A low-down and dirty guide to Ethernet.

By Mike Falconer

It's a word that can strike fear into the hearts of the toughest and roughest of lighting techs – Ethernet. The words of the lighting manufactures promise the earth: complete flexibility, no more DMX cables and low cost distribution solutions. But what is it? What do you need to know? Why should you care? And what the hell is an I.P. Address?

I'll start this by saying that I have no formal training in Information Technology or Networking. What I have learned, I've done so by reading, talking to people who are way smarter than I, and large amount of trial & error. This guide is meant to give you grounding in the real lighting applications of Ethernet that exist today. As with DMX and most things other things in lighting, knowledge of what works is all that is required to navigate your way around this new and exciting addition to our quirky industry. So eggheads and really clever people be warned – this is a low down and dirty guide!

Getting started

Don't get intimidated by the word "Network". If you put a lighting rig together using DMX you are already setting up a network. A network is, for want of a better definition, a collection of devices connected together so that they can share and exchange information. Ethernet is just a physical system to achieve a network.

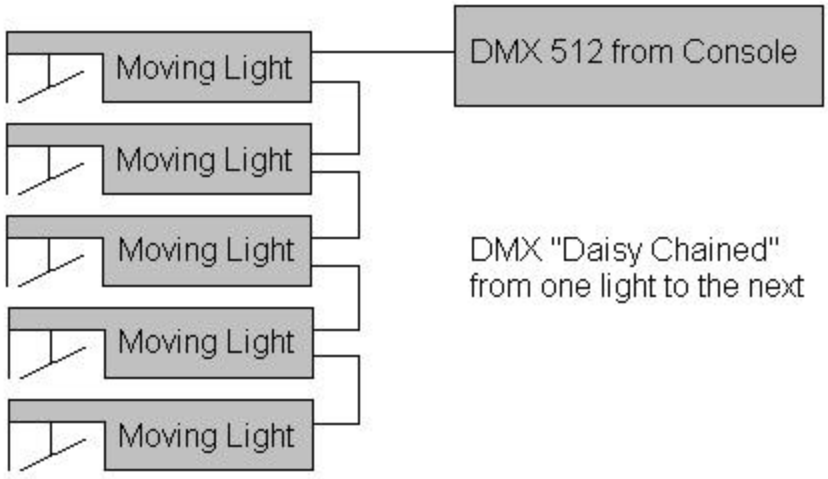
Most modern lighting Ethernet systems use what's called 10 base-T Ethernet (that's the thin, flexible wires with the phone jack like connectors) in a LAN or Local Area Network (A network which does not connect to the internet or go outside the confines of a building). There are some using 100 base T, which is significantly faster however they are in the minority and the current thinking is that 10 base T is plenty fast enough at this moment in time. TCP/IP, the protocol that makes the internet work, is the most common protocol that runs over a 10 base T Ethernet network and is used by most lighting Ethernet systems.

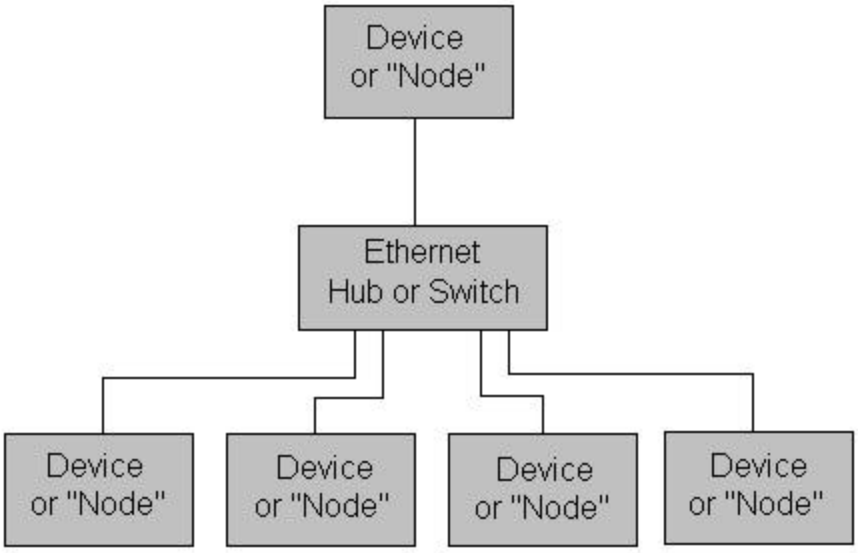
A word of warning before embarking into the world of Ethernet, DMX is pretty forgiving in it's implementation, things can work in a DMX system when by all rights they should not (I would drag out some anecdote about Y-splitting DMX but you've

