ZVEI: Die Elektroindustrie

The World of Connectors

– Technologies and Trends –

German Electrical and Electronic Manufacturers' Association

Connectors – Technologies and Trends –

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1. Introduction

This brochure is intended as a guide to give the reader a better grasp of the complexity and diversity of connectors. The explanations and technical details are structured in such a way that both specialists working in the field and newcomers to the field can understand the correlations and technologies involved. It is up to readers to decide how far they wish to delve into the subject. They may simply wish to gain an overview, or go into the subject in great detail and ultimately acquire an understanding of the basic principles of connectors from both a technical and market economy perspective. The guide thus represents a connector handbook in condensed form for everyday use designed to give customers and users, aspiring engineers and apprentices, managers and administrative staff insights into connector technology and the connector industry.

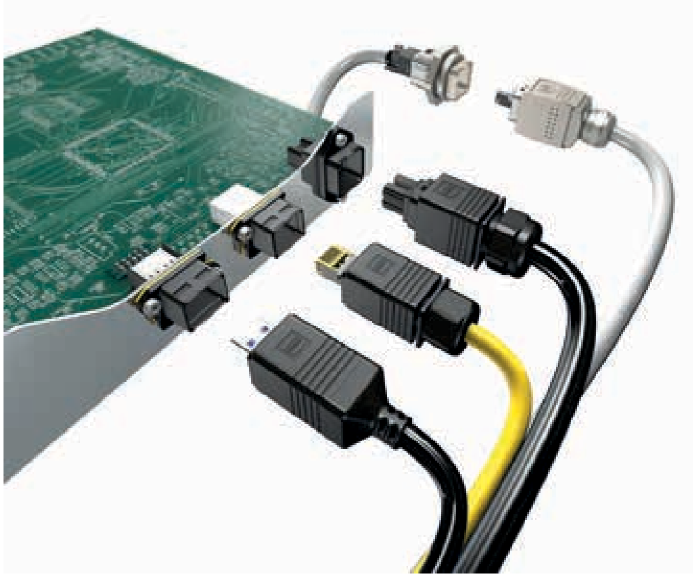


Figure 1: Industrial connector for data and power transmission – source: Harting

What are connectors and what are they used for?

Connectors are an essential part of electrical and electronic connections. In an increasingly electronic and digital world, connectors are the key to creating opportunities for networking and connectivity. They are used in all areas of electrical engineering and electronics. They range in size from miniature connectors to huge, heavy-duty connectors. A connector is basically a component which enables optimum use to be made of systems for the transmission of electrical energy or optical and electronic signals. Depending on the application area and transmission quality required, connectors are designed to satisfy the intended purpose or specific application in the best way possible – whilst taking into account technical conditions and commercial requirements, efficient production and processing methods, modifications to existing and future technologies, environmental and economic conditions, continuously increasing data transfer speeds and greater performance and reliability. To meet these demands, connectors are designed for a multitude of requirements and applications. The particular characteristics required for diverse areas of application are described below.

Figure 2: Mating face (contact arrangement) of a hybrid circular connector – source: Phoenix Contact

2. Market

The connectors market in Germany, and indeed worldwide, has been growing at a moderate but constant rate for years. The connectors sector has also been affected by the economic downturn, but with a sound structural basis and strategic technological focus, it has escaped lightly.

The relative stability of the market is largely a result of innovative technologies and the versatility of connectors, which enables them to adapt to new developments in the areas of application. In terms of product development, the close alignment between assemblies and devices and their connectors has made ground-breaking functional and technical advances possible (e.g. microsystems engineering).

The ZVEI closely monitors and analyses the connectors market, publishing the following sets of statistics on a quarterly and annual basis:

- Markets tables for Germany and the world indicating sales figures by region and segment
- Reported sales figures, order volumes and economic data.

The ZVEI regularly produces roadmaps showing long-term trends in the connector industry and brochures such as this one.

2.1. Market tables, sales

2.1.1. Germany

Connectors by sector Germany					
Market size Germany	**2010 million euros**	**2011 million euros**	**2012 million euros**	**2013 million euros**	**2014 million euros**
Consumer electronics	163	173	168	171	174
Data technology	132	139	138	142	148
Automotive electronics	880	933	951	961	980
Industrial electronics	565	610	574	582	597
Telecommunications	199	201	184	190	198
Total	1,939	2,055	2,015	2,047	2,097

Market growth Germany	2011 in %	2012 in %	2013 in %	2014 in %
Consumer electronics	6.0	-2.5	1.5	2.0
Data technology	5.0	-0.5	3.0	4.0
Automotive electronics	6.0	2.0	1.0	2.0
Industrial electronics	8.0	-6.0	1.5	2.5
Telecommunications	1.0	8.5	3.5	4.0
Total	6.0	-1.9	1.5	2.5

Market segmentation Germany	2010 in %	2011 in %	2012 in %	2013 in %	2014 in %
Consumer electronics	8.4	8.4	8.4	8.4	8.3
Data technology	6.8	6.7	6.8	6.9	7.0
Automotive electronics	45.4	45.4	47.2	47.0	46.7
Industrial electronics	29.1	29.7	28.5	28.4	28.5
Telecommunications	10.3	9.8	9.1	9.3	9.4
Total	100.0	100.0	100.0	100.0	100.0

Growth in the connectors market is driven by the general economic outlook and, to a greater extent, by technological trends and functional enhancements. The transition to renewable energies, electromobility and the digitalisation of industry (Industry 4.0) are future markets which promise growth potential for the connectors industry.

If we consider the segments individually, the following market trends emerge:

- Consumer electronics is affected purely by the need for replacement or functional improvements.
- Data technology and telecommunications are benefiting from the growth in communications requirements.
- In automotive electronics, requirements for connectors in cars are dictated by issues such as the need to reduce weight, functional enhancements, electromobility, miniaturisation etc.
- Industrial electronics is influenced by modularisation and increased demand for data technology and energy efficiency.

Consumer electronics	Data technology	Automotive electronics	Industrial electronics	Telecommunications
Audio devices	Mainframes	Engine electronics	Regenerative energy generation	End devices
Video devices	PCs	Transmission electronics	Power supply	Switching equipment
Studio technology	Data networks	Information electronics	Photovoltaics and solar thermal systems	Navigational devices
Recreational electronics	Accounting systems	Electronics for driver and passenger comfort	Materials handling and shop floor vehicles	Traffic (communication) infrastructure and signalling technology
Cameras	Office equipment	Safety electronics	Commercial electrical devices and machines	Data and signal transmission devices
Sports electronics	Security systems	Function control devices	Machines	
Musical instruments/ devices		Power supply electronics	Electrical/ electronic instruments	
Electronic toys		Traffic management systems	Energy efficiency	
Lighting technology			Regulation and control technology	
Electric heaters			Industrial automation	
Dishwashers			Process automation	
Washing machines and dryers			Power electronics	
Small household appliances			Medical engineering	
Fridges, freezers and heating appliances			Military and aerospace	
Electric tools			Railway engineering	
Condensing technology for oil and gas				
Boilers				
Cogeneration systems				
Ventilation equipment				
Exhaust systems				
Air conditioning technology				
Biogas plants				

Areas of application (segments) based on ZVEI definitions

2.1.2. Global market figures[1]

Connectors by region World					
Market size	**2010 million euros**	**2011 million euros**	**2012 million euros**	**2013 million euros**	**2014 million euros**
America	7,831	7,833	8,697	9,045	9,452
EMEA	7,541	7,543	7,926	8,005	8,165
including Europe	*7,202*	*7,272*	*7,563*	*7,638*	*7,791*
Japan	5,380	5,279	5,661	5,774	5,890
Asia/Pacific	12,036	12,956	14,245	15,171	16,233
including China	*7,808*	*8,703*	*9,616*	*10,289*	*11,061*
Total	32,789	33,611	36,530	37,996	39,741

Market growth	2011 in %	2012 in %	2013 in %	2014 in %
America	0.0	11.0	4.0	4.5
EMEA	0.0	5.1	1.0	2.0
including Europe	*1.0*	*4.0*	*1.0*	*2.0*
Japan	-1.9	7.2	2.0	2.0
Asia/Pacific	7.6	10.0	6.5	7.0
including China	*11.5*	*10.5*	*7.0*	*7.5*
Total	2.5	8.7	4.0	4.6

Market segmentation	2010 in %	2011 in %	2012 in %	2013 in %	2014 in %
America	23.9	23.3	23.8	23.8	23.8
EMEA	23.0	22.4	21.7	21.1	20.5
including Europe	*22.0*	*21.6*	*20.7*	*20.1*	*19.6*
Japan	16.4	15.7	15.5	15.2	14.8
Asia/Pacific	36.7	38.5	39.0	39.9	40.8
including China	*23.8*	*25.9*	*26.3*	*27.1*	*27.8*
Total	100.0	100.0	100.0	100.0	100.0

Regional growth rates vary widely around the world. The Asia/Pacific market benefits from growth in China, although this trend is in decline. America has strengthened its market position once again as result of newer technologies and the stabilisation of the automotive industry.

Japan is also experiencing a renewed upswing. Europe's figures are largely influenced by growth in Germany. Other European countries such as France and Italy remain weaker.

1 America: NAFTA, Central and South America (Latin America)
EMEA: Western and Eastern Europe and Africa, Middle East and other
Asia/Pacific: Tiger economies such as Taiwan, former CIS states such as Armenia, Georgia etc. Other Asian countries, especially China, India, Pakistan etc.
Oceania, including Australia and New Zeeland (Australasia) etc.

3. General Trends

3.1. Megatrends which influence the world of electrical engineering and electronics

Connectors enable assemblies, devices, systems and installations to be arranged in a modular structure. They simplify operation, production and maintenance, enable components to be exchanged rapidly and facilitate the integration of new functions into existing systems, thereby promoting efficient use. Connectors follow developments in all electrotechnical systems. For instance, it is already apparent that bandwidths are increasing for signal transmission in telecommunications, data technology and automation. This calls for connectors that can meet these requirements whilst maintaining the same level of reliability.

The main challenge for any connector manufacturer is to deliver maximum technical performance in the smallest possible package.

Academics have identified four megatrends which determine how we interact with another and have a significant impact on the nature and speed of innovation. Megatrends are defined as any large, epoch-making trend which lasts longer than 30 years. These trends – unlike projections and forecasts – change the world slowly, steadily and irreversibly. Rather than changing individual segments of our society or economy, they change entire societies.

The megatrend **"demographic change"** comprises three sub-trends:

- growing world population
- ageing society and
- increasing urbanisation.

Figure 4: Yokohama megacity – source: Souljedi, Fotolia

An ageing and shrinking population in industrialised countries is confronted by strong overall population growth, increased global migration flows and shifting consumer demand.

It is predicted that the global population will rise from a current 7 billion to 8.3 billion people by 2030, that it will become 5.1 years older and that 59 percent of the population will live in cities.

This will create new opportunities for electrical engineering/electronics and connector use in medical engineering and diagnostics, research and production equipment, zero-emission drives, multi-modal mobility concepts and efficient buildings for megacities.

The megatrend **"sustainability"** comprises the following sub-trends:

- resource efficiency
- environmental protection and
- social standards.

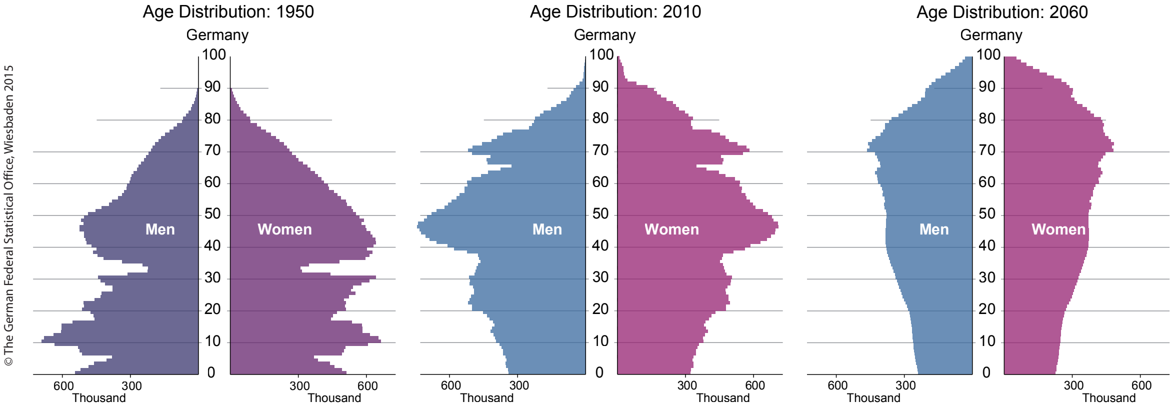


Figure 3: Age pyramids (age distribution) – source: The German Federal Statistical Office, Wiesbaden 2015

The finite nature of fossil fuels and the high levels of environmental pollution associated with their use are encouraging climate-friendly energy generation and sustainable environmental technologies. The same applies to finite supplies of individual raw materials such as lithium and "rare earths". At the same time, societies are striving for sustainability by setting social labour standards.

