

# Handbook of Mains Power Connectors (Electrical Components)



Lonnie Herron

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## Chapter 1

# AC Power Plugs and Sockets



CEE 7/4 Type F plug and socket



CEE 7/5 Type E socket

Plugs and sockets may sometimes combine male and female aspects, but the exposed pins or terminals in the socket are generally safe to touch.

**AC power plugs** and **sockets** are devices for removably connecting electrically operated devices to the power supply.

An **electric plug** connects mechanically to a matching socket. Usually plugs are movable connectors, and sockets are fixed to equipment.

**Wall sockets** (also known as **power points**, **power sockets**, **electric receptacles**, **plug sockets**, **electrical outlets** or just **sockets**) are mostly or completely female electrical connectors that have slots or holes which accept and deliver current to the prongs of inserted plugs.

To reduce the risk of injury or death by electric shock, some plug and socket systems incorporate a variety of safety features. Sockets can be designed to accept only compatible plugs and reject all others. There is some variation in male/female mating, in that some plugs can have sockets or exposed contact plates, while some wall sockets have pins or exposed contact plates. The exposed contacts in the wall socket are commonly used for safety purposes such as grounding and electrostatic energy dissipation.

## Terminology

There are differences between British and American nomenclature related to power plugs and sockets. Other regional variations (e.g. Australian) also exist.

British English	American English	Other Terms	Meaning
<i>mains power</i>	<i>line power</i> <i>service entrance conductors</i>		Primary electrical power supply wires serving a building, connected to the main fuses or circuit breakers.
<i>domestic power</i> <i>230 volt power</i>	<i>residential power</i> <i>household power</i> <i>AC power</i>		Single-phase 120 or 230 V AC power as used in a single-family residence
<i>earth connection</i>	<i>ground wire</i> <i>grounding conductor</i> (NEC)		Safety connection to the earth or ground
<i>live connection</i> <i>active connection</i> <i>line connection</i> (rare)	<i>hot wire</i> <i>live wire</i> <i>supply wire</i> <i>ungrounded conductor</i> (NEC)	<i>phase conductor</i> (electrical engineers)	Phase or active connection
<i>neutral connection</i>	<i>cold wire</i> <i>neutral wire</i> <i>return wire</i> <i>grounded conductor</i> (old NEC) <i>identified conductor</i> (old NEC)		Return or neutral connection
<i>pin plug</i>	<i>plug</i> <i>pin</i> <i>prong</i>		Part of male electrical connector
<i>power port socket</i>	<i>receptacle</i> <i>socket</i> <i>outlet</i> <i>jack</i>	<i>power point</i>	Female electrical connector
<i>flex lead</i> <i>mains lead</i> <i>mains wire</i> <i>mains wiring</i>	<i>line cord</i> <i>power cord</i>	<i>power lead</i> <i>lead</i>	Flexible electric cable from plug to appliance

mains extension lead	extension cord drop cord		Device providing single outlet at a distance from a single outlet
4, 6, or 8 way mains extension lead	power bar	power board	Device providing multiple outlets from a single outlet
mains extension adaptor	power strip	board	

Previous to 2008, the old US National Electrical Code (NEC) distinguished the terms *grounding*, **grounded**, and *ungrounded* conductor. As of 2008, the NEC has officially defined **neutral conductor** and is phasing out the use of the term **grounded conductor**.

In United Kingdom electrical engineering, the *line* voltage is that between the live conductors of the three-phase distribution system, while the *phase* voltage is that between live and neutral.

### ***The three contacts***

Each receptacle has two or three wired contacts. The contacts may be steel or brass, and may be plated with zinc, tin, or nickel. The **live** contact carries current from the source to the load. The **neutral** returns current to the source. Many receptacles and plugs also include a third contact for a connection to earth ground, intended to protect against insulation failure of the connected device. A common approach is for electrical sockets to have three holes, which can accommodate either 3-pin earthed or 2-pin non earthed plugs. The types below B, H, I, J, K and L use this approach (type B accepting type A plugs and types H, J, K and L accepting type C). The Europlug (type C) will fit type E and F sockets, and the earthed type E / F 2-pin plugs will fit type C (and certain hybrid) sockets though without making earthing contact. Types D, G and M plugs are exclusively 3-pin, used for both earthed and non-earthed appliances.

### **Polarization**

*Polarized* plugs and sockets are those designed to connect only in one orientation, so the live and neutral conductors of the outlet are connected (respectively) to the live and neutral poles of the appliance. Polarization is maintained by the shape, size, or position of plug pins and socket holes to ensure that a plug fits only one way into a socket. The switch of the appliance is then connected in series with the live wire. If the neutral wire were interrupted instead, the device would be deactivated but its internal wiring would still remain live. This is a shock hazard; if the energized parts are touched, current travels to earth through the body. Devices that especially present this hazard include toasters and other appliances with exposed heating elements, which with reversed polarity can remain live even when they are cool to the touch. Screw-in light bulbs with reversed polarity may have exposed portions of the socket still energized even though the lamp is switched off. Transposition of the live and neutral wires in the wiring to sockets defeats the safety

purpose of polarized sockets and plugs; a circuit tester can be used to detect swapped wires.

*Unpolarized* plugs and sockets are those which can connect either way around, so live and neutral wires are connected arbitrarily. Unpolarized plug/socket systems such as the Europlug rely on device construction requirements to avoid the shock hazards created by interchange of live and neutral connections.

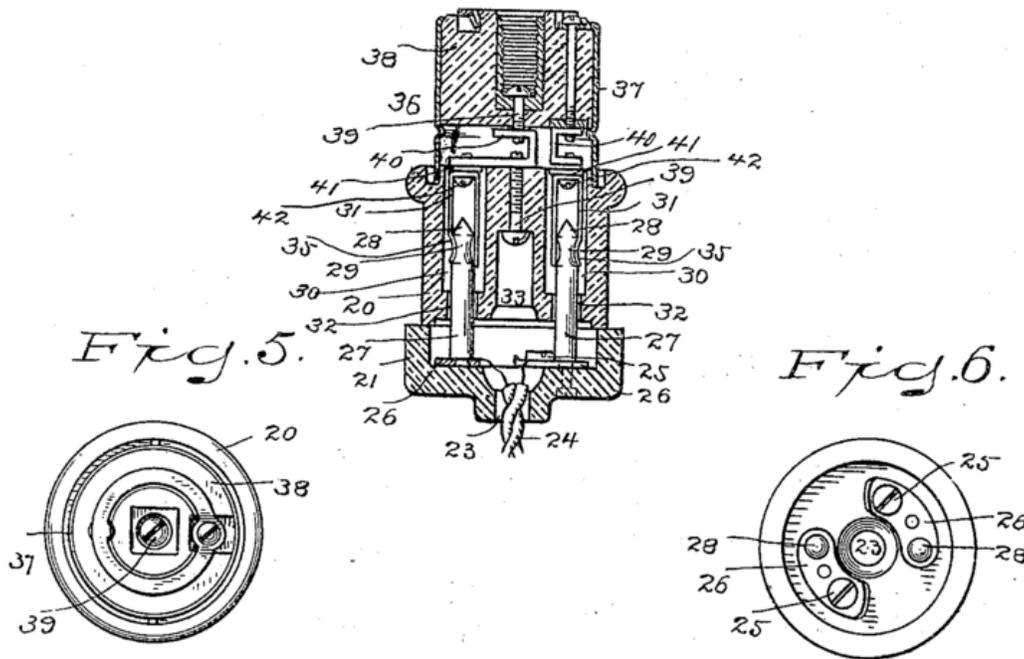
### ***Interchange hazards***

Plugs and sockets are designed as a system to meet standards for safety and reliability. Some types of receptacles may accept more than one type of plug; where this is an official, approved intention of the receptacle design, all the approved combinations will be tested to the applicable safety standards. Occasionally, plug and receptacle combinations may allow power to flow but may not meet product standards for mating force, grounding, current capacity, life expectancy, or safety. Improvised or user-modified connectors will not meet the product safety standards.

## ***History***

### **Early history**

When electricity was first introduced into the household, it was primarily used for lighting. At that time, many electricity companies operated a split-tariff system where the cost of electricity for lighting was lower than that for other purposes. This led to portable appliances (such as vacuum cleaners, electric fans, and hair driers) being connected to light bulb sockets.



U.S. Patent 774,250. The first electric power plug and receptacle.

However, as electricity became a common method of lighting houses and operating labour-saving appliances, a safe means of connection to the electric system other than using a light socket was needed. The original two pin electrical plug and socket were invented by Harvey Hubbell and patented in 1904. The original socket into which the user inserted the appliance's plug (of Hubbell's design) itself screwed into the sort of socket used for light bulbs, rather than being directly connected to the building's fixed wiring. (U.S. Patent #774,250) Other manufacturers adopted the Hubbell pattern and by 1915 they were widespread, although in the 1920s and even later, household and light commercial equipment was still powered through cables connected with Edison screw-base adapters to lampholders.

The grounded consumer plug has several claimants to its invention. The earliest patent for a grounded plug appears to be one applied for on January 11, 1915 by George P. Knapp, on behalf of the Harvey Hubbell company and granted on April 18, 1916. This patent covers the use of a grounding pin which extends further than the other two contacts to ensure that it is engaged first. However, the suggested configuration of the pins was that found in the Type I plug used today primarily in Australasia and China, which was not interoperable with existing two-contact ungrounded plugs. Other grounded plugs that are widely used today were developed later by others so as to be interoperable with ungrounded plugs.

The Schuko-system plug was invented by Albert Büttner, who patented it in 1926. The current American version of the grounded plug, with two vertical blades and a round grounding pin was invented by Philip F. Labre, while he was attending the Milwaukee

School of Engineering (MSOE). It is said that his landlady had a cat which would knock over her fan when it came in the window. When she plugged the fan back in, she would get an electric shock. Labre figured out that if the plug were grounded, the electricity would go to earth through the plug rather than through his landlady. He applied a patent on May 12, 1927 and was issued a US patent for grounding receptacle and plug in June, 1928. As the need for safer installations became apparent, earthed three-contact systems were made mandatory in most industrial countries.

## **Proliferation of standards**

During the first fifty years of commercial use of electric power, standards developed rapidly based on growing experience. Technical, safety, and economic factors influenced the development of all wiring devices and numerous varieties were invented. Gradually the desire for trade eliminated some standards that had been used only in a few countries. Former colonies may retain the standards of the colonising country, occasionally—as with the UK and a number of its former colonies—after the colonising country has changed its standard. Sometimes offshore industrial plants or overseas military bases use the wiring practices of their controlling country instead of the surrounding region. Hotels and airports may maintain receptacles of foreign standards for the convenience of travellers. Some countries have multiple voltages, frequencies and plug designs in use, which can create inconvenience and safety hazards.

## **Design for safety**

Design features and aspects of plugs and sockets have gradually developed to reduce the risk of electric shock and appliance destruction. Depending on the plug and socket system, safety measures may include pin and slot composition to permit only the precise insertion of plug into socket, earth pins longer than power pins so the device becomes earthed before power is connected, electrical insulation of pin shanks to reduce or eradicate live-contact exposure when a plug is partially inserted in a socket, socket slot shutters that open only for the correct plug, as well as inbuilt fuses and switches.

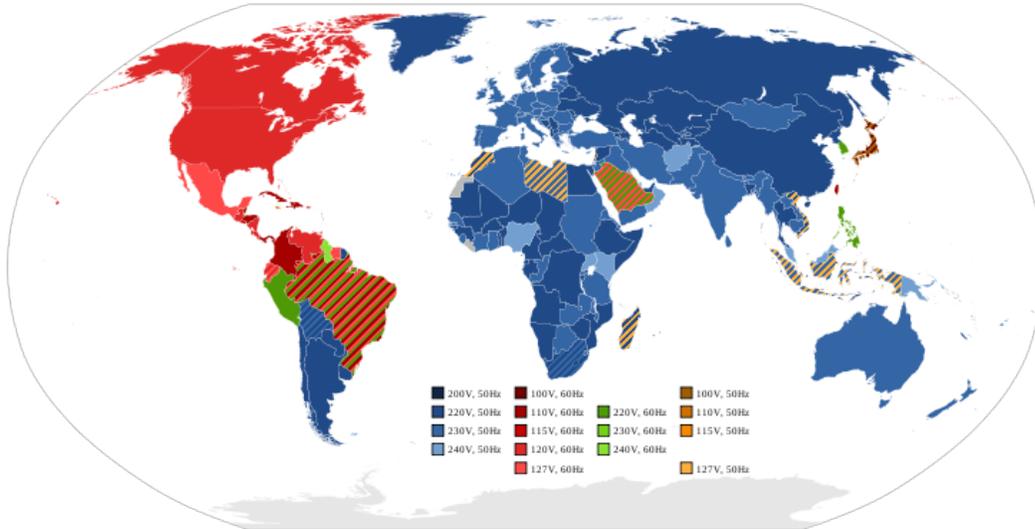
## **Consolidation of standards**

In recent years many countries have settled on one of a few *de facto* standards, which became formalised as official national standards, although there remain older installations of obsolete wiring in most countries. Some buildings have wiring that has been in use for almost a century and which pre-dates all modern standards.

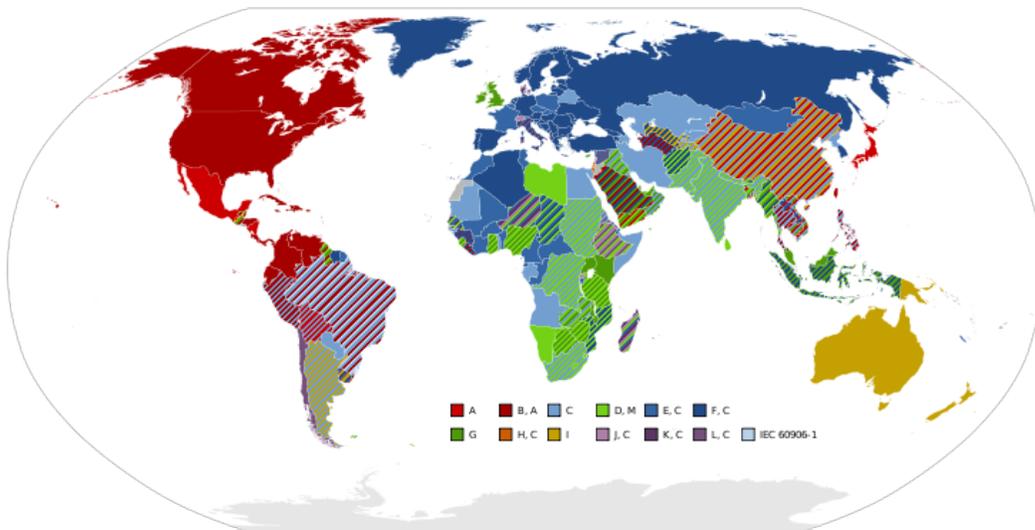
There has been some movement towards consolidation of standards for international interoperability. For example, the CEE 7/7 plug has been adopted in several European countries and is compatible with both Type E and Type F sockets, while the ungrounded and unpolarised Europlug is compatible with an even greater proportion of European and other socket types. IEC 60906-1 has been proposed as a common standard for all 230 V plugs and sockets worldwide but has only been adopted in Brazil to date.

Many manufacturers of electrical devices like personal computers have adopted the practice of putting a single world-standard IEC connector on the device, and supplying for each country a power cord equipped with a standard IEC connector on one end and a national power plug at the other. The electrical device itself is designed to adapt to a wide range of voltage and frequency standards. This has the practical benefit of reducing the amount of testing required for approval, and reduces the number of different product variations that must be produced to serve world markets.

## World maps



Voltage/Frequency.



Plugs.

There are two basic standards for voltage and frequency in the world. One is the North American standard of 120 volts at a frequency of 60 Hz, which uses plugs A and B, and the other is the European standard of 220–240 volts at 50 Hz, which uses plugs C to M.

Countries on other continents have adopted one of these two voltage standards, although some countries use variations or a mixture of standards. The outline maps show the different plug types, voltages and frequencies used around the world, color-coded for easy reference.

### ***Types in present use***

Electrical plugs and their sockets differ by country in shape, size and type of connectors. The type used in each country is set by national standards legislation. Here each type is designated by a letter designation from a U.S. government publication, plus a short comment in parentheses giving its country of origin and number of contacts. Subsections then detail the subtypes of each type as used in different parts of the world.

In many areas, different types of plugs are used depending on the IEC classes assigned to the electrical device. The assigned class depends on whether or not the device is earthed, and the degree of insulation it incorporates. Class I, for example, refers to earthed equipment, while class II refers to unearthed equipment protected by double insulation.

Special purpose sockets may be found in residential, industrial, commercial or institutional buildings. These may be merely labelled or coloured, or may have different arrangements of pins or keying provisions. Some special-purpose systems are incompatible with general-purpose lighting and appliances. Examples of systems using special purpose sockets include:

- "clean" ground for use with computer systems,
- emergency power supply,
- uninterruptible power supply, for critical or life-support equipment,
- isolated power for medical instruments,
- "balanced" or "technical" power used in audio and video production studios,
- theatrical lighting
- outlets for electric clothes dryers, electric ovens, and air conditioners with higher current rating.

Depending on the nature of the system, special-purpose sockets may just identify a reserved use of a system (for example, computer power) or may be physically incompatible with utility sockets to prevent use of unintended equipment which could create electrical noise or other problems for the intended equipment on the line.

## Type A



Unpolarized type A plug

NEMA 1–15 (North American 15 A/125 V ungrounded)

This plug and socket, with two flat parallel non-coplanar blades and slots, is used in most of North America and on the east coast of South America on devices not requiring a ground connection, such as lamps and "double insulated" small appliances. It has been adopted by 38 countries outside North America, and is standardized in the U.S. by the National Electrical Manufacturers Association. NEMA 1–15 sockets have been prohibited in new construction in the United States and Canada since 1962, but remain in many older homes and are still sold for replacement. Type A plugs are still very common because they are also compatible with newer type B (three-prong) sockets. In Pakistan Type A plug is used with hybrid socket, for home and small offices.

Initially, the plug's prongs and the socket's slots were the same width (or height, in a vertical orientation), so the plug could be inserted into the socket either way around. Most sockets and plugs manufactured from the 1950s onward are polarized by means of a neutral blade/slot wider than the live blade/slot, so the plug can be inserted only the right way. Polarized type A plugs will not fit into unpolarized type A sockets, which possess only narrow slots. But both unpolarized and polarized type A plugs will fit into polarized type A sockets and into type B (three-prong) sockets. Some devices that do not

distinguish between neutral and live, such as internally isolated electronic power supplies, are still produced with unpolarized type A pins (both narrow).

JIS C 8303, Class II (Japanese 15 A/100 V ungrounded)



Japanese outlet with ground post, for a washing machine.

The Japanese plug and socket appear physically identical to NEMA 1–15. However, the Japanese system incorporates stricter dimensional requirements for the plug housing, different marking requirements, and mandatory testing and approval by MITI or JIS.

Many Japanese outlets and multi-plug adapters are unpolarized—the slots in the sockets are the same size—and will accept only unpolarized plugs. Japanese plugs generally fit into most North American outlets without modification, but polarized North American

plugs may require adapters or replacement non-polarized plugs to connect to older Japanese outlets. However, in Japan the voltage is supplied at only 100 volts, and the frequency in eastern Japan is 50 rather than 60 Hz. Therefore, many North American devices which can be physically plugged into Japanese sockets may not function properly, though some devices with rectified power supplies may work without problems.

### **Type B**



NEMA 5-15 plug, left. Decorative-style duplex outlet, right



Ordinary duplex outlet

The type B plug has two flat parallel blades like type A, but also adds a round or U-shaped grounding prong (American standard NEMA 5-15/CSA 22.2, No.42). It is rated for 15 amperes at 125 volts. The ground pin is longer than the live and neutral blades, so the device is grounded before the power is connected. Both current-carrying blades on type B plugs are narrow, since the ground pin enforces polarity. Type A plugs are also compatible with type B sockets, in which case the socket enforces polarity by means of a wide and a narrow slot.

Adapters that allow a Type B plug to be fitted to a Type A outlet are readily available. Proper grounding is dependent on the outlet being an ordinary duplex receptacle with a

grounded center screw, and the grounding tab of the adapter being connected to that screw.

The 5–15 socket is standard in all of North America (Canada, the United States, and Mexico). It is also used in Central America, the Caribbean, northern South America (Colombia, Ecuador, Venezuela and part of Brazil), Japan, Taiwan and Saudi Arabia. Looking directly at a type B outlet with the ground at the bottom, the neutral slot is on the left, and the live slot is on the right. Outlets may also be installed oriented with the ground at the top, or on either side. Typically connections are:

- Ground: bottom, round hole, green terminal, green or bare wire
- Neutral: top left, larger flat slot, silver terminal, white wire
- Live/Hot: top right, narrower flat slot, brass terminal, black wire (or red wire for 2nd live circuit, top and bottom socket are then separated)

In some parts of the United States and all of Canada, tamper-resistant outlets are now required in new construction. These prevent contact by objects like keys or paper clips inserted into the receptacle.



5–20RA (Canada) or 5-20R (USA)T-slot receptacle mounted with the ground hole up. The neutral connection is the wider T-shaped slot on the lower right.

In theater lighting, this connector is sometimes known as *PBG* for "Parallel Blade with Ground", *Edison* or *Hubbell*, the name of a common manufacturer.

NEMA 5–20 (North American 20 A/125 V grounded)

This is a 20 amperes receptacle; type 5-20 A has a T-slot for the neutral blade which allows either 15 amperes parallel-blade plugs or 20 amperes plugs to be used.

JIS C 8303, Class I (Japanese 15 A/100 V grounded)

Japan also uses a Type B plug similar to the North American one. However it is less common than its Type A equivalent.

### **Type C**

CEE 7/16 (Europlug 2.5 A/250 V ungrounded)



**CEE 7/16 plug and old type c socket**

This two-prong plug is popularly known as the Europlug. The plug is ungrounded and has two round 4 mm (0.157 in) pins, which usually converge slightly towards their free ends. It is described in CEE 7/16 and is also defined in Italian standard CEI 23-5 and Russian standard GOST 7396. This plug is intended for use with devices that require 2.5 amperes or less. Because it is unpolarised, it can be inserted in either direction into the socket, so live and neutral are connected arbitrarily. The separation and length of the pins allow its safe insertion in most Type E (French), type F (CEE 7/4 "Schuko"), Type H (Israeli), CEE 7/7, Type J (Swiss), Type K (Danish) and Type L (Italian) outlets, as well as BS 4573 UK shaver sockets. It can be forced into type D (5 amperes) and some G sockets, if the shutters are opened, though the connection may be neither reliable in either case, nor safe regarding overcurrent or short-circuit protection with type G sockets which may well be wired on a ring circuit with a 30 A rewirable (semi-enclosed) BS3036 fuse or 32 A circuit breaker.

The Europlug (plug only, not socket from the picture) is used in Class II applications throughout continental Europe (Austria, Belgium, Bosnia and Herzegovina, Bulgaria, Czech Republic, Croatia, Denmark, Estonia, Finland, France, Germany, Greece, Greenland, Hungary, Iceland, Italy, Latvia, Lithuania, Luxembourg, Macedonia, the Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey). It is also used in the Middle East, most African nations, South America (Brazil, Chile, Argentina, Uruguay, Peru and Bolivia), Asia (Bangladesh, Sri Lanka, Indonesia, Pakistan and the Philippines) as well as Russia and the former Soviet republics, such as Ukraine, Armenia, Georgia, and many developing nations. It is also used alongside the BS 1363 in many nations, particularly former British colonies.

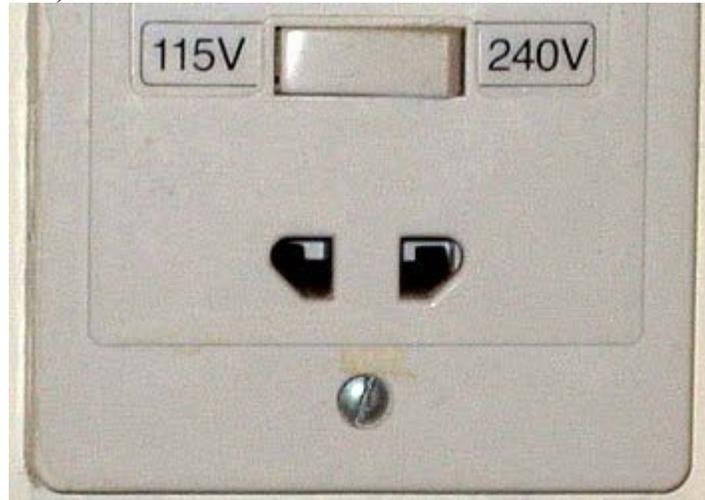
CEE 7/17 (German/French 16 A/250 V ungrounded)



CEE 7/17 plug

This plug also has two round pins but the pins are 4.8 mm (0.189 in) in diameter like types E and F and the plug has a round plastic or rubber base that stops it being inserted into small sockets intended for the Europlug. Instead, it fits only into large round sockets intended for types E and F. The base has holes in it to accommodate both side contacts and socket earth pins. It is used for large appliances, and in South Korea for all domestic non-earthed appliances. It is also defined in Italian standard CEI 23-5. Can also be safely inserted in to Israeli type H sockets, although with some difficulty.

BS 4573 (UK shaver)



**BS 4573** socket

In the United Kingdom and Ireland, what appears to be a larger version of the type C plug exists for use with shavers (electric razors) in bath or shower rooms. In fact it was not derived from the type C plug at all, but was a legacy from the obsolete 2 pin 5 amperes plug used in Britain in the 1920s and 1930s but still prevalent, especially in bathrooms, as late as the 1960s. It has 0.2 in (5.08 mm) diameter pins  $\frac{5}{8}$  in (15.88 mm) apart, and the sockets for this plug are often designed to accept unearthed CEE 7/16, US or Australian plugs as well. Sockets are often able to supply either 230 V or 115 V. In wet zones, they must contain an isolation transformer compliant with BS 3535.

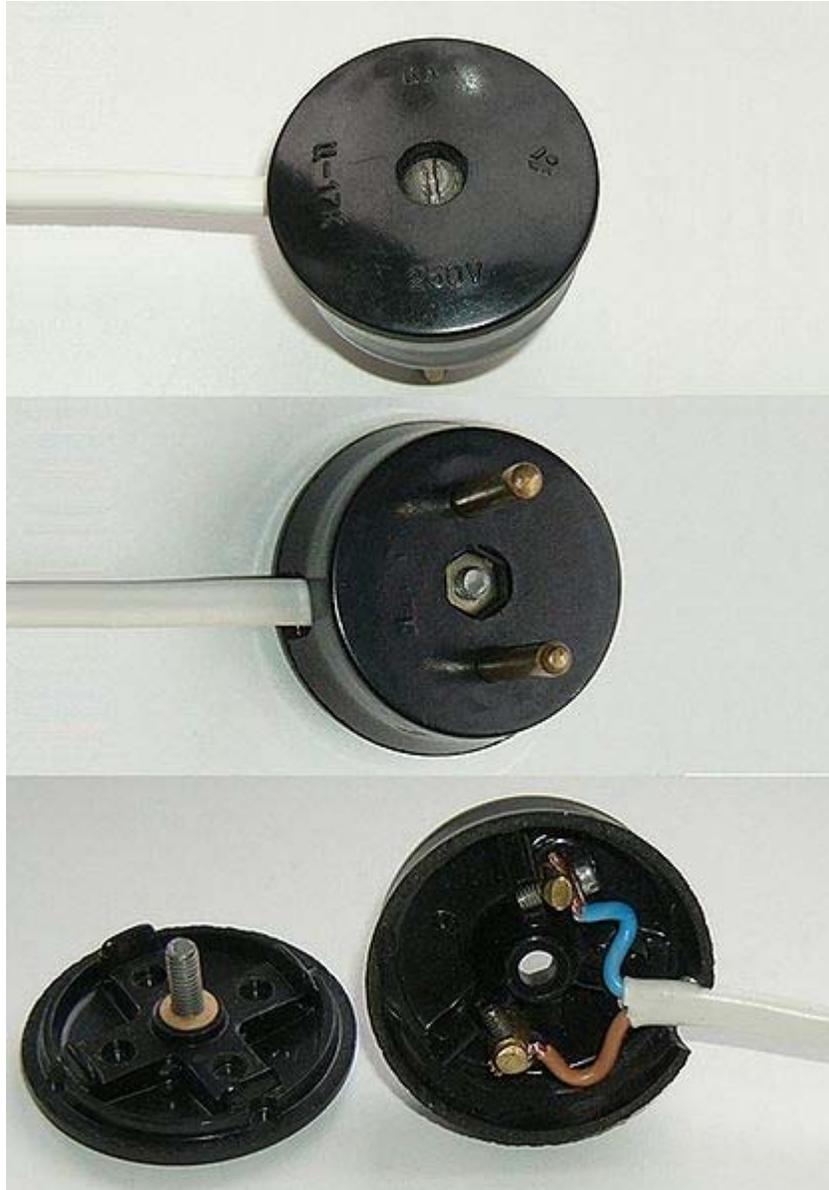
GOST 7396 C 1 (6 A or 16 A /250 V ungrounded)

This Soviet plug, still widely used in modern Russia, has pin dimensions and spacing equal to the Europlug, but lacks the insulation sleeves. Unlike the Europlug, it was rated for 6 A. It has a round body like the French type E or flat body with a round base like CEE 7/17. The round base has no notches. The pins are parallel and do not converge. The body is made of fire resistant thermoset plastic. The corresponding 6 A socket accept the Europlug, but not the type E or F plugs, nor the CEE 7/17 as the 4.5 holes are too small to accept the 4.8 mm pins of those plugs.

