Type MDF Microprocessor Frequency Relay

Effective: May 1992
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(|)Denotes Change Since Previous Issue

CAUTION

It is recommended that the user of this equipment become acquainted with information in this instruction leaflet before energizing the equipment. Failure to observe this precaution may result in damage to the equipment.

1. APPLICATION

The MDF is a digital frequency relay equipped with various combinations of functions.

A. One to four underfrequency setpoints, 55 to 60.05 hertz or 45 to 50.05 hertz (or overfrequency 60.1 to 65 hertz or 50.10 to 55 hertz). For the underfrequency application, the settings should be at least 0.2 hertz below the rated line frequency.

B. 50 or 60 hertz selection link.

C. Operates from 24, 48, 125, 250 V dc power supply or from 110/220 v (50 Hz), 120/240 v (60 Hz), ac line voltage depending on style.

D. One reclose enable setpoint 55 to 65 hertz or 45 to 55 hertz.

E. Adjustable cut off of frequency measurement for ac undervoltage. Setting range is 20% to 90% of rated nominal ac input for dc-powered relays, and 60% to 90% for ac-powered relays.

F. Time delay setting for underfrequency or overfrequency trip, 0.01 to 0.99 seconds.

G. Alarm for:
   1. underfrequency (or overfrequency) setting out of range
   2. reclose enable setting out of range
   3. reclose enable setting below an under-frequency trip setting
   4. low internal voltage
   5. unsatisfactory self-check

This relay is intended to sense hazardous underfrequency (or overfrequency) conditions and initiate selective load shedding to preserve service continuity to other loads. It is also applied to turbine-generators to trip the machine through external timers (minutes are required) to avoid possible turbine damage.

For the underfrequency application the reclose enable function allows load to be re-energized following system frequency restoration. Restoration should be accomplished with long time delay and/or in small blocks to avoid pumping. If this relay is used for overfrequency detection, the reclosing enable setting is functionally equivalent to the normal overfrequency setting, i.e. its contact closes if the frequency is above the setting.

2. CONSTRUCTION

The MDF relay is microprocessor-based under or over- frequency relay. It measures the line frequency by counting the pulses from a crystal oscillator and compares the period measurement to setpoint

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 representative should be contacted.

values. The relay consists of four modules, power supply (P/S), fuse, filter and processor. The relay has up to four frequency settings. Each frequency setting has its own indicator (LED), telephone relay contact output and a target seal-in unit (ICS). Two telephone relays and indicators (LED) are for alarm and restore functions.

The MDF relay is mounted in the semi-flush FT-32 Flexitest case. The internal schematics are shown in Figures 11 and 12 for dc and ac relay respectively.

2.1 Power Supply (P/S) Board

2.1.1 Dc MDF Relay

There are two transformers on the power supply board. Transformer TR2 and its associated components are used as a dc/dc converter to step down from a dc input voltage to a 5 volt power supply. Transformer TR1 is for monitoring ac line ac line frequency. The voltage on the secondary of TR1 is connected to the MDF board. Several transistors (Q4 to Q9) are used for driving the telephone relay. There are up to six telephone relays for the functions of alarm, reclose enable and trips. Two rows of capacitors on top and bottom of the circuit board are connected between every relay terminal and the relay chassis (ground) for the noise and surge suppression.

2.1.2 Ac MDF Relay

A conventional ac to dc converter is used for this application. A stepdown transformer TR2 supplies current to the logic circuits through a 5-volt voltage regulator and also directly supplies current to all the telephone relays. The other components, such as transformer TR1, transistors Q2 to Q8, etc., provide the same functions as described in the dc MDF power supply section.

2.2 MDF Board

The MDF board consists of a microprocessor (3870), timer (Intel 8253), crystal oscillator, under voltage detector, signal conditioning, power supply ready, program recovering circuit and several sets of BCD switches for frequency, reclose enable and time delay settings. A link (jumper) is provided for the selection of a system, 50 or 60 cycle. Up to six LEDs indicates the status of alarm, reclose enable and trips. For detail of the MDF board refer to the operation section.

2.3 Fuse Module

The fuse module contains two fuses, a varistor, a capacitor and a resistor where required. This module is used for dc power supplies only.

2.4 Filter Module

This module is used on all MDF versions. It is mounted behind the shield plate of the processor module. Contained within is a +5 to -5 Vdc converter IC, an op amp and several discrete resistors and capacitors.

2.5 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 deflect a spring located on the front of the switch which allows the target to drop. The target is reset from the outside of the case by a push rod located at the bottom of the cover.

3. OPERATION

The MDF relay's simplified internal schematics for single to four frequency settings (dc and ac) are shown in Figures 2 through 9. The relays block diagram and two internal schematic (dc and ac) are shown in Figures 10, 11, and 12 respectively.

The system has up to four settings used as either over or underfrequency outputs, indicated on the drawings as UF/OF 1 through UF/OF 4. These four settings are completely independent and are allowed, by the system, to be between 55.00 and 60.05 and 60.10 and 65.00 on a 60 Hz system or between 45.00 and 50.05 and 50.10 and 55.00 on a 50 Hz system. The base of the system, 50 or 60 cycle, is given by a link (jumper) position which is connected to pin 22 of the 3870 microprocessor. Settings in the lower portion of the allowable range are considered underfrequency settings, and an output is issued with line frequency at or below the value. Settings in upper position of the range are considered overfrequency settings with an output issued for line frequency at or above its set point. Each output has its own telephone relay, seal-in unit (ICS) and LED indicator.

The Reclose-Enable setting is for the restore function and is allowed to be between 55.00 and 65.00 Hz on a 60 Hz system and between 45.00 and 55.00 Hz on a 50 Hz system. The recloseable telephone relay contacts are closed for frequencies on or above its setting. In addition its settings are operative. If it is not or if any setting is out of range, the alarm telephone relay drops out its LED indicator turns on. All invalid settings are ignored by the processor until they are corrected and the alarm telephone relay and LED will show the error. Meantime, all other valid settings continue to be operative. A disconnected set of switches, all bits of a setting open, in not considered invalid for alarm purposes but rather just unused.

The time delay setting is two digits which represent 0.1 and 0.01 second respectively. The maximum adjustable time delay is 0.99 sec. The time delay is used in conjunction with each of the outputs, except alarm, in an independent fashion.

The logic used for performing or activating an output is as follows. For an underfrequency condition, there must be three consecutive cycles below the setting to allow an output. The time delay counting for a setting is started after the first cycle below the setting is detected. An output will occur at the end of the time delay or after the three consecutive below threshold cycles, whichever is longer. If any cycle not below the setting is measured before a third consecutive cycle occurs, then cycle and time relay evaluation is reset. Once the three successive below threshold cycles have occurred, it takes two consecutive above threshold cycles to reset the time delay counting and the output if it has occurred. Note that for an overfrequency condition, the logic would perform in a similar manner.

NOTE: In description of the following integrated circuits, the number in parentheses following the IC number will refer to the output pin of one of the four operational amplifiers contained in the linear IC package, e.g., IC1 (14) refers to the op. amp. In IC1 whose output pin is 14. Digital IC's will be identified in the same manner.

3.1 Processor Board

The main component on this board is a 3870 processor which is a single version of the F8 family of microprocessors. In order to achieve a high accuracy of 0.005 Hz at 60 Hz, the processor is used in conjunction with a programmable timer, such as the Intel 8253 package. The accuracy is also determined by the least significant bit of the timer with the given crystal frequency, 3.579545 MHz, and by the tolerance of the crystal itself. The tolerance of 50 ppm over the temperature range is suitable for the accuracy of 0.005 Hz. The integrated circuit IC4 is used as an Oscillator which is the time base for the system.

The power line frequency signal is taken through an input transformer (on P/S board) and an interface comparator IC1 (1) and then divided by two, by a flip flop IC2 (3). The waveform at TP1 whose half period segment represents a whole line cycle serves as the base for subsequent timing and evaluation.

The integrated circuit IC1 (14) detects low voltage conditions, e.g., the cutoff voltage. If the relative line voltage at T7 falls below the set threshold voltage at pin 8 of IC(14), then the voltage at TP3 drops to zero, resets the microprocessor, clears all outputs except alarm, and disables the relay until line voltage is restored to an acceptable value. The alarm is activated by this condition.

The circuit of IC1 (13) and Q4 is known as a deadman configuration. Normally, a positive pulse in every cycle will be applied to the base of Q4 discharging the capacitor C11 and maintaining a low voltage on C11, e.g., the voltage at TP3 maintains a "high" level. If the processor or oscillator would stop or if the processor or oscillator became "lost", the capacitor C11 would charge up according to the time constant R23xC11 and eventually pull the reset line (TP3) down to activate the alarm. The reset line is subsequently allowed to go back to its high state, due to the capacitor C11's discharge through R23, to give the processor the opportunity to restart.

The integrated circuit IC1 (2), transistors Q1, Q2 and Q3 are used for power-on ready circuit. It prevents an erroneous output before the +5 volt supply reaches an acceptable level.

The frequency, reclose enable and time delay settings are given by the switches shown on the right side of the schematic. This system uses binary coded decimal (BCD) switches. The diodes shown for each switch bit are for isolation to allow the bussing of information to the processor.

Figures 14 to 17 show the component locations of the MDF boards for single frequency setting and up to four frequency settings.

3.2 Power Supply (P/S) Board

3.2.1 Dc MDF Relay

The dc input power supply from relay terminals 6 and 7 is applied to two switching transistors Q1 and Q2. The transformer TR2 gives a positive feedback to start and maintain the switching action between Q1 and Q2, and is also used as a voltage stepdown transformation. After a rectifier (DP1) and dc voltage regulator (VR), a 5 volt dc output is obtained for supplying the whole logic circuit's power. The integrated circuit IC1 is a pulse generator whose pulses synchronize the switching time and force the switchover action of the transistors Q1 and Q2.

The transformer TR1 is used as a stepdown isolation which provides an ac voltage of 48 volts on secondary. Its output is connected to the input of the MDF board for voltage and frequency evaluation.

Transistors from Q4 to Q9 are telephone relay and LED drivers. The LED indicates the status of the telephone relay, e.g., if the LED turns on, the relay is energized in all cases except the alarm relay. The alarm relay is normally picked up; its normally closed contact is open and its LED if off. For underfrequency application, the setting of Reclose Enable is lower than the normal line frequency. When the MDF relay is energized, the reclose enable telephone relay and its LED are both turned on.

Figures 18 to 21 show the component location of the dc relay P/S board.

3.2.2 Ac MDF Relay

The ac line voltage from terminals 4 & 5 supplies the relay's power through a transformer TR2 and supplies a frequency signal source through TR1. Diodes D1 and D2 are used as a rectifier which drives the indicators (LED) telephone relays and supplies power to the solid-state circuits. The transistor Q1 and its associated components gives a relatively stable voltage at TP1. The voltage regulator VR supplies a constant 5-volt dc voltage source for logic and microprocessor circuits.

The reset components such as transformer TR1 and transistors Q2 to Q8, etc., are used to perform the same functions as described in the previous section.

3.3 Filter Module

The Filter Module is a fourth order butterworth low pass filter designed to suppress unwanted harmonics. IC1 is a dc voltage inverter to provide -5Vdc to the op amp.

4. CHARACTERISTICS

See Table I on page 5.

5. SETTINGS

5.1 Frequency Setting

Load shedding should be accomplished in an integrated, orderly pattern throughout an interconnected power system area. This will usually involve several levels of underfrequency relay settings at many different locations in the system.

The highest level of underfrequency setting should be below the level from which recovery is reliably accomplished such as 59.5 hertz (all references are to 60 hertz systems, 50 hertz settings being proportional. Spacing of frequencies for dropping load should be established by, first estimating maximum frequency decay rate (approximately P/2H per unit, where P is maximum generation deficiency and H is system inertia constant each based on remaining MVA). From the maximum decay rate for each step and acknowledge of the time required after the frequency crosses the setting level until load dropping takes place, an estimate of the minimum frequency following each step can be obtained. The next shedding level should be below this point. Large blocks of load 8 to 15% of total connected load) are usually shed at the top frequency setting. The larger the block, the more abrupt the arresting of the frequency decline, but also the greater the amount of overshedding for smaller overloads. Many utilities use four or more shedding levels.

Coordination must be considered between a load shedding pattern and a generator dropping underfrequency relaying scheme. Generator dropping should not be allowed until load shedding has been accomplished.

5.2 Trip Time Delay Setting

The single time delay setting affects all of the frequency set points and outputs together.

The total trip time, from the time the frequency of the ac input crosses the setting threshold to contact closure, is as follows:

TABLE I
CHARACTERISTICS

Temperature Range:	-20 deg. to +60 deg. C ambient
Frequency Range Base Frequency:	50 or 60 Hz
Under/overfrequency:	UF 45.00 to 50.05 Hz on 50 Hz system OF 50.10 to 55.00 Hz on 50 Hz system UF 55.00 to 60.05 Hz on 60 Hz system OF 60.10 to 65.00 Hz on 60 Hz system
Setting Resolution:	0.01 Hz
Accuracy:	+0.005 Hz
Trip Time Delay:	65 ms to 990 ±10 ms
Alarm Output for:	1. Invalid settings 2. Low line voltage (undervoltage) 3. Dead or "lost" processor
Outputs:	1. Up to four under/overfrequency settings, one reclose enable setting and one alarm output. 2. Indicating LEDs for alarm, reclose enable and trips. 3. Telephone relay contact output for alarm, reclose enable and trips. 4. Indicating contactor switch (target) for each under or overfrequency trip.
Indicating Contactor Switch:	0.2/2 amperes
Contact Rating:	1. Trip contacts with ICS-30 amperes at 250 volts dc for 2 seconds. 2. Telephone relay contacts -3 amperes at 125 volts.
Sensing Voltage:	Adjustable cutoff voltage between 20% and 90% of normal ac line voltage for dc relay and between 60% and 90% of normal ac line voltage for ac relay.
Power Supply:	dc - 24, 48, 125, 250 volts (+15% and -25%) ac - 110/220 v (50 Hz), 120/240 v (60 Hz)
Drain (dc):	dc Voltage of 48, 125 and 250 volts - 6 watts (max.) for logic circuit and 4 W per function such as alarm, reclose enable and each frequency settings. dc voltage of 24 volts-15 watts (max).
Burden (ac):	ac relay - 20 watts (max) dc relay - less than 1 watt

a. For switch setting between .00 and .03 seconds. Actual trip time (sec) = 0.075 ±0.01 sec.

b. For switch setting between .03 and .99 seconds. Actual trip time (sec) = Digital Setting +0.047 sec. ±0.01 sec.

For example, if a digital number of .06 is set, the actual trip time will be 0.095 seconds with an error of ±0.01 seconds.

Security is achieved through the multiple-cycle counting procedure, and the shortest delay settings can be used.

For virtually all normal load-shedding applications, extra time delay is undesirable. It reduces the ability of the load-shedding scheme to arrest rapid frequency decline, and makes coordination of generation dropping more difficult. The shortest trip time of .075 s is recommended; set the MDF delay timer function to less than .035 to obtain this.

For generator dropping, time delay is generally required. Set in accordance with turbine manufacturer's time-underfrequency limits and recommendations.

6. ADJUSTMENTS AND MAINTENANCE

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

6.1 Acceptance Tests

The following check is recommended to insure that the relay is in proper working order. Refer to the internal schematic and apply the rated dc voltage to terminals 7 (+) and 6 (-). Connect a variable ac voltage and frequency source to terminals 4 and 5. For those customers who want a quick check of the relay and do not have a variable frequency source, refer to step #8 for the relay's acceptance tests.

For 60 Hz line voltage system (typical), set the digital switches as follows:

Delay Time		.00
Reclose Enable		61.00
Frequency #1		57.50
Frequency #2	(Optional)	57.50
Frequency #3	(Optional)	57.50
Frequency #4	(Optional)	57.50

For 50 Hz one voltage system, set the digital switches 10 Hz below the above values and comparable input test frequency should be used. Before any test make sure that the voltage Vc on MDF board is between 4.75 and 5.25 volts.

6.1.1 Alarm Check

To verify alarm function perform the following tests:

a. Turn the dc power on and ac input off. The alarm LED should be on and the alarm telephone relay should drop out.

b. Apply the rated ac input frequency and voltage to the relay. The alarm relay picks up and its LED turns off.

c. Reduce the ac input voltage below 80% of the rated voltage. The alarm relay drops out and its LED turns on. Return the ac input voltage to the rated voltage.

