Predistortion algorithm for use with an external power amplifier

In early February 2013 we published information on the development of our special predistortion algorithm for the DDC/DUC transmission transceiver ZS- 1. We are very proud to say that the ZS- 1 is the second, after ADT-200a, and at the time of writing this morning, the **only** affordable, commercially available, Ham Band transceiver with integrated predistortion algorithm.

The results that we have achieved, can be found in earlier published material. Now we will focus on external Linear amplifiers test results.

As you known, the output power of the transceiver ZS-1 is 1 - 15 watts, which is quite enough for lovers of QRP. But often, the transceiver is used with an external power amplifier to produce 100 W to 1 kW or more. Unfortunately, not everyone knows about or cares what their Tx signal actually looks like on a Spectrum Analyzer. The advent of DDC/DUC Transceivers like the ZS-1 has given us an opportunity to look at our REAL-TIME LIVE Tx signal from the ZS-1 and from a Linear Amplifier. Sadly, for many, the primary option - is the **output power**, and how **clean** the signal is not so important.

As a result, it is not uncommon to see on the air signals that are very similar to these SSB signals.

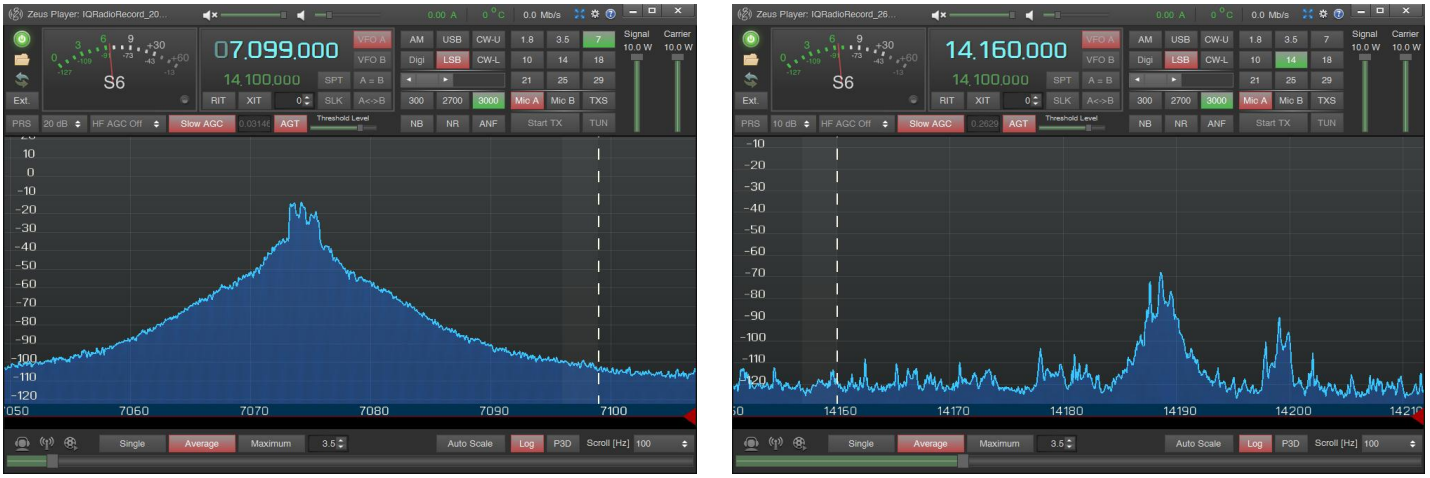

Figure 1: Left - one of the stations on the Valdai rally in summer 2013 on the right - signal of one of the participants in October 2013 CQWW.

At the same time it is easy to find radio amateurs having quality equipment, competent approach to the construction of the station, concern for his neighbors, and a desire to be a cooperative member of the Amateur Radio community.

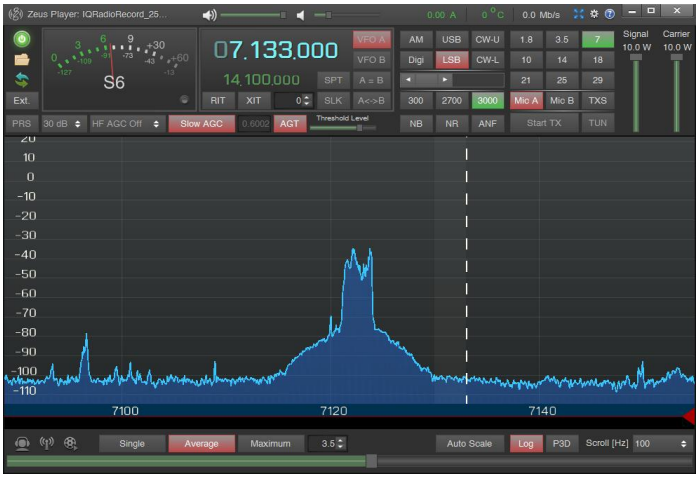

Figure 2: The signal of one of our neighbors, the output power of about 800 watts.

