GEK-65547B

INSTRUCTIONS

STATIC FREQUENCY RELAY

TYPE SFF33A

AND SFF33C

GE Meter and Control
205 Great Valley Parkway
Malvern, PA 19355-0715

CONTENTS

STATIC FREQUENCY RELAY

TYPE SFF33A/33C

DESCRIPTION

The Type SFF33A and SFF33C relays are static frequency relays that operate by digital technology to measure system frequency. They provide highly accurate and stable detection of frequency conditions on a power system.

The relay provides a single set point that can be set for any frequency over a range of 44 to 70 hertz. Detailed information on set point increments and repeatability is given in a later section, **SPECIFICATIONS**, which also describes the acceptable range of AC input voltage, the adjustable time delay, the AC undervoltage cutoff feature, nominal DC voltage and surge-withstand capability.

The output contact circuit consists of a set of transfer (C) contacts with target seal-in unit provided on the normally-open contact. The normally-open contact closes when the frequency of the AC input voltage is above the set point. The relay is housed in the medium-size, single-end (M1) drawout case, outline and panel drilling for which are shown in Figure 12. A functional block diagram of the relay circuit is in Figure 6.

An indicating lamp (LED) shows that the relay power supply is energized. It is mounted on the main printed circuit card and is visible above the center of the nameplate.

APPLICATION

The Type SFF33A/33C relay is applied wherever an extremely stable device is required to provide accurate detection of system frequency conditions. The relay can be set to operate on increasing frequency at the available set points between 44 and 70 hertz, with an adjustable time delay of 0.1 to 1.3 seconds.

The principal use of the relay is in overfrequency detection schemes, for example, to protect a generator from damage caused by operation at frequencies above rated value. As an overfrequency relay, the SFF33A/33C can also be used in load rejection schemes.

Another possible application of the relay is to protect a generator for the condition of accidental energization at sub-synchronous speed, or on turning gear. In such schemes the SFF33 relay would operate on increasing frequency to remove supplemental protection (such as overcurrent or power directional functions) enabled during off-line operation. The SFF33 would normally be set below the expected minimum emergency system operating level for this type of application. The SFF33 output relay will remain reset for any frequency below the set point for all values of applied AC potential at or below rating.

> **CAUTION: It should be recognized when applying the SFF33A relay that a loss of DC potential to the relay will cause the output relay to reset, enabling the associated off-line protection for the generator.**

Note: The SFF33C relay is an AC device. DC potential is not needed.

Typical external connections for the Type SFF33A/33C relay are shown in Figure 4.

SPECIFICATIONS

<table>
<tr><th></th><th>SFF33A</th><th>SFF33C</th></tr>
<tr><td>NOMINAL AC INPUT VOLTAGE</td><td colspan="2">120 Vrms, 44 to 70 hertz</td></tr>
<tr><td>Minimum operating AC input voltage</td><td>24 Vrms</td><td>60 V</td></tr>
<tr><td>Maximum AC input voltage</td><td>135 Vrms</td><td>135 V</td></tr>
<tr><td>FREQUENCY SETPOINT RANGE</td><td colspan="2">44.00 to 70.00 hertz</td></tr>
<tr><td>MINIMUM SETPOINT INCREMENTS</td><td colspan="2">0.016 hertz at 44.00 hertz
0.030 hertz at 60.00 hertz
0.040 hertz at 70.00 hertz</td></tr>
<tr><td rowspan="2">FREQUENCY SETPOINT REPEATABILITY</td><td colspan="2">±0.005 hertz over temperature range of $-20^{o}C$ to 65^{o}, and voltage range of</td></tr>
<tr><td>24 to 135 V AC</td><td>60 to 135 V</td></tr>
<tr><td>ADJUSTABLE TIME DELAY</td><td colspan="2">0.100 second to 1.3 seconds</td></tr>
<tr><td>TD1 repeatability</td><td colspan="2">±0.010 second or ±5% whichever is greater</td></tr>
<tr><td rowspan="2">AC UNDERVOLTAGE CUTOFF</td><td colspan="2">114 Vrms (95%) maximum</td></tr>
<tr><td>24 Vrms (20%) minimum</td><td>60 Vrms (50%) minimum</td></tr>
<tr><td rowspan="2">Undervoltage operate time</td><td colspan="2">10 milliseconds at 70%</td></tr>
<tr><td>15 ms at 20%</td><td>12 ms at 50%</td></tr>
<tr><td rowspan="2">Undervoltage reset time</td><td colspan="2">25 milliseconds at 70%</td></tr>
<tr><td>15 ms at 20%</td><td>19 ms at 50%</td></tr>
<tr><td>NOMINAL DC CONTROL VOLTAGE</td><td>Wired by user for 48, 110 or 125 V DC

External resistor required for 48, 110 and 125 V DC operation</td><td rowspan="3">Not Applicable</td></tr>
<tr><td>Minimum DC input voltage</td><td>80% of nominal</td></tr>
<tr><td>Maximum DC input voltage</td><td>112% of nominal</td></tr>
</table>

SURGE WITHSTAND CAPABILITY

Passes ANSI/C37.90-1978

Passes standard General Electric Fast Transient and RFI Tests

RATINGS

BURDENS

	SFF33A	SFF33C
DC current at nominal input	250 milliamperes	------
AC at nominal input	15 milliamperes	95 milliamperes
	1.32 VA	11.67 VA
	1.30 watts	10.0 watts
	0.20 vars	6.0 vars

AMBIENT TEMPERATURE

Operating: -20°C to 55°C

Will not malfunction, nor be damaged, in ambients up to 65°C

TELEPHONE RELAY CONTACTS

TELEPHONE RELAY CONTACT INTERRUPTING RATINGS

	INTERRUPTING AMPERES	
VOLTS	INDUCTIVE**	NON-INDUCTIVE
48 DC	1.0	3.0
125 DC	0.5	1.5
250 DC	0.25	0.25
115-60 Hz.	0.75	2.0
230-60 Hz.	0.5	1.0

** Inductance of average trip coil

TARGET SEAL-IN COIL AND CONTACTS

TARGET AND SEAL-IN UNIT

TAP	0.2	2
DC RESISTANCE ± 10% (OHMS)	8.3	0.24
MIN. OPERATING (AMPERES)	0.2	2.0
CARRY CONTINUOUSLY (AMPERES)	0.37	2.3
CARRY 30 AMPS FOR (SEC.)	0.05	4
CARRY 10 AMPS FOR (SEC.)	0.45	20
60 Hz IMPEDANCE (OHMS)	50	0.65
50 Hz IMPEDANCE (OHMS)	42	0.54
MINIMUM DROPOUT (AMPERES)	0.05	0.5

If the trip current exceeds 30 amperes, it is recommended that an auxiliary tripping relay be used.

CALCULATION OF SETTINGS

The frequency setpoint is determined by the mode of the range setting plug (SW21) and the 10 jumper-plug switches, SW1 through SW10. The "0" mode of the range plug should be used for a setpoint of 44.00 to 60.98 hertz. The basic reference period for the relay is 16,400 microseconds when the range plug is in the "0" mode. The "OH" mode of the range plug should be used for a setpoint of 61.00 to 70.00 hertz. The base reference period is 8,208 microseconds when the range plug is in the "OH" mode. Note that each plug switch has a "0" (lower) or "1" (upper) position and it also has a number above it, which corresponds to the number of microseconds represented by the switch when it is in the "1" position. The basic reference setpoint period is 16,400 or 8,208 microseconds (SW21 in "0" or "OH" mode, respectively) when all the plug switches are in the "0" position. The basic reference frequency is determined by dividing 1 second (10^6 microseconds) by 16,400 or 8,208, which is 60.98 or 121.83 hertz. The value of time (in microseconds) for each of the plug switches is shown in the table below.

PLUG SWITCH	10	9	8	7	6	5	4	3	2	1
TIME IN MICROSECONDS	4096	2048	1024	512	256	128	64	32	16	8

The total time period in microseconds for a given set of plug switches will be 16,400 or 8,208 plus the time value of each plug switch that has been placed in the "1" position.

When the desired trip frequency (TF) has been determined, refer to Tables V, VI and VII to determine the required position, "1" or "0," for each of the plug switches in a register. When the plug switch settings have been made according to the table, the set trip frequency can be checked by calculation. Use the following equation:

$$\text{TF (Hz)} = \frac{10^6}{16{,}400 + \text{sum of plug switches}}$$

where "sum of plug switches" refers to all switches that have been placed in the "1" position. The above equation can be transformed so as to be able to determine the necessary plug switch setting for any frequency as follows:

$$\text{Period (microseconds)} = \frac{10^6}{\text{TF}}$$

For example a TF of 58.56 would have a period of

$$\text{Period (microseconds)} = \frac{10^6}{58.56} = 17076.5\text{, rounded to } 17077$$

The necessary plug switch settings are determined as follows:

1. 17,077 minus 16,400 = 677 more needed

2. Set plug switch 7 (highest time value less than 677) in position "1," 677 minus 512 = 165 more needed

3. Add plug switch 5, 165 minus 128 = 37 more needed

4. Add plug switch 3, 37 minus 32 = only 5 less than 17,077

5. Actual period = 16,400 plus 512 plus 128 plus 32 = 17072

6. Actual frequency - TF = $10^6/17072$ = 58.5754

7. Error

$$\frac{58.5754 - 58.56}{58.56} \times 100 = \frac{0.0154}{58.56} = +0.0264\%$$

8. Put in plug switch "1" to add 8 microseconds; actual period becomes 17080, actual frequency becomes 58.548

9. Error

$$\frac{58.548 - 58.56}{58.56} \times 100 = \frac{-0.012}{58.56} = -0.0204\%$$

CHARACTERISTICS

OPERATING PRINCIPLES (Refer to Figure 6)

The SFF33 relay monitors an AC voltage and closes a telephone relay contact (TR1) when the frequency of the input voltage remains greater than a preset frequency setpoint (F1) for a preset time period (TIME DELAY 1). F1 is set by ten plug switches (SW1 - SW10) mounted on the large printed circuit card on the front of the relay. TIME DELAY 1 (TD1) is set by the locking potentiometer (R4) mounted above the printed circuit card. The relay (TR1) is deenergized when the magnitude of the AC input voltage is less than a value determined by the undervoltage adjust locking potentiometer (R20) located in the upper right-hand corner of the printed circuit card. The DC input is monitored by IC10D and deenergizes the telephone relay when the DC voltage is less than 70% of nominal. A manually resettable target and seal-in contact (TSI1) is energized by external DC trip current after the TR1 relay contact closes.

Switch SW21 allows the selection of the range of frequencies for either low range (44 to 61 hertz) or high range (61 to 70 hertz). The plug switch is located on the upper left corner of the printed circuit card and when it is vertically aligned in the "0" column it sets a reference time period of 16,400 microseconds for the low-set range. Inserting the plug in the "0H" column sets a reference time period of 8,208 microseconds for the high-set range.

A POWER ON indicator located on the printed circuit card assures the operator that the power supply is energized. Control power is provided by an external voltage of 48 or 125 VDC. Selection of the DC voltage is made by proper connection to the external power resistor. Internal regulation is provided by two 5-volt regulator diodes.

The fundamental principle of the relay is based on measuring the time period of successive cycles of the input voltage. The time between successive positive-going zero crossings of the AC voltage is measured and a comparison is made with a precisely-known time period. The known time period is generated by a stable crystal oscillator and a 16-stage binary counter. The counter is reset to the all-zero state by the zero-crossing pulse. Sixteen microseconds after the zero crossing, the counter is enabled for counting. The output states of counter stages 5 through 14 are monitored by the 11-input AND gate. Switches SW1 through SW10 select the normal or inverted counter output for inputting to the AND gate. An eleventh input signal to the AND gate is selected from either the fifteenth (high setpoint range) or sixteenth counter stage (low setpoint range), depending on the position of SW21. If switches SW1 through SW10 are kept in the "0" position, the known time base period is 16,400 microseconds, which corresponds to a frequency setpoint of 60.98 hertz when range switch SW21 is in the "0" position. If SW21 is in the "OH" position, the known time base period is 8,208 microseconds, which corresponds to 121.83 hertz (which is above the normal operating range of the relay). If the period of the input voltage is less than the time base period (an overfrequency condition), the counter will reset to a zero-count state before enabling the AND gate. However, if the period of the input is greater than the time base period (an underfrequency condition), the AND gate output will be enabled by the eleven high level signals at the input to the gate. The output of the AND gate is a narrow pulse that drives a pulse stretcher circuit producing a 30-millisecond-wide pulse. If a gate output pulse is continuously received every cycle, TIME DELAY 1 is held OFF. For an overfrequency condition, the gate output pulses do not occur and TIME DELAY 1 starts. After the elapsed time delay (TD1), an output transistor is turned ON, which energizes a telephone relay. However, if during the time delay period the input frequency drops below the setpoint, the time delay circuit is immediately reset.

If switches SW1 through SW10 are in the "1" position, the setpoint is determined by the base period selected (16,400 or 8,208 microseconds) plus the sum of the microsecond values of the switches in the "1" position. For example, if SW8 (32 microseconds), SW4 (512 microseconds), SW2 (2,048 microseconds) and SW1 (4,096 microseconds) are in the "1" position and range switch SW21 is in the "OH" position, the setpoint period is:

8,208	+ 4,096	+ 2,048	+ 512	+ 32	=	14,896 microseconds
(BASE)	(SW1)	(SW2)	(SW4)	(SW8)		

which corresponds to 67.132 hertz.

An adjustable AC undervoltage cutoff circuit disables the telephone relay when the input voltage drops below the preset setpoint. The response time of the SFF33A's AC undervoltage circuit ranges from 10 milliseconds at a setting of 84 volts, to 15 milliseconds at a minimum setting of 24 volts. The AC undervoltage circuit recovery time ranges from 15 milliseconds at a 24 volt setting, to 25 milliseconds at an 84 volt setting.

For the SFF33C relay, the response of the AC undervoltage circuit ranges from 10 milliseconds at a setting of 84 volts, to 12 milliseconds at a minimum setting of 60 volts. The AC undervoltage circuit recovery time ranges from 25 milliseconds at 84 volts to 19 milliseconds at 60 volts.

The DC undervoltage cutoff circuit operates and resets in less than 5 milliseconds. The "inhibit" level is fixed at approximately 70% of rated DC input.

The SFF33C relay does not have a DC undervoltage cutoff.

DETAILED PRINCIPLES OF OPERATION

Printed Circuit Board (See Figures 5A and 5B)

The AC input from transformer TA is filtered by R13 and C7 before being squared by transistor Q3. Q3 is turned ON when the input sine wave is positive and turned OFF when the sine wave is negative. When the collector of Q3 is switched down to reference, the output of IC9A also is switched down to reference. Integrated circuits IC9 and IC10 are high-speed, stable comparators with an NPN transistor collector as an output terminal. Four independent comparators are contained in each package. All comparator reference inputs are connected to the 5 volt bus. If the unknown input is connected to the plus (+) comparator input, the NPN output transistor will be turned ON when the unknown input is less than 5 volts. If the unknown input signal is connected to the minus (-) input, the NPN output transistor will be turned ON when the input is greater than 5 volts.

