Aligning the FM Stereo Radio

Much of the job is done before we come to the stereo section

By LEONARD FELDMAN

STEREO FM

WITH FM STEREO BROADcasting a mere five years old, millions of stereo-FM receivers are already in use. More than 400 FM stations are transmitting stereo part or full time. As FM stereo listening becomes more widespread, the need for professional servicing of the equipment increases proportionately.

While much has been written on multiplex circuit servicing and alignment, most of it has treated these subjects from the point of view of the decoder circuits alone. There has been little or no emphasis on the FM receiver as a whole. Yet, poorly aligned rf and i.f. sections of a stereo-FM receiver can often result in distorted reception, lack of separation and loss of stereo altogether. No amount of decoder realignment will correct those conditions.

We shall first analyze the steps that must be taken in the monophonic portions of the receiver or tuner, so that the multiplex decoder circuits that follow will have a proper signal to work on.

Many excellent pieces of stereo-FM test equipment have appeared on the market during the last two years. They range in price from a popular kit at less than $100 to completely wired units at around $250. All these units have built-in rf generators that can be modulated by internally created stereo composite signals. Generally, the composite signal is also available separately, for checking decoder circuits alone, but with an rf signal you can align the set from "antenna terminals to speaker."

If you are fortunate enough to own an FM generator with an accurately calibrated rf attenuator, the best test setup for stereo-FM alignment will include both the FM and the multiplex generator. A typical setup using both pieces of equipment is shown in Fig. 1. The composite multiplex signal is used to modulate the FM generator externally. The generator, in turn, is connected to the antenna terminals of the receiver under test. The applied rf signal can be reduced to a few microvolts, corresponding to the "weak-signal" conditions under which most FM-stereo reception problems occur.

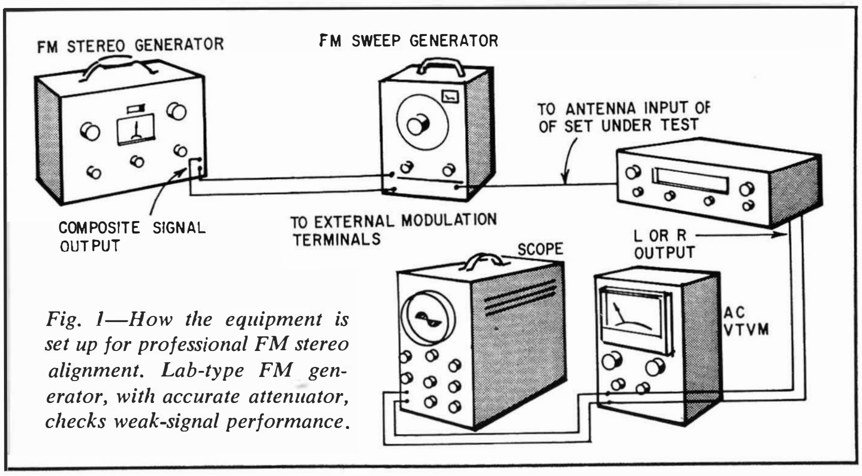

Fig. 1—How the equipment is set up for professional FM stereo alignment. Lab-type FM generator, with accurate attenuator, checks weak-signal performance.

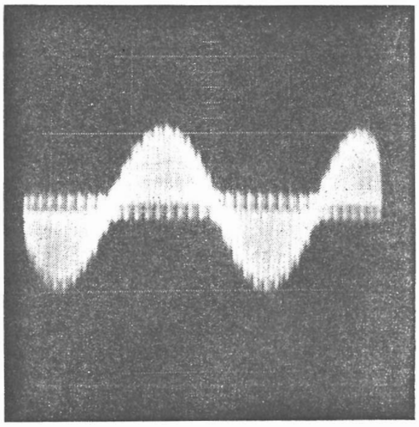

Fig. 2—Good left-only or right-only composite signal, as seen on scope connected at generator output or FM tuner detector.

The self-contained rf signal in most all-in-one generators usually cannot be attenuated enough to check weak-signal performance. Of course, coupling the rf leads loosely to the receiver can approximate weak-signal reception, but there is then no direct means of calibrating the number of microvolts actually applied. And a signal of 100 μV leads to far different results than would a signal of, say, 10 μV.

