

CROWN®

Macro-Tech[®] 5000VZ
POWER AMPLIFIER
SERVICE MANUAL

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The information furnished in this manual does not include all of the details of design, production, or variations of the equipment. Nor does it cover every possible situation which may arise during installation, operation or maintenance. If you need special assistance beyond the scope of this manual, please contact your Crown Dealer or the Crown Technical Support Group.

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CAUTION

TO PREVENT ELECTRIC SHOCK DO NOT REMOVE TOP OR BOTTOM COVERS. NO USER SERVICEABLE PARTS INSIDE. REFER SERVICING TO QUALIFIED SERVICE PERSONNEL. DISCONNECT POWER CORD BEFORE REMOVING REAR INPUT MODULE.

AVIS

À PRÉVENIR LE CHOC ÉLECTRIQUE N'ENLEVEZ PAS LES COUVERTURES. RIEN DES PARTIES UTILES À L'INTÉRIEUR. DÉBRANCHER LA BORNE AVANT D'OUVRIR LA MODULE EN ARRIÈRE.

**WARNING**

TO REDUCE THE RISK OF ELECTRIC SHOCK, DO NOT EXPOSE THIS EQUIPMENT TO RAIN OR MOISTURE!

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For mechanical artwork see Exploded Views, page 7-1. For module layouts see Modules, page 8-1.

PART I

Technical Information

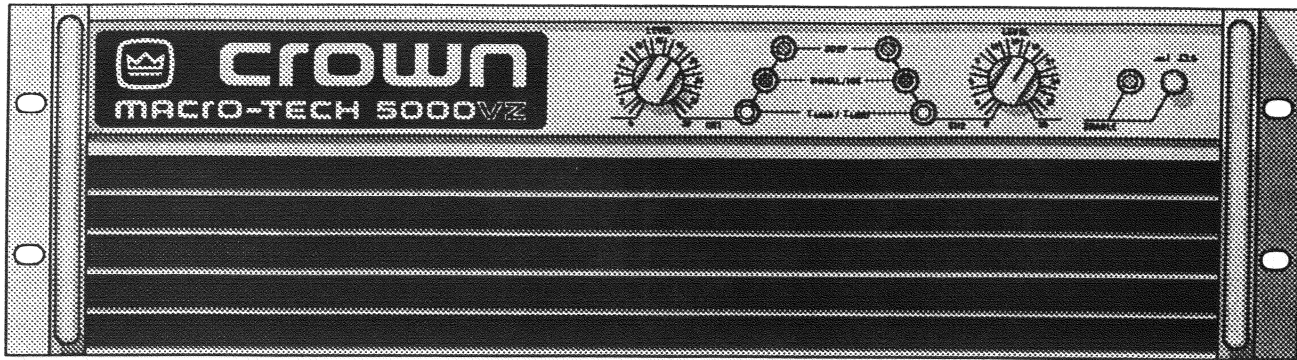


Fig. 1.1 Macro-Tech 5000VZ

1 Introduction

This manual contains service information on the Crown Macro-Tech® 5000VZ™ power amplifier. It is designed to be used in conjunction with the Macro-Tech 5000VZ Owner's Manual. Some important information is, however, duplicated in this Service Manual in case the Owner's Manual is not readily available.

NOTE: THE INFORMATION IN THIS MANUAL IS INTENDED FOR USE BY AN EXPERIENCED TECHNICIAN ONLY!

1.1 THE MACRO-TECH 5000VZ

The Macro-Tech 5000VZ amplifier is a compact, audio power amplifier designed for professional use. Providing high power amplification from 20Hz-20KHz with minimum distortion, this unit features balanced 1/4" phone and XLR inputs via the standard P.I.P.-FXQ, ODEP, SPI/IOC, and I Load/I Limit indication, bridged and parallel monophonic capability, switchable compression, switchable loudspeaker offset

integration (LOI), switchable sensitivity, and is fully P.I.P. compatible. Also, this unit can easily be configured to any standard world line voltage, at 50 or 60Hz.

1.2 WARRANTY

Each Owner's Manual contains basic policies as related to the customer. For further assistance please contact the Crown Technical Support Group at:

Crown International, Inc.
 Mailing: PO Box 1000
 Elkhart, IN 46515-1000
 or
 Shipping: 57620 C.R. 105
 Elkhart, IN 46517

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 FAX: (219) 294-8301

1.3 SPECIFICATIONS

Crown specifications are guaranteed for three years. Further, we guarantee that every Crown amplifier will exceed its published specs.

1.3.1 Performance

Note: Measurements made in Stereo, both channels driven into 8 ohms.

Frequency Response: ± 0.1 dB from 20 Hz to 20 kHz at 1 watt.

Phase Response: $\pm 10^\circ$ from 10 Hz to 20 kHz at 1 watt.

Signal to Noise Ratio: At 26 dB gain, better than 105 dB (A-weighted) below full output.

Total Harmonic Distortion (THD): $< 0.05\%$ from 20 Hz to 1 kHz, increasing linearly to 0.1% at 20 kHz at full output.

I.M. Distortion: $< 0.05\%$ from 410 milliwatts to full output at 26 dB gain, with an 8 ohm load.

Slew Rate: > 30 V per microsecond.

Damping Factor: > 1000 from 10 Hz to 400 Hz.

1.3.2 Power

Output Power: (Max. average power at 1 kHz with 0.1% THD.)

Stereo—1300 W/channel into 8 ohms, 2000W/channel into 4 ohms, 2500 W/channel into 2 ohms, both channels driven.

Bridged Mono—4000 W into 8 ohms, 5000 W into 4 ohms.

Parallel Mono—4000 W into 2 ohms, 5000 W into 1 ohm.

Load Impedance: Rated for 16, 8, 4, 2 ohm use. Safe with all types of loads, even reactive ones.

Required AC Mains: 60 Hz, 120VAC with 30A service. Convertable to 100/120/200/208/230/240VAC at 50/60 Hz.

AC Line: "TT" style 3 wire 30A grounded connector (for 120VAC units).

1.3.3 Controls

Front Panel: A push on/off power switch; also, a signal level control for each channel.

Back Panel: A three-position switch which selects Stereo, Bridged-Mono, or Parallel-Mono mode, loudspeaker offset integration (LOI) on/off switch for each channel, a three-position switch selects 0.775 V, 1.4 V, or 26 dB voltage gain input sensitivity for each

channel, a compressor switch selectable to fast, slow, or off for each channel, and a ground lift switch to isolate chassis from shield ground on the standard P.I.P.-FXQ.

Internal: Switches behind the front grill allow selection of normal VZ operation, lock to low voltage only, lock to high voltage only, and lock to low voltage under ODEP conditions.

1.3.4 Indicators

Amber Enable indicator shows on/off status of low-voltage power supply.

An amber **ODEP** indicator for each channel shows thermal reserve status. Normally on, this indicator will dim or go out in the event that a thermal condition causes signal limiting.

A green **SPI/IOC** indicator for each channel flashes dim green to show a signal is present at the input, and flashes brightly in the rare event distortion of any kind exceeds 0.05%, including input overload.

A bi-color (green/red) **LOAD/LIMIT** indicator for each channel flashes green with the output signal (when under a current load) and flashes red in the event of current limiting.

1.3.5 Input/Output

Input Impedance: Greater than 10 K ohms, balanced, and 5 K ohms, unbalanced.

Output Impedance: Less than 10 milliohms in series with less than 2 microhenries.

1.3.6 Connectors

Inputs: Balanced 1/4 inch phone jacks or XLRs with standard P.I.P.-FXQ module installed.

Outputs: Unique output bus with dual banana jacks on 3/4 inch centers, and high current ring or spade lug barrier connectors.

1.3.7 Construction

Black splatter-coat steel chassis with specially-designed flow-through front to rear ventilation system with ODEP derived proportional forced air cooling.

Dimensions: 19 inch wide, 5.25 inch high, 16 inch deep behind front mounting surface.

Weight: 77 lbs net, 86 lbs gross.

Mounting: Standard EIA 310 front-panel rack mount with supports for supplemental rear corner mounting.

2 Maintenance

In most cases you will be using the test procedures in section 2.3 after conducting your repairs. Before initially powering up the amplifier you should review section 2.1 and take appropriate steps for personal and equipment safety. Section 2.2 will help to determine whether the amplifier should be safe to turn on. This section also includes some additional checks that should be made prior to starting the actual check-out. Italicized print in the test procedures (section 2.3) includes basic troubleshooting hints to augment procedures in section 2.2. These hints do not cover every possibility, but should be helpful for a variety of symptoms. After troubleshooting and repair (or as a part of), the final step is to thoroughly test the amplifier to be certain that it meets the factory specifications. Test procedures in section 2.3 will help you do this as well as aid you in locating the cause of problem(s).

2.1 CAUTIONS AND WARNINGS

DANGER: The outputs of this amplifier can produce LETHAL energy levels! Be very careful when making connections. Do not attempt to change output wiring until the amplifier has been off at least 10 seconds.

WARNING: This unit is capable of producing high sound pressure levels. Continued exposure to high sound pressure levels can cause permanent hearing impairment or loss. User caution is advised and ear protection is recommended when playing at high volumes.

WARNING: Do not expose this unit to rain or moisture.

WARNING: Only properly trained and qualified technicians should attempt to service this unit. There are no user serviceable parts inside.

WARNING: When performing service checks with the power off, discharge the main power supply filter capacitors fully before taking any measurements or touching any electrical components. A 100 ohm 10W resistor is recommended for this. Hold the resistor with pliers, as the resistor may become extremely hot.

WARNING: Under load, with a sine wave signal at full power into both channels, the amplifier may draw in excess of 60 amperes from the AC service mains.

WARNING: When performing tests in section 2.3, do not connect any load to the amplifier until instructed to do so. There is no danger to the amplifier in operating without any load (open outputs).

WARNING: Do not change the position of the Stereo/Mono Switch when the amplifier is turned on. If the position of this switch is changed while the amplifier is

powered, transients may permanently damage your speakers.

WARNING: Heatsinks are not at ground potential. Touching either heatsink and ground, or touching both heatsinks will cause electrical shock.

CAUTION: Eye protection should be worn at all times when protective covers are removed and the amplifier is plugged in.

CAUTION: When performing tests in section 2.3 that require a load, the load must be resistive and must be capable of handling 3000W (per channel).

CAUTION: Disconnect power cord before installing or removing the P.I.P. module or any other cover or panel.

2.2 TROUBLESHOOTING

2.2.1 Pre-AC Checks

A number of checks can be made prior to powering up the unit. These should be done in order to prevent an unwanted disaster when turning the unit on. Once these checks are made power may be applied for further checks. Note: It will be necessary to remove top, rear, and bottom panels for complete access to all modules.

Step 1 is: acquire all information possible from the person(s) having the problem to determine the nature of the complaint. Ask questions like "Why was the amplifier brought in for repair?" "Does it do this right at turn on, does it take a while, or does it only happen sometimes?" If you observe nothing wrong, inquire tactfully how the unit was being used when the malfunction occurred to determine if it may have been misused, if the user misunderstood what happened, or if another system component may be at fault.

Step 2 is: always a complete visual inspection. A problem may be obvious just by looking. Things to look for include burned components, wires not connected, fan obstructions, loose hardware or connections, and soldering. Dirty air filters or plugged heatsinks greatly reduce amplifier efficiency and result in pre-mature ODEP limiting. The fan blades should spin freely. Burns and other physical damage should be repaired and components in the affected circuit areas should be checked carefully before continuing.

Whether a problem is identified by visual inspection or not, several checks should be performed prior to turning the amplifier on. These should be performed if catastrophic failure has been reported, no signal output with constant IOC is reported, or the condition of the amplifier is otherwise unknown but failure is suspected.

Channel 1 uses 100/300 series numbering and channel 2 uses 200/400 series numbering on the main module. 500 series numbering is used on the output and emitter modules, regardless of the channel. 700 and 800 series numbers are used on control, current sense, and terminator modules.

The third item on the "to do" list involves a number of electrical checks. Due to the protection features of the MA-5000VZ, it should be safe to turn-on under all circumstances, but these preliminary checks may allow a partial if not complete repair before power is ever applied. These checks are designed to find problems in the output stages. The ultimate guide should always be common sense.

To access all of the modules, simply remove the top cover, rear panel, and bottom cover. The main module will slide up and back for access to output module components by loosening four screws. The main module tray need not be removed in order to remove an output assembly, however, to perform component replacement on the main module the tray should be removed completely and the module removed from the tray. Note that the current sense module is actual comprised of two separate boards, connected by dual ribbon cables, hardwired at both ends. The smaller board is called current sense, the larger is, by itself, referred to as the terminator. Either name, however, may be applied to the pair. In section 8 they are covered as a single part, D 7994-3.

a.) Locate the flyback diodes D506, D507, D508, and D509 on the emitter modules and check for indications of a short. If a short is indicated, this means that an output device or driver transistor in parallel with that diode is shorted, usually not the diode itself. If a faulty output device is found, the entire output assembly may be replaced, or only the affected components. If an output device is found to be defective, emitter resistors should also be checked. If no output device is found defective, perform a quick check of driver, pre-driver, and bias transistors. Then, if no problem is found, move to power-on checks.

b.) Check driver and pre-driver transistors for shorts or opens. If a fault is found, do an in-circuit static check of all semiconductors on the output modules. If no output device and nothing upstream is found defective, move to power-on checks. Otherwise continue.

c.) If a failure has occurred anywhere in the output stages, check bias servo transistors on each (positive and negative) output module. Any failure

associated with bias transistors may result in repeat failure of the affected channel even if all other defective components have been found and replaced.

d.) If a failure is found in any LVAs, checks should continue up onto the main module in the voltage translator stage.

e.) Failure within the power supply itself is very rare, however a cursory check of major items is always prudent. A 30A fuse should not blow unless a catastrophic failure has occurred in the output stage or power supply. The low voltage fuse should not blow unless a failure has occurred, probably in the supply itself. If a failure has occurred in the output stages, check the MOSFET switches and other VZ control components, such as bridge rectifiers.

2.2.2 LED Checks

When power-off checks are complete and any defects found are corrected during that phase, the next step is to apply power. The MA-5000VZ includes several LED indicators to assist you in troubleshooting an amplifier malfunction.

All indicators on the amplifier, both front panel and internal, are important. External indicators include Enable, ODEP, SPI/IOC, and I_{LOAD}/LIMIT. Internal indicators include DC/LF, Fault (output module), Standby, and Over-voltage/Transformer Thermal.

A chart on the following pages lists likely LED combinations and likely causes. In each case it is assumed that the LED circuit itself is operating properly. If a failure is suspected, compare amplifier indicators with the chart.

In order to ensure that the problems are assessed correctly, perform the LED checks under the following conditions: Before power is applied, ensure that the Stereo/Mono switch is in the STEREO position. Do NOT connect any signal source or load to the amplifier. Turn the amplifier on. After approximately 4 seconds the turn-on delay should time out. During the delay IOC indicators will usually be on and ODEP indicators should be off. After the delay times out relays click on, IOC indication should go off, and ODEP indicators should come on. If this does not occur, definitely refer to the chart that follows. Although this chart contains most likely failures, it does not cover every possibility. Common sense and a study of schematics and circuit theory (provided in section 4) should lead ultimately to a proper repair.

Indicator	Condition	Cause
ODEP SPI/IOC ILOAD/ILIMIT STBY OV/THERM DC/LF OUTPUT MOD	One OFF Both OFF Both OFF Both OFF Both OFF Both OFF Both OFF	At any time the main relay is off (open), the ODEP indicator is also held off. Any protective action which will result in amplifier shut-down will cause the ODEP indicator on the affected channel to be off. The ODEP indicator will also be off when the amplifier is into "full ODEP" limiting. Under the initial conditions described, the conditions in the left column will only occur when there is a failure in one relay or relay control circuit, or if a failure has occurred in the ODEP circuit itself, or a thermal sensor for the ODEP circuit.
ODEP SPI/IOC ILOAD/ILIMIT STBY OV/THERM DC/LF OUTPUT MOD	One OFF Both OFF Both OFF One/Both ON Both OFF Both OFF Both OFF	An ODEP indicator off coupled with one or both internal STBY indicators lit is most often caused by low line voltage. It may also be caused by placing a logical low on a RS (remote standby function) connection to the P.I.P. module. First verify AC mains voltage and check the amplifier to ensure it is wired for the appropriate AC mains. The RS port from the P.I.P. module is not likely to be at fault, but if an IQ-P.I.P. is installed, it may be necessary to replace it with a blank module (such as the P.I.P.-FXQ) for testing purposes.
ODEP SPI/IOC ILOAD/ILIMIT STBY OV/THERM DC/LF OUTPUT MOD	Both OFF Both OFF Both OFF Both OFF Both ON Both OFF Both OFF	Both ODEP indicators off coupled with both internal OV/THERM indicators lit is most often caused by high line voltage (>10% above what the amplifier is wired for). It is extremely unlikely that the thermal switches in both amplifier channels will be activated. First verify AC mains voltage and check the amplifier to ensure it is wired for the appropriate AC mains. If fans are running at full speed, a transformer thermal condition is probably being simulated by a failed IC such as U707.
ODEP SPI/IOC ILOAD/ILIMIT STBY OV/THERM DC/LF OUTPUT MOD	One OFF Both OFF Both OFF Both OFF One ON Both OFF Both OFF	One ODEP indicator off coupled with one internal OV/THERM indicator lit will result from an open thermal switch in the toroid of the affected channel. Except for very early units with control module Q42930-0, fans should both be operating at high speed. If they are, a thermal switch is in fact open. If fans are off or nearly off (and control module is Q43096-9 or later), the problem is more likely a failed Q709 (Ch 1) or Q707 (Ch 2).
ODEP SPI/IOC ILOAD/ILIMIT STBY OV/THERM DC/LF OUTPUT MOD	One OFF One ON Both OFF Both OFF Both OFF One ON Both OFF	One ODEP indicator off coupled with IOC and DC/LF indications indicates a DC offset at the amplifier's output. The amplifier may attempt to cycle if a small offset is being caused by a malfunction. This may not be the direct result of an output device failure. It may rather be caused by a grossly mal-adjusted or faulty balance control within the amplifier. It may also be caused by any number of minor components failing in an unexpected manner. It may also be the result of an unbalanced ODEP circuit (\pm ODEP bias potentials unequal). If the DC/LF indication remains locked in, the OUTPUT MOD Fault circuit may be activated, but on occasion the DC/LF circuit will trigger faster causing this indication. Observe the output with a scope to determine if cycling action is in fact occurring.

Indicator	Condition	Cause
ODEP SPI/IOC ILOAD/ILIMIT STBY OV/THERM DC/LF OUTPUT MOD	Both OFF Both ON Both OFF Both OFF Both OFF Both ON Both OFF	Both ODEP indicators off coupled with both IOC and DC/LF indications indicates a DC offset at both of the amplifier's outputs. If possible, inquire if the user was operating the amplifier in a mono mode when the failure occurred. If so, then it is likely that output stage damage has occurred in both channels. If not, two unique problems may have occurred, or there may be an unexpected short on the terminator/current sense module. Other unexpected shorts may be possible. Mechanical integrity should be carefully checked.
ODEP SPI/IOC ILOAD/ILIMIT STBY OV/THERM DC/LF OUTPUT MOD	One OFF Either OFF/ON Either OFF/ON Both OFF Both OFF Both OFF One ON	An ODEP indicator off coupled with one internal OUTPUT MOD indicator lit may be accompanied with IOC and ILOAD/ILIMIT for the affected channel. Such a fault is latching and keeps the high voltage rails off. Such a fault is caused by conduction in both the positive and negative half of the output stage simultaneously. Under normal conditions this cannot occur at levels much above 100mW, assuming the amplifier is properly biased. Such a fault is usually the result of a failed output device, or possibly a failed bias network. It may also be caused by operating the amplifier at extremely high levels with ultra-sonics.
ODEP SPI/IOC ILOAD/ILIMIT STBY OV/THERM DC/LF OUTPUT MOD	Both OFF Both OFF Both OFF Both OFF Both OFF Both OFF Both OFF	Both ODEP indicators off with no other abnormal indication is almost impossible unless both relays fail, or the Power Loss IC (U111A) circuit has failed.

2.3 CHECKOUT/ADJUSTMENT PROCEDURES

The following instructions outline an orderly checkout and troubleshooting procedure. The purpose and arrangement of this procedure is to ensure proper operation after a repair has been completed. Before beginning these power-on tests review all cautions and warnings in section 2.1, and perform the checks listed in section 2.2. These checks will minimize the possibility of receiving a nasty surprise when turning on the MA-5000VZ.

WARNING!! Most adjustments are made with protective covers removed. This means prior to any AC power-off testing, discharge all power capacitors. Also, use extreme caution while making any internal adjustments when the unit is powered.

2.3.1 Equipment Required

The following is a list of standard equipment needed for manual performance of all tests listed in section 2.3.3:
Line Voltage Variac: 5kW or larger.
Oscilloscope: 2 Channel, 10MHz or better.
Digital Multimeter: Various measurements.
Watt Meter: For AC line draw.

ACVM: Peak reading RMS calibrated (all AC line voltage and amplifier output voltage checks).
I.M.D. Analyzer: 60Hz/7kHz in 4:1 ratio, accurate to 0.001% I.M.D.
T.H.D. Analyzer: Accurate to 0.001%.
Loads: 3000W continuous at 1 ohm.

2.3.2 Initial Conditions

The start of each step assumes all switches are pre-set to the following positions:
Dual Mono Switch: STEREO position.
Sensitivity Switches: Both to 0.775V position.
Compressor Switches: Both to OFF position.
LOI Switches: Both to OFF position.
VZ Mode Switches: Both to VZ position.
Level Controls: Both up (clockwise) fully.

2.3.3 Test Procedure

The following steps are arranged in order for best results and, for the most part, easiest use. Read each step carefully before proceeding. Read all precautions in section 2.1 before continuing. Use extreme caution and good common sense at all times. The preceding warnings and cautions are detailed for good reason.

WARNING: Do not connect any load to the MA-5000VZ power amplifier during these tests until specifically instructed to do so.

