July 2007

Issue #19

This newsletter is sent out to all who have called in on the AWA net with the hopes that it will encourage you to call in again and help to keep the AWA net alive and well.

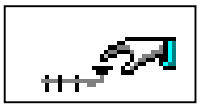
With some of the money gathered from sales of donated goods to the AWA, we are now able to pay for envelopes and mailing of the newsletter to almost all who want it.

Should you not want to receive any further publications of this newsletter, drop me a note and I will take you off the mailing list.

Happenings:

Dick Busby, who operates ZS1MUS and can often be heard on the AWA net, sent me a short mail in response to Cliff ZS6BOX article about being at Ysterplaat air base when the museum was closed. Dick has given his contact number and says that anyone wanting to visit the museum and the air base should contact him and they will make special arrangements for someone to be there. Dick can be contacted at *021 988 5411, or on cell 0842688588.*

ZS0AWA/CW.



Heard on frequency this last month has been Barrie ZS6AJY, Ian ZS5IAN, Clive ZS6AVP, John ZS5JON, Denis ZR6DNS, John ZS6JBJ, Barrie ZS5ZG. Join us on Saturday afternoons at 14:00 SAST. The net is run at ±12 wpm and so should meet the needs of all interested in CW. 7020 is the frequency.

AM Net:

Please come up and join us if you have the time and the inclination. 19:30 Wednesday evenings and 06:00 Saturday mornings on 3615. We have changed the time on Saturday's due to the band opening a bit later as the winter months approach and the sun raises it's head a bit later every day. Some of the ardent AM'ers are starting early on Wednesday evenings due to the band going out a bit later. 80m is open from early in the afternoon these days and has proved quite successful for AM transmissions. Listen out on 3615 from 17:30

The band certainly has not been very favourable , but we continue to stick it out.

The Saturday morning net has been well attended. Heard on frequency this month have been Gary ZS5NK, Rod ZS5RK, Don ZS5DR, Munro ZS5IN, Rad ZS6RAD, Barney ZS6BLL, Willem ZS6ALL, Denis ZR6DNS and yours truly ZS6ADY.

SSB Net:

40m is becoming increasingly more difficult to work on the morning SSB net for the div 6 stations. Once again we will be running an 80m relay which proved to be quite successful last year. Listen out on 3615 SSB and see if you can call in there instead of 40m, especially with the short skip being active these days.

We appeal to all of you, when calling in on 40m, should you not be able to hear the control station, try letting someone know who you can hear and you know can hear the control station. It's better than doubling over everybody.

We seem to be averaging around 20 callers every week, which goes to show the kind of interest being generated in valve rigs at the moment.

AMPLITUDE MODULATION & SINGLE SIDE BAND - WHAT'S THE DIFFERENCE ?

John Fielding ZS5JF

Introduction

Many amateurs are a little hazy as to what AM and SSB actually means. There have been several different methods of generating AM & SSB over the years which have been used in home brewed and commercial equipment. Let us start by looking at AM and then we can move onto SSB.

Amplitude Modulation

As the name suggest AM is a modulation scheme where the amplitude of the carrier wave is varied in sympathy with the modulating signal, either speech or music etc. To generate AM we need to start with a RF carrier and then apply this to a piece of circuitry called a "modulator". The constant level RF carrier is varied about the mean level by the modulating signal. On one half cycle of a sinusoidal audio signal the carrier level increases and on the other half cycle the carrier level is reduced. When the RF voltage increases to twice the quiescent level the carrier is said to be "100% modulated". On the opposite half cycle the carrier voltage swings down to

zero volts and of course no power is now transmitted. Attempting to exceed 100% modulation causes the carrier RF envelope to break up and this causes splatter to adjacent channels.

The spectrum of an AM transmitter is shown in Figure 1. Here the carrier component is constant and the modulation causes two identical extra *carriers* to be produced, which vary in amplitude in direct relationship with the *depth of modulation*. These are not in fact actual carriers but they behave like carriers when the modulating frequency is constant. These additional products are called "*sidebands*" and exist symmetrically about the main carrier signal. We call them *sidebands* because they contain a band of frequencies determined by the modulation source and exist either side of the carrier. Speech consists of many different frequencies of varying amplitude. Music is even more complex. For speech the useful range of frequencies to convey intelligibility extends from about 300Hz to 3kHz.

