Communication Systems-West

Interpreting L3 Cable/Harness Drawings

APPROVAL	**DATE** MO/DAY/YR
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TABLE OF CONTENTS

LIST OF FIGURES

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1 [B] PURPOSE AND SCOPE

The purpose of this document is to provide guidance on how to interpret unique aspects of cable/harness drawings produced by L3. Cable/harness drawings are manufacturing drawings that are governed by L3 internal standard IS-006 (Drawing Standards). IS-006 references ASME Y14.24. Cable/harness drawings created by L3 are based on sections 13.1 (Wiring Harness Drawing) and 13.2 (Cable Assembly Drawings) in ASME Y14.24. Dimensioning and tolerancing cable/harness drawings follow standard ANSI Y14.5M 1994 practices. L3 cable/harness drawings have evolved over time to meet the needs and requirements of L3 programs. This document provides information about those aspects of cable/harness drawing format and nomenclature that may be specific to L3. This document is broken into several sections that discuss different areas of the cable/harness drawing including the cable/harness depiction, wiring diagram, variable table, title block, and other items.

2 [-] APPLICABLE DOCUMENTS

The following documents form a part of this document to the extent specified herein and apply to interpretation of the cable/harness drawings.

2.1 [B] Government Documents

Document	Title
MIL-PRF-39012	Connectors, Coaxial, Radio Frequency, General Specification for
MIL-DTL-83513	Connectors, Electrical, Rectangular, Microminiature, Polarized Shell, General Specification for
MIL-DTL-38999	Connectors, Electrical, Circular, Miniature, High Density, Quick Disconnect, Environment Resistant, Removable Crimp and Hermetic Solder Contacts, General Specification for
MIL-DTL-24308	Connectors, Electric, Rectangular, Nonenvironmental, Miniature, Polarized Shell, Rack and Panel, General Specification for
MIL-DTL-23053	Insulation Sleeving, Electrical, Heat Shrinkable, General Specification for

2.2 [A] Other Publications

Industry Standards

Document	Title
ASME Y14.24	Type and Applications of Engineering Drawings
ASME Y14.5M	Dimensioning and Tolerancing
IPC/WMHA-A-620A	Requirements and Acceptance for Cable and Wire Harness Assemblies
J-STD-001	Requirements for Soldered Electrical and Electronic Assemblies

J-STD-004	Requirements for Soldering Fluxes
J-STD-006	Requirements for Electronic Grade Solder Alloys and Fluxed and Non-Fluxed Solid Solders for Electronic Soldering Applications

L3 Documents and Drawings

Document	Title
IS-001	Use of Alternate Size Hardware
IS-006	Drawing Standards
WS-000	Workmanship Specification
WS-003	Cable Harness Assembly
WS-012	Marking, Engraving and Labeling
60037425	Practices For EMC – Electromagnetic Compatibility
60083155	Torque Specification
60100697	Specification for Reduced Dielectric Withstanding Voltage (DWV) for Cable Assemblies
60112799	Molding Design Requirements and Reference

3 [B] ACRONYMS AND DEFINITIONS

3.1 [B] Acronyms

ADPTR – Adapter (typically used on a connector)

BOM – Bill of Material

BS – Butt Splice

CIR – Customer Information Request

CR – Change Request

DE- Design Engineer

DES – Designator or Designation

DWV – Dielectric Withstanding Voltage

ECR – Engineering Change Request

EIR – Engineering Information Release

EMC – Electromagnetic Compatibility

EMI – Electromagnetic Interference

IC – Integrated Circuit

IS – Internal Specification

ITAR – International Traffic in Arms Regulations

L3 – L3 Communications

NASA – National Aeronautics and Space Administration

N/C – No Connect

REV - Revision

SSC – Single Shielded Conductor

SERNO – Serial Number

SP – Splice

STP – Shielded Twisted Pair

TSP – Twisted Shielded Pair

TSQ – Twisted Shielded Quad

TST – Twisted Shielded Triple

WS – Workmanship Standard

WSM – Workmanship Standards Manual

3.2 [B] Definitions

Band-it – a metal band similar to a ziptie that is wrapped around material and cinched down. The excess length is trimmed.

boot (sleeve boot) – expanded shrink sleeving pulled over and completely covering the braid sock, overbraid and/or cable bundle**,** usually as a transition from a connector to the

cable bundle

braided ferrules – similar to solder ferrules except a drain braid is used rather than a drain wire

braid sock/braid boot – a transition braid used to fit over the rear flange of a connector or backshell when the main cable shield/gross overbraid can not transition to the larger diameter connector or backshell without violating the minimum 90% optical braid coverage over the cable/harness

branch/leg/bundle – a segment of the cable/harness assembly (ex. A Y-harness would have three branches/legs/bundles)

cable ties – typically ties like zipties used to hold cables or harnesses securely to the next higher assembly

coaxial ferrules – two-stage solder-sleeves that have a small solder band to terminate the coaxial center conductor to a wire and then a larger solder band to terminate the coaxial shield to a wire

contact – an element in the connector or other terminating device that mates with a corresponding element to permit the flow of current (ex. both pins and sockets are called contacts)

crimp lug – a lug for which the connection to the wire/conductor is made by crimping the shank of the lug to the wire/conductor

drain wire – a conductor frequently used in contact with cable shielding to provide a low-resistance ground return

Faraday cage – an enclosure made of conductive material that prevents the entry or escape of an electromagnetic field

gross overbraid – electrically conductive pull-on or woven-on braid that is the outermost shield on a cable/harness

inline splice – same as a solder splice

lanyard – a connection between two items, typically made of a rope or chain, that is hard fastened to both items.

lug – a terminal contact designed to go under or around a screw or other threaded cylinder.

NASA splice – same as a lash splice

overbraid – same as gross overbraid

pin – a male-type contact designed to plug into a socket contact

plug – a male electrical fitting that mates with a receptacle; typically the connector attached to a cable

pseudo ferrules – soldering a wire to the braid, then adding sleeving over the solder area

receptacle/jack – a female electrical fitting that mates with a plug; typically the fixed or stationary half of an electrical connection that is mounted on a panel

socket – a female-type contact designed to accept a pin contact

solder ferrules – solder-sleeves that come with a drain wire attached

solder lug – a lug for which the connection to the wire/conductor is made by soldering the conductor through a hole or to a tab on the lug

4 [B] CABLE/HARNESS DRAWING TEMPLATE

Figure 4-1, Figure 4-2 and Figure 4-3 show the different L3 cable drawing layout styles with each section of the drawing identified.

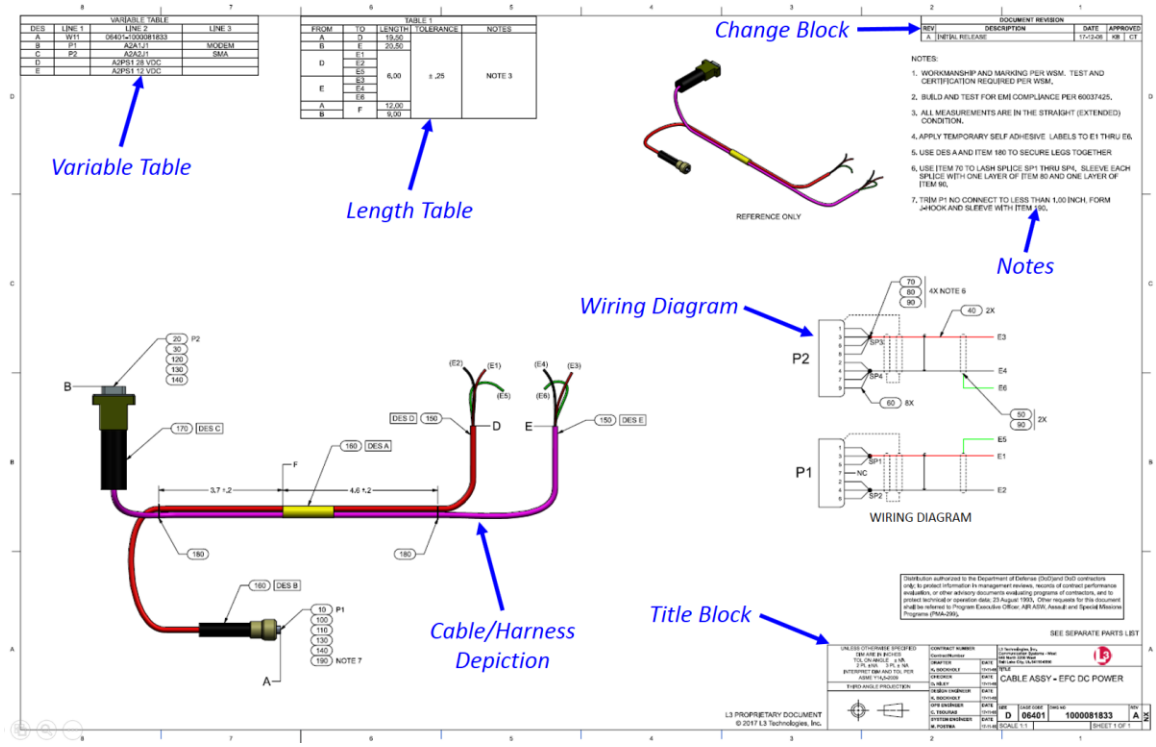


Figure 4-1 [B] Example of Cable/Harness Drawing (Model View Layout)

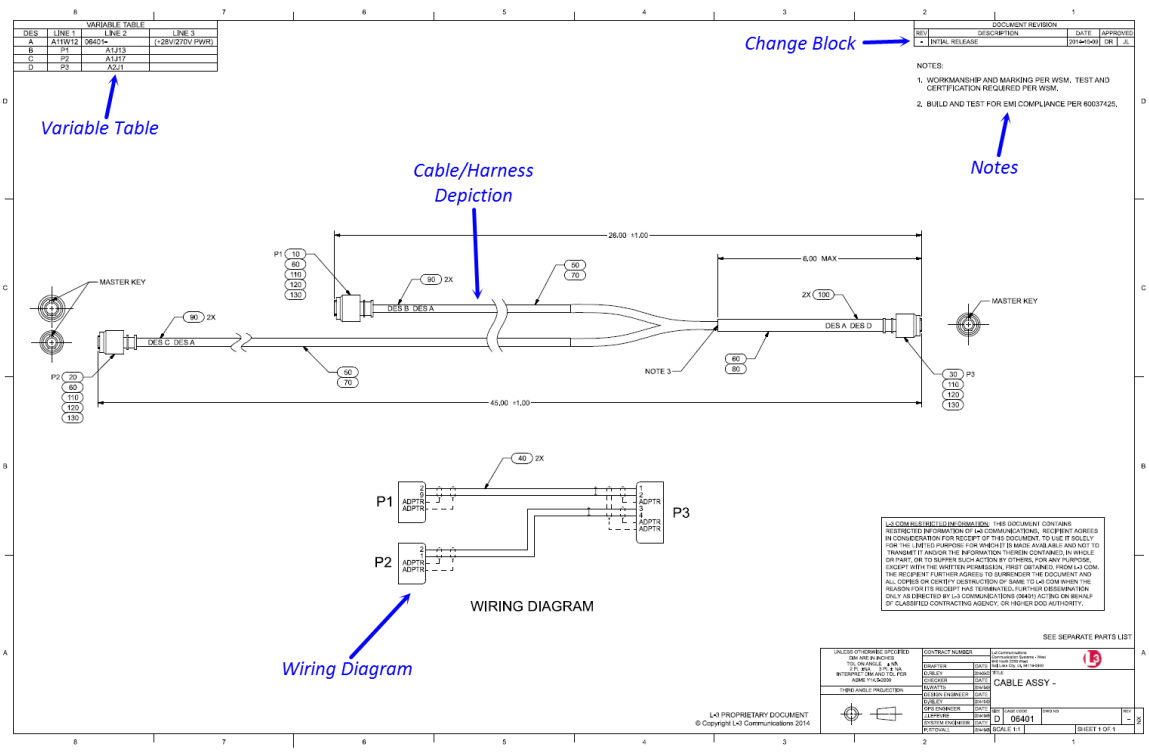


Figure 4-2 [B] Example of Cable/Harness Drawing (Formboard Layout)

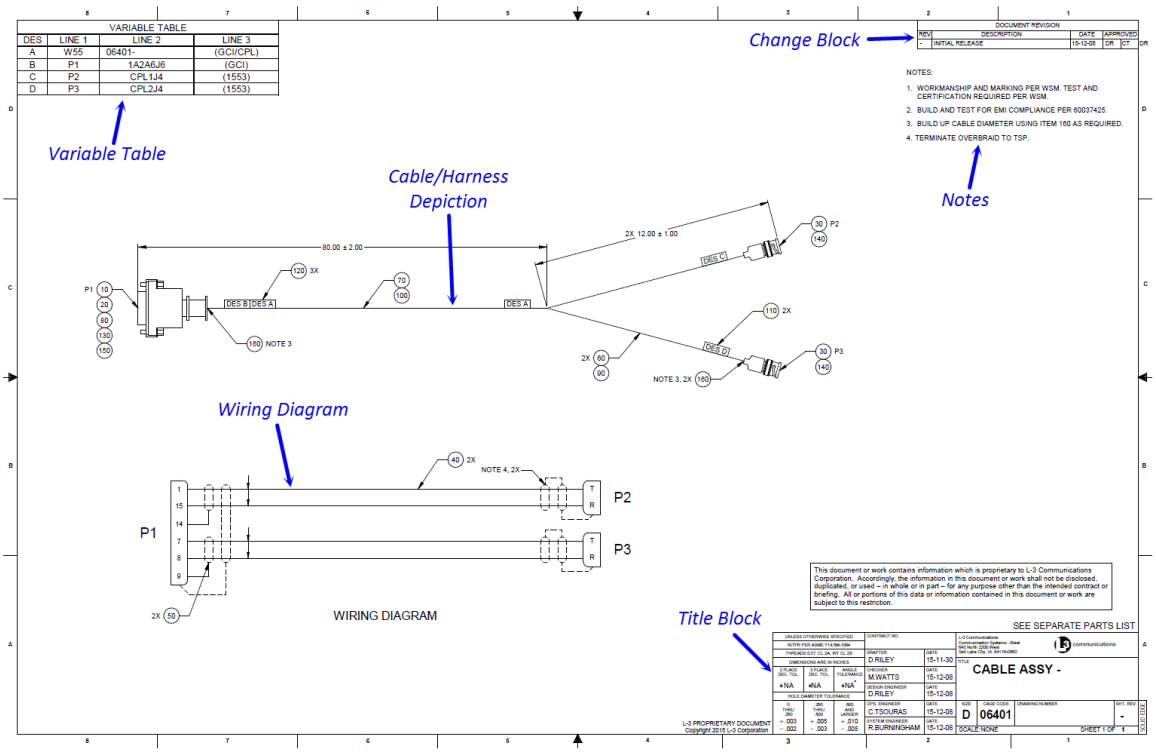


Figure 4-3 [B] Example of Cable/Harness Drawing (Stick Figure Formboard Layout)

4.1 [B] Cable/Harness Depiction

The cable/harness depiction will include a pictorial representation of all connectors and backshells. All cable/harness branches will be dimensioned in the pictorial representation or defined in a length table. All items on the cable/harness assembly parts list or bill of material (EBOM) will be identified by a balloon callout, referred to in a drawing note or listed in the wiring diagram. Reference designators (ex. P1, P2, J1, J2) will be identified next to the appropriate item balloon or in the wiring diagram.