Figure 5: Sustainable energy provision with wind power and photovoltaics – source: Visdia, Fotolia

New opportunities are emerging for electronics and connectors: new materials for environmental efficiency, new drive concepts, new technologies to reduce fuel consumption and optimise energy storage. This requires investments in environmental technologies, microsystems engineering and electronic demand management systems, for example in automotive, mechanical and electrical engineering. "Smart homes", "smart grids" and "smart cars" are the latest buzzwords to challenge the industry in terms of minimising connector size and maximising transmission rates and currents.

Figure 6: Smart home – source: Mimi Potter, Fotolia

The megatrend **"globalisation"**:
What sounds like a concept devised by some ivory-towered academic is another megatrend which has now been observed for several years and goes hand-in-hand with the sub-trend "mobility". The global exchange of capital, goods and people combined with extremely rapid communication has reached an unprecedented scale.

The economic rise of emerging economies offers substantial new sales markets as well as additional competition. The opening up of new markets in Asia is accompanied by innovative processes arising from national companies compelled to develop an international focus and workers flooding international markets. The Internet, connectivity and modern communications methods are contributing to the side-lining of national structures as they merge with international ones. Knowledge is concentrated in different regions, product life cycles are getting shorter, the pressure for faster, constant innovation represents a major challenge – no less so for electrical engineering components.

Figure 7: Mobility – source: Neuschäfer

The megatrend **"digitalisation"** includes the following sub-trends:
- miniaturisation
- new technologies and
- cross-sector cooperation.

The increase in processing efficiency brought about through digitalisation, new materials for more powerful processors and storage devices, and networking and control of different products through advanced microsystem and Internet technologies is giving rise to smaller, more complex and smarter electronic systems. Microsystems engineering is also the key to exploiting developments in the field of nanotechnology. This requires standardised connector interfaces that enable systems to interact in the first place.

Figure 8: Micro-contacts for mobile phones – source: Lumberg

3.2. Trend for regulation and standardisation

3.2.1. Standardisation

Connectors from different manufacturers have to be compatible with one another to enable individual connectors to be widely used. To achieve this, the interfaces between the free and fixed connector are standardised internationally according to the application, thereby ensuring compatibility and interchangeability. Other provisions also apply depending on the sector or country. These are initiated by interest groups such as manufacturers or users.

The flexible control of these diverse variants on the one hand, and efforts to achieve international standardisation on the other, are the driving force behind continuous technological improvements, thereby creating one of the prerequisites for global commercial success.

Figure 9: Standardised industrial Ethernet connectors – source: Weidmüller

In addition to standardised designs (e. g. RJ45, USB, HDMI, M12), requirements are increasingly being implemented in the form of customised solutions.

3.2.2. Regulation

Efforts to protect consumers and continuously improve the environment impose regulatory requirements on manufacturers of electrotechnical devices. These regulations relate to bans on certain substances, recycling requirements, safety precautions and energy consumption. Naturally, the connectors installed in these devices are also subject to the same regulatory requirements.

EU directive 2011/65/EU (RoHS Directive – Restriction of Certain Hazardous Substances) and the ELV Directive 2000/53/EC (End of Life Vehicles) ban the use of lead and other hazardous substances in devices and systems. As a result of this ban, thermal loads are significantly higher during soldering, thereby necessitating the use of new, temperature-resistant connector materials.

Other directives such as 2012/19/EU (WEEE Directive – Waste Electrical and Electronic Equipment) or Regulation (EC) 1907/2006 (REACH: Registration, Evaluation, Authorisation and Restriction of Chemicals) apply to the development of connectors.

Furthermore, specific regulations apply to certain fields (e. g. railway, medical and chemical engineering, food processing technology).

3.2.3. Certificate of conformity

To demonstrate that connector systems satisfy technical and safety requirements, components are certified either in in-house laboratories or by accredited external test centres. In some countries or for certain applications, type approvals are additionally required which are confirmed by the relevant test centre with a certification mark (e. g. VDE, TÜV, UL, CCC).

4. Technologies

4.1. General

Did you know that over the next few years sales in the global connector market will exceed 40 billion euros? Europe will account for a share of around 8.5 billion euros. Germany leads the way in this region, with the greatest export share. Every year, as much as six percent of turnover is reinvested in research and development alone to implement new electronic functions, smaller package spaces, new safety features and energy-saving measures in a sustainable way.

Smart, powerful, secure and rapid transmission solutions are required to satisfy continuously rising demands. Connectors are responsible for energy and signal distribution. There are basically three different types of connection:

- **Wire-to-wire:** Connection between one conductor (cable, wire) and another.
- **Wire(cable)-to-board:** Connection between a conductor and a circuit board.
- **Board-to-board:** Connection between one circuit board and another.

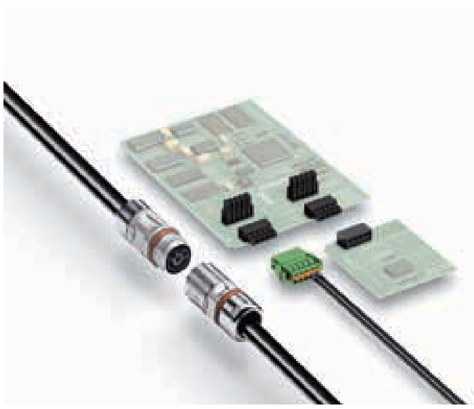
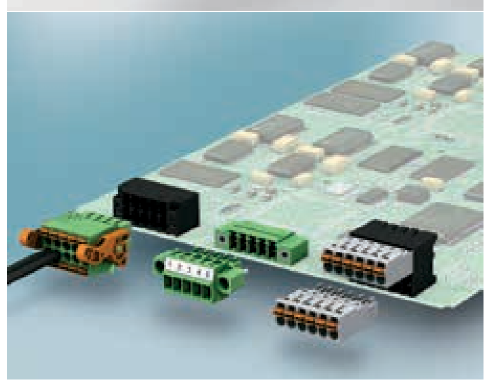


Figure 10: Connection options: wire-to-wire, wire-to-board and board-to-board – source: Phoenix Contact

Different connection technologies enable contact elements to be connected to conductors or circuit boards.

Contact is generally achieved via a rigid (pin or blade) and a flexible contact element (spring-clamp or jack). Contact to circuit boards may be direct or indirect. Contacts are conducted via housing elements and contact carriers. The distance between two contacts is described as the pitch. Polarity or keying of the mating face and pins prevents mismating of connectors. Spring-latch systems, snap-in hooks and screwed connections are used to prevent accidental separation.

Copper alloys are mainly used as contact elements due to their good conductivity. These are coated to ensure good corrosion protection and wear. Contact carriers are almost invariably made from plastics because of their electrically insulating properties. Plastics and metal alloys are used for housing.



Connector locking mechanisms –
Figure 11 top: source: Weidmüller
Figure 12 bottom: source: Phoenix Contact

Environmental conditions such as high or low temperatures, vibrations, contamination (soiling), chemicals, humidity, immersion and UV and electromagnetic radiation influence the design.

4.2. Electrical connection technologies

The purpose of using connectors is to make an electrical connection detachable. Connectors consist of contact elements placed in insulating compartments which can make electrical contact with their mating contacts. These are attached to the assigned electrical conductor in accordance with the application within the system and are often permanently connected. There are basically two types of conductor connection: Printed circuit board connections and wire or cable connections.

4.2.1. Circuit board connection technology

4.2.1.1. Soldering

Press-in technology is a solder-free electrical connection technology which is well-established in the electronics assembly sector and thus regarded as a stable and reliable method of mounting connectors and individual contacts on PCBs. This technology requires the use of two-layer PCBs with plated-through holes as a minimum requirement. One advantage compared with soldering is that the components can be mounted after assembly once the electrical function of the assembly has been tested. There are two different types of press-in connection; those with a solid press-in zone, and those with a compliant press-in zone.

In the case of solid, inflexible contact connections, the contact and retention force is provided by distortion of the hole in the PCB. In contrast, the compliant press-in zone is designed to be resilient, which substantially reduces the mechanical stress in the PCB hole compared with the solid pin. With this functionality it is possible to insert components several times, which makes repairs feasible. Connector manufacturers offer a wide range of reliable press-in zones in hole diameters ranging from less than 0.5 mm to over 1.6 mm.

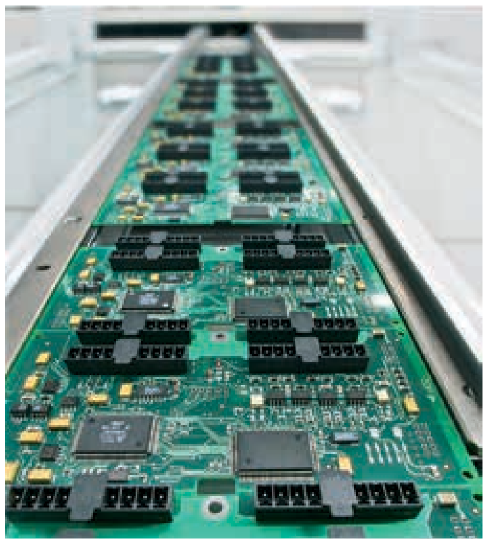


Figure 13: High temperature-resistant PCB connectors for pin-in-paste reflow soldering – source: Phoenix Contact

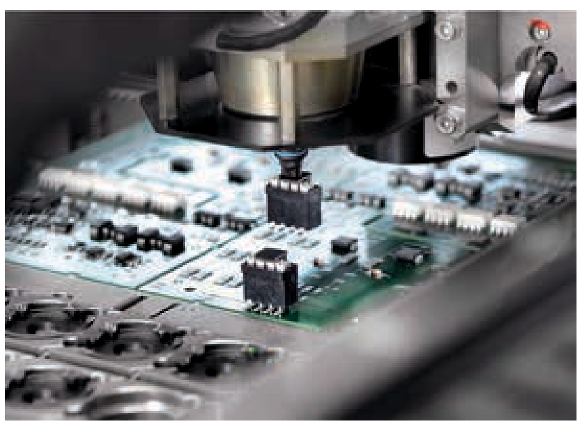


Figure 14: Pick+Place process for SMT PCB connectors – source: Weidmüller

4.2.1.2. Press-in technology

Press-in technology is a solder-free electrical connection technology which is well-established in the electronics assembly sector and thus regarded as a stable and reliable method of mounting connectors and individual contacts on PCBs. This technology requires the use of two-layer PCBs with plated-through holes as a minimum requirement. One advantage compared with soldering is that the components can be mounted after assembly once the electrical function of the assembly has been tested. There are two different types of press-in connection; those with a solid press-in zone, and those with a compliant press-in zone.

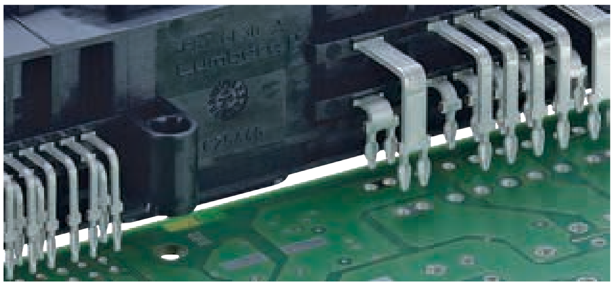


Figure 15: Flexible press-in contact via metal barrel in the circuit board – source: Lumberg

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4.2.2. Conductor connection technology

4.2.2.1. Crimping technology

Crimping is the most widely used connection technology for conductors. The individual strands in the crimping zone of the contact element are joined together by plastic deformation. A crimped connection cannot be detached without destroying it and must be replaced if a repair is needed. Crimped connections ensure a high degree of electrical and mechanical reliability.

Crimps come in a variety of shapes, largely depending on whether the crimp barrel is open or closed. With open versions, the stripped wires are inserted into the U-shaped crimping zone from above and compressed by rolling. These variants can be fully automated and are very cost-effective. With closed crimp barrels, which are commonly used with round contacts, the stripped wires in the crimping zone are compressed from several sides simultaneously.

Figure 16: Crimp contacts for automotive cable harness – source: TE Connectivity

Crimpable wire cross-sections range from 0.1 mm² to 50 m². In principle, crimping can be used to connect stranded, solid, enamelled wire and foil conductors. The crimping zone must be optimally configured to suit the conductor. It is easy to monitor the quality of this type of connection. With crimping the conductors are joined to the contact first, before being inserted in the connector housing.

4.2.2.2. Insulation-displacement technology

Unlike crimping, an insulation-displacement connection (IDC) does not need the conductors to be stripped of insulation. The wire is forced down into a fork shaped contact comprising a slot with cutting edges "displacing" insulation on either side of it and thus makes electrical contact with the conductor inside.

With insulation-displacement technology, the contacts are preassembled in the housing. The advantage of this method is that multiple conductors can be simultaneously connected in a single pass. An insulation-displacement connection is usually detachable.

Insulation-displacement terminations are available in various designs with single or double rows of contacts. The insulation-displacement termination must be compatible with the conductor type and insulation material. This technology can be used to contact stranded, solid and enamelled wire conductors with cross-sections ranging from 0.01 mm² (enamelled wire) to approximately six mm².

