A THREE TIMES FASTER AND EASIER WAY TO ALIGN FM RECEIVERS

Here's a technique that lets you measure receiver rf and audio quality on a scope -- no meters needed. And you don't even need to remove the receiver cabinet.

If you look upon the task of aligning f-m mono and stereo receivers as an exercise in frustration, then read on. Because we'll tell you about a quick technique and a new type of alignment generator that lets you do the job in just minutes. Not only that, but this technique lets you know for sure when you've achieved best alignment -- you don't have to tune in a station and do some final tweaking to make the receiver "sound right."

And there are some other things you can do with the technique that you'll like.

Let's first look at how simple and fast it is to check receiver alignment and audio quality (the technique does both). To start with, you merely connect the new generator, the receiver or tuner, and a scope as shown in Fig. 3. It's worth noting that you don't have to remove the receiver cabinet or go inside the receiver at all to check alignment or measure audio quality. The generator connects to the antenna terminals, and the scope connects to the receiver audio output through the generator.

When things are turned on and the receiver and generator tuned to the same rf frequency, you'll get a scope pattern like that in Fig. 1(a). What's of main interest in this scope pattern is the shape of the envelope. Why? Well, this particular generator is different from any other you've used. It sweeps a constant-deviation small f-m signal of some 10 kHz back and forth across the receiver bandwidth. At the output of the discriminator this same small f-m signal, now detected, will be superimposed on the familiar receiver S-curve shown in Fig. 1(b). The detected small 10 kHz signal can be seen in Fig. 1(b) as a ripple. Now if the S-curve of the receiver is exactly linear over its useful range, the detected 10 kHz signal will have a constant amplitude. But if the S-curve is not linear, the amplitude of the 10 kHz signal at the discriminator output will vary with position on the S-curve.

To enable us to look at the amplitude of the 10 kHz signal more clearly, the audio output of the receiver, which resembles Fig. 1(b), is connected to the generator (Fig. 3). There the small 10 kHz signal is separated from the low-frequency sweeping signal, amplified, and fed to the scope for vertical deflection. The vertical amplitude is thus proportional to the slope of the S-curve, i.e., to the small-signal gain of the receiver. The envelope you see in Fig. 1(a) is therefore a plot of the small-signal gain versus carrier frequency.

As you well know, if the S-curve is not linear, distortion will be produced in the receiver's demodulated signal. So sometimes alignments are done by just looking at the S-curve on a scope, but this gives only a gross result. That's why the discriminator has preferably (until now) been adjusted while watching a distortion meter connected to the audio output of the receiver. This, though, is a slow process, requires costly equipment and doesn't always give the best alignment.

In the new method the envelope tells you in numbers how good the distortion is, and it tells you how well the entire receiver is aligned. Also, the distortion measurement takes into account the entire bandwidth of the receiver and you can see exactly how distortion is increasing at the band edges. [The pattern shown in Fig. 1(a) is actually a visual presentation of intermodulation distortion -- the amplitude modulation of a small-amplitude high-frequency signal (10 kHz in this case) by a large-amplitude low-frequency signal (our sweep signal). The change in pattern height over a particular portion of the band gives the peak intermodulation distortion over that band portion. This is a very sensitive method of measuring distortion and the results are not confused, as they would be in the case of a measurement of total harmonic distortion, by the de-emphasis in the receiver which attenuates harmonics above about 2 kHz.]

In addition to these advantages the technique is fast. That's because it's a sweep method and you can see what you're doing. At the same time, again because it is a sweep method, it shows you the familiar i-f and discriminator sweep patterns (S-curve) whenever you wish (Fig 1(b, c)).

THE FAST WAY TO MEASURE DISTORTION

If the receiver S-curve were perfectly linear, the envelope (see Fig. 4) would have a completely flat plateau across the top. But the fact that unevenness is present in the plateau is the result of non-linearity in the S-curve. The amount of distortion caused by this non-linearity is the ratio of the p-p amplitude of this unevenness (ripple) to the p-p amplitude of the whole envelope. As indicated in Fig. 4(b), the ripple is measured over a 150 kHz portion of the center of the bandwidth. This 150 kHz portion corresponds to 100% modulation.

