Finding your way in

Telephone toyland

Now that there are so many telephones, modems, faxes and other communications devices available for connection to the telephone network, it's very useful to have a basic understanding of telephone operation and the correct connections. Here's the lowdown.

by STEWART FIST

It's getting much harder these days to tell a telephone from a computer. The traditional role of those twin wires linking your home and office to the outside world has been changing — and things will change even more in the coming years.

The telephone system is being modified from both ends. The traditional telephone handset is being supplemented by communicating computers, fax machines, teletext and modems, while at the exchange, digital transmission and switching technologies are taking the system in new directions. Packet Switching and Datel services have been with us for many years, and ISDN (Integrated Services Digital Network) is due for introduction early in 1988.

When you look back over old issues of *Electronics Australia* or any of the other electronics and computer magazines published in Australia, you find very few articles deal with telephones. Telecom have been very effective in erecting a "no trespass" sign over Australia's telephone system, and their monopoly control has ensured that very little has been published.

Consequently, many of us have learned about radios, amplifiers, television, computers, and even satellite communications, without knowing more than the basics about the most ubiquitous and most popular of all our communications technologies.

Now that Telecom's total control of the telephone system has been broken we need to know more. You can now connect non-Telecom modems, handsets and other equipment to the telephone lines without breaking the law . . . as long as these instruments comply with Telecom's technical specifications.

This is fair enough. Telecom have a responsibility to ensure that users don't accidentally or inadvertently feed 240 volts down the line and electrocute a few exchange workers. From the experimenter's point of view, it is probably also best if they don't call attention to their trials by burning up expensive switching gear!

So, let's have a look at the telephone system and try to understand the dos and don'ts.

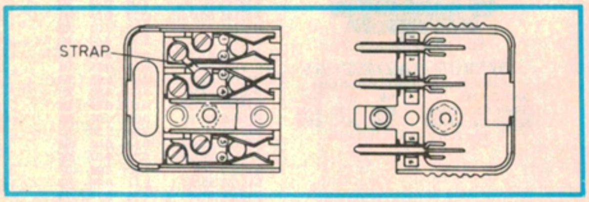
A standard single telephone set-up will usually have two pairs of incoming wires within the one cable. They are colour coded red/black and blue/white, but only the blue/white pair of these is actually used.

There is a DC voltage (of about 50V at the household end) across this pair, with the white having a positive polarity. The lines terminate at a standard 6-point Telecom socket, with the white going to contact 2 and the blue to contact 6.

If you open up the first socket in your household system, you will probably find a strap joining contacts 2 and 3, but this strap might not exist in extension sockets. Telecom's practice is to bring all signals into the premises on only two wires, then split into four after the first socket.

Traditionally, extension links extend from the first socket and create a parallel chain joining together all socket contacts 2 (white), contacts 3 (red), contacts 5 (black), and contacts 6 (blue). See Fig.1.

It is important that the strap between 2 and 3 is retained in the first *socket* so that an electrical connection between the two lines remains, even if the telephone is removed from this socket. This is essential with the Telecom-supplied Colorfones and Touchfones — from the plug on they have two separate circuits; the white (contact 2) connection for voice and dialing, and the red (contact



Above shows the construction of the standard 6-way plug and socket as used by Telecom and the majority of devices connected to the Australian switched telephone network — like extension phones, modems and fax machines. The connections are numbered from 1 to 6, from top to bottom as shown, with 2 and 3 often strapped together.

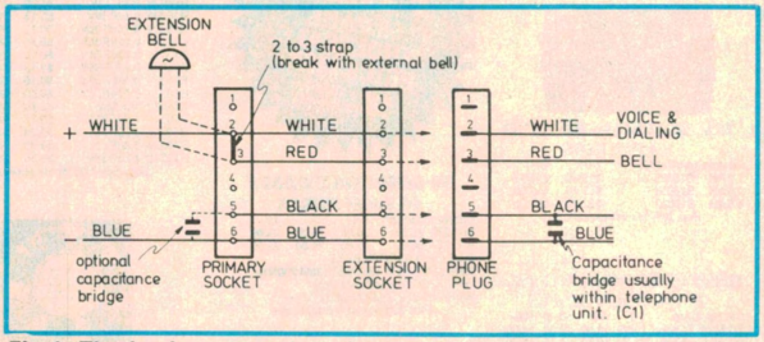


Fig.1: The basic connections for a primary socket, extension socket and telephone. The incoming line terminates at pins 2 and 6.

