August 2007
Issue #20

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 as well as donations being received from some of our readers, 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.

This news letter has gone out early this month as I will be away on leave for 2 weeks at the end of the month

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, John ZS5JON & Pierre ZS6BQS. 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. Although the band has not been that co-operative, we have still managed good Q5 signals on CW.

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.

The AM net has mostly turned in to an MF(Musical Frequency) net, but please don't be deterred from joining us on frequency.

SSB Net:

With 40m remaining a difficult prospect for local as well as div 5 stations, the 80m relay is proving to be quite popular. However, there are times that I will not be available to do the relay and wonder if there is anyone else who has the capability to do a relay from 40m to 80m and vise versa. The main thing is not just to have 2 HF rigs, but to have 2 separate antenna's, preferably in opposing directions. In other words one north/south and the other east west, if mounted close to each other. If you are able to assist with this, please contact Andy either by email or by phone on 082 448 4368.

Pine – ZS6GST, has secured the use of the Pretoria Centurion club repeater for use by the AWA on Saturday mornings to relay the net on to 145.775. We will certainly look in to this as well as this should make it a lot easier for the Pretoria stations to get in on the net as well. At present we may only relay the net there and not take call in's, until we can relay back to 80 and 40 from there.

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. Better still, try 80m.

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.

I also am aware of a few people who are getting in to some serious rebuilds, so let us have some articles and photo's of your labours of love.

Amplitude Modulation & Single Side Band - What's the Difference ?

(Part 2)

John Fielding ZS5JF

Single Sideband

It should be clear that a SSB transmission is an AM type but the carrier and one sideband has been removed by some method. The common way of generating SSB is firstly to apply a fixed carrier frequency to a special type of modulator, which nulls out the carrier component. This is known as a "*Balanced Modulator*" as the carrier is made to fall to insignificant amplitude by a phasing technique. In the balanced modulator a new RF carrier signal is generated, being 180° out of phase with the original carrier. At the output of the modulator these cancel and the amplitude of the carrier is now about 10,000 times smaller than the original signal. This is a carrier suppression of 50dB and is normally adequate for SSB transmitters.

The output of the balanced modulator contains the two sidebands and so we need to eliminate one of these, which one we choose to get rid of is determined by the "*frequency plan*" for the transmitter. In early days a common method was to generate the double sideband suppressed carrier at 9MHz because crystal filters were available at reasonable cost. The unwanted sideband is removed by passing the signal through a narrow band filter. This leaves just the wanted sideband. The design of a SSB filter is critical and a specialised item. Unlike a filter for an AM receiver the ideal SSB filter is not symmetrical. On one side of the carrier the filter response is much steeper than on the other. Figure 6 shows a typical SSB filter response.

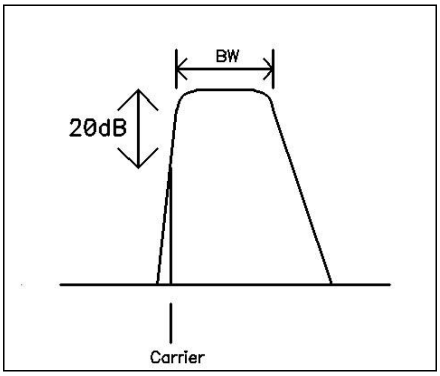

Figure 6 Typical SSB filter response

> This filter is an upper sideband filter (USB) because the carrier is at the low frequency side of the pass band center. A lower sideband filter would be the mirror image. In practice it is important to select the correct sideband filter. If we start with 9MHz and generate the SSB we can mix up or down to several amateur bands easily.

In Figure 6 can be seen the lopsided shape required. Also the position the carrier is placed is important. Normally the carrier is placed so that it is approx 20dB down from the peak of the filter response. This adjustment is critical to preserve the fidelity of the speech signal. In order to achieve this the carrier crystal is provided with a variable capacitor in the carrier oscillator so the crystal can be adjusted correctly. The reason the high frequency response is less steep than the low frequency side is due to the excessive phase distortion a sharp cut-off filter generates. Therefore we cannot tolerate a steep cut-off on the side of the response that corresponds with the higher audio frequencies, this makes the signal sound "*mushy*" and difficult to understand.

