

An Introduction to IP basics for users of the Sony Ethernet camera control system.

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Internet Protocol (IP) technology was originally developed in the 1970s to support some early research computer networks. Today, IP has become a worldwide standard for computer networking, and web browsers, e-mail programs etc all rely on IP protocols. The widespread availability of low cost IP hardware has resulted in IP technology being applied to many areas, since it offers the ability to deliver application specific data and control over standard physical network architecture.

TCP/IP (Transmission Control Protocol over IP) consists of a suite of control protocols that can be used to transmit data over a network.

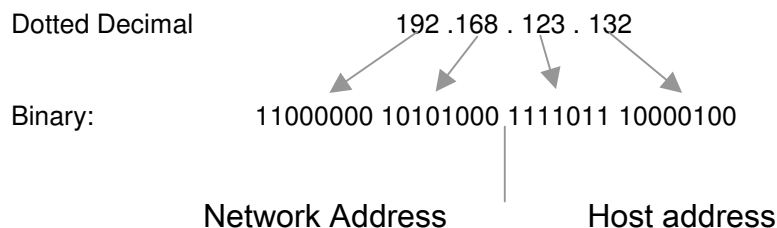
IP Address

To enable data to be delivered to the appropriate device, each physical device to be connected (for example in a camera system, each HDCU) must have a unique address to which data is transmitted. This address is known as the *IP Address*.

Most equipment today uses a 32-bit IP address (¹). For convenience, this address is normally expressed using dotted decimal notation, for example 192.168.123.132. Each group of digits is known as an *octet*.

To enable data to be transmitted efficiently, this address is split into two parts, the *Network Address* and the *Host Address*. Data is routed first to the appropriate network address, and then is delivered to the correct host (device) on that network.

Different networks can have different levels of complexity, so the split between the network and host addresses is not fixed. In this example, the network address uses 16 bits, and the remaining 16 bits form the host address.



¹ This is known as Internet Protocol Version 4, or IPv4. The 32-bit address can describe more than 4 billion devices, but the widespread application of IP technology means this may not be adequate in future, so IPV6 is now being developed, using 128-bit addresses. This will provide 2^{128} addresses, or approximately 5×10^{28} addresses for every living person on the planet. It is hoped this will provide sufficient room for future technology developments!

Three main network types are used, with 8, 16 or 24 bits used to describe the host address.

IP Address Class	Format	Purpose	Address Range	No. Bits Network/Host	Max. Hosts
A	NNN.HHH.HHH.HHH	Few large organizations	1.0.0.0 to 126.0.0.0	7/24	16777214 ($2^{24} - 2$)
B	NNN.NNN.HHH.HHH	Medium-size organizations	128.1.0.0 to 191.254.0.0	14/16	65534 ($2^{16} - 2$)
C	NNN.NNN.NNN.HHH	Relatively small organizations	192.0.1.0 to 223.255.254.0	21/8	254 ($2^8 - 2$)

Table 1: address classes

Subnet Mask

Most networks used for camera control will be Class C networks, but to further simplify the network infrastructure, networks can be subdivided into *Subnets*.

For example, the following:

172.16.1.0
172.16.2.0
172.16.3.0

could all be created as subnets within network 171.16.0.0

Subnets are defined by the *Subnet Mask*. Subnet masks also take the form of a 32 bit number, represented as dotted decimal notation, and define which part of the IP address is the subnet address, and which part is the actual host address

An example subnet mask might be

255.255.255.0

11111111 11111111 11111111 00000000

expressed as dotted decimal
in binary notation

This defines that the last 8 bits (the 8 zeros in the subnet mask) are to be treated as a host address. In this example, it allows the network to be split into 254 subnets, each of 254 hosts.

Subnet masks contain all "1"s as the left hand digits, and all zeros as the right hand bits. Other suitable network masks are:

255.255.255.192 11111111 11111111 11111111 11000000

255.255.255.224 11111111 11111111 11111111 11100000

1. 11111111 11111111 11111111 11110000

Most camera control networks will be contained within a single subnet.

