

STANDARDS AND INFORMATION DOCUMENTS

Call for comment on DRAFT AES72-xxxx AES standard on interconnections — Application of RJ45-type connectors and quad twisted pair cable for audio interconnections

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[Notes]

AES72-XXXX

Call for Comment on DRAFT **AES standard on interconnections — Application of RJ45-type connectors and quad twisted pair cable for audio interconnections**

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Abstract

This standard documents 8C8P (RJ45) pin-outs commonly used in professional audio applications, including channel/link order, signal polarity and phantom power compatibility. Type numbers are assigned to these variations, allowing manufacturers to easily specify which wiring standard is used in a particular piece of equipment. Users may use these type numbers to assess compatibility of disparate equipment in a given application. This standard also documents practical application details of interest to users of this technology.

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DRAFT FOR COMMENT ONLY - DRAFT FOR COMMENT ONLY**Foreword**

This foreword is not part of the AES72-2019 *AES standard on interconnections — Application of RJ45-type connectors and quad twisted pair cable for audio interconnections*.

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Marcus Natter, chair
SC-05-02 Working Group on Connectors
2019-02-15

Note on normative language

In AES standards documents, sentences containing the verb "shall" are requirements for compliance with the standard. Sentences containing the verb "should" are strong suggestions (recommendations). Sentences giving permission use the verb "may." Sentences expressing a possibility use the verb "can".

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AES standard on interconnections — Application of RJ45-type connectors and quad twisted pair cable for audio interconnections

0 Introduction

The RJ45 - 8P8C connector and quad twisted pair cable has become ubiquitous throughout the datacom (data communications) industry for Ethernet connections. This high-volume usage has greatly reduced costs, making the hardware attractive for other applications. In typical installations, it is necessary to connect multiple signals from one location to another. Consequently several manufacturers have developed schemes to connect 4 balanced analog audio signals or 4 balanced AES3 connections using this hardware. Unfortunately equipment from different manufacturers is often incompatible. This standard identifies the commercially available variants and specifies a labeling scheme so users may select compatible equipment or takes steps to alleviate the problems.

1 Scope

This standard documents 8C8P (RJ45) pin-outs commonly used in analog and digital professional audio applications, including channel/link order, signal polarity and phantom power compatibility. Conformance with this standard will identify mutually compatible devices, enabling users to avoid problems when employing equipment from multiple manufacturers.

2 Normative references

AES3-2003 *AES recommended practice for Digital Audio Engineering – Serial transmission format for two-channel linearly represented digital audio data* (Revision of AES3-1992), Audio Engineering Society, New York, NY, US, <http://www.aes.org>

AES14-1992 (r2014) *AES standard for professional audio equipment -- Application of connectors, part 1, XLR-type polarity and gender*, Audio Engineering Society, New York, NY, US, <http://www.aes.org>

ANSI/TIA-568-C *Generic Telecommunications Cabling for Customer Premises*, Telecommunications Industry Association, Arlington, VA, US, <http://www.tiaonline.org>

IEC 60268-12 *Sound system equipment - Pt 12: Application of connectors for broadcast & similar use*, International Electrotechnical Commission, Geneva, Switzerland, <http://www.iec.ch>

IEC 60603-7 *Connectors for electronic equipment – Part 7: Detail specification for 8-way, unshielded, free and fixed connectors*, International Electrotechnical Commission, Geneva, Switzerland, <http://www.iec.ch>

IEC 60603-7-1 *Connectors for electronic equipment – Part 7-1: Detail specification for 8-way, shielded, free and fixed connectors*, International Electrotechnical Commission, Geneva, Switzerland, <http://www.iec.ch>

DRAFT FOR COMMENT ONLY - DRAFT FOR COMMENT ONLY**3 Definitions and abbreviations**

For the purposes of this document, the following terms, definitions, and abbreviations apply.

3.1 8P8C

The 8 position 8 contact (8P8C) connector is a modular connector commonly used to terminate twisted pair and multi-conductor flat cable. These connectors are commonly used for Ethernet over twisted pair, registered jacks and other applications involving unshielded twisted pair, shielded twisted pair, and multi-conductor flat cable..

