THE PROFESSIONAL AUDIO DIVISION OF CROWN INTERNATIONAL, INC.

# RESOURCE TEXT

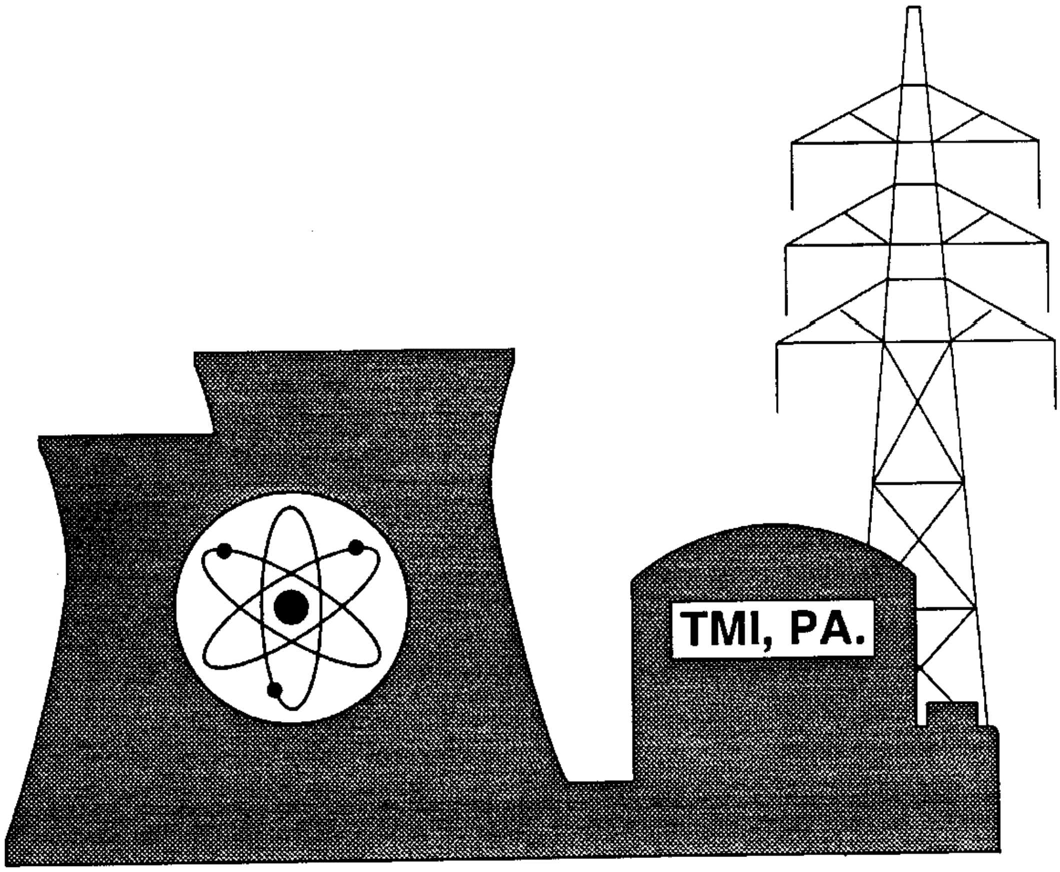
**For The**

# Crown® Professional Products SERVICE SCHOOL

PART 3

# AC POWER AND GROUNDING



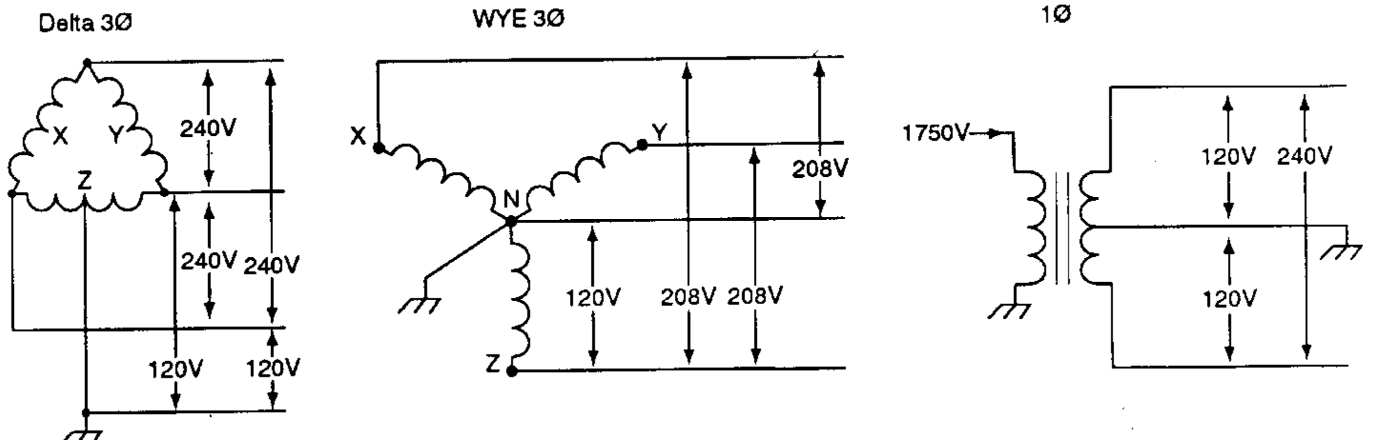


**Notes**

# AC POWER AND GROUNDING

Common Distribution Systems. The basic classification of distribution systems is according to voltage level:

1) 120-240V single-phase three wire
2) 208V three-phase (WYE)
3) 240V three-phase (DELTA)




*Voltage Classifications*

*Definitions:*

**Wye Configuration:** Consists of three alternating currents that differ by 120 degrees with a common grounded neutral current return.

**Delta Configuration:** Consists of three alternating currents that differ by 120 degrees. Delta generally does not have a grounded neutral current return.

**Grounded Neutral:** The grounded current return leg for every single phase of a wye configuration. The neutral lead is grounded every 500 to 1,000 feet on the line poles and at the building service entrance point.

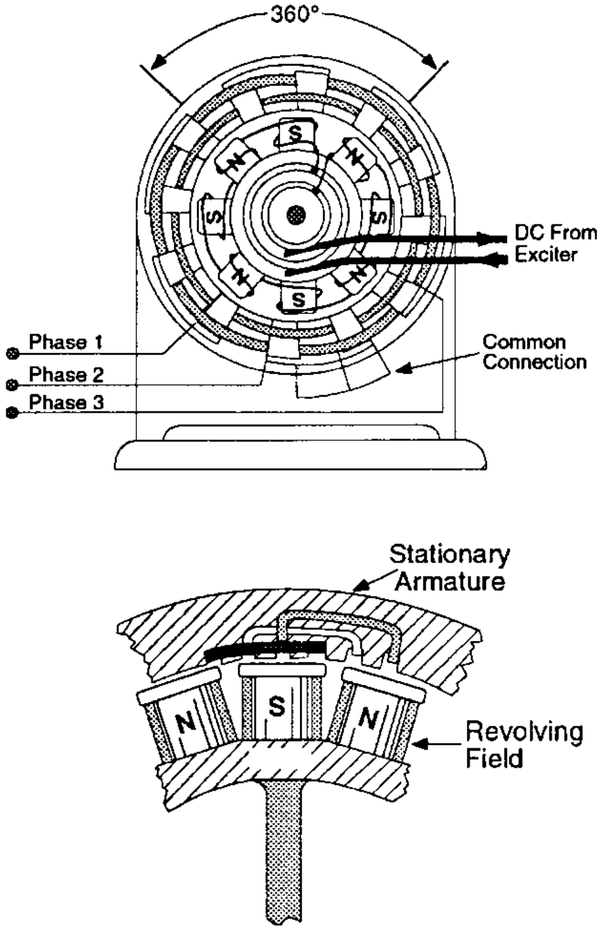
**Safety Ground:** A resistance of less than 25 ohms to earth ground at the service entrance that is used to maintain electrical equipment at the same low potential to prevent electrical hazard. Since the safety ground is not a current return, as is the grounded neutral, ground fault interrupt circuits should trip in case of safety ground current flow.