Number of Bits	Subnet Mask	Number of Subnets	Number of Hosts
2	255.255.255.192	2	62
3	255.255.255.224	6	30
4	255.255.255.240	14	14
5	255.255.255.248	30	6
6	255.255.255.252	62	2

Table 2: Class C Subnet masking

Ethernet Switches and Hubs

To enable devices to communicate, they can be connected to an *Ethernet Switch*, or *Ethernet Hub*. So a typical camera control network would consist of a number of CCUs connected by cables to such a switch, as shown here.

Camera control System Architecture

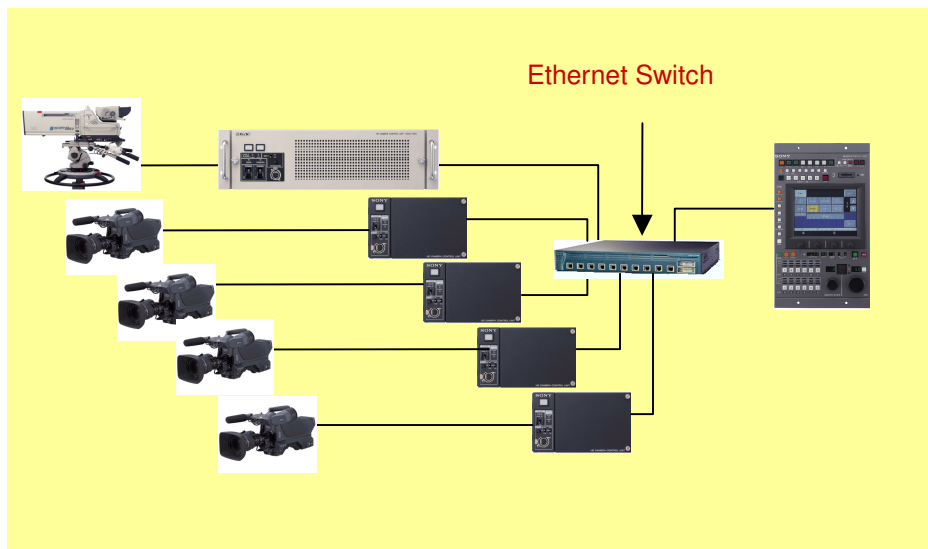


Figure 1

Each connected device (*host*) will have its own unique IP address, and the complete system will form a subnet.

The physical connection will normally be made with *Cat5e* cables fitted with *RJ45* connectors. Two types of cables are in common use. *Straight through* cables are connected so that pin 1 at one end connects to pin 1 at the other end, and so on. These are the standard type of cable. But watch out for *crossover* cables, which have pin 1 connected to pin 8, etc. Crossover cables allow two devices to be directly connected without any switch or hub.

An Ethernet *hub* will re-transmit data packets to all the devices connected to it. An Ethernet *switch* is 'smarter', and learns the address of all the devices connected to it, so it can route data to the destination device, minimising data traffic on the network.

Ethernet switches with up to 24 ports are widely available, but what happens if you want to connect more devices? There are several options; some types of switches can be expanded by a special 'link' connection to a second switch. Alternatively, they can be connected in a tree structure, as shown here.

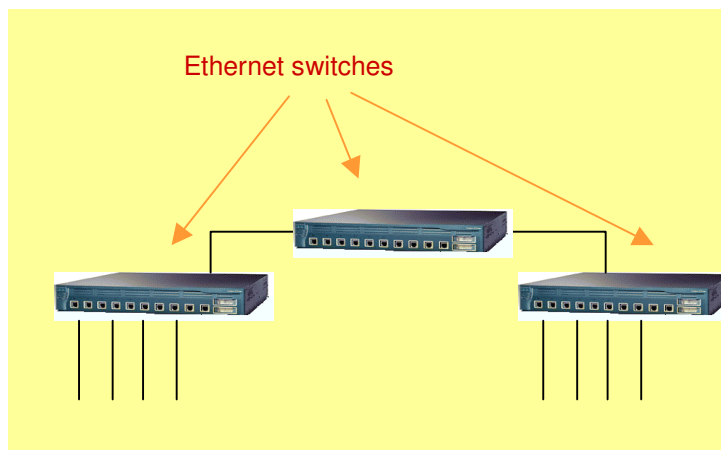


Figure 2

The exact configuration will depend on the hardware used, and the switches will require suitable configuration to work in this way.

