Wholehog III Ethernet system design guide

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Scope

This document is intended to aid those involved in design of Networked systems using the Flying Pig Systems Wholehog III control system.

Flying Pig Systems use Ethernet for distributed processing. Calculations are shared between all the Wholehog III components connected to the network. This results in a system with almost limitless expansion because the available processing power increases with the size of the system.

It is impossible to give detailed designs for every system, and whole books have been written on how to install and configure Ethernet networks. This guide intends to outline how the components of the Wholehog III range use Ethernet and how systems may be designed to be functional, reliable and cost effective.

Basics of network design

Wholehog III has been designed for use with a 100Mb/s Ethernet infrastructure. Before specifying or installing a network system for Wholehog III, we advise you to read a text book or primer on Fast Ethernet networking. This section is not intended to be a complete guide or replacement for such material. It does attempt however to answer some frequently asked questions.

UTP Cable

Always use Category 5 UTP cables or better.

As the computer industry migrates towards 1000BaseT (Gigabit Ethernet), Category 5 cable is being phased out in favour of Category 5e (Enhanced Category 5) and Category 6. These cables have performance exceeding that of Category 5 and are therefore suitable. In addition, they may also be able to withstand some less than perfect installation.

The maximum length of any segment of cable is 100 metres (328'). This is the maximum distance between two pieces of Ethernet equipment. If your design includes wall plates, patch bays, or flying leads, these should all be taken into account when determining segment length.

Ethernet running at 100 Mb/s on Unshielded Twisted Pair (UTP) cable is referred to as 100Base-T.

UTP Connectors

RJ45 connectors are standard for terminating Category 5 cables.

Some Wholehog products are fitted with Neutrik (www.neutrik.com) Ethercon sockets. These are compatible with RJ45 terminated cables, but may also be used with mating Ethercon connectors. The Ethercon connector features a robust diecast shell and secure latching making it more suitable for an entertainment environment. Ethercon connectors and cables are not widely available, but can be obtained from specialist distributors or Flying Pig Systems.

Fibre optics

The limit of 100m for category 5 cables means that it may be necessary to use a fibre optic link to connect parts of the network. A full duplex fibre optic link (two fibres – one for transmit, one for receive) can run for up to 2000m. In order to use fibre ensure that your Ethernet switch supports fibre optic connections.

A fibre optic connection is likely to cost more than the equivalent cable connection for the following reasons:

- Fibre optic capable switches are harder to find and aimed at top end users
- Fibre optic cables are more expensive than the equivalent UTP cables
- Fibre optic cables tend to be less robust than UTP cables and therefore require careful installation and protection
- Specialised techniques are needed to terminate and test fibre optic connections

Flying pig systems will be introducing a switch incorporating fibre optic connections as part of the Wholehog product range.

In some situations, it may be more cost effective to install an additional switch or repeater in your network to extend a UTP infrastructure rather than to use fibre.

It is possible to extend Ethernet connections further than 2000m using single mode fibre. However this requires specialised techniques, and we recommend that you use a networking professional.

Ethernet running at 100 Mb/s on two optical fibres is referred to as 100Base-FX.

Fibre optic connectors

There are two types of fibre connector in common use – SC and ST. Cables terminated with both types are widely available. The choice of which connector to use is largely dependent on what type of connector is fitted to your network switch.

Full duplex fibre connections require two fibres for a single connection (Transmit and Receive). Both fibres are accommodated in a single SC connector. Although a little less robust, the SC connector has been more widely adopted by the market.

Switches

Switches may be used to connect all parts of the network together. Their purpose is to route information between all the equipment connected to a network. Wholehog III uses the TCP/IP protocol suite for communication. This has become the de facto network standard and allows operation with virtually all common networking components.

A switch operates by receiving packets of information, analysing them and forwarding them to their required destinations. This active processing of network traffic leads to the big advantage that switches are immune from most topology rules. Switches may cost more than an equivalent repeater, but this differential is now small making a switch the right choice for most applications.

The Wholehog III network has few specialist requirements. You should ensure that the switch has all the correct cable and fibre connections you require and can support 100BaseT network traffic. Flying Pig Systems will be offering an Ethernet switch to complement the Wholehog III range. This will feature a range of connections including RJ45, Fibre and Neutrik Ethercon. The unit is compact, noise free and has styling to match other Wholehog III products.

Repeaters / Hubs

Repeaters provide an alternative way to connect network segments together. The repeater copies all received packets of information to all the other ports on the repeater without modification or delay. When using repeaters, messages from different pieces of equipment will collide. These collisions are normal, but necessitate restrictions being placed on the network topology.

