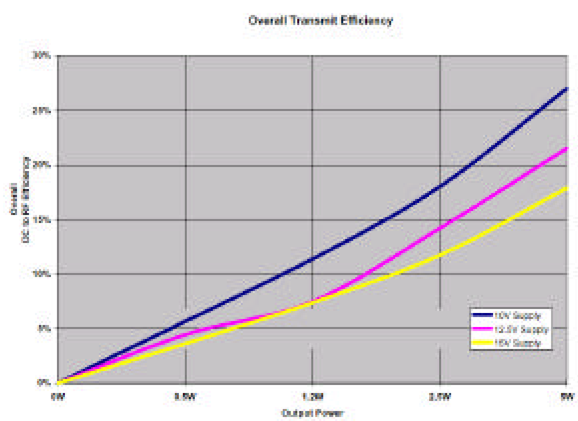
Modulation Processing for SSB

They say necessity is the mother of invention – when you are transmitting with the absolute minimum RF power to maintain contact, you will try everything to do the best with what you have. In portable operation what you can do is limited by the peak transmitter output and the battery.

Modulation processing focuses mainly on getting the best voice communication within the peak RF capability of your transmitter – we know that when using voice modulation on SSB the AVERAGE power out (and IN !) is much less than the transmitter is capable of during key-down (average power = peak power). Modulation processing focuses on increasing the AVERAGE power out within the same peak limit – this improves communication because it increases the actual amount of signal received. Yes, it does distort the original audio from what went into the microphone, but if it improves the intelligibility of the voice message, then no-one cares that it isn't hifi – in fact none of these techniques will help with music or data transmissions.

You may also ask whether this is really doing the most with the limited battery power available – I say yes, even though you are increasing battery drain by increasing the average power consumption – but at least all of the extra power in goes to produce useful power out. If you increase your average RF output from 1 watt to 4 watts you will increase battery drain, but not by 4 times. This is because idle current is quite significant and efficiency drops of rapidly as power output drops below peak output. Without a processor you would need to carry a 20 watt transmitter to be able to achieve 4 watts average output – and a 20 watt transmitter will have a much higher idle current than a 5 watt transmitter and will be much less efficient at 4 watt than a 5 watt amplifier at 4 watt. For the FT817 on 10volts DC, the DC-to-RF efficiency is 6% at 0.5W and 27% at 5W which shows that for battery efficiency it is better to run a transceiver as close to its peak capability as possible. I estimate that the FT817 putting out unprocessed voice averaging 1 watt would have an average efficiency of 12% whereas if processing can increase the average power by 6db to 4 watts the efficiency would average 25% - a doubling of the DC-to-RF efficiency.



FT817 DC-to-RF efficiency

Practical ways of improving SSB voice efficiency

Here I have listed four ways currently used for achieving improved voice communications – some apply for all types of RF modulation, one applies only for SSB.

Audio Frequency shaping

– some audio frequencies are more useful than others for conveying speech intelligence – usually the higher frequencies are emphasized for this reason. The Heil HC-4 element does this directly in the Microphone so you don't need to change anything the transceiver, although the same effect can be achieved with resistors and capacitors and all transceivers do this to some extent. The Heil HC-4 response is 500 Hz to 3,800 Hz with 10 dB rise at 2,000 Hz.

Background Noise and inteference suppression

– any sounds other than the actual voice will use up needless RF energy and will cause distracting "interference" to the listener. Providing this noise and interference is below the level of the voice most of the time, it can actually be filtered out by effectively turning down the Mic Gain whenever the input level drops below a certain threshold. This is helpful to prevent background noise getting into the microphone from other people nearby, cars etc and also with interference entering the microphone electrically such as hum and hash. The Microphone speech processors based on the SSM2165 developed AD5X and sold by W4RT do this.

Audio Dynamic range compression

– if you look at voice on an oscilloscope you will see that the voice signals vary over a large range. The aim of dynamic range compression is to increase the Mic Gain whenever the voice is at low levels to bring it closer to the peak levels. This increases the AVERAGE level and power in the voice signal, but importantly without increasing the peak level. When voice levels get higher than the peak levels you then want to reduce Mic Gain and if you do this progressively it will minimize distortion. The Microphone speech processors based on the SSM2165 developed by AD5X and sold by W4RT do this.