Rf and i.f. alignment

A proper "left-only" composite signal, as recovered from a well-aligned FM tuner is shown in Fig. 2. (A "right-only" signal would appear the same on an oscilloscope presentation of this kind.) The features to be noted in this waveform are:

1. Good sinusoidal outline of the

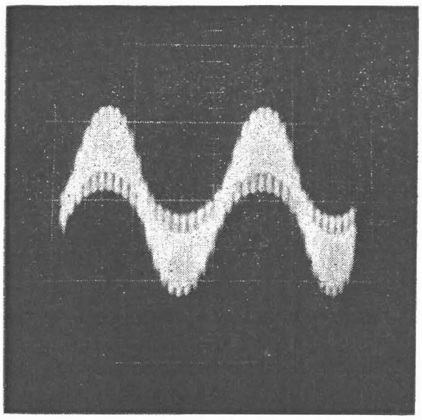

Fig. 3—Typical output from detector in which subcarrier component (L—R) is attenuated with respect to main carrier (L+R) component. Curved baseline is common.

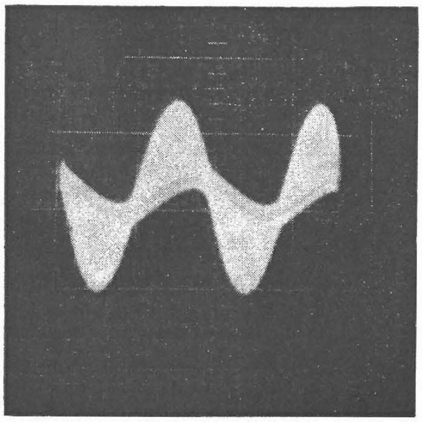

Fig. 4—Severe phase distortion of recovered composite signal at FM detector caused by misalignment of i.f. circuits. This results in tremendously reduced channel separation.

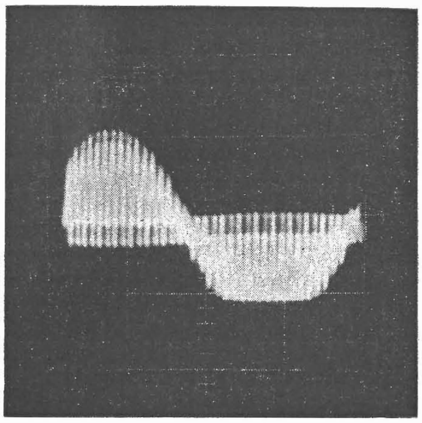

Fig. 5—This amplitude distortion of the recovered composite signal is caused by insufficient FM i.f. bandwidth, regeneration or oscillation in rf or i.f. circuits.

waveshape (no clipping or compression).

2. Clearly defined 19-kHz pilot carrier superimposed on the rest of the waveform.

3. Perfectly horizontal base-line (rather than curved or sawtooth baseline sections).

This is the type of signal that should be observed at the detector of a properly aligned FM tuner when an rf signal (modulated by a left-only composite signal from the multiplex generator) is applied to the antenna terminals of the receiver or tuner under test.

More often than not, some slight curvature of the baseline will be observed, as in Fig. 3. This indicates that the detector frequency response is deficient at the high-frequency end and that some of the high-frequency content of the composite signal (notably, the subcarrier sideband frequencies which range from 23 to 53 kHz) is being attenuated in the detector circuit or in its subsequent loading circuit. This does not *necessarily* indicate poor alignment, since compensating circuits in the following decoder may re-emphasize those highs. Should any of the other "defects" mentioned show up in the waveform, realignment is usually necessary.

Many manufacturers consider fixed-frequency methods of rf and i.f. alignment to be adequate. The results of sweep alignment are generally more uniform and controllable. The main causes of distorted composite-signal at the detector of an FM tuner are "regeneration" and not enough i.f. bandwidth. Usually, regeneration (or oscillation) in a receiver will be more prevalent at weak signal inputs, because the tuner or receiver is operating at or near maximum gain. Regeneration of any sort in a tuner narrows or compresses the bandwidth of the i.f. circuits because it increases the effective Q of the total circuit, especially when the entire i.f. strip becomes an oscillator at 10.7 MHz. Recovery of high-frequency subcarrier sideband components now becomes a hit-and-miss affair. Furthermore, what little subcarrier component is recovered is usually severely distorted, both in amplitude and phase, as shown in Figs. 4 and 5.

Fig. 6 shows a setup for sweeping an FM tuner or receiver. The modulating frequency voltage (usually 60 Hz from the FM sweep generator) is simultaneously applied to the horizontal input of the scope, which is set for external horizontal deflection. Modulate the generator more than ±75 kHz and tune the set under test to the center frequency of the generator (any clear spot from 88 to 108 MHz). Apply 1,000 μV of rf signal at the antenna terminals.

