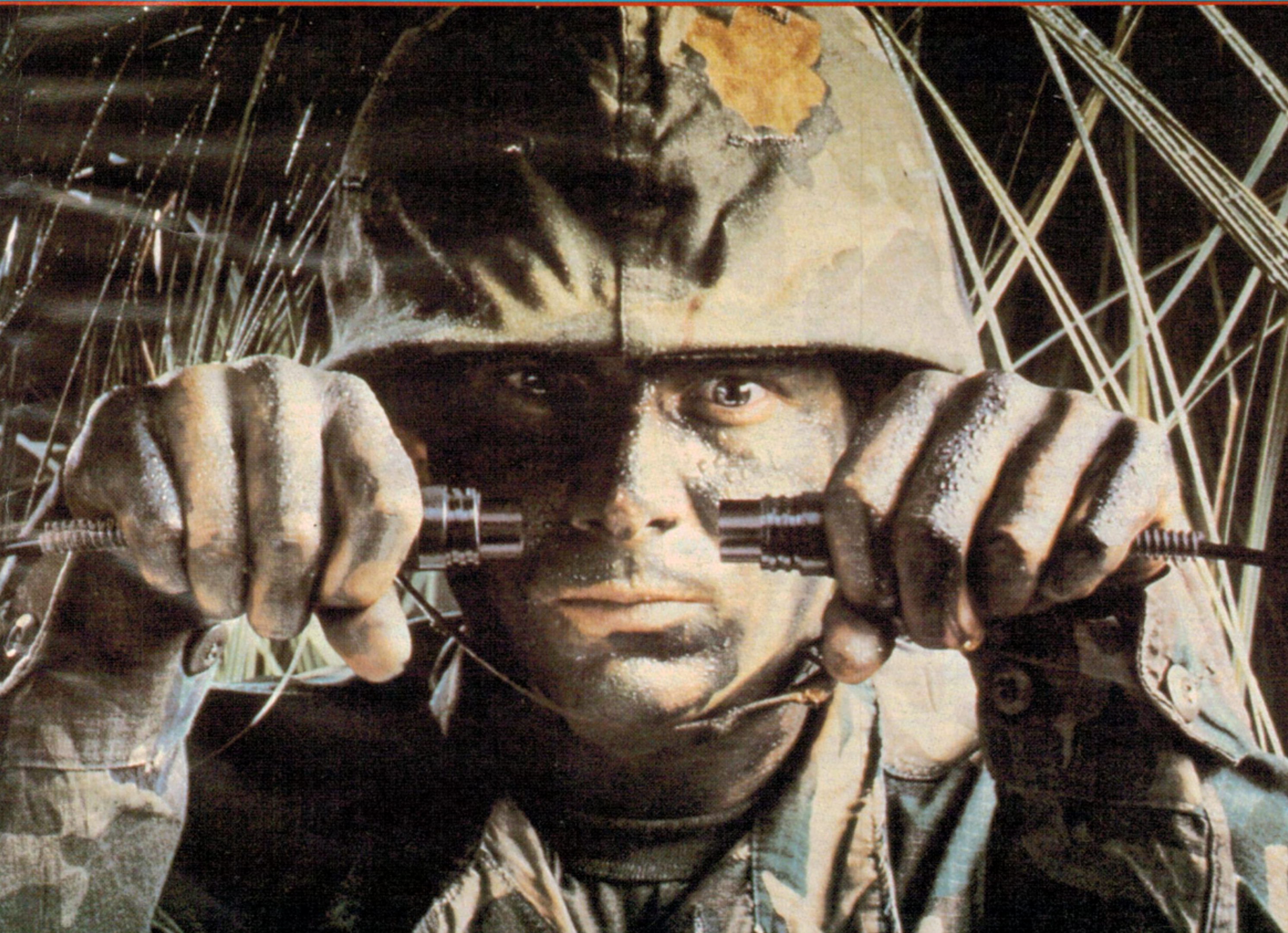
BATTLING THROUGH THE

CONNECTOR JUNGLE



THROUGH THE CONNECTOR JUNGLE

Jon Fairall

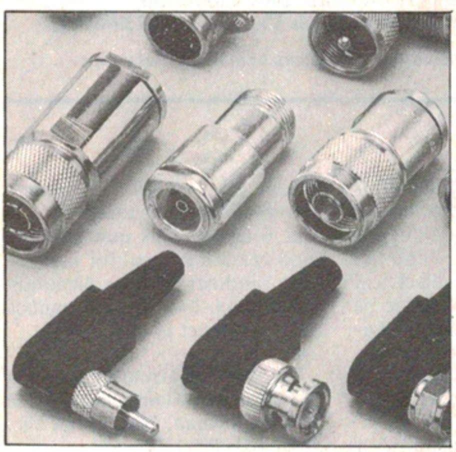
A WAG ONCE NOTED, with regard to the opposite sex, that there were fat ones and thin ones, big ones and little ones. He might have been talking about connectors.

To be a little more precise, connectors are the electromechanical devices that serve to interconnect the separate parts of a system, whether via wires, cables or printed circuit boards.

We have broken this huge field up into a number of categories based on the application of the connector, and then listed the most important types for that application, together with some information on the advantages and disadvantages of each type.

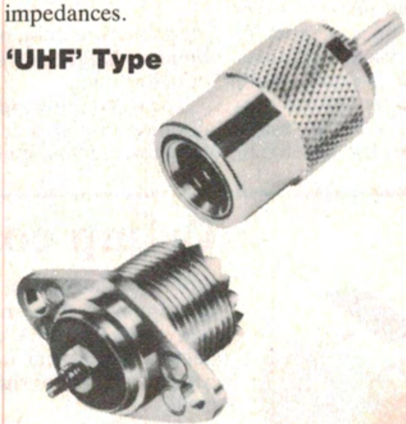
RF CONNECTORS

Radio frequency connectors are used in systems up to 10 GHz. By far the majority of RF connectors made are meant for attachment to coaxial cables. As a general rule, the different types of connector can be categorized according to the highest frequency they are designed to work. The higher the frequency the greater the dimensional precision and stability required. Also, the greater the price.



RF connectors are also categorised according to the characteristic impedance of the cable. Typical values of coaxial cable are 50 or 75 ohm. Most of the connectors listed here are available to suit both impedances.

'UHF' Type



There are a number of connectors especially made for connection to flexible coaxial cables. By far the most common are the PL259 and the SO239 type. These are US Army parts numbers for a plug and socket that have been adopted by the industry as a standard for working up to about 200 MHz. They are generally made of plated brass with a hollow centre pin. The dielectric can range from brown phenolic ('mud' in the trade) to PTFE (rare).