4.1.1 [B] Balloon Callouts

Notes or quantities next to a balloon apply to that item only. Notes or quantities next to a group of balloons apply to all items in the group. A group of balloons will be identified by a grouping bar next to multiple balloons (Figure 4-4).

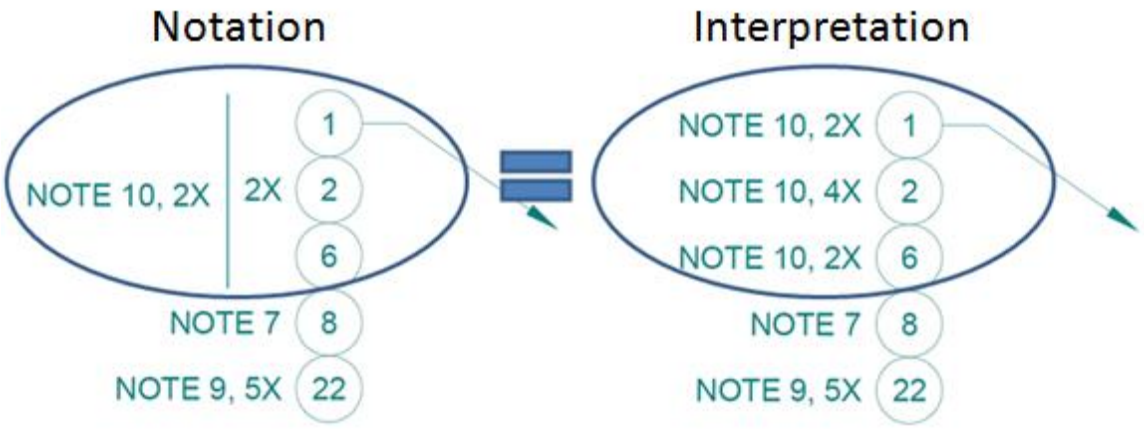


Figure 4-4 [-] Example of Grouping Balloons

Balloon call-outs from a connector will typically identify the connecter, adapter (backshell), hardware, contact sealing plugs, braid sock, boot, adhesive, dust cap, lanyard, etc. Balloons coming from a cable/harness branch will typically identify the overbraid shielding and sleeving. Cable ties are called out on the cable/harness branch showing the location of the zip tie or referenced in a note. Balloons coming from the marker labels will typically identify the label and may include clear sleeving to be placed over the label (Figure 4-5).

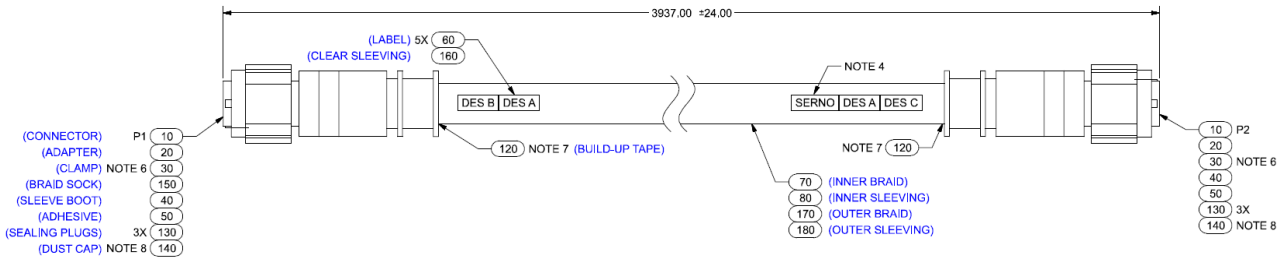


Figure 4-5 [B] Example of Typical Balloon Call-outs

When a dust cap and lanyard are used, they will typically be shown in the cable depiction showing the proper installation location. If a plug-type connector is used, the lanyard ring will be placed between the connector and backshell to prevent the lanyard from moving along the length of the cable/harness. If a jam nut connector is used, the lanyard ring is placed between the connector flange and the jam nut (Figure 4-6). When Panduit tie straps are called out, they are placed on the cable behind the adapter and may slide along the cable.

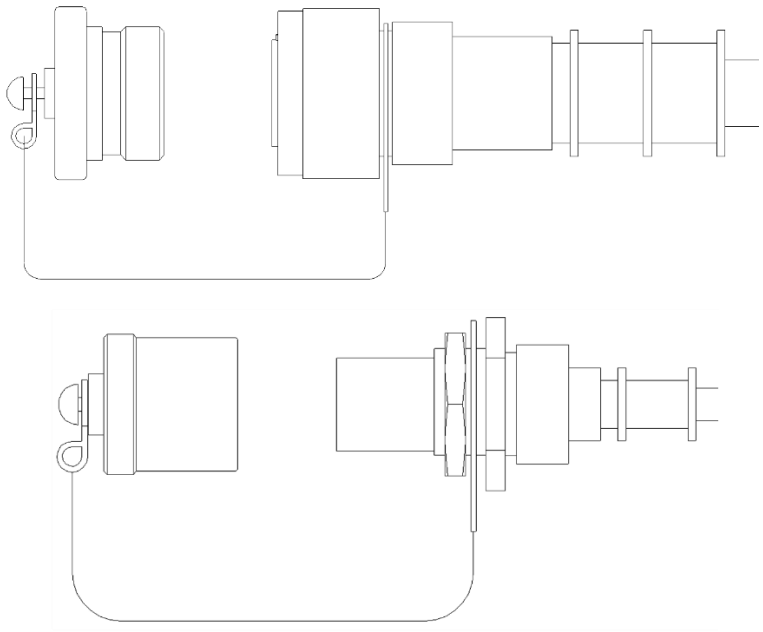


Figure 4-6 [B] Example of the Lanyard Placement

4.1.2 [B] Dimensions

Linear dimensions will be shown with a tolerance specified in the dimension or in the title block. Tolerances shown with the dimension take precedence over the tolerances shown in the title block. Angular dimensions will also be shown with a tolerance specified in a similar fashion. Dimensions are typically taken from the face of a connector to a cable/harness breakout or another connector face (Figure 4-11 and Figure 4-13). When the cable/harness is left in the routed condition, a length table will be included with from/to points specified on the drawing (Figure 4-1).

Dimensions to breakouts are assumed to be located at the end of the sleeving (jacket) or epoxy (Figure 4-7). Dimensions to formed cable bends are assumed to be the inside bend radius.

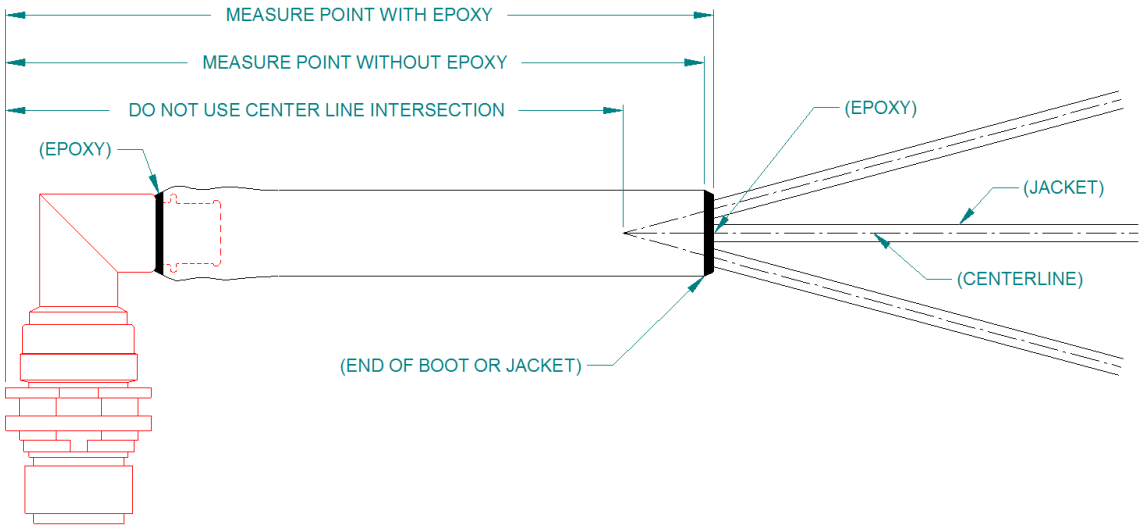


Figure 4-7 [B] Dimensions to Breakouts

4.1.3 [B] Labels

Cable/harness assemblies are typically labeled with identification markers that show the cable/harness reference designator, cage code with part number, and all connector reference designators located within the cable/harness assembly. Labels (or markers) are identified on the face of the cable/harness depiction as text boxes positioned along the wire run in proximity to each connector and close to a breakout area for harnesses. Each text box will contain a unique identifier that starts with DES followed by a letter which is defined in the DES column in the variable table (see section 4.4.3). DES A typically references the cable/harness reference designation, L3 cage code and part number, and cable description. DES B through DES XX typically reference the connectors (ex. P#, J# or E#) and all other terminations. The variable table identifies the lines of data to be placed on a label. The label typically includes a minimum of one line and a maximum of three lines (see section 4.4.3).

Installation of labels will be in accordance with the cable/harness depiction that shows the relative location of each DES marker. Workmanship Standards (IPC/WHMA-620, Section 12.4) specifies that the maximum distance from the end of a breakout or the rear most portion of a connector accessory to the label is 12 inches. If there are a group of labels in a common location along the wire run, the 12 inch limit is taken from the outermost edge of the last label in the group (Figure 4-8). If the cable/harness branch is less than 12 inches, the DES A label can be located on a connecting branch. Labels should not interfere with or overlap the breakout (Figure 4-9). Critical locations of labels will be dimensioned where the 12 inch rule does not apply.

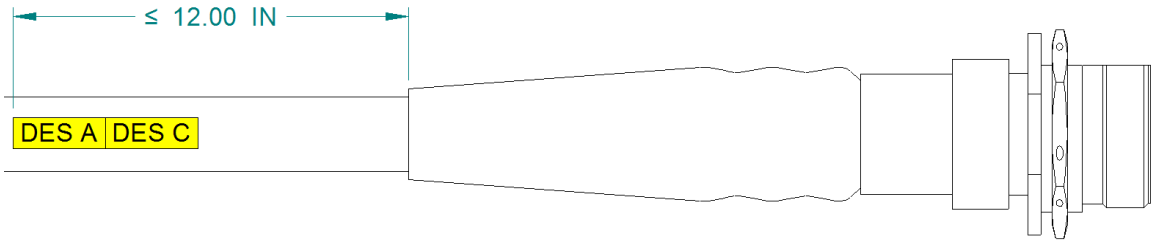


Figure 4-8 [B] Distance of Label from End of Boot

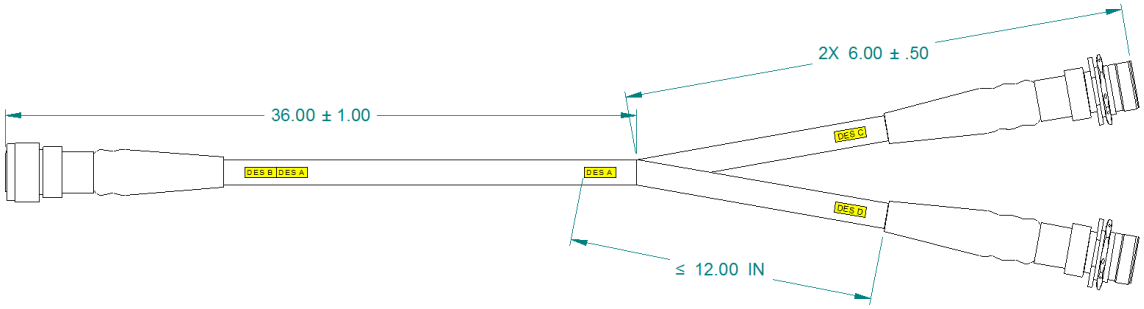


Figure 4-9 [B] Distance of Label from Breakout

Drawings do not indicate the text direction of the labels and are shown in a way that makes the drawing readable. WSM prefers that the connector label reads toward the connector, however, labels that read away from the connector are acceptable (Figure 4-10). Labels should be trimmed up to text to reduce the footprint of the label. Occasionally labels will be used as the boot and will be specified on the drawing.

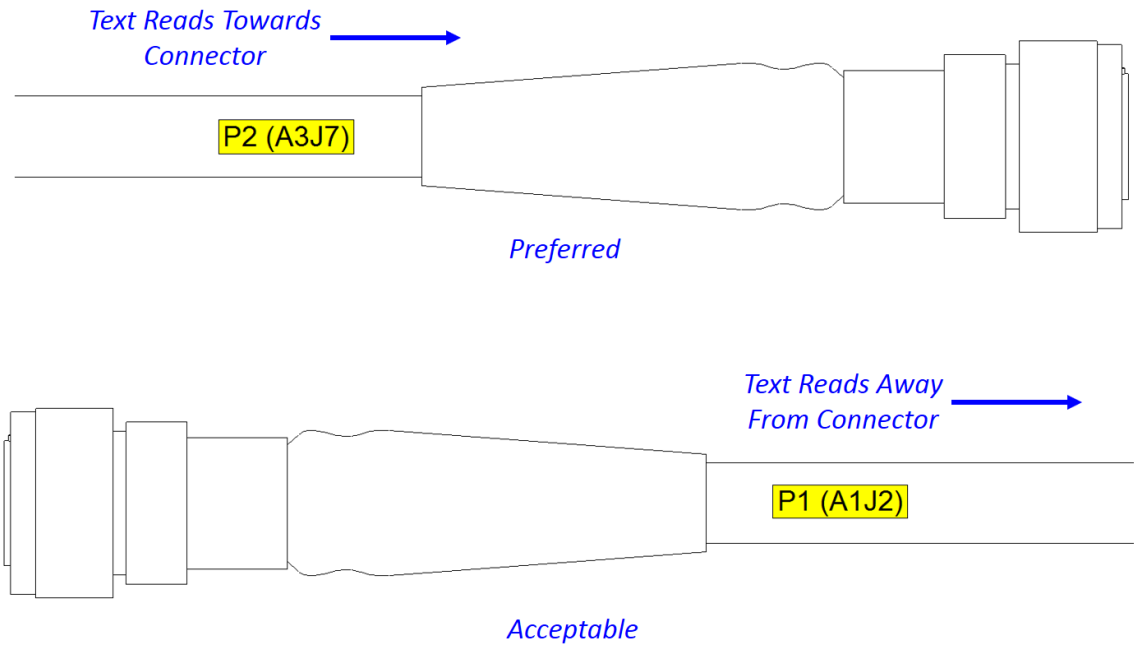


Figure 4-10 [B] Direction of Label Text

4.1.4 [B] Face Views

Connector face views showing orientation will be shown when the position of the connector is important for the next higher assembly. This is often critical with short, or stiff cables. These views will most often identify a key position, or one or more pins, but other defining features could also be used, if applicable. The views define the orientations of one connector relative to other connectors as shown in their respective views.

When the orientation of the keying is important, a face view will be shown identifying the master key and dimensions indicating the tolerance that the keyway may be rotated (Figure 4-13). If no dimensions are shown, the angular tolerance is 45° maximum in both clockwise and counter clockwise directions.

Connectors without physical pin markings will have a face view identifying pin locations and relate the pins to an identifiable feature of the connector, if applicable (Figure 4-11). Pin identification may infrequently be shown for the back side, rather than the face side, of the connector. In this case, view arrows and labeling will make clear which side of the connector applies.

Face views may (or may not) show pins shaded solid and sockets as open outline (not shaded). This is typically done with power connectors (Figure 4-12). If used, the solid depiction is representational only and does not override the contact type specified by the connector part number.

