Hunting Down Trouble In Stereo Receivers

The systematic way to tie the symptoms to the causes.

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STEREO FM

TROUBLESHOOTING stereo multiplex efficiently depends on knowing key tests to apply for each symptom. Here we will show you how to analyze several symptoms, and give key test points for locating faults quickly. We'll also look at alignment in detail.

The basic idea of *time-division* multiplex detection (also called *switching* or *envelope* detection) is illustrated in Fig. 1. The composite signal containing L + R and L − R is switched between the left and right output terminals at a rate of 38 kHz. Only the L − R signals change polarity on alternate halves of the 38-kHz cycles because L − R consists of sidebands of the 38-kHz subcarrier. The carrier itself is suppressed at the transmitter. After the switching, L − R is added to L + R to form the left-channel output. The negative version, − (L − R) or − L + R, is added to L + R to produce the right channel.

For many symptoms, the choice of tests depends on the method used in the multiplex circuit to obtain the 38-kHz switching voltage. The block diagrams of Fig. 2 show how the transmitted 19-kHz pilot signal can simply be amplified and doubled to 38 kHz. Or, the 19-kHz signal may be used to phase-lock a self-excited oscillator running at 38 kHz, or sometimes the 19-kHz pilot is first doubled to 38 kHz and then used to sync the oscillator.

Listener's complaint

The most common problem stereo–FM listeners have is a background hiss on stereo stations, while monophonic stations are clear. This is atmospheric noise, and noise from the receiver's front-end stages, beating with the 38-kHz switching voltage. When the receiver uses a 38-kHz oscillator that runs continuously, there may be a hiss on all stations, mono or stereo.

The cure is the same as you would recommend for a TV viewer troubled with snow on the screen: improve the signal-to-noise ratio by improving the antenna system. TV antennas, and the so-called "line-cord" antennas, which may work well enough for mono FM reception, are not usually satisfactory for stereo. This is because the composite signal is more susceptible to the effects of low signal strength. Also, operating a TV antenna in the FM band causes very high SWR, producing phase shift in the 23- to 53-kHz (L − R) sidebands. Loss of channel separation is the result.

Besides the hissing noise and poor separation caused by an inadequate antenna, weak signals may be distorted because phase-locked oscillators need a certain minimum amplitude. This means that some stations may sound normal, but others at whose frequency there's a high SWR may be distorted.

As with color TV (which is also a multiplex system), a strong input signal to the receiver without attenuation of certain frequencies and without phase-shifted reflections (ghosts) from nearby objects is terribly important.

There are three common causes for this symptom: (1) unequal forward and reverse resistance in the switching diodes; (2) incomplete doubling from 19 to 38 kHz; (3) defect in the 38-kHz input transformer that drives the switching diodes.

The diodes can be checked easily with an ohmmeter by reading their resistance in one direction and reversing the probes for another reading. A ratio of 5 to 1 is good enough, but 10 to 1 is better. The actual value is not as important as having the same ratio in all diodes. This is an easy fault to find. Just remember to use the same range on the ohmmeter for all readings.

If your scope shows a waveform like Fig. 3 at the output of the 38-kHz generator, you have incomplete doubling. Check at the base or grid of the oscillator for a symmetrical signal. It may not be a sine wave if a full-wave

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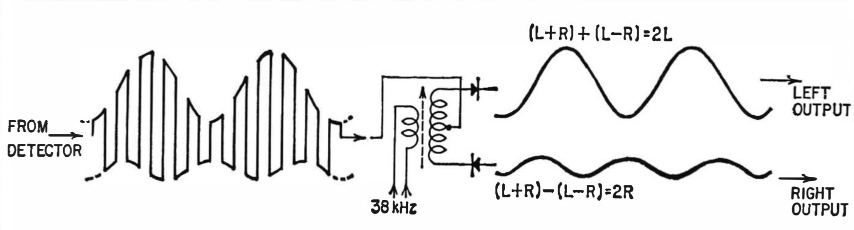


Fig. 1—Simplified scheme of envelope detection. Opposite edges of 38-kHz switching waveform carry the left and right channels.

