AM Broadcast Radio Principles

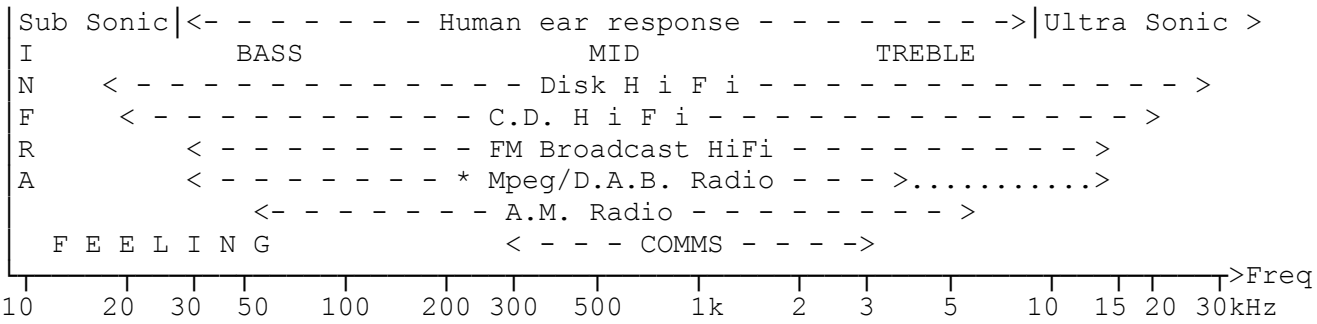
By G8MNY (Corrections Jan 10)
(8 Bit ASCII graphics use code page 437 or 850, Terminal Font)

AUDIO

There are 3 main parameters to Audio quality.

1/ FREQUENCY RANGE

Here is the approximate frequency plot for some audio sources. Note that the old disk system was not really upper limited like CDs & special equipment can do Quad audio with high frequency sub-carriers!



* Mpeg/D.A.B. & D.R.M. systems the quality is quite variable depending on the data rate chosen (same as internet broadcasting).

Broadcast AM (EU) uses 9kHz channel spacing so in theory 4.5kHz should be the upper limit, but in practice 7kHz is the top limit (-40dB@ 9kHz) to make it sound a bit better.

Comms Audio is the smallest bandwidth that can easily be understood, but not having no treble there is confusion over sounds of F & S, B P T D E C G, M N letters etc!

2/ SIGNAL TO NOISE RATIOS

This is the measure of unwanted noises below the wanted sound..
e.g. Hiss & Hum, or windage/engine noise, Neighbours/street noises etc.

COMMON S/N LEVELS

0dB	Noisy Conversations	
10	Poor Comms, NORMAL CAR	
20	Fair Comms	
30	VERY QUIET CAR	AM RADIO (GOOD PHONE)
40	Typical Cassette Tape, Quite Living rooms	
50	Reel-Reel tape, Dolby Cassette	TV SOUND
60	New Vinyl Record	FM RADIO
70	Mini disk (unmasked noise)	
80	Dat tape.	DAB*, TV NICAM
90	Perfect Digital CD, apparent Minidisk & Mpeg*	
100		
110		
120	Ear Threshold Noise/signal pain	

3/ HARMONIC DISTORTION

This the amount of unwanted signals generated in harmonics of the wanted signal in the audio pass band of interest. It is usually very dependent on the level, except for digital systems where it is a constant mathematical design feature.

It is measured as a % of the signal, so 10% = -20dB in harmonics.

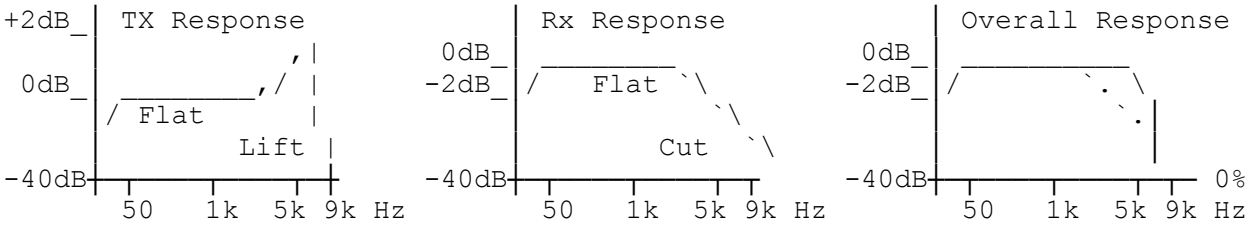
%	dB		
10	-20	Cheap AM Radio at high Volume, Comms Audio	
5	-26	Film Optical Sound (density type)	
3	-30	Cassette & Reel Tapes	Low bit DAB
1	-40	Quality Valve Amps	AM BROADCAST
.5	-46	High Quality Disk,	FM BROADCAST
.3	-50	Most Loudspeakers??	
.1	-60	Most AF Amps,	High Bit DAB, NICAM
0.05	-66	Good modern AF Amps.	
0.03	-70	Most Digital AF sources (not too compressed).	