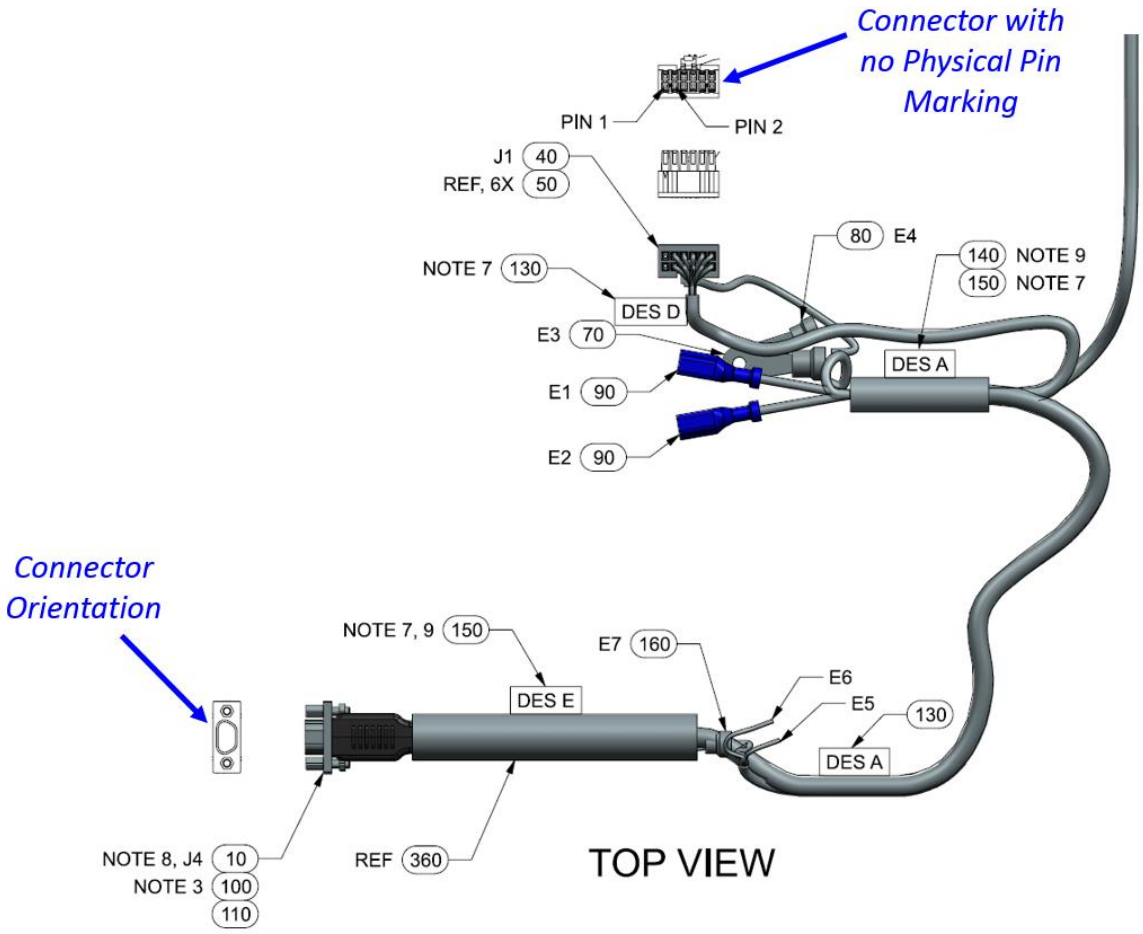


Figure 4-11 [B] Example of Connector Orientation and Pinout Information

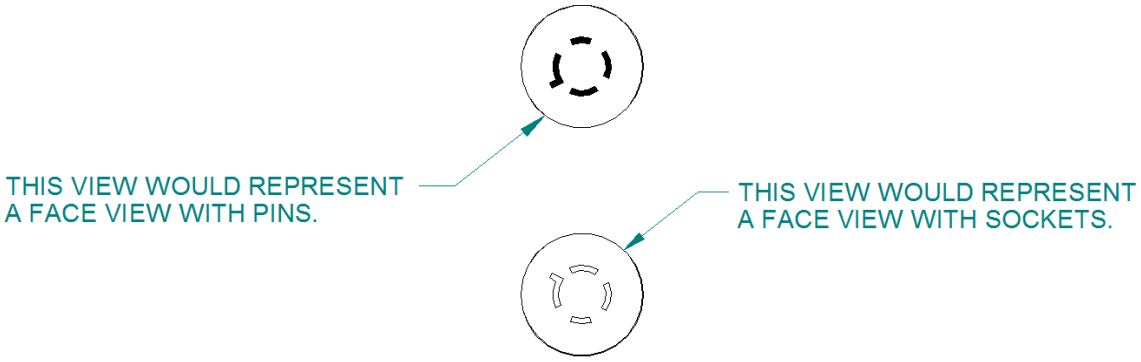


Figure 4-12 [-] Example of Pin or Socket Representation

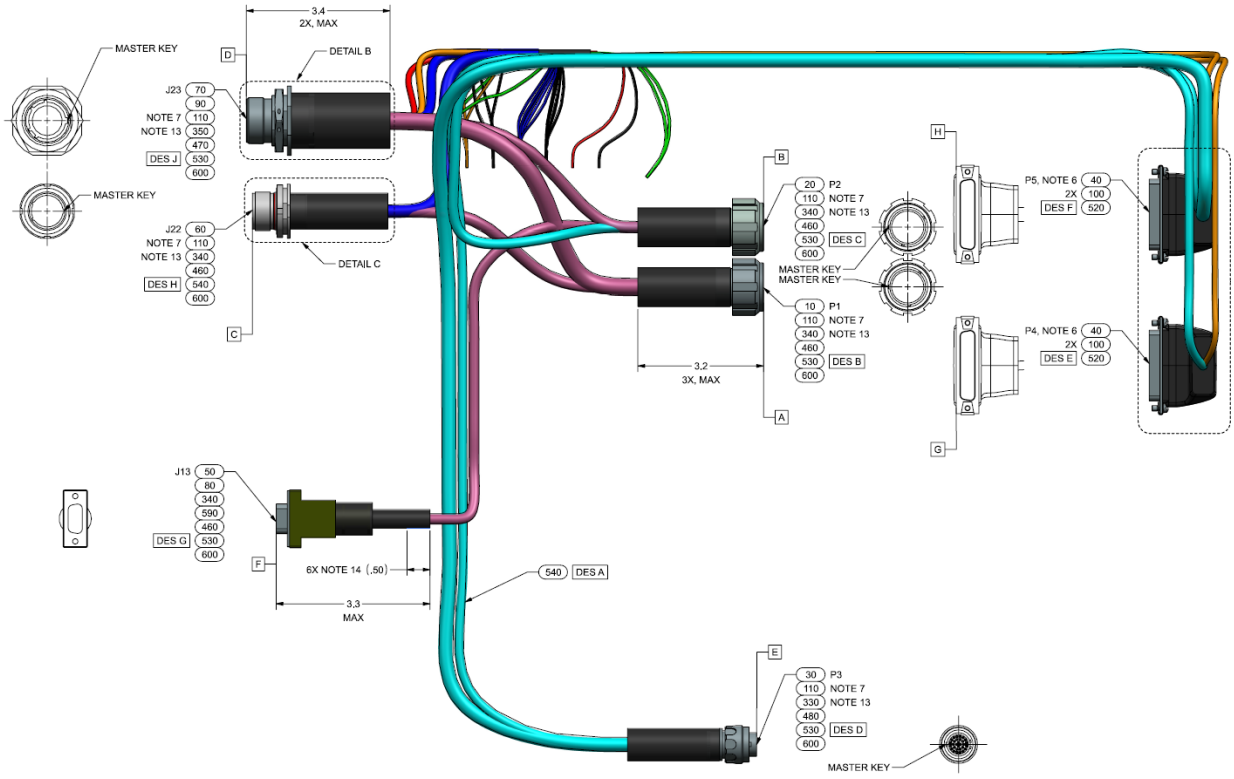


Figure 4-13 [B] Example of Master Key Orientation

4.1.5 [B] Shielded Molded Cables/Harnesses

When molded backshells or transitions are called out on the drawing, the cable/harness shall be molded per 60112799. Molded connectors and transitions are normally shown

with maximum dimensions, however more detail may be used when necessary. Backshells and mold material will be called out in the notes or parts list and identified on the face of the drawing. Cable/harness branch depictions may be shown with either a single line, or with parallel lines that are representative of the cable thickness (Figure 4-14).

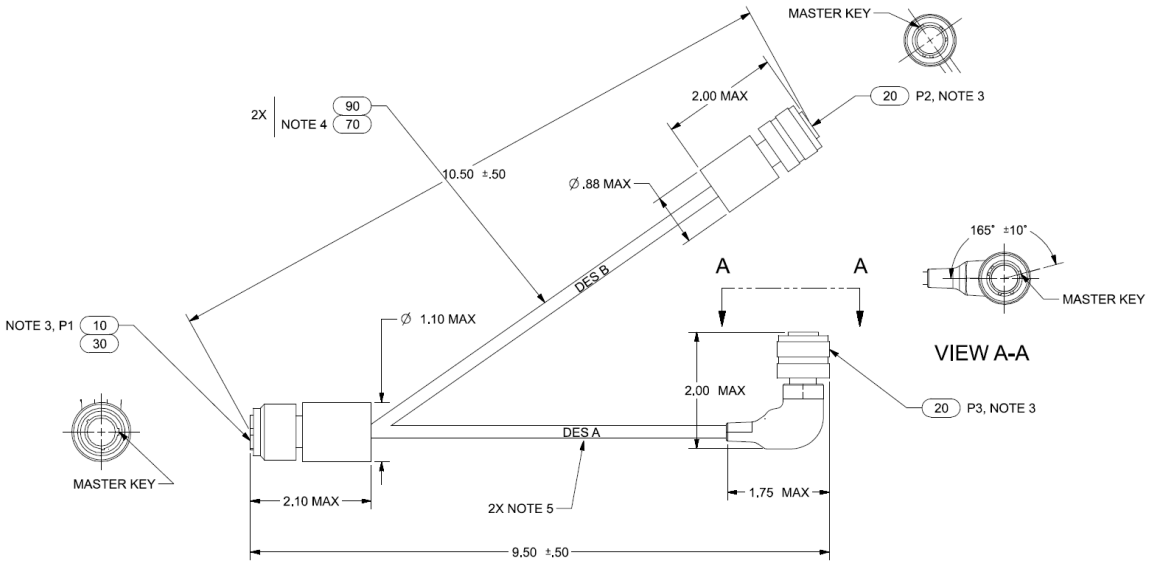


Figure 4-14 [B] Example of Molded Cable/Harness

4.2 [-] Wiring Diagrams

The wiring diagram shows electrical point to point connections for the cable assembly. It shows how each connector contact (pin or socket) is electrically connected and how the cable shielding is connected. See section 4.2.4 for items typically called out in the wiring diagram.

Figure 4-15 shows a typical L3 wiring diagram detailing how to interpret symbols on the diagram. The following paragraphs in this section describe wiring diagram nomenclature and symbols as well as common shielding termination examples.

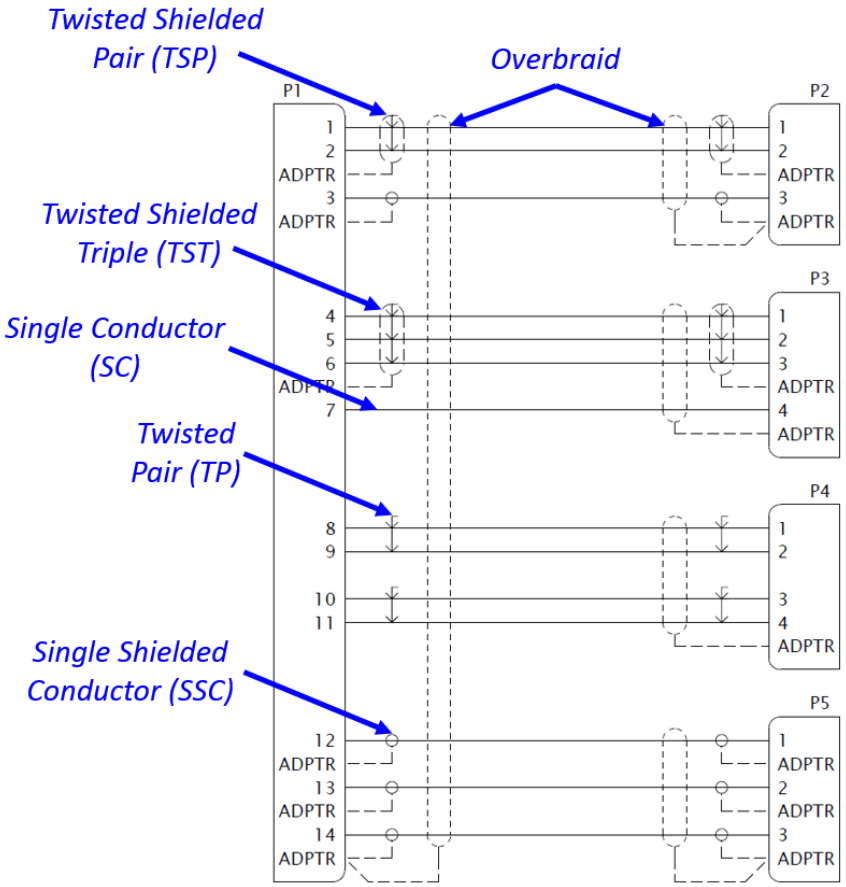


Figure 4-15 [B] Wiring Diagram

4.2.1 [B] Wiring Diagram Symbols and Nomenclature

The wiring diagram shows each connector on the cable/harness assembly with a box. The connector reference designator will be located near each box. Inside the box is listed each contact designation for that connector which makes an electrical connection to another contact within the assembly. Contacts that are not connected are normally not listed in the wiring diagram. Contact reference designations match the contact names on the connector. Numbers or letters are used for contact designations based on connector families and insert arrangements within those families. The term "ADPTR" is used within the connector box to indicate that shielding is connected or grounded to a backshell adapter (Figure 4-16). If the shields are grounded through the connector housing shell (no backshell), the label inside the box will be "SHELL" (Figure 4-17). If lower case letters are used, L3 uses a "/" in front of the letter to ensure proper case. For example a lower case "c" would have the designation "/C" to distinguish between a "C" and "c". Solid lines from the side of the box next to the pin or socket reference designator show wire connections.