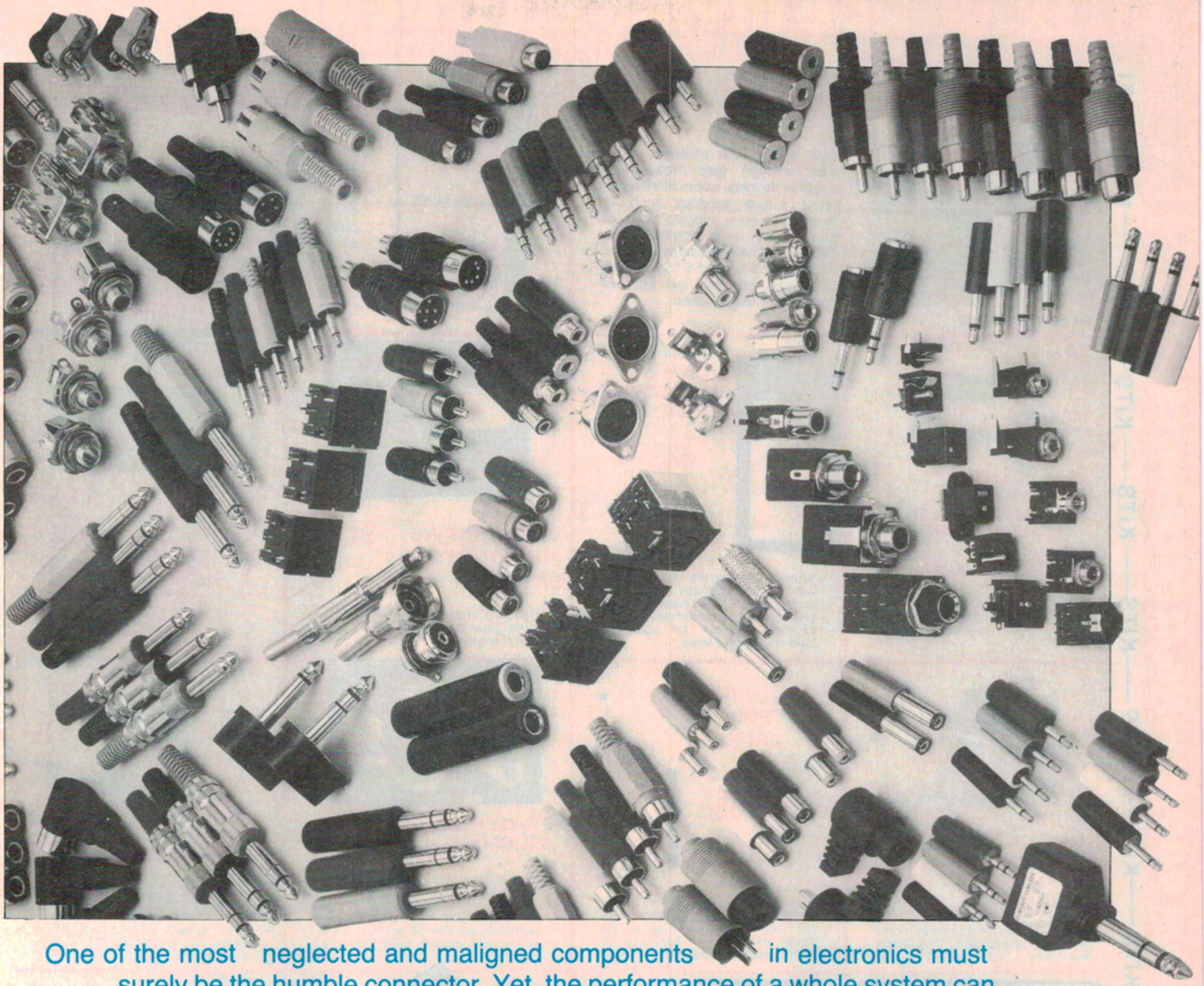
The PL259 plug has two parts: the body and the ferrule. The latter has an internal thread that mates with the socket which has an external thread (see illustration). The cable shield braid is soldered to the body just behind the mating shoulder. The latter has teeth on the facing edge that mate with teeth around the rim of the SO239. This prevents twisting in use. The centre pin of both the plug and socket is usually plated with one of the noble metals.

There are two sizes of PL259 available, intended for fitting on either 10 mm RG8/RG213 cable or 13 mm cable. The type to suit 10 mm cable is the most common. If there is a need it is possible to fit PL259s to 6.5 mm coax (RG58) with the use of an adaptor.

One reason for the popularity of UHF plugs and sockets is that when properly connected and terminated they are designed to be extremely rigid, so that they will hold even when subject to extremes of shock or vibration. They are also relatively inexpensive. However, they do have one limitation, and that is that they are not constant impedance types, and in modern applications they are not recommended above 50 MHz. They will give tolerable results up to about 200 MHz, and in fact were designed to do so, but now that better connectors for high frequency use are available they are losing favour in this type of application.

N-Type

One of the modern connectors to replace UHF types is the 'N-type'. This is a constant impedance type connector with much the same frequency limitations as coaxial cable itself — about 10 GHz. They tend to be about the same physical size as the UHF types, but the signal carrying components are recessed inside the body. Typically these will be silver plated spring copper while the body will be made of a hard copper alloy. The dielectric is usually PTFE. The plug's centre pin is solid, except for a short hollow section at the rear, designed to accept the cable inner conductor. The plug pin and the pin-socket in the socket mate such that the dimensional accuracy of the line is maintained. In addition, spring fingers in the plug mate with the inside rim of the socket, preserving the line's outer conductor integrity. It is these factors which make N-type connectors constant imped-



One of the most neglected and maligned components in electronics must surely be the humble connector. Yet, the performance of a whole system can critically depend on the performance of a single one. But, connector classes, types and styles must nearly match the species of life on Earth! It's a veritable jungle with many a pitfall and trap for the unwary. This article should help you battle through the connector jungle.

ance. Both 50 and 75 ohm versions are obtainable.

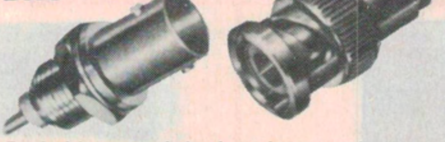
The N-type plug secures the cable's shield braid with an internal metal O-ring and clamp ferrule, plus a rubber ring that effectively seals the cable termination from the ingress of moisture. While originally designed to have the centre pin soldered to the cable centre conductor, crimp-on models have recently become available. Like the PL259, the N-type plug has a threaded ferrule to secure it to the socket.

When the plug and socket are properly screwed together the fitting is virtually moisture-proof, which is one of the advantages of N-type connectors. The assembly is also mechanically very strong.

A similar quick connect/disconnect bayonet-type fitting is available, called the C-type.

N-type plugs and sockets are available in a positively huge variety of configurations: right-angle, line and chassis mount, shrouded, etc. Reducing adaptors are available for terminating smaller diameter cables. N-types for fitting to rigid and semi-rigid coax are also available.

BNC



Probably one of the best known of all the RF types. BNC connectors are typically used up to 1 GHz for attachment to the smaller diameter (5 mm, 6.5 mm) coaxial cables, such as RG58 and RG59. They are constant impedance types, and so preserve the impedance of the cable at least up to their design frequency. Their construction emulates the N-type, except that the BNC plug features a bayonet securing ferrule. Both 50 and 75 ohm versions are obtainable, though the 50 ohm type is the most common.