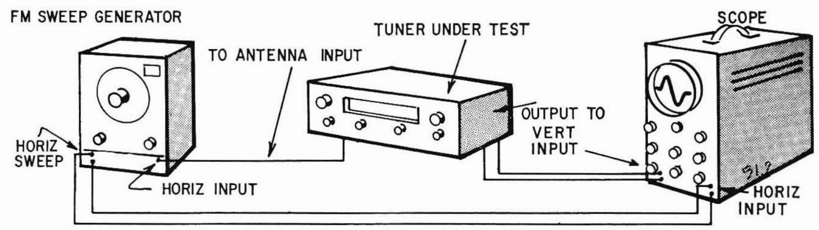

Fig. 6—Setup for aligning the rf and i.f. (monophonic) portions of FM tuner.

Such a strong signal will usually erase any traces of regeneration, and only a well-defined S-curve, as shown in Fig. 7, will be seen on the scope. Note that the linear portion of this curve is at least 150 kHz wide (usually even wider).

Next, reduce the signal applied to the antenna until the scope trace changes noticeably. The generator may require slight retuning as this is done. If the receiver is indeed marginally regenerative, the scope trace will suddenly "break" at some lower signal strength and look like Fig. 8. This indicates that the bandwidth is but a fraction of the 150 kHz required for good stereo reception. The i.f. transformers should be touched up slightly until the trace of Fig. 7 is restored (as nearly as possible). A good indication that no regeneration remains is the appearance of random noise on the scope screen when the generator is disconnected from the antenna terminals of the receiver. If the scope pattern shows some form of oscillation, the set is fairly certain to oscillate with a weak input signal.

Decoder-circuit alignment

Once we have a proper composite signal at the input to the decoder circuits of a stereo receiver, it is time to consider aligning these circuits. While decoder circuits may have one of two basic circuit configurations (the so-called "matrix" approach and the "time division" approach), certain points of alignment procedure are common to both.

Invariably, there will be some filter or trap arrangement for attenuating frequencies in the region of 67 kHz. If a 67-kHz signal is not available from your multiplex generator, it can be taken from an audio generator with a fair degree of accuracy. This is the *only* alignment signal that should be applied directly to the decoder input *without* going first through the entire receiver as modulation on an rf signal. In the block diagrams of Figs. 9 and 10, the 67-kHz signal would be applied at point A and a scope or ac vtvm connected at point B. If the circuit under test uses a free-running type of local 19-kHz oscillator, disable it for this step.

Adjust the 67-kHz trap (usually a variable inductance) for *minimum* 67-kHz at point B. In matrix-type circuits (Fig. 10), this trap is usually adjusted in combination with the bandpass filter elements to give flat response from about 23 kHz to 53 kHz, followed by a fast attenuation to minimum output at 67 kHz. For matrix circuits, next adjust the low-pass filter with an audio oscillator connected to point A (Fig. 10) while reading the output at point H. Response should be flat from 50 Hz to 15 kHz, with a fast rolloff beyond that upper frequency.

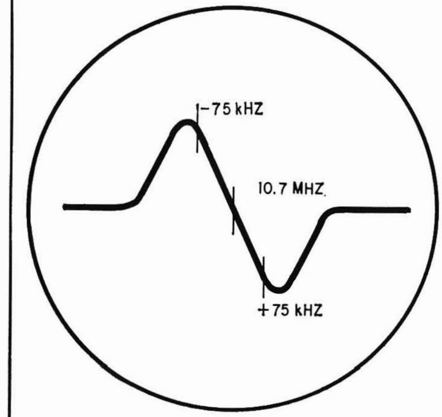

Fig. 7—S-curve in well designed FM set with adequate bandwidth. The linear portion must extend beyond ±75 kHz so that stereo signal is unattenuated.

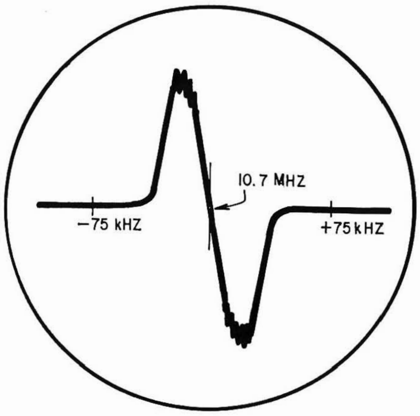

Fig. 8—S-curve showing severe regeneration, with resultant narrow bandwidth and oscillation on tips of waves. A usable stereo signal could not now be obtained.