To prove how relatively unimportant amplitude information is for intelligibility in a voice signal, you can go to extremes and remove all amplitude information through severe amplification and infinite clipping. The resulting audio sounds ghastly - but it is still quite intelligible.

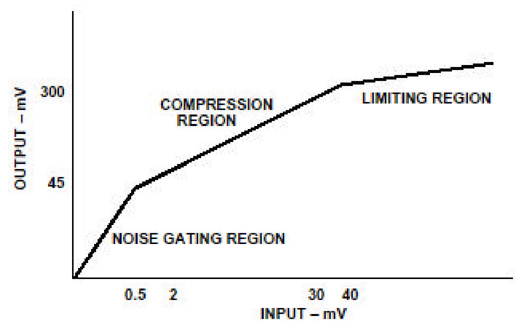


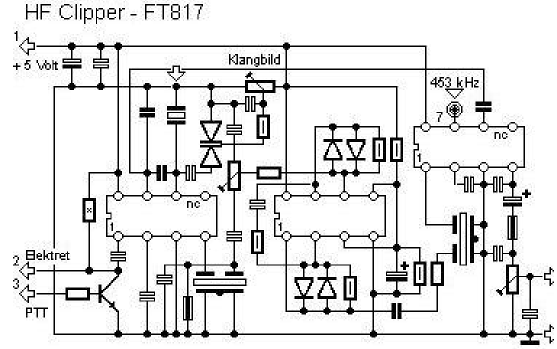
Figure 10. Transfer Characteristic

Input/Output Characteristics of the SSM2165

RF Dynamic range compression -

All three techniques mentioned above will be effective in achieving improved voice intelligibility within the same peak voice level whether transmitting the voice over AM, FM or just a Public Address system. However SSB modulation is a different situation because SSB modulation is non-linear – the RF output is not proportional to the amount of input modulation. With AM the RF level increases as the audio waveform level increases – with SSB the level of RF output depends on the waveshape as well as the level of the audio input. So here we have an additional opportunity to process the signal so that we get maximum AVERAGE RF output within the same peak RF limit imposed by any transmitter. RF level processing is actually easier than audio level processing because we can clip the RF signal pretty severely without causing audio distortion – it's easy t filter at RF to eliminate the out-of-band harmonics. Severe clipping at audio produces noticeable distortion quickly. This approach is used by RF Speech processors built into transceivers, but an interesting implementation is DF4ZS's version which can be built into any microphone.

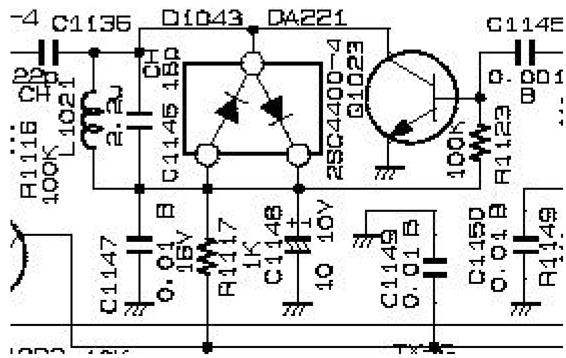
HF Clipper - FT817



Audio In–Audio Out RF Speech processor by DF4ZS

The microphone signal is DSB modulated to 453 kHz, RF clipped, and demodulated to audio. The output audio is now changed so that when it goes into an SSB amplifier, it will have a higher AVERAGE RF power than an unprocessed audio signal. I am uncertain about how much the filtering that is used in SSB modulator audio input circuits reduces the effectiveness of this approach though.Even though the output is audio, I class this as an RF processor because all processing occurs at RF after DSB modulation

I really wonder whether it would be easy to modify the existing FT817 circuitry to do RF speech processing because it already contains diodes for RF clipping, as these are needed for eliminating amplitude modulation on FM transmissions !



Existing RF-clipper diodes in FT-817 driver

But can you use all these techniques at the same time to good effect – I haven’t tried it, but I believe you can. The only uncertainty is about combining Audio and RF Dynamic Range Compression. Because SSB modulation is non-linear they produce different changes. As long as you apply moderate compression for each technique then Audio compression will lift up the levels of the quieter parts of speech and RF compression will squeeze a bit more RF energy through the peak limit of the transmitter.

So why have I called this article Modulation Processing – because it’s the only term I can think of that includes both audio and RF processing !

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