Transmitter Inter-Modulation Distortion (IMD)

By Larry E. Gugle K4RFE, RF Design, Manufacture, Test & Service Engineer (Retired)

Excessive **B**and **W**idth (EBW)

1. The full Emission Designator **'2K70J3E'** mode of operation, is **'2K70'** which means a 'Band Width of **2.7 kHz**' ***and*** **'J3E'** which means a '**S**ingle **S**ide **B**and **S**uppressed **C**arrier - **A**mplitude **M**odulation (**SSBSC - AM**)' Telephony Emission.

2. There are common causes of a Transmitted **SSBSC-AM** Telephony Emission having **'Excessive Band Width (EBW)',** commonly referred to as **'Splatter' or 'Buckshot'**.

3. **EBW** which is often heard by a Receiving Station listening *'3 kHz or more away'*, is not just the offending Transmitting station's **A**udio **F**requencies (**AF**) Fidelity applied to the Transmitter's Microphone Input, ***or*** the offending Transmitter's **B**and **P**ass **F**ilter (**BPF**), **B**and **W**idth (**BW**) setting being too wide, but includes several factors.

4. Let's examine some of the most common causes of Transmitter **EBW**.

Common Causes of a Transmitter having EBW:

1. **Improper adjustment of the 'Bias Voltage' Variable Resistors in a Transceivers Transmitter Module RF Power Amplifier (RFPA) stage.**

    a. Variable Resistors are connected in circuits inside a Transceiver configured using either all 'Three' legs, referred to as 'Potentiometers' or using only 'Two' of the 'Three' legs, referred to as 'Rheostats'. The most common Printed Circuit Board (PCB) configuration is the Potentiometer.

    b. *Potentiometers set the 'Bias' Voltage* for the Transmitter Modules RFPA Stage 'Driver' Transistor(s) and 'Final' Transistor(s) so they are in the appropriate class of operation.

    c. *Proper setting of the 'Bias' Voltage potentiometers*, ensures that the Transmitter Modules RFPA Stage is in a *Linear Mode* of operation using a SSBSC-AM Telephony Emission, which must be Class 'A', Class 'AB1', Class 'AB2', or Class 'B'.

    d. *Improper setting of the 'Bias' Voltage potentiometers*, can cause the Transmitter Modules RFPA Stage to be in a *Non-Linear Mode* of operation using SSBSC-AM Telephony Emission, which would be Class 'C'. *This will distort the SSBSC-AM Audio Frequencies (AF) modulating the Radio Frequency (RF) Carrier Signal.*

2. **Use of an Electron Tube *or* Solid State Semiconductor, RFPA, that does not have an Input 'Pi' or 'L' Configured Low Pass Filter (LPF) Coupling Network.**

    a. **An Input 'Pi' or 'L' configured LPF Coupling Network, *must* be applied to the 'Input Electrode', of any RFPA.** The Input Electrodes are the '*Cathode'* in a Power

Triode, the *'Control-Grid'* in a Power Tetrode, the *'Control-Grid'* in a Power Pentode, the *'Base'* of a Bipolar Junction Transistor (BJT) and the *'Gate'* of a Field Effect Transistor (FET).

b. An Input 'Pi' or 'L' configured LPF Coupling Network, **prevents input signal waveform distortion.**

c. An Input 'Pi' or 'L' configured LPF Coupling Network, **provides Intermodulation Distortion (IMD) Harmonic Reduction.**

d. An Input 'Pi' or 'L' configured LPF Coupling Network, **provides Impedance matching between the 'Characteristic Impedance' of the connected Input RF Feedline and the 'Input Electrode Impedance' of the RFPA.**

3. **Under-Coupling (also called Under-Loading) a Linear Mode** Class 'A', Class 'AB1', Class 'AB2' or Class 'B', Electron Tube or Solid State Semiconductor RF Power Amplifier (RFPA) when using SSBSC-AM mode.

4. **Using a Non-Linear Mode** Class 'C', Electron Tube or Solid State Semiconductor RFPA in SSBSC-AM mode.

5. **Setting a Transceiver's Microphone gain to high** (set outside the ALC range) and using excessive speech compression and/or processing.

6. **Enhancing both 'Bass' and 'Treble' Audio Frequencies (AF) from the Microphone which are outside a 300 Hz ~ 3000 Hz range.** This increases the Radio Frequency (RF) signal Band Width (BW).