In general, all these filter circuits should be optimized before attempting to align the carrier-restoration circuits or any of the final separation circuits. That is because each of the filters discussed thus far introduces some phase shift in the composite signal. These shifts will finally be compensated for by setting the carrier restoration (19 kHz and 38 kHz) section later.

38-kHz regeneration

It would be beyond an article of this kind to analyze all the ways manufacturers create a suitable 38-kHz signal for the multiplex demodulating process. Some amplify and double the incoming 19-kHz pilot carrier signal. Others use the incoming pilot signal to trigger a local oscillator at 19 kHz, doubling the oscillator output to provide the 38-kHz carrier. Still others use the 19-kHz pilot signal to synchronize or lock a locally generated 38-kHz oscillator. We can break all these methods down into the oscillator and nonoscillator types. In oscillator types, the oscillator stage itself should be disabled for these next steps.

With the modulated-rf sweep generator connected to the antenna terminals of the receiver, apply a 19-kHz signal from the multiplex generator strong enough to cause between 6 and 8 kHz of FM modulation of the carrier. See Fig. 1. Note the recovered 19-kHz pilot at point A (the input to the decoder circuits which is, in fact, the output of the FM discriminator or ratio detector). Examine the waveform at point C and adjust all tuned circuits associated with the 19-kHz amplifier stage(s) for maximum 19-kHz voltage at point C.

Restore the disabled local oscillator (if it had been previously disabled) and examine the output at point E. Adjust any tuned circuits relating to the oscillator or doubler to produce maximum waveform at point E. In locking-oscillator types, note that the output is actually *locked* in frequency by the incoming 19-kHz synchronizing signal. Lack

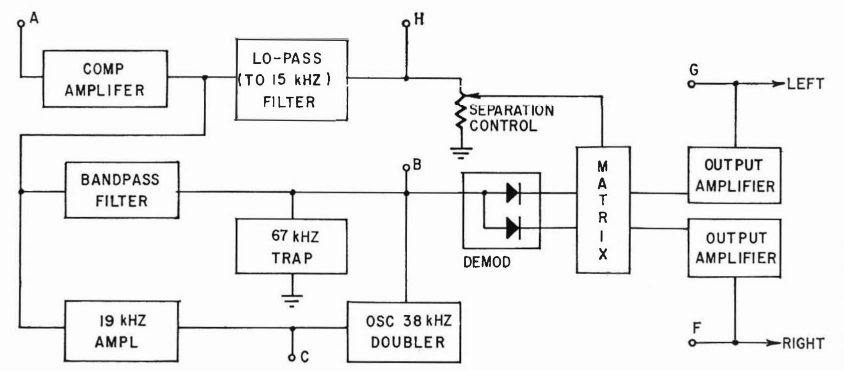

Fig. 9—Multiplex decoder using the time division system of demodulation.

of synchronization will be indicated by fuzziness of the waveform as well as by an audible motorboating or low-frequency tone from the speaker.

To insure lock-in at low signal strength, reduce the rf microvolts applied to the antenna until the local oscillator falls out-of-lock. Continue to touch up the tuned circuits until they lock in at the lowest possible input signal strength.

The resultant 38-kHz restored sub-carrier will look like Fig. 11. The reason for the alternate peaks and valleys is 19-kHz mixed with the 38-kHz carrier. This will not affect decoder performance and should not worry anyone.

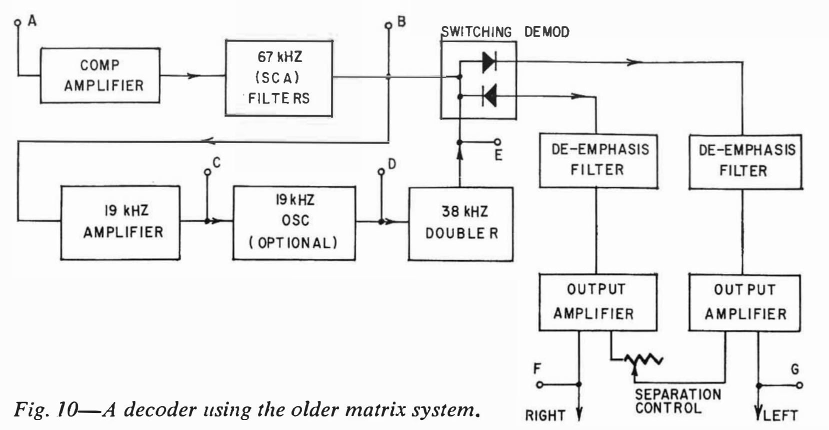

Fig. 10—A decoder using the older matrix system.

