MACRO-TECH 5000VZ

OVERVIEW

At first glance the MA-5000VZ looks a great deal like any other MA Series amplifier, except that it is physically larger and puts out more power. The internal structure of the MA-5000VZ is, however, quite different from other models in the MA line. To the user, this one is like the others, but with a few more features. To the technician, this amplifier represents a radical departure from the "normal" Crown design. Previous chapters covered the "normal," this chapter shall endeavor to take the MA-5000VZ as a unique entity.

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 current 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). 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 the *BASICS* section of this text.

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.

Output power of the amplifier is rated as follows (assumes 120V 60Hz AC mains):

Stereo 8 ohm: 1300W/Ch
Stereo 4 ohm: 2000W/Ch
Stereo 2 ohm: 2500W/Ch
Bridge Mono 8 ohm: 4000W
Bridge Mono 4 ohm: 5000W
Parallel Mono 2 ohm: 4000W
Parallel Mono 1 ohm: 5000W

Macro-Tech amplifiers utilize a wide bandwidth multiloop 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, the extrusion technology doesn't perform nearly as well as the thermal diffuser technology developed for Macro-Tech power amplifiers.

Our thermal diffusers are fabricated from custom cut fin stock that provides an extremely high ratio of area to volume, or area to weight. All power devices are mounted directly to massive heat spreaders that are electrically hot. Making the heat spreaders electrically hot allows

MA-5000VZ:
CHANNEL 1
SHOWN

MA-5000VZ Overall Block Diagram

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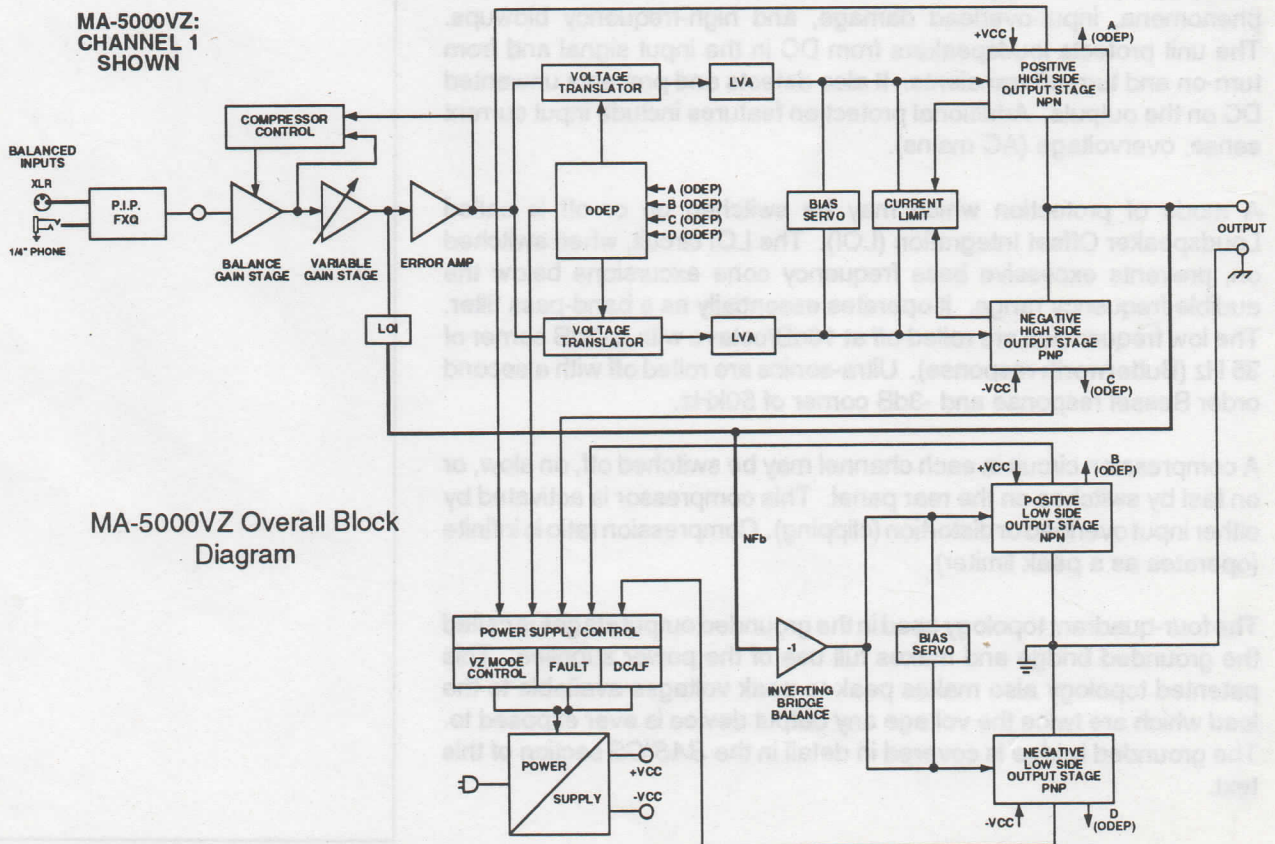
improved thermal performance by eliminating the insulating interface underneath the power devices. The chassis itself is used as part of the thermal circuit, and this maximizes utilization of the available resources.

Air flow in this amplifier is front to rear, also a departure from other Macro-Techs. Fan speed is a function of ODEP level. Although ODEP was covered in detail in the BASICS section of this text, the specifics of the MA-5000VZ ODEP circuit are unique and will be covered here.

OUTPUT STAGE CIRCUITRY

The MA-5000VZ, like other Macro-Techs, uses the grounded bridge. It does differ, however, in certain aspects. For example, quadrants use four devices in parallel rather than the normal maximum of three. Output stages are also physically built in a modular way, for ease of field replacement.

Electrically, there are also a few differences. Bias servo networks consist of two transistor devices per Vbe multiplier (one set for high side, one set for low side). Also, ODEP affects the low side as well as the high side by stealing low side bias and drive. Taking that a step further, any protective action which limits, mutes, or shuts down the amplifier will accomplish the same thing by stealing drive.

Circuitry on the positive and negative output modules include bias circuitry, current limit circuitry (the MA-5000VZ has two speed current limit), last voltage amplifiers (LVA's), pre-drivers, drivers, and output devices. Temperature sensors are also mounted to the heatsinks via the output modules. These deliver information to the main module which computes actual calibrated temperature for ODEP and temperature measurement.
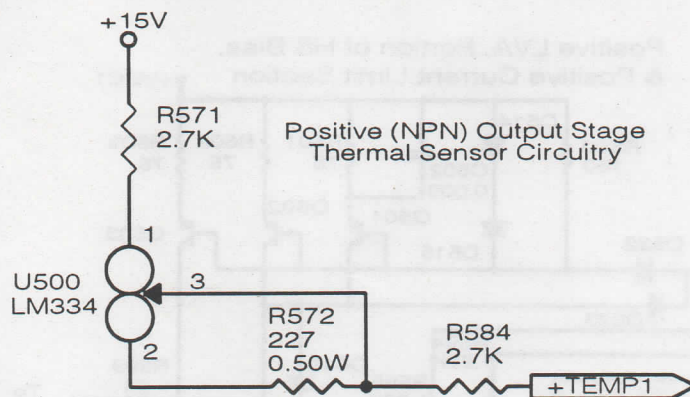
The positive LVA's (Q501, Q502, and Q503) convert the negative output of the voltage translator stage to a positive drive voltage for the NPN High Side (HS) predriver. There are three LVA transistors in parallel due to the very high voltages (therefor higher current and thermal requirements) that are 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.

Q503 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 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.

Positive LVA, Portion of HS Bias, & Positive Current Limit Section
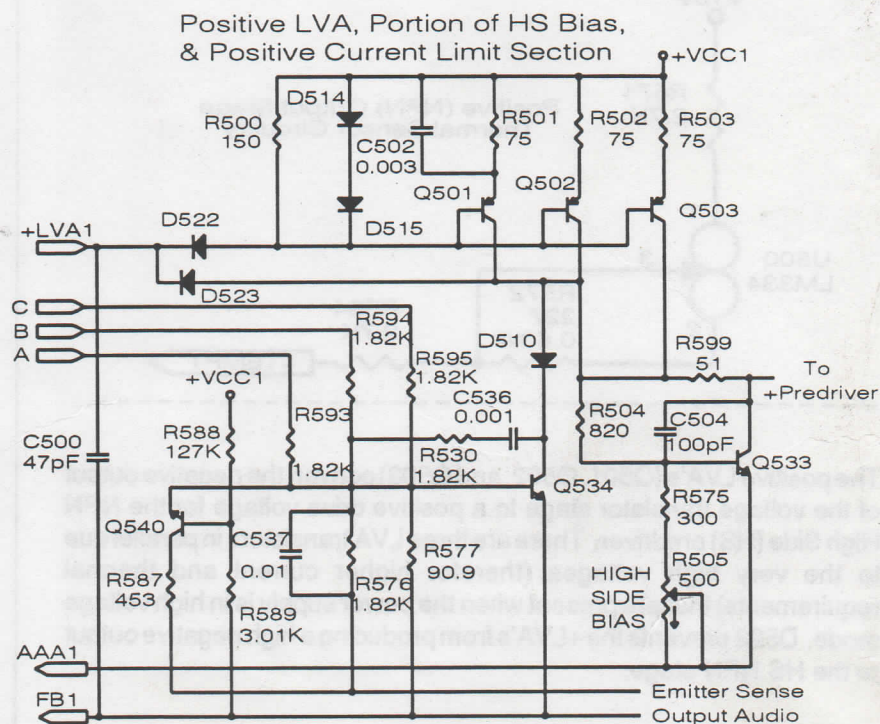
High Side +LVA's, Current Limit, and the portion of the Bias Servo Network on the Positive Output Module.

