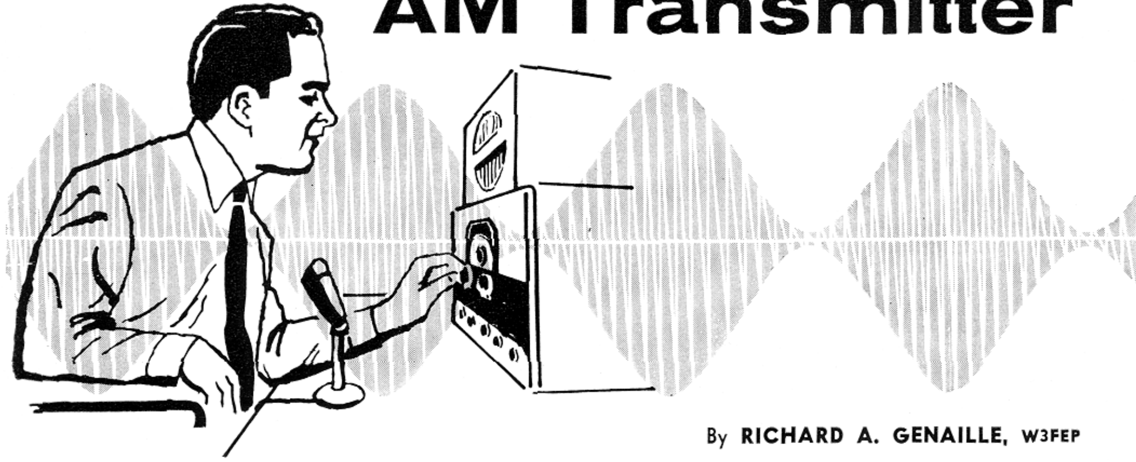
Shunt-Fed Modulation For Your AM Transmitter



By **RICHARD A. GENAILLE, W3FEP**

Little used ham modulation method provides increased flexibility in modulating that low-or high-power final.

SEVERAL years ago, the author made the mistake of attempting to modulate his 500-watt phone transmitter without the benefit of a load on the secondary of the modulation transformer. As anyone who has ever made this costly error can tell you, it didn't take much more than "Hello" into the microphone to send a 250-watt modulation transformer to join its ancestors. Of course, someone is going to say that anyone who doesn't have the necessary protection built into his transmitter to preclude such disasters deserves to lose a modulation transformer; however, there are many fine commercially manufactured ham transmitters on the market today that do not provide these safety features and there are many amateurs who dislike engineering a ham transmitter to death.

The purpose of this article is to illustrate a little-used method, among amateur operators, which makes possible a considerable range of choice in selecting modulation transformers for an amateur radiotelephone transmitter. Your problem of modulating that low- or high-power final amplifier, replacing defective modulation transformers, or designing your new AM transmitter can be simplified considerably by the knowledge and application of shunt feed in your audio system. You may also be able to save yourself quite a few dollars by using components from the shack junkbox.

Being faced with the problem of replacing the defunct modulation transformer and not having the necessary funds available to purchase same, it was decided to dig into the junkbox to see what, if anything, could be made to work. A modulation transformer originally used in the familiar ART-13 autotune airborne transmitter, manufactured by *Collins,* was discovered. This transformer, which has a fixed turns ratio, has two secondary windings; one for the r.f. amplifier plate and one for the screen. The ART-13 transmitter utilized push-pull 811's in class B to modulate a single 813 r.f. amplifier. The author's transmitter consisted of push-pull 813's in the r.f. amplifier operating with 1500 volts on the plates at a little over 500 watts input. The class B modulator tubes were 805's with the same plate voltage as the 813's. It was found that the turns ratio of the ART-13 modulation transformer was just about perfect for a match between the 805's and the 813's. Well, the matching problem was solved but it was ridiculous to think that this little modulation transformer, with a nameplate rating of 50 watts, could deliver the audio power necessary to 100% modulate the 500-watt final amplifier. Besides, neither of the secondaries could safely carry the final amplifier plate current. That did it. It looked as if the rig would be off the air for some time until the necessary $30 or so could be shaken loose from the family piggy-bank.

