Basic Cable Assemblies
Cable Types

- Hook-up & Lead Wire
- Most Basic
Cable Types

- Twisted Pair Cable
- A type of cable that consists of two independently insulated wires twisted around one another. The use of two wires twisted together helps to reduce crosstalk and electromagnetic induction.
Cable Types

- Coaxial Cable
Cable Types

- Flat or Ribbon Cable
Cable Types

- Multi-Conductor Cables
Simple Cable Assembly

- 3 Conductor
- Point to Point
- Different Terminations
Advanced Cable Assembly

- Multiple Terminations
- Various Wire Types/Sizes
- Multiple Connectors
More Complex Assemblies

- Multiple Sub Assemblies
- Various Connectors
- Some COTS Products
- Custom Metal Terminations
What is Molding

- In the event that the connector or cable does not exist, we are very capable of custom building and designing the part for you, based on your specifications, method of use and any specific requirements.
- Usually, this would be in a form of mold production for the specific connector and cable manufacturing.

Example of Custom made connectors using injection molding
Crimping Connectors

Different connectors require different tools.
No tools required
Soldered Connectors
What is a Conductor?

- Metallic component of cables through which electrical power or electrical signals are transmitted
- Size usually specified by American Wire Gauge (AWG), circular mil area, or square millimeters
  - The lower the number, the larger the conductor (i.e. #14 is larger than #18, etc...)
- Copper is most versatile and widely used conductor material
  - Compatible with numerous coatings to enhance termination/retard corrosion
  - Available in both solid and stranded versions
- Other metallic compositions available
  - Copperweld (copper clad steel)
  - Copper Alloy
  - Stainless Steel
Why So Many Options for Conductors?

Conductor used depends on use.

- **Copper Clad Steel (Copperweld)**
  - Steel core with a uniform copper covering
  - Greater strength than a solid copper conductor
  - Used in the manufacture of coax cables

- **Copper Alloy**
  - Achieved by alloying copper with cadmium, chromium and zirconium
  - Greater flex life and breaking strength than copper covered steel
  - Used in electronics and aerospace applications

- **Stainless Steel**
  - Highly used in medical lead wires and cables
  - Poor conductivity compared to copper, may need gold plating to improve the conductivity
What Function Does Plating on Copper Serve?

- **Bare (No Plating)**
  - Least expensive, will oxidize from exposure to the atmosphere
  - Oxide film is poor conducting material, must be removed to assure reliable connection
  - Coated with other metals to reduce oxidation and enhance termination.

- **Tin**
  - Least expensive coating, thin layer (20 micro-inches 0.000020”) applied on conductor
  - Used for improved corrosion resistance, solderability, reduce friction between strands in flexible cables

- **Silver**
  - Higher cost than tin copper, electroplated to copper with a 40 micro-inch coating
  - Used in high-temperature environments – 150C to 200C
  - Used for high frequency applications, high conductivity and skin effect reduce attenuation
  - Subject to tarnishing

- **Nickel**
  - Higher cost than silver plated
  - Used in higher-temperature environments – 200C to 450C
  - Poor solderability, high electrical resistance
## Conductor Composition

### Characteristics and Comparisons of Plating Materials

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Bare</th>
<th>Tin Plated</th>
<th>Silver Plated</th>
<th>Nickel Plated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Life Stability</td>
<td>Excellent – Slight loss of conductivity with heat aging</td>
<td>Conductivity and solderability deteriorates with heat aging</td>
<td>Excellent – no loss of conductivity with heat aging. Solderability shelf life remains good</td>
<td>Conductivity remains stable with heat aging</td>
</tr>
<tr>
<td>Crimp Terminability</td>
<td>Excellent – Contact resistance may vary with type of termination</td>
<td>Good – Contact resistance increases with time and can be variable</td>
<td>Excellent – Contact resistance remains low</td>
<td>Good – Contact resistance may vary with time</td>
</tr>
<tr>
<td>Solder</td>
<td>Good – when clean</td>
<td>Good – Originally deteriorates with shelf life</td>
<td>Excellent</td>
<td>Requires active flux</td>
</tr>
<tr>
<td>Service Temperature</td>
<td>210°F (99°C)</td>
<td>300°F (149°C)</td>
<td>390°F (199°C)</td>
<td>480°F (249°C)</td>
</tr>
</tbody>
</table>
What are the Advantages of Using Stranded Conductors

- Developed as means of overcoming rigidity of solid wires
- Greater number of strands with corresponding decrease in individual strand size, the more flexible and costly the conductor
- Stranding comes in many forms
  - Bunched
  - Concentric
  - Unidirectional
  - Unilay/Equilay
  - Rope
- Flexibility
  - Ease in bending; limpness; easy to route
- Flex life
  - Ability to withstand repeated flexing, constant movement
- More strands = better flexibility and flex life
- Diameter increases with the use of stranded wires.
What is the material used as a coating on the primary wires?

- Conductors/components in a cable need to be isolated
  - From other conductors
  - From other components such as shields
  - From the environment (oils, chemicals)
  - From physical forces (abrasion, crush, flexing)

- Two types of materials commonly used
  - Thermoplastic
    - Materials that soften and flow when heated
    - Definitive melting point
    - Can be heated and cooled repeatedly
  - Thermoset
    - Soft and pliable during one stage of processing, capable of molding and extruding
    - Materials are cured or set
    - Once cured materials cannot be soften by reheating
Is there a difference between insulating materials and jacketing materials?