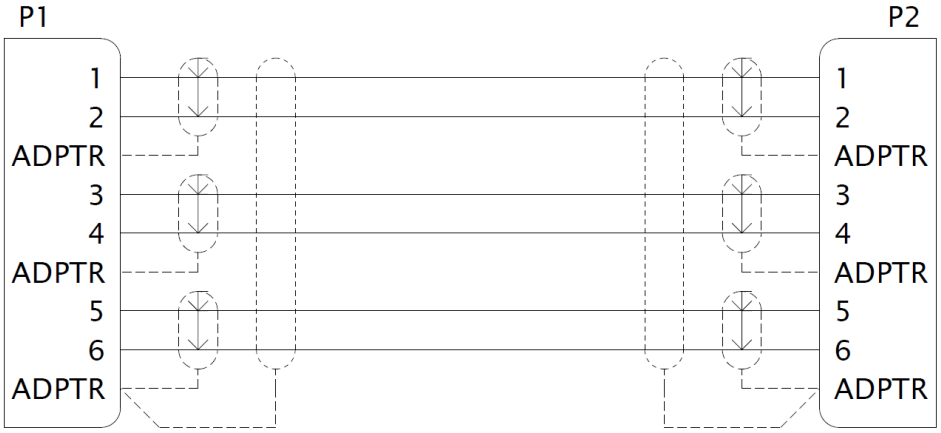


Figure 4-16 [B] Terminating Shield to Adapter/backshell

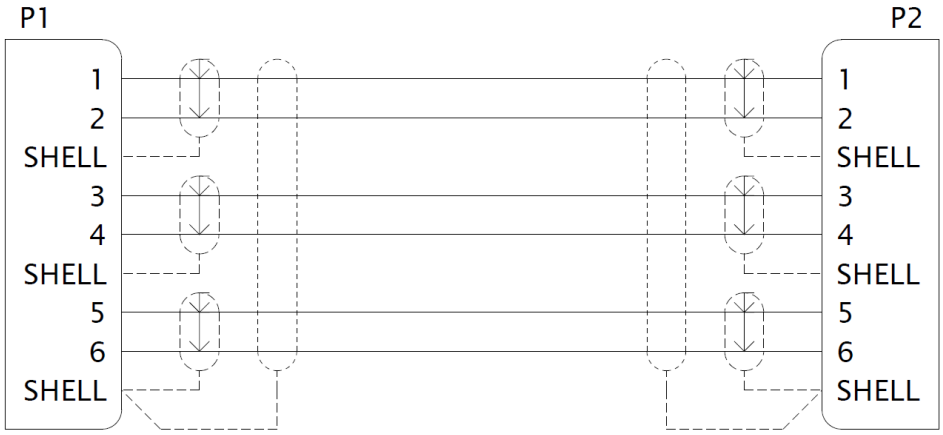


Figure 4-17 [B] Terminating Shield to Connector Shell

There are two line types shown on the wiring diagram, solid and dashed. In general terms, a solid line represents a wire and a dashed line represents a braid, shield or soldered connection. Shielding over any number of wires is shown with a pair of dashed ovals around the wires. This could be an overbraid or the shields of a twisted shielded set of wires. A solid or dashed line connected to the dashed oval lines indicates how that end of the shield is grounded or terminated to the connector or backshell. When a dashed single line connects to a dashed oval, a solder or mechanical connection has to be made that maintains the shield coverage. See section 4.2.2.1.1. The connection from the single dashed line to the corner of a connector symbol indicates an overbraid is grounded by clamping or soldering 360° to either the main connector or backshell. See section 4.2.2.2. A solid line, instead of a dashed line, from a dashed oval shielding symbol to the connector symbol would indicate a wire soldered to the overbraid and then grounded to the backshell or connector with a solder connection if no other grounding method is called out in the balloon stack up on the connector. All soldering is done per

Workmanship Standards and the EMI Work Instructions if called out on the drawing.

Dashed lines are also used between dashed oval shield symbols to indicate braid transitions. This braid transition is done by soldering one braid to another overlapping braid, or soldering an inner shield to the cable's gross overbraid. An example of the former is shown in 4.2.2.3 and the latter is shown in 4.2.2.1. On occasion a braid is used as a ferrule and is shown as a dashed line from a shield symbol to an "E" point (Figure 4-25).

When multiple arrows are shown between solid wire lines, this indicates that the wires are twisted together. Text identifying color may be shown on the solid line to indicate the wire color. This may be done to comply with electrical code or to aid in trouble shooting.

Contacts that are not connected on pre-wired connectors may have a N/C (no connect) symbol added next to the connector box of the wiring diagram (Figure 4-18). If the N/C symbol is used, a note is called out to indicate how to sleeve and terminate the wire. Some connectors that have a large number of unused contacts may also use a note to indicate a range of N/C connections.

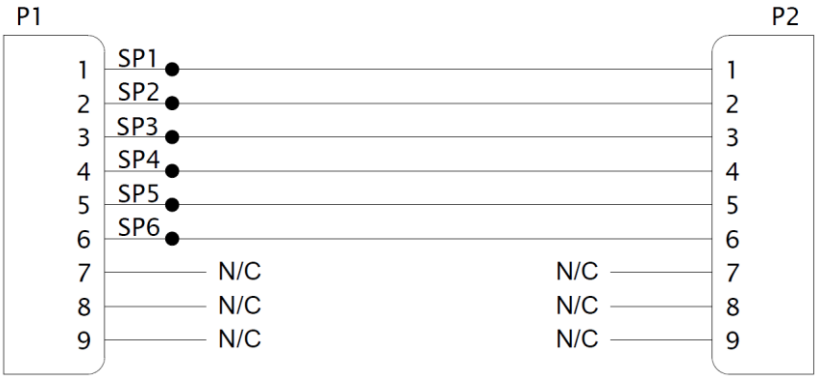


Figure 4-18 [B] N/C Example Using Pre-wired Connector

Sometimes an existing standard cable is modified by removing a connector from one end and replacing it with a different connector. The new connector many not need all of the supplied wires connected. The unconnected wires will be shown with N/C on the wiring diagram (Figure 4-19). A note will indicate how to sleeve and terminate the N/C connections. Some connectors with unused solder cup terminations may have the N/C label added and sleeving called out to indicate that sleeving is used to cover the unused solder cup.

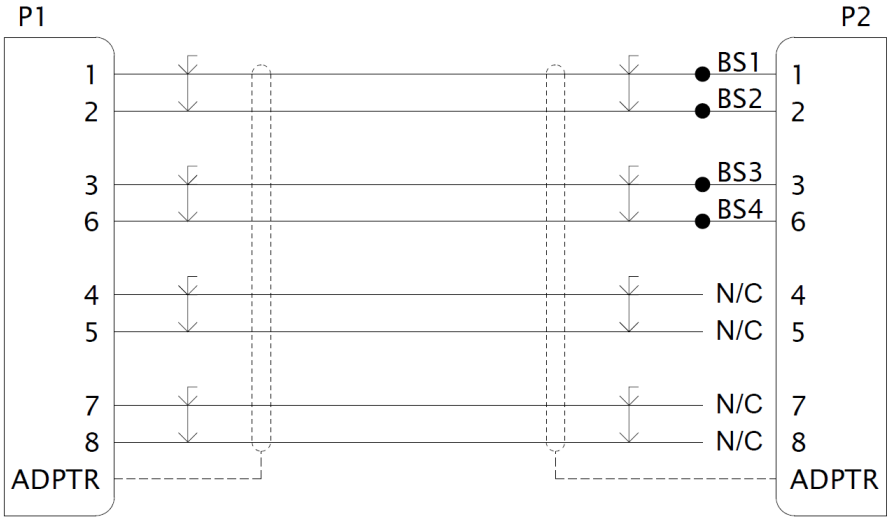


Figure 4-19 [B] N/C Example Using a Modified Cable

A BS or SP designator is used to indicate a splice. The designator may also be called out on the cable depiction to indicate where on the cable the splices are located. A note may also include information about where to locate the splices or other restrictions/requirements. Originally BS was used to indicate a butt-splice, but over time it has come to stand for any type of splice that joins two or more wires together, including in-line splices, parallel splices, etc. In order to differentiate between the different splice types, it is necessary to refer to the item callouts on the wiring diagram and the parts list. See section 4.2.3 for more information about the different types of splices.

Occasionally electrical devices, such as a capacitor or inductor, are embedded into a cable. Standard symbology is used in these instances to represent the electrical devices in the wiring diagram and standard reference designations are used for these parts. For example a C1 would represent the first capacitor. When electrical devices are used, cable design notes on the drawing will indicate what type of testing can be performed on the wires connected to the electrical device.

4.2.2 [B] Shielding

Shielding is used to protect electrical signals running through the cable/harness from outside electrical interferences and protects the signals from being inadvertently transmitted. The wiring diagram and cable depiction are drawn with the intent that cable shielding is to be done with pull-on overbraid. Pull-on overbraid is the most basic form of shielding; however a braiding machine can be used in place of pull-on overbraid or a combination of the two. This option to use a braiding machine instead of pull-on overbraid is detailed in IS-001.

In the past wiring diagrams intended to show braid overlaps of the pull-on braiding at the

cable/harness breakouts. These braid overlaps will not be shown any longer (Figure 4-15), instead, the shielding will only be shown at the connector ends and assume that the shielding at the breakouts will have 360° solder connections for continuous shielding from end to end of the cable/harness (unless otherwise noted in the drawing). Braid socks will not be shown in the wiring diagram but only as a balloon call-out on the connector (Figure 4-5).

4.2.2.1 [B] TSP to Gross Overbraid Termination

When terminating TSP shields to gross overbraid, first, solder the TSP shields together and then solder the overbraid 360° to the TSP shields. The overbraid will be terminated to the backshell or connector shell (Figure 4-20).

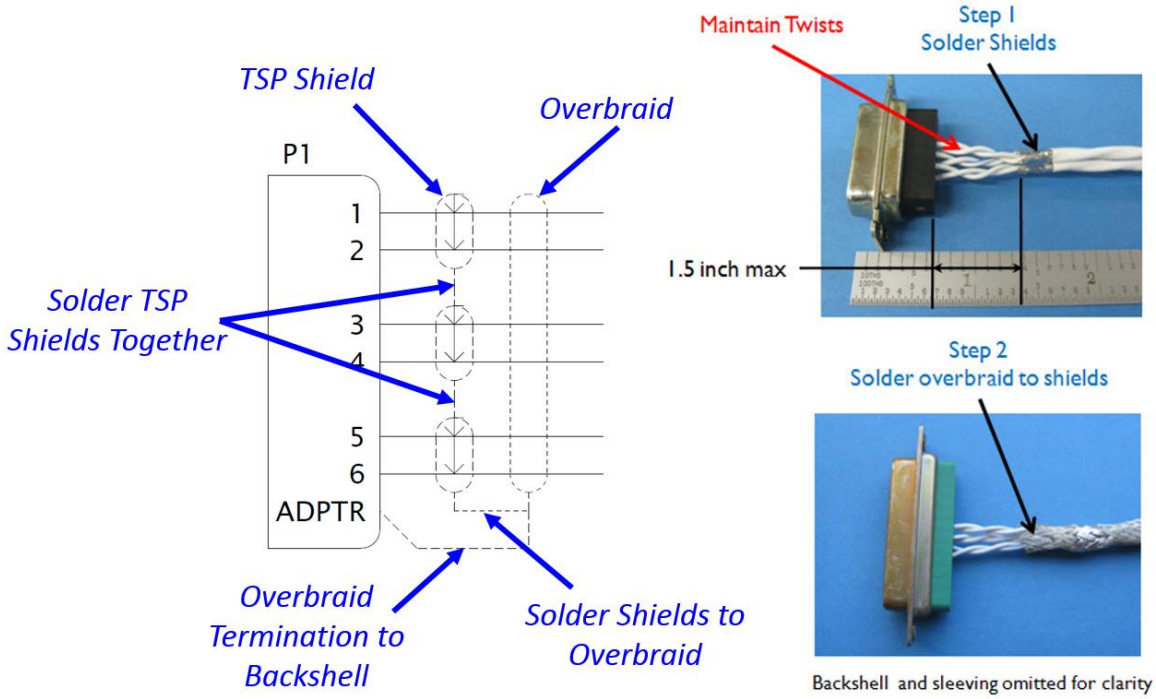


Figure 4-20 [B] TSP to Gross Overbraid Termination

4.2.2.1.1 [-] Soldering TSP to Gross Overbraid or Braid Sock

When internal TSP shields are to be soldered to the overbraid, it should be done by soldering all of the TSP shields together and then soldering the outer TSP shields 360° to the overbraid or braid sock. For cables with many TSP shields the preferred sequence to terminate to the braid is as follows: (1) solder the three middle TSP shields together and verify they are properly terminated, (2) solder three more TSP shields around the outside

trying to maintain a circular cross section and verify they are properly terminated, (3) continue until all TSP shields are soldered together, (4) the outer braid (either braid sock or gross overbraid) is soldered 360° to the TSP shield bundle, (5) the outer braid is terminated to the backshell or connector (Figure 4-21).

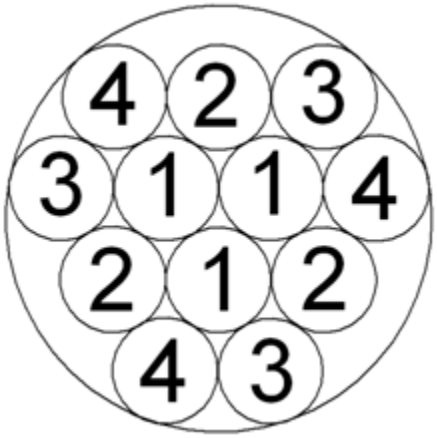


Figure 4-21 [-] TSP Shield Soldering Sequence

4.2.2.2 [-] Overbraid and Wire Shield Termination using Multi-shield terminating Backshell/Adapter

Some backshells use slots to feed the shields from the shielded wire to the backshell. The backshells also have a banding platform to secure a main overbraid to the backshell using a provided spring band. Please note, if the spring band cannot clamp down on all the cable/harness shields, a "Band-it" clamp may be used to secure the shields per IS-001 (Figure 4-22). The shields should be terminated to the backshell in the method specified by the shield-terminating hardware manufacturer unless otherwise specified in the notes. For example, if the backshell has a C-clamp or spring band included with the hardware, or a separate "Band-It" is ballooned with the connector or backshell on the parts list, then soldering is not required and the clamp is used to terminate the shield coverage.

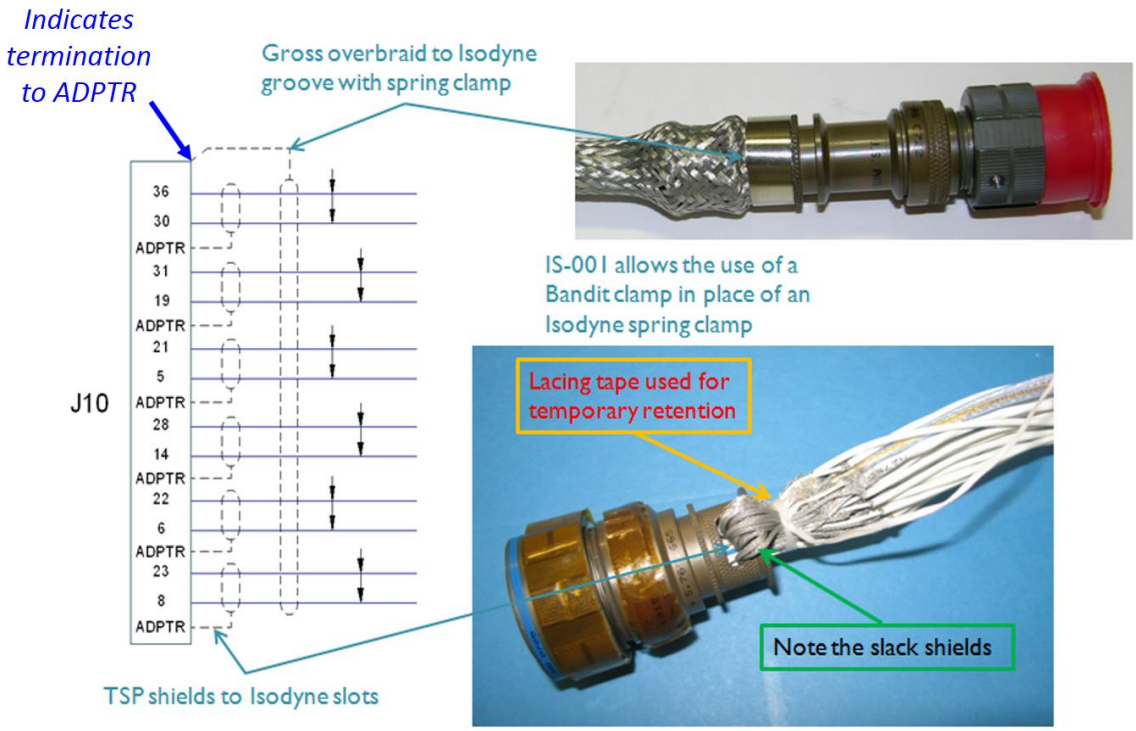


Figure 4-22 [-] Overbraid and Wire Shield Termination to Backshell

4.2.2.3 [B] Overbraid Overlap at a Breakout

At the breakouts the braid overlap shall be ½ diameter to 1 diameter and 360° soldered per 60037425 if the EMI compliance standard is called out on the drawing (Figure 4-23). Soldering needs to be performed per WS-003 which calls out J-STD-001 and -004 (SN63 or SN60 type solder). If outer braiding is done using a braiding machine rather than pull-on braid, solder is not needed at break outs per IS-001. If tack solder is preferred it will be called out on the drawing.