The maximum connection length for each Cat5e cable is 100metres. The use of multiple switches as above also allows the devices to be further apart.

Alternatively, individual subnets can be connected together through a *gateway*.

Gateway

Communication between networks or subnets is handled by *gateways*. Rather than every device needing to know the location of every other device, data intended for another network is passed to its *default gateway*, which then passes the data on to the correct network.

Each CCU connected to the switch will need to be told the address of the default gateway, which it will use for any data to be sent to devices not on the same local network. The switches will also need to be configured with the gateway addresses.

In most cases, a camera control network will consist of a single subnet, so will not require a gateway. Only in the case of large systems, or where devices are physically remote, will gateway settings be necessary

Date Speed and Negotiation.

Network data rates of 10 Mbps and 100 Mbps are the most common. Most hardware devices today support both data rates. Higher data rates are possible using *Gigabit Ethernet*, but this would give no benefit for a camera system.

Communication can be *half duplex* (where each device can only transmit or receive at any one time) or *full duplex* (each end can transmit and receive at the same time).

Connections are either *MDI* (Medium Dependent Interface), or *MDIX* (Medium Dependent Interface Crossover). In a typical computer network where a PC connects to a switch, the port on the switch will have the transmit and receive pin connections reversed compared to those on the pc so a straight through cable can be used. If two similar ports are connected (both MDI or both MDIX), then a crossover cable is necessary.

For easy set-up, the camera control hardware supports auto negotiation, so that the communication settings are automatically configured. This depends on the Ethernet switches also supporting such automatic configuration.

Public and Private Networks

The Internet is a global connection of networks, that are connected together, and share a common range of IP Addresses. Such public networks must use IP addresses set by the standards body (InterNIC)

In the case of a camera control system, the network will be a *Private Network*. Since this private network is not connected to the outside world, it could, in theory, use any IP address range.

However, three ranges of IP Addresses have been set aside specifically for such private networks

It is good practice to select addresses from one of these ranges

Private IP Addresses

Network Address Range		Default Subnet Mask
10.0.0.0	10.255.255.255	255.0.0.0
172.16.0.0	172.31.255.255	255.240.0.0
192.168.0.0	192.168.255.255	255.255.0.0

Table 3

Forbidden Addresses

Certain other limitations apply when choosing IP addresses. For example, do not use IP addresses with "0" or "255" as the last digit

Eg 192.168.255.0

These addresses are reserved for broadcast messages to the entire network. Similarly, do not use IP addresses with all 'zeros' or all 'ones' as the digits within the subnet mask.

MSU

In the case of a camera control network, the MSU is connected to the system in exactly the same way as the CCUs, and needs its own unique IP address.

With the current (V1.10) software, no more than 2 MSUs may be used on a control network. One must be defined as the master, the other as client. Only the Master MSU can control RCP assignment. In addition, each CCU needs to know the IP address of the Master MSU.

The Master MSU must be switched on whenever the system is in use. Switching off the Master MSU will result in all control being lost, including RCP control.

Summary of Camera Network Configuration

Ensure Network software is fitted to all CCUs, cameras, RCPs, and MSU
Provide the appropriate Ethernet hub or switch, together with the necessary cables.

Connect CCUs and MSU to Ethernet switch

For each MSU

- Set unique and appropriate IP address

- Enable "multi" (MCS) mode on MSU

- Set Net Mask and Gateway

- In the case of a second MSU, set the IP address of the Master MSU

For each CCU

- Set unique and appropriate IP address

- Set Net Mask and Gateway

- Set negotiation mode

- Set camera number

- Set Master IP address (Master MSU IP address)

- Enable IP control mode on each CCU (DIP switch setting)

Reboot all system components

Note that the first time the system is switched on, it will take some time for the MSU to recognise and control all of the cameras. However, on subsequent occasions, the system will be established much quicker, unless the Ethernet connections have been changed.