To more readily measure the ripple in Fig. 4(a), we increased scope sensitivity by 5x which magnifies the plateau as in Fig. 4(b). Now the ripple is about 0.6 cm p-p which in this particular case corresponds to .06 volt p-p (0.1 v/cm scope setting). The middle portion of the pattern in Fig. 4(a) is 6 cm high p-p which translates to 3 v p-p (0.5 v/cm scope setting). So the distortion is .06/3 or .02, i.e., 2%. Simple, no?

Please note, too, that what you are measuring is peak intermodulation distortion (IMD) and not rms or average intermodulation distortion. This latter distinction is important because IMD is a more sensitive indicator of distortion than total harmonic distortion (THD) and this is even more true for the case of peak IMD.

Incidentally, you can approximately convert a peak IMD measurement to a THD measurement by dividing the peak IMD value by 5. This assumes that the harmonic measurement is made on a signal low enough in frequency that the important harmonics in the THD measurement are not attenuated by the receiver's de-emphasis of high audio frequencies. If the important harmonics are so attenuated, the THD measurement will be incorrect (too low).

Just to prove the case between peak IMD and THD results, we measured the THD in the audio of the receiver that produced Fig. 4(a, b) with the very best laboratory equipment. We obtained a THD value of 0.37% (2% peak IMD divided by 5 would give us an equivalent THD of 0.4% so the correlation is certainly close). Thus you can see that the measurement is meaningful, to say the least.

READING RECEIVER BANDWIDTH

You can read receiver bandwidth directly from the scope pattern of Fig. 1(a) and 4. That's because the horizontal scale is linear and the deviation meter on the alignment generator is calibrated (accurately) to show the peak-to-peak sweep width, which you adjust with a panel control. For example, the sweep width in Fig. 4 is 500 kHz p-p (50 kHz/cm). The receiver is normally tuned to the center of this pattern and the signal you see in Fig. 4 is swung 250 kHz on either side of center.

RECEIVER ALIGNMENT

The alignment method we've described allows you to quickly align a receiver for what the designers call optimum linear bandwidth. A wide linear bandwidth is essential to prevent distortion on f-m modulation peaks, and it is extra important for stereo because the stereo sidebands are widely separated from the carrier -- much more so than for mono.

In aligning with this method you should strive for an envelope that is symmetrical and that has smooth rounded edges with a flat central plateau. If the plateau is not flat, the receiver will distort the audio. If the pattern has appreciable humps or abrupt drop-offs at the edges, the receiver will be difficult to tune.

OTHER PATTERNS

There's so much this new procedure can tell you, not just about the discriminator alignment but also about the i-f and even about the audio performance, that it's difficult to keep from showing you more pictures. So here are two more scope patterns you will find interesting.

First, Fig. 5. This pattern is found on occasion when a discriminator is aligned using an f-m broadcast station or a conventional signal generator as the signal source. Here, the discriminator is producing two plateaus. When the receiver is tuned to the right-hand plateau, the audio sounds pretty good because the plateau is fairly flat.

But notice, too, that the station can be received at two adjacent places on the dial since there are two plateaus. And each of the two will be rather hard to tune in because of the narrowness of the plateau. (Ever had this happen to you when tuning a set ?)

The narrow plateaus in Fig. 5, although they can accommodate 100% modulation (75 kHz peak deviation), will result in excessive distortion on modulation peaks since these frequently exceed 100% modulation. Fig. 6 is a scope photo of the audio from the discriminator of Fig. 5. At the top of the audio peak there is noise (not too visible in the photo but you can see slight wiggles). At the troughs of the audio there is severe clipping where the discriminator output fell abruptly.

INCREASES SHOP PROFIT

The method we've been describing is already in use in a number of factories and service shops throughout the country. It is even being used in clinics to show customers how well their receivers perform. There, a big advantage is that it is not necessary to remove the cover to see the highly informative sweep alignment pattern. When it comes to actual alignment, the method is fast because it lets you see what you're doing, as with any sweep method, and it provides a simple, direct view of distortion and tuning characteristics.

The service manager of a leading West Coast hi-fi sales and service organization estimates this method has cut the time required to align a 'known' receiver to one-third of that previously required, to say nothing of the improved quality of the work. Another shop owner feels that this method lets him now include an alignment with each repair job at little additional cost, thereby generating additional business.

