communications

DATAFILE BULLETIN

FILE UNDER: Receivers GENERAL

BULLETIN NO: 1000-6

DATE: April 1967

I-F ALIGNMENT
of
TWO-WAY RADIO FM RECEIVERS

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SUMMARY

This bulletin describes the types of I-F filters used in two-way radio FM receivers and tests which can be used to determine when I-F realignment is needed. The four methods of alignment commonly used are discussed and tips for aligning particular General Electric receivers are presented. Particular emphasis has been placed on the sweep alignment method. The Appendix provides instructions for building a simple sweep modulator and a low-frequency sawtooth generator.

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ECP-80 A

PRINTED IN U.S.A.

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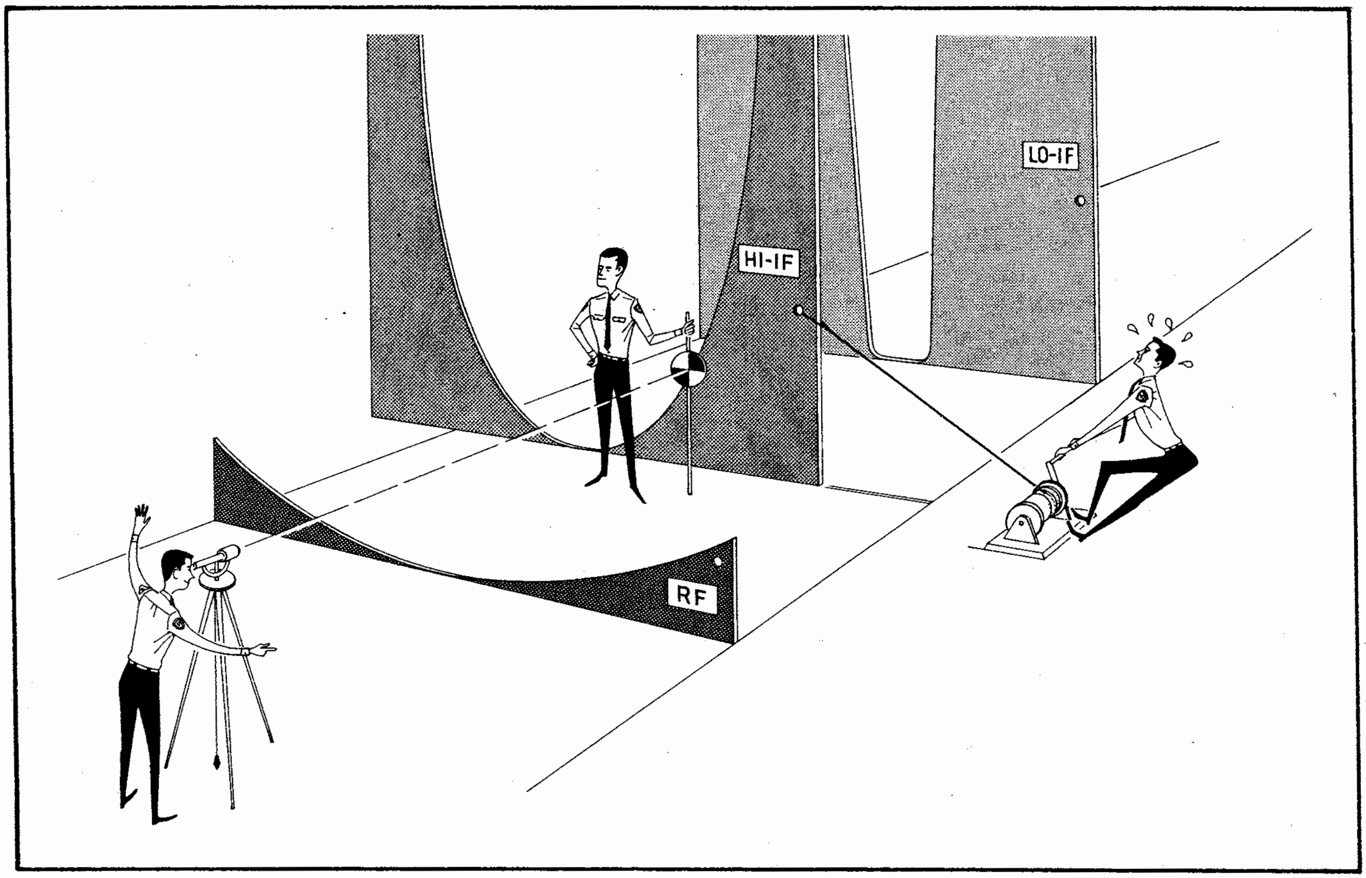

Fig. 1 - To align a receiver, the serviceman must line up the receiver's selective circuits (pictured here) so that desired signals can pass thru the center of each selectivity curve. He must also adjust the shape of the curves.

I-F ALIGNMENT

of

TWO-WAY RADIO FM RECEIVERS

"All FM receivers contain a large number of tuned circuits which must be adjusted correctly if the circuit is to function properly. Vibration, humidity, or temperature may cause the resonant circuits to drift off frequency in the field. Also, when a critical part is replaced, the associated resonant circuit may change frequency. The process of adjusting the tuned circuits of the receiver for optimum performance is called alinement [sic]."[1]

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[1] F-M Transmitters and Receivers, Department of the Army Technical Manual TM 11-668, September 1952, p. 182.

Chapter 1

I-F FILTERS USED IN FM RECEIVERS

The front end of an FM receiver produces an output signal, usually in the microvolt range, which must be amplified between 100,000 and 1,000,000 times in the I-F (intermediate-frequency) stages to supply a signal in the order of several volts to the detector. The I-F stages must also introduce sufficient selectivity to discriminate against stations operating in the adjacent channel, and still have response sufficiently broad that the outer sidebands of the FM signal are not distorted.

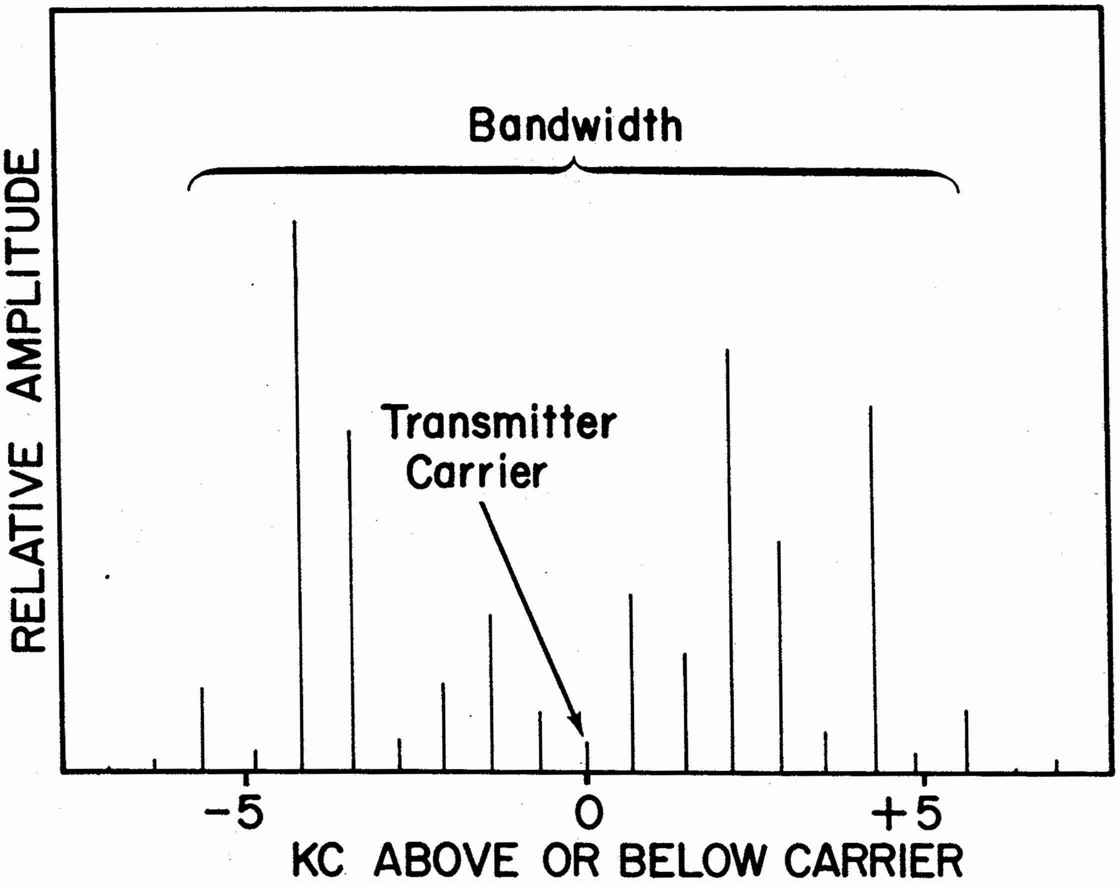


Fig. 2 - These vertical lines represent the transmitter carrier, with its sidebands spaced on both sides. Together, they compose a typical FM signal with voice modulation.

The sidebands of an FM signal (Figure 2) contain the information being transmitted. If the receiver's bandwidth is not wide enough to accept all of the significant sidebands, information will be lost. Some additional receiver bandwidth is also required to allow for transmitter and receiver frequency drift.

The selectivity of a receiver is the total response of all its tuned circuits. High selectivity cannot be obtained in a single I-F section. Double-conversion receivers separate the I-F section into two sections operating on different frequencies, which makes it easier to obtain good stability. In the past, the high intermediate frequency (Hi-IF) provided the necessary image rejection and the low intermediate frequency (Lo-IF) provided the selectivity necessary for adjacent-channel rejection. Today, some receivers using crystal filters have their most selective circuits in the Hi-IF, greatly improving the receiver's spurious response and desensitization characteristics. The use of a second converter and a Lo-IF is still economical in these receivers to provide the additional gain required. Frequency stability is easier to obtain at the lower I-F frequency and detection at the lower frequency is less expensive.

In addition to having the proper selectivity characteristics, the I-F filters used in two-way radios must be:

1. mechanically stable
2. electrically stable
3. temperature compensated
4. humidity resistant

Mechanical stability is required for filters to be electrically stable. Coil assemblies and tuning mechanisms must maintain their dimensions with time and vibration. This is particularly important in two-way radio, where mobile receivers are subject to shock and vibration while in use.

Dimensions which change with temperature must change linearly. Temperature compensation of the circuits is then possible. Temperature compensating capacitors are used to offset the change in inductance caused by changes in the dimensions of coils. In general, Q changes are not compensated.

Humidity protection can be obtained by coating coils with moisture-resistance coatings (such as wax, silicone oils, or epoxy) or by spacing turns so far apart that moisture films do not cause a problem (as with RF coils, for example). Continuous exposure to high humidity will eventually cause moisture to penetrate even the best protective coatings, but heat can be used to remove this moisture.

I-F TRANSFORMERS

Since the sidebands of an FM signal extend for a considerable distance on either side of the carrier, a broad flat response is desirable. Beyond this, a sharp decrease in response is necessary to attenuate the adjacent channels. It would be logical, therefore, to assume that the ideal receiver response curve would be similar to that shown in Figure 3.

Actually, this curve is not ideal, because the rapid changes in reactance at the sharp corners cause a rapid phase change and, therefore, phase distortion. Also, the flat top tends to increase impulse noise interference. For minimum phase distortion and noise interference, the "ideal" filter would have a Gaussian response (Figure 4), but this curve would not provide adequate adjacent-channel rejection.

In practice, therefore, FM receivers have a response curve (Figure 5) which is a compromise between those shown in Figures 3 and 4. The steep sidewalls provide adjacent-channel selectivity and the broad nose provides adequate bandwidth. At the same time, the rounded shoulders minimize phase distortion and impulse noise interference.

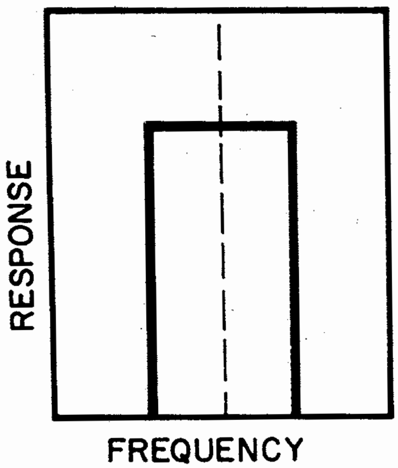


Figure 3

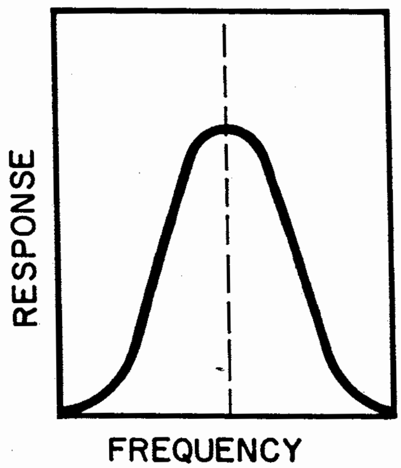


Figure 4

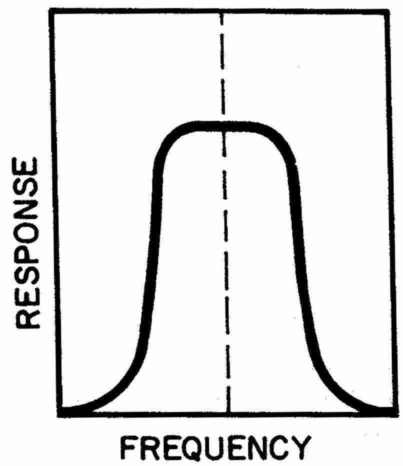


Figure 5

To understand how L-C circuits can be used to obtain the response shown in Figure 5, it is necessary to understand the three major factors which affect the response curve of an I-F transformer: (1) the Q of each tuned circuit in the transformer, (2) the coefficient of coupling between circuits, and (3) the number of tuned circuits used. Let's look at each of these in turn.

Q of Resonant Circuits

Q, you remember, is the "quality factor" of a resonant circuit and indicates the amount of energy used up (wasted) in the circuit --- largely due to resistive losses. Expressed mathematically:

$$Q = \frac{X_L}{R} \quad \text{or} \quad Q = \frac{X_C}{R}$$

in which X_L and X_C are the inductive and capacitive reactances of the resonant circuit and R is its series resistance. (In a resonant circuit, you remember, the capacitive reactance is equal to the inductive reactance.) As the resistance of the circuit increases, its Q is reduced. A high-Q circuit has low losses and a low-Q circuit has high losses.

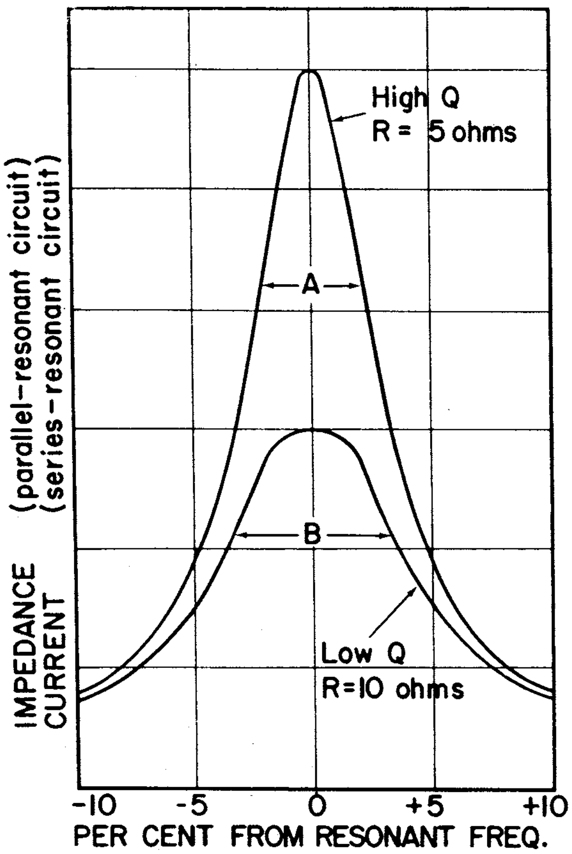


Figure 6 - Response curves for two resonant circuits having same inductance, but different series resistance

The slope of the resonance curve for a tuned circuit depends upon the Q of the circuit. Figure 6 shows the response curves for two resonant circuits having the same inductance, but different series resistance. Note that the circuit having the lower resistance has a higher Q and, therefore, a much steeper slope. Note also that the bandwidth at the half-power points on these selectivity curves (.707 of maximum) is much narrower for the high-Q circuit (A) than for the low-Q circuit (B).

In many applications of resonant circuits, the only power lost is that dissipated in the resistance of the circuit itself. In most circuits, this resistance is largely the resistance of the coil. When the circuit delivers energy to a load, however, the energy consumed in the circuit itself is usually negligible compared with that consumed by the load (Figure 7). By loading a circuit, the Q of the circuit is reduced to a value referred to as "loaded Q" (Q_L). When referring to Q in the following paragraphs, it will be loaded Q that we are talking about.

Loaded Q varies directly with the paralleled load resistance (R) and varies inversely with the reactance (X) of either the inductor or the capacitor in the tuned circuit:

$$Q_L = \frac{R}{X}$$

In Figure 8, an equivalent circuit showing the impedances of Figure 7, R1 and R3 represent the input and output loads connected to the tuned circuit and R2 represents the series resistance of the circuit. In order to keep the loaded Q as high as possible, the input and output impedances must be kept as high as possible --- compared to R2. Otherwise, current thru R2 will be small and the selective effect of the tuned circuit will be small.