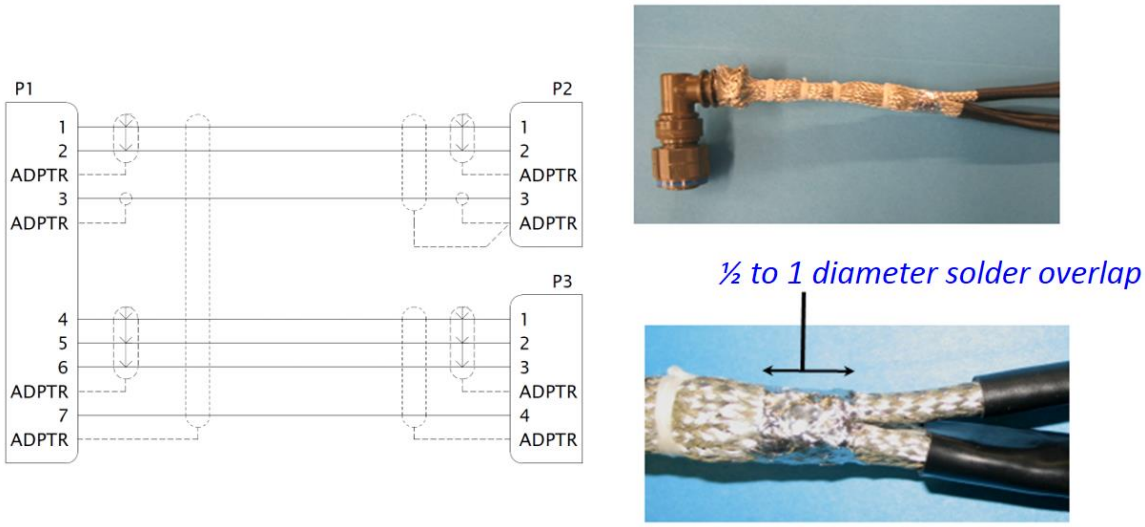


Figure 4-23 [B] Overbraid Transition at Breakout

4.2.2.4 [-] Double Overbraided Cable/Harness

Some cables/harnesses use a double-shield terminating backshell (Figure 4-24). These cables/harnesses usually have an inner layer of braid, followed by a layer of sleeving, then an outer layer of braid and another layer of sleeving. Shields from the shielded wire should be evenly distributed amongst backshell slots. Inner shield overbraid should be terminated to the banding platform farthest from the connector. Outer shield overbraid should be terminated to the banding platform closest to the connector. Inner and outer overbraid should be insulated from each other using sleeving except at the connector/backshell. Isolation must be maintained between inner and outer overbraid as far up the backshell as sleeving permits. When shield transitions are present, both inner and outer shield overbraid transitions should be soldered 360° per WS-003 and isolated from each other.

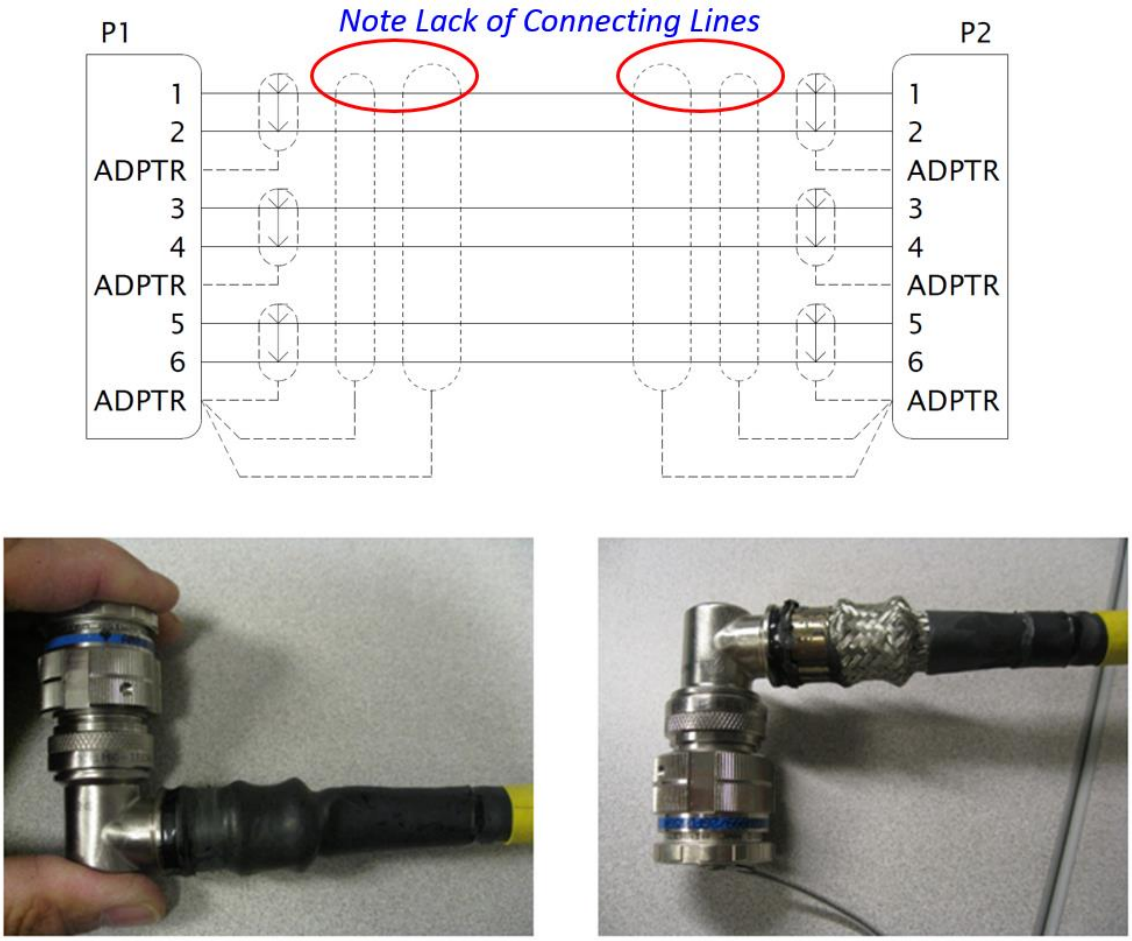


Figure 4-24 [-] Double Overbraided Cable/Harness Termination

4.2.2.5 [B] Ferrules (Solder Sleeve)

Figure 4-25Ferrules are used to terminated shielded wire to connector pins or backshells (Figure 4-27). Ferrules may be staggered to prevent bulging in the cable and to provide a better fit into a backshell.

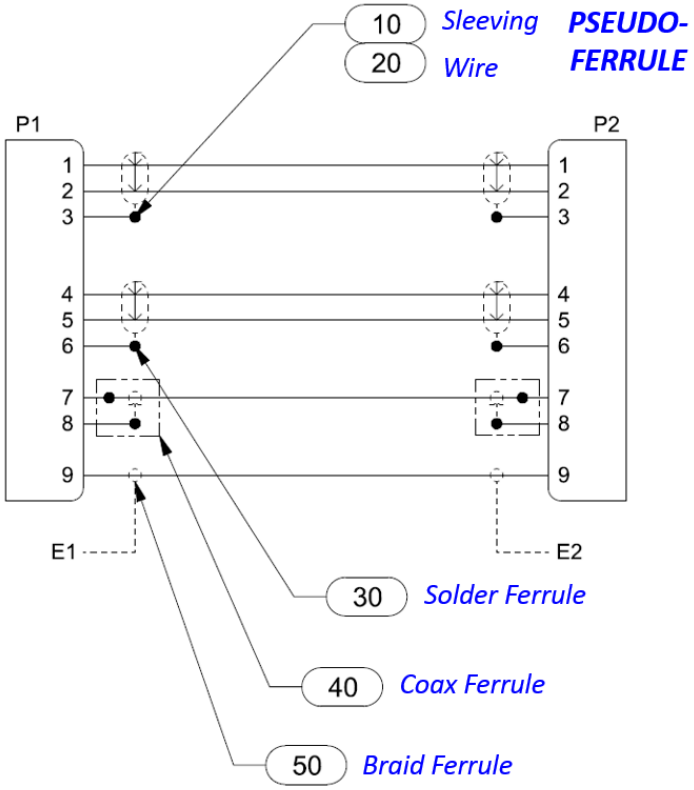


Figure 4-25 [B] Shield Termination using Ferrules

4.2.2.6 [-] Daisy Chaining Termination with Ferrules

All ferrule drain wires except for the final drain wire that goes to the connector should be kept short as possible (for EMI) and looped away from the connector (Figure 4-26). The final ferrule drain wire termination should exit the ferrule towards the connector.

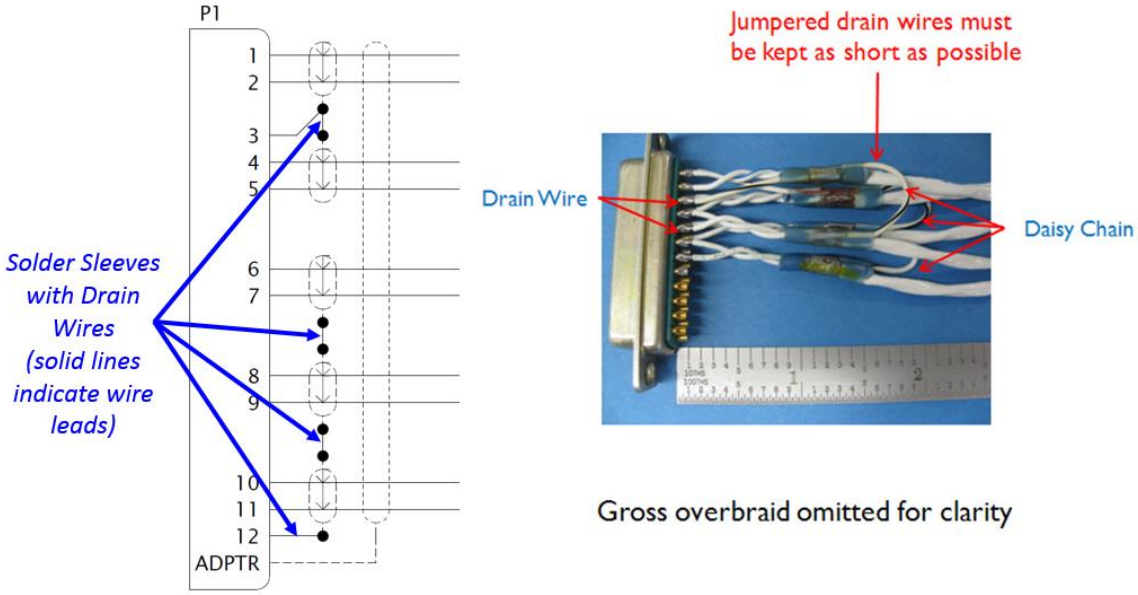


Figure 4-26 [B] Shield Termination using Daisy Chains

4.2.2.7 [-] Multiple Shield Terminations with Pseudo-Ferrules

The wiring diagram will typically call out pseudo-ferrules for this application. This method may be used with the daisy chaining termination in section 4.2.2.6.

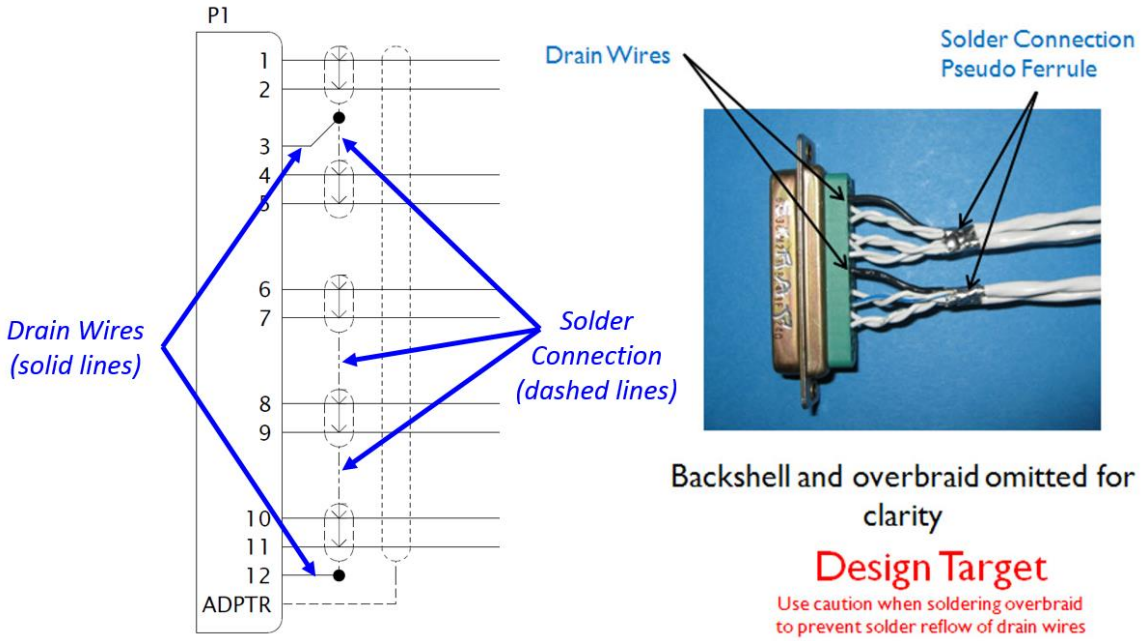


Figure 4-27 [B] Multiple Shield Terminations with Pseudo-Ferrules

4.2.2.8 [-] Molded Backshell Termination

L3's specification document IS-001 and 60112799 allows the cable manufacturer to choose the over-molding processes based on the design requirements and manufacturer's expertise. Molding methods must meet the dimensional constraints of the drawing, CAD models are often available from L3. Mold materials specified on the drawing or parts list shall be used. If the mold materials are missing, the cable builder can find approved materials listed 60112799. Hardware interface and mold clearances must be considered during the mold design. See 1000426206 for an example of a custom D-Sub thumbscrew that meets the functional standards of being captive and retractable. When questions exist, it is best to contact L3 prior to beginning work.