heard them all before). But this is also its biggest drawback as things can work perfectly well for days on end and then stop working for no apparent reason. Ethernet basically works or does not work there is no middle ground. This does have the advantage of making it pretty straightforward to diagnose problems.

Ethernet is both an electrical standard and a low level communication Protocol. In itself it can do very little, but when it is used to deliver a higher level protocol, such as TCP/IP, it becomes really powerful. The easiest way to think of it is as just a way of communicating. This communication could be between two intelligent devices, such as two consoles, or as a way of transporting DMX between two separate points, more commonly known as Nodes.

The biggest hurdle to overcome in your thinking about DMX vs 10 base T Ethernet is the way it all plugs together or what is called in computer geek speak: Topology! The topology of a 10 base T Ethernet system works in a star configuration as opposed to the daisy chain configuration, which we all use for DMX. This means that an individual cable needs to run from your splitter, called a hub or switch in the language of Ethernet, to each device, rather than just linking from one device to the next.





Another hurdle to overcome is that the cables & connectors used for 10 base T Ethernet do not lend themselves to being extended. They are male to male and although joiners are available they are not particularly reliable or recommended. This means that to extend a cable you need a hub or switch. One of the ways that earlier adopters of this technology in entertainment lighting have gotten around this problem is to have a supply of cable to hand with tools and knowledge to make cables on site if required.

TCP/IP basics

For any two devices (such as a lighting console or a computer) to talk via Ethernet they require a unique address. An I.P. (Internet Protocol) address is made up of 4 sets of numbers. Each set is a number from 0 to 255. For most applications the first three sets of numbers need to be the same with the last set being unique, for example:

192.168.0.1 or 192.168.0.130 or 192.168.0.221

The three sets of numbers above would all work together on the same network. **All devices on a network require a unique IP address!**

The easiest way to think about I.P. addresses is that anywhere an Ethernet cable plugs into (or a replacement for a cable i.e. in a wireless system) a device you need to assign an I.P. address. So a computer with a wireless Ethernet Card and a wired LAN connection will have an I.P. Address for each. A good analogy for IP addressing is a normal street address. The first set of numbers is the town, the second the street, the third the building number and the forth the apartment number.

Most business networks use a system called DHCP to automatically assign I.P. addresses to the computers on the network. This has great advantages as it makes the network connection essentially plug and play. This is also how the Internet works; your service provider automatically assigns you an I.P. Address each time you connect to the Internet. DHCP however is not used in most lighting networks and static I.P. Addressing, where you manually give each device an I.P., seems to be the order of the day as this makes the system significantly more robust as it does not rely on a central file server and a network administrator.

Subnet Mask – for the longest time I used to just ignore the setting for a subnet mask as it never seemed to make a difference when setting up the small closed networks that I was using most of the time. Indeed if you do not put a subnet mask in when you are setting up the IP for a computer it will automatically assign one - Cool Huh! For most applications a subnet mask of 255.255.255.0 will work just fine. You'll see that it looks very much like an IP address and in fact the two are closely interrelated. It is the subnet mask, which defines the range of numbers that are compatible with your IP address. So with a Subnet Mask of 255.255.255.0 the first three sets of numbers in your IP address must be the same. With a subnet of 255.0.0.0 only the first set of numbers needs to be the same. The rule of thumb (which could be the subtitle for this guide) is to use a subnet of 255.0.0.0 and you should never run into problems.