After the output of IC9A is switched to reference, C9, which initially has no charge, causes the input of IC9B to switch to reference level. The output of IC9B is turned ON and produces the start of the "clear" pulse for the binary counter.

The output of IC9A will be at reference level for 1/2 a cycle, or about 8 milliseconds. However, C9 will charge up toward 10 volts through R17, and when the C9 voltage exceeds 5 volts, it will switch the IC9B output OFF. The width of the "clear" pulse is 16 microseconds. After the "clear" pulse ends, the binary counter is allowed to begin counting.

The binary counter contains sixteen stages with two flip-flops in each integrated circuit package (IC1 through IC8). Each pair of flip-flops is controlled by a common CLOCK PULSE input (CP) and a common CLEAR DIRECT input (CD). Each flip-flop contains a "J" input, a "K" input, a normal output (Q) and a complementary output ($\overline{Q}$). The two flip-flops in each package are identified by a suffix, (a) or (b). The (b) flip-flop always operates at twice the frequency of the (a) flip-flop in the SFF relay. The operation of IC1 is representative of IC2 through IC8, except for operating frequency. The (b) flip-flop of IC1 has its JK inputs tied to +5 volts and this causes the (b) output to change state when the clock input (CP) goes negative. The (a) flip-flop of IC1 has its JK inputs tied to the normal output of the (b) flip-flop. The JK truth table is shown in Table II.

TABLE II - FLIP-FLOP TRUTH TABLE

t_n		$t_n + 1$
J	K	Q
0	0	Q_n
1	0	1
0	1	0
1	1	$\overline{Q}_n$

The (a) flip-flop will only change state when the clock goes negative and the normal output of the (b) flip-flop is in a "1" state. The frequency output of (a) will then be 1/2 the frequency of (b). The period of each flip-flop is shown in Table III.

TABLE III - BINARY COUNTER PERIODS

SW Nos.	IC No.	Output Pin No.	Period	Negative Gate
	1b	8	1 μs	
	1a	6	2 μs	
	2b	8	4 μs	
	2a	6	8 μs	
10 & 20	3b	8	16 μs	8 μs
9 & 19	3a	6	32 μs	16 μs
8 & 18	4b	8	64 μs	32 μs
7 & 17	4a	6	128 μs	64 μs
6 & 16	5b	8	256 μs	128 μs
5 & 15	5a	6	512 μs	256 μs
4 & 14	6b	8	1024 μs	512 μs
3 & 13	6a	6	2048 μs	1024 μs
2 & 12	7b	8	4096 μs	2048 μs
1 & 11	7a	6	8192 μs	4096 μs
Selected by	Hi-Range 8b	8	16384 μs	8192 μs
Range Switch SW21	Lo-Range 8a	6	32768 μs	16384 μs

Note that the eleventh input to the AND gate is from either IC8b or IC8a and determines the time base period of 8,208 or 16,400 microseconds respectively (the 16 microsecond width of the "clear" pulse must be added to 8,192 or 16,384 microseconds respectively).

The frequency-select plug switches connect the ten AND gate inputs to either the normal or the complementary outputs of the fifth through the fourteenth flip-flops in the chain of sixteen. When the "clear" pulse occurs, all sixteen normal flip-flop outputs go to the "0" level (see Figure 7). When the "clear" pulse ends, the counter begins counting. Since the 2-megahertz crystal oscillator is running asynchronously, there is a 1/2-microsecond uncertainty in the reference period. This uncertainty is approximately ± 0.001 hertz. Figure 7 is a timing diagram showing the initial state of the counter after the "clear" pulse ends. The initial timing waveforms are always the same, whereas the final timing waveforms are a function of the plug switch settings and the input frequency. Figure 8 is a timing diagram showing the final state of the counter for a frequency setpoint of 58.01 hertz and an input frequency of 57.94 hertz. The "clear" pulse is shown for reference only. The AND gate output is an 8-microsecond-wide pulse occurring 17,240 microseconds after the start of the "clear" pulse.

The AND gate output is high when all eleven inputs are high. If any gate input is low, the gate output will be low. For the example shown in Figure 8, the normal outputs "1" of the 8, 64, 256 and 512 flip-flop stages and the complementary outputs "0" of the 16, 32, 128, 1024, 2048 and 4096 flip-flop stages are switched into the AND gate. The normal output of the "16,384" stage is connected to the eleventh input of the AND gate. Control of the AND gate is by the "0" level inputs and the order of sequence is as follows:

Microseconds	Control Input	Control Pulse Width Microseconds
0 to 16	Clear pulse	16
16 to 16400	IC8-6 normal output	16384
16400 to 16912	IC6-8 normal output	512
16912 to 17168	IC5-6 normal output	256
17168 to 17232	IC4-6 normal output	64
17232 to 17240	IC3-8 normal output	8

Since the "clear" pulse period (or zero crossings of the input signal) is greater than the reference time period of 17,240 microseconds, an underfrequency condition will be detected by the AND gate output pulse occurring once every cycle of the input sine wave. All sixteen stages of the counter are shown switching from 0 to 5 volts for simplicity. Actually the first eight states (IC1 through IC4) operate between 0 and 5 volts but the final eight stages (IC5 through IC8) operate between 5 and 10 volts. Arranging the counter in this manner allows the DC current drain of the counter to be cut in half. Interfacing is accomplished by 5-volt reference diode ZD2 (for "clear" pulse), ZD3 (for stage 8 to stage 9 connection) and ZD11 (for AND gate connection between stage 8 and stage 9).

The AND gate output pulse is only 8 microseconds wide and must be stretched to about 30 milliseconds; Q5 and Q6 amplify the pulse to a level capable of charging C13 from 0 to 10 volts in less than 1 microsecond. The decay of the voltage on C13 is determined by R30. The normal decay time from 10 to 5 volts is about 30 milliseconds. However, as long as an underfrequency pulse is received each cycle, C13 is continually recharged to 10 volts and thus maintains the input to IC10A above the 5-volt reference level.

An input level greater than 5 volts to the inverting input of IC10A turns ON the output transistor stage of IC10A and keeps C14 discharged to 0 volts.

If the input frequency is greater than the setpoint (for instance 60.00 hertz), the period of the "clear" pulse (16,667 microseconds) is less than the setpoint period

(17,240 microseconds) and the counter is cleared before the eleven inputs to the AND gate are all at the "1" level. As soon as the overfrequency condition is detected, the voltage on C13 decays to 0. When the input to IC10A is less than 5 volts, the output transistor stage is turned OFF and capacitor C14 charges from 0 toward 10 volts by R32 plus the resistance of time delay potentiometer R4 mounted on the chassis. When the C14 voltage exceeds 5 volts, the output of IC9D switches ON and turns ON output transistor Q7, which energizes the telephone relay. The telephone relay contacts energize the target seal-in unit and the proper circuit breaker is opened.

The trip delay time is measured from the moment the last underfrequency pulse is detected to the closing of the normally-open telephone relay contacts. The preferred test connections are shown in Figure 9. Opening a double-pole, double-throw switch or relay contact triggers an oscilloscope or counter for the start of the timing period. The end of the timing period is determined by the closing of telephone relay contacts TR1.

The AC undervoltage detector operates from full-wave rectifier D45 and D46. The amplitude of the full-wave rectified signal is adjusted by the user with R20. Turning R20 clockwise decreases the amplitude of the signal to level detector ZD18. Turning R20 fully clockwise causes the relay to "inhibit" close to the normal AC input of 120 volts rms. When the peak AC voltage is greater than the breakdown voltage of ZD21 (5.1V), it causes Q4 to switch ON and discharge C10 by R23. When Q4 is OFF, C10 charges towards +10 volts by R24 and D47. The capacitor C10 voltage is compared to 5 volts by IC9C, and if it is less than 5 volts the relay can operate. However, if the voltage at IC9C-6 is greater than 5 volts, the "inhibit" command from IC9C discharges main timing capacitor C14 in less than 3 milliseconds. The voltage on C10 assumes an average value depending on the ratio of the input voltage to the "inhibit" voltage setting. For input voltage much greater than the "inhibit" setting, the average voltage on C10 is less than 1 volt. As the input voltage approaches the "inhibit" setting, the average voltage on C10 is 5 volts (50% duty cycle for Q4). For decreasing input voltage, the average C10 voltage rises toward 10 volts and causes the relay to be inhibited from operation.

The power supply for the DC model ("A" suffix) consists of two 5 volt reference diodes, ZD25 and ZD26. An LED and resistor are connected across both reference diodes to indicate that power is applied. The power supply current is limited by R3 and the external resistor. Operation at 48 VDC, 110 VDC or 125 VDC requires external series resistance of 100, 350 or 450 ohms respectively.

CONSTRUCTION

CASE

The components of each relay are mounted on a cradle assembly that can be easily removed from the relay case. The cradle is locked in the case by means of latches at the top and bottom. The electrical connections between the case blocks and cradle blocks are completed through removable connection plugs (see Figure 11). Separate testing plugs can be inserted in place of connection plugs to permit testing the relay in its case. The cover is attached to the front of the case and includes two interlock arms that prevent the cover from being replaced until the connection plugs have been inserted.

The case is suitable for semi-flush mounting on panels. Hardware is available for all panel thicknesses up to 2 inches. A panel thickness of 1/8 inch will be assumed unless otherwise specified on the order. Outline and panel drilling dimensions are shown in Figure 12.

One printed circuit board contains the circuit components. The board is vertically mounted on the front of the relay by two screws and two hexagonal studs holding the nameplate. Connections to the board are made with two connection blocks. Use care when removing or attaching the connector blocks to ensure proper lateral alignment and that the pins are straight and enter the connector properly. Each electrical card connection is made through a double set of wires and connectors.

The target seal-in unit is front-mounted above the telephone relay tripping unit. Target contacts and tap settings are easily accessible from the front of the relay.

The telephone relay is mounted above the printed circuit card and the armature and contacts are easily accessible from the front of the relay.

The time-delay potentiometer is mounted in the center of the relay above the printed circuit board. The potentiometer has a screw slot and is equipped with a locknut.

The input transformer, power resistors and surge suppression components are all mounted in the rear of the relay.

RECEIVING, HANDLING AND STORAGE

These relays, when not included as part of a control panel, will be shipped in cartons designed to protect them against damage. Immediately upon receipt of a relay, examine it for any damage sustained in transit. If injury or damage resulting from rough handling is evident, file a damage claim at once with the transportation company and promptly notify the nearest General Electric Sales Office.

Reasonable care should be exercised in unpacking the relay in order that none of the parts are injured or the adjustments disturbed.

If the relays are not to be installed immediately, they should be stored in their original cartons in a place that is free from moisture, dust and metallic chips. Foreign matter collected on the outside of the case may find its way inside when the cover is removed, and cause trouble in the operation of the relay.

ACCEPTANCE TESTS

GENERAL

The relay should be examined and tested upon delivery to make sure that no damage has been sustained in shipment and that the relay functions properly. If the examination or acceptance tests indicate that readjustment is necessary, refer to the section on **SERVICING.**

The following tests may be performed as part of the installation of the relay at the discretion of the user. Since most operating companies use different procedures for acceptance and for installation tests, the following section includes all applicable tests that may be performed on the relays.

VISUAL INSPECTION

Check the nameplate stamping to make sure that the model number is correct.

Remove the relay from its case and check that there are no broken or cracked molded parts or other signs of physical damage, and that all the screws are tight.

MECHANICAL INSPECTION

> **CAUTION: Mechanical adjustment of the target seal-in is not recommended.**
>
> **Improper adjustment of the telephone relay or target seal-in may affect seismic performance.**

1. The armature and contacts of the seal-in unit should move freely when operated by hand. There should be at least 10 mils wipe on the seal-in unit contacts.

2. The target in the seal-in unit must come into view and latch when the armature is operated by hand, and should unlatch when the target release lever is operated.

3. The telephone relay units used in these relays should be checked to have a contact gap of at least 10 mils and contact wipe of 5 mils. The contact wipe may be checked by inserting a 5 mil shim between the armature and pole piece and operating the armature by hand. The normally-open contacts should make contact with the shim in place when the armature is operated by hand.

4. Make sure that fingers and shorting bars in the relay cradle and case blocks agree with the internal connections diagram. See Figures 3A and 3B.

> **CAUTION: Every circuit in the drawout case has an auxiliary brush. It is especially important on current circuits and other circuits with shorting bars that the auxiliary brush be bent high enough to engage the connecting plug or test plug before the main brushes do. This will prevent the CT (current transformer) secondary circuits from being open-circuited during insertion of the connection plug.**

DRAWOUT CASE

Since all drawout relays in service operate in their cases, it is recommended that they be tested in their cases or an equivalent steel case. In this way, any magnetic effects of the enclosure will be accurately duplicated during testing. A relay may be tested without removing it from the panel by using a 12XLA13A test plug. This plug makes connections only with the relay and does not disturb any shorting bars in the case. The 12XLA12A test plug may also be used. Although this test plug allows greater testing flexibility, it requires CT shorting jumpers and the exercise of greater care, since connections are made to both the relay and the external circuitry.

CAUTION: When hi-potting the SFF relay, remove all wiring from terminal 6. The reason is that surge capacitors are rated for 600 VDC continuous and the hi-pot voltage may damage the capacitors.

POWER REQUIREMENTS, GENERAL

All alternating-current-operated devices are affected by frequency. Non-sinusoidal waveforms can be analyzed as a fundamental frequency plus harmonics of the fundamental frequency. It follows that alternating-current devices (relays) will be affected by the application of non-sinusoidal waveforms.

Therefore, in order to test alternating-current relays properly, it is essential to use a sine wave of current and/or voltage. The purity of the sine wave (i.e., its freedom from harmonics) cannot be expressed as a finite number for any particular relay; however, any relay using tuned circuits, RL or RC networks, or saturating electromagnets (such as time overcurrent relays) is affected by non-sinusoidal waveforms.

Similarly, relays requiring DC control power should be tested using DC and not full-wave rectified power. Unless the rectified supply is well filtered, many relays will not operate properly due to the dips in the rectified power. Zener diodes, for example, can turn OFF during these dips. As a general rule the DC source should not contain more than 5% ripple.

TARGET SEAL-IN UNIT TAP SETTING

When trip coil current falls within the range of 0.2 to 2.0 amperes at minimum control voltage, the tap screw of the target seal-in unit should be set in the low-ampere tap. When the trip coil current ranges from 2 to 30 amperes at minimum control voltage, the tap screw should be placed in the 2.0 ampere tap. The tap screw for the seal-in unit is the screw holding the right-hand stationary contact of the seal-in unit. To change the seal-in unit tap setting, first remove the relay connection plugs. Then take a screw from the left-hand stationary contact and place it in the desired tap. Next, remove the screw from the other (undesired) tap and place it back in the just-emptied left-hand contact. This procedure is necessary to prevent the right-hand stationary contact from getting out of adjustment. Screws should never be left in both taps at the same time.

TARGET SEAL-IN UNIT CHECKS

The pickup and dropout of the target seal-in unit can be tested as follows:

1. Connect the proper relay studs to a DC source, ammeter and load box so that the target coil current can be controlled over a range of 0.1 to 2.0 amperes DC.

