Tutorial
Structured Cabling

Knowledge of the content of this tutorial is essential for those booked into our Structured Cabling Course or the KRONE Master Installer Course.

It is recommended that if you are booked into either of these courses you should study their course preparation tutorial and answer the questions at the end of the tutorial.

The course instructor will assume that you have done this and will provide answers to the tutorial questions at the commencement of the course before proceeding with the course proper.

1. Introduction to Structured Cabling for Integrated Voice & Data

1.1. Prior to the 1990s, in Australia, the monopoly carrier, Telstra, installed cabling for provision of telephony services whilst computer networking companies installed the data cabling. A number of factors drove the development of a generic structured cabling system for voice and data.

1.2. Factors

1.2.3. Deregulation of the telecommunications industry enabled cablers to be licenced/registered to install telephony cabling in a customer’s premises from the network boundary. This enabled the computer cablers to also install telephony cabling facilitating an integrated approach to communications cabling.

1.2.3. Additionally, impetus for an integrated approach to voice and data cabling came from the need for both a telephony connection and a computer-networking connection at each “desk” of a commercial/industrial enterprises. Typical “desk workers” needed, as a minimum, a telephone and a network connection for their computers.

1.2.3. A third reason for a generic structured cabling system arose from the plethora of vendor-specific computer cabling systems spawned during the 1980s. When a customer changed his/her computer networking systems, the vendor-specific cabling associated with the obsolescent system was abandoned and a new cable type installed. The abandoned cabling began to block cabling pathways and impede the installation of the replacement system. IBM type 1 cable and various coaxial cables were in this obsolescent Category. A generic approach to cabling was needed so that new computer networking systems could be installed on an existing generic cabling system without having to abandon the existing cable.

1.2.4. Finally there was a need for a structured cabling system which would efficiently cope with the regular “move and changes” within the office environment, without having to run cables or re-route old cables, a process which greatly disrupt normal office operations.
1.2.5. **Generic Cabling Standards**

Generic structured cabling standards evolved in the 1990s to meet these needs.

In North America, the EIA/TIA 568 standard was promulgated.

International Standard, IS 11801 was produced.

In Australia / New Zealand, our own AS/NZS 3080 standard was produced by an industry committee of Standards Australia.

AS/NZS 3080 is closely modelled on IS11801. All three standards have been progressively updated as cable and components have increased in transmission quality enabling larger bandwidth to be utilised and higher and yet higher data rates to be supported. At the time of writing, early 2002, the 2nd edition of IS11801 is about to be released as is the version of AS/NZS 3080:2002. Both documents support generic structured cabling systems for commercial premises for data rate operation to 1 Gigabit/sec on twisted pair copper with even high rates to 10 Gb/s supported on optical fibre cabling.
1.2.6. Structured Cabling Components

The generic AS/NZS 3080:2002 cabling standard is based on:

a) Cabling using twisted pair copper and optical fibre

b) Outlets using 8 pin modular plugs and sockets commonly (and incorrectly called RJ45s); typically dual 8 pin modular sockets are installed as a minimum. This providing an outlet for a telephone connection and an outlet for a computer network connection at each work station position. Figure 3 refers.

c) Cable termination administration points using 8 pin modular jack patch panels or insulation displacement modules. Figure 4 and 5 refer.

d) Cross-connection changes at the cable termination administration points are made by “RJ45” patch cords or twisted pair jumpers for insulation displacement termination modules. In the case of optical fibre, cross connection changes at these central administration points are made by optical fibre patch cords.
It should be noted that coaxial cable is not included in any of these generic structured cabling standards. However, they do allow for shielded versions of the twisted pair cables.

Figure 3
Dual 8 Pin Modular Sockets

Figure 4
8 Pin Modular Socket Patch Panel
1.2.7. Twisted Pair Cable Descriptions

The most common (and lowest cost) twisted pair cabling is unshielded twisted pair (UTP). It is produced in 4 pair, 24/25 pair and 96/100 pair sizes. Figure 6 refers.

A high percentage of office floor cabling to desk outlets is done in 4 pair UTP.

A foil shielded version of the twisted pair is FTP. An aluminium shield is wrapped around all pairs under a PVC sheath. The purpose of FTP is to prevent high intensity electromagnetic interference entering the cable. Both the cable and it’s termination arrangements impose a cost penalty over UTP. Figure 7 refers.
A version of twisted pair cable in which the individual pairs are shielded from each other using an aluminium foil around each pair is called shielded twisted pair or **STP or ScTP**. **Figure 8 refers.** The purposes of individually shielding pairs is to reduce crosstalk interference between the pairs. In addition, some versions of this type of cable construction, have an overall shield (braided copper or aluminium) around all pairs and underneath the outer PVC jacket, to reject intense external electromagnetic interference. STP is even more expensive than FTP both in cable cost and termination of the cables at outlets.
1.2.8. Categories of Transmission and Classes of Operation

1.2.8.1. To distinguish between the various levels of transmission quality in both cable and termination components, the term **Category** is used.

