Realign Your FM Receiver

Crosstalk, modulation-time errors and phase-shift problems all result from misaligned FM receivers. Here's how to realign your FM receiver yourself

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THE ALMOST UNIVERSAL USE OF STEREO FM receivers makes stereo receiver test equipment an essential in any modern consumer electronics service shop. With today's high-performance receivers, sophisticated test equipment is needed. There are times when the customer must be convinced that the reason for not receiving a good stereo signal is not a fault in his stereo FM tuner but that the trouble is a defective antenna, for example.

Most faults are caused by a failure in the FM decoder circuitry or by component drift. These troubles can be located and corrected fairly simply; the latter simply by realigning the receiver.

But the problem with the normal transmitted stereo signal is that it is difficult to quantify. The signals are not adequate for use as test signals. Even the relatively few stereo test transmissions are useful for little more than balancing the speakers.

The need is for some form of signal source that can provide a complete easy-to-measure stereo signal. One solution is the *Philips PM 6456* FM stereo generator. It simulates a transmitter signal with signals that can be selected, reproduced and measured.

The FCC standards

Stereo broadcasting brings with it problems not imaginable with a simple domestic record or tape player that has separate right and left channels. The result is that standards are very exacting. The system most widely used is based on the FCC requirements, which insure good reproduction both in stereo and monophonic receivers.

The transmitted stereo FM signal is split into three components:

- The sum of the left and right channels (L + R), containing all information for monophonic transmission, called the M signal.
- The sideband formed by amplitude modulation with a suppressed subcarrier of the difference signal (L – R), called the Sm signal; and
- A pilot signal, with a frequency one-half that of the suppressed subcarrier, which is used to regenerate the subcarrier in the receiver, called the P signal.

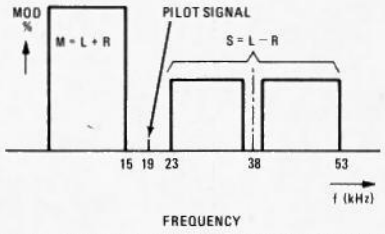

FIG. 1—THE FREQUENCY SPECTRUM of the FCC stereo multiplex signal shows the relative positions of the pilot, M, and Sm signals.

Fig. 1 shows the spectrum of the resulting stereo multiplex signal.

Some idea of the technical demands of stereo transmission can be gathered from the FCC requirements for a stereo transmission system:

- The 19-kHz pilot signal must be accurate within ±2 Hz.
- The phase relationship between the pilot and the subcarrier must be rigidly maintained; zero-axis crossings of the subcarrier in the positive direction must coincide with those of the pilot.
- If only the L or R signal is used for modulation, the amplitude of the M signal must not be more than 3% different from the Sm signal.
- If only the L or R signal is used for modulation, then the phase difference between the M signal and the envelope of the Sm signal must not be less than 3°.

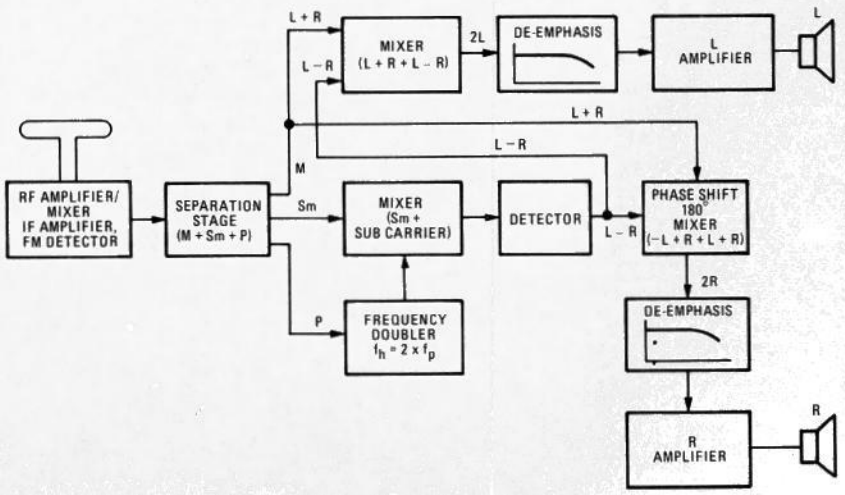

FIG. 2—SIMPLIFIED BLOCK DIAGRAM of a stereo FM receiver.