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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.
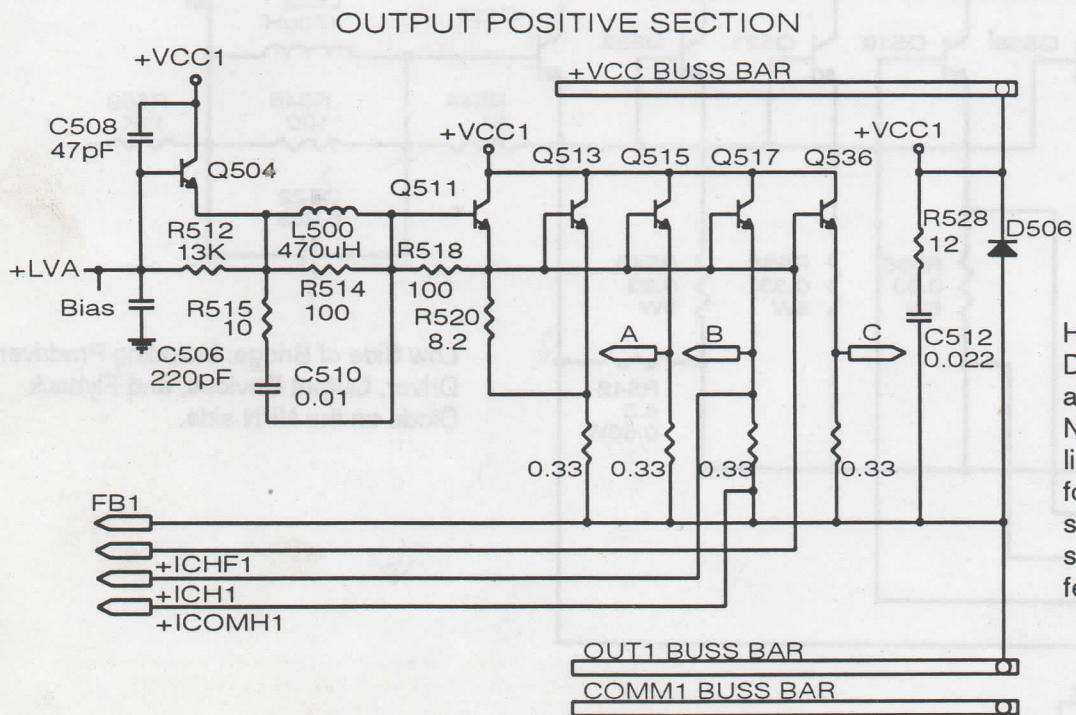
The LS senses output voltage and common (ground) buss potential. The audio output is inverted by U503. Also in the U503 input circuitry are static and dynamic balance controls. These controls provide a fine balance of the grounded bridge. Output of the op-amp drives the LS pre-driver circuits through the LS bias network.
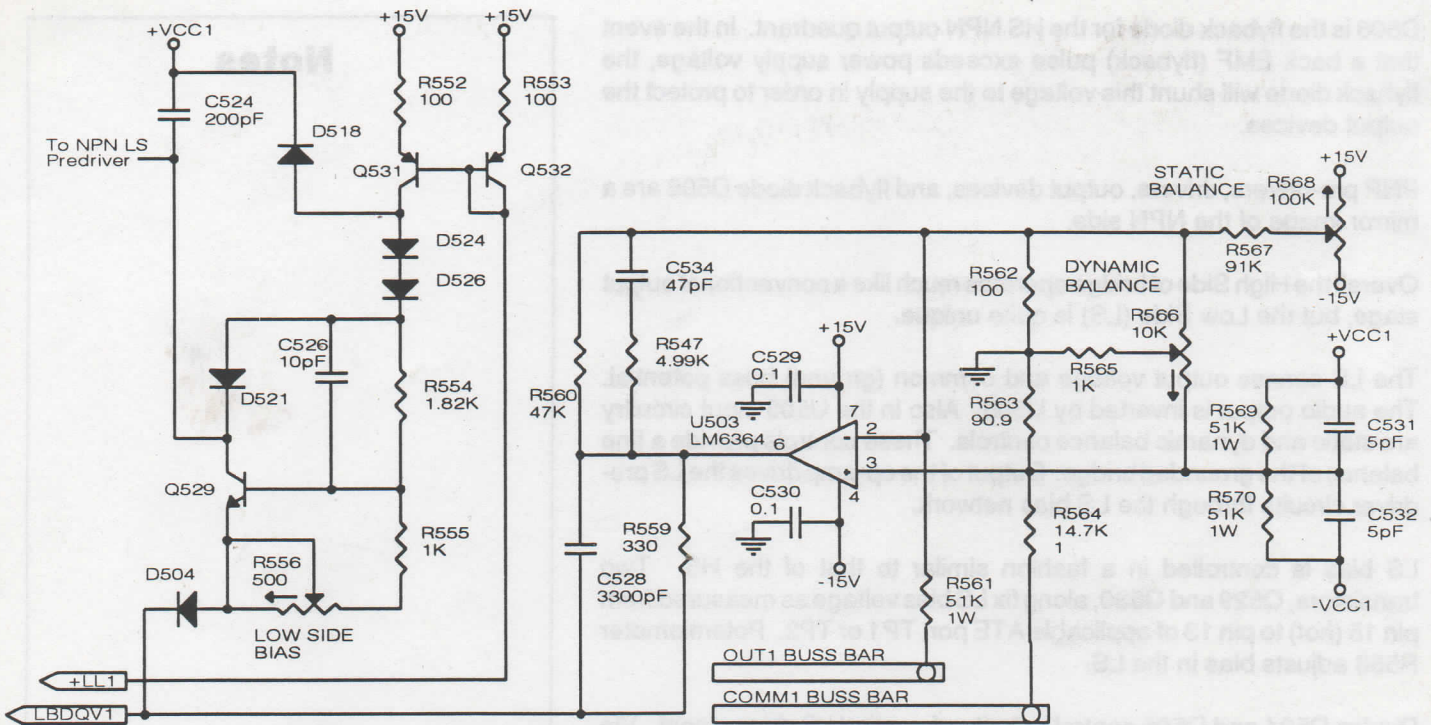
LS bias is controlled in a fashion similar to that of the HS. Two transistors, Q529 and Q530, along fix LS bias voltage as measured from pin 15 (hot) to pin 13 of applicable ATE port TP1 or TP2. Potentiometer R556 adjusts bias in the LS.

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).
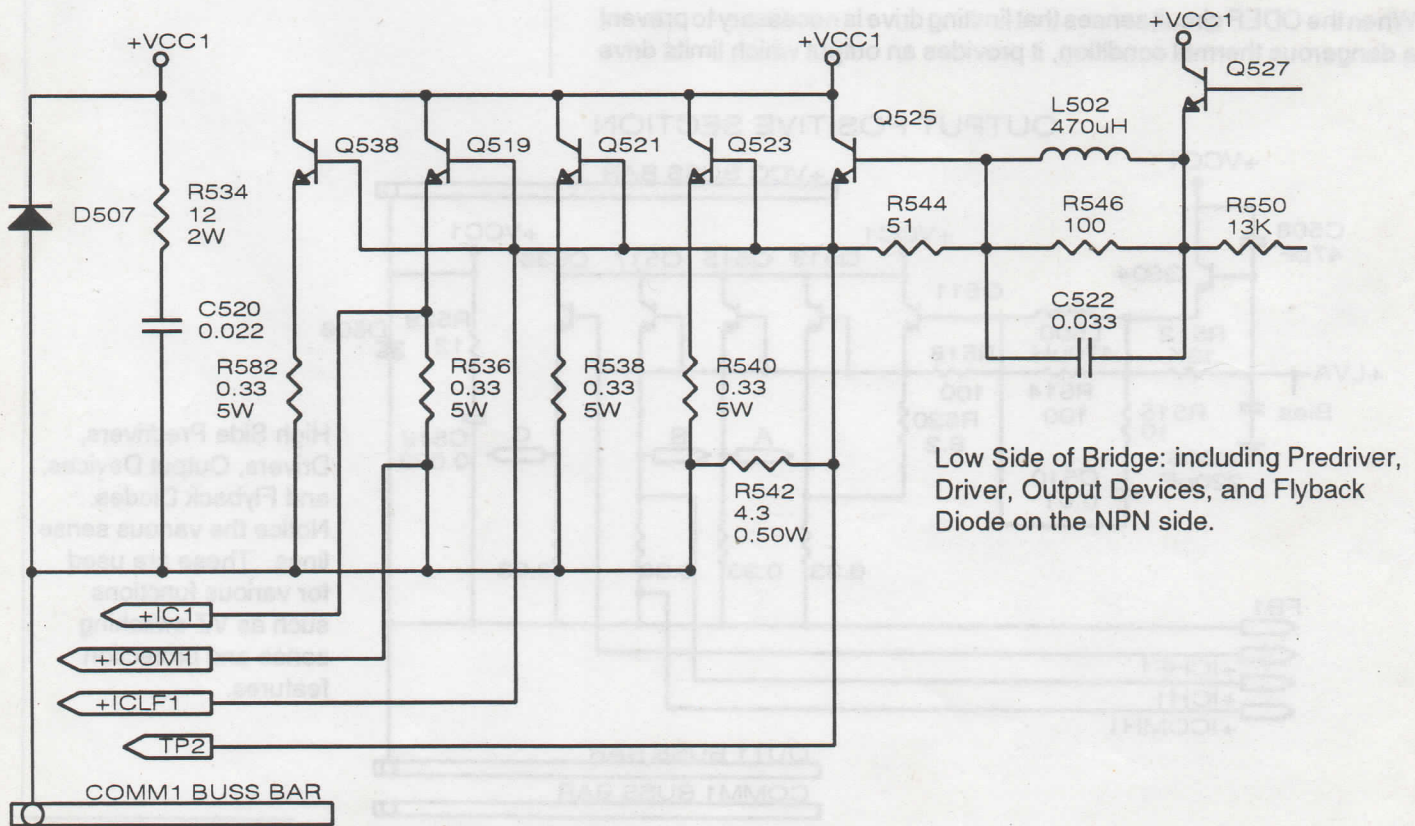
When the ODEP circuit senses that limiting drive is necessary to prevent a dangerous thermal condition, it provides an output which limits drive

OUTPUT POSITIVE SECTION

High Side Predrivers, Drivers, Output Devices, and Flyback Diodes. Notice the various sense lines. These are used for various functions such as VZ switching sense and protection features.

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+VCC1

C524
200pF

D518

To NPN LS
Predriver

+15V   +15V

R552   R553
100   100

Q531   Q532

D524

D526

C526
10pF

D521

Q529

R554
1.82K

R560
47K

R555
1K

D504

R556
500

LOW SIDE
BIAS

+LL1

LBDQV1

C534
47pF

R547
4.99K

C529
0.1

+15V

U503
LM6364

R559
330

C530
0.1

-15V

C528
3300pF

R562
100

R566
10K

R565
1K

R563
90.9

R564
14.7K
1

R561
51K
1W

OUT1 BUSS BAR

COMM1 BUSS BAR

STATIC
BALANCE

R568
100K

+15V

R567
91K

-15V

DYNAMIC
BALANCE

+VCC1

R569
51K
1W

C531
5pF

R570
51K
1W

C532
5pF

-VCC1

Low Side of Bridge: sensing amplifier output and inverting the signal,
Low Side Bias (portion on positive output module), and differential
circuit which clamps Low Side signal in the event of ODEP or other
protective function.

+VCC1

D507

R534
12
2W

C520
0.022

R582
0.33
5W

Q538   Q519   Q521   Q523

R536
0.33
5W

R538
0.33
5W

R540
0.33
5W

R542
4.3
0.50W

+VCC1

Q525

R544
51

+VCC1

Q527

L502
470uH

R546
100

C522
0.033

R550
13K

+IC1

+ICOM1

+ICLF1

TP2

COMM1 BUSS BAR

Low Side of Bridge: including Predriver,
Driver, Output Devices, and Flyback
Diode on the NPN side.

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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 ±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).

VZ POWER SUPPLY

The VZ supply in the MA-5000VZ works, in concept, very much like the MA-3600VZ. For the sake of completeness, some conceptual things will be duplicated here.

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.

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.
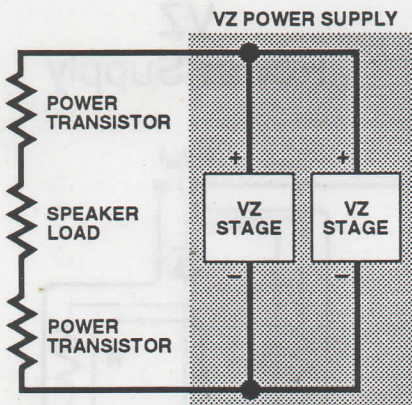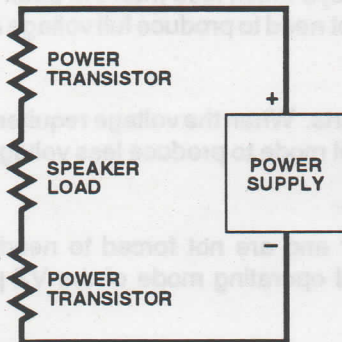
Low Voltage, High Current Mode
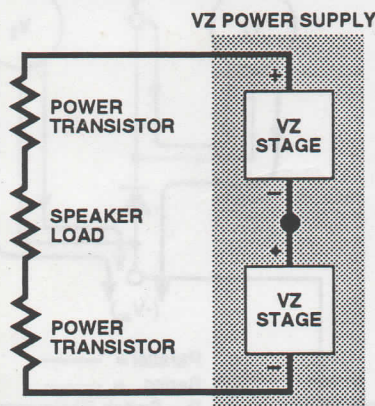
High Voltage, Low Current Mode

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Reducing the voltage reduces the heat. Since the amplifier runs cooler, you can safely pack more power into the chassis.

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.

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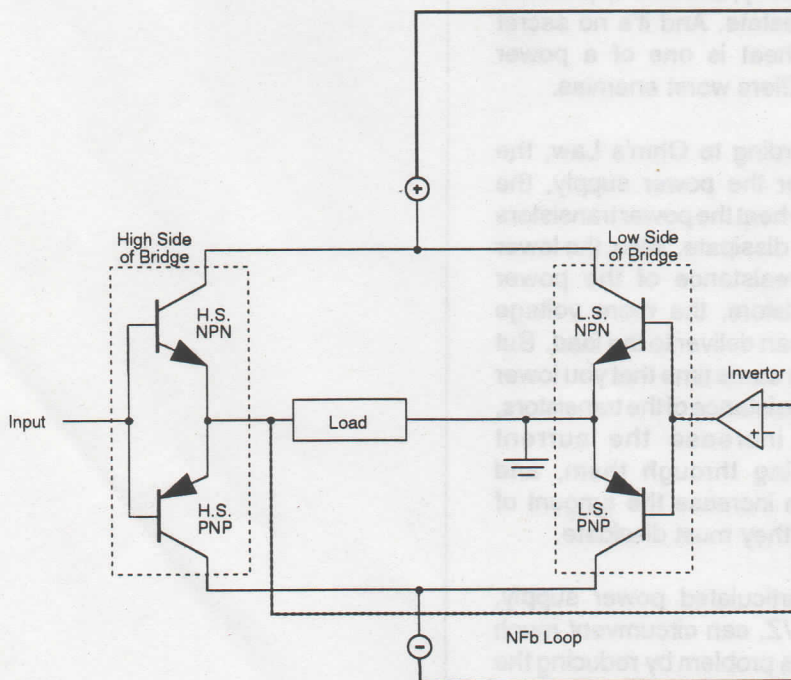
The VZ supply is divided into two parts. When the voltage requirements are not high, it operates in a parallel mode to produce less voltage and more current.

