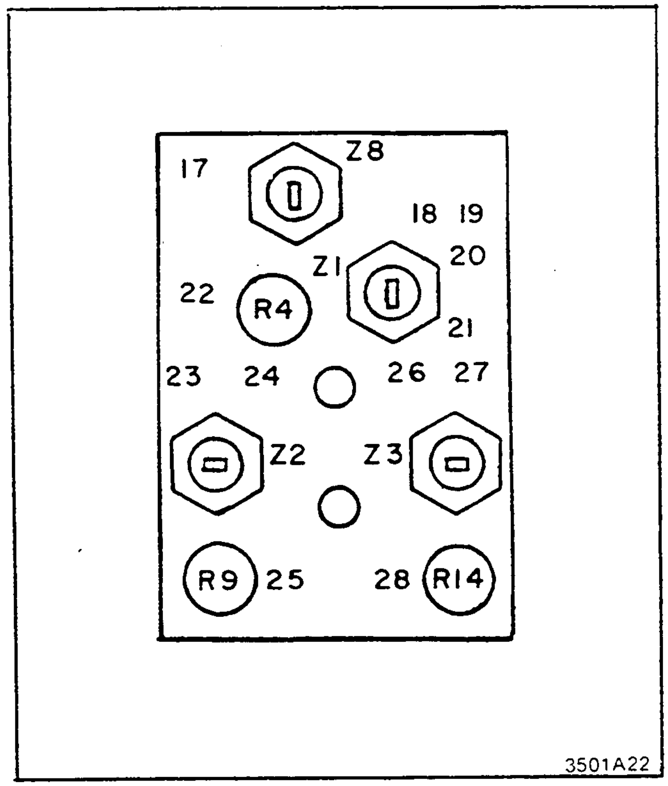


Fig. 6. Component Location on Zener Diode Module.