Three Phase Wye Voltage Relationships - the voltage between any two phases in a wye configuration can be calculated by the formula below:

$$V_{xy} = V_{nx}\sqrt{3}$$
$$V_{nx}\ (1.73)$$

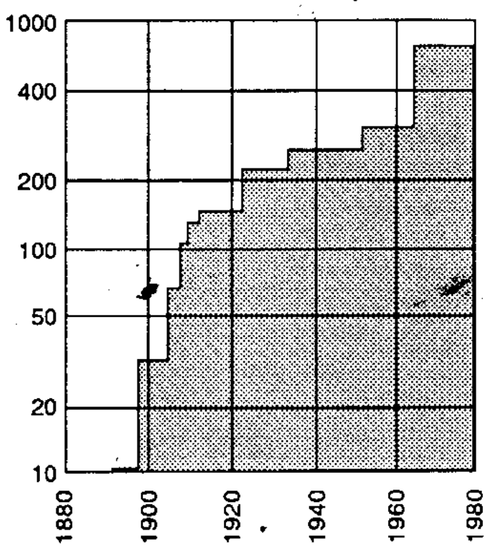
**AC Power Generation:** The next figure is an inside view of a typical generator. Generators may be constructed with either the armature coil or field coil structures as the revolving member. Above 13KV, generators commonly employ the revolving field construction.

The revolving field coils receive direct current from the exciter. The induced current in the stationary armature coil varies as the field coil revolves. Each individual phase output is 120 degrees (2.09 radians) behind the previous phase. Utility generator output voltage varies from 13KV to 24KV. The common connection is grounded and is used as the neutral current return for the entire AC transmission and distribution system.



*AC Power Generator*

**The Transmission Line:** Overhead transmission of electrical power remains one of the most important elements of today's electrical power system. Since the beginning of the electrical industry, research has been directed toward higher and higher voltages for transmission. Thus it is common to see, for example, voltage levels of 115KV, 230KV, 345KV, 500KV, and 765KV (the greater the distance of transmission, the greater the voltage level {usually}. The highest AC voltage in commercial use is 765KV, however, research and test lines have explored voltages as high as 1500KV. The fundamental purpose of the electrical utility transmission system is to transmit power from the generating units to the distribution systems.



*Line Voltage Trends in North America*

Electrical design of an AC system involves (1) power flow requirements, (2) system stability and performance, (3) voltage level selection, (4) VAR control, (5) conductor selection, (6) losses, (7) corona-related performance, (8) electromagnetic field effects, (9) insolation and overvoltage design, (10) switching, (11) circuit breakers, (12) protective relaying. Many of the above design requirements are, of course, important parameters found throughout the entire AC distribution system.
Power sharing, through system

## Notes

**Notes**

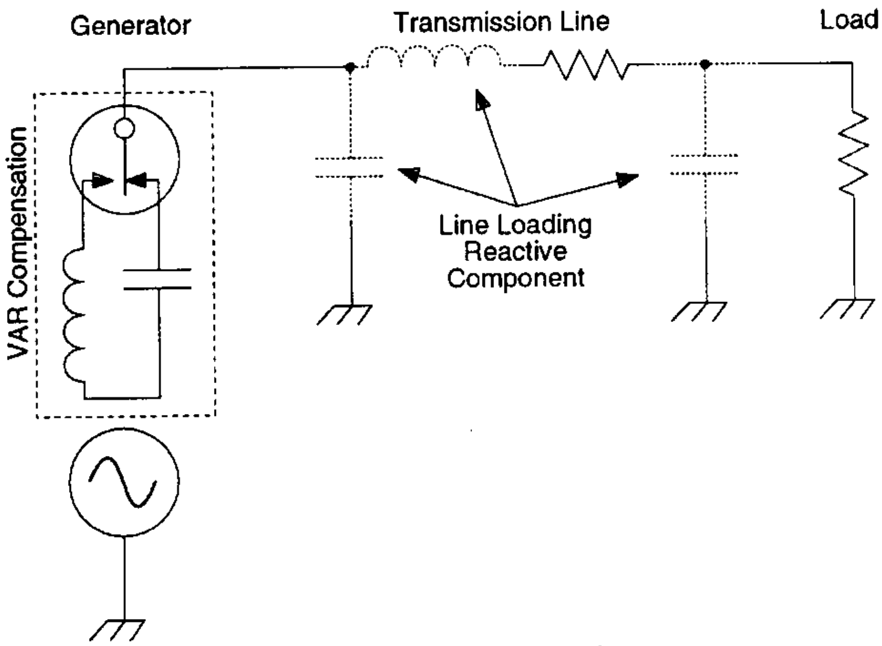
interconnection increases reliability and lowers overall power generation costs. System interconnection requires monitoring and synchronization of (1) voltage level, (2) voltage frequency, (3) and voltage time phase.

As with any electronic circuit, the transmission line has reactive components. This reactive component shows itself as:

1) Series line resistance
2) Series line inductance
3) Line to line and line to ground capacitance

This line reactance is commonly called VAR (Voltage-Ampere-Reactance). A heavily loaded transmission line will appear Inductive because of the large magnetic field present. Large capacitors are inserted at the generating station to balance this increase in inductance. A lighter loaded transmission line will appear capacitive. Large inductors are switched in at the generating station to balance this increase in capacitance.

Power Factor is the time/phase relationship of the voltage and current wave-




*Power Grid Schematic*

forms. A highly reactive transmission line will have a low power factor causing line voltage sag. The more resistive and less reactive the transmission line appears, the higher the power factor. As a ratio of real power (watts) over apparent power (Volt-Amperes), power factor can be determined by:

$$pf = \frac{\text{Real Power}}{\text{Apparent Power}}$$

*Where:*

*Real Power = Watts*

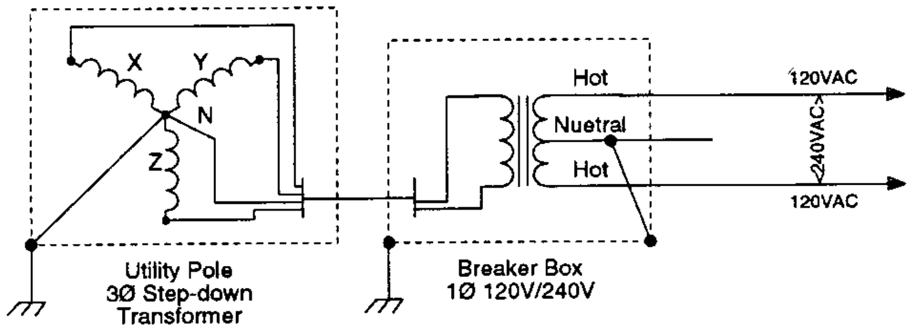
*Apparent Power = Volts x Amps*

**Distribution Systems:** Metropolitan distribution systems are almost exclusively three-phase Wye. Voltage levels do vary with distance:

1) 2.4KV to 7.5KV up to five mile radius of substation
2) 7.5KV to 20KV over five mile radius of substation

The neutral circuit must be a continuous metallic path along the primary routes of the feeder and to every user location. The neutral is grounded at each distribution transformer, every 500 to 1,000 feet where no transformers are connected, and to either a metal water pipe of a driven ground at the service entrance.