Note: The cutoff voltage is set at 80% of the rated line voltage when the relay is shipped from the factory.

d. Invalid settings for Frequency #1 (F1). The alarm LED should be turned on for any one of the following settings:

- Set the F1 switches to 54.99
- Set the F1 switches to 60.06
- Set the F1 switches to 65.01

Return the F1 switches to 57.50.

e. Repeat step (d) for F2, F3, F4 (optional) if they are supplied with the relay.

f. Invalid or improper settings for Reclose Enable (optional). The alarm LED should be turned on, if the Reclose Enable (R) is set at any one of the following numbers.

- Set the R switches to 57.49
- Set the R switches to 54.99
- Set the R switches to 65.01

6.1.2 Reclose Enable

To verify the Reclose Enable function, perform the following tests:

a. Set the Reclose Enable switches to 59.90.

b. With a rated ac voltage and 60 Hz input, the reclose enable telephone relay should be picked up and its LED should be turned on.

c. Reduce the ac input frequency to 59.80 Hz. The reclose enable telephone relay drops out and its LED turns off.

d. Change the input frequency to 57.55 Hz and set the reclose enable switches on 57.45. The alarm LED should be turned on.

6.1.3 Trip Condition and Accuracy

a. Set the Reclose Enable switches to 59.50 and Frequency #1 switches to 59.00.

b. With a rated ac input voltage, gradually lower the input frequency from 60 Hz. The Reclose Enable LED should be turned off at 59.49 Hz. The Frequency #1 LED turns on at 58.99 Hz and its telephone relay picks up. Return the Frequency #1 setting to 57.50.

c. Repeat step (a) and (b) for Frequency #2, #3 and #4 (if supplied).

6.1.4 Cut-Off Voltage Setting (Trimpot P1)

The relay has been set at 80% ±2% of the line voltage. The procedures for checking and changing the setting are shown as follows:

a. A scope probe to TP3 on MDF board and scope common to COM.

b. A rated ac input voltage and frequency, the voltage at TP3 should be "1" (approximately 5v).

c. The ac input voltage below 80% of the line voltage. The voltage at TP3 should be "0" (below 0.5v).

d. Set the ac input voltage to the desired cutoff voltage. Adjust the trimpot P1 to obtain the Voltage at TP3 which jumps from "1" to "0".

6.1.5 Cut-off Voltage Dropout Ratio

Normally, the dropout ratio is between 92% and 97% for a 60 Hertz system, and between 94% and 99% for a 50 Hertz system. However, the dropout ratio can be changed by replacing the resistor R11 on the MDF module. By increasing or decreasing the value of R11, the relay will have higher or lower dropout ratio respectively. If the R11 is changed, be sure that the voltage at TP3 is a solid voltage, high or low, near the cut-off voltage setting. No pulse type waveform should appear.

6.1.6 Time Delay

Use a voltage controlled oscillator (VCO) and DPDT switch for this section test. One set of the DPDT switch contacts is for the frequency change from 60 Hz to 55 Hz by the sudden change of the biasing voltage of the VCO and another set of the contacts is for timer start. At normal condition, the ac input is set at 60 Hz.

a. Set the time delay BCD switches to 00.

b. Use a digital timer to measure the time delay. Connect the timer start to one set of the DPDT switch contacts and connect the timer stop to the Frequency #1's telephone relay contact, e.g., the relay terminals 2 and 3.

c. Suddenly switch the ac input switch (DPDT) from 60 Hz to 55 HZ. The delay time should be between 55 and 75 milliseconds-seconds.

d. Repeat step (c) for the following time delay settings:

Delay Time Settings (sec)	† Min & Max. Reading (ms)
.00	65 - 85
.10	137 - 162
.55	587 - 612
.90	937 - 962

† NOTE: This tolerance is based on the input frequency of 55 Hz.

6.1.7 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 ICS's rated current. The operation indicator target should drop freely.

The contact wipe should be approximately 0.016 inches. The bridging moving contact should touch both stationary contacts simultaneously.

6.1.8 Relay Check

This relay can be checked easily and quickly in the field by applying the line voltage and frequency to the relay terminals 4 and 5.

a. Use the step #1 for the Alarm condition check.

b. Use the step #2 for the Reclose Enable check by varying the RE switches near the rated line frequency. The RE's LED and telephone relay should pick up or drop out if the setting is lower or higher than the line frequency respectively.

c. The accuracy can be checked by setting the RE switches at 61.00 Hz and F2, F3 and F4 switches at 60.04 Hz. By varying the setting of F1, the F1's LED and telephone relay should pickup or drop out if the setting is higher or lower than the line frequency respectively. Repeat the same test for F2, F3 and F4.

d. Use the step #4 and #5 for the cut-off voltage setting.

6.2 Routine Maintenance

All relays should be checked and contacts should be cleaned at least once every year. A contact burnisher S#182A836H01 is recommended for cleaning.

6.2.1 Calibration

The relay's accuracy is mainly determined by an internal crystal oscillator. The only parts needed to be calibrated are as follows:

a. Cut-off Voltage Setting (Trimpot P1)

The procedures for setting of the cut-off voltage is discussed in section 4 of the acceptance test. The relay is set at 80% of the line voltage. The cut-off voltage can be set between 20% and 90% of the line voltage for dc relay and between 60% and 90% for ac relay.

b. Indicating Contact Switch (ICS)

Initially adjust unit on the pedestal so that armature fingers do not touch the yoke in the reset position. This can be done by loosening the mounting screw in the mold pedestal and moving the ICS in the downward position.

Adjust the stationary contacts so that both stationary make with the moving contacts simultaneously and wipe 1/64" to 3/64" when the armature is against the core. Manually raise the moving contacts and check to see that the target drops at the same time as the contacts made or up to 1/16" ahead. The cover may be removed and the tab holding the target reformed slightly if necessary. However care should be exercised so that the target will drop with a slight jar.