3.2 CATn Cable

Quad twisted pair cables are manufactured in different speed grades which differ in their high frequency attenuation, crosstalk and return loss specifications. CAT6 cables are rated to higher frequencies than CAT5 cables.

3.3 Crossover Cable

is a quad twisted pair cable manufactured to the T568A standard at one end and the T568B standard at the other end. The result is to swap pins 1&2 with pins 3&6.

3.4 Link

is the term used in this document for a signal connection established across a pair of conductors in the quad twisted pair cable. If the signal is analog, each link is an audio channel. If the signal is AES3, the link will contain two digital audio channels.

3.5 Positive Polarity Pin**Positive Polarity Conductor**

the pin or conductor on which a positive signal shall be measured with respect to the oppositely polarized pin when a positive-polarity signal is applied as observed with an oscilloscope or similarly functioning instrument. See AES14.

3.6 Return Pin**Return Conductor**

the pin or conductor which is polarized opposite to the positive-polarity pin or conductor, that is, the negative-polarity pin or conductor. See AES14.

3.7 QTP**Quad Twisted Pair**

Quad twisted pair (QTP) cables contain 4 pairs of conductors, each of which form a single circuit. Each pair are twisted together in order to cancel out electromagnetic interference (EMI) from external sources. QTP cables may be shielded or unshielded.

3.8 RJ**Registered Jack**

A registered jack (RJ) is a standardized telecommunication network interface connector first defined in the Universal Service Ordering Code (USOC) system of the Bell System. The specification includes physical construction, wiring, and signal semantics. Registered jacks are named by the letters RJ, followed by two digits that express the type.

3.9 RJ45

RJ45's are a registered jack with 8 pins. Strictly applied it refers to telephone applications with a keyed connector. However, in common usage it now refers to connectors used for twisted pair Ethernet applications.

DRAFT FOR COMMENT ONLY - DRAFT FOR COMMENT ONLY**4 Pin assignments for professional audio applications****4.1 Pin and pair grouping assignment**

The pin and pair grouping assignment of IEC 60603-7 clause 6.2 applies.

4.2 Type descriptor assignment

There are numerous commercial implementations which carry 4 audio links on QTP. These vary in their assignment of links to the defined pairs. All known commercial implementations have been surveyed and assigned a descriptive type number and letter. These descriptors are listed in Table 1.

The type number describes the assignment of links to pairs and the type letter describes the link polarity on each pair. The letter E shall denote implementations which assign the positive polarity pins to even numbers. The letter O shall denote implementations which assign the positive polarity pins to odd numbers. The letter M shall denote implementations which assign the positive polarity pins to odd numbers except for the pin 4&5 pair.

Type	Pin #								Polarity
	1	2	3	4	5	6	7	8	
Type 1E	1 –	1 +	2 –	3 +	3 –	2 +	4 –	4 +	Even = +
Type 1O	1 +	1 –	2 +	3 –	3 +	2 –	4 +	4 –	Odd = +
Type 1M	1 +	1 –	2 +	3 +	3 –	2 –	4 +	4 –	Mixed
Type 2O	2 +	2 –	3 +	1 –	1 +	3 –	4 +	4 –	Odd = +
Type 3E	3 –	3 +	2 –	1 +	1 –	2 +	4 –	4 +	Even = +
Type 3M	3 +	3 –	2 +	1 +	1 –	2 –	4 +	4 –	Mixed
Type 4E	1 –	1 +	3 –	2 +	2 –	3 +	4 –	4 +	Even = +
Type 5E	3 –	3 +	4 –	1 +	1 –	4 +	2 –	2 +	Even = +
Type 6E	4 –	4 +	3 –	2 +	2 –	3 +	1 –	1 +	Even = +

Table 1 Current uses of QTP cabling in professional audio equipment

NOTE The polarity of DMX devices is inverted relative to professional audio. ANSI 1.27-2, USITT 512 DMX, and DIN56930-2 define polarity on XLR connectors as: Pin1 = GND, Pin2 = Data-, Pin3 = Data+.

There is no consistency in link assignment across manufacturers. This inconsistency will result in links being interchanged when equipment from different manufacturers is used at opposite ends of a QTP cable.