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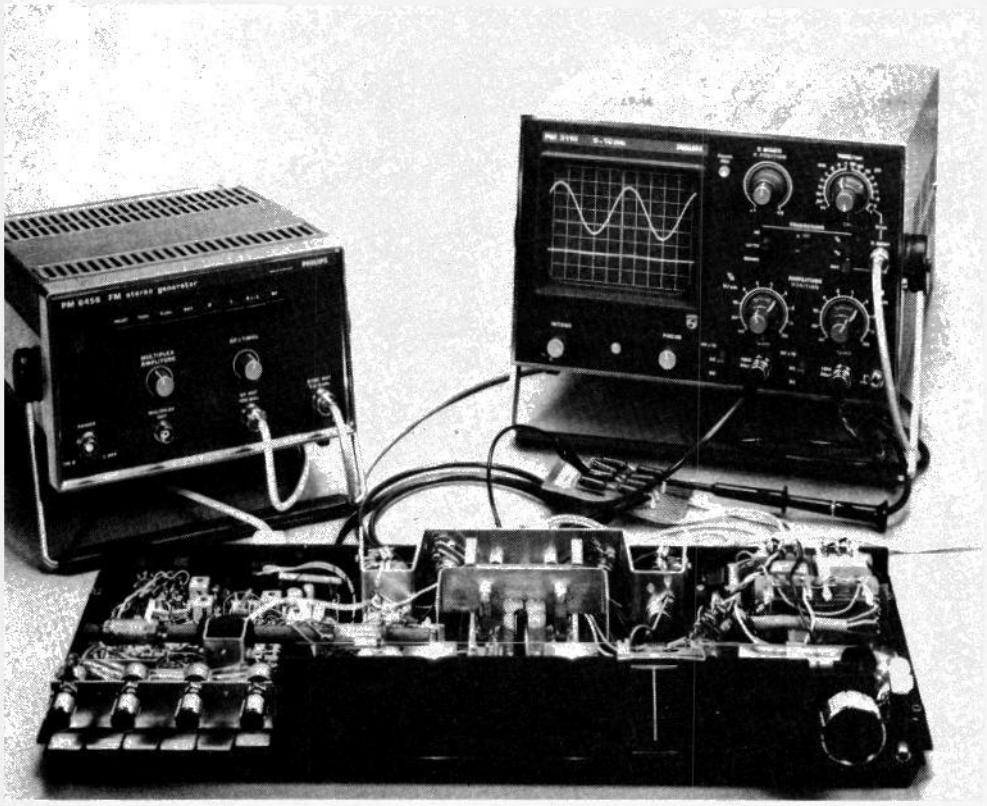

• Crosstalk of the L signal on the right audio channel and vice-versa must be lower than 30 dB.

Obviously if the transmitted signal has to meet such stringent standards, a great deal of attention must be paid to receiver adjustment.

To align or troubleshoot a stereo FM receiver, the only suitable method is to use an FM stereo generator that provides a suitable signal source. It must simulate the transmitter signal, yet provide a choice of stable signals, which—in contrast to music and speech—can be accurately reproduced and measured.

Another indispensable instrument is an oscilloscope, so that the amplitude, frequency and distortion (if any) can be measured directly and in full detail.

Receiver operation

Figure 2 is a simplified block diagram of a typical stereo FM receiver/decoder. The receiver detects the multiplex stereo signal and splits it into its three components—M, Sm and P. The pilot signal is fed through a frequency doubler to regenerate the subcarrier for the Sm signal, to which it is added. The L–R signal is detected from the resulting Sm signal. This L–R signal is then added to the L + R signal (M). In this way, a 2L signal is obtained. [(L+R)+(L–R)=2L]. To get the R signal, the L – R signal is phase-shifted by 180° and added again to the L + R signal, resulting in a 2R signal [(L+R) – (L–R)=2R].

One final stage is de-emphasis. Before the original left- and right-channel signals are fed to the transmitter, the higher frequencies are given pre-emphasis to help increase the high-frequency signal-to-noise ratio. This emphasis has to be removed. After de-emphasis and amplification the left and right signals are applied to their loudspeakers.

Alignment faults

Typical troubles that arise are phase shift between the 19-kHz pilot signal and the 38-kHz signal regenerated in the decoder; demodulation time errors; and, perhaps most common of all, crosstalk between the left and right channels.

All these faults can be cured by realignment, using a stereo generator. Adding an oscilloscope to the test set-up makes possible direct measurement not only of amplitude and frequency, but also of crosstalk, phase-relation and distortion.