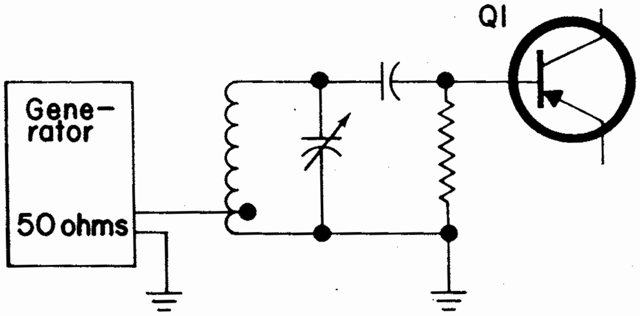


Fig. 7 - Resonant circuit, loaded by input impedance of Q1 and by generator source impedance

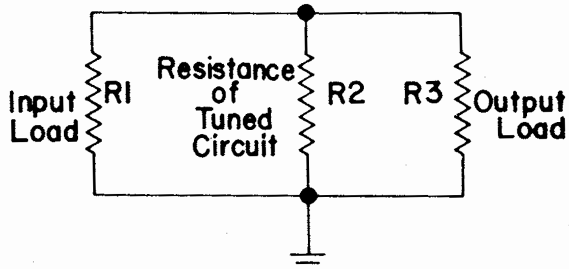


Fig. 8 - Equivalent circuit for Figure 7, showing impedances of tuned circuit and its loads

Coefficient of Coupling

Another factor which affects the response curve of an I-F transformer is the amount of coupling between the resonant circuits. The coefficient of coupling (k) indicates the relative amount of energy transferred between two circuits. If 100% of the energy were transferred, with no loss, the coefficient of coupling would be 1. Figure 9 illustrates the effect of coupling on the response of an I-F transformer in which both circuits are tuned to resonate at the same frequency. The response is similar for transformer-coupled circuits (Figure 10), capacitively-coupled circuits, resistively-coupled circuits or inductively-coupled circuits.

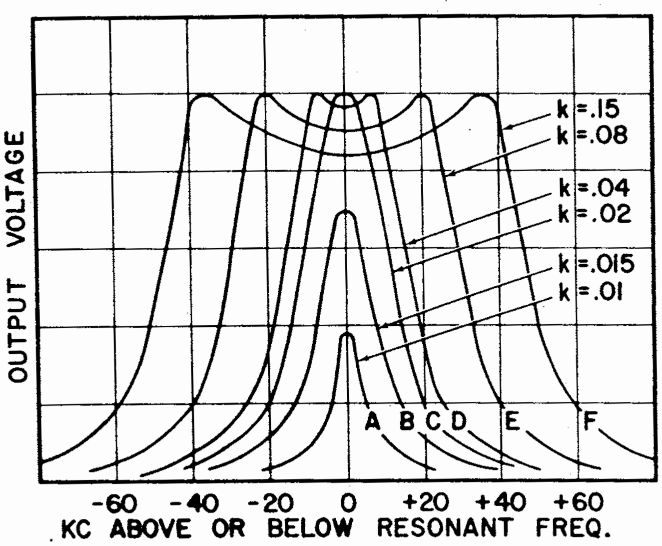


Figure 9 - Response curves showing how response changes with coupling

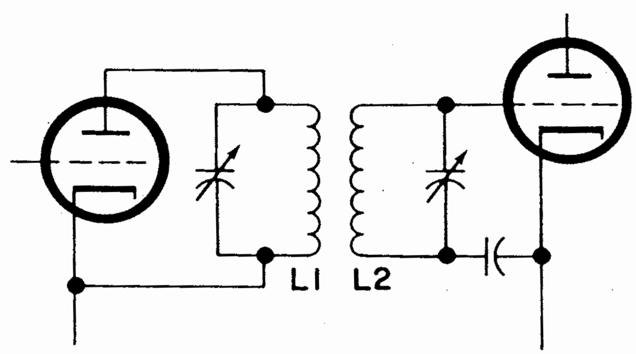


Figure 10 - I-F amplifier circuit

With loose coupling (Curves A and B), the output voltage is small and the selectivity is high. Increasing the coupling between L1 and L2 (by moving them closer together or changing their orientation) would increase the energy transferred from one coil to the other. As the coupling between the coils increases, the secondary voltage also increases until a certain point called "critical coupling" (Curve C) is reached. At this point, the output voltage at the resonant frequency is maximum, but the selectivity is broader than with looser coupling.

At still tighter coupling (Curve D), the output voltage at the resonant frequency actually decreases. Note the small depression in the center of Curve D. As the frequency is varied to either side of resonance, however, two "humps" are found --- one on either side.

With very tight coupling (Curves E and F), there is a further decrease in the output voltage at resonance and the "humps" are farther away from the resonant frequency. This condition is referred to as "overcoupled". Note that the off-resonant humps have the same maximum value as the resonant output voltage at critical coupling. These humps are caused by the reactance coupled into the primary at frequencies above and below resonance. Each hump represents a new condition of critical coupling at a frequency to which the primary is tuned by the coupled-in reactance (inductive on one side of resonance, capacitive on the other).

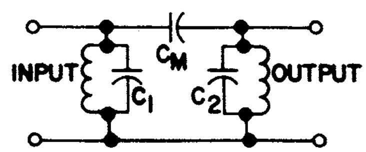
Overcoupled circuits are particularly useful in the most selective I-F filters in FM receivers. Their high Q produces a steep slope which provides good adjacent-channel selectivity. At the same time, they have adquate bandwidth --- which undercoupled Hi-Q circuits lack.

Coupling between resonant circuits of an I-F filter can be expressed in several ways, depending upon the type of coupling used:

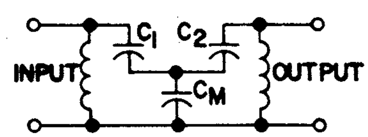
$$k \cong \frac{Z_M}{\sqrt{Z_1 Z_2}}$$ general formula for coupling (k)

$$k = \frac{M}{\sqrt{L_1 L_2}}$$ for transformer coupling

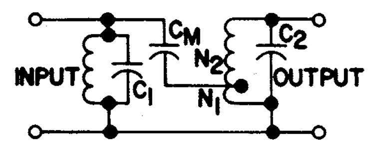
$$k \cong \frac{C_M}{\sqrt{C_1 C_2}} \cong \frac{C_M}{C_2}$$ for



$$k \cong \frac{\sqrt{C_1 C_2}}{C_M}$$ for



$$k \cong \frac{C_M}{C_2} \cdot \frac{N_1}{N_1 + N_2}$$ for



in which Z_M is a common impedance between the two resonant circuits (whose impedances are Z_1 and Z_2) and M is the mutual inductance between the primary and secondary coils (whose inductances are L_1 and L_2).

The last I-F filter circuit shown above has been used in several recent receiver designs (Porta-Mobil and MASTER Executive Series, for instance) because of its symmetrical response. The response of the other filter circuits shown slopes off on the high-frequency side, because the capacitors form a divider circuit which has a finite attenuation at frequencies above resonance.

Critical coupling is frequently used in I-F transformers because it gives the highest output voltage and the effect of tuning the secondary still has very little effect on the primary. In the special case of critical coupling:

$$k_c = \frac{1}{\sqrt{Q_P Q_S}}$$

in which Q_P and Q_S are the Q's of the primary and secondary. In practical circuit design, the value of k is usually increased by 50% to allow for component tolerances:

$$K_c = \frac{1.5}{\sqrt{Q_P Q_S}} \quad \text{or} \quad Q_P Q_S = \frac{2.25}{K_c^2}$$

This formula can be written in a more general form to cover all degrees of coupling:

$$p = K^2 Q_L^2$$

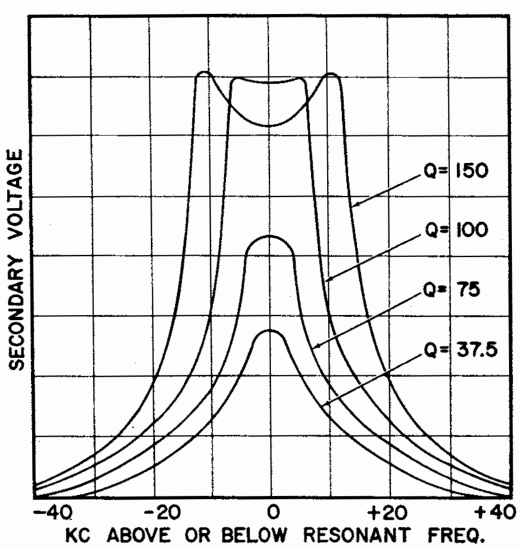


Figure 11 - Response curves for I-F transformer showing how response changes with Q (coupling remains constant)

The "grade of coupling" (p) combines the coefficient of coupling and the loaded Q of the transformer to a parameter which determines the form of the selectivity curve. The special case of p = 1 in a two-circuit filter produces critical coupling. For p less than one, the coupling is less than critical (undercoupled) and when p is more than one, the coupling is more than critical (overcoupled).

We have shown how changing the coupling affects the response curve of an I-F transformer. Response can also be changed by holding the coupling constant and changing the loaded Q of the resonant circuits, as shown in Figure 11. If the Q of an undercoupled filter is increased (by reducing the loading, for instance), the point of critical coupling may be reached --- without changing the coefficient of coupling. If the Q is increased further, the circuit becomes overcoupled.

Number of Tuned Circuits

Additional resonant circuits can be added to a filter to either increase the selectivity (with the same insertion loss) or to reduce the insertion loss (with the same selectivity). Tuning, however, becomes more difficult --- especially if the circuits are overcoupled. The interaction of circuits makes it necessary to use one of the special alignment procedures described in Chapter 3.

Circuits are also added to I-F filters to improve the shape of their response curves. By adding a single-tuned circuit to the double-humped curve characteristic of overcoupled resonant circuits, the shallow depression in the center can be raised, giving a broad, flat-nosed curve. The 6-coil Lo-IF transformers in Progress Line receivers use a slightly different amount of overcoupling between each of the three pairs of coils. The result is a response curve very similar to Figure 5.

CERAMIC FILTERS

Pacer receivers use 455-KC ceramic filters in their Lo-IF stages. These filters contain ceramic elements of the PZT type (lead zirconium titanate), having piezoelectric properties. Although ceramic filters are reasonably low in cost, their temperature coefficient (variation in center frequency with temperature) is not as good as L-C filters or crystal filters. By using them in the Lo-IF, however, the effects of this variation are not as significant as they would be at a higher frequency.

During manufacture, the resonant frequency of each ceramic filter is permanently adjusted, eliminating the need for tuning in the field. The input and output matching circuits do have a significant effect on the nose shape of the filter response curve and these may occasionally need adjustment.

CRYSTAL FILTERS

MASTR Professional Series receivers use quartz crystal filters to obtain the major portion of their selectivity. Crystal filters also provide a significant portion of the selectivity in MASTR Executive Series receivers. Typical response curves for the filters used in narrow-band MASTR receivers are shown in Figure 12. Their excellent temperature stability permits use of crystal filters in the Hi-IF stages. This has several significant advantages. Placing this high selectivity close to the front end of the receiver greatly improves the receiver's desensitization and spurious response characteristics. Spurious and image responses of the second mixer are virtually eliminated.

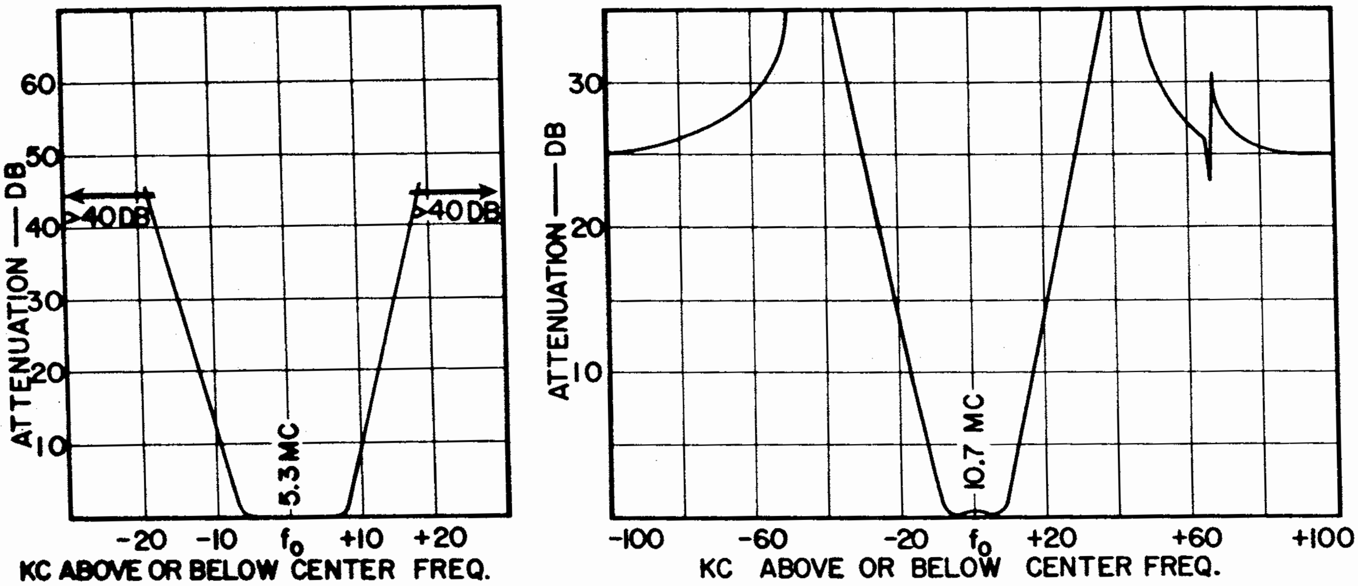


Fig. 12 - Response of Hi-IF crystal filters used in MASTR Professional Series receivers (left) and MASTR Executive Series receivers (right)

In addition to their excellent temperature stability, crystal filters provide rugged performance and fairly low insertion loss. When proper input and output terminations are provided, the nose shape of the filter response curve is good --- though not as good as multi-section I-F transformers. A resistor is often used across the input terminals and across the output terminals to stabilize the loading. The input and output circuits must be tuned for proper matching, rather than for resonance, to obtain minimum ripple on the response curve nose. For this reason, these circuits should be aligned by the sweep method, so that the serviceman can actually watch the nose shape change as he tunes the circuits.

MECHANICAL FILTERS

Because their cost is considerably higher than that of other types of filters, mechanical filters are not commonly used in two-way radio communications. These filters offer good adjacent-channel selectivity, but their sharp cut-off characteristic produces too much phase distortion and noise interference for good FM reception.

Chapter 2

HOW TO TELL WHEN I-F REALIGNMENT IS NEEDED

Servicemen should remember that I-F realignment is not normally required unless components have been replaced in an I-F filter. A possible exception would be slight adjustment of the Hi-IF to phase tune some receivers. Routine alignment should be confined to the RF, oscillator and multiplier stages.

REASONS WHY I-F REALIGNMENT MAY EVENTUALLY BECOME NECESSARY

As mentioned above, replacement of components in I-F tuned circuits usually makes I-F realignment necessary. Only rarely does the slow aging of components in tuned circuits change the bandwidth or the center frequency of the filters enough to require realignment.

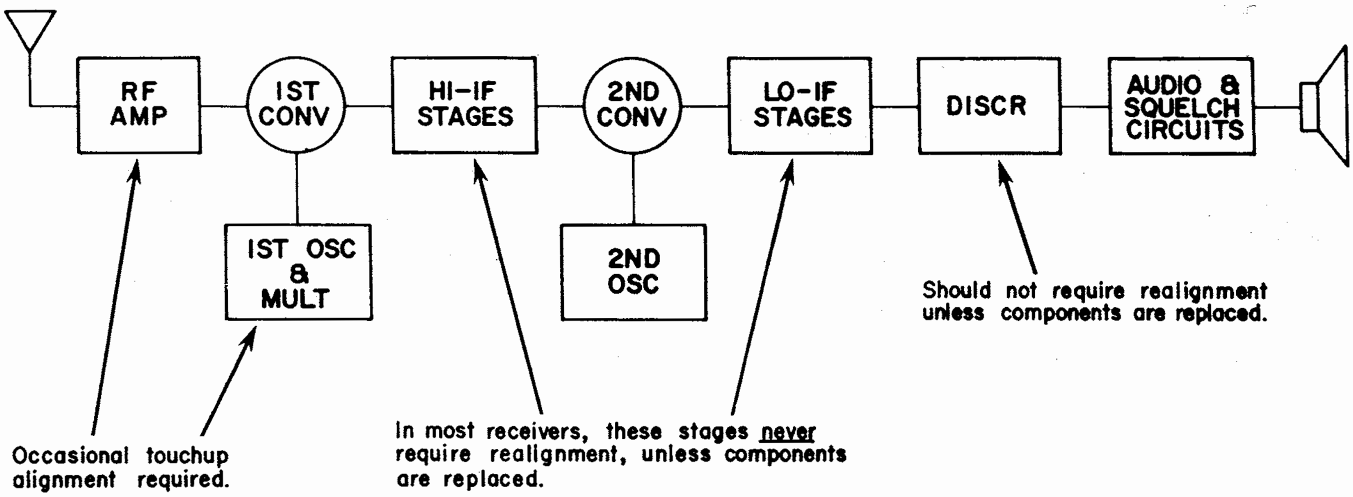


Fig. 13 - During routine maintenance, only the RF, oscillator and multiplier stages require occasional realignment.

Perhaps the most frequent reason for realigning a receiver is to correct the work of a "twiddler", who attempted realignment when it was not needed. Inexperienced servicemen are apt to confuse a number of different problems with misalignment, because they produce similar symptoms. By means of this bulletin, we hope to reduce the number of "twiddlers" and increase the number of knowledgeable servicemen.

Receiver modification sometimes makes realignment necessary. Converting a receiver from wide band to narrow band operation, for instance, usually necessitates realignment.

Sometimes, crystal aging causes injection to be too far off frequency for the crystal trimmer to bring a receiver back on frequency. Rather than replace the crystal, some servicemen elect to move the IF's to place the receiver on frequency again. If checked against an I-F standard later, of course, this receiver would appear misaligned.

SYMPTOMS OF MISALIGNMENT

Receiver realignment is required if the I-F passbands are not centered on the incoming signal, if the passbands are not symmetrical, or if the bandwidth is too narrow or too wide. Servicemen should learn to recognize the symptoms which each of these problems produces. We will discuss these problems first, and then the other problems which are often confused with misalignment. To conclude the chapter, we will describe tests servicemen can use to determine if realignment is needed.

I-F Passband Off Center Frequency

The most sensitive indication that a receiver's most selective I-F filters are not centered on the incoming signal is the presence of high impulse noise, heard with weak signals. This noise results when the ringing frequency of the filters is not centered on the discriminator center frequency. The mechanics of impulse noise are discussed on pp. 23 and 24 of DATAFILE Bulletin No. 10002-2, "RFI in Two-Way FM Radio Systems".

Off-frequency filters may also produce a high discriminator idling reading. The idling reading is the DC reading at the discriminator jack with a resistive load connected to the receiver input (antenna disconnected). Any thermal noise or oscillator noise which gets thru the I-F passbands is detected by the discriminator. If this noise energy is centered on the discriminator, the discriminator reading (which averages the individual noise spikes) will vary around zero (left half of Figure 14). If the most selective I-F filters are not centered on the discriminator, the noise reaching the discriminator will be off-center, producing a positive or negative discriminator reading (right half of Figure 14).