Sometimes the above parameters are joined together in a Signal In Noise And Distortion (SINAD) rating for measured RF signal level of a Rx.

EMPHASIS

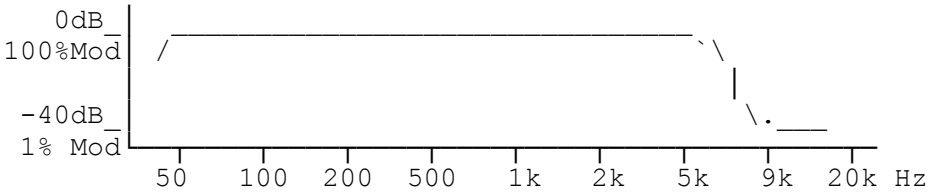
With AM there is not enough bandwidth or dynamic range to really use pre-emphasis & de-emphasis, as there is with FM Radio, & unlike FM the noise floor is quite flat & noise does not need masking so much.

However most Rx do cut the treble in their narrow IFs & AF detectors & some compensation of the odd dB or so of treble lift is sometimes applied below the sharp 7kHz cut off at the Tx.



9kHz WALL FILTER

There is a requirement that the Tx sidebands do not interference to adjacent AM channels, so higher AF frequencies that would cause Tx sidebands that would interfere with adjacent channel carrier MUST BE removed to > -40dB level.



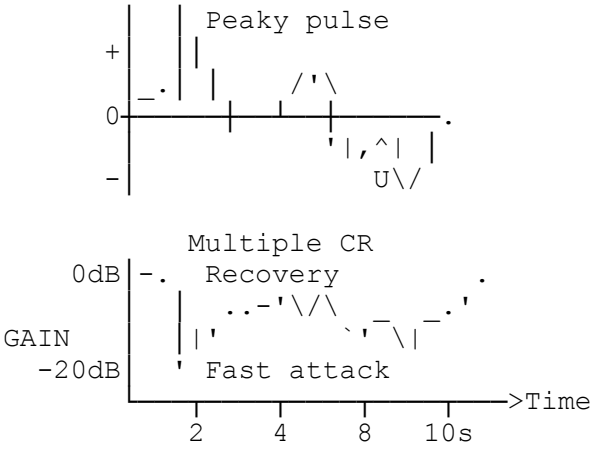
To give this level of filtering something like a 2 stage M derived filter is needed to give the sharp cut off starting @ 7kHz.

LIMITING

As AM must not be over 100% modulated, a limiter is used, this is not like a simple clipper used on comms Tx that lets the signal distort.

Broadcast limiters have electronic gain controls with fast attack to cope with the spikiest peak, but the gain recovery uses several decay time constants to mask the limiter's "breathing effects".

Complex limiters may be multi band & treat the treble separately with separate faster time constants, as the treble content will be a more prominent on some types of programme content.

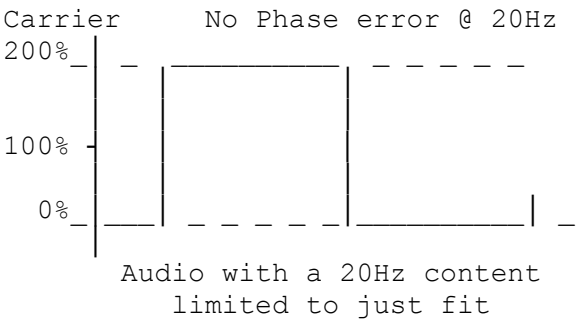


The result is a signal that has it's ± peak value accurately limited, but sounds perfect!

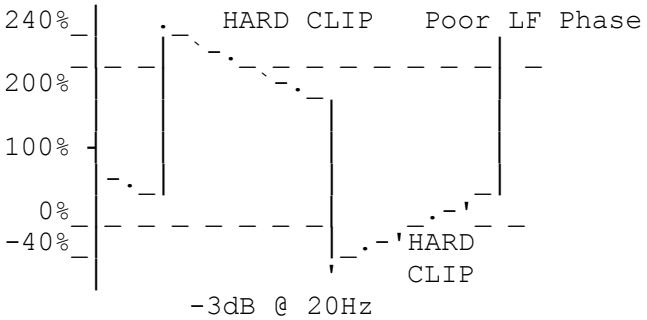
With a good limiter you should not be able to tell the difference between a live studio feed & off air even with high limiting levels of around 12 - 24dB used for AM.

As the limiting process must have fast attack times to handle all the peaks one half cycle will Rx a different compression factor to the other half cycle this results in some low frequencies down to near DC being added to the signal!

