ABB Power T&D Company Inc.
Relay Division
Coral Springs, FL 33065

Instruction Leaflet

41-830.11B

Type ALS and DLS Power Supplies

Effective: August 1990
Supersedes 41-830.11A, dated February 1990
* Denotes Change Since Previous Issue

CAUTION

Before putting this equipment into service, it is recommended that the user of this equipment become acquainted with the information in these instructions. This supply module should not be removed or inserted while the cabinet is energized with dc quantities. Failure to observe this precaution can result in undesired operation or component damage.

Some components used on this module are sensitive to and can be damaged by the discharge of static electricity. Electro-static discharge precautions should be observed when handling modules or individual components.

1. APPLICATION

The ALS and DLS power supply modules isolate the relay system logic and sensing circuits from the station battery. The ALS module provides a source of plus and minus 15 Vdc needed by the operational amplifier and digital logic circuits, while the DLS module provides the additional +15 Vdc capacity for driving large amounts of digital logic circuits and for extra trip outputs.

The ALS and DLS modules (with the AMP connector or the DIN connector), are grouped for ordering purposes as follows:

- G01 (48 Vdc) ALS for Uniflex
- G02 (125 Vdc) ALS for Uniflex
- G03 (250 Vdc) ALS for Uniflex
- G04 (48 Vdc) DLS
- G05 (125 Vdc) DLS
- G06 (250 Vdc) DLS
- G07 (48 Vdc) ALS for LDAR
- G08 (125 Vdc) ALS for LDAR
- G09 (250 Vdc) ALS for LDAR

Parts List 1349D85 (for ALS/DLS with **AMP** connector) shows PC Board 1584C87H01. Parts List 1355D49 (for ALS/DLS with **DIN** connector) shows PC Board 1609C48H01. Both PC Boards are used for all nine applications.

2. CONSTRUCTION

The ALS and DLS modules are self-contained power supplies with isolated outputs. The supplies consist of an inverter, rectifier assembly or assemblies, and feedback regulator that is sampled on the main +15V supply for both the ALS and DLS modules. The -15V supply on the ALS is a shunt-regulated supply.

All of the circuitry for both supplies are housed in modules approximately 4.875" x 10" x 2" and have 2" panels on which are mounted power ON/OFF switches, fuses, LED indicators, test jacks and output adjusters. Except for the connectors, the modules are completely enclosed in aluminum cases which serve both as heat sinks and RFI noise shields. Each supply requires two module spaces in the standard 3 rack unit chassis and is designed to fit in any position in the chassis.

3. SPECIFICATIONS

DC Input

48V(nom)	38 to 66	Vdc @ 2.6 Amps
125V(nom)	80 to 145	Vdc @ 1.4 Amps
250V (nom)	170 to 290	Vdc @ 0.6 Amps

DC Output

ALS Supply	+15 volts	@ 3 Amps (Max.)
	-15 volts	@ 1 Amp (Max.)
DLS Supply	+15 volts	@ 4 Amps (Max.)

Regulation on the +15 Vdc supplies is ±150 mV; regulation on the -15 Vdc supply is ±450 mV.

NOTE: All ratings are at rated loads.

4. OPERATION

Referring to the ALS/DLS Block Diagram (Figure 1), the primary side is to the left while the secondary side is to the right. Rated dc input voltages are applied to terminals 33 (for battery positive) and 35 (for battery negative) for a power supply with the AMP connector; apply to terminals 30 A/C (for battery positive) and 32 A/C (for battery negative) for a power supply with a DIN connector. The rated input voltages are transmitted through the switch and fuses. During operation, any noise generated by the power supply or noise on the battery supply lines is attenuated by the common and differential mode noise rejection circuits. An energy storage capacitor is used to limit the effect of transitory input voltage fluctuations. The input voltage is also sensed for protection against overvoltage. The dc input light emitting diode is illuminated to indicate presence of the input voltage.

The switching signal from the control logic is applied to the pulse width modulator driver which, in turn, switches the primary of the transformer. The resulting secondary waveform is rectified and filtered at a sufficient voltage level that will sustain secondary circuit operation. The voltage level detection circuit enables the start-up oscillator through an optical isolator and also enables the pulse width modulator circuit to produce a 27.5 kHz switching signal. This signal from the pulse width modulator is coupled by a second optical isolator to the primary control logic, which is then applied to the pulse width modulator driver and the transformer primary is switched.

The switching frequency is always 27.5 kHz. However the "ON" time of the primary, which is the width of the pulse, is a function of the output voltage under load conditions. Power fold-back protection operates whenever the output load demand is greater than the power supply rating. The overload condition is constantly sensed by the power fold-back memory and allows normal operation once the overload condition is removed. The pulse width applied to the driver through the control logic, during overload conditions, is less than the pulse width under normal loads, which insures the safe operation of switching components.

5. DESCRIPTION

Referring to schematic drawing Figure 5A (ALS supply with AMP connector), or Figure 5B (ALS supply with DIN connector) the Balun transformer (T1) acts to suppress any noise that is of the same phase on both leads from the battery, or from the switching supply back through the leads. D1 protects against accidental battery polarity reversal or transient battery reversal while C7, L1, and C2 suppress differential mode noise. Resistor (R1) limits the inrush current to the supply and C1 stores energy to allow uninterrupted operation even when the dc input voltage experiences transients.

Components Z1, R9, R10, C9 and Q5 form an overvoltage shutdown circuit to limit the stress on components when subjected to prolonged overvoltage. Whenever the input voltage is too great, Z1 conducts turning on Q5, which blocks the signal at the gate of Q4 (the main switching device) through IC1, Q2 and Q3.

When the input dc voltage is applied, light emitting diode (D2) is turned ON. Z2, Q1, and associated circuitry will keep the startup oscillator disabled until a positive 15 volts is obtained at test point one. Once the 15 volts is there, the startup oscillator is enabled and a 25 kHz switching signal is applied to the control circuit IC1 pin 2. This signal is applied by IC1 to transistors Q2 and Q3, providing a low impedance source and sink to drive the gate of the MOSFET Q4. Components C6, R6, and D3 form a circuit to allow a core recovery of the transformer (T2). Zener diodes (Z3 and Z7) prevent excessive voltage from appearing at the drain of the MOSFET (Q4) while R8 and C8 suppress transient ringing. Resistor (R7) functions as a current sensor. When an overcurrent condition occurs at a level which is determined by the adjustments of P1, Q6 is biased ON setting flip flop IC2. This causes the MOSFET to turn OFF immediately. The flip flop will remain in this state until the arrival of the next switching pulse from the pulse width modulator (IC5). The arrival of this switching pulse will reset the flip flop and allow the MOSFET to conduct. If the overcurrent condition still exists, the flip flop will be set again. As a result, the MOSFET will be switched ON and OFF until the overcurrent condition is removed.

The conduction time of the MOSFET is inversely proportional to the overcurrent magnitude, i.e., the more severe the overcurrent the shorter the MOSFET conduction time. This characterizes a unique feature known as power fold-back in the power supply design.

Components D6, R22, C13, R23 and D7, along with a transformer winding, form a circuit which provides auxiliary power to the primary side circuitry after startup. The secondary voltage is rectified by the fast recovery diodes (D9 and D10) for the negative supply and D11 and D12 for the positive supply. Filter circuits L2, C16, and L3, C19 produce the final supply voltages. During initial power-up, the voltage rises on the secondary and charges capacitors C21 and C22 through D13. When this voltage rises above 10 volts, zener diode (Z8) conducts, turning on transistors (Q7 and Q8). Q7 turns on optical isolator IC4, which disables the startup oscillator and, at the same time, enables the pulse width modulator (IC5) to produce a switching signal at test point 9. This signal is adjusted to 27.5 kHz by potentiometer (P2).

The positive output voltage level (which is also controlled by IC5), is adjusted to 15 Vdc by potentiometer P3 (referred to as "OUTPUT ADJUST" on the front panel of the module). The negative 15 Vdc tracks the positive voltage by comparing both voltage levels in one section of operational amplifier IC6, which biases shunt regulator Q11 in order to regulate the negative 15 Vdc output.

The switching signal, at TP9, is coupled to the primary through optical isolator IC3. The output of the optical isolator is applied to the control circuit and then to the gate drive of the MOSFET.

The output voltage of the power supply is monitored for over and undervoltage. The under and overvoltage is sensed by two sections of integrated OP-AMP circuit IC6. When an unfavorable voltage level exists, pins1 or 7 or IC6 will go low, removing the base drive from Q10 thereby causing output LED D21 to turn OFF and alarm relay RR1 to drop out. In addition, bias is applied to transitor Q9 to drop the normal 10 Vdc PSME signal to a low of < 4 Vdc. The PSME signal is used to control logic circuits elsewhere in the relay system.

The DLS power supply (Figure 6A, DLS supply with AMP connector or Figure 6B, DLS supply with DIN connector) provides additional isolated +15 Vdc capacity for powering large numbers of digital logic circuits and for extra trip outputs. Figures 6A/6B do not include circuits for the generation of -15 Vdc. Otherwise, the construction and circuitry is identical to that for the ALS power supply. Deleted are the shunt regulator Q11 and the tracking voltage comparator IC6. In addition, the two secondary windings of T2 are paralleled to achieve the 60 watt power capability for the +15 Vdc output.