The body is made of plated brass, the dielectric usually being PTFE. The cable terminating arrangements are similar to the N-type. Crimp types have latterly become available, avoiding the necessity of soldering. Both the centre pin, shield braid and sheath are clamped, making this type of BNC mechanically very strong. A special tool is required.

The biggest advantages of BNCs are relative cheapness, small size and the fact that the bayonet lock allows for quick and easy connect and disconnect.

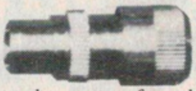
BNC connectors come in a number of different configurations. You can choose between in-line or panel mounting versions, right-angle etc, for both the sockets and plugs. BNCs for fitting to rigid and semi- ▶

rigid coax can also be obtained.

Physically, they are quite a bit smaller than N-types or UHFs. It is possible to get versions sealed into nylon jackets to increase their resistance to oils, salt water and the like. Adaptors for fitting BNCs to small diameter coax are also available (e.g: to fit RG 734, 3 mm coax).

Typical materials used in BNC connectors include silver plated brass for the cable termination, and sometimes for the whole body of the plug. The centre contacts are usually beryllium copper or brass, a choice of contact material that minimizes contact erosion with repeated insertion.

Belling-Lee or PAL types



'Belling-Lee' is the trade name for the 'standard' 75 ohm coaxial connector for TV antenna installations, after the company, Belling & Lee, that first introduced them. Latterly, as many companies now make facsimilies, they are referred to as 'PAL' connectors (after the 625-line TV system). They are designed to be as simple and cheap as possible while still giving adequate service across the VHF and UHF television bands. Note that the Belling-Lee company makes a wide variety of all types of connectors.

The plug body has three parts: the barrel, ferrule and clamp. The barrel is generally made of aluminium alloy these days, though other alloys (e.g: brass) are sometimes employed. The ferrule serves to secure the clamp which holds the cable shield against the rear end of the barrel. The clamp is usually of plated copper and has fingers which also clamp the cable sheath when the ferrule is screwed down. The ferrule is made either of the body material or plastic. The cable centre conductor is passed through the hollow centre pin and soldered at the tip. The dielectric is generally a translucent thermoplastic and care has to be exercised when soldering the centre pin to avoid melting the dielectric and misaligning the centre pin.

The Belling-Lee socket has a split body with an encircling spring clip to ensure good mating and contact with the plug barrel. Some models have plastic bodies with internal metal spring fingers. They are less robust than the all-metal types. The pin-socket is bifurcated and usually made of spring copper, plated with one of the noble metals. Again, the dielectric is usually of thermoplastic and care must be exercised when soldering to the centre pin.

No doubt because they are the domestic TV standard, and thus very popular, there is an enormous variety of assembly arrangements in Belling-Lee connectors. Although all have the same basic centre contact and shield it is possible to buy a number of different configurations. Many of the cheap ones have a plastic body assembly with metallic contacting parts. Others are moulded into a box containing a balun, allowing direct interfacing to 300 ohm twin-wire line.

CONTACT RESISTANCE — THE SEARCH FOR THE PERFECT JOINT

Contact resistance, as the name implies, is the resistance that appears across a connector. We can consider it as the sum of three resistances, i.e: the resistance across the wire-to-conductor interfaces on both sides of the connector, and the interface between the mated halves of the connector itself.

In most applications, the wire-to-connector interface will be a soldered joint. The better the joint, the less the resistance. To find out what is meant by a good joint read the article on soldering elsewhere in this issue.

The connection inside the plug, the interface, also has a resistance. It depends on four factors: the material from which the contacts are made, the condition of the surface, its shape and finally, the pressure upon the contacts. Unfortunately, these factors impose contradictory requirements on the design, so the final solution has to be a compromise, in which certain aspect of the total requirements are emphasised at the expense of others.

Consider the material from which the plug is to be made. We want it to have low resistance, obviously, but we also require that it should be as hard as possible, so that it doesn't wear away with repeated use. Unfortunately, it seems that the materials with the best electrical qualities are also the softest, as well as being the most expensive. Gold, silver and copper are all excellent conductors, but they are also comparatively soft. On the other hand, the materials renowned for hardness, iron or tungsten for instance, are terrible electrical conductors. We can lift the game somewhat with alloys and even more so with plating techniques, but the basic problem remains.

The preferred contact material is gold. It's expensive, of course, but it's the only element that combines outstanding electrical qualities with low susceptibility to oxidation. Oxidation is the process by which the element is converted into its oxide by exposure to the atmosphere. What happens is that, over time, a layer forms on all the exposed parts of the metal. A group of elements, notably gold and silver (the noble metals), form an extremely thin layer, only a few molecules thick, and are then completely stable. Others, like copper or iron, form oxides very readily, and once started will continue until all the metal is consumed. (Note that rust is just the oxide of iron).

There are a few elements that break down over time to something other than an oxide. Silver is one of these. The black layer that covers tarnished silver is a sulphide, silver sulphide, which forms when the silver comes in contact with contaminants in the air.

How serious a problem this is depends on the electrical qualities of the oxide. Gold, silver and nickel are all used because, even when an oxide forms, its presence doesn't affect the electrical parameters of the contact by any significant amount. Predictably, copper oxide (CuO), is a terrible conductor. Worse still, it can form a semi-conductor.

Experience has shown that there are certain physical characteristics of contact surfaces that minimize resistance. Contrary to one's intuition, the surface should not be too smooth. A slight degree of roughness actually maximizes the area through which current will flow. Lubrication can also help under the right conditions, depending very much on the composition of the lubricant. It goes without saying that dirt on the contacts really messes things up.

The shape of the contact surface should be such as to maximize contact area. Bear in mind that resistance is related to the total area in contact (all other things being equal). The other criterion is that there should be no sharp corners, as it then becomes possible to wear away the mating surface in an irregular fashion. This leads to an optimum requirement for a round, pillar-like contact.

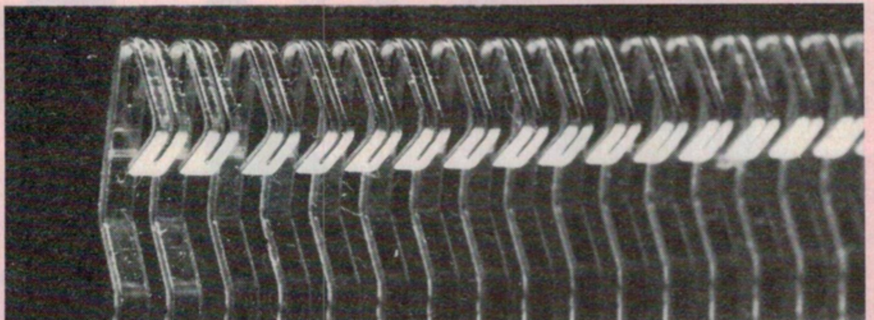
The problem with round contacts is that it's difficult to design a socket for one that can exert pressure to the same degree as a rectangular one. We want maximum pressure on the contacts to ensure the greatest possible mechanical bonding between the two surfaces. However, this causes a number of other problems.