Figure 17: RJ-45 connector with insulation-displacement contact – source: Metz Connect

Figure 18: Assembled RJ-45 connector – source: Metz Connect

4.2.2.3. Insulation-piercing technology

Like insulation-displacement connectors, insulation-piercing connectors also eliminate the wire stripping operation. Electrical contact is made by piercing the stranded wire with a round or blade-like contact spike. The pressing force required to make contact is provided by the wire insulation and the wire guide in the plastic housing.

As with IDC technology, multiple conductors can be connected simultaneously. The piercing contact must be compatible with the stranded wire. This method is suitable for contacting stranded wires with cross-sections ranging from 0.1 mm² to 4.0 mm². Piercing technology is most commonly used for RJ connectors in telecommunications.

Figure 19 top: Circular connector with axial piercing contacts – source: Phoenix Contact

Figure 20 bottom: Single connector contact with triple piercing and insertion aid – source: Phoenix Contact

4.2.2.4. Screw and spring-clamp terminals

A screw-clamp connection is the traditional connection technology in which the stripped wire is inserted into a hole or barrel of the contact terminal and retained by a screw. The spring-clamp terminal is a further development of this type of connection. Here, the high pressing force required to ensure a reliable contact is applied by a pre-tensioned spring. The wires are generally fixed in the clamp connection by means of a self-locking mechanism. Spring-clamp and screw-clamp connections are therefore detachable and friction-locked. Spring-clamp connections – especially the push-in type – enable shorter assembly times compared with screw-clamp connections and are thus becoming increasingly common in switch cabinet construction and electrical installation technology.

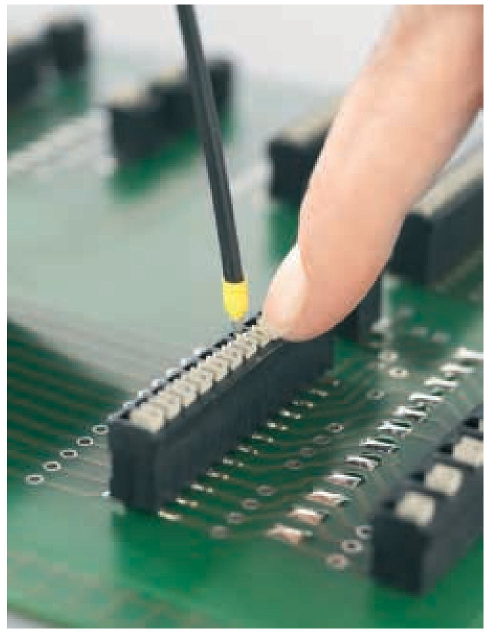

Figure 23: Direct plug-in PCB connector with release button (pusher) – source: Weidmüller

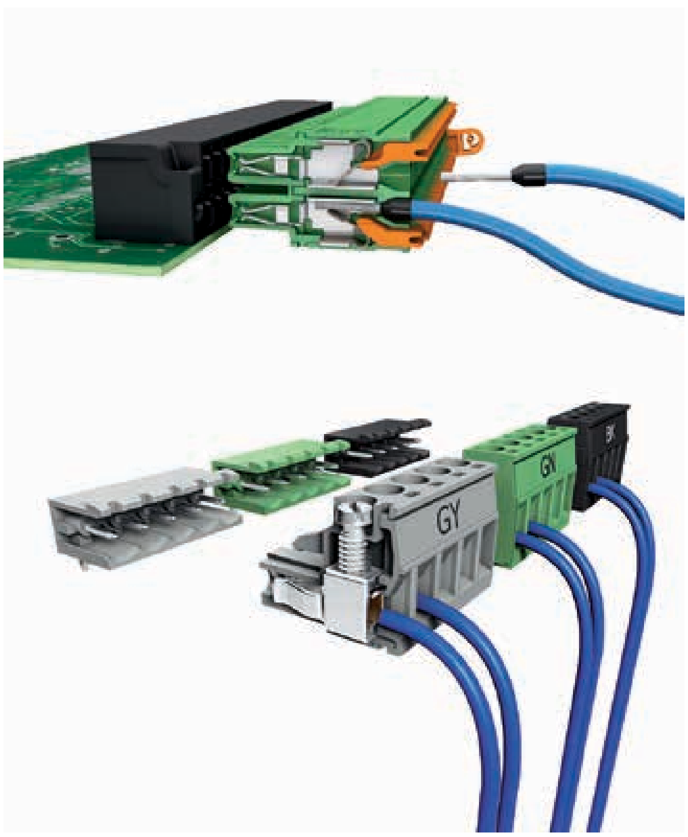

Figure 21 top und Figure 22 buttom:
Push-in and screw-clamp cable connectors – source: Phoenix Contact

4.3. Connector styles

4.3.1. Circular connectors

Circular connectors can be identified by the cylindrical housing and round mating face. They are mainly used to connect flexible cables and have a compact design which takes up little space. The arrangement of contacts in the mating face can be symmetrical, asymmetrical, circular or linear and depending on the connector style, can accommodate between one and 100 pins.

Figure 24: Various sizes of metric circular connectors for connecting data, signal and power cables – source: Phoenix Contact

4.3.2. Rectangular connectors

Rectangular connectors have a rectangular or trapezoidal mating face. This connector style helps to ensure correct orientation during insertion. They are used for routing flexible cables from a housing or component.

Figure 25: Different styles of rectangular connectors – source: Harting

Rectangular connectors usually have a uniform contact arrangement. Power transmission ranges from a few milliamps to several hundred amps. Interfaces for data transmission up to the gigabit range are also available. Rectangular connectors can have up to 300 pins, depending on the size and transmission.

Rectangular connectors can be incorporated into modular systems, whereby different inserts, known as modules, are arranged in a rectangular housing to create a customised connector.

4.3.3. RAST connectors

RAST is a German acronym that stands for "Raster-Anschluss-Steck-Technik", roughly translated as Pitch Connection Plug Technology. RAST connectors are mainly used in household appliances, in particular the RAST 2.5 and RAST 5 families. RAST connectors can be used for indirect contact to pin strips or direct contact to the edge of a circuit board.

RAST specifications standardise a range of connection properties, e.g. the geometric housing dimensions, all function-related dimensions and connector characteristics such as internal or external latching.

Designed for two output ranges – RAST 2.5 for signal currents, RAST 5 for load currents – the aim of the RAST standard was to ensure connector conformity between different manufacturers, eliminate errors in the production process caused by incorrectly mated connections, simplify mounting during the assembly of end devices and prevent faulty wiring. RAST allows connections to be grouped, thereby minimising the need for individual wiring. RAST connectors typically use installation-displacement, crimping and screw-clamp technology and are available in a wide range of coding options with one to twenty pins.

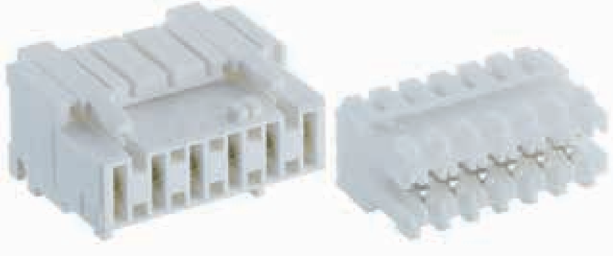

Figure 26: RAST 5 and RAST 2.5 connectors – source: Lumberg

Figure 27: Colour-coded RAST 5 connector in a control unit – source: Lumberg

Figure 28: Different types of coaxial connectors – source: Molex

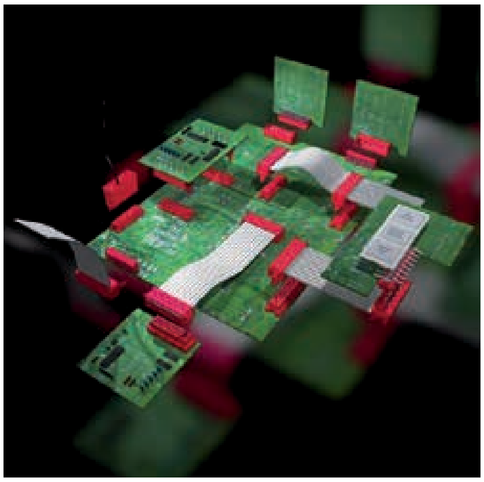

Figure 30: Printed circuit board connector for ribbon cable and board-to-board connections – source: TE Connectivity

4.3.4. Coaxial connectors

Coaxial cables consist of an inner conductor surrounded by an insulating layer (dielectric) and an outer conductor (coaxial sheath). Coaxial connectors are used to connect circuit boards, cables and devices which can transmit very high frequencies. Therefore it is essential that uniform impedance is continously maintained in the transmission system.

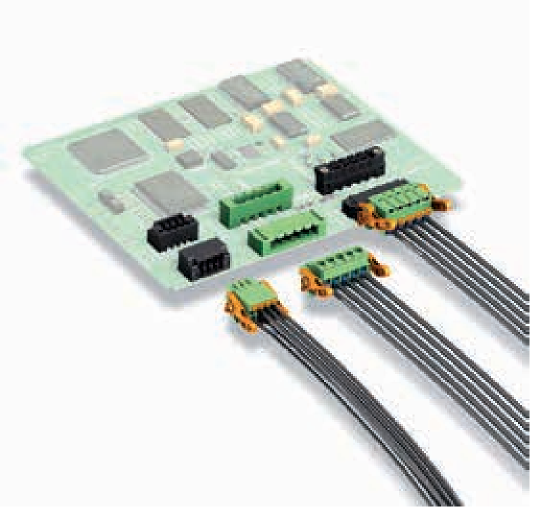

Figure 31: Connectors for individual conductors in the signal range –source: Phoenix Contact

4.3.5. PCB connectors

PCB connectors are used to connect to contacts on a printed circuit board. There are three types of PCB connector: wire-to-board for connecting individual wires to PCBs, cable-to-board for connecting circular or ribbon cable to PCBs and board-to-board for connecting two PCBs together.

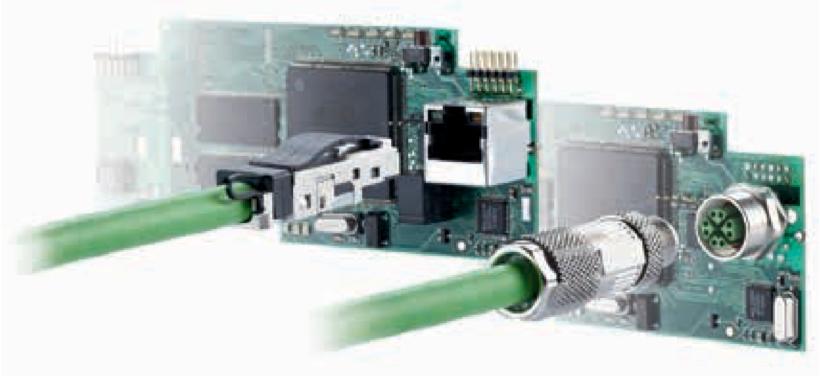

Figure 29: Printed circuit board connections – source: Metz Connect

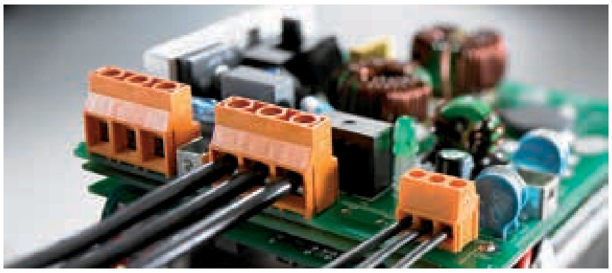

Figure 32: Printed circuit board connection terminals for individual conductors in the power and signal range – source: Weidmüller

PCB connectors range from signal and high-current applications with a small number of pins right up to connectors for communications technology with over 1000 pins for transmission rates in excess of 20 Gbit/s.

PCB connectors can be connected directly or indirectly to the circuit board. Indirect insertion is a two-part contacting method in which a connector is connected to a mating part. Direct insertion is a one-part solution where the connector comes into direct contact with the conductive tracks on the circuit board without the use of a mating part.

4.3.6. Optical fibre connectors

Unlike conventional electrical connectors, the transfer medium for optical fibre connectors are optical fibres made from glass or plastic. These fibres have to be aligned and connected with the utmost precision (sub-µm) to ensure optical transmission. This is achieved using ferrules (ultra-high-precision guides), which can be connected to one another in circular or rectangular connectors. This method enables between one and 100 fibres to be connected.

Technical advances and new fields of application have led to the development of different connector styles (including LC-, SC-, F-SMA, MPO, MTRJ) and coupling mechanisms (e. g. push-pull, bayonet, screw and snap-lock).

The advantages of optical fibre conduction technology are very high transmission rates and ranges, lower mass, smaller dimensions and no electromagnetic interference.

