The Ultra Modulation System

Using Higher Audio Power without Splatter

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• A novel method of wave-form shaping, applied only to the downswing of modulation, that permits the application of increased audio power in plate modulation without exceeding 100 per cent modulation on the down peak. Because there are no sharp breaks or bends in the wave form there are no high-order harmonics of appreciable amplitude, hence the signal occupies no more spectrum space than one with the normal modulation percentage.

It is interesting to note the number of articles appearing in amateur publications that deal with circuit techniques for increasing the modulation percentage of a.m. transmitters. Most of them emphasize the importance of operating the phone transmitter at 100 per cent modulation, and recommend methods of avoiding overmodulation and splatter when the modulation level is cranked a bit too high. Various speech-clipper circuits have been devised and many speech-limiting amplifiers have been designed, all with the prime purpose of maintaining the modulation percentage as close to an average of 100 per cent as possible. Why should so many topnotch amateurs struggle with their rigs to squeeze out the maximum audio and still not overmodulate?

The answer is quite simple to the old-timer, but for the newcomer to amateur radio a brief explanation is in order. As an example, it is a well-known fact that a 100-watt transmitter modulated 100 per cent is equal in communication effectiveness to a 400-watt transmitter modulated only 50 per cent (since in both cases the audio power is 50 watts) and gives less heterodyne interference. How much more effective would the 100-watt transmitter in question be if the audio level could be increased to 100 watts? This question in turn raises another: How can the audio level be increased beyond 50 watts on the 100-watt transmitter without overmodulation? The answer is the purpose of this article.

Shortly after I designed and built my first phone transmitter, I realized that although my modulators were adjusted for 100 per cent on voice peaks, the average modulation level was only 70 per cent. Although this may not appear to be too bad percentage-wise, it means that the average power in the side bands is only one half of the audio power developed. In other words, my 200-watt transmitter had only 50 watts average power in the side bands.

At about this time speech clipping was first being introduced. With speech clipping I could raise my average modulation percentage to close to 100 per cent, but there was a limit to how much clipping could be used. The results obtained from using higher audio power with speech clipping were encouraging but I was not satisfied, so I began experimenting with peak limiting circuits.

Others have had the same object, and have tried various and devious methods to accomplish it. As early as 1920 attempts were made to increase the level of audio beyond the conventional limits of 50 per cent audio power to 100 per cent carrier power. In most cases, the effort was made to limit the negative half cycle of the modulation envelope since overmodulation downward is principally responsible for overmodulation splatter. The methods used were for the most part unsuccessful because of the squaring off of the negative peaks and sometimes even the positive peaks. The resulting spurious frequencies generated were suppressed with filters and chokes.

It was obvious that in order to increase the audio power in the side bands, the increase could only be realized on the positive half cycle. The audio voltage in the negative half cycle could not exceed the d.c. plate voltage on the r.f. amplifier being modulated.

Circuit Details

The first problem was to control the negative half cycle and still permit the positive half cycle

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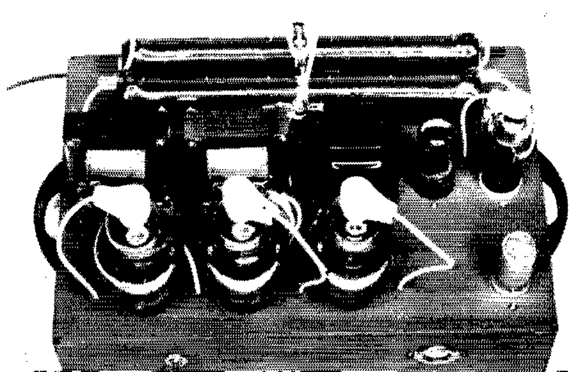

A typical parts layout for an Ultra Modulation unit. Aside from providing adequate insulation, there are no critical features in the construction.

to rise unimpeded to high levels. This was accomplished in part by the use of two diodes, V_2 and V_3, Fig. 1, in series with the leads from the secondary of the modulation transformer to the modulated stage. The purpose was to have one diode, V_3, pass the unlimited positive alternations of the audio to the r.f. stage, and the other diode, V_2, pass controlled negative alternations. This was necessary to prevent carrier cutoff and negative-peak overmodulation at high audio levels.