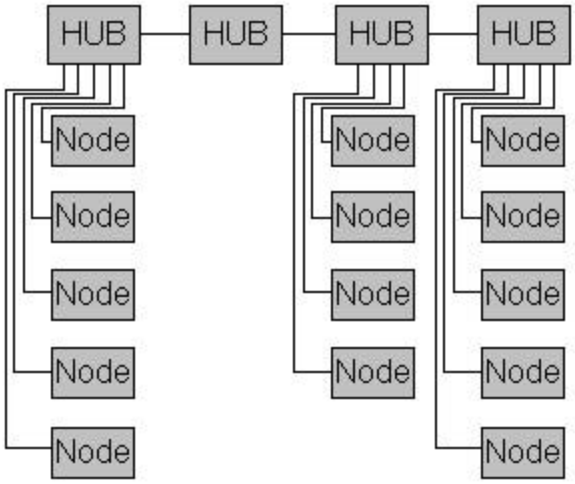
Hardware

Ethernet, and in particular 10 base T, hardware is very low cost when compared to DMX hardware, which is one of the things that make it so attractive. Please remember however that off-the-shelf computer peripherals for Ethernet are really designed for office or domestic use so again, as a rule of thumb, you get what you pay for!

Cables – There are basically two wiring schemes for cables and two types of cable. Just to make things more interesting it is almost impossible to tell apart by just looking at them. A straight cable is a pin-to-pin category 5 cable with a male RJ-45 connector at either end. This cable is used to go between an Ethernet hub, or a switch, to a device such as a computer. A crossover cable is a patch cable that twists the connection between the pins (1 to 3, 2 to 6, 3 to 1 and 6 to 2). This cable allows two devices, such as two computers to be linked together without the need for a hub. I strongly recommend that you mark up any crossover cables that you may have as they reek havoc when you are trying to cable a system and wondering why part of it does not work. In my office all of our cross over cables are orange to distinguish them from our straight cables that are all green. The two cable types are patch and installation. For entertainment applications patch cables are strongly recommend unless you are in a permanent installation scenario. Patch cables use stranded cores and are flexible. They have a maximum length of 200 feet as opposed to an installation cable that has a maximum length of 300 feet however it uses solid cores and should only be used where the cable can remain rigid.

Splitters – An Ethernet hub is the core of any Ethernet system and, as it's name suggests, it's the hub that allows multiple devices to talk to each other. An Ethernet switch is very similar to a hub however they can be significantly faster in certain applications and for larger networks. When a device sends a message to another device on the network via a hub the hub broadcasts that message to all the devices that are connected to it. When a switch is used it routes the message only to the device concerned, that way minimizing the amount of superfluous information floating around your network. It's actually getting harder to find hubs as opposed to switches as the prices of switches come down. The limited cable (or

segment to give it's proper Ethernet talk title) length of 10 Base T Ethernet can easily be extended by using a hub as a joiner however a total of only 4 hubs can be used in system and only 3 segments can be active at any one time. An active segment is a one that has a node on it as opposed to one that just joins two hubs together. This is more commonly known as the 5-4-3 rule. So between any two devices on the network (or nodes if you prefer) there can be no more than 5 Segments, 4 repeaters and 3 active segments. For longer runs fiber optics and other solutions must be looked at.



Wireless gateway / access point / Router. All of these devices essentially do the same thing provide a connection point for wireless devices to a wired Ethernet network. Most of them come with lots of bells and whistles to allow home users an easy way to access their DSL service etc etc, however for most lighting applications all that you need worry about is whether the unit is going to work for you and it's range. Wireless gateways tend to have an IP address so that you can configure them from a web browser however this IP does not need to be in your domain /subnet (first three sets of numbers the same) in order for your other wireless devices to access the wired part of your network. Technically these wireless devices are not Ethernet however many people including, I have to admit, me use the term "Wireless Ethernet". More on "Wireless Ethernet" later.

Ethernet Systems

There are (and here comes a controversial statement of ever there was one) two basic functions that Ethernet offers the lighting world.

