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Application Note:

Recommended CAT5/5E (RJ45) Cable Assemblies For Use With Lantronix Device Servers

Intellectual Property

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Revision History

Date	Rev.	Comments
January 2024	A	Initial document.
May 2024	B	Added Summary section.

For the latest revision of this product document, please check our online documentation at
www.lantronix.com/support/documentation.

Overview

This application note provides information for making CAT5/5E (RJ45) cable assemblies to facilitate good communications between a client and a Lantronix Device Server. It also reviews the components and tooling used when making a CAT5/5E cable assembly.

Summary

Lantronix Device Servers are designed, and qualification tested using pre-made (factory made) CAT5/5E cable assemblies that are purchased in fixed lengths. Using this type of cable assembly will provide excellent link connections and data communication. For many applications in the field, it is not always feasible to use these cable types and the user must build their own cable assemblies. In these situations, it is essential to make a good crimp connection between the RJ45 plug contacts and the cable conductors (See Figure 2). This paper provides recommendations that will help the user achieve this.

Poorly made field cable assemblies can cause damage to the XPort RJ45 jack and result in a poor or intermittent Ethernet link. A study of the many types of CAT5/5E cable assemblies, bulk cable and RJ45 plugs has been completed. The study includes a review of cable assembly components / tooling and analyzes the results of 9 different field made cable assemblies.

Note – if a bad field made cable assembly is forced into the XPort jack, it will damage or deform the gold contacts such that it is no longer possible to make a good connection even when using factory made cable assemblies.

Appendix A provides a list of recommended components for building CAT5/5E cable assemblies and includes contact information.

Recommendations for CAT5/5E cable assemblies for XPort

Based on the results of the study there are two important criteria for making good CAT5/5E cable assemblies (For more details, please refer to section "The Results"). They are:

1. You must use RJ45 plug connectors that are designed for the type of cable you are using. For example, if you are using solid conductor cable, the RJ45 plugs must be designed to work with solid conductors.
2. You must use a quality professional hand application tool to crimp the RJ45 plug connectors onto the cable.

Lantronix Device Servers have proven to work well with factory made CAT5/5E cable assemblies. In reviewing these cable types, it is easy to understand why. Most factory-made cable assemblies are made with stranded conductor cables and are crimped using professional production tooling. It is strongly advised to obtain and use stranded conductor cable.

For our study, local electronic stores (Best Buy, Circuit City) and home improvement centers (Home Depot, Menards) were investigated for bulk cable and RJ45 plug connectors. Most of the CAT5/5E bulk cable sold thru this channel is solid conductor cable. To further complicate your sourcing choices, the RJ45 plugs sold thru this channel are not always designed for solid conductor cable. To obtain stranded conductor cable, you must order from an Electronic/ Electrical distributor or Internet store.

Although stranded cable proved to provide a better crimp contact to the RJ45 plug contacts, solid cable can provide a solid connection if the right RJ45 plug connector and hand tooling is used.

From our study, we found that using a low cost or inferior tool will produce poor results. There are many hand application tools available, but of the two we did review, the AMP tool produced much better results. We strongly recommend the Amp professional Hand Application tool (See *Appendix A*).

Appendix A lists known cable and connector vendors, part numbers and contact information for sourcing.

Bulk cable is also offered in different insulation types. The different insulation types are not considered a primary factor in the quality of the crimp connection. The insulation type is related to the space where the cable will be installed. The cable will need a Teflon insulated, Plenum jacket if it will be used in air returns, dropped ceilings, air ducts and in public buildings where required by code. Otherwise, a cable with high-density polyethylene insulation, PVC jacket is acceptable.

Details from the Study

In our efforts to determine the merits of a good cable assembly versus a bad one, a study of the various cable, connectors and assembly tools was completed. The following section provides an overview of this study. The study concentrated on the following topics:

- Factory made (complete) cable assemblies
- CAT5/5E bulk cable
- RJ45 plug connectors
- RJ45 cable assembly tooling
- Results of the study

The study was limited to round (solid and stranded conductor) unshielded cable assemblies and bulk cable.

