

# element14 Essentials: Connectors I



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Connectors I



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## 1.0 Introduction

A connector system performs the all important role of interconnecting a product's printed circuit boards (PCBs), power supplies, control panels and other sub-assemblies. While connectors may appear to play a passive role in an end-product's performance, in reality, they influence the safety, reliability, and ease-of-maintenance of a product. To select the ideal type of connector for a specific design or application, a design engineer can benefit from a basic knowledge of connector technology.

## 2.0 Objective

The objective of this course is to provide you with the essentials of connector technology. You will first learn the purpose, function, and components of a connector. In the later sections, you will gain a deeper understanding of the types, materials, features, and applications of PCB, Card/Slot and I/O connectors.

*Upon completion of this course, you will be able to:*

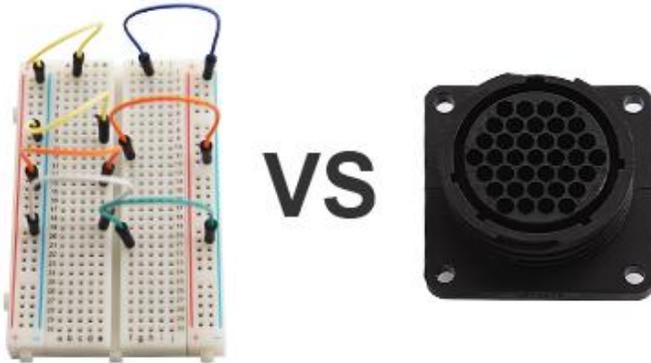
- Define what connectors are and the purpose they serve.
- Discuss the primary functions of a connector.
- Describe the anatomy of a connector.
- Identify the most common types of connectors.

## 3.0 Definition

What is a connector? Is a connector simply a means to connect two electrical points of a circuit, or is its purpose broader in scope? To understand the purpose of a connector, let us consider a jumper wire. Is a typical jumper wire – one that connects circuit components together on a prototyping breadboard – a connector?



A jumper wire can connect two points of a circuit together, but lacks the mechanical integrity or environmental protection required in an end-product that is subjected to vibrations, abuse, corrosion or water sprays. In this respect, a connector provides more than a means of electrical connection, but should offer a durable mechanical or mating connection as well. So, maybe a jumper wire falls short as a connector.



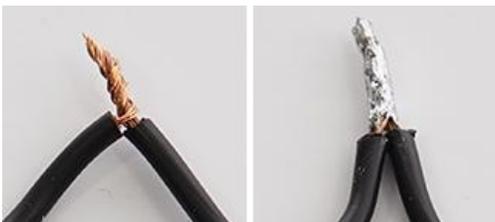
If a jumper wire isn't a connector, then what exactly is? Let's look at the definition of connector to find out:

*A connector is a device that is capable of connecting two circuit points, signals, or sub-systems with electrical integrity, mechanical durability, environmental protection and safety.*

- **Electrical Integrity** - when connectors mate two points of a circuit with a very low contact resistance and provide protection from electromagnetic interference (EMI) and/or electrostatic discharge (ESD).
- **Mechanical Durability** - when a connector can withstand vibrations or environmental abuse without causing a failure in electrical integrity.
- **Environmental Protection** - when a connector's design meets the IP (Ingress Protection) ratings defined in the international standard EN/IEC 60529 for preventing the ingress of water, dust, debris, and other contaminants that would otherwise interfere with the electrical integrity of the connection.
- **Safety** - when a connector is designed with features that eliminate personnel hazards, or the risk of fire, shock or electrocution.

## 4.0 Function

To understand the function of a connector, let's imagine for a moment a world without connectors. What would be the practical outcome of such a scenario?



In such a world, all electronic components, sub-assemblies and electrical power would be connected by bare metal wiring. This means everything would be soldered, mechanically attached or twisted together. Doesn't sound convenient, does it?

