Technical Engineering Support Application Notice (TESAN)

Tesan S006-05
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Subject: Line Loss in Voice Evacuation Speaker Circuits

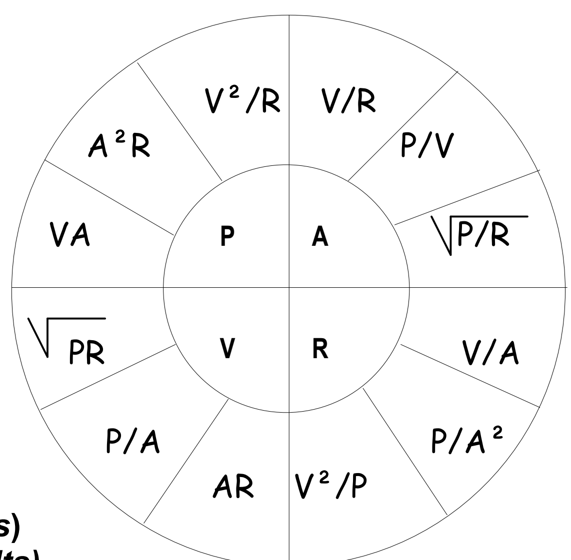
Line loss in speaker circuits (the actual loss in SPL, sound pressure level or volume) is directly related to the amount of resistance in wire runs. Thus, the chosen wire gauge can have a large impact on voice evacuation system performance.

OHM'S LAW

Ohm's law allows us to express characteristics of electrical circuits in terms of four (4) primary components:
Current, in amperes; ***Voltage,*** in volts; ***Resistance,*** in ohms; and ***Power,*** in watts.
The Classical Wheel illustrates the inter- relationships of Ohm's Law:

OHM'S LAW:

The Classical Wheel



P = Power (in *Watts*)
V = Voltage (in *Volts)*
A = Current (in *Amperes)*
R = Resistance (in *Ohms*

This convenient at-a-glance tool helps us to understand fundamental relationships in electrical circuits. Audio speaker circuits are no exception.

Line loss is due to the amount of resistance, in ohms, that the wire presents to the circuit. This is probably best understood by looking at the voltage drop.
Voltage drop in a circuit is expressed by the relationship

Vd = AL X RL

Where: **Vd = Voltage drop (in volts)**
AL = Load current (in amperes)
RL = Line resistance (in ohms)

Let's examine an 80 watt audio power circuit, using 500 feet of #16 awg (American wire gauge) wire. Since most commercial and fire evacuation audio circuits are 70 volts, we will use this as the standard operating voltage. 80 watts is the actual speaker load, not the amplifier's rated output.
Looking at the Classical Wheel, we see that Current (in amperes) is the product of dividing the Power (in watts) by the Voltage (in volts).
A = P/V
Therefore, A = 80/70, or 1.14 amperes
We now know the load current for 80 watts of audio power in a 70 volt system: 1.14 amperes.
The *line resistance* is simply the amount of resistance present in a length of copper wire. Speaker circuits consist of ***two wires***, the amount of wire on one conductor to the load, and the amount of wire back to the source. Wire resistance charts are widely available; they can be found in the NEC (National Electric Code). For #16awg wire, the resistance is 0.00402 ohms/foot. A 500 foot circuit means 1000 feet of wire, multiplied by 0.00402, for 4.02 ohms total resistance.

Plugging this into our voltage drop formula, we find:
Vd = 1.14 x 4.02
Vd = 4.58 volts, the actual loss in voltage from our 70 volt line. This leaves us with an operating voltage of 65.42 volts. Note that this represents a 6.5% drop in voltage: local Authorities Having Jurisdiction (AHJs, Fire Marshals, etc.) usually allow 10% voltage drop in signaling circuits.

The loss in SPL can be expressed in dB as follows:
Vf/Vi log 20 where the ratio Vf/Vi is the final voltage divided by the initial voltage. We then take the log of this result, and multiply by 20. The result is a negative number, reflecting the loss.
Thus:
65.42/70 log 20 = - .58 dB, less than 1 dB lost due to wire size. This is perfectly acceptable; most wire size charts allow ½ dB loss as an acceptable loss due to wire size.
To put things in perspective, it takes a 10dB change to lose half the volume.