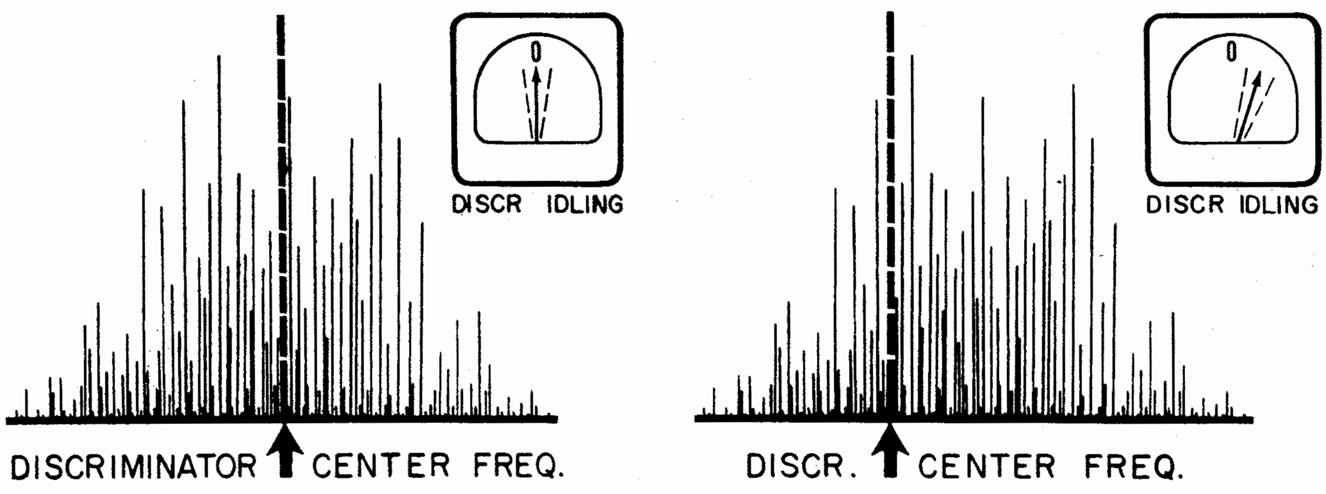


Figure 14 - Discriminator idling is a good indication of whether the receiver's Lo-IF passband is centered on the discriminator.

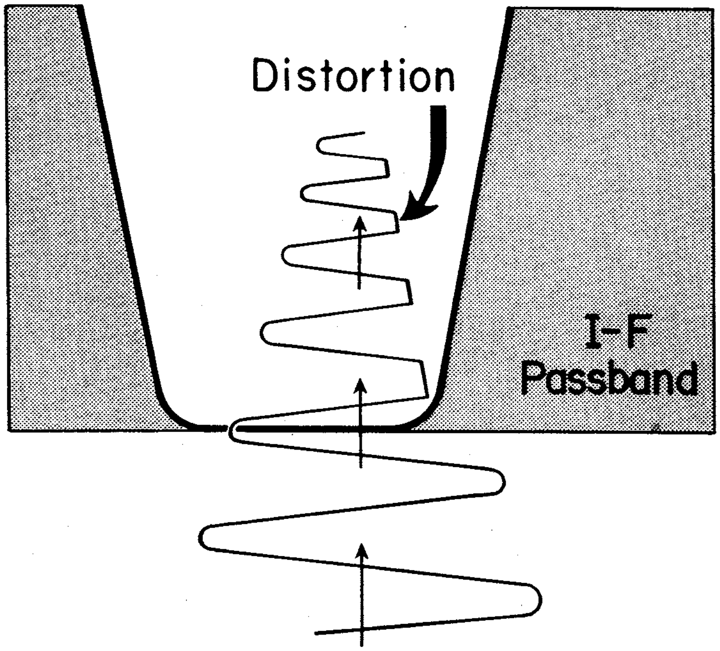


Figure 15 - Distortion results when desired signals hit the side of the I-F passband.

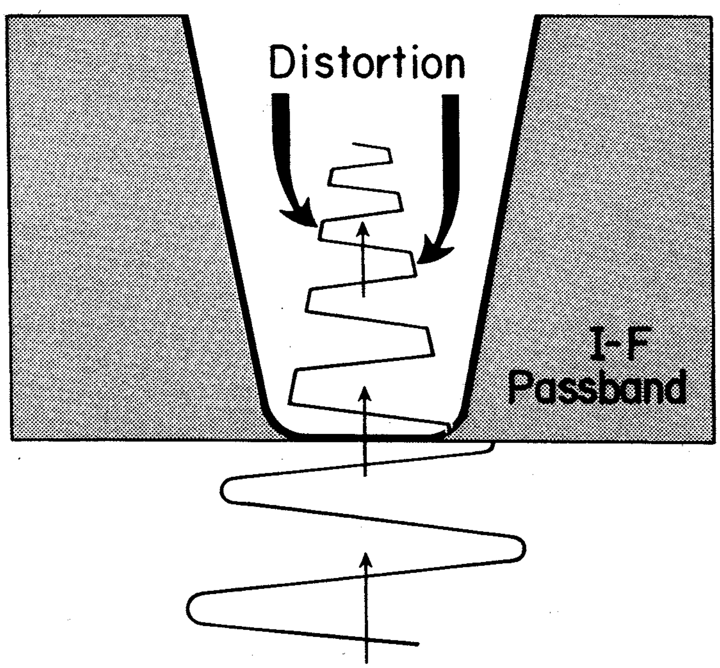


Figure 16 - Distortion can result if the receiver bandwidth is too narrow.

Discriminator idling is a better indication of misalignment in receivers having their most selective circuits in the Lo-IF (such as Progress Line or TPL receivers) --- than in receivers having selectivity concentrated in their Hi-IF (such as MASTR Professional receivers). The Lo-IF in MASTR receivers can be farther out of line (producing a higher discriminator idling) without appreciably degrading receiver performance.

If the receiver's most selective filters are badly off center frequency, as in Figure 15, one side of desired signals will be clipped on modulation peaks. Voice peaks will sound distorted. If the distortion is severe enough, the noise amplifier may recognize the distortion as noise and cause the squelch circuit to operate, producing squelch clipping on voice peaks.

If the receiver's less selective filters (such as the Hi-IF filters in Progress Line receivers or the Lo-IF filters in MASTR Professional receivers) are off center frequency, distortion or clipping will not result, but a loss of sensitivity will be apparent. Poor 20-db quieting sensitivity is not an indication of I-F misalignment, because the test signal used to measure this characteristic does not approach peak modulation. Poor SINAD sensitivity, however, may be an indication of misalignment.

Limiter readings in receivers which are properly aligned usually decrease slightly on voice peaks. If a receiver's I-F filters are badly off frequency, the limiter readings follow the voice peaks.

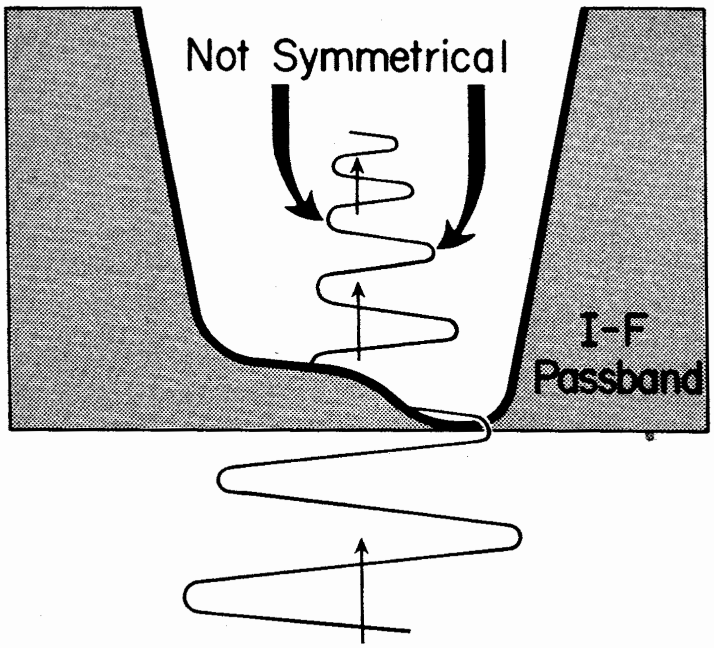


Figure 17 - Even if the signal is centered in the passband, a non-symmetrical passband will distort the signal.

Bandwidth Too Narrow

Receivers with inadequate bandwidth may show symptoms similar to receivers with I-F passbands off-frequency: distortion, squelch clipping, and limiter readings which follow voice peaks. As shown in Figure 16, both sides of voice peaks are clipped as they hit the sidewall of the I-F passband.

Bandwidth Too Wide

Adjacent-channel interference ("monkey-chatter") may result if the receiver's bandwidth is too wide. This will usually be accompanied by a high discriminator reading, indicating the presence of off-frequency signals.

Passband Not Symmetrical

High impulse noise may result if the receiver's passband is not symmetrical. If severe enough, distortion may be apparent (Figure 17). Since the noise in one half of the passband will not balance out the noise in the other half, a high discriminator idling voltage will be noted.

FALSE INDICATIONS OF MISALIGNMENT

Table 1 lists the symptoms of misalignment discussed in the preceding section. Servicemen must remember, however, that there are many other common problems which are more apt to produce these same symptoms. We have listed some of them in Table 1. Over-modulation, for instance, may produce distortion and clipping on voice peaks. These same symptoms may also result if the transmitter or the receiver is off frequency or if the squelch circuit is not operating properly.

Therefore, a serviceman should always make tests to be certain that a receiver is actually misaligned before attempting realignment. Otherwise, there is a good chance that performance of the receiver will be degraded, rather than improved.

TESTS TO SEE IF REALIGNMENT IS NEEDED

Distortion and squelch clipping on voice peaks are the two symptoms of misalignment servicemen are most apt to notice. Although high impulse noise is a very sensitive indication of misalignment, it is not a conspicuous symptom because of the noise normally heard with weak signals. Most servicemen would assume that the noise was due to an unusually noisy vehicle or to some other source of noise.

The following procedure for determining if realignment is needed is summarized in Figure 18. Study the figure after you have read this discussion. It indicates what should be going on in a serviceman's mind as he decides whether or not to realign a receiver.

1. Check Netting

Since most of the symptoms listed in Table I could result from off-frequency operation, the first step is to check the discriminator reading on a steady signal to see that the transmitter and receiver are tuned to the same frequency.

2. Check Other Receivers

Over-modulation will also produce many of the symptoms in Table I. However, these symptoms would then appear in other receivers in the

Table I - PROBLEMS FREQUENTLY CONFUSED WITH MISALIGNMENT

Symptom of Misalignment	Other Problems Producing this Symptom
Distortion on voice peaks	• Distortion in almost any transmitter or receiver circuit • Transmitter over-modulating • Transmitter or receiver off-frequency
Squelch clipping on voice peaks	• Transmitter over-modulating • Transmitter or receiver off-frequency • Faulty squelch circuit
Poor SINAD sensitivity	• Defective R-F, I-F, or audio circuit in receiver.
High impulse noise	• Noisy environment (ignition noise, etc.)
High discriminator idling	• Improperly aligned discriminator • Poor ground on meter
Limiter readings follow voice peaks	• Receiver or transmitter off frequency • Defect in transmitter modulator
Adjacent-channel interference	• Many types of interference (intermodulation, spurious response, etc.)

system. Be sure to check, therefore, to see if any other receivers have been experiencing the same symptoms.

3. Check Sensitivity

Check the SINAD sensitivity of the receiver to be sure that the front end is properly aligned and that the gain thru the receiver is satisfactory. If the sensitivity is poor, realign the front end of the receiver and check the sensitivity again. If it is still poor, make gain measurements thru the receiver to be sure that some component is not at fault, before attempting I-F realignment.

4. Check Discriminator Idling

Next, check the discriminator idling, with a resistive load at the antenna jack (antenna disconnected). The easiest way to do this is to connect the receiver to a signal generator, with the generator's output reduced to zero and set off-frequency. If the idling reading fluctuates around zero, it indicates that the Lo-IF ringing frequency is centered on the discriminator center frequency. It does not mean that the Lo-IF or the discriminator are aligned exactly on 290 KC or 455 KC, but that they are aligned to the same frequency. If one of them is off, they both are off.

It is not essential that the Lo-IF and the discriminator be aligned exactly on 290 KC or 455 KC, as long as there is sufficient first oscillator trim to center the RF signal in the I-F passband. It is important that they be centered on the same frequency, so that on-frequency signals will produce a zero discriminator reading.

The actual idling voltage read will depend upon the type of meter used, the bandwidth of the receiver, and whether the receiver has been phase tuned. Failure to phase-tune properly is a good indication that the receiver's Lo-IF is misaligned.

Table II gives the maximum idling readings for most GE two-way FM receivers. If the idling is too high, you know that the Lo-IF and the discriminator center frequencies are not lined up with each other.

5. Check Discriminator Frequency

If the idling is found to be too high, determine whether it is the Lo-IF or the discriminator which is off-frequency. This can be readily done by checking the discriminator with an I-F frequency standard (such as I-F Generator EX-7-A). If the discriminator is off frequency, retune it and recheck the idling.

If the discriminator is on frequency, you know that the Lo-IF and/or the Hi-IF is misaligned. If the receiver's major selectivity is in the Lo-IF (Progress Line, TPL, Porta-Mobil or Accent 450), align the Hi-IF if the idling is only slightly high. Align both the Lo-IF and the Hi-IF if the idling is very high. If the receiver's major selectivity is in the Hi-IF (MASTR Professional or Executive), realign the Lo-IF, the Hi-IF, and the discriminator.

6. Check Discriminator on Carrier

If the discriminator idling is within the limits indicated in Table II, feed a signal known to be on frequency into the receiver. If the discriminator reading is not within the limits specified in the maintenance manual for the receiver, adjust the first oscillator for a zero reading. You now know that the IF's and the discriminator are lined up properly. The only remaining question is whether the receiver's bandwidth is correct.

7. Check Modulation Acceptance

Using the standard test procedure described in the GE Test and Troubleshooting Handbook (ECP-165), determine the receiver's modulation acceptance bandwidth. Be sure that your signal generator deviation is calibrated accurately. Check it against your modulation monitor if you are not certain. If the bandwidth of the receiver is too narrow or too wide, realign both the Lo-IF and the Hi-IF.

Table II - MAXIMUM PERMISSIBLE DISCRIMINATOR IDLING READINGS

Type of Receiver	Discriminator Idling Reading	
Progress Line	On VTVM	On 20K-Ohm Voltmeter*
25—54, 72—76 & 130—174 MC	±0.6 volt	±0.2 volt
406—420 and 450—470 MC ...	±1.0 volt	
Progress Line Portables	±10 microamperes	
TPL and Business Mate	±10 microamperes	
General Electric Pacer	±0.7 volt on 20K-ohm voltmeter*	
Accent 450	±0.8 volt on VTVM	
Message Mate	±5 microamperes (squelch disabled)	
Voice Commander, Voice Director	1.25 volts on VTVM (1.0 volt for 25—54 MC receiver ER-34-A)	
Porta-Mobil & Motorcycle	±0.8 volt on VTVM (±0.12 volt on 20K-ohm voltmeter*)	
MASTR Professional Series		
Narrow Band	±.06 volt on 20K-ohm voltmeter*	
Wide Band	±.10 volt on 20K-ohm voltmeter*	
MASTR Executive Series	±0.8 volt on VTVM (±0.12 volt on 20K-ohm voltmeter*)	

*Such as GE Test Set EX-1-C, EX-1-D, EX-3-A or EX-8-K.

A rough measurement of bandwidth can be made by applying a weak signal (1 microvolt) on the receiver frequency and gradually increasing the modulation to the point at which audio output stops increasing --- or until audio distortion begins to increase drastically. (The VOLUME control setting must be reduced to keep the audio output below rated power.) The deviation at this point is the approximate receiver bandwidth and should be one or two KC more than the permissible transmitter modulation. For narrow band, the bandwidth should be ±6—7 KC and for wide band, ±16—17 KC.

8. Double-Trace Sweep Examination

Another useful test, which can be used in place of some of those described above is to examine a double-trace sweep of the receiver's passband on an oscilloscope. This procedure (described in Chapter 3) will immediately show if the passband is unsymmetrical or off-frequency. To a technician familiar with alignment of the particular receiver under test, it may also show if the passband is too wide or too narrow.

Summary

The alignment of a receiver which passes the above tests should be more than adequate for good reception. Each of the requirements for good alignment has been met:

- The receiver has adequate sensitivity.
- The Lo-IF and discriminator center frequencies are aligned with each other.
- On-frequency signals fall in the center of the discriminator.
- The bandwidth of the receiver is correct.