2. Short the TR contacts by manually closing the telephone relay contacts.

3. Increase the current slowly until the seal-in unit picks up. See Table IV for correct pickup values.

4. Release the telephone relay, and the seal-in unit should remain in the picked-up position.

5. Decrease the current slowly until the seal-in unit drops out. See Table IV for correct dropout values.

TABLE IV

UNIT	TAP	PICKUP AMPERES	DROPOUT AMPERES
0.2/2.0	0.2	0.15 - 0.195	0.05 or more
	2.0	1.50 - 1.95	0.5 or more

FREQUENCY SETPOINT CHECK

If a variable-frequency oscillator is not available, the relay operation can be checked using a normal 60 hertz input, by setting the range switch (SW21) to the "0" position and the plug switches to 0000100001 (60.01 hertz) and checking for no-trip action. Change the plug switch setting to 0000100010 (59.981 hertz) and check for trip action. If chatter is encountered in either of the preceding checks, try the next higher 0000100000 (60.038) or lower 0000100011 (59.952) setting, which should provide a stable no-trip or trip state respectively.

NOTE

When checking the frequency setting, if highest accuracy is required, the time delay should be set at minimum. This is necessary because the relay will not trip unless the lowest frequency during the trip time delay is higher than the set point. If the AC power source has slight variations in frequency, the frequency indication of the AC power source will usually be the average rather than the lowest frequency, and this indicated value will not be the true operating point of the relay.

TIME-DELAY CALIBRATION

The time delay is best measured with a dual-trace storage oscilloscope. A normal single-trace oscilloscope may be used if external trigger input is provided, but it is more difficult to obtain the desired results.

The time delay is measured from the opening of the double-pole, double-throw test switch until the TR1 telephone relay contacts close. The test arrangement is shown in Figure 9.

Set the relay to the desired range (44 to 60.98 or 61 to 70 hertz) for the time-delay calibration test. Set the desired frequency set point and follow the test sequence listed in Figure 9. Scope should be triggered on positive DC from EXT TRIGGER. Adjust TIME DELAY 1 potentiometer for desired time delay and lock. Check time delay again after locking potentiometer, and readjust if necessary.

Another test set-up is shown in Figure 10. Note that an overfrequency condition can actually begin at any time, so one period of the setpoint frequency should be added to the time delay to determine the maximum trip time.

INSTALLATION PROCEDURE

INTRODUCTION

The relay should be installed in a clean, dry location, free from dust and excessive vibration, and well lighted to facilitate inspection and testing.

The relay should be mounted on a vertical surface. The outline and panel drilling dimensions are shown in Figure 12.

The internal connection diagram for the SFF33A relay is shown in Figure 3A; that of the SFF33C relay is shown in Figure 3B. A typical connections diagram is shown in Figure 4.

SURGE GROUND AND RELAY CASE GROUND CONNECTIONS

CAUTION

One of the mounting studs or screws should be permanently connected to ground by a conductor not less than AWG No. 12 copper wire or its equivalent. This connection is made to ground the relay case. In addition, the terminal designated as "surge ground" on the internal connections diagram must be tied to ground for the surge suppression networks in the relay to perform properly. This surge ground lead should be as short as possible to ensure maximum protection from surges (preferably 10 inches or less to reach a solid ground connection).

With terminal connected to ground, "surge ground" is connected electrically to the relay case. The purpose of this connection is to prevent high frequency transient potential differences from entering the solid state circuitry. Therefore, with terminal connected to ground, the surge capacitors are connected between the input terminals and the case. Caution must be exercised when hi-potting between these terminals and the case.

CAUTION: The surge capacitors used in this relay are not suitable for AC hi-pot testing; thus the surge ground lead must be removed from terminal 6 when hi-potting.

The surge capacitors are not subjected to high frequency surge potentials of any appreciable level, as their impedance at surge frequencies is very low, less than 1 ohm usually, and the various source and circuit impedances along the surge path to the relay usually limit the surge currents to less than 25 amperes. Therefore, the surge voltage drop across a surge capacitor is small.

Surge capacitors of sufficient voltage rating to pass relay hi-pot tests are physically large; too large in fact to allow use of the required numbers inside most component relays as surge filter elements. We are continually monitoring developments in this area in an effort to be able to respond to requests for such ratings. To date, no practical capacitor of suitable compactness has been found.

Hi-pot is defined by ANSI C37.90 under section entitled "Dielectric Tests."

TEST PLUGS

The relay may be tested without removing it from the panel by using a 12XLA13A test plug. This makes connections only with the relay and does not disturb any shorting bars in the case. Of course, the 12XLA12A test plug may also be used. Although this test plug allows greater testing flexibility, it also requires CT shorting jumpers and the exercise of greater care, since connections are made to both the relay and the external circuitry. Additional information on the XLA test plugs may be obtained from the nearest General Electric Sales Office.

ELECTRICAL TESTS AND SETTINGS

Most operation companies use different procedures for acceptance and for installation tests. The section under **ACCEPTANCE TESTS** contains all necessary tests that may be performed as part of the installation procedure. Procedures for setting the relay are discussed in the **SERVICING** section in this book.

SERVICING

CAUTION

Remove ALL power from the relay before removing or inserting any of the printed circuit boards. Failure to observe this caution may result in damage to and/or misoperation of the relay.

GENERAL

Before removing the cover, remove any dust or foreign matter that has accumulated on the top of the cover. Otherwise it may find its way inside when the cover is removed and cause trouble in the operation of the relay.

TARGET SEAL-IN UNIT TAP SETTING

Refer to the section of this same title under **ACCEPTANCE TESTS** for details on changing taps.

CONTACT CLEANING

For cleaning fine silver contacts, a flexible burnishing tool should be used. This consists of a flexible strip of metal with an etched roughened surface, resembling in effect a superfine file. The polishing action is so delicate that no scratches are left, yet corroded material will be removed rapidly and thoroughly. The flexibility of the tool ensures the cleaning of the actual points of contact.

Contacts should not be cleaned with knives, files or abrasive paper or cloth. Knives or files may leave scratches, which increase arcing and deterioration of the contacts. Abrasive paper or cloth may leave minute particles of insulating abrasive material in the contacts, thus preventing closing. The use of contact cleaning sprays or liquids should be avoided because some of these liquids may leave deposits in portions of the relay, which may be injurious to materials or components.

The burnishing tool described above can be obtained from the factory.

PERIODIC CHECKS AND ROUTINE MAINTENANCE

In view of the vital role of protective relays in the operation of a power system, it is important that a periodic test program be followed. It is recognized that the interval between periodic checks will vary depending upon environment, type of relay and the user's experience with periodic testing. Until the user has accumulated enough experience to select the test interval best suited to his individual requirements, it is suggested that the points listed below be checked at an interval of from one to two years.

The telephone-type relay units should be checked to see that they operate smoothly and their contacts are correctly adjusted.

With each telephone relay unit deenergized, each normally-open contact should have a gap of 0.010 to 0.015 inch. Each normally-closed contact should have wipe (overtravel after contact) of 0.005 inch. This can be observed by deflecting the stationary contact member toward the frame.

In the energized position each normally-open contact should have approximately 0.005 inch wipe. This can be checked by inserting a shim between the armature and pole piece and operating the armature by hand. Use an 0.0025 shim for the TR relay and an 0.005 shim for the RS relay. The normally-open contacts should close before the residual screw or armature strikes the shim.

RENEWAL PARTS

It is recommended that sufficient quantities of renewal parts be carried in stock to enable the prompt replacement of any that are worn, broken or damaged.

It is not recommended that renewal parts obtained from sources other than the General Electric Company be used. Many parts in relays that appear superficially similar to parts generally available have special features or construction that are not apparent on inspection. This is true in some cases even though the parts have the same manufacturer's part number. Other parts, while the same as those generally available, are specially selected or tested for their specific applications.

Should a printed circuit card become inoperative, it is recommended that this card be replaced with a spare. In most instances, the user will be anxious to return the equipment to service as soon as possible and the insertion of a spare card represents the most expeditious means of accomplishing this. The faulty card can then be returned to the factory for repair or replacement.

Although it is not generally recommended, it is possible with the proper equipment and trained personnel to repair cards in the field. This means that a trouble-shooting program must isolate the specific component on the card that has failed. By referring to the internal connection diagram for the card, it is possible to trace through the card circuit by signal checking, and thus determine which component has failed. This, however, may be time consuming and if the card is being checked in place in its unit, as is recommended, will extend the outage time of the equipment.

CAUTION: Great care must be taken in replacing components on the cards. Special soldering equipment suitable for use on the delicate solid-state components must be used and, even then, care must be taken not to cause thermal damage to the components, and not to damage or bridge-over the printed circuit buses. The repaired area must be re-covered with a suitable high di-electric plastic coating to prevent possible breakdowns across the printed circuit buses due to moisture or dust.

ADDITIONAL CAUTION: Dual in-line integrated circuits are especially difficult to remove and replace without specialized equipment. Furthermore, many of these components are used in printed circuit cards that have bus runs on both sides. These additional complications require very special soldering equipment and removal tools, as well as additional skills and training, which must be considered before field repairs are attempted.

When ordering renewal parts, address the nearest Sales Office of the General Electric Company, specify quantity required, name of part wanted, and give the complete model number of the relay for which the part is required.

TABLE V - PLUG SWITCH SETTINGS - 70 Hertz

APPROX. SETPOINT FREQUENCY (Hz)	EXACT PERIOD (MICROSECONDS)	SWITCH SETTINGS									
		4096	2048	1024	512	256	128	64	32	16	8
70.03	14280	1	0	1	1	1	1	0	1	1	1
69.02	14488	1	1	0	0	0	1	0	0	0	1
68.01	14704	1	1	0	0	1	0	1	1	0	0
66.99	14928	1	1	1	0	0	0	1	0	0	0
66.00	15152	1	1	0	1	1	0	0	1	0	0
65.00	15384	1	1	1	0	0	0	0	0	0	1
64.30	15552	1	1	1	0	0	1	0	1	1	0
64.27	15560	1	1	1	0	0	1	0	1	1	1
64.23	15568	1	1	1	0	0	1	1	0	0	0
64.20	15576	1	1	1	0	0	1	1	0	0	1
64.17	15584	1	1	1	0	0	1	1	0	1	0
64.14	15592	1	1	1	0	0	1	1	0	1	1
64.10	15600	1	1	1	0	0	1	1	1	0	0
64.07	15608	1	1	1	0	0	1	1	1	0	1
64.04	15616	1	1	1	0	0	1	1	1	1	0
64.00	15624	1	1	1	0	0	1	1	1	1	1
63.97	15632	1	1	1	0	1	0	0	0	0	0
63.94	15640	1	1	1	0	1	0	0	0	0	1
63.91	15648	1	1	1	0	1	0	0	0	1	0
63.87	15656	1	1	1	0	1	0	0	0	1	1
63.84	15664	1	1	1	0	1	0	0	1	0	0
63.81	15672	1	1	1	0	1	0	0	1	0	1
63.78	15680	1	1	1	0	1	0	0	1	1	0
63.74	15688	1	1	1	0	1	0	0	1	1	1
63.71	15696	1	1	1	0	1	0	1	0	0	0
63.68	15704	1	1	1	0	1	0	1	0	0	1
63.65	15712	1	1	1	0	1	0	1	0	1	0
63.61	15720	1	1	1	0	1	0	1	0	1	1
63.58	15728	1	1	1	0	1	0	1	1	0	0
63.55	15736	1	1	1	0	1	0	1	1	0	1
63.52	15744	1	1	1	0	1	0	1	1	1	0
63.48	15752	1	1	1	0	1	0	1	1	1	1
63.45	15760	1	1	1	0	1	1	0	0	0	0
63.42	15768	1	1	1	0	1	1	0	0	0	1
63.39	15776	1	1	1	0	1	1	0	0	1	0
63.36	15784	1	1	1	0	1	1	0	0	1	1
63.32	15792	1	1	1	0	1	1	0	1	0	0
63.29	15800	1	1	1	0	1	1	0	1	0	1
63.26	15808	1	1	1	0	1	1	0	1	1	0
63.23	15816	1	1	1	0	1	1	0	1	1	1
63.20	15824	1	1	1	0	1	1	1	0	0	0
63.16	15832	1	1	1	0	1	1	1	0	0	1
63.13	15840	1	1	1	0	1	1	1	0	1	0

TABLE V - PLUG SWITCH SETTINGS - 70 HERTZ (Continued)

APPROX. SETPOINT FREQUENCY (Hz)	EXACT PERIOD (MICROSECONDS)	SWITCH SETTINGS									
		4096	2048	1024	512	256	128	64	32	16	8
63.10	15848	1	1	1	0	1	1	1	0	1	1
63.07	15856	1	1	1	0	1	1	1	1	0	0
63.04	15864	1	1	1	0	1	1	1	1	0	1
63.00	15872	1	1	1	0	1	1	1	1	1	0
62.97	15880	1	1	1	0	1	1	1	1	1	1
62.94	15888	1	1	1	1	0	0	0	0	0	0
62.91	15896	1	1	1	1	0	0	0	0	0	1
62.88	15904	1	1	1	1	0	0	0	0	1	0
62.85	15912	1	1	1	1	0	0	0	0	1	1
62.81	15920	1	1	1	1	0	0	0	1	0	0
62.78	15928	1	1	1	1	0	0	0	1	0	1
62.75	15936	1	1	1	1	0	0	0	1	1	0
62.72	15944	1	1	1	1	0	0	0	1	1	1
62.69	15952	1	1	1	1	0	0	1	0	0	0
62.66	15960	1	1	1	1	0	0	1	0	0	1
62.63	15968	1	1	1	1	0	0	1	0	1	0
62.59	15976	1	1	1	1	0	0	1	0	1	1
62.56	15984	1	1	1	1	0	0	1	1	0	0
62.53	15992	1	1	1	1	0	0	1	1	0	1
62.50	16000	1	1	1	1	0	0	1	1	1	0
62.47	16008	1	1	1	1	0	0	1	1	1	1
62.44	16016	1	1	1	1	0	1	0	0	0	0
62.41	16024	1	1	1	1	0	1	0	0	0	1
62.38	16032	1	1	1	1	0	1	0	0	1	0
62.34	16040	1	1	1	1	0	1	0	0	1	1
62.31	16048	1	1	1	1	0	1	0	1	0	0
62.28	16056	1	1	1	1	0	1	0	1	0	1
62.25	16064	1	1	1	1	0	1	0	1	1	0
62.22	16072	1	1	1	1	0	1	0	1	1	1
62.19	16080	1	1	1	1	0	1	1	0	0	0
62.16	16088	1	1	1	1	0	1	1	0	0	1
62.13	16096	1	1	1	1	0	1	1	0	1	0
62.10	16104	1	1	1	1	0	1	1	0	1	1
62.07	16112	1	1	1	1	0	1	1	1	0	0
62.04	16120	1	1	1	1	0	1	1	1	0	1
62.00	16128	1	1	1	1	0	1	1	1	1	0
61.97	16136	1	1	1	1	0	1	1	1	1	1
61.94	16144	1	1	1	1	1	0	0	0	0	0
61.91	16152	1	1	1	1	1	0	0	0	0	1
61.88	16160	1	1	1	1	1	0	0	0	1	0
61.85	16168	1	1	1	1	1	0	0	0	1	1
61.82	16176	1	1	1	1	1	0	0	1	0	0
61.79	16184	1	1	1	1	1	0	0	1	0	1