There is no consistent assignment of link polarity across manufacturers. When equipment from different manufacturers is used at opposite ends of a QTP cable carrying analog audio signals this will result in channel phasing issues and surround/stereo/mono downmix compatibility problems. Links carrying AES3 signals are not affected by polarity inversion.

4.3 Cable shielding

When balanced link connections are used, the high twist accuracy and close conductor spacing of QTP cable will result in low EMI interference even without cable shielding. Shielded CAT cable may offer some improvement in electrostatic interference rejection but will offer little improvement in magnetic interference rejection. Since most low frequency EMI problems are magnetic, shielded cable will generally provide no benefit.

If shielded cabling is used it shall be terminated with connectors conforming to IEC 60603-7-1

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When a shielded fixed connector is used, the shield shall be connected to chassis with the lowest practical impedance at radio frequencies.

Shielded connectors and cable shall be used in applications where phantom power is required, as the only path for return current is through the cable shield. To reduce inter-device chassis ground currents, it is recommended that QTP implementations of microphone lines be connected to a single bank of microphone preamps with a common ground.

4.4 Equipment labeling

When RJ45 connections are used to transport audio in compliance with this standard the connector wiring shall be described using the type listed in Table 1.

The type descriptor shall be prominently displayed on the equipment near the RJ45 connector. It shall also be clearly documented in the data sheet and users manual.

If the RJ45 jack does not implement ground this shall also be indicated.

For example, a connector wired according to Type 3E in Table 1 would be labeled “AESxx Type 3E”. One which does not support ground would be labeled “AESxx Type 3E, not grounded”.

4.5 Implementation Compatibility

Implementations with the same type number will maintain link order when interconnected.

Implementations with the same type letter will maintain link polarity when interconnected.

Care must be taken with type “M” (mixed polarity) implementations if cables are cut and conductors stripped for connection. The presence or absence of a stripe on a conductor will not be a consistent indication of polarity. Table 1 must be consulted when making such connections.

For interconnection of AES3 links only the type number is important as the interface is insensitive to polarity.

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Annex A (Informative) – Modular connectors

The information below may be useful when implementing the connector wiring specified in this standard.

A.1 Terminology

The various types of RJ connector are the standard telecommunication network interface for connecting voice and data equipment. The specifications for these include physical construction, geometry, wiring, and signal semantics, and are named with the initials “RJ” followed by a two digit code. The RJ45 is a subset of the 8P8C (8 position 8 contact) connector group.

A.2 Connector pin numbering

The RJ45 connector pin numbering used within this document is illustrated in Figure A1.

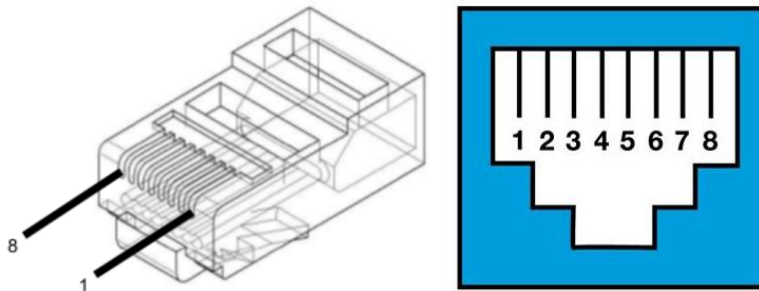


Figure A1 – Connector pin numbering, plug (left) and jack (right)

A.3 Connector wiring standards

The largest application of QTP/RJ45 connections in the datacom industry is the Ethernet protocol. The datacom industry chose to follow existing conventions of the telecom industry. Foremost among these is the requirement that the center pair be surrounded by a split pair. Though now a limitation in very high speed datacom applications, this has no impact at audio frequencies.

Two different pin-out configurations are specified in TIA-568, each assigning different cable colors to link pairs. These assignments are summarized in Table A1. The T568A configuration is the most common and is preferred. Note that in both cases the solid colors are assigned to even numbered pins and the white striped conductors are assigned to odd numbered pins.