6. ACCEPTANCE CHECK

The following equipment is required:

- Digital Voltmeter (DVM)
- Loads for ALS and DLS supply)
  ALS supply (5 and 15Ω, 100W)
  DLS supply (3.75 Ω, 100W)

6.1 Input Voltage Range Check

a. Apply rated voltage to terminals of supply.

b. Turn on the power supply switch.

c. The DC INPUT light should come ON.

d. Raise the input voltage to the voltage value from the table below; the DC OUTPUT light should go OFF:

CAUTION: Apply the excess voltage for less than 1 second to prevent undue stress on components.

For AMP Connector

1349D85A01, A04, A07	85V
1349D85A02, A05, A08	200V
1349D85A03, A06, A09	350V

For DIN Connector

1355D49A01, A04, A07	85V
1355D49A02, A05, A08	200V
1355D49A03, A06, A09	350V

e. Lower the input voltage to the value from the table below; the DC INPUT light should remain ON.

For AMP Connector

1349D85A01, A04, A07	38V
1349D85A02, A05, A08	80V
1349D85A03, A06, A09	170V

For DIN Connector

1355D49A01, A04, A07	38V
1355D49A02, A05, A08	80V
1355D49A03, A06, A09	170V

6.2 Output Voltage Checks

a. Apply rated nominal voltage to the input terminals of the supply.

b. Turn on the power supply switch.

c. Measure the open circuit voltage at terminals 21(+) and 31 (COM) with a digital voltmeter (for a power supply with the AMP connector); apply to terminals 18A/C (+) and 28A/C (COM) for a power supply with the DIN connector. The voltage should be +15 Vdc. "OUTPUT ADJUST" potentiometer (P3) can be used to adjust the output to +15 Vdc. The -15 Vdc output on the ALS supply should track the +15 Vdc output within ± 0.10 volts.

d. Load the outputs of the supplies per the following table.

ALS Supplies

+15 Vdc output (5Ω , 100W) 3A

-15 Vdc output (15Ω, 100W) 1A

DLS Supplies

+15 Vdc output (3.75Ω, 100W) 4A

The output voltages should not change by > 0.150 Vdc from their adjusted open circuit values. No alarms should occur and the dc output LED should remain lit as the load is changed from full to no load.

7. REPAIR CALIBRATION

NOTE: If the power supply is malfunctioning, it is recommended that the supply be sent back to the factory for repair. However, if repairs must be made in the field, the following test and calibration procedure should be used.

Equipment Required:

- Oscillator (dual trace).
- Frequency counter.
- Digital voltmeter.
- Separately adjustable +15 Vdc and -15 Vdc power supplies.
- 0-350 Vdc power supply.
- Loads specified for the Acceptance Check (see segment 6).

7.1 Procedures for ALS and DLS Power Supplies

This part should be done on a test bench and only if it is suspected that the supply is malfunctioning.

a. Working at a test bench, remove the cover and open any two leads from the MOSFET Q4, in order to separate the primary and secondary of the transformer (T2). (See Figure 2, bottom view; Q4 is the left-hand transistor when the case is open and the connector is to the right.) Refer to internal schematics (see Figures 5A, 5B or 6A, 6B).

b. Connect the DVM between TP1 (see Schematic, upper-left) and common (see Schematic, upper-right). Apply rated nominal input voltage to input terminals. The DVM should measure +15 Vdc at TP1.

c. The waveform at TP3 (see Schematic, upper-center), monitored on an oscilloscope, should be a square wave pulse train, with an approximately 40% duty cycle on the positive portion, at a frequency of 25000 to 26000 Hz (see Figure A). The waveform at TP2 is the inverse of the waveform at TP3.

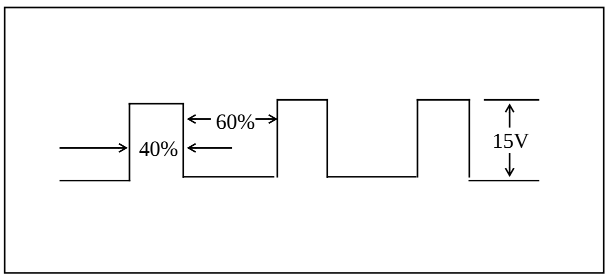


Figure A

d. Next, monitor TP3 with an oscilloscope. Jumper TP4 to TP3, and the waveform at TP3, will change to a positive duty cycle of < 10% (Figure B). Remove jumper and the waveform will return to the normal 40% duty cycle.

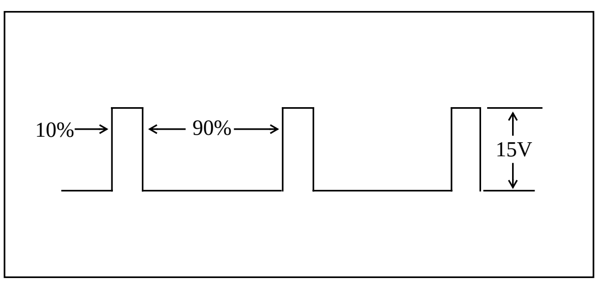


Figure B

e. Raise the input voltage to the value from the table below; the waveforms at TP2 and TP3 should disappear.

85V for	48V	version
200V for	125V	version
350V for	250V	version

f. Next, lower the input dc voltage until 9 Vdc is measured with a digital voltmeter at TP1. The startup oscillator is disabled and the waveform at TP2 will disappear.

g. Turn off the input power supply.

7.2 Procedures for ALS (±15 Vdc) Power Supplies

a. With external adjustable +15 Vdc and -15 Vdc power supplies, apply + and - 14.5 Vdc to the output terminals of the ALS supply. Use a DVM for measurement. The LED (D21) will be turned ON.

b. Monitor TP9 (see Schematic, lower-right), with a frequency counter and adjust the frequency with potentiometer (P2) to 27.5 ± 0.01 kHz. Lower the positive voltage from +14.5 Vdc to +7Vdc and the waveform at TP9 will be disabled. Bring the voltage back to +14.5 Vdc.

c. Monitor output terminal PSMP to common with a DVM. The voltage should be 13.8 Vdc (±1 Vdc).

d. Monitor output terminal PSME to common. The voltage should be 9 Vdc or greater. Increase the +14.5 Vdc to +16.4 Vdc. The voltage at terminal PSME will drop to 1 Vdc or less and LED (D21) will turn OFF. Lower the +14.5 Vdc to 13.4 Vdc; terminal PSME will drop to 1 Vdc or less and LED (D21) will turn OFF. Return the positive voltage to +14.5 Vdc and follow the same procedure for the -14.5 Vdc.

7.3 Procedures for DLS (+15 Vdc) Power Supplies

Follow the same procedure as that in 7.2a, b, c, and d for +15 Vdc only (references to -15 Vdc do not apply).

7.4 Procedures for ALS and DLS Power Supplies

a. Apply rated voltage to the input terminals while maintaining the ±14.5 Vdc for ALS supplies and +14.5 Vdc for DLS supplies at the output terminals. With an oscilloscope, monitor TP11 (see Schematic, lower-center). The signal at TP11 (Figure C) will be a 27.5 kHz waveform generated by IC5 and isolated from the secondary by IC3. IC4 will shut down the startup oscillator, creating a +15 Vdc level at TP2.

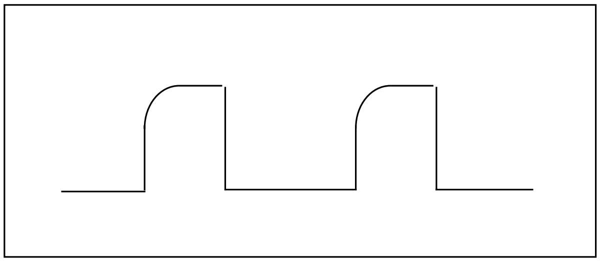


Figure C

b. Monitor TP3 for the 27.5 kHz waveform (Figure D).