TABLE V - PLUG SWITCH SETTINGS - 70 HERTZ (Continued)

APPROX. SETPOINT FREQUENCY (Hz)	EXACT PERIOD (MICROSECONDS)	SWITCH SETTINGS									
		4096	2048	1024	512	256	128	64	32	16	8
61.76	16192	1	1	1	1	1	0	0	1	1	0
61.73	16200	1	1	1	1	1	0	0	1	1	1
61.70	16208	1	1	1	1	1	0	1	0	0	0
61.67	16216	1	1	1	1	1	0	1	0	0	1
61.64	16224	1	1	1	1	1	0	1	0	1	0
61.61	16232	1	1	1	1	1	0	1	0	1	1
61.58	16240	1	1	1	1	1	0	1	1	0	0
61.55	16248	1	1	1	1	1	0	1	1	0	1
61.52	16256	1	1	1	1	1	0	1	1	1	0
61.49	16264	1	1	1	1	1	0	1	1	1	1
61.46	16272	1	1	1	1	1	1	0	0	0	0
61.43	16280	1	1	1	1	1	1	0	0	0	1
61.40	16288	1	1	1	1	1	1	0	0	1	0
61.37	16296	1	1	1	1	1	1	0	0	1	1
61.34	16304	1	1	1	1	1	1	0	1	0	0
61.31	16312	1	1	1	1	1	1	0	1	0	1
61.28	16320	1	1	1	1	1	1	0	1	1	0
61.24	16328	1	1	1	1	1	1	0	1	1	1
61.21	16336	1	1	1	1	1	1	1	0	0	0
61.19	16344	1	1	1	1	1	1	1	0	0	1
61.16	16352	1	1	1	1	1	1	1	0	1	0
61.13	16360	1	1	1	1	1	1	1	0	1	1
61.09	16368	1	1	1	1	1	1	1	1	0	0
61.06	16376	1	1	1	1	1	1	1	1	0	1
61.04	16384	1	1	1	1	1	1	1	1	1	0
61.01	16392	1	1	1	1	1	1	1	1	1	1

TABLE VI - PLUG SWITCH SETTINGS - 60 Hertz

APPROX. SETPOINT FREQUENCY (Hz)	EXACT PERIOD (MICROSECONDS)	SWITCH SETTINGS									
		4096	2048	1024	512	256	128	64	32	16	8
60.98	16400	0	0	0	0	0	0	0	0	0	0
60.038	16656	0	0	0	0	1	0	0	0	0	0
60.01	16664	0	0	0	0	1	0	0	0	0	1
59.98	16672	0	0	0	0	1	0	0	0	1	0
59.95	16680	0	0	0	0	1	0	0	0	1	1
59.92	16688	0	0	0	0	1	0	0	1	0	0
59.89	16696	0	0	0	0	1	0	0	1	0	1
59.87	16704	0	0	0	0	1	0	0	1	1	0
59.84	16712	0	0	0	0	1	0	0	1	1	1
59.81	16720	0	0	0	0	1	0	1	0	0	0
59.78	16728	0	0	0	0	1	0	1	0	0	1
59.75	16736	0	0	0	0	1	0	1	0	1	0
59.72	16744	0	0	0	0	1	0	1	0	1	1
59.69	16752	0	0	0	0	1	0	1	1	0	0
59.67	16760	0	0	0	0	1	0	1	1	0	1
59.64	16768	0	0	0	0	1	0	1	1	1	0
59.61	16776	0	0	0	0	1	0	1	1	1	1
59.58	16784	0	0	0	0	1	1	0	0	0	0
59.55	16792	0	0	0	0	1	1	0	0	0	1
59.52	16800	0	0	0	0	1	1	0	0	1	0
59.50	16808	0	0	0	0	1	1	0	0	1	1
59.47	16816	0	0	0	0	1	1	0	1	0	0
59.44	16824	0	0	0	0	1	1	0	1	0	1
59.41	16832	0	0	0	0	1	1	0	1	1	0
59.38	16840	0	0	0	0	1	1	0	1	1	1
59.35	16848	0	0	0	0	1	1	1	0	0	0
59.33	16856	0	0	0	0	1	1	1	0	0	1
59.30	16864	0	0	0	0	1	1	1	0	1	0
59.27	16872	0	0	0	0	1	1	1	0	1	1
59.24	16880	0	0	0	0	1	1	1	1	0	0
59.21	16888	0	0	0	0	1	1	1	1	0	1
59.19	16896	0	0	0	0	1	1	1	1	1	0
59.16	16904	0	0	0	0	1	1	1	1	1	1
59.13	16912	0	0	0	1	0	0	0	0	0	0
59.10	16920	0	0	0	1	0	0	0	0	0	1
59.07	16928	0	0	0	1	0	0	0	0	1	0
59.05	16936	0	0	0	1	0	0	0	0	1	1
59.02	16944	0	0	0	1	0	0	0	1	0	0
58.99	16952	0	0	0	1	0	0	0	1	0	1
58.96	16960	0	0	0	1	0	0	0	1	1	0
58.93	16968	0	0	0	1	0	0	0	1	1	1
58.91	16976	0	0	0	1	0	0	1	0	0	0
58.88	16984	0	0	0	1	0	0	1	0	0	1
58.85	16992	0	0	0	1	0	0	1	0	1	0

TABLE VI - PLUG SWITCH SETTINGS - 60 Hertz (Continued)

APPROX. SETPOINT FREQUENCY (Hz)	EXACT PERIOD (MICROSECONDS)	SWITCH SETTINGS									
		4096	2048	1024	512	256	128	64	32	16	8
58.82	17000	0	0	0	1	0	0	1	0	1	1
58.80	17008	0	0	0	1	0	0	1	1	0	0
58.77	17016	0	0	0	1	0	0	1	1	0	1
58.74	17024	0	0	0	1	0	0	1	1	1	0
58.71	17032	0	0	0	1	0	0	1	1	1	1
58.69	17040	0	0	0	1	0	1	0	0	0	0
58.66	17048	0	0	0	1	0	1	0	0	0	1
58.63	17056	0	0	0	1	0	1	0	0	1	0
58.60	17064	0	0	0	1	0	1	0	0	1	1
58.58	17072	0	0	0	1	0	1	0	1	0	0
58.55	17080	0	0	0	1	0	1	0	1	0	1
58.52	17088	0	0	0	1	0	1	0	1	1	0
58.49	17096	0	0	0	1	0	1	0	1	1	1
58.47	17104	0	0	0	1	0	1	1	0	0	0
58.44	17112	0	0	0	1	0	1	1	0	0	1
58.41	17120	0	0	0	1	0	1	1	0	1	0
58.38	17128	0	0	0	1	0	1	1	0	1	1
58.36	17136	0	0	0	1	0	1	1	1	0	0
58.33	17144	0	0	0	1	0	1	1	1	0	1
58.30	17152	0	0	0	1	0	1	1	1	1	0
58.28	17160	0	0	0	1	0	1	1	1	1	1
58.25	17168	0	0	0	1	1	0	0	0	0	0
58.22	17176	0	0	0	1	1	0	0	0	0	1
58.19	17184	0	0	0	1	1	0	0	0	1	0
58.17	17192	0	0	0	1	1	0	0	0	1	1
58.14	17200	0	0	0	1	1	0	0	1	0	0
58.11	17208	0	0	0	1	1	0	0	1	0	1
58.09	17216	0	0	0	1	1	0	0	1	1	0
58.06	17224	0	0	0	1	1	0	0	1	1	1
58.03	17232	0	0	0	1	1	0	1	0	0	0
58.00	17240	0	0	0	1	1	0	1	0	0	1
57.00	17544	0	0	1	0	0	0	1	1	1	1
56.00	17856	0	0	1	0	1	1	0	1	1	0
55.02	18176	0	0	1	1	0	1	1	1	1	0
54.00	18520	0	1	0	0	0	0	1	0	0	1

TABLE VII PLUG SWITCH SETTINGS - 50 Hertz

APPROX. SETPOINT FREQUENCY (Hz)	EXACT PERIOD (MICROSECONDS)	SWITCH SETTINGS									
		4096	2048	1024	512	256	128	64	32	16	8
53.01	18864	0	1	0	0	1	0	0	1	0	0
52.00	19232	0	1	0	1	1	0	0	0	1	0
51.00	19608	0	1	1	0	0	1	0	0	0	1
50.00	20000	0	1	1	1	0	0	0	0	1	0
49.98	20008	0	1	1	1	0	0	0	0	1	1
49.96	20016	0	1	1	1	0	0	0	1	0	0
49.94	20024	0	1	1	1	0	0	0	1	0	1
49.92	20032	0	1	1	1	0	0	0	1	1	0
49.90	20040	0	1	1	1	0	0	0	1	1	1
49.88	20048	0	1	1	1	0	0	1	0	0	0
49.86	20056	0	1	1	1	0	0	1	0	0	1
49.84	20064	0	1	1	1	0	0	1	0	1	0
49.82	20072	0	1	1	1	0	0	1	0	1	1
49.80	20080	0	1	1	1	0	0	1	1	0	0
49.78	20088	0	1	1	1	0	0	1	1	0	1
49.76	20096	0	1	1	1	0	0	1	1	1	0
49.74	20104	0	1	1	1	0	0	1	1	1	1
49.72	20112	0	1	1	1	0	1	0	0	0	0
49.70	20120	0	1	1	1	0	1	0	0	0	1
49.68	20128	0	1	1	1	0	1	0	0	1	0
49.66	20136	0	1	1	1	0	1	0	0	1	1
49.64	20144	0	1	1	1	0	1	0	1	0	0
49.62	20152	0	1	1	1	0	1	0	1	0	1
49.60	20160	0	1	1	1	0	1	0	1	1	0
49.58	20168	0	1	1	1	0	1	0	1	1	1
49.56	20176	0	1	1	1	0	1	1	0	0	0
49.54	20184	0	1	1	1	0	1	1	0	0	1
49.53	20192	0	1	1	1	0	1	1	0	1	0
49.51	20200	0	1	1	1	0	1	1	0	1	1
49.49	20208	0	1	1	1	0	1	1	1	0	0
49.47	20216	0	1	1	1	0	1	1	1	0	1
49.45	20224	0	1	1	1	0	1	1	1	1	0
49.43	20232	0	1	1	1	0	1	1	1	1	1
49.41	20240	0	1	1	1	1	0	0	0	0	0
49.39	20248	0	1	1	1	1	0	0	0	0	1
49.37	20256	0	1	1	1	1	0	0	0	1	0
49.35	20264	0	1	1	1	1	0	0	0	1	1
49.33	20272	0	1	1	1	1	0	0	1	0	0
49.31	20280	0	1	1	1	1	0	0	1	0	1

TABLE VII PLUG SWITCH SETTINGS - 50 Hertz (Continued)

APPROX. SETPOINT FREQUENCY (Hz)	EXACT PERIOD (MICROSECONDS)	SWITCH SETTINGS									
		4096	2048	1024	512	256	128	64	32	16	8
49.29	20288	0	1	1	1	1	0	0	1	1	0
49.27	20296	0	1	1	1	1	0	0	1	1	1
49.25	20304	0	1	1	1	1	0	1	0	0	0
49.23	20312	0	1	1	1	1	0	1	0	0	1
49.21	20320	0	1	1	1	1	0	1	0	1	0
49.19	20328	0	1	1	1	1	0	1	0	1	1
49.17	20336	0	1	1	1	1	0	1	1	0	0
49.16	20344	0	1	1	1	1	0	1	1	0	1
49.14	20352	0	1	1	1	1	0	1	1	1	0
49.12	20360	0	1	1	1	1	0	1	1	1	1
49.10	20368	0	1	1	1	1	1	0	0	0	0
49.08	20376	0	1	1	1	1	1	0	0	0	1
49.06	20384	0	1	1	1	1	1	0	0	1	0
49.04	20392	0	1	1	1	1	1	0	0	1	1
49.02	20400	0	1	1	1	1	1	0	1	0	0
49.00	20408	0	1	1	1	1	1	0	1	0	1
48.98	20416	0	1	1	1	1	1	0	1	1	0
48.96	20424	0	1	1	1	1	1	0	1	1	1
48.94	20432	0	1	1	1	1	1	1	0	0	0
48.92	20440	0	1	1	1	1	1	1	0	0	1
48.91	20448	0	1	1	1	1	1	1	0	1	0
48.89	20456	0	1	1	1	1	1	1	0	1	1
48.87	20464	0	1	1	1	1	1	1	1	0	0
48.85	20472	0	1	1	1	1	1	1	1	0	1
48.83	20480	0	1	1	1	1	1	1	1	1	0
48.81	20488	0	1	1	1	1	1	1	1	1	1
48.79	20496	1	0	0	0	0	0	0	0	0	0
48.77	20504	1	0	0	0	0	0	0	0	0	1
48.75	20512	1	0	0	0	0	0	0	0	1	0
48.73	20520	1	0	0	0	0	0	0	0	1	1
48.71	20528	1	0	0	0	0	0	0	1	0	0
48.70	20536	1	0	0	0	0	0	0	1	0	1
48.68	20544	1	0	0	0	0	0	0	1	1	0
48.66	20552	1	0	0	0	0	0	0	1	1	1
48.00	20832	1	0	0	0	1	0	1	0	1	0
47.00	21280	1	0	0	1	1	0	0	0	1	0
46.00	21736	1	0	1	0	0	1	1	0	1	1
45.00	22224	1	0	1	1	0	1	1	0	0	0
44.00	22728	1	1	0	0	0	1	0	1	1	1

