

Section 3. Specifications

3.1 PM4000M Mixing Console: General Specifications

Total Harmonic Distortion (Group & Stereo Outputs)	<0.1% (THD+N)	20 Hz – 20 kHz @ +14 dBu, 600Ω	
	<0.01% (2nd – 10th harmonics)	20 Hz – 20 kHz @ +14 dBu, 600Ω	
Frequency Response (Group & ST Out)	0 ±1/3 dB	20 Hz – 20 kHz @ +4 dBu, 600Ω	
Hum & Noise (52 Channels)* (20 Hz – 20 kHz) R _s = 150Ω Input Gain = Max. Input Pad = OFF Input Sensitivity = -70 dB <small>*measured with a 6 dB/oct. filter @ 12.7 kHz; equivalent to a 20 kHz filter with -6 dB/oct. attenuation.</small>	-128 dBm	Equivalent Input Noise	
	-100 dBu	Residual Output Noise	
	-81 dB (85 dB S/N)	GROUP OUT Master control at nominal level, all channel mix controls at minimum level	
	-80dB (84 dB S/N)	STEREO OUT Master control at nominal level, all channel mix controls at minimum level	
	-54 dB (58 dB S/N)	STEREO OUT Master and one channel mix control at nominal level	
Crosstalk	-80 dB @ 1 kHz, -70 dB @ 10 kHz	adjacent inputs	
	-80 dB @ 1 kHz, -70 dB @ 10 kHz	input to output	
Maximum Voltage Gain	90 dB	CH IN to GROUP OUT (PRE) / STEREO OUT (PRE/LVL)	
	87 dB	CH IN to ST OUT (PRE/PAN)	
	100 dB	CH IN to GROUP OUT (POST) / ST OUT (POST/LVL)	
	97 dB	CH IN to ST OUT (POST/PAN)	
	100 dB	CH IN to ST OUT (PRE/LVL) (GROUP to ST)	
	74 dB	CH IN to CH DIRECT OUT	
	84 dB	CH IN to CUE OUT (INPUT CUE)	
	64 dB	TB IN to TB OUT	
Channel Equalization	±15 dB maximum	HIGH 1k – 20 kHz (shelving/peaking, Q = 0.5 – 3)	
		HI-MID 0.4 k – 8 kHz (peaking, Q = 0.5 – 3)	
		LO-MID 80 – 1.6 kHz (peaking, Q = 0.5 – 3)	
		LOW 30 – 600 Hz (shelving/peaking, Q = 0.5 – 3)	
Channel High Pass Filter	12 dB/octave	Roll off below 20 – 400 Hz @ -3 dB points	
Master Equalization	±15 dB maximum	HIGH 1k – 20 kHz (peaking, Q = 0.5 – 3) HI-MID 0.4 k – 8 kHz (peaking, Q = 0.5 – 3) LO-MID 80 – 1.6 kHz (peaking, Q = 0.5 – 3) LOW 30 – 600 Hz (peaking, Q = 0.5 – 3)	
Oscillator/Noise Generator	Switchable sine wave @ 100 Hz, 1 kHz, 10 kHz or pink noise	Frequency sweepable at x0.2 to x2.0 nominal; less than 1% THD at +4 dBu	
CH Preamp & EQ Peak Indicators	Red LED	Built into each input module; turns on when pre-EQ level or post-EQ level reaches 3 dB below clipping	
Channel LED Meter	6 LEDs (Peak/+6/0/-6/-20 dB)	Level meter built into each input module	
VU Meters (0 VU = +4 dBu output) (For 44 or 52 channel mainframes)	18 Dedicated meters, illuminated	#1–10 GROUP 1 – 10 #19 ST1 L #21 ST2 L	#15–18 GROUP 15–18 #20 ST1 R #22 ST2 R
	4 Switchable meters, illuminated	#11 GROUP 11 / TB #13 GROUP 13 / CUE L	#12 GROUP 12 / OSC #14 GROUP 14 / CUE R
(For 36 channel mainframe; this mainframe not available in U.S.A.)	10 Dedicated meters, illuminated	#1–10 GROUP 1–10	
	8 Switchable meters, illuminated	#11 GROUP 11 / TB #13 GROUP 13 / CUE L #15 GROUP 15 / ST1 L #17 GROUP 17 / ST2 L	#12 GROUP 12 / OSC #14 GROUP 14 / CUE R #16 GROUP 16 / ST1 R #18 GROUP 18 / ST2 R

PM4000M Mixing Console: General Specifications (Continued)

VU Meter Peak Indicators		LED (red)	Built into each VU meter, the LED turns on when the pre-line amp level reaches 3 dB below clipping
Phantom Power		+48 V dc	Available at balanced inputs (via 6.8 kΩ current limiting/isolation resistors) for powering condenser microphones; may be turned ON or OFF via rear-panel Phantom Master switch. When Master is ON, individual channels may be turned OFF or ON via +48V switches on each input module and the talkback module
Dimensions (W x H x D)	52 Channel	2086 x 346 x 1121 mm	82 ^{-1/8} x 13 ^{-5/8} x 44 ^{-1/8} inches
	44 Channel	1846 x 346 x 1121 mm	72 ^{-11/16} x 13 ^{-5/8} x 44 ^{-1/8} inches
	36 Channel	1586 x 346 x 1121 mm	62 ^{-3/8} x 13 ^{-5/8} x 44 ^{-1/8} inches (Not available in U.S.A.)
Weight	52 Channel	192 kg	423.3 lbs
	44 Channel	167 kg	368.2 lbs
	36 Channel	142 kg	313.1 lbs
Option		MN4000M	Monaural Input Module
		GRM4000M-1	Group Master Module 1
		GRM4000M-2	Group Master Module 2
		STM4000M	Stereo Master Module
		TB4000M	Talkback Module
		SU4000	Switching Unit
		IT4000	Input Transformer

3.2 PW4000 Power Supply Specifications

Power Requirements	Japan	100 V, 50/60 Hz	32 Channel	900 W
			52 Channel	1100 W
	CSA/UL General	120 V, 60 Hz	44 Channel	1000 W
			1500 VA	1250 W
	230/240 V, 50/60 Hz		1250 W	
DC Output Voltages			±19V	13 A
			+12V	8 A
			+48 V	0.7 A
Fuses		Main (x3)	6 A	250 V
		Sub (x1)	2A	250 V
Dimensions (W x H x D)		480.0 x 186.0 x 460.6 mm	18.8 x 7.3 x 18.1 inches	
Weight		36 kg	79.4 pounds	

3.3 SU4000 Optional Switching Unit Specifications

Power Requirements	No separate power supply; draws negligible power from the two PW4000 power supplies to which it is connected.	
Input Terminals	POWER SUPPLY (x2)	for PW4000
Output Terminals	CONSOLE (x1)	for any PM4000 series console
Indicator LEDs	PRIMARY	Green
	BACK UP	Orange
Dimensions (W x H x D)	480.0 x 98 x 404.2 mm	18.8 x 3.8 x 15.8 inches
Weight	Switching Unit	6.2 kg
	Cables	1.0 kg
		13.7 pounds
		2.2 pounds
Accessories	1.2 m (3.9 foot) cable (x2)	

3.4 INPUT CHARACTERISTICS

Connection	Pad	Gain Trim	Actual Load Impedance	For Use With Nominal	Input Level ³			Connector In Console ²
					Sensitivity ⁴	Nominal	Max. Before Clip	
CH INPUT 1 ~ CH ¹	0 30 0 30	-70 -20	3K ohms if electronically balanced; 1K ohms if Xlfr bal.	50 ohm to 600 ohm mics and 600 ohm lines	-86 dBu (0.039 mV) -56 dBu (0.123 mV) -36 dBu (12.3 mV) -6 dBu (388 mV)	-70 dBu (0.25 mV) -40 dBu (7.75 mV) -20 dBu (77.5 mV) +10 dBu (2.45 V)	-48 dBu (3.09 mV) -18 dBu (97.6 mV) +2 dBu (0.975 V) +32 dBu (30.9V)	XLR-3-31 type
SUB IN: GROUP 1 ~ 18 ST1 (L, R) ST2 (L, R) CUE (L, R)			10K ohms	600 ohm lines	-6 dBu (388 mV)	+4 dBu (1.23 V)	+26 dBu (15.5 V)	XLR-3-31 type
TALKBACK IN	-50 +4		3K ohms	50 – 600 ohm mics 600 ohm lines	-70 dBu (0.25 mV) -16 dBu (123 mV)	-50 dBu (2.45 mV) +4 dBu (1.23 V)	-28 dBu (30.9 mV) +26 dBu (15.5 V)	XLR-3-31 type
CH INSERT IN 1 ~ CH ¹			10K ohms	600 ohm lines	-12 dBu (195 mV)	+4 dBu (1.23 V)	+26 dBu (15.5 V)	Phone Jack (Tip/Ring/Sleeve)
GROUP 1~18 INSERT IN ST1 INSERT IN (L, R) ST2 INSERT IN (L, R)			10K ohms	600 ohm lines	-6 dBu (388 mV)	+4 dBu (1.23 V)	+26 dBu (15.5 V)	Phone Jack (Tip/Ring/Sleeve)

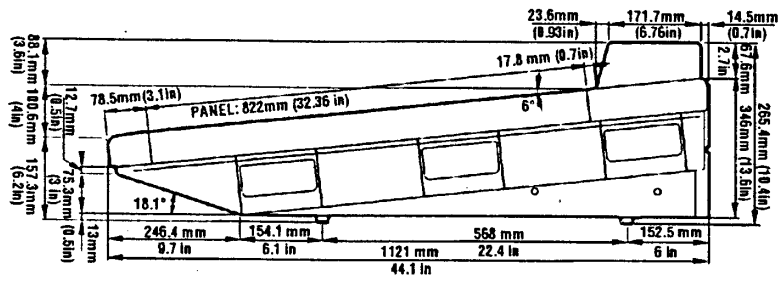
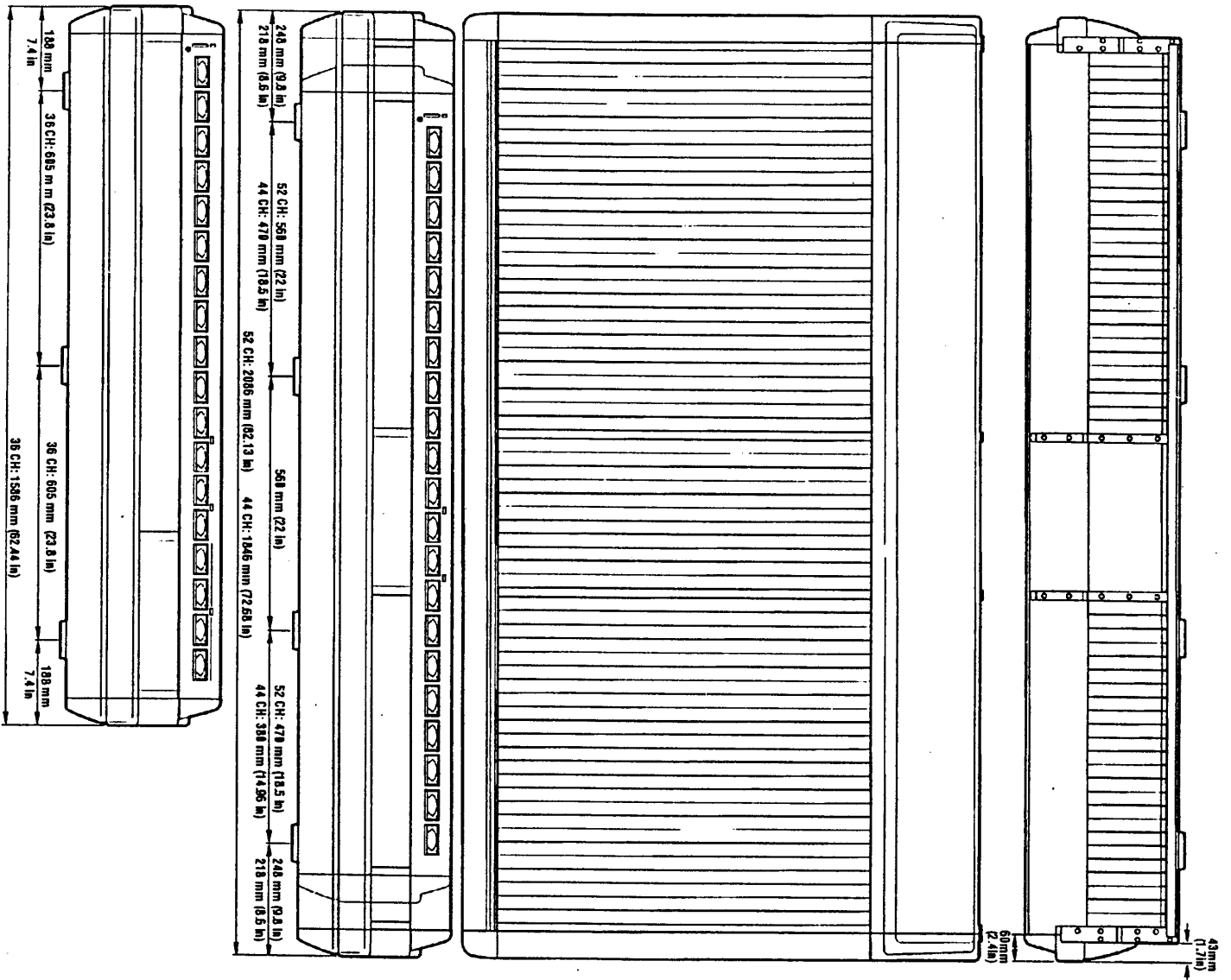
1. PM4000M – 36 = 36 Channels; –44 = 44 Channels; –52 = 52 Channels. 36 Channel version not sold in U.S.A.
2. All XLR connectors are balanced. Phone jacks are also balanced; Tip = (+), Ring = (-), Sleeve = Ground.
3. In these specifications, 0 dBu is referenced to 0.775 Vrms.
4. Sensitivity is the lowest level that will produce an output of +4 dBu (1.23V), or the nominal output level when the circuit whose sensitivity is being rated is set to maximum level.

3.5 OUTPUT CHARACTERISTICS

Connection	Actual Source Impedance	For Use With Nominal	Output Level ³		Connector In Console ²
			Nominal	Max. Before Clip	
GROUP OUT 1 ~ 18 STEREO 1 OUT L, R STEREO 2 OUT L, R CUE A & CUE B OUT 1 ~ 4 OSC OUT TALKBACK OUT	150 ohms	600 ohm lines	+4 dBu (1.23 V)	+24 dBu (12.3 V)	XLR-3-32 type
CH DIRECT OUT 1 ~ CH ¹	150 ohms	600 ohm lines	+4 dBu (1.23mV)	+24 dBu (12.3 V)	Phone Jack (T/R/S)
CH INSERT OUT: 1 ~ CH ¹ GROUP 1 ~ 18 INSERT OUT ST1 INSERT OUT L, R ST2 INSERT OUT L, R	150 ohms	10K ohm lines	+4 dBu (1.23mV)	+24 dBu (12.3 V)	Phone Jack (Tip/Ring/Sleeve)
PHONES 1, 2 OUT L, R	15 ohms	8 ohm phones 40 ohm phones	75 mW 65 mW	150 mW 150 mW	Phone Jack (T/R/S, Stereo Wired)

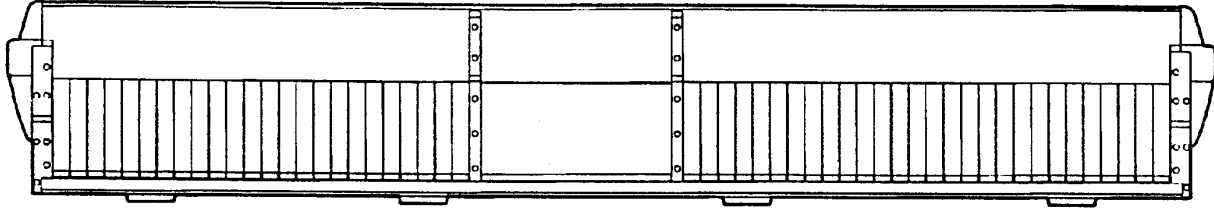
1. PM4000M – 36 = 36 Channels; –44 = 44 Channels; –52 = 52 Channels. 36 Channel version not sold in U.S.A.
2. All XLR connectors are balanced. Phone jacks (except for PHONES outputs) are balanced; Tip = (+), Ring = (-), Sleeve = Ground. PHONES output phone jacks are unbalanced T/R/S.
3. In these specifications, 0 dBu is referenced to 0.775 Vrms.