Figure 34: Optical fibre connectors with F-SMA interface – source: Spinner

Figure 35: Optical fibre adapters – source: Molex

Figure 36: Optical fibre TOC connector (Telecommunication Outdoor Connector) as LC duplex – source: Telegärtner

Figure 33: Examples of fibre-optic connectors – source: TE Connectivity

4.3.7. Mixed and special connector styles

4.3.7.1. Modular connectors

A modular connector integrates similar or different contact systems in a common housing. Typically this is assembled in a type of modular unit. The contact systems can consist of signal and power contacts. Some types additionally include optical fibre and/or pneumatic contact systems.

Modular systems are essentially designed to be customised; the manufacturer or user specifies the contact arrangement and housing design to suit the application.

Modular connectors are used predominantly in the automotive industry, industrial applications, energy, automation, railway and medical engineering.

Modular connectors are mostly designed for cable-to-cable connection, as well as cable to a fixed interface (e. g. printed circuit board, housing, switch cabinet). Modular connectors are usually sealed, depending on the application.

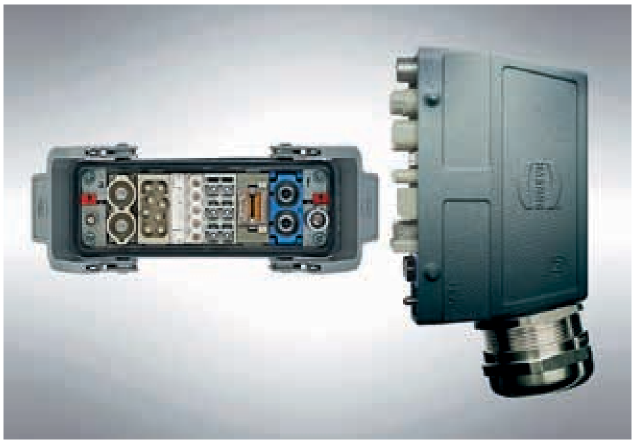

Figure 37: Modular connector for transmitting power, signals (including by optical fibre), data and compressed air (blue module) – source: Harting

Figure 38: Modular connector for switch cabinet assembly – source: Phoenix Contact

Figure 39: Modular plastic connector for supplying power and signals to stage equipment – source: Robolights

4.3.7.2. Customised applications

In many sectors connectors are designed specifically to meet customer requirements. The reason for this is that available package spaces and physical conditions (vibration, climate and temperature) impose specific requirements. Furthermore, these requirements generate certain preferences and limitations. Many customers are not interested in plug compatibility and will only authorise stand-alone solutions.

Figure 40: Customised connector system for data and power cables in electric vehicle charging stations – source: Phoenix Contact

In the automotive industry, for instance, every OEM (original equipment manufacturer) decides for themselves what connectors to use for the components and interfaces used in each generation of their vehicle series. This has led to a situation where contact families are installed in a very wide variety of customised housing designs, e. g. metal lugs or clean-body-contacts.

Figure 42: Customised connector for railway engineering – source: Weidmüller

Figure 41: Cable connection technology for automotive electronics – source: TE Connectivity

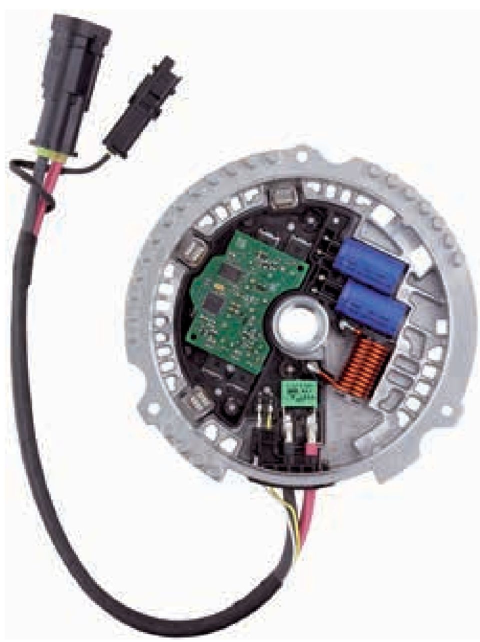

Figure 43: Connectors and contact elements in a cooling fan control unit for a car – source: Lumberg

5. Sectors and Areas of Application

The versatility of connectors is reflected in the diverse applications in which they are used. The ZVEI has defined the following areas of application: Automotive electronics, industrial electronics, consumer electronics, data technology and telecommunications.

Figure 44-50: Areas of application for connectors – sources: ZVEI, Rainer Plendl-Fotolia, Spinner, Stephan Leyk-Fotolia, ODU, Lumberg, Harting

5.1. Industrial electronics

Industrial electronics is one of the fastest growing sectors of industry. Characterised by automation and traditional energy technology, industrial electronics covers a broad spectrum ranging from process and production engineering, building and home automation, regenerative energy generation and distribution, transportation (transport technology, rail, air and maritime transport) to medical engineering and professional entertainment systems.

Figure 51: Sensor/actuator distributor in production automation – source: Phoenix Contact

5.1.1. Process and production automation

Connectors used in machinery and systems engineering and process optimisation nowadays are subject to particularly complex and wide-ranging requirements. Individual technological solutions are called for to suit the application, yet at the same time the connection must be capable of withstanding extreme conditions such as moisture, dust, chemical substances, high temperatures, vibrations etc. throughout the intended life cycle.

Furthermore, systems safety must be ensured and both regional and industry standards upheld.

Figure 52: Servo drive with data, signal and power interfaces – source: Weidmüller

The **automation components** and **devices** such as control units, I/O elements, frequency converters etc. in the switch cabinet (IP20) are usually equipped with specific connectors for single-wire connection. This ensures maximum flexibility for the connection of sensors and actuators inside the switch cabinet as well as for the energy supply between all components and from components to the field.

In **power electronics** PCB connectors are increasingly replacing clamped solutions, thus allowing more compact and flexible devices with higher current-carrying capacity. Increased safety, shielding and compliance with standards are essential criteria for these connectors.

Figure 53: Motor controller with PCB and circular connectors for connecting signal and power cable – source: Phoenix Contact

In the **signal electronics sector** features such as a large number of variants, coding (keying) and locking are particularly important, in addition to low cost, high packing density and ease of use.

Figure 54: Machine control cabinet with signal and data connectors – source: Phoenix Contact

The **switch cabinet wall** (or decentralised distribution box) is the interface to the field wiring and frequently requires a significantly higher protection class and more robust design of devices and connectors.

Modular (hybrid) connector systems are suitable for automation, since in these applications energy, signals and data often have to be routed in parallel from the switch cabinet to the field.

Figure 55: I/O element (input/output) with sensor connectors – source: Weidmüller

Figure 56: Field device with data interfaces (fibre-optic and copper) – source: Phoenix Contact

Data connections are currently switching from traditional fieldbus systems to industrial Ethernet. As a result, industry-compliant, standardised connectors such as RJ45 or circular connectors are becoming increasingly widespread. Optical fibre connectors are used to transport large quantities of data up to control level quickly and reliably through large systems.

Figure 57: Connectors on rail-mounted devices – source: Weidmüller

5.1.2. Building automation

Due to the installation conditions, cable connectors for field assembly are mainly used in building automation, especially pluggable terminals. The individual cores of a cable are connected to the connector on site by the installers. Screw clamps, once widely used, are increasingly being superseded by spring-clamp contacts. Insulation-displacement connection technology is also used in some areas.

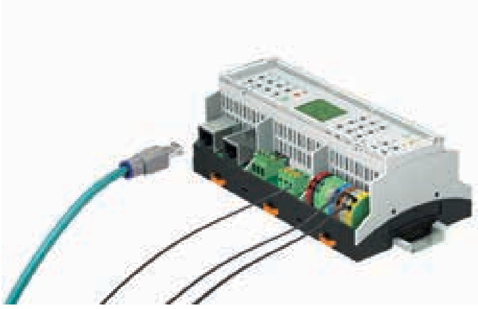

Figure 58: Building control unit with data interfaces and sensor/actuator connections – source: Phoenix Contact

Figure 59: Connector on actuating drive for building ventilation systems – source: Lumberg

Connectors which are protected from environmental influences (e. g. metric circular connectors) are used for outdoor applications such as weather stations or surveillance cameras. The trend for highly communicative 'smart homes' is leading to the use of data networks for connecting devices to higher control. Customary connectors for data technology are used for this purpose.

Due to the long lifetime of buildings and the fact that some applications are safety-relevant (e.g. fire protection or access control), connectors used in building automation must have a high level of reliability and a long life cycle. They must be able to transmit small signals from sensors (e. g. for temperature, brightness, presence of people or air quality) as well as higher currents for actuators (e. g. actuating drives, fans or lights).

5.1.3. Regenerative energy

Our society needs a new energy concept for the future. Oil, coal and gas supplies are finite and dwindling. Furthermore, combustion of these resources is damaging the environment, the climate and therefore humankind. Nuclear energy also poses risks in the long term.

However, Germany leads the way internationally in promoting wind and solar energy generation to secure a sustainable and environmentally friendly power supply.

5.1.3.1. Wind energy

Modern wind turbines have a modular design which allows functional units to be prefabricated and factory tested. This reduces installation, commissioning and servicing costs.

Figure 60: Connectors connecting motors which align the turbine rotor blades with the wind direction (yaw) – source: Harting

Examples of such modules include control units and drive controls for yaw, rotor adjustment and control and safety systems (e.g. breaking and firing). Systems for generation, preparation and conversion to electrical energy are also designed as modular units. Wind turbines function efficiently when all these parts work together in an optimal manner. This requires them to have effective connection technology to ensure that signals, data and power are reliably transmitted. Connector manufacturers are working together with the wind energy industry to optimise wind turbine performance to increase availability and reduce downtimes.

Figure 61: EMC-protected transmission of signals and power in the nacelle of a wind turbine. – source: Harting

To reduce the installation times for the electrical components in wind turbines, reliable and shock and vibration resistant connection technologies such as spring-clamp termination are becoming increasingly popular alongside traditional technologies such as crimping, soldering and screwing.

Robust connector housings are required to withstand the special operational and environmental conditions such as severe temperature fluctuations, moisture, heat, dust, vibrations, impact loads and salt-laden air. So housings have been developed which are either made from corrosion-resistant pressure die-cast aluminium alloys or high-performance plastics or have a corrosion-resistant coating.

The transmission distances for data and signals from wind turbines have increased. Ethernet optical fibre cables are used to transmit data from tower heights (hub heights) above 100 m. Optical connectors from data technology or optical contact systems are combined with power and signal contacts in hybrid or modular connectors.

5.1.3.2. Photovoltaics (PV)

The solar industry has designed special connectors for wiring photovoltaic systems, whether megawatt-strong solar parks or roof-mounted modules for private homes. This enables installers to quickly wire PV modules and converters on site without needing special tools.

Connectors have been developed which accommodate PV cables with conductor cross-sections from 2.5 to 16 mm², transmit currents up to 65 A and are designed for higher DC voltages of up to 1500 V. These have an international protection rating of IP68 (protection against ingress of dust and water) and can be field-assembled without using special tools. As yet there is no standard for PV connectors to ensure compatibility. Mating compatibility often fails due to different manufacturer tolerances or different materials. Nowadays the module manufacturer who pre-assembles the outlet on the PV module determines which connector an electrician uses.

Figure 62 and 63: Push-in connector for field assembly on a PV module
Figure left: source: Weidmüller, Figure right: source: Phoenix Contact

In the PV sector, crimp connection technology is increasingly giving way to crimp-free connectors which rely on push-in or click-in connection technology. Here the wire – which still has to be stripped – is inserted into the terminal of the connector and retained by a "twist and snap-in" spring-clamp contact which greatly reduces the installation time.

5.1.4. Railway engineering

Connectors are indispensable in modular vehicle manufacturing because they facilitate transitions between electrical subsystems flexibly and quickly. They ensure that all units of the vehicle are supplied with power, data and/or signals. At the same time they reduce operational and maintenance costs.

Electrical assemblies fitted to the outside of rolling stock are exposed to severe vibrations and impacts, electromagnetic fields and extreme weather.

Robust connectors are therefore used which have special mechanical locking mechanisms (interlocking) and high protection ratings (IP68/IP69K). Lower protection requirements are needed for interior applications. Electromagnetic interference can be avoided using special shielded connectors.

For carriage transitions, preassembled cable harnesses with special coded connectors, frequently hybrid, are used which are factory-tested to increase reliability.

Modern trains have Ethernet networks running throughout the carriages which supply cameras, digital entertainment and displays for status information. RJ45 and M12 connectors are used for this purpose.

Figure 64 to 66: Robust connectors for the railway industry – undercarriage container (left), carriage transition (centre) and temperature sensor for the brakes (right) – source: Harting

Connector technology is also influenced by the development of standards in the rail industry. This includes increased resistance to aggressive media such as detergents, hydraulic oil etc. (EN 50467).

5.1.5. Military, aerospace and shipping

Connectors are used in aeroplanes, ships and military aircraft to supply power to drives, for electronic control systems or sensors, for the continuously growing field of communication electronics and for weapons systems. The majority are standardised connectors with round contacts and metal housings. Specific standards such as VG, MIL and SAE specify the connectors in detail and stipulate requirements for product testing and approval. Typical product requirements include resistance to operating resources, temperature, high pressure and vibration, good shielding characteristics and high acceleration. In order to safeguard functionality, materials are still used which are no longer permitted in commercial applications due to environmental regulations.