LIST OF ILLUSTRATIONS

FIGURE

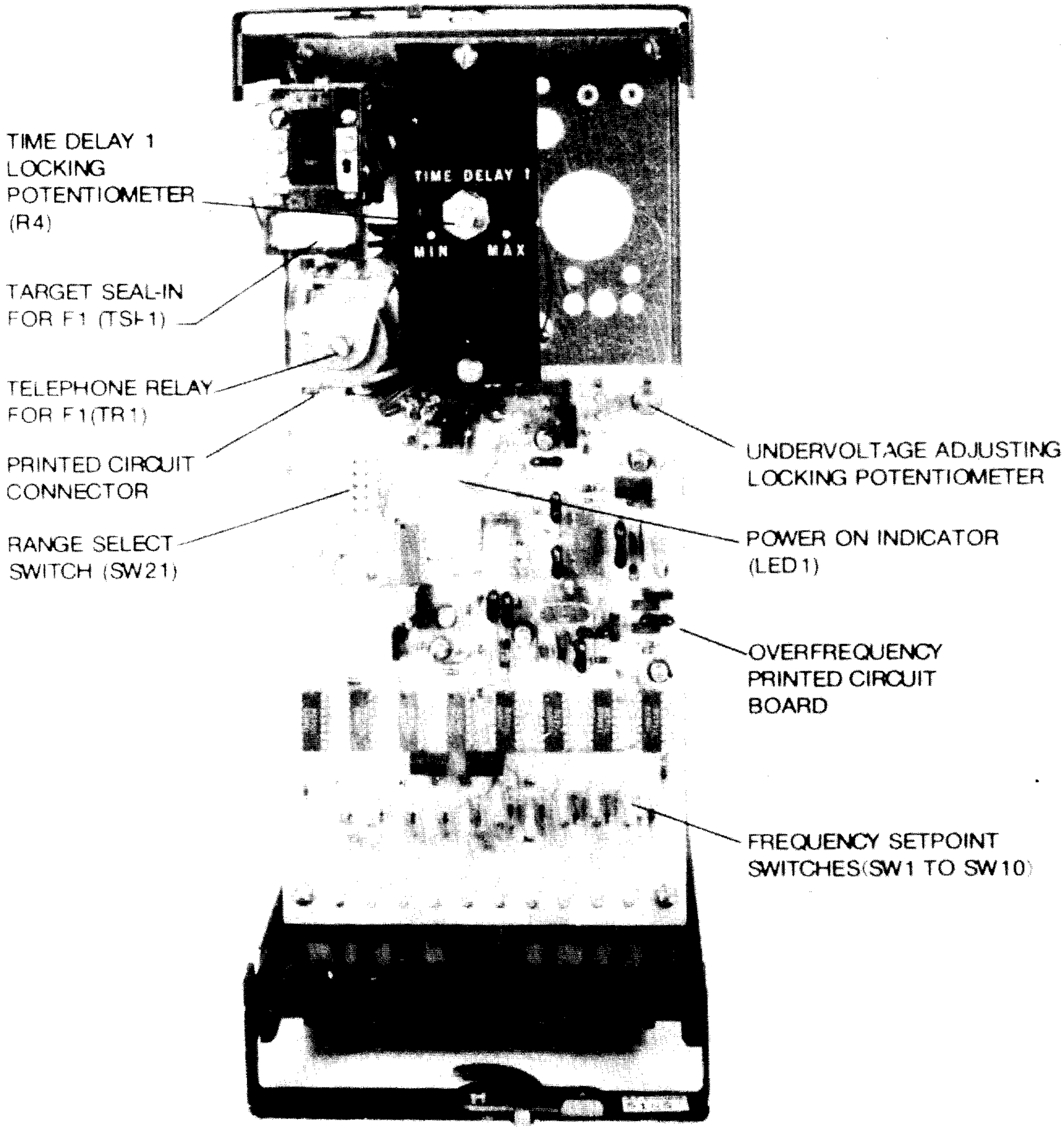


Figure 1 (8043599) SFF33A Front View - Removed from Case

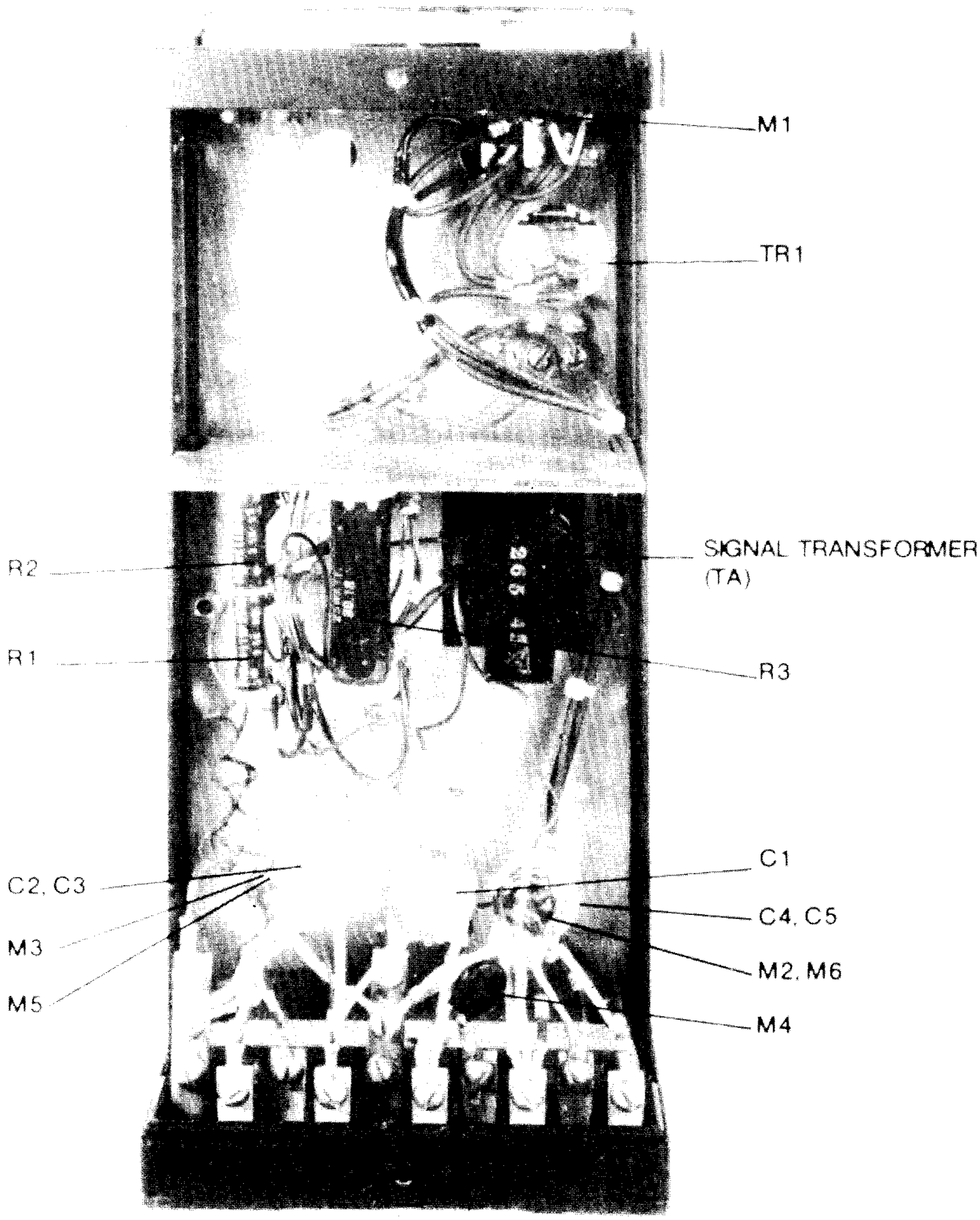


Figure 2 (8043600) SFF33A Rear View - Removed from Case

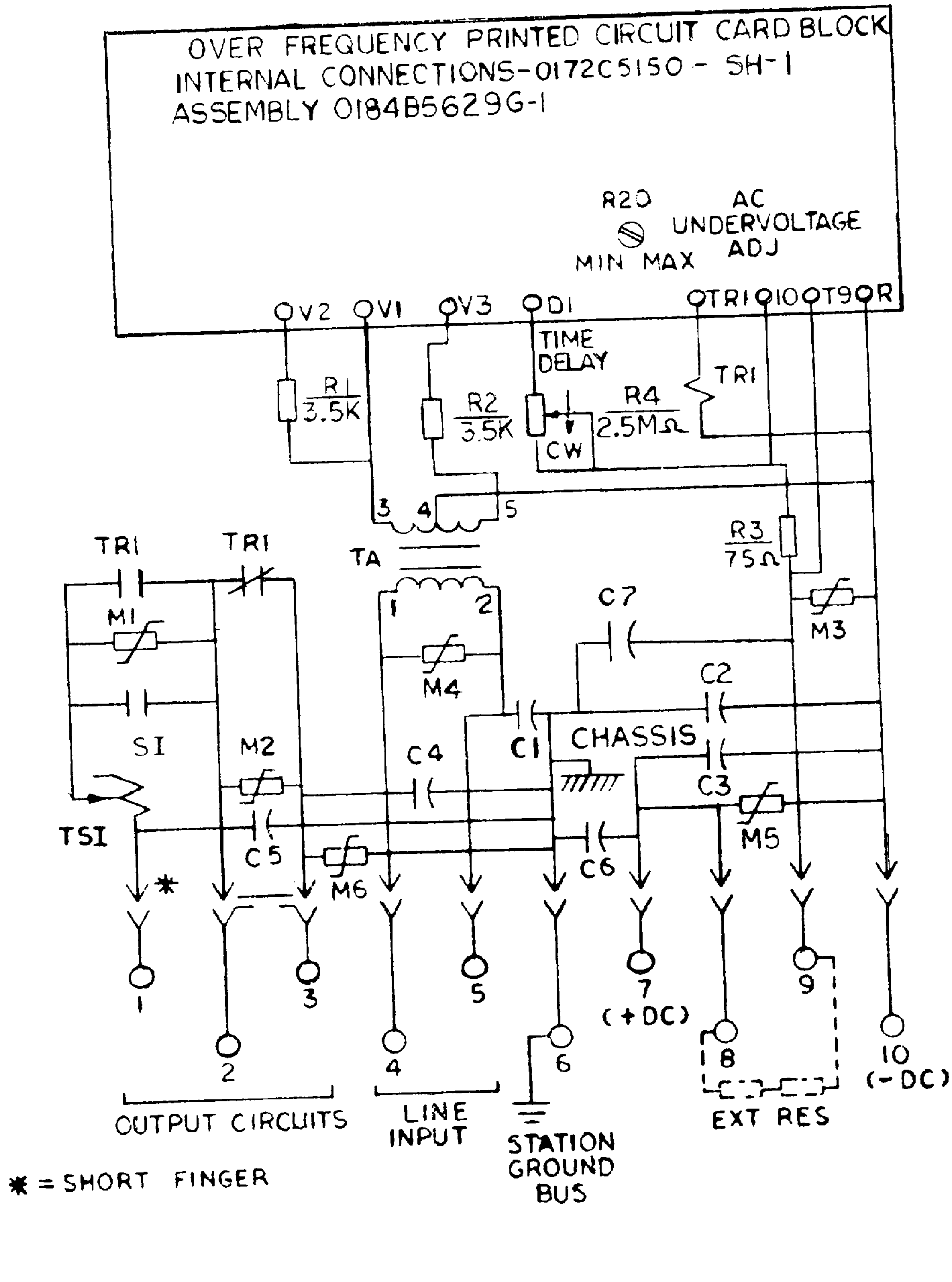


Figure 3A (0275A4487-2) SFF33A Internal Connections - Front View

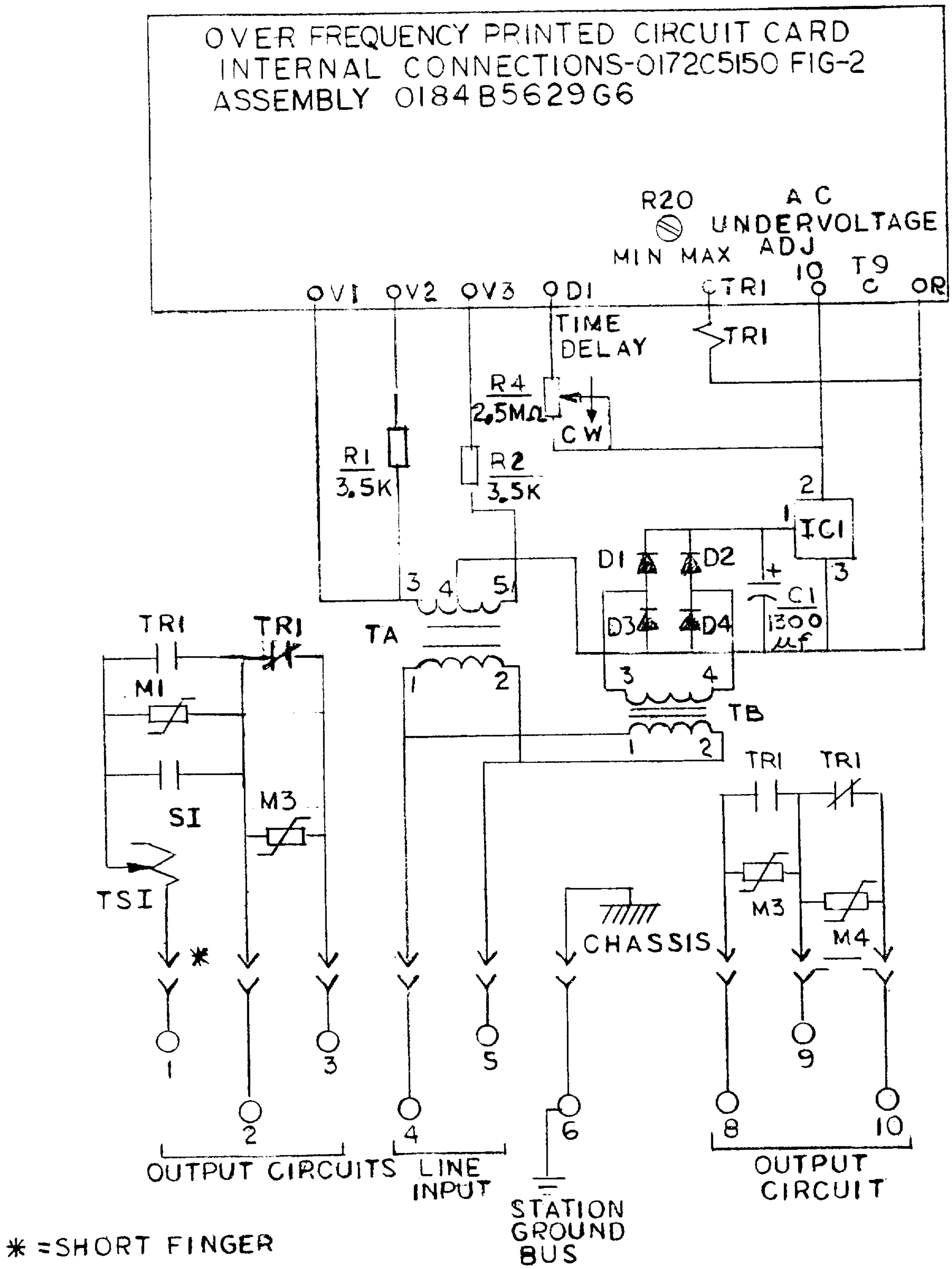
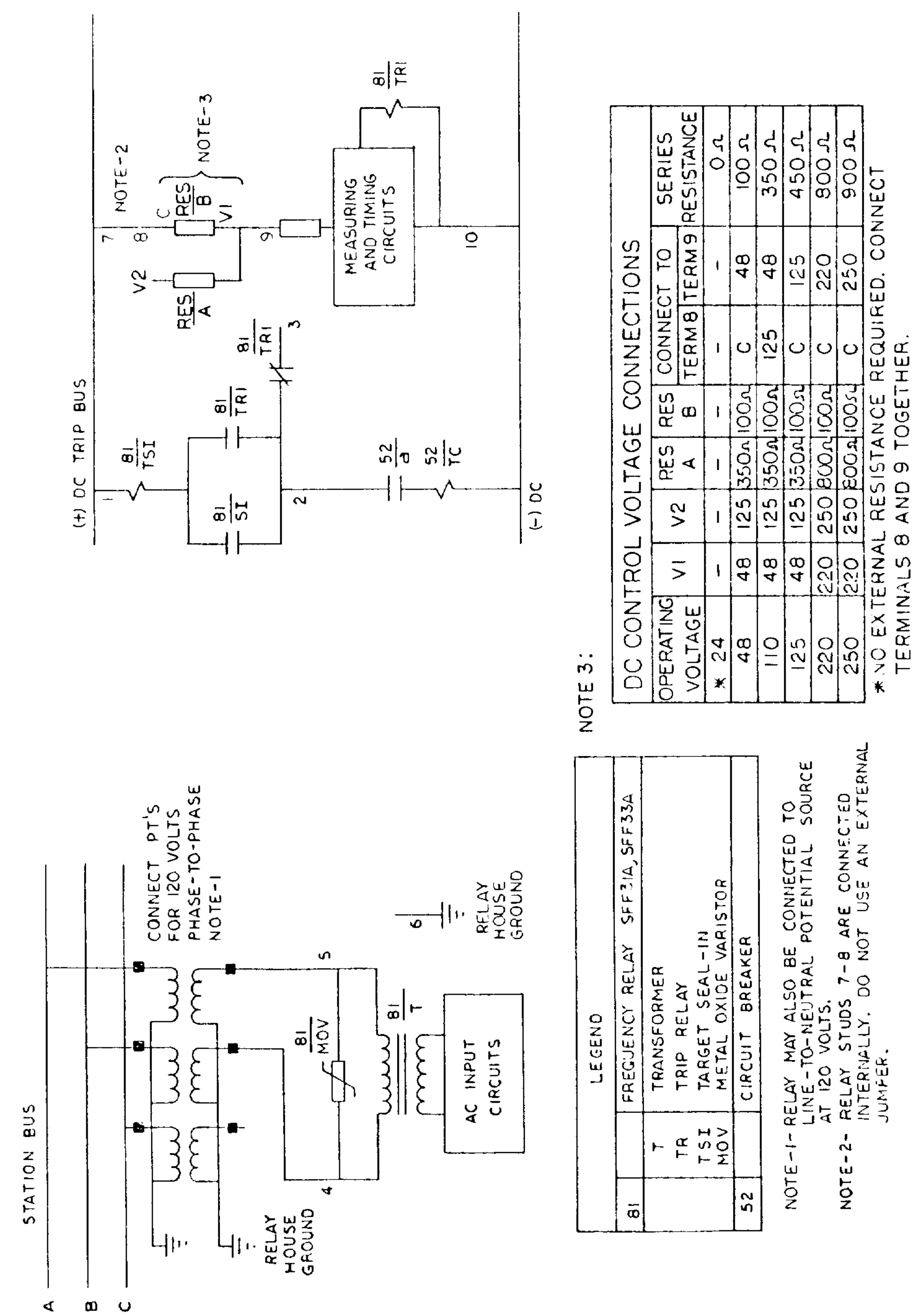