The power transistors stay cooler and are not forced to needlessly dissipate heat. This is the normal operating mode of the VZ power supply.
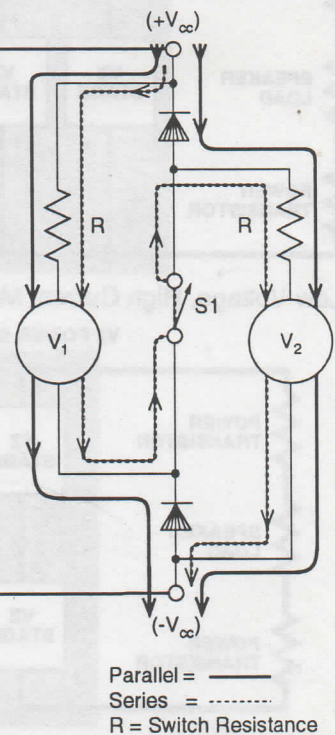
When the voltage requirements are high VZ switches to a series mode to produce higher voltage and less current. The amplified output signal never misses a beat and gets full voltage when it needs it—not when it doesn't need it.

Sensing circuitry watches the voltage of the signal to determine when

GROUNDED BRIDGE
OUTPUT STAGE

VZ
Power Supply

High Side of Bridge — H.S. NPN — H.S. PNP — Load — Input — Low Side of Bridge — L.S. NPN — L.S. PNP — Invertor — NFb Loop

(+V$_{cc}$) — R — R — S1 — V$_1$ — V$_2$ — (-V$_{cc}$)

Parallel = ———
Series = --------
R = Switch Resistance

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.

Actual current flow with power supply and grounded bridge operating together is shown on the previous page.

The individual components are shown below. 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.
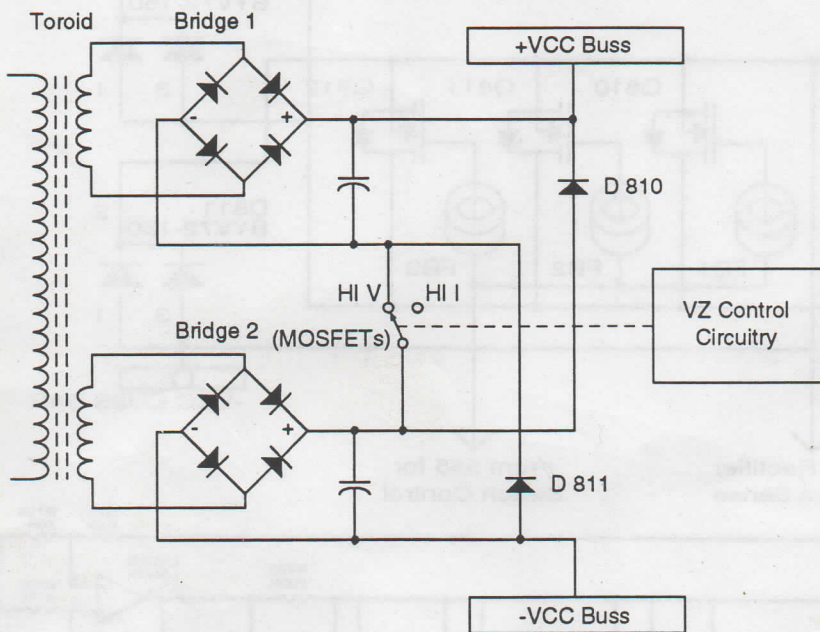

In both examples it can be seen that when the MOSFET switch is off, the dual supplies are forced to operate in a parallel mode. Audio level is sensed via a line tapping off the NFb loop. When audio level is rising and at about 80% of the parallel mode supply voltage, the MOSFETs (the switch is actually 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 normal VZ mode, the user may switch modes to lock low voltage (high current), lock high voltage, or operate the supply in Bi-ODEP mode. Bi-ODEP is similar to normal VZ

Notes

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, this may be a worse condition for speakers. Seldom will the amplifier be operated locked in high current mode unless a very low impedance is being driven. By the same token, it is also unlikely that a user will operate the amplifier locked in high voltage mode for the thermal reasons mentioned.

VZ Switch

VZ Switch Control Circuitry

10 - MA-5000VZ
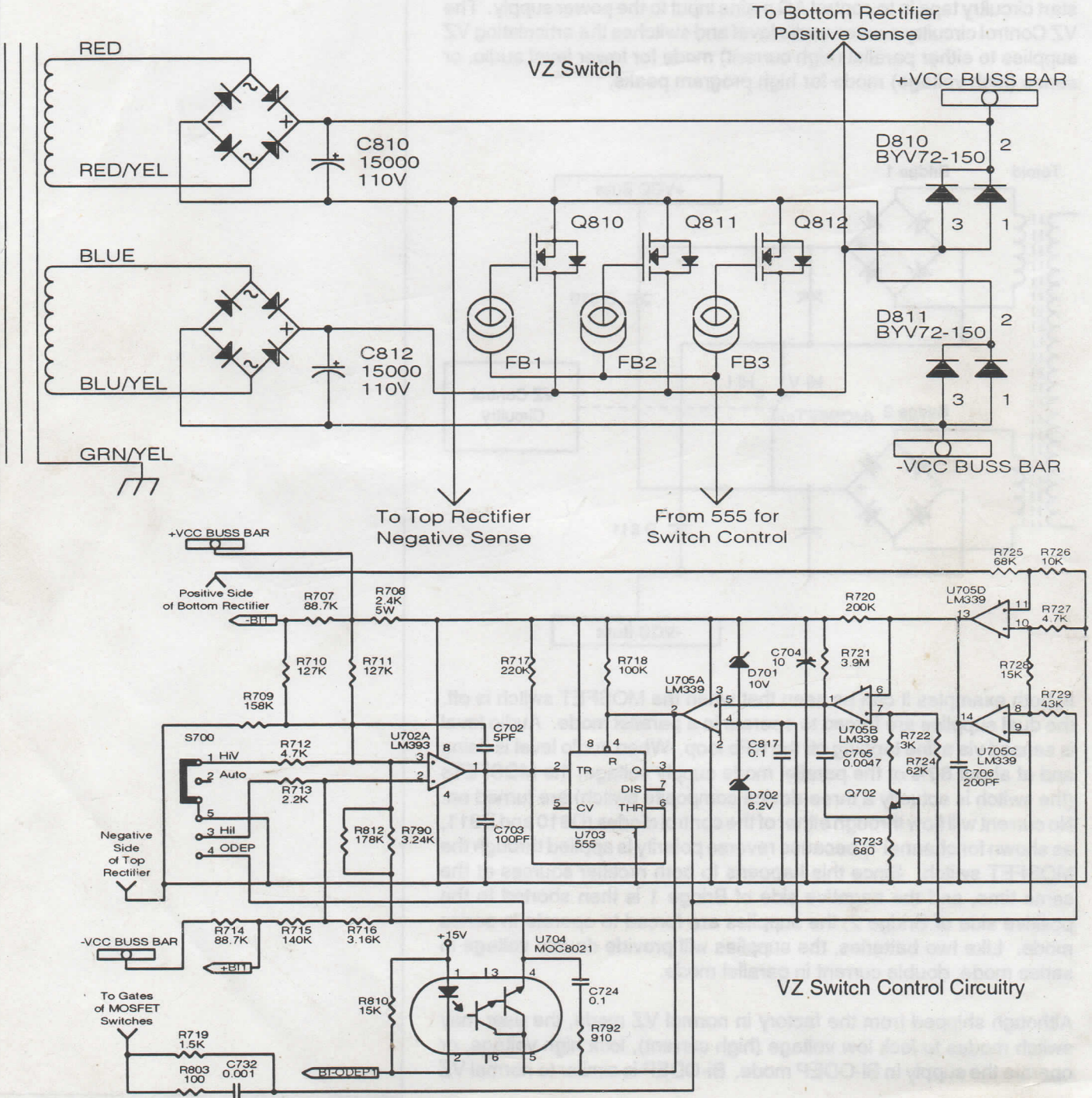
VZ SUPPLY CIRCUITRY

For simplicity, only channel 1 circuitry will be covered unless noted otherwise. Circuitry for the VZ supply (and low voltage supply) is located on the control module. The actual VZ switch circuit is located on the VZ switch assembly. In this assembly are the two bridge rectifiers, two filter capacitors, MOSFET switches, and control diodes D810 and D811. Three MOSFETs are used in parallel for sharing the high currents supplied to the rails.

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 when and how desired.

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 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
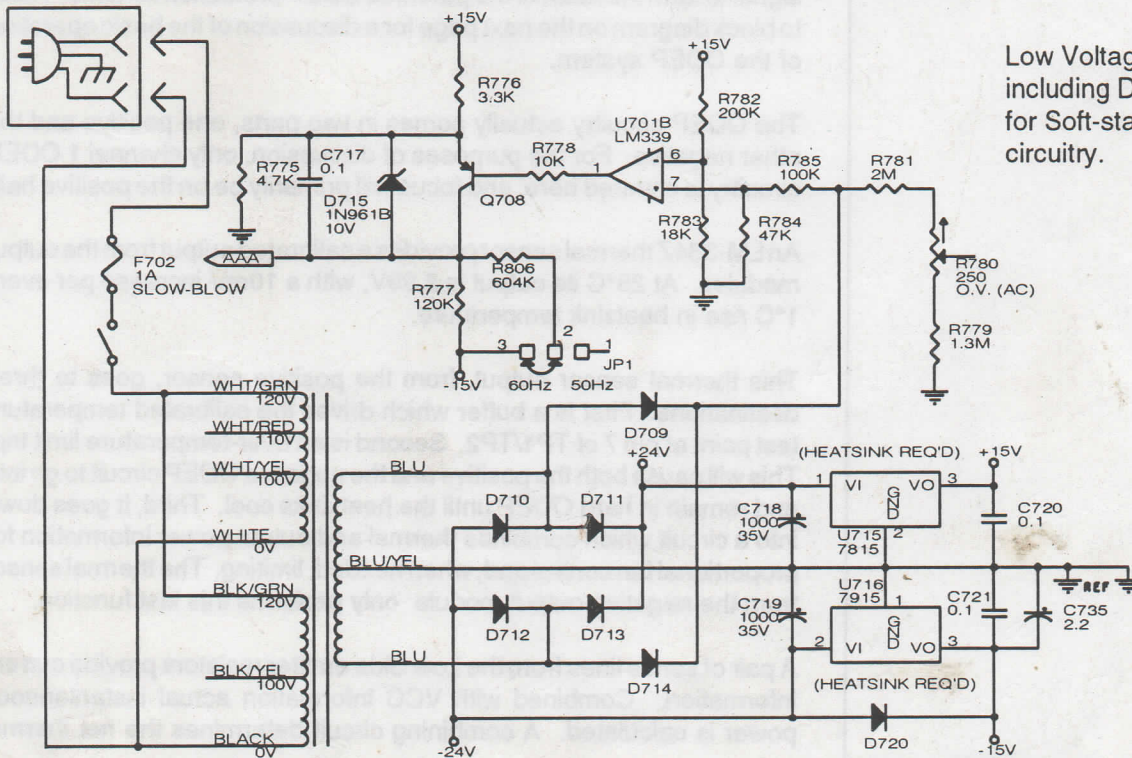
Low Voltage Power Supply, including DC Pulse network for Soft-start and Fan Control circuitry.

level has dropped sufficiently. Capacitors in the U705 circuitry control the speed of the down-shift. In the Bi-ODEP mode, the switch operates as it would in AUTO mode unless ODEP limiting is in progress. When ODEP limiting occurs optic coupler U704 shorts a negative potential (-VCC) to the 555 reset control 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. See 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 transformer produces ±24VDC unregulated. U715 and U716 produce regulated ±15VDC respectively. A separate fullwave rectifier produces pulsed DC for Over-voltage sense and Soft-start control.

ODEP THEORY: MA-5000VZ

To protect the output stages from adverse thermal conditions, a specially developed "ODEP" (Output Device Emulation 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 the patented ODEP protection scheme. Refer to block diagram on the next page 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. 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 for proportional fan control and, when needed, limiting. The thermal sensor from the negative output module only performs this last function.

