# What you need to know about lighting and power

Behind effective and aesthetically pleasing lighting visuals is electrical power, quite possibly a lot of power. **John Black** addresses the fundamental knowledge of electrical engineering that every lighting professional should know

**ELECTRICITY. IT'S DIFFICULT TO** imagine that there was once a time when stages were illuminated by light sources not requiring electricity. Attend any major live event or large house of worship, look up, and you will see hundreds of light sources illuminating the stage in colours, patterns, movement and a whole variety of effects. Gone are the days of candles, oil lamps and gas burners as primary sources of illumination.

Today, electricity is available (or can be made available) almost anywhere, meaning that a lighting system can be assembled and used in an alley, living room, auditorium, garage, or elsewhere. While lighting technicians do not need to have all of the skills of an electrical engineer, it is important that they have a basic understanding of electrical power and the relationship between lighting equipment and power to ensure personal safety as well as the safe use of the systems and equipment.

## The language of electricity

To begin understanding power systems, it is important that a lighting technician understand the language of electricity and how it works. A couple of key terms to understand are amps and volts. Every electronic device you come across – fixture lamps, computers, cell phone chargers, wireless keyboards, batteries – will be have a volt and amp rating. The 'ampere' is the unit of measurement for the electrical current of the device. An electrical current is defined as the flow of electrons from one point to another (from a negatively charged body to a positively charged body). The 'volt' is the measurement of potential strength of the electrical system, or the difference in the electrical charge between a negatively-charged body and a positively-charged body. The greater the difference in potential strength (voltage), the more work the system can do. Therefore, a 220V system is capable of doing more work than a 110V system.

In all electrical systems, which includes lighting systems, there are

## MEET THE AUTHOR

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three components: the source, the load, and the circuit. The ‘source’ is defined as the mechanism (whether a battery, generator, or wall outlet) that provides the difference in potential (voltage). The ‘load’ is defined as the device (lamp, control console, or other fixture) that uses the electricity to perform some function. Finally, the ‘circuit’ is the path that the current flows through (from negative to positive). If you think back to your early schooling in elementary or middle school science class and remember connecting a battery to a light bulb with two wires, that activity demonstrates all of the essential parts existing in an electrical system.

## The power formula – watts

All of the terms used above are inter-related and useful when working with your lighting system. A useful formula to know is called ‘the power formula’, which is used when determining how much power will be consumed by a

**An MA Lighting digital dimmer rack**

circuit. The amount of power consumed is measured in watts. This is another term typically located on the label of electronic devices. The power formula itself is W = VA (watts = voltage x amps). When working with electricity, watts, volts and amps are important to know and this formula can be used to find an unknown factor in the circuit if the other two are known.

## How is this useful?

Lighting systems are just expansive electrical systems and all of these terms apply. The electrical source will typically be either a dimming rack or a power distribution rack. The loads

**ETC HSR48+ Sensor HD15 dimmers providing the stage lighting**

of the system will be lighting fixtures (conventional, automated, LEDs), lighting consoles, or other electronic equipment. The circuits in the system are all of the cables connecting the components to each other, through which current travels.

Having an understanding of amps, volts and watts will help guide you in selecting and working with lighting equipment safely as each component is designed to work within certain limits. Usually there is a protective device (circuit breaker) in the circuit that will stop the flow of electricity if the limit of the circuit is exceeded. If there is no protective device and the limit is exceeded, it is possible for components to heat up to the point where they may melt or cause a fire, especially if there are combustible materials nearby.

So let’s make this practical. My facility has installed a dimming system that outputs 120V (source) to all of the locations in my facility where I can connect fixtures (loads). I also know that the dimmer module I have installed (which also acts as a circuit breaker) can handle 20A of current. By using the power formula, I can calculate the total wattage that can be safely handled by the dimmer module:

W = VA
W = 120V x 20A
W = 2,400W

Additionally, I know that the cabling from the dimmer module to my fixture is 12-gauge cable. All electrical cables are designed to handle up to a certain amount of current safely. A 12-gauge cable is designed to handle up to 20A of current safely. Again, using the power formula, I can determine the safe load the cable can handle:

# Laying down the laws

**BASIC ELECTRICAL MATHS** – current, voltage, resistance and power – is pretty simple. It just takes a little multiplication, division, and when you get a bit more sophisticated, some basic algebra with an occasional square root (none of which is an issue with a calculator in every phone).

Ohm's Law is the foundation (Figure 1). Just to confuse a simple formula, traditional physics uses 'I' for current, instead of 'A' for the current unit amps (I for Intensity, from a French phrase that translates to Current Intensity). 'E' is used for voltage (E for Electromotive force). Resistance is 'R', even though measured in ohms. The triangle shape helps stage the formulas. E (voltage) equals I (current) times R (resistance), or, E=IR, R=E/I and I=E/R. If you know any of the two variables, you can solve easily for the third.