- The maximum distance between <u>any</u> two pieces of equipment connected by a repeater using 100Base-T cabling may not exceed 200 metres and may not include more than one repeater.

The pieces of equipment connected together by repeaters are often referred to as being in the same collision domain. A repeater has all the ports connected to a single collision domain. This may be compared to a switch which will provide a separate collision domain on every port.

Wholehog III control system design

The Wholehog III console has no output capability in itself. Therefore, all systems will require some networking.

There are a number of Flying Pig products planned which will connect to the network. These can be added to provide the services you require in the place they are needed. The Wholehog III range is expected to include the following. Full details of these may be found in literature and on the website. However, Flying Pig Systems should be contacted regarding availability, as not all are available at product launch.

- Console – Control surface
- DMX processor – 4 universes of DMX output on 5 pin XLRs.
- MIDI/Timecode processor – Connections for MIDI and Timecode
- Show control processor – Connections for serial and other generic links
- Network processor – 2000 Channels of control output over Ethernet
- Backup/replay software – Acts as a backup or replay unit when used on a networked PC
- Designer's software –Custom views and tools for lighting designers when used on a networked PC
- Tech. station software – Custom views and tools for technicians maintaining an installation when used on a networked PC

The simplest possible system will be a single console connected to a single DMX processor. This is shown in Figure 1. In this case, a switch is not required as the two units may be connected using a Category 5 Crossover cable.

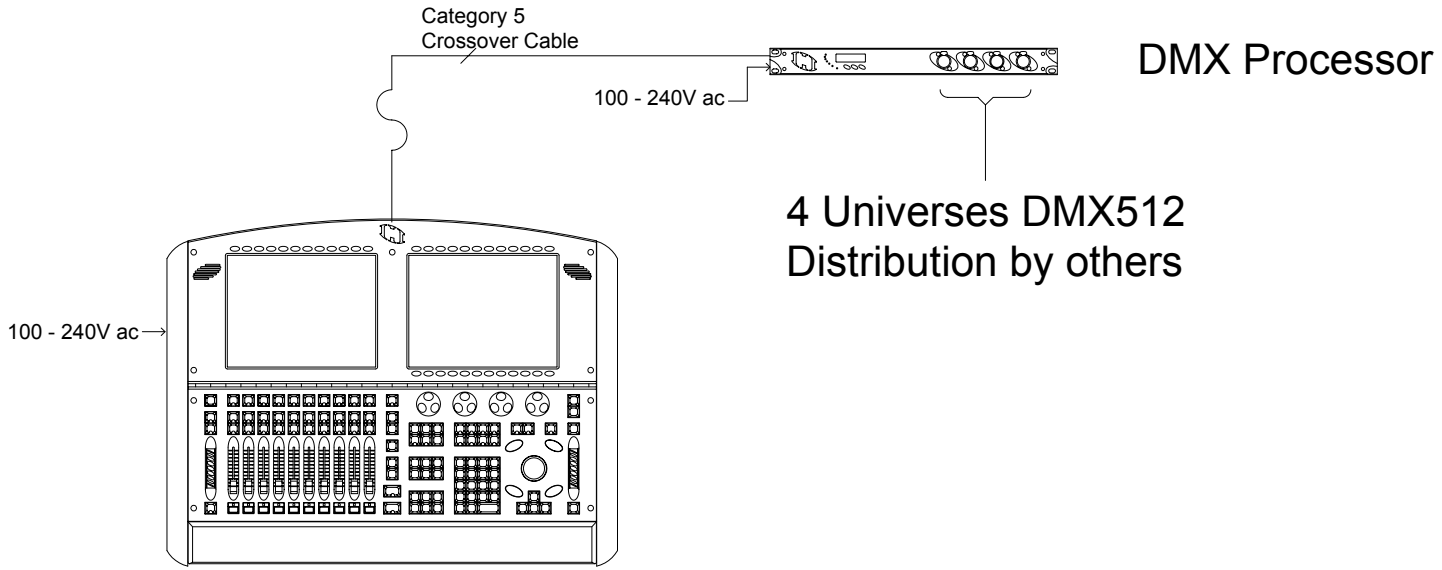
For anything beyond this special case, an Ethernet switch will be required to connect the elements of the system together. Figure 2 shows a system with output for eight DMX universes. In this system there are three network components – a console plus two DMX processors. Each of these connects to the Ethernet switch.