Rules of Thumb for Intermodulation Distortion (IMD) Band Width (BW):

1. The maximum frequency spacing of new IMD products is the difference between the Lowest and Highest pitched Audio Frequencies (AF) modulating the transmitter.

2. The total occupied Band Width (BW) of a SSBSC-AM emission (2K70J3E), when we include 3rd Order IMD Products (abbreviated 'IM3') is approximately three times ('3x') the AF Band Width (BW) of the system.

3. The BW of the Transmit Band Pass Filter (BPF) does not set the BW of the transmitted signal.

4. Every increase in frequency difference between the highest and lowest modulation frequencies increases AF BW greatly. An increase in level increases the strength of the IMD Products in even greater proportion than we might expect.

Description of IMD:

1. In a Transceiver there is a controlled Local Oscillator (LO) generating a frequency which is combined in a mixer, to produce a sum and difference frequency of any Received or Transmitted Radio Frequency (RF) Signal. We don't hear the IMD caused by this non-linear mixer because it is primarily developed out-of-band or off-frequency, and the mixing products are filtered out or rejected by tuned circuits. A well-designed high Dynamic Range Mixer will actually terminate these unwanted frequencies in a dummy load, so they do not reflect back into the mixer. Transceiver's include a multitude of amplifier stages, as well as some mediocre mixers and/or frequency converters, conducting much less than 360 degrees. Most of these stages are operating in class AB1 or AB2 mode, where the full sine wave isn't amplified, only a portion of it.

2. Mixing between various AF Signals with a Transmitted RF Carrier Frequency (CF) Signal caused by even the slightest amount of 'Non-Linearity' will generate new frequencies. Mixing in a SSBSC-AM system creates new 'off-frequency' IMD products, which are outside the Passband of a Receiver's Band Pass Filter (BPF) tuned to the Carrier Frequency (CF).

3. The most important factor is 'Linearity', which can be expressed as a transfer function of 'input level' versus 'output level', and If the transfer function were perfect, an 'X' percentage input power level change would produce an identical 'X' percentage output power level change. In this case IMD would not be much of an issue.

4. Unfortunately Manufacturers have caused RF Communication-Electronics Design Engineers, to compromise linearity in their designs, in an effort to reduce the expense, size, heat, and power requirements in Transceivers.

5. Transmitter IMD reduction has taken a backseat to Receiver IMD reduction, and we have come to accept this poor performance.

    a. Most new Transmitters have Odd-Order IMD products in the 30 dB below Peak Envelope Power (PEP) range.

    b. Numbers like that would be considered terrible in receivers.

    c. If there is any doubt about this fact, look at the Transceiver Test Reviews published in the ARRL QST Magazine, by Sherwood Engineering Labs, or in the Transceiver Manufacturers own specifications datasheet.

How IMD Product Frequencies are created:

1. In SSBSC-AM systems, IMD Products are Harmonics (Even-Order: 2, 4, 6, 8th etc. and Odd-Order: 3, 5, 7, 9th etc.) created by the mixing of a RF Carrier Frequency (CF) Signal and multiple Audio Frequency (AF) Signals. IMD products are a major cause of EBW. The mixing of two or more AF modulating a RF carrier, produces IMD products. They can cause splatter or buckshot that cannot be heard listening to the conversation on the CF and cannot be detected by the transmitting station using an oscilloscope displaying the modulation envelope or trapezoid. A Spectrum Analyzer must be used to observe the IMD Product frequencies!

2. Amplitude linearity describes how closely the input to output transfer response (or gain) of an amplifier or mixer resembles a straight line. When an amplifier's input level increases by a certain percentage, its output level must increase by the same percentage, otherwise distortion is produced. The deviation from a straight-line can be represented by a power series. For most RF Communication-Electronics (RFCE) applications, Harmonic Band Width (BW) of less than an octave, can be eliminated by filtering. However in a SSBSC-AM system it is different, and each 'Speech AF', is a frequency that changes amplitude and frequency with our voice. In other words the SSBSC-AM generator in our Transceiver simply up converts base band AF applied to the microphone input to a RF.

3. When more than one AF input is present, more than one RF output 'carrier' varying in frequency and level is present. Beat products are produced in the vicinity of these RF output 'carriers'. The new signals are known as IMD products. They are located at frequency intervals equal to the separations of the desired carriers. Filtering cannot eliminate IMD products, because the IMD products are located on the same frequency, or nearby the desired output frequency.