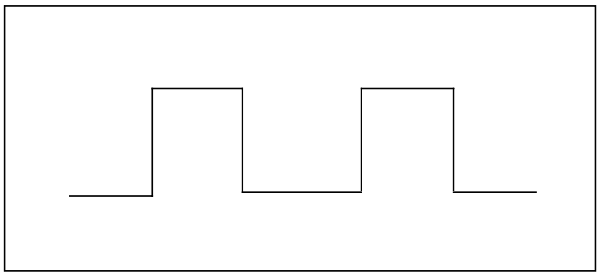


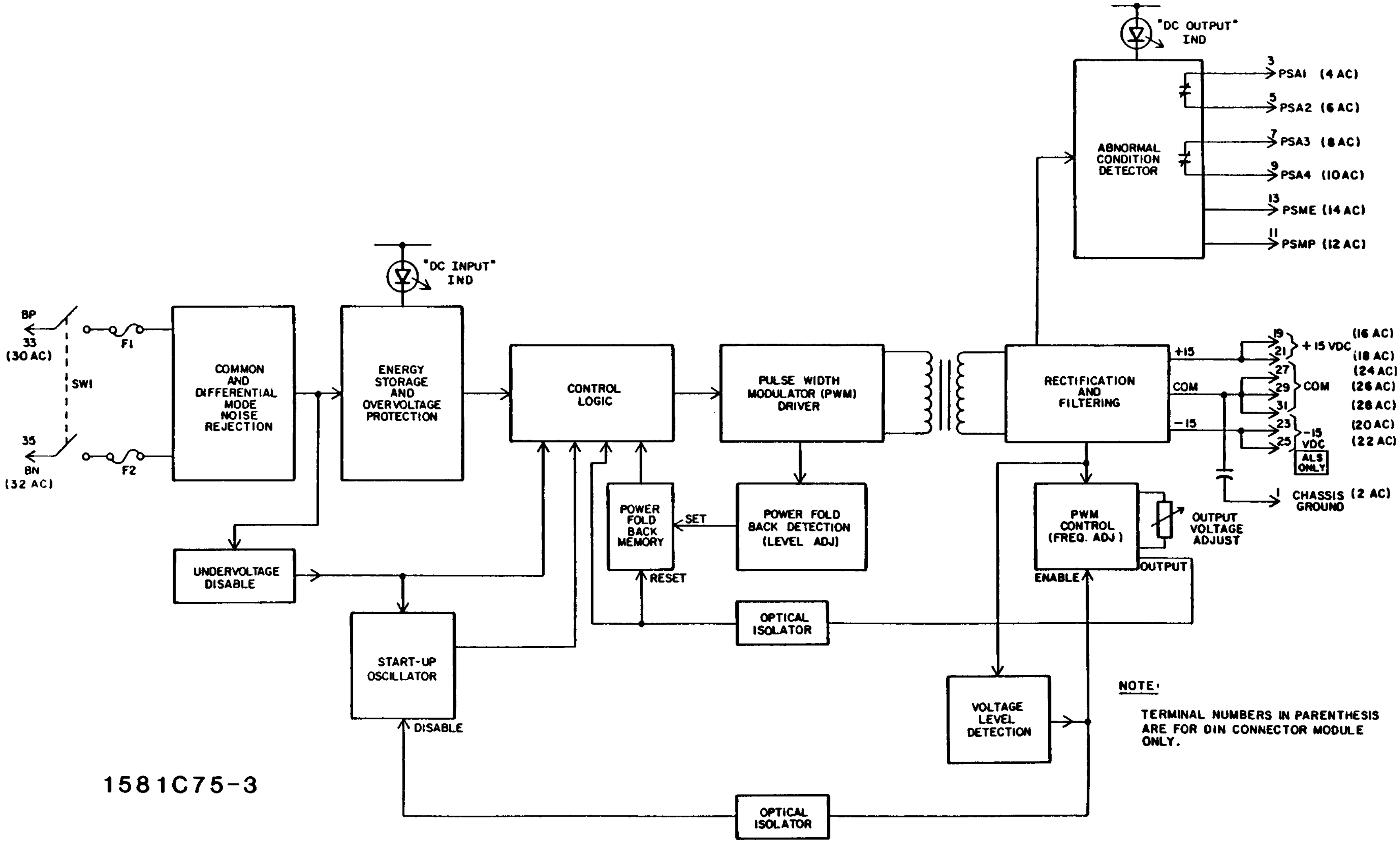
Figure D

c. Remove all external voltage supplies and reconnect the proper leads to Q4.

d. Replace cover and perform the Acceptance Check (see Section 6).