The Wholehog III processors and switches have been designed for mounting in 19" rack systems. They may be mounted together in roadcases or fixed equipment racks. Their shallow 4.5" depth makes also makes them suitable for wall mount cabinets.

Further components may be added to build up more complex systems. The principals remain the same. As systems become more extensive, more switches will be needed, and it may become necessary to include fibre links. Figure 3 shows such a system.

In installed networks, it is worth including patch panels in your design. A patch panel will allow links to be easily tested and reconfiguration of the network if necessary. You should also always include additional cabling in your building to allow for future expansion of your network.

Control Position



Bill of Materials

Qty	P/N	Description
1	61020001	Wholehog III Console
1	61040001	Wholehog III DMX Processor (4 way, rackmount)
1	-	3m Category 5 Ethercon crossover cable

Notes

1. 100Base-TX - All Ethernet cable is Category 5 certified UTP
   Cable length for 100Base-TX links must not exceed 100m
2. 100Base-FX - All fibre is Full-duplex 62.5um multimode fibre
   Fibre length for 100 Base-FX links must not exceed 2000m
3. Drawing does not show DMX cabling (by others)
4. Drawing does not show equipment racks
5. See attached cable schedule for wiring detail

Figure 1 - Simplest possible system

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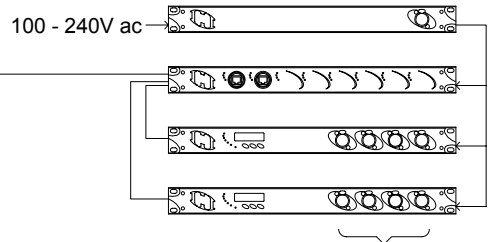
Control Position

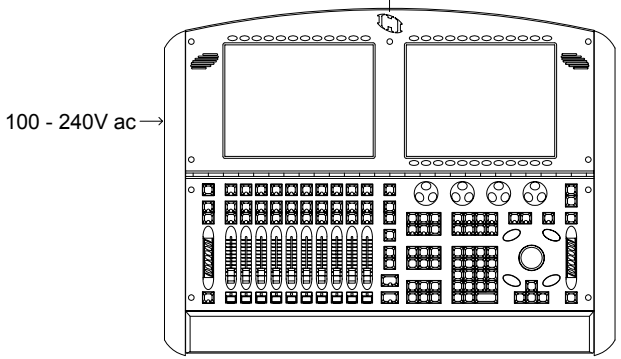
Stage

LCR 01



Rack distribution unit
Ethernet Switch
DMX Processor
DMX Processor

Category 5 Cable



Console

8 Universes DMX512
Distribution by others

Bill of Materials

Qty	P/N	Description
1	61020001	Wholehog III Console
2	61040001	Wholehog III DMX Processor (4 way, rackmount)
1	TBC	Wholehog III Power distribution (rackmount)
1	61040005	Wholehog III Ethernet switch (8 way, rackmount)
1	-	30m Category 5 Ethercon cable

Notes

1. 100Base-TX - All Ethernet cable is Category 5 certified UTP
   Cable length for 100Base-TX links must not exceed 100m
2. 100Base-FX - All fibre is Full-duplex 62.5um multimode fibre
   Fibre length for 100 Base-FX links must not exceed 2000m
3. Drawing does not show DMX cabling (by others)
4. Equipment racks & internal wiring not included in BoM (by others)
5. See attached cable schedule for wiring detail