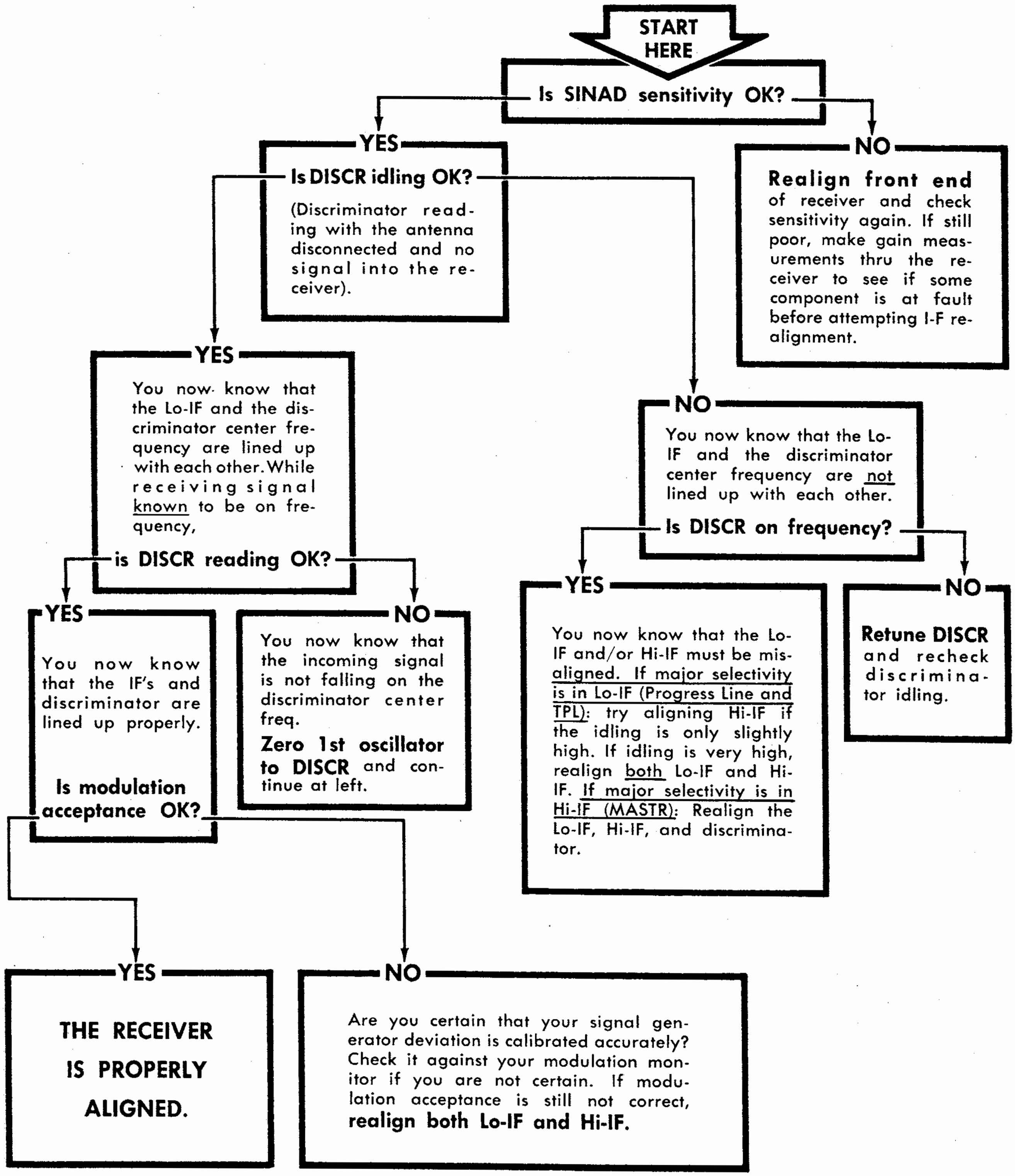
If the receiver still exhibits symptoms of misalignment, look for some other cause for the problem.

HOW TO TELL WHEN I-F REALIGNMENT IS NEEDED

Check to see that other receivers are not experiencing the same problem. Then check to see that the symptoms of misalignment are not due to:

- Receiver off frequency
- Transmitter off frequency
- Transmitter over-modulating

After eliminating these possibilities, make the following tests:



Chapter 3

ALIGNMENT PROCEDURES

Receiver alignment should not be attempted unless it has definitely been determined, as described in Chapter 2, that the receiver is actually misaligned. Misalignment is only one of the problems which can produce such symptoms as loss of sensitivity, squelch clipping, distortion, and high response to impulse noise. The presence of one or more of these symptoms is not proof that alignment is needed. Remember --- I-F circuits do not normally require realignment. Realign IF's only when you are sure it is needed.

> In other words,
>
> Think before you twiddle! It'll save your valuable time!

Don't touch any tuning adjustment until all test equipment required to perform the alignment is available. Be certain that the test equipment is in good working order and properly calibrated.

To assure a good alignment, it is absolutely necessary that you use great care and continually recheck your work. Otherwise, receiver performance may be degraded, instead of improved.

GENERAL ALIGNMENT INFORMATION

Before aligning any FM receiver, set the input voltage to the standard operating voltage specified in the receiver maintenance manual. Allow the receiver to warm up to room temperature. Tubed receivers and signal generators need time after power is applied for their circuits to stabilize. Half an hour should be sufficient for a tubed receiver, but the signal generator may require several hours.

In receivers provided with AFC or AGC, disable this function during alignment if the test signal is applied at the operating frequency. This can be done by shorting the AFC or AGC voltage to common. The circuit need not be disabled if the test signal is injected at an I-F frequency.

Throughout the alignment, check the test signal frequently to:

1. Keep the test signal on frequency.
2. Keep the test signal below limiting.

The frequency of any signal generator used to align a receiver must be frequently checked throughout the alignment and readjusted if it drifts off frequency. In FM receivers, this can be easily done by keeping the generator frequency "zeroed" to the discriminator --- once the discriminator has been set on frequency. Remember to remove the modulation while checking the signal frequency. Heavy modulation may move the discriminator reading off zero. When using the sweep method of alignment, a marker generator can also be used to check the signal frequency.

The input signal level must be kept below that which produces limiting at the point used for metering. Otherwise, the proper peak or scope trace will not be seen as each circuit is tuned. Some stages in FM receivers may limit even with no signal present. If it is necessary to meter at a point which limits on noise, reduce the gain until the metering point is below limiting.

One way to reduce gain is to remove an RF amplifier tube or transistor, substituting a capacitor from grid to plate (or from base to collector). Another method is to temporarily connect a low value resistor from grid to ground (or from base to common) in a preceding untuned stage. Removing a tube from a 6/12-volt tubed receiver operating from 12 volts, however, would produce filament unbalance. A small resistor from grid to ground could be used in this case to reduce gain.

A better way to solve the limiting-on-noise problem is simply to select a metering point closer to the front of the receiver --- a point which does <u>not</u> limit. This will usually require the use of a metering probe, such as the one shown in Figure 33.

As alignment progresses, gradually reduce the test signal level to avoid limiting. Check frequently to verify that the metering point remains below limiting, by increasing the signal level slightly. The meter reading should also increase. If it doesn't, the stage being metered is limiting. The test signal level or the gain must therefore be reduced or a new metering point must be used. If the meter is moved to a new test point, check to see that this point is below limiting.

Another way to see if the test point is below limiting is to note how an oscilloscope trace of the receiver's bandpass changes as the signal level is increased slightly. This is discussed later in this chapter.

Be very careful when tuning a circuit for a peak or dip indication on a tuning meter. Remember --- no meter can react instantly to voltage changes at the metering point. <u>You can't rush a tuning meter!</u> If you tune rapidly, the needle will lag behind the actual voltage reading and may overshoot the resonant point.

When your tuning meter shows that you are approaching a peak or dip, s-l-o-w d-o-w-n, so that the meter movement can closely follow your tuning. Tune past the resonant point. Then tune slowly back and forth across the resonant point several times in progressively smaller arcs until you are sure you have found the exact center of the peak or dip. Remember that even a small error in tuning each of the resonant circuits in a receiver may have a significant effect on the overall alignment.

PEAKING METHOD

The peaking method for aligning I-F filters consists of injecting an unmodulated on-frequency signal ahead of the circuit to be tuned and then tuning for a maximum meter reading (peak) at the grid or base of a following stage. The undercoupled or critically-coupled tuned circuits used in the RF stages of many receivers are normally tuned by this method, because the peak can be readily seen on a meter. Many receivers also have critically coupled I-F stages (usually Hi-IF stages) which can be peaked. For tuning the most selective I-F filters, however, the peaking method is unsatisfactory.

Although the peaking method is simple, quick, and requires a minimum of test equipment, it should never be used for aligning overcoupled I-F circuits or crystal filters. These circuits provide the necessary bandwidth and sharp selectivity required in two-way FM communication systems. Since they do not have a sharp peak that can be seen on a tuning meter, only special tuning procedures, such as the three that follow, can be used.

PEAK AND DIP METHOD

When a parallel-tuned circuit is resonated, the RF voltage across it increases to a large value. By injecting an on-frequency signal into the 6-coil I-F transformer shown in Figure 19, and connecting an AC VTVM (or an oscilloscope) as shown, coil L1 can be tuned for a peak meter reading if the effect of subsequent coils is eliminated by shorting coil L2.

If the short across L2 is now moved to L3 and L2 is tuned, L2 will draw energy from L1 when it resonates. This will appear as a dip on the meter. Next, the short is moved to L4 and L3 is tuned for the peak produced by the energy it reflects back to L1 at resonance. Similarly, L5 is shorted while L4 is tuned for a dip and L6 is shorted while L5 is peaked. Finally, L6 is tuned for a small dip with no coils shorted. This dip may be difficult to see (particularly on narrow band Progress Line receivers).

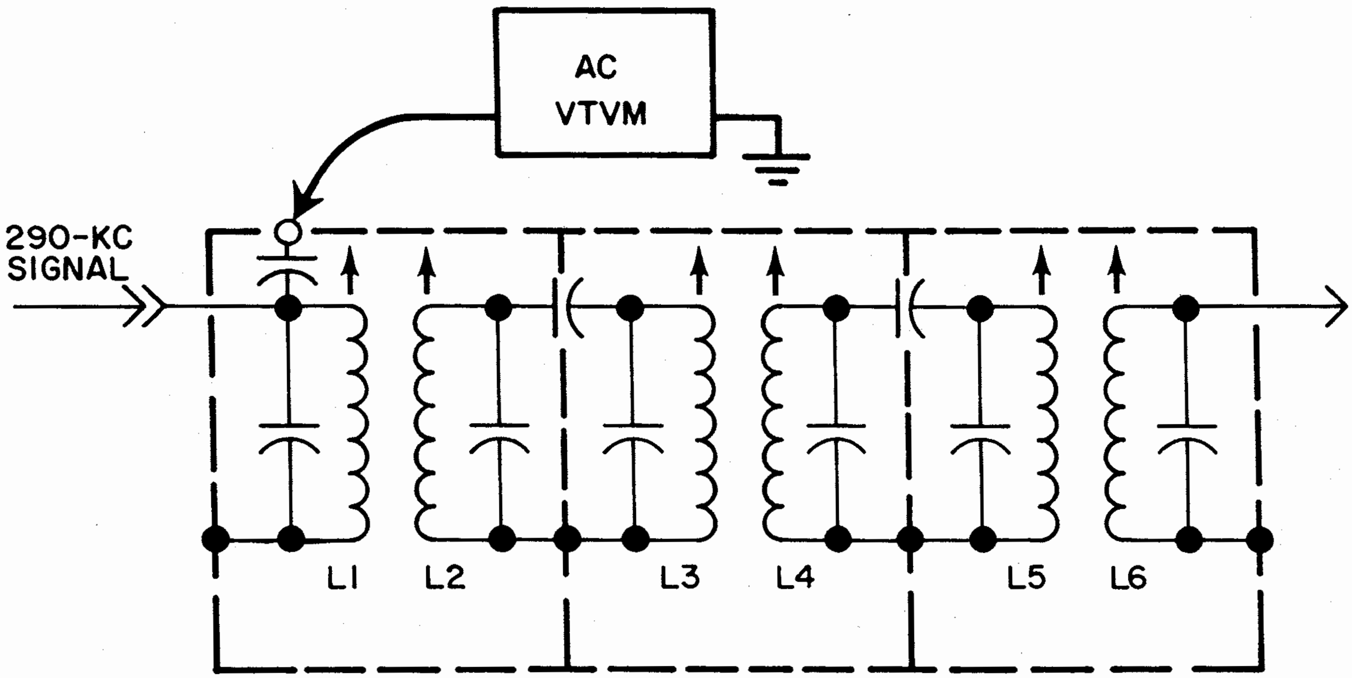


Figure 19 - Test setup for aligning a 6-coil Progress Line Lo-IF transformer by the peak and dip method

A 100-pf capacitor is built into Progress Line 6-coil transformers for connecting the meter to L1 (see Figure 19). The metering point is accessible thru the small hole beneath the tuning slug for L1. To prevent the probe capacity from detuning L1 any more than necessary, use a low-capacity probe or use a 1/2 to 1-megohm resistor (with short leads) in series with the probe. If it is more convenient, the meter can be connected to the plate of the stage feeding L1, using a small blocking capacitor (100 pf or smaller).

After completing the peak and dip tuning, the tuning of L1 can usually be improved slightly by loading L2 with a resistor (100K ohms for narrow band Progress Line receivers or 68K ohms for wide band Progress Line receivers) and tuning L1 for maximum first limiter reading. This adjustment compensates for the capacity of the meter probe used for peak and dip tuning. If possible, check the alignment of the filter by sweeping it and adjusting the coils slightly for the best scope trace. This procedure is described later in this chapter.

The peak and dip method has good accuracy and is reasonably fast. Only a signal source and an AC VTVM (or oscilloscope) are required. An on-frequency transmitter can be used as the signal source. If an AC meter is not available, a microammeter and diode may be substituted.

RESISTOR-LOADING METHOD

The resistor-loading method is also used for aligning overcoupled circuits. Figure 11 shows how the response of an I-F transformer changes with the loaded Q of its resonant circuits. The response can be easily changed, therefore, by loading one of the coils with a resistor. Using the resistor-loading method, a resistor is temporarily connected across one coil to change its response to just below critical. Undercoupled coils, you remember, can be tuned by the simple peaking method previously described. If the coil being tuned is coupled to a coil on each side of it, both of the adjacent coils must be loaded.

The value of the loading resistors is chosen to produce coupling slightly less than critical. A tolerance of ±10% is usually adequate. Too high a resistance does not reduce the coupling enough to give a sharp peak. Too low a resistance produces a broad peak which is also difficult to tune precisely and is off frequency when the load is removed.

Alignment by the resistor-loading method is accomplished by injecting an on-frequency signal into the receiver or into the I-F transformer, metering at the first limiter, and peaking one coil at a time with the adjacent coils loaded. The entire alignment should be repeated to correct any errors which have been made and to improve the alignment of the I-F transformer slightly.

The resistor-loading method is probably the least subject to operator error. Although it is somewhat more involved than the peak and dip method, slightly better results can be obtained if the operator is careful to observe detail. Careless tuning will result in improper tuning. Watch for these potential pitfalls:

1. The test signal must remain on frequency (zero discriminator).
2. The test signal must be kept below limiting.
3. The loading resistors must make good contact and their leads must be kept short to introduce minimum stray capacitance.
4. Each circuit must be carefully tuned to the exact peak.
5. The entire alignment must be repeated.

SWEEP METHOD (OSCILLOSCOPE ALIGNMENT)

Although the sweep method of I-F alignment requires the most test equipment, it produces the most accurate alignment. The following equipment is used:

1. FM signal generator which can be externally modulated (such as the Measurements 560 or the Boonton 202)
2. Sweep modulator or sawtooth generator (can be constructed as described in the Appendix)
3. Oscilloscope
4. VOM or VTVM
5. Audio oscillator (optional for double-trace method)
6. Marker generator (if single-trace method is used)

Most mobile radio service shops have the test equipment required for sweep alignment --- with the possible exception of the sweep modulator or sawtooth generator. These units can be easily contructed, as described in the Appendix. Almost any oscilloscope in good operating condition is adequate for sweep alignment.

To sweep align a receiver, the serviceman first applies a test signal ahead of the I-F circuit to be aligned, zeroes the signal to the discriminator, and then frequency modulates (sweeps) the signal at an audio rate. The deviation must exceed the I-F bandwidth. For convenience, 60 cps is sometimes used as the modulating frequency. If possible, however, a 20-cps sweep should be used --- particularly for receivers with crystal filters. The oscilloscope displays the output of the I-F circuit and the serviceman aligns the tuned circuits so that a particular pattern (trace) is obtained on the scope.

The first limiter metering jack normally provides the vertical input signal for the scope. At other points in the receiver, an RF probe may be used to obtain input for the scope.

Since the test signal injected into the receiver has a constant amplitude, while its frequency sweeps back and forth across the receiver's passband, the scope display is a graph showing signal frequency versus receiver first limiter current (with the signal below limiting). This display is shaped by the receiver's selective circuits, producing a complete picture of the receiver's selectivity between the injection point and the metering point. As an I-F filter is tuned, the scope trace immediately shows how the receiver's response curve has been affected.

Double-Trace Sweep Alignment

The I-F filters of FM receivers are usually aligned so that their response curve is symmetrical. This can be easily done by synchronizing the scope at twice the modulating frequency, producing two overlapping traces (double trace) on the scope. One trace shows the response as the I-F filter is swept from below its center frequency to above its center frequency. The other trace shows the response when swept from above to below. One trace is simply the reverse picture of the other. This makes it particularly easy to align a receiver so that its response is symmetrical --- by simply tuning the I-F filters so that the two traces coincide.

Trace coincidence does not necessarily indicate perfect alignment. The I-F filters must also be tuned for maximum gain (maximum trace height). If it is necessary to sacrifice gain to obtain coincidence, the peak and dip method should be used first to bring the tuned circuits close to alignment and then the alignment should be completed using the sweep method.