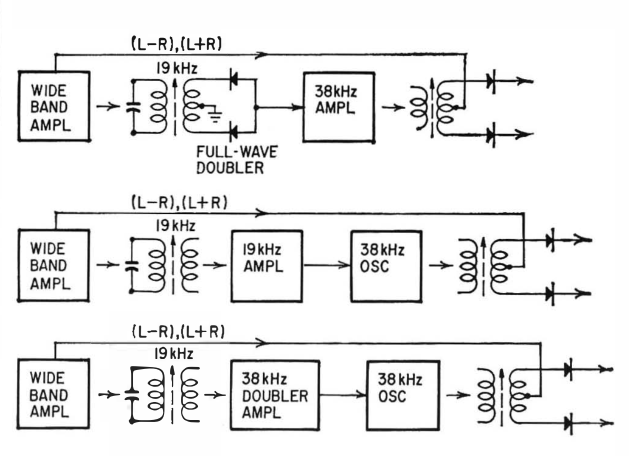


Fig. 2—Three ways of winning back a properly phased 38-kHz subcarrier.

rectifier is used for doubling, but the pulses should be symmetrical. Fig. 4 shows what to expect. If you don't find the correct signals, suspect D1 or D2, C1, Q1 or Q2, or T1, depending on where you find the wrong waveform.

When all waveforms are normal, and the switching diodes check OK, try a new transformer for T2.

Poor sync

This causes distortion in both channels, and for reasons different from the ones mentioned for single-channel distortion. So to be sure you are on the right track: disconnect each speaker separately and listen for distortion. Extreme cases have a low-pitched growling sound which seems to respond to adjustment of the 19-kHz phase. But, unless someone has merely misadjusted the control, more extensive repairs will be needed to restore good separation and assure that the sync will not fail again.

Fig. 5 illustrates an interesting case where loss of sync was caused by a defective component. The signal was normal on mono but distorted on stereo, and the stereo indicator lamp blinked intermittently. After determining that both channels were affected, the technician attempted to touch up the alignment of the 19-kHz tank, L13. The tuning was so critical that a quarter turn of the slug produced a low growling sound. With some difficulty, the growling sound was finally brought to zero-beat and the receiver operated for a few minutes without distortion, but with very little separation. But it soon went out of sync again.

One end of the 100K resistor, R, was temporarily disconnected to eliminate the possibility of excessive loading on the 19-kHz doubler output by a defect in the indicator circuit. This made no difference.

The waveform at the collector of Q3 was unstable in frequency, quite low in amplitude, and showed unequal and asymmetrical peaks characteristic of incomplete doubling. As a result, all voltages at the terminals of Q2 and Q3 were checked. The collector of Q2 had only 4 volts, which indiated that Q2 might be defective.

There are three ways to spot a transistor with excessive collector-to-emitter leakage:

1. Its emitter voltage is too high.
2. It is warm after a few minutes' operation.
3. Its collector-to-emitter voltage is low.

The final check for leakage is to measure the collector voltage while you short the base to the emitter. If the transistor is OK, its collector current will be cut off, giving a sudden rise in collector voltage. This test was applied to Q2 and the collector voltage jumped up to 10.8, indicating no leakage.

This all pointed to trouble in the collector circuit of Q2, so the ohmmeter was touched across L14. That was it—4,700 ohms! The coil was open. The 4,700 ohms permitted some signal input to Q3, but very little, resulting in a weak, unstable and asymmetrical signal driving the switching diodes.

The symptom that clearly indicates the need for complete alignment is when the left channel, for example, produces a "left only" signal, but the right channel is monophonic. This is a very common symptom even in new units, and is often mistaken for poor separation when there may in fact, be excellent separation on one channel. The remedy is a thorough alignment of the tuner, i.f.'s, ratio detector or discriminator, and the multiplex circuits.

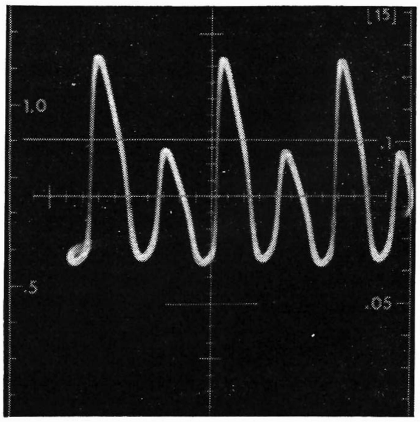


Fig. 3—If you find a waveform like this at the collector (or plate) of the 38-kHz generator, it signifies incomplete doubling.