Figure 2 - Switch connects network components

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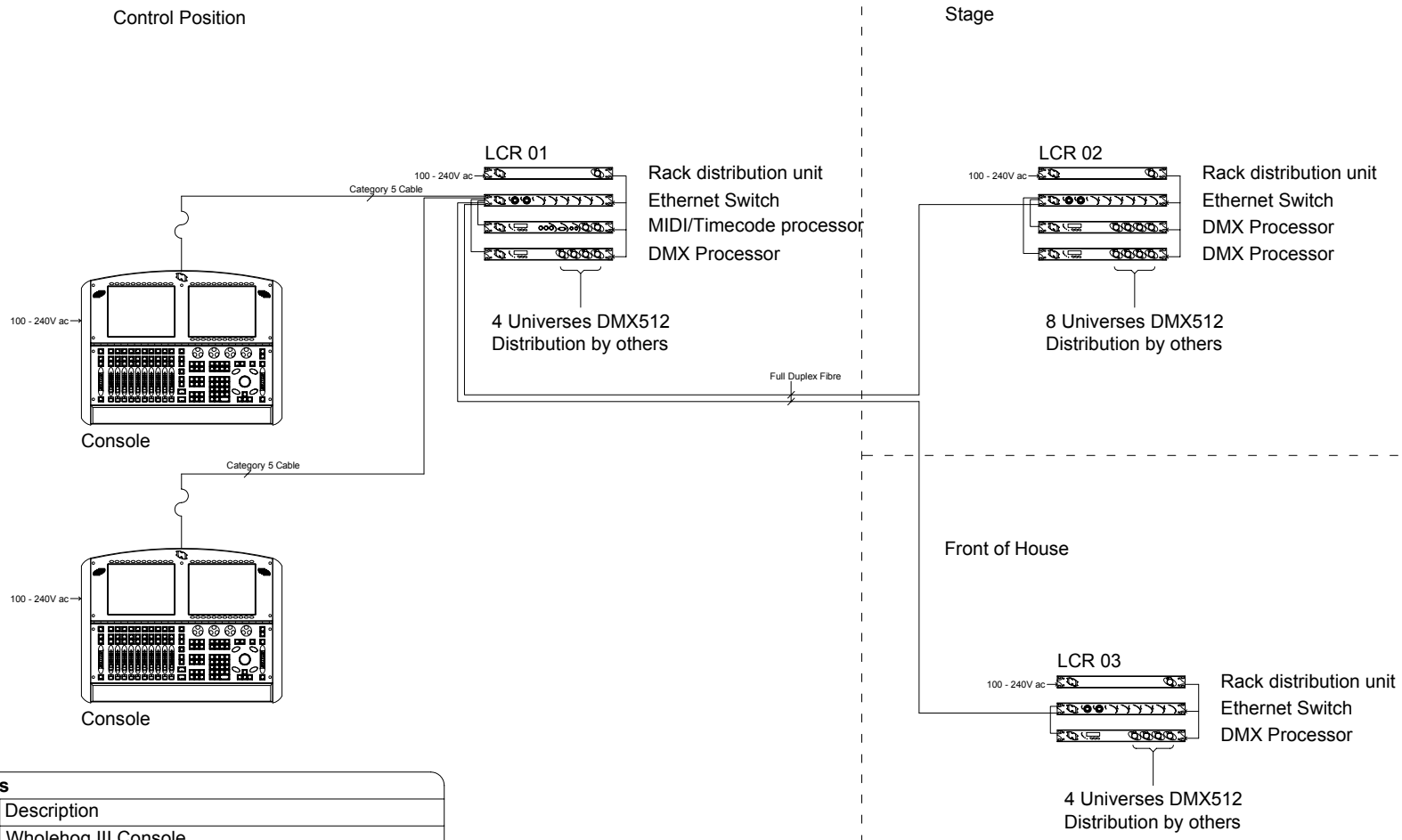

Bill of Materials

Qty	P/N	Description
2	61020001	Wholehog III Console
4	61040001	Wholehog III DMX Processor (4 way, rackmount)
1	61040003	Wholehog III MIDI/Timecode Processor (rackmount)
3	TBC	Wholehog III Power distribution (rackmount)
3	61040005	Wholehog III Ethernet switch (8 way, rackmount)
2	-	3m Category 5 Ethercon cable

Notes

1. 100Base-TX - All Ethernet cable is Category 5 certified UTP
   Cable length for 100Base-TX links must not exceed 100m
2. 100Base-FX - All fibre is Full-duplex 62.5um multimode fibre
   Fibre length for 100 Base-FX links must not exceed 2000m
3. Drawing does not show DMX cabling (by others)
4. Equipment racks & internal wiring not included in BoM (by others)
5. See attached cable schedule for wiring detail
6. Installed and fibre optic cabling by others

Figure 3 - A larger system

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Network Configuration

The Wholehog III has been designed so that the minimum amount of manual intervention is required for a system to automatically configure. This is achieved by allowing the console to act as a DHCP server. This means that it is able to allocate network settings to other equipment on the network.

There are a number of settings that are used by Wholehog III system components.

- DHCP on/off
  Determines whether the equipment should use a fixed (static) IP address (off) or whether it should be allocated an address by a DHCP server. By default, consoles are shipped with a static address of 172.31.0.1 and are set to act as the DHCP server. All other equipment is by default configured to get an address from a DHCP server.
- IP Address
  A 32 bit numeric address that uniquely identifies a piece of equipment on the network. By default Flying Pig Systems equipment uses Class B addresses in the range 172.31.0.1 to 172.31.255.254.
- Subnet mask
  Determines what subnet an IP address belongs to. By default , Flying Pig Systems equipment has a subnet mask of 255.255.0.0.
- Port
  A four digit number identifying a channel which the network components use to communicate with each other. By default all equipment is shipped with the port number set to 6600.