The greater the pressure on the contact surfaces the more the contact surface will be worn away when the plug is operated. There's not much point designing an exotic, low resistance conducting surface if it's going to be worn away when the plug has been operated half a dozen times. Whatever the contact shape, the greater the pressure you apply it, the more it will deform as the two halves slide over each other.

In practice, these considerations have led to a number of standard designs which experience has shown are a reasonable compromise between the competing requirements. Typically, there will be a hard core, made of some hard conductor like beryllium-copper, brass etc, coated with some softer contact material like gold or silver, or, in cheaper plugs, nickel.

As to shape, the bellows-type connector, in which the natural spring of the contact material exerts the pressure is one answer. These are frequently used in edge connectors and such like application.

Round pillar-and-sockets are also extremely common. As well as the properties discussed above, these types also have the advantage that oxidation is less of a problem due to the scraping action as the plug slides into the socket. As a result they frequently use nickel as the contact material. Pressure is often applied to the joint by a screw top or spring loaded catch of some kind.



Gold! Plated contacts before assembly in an edge connector. Note the shape of the contacts. When the circuit board is slotted into place pressure on the contacts will be maintained by the springiness of the metal.

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AUDIO CONNECTORS

The types described here are used almost exclusively for audio applications. Other types often used in audio work have been included under multiway connectors because of the flexibility of their pin layouts and their wide use in other applications.

Tip-sleeve 'jacks'

Tip-sleeve and tip-ring-sleeve 'jack' connectors have a long barrel with either a shaped, insulated tip or an insulated tip with a ring behind it. The barrel serves as the common or 'ground' connection, while the tip and/or ring provide the 'live' connections. The standard jack plug has a 6.5 mm diameter barrel. The tip-sleeve type is for mono (single channel) use, while the t-r-s jack is for stereo (or dual channel) use. In stereo applications the right channel connects to the tip and left goes to the ring.

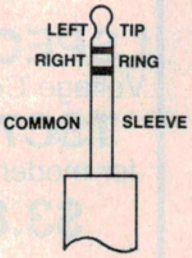

Figure 2: The layout of a typical tip-ring-sleeve jack.

A shroud or ferrule screws on the rear, covering the connections. A large lug attached to the shoulder behind the barrel has lugs to secure the incoming cable sheath, the ground or shield being soldered to this lug too. The shroud can be either metal or hard plastic.

The tip and ring contacts are brought up the centre of the plug to solder tag terminations under the plastic shroud.

The sockets comprise a hollow threaded metal shaft which serves to both secure the socket and provide contact to the plug barrel. Spring fingers contact the tip and/or ring. Some types have integral shorting contacts that ground the live connections when the plug is not inserted. More complicated versions have multiple switch contacts, rather like a relay, that are operated when the plug is inserted.

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CABLE TERMINATION — GETTING THE END RIGHT

Obviously, the joint you make between the wire and the connector itself is just as significant in determining the overall electrical characteristics of the unit as any other design consideration. There are a number of ways of doing it, all of varying degrees of difficulty.

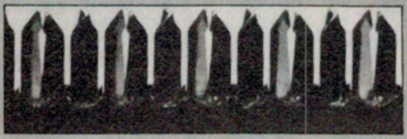
IDC CONNECTORS

The easiest to do are the Insulation Displacement Connector (IDC) types. They come in two halves, one side carrying the contacts, the other a backing plate. Each contact has split knife blades, such that when cable is placed between the two halves and squeezed together the knives cut through the insulation and come into contact with the conductor.

IDCs really come into their own with ribbon cable. They offer the wonderful advantage of not needing any solder, and if you've ever tried to solder up a 36-pin plug, you'll know how wonderful it is! They also make it possible to 'daisychain' DIL connectors on a cable rather easily, i.e: place a number of connectors in parallel along a length of ribbon cable. This is frequently required in computer systems, where various busses need to be fed to a number of different locations. While this is certainly possible with solder joints, in practice it is very infrequently found because it's so difficult to do properly.

CRIMP

Another type of jointing technique is crimping. Here the wire is squeezed between two metal flanges on the connector. Provided this is done properly it's actually a surprisingly good method of terminating cable. Crimping often requires no more than a pair of shaped pliers with which to squeeze the flanges together. Some manufacturers make special proprietary systems in which the connector must be terminated with a special tool. The spade connectors on telephone handsets are a good example of this.



Above: The cutting edge of an IDC. The wire gets forced down between the knife blades which cut the insulation as it does so.

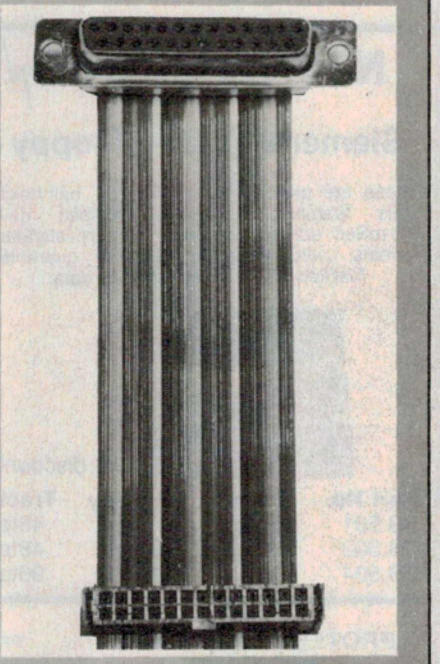
Right: A daisychain formed by an IDC connector joined to some ribbon cable.

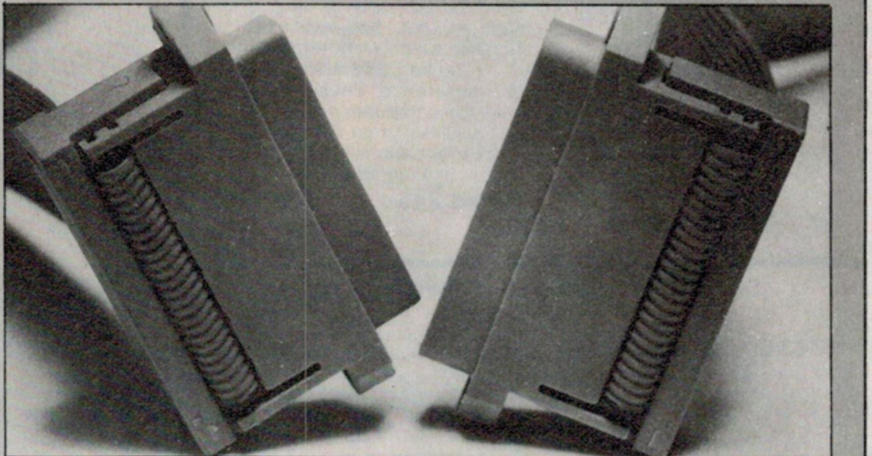
Below: Two D type IDC plugs.

