Type SOQ
Negative Sequence Time Overcurrent Relay

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(|) Denotes Text change since previous issue.
(*) Denotes Figure change since previous issue.

Device Number: **46**

A = Add New Information ❖ **C** = Change Existing Information ❖ D = Delete Information

A

ICS Unit For any references to the ICS Unit, the following note applies:

NOTE: For some SOQ relays, the ICS Unit is replaced with an ACS Unit, which is an ac indicating unit. This is for use in applications where the SOQ trip contact is an ac voltage circuit instead of dc.

C

SOQ Input Module Effective February 1990, a Slide Switch (S1) replaced the Thumbwheel Switch (SW) located on the Input Module, therefore all references to the Thumbwheel Switch also refer to the Slide Switch.

The Thumbwheel Switch was numbered from 0 to 12. The Slide Switch nameplate reads from 1 to 13. Relays with slide switch should increment by one (1) all references to the old Thumbwheel Switch, in order to make it correspond with new positions.

References: Figures 7 & 8 - Input Module with Thumbwheel Switch.

Figures 9 & 10 - Input Module with Slide Switch.

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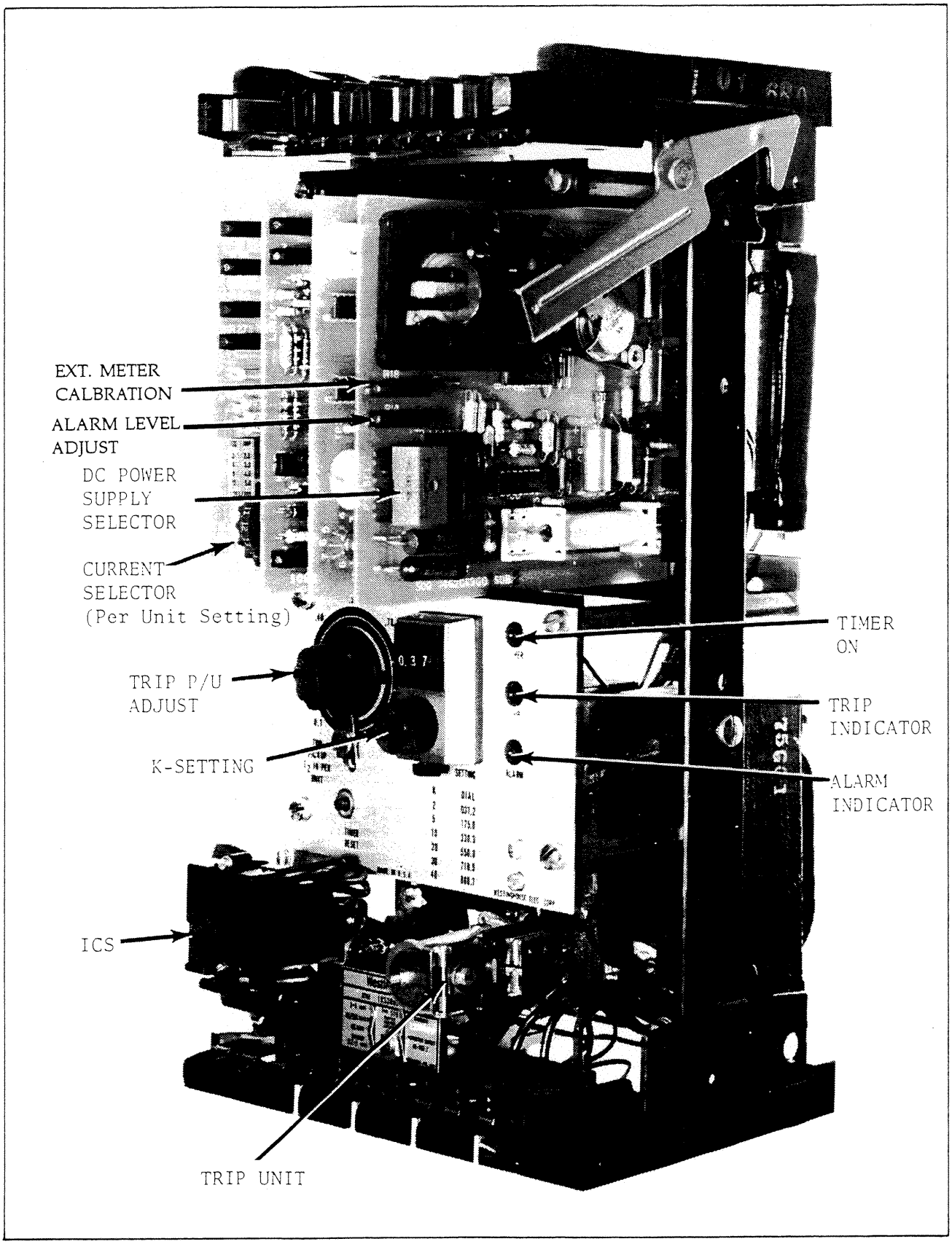


Figure 1. SOQ Relay in FT-32 Case

CAUTION: Before putting protective relays into service, remove all blocking which may have been inserted for the purpose of securing 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 SOQ relay is a solid state time overcurrent device intended for use in protecting rotating machinery against excessive heating due to prolonged unbalanced current. It is suitable for use with directly-cooled or indirectly-cooled turbine generators, salient pole generators, synchronous condensers, or any rotating machine having a known I_2^2t limit.

The SOQ relay has settings that are compatible with the ANSI standard requirements for I_2^2t limits for generators covering the range of 2 to 40. It has a per unit adjustment that allows the relay to be related to the full load current of the machine. I_2 trip pickup can be independently adjusted from 0.1 to 1.0 per unit, allowing time delayed tripping to occur at any I_2 level above this.

The alarm feature in the SOQ relay allows an operator to be alerted to the presence of an abnormal I_2 level in the machine. It can be set to 0.03 to 0.2 per unit.

The SOQ relay is equipped with provision for remote indication of per unit I_2 level flowing in the machine. Using this, an operator can estimate the severity of the unbalanced loading and take appropriate action.

The exponential resetting action of the timer has been made compatible with that of typical air cooled and hydrogen cooled turbine generator.

CONSTRUCTION

The SOQ relay is mounted in the semi-flush FT-32 flexitest case and is shown in Fig. 1.

The relay consists of two input current transformers, four printed circuit boards, an output telephone relay, an indicating contactor switch and a front panel with two potentiometers, three indicating lights (LED) and a reset push button.

Input Transformers – The two input current transformers are electrically identical. Each transformer contains three windings – two for primary input currents and one for secondary voltage output. A ten ohms load on the Input board is connected to the secondary.

Front Panel and Dial Plate – The front panel is made of Micarta with an aluminum scale plate on it. A digital ten-turn linear potentiometer is used for the K-setting. Another single turn potentiometer is used for trip pickup level setting. Three light-emitting-diodes (LED) indicate the timer-on, trip and alarm conditions respectively. A reset push button resets the timer and its LED; this function is used for relay test or acceptance test.

All possible contingencies which may arise during installation, operation or maintenance, and all details and variations of this equipment do not purport to be covered by these instructions. If further information is desired by purchaser regarding this particular installation, operation or maintenance of this equipment, the local ABB Inc. representative should be contacted.

Output Contacts – A telephone type relay equipped with 2-A type contacts is provided. One of the normally open contacts is used with a target seal-in unit for tripping. In addition, there are two auxiliary normally open contact reed relays on the printed circuit board and their contacts are used for the alarm and oscillograph start unit.

Indicating Contactor Switch (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 magnetic 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 deflects 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.

Remote Readout Meter – An optional meter may be provided to permit monitoring the negative sequence current (I_2) level at a remote location. The meter is a switchboard mounting Westinghouse type KX-241. It is a 1 milliampere dc meter to represent a full scale of 0.2 per unit.

Printed Circuit Boards – Four printed circuit boards are used in SOQ relay:

1. Input Board (slot A)
2. Timer Board (slot B)
3. Control Board (slot C)
4. Power Supply Board (slot D)

All of the printed circuit boards slide into position to engage four terminal blocks at the rear of the relay. Each board and terminal block are keyed so that they cannot be accidentially inserted into the wrong slot location. The boards may be for replacement or for use in conjunction with a board extender (style no. 644B315G0) which permits access to the boards test points and terminals for making measurement while the relay is energized.

OPERATION

The SOQ relay simulates a generator's charactertistic, e.g. $I_2^2t=K$ where I_2 is the negative-sequence current per unit, t is the duration of the unbalanced condition and K is a machine constant. For SOQ relay, t is the delay time for tripping.

With reference to the logic diagram 1334D69 (fig. 2) and the internal schematics associated with the printed circuit boards for understanding the SOQ logic.

NOTE: In the description of the integrated circuits, the number in parenthesis following the IC number will refer to the output pin of one of the two operational amplifiers contained in the linear IC package, e.g. IC1(12) refers to the op. amp. in IC1 whose output pin is 12. Digital IC's will be identified in the same manner.

1. Input Board (Slot A)

   The input board contains the following function blocks.

   a. Negative sequence filter – A voltage (V_C-V_B) from transformer T2 is shifted by 60° in phase, e.g. the voltage at TP1 is equal to $-(V_C-V_B)\angle -60°$. Another voltage (V_A-V_B) from transformer T1 is added with the voltage at TP1 by an operational amplifier IC1(10). The resultant voltage at TP2 is equal to $A \bullet [(V_A-V_B) - (V_C-V_B)\angle -60]$ which is an expression for negative sequence voltage and the constant A is a predetermined weight.

   b. Per unit setting – A single-pole 16-position rotary thumb wheel switch is used for per unit setting. Thirteen positions from #0 to #12 are provided in 0.25 ampere steps from 2.0 to 5.0 amperes/unit for matching to the CT secondary current corresponding to one per unit generator current. Setting at positions from 13 to 15 is not permissible. The different setting position actually varies the negative feedback of the op-amp IC2(12); therefore, the gain of the amplifier is changed.

c. Band-pass (60 Hz) filter – The operational amplifier IC2(10) and its associated components are used as a band-pass filter. The gain of this filter at 60 Hz and 180 Hz is approximately equal to 1 and 0.25 respectively.

d. Full wave rectifier and ac to dc converter – The amplifiers IC3(10) and IC3(12) are used as an absolute value circuit. This means that the gain of the circuit is equal to 1 or -1 for a positive or negative waveform respectively. The amplifiers IC4(10) and IC5 combined with the resistor R34 and capacitor C7 are a peak value dc amplifier. The IC4(12) is an average value dc amplifier with a gain of 1.6.

The dc output voltages at pin 10 and 9 are adjusted so that one volt represents one per unit of the negative-sequence input current I_2.

Fig. 7 shows the schematic of this board and Fig. 8 shows the component location on the board.

2. Timer Board (Slot B)

a. Square Function – The IC1(10) combined with a K-setting potentiometer on front panel is used for scaling K adjustment. The IC2 is a square function amplifier. For the same input I_2, if the higher value of K is set, the lower voltage at TP2 will be obtained.

b. Ramp timer and trip level detector – The voltage at TP2 is integrated by IC3 with a time constant of C4 • (R10+R13). The wave-form at TP4 is a negative going ramp type and is connected to a level detector IC6(12). As soon as the voltage at TP4 is lower than the setting voltage at pin 2 of IC6(12), the trip condition will be occurred.

c. High current I_2 compensation – Because of the loss in current transformers T1 and T2 a level detector 1C6(10) is used as high current I_2 compensation. If the voltage at TP2 exceeds a certain level, a reed relay RY3 will operate; therefore, some additional current will flow though the contacts of RY3 to speed up the charging time of the capacitor C4.

d. Low current I_2 compensation – Because a low input current I_2 will cause a very low voltage at TP2, the offset or drift voltage of IC2 cannot be neglected. The IC5 and reed relay RY4 are used to compensate this effect. Normally, the output transistor of IC5 is turned on and the RY4 is energized. The biasing voltage of IC3 is the same as the offset voltage of IC2. Once the input I_2 exceeds the setting of the trip pickup level detector (on board C), the IC5 will generate a series of negative pulses and to energize the RY4 for 2 milliseconds per every one second (approx.). During this 2 milliseconds, the capacitor C3 is charged to the same offset voltage of IC2. The voltage on C3 will be held to bias the IC3.

e. Reset Cycle – At normal condition, a reed relay RY2 is energized, RY1 is de-energized and capacitor C4 is shorted. As soon as the input I_2 exceeds the set point level of trip pickup (on front panel) the RY2 will be de-energized and RY1 will be energized. The ramp timer will start to operate. If I_2 falls below the set point of Trip Pickup before the trip time has been reached, the RY1 and RY2 are both deenergized, and a reset period is started. During the reset cycle, the ramp timer integrator will be held and the capacitor C4 is discharged through resistors R18, R19, R20 and R21 in an exponential decaying form. The reset time constant is determined by a link (jumper). It is approximately 80 seconds for the link out or 38 seconds for the link in. If I_2 increases above pickup, the integrator will again be initiated, beginning at whatever value the reset function has reduced it to.

f. Trip Pickup amplifier – An IC1(12) is used as an amplifier with a gain of 10. Its input is a full wave rectifier (on Bd. A) and its output is connected to an alarm amplifier (on Bd. D) and to a trip pickup level detector (on Bd. C).

Fig. 9 shows the schematic of this board and Fig. 10 shows the component location on the board.

3. Control Board (Slot C)

a. Timer Start (Trip Pickup) level detector – The IC1(12) combined with a potentiometer P2 (on front panel) is used as a level detector. If I_2 increases above the set point, the logic state at TP1 is "1" which is a low voltage due to using a negative logic symbol. The IC2(3) and IC3(8) are used to start the ramp timer by energizing a DIP relay RY1 (on Bd. B) and to start an oscillograph by energizing a reed relay OSCG.

b. Initial disabled timer 0.2 sec./0 – The trip signal from Bd. B is connected to IC3(6) in "AND" form. Normally, the voltage at pin 6 of IC3(6) is zero. If I_2 increases above the set point of the trip pickup, the voltage at pin 6 of IC3(6) will stay zero to inhibit trip for 0.2 second due to the time delay from IC1(10), R4 and C1.

c. Final Trip Timer 250 sec./0 – If I_2 is above the set point, capacitor C2 will be charged through R9, R10 and R11. After a long time delay (250 seconds), the voltage at TP3 will become zero and trip transistor Q1.

d. Reset timer 0/250 sec. – If I_2 is to decrease under the set point again, the voltage at TP1 will be 30 volts and the capacitor C6 will be charged through R25, R26 and R27. After a long time delay (250 seconds), the voltage at TP6 drops to energize in a DIP relay RY2 and Bd. B.

e. Power-on and manual reset circuits – In order to reset the reset timer IC5 (0/250) when the dc power is turned on, a transistor Q2 and its associated components are used as an automatic reset circuit.

A large current, in a short period, flows through Q2 to charge C6 to full voltage. Another way to reset the timer (0/250) is to use the push button (on front panel) to speed up capacitor C6's charging time. This way may be used during the relay test to avoid a long waiting time in order to take the data of trip delay time for different K setting. Fig. 11 shows the schematic of this board and Fig. 12 shows the component location on the board.

4. Power Supply Board (Slot D)

a. DC Power Supply – A DIP header in front of the board can be unplugged and turned over for 48 or 125 volts power supply selection. The IC1, IC2(12), Q1, Q2 and Q3 are used as a voltage regulator to generate +15 and +30 volts.

b. Alarm Function – The IC3(12) is an alarm amplifier with a gain of 5, and IC3(10) is an alarm level detector. A trimpot R14 is used for alarm level setting. Once I_2 exceeds the set point of alarm, the voltage at TP3 will drop from high to low. After a two-second time delay due to C8, R15 and Z3, transistor Q4 will turn on to energize the alarm reed relay.

c. Voltage to current converter – The output of alarm amplifier IC3(12) also applies to IC2(10) which is used as a voltage to current converter. The output current is proportional to the voltage at TP2 and is used to drive a remote instrument.