4.2.2.8.1 [B] Foil/Shield Molding

Foil/Shield molding is a two shot or two layer mold process where a conductive adhesive lined copper foil tape is used between the two layers. The foil tape forms a complete Faraday cage from the connector to the braid with all foil edges soldered for EMI (Figure 4-28). The second shot or outer layer protects the Faraday cage and provides an environmental covering including the mold to jacket interface. Inserting all the shields and the gross overbraid into the first shot is best practice. Using a piece of temporary tape or other barrier to prevent solder wicking which reduces cable flexibility is also best practice. When there is not enough room to insert all the shields inside the foil with the

gross overbraid, placement of the shields outside the foil is permitted provided the shield termination and flexibility is maintained.

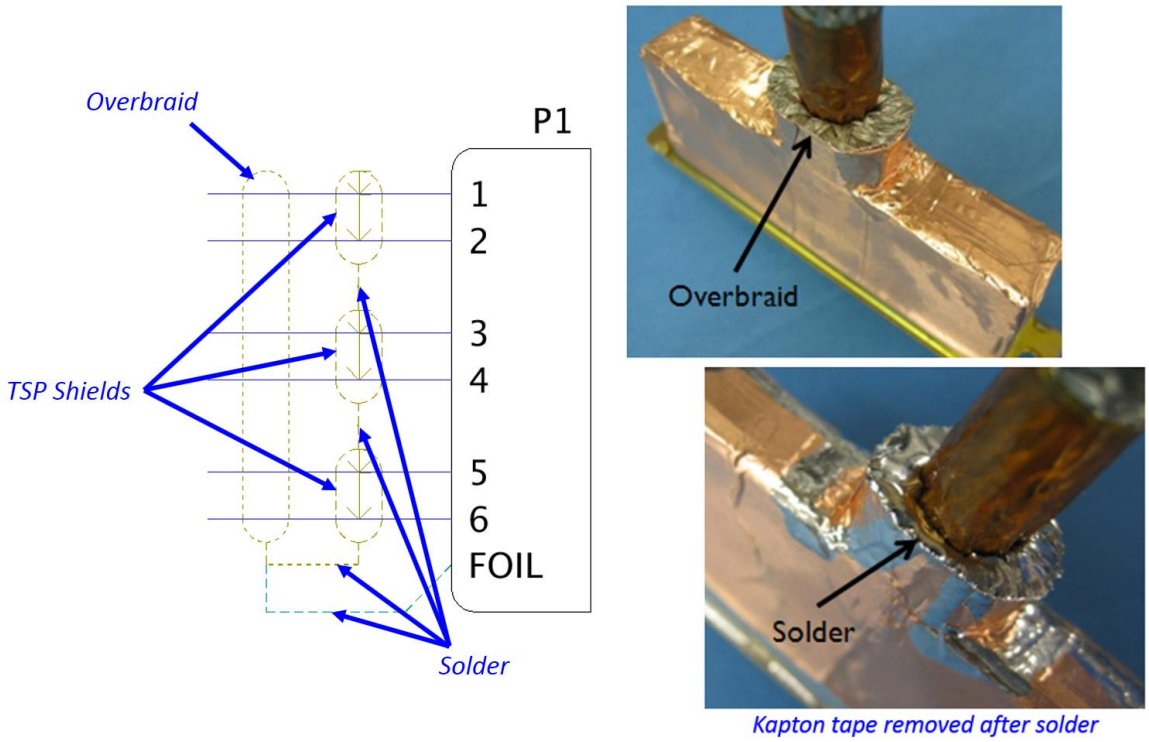


Figure 4-28 [B] Shielded Mold Example

4.2.2.8.2 [B] Mechanical Molded Backshell

A custom-made metal backshell that provides 360° EMI protection is also an approved L3 method. The material and plating requirements of the backshell may be specified on the drawing or found in 60112799. See Figure 4-31 for an example of a custom made backshell shell with an maximum anodic index delta of 0.25 volts. Some designs may also employ a combination of copper foil and a custom metal to achieve the Faraday cage. Best practices outlined in the Foil/Shield Molding also apply to custom made metal backshell.

Figure 4-29 [B] Custom Metal Backshell

4.2.3 [B] Splices

Splices are used to connect wires together and are referenced on the L3 wiring diagram with a designator BS or SP (Figure 4-30). The three types of splices that are typically used on the wiring diagrams are solder splices (Figure 4-31), mechanical (crimp) splices (Figure 4-32) and lash splices (Figure 4-33).

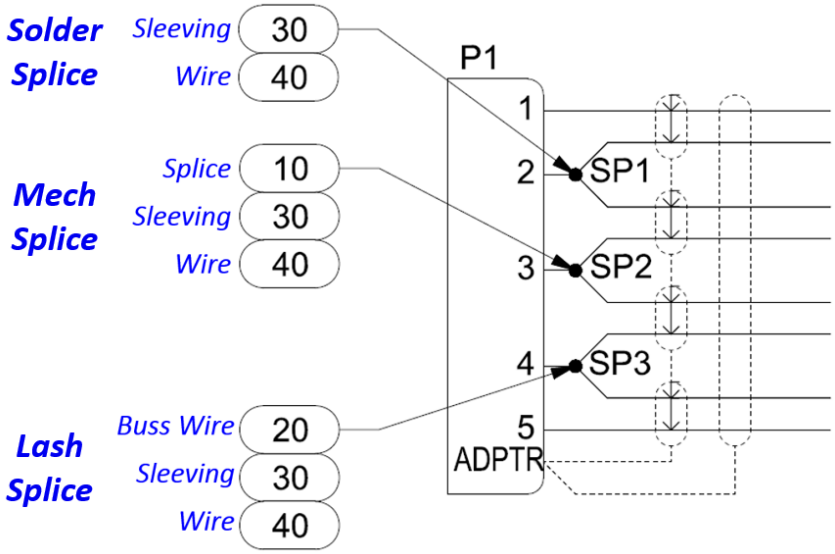


Figure 4-30 [B] Splice Types

Figure 4-31 [-] Solder Splice Examples (sleeving not shown)

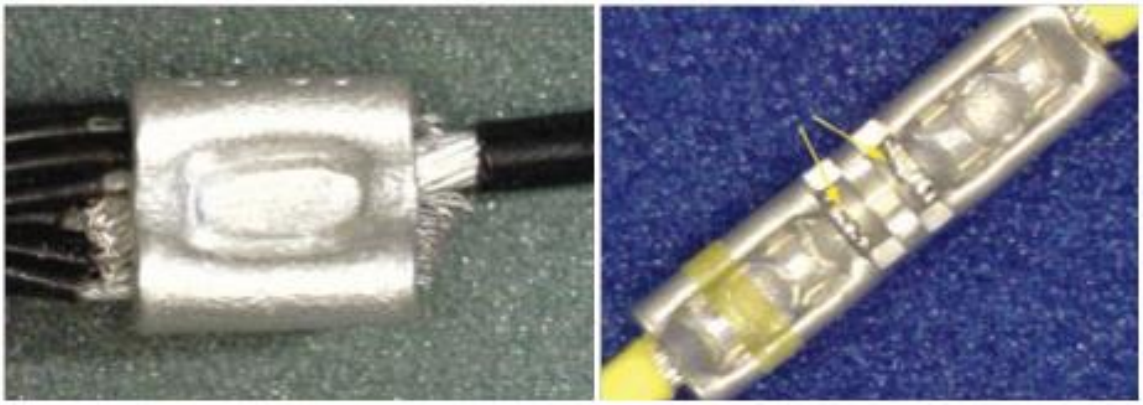


Figure 4-32 [-] Mechanical Splice Examples (sleeving not shown)

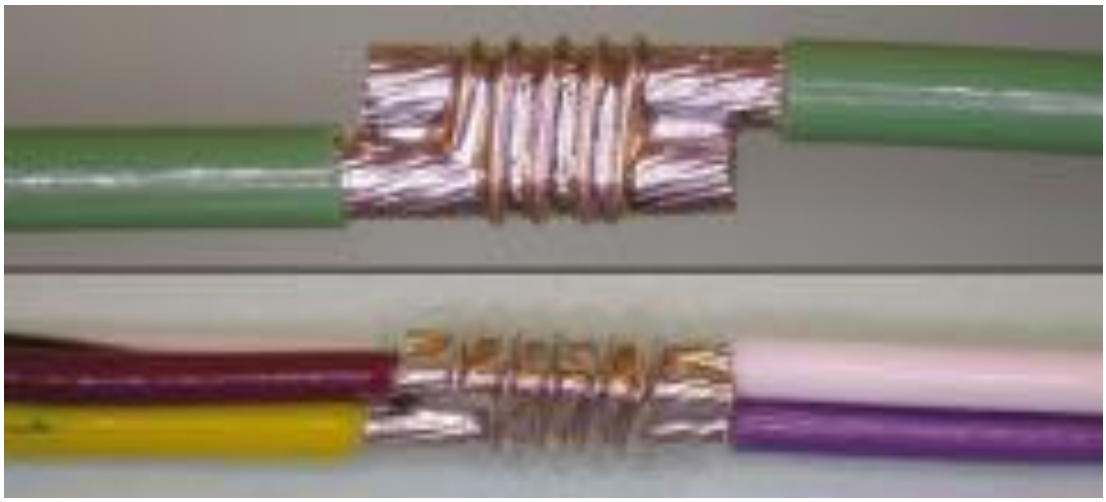


Figure 4-33 [-] Lash Splice Examples (sleeving not shown)

4.2.4 [B] Balloon Callouts

Balloon callouts for the following items may be called out on the wiring diagram:

- Wire (**Error! Reference source not found.**).
- Splices, which includes ferrules, wire and/or sleeving as needed (Figure 4-30).
- Electrical components that are not located on the cable/harness depiction. This should also include lead insulators and heat shrink for splices as needed (Figure 4-35).
- Braids that only shield a subsection of the main cable/harness branch (Figure 4-36).
- Insulation for solder cup/solder lug connections, as well as insulation for No-Connect wires on a pre-wired connector.

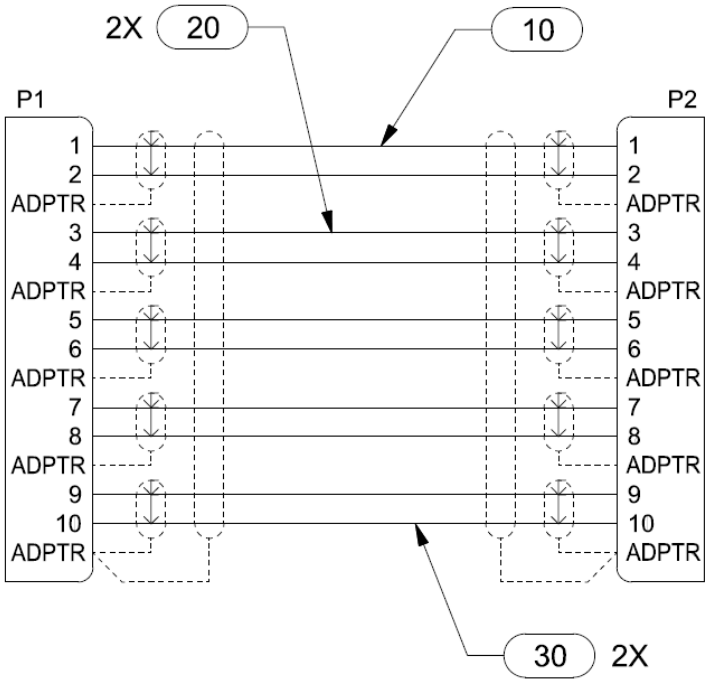


Figure 4-34 [B] Example of Balloon Callout for Quantity of Wire

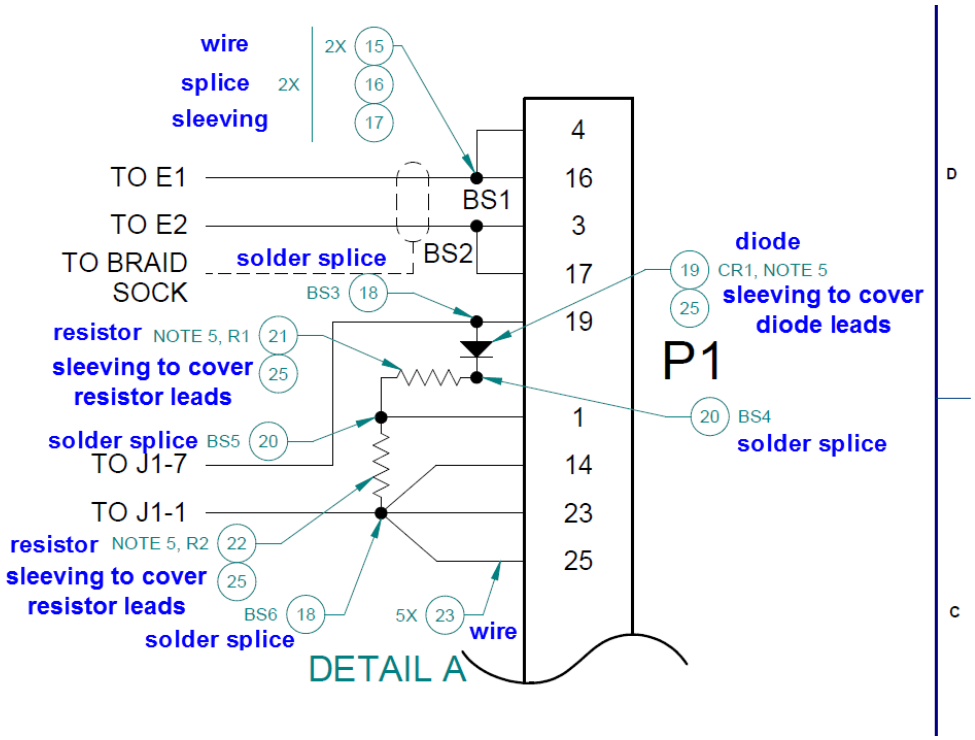


Figure 4-35 [B] Example of Ballooning for Components

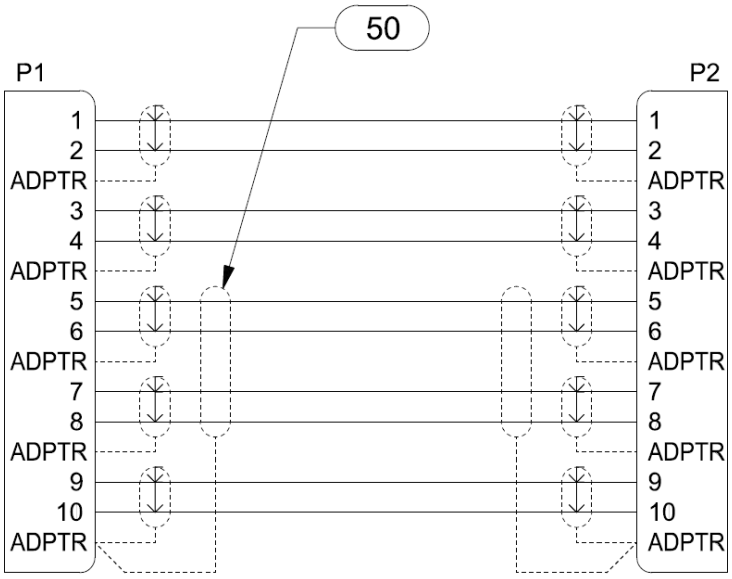


Figure 4-36 [B] Braid Shielding a Subsection of the Main Cable/Harness

The items listed are not usually ballooned on the wiring diagram (except as a reference for clarification): main cable/harness overbraid, main cable/harness sleeving, connectors, backshells, braid socks, sleeving boots, pin/socket/contacts, labels, lugs, dust caps, epoxy, and hardware.