7. RENEWAL PARTS

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

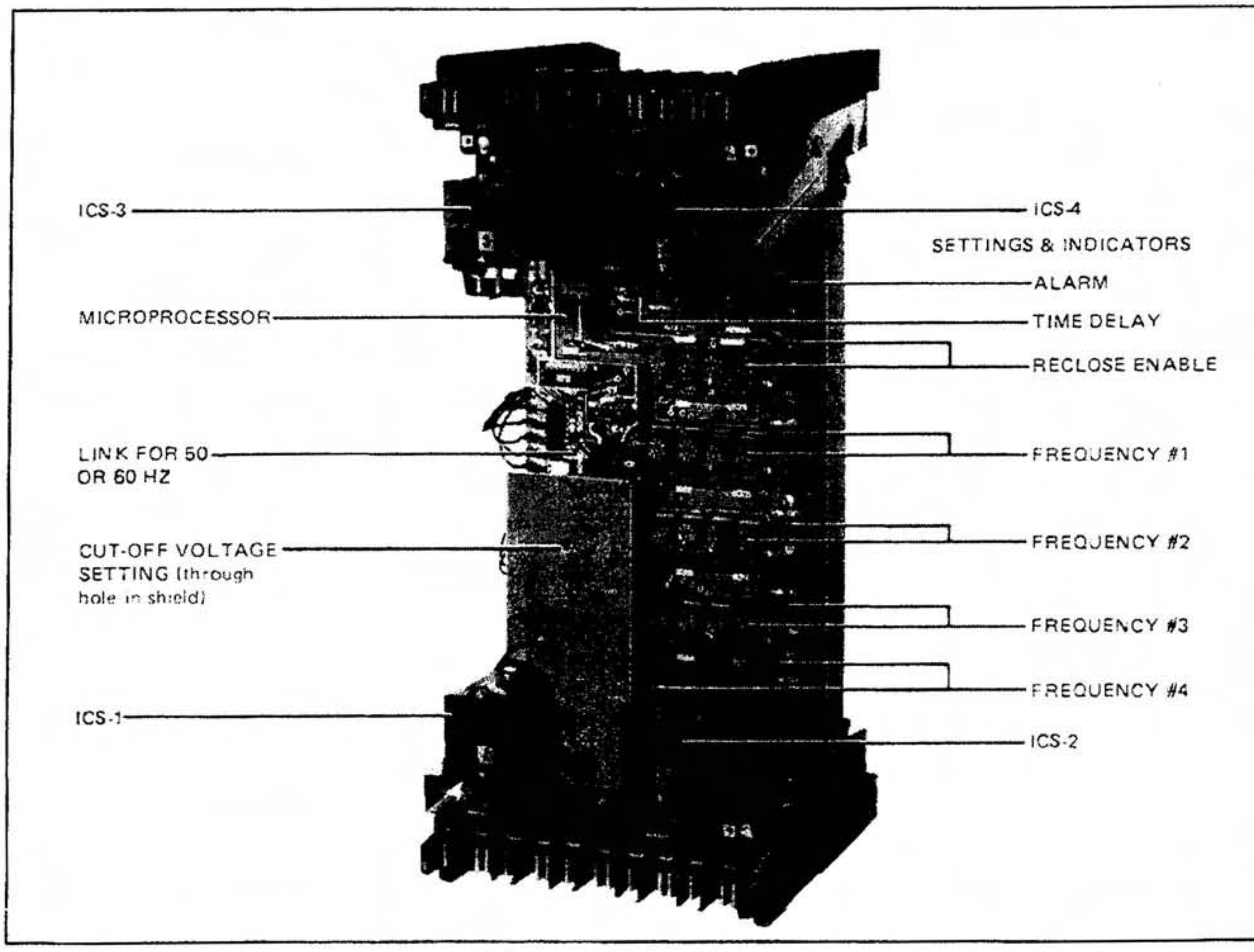


Figure 1. MDF Relay

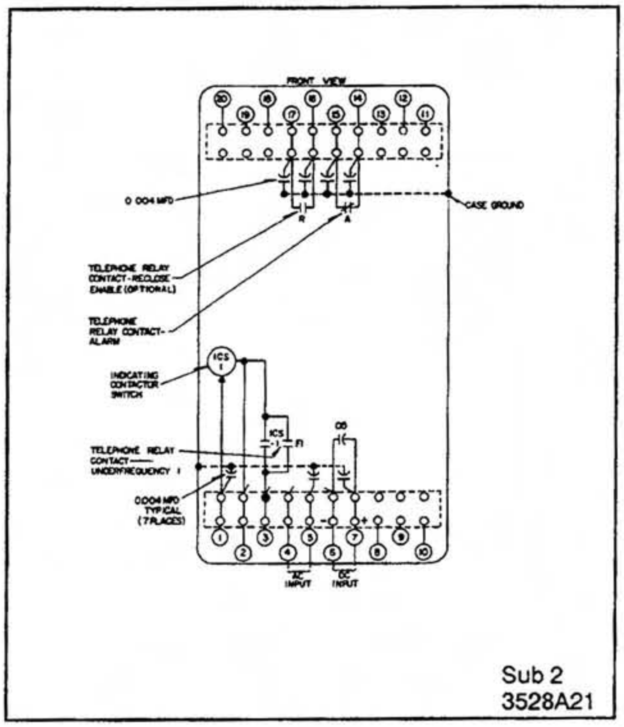


Figure 2. Simplified Internal Schematic (dc) MDF-1

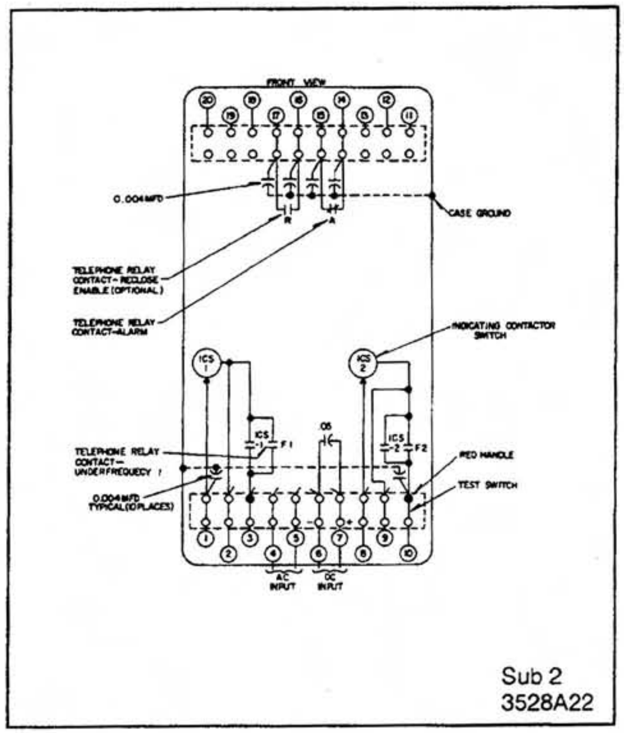


Figure 3. Simplified Internal Schematic (dc) MDF-2

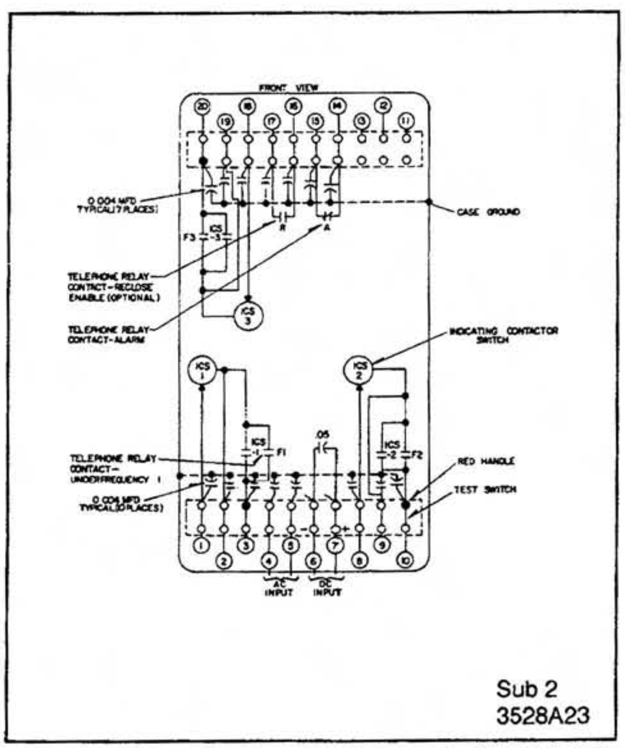


Figure 4. Simplified Internal Schematic (dc) MDF-3

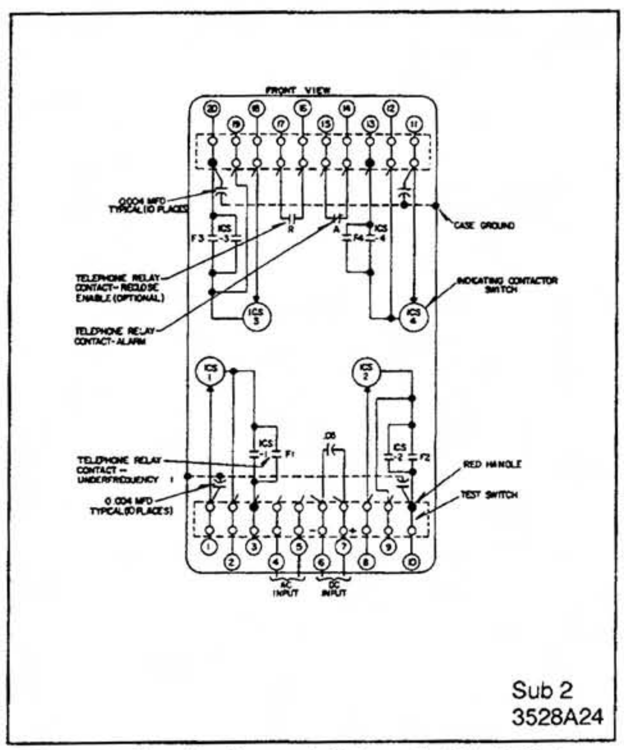


Figure 5. Simplified Internal Schematic (dc) MDF-4

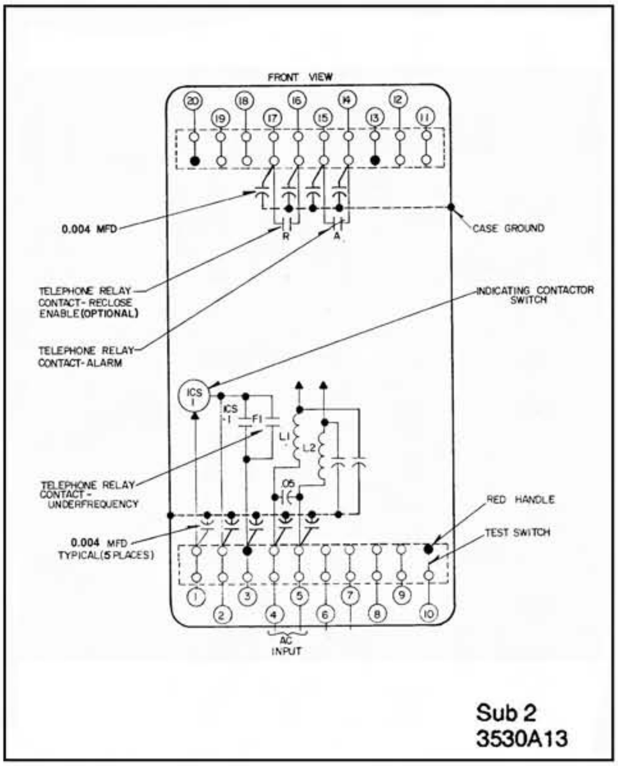


Figure 6. Simplified Internal Schematic (ac) MDF-1

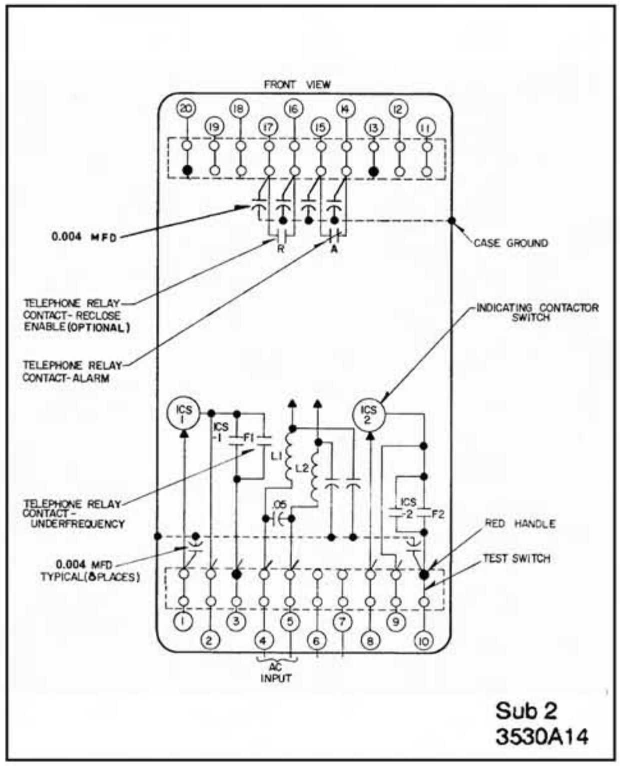


Figure 7. Simplified Internal Schematic (ac) MDF-2

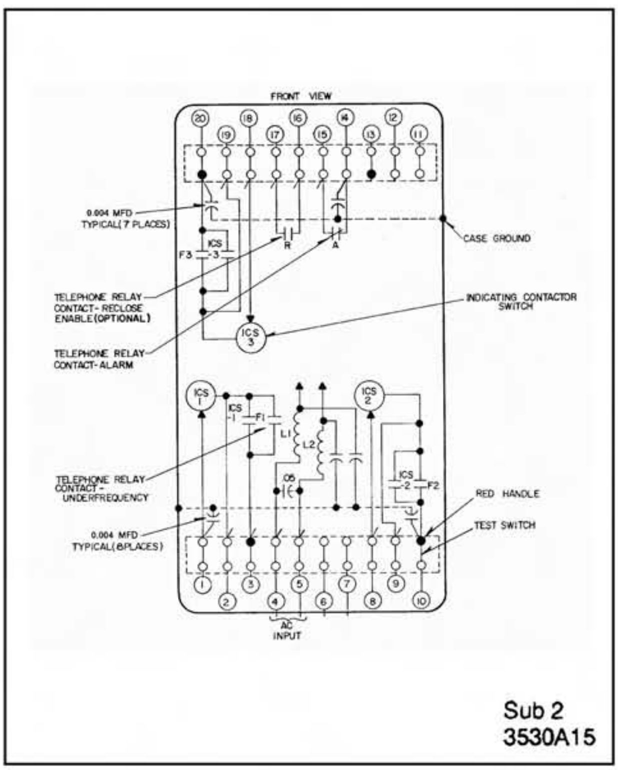


Figure 8. Simplified Internal Schematic (ac) MDF-3

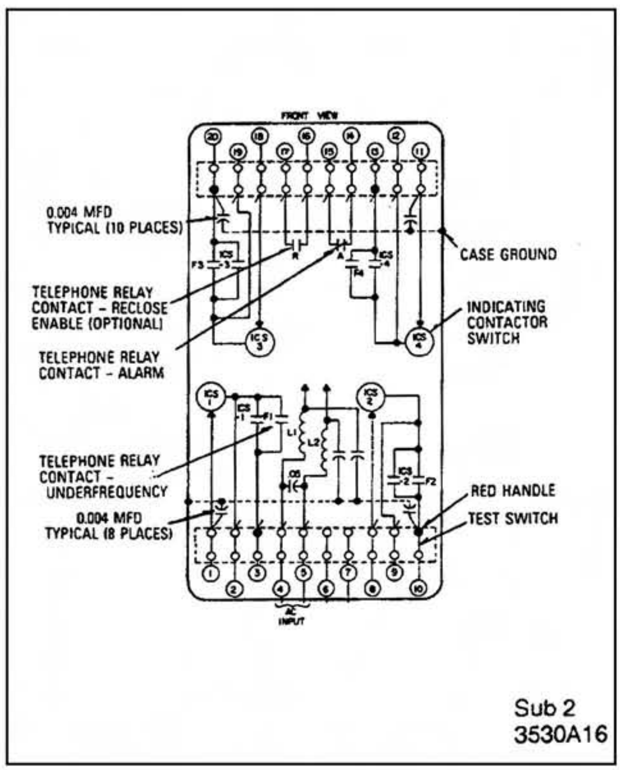


Figure 9. Simplified Internal Schematic (ac) MDF-4

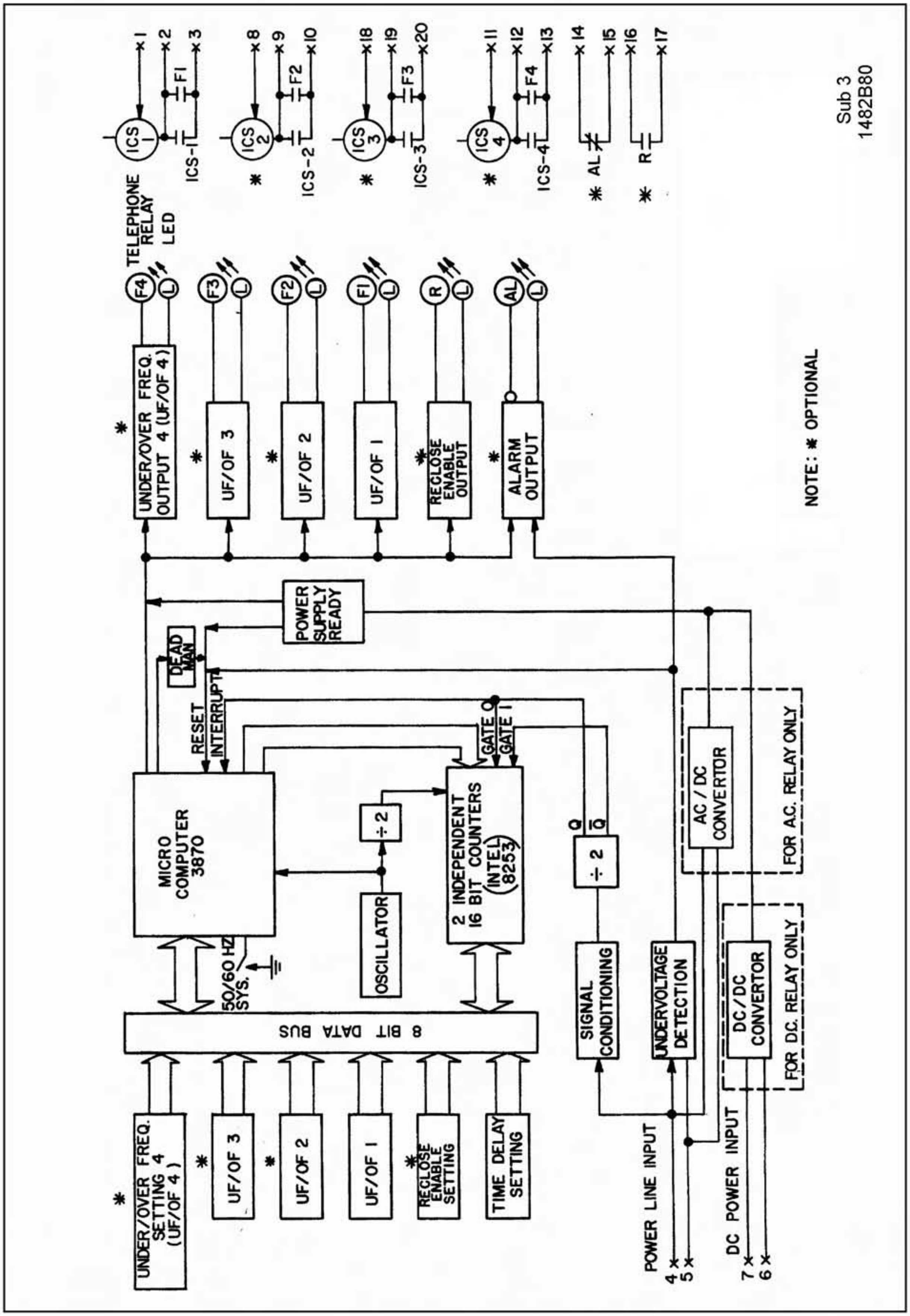


Figure 10. Block Diagram for the MDF Relay

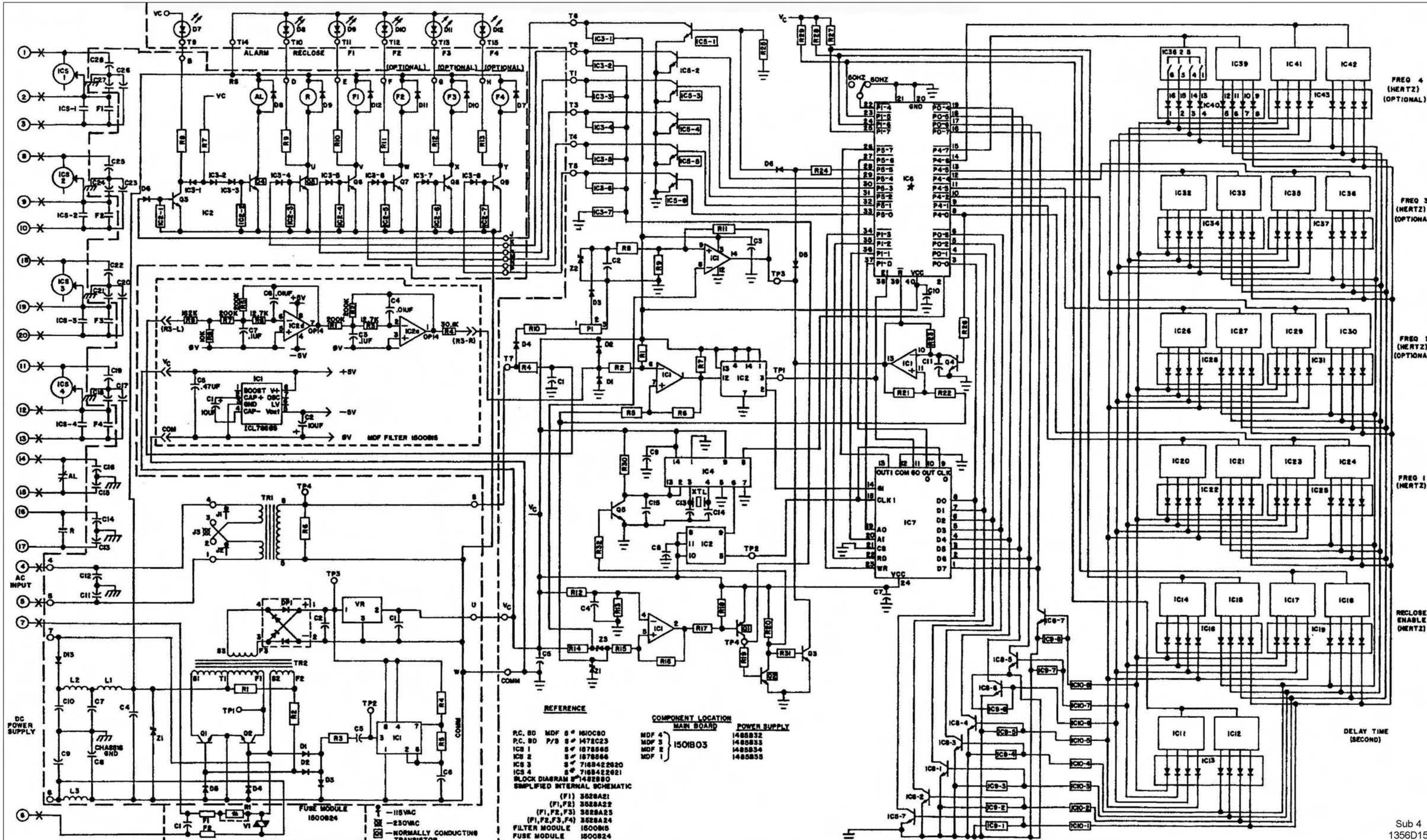


Figure 11a. DC Internal Schematic, MDF Relay

MAIN BOARD 1610C79

COMPONENT		DESCRIPTION	STYLE NO.
C1	CAPACITOR	.100UF 100V	762A680H14
C2	CAPACITOR	0.22 UF 100V	763A219H21
C3	CAPACITOR	.100UF 100V	762A680H14
C4	CAPACITOR	1.0UF 100V	3526A65H07
C5	CAPACITOR	10.000UF 20V	184A661H24
~~C6~~	~~CAPACITOR~~	~~.100UF 100V~~	~~762A680H14~~
C7	CAPACITOR	.100UF 100V	762A680H14
C8	CAPACITOR	.100UF 100V	762A680H14
C9	CAPACITOR	.100UF 100V	762A680H14
C10	CAPACITOR	.100UF 100V	762A680H14
C11	CAPACITOR	1.000UF .50V	849A437H08
CONT. BELOW			
D1	DIODE	IN645A	837A692H03
D2	DIODE	IN645A	837A692H03
D3	DIODE	IN645A	837A692H03
D4	DIODE	IN645A	837A692H03
D5	DIODE	IN645A	837A692H03
D6	DIODE	IN645A	837A692H03
IC1	INT. CKT.	LM239AJ	3524A65H01
IC2	INT CKT	SN54107J	3513A25H02
IC3	INT CKT	3168152	3524A68H04
IC4	INT CKT	SN54LS624J	3524A66H01
IC5	INT CKT	CA3081	3524A67H01
IC6	INT CKT	SC80247L	1465C38H02
IC7	INT CKT	8253	1479671H01
IC8	INT CKT	CA3081	3524A67H01
IC9	INT CKT	3168153	3524A68H05
IC10	INT CKT	3168103	3524A68H02
IC11	INT CKT	230002G	3524A70H01
IC12	INT CKT	230002G	3524A70H01
IC13	INT CKT	FSA2619M	3524A69H01
IC14	INT CKT	230002G	3524A70H01
IC15	INT CKT	230002G	3524A70H01
IC16	INT CKT	FSA2619M	3524A69H01
IC17	INT CKT	230002G	3524A70H01
IC18	INT CKT	230002G	3524A70H01
IC19	INT CKT	FSA2619M	3524A69H01
IC20	INT CKT	230002G	3524A70H01
IC21	INT CKT	230002G	3524A70H01
IC22	INT CKT	FSA2619M	3524A69H01
IC23	INT CKT	230002G	3524A70H01
IC24	INT CKT	230002G	3524A70H01
IC25	INT CKT	FSA2619M	3524A69H01
IC26	INT CKT	230002G	3524A70H01
IC27	INT CKT	230002G	3524A70H01
IC28	INT CKT	FSA2619M	3524A69H01
IC29	INT CKT	230002G	3524A70H01
IC30	INT CKT	230002G	3524A70H01
IC31	INT CKT	FSA2619M	3524A69H01
IC32	INT CKT	230002G	3524A70H01
IC33	INT CKT	230002G	3524A70H01
IC34	INT CKT	FSA2619M	3524A69H01
IC35	INT CKT	230002G	3524A70H01
IC36	INT CKT	230002G	3524A70H01
IC37	INT CKT	FSA2619M	3524A69H01
IC38	INT CKT	230002G	3524A70H01
IC39	INT CKT	230002G	3524A70H01
IC40	INT CKT	FSA2619M	3524A69H01
IC41	INT CKT	230002G	3524A70H01
IC42	INT CKT	230002G	3524A70H01
IC43	INT CKT	FSA2619M	3524A69H01
P1	POT.	20.0K .50W	3523A42H02
Q1	TRANSISTOR	2N2907A	762A672H17
Q2	TRANSISTOR	2N2222A	762A672H15
Q3	TRANSISTOR	2N2222A	762A672H15
Q4	TRANSISTOR	2N2222A	762A672H15
Q5	TRANSISTOR	2N2222A	762A672H15
Z1	ZENER	ICL8069DM5Q 1.23V	9649A34H01
Z2	ZENER	IN5235B 6.8V	862A288H07
Z3	ZENER	ICL8069DM5Q 1.23V	9649A34H01
R1	RESISTOR	162K .50W 1%	848A821H62
R2	RESISTOR	30.1K .50W 1%	848A820H91
~~R3~~	~~RESISTOR~~	~~30.1K .50W 1%~~	~~848A820H91~~
R4	RESISTOR	100.0 .50W 1%	848A818H51
R5	RESISTOR	10.0K .50W 1%	848A820H45
R6	RESISTOR	150.0K .50W 1%	848A821H59
R7	RESISTOR	10.0K .50W 1%	848A820H45
R8	RESISTOR	150.0K .50W 1%	848A821H59
R9	RESISTOR	150.0K .50W 1%	848A821H59
R10	RESISTOR	5.0K .50W 1%	848A820H16