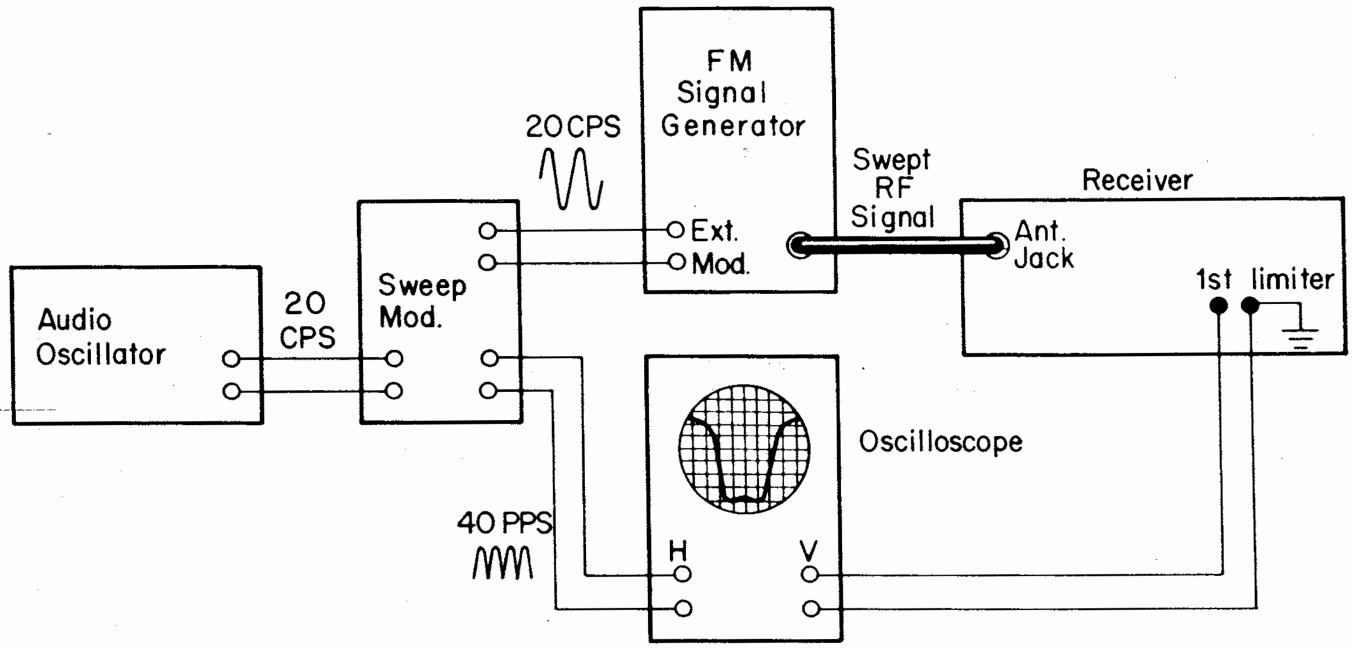


Figure 20 - Test setup for 20-cps double-trace sweep alignment

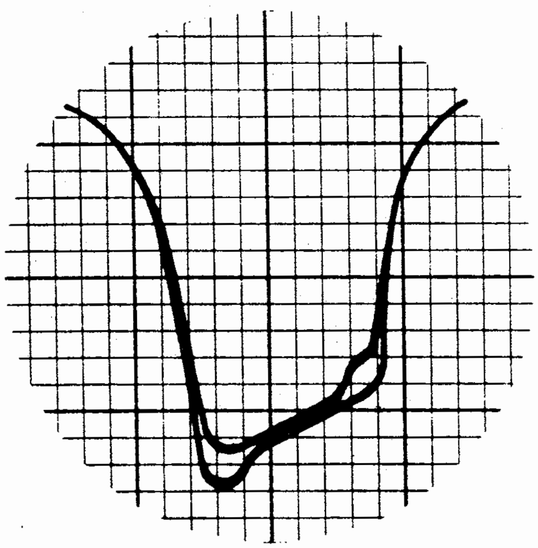


Figure 21 - Note that the noses of both traces slope in the same direction, indicating the sweep rate is too high.

The construction of a simple sweep modulator is described in the Appendix. Using the 20-cps output of an audio oscillator, the sweep modulator provides an adjustable 20-cps signal to modulate the FM signal generator and a 40-pps sync for the oscilloscope. Figure 20 shows the test setup for double-trace sweep alignment. The sweep modulator also provides a means of adjusting the phase and polarity of the sync pulse.

If too high a sweep rate is used, a trace similar to that shown in Figure 21 will be obtained. Note that the noses of both traces slope in the same direction. This slope is caused by the first limiter time constants in the receiver and indicates that the sweep rate should be reduced. Sweep rates as high as 60-cps could be used for aligning most older receiver models. Newer models, particularly those using Hi-IF crystal filters, require lower sweep rates. The 20-cps test set-up shown in Figure 20 should work well for all current receivers.

Single-Trace Sweep Alignment

If the same audio frequency used to modulate the signal generator is also used for the horizontal input to the scope, a single trace will be produced which shows the receiver's bandpass swept in one direction only. Single-trace alignment requires the use of additional equipment to center the receiver passband on the receiver center frequency. Figure 22 shows the test setup. A marker generator (a signal generator with good stability) is used to provide a marker on the scope display which can be used as a reference frequency. Markers provide an excellent way of detecting frequency drift.

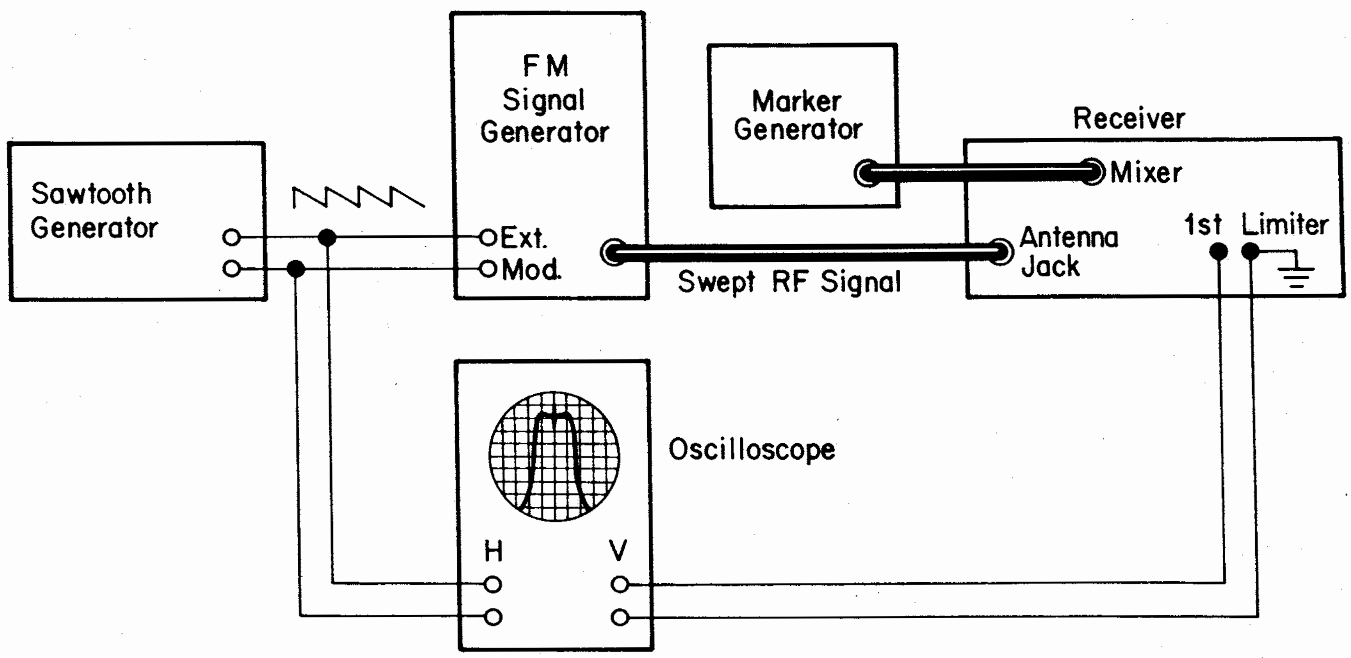


Figure 22 - Test Setup Used for Single-Trace Sweep Alignment

The marker generator provides an I-F signal which is fed into the 1st mixer (Hi-IF marker) or 2nd mixer (Lo-IF marker). The zero beat produced by the marker frequency and the test signal appears on the scope as a pip, showing the center frequency of the circuit being tuned. By keeping the nose of the trace centered around the pip and tuning for a symmetrical pattern, the I-F filters can be aligned on frequency (Figure 23). As with the double-trace method, gain must not be sacrificed to obtain a good scope pattern. If necessary, use the peak and dip method first to bring the tuned circuits close to alignment.

The single-trace sweep does not show trace distortion caused by time constants as obviously as the double-trace does (Figure 21). It is important, therefore, to use a slow sweep (20 cps or less). The sawtooth generator described in the Appendix can be constructed for this purpose. Another advantage of using a slow sweep is that the marker pip appears sharper on the scope display.

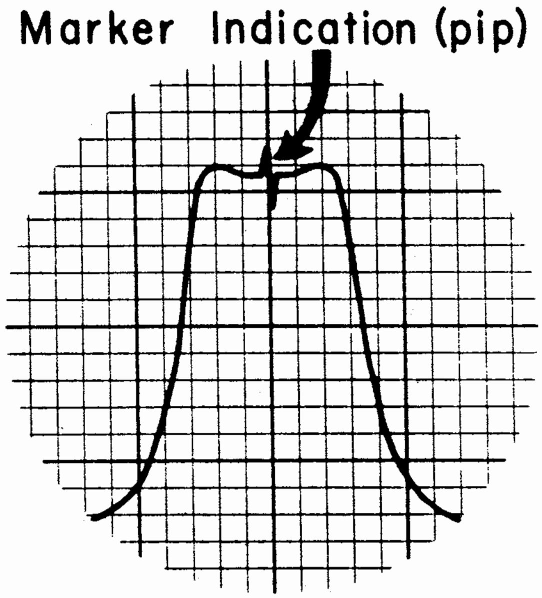


Figure 23 - When using a marker generator for symmetrical alignment of an I-F circuit, keep the nose of the curve centered around the pip.

For aligning receivers with Hi-IF crystal filters, a Hi-IF marker is useful. Some RF signal generators are available which can be used if they are set by means of a frequency counter. Some marker generators for broadcast FM receivers have crystal-controlled frequencies which can also be used. If desired, an oscillator similar to the second oscillator in most two-way radio FM receivers can be constructed for use as a marker generator. (The transistorized oscillator in Porta-Mobil Receiver Type ER-44-A works particularly well.) Most crystal manufacturers can supply crystals at the desired Hi-IF for use in the oscillator. To align a Hi-IF filter, the marker frequency is usually injected at the 1st mixer and the scope input is obtained at the 2nd mixer by means of a detector probe. After tuning the Hi-IF, the scope input is connected directly to the LIM-1 jack for aligning the Lo-IF.

I-F Generator EX-7-A provides crystal-controlled 290-KC and 455-KC signals which can be used as markers for aligning receivers having their major selectivity in the Lo-IF. The marker is usually injected at the 2nd mixer and the scope input is obtained at the LIM-1 jack.

A transmitter on the receiver operating frequency can also be used as a marker generator, if adjusted to produce an accuracy within ±100 cps at the discriminator. The marker is injected at the front end of the receiver, along with the sweep generator signal, and the scope is connected at the stage immediately following the filter being aligned. Whenever possible, the generator having the lowest useable marker frequency should be used, because it usually has the best frequency stability.

Test Signal

For sweep alignment, the swept test signal is applied at some point ahead of the circuit being tuned. If a swept Lo-IF or Hi-IF signal is not available, a swept signal at the receiver operating frequency can be used. Since frequency drift is usually greatest at higher frequencies, use the lowest available swept frequency source. The test signal must be kept zeroed to the discriminator and must be kept below limiting.

Use a meter at the discriminator to keep the test signal on frequency. Remove the modulation occasionally throughout the alignment to see that the signal remains zeroed to the discriminator. Check to see that the signal generator does not shift frequency when modulation is applied. This can be easily done by watching the discriminator meter and increasing the modulation. The discriminator is a good indicator of center frequency up to rated system deviation. If no shift is observed up to this point, the generator is reasonably symmetrical.

The scope trace can be used to determine if the test signal is below limiting. Below limiting, the nose of the trace moves up and down as the signal level is adjusted slightly, but does not change shape (Figure 24). Beyond saturation, the nose of the trace flattens out and details on the nose disappear as the signal level is increased slightly (Figure 25). On some receivers, the gain (trace height) may decrease slightly as the signal is increased.

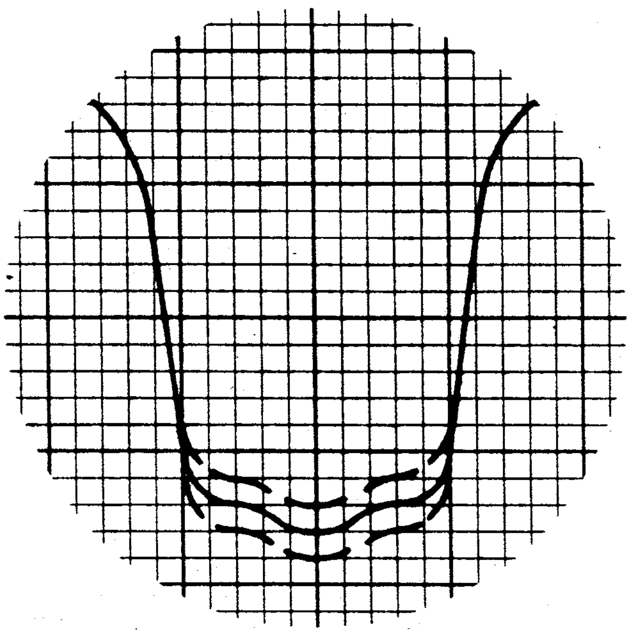


Figure 24 - Below limiting, note how nose moves up and down (but does not change shape) as signal level is adjusted slightly.

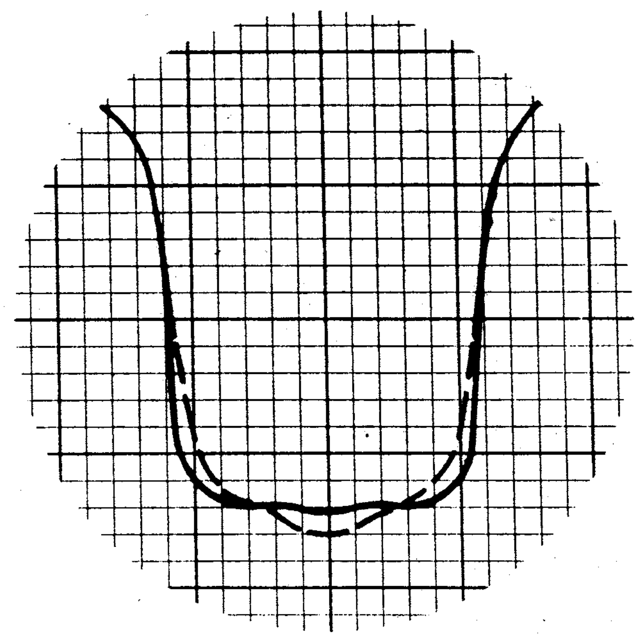


Figure 25 - Beyond saturation, note how nose flattens out as signal level is increased. Gain may actually decrease.

As a general rule, the modulation required to sweep align a circuit is approximately twice the expected bandwidth of the circuit. For the most selective circuits, therefore, ±14—16 KC is required for narrow band receivers and ±30—50 KC for wide band receivers. If too little modulation is used, only the nose of the selectivity curve will appear on the trace, and not the skirts which also contribute to misalignment. Excessive modulation is also undesirable, because it removes details of the trace.

Any tuned circuit can be tuned by sweep alignment, limited only by the capability of the test equipment available. Naturally, RF stages would require a signal generator with a very wide sweep range, as well as a very sensitive oscilloscope. Since RF stages (and Hi-IF stages in receivers without Hi-IF crystal filters) can be easily tuned by simple peaking, however, sweep alignment is not normally used.

NOTE

When using the Measurements 560 signal generator, additional sweep range can be obtained by switching the modulation selector to a lower frequency scale than the frequency range selector. Over 100 KC of deviation can be obtained on the 400—470 MC range (band "E"), for instance, with the modulation selector in position "A". Use extra care to keep the signal on frequency.

Another useful (though expensive) piece of test equipment for sweep alignment is the Hewlett-Packard (formerly Boonton) Univerter Model 207. This unit is a converter with a stable 150-MC local oscillator which can be used to beat against an FM signal generator (such as the M560) to provide a test signal from 100 KC to 55 MC. The signal generator must provide a frequency equal to the desired output plus 150 MC. By modulating the signal generator with a sweep modulator or sawtooth generator, swept I-F signals can be generated for single-trace or double-trace sweep alignment.

DISCRIMINATOR ALIGNMENT

Discriminator alignment is always included in a complete receiver alignment. In fact, the alignment of the discriminator transformer should be checked before concluding that a complete I-F alignment is needed. This is the reason for including the following discriminator alignment information in this bulletin --- even though the discriminator is actually a detector circuit, rather than an I-F circuit.

Most General Electric two-way radio receivers use a Foster-Seeley discriminator circuit, such as the transistorized version shown in Figure 26. Except for Message Mate receivers (which use ratio detectors) the following discriminator alignment procedure can be used.

Equipment Required

Whenever possible, use a crystal-controlled I-F generator to align the discriminator. The test signal should be held within ±100 cps of the Lo-IF frequency.

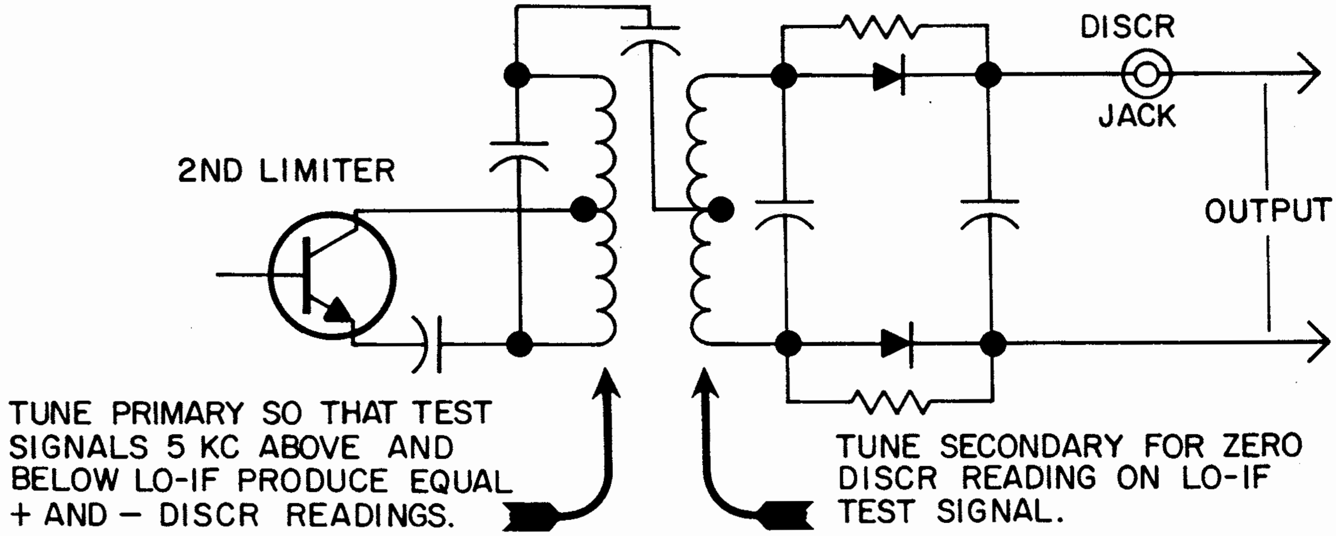


Figure 26 - Tuning procedure for a typical Foster-Seeley discriminator

1. I-F Generator Type EX-7-A (or a similar generator capable of supplying the Lo-IF frequency and frequencies 5 KC above and below the Lo-IF)

2. Test Set EX-3-A (or a 0—3 volt, 20K ohm-per-volt meter)

Procedure

1. Meter the discriminator circuit. If possible, disable the second oscillator to prevent extraneous signals or noise from interfering with the alignment.

