Modifications to the KSB2 to Improve IMD in PSK31 Transmissions

The design of the K2's KSB2 SSB modulator includes circuitry for adjusting the gain so that the peak power output of the K2 will adjust itself to the level set by the front panel Power control. This is accomplished by adjusting a diode attenuator in the KSB2 using the output power monitor on the K2 or KAT2. The circuitry works quite well for SSB transmissions. However, on PSK31 transmissions the circuitry can add some additional IMD distortion to the PSK31 signal. *(Especially when the K2 is driven hard into its ALC region by the PSK31 audio signal from the sound card. - ed.)* This article describes some simple changes to the KSB2 to improve its PSK31 IMD.

THEORY OF OPERATION FOR ALC CIRCUIT

Please refer to the KSB2 schematic to help understand the following discussion. The SSB signal is generated by creating a DSB signal with a NE602 and then filtering it in the SSB Crystal Filter to eliminate one sideband. The SSB signal then passes through a diode attenuator formed by R10, R8, D1 and D2. The current in the two diodes is adjusted so that the K2 transmitter will reach the desired power level. A higher current in each diode will result in greater attenuation.

The drive current to diode D1 is set by the KSB2 microprocessor. This is a long term ALC adjustment and doesn't depend on what has just been transmitted. The drive current to D2 is set by an analog ALC circuit that includes Q1, R9, C38, and R4. The VRFDET signal comes from the diode output power detector on the K2 RF board or the KAT2 detector if it is present.

The ALCTHR signal is set by the front panel Power control. When VRFDET exceeds ALCTHR by the base-emitter voltage drop, the voltage across C38 is increased. This increases the current flowing through D2 which causes greater attenuation in the diode detector. When VRFDET does not exceed this level, C38 discharges through R9 and R4 and the attenuation decreases. With this circuit the peak power output of the K2 tracks the audio peaks at the desired power level.

The original design of the KSB2 had an attack time of several milliseconds and a decay time of 10-20 milliseconds. This works fine for SSB, but the ALC circuit will add distortion to a PSK31 signal. A PSK31 idle tone is a half-cosine with peaks separated by 16 milliseconds. Half-way between each peak is a dip to zero power output. The fast decay time of the original design causes the K2 to attempt to keep a constant power output and acts as a soft clipping circuit, degrading the IMD level under PSK31.

The changes to the circuit significantly increase the ALC decay time constant by changing the values of C38, R9, and R4. Additionally, the value of R7 is changed so that the computer controlled ALC has a more linear range of control which increases the ALC loop stability. The modified circuit still has an attack time of several milliseconds, but the decay time has been increased to 500 milliseconds. This is more than adequate for PSK31 signals, and would even work if slower versions of PSK31 are created.

MODIFICATION INSTRUCTIONS FOR KSB2

This set of changes has been thoroughly simulated in SPICE and tested on my KSB2. It works fine and lab measurements show that the PSK31 IMD has been reduced to better than -30 dB. *(These changes have now been field tested by a number of K2 owners with excellent results. Also, they do not change the KSB2's regular voice SSB performance. - ed.)*

This modification involves changing four parts in the KSB2. You will need to obtain a **47 uF 16 volt or greater electrolytic** capacitor in the same form factor as C38, and three **1/4 watt resistors** with values of **56K, 33K,** and **10K**.

1. Remove C38, R4, R7, and R9. It is easier to remove resistors from the board if you cut them in half with a wire cutters before removing the leads. Clean up the excess solder around the holes with solder wick or equivalent. I find it easier to remove the old solder if you first apply a little new solder to the hole and then use a solder wick or solder sucker to remove it.
2. Replace C38 with the 47 uF capacitor. One could use a value from 22 uF to 68 uF if you can't get the 47 uF size, but this will change the decay time constant slightly.
3. Replace R4 with the 56K resistor.
4. Replace R7 with the 33K resistor.
5. Replace R9 with the 10K resistor.

Plug the KSB2 back into the K2 and connect a dummy load to the output. Make sure that your K2 is set to SSBC 1-1 and the Power is set to 5 watts or less.

Transmit a PSK31 idle signal. The input audio level should be set so the first ALC light is lit, but higher input levels should not cause any distortion with the modified ALC circuitry.

You should now be able to transmit PSK31 with an IMD of better than -30 dB at power levels of 5 watts. The unit should still function normally on SSB. (To my ear, the SSB signal sounds more natural with compression off since the ALC circuit was no longer tracking the fast changes in your voice.)

There is one other way to create distortion in the KSB2 with a PSK31 signal. It is possible to overdrive the audio into the NE602 which causes it to clip. On SSB signals this is not a problem since the SSB Crystal Filter will remove the distortion outside the audio band. However, on PSK31 this distortion results in higher IMD and can give performance degradation similar to the original ALC circuit. To avoid this problem, be sure to turn off the audio compression (SSBC 1-1) and do not drive the K2 audio input with more than 40 mV peak-to-peak (10 mV RMS) of PSK31 signal.

One can also avoid this issue by putting a 5.6K resistor across R1; this will reduce your audio gain by 6 dB, so don't do it unless you have enough audio output from your microphone to drive the K2 to full power on all bands after the change. With this change you can run PSK31 with speech compression on since the speech compression circuitry doesn't distort the PSK31 signal.