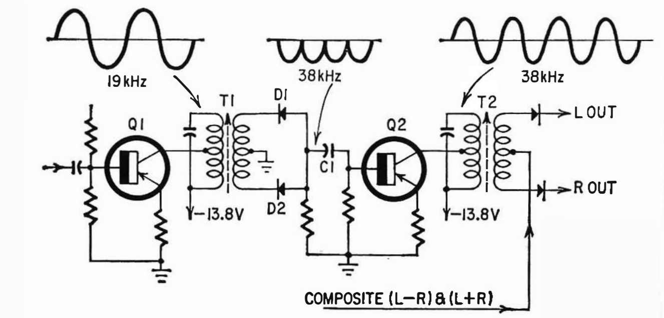
Many troubles in stereo multiplex receivers can be cured by careful alignment. So let's look at the procedure in detail.

A stereo generator is practically a necessity, not only for the special stereo signals it provides but also for the composite rf output, which you can use instead of a regular sweep generator to align the i.f. stages. If you have ever aligned an FM receiver with a standard sweep generator, you will appreciate the convenience of working with a stereo generator. You may be surprised to find that *we do not strive for the best overall shape of the response curve.* For good stereo reception we are mainly interested in getting the 23- to 53-kHz (L − R) signals through the tuner and i.f.'s with a minimum of phase shift or attenuation.

Start by tuning the 67-kHz trap for minimum output on a scope or vtvm connected to the output end of the trap while feeding 67 kHz to the base or grid of the first stage in the multiplex section.

Next, feed the composite stereo signal from the generator to the receiver's antenna terminals through 120Ω resistors in series with each lead. Fig. 6 shows the waveforms you will get at the audio output terminals of the FM detector stage. Adjust the i.f. transformers and the detector transformer to get the center line as flat as possible (Fig. 6-a). Considerable attenuation of L − R is indicated by the wavy base in Fig. 6-b.

Fig. 4—Typical wave forms in a transistor multiplex detector.



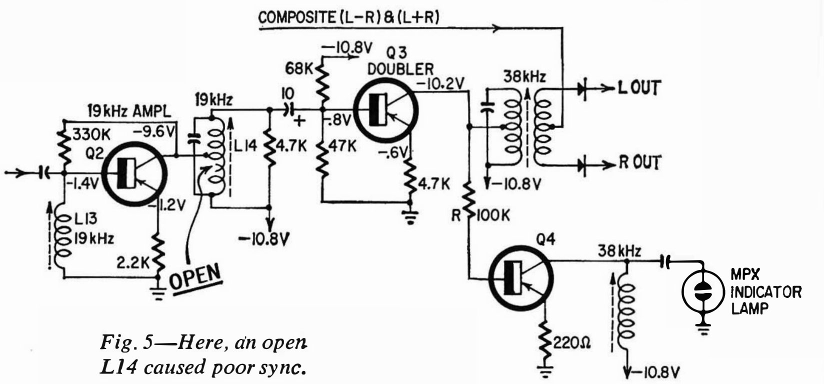


Fig. 5—Here, an open L14 caused poor sync.

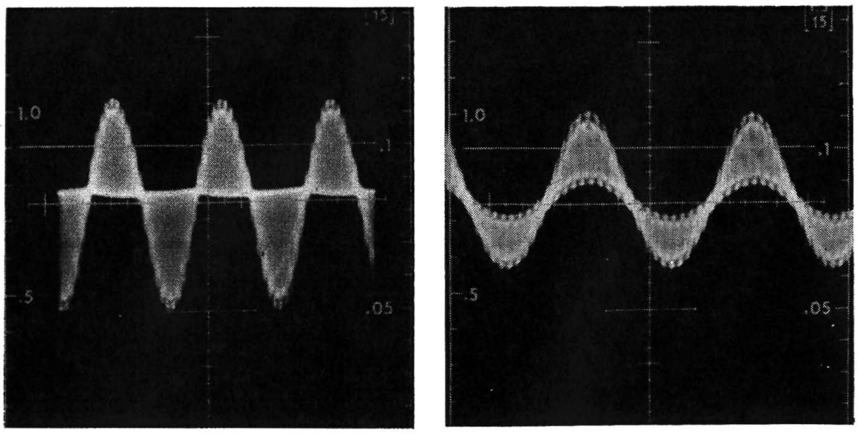


Fig. 6—Adjust FM i.f. and detector transformers to get the base line as flat as possible, as in (a-left); wavy baseline (b-right) means attenuation of L-R and loss of separation.

Symmetry of the positive and negative peaks of the waveform is more important than amplitude. Don't depend entirely on the receiver's tuning meter as an indication of best alignment. Try to get the adjustment which gives the highest meter reading consistent with symmetrical peaks.

