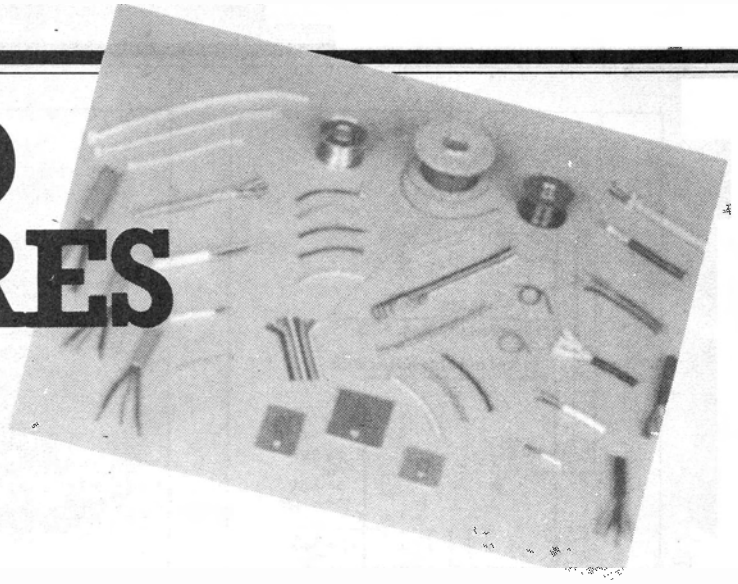
WIRES AND WHEREFORES



by Christopher Roper

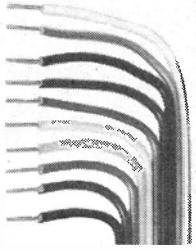
On first sight, a casual glance through the local electronic retailers catalogue usually reveals a bewildering assortment of wires and cables which are available to the amateur enthusiast. With such a wide choice, difficulty may be experienced in choosing the right wire for the job in hand, but armed with a few facts it is relatively simple to decide on the appropriate cable. Having said this it should be borne in mind that the average length of wire is itself something of a technological feat; as I hope this article will show.

Cables and wires usually fall into one of several groups, dictated by their usage; e.g. power cables, signal cables etc, although there is often some overlapping between groups. Consider cables in general. Looking through the appropriate catalogue pages usually reveals several descriptive facts and figures relating to number of strands per core, current ratings, voltage ratings and, in the case of screened cables and some multicore cables, a figure for capacitance is usually given. The figure quoted for the number of strands is given in two parts, e.g. 7/0.2 or 16/0.2. The first number gives the number of strands within the core and the second number gives the diameter of each strand in millimeters. Therefore a wire which is listed as being 7/0.2, has seven strands each of which has a diameter of 0.2mm.

The maximum voltage rating is the maximum potential that can be applied across the conductor's insulation without it breaking down due to electrical stress. For obvious reasons this rating should not be exceeded. The current rating is the maximum current that the conductor should be allowed to carry, but although this should never be exceeded it is often necessary to derate this value under certain conditions. The factors which determine the current capacity of a conductor, apart from its cross sectional area and the type of insulation surrounding it, are its proximity to other current carrying conductors, the ambient air temperature and the type of equipment that it is built into.

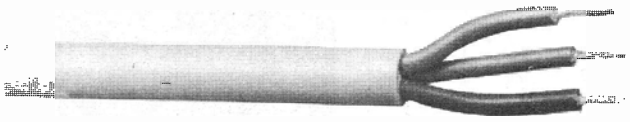
The amount of heat generated by current flowing in the conductor, should not be allowed to exceed the temperature rating of the insulation and as the number of individually insulated conductors which are loomed together, is increased, the heat dissipation is decreased. Further restriction of the cables, such as within an enclosed chassis, will further lower the heat dissipation.

When dealing with the above situations it is often necessary to have some form of guide as to the amount by which the current capacity of the cables should be derated. For example, a loom consisting of thirty or more individual conductors may need to have the current rating of each conductor derated by as much as 50%. These considerations can become important when dealing with projects such as hi fi amplifiers and the like, which draw appreciable amounts of current.



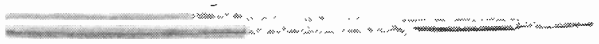
Ribbon cable with end fanned-out (XR06G).

Multi-strand single core wire 7/02 (BL00A).



Heavy-duty mains cable 3-core (XR10L).

Cotton-covered rubber mains cable 3-core (XR24B).



Single-core audio screened cable (XR15R).

High-frequency co-axial cable (XR19V).

Screened Cables

Current flowing in a wire can cause other problems, apart from those already mentioned. Consider for example, screened cables. These are usually used when outside interference sources can be troublesome. The cable screen is usually connected to zero volts or ground and helps to minimise interference induced signals, as well as helping to contain the transmitted signal. Capacitive effects within screened cables dictate to some extent their usage. The inner insulation of the cable acts as the dielectric of a capacitor, with the screen and the inner conductor acting as the capacitor plates. The capacitive effects which are produced can result in a finite time delay being imposed on the transmitted signal. In general terms a cable with a lower capacitance is more suitable for audio and radio frequencies; bearing in mind that the measure of capacitance in both cases is in pico farads i.e. 100-300pf/m.