COAXIAL

Probably the most difficult terminating job involves joining coaxial cable to connectors. The precise details of how this is done vary from connector to connector, but generally you need to solder the centre conductor to the centre pin, and then connect the outer to the shroud in some way. The usual system is that when the shroud is screwed down on the body of the connector the shield braid gets squeezed between the two. This means that the shield braid provides strain relief for the soldered joint in the centre, and is responsible for the integrity of the entire joint. Some types also clamp the outer sheath, reducing the strain relief role of the shield braid.

Another type of termination, much favoured on DIL connectors, is wire wrapping. Wire wrap terminals are square to give a good grip to the cable that is twisted around them. They have a number of advantages over other methods, including the fact that as the cable is twisted around the terminal it breaks through the oxide layer on it, thereby ensuring a tight, low resistance joint. It is also possible to vary the resistance by increasing or decreasing the area under the wrap. But perhaps the greatest advantage of all is that if you blow it, you get another chance!





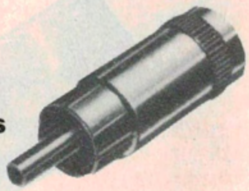
The 6.5 mm jack is predominantly found on guitar and headphone leads, applications where ease of insertion and withdrawal is important. They are designed to be operated a great many times with perfect reliability.

The spring metal tip contact fits into a groove in the tip of the plug. This means the plug will be held securely even after many thousands of insertions. Lateral pressure holds the plug barrel securely against the socket ferrule. Note that some sockets have an insulated ferrule with internal spring metal contacts.

In 6.5 mm plugs, the metal parts are usually of copper alloy or brass plated with a thick, hard layer of nickel or chrome to resist wear and prevent surface corrosion of the base metal.

For domestic applications, smaller versions of the 'standard' 6.5 mm jack are available. These follow the same pattern but come in 2.5 mm and 3.5 mm diameter versions. They are popular for much the same reasons as the bigger one, although they tend to be less robust, but then they're cheaper as well. They are very convenient where space is at a premium, hence you find them used as headphone and microphone connectors on portable cassette recorders etc.

RCA connectors



This line audio connector is a low cost utility type originally designed by RCA for use in semi-permanent applications with coaxial or shielded leads. They consist of a single hollow centre connector with a concentric metal body having slits around the rim that provide laterial pressure on the socket body. This ensures good contact and mechanical stability. The insulator holding the centre pin is usually of moulded phenolic. The cable centre conductor passes through the centre pin and is soldered at the tip. The cable shield simply solders to the rear of the plug body. A coloured plastic shroud covers the termination at the rear. The metal parts are usually of copper alloy, generally plated with nickel or some other corrosion-resistant metal. 'Deluxe' types are gold-plated.

The sockets are quite simple with a split barrel-type centre pin and a concentric metal body. Again, the insulator holding the centre pin is usually moulded phenolic.

RCA plugs and sockets can be bought in a variety of configurations: in-line, chassis mount, insulated chassis mount, etc. One very useful variation has a number of sockets mounted on a single strip. You'll mostly find such things on the rear of audio gear such as amplifiers, cassette decks etc. in a neat row.

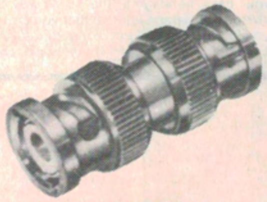


Figure 3: A double-male BNC sex changer.

WIRING AC CONNECTORS — HOW TO STAY ALIVE

No one with an interest in electronics should forget that it's a potentially lethal interest, and no more so than when dealing with the mains. No piece of equipment you use should allow a user direct access to 240 Vac under any circumstances.

Equipment in protected by two different methods — earthing and double-insulating. Double-insulated equipment usually only has a two prong plug and frequently carries a warning "double insulated — do not earth". Double insulated equipment has, as its name suggests, two sets of insulation between any live conductor and the user. The equipment should be laid out such that in the event of failure of any single insulator the equipment is still safe.

Earthed equipment, on the other hand, has a connection between the case and local ground via the third pin on the plug. This means that no significant potential can exist between the case and a person touching it.

It goes without saying that it is vital that any mains connection you do should be done properly. Cable for mains use comes in combinations of red, black and green, or brown, blue and green/yellow, which carry the active, neutral and earth respectively. (See diagram)

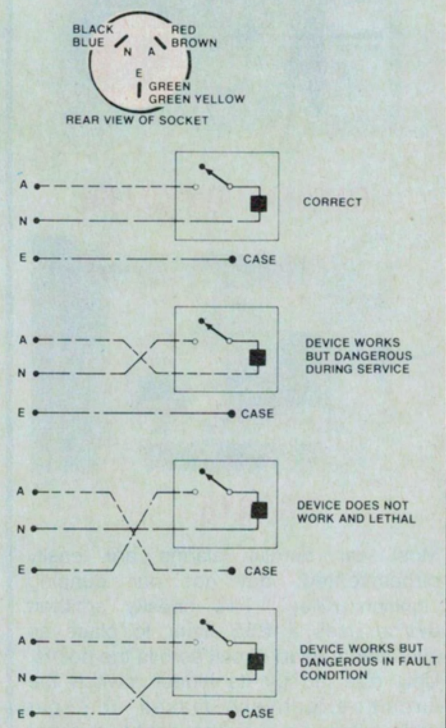
Note that a number of mistakes can be made in wiring up mains connectors that will result in a hazardous situation existing, even though the device may work. If, for instance, you interchange active and neutral (a very common mistake) the device will still work, and will still be protected by the earth lead. However, the switch in the device will be inserted into the active line. So, if you have the plug wiring the wrong way around a situation could arise where, even though the switch is off all the components inside are still live. Moral: always unplug before fiddling.

Another tricky one is interposing neutral and earth. The device will still work, but is no longer protected by the earth cable. If a short develops between the supply and the case then it will rise to supply potential, and so will anything else attached to it. Since this will include every other metal case attached to the earth circuit this is a very dangerous situation, and one that could lie dormant for years.

Should you ever transpose active and earth, you get one chance to realize you've made a mistake: the device will not work. However, if you touch the case, you probably won't be in any condition to worry about it!

The mechanics of wiring up plugs vary from maker to maker. One point worth noting, however, is that mains plugs do not rely on the connection between the wire and the pin to take cable strain. Older style plugs had a cable clamp that need to be screwed down. Modern types rely on a tortuous path for the cable inside the plug to take the strain. In either case do not be tempted to take short cuts — the plug may work now, but will it in six months time when it has been stressed a couple of times.

Another tip worth noting is that when wiring up mains cable always try to leave the earth connector slightly longer than the other two. This means that if the cable is stressed, and the clamps or whatever do not work properly, at least the earth connection will be the last to feel the strain.



Caution. One correct and three incorrect ways of wiring up a mains plug. Examples of interconnections with pin headers.

ADAPTORS

With so many different types of connectors available, it is inevitable that a need for adaptors will present itself. Many manufacturers make a range to not only adapt between connector types but to change the sex too! Sex changers are usually simple arrangements (Figure 3) in which either plugs or sockets are mounted back to back.