3.6 Dimensional Drawings

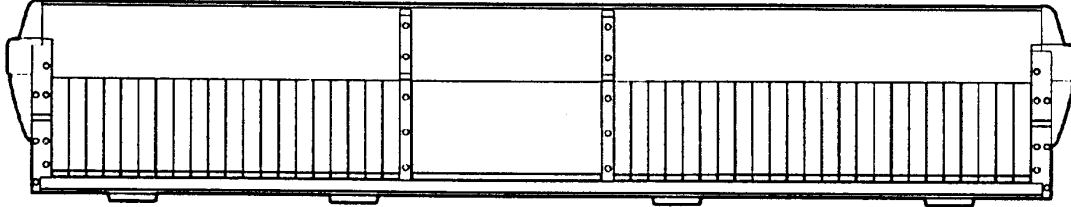


PM4000M Console (all versions)

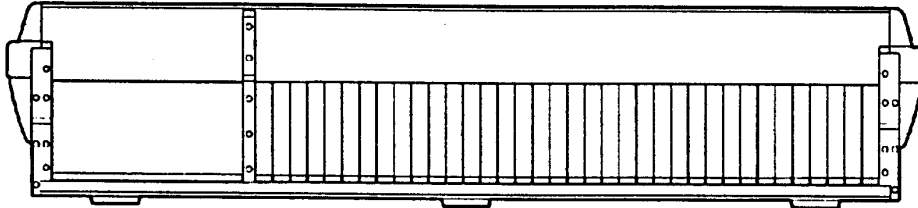
52 CHANNEL REAR PANEL

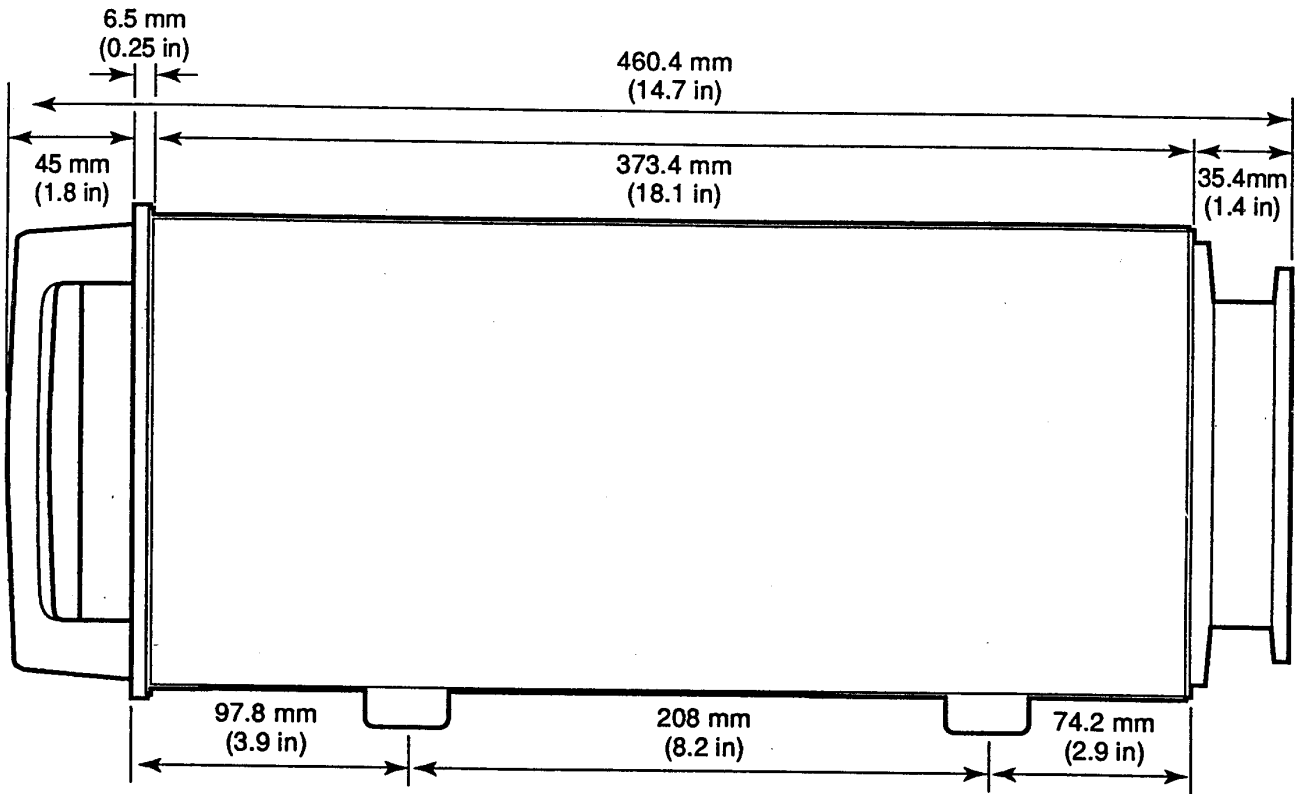


44 CHANNEL REAR PANEL

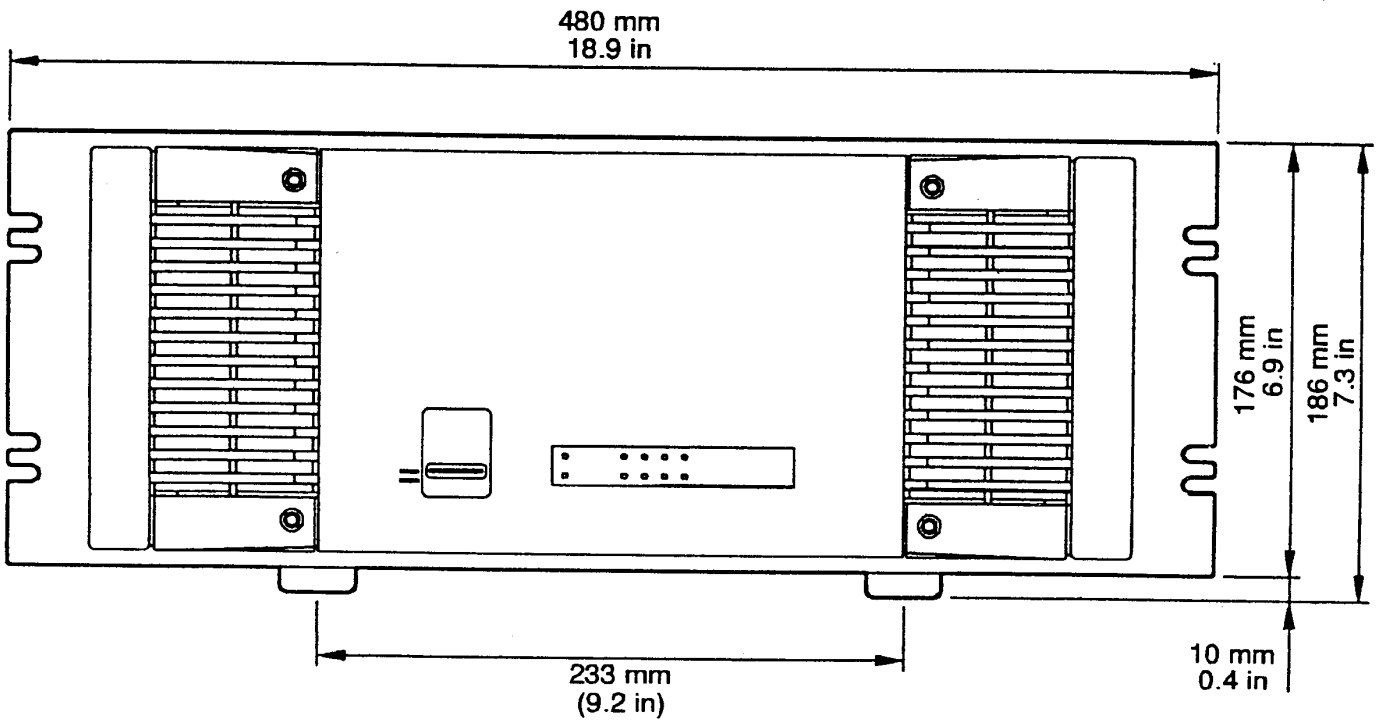


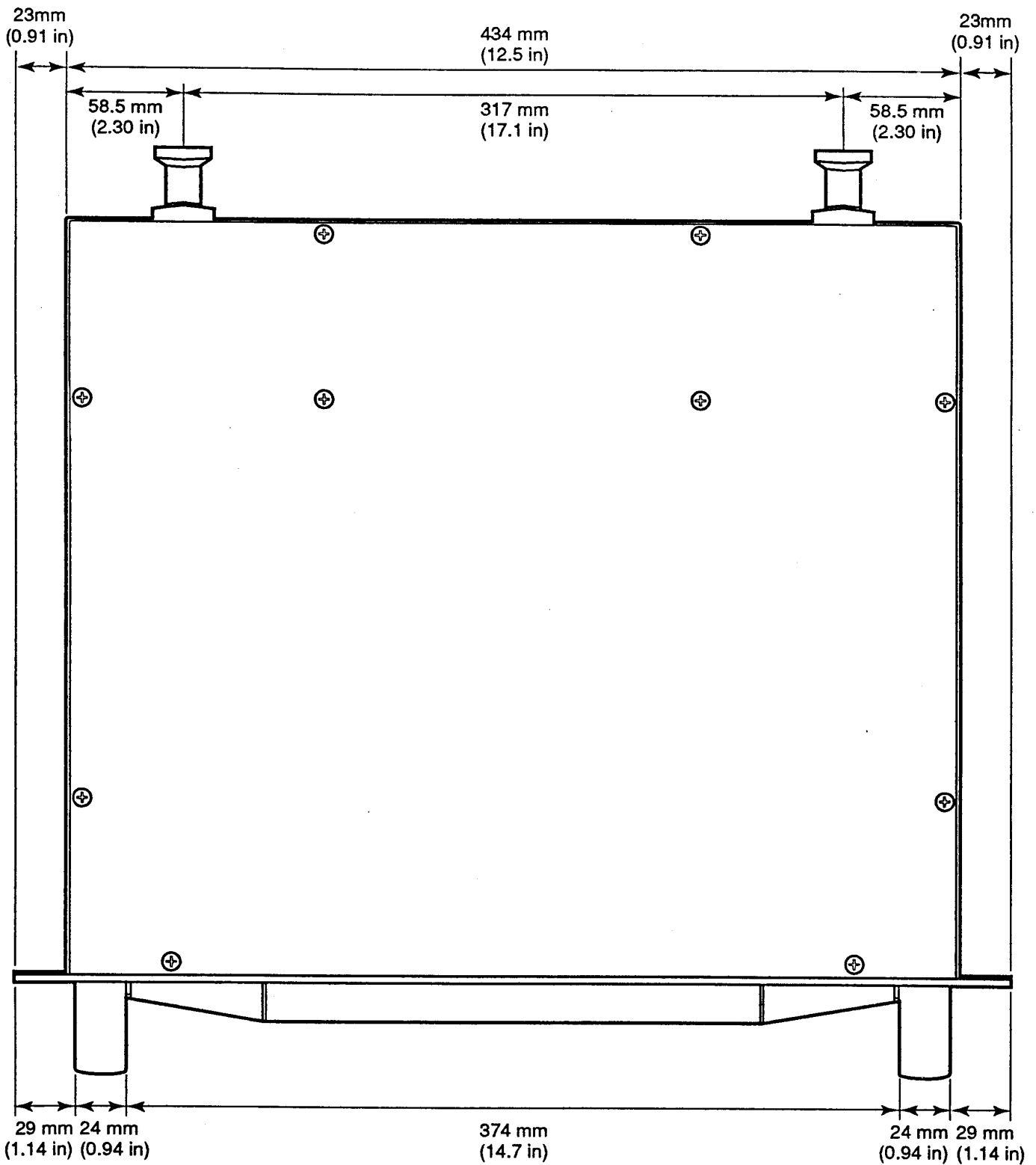
36 CHANNEL REAR PANEL



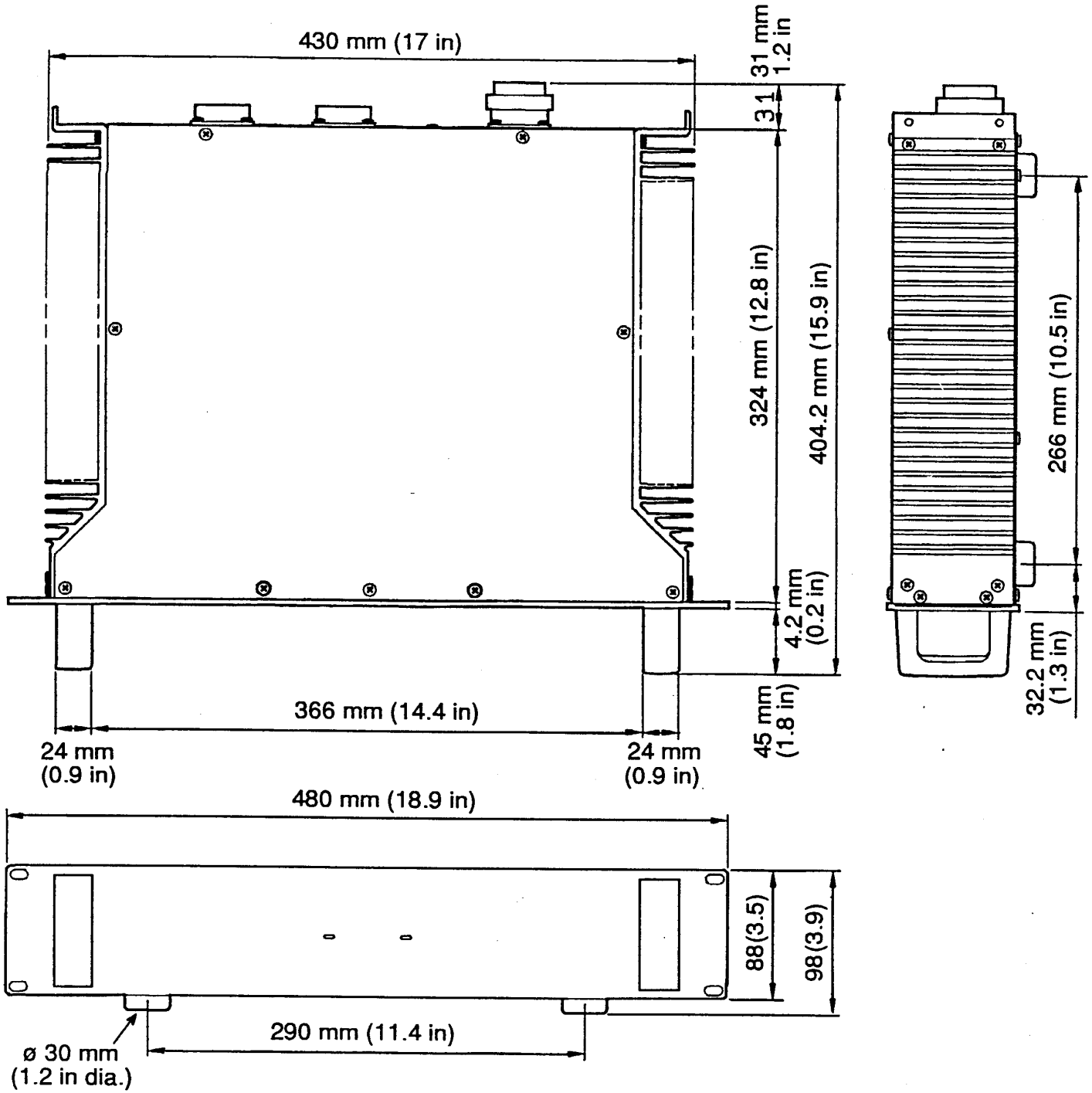


PW4000 Dimensions (side view)



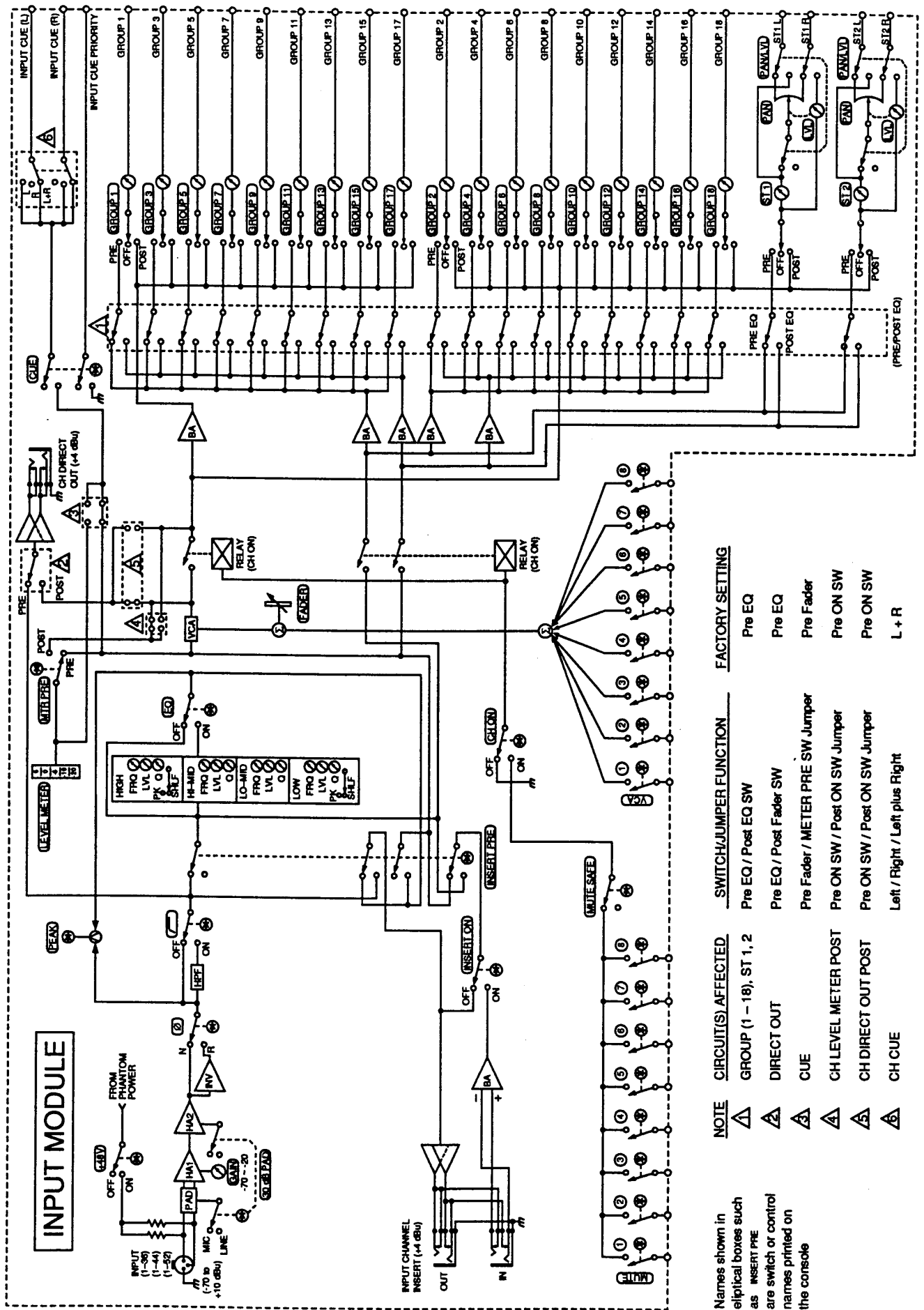


PW4000 Dimensions (top view)