Figure 3B (0285A8124-0) SFF33C Internal Connections - Front View



DC CONTROL VOLTAGE CONNECTIONS

OPERATING VOLTAGE	V1	V2	RES A	RES B	CONNECT TO TERM8	CONNECT TO TERM9	SERIES RESISTANCE
* 24	-	-	-	-	-	-	0 Ω
48	48	125	350Ω	100Ω	C	48	100 Ω
110	48	125	350Ω	100Ω	125	48	350 Ω
125	48	125	350Ω	100Ω	C	125	450 Ω
220	220	250	800Ω	100Ω	C	220	800 Ω
250	220	250	800Ω	100Ω	C	250	900 Ω

* NO EXTERNAL RESISTANCE REQUIRED. CONNECT TERMINALS 8 AND 9 TOGETHER.

LEGEND

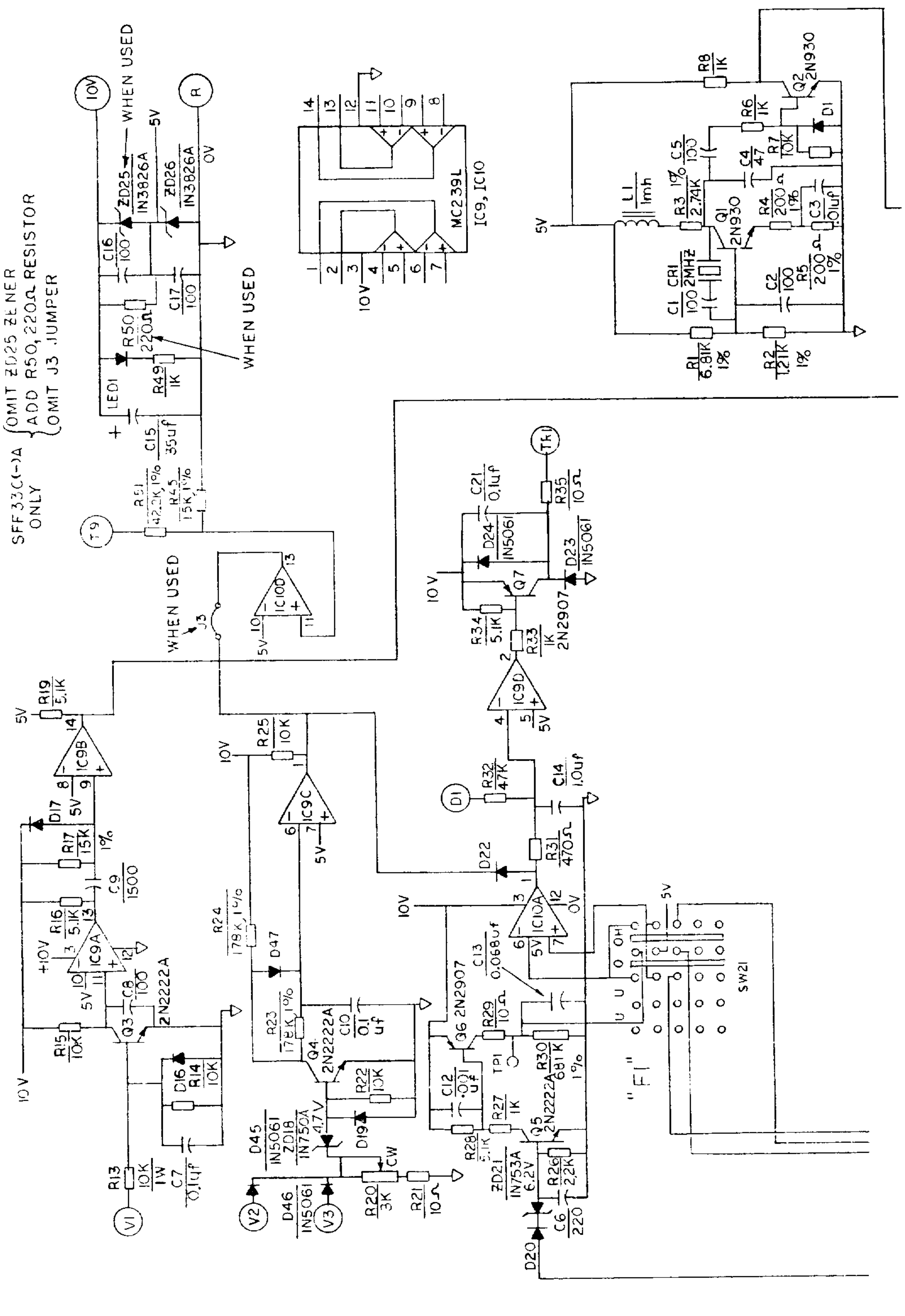
81		FREQUENCY RELAY SFF31A, SFF33A
	T	TRANSFORMER
	TR	TRIP RELAY
	TSI	TARGET SEAL-IN
	MOV	METAL OXIDE VARISTOR
52		CIRCUIT BREAKER

NOTE-1- RELAY MAY ALSO BE CONNECTED TO LINE-TO-NEUTRAL POTENTIAL SOURCE AT 120 VOLTS.

NOTE-2- RELAY STUDS 7-8 ARE CONNECTED INTERNALLY. DO NOT USE AN EXTERNAL JUMPER.

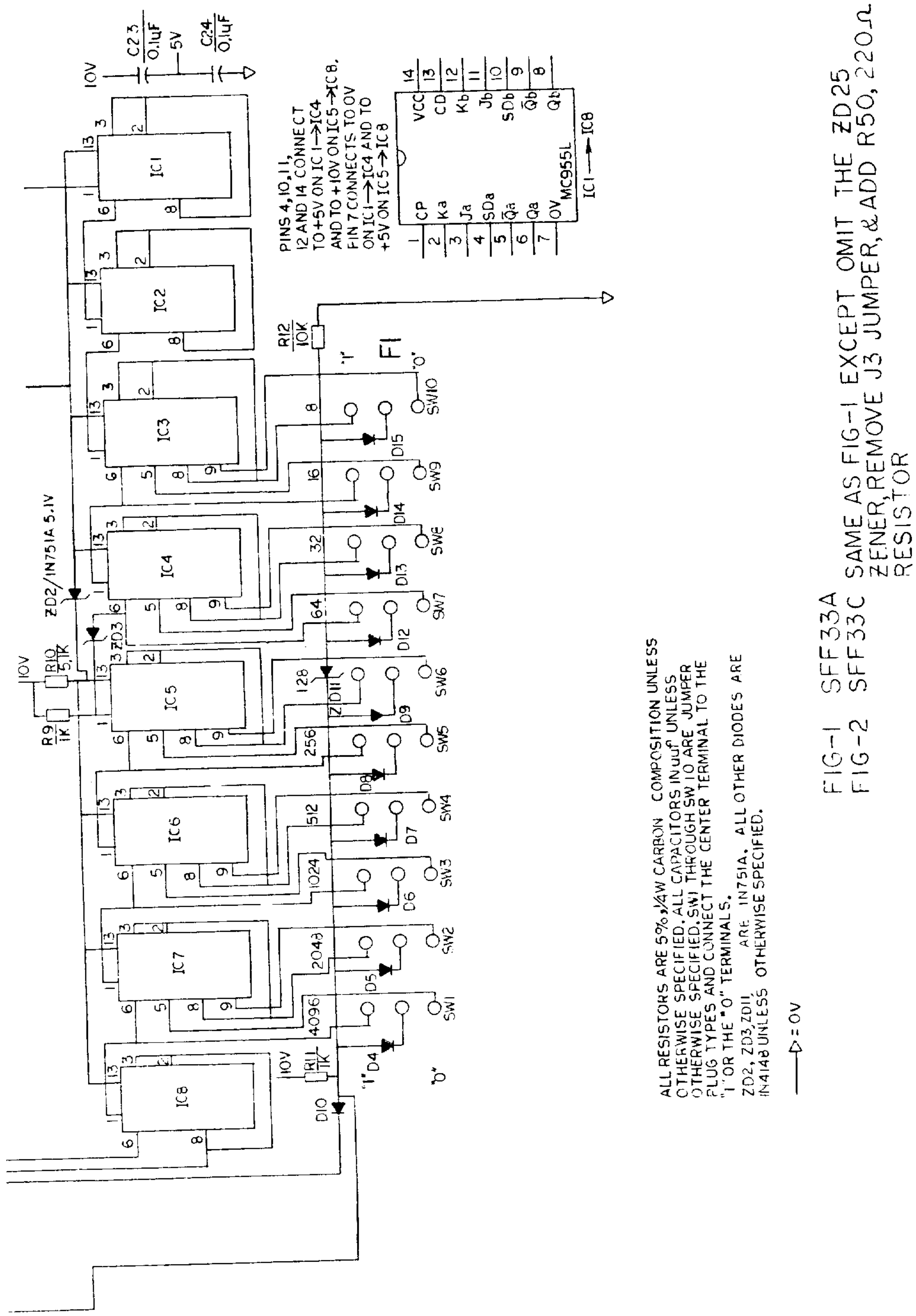
* Figure 4 (0108B9171 Sh. 1 [4]) SFF33A External Connections

* Revised since last issue



* Figure 5A (0172C5150 Sh. 1 [3]) SFF33A,C Overfrequency Board - Internal Connections

* Revised since last issue



* Figure 5B (0172C5150 Sh. 1 [3] continued) SFF33A,C Overfrequency Board - Internal Connections