Time is saved for the shop because the generator has incorporated in it a precision stereo and monaural modulation capability. Separate controls are used for the sweep function, so very little time is lost when switching between the sweep function and mono or stereo. A separate control and test pushbutton let you quickly set pilot level with all other modulation removed.

THE GENERATOR

The new alignment generator, the Sound Technology Model 1000A, (Fig. 2) that includes this special sweep has many other qualities that make it a beauty. First, it is basically a small, high-quality f-m transmitter that has an exceedingly pure signal -- total harmonic distortion at the r-f output at 100% modulation is rated as less than 0.1% mono or 0.2% stereo. To get this signal purity, the generator has a specially-developed linear modulator.

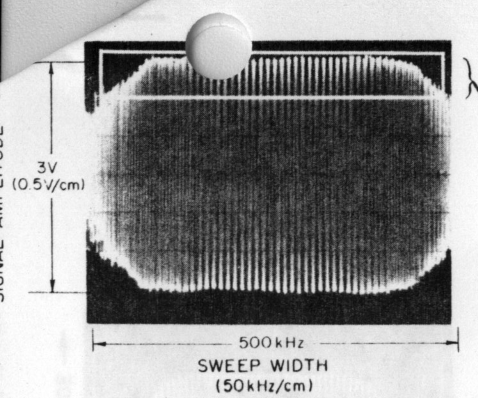
And the 1000A includes all the other requirements necessary to test stereo equipment including L, R, L+R, and L - R signals and a digital stereo system that gives in excess of 50 dB separation. It also has an internal 67 kHz modulation source for aligning SCA traps. Modulation of the generator with full SCA program material while simultaneously modulating with stereo or mono signals can be done by using an auxiliary wide band input on the rear panel (Option M1).

The unit is also capable of all conventional sweep alignment functions.

One extra-important feature is the precision piston output attenuator that lets you make a fast check of receiver alignment at various r-f levels. Some receivers will change alignment with r-f level and this attenuator lets you check at levels from 0.5 microvolt to 30,000 microvolts with one continuous turn of the knob.

All in all, the Model 1000A, in addition to its new features, is such as to make it a laboratory instrument as well as one that will certainly make its mark in the service field. The experienced stereo man can infer the quality of some of its signals by looking at Figs. 7 and 8.

Written by: F. J. Burkhard
Frank Burkhard Company.



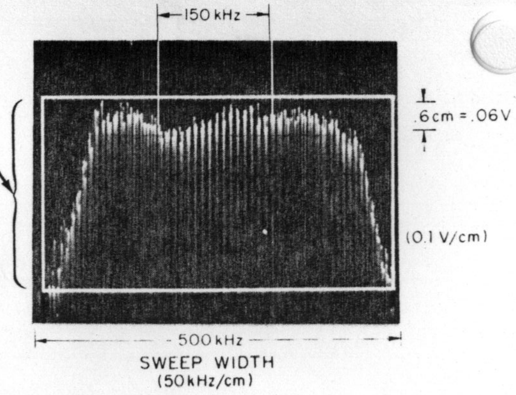


Fig. 4(a). Fig. 4(b)

Top of alignment pattern in (a) is magnified 5 times in (b) to facilitate measuring ripple. Ripple across top is caused by receiver non-linearity and is a direct measure of the receiver's peak intermodulation distortion. Numbers are discussed in article.

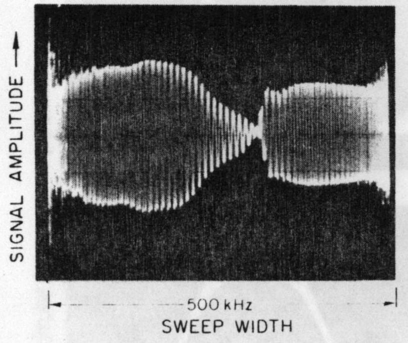


Fig. 5. Two-plateau receiver alignment pattern caused by mis-aligned receiver. This receiver tunes in same station at two adjacent points on dial. Narrowness of pattern plateau means receiver has inadequate bandwidth for high modulations and is hard to tune to stations.