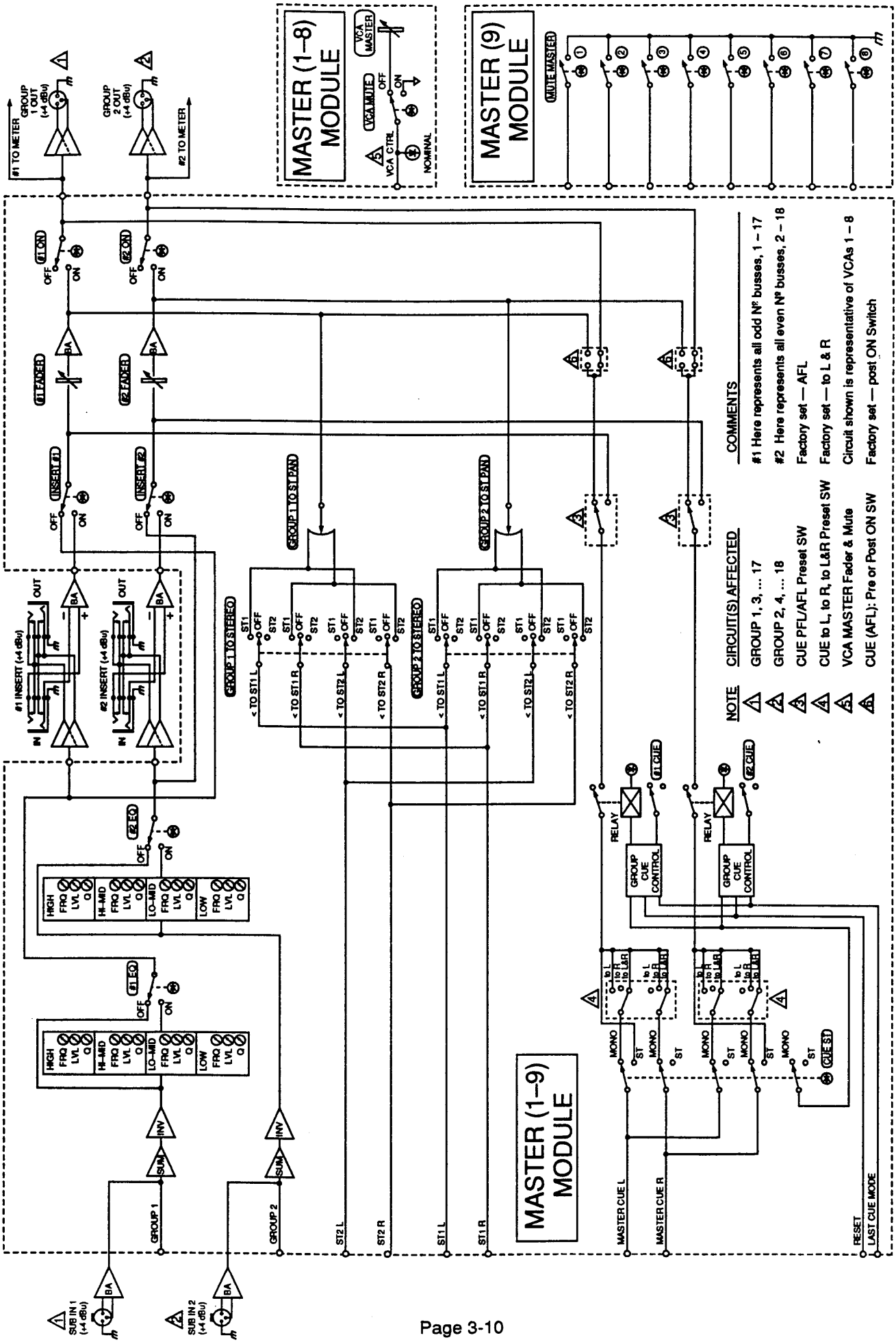
3.7 Module Block Diagrams

The following pages contain block diagrams of each module and major subsystem.



NOTE	CIRCUIT(S) AFFECTED	SWITCH/JUMPER FUNCTION	FACTORY SETTING
△	GROUP (1 - 18), ST 1, 2	Pre EQ / Post EQ SW	Pre EQ
△	DIRECT OUT	Pre EQ / Post Fader SW	Pre EQ
△	CUE	Pre Fader / METER PRE SW Jumper	Pre Fader
△	CH LEVEL METER POST	Pre ON SW / Post ON SW Jumper	Pre ON SW
△	CH DIRECT OUT POST	Pre ON SW / Post ON SW Jumper	Pre ON SW
△	CH CUE	Left / Right / Left plus Right	L + R

Names shown in
 eliptical boxes such
 as INSERT PRE
 are switch or control
 names printed on
 the console



