# DESIGN IDEAS

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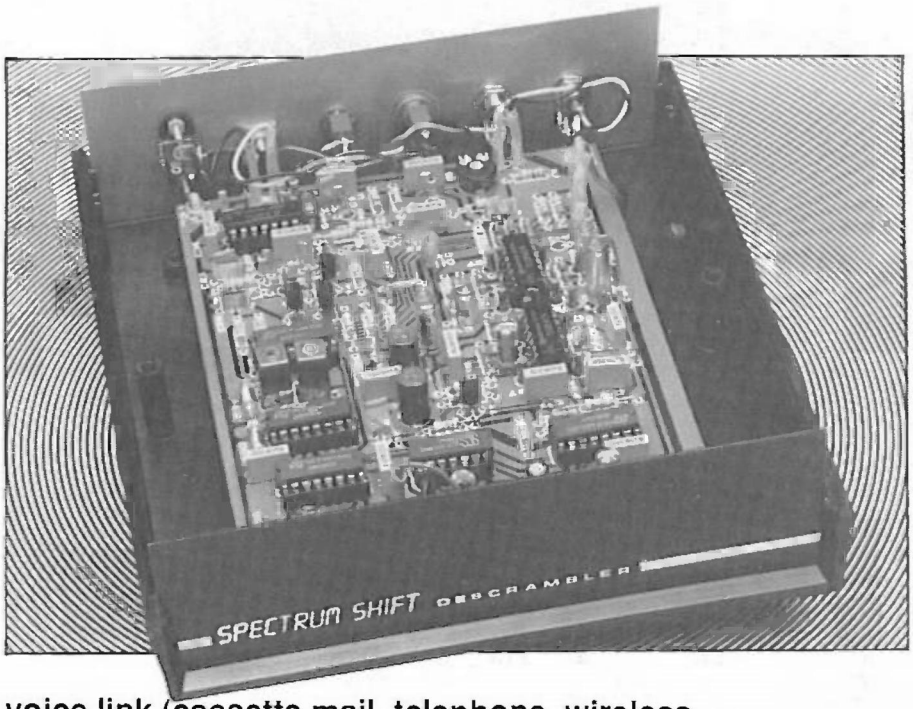
## AUDIO SPECTRUM SHIFT TECHNIQUES




**Although spectrum shift and spectrum inversion have been known for quite some time as a means of protecting voice links mainly over the telephone, little has been written on the design and operation of the electronics involved. This article aims at offering you a design base and two practical circuits to start experimenting with an interesting form of analogue audio scrambling and descrambling which may be used to, say, personalize a voice link (cassette mail, telephone, wireless babysitter, etc.). Remarkably, you will not be able to tell the difference between the encoder and the decoder until you compare the two units and spot a couple of components with different values.**

**by C. White Halfoat**

ONE may wonder why analogue audio scrambling is still used when digital encoding systems are relatively simple to implement whilst offering a good degree of security. The reason is simple: digitized audio data requires a bandwidth which is greater than that of the analogue source signal. Thus, where a limited bandwidth is available to convey an audio signal — say, 3 kHz for voice signals, and 15 kHz for music signals — digital encoding is simply out of the question, and different means must be sought to protect the information as it is conveyed from the transmitter to the licensed receiver.

### Encoding principle

An all-analogue encoding system is described that renders an audio signal totally unintelligible by shifting the entire spectrum between 50 Hz and about 10 kHz by 1 to 2 kHz within the existing channel. When the shift is 1 kHz, a source signal of 50 Hz is shifted to 1,050 Hz, while a source signal of 10 kHz is shifted to 11 kHz. In this system, the frequency range below 1,050 Hz is, in principle, empty after encoding. The shift operation is shown diagrammatically in Fig. 1a. Figure 1b shows an alternative version, where the audio spectrum is additionally mirrored around a certain frequency. Both encoding systems yield a new audio signal that is virtually unintelligible, with speech pauses and stress on utterances (i.e., volume variations) as practically the only recognizable features (in fact, we have heard such scrambled signals described as the sound of "*a lot of squabbling chipmunks*").

Each of the two encoding systems described by Figs. 1a and 1b has its advantages and disadvantages. The second system (Fig. 1b) is simple to realize both at the transmitter and the receiver. However, when applied to an FM (frequency modulation)

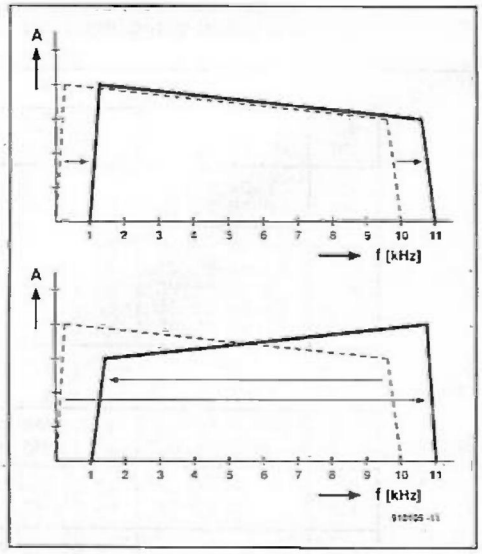



Fig. 1. Principle of spectrum shift (upper drawing) and spectrum inversion (lower drawing). Both techniques are used to scramble audio signals conveyed over air, via cables or magnetic media.