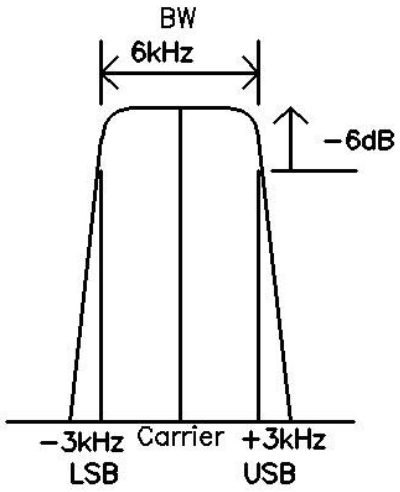


Figure 1 AM spectrum

The spacing from the carrier of the two sidebands is determined by the modulating frequency. For intelligible speech a maximum modulating frequency of 3kHz is adequate and this produces the "*lower sideband*" at a frequency 3kHz lower than the carrier. Similarly the "*upper sideband*" occurs at +3kHz from the carrier. In Figure 1 the filter response has been added to show that required for "*communications quality*". The receiver requires an IF bandwidth of 6kHz minimum. For music the IF bandwidth is somewhat wider. If the highest audio frequency is 5kHz then the IF bandwidth needs to be at least 10kHz.

At 100% modulation the amplitude of the sidebands is 6dB below the carrier level. This means that the power contained in each sideband is 25% of the carrier power. Because there are two identical sidebands, each of which contains the same information, the total power in the sidebands is 50% of the carrier level. If the RF carrier before modulation is 100W then each sideband is equal to a 25W "*carrier*" when modulated to 100%. Hence, the total sideband power is 50W and the peak envelope power (pep) of a 100W carrier when fully modulated would be expected to be 100 + 50 = 150W. In fact this is not so. The two sets of signals add algebraically. To produce the modulated carrier several methods can be used. Traditionally the modulation is applied to the final power amplifier stage (PA) with a modulation transformer. This requires a high power audio amplifier to generate the modulating signal. For 100% modulation the audio power requires is half the DC input power to the RF amplifier. For a 150W DC input Class-C amplifier we need 75W of audio power. Essentially the anode and screen grid of a tetrode or pentode is supplied with the anode voltage from the power supply. In series with the supply is the secondary winding of the modulation transformer (see Figure 2). When the audio amplifier is driven the voltage across the modulation transformer secondary varies about the mean anode DC supply level.

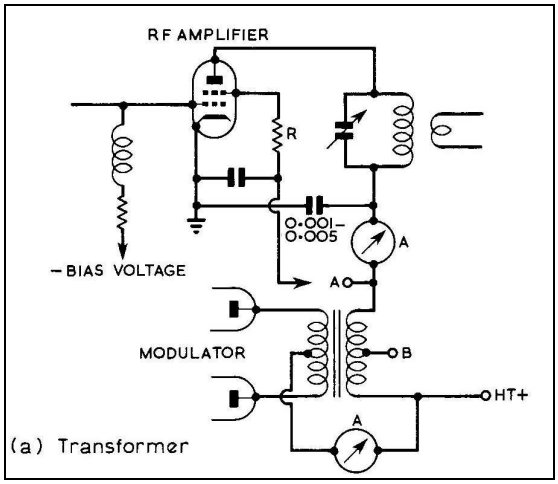


Figure 2 Anode & screen grid modulation

Suppose the anode DC supply is 600V and the audio amplifier has sufficient power to swing the anode voltage 600V p-p. This means that on the positive half cycle the anode voltage swings up to 600 + 600V = 1200V and down to 600 - 600V = 0V. Assuming the valve transfer characteristic is linear (a very big assumption in most cases!) then the doubling of the anode voltage causes a doubling of the anode current. Since Power = I^2 x R (R being the effective anode resistance the valve presents to the power supply), then the power rises to 4-times the quiescent carrier level. For a 100W carrier power amplifier the peak envelope power is 400W.

In practice the anode transfer characteristic is anything but linear at peak anode voltage and so the curve bends away from a straight line. This introduces distortion and to counter this we need to limit the peak modulation percentage to around 80% to prevent the distortion products becoming excessive, which cause splatter on adjacent channels. A method to correct some of the non-linearity is to also modulate the screen grid of the tetrode or pentode. This to some extent straightens the curve but only by a small amount. Determining the exact proportion of the screen voltage to vary about the nominal can be a tricky task.