Figure 67 and 68: Vibration and shock-proof metal circular connectors for power and signal supplies in aircraft and military equipment – source: ITT Interconnect Solutions

Figure 69: Pilot cockpit at night – source: Udo Kroener, Fotolia

Connectors are used in civilian aviation and shipping for applications such as motors, control systems, communication, entertainment, lighting and safety systems.

Military-grade connectors are used in safety-relevant areas and outside the cabin of civilian airlines. In the cabin area, connectors from communications and industrial electronics are additionally used for seating and entertainment. Glass-fibre systems and optical fibre connectors are becoming more widespread for communication and control due to the increased bandwidth.

Figure 70: Rectangular connector for copper and fibre-optic data cables: used in airlines, e.g. for on-board audio and video systems – source: ITT Interconnect Solutions

5.1.6. Medical engineering

Figure 71: A multi-therapy infusion system combines high-end functionality with compact size and low weight – source: ODU

Figure 72: Blood sugar indicator – source: ODU

Connectors are used in a very wide range of applications in medical engineering, for example diagnosis, therapy, in operating theatres and in the homecare sector. In addition to contact reliability, high mating cycles, specific medical standards and licensing requirements, special consideration must also be given to shielding, touch protection, impermeability and suitability for autoclaving.

High quality disposable solutions intended for single-use only also exist as a special case in medical engineering.

5.1.7. Studio and stage technology

Studio technology covers areas such as lighting, sound and film engineering. In the broader sense this also includes TV, radio and film studios, broadcasting stations, concert halls and theatres and even fairground/theme-park attractions, which are grouped under the general term “Broadcast & Entertainment”.

This illustrates the broad spectrum of connector requirements in this field, ranging from transmitting electronic and digital signals to robust exterior use. Circular and rectangular connectors are predominantly used, often now in hybrid form, coaxial connectors are still commonly used and in the digital environment USB connectors for connecting to peripheral devices have become widespread. Special connectors are required for the high quality transmission of audio and video signals by optical fibre cables.

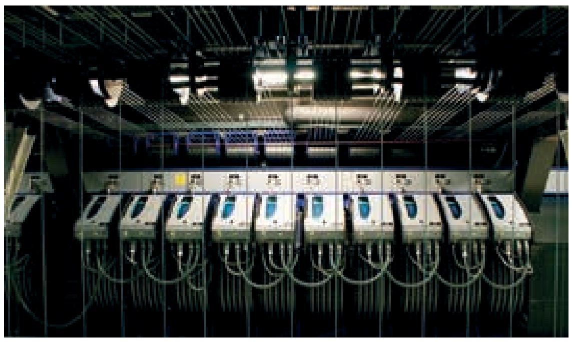

Figure 73: Cable winch control system for a musical at the London Palladium Theatre – source: Courtesy of Trekwerk

Figure 74: Plug connection between microphone head and microphone – source: Lumberg

5.2. Data and telecommunications electronics

Communication underpins all current trends. “The Internet of Things”, “Industry 4.0” or “Mobility” – these developments would not be possible without high-performance communication links and the wide availability of data. Connectors form an important basis for the construction of these networks, the maintenance and migration of which is leading to ever higher data rates. The broad distribution of these systems requires a high degree of connector standardisation. RJ45 or USB connectors, for example, are currently among the most widely used components in the world.

5.2.1. PC/data centres, switching technology (backplane)

Data centres and switching equipment nowadays have to be highly available. Reliability and maximum data transmission rates are the most important criteria for connectors in modern data centres. Transmission rates of up to 40 Gbit/s are currently being developed for cable-based electrical connectors, and even higher in some cases for board-to-board connections inside the equipment (backplane). Connectors for optical fibre cables are capable of achieving data rates in excess of 100 Gbit/s. RJ45 for copper, LC and MPO for optical fibre cables are frequently used for connections between devices.

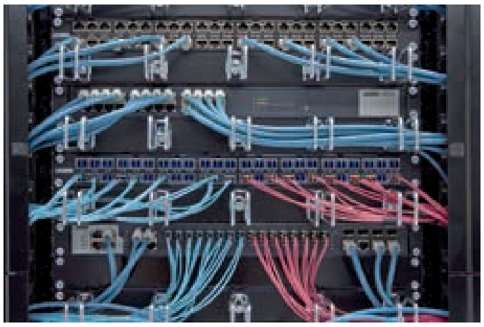

Figure 75: Patch panel with RJ45 data connectors and high-speed optical fibre connectors in one server – source: Phoenix Contact

5.2.2. Mobile devices

Mobile devices such as smartphones, tablets etc. today offer an enormous variety of technology in an astonishingly small package. Only the smallest of spaces is available for connecting the integrated assemblies, which demands an extreme level of connector miniaturisation.

Data rates for mobile phone standards are continuously rising. In contrast, the life cycle of end devices and their components, currently around 1.5 years, is falling, making environmentally friendly disposal and recycling more important.

The sheer variety of components such as keys, touchscreen, battery, Sim card, memory cards, antennae, charging connection, printed circuit boards etc. requires individual designs and precise technology.

Figure 76: Different smartphone connectors – source: Olexandr Fotolia

This means connectors with overall heights of less than 1 mm and pitch less than 0.3 mm which at the same time provide maximum reliability. External interfaces (e. g. battery, charging connection, memory card) must guarantee high mating cycles.

Typical applications for these devices include:

- Foil connectors,
- Board-to board connectors,
- Battery connectors,
- Antennae connectors,
- Micro USB jacks,
- Memory and Sim card sockets,
- Camera sockets,
- Audio jacks.

Figure 77: Micro-connectors for smartphone loudspeakers magnified several times – source: Lumberg

5.2.3. Network technology (LAN), infrastructure (office, industry)

In local area networks, connectors are defined by standards for structured premises cabling. Rectangular connectors (RJ45) and optical fibre connectors can be used for this purpose. The connectors are integrated into junction boxes/outlets and distribution fields (patch panel). Although the mating face is standardised worldwide, the installation conditions in buildings vary greatly from one country to another. For this reason, several different versions of these products are required.

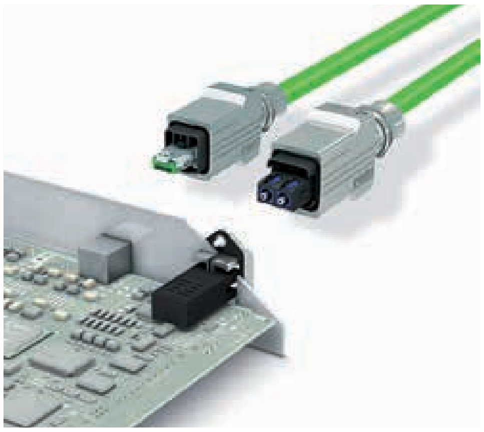

Figure 78: Data connector with protective housing for connecting copper and optical fibre cable – source: Phoenix Contact

Figure 79: Network outlet and RJ45 connector for field assembly – source: Metz Connect

In areas where particularly robust connectors are required (e. g. production facilities, machines), RJ45 connectors – originally developed for office environments – are provided with additional protective housings to protect them from mechanical influences or dust and moisture ingress. Type M12 circular connectors are used as an alternative. These were developed for a harsh industrial environment and are suitable for transmission rates of up to 10 Gbit/s.

5.2.4. Wide area network (WAN)

Whilst LAN networks are restricted to rooms, buildings or premises, WAN networks span large geographical distances (countries, continents) and can generally connect an unlimited number of computers. Some WANs are owned by large companies and countries. They are very often operated by Internet or telecommunications providers.

As with other networks, components such as routers, gateways and switches must be linked to one another by means of connectors. The uses for these connectors are equally varied, e. g. I/O, backplane, RF, RJ45, fibre-optics, antenna connection technology.

Figure 80: Standardised coaxial connector style 7-16 for connecting to highly flexible corrugated cable for mobile phone applications – source: Spinner

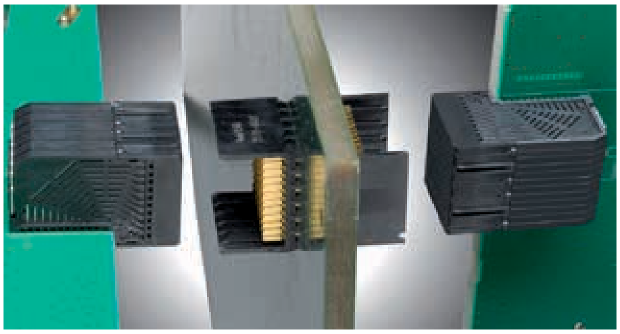

Figure 81: Backplane connector for high data rates – source: Molex

5.3. Consumer electronics

A key segment in the consumer goods market is household appliances, which are commonly referred to as **"white goods"**. These include washing machines, dryers, fridges, freezers, dishwashers, ovens and microwaves as well as small appliances such as coffee machines, toasters, mixers, vacuum cleaners and razors.

Figure 82: Control element of a washing machine with assembled cable harness – source: Lumberg

The term **"red goods"** refers to heating products and covers a broad spectrum ranging from traditional boilers to heat pumps and combined heat and power systems.

These sectors are characterised by the fact that appliance life cycles of ten years and more are required. In Europe, RAST connectors are widely used in both sectors. Other applications include flat connectors, screw-clamp connectors, ribbon cable connectors and foil connectors. The trend for devices with communication capabilities is leading to an increased use of data connectors.

Figure 83: Solar system control unit with colour-coded RAST connectors – source: Lumberg

The home entertainment electronics segment, the **"brown goods"**, basically covers audio, TV and video devices and games consoles.

Standardised I/O connectors only, such as HDMI, USB, RJ45, D-SUB, memory and smart-card sockets, coaxial, cinch and jack plugs, are used for external device interfaces.

Various types of board-to-board, wire-to-board and ribbon cable connectors are used for internal wiring.

Figure 84: Connectors on a radiant heating element and energy regulator for a glass ceramic hob – source: Lumberg

5.4. Automotive electronics

5.4.1. Cars and commercial vehicles

Connectors in cars are an essential component of the on-board power supply and are designed as wire-to-wire or wire-to-board. Crimp contacts are used almost exclusively to connect the cable to the contact.

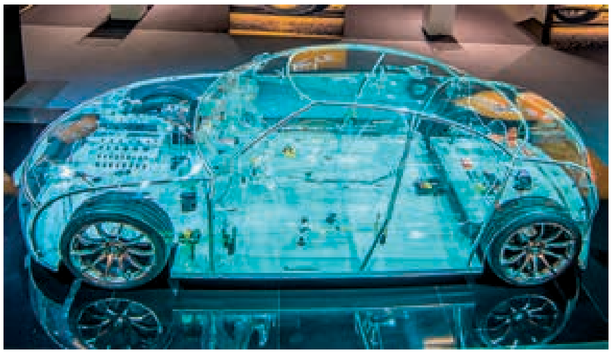

Figure 85: Diverse range of electrical connection technology in a transparent vehicle – source: TE Connectivity

Connectors for automotive applications take various different forms and are categorised by their function:

- by installation space and number of pins,
- for signal or high-current,
- in spring latch or as clean-body contacts for primary and secondary interlocking,
- unsealed or sealed with single-core seals or group seals,
- with housings for connector position assurance (CPA), bayonet or push-pull interlocking,
- with or without EMC resistance (electromagnetic compatibility),
- for data transfer.

Figure 86: Connectors for airbag control units – source: TE Connectivity

Contact systems in the following dimensions are most widely used:

- **Signal:** with 0.5 mm/0.63 mm/1.2 mm and 1.5 mm blade/contact width,
- **High current:** with 2.8 mm/4.8 mm/6.3 mm/8 mm/9.5 mm/12 mm blade/contact width.

Figure 87: On-board electronics control units with connectors – source: Lear

The automotive market demands the highest safety requirements and the lowest cost. To reduce weight and package space manufacturers are continually striving to make connectors more compact. As a consequence, contact density is rising and already exceeds 300 contacts in some systems. With the aim of making components as small as possible, contact families are now made with high-performance alloys (e. g. CuNiSi), which makes them significantly more conductive than the previous systems. Miniaturised systems nowadays require group seals instead of single-core seals.

Connectors with rectangular contact arrangements, in some cases of modular construction, are normally used in cars. Circular connectors are widely used in commercial vehicles where requirements for installation space and weight are less stringent. Trucks and vans are designed to travel far greater distances than cars, so contact systems in this sector are of a more robust design.

Figure 88: RAST connectors in the gear selector of an automatic drive – source: Lumberg

The mating cycle in the automotive sector is dictated purely by the frequency of repairs or servicing. On this assumption, the most widely used contact surface is tin, and silver for power contacts.

With the rise in electrical functionality, communication density and safety requirements, the demand for contacts in the automotive sector will continue to grow against a background of increasingly decentralised on-board electrical systems.