COMPONENT		DESCRIPTION	STYLE NO.
R11	RESISTOR	432.0K .50W 1%	848A822H04
R12	RESISTOR	10.0K .50W 1%	848A820H45
R13	RESISTOR	3740.0 .50W 1%	848A820H04
R14	RESISTOR	10.0K .50W 1%	848A820H45
R15	RESISTOR	4990.0 .50W 1%	848A820H16
R16	RESISTOR	249K .25W 1%	3532A38H39
R17	RESISTOR	1000.0 .50W 1%	848A819H48
R18	RESISTOR	10.0K .50W 1%	848A820H45
R19	RESISTOR	10.0K .50W 1%	848A820H45
R20	RESISTOR	10.0K .50W 1%	848A820H45
R21	RESISTOR	51.1K .50W 1%	848A821H14
R22	RESISTOR	10.0K .50W 1%	848A820H45
R23	RESISTOR	150.0K .50W 1%	848A821H59
R24	RESISTOR	1000.0 .50W 1%	848A819H48
R25	RESISTOR	10.0K .50W 1%	848A820H45
R26	RESISTOR	10.0K .50W 1%	848A820H45
R27	RESISTOR	4990.0 .50W 1%	848A820H16
R28	RESISTOR	4990.0 .50W 1%	848A820H16
R29	RESISTOR	4990.0 .50W 1%	848A820H16
R30	RESISTOR	20.0K .50W 1%	848A820H74
R31	RESISTOR	4.02K .50W 1%	848A820H07
R32	RESISTOR	4.02K .50W 1%	848A820H07
D7	LED	RED	3508A22H04
D8	LED	YELLOW	3506A22H05
D9	LED	RED	3508A22H04
D10	LED	RED	3508A22H04
D11	LED	RED	3506A22H04
D12	LED	RED	3506A22H04
C13	CAPACITOR	10.5 PF 500V	187A610H02
C14	CAPACITOR	10.5 PF 500V	187A610H02
C15	CAPACITOR	0.22 UF 50V	188A669H12
~~C16~~	~~CAPACITOR~~	~~.0022uF 100V~~	~~3509A34H07~~

FILTER MODULE-1500B15G01

C1	CAPACITOR	10.0uF 20V 20% TANTALUM	184A661H24
C2	CAPACITOR	10.0uF 20V 20% TANTALUM	184A661H24
C3	CAPACITOR	0.1uF 500V 2% METAL MYLAR	3526A65H10
C4	CAPACITOR	0.01uF 200V 5%	3502A85H13
C5	CAPACITOR	0.47uF 50V 20%	762A680H04
C6	CAPACITOR	0.01uF 200V 5%	3502A85H13
C7	CAPACITOR	0.1uF 500V 2% METAL MYLAR	3526A65H10
R1	RESISTOR	200K .25W 1% METAL FILM	3532A38H30
R2	RESISTOR	200K .25W 1% METAL FILM	3532A38H30
R3	RESISTOR	12.7K .25W 1% METAL FILM	3535A37H11
R4	RESISTOR	30.1K .25W 1% METAL FILM	3535A37H47
R5	RESISTOR	200K .25W 1% METAL FILM	3532A38H30
R6	RESISTOR	12.7K .25W 1% METAL FILM	3535A37H11
R7	RESISTOR	200K .25W 1% METAL FILM	3532A38H30
R8	RESISTOR	10K .25W 1% METAL FILM	3535A37H01
R9	RESISTOR	162K .25W 1% METAL FILM	3532A38H21
IC1	INT CKT	VOLT. CONVERTER ICL7660	9649A49H01
IC2	INT CKT	OP-14DZ	9642A94H01

FUSE MODULE-1500B24G01-G02-G03

C1	CAPACITOR	0.05uF 500V 20%	879A911H13 (ALL GRPS)
R1	RESISTOR	20 OHM 3W 5% WW	184A859H01 (GRPS 1-3)
R1	BARE WIRE	ONE INCH LONG	09Z0100000 (GRP 2)
F1	FUSE	0.5A SLO-BLO	183A981H11 (ALL GRPS)
F2	FUSE	0.5A SLO-BLO	183A981H11 (ALL GRPS)
V1	VARISTOR	175Vdc MAX.	3509A31H17 (GRP 1)
V1	VARISTOR	100Vdc MAX.	3509A31H06 (GRP 2)
V1	VARISTOR	320Vdc MAX.	3509A31H01 (GRP 3)

POWER SUPPLY BOARD 1472C23

C1	CAPACITOR	10.000UF 35V	CJ1005JGA8
C2	CAPACITOR	100.000UF 20V	CJ1006MD06
C4	CAPACITOR	40.000UF 350V	CA40055TB8
C5	CAPACITOR	.560UF 100V	CE5603ML93
C6	CAPACITOR	.100UF 200V	CE1003KP25
C7	CAPACITOR	.010UF 3000V	CQ1002M380
C8	CAPACITOR	.010UF 3000V	CQ1002M380
C9	CAPACITOR	.010UF 3000V	CQ1002M380
C10	CAPACITOR	.010UF 3000V	CQ1002M380
C11	CAPACITOR	.010UF 3000V	CQ1002M380
C12	CAPACITOR	.010UF 3000V	CQ1002M380
C13	CAPACITOR	.010UF 3000V	CQ1002M380
C14	CAPACITOR	.010UF 3000V	CQ1002M380
C15	CAPACITOR	.010UF 3000V	CQ1002M380
C16	CAPACITOR	.010UF 3000V	CQ1002M380
C17	CAPACITOR	.010UF 3000V	CQ1002M380
C18	CAPACITOR	.010UF 3000V	CQ1002M380
C19	CAPACITOR	.010UF 3000V	CQ1002M380
C20	CAPACITOR	.010UF 3000V	CQ1002M380
C21	CAPACITOR	.010UF 3000V	CQ1002M380
C22	CAPACITOR	.010UF 3000V	CQ1002M380
C23	CAPACITOR	.010UF 3000V	CQ1002M380
C24	CAPACITOR	.010UF 3000V	CQ1002M380
C25	CAPACITOR	.010UF 3000V	CQ1002M380
C26	CAPACITOR	.010UF 3000V	CQ1002M380
C27	CAPACITOR	.010UF 3000V	CQ1002M380
C28	CAPACITOR	.010UF 3000V	CQ1002M380
D1	DIODE	IN645A	837A692H03
D2	DIODE	IN645A	837A692H03
D3	DIODE	IN645A	837A692H03
D4	DIODE	IN645A	837A692H03
D5	DIODE	IN645A	837A692H03
D6	DIODE	IN645A	837A692H03
D7	DIODE	IN482 500V	188A342H16
D8	DIODE	IN482 500V	188A342H16
D9	DIODE	IN482 500V	188A342H16
D10	DIODE	IN482 500V	188A342H16
D11	DIODE	IN482 500V	188A342H16
D12	DIODE	IN482 500V	188A342H16
D13	DIODE	IN4822 600V	188A342H11
IC1	INT CKT	SE555CV	774B956H01
IC2	INT CKT	3168103	3524A68H02
IC3	INT CKT	FSA2619M	3524A69H01
J1	JUMPER	0 OHM RESISTOR	862A478H01
J2	JUMPER	0 OHM RESISTOR	862A478H01
J3	JUMPER	0 OHM RESISTOR	862A478H01
J4	JUMPER	0 OHM RESISTOR	862A478H01
J5	JUMPER	0 OHM RESISTOR	862A478H01
J6	JUMPER	0 OHM RESISTOR	862A478H01
Q1	TRANSISTOR	ST1701	3503A41H04
Q2	TRANSISTOR	ST1701	3503A41H04
Q3	TRANSISTOR	2N2222A	762A672H15
Q4	TRANSISTOR	2N4063	878A432H01
Q5	TRANSISTOR	2N4063	878A432H01
Q6	TRANSISTOR	2N4063	878A432H01
Q7	TRANSISTOR	2N4063	878A432H01
Q8	TRANSISTOR	2N4063	878A432H01
Q9	TRANSISTOR	2N4063	878A432H01
R1	RESISTOR	270.0K 1.00W 5%	187A643H85
R2	RESISTOR	475.0 .50W 1%	848A819H17
R1	RESISTOR	120.0K 1.00W 5%	187A643H77
R2	RESISTOR	475.0 .50W 1%	848A819H17
R1	RESISTOR	47.0K 1.00W 5%	187A643H67
R2	RESISTOR	475.0 .50W 1%	848A819H17
R3	RESISTOR	100.0 .50W 1%	848A818H51
R4	RESISTOR	5620.0 .50W 1%	848A820H21
R5	RESISTOR	1.0K .50W 1%	848A819H48
R6	RESISTOR	10.0K 1.00W 5%	187A643H51
R7	RESISTOR	511.0 .50W 1%	848A819H20
R8	RESISTOR	267.0 .50W 1%	848A818H92
R9	RESISTOR	10.0K 5.00W 1%	763A130H02
R10	RESISTOR	10.0K 5.00W 1%	763A130H02
R11	RESISTOR	10.0K 5.00W 1%	763A130H02
R12	RESISTOR	10.0K 5.00W 1%	763A130H02
R13	RESISTOR	10.0K 5.00W 1%	763A130H02
R9	RESISTOR	3.9K 3.00W 5%	763A127H13
R10	RESISTOR	3.9K 3.00W 5%	763A127H13
R11	RESISTOR	3.9K 3.00W 5%	763A127H13
R12	RESISTOR	3.9K 3.00W 5%	763A127H13
R13	RESISTOR	3.9K 3.00W 5%	763A127H13
R9	RESISTOR	25.0K 12.00W 5%	763A098H10
R10	RESISTOR	25.0K 12.00W 5%	763A098H10
R11	RESISTOR	25.0K 12.00W 5%	763A098H10
R12	RESISTOR	25.0K 12.00W 5%	763A098H10
R13	RESISTOR	25.0K 12.00W 5%	763A098H10

COMPONENT		DESCRIPTION	STYLE NO.
Z1	ZENER	15KE200 200.0V	878A619H01 (125 VDC)
~~Z2~~	~~ZENER~~	~~IN3048B 150.0V~~	~~188A302H19~~
~~Z3~~	~~ZENER~~	~~IN3048B 150.0V~~	~~188A302H19~~
Z1	ZENER	1.5KE300A 300.0V	878A619H07 (250 VDC)
TP1	TEST POINT		849A242H01
TP2	TEST POINT		849A242H01
TP3	TEST POINT		849A242H01
TP4	TEST POINT		849A242H01
F1	TEL. RELAY	48V	407C733H06
F2	TEL. RELAY	48V	407C733H06
F3	TEL. RELAY	48V	407C733H06
F4	TEL. RELAY	48V	407C733H06
AL	TEL. RELAY	48V	407C733H06
R	TEL. RELAY	48V	407C733H06
F1	TEL. RELAY	125V	407C733H07
F2	TEL. RELAY	125V	407C733H07
F3	TEL. RELAY	125V	407C733H07
F4	TEL. RELAY	125V	407C733H07
AL	TEL. RELAY	125V	407C733H07
R	TEL. RELAY	125V	407C733H07
F1	TEL. RELAY	250V	407C733H08
F2	TEL. RELAY	250V	407C733H08
F3	TEL. RELAY	250V	407C733H08
F4	TEL. RELAY	250V	407C733H08
AL	TEL. RELAY	250V	407C733H08
R	TEL. RELAY	250V	407C733H08
TR1	TRANSF.		1479B94H01
TR2	TRANSF.	48V	1480B05G02
TR2	TRANSF.	125V	1480B05G01
TR2	TRANSF.	250V	1480B05G03
L1	CHOKE		3516A94H01
L2	CHOKE		3500A27H01
L3	CHOKE		3500A27H01
VR	VOLT. REG.	LAS15A05	775B891H01
DP1	RECTIFIER	VM48	3511A90H01

* NOTE- WHEN USING uP 1465C38G03, ADD RESISTOR 848A820H16 AS PER FIG. A BELOW.