8. RENEWAL PARTS

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



Sub 3
1581C75

Figure 1. ALS/DLS Block Diagram

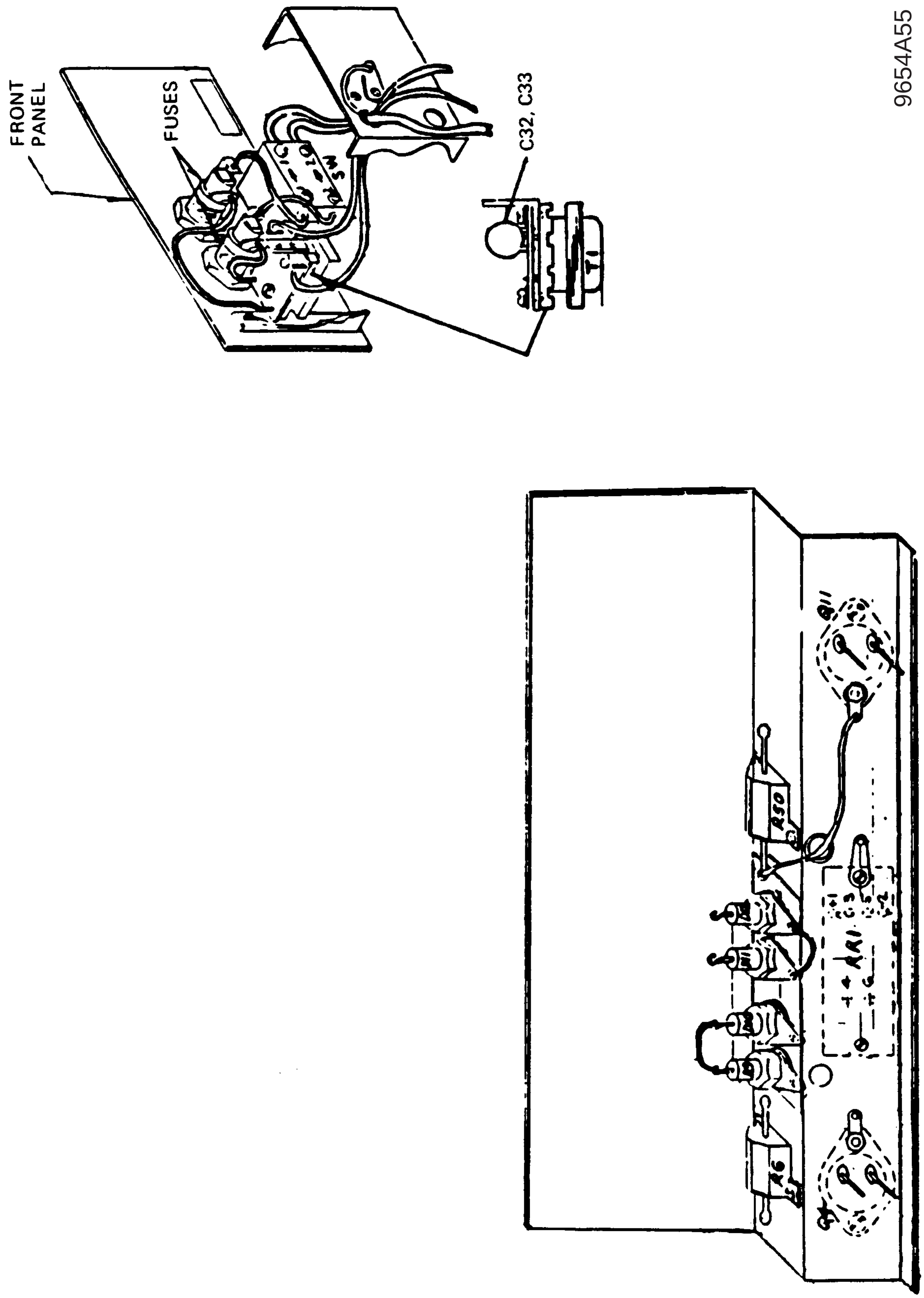
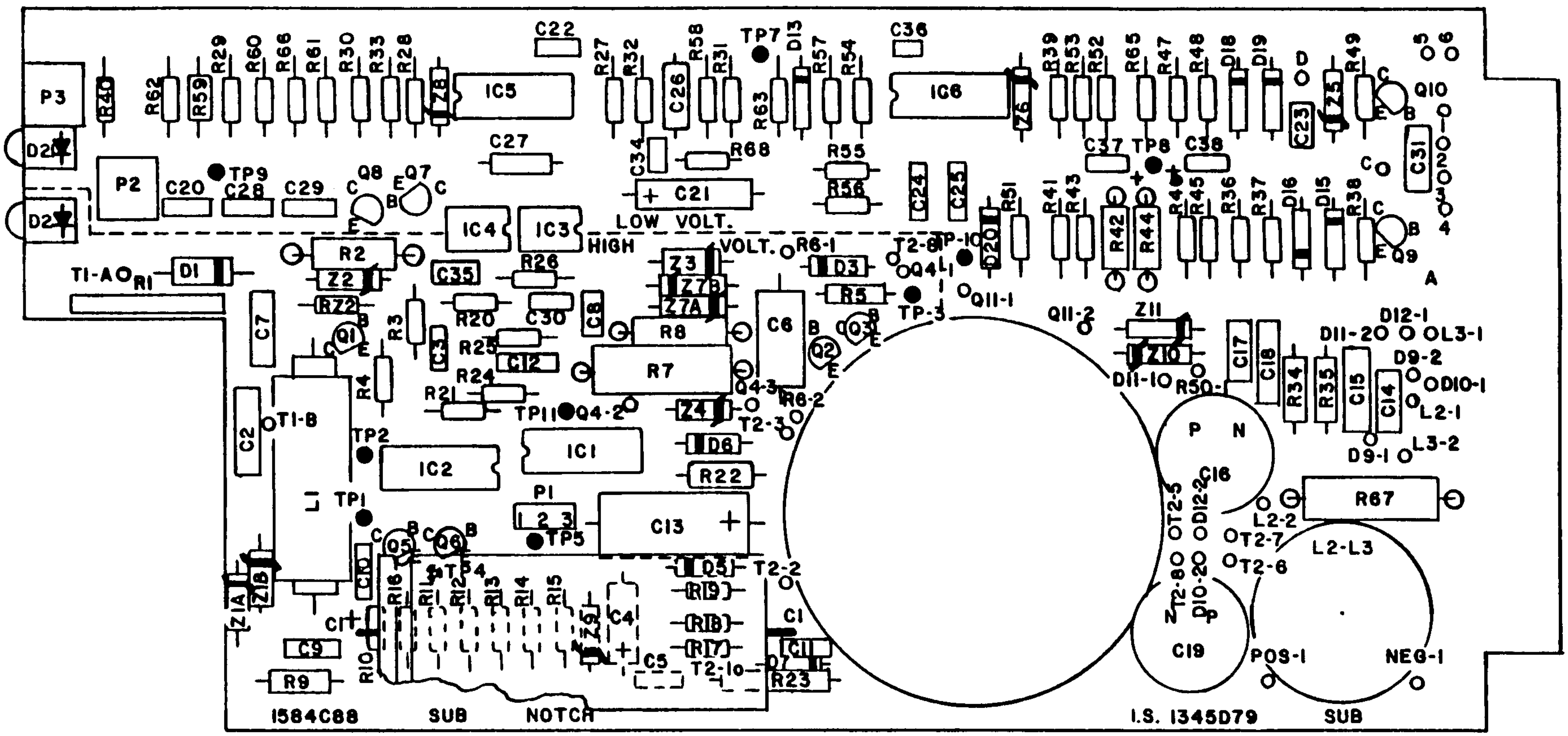
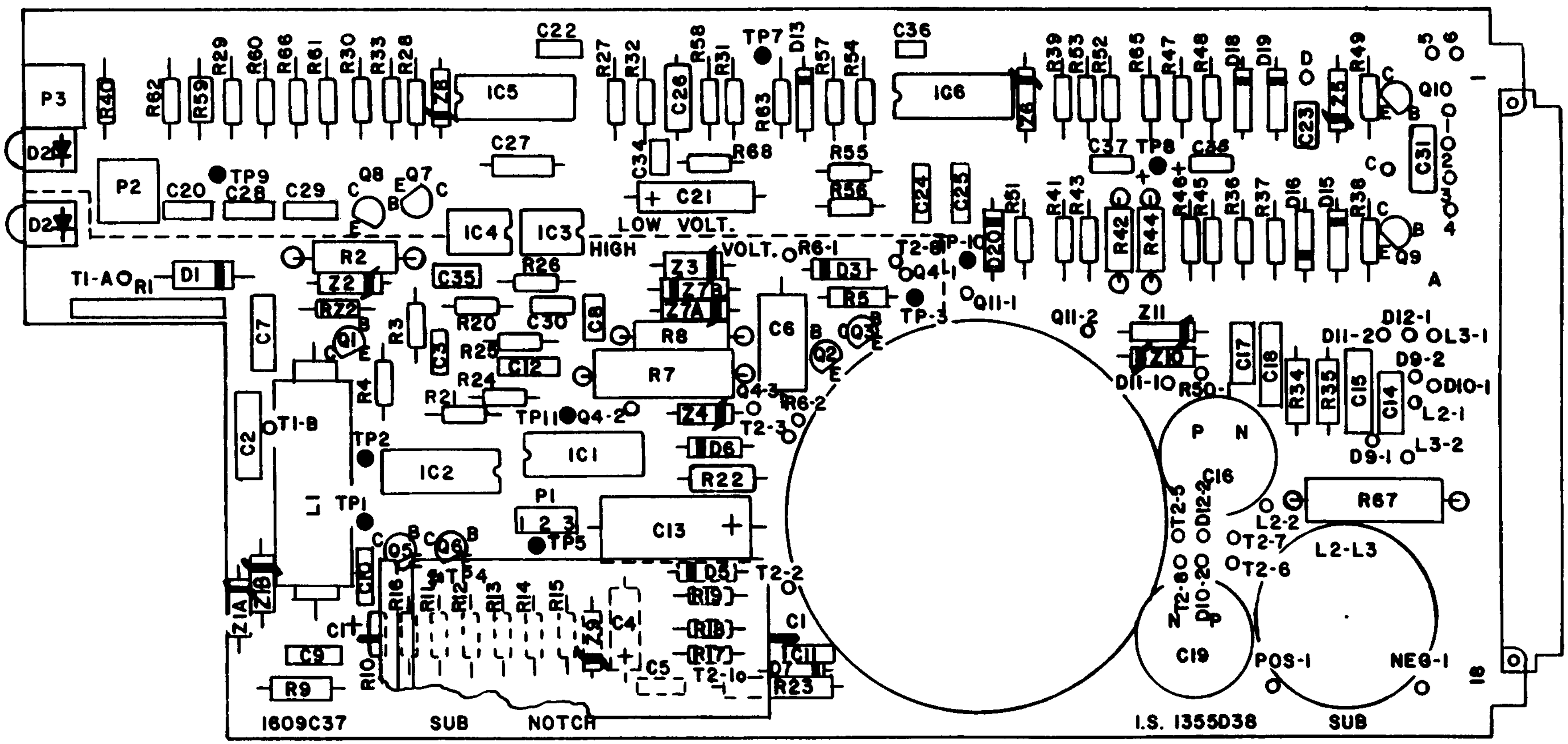