The default settings configure the system to operate on a Class B network.

The console includes additional settings to configure whether the console should act as the DHCP server and if so what range of addresses it should allocate to other equipment. By default it will allocate IP addresses in the above range with the above subnet mask.

Using multiple consoles

All consoles by default ship with the same IP address (172.31.0.1). This will cause a conflict if two consoles are attached to the same network.

The second console could be set to obtain its address using DHCP from the first console. However this requires that the first console always be active to use the second. Alternatively, the second console may be configured to have a different static IP address of say 172.31.0.2 and to act as a DHCP server. This will then be able to operate and communicate with system components independently of the first console.

This addressing scheme can be extended for any number of consoles or PC based backup / replay units. The DHCP servers should be set to allocate addresses in a range that does not include these static addresses e.g. 172.31.0.10 to 172.31.255.254.

In some instances it may be necessary to have logically independent systems on the same network. For example in a TV studio there may be multiple consoles on a common network independently controlling the lighting in individual studios. In addition to the notes above for multiple consoles, it will be necessary to give the equipment in each independent subsystem a different port number. In this example Studio 1 consoles and DMX processors could have their port number set to 6601; studio 2 could be set to 6602 and so forth.

Design for reliability

The distributed nature of the Wholehog III system ensures a degree of reliability. If one part of the system fails, the remainder is able to keep running. For example DMX will continue to be output from DMX processors even if a console loses power or becomes disconnected from the network. There are additional measures which may be taken to ensure your network is reliable. These are described in this section and illustrated in Figure 4.

Power protection

All elements of your network are vulnerable to power outages. This includes not only Consoles and remote processors, but also Ethernet switches used to connect these elements. It is recommended that UPS systems be used to provide back up power for all system components.

Backup show server

In a typical installation the console will act as the show server. The server is the central store for the show and co-ordinates the activities of the other components. It is possible to have one or more backup show servers. These may either be additional consoles or dedicated server PCs. In the latter case, the PC may be equipped with RAID disk arrays to further protect your show.

The backup show server will be able to take over from the main console in the event of a problem.

Cabling

A single Ethernet cable will carry all the communications of your network. It is important that this cable can be relied upon for your show critical data.

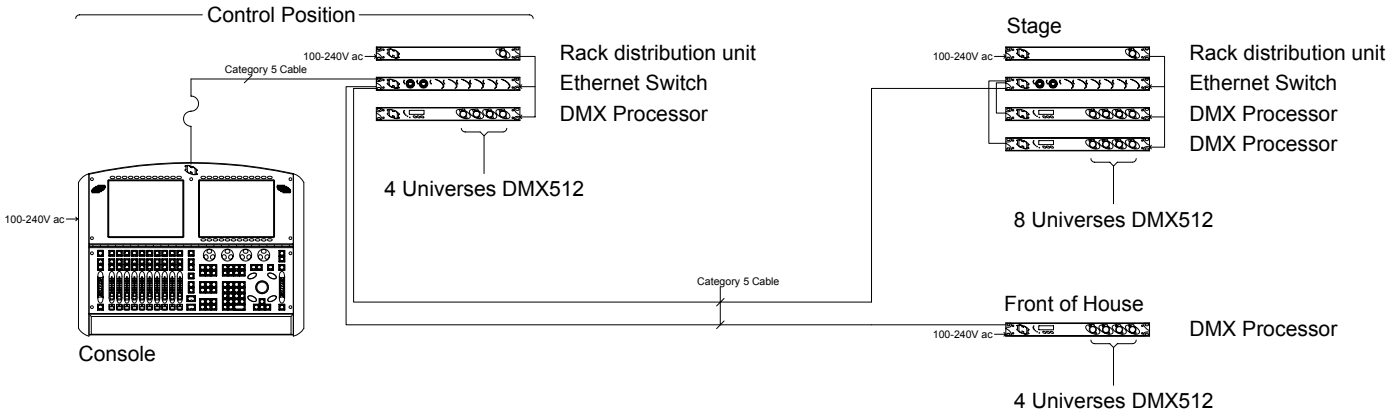
- Where temporary cable is used ensure your cable is robust enough for the environment it is used in, and that it is well terminated and approved to Category 5 or better.
- Where cable is installed, use a reputable contractor and quality cable. Ensure that your installation is certified to confirm that the cabling's performance meets Category 5 standards or better.
- Determine the run length of all installed cables, and ensure that total run length including any temporary cables can not exceed 100m.