There were also moulded rubber plugs available for devices up to 16 A similar to CEE 7/17, but with a round base without any notches. They could be altered to fit a type E or F socket by cutting notches with a sharp knife.



Soviet grip plug, 6 A 250 V AC, thermoset plastic



Soviet round plug, 6 A 250 V AC, thermoset plastic, half height



Moulded rubber soviet plugs cut with knife in attempt to be similar to CEE 7/16 (left) and CEE 7/17 (right). Originally the plugs had a round base.



Soviet shaver power cord. The plug is similar to CEE7/16, but has different configuration. Thermoplastic plug is rated for 6 A 250 V.

#### Variations in sockets

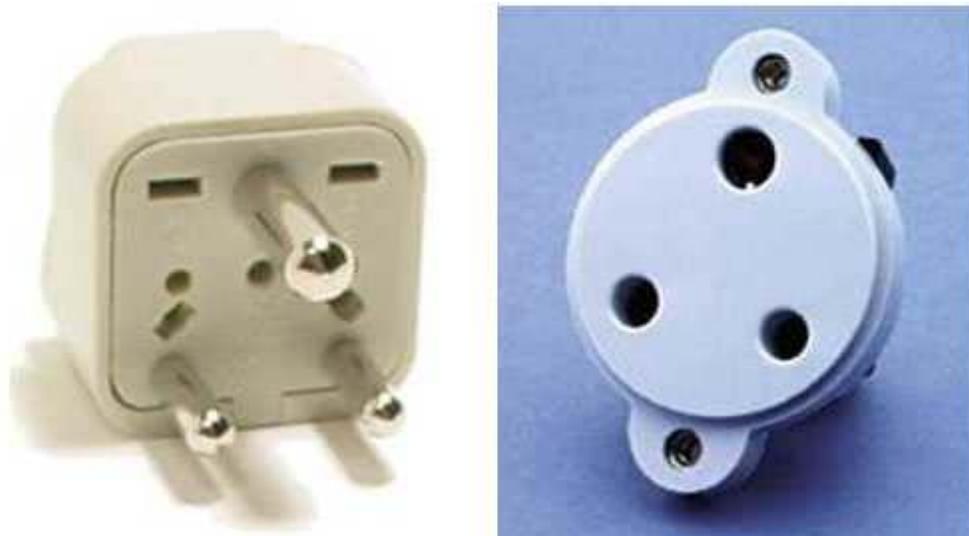


Unearthed socket compatible with both Schuko and French plugs

Type C sockets have no ground provisions and consequently have been phased out in most countries. For example, in Germany, ungrounded outlets are rare, found only in very old installations, whereas in the Netherlands they are common in "dry areas" such as in bedrooms or living rooms. Standards also vary between countries as to whether child-resistant shutters are required. Depending on the country and the age of the socket these sockets may have 4.0 or 4.8 mm receptacles. The latter accept type E and F plugs in addition to type C, though without ground connection. Countries using the type E or F standards vary in whether ungrounded type C outlets are still permitted in environments where the need for grounding is less critical. Adaptors and trailing sockets and power strips designed to accept only Europlugs with 4 mm (0.157 in) pins may also have plastic barriers in place to prevent CEE 7/17, Schuko or French plugs from entering.

### **Type D**

BS 546 (United Kingdom, 5 A/250 V grounded), equivalent to IA6A3 (India), rated at 6 A / 250 V



D Plug

India and Pakistan have standardised on a plug which was originally defined in British standard BS 546. It has three large round pins in a triangular pattern. The BS 546 standard is also used in parts of the Middle East (Kuwait, Qatar) and parts of Asia and South East Asia that were electrified by the British. This type was also previously used in South Africa, but has been phased out in favour of the 15 A version there. Similarly, in Ghana, Kenya and Nigeria, the plug has been mostly replaced by the British 3-pin (Type G). This 5 A plug, along with its smaller 2 A cousin, is sometimes used in the UK for centrally switched domestic lighting circuits, in order to distinguish them from normal power circuits.

BS 546 (United Kingdom, 15 A/250 V grounded), equivalent to IA16A3 (India) & SABS 164 (South Africa), rated at 16 A / 250 V



M Plug

This plug is sometimes referred to as type M, but it is in fact merely the 15 A version of the plug above, though its pins are much larger at 7.05 by 21.1 mm (0.278 by 0.831 in). Live and neutral are spaced 1 in (25.4 mm) apart, and earth is  $1\frac{1}{8}$  in (28.58 mm) away from each of them. Although the 5 A version is standard in India, Pakistan, Sri Lanka, Nepal and Namibia, the 15 A version is also used in these countries for larger appliances. Some countries like South Africa use it as the main domestic plug and socket type, where sockets always have an on-off switch built into them. Type M is still commonly found in installations in Hong Kong and Botswana, alongside type G. The Type M was almost universally used in the UK and Ireland for indoor dimmable theatre and architectural lighting installations, but there is now a widespread move to using CEE 16 A industrial sockets in new installations. It was also often used for non-dimmed but centrally controlled sockets within such installations. The main reason for doing this is that fused plugs, while convenient for domestic wiring (as they allow 32 A socket circuits to be used safely), are not convenient if the plugs and sockets are in hard-to-access locations (like lighting bars) or if using chains of extension cords since it is hard to figure out which fuse has blown. Both of these situations are common in theatre wiring. This plug is also widely used in Israel, Singapore, Sri Lanka and Malaysia for air conditioners and clothes dryers.

A socket has been developed for the Indian subcontinent that accepts both type D and type M plugs, with adjacent holes of the appropriate gauge.

### **Type E**

CEE 7/5 (French type E)



French socket



French plug

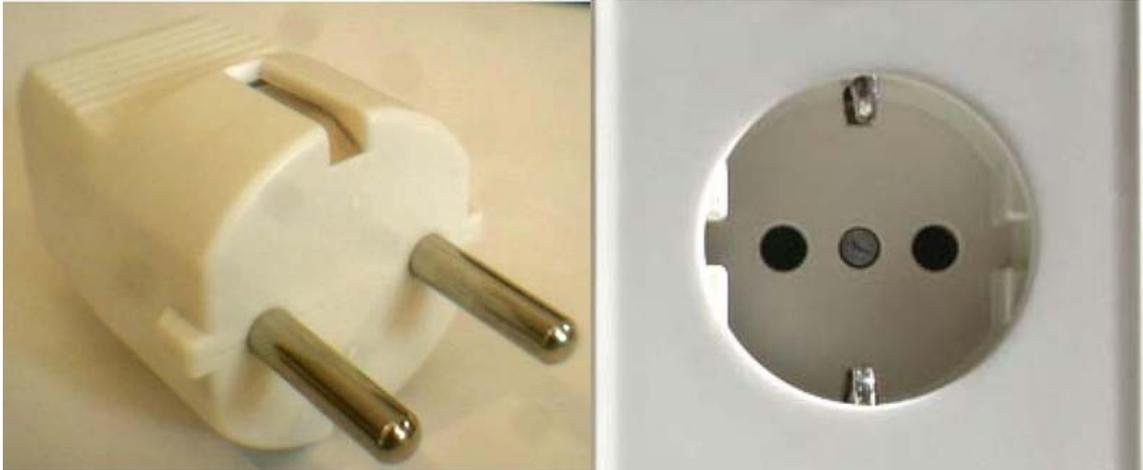
France, Belgium, Poland, Czech Republic, Slovakia and some other countries have standardized on a round plug with two round pins measuring 4.8 by 19 mm (0.189 by 0.748 in), spaced 19 mm (0.748 in) apart and with a hole for the socket's ground pin. This standard will also accept Europlug (type C) and CEE 7/17 plugs. Sockets are installed with the earth pin upwards. Although the plug is polarised, there is no universally observed standard for connecting the live and neutral. In the former Czechoslovakia Standard ČSN 33 2180:1979, section 6.2.2. required live to be on the left side of socket. Child-resistant outlet shutters are required by French and Belgian standards, however they are not required in all countries where this type is used.

Although similar under many aspects, type E plug is not compatible with the CEE 7/4 socket (type F) standard in Germany and other continental European countries. The reason for incompatibility is that grounding in the E socket is done by a round male pin permanently mounted in the socket. As well as type F plug below, type E plug will fit some other types of socket either easily or with force. However, there will be no ground connection with such sockets, and in some cases forcing the plug may damage the socket.

This type has been authorised in Denmark since 1 July 2008, but sockets of this kind are not yet common.

## Type F

CEE 7/4 (German "Schuko" 16 A/250 V grounded)



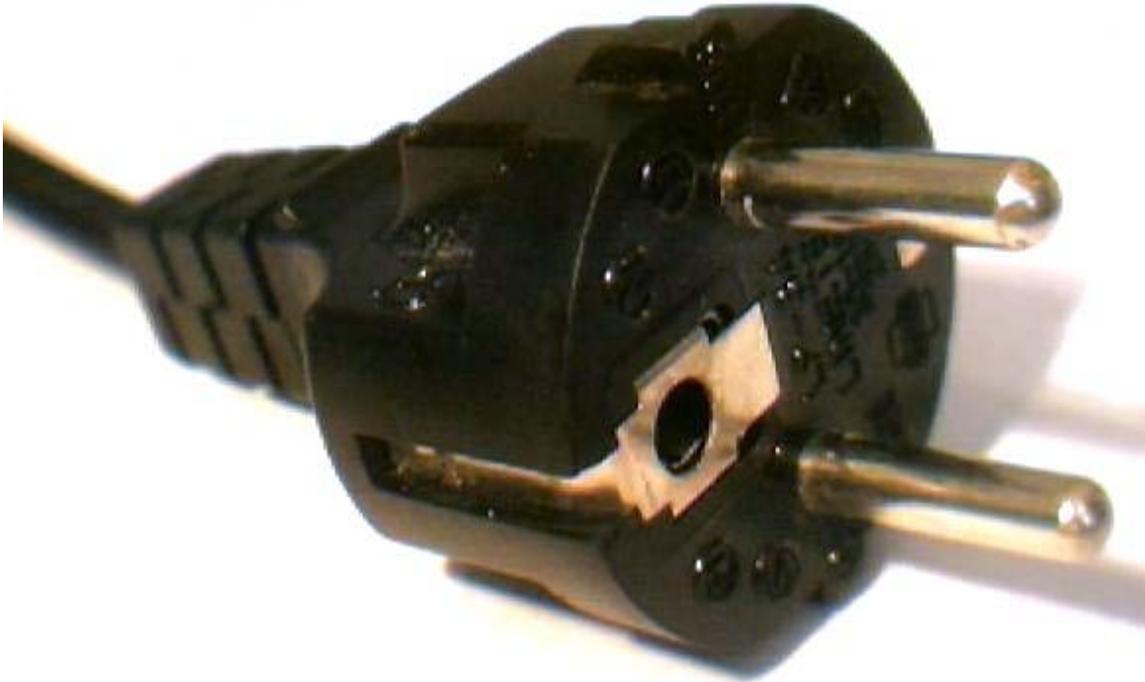
Schuko plug and socket

The type F plug, defined in CEE 7/4 and commonly called a "Schuko plug", is like type E except that it has two grounding clips on the sides of the plug instead of a female ground contact. The Schuko connection system is symmetrical and unpolarised by design, allowing live and neutral to be reversed. The socket also accepts Europlugs and CEE 7/17 plugs. It supplies up to 16 amperes. It is used in Austria, Bulgaria, Chile, Croatia, Estonia, Finland, Germany, Greece, Hungary, Iceland, Indonesia, Italy, Latvia, Luxembourg, the Netherlands, Norway, Pakistan, Portugal, Romania, Russia, Serbia, Slovenia, South Korea, Spain, Sweden, Turkey and Uruguay.

"Schuko" is an abbreviation for the German word *Schutzkontakt*, which means "Protective (that is, grounded) contact".

Some countries – notably Finland, Norway and Sweden – require child-proof outlet shutters; the German Schuko standard does not have this requirement.

## Type E / F hybrid



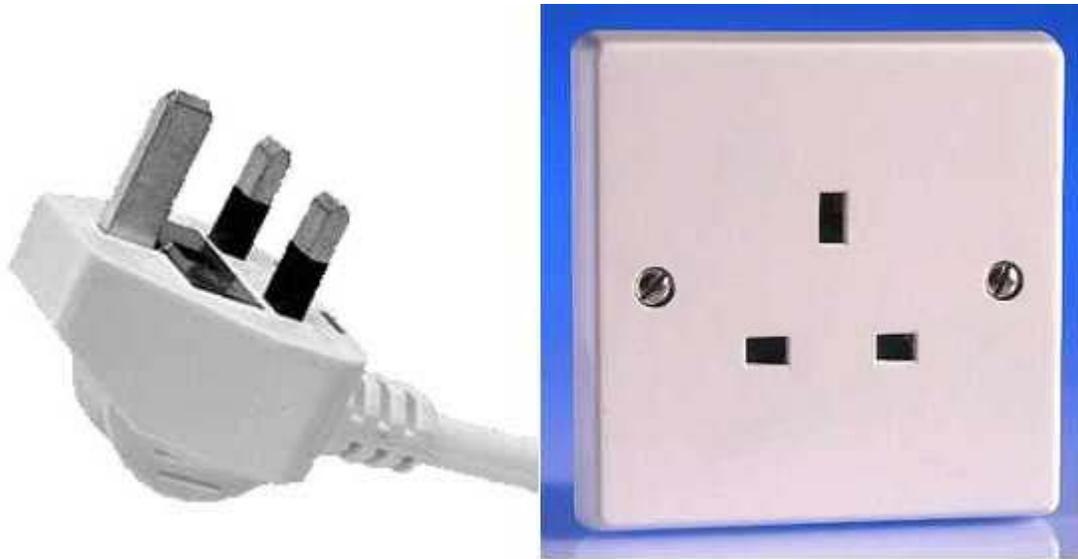
CEE 7/7 plug

CEE 7/7 (French/German 16 A/250 V grounded)

In order to bridge the differences between sockets E and F, the CEE 7/7 plug was developed. It is polarised to prevent the live and neutral connections from being reversed when used with a type E outlet, but allows polarity reversal when inserted into a type F socket. The plug is rated at 16 A. It has grounding clips on both sides to connect with the CEE 7/4 socket and a female contact to accept the grounding pin of the type E socket. It is also used in Spain and Portugal. Currently, when appliances are sold with type E/F plugs attached, the plugs are CEE 7/7 and non-rewirable. This means that the plugs are now identical between countries like France and Germany, but the sockets are different.

## Type G

BS 1363 (British 13 A/230-240 V 50 Hz grounded and fused), equivalent to IS 401 & 411 (Ireland), MS 589 (Malaysia) and SS 145 (Singapore), SASO 2203 (Saudi Arabia)



BS 1363

The British Standards 1363 plug. This design is used not only in the United Kingdom, but also in Pakistan, Ireland, Sri Lanka, Maldives, Bahrain, UAE, Qatar, Yemen, Oman, Jordan, Cyprus, Malta, Gibraltar, Botswana, Ghana, Hong Kong, Macau, Brunei, Malaysia, Singapore, Indonesia, Bangladesh, Kenya, Uganda, Malawi, Nigeria, Mauritius, Iraq, Kuwait, Tanzania, Zambia and Zimbabwe. BS 1363 is also standard in several of the former British Caribbean colonies such as Belize, Dominica, St. Lucia, Saint Vincent and the Grenadines and Grenada. It is also used in Saudi Arabia in 220 V installations although 110 V installations using the NEMA connector are more common.

This plug, commonly known as a "13 amp plug", is a large plug that has three rectangular prongs forming a triangle. Live and neutral are 18 mm (0.709 in) long, and spaced 22 mm (0.866 in) apart. 9 mm (0.354 in) of insulation at the trailing ends of the prongs prevents accidental contact with a bare connector while the plug is partially inserted. The earth prong is approximately 4 by 8 mm (0.157 by 0.315 in) and 23 mm (0.906 in) long.

The plug has a fuse inside. The fuse is required to protect the cord, as British wiring standards allow very high current ring main circuits to the socket. Accepted practice is to choose the smallest standard fuse (3, 5 or 13 A) that will allow the appliance to function. Using a 13 A fuse on an appliance with thin cord is a fire hazard. The fuse is 1 in (25.40 mm) long, conforming to standard BS 1362. Sockets are required to be wired with neutral on the left and live on the right (viewed from the front of the socket) so that the fuse in the plug disconnects the live feed if it blows. The same convention is used for all British sockets connected directly to "mains" wiring.

UK wiring regulations (BS 7671) require sockets in homes to have shutters over the live and neutral connections to prevent the insertion of objects other than electric plugs. On most designs, these shutters are opened by the insertion of the longer earth prong. On some designs they are opened by the simultaneous insertion of the live and neutral prongs

of the right shape and spacing. The effect of the shutters is to help prevent the use of plugs made to other standards, and to prevent children and others poking things into the dangerous connections. On plugs for Class II appliances that do not require an earth, the earth pin is often plastic and serves only to open the shutters and to enforce the correct orientation of live and neutral. It may be possible to open the shutters by putting a screwdriver blade into the earth socket, so as to insert a Type C Plug (but not the BS 4573 UK shaver) or other plug types, but this can be dangerous for such plugs will not have a fuse and will often not fit properly.

BS 1363 plugs and sockets started appearing in 1946 and BS 1363 was first published in 1947. By the end of the 1950s, it had replaced the earlier type D BS 546 in new installations, and by the end of the 1960s, most earlier type D installations had been rewired to BS 1363 standards. Outlets usually include switches on the live side for convenience and safety.

## Type H



Two Israeli plugs and one socket. The left plug is the old standard, the one on the right is the 1989 revision.

SI 32 (Israeli 16 A/250 V grounded)

This plug, defined in SI 32 (IS16A-R), is unique to Israel and is incompatible with all other sockets. It has three flat pins to form a Y-shape. Live and neutral are spaced 19 mm

(0.75 in) apart. The Type H plug is rated at 16 A but in practice the thin flat pins can cause the plug to overheat when connecting large appliances. In 1989, the standard was revised to use three round 4.5 mm (0.177 in) pins in the same locations. Sockets made since 1989 accept both flat and round pins for compatibility with both old and new plugs. This also allows the Type H socket to accommodate the type C plugs used in Israel for non-earthed appliances. Older sockets, from about the 1970s, have both flat and round holes for live and neutral in order to accept both Type C (CEE 7/16 Europlug) and Type H plugs. As of 2008, type H sockets which accept only old-style type H plugs are very rare in Israel.

This plug is also used in the areas controlled by the Palestinian National Authority in the West Bank and all of the Gaza Strip.

Thai 3 pin plug TIS 166-2549 (2006)

Thai multi-standard 3-pin sockets (like that shown in the section on multi-standard sockets below) safely accept type A, B, C and H plugs, and also the Thai 3 pin plug. This round-pin plug is similar to the Israeli plug but its pin dimensions are 4.8 mm instead of 4.0 mm and the pins are insulated.

## **Type I**

AUS/NZS 3112 (Australasian 10 A/240 V)



Australasian switched 3-pin dual power point (socket)

This plug, used in Australia, New Zealand, Fiji, Argentina, Solomon Islands and Papua New Guinea, has a grounding pin, and two flat current-carrying pins forming an upside down V-shape. The flat blades measure 6.5 by 1.6 mm (0.256 by 0.063 in) and are set at 30° to the vertical at a nominal pitch of 13.7 mm (0.539 in). Australian and New Zealand wall sockets almost always have switches on them for extra safety, as in the UK. An unearthed version of this plug with two angled power pins but no earthing pin is used with small double-insulated appliances, but the powerpoint (wall) outlets always have three pins, including a ground pin.

There are several AS/NZS 3112 plug variants, including ones with larger pins and/or differently shaped ground pins used for devices drawing 15, 20, 25 and 32 amps. These sockets accept plugs of equal or of a lower current capacity, but not of higher capacity. For example, a 10 A plug will fit all sockets but a 20 A plug will fit only 20, 25 and 32 A outlets.



Australian 2005 standard power plug

Australasia's standard plug/socket system was originally codified as standard C112 (floated provisionally in 1937, and adopted as a formal standard in 1938), which was superseded by AS 3112 in 1990. As of 2005, the latest major update is AS/NZS 3112:2004, which mandated insulated pins by 2005 at the point of sale in all Australian States and New Zealand. However, equipment and cords made before 2003 can still be used.



Chinese sockets accepting plug types A, C (upper) and I (lower, standard)

CPCS-CCC (Chinese 10 A/250 V)

Although the pins on the Chinese plug are 1 mm (0.039 in) longer, the Australasian plug can be used with mainland Chinese socket. The standard for Chinese plugs and sockets is set out in GB 2099.1–2008 and GB 1002–2008. As part of China's commitment for entry into the WTO, the new CPCS (Compulsory Product Certification System) has been introduced, and compliant Chinese plugs have been awarded the CCC Mark by this system. The plug is three wire, earthed, rated at 10 A, 250 V and used for Class 1 applications.

In China, the sockets are installed upside-down relative to the Australasian ones.

China also uses American/Japanese "Type A" sockets and plugs for Class-II appliances. However, the voltage across the pins of a Chinese socket will always be 220, no matter what the plug type.

IRAM 2073 (Argentinian 10 A/250 V)

The Argentinian plug is a three-wire earthed plug rated at 10 A, 250 V defined by IRAM and used in Class 1 applications in Argentina and Uruguay.

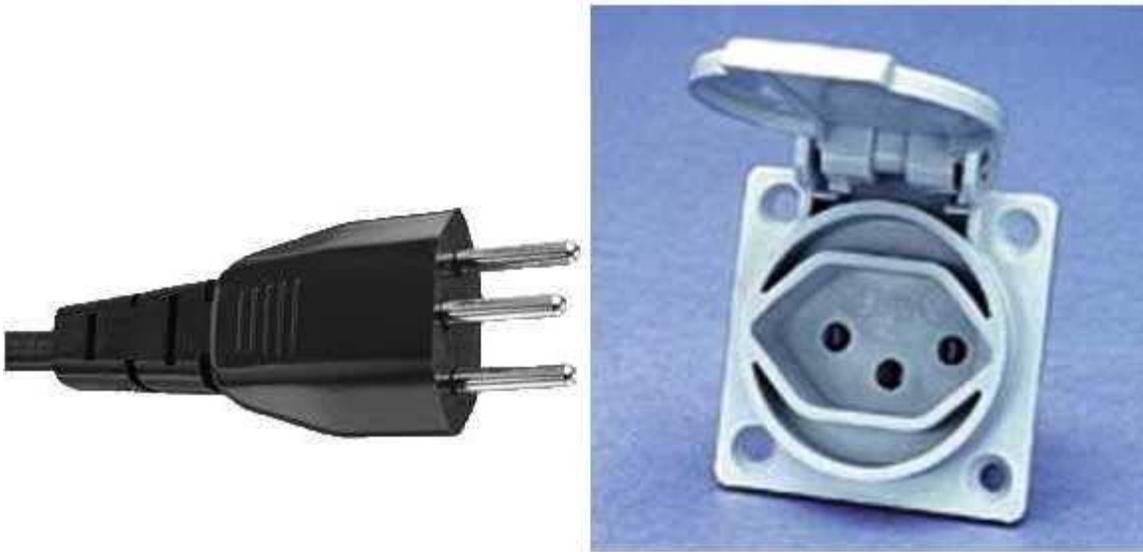
This plug is similar in appearance to the Australasian and Chinese plugs. The pin length is same as the Chinese version. The most important difference from the Australasian plug is that the Argentinian plug is wired with the live and neutral contacts reversed.

### Brazil

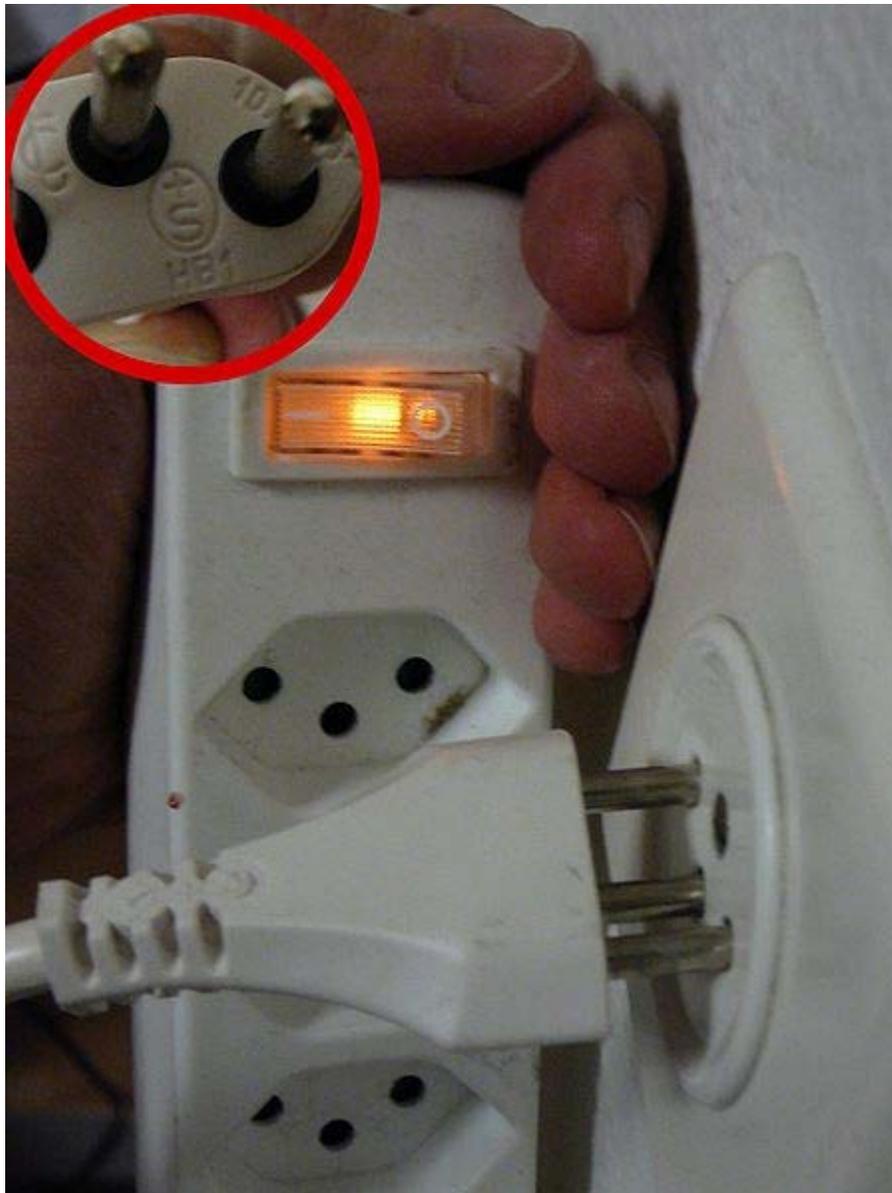
In Brazil, this kind of plug is still commonly found in high-power appliances like air conditioners, dishwashers, and household oven. Since the adopted IEC 60906-1 standard prescribes a high-current plug version, the original motivation to use the "Argentinian" plug ceased to exist, and the new standard should prevail in the long term.