Fig. 13 shows the schematic of this board and Fig. 14 shows the component location on the board.

5. K-Setting (on front panel)

A precision ten-turn digital potentiometer on the front panel is used for K-setting. Although there are only six K numbers – 2, 5, 10, 20, 30 and 40 – indicated on front panel, any K value between 2 and 40 can be set with an accuracy of 2%.

The relationship between K and the digital reading can be expressed as follows:

$$\text{Digital Number Setting} = \frac{7.5 - 2\sqrt{\frac{20}{K}}}{\sqrt{\frac{20}{K}}} \times 100$$

A typical time – current curve diagram with different K setting is shown in Fig. 4.

6. Trip Function

The Trip Pickup (on front panel) can be set between 0.1 and 1.0 per unit. If I_2 is below the set point, the ramp timer (on Bd. B) will not be started, e.g. the trip action can not occur. If I_2 exceeds the set point, a timer-on lamp will be turned on and the following three timers will be energized.

a. Ramp Timer (on Bd. B) – The trip time delay is determined by I_2 and K-setting according to the curves shown in Fig. 4. A trip indicating lamp will show the trip action, if it occurs.

b. Initially Disabled Timer (on Bd. C) – This timer will prevent the relay from tripping for 0.2 second since system relay may give some proper actions.

c. Final Trip Timer – After a long time delay of 250 seconds, if I_2 still exceeds the set point of trip pickup, the relay will be tripped automatically.

7. Reset Function

Once I_2 falls below the set point of Trip Pickup before the trip time has been reached, the trip ramp timer integrator will be held and the reset cycle will be started. The relay's reset is in an exponential decaying form with a time constant of either 80 or 38 seconds which simulates a heat dissipation in an air cooled or a hydrogen cooled machine respectively. If I_2 is to increase above pickup level again the integrator will again be initiated, beginning at whatever value the reset function has reduced it to. The reset characteristics are shown in Fig. 5 and 6 for time constant of 80 and 38 seconds respectively. The voltage of the trip level detector is set at 6 volts.

The following two methods can be used to determine the total time for tripping.

a. Calculation from formula

Define the symbols as follows

t_1 - integrator charging time (linear)
t_2 - discharging time (exponential decaying)
t_3 - charging time after reset period
I_2 - negative-sequence current per unit
I_{22} - negative sequence current per unit after reset period.
K - machine constant ($I_2^2 t = K$)
T - reset time constant

$$t_3 = \frac{K\left(1 - \frac{I_2^2}{K} \cdot t_1 \cdot e^{-\frac{t_2}{T}}\right)}{I_{22}^2}$$

Total time for tripping = $t_1 + t_2 + t_3$

Assume: Set K=2 and apply I_2 = 0.2 amps/unit for t_1 = 41.7 seconds, then turn off for t_2 = 73.3 seconds. After the reset time t_2, reapply I_{22} = 0.2 unit. The total time delay for tripping should be:

$$t = t_1 + t_2 + t_3 = t_1 + t_2 + \frac{K\left(1 - \frac{I_2^2}{K} \cdot t1 \cdot e^{-\frac{t_2}{T}}\right)}{I_{22}^2}$$

If the reset link is for T = 80 seconds, the total time delay is:

$$t = 41.7 + 73.3 + \frac{2\left(1 - \frac{0.2^2}{2} \cdot 41.7 \cdot e^{\frac{-73.3}{80}}\right)}{0.2^2}$$

$$= 115 + \frac{1.33}{0.04} = 115 + 33.3 = 148.3 \text{ seconds}$$

b. Graphic Method (Fig. 5)

The output voltage (V) of the ramp timer (intergrator) is

$$V - V_i = V_t \frac{I_2^2}{K} t$$

or

$$t = \frac{(V - V_i) K}{I_2^2 V_t}$$

where Vi is the initial voltage and V_t is the trip voltage which has been set at 6 volts.

For the example shown in part (a), the following procedures can be used.

At the time $t=t_1$, the integrating capacitor is charged to voltage V_1 . ($V_i=0$)

$$V_1 = V_t \frac{I_2^2}{K} t_1 = 6 \cdot \frac{0.2^2}{2} \cdot 41.7 = 5 \text{ volts}$$

During the reset period. the capacitor will be discharged from the point (t_1, V_1) to (t_1+t_2, V_2) as shown in Fig. 5, e.g. from (41.7, 5) to (115, 2). This means that the capacitor's voltage will drop from 5 volts to 2 volts between t=41.7 and t=115 seconds. When the capacitor is recharged again, until voltage reaches to the trip voltage V_t, the charging time t_3 should be:

$$t_3 = \frac{K (V - V_i)}{I_{22}^2 V_t}$$

where $V = V_t = 6$ volts, $V_i = 2$ volts, $K = 2$ and $I_{22} = I_2 = 0.2$

$$\therefore t_3 = \frac{2 (6-2)}{0.2^2 \times 6} = 33 \text{ seconds}$$

the total time delay for tripping is

$t = t_1 + t_2 + t_3 =$

41.7 + 73.3 + 33 = 148 seconds

8. Remote Readout (Optional)

An optional meter may be provided to permit monitoring the negative sequence current (I_2) level at a remote location. The meter is a switchboard mounting Westinghouse type KX-241. It is a dc 1 milliampere meter to represent a full scale of 0.2 per unit.

CHARACTERISTIC

Ambient Temperature:	-20° to +55°C
Current Transformer:	Continuous rating - 10 amperes One second rating - 300 amperes
Constant K Setting:	2 to 40 - 2%
Current Range Setting:	2 to 5 amperes per unit with 0.25 ampere per step
Operating Time: (Fig. 4)	0.2 to 50 seconds - 5% 50 to 250 seconds - 10%
Timer Start Pickup:	0.1 to 1.0 per unit - 5%
Alarm Pickup:	0.03 to 0.2 per unit - 5%
Alarm Time Delay:	2 seconds - 25%
Initial Disable Trip Time:	0.2 second - 10%
Final Trip Time:	250 second - 10%
Reset Exponential Time Constant:	38 or 80 seconds - 10%
Frequency Response:	No response to 57 Hz. positive sequence current at 5 amperes
DC Power Supply:	48/125 Volts
DC Current Drain:	0.17 ampere (max.)
Burden (ac):	1.6 volt - ampere (max.) at 5 amperes and 60 Hz.
Indicating Contactor Switch (ICS):	0.2/2 amperes
Contact Rating:	1. Trip contacts with ICS – 30 amperes at 250 volts dc for 0.2 second. 2. Trip contacts (telephone relay) – 0.1 ampere at 125 Vdc. 3. Alarm contacts (reed relay) – 0.1 ampere at 125 Vdc. 4. Oscillograph start (reed relay) – 0.1 ampere at 125 Vdc.

INSTALLATION

The relays should be mounted on switchboard panels or their equivalent in a location free from dirt, moisture, excessive vibration, and heat. 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.

SETTINGS

The SOQ requires settings of:

1. Per unit
2. K
3. Trip Pickup
4. Alarm level
5. Reset time constant

1. Per unit – choose the setting nearest to, but less than the full load current of the machine converted to relay amperes. For hydrogen cooled machines, this setting should be related to the capability of the machine for the particular hydrogen pressure involved.

2. The K setting is chosen to correspond to the I_2^2t limit for the particular machine. These are typically:

Type of Machine	$I_2^2t=K$	Dial Setting
Salient Pole	40	860.7
Synchronous condenser	30	718.5
Cylindrical rotor		
Indirectly Cooled	30	718.5
Directly Cooled	10 (or less)	330.3 (or less)

3. The trip-pickup level is the lowest level of I_2 at which tripping will be permitted. That level of sustained I_2 that could produce tripping at 250 seconds is a reasonable level to consider. This would be $\sqrt{K/250}$. If, for example, K were 10 for the particular machine the level would be adjusted for:

$$I_2 = \sqrt{10/250} = 0.2 \text{ per unit}$$

4. The alarm level should be set at the lowest level consistent with normal load unbalance but in no case greater than the maximum continuous I_2 level for the machine. Typical values for generators are:

Type of Machine	Permissible I_2(%)
Salient Pole	
with connected amortisseir windings	10
with non-connected amortisseir windings	5
Cylindrical Rotor	
Indirectly cooled	10
Directly cooled	
0 to 960 MVA	8
961 to 1200 MVA	6
1201 to 1500 MVA	5

For a machine with a continuous I_2 capability of 10%, a reasonable alarm level setting is 0.05 (that is, 5%).

5. The SOQ timer has an inverse resetting characteristic similar to that of typical generators to allow for any cumulative effects that take place due to reclosing, for example. Two conservative values are available and may be chosen by a link on the "Timer Board". Cooling time constant for hydrogen cooled turbo-generators, are typically less than 40 seconds and for air cooled turbo-generators are typically less than 80 seconds. With the link "in", a timer constant of 38 seconds is chosen. With the link "out", a time constant of 80 seconds is chosen. In the absence of specific information the link should be removed and the 80 second time constant used. Where the actual cooling time constant is known, the lowest value that is higer than the machine time constant should be selected. Where reclosing is not applied, remove the link.

ADJUSTMENT 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.

1. Power Supply

   a. Check the power selector and select the proper input voltage rating. It is a DIP type plug on power supply board.

   b. Apply rated dc input voltage to relay terminals 20 and 11 (com). The dc voltage between p.c. board terminals D11 and D10 (com.), D3 and D10 should be between 14 and 16 volts. The dc voltage between pc board terminals D12 and D10 (com.), D2 and D10 should be between 29 and 31 volts.

2. Per Unit Setting

   Use single phase current to simulate the negative-sequence current. Note $I_2 = \sqrt{3} I_{1\phi}$

   a. Set the thumbwheel switch (on Bd. A) on position #12.

   b. With relay terminals 5, 7 & 9 connected together, apply a single phase current per the following table to relay terminals 4 and 6 or 6 and 8 or 8 and 4 and measure the dc voltage between pc board terminals A10 and A3 (com.). The voltage reading should be less than ±5% from nominal value.

Input (5 Amps/Units)		Voltage at A10
Unit	Amps	Volts (±5%)
0.1	0.86	0.1
0.5	4.33	0.5
1.0	8.66	1.0
2.0	17.32	2.0

   c. Set the thumbwheel switch (on Bd.A) on position #0 and repeat step (b) per following Table.

Input (2 Amps/Unit)		Voltage at A10
Unit	Amps	Volts (±5%)
0.1	0.346	0.1
0.5	1.73	0.5
1.0	3.46	1.0
2.0	6.92	2.0

3. K – Setting

   a. Set K = 20, e.g. dial setting of 550.0 K-setting potentiometer can be locked or released by pushing the lever under the dial to the right or left respectively.

   b. Set the thumbwheel switch (on Bd. A) on position #12, e.g. I_2=5 amps/unit.

   c. Set the Trip Pickup at 0.1 unit (on front panel).

   d. Connect the test circuit as shown in Fig. 15.

   e. Reset the timer by pushing the reset button for every following reading.

   f. Apply an input current and measure the time delay for tripping per the following table.

Input (5 amps/unit)		Time Delay
Units	Amperes	Seconds (±5%)
0.5	4.33	80
1.0	8.66	20
2.0	17.32	5

   NOTE: For more accurate K-setting, change the dial number slightly to obtain the right time delay.

   g. Repeat the test except set K=2, e.g. dial setting at 037.2 and test according to the following table.

Input (5 amps/unit)		Time Delay
Units	Amperes	Seconds (±5%)
0.2	1.732	50
0.5	4.33	8
1.0	8.66	2
2.0	17.32	0.5

4. Reset Check

   The following test is based on the example shown in Section 7 of paragraph "Operation".

   a. Set the thumbwheel switch at position #12 and K=2 (dial number 037.2).

   b. Use the test circuit shown in Fig. 15 and use a watch (or stop watch) to count the time.

c. Reset the timer by pushing the reset button.

d. Apply an input current of 1.73 amps (0.2 unit) to the relay and start to count the time delay. After 41.7 seconds, turn off the input current for 73.3 seconds. After the total time of 115 seconds, turn on the input current again until the trip light is on and measure the total trip time. It should be 148 seconds with an error of ±10%.

5. Alarm Check

a. In test circuit shown in Fig. 15, connect the scope probe to the alarm contacts.

b. Adjust input current above the alarm setting, e.g. 0.05 unit or 0.43 ampere for per unit setting at position #12.

c. Turn on the input switch. The alarm relay should be picked up in 2 seconds (±25%).

d. For alarm level setting other than the factory setting (0.05 unit), the following procedures can be used.

(i) Apply an input current $I_{in}=\sqrt{3}\bullet$ Iu$\bullet$ (per unit setting) where Iu is the desired alarm current in unit.

(ii) Adjust trimpot R14 on power supply board to the extreme clockwise position.

(iii) Slowly adjust R14 counterclockwise until the alarm reed relay is picked up.

6. Trip Pickup

Trip pickup can be set between 0.1 and 1.0 unit. Setting in between the scale mark can be made as follows.

a. Apply an input current $I_{in}=\sqrt{3}\bullet\ I_u\bullet$ (Per unit setting) where I_u is the desired trip pick current in unit.

b. Connect the scope probe to the contacts of oscillograph start as shown in Fig. 15.

c. Slowly turn the trip pickup potentiometer counterclockwise from it extreme clockwise position until the oscg. reed relay picks up.

7. Timer 0.2 Sec/0

a. Connect the scope probe to the trip contacts as shown in Fig. 15.

b. Set Per Unit Setting at position #12 and K-setting at 2 (dial on 037.2).

c. Suddenly apply 30 amperes to SOQ relay. The relay should be tripped in 0.2 second (±10%).

8. Timer 250 sec/0

a. Set Per Unit Setting at position #12, K-Setting at 40 (dial on 860.7) and Trip Pickup at 0.1 Unit.

b. Use a watch or stop-watch to count the time delay and reset all the lights.

c. Apply a single phase current 1.5 amperes to terminals 4 and 6 and start to count delay time until the trip light is turned on. The time delay should be 250 seconds (±10%).

9. Timer 0/250 sec.

a. Set Per Unit Setting at position #12, K-setting at 2 (dial on 037.2) and Trip Pickup at 0.1 unit.

b. Use a watch or stop-watch to count the time delay.

c. Apply a single phase current of 5 amperes to terminals 4 and 6. The alarm and timer lights will be turned on. After a few seconds, the trip light will be turned on.

d. Turn off the input current and start to count the time delay until the timer light goes off. It should be 250 seconds (±10%).

10. Remote Meter (Optional)

a. Set Per Unit Setting at position #12.

b. Connect a dc 1 milliampere meter (supplied) to relay terminals 12 (+) and 13 (-).

c. Apply a single phase current of 1.73 ampere (0.2 unit) to terminals 4 and 6. The meter's reading should be 0.2 unit (full scale) with a maximum error of 2%.

d. Change input current to 0.86 and 0.43 ampere. The meter's reading should be 0.1 and 0.05 unit respectively with a maximum 2% error of full scale.

11. Indicating Contactor Switch (ICS)

a. Apply an ac input current of 5 amperes until the SOQ telephone relay is picked up.

b. Apply 200% of ICS's rated tap value dc current through ICS coil. The target should drop freely and both moving contacts should be closed simultaneously with a wipe from 1/64" to 3/64".

c. De-energize the input current. The telephone relay should drop out but ICS should stay picked up.

Routine Maintenance

The relay's calibration should be checked and the contacts should be cleaned at least every year. A contact burnisher S#182A836H01 is recommended for cleaning purposes.

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.