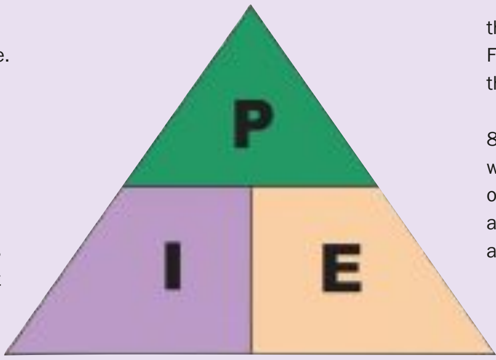

**Figure 2, Watt's Law**

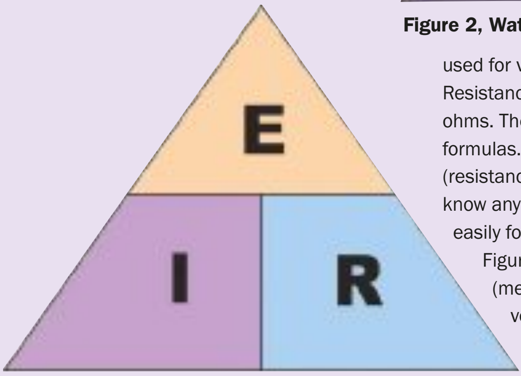

**Figure 1, Ohm's Law**

Figure 2 is Watts Law, where 'P' for Power (measured in watts) equals IE, or current x voltage. You can derive the same type of relationship for these three variables as with Ohm's law. You can also get a bit more sophisticated by blending the two laws, as shown in Figure 3.

For instance, since P=IE and E=IR, it also follows that P=IIR or P=I²R.

A quick practical example from audio: An 8-ohm loudspeaker fed with 200W of power would draw 5A of current. See if you can figure out what the voltage produced by the power amp would be in the same scenario by using the appropriate variations on the core formulas.

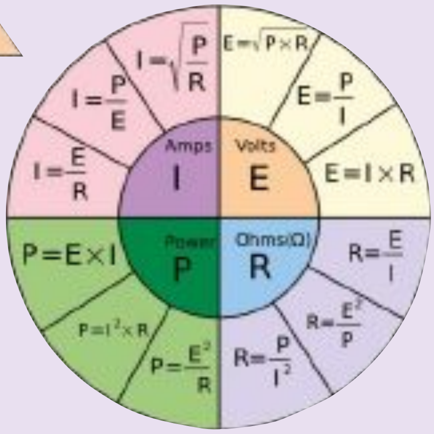

**Figure 3, Ohm's and Watt's laws combined**

W = VA
W = 120V x 20A
W = 2,400W

In this case it's the same. In some facilities, it may not be the same, so be sure to find out the specifications of all of the system components in your facility. If you are mobile and set up in a new facility or location often, be sure you know the limits of the system you travel with or that you plug in to.

Now that I know how much power can be safely consumed by my dimmer modules and cabling, I want to hook up some fixtures. Let's say I want to hook up my PR Lighting XL700 automated fixtures and want to know how many of them I can power on each circuit. By looking at the fixture manual, I know that each XL700 can be powered by my 120V system and each draws about 7A. Even though these fixtures use lamps that consume 700W, the fixtures actually consume more wattage because of the other systems requiring power in the fixture (motors for colour, gobos, positioning). So, using the power formula:

W = VA
W = 120V x 7A
W = 840W

As I know that the cabling and dimmer modules in my system can handle up to 2,400W safely:

2,400W ÷ 840W = 2.85 fixtures

Obviously, I can't put 0.85 of a lighting fixture onto the circuit, so I know that I can only safely connect two of my XL700 fixtures to each circuit.


**A Strand S21 dimmer strip**

## Dimming vs non-dim

In the lighting world, knowing that the equipment making up the load on a circuit can be safely handled by the system is not the only thing you need to be concerned about. Several times in this article I have made mention of a dimming rack and dimming module. The ability to dim a lamp to various intensities is desirable in stage lighting – more and more in housing and commercial installations as well – because of the way that mood and atmosphere can be influenced through a variety of intensities of light. When stage lighting was purely driven by the workhorses of conventional fixtures (high-wattage incandescent lamps), dimming racks met this desire, allowing very large systems to have individual intensity control.

Today, many lighting fixtures incorporate the use of programmable chip boards and small motors. If you open up the case of any automated fixture you will find many more parts than just the lamp. All of those components also require power to operate, but would be damaged by fluctuating the amount of voltage supplied. As such, automated fixtures, most LED fixtures, and other equipment containing PCBs require a constant power source. These types of equipment are typically powered either through the integration of a secondary power system through using a power distribution rack, or through changing out the dimmer modules in a dimmer rack to 'constant current modules'.

Employing the use of a power distribution rack requires connecting the rack to a high-voltage power source. This should really only be done by a trained electrician due to the risks associated with high voltage. If simply changing out modules on a dimmer rack, you can use all of the existing infrastructure of your lighting system and use non-dim fixture types where you are already equipped to plug into the system.

This was just a very brief overview of electricity and some basics you should know if you are a lighting technician. It is important to remember that not only can electricity damage equipment when limits are surpassed, but there are significant personal safety risks – including death. In my own workplace where I utilise a lot of volunteers, my rule is: 'If it's plugged in, but doesn't turn on, ask John'. The last thing that I want is for one of my crew members to receive an electrical shock or worse. If you know that you want to be a lighting technician or work in production more extensively, I would recommend finding a basic electricity course, a seminar or a workshop where you can be more formally trained on working with electrical systems. There are also a number of excellent books available about electricity for entertainment systems, but nothing can replace a hands-on session with an expert. After all, my ultimate rule of thumb for my crews is: 'Safety first!'