The first is the transport of DMX, or another lighting control protocol, from point A to point B over a network. The benefits of this come in the form of flexibility as blocks of channels of whole universes of DMX can be routed, merged and split without any additional hardware. Several systems are available which translate DMX into Ethernet and then back again. In such systems a "Node" is used to convert the DMX data into 10 Base T Ethernet where it can be manipulated and monitored using a software program. Common manipulations include LTP & HTP merging of DMX universes and the outputting of a single universe to multiple locations much like a normal DMX splitter would do. The configuration of such networks tends to be via software running on a computer or PDA connected to the network. Small adjustments or significant changes can be made to your system at the click of a mouse. Other benefits include electronic labeling and access to low cost solutions to common problems such as wireless access and long distances. An inherent problem with Ethernet is that a single CAT 5 cable has a maximum length of only 300 feet as opposed to 1000 feet with DMX. However connections to fiber optic technologies for 10 base T Ethernet are readily available and can expand this distance dramatically for relatively little cost.

A second basic function that Ethernet can perform is an improvement in the way consoles communicate between each other. This is perhaps the most exciting aspect of using Ethernet in the entertainment lighting environment where time is always in short supply. Networked lighting consoles can allow two or more operators to work on the same show at the same time handling the same lights and then be played back on a single console without the need for the merging of show data. Another use is remotes; low cost PDA devices can be used as riggers and designers remotes. Need to give a Lighting Designer their own monitor? Just plug their laptop into the network running offline software. Offline editor software suddenly becomes on-line editor software in a multi-user environment. This also brings up the idea of a user being able to "surf" from one lighting session to another.

There are also systems that combine both of these ideas into one single system called distributed processing. In a distributed processing system the "nodes" as well as outputting DMX data, also process the data locally rather than having the console do it. The advantage of a distributed processing system is it's theoretically unlimited channel count as the total number of DMX channels depends only on the number of processing nodes available.

Connectors & Cable

10 Base-T Ethernet uses Category 5 cable. This 8-core cable has been designed to be cheap and lightweight. Cat 5 cables are not designed to be coiled, run over by fork lifts and generally take the abuse that they will get in an entertainment lighting environment. There are a number of heavier duty cables coming on to the market that have stranded cores and are double jacketed and they are a wise investment if your Ethernet cables are going to have to deal with a harsh environment.

As far as connectors go you have a number of choices. The standard RJ-45 connector is really not an option on it's own and even the hood that comes on most pre-made cables will only supply a minimal amount of protection. Of course if you choose a completely new connector you lose one of the main benefits of Ethernet in terms of low cost off-the-shelf hardware from the consumer and business markets. Neutrik have come up with an ingenuous solution in the form of the Ether-Con. This is a robust XLR type jacket that fits over an existing RJ-45 connector and can be assembled and disassembled without the need for tools thus is ideal for swapping back and forth. Woodhead Connectivity has an IP67 rated version of the RJ45, which has a screw down locking ring and is available in sealed and field attachable versions.
Socapex also have a protective shell to encase a standard RJ-45 and is available in plastic, Metallic Bayonet or Metallic full military spec versions.

"Wireless Ethernet"

My good friend Robert Bell wrote a great article about programming a casino in Canada while he was across a river, 400 yards away, in the U.S. (Lighting Dimensions December 2002) with his laptop using a "wireless Ethernet" system. This is a great example of what is possible with off-the-shelf technology using Ethernet. A gateway and a wireless card can cost as little as $150 (some one will have found one for less by the time you read this). What you do have to be aware of however is the nature of the technology. I would not use wireless technology unless it was impossible or highly impractical to use a normal Ethernet cable. Cable is always going to be more reliable than wireless, just ask a soundman!

802.11b (or Wi-Fi) is the standard that most of the low cost wireless products use. The thing to keep in mind is that 802.11b is not as much of a standard as some of the manufacturers would have you believe (sound familiar?) and thus certain software programs may have problems talking to devices or getting devices to talk to each other. It's worth checking with the manufacturer of any specialized software as to what has been tested and what they recommend.