### **Type J**

SEV 1011 (Swiss 10 A/250 V)



regular Type J plug and covered socket



Type J plugs and non-SEV 1011 socket showing a potential shock hazard: the appliance is energised although the plug is not fully inserted.

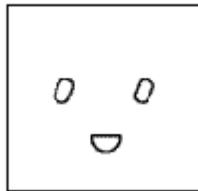
Switzerland has its own standard which is described in SEV 1011. (ASE1011/1959 SW10A-R) This plug is similar to the type C Europlug (CEE 7/16), except that it has an offset earth pin and the pin shanks are not insulated, so plugs partially inserted into non-recessed sockets present a shock hazard. Sockets used in kitchens, bathrooms and other wet areas are recessed, while those used elsewhere are not. Some plugs and adaptors have a tapered form and can be used in either environment, while others will fit only the non-recessed sockets. Swiss sockets accept Swiss plugs or Europlugs (CEE 7/16). There is also a non-earthed two-pin variant with the same pin shape, size, and spacing as the SEV 1011's live and neutral pins, but with a more flattened hexagonal form. It fits into round and hexagonal Swiss sockets and CEE 7/16 sockets, and is rated for up to 10 A.

A less-common variant has 3 square pins and is rated for 16 amperes. Above 16 amperes, equipment must either be hardwired to the electrical supply system with appropriate branch circuit protection, or connected to the mains with an appropriate high power industrial connector.

### **Type K (Danish standard)**



Danish 107-2-D1, standard DK 2-1a, with round power pins and half round ground pin



Outlet for Danish computer equipment plug's tilted flattened pins and half round ground pin (mainly used in professional environment), standard DK 2-5a  
Section 107-2-D1 (Danish 13 A/250 V earthed)

This Danish standard plug is described in the Danish Plug Equipment Section 107-2-D1 Standard sheet (SRAF1962/DB 16/87 DN10A-R). The plug is similar to the French type E except that it has an earthing pin instead of an earthing hole (and vice versa on the socket). This makes the Danish socket more unobtrusive than the French socket which is a cavity into the wall to protect the earthing pin from mechanical damage (and to protect from touching the live pins). The Danish standard provides for outlets to have child-resistant shutters.

The Danish socket will also accept the type C CEE 7/16 Europlug or type E/F CEE 7/17 Schuko-French hybrid plug. Type F CEE 7/4 (Schuko), type E/F CEE 7/7 (Schuko-French hybrid), and grounded type E French plugs will also fit into the socket but should not be used for appliances that need earth contact. The current rating on both plugs is 13 A.

A variation (standard DK 2-5a) of the Danish plug is for use only on surge protected computer outlets. It fits into the corresponding computer socket and the normal type K socket, but normal type K plugs deliberately don't fit into the special computer socket. The plug is often used in companies, but rarely in private homes.

There is a variation for hospital equipment with a rectangular left pin, it is used for life support equipment.

Traditionally all Danish sockets were equipped with a switch to prevent touching live pins when connecting/disconnecting the plug. Today, sockets without switch are allowed, but then it is a requirement that the sockets have a cavity to prevent touching the live pins. However, the shape of the plugs generally makes it difficult to touch the pins when connecting/disconnecting.

Since the early 1990s grounded outlets have been required in all new electric installations in Denmark. Older outlets need not be grounded, but all outlets, including old installations, must be protected by ground-fault interrupters (HFI or HPFI in Danish) by 1 July 2008.

As of 1 July 2008, wall outlets for type E (French 2-pin, female earth) are permitted for installations in Denmark. This was done because no electrical equipment sold to private users is equipped with a type K plug, and to break the monopoly of Lauritz Knudsen — the only company making type K sockets and plugs.

Sockets for the Schuko F type will not be permitted. The reason is that a large number of currently used Danish plugs (coincidentally made by the afore mentioned Lauritz Knudsen monopoly) will jam when inserted into a Schuko socket. This may cause damage to the socket. It may also result in a bad connection of the pins, with resultant risk of overheating and fire. Broken type F sockets are often seen in German hotels visited by Danes. Many international travel adapter sets sold outside Denmark match type C CEE 7/16 (Europlug) and type E/F CEE 7/7 (Schuko-French hybrid) plugs which can readily be used in Denmark.

### **Type L**

CEI 23-16/VII (Italian 10 A/250 V and 16 A/250 V)



23-16/VII plug with socket



Side by side comparison of Italian type L plugs rated 16 amperes (left) and 10 amperes (right).



An Italian installation carrying both Italian type L sockets (16 A on the left; 10 A on the right).

The Italian earthed plug/socket standard, CEI 23-16/VII, includes two models rated at 10 A and 16 A that differ in contact diameter and spacing. Both are symmetrical, allowing the live and neutral contacts to be inserted in either direction.

The double standard was initially adopted because in Italy, up to the second half of the twentieth century, the electric power used for lamps (*Luce* = lighting) and the one used for all other appliances (*Forza* = electromotive force; or *Usa Promiscuo* = general purpose) were sold at different fares, charged with different taxes, accounted with separated electricity meters, and sent on different wire lines that ended with different sockets. Even though the two electric lines (and respective fares) were definitively unified during the summer of 1974 many houses kept twin wires and twin electricity meters for years thereafter. The two gauges for plugs and sockets thus became a de facto standard which is still in use today and has been standardized with CEI 23-16/VII. Older installations often have sockets that are limited to either the 10 A or the 16 A style plug, requiring the use of an adapter if the other gauge needs to be connected.

CEE 7/16 (type C) ungrounded Europlugs are also in common use; they are standardized in Italy as CEI 23-5 and fit most of the appliances with low current requirement and double insulation.

Appliances with CEE 7/7 Schuko-French plugs are often sold in Italy too; however not every socket will accept them since the pins of the CEE 7/7 Schuko-French plugs are thicker than the Italian ones. Adapters are cheap and commonly used to connect CEE 7/7 plugs to CEI 23-16/VII sockets, though the power rating may be mismatched (16 A to 10 A) and may lead to potentially unsafe connection in some cases.

The current Italian standard provides for outlets to have child-resistant shutters.

CEI 23-16/VII (Italian 10 A/250 V)

The 10 (former 6) amperes style extends CEE 7/16 by adding a central earthing pin of the same gauge. Thus, CEI 23-16-VII 10 A sockets can accept CEE 7/16 Europlugs. This is the plug shown in the first picture.

CEI 23-16/VII (Italian 16 A/250 V)

The 16 amperes style looks like a magnified version of the 10 A style, identical in shape. However, the pins are 5 mm (0.197 in) thick (being 4 mm (0.157 in) thick in 10 A type), 8 mm (0.315 in) apart (while 5.5 mm (0.217 in) apart in 10 A type) and 7 mm (0.276 in) longer. The packaging of these plugs in Italy may claim they are a "North European" type. In the past they were also referred to as *per la forza motrice* (for electromotive force, see above) or sometimes *industriale* (industrial), although the latter has never been a correct definition as factories used predominantly three-phase current and specialized connectors.

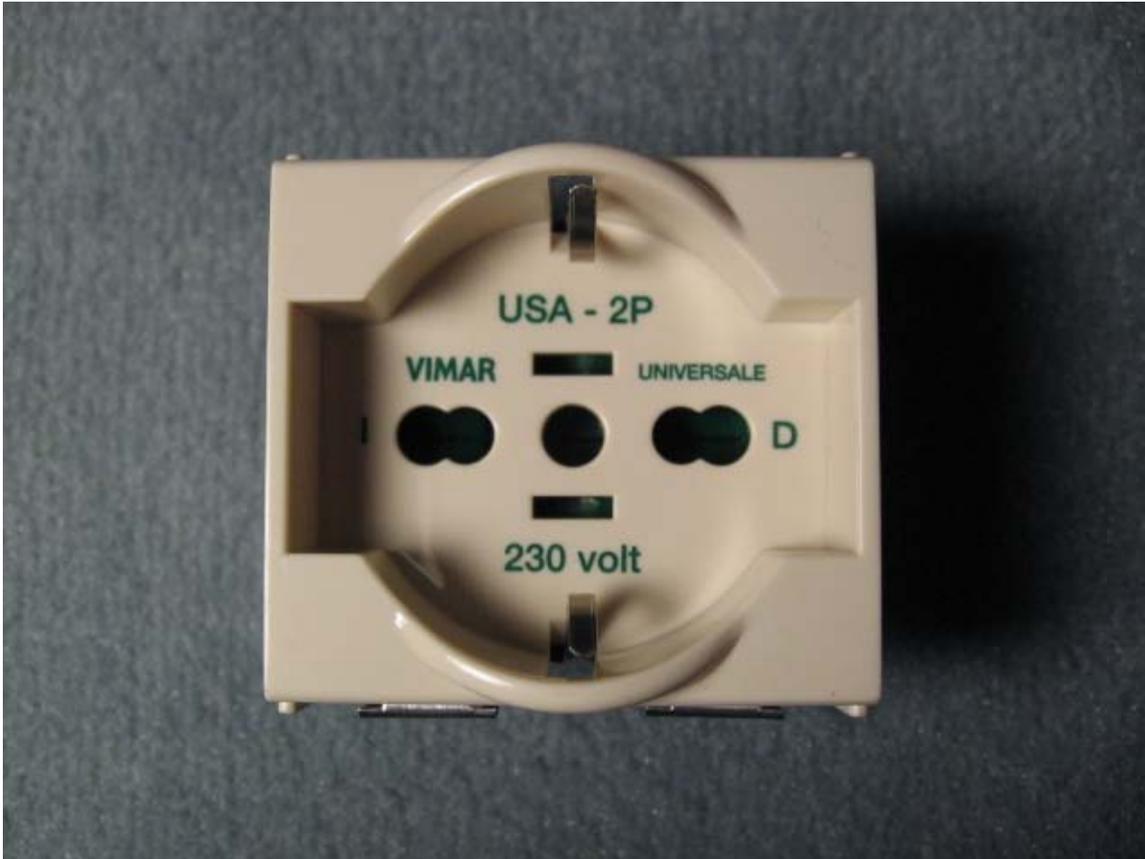
Twin-gauge or multi-type sockets



A *bipasso* socket (number 1) and an Italian adapted *schuko* (number 2 in the photo) in a modern installation.

Given that the plug with which appliances are fitted and sold varies, modern installations in Italy (and in other countries where type L plugs are used) are likely to use sockets that can accept more than one standard. The simpler type has a central round hole and two 8-shaped holes above and below. This design allows the connection of both styles of type L

plugs (CEI 23-16/VII 10 A and 16 A) and the type C CEE 7/16 Europlug. The advantage of this socket style is its small, compact face. VIMAR brand claims to have patented this socket first in 1975 with their *Bpresa* model; however soon other brands started selling similar products mostly naming them with the generic term *presa bipasso* (twin-gauge socket) that is now of common use.



An Italian VIMAR brand *universale* socket which can accept type C (most sorts of), F, and E/F hybrid plugs as well as both 10 A and 16 A type L plugs.

A second, quite common type looks like a type F socket, but adds a central grounding hole. This design can accept CEE 7/7 (type E/F) plugs, in addition to type C and type L 10 A plugs. Some of these sockets may also have 8-shaped holes to accept type L 16 A plugs as well. One drawback is that it is twice as large as a normal type L socket; also, 90° angled type L plugs often do not fit these sockets because they are too much recessed.

Other types may push compatibility even further. The VIMAR-brand *universale* (all purpose) socket, for example, accepts CEE 7/7 (type E/F) plugs, type C plugs, both 10 A and 16 A type L plugs, and American/Japanese type A plugs as well.

Other countries

Outside of Italy, type L CEI 23-16/VII (Italian 10 A/250 V) plug is found in Syria, Libya, Ethiopia, Chile, Uruguay, various countries in North Africa, and occasionally in older buildings in Spain.

### **Type M**

BS 546 (South African 15 A/250 V)

Type M is sometimes used to describe the 15 A version of the old British type D, used in South Africa and elsewhere.

### **North American oven and dryer outlets**

NEMA 14-30

A 30 amperes, 3 wire single-phase grounding receptacle is often used for electric clothes dryers. 240 volts from the split phase system is used for the heating elements, and the motor and controls run on 120 volts.

NEMA 14-50

A 50 amperes 3 wire single-phase grounding outlet is usually installed in kitchens and used for electric cooking ranges and ovens. As for dryers, lighting and motors run on 120 V and the main heating element is connected for 240 V.

## ***Proposed common standard***



A Brazilian socket for 20 A/250 V, meant for use with larger pins than 10 A version IEC 60906-1 (Brazilian 10 A and 20 A /250 V - NBR 14136:2002)

In 1986, the International Electrotechnical Commission published IEC 60906-1, the specification for a plug that looks similar but is not identical to the Swiss (Type J) plug. This plug was intended to one day become the common standard for all of Europe and other regions with 230 V mains, but the effort to adopt it as a European Union standard was put on hold in the mid 1990s.

Brazil, which had been using mostly Class II Europlugs (while households also commonly presenting socket fittings for the NEMA 1–15 and NEMA 5–15 standards), set out IEC 60906-1 as the national standard in 2001 under specification NBR 14136. However, this standard was never really enforced or encouraged in that country until 2007, when the adoption of IEC 60906-1 was made optional for manufacturers. Also, it helped domestic consumers that most of Class II plugs fitted in the new IEC 60906-1 socket.

Since January 1, 2010, new electrical appliances in Brazil must now comply with the new IEC 60906-1 requirement. End-user stores and resellers can sell equipments without adoption deadlines, but importers will no longer be allowed to bring in nonconforming devices, nor will manufacturers be able to sell them in Brazil.

There are two types of sockets and plugs in this system: one for 10 A, with a 4mm pin diameter, and another for 20 A, with a 4.8 mm pin diameter, the latter used for heavier appliances such as microwave ovens.

South Africa has also introduced the IEC 60906 standard as SANS 164-2 in parallel with the types C and M standard.

### **Comparison of plugs**

Type	Plug standard	Power rating	Grounded	Polarised	Fused	Insulated pins
A	NEMA 1–15 unpolarised	15 A/125 V	No	No	No	No
	NEMA 1–15 polarised	15 A/125 V	No	Yes	No	No
	JIS C 8303, Class II	15 A/100 V	No	No	No	No
B	NEMA 5–15	15 A/125 V	Yes	Yes	No	No
	NEMA 5–20	20 A/125 V	Yes	Yes	No	No
	JIS C 8303, Class I	15 A/100 V	Yes	Yes	No	No
C	CEE 7/16 (Europlug)	2.5 A/250 V	No	No	No	Yes
	CEE 7/17	16 A/250 V	No	No <sup>1</sup>	No	No
	GOST 7396 C 1	6 A/250 V 16 A/250 V	No	No	No	No
D	BS 546 (2 pin)	2 A/250 V 5 A/250 V = BS 4573	No	No	No	No
	BS 546 (3 pin)	2 A/250 V 5 A/250 V 15 A/250 V = SABS 164 30 A/250 V	Yes	Yes	No	No
E	CEE 7/5	16 A/250 V	Yes	Yes	No	No
F	CEE 7/4 (Schuko)	16 A/250 V	Yes	No	No	No
E+F	CEE 7/7	16 A/250 V	Yes	Yes <sup>2</sup>	No	No
G	BS 1363, IS 401 & 411, MS 589, SS 145	13 A/230-240 V	Yes	Yes	Yes	Yes

H	SI 32	16 A/250 V	Yes	Yes	No	No
	TIS 166–2549	16 A/250 V	Yes	Yes	No	Yes
I	AS/NZS 3112	10 A/240 V 20 A/240 V 25 A/240 V 32 A/240 V	Yes and No	Yes	No	Yes
	CPCS-CCC	10 A/250 V	Yes	Yes	No	No
	IRAM 2073	10 A/250 V	Yes	Yes	No	No
J	SEV 1011	10 A/250 V 16 A/250 V	Yes	Yes	No	No
K	Section 107-2-D1	13 A/250 V	Yes	Yes	No	No
L	CEI 23-16/VII	10 A/250 V 16 A/250 V	Yes	No	No	Yes
—	IEC 60906-1 (2 pin)	10 A and 20 A/250 V	No	No	No	Yes
	IEC 60906-1 (3 pin)	10 A and 20 A/250 V	Yes	Yes	No	Yes

<sup>1</sup> There are some CEE 7/17 plugs with special shape which are polarised when used with french socket of type E (mechanically only)

<sup>2</sup> Plug can only be inserted one way with French socket of type E, but lack of wiring convention means that the type is not polarised in practice

### **Multi-standard sockets**



A standard grounded **Thai** outlet supporting European 2-pin plugs and earthed and unearthed American plugs and Thai 3 pin plugs. Though this receptacle accepts standard US Type A or B plugs, the standard Thai voltage is 220 volts.

Sockets that take a variety of plug types can be found in various countries where market size or local market conditions make a specific plug standard impractical to implement. These socket accept plugs fitting various European, Asian and North American standards. Since many plug standards are also associated with corresponding voltages, multi-standard sockets do not safeguard against devices being damaged by the wrong voltage. This forces users to be aware of the voltage requirements of their appliances as well as the prevailing local voltage. Devices designed to adapt automatically to whatever voltage and frequency is supplied, and which don't require grounding, are generally safe to use with these sockets.

These sockets have one or more ground holes to allow 3-pin plugs. On properly wired circuits, the ground contact may be actually grounded; however, as with most other forms of plugs, they are not immune to poor wiring. They may also not provide grounding to all types of plugs, as is the case of Schuko or French plugs where the grounding pin that mates with the plug is part of the socket rather than the plug.

### **Adapters**

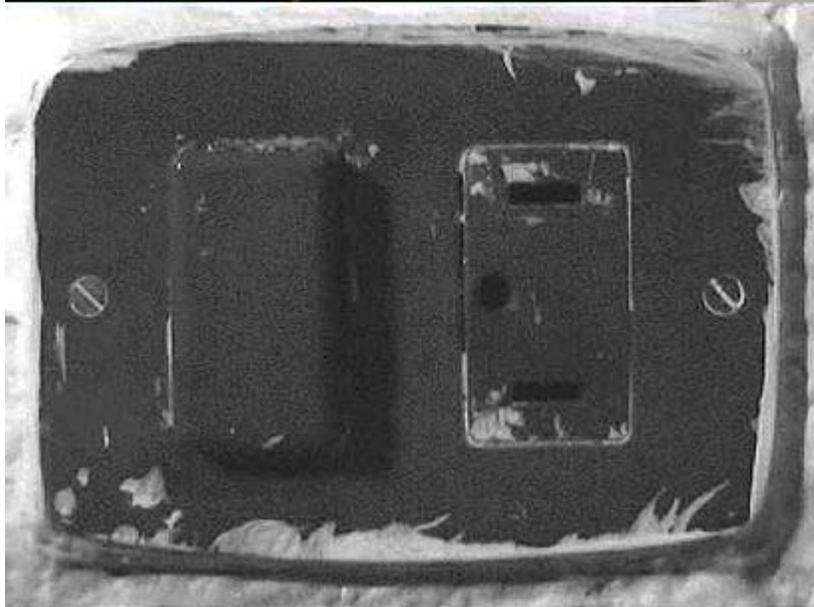
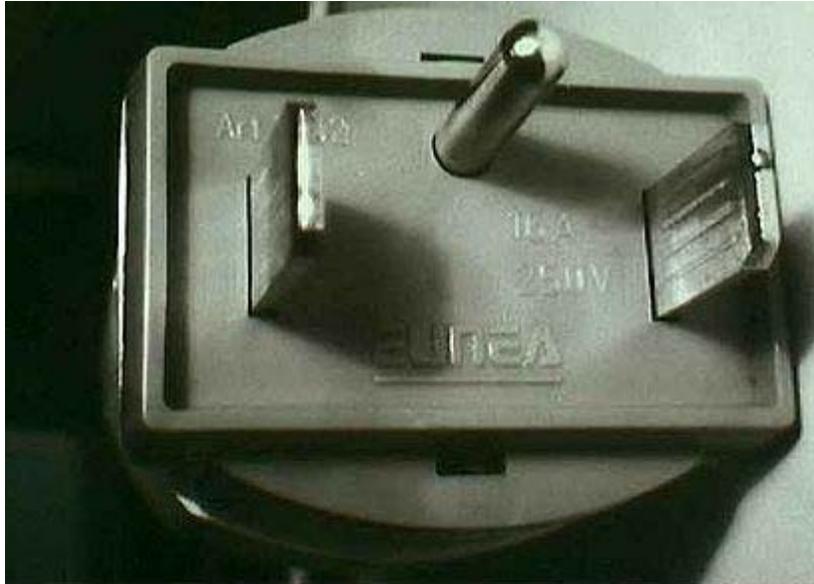


A type M (15 A version of type D) travel adapter

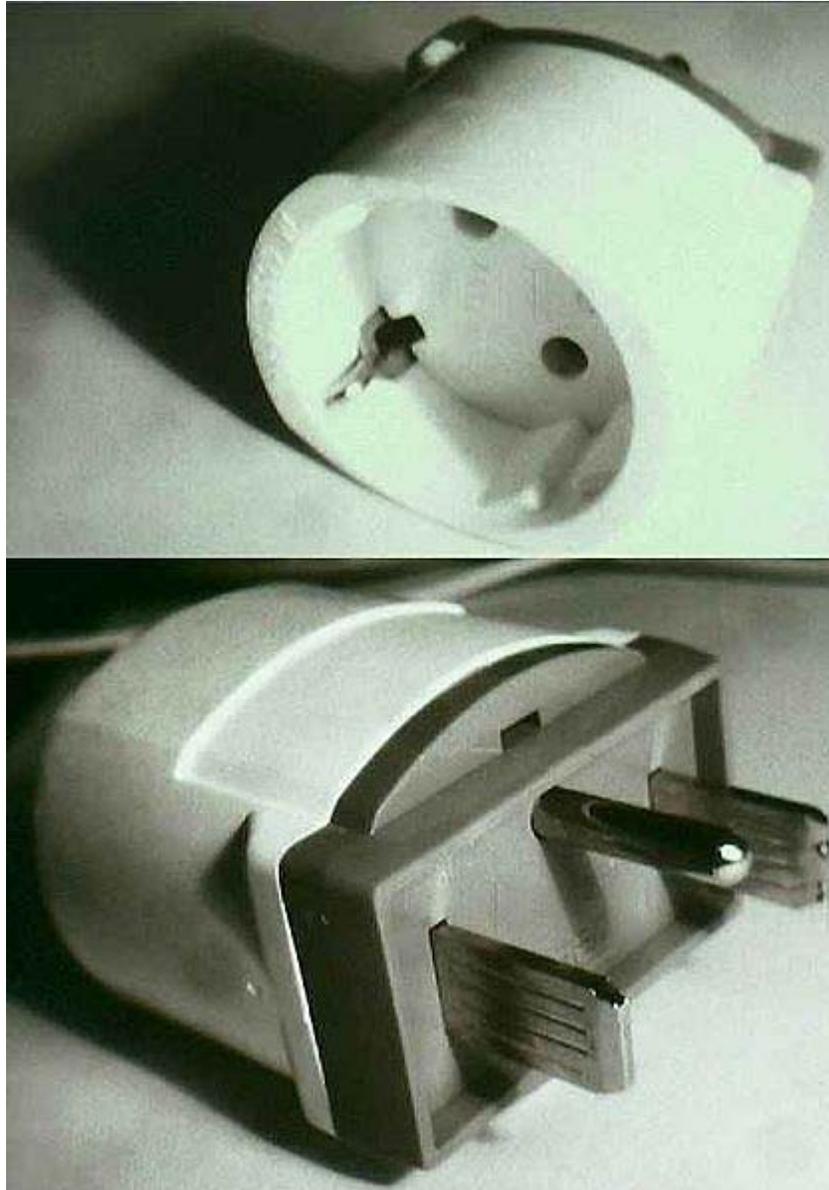
To facilitate travelers' use of personal electric devices, adapters are available to permit the interconnection of normally incompatible plugs and sockets. Such adapters overcome only the physical incompatibilities between plugs and sockets built to different standards; often a voltage converter is required for electrical compatibility.

***Obsolete types***

**Old Spanish sockets**



Spanish three-prong plug and socket, with easily removable fuse



An adapter to allow types C and F to be inserted

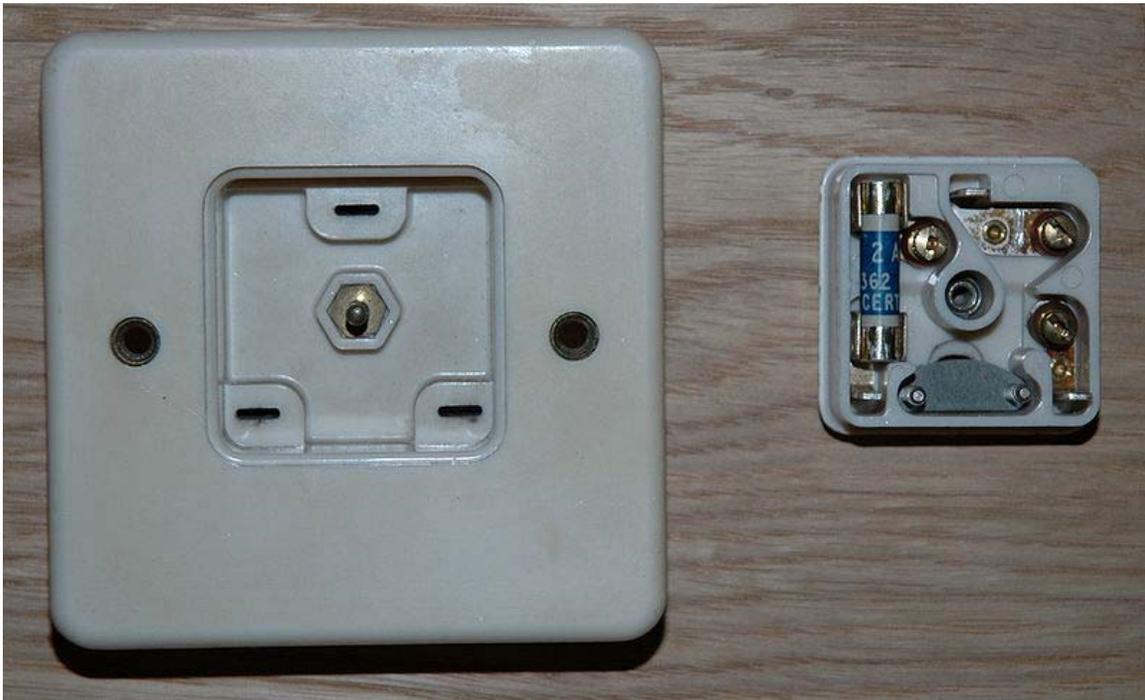
Some older industrial buildings in Spain used sockets that took a particular type of plug which was rated for higher current and had two flat contacts and a round ground pin, somewhat similar in design to the ones found on American plugs but larger in size.

The live and neutral measure 9 by 2 mm (0.354 by 0.079 in), and are 30 mm (1.181 in) apart. All three pins are 19 mm (0.748 in) long, and the earth pin is a cylinder of 4.8 mm (0.189 in) diameter.