In all cases run spare cables so that if the main link breaks, the second may be called into action. By incorporating patch panels into your design changing to a backup cable can be quick and easy.

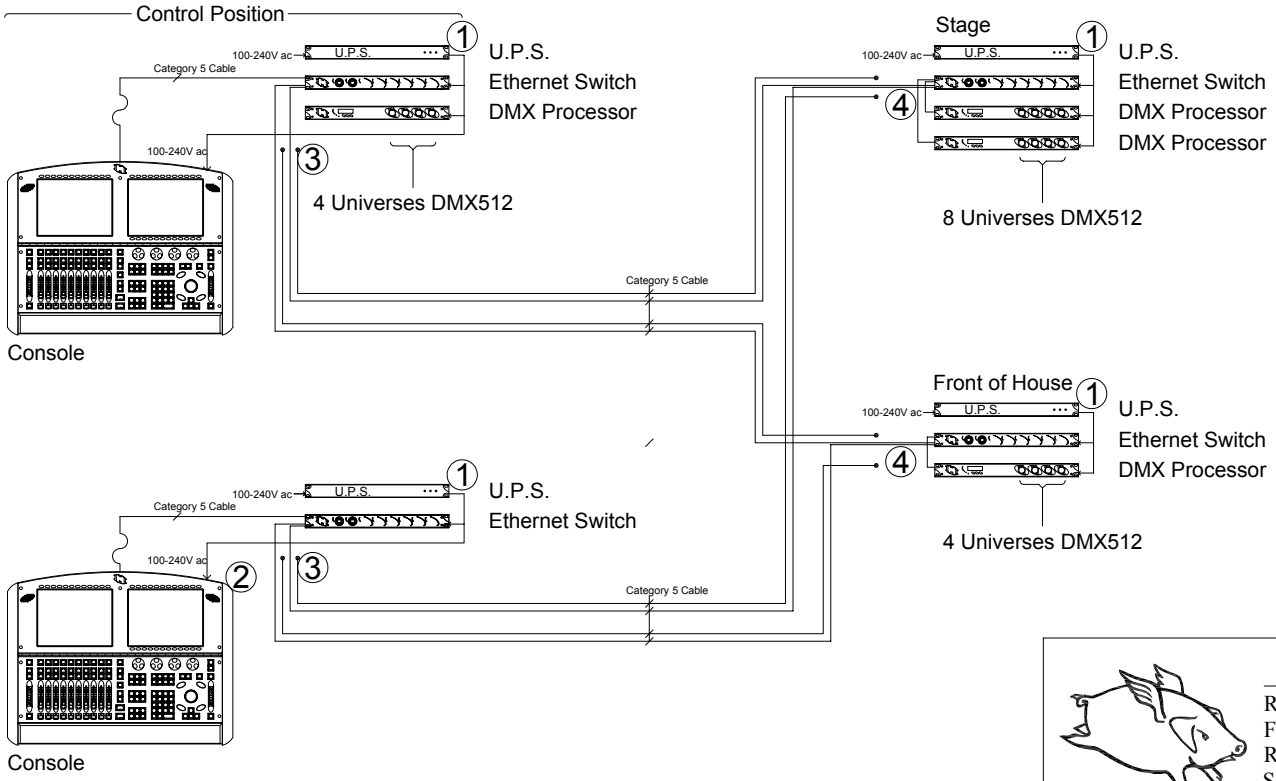
Resilient network topologies

Many Ethernet switches support the 802.1d Spanning Tree Algorithm. This allows you to incorporate redundant or parallel links into your network. In the event of a primary link failing, the network will be able to self heal by using the secondary link.

Typical Wholehog III network configuration



Configuration incorporating features for network resilience



Ethernet design for reliability

1. Power protection provided for all network components using distributed UPS units
2. Second console provided as backup show server
3. Spare cables run allow to allow easy replacement if the primary cable becomes damaged
4. Redundant network links allow for the failure of a individual cables or switches with mimimal impact

Figure 4 - Design for Reliability

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Connecting other equipment to a Wholehog III network

Using Wholehog III equipment with equipment from other manufacturers on a single network should only be attempted with extreme caution. The following notes are intended to explain some of the issues with shared networks, rather than to encourage their use. A dedicated network will almost certainly be more trouble free than one combined with other services.

Wholehog III uses the TCP/IP protocol set. This is in common with office equipment and most other lighting equipment manufacturers. As a result, Wholehog III is able to co-exist on a network with a large number of other types of equipment. Indeed, the Wholehog III system has been successfully attached to a typical office network with no noticeable degradation in functionality.

