SHORTWAVE MYTHS

Tuning Tricks Challenge SAM

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The information below is not guaranteed to be error free.

1. Introduction

Recently *Dallas Lankford* stated: "*The more I study and use AM synchronous detectors the more I am mystified as to why they are so highly acclaimed*". It is possible synchronous AM (SAM) detectors are praised because: 1) tuning tricks are not being employed, and 2) most SW receivers do not have accurate or stable enough frequency synthesis for optimum SSB reception. Most SAM units do not live up to that inside the legendary R8B. Note: DSB (double-sideband full-carrier) SW signals and SSB (single-sideband suppressed-carrier) ham signals are both amplitude modulated.

2. Sideband-Selected AM Trick R75 COOKBOOK "AM DETUNING TRICK" 2002

- Select AM-mode, narrow filter (ex. 4-kHz), and slow-AGC.
- Offset-tune by plus (USB) or minus (LSB) nearly half the filter's bandwidth.

This trick minimizes selective fading distortion and allows selection of the cleaner sideband (determined by SSB). With a 4-kHz filter the BBC at 5975 kHz is USB tuned at 5977 kHz and LSB tuned at 5973 kHz. Audio (fidelity) brightens most near half the filter's bandwidth. PBT can attain similar results. Ceramic filters often work better than mechanicals due to their wider skirts. Under *normal* selective fading this trick works well and is feasible on low-cost portables. Look for radios with double-conversion, PLL-synthesis, 1-kHz steps, and a narrow filter (ex. DE1102 or DE1103).

Many ways exist to select one sideband of a DSB signal. The filter method is often done automatically in SSB-mode. The trick above uses a filter in AM-mode. Another method is audio phasing using op-amps (operational amplifiers; ex. E1) or PSN (phase shift networks). PSN allows more adjacent sideband rejection (over 70 dB versus ~30 dB) and less distortion (see *Polyphase Network Calculation using a Vector Analysis Method*) than op-amps. An added method is software.

3. Precision ECSS Trick R75 COOKBOOK "ECSS FINE TUNING TRICK" 2002

- Select SSB-mode, wide filter (ex. 6-kHz), and slow-AGC.
- Fine-tune in 1-Hz steps until flutter stops.
- Engage the SSB filter (ex. 2.5-kHz) for listening.

This trick quickly and precisely tunes the BFO to within 2-Hz or less of a station's carrier. This is ECSS: tuning DSB signals as SSB. Flutter occurs because: 1) the wide filter passes both sidebands, and 2) a discrepancy exists between the BFO and carrier (the resultant tone is too low to hear). A single tone (ex. 1000 Hz; 3 Hz off) is heard as two sideband tones (ex. 997 Hz, 1003 Hz). This disparity allows effortless BFO fine-tuning (see JND below). Small tuning steps (1-Hz) and high stability (±1 ppm) are needed for precise ECSS. Stations are quite stable. Under *heavy* selective fading ECSS is *superior* to SAM. ECCS requires no lock and works on faint signals (DX).

The acronym JND stands for "Just Noticeable Difference". The human ear has a JND of 1.5 Hz at 500 Hz. Given a 500 Hz tone, a tone of 501.5 Hz or greater is detectable as being different. JND varies with frequency: JND is 2.9 Hz at 1000 Hz, 5.8 Hz at 2000 Hz, and 8.7 Hz at 3000 Hz. The ear acts as a mechanical spectrum analyzer; sensing amplitudes for each frequency. Humans cannot hear phase differences between the different components of a tone: Ohm's law of hearing.

4. Carrier Dropout Distortion

A 50,000 Watt DSB transmission at 30% modulation outputs 1,125 Watts of power into each sideband. Total power is 52,250 Watts and together both sidebands, which contain *all* the audio information, receive only 4.3% of that power. Carrier power, which is held *constant*, will receive the other 95.7%. DSB "wastes" power in order to permit low-cost envelope detection.