While the plug resembles an American connector, the two flat contacts are much wider apart than on a standard American plug, which will therefore not fit in these sockets.

No domestic appliances were ever sold with these plugs.

### **UK electric clock connector**



British electric clock connector, 3-pin made by MK. Showing the rear of the plug with its 2 A fuse. Different manufacturers' clock connectors were generally not compatible.

Fused plugs and sockets of various proprietary and non-interchangeable types are found in older public buildings in the UK, where they are used to feed AC electric wall clocks. They are smaller than conventional socket outlets, commonly being made to fit BESA junction boxes, and are often of very low profile. Early types were available fused in both poles, later types fused in the live only and provided an earth pin. Most are equipped with a retaining screw or clip to prevent accidental disconnection. The prevalence of battery powered quartz controlled wall clocks has meant that this connector is rarely seen in new installations.

## NEMA 1-15 5-receptacle Type A outlet



Unusual American 5-receptacle Type A outlet, ca. 1928

This is a very rare 5-way outlet from circa 1928, and is able to accept modern ungrounded polarized NEMA 1-15 plugs because the outlet itself is polarized. However, the outlet itself is still obsolete as the NEMA standard only provides for having at most 3 outlets from a single wallplate.

## American "Type I"



American Type I duplex outlet



### Compatibility of American and Australian Type I plugs

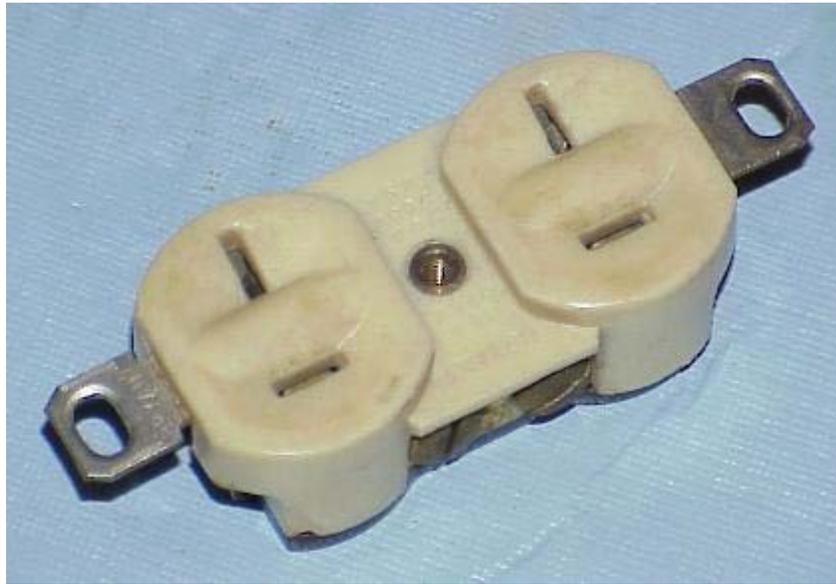
The American electrical supply manufacturers Hubbell, Eagle, and possibly others made outlets and plugs that would match Type I plugs and sockets exactly. Type I connectors are used in Australia for 240 V service. These American outlets date back to at least 1915 (as seen in US Patent 1,179,728 filed in 1915), antedating the American 3 prong Type B sockets and plugs. They were meant for appliances that needed grounding (120 V at 15 amperes), and to be used in laundry rooms for washing machines and gas dryers (to power the motor). These did not become popular because American type A 2-prong plugs would not fit.

### Split current/voltage ratings

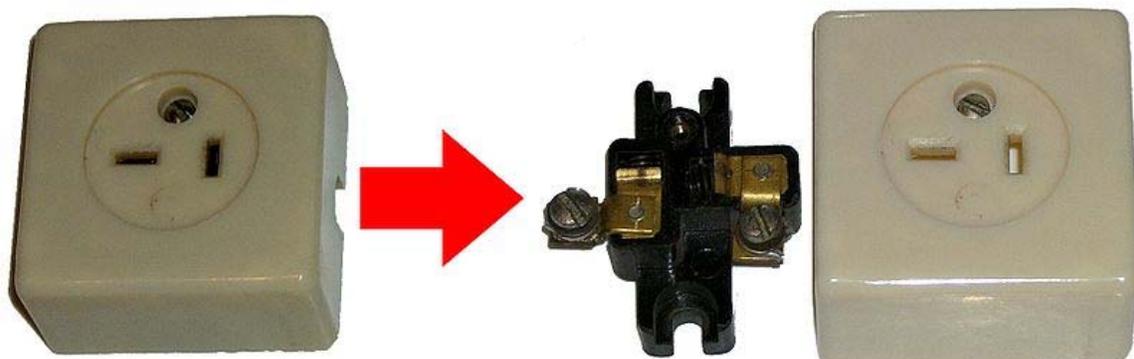
Many older North American receptacles have two different current and voltage ratings, most commonly 10 A 250 V/15 A 125 V. This has to do with a peculiarity of the National Electrical Code from 1923 to the 1950s. Originally, receptacles were rated at 10 A 250 V, because the NEC limited lighting circuits to 10 amperes. In 1923, the code changed to allow lighting circuits to be fused at 15 amperes; however, the old rule still applied to circuits over 125 volts. The higher voltages were rarely used for lighting and appliances. Most receptacles with this rating are of the "T-slot" type. This type of rating was phased out in the 1950s, and finally abolished in the 1960s with the adoption of the current NEMA standards.

Pre-NEMA *twist-lock* devices can sometimes be found with split 250/600 V ratings. These are also obsolete.

## U.S. perpendicular outlet



Perpendicular slot duplex outlet



## Розетка РП-2Б ~10А 42В

Perpendicular slot RP-2B outlet 10 A 42 V AC

Another obsolete outlet, made by Bryant, 125 V 15 A and 250 V 10 A rating. A NEMA 5-20 125 V 20 A or 6-15 250 V 15 A plug with a missing ground pin would fit this outlet, but a NEMA 2-20 plug is slightly too big to fit.

The upper slots as seen in the illustration connect to silver-colored wiring screws on the upper side, and the lower slots connect to brass-colored wiring screws on the lower side.

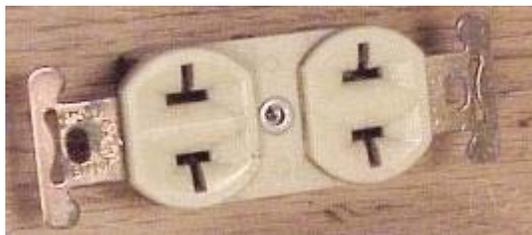
In Australia, the same or similar T-configuration sockets are used for DC power outlets, such as in stand-alone power systems (SAPS) or on boats.

In Soviet Union and now Russia this socket is commonly used for wiring in places where the voltage is lowered for safety purposes, like in schools, gas stations or in wet areas, rated 42 V 10 A AC. Such an unusual connection is intended specifically to make the connection of standard higher-voltage equipment impossible.

### **U.S. Combination duplex outlet**



An extremely old "Nurpolian"-brand black parallel and tandem duplex outlet rated at 250 V 10 A (although this type was normally supplied with 120 V).



T-slot duplex outlet.

The parallel and tandem outlet accepts normal parallel NEMA 1–15 plugs and also tandem NEMA 2–15 plugs. Both pair of receptacles are fed internally by the same supply.

A more recent and fairly common version of this type is the T-slot outlet, in which the locations of the tandem and the parallel slots were combined to create T-shaped slots. This version also accepts normal parallel NEMA 1–15 plugs and also tandem NEMA 2–15 plugs. Incidentally, a NEMA 5–20 (125 V, 20 A), a NEMA 6-15 (250 V, 15 A) or 6–20 (250 V, 20 A) plug with a missing ground pin would fit this outlet. This type is no longer available in retail shops since the 1960s.

## U.K. Dorman & Smith (D&S)



D&S Socket

The D&S plugs and sockets were rated at 13 amperes and were one of the early competing types for use on ring main circuits. They were never popular in private houses but were widely deployed in prefabricated houses and council housing. The BBC also used them. D&S supplied the sockets to local authorities at very low cost, with the intention of making money out of the sales of plugs typically priced at 4 times the price of a type G plug. It is not known exactly when D&S ceased manufacturing the plugs and sockets but some local authorities continued to use them in new installations until the late 1950s. Many D&S sockets were still in use until the early 1980s, although the difficulty in obtaining plugs for them after around 1970 often forced their users to replace them with type G sockets. This generally violated local authority regulations on alterations to council housing. The D&S plug suffered from a serious design fault: the live pin was a fuse which screwed into the plug body and tended to come unscrewed on its own in use. A fuse that worked loose could end up protruding from the socket, electrically live and posing a shock hazard, when the plug was removed.

## U.K. Wylex Plug



Wylex 13A Plug

The Wylex plugs and sockets were produced by Wylex Electrical Supplies Ltd. as a competitor to the type G and D&S sockets for use on ring main circuits. The plugs were available in both 5 A and 13 A versions, differing only by the widths of the live and neutral pins, and contained an internal fuse of the same rating as the plug. A plug had a central round earth pin and two flat pins, one on each side of the earth pin, for live and neutral. The two flat pins were slightly offset above and below the line cutting through the horizontal diameter of the earth pin. Wall sockets were rated at 13 amperes and took both 5 A and 13 A plugs. Many 13 A plugs had a socket on the back which took a 5 A plug, but would not take another 13 A plug because the slots for the live and neutral pins were narrower than those of the wall sockets, resulting in a stacked arrangement. Wylex sockets were used in council housing and public sector buildings, and for a short while in private housing. They were particularly popular in the Manchester area although they were installed throughout England, mainly in schools, university accommodation, and government laboratories. Wylex plugs and sockets continued to be manufactured for several years after type G sockets became standard and were commonly used by banks and in computer rooms during the 1960s and 70s for uninterruptible power supplies or "clean" filtered mains supplies. It is not known exactly when Wylex ceased manufacturing its plugs and sockets; however plugs were available in electrical shops of the Manchester area until the mid 1980s.

### Lampholder plug



Two Italian bypass lampholder plugs with Edison screw mount. Left: early type (porcelain and brass, circa 1930); right: late type (black plastic, circa 1970).

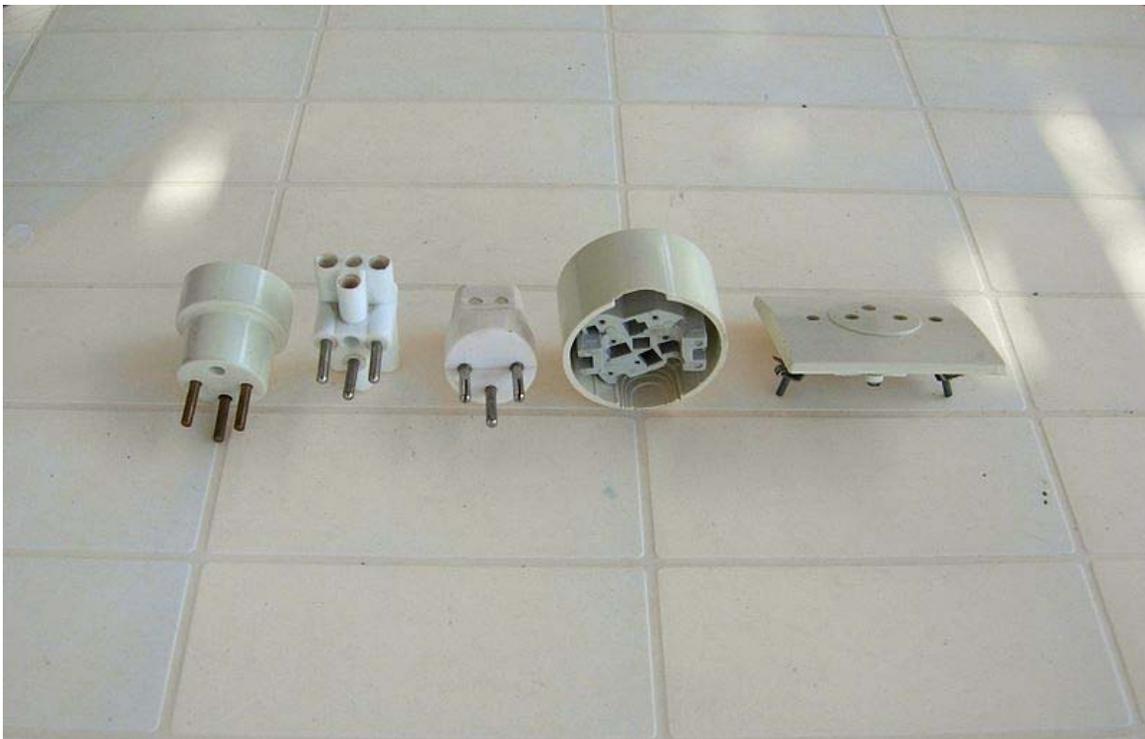
A lampholder plug fits into the Bayonet cap or Edison screw socket of a lampholder in place of a light bulb and enables an electrical appliance to be powered from a wall or ceiling light fitting. They were commonly used during the 1920s to 1960s when wall sockets were scarce or nonexistent in many houses. Lampholder plugs were rarely fused.

Conventional practice in the U.K. is to protect lighting circuits with a 5 A or 6 A fuse or circuit breaker, which will rapidly blow or trip when one attempts to utilise a lampholder plug to power an appliance requiring significantly more than 5 A or 6 A. If the current-draw is only slightly higher (e.g. 45%) than the circuit breaker rating, the circuit breaker may take more than 1 minute to trip and can take 1 hour to trip with a current that is 10% above the rating of the circuit breaker. Wiring regulations in the U.K. and some other countries no longer approve lampholder plugs because of the risks of overheating and fire.

In Italy, bypass lampholder plugs with Edison screw mount were in broad use until light wire cables were separated from general purpose wire cables and some areas of the house (cellars, etc.) were commonly not provided with sockets.

Edison screw lampholder adaptors (for Type A plugs) are still easily found and commonly used in the Americas.

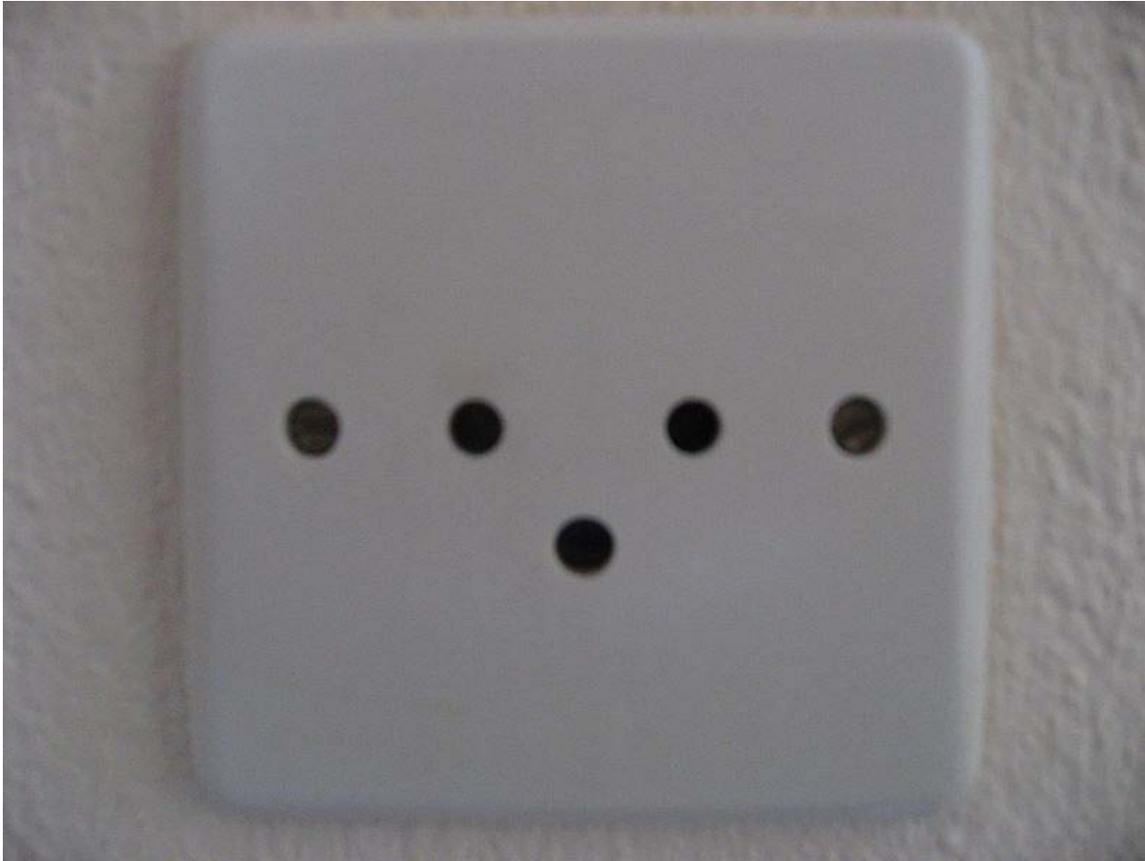
### **Old Greek sockets**



old earthed standard adaptor



plugs



socket

Called "Tripoliki" (τριπολικές) the 3 Pin round standard similar to type J and post-1989 type H, virtually abandoned by 1995.

Previous to the large-scale adoption of schuko plugs, this was the only way to use an earthed appliance.

### ***Unusual types***

#### **NEMA 2–15 and 2–20**

These ungrounded plugs with two flat parallel prongs are variants of the 1–15 but are intended to deliver 240 volts instead of 120. The 2–15 has coplanar current prongs (rotated 90° from ordinary American plugs), and is used for 240 V service at 15 amperes, while the 2–20 has the two current prongs rotated 90° relative to each other (one vertical, one horizontal) and is used for 240 V service at 20 amperes. NEMA 2 plugs and sockets are rare because they have been prohibited for household use in the United States and Canada for several decades. They are potentially hazardous since they have no ground or neutral, and in some cases plugs can be inserted into incorrect-voltage sockets. Prior to the adoption of the NEMA standard, a plug nearly identical to the 2–20 was used for 120

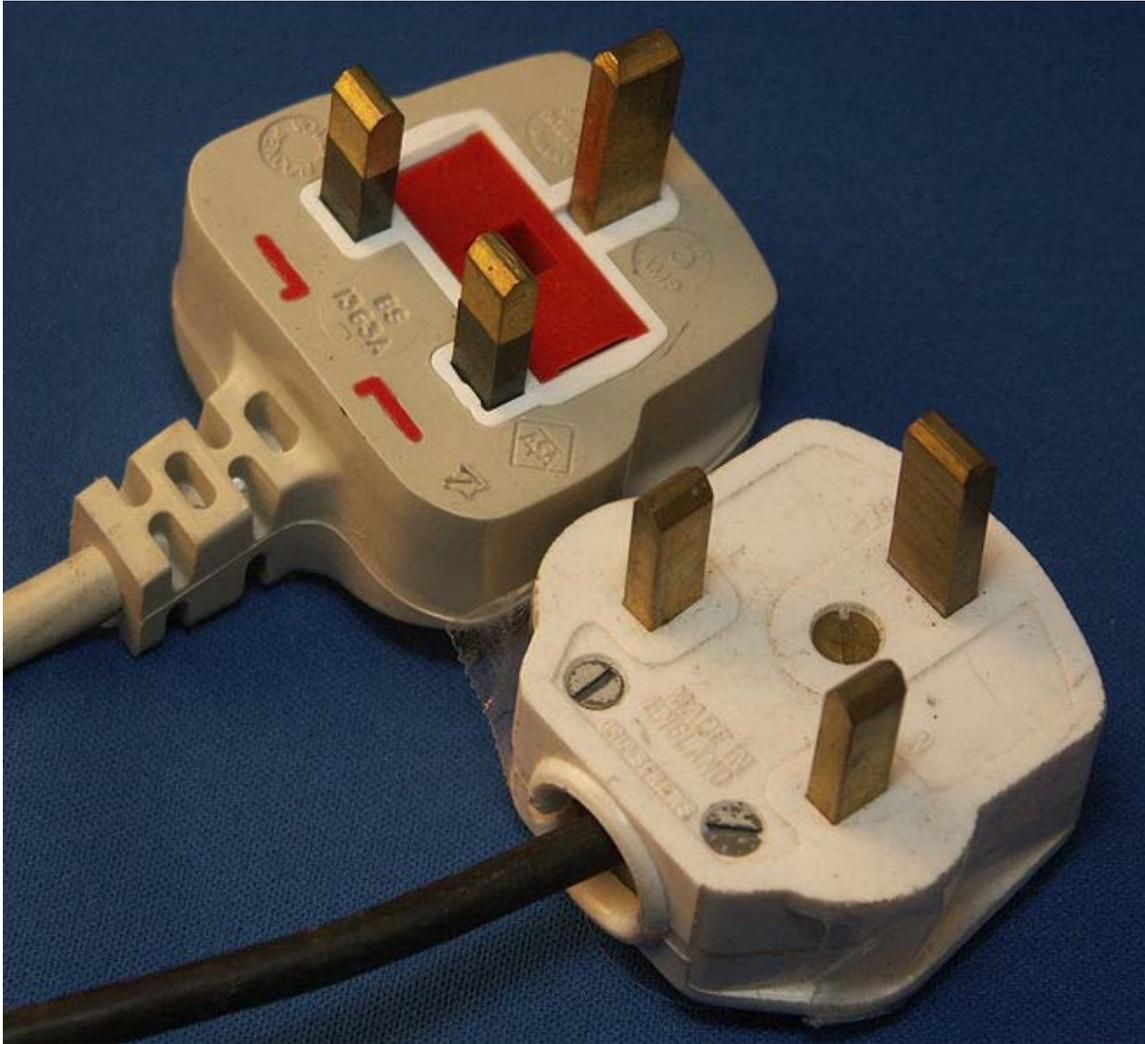
V at 20 A. That obsolete plug would fit into 5–20 and 6–20 sockets, which supply different voltages, but the NEMA 2-20 plug is dimensionally incompatible.

### **Soviet adaptor plugs**



Some appliances sold in the Soviet Union had a flat unearthed plug with an additional pass-through socket on the top, allowing stacked arrangement of plugs. This design was very helpful (for the usual Soviet apartment of the 1960s had very few wall sockets), but completely unsafe, as the brass cylinders of the secondary socket were uncovered at the ends (to unscrew them easily), recessed only for 3 mm and provided bad contact because they relied on the secondary plug's bisected expanding pins. The pins of the secondary plug (without insulation sleeves) could not be inserted into the cylinders completely, and were accessible through a 5mm gap between the primary and secondary plugs.

## U.K. Walsall Gauge plug



Walsall Gauge 13 A plug (bottom) compared to regular BS 1363 plug

Unlike the standard BS 1363 plugs found in the U.K., the earth pin is on a horizontal axis and the live and neutral pins on a vertical axis. This style of plug/socket was used by University laboratories (from batteries) and the BBC, and is still in use on parts of the London Underground for 220V DC voltage supply.

**Italian Bticino brand Magic security connector**



Bticino Magic Security receptacle, detail.



assortment of Magic Security receptacles (in orange, the industrial three-phase type).



assortment of Magic Security plugs.

This style of connector, produced by Italian brand Bticino, appeared in the 1960s and was intended as an alternative to the Europlug or type L connectors then in use. The socket is an almost rectangular receptacle, with one or more lateral key pins and indents to prevent inverting the plug (it is polarised), or connecting plugs and sockets with different ampere ratings. At least four models were produced: three single-phase general purpose connectors rated respectively 10 A, 16 A and 20 A; plus a three-phase industrial connector rated 10 A; all of them have different key-pin positioning so plugs and sockets cannot be mismatched. The socket is closed by a safety lid (bearing the word "Magic" on it) which can be opened only with an even pressure on its surface, thus preventing the insertion of objects (except the plug itself) inside the socket. The contacts are blades positioned on both sides of the plug; the plug is energized only when it is inserted fully into the socket.

The obvious drawback of the system is that it is not compatible with europlugs. As household appliances were never sold fitted with these security plugs and the use of adapters would defeat all of the newly introduced safety features, once this system is adopted all standard plugs must be cut off and replaced with the appropriate security connector. However, the *Magic* security system had some success at first because its enhanced safety features appealed to customers; standard connectors of the day were considered not safe enough. The decline of the system occurred when safety lids similar

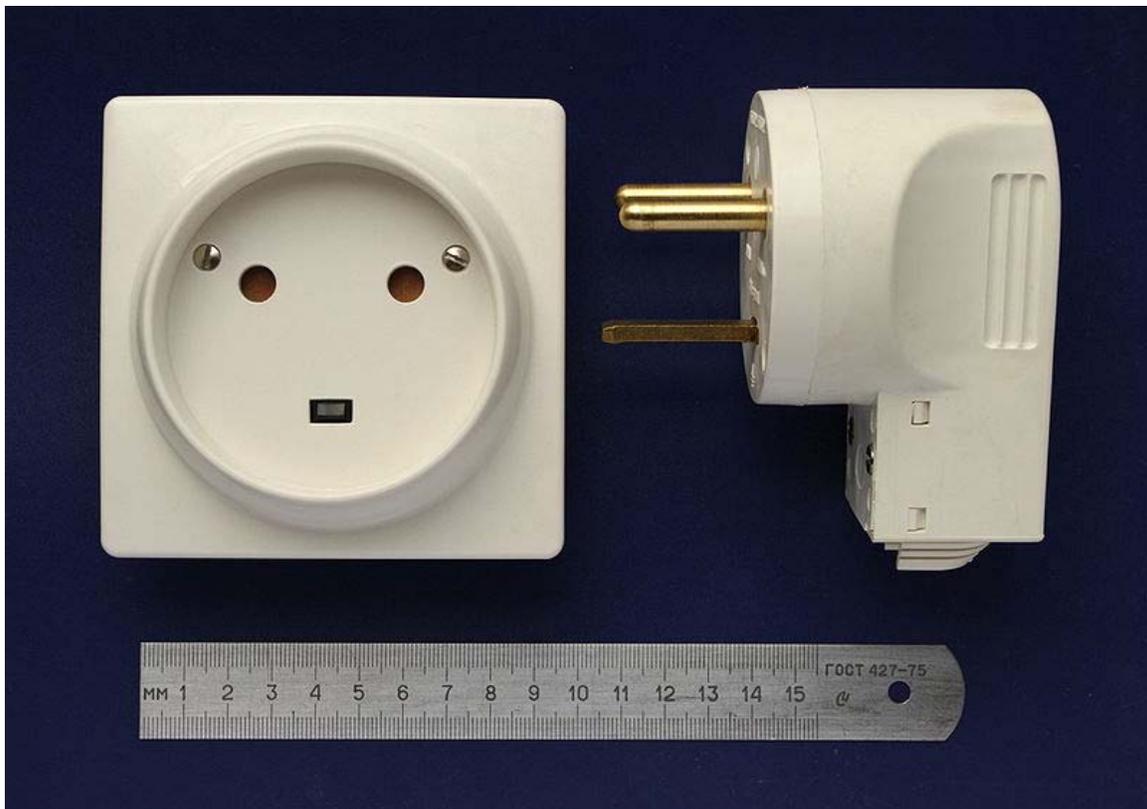
to the Magic type were developed (VIMAR Sicury) and then applied to standard type L sockets by third brands and by Bticino itself.

In Italy, the system was never definitively abandoned and, though rarely seen today, is still marked as available in Bticino's products catalogue.

In Chile, 10 [A] Magic connectors are commonly used for computer/laboratory power networks, as well as for communications or data equipment. This allows delicate electronics equipment to be connected to an independent circuit breaker, usually including a surge protector or an uninterruptible power supply backup. The different style of plug makes it more difficult for office workers to connect computer equipment to a standard unprotected power line, or to overload the UPS by connecting other office appliances.

In Iceland, Magic connectors were widely used in homes and businesses alongside Europlug and Schuko installations. Their installation in new homes was still quite common even in the late 1980s.