4. As two or more pure Speech AF from our voices pass through a less-than-perfectly linear stage or component, harmonics are generated. It doesn't matter if the devices are in push-pull or single-ended configuration, and it doesn't matter if we cannot hear the distortion, it is always there to some extent.

5. Various harmonics created, even though greatly attenuated, mix with the fundamental desired AF and other harmonics of the AF. Most undesired products fall far outside the band we are using and are easily cleaned up. Unfortunately some products fall in band, just outside the desired occupied Band Width. The products that fall in band are the Odd-Order IMD products. The Odd-Order IMD products are the problems that are difficult or impossible to filter. We identify the troublesome products by the harmonic relationship of the AF being mixed and the lowest order harmful products creating splatter. The Third-Order product is the lowest order product that is a problem.

6. When a single carrier input signal is substituted into the equation below, the output waveform will contain the original carrier and harmonic distortion products.

$$V_{out} = K_1 V_{in} + K_2 V_{in}^2 + K_3 V_{in}^3 ... + K_n V_{in}^n \qquad (1)$$

Standard Intermodulation Distortion (IMD) Testing:

1. **The standard IMD test is the <u>Two-Tone Audio Frequency (AF) Test,</u>** which produces IMD Harmonic Products.

    a. The '<u>Even Order</u>' IMD Products produced by this test are the 2nd Order IMD (IM2), 4th Order IMD (IM4), 6th Order IMD (IM6), and 8th Order IMD (IM8) etc.

    b. The '<u>Odd Order</u>' IMD Products produced by this test are the 3rd Order IMD (IM3), 5th Order IMD (IM5), 7th Order IMD (IM7), and 9th Order IMD (IM9) etc.

2. **If testing a Transceiver**, Two AF Tones are fed into the Microphone audio jack. The two steady AF Tone signals, are generally a few kHz apart, not harmonic related to each other, within the Passband of the Audio Filters Bandpass (300 Hz ~ 3000 Hz). However the human voice speech modulation has many more AF that vary at syllabic rates.

   a. In general the Two AF Tone Test is a pretty poor test for a system designed to process speech and it generally show us the very BEST a Transceiver will do.

   b. **Two-tone tests DO NOT show power supply deficiencies.** The varying load on power and bias supplies is at the separation of the two frequencies. Small capacitors filter the time-varying load, while the long-term (or low frequency) dynamic load remains constant.

   c. Slow variations in speech level, load and unload plate and bias power supplies. This causes supplies to 'wobble around'. The conclusion of some is that screen grid or control-grid bias regulation is 'unimportant', but that conclusion is mostly rooted in the fact the tester actually used a flawed test method that does not show low frequency dynamic regulation problems. We cannot test for distortion created by poor low-frequency dynamic regulation when the test method provides a constant load on the supplies!

3. **If testing a RF Power Amplifier (RFPA), Two Steady RF Carrier Signal must generally be generated from two separate RFPAs. The two RF Carriers are mixed through a combiner and used to drive the RF Power Amplifier Under Test. The reason two separate RFPAs generating steady RF Carriers are used in testing another RF Power Amplifier**, especially Cathode Driven (CD) Triodes, **is because a RFPA is far cleaner than most modern Transceivers and if a Transceiver's Two AF Tone IMD test output were used in stead of a steady RF Carrier from two separate RFPAs, the Transceiver's IMD would establish the IMD limit not the RFPA under test in most cases.**

Example Transmitter Two-Tone 'Odd Order' IMD Test:

A Transmitter using Telephony Emission Designator '**2K70J3E**' in the **Lower Side Band (LSB) mode**, on a **Carrier Frequency (CF) of 1,850,000 Hz**, modulated by a Two Tone **Audio Frequency (AF) of 700 Hz and 1900 Hz**, would have the following two **Mixed Frequencies (F1 and F2):**

Two-Tone 'Odd-Order" Intermodulation Distortion (IMD) Frequency Calculator					
Carrier Frequency (Hz) =	1,850,000				
Audio Frequency (Hz) =	-1,900				
Audio Frequency (Hz) =	-700				
Carrier Frequency and Audio Frequency Mixing					
ITEM	Carrier Frequency (CF)	Audio Frequency (AF)	Mixing	Mixed Frequency (MF)	Notes:

F1	**1,850,000**	**-1,900**	**F1 = CF + AF**	**1,848,100**	**Below Carrier**
F2	**1,850,000**	**-700**	**F2 = CF + AF**	**1,849,300**	**Below Carrier**
Odd-Order Intermodulation Distortion (IMD) 'Below' Carrier Frequency					
	IMD Formula	**F1 Mix**	**F2 Mix**	**F1 Mix - F2 Mix**	**Notes:**
IM3	(2 x F1) - (1 x F2)	3,696,200	1,849,300	1,846,900	Below Carrier
IM5	(3 x F1) - (2 x F2)	5,544,300	3,698,600	1,845,700	Below Carrier
IM7	(4 x F1) - (3 x F2)	7,392,400	5,547,900	1,844,500	Below Carrier
IM9	(5 x F1) - (4 x F2)	9,240,500	7,397,200	1,843,300	Below Carrier
Carrier Frequency =1,850,000					
Odd-Order Intermodulation Distortion (IMD) 'Above' Carrier Frequency					
	IMD Formula	**F2 Mix**	**F1 Mix**	**F2 Mix - F1 Mix**	**Notes:**
IM3	(2 x F2) - (1 x F1)	3,698,600	1,848,100	1,850,500	Above Carrier
IM5	(3 x F2) - (2 x F1)	5,547,900	3,696,200	1,851,700	Above Carrier
IM7	(4 x F2) - (3 x F1)	7,397,200	5,544,300	1,852,900	Above Carrier
IM9	(5 x F2) - (4 x F1)	9,246,500	7,392,400	1,854,100	Above Carrier

A Transmitter using Telephony Emission Designator '**2K70J3E**' in the **Upper Side Band (USB) mode**, with a **Carrier Frequency (CF) of 14,200,000 Hz,** modulated by a Two Tone **Audio Frequency (AF) of 700 Hz and 1900 Hz**, would have the following two **Mixed Frequencies (F1 and F2):**

Two-Tone 'Odd-Order" Intermodulation Distortion (IMD) Frequency Calculator					
Carrier Frequency (Hz) =	**14,200,000**				
Audio Frequency (Hz) =	**1,900**				
Audio Frequency (Hz) =	**700**				
Carrier Frequency and Audio Frequency Mixing					
ITEM	**Carrier Frequency (CF)**	**Audio Frequency (AF)**	**Mixing**	**Mixed Frequency (MF)**	**Notes:**
F1	**14,200,000**	**1,900**	**F1 = CF + AF**	**14,201,900**	**Above Carrier**
F2	**14,200,000**	**700**	**F2 = CF + AF**	**14,200,700**	**Above Carrier**
Odd-Order Intermodulation Distortion (IMD) 'Below' Carrier Frequency					
	IMD Formula	**F1 Mix**	**F2 Mix**	**F1 Mix - F2 Mix**	**Notes:**
IM3	(2 x F1) - (1 x F2)	28,403,800	14,200,700	14,203,100	Above Carrier
IM5	(3 x F1) - (2 x F2)	42,605,700	28,401,400	14,204,300	Above Carrier
IM7	(4 x F1) - (3 x F2)	56,807,600	42,602,100	14,205,500	Above Carrier
IM9	(5 x F1) - (4 x F2)	71,009,500	56,802,800	14,206,700	Above Carrier
Carrier Frequency =14,200,000					

Odd-Order Intermodulation Distortion (IMD) 'Above' Carrier Frequency					
	IMD Formula	**F2 Mix**	**F1 Mix**	**F2 Mix - F1 Mix**	**Notes:**
IM3	(2 x F2) - (1 x F1)	28,401,400	14,201,900	14,199,500	Below Carrier
IM5	(3 x F2) - (2 x F1)	42,602,100	28,403,800	14,198,300	Below Carrier
IM7	(4 x F2) - (3 x F1)	56,802,800	42,605,700	14,197,100	Below Carrier
IM9	(5 x F2) - (4 x F1)	71,003,500	56,807,600	14,195,900	Below Carrier

Notes:

a. Emission Designator **2K70J3E** is, Single Side Band Suppressed Carrier - Amplitude Modulation (**SSBSC-AM**) Telephony using either '**USB'** or '**LSB'**.