Network Traffic

When using Ethernet, a quick response is dependent on having a relatively low network usage. Response time will start to rise once the network is around 30% utilised. The packets will then start to be delayed and subject to some jitter. As systems are combined on a single network, this network will become increasingly heavily loaded.

In an entertainment environment, real time operation is essential – When the 'go' button is pressed we demand an instant response, when a fader is moved we expect an even fade. For these reasons the network must be lightly loaded. Other systems using the network may also require a fast speed of response. This will be particularly true of DMX distribution and other control systems.

Wholehog III traffic is largely multicast and the messages will travel to all points on the network. This makes communication efficient as a single Ethernet message from a console can carry information to all remote processors. Likewise a single message from a remote processor carries information to all consoles. Many control systems operate in this way to optimise their operation.

Multicast traffic however has the disadvantage that it floods to all points on the network whether it is required there or not. Where multicast or broadcast traffic is used, and two systems are combined the traffic will combine at all points on the network. This may result in unacceptable network delays. The Wholehog III has been designed for use on a 100BaseT network. If the network includes 10BaseTequipment, these nodes are likely to become overloaded as the Wholehog III traffic floods into these lower bandwidth links.

It should also be noted that the Wholehog III transfers a lot of information during startup. This could generate problems even though the steady state traffic is observed to be relatively low.

Precautions for shared network design

If a shared network is required, it will require careful design from the outset, and frequent monitoring of traffic levels.

Configuration

In a shared network, it is likely that it will be necessary to change some of the configuration settings to enable the Flying Pig Systems equipment to co-exist with other manufacturers.

If there is already a DHCP server connected to the network, the console DHCP server must be switched off to avoid equipment being allocated conflicting address ranges. There are then two possible approaches:

- Allow the existing DHCP server to allocate addresses to the Flying Pig Systems equipment. You should ensure that the DHCP server is reliable. If this fails the lighting network will not receive the configuration information it needs and therefore will not operate
- Specify static IP addresses for all Flying Pig Systems equipment. Addresses should be chosen so that the equipment will operate on a subnet not used by any other equipment on the network.

If there is a network administrator he/she should be consulted and will be able to advise on the best settings for the shared network.

Patch panels

Include patch panels in your design to allow you to separate the Wholehog III system from other parts of the network. This will allow you to fully commission the system and establish traffic levels before combining with other equipment.

A well designed patch panel will also allow systems to be permanently separated if it becomes necessary.

Using managed switches

Traffic may be segregated and monitored using managed switches. Although a managed switch introduces complexity into your network, it may be usefully configured to segregate traffic from different systems.

Switches that support VLANs can be of used to limit the propagation of broadcast and multicast packets. A VLAN is a logical group of nodes on the network. Multiple VLANs are able to share the same physical infrastructure. This may also allow for high bandwidth backbones to be usefully incorporated into your system.

If managed switches are used, it is essential that all the configuration settings be carefully recorded so that in the event of switch failure reconfiguration of the network may be carried out quickly and accurately.