Ordinary telephone (voice) quality twisted pair is **Category 1** and it only supports low bandwidth classes of operation such as the telephone/fax/basic internet connection.

**Category 5** is commonly used in 4 pair structured cabling of office floors to the desk outlets.

**Category 5** supports 1000 Mb/s data rates on a bandwidth of 100 MHz using all 4 pairs of a 4 pair cable; typical system operation is Gigabit Ethernet (1000 Mb/s).

**Category 6** cable supports a bandwidth of 250 MHz and operation of Gigabit Ethernet (1000 Mb/s) on 2 of the 4 pairs of a 4 pair cable using them as go/return pairs.

**Category 5** and **Category 6** twisted pair cables are available in both UTP and FTP.

**Category 7** twisted pair is under development at the time of writing and is expected to be STP (ScTP) in construction.

AS/NZS 3080:2002 supports Cat 3, Cat 5 and Cat 6 twisted pair.

**Category 3** is the minimum transmission level supported and this level supports data rates as high as 10 Mb/s but is relegated to telephony/fax/internet service provision.

1.2.8.2. What Cable Characteristic(s) Determine its Category?

The primary determinate of transmission quality is the frequency and accuracy of the twist rate of each pair as well as the uniformity and accuracy of its physical construction.

**Category 1** twisted pair (ordinary telephone cable) has a very loose and infrequent pair twist.

**Category 5/6** has a very frequent pair twist with unique twist rates for each pair. A critical aspect of installation is to maintain these pair twist to within 10-13mm of the actual wire termination points at sockets and not to disrupt pair twists and wire geometry through poor installation practices.
1.2.8.3. Difference in Performance of Old Category 5 Versus New Category 5.

New Category 5 (previously referred to as Cat 5E), 4 pair cable supports Gigabit Ethernet (1000M/bs) using all four pairs simultaneously in the direction – “four traffic lanes” on the super highway.

Old Category 5, 4 pair cable will support 100 BASE T (100 Mb/s using only two pairs, one for transmit and one for receive – “two traffic lanes”, one in each direction on the super highway. New Category 5 cable is therefore more extensively tested using additional tests such as power sum near end and equal level far end, crosstalk as well as delay skew and return loss.

Old Cat 5 refers to specification in AS/NZS 3080:96 where as new Cat 5 is specified in AS/NZS 3080:2002.

These testing parameters are described in Chapters 4 and 8.

1.2.9. Termination Hardware Categories

Termination hardware such as modules and 8 pin modular jacks are similarly specified by Category in AS/NZS 3080:2002 ie Cat 3, Cat 5, Cat 6.

Category 5 termination hardware must be used as a minimum with Category 5 cable, if the overall transmission performance is to be maintained at this level.

Likewise, connecting leads and patchcords must be of the same transmission Category in an overall channel if the transmission performance is to be maintained to that transmission Category.

1.2.10. Class of Operation

The installed balanced cable including terminations, patchcords and equipment connecting leads constitutes a channel. When transmission equipment is connected to either end of the channel, we have an application (operating system).

A class A channel supports class A applications, etc.

A class B channel does not support class C application.

Classes of operation are specified by performance to a specified highest frequency of operation, sometimes called the bandwidth of operation.
Table 1 is a summary of CLASSES specified for Balanced Cabling in AS/NZS 3080:2002.

<table>
<thead>
<tr>
<th>Relevant Cable “Category”</th>
<th>Class of Application</th>
<th>Frequency to Which Performance is Specified</th>
<th>Typical Maximum Data Rates</th>
<th>Typical Transmission Systems</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>(1)</em></td>
<td>A</td>
<td>100kHz</td>
<td>58 kb/s – 144 kb/s maximum</td>
<td>Fax modems, Basic Rate ISDN</td>
</tr>
<tr>
<td><em>(2)</em></td>
<td>B</td>
<td>1 MHz</td>
<td>2 Mb/s</td>
<td>Primary Rate ISDN</td>
</tr>
<tr>
<td>3</td>
<td>C</td>
<td>16 MHz</td>
<td>10 Mb/s</td>
<td>10 BASE T Ethernet</td>
</tr>
<tr>
<td><strong>5</strong></td>
<td>D</td>
<td>100 MHz</td>
<td>100 Mb/s on 2 pairs (go/return) or 1000 Mb/s on all 4 pairs</td>
<td>100 BASE T Ethernet (2 pairs) or Gigabit Ethernet (4 pairs)</td>
</tr>
<tr>
<td>6</td>
<td>E</td>
<td>250 MHz</td>
<td>1000 Mb/s on 2 pairs (go/return)</td>
<td>Gigabit Ethernet (2/4 pairs)</td>
</tr>
<tr>
<td>7</td>
<td>F</td>
<td>600 MHz</td>
<td>yet to be determined</td>
<td>?</td>
</tr>
</tbody>
</table>

Notes

* Whilst Category 1 and Category 2 cable supports the classes shown, AS/NZS 3080:2002 does not support cable quality lower than Category 3.