- Insulating materials possess good dielectric properties
- Jacketing materials provide protection from external mechanical and chemical factors and possess necessary resistance to flame and smoke requirements
- Materials used depend on application (environment, electric performance)
- Thermoplastics
  - PVC (Polyvinyl Chloride)
  - Polyolefins (Polyethylene, polypropylene)
  - Fluoropolymers (Teflon, Tefzel, Halar, Kynar, Solef)
  - TPE (Thermoplastic Elastomer)
  - Polyurethane
- Thermosets
  - CPE (Chlorinated Polyethylene)
  - Neoprene
  - XLP, XLPE (Cross-linked polyethylene)
  - ERP (Ethylene Propylene Rubber)
  - Silicone
  - Fibrous Coverings (textile braids, fiberglass, K-fiber, impregnated with flame and heat retardant finish)
Why are fillers used in cable designs? What is their purpose?

- Fillers are used in cables
- Used for three general reasons
  - Fill gaps in a cable for a more attractive appearance
  - Create and maintain a sequence or lay-up of components
  - Add strength to a cable
- There are several types of fillers that can be used
  - Solid plastic (PVC) – available in any size and are commonly used as the core of cables
  - Paper – Used extensively in power cords
  - Foamed and fibrillated polypropylene – Used for their ability to “mold” to fill a gap. Most commonly used in computer/data processing cables
  - Cotton, Rayon – Used as a good middle choice between solid and fibrillated fillers due to their ability to “fill” gaps and their low cost
  - Kevlar – Used mainly as a strength member, very expensive and should be used when longitudinal strength is needed. Can be used as a ripcord under the jacket as well.
Under the jacket of a cable there are different tapes and metal weaves. These can be difficult to remove, are the actually needed?

- Binders and shields are commonly used in the design and manufacture of cables
- **Binders**
  - Tapes – Polyester and polypropylene tapes commonly used to hold bundles together and to provide isolation between cable components and the shields
  - Nylon – Mainly used when flexibility of a cable is needed
  - Textiles – Mainly used for strength, can be braided or served
- **Shields**
  - Aluminum foil tapes – Can be single sided, dual sided, or foil edge free. Allows 100% effective coverage
  - Braid shield – Most common method of shielding, accomplished by crossing layers of individual metal strands over a cable core or an insulated conductor
  - Serve or spiral shield – Manufactured by applying metal strands in a helical fashion
What does all of the printing on a cable represent?

- Cables that are Recognized (Appliance Wiring Material) or Listed under the NEC code must be printed with certain information in accordance with UL and CSA guidelines
  - Temperature rating/voltage rating
  - Manufacturing company name or file number
  - Size and quantity of conductors
  - Style number

- Cables can be identified in various ways
  - Surface Markings
    - Indent printing
    - Surface ink
    - Embossed legend
  - ID Threads
    - Each manufacturer has identification threads that can be put inside the cable
  - ID tapes
    - Tapes with the appropriate UL and CSA information can be run inside the cable
Do the cables used in our assemblies contain any hazardous substances?

- All cables and hookup wires used, to the best of our knowledge, do not contain any hazardous substances. Our products comply with the following:
  - RoHS & RoHS 2 – Restriction of Hazardous Substances Directive, adopted by the European Union
    - Restricted substances
      » Lead (Pb)
      » Mercury (Hg)
      » Cadmium (Cd)
      » Hexavalent chromium (Cr$^{6+}$)
      » Polybrominated biphenyls (PBB)
      » Polybrominated diphenyl ether (PBDE)
  - Reach – regulation of chemicals and their safe use, adopted by the EU
  - Proposition 65 (The Safe Drinking Water and Toxic Enforcement Act of 1986)
    - California Law passed 1986
    - Goals are to protect drinking water sources from toxic substances that cause cancer and birth defects and to reduce or eliminate exposures to those chemicals generally
    - Regulates substances officially listed by California as causing cancer or birth defects or other reproductive harm
      » Prohibits businesses from knowingly discharging listed substances into drinking water sources, or onto land where the substances can pass into drinking water sources
      » Prohibits businesses from knowingly exposing individuals to listed substances without providing a clear and reasonable warning.
IPC/WHMA-A-620

Requirements and Acceptance for Cable and Wire Harness Assemblies
Our Products

- Battery Packs
- Flex & Rigid-Flex PCB’s
- User Interfaces
- Fans & Motors
- Cable Assemblies
- Printed Circuit Boards
The Difference is Quality and Delivery

1. **Quicker Delivery** - Epec's technology infrastructure and people, including the Asian and US based operations and engineering teams, enable jobs to get started the same day the order data is electronically received by our factory.

2. **Accurate Information** - Epec's on-site personnel provide accurate daily Work In Process reports so customers can receive immediate order status information, along with in person verification of all daily reports by Epec staff.

3. **Better Quality** - Epec ensures higher levels of quality through three key additional processes. On-site QA inspectors at each facility provide an additional audit before it leaves Asia, Epec maintains dual UL approval at each facility with quarterly audits, and perform QA audits at our headquarters in Boston, MA.

4. **Flexibility** - Each of our manufacturing facilities have been selected for their best-in-class niche product and delivery solutions, ensuring our optimal facility is building every order.
If you require additional information please contact us with any questions or requests.

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