Type of Test or Adjustment	Input Signal and Load Parameters	Comments
1. Turn-on Delay	No Signal No Load	<p>Check for a delay of approximately 4 seconds from the time the power push button is pressed until the IOC indication clears and ODEP indicators come on. <i>If the IOC fails to clear in one channel, check for presence of rail voltages and for a DC offset. Also check circuit board LED for indication of a fault - DC/LF, Output Module, and OV/TSW. Turn unit off, disconnect the power cord, discharge power supplies, and check for a failure in the output stage of the affected channel, or other applicable circuit area. If the fans lock in high speed after delay times out, check fan control components, ODEP output, and LM334Z devices on the output modules.</i></p>
2. DC Output Offset	No Signal No Load	<p>With the input level controls turned fully clockwise, the DC offset for both channels should be less than ± 10 millivolts. Note: There are no output offset adjustments for the MA-5000VZ. <i>A small DC offset may indicate an ODEP failure. A large DC offset usually indicates a failure in the output stage, though such an offset should have shut down the amplifier on a DC/LFI signal.</i></p>
3. Quiescent Power	No Signal No Load	<p>While there is no published specification on quiescent power (at the time of this printing), it should be checked. A power draw with the fans off or operating slowly will normally be less than 150W (<1.5A). <i>Turn amplifier off immediately if quiescent power greatly exceeds expectation and search for power supply or output failure. If quiescent draw exceeds expectation by a "small" amount check bias immediately.</i></p>
4. High Side Bias	No Signal No Load	<p>Bias voltage is set while the amplifier is at room temperature. If the amplifier is hot from prior testing for repair or other purposes, it should be set aside until it has cooled before continuing with this check. Bias, once factory set, normally will not require adjustment. For channel 1: Measure the voltage at TP1 pin 2 with respect to pin 4 (DO NOT measure from ground reference). The bias voltage should equal $.350 \text{ VDC} \pm 10$ millivolts. If the bias voltage needs to be adjusted, adjust R505 on the channel 1 output assembly for the correct bias voltage. For channel 2: Measure the voltage at TP2 pin 2 with respect to pin 4 (DO NOT measure from ground reference). The bias voltage should equal $.350 \text{ VDC} \pm 10$ millivolts. If the bias voltage needs to be adjusted, adjust R505 on the channel 2 output assembly for the correct bias voltage.</p>

Type of Test or Adjustment	Input Signal and Load Parameters	Comments
5. Low Side Bias	No Signal No Load	Bias voltage is set while the amplifier is at room temperature. If the amplifier is hot from prior testing for repair or other purposes, it should be set aside until it has cooled before continuing with this check. Bias, once factory set, normally will not require adjustment. For channel 1: Measure the voltage at TP1 pin 15 with respect to pin 13 (DO NOT measure from ground reference). The bias voltage should equal .350 VDC \pm 10 millivolts. If the bias voltage needs to be adjusted, adjust R556 on the channel 1 output assembly for the correct bias voltage. For channel 2: Measure the voltage at TP2 pin 13 with respect to pin 15 (DO NOT measure from ground reference). The bias voltage should equal .350 VDC \pm 10 millivolts. If the bias voltage needs to be adjusted, adjust R556 on the channel 2 output assembly for the correct bias voltage.
6. O.D.E.P Null	No Signal No Load	ODEP Nulls are based on heatsink temperatures. To check and, if necessary, adjust ODEP bias voltages, heatsink temperatures must be measured. For positive ODEP: Measure TP1/TP2 pin 17 with respect to ground. Refer to the chart (Fig. 2.1) below. If measured voltage falls outside the listed range, the amplifier is too hot or too cold. Measure TP1/TP2 pin 11 with respect to ground. Observe the below listed ODEP Set Voltage with a negative polarity, \pm 0.1V. If necessary adjust R182/R282. For negative ODEP: Measure TP1/TP2 pin 17 with respect to ground. Refer to the chart (Fig. 2.1) below. If measured voltage falls outside the listed range, the amplifier is too hot or too cold. Measure TP1/TP2 pin 9 with respect to ground. Observe the below listed ODEP Set Voltage with a positive polarity, \pm 0.1V. If necessary adjust R191/R291.

Voltage Measured	ODEP Set Voltage	Voltage Measured	ODEP Set Voltage
2.90 mV	12.96 V	3.00 mV	11.76 V
2.91 mV	12.64 V	3.01 mV	11.64 V
2.92 mV	12.72 V	3.02 mV	11.52 V
2.93 mV	12.60 V	3.03 mV	11.40 V
2.94 mV	12.48 V	3.04 mV	11.28 V
2.95 mV	12.36 V	3.05 mV	11.16 V
2.96 mV	12.24 V	3.06 mV	11.04 V
2.97 mV	12.12 V	3.07 mV	10.92 V
2.98 mV	12.00 V	3.08 mV	10.80 V
2.99 mV	11.88 V	3.09 mV	10.68 V

Fig. 2.1 ODEP Set Voltage Chart

WARNING: Many of the following checks are done by connecting a resistive load to the output of the amplifier. Use caution and follow check-out procedures carefully to ensure correct results. These tests require a resistive load capable of over 3000W continuous into as low as 1 ohm.

WARNING: The MA-5000VZ is capable of drawing in excess of 80 Amperes of current from 120VAC Mains when loaded to 2 ohms per channel and with both channels driven by a 1kHz sine wave.

CAUTION: 30A fuses should be replaced after completion of tests, as they will be stressed during high power tests. Special 30A test fuses may used during testing, if they are replaced with the stock fuses after the tests.

Type of Test or Adjustment	Input Signal and Load Parameters	Comments
7. CMR Null	1kHz Sq. Wave No Load	Insert a common mode 1kHz 0dBu square wave into channel 1 (phono tip & ring shorted or XLR pins 2 and 3 shorted). At the output jacks measure less than 16 mV. If necessary adjust R105. Repeat test for channel 2, adjust R205 if necessary.
8. LED Check	1kHz Sine/Sq Wave Various Loads	Turn the amplifier off and leave it off for about 10 seconds. Turn the amplifier on. Observe the ODEP lights come on after about 4 seconds. The SPI/IOC lights should go off (if on during delay) at this time. Input a 1kHz 2V _{RMS} sine wave into each channel and observe the SPI/IOC lights on brightly. Turn down the input level to about 0.5V _{RMS} and observe the SPI/IOC lights remain on, but dimly. Remove the input signal and load the amplifier to 8 ohms/Ch. Insert the 0.5V _{rms} signal again and note the I _{LOAD} /I _{LIMIT} indicators come on green. Change the load to 1 ohm/Ch, switch to a square wave (20% Duty Cycle), and increase input level to 2V _{RMS} . Note the I _{LOAD} /I _{LIMIT} indicators turn red. This check also constitutes the Current Limit Check.
9. Sensitivity	1kHz Sine Wave No Load	Set the sensitivity switches to the 26dB position, check both level controls full clockwise. Insert a .775V 1kHz sine wave and measure 15.04V-15.97V at the output of each channel. Set sensitivity to the 0.775V position and measure 96.4V-107.6V at the output of each channel. Set the sensitivity switches to 1.4V position and measure 53.0V-59.2V at the output of each channel. At completion of test return sensitivity switches to 0.775V position.

Type of Test or Adjustment	Input Signal and Load Parameters	Comments
10. LOI	Sine Wave 8 Ohms	Place sensitivity switches in 26dB position; check or place LOI (EPS) switches to OFF (BYPASS) position. Insert a 1kHz sine wave and adjust for 2.8V _{RMS} (1W) output into 8 ohms. Adjust to 30Hz then to 20Hz, level should remain constant. Switch LOI (EPS) to ON (ENABLE). Check output at 30Hz at -2dB ±.1dB. Adjust frequency to 20Hz and measure output level at -11dB ±.1dB. Return LOI/ESP and sensitivity switches to initial condition (section 2.3.1).
11. Bridge Mono	1kHz Sine Wave No Load	<i>Note: Always turn power to the amplifier off prior to changing the position of the Stereo/Mono Switch. With the dual/mono switch in the bridge mono position, set the channel two input level control to full CCW. Insert a .775V_{RMS} 1kHz signal into channel one input. There should be signal present on both channel outputs, equal in amplitude, with channel two 180 degrees out of polarity from channel one (see Fig. 2.2). Channel one input level control should control the output level for both channels. Return the amplifier to stereo operation.</i>
12. Parallel Mono	1kHz Sine Wave No Load	<i>Note: Always turn power to the amplifier off prior to changing the position of the Stereo/Mono Switch. With the dual/mono switch in the parallel mono position, insert a .775 VAC 1 kHz signal into channel one. There should be two signals with the same polarity present, equal in amplitude, at the outputs of channels one and two. Both of these signals will be controlled by the channel one input level control. Switch the stereo/mono switch to stereo. There should be signal present only on the channel one output.</i>

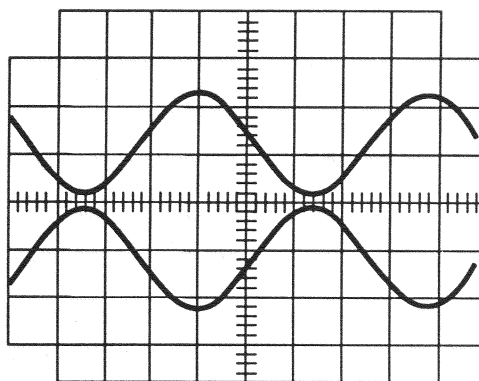


Fig. 2.2 Bridge MONO

Type of Test or Adjustment	Input Signal and Load Parameters	Comments
13. Static Balance	No Signal No Load	Place the VZ Mode switches in the VZ-ODEP position (see Fig. 2.4). Measure $\pm V_{CC}$ with respect to ground for channel 1. Values should be of equal magnitude and opposite polarity. If magnitudes vary by more than 500mV, adjust static balance pot R568 on the output module for null (no difference in magnitude). Switch to VZ (AUTO) position and verify null is maintained. Re-adjust only if necessary. Repeat check for channel 2, adjust if necessary.
14. Compressor	1kHz Sine Wave 8 Ohm	With each channel loaded to 8 ohms, insert a 1kHz sine wave and increase level until the amplifier is well into clip. Place the compressor switches in SLOW position and check for non-clipped output. Move switches to FAST position and again verify non-clipped output. Return switches to OFF position.
15. Dynamic Balance	1 kHz Sine Wave 2.7 Ohm	With channel 1 loaded to 2.7 ohms, increase input to obtain slight clipping. Watching TP1 pin 10 (main error amp output) and TP1 pin 16 (Low Side error amp output), simultaneously on a dual trace oscilloscope, verify that the output of the Low Side error amp clips at least as much (or very slightly more) than the main error amp output, and clip peaks reach 12-13V peak. If necessary adjust the dynamic balance pot R566 on the channel 1 output module. Repeat test for channel 2 measuring TP2 pin 10 and TP2 pin 16. <i>Note: 2.7 Ohm load is attained by placing three 8 Ohm loads in parallel.</i>
16. Over-voltage	No Signal No Load	With the amplifier powered from a variac, increase line voltage to 12% above the line voltage for which the amplifier is wired. The amplifier should trip off at 10.5% to 11% above the line voltage for which it is wired. If it does not set line voltage to 10.5% high and slowly adjust R780 on the control module until the amplifier trips into protect mode. If adjustment is performed, retest new adjustment.
17. ODEP & VZ-ODEP	60 Hz Sine Wave 2 Ohm	For the following tests, the cooling fan blade must be stopped. To stop the fans turn off and unplug the amplifier. Lift fan wire connector from P729/P730. Turn the amplifier back on and continue testing. At the end of this test step turn the amplifier off, unplug it, and return the fan wires to the appropriate position (P729 or P730). Place the VZ mode switches in the AUTO position (see Fig. 2.4). With a 2 ohm load per channel and output voltage of 60V _{RMS} 60 Hz to both channels, allow the heatsinks to heat up until the ODEP

Type of Test or Adjustment

Input Signal and Load Parameters

Comments

<p>18. Current Sense Balance</p>	<p>No Signal No Load</p>	<p>starts to limit the output signal (this should take a few minutes). A waveform like that in Fig. 2.3 below should be observed. Note: In VZ AUTO mode the flattened portion of the wave will probably not have the "clean" appearance of Figure 2.3, but should still resemble it. Check to see that the IOC LED is lit and that the ODEP LED dims and extinguishes when ODEP is activated. While ODEP limiting is taking place, switch the VZ mode switches to the VZ-ODEP position and verify that the amplifier locks into low voltage mode (the ODEP waveform should appear much more "clean"). Next configure the amp for parallel mono operation. With the input signal now present on channel one only, load channel one output with 8 ohms and channel two with 2 ohms. Observe that channel two ODEP protection circuit is limiting both channel one and channel two outputs. Next load channel one with 2 ohms and channel two with 8 ohms. Observe that channel one ODEP protection circuit is limiting both channel one and channel two outputs. Return the cooling fan blade to normal operation after this test has been completed, and allow a few minutes for the amplifier to cool with no signal input. Return all controls to initial conditions per section 2.3.1. <i>Correct operation of the ODEP circuit is dependent upon correct ODEP null settings (Step 6).</i></p> <p>Place the Stereo/Mono switch in the PARALLEL MONO position. Measure the channel 1 hot output with respect to the channel 2 hot output. Verify null of less than $\pm 10\text{mVDC}$. If necessary adjust null via R2 current sense balance pot.</p>
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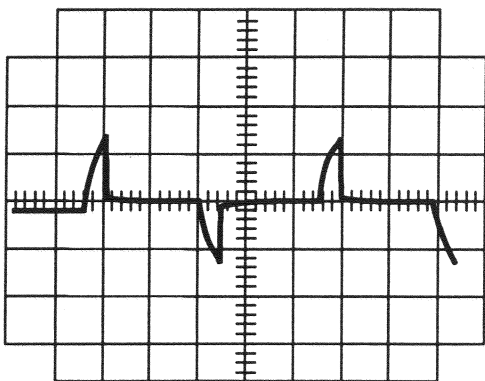


Fig. 2.3 ODEP Protection

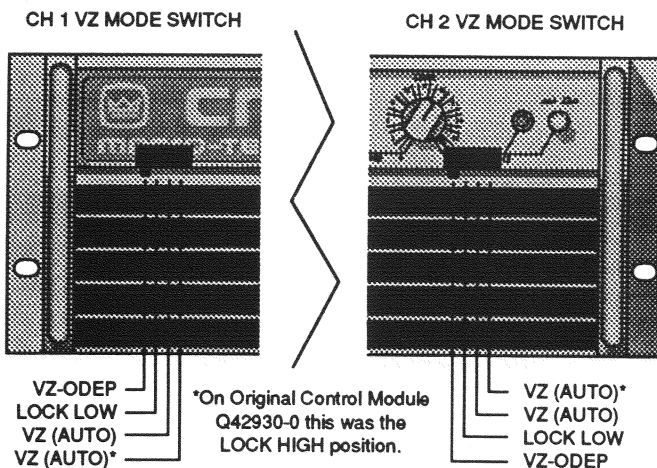


Fig. 2.4 VZ Mode Switch Locations

Type of Test or Adjustment	Input Signal and Load Parameters	Comments
19. Parallel Balance	1 kHz Sine Wave 8 ohm	Place the Stereo/Mono switch in the PARALLEL MONO position. Load each channel to 8 ohms separately, (loads must be precisely equal) and insert a 1 kHz sine wave. Adjust for 60V _{RMS} output. Measure the channel 1 hot output with respect to the channel 2 hot output. Verify null of less than $\pm 40\text{mVAC}$ with signal applied. If necessary adjust null via R4 parallel balance pot. Ensure Stereo/Mono switch is returned to STEREO upon completion of this check.
20. Current Sense Cal.	1 kHz Sine Wave 1 ohm	Factory set adjustment normally will not require recalibration. Perform this check as a verification, adjust only if the measurement is out of tolerance. With channel 1 loaded to 1 ohm, insert a 1 kHz sine wave and adjust for an output of 10V _{RMS} , $\pm 20\text{mV}$. Measure TP1 pin 1 with respect to ground. Value should be 2V _{RMS} $\pm 10\text{mV}$. If necessary adjust V/A cal pot R759 on the current sense module. Repeat test for channel 2 measuring TP2 pin 1; adjust R859 if necessary.
21. Current Limit Test	1kHz Sq. Wave 1 ohm	Note: The current limit check is performed as a part of the LED check in step 8. It is not necessary to repeat this check or perform more in depth checks as current limit circuitry is pretested when modules are manufactured. If a component affecting current limiting is replaced as a part of the repair, note that current limiting should occur at about 52-57V _{RMS} into a 1 ohm load with a 1 kHz (20% Duty Cycle) square wave input.
22. 10 kHz Square Wave Slew Rate Test	10kHz Sq. Wave 8 ohm	With an 8 ohm load on each channel, insert a 10 kHz square wave and adjust amplitude to produce an output 10V below clipping (Fig. 2.4, following page). Observe a 30V/ μS (or higher) slew rate. The output waveform should be stable with no ringing or overshoot.
23. DC/LFI	4 Hz Sq. Wave 8 ohm	Insert a 5Vpp 4 Hz square wave with an 8 ohm load on the output. The protection relay should cycle.

Type of Test or Adjustment	Input Signal and Load Parameters	Comments
24. 1kHz Power + THD	1 kHz Sine Wave Various Loads	<p>Note: Operation with a sine wave into a low impedance load, when operating at AC voltages of less than 200VAC, will cause the 30A fuses to blow after 30 to 60 seconds.</p> <p>AC Mains at 60Hz; or 230V, or 240V at 50Hz: 8 Ohm Load: Minimum voltage is 101.99VAC (1300W) with <0.05% THD.</p> <p>4 Ohm Load: Minimum voltage is 89.4VAC (2000W) with <0.05% THD.</p> <p>2 Ohm Load: Minimum voltage is 70.8VAC (2500W) with <0.05% THD.</p> <p>AC Mains of 100-220V 50Hz: 8 Ohm Load: Minimum voltage is 101.99VAC (1300W) with <0.05% THD.</p> <p>4 Ohm Load: Minimum voltage is 86.0VAC (1850W) with <0.05% THD.</p> <p>2 Ohm Load: Minimum voltage is 69.3VAC (2400W) with <0.05% THD.</p>
25. Inductive Load	1 kHz Sine Wave 8 ohm + Inductor	<p>Insert a 1 kHz sine wave into both channels and adjust for approximately 36V into an 8 ohm load on the output. Connect a 163 microhenry inductive load (14AWG minimum), in parallel with an 8 ohm resistor, on the output of each channel and observe the output waveform. It should be similar to that in Fig. 2.6, below.</p> <p>Note: Under the conditions of this test, certain variations may be present in the waveform including flyback limiting.</p>

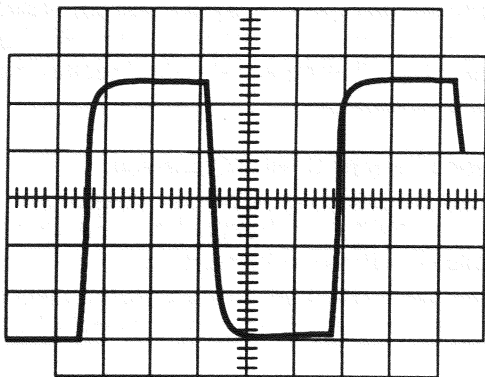


Fig. 2.5 10kHz Square Wave

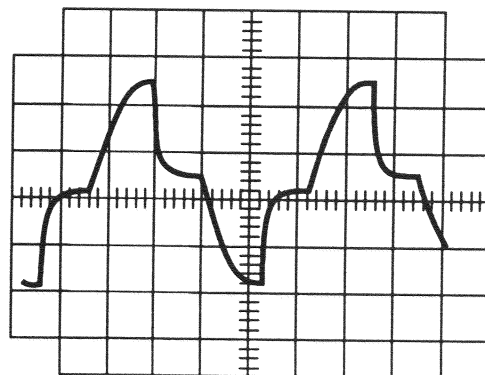


Fig. 2.6 Inductive Load

Type of Test or Adjustment	Input Signal and Load Parameters	Comments
26. I.M.D.	I.M. Signal Source 8 ohm	Place the sensitivity switches in the 26 dB position. Using a 60Hz/7 kHz input signal summed in a 4:1 ratio with the 60 Hz portion at 76.49V and 8 ohm loads on both channels, measure the I.M. distortion of each channel. Check in -5dB (power) steps until -35dB is reached (range is 1300W down to 0.41W). Readings should be less than .05% at each level.
27. Noise	No Signal No Load	Set the sensitivity switches to the 26dB position, level controls fully clockwise. Using a 20-20kHz bandpass filter on the input of the voltmeter, check that the noise level is 105dB below rated (1300W) output, with an 8 ohm load.
28. Crosstalk Check	1kHz Sine Wave 8 ohm	Set the sensitivity switches to the 26dB position. With each channel loaded to 8 ohms, insert a 1 kHz sine wave into channel 1 and adjust for 45V _{RMS} output. Measure <25mV on the output of channel 2. Move signal from channel 1 to channel 2 (ensure channel 2 output is 45V _{RMS}) input and measure <25mV at the output of channel 1. There is not adjustment for crosstalk.
29. VZ Modes	1 kHz Sine Wave 8 ohm	<i>Note: VZ-ODEP mode was checked during the ODEP test, step 17. I.M.D. and 1 kHz power checks adequately tested the VZ (AUTO) mode. LOCK HIGH was (if present) checked adequately in the static balance adjustment check, step 13. Place the VZ Mode Switches in LOCK LOW. With an 8 ohm load on each channel, insert a 1 kHz sine wave into each channel. Clipping should occur at approximately 36V_{RMS} (410W).</i>
Post-testing Procedure:		<p>At the completion of testing, replace the 30A fuses (if testing was done at 100 - 120VAC, and set all switches per customer request. If none are specified by the customer, the following are standard factory settings for original shipment:</p> <p>Dual Mono Switch: STEREO position. Sensitivity Switches: Both to 1.4V position. Compressor Switches: Both to FAST position. LOI Switches: Both to ON position. VZ Mode Switches: Both to VZ-ODEP position. Level Controls: Both down (counter-clockwise) fully.</p> <p>In most applications, VZ-ODEP is the best position for the VZ Mode switches for best thermal performance.</p>

3 Voltage Conversion

This Macro-Tech® 5000VZ™ power amplifier may easily be converted to a variety of AC mains voltages

and may operate at 50 or 60 Hz. Complete directions to accomplish line voltage and/or frequency changes are found on a label placed under the top cover of the unit. For convenience this information is duplicated here and on the following page. Wiring lists and instructions are below with a graphic of the unit showing physical wire locations on the following page.