** All reputable 4 pair balanced UTP is manufactured to new Category 5 quality at the time of writing (2002). There is a significant installed base (pre-2002) of old Category 5 cable which supports 100 Mb/s on go/return pairs but which would need to be tested for new Class 5 performance in order to verify its ability to support 1000 Mb/s on 4 pairs.

Table 1
Classes Specified for Balanced Cabling in AS/NZS 3080:2002

1.2.11. Maximum Distances for Cable Categories and Application Classes

Whilst Table 1 shows the relationship between categories of twisted pair copper cable and Classes of Application which that cable will support, the table does not indicate the maximum distance over which the cable support particular applications. Maximum distances for balanced twisted pair cable are discussed in Chapter 3 under 3.5.2 (for horizontal cabling) and 3.6.4 (for backbone cabling).

As a general rule however, high data rate applications such as class D and E on Category 5 and Category 6 cables respectively, are limited to 100 metre lengths between active equipment. This 100 metre maximum includes patch cords and equipment connecting leads. The fixed cable component is limited to 90 metre maximum. This length limitation tends to confine twisted pair copper cable to the office (horizontal) distribution for the high data rate applications.
Twisted pair copper cabling is used over longer distances for low data rate (low bandwidth) applications. For example multi-pair copper cables may be used over distances of 1 – 2 km if only carrying Class A Applications voice telephony circuits such as CSS extensions and fax modem circuits.

Where optical fibre is used in structured cabling to carry high data rate applications, much greater distances can be supported. For example 300 metres on MMOF (multi-mode optical fibre) supporting Gigabit Ethernet. SMOF (single-mode optical fibre) will support Gigabit Ethernet and high data rates over distances in excess of 3km. Optical fibre therefore finds its place in structured cabling for backbone high data rate links such as inter-building and inter-floor multi-storey LAN connections.

1.2.12. Horizontal or Floor Cabling

1.2.12.1. On each floor of a commercial building is at least one floor distributor (FD). From this floor distributor cables are installed to the sockets close to each work position on that floor.

This cabling is called the horizontal cabling in a structured cabling system to AS/NZS 3080:2002.

The FD provides an administration point at which work station connections can be made:

- into a LAN Hub (active equipment inter-connecting the computers on that floor)
- into a backbone cable giving a connection to a CSS for telephony services or more directly to a carrier’s network for a direct fax or internet connection.

This inter-connection administration at the FD is performed using patch cords or jumpers.

Category 5/6 UTP of 4 pair construction is the dominant cabling media used in this horizontal cabling.

With its very high bandwidth it has become a “universal” cabling media as it supports all domains of operation from Class A (voice telephony) to Class D/E (Gigabit data transmission).

It is generic to a wide variety of vendors and systems and because of its high bandwidth is a “future-proofing” cabling media.

Optical fibre (MMOF) currently has a more limited role in the horizontal cabling structure due to its cost in comparison with UTP and is utilised where security, high bandwidth and electrical noise immunity is mandatory for specialised desk top applications.
1.2.13. Backbone Cabling

Backbone cabling provides communications connections between:

- Floor Distributors (FDs) on each floor of a multi-storey building
- FDs and the building’s Building Distributor (BD)
- Building Distributors (BDs) in a multi-building, “campus-style” customer’s premises
- Building Distributors (BDs) and the Campus Distributor (CD)

The Campus Distributor also provides the interface connections to carrier’s networks.

Generally backbone circuits are grouped into:

- Low bandwidth applications (Classes A, B & C) and
- High bandwidth applications (Classes D, E & F)

Low bandwidth backbone services such as CSS extensions, voice modems and low bandwidth internet services are carried on Category 3 (sometimes Cat 1) multi-pair balanced copper cable.

High bandwidth backbone services such as 100 BASE T or Gigabit Ethernet are carried on Cat 5/Cat 6.

UTP/FTP over distance not exceeding 90m and on optical fibre for greater distances.

Since in many cases, inter-building backbone connections exceed 90m, optical fibre is the dominant inter-building cabling medium used for high speed data / LAN connections.

MMOF is used for the shorter distances, 300 – 500m, at Gigabit data rates and SMOF for the longer distances, up to 3km at Gigabit data rates.

Multi-pair copper is then relegated to support the voice telephony connections which are low in bandwidth but high in numbers of circuits. 50 pair, 100 pair and higher multi-pair copper cables are used in this role. Distances of 2km can be supported.