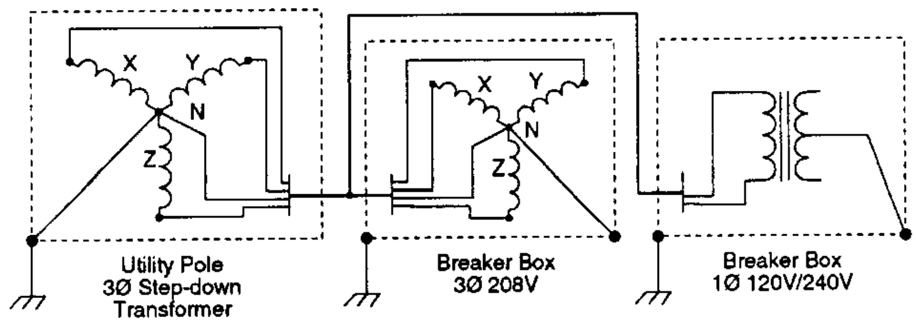
**Residential System** - the typical system involves a single 2.4KV-7.5KV feeder, with a grounded neutral running through the neighborhood. This feeder is the, periodically, transformed to 120/240 single phase. At every line pole transformer the neutral is grounded on the primary side. The secondary center tap serves as the neutral for the house and is grounded at the service entrance.




*Residential Power System*

**Commercial System** - 2.4KV to 208 three phase transformation takes place at the utility pole. The neutral is grounded at both the pole and the service entrance. There can only be one service entrance location per building. Once inside the building the service conductor feeds are routed to the distribution panel, and then out to multiple breaker panels servicing multiple outlets.

## Amplifier AC Power Requirements




*Commercial Power System*

**Current Draw** - In order to correctly design for AC power current needs for each amplifier need to be determined. All Crown amplifiers will have a quiesent level of power drawn from the AC source. Summed with this value will be the output power and a percentage of power labeled as the *inefficiency* factor. This *inefficiency* factor value will be determined by the output power required from the amplifier.

*Example:*
CT-800 with an 4 ohm load, both channels driven, 50% duty cycle:
AC draw in Watts: 765
Heat generated in BTU/Hr: 920

Basic assumptions:

**Notes**

## Notes

Amplifier efficiency at full rated output: 65%
Ambient power draw: 90W
Amplifier output power: Maximum Average rating at the load specified.

**British Thermal Units (BTU)** - Any audio product (especially amplifiers)

$$W_{AC} = \left(\frac{W_{output}}{\eta}\right) \text{Duty Cycle} + \text{Quiescent Power}$$

*Where:*
$W_{AC}$ *= AC power from source, in Watts*
$\eta$ *= Efficiency (typically 65%)*
*Duty Cycle = 50% Pink Noise*
*= 40% Compressed Mid-range Rock*
*= 30% Clean Full-range Rock*
*= 20% Acoustic Instrument*
*= 10% Continuous Speech*

dissipate a certain quantity of power in the form of heat. An amplifier with a quiesant power draw of 90 watts will dissipate this energy in the form of heat. In large systems where dozens of amplifiers are housed in one room air conditioning may be required in order to maintain optimum performance. The quantity of heat generated by the overall system can be calculated by the following formula:

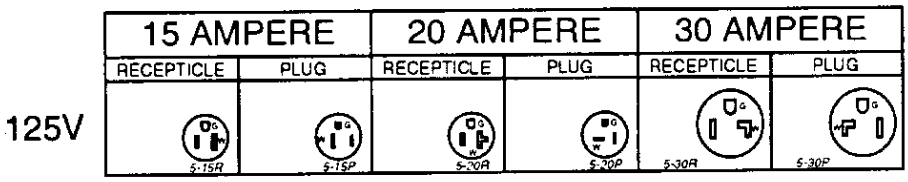
In order to obtain the BTU value of the entire system add together all of the individual values obtained brome the individual amplifiers.

Example:
A single CT-800 with a quiesent power draw of 90 watts would generate 307 BTU's (90 x 3.415).

$$BTU/Hr = 3.415 \times Watts$$

**Size of Service Conductors** - Service conductors must have a current carrying capacity to supply the load with minimums set by the National Electric Code (N.E.C.). Design of an installation in accordance with the NEC (National Electric Code) minimizes fire and accident hazards but does not guarantee the full 120VAC available at the AC receptacle. As conductor size increases, less line loss, less line voltage sag, and less conductor heating will occur. The conductor 'gauge vs amperage vs temperature' standards are set by the NEC. Please note, again, the NEC standards are minimums only. A 20 amp circuit will only provide 20 amperes continuously without overheating the conductors. There is no guarantee of the line voltage at the AC receptacle when this 20 amperes is being drawn.

**AC Line Connector Type vs Amperage** - *Recepticles connected to circuits*




*Connector vs Amperage*

# TABLE 19-21 Ampacities of Three Single-Insulated Conductors, Rated 0-200V, in Underground Raceways (Three Conductors per Raceway)*

Based on ambient earth temperature of 20°C, raceway arrangement per Fig. 19-1, 100% load factor, thermal resistance (RHO) of 90, conductor temperature 75°C

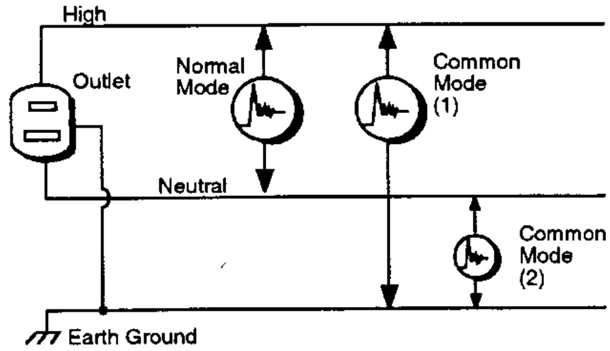
| Size: AGW, MCM | 1 Raceway (Fig. 19-1 Detail 1) | 3 Raceway (Fig. 19-1 Detail 2) | 6 Raceway (Fig. 19-1 Detail 3) | 1 Raceway (Fig. 19-1 Detail 1) | 3 Raceway (Fig. 19-1 Detail 2) | 6 Raceway (Fig. 19-1 Detail 3) |
|---|---|---|---|---|---|---|
| | Types *RHW,*THW, *THWN, *XHHW, *USE | Types *RHW,*THW, *THWN, *XHHW, *USE | Types *RHW,*THW, *THWN, *XHHW, *USE | Types *RHW,*THW, *THWN, *XHHW, *USE | Types *RHW,*THW, *THWN, *XHHW, *USE | Types *RHW,*THW, *THWN, *XHHW, *USE |
| | Copper | | | Aluminum or copper-clad aluminum | | |
| 12 | 36* | 31* | 36* | 28* | 22* | 18* |
| 10 | 46* | 41* | 46* | 36* | 31* | 25* |
| 8 | 58 | 51 | 58 | 45 | 40 | 34 |
| 6 | 77 | 67 | 77 | 60 | 52 | 44 |
| 4 | 100 | 86 | 36* | 78 | 67 | 57 |
| 3 | 116 | 99 | 46* | 91 | 77 | 65 |
| 2 | 132 | 112 | 58 | 103 | 87 | 73 |
| 1 | 153 | 128 | 77 | 119 | 100 | 83 |
| 0 | 175 | 146 | 121 | 136 | 114 | 94 |
| 00 | 200 | 166 | 136 | 156 | 130 | 106 |
| 000 | 228 | 189 | 154 | 178 | 147 | 121 |
| 0000 | 263 | 215 | 175 | 205 | 168 | 137 |
| 250 | 290 | 236 | 192 | 227 | 185 | 150 |
| 300 | 321 | 260 | 210 | 252 | 204 | 165 |
| 350 | 351 | 283 | 228 | 276 | 222 | 179 |
| 400 | 376 | 302 | 243 | 297 | 238 | 191 |
| 500 | 427 | 341 | 273 | 338 | 270 | 216 |
| 600 | 468 | 371 | 296 | 373 | 296 | 236 |
| 700 | 509 | 402 | 319 | 408 | 321 | 255 |
| 750 | 529 | 417 | 330 | 425 | 334 | 265 |
| 800 | 544 | 428 | 338 | 439 | 344 | 273 |
| 900 | 575 | 450 | 355 | 466 | 365 | 288 |
| 1000 | 605 | 472 | 372 | 494 | 385 | 304 |
| Ambient temp. °C | For ambient temperatures other than 20°C multiply the ampacities shown above by the appropriate factor shown below. | | | | | |
| 6-10 | 1.09 | 1.09 | 1.09 | 1.09 | 1.09 | 1.09 |
| 11-15 | 1.04 | 1.04 | 1.04 | 1.04 | 1.04 | 1.04 |
| 16-20 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 21-25 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 |
| 26-30 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 |