COMMENTS

#1 Here represents all odd N^o buses, 1 - 17

#2 Here represents all even N^o buses, 2 - 18

Factory set — AFL

Factory set — to L & R

Circuit shown is representative of VCAs 1 - 8

Factory set — post ON Switch

NOTE

CIRCUIT(S) AFFECTED

GROUP 1, 3, ... 17

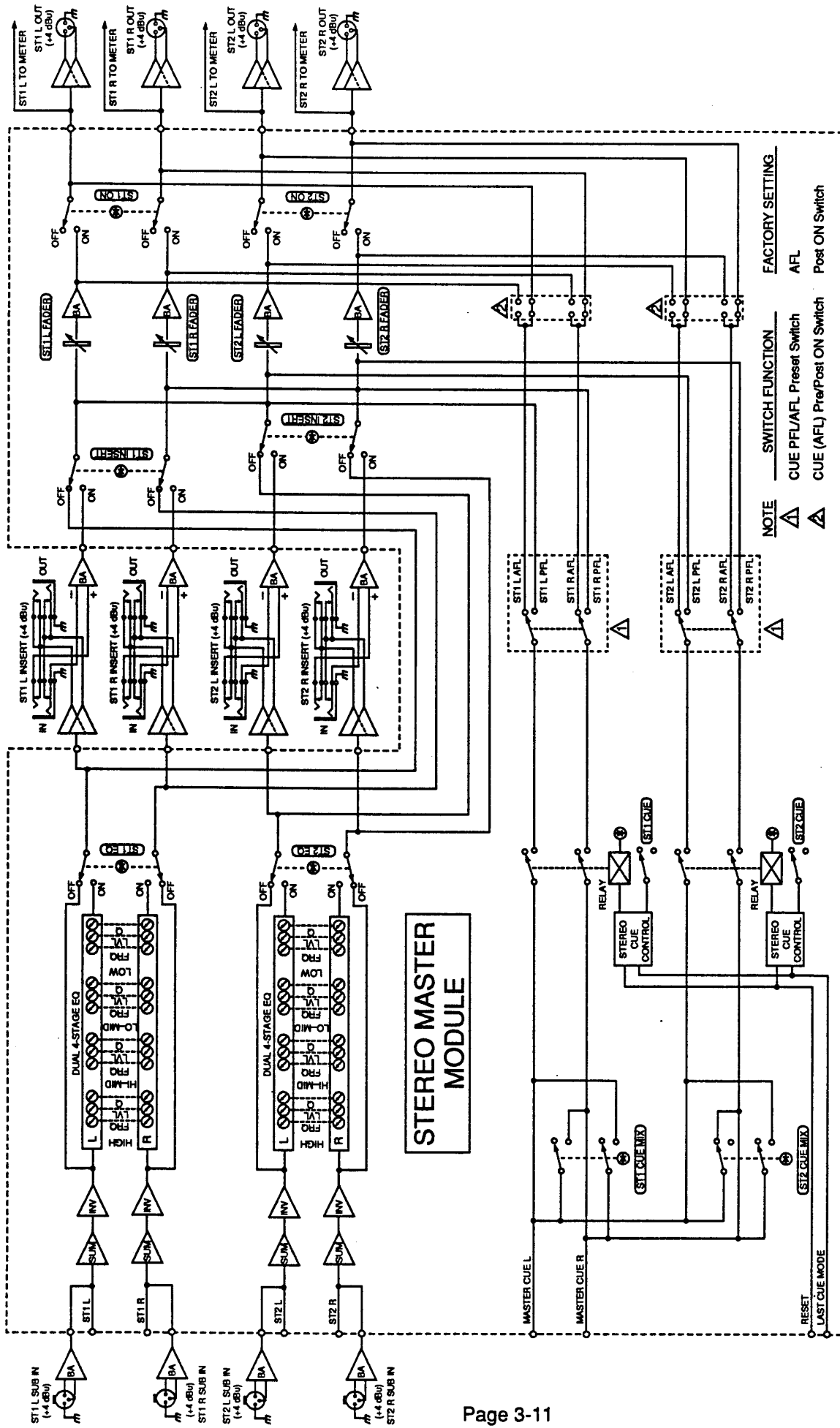
GROUP 2, 4, ... 18

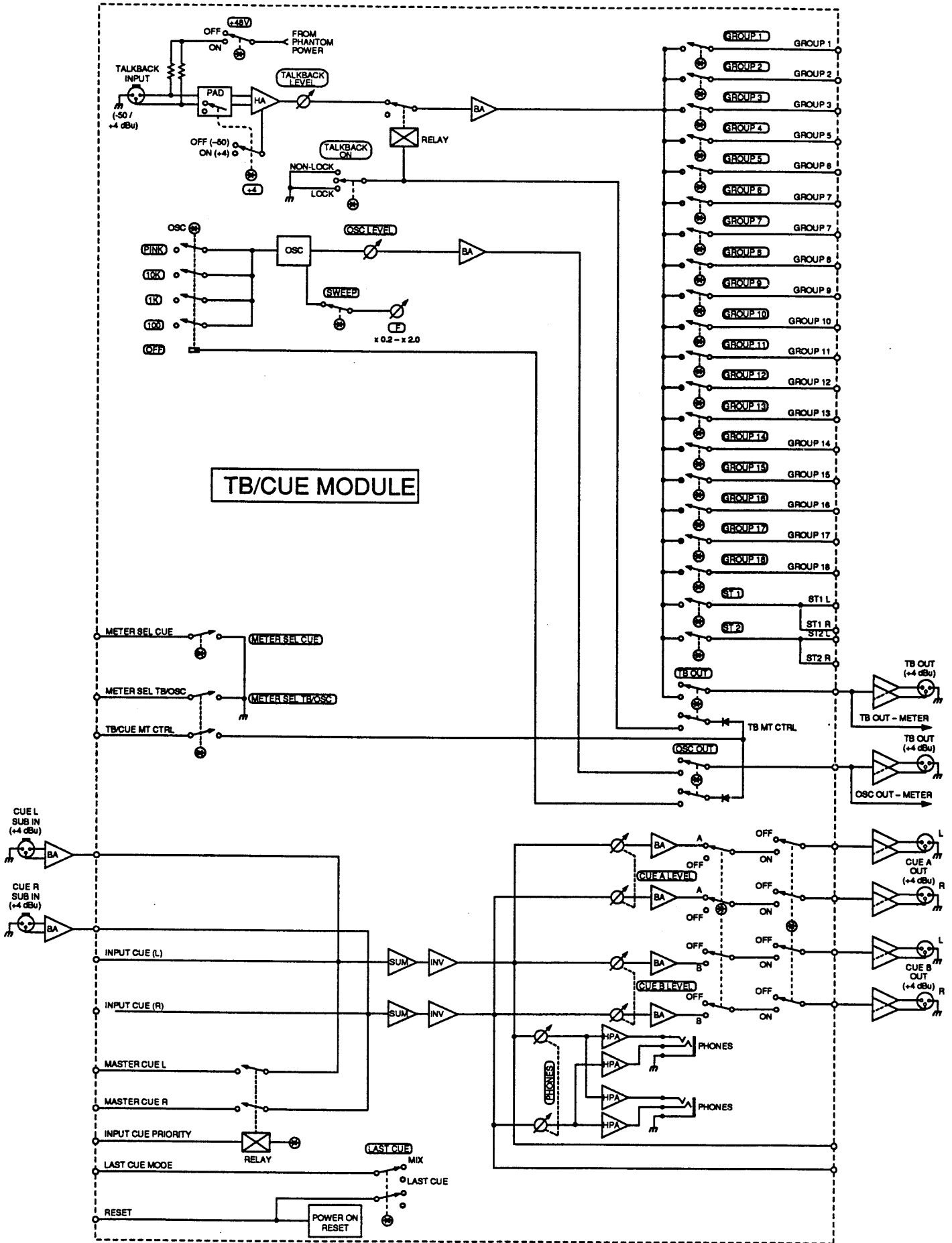
CUE PFL/AFL Preset SW

CUE to L, to R, to L&R Preset SW

VCA MASTER Fader & Mute

CUE (AFL): Pre or Post ON SW

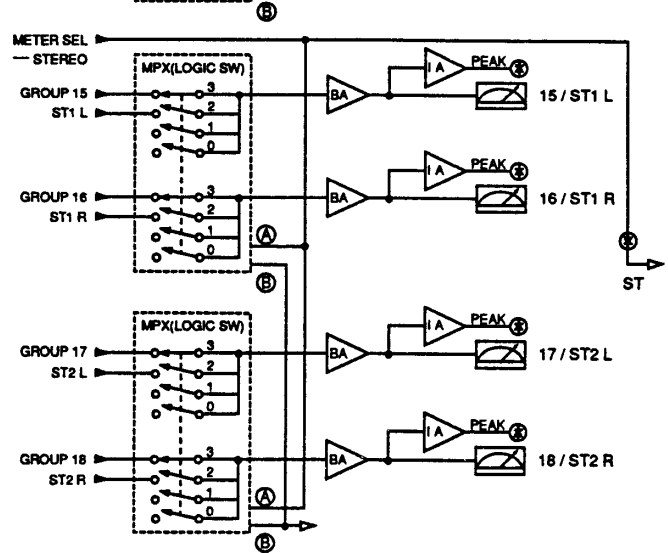
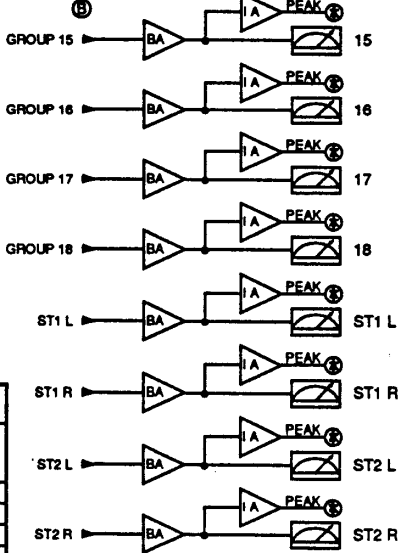
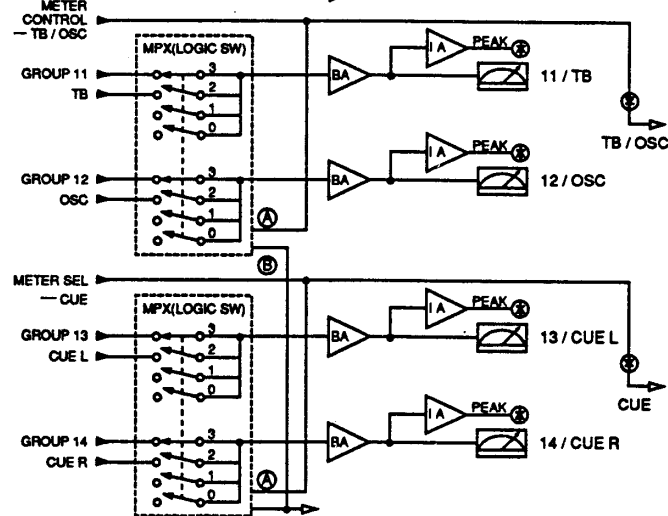
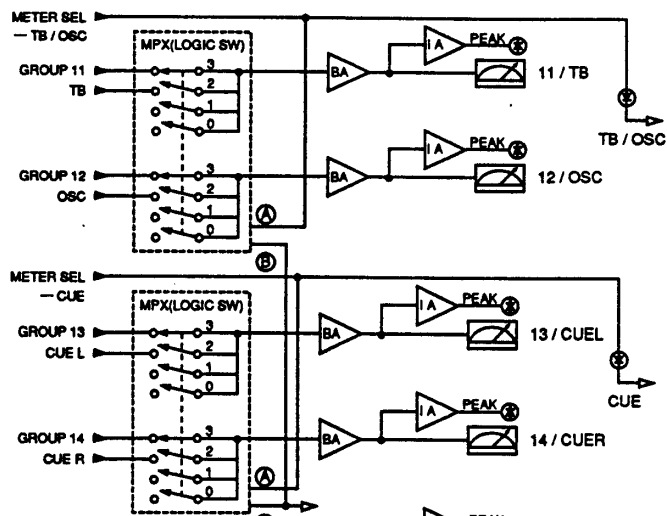
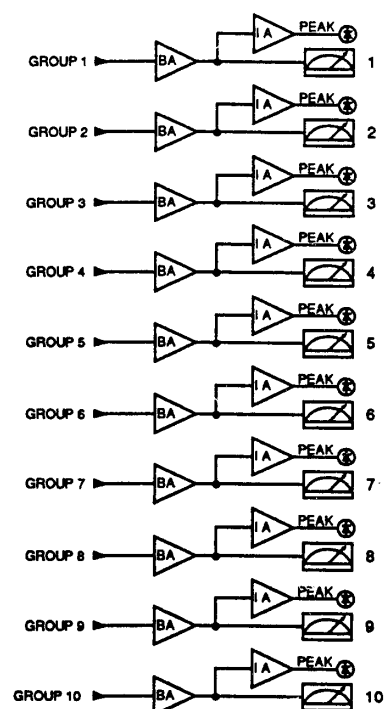
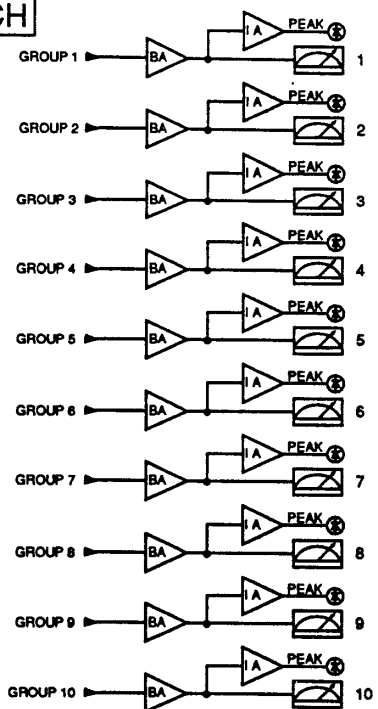




44 CH, 52 CH

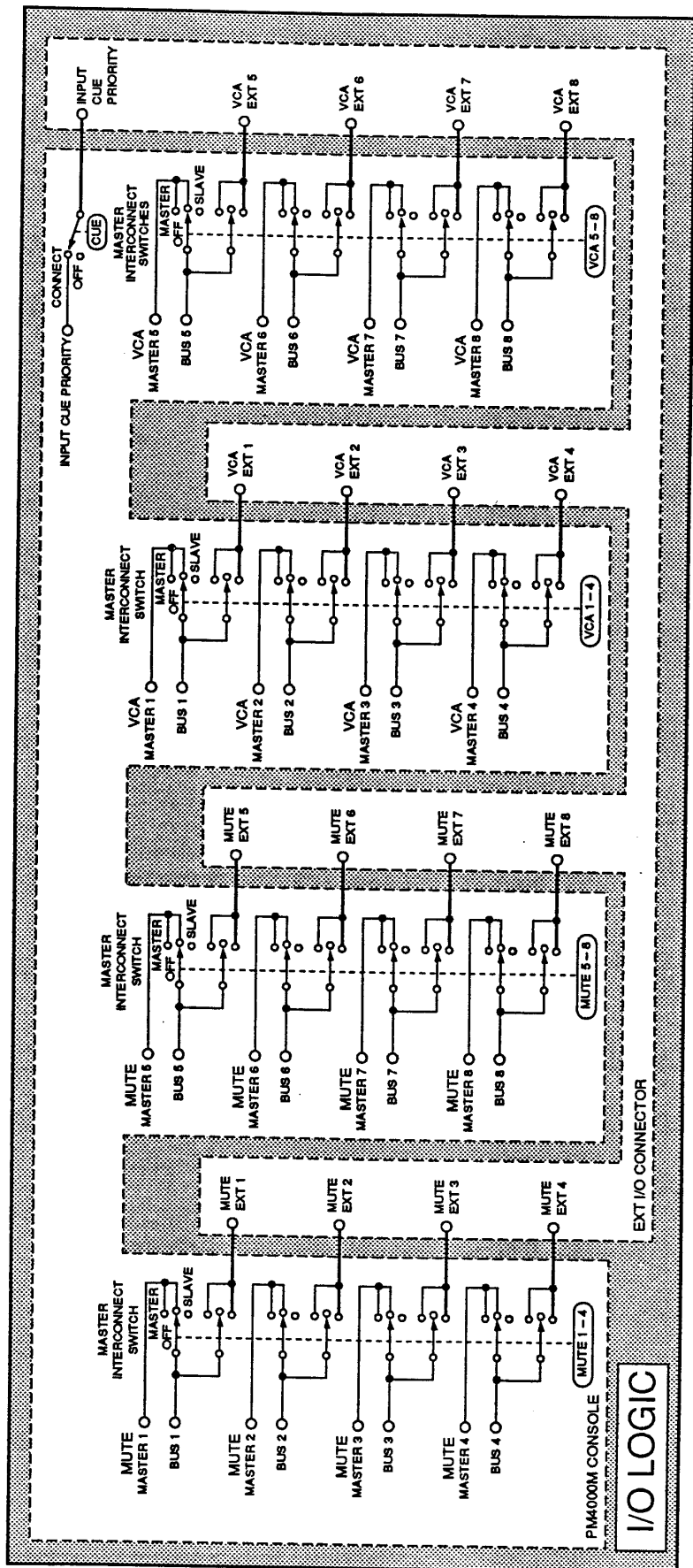
VU METERS

36 CH

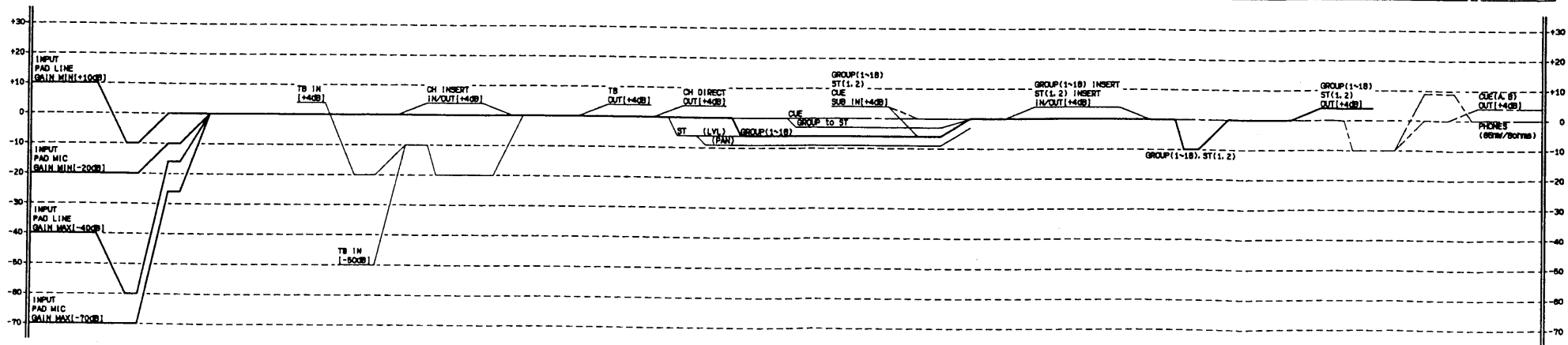
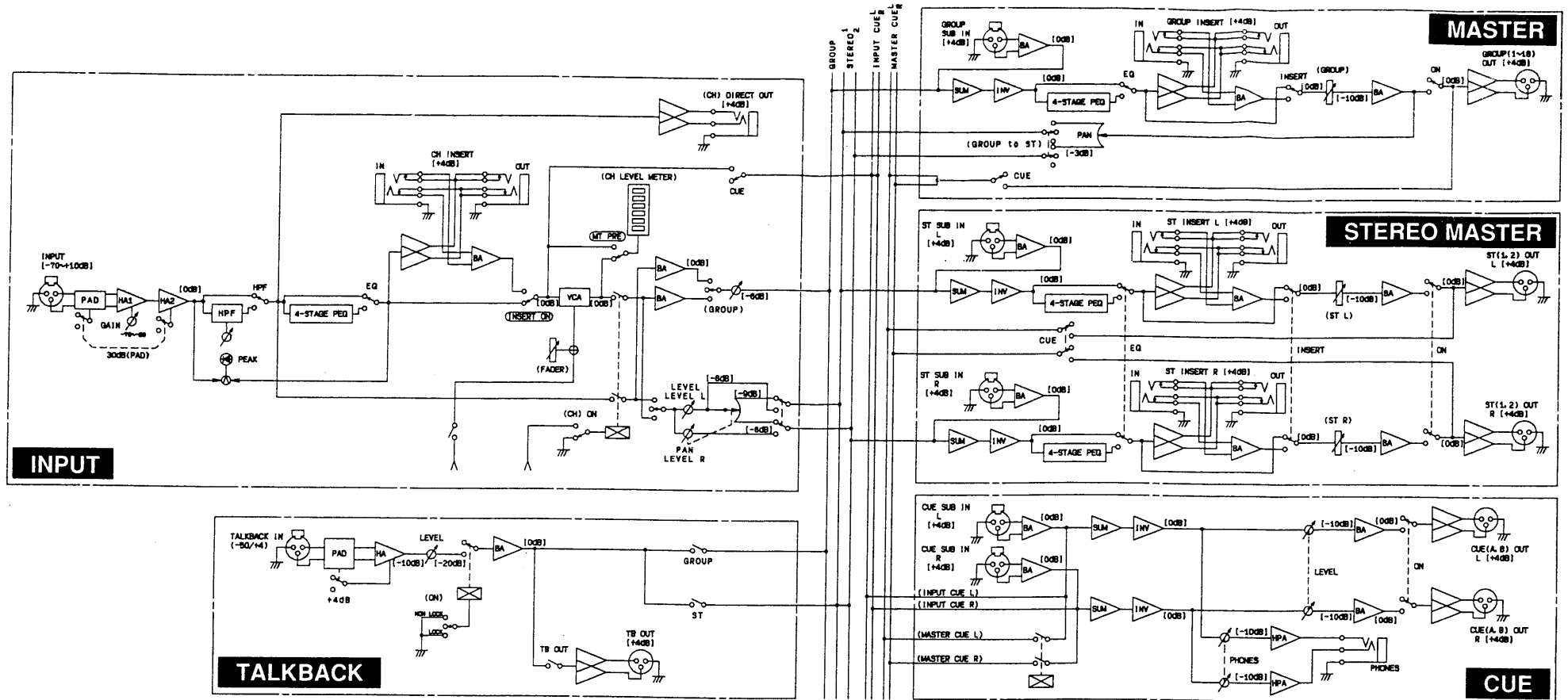


MPX SWITCH LOGIC TRUTH TABLE

LOGIC SIGNALS		SWITCH TURNED ON
(A)	(B)	
HI	HI	3
LO	HI	2
HI	LO	1
LO	LO	0



3.8 Block and Level Diagram



Section 4.

Installation Notes

4.1 Planning An Installation

Before installing the PM4000M, it is worthwhile considering how it will be used, how it is going to be connected, and what is the best way to implement the installation.

To begin with, there must be a surface upon which the console can be mounted. A desk or table can be utilized to support the console. It should be capable of supporting at least the weight of the console (see the specifications in Section 3) plus a human console operator leaning on the arm rest; the sturdier, the better. There should be adequate access behind the console to allow for cable connections and "service loops" of extra cable so that the console can be moved without disconnecting everything. For custom installations, the dimensions listed in the Section 3 of this manual can be given to the carpenter or other personnel responsible for building the console support.

Be sure to provide a location within 10 feet (3.5 meters) of the console for housing the PW4000 power supply. This supply may be rack mounted, or it may be placed on a shelf. For touring or critical fixed applications, it may be advisable to purchase a spare PW4000 supply and to mount it next to the main supply; automatic changeover is then possible in the rare event of a problem.

Experienced sound system installers will prepare a detailed block diagram of the entire sound system prior to installation. They will figure out all the necessary cables, where they run, and the required length so that the cables can be prepared ahead of time. In fixed installations, this will enable appropriate conduit to be installed (be sure to allow some extra "breathing room" in the conduit to allow for cable replacement or future additions. For open-air installations, such as outdoor amphitheatres, there is no substitute for waterproof conduit (it excludes moisture in the event of rain or when the venue is washed down, thereby preventing deterioration and short circuit of audio and power cables).

4.2 Power Mains

4.2.1 Verify The Correct Mains Voltage

PW4000 power supplies sold in the U.S.A. and Canada are designed to operate with 110 to 120 volt, 50 or 60 Hz AC power mains. The General Export model operates on 220 to 230 volt, 50 or 60 Hz AC mains. The British model operates on 240V AC mains. If you are traveling with this equipment, be sure to test the power mains, and to use the appropriate power supply. Consult your Yamaha PM4000M dealer for assistance.

4.2.2 Ensure There is a Good Earth Ground

The console must be grounded for safety and proper shielding. A 3-wire power cable is provided for this purpose. Use a special circuit tester to insure that the outlet is properly grounded, and that the "neutral" is not weak or floating. If a grounded, 3-wire outlet is not available, or if there is any chance the outlet may not be properly grounded, a separate jumper wire must be connected from the console chassis to an earth ground.

In the past, cold water pipes often were relied upon for an earth ground, although this is no longer the case in many localities. Modern building codes often specify that the water meter be isolated from the water mains by a length of plastic (PVC) pipe; this protects water company personnel working on the water mains from being shocked. It also insulates the cold water pipes from the earth ground. While an electrical wire bypasses the water meter in some locations, this ground path should not be assumed. For similar reasons, avoid hot water pipes. Gas pipes should not be used because if there is a poor electrical connection between two sections of pipe, and if a ground current is being dissipated through the pipe, there exists the potential for a heat or spark-generated fire or explosion. The safest and most reliable approach is to provide your own ground. Drive at least 5 feet (1.5m) of copper pipe into moist, salted earth, and use that for a ground, or use one of the specially made chemical-type ground rods available for this purpose.

CAUTION: Connect the PW4000 power supply to the power mains only after confirming that the voltage and line frequency are correct. At the least, use a

voltmeter. It is also a good idea to use a special outlet tester that will also indicate reversed polarity, weak or missing neutral, and weak or missing ground connections in the outlet. Test the power supply before connecting the umbilical cable to the console.

Severe over voltage or under voltage in the power mains can damage your equipment. For U.S.A. and Canadian models, the power line must measure more than 105V and less than 130V RMS. The tolerance for General Export models is plus or minus 10%. Some lines are "soft," meaning that the voltage drops when the line is loaded due to excessive resistance in the power line, or too high a current load on the circuit. To be certain the voltage is adequate, check it again after turning on the PW4000 with the PM4000M connected, and with any power amplifiers turned on if they are connected to the same power mains.

If the power line voltages do not fall within the allowable range, do not connect the PW4000 to the mains. Instead, have a qualified electrician inspect and correct the condition. Failure to observe this precaution may damage the power supply and console, and will void the warranty.

NOTE: The following discussions of AC outlet wiring are written for U.S.A. and Canadian power systems, although the principles generally apply worldwide. In other areas, however, be sure to check local codes for specific wiring standards.

4.2.3 How To Obtain a Safety Ground When Using a 2-wire Outlet

Two-wire AC outlets do not have a hole for the "safety ground" prong of a 3-wire power cord. A two-wire to three-wire AC adaptor is required if you want to use one of these two-wire outlets with the three-wire AC plug on your sound equipment. These adaptors can maintain a safe ground for the sound system if you connect the loose green wire on the adaptor to a grounded screw on the two-wire outlet. How do you know whether or not the screw is grounded?

1. Connect the adaptor's green wire to the screw on the two-wire outlet.
2. Plug the adaptor into the outlet.
3. Plug in your three-wire AC outlet tester into the adaptor. The AC outlet tester will indicate whether the screw is grounded.

If the screw is not grounded, connect the adaptor's green wire to some other ground point in order to maintain a safe ground for your system. If the outlet tester indicates a good ground but reversed polarity on your two-wire to three-wire adaptor, sometimes you can reverse the adaptor in the outlet by pulling it out, twisting it a half-turn and reconnecting it; this may not be possible if the outlet or adaptor is "polarized" with one prong larger than the other.