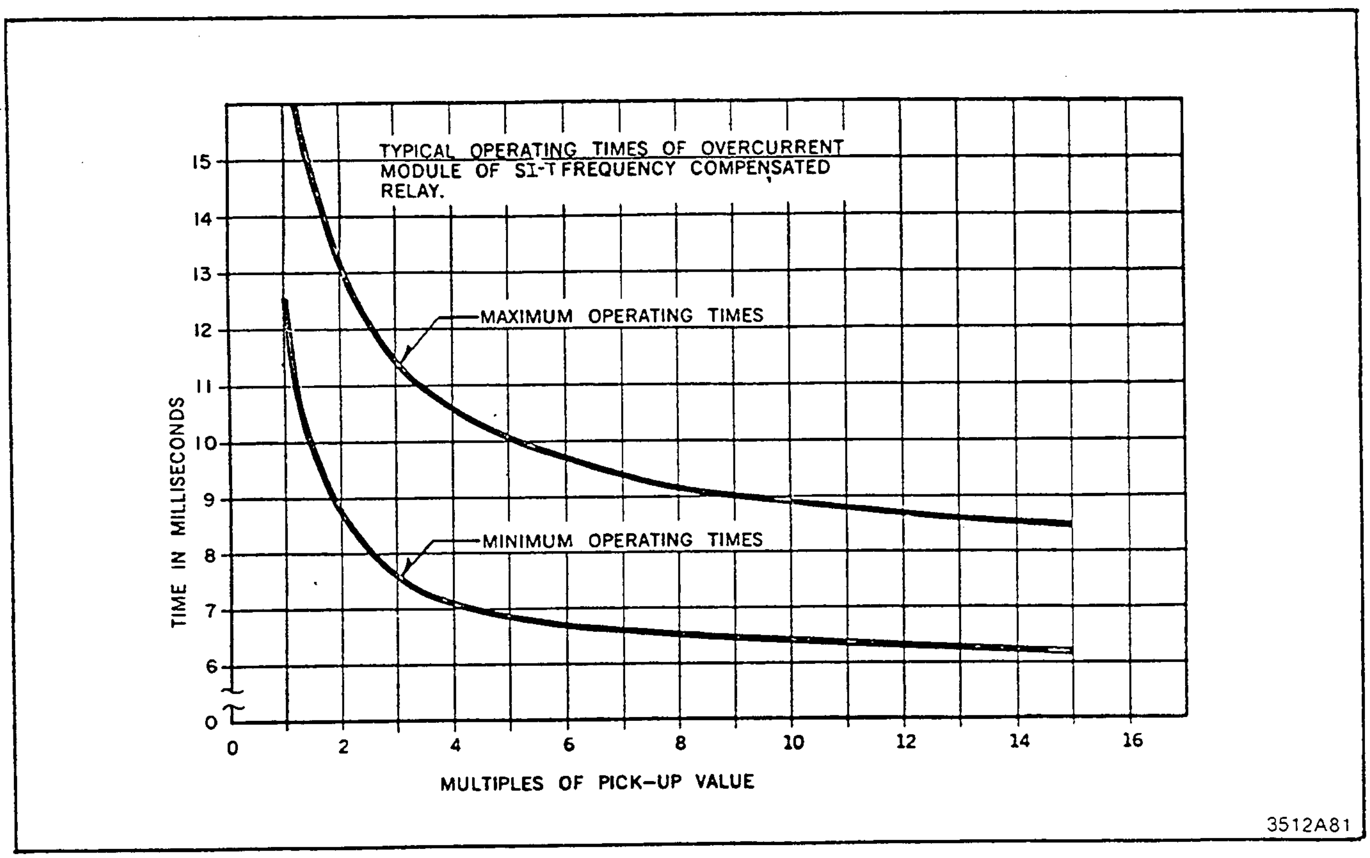


Fig. 7. Typical Operating Time of the Type SI-T Relay.