*Effective January 1, 1978.
NOTE: The over current protection for conductor types marked with an astorisk (*) shall not exceed 20A for 12 AWG and 30A for 10 AWG copper: or 15A for 12 AWG and 25A for 10 AWG aluminum and copper-clad aluminum.

*Wire Gauge/Ampacity Chart*

**Notes**

*having different voltages, frequencies or types of currents (AC or DC) on the same premises shall be of such design that the attachment plugs used on these circuits are not interchangeable* - N.E.C. ARTICLE 210-7(f).




*AC Line Noise*

**AC Line Noise** - There are two classifications of noise found on AC power lines:

1) NMN-Normal Mode Noise refers to noise occurring between the two current carrying conductors (hot and neutral). NMN is sometimes termed TMN, or "Transverse Mode Noise".

2) CMN-Common Mode Noise refers to noise occurring between one or both current carrying conductors and ground, producing voltage spikes between ground and transformer primary.

Because the common mode transients are seldom exactly equal in phase and magnitude, a considerable voltage difference can also exist between the two current carrying conductors. It is not unusual to see both normal mode and common mode transients at the same time. Suppression of CMN is an important attribute of a good suppressor because most equipment is more susceptible to CMN than to NMN.

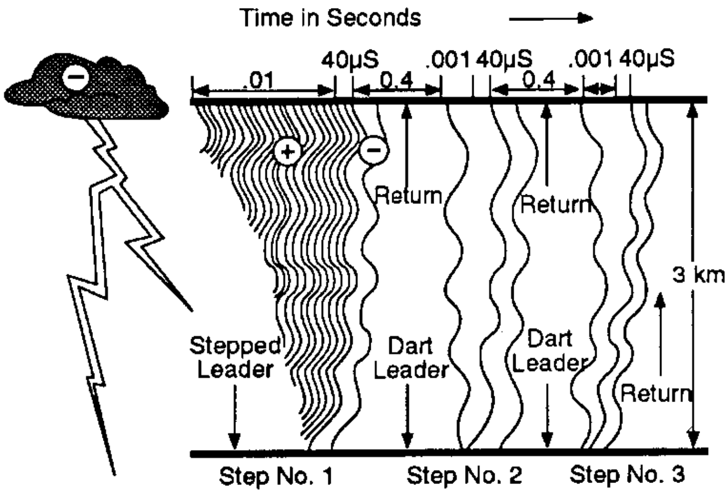
3.) Noise Reduction

a.) Larger gauge conductors will result in lower DC resistance between the neutral and ground, thus lowering the level of noise spikes (I R drop).

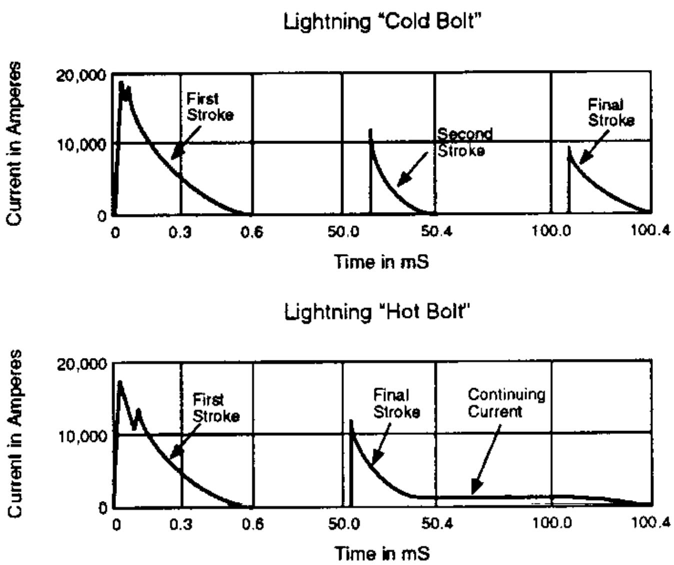
b.) Utilize separate breaker panels going back to the distribution panel for noise sensitive and non-sensitive AC lines. This reduces resistance between ground and neutral, which will translate into a reduction in CMN or NMN levels.

**Lightning** - Recognized as one of the nation's worst threats to life, lightning is also believed to have become the costliest weather related force. A typical cloud-to-ground lightning strike is initiated when an avalanche of free electrons sets off from the base of a thundercloud toward the intense positive charge that has been building up below. As this first "stepped leader stroke" approaches ground in discrete steps of 50 mS or more, a multitude of positive "point discharge currents" strain upward toward it from the corners and edges of buildings, trees, poles, vehicles, people and even blades of grass. When the leader stroke is a step or more above effective ground, a positive streamer shoots upward from a dominant pointed object. When the positive stream meets the negative leader, an ionized path is completed between cloud and earth. Instantly an intensely luminous "return stroke" takes place.

Lightning currents very from a few thousand to more than 300,000 amperes. 30MV of potential is perhaps average among destructive strikes. A typical strike consists of a downward stepped leader stroke of free electrons which ionizes a




Lightning Flash Comprised of Three Component Strikes




*Lightning Strike Time Durations*

path from cloud to earth (the first return stroke). Another dart leader followed by a return stroke and finally one or two more sequences of dart leader/return stroke. Such a flash has a time duration of about 400mS. The stepped leader descends in discrete steps of 50mS or more. A dart leader descends in a single, long step along the already ionized path. Each leader stroke lays down a negative charge which flows to earth during the following return stroke. Leader strokes descend from cloud to earth in milliseconds. The massive luminous return strokes are measured in microseconds.

"Cold Bolts" consist of strokes that have a core heat as high as 27,000° F. However, because the duration is only in microseconds they do not transfer enough heat to ignite most types of material.

"Hot Bolts" on the other hand transfer enough heat to create massive damage. Damage is likely to occur to masonry or other facing as well as to any parapets and roof mounted equipment. Sparking or side flashing between a conducting column and grounded interior equipment may occur. Lightning current will follow

**Notes**

Notes

metal rebars towards earth, but the journey may be marred by wall damage, perhaps unseen as the current meanders its often interrupted and impeded way down a maze of rebars.

**Lightning Protection -** Lightning arresters are used to limit these voltages to a safe value and provide a path to ground for the dissipation of the energy of the surge. In order to provide this protection satisfactorily, lightning arresters must fulfill the following functions:

1. They must not allow the passage of current to ground so long as the voltage is normal.
2. When the voltage rises to a definite amount above normal, they must provide a path to ground for dissipation of the surge energy without further rise in the voltage of the circuit.
3. As soon as the voltage has been reduced below the setting of the arrester, it must stop the flow of current to ground and reseal itself so as to insulate the conductor from ground.
4. They must not be injured by the discharge and must be capable of automatically repeating their action as frequently as is required.