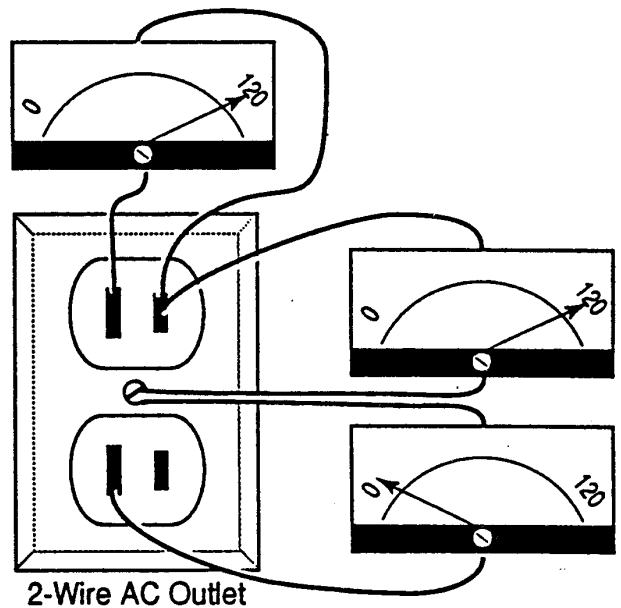


Figure 4-1. Testing a 2-wire AC Outlet

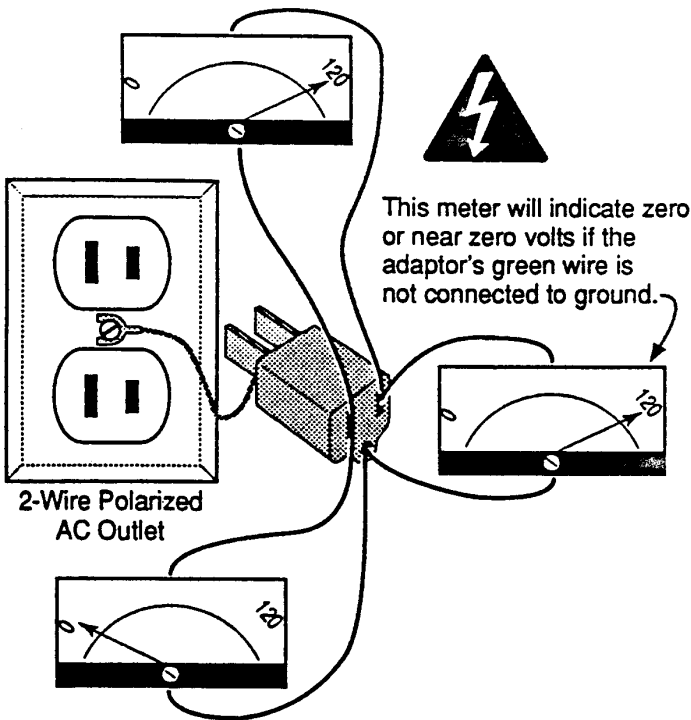


Figure 4-2. Testing a 2-wire AC Outlet and a 3-Prong to 2-Prong Adaptor

4.2.4 Improperly Wired AC Outlets: Lifted Grounds

A "lifted ground" condition exists if the ground or green wire from the outlet's safety ground is disconnected or missing. In older wiring, the heavy green wire was sometimes omitted from internal wall wiring in favor of letting the metal flex conduit or pipe suffice as the ground path from the electrical service entrance. This method of grounding is generally acceptable, as long as the metal conduit in the wall is intact and all the screws holding the joints together are secure. However, a single loose screw in a conduit joint inside a wall can remove the safety ground from the next outlet box in the line, and from all the subsequent boxes on that same line.

4.2.5 Improperly Wired AC Outlets: Lifted Neutral

If the neutral becomes lifted at a power outlet, it is possible that items plugged into the outlet will be fed the full 220 to 240 volts available from the power service instead of the desired 110 to 120 volts.

Such outlets may operate, but the voltage can swing from 0 volts to 220 or 240 volts AC (or whatever the maximum voltage at the service entrance), creating a shock hazard and possibly damaging your equipment.

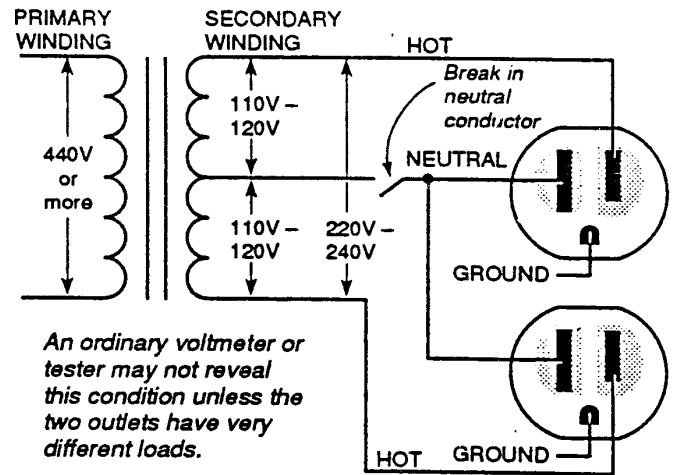


Figure 4-3. Schematic of an Outlet With a Lifted Neutral

If the PW4000 is plugged into one socket of the two outlets with lifted neutral, and a rack of signal processing equipment or power amplifiers is plugged into the other, fuses would probably blow upon turning on the system, and some of the sound equipment could be destroyed.

If you detect any voltage between the larger slot (white wire) in an outlet and the ground terminal (round prong, green wire) when there is no load on that line, you should contact a licensed electrician to check it out and correct the situation.

WARNING: In AC power wiring, black is hot, and white is neutral—the opposite of most audio signal wiring and speaker wiring. It is safer to consider all AC wiring as potentially lethal. It is possible someone miswired the system, or that a short circuit has developed. Test the voltages yourself, and be safe.

Although the white wires (neutral) and the green wires (ground) in the AC wiring are technically at the same potential (voltage), and should measure the same potential using a voltmeter, the ground prong connections at the outlets should be connected to the grounding bar that was driven into the earth as an additional safety precaution in case something should happen to the wires running from the service entrance transformer to the building or within the equipment itself. If a short should occur within the equipment, hopefully the electricity will find its

way to ground via the safety ground, instead of via a person's body. When checking AC power lines at the outlet, be sure you have proper testing tools and some familiarity with the danger of shock hazards from AC power. Follow the diagram shown here, being careful not to touch metal with your hands. Do not short the test leads together. If you are not familiar with AC power distribution, don't experiment; have a licensed electrician perform these tests and correct any discrepancies.

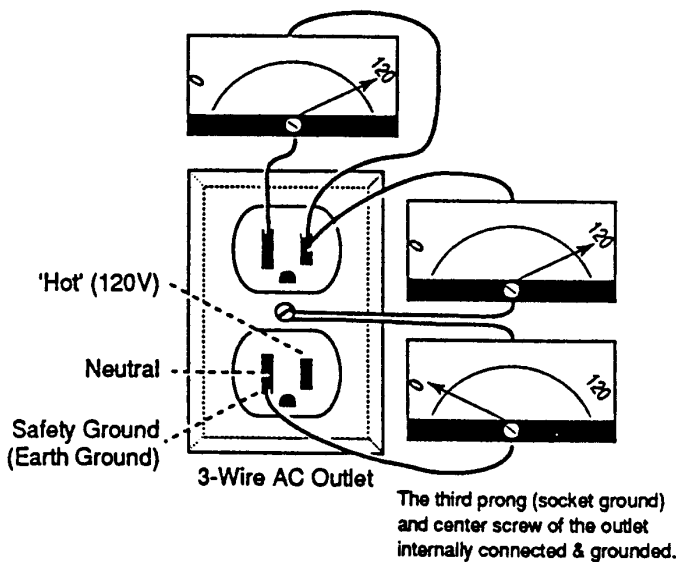


Figure 4-4. Testing A 3-wire AC Outlet

4.2.6 AC Safety Tips

1. If you are going to verify the quality of AC wiring, there are two inexpensive items you should carry. One of these is a commercial outlet tester, the other is a neon lamp type AC voltage tester. These items are inexpensive and available at most hardware stores, electrical supply houses and some lighting stores. It is advisable to also have an RMS (or averaging) voltmeter to measure the exact AC line voltage.
2. The outlet tester should be used on all power outlets. The neon voltage tester should be used to check for voltage differences between microphone and guitar amps, microphones and electric keyboard chassis, and so forth.
3. If you're not sure whether an outlet is good, don't use it. Just in case, carry a long, heavy duty extension cord. A good extension should be made of

#12-3 (12 gauge, 3 wires), and no longer than 15 meters (about 50 feet).

4. If there is no suitable power source at a venue, don't plug in your equipment. Any fault in the wiring of the AC outlet is potentially hazardous. Rather than take a chance with damage to equipment and possibly lethal shock, it is best to refuse to use a faulty outlet until it has been repaired by a licensed electrician. Don't take unnecessary risks.

4.2.7 Power Source Integrity

Finally, make every effort to assure that your source of power is clean and reliable. Synthesizers, computer sequencers and other digital equipment, in particular, normally require a filtered power source with surge protection in order to avoid glitches, system hangups and possible component damage. Power distribution strips with such protection built in are widely available commercially. The ultimate protection is provided by using a power line isolation transformer, such as the "Ultra Isolation" transformers sold by Topaz. Such devices are designed not only to exclude noise and distortion in the AC signal, but also to hold the voltage at the device's output to a nearly constant value regardless of major fluctuations of the line voltage at its input.

4.2.8 Turn-On Sequencing

In larger systems, it is often difficult to obtain a sufficient number of 20-amp circuits to accommodate the power surges that may occur when the equipment is turned on. Many modern power amplifiers, for example, each require the full capacity of a 20-amp circuit at turn-on, though their operating current requirement is usually much lower. The solution to this problem is to use a stepped turn-on sequence; in fixed installations, the turn-on sequence is sometimes automated with timing and control circuitry.

4.3 Theory of Grounding

Grounding is an area of “black magic” for many sound technicians and engineers, and certainly for most casual users of sound systems. Everyone knows that grounding has something to do with safety, and something to do with hum and noise suppression, but few people know how to set up a proper AC power distribution system, and how to connect audio equipment grounds so that noise is minimized. This subsection of the manual won’t make anyone an expert, but it does point out a few of the principles and precautions with which everyone should be familiar. Whether you read this material or not, before you start cutting shields and lifting grounds, read this warning:

WARNING: In any audio system installation, governmental and insurance underwriters’ electrical codes must be observed. These codes are based on safety, and may vary in different localities; in all cases, local codes take precedence over any suggestions contained in this manual. Yamaha shall not be liable for incidental or consequential damages, including injury to any persons or property, resulting from improper, unsafe or illegal installation of a Yamaha mixing console or of any related equipment; neither shall Yamaha be liable for any such damages arising from defects or damage resulting from accident, neglect, misuse, modification, mistreatment, tampering or any act of nature. (IN PLAIN WORDS... IF YOU LIFT A GROUND, THE RESULTING POTENTIAL FOR ELECTRICAL SHOCK IS YOUR OWN RESPONSIBILITY!)

Never trust any potentially hazardous system, such as an AC power system of any type, just because someone else tells you that it’s okay. People can get killed by faulty or improperly wired sound equipment, so be sure you check things out yourself.

Ground is the electrical reference against which potentials (voltages) are expressed. In a practical audio system, a number of different independent references exist in various local subsystems. These may or may not be at the same electrical potential. If handled properly, they certainly need not be at the same potential.

For purposes of clarity in discussing audio connection practices, we will distinguish among three specific ground references:

- **Signal Ground** — the reference point against which signal potentials in a specific piece of equipment or group of components are expressed.
- **Earth Ground** — the local electrical potential of the earth. In practice, earth is the potential of the central, rounded terminal in a U.S. standard three-prong 120-volt outlet. Earth is sometimes obtained from a metal cold water pipe (though this practice has been criticized recently as unreliable due to increasing use of non-conductive ABS plastic pipe sections), or from a chemical earthing rod sunk into the moistened ground.
- **Chassis Ground** — the chassis connection point of a specific component. In equipment fitted with a three prong AC plug, the chassis is normally connected to earth, with provision to connect signal ground to earth as well. Equipment having a two prong AC plug will normally have the chassis connected to signal ground.

As we will see, connections among these various reference points are an all-important factor in assembling a successful audio system.

4.3.1 Why Is Proper Grounding Important?

In practical operating environments, any signal conductor is susceptible to induced currents from several types of sources such as radio frequency (RF) emissions, AC power lines, switching devices, motors and the like. This is why audio signal cables are invariably shielded. The function of the shield is to intercept undesirable emissions. A major goal of grounding technique is to keep unwanted signal currents that are induced in the shield away from the signal conductor(s), and drain them to ground as directly as possible.

Beyond minimizing noise and hum, an equally important consideration in grounding is safety. The connection between a chassis and earth is commonly referred to as a safety ground – and with good reason. Consider the possibility that a chassis might become connected to the hot leg of the AC mains (120 volts RMS AC) due to faulty wiring, an inadvertent short or moisture condensation. Suddenly, that innocuous looking box could be transformed into what engineers gruesomely call a widow maker. Someone who is touching a grounded guitar, mic stand, or other equipment will complete the circuit when touching the now electrically charged chassis, and receive the full brunt of whatever power is available. If the chassis is connected to earth, it will simply blow a fuse or circuit breaker.

Dangerous potential differences can also occur without such shorts. Two individual localized ground points, if they are not directly connected, cannot be assumed to be at the same potential – far from it, in fact. Virtually anyone who has played in a band has, at one time or another, experienced a shock when touching both the guitar and the microphone. The guitar may be grounded onstage while the mic is grounded at the console on the other side of the room but the two grounds are at very different potentials. By completing the circuit between them, the performer gets zapped. Good grounding practice seeks to control such potential differences for the comfort and longevity of all concerned.

4.3.2 Ground Loops

AC line-frequency hum is, without question, the single most common problem in sound systems, and the most common cause of hum is ground loops.

A ground loop occurs when there is more than one ground connection path between two pieces of equipment. The duplicate ground paths form the equivalent of a loop antenna which very efficiently picks up interference currents, which are transformed by lead resistance into voltage fluctuations. As a consequence, the reference in the system is no longer a stable potential, so signals ride on the interference.

Ground loops often are difficult to isolate, even for

experienced audio engineers. Sometimes, in poorly designed sound equipment (which sometimes includes expensive sound equipment), ground loops occur inside the chassis even though the equipment has balanced inputs and outputs. In this instance, little can be done to get rid of the hum short of having a skilled audio engineer redesign the ground wiring inside. It's better to avoid this kind of equipment. It is also best to avoid unbalanced equipment in professional sound systems (unless the equipment is all going to be very close together, connected to the same leg of the AC service, and not subject to high hum fields).

If all connections are balanced and the equipment is properly designed and constructed, such ground loops will not induce noise. Unfortunately, much of the so-called professional sound equipment sold today is not properly grounded internally, so system-created ground loops can create very real problems.

Figure 4-5 shows a typical ground loop situation. Two interconnected pieces of equipment are plugged into grounded AC outlets at separate locations, and signal ground is connected to earth in each of them. The earth ground path and duplicate signal ground path form a loop which can pick up interference. Normally, this kind of ground loop should not cause any noise in the audio circuits if (a) the circuits are truly balanced or floating, and (b) the audio common is maintained separately from the chassis ground within the equip-

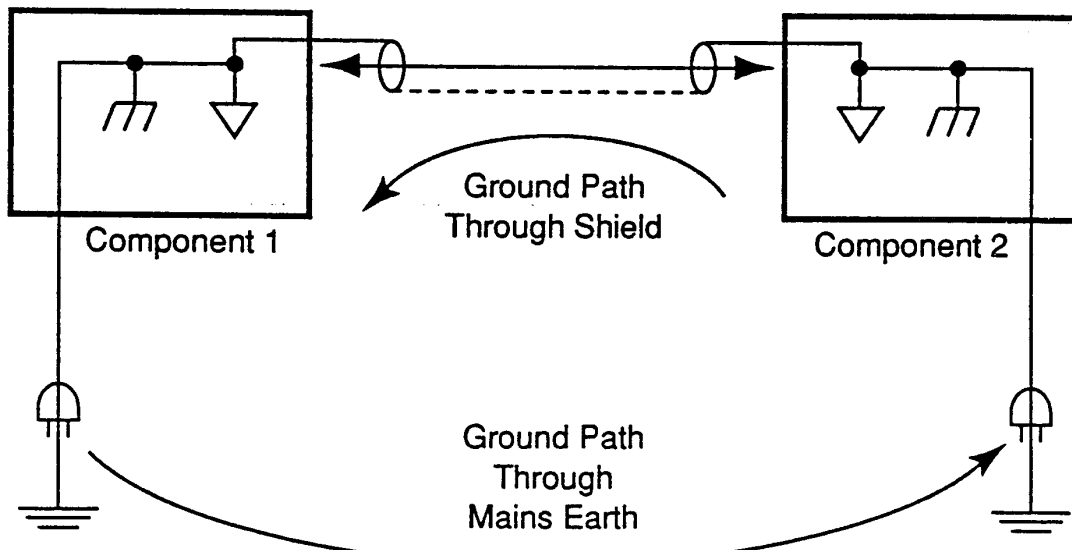





Figure 4-5. Formation of Ground Loops

 = Signal Ground	 = Mains Earth	 = Chassis Ground
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Key for Figure 4-5 through 4-10

ment. If one of these conditions is not met, then instead of going directly to earth ground and disappearing, these circulating ground loop noise currents (which act like signals) travel along paths that are not intended to carry signals. The currents, in turn, modulate the potential of the signal-carrying wiring (they are superimposed on the audio), producing hum and noise voltages that cannot easily be separated from program signals by the affected equipment. The noise is thus amplified along with the program material.