* Revised since last issue

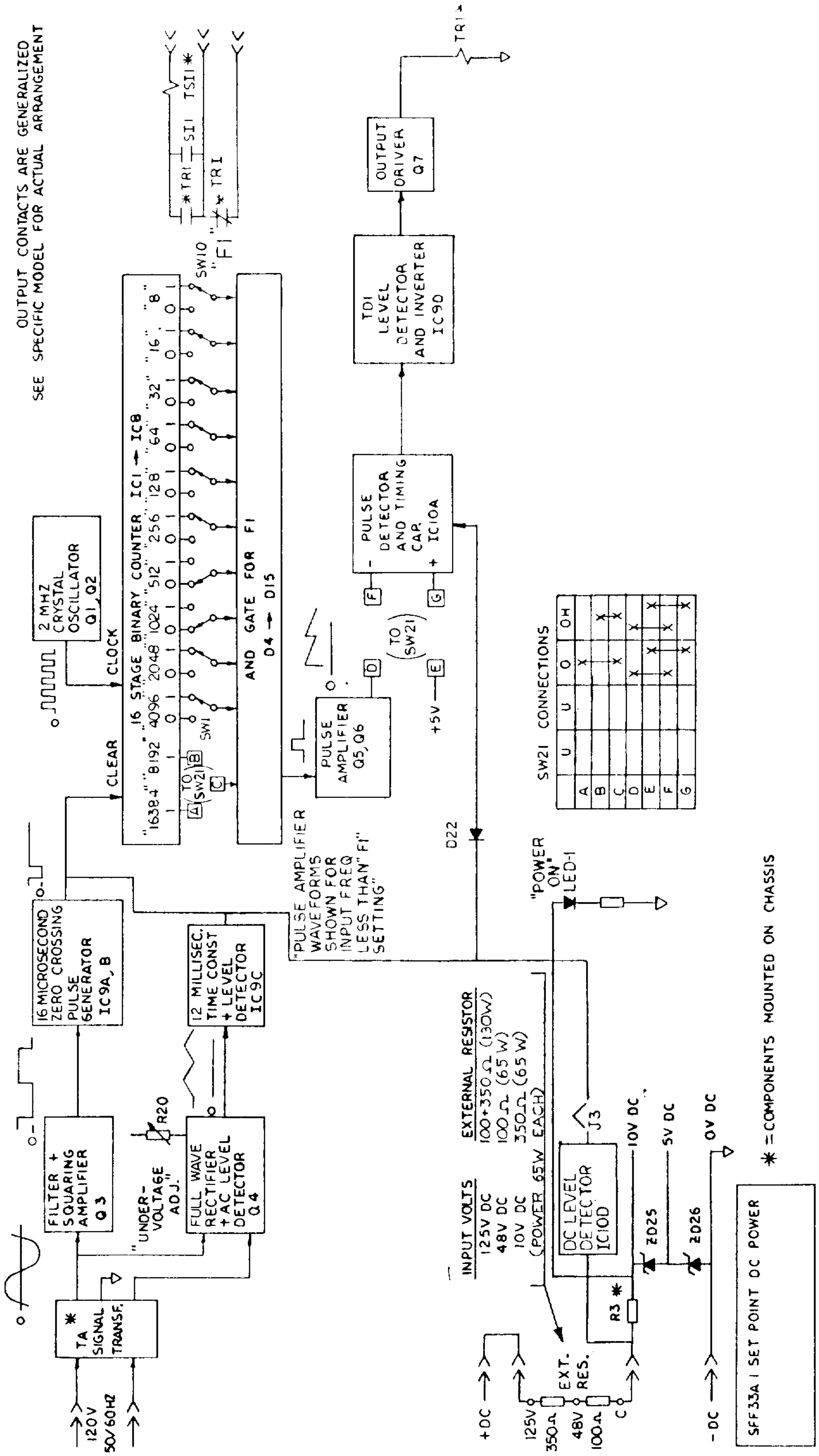


*Figure 6 (0108B9170-3, Sh. [4]) SFF Block Diagram

* Revised since last issue

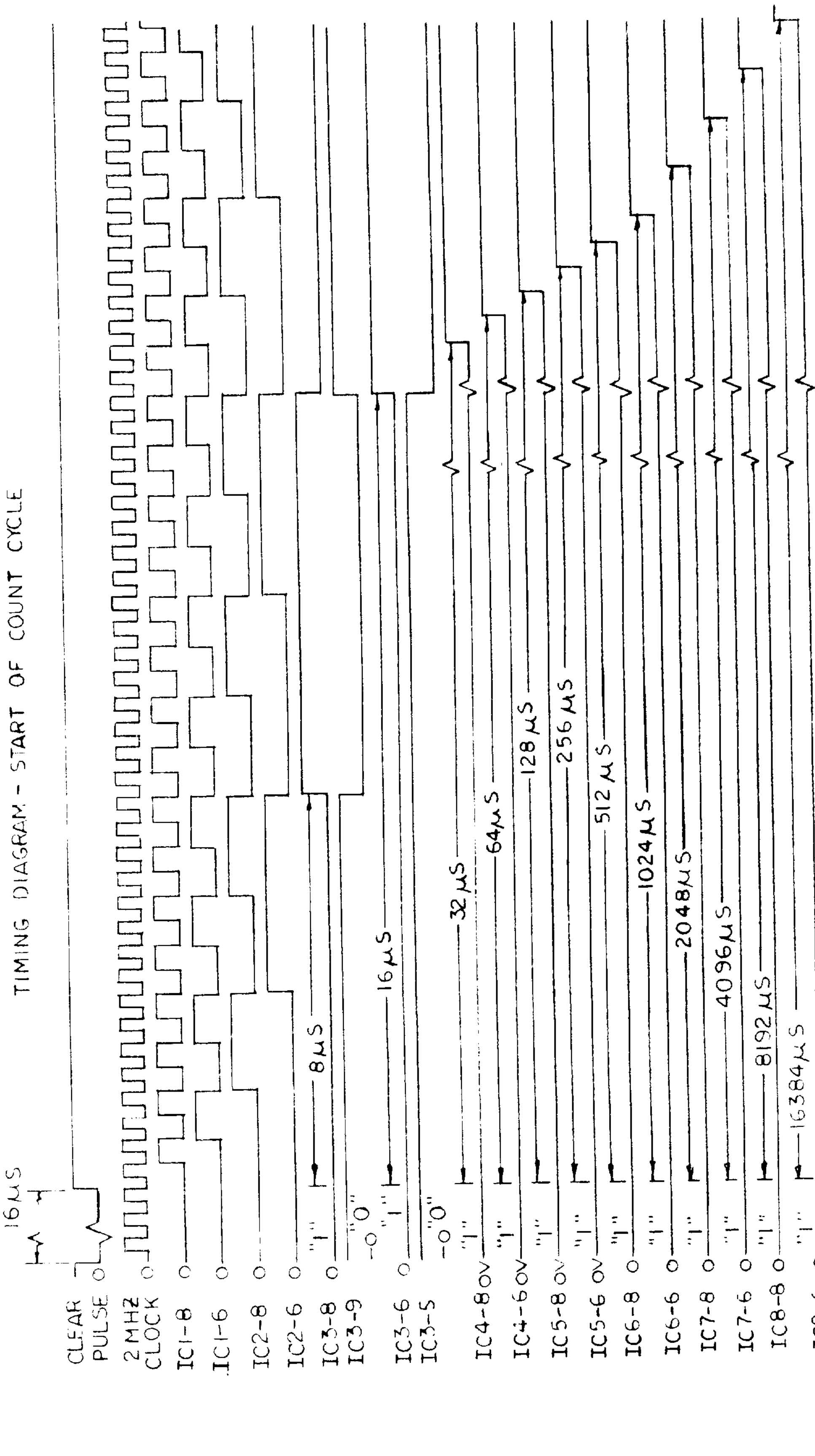


Figure 7 (0273A9562-0) Timing Diagram - Start of Count Cycle

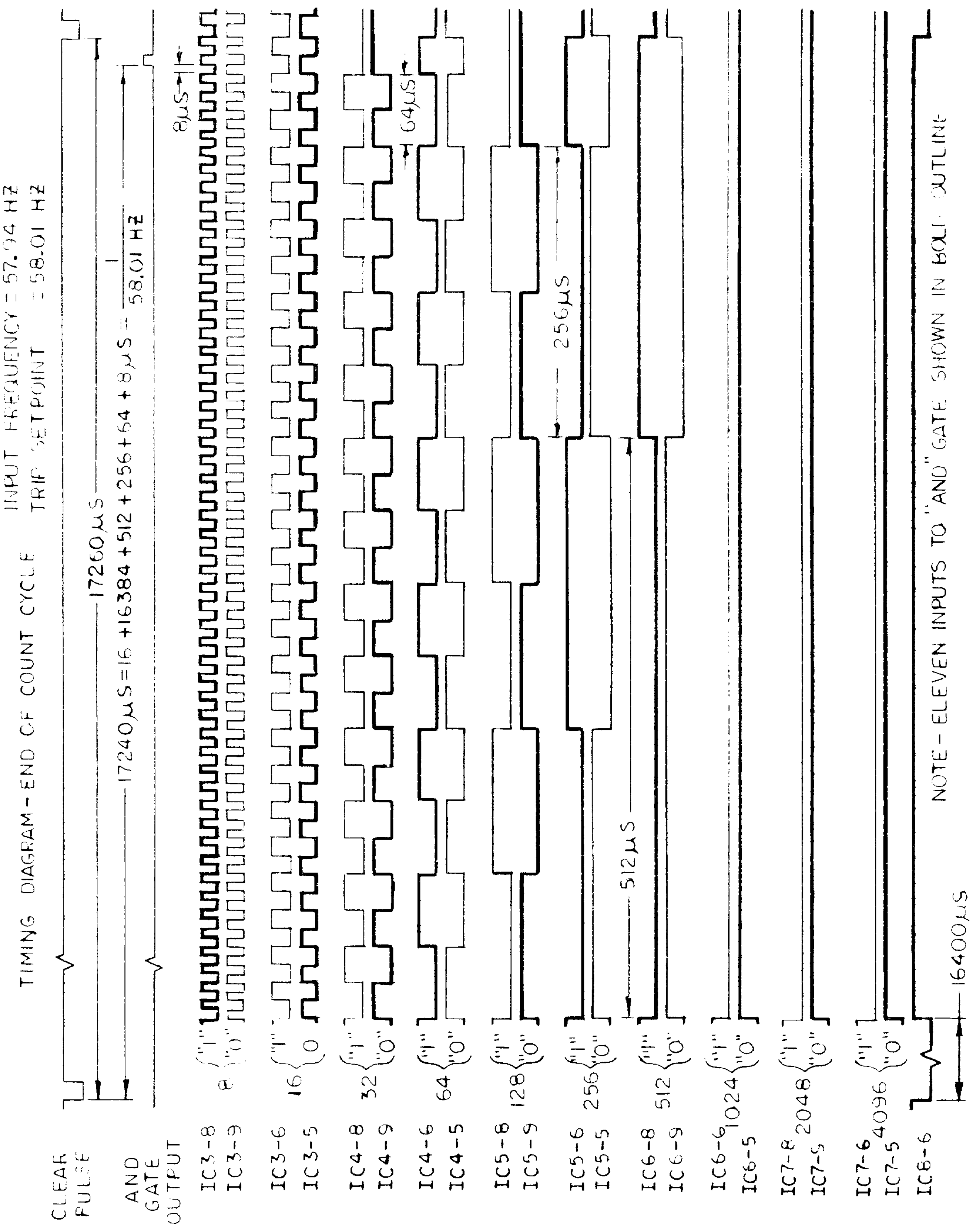
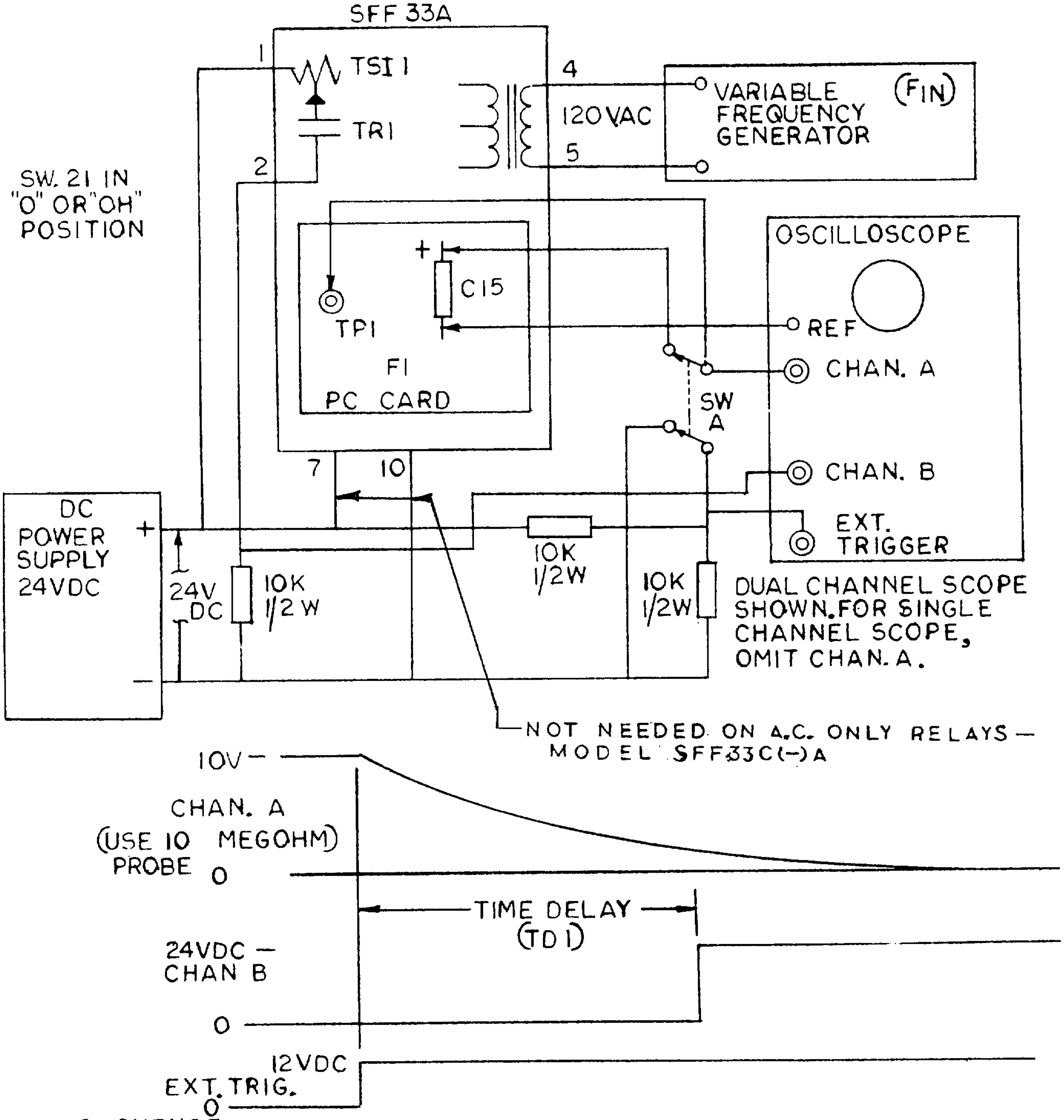


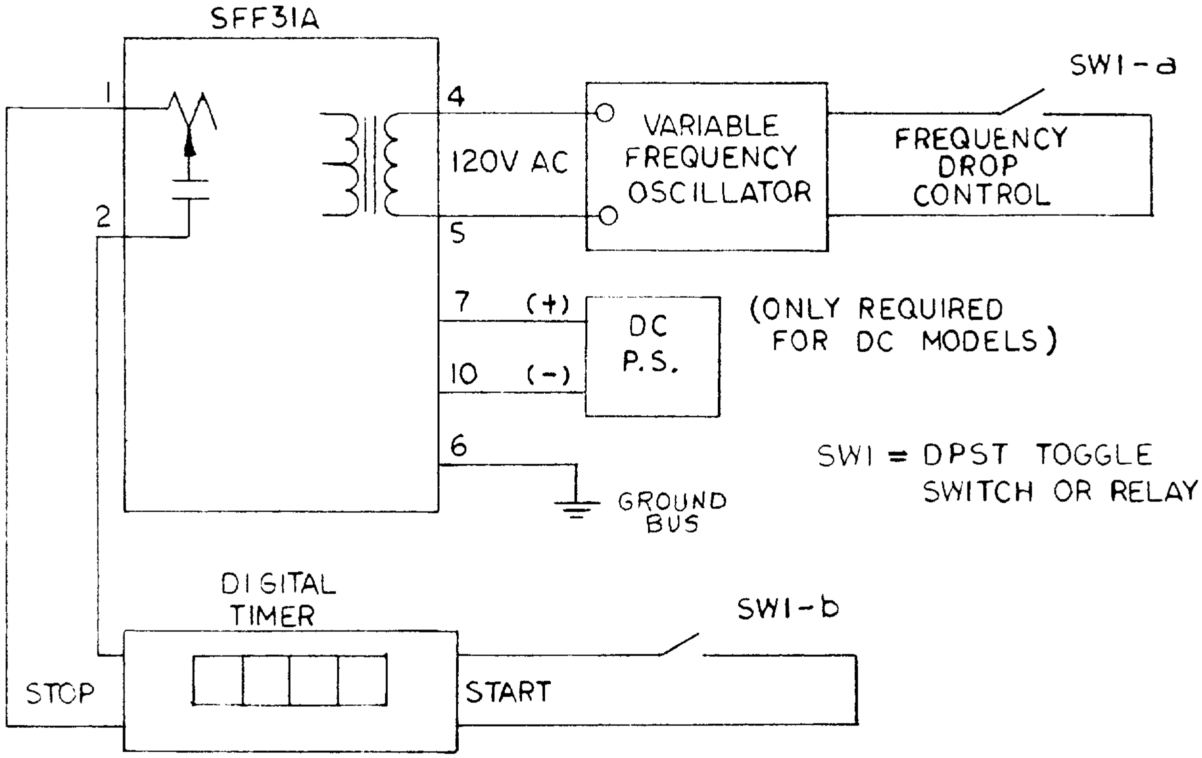
Figure 8 (0273A9563-0) Timing Diagram - End of Count Cycle



TEST SEQUENCE

1-SET INPUT FREQUENCY (FIN) ABOVE RELAY SETPOINT (F1).
2-RESET SCOPE TRIGGER AND OPEN SW A.
3-MEASURE TIME DELAY (TD1) AS SHOWN.