### ***Single phase electric stove plugs and sockets***



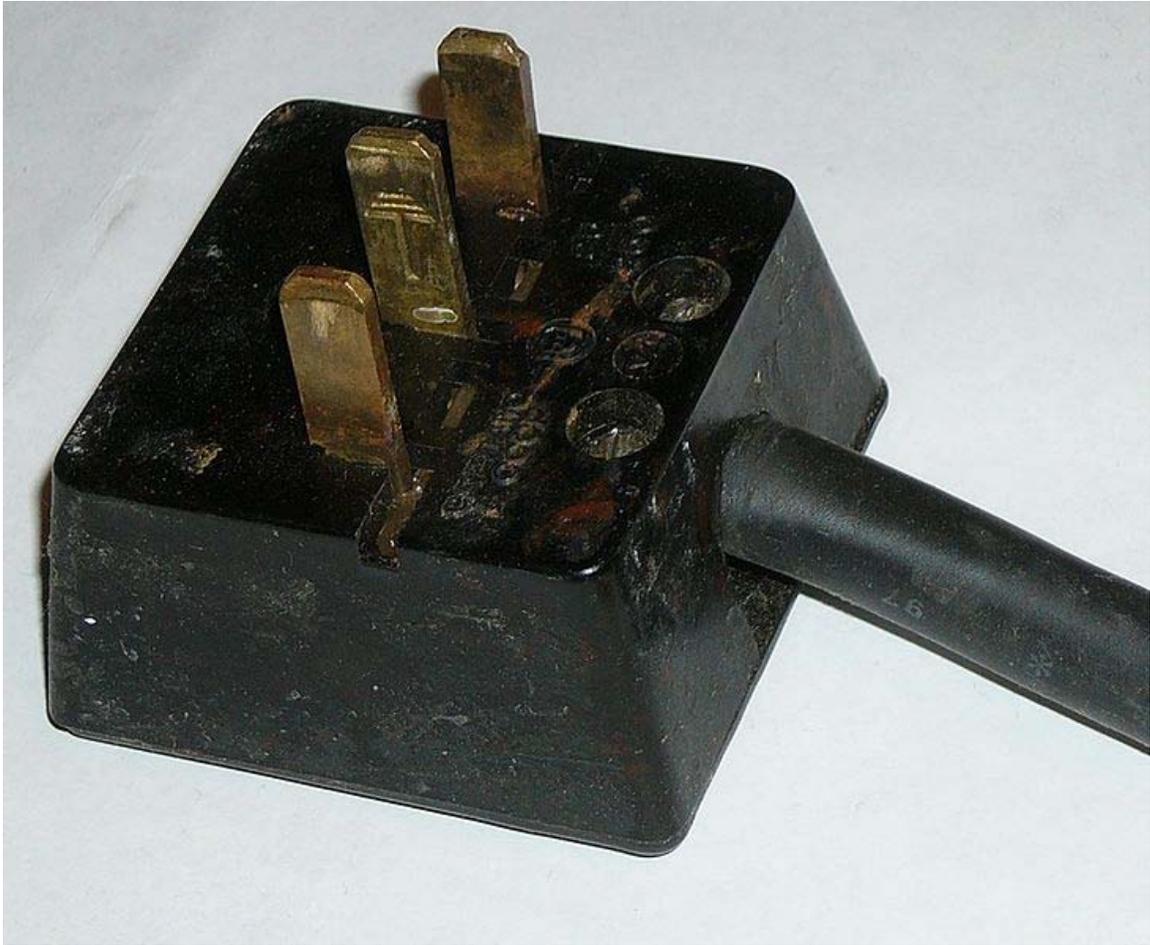
Power connector Legrand (400 V, 32 A)



Russian stove connectors rated for 250 V 25 A AC. Plug and Socket



Socket.



Plug

The plugs and sockets used to power electric stoves from a single-phase line have to be rated for greater current values than ones for three-phase system because all the power has to be transferred through a single line. Electric stoves are often hardwired to the electrical supply system, connected to the mains with an appropriate high power industrial connector or with non-standard high power proprietary domestic connector (as some countries do not have wiring regulations for single-phase electric stoves). In Russia an electric stove can be often seen connected with an 25–32 amperes connector.

## Chapter 2

# BS 1363



Top: a typical moulded BS 1363 plug, showing the fuse access from the underside of the plug. Bottom: a typical rewireable plug; the large central screw releases the cover, allowing access to the terminals and also the fuse

**BS 1363** is a British Standard which specifies the most common type of domestic AC power plugs and sockets that are used in the United Kingdom, Cyprus, Hong Kong, Ireland, Malta, Malaysia, Singapore, and many former British colonies. Of these, Ireland, Malaysia and Singapore have equivalent standards—IS 401 & 411, MS 589, and SS 145, respectively. The standard was introduced in 1947, shortly after the Second World War, as part of a new standard for electrical wiring in the United Kingdom.

Trading standards legislation in both the UK and Ireland requires that all domestic electrical goods sold in either country should be fitted with a BS 1363 or IS 401 (as applicable) plug.

Other plug types used in the same area include IEC 60309, only used in industrial and some outdoor applications, and BS 546, limited to old installations and specialised applications where either the BS 1363 plug is unsuitable or where mateability with the standard variety is not desired (for example, where lamps are controlled by a switch or dimmer).

## ***Origins***



BS 1363 type electrical socket. The closed shutters block entry of foreign objects

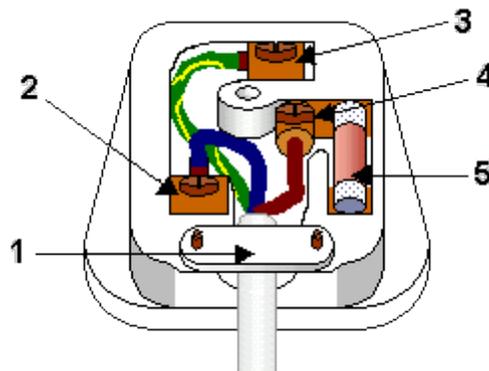
In 1941 Lord Reith, the then minister of Works and Planning, instigated the establishment of a series of committees to investigate and report on the problems likely to affect the peace time rebuilding of Britain. One of these, the Electrical Installations Committee, was charged with the study of all aspects of electrical installations in buildings. Convened in 1942, they reported in 1944.

One of the most far reaching recommendations, still in effect in the 21st century, was the introduction of the ring circuit system (often informally called "ring main"), where, instead of each socket being individually wired, a cable was brought from the fuse or circuit breaker in the distribution board and wired in sequence to a number of sockets before being taken back to the distribution board and wired to the same fuse or circuit breaker. This provided considerable savings in the copper required to wire the circuit.

Since the fuse or circuit breaker had to be rated for the maximum current the ring could carry (30 A or 32 A for breaker), it was required that the plugs used to connect to the ring each contained their own fuse rated for the appliance that it connected.

The plug and socket system defined in BS 1363 is a result of another of the report's recommendations. Britain had previously used a combination of 5 amp and 15 amp round pin sockets, where each had to be wired to the distribution board where it would be provided with its own fuse. In a supplementary report, published as an appendix to the main report (July 1944), the committee proposed a completely new socket outlet and fused plug should be adopted as the "all-purpose" domestic standard. A number of technical details were required of the new standard, first of which was that "To ensure the safety of young children it is of considerable importance that the contacts of the socket-outlet should be protected by shutters or other like means, or by the inherent design of the socket outlet." This requirement for a new system of plugs and sockets led to the publishing in 1947 of "British Standard 1363 : 1947 Fused-Plugs and Shuttered Socket-Outlets".

## ***Design***



Internal wiring. There is more slack in the neutral wire than the live, ensuring that if the lead is forcibly removed, the live wire will disconnect first. #1 Cable grip; #2 Neutral terminal; #3 Earth terminal; #4 Line terminal; #5 Fuse

A BS 1363 plug has two horizontal, rectangular pins for line (commonly termed "live") and neutral, and above these pins, a larger, vertical pin for an earth connection. Unlike most other types of sockets, the earth pin is necessary for use of the BS 1363 plug, as it is needed to push open a shutter in the socket to allow the line and neutral pins to be inserted. It also polarises the plug, ensuring that the line pin is connected to the correct terminal in the socket. Moulded plugs for unearthed, double-insulated appliances may substitute this contact with a non-conductive plastic pin to open the shutter. Most non-fixed domestic equipment is connected using the BS 1363 plugs, the main exceptions being equipment requiring more than 13 amps (e.g. larger electric cookers, which are hard-wired); remotely switched, non-fixed lighting (which use proprietary or BS 546 plugs); and low-power portable equipment, such as shavers, which may be used in several countries. Many bathrooms, particularly in hotels, have 2-pin standard "shaver sockets", which usually accommodate both European and US 2-pin plugs.

BS 1363 part 1 is the specification for the plug. As there are no moving parts in a plug it is practicable to define the dimensions of the plug in an absolute manner. BS 1363 part 2 contains the specifications for sockets, to allow some flexibility in design the socket is defined partly in terms of the plug with which it will be used. It therefore follows that the performance of the socket is unpredictable if anything other than a BS 1363 compliant device is inserted into the socket.

The requirement for smaller plugs which may easily fit into laptop bags etc has led to several designs of folding plugs with varying degrees of success.

## Shuttering



Detail of an MK Logic Plus wall socket showing shutters which are operated only when all three pins are simultaneously inserted

As mentioned in "Origins" above, standard UK sockets incorporate shutters on the line and neutral contacts to prevent the insertion of a foreign object into the socket. Sockets from most manufacturers have shutters which are opened by the earth pin alone. This is longer than the others and must always be present (though on double insulated equipment it may be plastic). Sockets manufactured by MK use a proprietary system which requires that both line and neutral pins as well as the earth pin of correct dimensions must be inserted simultaneously.

It is of interest to note that the concept of automatic shutters being used in UK sockets for protection dates back to at least 1927.

Socket covers are marketed as preventing children from inserting objects into sockets. The UK Government safety advice is that sockets are safe and covers unnecessary. Similar advice is given by RoSPA and CAPT. Despite the official advice, plug-in socket covers are generally available, it is normal for such socket covers to be only approximately in conformance with the BS 1363 standard for plugs, and therefore the performance of the socket and cover combination is unpredictable. Which? has reported on the danger which results from children inserting easy to remove socket covers into the earth hole only, thus opening the shutters in conventional sockets. Research has shown that there are no socket covers which comply to BS 1363 dimensions. None of the plug-in covers on the UK market has been shown to conform to the recommendations which have been made by ANEC (European Association for Consumer Representation in Standardisation) setting out the basic requirements and proposed test methods which

should be adopted by EU Member States to ensure that child safety devices are effective and safe.

The majority of these plug-in devices can be inserted upside down, which serves to disable the internal shutters and results in compromised safety. It has been demonstrated that some of the most popular types on the market actually allow objects such as paper clips to be inserted alongside the line pin of the socket cover. The [FatallyFlawed.org.uk](http://FatallyFlawed.org.uk) campaign was founded in August 2008 to raise awareness of this issue and publishes photographic and video evidence of the dangers.

BS 1363 places no restrictions on the distance of the earth pin to the top edge of the socket faceplate (although there is a minimum distance specified between the power pins and the lower edge of the faceplate). As a result there are many designs of multi-way extension sockets (and also the older multi-way adapter blocks) which allow a normal plug to be inserted upside down. This completely defeats the correct operation of the safety shutters. This method is sometimes used to allow a European-style plug (with two small round pins and no earth pin) to be inserted into the open line and neutral ports.

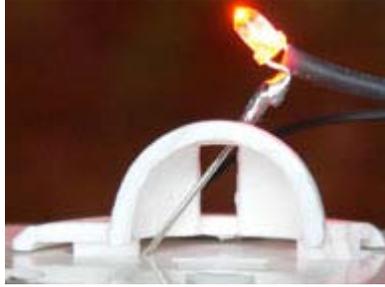
#### **Dangers caused by socket covers**



Shows how an inverted socket cover opens shutters to expose live parts.



Common socket cover type allows paper clips etc. to be inserted into live socket.



Extraction hole in domed socket cover allows access to live parts (cutaway cover).

**Shows how an error in BS 1363 permits dangerous multi-way extensions.**

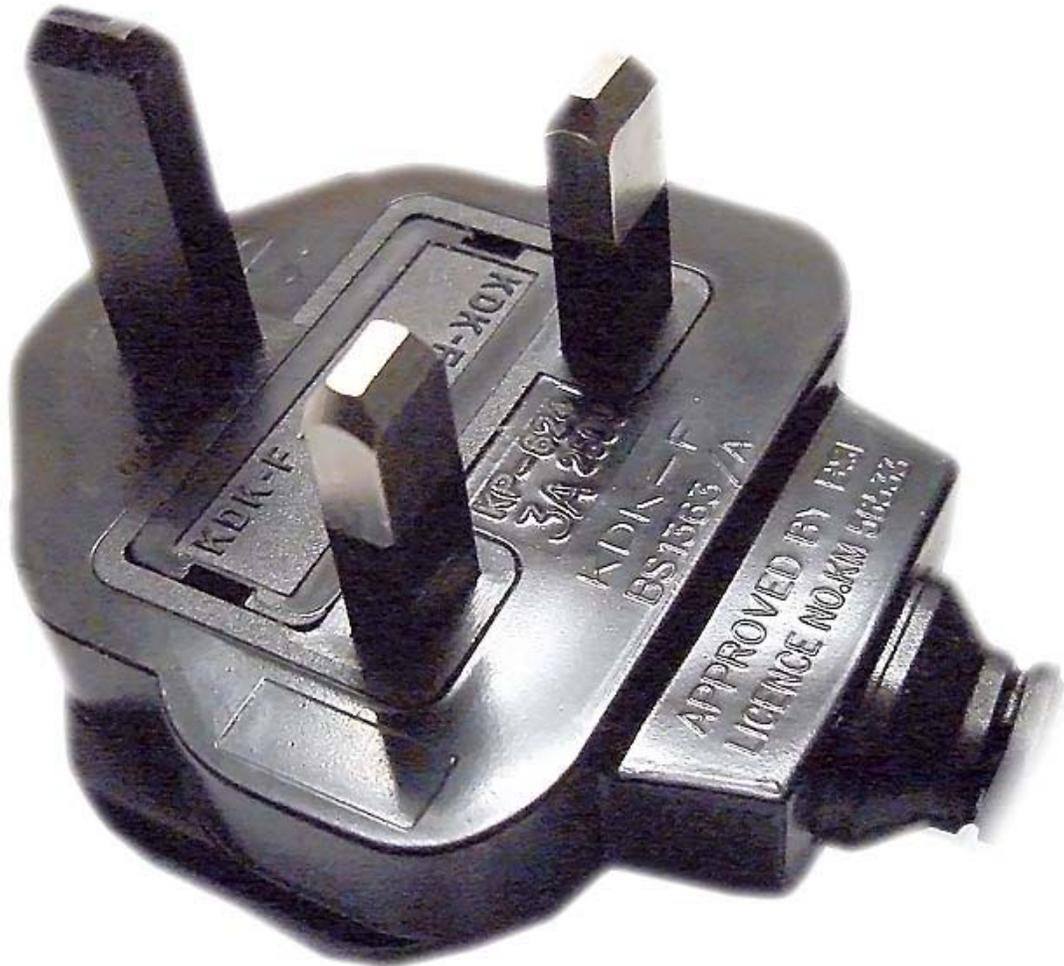


Shows a multi-way extension with insufficient distance between the earth pin and edge of faceplate, this allows an inverted plug to be placed in the extension.



Shows how an inverted plug can open shutters in a multi-way extension to expose live parts.

## Pin insulation



BS 1363 plug, with an ISOD (Insulated Shutter Opening Device) which is used when an earth pin is not required

The phase and neutral pins on modern plugs have insulated bases to prevent finger contact with pins and also to stop metal sheets (for example, fallen window blind slats) from becoming live if lodged between the wall and a partly pulled out plug.

## Dimensions

The line and neutral pins have a rectangular cross section  $6.35 \pm 0.13$  mm wide and  $3.975 \pm 0.075$  mm height. They are  $17.7 \pm 0.5$  mm long and their centre lines are horizontally  $11.115 \pm 0.065$  mm on either side of the symmetry plane of the plug. The protective-earth pin is centred on the symmetry plane, is  $22.73 \pm 0.5$  mm long and has a

cross section  $3.975 \pm 0.075$  mm wide and  $7.925 \pm 0.125$  mm height. The centre lines of the line/neutral pins and the protective pin are vertically  $22.23 \pm 0.13$  mm apart.

(These dimensions may be more easily remembered in the original imperial units, which are not mentioned in the current standard:  $1/4 \pm 0.005$  inch wide by  $5/32 \pm 0.0025$  inch high, and  $0.695 \pm 0.02$  inch long. They are  $7/8 \pm 0.005$  inch horizontally from each other, and the same distance vertically from the earth pin, which is  $0.895 \pm 0.02$  inch long. The pin lengths were presumably originally 0.7 and 0.9 inches, and assigned an asymmetric tolerance of  $+0.005/-0.015$ .)

### **Other safety features**

- The plug base is broadened near the pins to help keep fingers away from the pins (this was a very early modification to the standard, which was later improved by the use of the insulated pin bases described above).
- The plug sides are shaped to improve grip and make it easier to remove the plug from a socket without placing fingers behind the plug where the pins are.
- The plug is polarised, so that it cannot be inserted with the phase and neutral pins reversed. This feature is important to make sure the fuse is in the phase side of the supply.
- The longer earth pin ensures that the earth path is connected before the live pins, and remains connected after the live pins are removed.
- The design of the earth pin being of a larger dimension prevents it from being inserted into the phase or neutral sockets should this be attempted in error
- The plug is firmly fitting and therefore difficult to dislodge by accidental knocks or strains on the cord.
- The cable always enters the plug from the bottom, thus making it difficult for people to unplug the plug by tugging on the cable. This practice, possible with many other plug designs but difficult with BS 1363, can be hazardous as it can damage the cable insulation causing shorts or tear the conductors, leading to overheating or even internal arcing across the resulting break in the conductor. On the other hand this tight fitting and bottom entry of cable means that the stresses on the cable when it is pulled hard (by for example tripping over it) are even higher.
- If the cable is pulled from the plug with enough force to break the wires inside, the phase wire disconnects first, the neutral second, and the earth wire last. This is ensured by forcing the different wires to have varying amounts of slack in them by design of the internal channel of the plug.

## Fuses



BS 1362 fuses (for BS 1363 plugs)

Because typical British circuits (especially ring circuits) can deliver more current than many appliance power cords can safely handle, BS 1363 plugs are required to carry a cartridge fuse. The fuse is manufactured to **BS 1362** and are normally rated at 3, 5, 10, or 13 amperes. The maximum load that can be placed on a socket is 13 A; triple and larger sockets are fitted with a 13 A fuse of the same type used in the plugs. The plugs and sockets are designed to carry up to 250 volts AC, 50 hertz.

All plugs with the exception of some plug top power supply units are fused. This is in addition to the fuses or circuit breakers in consumer units/distribution boards.

Fuses are available in 1, 2, 3, 5, 7, 10, and 13 amps but commonly seen and used are only 2 (black or blue), 3 (red), 5 (black or grey), 10 (black or yellow), and 13 (brown) amps. Note that the use of black on 2, 5, and 10 amp fuses indicates a "non-standard" choice, since 3 and 13 amps have become the de facto standard choices and are by far the most common. Plugs (when supplied separately from any appliance) are normally fitted with a 13 A fuse, but the need to buy plugs has reduced considerably since moulded power cords are now supplied with most equipment — in part to avoid users failing to replace the 13 amp fuse in a newly-purchased plug with a lower-rated fuse when appropriate.

Prior to the introduction of the 13 amp plug the BS 546 2 A, 5 A, and 15 A plugs were used. With this system, the only fuses were in the consumer unit. 15 A sockets were generally given a dedicated 15 A circuit, while 5 A sockets might be on a 15 A circuit with multiple sockets or on a dedicated 5 A circuit. 2 A sockets were generally connected to the lighting circuit, which was fused at 5 A. Adaptors were available to use 5 A plugs in 15 A sockets and to use 2 A plugs in 5 A sockets, so it was quite possible for an appliance with the smallest size of flex to be protected only by a 15 A fuse.

When the practice of using 30 A ring circuits was introduced (to save copper while also allowing more flexibility), it was considered unsafe to allow appliance flexes to be connected to such a high rated circuit with no further protection, and the plug/socket combination had to provide the fuse. It was decided to place the fuse in the plug and to use a new plug configuration so that older, unfused plugs could not be used.

Putting the fuse in the plug also allows a range of ratings to be fitted, providing superior protection for smaller flexes. This is especially useful for long small flexes or for extension leads that are not rated at the full 13 A. Fuses for fittings to BS 1363 must conform to BS 1362. This specification describes a sand-filled ceramic-bodied cylindrical fuse, 1" (25.4 mm) in length, with two metallic end caps of 1/4" (6.3 mm) diameter and roughly 1/5" long.

BS 1362 specifies breaking-time/current characteristics only for fuses with a current rating of 3 A (marked in red) or 13 A (marked in brown). Examples for the required breaking-time ranges are

- For 3 A fuses: 0.02–80 s at 9 A, < 0.1 s at 20 A and < 0.03 s at 30 A.
- For 13 A fuses: 1–400 s at 30 A, 0.1–20 s at 50 A and 0.01–0.2 s at 100 A.

3 A fuses are intended mainly for small load (< 750 W) appliances, such as radios and lights. 13 A fuses are for larger load (<3.2 kW) appliances, such as heating and heavy-duty electric motors.

BS 1362 requires that plug fuses with any other current rating be marked in black. 5 A fuses are also commonly used for medium load (1250 W max.) appliances such as desktop computers and TV sets. Ratings of 1, 2, 7, and 10 amperes are also produced but rarely used (1 A, as found in some shaving-socket adapters, is 20 mm long (BS 646), but a BS 1362 version does exist).

The fuses are mechanically compatible; it is up to the user or appliance manufacturer to use the most appropriate rating.

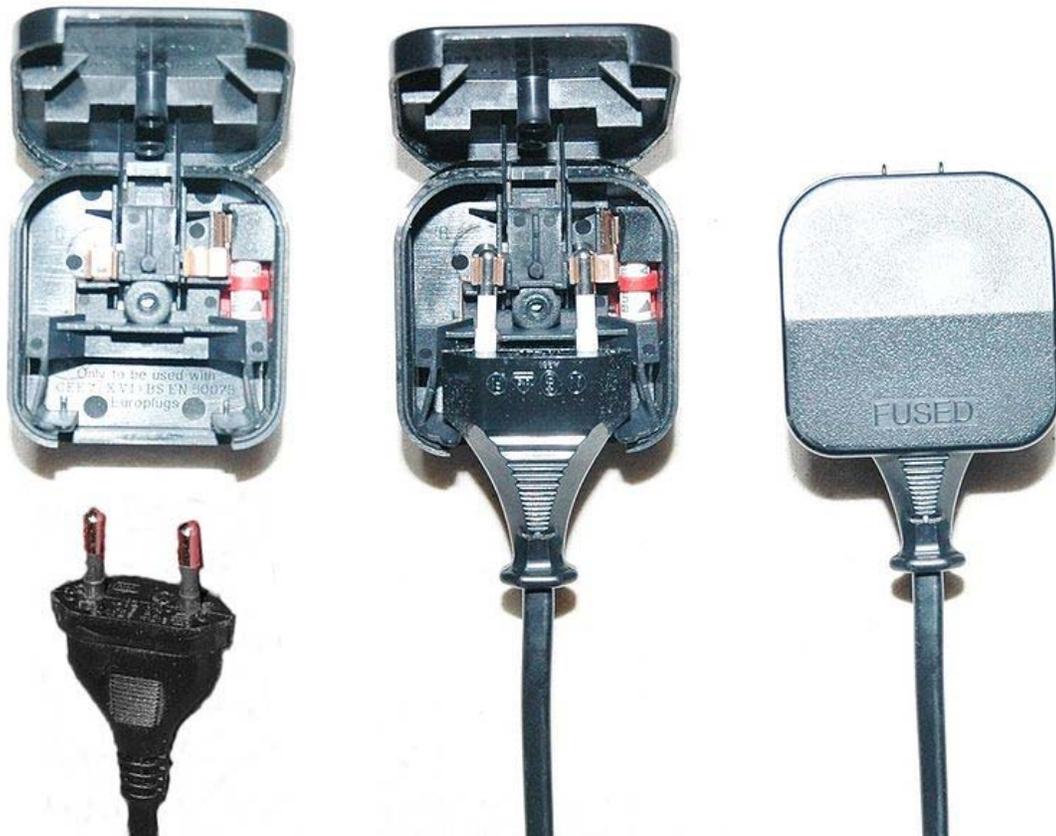
Rewirable BS 1363 plugs are always sold fitted with a fuse, usually 13 A. This fuse must be changed if fitting the plug to an appliance or flex which requires a fuse with a smaller rating. Plugs with smaller fuse sizes already fitted are sold but are not as common.

## **Replacement**

Plugs for hand-wiring are commonly available and are usually attached with instruction cards displaying recommended wire lengths. They can be assembled or opened with a flat-head and/or cross-head screwdriver—modern plugs often have external screws which accommodate both types, but the terminal screws inside are more often flat-headed; the cross-head and combination screw-heads tend to be made to accommodate Pozidriv rather than Phillips screwdrivers, but this varies between manufacturers. Most modern products come fitted with moulded plugs with removable fuse sections (these plugs can only be easily removed by cutting off), with some exceptions, such as most lamps, which usually have normal hand-wired plugs along with a label with wiring instructions wrapped around the flex.

The secondary school physics syllabuses in the United Kingdom, Hong Kong and Singapore include the procedure for wiring BS 1363 plugs, as well as the concept of a ring circuit and a radial circuit (except in Hong Kong). In Malaysia, however, the procedure for wiring BS 1363 plug are taught in Living Skills subject (*Kemahiran Hidup*) for Form 1 (secondary school year 1) students.

## **Compatibility**



euro converter plug, empty, europlug inserted and closed

Some manufacturers/distributors use a special type of plug for conversion of Class 2 appliances from mainland Europe which are fitted with moulded europlugs. Unlike a travel adaptor these plugs when closed look fairly similar to normal plugs, although larger and squarer. Inside are two metal clips into which the metal ends of the europlugs pins are clipped. The body of the converter plug is shaped to grip the europlug. The hinged lid is then shut to cover the connections to the europlug and is screwed shut. These plugs have a plastic earth pin and a fuse accessible from the outside and in some cases are fitted with screws that are made to be difficult to unscrew. Similar converters are available for a variety of other plug types but do not seem to be seen much in practice.

These adaptors are usually supplied fitted on all recent Class 2 Sony electrical products with fixed wiring (and not IEC C7 cables) sold in the British Isles instead of typical moulded plugs, probably as a measure to reduce costs by fitting the same plug for all European markets.

### **Adoption**

The BS 1363 design is not only in use in the United Kingdom and Ireland, but also in Sri Lanka, Kuwait, Bahrain, UAE, Qatar, Yemen, Oman, Cyprus, Malta, Gibraltar, Botswana, Ghana, Hong Kong, Jordan, Macau, Brunei, Malaysia, Singapore, Kenya, Uganda, Nigeria, Iraq, Tanzania, Zambia and Zimbabwe. BS 1363 is also standard in several of the former British Caribbean colonies such as Belize, Dominica, St. Lucia, St. Vincent, and Grenada. It is also used in Saudi Arabia in 230 V installations, although 110 V installations using the NEMA connector are more common.

The National Standards Authority of Ireland (*NSAI*) issued the Irish Standard "I.S. 401 Safety Requirements for Rewireable 13A Fused Plugs for Normal and Rough Use Having Insulating Sleeves on Line and Neutral Pins", which is largely similar to BS 1363. Any relevant plugs originating or sold in the country must pass the Irish Standard or an equivalent standard of a member of the European Union, which includes BS 1363.