b. **In accordance with extensive testing done by Bell Laboratories for almost a century, True Intelligence in the Voice Communication Spectrum is 300 Hz ~ 3000 Hz.**

c. As a standard, the Two AF Tones, ***must*** be between 300 Hz ~ 3000 Hz and Non-Harmonically related to each other, with at least a 1000 Hz separation between them. F1 and F2 can be either AF tone with the same results.

d. IMD products are caused by mixing of Even-Order Harmonics and Odd-Order Harmonics, which creates new undesired frequencies.

e. The 3rd Order IMD ('IM3') product frequencies are both 'OUTSIDE' the Band Width (BW) occupied by the desired pure F1 and F2 frequencies. This bothers other operators up or down the band. F1 and F2 can be either AF tone with the same results.

f. Any odd order product adds Band Width (BW) to the signal that is outside the Passband of the original audio!

g. **Odd-Order IMD products create most of the problems.** This occurs because Odd-Order products can fall outside the normal filter Passband of a typical SSBSC-AM transmitter, spreading unwanted and undesirable distortion energy throughout adjacent voice channels.

Example Transmitter Two-Tone 'Even Order' IMD Test:

A Transmitter using Telephony Emission Designator '**2K70J3E**' in the **Lower Side Band (USB) mode**, with a **Carrier Frequency (CF) of 1,850,000 Hz**, modulated by two **Audio Frequency (AF) Tones, of 3000 Hz and 1000 Hz,** would have the following two **Mixed Frequencies (F1 and F2):**

Two-Tone 'Even-Order' Intermodulation Distortion (IMD) Frequency Calculator	
Carrier Frequency (Hz) =	**1,850,000**
Audio Frequency (Hz) =	**-1,900**
Audio Frequency (Hz) =	**-700**

Carrier Frequency and Audio Frequency Mixing					
ITEM	Carrier Frequency (CF)	Audio Frequency (AF)	Mixing	Mixed Frequency (MF)	Notes:
F1	1,850,000	-1,900	F1 = CF + AF	1,848,100	Below Carrier
F2	1,850,000	-700	F2 = CF + AF	1,849,300	Below Carrier
Even-Order Intermodulation Distortion (IMD) 'Out-of-Band'					
	IMD Formula	F1 Mix	F2 Mix	F1 Mix - F2 Mix	Notes:
IM2	(1 x F1) - (1 x F2)	1,848,100	1,849,300	1,200	Out-of-Band
IM4	(2 x F1) - (2 x F2)	3,696,200	3,698,600	2,400	Out-of-Band
IM6	(3 x F1) - (3 x F2)	5,544,300	5,547,900	3,600	Out-of-Band
IM8	(4 x F1) - (4 x F2)	7,392,400	7,397,200	4,800	Out-of-Band
Carrier Frequency =1,850,000					

A Transmitter using Telephony Emission Designator '**2K70J3E**' in the **Upper Side Band (USB) mode**, with a **Carrier Frequency (CF) of 14,200,000 Hz**, modulated by two **Audio Frequency (AF) Tones, of 3000 Hz and 1000 Hz,** would have the following two **Mixed Frequencies (F1 and F2):**

Two-Tone 'Even-Order' Intermodulation Distortion (IMD) Frequency Calculator					
Carrier Frequency (Hz) =	14,200,000				
Audio Frequency (Hz) =	1,900				
Audio Frequency (Hz) =	700				
Carrier Frequency and Audio Frequency Mixing					
ITEM	Carrier Frequency (CF)	Audio Frequency (AF)	Mixing	Mixed Frequency (MF)	Notes:
F1	14,200,000	1,900	F1 = CF + AF	14,201,900	Above Carrier
F2	14,200,000	700	F2 = CF + AF	14,200,700	Above Carrier
Even-Order Intermodulation Distortion (IMD) 'Out-of-Band'					
	IMD Formula	F1 Mix	F2 Mix	F1 Mix - F2 Mix	Notes:
IM2	(1 x F1) - (1 x F2)	14,201,900	14,200,700	1,200	Out-of-Band
IM4	(2 x F1) - (2 x F2)	28,403,800	28,401,400	2,400	Out-of-Band
IM6	(3 x F1) - (3 x F2)	42,605,700	42,602,100	3,600	Out-of-Band
IM8	(4 x F1) - (4 x F2)	56,807,600	56,802,800	4,800	Out-of-Band
Carrier Frequency =14,200,000					

Even-order mixing clearly isn't a problem in RF Transmitters. This is the reason why Push-Pull RF Power Amplifiers don't help Audible distortion and don't help Band Width. Push-pull designs do reduce Odd-Order Harmonic Distortion. This in turn relaxes output filter requirements, but output filtering is generally a non-issue anyway. Even a simple 'Pi' Output Coupling Network provides adequate harmonic suppression.