Diode detection of DSB is forgiving of unstable local oscillators (LO). During LO frequency shifts, the sidebands move in step with the carrier: the carrier, akin to being a BFO, is essentially perfectly "synchronized". For lower distortion detectors look up precision half-wave rectifiers (see *An Improved Precision Full-wave AM Detector* and *Low Distortion/High Dynamic Range Detector*).

Selective fading causes sideband attenuation and carrier dropouts. The later can make SW listening unpleasant. During carrier reduction, signals appear over-modulated. With regular diode detection, total harmonic distortion (THD) increases with modulation index. Although with normal modulation, diodes are capable of fairly *low* distortion: 0.14% THD at 30% modulation index. The best SAM distortion value is 0.40% for the R8B. Other SAM distortion values are: 8.20% for the WJ-8711A, 2.6% for the RX-340, 2.0% for the 7030, 2.4% for the Sat800, and 2.6% for the E1.

5. Illustrations

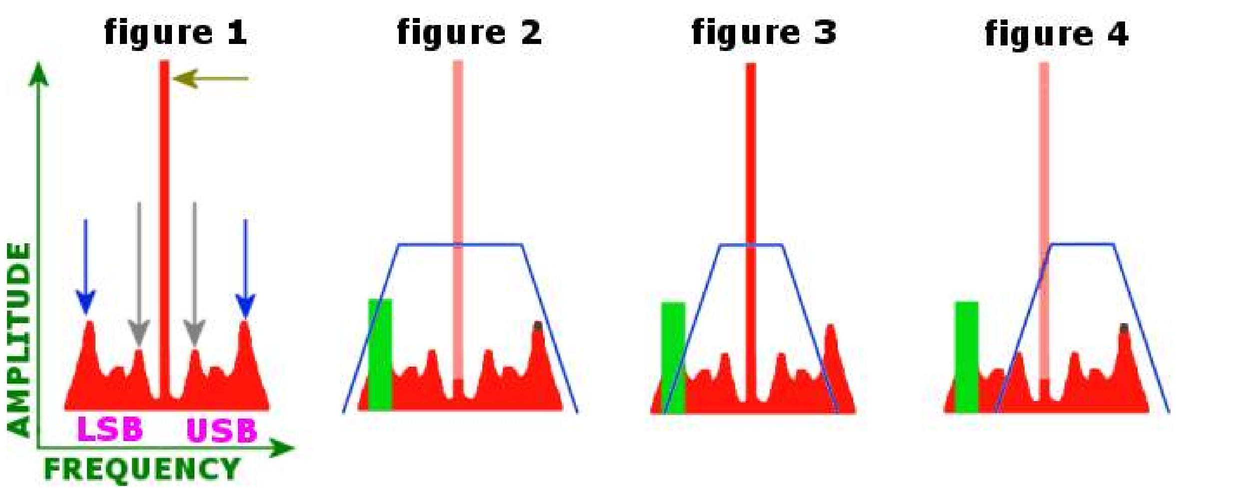


Figure 1: High amplitude (gold arrow) carrier energy and positions of LSB and USB audio. Lower tones (1000 Hz; gray arrows) are close to the carrier; higher tones (3000 Hz; blue arrows) are father away. Sidebands can be seen dancing in unison. **Figure 2:** Wide filter (6-kHz) passes the offending green tones in AM-mode. Carrier dropout is depicted by a shaded red carrier dipping into the noise floor. **Figure 3:** Centered narrow filter (4-kHz) with low fidelity (2000 Hz @ -6 dB) passes offending green tones. **Figure 4:** Upward (USB) offset-tuning of the narrow (4-kHz) filter (or applying PBT) attenuates the offending green tones and increases fidelity (4000 Hz @ -6 dB). This illustrates selecting the cleaner sideband of a DSB signal via the filter method in AM-mode.