Control Board Wiring for Different AC Voltages							
NO.**	100 V	120 V	200 V	208 V	230 V	240 V	
GROUP 1	P712	BLK	BLK	BLK	BLK	BLK	BLK
	P711	WHT	WHT	NONE	NONE	NONE	NONE
	P724B	BLU*	BLU*	BLU*	BLU*	BLU*	BLU*
	P707	BLK/GRN	BLK/YEL	BLK/GRN	BLK/GRN	BLK/YEL	BLK/YEL
	P704	NONE	NONE	BLK/YEL	BLK/YEL	WHT	WHT
	P705	NONE	NONE	WHT	WHT	BLK/GRN	BLK/GRN
	P710	WHT/GRN	WHT/YEL	WHT/RED	WHT/YEL	WHT/YEL	WHT/YEL
	P706	WHT/RED	WHT/RED	WHT/GRN	WHT/GRN	WHT/GRN	WHT/RED
	P708	WHT/YEL	WHT/GRN	WHT/YEL	WHT/RED	WHT/RED	WHT/GRN
	P703	BLK/YEL	BLK/GRN	NONE	NONE	NONE	NONE
	P701	GRY	GRY	GRY	GRY	GRY	GRY
	P700	GRY	GRY	GRY	GRY	GRY	GRY
P702	GRN/YEL	GRN/YEL	GRN/YEL	GRN/YEL	GRN/YEL	GRN/YEL	
GROUP 2	P713	BLK/YEL	BLK/GRN	NONE	NONE	NONE	NONE
	P714	WHT/YEL	WHT/GRN	WHT/YEL	WHT/RED	WHT/RED	WHT/GRN
	P722	BRN*	BRN*	BRN*	BRN*	BRN*	BRN*
	P749	WHT/RED	WHT/RED	WHT/GRN	WHT/GRN	WHT/GRN	WHT/RED
	P750	WHT/GRN	WHT/YEL	WHT/RED	WHT/YEL	WHT/YEL	WHT/YEL
	P718	NONE	NONE	WHT	WHT	BLK/GRN	BLK/GRN
	P718	NONE	NONE	BLK/YEL	BLK/YEL	WHT	WHT
	P721	BLK/GRN	BLK/YEL	BLK/GRN	BLK/GRN	BLK/YEL	BLK/YEL
	P719	BLK	BLK	BLK	BLK	BLK	BLK
	P715	WHT	WHT	NONE	NONE	NONE	NONE
	P724A	BLU*	BLU*	BLU*	BLU*	BLU*	BLU*
	GROUP 3	P736	GRN/YEL	GRN/YEL	GRN/YEL	GRN/YEL	GRN/YEL
P735		GRY	GRY	GRY	GRY	GRY	GRY
P734		GRY	GRY	GRY	GRY	GRY	GRY
P742		BLK/YEL	BLK/GRN	NONE	NONE	NONE	NONE
P737		WHT/YEL	WHT/GRN	WHT/YEL	WHT/RED	WHT/RED	WHT/GRN
P744		WHT/RED	WHT/RED	WHT/GRN	WHT/GRN	WHT/GRN	WHT/RED
P743		WHT/GRN	WHT/YEL	WHT/RED	WHT/YEL	WHT/YEL	WHT/YEL
P738		NONE	NONE	WHT	WHT	BLK/GRN	BLK/GRN
P739		NONE	NONE	BLK/YEL	BLK/YEL	WHT	WHT
P745		BLK/GRN	BLK/YEL	BLK/GRN	BLK/GRN	BLK/YEL	BLK/YEL
P724C		BLU*	BLU*	BLU*	BLU*	BLU*	BLU*
P741		WHT	WHT	NONE	NONE	NONE	NONE
P740	BLK	BLK	BLK	BLK	BLK	BLK	
P729*** P730***	120 V Position		240 V Position				

INSTRUCTIONS

CAUTION: Because there is a risk of electric shock, only a qualified technician should change the line voltage configuration.

1. Turn the amplifier off and disconnect it from the AC power source. (The enable switch alone does not remove lethal voltage from the line cord.) Wait at least 10 seconds before proceeding.
2. Drain any remaining energy from the power supplies by shorting them as follows: Touch a 100 ohm, 10 watt resistor across terminals A1 and A2 and across terminals B1 and B2 as shown in the illustration. The resistor should be held across the terminals for 10 seconds. **Be careful—the resistor can become hot.**
3. Locate the Control Board. It is the circuit board closest to the front of the amplifier. It contains numerous power supply connections which set the voltage and one jumper block which sets the frequency.
4. Use the information in the table at left to connect the color-coded wiring harness correctly for the desired voltage. Configure each wire group one at a time so the wires are not confused. **Do not mix wires between groups.** This step may require you to cut one or more tie wraps. If you do, replace them to make sure no loose wires are able to prevent the fans from rotating.
5. Locate the frequency jumper (JP1) and set it for either 60 Hz (left) or 50 Hz (right).
6. Double check that all connections are correct and replace the top cover.

*Wire colors marked with a single asterisk connect to the power cord.

**The connector numbers are listed in clockwise order from left to right as you face the front of the amplifier.

***Connection P729 and P730 are combined on a single four-pin connector. It mates to a "120 V" connector for 100 or 120 V operation or a "240 V" connector for 200, 208, 230 or 240 V.

Fig. 3.1 Voltage/Frequency Conversion Chart

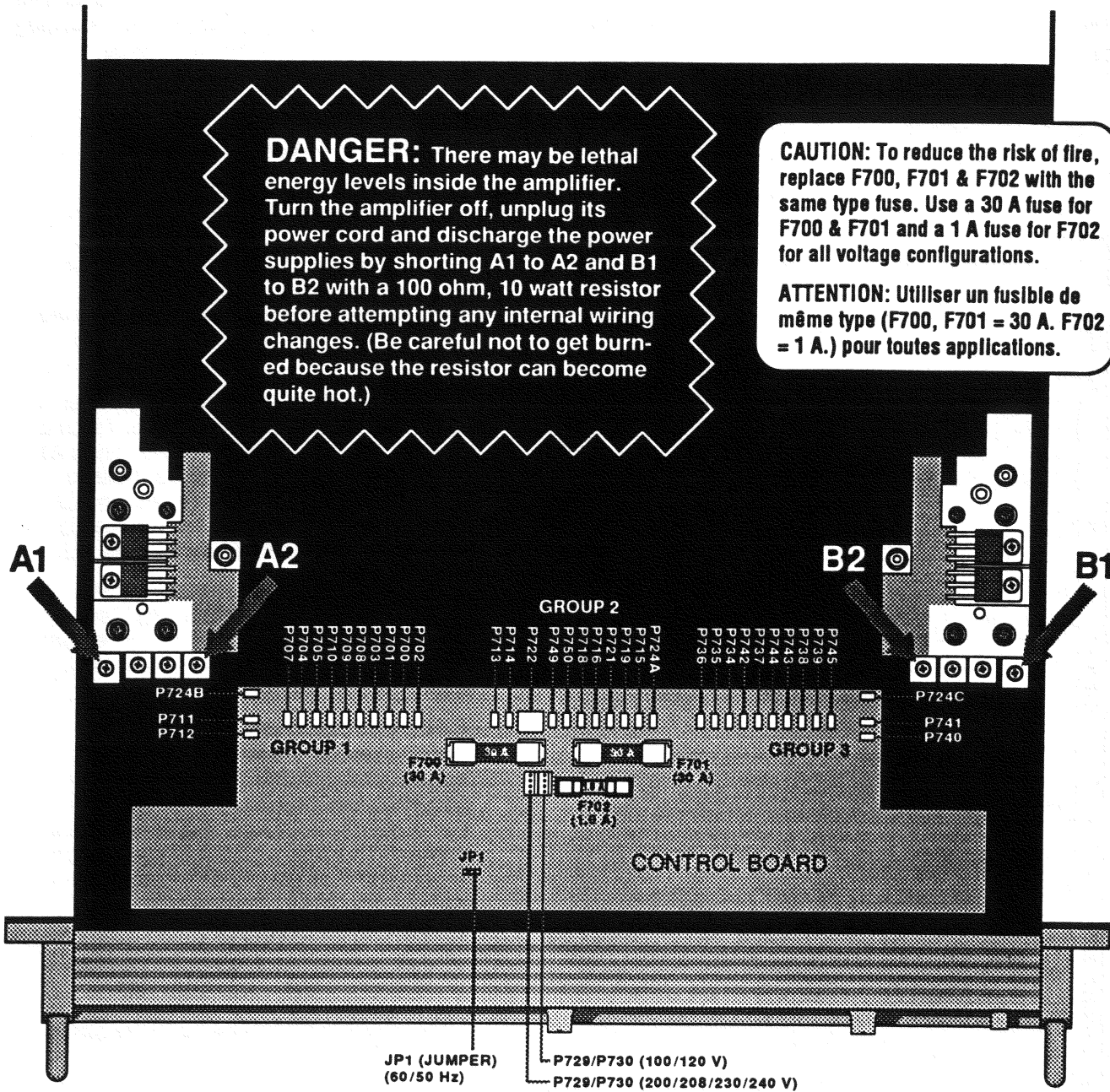


Fig. 3.2 Voltage/Frequency Conversion Physical Layout

4 Circuit Theory

4.1 OVERVIEW

Note: Sketches have been added to this section for clarification of the various concepts presented, as well as block diagrams for the amplifier and specific portions of the amplifier. For detailed schematics refer to section 6.

The Macro-Tech 5000VZ amplifier incorporates several new technological advancements including real-time computer simulation of output transistor stress, low-stress output stages, an advanced heat diffuser embodiment, a programmable input processor (P.I.P.) expansion system, and articulated VZ power supplies. Custom circuitry is incorporated to limit temperature and current to safe levels—making it highly reliable and tolerant of faults. Unlike many lesser amplifiers, it can operate at its voltage and current limits without self-destructing.

Real-time computer simulation is used to create an analog of the junction temperature of the output transistors (herein referred to as the output devices). Current is limited only when the device temperature becomes excessive—and just by the minimum amount necessary. This patented approach, called ODEP® or Output Device Emulation Protection, maximizes the available output power and eliminates overheating—the major cause of device failure. ODEP, in the MA-5000VZ, also provides indication of amplifier thermal reserve (front panel ODEP indicators) and may provide control of VZ mode when the VZ mode select switches are placed in the VZ-ODEP position.

The amplifier is protected from all common hazards that plague high-power amplifiers, including shorted, open or mismatched loads, overloaded power supplies, excessive temperature, chain-destruction phenomena, input-overload damage, and high-frequency blowups. The unit protects loudspeakers from DC in the input signal and from turn-on and turn-off transients. It also detects and prevents unwanted DC on the outputs. Additional protection features include input voltage sense, overvoltage (AC mains).

A mode of protection which may be switched on or off is called Loudspeaker Offset Integration (LOI). The

LOI circuit, when switched on, prevents excessive bass frequency cone excursions below the audible frequency range. It operates essentially as a band-pass filter. The low frequencies are rolled off at 18dB/octave with a -3dB corner of 35 Hz (Butterworth response). Ultra-sonics are rolled off with a second order Bessel response and -3dB corner of 50kHz.

A compression circuit in each channel may be switched off, on slow, or on fast by switches on the rear panel. This compressor is activated by either input overload or distortion (clipping). Input overload compression is in fast speed when compressor switch is in off position. Compression ratio is infinite (operates as a peak limiter).

The four-quadrant topology used in the grounded output stages is called the grounded bridge and makes full use of the power supplies. This patented topology also makes peak-to-peak voltages available to the load which are twice the voltage any output device is ever exposed to. The grounded bridge is covered in detail in section 4.2.

The two channels may be used together to double the voltage (bridged-mono) or the current (parallel-mono) presented to the load. This feature gives the user flexibility in maximizing the power available to the load.

Macro-Tech amplifiers utilize a wide bandwidth multiloop feedback design with state of the art compensation techniques. This produces ideal behavior and results in ultra-low distortion values.

Aluminum extrusions have been widely used for heatsinks in power amplifiers due to their low cost and reasonable performance. However, measured on a watts per pound or watts per volume basis, that extrusion technology doesn't perform nearly as well as the cut fin radiator technology developed for Macro-Tech 5000VZ power amplifier.

Our thermal diffusers are custom cut radiator fins on a solid heat sink block. They provide an extremely high ratio of area to volume, or area to weight. All power devices are mounted directly to massive heat spreaders, which are electrically hot. Making the heat spreaders electrically hot allows improved thermal performance by eliminating the insulating interface underneath the power devices. The chassis itself is used as part of the thermal circuit, and this maximizes utilization of the available resources.

Simplified Grounded Bridge... In Operation
(MA-5000VZ with supply in high voltage mode)

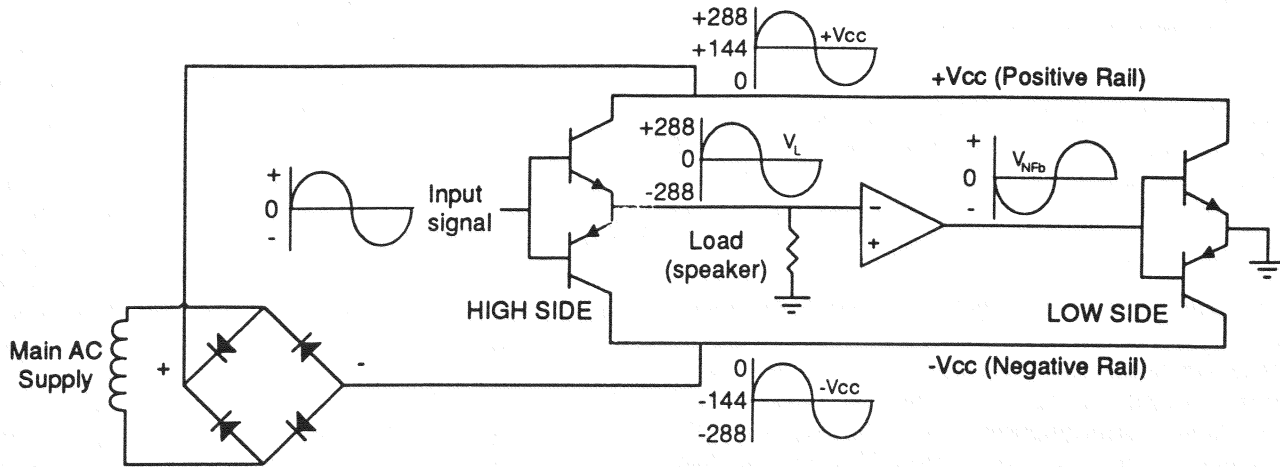


Fig. 4.1 Simplified Grounded Bridge

4.2 GROUNDED BRIDGE THEORY

The Grounded Bridge topology is ground-referenced by the output stages rather than the power supply. Composite devices are constructed to function as gigantic NPN and PNP devices since the available currents exceed the limits of existing individual devices.

The devices connected to the load are referred to as "high-side NPN and PNP" and the devices connected to ground are referred to as "low-side NPN and PNP." Positive voltage is delivered to the load by increasing conductance simultaneously in the high-side NPN and low-side PNP stage, while decreasing conductance of the high-side PNP and low-side NPN in synchrony.

4.2.1 Grounded Bridge Operation

Fig. 4.1 is a *simplified* example of Crown's patented Grounded Bridge output topology (ignoring the articulating characteristics of the VZ supply). It consists of four quadrants of three deep Darlington (composite) emitter-follower stages per channel: one NPN and one PNP on the high side of the bridge (driving the load), and one NPN and one PNP on the low side of the bridge (controlling the ground reference for the rails). The output stages are biased to operate class AB+B for ultra low distortion in the signal cross-over region.

The high side of the bridge operates similar to a conventional bipolar push-pull output configuration.

As the input drive voltage becomes more positive the high side NPN conducts current and delivers positive voltage to the speaker load. Eventually full +Vcc is across the load. At this time the high side PNP is biased off. When the drive signal is negative the high side PNP conducts to deliver -Vcc to the load and the high side NPN stage is off.

The low side operates quite differently. The power supply bridge rectifier is not ground referenced. This allows the power supply to deliver +Vcc and -Vcc from the same bridge rectifier and filter as a total difference in potential, regardless of their voltages with respect to ground. The low side of bridge uses inverted feedback from the high side output to control the ground reference for the rails.

As the output swings positive the output signal is fed back to the low side and is inverted to drive the low side with a negative signal. The negative signal causes the low side PNP to conduct (as the high side NPN conducts) shifting the ground reference to toward -Vcc until, at the peak, -Vcc = 0V. At this time +Vcc equals the full potential (from rail to rail, not rail to ground) of the power supply with positive polarity. Since the high side is delivering +Vcc to the speaker load (which is ground referenced at all times), the speaker sees the full potential developed by the power supply with a positive polarity.

When the input drive signal is negative and the high side PNP conducts to deliver a negative voltage to the

load, that output is again fed to the low side and inverted to cause the low side NPN to conduct. As the low side NPN conducts, +Vcc swings toward the 0V ground potential. At the peak: +Vcc = 0V. At this time -Vcc equals the full potential developed by the power supply, but with negative polarity. Since the high side is delivering -Vcc to the speaker load, the load sees the full (negative) potential developed by the power supply.

The total effect is to deliver a peak to peak voltage to the speaker load which is twice the (static) voltage produced by the power supply. Benefits include full utilization of the power supply (it conducts current during both halves of the output signal; conventional designs require two power supplies per channel, one positive and one negative), and never exposing any output device to more than half of the peak to peak output voltage (which does occur in conventional designs).

4.2.2 Output Stage Circuitry

Circuitry on the positive and negative output modules include bias circuitry, current limit circuitry, last voltage amplifiers (LVA's), pre-drivers, drivers, output devices, and the Low Side error amp. Temperature sensors are also mounted to the heatsinks via the output modules.

The positive LVA's (Q501, Q502, and Q503) convert the negative output of the voltage translator stage to a positive drive voltage for the NPN High Side (HS) predriver. There are three LVA transistors in parallel due to the very high voltages (therefor higher current and thermal requirements) that are present when the power supply is in high voltage mode. D522 prevents the +LVA's from producing a high negative output to the HS NPN stage.

Q507, Q508, and Q509 are the -LVA's and are arranged in mirror image to the +LVA's, including D513.

On the positive side D514, D515, and C506 via the +LVA's act to limit slew rate. D514 and D515 also prevent dangerously excessive current through the LVA's. D516, D517, and C507 are the negative HS mirror image.

Q534 and Q540 provide two-speed current limiting in the output stage. Sense lines are arranged such that excessive current through any single HS output device will result in current limit protection. Q535 and Q541 are the negative side mirror image.

Q505 on the positive output module works in tandem with Q505 on the negative output module as a Vbe multiplier circuit. They produce and, with great stability, control bias for the High Side NPN and PNP devices. Potentiometer R505 is used to precisely set bias voltage. Bias voltage is easily measured from pin 2 (hot) to pin 4 of ATE ports TP1 and TP2. Refer to section 2 for appropriate test procedures.

Q504 is the HS NPN pre-driver and Q511 is the HS NPN driver. These devices are biased class AB for ultra low distortion in the zero-crossing region.

Q513, Q515, Q517, and Q536 are the HS NPN output devices. These devices are biased class B, in soft cut-off. Together with driver and pre-driver, they function as a three-deep darlington. The output devices work in parallel as a giant composite. The over-all bias topology is referred to as AB+B, originally conceived and patented by Crown engineers in 1966. This is still the most efficient, stable, and distortion free method used today.

D506 is the flyback diode for the HS NPN output quadrant. In the event that a back EMF (flyback) pulse exceeds power supply voltage, the flyback diode will shunt this voltage to the supply in order to protect the output devices.

PNP pre-drivers, drivers, output devices, and flyback diode D508 are a mirror image of the NPN side.

Overall the High Side of bridge operates much like a conventional output stage, but the Low Side (LS) is quite unique.

The LS senses output voltage and common buss (0.04 ohms above ground) potential. The audio output is inverted by U503. Also in the U503 input circuitry are static and dynamic balance controls. These controls provide a fine balance of the grounded bridge. Output of the op-amp drives the LS pre-driver circuits through the LS bias network.

LS bias is controlled in a fashion similar to that of the HS. Two transistors, Q529 and Q530, along fix LS bias voltage as measured from pin 15 (hot) to pin 13 of applicable ATE port TP1 or TP2. Potentiometer R556 adjusts bias in the LS.

Diodes D504 and D505 control polarity of applied LS drive signal. Via the bias transistors signal is delivered to the bases of the pre-drivers Q527 (NPN) and Q528

(PNP). Pre-drivers, drivers, and output devices in the LS operate class AB+B, exactly like the HS. The major difference is that rather than driving a load, the NPN and PNP stages control the ground reference for the high voltage rails. As the HS NPN's conduct, LS PNP's conduct, and vice versa (as explained in section 4.2.1).

When the ODEP circuit senses that limiting drive is necessary to prevent a dangerous thermal condition, it provides an output which limits drive to the output stages. For the HS, this limiting is accomplished on the main module and is explained in section 4.4. For the LS, ODEP provides (via wires labeled $\pm LL$) a signal which limits bias feed to the LS output devices. This is accomplished through current mirrors Q532 and Q531 (LS NPN quadrant), and Q542 and Q543 (LS PNP quadrant).

4.3 VZ POWER SUPPLY

VZ means Variable Impedance and is the name of Crown's patented articulated power supply technology. It enables Crown to pack tremendous power into just 5.25 inches of vertical rack space.

A power supply must be large enough to handle the maximum voltage and current necessary for the amplifier to drive its maximum rated power into a specified load. In the process of fulfilling this requirement conventional power supply designs produce lots of heat, are heavy, and take up precious real estate. And it's no secret that heat is one of a power amplifiers worst enemies.

According to Ohm's Law, the bigger the power supply, the more heat the power transistors must dissipate. Also, the lower the resistance of the power transistors, the more voltage you can deliver to the load. But at the same time that you lower the resistance of the transistors, you increase the current passing through them, and again increase the amount of heat they must dissipate.

4.3.1 VZ Supply Operation

An articulated power supply, like VZ, can circumvent much of this problem by reducing the voltage applied to the transistors when less voltage is required. Reducing the voltage reduces the heat. Since the amplifier runs cooler, you can safely pack more power into the chassis.