To keep the secondary of the modulation transformer from swinging "free" without a load during that portion of the negative half cycle when the negative audio voltage exceeded the B-plus voltage to the final, another diode, V_1, was connected across the modulation transformer secondary, in series with a load resistor, R_1. This resistor had approximately the same value in ohms as the modulating impedance of the r.f. amplifier.

The most difficult problem was to get the right amount of negative audio voltage to the final. This was done by connecting the plate of the diode, V_2, used for control of the negative half cycle to a tap on the load resistor, R_1. Only negative audio voltage was developed across this resistor since it acted as a load for the modulation transformer only during the negative half cycle. The tap was set so that just the proper amount of negative audio voltage was fed to the final to give approximately 100 per cent modulation on negative peaks. The positive half cycle rose to the maximum level developed in the modulator stage.

Oscilloscope patterns of various audio-to-carrier-power ratios are shown in Fig. 2, with and without the Ultra Modulation circuit. The unmodulated carrier is superimposed at the left in each photograph for reference purposes. No splatter or increased band width was detected at audio-to-carrier-power ratios up to 5 to 1.

The Final Amplifier

The effect of all this audio on the final r.f. amplifier was interesting. The d.c. plate current flowing in the final increased in proportion to the increase in audio over that required for normal modulation. As a result, the final plate-current meter showed increased plate current when the audio peaks caused the modulator plate-current meter to swing upward. However, it must be kept in mind that the final amplifier must be capable of handling the combined audio and carrier power developed.

In transmitters using tetrodes in the final amplifier with a separate screen supply and an audio choke, Fig. 3A, the "floating" screen causes considerable distortion when the audio power exceeds the carrier power, although at audio levels below the carrier level the floating screen causes negligible distortion. To eliminate this type of distortion, the screen should be modulated along with the plate by means of a dropping resistor, as shown in Fig. 3B. The actual value of this resistor can be easily determined by referring to the chapter on Amplitude Modulation in *The Radio Amateur's Handbook.*

Modulation Indicator Circuit

The modulation indicator circuit shown in Fig. 1 serves two functions. Primarily, it is intended to simplify the initial adjustment of the transmitter. It also serves as a negative-modulation indicator during transmission. The circuit is con-

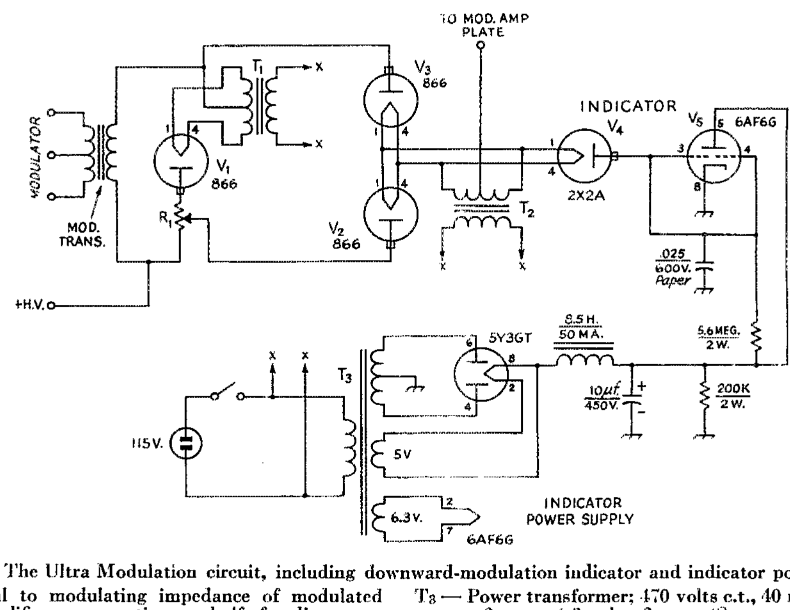

Fig. 1 — The Ultra Modulation circuit, including downward-modulation indicator and indicator power supply.

R_1 — Equal to modulating impedance of modulated amplifier; power rating one half of audio output from modulator.

T_1, T_2 — Filament transformer, 2.5 volts c.t., 10 amp.; 10,000-volt insulation.

T_3 — Power transformer; 470 volts c.t., 40 ma.; 5 volts, 2 amp.; 6.3 volts, 2 amp. (Stancor PC-8401).

V_1, V_2, V_3 — 866 or 816, where d.c. currents are within tube ratings.