The UK, and some of these other countries, also use the older BS 546 round-pin socket standard.

BS 546 is duplicated by Group B2 of the Soviet GOST 7396 standard.

In some continental European countries (e.g., Germany), the BS 1363 system is today often used for Low Voltage (12 V or 24 V) DC connections in photovoltaic systems, because it provides easily available high-current connectors with fixed polarity that cannot accidentally be connected into higher-voltage Schuko system and Europlug sockets.

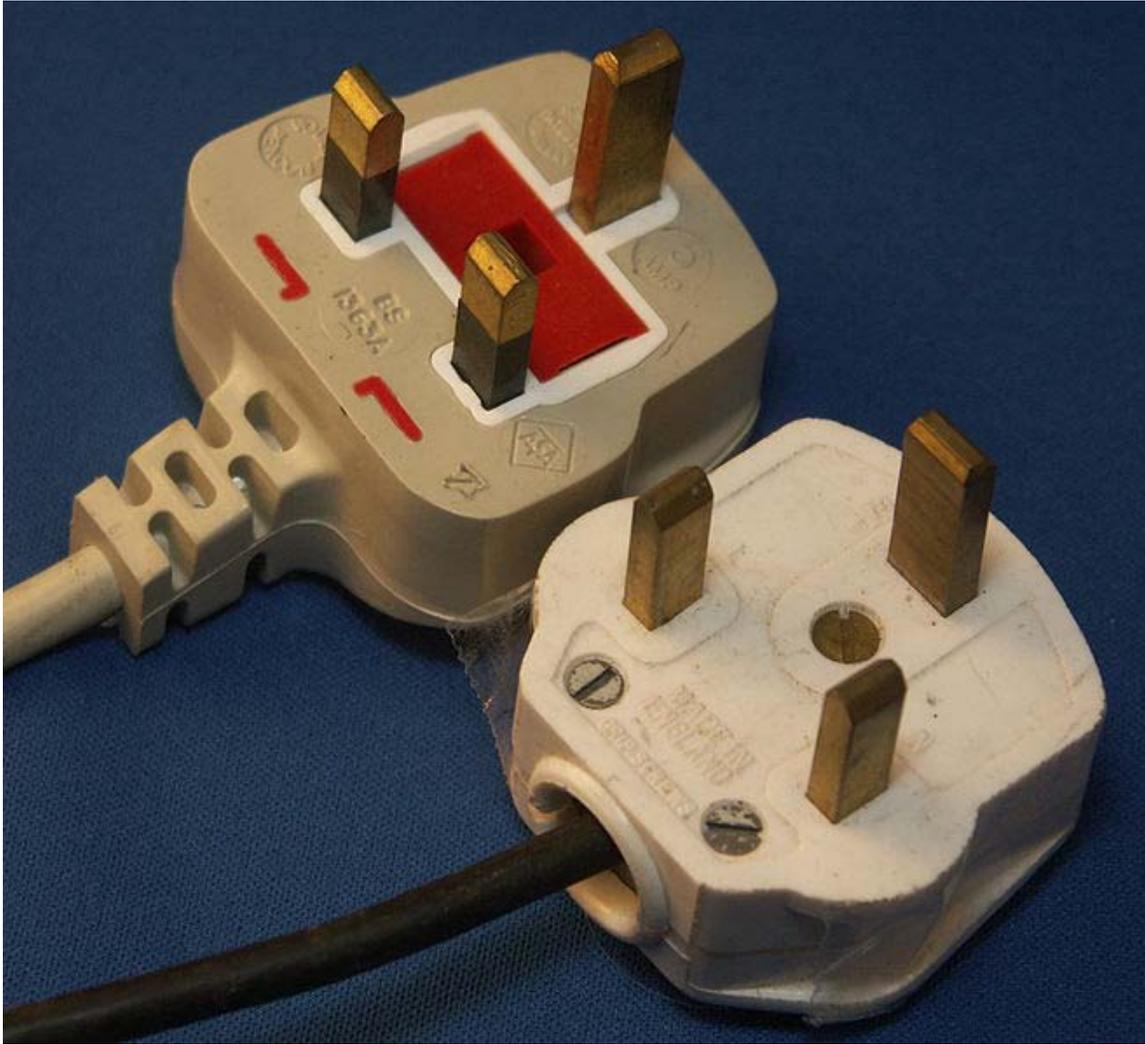
## ***Variants***

Several manufacturers have made deliberately incompatible variants for use where intermateability with standard plugs and sockets is not acceptable. Examples include filtered supplies for computer equipment and cleaners' supplies in public buildings and areas (to prevent visitors plugging things in). The most commonly seen variant is one made by MK that has a T-shaped earth pin.

The Walsall Gauge 13 A plug, which has each pin rotated 90°, was used by the BBC for technical supplies, and sockets for these plugs can be seen in some London Underground stations.

Due to the size of the standard UK power plug BS 1363, a number of attempts have been made to develop a UK folding plug. Only one of these has been approved for sale (as at 21/08/10), the SlimPlug, which is available only as part of a complete power lead terminating in an IEC C7 unpolarized connector. In 2009 another concept of folding plug, the ThinPlug, received a "red dot" award for product design, the ThinPlug has now received BS 1363 approval. Another design (The Folding Plug), featuring a pivot which allows the plug's pins to be aligned vertically, won the Brit Insurance design of the year award in 2010, but as described in the promotional video it does not meet BS 1363, and has not been approved for sale in the UK. An international patent application for the Folding Plug describes various alternative configurations, but inspection of the application shows that an actual plug incorporating the safety requirements of BS 1363 would differ significantly from the design which won the award.

## Variant plugs



Walsall Gauge 13 A plug (bottom) compared to regular BS 1363 plug



Walsall Gauge 13 A plug



MK 13 A Plug with a T-shaped earth pin



The SlimPlug folding plug



The SlimPlug folding plug with pins retracted

### ***Other devices in the standard***

BS 1363 specifies 13 A plugs and sockets. It also specifies the following devices:

- Adaptors, which permit two or more plugs to share one socket.
- Switched and unswitched fused connection units, which take the same BS 1362 fuses as the plugs. These are the standard means of connecting permanently wired appliances to a socket circuit (most often but not always a 30 A ring circuit). They are also used in other situations where a fuse or switch (or both) is required, such as when feeding lighting off a socket circuit, to protect spurs off a ring circuit with more than one socket, and sometimes to switch feeds to otherwise concealed sockets for kitchen appliances (20 A DP switches are also sometimes used for this, but doing so can easily violate the rule of no more non-fused spurs than sockets on the ring).

## Chapter 3

# BS 546



BS 546 3-pin plugs. Left to right: 15 A, 5 A and 2 A.

**BS 546** is an old British Standard for domestic AC power plugs and sockets that is also the precursor of current Indian and South African plug standards. This plug is also used in Singapore to a limited extent. These are also known as type D (for the 5-A 3-pin) and type M (for the 15-A 3-pin) in US documentation. When viewed in photographs with no indication of scale the different ratings look similar, but where a photograph shows more than one type the difference in size is obvious. There are 6 different versions that are not interconnectable. Whilst these sockets are no longer used in Britain for general appliances (although still permitted by the UK wiring regulations), some of the varieties remain in use in other countries and in more specialist applications (a notable example being stage lighting).

Prior to the development of the BS 546 standards there were around two dozen different types of power socket in use throughout Britain with different types in use in different cities.

15 A sockets were generally given a dedicated 15 A circuit. 5 A sockets might be on a 15 A circuit with multiple sockets or on a dedicated 5 A circuit. 2 A sockets were generally connected to the lighting circuit which was fused at 5 A. Adaptors were available from 15 A down to 5 A and from 5 A down to 2 A so in practice it was quite possible for an appliance with the smallest size of flex to be protected only by a 15 A fuse. This is a similar level of protection to that seen for portable appliances in other countries but less than that offered by the BS 1363 fused plug that replaced them. Fused BS 546 plugs using a BS 646 fuse are available but are rarely seen in practice.

In theory, 15 A plugs were proposed to be used for larger appliances (e.g. electric heaters) while smaller appliances (e.g. radios, table lamps) were supposed to use 5 A. In practice this was found to be inconvenient and in many households the 15 amp plug was used for everything. Adaptors were available which allowed 2 or 5 amp plugs to be used in 15 amp sockets.

The 3-pin sockets were not shuttered when BS 546 was in common use domestically in the UK, but the current revision of the standard does specify shutters and BS 546 sockets sold in the UK today are shuttered in the same basic manner as BS 1363 ones. Current UK wiring regulations require socket outlets installed in homes to be shuttered. The three pin variety had the larger top pin as the earth connection, the left hand pin as neutral and the right hand pin as live (when looking at a socket or at the rear of a plug).

BS 546 is duplicated by Group B1 of the GOST 7396 standard.

## **2 A 2 pin**



BS 546 un-shuttered 5 A and 2 A 2 pin sockets

This plug did not find general use and is now rarely seen. It was rendered incompatible with the 2 A 3 pin variant by variation of the pin gauge and this may have contributed to its lack of adoption.

## **5 A 2 pin**

This plug is what became the UK standard shaver plug (BS 4573) and is similar but slightly larger than the Europlug (and the pins are only 16mm apart). British shaver sockets and adaptors tend to be sized to accept this, Europlugs and two pin American and Australian plugs.

## **2 A 3 pin**

This plug was used to connect low power appliances to the lighting circuit (and to adaptors from the larger socket types). Sometimes still used to connect lamps (and other lights which aren't attached, or built-in to the fabric of the building - e.g. lights which are mounted on kitchen cabinets, bookshelves etc.) to the lighting circuit.

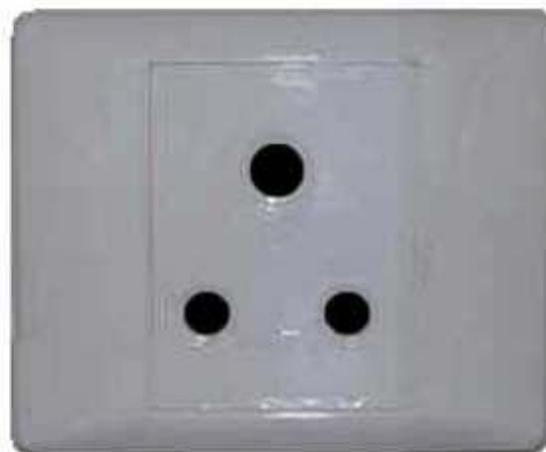
### **5 A 3 pin**



This plug was used for moderate sized appliances either being on its own 5 A circuit or a multi socket 15 A circuit and also on many adaptors (both multi socket 5 A adaptors and adaptors that also had 15 A pins). Some 5 A 3 pin sockets also have 2 extra holes above the live and neutral holes to allow a 5 A 2 pin plug to be connected.

India has standardised on this plug as Indian Standard IA6A3, rated at 6A / 250V, and it is now almost exclusively used in India, Sri Lanka, Nepal and Namibia. However, this 5 A plug, along with its 2 A cousin, is sometimes used in the UK for centrally switched domestic lighting circuits, in order to distinguish them from normal power circuits. This is quite common in hotel rooms. This plug was also once used in theatrical installations for the same reasons as the 15 A model below, but is now only used for this purpose in schools and other rarely used installations (presumably because those operating multiple installations wanted to standardise on one plug type for all their lights and the 5 A plug was unsuitable for larger lights).

### **15 A 3 pin**



This is the largest plug in domestic use. Live and neutral are spaced 1 inch apart, and earth is 1 1/8 inches away from each of them. Although the preceding type is standard in Pakistan, India, Sri Lanka, Nepal, and Namibia, the 15 A version is also used in these countries for larger appliances. In India it is rated at 16A under Indian Standard IA16A3. Some countries like South Africa use it as the main domestic plug and socket type as South African standard SABS 164. Sockets almost always have an on-off switch built into them. The Type M is almost universally used in the UK for indoor dimmable theatre and architectural lighting installations. It is also often used for non-dimmed but centrally controlled sockets within such installations. The main reason for doing this is that fused plugs, while convenient for domestic wiring (as they allow 32 A socket circuits to be used safely), are not convenient if the plugs and sockets are in hard to access locations (like lighting bars) or if using chains of extension leads (since it is hard to figure out which fuse has blown). Both of these situations are common in theatre wiring. This plug is also widely used in Israel, Malaysia and Singapore for air conditioners and washing machines.

### **30 A 3 pin**

The 30 A plug is the largest of the family, being slightly larger than the 15 A plug. This was used for high power industrial equipment up to 7.2 kW, such as industrial kitchen appliances, dimmer racks for stage lighting, etc. Plugs and sockets were usually of an industrial waterproof design with a screw locking ring on the plug to hold it in the socket against waterproof seals, and sockets often had a screw cap chained to them to be used when no plug was inserted to keep them waterproof. Use of the BS 546 30 A plugs and sockets diminished through the 1970s as they were replaced with BS 4343 (which later became IEC 60309) industrial combo plugs and sockets.

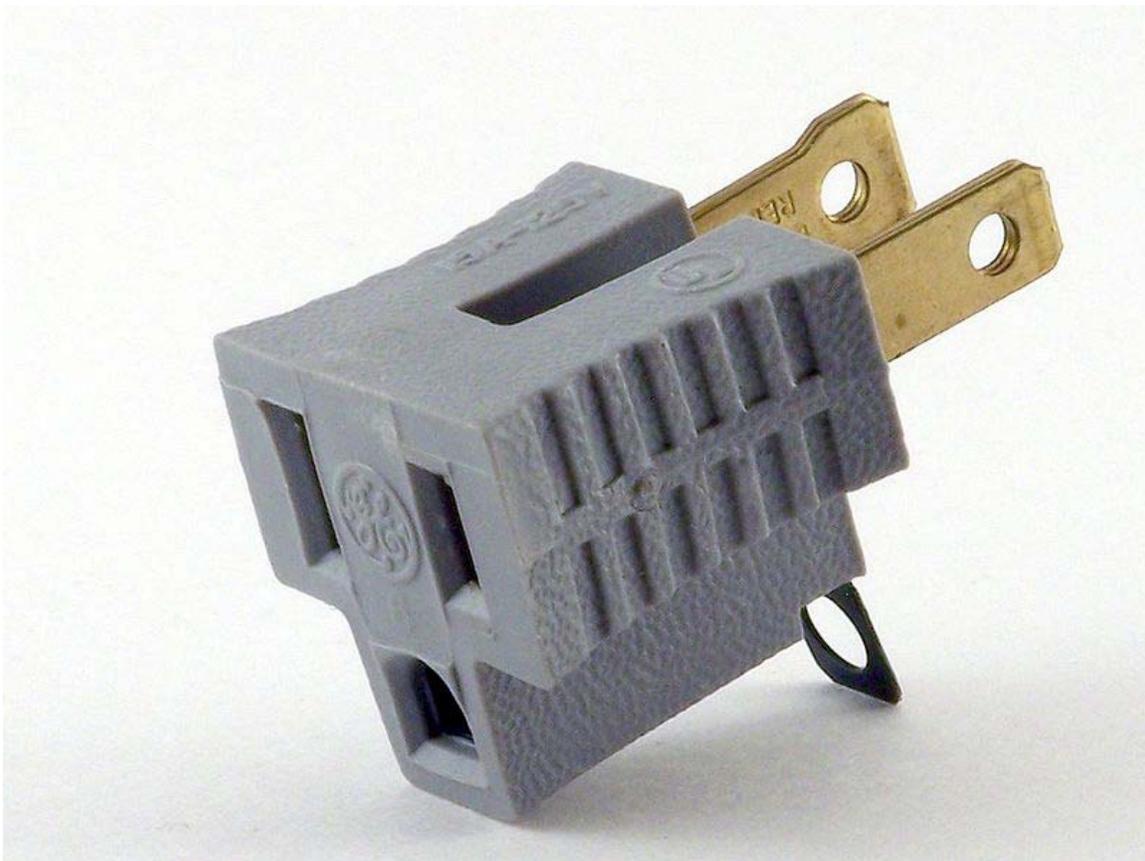
### **Characteristics of BS 546 plugs**

	<b>type ? 30A</b>	<b>type M 15A</b>	<b>type D 5A</b>	<b>type ? 2A</b>
Diameter L and N pins	7.92 mm	7.06 mm	5.08 mm	3.56 mm
Diameter earth pin	9.53 mm	8.71 mm	7.06 mm	5.08 mm
Centre distance between L and N pin	36.50 mm	25.40 mm	19.05 mm	14.48 mm

## Chapter 4

# Cheater Plug & Europlug

## Cheater Plug



A cheater plug, with metal grounding tab

A **cheater plug**, **AC ground lifter** or **three-prong/two-prong adapter** is an adapter that allows a NEMA 5-15P grounding-type plug (three prongs) to connect to a NEMA 1-15R non-grounding receptacle (two slots). The use of such an adapter avoids the need to replace receptacles, but is potentially hazardous, if the grounding tab is not actually connected to electrical ground. An alternative identified in the U.S. and Canadian electrical codes is to replace the outlet with a GFCI breaker outlet.

Cheater plugs were previously available with a short flexible grounding wire rather than a screw tab. This allows use of the second duplex outlet that does not have a faceplate screw in the correct location for the screw tab. The grounding wire would be wrapped around the adapter to reach the faceplate screw. However, this ground-wire style of cheater plug was discontinued when it was noted that a loose unattached grounding wire could by accident become inserted into the "hot" blade socket of a nearby outlet, potentially leading to electrocution.

Cheater plugs are also used to break ground loops in audio systems. This practice has been condemned as disregarding electrical safety.

### ***Use in residences***

Three-prong plugs do not fit into the older, two-prong receptacles. When used as intended, the ground pin of the 3-wire receptacle is to be connected to the grounded cover screw, or to an external ground. In 1969 Underwriters Laboratories mandated three-prong plugs on small appliances for safety. At that time, only half of the receptacles in U.S. homes were three-prong. Wiring in most homes did not include a grounding wire. The screws and outlet boxes were either connected to the neutral, or connected to nothing. Only in rare jurisdictions where non-metallic cable was prohibited, and armored cable required, do cheater plugs work as intended. In 1971 the U.S. National Electrical Code (NEC) required grounded receptacles in all locations of the home (effective January 1, 1974).

### ***Safety***

In the professional audio and video fields, the cheater plug has been identified as a serious safety problem. Its casual use as a method for avoiding ground loops in analog audio and video signals (to eliminate hums and buzzes) is dangerous. Bill Whitlock, president of Jensen Transformers, writes, "never, ever use devices such as 3 to 2-prong AC plug adapters, a.k.a. 'ground lifters', to solve a noise problem!" Whitlock relates how an electrical fault in one device that is connected to its electricity source through an ungrounded cheater plug will result in dangerous, high current flowing through audio or video cables. Whitlock notes that in 1997, consumer audio and video equipment electrocuted nine people.

The cheater plug is also recognized as a safety hazard in laboratory settings. For example, in August 2005, Tarun Mal, an associate professor at Cleveland State University, was electrocuted when he plugged a defective fluorescent lamp into a lamp timer using a

cheater plug. Subsequently, the state of Ohio issued seven citations to the university for unsafe electrical conditions. *The Scientist* notes that four of the University's seven environmental safety experts agreed that use of the cheater plug "is not uncommon in US university labs". Jim Kaufman, CEO of the Laboratory Safety Institute, says, "When you inspect labs, it's not unusual to find anywhere from one to seven that way."

## **Alternatives**

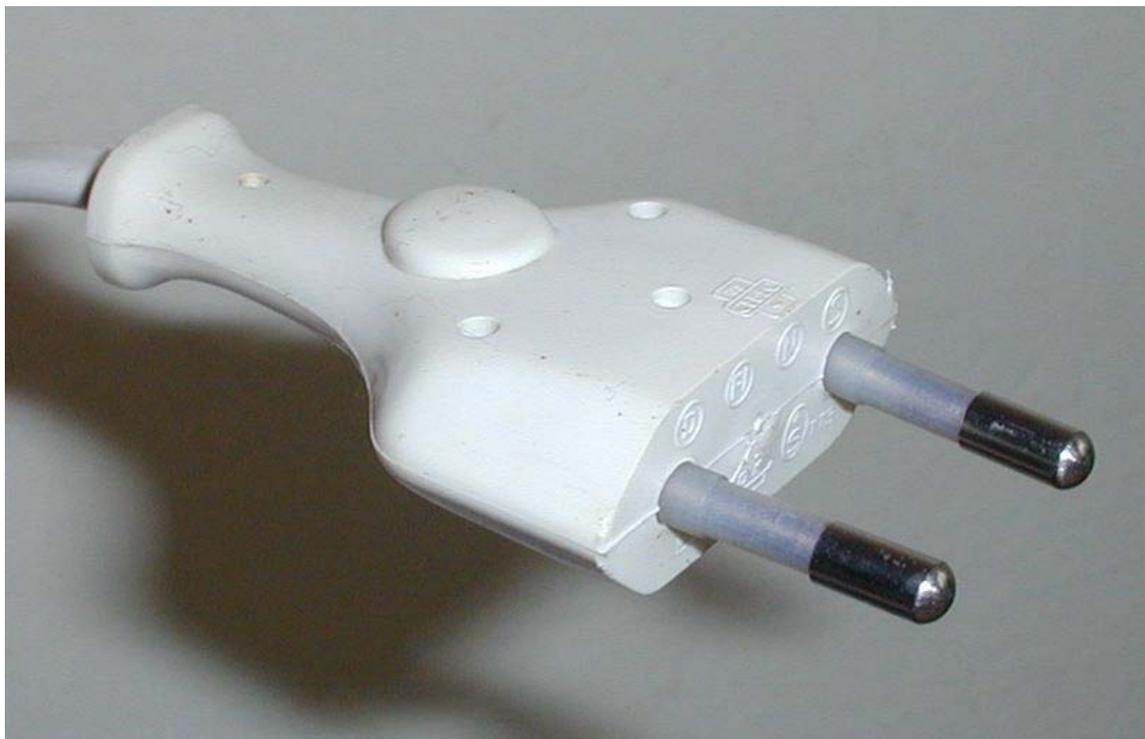
There are several alternatives for connecting newer appliances to two-prong receptacles without rewiring the building: removing the grounding pin of the plug, replacing the receptacle with a three-prong outlet, or replacing the receptacle with a GFCI; only the last (GFCI) is safe.

Removing the grounding pin of the appliance's plug leaves the appliance without proper grounding even when relocated and plugged into a properly grounded three-prong receptacle.

Replacing the receptacle with the three-prong type and leaving the ground screw unconnected is neither more safe nor less safe than using a cheater plug. However, if the ground screw of the receptacle is connected to the neutral side, electric shock is possible even if the appliance is properly functioning. This is called a "false" or "bootleg" ground and is a serious safety hazard often undetected by common receptacle testers.

Replacing the receptacle with a GFCI receptacle is the safest alternative. If a GFCI receptacle is properly functioning, then it will shut off the power to a faulty appliance to prevent electric shock. As a safe option that protects all appliances plugged into that receptacle, the National Electrical Code permits such replacement if the installer marks the GFCI as having "No Equipment Ground".

# Europlug



Example of a Europlug



Italian plug type L, grounded, similar, but not equal to Europlug

The **Europlug** (CEE 7/16) is a flat, two-pole domestic AC power plug that is generally supplied moulded on the end of an appliance's flex or a power cord, designed for voltages up to 250 V and currents up to 2.5 A. It was designed such that it can safely be used in the domestic power sockets of all European countries, except for the BS 1363 system found in Britain, Cyprus, Gibraltar, Ireland and Malta.

### ***History***

The Europlug design appeared first in 1963 as Standard Sheet XVI in the second edition of CEE Publication 7, a document that summarized all the national domestic AC plugs and sockets used across Europe. The Europlug is therefore sometimes also referred to as the "CEE 7/16" plug. It was also adopted in 1975 as plug C5 in IEC Technical Report 83 (now IEC/TR 60083), and as European standard EN 50075 in July 1990.

### ***Design considerations***

The dimensions of the Europlug were chosen for compatibility and safe use, such that with all European domestic power sockets

- reliable contact is established when the plug is fully inserted;

- no live conductive parts are accessible while the plug is inserted into each type of socket;
- it is not possible to establish a connection between one pin and a live socket contact while the other pin is accessible.

Europlugs are only designed for low-power (less than 2.5 A) Class II (double-insulated) devices that operate at normal room temperature and do not require a protective-earth connection.

### ***Details***

The pins of the Europlug are 19 mm long. They consist of a 9 mm long conductive tip of 4 mm diameter with a rounded ending, followed by a 10 mm long flexible insulated shaft of not more than 3.8 mm diameter. The two pins are not exactly parallel and converge slightly; their centres are 17.5 mm apart at the tip and 18.6 mm apart at the base. The elasticity of the converging pins provides sufficient contact force for the Europlug's current rating with a variety of socket-hole arrangements. The entire plug is 35.3 mm wide and 13.7 mm high, and must not exceed these dimensions within 18 mm behind its front plane (this allows for the recesses on many European socket types). The left and right side of the plug are formed by surfaces that are at 45° relative to the horizontal plane.

### ***Incompatibility with British sockets***

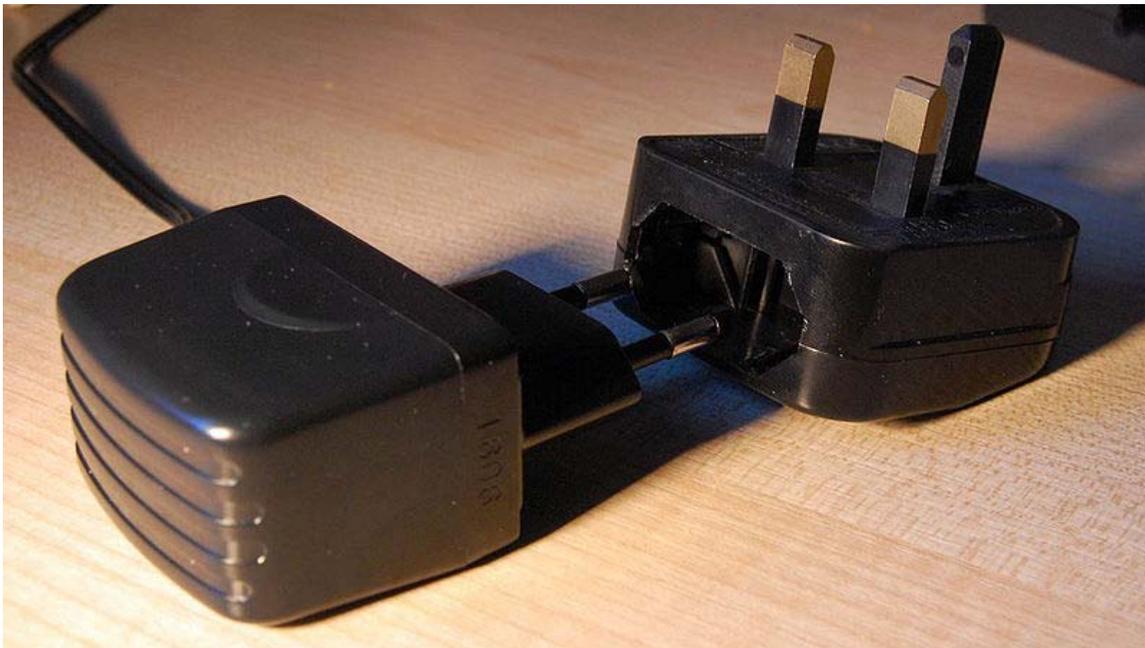
The Europlug is not compatible with British BS 1363 13 A sockets for (at least) three reasons:

- BS 1363 sockets contain a child-safety shutter and need an earth pin to be inserted before the live and neutral contacts become accessible.
- The ring circuits found in many British homes are only protected by high-current breakers (typically 32 A) and therefore rely on a lower-current fuse (typically 3–13 A) in each plug to protect the appliance cable from dangerous overcurrents when a fault occurs. Europlugs are not designed to contain fuses or switches. In most other European countries, it is customary to use radial circuits, where smaller groups of sockets are each protected with a fast-acting 10–16A circuit breaker, a current limit that even Europlug cords can support briefly in fault situations.
- The free space between Europlug pins ( $13.5\pm 0.5$  mm) is about 2 mm less than the corresponding dimension in a BS 1363 socket (15.8 mm). To force a Europlug into a UK socket, each pin has to be bent by about 1 mm. The pins' flexibility usually allows for this, but the resulting bending force plus the fact that the conductive tip of each pin is 0.2 mm wider than the non-conductive shaft can sometimes make the pins difficult to remove from a BS 1363 socket. Although the 4 mm diameter of the Europlug pin gives it the same height as the corresponding

BS 1363 pins, the latter are with 6.35 mm substantially wider, and are also located further apart. Therefore, whether a Europlug can achieve proper contact inside a BS 1363 socket depends on the exact manufacturer-specific construction of the contacts inside the socket. Proper contact is not guaranteed by the relevant standards.