Conflicting Standards of IMD Testing:

The Eimac Commercial Data Sheet IMD Test Specifications compare **dB below one-tone of two-tones to the third-order spurious signals**.

The ARRL and Other Manufacturer Data Sheet IMD Test Specifications compare **dB below Peak Envelope Power (PEP)**. **Using PEP inflates IMD results, making everything appear '6 dB' better than the standard dB below-one-tone of two-tones used commercially.**

One United States Manufacturer, who imports and uses *Russian Power Tetrodes* in their RFPA Products, conducts their IMD tests using *dB below Peak Envelope Power (PEP)* to compare the quality of their products to other Manufacturers who use *Eimac Power Triodes*. ***This Manufacturer wrongly claims that the Russian Tetrodes are 'cleaner' than the Eimac's Power Triodes, when in fact they are not.***

If you look at the ARRL QST Review tests of the ETO, QRO, and Ameritron AL-800H RFPAs, you will notice that the Eimac 3CX800 Power Triode in the Ameritron AL-800H greatly surpass the Russian 4CX800 Power Tetrodes used in the ETO and QRO amps for 3rd Order (IM3) and 5th Order (IM5). ***This confusion is a clear example of how mixed standards gets us in trouble.***

Better IMD Testing:

1. **A normal two-tone AF test is not really very effective in measuring a SSBSC-AM signal, because there is no slow dynamic change typical of a voice.** Voltage regulation problems are masked and do not show up when a two-tone test is used, because load currents all average the same amount. Filter capacitors and other energy storage components mask any voltage regulation problems. We can, as a general rule, be confident that the actual SSBSC-AM voice performance is LESS than a two-tone test indicates.

    a. One test is an adjacent channel power test, using normal voice modulation of the transmitter.

        1. The adjacent channel power test simply uses normal voice operation and compares the long-term peak power in an adjacent channel to the peak power in the desired channel

    b. One test uses a three-tone signal.

        1. The three-tone test injects a third low-frequency tone into the system. The third tone is anything from a warble to a low-pitched hum causing a slow variation in power levels of the two major tones. The Spectrum Analyzer reads the peak amplitudes of mixing in the higher frequency tones while the level is varied at a syllabic to low pitched audio rate. The low pitch amplitude

modulation is varied in frequency until the worse case IMD is produced. The variation causes the power to change at a speech rate, testing supply regulation effects on wide spaced distortion at all important frequencies for speech.

2. A large improvement occurs with a three-tone test, when levels are varied at syllabic rates as well as higher frequencies in the voice range. This tests voltage regulation problems otherwise hid in a two-tone test, because all speech frequencies ranges are included. The most accurate test, of course, is with actual speech. The FCC now requires some commercial radios used on congested bands to be tested with actual speech.

2. Either one of these tests gives a much more reliable indication of transmitter Band Width than a two-tone test. Remember, a two-tone test is generally a 'best case' scenario.

Speech Processing or Compression:

The multiple AF signals in our voices contain low and high-pitched AF signals that mix. The strength of the distortion products outside the desired communications frequency depends heavily on the average power level of low and high pitches and the frequency spread between the lowest and highest pitches modulating the transmitter. Since the average level of lowest and highest modulating AF increase with speech processing. Any form of speech processing or compression (even ALC) increases off-channel average IMD power levels.

Processing is a bit of a double-edged sword that isn't all bad. Processing that controls peak levels reduces chances of overdriving stages following the processing. Decreasing the ratio of peak to average power produces a steadier load on power supplies. It also can prevent later stages from limiting or clipping. Although processing brings the average power level of lows and highs up, it can also decrease overdrive problems. Light or modest processing is actually beneficial in reducing splatter!

Automatic Level Control (ALC):

ALC is normally plagued with inherent problems. Filters in radios add group delay, in other words, the signal takes noticeable time to move through filters, and the ALC loop adds a time-delay of its own. The result can be a leading edge signal power overshoot, which often shows up as an adjacent channel 'spit' or 'pop' on leading or rising edges of CW or voice on SSB.