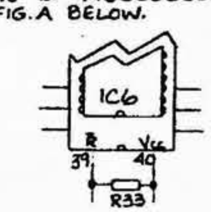


FIG. A

Sub 4
1356D15

Figure 11b. Parts List for DC Internal Schematic, MDF Relay

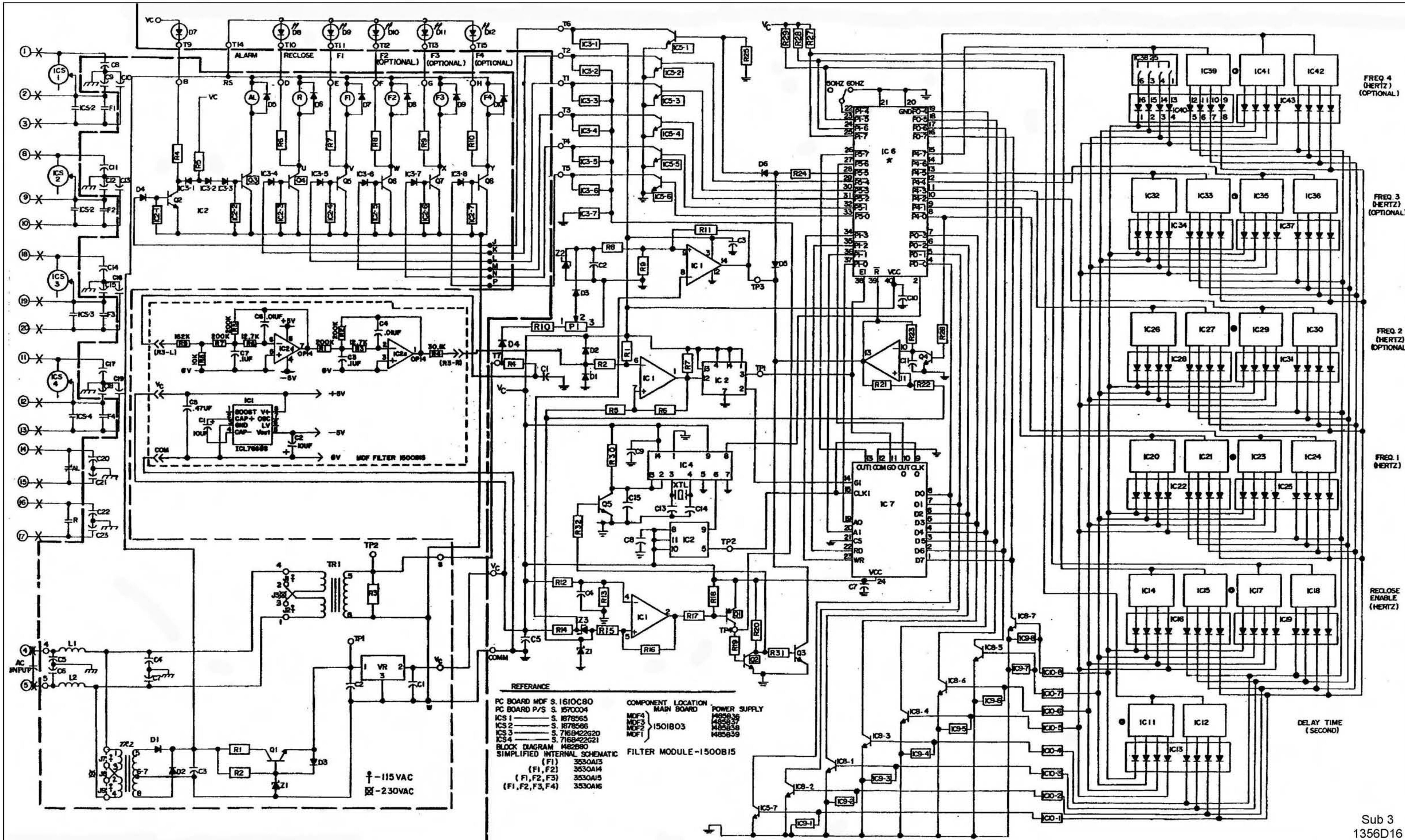


Figure 12a. AC Internal Schematic, MDF Relay

MAIN BOARD 1610C79

COMPONENT		DESCRIPTION	STYLE NO.
C1	CAPACITOR	.100UF 100V	762A680H14
C2	CAPACITOR	0.220UF 100V	763A219H21
C3	CAPACITOR	.100UF 100V	762A680H14
C4	CAPACITOR	1.0 UF 100V	3526A65H07
C5	CAPACITOR	10.000UF 20V	184A661H24
~~C6~~	~~CAPACITOR~~	~~.100UF 100V~~	~~762A680H14~~
C7	CAPACITOR	.100UF 100V	762A680H14
C8	CAPACITOR	.100 UF 100V	762A680H14
C9	CAPACITOR	.100 UF 100V	762A680H14
C10	CAPACITOR	.100 UF 100V	762A680H14
C11	CAPACITOR	1.000UF 50V	849A437H08
CONT. BELOW			
D1	DIODE	1N645A	837A692H03
D2	DIODE	1N645A	837A692H03
D3	DIODE	1N645A	837A692H03
D4	DIODE	1N645A	837A692H03
D5	DIODE	1N645A	837A692H03
D6	DIODE	1N645A	837A692H03
IC1	INT. CKT.	LM239AJ	3524A65H01
IC2	INT. CKT.	SN54107J	3513A25H02
IC3	INT. CKT.	316B152	3524A68H04
IC4	INT. CKT.	SN54LS624J	3524A68H01
IC5	INT. CKT.	CA3081	3524A67H01
IC6	INT. CKT.	SC80247L	1465C38H02
IC7	INT. CKT.	8253	1479B71H01
IC8	INT. CKT.	CA3081	3524A67H01
IC9	INT. CKT.	316B153	3524A68H05
IC10	INT. CKT.	316B103	3524A68H02
IC11	INT. CKT.	230002G	3524A70H01
IC12	INT. CKT.	230002G	3524A70H01
IC13	INT. CKT.	FSA2619M	3524A69H01
IC14	INT. CKT.	230002G	3524A70H01
IC15	INT. CKT.	230002G	3524A70H01
IC16	INT. CKT.	FSA2619M	3524A69H01
IC17	INT. CKT.	230002G	3524A70H01
IC18	INT. CKT.	230002G	3524A70H01
IC19	INT. CKT.	FSA2619M	3524A69H01
IC20	INT. CKT.	230002G	3524A70H01
IC21	INT. CKT.	230002G	3524A70H01
IC22	INT. CKT.	FSA2619M	3524A69H01
IC23	INT. CKT.	230002G	3524A70H01
IC24	INT. CKT.	230002G	3524A70H01
IC25	INT. CKT.	FSA2619M	3524A69H01
IC26	INT. CKT.	230002G	3524A70H01
IC27	INT. CKT.	230002G	3524A70H01
IC28	INT. CKT.	FSA2619M	3524A69H01
IC29	INT. CKT.	230002G	3524A70H01
IC30	INT. CKT.	230002G	3524A70H01
IC31	INT. CKT.	FSA2619M	3524A69H01
IC32	INT. CKT.	230002G	3524A70H01
IC33	INT. CKT.	230002G	3524A70H01
IC34	INT. CKT.	FSA2619M	3524A69H01
IC35	INT. CKT.	230002G	3524A70H01
IC36	INT. CKT.	230002G	3524A70H01
IC37	INT. CKT.	FSA2619M	3524A69H01
IC38	INT. CKT.	230002G	3524A70H01
IC39	INT. CKT.	230002G	3524A70H01
IC40	INT. CKT.	FSA2619M	3524A69H01
IC41	INT. CKT.	230002G	3524A70H01
IC42	INT. CKT.	230002G	3524A70H01
IC43	INT. CKT.	FSA2619M	3524A69H01
P1	POT.	20.0K .50W	3523A42H02
Q1	TRANSISTOR	2N2907A	762A672H17
Q2	TRANSISTOR	2N2222A	762A672H15
Q3	TRANSISTOR	2N2222A	762A672H15
Q4	TRANSISTOR	2N2222A	762A672H15
Q5	TRANSISTOR	2N2222A	762A672H15
Z1	ZENER	ICL8069DMSQ 1.23V	9649A34H01
Z2	ZENER	1N5235B 6.8V	862A288H07
Z3	ZENER	ICL8069DMSQ 1.23V	9649A34H01
R1	RESISTOR	162.0K .50W 1%	848A821H62
R2	RESISTOR	30.1K .50W 1%	848A820H81
~~R3~~	~~RESISTOR~~	~~30.1K .50W 1%~~	~~848A820H81~~
R4	RESISTOR	100.0 .50W 1%	848A818H51
R5	RESISTOR	10.0K .50W 1%	848A820H45
R6	RESISTOR	150.0K .50W 1%	848A821H59
R7	RESISTOR	10.0K .50W 1%	848A820H45
R8	RESISTOR	150.0K .50W 1%	848A821H59
R9	RESISTOR	150.0K .50W 1%	848A821H59
R10	RESISTOR	5.0K .50W 1%	848A820H16

COMPONENT		DESCRIPTION	STYLE NO.
R11	RESISTOR	432.0K .50W 1%	848A822H04
R12	RESISTOR	10.0K .50W 1%	848A820H45
R13	RESISTOR	3740.0 .50W 1%	848A820H04
R14	RESISTOR	10.0K .50W 1%	848A820H45
R15	RESISTOR	4990.0 .50W 1%	848A820H16
R16	RESISTOR	249K .25W 1%	3532A38H39
R17	RESISTOR	1000.0 .50W 1%	848A819H48
R18	RESISTOR	10.0K .50W 1%	848A820H45
R19	RESISTOR	10.0K .50W 1%	848A820H45
R20	RESISTOR	4.02K .50W 1%	848A820H07
R21	RESISTOR	51.1K .50W 1%	848A821H14
R22	RESISTOR	10.0K .50W 1%	848A820H45
R23	RESISTOR	150.0K .50W 1%	848A821H59
R24	RESISTOR	1000.0 .50W 1%	848A819H48
R25	RESISTOR	10.0K .50W 1%	848A820H45
R26	RESISTOR	10.0K .50W 1%	848A820H45
R27	RESISTOR	4990.0 .50W 1%	848A820H16
R28	RESISTOR	4990.0 .50W 1%	848A820H16
R29	RESISTOR	4990.0 .50W 1%	848A820H16
R30	RESISTOR	20.0K .50W 1%	848A820H74
R31	RESISTOR	4.02K .50W 1%	848A820H07
R32	RESISTOR	4.02K .50W 1%	848A820H07
D7	LED	RED	3508A22H04
D8	LED	YELLOW	3508A22H05
D9	LED	RED	3508A22H04
D10	LED	RED	3508A22H04
D11	LED	RED	3508A22H04
D12	LED	RED	3508A22H04
C13	CAPACITOR	10.5 PF 500V	187A610H02
C14	CAPACITOR	10.5 PF 500V	187A610H02
C15	CAPACITOR	0.22 UF 50V	188A669H12
~~C16~~	~~CAPACITOR~~	~~.0022µF 100V~~	~~3509A34H07~~

POWER SUPPLY BOARD 1570C04

COMPONENT		DESCRIPTION	STYLE NO.
C1	CAPACITOR	100.000UF 35V	CJ1006MGC4
C2	CAPACITOR	100.000UF 35V	CJ1006MGC4
C3	CAPACITOR	250.000UF 50V	CR25065HA1
C4	CAPACITOR	.010UF 3000V	CQ1002M380
C5	CAPACITOR	.010UF 3000V	CQ1002M380
C6	CAPACITOR	.010UF 3000V	CQ1002M380
C7	CAPACITOR	.010UF 3000V	CQ1002M380
C8	CAPACITOR	.010UF 3000V	CQ1002M380
C9	CAPACITOR	.010UF 3000V	CQ1002M380
C10	CAPACITOR	.010UF 3000V	CQ1002M380
C11	CAPACITOR	.010UF 3000V	CQ1002M380
C12	CAPACITOR	.010UF 3000V	CQ1002M380
C13	CAPACITOR	.010UF 3000V	CQ1002M380
C14	CAPACITOR	.010UF 3000V	CQ1002M380
C15	CAPACITOR	.010UF 3000V	CQ1002M380
C16	CAPACITOR	.010UF 3000V	CQ1002M380
C17	CAPACITOR	.010UF 3000V	CQ1002M380
C18	CAPACITOR	.010UF 3000V	CQ1002M380
C19	CAPACITOR	.010UF 3000V	CQ1002M380
C20	CAPACITOR	.010UF 3000V	CQ1002M380
C21	CAPACITOR	.010UF 3000V	CQ1002M380
C22	CAPACITOR	.010UF 3000V	CQ1002M380
C23	CAPACITOR	.010UF 3000V	CQ1002M380
D1	DIODE	1N4818	188A342H06
D2	DIODE	1N4818	188A342H06
D3	DIODE	1N645A	837A692H03
D4	DIODE	1N645A	837A692H03
D5	DIODE	1N4821	188A342H16
D6	DIODE	1N4821	188A342H16
D7	DIODE	1N4821	188A342H16
D8	DIODE	1N4821	188A342H16
D9	DIODE	1N4821	188A342H16
D10	DIODE	1N4821	188A342H16
IC1	INT. CKT.	FSA2619	3524A69H01
IC2	INT. CKT.	316B103	3524A68H01
J1	JUMPER	0 OHM RESISTOR	862A478H01
J2	JUMPER	0 OHM RESISTOR	862A478H01
J3	JUMPER	0 OHM RESISTOR	862A478H01
J4	JUMPER	0 OHM RESISTOR	862A478H01
J5	JUMPER	0 OHM RESISTOR	862A478H01
J6	JUMPER	0 OHM RESISTOR	862A478H01
J7	JUMPER	0 OHM RESISTOR	862A478H01
J8	JUMPER	0 OHM RESISTOR	862A478H01
J9	JUMPER	0 OHM RESISTOR	862A478H01
J10	JUMPER	0 OHM RESISTOR	862A478H01
J11	JUMPER	0 OHM RESISTOR	862A478H01
Q1	TRANSISTOR	2N3055	187A673H08
Q2	TRANSISTOR	2N2222A	762A672H15
Q3	TRANSISTOR	2N4063	878A432H01
Q4	TRANSISTOR	2N4063	878A432H01
Q5	TRANSISTOR	2N4063	878A432H01
Q6	TRANSISTOR	2N4063	878A432H01
Q7	TRANSISTOR	2N4063	878A432H01
Q8	TRANSISTOR	2N4063	878A432H01
R1	RESISTOR	10.0Ω 5.00W 3%	629A923H15
R2	RESISTOR	500.0 5.00W 5%	762A679H04
R3	RESISTOR	10.0K 1.00W 5%	187A643H51
R4	RESISTOR	274.0 .50W 1%	848A818H93
R5	RESISTOR	511.0 .50W 1%	848A819H20
R6	RESISTOR	2.0K 3.00W 1%	763A127H03
R7	RESISTOR	2.0K 3.00W 1%	763A127H03
R8	RESISTOR	2.0K 3.00W 1%	763A127H03
R9	RESISTOR	2.0K 3.00W 1%	763A127H03
R10	RESISTOR	2.0K 3.00W 1%	763A127H03
Z1	ZENER	1N2977B	629A798H02
TR1	TRANSF.		1479B94H01
TR2	TRANSF.		1479B94H02
L1	CHOKE		3500A27H01
L2	CHOKE		3500A27H01
VR	VOLT. REG.	LAS15A05	775B891H01
TP1	TEST POINT		849A242H01
TP2	TEST POINT		849A242H01
F1	TEL. RELAY	24V	407C733H05
F2	TEL. RELAY	24V	407C733H05
F3	TEL. RELAY	24V	407C733H05
F4	TEL. RELAY	24V	407C733H05
AL	TEL. RELAY	24V	407C733H05
R	TEL. RELAY	24V	407C733H05

FILTER MODULE-1500B15G01

C1	CAPACITOR	10.0uF 20V 20% TANTALUM	184A661H24
C2	CAPACITOR	10.0uF 20V 20% TANTALUM	184A661H24
C3	CAPACITOR	0.1uF 500V 2% METAL MYLAR	3526A65H10
C4	CAPACITOR	0.01uF 200V 5%	3502A85H13
C5	CAPACITOR	0.47uF 50V 20%	762A680H04
C6	CAPACITOR	0.01uF 200V 5%	3502A85H13
C7	CAPACITOR	0.1uF 500V 2% METAL MYLAR	3526A65H10
R1	RESISTOR	200K .25W 1% METAL FILM	3532A38H30
R2	RESISTOR	200K .25W 1% METAL FILM	3532A38H30
R3	RESISTOR	12.7K .25W 1% METAL FILM	3535A37H11
R4	RESISTOR	30.1K .25W 1% METAL FILM	3535A37H47
R5	RESISTOR	200K .25W 1% METAL FILM	3532A38H30
R6	RESISTOR	12.7K .25W 1% METAL FILM	3535A37H11
R7	RESISTOR	200K .25W 1% METAL FILM	3532A38H30
R8	RESISTOR	10K .25W 1% METAL FILM	3535A37H01
R9	RESISTOR	162K .25W 1% METAL FILM	3532A38H21
IC1	INT CKT	VOLT. CONVERTER ICL7660	9649A49H01
IC2	INT CKT	OP-14DZ	9642A94H01

NOTE-
WHEN USING uP 1465C38G03, ADD RESISTOR 848A820H16 AS PER FIG. A BELOW.