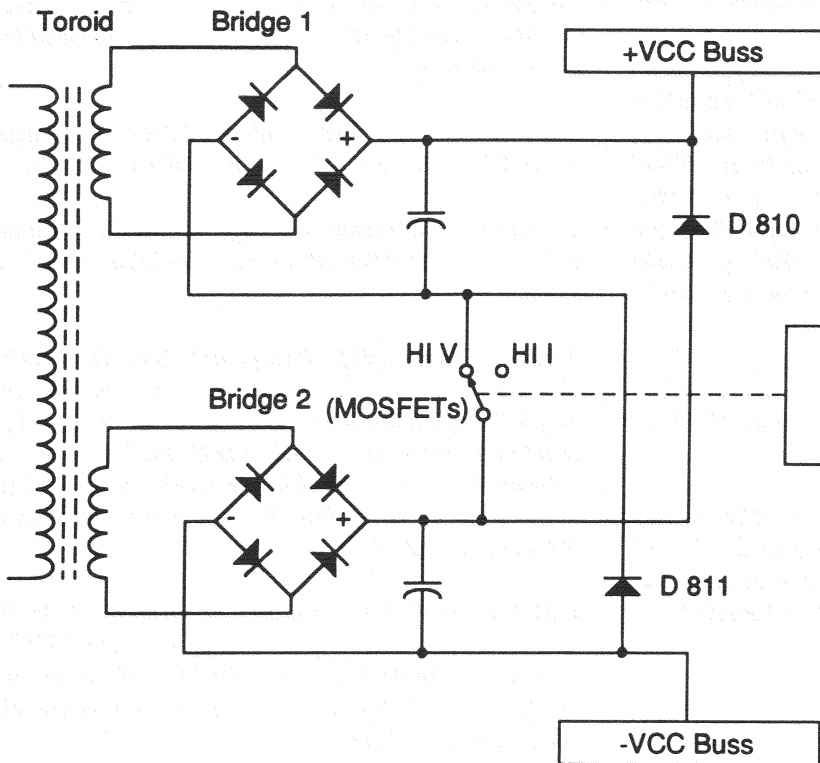


Fig. 4.2 Simplified VZ Supply Diagram

The VZ supply is divided into segments to better match the voltage and current requirements of the power transistors. Remember that audio signals like music are complex waveforms. Refer to Fig. 4.2 and 4.3.

For music the average level is always much less than the peak level. This means a power supply does not need to produce full voltage all the time.

The VZ supply is divided into two parts. When the voltage requirements are not high, it operates in a parallel mode to produce less voltage and more current.

The power transistors stay cooler and are not forced to

VZ Power Supply & Grounded Bridge Output Topology

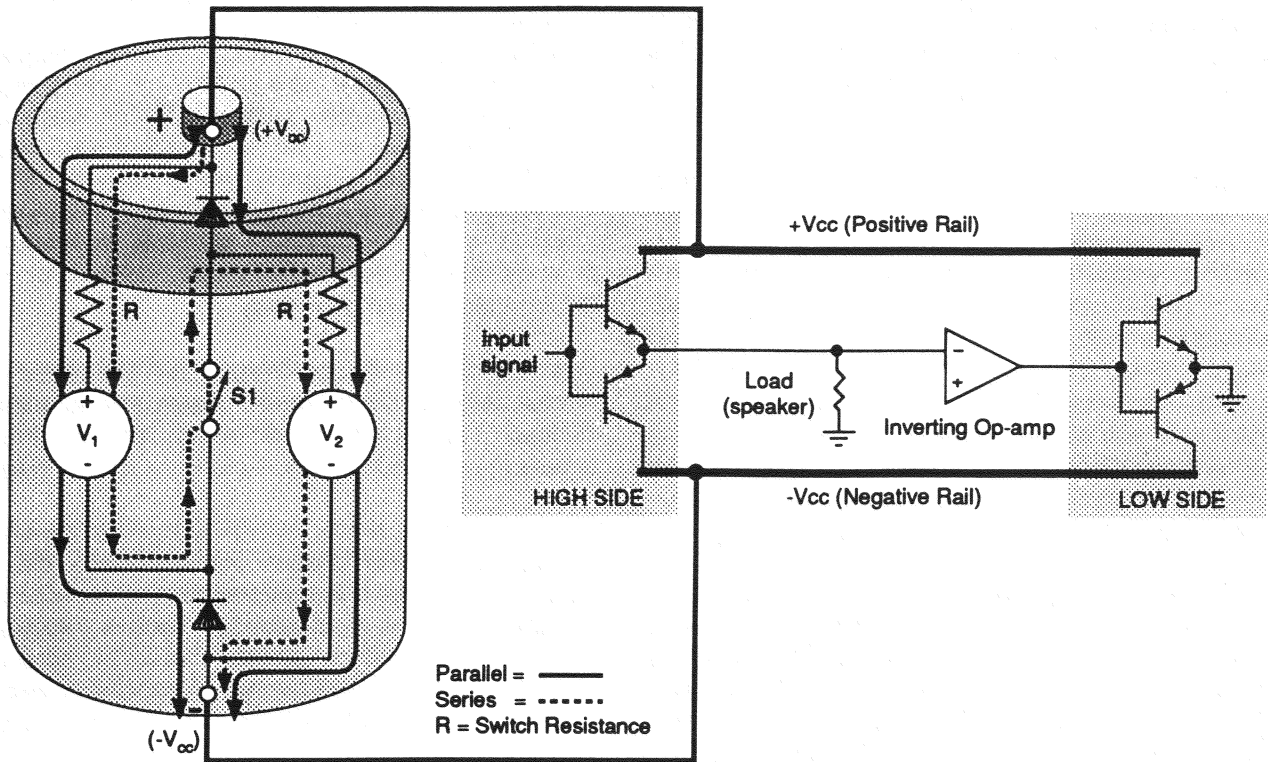


Fig. 4.3 Simplified VZ Supply in Operation

needlessly dissipate heat. This is the normal operating mode of the VZ power supply.

When the voltage requirements are high VZ switches to a series mode to produce higher voltage and less current. The amplified output signal never misses a beat and gets full voltage when it needs it—not when it doesn't need it.

Sensing circuitry watches the voltage of the output signal to determine when to switch VZ modes. The switching circuitry is designed to prevent audible switching distortion to yield the highest dynamic transfer function — you hear only the music and not the amplifier. You get not only the maximum power with the maximum safety, you also get the best power matching to your load.

In Fig 4.2, the individual components are shown. Upstream of the toroid transformer, though not shown, is where shutdown protection and soft-start circuitry taps in to control AC mains input to the power supply.

The VZ Control circuitry senses audio level and switches the articulating VZ supplies to either parallel (high current) mode for lower level audio, or series (high voltage) mode for high program peaks.

Fig. 4.3 shows current flow with power supply and grounded bridge operating together. Notice that the ungrounded VZ supply operates much like a battery. More exactly, it is a floating DC supply made up of two internal batteries which operate in either series or parallel.

In both examples it can be seen that when the MOSFET switch is off, the dual supplies are forced to operate in a parallel mode. Audio level is sensed via a line tapping off the NFB loop. When audio level is rising and at about 80% of the parallel mode supply voltage, the MOSFETs (the switch is actually a three-device composite switch) are turned on. No current will flow through either of the control diodes (D810 and D811, as shown for channel 1) because reverse polarity is applied through the MOSFET switch. Since this

happens to both rectifier sources at the same time, and the negative side of Bridge 1 is then shorted to the positive side of Bridge 2, the supplies are forced to operate in series mode. Like two batteries, the supplies will provide double voltage in series mode, double current in parallel mode.

Although shipped from the factory in VZ-ODEP mode, the user may switch modes to Lock Low voltage (high current), or operate the supply in VZ-AUTO mode. VZ-ODEP is similar to VZ-AUTO mode, except that in the event ODEP is activated to protect the amplifier, the VZ will automatically lock into low voltage (high current) mode. While this mode of operation will cool the amplifier more quickly in the event that the thermal reserve is exhausted, it may cause voltage clipping rather than ODEP limiting. Seldom will the amplifier be operated locked in high current mode unless a very low impedance is being driven.

4.3.2 VZ Supply Circuitry

For simplicity, only channel 1 circuitry will be covered unless noted otherwise. The actual VZ switch circuit is located on the VZ switch assembly. In this assembly are the filter capacitors, MOSFET switches, and control diodes (D810 and D811). Three MOSFETs are used in parallel for sharing the high current supplied to the rails. Operation of this section was covered in detail, minus circuit designations, in section 4.3.1.

WARNING: From a service standpoint, it is critical to note that VZ switch control circuitry is NOT ground referenced. Any attempt to take voltage measurements using a ground reference when voltage is applied will not only be unreliable, but may be extremely dangerous. Serious damage to equipment or personnel may occur if this is attempted.

The output of a 555 timer (U703) on the control module determines whether the MOSFETs are switched on (high) or off (low). This 555 device and the various sources that feed the 555 are the things that make the articulation work.

The master 555 trigger is controlled by the output of U702A. S700, physically accessible from behind the front grille, determines the VZ operating mode. In high voltage mode (Q42930-0 Control Module only) the output of U702A is held low. This in turn keeps the 555 output high and the MOSFETs are kept on. In the high current mode U702A is held in the opposite polarity keeping the output of the 555 low and the MOSFETs off. In the AUTO position of S700, the audio level

sense circuitry controls the threshold and reset inputs to the 555. The 555 will then switch states to high voltage when the audio level is sufficient and will switch back down automatically when level has dropped sufficiently. Capacitors in the U705 circuitry control the speed of the down-shift. In the VZ-ODEP mode, the switch operates as it would in AUTO mode unless ODEP limiting is in progress. When ODEP limiting occurs, optic coupler U704 pulls the reset control low to the 555 to turn the MOSFET switches off, and keep them off (low voltage/high current mode) until the ODEP limiting condition clears.

Upstream of the toroids are the soft-start and protection mechanisms used to power down the amplifier. Although tied into the power supply primary, these circuits are covered in section 4.6, Protection Systems.

The low voltage power supply utilizes a separate transformer. The front panel power switch and a 1A fuse (F702) are the only components upstream of this transformer. The output of the rectifier produces $\pm 24\text{VDC}$ unregulated. U715 and U716 produce regulated $\pm 15\text{VDC}$ respectively. (A separate fullwave rectifier produces pulsed DC for Over-voltage sense and Soft-start control.)

4.4 ODEP THEORY

To protect the output stages from adverse thermal conditions, a specially developed "ODEP" (Output Device Emulator Protection) circuit is used. It produces a complex analog output signal proportional to the always changing safe-operating-area (SOA) margin of the output transistors. This output signal controls the Voltage Translator stage and Low Side output stage bias. This action removes only the drive that may exceed the safe-operating-area of the output stage.

Thermal sensors give the ODEP circuitry vital information on the operating temperature of the heat sinks on which the output devices are mounted. This temperature signal combines with the complex ODEP signal to form the heart of our patented ODEP protection scheme.

4.4.1 ODEP Operation

Refer to Fig. 4.4. for a discussion of the basic operation of the ODEP system.

The ODEP circuitry actually comes in two parts, one positive and the other negative. For the purposes of

discussion, only channel 1 ODEP circuitry is covered here, and focus will primarily be on the positive half.

An LM-334Z thermal sensor provides a calibrated output from the output modules. At 25°C its output is 2.98V, with a 10mV increase per every 1°C rise in heatsink temperature.

This thermal sensor output, from the positive sensor, goes to three destinations. First is a buffer which drives

the calibrated temperature test point at pin 7 of TP1/TP2. Second is an over-temperature limit trip (thermal limit amplifier, as shown below). This will cause both the positive and the negative ODEP circuit to go into and remain in hard ODEP until the heatsinks cool. Third, it goes down into a circuit which combines thermal and output power information.

The thermal sensor from the negative output module only performs this last function.

Channel 1 ODEP Circuitry shown (channel 2 is identical)

- | | |
|--|--|
| <p>ODEP Inputs:
 Temperature
 ±VCC
 Output Current</p> | <p>ODEP Outputs:
 Calibrated Temperature, for monitoring
 ±ODEP Level, for monitoring
 ±ODEP Level, for Bi-ODEP control of VZ Supply
 ±ODEP Level, to limit drive at ±Voltage Translators (±LH)
 ±ODEP Level, to limit Low Side Bias (±LL)
 ODEP Indication (front panel LEDs)</p> |
|--|--|

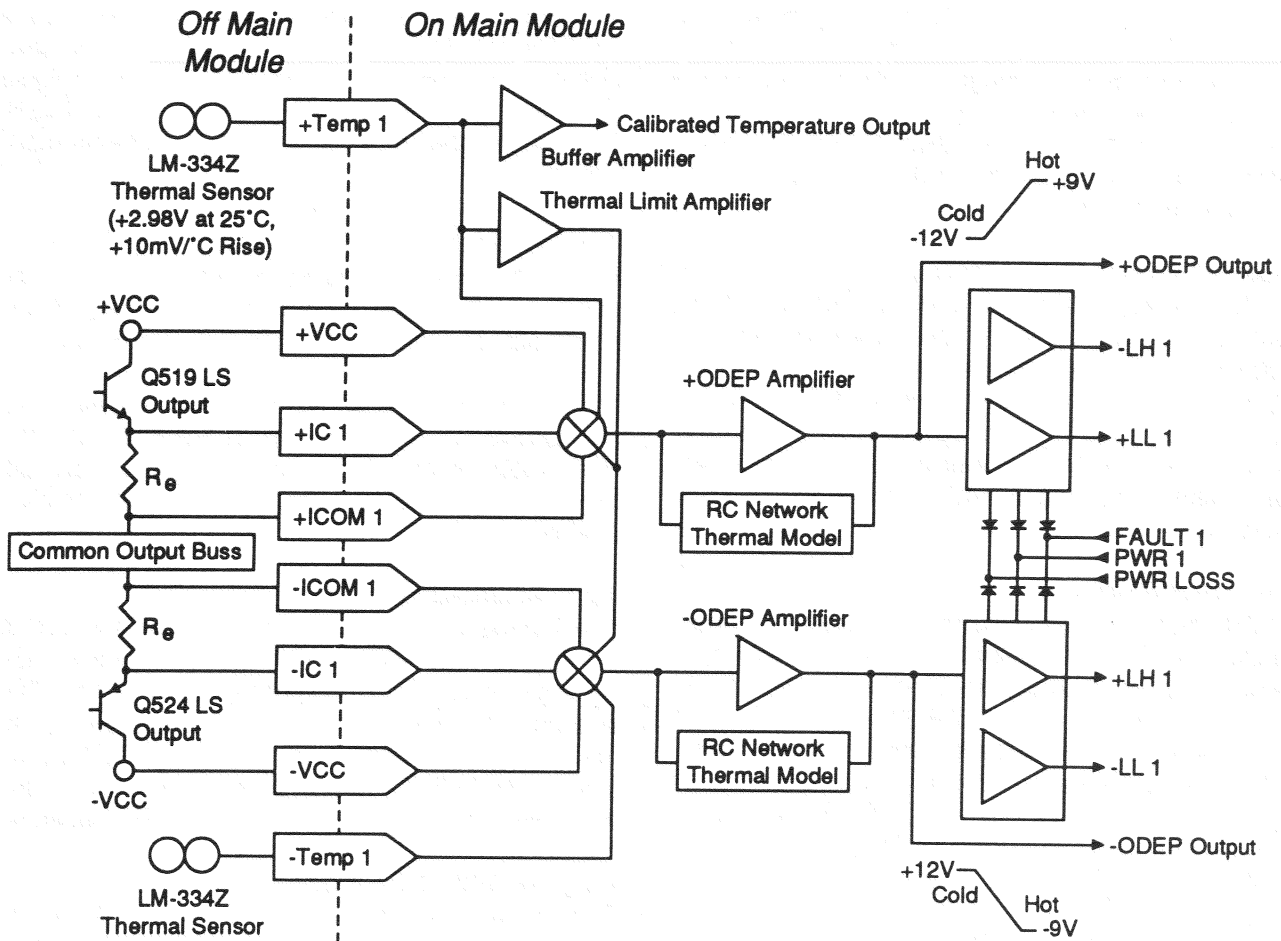


Fig. 4.4 Simplified ODEP Circuitry

A pair of sense lines from the Low Side emitter resistors provide current information. Combined with VCC information actual instantaneous power is calculated. A combining circuit determines the net thermal condition based on the power being delivered for the existing heat level. The ODEP amplifier accepts this input information and, using an RC model of the heat transfer characteristics of the output devices (as mounted in the heatsinks), creates a complex output proportional to the thermal reserve of the output devices.

Output from the positive ODEP amplifier ranges from -12V (cold) to +9V (hard ODEP). This output drives the positive LS bias feed control circuit (see section 4.2.2) and the negative HS Voltage Translator feed control circuit (see section 4.5.2). Also, this circuit provides test point monitoring information and VZ-ODEP VZ mode control information.

Output from the negative ODEP amplifier ranges from +12V (cold) to -9V (hard ODEP). This output drives the negative LS bias feed control circuit (see section 4.2.2) and the positive HS Voltage Translator feed control circuit (see section 4.5.2). Also, this circuit provides test point monitoring information, VZ-ODEP control information, and front panel ODEP (thermal reserve) LED control information.

Also tapping in to the ODEP output control of LS bias feed and Voltage Translator feed are signals from the fault, power (turn-on delay), and power loss (brown-out) circuits. By using the output of ODEP for \pm LL and \pm LH control, these sources can mute the audio to the output stage: a. until power-up delay has timed out; b. immediately upon indication of any failure mode; c. and immediately upon loss of AC mains (power-down or actual loss of AC service).

4.4.2 ODEP Circuitry

\pm TEMP signals are produced by U500 and U501 on the output modules. U108, on the main module, is a buffer which drives the temperature sense test point. U117A has a fixed window voltage of 6.2V via Zener D129. If heatsink temperature level exceeds about 130°C U117A output will cause both the positive and negative ODEP amplifiers to go into hard ODEP limiting. When the thermal condition clears this limiting condition will also clear.

+VCC enters via dual PNP transistor pack U116. Positive ODEP bias is adjusted by R182. The voltage at that point controls the static balance of the U116

device. U116 combines the VCC and output current sense information, the output of which represents output power level. The common output is brought into RN101 where it provides the reference for temperature and power. U112B is the active device and, together with the power signal, drives the ODEP amplifier U112A. The RC network in the feedback path of U112A models the thermal junctions from output device die to housing, housing to case, and case to heatsink under both static and dynamic conditions.

The output of the positive ODEP amplifier drives +ODEP test point pin 11. It also drives U114A and U114B which in turn drive -LH and +LL respectively. The output of the negative ODEP amplifier drives the ODEP indication circuitry and -ODEP test point pin 9. Negative ODEP also drives U114C and U114D which in turn drive +LH and -LL respectively.

Also entering the U114 comparator networks are the PWR (power relay engage), PWRLOSS (brown-out), and FAULT (any protection which shuts down the amplifier) signals via blocking diodes. If any of these signals drop low the feed to LS bias and Voltage Translator drive will be shut down via \pm LL and \pm LH. This action mutes all audio in the event of a dramatic failure.

4.5 FRONT END THEORY

Fig. 4.5 on the following page explodes the front-end portion of the over-all block diagram (Fig. 4.). Once again, only channel 1 will be discussed in detail.

Input to the amplifier is only via P.I.P. module. The standard module shipped with the MA-5000VZ is the P.I.P.-FXQ. Whether this or any other module is used, the amplifier senses a balanced input from the installed module.

4.5.1 Balanced Gain Stage

The Balanced Gain Stage (BGS) amplifier U100A converts the input audio from a balanced configuration to single-ended with (electrically) unity gain. The compression device is essentially a resistive shunt across the balanced BGS input. The BGS drives the Variable Gain Stage and provides information to the compressor control circuit and to the P.I.P. connector.

4.5.2 Variable Gain Stage

The Variable Gain Stage (U100B) taps signal from the wiper of the front panel level control (R120). Gain of the front-end is set by the gain of this stage. The sensitivity switch (S100, located on the rear panel) selects the

MA-5000VZ FRONT END: (CHANNEL 1 SHOWN)

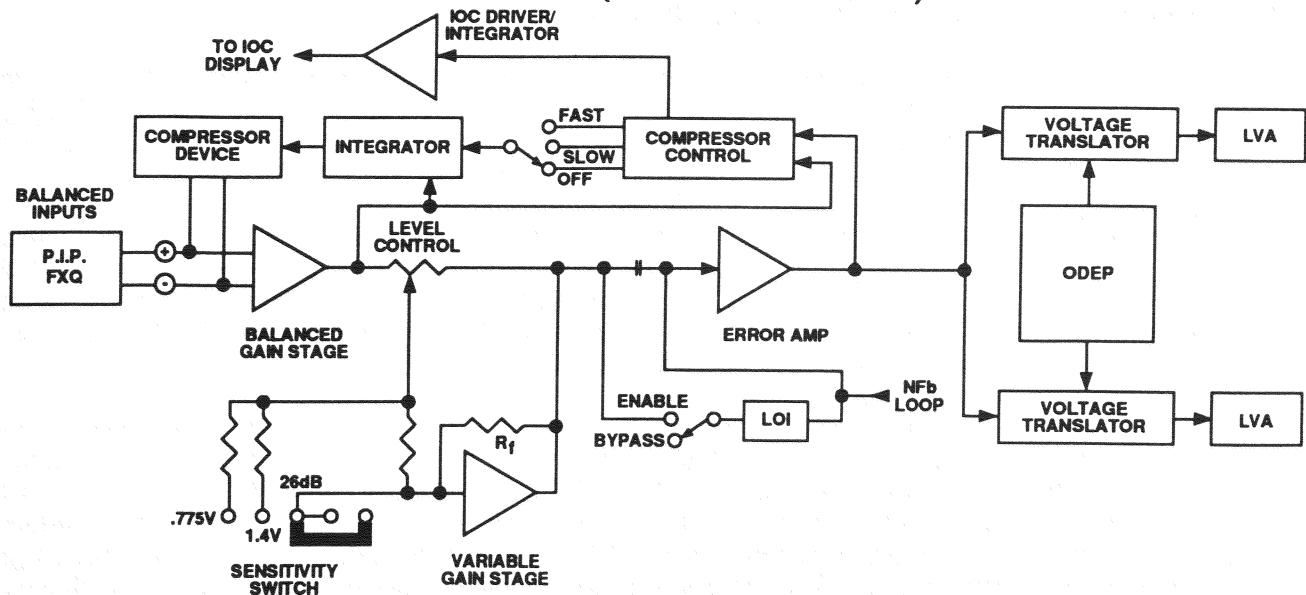


Fig. 4.5 Front End Circuitry Block Diagram

amount of gain in this stage. Overall amplifier sensitivity may be set for 26dB fixed gain (about 5.1V_{RMS}), 1.4V, or 0.775V. Since overall amplifier gain after this stage is 26dB, this stage will have a fixed gain of 0dB (26dB setting), about +12dB (1.4V setting), or about +16dB (0.775V setting). The output of this stage drives the Error Amp.