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

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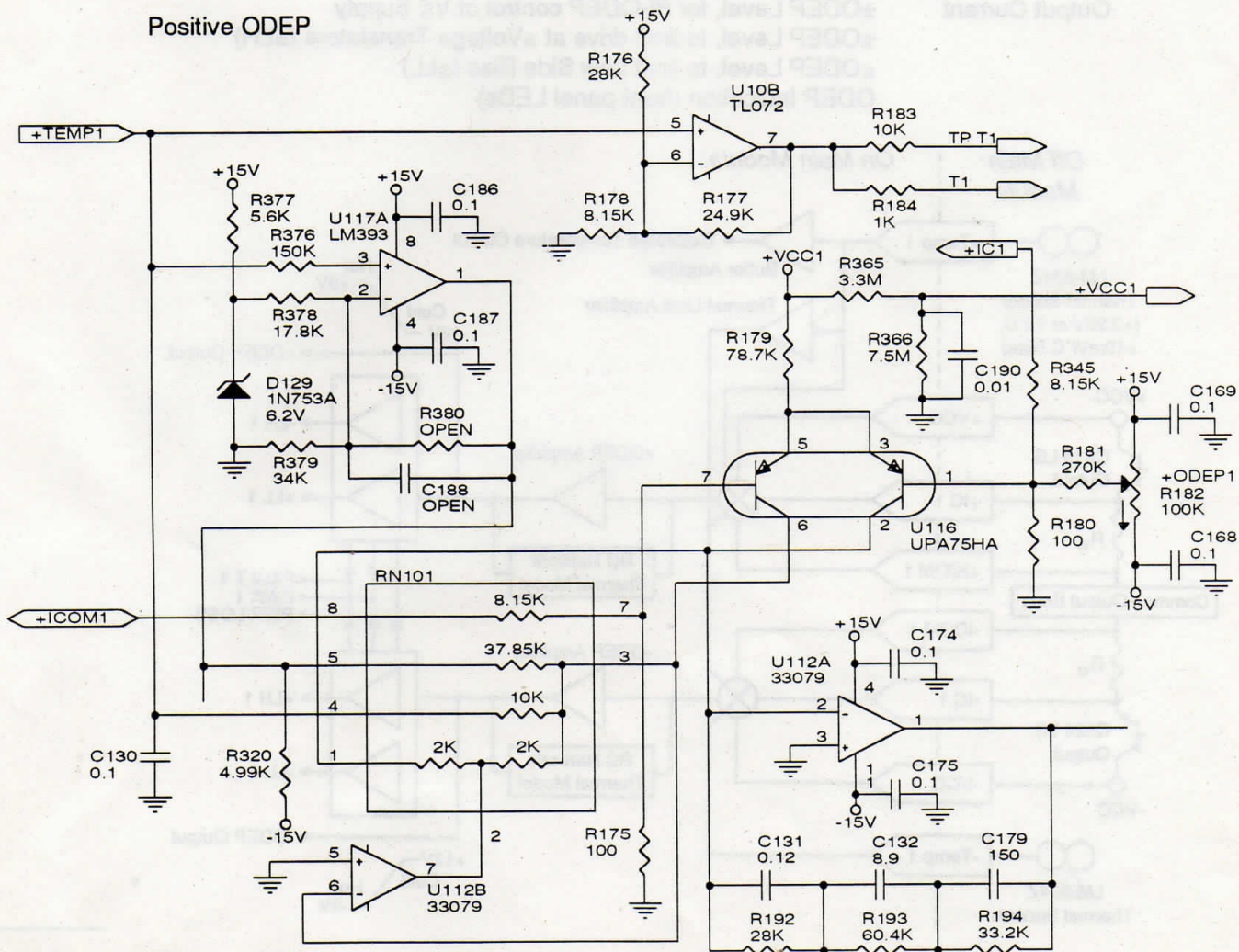
Also tapping in to the ODEP output control of LS bias feed and Voltage Translator feed are signals from the fault, power (turn-on delay), and power loss (brown-out) circuits. By using the output of ODEP for ±LL and ±LH control, these sources can mute the audio to the output stage: a. until power-up delay 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).

±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

Positive ODEP

+TEMP1

R176 28K · +15V

U10B TL072
5 / 6 / 7
R177 24.9K
R178 8.15K
R183 10K → TP T1
R184 1K → T1

+15V
R377 5.6K
R376 150K
U117A LM393
3 / 2 / 8 / 1 / 4
C186 0.1
C187 0.1
R378 17.8K
D129 1N753A 6.2V
-15V
R380 OPEN
R379 34K
C188 OPEN

+VCC1
R365 3.3M → +VCC1
+IC1
R179 78.7K
R366 7.5M
C190 0.01
R345 8.15K
+15V
C169 0.1
5 / 3
7 / 1
6 / 2
U116 UPA75HA
R181 270K
R182 100K → +ODEP1
R180 100
C168 0.1
-15V

RN101
+ICOM1
8 — 8.15K — 7
5 — 37.85K — 3
4 — 10K
1 — 2K — 2K
2
R175 100

+15V
C174 0.1
U112A 33079
2 / 3 / 4 / 1
C175 0.1
-15V

C130 0.1
R320 4.99K
-15V
5 / 6 / 7
U112B 33079

C131 0.12
C132 8.9
C179 150

R192 28K
R193 60.4K
R194 33.2K

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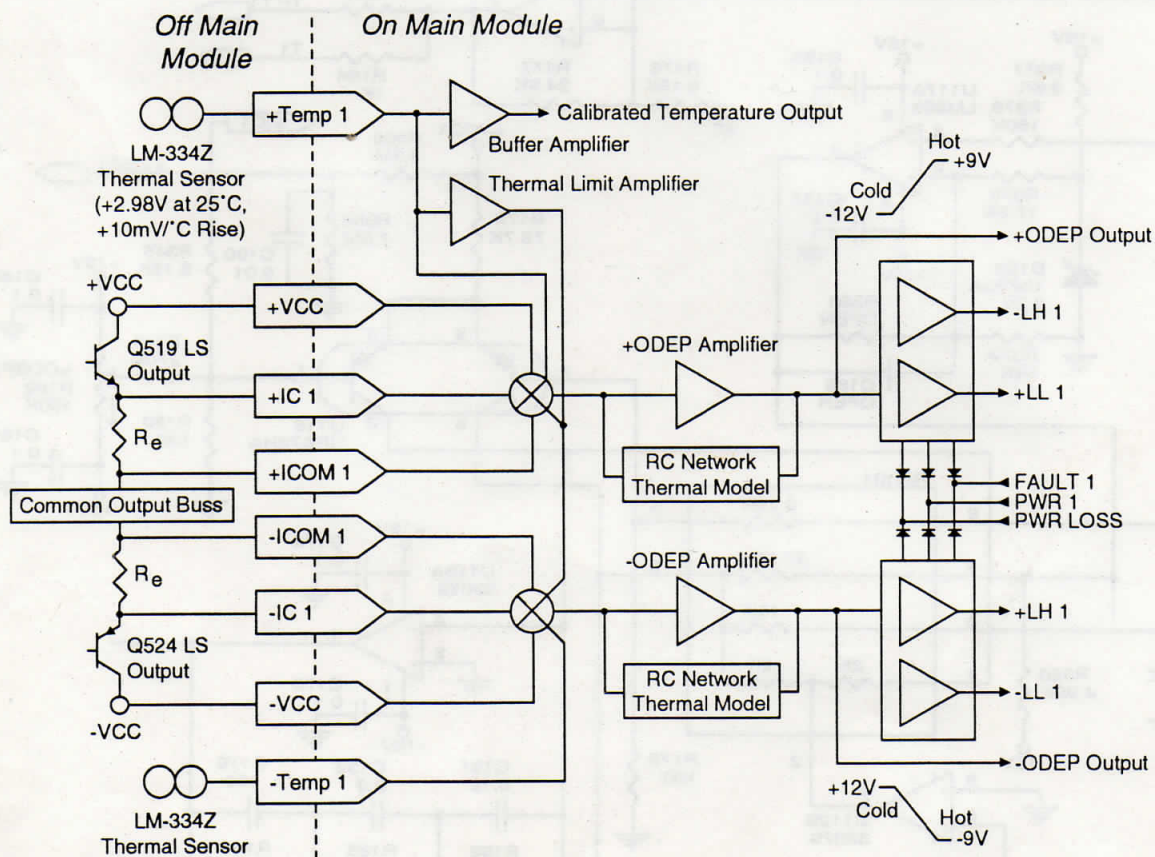
Output from the positive ODEP amplifier ranges from -12V (cold) to +9V (hard ODEP). This output drives the positive Low Side bias feed control circuit and the negative High Side Voltage Translator feed control circuit. Also, this circuit provides test point monitoring information and Bi-ODEP VZ mode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

Channel 1 ODEP Circuitry shown (channel 2 is identical)

ODEP Inputs:
Temperature
±VCC
Output Current

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)

Off Main Module | On Main Module

LM-334Z
Thermal Sensor
(+2.98V at 25°C,
+10mV/°C Rise)

+Temp 1 — Calibrated Temperature Output
Buffer Amplifier
Thermal Limit Amplifier

Hot +9V
Cold -12V

+VCC
Q519 LS Output
R_e
Common Output Buss
+VCC
+IC 1
+ICOM 1
-ICOM 1

+ODEP Amplifier
RC Network Thermal Model

+ODEP Output
-LH 1
+LL 1

FAULT 1
PWR 1
PWR LOSS

R_e
Q524 LS Output
-VCC
-IC 1
-VCC

-ODEP Amplifier
RC Network Thermal Model

+LH 1
-LL 1

-Temp 1
LM-334Z
Thermal Sensor

-ODEP Output
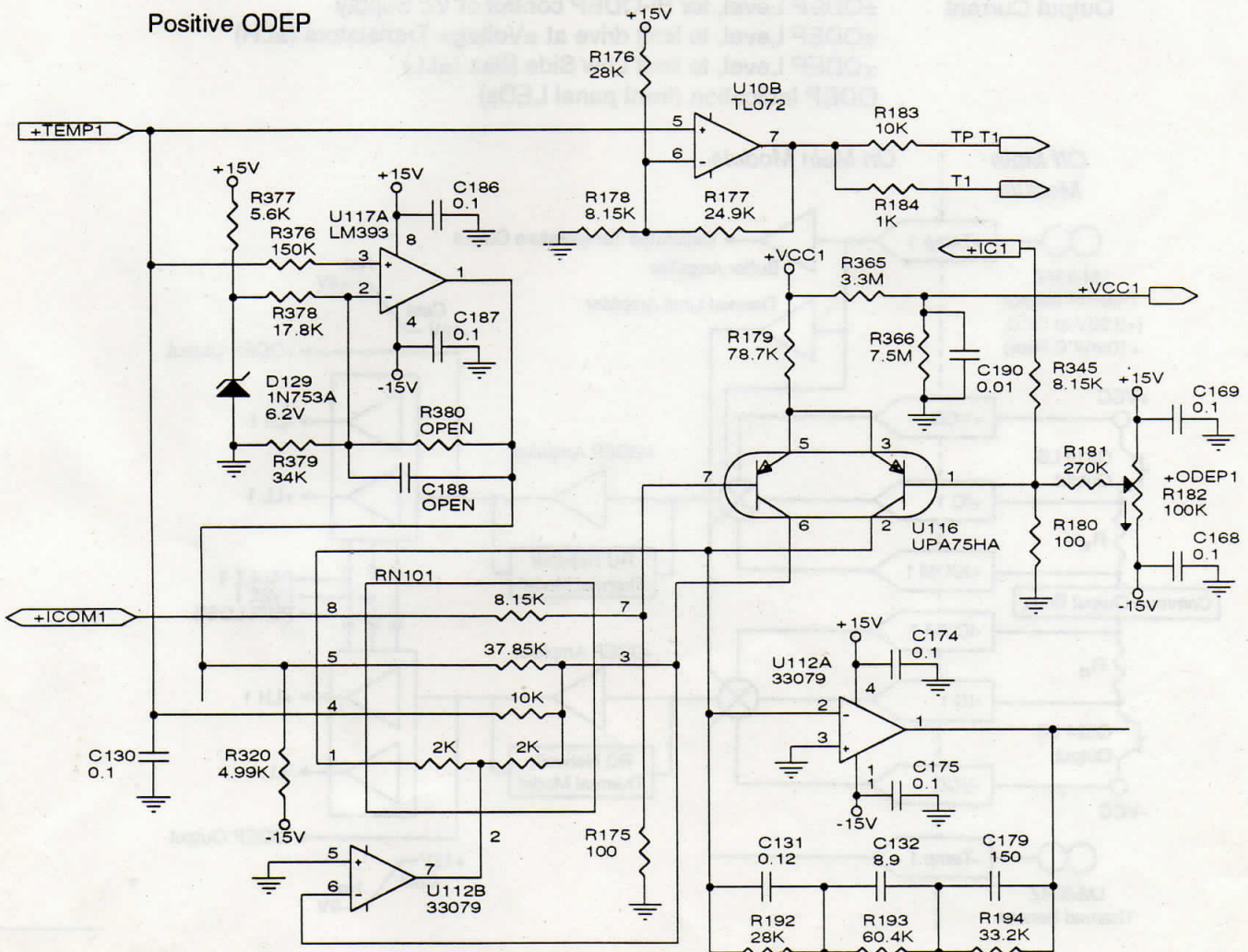
+12V Cold
Hot -9V

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Notes

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 ±LL and ±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).