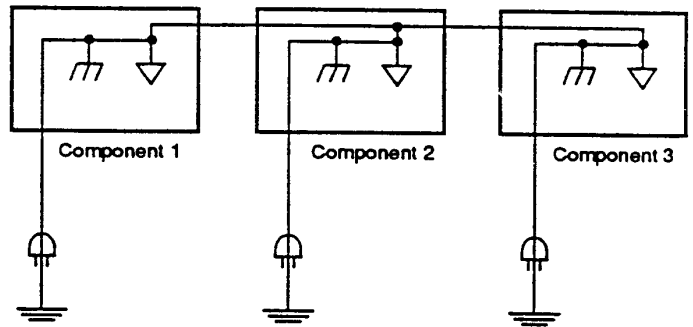


Figure 4-7. Multiple-Point Grounding

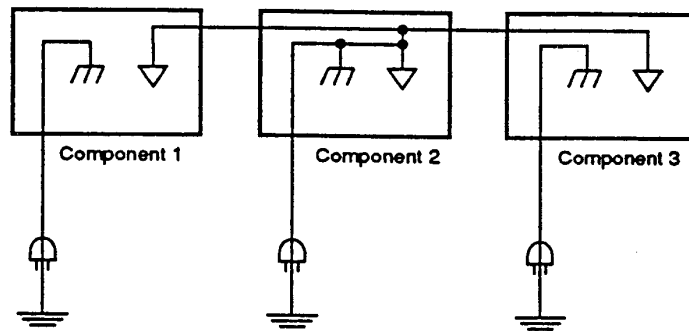


Figure 4-6. Single-Point Grounding

4.3.3 Basic Grounding Techniques

We will discuss four basic approaches to handling grounds within audio systems: single point, multiple point, floating, and telescoping shield. Each has specific advantages in different types of systems.

Figure 4-6 illustrates the single-point grounding principle. Chassis ground in each individual component is connected to earth; signal ground is carried between components and connected to earth at one central point. This configuration is very effective in eliminating line frequency hum and switching noise, but is most easily implemented in systems (or subsystems) that remain relatively fixed. Single point grounding is very often used in recording studio installations. It is also effective in the wiring of individual equipment racks. It is almost impossible to implement in complex, portable sound reinforcement systems.

Multiple point grounding is shown in Figure 4-7. This situation is common in systems that use unbalanced equipment having the chassis connected to signal ground. It has the advantage of being very simple in practice, but it is not very reliable – particularly if the connection configuration of the system is changed frequently. Multiple point grounding systems which include unbalanced equipment are inherently rife with ground loops. Hum and noise problems can appear and

disappear unpredictably as pieces of equipment are inserted or removed. When they appear, problems are very difficult to isolate and fix. Multiple point ground systems that employ balanced circuits with properly designed equipment may present no special noise problems.

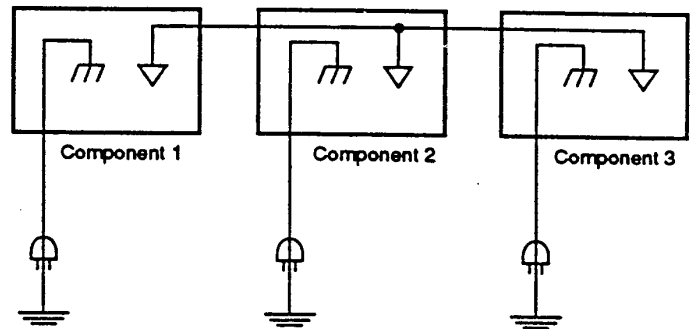


Figure 4-8. Floating Ground Connections

Figure 4-8 shows the floating ground principle. Note that signal ground is completely isolated from earth. This scheme is useful when the earth ground system carries significant noise, but it relies on the equipment input stages to reject interference induced in cable shields.

The principle of telescoping shields is illustrated in Figure 4-9. This scheme is very effective in eliminating ground loops. If shields are connected only to earth, unwanted signals that are induced in them can never enter the signal path. Balanced lines and transformers

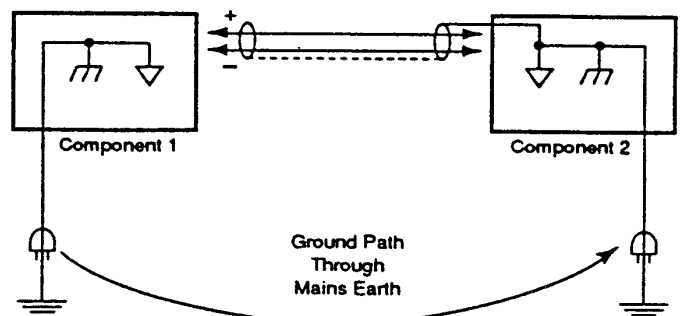


Figure 4-9. Telescoping Shield Connections

are required to implement this approach, since ground is not carried between components. One drawback is that cables may not all be the same – some having shields carried through at both ends, and others not, depending on the equipment – so it becomes more complicated to sort out the cabling upon setup and breakdown of a portable system.

Figure 4-10 illustrates a typical audio system in which various grounding techniques are combined. The basic rules that guide the choice of grounding schemes may be summarized as:

- 1) Identify separate subsystems (or equipment environments) that may be contained within an electrostatic shield which drains to earth.

- 2) Connect signal ground within each separate subsystem to earth at one point only.
- 3) Provide maximum isolation in connections between subsystems by using transformer coupled floating balanced connections.

4.3.4 Balanced Lines and Ground Lift Switches

By using balanced signal lines between two pieces of sound equipment, you can lift (disconnect) the shield at one end (usually at the output) of an audio cable and thus eliminate the most likely path that carries ground loop currents. In a balanced line, the shield does not carry audio signals, but only serves to protect against static and RFI, so you can disconnect the shield at one

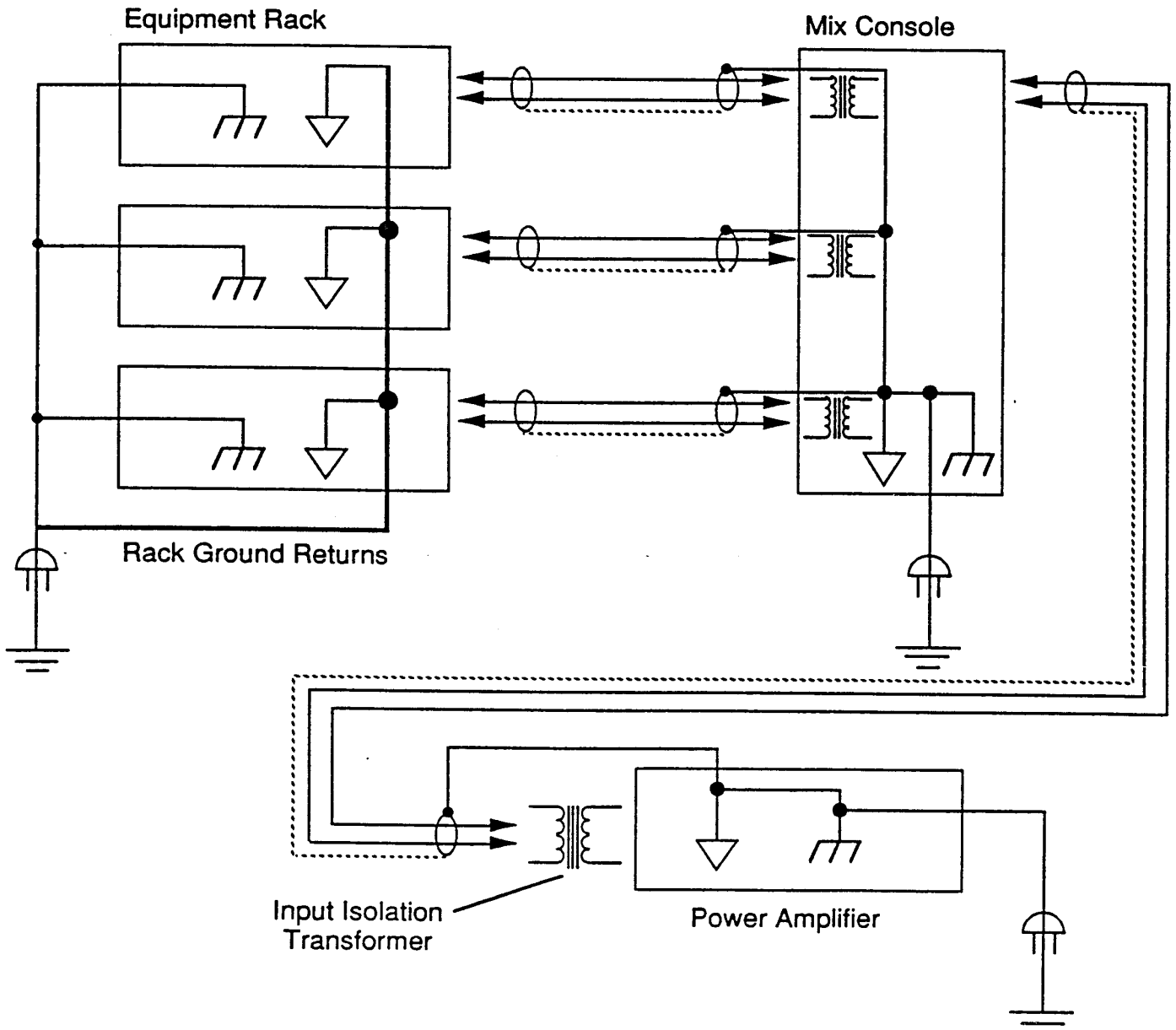


Figure 4-10. Combining Grounding Techniques in a Practical System

end without affecting the audio signal on the two inner conductors of the cable, and with little or no effect on the shielding. Unfortunately, this is not a very practical solution to the ground loop problem for portable sound systems because it requires special cables with shields disconnected on one end. Fortunately, some professional audio equipment, including Yamaha PC-Series amps, is equipped with ground lift switches on the balanced inputs.

CAUTION: Microphone cases typically are connected to the shield of the cable, and the shield is tied to the console chassis via pin 1 of the XLR connector. If there is any electrical potential on any external equipment, such as a guitar amp chassis, then a performer who holds the mic and touches the other equipment may be subject to a lethal electrical shock! This is why you should avoid “ground lift” adaptors on AC power connections if there is any other way to eliminate a ground loop.

In those audio devices which anticipate ground loops by providing “ground lift” switches next to XLRs or three-wire phone jacks, the ground lift switch makes and breaks the connection between the connector’s shield and the chassis of the particular device. Ground lift switches are usually found on “direct boxes”, which are used when an electric musical instrument is to be plugged directly into a console whose inputs are not designed to accommodate direct connection of such instruments (a direct box also includes a transformer and/or isolation amplifier, as discussed in Section 4.5).

One of the best ways to exclude noise from a microphone input is to use a high-quality, low-impedance microphone and to connect it to the console’s low-impedance, balanced (or “floating”) input. Use high-quality microphone cables fitted with XLR connectors, and keep microphone cables as short as possible. Also, physically separate mic cables from line-level (console output) cables, speaker cables and AC cables.

4.4 Audio Connectors and Cables

The signal-carrying cables in a sound system are as much an audio “component” as any other part of the system. Improper cables between the equipment can result in exaggerated or deficient high frequency response, degradation of signal-to-noise ratio, and other problems. Use of the proper cables is essential if the full potential of high quality sound equipment is to be realized.

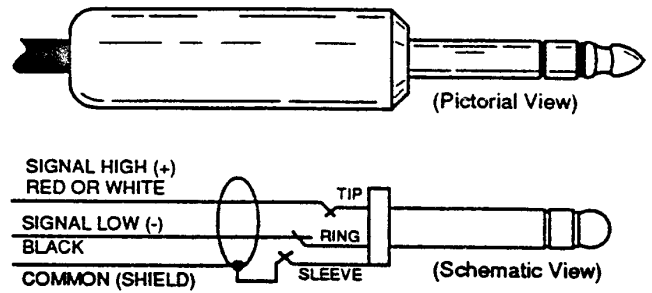


Figure 4-11a. T/R/S Phone Plug Wiring For PM4000M Insert In/Out Jacks and Direct Out Jacks

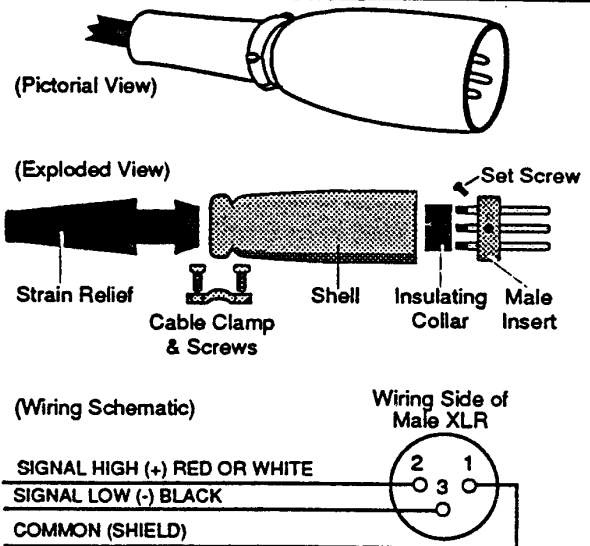


Figure 4-11b. Male XLR Connector Wiring For PM4000M 3-Pin XLR Inputs

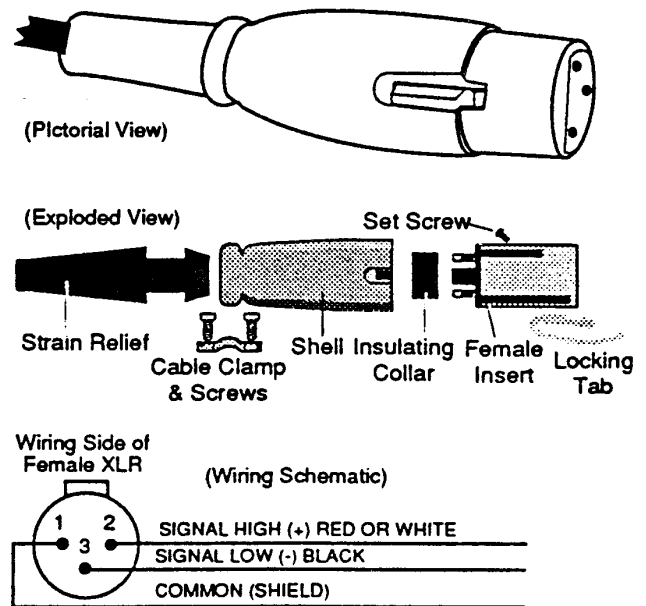


Figure 4-11c. Female XLR Connector Wiring For PM4000M 3-Pin XLR Outputs

The PM4000M is fitted with only two types of audio connectors: 3-pin XLRs, both male and female, and 3-circuit (tip/ring/sleeve) 1/4" phone jacks (also known as stereo phone jacks, although their function is sometimes to carry a balanced mono signal rather than a stereo signal).

4.4.1 Types of Cable To Use

2-conductor (twisted pair) shielded cable is best for all XLR connections. Belden 8412, Canare L4E6S, or an equivalent are excellent choices due to their heavy duty construction, multiple strands that avoid breakage, good flexibility, and good shielding. Such cables are suitable for all portable applications, and for microphones. For permanent installation or for cables confined to portable racks or cases, a lighter duty cable such as Belden 8451, Canare L-2E5AT or an equivalent are suitable. "Snake" type multi-core cables containing multiple shielded pairs must be handled very carefully because the leads tend to be fragile, and a broken conductor cannot be repaired. If you are using a "snake," allow at least one or two spare channels that can be used in case of breakage in one of the channels in use.

4.4.2 Cable Layout

Never run AC power lines in the same conduit, or even closely bundled, with audio cables. At the very least, hum can be induced from the relatively high voltage AC circuits into the lower voltage audio circuits. At worst, a fork lift or other object rolling or dropped across the cables could cut through insulation, shunt the AC into the audio cable, and instantly destroy the audio equipment. Instead, separate AC and audio lines by as wide a distance as is practical, and where they must cross, try to lay them out to cross at as close to a right angle as possible.

Similarly, avoid closely bundling the line-level outputs from the PM4000M with any mic-level inputs to the console. Specifically, avoid using a single multi-core "snake" cable for running mic lines from the stage and power amp feeds up to the stage. The close proximity of such cables promotes inductive and/or capacitive coupling of signals. If the stronger output signal from the console "leaks" into the lower-level mic or line feeding a console input, and that weaker signal is amplified within the console, a feedback loop can be established. This will not always be manifest as audible "howling," but instead may be manifest as very high frequency (ultrasonic) oscillation that indirectly causes distortion of the signal and that can lead to premature component failure. The best solution is to widely separate mic input cables from line-level output cables or, if not practical, to at least bundle them loosely.