4.5.3 Error Amp

The Error Amp (U105) input comes from the Variable Gain Stage with or without Loudspeaker Offset Integration (LOI), and is summed with amplifier output in a negative feedback (NFB) configuration. Output of the Error Amp drives the Voltage Translators and provides error signal information. An error signal (spike) is produced any time the shape of the output waveform differs from the output of the Variable Gain Stage and LOI by more than 0.05%. This error signal drives the error signal (ES) input to the P.I.P. connector, the error signal sense test point, and the compression control circuit.

4.5.4 Compressor

The compression circuitry senses error signal and BGS level. If the BGS overloads, or an error signal is present, the compression control circuit (U101) produces a compression drive pulse. A switch on the rear panel selects speed of the integrator circuit to follow. In the off position the error driven compression

is disabled, but the input overload compression remains on (in fast speed) to protect the front end. The compression drive pulse also drives the IOC Integrator (U102). The IOC integrator not only tells the IOC indicator circuit when to turn on, but ensures that the indicator will remain on long enough to be visible to the human eye.

The compression integrator (U102, Q100) sets compression speed and produces an output pulse which controls attack and decay times. An optic device (U103) provides a resistive shunt to the input audio according to the degree of compression required and the duration of that compression. The amplifier input impedance is not affected by compressor operation.

4.5.5 Loudspeaker Offset Integration

LOI (U104A/B) senses amplifier feedback and prevents dynamic DC offset. It operates essentially as a dual filter system with band pass from about 35 Hz to about 50kHz. The upper roll-off has a second order Bessel response while the lower roll-off has a third order Butterworth response.

4.5.6 Voltage Translator and LVA Stages

The Voltage Translator stages (Q104, Q104) channel the signal to the Last Voltage Amplifiers (LVA's, located on the output modules), depending on the signal polarity, from the error amp U105. The \pm LVA's, with

their push-pull effect through the High Side bias servo devices, drive the fully complementary output stage. For more information on the LVA's, refer to section 4.2.

U106 and U107 bring in feedback information and protection muting to the Voltage Translator stages. The feedback controls gain from Voltage Translators to output jacks. The protection inputs (\pm LH) pull off feed to the Voltage Translators in proportion to ODEP limiting, and completely in the event of power-down or a Fault.

4.5.7 Inverting Stages

Overall the amplifier is non-inverting. Four stages within the amplifier, however, do invert the audio signal for a net non-inversion. The individual stages are: the BGS, which inverts the audio; the Variable Gain Stage, which inverts it back, the input side of U106 and U107 which drive the Voltage Translators re-inverts the audio (the Voltage Translators are a common-base configuration for high voltage gain); and finally the LVA's invert the audio for the last time for a net non-inversion through the amplifier.

4.6 PROTECTION SYSTEMS

The MA-5000VZ has several protection mechanisms to limit drive or shutdown the amplifier completely in the event of a fault of almost any kind. Mechanisms include: ODEP (covered in depth in section 4.4), current limit (covered in section 4.2.2), over-voltage (on AC mains), DC/LFI, common mode output current, output thermal, transformer thermal, FET thermal, loss of AC mains, compression (covered in section 4.5.4), LOI (covered in section 4.5.5), and slew rate limit (covered in section 4.2.2). After any non-latching fault clears which has shut down the amplifier, the amplifier will automatically power back up via soft-start. Because the fans within the MA-5000VZ cool the amplifier to (under normal conditions) prevent thermal shutdowns and ODEP limiting, the fan control circuit is also covered in this section.

Refer to Fig. 4.6, 4.7, and 4.8. Fig. 4.7 shows soft-start and fan control. Fig. 4.7 shows the soft-start control signals. Fig. 4.8 shows the over-all protection scheme of the MA-5000VZ. Each augments the others, and explode the basic block diagram of the unit (Fig. 4.9).

4.6.1 Soft-start

Soft-start circuitry controls the rate at which power is initially applied to the primary of the toroid transformers for the high-voltage power supplies. For ease of

explanation, assume the amplifier is operating properly and is just being turned on from the front panel power switch.

Before the power switch push-button is depressed, the input to the low voltage supply is open. The high voltage supply is isolated via input relay K700 and triac Q701 (which is in parallel with K700).

Several things occur immediately at turn-on. First the low voltage supply powers up and produces its main unregulated \pm 24VDC and regulated \pm 15VDC. It also immediately produces pulsed DC via full-wave rectifier D709/D714.

As this occurs all op-amps in the amplifier receive power, including front-end stages, relay power control U111C, and standby control U111B. The output of U111C powers relay K700 via relay drive transistor Q700. When the output of this op-amp goes high, Q700 turns on and the relay closes. The output of U111C is held low until the amplifier delay times out by comparing a high voltage on its inverting input to an RC network voltage on its non-inverting input. R329 and R330 fix a window at about +10.4VDC. At turn-on C220 (a 10 μ F cap) is fully discharged. In that first instant it keeps -15V on the non-inverting input of U111C, keeping its output low. As the capacitor charges it produces a ramped rise in voltage as it charges through R327. After about 4 seconds the voltage between R327 and R328 exceeds the window voltage and U111C output goes high, in turn causing relay K700 to close.

Note: Any protection signal within the amplifier which is used to shut it down will discharge this capacitor (C120) immediately causing the relay (K700) to open. Upon clearance of such shut-down protection signal, the charge will begin again with the same ramp effect and same delay.

The ramped voltage on the capacitor C120 is also sensed by Standby amplifier U111B. Its unity gain output is non-inverting. It drives the Soft-start op-amp (U701A) inverting input with its ramp to control the rate at which the field develops in the toroid. On the non-inverting input to U701A is the pulsed DC drive from the U701B/Q708 pulse circuit. Jumper JP1 may be set to 50 or 60Hz, but must be set properly to have the correct pulse width for soft-start. Pulse width is determined by C717 and either R777 (50Hz) or R777 in parallel with R806 (60Hz).

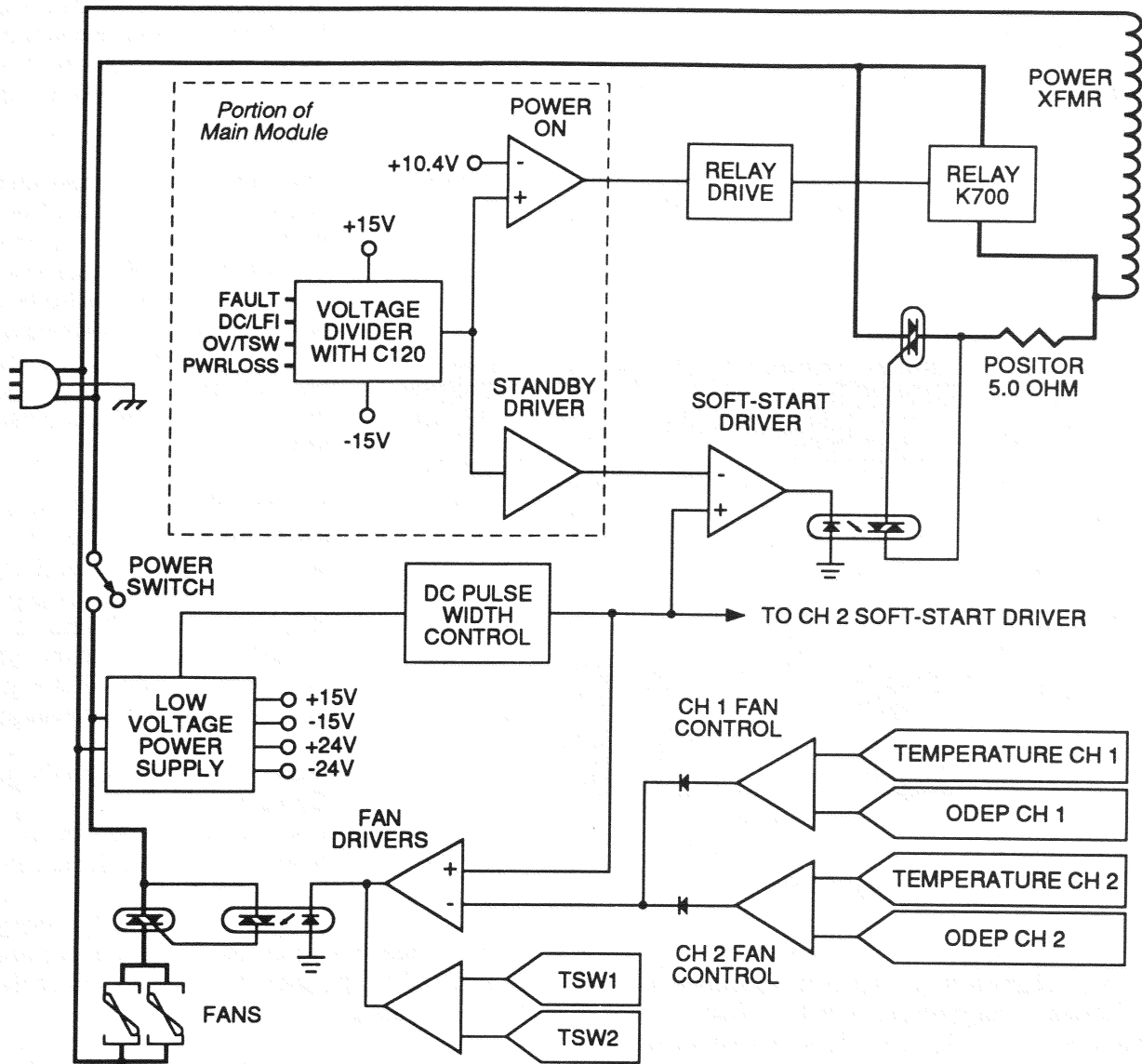


Fig. 4.6 Soft-start and Fan Control

The output of U701A controls the Soft-start. Refer to Fig. 4.6 for a graphic of Soft-start operation.

When the output of U701A goes low, the opto-triac device U700 turns on. While on the input triac Q700 conducts. Positor R702 limits peak input current to the toroid to a maximum of 22A peak (with 120VAC mains). U701A combines the sloped input from the C120 circuitry on the main module with the pulsed DC. As the portion of time which the output of U701A goes low increases, the amount of time where AC mains conduct to the transformer (via Q700 and R702) increases until it remains on. When the U111C PWR circuit times out, the relay closes bypassing the current

limiting soft-start circuit. Soft-start control signals are shown in Fig. 4.7. The upper signal is that produced by C120. At time 0 the amplifier is off. At time 1: the power switch is pressed (on). At time 2: C120 has fully charged, the magnetic fields have built up in the high voltage supply, and the main relay closes. At time 3: a protective action occurs; note that the DC supply remains. At time 4: the condition clears and the restart begins. Time 5 is akin to time 2, and time 6 is another protective action. The lower graph shows Q701 operation (high = on).

Any time a protection mechanism has acted and the condition then clears, this entire process repeats.

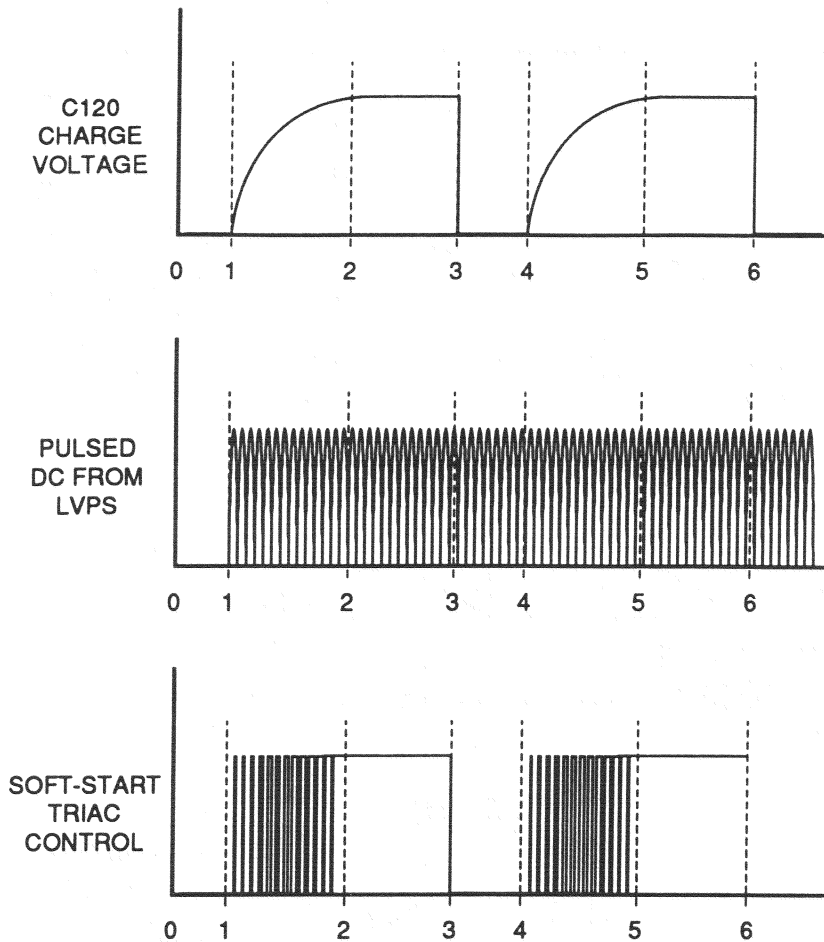


Fig. 4.7 Soft-start Signal

4.6.2 Over-voltage

One mode of amplifier protection is a shutdown in the event of over-voltage on the AC mains. This is sensed by the pulsed DC signal produced by the full-wave rectifier in the low voltage supply.

R780 picks off the pulsed DC and U707D will, if the voltage is too high, shift its output to a low. When this happens the over-volt/therm red LED on the control module lights and signal OV1 goes low to the main module.

A low (over-voltage condition) on OV1 causes U211C to shift to a low output. This low, through D1, causes C120 to discharge immediately. This in turn causes the main relay to drop out, soft-start to reset, and the $\pm LL$ and $\pm LH$ to clamp audio drive. Over-voltage is a non-latching fault condition.

4.6.3 DC/LF

The amplifier senses its own output for DC or very low frequency and will interrupt the amplifier channel in the event of DC or low frequency.

The feedback loop is sensed for voltage and the current sense signal provides current information. An RC network at the input to U109C/D will prevent the LF circuit from activating with normal audio frequency material, and will ensure activation with high level subsonic currents or voltages.

If U109C/D sense a DC (or LF) level, it will output a low which will, through D102, discharge C120 and initiate power supply shutdown. A low will also cause the DC/LF red LED on the main module to light. DC/LF is a non-latching protection mechanism.

4.6.4 Common Mode Output Current

Common mode current in the output stage can only be due to an output stage failure, or full power output of RF energy.

Common mode current occurs when a high current level exists in both the positive and the negative halves of the output stage.

U115 is a specialty device. It serves as both an Opto-SCR, and as a conventional SCR. It must have both an optic gate and conventional gate firing at the same time in order to latch. The conventional gate is fired by current sense of the output stage Low-side. The optic gate is fired by the High-side current sense. If high currents exist in both sides simultaneously, the SCR will latch on, and remain on until the unit is turned off.

When the SCR latches, low voltage causes the red LED (labeled Output Module) to light, and places a low on the FAULT signal line. A low on the FAULT line is sensed, via D112, by C120. Once again, a low here discharges C120 and shuts down the amplifier. FAULT is a latching protection mechanism (the only one in the amplifier).

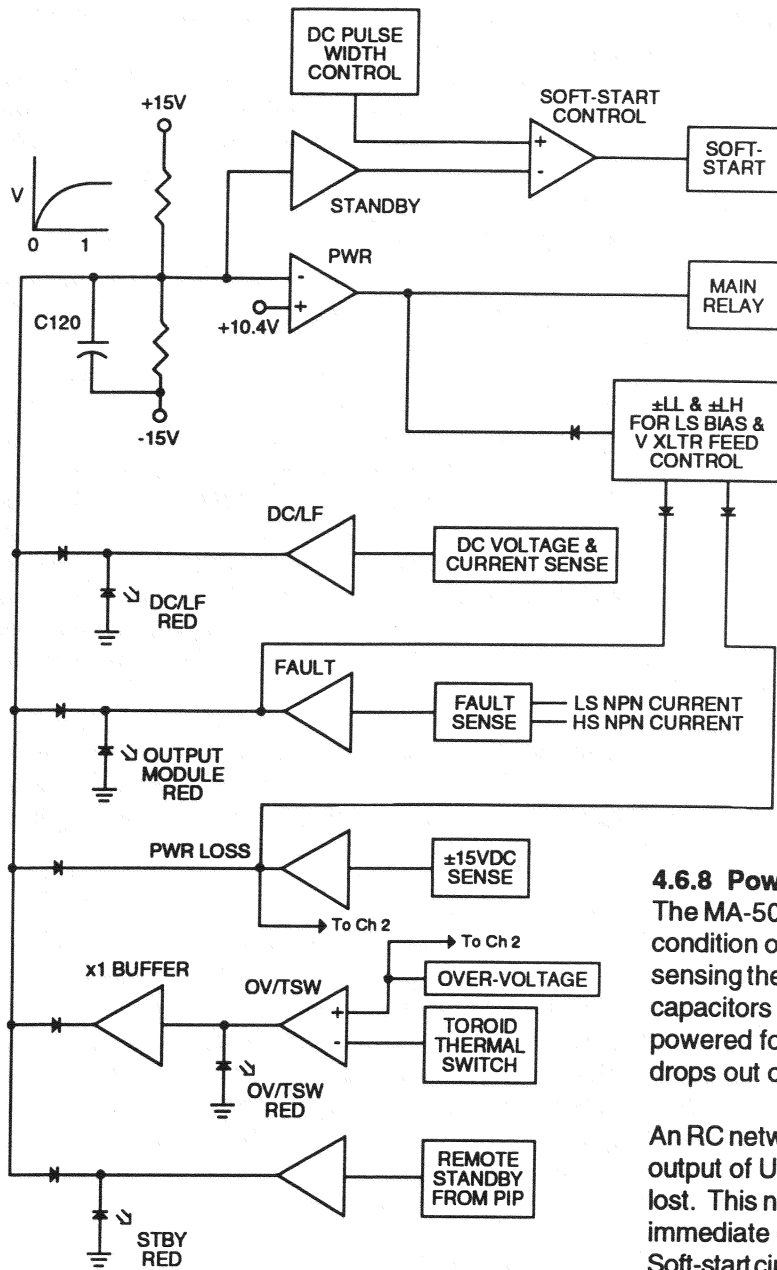


Fig. 4.8 Over-all Protection Scheme

4.6.5 Output Thermal

Output over-temperature protection has been covered, to a degree, in section 4.4.2 ODEP Circuitry. The calibrated temperature sense from the positive half of the output stage drives an over-temperature amp, U117A. If heatsink temperature exceeds a limit of about 130°C, the amplifier will go into hard ODEP. This does not shut down the amplifier, but does clamp the audio. Refer to section 4.4.2.

4.6.6 Transformer Thermal

The main power transformers have built-in thermal switches which open in the event of transformer over-temperature. In the event that the thermal switch opens in the channel 1 toroid, Q709 turns on causing U707D to go low. When it does, the over-voltage/thermal switch LED on the control module is energized and the OV1 signal is tripped; the fans are also forced to high speed. Transformer thermal protection is self-resetting. This results in amplifier shutdown by way of shared over-voltage circuitry. Refer to section 4.6.2.

4.6.7 FET Thermal

A special circuit has been designed into the MA-5000VZ to protect the MOSFET switches in the VZ supply. The voltage drop across the FETs (while conducting) is proportional to device temperature. Control circuitry senses the voltage and if necessary, the supply will be forced into low voltage (high current) mode to allow the FET devices to cool.

4.6.8 Power Loss

The MA-5000VZ has the ability to sense a "brown-out" condition on the AC service. This is accomplished by sensing the low-voltage power supply at U111A. Local capacitors on the ±15VDC supply to this chip keep it powered for a short time after the low voltage supply drops out on power-down/loss.

An RC network, consisting of C1 and R6, will cause the output of U111A to shift low the instant low voltage is lost. This negative potential discharges C120 causing immediate opening of the main relay, and reset of the Soft-start circuitry. It is essential that C120 be discharged immediately in the event that power is restored before C120 would otherwise discharge. The power-loss circuit is common to both channels. Its output goes to ±LL and ±LH to immediately mute audio upon power-down or power-loss, thus preventing turn-off audio noise.

4.6.9 Fan Control

The MA-5000VZ, unlike other members of the Macro-Tech family, has two onboard fans. They are mounted to the chassis divider assembly and pull cool air from the front and discharge it across the output stage heatsinks to the rear of the amplifier. Also unlike the

other Macro-Techs, the fans are fully ODEP proportional (operate in proportion to output stage temperature and calibrated ODEP control voltage).

U713B combines channel 1 temperature and ODEP level, U713A for channel 2. D706 and D707 form a diode OR gate. The output of the OR gate drives one input to U707B. The other input to U707B is from the DC pulse width control circuit (U701B). U707B operates in a fashion similar to that of U707A, the Soft-start control amplifier. A graphic example of the fan control waveforms would look a good deal like those in Fig. 4.7, except that the thermal drive would be unique from that of the Soft-start ramp.

The fans will also be forced to operate at full speed in the event a toroid transformer thermal switch trips open. Note that very early units did not include this additional circuit.

4.7 DISPLAY

Amplifier front panel indication includes a total of 7 LED's. These include Enable, ODEP, SPI/IOC, and ILOAD/LIMIT.

The Enable indicator is an amber light which indicates presence of the low voltage supply. It is powered by the unregulated +24VDC supply. It will be on any time the power switch is depressed (unless the low voltage fuse blows).