Figure 2. Location of Components not on PC Board



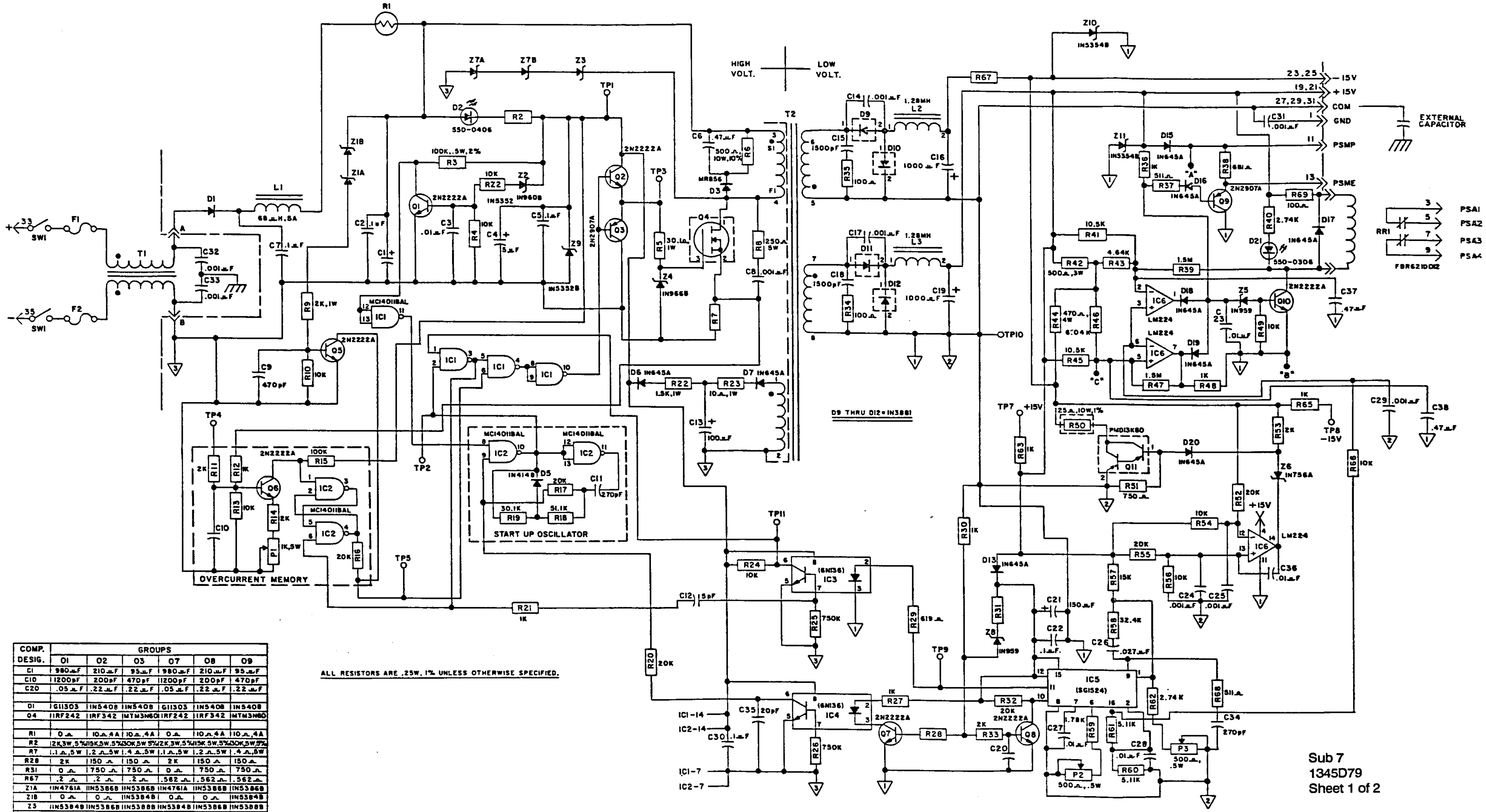
Sub 1
1501B98

Figure 3. Component Location (AMP) Connector



Sub 1
1501B99

Figure 4. Component Location (DIN) Connector

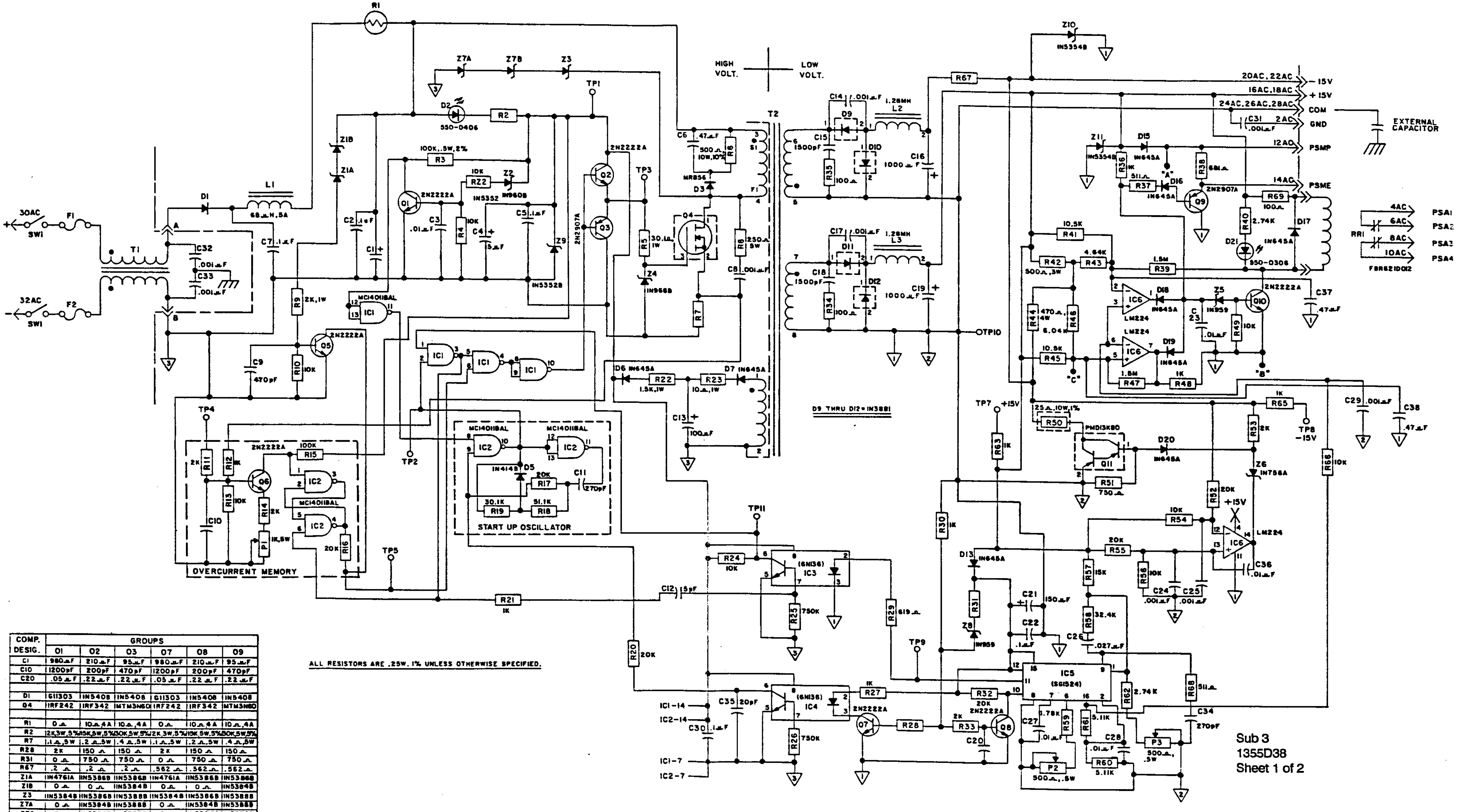


ALL RESISTORS ARE .25W, 1% UNLESS OTHERWISE SPECIFIED.

COMP. DESIG.	GROUPS					
	01	02	03	07	08	09
C1	980μF	210μF	95μF	980μF	210μF	95μF
C10	1200pF	200pF	470pF	1200pF	200pF	470pF
C20	.05μF	.22μF	.22μF	.05μF	.22μF	.22μF
D1	G11303	1N5408	1N5408	G11303	1N5408	1N5408
Q4	IRF242	IRF342	MTM3N60	IRF242	IRF342	MTM3N60
R1	0Ω	10Ω,4A	10Ω,4A	0Ω	10Ω,4A	10Ω,4A
R2	2K,3W,5%	15K,5W,5%	30K,5W,5%	2K,3W,5%	15K,5W,5%	30K,5W,5%
R7	.1Ω,5W	.2Ω,5W	.4Ω,5W	.1Ω,5W	.2Ω,5W	.4Ω,5W
R28	2K	150Ω	150Ω	2K	150Ω	150Ω
R31	0Ω	750Ω	750Ω	0Ω	750Ω	750Ω
R67	.2Ω	.2Ω	.2Ω	.562Ω	.562Ω	.562Ω
Z1A	1N4761A	1N5386B	1N5386B	1N4761A	1N5386B	1N5386B
Z1B	0Ω	0Ω	1N5384B	0Ω	0Ω	1N5384B
Z3	1N5384B	1N5386B	1N5388B	1N5384B	1N5386B	1N5388B
Z7A	0Ω	1N5384B	1N5388B	0Ω	1N5384B	1N5388B
Z7B	0Ω	1N5384B	1N5388B	0Ω	1N5384B	1N5388B
F1 & F2	4A.	2A.	1.5A.	4A.	2A.	1.5A.