Taking a typical valve PA using two 6146 valves we can look at what is possible. RCA in the data sheet for the 6146 gives the peak and average RF output when used for SSB duty. A single 6146 can deliver an average power (that which we measure with our through-line wattmeter) of about 30W carrier and a peak envelope power of 60W. Hence, two 6146s operated in parallel will give a maximum average carrier power of 60W and approx 120W pep.

Because the AM transmission peaks at 4-times the average carrier power this places a maximum carrier level of about 30W, being a quarter of the 120W pep the two valves can safely deliver. With the normal DC to RF efficiency to be expected at low HF bands, we can only run the two 6146s at about 50W DC input to ensure we do not over modulate and “flat-top” the carrier.

> As a rough guide to what a particular valve is capable of we can take the anode dissipation and multiply by 3. The 6146 valve has an anode dissipation of 20W, so two in parallel is 40W. Three times 40W = 120W and this sets the pep possible without exceeding the linearity criteria.

Incidentally this explains why we in this country (and the UK) the 400W pep limit when SSB is used. In the days when AM was the primary mode, SSB was far in the future. The Post Office decided that 150W DC input was the maximum that an amateur station should be allowed to use. This assumption was based on a certain DC to RF efficiency. A fairly typical value for a Class-C PA was 66.66% or 2/3rds. For

150W DC input the PA would deliver 100W of carrier. When fully modulated the peak envelope power is 400W pep. For a PA running 150W DC input 50W is dissipated in the valve anode as heat. But the valve has to be capable of at least 400W carrier output to ensure the modulated transmission is not distorted. This means we need an anode dissipation of at least 133.33W if the valve is going to be capable of 400W pep on the modulation peaks.

Some pictures of an AM modulated carrier are shown below. The difference between 80% and 100% is not that great. But the over modulated condition shows the "*carrier is broken*" in the troughs and this causes splatter.

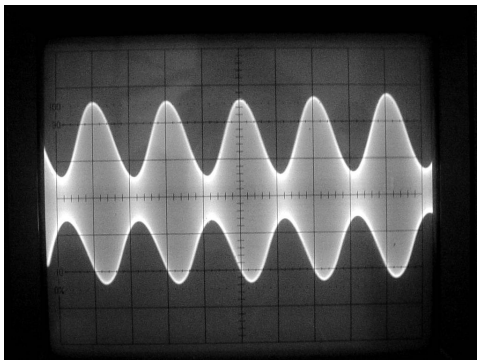


Figure 3 **80% AM modulated**

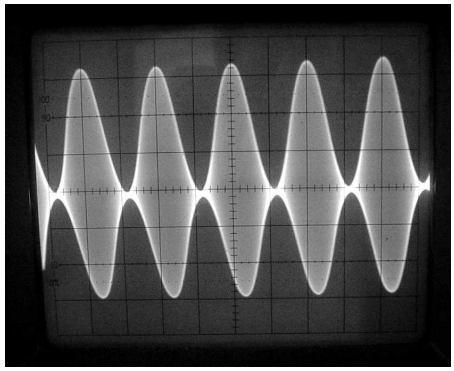


Figure 4

100% AM modulated

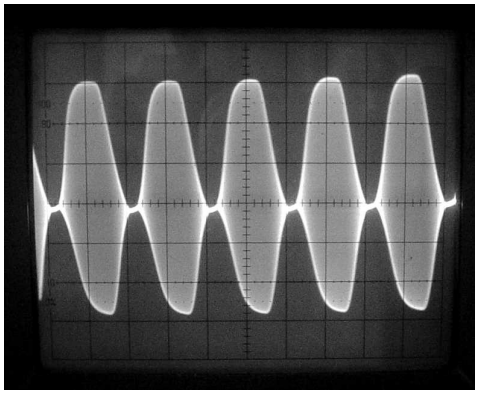


Figure 5 **Over modulated carrier**

Amplitude modulation is normally performed at the final carrier frequency, although it can be generated at a lower frequency and then mixed up to the final frequency but this adds extra complexity to the transmitter. SSB transmitters normally generate the single sideband at a fixed low frequency and then using frequency mixers it is brought to the final output frequency.

