Using A DMM To Improve Sound System Installations (part1)

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A competent sound system installer must be a jack of all trades. For starters, he or she must have a solid understanding of acoustics, mechanics, electro-mechanics, and electronics. The need to understand acoustics is obvious: it is very difficult to select suitable speaker and microphones locations, or equalize a system, without some understanding of the principles of sound and of electro-acoustical transducers. Likewise, it is important for reasons of safety and sonic performance that the installer possess a basic knowledge of mechanics: having speakers rattle and vibrate — or in our worst nightmare fall on top of people — would be typical consequences of incompetence in this area. And without some understanding of electro-mechanics, an installer is likely to make wiring errors by choosing unsuitable wire, connectors, switching, and/or patching or by installing these critical items incorrectly. So far, all this is obvious. But to many installers it is less obvious why they should learn the basics of electronics. The installer may feel that he does not need a solid grounding in electronics because most major electronic repairs are made on the bench by technicians and proper electronic design is usually the responsibility of the equipment manufacturer and the system designer.

These arguments are true, but they fail to take into account the fact that there are many critical electronic measurements and adjustments that should be made on site. Unfortunately many — perhaps most — installers fail to perform these operations. In fact, one of the most pervasive contributors to faulty sound system installations are errors and oversights resulting from a lack of electronic skills in installers.

The purpose of this article is to acquaint the sound system installer with a few basic electronic and audio concepts, measurements and adjustments. First we will discuss a few relevant electronic formulas and concepts. Most readers will have sufficient background in electronics to easily understand these concepts. The novice, however, should read the accompanying primer entitled "The Basics." Next we will see how to make important measurements using a high quality digital multimeter (DMM). Finally, we will see how the rough data from DMM measurements can be used to make adjustments to the sound system that can greatly improve performance and reliability.

Ohm's Law

The most common electrical formulas used in audio are based on Ohm's law. Most of the basic Ohm's law formulas express the logical relationships between volts, amps, ohms, and power that are implicit in basic electricity. For example, consider these variations: E/R = I, E/I = R, EI = P, VP/R = I, IR = E, P/E = I, I2R=P; where E = voltage, R = resistance, I = current in amps, P = power in watts.

Taking the first formula, E/R = I, we see that with a given voltage, an increase in resistance decreases current: just the sort of logical relationship one would expect.

As an example of the utility of Ohm's law, let's say that an audio engineer totals up the power consumption of a sound system and determines that the total (input) power is 12,450 watts. If all the equipment operates on 120VAC (which most audio equipment does), we can determine the total current draw on the house AC service by referring to the formula P/E = I. Thus, 12,450 / 120 = 103.75 amps.

Or let's say that one wishes to determine the right value of fuse to protect a loudspeaker. This can only be done only approximately because of the difference between resistance and impedance, and because fuses are more linear in their response to current than loudspeakers. So it may be best to err on the side of caution and choose a lower amperage fuse than the formula indicates. If the loudspeaker has an impedance of 8Ω and a power rating of 200 watts, we can plug these values into I2R=P. We get I28=200 or (through algebraic manipulation) I2=200/8 or I2=25, or I=5. If you feel the loudspeaker is rated conservatively, you could use a five amp fuse.

The Decibel

Many of the theories and formulas that are used in professional audio require a solid understanding of decibel notation. A decibel can be defined as a unit of level equal to ten (or twenty) times the logarithm of the ratio of two powers. There are numerous decibel scales with different zero references. If the scale is based on units of power, velocity or intensity, it will be a 10log decibel scale. If the scale is based on units of voltage or current, then the decibel scale will be 20log.