It would be pretty hard to design products with high-circuit densities in a "No Connectors Allowed" world. Smart phones would probably be a lot bigger. And forget about portable charging stations or even your handy power adapter!

What about electrical safety? Would a "No Connectors Allowed" world be safer for a user? Could you safely connect the 120/230V mains to your home appliance without sparks flying? (Probably not!) It's time to go back to a world with connectors and learn the primary functions of a connector.

*The primary functions of a connector are:*

- **Quick Connection/Disconnection:** Connectors provide a safe, quick and convenient means for connecting and disconnecting components, modules, systems and sub-assemblies during prototyping, manufacturing, installation, operation, or maintenance.
- **Efficient Manufacturing:** Connectors allow for the efficient production of products by eliminating many time-consuming tasks such as soldering.
- **Easy Upgrades/Configurations:** Connectors enable users to easily upgrade products or quickly configure new devices for these products.
- **Eliminate Safety Hazards:** Connectors shield users from hazardous currents that could pose a shock or electrocution hazard.

## 5.0 The Anatomy of a Connector

There are many types and styles of connectors, yet they all share common characteristics. In this section, we will discuss the common components and features of a connector.

*The three main parts of a connector are:*

- Housing
- Shell
- Contact

### - 5.1 Description of a Housing

The housing is the component that provides a connector the mechanical durability, environmental protection and electrical insulation for the contact terminals.

TE Connectivity /Amp Circular Plastic Connector Housing



*Connector housings have the following characteristics:*

- **Materials:** Housings are made of stabilized, heat resistant, self-extinguishing thermoplastic material.
- **Locking:** Housings often have a locking tab to prevent connector housing halves from disconnecting and interrupting a circuit.
- **Polarization:** Housings are polarized to ensure the connector halves are mated correctly.
- **Keying:** Housings are keyed or arranged so only compatible contacts or circuits can be mated with one another.
- **Environmental Protection:** Housing often have shrouds or seals (depending upon the specifications of a connector) to prevent the ingress of dust, moisture, chemicals and other contaminants that could degrade the electrical integrity of the connection.
- **Mounting:** Housings can be mounted in a variety of ways, including PCB, panel, and wire-to-wire configurations.
- **Fire Safety:** High-performance composite materials help meet the low smoke, toxicity and flammability (UL 94V-0 rated) requirements of the application.

### *- 5.2 Description of a Shell*

The shell encloses the connector housing thereby offers added strength and protection to the housing. Since shells are made of a nickel-plated, zinc alloy, they also offer excellent corrosion resistance.



TE Connectivity / AMP Circular Metal Connector CMC Receptacle

### *- 5.3 Description of Contacts and Terminals*

The contact consists of highly conductive material with very low resistance that allows the easy flow of electrical current through the two mated contacts.

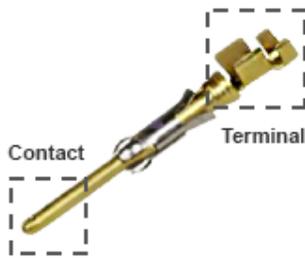


TE Connectivity/AMP  
Pin (Male) contact  
Terminal, Crimp Style



TE Connectivity/AMP  
Socket (Female) contact  
Terminal, Crimp Style

While the contact is the point where circuit current flows, the terminal is the means by which the contact is attached (or terminated) to a circuit's conductor. Often times the functions of both the contact and terminal are combined in one device. In this case, the word terminal and contact maybe used interchangeably.



*Contact terminals have the following characteristics:*

- **Materials:** A variety of materials or alloys are used for electrical contacts and terminals based upon cost, electrical and thermal properties, resistance to oxidation (corrosion) and durability. The most common contact metals include: brass, phosphor bronze, and high copper alloy. Contacts are often plated for added strength, better conductivity and corrosion resistance. Plating materials include gold, silver nickel, tin, and palladium-nickel.
- **Types:** Contacts are constructed in the form of insertable/removable pins and sockets (informally referred to as “male” and “female,” respectively).
- **Locking:** Terminals often have locking wing tabs to securely hold the terminal in the connector’s housing

#### ***- 5.4 Description of Terminations***

Terminations are the manner by which the circuit’s conductors are attached to the connector’s contact terminals. The quality of the terminations is critical to the proper functioning of the circuits connected by a connector.