±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


Positive ODEP

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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 ±LL and ±LH. This action mutes all audio in the event of a dramatic failure.
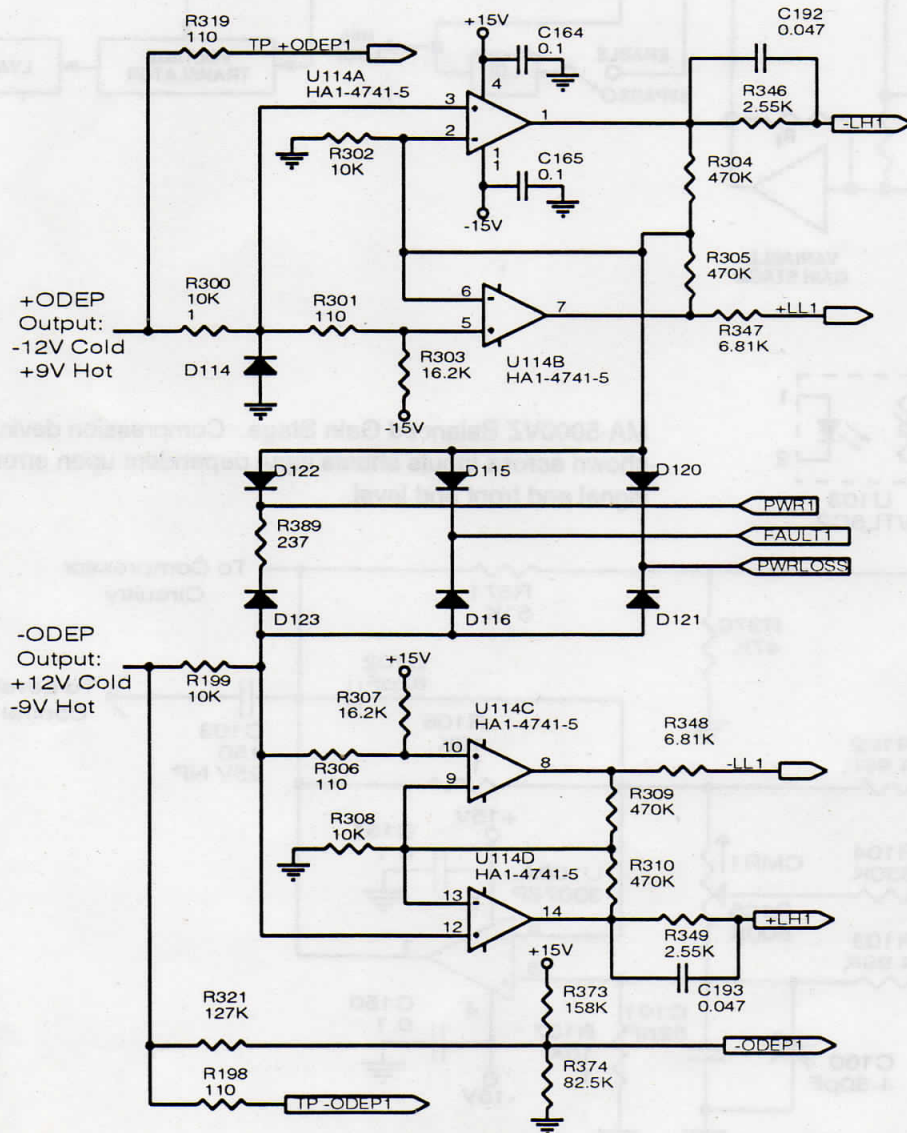
This circuit is essentially the "result" of ODEP, its output. ±LH control Voltage Translator current; ±LL control Low Side Bias current. ±LL/LH voltages will also be activated by the FAULT circuit, the "brown-out" Power Loss circuit, or any time the main power relays are not closed.
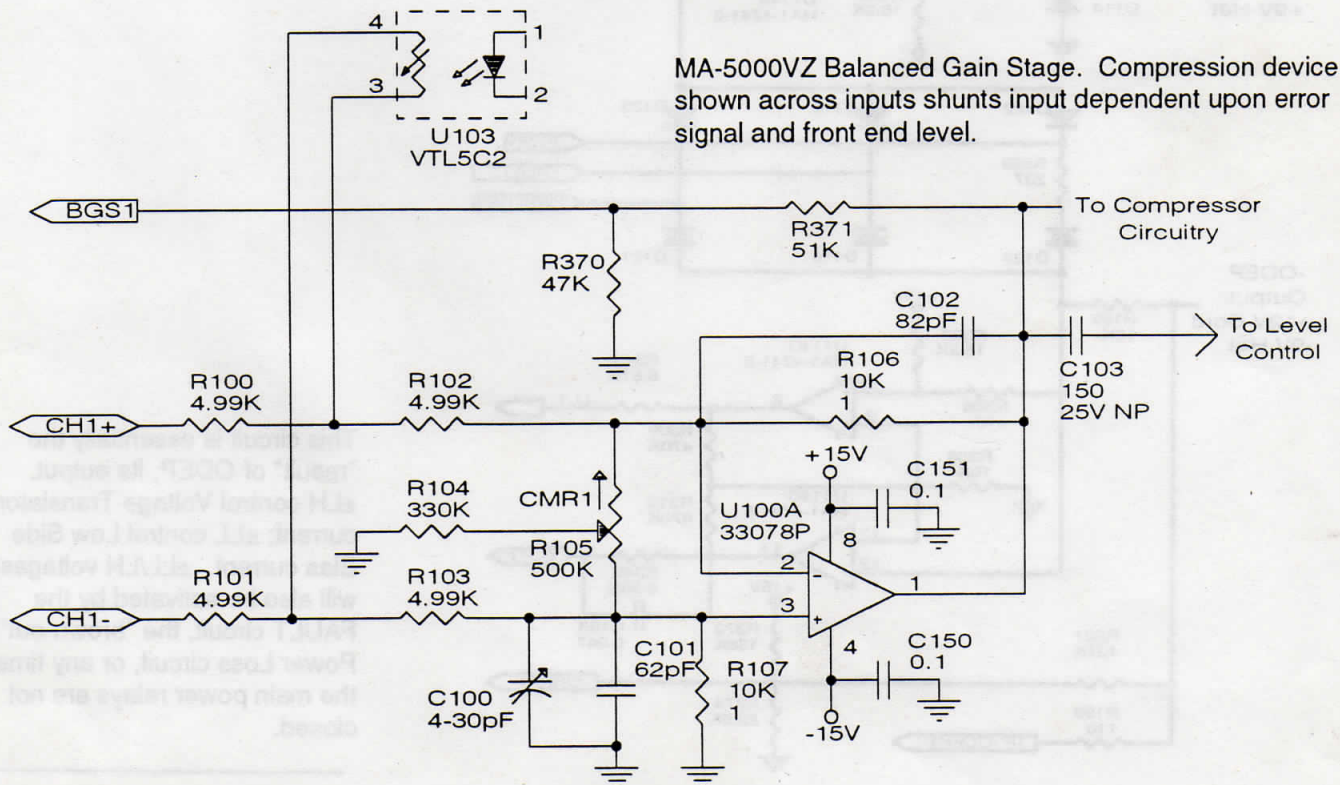
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FRONT END THEORY

The front-end portion of the over-all block diagram has been exploded in the diagram below. Once again, only channel 1 will be discussed in detail. The Balanced Gain Stage circuitry is shown at the bottom.

MA-5000VZ FRONT END: (CHANNEL 1 SHOWN)
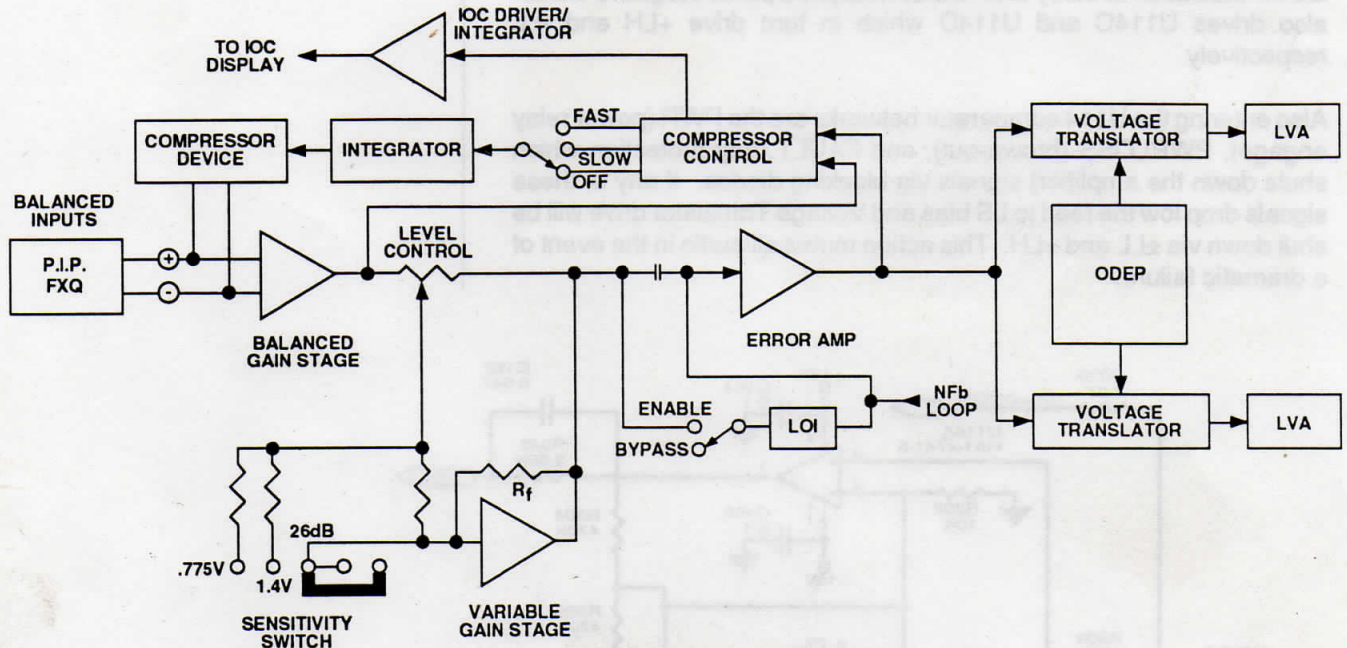
MA-5000VZ Balanced Gain Stage. Compression device shown across inputs shunts input dependent upon error signal and front end level.

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.

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 shunt across the balanced input lines. The BGS drives the Variable Gain Stage and provides information to the compressor control circuit and to the P.I.P. connector.