Consider carrier dropouts in **figure 2** and **figure 4**. Imagine mixing between the USB peak (black dot) and frequencies farthest to the left during carrier loss. The centered 6-kHz wide filter allows 3-kHz fidelity but noises up to 6-kHz can be emitted during a carrier dropout. However, the offset-tuned 4-kHz wide filter allows 4-kHz of fidelity but noises up to *only* 4-kHz can be emitted. Audio filtering, which can reduce carrier dropout distortion, is less vital when using offset-tuning. Improper usage of a fast-AGC (normally used for scanning or CW) further complicates the carrier dropout problem by activation of the radio's AGC system (carriers contain most of the RF energy).

6. Radio Design for TUNING TRICKS

A quality receiver will utilize double-conversion for image rejection (up-conversion), gain distribution, and filter shape (down-converting to 455-kHz). Two filter bandwidths (7-kHz; 4-kHz) could be mated to a ±3.5 kHz PBT, and a matched-LC phase shift network. Add toggle controls for **SIDEBAND-SELECTED AM** (local oscillator shifter) and **PRECISION ECSS** (shutting off the PSN). The unit should have 1-Hz tuning steps, ±1 ppm stability, and a slow-AGC (two second plus release time).

Examples close to the radio described above are the R75 (missing audio phasing) and the E1 (missing fine steps and high stability). The twin-PBT (R75) and phasing-PBT (E1) combinations are analog methods of creating multiple filter bandwidths. *The R75 requires AM AGC modification.*

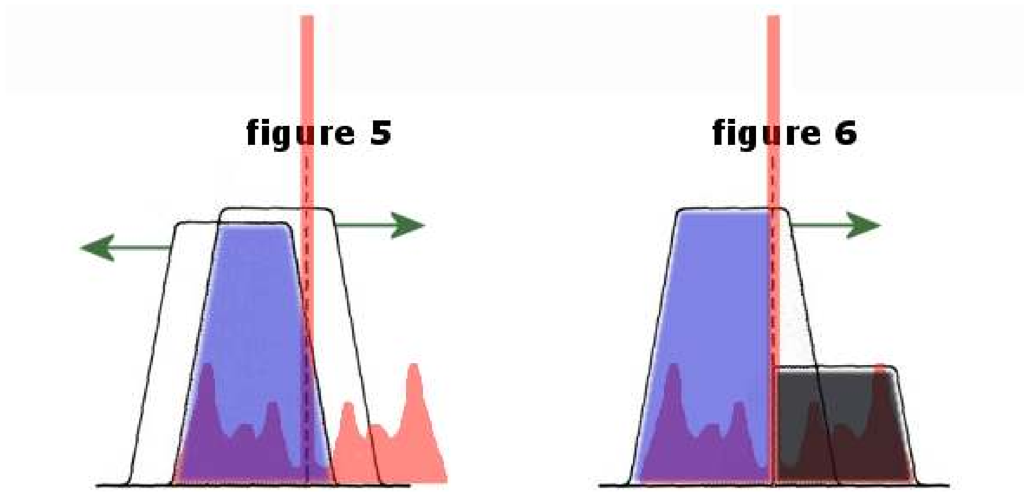


Figure 5: Twin-PBT (PBT movement depicted with green arrows) selects LSB (blue area is passed). Audio lows near the carrier (and the carrier itself) are partially attenuated. This can lead to *tinny* sound. **Figure 6:** Phasing-PBT selects LSB. The phasing unit eliminates (black area) USB.

IF-DSP receivers also provide multiple filters and hold much future promise. However, their current 8-bit "mechanical" sound is not ideal for SWL. The ADC's first 8-bits typically go for audio; the rest are for dynamic range (DR). At ~6 dB per remaining bit, 20-bits are needed for good DR.