Before making any adjustment, make sure that the power supply selector is selected for rated input dc voltage (48 or 125 volts). The output of the power supply board should be +15 and +30 volts with an error less than ±1 volt.

A. Input Board (Slot A)

1. Negative Sequence Filter

a. Apply three phase current source I_A, I_B and I_C to terminals 4, 6 and 8 respectively and set $I_A = I_B = I_C = 5$ amps. Connect terminals 5, 7 and 9 together.

b. Use a phase angle meter to compare the phase between PC board terminal A18 and TP1 with common lead on terminal A12. It should be 180° ± 1°. Adjustment can be made by trimpot R5.

c. Connect a scope probe on TP2 with common lead on pc board terminal 14.

d. Adjust trimpot R7 to minimize the largest amplitude.

NOTE: If a phase angle meter is not available, alternately adjust trimpots R5 and R7 to minimize the amplitude on TP2.

2. DC Offset Adjustment

a. Set the rotary thumbwheel switch at position #12 and connect the common lead of a dc digital voltmeter to pc bd. terminal A3.

b. With ac input switch on OFF position and dc switch on ON position, measure the voltages at TP4, TP5, TP6 and terminal A10 and adjust R27, R30, R33 and R36 respectively; they should be less than 0.5 millivolt.

3. Input Range Check

Steps (a) to (c) can be omitted if cutomers have difficulty to obtain a balanced three-phase current source.

a. With the same setting as shown in steps 1, 2 and input current $I_A = I_B = I_C = 5$ amps, turn on the dc and ac switches.

b. Measure the voltage between A10 and A3 (com.).

c. Adjust trimpot R9 until the reading is 1.000 volt.

d. Turn off the ac current and reconnect the input as shown in Fig. 15.

e. Apply single phase current of 8.66 amperes to relay terminals 4 and 5. The dc voltage between A10 and A3 (com.) should be closed to 1.000 volt. Adjustment can be made by trimpot R9. The voltage between A9 and A3 should be less than 5% of the voltage at A10.

f. Adjust the input current to 0.866 ampere. Adjust trimpot R36 until the dc voltage at terminal A10 is equal to 0.100 volt.

g. Repeat steps (e) and (f).

h. Adjust the input current to 3.464 amperes and select the rotary thumbwheel switch to position #0. The dc voltage at terminal A10 should be between 0.980 and 1.020 volts.

i. Repeat step (h) except connect the ac input to relay terminals 8 and 4 instead of 4 and 6.

j. Connect the ac input to terminals 6 and 8 instead of 8 and 4 and adjust the input current to 8.66 amperes. Set the rotary thumbwheel switch to position #12. The dc voltage at terminal A10 should be between 0.980 and 1.020 volts.

k. Connect the ac input back to relay terminals 4 and 6.

B. Control Board (Slot C)

Use the single phase current test circuit shown in Fig. 15 for the following test. Set the thumbwheel rotary switch (on Bd. A) at position #12.

1. Calibration for Trip Pickup

a. Connect a scope probe to TP1 on Bd. C.

b. Turn on the ac and dc switch, and adjust the input current to 0.866 ampere.

c. Adjust the Trip Pickup knob on the front panel counterclockwise from extreme clockwise position such that the white pointer directs at the lowest scale mark (0.1 unit) and the scope trace just jumps from high (29V) to low (5V).

d. Turn the trip pickup knob fully clockwise.

e. Apply ac input current of 8.66 amperes and turn the knob CCW until the scope trace jumps from high to low. Mark dial (1.0 unit).

f. Repeat step (e) and calibrate dial plate per following information.

Input (Amps)	8.66	7.36	6.06	4.76	3.46	2.06	0.86
Dial (Unit)	1.0	0.85	0.70	0.55	0.40	0.25	0.10

2. Timer 0.2 Sec/0

a. Apply an ac input current of 8.66 amperes.

b. Connect a scope probe to TP2 (Bd. C) and set scope trigger at positive pulse.

c. Close the input ac switch. The delay time on scope should be between 180 and 220 MS.

NOTE: Adjustment of this timer can be made by changing R4 (Bd. C) if time is close to limits.

3. Timer 0/250 Sec

a. Use a watch or stop watch to count the time delay.

b. Push the reset button on the front panel to reset the timer light.

c. Suddenly apply a current of 8.66 amperes and the timer light will be on.

d. Turn off the input ac switch and start to count the time until the timer light goes off. It should be between 225 and 275 seconds.

NOTE: Adjustment of this timer can be made by changing R29 (Bd. C) if time is close to limits.

4. Timer 250 Sec/0

a. Use a watch or stop watch to count the time delay.

b. Connect a jumper between pc board terminals C17 and C10.

c. Push the reset button to reset the timer light.

d. Suddenly apply a current of 8.66 amperes. The trip light should be on between 225 and 275 seconds.

NOTE: Adjustment of this timer can be made by changing R13 (Bd. C) if time is close to limits.

e. Turn off the ac and dc switches and disconnect the jumper between C17 and C10.

5. Power-On Reset (Auto)

Turn off the dc power supply switch for 2 seconds and then turn it back on again. None of the lights should be on.

C. Timer Board (Slot B)

Use single phase current test circuit shown in Fig. 15 for the following test. Set the thumbwheel rotary switch (on Bd. A) at position #12 and the Trip Pickup setting slightly below 0.1 unit.

1. Offset Adjustment

a. Turn off the ac input switch and turn on the dc power switch. Set the K-setting potentiometer (on front panel) to mid-position.

b. Connect a jumper between PC board terminals B13 and B3.

c. Use a digital voltmeter to measure the voltage between TP1 (Bd. B) and terminal B3 (com). Adjust trimpot R4 to obtain the reading of 0 $\pm$ 0.2 millivolt

d. Disconnect the jumper between terminals B13 and B3.

2. Oscillator Circuit

a. Connect the test circuit as shown in Fig. 15 except connect the scope probe to TP5 (Bd. B). The voltage at TP should be between 14 and 16 volts.

b. Apply ac current of 8.66 amperes to the relay. A series of pulses should be seen on the scope. The pulse width should be between 1.5 and 4.0 milliseconds and the pulse period should be between 700 and 1400 milliseconds.

3. K-Setting Potentiometer and Square Function

a. Turn the K-setting potentiometer on front panel to the extreme counter-clockwise position.

b. Pull out the knob from K-setting potentiometer's shaft.

c. Free the shaft by loosening the set screw.

d. Set the digital number at 037.2(K=2).

e. Apply an input current of 8.66 amperes. Use a digital dc voltmeter to measure the voltage between terminal A10 and B3 (com.). It should be 1.000 volt (slight adjustment of input current may be necessary).

f. Use the same digital voltmeter to measure the voltage between TP1 (on Bd. B) and terminal B3. Calibrate to -3.162 volts at TP1 by adjusting the K-setting potentiometer while maintaining the digital number at 037.2.

g. Lock the set screw and shaft of the K-setting potentiometer.

h. Recheck the steps (e) and (f). Push back the knob on the shaft of the potentiometer.

i. Apply ac input current of 0.866 ampere. The dc voltage at TP2 (on Bd. B) should be 0.010$\pm$0.001 volt.

4. High Current Compensation

CAUTION: When using current greater than 12 amperes, DO NOT leave transformers energized for more than 5 seconds.

a. Set K-setting at K=2 (dial at 037.2) and connect a dc digital voltmeter between TP6 (Bd. B) and terminal B11 (com.).

b. Turn the dc and ac switches on and adjust the ac current to 9 amperes. The voltmeter's reading should be greater than 14 volts.

c. Adjust ac input current to 11 amperes. The voltmeter's reading should be a negative voltage. The DIP relay RY3 should be picked up.

d. Move the dc voltmeter's probe from TP6 to TP3 and adjust the ac input current to 27.4 amperes.

e. Adjust trimpot R7 to read 10 volts at TP3.

5. Ramp Timer

NOTE: Before making any new time delay reading, reset the timer light by pushing the reset button on the front panel. Use a digital timer to measure the time delay. If it is not available, a scope and a stopwatch can be used.

a. Make sure that the rotary switch (on Bd. A) is set on position #12. The dial of K-setting is set at 037.2 and the trip pickup (on panel) is set slightly below 0.1 unit.

b. Turn on the dc power supply switch. None of the LED lights should be on.

c. Suddenly apply an ac input current of 8.66 amperes. The digital timer should start and stop after a time delay of 2 seconds. The time delay can be increased or decreased by adjusting the trimpot R10 (Bd. B) clockwise or counterclockwise respectively.

d. Adjust the ac input current to 1.732 amperes. Turn off the ac input switch and reset the relay.

e. Turn on the ac input switch. The digital timer should start and stop after a time delay of 50 $\pm$ 1 seconds. The time delay can be increased or decreased by adjusting the trimpot R24 counterclockwise or clockwise respectively.

f. Adjust ac input current to 17.32 amperes. Turn off the ac switch and reset the relay.

g. Turn on the ac input switch. The digital timer should start and stop after a time delay of 500 $\pm$ 25 milliseconds. Adjustment of this time delay can be made by slightly adjusting the trimpot R7, if time is close to limits.

h. Check the time delay per the following table.

Input Current (a)	25.98	17.32	12.28	8.66	4.33	1.732	0.866
Time Delay (sec)	0.222	0.500	1.000	2.000	8.000	50.00	200.00
Error ($\pm$ sec.)	0.011	0.025	0.050	0.010	0.400	1.28	20.00
Adjustment		R7		R10		R24	

i. Adjust the ac input current to 17.32 amperes and turn off the input switch. Set K-setting dial to 860.7 and reset the relay.

j. Turn on ac input switch. The digital timer should start and stop after a time delay of 10$\pm$ 0.2 seconds. Adjustment can be made by changing the dial number of K-setting potentiometer but the dial number should be within the range of 845.7 and 875.7.

D. Power Supply Board (Slot D)

1. Alarm level and range

a. Connect the test circuit as shown in Fig. 15 and connect the scope probe to alarm contacts (relay terminals 14 and 15).

b. Set the rotary switch (Bd. A) on position #12 and ajust the trimpot R14 on Bd. D to the extreme clockwise position.

c. Apply ac input current of 1.732 amperes (0.2 unit). The alarm relay should not operate, e.g. the scope trace should be at low level (zero volt).

d. Slowly adjust the trimpot R14 counterclockwise until the alarm relay operates, e.g. the scope trace should jump from low to high and the alarm LED should be on.

e. Adjust the ac input current to the desired current which is the product of $\sqrt{3}$x5 xI_2, e.g. the input current of 0.432 ampere represents that I_2 is equal to 0.05 unit.

f. Repeat step (d) to obtain the final setting.

2. Alarm Timer 2 sec/0

a. Connect the same test circuit as step (1) and set the scope trigger on positive pulse.

b. Suddenly apply an input current of 5 amperes, the timer (scope) should read a time delay between 1.5 and 2.5 seconds. (NOTE: If time is outside and close to limits, resistor R15 may be changed).

3. Voltage to Current Inverter (Optional)

a. Connect the input current circuit as shown in Fig. 15 and an one milliampere (optional) dc meter to relay terminals 12(+) amd 13(-).

b. With an input current of 1.732 amperes, adjust the trimpot R18 (Bd. D) to obtain full scale reading (1ma).

c. Adjust the ac input current to 0.433 ampere, and adjust the trimpot R41 (Bd. B) to obtain one quarter of full scale reading (0.25 ma).

d. Repeat steps (b) and (c) to satisfy both readings with an error less than 0.02 ma.

E. Indicating Contactor Switch (ICS)

Close the main relay contacts and pass sufficient dc 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 wipe should be approximately between 1/64" and 3/64". The bridging moving contact should touch both stationary contacts simultaneously.

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.

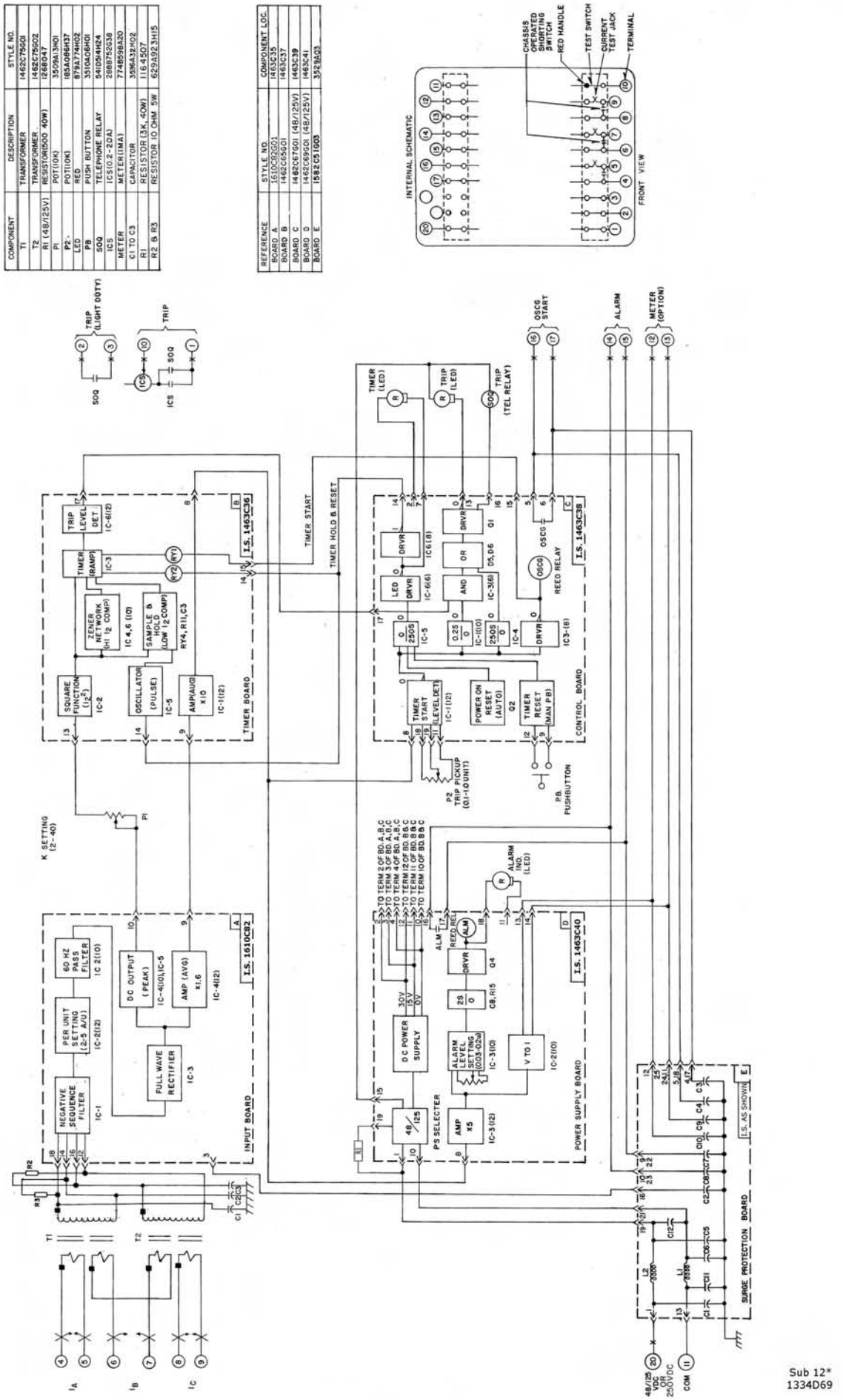
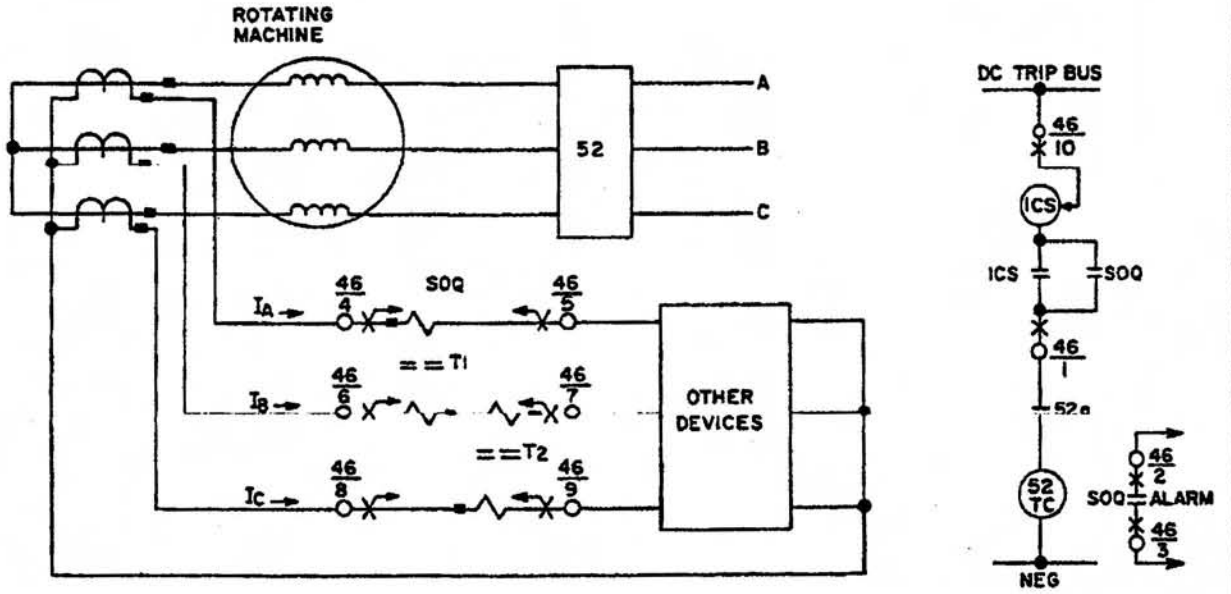