With the rig off the air, it seemed like a good time to catch up on my technical reading. Maybe this would be a good time to make the transition to SSB or, better yet, why not do some c.w. work for a change. The move to SSB was out of the question for the same reason that a new modulation transformer could not be purchased and c.w. had lost its charm after the first three or four years of "brass pounding." What to do?

While thumbing through the audio section of one of the handbooks to find a cheap and dirty way of modulating the transmitter, an interesting circuit was discovered. Here was a schematic showing shunt feed of audio to an r.f. amplifier. Why had I not thought of that before? This has been done almost since the time that commercial broadcast transmitters first came into existence. Why should I worry about too much current through the secondary of my surplus modulation transformer when I can shunt the final amplifier plate current through a choke? This way I won't have any r.f. amplifier plate current going through the secondary. No d.c. through the secondary should practically eliminate the heating problem.

The standard arrangement for class B plate modulation of an r.f. amplifier is shown in Fig. 1. Fig. 2 shows the shunt-feed arrangement. The r.f. amplifier plate supply in the author's transmitter contained both a swinging and a smoothing choke. It was decided that the power supply could get along very nicely without the smoothing choke, without objectionable lack of filtering and that the smoothing choke might possibly be used as the audio isolation choke. The defunct modulation transformer was removed and the ART-13 modulation transformer was installed. The transformer has a test voltage rating of 4000 volts but to insure against a.f. breakdowns to the case, four 1-inch stand-off insulators were used to mount the new transformer. As shown in Fig. 2, the smoothing choke (L) was simply relocated in the circuit and used as the audio choke while the bleeder resistor and output filter capacitor were reconnected in the circuit just after the swinging choke. The arrangement of Fig. 2 permits the class C amplifier plate current to be fed through the modulation choke in contrast to running the current through the secondary of the modulation transformer as shown in Fig. 1. The use of an adequate sized choke for L and a capacitor of moderate size for C improves the low-frequency response over that of the circuit shown in Fig. 1. For this reason, the shunt-feed arrangement is commonly used for commercial broadcast transmitters. One might say that the improved low-frequency response is of no value from the standpoint of a ham transmitter. This is usually true; however, to avoid the undesirable slope or "cant" on clipped speech waveforms resulting from phase differences throughout the modulator, it is necessary that the audio system, after clipping and filtering, have good low-frequency response. The lows can be eliminated in the early stages of the speech amplifier that is used.

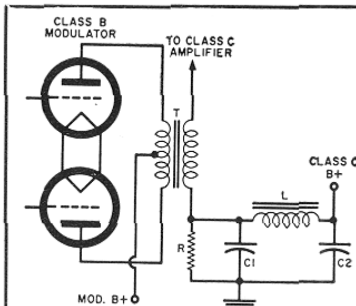
Choke L in Fig. 2 should have an inductance high enough to give an inductive reactance at least equal to the class C amplifier load impedance at the lowest frequency to be modulated. Capacitor C should have a capacitive reactance much lower than the class C amplifier load impedance at the lowest audio frequency to be transmitted. The shunt-feed arrangement will give improved phase-shift characteristics for clipped speech waveforms over the usual plate modulation system shown in Fig. 1. The coupling capacitor (C) shown in Fig. 2 should have a voltage rating at least equal to the highest d.c. plate supply voltage impressed upon it and should be of the oil-filled type. Impedance matching is accomplished as per usual. The shunt feeding does not change anything as far as securing the proper impedance match is concerned. In the author's transmitter, capacitor C was insulated from the chassis by means of 1-inch stand-off insulators to insure against breakdowns.