It is, in principle, possible to insert a Europlug into a BS 1363 socket by inserting another object (such as a screwdriver or key) into the earth hole first. Doing so is not recommended for the above reasons. An easy method however is to use a 4-way extension socket and place a G type plug into the earth pin inverted, lowering the shutter and exposing the live and neutral sockets, allowing a Europlug to be inserted easily. Nevertheless, in many countries where both BS 1363 and Europlug connectors are on the market (e.g., Malaysia, Singapore), such forcing of a Europlug into a BS 1363 socket is not an uncommon practice. It may also be possible to remove the safety shutter from the socket completely, depending on the design of the socket.

Equipment sold in Britain with a Europlug must be marked with or accompanied by a warning that it is not suitable for use in a British mains socket. The exception is that shavers, electric toothbrushes and similar personal hygiene products may be supplied with a europlug as an alternative to the larger BS 4573 2-pin plug. The Europlug is compatible with 2-pin shaver sockets used in British bathrooms, which have isolating transformers.



Europlug with fused BS 1363 converter plug



Side by side comparison of converter plug, typical BS1363 plug and Schuko adaptor

The flat design of the Europlug and the comparatively large shape of the British plug made it possible to design fused converter plugs that have outer dimensions only slightly larger than most normal BS 1363 plugs and that encapsulate an entire Europlug internally. They can be fitted quickly and safely by relatively unskilled personnel (there is no real way to get it wrong unlike a normal rewirable plug which can be miswired), making them attractive to manufacturers and importers who sell equipment in the UK that was manufactured using moulded Europlugs.

### **BS 546**

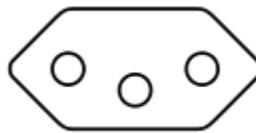
While most modern BS 546 sockets include the safety shutter found on BS 1363 sockets the Europlug should fit in the 5A type of BS 546 socket. In modern sockets it may also be possible to push down the shutter with a blunt object or remove it completely.

## Chapter 5

# IEC 60906-1 & GOST 7396

## IEC 60906-1

**IEC 60906-1** is the international standard 230 V household plug system. It was intended to become the common mains plug and socket standard, to be used one day everywhere in Europe and other regions with 230 V mains. The standard was published by the International Electrotechnical Commission in 1986. So far, only Brazil and South Africa introduced a standard based on it. The biggest differences being that in parts of Brazil the mains voltage is 127 V and the introduced standard has a pin diameter of 4mm for the 10A plug and 4.8mm for the 20A plug, while the original standard has a single pin diameter of 4.5mm and a maximum current of 16A. Although it looks similar to the Swiss plug, its dimensions are different.



IEC-906-1-plug

### **Features**

The IEC 60906-1 system is rated for AC voltages up to 250 V and currents up to 16 A. It defines both 3-pin connectors for Class I appliances and 2-pin versions for Class II appliances.

The plug

- has round (cylindrical) live and neutral pins, which are 19 mm apart and 4.5 mm in diameter (similar to the Schuko plug);
- has an insulating sleeve around the base of the live and neutral pin (similar to the Europlug);
- is smaller than any other European 3-pin plug, and only slightly larger than the 2-pin 2.5 A Europlug.

#### The socket

- has either a 10 mm deep recess or a 12 mm high rim, to ensure that no commonly used plug can be inserted in a way that establishes contact to one pin while leaving the other pin exposed;
- ensures that the protective-earth pin establishes contact before the live and neutral pins;
- can be equipped with a child-safety shutter for the live and neutral contacts (similar to BS 1363 sockets);
- is compatible with the Europlug;
- is compact enough to permit the installation of two sockets in the space needed by a single Schuko or BS 1363 socket.

For most existing European systems (Schuko, etc.), it would be possible to design sockets that can accept both the traditional plug as well as the IEC 60906-1 Class I and II plugs, thereby enabling a smooth transition to the new system. However, the IEC 60906-1 standard explicitly discourages the use of multi-standard sockets, claiming that such sockets are likely to create safety problems when used with plugs from other countries.



A 20A Brazilian socket based on the in IEC 60906-1 standard

### ***Comparison with traditional systems***

Thanks to modern injection molding technology, robust and safe plugs can have much smaller dimensions today than what was considered feasible when the old Schuko and BS 1363 systems were designed in the early and mid 20th century.

### **BS 1363**

The IEC 60906-1 system features many of the advantages of the BS 1363 plug, but avoids the main problems with the system currently used in Britain, Ireland and many Commonwealth countries:

- incompatibility with the ubiquitous Europlug (though this could easily be changed if wiring regulations were changed to make it safe to do so);
- lack of a practical way to design a migration socket that also accommodates the Schuko system;
- large size;
- current capacity limited to 13 amps (as opposed to 16 amps for Schuko and IEC 60906-1);

- risk of foot injury through a plug shape that makes it likely that the sharp pins face upwards when a plug lies on the floor.

However, unlike with BS 1363, IEC 60906 does not mandate a fuse in each plug. It may well be feasible to design IEC 60906-1 plugs with an integrated fuse. Handing over the protection measures to sockets would violate British wiring rules because each plug is hardwired to its power cord and each power cord, depending on wire thickness, requires an appropriate fuse. The socket can not have a universal fuse which would match the power cord's current capacity of each appliance. The other way to meet British wiring rules is to use power cord for 16 Amps (maximum for IEC 60906-1) regardless of device power rating. Also the plug is unlikely to have as low a profile to the wall, making use behind cupboards harder. (It is technically possible to make an IEC 60906-1 plug/socket combination with a similar profile to a BS 1363, but only if the socket has a recess and the cord exit angle exceeds the recommendations of the specification.)

## **Schuko**

The IEC 60906-1 system also avoids the problems of the Schuko system currently used in most of Europe and large parts of Asia:

- Ambiguity between live and neutral.
- Lack of a practical way to design a migration socket that also accommodates the BS 1363 system;
- Large size;
- Mateability of Class I plugs with commonly used (non-Schuko) sockets that lack protective-earth contacts.

## **Swiss plug**

Although the IEC 60906-1 plug looks remarkably similar to the Swiss SEV 1011 plug, there are a number of significant differences. The Swiss plug

- lacks insulating sleeves around the live and neutral pins
- has the earth pin further away from the centre line (5 mm instead of 3 mm)
- has slightly thinner pins (4 mm instead of 4.5 mm)

## ***Dimensions***

The Class I and II plugs' shapes are similar to the Europlug; their front profile is also a flat hexagon, but it is slightly thicker. Both plugs are 35.5 mm wide. The 3-pin Class I plug is 17 mm high, whereas the 2-pin Class II plug is with only 14 mm slightly slimmer (the Europlug is only 0.3 mm smaller). The parallel side faces are 26 mm apart, and the two pairs of side faces are orthogonal to each other. As on the Schuko plug, the live and neutral pin have 19 mm center distance and 19 mm length. However, their diameter is 4.5mm, unlike the Schuko and the Class I-lookalike Brazilian 20-amp NBR 14136 plug, which both have 4.8mm pin diameter, while the 10A Brazilian plug has a diameter of

4mm. A further distinction with the Schuko plug is the insulating sleeve around the base of the live and neutral pin (as on the Europlug). The 3-pin version also has a round protective-earth pin. It has the same length and diameter as the live and neutral pins, but lacks an insulating sleeve. The protective-earth pin's center is offset 3 mm from the center point between the live and neutral pin.

### **Class 0 plug and socket**

In addition to the hexagonal Class I and Class II plugs and sockets, Appendix A of the standard also defines a 2-pin plug and socket with oval profile, for countries that still permit the use of Class 0 appliances, which are considered unsafe in most industrialised countries today. The Class II plug fits also into Class 0 sockets; it is up to national regulations of countries using the Class 0 socket, whether they permit an additional dummy hole in it, such that even Class I plugs will fit. However, none of the Class 0 plugs fit into a Class I or Class II socket. This way, the system prevents that Class 0 equipment can be operated easily in regions that do not permit such devices. The full mateability matrix of all plugs and sockets defined in IEC 60906-1 looks like this:

		Plug		
		Class 0 (2 pin)	Class I (3 pin)	Class II (2 pin)
Socket	fits into			
	Class 0 (3 hole)	Yes	Yes	Yes
	Class 0 (2 hole)	Yes	No	Yes
	Class I (3 hole)	No	Yes	Yes
Class II (2 hole)	No	No	Yes	

As a result of the increasing global harmonization of electrical safety standards, IEC is phasing out the entire concept of Class 0 appliances from its standards. It is therefore unlikely that the oval Class 0 plug and socket variant will ever be introduced anywhere. The appendix that introduces it was probably merely added to address the concern that a system of country-independent plugs and sockets could permit the easy use of imported Class 0 equipment that does not meet national safety standards.

## **GOST 7396**

**GOST 7396** (*FOCT 7396* in Cyrillic) is a series of Soviet and later Russian standards that specify basic dimensions and safety requirements for power plugs and sockets used in Russia and other former Soviet Republics, as well as for export to markets that use American or British plugs.

Many official standards in Eastern Europe are virtually identical to the Schuko standard. One of the protocols governing the reunification of Germany required that the DIN and VDE standards would prevail without exception, so the former East Germany had to conform to the Schuko standard. Most other Eastern European countries use the Schuko

standard internally but, prior to its collapse, they exported large volumes of appliances to the Soviet Union with the Soviet standard plug installed. Because of that, many of the Russian plugs found their way into other Eastern European countries. One peculiarity of the Soviet standard is the use of an ungrounded plug with 4.0 mm diameter pins for 6 A and a corresponding socket that would not accept the 4.8 mm diameter pins of devices that could draw as much as 16 A. Another is that sockets that in other places would be supplied with 16 A may have been wired for only 10 A during the Soviet era.

The series includes the following standards:

- **GOST 7396.1-89** Plugs and Socket-Outlets for Household and Similar Purposes - Basic Dimensions
- **GOST 7396.2-91** Plugs and Socket-Outlets for Household and Similar Purposes - Particular Requirements for Fused Plugs - General Technical Specifications

### ***Group A***

Group A connectors consist of the non-locking NEMA connectors (Types A and B), which are defined for the assistance of exporters. Thus for example, an A 5-15 plug is the standard NEMA 5-15 household grounded plug used in North America.

### ***Group B***

Group B connectors are also defined for the assistance of exporters to countries that use connectors based on British standards. The B 1 series defines the BS 546 (Type D) 3 pin unfused plugs of 2 A, 5 A, and 15 A, while the B 2 plug is the same as the BS 1363 (Type G) fused plug.

## Group C



6 A variety of the C 1 plug

Group C connectors are various CEE 7 plugs used in continental Europe, with allowances made for various Soviet era plugs that are compatible with them. Note that under Soviet-era construction the 16 A versions may have been supplied with only a 10 A service.

### C 1 - 2 pin ungrounded 6 A and 16 A (Type C)

Both varieties of this connector use two pins with centers spaced 19.0 mm apart. The 6 A variety has pins on the plug with a 4.0 mm diameter with the corresponding socket holes having a diameter of 4.5 mm. The corresponding dimensions on the 16 A are 4.8 mm and 5.5 mm respectively. Thus a 6 A plug fits

into both varieties of this socket, but the 16 A plug does not fit into the 6 A socket.

**C 2 - CEE 7/4 Schuko 16 A (Type F)**

This is the standard Schuko connector used in much of continental Europe. The Schuko plug will fit into the 16 A variety of the C 1 socket, but will not be grounded.

**C 3 - CEE 7/5 French 16 A (Type E)**

This is the standard connector found in France, Belgium, Poland, Czech Republic, and Slovakia. The plug will fit into the 16 A variety of the C 1 socket, but will not be grounded.

**C 4 - CEE 7/7 16 A (Type E/F)**

This is the compromise plug designed to be accepted and to be grounded in both the Schuko and French sockets. The plug will fit into the 16 A variety of the C 1 socket, but will not be grounded.

**C 5 - CEE 7/16 Europlug 2.5 A (Type C)**

The standard Europlug is defined here, as is a version of the C 6 (CEE 7/17) plug, but with 4.0 mm diameter pins. The standard allows for the use of devices that draw as much as 6 A with these round variants.

**C 6 - CEE 7/17 16 A (Type C)**

The standard CEE 7/17 ungrounded plug with 4.8 mm diameter pins is defined here. Note that the GOST standard defines a variant with 4.0 mm diameter pins for use with devices of 6 A or less, which it classifies as a variant shape of the C 5 plug.

Compatibility Table

		Plugs						
		C 1		C 2	C 3	C 4	C 5	C 6
		6 A	16 A					
Sockets	C 1 6 A	Y	N	N	N	N	Y	N
	C 1 16 A	Y	Y	Y	Y	Y	Y	Y
	C 2	N	N	Y	N	Y	Y	Y
	C 3	N	N	N	Y	Y	Y	Y

## Chapter 6

# Industrial and Multiphase Power Plugs and Sockets



Pin and sleeve connectors

**Industrial and multiphase plugs and sockets** provide a connection to the electrical mains rated at higher voltages and currents than household plugs and sockets. They are generally used when more than two current carrying conductors (polyphase system), high currents and/or protection from environmental hazards (particularly water) are required.

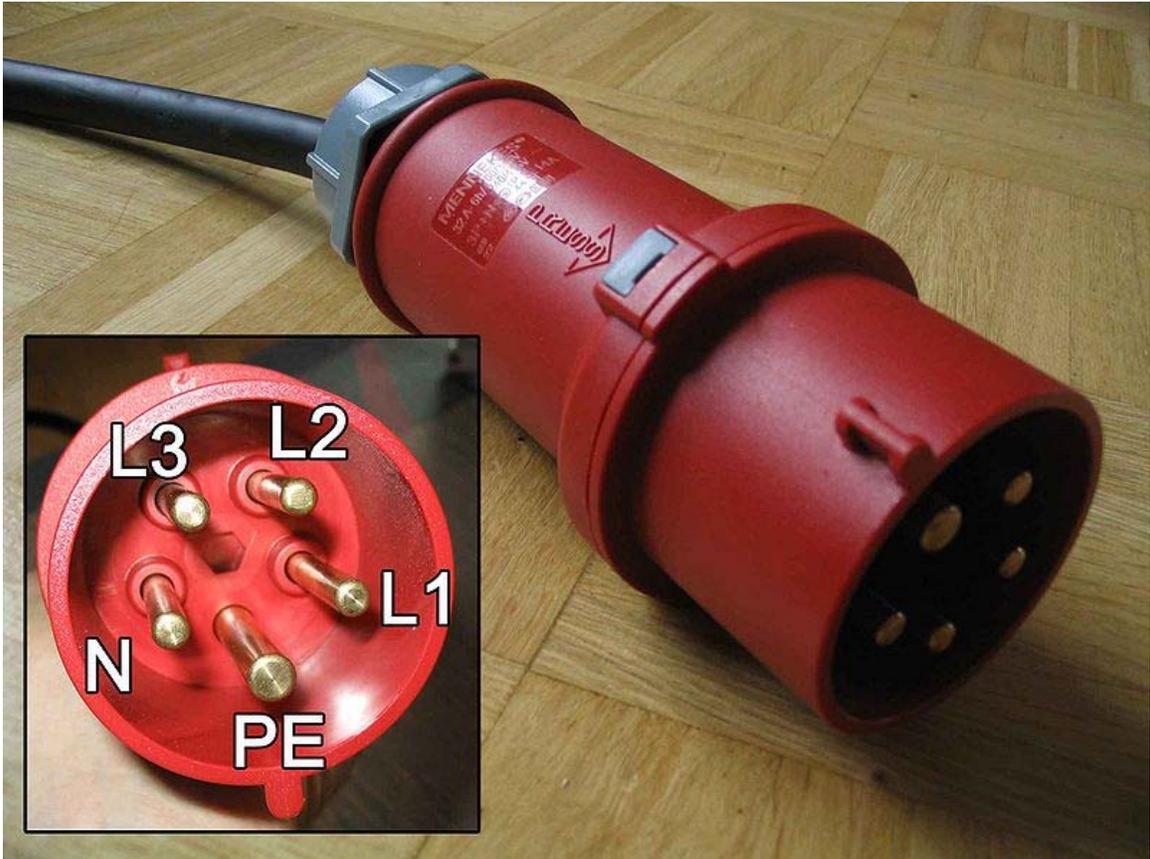
In many countries sockets are available that completely enclose a normal plug and have seals around the cable to exclude water. These reduce the need for special plugs and sockets but are often only suitable for fixed sockets due to their bulk, shape, and cable entry arrangements. Sockets on domestic extension leads are usually either not covered at all or covered with small covers that don't enclose an inserted plug.

Some connectors exist that are neither industrial nor multiphase but have higher voltage or current ratings than the normal plugs and sockets (e.g., the 16 A Italian socket and the 20 A American sockets). These are listed in the AC power plugs and sockets article grouped with the normal plugs and sockets of which they are variants.

Almost all three-phase power plugs have an earth (ground) connection, but may not have a neutral, because large equipment (circular saws, welding sets, pumps, air conditioners) tend to be delta connected. Such plugs have only four prongs (earth, and the three phases). An example of a socket with neutral is the L21-30 (30 A) and the L21-20 (20 A) both of which have five pins (earth, neutral, and X, Y, Z phases).

While some forms of power plugs and sockets are set by international standards, countries may have their own different standards and regulations. For example, the colour-coding of wires may not be the same as for small mains plugs.

**Europe**



32 A 400VV 3P+N+E



16 A 2P+E 230 V plug



Mated 16 A plug and wall-mounted socket

### **Europe-wide IEC 60309 system**

In Europe, the most common range of heavy commercial and industrial plugs are made to IEC 60309 (formerly IEC 309) and various standards based on it (including BS 4343 and BS EN 60309-2). These are often referred to in the UK as CEE industrial, CEEform or simply CEE plugs, or as "commando connectors" (presumably after the MK Commando range that contains these connectors).

Plugs are available in 2P+E (single phase), 3P+E (3 phase without neutral), and 3P+N+E (three phase with neutral). Current ratings available are 16 A, 32 A, 63 A, 125 A and 200 A.

Voltage and other characteristics are represented by a colour code (in three-phase plugs the stated voltage is the phase-phase voltage, not the phase-neutral voltage). The different voltages have the earth pin of a larger diameter than the others, and located in different places depending on the voltage rating, making it impossible to mate, for instance, a blue plug with a yellow socket. Since the different current ratings have different overall sizes, it is also not possible to mate different pin configurations or current ratings. For example, a 16 A 3P+E 400 V plug will not mate with a 16 A 3P+N+E 400 V socket and a 16 A 2P+E 230 V plug will not mate with a 32 A 2P+E 230 V socket.

Characteristic	Colour
20–25 V	Purple
40–50 V	White
100–130 V	Yellow
200–250 V	Blue
380–480 V	Red
500–690 V	Black
>60–500 Hz	Green
None of the above	Grey

Yellow 2P+E, blue 2P+E, yellow 3P+E, red 3P+E, and red 3P+N+E are by far the most common arrangements. Blue 2P+E sockets (generally 16 A, although 32 A is becoming more common) are used near-universally by GB and DK campsites and yacht marinas to provide 240-volt domestic mains power to frame-tents, trailer-tents, caravans, and boats; they are also used elsewhere in Europe for the same purpose, though in some countries the local domestic plug is also widely used. The blue 2P+E 16-amp version carrying 240-volts is also used in shopping malls and their peripherals to power 'temporary' stalls not incorporated within a lock-up shop, with a probable World-wide usage in 240-volt areas - as it has been encountered in Siamese shopping malls; there is also widespread use in domestic gardens within Britain to power garden equipment, barbeques, and temporary lighting. The yellow 2P+E 16-amp version carrying 120-volts is used extensively on the London Underground Railway system to power temporary usage of heavy-duty fans; it is also frequently used by tradesmen within GB, built-in to a portable transformer box that is powered from a standard 13-amp 240-volt mains supply, to run heavy-duty power-tools designed to operate at 120-volts. The red three-phase connector is frequently found in domestic and small farm situations in Britain where a wine press is used.

A small number of marinas provide 230 V single-phase power through a red three-phase connector (breaking the relevant standards in the process). This goes some way to ensuring that only boats that have paid the required fee (and thus obtained an appropriately made-up adaptor cable) are able to use the electricity.

## **Entertainment industry**

Throughout Europe one of the common uses of industrial power connectors is in the Entertainment and Broadcast industries, where there is a need for vast amounts of power, delivered through quickly pluggable and unpluggable connectors.

In this industry they are referred to as *Ceeform* connectors. 230 V single-phase (blue) and 400 V three-phase (red) connectors between 16 A and 125 A ratings are used.

Where more current carrying capacity is required, such as between generator sets and distribution boards, VEAM Powerlocks or Camlocks are the choice. These connectors are single pole so 5 are required for a 3PH+N+E supply. Powerlocks have a rating of 400 A or 660 A at 1 kV. Camlocks E1016 Series are rated at 600 V 315 A.

Powerlocks are identified with the European harmonised colour code, they are also annotated as follows:

- Brown, L1
- Black, L2
- Grey, L3
- Blue, N
- Green, Earth

Camlocs are also available in these colours.

## **UK: Lewden plugs**

Lewden plugs and sockets are metal bodied waterproof plugs and sockets made by Lewden. The pin arrangements of the smaller single phase varieties are the same as BS 1363 and BS 546 plugs and sockets. These plugs and sockets will mate with normal plugs and sockets of the same pin arrangement but they are only waterproof when a Lewden plug is used in a Lewden socket and the screw ring is properly tightened (sockets have a metal cover that screws on to waterproof them when not in use).

## **Sweden, Germany & Netherlands: Perilex plugs**

Perilex plugs and sockets are 5-pin 3-phase connectors. The system provides 400 V 3P+N+PE and exists in 16 A and 25 A versions. In Sweden, the 16 A is generally used for stoves and to some extent for other heating devices in kitchens.

## **North America**

### **Pin and sleeve**



Pin and sleeve plug

Pin and Sleeve circular connectors are not compatible with the newer IEC 309 type. Current ratings are 30, 60, 100, 200, and 400 A. All are rated for voltages up to 250 V DC or 600 V AC. Contact arrangements are from 2 to 4 pins. There are two styles depending on the treatment of the ground. Style 1 grounds only on the shell. Style 2 uses one of the contacts as well as the shell, internally connected together. They are not strongly typed for specific circuits and voltages as the IEC 309 are. One insert rotation option is available to prevent mating of similar connectors with different voltages.

The contacts in the plug are simple cylinders (sleeves), while the pin contacts in the receptacle have the spring arrangement to hold contact pressure, the reverse of the IEC 309 type connectors. All contacts are the same diameter. Originally metal construction was used, but now they are also made with plastic shells. Since only keying in the connector shell is used, and since the keys can be damaged in industrial use, it is possible to mis-match worn connectors.

## NEMA connectors

NEMA devices are not exclusively industrial devices, and some types are found in nearly all buildings in the United States. Many of these standards are identical to their counterparts in Canada, although there are some exceptions. NEMA wiring devices are made in current ratings from 15–60 A, and voltage ratings from 125–600 V.

There are two basic classifications of NEMA device: straight-blade and locking. The locking type is preferred in many industrial environments, while the residential and commercial environment is home to straight-blade devices. (Of course, the straight-blade 5-15 and 5-20 are found nearly everywhere.) Numbers prefixed by *L* are twistlock, others are straight blade.

### NEMA 10-20, 10-30 and 10-50



NEMA 10-30

NEMA 10 devices are a curious throwback to an earlier time. They are classified as 125/250 V non-grounding, yet they are usually used in a manner that effectively grounds the appliance, albeit not in a manner consistent with most modern practice.

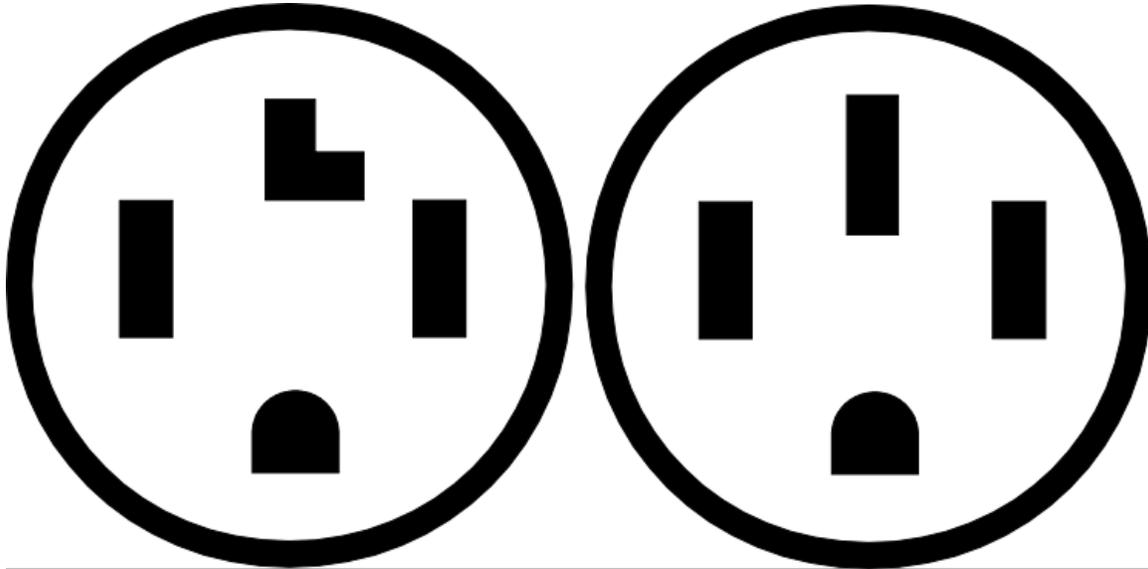
As commonly used, 10-30 and 10-50 plugs have the frame of the appliance grounded through the neutral pin. This was a legal grounding method under the National Electrical Code for electric ranges and electric clothes dryers from the 1947 to the 1996 edition. Since North American dryers and ranges have certain parts (timers, lights, fans, etc.) that run on 120 V, this means that the wire used for grounding is also carrying current. Although this is contrary to modern grounding practice, such installations remain extremely common in the United States and are relatively safe, because the larger conductors used are less likely to be broken than the smaller conductors used in ordinary appliance cords.

Persons moving their older appliances to newer NEMA 14-equipped buildings (or vice-versa) should have the cords replaced by a qualified electrician, as the grounding details may be quite confusing to the uninitiated.

NEMA 10-20 devices are very rare nowadays. There is also a similar obsolete design, lacking a NEMA configuration number, rated 125 V 15 A or 250 V 10 A which is nearly

identical to the AS/NZS 3112 standard used in Australia/New Zealand. These are also extremely rare.

## NEMA 14



NEMA 14-30 and 14-50 receptacles

The NEMA 14 devices are 4-wire grounding devices available in ratings of 15–60 A. Of the straight-blade NEMA 14 devices, only the 14-30 and 14-50 are common. The voltage rating is a design maximum of 125/250 V. They are essentially the replacements for the connectors above with the addition of a separate grounding connection.