Figure 2. SOQ Logic Diagram



DEVICE NUMBER CHART

46-NEGATIVE SEQUENCE GENERATOR RELAY TYPE SOQ

ICS-INDICATING CONTACTOR SWITCH IN SOQ RELAY

52-POWER CIRCUIT BREAKER

a-BREAKER AUXILIARY CONTACT

TC-BREAKER TRIP COIL

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1480B69

Fig. 3. System Application Diagram of the SOQ Relay

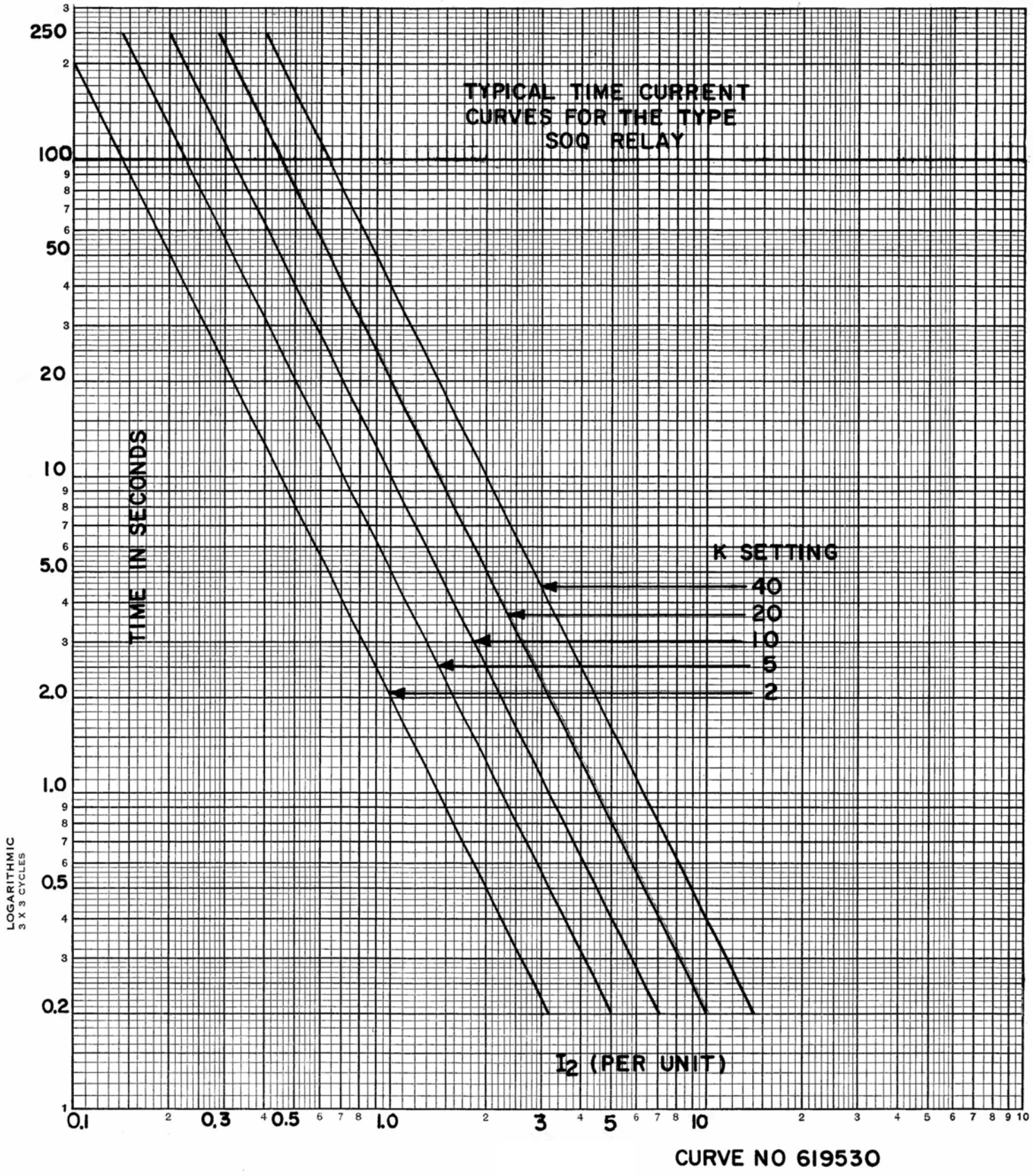


Figure 4. Typical Time Current Curves for SOQ Relay

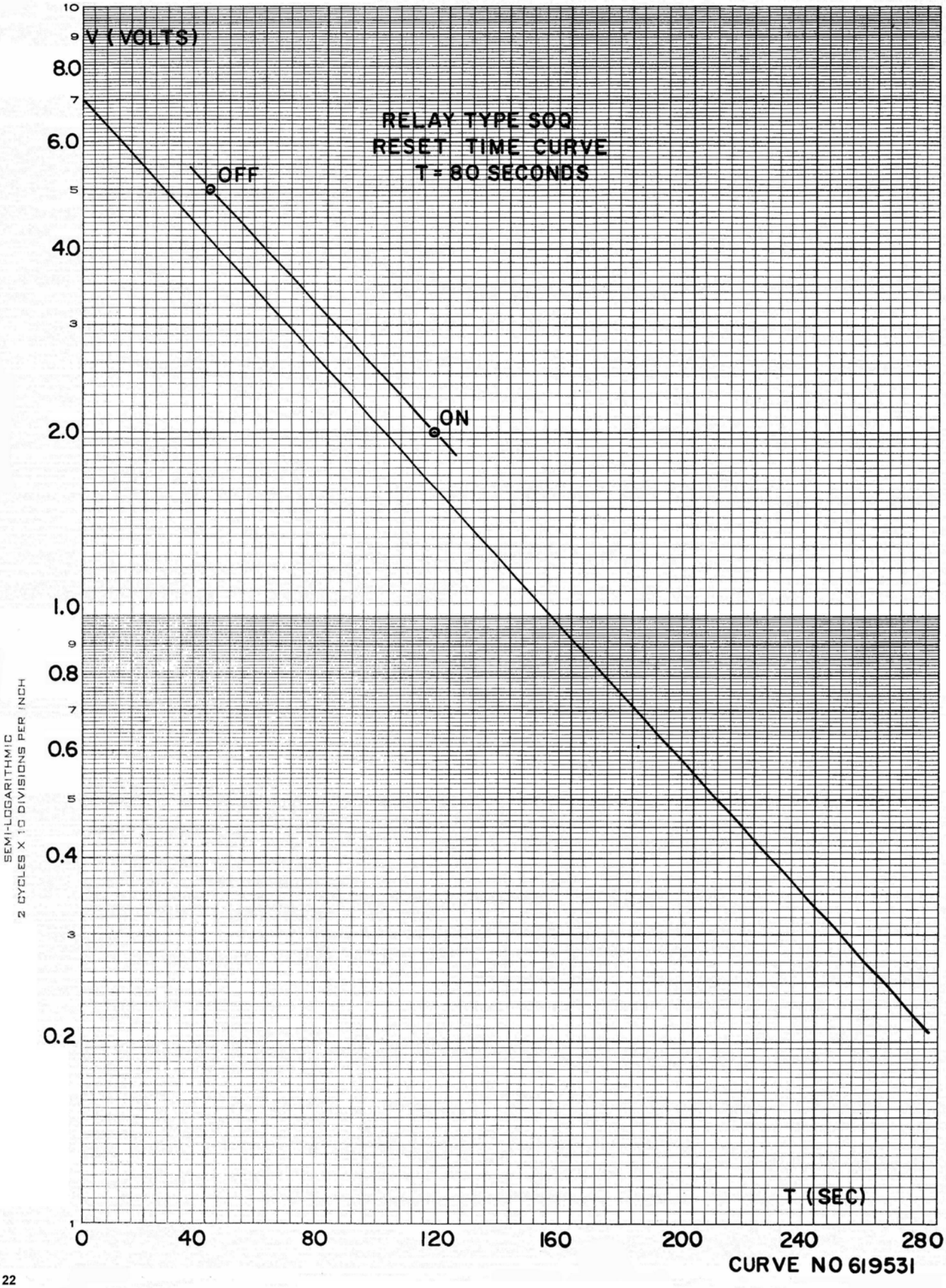


Figure 5. Reset Time Curve, SOQ Relay (T = 80 Seconds)

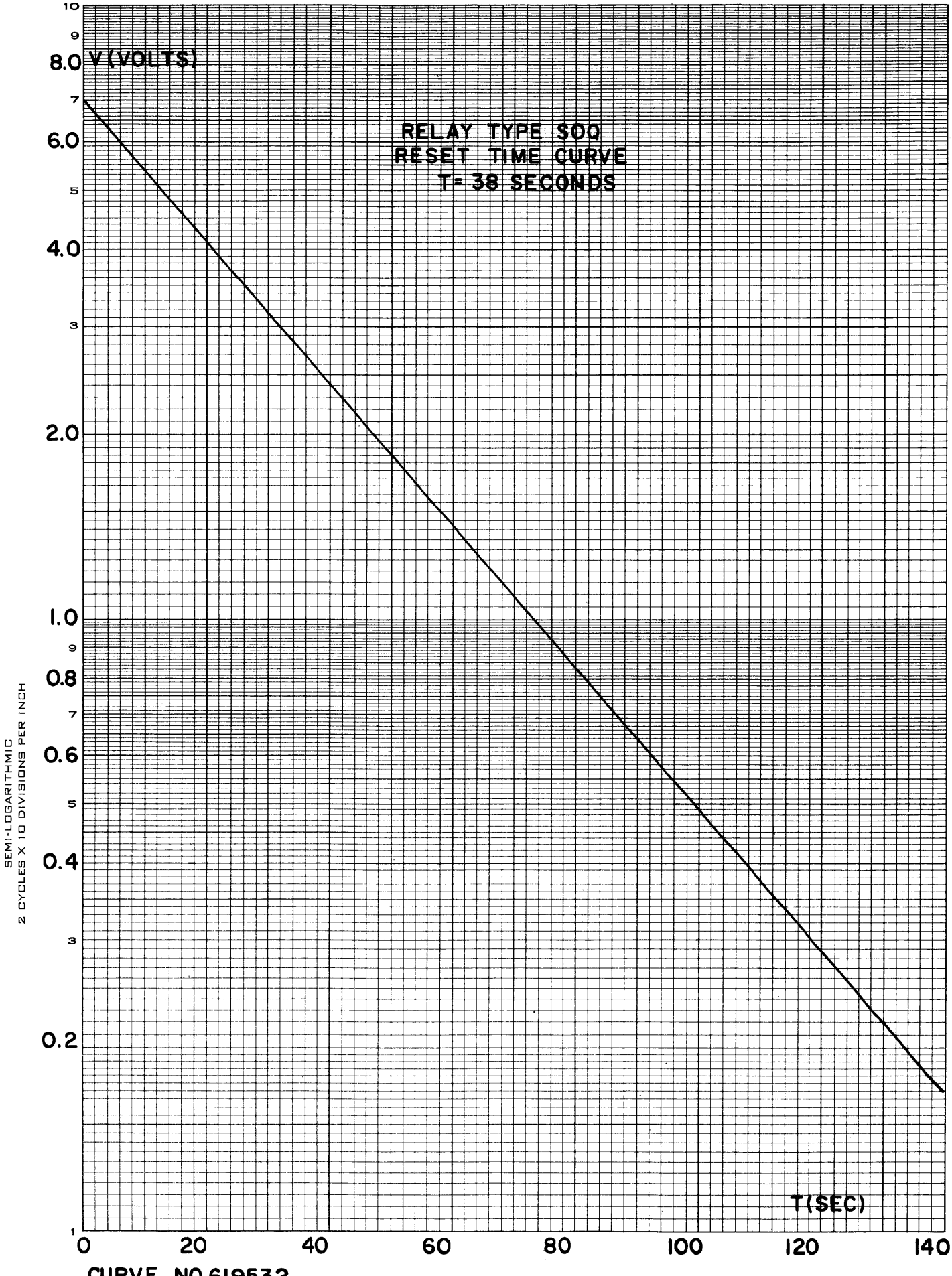


Figure 6. Reset Time Curve, SOQ Relay (T = 38 Seconds)