4.2.5 [B] Reference Designation

Reference designators for electrical connections shall be present on the wiring diagram. These reference designators shall match the cable/harness depiction and the parts list, with a few exceptions.

Solder and lash splices should have splice reference designators associated with the wiring diagram but may not have reference designators in the parts list. With the implementation of the Capital Logic wiring design tool, reference designators SP1, SP2, etc. are used for a splice reference designator, which is interchangeable with the traditional BS reference designator. Either one may be used, but the designators should not be mixed on the same drawing. Unterminated wires may be designated E1, E2, etc. on the wiring diagram and on the cable/harness depiction, but not on the part list.

Occasionally, active electrical components may be used in a cable/harness (example: Resistor, Diode, IC, etc.). These active electrical components should be given reference designators on the parts list and wiring diagram.

All splices and active electrical components should be located as indicated in the notes or cable/harness depiction. If the notes do not indicate their locations, splices and active electrical components should be located near the closest defined electrical components on the wiring diagram. As shown in Figure 4-25, BS1 should be located near P1, unless the cable/harness depiction or notes on the drawing indicate otherwise.

The inclusion of electrical components in the cable may affect DWV (hi-pot) testing. If there are electrical components in the cable, check the drawing notes for any exclusions or modifications for testing.

4.3 [B] Cable/Harness Drawing Notes

4.3.1 [B] Common Cable/Harness Drawing Notes

4.3.1.1 [B] WORKMANSHIP AND MARKING PER WSM. TEST AND CERTIFICATION REQUIRED PER WSM.

WSM stands for Workmanship Standards Manual, or more correctly Workmanship Standards. WSM is applicable to all cable/harness drawings so it is usually on every drawing.

Workmanship Standards are a collection of separate documents encompassing all manufacturing activities. The documents under WSM that may apply specifically to cable and harness assembly are:
WS-000 Workmanship Standards Introduction
WS-003 Cable Harness Assembly
WS-012 Marking, Engraving and Labeling

Other documents may also apply.

It is important to note that the WS documents include several industry standard documents, such as IPC/WHMA-A-620, J-STD-001, J-STD-004, J-STD-006, and others. Vendors who build products per L3 drawings should obtain the standards documents listed on the drawing and related embedded documents as they pertain to the product and comply with their requirements.

The phrase “TEST AND CERTIFICATION REQUIRED PER WSM” means that a C&R (Continuity and Resistance) test and a DWV (Dielectric Withstanding Voltage or “Hi-pot) test must be performed for every cable, as applicable. “Certification” means that, at a minimum, the vendor has recorded the acceptable results of the tests. At a maximum, the vendor provides the automated printout of the test results.

4.3.1.2 [B] BUILD AND TEST FOR EMI COMPLIANCE PER 60037425.

The specification for EMI compliance is 60037425 (which then references W-432).

Important issues that are covered by this standard include cleaning prior to assembly, shield terminating wire length (ferrule wire lead length), maintaining wire twists up to the connector, shielding and shield termination, and the milliohm test procedure.

4.3.1.3 [B] TORQUE HARDWARE PER ITEM 60083115.

The torque specification document is 60083115 (also called out in WSM). Torque per this document is required on any assembly with threaded fasteners that are joined in building the assembly.

This document includes instructions and a listing of torque values for most of the threaded hardware used at L3. A good way to quickly check for a torque value is to search for the connector part number in the MS Word file. It is probably more effective to search for just the base portion of part number and then look for more specifics near where the base part number is found. Part numbers in the list may be generalized, or intentionally incomplete, since part number indicators such as contact style and key position are not related to the installation torque.

Occasionally, the torque value is stated in a note. For example: TORQUE ITEM 4 AND ITEM 2 TO 150 ± 5 IN-LBS, PER S03. The torque on the drawing takes precedence over the torque specification.

If the torque value for the threaded fasteners to be joined cannot be found in the torque specification document or on the drawing, please contact L3 engineering for the torque requirement.

4.3.1.4 [B] APPLY TEMPORARY SELF-ADHESIVE LABELS FOR E1 THRU [EX].

The temporary labels referred to are usually specified for marking the ID or destination of flying leads or wire ends that will be connected at the next higher assembly. The text to be marked is usually indicated on the field of the drawing rather than in the variable table as is done for permanent markers.

Self-adhesive labels, such as Avery office labels, are acceptable. These labels are not on the parts list and are left somewhat to the vendor's discretion. Text may be printed or hand written but must be legible and not rub off. Labels should be applied flag-style and should be securely attached. Installation of labels will be approximately half way between the breakout and the end of the wire, or three inches from the end of the wire, which ever is closer. They are not intended to be permanent.

4.3.1.5 [B] REPLACE O-RING ON ITEM [X] WITH ITEM [Y].

This note usually applies to jam-nut type connectors and is used when the connector includes an O-ring, but needs a different O-ring to meet EMI, or other requirements when

it is installed at the next higher assembly. Occasionally, the note is omitted on the cable/harness drawing and the replacement happens at the next higher assembly. The replacement O-ring must not be damaged from handling or installation. The unused O-ring can be discarded.

A similar note for hardware is often used, such as "REMOVE AND DISCARD HARDWARE AND REPLACE WITH ITEM [X]."

4.3.1.6 [B] USE CLEAR SLEEVING TO COVER MARKER

The intent of this note is to provide clear-sleeve protection over labels subject to frequent use or circumstances where there is a risk of the marker text wearing off. It is a common practice for test cables/harnesses, but not typical for production cables/harnesses.

This is now usually specified by attaching the clear sleeving item number balloon to the marker sleeving balloon, instead of using the note. When the assembler sees the marker sleeving and the clear sleeving called out together, it should be apparent that the clear sleeving goes over the marker, rather than the marker going over the clear sleeve. The intent of covering the marker with clear sleeving is more frequently specified by the items called out on the drawing as explained, rather than by the note, but either method can be used and the meaning is the same..

4.3.1.7 [B] TWIST INDICATED WIRES PER IPC/WHMA-A-620.

This note is used when the desired twisted-wire make up is to be constructed by twisting individual wires together rather than by using wires already twisted. It is often used when the wires of a pre-wired connector need to be twisted in place of splicing in the pre-twisted wire. Refer to the IPC 620 document for the amount of twisting needed.

Older drawings have the note "TWIST INDICATED WIRES A MINIMUM OF [X] TWISTS PER INCH". This note is no longer used in favor of the IPC-reference note.
The number of twists specified per inch depends on the number of wires and the wire size (AWG). There is usually a leader on the wiring diagram pointing to the wire and referencing the note. Variations of this note are used as needed, for example:
TWIST INDICATED WIRES AS APPLICABLE: PAIRS, A MINIMUM OF 4 TWISTS PER INCH; TRIPLES, A MINIMUM OF 3 TWISTS PER INCH; QUADS, A MINIMUM OF 2.5 TWISTS PER INCH.

4.3.1.8 [-] SOLDER RESISTOR LEADS INTO CONTACTS, SLEEVE LEADS USING ITEM [X].

Solder notes involving component leads are used as needed. These are infrequently used and self-explanatory. It is used for emphasis that a solid lead or a solid wire should not be terminated by crimping alone.

4.3.1.9 [-] CONNECTS AT NEXT HIGHER ASSEMBLY.

This note indicates that the item is not connected at this assembly. The next higher assembly drawing will indicate where to connect the item.

4.3.1.10 [-] CUT AND SLEEVE UNUSED (N/C) WIRES USING ITEM [X].

Variations of this note are sometimes used, for example "CUT N/C WIRES TO 1.00 INCH AND SLEEVE USING ITEM [X]" or "MAKE ALL N/C WIRE LENGTHS TO ALLOW FOR FUTURE WIRE TERMINATION TO THE CONNECTORS." These are all fairly self-explanatory, and the sleeving item is usually called out on the wiring diagram, with the note reference as a suffix to the item balloon.

4.3.1.11 [B] MOLD PER 60112799.

This note will be used for molded backshells and cable/harness transitions (see Section 4.2.2.8).

4.4 [-] Title Block, Markings and Tables

The L3 drawing format in Figure 4-1 represents the current drawing format.

4.4.1 [-] Title block

The standard title block includes a variety of information (Figure 4-37). If necessary, the design engineer will add tolerance information in the tolerance block section such as an angular tolerance. L3 cables/harnesses are generally not to scale. This helps to fit the drawings depiction on the sheet. Other information such as the page number, drawing title, engineering names and dates are for reference.

4.4.2 [B] Document Markings

L3 cable/harness drawings will typically have the following document markings located near the title block on the front page of the drawing (Figure 4-37):

- Dissemination Notice provides the supplier with the following restrictions:
  - Distribution Notice – requiring supply distribution limits and copying.
  - Destruction Notice – only if the program requires it.
- Proprietary Statement – this applies to all trade secrets which are not to be sent to competitors.
- Copyright – usually reflects the year and that L3 are the author and creator of the document.

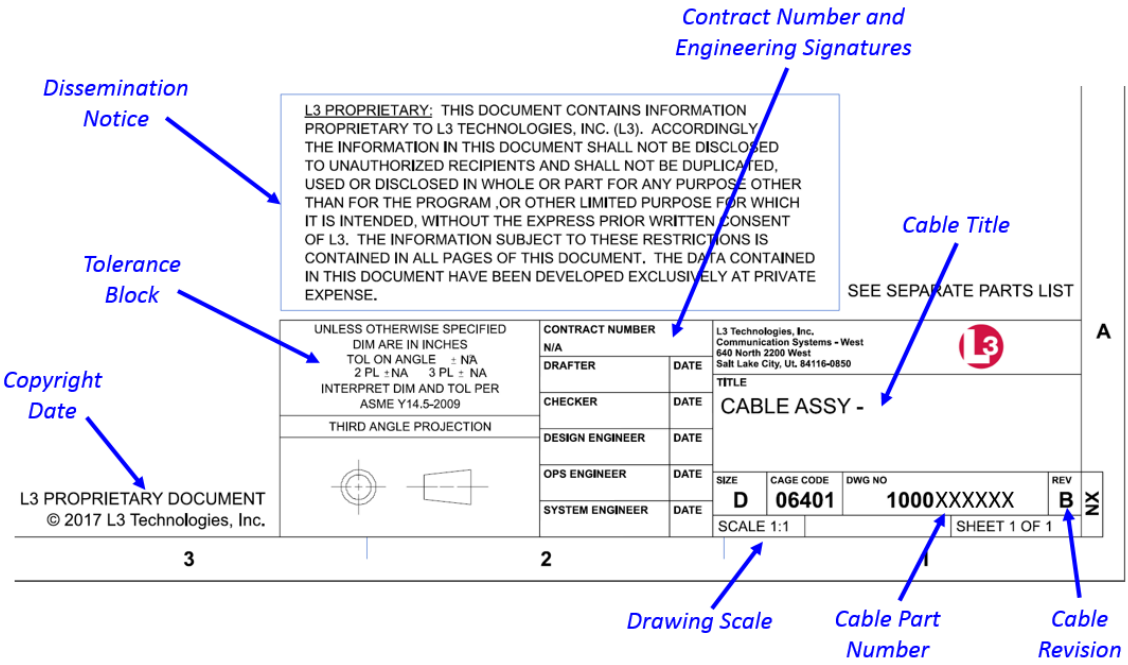


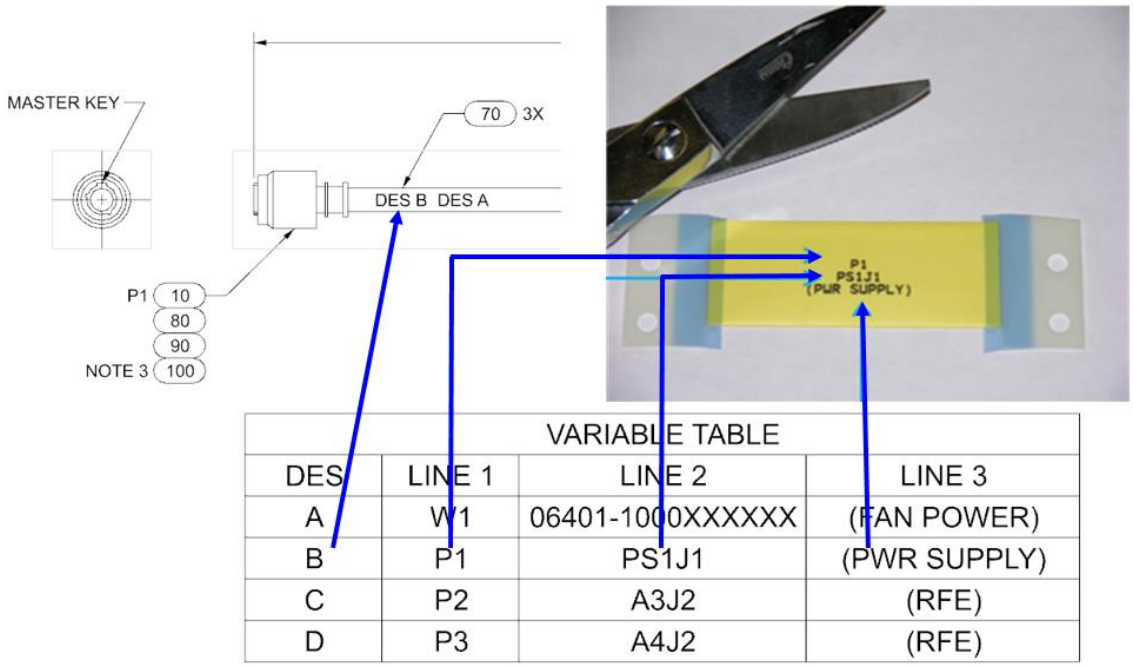
Figure 4-37 [B] Drawing Title Block and Document Markings

4.4.3 [B] Variable Table

The L3 variable table (Figure 4-38) specifies cable/harness label text information. Column 1 references a letter designation of the label shown in the cable depiction. It is only used as a reference on the cable depiction and is not printed. Columns 2 through 4 show specific text to print on lines 1 through 3 on the label (Figure 4-39). The reference designator information identifies where to connect the cable at the next higher assembly and provides part number information for field use. Each line of text is horizontally placed, centered and printed below the previous line of information unless otherwise specified per the drawing. If there is no text in one of the boxes there is no need to have a blank line on the label. Labels should be trimmed to text.

COLUMN 1	COLUMN 2	COLUMN 3	COLUMN 4
VARIABLE TABLE			
DES	LINE 1	LINE 2	LINE 3
A	W1	06401-1000XXXXXX	(FAN POWER)
B	P1	PS1J1	(PWR SUPPLY)
C	P2	A3J2	(RFE)
D	P3	A4J2	(RFE)

Figure 4-38 [B] Variable Table



VARIABLE TABLE			
DES	LINE 1	LINE 2	LINE 3
A	W1	06401-1000XXXXXX	(FAN POWER)
B	P1	PS1J1	(PWR SUPPLY)
C	P2	A3J2	(RFE)
D	P3	A4J2	(RFE)

Figure 4-39 [B] Cable/Harness Marking Designation

4.4.4 [B] Document Revision Block

The document revision portion of the title block (Figure 4-40) provides the current cable/harness drawing revision, CR number and engineering signature information.