Factory made (complete) cable assemblies

The factory-made cable assemblies were analyzed, and it was quickly determined that the majority of these cables are well-made and use stranded cable. From our tests, stranded cable proved to provide better crimp connections with the RJ45 plug and subsequently a better connection with the RJ45 jack. The plug contacts were all well seated in the RJ45 plug connector. (See Figure B).

Most of these cables are made with snag less boots from the connector to the cable. This did not seem to be a factor in making a good cable assembly. The snag less boots allows the cable assembly to be pulled thru a wall or conduit without catching on the edge of the connector.

CAT5/5E bulk cable

There are two basic types of round CAT5/5E cable being sold today – Solid or Stranded conductors. For CAT5/5E cable, there are four twisted pairs or eight conductors. The Conductor size is 24 AWG. Typically, the conductor OD is less than 039" [0.991mm] with .029" [0.736mm] being the minimum. The maximum outer diameter of the cable is .215" [5.46 mm].

For this study, two different sources for the CAT5/5E bulk cable were considered: Electrical distribution and home improvement (retail) outlets. Retail outlets offer mostly solid conductor CAT5/5E bulk cable.

Although, one advantage of the retail outlet is that you can purchase smaller amounts of bulk cable (100 ft and 500 ft). With the electrical distributor, you can easily purchase cable with solid or stranded conductors in many colors and insulation types.

The following cables were used in the study.

Manufacturer	Part Number	Type	Purchased	Comments
General Cable	2133630H	Solid Conductor	Home Depot	
Amp	219538-6	Solid Conductor	Avnet Elect	
Belkin	A7J304-xxx	Stranded Cond.		

RJ45 plug connectors

RJ45 plug connectors (also referred to as modular plugs) are offered in many different varieties including various positions and housing styles. In many respects, this is a commodity product. It can be sourced from many places including Internet stores. For a standard Ethernet connection, the RJ45 plug connector must have eight contacts. The RJ45 plugs are one-piece construction with the contacts preloaded into the connector. They use the insulation displacement (IDC) method to make the electrical connection to the conductors.

For the objective of this study, the most interesting point of difference is that most RJ45 plugs are designed for use with either solid or stranded conductors but not both. The major difference is in the individual contact design. Several RJ45 plug connectors were reviewed in this study. What was learned is that it is very important that the correct RJ45 plug is used depending on whether the cable is solid or stranded conductors. Please refer to the results section for an overview.

The following RJ45 plug connectors were used in the study.

Manufacturer	Part Number	Type	Purchased	Comments
Belkin	R6G088aR-25	Stranded Cond.	Best Buy	
Amp	5-558530-4	Stranded Cond.	Avnet Elect	Very good connector
Amp	5-569278-3	Solid Conductor	Avnet Elect	Very good connector
Ideal	85-346	Solid Conductor	Home Depot	

RJ45 cable assembly tooling

Most RJ45 plug connector manufacturers offer hand application tooling to properly strip the cable and to terminate the connector to the cable. Two application tools were reviewed, and it was discovered that all tools are not created equal!. There was a significant difference in the quality of the crimped connection when using the different tools. The Amp tool produced much better results.

The AMP professional hand tool offered ratchet control to provide a complete termination cycle. In other words, once the crimp was completed, the ratchet was released to the starting position. With the Ideal hand tool, you squeezed it until you thought you had a good connection, or your hand became tired. Please refer to the results section for a complete overview.

The following RJ45 application tools were used in the study.