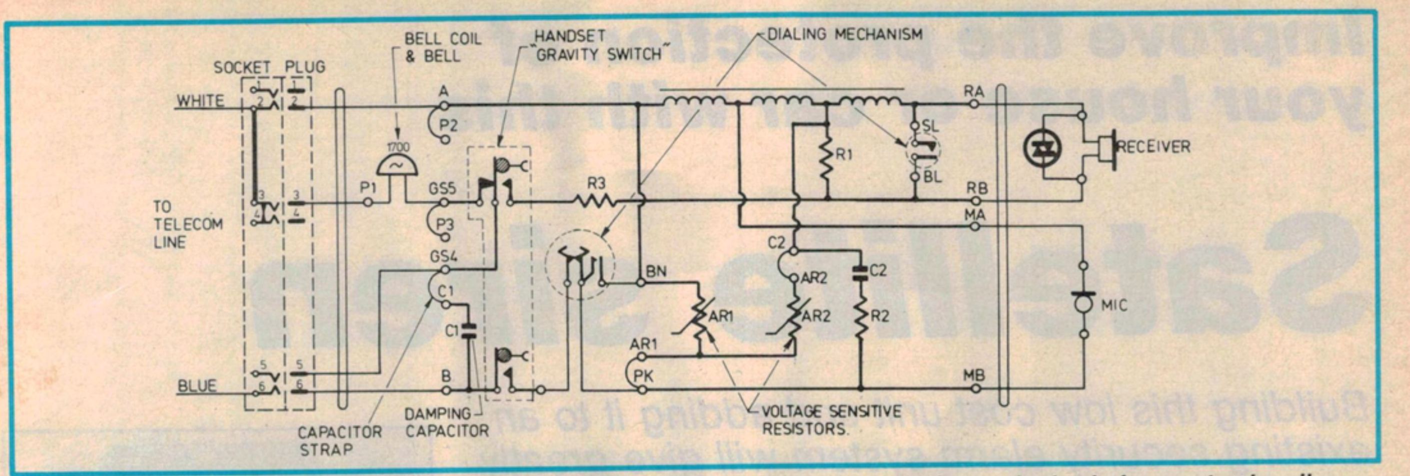


Fig.2: The circuit of a standard Telecom 800-series "Colorfone", which generally forms the basis for most subscriber services. An understanding of its basic operation helps when you're working with modems and other devices.

3) which provides the links for bell signalling.

Note however, that the bell current still exists at contact 2 and in the voice circuitry; most of the small push-button telephones you can buy use only contacts 2 and 6. The standard Colorfone (No.802) and Touchfone (Nos.805 and 806) require the four-wire link to the handset.

Contacts 5 and 6 are not strapped in the primary socket, but they are coupled by a large electrolytic capacitor within the first telephone — we'll deal with this later.

Contacts 2 and 3 can be strapped together at the primary socket and at all extension sockets in most cases. However if you want to add a special extension bell, this is usually done across the primary socket contacts 2 and 3, and the connector strap/s must then be removed. The extension bell then sits in series with the bell of the handset/s, and it creates the necessary linkage between the two wires.

The linkage between contact 5 and 6 is via a 0.75μF electrolytic capacitor (C1 in Fig.2). This is the damper capacitor that handles the AC component of the bell signal, but blocks the DC.

The capacitance across the incoming lines is not especially critical, but you don't want to double it or triple it by adding extra phones. Telecom technicians at the local exchange measure and record the total line capacitance, to monitor whether additional items are being hung on their line. In the past, a sudden doubling of the capacitance would trigger a visit from an inspector looking for the illegal extension phone.

If you have a number of extension sockets but only one moveable phone, these contact connections aren't modified at all. However, if you have two or more Colorfones or Touchfones on the same line, the extensions should be modified to remove the extra capacitance from the circuit. This is done by removing the internal strap between two contacts at the back of the phone, GS4 and C1. All contact points in the diagram (Fig.2) are prominently marked on the telephone's circuit board.