The equipment should provide a logical sequence of test signals to enable accurate and fast alignment of a stereo decoder or a complete receiver. The test sequences should include a 19-kHz pilot, internal AF modulation with provision for external modulation, right-channel- and left-channel-only signals, and a right equals minus left signal. A 100-MHz ±1 MHz RF signal is also very useful, and is essential for checking a receiver.

Generator description

Figure 3 is a block diagram of the type of FM generator mentioned earlier in this article.

Signals of 1 and 5 kHz are produced by an audio-frequency oscillator and are pushbutton-selected for channel R, channel L, or both channels in antiphase (R=–L). The selected AF signal is also available as an external trigger signal—for an oscilloscope, for example.

The 38-kHz subcarrier is derived from the 19-kHz crystal-stabilized pilot-tone oscillator. The pilot tone is also pushbutton-selected.

In the 19-kHz to 38-kHz frequency converter, the pilot signal is doubled to create the subcarrier signal and is applied to the stereo modulator.

The audio input signal (R or L, or both) is modulated together with the 38-kHz subcarrier frequency.

At point 4 of the stereo modulator the input signal is phase-shifted 180° to insure that the channels are in antiphase when R =–L is selected.

If the EXT pushbutton is depressed, the complete stereo signal of a recorder or record player can be introduced. The adder circuit adds the 19-kHz pilot tone, when selected, to the stereo multiplex signal. The attenuator adjusts the multiplex signal continuously for the required input level of a stereo FM decoder.

From the moment the RF button is depressed the multiplex stereo signal is RF-modulated at a 100-MHz carrier frequency.

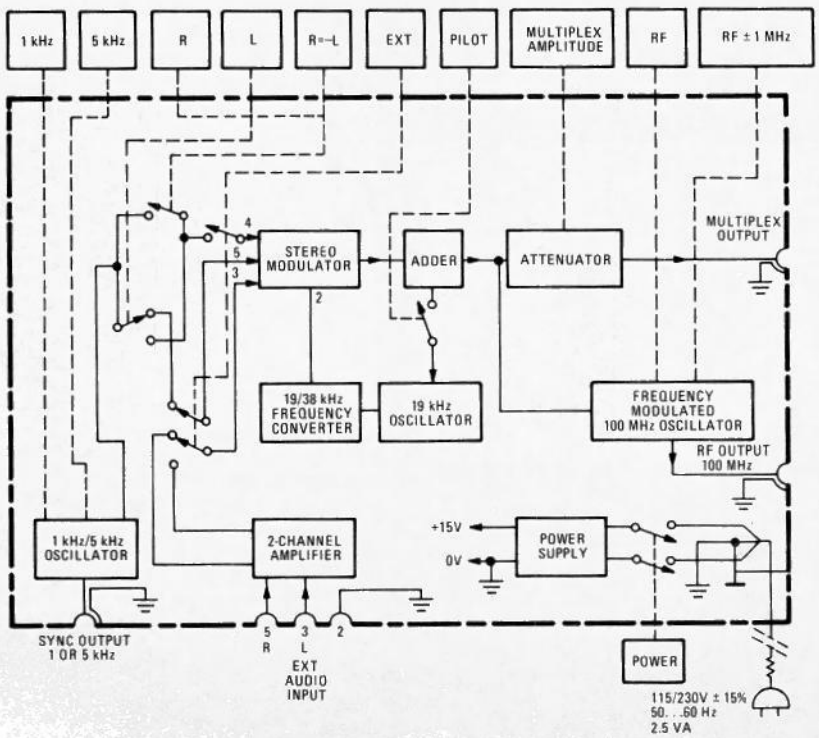

FIG. 3—THIS BLOCK DIAGRAM of a stereo FM generator gives some idea of the facilities available.

The center frequency is adjustable ±1 MHz to avoid interference with transmitters on adjacent frequencies.

The complete stereo multiplex signal comprises three components: The sum of the L and R channels, the difference of the L and R channels modulated at the subcarrier frequency, and the pilot frequency.

It will be clear that, although a stereo FM generator is simple compared to a real transmitter, its specifications must be close to the requirements that have to be met by the transmitter signal.

The *Philips PM 6456* FM stereo generator offers:

- Crosstalk suppression between the L and R signals for 1 and 5 kHz > 40 dB.
- Phase shift between the pilot and subcarrier 3°
- Subcarrier suppression > 40 dB.
- Accuracy of the pilot frequency, 19 kHz ±2 Hz.