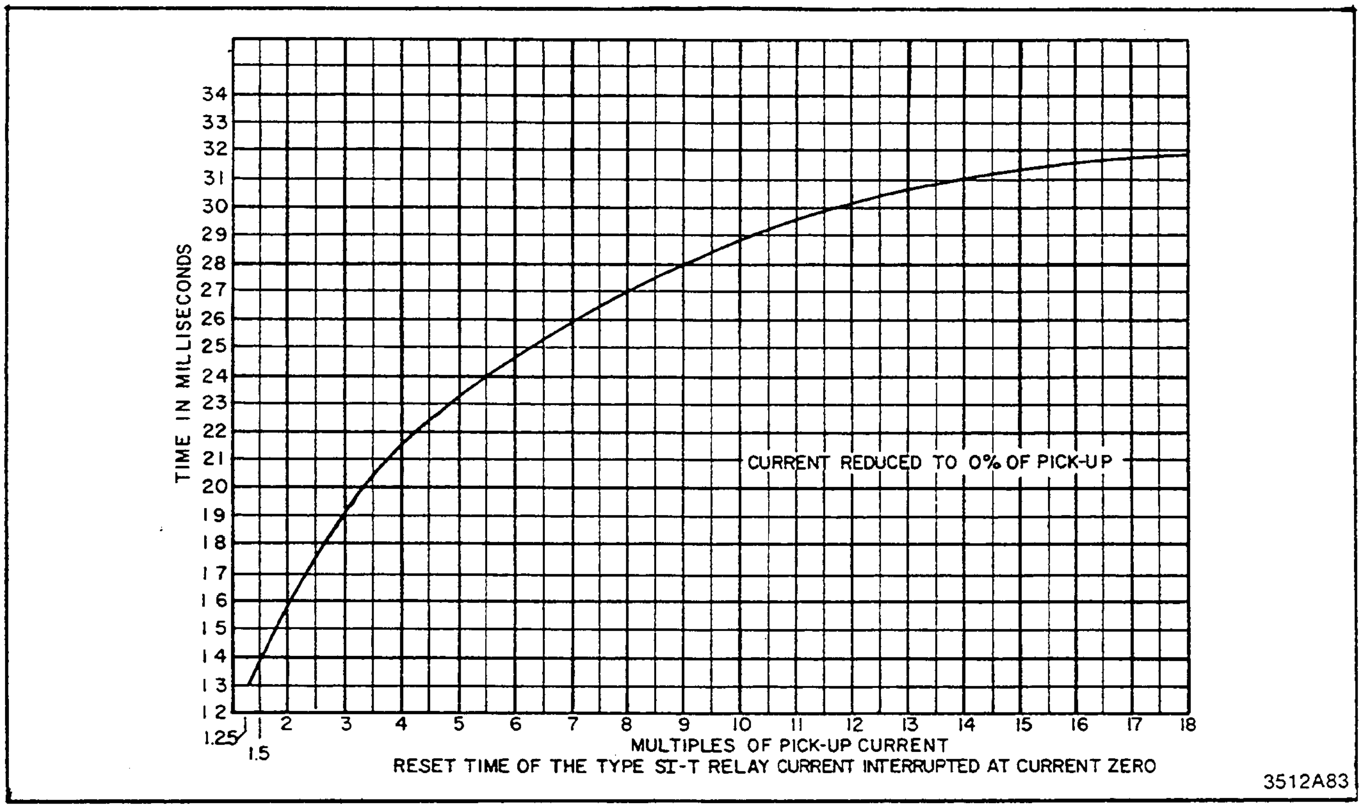


Fig. 8. Typical Reset Time of the Type SI-T Relay.