This problem is not only harmful for Band Width it also can damage amplifiers. The problem often gets WORSE as the exciter power level is turned down! Gain should be set so ALC just starts to take effect, if a drive control is available.

Extended Single Side Band 'ESSB' Audio also referred to as High-Fidelity Single Side Band 'Hi-Fi SSB' Audio:

ESSB Audio or Hi-Fi SSB Audio, is a generally a bad idea, since it adds and boosts unnecessary Low (Base) and High (Treble) Audio Frequency (AF) Signals*. Audio response* *flattening brings levels of unnecessary low and high frequencies up, and this rapidly increases power levels in unwanted off-frequency products compared to normal communications audio. The frequency difference between lows and highs is wider, so the 'junk' extends further than normal. The level of lows and highs are significantly stronger than levels in normal communications audio, and this makes IMD products much stronger. Energy in IMD products do not follow a linear increase as base and treble are increased! Unwanted power on adjacent frequencies increases at several times the rate of the power increase in the Base and Treble Audio Frequencies!* This is why 'ESSB' Audio or 'Hi-Fi SSB' Audio using increased Bass and Treble Audio Frequencies are a very poor idea on crowded bands. Make no mistake about it, ESSB Audio or Hi-Fi SSB Audio, even with perfect 'brick wall' filtering, is always going to have significantly more unwanted energy on adjacent frequencies when compared to regular communications audio (limited to 300 Hz ~ 3000 Hz Audio Frequencies) through the same system.

Many of the Transceivers popular with the ESSB Audio or Hi-Fi SSB Audio crowd are among the poorer Transceivers for IMD performance! The use of this mode on emptier bands may be okay, but we should do all we can to discourage it use on crowded bands or near weak signal areas.

Some users of this mode think the Band Width (BW) of their Transmitter Band Pass Filter (BPF) sets the Band Width (BW) of their signal. They also think they can hear the distortion that causes splatter, and if they 'sound clean' on frequency to their friends, they have no splatter bothering off-frequency operations 3 kHz away from them.

If somebody above or below you is running Enhanced Bass you will almost certainly notice greatly increased adjacent channel interference problems, and it is not likely to be your receiver's fault. Enhanced Bass increases distortion product Band Width, and do not let anyone kid you, modern SSBSC-AM transceivers all add very noticeable distortion products in the RF sections. The more we restrict bass frequencies from the microphone, the less overall distortion Band Width we have! Also most Tetrode Grounded Cathode (GC), Grid-Driven (GD), RF Power Amplifiers are also much worse than most Triode Cathode-Driven (CD), Grounded Grid (GG) RF Power Amplifiers, just look at reviews.

The worse case for Band Width and splatter is when the both the Bass and Treble Audio Frequencies (AF) are simultaneously increased! This gives the widest spread between strong frequencies in the RF signal, moving IMD products the greatest possible distance from our 'carrier' frequency. This is true even when we use good filters, and low distortion audio chains driving the transmitter.

We can help ease spectrum pollution by:

1. **Strongly discouraging use of Extended Single Side Band (ESSB) or High-Fidelity Single Side Band (Hi-Fi SSB)** Audio is selfish and inconsiderate. Enhanced Bass and Enhanced Treble Audio Frequencies has no place on crowded bands or near weak signals even when it uses a 3 kHz filter because of the increase in level and frequency spread of IMD products beyond 3 kHz.

2. **Discouraging and chastising people who turn up the power limit or drive limit control inside Transmitters**. There isn't a Transmitter made that will tolerate a user-increase in power limit without a serious degradation in IMD performance. If you have a friend who

turns or peaks up the power control inside a Transceiver, tell him why it is bad. Transceivers are bad enough without removing even more headroom. Even the best transistors cannot be driven more than about half of saturated power before IMD becomes unacceptable.

3. **If Speech Processing and ALC are used, ensure that they are used at modest levels.** The meter needles should just start to show compression.

4. **Making sure any external inline RFPA is tuned correctly**.

5. **Avoid using 12.6 VDC Bipolar Junction Transistor (BJT), RFPAs whenever possible, especially those that do not have Input and Output Low Pass Filter configured 'Pi' and 'L' Coupling Networks**.