Stereo FM alignment

The measuring set-up is simple. The multiplex output of the generator is connected to the decoder input.

The alignment is performed step-by-step (see Fig. 4).

1. The 19-kHz pilot signal is applied without an M and Sm signal (Fig. 5). The input voltage is adjusted to 200 mV peak-to-peak on the scope, using the attenuator in the multiplexer output. The pilot and subcarrier filters are adjusted at this stage. After the pilot and subcarrier frequencies are measured, the oscilloscope—preferably dual-trace—is connected to the right- and left-channel outputs, respectively.

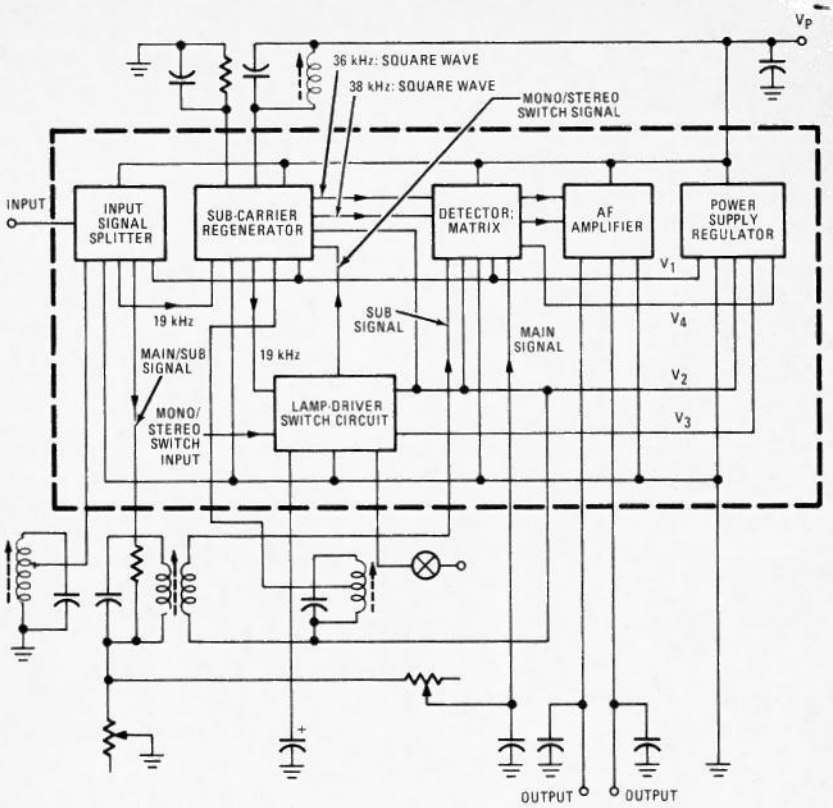

FIG. 4—A STEREO FM DECODER ready for checking and realigning.

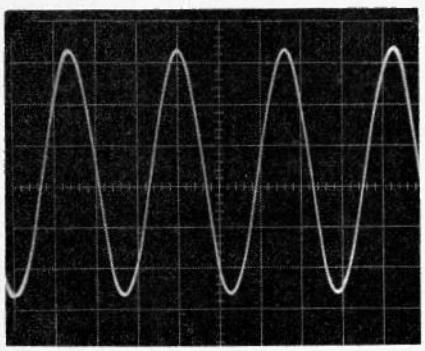

FIG. 5—THE FIRST STEP is to apply the 19-kHz pilot signal, without the M or Sm signals.

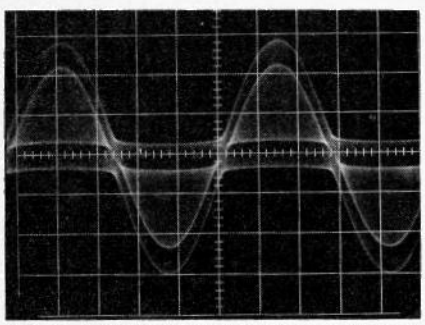

FIG. 6—THE AMPLITUDE OF the multiplex signal at the input is adjusted for 1 volt peak-to-peak.

2. A multiplex signal modulated with only one channel—say L—is now applied, and the decoder adjusted for minimum channel crosstalk. The amplitude of the multiplex signal at the input is 1 volt peak-to-peak (Fig. 6). Figure 7 shows a typical display of part of the L signal causing crosstalk in the R channel. Amplitude and phase then have to be adjusted to minimize this crosstalk (Fig. 8). The process is repeated to check the second channel, in this case, the R channel (Fig. 9). Now the crosstalk in the left channel is minimized.