Table A1 Pin/pair assignment for QTP cable

PIN #	1	2	3	4	5	6	7	8
T568A Wire Color	W/GR	Green	W/OR	Blue	W/BL	Orange	W/BR	Brown
Pair Color	Green		Orange	Blue		Orange	Brown	
T568B Wire Color	W/OR	Orange	W/GR	Blue	W/BL	Green	W/BR	Brown
Pair Color	Orange		Green	Blue		Green	Brown	

Because of their identical pair groupings, patch cords terminated in either T568A or T568B may be used interchangeably. So called “crossover cables” which use different pinouts at each end will change the link order. The connector wiring standard is also an issue if a plug is present at one end of a cable and the individual pairs are connected at the other end. Compliance with either standard can be easily checked by the location of the green and orange solid colors imbedded in the clear plastic of the RJ45 plug. To guard against crossover cables the color orders should be checked at both ends.

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Annex B (Informative) – Application details

The information below may be useful when implementing the connector wiring specified in this standard.

B.1 Connectors for stranded and solid wire

Category cable is available with either solid or stranded conductors. Solid conductor cable is generally less expensive and is used intended for use in permanent installations. Stranded conductor cable is more flexible and is generally used for interconnect cables which may be flexed.

These two types of cable require different connectors since the conductor deforms differently in each case. If the appropriate connector is not used for a given cable there will likely be early failure due to oxidation, conductor breakage, or inadequate conductor contact pressure.



Figure B1 – Connectors for solid wire (top left) and stranded wire (bottom right)
(unshielded connectors are shown for convenience, shielded connectors are recommended)

B.2 PCB footprint layout

The routing examples provide a ground plane separating every link and the shield of the connector is bonded to a ground plane. Those creating other designs should refer to the Pin 1 problem as described in AES14.

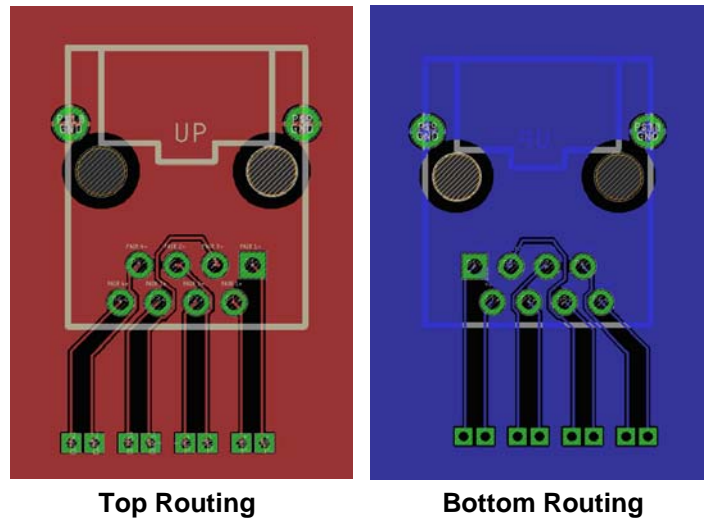


Figure B2 – Example PCB Layouts

DRAFT FOR COMMENT ONLY - DRAFT FOR COMMENT ONLY**B.3 Orientation**

The most common way to install a jack in a wall or panel is with the tab side oriented downwards, allowing dust and debris to fall away from the electrical contacts.

B.4 Dimensions

Detailed connector dimensions may be found in IEC 60603-7.

B.5 Cable category ratings

The conductors in a CAT cable are twisted well enough that balanced transmission systems will adequately reduce interference. Different levels of CAT cables differ in their very high frequency (100MHz and above) behavior and will provide little difference at audio frequencies. If EMI issues still exist they may be addressed using ferrites, filters, or transformers.

B.6 Termination issues

CAT cable wires, particularly solid conductors, are designed to be terminated with compression fit connectors. Numerous practical issues arise if these wires are terminated with conventional audio connectors.

When soldered to common audio connectors such as XLR's the conductors frequently break, probably by being nicked when stripped. Breakage has also occurs inside the insulation, apparently from repeated flexing. Cable is available which uses annealed conductors which can handle thousands of flexures without breaking from fatigue. Cables are not all the same and should not be viewed as interchangeable.