It should be noted that a decibel is not a fixed unit like a volt, dollar, ounce, or mile. It is a ratio, and the actual "value" of a decibel will vary. For example, on a decibel scale used to measure electrical power, each consecutive decibel (in the positive direction) represents increasingly larger values of wattage. So if we measured the wattage represented by the decibel between -10dbm to -9dbm, we would find that it represents a much higher value of wattage than the decibel between -40dbm to -39dbm. Thus, a decibel scale is a method of expressing very large changes and/or quantities of units in easier to handle quantities. For example, the decibel scale for sound pressure level ranges from about 10db (the threshold of hearing) to 135db (the threshold of pain). A scale of 10db to 135db is an easy scale to handle, but if we expressed that same

The Basics

Everything around us is made up of atoms, and each atom consists of a nucleus containing a certain number of positively charged particles called protons and chargeless particles called neutrons. Around this nucleus orbits electrons; these have an equivalent charge to the protons but are of negative polarity. So long as the number of protons equal the number of electrons, the atom is electrically neutral since the positive and negative charges are in balance. Neutrality is the natural state of an atom, and should an electron depart an outer orbit — thus causing an overall positive charge — the atom will try to return to an electrically neutral state by reacquiring a replacement electron. Similarly, if an atom finds itself with an extra electron in its orbit — thus causing an overall negative charge — the atom will attempt to expel the unwanted particle.

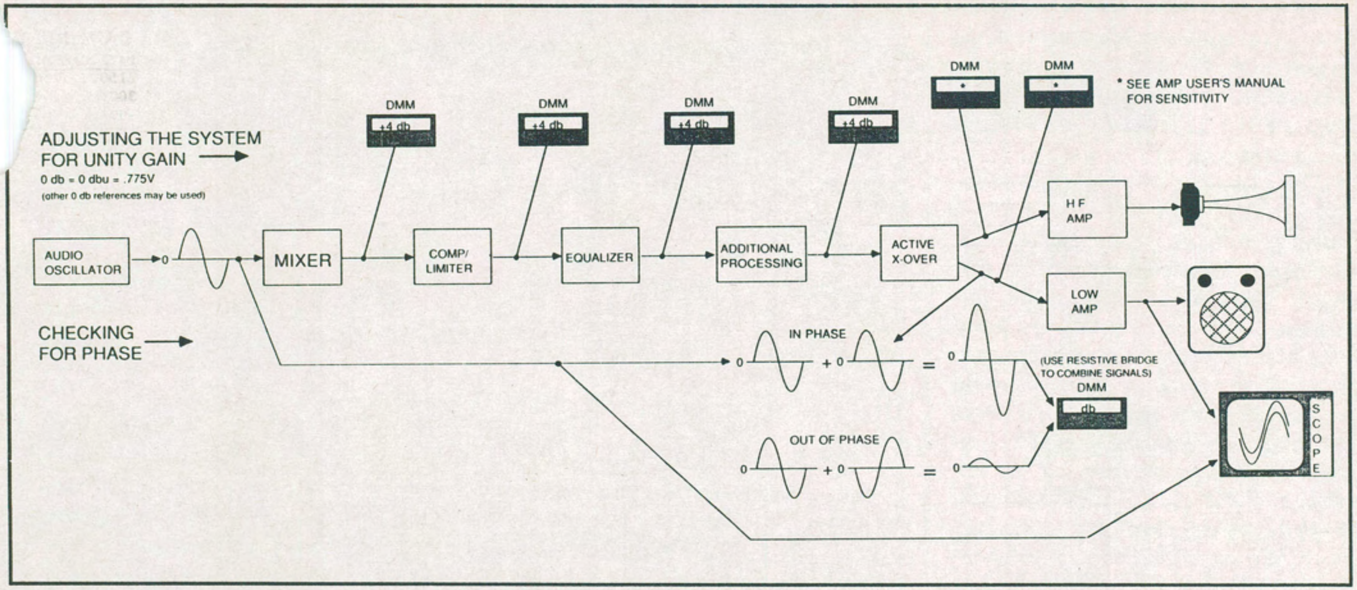
So electricity is simply the migration of electrons from a material that has an excess of electrons to a material that has a shortage of electrons. For example, the negative charged pole of a chemical battery contains a quantity of surplus electrons, and the positively charged pole will have a deficiency of electrons. The greater the numerical imbalance of electrons between the two poles of our battery, the greater the potential between the poles. In order for the battery to do any work in a practical sense (start a car, power a flashlight, etc.) the quantity of electrons needed will be in the billions. In order to express these quantities in manageable numbers we use the coulomb which is a unit representing 6.25 1018 electrons. The measurement of work required to move one coulomb of charge out from the dielectric is the volt (V). (Though beyond the scope of this article, and unnecessary for our understanding here, a technically preferable definition would be: one volt equals one joule [0.7267 foot/pounds] of work per coulomb of charge.) You will often see the symbol E used to represent voltage because voltage can also be described as electromotive force (E or emf).