ODEP indicators provide an on-line indication of amplifier thermal reserve. The LED's are amber (although they may have a reddish appearance) and are normally on. They dim and/or extinguish in the event that the amplifier's thermal reserve is exhausted. ODEP indicators will also extinguish whenever the main supply relays are open (such as a protection action being activated, or during Soft-start time-out).

Green SPI/IOC LED's show signal presence (SPI) and any form of distortion (IOC). They flash dimly with the audio to show signal. In the event of an IOC condition (output waveform differs from input by >0.05%, or input overload) the light will be on brightly. An occasional flash of IOC usually indicates clipping. If the IOC light locks in it usually indicates a protective action, or "hard" ODEP limiting.

ILOAD/LIMIT LED's flash green with the audio when program material is being delivered to a load. Its

function is similar to that of the SPI, except that SPI is voltage driven and does not require a load. ILOAD comes on when the amplifier is loaded, and brightness in proportion to the output current. This is the ILOAD function. In the event of current limiting action, the light will flash to red. This is the LIMIT function.

4.8 MONO MODES

The MA-5000VZ has three main operating modes, namely dual (stereo), bridge mono, and parallel mono.

There are a number of precautions which should be taken when operating the amplifier in either mono mode. The VZ mode switches for each channel must be set the same. Sensitivity, LOI, and Compressor switches for channel 2 make no difference. The input must be to channel 1 only. The input to channel 2 and controls for channel 2 are NOT defeated in either mono mode, therefore no connection to channel 2 may be made in either mono mode. The channel 2 level control should be turned down (counterclockwise) fully in either mono mode.

Monaural amplifier operating modes are covered in detail in the MA-5000VZ Owner's Manual. The discussion below primarily aids in understanding how the mono modes work for testing purposes.

4.8.1 Bridge Mono

Bridge mono is intended for loads of 4 ohms or greater. The feedback loop for channel 1 also drives the input to channel 2 in this mono mode. The input to channel 2 is, however, inverted. This causes the output of channel 2 to be of equal magnitude and opposite polarity (for double voltage output) the output of the amplifier is balanced, and channel hot output is connected to load hot (+), channel 2 hot output is connected to load return (-).

4.8.2 Parallel Mono

Parallel mono is intended for loads less than 4 ohms (as low as 1 ohm) in a monaural amplifier configuration. The channel 1 and 2 amplifier hot outputs must be shorted by an external shorting buss (10 AWG or larger). The amplifier output to the load(s) is taken from either channel's hot output to load hot, and either channel's negative output to the load return (-). The shorting buss must be removed prior to changing from parallel mono to either other mode.

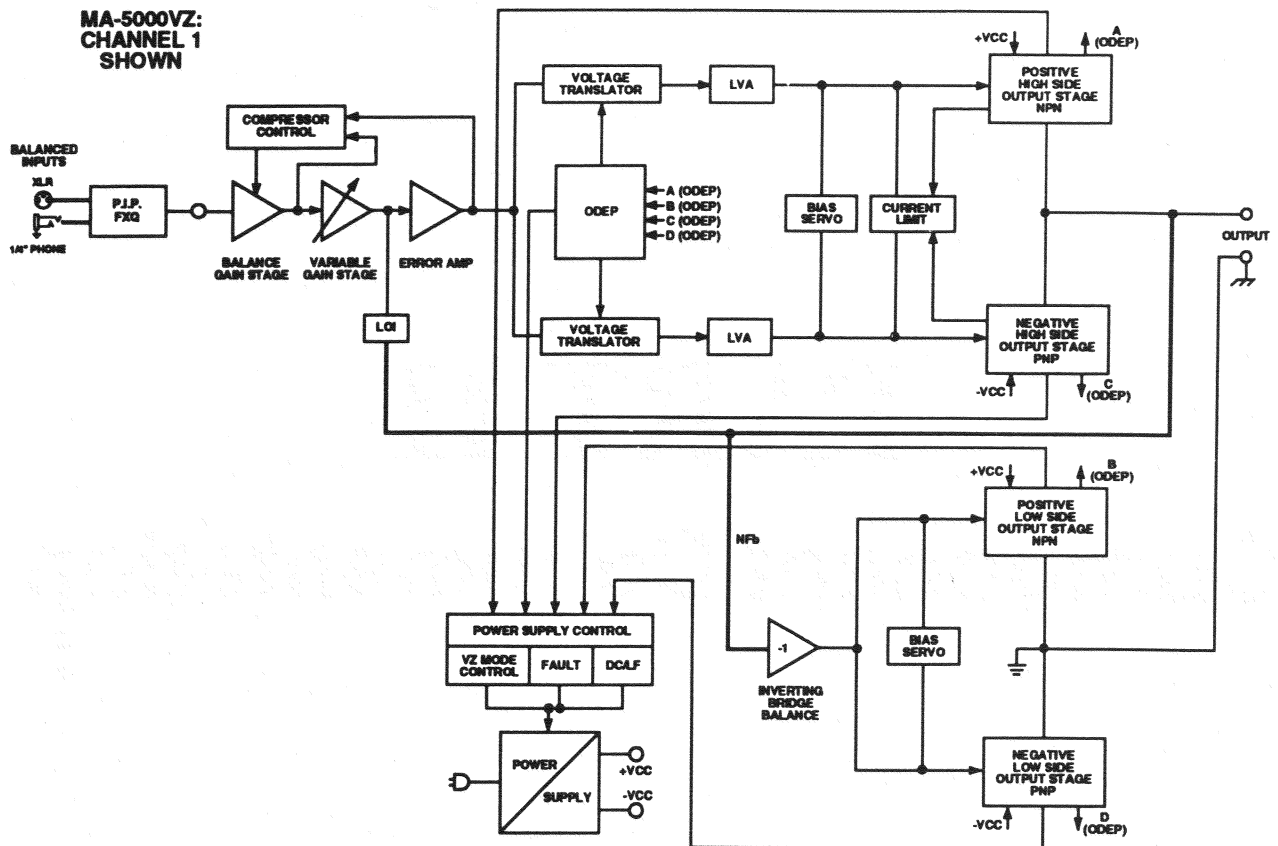


Fig. 4.9 Macro-Tech 5000VZ Amplifier Block Diagram

PART II

Component Documentation

5 Parts

5.1 GENERAL INFORMATION

Chapter 6 includes schematics used for referencing the circuit board components found in chapter 8. Chapter 7 contains exploded view drawings and artwork with associated parts listings.

Most mechanical and structural items are illustrated and indexed in the exploded view drawings. Where electronic parts are shown in these drawings the schematic designations are also given.

Electronic parts located on printed circuit boards are illustrated by schematic symbols on the trace side and by component shape symbols on the component side. Where applicable, quantities of parts are also given.

5.2 STANDARD AND SPECIAL PARTS

Many smaller electrical and electronic parts used in the Macro Tech amplifiers are stocked by and available from electronic supply houses. However, some electronic parts that appear to be standard are actually special. A part ordered from Crown will assure an acceptable replacement. Structural items such as covers and panels are available from Crown only.

5.3 ORDERING PARTS

When ordering parts, be sure to give the amplifier model and serial number and include a description and Crown Part Number (CPN) from the parts listing. Price quotes are available on request.

5.4 SHIPMENT

Shipment will be normally made by UPS or best other method unless you specify otherwise. Shipments are made to and from Elkhart, In, only. Established accounts with Crown will receive shipment freight prepaid and will be billed. All others will receive shipment on a C.O.D. or pre-payment (check or credit card) basis.

5.5 TERMS

Normal terms are pre-paid. Net-30 days applies to only those firms having pre-established accounts with Crown. If pre-paying, the order must be packed and weighed before a total bill can be established, after which an amount due will be issued and shipment made upon receipt of pre-payment. New parts returned for credit are subject to a 10% re-stocking fee, authorization from the Crown Parts Department must be obtained before returning parts for credit.

Crown is not a general parts warehouse. Parts sold by the Crown Parts Department or solely for servicing Crown products. **Part prices and availability subject to change without notice.**

To order parts...
Call the Crown Parts
Department at:

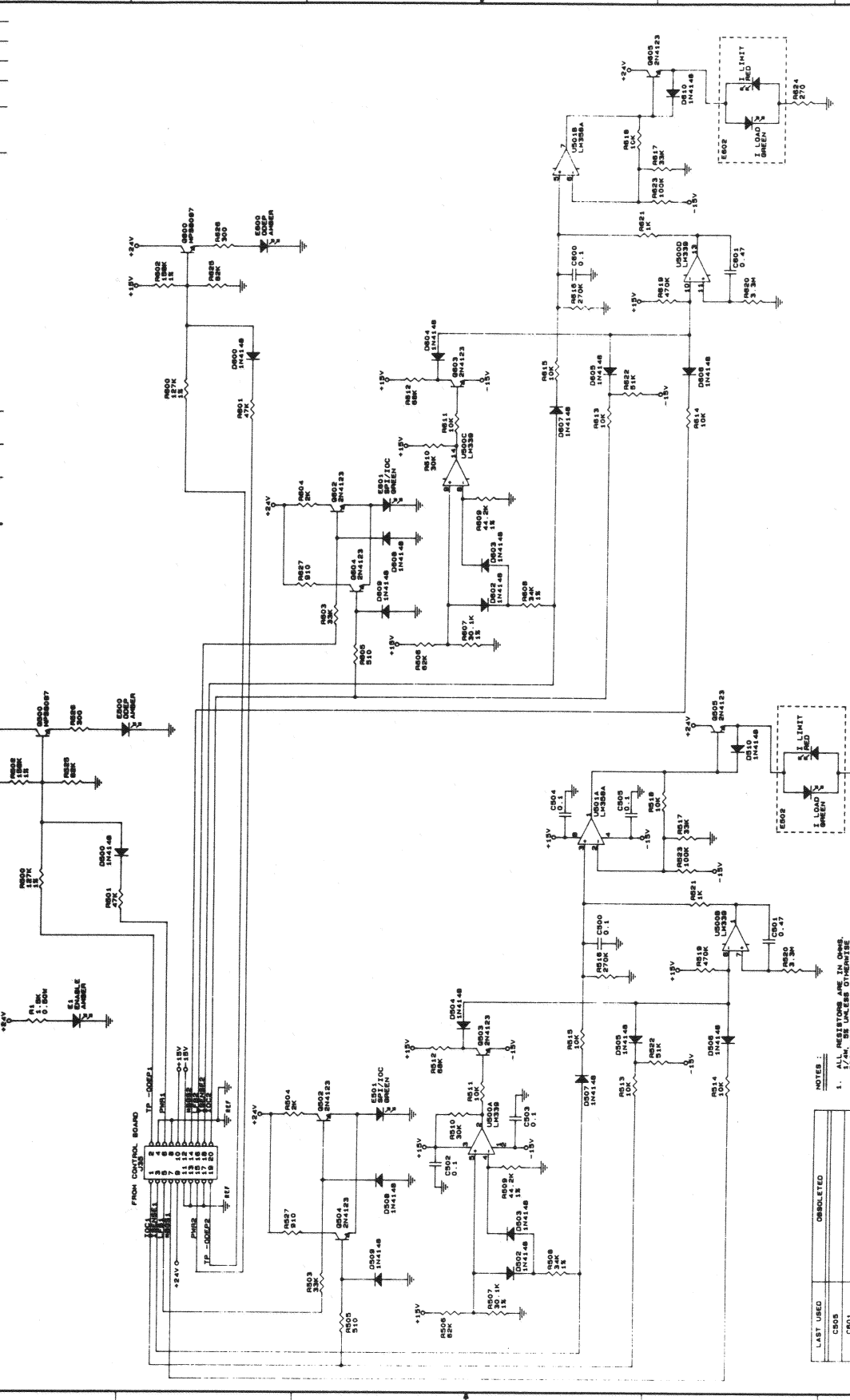
Ph. (219) 294-8210
or (219) 294-8211
Toll Free: (800) 342-6939
Fax: (219) 294-8301

6 Schematics

- J 0489-5 Main Module Rev B
- J 0488-7 Output Modules Rev C
- J 0491-1 Display Module Rev A
- J 0490-3 Control Module
- J 0490-3 Control Module Rev C
- J 0487-9 Terminator (Current Sense Module)
- J 0492-9 P.I.P.-FXQ

Note: Interconnections are mapped on the individual schematics.

C.P.N. J0491-1 REV. 0		DESCRIPTION		DATE		BY	
CROWN INTERNATIONAL, INC.		CROWN INTERNATIONAL, INC.		8/31/82		TLM	
1718 WEST HISHAMATA ROAD		ELKHART, IN. 46517		PHONE (219) 294-8000			



CROWN INTERNATIONAL, INC.
 1718 WEST HISHAMATA ROAD ELKHART, IN. 46517 PHONE (219) 294-8000

SCHEMATIC: MA-5000VZ DISPLAY

PRINTS TO	0
DRAWN	TLM
CHECKED	ME
SCALE	NONE
PROJ. #	DD47
REV	0

APPROVED BY:	DO NOT SCALE PRINT
DATE	8/10/82
SCALE	E.C.N.
PROJ. #	DD47
REV	0

REV	0
DATE	8/10/82
SCALE	E.C.N.
PROJ. #	DD47
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PROJ. #	DD47
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PROJ. #	DD47
REV	0

REV	0
DATE	8/10/82
SCALE	E.C.N.
PROJ. #	DD47
REV	0

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- NOTES:
1. ALL RESISTORS ARE IN OHMS UNLESS OTHERWISE SPECIFIED.
 2. ALL CAPACITORS ARE IN MICROFARADS UNLESS OTHERWISE SPECIFIED.
 3. (H) DENOTES A NOT STATEMENT.
 4. PCB C.P.N. D7848-7 (REV. A)
 5. MODULE DOC. C.P.N. 04282-2 (REV. B)



7 EXPLODED VIEW DRAWINGS

The **Exploded Views** section of this service manual is the compilation of drawings of the chassis parts and components found within the Macro-Tech 5000VZ amplifier. For schematic drawings see section 6 and for circuit board layouts along with parts lists see **Modules**, section 8.

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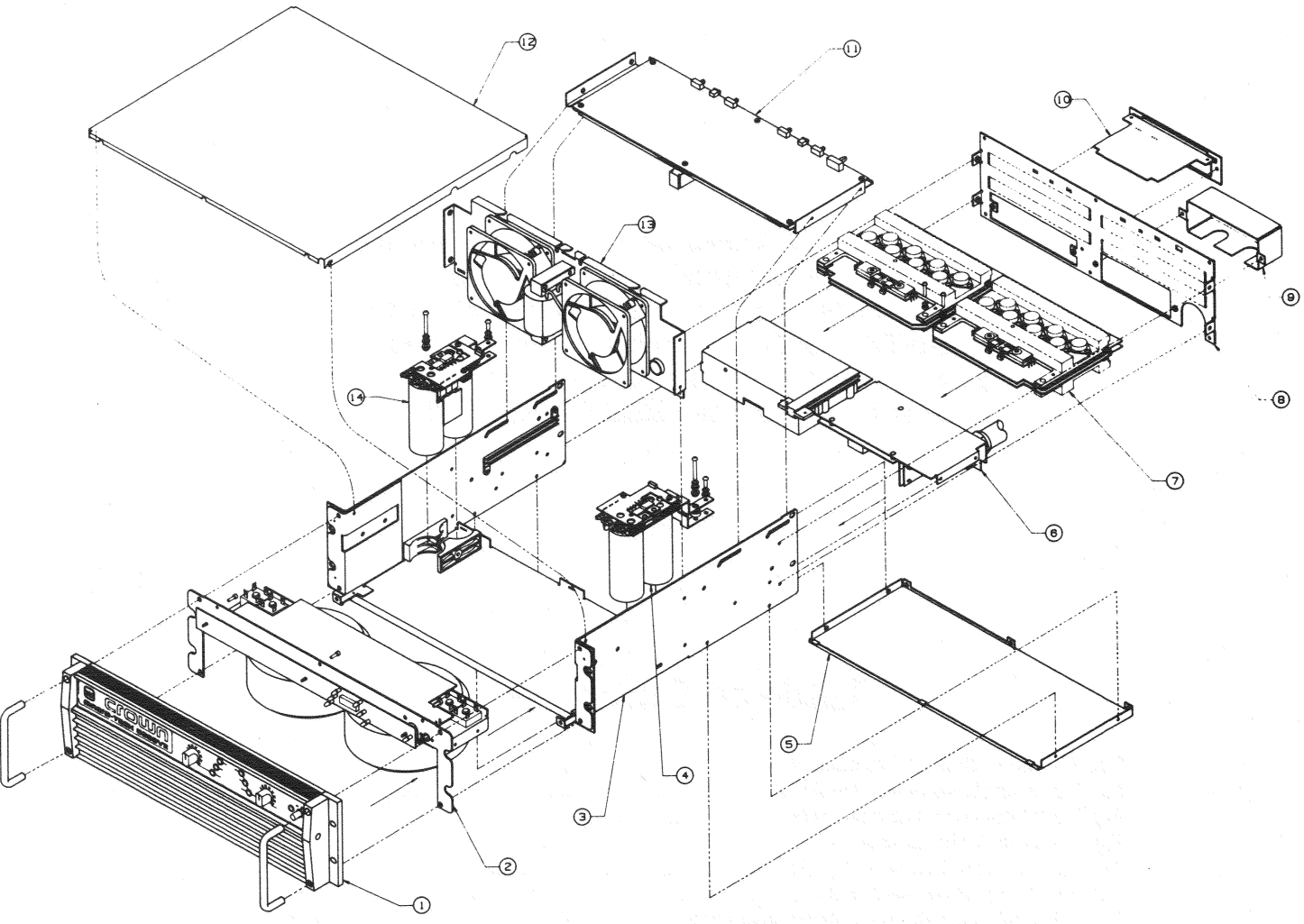


Fig. 7.1 Main Chassis Exploded View

MAIN CHASSIS ASSEMBLY

ITEM#	QTY	PART #	DESCRIPTION	NOTES
1	1	---	Front Panel Assembly	See Page 4
2	1	---	Transformer Assembly	See Page 11
3	1	M21193J3	Chassis	
4	1	---	Ch 1 Capacitor Assembly	See Page 13
5	1	F12174J2	Bottom Cover	
6	1	---	Terminator Assembly	See Page 17
7	1	---	Output Assembly	See Page 21
8	1	---	Back Panel	See Page 17
9	1	F12302J9	Output Cover	
10	1	M45059-9	P.I.P.-FXQ	
11	1	---	Main Board Tray Assembly	See Page 20
12	1	F12176J7	Top Cover	
13	1	---	Chassis Divider Assembly	See Page 10
14	1	---	Ch 2 Capacitor Assembly	See Page 15

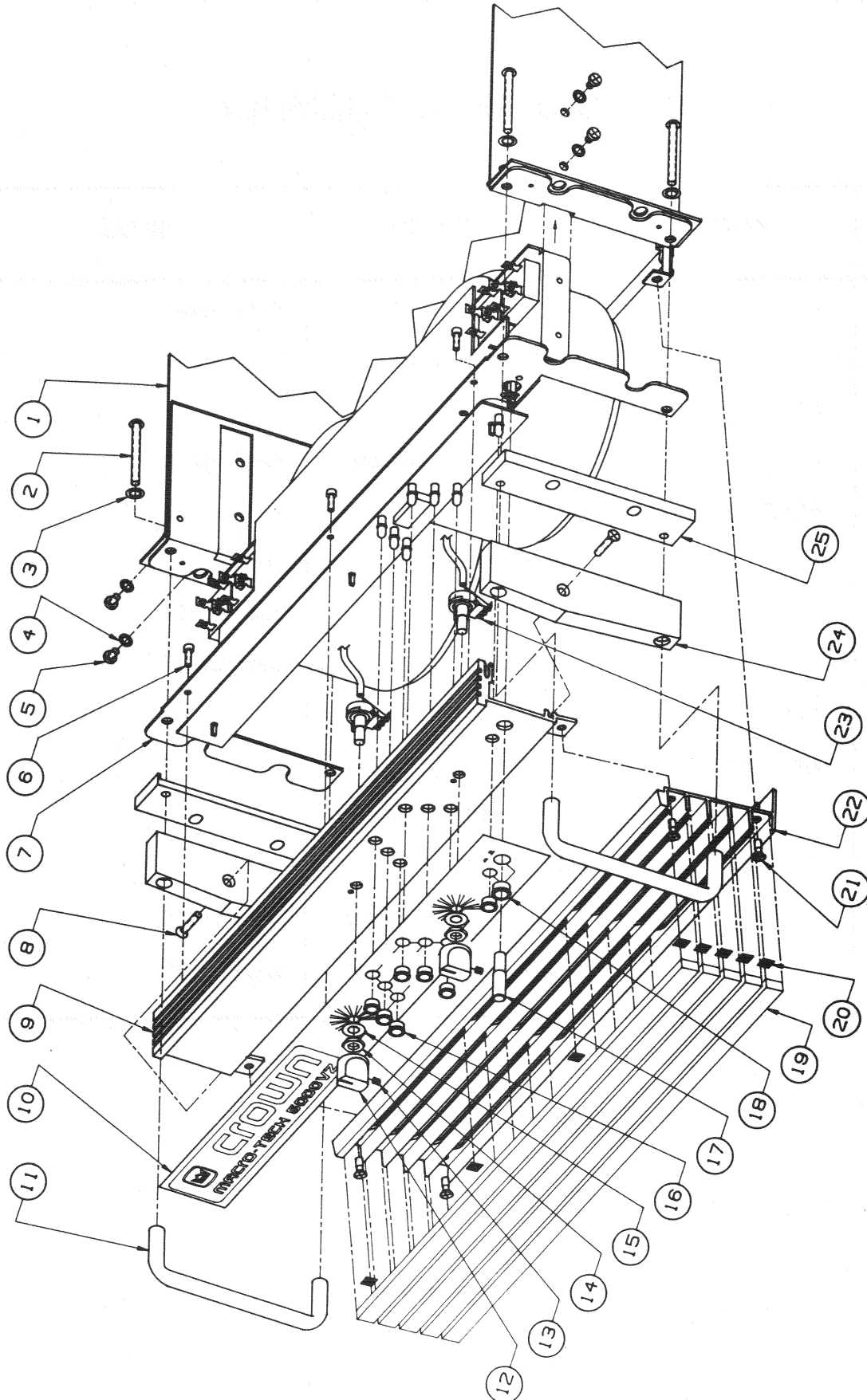


Fig. 7.2 Front Chassis Assembly

FRONT CHASSIS ASSEMBLY

ITEM#	QTY	PART #	DESCRIPTION	NOTES
1	1	M21193J3	Chassis	
2	4	A10089-11032	Screw	
3	4	A10094-8	Washer	
4	4	A10094-5	Washer	
5	4	C 8874-7	Screw	
6	3	A10094-5	Screw	
7	1	---	Transformer Bracket	See Transformer Assembly, Page 11
8	2	A10091-10812	Screw	
9	1	D 8066J0	Front Panel	Silver color
10	1	F12163J5	MA-5000VZ Lexan Overlay	Crown
	1	F12164J3	MA-5000VZ Lexan Overlay	Amcron
11	2	F12159J3	Handle	
12	2	D 6265-9	Knob	
13	2	C 6005-0	Lockscrew	
14	2	---	Nut	Part of item 23
15	2	---	Washer	Part of item 23
16	7	D 7937-2	LED Collar	
17	1	D 7872-1	Pushbutton	
18	1	D 4108-3	Pushbutton Collar	
19	5	D 7696-4	Foam	
20	20	B 5796-6	Velcro .5" x .25"	
21	4	C 7965-4	Screw	
22	1	F12161J9	Grille Extrusion	
23	2	C 7280-8	5K ohm Level Pots	Includes hardware items 14 and 15
24	2	F12160J1	Panel Cap	
25	2	F12296J3	End Cap	