Coaxial cable, which used to have a backbone cabling role for network connections is not supported by the structured cabling standards. It is considered to be an inflexible medium associated with vendor-specific networking products. It currently has a limited area of use confined to cable TV distribution legacy 10 BASE T Ethernet LANs.
2. Assessment Questions

2.1. State four factors which have driven the development of a generic structured cabling standard:

   a) .................................................................
   b) .................................................................
   c) .................................................................
   d) .................................................................

2.2. State the name/number of the following version of generic structured cabling standards:

   North America: .................................
   International: .................................
   Australian / New Zealand: .........................

2.3. State which of the following type of work station socket specified in the Australian / New Zealand generic structured cabling standard:

   a) 610 socket
   b) 8 pin modular socket ("RJ45")
   c) 6 pin modular socket ("RJ12")
   d) 4 pin modular socket ("RJ14")

2.4. How would you distinguish between Category 1 (voice telephone quality) cable and the high bandwidth Category 5/6 quality cable?

   ........................................................................
   ........................................................................
   ........................................................................
   ........................................................................

2.5. What does the abbreviation UTP stand for?

   ........................................................................

2.6. What feature of Category 5/6 UTP gives it the ability to carry high data rate transmission?

   ........................................................................
   ........................................................................

2.7. Describe the difference between FTP and UTP?

   ........................................................................

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2.8. Describe the difference between STP or ScTP and FTP?

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2.9. State two advantages which Category 5, 4 pair, UTP has over Category 5, 4 pair, FTP.

a) ........................................................................................................
b) ........................................................................................................

2.10. State an advantage which Category 5, 4 pair FTP has over Category 5, UTP.

........................................................................................................
........................................................................................................

2.11. What is the minimum Category quality specified in AS/NZS 3080:2002?

a) Category 1
b) Category 3
c) Category 5
d) Category 6

2.12. Name two applications which will operate on Category 3 quality cable?

........................................................................................................
........................................................................................................

2.13. Name two high speed data applications which will operate on Cat 5, UTP cable:

a) ........................................................................................................
b) ........................................................................................................

2.14. How many pairs of a 4 pair Category 5 UTP cable are needed for a 100 BASE Tx application?

a) 1 pair
b) 2 pairs
c) 3 pairs
d) 4 pairs

2.15. How many pairs of a 4 pair Category 5 UTP cable are needed for a Gigabit Ethernet?

a) 1 pair
b) 2 pairs
c) 3 pairs
d) 4 pairs
2.16. In what manner is the performance specification for 4 pair, new Category 5 cable to AS/NZS 3080:2002 different to that for old Category 5 cable?

..............................................................................................................................................................
..............................................................................................................................................................

2.17. In the case of Category 5 and 5, cable performance is tested to a top frequency of:

a) 1 MHz  
b) 10 MHz  
c) 100 MHz  
d) 1000 MHz

2.18. In the case of Category 6, cable performance is tested to a top frequency of:

a) 10 MHz  
b) 100 MHz  
c) 250 MHz  
d) 1000 MHz

2.19. What type of application and what maximum data rate will Category 5, 4 pair cable support?

a) Application: .................................................................

b) Maximum data rate: ..............................................

2.20. How many pairs are required to support Gigabit Ethernet on Category 6, 4 pair UTP cable?

a) 1 pair  
b) 2 pairs  
c) 3 pairs  
d) 4 pairs

2.21. State which classes of application will be supported on Category 5 cable?

a) Class D only  
b) Class D, E and F  
c) Class D, C, B and A  
d) All classes A to F

2.22. In a generic structured cabling design to AS/NZS 3080:2002, Category 5, 4 pair UTP is mainly used in:

a) Patch cords for FD and BD cross connections  
b) Horizontal (floor) cabling from FD to work area sockets  
c) Backbone cabling, (voice and data services), BD to FD  
d) Backbone cabling, (high data rate services), CD to BD and BD to FD
2.23. In a generic structured cabling design to AS/NZS 3080:2002 optical fibre cable is mainly used for:

- a) Patchcords for FD and BD cross connections
- b) Horizontal (floor) cabling from FD to work area sockets
- c) Backbone cabling, (voice and data services), BD to FD
- d) Backbone cabling, (high data rate services), CD to BD and BD to FD

2.24. In a generic structured cabling design to AS/NZS which cabling media is mainly used for low bandwidth, voice telephony and fax modem connections in the backbone, CD to BD and BD to FD?

- a) Category 5, UTP balanced multi-pair
- b) Category 3, UTP balanced multi-pair
- c) Category 5 UTP, balanced multi-pair
- d) Category 6 UTP, balanced multi-pair

2.25. Does coaxial cable have a defined role in a structured cabling system to AS/NZS 3080:2002?

- a) Yes
- b) No