Suppose we wish to cover 80m and 20m with our SSB transmitter. We will mix the 9MHz SSB up to 20m by using a VFO of 5 to 5.5MHz. (9 + 5 = 14MHz & 9 + 5.5 = 14.5MHz). As we normally use USB on 20m this means the filter needs to be a USB type.

For 80m we need to mix the 9MHz SSB down to 3.5 to 3.8MHz. When we mix down we invert the sense of the SSB, so now we have LSB with the same VFO range. In fact we can cover 3.5 to 4.0MHz with this VFO.

The carrier crystal being placed 20dB down the filter slope gives us additional carrier suppression of 20dB so the balancing of the balanced modulator is not as critical. The amount the unwanted LSB signal is suppressed is purely determined by how good the SSB filter is. Typically 50dB of unwanted sideband suppression is achievable and is normally adequate.

If we wished to use USB on 80m or LSB on 20m then we have two choices. Either we use two SSB filters with a common carrier crystal suiting LSB & USB or we can use two carrier crystals with a single SSB filter with a more symmetrical response. Because SSB filters are expensive this second choice is normally made, although it is inferior to two correct filters. Professional SSB transmitters normally use the more expense option of two asymmetrical SSB filters.

Generation of SSB by phasing

Early SSB transmitters, before SSB filters became available, using a "*Phasing Exciter*" to generate the signal. Essentially this is a "*double-double-balanced mixer*" where the RF carrier and the audio signals where shifted in phase by 90° and drove RC networks to cancel out the carrier and one sideband. Phasing exciters work best at low frequencies and tend to be tricky to set up; they also tend to drift out of alignment fairly quickly, especially if the ambient temperature varies over a wide range. For these reasons they are no longer used today. Later we will look at the new phasing method, which has become very popular.

Linearity of Amplifier Stages

In an AM transmitter where the modulation occurs in the PA all the stages can be designed for Class-C with its superior efficiency. For a low level generated AM signal that is then mixed up to the final frequency and then amplified, all the stages after the modulator need to be very linear, typically running in Class-AB1 or AB2 for lowest distortion. For SSB where the signal is generated at low level and then mixed up the same applies, but the linearity becomes more critical. Often the stages preceding the PA run in full Class-A, which leads to poor efficiency but the best linearity.

Alternative modulation methods

An alternative to high level AM modulation, which allows far lower audio power to achieve the modulation, is the *series gate modulator* or driver stage modulation. In series gate modulation the PA stage can be Class-C for best efficiency but the anode voltage is fixed and the screen grid of the tetrode or pentode is modulated. The series gate modulator is in effect an *adjustable high voltage linear regulator* with a valve as the series element. The quiescent voltage applied to the screen grid is set at 50% of that required for maximum RF output and the audio signal swings the screen grid voltage plus and minus about the nominal value. This requires very little power but the maximum modulation percentage is limited to about 80% due to the non-linear transfer characteristics of the valve. However, this is normally adequate. An added benefit of series gate modulation is the inclusion of a carrier level control, which sets the quiescent screen grid voltage and hence carrier power. It is necessary to adjust both the screen grid voltage and the microphone gain to get acceptable modulation.

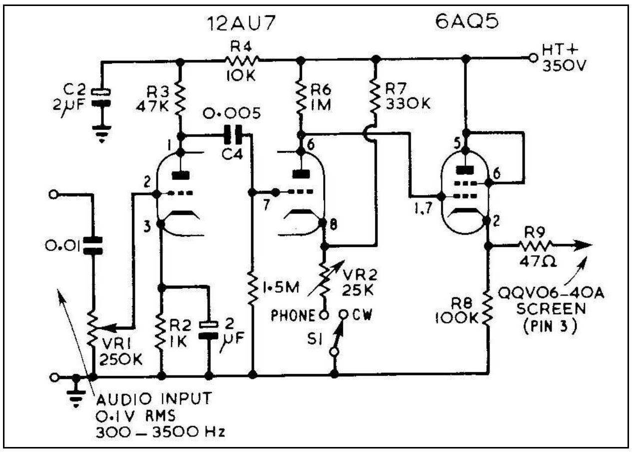

Figure 7 Series Gate Modulator

The alternative scheme uses high level anode and screen grid modulation of the driver stage. For a pair of 6146s valves at HF the maximum drive power is no more than 2W worst case, on 80m as little as 250mW of drive is adequate to drive a pair of 6146s to full output. This means about 1W of audio power is sufficient to fully modulate the driver valve.