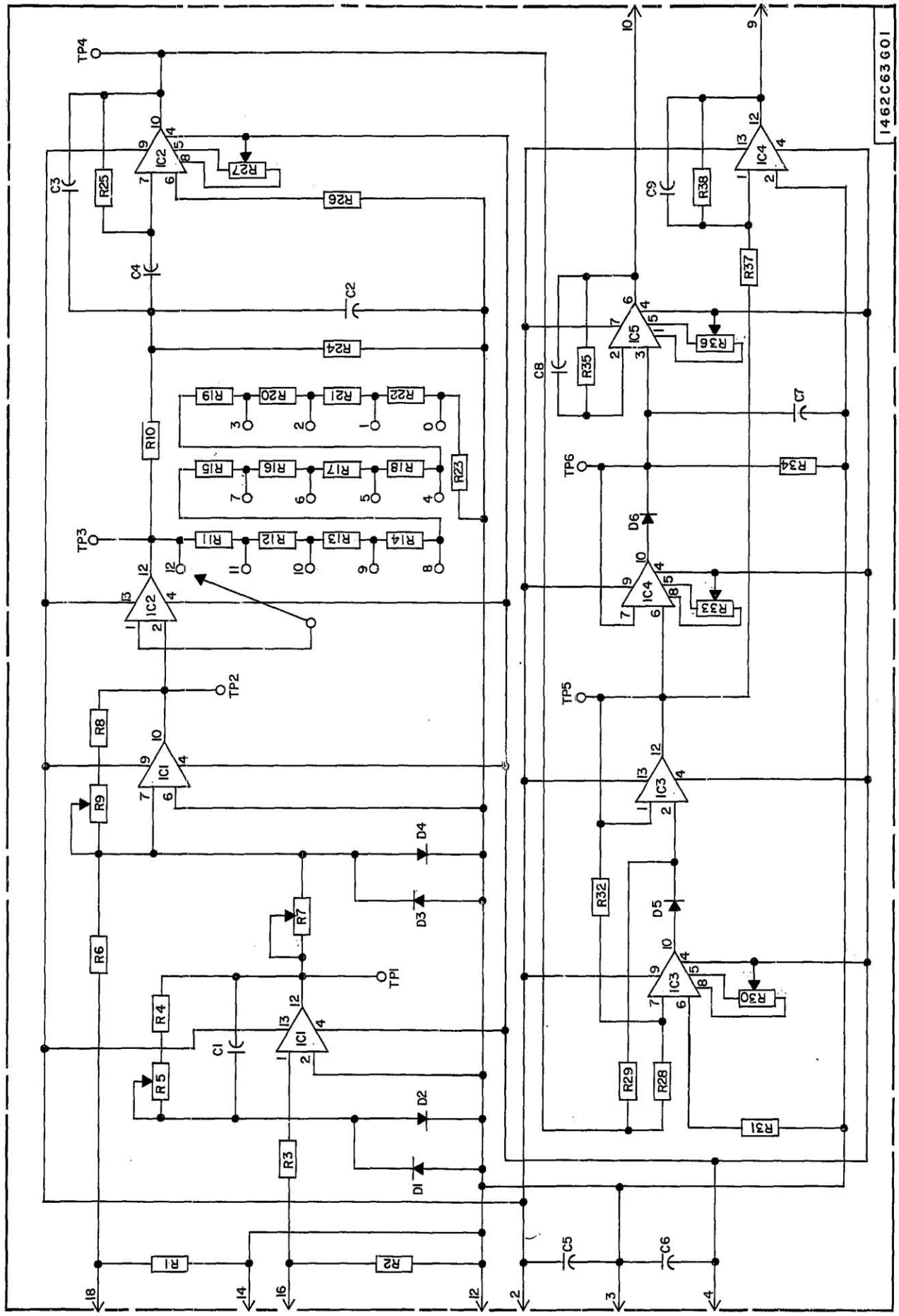


Figure 7. Internal Schematic - SOQ Input Module with Thumbwheel Switch (SW)

Component List - SOQ Input Module

COMPONENT		DESCRIPTION	STYLE NO.
C1	CAPACITOR	.470UF 100V	3508A89H03
C2	CAPACITOR	.0047UF 100V	763A487H13
C3	CAPACITOR	.220UF 100V	3508A89H02
C4	CAPACITOR	.220UF 100V	3508A89H02
C5	CAPACITOR	.100UF 50V	3509A34H03
C6	CAPACITOR	.100UF 50V	3509A34H03
C7	CAPACITOR	2.000UF 50V	863A518H05
C8	CAPACITOR	.100UF 100V	3510A63H02
C9	CAPACITOR	1.000UF 50V	3512A08H01
D1	DIODE	1N914	836A928H01
D2	DIODE	1N914	836A928H01
D3	DIODE	1N914	836A928H01
D4	DIODE	1N914	836A928H01
D5	DIODE	1N914	836A928H01
D6	DIODE	1N914	836A928H01
IC1	INT CKT	747DM	1443C52H01
IC2	INT CKT	747DM	1443C52H01
IC3	INT CKT	747DM	1443C52H01
IC4	INT CKT	747DM	1443C52H01
IC5	INT CKT	CA3140	1478B14H01
R5	POT	5.0K .75W	880A826H09
R7	POT	20.0K .75W	880A826H01
R9	POT	5.0K .75W	880A826H09
R27	POT	20.0K .75W	880A826H01
R30	POT	20.0K .75W	880A826H01
R33	POT	20.0K .75W	880A826H01
R36	POT	100.0K .75W	880A826H07

COMPONENT		DESCRIPTION	STYLE NO.
R1	RESISTOR	10.0 5.00W 3%	629A923H15
R2	RESISTOR	10.0 5.00W 3%	629A923H15
R3	RESISTOR	12.1K .50W 1%	848A820H53
R4	RESISTOR	8060.0 .50W 1%	848A820H36
R6	RESISTOR	15.0K .50W 1%	848A820H62
R8	RESISTOR	2.0K .50W 1%	848A819H77
R10	RESISTOR	17.8K .50W 1%	848A820H69
R11	RESISTOR	1000.0 .50W 1%	848A819H48
R12	RESISTOR	1000.0 .50W 1%	848A819H48
R13	RESISTOR	1000.0 .50W 1%	848A819H48
R14	RESISTOR	1000.0 .50W 1%	848A819H48
R15	RESISTOR	1000.0 .50W 1%	848A819H48
R16	RESISTOR	1000.0 .50W 1%	848A819H48
R17	RESISTOR	1000.0 .50W 1%	848A819H48
R18	RESISTOR	1000.0 .50W 1%	848A819H48
R19	RESISTOR	1000.0 .50W 1%	848A819H48
R20	RESISTOR	1000.0 .50W 1%	848A819H48
R21	RESISTOR	1000.0 .50W 1%	848A819H48
R22	RESISTOR	1000.0 .50W 1%	848A819H48
R23	RESISTOR	8060.0 .50W 1%	848A820H36
R24	RESISTOR	5110.0 .50W 1%	848A820H17
R25	RESISTOR	34.8K .50W 1%	848A820H97
R26	RESISTOR	34.8K .50W 1%	848A820H97
R28	RESISTOR	20.0K .50W 1%	848A820H74
R29	RESISTOR	10.0K .50W 1%	848A820H45
R31	RESISTOR	10.0K .50W 1%	848A820H45
R32	RESISTOR	20.0K .50W 1%	848A820H74
R34	RESISTOR	1.0M .50W 1%	848A822H39
R35	RESISTOR	2.0K .50W 1%	848A819H77
R37	RESISTOR	10.0K .50W 1%	848A820H45
R38	RESISTOR	16.5K .50W 1%	848A820H66

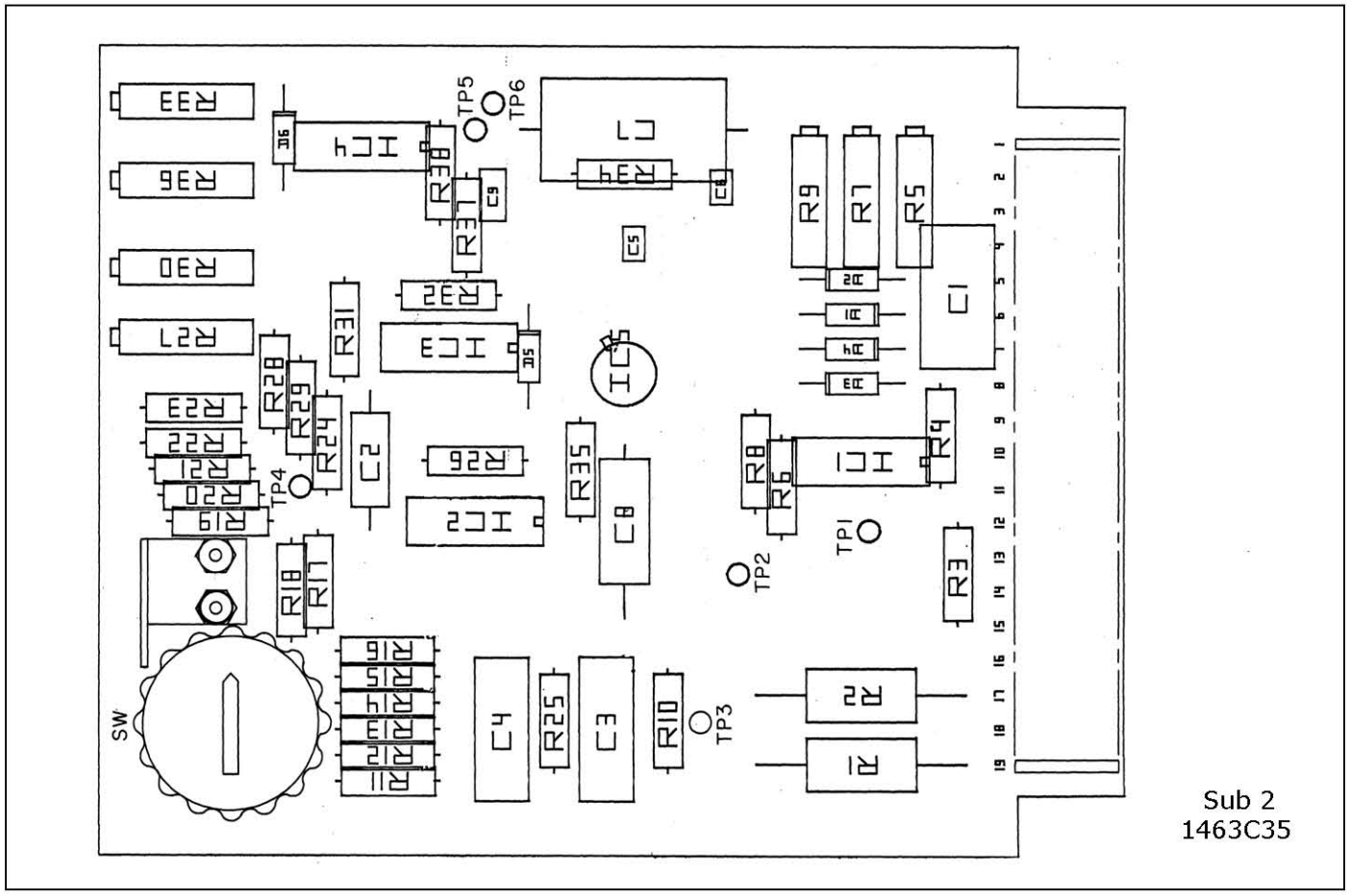
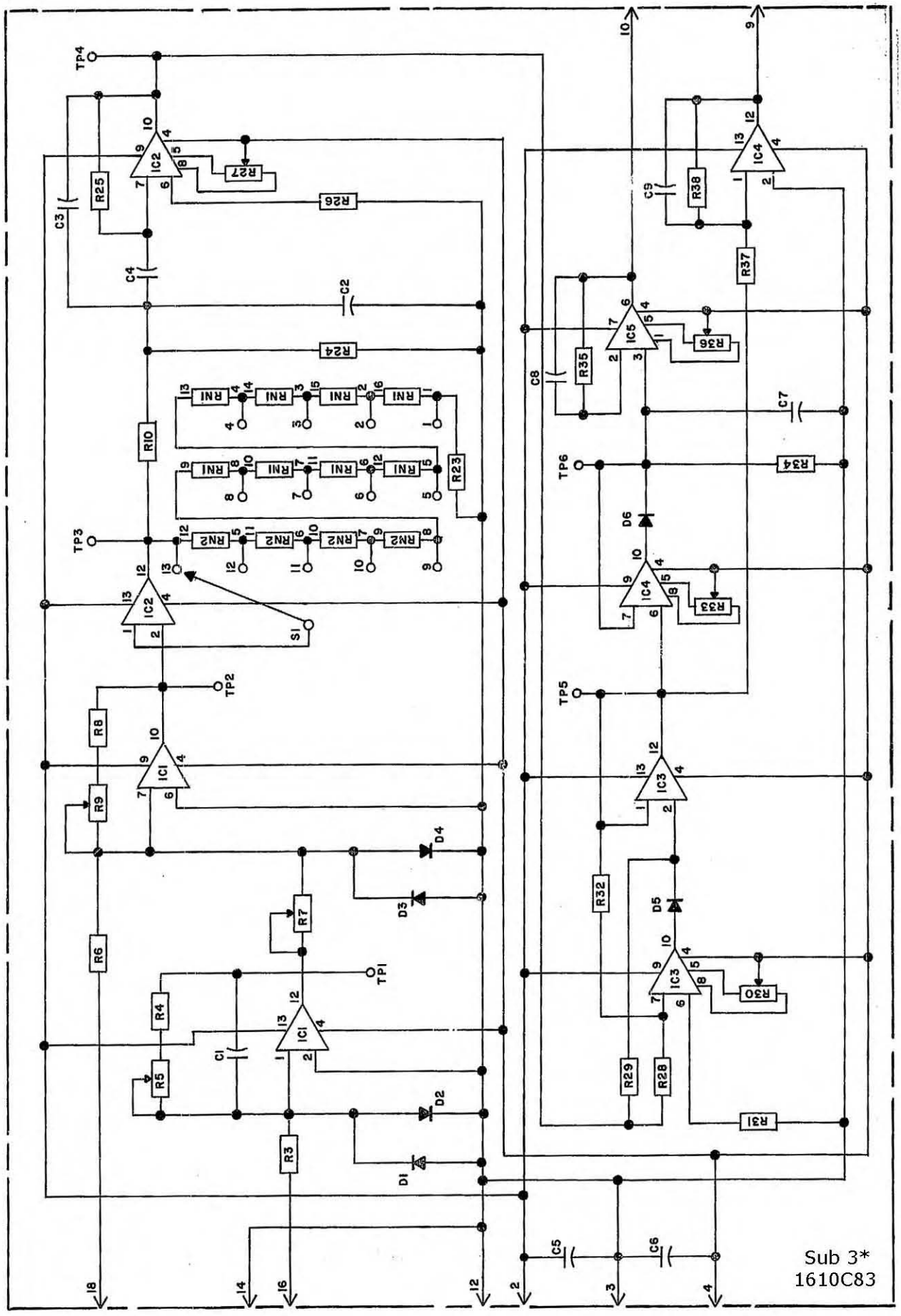


Figure 8. Component Location - SOQ Input Module with Thumbwheel Switch (SW)



COMPNENT LOCATION: 1501B78

Figure 9. SOQ Input Module with Slide Switch (S1)

Component List - SOQ Input Module

COMP	DESCRIPTION	STYLE
CAPACITORS		
C1	0.470 µf, 100V, ± 1%	3526A65H06
C2	0.0047 µf, 100V	763A487H13
C3	0.220 µf, 100V	3508A89H02
C4	0.220 µf, 100V	3508A89H02
C5	0.100 µf, 50V	3532A39H13
C6	0.100 µf, 50V	3532A39H13
C7	2.0 µf, 50V	863A518H05
C8	0.100 µf, 100V	3510A63H02
C9	1.0 µf, 50V	3512A08H01
DIODES		
D1	75V, .01A (IN4148)	836A928H06
D2	75V, .01A (IN4148)	836A928H06
D3	75V, .01A (IN4148)	836A928H06
D4	75V, .01A (IN4148)	836A928H06
D5	75V, .01A (IN4148)	836A928H06
D6	75V, .01A (IN4148)	836A928H06
INT CIRCUIT		
IC1	747DM	1443C52H01
IC2	747DM	1443C52H01
IC3	747DM	1443C52H01
IC4	747DM	1443C52H01
IC5	CA3140	1478B14H01