The system just described has been in operation at the author's station, W3FEP, for over two years and was originally installed when the old call was W5RSN. The total operational time is almost 5 years during which no trouble has ever been encountered with the modulation system. The transmitter has been operated continuously for periods of up to 29 hours during the annual Sweepstake and DX contests with no audio system failures. At the time of the original change to shunt feed, the writer had some misgivings about the length of time that the "little ole" ART-13 modulation transformer would hold up and a spare was obtained for a rainy day. The spare transformer is still in the box it came in and it doesn't appear as if it will ever be needed as a replacement. Another bonus was obtained through the use of this particular transformer since it was designed specifically for voice communication and the frequency rating of the transformer is from 400 to 4000 cycles. Undoubtedly there are many surplus modulation transformers of low power-handling capabilities still kicking around that were originally designed for voice work that could be used very satisfactorily in low- or high-power AM transmitters by using the shunt-feed system. While the author's arrangement makes use of one particular transformer, there is no reason why a commercial 50-watt multi-tap transformer could not be substituted. On the basis of the 50-watt rating transformer being capable of delivering the necessary audio for modulating the 500-watt r.f. amplifier, it would appear that a 100-watt transformer could be used for obtaining the necessary audio to modulate a 1-kilowatt r.f. amplifier or a 10-watt transformer could be used for obtaining 50 watts of audio. One of the problems often encountered in modulating a low-voltage, high-current type of r.f. amplifier is that many of the commercially available modulation transformers cannot safely handle the high current through the secondary. This necessitates the use of a transformer of a higher power rating which is not only wasteful but costly as well. Running the r.f. amplifier plate current through the choke, which was previously used in the power supply filter section and consequently can handle the r.f. amplifier plate current plus, reduces the heating of the modulation transformer due to the high secondary current. The d.c. potential existing *between* the primary and secondary of the modulation transformer in the author's transmitter is zero since the same voltage is used on the class B modulator as is used on the class C r.f. amplifier. Insulating the case of the transformer from the chassis insures against d.c. and a.f. voltage breakdown from the windings to the case of the modulation transformer.

For the information of those amateur operators who might wish to modulate their 500-watt push-pull 813 final amplifiers, the author's circuit parameters are as follows: push-pull 813's r.f. final amplifier, 1500 volts at 375 ma., plate-load impedance is 4000 ohms; push-pull 805's class B modulator, 1500 volts at 400 ma. on peaks, −16 volts bias, and plate-to-plate load impedance of 8200 ohms.

In Fig. 2, C is a 4 μfd., 1500 volt oil-filled capacitor while L is a 15 henry, 500 ma. filter choke. The modulation transformer is a surplus ART-13 modulation transformer or a commercial 50-watt unit. The screen winding on the ART-13 modulation transformer is not used. The primary-to-secondary turns ratio is 1 to .695 step down.

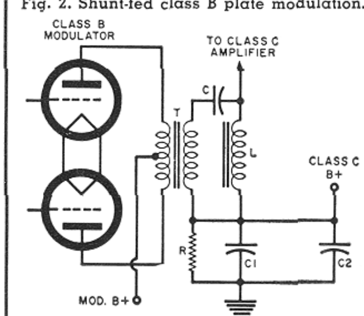
(*Continued on page* 108)



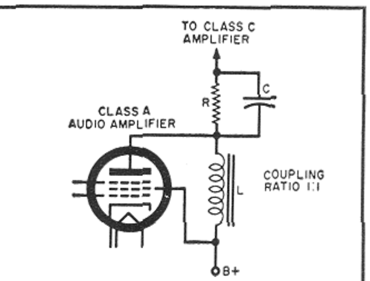
C1, C2–POWER SUPPLY FILTER CAPACITORS
L–POWER SUPPLY SMOOTHING CHOKE
R–POWER SUPPLY BLEEDER RESISTOR
T–MODULATION TRANSFORMER

Fig. 1. Class B plate modulation circuit.

Fig. 2. Shunt-fed class B plate modulation.



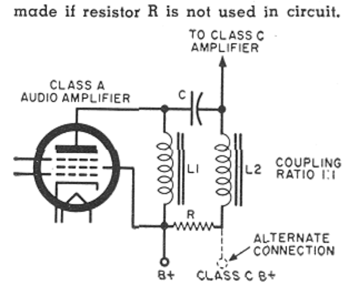
C–COUPLING CAPACITOR (OIL)
C1, C2–POWER SUPPLY FILTER CAPACITORS
L–MODULATION CHOKE (FORMERLY POWER SUPPLY SMOOTHING CHOKE)
R–POWER SUPPLY BLEEDER RESISTOR
T–MODULATION TRANSFORMER



C–AUDIO BYPASS CAPACITOR
L–AUDIO CHOKE (L MUST HAVE A HIGH IMPEDANCE AT AUDIO FREQUENCIES)
R–DROPPING RESISTOR (ADJUSTED FOR 100% MODULATION)

Fig. 3. Partial schematic diagram showing the choke-coupled (or Heising) plate modulation system described above.

Fig. 4. Shunt-fed choke-coupled Heising modulator. The alternate connection is made if resistor R is not used in circuit.