Figure 89: Automotive cable harness – source: Lear

The trend towards weight reduction is leading to the use of alternative materials for conductors, for example aluminium, or copper alloys (CuMg, CuAg) for smaller wire cross-sections. Connector contacts must be adapted and optimised accordingly.

Figure 90: Automotive contacts, sealed – source: Lear

5.4.2. Electromobility, electric drives and hybrids

Manufacturers are adopting various different concepts to integrate electrical drives into vehicles. These drives can be designed purely as an electric engine, or with an additional combustion engine (hybrid).

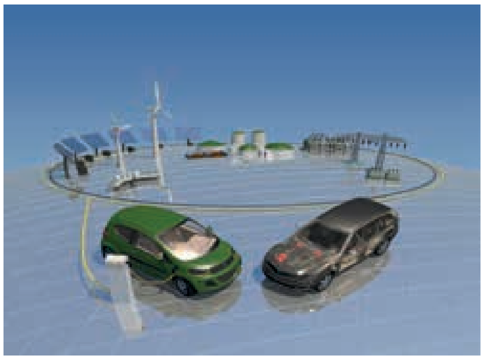

Figure 91: Charging points and connectors are the link between electromobility and the grid – source: Harting

Figure 92: Circuit breaker for electromobility – source: TE Connectivity

The voltage and current classes are defined by the respective drive concept. These are not standardised, but vary between the OEMs and in individual OEMs' own model classes. As a consequence, current systems are normally custom-designed.

Both circular and rectangular contact systems are used, which are mostly shielded.

Hybrid and electric vehicles are subject to significantly higher temperatures and vibrational forces than conventional vehicles. This places more stringent requirements on the connector design, base materials and contact surfaces.

Currently, there is a need to define standards in different regions and OEM working groups. Concrete specifications have been defined only for isolated cases, with each OEM relying on individual solutions most of the time. Furthermore, the regulatory framework with regard to safety requirements varies from one region to another.

5.4.3. Charging connectors for electric vehicles and plug-in hybrids

A standard charging infrastructure is crucial for electromobility. Electric vehicles worldwide are reliably charged with the aid of standardised connectors. Although there may be regional variations in the design of these connectors, they all conform to a standard. There are three different standards for charging connectors: **Type 1**, **Type 2** and **GB/T**.

Figure 93: AC/DC charging plug with Combined Charging System (CCS) – source: Phoenix Contact

The Type I connector conforms to standard SAE J1772 and is used in the American and Japanese market. In the past some vehicle manufacturers installed the Type I standard in vehicles for Europe. Now, however, vehicles for the European market are fitted with the Type 2 connector as standard, which conforms to IEC 62196. The GB/T connector is used by vehicle and infrastructure manufacturers in the Chinese market.

Since European vehicle manufacturers have exclusively adopted the Type 2, manufacturers of charging infrastructure have followed their example. Type 1 to Type 2 adapter cables are available for European cars fitted with a Type I vehicle inlet (charging socket).

Figure 94: Electric vehicle charging point – source: Harting

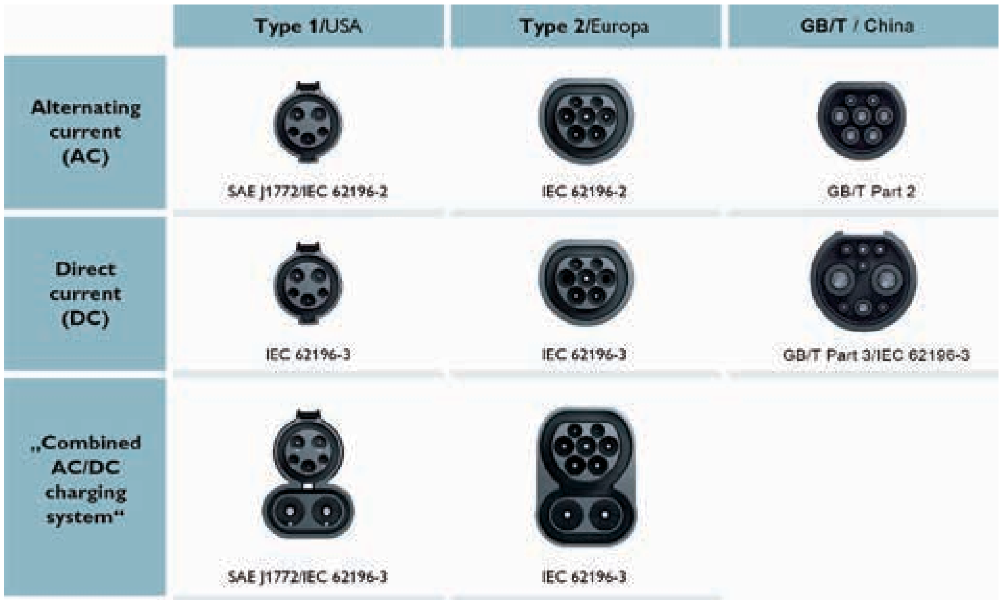

Figure 95: Overview of international charging standards – source: Phoenix Contact

The majority of vehicle and infrastructure manufacturers rely on the **Combined Charging System (CCS)**. The CCS vehicle socket has a DC rapid-charge port which allows the vehicle to be charged in under 30 minutes. The CCS vehicle socket is available in the Type I and Type 2 standard. The mating face of this vehicle socket is designed to receive either an alternating current (AC) charging plug or a direct current (DC) charging plug of the same standard. This means that the vehicle can be charged overnight by plugging into a household socket, a wall box or an AC or DC charging point. The CCS vehicle socket is the ideal charging interface for everyday charging.

6. Terms and Definitions in Connector Technology

Adapter connector
Fixed or free component (➩attachment) to permit electrical connection between two or more connectors where direct connection is mechanically impossible.

Attachment
A distinction is made between:
- fixed connectors for attachment to rigid surfaces, e. g. rack, slot, wall, board, device
- floating connector, i. e. fixed connectors which tolerate a certain degree of movement during attachment to facilitate connection to a mating connector
- free connectors for attaching to the free ends of flexible conductors or ➩cables
- free coupling connectors for connections between cables or conductors.

Attenuation of optical fibres
Attenuation at a given wavelength is the reduction of optical signal power between two points of an optical transmission path. It is caused mainly by dispersion and light loss in ➩connectors and ➩splices (➩insertion loss ➩coupling losses). It is expressed as the attenuation coefficient of attenuation A in dB/km.

Bayonet coupling
This technology uses a rotatable bayonet ring to lock together the two mating parts (e. g. BNC connector). ➩Coupling types

Blade contact
Flexible ➩contact with a rectangular cross-section, usually with a chamfered mating edge or tip.

Blade contact strip (multipoint connector)
➩Solid connector with ➩blade contacts in a linear arrangement.

Butting connector
Connector in which connection is achieved by non-penetrating contacts and maintained by axial pressure.

Cable
In contrast to a ➩wire, a cable is suitable for permanent installation. Cables may be laid inside, outside, underground and in water. Cables can have thicker insulation and sheathing and higher quality insulation and sheath materials to suit their intended use e. g. for laying underground or in a harsh industrial environments. Cables are always encased in a sheath which can be made from plastic, rubber or even metal. The terms cable and wire are often used interchangeably ➩wire.

Cable outlet
Exit opening for a cable of a connector from its ➩housing. The cable outlet may be straight or angled and may incorporate a ➩strain relief clamp, seal and shielding.

Characteristic values
Values which form the basis for rating a component.

Circular connector
Connector which is basically cylindrical and has a mating face with a basically circular body.

Clamp connection
A solderless connection made by pressing a stripped wire into a clamp.

Clean-body contact
Contact without snap-in hooks which locks over the housing.

Clearance
The shortest distance in air between two conductive parts (as per DIN EN 60664, DIN VDE 0110).

Click-in connector technology
Simple push-and-click connection system.
➩Push-in connector technology

Climatic data (characteristic values)
General term for climatic characteristic values such as high and low temperatures, tropical climate, termite damage, high air humidity (➩damp heat), low air pressure, atmospheric influences (➩industrial atmosphere). Climatic conditions for tests are laid down in DIN EN 60068 and DIN EN 60512.

Clip locking
A locking device operated by actuating a lever designed as a clip to hold two mated connectors together.

Coaxial connector
According to DIN 47299, a coaxial connector is a connector for coaxial cables and pipes with an inner conductor and a coaxial outer conductor. Coaxial connectors comprise a ⇨coupler and a connector.

Coding (alignment)
Designed to prevent mismating, e. g. by
- mechanical structures (e. g. polarisation)
- visual identification (e. g. colour-coding)

Compatible connector
Two connectors are compatible when they are mechanically interchangeable and intermateable and fulfil the same technical requirements.

Conductance
⇨Contact materials vary in their ability to conduct electrical current. Conductance is the reciprocal value of resistance.

Conductor barrel
Section of a terminal end or splice which accommodates the conductor.

Conductor resistance
Electrical resistance of a conductor, determined by its length, cross-section and the ⇨conductance of the material.

Connection
An electrical connection consists of two ⇨connectors, i. e. at least two contact elements. All other components such as housing, contacts folder, contact retainer etc. perform secondary functions.

Connection slot
Specially shaped opening of an insulation displacement termination suitable to displace the insulation of a wire and to ensure a gas-tight connection between the termination and the conductor(s) of the wire.

Connector
Component which terminates electrical conductors for the purpose of providing connection and/or disconnection to a suitable mating component.
Connectors are operating materials which, when used as intended, are not to be inserted or withdrawn live (in contrast to ⇨plug-in devices). Depending on the ⇨attachment, connectors are classified as detachable or permanent. A connector comprises the connector housing and the contact elements. The connector housing contains the ⇨contact holder and the ⇨contact retainer, where applicable.

Connector family
Connectors belonging to the same connector family have similar characteristics. The mating dimensions are specified in the standard for the connector type. Connectors of the same construction and based on the same design principles but in different sizes are also designated as a connector family.

Connector housing
Part of a connector which accommodates the connector insert and contacts.

Connector, scoop-proof
Connector featuring a longer shell design on the PIN half that protects the contact pins (male or female) from getting damaged when the mating shell is "scooped" into it during the mating process.

Connector style
Particular connector within a type, e. g. rectangular connector with mounting flange.

Connector technology
Methods for connecting wires to the components, e. g. solderless connections compliant with IEC 60352 and DIN EN 60352: crimped, wrapped, press-in, piercing, spring-clamp and insulation-displacement, screwed and soldered connections as well as fusion or adhesion for optical fibre connectors.

Connector type
Connectors within a particular subfamily, e. g. connectors for printed circuit boards.

Connector with assessed quality

Connector, which is produced and tested in accordance with a quality assessment specification. Connectors of this type are widely used in commercial, military and aerospace applications.

Connectors with breaking capacity (formerly: plug-in device)

Operating materials which, when used as intended, are designed to be inserted or withdrawn live or under load (in contrast to ⇨connectors). The earthing contact has to premate during insertion and retard during removal of the connector. ⇨pre-mating contact

Contact arrangement

Number, spacing and configuration of contacts in a connector or component.

Contact area

Physically effective area which allows electrical current to flow between two ⇨contact elements, two electrical conductors or a conductor and a contact.

Contact, bifurcated

A resilient ⇨forked contact element forming two arms which press down independently in the same direction on a shared counter contact.

Contact density

Frequency of occurrence of contacts in a ⇨mating face. ⇨Contact arrangement

Contact, electrical

According to VDE 0660 an electrical contact is the condition that arises when the ⇨contact surfaces of two electrically conductive contacts touch each other, allowing electric current to pass from one to another.

Contact element (contact)

An electrically conductive part in a component which achieves an electrical connection (⇨electrical contact) via its mating part. The contact elements are the parts of a connector responsible for the electrically conductive function. They comprise a mating area and a terminal area. The terminal area may be fixed or detachable. Soldered, crimped, insulation-displacement, wire-wrap and press-in connections are fixed. Screwed and spring-clamp connections are detachable.

Contact, female (socket)

⇨Contact element intended to make electrical contact on its inner surface and which can accommodate a suitable male contact.

Contact float

Permitted free movement of a contact in a component.

Contact force

Perpendicular force exerted on the ⇨contact surface (normal force) providing contact pressure.

Contact holder and contact retainer

The contact holder houses the individual contact elements and also acts as an insulator. The contact holder can also be the housing. The contact retainer holds the contact element in place.

Contact, male (pin)

⇨Contact element intended to make electrical contact on its outer surface which can be inserted into a suitable female contact.

Contact material

The choice of contact material – usually copper or copper alloys – depends on the required characteristics of the connector.
Contact resistance and insertion and withdrawal forces are particularly important in this respect. In addition to mating cycles and environmental influences, these characteristics also determine the choice of surface coating, e.g. nickel, tin, gold, silver, palladium. Surface coatings are applied by electroplating or rolling. ⇨Contact surfaces

Contact, resilient

⇨Contact element, which can exert a force on its mating part due to its elastic properties.

Contact resistance

Electrical resistance between the mated set of contacts in the ➪contact area. It comprises ➪constriction resistance and ➪contamination resistance.