COMP	DESCRIPTION	STYLE
RESISTOR		
R3	12.1 K, .5 W, 1%	848A820H53
R4	8.06 K, .5 W, 1%	848A820H56
R5	5.0 K, .75W, 10% POTENTIOMETER	880A826H09
R6	15.0 K, .5 W, 1%	848A820H62
R7	20.0 K, .75W, 10% POTENTIOMETER	880A826H01
R8	2.0 K, .5 W, 1%	848A819H77
R9	5.0 K, .75W, 10% POTENTIOMETER	880A826H09
R10	17.8 K, .5 W, 1%	848A820H69
R24	5.11 .5 W, 1%	848A820H17
R25	34.8 K, .5 W, 1%	848A820H97
R26	34.8 K, .5 W, 1%	848A820H97
R27	20.0 K, .75W, 10% POTENTIOMETER	880A826H01
R28	20.0 K, .5 W, 1%	848A820H74
R29	10.0 K, .5 W, 1%	848A820H45
R30	20.0 K, .75W, 10% POTENTIOMETER	880A826H01
R31	10.0 K, .5 W, 1%	848A820H45
R32	20.0 K, .5 W, 1%	848A820H74
R33	20.0 K, .75W, 10% POTENTIOMETER	880A826H01
R34	1.0 M, .5 W, 1%	848A822H39
R35	2.0 K, .5 W, 1%	848A819H77
R36	100.0 K, .75W, 10% POTENTIOMETER	880A826H07
R37	10.0 K, .5 W, 1%	848A820H45
RES NET. (DIPS)		
RN1	8X1K, 2%	3524A68H08
RN2	8X1K, 2%	3524A68H08

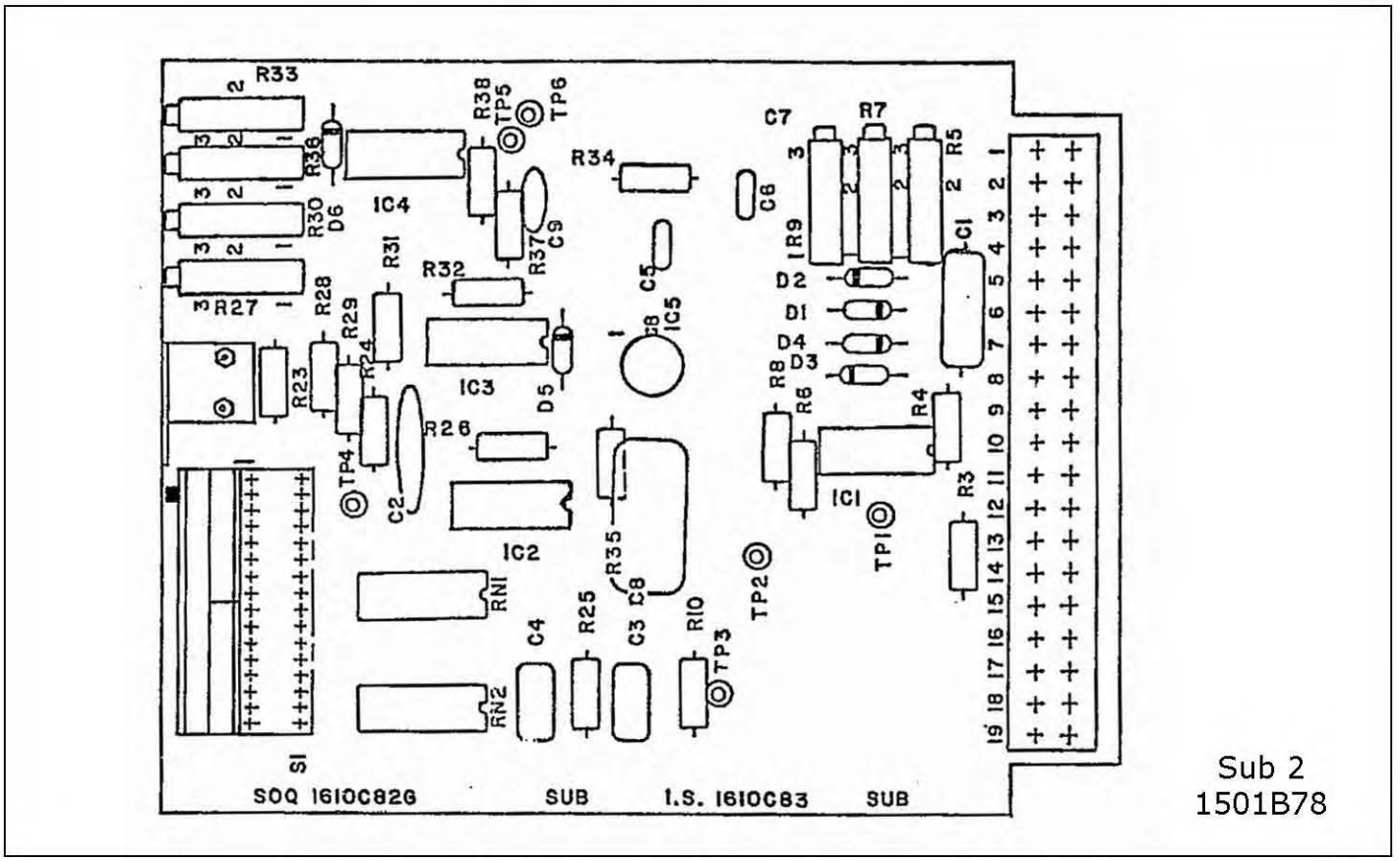


Figure 10. Component Location - SOQ Input Module with Slide Switch (S1)

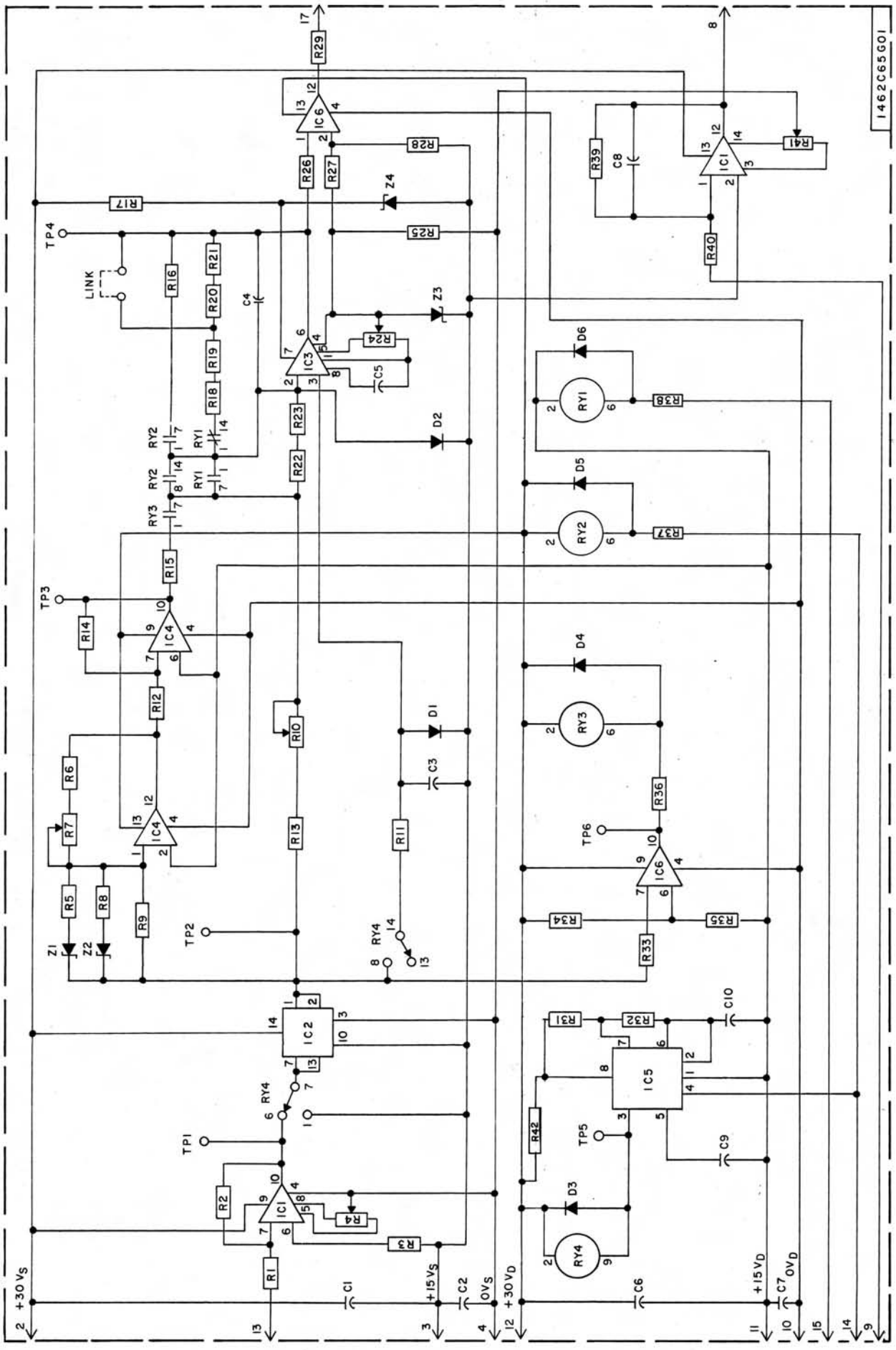


Figure 11. Internal Schematic - SOQ Timer Module

Sub 6
1463C36

Component List - SOQ Timer Module

COMPONENT		DESCRIPTION	STYLE NO.
C1	CAPACITOR	.100UF 50V	3509A34H03
C2	CAPACITOR	.100UF 50V	3509A34H03
C3	CAPACITOR	.100UF 100V	763A219H25
C4	CAPACITOR	2.000UF 50V	863A518H05
C5	CAPACITOR	100.000PF 500V	762A757H01
C6	CAPACITOR	.100UF 50V	3509A34H03
C7	CAPACITOR	.100UF 50V	3509A34H03
C8	CAPACITOR	1.000UF 50V	3512A08H01
C9	CAPACITOR	.100UF 50V	3509A34H03
C10	CAPACITOR	2.000UF 50V	863A518H05
D1	DIODE	FD333	837A942H03
D2	DIODE	FD333	837A942H03
D3	DIODE	1N645A	837A692H03
D4	DIODE	1N645A	837A692H03
D5	DIODE	1N645A	837A692H03
D6	DIODE	1N645A	837A692H03
IC1	INT CKT	747DM	1443C52H01
IC2	INT CKT	BB4204J	1478B12H01
IC3	INT CKT	CA3130AT	1478B14H02
IC4	INT CKT	747DM	1443C52H01
IC5	INT CKT	SE555CV	774B956H01
IC6	INT CKT	747DM	1443C52H01
R4	POT	20.0K .75W	880A826H01
R7	POT	10.0K .75W	880A826H05
R10	POT	50.0K .75W	880A826H06
R24	POT	100.0K .75W	880A826H07
R41	POT	20.0K .75W	880A826H01
R1	RESISTOR	2.0K .50W 1%	848A819H77
R2	RESISTOR	7.5K .50W 1%	848A820H33
R3	RESISTOR	3010.0 .50W 1%	848A819H94
R5	RESISTOR	11.3K .50W 1%	848A820H50
R6	RESISTOR	2.0K .50W 1%	848A819H77
R8	RESISTOR	11.3K .50W 1%	848A820H50
R9	RESISTOR	51.1K .50W 1%	848A821H14

COMPONENT		DESCRIPTION	STYLE NO.
R11	RESISTOR	2.0K .50W 1%	848A819H77
R12	RESISTOR	20.0K .50W 1%	848A820H74
R13	RESISTOR	121.0K .50W 1%	848A821H50
R14	RESISTOR	20.0K .50W 1%	848A820H74
R15	RESISTOR	2.2M .50W 1%	187A290H26
R16	RESISTOR	100.0 .50W 1%	848A818H51
R17	RESISTOR	681.0 .50W 1%	848A819H32
R18	RESISTOR	15.0M .50W 5%	187A290H40
R19	RESISTOR	2.2M .50W 5%	187A290H26
R20	RESISTOR	10.0M .50W 5%	187A290H27
R21	RESISTOR	10.0M .50W 5%	187A290H27
R22	RESISTOR	20.0M .50W 5%	187A290H41
R23	RESISTOR	20.0M .50W 5%	187A290H41
R25	RESISTOR	681.0 .50W 1%	848A819H32
R26	RESISTOR	5110.0 .50W 1%	848A820H17
R27	RESISTOR	1000.0 .50W 1%	848A819H48
R28	RESISTOR	12.1K .50W 1%	848A820H53
R29	RESISTOR	6.8K .50W 2%	629A531H52
R31	RESISTOR	681.0K .50W 1%	848A822H23
R32	RESISTOR	2.0K .50W 1%	848A819H77
R33	RESISTOR	10.0K .50W 1%	848A820H45
R34	RESISTOR	30.1K .50W 1%	848A820H91
R35	RESISTOR	2940.0 .50W 1%	848A819H93
R36	RESISTOR	681.0 .50W 1%	848A819H32
R37	RESISTOR	150.0 .50W 2%	629A531H12
R38	RESISTOR	150.0 .50W 2%	629A531H12
R39	RESISTOR	49.9K .50W 1%	848A821H13
R40	RESISTOR	4990.0 .50W 1%	848A820H16
R42	RESISTOR	200.0 .50W 2%	629A531H15
Z1	ZENER	1N957B 6.8V	186A797H06
Z2	ZENER	1N748A 3.9V	186A797H13
Z3	ZENER	1N5235B 6.8V	862A288H07
Z4	ZENER	1N5235B 6.8V	862A288H07
RY1	REED RELAY	DIP RELAY 12V	1478B13H01
RY2	REED RELAY	DIP RELAY 12V	1478B13H03
RY3	REED RELAY	DIP RELAY 12V	1478B13H01
RY4	REED RELAY	DIP RELAY 12V	1478B13H02