Separation adjustments

Now it is time to apply a complete composite signal to the receiver. Add a left-only or a right-only audio signal to the 19-kHz modulation already present, so as to modulate the FM generator to a total of about 45 kHz. This is the total amount of modulation you can get in practice with a left- or right-only signal. Full 75-kHz deviation occurs only when both left and right channels are fully modulated. If a right signal is being applied, examine the output at the *left* output terminal (G) and vice versa.

Slightly re-adjust all 19-kHz and 38-kHz tuned circuits for *minimum* output. This step is really a fine-tuning adjustment for these circuits to compensate for slight phase shifts, etc. Switch the input signal from the multiplex generator to the opposite channel and note an increase in output. The difference in the two outputs is the amount the decoder circuits can separate the two channels.

If there is a potentiometer-type separation control, adjust it now, reading the "null" side rather than the "high-output" side. Repeat the entire procedure on the opposite channel. That is, if a left signal was applied and you read the output null on the right, apply a right signal and read the null at the left output.

Often, the separation of the left channel will not equal that on the right. For example, the right channel, after adjustment, may show separation of 30 dB at mid-frequencies while the left channel may show only 20 dB of separation. It is best to compromise the settings in such cases so that each channel provides, say, 25 dB separation. This is done by touching up the separation control, as well as the 19-kHz and 38-kHz circuits.

As a final check of overall performance, you may want to check separation at some higher audio frequency, usually 5 kHz or 10 kHz. Don't be startled if the separation at the higher frequencies is considerably poorer than at mid-frequency. Most commercial decoder circuits behave that way. It is rare indeed to find a stereo receiver that can maintain 25 or 30 dB of separation all the way from 50 Hz to 15 kHz.

Proof of performance

You may well find—even after you have carefully gone through all the steps above—that stereo reception leaves much to be desired. Common problems include noisy reception in stereo (while mono reception of the same station is noise-free) and a persistent sibilant or harsh sound in spoken words containing the letter *s*. These problems probably have nothing to do with your just-completed alignment. Good reception of stereo-FM usually needs a rf signal much stronger than for monophonic FM. Also, the distortion can often be due to multipath reflections (like ghosts in TV reception).

If these ills are to be cured at all, it will be with a properly selected and installed outdoor FM antenna. While many FM listeners will resist this solution at first (having become accustomed to good mono FM without such an installation), it is the only solution in a great many cases.

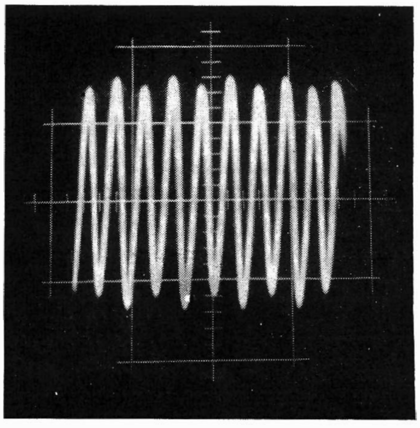

Fig. 11—Typical 38-kHz signal in decoder circuits. Larger alternate waves show the presence of some residual 19-kHz signal.

Beacons, indicators and automatic switches

In general, such refinements as visual stereo indicators, lights, etc. depend on the incoming 19-kHz signal for their operation. Thus, if all the circuits associated with the pilot signal have been peaked, the visual indicator should work automatically (barring a burnt-out light bulb!). But some beacon or light circuits have tunable coils of their own which also need to be peaked. Such needs can best be learned from the schematic and service instructions.

Automatic switching from FM to FM-stereo also depends on receiving a 19-kHz signal, which of course means that an FM stereo signal is being transmitted. Here, too, you must refer to the receiver schematic, since there are a great many variations.

Off-the-air alignment

It has been suggested that any stereo broadcasting station can serve as a ready-made multiplex-and-rf generator. To some extent, that is true. Certainly, a very precise 19-kHz signal is available and can be used for peaking the 19-kHz and 38-kHz circuits as previously outlined. Unfortunately, however, the signal from a given station will be at a single level of strength, giving you only doubtful ways to check weak-signal or strong-signal performance. Then, too, separation can't be judged on ordinary program material (unless an announcer is kind enough to speak for long periods of time on one channel only and tells the listeners he is doing so).

To sum up, some cursory alignment steps can be made using a station as a signal source, but for a professional alignment job, you will need an FM-multiplex generator. END