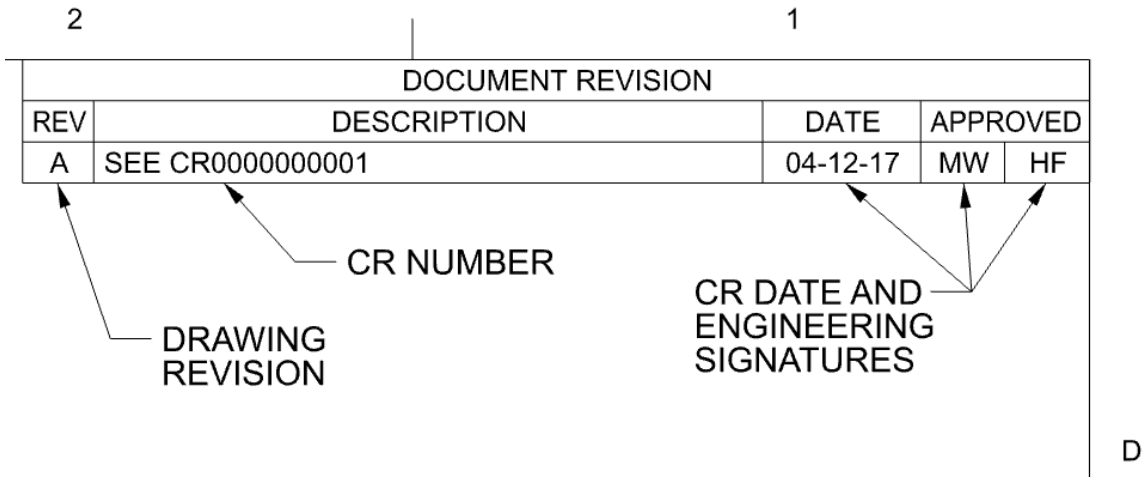


Figure 4-40 [B] Document Revision Block

5 [-] LEGACY DRAWINGS

5.1 [-] Legacy Drawing

Over years of operation L3 has had many different types of cable/harness drawing formats. Some formats contained minimal information and others contained more detailed information (Figure 5-1).

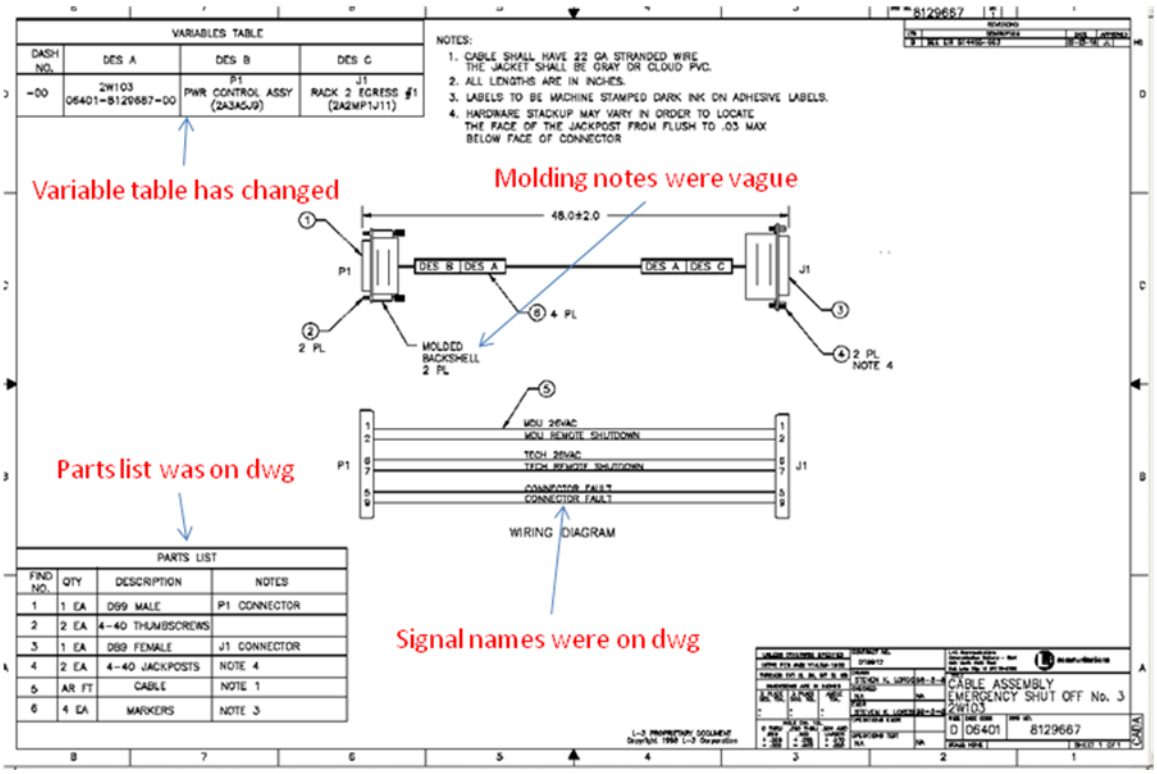


Figure 5-1 [-] Legacy Drawing Example

Some legacy drawings displayed stick figures (Figure 5-2) for the cable/harness depiction that only showed text references to connectors and backshells, no visual references to where labels were to be placed, and had minimal dimensions for features or breakouts. Variable tables were formatted different from the current standard. Occasionally lengths will appear in the variable table, designated by "L", when there are multiple configurations with varying segment lengths. The variable table is referenced in this situation to define the length of the option being built. Wire tables (Figure 5-3) were used in place of a wiring diagram and cable/harness depiction on many drawings. These simplified drawings were created when all cables and harnesses were built internal to L3 and minimal information was necessary to communicate design intent. As L3 has partnered with different cable houses these legacy cable drawings became inadequate.

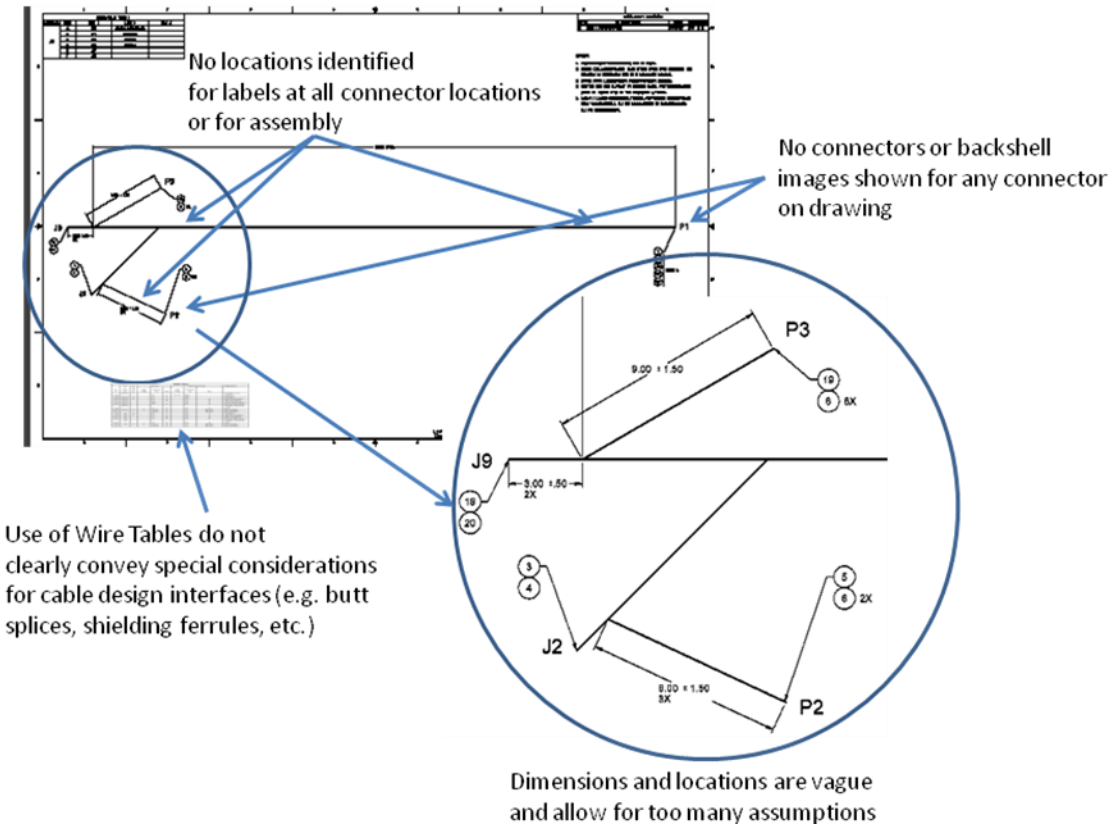


Figure 5-2 [-] Legacy Drawing Stick Figure Example

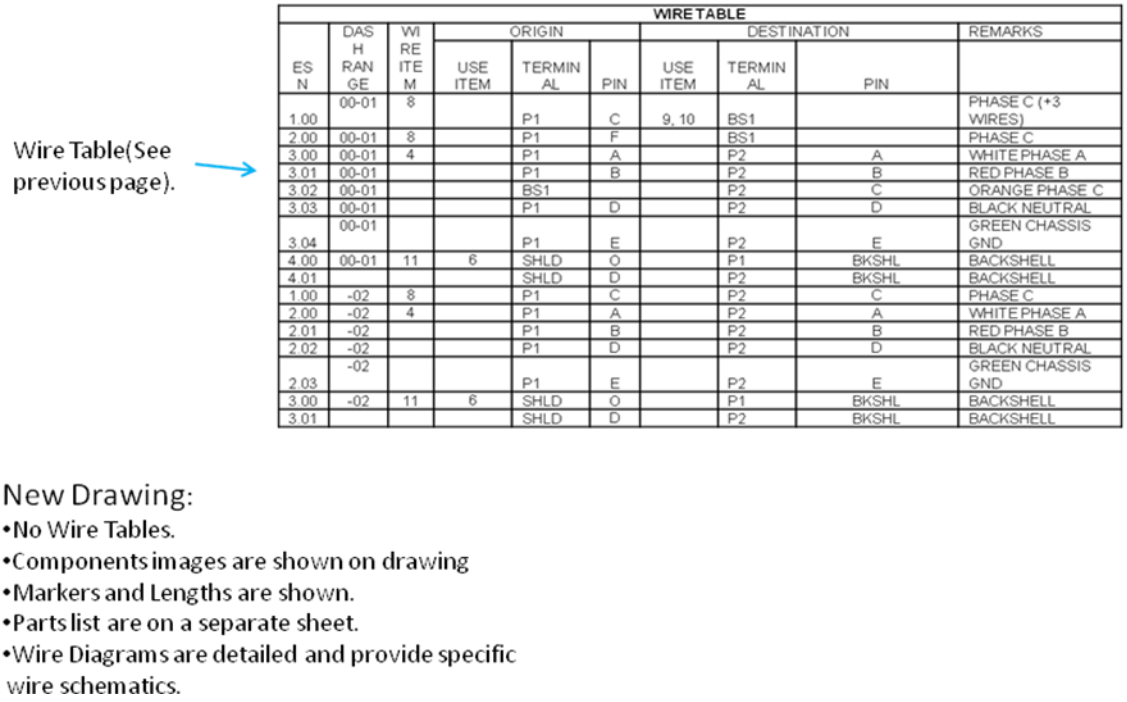


Figure 5-3 [-] Legacy Drawing Wire Table Example

It is important to note that the cable/harness engineering drawing along with the parts list, Internal Standards (IS documents) and specification documents (S01 Workmanship, etc.) should be all the information necessary to fabricate the cable/harness assembly. Some legacy drawings may need to be reformatted to current drawings standard so the drawing can be interpreted without making assumptions.

5.2 [B] Legacy Notes

Some legacy drawing notes called out special processes. This section identifies some of these notes and explains their meaning. Not all legacy notes are listed, if there is a question about a note, please contact L3 for clarification.

CABLE SHALL BE BUILT FOR OUTDOOR APPLICATION IN COMPLIANCE WITH WORKMANSHIP STANDARD WS003.

This note requires that all sleeve overlaps, breakouts and sleeving-to-connector interfaces should be sealed with adhesive per WS-003, paragraph 3.16.3.

CABLE SHALL BE BUILT FOR INDOOR APPLICATION IN COMPLIANCE WITH WORKMANSHIP STANDARD WS003.

This note requires that sleeving-to-connector interfaces should be sealed with adhesive per WS-003, paragraph 3.16.2.

CABLE SHALL BE BUILT FOR INDOOR APPLICATION.
This note requires that sleeving-to-connector interfaces should be sealed with adhesive per WS-003, paragraph 3.16.2.

USE EZ MARKS FOR E1 THRU [X].
This note implies to use self-adhesive wrap around labels as flag type. See section 4.3.1.4 for current note.

WORKMANSHIP AND MARKING PER S01. TEST AND CERTIFICATION REQUIRED PER S01.
This note is referencing WSM the workmanship standard for L3 Communications. See the WSM section of this document for more detail.

BUILD AND TEST FOR EMI COMPLIANCE PER S02
This note is referencing document 60037425 (W-432) the EMI compliance document for L3 Communications. See the EMI compliance section of this document for more detail.

THIS MARKER SHALL CONTAIN THE VENDOR CAGE CODE AND THE CABLE SERIAL NUMBER IN THE FOLLOWING FORMAT:

CAGE CODE (XXXXX), SERIAL NUMBER (ZZZZ), DATE CODE (YYWW) AND PART LIST REVISION.

XXXXX-SERNO-ZZZZ
YYWW REV __

This note was to describe serialization of the cable (there are several similar serialization notes). Unless the drawing is updated, the format of the note must be followed for the cable to pass L3 incoming inspection

CONNECTOR SHALL HAVE 360º SOLDER/SHIELD/MOLD TERMINATION TO THE CONNECTOR. ALL MOLDING PROCESSES SHALL BE APPROVED BY L3 ENGINEERING.
MOLDED BACKSHELL MATERIAL SHALL COMPLY WITH AN OPERATING TEMPERATURE RANGE OF -50ºC TO 105ºC POLYVINYLCHLORIDE (PVC) NOT ALLOWED.
This note was to communicate the need for a Faraday cage transition between the shielding on the cable and the connector shell. Refer to molding document 60112799 for expected procedure.

UNLESS OTHERWISE SPECIFIED, THUMBSCREWS WHALL BE PASSIVATED 300 SERIES CRES STEEL. THUMBSCREW SHALL MEET ALL INDUSTRY STANDARDS IN FUNCTIONALITY.
This note frequently accompanies a mold note for a D-shell connector. The thumbscrews need to be functional with the molded backshell and secure the connector to its mating

interface. See 1000426206 for an example of a custom thumbscrew that meets the functionally standards of being captive and retractable within the mold.
Some of the legacy drawings include notes for build-up tape or lacing tape but the part is not listed in the part list.

6 [-] NOTES

6.1 [-] Revision Level

Changes to this specification are controlled by paragraph rather than by sheet to facilitate word processing and change control. The revision level for this specification is the latest revision letter of any paragraph, figure, or table. Each paragraph, figure, or table has its revision letter enclosed in brackets between its number and its title or caption. The letter for paragraphs, figures, and tables should not be confused with security markings. Security markings are typically enclosed in parentheses rather than brackets.

6.1.1 [-] Revision Index

The table of contents, list of figures, and list of tables following the title sheet serve as the revision index for all paragraphs, figures, and tables within this specification. This index identifies the portion of the specification affected by the latest change.

6.1.2 [B] Revision History

The revision chronology for changes to this specification is given below.

REV	DATE	EIR	APPROVAL		DESCRIPTION
			ENGR	PUBS	
-	5/7/2012	K. Smith			Initial Release
A	7/12/2016	K. Smith			Removed all references to WS-021(torque specification)
B	4/10/2018	K.Smith			Updated wording of numerous paragraphs, updated dimensioning breakouts, updated shielding depicted in wiring diagrams

7 [-] RECORDS

There are no records associated with this document.