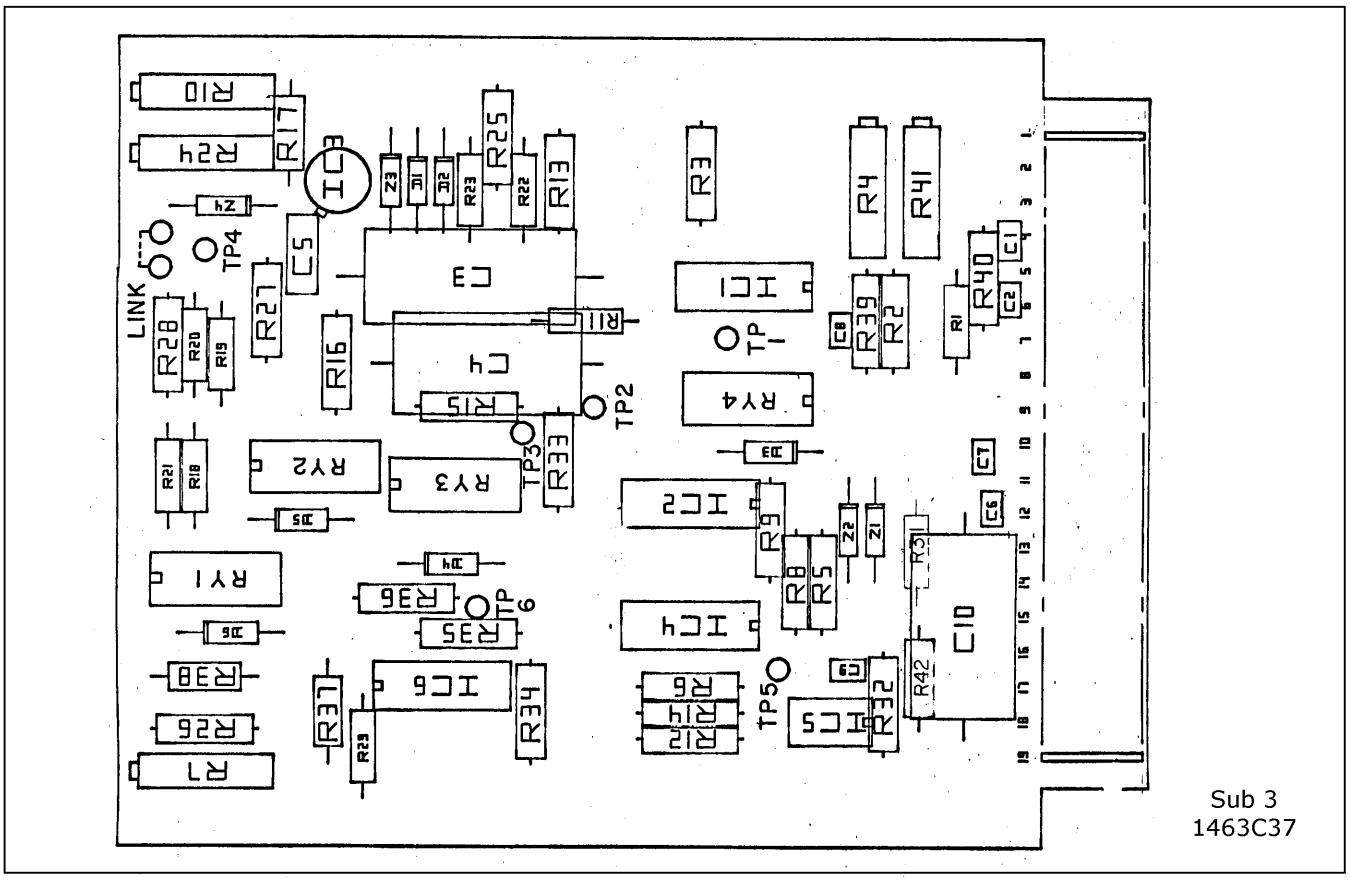


Figure 12. Component Location - SOQ Timer Module

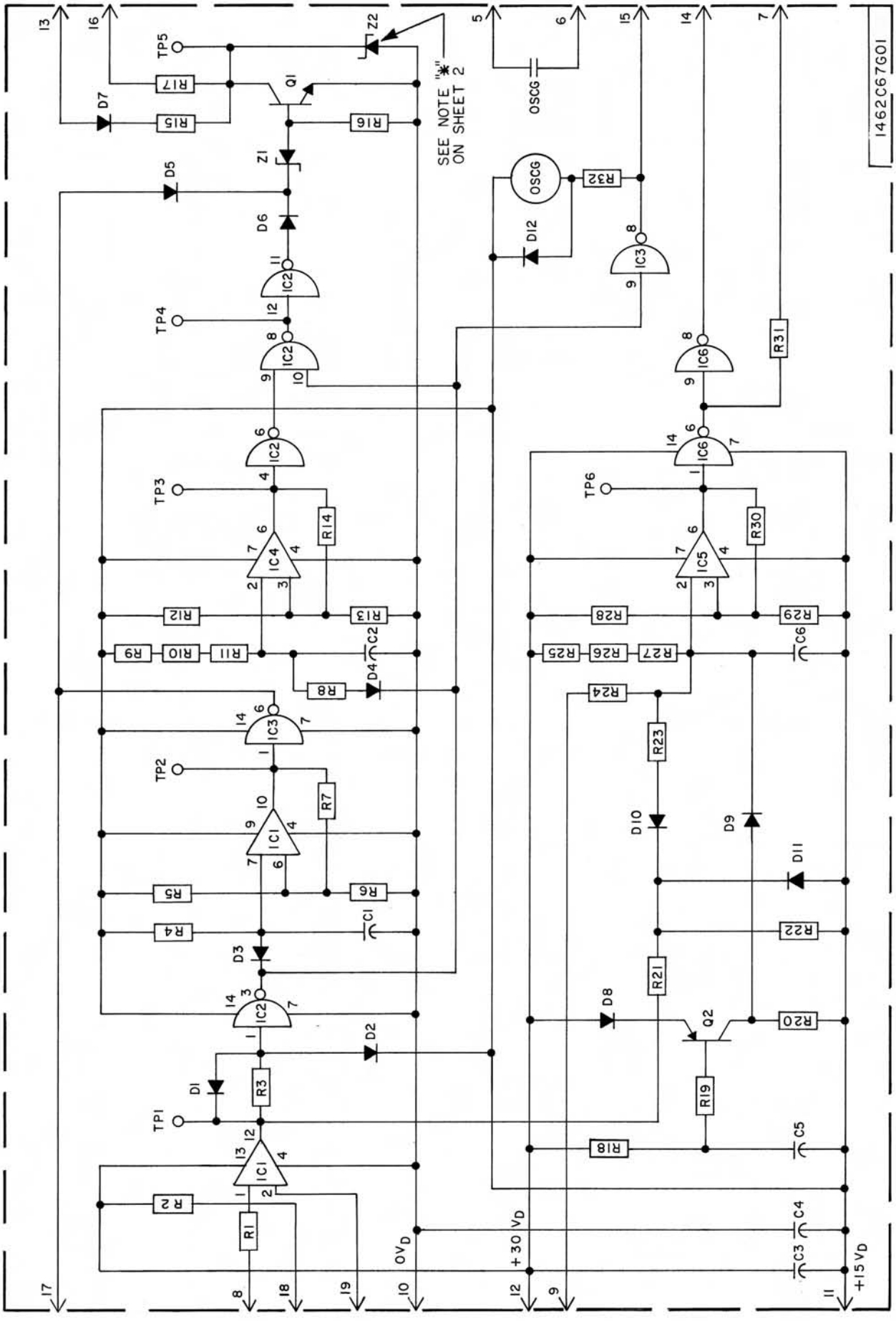


Figure 13. Internal Schematic - SOQ Control Module

Component List - SOQ Control Module

COMPONENT		DESCRIPTION	STYLE NO.
C1	CAPACITOR	10.000UF 20V	184A661H24
C2	CAPACITOR	5.000UF 100V	763A219H12
C3	CAPACITOR	.100UF 50V	3509A34H03
C4	CAPACITOR	.100UF 50V	3509A34H03
C5	CAPACITOR	4.700UF 35V	184A661H12
C6	CAPACITOR	5.000UF 100V	763A219H12
D1	DIODE	1N645A	837A692H03
D2	DIODE	1N645A	837A692H03
D3	DIODE	1N645A	837A692H03
D4	DIODE	FD333	837A942H03
D5	DIODE	1N645A	837A692H03
D6	DIODE	1N645A	837A692H03
D7	DIODE	1N645A	837A692H03
D8	DIODE	1N645A	837A692H03
D9	DIODE	FD333	837A942H03
D10	DIODE	FD333	837A942H03
D11	DIODE	1N645A	837A692H03
D12	DIODE	1N645A	837A692H03
IC1	INT CKT	MC1747L	1443C52H04
IC2	INT CKT	MC668L	6296D58H05
IC3	INT CKT	MC679L	6296D58H02
IC4	INT CKT	CA3140	1478B14H01
IC5	INT CKT	CA3140	1478B14H01
IC6	INT CKT	MC679L	6296D58H02
Q1	TRANSISTOR	2N4063	878A432H01
Q2	TRANSISTOR	2N2907A	762A672H17
Z1	ZENER	1N957B 6.8V	186A797H06
Z2	ZENER	1N3050B 180.0V	187A936H17
* Z2	ZENER	1.5KE300	878A619H07
OSCG	REED RELAY	600Ω 12V	1436C85H04

*=GROUP 2 ONLY

COMPONENT		DESCRIPTION	STYLE NO.
R1	RESISTOR	10.0K .50W 1%	848A820H45
R2	RESISTOR	3.3K .50W 2%	629A531H44
R3	RESISTOR	10.0K .50W 1%	848A820H45
R4	RESISTOR	18.0K .50W 2%	629A531H62
R5	RESISTOR	10.0K .50W 1%	848A820H45
R6	RESISTOR	20.0K .50W 1%	848A820H74
R7	RESISTOR	100.0K .50W 1%	848A821H42
R8	RESISTOR	100.0 .50W 1%	848A818H51
R9	RESISTOR	22.0M .50W 5%	187A290H36
R10	RESISTOR	22.0M .50W 5%	187A290H36
R11	RESISTOR	22.0M .50W 5%	187A290H36
R12	RESISTOR	20.0K .50W 1%	848A820H74
R13	RESISTOR	20.0K .50W 1%	848A820H74
R14	RESISTOR	200.0K .50W 1%	848A821H71
R15	RESISTOR	4300.0 .50W 2%	629A531H47
R16	RESISTOR	10.0K .50W 1%	848A820H45
R17	RESISTOR	1.5K .50W 1%	848A819H65
R18	RESISTOR	10.0K .50W 1%	848A820H45
R19	RESISTOR	20.0K .50W 1%	848A820H74
R20	RESISTOR	100.0K .50W 1%	848A821H42
R21	RESISTOR	10.0K .50W 1%	848A820H45
R22	RESISTOR	20.0K .50W 1%	848A820H74
R23	RESISTOR	100.0 .50W 1%	848A818H51
R24	RESISTOR	470.0 .50W 2%	629A531H24
R25	RESISTOR	20.0M .50W 5%	187A290H41
R26	RESISTOR	20.0M .50W 5%	187A290H41
R27	RESISTOR	20.0M .50W 5%	187A290H41
R28	RESISTOR	20.0K .50W 1%	848A820H74
R29	RESISTOR	20.0K .50W 1%	848A820H74
R30	RESISTOR	200.0K .50W 1%	848A821H71
R31	RESISTOR	1.5K .50W 1%	848A819H65
R32	RESISTOR	150.0 .50W 2%	629A531H12