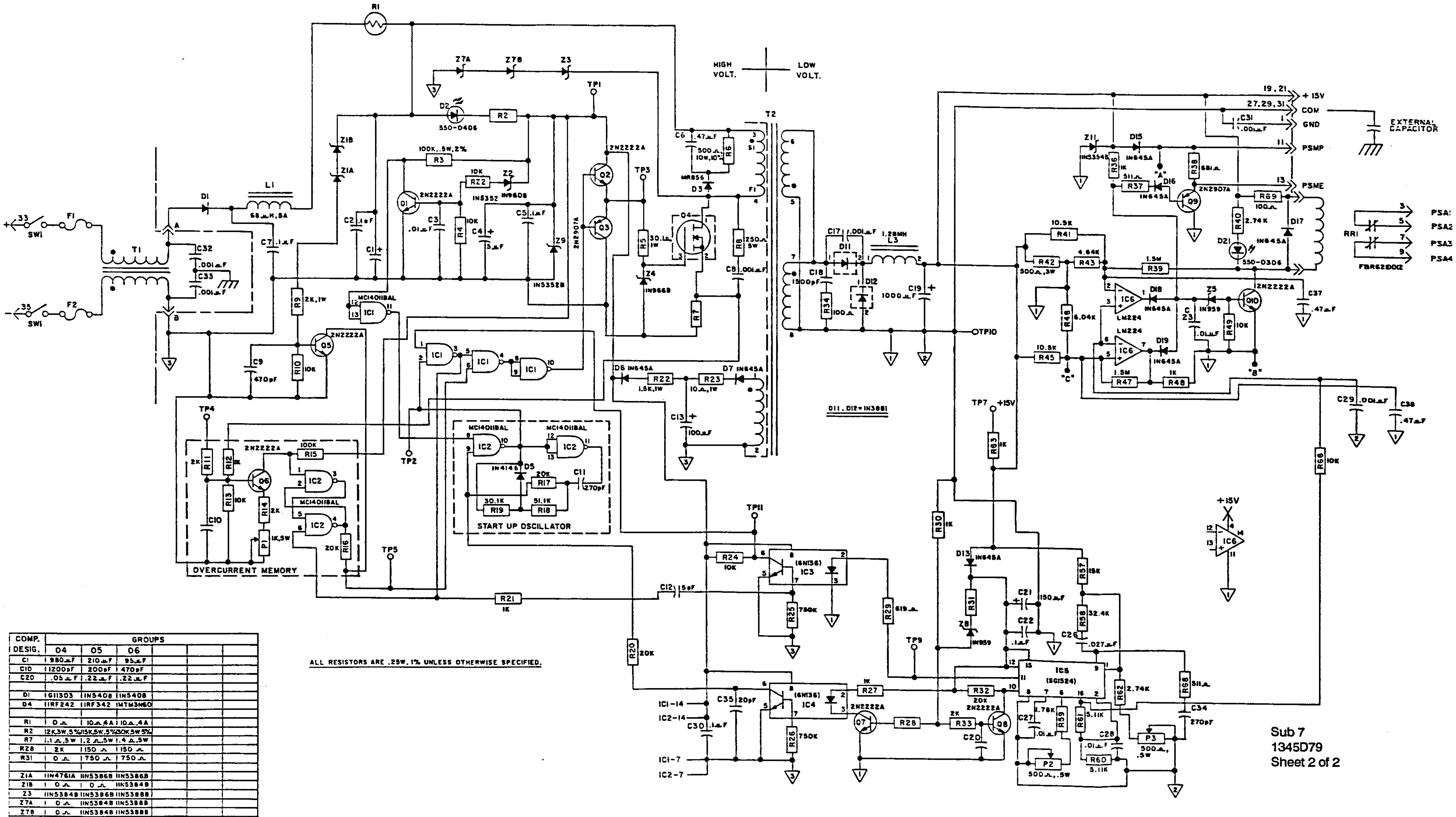
Sub 7
1345D79
Sheet 1 of 2

Figure 5A. Internal Schematic ALS with AMP Connector



COMP. DESIG.	GROUPS					
	01	02	03	07	08	09
C1	980μF	210μF	95μF	980μF	210μF	95μF
C10	1200pF	200pF	470pF	1200pF	200pF	470pF
C20	.05μF	.22μF	.22μF	.05μF	.22μF	.22μF
D1	G11303	IN5408	IN5408	G11303	IN5408	IN5408
Q4	IRF242	IRF342	MTM3N60	IRF242	IRF342	MTM3N60
R1	0 Ω	10Ω,4A	10Ω,4A	0 Ω	10Ω,4A	10Ω,4A
R2	2K,3W,5%	15K,5W,5%	30K,5W,5%	2K,3W,5%	15K,5W,5%	30K,5W,5%
R7	.1Ω,5W	.2Ω,5W	.4Ω,5W	.1Ω,5W	.2Ω,5W	.4Ω,5W
R28	2K	150 Ω	150 Ω	2K	150 Ω	150 Ω
R31	0 Ω	750 Ω	750 Ω	0 Ω	750 Ω	750 Ω
R67	.2 Ω	.2 Ω	.2 Ω	.562 Ω	.562 Ω	.562 Ω
Z1A	IN4761A	IN5386B	IN5386B	IN4761A	IN5386B	IN5386B
Z1B	0 Ω	0 Ω	IN5384B	0 Ω	0 Ω	IN5384B
Z3	IN5384B	IN5386B	IN5388B	IN5384B	IN5386B	IN5388B
Z7A	0 Ω	IN5384B	IN5388B	0 Ω	IN5384B	IN5388B
Z7B	0 Ω	IN5384B	IN5388B	0 Ω	IN5384B	IN5388B
F1 & F2	4A.	2A.	1.5A.	4A.	2A.	1.5A.

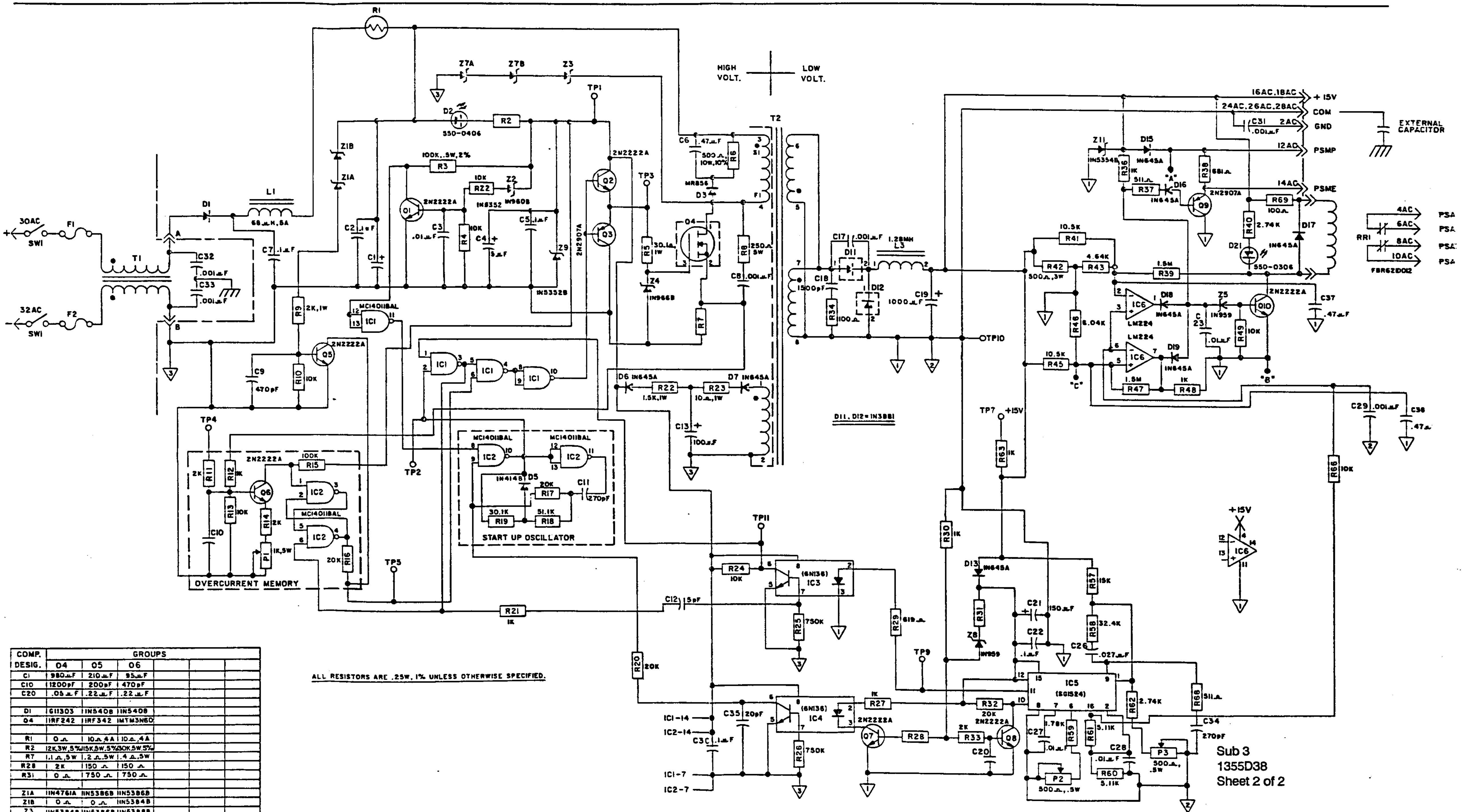
Figure 5B. Internal Schematic ALS with DIN Connector



ALL RESISTORS ARE .25W, 1% UNLESS OTHERWISE SPECIFIED.

COMP. DESIG.	GROUPS					
	04	05	06			
C1	980 µF	210 µF	95 µF			
C10	1200pF	200pF	470pF			
C20	.05 µF	.22 µF	.22 µF			
D1	G11303	1N5408	1N5408			
Q4	IRF242	IRF342	MTM3N60			
R1	0 Ω	10 Ω, 4A	10 Ω, 4A			
R2	12K,3W, 5%	15K,5W, 5%	30K,5W, 5%			
R7	.1 Ω, 5W	.2 Ω, 5W	.4 Ω, 5W			
R28	2K	150 Ω	150 Ω			
R31	0 Ω	750 Ω	750 Ω			
Z1A	1N4761A	1N5386B	1N5386B			
Z1B	0 Ω	0 Ω	1N5384B			
Z3	1N5384B	1N5386B	1N5388B			
Z7A	0 Ω	1N5384B	1N5388B			
Z7B	0 Ω	1N5384B	1N5388B			
F1 & F2	4A.	2A.	1.5A.			

Figure 6A. Internal Schematic DLS with AMP Connector



COMP. DESIG.	GROUPS					
	04	05	06			
C1	980 µF	210 µF	95 µF			
C10	1200pF	200pF	470pF			
C20	.05 µF	.22 µF	.22 µF			
D1	G11303	1N5408	1N5408			
Q4	IRF242	IRF342	MTM3N60			
R1	0 Ω	10 Ω, 4A	10 Ω, 4A			
R2	12K,3W,5%	15K,5W,5%	30K,5W,5%			
R7	.1 Ω, .5W	.2 Ω, .5W	.4 Ω, .5W			
R28	2K	150 Ω	150 Ω			
R31	0 Ω	750 Ω	750 Ω			
Z1A	1N4761A	1N5386B	1N5386B			
Z1B	0 Ω	0 Ω	1N5384B			
Z3	1N5384B	1N5386B	1N5388B			
Z7A	0 Ω	1N5384B	1N5388B			
Z7B	0 Ω	1N5384B	1N5388B			
F1 & F2	4A.	2A.	1.5A.			

Figure 6B. Internal Schematic DLS with DIN Connector

1349D85 ALS /DLS Power Supply with AMP Connector .... Sub 22 1/ 31/90

1355D49 ALS /DLS Power Supply with DIN Connector .... Sub 3 1/ 31/90

PC BOARD	MODULE/GROUP # (AMP or DIN)		
1584C87 H01 **AMP** Connector	ALS for Uniflex	48V	1584C88G 01
		125V	1584C88G 02
		250V	1584C88G 03
	DLS	48V	1584C88G 04
		125V	1584C88G 05
		250V	1584C88G 06
	ALS for LDAR	48V	1584C88G 07
		125V	1584C88G 08
		250V	1584C88G 09
1609C48 H01 **DIN** Connector	ALS for Uniflex	48V	1609C37G 01
		125V	1609C37G 02
		250V	1609C37G 03
	DLS	48V	1609C37G 04
		125V	1609C37G 05
		250V	1609C37G 06
	ALS for LDAR	48V	1609C37G 07
		125V	1609C37G 08
		250V	1609C37G 09