The most common adaptors are undoubtedly those that change the various sizes of coaxial plug. These generally come as an in-line unit with a plug on one side and a socket on the other. Another very common type permits interconnection of BNC to the other RF types. But with a bit of perseverence it should be possible to find just about any combination you want. Some companies make N-type to 2.5 mm jacks others, BNC to GR plug etc!

Another very common type of adaptor permits the connection of three cables, usually one input and two outputs, but some- ►

times an output and two inputs. Because they are generally t-shaped, they are called T-adaptors (obviously!).

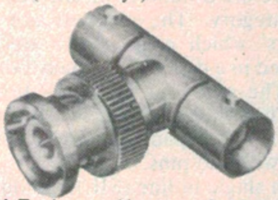


Figure 4. A T-adaptor with one socket between two plugs.

PC BOARD CONNECTORS

There are two main types of connectors designed specifically for printed circuit applications: edge connectors and in-line types.

There are certainly plenty of other types of connectors adapted for mounting on pc boards, but here we'll consider only those types specifically designed for use in conjunction with pc boards. Let us take them in turn.

Edge connectors

An edge connector is designed, as its name suggests, to provide connections to and from a printed circuit board via tracks brought out conveniently to an edge of the board. It is undoubtedly the cheapest and simplest way of connecting wires to a pc board in a non-permanent way. From the design point of view it is also one of the most flexible. There are two fundamental types: direct and indirect.

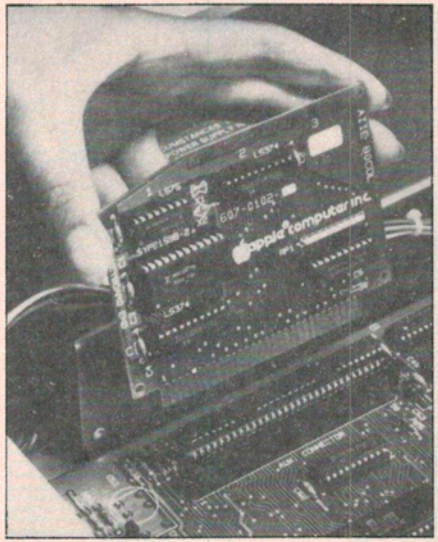


Figure 5: A typical edge connection system as utilized by the Apple IIe.

Direct edge connectors are sockets that mate directly with tracks that terminate at the edge of a board, arranged in certain standard widths and spacings (the 'pitch'). Probably the most familiar application is seen on computing equipment. In 'the trade', several are well known through wide application: the 100-pin 'S100' buss connector, the 56-pin STD buss connector, the

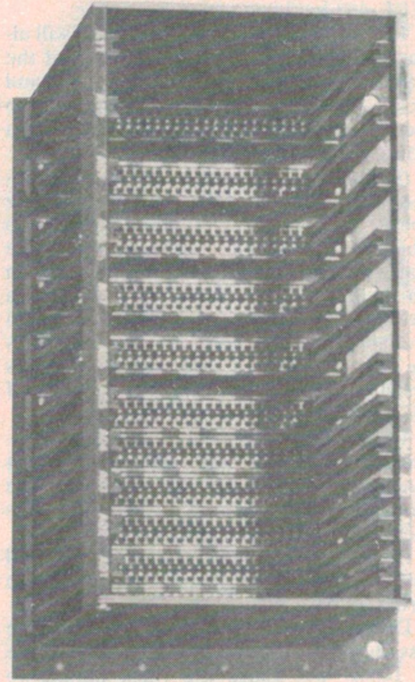


Figure 6: A typical rack assembly. Printed circuit boards can be slid in or put on the rack to maximise ease of servicing.

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CONNECTORS

IEEE-488 buss connector, etc.

The connector tracks on the board will always be plated to prevent corrosion of the copper track and to reduce wear. Tin and nickel plating are common. Gold is also used, usually plated over nickel but, as you would expect, it's more expensive.

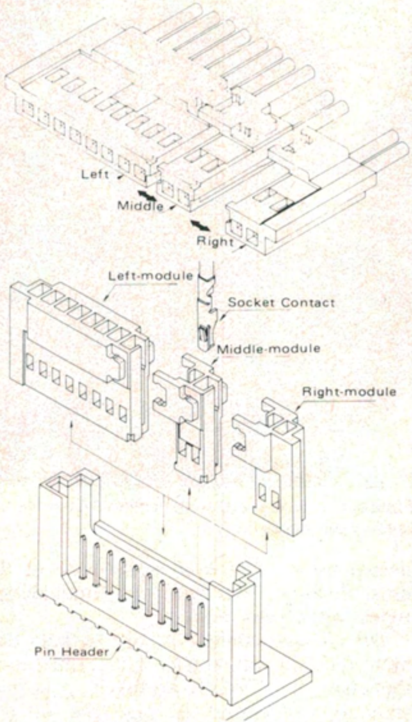
Indirect edge connectors are of the plug-&-socket variety. One mounts on the board, its pins being soldered to pads to which the connections are brought out. The mating connector mounts on the chassis in which the board is mounted, usually in a slide-in/out rack assembly. (See Figure 6) Probably the two most familiar examples are the ISEP and the G06/G60 types designed to meet the European DIN and IEC electronic packaging standards.

Typically it is possible to find edge connectors with almost any number of contact ranging from four to 100 or more. The dielectric body is generally made of plastics such as polyester or polycarbonate.

Edge connector sockets can be obtained with either solder-trype or wire-wrap terminations.

Direct edge connectors suffer from one dissadvantage — repeated insertions of the pc board will cause the track plating to deteriorate. For this reason, heavy plating with one of the hard metals or alloys is often employed.

In-line connectors



Above. A pin-header and plugs. Modular design means the user decides how many connectors there should be.

Another way of connecting wires onto circuit boards is via in-line packages where the connector pins are arranged side-by-side in line — hence the name!

There are a number of different types in this category. The simplest are the 'pin headers' which consist of a row of pins mounted in a dielectric (usually polycarbonate). The pin stubs protrude through one side. These fit into the pc board and are soldered to track pads. A pin header socket mates with the pins.

Both single in-line (SIL) and dual in-line (DIL) styles are available. As the name implies, the DIL type has parallel rows of pins. The pins are generally of hard copper alloy, plated with nickel or gold, though other metals are used.

A variation of this theme are those plugs designed to fit into IC sockets. These come in the familiar 14- to 40-pin DIP (Dual in-line package) versions.