The PA now needs to be linear and a type identical to a SSB transmitter is used biased for Class-AB1. Using a typical RF driver valve such as the 5763, 6BW6, 6CH6 or 12BY7A requires as little as 1W of audio power and this can be conveniently obtained using an audio IC such as the TDA-2003 (see Figure 8).

The TDA-2003 is a 10W audio amplifier intended for car radios and operates on 12V DC. In the writer's AM transmitter the modulation transformer used was a small mains transformer (10VA) with 230V and 9V windings. The anode supply uses the 230V winding and the audio IC driving the 9V winding. It was rather surprising to measure the frequency response of this inexpensive Taiwanese transformer. It was flat within ±1dB from about 50Hz up to 5kHz and at 10kHz it was only 2dB down. For speech and music this is more than adequate. Frequency shaping in the microphone gain stages would set the higher frequency roll-off. The TDA-2003 frequency response is flat to 15kHz, which high fidelity music requires.

> A SSB transmitter could be easily modified by adding the TDA-2003 IC and using this to modulate the 12BY7A driver valve. To operate the transmitter the CW mode is used and the carrier level adjusted to obtain 50% of the normal anode current. (When CW mode is selected the carrier crystal is pulled into the centre of the crystal filter and the balanced modulator is disabled).

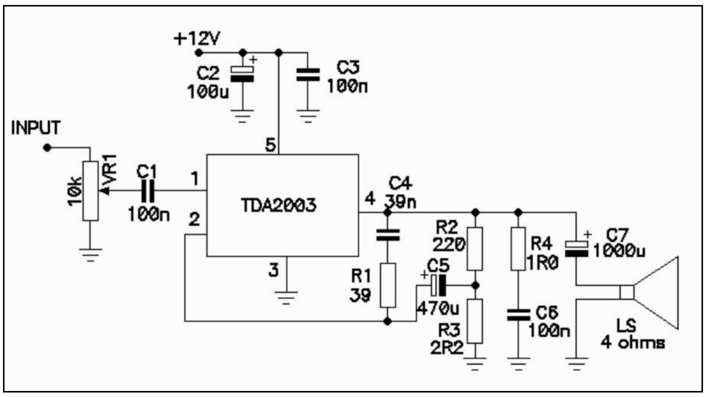

Figure 8 TDA-2003 10W audio amplifier

To use as an AM modulator the low voltage winding of a mains transformer is driven by the TDA-2003 and the anode voltage applied to the 230V winding (the original primary winding).

For this scheme to work the driver valve quiescent anode supply voltage needs to be reduced to approx 50% of normal. A convenient way to do this is either a series variable feed resistor or a variable voltage regulator. In the writer's transmitter the 6AQ5, which was the original series gate valve, was supplied with a variable DC voltage via a 100kΩ potentiometer from the unregulated +250V DC rail. This allows the PA current and hence RF output to be set to the required level. With +700V anode supply and a regulated +200V screen supply the best linearity was with 75mA anode current. This is about 50W DC input and about 35W RF carrier output, which then swings up to 120W pep when fully modulated.