## Grounding Procedures

**Grounding and Shielding -** Earth Grounds-Rods of specific length and diameter driven directly into earth. The resultant resistance must be less than 25 ohms (less than 3 ohms in the case of a water pipe). Lower resistance will increase safety and lower noise levels.

1) Single Rod resistance can be determined by the nomograph on the following page.

2) Multiple Rod spacing should be equal to the length of the individual rods. Multiple Vertical Rod Resistance is calculated by:

3) Solid Square: refers to a geometric square figure of ground rods.

$$R = \frac{\rho}{191.5L(n)}\left[Ln\left(\frac{96L}{D}\right) - 1 + \frac{2KL}{\sqrt{A}}(\sqrt{N}-1)^2\right]$$

*Where:*

*R = Resistance (Ohms)*
*ρ = Soil Resistivity (Ohms per cm)*
*L = Rod Length (Ft)*
*D = Rod Diameter (In)*
*A = Area (Square Ft)*
*n = Number of Rods*
*K ≅ 1.37*

4) Hollow Square: refers to a geometric square figure of ground rods spaced evenly along the perimeter of the square.

5) Ring of wire: generally run in the ground around the foundation of a building.

6) Ufer ground: refers to a rod or ring of wire encased in concrete, and in direct contact with earth.

Resistivity is determined by the rod length and diameter as well as soil resistivity. The greater the length and diameter, the lower the ground rod resistance. Different types of Soil contain varying amounts of moisture therefore the higher the moisture content of the soil the lower the ground rod resistivity. Generally speaking, doubling the rod length reduces resistance by an additional 40%. Doubling the diameter of rod reduces resistance by less than 10%.

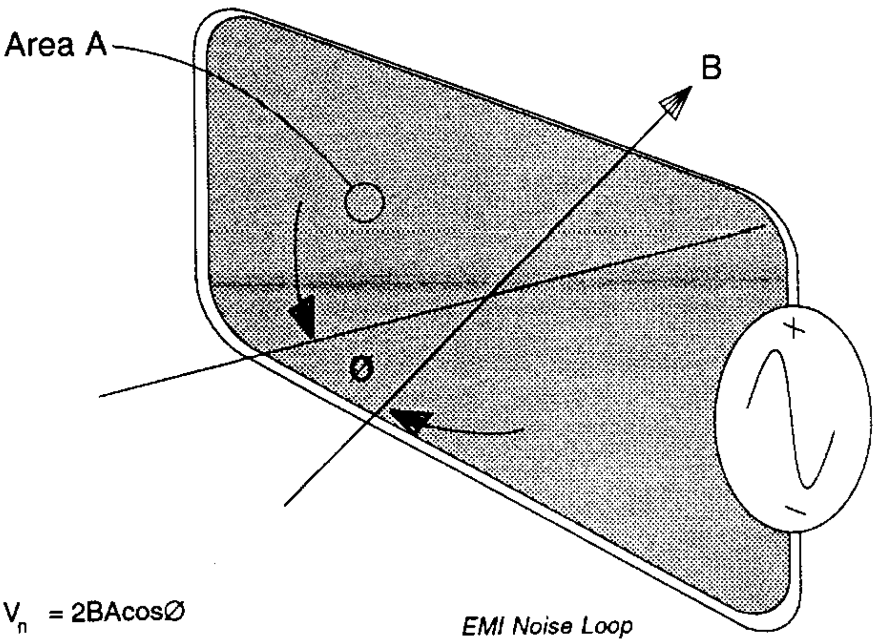
Soil resistivity is also influenced by temperature. Therefore the resistivity of any grounding system will vary throughout the different seasons. The effective length of a ground rod is equal to the length of the rod minus the frost line depth (2 feet) in affected areas.

Earth currents concentrate under transmission lines (2-10 Amperes). This can elevate earth ground potential and should be kept in mind when installing a ground system.

| Soil | Resistivity Ohms-cm (Range) |
|---|---|
| Surface soils, loam, etc. | 100-5,000 |
| Clay | 200-10,000 |
| Sand and Gravel | 5,000-100,000 |
| Surface Limestone | 10,000-1,000,000 |
| Limestone | 500-400,000 |
| Shale | 500-10,000 |
| Sandstone | 2,000-200,000 |
| Granites, basalts, etc. | 100,000 |
| Decompossed gneisses | 5,000-50,000 |
| Slates, etc. | 1,000-10,000 |

*Soil Resistivity Chart*

**EMI** - Electro Magnetic Induction refers to current induced into a circuit and is directly related to flux density and the area of the closed loop. If the conductor is not closed, there is no enclosed area.




$V_n = 2BA\cos\varnothing$

*EMI Noise Loop*

*Where:*

*A = Closed Loop Area*

*B = RMS value of flux density varying sinusoidally*

*Ø = Angle between flux vector and plane surface of area A*

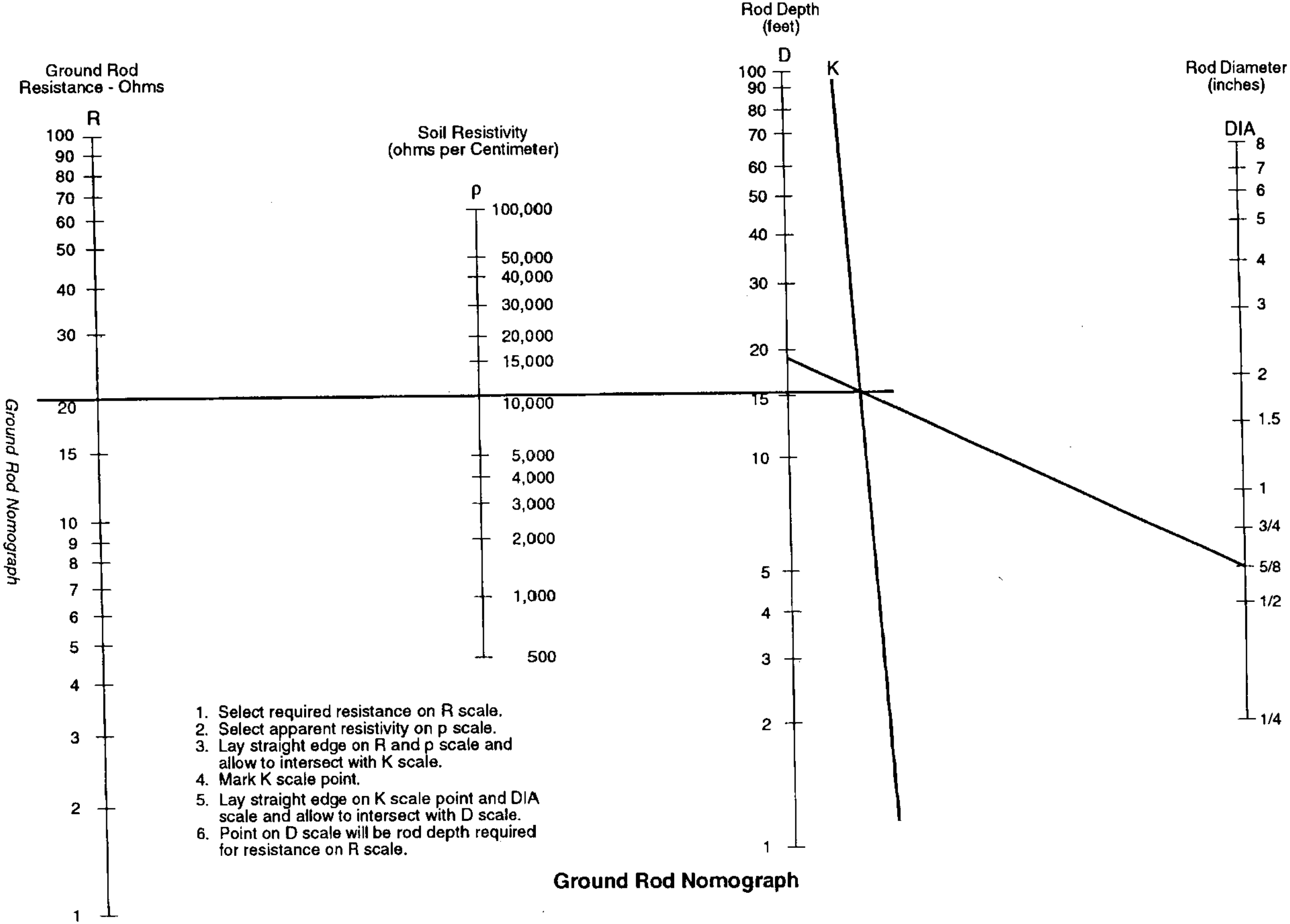
*$V_n$ = RMS value of induced noise voltage*