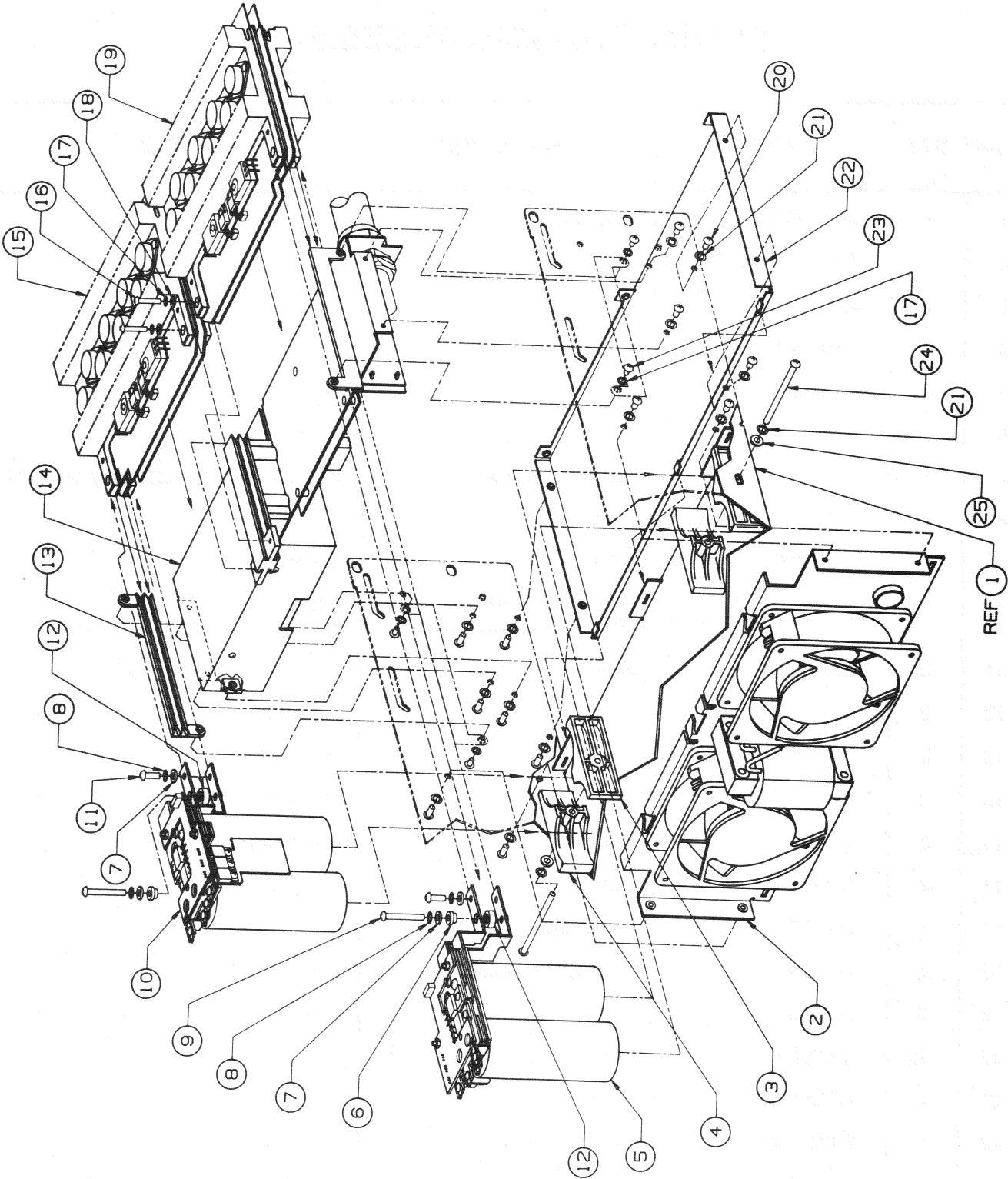


Fig. 7.3 Middle Chassis Assembly

MIDDLE CHASSIS ASSEMBLY

ITEM#	QTY	PART #	DESCRIPTION	NOTES
1	1	M21193J3	Chassis	
2	1	---	Divider Assembly	See Pg 10
3	2	D 7927-3	Capacitor Holder, Inner	
4	2	D 7928-1	Capacitor Holder, Outer	
5	1	M45110-0	Ch 2 Bi-Level Switch Assby	See Pg 15
6	2	D 7870-5	Valox Washer	
7	6	A10100-10	Flat Washer	
8	6	A10094-6	Lock Washer	
9	2	A10089-70820	Screw	
10	1	M45109-2	Ch 1 Bi-Level Switch Assby	See Pg 13
11	2	A10089-10808	Screw	
12	4	D 7871-3	Valox Spacer	
13	2	D 7818-4	Output Slide Guide	
14	1	---	PIP Terminator Assembly	See Pg 17
15	1	---	Ch 1 Output Assembly	See Pg 21
16	2	A10089-10612	Screw	
17	2	A10094-4	Lock Washer	
18	2	A10100-4	Flat Washer	
19	1	---	Ch 2 Output Assembly	See Pg 21
20	13	C 8874-7	Screw	
21	15	A10094-5	Lock Washer (Black)	
22	15	F12174J2	Bottom Cover	
23	4	A10109-70604	Screw	
24	2	A10089-70844	Screw	
25	2	A10100-12	Flat Washer	

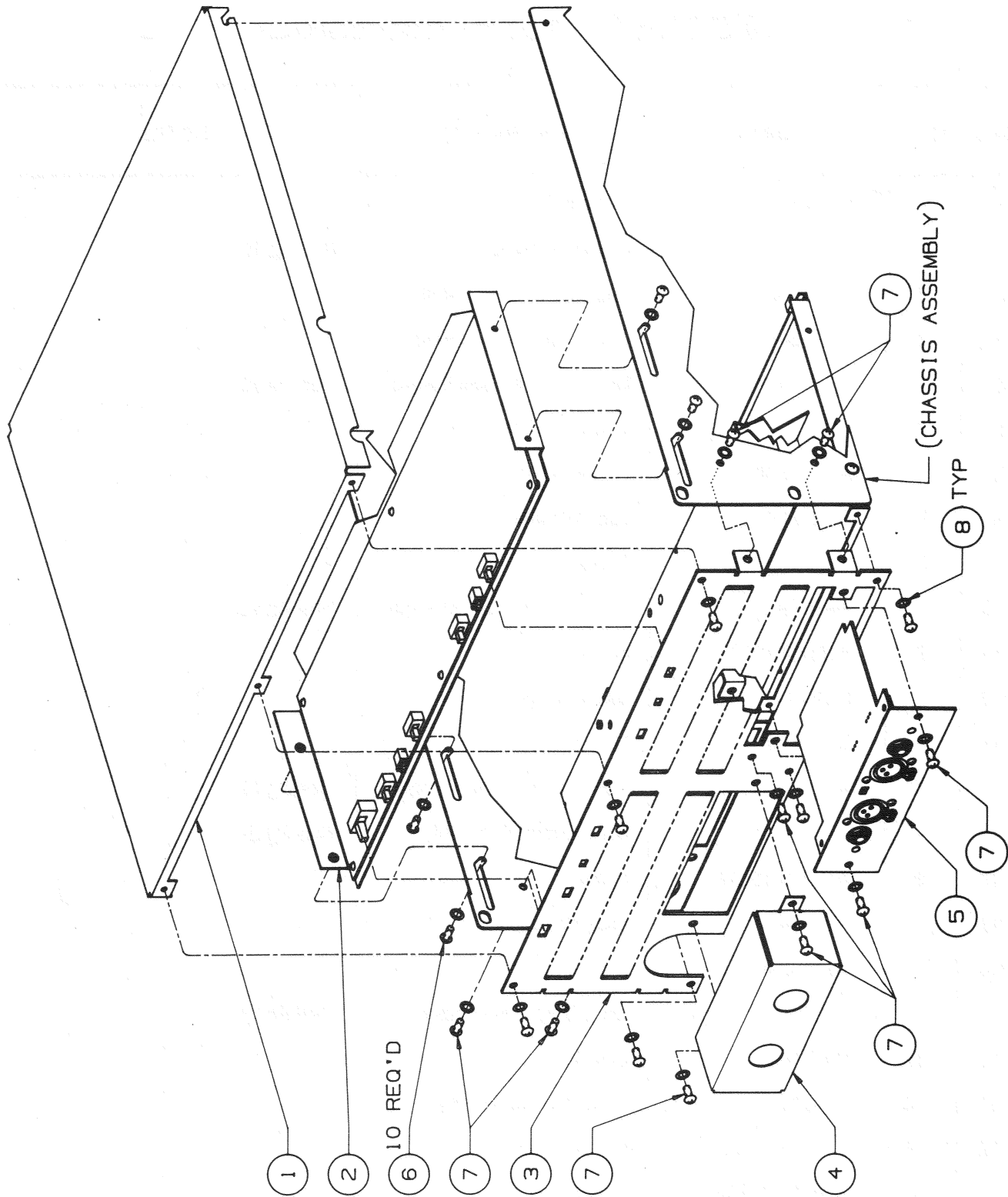


Fig. 7.4 Rear Chassis Assembly

REAR CHASSIS ASSEMBLY

ITEM#	QTY	PART #	DESCRIPTION	NOTES
1	1	F12176J7	Top Cover	
2	-	---	Main Board Tray Assembly	See Pg 20
3	1	M21192J5	Back Panel	
4	1	F12302J9	Box Shield	Output post protective cover
5	1	M45059-9	P.I.P.-FXQ	
6	4	C 8874-7	Screw	
7	13	A10089-70806	Screw	
8	17	A10094-5	Lock Washer	

CHASSIS DIVIDER (FAN) ASSEMBLY

ITEM#	QTY	PART #	DESCRIPTION	NOTES
1	1	F12175J9	Divider Plate	
2	2	C 7858-1	Fan	
3	1	D 7883-8	XFMR	Low Voltage Transformer
4	1	C 9069-3	Bushing, Universal 0.875	
5	8	A10110-10808	8-32x.5 Screw	Phillips, pan-head, tri-lobe

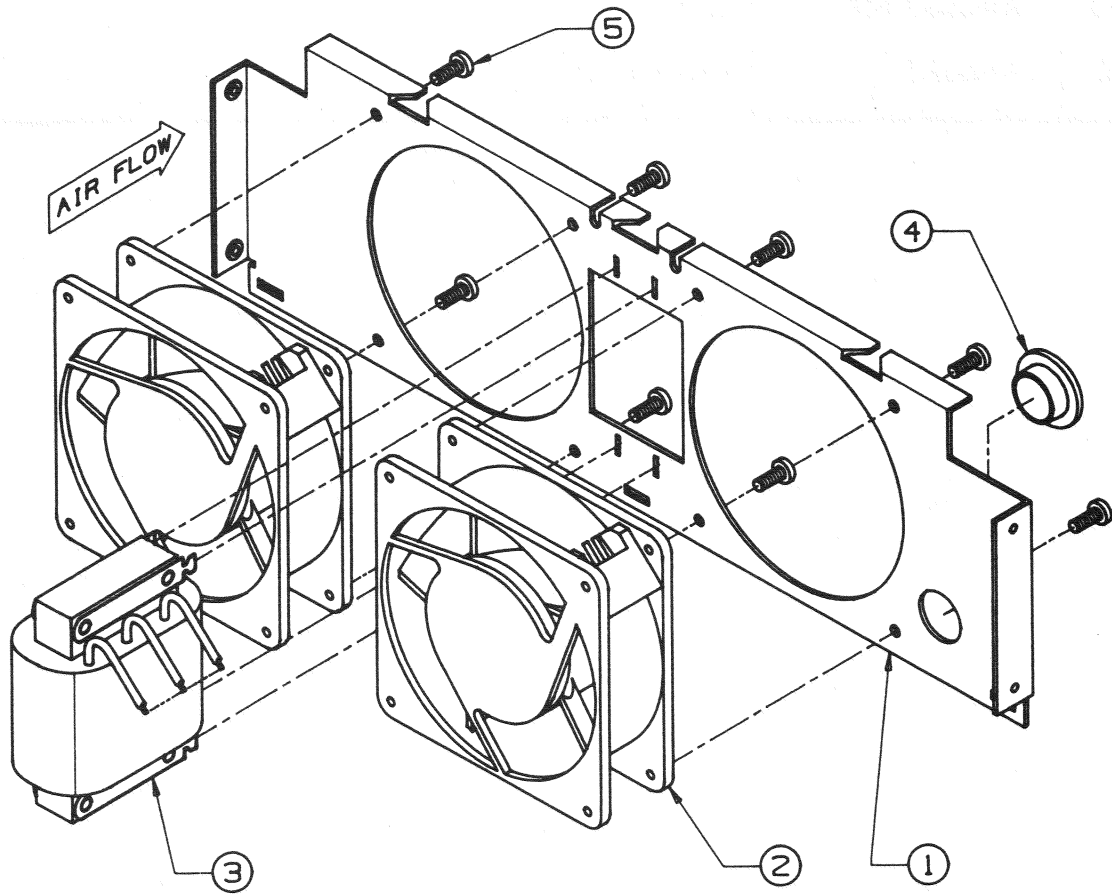


Fig. 7.5 Chassis Divider (Fan) Assembly

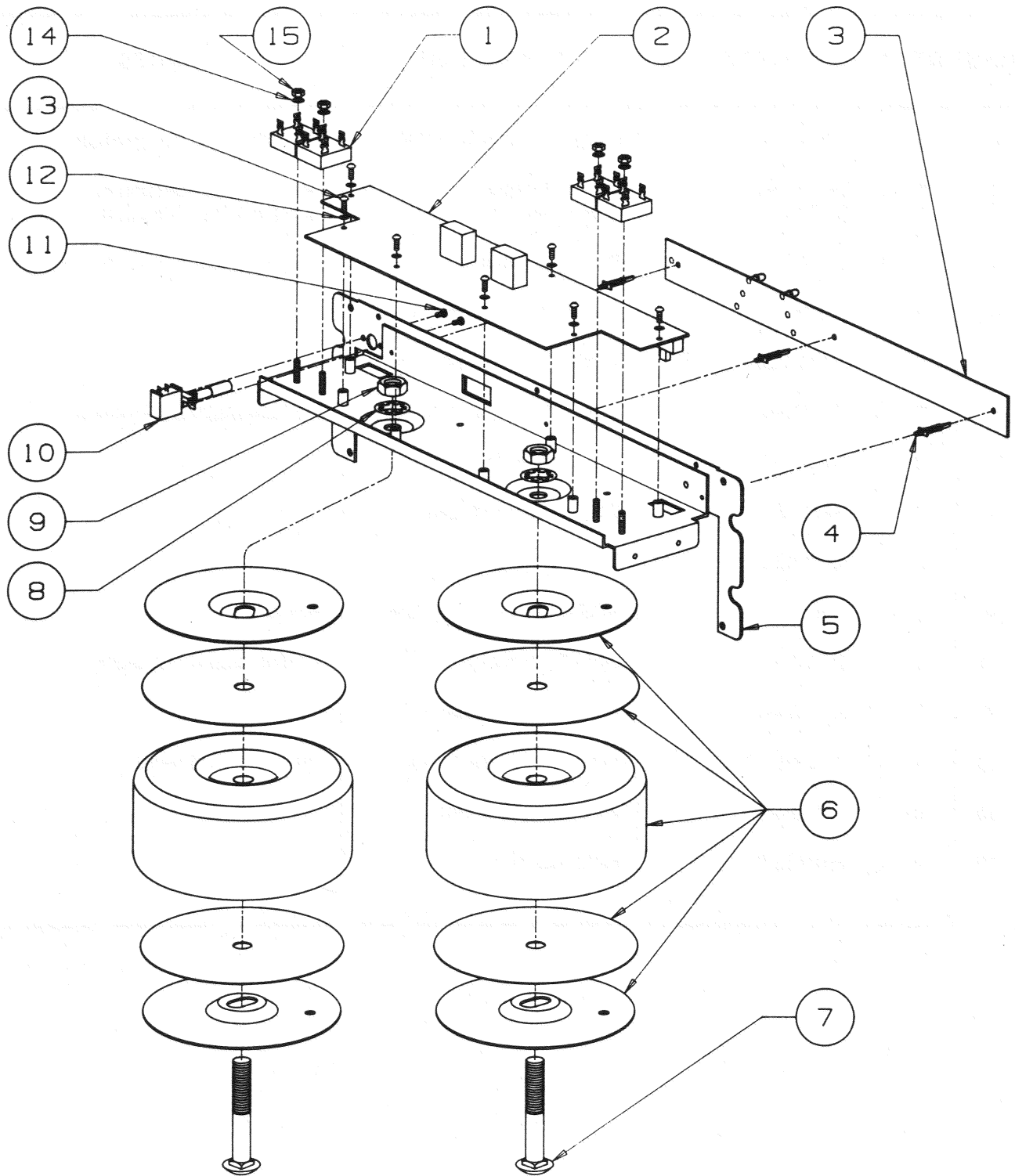


Fig. 7.6 Transformer Assembly

TRANSFORMER ASSEMBLY

ITEM#	QTY	PART #	DESCRIPTION	NOTES
1	4	C 8962-0	Bridge Rectifier 35A 200V	No Schematic Designations
2	1	Q42930-0	Control Module	See Modules, Section 8.
	1	Q43096-9	Control Module	See Modules, Section 8.
3	1	Q42929-2	Display Module	See Modules, Section 8.
4	3	C 8852-3	0.5" PC Board Support	
5	1	M41063J8	XFMR/Sub-front Bracket	
6	2	D 7775-6	Main Power Toroid XFMR	No Schematic Designations
7	2	C 8919-0	0.5" Steel Bolt	
8	2	A10095-7	0.5" Ext. Lockwasher	
9	2	A10102-21	0.5" Hex Nut	
10	1	C 8810-1	SPST Pushbutton Switch	Power Switch
11	2	D 7261-7	3x.5x7mm Screw	Phillips, pan-head, black
12	7	A10094-4	#6 Int. Star Washer	
13	7	A10086-10608	6-32x.5 Machine Screw	Phillips, round-head
14	4	A10094-6	#8 Int. Star Washer	
15	4	A10102-6	8x32 Hex Nut	

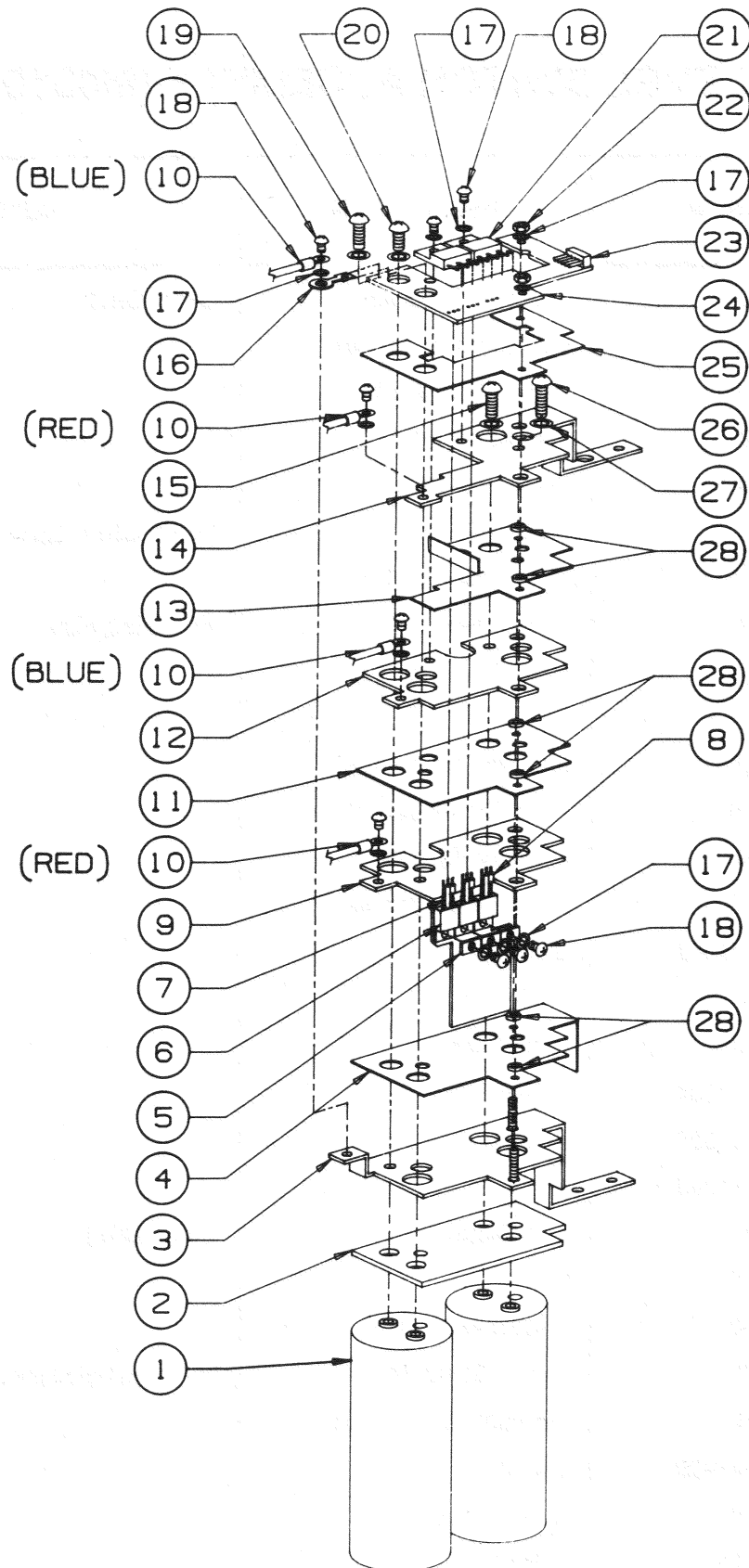


Fig. 7.7 Channel 1 Bi-Level Switch Assembly

CH 1 BI-LEVEL SWITCH ASSEMBLY (M45109-2)