802.11b separates down into two systems, AdHoc and Infrastructure. As the names suggest one is used for a more informal network arrangement and the other is for a more structured environment. AdHoc is really to allow laptop users to talk to each other and as such is of limited use in the lighting world (although there are some hoopy things you can do with it) Infrastructure is where a gateway/ access point / router what have you is used as the connection to the network and all wireless devices connect through this to LAN.

Now it is possible, as more and more wireless devices get out there, for things to get very confusing so the wireless part of your network has it's own ID called an SSID. This means that if you are in a building with multiple wireless access point and potentially compatible IP addresses you can pick and choose which one you would like to connect to. An SSID is typically a word, try to be original and use something other than "Wireless" or "Default"!

All wireless devices that want to communicate need to have the same SSID in order to work. As I said earlier all of the wireless gateways that I have seen have their own IP address which allows you to use a web browser such as Internet Explorer to configure them. The SSID of the unit has to be the same as that of all the other wireless devices however this, for want of a better expression, "configuration IP address" does not have to be compatible with the IP addresses of other wireless devices.

Practicalities

So you want to work with Ethernet do you? O.K. lets take a look at setting an IP address. For this example I'm using Microsoft Windows 2000®, however if you have a different operating system the process is pretty much the same.

Please note if you are already part of a network please check with your network administrator before changing your IP settings (you may not need to!) and before connecting any device, such as a lighting console, to an existing network.

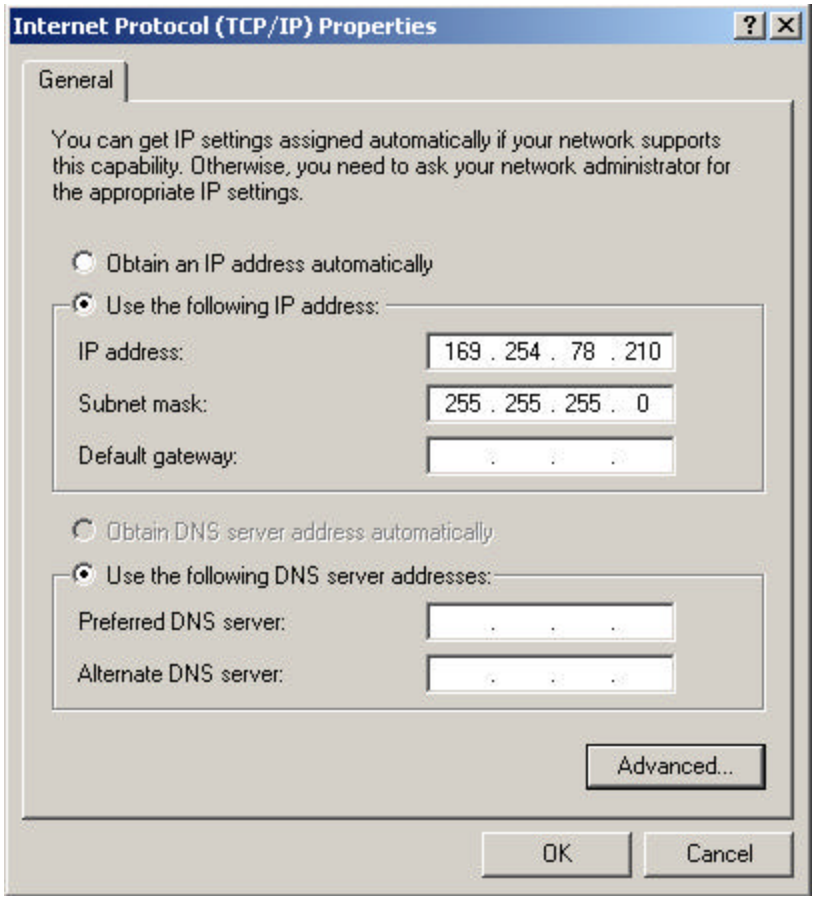
START – SETTINGS -NETWORK & DIAL-UP CONNECTIONS

Double click on LOCAL AREA CONNECTION

Click on PROPERTIES

Select INTERNET PROTOCOL (TCP/IP) from the list of protocols.