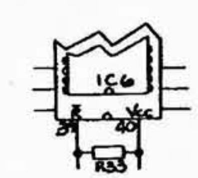
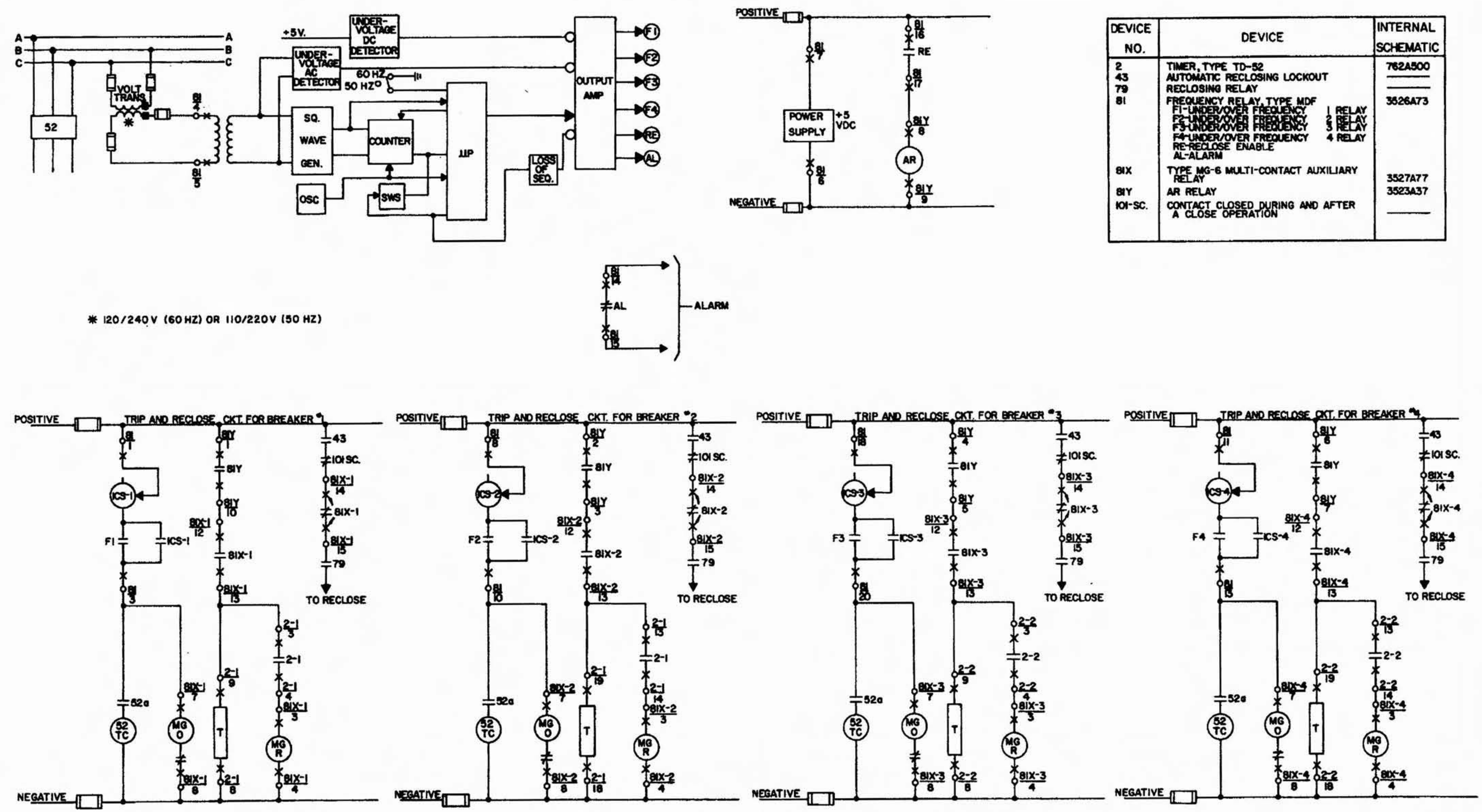


FIG. A

Sub 3
1356D16

Figure 12b. Parts List for AC Internal Schematic, MDF Relay



DEVICE NO.	DEVICE	INTERNAL SCHEMATIC
2	TIMER, TYPE TD-52	762A500
43	AUTOMATIC RECLOSING LOCKOUT	———
79	RECLOSING RELAY	———
81	FREQUENCY RELAY, TYPE MDF F1-UNDER/OVER FREQUENCY 1 RELAY F2-UNDER/OVER FREQUENCY 2 RELAY F3-UNDER/OVER FREQUENCY 3 RELAY F4-UNDER/OVER FREQUENCY 4 RELAY RE-RECLOSE ENABLE AL-ALARM	3526A73
81X	TYPE MG-6 MULTI-CONTACT AUXILIARY RELAY	3527A77
81Y	AR RELAY	3523A37
101-SC.	CONTACT CLOSED DURING AND AFTER A CLOSE OPERATION	———