For the same reasons that mic and line level cables should be separated, so, too, should speaker cables (the cables run between the power amp output and the speakers) be separated from mic or line level cables. If speaker cables cross other audio cables, they should do so at right angles. If they must be run along the same path, they should not be bundled tightly.

4.4.3 Balanced versus Unbalanced Wiring

In a general sense, there are two types of signal transmission systems for low to medium level audio signals: the balanced line, and the unbalanced line. Either type can be used with high or low impedance circuits; the impedance of a line bears no necessary relationship to its being balanced or not.

The unbalanced line is a "two-wire" system where the shield (ground) acts as one signal-carrying wire, and the center (hot) wire enclosed within that shield is the other signal-carrying wire.

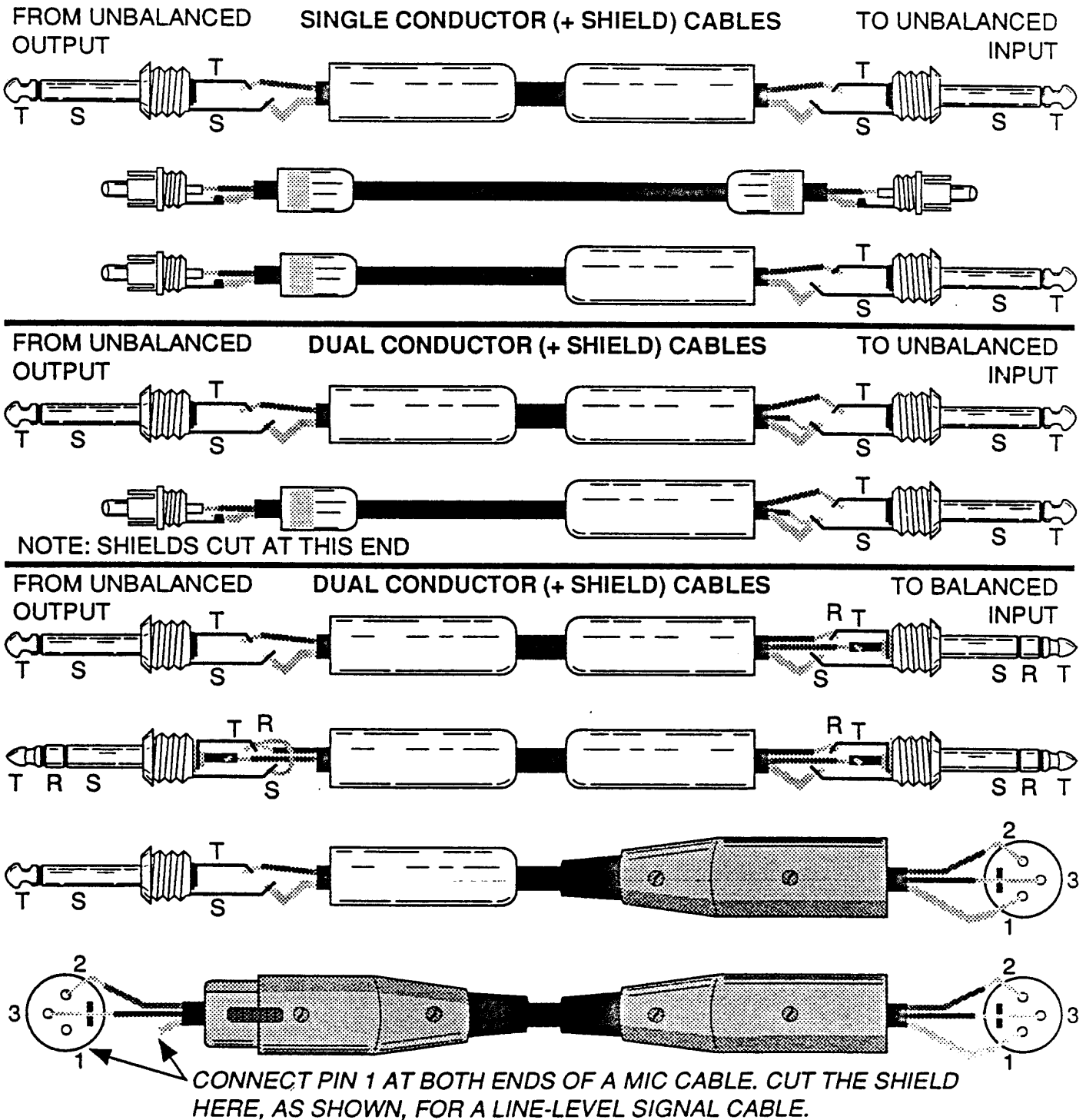
The balanced line is a three-wire system where two signal wires carry an equal amount of potential or voltage with respect to the shield (ground) wire, but of opposite electrical polarity from each other. The shield (ground) in a balanced line does not carry any audio signal, and is intended strictly as a "drain" for spurious noise current that may be induced in the cable from external sources.

The shield in balanced and unbalanced cables is typically a shell made of fine, braided wires, although some cables have "served" (wrapped) shields or foil shields instead.

Balanced wiring is more expensive to implement than unbalanced wiring. It is often used, however, because it offers useful advantages, especially in portable sound systems. There is nothing inherently "better" or more "professional" about balanced wiring; the application dictates whether one system or the other is appropriate.

Unbalanced wiring works best when high-quality cable is used, the cable extends over relatively short distances, and one leg of the AC power system feeds all the equipment. Unbalanced wiring is often used for radio and TV signal transmission, computer data transmission, and laboratory test equipment.

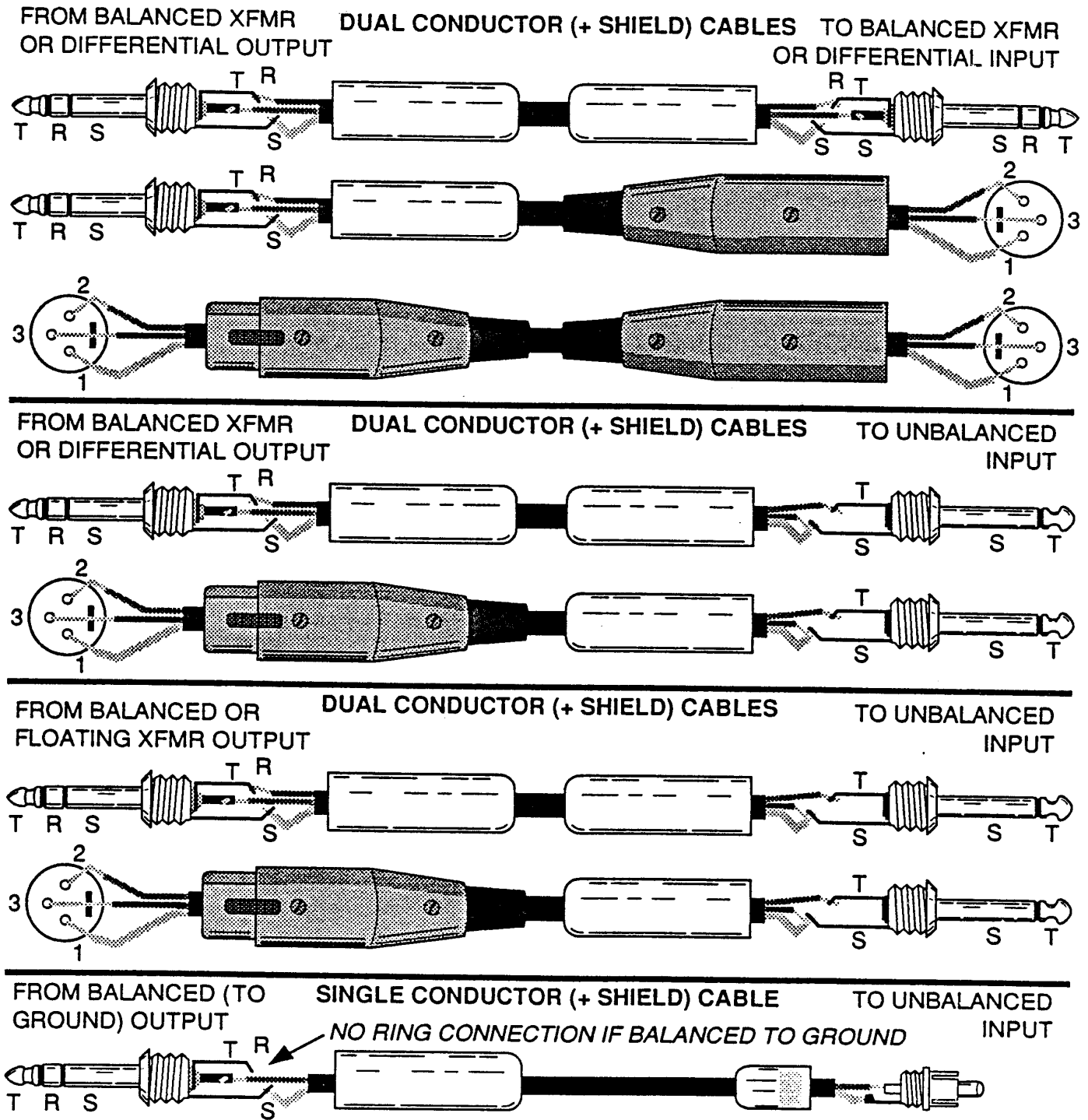
Balanced wiring helps eliminate some types of externally-generated noise. The two wires of the "balanced" cable carry the same signal, but each wire is opposite in signal polarity to the other. In a balanced input, both of the signal-carrying wires have the same potential difference with respect to ground (they are "balanced" with respect to ground), and the input is



See Note, Page 4-10

Figure 4-12. Cables For Use With Unbalanced Sources

NOTE regarding Figure 4-12. For microphone cables, connect the shield to pin 1 at both ends of the XLR cable. For line-level signal cables, cut the shield as illustrated.



See Note on Page 4-13

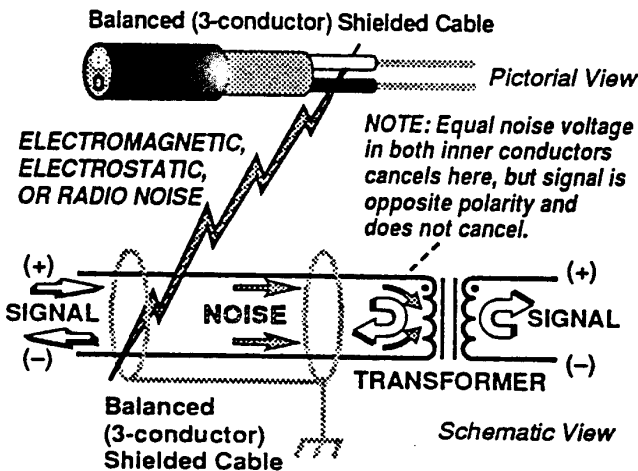
Figure 4-13. Cables For Use With Balanced Sources

designed to recognize only the difference in voltage between the two wires, and (hence the term "balanced differential input"). Should any electrostatic interference or noise cut across a balanced cable, the noise voltage will appear equally – with the same polarity – on both signal-carrying wires. The noise is therefore ignored or "rejected" by the input circuit. (This is why the term "common mode rejection" applies; signals in common to the two center wires are rejected.)

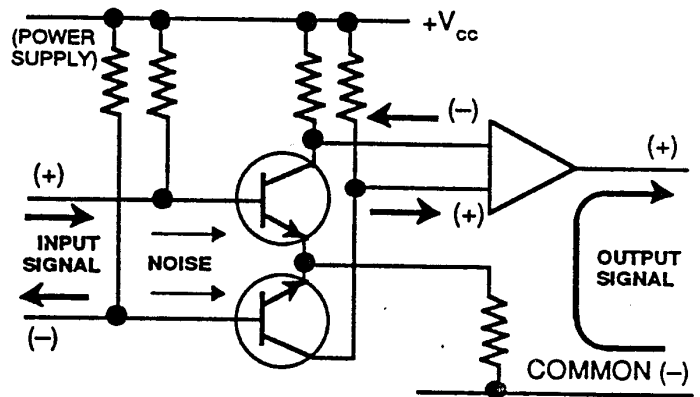
Not all balanced wiring has a shield. In older telephone systems, many miles of cable were run with no shielding in order to save money (now fiber optic cables are replacing costly copper with inexpensive glass or plastics). Out in the open, wires are subjected to radio interference and to hum fields emitted by power lines. Balancing the two signal hot wires with respect to

ground gives long lines immunity to external interference. Twisting two wires together theoretically subjects each wire to the same amount of electrostatic or electromagnetic noise. A balanced input will then cancel the unwanted noise signals common to both wires, while passing the desired audio signal, as illustrated in Figures 4-14.

The RFI (radio frequency interference) cuts across both conductors, inducing equal voltages in the same direction. These voltages "meet" in the differential amplifier (or transformer), and cancel out, while the signals generated by the microphone flow in opposite directions in each conductor, and hence do not cancel out. Thus, in a theoretically perfect balanced system, only the desired signal gets through the differential amplifier or transformer.



(A) Transformer Balanced (Floating) Input



(B) Balanced Differential Input

Figure 4-14. Noise Rejection In a Balanced Line

NOTE regarding Figure 4-14. There are significant differences in the way various balanced outputs are designed. When a balanced output is driving an unbalanced input, it is best to use a dual-conductor shielded cable, connecting the shield at both ends and allowing the low side of the cable to join the shield at the unbalanced input end of the cable. This provides most of the hum protection of a fully balanced line. In some cases, notably with a balanced to ground output, it is best to use a single conductor shielded cable, as illustrated in Figure 4-13. In other cases, such as in equipment racks where jacks are grounded through the rack frame, it may prove necessary to cut the shield at the output end of the cable. Unfortunately, there is no one right way to make a cable for all installations.

4.4.4 The Pro's And Con's of Input Transformers

As illustrated, there are two means to achieving a balanced input; either with a transformer or with a differentially balanced amplifier (an "electronically balanced input"). The latter approach is used in the PM4000M, and was chosen for several reasons: (1) it is more "transparent" sounding than most transformer inputs, (2) it cannot be saturated by low frequency, high-level signals as can a transformer, (3) it is lighter in weight.

There are a number of reasons why input transformers are used in some installations. In the case of certain audio equipment which has an unbalanced input (not this console), a transformer converts the unbalanced input to a balanced input. Beyond that, there are cases

where a transformer is desirable even if the input is electronically balanced. For example, where there is a significant amount of electrostatic or electromagnetically induced noise, particularly high-frequency high-energy noise (the spikes from SCR dimmers, for example), the common mode rejection ratio (CMRR) of an electronically balanced input may be insufficient to cancel the noise induced in the cable. In such cases, input transformers can be useful. Also, there is incomplete ground isolation with an electronically balanced input. For the ultimate in safety, there are instances when a transformer will isolate the console ground from the external source. Consider what happens, for example, when a performer is touching a mic and also touches an electrically "hot" item such as a guitar which is electrically "live" due to a fault in the guitar amp; if the mic is grounded, current will flow. The performer can be subjected to very high currents, and to consequently severe AC shock. If the mic is isolated from ground, via a transformer, then that low-resistance return path for the AC current is eliminated, and the performer has a better chance of surviving the shock. (In reality, the transducer capsule in a microphone is generally isolated and insulated from the mic case, so an electronically balanced input still would not permit a current to flow through the mic... assuming everything is wired correctly in the microphone.) If a transformer is used in this way, primarily for ground isolation and to obtain the benefits of a balanced line, it is said to be an "isolation" transformer.

If the transformer is also used to prevent a low impedance input from overloading a high impedance output, it is known as a "bridging" transformer (not to be confused with the "bridged" connections of a stereo power amp output in mono mode).

In general, the PM4000M has no need for input transformers since it already has electronically balanced inputs. In the occasional instances where absolute isolation of the grounds between the console and the other equipment must be obtained, as cited above, there is no viable substitute for a transformer, and an optional input transformer kit (Model IT3000) can be installed in individual input modules. Similarly, PM4000M outputs can be transformer isolated by purchasing one or more optional output transformer sets. The Model OT3000 output transformer set contains 8 transformers, with XLR connectors, in a compact 19-inch rack mountable box that is external to the PM4000M. In this way, those inputs or outputs which require a transformer can be so equipped, and it is not necessary to pay the price, carry the weight or incur the slight performance penalty that comes with the transformers.

NOTE: There are other ways to achieve isolation. The most common means is with a wireless radio mic. One can digitize the audio signal and transmit it by means of modulated light in fiber optics, but this can be much more expensive than using a transformer, with no great performance advantage. One can use the audio signal to modulate a light, and pick up the light with an LDR (light dependent resistor), thus achieving isolation at the expense of increased noise and distortion. Some systems, such as those for hearing impaired theatre goers, even do this over 10 to 100 foot distances using infra-red LEDs for transmitters and infra-red sensing photo sensors for receivers. The guitarist who places a microphone in front of the guitar amp speaker, rather than plugging a line output from the guitar amp into the console, has achieved electric isolation between the guitar and console by means of an acoustic link.

