Hybrid networks make signals invisible

AS DIGITAL SIGNALS BECOME INCREASINGLY more intertwined with the common telephone system, a device you're more likely to run across in both the design and maintenance of a communications system is the *hybrid network*, which is often called a *hybrid coil*. Those of you who are up on your telephone technology are certain to recognize that the hybrid network is part of the common telephone, where it's called the *induction coil*. Others, who enjoy listening to call-in radio and TV programs, will certainly recognize it as the device that allows the studio audio to be mixed with the telephone signal, without having the station's audio system break into howling caused by positive feedback. And if you didn't know how the caller and callee were mixed without feedback, you'll find out now, because this month's subject is the hybrid network. (And those of you who are amateur radio operators and are familiar with, and have cursed the hybrid-network telephone patch, will also find out why your particular patch sounds so bad.)

The reason we're getting into hybrid networks, which is really part of the telephone system and broadcast call-in equipment, is because it is absolutely necessary for interleaving digital data and communications into the dial-up telephone. Long-haul circuits require distortion-free amplification to get signals error-free from one part of the country to another. Normally, the amplification is provided in the connecting wires between central offices, or within the signal equipment. For example, a single pair of wires carries your voice or digital data to a central office, but between central offices—where the amplification is done—there are actually two pairs of wires: one for the transmitted signal, the other for the received signal.

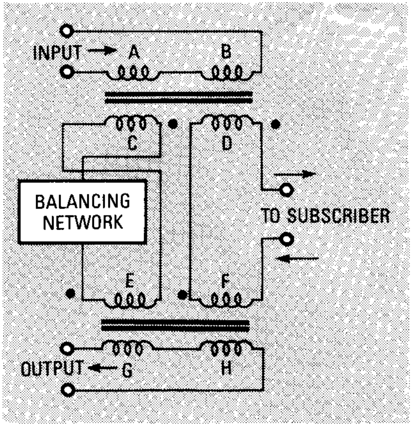

FIG. 1

Two inputs, one output

Figure 1 shows a *communications hybrid network*. It's described as a communications hybrid because it is completely different from the audio-mixing hybrid network found in movie- and TV-production studios. Everything we say this time out refers only to a communications hybrid that resembles Fig. 1.

Notice that there are actually two transformers, T1 and T2. They might be individual units, as they often are in an inexpensive hybrid phone patch, or they might both be enclosed in a single metal "can," as they are in a telephone.

Let's assume that the hybrid shown in Fig. 1 is the one at your local telephone office. Signals—analog or digital—from a distant source are fed into the INPUT and eventually exits at the SUBSCRIBER terminals, which are in turn connected to the wires that connect to your home telephone.

Signals originating in your home pass into the subscriber connections and exit via the network's output. No signal on the subscriber line can exit from the network's input, nor can any signal on the input or output mix or crosstalk with each other.

The entire system depends on phase coherence throughout the network, which is accomplished by the device labeled BALANCING NETWORK. That is simply a "black box" whose reactance and resistance exactly matches that of the subscriber circuit from the network to the telephone equipment.

Phase matching

Notice that T1 and T2's four secondary windings are identified by a dot that indicates their phasing. The hybrid network won't work if the phasing is incorrect.

Now let's follow some signals through the hybrid network. Assume that a signal is applied to the input. Its current flows through primary windings A and B, inducing current in windings C and D. The current flowing in B induces a current that flows through D, F, and Z_L (the load); so the input signal appears at the load.

The current through F induces a current in H. Meanwhile, the input current through C also flows through E and the balancing network, which is a mirror image of Z_L. The current through E induces a current into G, which is exactly the same value but 180° out of phase with the current induced in H; so the current in G cancels the current in H and, in result, no part of the input signal appears at the hybrid's output.

Now let's work the other way. A signal originates at the subscriber's input, causing current to flow in D and F. F induces a current in H that also flows through G and on to the output. The current in G induces a current in E that flows through the balancing network and also C.

Winding C induces a signal in A which is equal to and 180° out of phase with the signal induced by the subscriber signal from D to B, so that no part of the subscriber signal appears in the network's input.

It's magic

That's the whole magic of hybrid networks. "Aha," you say, drawing your .357-magnum pen and getting set to write in and protest our taking a three-day subject (in school) and converting it into a few paragraphs, "if hybrids keep the input from the output, why do we hear ourselves when we speak into the telephone?"

That's a matter of psychology. Back in the early days of telephones, people could not hear what they said—the transmitter and receiver were isolated—so they tended to shout, louder, and Louder, and LOUDER. After a while, the telephone people decided to feed back a small part of the transmitted signal (from the telephone's microphone) into the receiver (earphone) so the user could hear that the equipment was, in fact, working properly. The feedback is called *sidetone*. **R-E**