Regardless of the terminology used to describe the potential to move electrons, it is important to remember that, so far, we have considered potential only — static stress, i.e. electricity at rest. But if we want to power a flashlight or start a car, we need to move electrons from one pole of our battery to the other. To do this, we must provide a circuit consisting of a material that has sufficient free electrons so that when an electron goes in one end, another electron will virtually instantaneously come out the other end — much like a tube full of marbles. Some materials, copper and silver for example, have sufficient free electrons to be considered conductors. Other materials have relatively few free electrons and will obstruct or restrict current flow; these are called insulators or semi- conductors.

Once a circuit providing a sufficient degree of conductivity has been established between the two poles of our battery, electrons will flow. The number of electrons that pass a given point in the circuit can be described as current which we measure in amps (A or I for intensity). One coulomb per second at a given point is equal to one amp.

Most circuits are designed to control and restrict the current flow as part of the process of turning electricity into something useful such as heat, light, motion, etc. The most basic measurement of opposition to current flow is resistance (R) which is expressed in ohms (O). If one amp flows in a circuit for one second and produces .24 calorie of heat, the circuit has a resistance of one ohm. Power (P) is the total amount of work generated by a circuit. Power is expressed in watts (W); and one watt of power equals the work done in one second by one volt of potential in moving one coulomb of charge. In other words, power equals voltage times current.

We have used a battery to demonstrate electrical principles and define terminology. This has been for the sake of clarity; regardless of the actual source of emf (chemical, thermal, photoelectric, or electromagnetic) the principles and terminology are the same. However one important difference between battery power and household power is that batteries provide DC (direct current) and household power is AC (alternating current). In most audio equipment the AC is



scale in terms of fixed units like the dyne (an acoustical unit of force), the scale would range over tens of millions of units.

As an example of how an audio engineer might use a decibel scale, let's say that he had two loudspeakers that put out a total of 100db spl at 100 watts input each, and he needed to know what would be the total spl output if he added 8 identical loudspeakers, assuming that each additional speaker also had 100 watts of input. The formula would be: S1 (original qty of speakers) + S2 (additional speakers) / S1 = R. Find the common log of R and multiply it by 10. Add this decibel number to the original decibel output of S1. So, (2+8) / 2 = 5. Log of 5 is .699. .699(10) = 6.9. 100db + 6.9db = 106.9db. So, the total output of the five speakers will be 106.9db spl. If we had been dealing with voltages, rather than power (in this case acoustical power) we would have used a 20log scale, rather than a 10log scale, and the total output would have been 113.98db.

In audio, common decibel scales include: dba (A weighted, spl), dbb (B weighted, spl scale), dbc (C weighted, spl scale), dbm (zero reference: 1mw across a 600 ohm load), dbv (zero reference: 1 volt), and dbu (zero reference: .775 volt).

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rectified into DC, but where you are dealing with certain AC signals and circuits (power amplifier outputs feeding loudspeakers, for example) it is important to realize that resistance is opposition to DC, whereas opposition to AC is often measured in impedance (Z and also Ω). Anyone who has ever measured an 8 Ω speaker with an ohmmeter has discovered that impedance and DC resistance are not the same: the meter will read approximately 6Ω. Thus formulas that call for values of resistance may produce inaccuracies if applied to AC circuits. Generally speaking, however, the field technician need not be troubled by this fact and can safely rely on formulas that call for values of resistance. ❐