Pete Gianakopoulos is a proponent of usage of low-NF (noise figure) moderate-IP3 mixers to avoid using IP3-degrading RF-amplifiers. Usually RF-amps are used to decrease NF (mixers are noisy devices compared to amplifiers); thus increasing MDS (sensitivity). Receivers with high-IP3 high-NF mixers (ex. RA6790GM's Quad-JFET) *require* RF-amps for optimal sensitivity. The TAK-3H (*Mini-Circuits*) is a level 17 mixer (+14 dBm @1 dB) with a conversion loss (approximates NF in a passive diode ring mixer) of *only* 4.82 dB. With no RF-amp the RA6790GM (6 kHz; 10 dB S/N) has a 2.5 µV sensitivity; a radio with an 8.5 dB composite NF (using a TAK-3H) is capable of ~0.3 µV.

7. Other Tricks

Features, other than SAM-mode, can also be worked around when tuning DSB stations in AM-mode. Amplified tuned-loops can lower NF, reduce unwanted mixer energy, and be rotated to attenuate local noise sources. A loop is a decent substitute for a random wire in urban locations.

Feature	Alternative
ss-SAM	**SIDEBAND-SELECTED AM** or **PRECISION-ECSS**.
PBT	Variable offset-tuning.
Notch	**SIDEBAND-SELECTED AM**; selecting the clean sideband.
Noise Blanker	Determine and eliminate the noise source.
DSP NR	Amplified tuned-loop antenna.
Tone Control	Variable offset-tuning with narrow filter.
IF DSP Filters	Twin-PBT or Phasing-PBT.

8. Discussion

The SW community is reluctant to speak critically of SAM detection. I have owned several SAM units but most of my listening was done in AM-mode with an offset-tuned narrow filter and a slow-AGC (**SIDEBAND-SELECTED AM**). With harsh fading I used **PRECISION ECSS**. SSB-mode on the E1 and Sat800 sounded better than SAM-mode during carrier drops. Audio phasing insured that ECSS did not have the *tinny* sound sometimes associated with filter sideband selection. Since audio is disturbed less during carrier drops, ECSS is often superior to SAM during heavy selective fading.

Without knowing tricks one might assume 1-Hz tuning steps are overkill or that AM-mode is defenseless against selective fading distortion. While listening in AM-mode it is easy to assume that SAM-mode would have recovered audio which in truth was forever lost in a sideband fade.

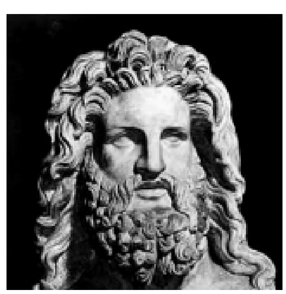
It is hard to create an accurate, stable, and clean local oscillator. Of the current receivers only the $4250 RX-340 and $550 R75 have 1-Hz steps and ±1 ppm stability (for optimum ECSS). Ironically *Dave Zantow* calls the RX-340 SAM "*almost worthless*". *Dallas Lankford* calls the $1500 7030+ SAM "*unacceptable*". It is clear that even high-priced SAM units can whistle, hiss, distort, and have trouble gaining and holding lock. The $500 E1 contains a quality, Drake-designed SAM.

Considering the complexity needed to create SAM units, phasing units, and precision local oscillators, companies may wish to promote usage of **SIDEBAND-SELECTED AM**. I suggest adding an "**U**PPER, **C**ENTERED, **L**OWER" labeled button that shifts the local oscillator while keeping the displayed frequency constant. Usage would automatically select AM-mode, a narrow filter, and a slow-AGC.

The myth is that "SAM" alone reduces selective fading distortion. In reality it is a slow-AGC and bandwidth limiting (often suppression of one entire sideband) that is doing *much* of the work at reducing carrier dropout related distortion. Bandwidth limiting is possible through audio phasing (superior fidelity), IF filtering (**SIDEBAND-SELECTED AM** or **PRECISION ECSS**), and audio filtering (such as ELPAF). I wish to thank *Pete Gianakopoulos* for previewing this article. *Error reports welcome.*

CONTACT

Please direct comments to just_rtfm@<NOSPAM>yahoo.com. dr phil :)



The dice of Zeus always fall luckily.