Contact retainer

Device either on the contact or in the insulating body (contact insert) used to retain the contact in the insulation.

Contact size

Designation used to differentiate contacts according to one of the following systems:

- Labeling **system:** The size of the contact is denoted by the maximum connectable wire size (AWG – American Wire Gauge).
- **Current rating system:** The size of the contact is denoted by its maximum current-carrying capacity ➪nominal current
- **Cross-sectional area system:** The size of the contact is denoted by the maximum connectable cable cross-section ➪conductor resistance

Contact style

A distinction is made between pin, blade, spring, jack, fork, tulip, hermaphroditic contact etc. depending on the shape.

Contact surfaces

To achieve the lowest possible ➪contact resistance, contact surfaces must be as uniformly flat as possible to minimise ➪constriction resistance and surface coatings must be made from precious metals or tin to minimise ➪surface contamination resistance.

Contact zone

Minimum to maximum distance between the reference planes of a pair of connectors within which the specified parameters are met (contact overlapping allowing for possible misalignment of contact elements).

Coplanarity

Flatness of the connector pins of a SMT component on the circuit board.

Core

Assembly comprising a conductor with its own ➪insulation including any conductive layers. ➪Cables can have one or several cores.

Coupler

Passive optical component which transmits light between a light source and one or more ➪optical fibres.

Coupling losses

➪Attenuation losses which occur at the point where two fibre-optic cables meet.

Coupling types

Various locking mechanisms are used to couple circular connectors:

➪bayonet coupling
➪rotary coupling
➪pull-off coupling
➪push-pull coupling
➪screw/quick connect and disconnect coupling

Creepage current

Current flowing across the surface of an insulating material between live metal parts.

Creepage distance

Shortest distance along the surface of an insulating material between two conductive parts. Variations in the tracking resistance of insulating materials must be taken into account when specifying creepage distances.

Crimping die

Part of a crimping tool which deforms the crimping zone and usually incorporates the crimp anvil, crimp indentor and tool positioner.

Crimping zone

Part of a crimp barrel where the crimped connection is achieved by pressure deformation or reshaping of the barrel around the conductor.

Crimp barrel (ferrule)

Conductor barrel(ferrule) designed to accommodate one or more conductors and to be crimped by means of a crimping tool.

Crimp barrel (ferrule), closed
A ⇨crimp barrel (ferrule) with a closed shape before crimping.

Crimp barrel (ferrule), open
A ⇨crimp barrel (ferrule) with an open shape before crimping.

Crimp barrel (ferrule), pre-insulated
A ⇨crimp barrel (ferrule) with a permanent layer of insulation on the outside through which the crimp is made.

Crimp contact
A contact having a conductor barrel designed to be crimped.

Crimped connection
A solderless connection formed (made) by crimping. The crimping zone of the contact part is deformed by means of a crimping tool to establish a permanent, gas-tight connection between contact and conductor. Single or multiple-wire conductors as well as superfine stranded wires can be crimped. Crimped connections can be made using hand crimping tools or by semi-automatic or fully automatic crimping machines. Stripping of wires and crimping can be accomplished in one step.
(Requirements and testing as per DIN EN 60352)

Crimping
Method of permanently reshaping the barrel around an electrical conductor to establish good electrical and mechanical connection.

Current-carrying capacity
Rated currents, contact size

Damp heat
Standardised testing of temperature and moisture loading.

Derating curve
The graphic representation of the current-carrying capacity of a component dependent on the ambient temperature. From the derating curve it is possible to deduce which currents can continuously be carried simultaneously through all contacts at a specified ambient temperature without exceeding the upper limiting temperature.
(Testing as per DIN EN 60512-5-2)

Direct insertion
For ⇨PCB connectors: Connector into which the edge of a printed board is inserted to make contact directly to edge-board contacts. ⇨Indirect insertion

Dynamic stress
General term describing conditions such as vibration, acceleration, impact, shock and drops.

Electrical data
General term for electrical characteristics such as ⇨rated voltage, ⇨contact resistance, ⇨overvoltage category, etc.

Electrical engagement length
Distance a contact glides on the surface of its mating contact during engagement and separation.

Electromagnetic interference
As far as connectors are concerned, undesirable electro-magnetic disturbance of cables or the environment is prevented by ⇨shielding. Connectors normally have a mechanism to attach and contact the cable shielding to the cable outlet.

Electro-optical converter
⇨Receiver, optical

Engaging force
Force required to engage or disengage fully a pluggable component including the effect of a coupling, locking or similar device.

Environmental conditions

General term for environmental influences which have an effect on connectors (temperature, air humidity, condensation, air pollution, etc.):

- An environmentally stable connector is protected against high humidity, excess temperature and impurities.
- Connectors are deemed to be submersible if they can withstand immersion to a specified depth of water.
- Fire-proof connectors are briefly flame-proof under specified conditions.
- Gas-type connectors have a seal which provides a specified gas tightness.

Equipment practice

Mechanical structure involved in the housing and mounting of electronic and electro-mechanical systems.

Female multi-point connector

Connector with a linear arrangement of ➪spring contacts.

Field-assembly connectors

Connectors which can be connected to a cable in the field.

Filter connector

Connector with integrated attenuation of interference voltages in certain frequency ranges.

Fresnel loss

Loss of optical signal caused by reflections (➪reflection factor) on optical boundaries

Hermaphroditic contact

A contact which is intended to mate with an identical contact. The ➪contact element is neither to be designated as male or as female.

Housing and accessories

The purpose of the housing is to protect all connector components and prevent contact with electrical parts. It can be made of plastic or metal (with a contact holder for insulation). The housing and accessories may perform additional functions such as:

- locking
- polarisation
- coding
- electrical shielding
- sealing
- strain relief.

The electrical contact elements have different types of connection for attaching the cables depending on the application. IEC 60352 DIN EN 60352 distinguishes between soldered connections and solderless connections.

Housing seal

➪Seals

Hybrid connector

A hybrid connector combines different contact types and systems in one housing. ➪Modular connector

Indirect insertion

Connection of circuit boards or cables via pin and jack contacts.

Industrial atmosphere

An atmosphere contaminated by industrial exhaust gases (such as sulphur, chlorine and nitrogen compounds). ➪Resistance to climatic conditions (test procedures as per DIN EN 60512-6-7, Test 11)

Insulation

Non-conductive intermediate layer and/or cover intended to separate live parts and prevent access to them.

Insulating body (insulator)

Part of a connector, in most cases identical to the contact.

Insulation coordination
Reciprocal assignment of the insulation parameters of electrical equipment which takes into account expected micro-environmental conditions and other relevant stresses.

Insulation displacement connection (IDC)
Solderless connection made by inserting individual wires into precisely aligned slots such that the sides of the slots pierce the insulating sheath.

Insulation displacement termination
Termination intended to accept a wire to produce an ⇨insulation displacement connection.

Insulation group
Obsolete and no longer used, see ⇨overvoltage category and ⇨degree of contamination.

Insertion loss
The loss of power from ⇨optical fibre caused by the insertion of an optical component, e.g. a ⇨connector or a ⇨coupler into an optical transmission system. When connecting identical optical fibres, loss may be caused by misalignment, ⇨fresnel's reflection loss, contamination etc. When connecting different optical fibres which are otherwise perfectly aligned, loss may be caused by different optical parameters. Loss is generally directional.

Insulation materials
Plastics are the only insulation materials used for connectors. The choice of material depends on the thermal and mechanical properties required. Both thermoplastic and duroplastic materials have proved suitable for use with connectors.

Insulation material group
Classification of insulation materials into four groups according to their CTI values (comparative tracking index): Group I, II, IIIa and IIIb.

Insulation piercing connection (IPC)
Solderless connection in which suitable contact elements (e. g. blades(lances), spikes(tips) and sharp edges) pierce through the cable insulation to provide contact with the conductor. This connection technology requires the precise alignment of the individual conductors. All terminals within the connector can be contacted in a single operation.
(Requirements and testing as per DIN EN 60352-6)

Insulation resistance
Resistance of the ⇨insulation between two conductive parts(elements). The insulation capacity of a material which separates two adjacent contacts or one contact to earth with maximum impedance.
(Measurement and test procedures as per DIN EN 60512-2-3-1, Test 3a)

Insertion or withdrawal force
Force required to fully insert or withdraw a set of mating components without the effect of a coupling, locking or similar device.
(Testing as per DIN EN 60512-13-2, Test 13b)

Interface
Boundary and transition between two systems that are compatible, i. e. they must be interchangeable and share the same characteristics. Interfaces are generally internationally standardised.
⇨mating face

Inverted connection
⇨Indirect connection whereby the ⇨female multi-point connector is mounted on the non-live side (PCB-side) rather than the live side (wiring side).

I/O
Input/output

IP code (ingress protection)
Rating which indicates the degree of protection afforded by a housing against ingress of external media such as dust and/or water.

Latching mechanism

Mechanical retention of a mated pair by snap-in hooks, slider, clip and toothed segments (locking).

Limiting temperatures

Upper and lower temperatures which will not cause damage to materials. The ➪operating temperature range lies between these temperatures.

- **Lower limiting temperature:** Minimum permissible temperature at which a connector or plug-in device is intended to operate.
- **Upper limiting temperature:** Maximum permissible temperature at which a connector or plug-in device is intended to operate. It includes self-heating (including contact heating) and ambient temperature.

Locking mechanism

Locking or coupling mechanisms (➪coupling types) are generally mechanical devices mounted on the connector housing which engage securely with one another to prevent unintentional separation of the connection.

➪bayonet coupling
➪locking
➪rotary locking
➪pull-off coupling
➪push-pull coupling
➪snap-lock
➪screw lock
➪spring-latch coupling

In addition, in the automotive sector individual contacts are retained in the plastic body by a two-step locking mechanism (primary and secondary).

Lower limiting temperature

Minimum permissible temperature specified by the manufacturer at which a connector is intended to operate.

Low-frequency connector

According to the International Electrotechnical Commission (IEC), low-frequency connectors are suitable for use with frequencies below 4 MHz.

Making and breaking capacity

Value of a current which the ➪connector with breaking capacity (formerly: plug-in device) can make and break under specified conditions.

Mating cycles

Mechanical operation of ➪connectors and ➪plug-in devices by insertion and withdrawal. A mating cycle comprises one insertion and withdrawal operation.

Mating face

Mechanical interface between a connector and a suitable mating component.

Mechanical data

General term for mechanical characteristic such as protection system, insertion and withdraw force, mechanical endurance, vibration, etc.

Mechanical endurance

Number of mating cycles that can be performed before the ➪contact surfaces become abraded, causing ➪contact resistance to increase to an unacceptable level. (Measurement and test procedures as per DIN EN 60512-9-1, Test 9a)

Mixed strip/connector

Mostly ➪PCB connectors with different types of contact, e. g. various designs of electrical contact or contacts for ➪coaxial connectors and optical fibre connectors.

Modular connector

Similar or different contact systems combined in a common housing.
➪Hybrid connector

Multi-mode fibre

➪Optical fibre with a step-index or a graded-index profile which supports propagation in several modes. An optical fibre with a step-index profile is characterised by a uniform refractive index within the core and a sharp decrease in refractive index at the core-cladding interface. A graded optical fibre has a graded-index that is constant across the cross-sectional area of an optic fibre.

Nominal current
Effective value of the current which is permitted to flow through all contacts of a connector simultaneously taking into account the connector test category and its self-heating. ➪Limiting current, ➪limiting temperature.

Nominal voltage
Suitable approximate value of the voltage used to designate a component.

Non-rewirable connector
Connector so constructed that the flexible cable cannot be separated from the connector without making it permanently unusable.

Operating temperature range
Range between upper and lower limiting temperatures that can be utilised in an application.

Operating voltage
Voltage which may be permanently applied between specified contacts or to the ground.

Optical fibre
Dielectric waveguide with a core consisting of optically transparent material with low ➪attenuation (quartz glass or transparent plastic) and a sheath with a lower refractive index than the core. It uses electromagnetic waves to transmit signals in the optical frequency range (light). The term "glass fibre" is also used in place of optical fibre. Optical fibres are usually coated. They can have different modes (discrete lightwave forms or propagation paths).

Overvoltage category
Assignment of an electrical operating material to the anticipated overvoltage. Overvoltage is classified into overvoltage category I, II, III and IV.

PCB
Abbreviation for ➪printed circuit board

PCB connectors
Connector for mounting on a circuit board or plugging into a circuit board (➪direct insertion). Connectors for mother-daughter circuit boards connect these boards together.
➪Indirect insertion

Pin-in-Paste
➪through-hole-reflow (THR)

Pitch
According to DIN EN 40801 pitch denotes the distance between two adjacent gridlines on which contacts, mounting holes etc. are located. Typical pitch values for printed circuit boards are 2.54 mm (0.1"), 1.27 mm (0.05") and 0.635 mm (0,025") and hard metric values such as 2.5 mm, 2.00 mm, 1.25 mm, 0.635 mm and 0.5 mm.