Sub 3 - 1342D76

Figure 13. External Schematic for MDF Relay

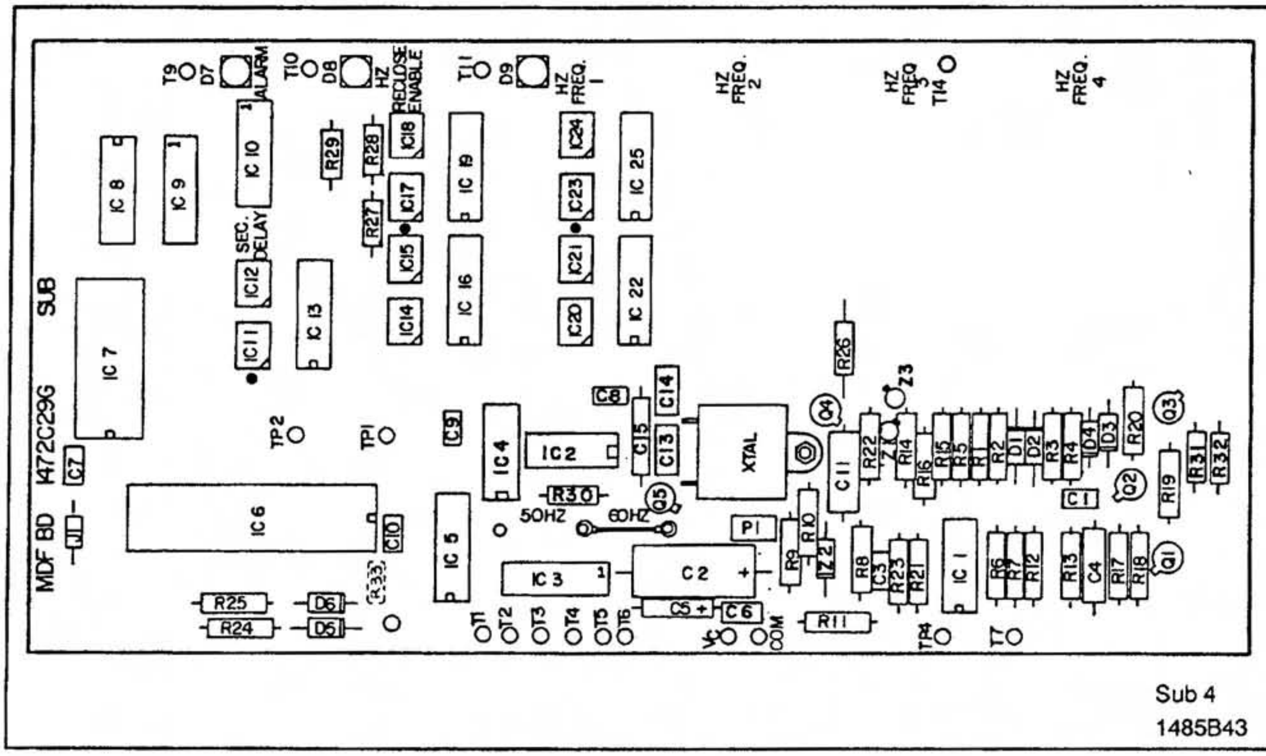


Figure 14. Component Location of MDF Board - One Frequency Setting

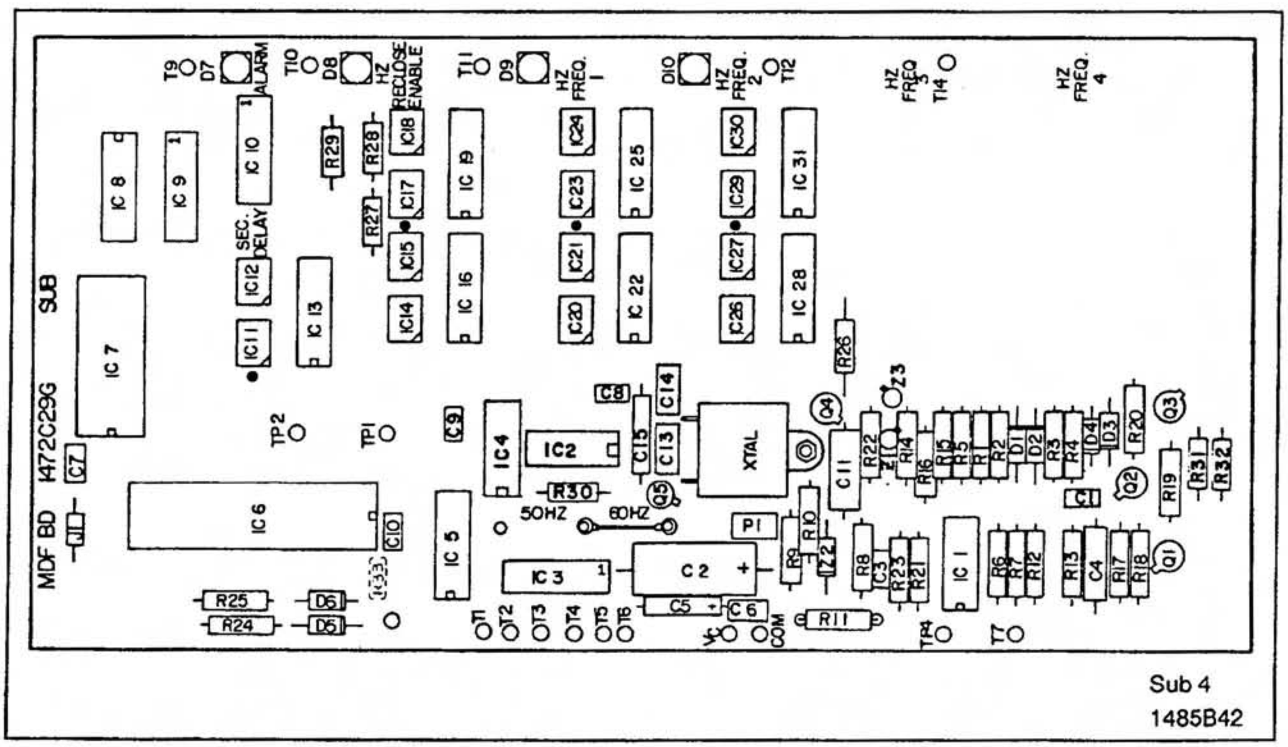


Figure 15. Component Location of MDF Board - Two Frequency Setting

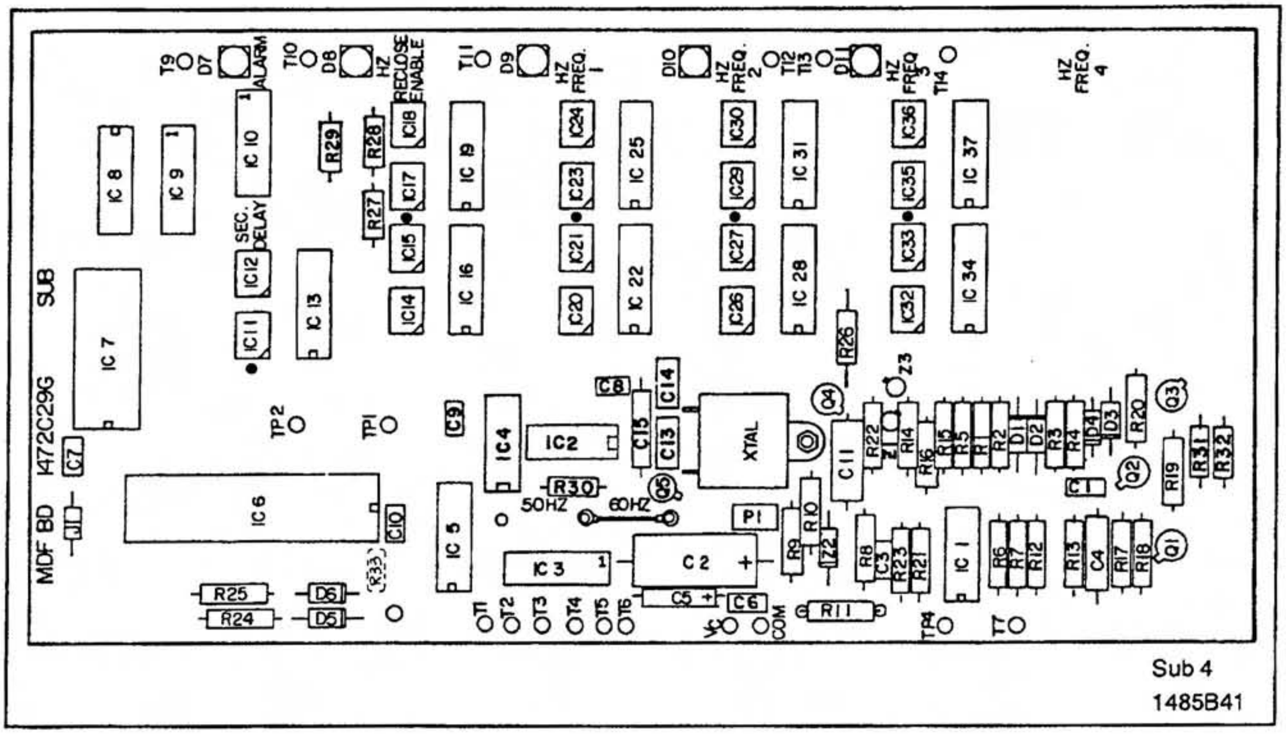


Figure 16. Component Location of MDF Board - Three Frequency Settings

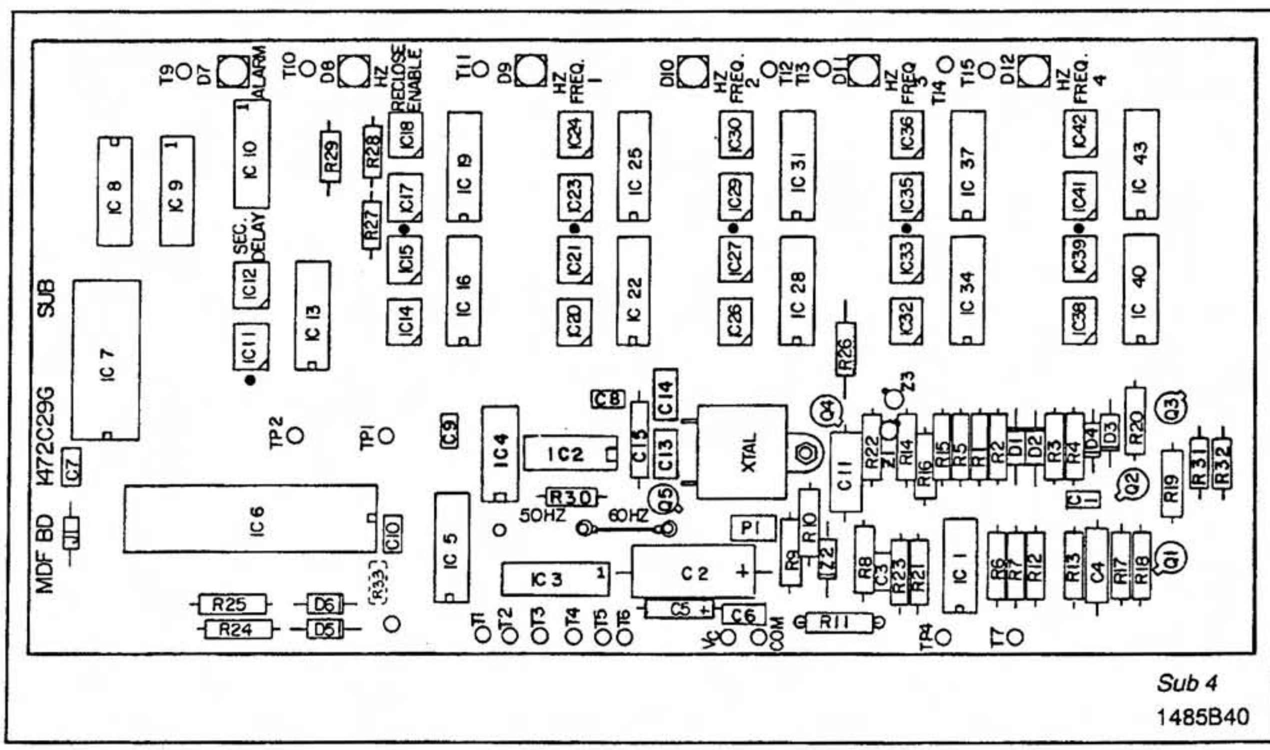


Figure 17. Component Location of MDF Board -Four Frequency Settings

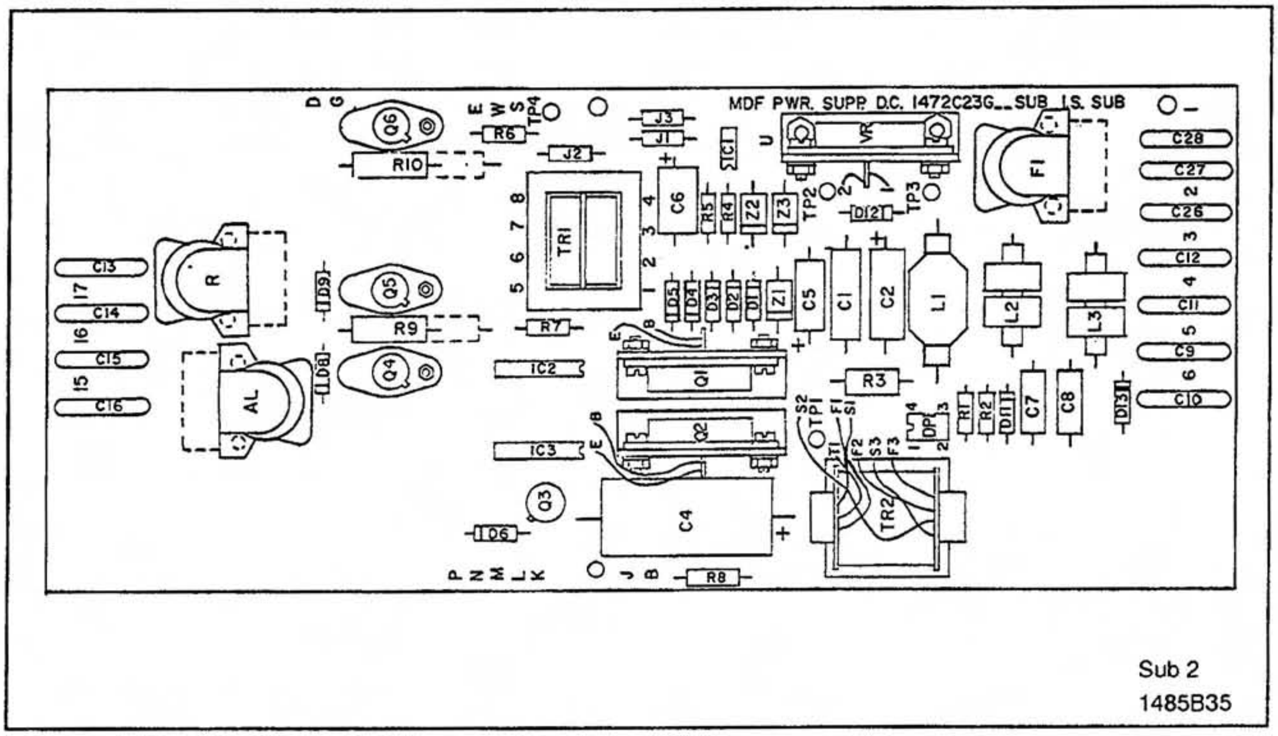


Figure 18. Component Location of Power Supply Board (dc) - One Frequency Setting

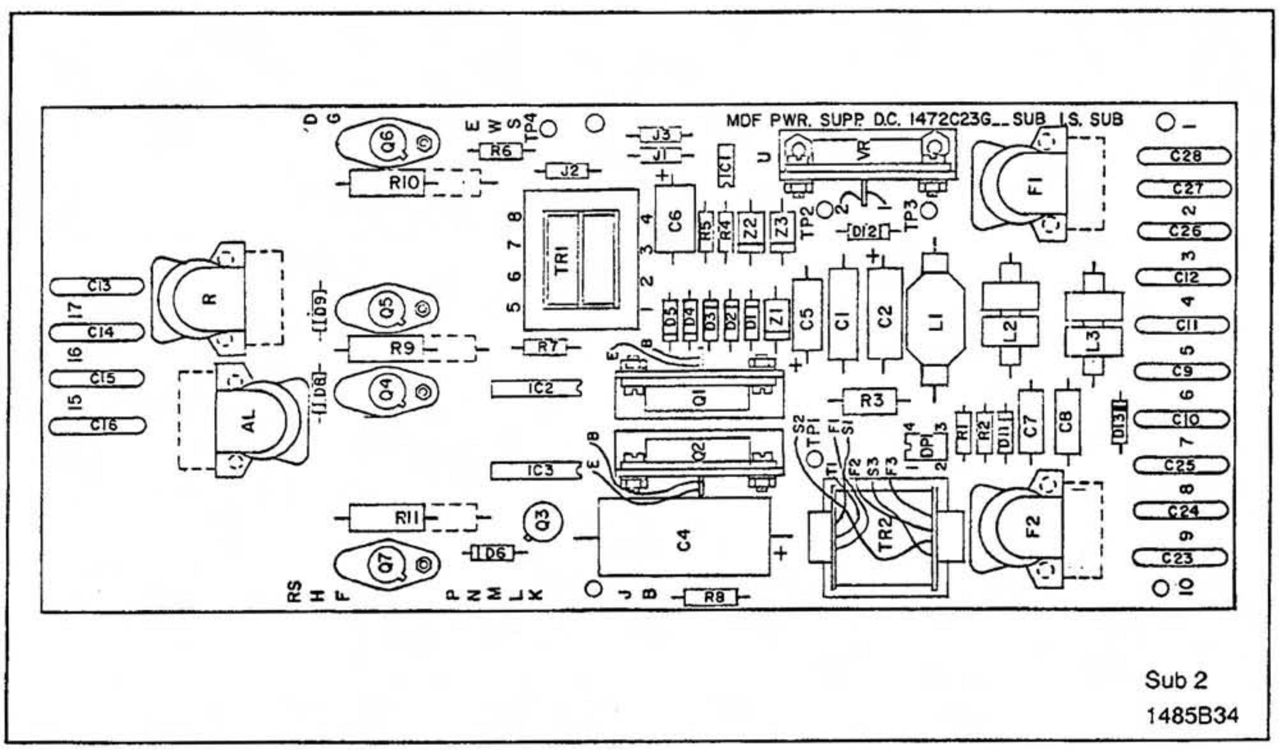


Figure 19. Component Location of Supply Board (dc) - Two Frequency Settings

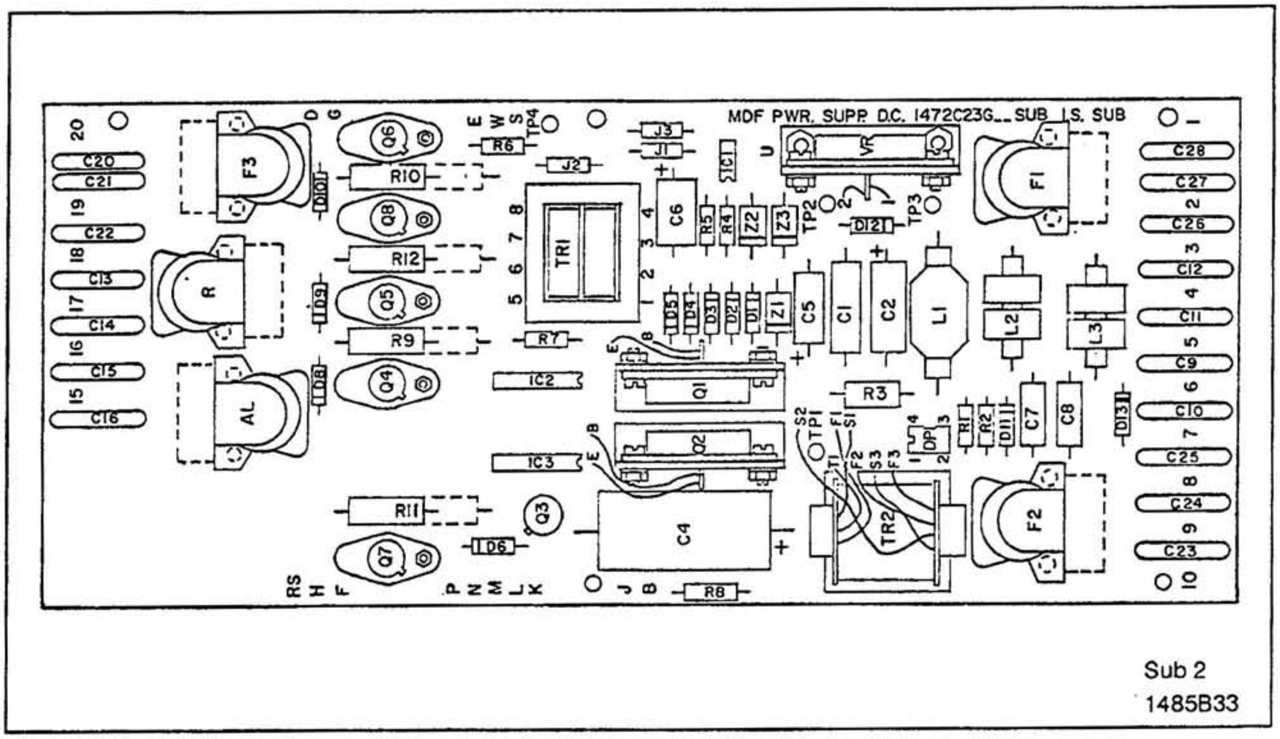


Figure 20. Component Location of Power Supply Board (dc) - Three Frequency Settings