BAD LF RESPONSE AFTER LIMITER
It is also important that there is no phase distortion between the limiter & the Tx modulation process, over all the frequencies to be transmitted. If there is then the carefully peak limited signal can actually get larger....



Audio with a 20Hz content limited to just fit inside this envelope.



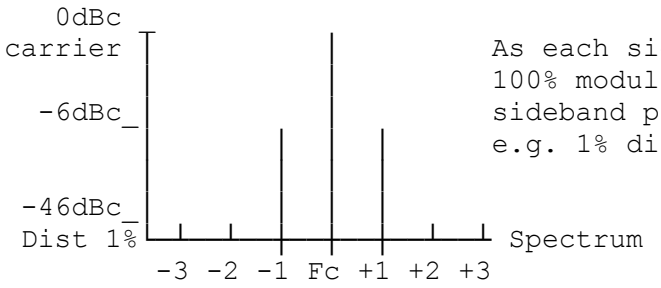
-3dB @ 20Hz
Tx Peaks now seriously over modulated

In AM Tx, poor LF phase response on high level Modulation Transformers often cause unexpected hard clipping on certain waveforms!

Poor LF phase causes over modulation on some programme material containing deep LF. This is one reason why loud LF is often cut on input of broadcast limiters.

TX LINEARITY
The AM sidebands should be symmetrical & contain no significant levels of sideband harmonics. This is all about modulation linearity.

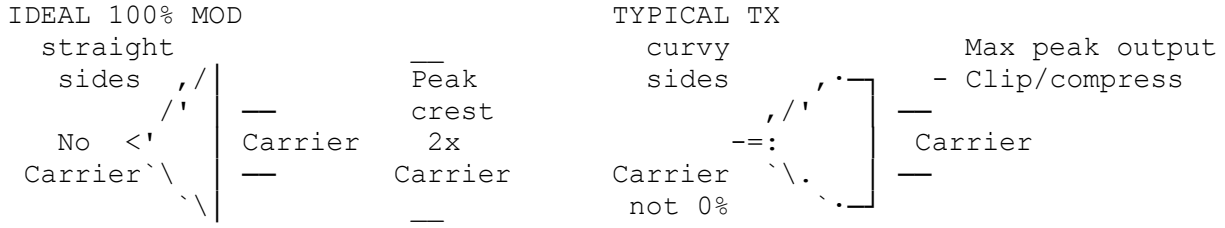
Methods of checking linearity use pure sine wave modulation source an either an AF distortion analyser with a perfect Rx or a spectrum analyser.



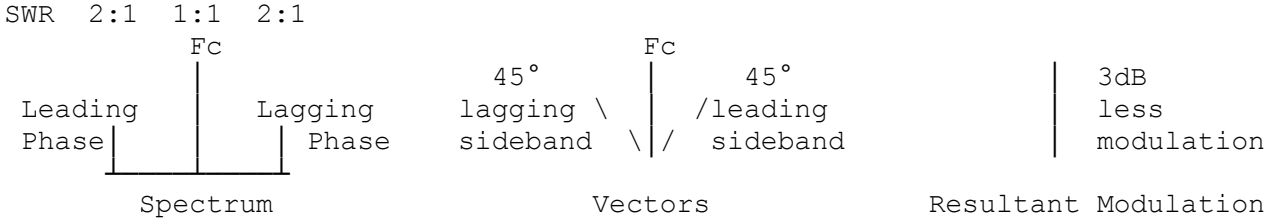
As each sideband can only peak to -6dBc with 100% modulation depth, subsequent distortion sideband products are with respect to that.
e.g. 1% distortion harmonic is @ -46dBc.

While this is sort of testing is OK into a dummy load for actual performance figures, it does not reflect the modulation process into a typical high Q aerial system.

One old & easy way to see the linearity while programme is being Tx is to use a scope in XY mode, with the applied modulation on the X axis & RF on the Y axis.



UNWANTED PHASE MODULATION
Due to Hi Q tuned circuits in the PA & especially the aerial itself, there is significant risk of the higher audio frequency sidebands being phase shifted. This means there vectors will no longer add up to produce 100% carrier modulation in the Rx. This effect looks like reduce bandwidth which it is. It normally shows up shows up as an effect of kicking SWR to syllabance showing the sidebands are seeing the bad aerial match.



But it can be in earlier stages as well, reducing the treble modulation level even further.

TX RF Harmonics & Mixes
These should all be > -60dBc, so added filters are normal. On multiple Tx sites there is a risk of PA mixing, where RF from a nearby Tx can be Rx at the Tx PA at enough strength to cause a Mix. A narrow resonant channel filter (aerial tuning L & C are normally enough in most designs!) in the Tx feed can protect the Tx from these or specific suckout may be needed.

Also see my buls on "1W @ 531kHz MW station system".

Why Don't U send an interesting bul?
73 de John G8MNY @ GB7CIP