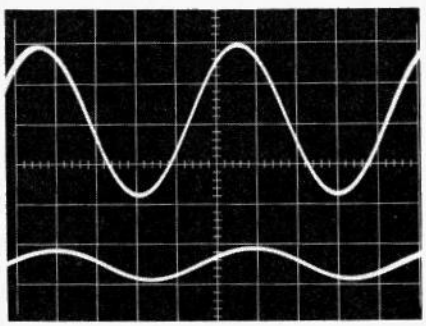

FIG. 7—A DUAL-BEAM OSCILLOSCOPE facilitates the examination of crosstalk between L and R channels. The upper trace shows the signal on the L channel, which results in the crosstalk on the R channel in the lower trace.

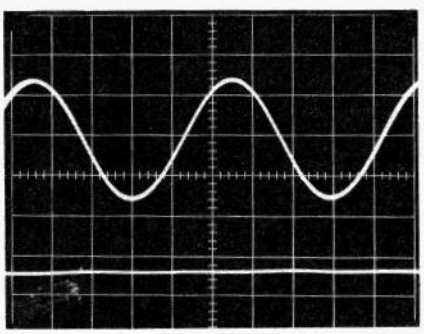

FIG. 8—THE STEREO GENERATOR provides a 1-kHz signal with a pilot to the L channel. Adjustment is made to minimize crosstalk.

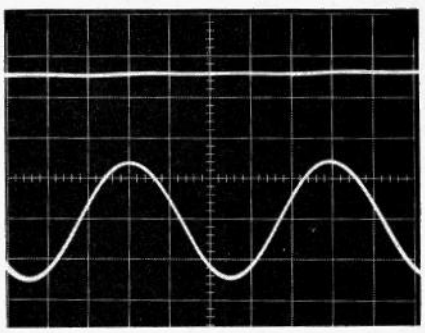

FIG. 9—THE SAME SIGNAL is then applied to the R channel, and crosstalk on the L channel is minimized.

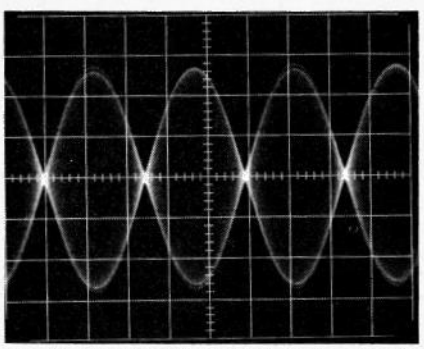

FIG. 10—THE AMPLITUDE OF the Sm signal is adjusted to give zero-axis crossing.

3. Applying only a sideband signal—the addition of the modulating L or R signal in phase opposition in the mixer stage, without the pilot—should result in Sm signals with equal amplitude and phase, providing a display with a sharp zero-axis crossing (Fig. 10).

4. The sideband signal is then applied with the pilot signal, and the resulting L and R output signals are adjusted to the same

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FM ALIGNMENT

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amplitude (Fig. 11). Some readjustment may then be necessary for crosstalk and maximum pilot because the same adjustment is used for all three.

The result should be a correctly adjusted stereo decoder.

For further refinement, the RF output of the generator in the FM band allows complete checking on the RF, IF, and AF sections of monophonic and stereo FM receivers. This RF

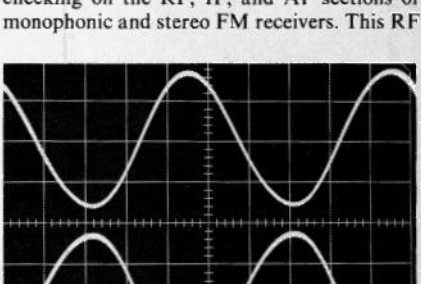

FIG. 11—THE RESULT OF THE REALIGNMENT should be a good clean stereo signal as shown here. The test signal applied is R = –L, so the signals should have equal amplitude and opposite phase.

output should be on 100 MHz, as this frequency is seldom used, so that external transmissions will not interfere with the test. But facilities for adjusting this frequency up to ±1 MHz are useful.

The external modulation allows a final check by applying an external signal, such as a record player or stereo cassette recorder. This also makes a useful stereo demonstration tool. **R-E**