Click on PROPERTIES



In the properties window you will see either your existing IP address or a selection that says OBTAIN AN IP ADDRESS AUTOMATICALLY. This is where you choose whether to have a static IP address or use DCHP address.

Click on the radio button USE FOLLOWING IP ADDRESS.

Click OK once you have entered your required IP address.

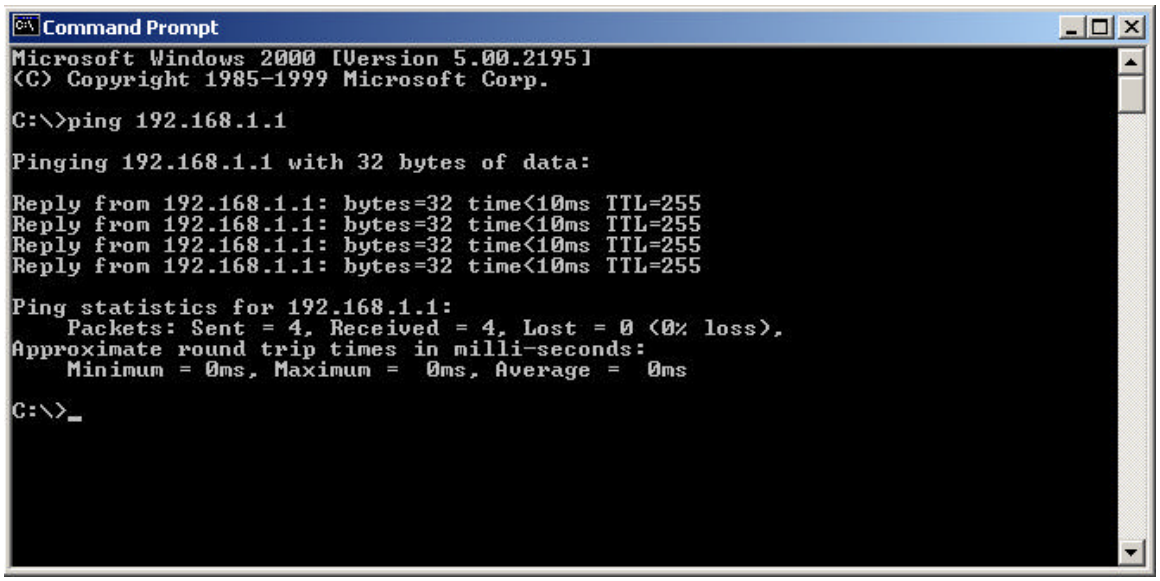
If you leave the SUB NET MASK field blank Windows® will prompt you that you need a SUBNET MASK and will then proceed to give you the default mask of 255.255.255.0 Just click OK to leave this menu and you're all set! Your computer now has an IP

address. Just a word of warning if you are using a Windows operating system pre-Windows 2000® you will need to re-boot.

There are a number of useful commands to be found in DOS for networking and are worth keeping in mind when things don't work first time.