C–COUPLING CAPACITOR (OIL)
L1, L2–AUDIO CHOKES
R–DROPPING RESISTOR (ADJUSTED FOR CORRECT CLASS C AMPLIFIER PLATE VOLTAGE)

Use Shunt Feed
(*Continued from page* 47)

Since the shunt-fed class B plate modulator worked so successfully, the author decided to apply the shunt-feed system to a choke-coupled (Heising) modulator for a low-power transmitter. The usual problem in Heising modulation is that of having to reduce the plate voltage on the modulated r.f. amplifier in order to achieve 100% modulation. Heising modulation is the oldest system of plate modulation and usually consists of a class A audio amplifier coupled to the r.f. amplifier by means of a modulation choke coil, as shown in Fig. 3. The d.c. plate voltage and plate current in the r.f. amplifier must be adjusted to a value which will cause the plate impedance to match the output of the modulator since the modulation choke gives a 1-to-1 coupling ratio. In choke-coupled modulators, the output peak voltage of the modulator must be such that the a.f. voltage on the plate of the amplifier is equal to the d.c. plate voltage on the r.f. amplifier if 100% modulation is to be obtained. Then the r.f. output will fluctuate between twice the unmodulated r.f. voltage and zero. To obtain 100% modulation, *i.e.,* in order that the peak a.f. voltage developed across the choke shall be equal to the d.c. voltage on the amplifier tube, it is necessary that the voltage on the r.f. amplifier plate be reduced from that on the modulator tube by means of a resistor (R) as shown in Fig. 3. Capacitor C in Fig. 3 is used to bypass the audio frequencies around R. This type of modulator is rarely used except for very low power sets of the portable type. A higher degree of distortion can be tolerated in low-power emergency phone transmitters using pentode modulator tubes so the series resistor and bypass capacitor are usually omitted in such transmitters.

Fig. 4 shows the shunt-feed system as applied to choke-coupled modulation. If the final amplifier tube of the r.f. section has been decided upon, the normal plate voltage can be determined as well as the plate current. Simple calculations will give us the r.f. amplifier plate impedance and the amount of audio required for 100% modulation. Since the arrangement shown will give a 1-to-1 coupling ratio, the tube selected for the class A amplifier modulator should be capable of delivering the necessary audio at the same plate impedance as the final amplifier. As stated previously, the a.f. voltage on the plate of the modulator tube should swing to a point equal to the d.c. plate voltage on the r.f. amplifier for 100% modulation. In Fig. 4, in order to accomplish 100% modulation, the plate voltage on the modulator should be somewhat higher than the d.c. applied to the r.f. amplifier.

The author applied the shunt-feed system to a very low power 29 mc. transmitter to determine its effectiveness. The results were most gratifying. The input to the final amplifier in this small transmitter is 1.08 watts. Allowing for circuit losses, it was determined that about 0.6 watt of audio would be required to adequately modulate the amplifier. It didn't take long in checking the available tube manuals and charts to come up with a suitable class A amplifier. A 6AK6 with 135 volts on the plate delivers 0.6 watt of audio with a load resistance of 12,000 ohms. The subminiature tube in the final runs full power with 120 volts at 9 ma. on the plate. The impedance mismatch is negligible. Reports received from local stations are gratifying. Every station worked has commented upon the excellence of the modulation voice quality as well as percentage. More often the comment is that the rig is the best sounding low-power transmitter that has been heard. The results around the Washington, D. C. area have been most satisfying to the author who now plans to utilize the flea-power transmitter for portable operation.

It is hoped that this review of shunt feed of audio may be of assistance in expanding your approach to plate modulation of your present transmitter or the new one that you may be planning. The shunt-feed system may save money in that you may already have, in your junkbox, the necessary components for modulating that low- or high-power rig effectively and at less cost to you. Try it and be pleasantly surprised! —30—

ANCHOR CHUCK KEY

By PETER BARNA

HAVING tired of always looking for my chuck key, I wrapped a heavy elastic band around the power cord close to the drill handle, then tied a short, stout string to the chuck key and the loose end of the elastic.

When in use the elastic allows enough stretch to tighten the chuck, meanwhile keeping the key well out of the way when not needed. The length of the string will be determined by the size of the drill and the stretch of the elastic used. —30—

Use elastic to keep chuck key anchored.