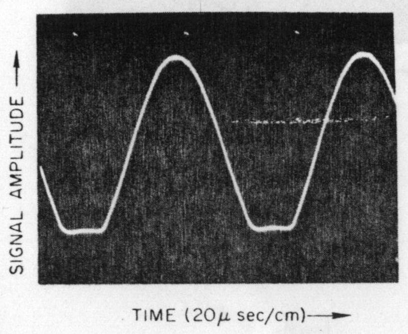
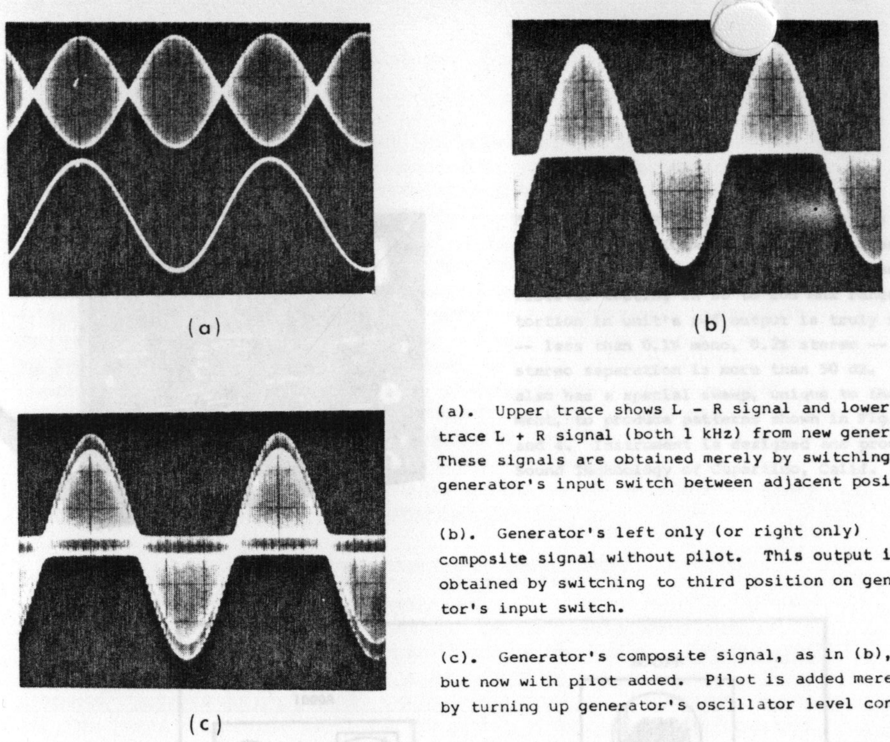


Fig. 6. Audio test signal obtained from receiver of Fig. 5 when receiver was tuned to right-hand plateau in Fig. 5. Noise visible on waveform peaks and severe clipping on waveform troughs is caused by narrowness of plateau in Fig. 5.



(a). Upper trace shows L - R signal and lower trace L + R signal (both 1 kHz) from new generator. These signals are obtained merely by switching generator's input switch between adjacent positions.

(b). Generator's left only (or right only) composite signal without pilot. This output is obtained by switching to third position on generator's input switch.

(c). Generator's composite signal, as in (b), but now with pilot added. Pilot is added merely by turning up generator's oscillator level control.

Fig. 7. Stereo signals produced by new Sound Technology FM Alignment Generator.

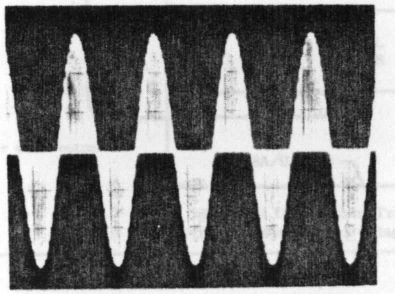
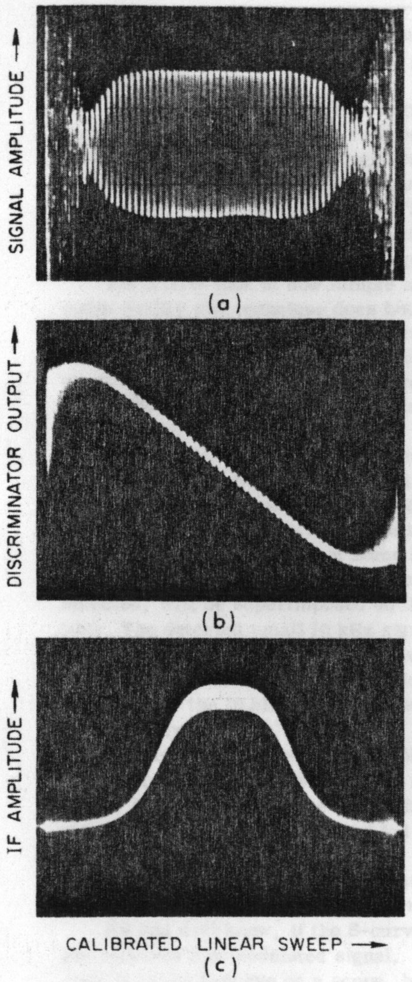