*A = Area (Square Ft)*

*n = Number of Rods*

*K ≅ 1.37*

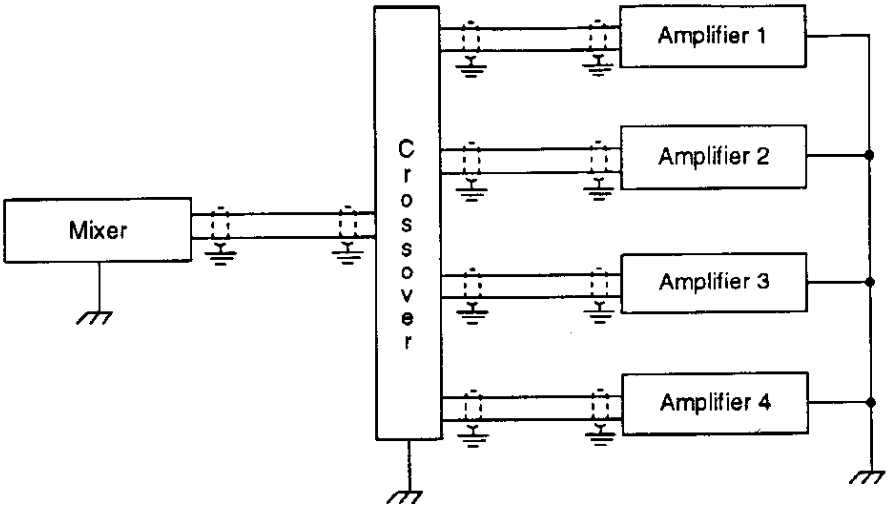
## Notes




1. Select required resistance on R scale.
2. Select apparent resistivity on p scale.
3. Lay straight edge on R and p scale and allow to intersect with K scale.
4. Mark K scale point.
5. Lay straight edge on K scale point and DIA scale and allow to intersect with D scale.
6. Point on D scale will be rod depth required for resistance on R scale.

**Ground Rod Nomograph**

*Ground Rod Nomograph*




*Typical Sound System*

**Equipment Grounding:** Any electronic component wants only one ground. Interconnecting two or more components, such as an amplifier and mixer, each with their own safety grounds, will create a ground loop. The first ground is the amplifier's own safety ground, and the second ground (the amp senses) is the mixer ground via the signal line shield. Lines of flux will induce a current into this loop which will modulate the ground network. A component electrical ground can be obtained from one or all of the following areas:

1) AC safety ground
2) Equipment rack rails
3) Signal line grounds or shields
4) Interconnecting of Amplifier output Grounds

All three areas must be taken into consideration when engineering or trouble-shooting a system. For example, a basic four way system is shown, and in it exist a number of ground loops. The hum level will, of course, vary depending upon stray 60Hz magnetic field from AC wiring, fluorescent lights, SCR controlled lighting or product power transformers.

**The loops appear as follows:**

1) The mixer and crossover each have a ground from the AC safety ground as well as a second ground through the signal shield.

2) The crossover and amplifiers each have a ground from the AC safety ground as well as through the signal shield. Just lifting the AC safety ground may not eliminate all alternate grounds. Isolating the amplifiers from the rack rails and from each other is sometimes necessary.

3) An input panel on the back of an amplifier rack can create intra-amplifier loops. If the patch panels signal grounds are common, each amplifier not only sees an AC safety ground, but also a second ground path from other amps in the rack via the patch panel common.

4) In the event the crossover AC safety ground is isolated the amplifiers and mixer still have AC grounds with the signal shield ground through the crossover connection.

5) In some multiamplifier systems a large multiple conductor cable is used for speaker cabling. All amplifier output grounds are sometimes tied together within the rack and a single large speaker ground return is used. Ignoring an arrangement like this allows a ground loop even when isolating the AC safety grounds and isolating each chassis from each other in the rack.

Any electronic circuit within a metal box will have literally hundreds of mutual

**Notes**

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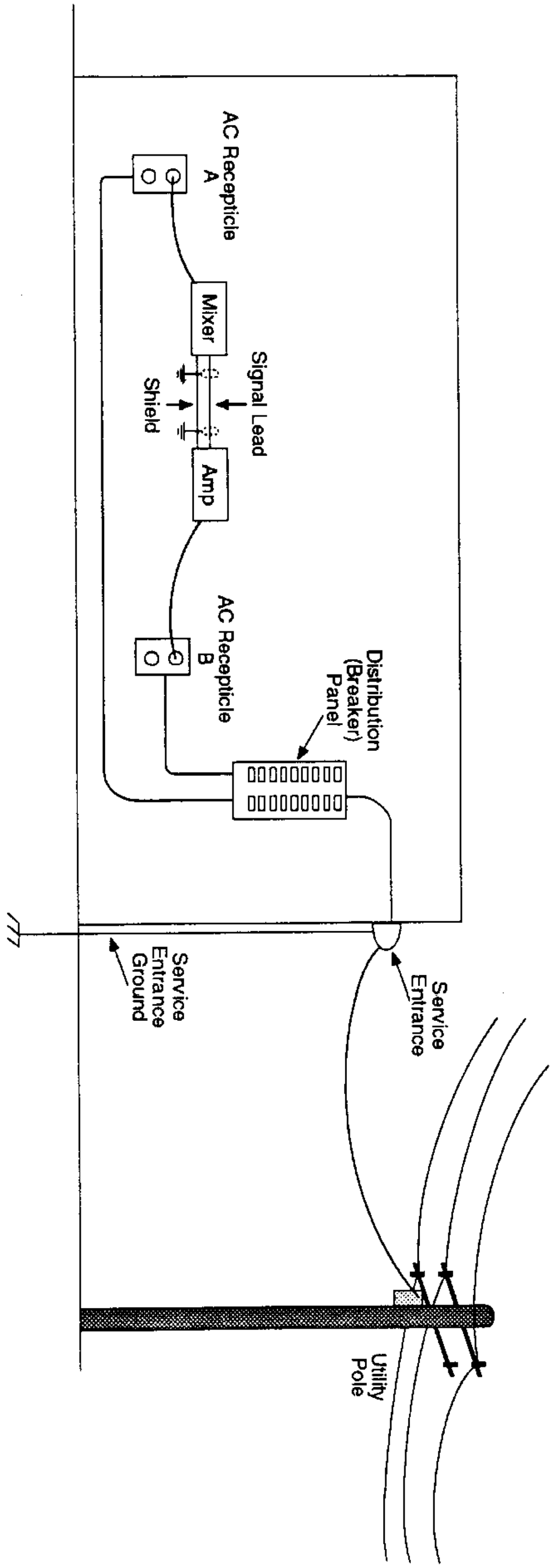
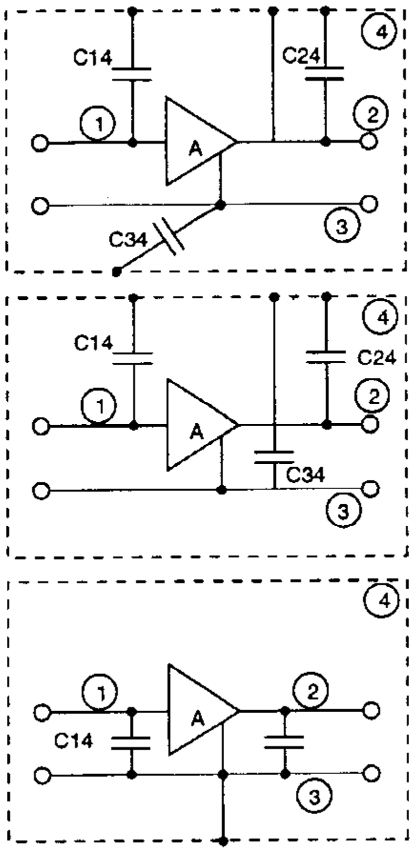