Electrically sound terminations maintain a desirable low contact resistance at the point of connection. Conversely, terminations that are not electrically sound —opened, shorted, or high resistance points — can be detrimental to the proper functioning of the circuit. This is a particular concern in high vibration environments (industrial machinery or automotive applications).

*The common types of terminations include:*

#### **Solder Cup**

A type of termination where individual circuit wires are soldered on the connector’s “cup” terminals.



AMPLIMITE\* HDP-20 Connectors with Solder Cup Contacts

#### **Crimping**

A type of termination that creates a secure and separable connection between the contacts and terminal wires



TE Connectivity/AMP Wire-To-Board Connector, AMP CT Series, Crimp, Receptacle

## PCB Solder

A type of termination where the contact terminals are soldered directly onto a PCB via through-holes.



TE Connectivity/AMP Circular Plastic Connector, Series 1, PCB Mount

## Press Fit

A type of termination where connector's contact terminals are pressed through plated-through holes on a printed circuit board (PCB). The primary advantages include eliminating thermal stresses of PCB soldering and enabling higher density circuit applications.



TE Connectivity 1735690-1 SAS Receptacle, Press-Fit

## Surface Mount

A type of termination where the connector is mounted to the surface of a PCB and bonded to conductive pads via soldering.



TE Connectivity/Amp Mini USB, 2.0 Type A, Receptacle, Surface Mount

## Insulation Displacement Termination (IDC)

A type of termination that connects insulated wire without requiring the pre-stripping of the insulation.



TE Connectivity/AMP Wire-To-Board Connector, AMPMODU Series, IDC Plug

## 6.0 Types of Connectors

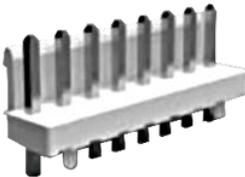
There are a wide variety of connector-types used by design engineers and employed in prototypes and end-products. *In general, connectors are grouped into the following main categories:*

- PCB
- Card/Socket
- Input/Output

### - 6.1 PCB Connectors

#### Wire to Board

A type of connector that offers a separable connection between electronic sub-assemblies, PCBs, and rack/panels. Benefits include saving PCB space, enabling high-density connections, and providing design flexibility.



TE Connectivity 1744057-5 wire-to-board connector, Economy Power

#### Board to Board

A type of connector that connects one PCB to another in a stacking configuration. These connectors are for low-profile, tight-packaging or backplane connector applications.



TE Connectivity Board to Board Connector, Fine Pitch

## **Zero Insertion Force (ZIF)**

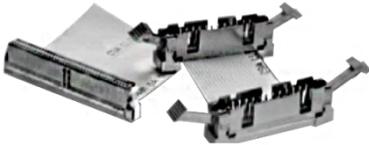
a type of wire-to-board connector that minimizes the insertion or extraction force, reducing contact wear. It is used with flat flex ribbon cable and has a mechanical arm that locks the contacts in place upon connection.



TE Connectivity 3-2041390-9 ZIF Flexible Printed Circuit Connector

## **Ribbon**

a type of connector used with flat ribbon cable to connect internal peripherals in computers, such as hard drives, CD drives and floppy drives. The ribbon connector is typically attached to the cable via insulation displacement rather than crimping or soldering, which allows for the mass termination of contacts.