Fig. 8. Same as Fig. 7(b) except on slower time scale to illustrate generator's high channel separation of 50 dB or more (indicated by flatness of base line).



CAPTIONS

(a). Typical alignment pattern obtained with technique discussed in article. The envelope of this pattern tells you how much audio distortion exists in the receiver and how well the receiver is aligned. If receiver is poorly aligned, the envelope will usually have excessive ripple across top and bottom. It may also have humps or abrupt drop-offs.

(b). Typical receiver S-curve obtained with setup of Fig. 3, except scope vertical input comes directly from discriminator test point. Ripple on curve is 10 kHz produced by generator. This 10 kHz signal, when separated from low-frequency sweep signal, forms alignment pattern shown in Figs. 1(a) and 4.

(c). All of the usual sweep generator functions are obtainable with the new generator. Here is the typical receiver i-f curve as obtained with the setup of Fig. 3, except that scope vertical input is now taken from receiver i-f test point.

Fig. 1. Sweep alignment patterns obtained using generators described in article. Horizontal scale is carrier frequency; sweep width here was set to 750 kHz to show response to well past band edges. Sweep width on generator is meter-calibrated to 600 kHz but may be set to as wide as approximately 800 kHz.

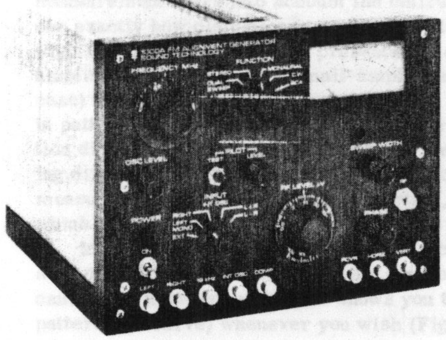


Fig. 2. New FM Alignment Generator is basically a very high performance f-m transmitter which produces all signals needed for mono and stereo receiver testing in 88 to 108 MHz range. Distortion in unit's r-f output is truly negligible -- less than 0.1% mono, 0.2% stereo -- while stereo separation is more than 50 dB. Generator also has a special sweep, unique to this instrument, to produce patterns shown in Fig. 1(a) and 4. Instrument is designed and produced by Sound Technology of Cupertino, Calif.

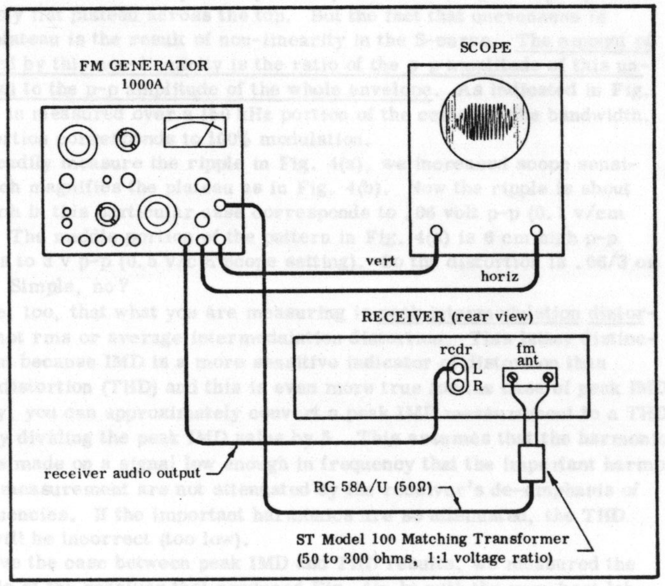


Fig. 3. This one simple setup is all you need to align a receiver and measure its distortion. Note that receiver output is routed through generator.