2. Apply a Lo-IF signal to the input of the first limiter and adjust the signal level to saturate the second limiter.

3. If the discriminator is completely detuned, perform steps 3a. and 3b. If not completely detuned, go to step 4.

   a. Tune the secondary of the discriminator transformer so that the DISCR reading is almost zero. This will give you a small reading to watch while resonating the primary.

   b. Tune the primary for a peak DISCR reading.

4. Tune the secondary for zero DISCR reading.

5. Change the test signal to a frequency 5 KC above the Lo-IF and note the DISCR reading. Then change to a test signal 5 KC below the Lo-IF and note the DISCR reading. Now adjust the primary until the ±5 KC test signals produce equal positive and negative DISCR readings.

6. Repeat steps 4 and 5.

Chapter 4

TIPS FOR ALIGNING PARTICULAR G-E RECEIVERS

The information presented in this chapter for aligning General Electric two-way radio receivers will help servicemen who have not aligned a particular model before. The intermediate frequencies of the receivers are listed, the circuits providing adjacent-channel selectivity are pointed out, the modulation acceptance bandwidth is given, and alignment hints are presented. I-F sweep alignment procedures are provided for most of the receivers.

NOTE

> This bulletin does not provide complete alignment information for any receiver model. Always refer to the Bench Alignment Procedure in the receiver maintenance manual for complete details.

PRE-PROGRESS LINE RECEIVERS

Freq. Range	Model Number	Intermediate Frequencies	
		Hi-IF	Lo-IF
25—50 MC	4ER6A4—9, 4ER6C4—9 4ER7A4—6 4ES22A1—3, 4ES22C4—6 7484534-G3 thru -G5	6 MC	455 KC (4-coil)
72—76 MC	4ER8A1	6 MC	750 KC (3-coil)
152—174 MC	4ER21A1 4ES12A3 and 4ES12B3 4ES12C1 4ES13A3 and 4ES13B3 4ES16A2 and 4ES16B2 7484534-G1 and -G15	7.035 MC	455 KC (4-coil)
405—425 MC or 450—470 MC	4ER22A1 and 4ER22A2 4ES14A1 7668326-G1 and -G2	48 MC and 3.2 MC	290 KC (6-coil)

Servicemen will encounter very few 3-coil Lo-IF receivers still in commercial service, now that the conversion to narrow band technical standards has been completed. Many Pre-Progress Line receivers using 4-coil Lo-IF transformers are still in use. These receivers all have their most selective circuits in the Lo-IF stages. The second limiter must be used for metering on these receivers, but this stage saturates on noise. Therefore, the gain must be reduced as described in Chapter 3 before using this jack for alignment.

The 450—470 MC Pre-Progress Line receiver is a triple-conversion receiver and was the first to use the 6-coil, 290-KC Lo-IF transformer later used in Progress Line receivers. Refer to the Progress Line alignment techniques which follow for aligning these transformers. The Bench Alignment Procedure for this receiver includes sweep alignment information. Be sure to allow sufficient time for this receiver to warm up to room temperature. Disable the AFC circuit before alignment.

PROGRESS LINE RECEIVERS

Type Number	Freq. Range	I-F Frequencies		Modulation Acceptance Bandwidth	Max. Discr. Idling (VTVM)
		Hi-IF	Lo-IF		
ER-24-A	25—54 MC	3.2 MC	290 KC	± 6.5— 9.0 KC	±0.6 volt*
ER-24-B	25—54 MC	3.2 MC	290 KC	±14.5—16.5 KC	±0.6 volt*
ER-24-C	30—54 MC	3.2 MC	290 KC	± 7.5—10.5 KC	±0.6 volt*
ER-25-A	144—174 MC	8.7 MC	290 KC	± 6.5— 8.0 KC	±0.6 volt*
ER-25-B	144—174 MC	8.7 MC	290 KC	±14.5—18.0 KC	±0.6 volt*
ER-25-C	130—174 MC	8.7 MC	290 KC	± 6.5— 8.0 KC	±0.6 volt*
ER-25-D	130—174 MC	8.7 MC	290 KC	±14.2—17.0 KC	±0.6 volt*
ER-25-E	150.8—174 MC	8.7 MC	290 KC	± 6.5— 8.0 KC	±0.6 volt*
ER-25-F	150.8—174 MC	8.7 MC	290 KC	±14.2—17.0 KC	±0.6 volt*
ER-26-B	406—420 MC & 450—470 MC	48 MC & 3.2 MC	290 KC	±14.5—20.0 KC	±1.0 volt
ER-30-B	72—76 MC	3.2 MC	290 KC	±13.5—16.5 KC	±0.6 volt*

* ±0.2 volt on a 20K-ohm voltmeter.

All Progress Line receivers except 406—470 MC receiver ER-26-B are double-conversion receivers which use two 6-coil (or one 2-coil and one 6-coil) Lo-IF transformers to obtain adjacent-channel selectivity. Receiver ER-26-B is a triple-conversion receiver. All coils in the Lo-IF transformers (both 2-coil and 6-coil) are overcoupled. Since the Hi-IF coils are critically coupled, they can be aligned by simple peaking.

A typical response curve for one or two 6-coil transformers is shown at the top of Figure 27. Figure 28 shows the response of the 2-coil transformer. In receivers using a 2-coil and a 6-coil transformer, the overall response curve has a bottom which is quite flat.

Coils L2, L3 and L5 in the 6-coil transformers (Figure 14) have two alternate sets of mounting holes, one for narrow-band operation (N) and one for wide-band (W). During narrow-band conversion, these coils are moved from the "W" holes to the "N" holes.

Mounting holes for L1, L4 and L6 are slotted so that coupling can be adjusted slightly to compensate for component tolerances. A small mark near the coil-mounting screws indicates the center of the slots, which cannot be seen without removing the coil. In general, the adjustment of the coupling of L6 will control bandwidth more than adjustment of L1 or L4. If, after alignment, the I-F bandwidth is too

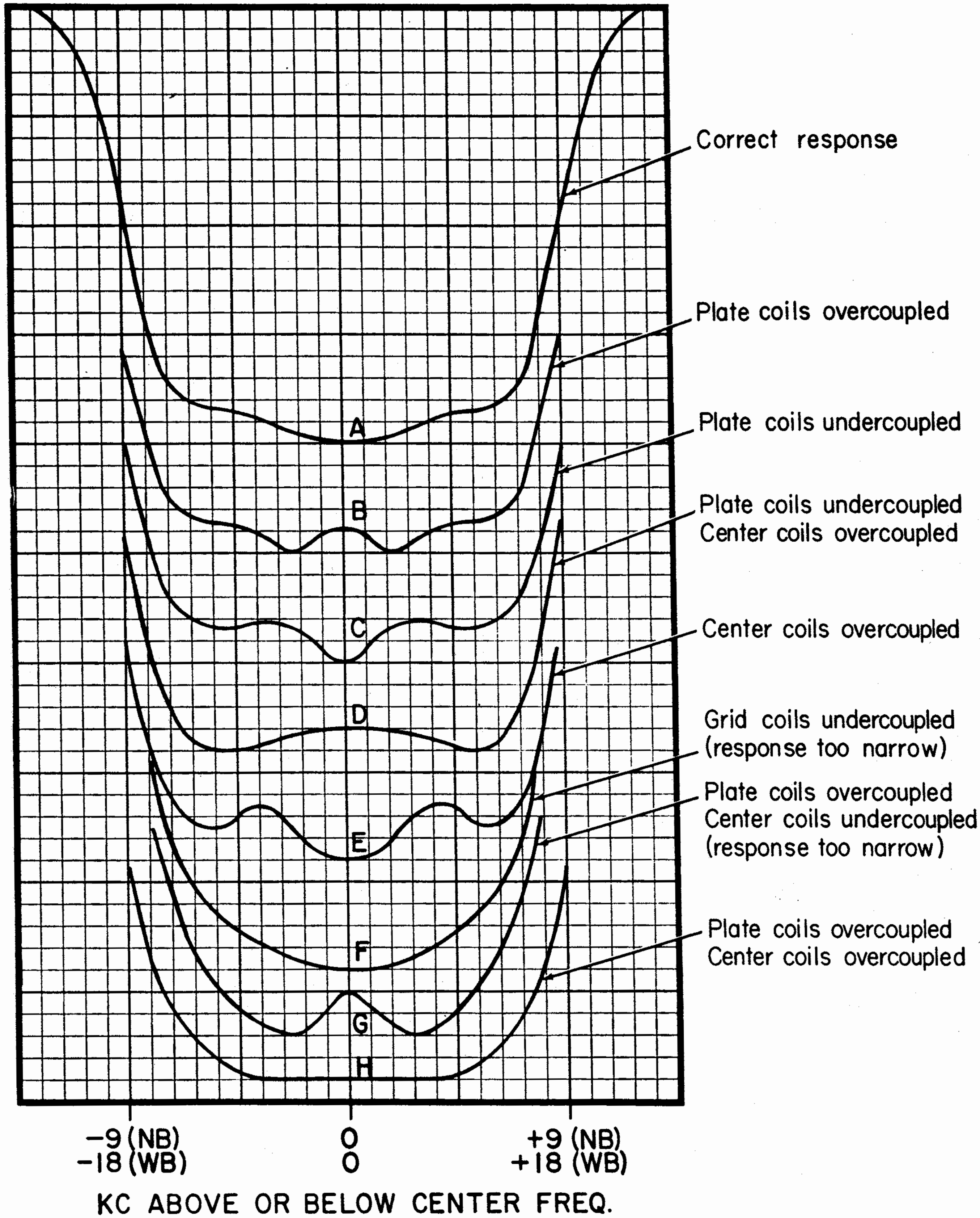


Figure 27 - Typical response curves for Progress Line 6-coil transformers with proper coupling (A) and incorrect coupling (B thru H)

narrow, couple L6 closer to L5 and realign the transformer. Figure 27 shows typical response curves which will be obtained when different pairs of coils are overcoupled or undercoupled. This can be corrected by moving the coil indicated. In touchup alignment, no movement of coils should be needed.

Touch-Up Alignment (Double-Trace Sweep Method)

Apply a signal which can be swept (either Lo-IF, Hi-IF or RF) to the receiver. Zero the signal frequency to the discriminator, apply sweep, and observe the pattern at the 1st limiter jack. If the traces almost coincide, slight adjustment of the 6-coil I-F transformer may be needed, but the following tests should be made first:

1. While receiving an on-frequency signal, tune each circuit in the Hi-IF for peak first limiter reading. Recheck the sweep picture.

2. Since it is relatively easy to adjust the discriminator, someone may have done so. Check the discriminator against a 290-KC source and adjust the transformer, if necessary.

If both the Hi-IF and the discriminator are properly aligned and the sweep traces still do not coincide, the 6-coil Lo-IF may be tuned slightly to bring the traces together.

Under field conditions, where time is limited, it may be expedient to swing the discriminator secondary slightly to center it on the Lo-IF. To do this, inject an on-frequency signal that is swept and examine the oscilloscope trace of the I-F passband. Carefully tune the signal generator until the traces coincide. Remove the modulation from the generator and note how far off frequency the generator reads. If the off-frequency condition is less than 500 cps, the secondary of the discriminator may be moved to reduce the voltage to zero. This small change will not produce any detrimental effect on reception. After zeroing the secondary, the modulated signal should be applied again and the oscilloscope traces examined to be certain that they still coincide. Do not zero the discriminator on noise.

Lo-IF and Discriminator Alignment (Double-Trace Sweep Method)

If complete realignment of the receiver is necessary, tune the RF and oscillator stages of the receiver and proceed as follows:

1. Check the discriminator against a 290-KC standard. Insert the test signal at the 1st limiter grid, using a level which will saturate the 2nd limiter. If the reading is not zero, tune the top slug (secondary) of the discriminator transformer for zero. Using signals equally spaced from 290 KC (such as 285 and 295 KC), check the discriminator balance. The positive and negative voltages should be equal. It they are not equal, adjust the bottom slug (primary) for equal readings. Recheck and adjust the secondary against the 290-KC standard.

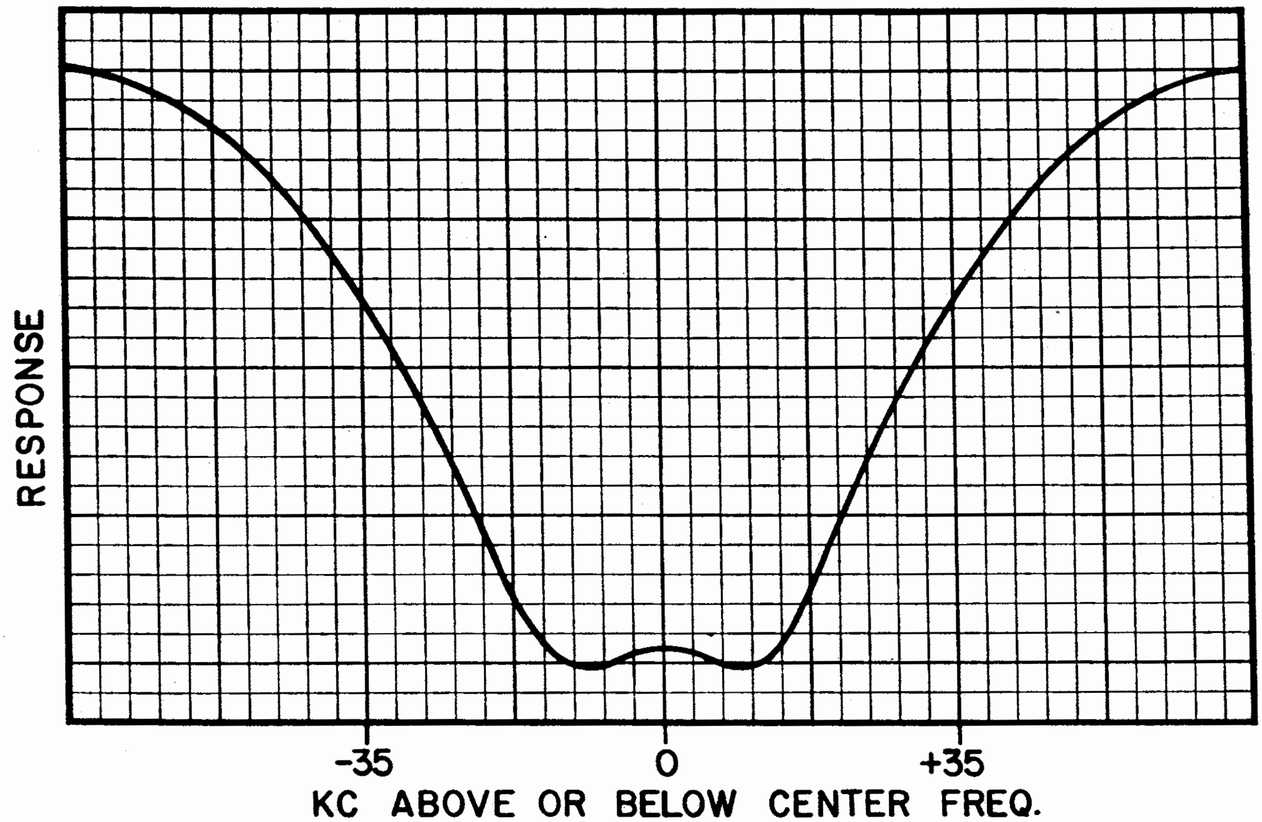


Figure 28 - Typical response curve of 2-coil Lo-IF transformer used in some Progress Line receivers

2. If a swept 290-KC signal is available, apply it at the 1st limiter grid and connect the oscilloscope at the 2nd limiter metering jack. Tune the 2nd limiter transformer for trace coincidence, unless the receiver has fix-tuned coils in this transformer.

3. Move the generator toward the front of the receiver, one stage at a time, following with the oscilloscope, until the last metering jack is reached. Some receivers have only LIM-1 and LIM-2 jacks; some also have an IF AMP jack.

4. If the 6-coil I-F transformer does not readily tune to a single trace, without sacrificing gain, use the peak and dip method to bring it close to alignment. After peak and dip tuning, adjustment of the first coil in the transformer should cause the traces to coincide. Align only one 6-coil transformer at a time. Attempting to align 12 coils simultaneously is so confusing that improper alignment is certain to result.

Remember that trace coincidence must be obtained with very little loss of gain. Use peak and dip alignment first, if necessary.

If a swept 290-KC signal is not available, a swept signal at the Hi-IF or operating frequency may be used. If only touch-up alignment is needed, it may not be necessary to use the RF probe to check each stage.

PROGRESS LINE PORTABLE RECEIVERS

Type Number	Freq. Range	Intermediate Freq's		Modulation Acceptance Bandwidth
		Hi-IF	Lo-IF	
Early Models				
ER-27-A	25—54 MC	4.7 MC	290 KC	± 7—9 KC
ER-27-B	25—54 MC	4.7 MC	290 KC	±14—17 KC
ER-28-A	144—174 MC	8.7 MC	290 KC	± 7—9 KC
ER-28-B	144—174 MC	8.7 MC	290 KC	±14—17 KC
Later Models				
ER-31-E	130—174 MC	8.7 MC	290 KC	± 7—9 KC
ER-31-F	130—174 MC	8.7 MC	290 KC	±14—17 KC
ER-32-C	25—50 MC	4.7 MC	290 KC	± 7—9 KC
ER-32-D	25—50 MC	4.7 MC	290 KC	±14—17 KC

Progress Line Portable receivers obtain their adjacent-channel selectivity from a 6-coil Lo-IF transformer. Early models use a Lo-IF filter board with a PNP amplifier. Later models use a very similar filter board (EL-10-A or -B) having an NPN amplifier. Filters EL-10-A and -B were also used in TPL receivers. The TPL resistor-loading alignment procedure can be used for all Progress Line Portables. (Refer to the section which follows.) Double-trace sweep alignment is then recommended to touch up the coils. Discriminator idling in these receivers should not exceed ±10 microamperes.