ITEM#	QTY	PART #	DESCRIPTION	NOTES
1	2	D 7882-0	15000 μ F Capacitor	C810, C812
2	1	P10357-5	Insulator: Ch 1 & 2 #1	
3	1	M21070-4	Plate: Ch 1 -Vcc #1	
4	1	D 7821-8	Insulator: Ch 1 #2	
5	3	C 6541-4	Torque Spreader	
6	3	C 8516-4	MOSFETs	Q810, Q811, Q812
7	3	H43224-7	Lead Insulation Tube	
8	3	C 8341-7	Ferrite Bead	FB1, FB2, FB3
9	1	M21071-2	Plate: Ch 1 FET #2	
10	-	---	Wires	
11	1	D 7825-9	Insulator: Ch 1 & 2 #3	
12	1	M21072-0	Plate: Ch 1 Diode #3	
13	1	D 7822-6	Insulator: Ch 1 #4	
14	1	M21073-8	Plate: Ch 1 +Vcc #4	
15	1	A10086-11008	Screw	
16	1	D 2934-4	Solder Lug	
17	11	A10094-4	Lock Washer	
18	9	A10086-10604	Screw	
19	1	A10086-11006	Screw	
20	1	A10086-11005	Screw	
21	2	C 8855-6	Dual Diode	D810, D811
22	2	A10102-5	Hex Nut	
23	1	H43171-0	Header (with wires)	
24	1	D 7843-2	Switch Board Ch 1	(Ch 1 half of blank part D 7843-2)
25	1	D 7880-4	Insulator: Ch 1 & 2 #5	
26	1	A10086-11009	Screw	
27	4	A10094-8	Lock Washer	
28	8	A10101-26	Nylon Washer	

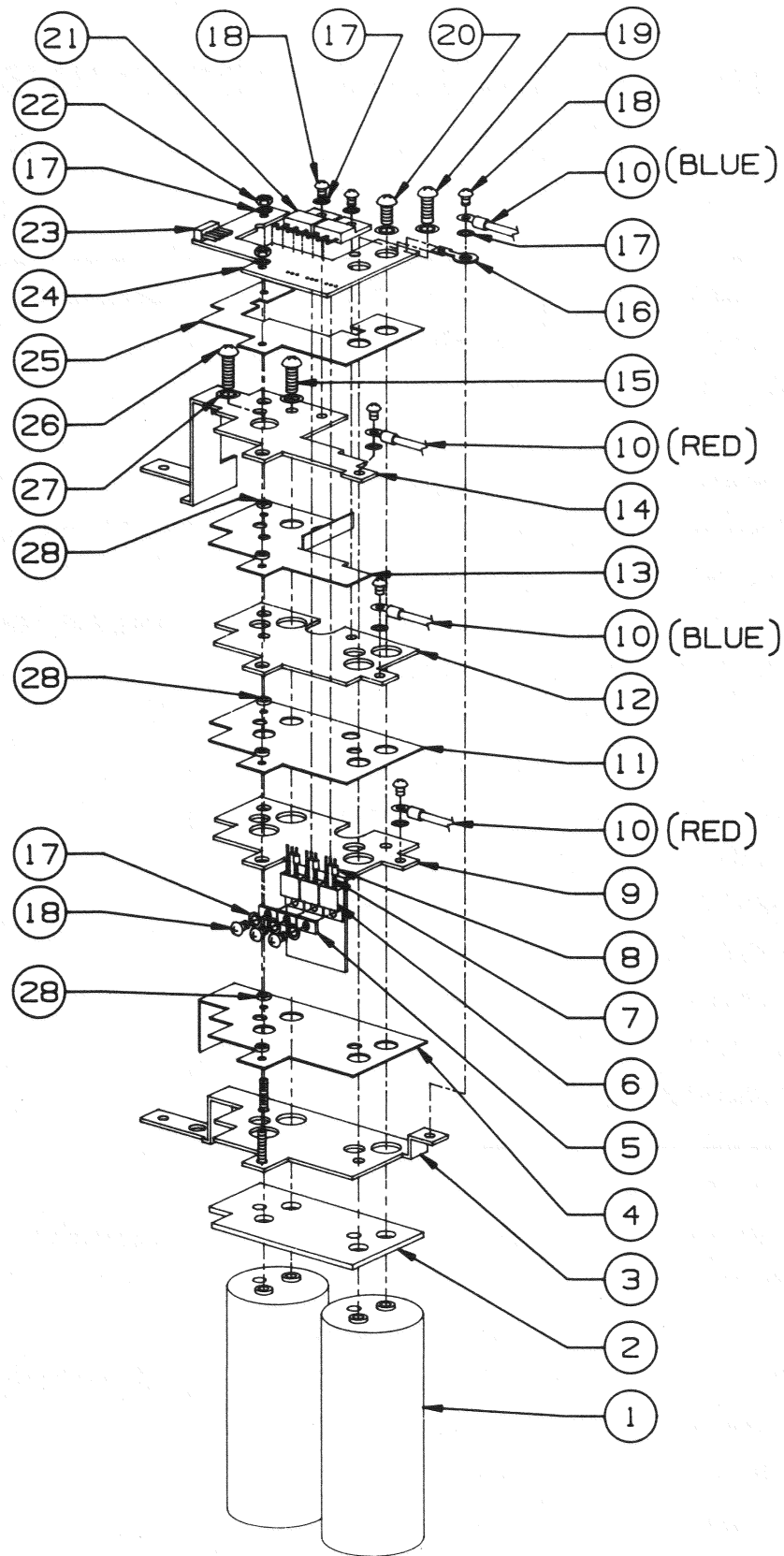


Fig. 7.8 Channel 2 Bi-Level Switch Assembly

CH 2 BI-LEVEL SWITCH ASSEMBLY (M45110-0)

ITEM#	QTY	PART #	DESCRIPTION	NOTES
1	2	D 7882-0	15000 μ F Capacitor	C800, C802
2	1	P10357-5	Insulator: Ch 1 & 2 #1	
3	1	M21074-6	Plate: Ch 2 -Vcc #1	
4	1	D 7824-2	Insulator: Ch 2 #2	
5	3	C 6541-4	Torque Spreader	
6	3	C 8516-4	MOSFETs	Q800, Q801, Q802
7	3	H43224-7	Lead Insulation Tube	
8	3	C 8341-7	Ferrite Bead	FB4, FB5, FB6
9	1	M21075-3	Plate: Ch 2 FET #2	
10	-	---	Wires	
11	1	D 7825-9	Insulator: Ch 1 & 2 #3	
12	1	M21076-0	Plate: Ch 2 Diode #3	
13	1	D 7820-0	Insulator: Ch 2 #4	
14	1	M21077-9	Plate: Ch 2 +Vcc #4	
15	1	A10086-11008	Screw	
16	1	D 2934-4	Solder Lug	
17	11	A10094-4	Lock Washer	
18	9	A10086-10604	Screw	
19	1	A10086-11006	Screw	
20	1	A10086-11005	Screw	
21	2	C 8855-6	Dual Diode	D800, D801
22	2	A10102-5	Hex Nut	
23	1	H43171-0	Header (with wires)	
24	1	D 7843-2	Switch Board Ch 2	(Ch 2 half of blank part D 7843-2)
25	1	D 7880-4	Insulator: Ch 1 & 2 #5	
26	1	A10086-11009	Screw	
27	4	A10094-8	Lock Washer	
28	8	A10101-26	Nylon Washer	

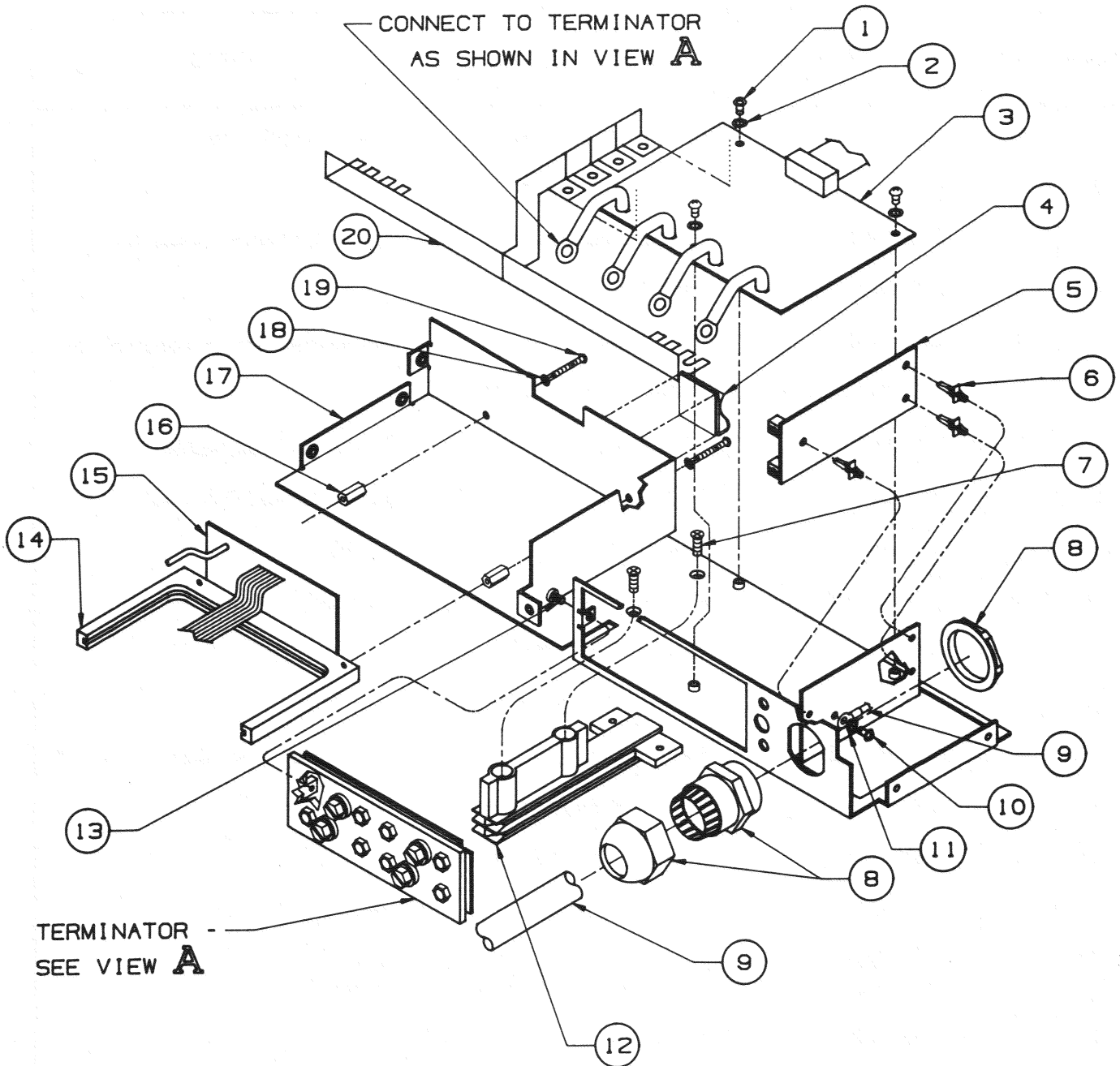


Fig. 7.9 P.I.P. Terminator Shelf Assembly

P.I.P. TERMINATOR SHELF ASSEMBLY

ITEM#	QTY	PART #	DESCRIPTION	NOTES
1	3	A10086-10604	6-32-.25 Machine Screw	Phillips, round-head
2	3	A10094-4	#6 Int. Star Washer	
3	1	Q42932-6	Current Sense Module	Terminator Portion of Item #5
4	1	C 7705-4	Cable Clamp	
5	1	Q42932-6	Current Sense Module	Current Sense Portion of Q42932-6
6	3	C 8823-4	0.125" PC Board Support	
7	2	D 5903-6	8-32x.5 Screw	Phillips, flat-head, taptite
8	1	F11160-3	Strain Relief	For Power Cord D 7890-3
9	1	D 7890-3	Power Cord	30A 10/3
10	1	A10111-10806	#8x.375 Sheetmetal Screw	Pan-head
11	1	A10095-2	#8 Int. Star Washer	
12	1	D 7817-6	Center Output Slide Guide	
13	1	A10109-7064	6-20x.25 Screw	Phillips, pan-head, black
14	1	C 6821-0	22 Pin PIP Edge Connector	
15	1	Q43052-2	PIP Interconnect Board	
16	2	A10100-7	Spacer, Aluminum	.250Dx.141Dx.312L
17	1	M21189J1	Terminator/PIP Shelf Bracket	Crown Only
	1	M21190J9	Terminator/PIP Shelf Bracket	Amcron Only
18	2	A10094-2	#4 Int. Star Washer	
19	2	A10086-10410	4-40x.62 Machine Screw	Phillips, round-head
20	1	D 7826-7	Output Flex Bar Ch 1	
	1	D 7827-5	Output Flex Bar Ch 2	
*	2	C 8884-6	Red Binding Post (w/ hdwr)	*Amcron Only - Not Shown
*	2	C 8885-2	Black Binding Post (w/ hdwr)	*Amcron Only - Not Shown

P.I.P. TERMINATOR SHELF ASSEMBLY, VIEW "A" (CROWN ONLY)

ITEM#	QTY	PART #	DESCRIPTION	NOTES
1	16	C 8835-8	.25-32 Nut	
2	12	A10094-9	Lockwasher	
3	4	M21078-7	Terminator Bar	
4	4	D 7924-0	Bushing, Steel	
5	1	D 7816-8	Terminator Panel	
6	8	C 8794-7	Un-insulated Banana Jack	
7	4	C 8900-0	.25-20x1 Machine Screw	Output, slot hex-washer head

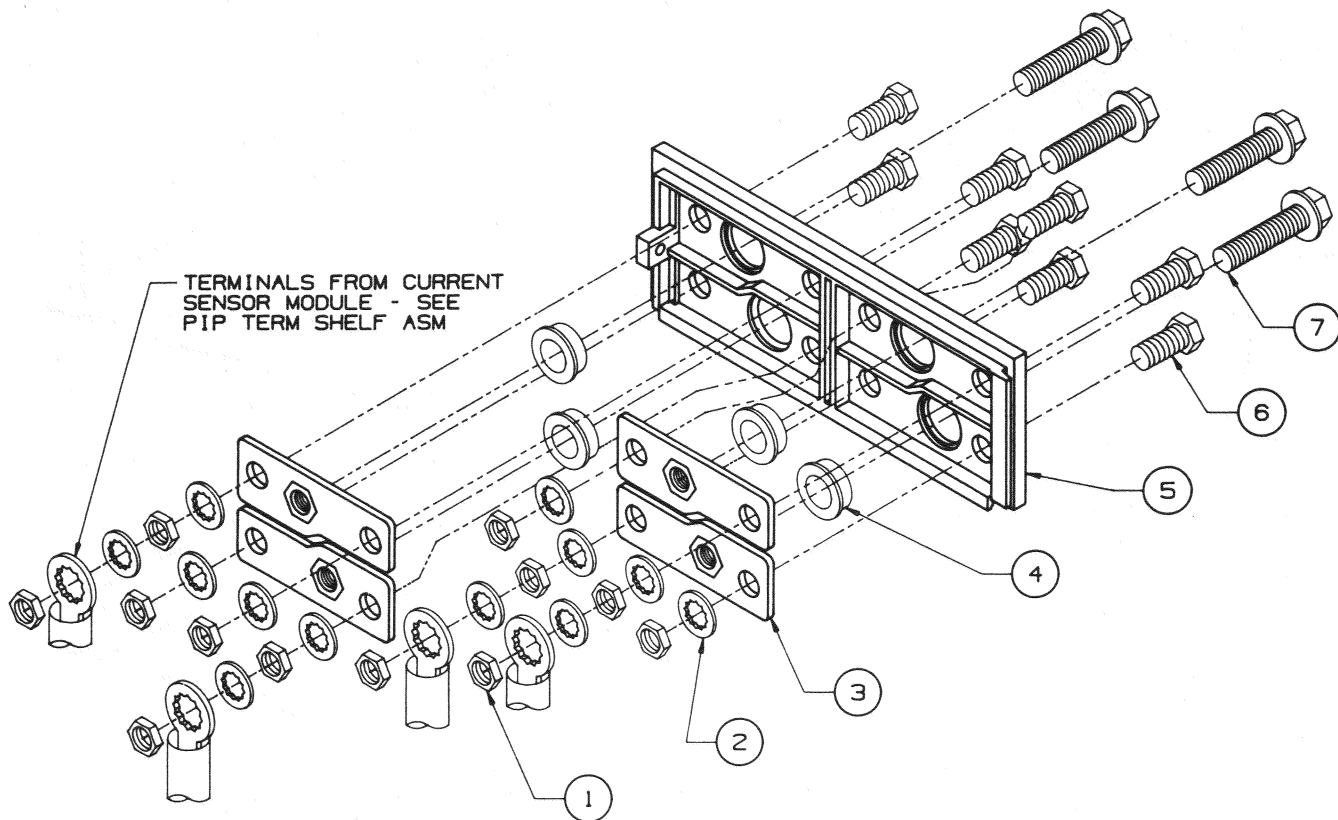


Fig. 7.10 PIP Terminator Shelf Assembly, View "A"

MAIN BOARD TRAY ASSEMBLY

ITEM#	QTY	PART #	DESCRIPTION	NOTES
1	1	M21201J4	Main Board Tray	
2	1	Q42928-4	Main Module	See Modules, Section 8.
	1	Q43095-1	Main Module #2	See Modules, Section 8.
3	6	A10094-4	#6 Int. Star Washer	
4	6	A10086-10604	6-32x.25 Machine Screw	Phillips, round-head

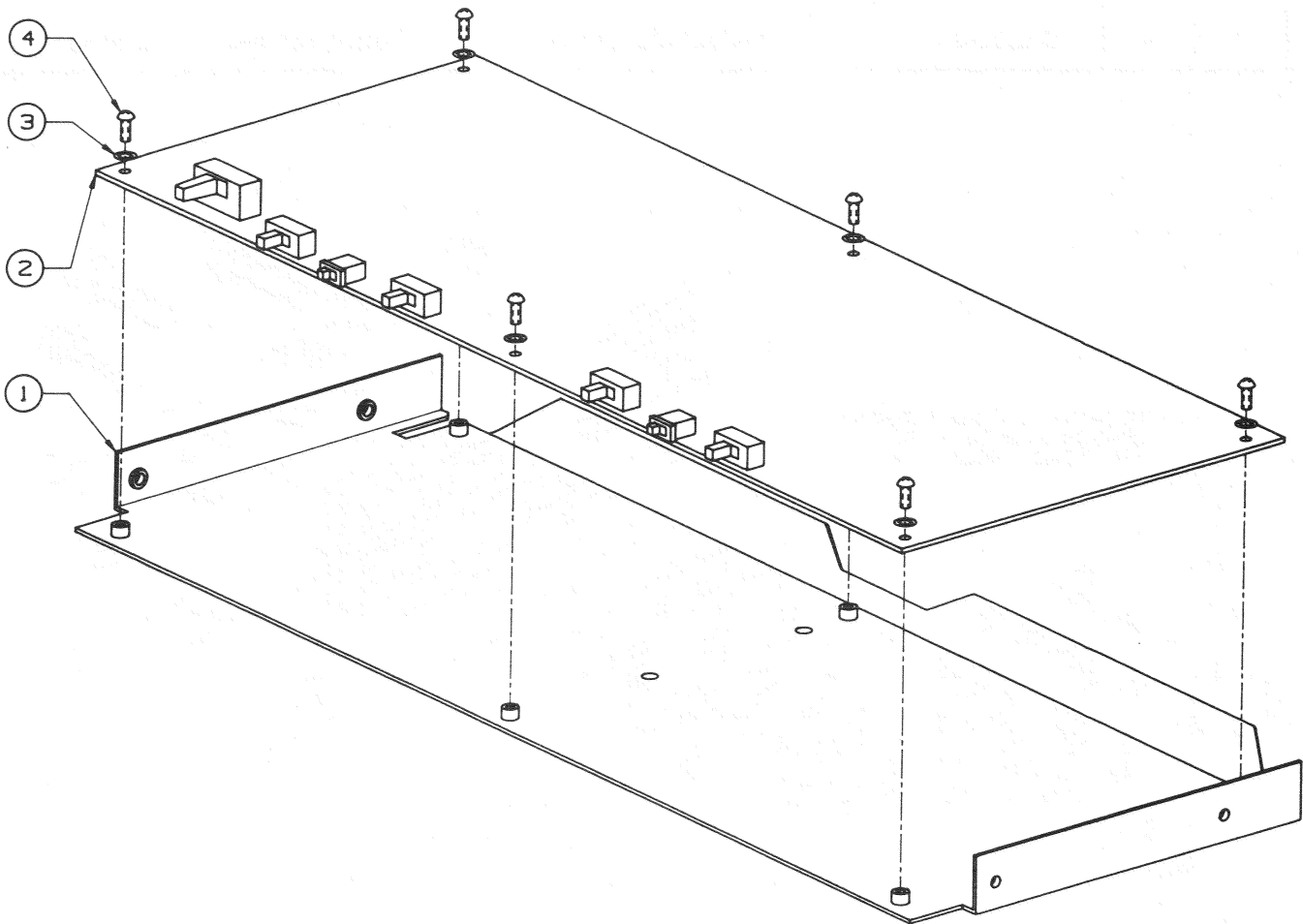


Fig. 7.11 Main Module Tray Assembly