Plug
In optical fibres, a component that enables quick and easy connection and disconnection of two ➪optical fibres (usually the insertion loss of a plug is higher than that of a ➪splice). The term "plug" is also commonly used in place of connector, e. g. power plug, antenna plug, HF adapter plug etc.

Plug-in unit
Mechanical structure designed to accommodate electrical and electronic assemblies.

Pollution degree
Characterising the expected pollution of the micro-environment. Pollution degrees 1, 2, 3 and 4 are used. Allocation of clearance and creep pitch distances.

Pre-mating contact
Extended contacts are used if the circuit design requires one or more contacts of a connector to be connected first before the other contacts (protective conductor or to earth) and to be disconnected last (first make-last break).

Press-in connection
Solderless electrical connection made by inserting a compliant or a solid press-in pin into a plated-through hole of a printed circuit board. Compliant press-in pins are optimally adapted to the specific hole diameter and minimise mechanical stresses exerted on the printed board.
(Requirements and testing as per DIN EN 60352-5)

Press-in pin

Termination having a specially shaped section suitable for a solderless press-in connection. There are two types of press-in pin:

- **Solid pins:** These have a solid press-in zone. The forces necessary to provide the press-in connection are generated by deformation of the plated-through hole into which the solid pin is inserted.
- **Compliant pins:** These have a compliant press-in zone. The forces necessary to provide the press-in connection are generated by deformation of the compliant pin.

Printed circuit board (PCB)

The term includes circuit boards with conductive patterns printed on one or both sides and multi-layer boards. These circuit boards have plated-through holes for axial ⇨soldered connections, for solid or compliant press-in pins (⇨press-in pin, press-in connection) or connection points (pads) for surface mounted devices (SMDs).

Protected connector (class II)

Connector having double or reinforced insulation to protect against unintentional contact (direct contact).

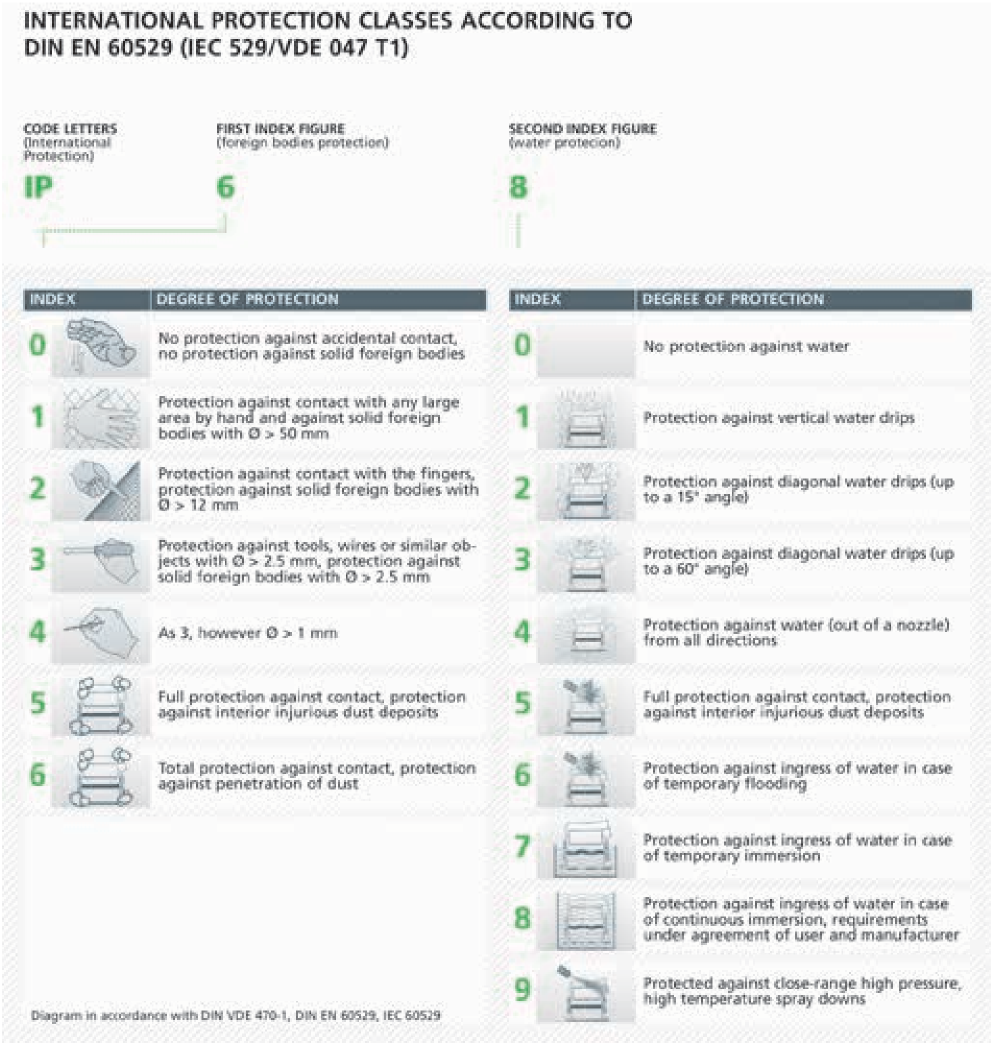

Figure 96: IP protection classes – source: Lumberg

Pull-off coupling
Coupling mechanism in which unlocking is achieved by an axial pull on a coupling ring mounted on the connector housing. ➩Coupling types

Push-in
A variation of the ➩spring clamp for connecting solid wires via direct insertion without the need for tools.

Push-on contact
Contact with which a connection is achieved by axial force, separation being restricted by friction, e. g. for DIN 46244 and DIN 46247 tab connectors.

Push-pull connector
Connector having a push-pull coupling.

Push-pull coupling
Quick self-locking coupling device mainly used in circular connectors. Locking and unlocking is achieved by an axial pull on the coupling ring.

Pull-release
Pull-release connectors automatically unlock and decouple when a specified tensile force is applied to the ➩cable.

Quick connect and disconnect coupling
Type of locking mechanism for quick, screwless connection (e. g. ➩bayonet, ➩push-pull).

Rack and panel connector
Connector intended to provide an electrical connection between mounting racks and devices and their plug-in or similar units. These are normally equipped with an alignment device to ensure correct mating.

RAST
German acronym for "Raster-Anschluss-Steck-Technik", roughly translated as Pitch Connection Plug Technology

Rating values, electrical
A distinction is made between:
- **Rated voltage:** Value of voltage assigned by the manufacturer to a component and to which operation and performance characteristics are referred.
- **Rated impulse voltage:** Value of an impulse withstand voltage assigned by the manufacturer to the connector characterising the specified withstand capability of its insulation against transient over voltages. (Basis for determining clearance distances)
- **Rated current:** Value of the electrical current which a connector or plug-in device can carry continuously (without interruption) and simultaneously through all its contacts without exceeding the upper ➩limiting temperature.
- **Test voltage:** Voltage which a connector or plug-in device is able to withstand under specified conditions without disruptive discharge or flashover.
- **Making and breaking capacity:** Capacity which a ➩plug-in device is able to switch under specified conditions.

Receiver, optical
Assembly for the conversion of optical signals into electrical signals. It comprises a photodiode with ➩terminal fibres and ➩connectors as well as a low-noise amplifier and electronic circuits for signal preparation. Where possible, the main components of a receiver are usually combined to form a compact subunit, the receiver module.

Rectangular connector
Connector which is basically rectangular and has a basically rectangular mating face.

Reference voltage
➩Rated voltage

Reflection coefficient
In coaxial cables, the ratio of the value of the voltage of the reflective wave to that of the incident wave.

Ribbon cable connector
Connector which can be connected to ribbon cables by means of ➩insulation-displacement or ➩insulation-piercing technology.

Rotary locking
A device for the mechanical coupling of two connectors by rotation after axial insertion.

Screw connection
In a screw connection the stripped wire is clamped to the contact part of the connector by a screw. This clamping screw may act both in the longitudinal axis (axial clamping screw) of the conductor and transverse to the conductor and can easily be unscrewed.

Screw lock
Use of one or more screws to locate connectors.

Seals
Seals are designed to prevent the ingress of moisture and contaminants. Seals can be classified as follows in accordance with DIN 47 299 Part 1:

- **Longitudinal seal/barrier seal:** Seal inside a connector which prevents the passage of gases or moisture between the housing and insulating body as well as between the insulating bodies and contacts.
- **Transverse seal:** Seal at the mating point or covering the entire plug system which prevents the ingress of gases or moisture into any part of a mated connection.
- **Mounting seal:** Seal which prevents the passage of gases or moisture through the gap between the installation hole in the chassis and the body of the fixed connector.
- **Hermetic seal:** Longitudinal and/or mounting seal which satisfies the Qk test as per DIN 40 046 Part 15.

Shield effectiveness (screening attenuation)
Difference between the field strength inside the cable and that outside the shield.

Shield terminal
➩Strain relief clamp for connection of the shield braid of a cable.

Single-mode fibre
Optical fibre which supports propagation in one mode only, the basic mode. The fibre radius in this case must be between 2 and 8 µm. Single-mode fibres have very low attenuation losses.

Smart card connector
Connector designed to provide electrical connection to chip cards.

SMT (surface-mount technology)
Method of soldering surface-mounted components onto circuit boards without using through-holes.

Snap-in contacts
➩Contact elements which are retained by snapping a locking lance into the ➩contact retainer or by snapping resilient elements of the contact retainer behind a locking shoulder of the contact element in the contact holder. They can be disengaged either from the front, i.e. from the mating face, or from behind, i. e. from the wiring side.

Snap-lock
Mechanical engagement of one or more lugs of the connector housing in corresponding slots in the mated housing.

Soldered connections
A soldered connection is a semi-detachable connection technique using soft solder.

Splice connection
Permanent connection of two ➩optical fibres which is accomplished by fusing (fusion splice) or gluing (mechanical splice) the ends together.

Spring-clamp connection
Solderless electrical connection achieved by clamping a single stripped wire with a spring-clamp termination. The connection can be detached only by releasing the spring. Several spring-clamp connections can be combined in one insulated housing.
(Requirements and testing as per DIN EN 60352-7)

Spring contact
Elastic contact element of a connector, e.g. a female multi-point connector, as opposed to a rigid ➩blade contact, e.g. in a male multi-point connector, which exerts forces on its mating part due to its elastic properties.

Spring-latch coupling
Fixing an actuator lever in mated condition.

Strain relief
Cable accessory on the housing or connector to protect the cable, connections and contacts from excess mechanical stress.

Terminal
Part of a component which provides a re-usable connection.

Termination
Permanent connection
Part of a contact element, terminal or terminal end to which a conductor is connected.

Test voltage
Voltage which a connector or ➩plug-in device is able to withstand under specified conditions without disruptive discharge or flashover. The test voltage is above the ➩nominal voltage. It is used to test the insulating capacity of the connector.

Through-hole reflow (THR)
Unlike conventional ➩SMD assembly, with THR the SMD components are placed on the SMT board together with wired components (➩PCB connectors) and reflow soldered. THR technology offers higher mechanical strength than ➩SMD technology. The process is also referred to as ➩Pin-in-Paste (PIP)

Tuning fork contact
➩Resilient contact having a shape similar to that of a tuning fork, the two arms of which apply contact force in opposite directions.

Umbilical connector
A connector used to connect a cable to a vehicle (aircraft) which is separated automatically before or during the initial movement of the vehicle.

Upper limiting temperature
Maximum permissible temperature specified by the manufacturer at which a connector is intended to operate. It includes self-heating of the contacts by the current and ambient temperature.

Volt-free-switching
Mechanical or circuit-based (wired) measure which automatically ensures zero-potential insertion and withdrawal.

Wire
Wires consist of one or more ➩cores, their insulating sheaths (if any), their ➩shielding (if any) and their protective covering (if any). The terms cable and wire are often used interchangeably. Flexible cables, ribbon cables, hoses, shielded cables and coaxial cables are predominantly used for connection to connectors. For further definitions see ➩cable.

Working voltage
Highest r. m. s. value of the AC or DC voltage across any particular insulation which can occur when the equipment is supplied at rated voltage.

Wrapped connection
A solderless connection achieved by wrapping a connector around a sharp-edged wrap post under controlled mechanical tension.

Zero insertion force connector
Connector designed to eliminate insertion and withdrawal forces during mating and unmating (keylock connector). ➩ZIF connector

ZIF connector
ZIF ➩zero-insertion force connector

7. Members of the Connector Department at the ZVEI

AB Elektronik

Amphenol-Tuchel Electronics

Conec Elektronische Bauelemente

Contact

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Delphi

Escha Bauelemente

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Franz Binder

Harting

Hirschmann Automation and Control

HoTec Electronic Hollenberg

Huber + Suhner

Hummel

ITT Cannon

Kostal Kontakt Systeme

Lear Corporation

Lumberg

MCQ Tech

Metalluk Bauscher

Molex Deutschland

MPE - Garry

Multi-Contact Deutschland

ODU

Pancon

Panduit Europe

Pepperl + Fuchs

Phoenix Contact

Provertha Connectors, Cables & Solutions

Radiall

Schaltbau

Spinner

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