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 amount of gain in this stage. Overall amplifier sensitivity may be set for 26dB fixed gain (about 5.1Vrms input), 1.4V (+4dBu, unbalanced, with 8 ohm load), or 0.775V (0dBu, unbalanced, with 8 ohm load). 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.
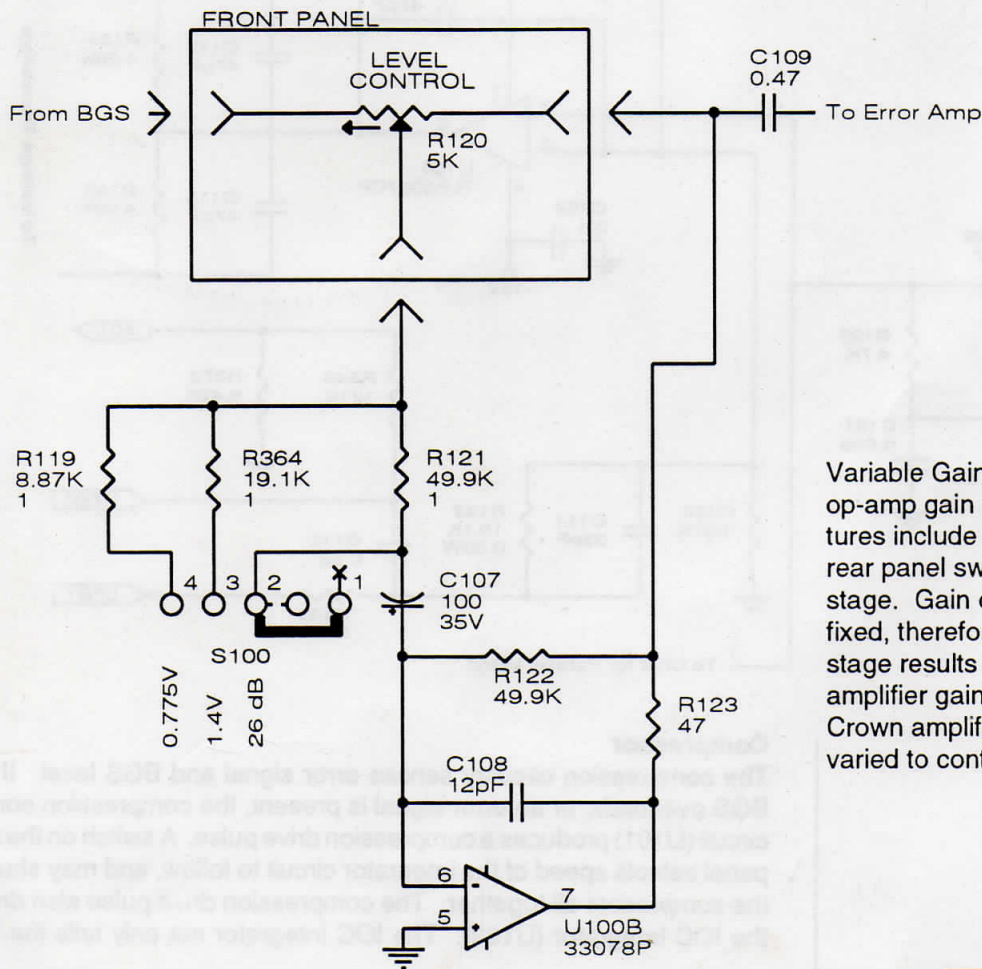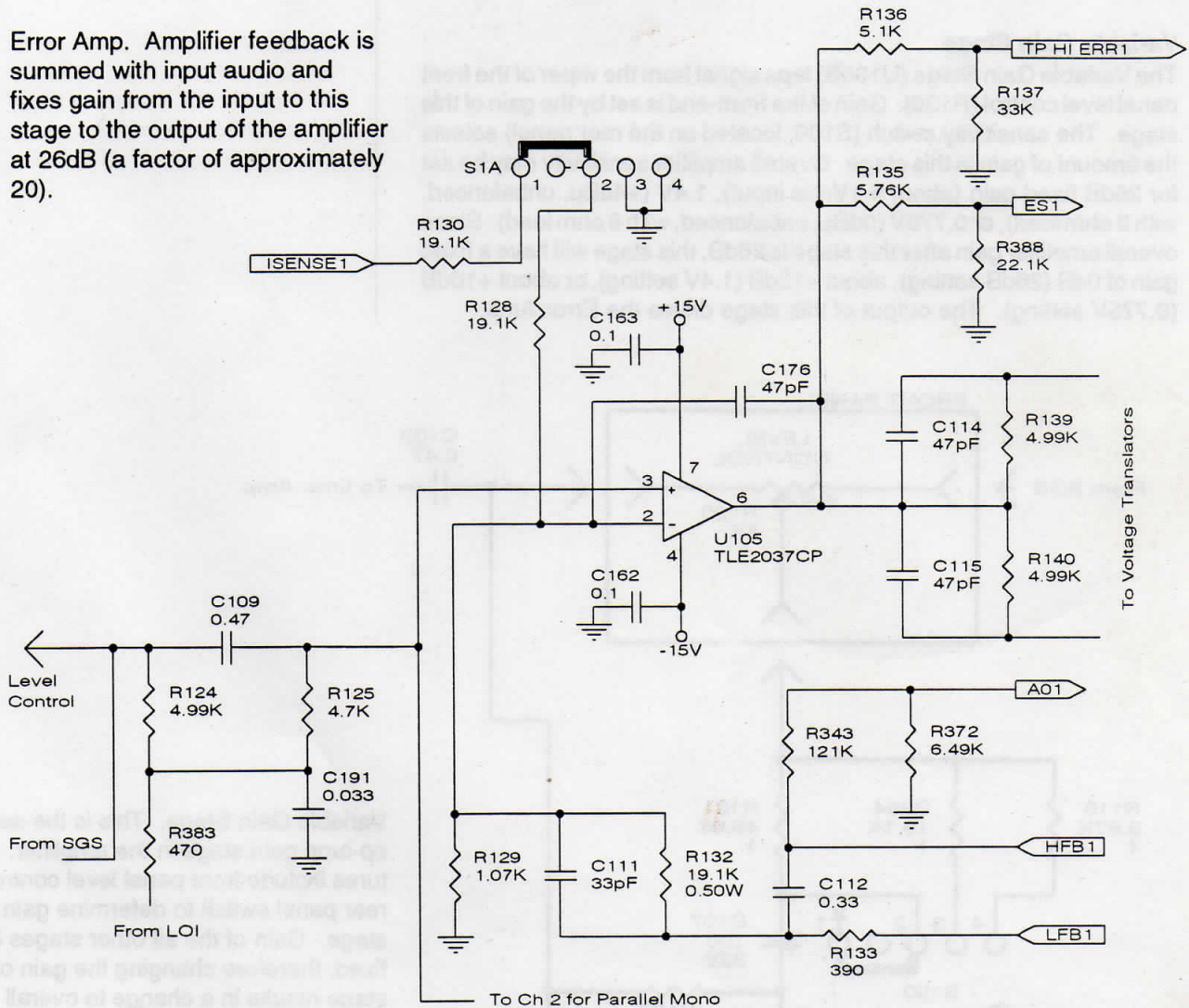

Variable Gain Stage. This is the second op-amp gain stage in the amplifier. Features include front panel level control a rear panel switch to determine gain of this stage. Gain of the all other stages is fixed, therefore changing the gain of this stage results in a change to overall amplifier gain. In this case (like other Crown amplifiers) the input impedance is varied to control gain of the op-amp.

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.

Error Amp. Amplifier feedback is summed with input audio and fixes gain from the input to this stage to the output of the amplifier at 26dB (a factor of approximately 20).

Schematic: Error Amp circuit with U105 TLE2037CP, components including R136 5.1K, R137 33K, R135 5.76K, R388 22.1K, R130 19.1K, R128 19.1K, C163 0.1, C176 47pF, C114 47pF, R139 4.99K, C115 47pF, R140 4.99K, C162 0.1, C109 0.47, R124 4.99K, R125 4.7K, C191 0.033, R383 470, R129 1.07K, C111 33pF, R132 19.1K 0.50W, C112 0.33, R133 390, R343 121K, R372 6.49K. Signals: ISENSE1, TP HI ERR1, ES1, Level Control, From SGS, From LOI, To Voltage Translators, A01, HFB1, LFB1, +15V, -15V, S1A. "To Ch 2 for Parallel Mono"

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, and may shut off the compressor all together. The compression drive pulse also drives the IOC Integrator (U102). The IOC integrator not only tells the IOC

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.

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 previously), current limit (also covered previously), over-voltage (on AC mains), DC/LFI, common mode output current, output thermal, transformer thermal, FET thermal, loss of AC mains, compression (covered previously), LOI (covered previously), and slew rate limit (covered previously). 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.

On the following pages you will find block diagrams of both the Soft-start circuitry and the overall protection scheme. Each augments the other.

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 ±24VDC and regulated ±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 10μF 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.
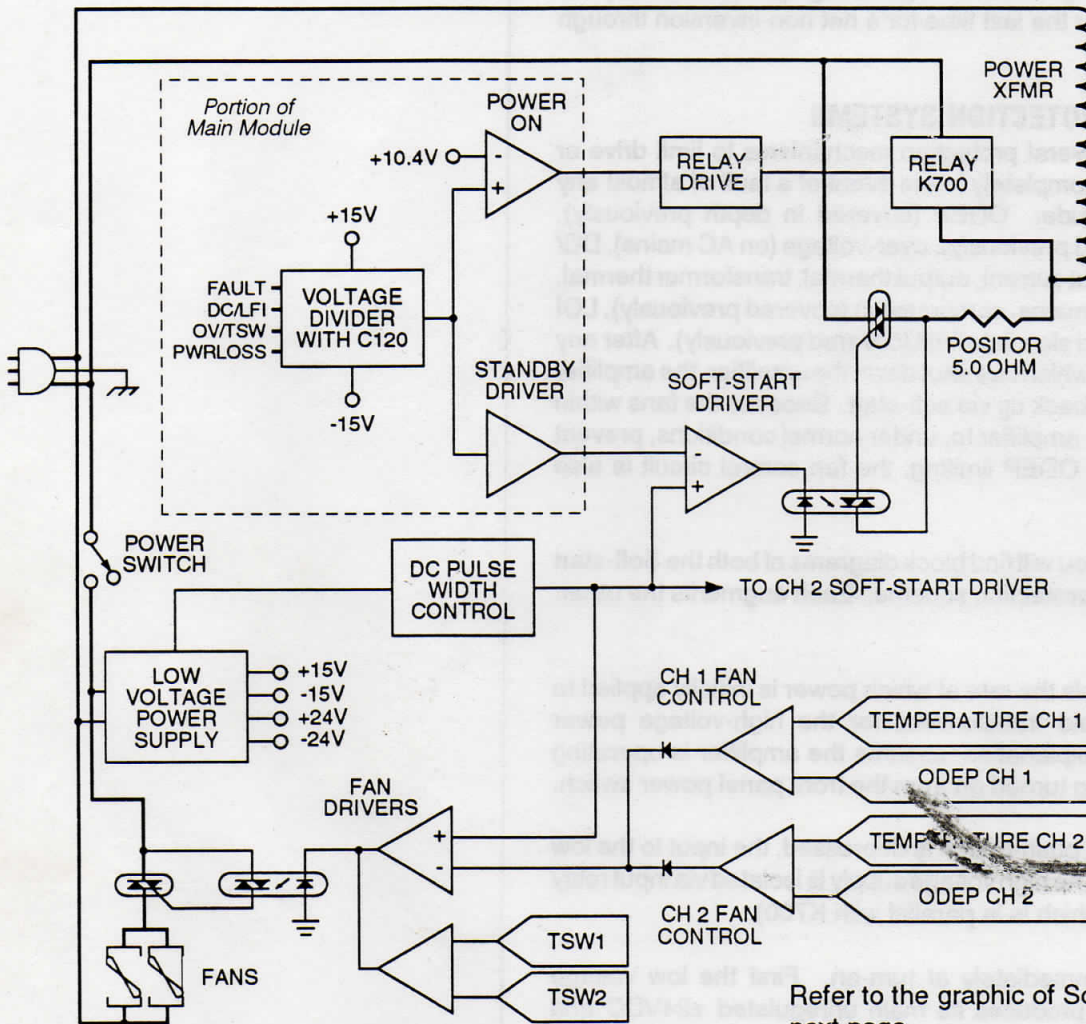
The ramped voltage on the capacitor C120 is also sensed by Standby amplifier U111B. Its unity gain output is non-inverting. It drives the Soft-start op-amp (U701A) inverting input with its ramp to control the rate at which the field develops in the toroid. On the non-inverting input to U701A is the pulsed 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 R7?? (50Hz) or R7?? in parallel with R806 (60Hz).

It is the output of U701A that really controls the Soft-start. Refer to the graphic of Soft-start waveforms on the next page.

Soft-start block diagram. Note: DC pulse stretching circuit shown in Low Voltage Power Supply schematic cutaway on page 11.

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 (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 at the top of the next page. The upper signal is 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
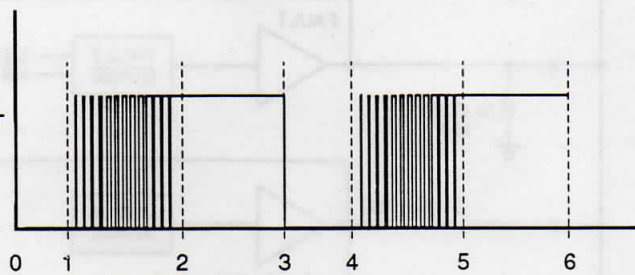
C120 CHARGE VOLTAGE

0   1   2   3   4   5   6
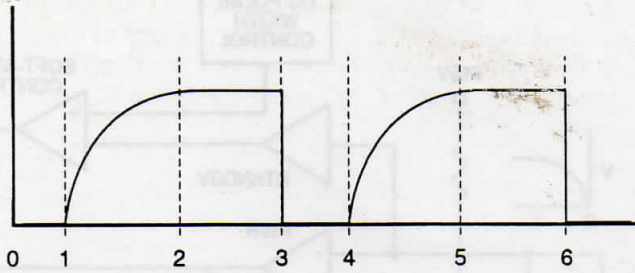
PULSED DC FROM LVPS

0   1   2   3   4   5   6
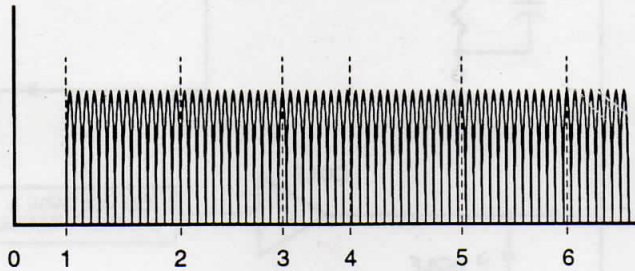
SOFT-START TRIAC CONTROL

0   1   2   3   4   5   6

6 is amplifier shutdown via power switch. The lower graph shows Q701 operation (high = on) The longer Q701 is on, the more the main transformer field is allowed to build.