COMP	DESCRIPTION	STYLE	GROUP #
CAPACITORS			
C1	980 uF +50-10% 100V ALUMINUM	3529A07H02	01,04,07
C1	210 uF +50-10% 250V ALUMINUM	3529A07H01	02,05,08
C1	95 uF +50-10% 400V ALUMINUM	3529A07H06	03,06,09
C2	0.1 uF 20% 500V CERAMIC DISC	184A663H14	01 thru 09
C3	0.01 uF 20% 100V CERAMIC DISC	184A663H01	01 thru 09
C4	5.0 uF +75-10% 25V ALUMINUM	186A341H07	01 thru 09
C5	0.1 uF 20% 100V MONO CERAMIC	762A680H14	01 thru 09
C6	0.47 uF 5% 200V MET POLYESTER	876A409H17	01 thru 09
C7	0.1 uF 20% 500V CERAMIC DISC	184A663H14	01 thru 09
C8	0.001 uF 10% 1000V Z5P CERAMIC DISC	762A680H02	01 thru 09
C9	470 pF 10% 1000V CERAMIC DISC	879A911H10	01 thru 09
C10	1200 pF 2% 200V C0G MONO CERAMIC	880A397H08	01,04,07
C10	200 pF 2% 500V DIPPED MICA	762A757H11	02,05,08
C10	470 pF 10% 1000V CERAMIC DISC	879A911H10	03,06,09
C11	270 pF 2% 500V DIPPED MICA	762A757H12	01 thru 09
C12	5.0 pF 2% 500V DIPPED MICA	763A209H25	01 thru 09
C13	100 uF +100-10% 50V ALUMINUM	3535A92H01	01 thru 09
C14	0.001 uF 10% 1000V Z5P CERAMIC DISC	762A680H02	01,02,03,07,08,09
C15	1500 pF 10% 1000V Y5E CERAMIC DISC	762A680H05	01,02,03,07,08,09

COMP	DESCRIPTION	STYLE	GROUP#
C16	1000 uF 20% 25V ALUMINUM	3529A32H01	01,02,03,07,08,09
C17	0.001 uF 10% 1000V Z5P CERAMIC DISC	762A680H02	01 thru 09
C18	1500 pF 10% 1000V Y5E CERAMIC DISC	762A680H05	01 thru 09
C19	1000 uF 20% 25V ALUMINUM	3529A32H01	01 thru 09
C20	0.05 uF 20% 100V CERAMIC DISC	184A663H02	01,04,07
C20	0.22 uF 20% 100V MONO CERAMIC	3512A08H02	02,03,05,06,08,09
C21	150 uF 5% 35V TANTALUM	880A363H12	01 thru 09
C22	0.1 uF 20% 100V MONO CERAMIC	762A680H14	01 thru 09
C23	0.01 uF 20% 100V CERAMIC DISC	184A663H01	01 thru 09
C24	0.001 uF 10% 1000V Z5P CERAMIC DISC	762A680H02	01,02,03,07,08,09
C25	0.001 uF 10% 1000V Z5P CERAMIC DISC	762A680H02	01,02,03,07,08,09
C26	0.027 uF 10% 50V MET POLYESTER	188A669H14	01 thru 09
C27	0.01 uF 5% 200V MET POLYCARB	3534A68H03	01 thru 09
C28	0.01 uF 20% 100V CERAMIC DISC	184A663H01	01 thru 09
C29	0.001 uF 10% 1000V Z5P CERAMIC DISC	762A680H02	01 thru 09
C30	0.1 uF 20% 100V MONO CERAMIC	762A680H14	01 thru 09
C31	0.001 uF 20% 3000V Z5U CERAMIC DISC	3536A32H01	01 thru 09
C32	0.001 uF 20% 3000V Z5U CERAMIC DISC	3536A32H01	01 thru 09
C33	0.001 uF 20% 3000V Z5U CERAMIC DISC	3536A32H01	01 thru 09
C34	270 pF 2% 500V DIPPED MICA	762A757H12	01 thru 09
C35	20 pF 2% 500V DIPPED MICA	763A209H07	01 thru 09
C36	0.01 uF 20% 50V Z5U MONO CERAMIC	3509A34H02	01,02,03,07,08,09
C37	0.47 uF 20% 50V DIPPED TANTALUM	3533A75H07	01 thru 09
C38	0.47 uF 20% 50V DIPPED TANTALUM	3533A75H07	01 thru 09
CHOKES			
L1	68 uH 5 AMPS	3516A94H01	01 thru 09
COILS			
L2	1.28 mH	3535A63G01	01,02,03,07,08,09
L3	1.28 mH	3535A63G02	01 thru 09
DIODES			
D1	1N5408 1000V 3A	188A342H23	02,03,05,06,08,09
D1	GI1303 150V 6A FAST	3529A30H01	01,04,07
D3	MR856 600V 3A FAST	3535A29H01	01 thru 09
D5	1N4148 75V 0.01A	836A928H06	01 thru 09
D6	1N645A 225V 0.4A	837A692H03	01 thru 09
D7	1N645A 225V 0.4A	837A692H03	01 thru 09
D9	1N3881	3535A29H02	01,02,03,07,08,09
D10	1N3881	3535A29H02	01,02,03,07,08,09
D11	1N3881	3535A29H02	01 thru 09
D12	1N3881	3535A29H02	01 thru 09
D13	1N645A 225V 0.4A	837A692H03	01 thru 09
D15	1N645A 225V 0.4A	837A692H03	01 thru 09
D16	1N645A 225V 0.4A	837A692H03	01 thru 09
D17	1N645A 225V 0.4A	837A692H03	01 thru 09
D18	1N645A 225V 0.4A	837A692H03	01 thru 09
D19	1N645A 225V 0.4A	837A692H03	01 thru 09
D20	1N645A 225V 0.4A	837A692H03	01,02,03,07,08,09

COMP	DESCRIPTION	STYLE	GROUP#
FUSES			
F1,F2	4A	FAST BLOW	837A964H1001,04,07
F1,F2	2A	FAST BLOW	183A981H0402,05,08
F1,F2	1.5A	SLOW BLOW	183A981H2303,06,09
IC SOCKETS			
IC1	14 PIN	3534A76H03	01 thru 09
IC2	14 PIN	3534A76H03	01 thru 09
IC3	8 PIN	3534A76H02	01 thru 09
IC4	8 PIN	3534A76H02	01 thru 09
IC5	16 PIN AUGUT	3534A76H04	01 thru 09
IC6	14 PIN	3534A76H03	01 thru 09
INT CKTS			
IC1	MC14011BAL QUAD 2-INPUT NAND	3527A09H02	01 thru 09
IC2	MC14011BAL QUAD 2-INPUT NAND	3527A09H02	01 thru 09
IC3	6N136 OPTOCOUPLER	3534A93H01	01 thru 09
IC4	6N136 OPTOCOUPLER	3534A93H01	01 thru 09
IC5	SG1524J PULSE-WIDTH MODULATOR	3534A92H01	01 thru 09
IC6	LM124J QUAD OP-AMP	3510A61H01	01 thru 09
JUMPERS			
R1	ZERO OHM RESISTOR	862A478H01	01,04,07
R31	ZERO OHM RESISTOR	862A478H01	01,04,07
Z1B	ZERO OHM RESISTOR	862A478H01	01,02,04,05,07,08
Z7A	ZERO OHM RESISTOR	862A478H01	01,04,07
Z7B	ZERO OHM RESISTOR	862A478H01	01,04,07
OPTOELECTS			
D2	RED LED (EDGE MOUNT) 550-0406	3508A22H01	01 thru 09
D21	YELLOW LED(EDGE MOUNT) 550-0306	3508A22H02	01 thru 09
POTENTIOS			
P1	1K 5W 25T TOP ADJ.	3534A25H04	01 thru 09
P2	500-OHM 0.5W 1 TURN CERMET TOP ADJ.	3502A17H08	01 thru 09
P3	500 OHM 1T POT (SIDE ADJUST)	3529A31H01	01 thru 09
RELAYS			
RR1	FBR621D012	9645A10H04	01 thru 09
RESISTORS			
R2	2.0 KILOHMS 5% 3W WIREWOUND	763A127H03	01,04,07
R2	15 KILOHMS 5% 5W WIREWOUND	763A129H09	02,05,08
R2	30 KILOHMS 1% 5W WIREWOUND	763A130H10	03,06,09
R3	100 KILOHMS 5% 0.25W METAL FILM	863A175H97	01 thru 09
R4	10.0 KILOHMS 1% 0.25W METAL FILM	863A175H01	01 thru 09