*Typical Ground Loop*

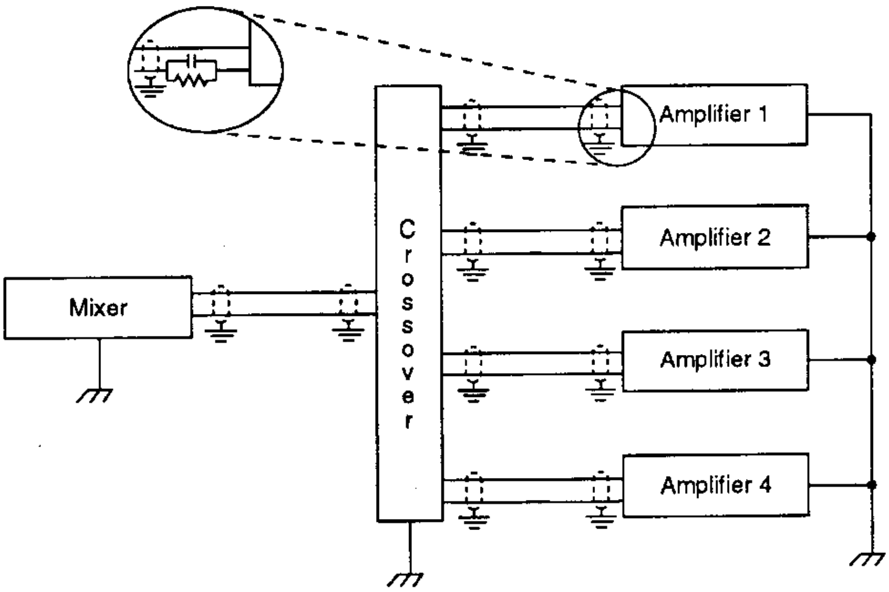
capacitances. These mutual capacitances are not only intra-circuit (coupling between circuit components) but circuit to chassis as well. In linear gain circuits these capacitances can form feedback structures around the gain element. The effect of these capacitances upon the gain element an be very apparent. These capacitances cannot be avoided. However, the obvious stray capacitive feedback process can be eliminated by ohmically tying the circuit ground to the chassis (at only one point). This ohmic connection can be a short or a low ohmage resistance. This practice will short out capacitor C34 (see figure) leaving only C14 and C24. If the circuit and chassis grounds of any electronics device, with gain, are allowed to float the result will be positive feedback. Positive feedback, of course, will result in circuit instability (ultrasonic and RF oscillations). There can be signal to noise degradation, distortion and high common mode currents. The end result being reliability problems. If hum problems, caused by ground loops, are encountered, complete (infinite impedance) isolation of chassis and circuit grounds should never be an alternative measure as a solution.



*Chassis/Circuit Ohmaic Connection*

**Summary** - There are 3 major ways of engineering a system to prevent ground loop hum and noise

1. Connect all AC safety grounds to one common point, such as in a star ground arrangement. Connect all output shields and disconnect all input shield connections. In high RFI areas reconnect the input shields using a small resistor/

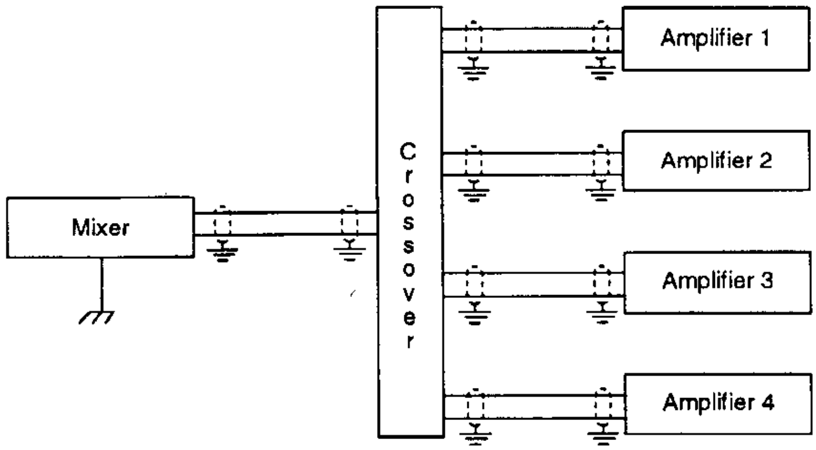


*Grounding Method #1*

## Notes

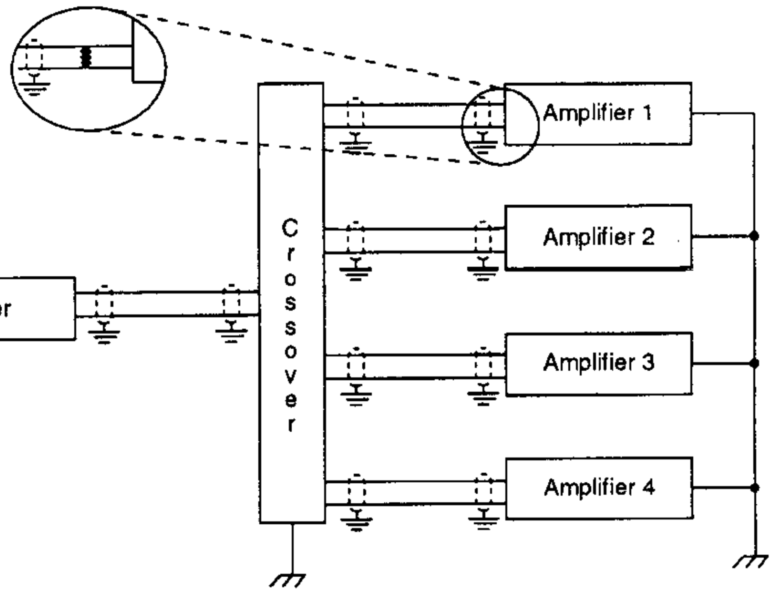
**Notes**

capacitor network (20 ohms., .01ufd) in series.
2. Disconnect all AC safety grounds, isolate all chassis connections from rack mounts and interchassis connections using the signal shield for the ground.
3. Install input transformers to isolate intercomponent shield connection, and




*Grounding Method #2*

maintain AC safety ground.