TPL AND BUSINESS MATE RECEIVERS

Type Number	Freq. Range	Intermediate Freq's		Modulation Acceptance Bandwidth
		Hi-IF	Lo-IF	
TPL Receivers				
ER-31-A and -C	130—174 MC	8.7 MC	290 KC	± 7—9 KC
ER-31-B and -D	130—174 MC	8.7 MC	290 KC	±14—17 KC
ER-32-A	25—50 MC	4.7 MC	290 KC	± 7—9 KC
ER-32-B	25—50 MC	4.7 MC	290 KC	±14—17 KC
Business Mate				
ER-31-H	130—174 MC	8.7 MC	290 KC	± 7—9 KC
ER-31-J	130—174 MC	8.7 MC	290 KC	±14—17 KC
ER-32-H	25—50 MC	4.7 MC	290 KC	± 7—9 KC
ER-32-J	25—50 MC	4.7 MC	290 KC	±14—17 KC

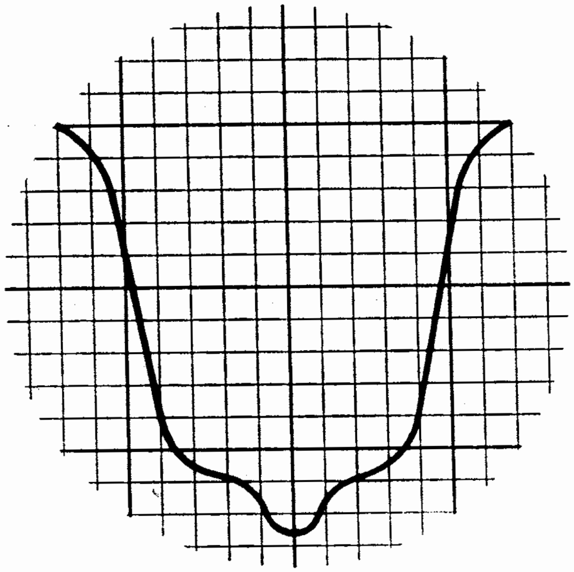


Fig. 29 - Typical Response curve for TPL & Business Mate receivers

TPL (Transistorized Progress Line) receivers obtain their adjacent-channel selectivity from two 6-coil Lo-IF transformers. Business Mate receivers have only one 6-coil transformer. To align TPL receivers, it is necessary to remove the RF Assembly from the frame and reconnect the wiring. This permits access to the lower side of the board with power applied to the receiver.

DATAFILE Bulletin 1064-1 (EL-10-A and EL-10-B Folder) describes how to align the 6-coil transformers by the resistor-loading method. Use 39K-ohm loading resistors for narrow-band receivers or 22K-ohm resistors for wide-band receivers. The tuning slug and loading point for each coil is accessible thru the oval hole beneath each coil. After resistor loading, double-trace sweep alignment can be used to touch up the tuning of the first and last coils in each transformer. Response should be similar to Figure 29.

In a few receivers, crystal aging may have caused the frequency to shift beyond the range of the crystal trimmer. If a replacement crystal is not available, the I-F frequencies can be moved slightly.

Idling current in TPL or Business Mate receivers should not exceed ±10 microamperes. Two procedures for completely aligning a receiver by the sweep method are provided below.

If Swept 290-KC Signal is Available

1. Check the discriminator against a 290-KC standard. If the reading is not zero, adjust the secondary (top slug) of the discriminator transformer for zero. Then check to see that 285-KC and 295-KC test signals produce equal positive and negative discriminator readings. If not, adjust the primary (bottom slug).

2. Connect the oscilloscope between the 1st limiter jack and receiver common.

3. Apply a swept 290-KC signal thru a blocking capacitor to the input of the amplifier feeding the last 6-coil transformer.

4. Align the last 6-coil transformer for proper trace coincidence.

5. Apply the 290-KC swept signal to the input of the 2nd mixer, thru a blocking capacitor.

6. Tune the first 6-coil transformer for proper trace coincidence.

7. Apply an RF signal on the receiver frequency at the antenna jack.

8. While keeping the signal below limiting, tune the Hi-IF for peak 1st limiter reading.

<u>If Only Swept Signal at Operating Freq. is Available</u>

1. Check the tuning of the discriminator transformer as described in step 1 above.

2. Connect the oscilloscope between the 1st limiter jack and receiver common.

3. Apply swept RF signal at the antenna jack. Keep the signal frequency zeroed to the discriminator and below limiting level.

4. Try adjusting each of the twelve slugs <u>slightly</u> to obtain trace coincidence and maximum gain.

5. If slight movement of the slugs will not produce coincidence, an RF probe can be used to align just the first I-F filter board. Then the scope can be returned to the limiter jack and the second I-F filter aligned. If an RF probe is not available, temporarily by-pass the first 6-coil transformer and tune the second transformer as follows:

   a. Remove the transistor from the first I-F filter board.

   b. Connect a DC blocking capacitor (keeping the leads short) between the top of R1 or R6 on the first I-F filter board and R1 or R6 on the second board. R1 (47K ohms) is present on wide-band I-F boards and R6 (220K ohms) is present on narrow-band boards.

   c. By using a somewhat stronger signal, the second I-F filter can be aligned without the additional confusion of the shaping produced by the first filter.

   d. Remove the capacitor and reinstall the transistor.

   e. Align the first I-F filter and retune the first coil on the second filter (which was detuned by the capacitor).

6. Remove the modulation from the test signal.

7. While keeping the signal below limiting, tune the Hi-IF for peak 1st limiter reading.

PACER RECEIVERS

Type No.	Frequency Range	Intermediate Freq's		Modulation Acceptance Bandwidth
		Hi-IF	Lo-IF	
ES-27-A	150—174 MC	4.3 MC	455 KC	±6.0—8.4 KC
ES-28-A	27—50 MC	4.3 MC	455 KC	±6.0—8.4 KC
ES-29-A	27—50 MC	4.3 MC	455 KC	±6.0—8.4 KC
ES-30-A	150—174 MC	4.3 MC	455 KC	±6.0—8.4 KC

Although Pacer receivers obtain most of their selectivity from a 455-KC ceramic filter in the Lo-IF, the impedance-matching coils adjacent to the filter have a noticeable effect on the trace coincidence around the shoulders and nose of the trace. Since these coils tune broadly, so far as amplitude is concerned, sweep alignment of the Lo-IF is recommended.

Since the Hi-IF transformers also have considerable effect on the trace, they should also be tuned by sweep alignment for coincidence and maximum gain. Idling voltage in Pacer receivers should not exceed ±0.7 volt on a 20K-ohm voltmeter.

Double-Trace Sweep Alignment

To properly align a Pacer receiver, the middle frequency of the ceramic filter must first be found and the discriminator transformer must then be zeroed to this frequency:

1. Apply a 455-KC test signal to the Lo-IF and adjust the secondary (top slug) of the discriminator transformer for a zero discriminator reading. Remove the signal.

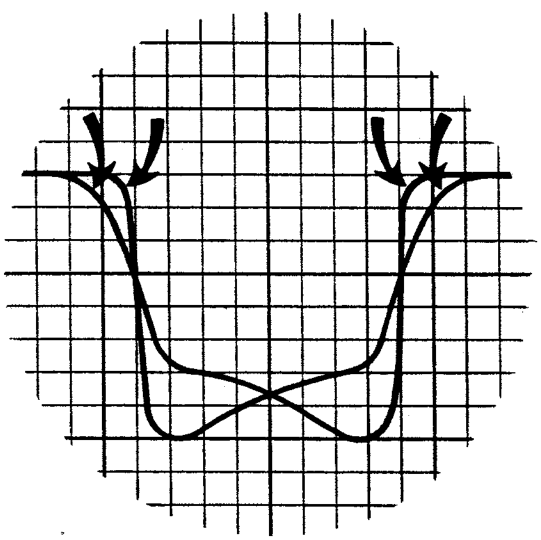


Fig. 30 - Note that shoulders of traces do not coincide, indicating that sweep frequency is not centered on fixed-tuned filter.

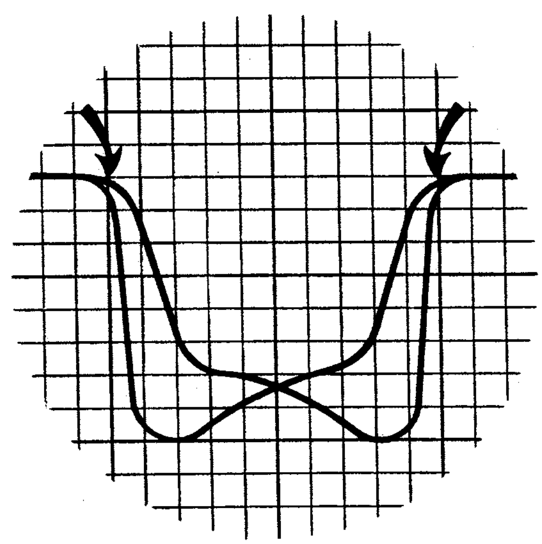


Fig. 31 - Note that shoulders of traces coincide, indicating that sweep frequency is centered on fixed-tuned filter.

2. Apply a swept test signal, depending upon the equipment which is available: a 455-KC signal to the Lo-IF, a 4.3-MC signal to the Hi-IF, or a signal at the operating frequency to the antenna jack. Keep the signal level well below limiting.

3. Connect the oscilloscope at the LIM GRID jack.

4. Adjust the frequency of the signal generator so that the shoulders of the traces coincide. (See Figures 30 and 31.) This centers the generator on the center frequency of the ceramic filter.

5. Remove the modulation and readjust the top slug of the discriminator transformer for zero.

6. Reapply modulation and tune the Lo-IF and Hi-IF coils so that the traces coincide.

7. If the shoulders of the trace do not maintain coincidence as the I-F coils are tuned, repeat steps 4 thru 6.

Alternate Method, Using RF Probe

Apply a strong, swept signal and use an RF probe on the oscilloscope, connected at the output of the ceramic filter. This will remove most possibilities for error and allow the filter center to be found more easily. Tune the generator frequency for coincidence of the trace shoulders (Figures 30 and 31), remove the modulation, and zero the secondary (top slug) of the discriminator transformer. Then reapply modulation, move the scope to the limiter jack, and adjust the I-F coils for the best picture.

ACCENT 450 RECEIVERS

Type Number	Freq. Range	Intermediate Freq's		Modulation Acceptance Bandwidth
		Hi-IF	Lo-IF	
ES-31-A (mobile)	450—470 MC	10.7 MC	455 KC	±16—22 KC *
ES-32-A (station)	450—470 MC	10.7 MC	455 KC	±16—22 KC *

*Bandwidth of receiver was originally ±10—15 KC. See Bulletin 9012-4.

Accent 450 receivers are double-conversion receivers which obtain their adjacent-channel selectivity from an 8-coil Lo-IF transformer. Because of the very wide bandwidth required in the 450—470 MC band, only sweep alignment will produce the smooth trace and adequate bandwidth needed. Peak and dip alignment or resistor-loading alignment are valuable for pre-tuning a receiver which is badly out of line, but sweep alignment should be used to complete the tuning. Discriminator idling should not exceed ±0.8 volt on a VTVM.

Double-Trace Sweep Alignment

1. Apply a 455-KC test signal to pin 1 of V302 (below limiting) and tune L310 and L311 for maximum LIM GRID reading.

2. Increase the signal level to saturate the limiter and tune the secondary (top slug) of the discriminator transformer for zero discriminator reading.

3. Check to see that 455-KC and 465-KC test signals produce equal positive and negative discriminator readings. (If I-F Test Set EX-7-A is available, use 450 KC and 460 KC.) If the readings are not equal, disregarding polarity, tune the primary (bottom slug) of the discriminator transformer until equal readings are produced.

4. Apply a 455-KC signal, zeroed to the discriminator, at pin 9 of V301. Keeping the signal below saturation, tune L310 and L311 for maximum LIM GRID reading.

5. Align the 1st oscillator, RF and Hi-IF stages as described in the maintenance manual.

6. Apply an RF signal on the receiver frequency at the antenna jack and zero the signal to the discriminator.

7. Sweep the signal at twice the rated system deviation. If possible, use a 20-cps sweep rate.

> NOTE
>
> When using the 400—470 MC range (band "E") of an M560 signal generator, over 100 KC of deviation can be obtained by switching the modulation selector to Position A, instead of Position E. Use extra care to keep the signal on frequency.

8. Connect the oscilloscope input to the junction of R335 and R336 on the IF/Audio Board. Connect the scope sync to the sweep modulator to obtain a double trace.

9. Tune the Lo-IF coils for trace coincidence.

MESSAGE MATE RECEIVERS

Type No.	Frequency Range	Intermediate Freq's Hi-IF	Intermediate Freq's Lo-IF	Modulation Acceptance Bandwidth
ER-35-A	150.8—174 MC	8.88 MC	455 KC	±5.6— 8.4 KC
ER-36-A	25—54 MC	8.88 MC	455 KC	±5.6— 8.4 KC

Message Mate receivers obtain the major portion of their selectivity from their 3-coil Lo-IF filters. These circuits can be aligned by simple peaking, using a signal zeroed to the discriminator and kept below limiting. Discriminator idling should not exceed ±5 microamperes (with the squelch disabled).

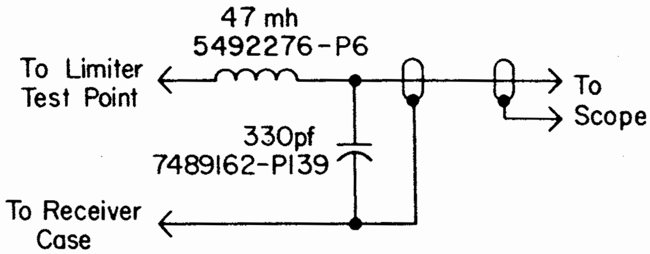
NOTE

Since Message Mate receivers use a ratio detector, rather than a discriminator, the detector is not tuned in the same manner as the other receivers discussed in this bulletin. Follow the procedure provided in the Maintenance Manual.

VOICE COMMANDER & VOICE DIRECTOR RECEIVERS

Type Numbers	Freq. Range	Intermediate Freq's		Modulation Acceptance Bandwidth
		Hi-IF	Lo-IF	
Early Models				
ER-33-A	132—174 MC	8.7 MC	290 KC	± 5—9 KC
ER-33-B	132—174 MC	8.7 MC	290 KC	±18—25 KC
ER-34-A	25—54 MC	8.7 MC	290 KC	± 5—9 KC
Later Models				
ER-37-A	132—174 MC	8.7 MC	290 KC	± 5—9 KC
ER-37-B	132—174 MC	8.7 MC	290 KC	±18—25 KC
ER-38-A	25—54 MC	8.7 MC	290 KC	± 5—9 KC

Voice Commander and Voice Director receivers obtain their adjacent-channel selectivity from a 4-coil Lo-IF filter. In narrow-band models, this filter can be aligned by simple peaking at the LIM-1 metering jack, using an on-frequency signal zeroed to the discriminator and kept below limiting. Alignment of the wide-band Lo-IF filter, however, should only be attempted if the sweep alignment method is used. Figure 32 shows an I-F filter probe which can be used when sweep aligning any of these receivers. Typical response curves for both narrow-band and wide-band receivers are also shown. Discriminator idling should not exceed 1.25 volts on a VTVM (1.0 volt for 25—54 MC receiver ER-34-A).



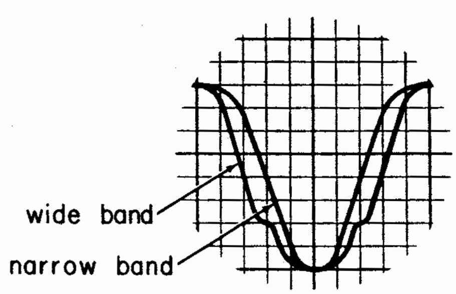


Figure 32 - I-F filter probe for sweep aligning Voice Commander and Voice Director receivers (left) and typical response curves (right)

PORTA-MOBIL AND MOTORCYCLE RECEIVERS

Type No.	Frequency Range	Intermediate Freq's Hi-IF	Intermediate Freq's Lo-IF	Modulation Acceptance Bandwidth
ER-43-A	25—50 MC	5.26 MC	455 KC	±6.0—8.4 KC
ER-44-A	132—174 MC	10.7 MC	455 KC	±7.0—9.8 KC

Receivers used on Porta-Mobil and Motorcycle combinations are double-conversion receivers which obtain their adjacent-channel selectivity from an 8-coil Lo-IF transformer. The maintenance manuals for these receivers include a single-trace sweep alignment procedure for the Lo-IF stages. They can also be aligned by the double-trace method as described below. Discriminator idling should not exceed ±0.8 volt on a VTVM (±0.12 volt on Test Set EX-3-A).

Double-Trace Sweep Alignment

1. Align the discriminator, following the standard procedure.
2. Apply an RF signal on the receiver frequency at the antenna jack. Zero the signal to the discriminator and keep the signal level below limiting.
3. Tune all Hi-IF circuits for maximum LIM-1 meter reading (position "B" on Test Set EX-3-A).
4. Sweep the test signal at 20 cps, if possible. Otherwise, use a 60-cps sweep.
5. Connect the oscilloscope to the LIM-1 metering jack (pin #2 on metering jack J312). Connect the scope to obtain a double trace. Keep the signal well below limiting.
6. Tune the Lo-IF circuits for trace coincidence, with maximum gain.

MASTR PROFESSIONAL SERIES AND IMTS RECEIVERS

MASTR Professional Series receivers and IMTS receivers are double-conversion receivers which obtain their adjacent-channel selectivity primarily from Hi-IF crystal filters. Narrow-band Professional Series receivers use a 5.3-MC Hi-IF (except for some early revisions, which use 5.26 MC) and wide-band receivers use a 12.4-MC Hi-IF. IMTS Receiver Type ER-45-A has a 5.26-MC Hi-IF. The tuned circuits on each side of the crystal filter help to shape the selectivity curve of these receivers, but are provided primarily for impedance matching. In low-band receivers, the circuit preceding the crystal filter cannot be tuned by peaking, but can be tuned only by sweep alignment.

The 455-KC Lo-IF filters in these receivers contribute somewhat to selectivity. Their primary purpose, however, is to shape the nose of the selectivity curve and to improve sensitivity. For this reason, sweep alignment is also recommended for the Lo-IF filters.