In addition to breakage, clamping the conductors in "euro" or "Phoenix" push on connectors is problematic. Excessive tightening of the screw nicks or deforms the wire, and it breaks when flexed. Insufficient tightening allows it to pull out. Putting two or more wires of different gage or one solid and one stranded wire in the same connector generally results in the smaller one pulling, or falling, out. These problems are exacerbated by the fact that most of the connectors used either have no provision for strain relief or the strain relief is designed for larger diameter cable.

CAT cables should only be spliced with compression based splices specifically designed for this purpose. They should not be spliced by stripping and twisting the mating conductors together, with or without electrician's "wire nuts". Providing strain relief by tying the two cables together in a knot as if they were rope does not legitimize this approach.

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Annex C (Informative) – Link order in mixed systems

Users may encounter situations where equipment with different connector types must be interconnected. Cross connecting equipment using different connector wiring will result in interchanged links and some of those links may have their polarity inverted.

C.1 Cross connection link order

Table C1 documents the Link appearing at the output of each type receiver when driven from each of the types of sender. Links which appear correctly at the receiver are shown on a green background. Implementations with the same type letter will maintain link polarity when interconnected.

Table C1 Cross connection link order

	Type 1 receiver link contents				Type 2 receiver link contents				Type 3 receiver link contents				Type 4 receiver link contents				Type 5 receiver link contents				Type 6 receiver link contents			
Receiver Link	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Type 1 Sender Link	1	2	3	4	3	1	2	4	3	2	1	4	1	3	2	4	3	4	1	2	4	3	2	1
Type 2 Sender Link	2	3	1	4	1	2	3	4	1	3	2	4	2	1	3	4	1	4	2	3	4	1	3	2
Type 3 Sender Link	3	2	1	4	1	3	2	4	1	2	3	4	3	1	2	4	1	4	3	2	4	1	2	3
Type 4 Sender Link	1	3	2	4	2	1	3	4	2	3	1	4	1	2	3	4	2	4	1	3	4	2	3	1
Type 5 Sender Link	3	4	1	2	1	3	4	2	1	4	3	2	3	1	4	2	1	2	3	4	2	1	4	3
Type 6 Sender Link	4	3	2	1	2	4	3	1	2	3	4	1	4	2	3	1	2	1	4	3	1	2	3	4

C.2 Cross connection link order using a crossover cable

Cross connecting equipment with a crossover cable will further change link order. Table C2 documents the link appearing at the output of each type receiver when driven from each of the types of sender when using a crossover cable. Links which appear correctly at the receiver are shown on a green background.

Table C2 Cross connection link order using a crossover cable

	Type 1 receiver link contents				Type 2 receiver link contents				Type 3 receiver link contents				Type 4 receiver link contents				Type 5 receiver link contents				Type 6 receiver link contents			
Receiver Link	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Type 1 Sender Link	2	1	3	4	1	3	2	4	2	3	1	4	3	1	2	4	4	3	1	2	3	4	2	1
Type 2 Sender Link	3	2	1	4	2	1	3	4	3	1	2	4	1	2	3	4	4	1	2	3	1	4	3	2
Type 3 Sender Link	2	3	1	4	3	1	2	4	2	1	3	4	1	3	2	4	4	1	3	2	1	4	2	3
Type 4 Sender Link	3	1	2	4	1	2	3	4	3	2	1	4	2	1	3	4	4	2	1	3	2	4	3	1
Type 5 Sender Link	4	3	1	2	3	1	4	2	4	1	3	2	1	3	4	2	2	1	3	4	1	2	4	3
Type 6 Sender Link	3	4	2	1	4	2	3	1	3	2	4	1	2	4	3	1	1	2	4	3	2	1	3	4

Note that a crossover cable will allow proper link alignment when connecting a Type 2 device to a Type 4 device. Since all known Type 2 interfaces are odd and all known Type 4 interfaces are even, there will be an inversion of all links. However, there will be no effect on interchannel phase.

DRAFT FOR COMMENT ONLY - DRAFT FOR COMMENT ONLY**Bibliography**

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