4.4.5 Noise And Losses In Low and High Impedance Lines

The length and type of cable can affect system frequency response and susceptibility to noise. The impedance of the line has a major influence here, too.

Signal cables from high impedance sources (actual output impedance of 5000 ohms and up), should not be any longer than 25 feet, even if low capacitance cable is used. The higher the source impedance, the shorter the maximum recommended cable length.

For low impedance sources (output impedances of 600 ohms or less), cable lengths of 100 feet or more are acceptable. For very low impedance sources of 50-ohms or less, cable lengths of up to 1000 feet are possible with minimal loss.

In all cases, the frequency response of the source, the desired frequency response of the system, and the amount of capacitance and resistance in the cable together affect actual high frequency losses. Thus, the cable lengths cited here are merely suggestions and should not be considered "absolute" rules.

Susceptibility to noise is another factor which affects cable length. All other factors being equal (which they seldom are), if a given noise voltage is induced in both a high impedance and a low impedance circuit, the noise will have a greater impact on the high impedance circuit. Consider that the noise energy getting into the cable is more-or-less constant in both instances. The low impedance input is being driven primarily by current, whereas the high impedance input is being driven primarily by voltage. The induced noise energy must do more work when it drives a lower impedance, and because the noise does not have much power, less noise is amplified by the input circuit. In contrast, the induced noise energy is not loaded by a high impedance input, so it is amplified to a greater degree.

4.5 Direct Boxes

The so-called "direct box" is a device one uses to overcome several of the problems that occur when connecting electric guitars and some electronic keyboards to a mixing console. By using a transformer, the direct box provides important grounding isolation to protect a guitarist from inadvertent electrical shock in the event of a failure in the guitar amplifier or other equipment's power supply. The second thing the direct box does is to match the impedance of the instrument to that of the console input. Electric guitar pickups are very high impedance devices, and they are easily overloaded by anything less than a 100,000 ohm input termination. Connection of an electric guitar to the typical 600 to 10,000 ohm console input will cause a noticeable loss in signal level and degradation of high frequencies. While the impedance and level mismatch is less of a problem with electronic keyboards, such instruments often have unbalanced outputs which are, nonetheless, susceptible to hum and noise where long cables are required to reach the mixing console. To avoid these problems, a direct box can be connected near the instrument, and the output of the direct box then feeds the console.

NOTE: If a preamplifier head is used, a direct box is not necessary since the head provides a balanced, isolated output to a console.

One further application of the direct box is to isolate and pad the speaker-level output of an instrument amplifier so that signal can be fed to the console input. Normally, one would not connect a speaker-level signal to a console input. However, the reverb, tremolo, distortion, EQ, and other characteristics of many instrument amps are an integral part of the instrument's sound. If the amp head does not provide a line-level output for a console, then a suitably designed direct box can "tap" the speaker output for feed to the console. Even where a line level output is provided, sometimes the coloration of the signal at the speaker output (due to intentional clipping of the power amp section of the guitar amplifier, and back EMF from the speaker) is desired, and can only be obtained at the speaker terminals.

There are two main variations of the direct box: the passive version, with only a transformer, and the active version, which employs a powered circuit in addition to the transformer and thus provides minimum pickup loading while boosting low level signals from the guitar pickup for maximum noise immunity. We present information here for constructing one of each of these types of direct boxes, originally designed by the late Deane Jensen. While these designs are believed to work well with the PM4000M, their inclusion in this manual

does not represent an endorsement by Yamaha of the specific products mentioned. The specified transformers are available from Jensen Transformers, Inc., 10735 Burbank Blvd., North Hollywood, CA 91601. Phone (213) 876-0059.

4.5.1 Passive Guitar Direct Box

This direct box is not a commercial product, though it can be assembled by any competent technician. It can be used in three ways:

1. At the output of a standard electric guitar, without an amplifier (pad switch open, ground switch closed),
2. At the output of a standard guitar with a guitar amplifier also connected (pad switch open, ground switch open or closed),
3. At the output of a guitar or instrument amplifier (pad switched in, ground switch open or closed).

The filter switch, which only works when the pad switch is closed, simulates the high frequency roll off of the typical guitar amp speaker. Since clipping distortion in a guitar amp creates high frequency harmonics, the filter switch, by attenuating the high frequency response, also cuts distortion. The filter and pad, however, are optional and may be omitted if the box is to be used strictly between the guitar pickup and the console.

The transformer was designed specifically for use in a guitar direct box. When connected to a typical electric guitar pickup, and an XLR channel input on a PM4000M, the transformer reflects the optimum load impedance to both the guitar pickup and the mic preamp input. This preserves optimum frequency response and transient response. The transformer has two Faraday shields to prevent grounding and shielding problems that could cause hum in the PM4000M or the guitar/instrument amplifier. Place the ground switch in whichever position works best.

Assembly can be accomplished in a small metal box. Keep the phone jack electrically isolated from the chassis of the box. During operation, keep the chassis of the box away from the chassis of any guitar/instrument amp or any other grounded object. If you decide to use a transformer other than the Jensen model JT-DB-E, it should have similar characteristics: an impedance ratio of 20K ohms (primary) to 150 ohms (secondary), dual Faraday shields, very low capacitance primary winding, and full audio spectrum frequency response. Note that, as used, this produces an approximate 133K ohm "load" for the guitar when connected to a nominal 1K ohm console input (the approximate actual load impedance of most mic inputs). The PM4000's electronically balanced XLR inputs are rated at 3K ohms, so the load on the guitar pickup would be nearly 500K ohms,

which is ideal. Each winding, each Faraday shield, and the transformer chassis shield should have separate leads.

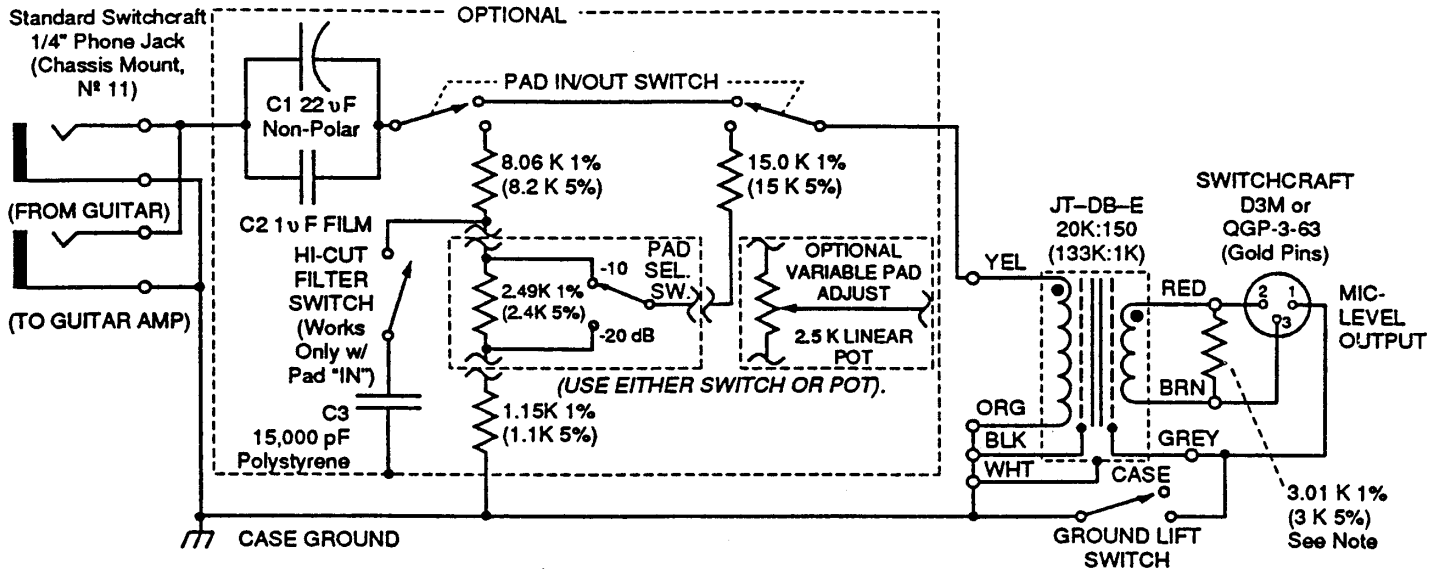


Figure 4-15. Passive Musical Instrument Direct Box (D.I. Box) Schematic Diagram

Notes Regarding Figure 4-15:

1. C1 is a high quality, non-polar aluminum electrolytic, such as Roederstein type EKU. Voltage rating should be 25 V or higher. If non-polar cap is not available, use two 47 μ F, 25V polarized electrolytics in series. Because of their high distortion, tantalum capacitors are not recommended for C1.
2. C2 is an optional high quality (polypropylene or polycarbonate) film capacitor used together with C1 to improve the sonic quality of the input capacitor.
3. C3 is a high quality (polystyrene or polypropylene) film capacitor. Adjust the value for the desired high-frequency rolloff (filter works only with pad in circuit).
4. Pad circuitry must always be used when the source is line or speaker level (synthesizer, guitar amp output, etc.).
5. 1% metal film resistors such as Roederstein (resista) MK-2 are recommended for their low noise and audio quality, although the nearest 5%, 1/4 watt carbon film (values shown in parentheses) will work with reduced accuracy.
6. Optional 2.5 k Ω linear taper potentiometer allows continuously variable attenuation between -10 dB and -20 dB. Conductive plastic is recommended, but carbon will work OK.
7. Pin 2 of the microphone-level output connector is "Hi," Pin 3 is "Lo," in order to comply with I.E.C. standards. This is compatible with Neumann, AKG, Beyer, Shure, Sennheiser, Crown, EV, and Shoeps microphones, all of which are Pin 2 "Hot." Incidentally, the AES (Audio Engineering Society) is promulgating a new standard which may ultimately resolve the differences in which XLR pin is "Hi" and it looks like pin 2 will be the choice.
8. 3 k Ω resistor across transformer secondary should be installed when the direct box is used with inputs having greater than 2 k Ω actual termination impedance (for example, a standard Yamaha PM4000M input). It is OK to leave the resistor in circuit with 1 k Ω inputs, although better results will be obtained if the resistor is omitted in this case.
9. Parts kit DB-E-PK-1 containing all resistors and capacitors needed to build the above circuit is available from Jensen Transformers, N. Hollywood, CA for a nominal fee.

4.5.2 Active Guitar Direct Box

The active direct box shown here can be used at the output of a standard electric guitar, with or without an amplifier. Because of its very high input impedance, it can be used with a piezoelectric instrument pickup, taking the place of the preamp that is normally included with such pickups. This box is not meant for use at the output of a guitar amplifier (see **PASSIVE DIRECT BOX** information). The active direct box can be powered by its own pair of standard 9V "transistor radio" type batteries, or by phantom power from the PM4000M or any condenser microphone power supply.

The circuit can be constructed on a piece of perf board, or on terminal strips, or on a printed circuit layout. It should be assembled into a shielded case, using isolated (insulated) phone jacks, as shown. When the direct box is used between the guitar and guitar amplifier, place the ground switch in the position that yields the minimum hum. As with the passive direct box, any part substitution should be carefully considered.

4.6 Configuring Equipment Racks

The great majority of audio equipment manufacturers make provision for their electronic products to be mounted in EIA standard 19 inch wide equipment racks. (The equipment may be only 17 to 18 inches in width, or even less. The rack ears that mount to the rack rails extend to 19 inches.) Panel heights for rack mounting equipment are standardized on multiples of a single rack unit space (1 RU) of 1.75 inches.

When selecting electronic equipment it is important to bear in mind eventual rack mounting. Not only the height but also the depth of the unit should be considered. Particularly in portable applications, the integrity and strength of the front panel and/or rack mounting ears also must be examined in relation to the chassis weight. Heavy components such as power amplifiers should be supported at the rear as well, rather than relying only on the front rack ears. Even if a piece of equipment seems secure when you screw its front panel to the rack rails, the vibration and shock encountered in the back of a semi-trailer may quickly bend metal or break it right out of the rack.

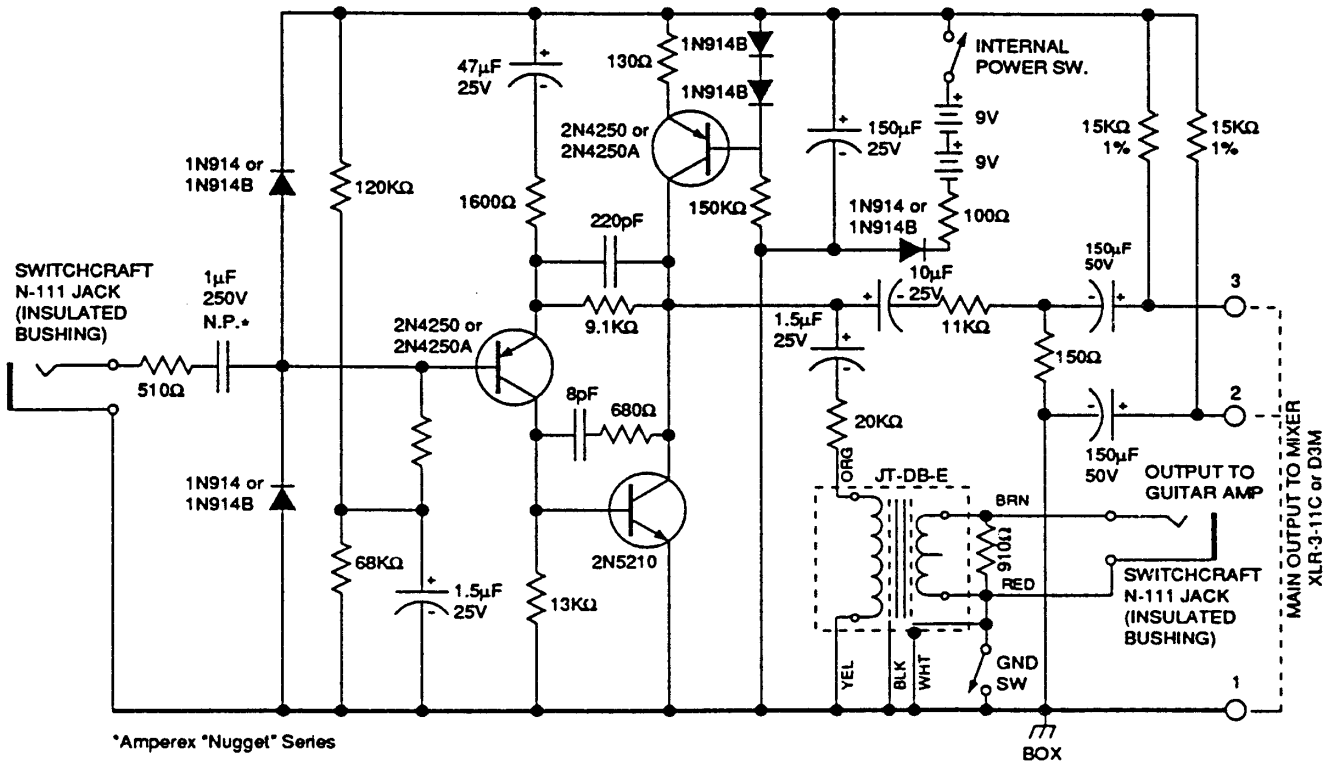


Figure 4-16. Active Musical Instrument Direct Box (D.I. Box) Schematic Diagram

Before actually mounting the selected components, it is wise to carefully plan out each rack with an eye to signal flow, heat flow, and weight distribution. It might be best to mount together components that function as a group: the equalizer, active crossover and power amplifier for a single loudspeaker or array, for example. On the other hand, some prefer to mount all the equalizers for the system in one rack, all the power amplifiers in another, and so on. If you select the latter approach, you may find that the power amplifier racks are dangerously heavy. Also, if one all the same rack is damaged, you could be out of business, whereas loss of a mixed rack will only partially impair the system. It is far better to put some thought into such matters beforehand than to do all the work and then correct mistakes after they cause major problems.

At its best, configuring equipment racks is a true craft combining a focus on practical utility and careful engineering with a concern for clean appearance. In a well prepared rack, electronic devices are accessible yet protected, and are neatly and consistently mounted with proper hardware. Interior and exterior work lamps, integral power distribution, ground-fault indication and a well stocked spare fuse compartment are among the extra touches that are usually provided. Equipment that may generate strong electromagnetic fields (power amps with large transformers) should be separated from equipment that has high gain (microphone and phono cartridge preamplifiers or cassette decks).

The hallmark of a professional rack is the care that is taken with the internal wiring. Color coding and/or clear and logical cable marking facilitate troubleshooting and reflects an understanding of the electronic signal flow. Related groups of connections are neatly routed and bundled with cable ties. Audio signal cables are kept separate from power cords, and low level signal cables are separated from high level signal cables. Excess cable (including any service loop) is neatly stowed and tied down, and all connections are secured so that they stay in place in shipment.

Finally, touring sound professionals protect their equipment racks in foam-lined flight cases equipped with wheels and handles to facilitate handling. Given the considerable investment in equipment, materials and time that a fully loaded rack represents, such protection is essential. Flight cases in standard sizes are available from a number of manufacturers, and it is generally not necessary or economical to make them yourself.