Type No.	Freq. Range	I-F Frequencies		Modulation Acceptance Bandwidth	Maximum Discriminator Idling (20K-ohm meter)
		Hi-IF	Lo-IF		
ER-39-A	25—50 MC	5.3 MC*	455 KC	± 6—8 KC	±.06 volt
ER-39-B	25—50 MC	12.4 MC	455 KC	±15—19 KC	±.10 volt
ER-40-A	66—88 MC	5.3 MC	455 KC	± 6—8 KC	±.06 volt
ER-40-B	66—88 MC	12.4 MC	455 KC	±15—19 KC	±.10 volt
ER-41-A	132—174 MC	5.3 MC*	455 KC	± 6—8 KC	±.06 volt
ER-41-B	132—174 MC	12.4 MC	455 KC	±17—23 KC	±.10 volt
ER-42-B	406—420 MC and 450—470 MC	12.4 MC	455 KC	±19—23 KC	±.10 volt
ER-45-A	152—162 MC	5.26 MC	455 KC	± 6—8 KC	±.06 volt

* Some early models used 5.26-MC Hi-IF crystal filters.

Double-Trace Sweep Alignment

First, align the receiver as described in the maintenance manual, including resistor-loading alignment of the Lo-IF. Then sweep align the Lo-IF and Hi-IF as follows:

1. Apply an RF signal at the receiver's operating frequency at the antenna jack and zero the signal to the discriminator.

2. Sweep the generator at twice the rated system deviation. If possible, use a 20-cps sweep rate. Otherwise, use 60 cps.

3. Using the detector probe shown in Figure 33, connect the scope input to the collector of Q3 (1st limiter) on the IF, Audio and Squelch Board.

4. Connect the scope sync to the sweep modulator to obtain a double-trace.

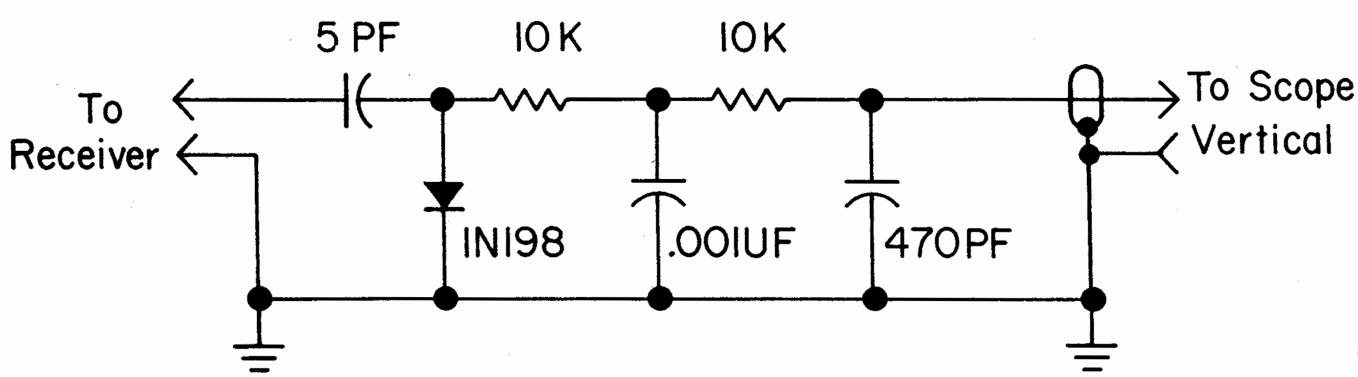


Figure 33 - Detector probe for sweep alignment of MASTR receivers

5. Tune the three Lo-IF coils and the one Hi-IF coil on the 2nd Mixer Board for trace coincidence (or reasonably close coincidence).

6. Tune the Hi-IF circuit which precedes the crystal filter for trace coincidence (or reasonably close coincidence).

MASTR EXECUTIVE RECEIVERS

Type No.	Freq. Range	Intermediate Freq's		Modulation Acceptance Bandwidth
		Hi-IF	Lo-IF	
ER-46-A	25—50 MC	5.3 MC	455 KC	± 6— 8 KC
ER-46-B	25—50 MC	5.3 MC	455 KC	±15— 20 KC
ER-47-B	66—88 MC	10.7 MC	455 KC	±16— 21 KC
ER-48-A	132—174 MC	10.7 MC	455 KC	± 8—10 KC
ER-48-B	132—174 MC	10.7 MC	455 KC	±16—21 KC

MASTR Executive Series receivers are double-conversion receivers which obtain the major portion of their selectivity from an 8-coil Lo-IF transformer. The Hi-IF crystal filter also makes a significant contribution to the receivers' selectivity.

The maintenance manuals for Executive Series receivers provide a single-trace sweep alignment procedure which requires a 5.3-MC or 10.7-MC signal generator and a marker generator. Here is a double-trace sweep alignment procedure for these receivers which uses a swept RF signal. Discriminator idling should not exceed ±0.8 volt on a VTVM (±0.12 volt on Test Set EX-3-A).

Double-Trace Sweep Alignment

1. Remove the 1st oscillator crystal and apply a 455-KC test signal thru a .01-μf capacitor at the base of 1st Lo-IF amplifier transistor Q311.

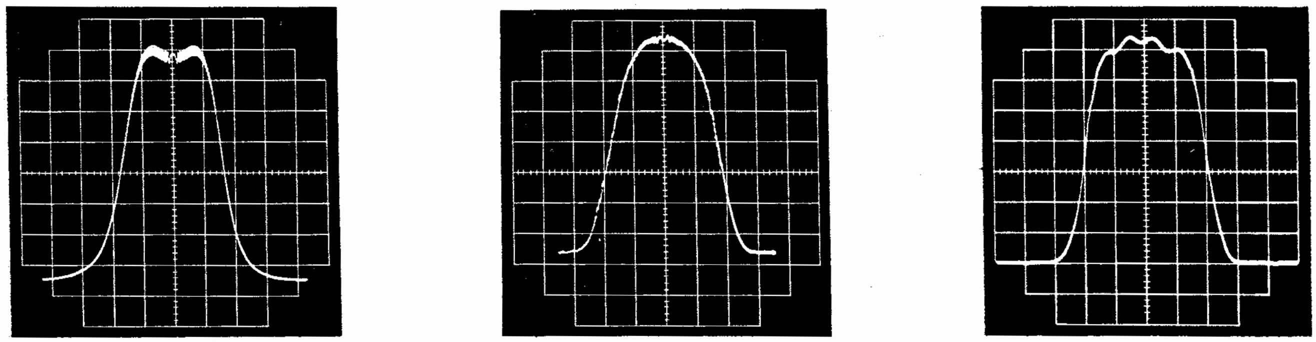
2. Adjust L329 (discriminator primary) 1/2 turn up from the bottom of its range.

3. Tune L330 (discriminator secondary) for zero discriminator reading. Remove the test signal and replace the crystal.

4. Apply an RF test signal on the receiver frequency at the antenna jack. Zero the signal to the discriminator.

5. Align the RF and multiplier stages, following the instructions in the maintenance manual for the receiver.

6. If the I-F circuits are badly out of alignment, tune the Hi-IF and Lo-IF circuits for peak LIM-1 reading. Keep the test signal below limiting.



A. Hi-IF Trace B. Lo-IF Trace (NB) C. Lo-IF Trace(WB)

Figure 34 - Response curves for MASTR Executive Series receivers

7. Sweep the test signal at twice the rated system deviation, using a 20-cps sweep rate.

8. Using the detector probe shown in Figure 33, connect the oscilloscope input to the base of the second mixer transistor. Connect the scope sync to the sweep modulator to obtain a double trace. Keep the signal below limiting.

9. Tune the capacitor on each side of the Hi-IF crystal filter for the trace shown in Figure 34-A.

10. Without using the detector probe, connect the scope input directly to the LIM-1 metering jack (pin #2 on metering jack J304).

11. Tune the Lo-IF circuits for the trace shown in Figure 34-B (narrow band) or Figure 34-C (wide band).

12. Retune the capacitor on each side of the Hi-IF crystal filter slightly for best trace coincidence.

APPENDIX A

HOW TO BUILD A SIMPLE SWEEP MODULATOR

The sweep modulator shown in Figure 35 can be easily constructed in the field for sweep aligning receivers by the double-trace method. Figure 20 shows the test setup. Any audio oscillator with an output of at least one tenth of a watt can be used to supply the audio input signal. Whenever possible, a 20-cps signal should be used. This sweep rate is low enough to prevent distortion of the trace caused by time constants in the first limiter circuit or in the detector probe (see Figure 21).

CIRCUIT

The 20-cps input signal is applied directly to the EXT MOD terminals of the FM signal generator, producing a swept signal used to align the receiver. Deviation control R4 provides a means of adjusting the modulation level when using an FM signal generator which does not have an external modulation adjustment. For use with the M560, R4 could be deleted.

The full-wave rectifier bridge connected across the secondary of transformer T1 provides a 40-pps sync for the oscilloscope (if the input signal is a 20-cps tone). Since this is twice the modulating frequency, a double trace is produced on the scope. R1 can be used to adjust the phase of the sync and S1 is provided to select the sync polarity.

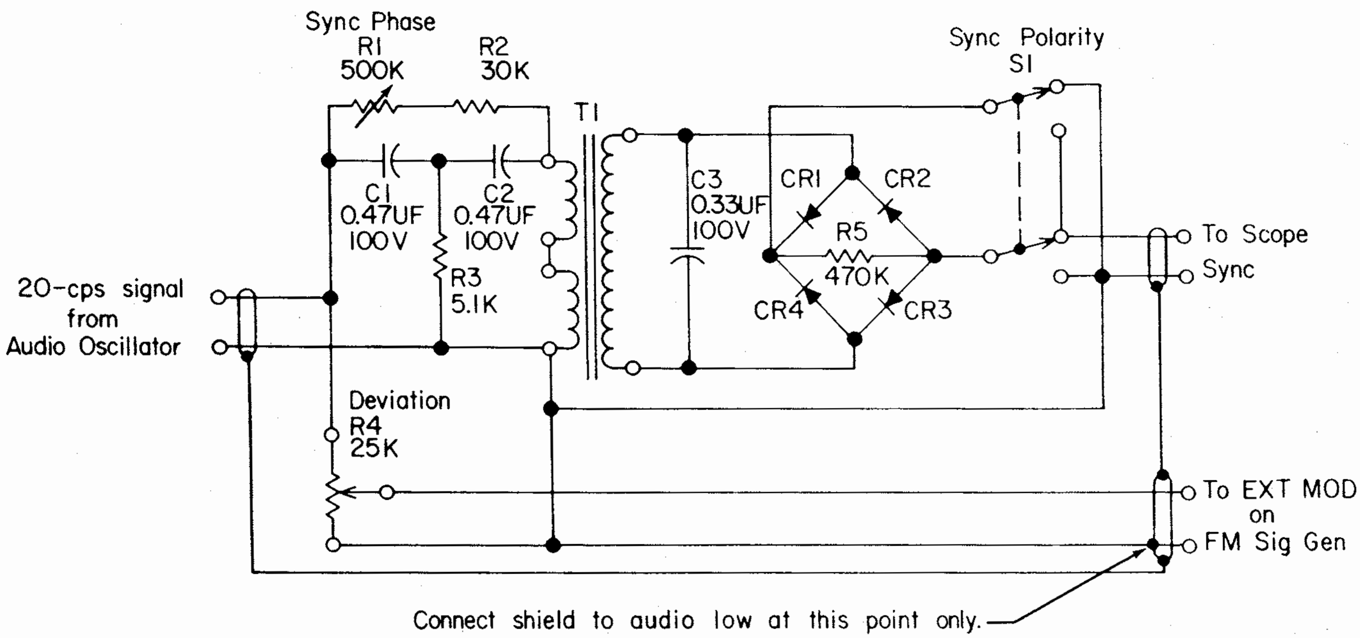


Figure 35 - Sweep Modulator Circuit (see parts list on following page)

SWEEP MODULATOR

CONSTRUCTION

The sweep modulator can be constructed in a 2" by 4" by 4" Minibox. Order the parts listed below, or use the parts list as a guide for selecting components. Transformer 5490525-P3 is designed for mounting on a printed wiring board, but a special bracket can be easily designed for mounting the transformer. Note that the secondary windings of the transformer are used as the primary in this circuit. Note also that the audio shield is grounded at only one point in the circuit.

PARTS LIST FOR SPK-218

The following components can be obtained by ordering SPK-218 from Service Parts (price $15.50, subject to change). Chassis, mechanical parts, knobs and wiring are not included.

Symbol Number	GE Part Number	Description
C1 and C2	19A115028-P19	Capacitor, polyester dielectric: 0.47 μf ±20%, 100 VDCW.
C3	19A115028-P17	Capacitor, polyester dielectric: 0.33 μf ±20%, 100 VDCW.
CR1 thru CR4	4037822-P1	Diode, silicon: 200 volts PIV.
R1	5490032-P4	Potentiometer: 500K ohms ±20%, 2.25 watts, mod log taper, sim to Allen-Bradley Type J.
R2	3R77-P303K	Resistor, fixed: 30K ohms ±10%, 1/2 watt.
R3	3R77-P512K	Resistor, fixed: 5.1K ohms ±10%, 1/2 watt.
R4	2R74-P16	Potentiometer: 25K ohms ±20%, 1.13 watts, mod log taper.
R5	3R77-P474K	Resistor, fixed: 470K ohms ±10%, 1/2 watt.
S1	7145098-P1	Switch, slide: DPDT.
T1	5490525-P3	Transformer, audio: printed circuit mounting Primary impedance: 35,000 ohms Secondary No. 1 impedance: 2000 ohms Secondary No. 2 impedance: 2000 ohms

APPENDIX B

HOW TO BUILD A LOW-FREQUENCY SAWTOOTH GENERATOR

The sawtooth generator shown in Figure 36 can be used with an FM signal generator, such as the M560, to provide the low-frequency sweep required for single-trace sweep alignment of FM receivers --- particularly those receivers whose traces distort with a 60-cps sweep. The generator maintains a linear sweep over a range of approximately 4 cps to 40 cps.

CIRCUIT

The 0.1-µf capacitor gradually charges (at a rate determined by the setting of the FREQ ADJ control) until the breakdown voltage of the neon lamp is reached. At this point, the lamp fires, discharging the capacitor. As the capacitor periodically charges and discharges, a saw-

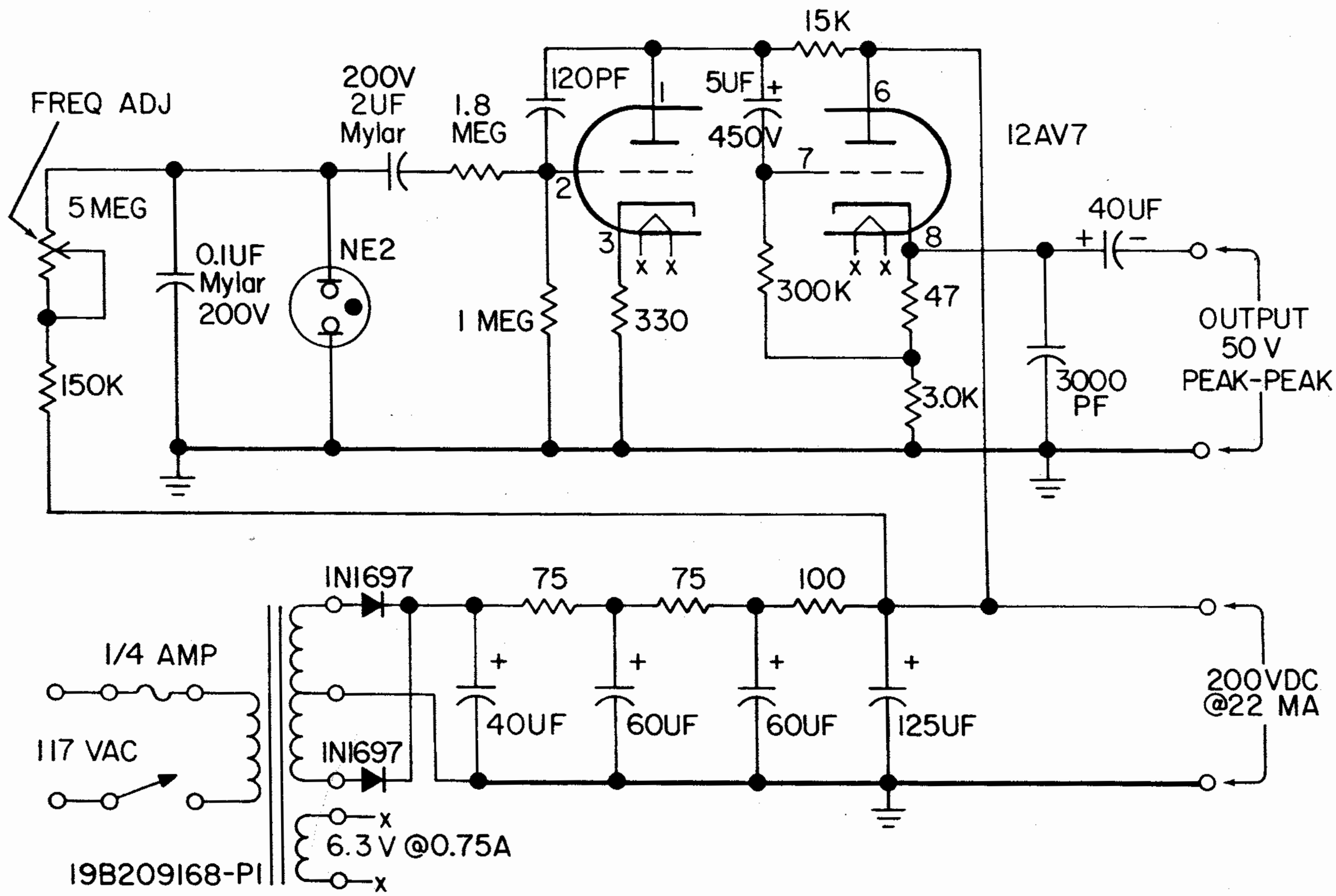


Figure 36 - Schematic Diagram of Low-Frequency Sawtooth Generator

tooth voltage is developed which is amplified by the first triode section of the 12AU7 vacuum tube. The other triode section operates as a cathode follower to match the generator output to the 5K-ohm input impedance of the M560 FM signal generator. The peak-to-peak output of the sawtooth generator is about 50 volts --- enough to modulate the M560 about ±30 KC.

The +200-VDC output of the power supply circuit is well filtered. This output can be brought out on terminals as shown in Figure 36 for use as an auxiliary B-plus supply.

TEST SETUP

Figure 22 shows the test setup for single-trace sweep alignment. Connect the output of the sawtooth generator to the EXT MOD terminals on the signal generator and to the horizontal input of the oscilloscope. For most receivers, a 20-cps sweep will produce the best trace.

NOTES

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