TE Connectivity Ribbon Cable Connectors

## **- 6.2 Card/Socket Connectors**

### **Card Edge**

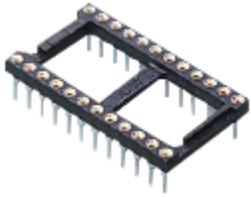
A multi-circuit receptacle (female) that mates with the header (male) that's formed out of the traces that run to the edge of a PCB. They are primarily used in personal computers for connecting expansion cards, cartridges and computer memory to the system bus.



TE Connectivity AMP 1761465-3 Card Edge Connector Receptacle

### **Package to Board (IC Socket)**

A connector that provides a separable connection between an IC chip and a PCB via a through-hole soldered socket.



TE Connectivity/AMP IC & Component Socket, 800 Series, DIP

## Memory Card

A type of connector that connects microSD, SD, SIM, and/or MMC memory cards to portable or remote devices. They offer a variety of ejector types (e.g., push-push and push-pull) and provide polarization features to prevent improper card insertion



TE Connectivity 1939870-1 SD Card Connector EMBOSS ASSY

## - 6.3 Input/Output Connectors

### Circular Plastic/Circular Metal

A type of customizable, sealed or unsealed, commercial connector designed for power and signal connections and used in industrial, automotive, signal processing, power management and computer applications. Both CPC and CMC connectors are made of stabilized, heat resistant, self-extinguishing thermoplastic material. CMC connectors have an additional metal shell to add greater strength and durability.



TE Connectivity/ AMP Circular Plastic Connector Housing / Metal-Shell Circular Plastic Connector Housing

## S-Video

An audio/visual connector used for transmitting Super-Video (S-Video) signals. The connector separates luminance and chrominance for a better picture and also to eliminate dot crawl.



TE Connectivity/AMP 5749230-1 DIN Audio Video Connector PCB Mount

## Video Graphics Array (VGA)

An analog, audio/visual connector for connecting PC displays. In graphics mode, the resolution is either 640 by 480 (with 16 colors) or 320 by 200 (with 256 colors). The original VGA standard has evolved over time to provide better resolution and more colors (e.g., SVGA and XGA).



TE Connectivity/AMP 5749768-1 Standard D Sub Connector Amplimite HD-22 Series DE-15

## Digital Visual Interface (DVI)

A digital video connector used as an interface between computers, LCD monitors, projectors and other digital display equipment. It's based on the standard created by the Digital Display Working Group (DDWG) for converting analog signals into digital signals. It uses differential pairs for higher quality and better resolutions than VGA. It has RGB pins for backwards compatibility. It comes in a variety of flavors, including DVI-D single link, DVI-D dual link, DVI-I single link, DVI-I dual link and DVI-A, analog.



TE Connectivity 1734148-1 DVI Digital Video Interface Connector, Integrated Analog & Digital (DVI-I), PCB Mount

## High-Definition Multimedia Interface (HDMI)

An uncompressed, all-digital, audio/video interface/connector between any audio/video source, such as a set-top box, DVD player or A/V receiver, and an audio/video monitor such as a digital television (DTV). Unlike DVI, HDMI is both an audio and visual interface. HDMI has the capacity to support existing high-definition video formats such as 720p, 1080i, and 1080p, among others.



## DisplayPort

A digital display connector that employs packetized data transmission to connect a video source to an high definition (HD) video display. Developed by the Video Electronics Standards Association (VESA), it's an evolution of HDMI that supports higher resolutions as well as daisy-chaining. DisplayPort is backward compatible with VGA and DVI through the use of adapters.



TE Connectivity/AMP 2040210-1 DisplayPort Digital Audio Connector Receptacle PCB Mount

## D-subminiature (D-sub)

A peripheral connector commonly used for connecting RS-232 serial communication devices. It contains a D-shaped metal shield that provides mechanical support, ensures correct orientation, and offers some level of EMI protection. It is easy to work with and solder, and its pin numbers are labeled on the connector. But it is not as popular as in the past. It also takes up a lot of space and has limited mounting options.