All NEMA 14 devices offer two hots, a neutral and a ground, allowing for both 120 V and 240 V (or 120 V and 208 V if the supply system is three phase wye rather than split phase or three phase center tapped delta) appliances. They differ in rating and shape of the neutral pin. The 14-30 has a rating of 30 A and an L-shaped neutral pin. The 14-50 has a rating of 50 A and a straight neutral pin sized so that it will not fit in the slot of a 14-30.

NEMA 14-30 devices are most commonly found serving electrically-heated clothes dryers, while 14-50 devices most commonly serve kitchen ranges. In the United States, these are generally found in buildings constructed after the 1996 National Electrical Code, although they are also found in considerably earlier mobile homes. In Canada, the use of NEMA 10 devices was discontinued much earlier (if it was ever permitted at all), so NEMA 14 devices are more common there.

## Twist-locking connectors

Twist-locking connectors were first invented by Harvey Hubbell III in 1938 and *Twist-Lock* remains a registered trademark of Hubbell Incorporated to this day, although the

term tends to be used generically to refer to NEMA twist-locking connectors manufactured by any company. Unlike non-locking connectors, twist-locking connectors all use curved blades that have shapes that conform to portions of the circumference of a circle. Once pushed into the receptacle, the plug is twisted and its now-rotated prongs latch into the receptacle. To unlatch the plug, the rotation is reversed. The locking coupling makes for a very reliable connection in commercial and industrial settings.

Like non-locking connectors, these come in a variety of standardized configurations and follow the same general naming scheme except that they all begin with an *L* for *locking*. Once again, the connector families are designed so that 120 V connectors, 208/240 V connectors, and various other, higher-voltage connectors can not be accidentally intermated.

### Stage pin connectors



A stage pin connector. Note the **GR** denoting the longer ground pin, which is not quite in the center to prevent the plug being inserted upside down

A *stage pin connector* (SPC), or *grounded stage pin* (GSP), is a connector used primarily in the theatre industry for stage lighting applications in the United States. Stage pin connectors are generally used for conducting dimmed power from a dimmer to stage lighting instruments, although occasionally they can power other equipment.

The primary advantage of the stage pin connector over the NEMA 5-15 connector (commonly known as an Edison connector in the theatre industry) is its increased durability and resistance to damage due to its more robust construction and the ability to compensate for wear with a pin splitter. Having a distinct connector designated for dimmable power also helps prevent confusion of dimmed and non-dimmed circuits which could lead to equipment damage. Even the smallest stage pin connectors are rated for 20 A, which translates to 2.4 kW at 120 V, compared to the 15 A and 1.8 kW of the NEMA 5-15. In applications where cables are on the floor, the low profile of the connector allows for connections that are only slightly higher than the cables they connect.

## Australia



Australian 3-phase socket outlet, rated at 20 A, IP56. Single-phase Australian socket outlets are seen in the background.

In Australia, New Zealand and some Pacific islands, a different standard is used. The plugs and sockets are manufactured by Clipsal (Australia) and PDL (New Zealand) respectively. The most common is arguably the 32 A version of the Clipsal 56 series, named after its IP 56 rating. Also available are metal-clad and the 66 series and some European CEE standard outlets. The 56 series only allows metal-clad housings for 50 A and above, while the 66 series allows plastic housings with interlocks (cannot mate or separate some interlocking plugs with the power on) however it has a different pin configuration (AS3123).

Multiple pin version are available, 3 pins for single phase in 10, 20 and 32 A, 4 pins for 3 phase motors that do not require neutral connection in 10, 20, 32, 40, 50 and 60 A and 5 pins for equipment and distribution boards that require neutral and earth. 6 and 7 pin versions are also available in 10 and 20 A in 56 series and 50, 63 and 80 A in 66 series with extra control pins. Since neutral is the central pin, 4 pin plugs will fit 5 pin sockets, but the same does not hold for 3 pin plugs. While all residential Australian sockets will accept plugs of a lower rating, apparently only 32, 40 and 50 A industrial sockets of the same series will accept plugs of lower ratings, but 10 and 20 A are different again. For this reason it is prudent to check exactly which type of connector in terms of number of pins and current. Adaptor leads and boards are also quite common, however they can easily add up to thousands of dollars.

## Chapter 7

# NEMA Connector



A **NEMA 5-15 plug and receptacle**. (Different scales. Blade spacing is 0.75 inches (19.1 mm) for both.) Note that the receptacle will also accept an ungrounded plug whether polarized or unpolarized.

**NEMA connectors** are AC power plugs used for mains electricity in North America and other countries that use the standards set by the U.S. National Electrical Manufacturers Association. Some types are found in nearly all buildings in the United States. Similar and interchangeable connectors are used in Canada, Mexico, and other countries using the same type of receptacle, although there are some exceptions. NEMA wiring devices are made in current ratings from 15 to 60 amperes, and electrical potential (voltage) ratings from 125 to 600 volts. Different combinations of contact blade widths, shapes, orientation, and dimensions give non-interchangeable connectors that are unique to a particular voltage, current capacity, and grounding system. NEMA 1 (two prong) and NEMA 5 (three prong) are used for commonplace domestic equipment; the others are for heavy duty or special purposes. The dimensional standard for electrical connectors is ANSI/NEMA WD-6 and is available from the NEMA website.

### ***NEMA nomenclature***

There are two basic classifications of NEMA device: straight-blade and locking. The straight-blade 5-15 and 5-20 are found nearly everywhere in countries using the NEMA standards, and are intended for supplying lighter-duty, general-purpose electrical devices. Twist-locking types are used for heavy industrial and commercial equipment, where increased protection against accidental disconnection is required. Numbers prefixed by **L** are curved-blade, twist-locking connectors; others are straight blade and non-locking.

The numeral preceding the hyphen in NEMA nomenclature indicates the configuration, that is, the number of poles, number of wires, voltage, and whether single- or three-phase. A grounding type of device will be described as two-pole, three-wire; or four-pole, five-wire; etc. A non-grounding device will be two-pole, two wire; or three-pole, three-wire; etc.

The numeral following the hyphen is the rating of the device in amperes. The number is followed by the letter R to indicate a receptacle (female connector) or the letter P to indicate a plug (male connector).

As an example, the 5-15R is the common 125 V two-pole, three-wire receptacle. The L5-15R, while sharing the same electrical rating, is a locking design which is not physically compatible with the straight-blade 5-15 design. The 5-30 has the same two-pole, three-wire configuration and 125 V rating, but is rated 30 A.

Although there are several non-grounding device types in the NEMA standards, only three of them are in widespread use today. These are the two-pole 1-15, still in use in millions of buildings built before the 1960s, and the three-pole 10-30 and 10-50.

The small hole near the end of the power (non-ground) blades of some NEMA plugs is used for convenience in manufacturing; if present it must be of specified diameter and position.

## ***Non-locking connectors***

NEMA non-locking connectors all use blades of various flat and folded shapes (except for the round pins used on grounding connectors). The plugs can be detached from the receptacles by pulling back on the plug body. These connector families have been designed so that grounding connectors for 120 V and 208/240 V cannot be accidentally intermated.

NEMA wall receptacles can be found installed in any orientation. Neither NEMA nor the U.S. National Electrical Code nor the Canadian Electrical Code specify a preferred orientation, and different orientations may be found in the same building. When the ground blade of a receptacle is on the bottom, the neutral blade is on the upper left and the hot blade is on the upper right. All descriptions below assume this orientation.

### **NEMA 1**



A non-polarized 1-15P plug

All NEMA 1 devices are two-wire non-grounding devices (hot-neutral) rated for 125 V maximum. NEMA 1-15P plugs have two parallel flat blades,  $\frac{1}{4}$  inches (6.35 mm) wide, 0.06 inches (1.524 mm) thick,  $\frac{5}{8}$ – $\frac{23}{32}$  inch (15.875–18.256 mm) long, and spaced  $\frac{1}{2}$  inches (12.7 mm) apart, and are commonly found on household lamps and consumer

electronics such as clocks and radios. Standards exist for 1–15P, 1–20P and 1–30P plugs, and the 1–15R receptacle. There are no 1–20R and 1–30R receptacles; 1–20P and 1–30P mate with a corresponding NEMA 5 receptacle. Plugs may be and receptacles must be (since 1948) polarized to preserve the identity of the neutral conductor; the blade connected to neutral will be wider ( $\frac{5}{16}$  in/7.938 mm) than the other, and polarized sockets will only accept a polarized plug in the correct orientation.

## **NEMA 2 (obsolete)**

All NEMA 2 devices are two-wire non-grounding devices (hot-hot) rated for 250 V maximum. Although standards exist for 2–15, 2–20 and 2–30, this series is obsolete, and only Hubbell still manufactures 2-20 devices.

## **NEMA 5**



5–20R T-slot receptacle mounted with the ground hole up. The neutral connection is the wider T-shaped slot on the lower right.

All NEMA 5 devices are three-wire grounding devices (hot-neutral-ground) rated for 125 V maximum, with the 5–15, 5–20 and 5–30 being grounded versions of the 1–15, 1–20 and 1–30, respectively. The addition is a  $\frac{3}{16}$ -inch (4.763 mm) diameter round or U-shaped ground pin,  $\frac{1}{8}$  in (3.175 mm) longer than the power blades (so the device is

grounded before the power is connected) and located  $\frac{1}{4}$  in (6.35 mm) below them. ( $\frac{1}{4}$  in/6.35 mm is edge-to-edge;  $\frac{15}{32}$  in/11.906 mm center-to-center.)

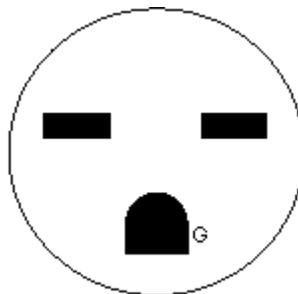
The 5-20P plug has the neutral blade rotated  $90^\circ$  and shifted so its inner edge is approximately  $\frac{1}{2}$  in (12.7 mm) from the hot blade. The 5-20R receptacle may have a T-shaped neutral hole, to accept both 5-15P and 5-20P plugs. The 5-30 and 5-50 are larger, with 1 inch between power pins. All of these are uncommon, as twist-locking plugs are generally used for high-current applications.

Nearly always both current blades on 5-15P plugs are narrow since the ground pin enforces polarity. If the ground pin is removed in order to fit it to a 1-15R outlet or extension cord, the live/neutral polarity is lost. 1-15P plugs are also compatible with 5-15P sockets. In this case, the socket retains polarity enforcement. Cheater plugs, adapters that allow a 5-15P plug to be fitted to a 1-15R outlet, are readily available. Proper grounding is dependent on the outlet being an ordinary duplex receptacle with a correctly grounded center screw, and the grounding tab of the adapter being connected to that screw.

The 5-15R is by far the most common electrical outlet in North America in buildings built since the mid-twentieth century. It is usually installed in a twin duplex configuration (which may be on a common circuit or with each receptacle on a separate circuit, sometimes switched).

The standard 5-15 (and its 1-15 two prong counterpart) is sometimes called an "Edison plug" in the film and theatre industry, where that name distinguishes it from more specialized theatrical connectors. This is presumably a reference to Thomas Edison or the various Edison utility companies which supply electric power. In the motion picture and TV production industries, an extension cord that uses this type of connector (usually 12 AWG or 10 AWG) is known as a "stinger". Generally, lighting technicians use these extension cords to deliver power to lights 2000 W and less.

## NEMA 6



NEMA 6-15



50A power socket with dustproof flexible shroud, used on a farm silo unloader.

All NEMA 6 devices are three-wire grounding devices (hot-hot-ground) used for 208 V and 240 V circuits and rated for 250 V maximum, with the 6–15, 6–20 and 6–30 being grounding versions of the 2–15, 2–20 and 2–30, respectively. The 6-15 resembles the 5-15, but with collinear horizontal pins, spaced  $\frac{23}{32}$  in (18.256 mm) center-to-center. The 20 A plug has a blade rotated 90°, and the 6–20R receptacle may have a T-shaped hole, to accept both 6–15P and 6–20P plugs. The 30 A plug and socket look similar to the 15 A one but larger. The higher-current versions are rare, with twist-locking plugs such as L6-30 or direct wiring more common. Generally 6-series non-locking plugs are used for such appliances as large room air conditioners, commercial kitchen equipment, and the occasional home arc welder. Single phase 6-50 is commonly used on farms for the silo unloader, and is used with a 6 gauge flexible power cord up to 200 ft long (61 m).

NEMA 6 devices, while specified as 250 V, may be used for either 208 V or 240 V circuits, generally depending on whether the building has a three-phase or split-phase power supply. Visitors to North America should not regard the NEMA 6–20R or 6–30R found in many hotel rooms as a source of 240 V power, since in most cases they are supplied with 208 V, and electrical equipment may be designed for a hot-neutral configuration instead of two hots.

Although it is technically possible to derive 120 volts by using the NEMA 6 ground pin as a neutral, this is not an approved usage. Some specialty devices such as uninterruptible power supplies designed for NEMA-6 may malfunction if used to supply 120 volts to a load, because the UPS is not designed to divide the voltage it supplies.

## **NEMA 10**



NEMA 10-30

NEMA 10 devices are a curious throwback to an earlier time. They are classified as 125/250 V non-grounding (hot-hot-neutral), yet they are usually used in a manner that effectively grounds the appliance, though not in a manner consistent with most modern practice.

As commonly used, 10–30 and 10–50 plugs have the frame of the appliance grounded through the neutral blade. This was a legal grounding method under the National Electrical Code for electric ranges and electric clothes dryers from the 1947 to the 1996 edition. Since North American dryers and ranges have certain parts (timers, lights, fans, etc.) that run on 120 V, this means that the wire used for grounding is also carrying current. Although this is contrary to modern grounding practice, such installations remain common in the United States and are relatively safe, because the larger conductors used are less likely to be broken than the smaller conductors used in ordinary appliance cords, and the current carried is small.

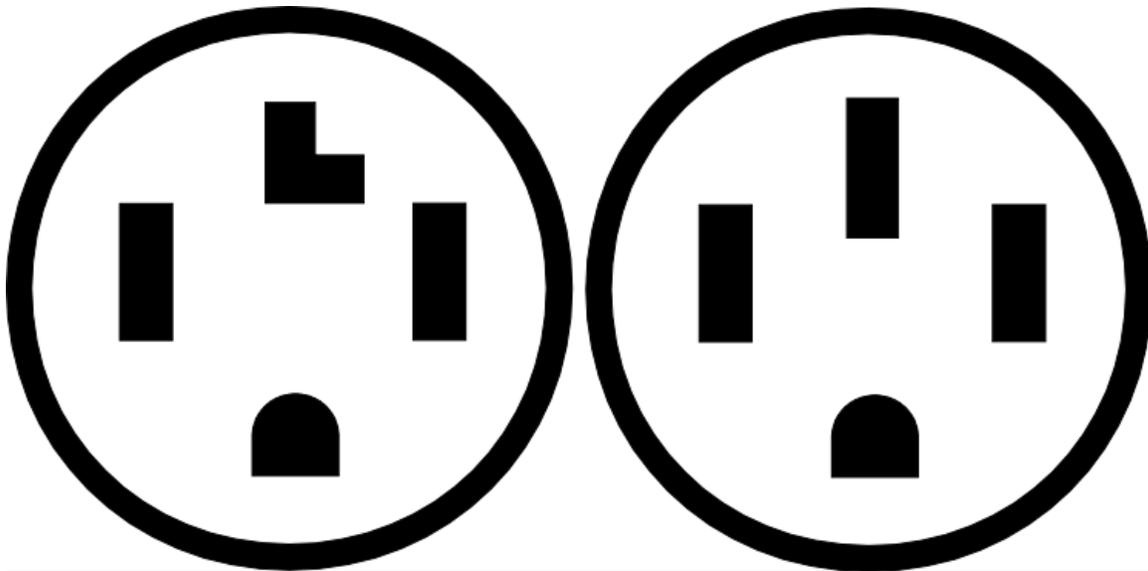
Persons moving their older appliances to newer NEMA-14-equipped buildings (or vice-versa) should have the cords replaced by a qualified electrician.



Obsolete 125 V, 15 A / 250 V, 10 A duplex outlet

NEMA 10–20 devices are very rare nowadays, but are occasionally found in homes that once had a large window air conditioner. There is also a similar obsolete design, lacking a NEMA configuration number, rated 125 V, 15 A / 250 V, 10 A which is nearly identical to the AS/NZS 3112 standard used in Australia/New Zealand. It has existed as far back as 1915, and is seen in US patent 1,179,728. They are also extremely rare.

### **NEMA 14**



NEMA 14–30 and 14–50 receptacles

The NEMA 14 devices are four-wire grounding devices (hot-hot-neutral-ground) available in ratings from 15 A to 60 A. Of the straight-blade NEMA 14 devices, only the 14–30 and 14–50 are common. The 14–30 is used for electric clothes dryers and the 14–50 for electric cooking ranges. The voltage rating is 250 V. They are essentially the

replacements for the NEMA 10 connectors above with the addition of a separate grounding connection.

All NEMA 14 devices offer two hots, a neutral and a ground, allowing for both 120 V and 240 V (or 120 V and 208 V if the supply system is three-phase rather than split phase). The 14-30 has a rating of 30 A and an L-shaped neutral blade. The 14-50 has a rating of 50 A and a straight neutral blade sized so that it will not fit in the slot of a 14-30.

NEMA 14-50 devices are frequently found in RV parks, since they are used for shore power connections of larger recreational vehicles. Also, it was formerly common for mobile homes to be connected to utility power via a 14-50 device.

### NEMA TT-30



NEMA TT-30 plug and receptacle. (The center hole on the receptacle is not a contact.)

NEMA TT-30 (TT stands for Travel Trailer) is a 30 A, 125 V recreational vehicle standard (hot-neutral-ground) which may also be known as RV 30. It is frequently (and sometimes disastrously) confused for a NEMA 10-30. The RV receptacle is common in nearly all RV parks in the United States and Canada, and all but the largest RVs manufactured since the 1970s use this plug. The hot and neutral blades are angled at 45° from vertical and 90 degrees to each other, similar to NEMA 10 devices. The plug is slightly smaller than a NEMA 10 but larger than ordinary 5-15 plugs. The ground pin, however, is round, like those on straight-blade NEMA grounding devices. Referring to the diagram, the orientation is the same as the NEMA 5 plug and socket, with the receptacle neutral on the lower right. Due to the appearance of this plug, many people assume that it is to be wired for 240 V, but this is a 120 V device. Adapters exist with the TT-30 plug on one side and a 5-15 or 5-20 socket on the other side. When the cord is detachable from the RV an L5-30 is usually used on the RV end of the cord.

***Twist-locking connectors***



L21-30 plug



receptacle

Twist-locking connectors were first invented by Harvey Hubbell III in 1938 and “Twist-Lock” remains a registered trademark of Hubbell Incorporated, although the term is used generically to refer to NEMA locking connectors manufactured by any company. Locking connectors use curved blades. Once pushed into the receptacle, the plug is twisted and its now-rotated blades latch into the receptacle. To unlatch the plug, the rotation is reversed. The locking coupling makes for a more reliable connection in commercial and industrial settings, where vibration or incidental impact could disconnect a non-locking connector.

Locking connectors come in a variety of standardized configurations that follow the same general naming scheme except that the designations all begin with an “L” for “locking”.

Locking connectors are designed so the different voltages and current ratings can not be accidentally intermated. Many specific types exist; only a few are listed below. Other types include miniature locking connectors, and special purpose connectors for boats, 400 Hz circuits such as used for aircraft, and direct-current use.

One disadvantage of twist-lock connectors is that in the event that the cable is accidentally pulled too hard, rather than the plug falling out of the receptacle, the exposed conductors may come out of the plug, causing dangerous shorts or shock hazards if the circuit is live.

## **NEMA L5**

NEMA L5 connectors are a series of locking connectors with a maximum specified voltage of 125 V. Supply connections are intended to be single-pole hot-neutral-ground circuits with a nominal voltage of 120 V RMS.

## **NEMA L6**

NEMA L6 connectors are used with circuits with a maximum specified voltage of 250 V. Supply connections are intended to be two-pole, three wire hot-hot-ground circuit with nominal supply voltage of 240 V or 208 V depending on phase configuration. The L6 connector does not provide a neutral line.

L6-20 and L6-30 connectors are commonly found on in-rack power distribution units in countries where the mains supply voltage is greater than 120 V. They are also found in the US for heavy-duty 240V equipment such as welders, where the higher supply voltage allows a lower current draw. These connectors are thus found where industrial equipment or large power tools are commonplace.

## **NEMA L7**

NEMA L7 connectors are used with circuits with a maximum specified voltage of 277 V AC. Supply connections are intended to be single-pole, three-wire hot-neutral-ground circuits with a nominal supply voltage of 265 V.

Typically, these connectors are found in commercial or industrial lighting circuits, especially where metal halide lamps are common.

## **NEMA L8**

NEMA L8 connectors are used with circuits with a maximum specified voltage of 480 V AC. Supply connections are intended to be two-pole, three-wire hot-hot-ground circuits with a nominal supply voltage of 460 V.

## **NEMA L9**

NEMA L9 connectors are used with circuits with a maximum specified voltage of 600 V AC. Supply connections are intended to be two-pole, three-wire hot-hot-ground circuits with a nominal supply voltage of 600 V.

## **NEMA L14**

NEMA L14 connectors are used with circuits with a maximum specified voltage of 125/250 V. Supply connections are intended to be two-pole, four-wire hot-hot-neutral-ground circuits with a nominal supply voltages of 240 V or 208 V hot-to-hot and 120 V hot-to-neutral.

These connectors are common on household backup generators, and on racks of power amplifiers in large audio systems.

## **NEMA L15**

NEMA L15 connectors are used with circuits with a maximum specified voltage of 250 V AC. Supply connections are intended to be three-phase, four-wire L-L-L-G circuits with a nominal supply voltage of 208 V L-L (WYE three phase) or 240 V L-L (delta three phase).

## **NEMA L16**

NEMA L16 connectors are used with circuits with a maximum specified voltage of 480 V AC. Supply connections are intended to be three-phase, four-wire L-L-L-G circuits with a nominal supply voltage of 460 V.

## **NEMA L17**

NEMA L17 connectors are used with circuits with a maximum specified voltage of 600 V AC. Supply connections are intended to be three-phase, four-wire L-L-L-G circuits with a nominal supply voltage of 600 V.

## **NEMA L18**

NEMA L18 connectors are used with circuits with a maximum specified voltage of 120/208 V AC. Supply connections are intended to be WYE three-phase, four-wire L-L-L-N circuits with a nominal supply voltage of 208 V L-L and 120 V L-N.

## **NEMA L21**

NEMA L21 connectors are used with circuits with a maximum specified voltage of 120/208 V AC. Supply connections are intended to be WYE three-phase, five-wire L-L-L-N-G circuits with a nominal supply voltage of 208 V L-L and 120 V L-N.

These three-phase connections include neutral and ground. The pin in the middle is ground, and the blade with a right angle on the tab is neutral.

## **NEMA L22**

NEMA L22 connectors are used with circuits with a maximum specified voltage of 277/480 V AC. Supply connections are intended to be three-phase, five-wire L-L-L-N-G circuits with a nominal supply voltage of 460 V L-L and 265 V L-N.

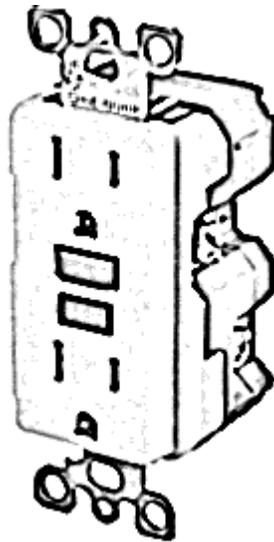
## **NEMA L23**

NEMA L23 connectors are used with circuits with a maximum specified voltage of 347/600 V AC. Supply connections are intended to be three-phase, five-wire L-L-L-N-G circuits with a nominal supply voltage of 600 V L-L and 347 V L-N.

### ***Special safety features***

Over time, electrical codes in the U.S. and Canada began to require special safety features in the basic NEMA 5-15R and 5-20R configurations to address specific electric shock hazard concerns. The safety features listed below are not mutually exclusive; tamper resistant GFCI receptacle outlets are sold.

### **Ground fault circuit interrupter (GFCI) receptacles**



Type B (NEMA 5-15) GFCI receptacle

These versions of the 5-15 or 5-20 receptacle are residual-current devices and have *Test* and *Reset* buttons (and sometimes an indicator light). In the U.S. and Canada, they are required in many potentially wet locations, including outside outlets, bathrooms, some places in kitchens, basements, and crawl spaces. They work by comparing the current going out on the hot line, to the current returning on the neutral line, and will disconnect

the circuit if the difference exceeds 4–6 milliamperes. They are cheaper than GFCI circuit breakers and can be wired to feed additional "downstream" outlets so that putting one GFCI receptacle in a circuit will protect all the plugs, lights, and switches downstream from it. They are also recommended for power tool outlets and locations where children might insert conductive objects into the receptacles.

### **Tamper-resistant receptacles**

Starting with the 2008 National Electrical Code and the 2009 Canadian Electrical Code, listed tamper-resistant receptacles that address electric shock hazards to children must now be installed in almost all areas of new or renovated dwellings. According to statistics cited by the NFPA, the code change adds only \$40 to the cost of building an average, 75-receptacle home in the U.S., yet prevents shock hazards to a child that sticks a single, metal object into the receptacle. The new receptacles are expected to reduce the number of electric shocks to children because inserting a normal, two-prong electrical plug applies pressure on both sides of the outlet to open an internal, spring-loaded shutter, but a foreign object fails to do so and therefore does not make contact with the live electrical contacts. However, the device can still be defeated by inserting two objects simultaneously. Despite its weaknesses, the tamper-resistant receptacle is believed to be vastly superior to protective plastic outlet caps (they need to be individually installed to each receptacle and are a choking hazard when removed) and sliding covers that children easily learn to defeat.

### ***Leak-current detection and interruption (LCDI) plugs***

Because portable air conditioners have caused many electrical fires, those sold in the United States now must have leak-current detection and interruption (LCDI) plugs. The cords have a fine wire mesh around the conductors and circuitry to detect any current leaking from the conductors to the mesh, which would happen if the cord was damaged or frayed. These could be NEMA 5–15, 5–20, 6–15, 6–20 or 6–30 plugs, depending on the air conditioner. The plug is equipped with "Test" and "Reset" buttons on the housing.

### ***Color code***

The color of a device neither identifies its voltage class nor power system. Because the colors are not regulated by national standards, the purpose of color-coding a receptacle is set by the building owner. In this case, building owners may select brown, ivory, white, almond, grey, and black receptacles in the 5–15 configuration to blend with the decor of a room.

- Blue receptacles may indicate built-in surge suppressors.
- A red receptacle may indicate a special-service outlet such as one connected to an emergency standby power source.
- At least one manufacturer makes a yellow receptacle which identifies it as corrosion-resistant.

- A receptacle with a green dot is a so-called “hospital grade” device; such devices are tested to survive harder use than wiring devices intended for residential or commercial purposes. However, the NEMA standard does not define green as a color for wiring devices.

A receptacle with an orange triangle is an isolated ground device, where the grounding pin of the receptacle is connected to ground independently of the frame of the receptacle and wiring outlet box. The receptacle itself may be any color, but contrary to popular belief, a receptacle is no longer an isolated ground device because the receptacle itself is orange, although this was formerly the case in the United States.

### ***Break-away tabs***

Duplex receptacles usually have break-away tabs to separate the top and bottom halves so that the two outlets can be placed on separate circuits. This may allow for one switched outlet for a lamp or for two circuits to be used when heavy loads are anticipated. Two branch circuits may share a neutral terminating on duplex receptacles, a condition sometimes referred to as "split-wiring", "split-receptacle", or "half-split".

Neglecting to break the tabs when replacing a split-receptacle can result in a 240V line-to-line fault.