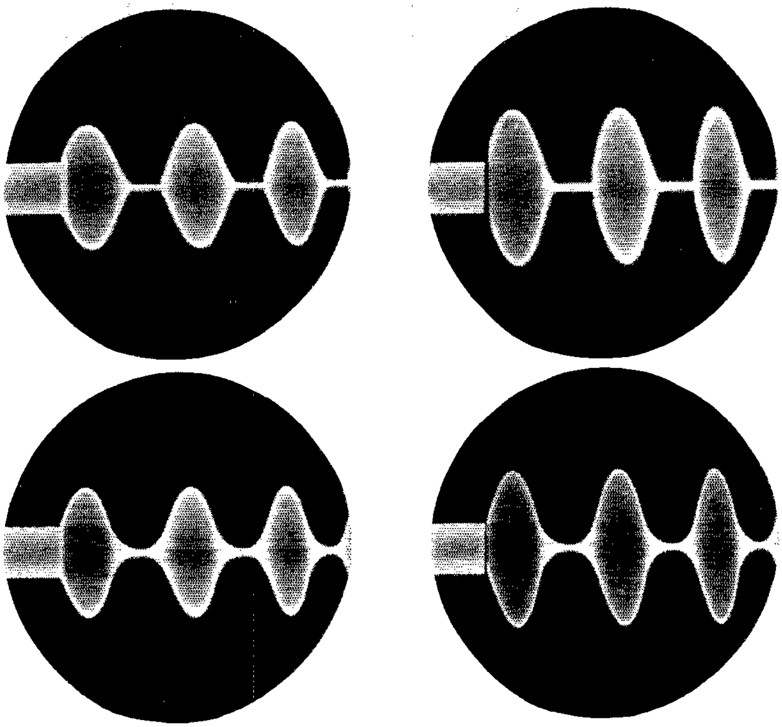

Fig. 2—Oscilloscope patterns of carriers modulated at high levels with and without the Ultra Modulation circuit. Upper left: 100-watt carrier modulated with 100 watts of audio, conventional circuit. Lower left: same conditions, but using Ultra Modulation circuit. Corresponding patterns for a 100-watt carrier modulated with 200 watts of audio are shown at the right.

nected so that the eye will open fully (90 degrees) when overmodulation begins. The setting of the tap on resistor R_1 determines how far the eye will open on negative modulation peaks. At the proper setting of R_1 the eye will open to approximately 45 degrees on modulation peaks. With the tap set at the end nearest the diode, the eye will just begin to flicker open when the audio voltage slightly exceeds the voltage for conventional 100 per cent modulation. The additional audio voltage is necessary because of the voltage drop across the diodes in the circuit, plus the drop across the small resistance remaining between the tap and the resistor terminal.

The value of R_1 in ohms is the same as the modulating impedance of the r.f. amplifier. It can be determined by dividing the plate current (without modulation) into the plate voltage. The power rating required of R_1 is half the maximum audio power developed in the modulator stage.

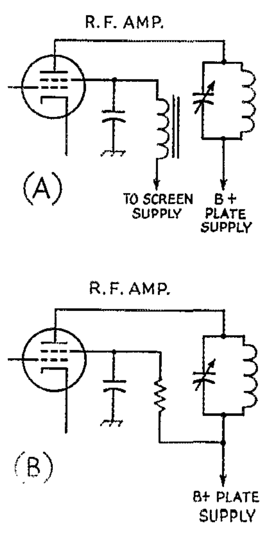

Fig. 3—A—plate-and-screen modulation of a tetrode r.f. amplifier using fixed screen supply and audio impedance in screen lead; B—using a screen-dropping resistor.

Construction

The circuit can be constructed on any chassis of suitable size, or may be built right into the modulator deck of a transmitter. The diode sockets should be mounted on stand-off insulators in high-power rigs, and high-voltage wire should be used throughout. A single filament transformer with two secondary windings can be used for T_1 and T_2, and diodes such as the 816 can be used at V_1, V_2 and V_3 for transmitters in the DX-100 and Viking II class. Shielding should be used around the leads running from the unit to the secondary of the modulation transformer.

An oscilloscope is not actually necessary for the adjustment of the circuit, but is useful for determining when the speech amplifiers or modulators begin to distort, or when the modulation transformer begins to saturate. *The Radio Amateur's Handbook* gives photographs of scope patterns of the various types of distortion developed in a phone transmitter.

The Ultra Modulation circuit is presently in use by many amateurs throughout the country; also, two of the Armed Services are exploring the use of this circuit on military sets under all possible conditions.