COMP	DESCRIPTION	STYLE	GROUP#
R5	30.1 OHMS 1% 1W METAL FILM	862A374H47	01 thru 09
R6	500 OHMS 1% 10W	3529A22H02	01 thru 09
R7	0.1 OHMS 1% 5W WIREWOUND	3529A29H01	01,04,07
R7	0.2 OHMS 1% 5W WIREWOUND	3529A29H02	02,05,08
R7	0.4 OHMS 1% 5W WIREWOUND	3529A29H03	03,06,09
R8	250 OHMS 1% 5W WIREWOUND NON IND	3529A28H01	01 thru 09
R9	2.0 KILOHMS 2% 1W METAL FILM	629A531H39	01 thru 09
R10	10.0 KILOHMS 1% 0.25W METAL FILM	863A175H01	01 thru 09
R11	2.00 KILOHMS 1% 0.25W METAL FILM	863A174H30	01 thru 09
R12	1.00 KILOHMS 1% 0.25W METAL FILM	863A174H01	01 thru 09
R13	10.0 KILOHMS 1% 0.25W METAL FILM	863A175H01	01 thru 09
R14	2.00 KILOHMS 1% 0.25W METAL FILM	863A174H30	01 thru 09
R15	100 KILOHMS 5% 0.25W METAL FILM	863A175H97	01 thru 09
R16	20.0 KILOHMS 1% 0.25W METAL FILM	863A175H30	01 thru 09
R17	20.0 KILOHMS 1% 0.25W METAL FILM	863A175H30	01 thru 09
R18	51.1 KILOHMS 1% 0.25W METAL FILM	863A175H69	01 thru 09
R19	30.1 KILOHMS 1% 0.25W METAL FILM	863A175H47	01 thru 09
R20	20.0 KILOHMS 1% 0.25W METAL FILM	863A175H30	01 thru 09
R21	1.00 KILOHMS 1% 0.25W METAL FILM	863A174H01	01 thru 09
R22	1.5 KILOHMS 2% 1W METAL FILM	629A531H36	01 thru 09
R23	10.0 OHMS 1% 1W METAL FILM	862A374H01	01 thru 09
R24	10.0 KILOHMS 1% 0.25W METAL FILM	863A175H01	01 thru 09
R25	750 KILOHMS 1% 0.5W METAL FILM	848A822H27	01 thru 09
R26	750 KILOHMS 1% 0.5W METAL FILM	848A822H27	01 thru 09
R27	1.00 KILOHMS 1% 0.5W METAL FILM	848A819H48	01 thru 09
R28	150 OHMS 1% 0.25W METAL FILM	863A173H18	02,03,05,06,08,09
R28	2.00 KILOHMS 1% 0.25W METAL FILM	863A174H30	01,04,07
R29	619 OHMS 1% 0.5W METAL FILM	848A819H28	01 thru 09
R30	1.00 KILOHMS 1% 0.25W METAL FILM	863A174H01	01 thru 09
R31	750 OHMS 1% 0.25W METAL FILM	863A173H85	02,03,05,06,08,09
R32	20.0 KILOHMS 1% 0.25W METAL FILM	863A175H30	01 thru 09
R33	2.00 KILOHMS 1% 0.25W METAL FILM	863A174H30	01 thru 09
R34	100 OHMS 1% 0.5W METAL FILM	848A818H51	01 thru 09
R35	100 OHMS 1% 0.5W METAL FILM	848A818H51	01,02,03,07,08,09
R36	1.00 KILOHMS 1% 0.25W METAL FILM	863A174H01	01 thru 09
R37	511 OHMS 1% 0.25W METAL FILM	3535A39H69	01 thru 09
R38	681 OHMS 1% 0.25W METAL FILM	863A173H81	01 thru 09
R39	1.50 MEGOHMS 1% 0.25W METAL FILM	3532A39H18	01 thru 09
R40	2.74 KILOHMS 1% 0.25W METAL FILM	863A174H43	01 thru 09
R41	10.5 KILOHMS 1% 0.25W METAL FILM	3535A37H03	01 thru 09
R42	500 OHMS 1% 4W WIREWOUND	763A126H11	01 thru 09
R43	4.64 KILOHMS 1% 0.25W METAL FILM	3535A38H65	01 thru 09
R44	470 OHMS 1% 4W WIREWOUND	763A126H55	01,02,03,07,08,09
R45	10.5 KILOHMS 1% 0.25W METAL FILM	3535A37H03	01 thru 09
R46	6.04 KILOHMS 1% 0.25W METAL FILM	3535A38H76	01 thru 09
R47	1.50 MEGOHMS 1% 0.25W METAL FILM	3532A39H18	01 thru 09
R48	1.00 KILOHMS 1% 0.25W METAL FILM	863A174H01	01 thru 09
R49	10.0 KILOHMS 1% 0.25W METAL FILM	863A175H01	01 thru 09
R50	25 OHMS 1 % 10W	3529A22H01	01,02,03,07,08,09

COMP	DESCRIPTION	STYLE	GROUP#
R51	750 OHMS 1% 0.25W METAL FILM	863A173H85	01,02,03,07,08,09
R52	20.0 KILOHMS 0.1% 1W METAL FILM	3534A73H03	01,02,03,07,08,09
R53	2.00 KILOHMS 1% 0.25W METAL FILM	863A174H30	01,02,03,07,08,09
R54	10.0 KILOHMS 0.1% 1W METAL FILM	3534A73H02	01,02,03,07,08,09
R55	20.0 KILOHMS 0.1% 1W METAL FILM	3534A73H03	01,02,03,07,08,09
R56	10.0 KILOHMS 0.1% 1W METAL FILM	3534A73H02	01,02,03,07,08,09
R57	15.0 KILOHMS 1% 0.25W METAL FILM	863A175H18	01 thru 09
R58	32.4 KILOHMS 1% 0.25W METAL FILM	863A175H50	01 thru 09
R59	1.78 KILOHMS 1% 0.25W METAL FILM	863A174H25	01 thru 09
R60	5.11 KILOHMS 1% 0.25W METAL FILM	863A174H69	01 thru 09
R61	5.11 KILOHMS 1% 0.25W METAL FILM	863A174H69	01 thru 09
R62	2.74 KILOHMS 1% 0.25W METAL FILM	863A174H43	01 thru 09
R63	1.00 KILOHMS 1% 0.25W METAL FILM	863A174H01	01 thru 09
R65	1.00 KILOHMS 1% 0.25W METAL FILM	863A174H01	01,02,03,07,08,09
R66	10.0 KILOHMS 1% 0.25W METAL FILM	863A175H01	01 thru 09
R67	0.2 OHMS 1% 5W WIREWOUND	3529A29H02	01,02,03
R67	0.562 OHMS 1% 3W WIREWOUND	763A531H02	07,08,09
R68	511 OHMS 1% 0.25W METAL FILM	3535A39H69	01 thru 09
R69	100 OHMS 1% 0.5W METAL FILM	848A818H51	01 thru 09
RZ2	10.0 KILOHMS 1% 0.25W METAL FILM	863A175H01	01 thru 09
SWITCHES			
SW1		3534A91H01	01 thru 09
TERMINAL			
TP1	TEST POINT	849A242H01	01 thru 09
TP2	TEST POINT	849A242H01	01 thru 09
TP3	TEST POINT	849A242H01	01 thru 09
TP4	TEST POINT	849A242H01	01 thru 09
TP5	TEST POINT	849A242H01	01 thru 09
TP7	TEST POINT +15V RED	187A332H01	01 thru 09
TP8	TEST POINT -15V BLACK	187A332H02	01,02,03,07,08,09
TP9	TEST POINT	849A242H01	01 thru 09
TP10	TEST POINT WHITE	187A332H03	01 thru 09
TP11	TEST POINT	849A242H01	01 thru 09
THERMISTORS			
R1	10 OHM 4A 1 INCH DIA.	182A879H02	02,03,05,06,08,09
TRANSFORMERS			
T1	RENCO 1361-2-270	3535A73H01	01 thru 09
T2	(Varies with voltage input; must be assembled at factory.)		01 thru 09
TRANSISTORS			
Q1	2N2222A 40V 0.8A 0.4W NPN	762A672H15	01,02,03,07,08,09
Q2	2N2222A 40V 0.8A 0.4W NPN	762A672H15	01 thru 09

COMP	DESCRIPTION	STYLE	GROUP#
Q3	2N2907A 60V 0.6A 0.4W PNP	762A672H17	01 thru 09
Q4	IRF242	3529A20H01	01,04,07
Q4	IRF342	3529A19H01	02,05,08
Q4	MTM3N60	3529A20H02	03,06,09
Q5	2N2222A 40V 0.8A 0.4W NPN	762A672H15	01,02,03,07,08,09
Q6	2N2222A 40V 0.8A 0.4W NPN	762A672H15	01 thru 09
Q7	2N2222A 40V 0.8A 0.4W NPN	762A672H15	01,02,03,07,08,09
Q8	2N2222A 40V 0.8A 0.4W NPN	762A672H15	01,02,03,07,08,09
Q9	2N2907A 6 0V 0.6A 0.4W PNP	762A672H17	01,02,03,07,08,09
Q10	2N2222A 40V 0.8A 0.4W NPN	762A672H15	01,02,03,07,08,09
Q11	PMD13K80	3529A21H01	01,02,03,07,08,09

ZENERS

Z1A	1N4761A 75V 5% 1W	849A487H05	01,04,07
Z1A	1N5386B 180V 5% 5W	862A288H37	02,03,05,06,08,09
Z1B	1N5384B 160V 5% 5W	862A288H35	03,06,09
Z2	1N960B 9.1V 5% 0.4W	186A797H10	01 thru 09
Z3	1N5388B 200V 5% 5W	862A288H13	03,06,09
Z3	1N5384B 160V 5% 5W	862A288H35	01,04,07
Z3	1N5386B 180V 5% 5W	862A288H37	02,05,08
Z4	1N966B 16V 5% 0.4W	862A288H05	01 thru 09
Z5	1N959 8.2V 10% 0.4W	837A398H12	01,02,03,07,08,09
Z6	1N756A 8.2V 5% 0.4W	862A606H13	01,02,03,07,08,09
Z7A	IN5384B 160V 5% 5W	862A288H35	02,05,08
Z7A	IN5388B 200V 5% 5W	862A288H13	03,06,09
Z7B	IN5384B 160V 5% 5W	862A288H35	02,05,08
Z7B	IN5388B 200V 5% 5W	862A288H13	03,06,09
Z8	1N959 8.2V 10% 0.4W	837A398H12	01,02,03,07,08,09
Z9	1N5352B 15V 5% 5W	862A288H04	01,02,03,07,08,09
Z10	1N5354B 17V 5% 5W	862A288H11	01,02,03,07,08,09
Z11	1N5354B 17V 5% 5W	862A288H11	01 thru 09

UNREFERENCED ITEMS (DIN CONNECTOR ONLY)

CONNECTOR		9646A11H02	01 thru 09
ROLL PIN		9644A92H01	01 thru 09
SPACER		9640A72H01	01 thru 09