Ideal Telemaster p/n 30-496
Amp Professional Hand tool p/n 3-231652-0. Purchased from Avnet Electronics. (See Appendix A)

Results of the Study

The objective of this study was to determine the various factors that make up a good RJ45 (CAT5/5E) cable assembly to provide a reliable, solid connection with the Lantronix XPort. The study reviewed many types of CAT5/5E cable, RJ45 plug connectors as well as the application tooling required to make the cable assembly. Several different types of cable, connectors and tooling were procured, and nine different combinations of cable assemblies were created to test the results. Five of these cable assemblies were made to the manufacturer's recommendations. However, four of these cable assemblies were made against their intended application to analyze the results.

The following table provides an overview of the five cable assemblies that were made to specifications:

Cable Type	RJ45 Plug Connector	Application Tool	Results
Stranded	Belkin for Stranded	Ideal	Good – plugs into XPort and latches
Stranded	Amp for Stranded	Amp	Excellent – easily plugs into XPort and latches quickly
Solid	Amp for Solid	Amp	Good – plugs into XPort and latches
Solid	Ideal for Solid	Ideal	OK – plugs into XPort and slowly latches
Solid	Ideal for Solid	Amp	Excellent – easily plugs into XPort and latches quickly

From these results, you can see that if you use the right connector with the right cable the results will be acceptable. The interesting point to notice is that the hand tool makes a big difference in the quality of the crimped connection. Two cable assemblies were made using the same Ideal RJ45 plug connectors and cable (please refer to the last two cable assemblies). However, one of the cable assemblies was crimped using the AMP tool and the other using the Ideal tool. The Amp tool produced much better results.

The following four cable assemblies were made against their intended application.

Cable Type	RJ45 Plug Connector	Application Tool	Results
Solid	Belkin for Stranded	Ideal	Bad – must force the plug into XPort. This damages XPort's jack contacts
Solid	Belkin for Stranded	Amp	OK – plugs into XPort and slowly latches
Solid	Amp for Stranded	Ideal	Bad – must force the plug into XPort. This damages XPort's jack contacts
Solid	Amp for Stranded	Amp	Good – plugs into XPort and latches

In each of these cases, upon reviewing the crimped contact between the RJ45 plug and the conductors, the contacts were not fully seated into the RJ45 plug (see figure A). The worst case was when the Ideal tool was used. From these results, the Ideal tool did not produce acceptable results.

These cable assembly results confirm that it is best to use the right connector for the right cable. The following diagram shows a bad crimp between the RJ45 plug contacts and the wire that was typical for three of the last four cable assemblies. On a bad crimp, the contacts are not recessed in the housing, and they are uneven.
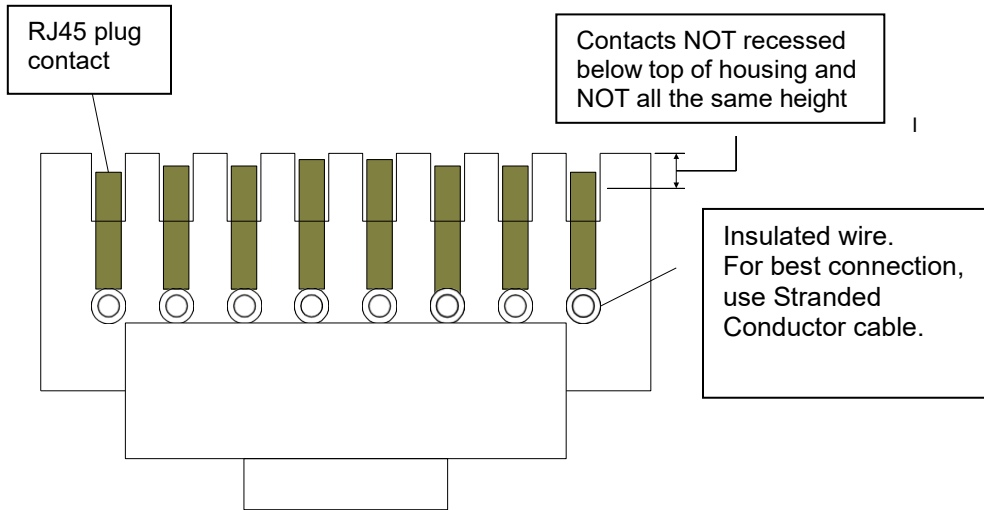
RJ45 plug contact

Contacts NOT recessed below top of housing and NOT all the same height

Insulated wire. For best connection, use Stranded Conductor cable.