Obviously, it is not good enough to just have a transceiver with a good linearity. It is also necessary to have power Linear Amplifier with the same high quality standards. In the manufacture of homebrew gear, this is not an easy task. **Production models typically have an IMD of about -30 dB IMD at full output.** This meets the U.S. FCC minimum requirements.

In connection with this, we modified our algorithm for predistortion correction of external power amplifiers used with ZS- 1. This algorithm will significantly reduce intermodulation components at the output – thus generating them at an acceptable level using an amplifier with higher efficiency.

We took measurements with a sufficiently widespread models Power amplifiers: HLA- ACOM- 300 and 1000.

Figure 3: From top to bottom: ZS- 1, MFJ-993B, ACOM- 1000 HLA- 300.

Measurements were carried out at spacing between tones of 500 Hz, the output of the ZS- 1 was calibrated at 15W. To display the spectrum signal generated, we unused second transceiver ZS- 1 in the receive mode. We used the easy RECORD IQ signal feature of our ZEUS Software during the measurements. The following screenshots were obtained when playing these signals back using the companion program IQ Player.

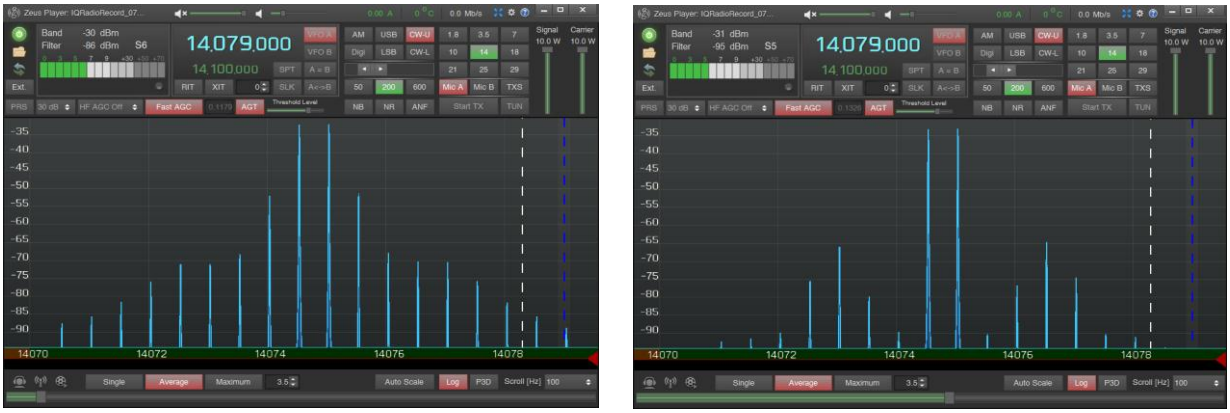

Figure 4 : HLA- 300 is turned off (left) and on (right) algorithm predistortion.

At the output of HLA- 300 power was about 200 watts. at startup predistortion algorithm level intermodulation third decreased by about 37 dB, 5 th - 9 dB, and 7th - increased by 5 dB.\

Figure 5 : ACOM- 1000 predistortion is turned **off** (**left**) and **enabled** (**right**).

The ACOM- 1000 was tuned for about 340 watts. Our predistortion algorithm was able to create an intermodulation third order signal decreased by about 25 dB, 5th - 3 dB, and the 7th - increased by 6 dB.

It is worth noting that by choosing the parameters of the algorithm, predistortion can automatically seek as a minimum, for example, 3rd order products in this example. We also conducted tests to observe the effect of different levels of IMD products output.

According to figures 4 and 5 it can be seen that the level of the fundamental tone at inclusion of pre-emphasis decreases slightly. Unfortunately, this fee result in a purer signal and not real microphone generated human speech.

The HLA- 300 is a decrease was 0.9 dB for ACOM- 1000 - 1.1 dB. That is, instead of 200 W in the case of HLA- 300, we have obtained at the output of 160 W, 270 W and 340 W as compared to the ACOM-1000.

Of course we tried to include both amplifiers in series : ZS- 1 -> HLA- 300 -> ACOM- 1000. But in order to obtain at the output of 1 kW had output ZS- 1 lowered to 1-2 watts. It was evident that our predistortion algorithm works extremely well, but our results suggest that adjust parameters strongly decreases the power output. This interesting interaction between output power and IMD will be a focus for our programmers when they implement the algorithm in future versions of our software.

As a summing up we can say that the algorithm has shown himself quite successfully and provides improved signal quality, independently of the amount and type of amplification stages amplifying element (transistor or tube).

The disadvantages include its need for manual adjustment parameters in each band passed on using the analyzer spectrum (we used the second ZS- 1). But at the same time, there is no the need for any special external RF sampler (sniffer) in order to feed it back to the transceiver. And despite the lack of feedback and automatic correction algorithm parameters, the data we have about working in continuous mode (heating amplifier, change VSWR) allow us to expect an improvement in intermodulation third on the order of 10-15 dB.

ZS- 1 team
12/09/2013