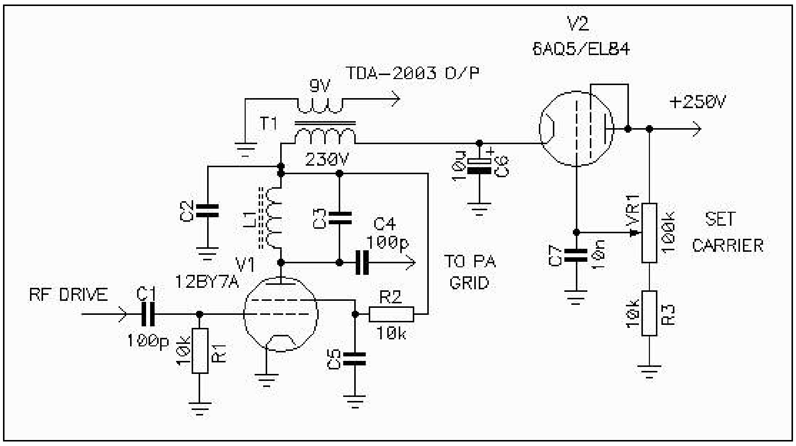

Figure 9 AM modulation of driver valve

Commercial SSB transmitters and AM

Some commercial SSB transmitters/transceivers have an AM mode, but in many cases it isn't true AM at all. A typical example is the Yaesu FT-101 series. To use this on AM you need to adjust the carrier level control on the front panel and also the microphone gain control. These two interact and getting the correct setting is tricky if the transmission is to sound good. Let us look at how Yaesu and many others generate the AM.

The balanced modulator generates the double sideband suppressed carrier in the normal manner and then the SSB filter strips off the unwanted sideband. So now we have a normal SSB signal. We cannot *unbalance* the modulator to raise the carrier level because the SSB filter will reduce this by 20dB as we have seen already. As we have seen the carrier needs to be 6dB higher in level than the SSB signal.

So what is done is to "*re-insert*" the carrier after the SSB filter and prior to the first transmit mixer stage. This is a signal that only contains one sideband but the correct level carrier. When you listen to a FT-101 running AM on a SSB receiver the carrier is normal and if you use the correct sideband and zero beat the carrier it sounds like AM. But switch to the other sideband and the modulation is almost non-existent! What you do hear is a combination of phase distortion products and the remnants of the suppressed sideband. On an AM receiver it sounds normal but lacking in punch, this is because only one sideband is present. KW Electronics in their marine radio version of the KW-2000A (the KW-2000CA) also did this but marked the AM mode switch "*AM-LSB*" and "*AM-USB*" to denote which sideband was being used. The amateur version (KW2000 etc) did not have AM fitted.

Those commercial transmitters that generate AM in a similar manner use a correct bandwidth AM filter (about 6kHz wide) to allow both the sidebands to pass and then re-insert the carrier after the filter. This is a much better method but requires an additional (expensive) crystal filter. In a transceiver which uses the filters both on receive and transmit this is a possible technique, if the switching allows the correct filter to be selected on transmit as well as receive.

Modern Phasing Exciters

The traditional phasing exciter to generate SSB used close tolerance RC networks to provide the necessary 90° phase shifts. Today the method is now used with *Digital Signal Processing* ICs (DSP). These are very powerful and do not suffer from the drift that the earlier types where plagued with.

The balanced modulator requires two sets of signals, one "*in-phase*" and one 90° out of phase, or in "*quadrature*". These are known as "*I & Q*" and can be readily generated at any frequency required by the DSP ICs. This allows the SSB generation to be done at the final frequency in some cases. This eliminates all the mixing stages and reduces the level of mixing spurious, which previously needed to be filtered out in the transmitter. This dramatically reduces the component count and size as well as eliminating many of the inherent problems with mixing, along with the conversion oscillators etc. Although suitable DSP ICs are still expensive the reduction of all the other components to only those essential lowers the overall cost by a large factor.

Using I & Q signals, generated by the DSP, allows any modulation scheme to be implemented with one piece of hardware. The only thing that changes is the software. Today CW, AM, FM, LSB, USB, FSK, QPSK, BPSK and many others can be generated with low levels of spurious and excellent linearity for little cost.

(Our thanks to John for this extremely interesting article)

Swap Column:

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.

William ZS5WC, has some fine Collins equipment for sale, namely 2 KWM2-A's and a 30L-1 linear. Should you be interested, contact William 083 309 7692.

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.

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)

Cliff – ZS6BOX, sent me this photo of his shack. Well done Cliff it looks great.

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.

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