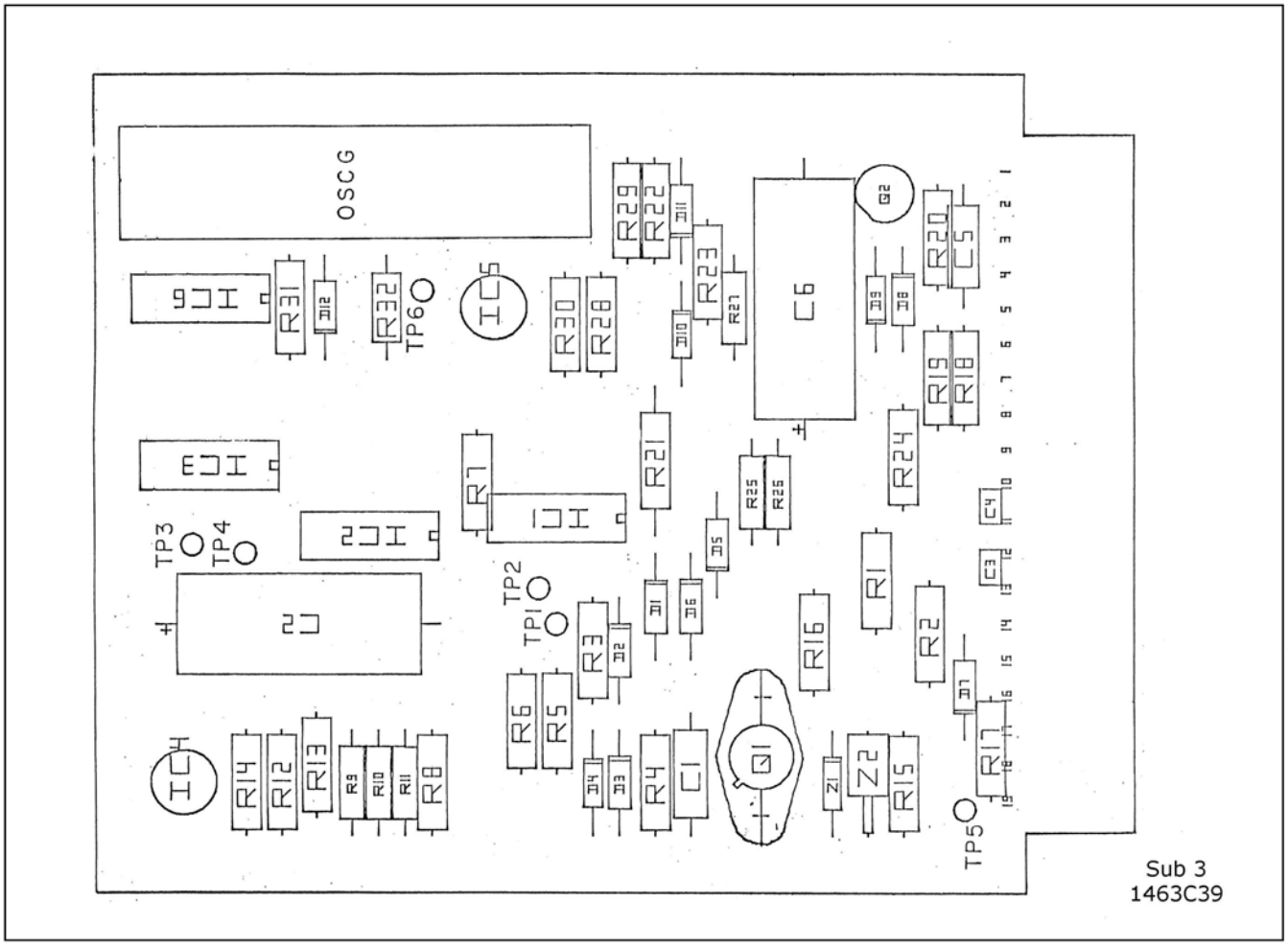


Figure 14. Component Location - SOQ Control Module

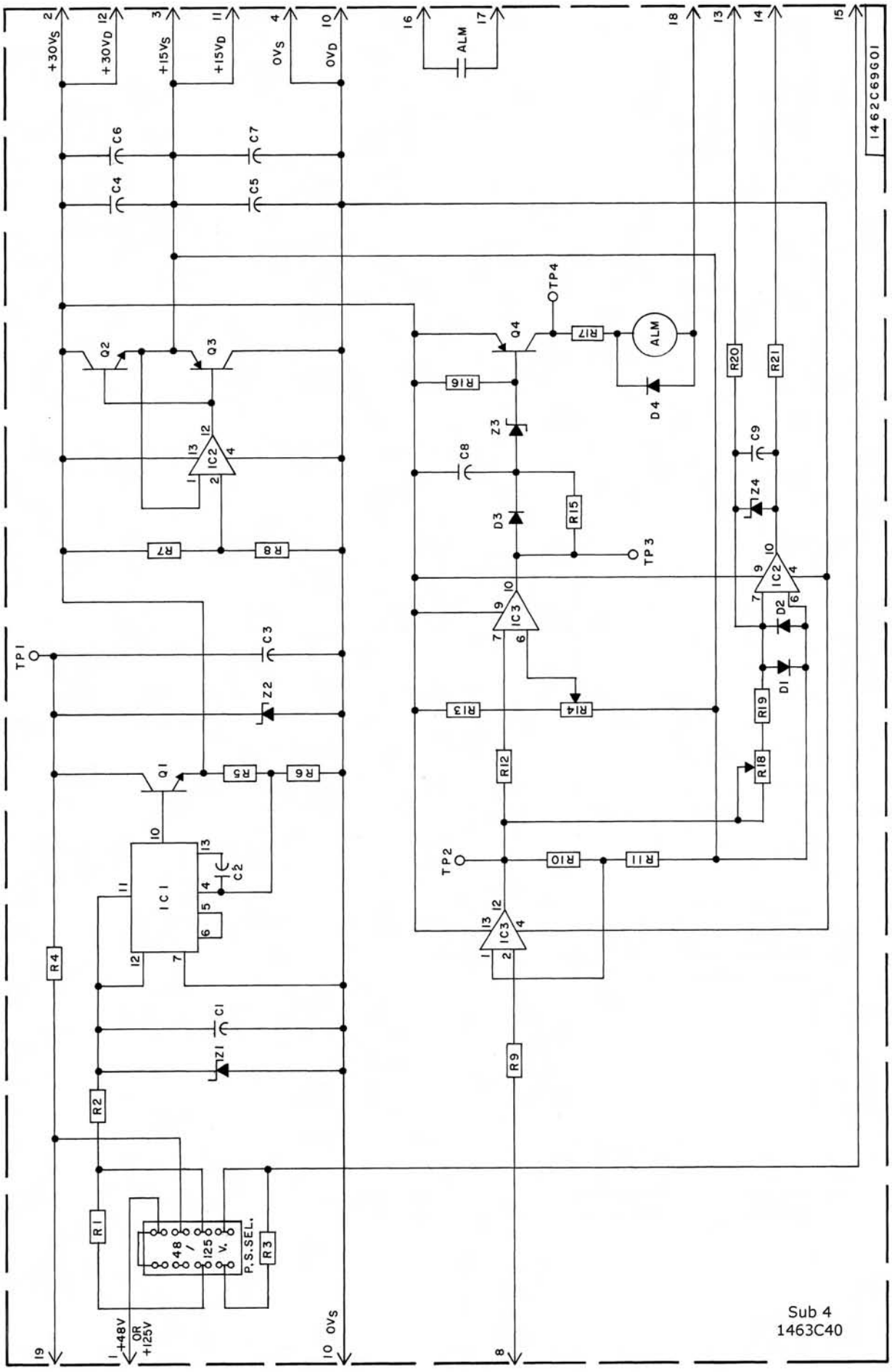


Figure 15. Internal Schematic - SOQ Power Supply Module

Component List - SOQ Power Supply Module

COMPONENT		DESCRIPTION		STYLE NO.
C1	CAPACITOR	.470UF	50V	762A680H04
C2	CAPACITOR	100.000PF	500V	762A757H01
C3	CAPACITOR	.220UF	100V	3512A08H02
C4	CAPACITOR	22.000UF	35V	184A661H16
C5	CAPACITOR	22.000UF	35V	184A661H16
C6	CAPACITOR	.100UF	50V	3509A34H03
C7	CAPACITOR	.100UF	50V	3509A34H03
C8	CAPACITOR	47.000UF	35V	187A508H12
C9	CAPACITOR	.022UF	100V	3508A16H02
D1	DIODE	1N645A		837A692H03
D2	DIODE	1N645A		837A692H03
D3	DIODE	1N645A		837A692H03
D4	DIODE	1N645A		837A692H03
IC1	INT CKT	UA723		6277D61H09
IC2	INT CKT	747DM		1443C52H01
IC3	INT CKT	747DM		1443C52H01
Q1	TRANSISTOR	2N3055		187A673H08
Q2	TRANSISTOR	2N4063		878A432H01
Q3	TRANSISTOR	2N4903		187A673H13
Q4	TRANSISTOR	2N2907A		762A672H17
Z1	ZENER	1N4477	33.0V	862A435H01
Z3	ZENER	1N965B	15.0V	186A797H08
Z4	ZENER	1N759A	12.6V	837A693H01
Z2	ZENER	IN2999B	56 V	629A798H04
ALM	REED RELAY	600Ω	12 V	1436C85H04

COMPONENT		DESCRIPTION		STYLE NO.
R14	POT	10.0K	.75W	880A826H05
R18	POT	1.0K	.75W	880A826H03
R1	RESISTOR	10.0K	5.00W 1%	763A130H02
R2	RESISTOR	1.5K	.50W 1%	848A819H65
R3	RESISTOR	3.0K	7.00W 5%	878A330H01
R4	RESISTOR	75.0	5.00W 1%	763A130H21
R5	RESISTOR	22.1K	.50W 1%	848A820H78
R6	RESISTOR	6810.0	.50W 1%	848A820H29
R7	RESISTOR	20.0K	.50W 1%	848A820H74
R8	RESISTOR	20.0K	.50W 1%	848A820H74
R9	RESISTOR	10.0K	.50W 1%	848A820H45
R10	RESISTOR	20.0K	.50W 1%	848A820H74
R11	RESISTOR	5110.0	.50W 1%	848A820H17
R12	RESISTOR	10.0K	.50W 1%	848A820H45
R13	RESISTOR	4020.0	.50W 1%	848A820H07
R15	RESISTOR	43.2K	.50W 1%	848A821H07
R16	RESISTOR	10.0K	.50W 1%	848A820H45
R17	RESISTOR	150.0	.50W 2%	629A531H12
R19	RESISTOR	9530.0	.50W 1%	848A820H43
R20	RESISTOR	5110.0	.50W 1%	848A820H17
R21	RESISTOR	5110.0	.50W 1%	848A820H17

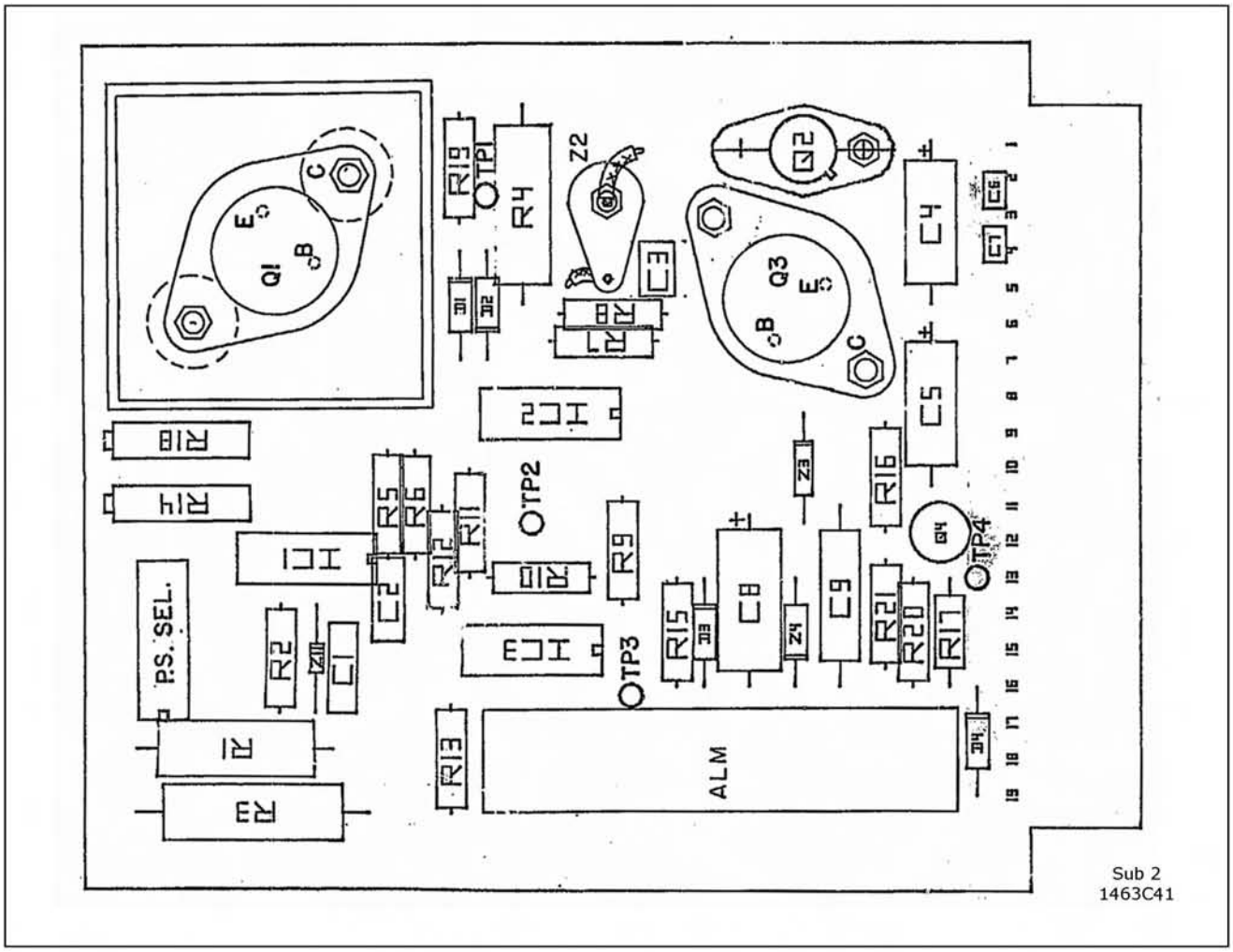


Figure 16. Component Location - SOQ Power Supply Module

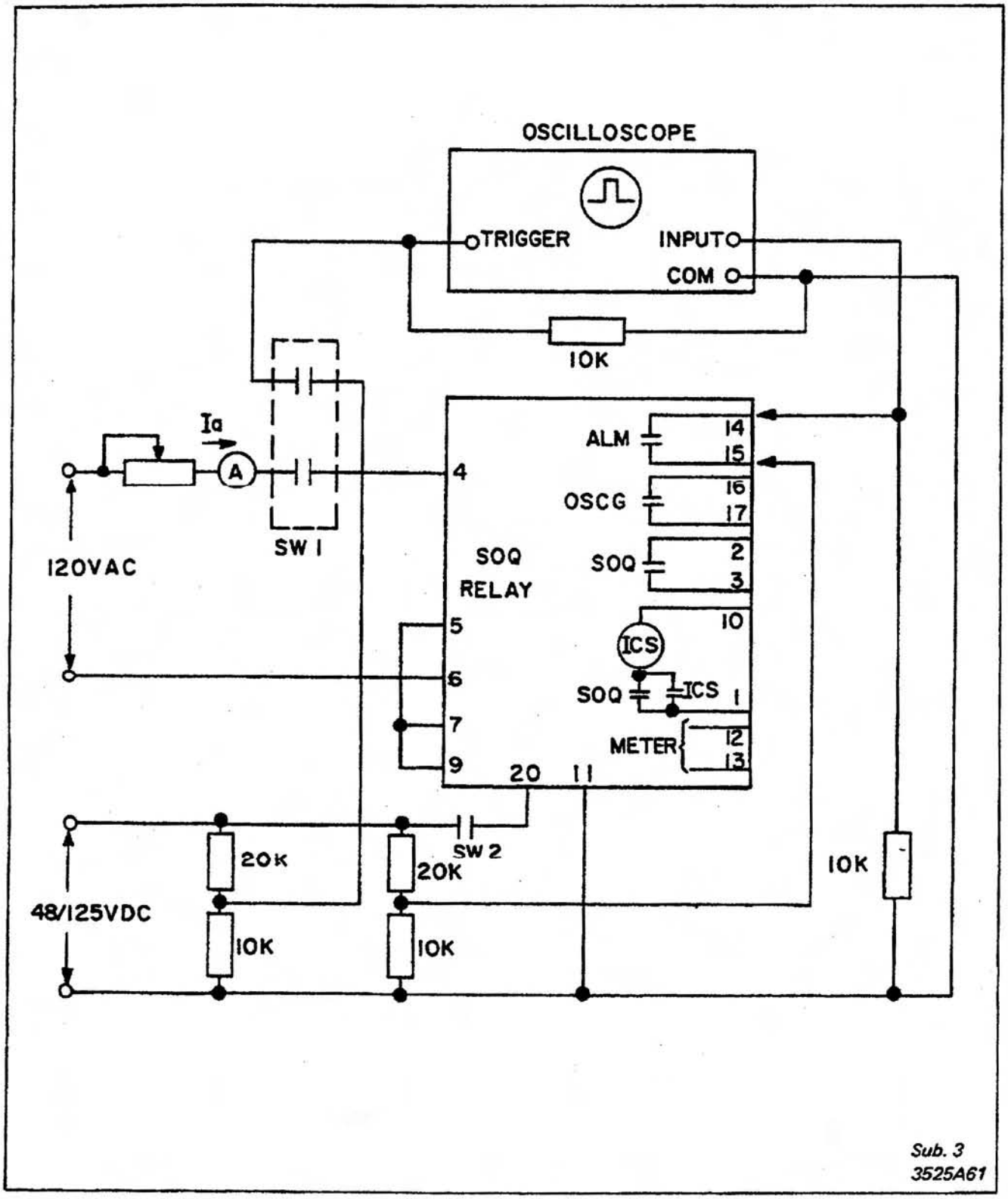


Figure 17. Test Circuit Diagram

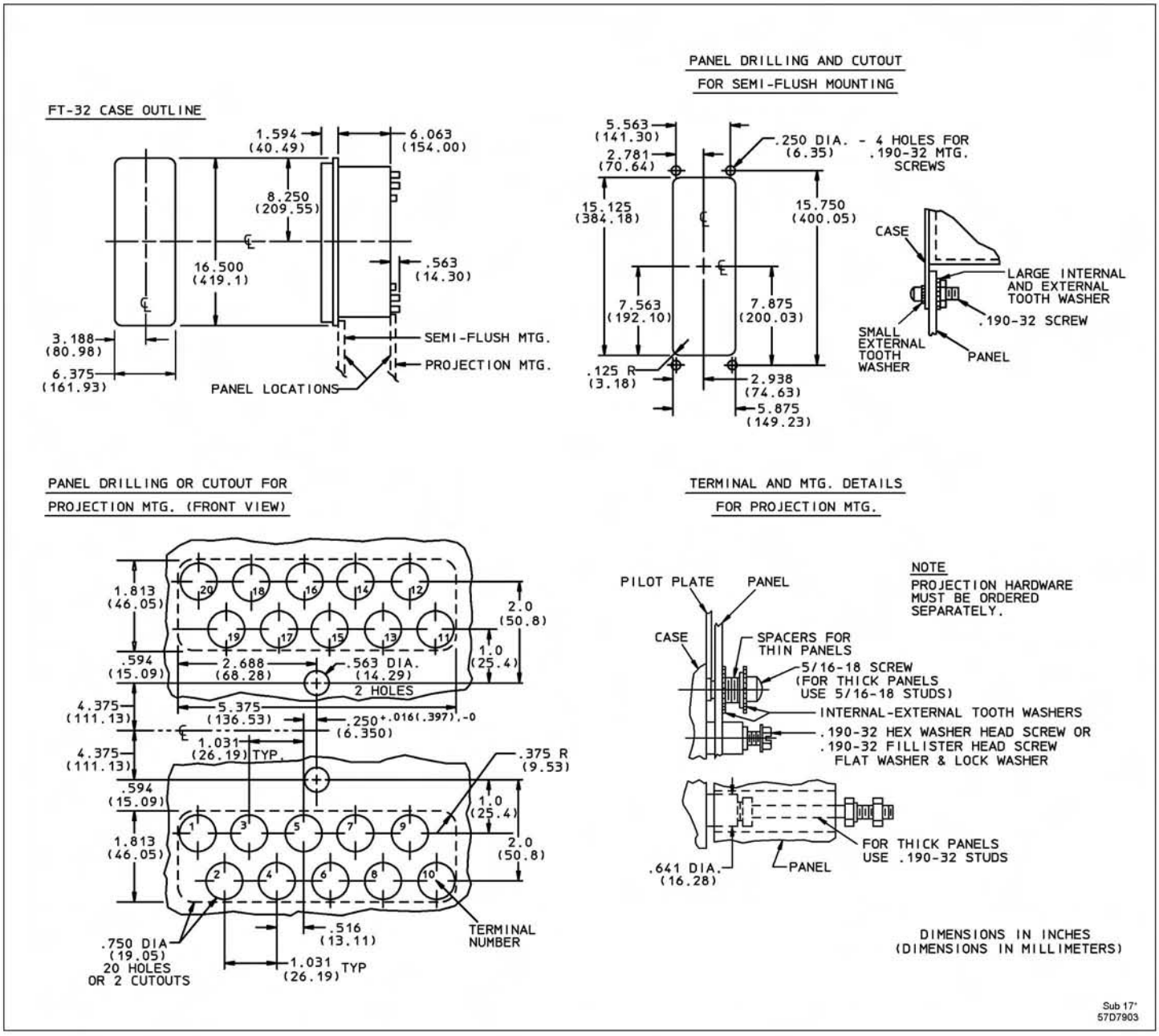


Figure 18. Outline and Drilling Plan for SOQ Relay in the Type FT-32 Case.

IL 41-161.1 - Revision C

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