These changes assume that the first phone in the system will supply the necessary capacitance, but if this is to be a moveable phone then it is conceivable that it may not be in circuit when needed. To be sure, it is best to disable all internal capacitors and to fit a permanent external one between contacts 5 and 6 behind the first telephone socket.

Dial phones work by breaking and making the DC line current across the incoming "twisted pair". When you pick up the handset to dial out, the "gravity switch" ("GS" in Telecom's schematic code) creates a direct short across the incoming pair through the dial mechanism.

At the telephone exchange a linefeed concentrator which scans a number of incoming lines, detects the voltage change; at this point you will get the artificially generated dialling-tone in the handset.

If you now dial say the number 5, there are five 70ms "break" pulses transmitted down the line, and these are used to activate the first "group" selector. After a pause of about 200ms, the control will pass to the second selector. How this works depends on the type of exchange equipment, but the procedure is always the same.

The first two or three digits in a telephone number (the "code") identify the destination exchange, and the last four digits (the "numericals") define the location of the subscriber. In the older exchanges these dialled digits are stored in a local register/translator called a "director", with the code being treated separately from the numericals.

By using the code, the director controls the routing arrangements through any intermediate exchanges until it makes contact with the first numerical group selector in the destination exchange. It then switches to repeat the "numerical" digits, to drive the subsequent selectors until the destination line is reached.

The first automatic telephone switching system used a stepping switch invented by a Kansas City undertaker named Almon Strowger, and modified "Strowger" step-by-step exchanges are still to be found around the country.

Later developments saw the introduction of the Crossbar exchange, which used "registers" to store all digits until dialling was complete. A "marker" then takes the dialled intelligence and initiates the connection.

In later exchanges the crossbar switches have been replaced by "ferreed arrays". These are ferrite material in a small reed relay encapsulated in a small class envelope and surrounded by an operating coil. "Markers" have also gone through an evolution from simple electronic components to computers.

Nowadays in a modern electronic exchange a scanner "looks" at the lines and trunks periodically to detect changes in state. When you lift the handset to call, space is allocated in temporary computer memory to store the dialled digits. This information is then compared with the translation routing data stored in semi-permanent memory, and a trunk line is selected.

Along with these modifications we also have changes in the dialling methods. Touch-tone (DTMF — Dual-tone multi-frequency) telephones don't use a

Continued on page 121

Continued from page 65

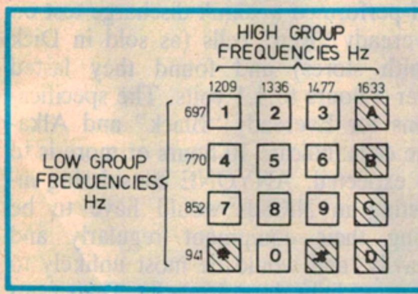


Fig.3: Many modern electronic phones and attachments use dual-tone multifrequency (DTMF) dialling, rather than the older and slower pulse dialling. Here are the frequency pairs used for each digit.

make and break method of signalling; instead they generate tone-pairs, each of which correspond to one of 16 codes.

Tone signalling is more convenient and more efficient than the old methods. It offers higher reliability and has uses outside the basic switching function — in answering machines, radio communications, data transmission and remote control.

With DTMF the telephone handset generates a composite audio signal, made up by superimposing two tones selected by a line-and-column addressing of a keyboard. (See Fig.3). The fourth column of buttons using the 1633Hz tone is not found on most of today's touch-phones, but it has been set aside for future signalling use.

The DTMF frequencies were chosen so that neither harmonics or intermodulation products would fall in any one of the tone bands. You get about 10% separation between tones. The tones are sent over the lines to the exchange, where decoder circuitry converts the DTMF signal to a binary format. For the traditional dial-pulse equipment, a further conversion takes place in a tone-to-pulse converter.

DTMF technology lends itself to a variety of remote-control applications, including those using radio-telephone stages. Tone signalling allows radio links to plug-in transparently to the telephone network.

Remote data entry is also possible, as are automatic credit-card verification systems, home banking and shopping. Coupled with voice synthesis techniques, DTMF brings many of the advantages of ATMs and point-of-sale equipment directly into the home without adding subscriber equipment. One can only wonder why we haven't all been using them for years.