Capacitive effects can also cause problems between two individually insulated conductors, which are in close proximity, when one or both are carrying alternating currents; under certain circumstances it is possible for signals being carried in one lead to become superimposed on those being carried in the other lead. The use of screened cables in this situation will help to minimise the effect, although this is not always the answer, especially when dealing with power supply leads. In this case it is best to avoid running power supply cables and signal leads within the same loom.

High Frequency Cables

Certain conductors are designed specifically to carry very high frequencies. On first sight it might seem that a conductor with virtually zero resistance will carry high frequency signals as efficiently as it will carry low frequency signals, but this is not the case. The effective resistance of a conductor increases with frequency, and at high frequencies its resistance may be many times greater than its low frequency resistance. As the signal frequency increases, the signal current tends to flow more within the surface layers of the conductor and less within its central core, giving rise to the phenomenon known as 'skin effect'. The explanation for skin effect is fairly straightforward, when one considers the effect on a conductor which is within its own associated magnetic field.

A current flowing in a conductor produces lines of magnetic flux which actually exist within the conductor itself and there is a greater concentration of flux lines nearer the centre of the conductor than at the surface layers. From this it follows that in a multi strand conductor, the individual con-

ductor nearest the centre of the bundle has induced within it a greater back e.m.f. (electromotive force) than one nearer the outside. This greater induced e.m.f. results in a greater inductive reactance which is effectively an increase in its resistance. At low frequencies this inductive reactance is negligible, but at much higher frequencies it can become troublesome.

The most commonly used cable for high frequency work, i.e. VHF and UHF is Co-ax. This is similar to the screened cables usually with a centre stranded section of copper wires in a polythene insulation covered with a braided screen. However, the spacing between the core and screen is accurately defined which produces capacitances usually around 50-60 pF/m, i.e. much less than screened cables and also maintains a more consistent impedance level.

A less common method of overcoming high frequency problems is to plate the conductor with silver. The silver has a lower resistance than the copper, which offsets the increase in the relative resistance of the conductor as the signal frequency increases. As the frequency rises, more and more of the current will flow in the silver so that the resistance remains fairly constant over a wide range of frequencies.

For specific purposes where a large number of conductors are required all carrying high frequency signals. Litz wire (Litzendraht) can be used. This type of cable has individually insulated strands which are wound around its neighbours in such a way that each occupies the centre of the bundle in succession. This type of wire comprises 3, 9 or 27 strands which are all plaited together in this manner.

Which Wire?

The majority of cables and wires that are available, are based on perhaps half a dozen different designs. At the bottom of the table are the relatively simple single cored, multi-strand conductors such as 10/0.1mm and 7/0.2mm, which, for their respective sizes, have useful current carrying capacities. They are ideal for most projects and as general hook-up wire.

Ribbon Cable

A logical development of this type of wire is ribbon cable. Ribbon cable is usually comprised of ten or twenty individually insulated and colour coded conductors which are bound together lengthways so as to form a ribbon of cable. It may be split into any number of ways and any single conductor may be branched off at any point. It is useful where space is limited as it lies flat against any chassis. Some types of ribbon cable are designed so as to be fitted with multipin plugs which fit neatly into standard IC sockets. This is useful for compact interconnections between circuit boards.

A further development of ribbon cable is interboard jumper cable. This is similar to ribbon cable but is designed specifically for interconnecting circuit boards.

For low to medium power applications, 16/0.2mm is a good general sized wire with a current carrying capacity of about 3 amps. This, alongside with 7/0.2mm is a useful choice for the amateur workbench. For myself, these two wire sizes form the bulk of my stock and although the amount on the wire rack is dependant on the types of projects being built, it is useful to have several metres of each colour.

Screened

There are many types of screened cable, ranging from single cored to multi-cored, and from single screened to multi-screened. As mentioned before capacitive problems with these types of cables, tends to make the appropriate choice more difficult. As a general guide for the spares box, a few metres each of single core, twin cored and four core should be useful; but this will obviously depend again on the individual requirements.

Mains Cables

The choice of cable suitable for making external mains connections to equipment is one that requires special attention. Whilst overloading the internal wiring of equipment may lead to the rapid demise of its component parts in a puff of smoke, overloading a mains cable can have consequencies which cannot be overstressed. The wires and cables already mentioned should never be connected to the mains directly; with the possible exception of 16/0.2mm in certain cases, and then only within the equipment itself. To comply with British Standards mains cables must have two separate insulation layers.

Apart from acting as an insulator, it must be capable of withstanding a certain amount of general abuse, and in many cases, the equipment that the cable is fitted to, has a bearing on the type of insulation that is used. For most applications PVC or rubber insulated mains cable of suitable current rating, is probably sufficient, but where there is a possibility of accidental contact with hot appliances, e.g. irons, toasters, fires, etc., it is advisable to use one of the cotton covered heat resistant type.