Use full deviation from the generator, but use the rf attenuator to avoid overloading the tuner stages. Work slowly and very carefully, moving from one transformer to the next in whatever order seems to produce the best results. As with all kinds of alignment, picture-perfect results are not necessary, or even possible. In fact the waveform shown in Fig. 6-b was taken from a receiver which actually produced fairly good stereo in spite of the apparent attenuation.

The next step is to lock in the 38-kHz stage in the receiver. Switch the scope for external horizontal input and connect the horizontal-input terminal to the 38-kHz stage where it feeds the switching diodes. Put the vertical probe on the audio output from the radio detector or discriminator, and feed in the 19-kHz signal from the generator at that same point. Adjust the 38-kHz output tank for maximum horizontal deflection first, and then adjust the 19-kHz tank for a figure-8 on the screen, indicating perfecting doubling with no phase shift.

You can adjust 38-kHz lock-in by listening to a stereo station instead of using the generator. Wait for a quiet moment in the programing to view the figure-8 without the station's audio superimposed on it.

The last step is adjusting the separation. One way to do this is to use an electronic switch connected as shown in Fig. 7.

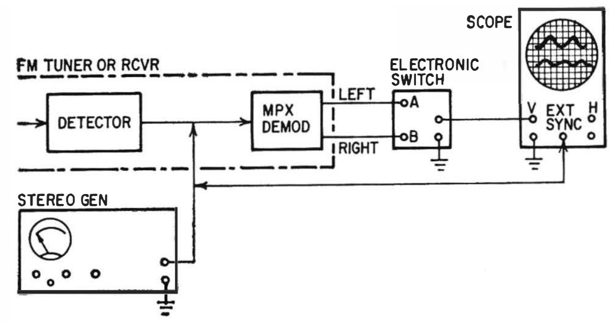
With the scope on internal sweep and locked-in on the audio tone from the stereo generator, you should see waveforms as in Fig. 8. The right channel is on the top in both pictures. In Fig. 8-a, the "left-only" signal was supplied from the generator and the separation was not very good. Fig. 8-b shows excellent separation with the generator supplying a "right-only."

Best separation comes from touching up the 38-kHz tank with the "left-only" signal, and the 19-kHz tank with the "right-only" signal. Rock the separation control on either side of center while working with channel until you find the best overall combination which gives equal separation both ways, from left channel to right and right to left.

If your scope is calibrated and the amplitude controls of the electronic switch in Fig. 7 are adjusted equally, you can determine the separation in dB by comparing the peak-to-peak voltages of the two signals. The separation in dB is 20 times the common log of the voltage ratio. In Fig. 8-a this is 8 dB. The practical maximum is about 30 dB.

It is interesting to watch the signals with a scope and electronic switch while listening to a stereo station. Your customers will appreciate what the stereo receiver is doing when they see this demonstration. Instead of using an electronic switch you can get similar results by connecting the right channel to the vertical input of the scope and the left channel to the horizontal input. With the scope switched to external horizontal input, the right channel will produce a vertical line and the left channel will produce a horizontal line. A musical program in stereo makes a pattern that looks like a tangled bunch of thread, pulsating continuously in time to the music. **END**

Fig. 7—Using an electronic switch to get both channels on a scope screen.



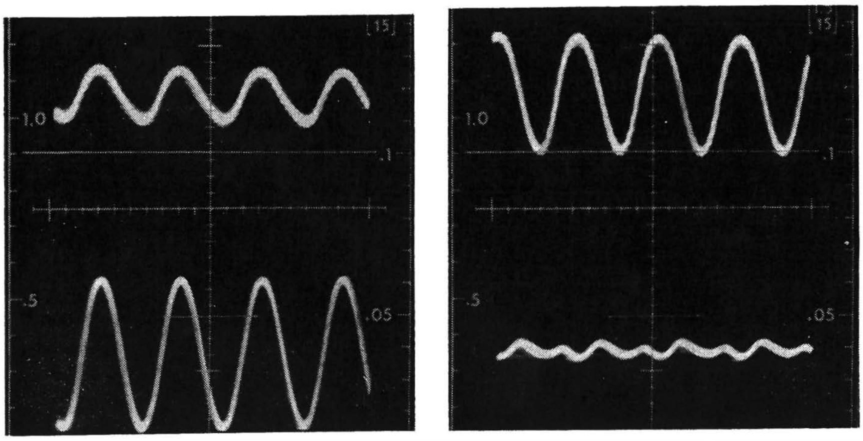


Fig. 8-a (left)—Separation was poor when left-only signal was applied. Was much better (b-right) with a right-only signal. Separation is determined by heights of two waveforms.