TE Connectivity/AMP 3-1634222-2 Standard D Sub Connector AMPLIMITE HD-20 Series DE Receptacle 9

## USB

A connector based on the Universal Serial Bus specification, developed by the USB Implementers Forum, to standardize the connection of computer peripherals to personal computers, for both communicating and supplying electric power. The current types include:

- **USB Type-C**

The new standard plug or receptacle providing a multi-function, reversible, single cable solution for USB, power, and audio/video.



TE Connectivity 2129691-1 USB, 3.1 TYPE C

- **Micro USB 2.0**

Mostly used in mobile devices and are the smallest connector series in the USB family.



TE Connectivity/AMP 1981568-1 MICRO USB 2.0 TYPE B, RCPT, SMT

- **USB 3.0**

Supports a 5Gbps data rate for fast syncing on the go—a 10x performance increase over USB 2.0.



TE Connectivity 1932258-1 USB 3.0 TYPE A RECEPTACLE SMTT

## Coaxial

An I/O connector that's designed to work at radio frequencies in the multi-megahertz range.

Product	BNC	Mini BNC	SMA	QMA	QSL	SMB	UMCC	MMCX	SMP	Compression Coax	N	7-16	Siemax, Din1.0/2.3 interface
Operating Frequency	DC-4 GHz	DC-2 GHz	DC-26 GHz Range	DC-6 GHz	DC-6 GHz	DC-4 GHz	DC-6 GHz	DC-6 GHz	DC-40 GHz	DC-6 GHz	DC-11 GHz	DC-7 GHz	DC-5 GHz
Impedance	50   75	75	50	50	50	50   75	50	50	50	50	50	50	75
VSWR	1.3@4 GHz	1.6@1 GHz	1.2@11 GHz Dependent on Cable Type	1.15@6 GHz	1.3 Max @3 GHz	1.25@4 GHz	1.3 Max@3GHz, 1.4 Max@3-6GHz	1.25@6 GHz	1.1 Max@23GHz, 1.15 Max@23GHz to 26GHz, 1.40 Max@26GHz to 40GHz	1.25@6 GHz	1.3 Max@4GHz	1.02 + 0.03f up to 7GHz	1.2@1GHz, 1.4@5GHz
Durability Cycles	500	500	500	100	500	500	30	500	100	25	500	500	500
Operating Temp.	-55° to 85°C	-40° to 85°C	-65° to 165°C	-40° to 125°C	-40° to 85°C	-65° to 165°C	-40° to 90°C	-55° to 155°C	-65° to 165°C	-40° to 125°C	-55° to 85°C commercial, -65° to 165°C Mil style	-55° to 155°C	-40° to 85°C
Connect Style	Bayonet	Bayonet	Thread	Snap On	Push Pull	Snap Fit	Snap On	Snap On	Push On	Surface Mount	Thread	Thread	Push On
Product Types	Cable, PCB, Bulkhead	Cable, PCB, Bulkhead	Cable, PCB, Bulkhead, Edgemount, Hermetic	Cable, PCB, BSA	Surface Mount Thru Hole	Cable, PCB, BSA	PCB	PCB, Edge Mount, Cable	PCB, Flange Mount, Cable, Board to Board, Birdmate	Board to Board	Cable, Bulkhead, Flange	Panel Mount, BSA, Bulkhead	Surface Mount

All products are RoHS compliant Based on product type, design and manufacture to comply with standards: MIL-C-39012, Mil-STD-348, CECC, IEC for features and applications visit TE.com

## Modular Jack

Used to connect telephone systems or Ethernet networks. Common examples are RJ11 (telephone) and RJ45 (Ethernet) jacks.



TE Connectivity/AMP 2170668-1 CONN RJ45 CAT6

## 8.0 Test Your Knowledge

Are you ready to demonstrate your Connectors knowledge? Then take a quick 15-question multiple choice quiz to see how much you've learned from this Essentials Connectors 1 module. [Take The Quiz](#)