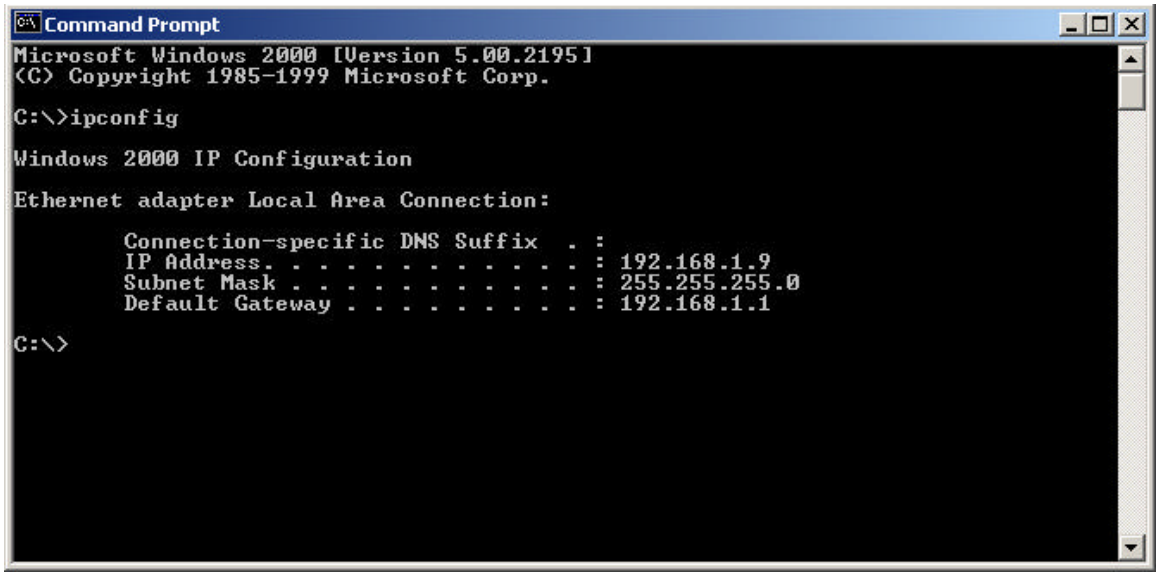
PING – To confirm that a device is on the network and that your PC can communicate with it:

START-PROGRAMS-ACCESSORIES-COMMAND PROMPT



From this DOS environment type if you typed: PING 192.168.1.1
You would get a response from the device with that IP if the message got through. If not you will get a time out message.

IPCONFIG – If you are using DCHP addressing and you want to know what your IP address is, or if you have any doubts about your IP settings you can use the same Command Prompt environment to run IPCONFIG and this will tell you the IP address that you are using on your computer.



IPCONFIG /ALL – This command, again run from the Command Prompt environment, will give you all the IP addresses in use on your computer when you are using multiple Ethernet cards.

Final words from the bunker

Ethernet is a new and exciting tool that has been creeping into our industry for years now. It is highly powerful and highly flexible which of course means that a certain level of complexity is only to be expected. As long as common sense prevails it can only be of benefit. I can't envision Ethernet cables going directly into lights anytime soon although I'm sure we'll see it at some point. Just like DMX before it the people who embrace this new technology will find themselves able to achieve things un-dreamt of by their counter parts that do not adopt it. Ethernet is just another tool in the toolbox and as such it makes a great compliment to the other tools we currently have such as effects generators for moving lights, visualization software and DMX.

R.D.M. (Remote Device Management) and A.C.N. (Advanced Control Network) are both up and coming protocols that could have a huge impact on our industry

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and the way that we work. R.D.M. runs over existing DMX cable and allows for the remote identification and configuration of devices such as Moving Lightings, color scrollers and dimmers. R.D.M. when it comes out will most likely be completely compatible with the DMX-over-Ethernet systems that are on the market as a number of them have had a hand it it's development. A.C.N. Is a completely new way of controlling and handling devices and it looks like it will take advantage of Ethernet.

I for one am a great supporter of these new and exciting tools but the bottom line is that DMX will be here for years to come as, I imagine, will Ethernet!

Points to remember

Ethernet networks can be highly flexible and offer low cost hardware however remember that, in general, you get what you pay for.

Everything needs an IP address and, with a few exceptions, an IP address is four sets of numbers between 0 & 255 with the first three sets of numbers identical and the last set unique.

Ethernet networks are not very forgiving, so they will either work or not work, this is both a good point and a bad point depending on your point of view. Remember the DOS tools that are available to you help troubleshooting.

Keep track of your cables, in particular crossover cables, as these can cause huge amounts of confusion if they get mixed in with normal patch cables.

When extending cables remember the 5, 4, 3 rule. Between any two to nodes there can only be 5 segments, 4 repeaters and 3 active segments.

Be sure of why you are using Ethernet Technology and what you hope to gain from using it.

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