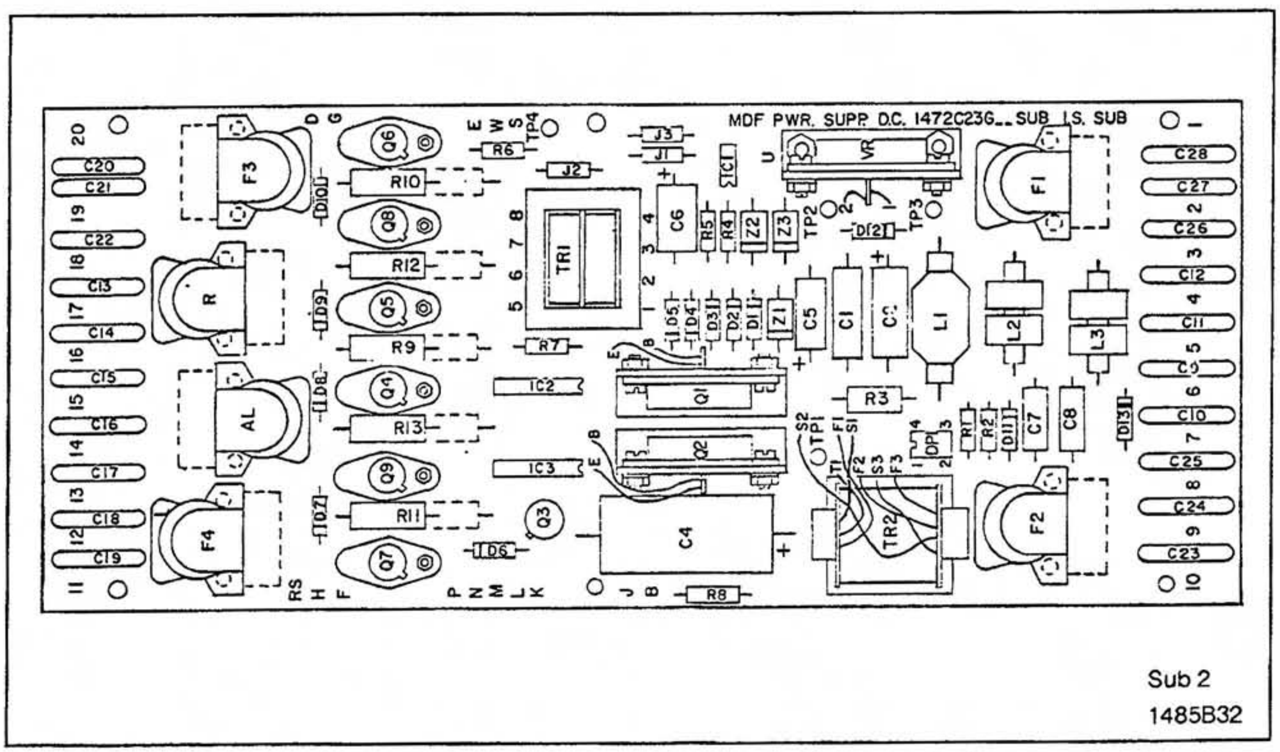


Figure 21. Component Location of Supply Board (dc) - Four Frequency Settings

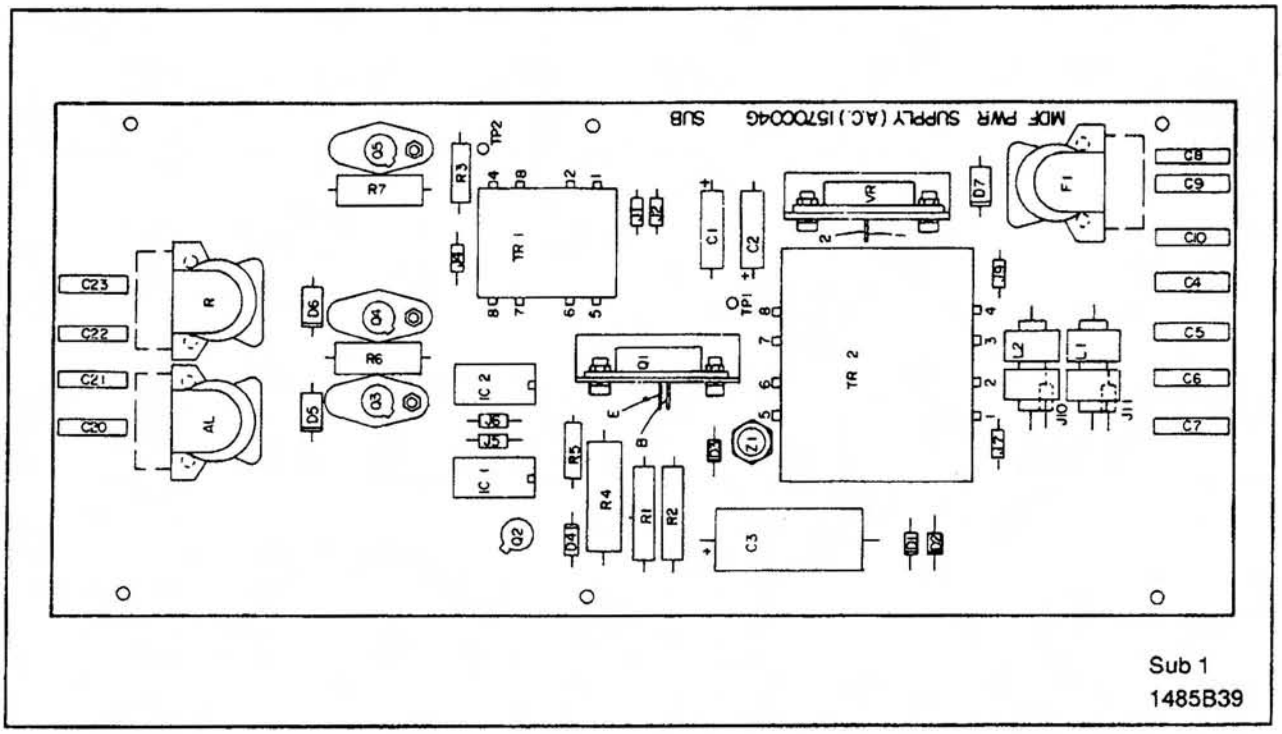


Figure 22. Component Location of Power Supply Board (ac) - One Frequency Setting

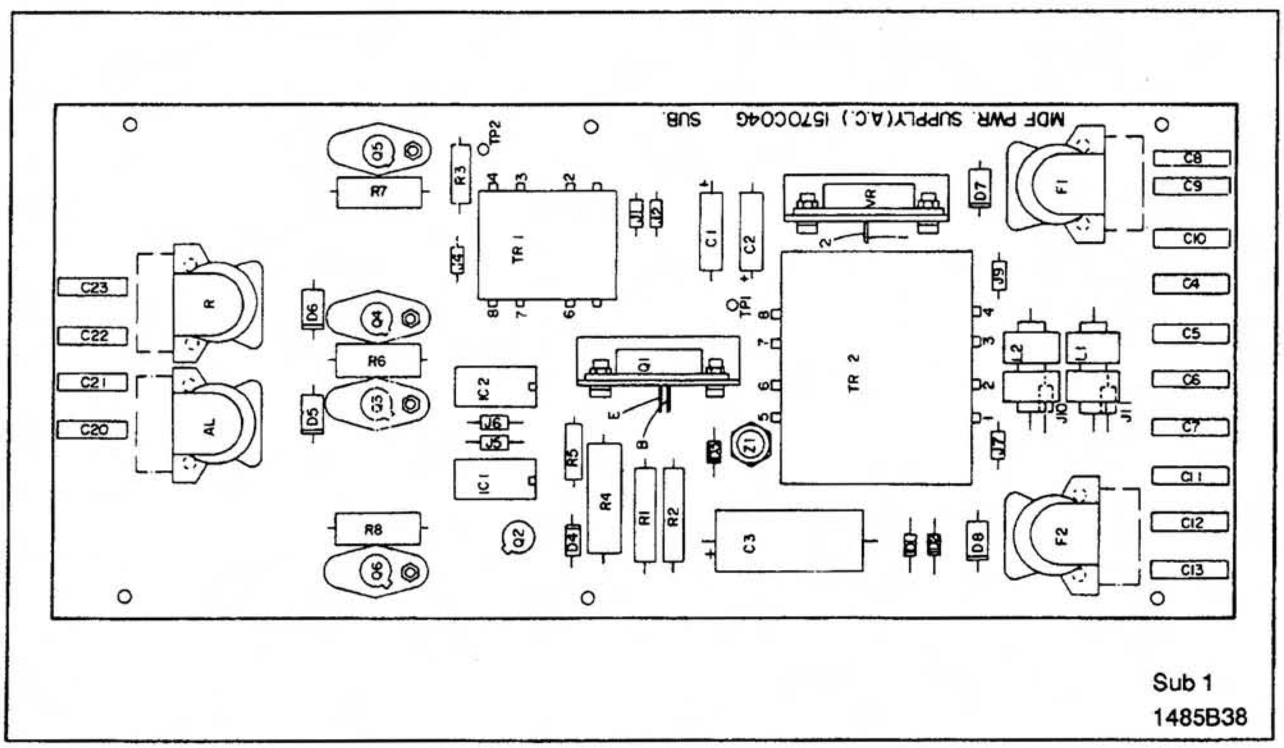


Figure 23. Component Location of Supply Board (ac) - Two Frequency Settings

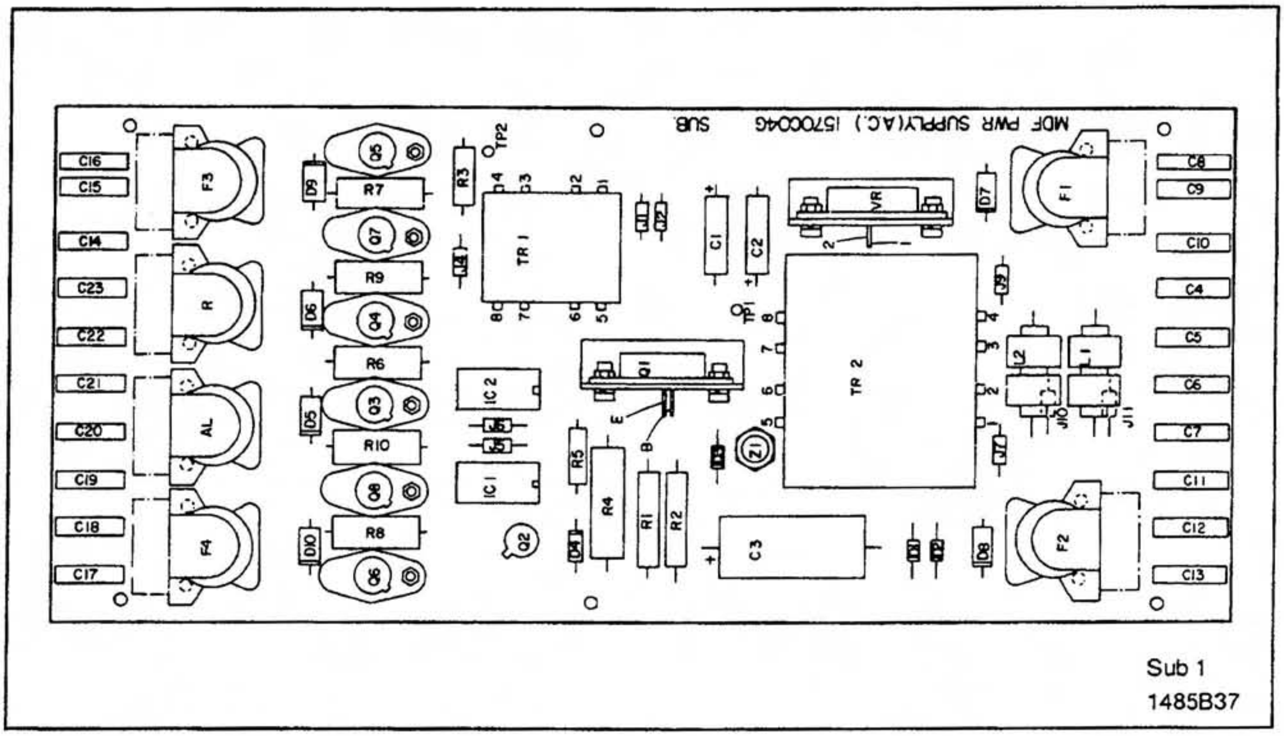


Figure 24. Component Location of Power Supply Board (ac) -Three Frequency Settings

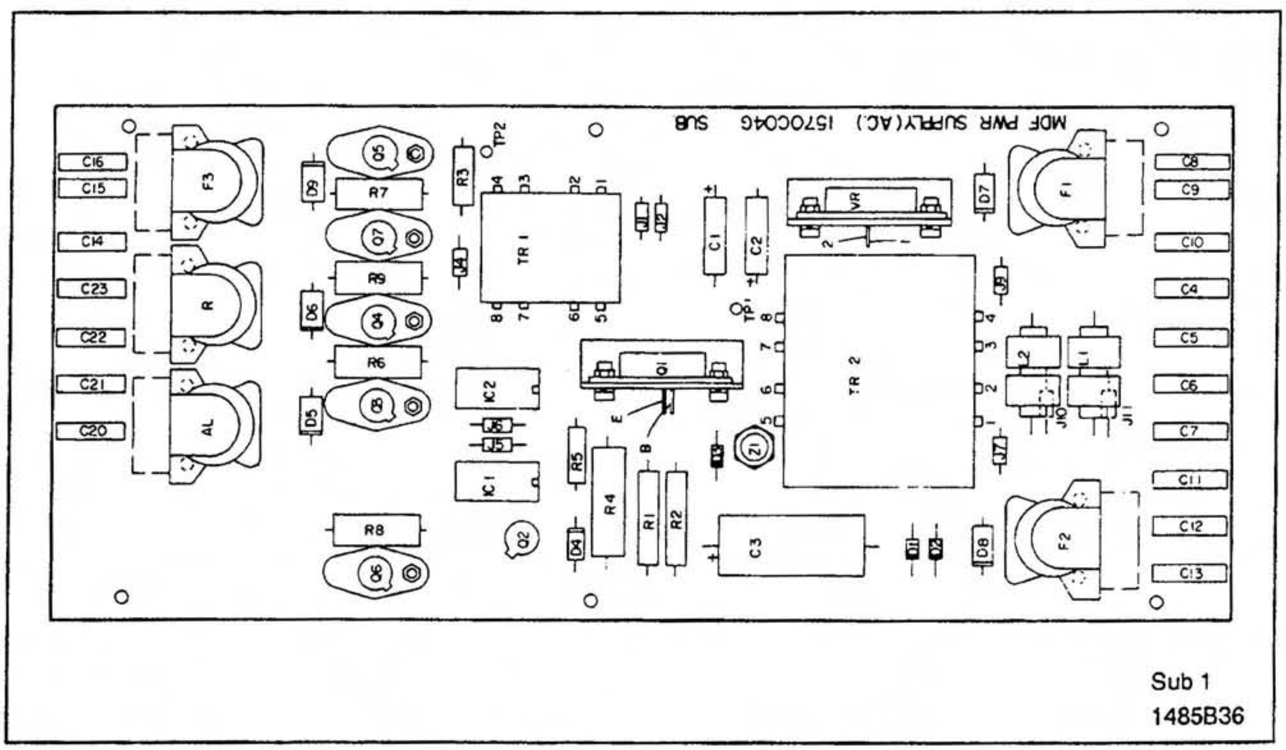
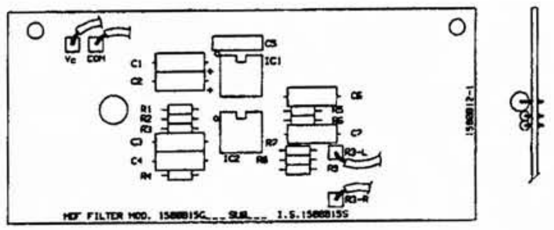


Figure 25. Component Location of Supply Board (ac) - Four Frequency Settings



ITM	PART NAME	DESCRIPTION	STYLE NO.	G01	COMP. LOCATION
01	CAPACITOR	0.1uF 500V 2% MET MYLAR	3526A65H10	2	C3,7
02	CAPACITOR	0.01uF 200V 5%	3502A85H13	2	C4,6
03	CAPACITOR	0.47uF 50V 20%	762A680H04	1	C5
04	CAPACITOR	10.0uF 20V 20% TANTALUM	184A661H24	2	C1,2
05	RESISTOR	200K .25W 1% METAL FILM	3532A38H30	4	R1,2,5,7
06	RESISTOR	30.1K .25W 1% METAL FILM	3535A37H47	1	R4
07	RESISTOR	12.7K .25W 1% METAL FILM	3535A37H11	2	R3,6
08	RESISTOR	10K .25W 1% METAL FILM	3535A37H01	1	R8
09	RESISTOR	162K .25W 1% METAL FILM	3532A38H21	1	R9
10	INT CKT	OP-14DZ	9642A94H01	1	IC2
11	INT CKT	VOLT. CONVERTER ICL7660	9649A49H01	1	IC1

Sub 2
1500B15

Figure 26. Module Assembly MDF Filter Module

	02	CAPACITOR		0.05uF 500V 20%	879A911	H13				C1
	03	RESISTOR		200 3W 5% WW	184A859	H01				R1
	04	VARISTOR		175Vdc MAX.	3509A31	H17				V1
	05	FUSE HOLDR			9644A50	H01				
	06	FUSE		0.5A SLO-BLO	103A981	H11				F1,2
	07	INSULATION			44791KV	80A				
	08	LEAD			2520400251					
	09	VARISTOR		100Vdc MAX.	3509A31	H06				V1
	10	LEAD		BARE WIRE 1"	0970100000					R1
	11	VARISTOR		320vac [illegible]	3509A31	H01				V1

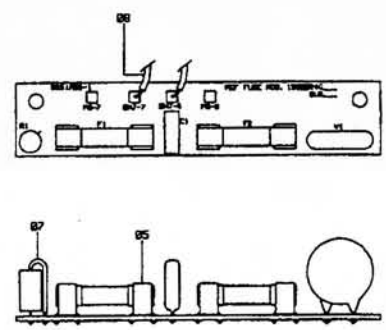
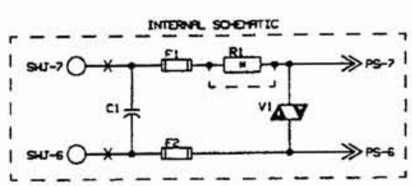


FIG. 1



* - WHEN USED

USE JUMPER (LEAD, ITM. 10) IN PLACE OF R1 FOR G02

FIG. 2
(OTHERWISE SAME AS FIG. 1)

* Sub 2
1500B24

Figure 27. Module Assembly MDF Fuse Module

* Denotes Change

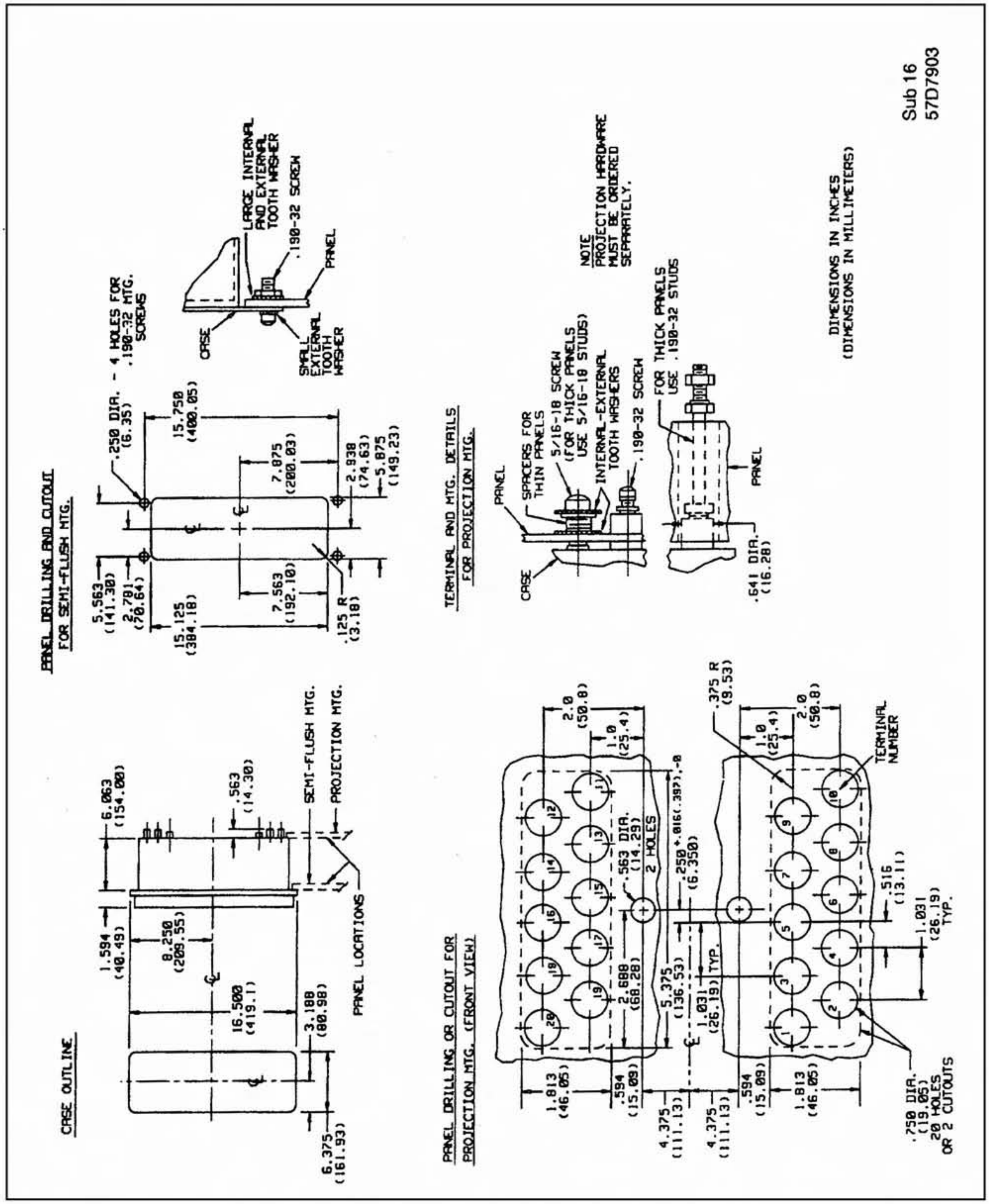


Figure 28. Outline & Drilling Plan for MDF Relay in FT-32 Case

THIS PAGE RESERVED FOR NOTES

IL 41-505 - Revision D

ABB Inc.

4300 Coral Ridge Drive
Coral Springs, Florida 33065

Telephone: +1 954-752-6700
Fax: +1 954-345-5329

www.abb.com/substation automation