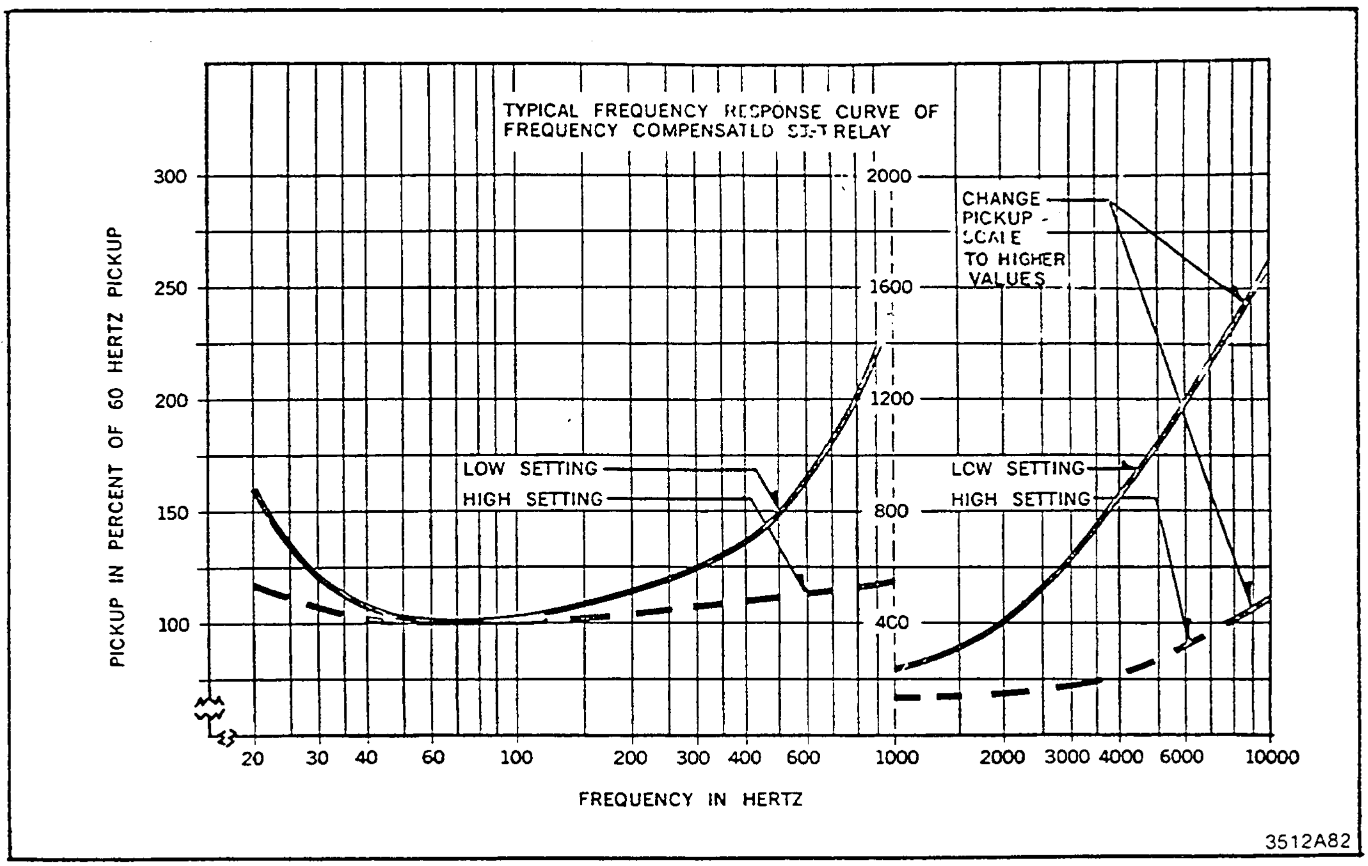
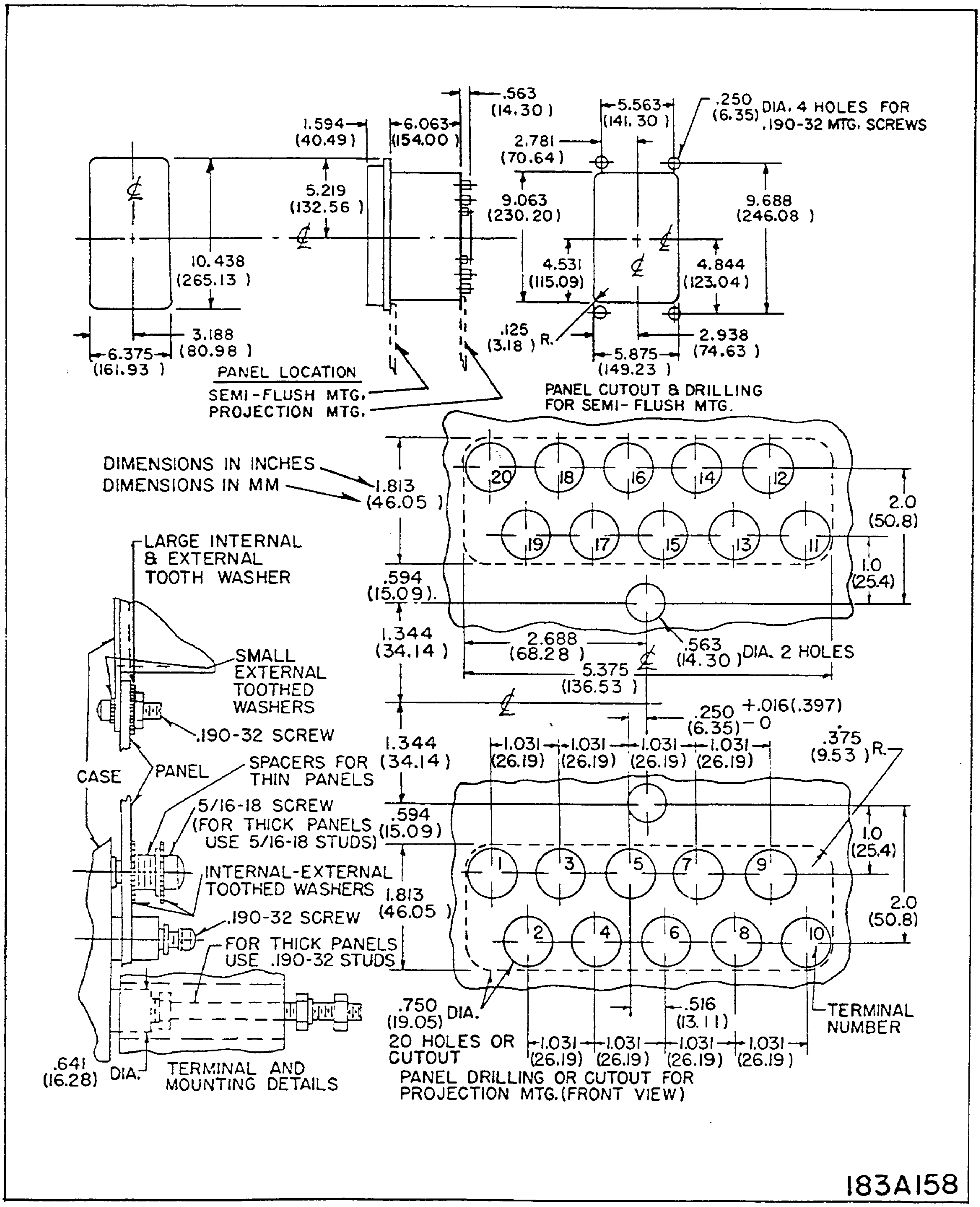


Fig. 9. Typical Frequency Response Curve of the Type SI-T Relay.



✪ *Fig. 10. Outline and Drilling Plan for the Type SI-T Relay in the FT-22 Case.*

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