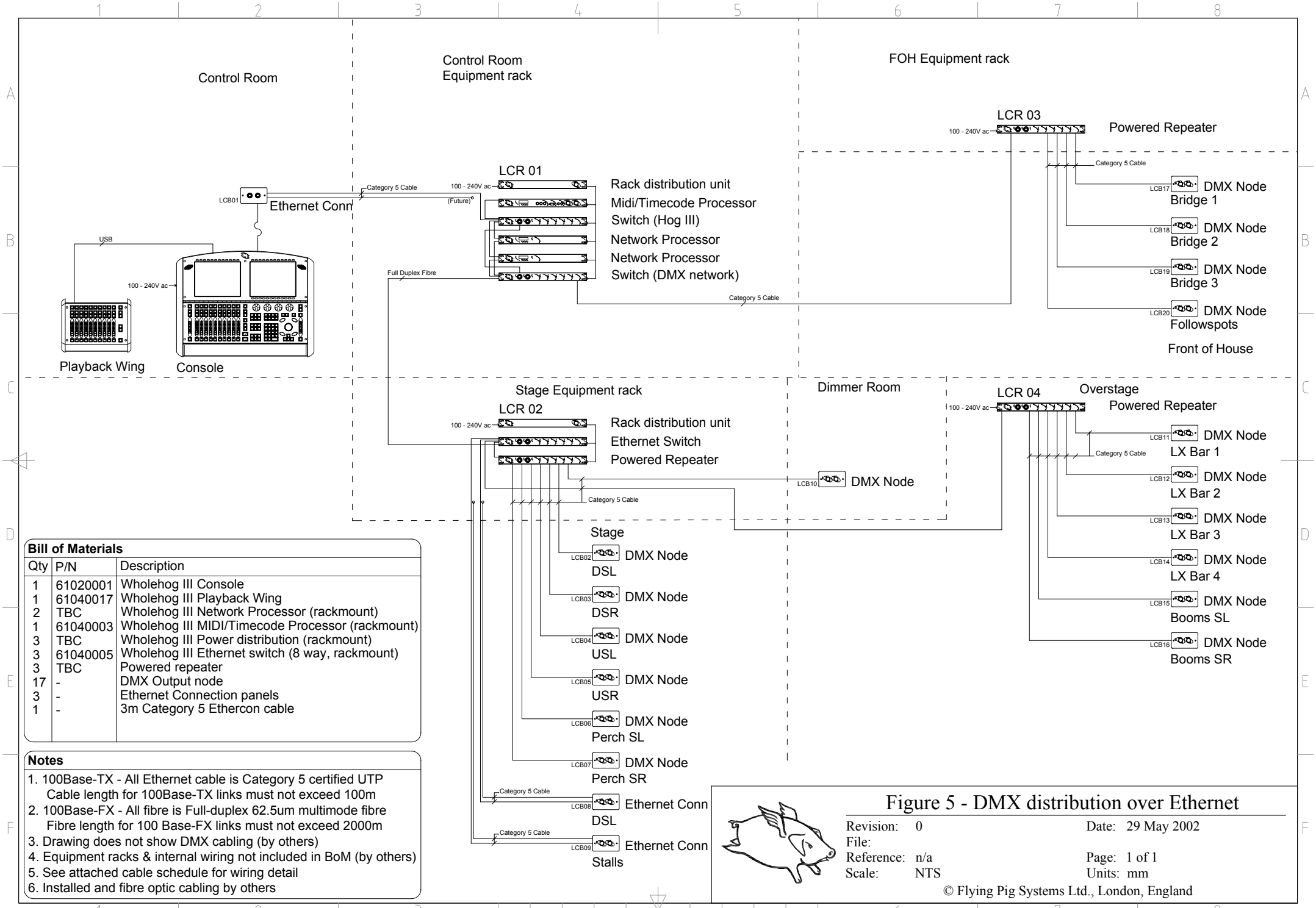
Often managed switches include tools to monitor traffic travelling in different parts of the network. These can be an essential aid in troubleshooting your installation.

Distributing DMX using Ethernet

A number of third party products are available for the distribution of DMX over Ethernet. The network for data distribution should be separated from the Wholehog III control network. This is particularly true as many of the DMX distribution protocols support 10BaseT data distribution. The 10BaseT legs are vulnerable to overloading by Wholehog III traffic and therefore may become subject to unacceptable delays.

It is recognised however that for many systems, a common network for control and data distribution is highly desirable. For small systems - up to eight DMX universes (4000 channels) - it will be possible to combine Wholehog III control and DMX distribution on a single network without significant impact on your system’s response. This is a rule of thumb based on ArtNet and Pathway protocols. Any larger systems with more DMX traffic will need careful analysis and design by the system integrator.

Figure 5 shows a Wholehog III system with eight universes of DMX distributed on a common network.



Bill of Materials

Qty	P/N	Description
1	61020001	Wholehog III Console
1	61040017	Wholehog III Playback Wing
2	TBC	Wholehog III Network Processor (rackmount)
1	61040003	Wholehog III MIDI/Timecode Processor (rackmount)
3	TBC	Wholehog III Power distribution (rackmount)
3	61040005	Wholehog III Ethernet switch (8 way, rackmount)
3	TBC	Powered repeater
17	-	DMX Output node
3	-	Ethernet Connection panels
1	-	3m Category 5 Ethercon cable

Notes

1. 100Base-TX - All Ethernet cable is Category 5 certified UTP
   Cable length for 100Base-TX links must not exceed 100m
2. 100Base-FX - All fibre is Full-duplex 62.5um multimode fibre
   Fibre length for 100 Base-FX links must not exceed 2000m
3. Drawing does not show DMX cabling (by others)
4. Equipment racks & internal wiring not included in BoM (by others)
5. See attached cable schedule for wiring detail
6. Installed and fibre optic cabling by others

Figure 5 - DMX distribution over Ethernet

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