A modulator is a type of *mixer* with one input signal being a RF carrier and the other a frequency in the audio spectrum. Although one of the input signals to the mixer is audio the modulator behaves in the same way as a conventional mixer for RF.

If the RF carrier is denoted as F_{rf} and the audio as F_{af} then the complex mixing equation yields the following products.

Output = $F_{rf} + (F_{rf} + F_{af}) + (F_{rf} - F_{af})$

If F_{rf} = 1MHz and F_{af} = 1kHz then the two sidebands will occur at 1.001MHz and 0.999MHz, a separation of 2kHz.

In addition to the *first order products* (the ones we wish to generate) we also have extra products of the RF carrier and the audio signal. If the audio signal is not a perfect sinusoidal waveform then harmonics of the audio will occur at 2-times, 3-times etc and these produce extra sidebands either side of the main carrier. Hence, the audio amplifier needs to be as linear as possible to prevent these unwanted products being of significant amplitude. Harmonics of the carrier are normally not too serious as they can be filtered out with band pass filters or in the case of the PA stage with low pass harmonic filtering.

(This article will be continued in next months newsletter where John goes on to talk about SSB)

Swap Column:

Graham – ZS2ABK is looking for an 11 pin female socket for the power supply to his Collins KWM2-A. If any one has spare, please let us know or contact Graham direct. His email address is listed in the SARL website.

Any swaps or items for sale in the antique line ? Let me have the details and we will advertise it here.

There is an online swap shop on the website of the Highway Amateur Radio Club for ALL amateurs and interested parties to use - it is not restricted to members only. We have been invited to make use of this facility too. Should you want to, use the link to the HARC at the end of the page to take you to their website.

If you would like to forward this newsletter to any other interested parties, please feel free to do so. Print it out and put in on your club notice board, or give it to someone interested in valve radios. If you know of any who report in on the net but don't have email, print it out and give them a copy.

I received this email from Mike ZR6BRI, in response to his request for information which I forwarded to those on the internet:

Hi there guys

Thank you all for your responses. I have put the word out and I have received positive responses from the most unlikely of sources. Petrus ZR6DPH heard about the project, and he has another one. He dropped by today with a CD onto which he had scanned some tech docs on old radio's including the schematics of the TBY-8. There are schematics and pix for about 40+ Transceivers on the CD.

Including ARC-4, ARC-5 LF, ARC-5 VHF, ARN-5, ASB-7, BC-312, BC-342, BC-314, BC-344, BC-348, BC-603, BC-624, SCR-522, BC-611, BC-652, BC-654, BC-669, BC-728, 'Model 524' BC-1306, BC-1335-A, BC-AR-231, GF-11, CRC-7, 'Radio Receiver and Transmitter Mark II', MN-26, RAK-5, RAL-5, TBY-8, TCS-? , and some. There are also some component marking charts. There are some very interesting ones ... like the CRC-7 Lifeboat transceiver.(in a can) . A very simple and cute little transceiver. Its on the website.

Would anyone be interested in this CD?. Perhaps you could let yr members know.

I started uploading the scans and have moved the project to the club website. www.zs6pot.org In particular, the page http://www.zs6pot.org/library.htm where I was thinking of starting a technical library on these 'boatanchors.' I have put up a couple and was thinking of adding more as time goes by. If your

members have anything they may want to add etc, maybe u could let them know and I could build up a library as time goes by.

You can review progress on the TBY-8 project on page http://www.zs6pot.org/renovation00.htm

Does ZS0AWA have a web ? Member list, Etc.

Best regards
Mike Brink ZR6BRI

Net days and times:

Saturday 06:00 AM Net – frequency 3615Mhz
Saturday 08:30 SSB net - frequency – 7070 with a relay on 3615
Saturday 14:00 CW net – frequency 7020Mhz
Wednesday 19:30 AM net – frequency 3615 (-5 for QRM)

This, and past copies of the AWA Newsletter can be downloaded from http://members.harc.org.za/newsletters/AWA/. Our thanks to the Highway Amateur Radio Club in Durban (http://www.harc.org.za) for providing this service to our members and other interested parties.

Thanks for the bandwidth.

DE ZS6ADY FOR ZS0AWA