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

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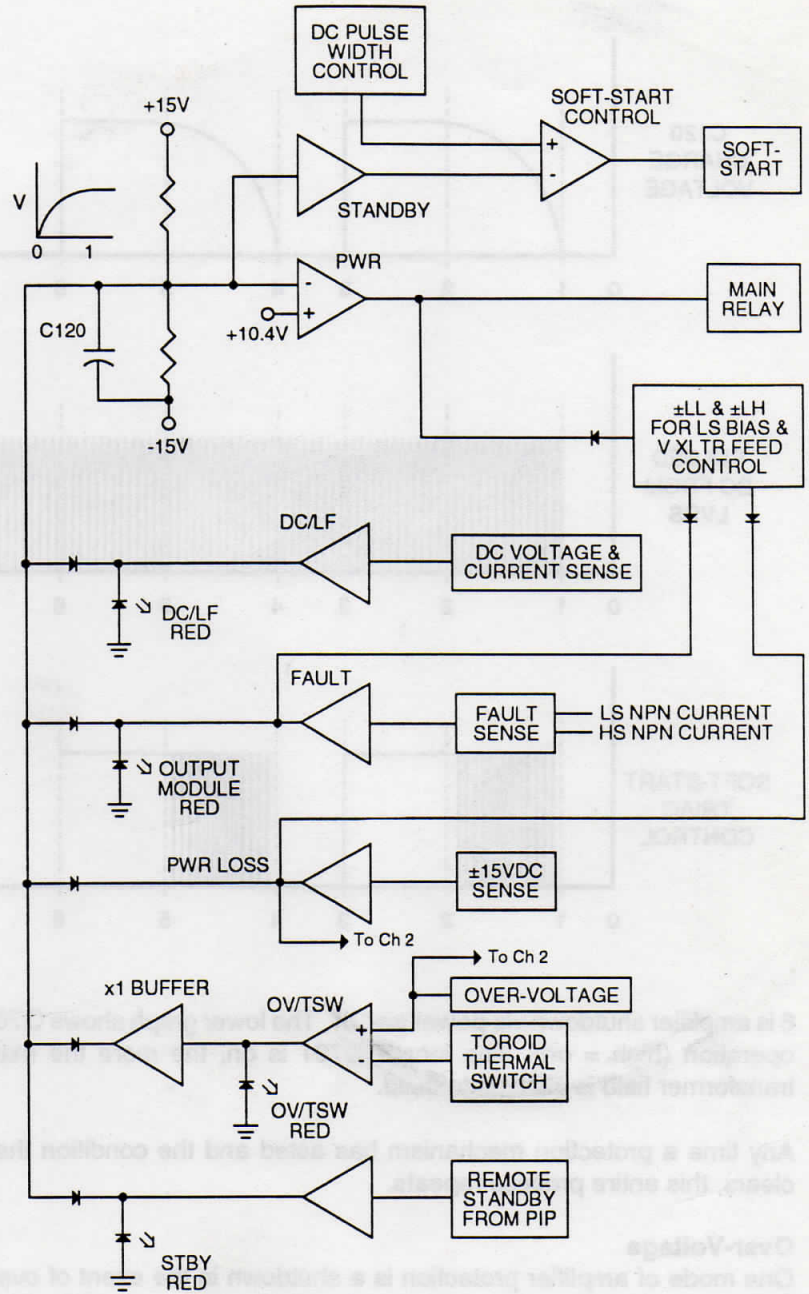
R780 picks off the pulsed DC and U707D will, if the voltage is too high, shift its output to a low. When this happens the over-volt/therm red LED on the control module lights and signal OV1 goes low to the main module.

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 ±LL and ±LH to clamp audio drive. Over-voltage is a non-latching fault condition.

Overall protection scheme block diagram.

DC/LFI

The amplifier senses it 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 LFI circuit from activating with normal audio frequency material, and will ensure activation with high level subsonic currents or voltages.
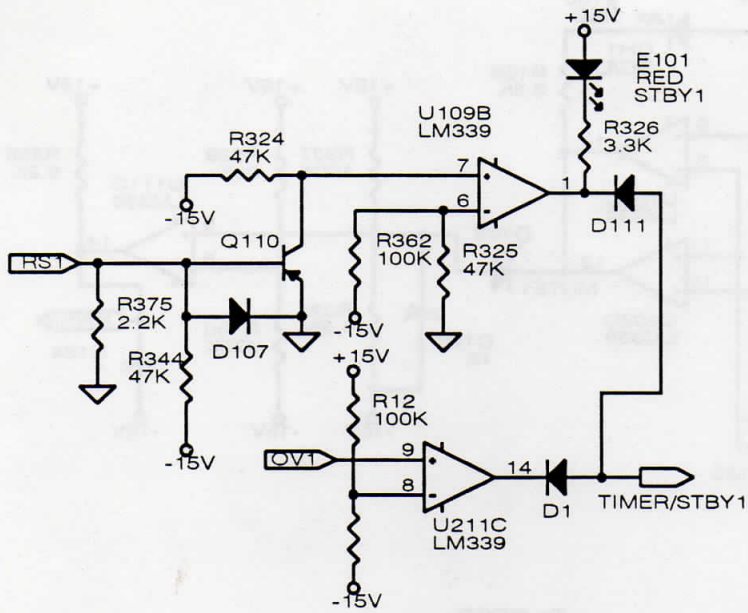
Notes

Over-Voltage and Thermal Switch information combines to produce the "OV" signal driving U211C. The remote standby (RS) function (from the P.I.P. module) also ties into the signal path labelled TIMER/STBY. They are shown together since, schematically, they share a common control line to the C120 Soft-start and PWR (relay) control circuitry.
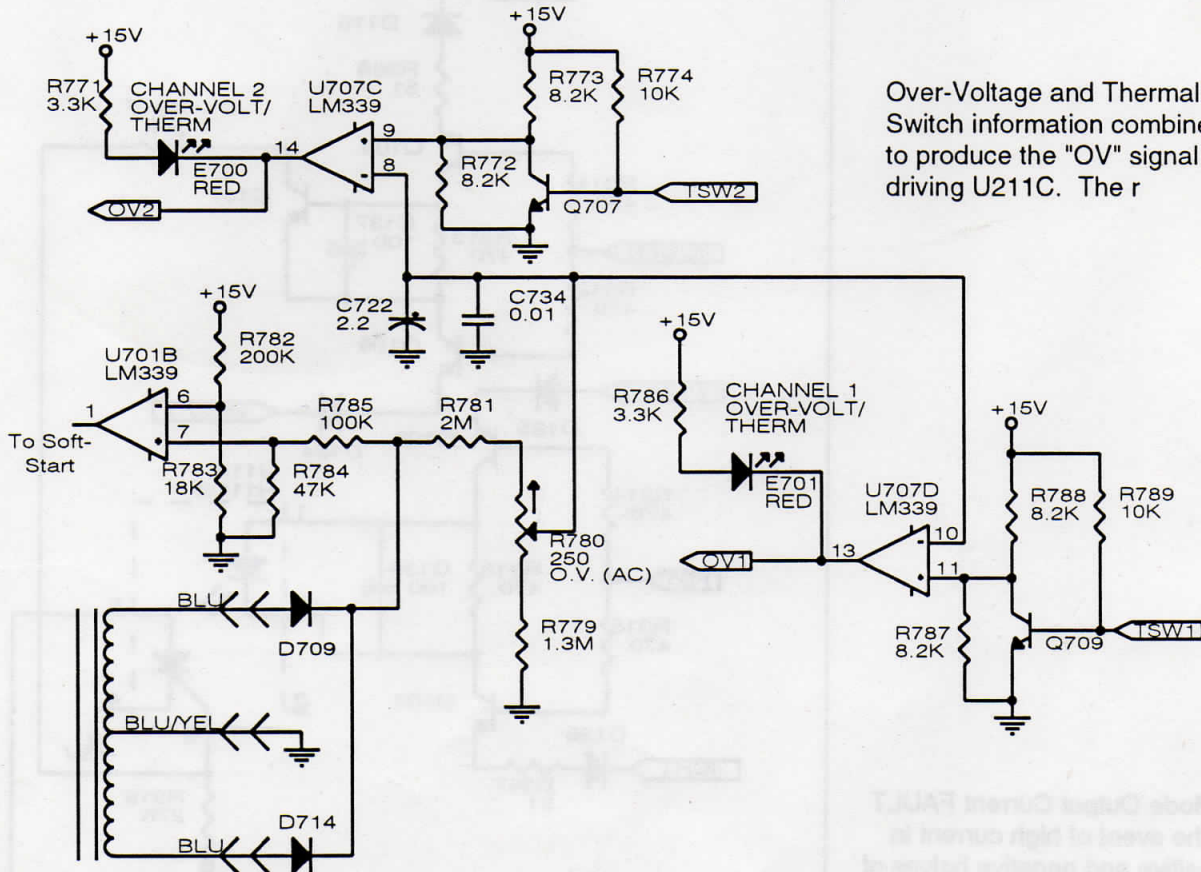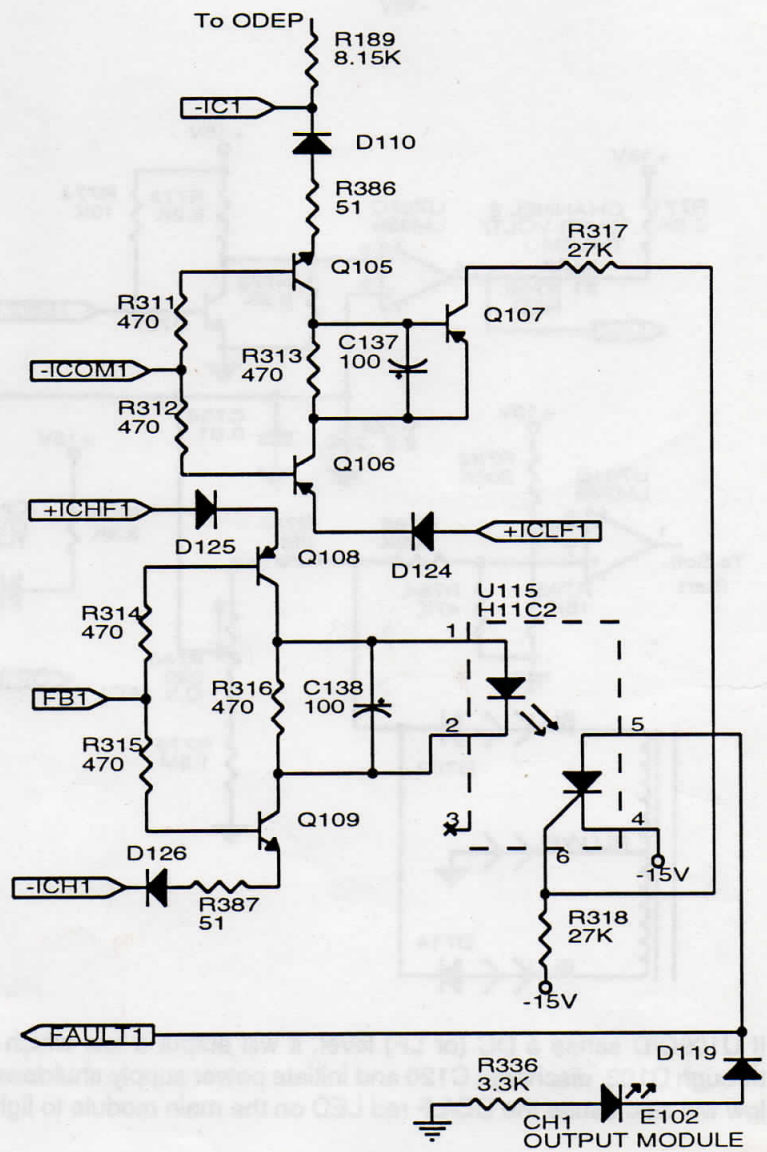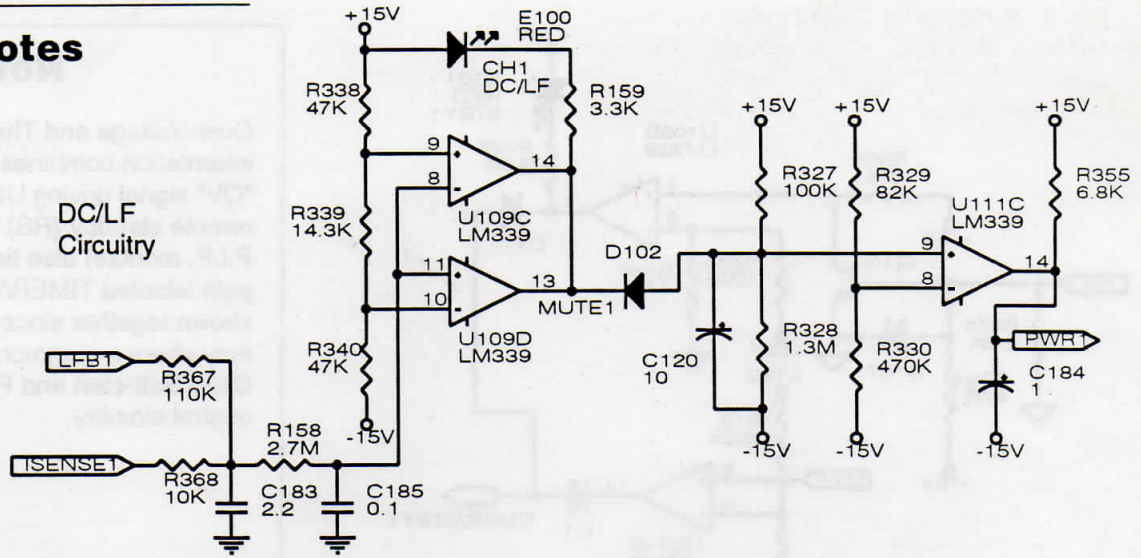
Over-Voltage and Thermal Switch information combines to produce the "OV" signal driving U211C. The r