Figure 1. Bad Crimp on wire

In most cases, the contacts on this RJ45 plug will deform the mating contacts in the RJ45 jack when inserted and cause a bad connection or link.

For a good crimp, the RJ45 contacts must be well recessed below the top of the connector housing, and all be at the same height. The following diagram shows a good crimp.
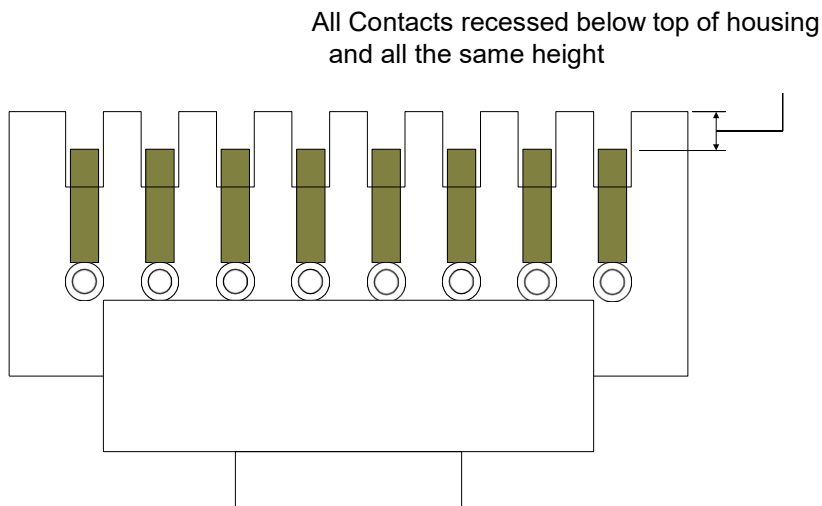
All Contacts recessed below top of housing and all the same height

Figure 2. Good Crimp on wire

When the RJ45 contacts are well recessed below the top of the connector housing and have a uniform height the connection to the mating RJ45 jack is excellent. A good crimp was easily achieved by using stranded conductor cable and the AMP professional hand tool. This type of crimp is also typical on a factory-made cable assembly.

Appendix A

Recommended Sources for Bulk Cable, Connectors and Tooling to build CAT5/5E cable Assemblies.

Bulk Cable

Manufacturer	Part Number	Type	Purchased	Comments
General Cable	2133630H	Solid Conductor	Home Depot	
Amp	219538-6	Solid Conductor	Avnet Elect	
Belkin	A7J304-xxx	Stranded Cond.		
Cypress	RCUTP5EST1000FBL	Stranded Cond.	Cypress	

RJ45 Plug Connectors

Manufacturer	Part Number	Type	Purchase From	Comments
Belkin	R6G088aR-25	Stranded Conductor	Best Buy	
Amp	5-558530-4	Stranded Conductor	Avnet Elect	Very good connector
Molex	87522	Stranded Conductor	Arrow	
Pacific	R45	Stranded Conductor	Pacific	
Amp	5-569278-3	Solid Conductor	Avnet Elect	Very good connector
Ideal	85-346	Solid Conductor	Home Depot	

Application Hand Tools

Manufacturer	Part Number	Purchase From	Comments
Amp	3-231652-0	Avnet or Arrow	Very good tool – www.amp.com

Vendor Contact Information

Avnet Electronics (800) 408-8353 www.em.avnet.com	Arrow Electronics (800) 833-3557 www.arrow.com
Pacific Custom Cable 800-931-3133 www.pacificcable.com	Cypress Industries 866-844-6699 www.cypressindustries.com