*Grounding Method #3*

Proper grounding and hum elimination is not black magic, but experienced insight into all possible ground loop circuits a customer can conceive of and usually hide.

## AC Line Voltage

**AC Line voltage measurements:** Using the proper line voltage level is paramount when testing or operating any power amplifier. If the current rating of the AC line is low the end result will, in all likelyhood, be a drop in AC voltage level. Since most high energy power supplies are unregulated the DC voltage levels will decrease as the AC input levels drop. In reality most line voltage drops are not a linear attenuation but a clipping of the waveform not unlike what is seen in power amplifier output stage clipping. There are two popular AC to DC converters used in meters available today 1.) RMS and 2.) Averaging. The following are the mathematical formulas used in calculating both:

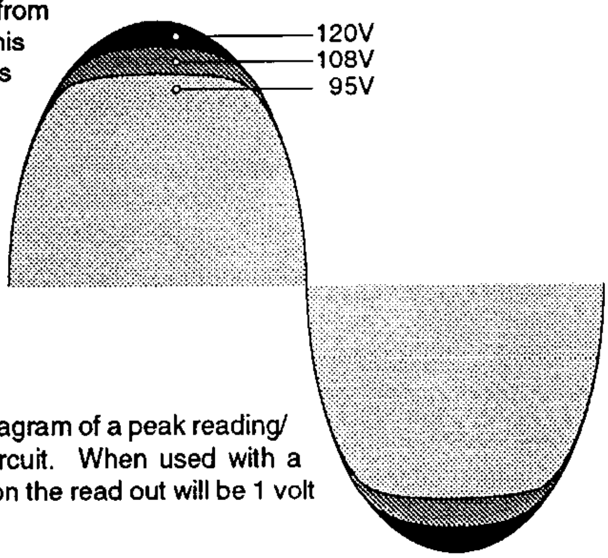
**RMS:** The effective (Root-Mean-Square) value of a waveform is equal to the Direct Current which dissipates the same energy in a given resistor. It is calculated as the instantaneous voltage value at the 45° point on the sinusoidal waveform. The RMS is equivalent to the DC because the waveform spends as much time above the 45° point as it does below the 45° point in any 1/4 cycle.

$$V_{RMS} = V_{PK}(\sin 45°)$$

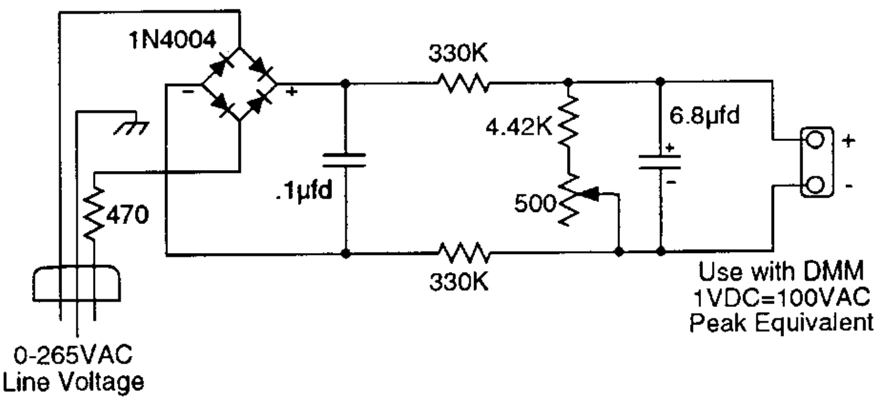
**Average:** The average value of a periodic waveform is equal to the algebraically summed area under the waveform curve divided by period t. The average voltage is of little real value since it does not equate directly to a DC equivalent, nor does it have baring on peak or peak to peak values. Most DMM's, however, measure average level and provide an output calibrated in RMS. Only for pure sinusoids is such a measurement accurate.

When attempting to determine average values from a given sine wave the distortion of the given sine wave must be less than .1% THD. If an attempt is used to measure the AC line voltage level, which has typical distortion values in excess of 5% erroneous peak to rms values will result. Greater voltage envelope distortion levels result in peak/rms value reading errors.

**Peak Equivalent:** The Peak to RMS value relationship where the RMS value is algebraically calculated from the sinusoidal Peak. This measure of RMS is accomplished by measuring the peak value. Meter output is calibrated in RMS, readings being equal to the peak value times the sine of 45°. Typical digital multimeters are not peak reading/RMS calibrated.




Below is the schematic diagram of a peak reading/ RMS calibrated meter circuit. When used with a DMM in the 20 volt position the read out will be 1 volt equals 100 volts AC.




*Peak reading/rms calibrated metering circuit*

**Notes**

# *How to make loud music...*

It starts with a neutron. The neutron strikes a uranium atom. The atom divides into two smaller pieces. The two smaller pieces are very hot (heat is really a measure of how fast atoms vibrate). This heat is conducted to the outer wall of the metal matrix by causing other nearby atoms to vibrate. Here at the wall the heat energy is transferred to a water molecule. The water molecule then absorbs the heat (begins to vibrate) as it flows by. It flows through long insulated pipes until at last it is forced to go through a very thin austenitic stainless steel tube. In the tube this molecule transfers its heat energy to atoms in the wall of the tube, causing them to vibrate. The heat moves through the tube wall and into another water molecule on the other side. This vibrating water molecule, subjected to a lower pressure, then turns to a steam molecule. The steam molecule is then forced to go down another long insulated pipe. At the end of the pipe it strikes the blade of a turbine and causes it to turn.

At the other end of the turbine shaft is a generator. On the generator end of the shaft is a magnet. As the magnet spins it causes the electron in the stator's armature to move down the length of its winding. This electron, once it gets going, moves on out through the wire and travels to a transformer. When it gets there it moves around through a winding, transferring its energy into a magnetic line of flux. This flux line moves across another winding. When this happens the flux line gives its energy to an electron (second leg of the electron relay team) waiting in this second winding. Once this electron gets the energy to move, it heads down its long length of wire. Once this electron reaches our part of town it gets to another transformer where it hands off to a third electron. This electron brings its energy to our neighborhood where it hands off again. One last relay electron (the anchor man) picks up the energy from the last transformer at our site. It comes into our building through its wire road and moves easily across beakers we have closed.

Once safely inside the electron moves down wires inside to the outlet where the MA-5000VZ is plugged in. It goes up the power cord, through the power switch, through a closed relay contact, and into the transformer. Once again it transfers its energy to a magnetic flux line that transfers its energy to an electron waiting on the secondary side. The electron waiting on the secondary moves out of the secondary winding and down a short wire to the bridge rectifier. From there it passes through to the filter capacitor where it is pulled in with other waiting electrons. When an audio signal enters the amplifier, the electron races back out of the capacitor and down to the high voltage rail. From the rail it goes through the output transistor, through the terminating circuit, and down the speaker cable. When it reaches the speaker it goes into another coil. Here it produces another magnetic line of flux. Since the speaker already has its own magnet, the two attract (every other time past they repel). This pulls the speaker's cone. When the speaker cone moves it creates a vacuum, pulling an air molecule behind it. To fill its place another air module moves, and another behind it, and so forth. This moving vacuum causes a small reduction in air pressure which moves like a wave, out from the speaker cone.

When the wave reaches the human ear, its vacuum tugs on the ear drum to try to fill the hole where the air molecule used to be. The movement of the ear drum causes tiny little bones in the ear to move. These bone movements are felt by nerve endings deep down inside the ear. These nerves convert the motion energy to pulses. These pulses in turn travel straight to the brain. The brain accepts this information as sound and tells your mind that you are hearing something. Your mind determines if the information means anything, and whether it is pleasing or not. Of course it takes a lot of neutrons to make you hear a whole song.