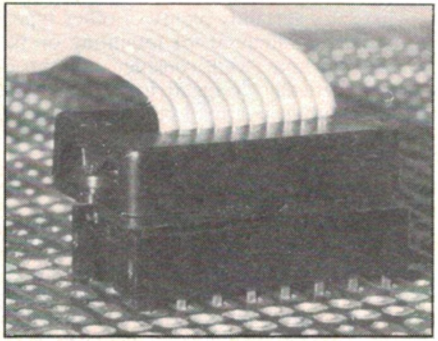


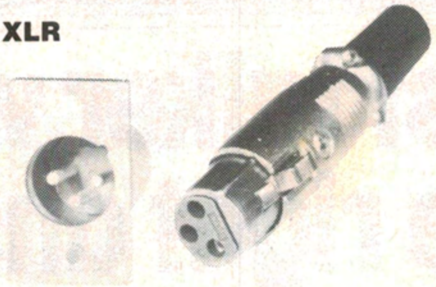
Figure 7. A 14 pin DIP IDC fitted to an IC socket ▶

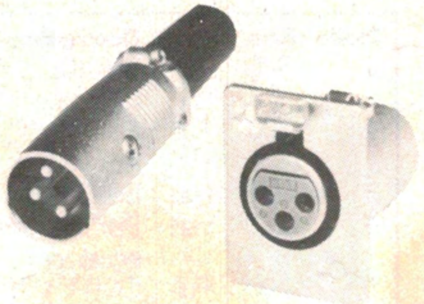
MULTIWAY CONNECTORS

This is a category for all those types of connectors that have more than two pins, in various configurations, and that have applications in various fields and don't comfortably fit into the other categories!

Probably the two most famous types would be 'XLR' and 'MS' connectors. However, special connectors are now made for the narrowest applications and multiway connector types are legion. We can only hope to cover the common generic types here.

XLR





The XLR started out as the 'industry standard' for audio interconnections. It is produced by a number of different manufacturers and comes under a variety of names.

Originally produced by Cannon, it is often simply called by that proprietary name. Cannon themselves recently released a new version of the XLR called the AXR, with lower cost components and fewer parts. Other compatible products include types made by Neutrik, the Switchcraft Q6 or the Radiospares X series, for example.

All these names describe a product that has a circular metallic body surrounding a dielectric having between two and seven pins in a standard arrangement. The body can serve as an integral part of the connection scheme, as a common or ground, while providing mechanical coupling and rigidity, or it may be isolated.

The plug pins are solid, hard copper alloy, plated with a hard-wearing metal. The socket pins employ a split-finger construction and are made of the same material as the plug pins. They can be obtained with gold-on-silver plating for best wear characteristics. A locking finger on the socket snaps into a channel in the plug. This construction provides a rugged, hard-wearing, low noise connector that cannot be dislodged under cable tension.

The most popular version in audio applications is the 3-pin type, while a special 4-pin version is often used for dc and ac power applications. By convention, the latter type has a red dielectric. Versions with five, six and seven pins are obtainable. The contacts on the 3-pin versions can carry currents up to 15 amps. The 4-pin one will carry up to 10 amps per contact, while the five and six pin versions are rated at 7.5 amps per contact. The 7-pin one will carry 5 A per contact. The dielectric is rated at 250 Vac (RMS).

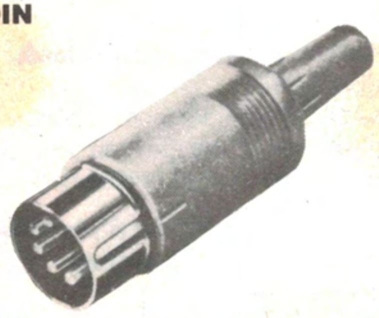
Other fields of application include video and medical equipment, industrial control devices and telecommunications equipment.

Because of their fields of application, the design of the XLR has emphasised rugged construction and the ability to handle extreme environmental conditions even after many insertions. The insulator, for instance, is manufactured with special anti-vibration ribs to eliminate the effects of vibration.

The design of the contacts maximizes ease of insertion, while at the same time minimizing the erosive effects of wear. The socket has a conical shoulder to guide the incoming plug.

An enormous range of styles is available. Both plugs and sockets are available with shrouds for in-line terminating, or with a flange for panel mounting. The flange can be square or round or specially designed for wall mounting. Others are designed for right-angled cable entry. All in-line types feature a cable camp to prevent stress on the terminations when the cable is under tension.

DIN



Another very common type of multiway connector is the DIN family. DIN is an acronym for a German industrial standards body. They consist of between two and seven connectors surrounded by a metal shield/connector body. The multi-pin types have the pins arranged around a semicircle in the dielectric, which may be of thermoplastic material or polycarbonate, etc. The two-pin types are a little different. The body parts may be all-metal of diecast construction, or a combination of moulded plastic and stamped metal parts. A variety of cable securing methods are used.

DIN connectors were originally used in audio applications, though these days they are found in all sorts of fields.

The two-pin type consists of one square and one round connector, mounted one above the other. It is intended primarily for domestic audio use on speaker cables and similar applications, though they're often used as a general purpose polarised connector (e.g: on the dc lines).

►

The three, five, and seven pin versions all consist of solid, round plated copper alloy connectors placed in a semi-circle around the inside of the shield. The DIN specification designates the central pin (pin 2) as the signal earth. (See the accompanying diagram) and the chassis earth goes on the shield (in applications where the two are separated. Sometimes the shield is not connected at all).

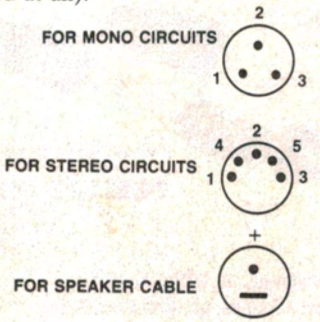


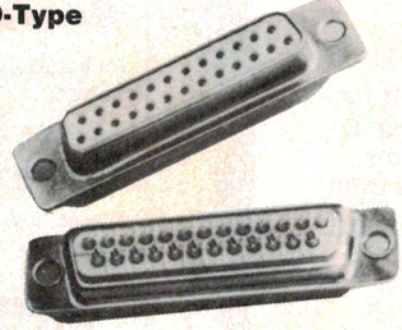
Figure 8: The three basic DIN configurations. Notice the strange pin numbering system on the five pin DIN. Seen from the back of the plug.

DIN plugs come in a variety of mounting styles. For instance, they are available as in-line connectors to be used when connecting two cables together. Generally, this type has a grey plastic shroud, but some manufacturers are now starting to supply them with a variety of coloured plastic covers for colour-coding.

Types with a locking ring to prevent accidental uncoupling are available, along with types having a special shroud for moisture-proofing, etc. Some manufacturers provide latch-locking types, too. They are also available with flanges to enable panel mounting (either male or female). Usually the flange is connected directly to the shield, but it is possible to find ones where the flange is completely insulated.

There is usually provision for either terminating the connectors in wires or directly onto a printed circuit board. Often this type has the pins at 90 degrees to enable the plug to be mounted vertically on a horizontal board.

D-Type



So-named because of its cross-sectional shape, the D-type is heavily favoured in the computer industry where it is almost universally used for input/output ports. To accommodate a wide variety of needs in the industry it is possible to specify between five and seventy-odd pins in the D-type format. Indeed, such is the flexibility of the system, it is possible to buy the dielectric, pins and shell separately and assemble them in any desired configuration. The common element in all cases is the trapezoidal polarizing flange which locates the male over the female.