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.

Notes

DC/LF Circuitry

+15V E100 RED CH1 DC/LF

R338 47K
R339 14.3K
R340 47K

9
8
U109C LM339
14

11
10
U109D LM339
13 MUTE1

R159 3.3K

D102

+15V +15V +15V

R327 100K
R329 82K
R355 6.8K

9
8
U111C LM339
14

C120 10
R328 1.3M
R330 470K

-15V -15V -15V

PWR1
C184 1

LFB1 R367 110K
R158 2.7M

ISENSE1 R368 10K
C183 2.2
C185 0.1

-15V

To ODEP R189 8.15K

-IC1
D110
R386 51
Q105

R311 470
R313 470
C137 100
Q107
R317 27K

-ICOM1

R312 470
Q106

+ICHF1 D125 Q108 D124 +ICLF1

R314 470
FB1
R315 470

R316 470
C138 100

Q109

1
U115 H11C2

2

3

5

4

6
-15V

R318 27K

-ICH1 D126 R387 51

-15V

Common Mode Output Current FAULT circuit. In the event of high current in both the positive and negative halves of the output stage simultaneously, this circuit will shut down the amplifier. This is the only latching protection function in the MA-5000VZ

FAULT1
R336 3.3K

CH1 OUTPUT MODULE
E102
D119

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.

Output Thermal

Output over-temperature protection was covered in the ODEP Circuitry section of this text. 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.

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. This results in amplifier shutdown by way of shared over-voltage circuitry.

FET Thermal

The MOSFET switches in the VZ supply have built-in thermal protection. In the event of over-heat they functionally open, locking the VZ supply in low voltage (high current) mode, regardless of the control signal.

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 also goes to ±LL and ±LH to immediately mute audio upon power-down or power-loss, thus preventing turn-off audio noise.
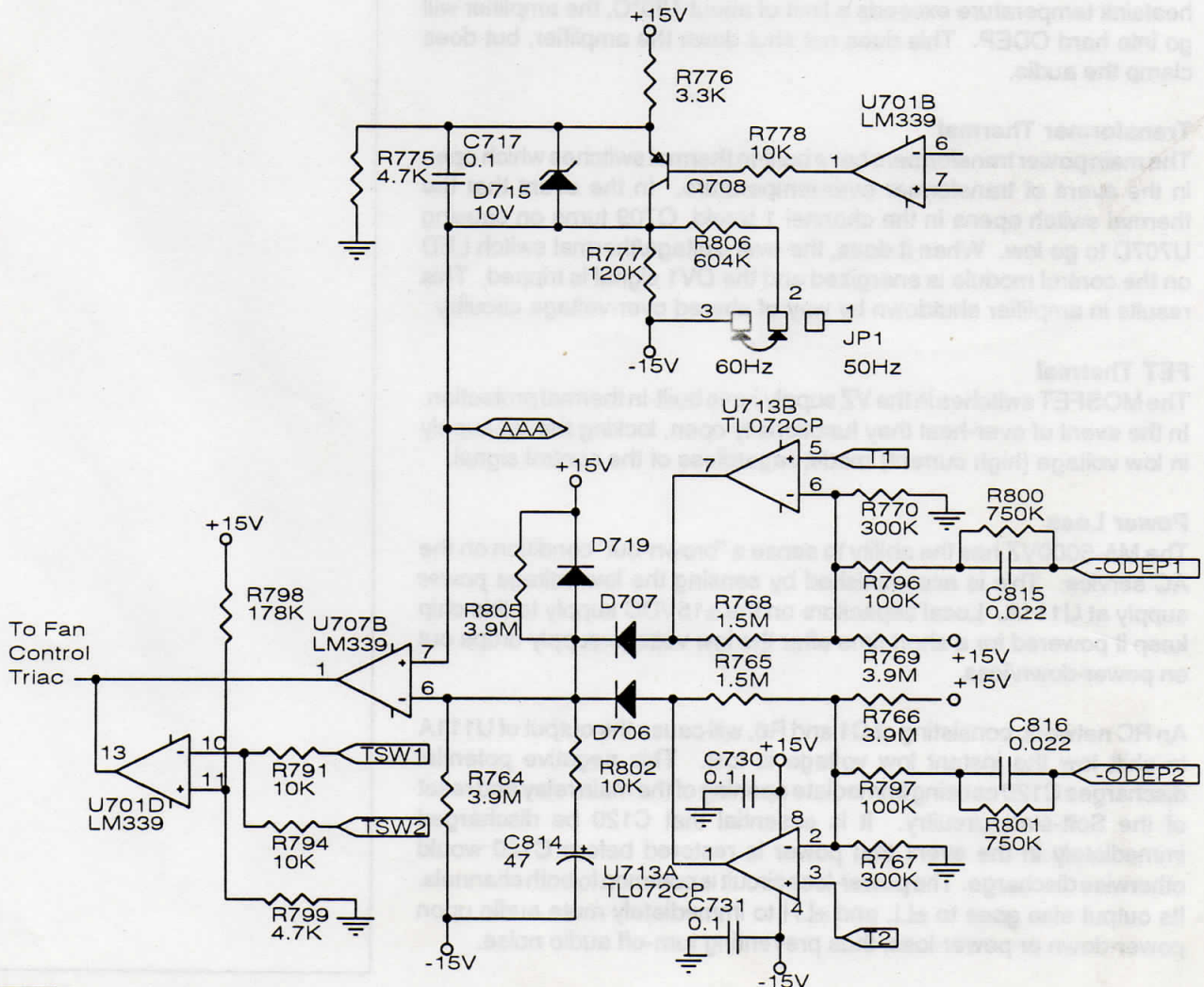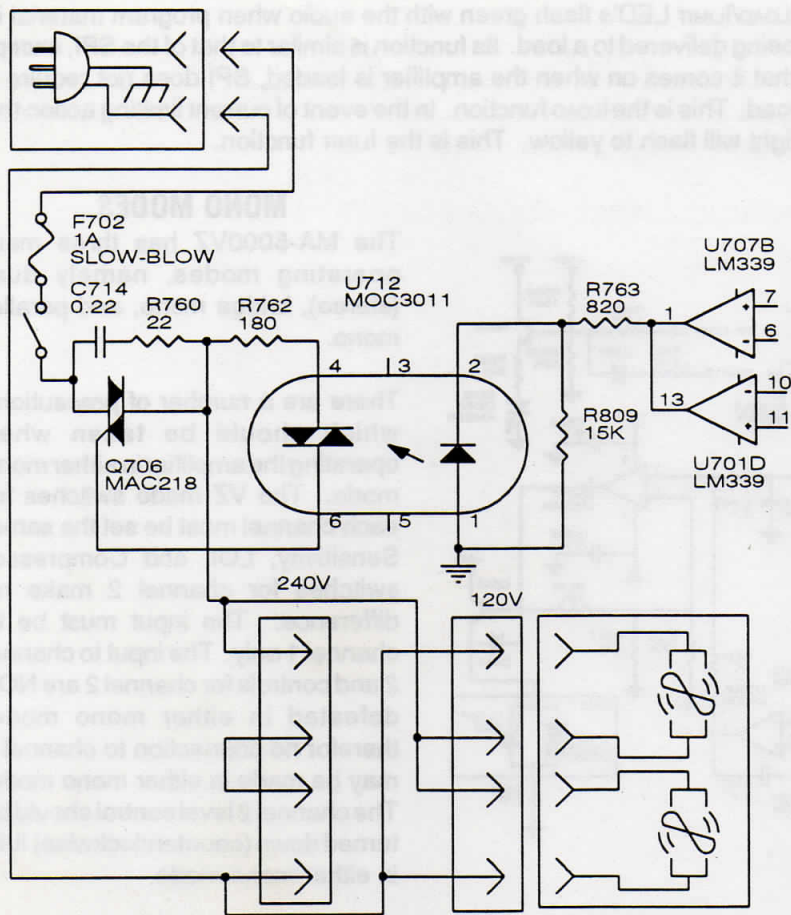
Fan Control

The MA-5000VZ, unlike other members of the Macro-Tech family, has two on board 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.

Component labels in schematic: F702 1A SLOW-BLOW, C714 0.22, R760 22, R762 180, Q706 MAC218, U712 MOC3011, R763 820, R809 15K, U707B LM339, U701D LM339, 240V, 120V

DISPLAY

Amplifier front panel indication includes a total of 7 LED's. These include Enable, ODEP, SPI/IOC, and ILOAD/ILIMIT.
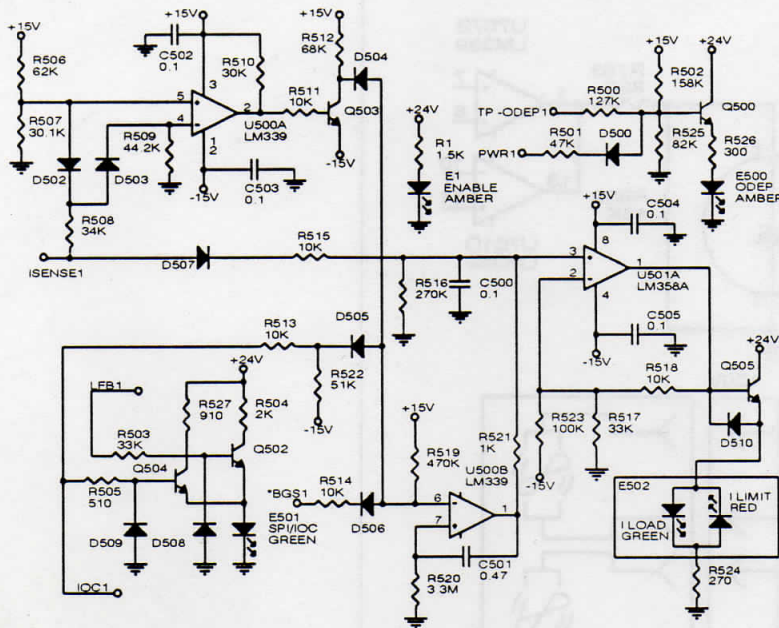
The Enable indicator is an amber light which indicates presence of the low voltage supply. It is powered by the unregulated +24VDC supply. It will be on any time the power switch is depressed (unless the low voltage fuse blows).

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%) 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, including ODEP limiting.

ILOAD/ILIMIT 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 it comes on when the amplifier is loaded, SPI does not require a load. This is the ILOAD function. In the event of current limiting action the light will flash to yellow. This is the ILIMIT function.

Notes

MA-5000VZ Front Panel Display Circuitry

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, therefor 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 aides in understanding how to the mono modes work for testing purposes.

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 (-).

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.