Figure 9 (0273A9564 Sh. 2 -3) Recommended Time-delay Calibration Test Connection



TEST SEQUENCE

1- SET INPUT FREQUENCY ≈0.10 HZ ABOVE SETPOINT (SW1 OPEN).
2- CLOSE SW1 CAUSING VARIABLE FREQUENCY OSCILLATOR TO DROP FREQUENCY BELOW SETPOINT.
3- MEASURE TIME DELAY RECORDED ON DIGITAL TIMER.

* Figure 10 (0273A9580-1) Typical Time-delay Test

* Revised since last issue

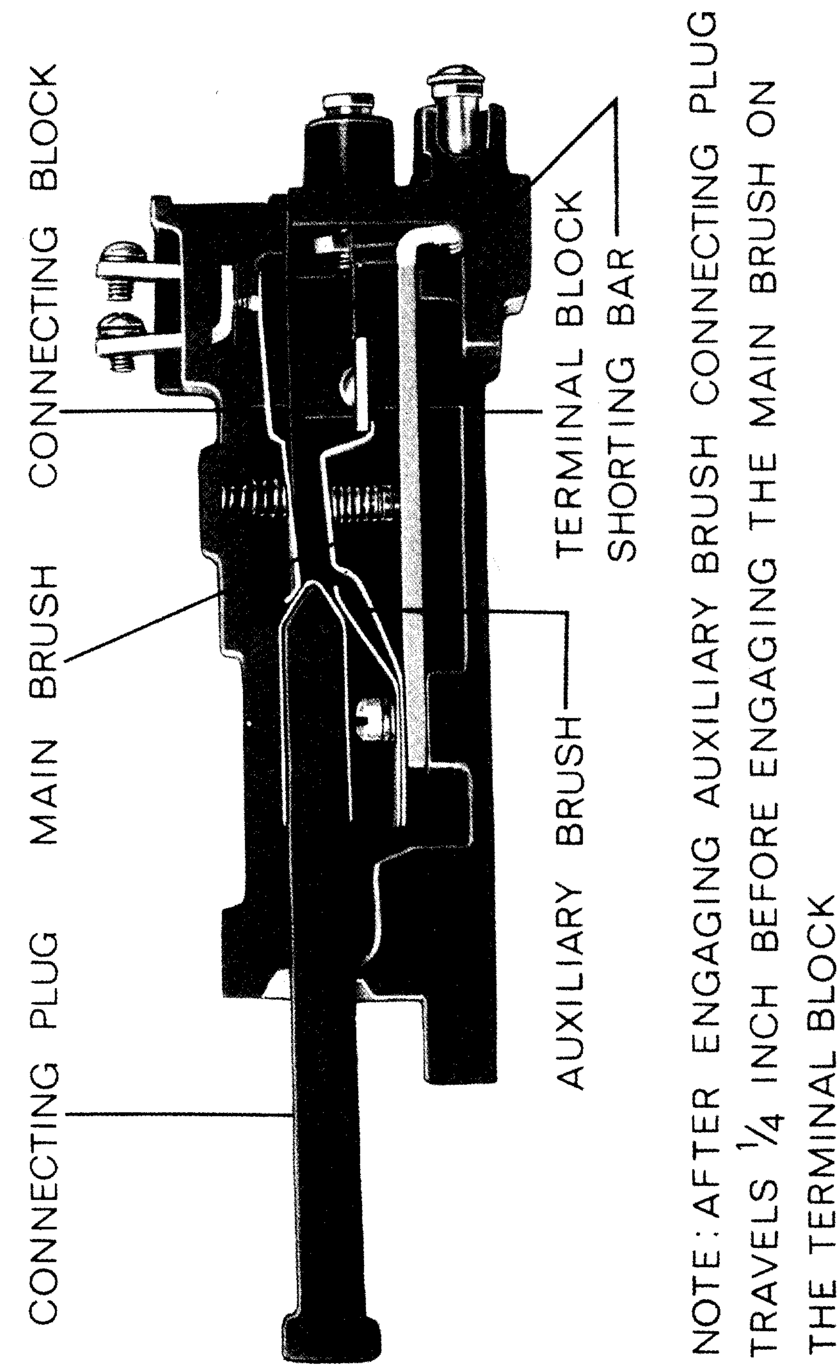
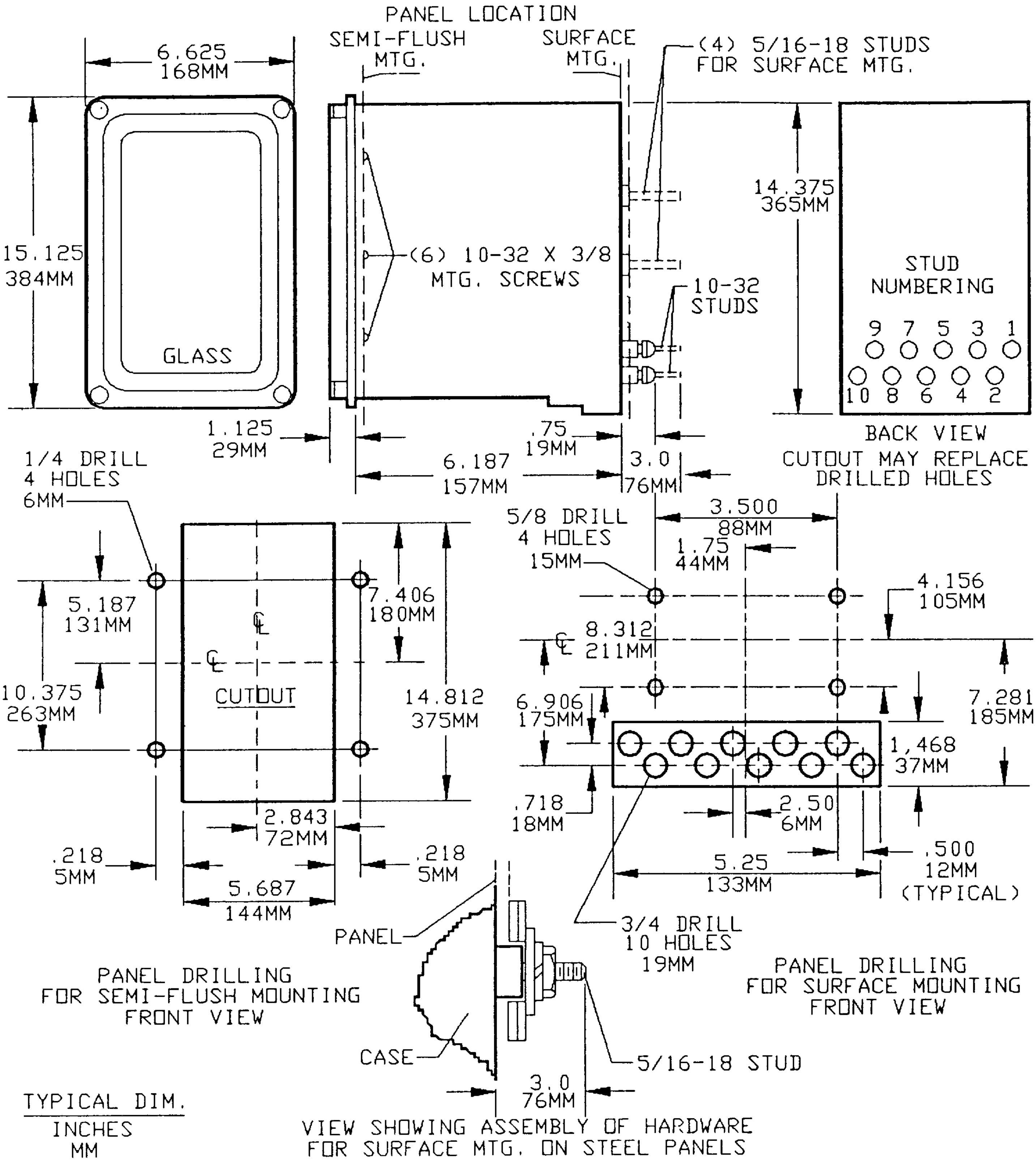
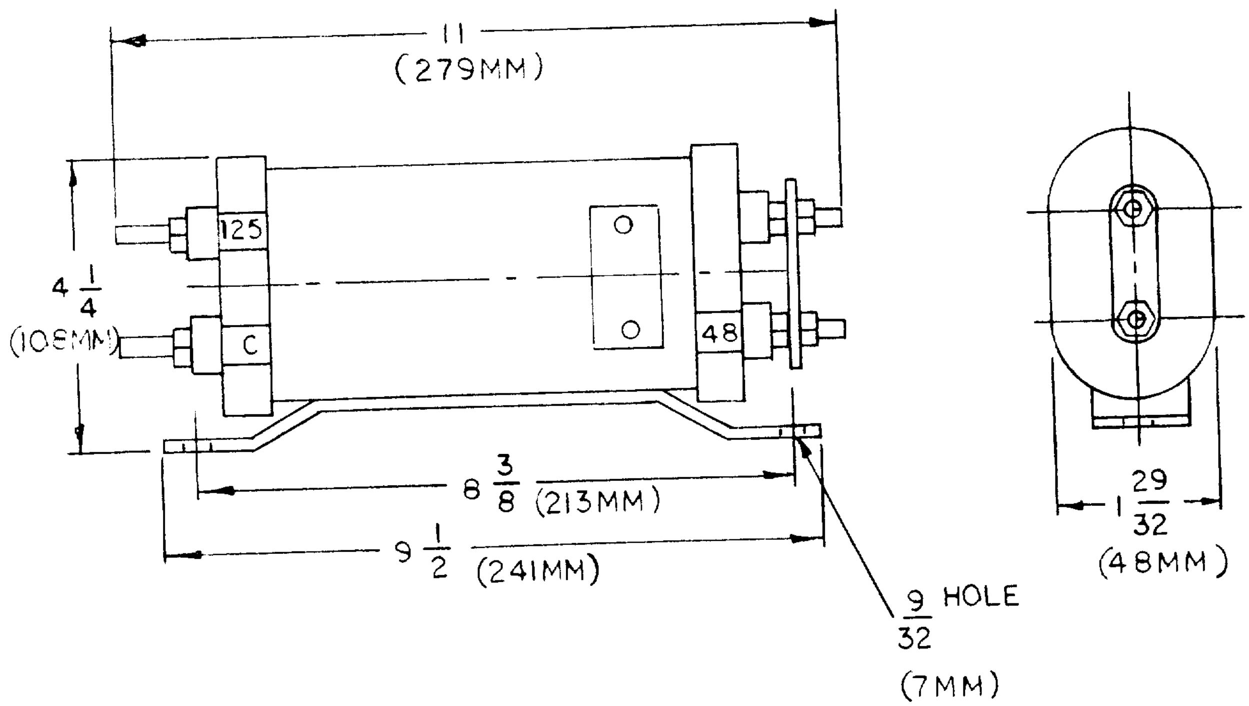


Figure 11 (8025039) Drawout Case - Contact Assembly



* Figure 12 (K6209273-5) Outline and Panel Drilling - M1 Case

* Revised since last issue



* Figure 13 (0273A9565 Sh.1[1]) Outline for External Resistor

* Revised since last issue

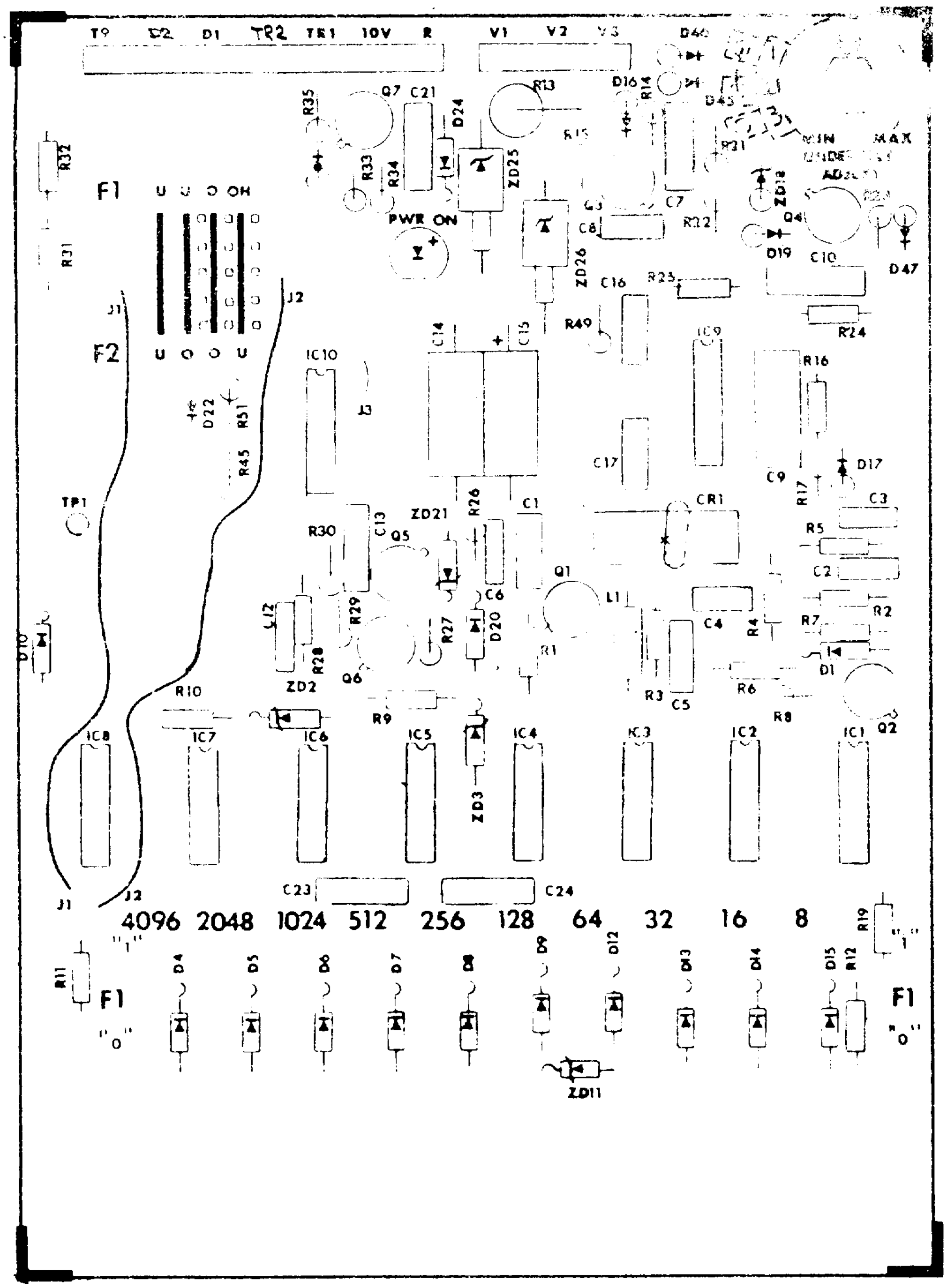


Figure 14 (0273A9590 Sh. 3 -1) Frequency Board Assembly

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