A wide variety of shell types are available for the D-type. A cable clamp is provided to secure the cable and prevent any tension straining the cable terminations. Most have some type of locking mechanism on them, generally consisting of screws passing through flanges at either side of the connector body. Both metal and plastic shells are available in clip-on and screw-on styles. (See also 'IDC' connectors).

Pin construction varies widely, from solid, plated copper alloy to rolled-plate pins. The body dielectric is usually a polycarbonate material.

The 25-pin 'RS232' computer connector is probably one of the most well-known, along with the 9-pin type commonly used on home computer joystick interfaces.

Another common D-type is known as the 'JD' series. These employ a cantilever-type flat spring leaf contact on both the plug and socket. They are generally obtainable in 14, 24, 36 and 50 pin versions. The socket is generally for chassis mounting and the plug for line termination. A lock spring mechanism for holding the plug to the socket is sometimes employed. The 36-pin version is known as a 'Centronics' connector in the computer trade, commonly used on printer interfaces.

Circular multipins

Multipin circular connectors come in a huge variety of configurations. They are available with up to 50 or so pins and are much favoured by the military where their rugged construction and environmental tolerance are much appreciated. Originally known as 'military series' connectors. Similar, low-cost versions are known as CA types.

Typically the shell is made of some aluminium alloy, perhaps with an anti-corrosion coating like cadmium. Contacts are usually a copper alloy with hard gold plating. Often the pin enclosure is sealed with rubber gaskets around the cable entry. Mostly they are held together with a screw ring. The cable is generally held in a screwed-down clamp. The plug has a slot on one side to mate with a key in the socket that guides it in during insertion and prevents rotary shear pressure being exerted on the pins. Mounting arrangements provide for both line and chassis, or 'bulkhead', mounting.

▶

Pin current ratings vary widely, as does the insulation voltage rating. Cable termination is by soldering.

Other common multipin connectors are the 'K' type which feature quick connect/disconnect and the 'EP' series which are a keyed spring-latch type. Similar miniature types are known as SRC series. All have circular construction.

Square types

Square multipin connectors are usually blocks of Nylon that comes with the contacts separate from the body of the plug. After the wire has been soldered to the contact they are rammed into the body so that when the plug and socket are mated together that Nylon body completely encloses the contacts and terminations. Most have a latch locking mechanism integral with the body.

As a result of their construction they are relatively impervious to hostile environments and are much favoured for use in motor cars and other vehicles. They are virtually immune to the effects of vibration, oil humidity and temperature experienced in vehicles.

TEMPORARY CONNECTORS

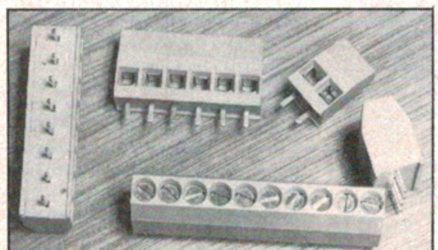
This category covers a multitude of connector types that can be used for making temporary connections. The common factor among them all is that they are very simple to use.

Hook connectors

One popular form of temporary connector is the hook connector. It is often supplied as standard with measuring instruments. The

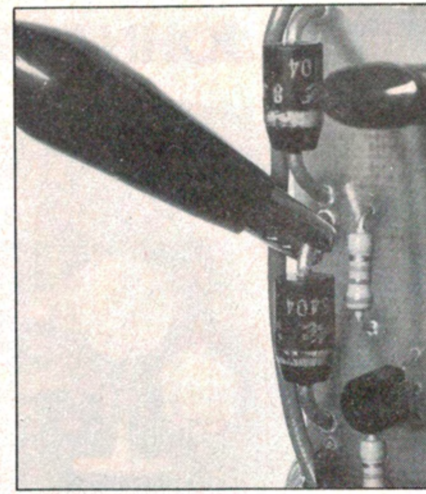
connector consists of a plastic handle with a spring-loaded button on it. Operation of the button causes a small hook to protrude from the bottom of the instrument. This can then be hooked over any appropriate component lead, the spring maintaining tension on the joint.

Terminal blocks



The perennial experimenters problem, of course, is how to get wires onto a printed circuit, matrix or vero board with connections that don't fall apart when you breath on them. One modern answer is the terminal block (like electricians use) with a printed circuit board pin at the bottom. They provide a quick and exceptionally reliable way of making connections. The connection is made by inserting wires into a bored-out metal block which has a grub screw through the side to secure the wires.

There are a number of different styles on the market. Some are square, others have the front face sloped at 45 degrees to make for easier cable access. Some types are supplied individually and some in long strips that can be cut down to your own requirements. The dielectric is either a soft thermoplastic or a polycarbonate material.



Alligator clips

Another option is the alligator clip. These consist of two spring loaded jaws between which the wire or whatever can be squeezed. Their chief advantage is convenience and ease of use. One disadvantage is that the contact they make is unreliable, especially when the spring ages a bit and/or wear allows corrosion of the teeth.

Another disadvantage is that the body of the clip consists of a beautiful short circuit just waiting to happen. There are varieties available with a plastic shroud over them to solve this problem. Cost is directly proportional to quality.

Spade connectors

Spade connectors consist of a flat piece of metal that slips into a mating shell to make the contact. Flying leads may be joined to the connector with solder or by crimping, or even, in some cases, by screws. More expensive versions often come with a plastic shroud over them to prevent short circuits.

Typical construction materials are aluminium, brass or copper alloys. They are generally nickel plated or passivated.

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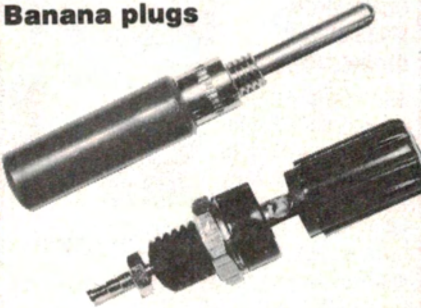
Banana plugs



Banana plugs are one of the most well regarded options for temporary connectors. These consist of a pin with spring metal sides (the banana) which fits into a metal socket called the binding post. The binding post has a screw bottom to secure the post and a plastic thumb nut on top. Often the post has a lateral hole in it to facilitate the connection of probes. Flying leads can be connected under the thumb nut.

To increase their flexibility even further it is possible to buy banana plugs in which the plug has a socket on its back, so that plugs can be stacked ('piggybacked') one on top of the other to make multiple connections.

While banana plugs are an enormously flexible connection system, they do have the disadvantage that the quality of the contact depends on the force of the spring contact in the barrel. When this wears the force diminishes and intermittent contact, or miscontact is the result.

A variation of the plug is the 'GR' plug, designed by the US General Radio corporation. It consists of a rectangular insulating body holding two banana plugs spaced 0.75" (19 mm) apart. Like the piggyback banana plugs, integral sockets behind the plug pins permit stacking of GR connectors. The cable is secured by the plug body and grub screws in the side of the pins at the body provide termination of the wire.