Analysis of the DF0MTL 144 MHz Signal

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October 15, 2009

Abstract

Noise measurements as well as a spectral analysis of real signals transmitted by the setup used by the DF0MTL contest station have been carried out. These measurements demonstrate that the signal quality is state-of-the-art and doesn't need any improvement to be used during the contests.

Additionally, we will show that interferences encountered by station(s) in the near field are inevitable when today's state-of-the-art equipment is used, and antenna systems pointing to each other.

1 Introduction

We — that is the DF0MTL contest group — have been trying to operate the last IARU Region I VHF contest from mount Hirtstein, JO60OM. However, an alleged bad signal quality has been reported by the fellow well-known contesters station OL4A aka OK1KIM operating in the near field from locator JO60RN. Both stations have direct visual contact with an actual distance of about 18 km.
The 2 m equipment used by DF0MTL is as following:

- **Antenna:** 4×6 element according to DL2RSX with a gain of 9.6 dBd for the individual antenna, i.e. an antenna gain of about 15 dBd for receive and transmit (no pre-amplifier used)
- **Power Amplifier:** Beko HLV-600
- **TRX:** TR 144H+40 transverter by Kuhne electronic together with K3 transceiver by Elecraft

Unfortunately, a direct measurement of the signal transmitted had not been possible on site. Therefore, we have been operating with backup equipment (TR790 and K2 instead of K3). However, there have been still considerable collisions with the operating of the OL4A team. As a consequence a complete measurement of the signal transmitted by the setup intended to be used during the contest — except from the antenna — has been carried out. The results are presented in the following.
In addition we present a model giving a rough estimation of signal magnitudes to be expected in the near-field. The results obtained show clearly that even with the state-of-the-art equipment used and the relatively short distances involved strong levels of

interferences are inevitable and need to be solved otherwise, e.g. by turning away the main gain lobe of the antenna systems or operating contests in an alternating order.

2 Signal Quality Measurements

2.1 Measurement Setup

The measurement setup used to carry out the signal quality measurements is illustrated in the following sketch:

K3	→	TR144H+40	→	HLV 600	→	-40dB	→	FSUP
Transceiver		**Transverter**		**Amplifier**		**Attenuator**		**Analyzer**

The signal produced by the contest setup consisting of the K3 transceiver, TR144H+40 transverter, and the BEKO HLV-600 power amplifier is attenuated by about 40 dB by a high quality dummy load. Afterwards, it is analyzed by a *Rhode & Schwarz* FSUP Signal Source Analyzer. Both, the dummy load, the Signal Source Analyzer, as well as the measurement expertise have been provided by Michael (DB6NT) and Vico (DG1NPV) of Kuhne Electronic.

2.2 Phase Noise Measurement

The phase noise measurements have been carried out by transmitting a continuous tone (K3 in CW mode using the TUNE feature) into the dummy load and Signal Source Analyzer, respectively. A power level of about 0.5 mW of the K3 transceiver resulting in about 6 W output from the TR144H+40H transverter are sufficient to drive the power amplifier into full saturation. Thus, giving an output power of more than 550 W.
The resulting spectra for power levels of 400 W and 550 W, respectively, are shown in Fig.1. In principle, both plots look almost alike showing only very small deviations. The signal-to-noise ratio drops rapidly to about 125 dBc/Hz at a frequency offset of 10 KHz. It levels to about 30 KHz and then dropping fast again under a threshold of 140 dBc/Hz for frequency offsets larger than 70 KHz.
The curves do not display any particular problems or otherwise noticeable abnormality. Specific numbers are given in Tab.1. All phase noise numbers — but the 5 KHz value — are in excellent agreement with the ones for a stand-alone K3 given by [1, 2, 3]. However, the 5 KHz value is by no means from great interest when dealing with near-field stations. This is due to the fact that the operation frequencies will normally be different by a greater margin. Please note that the numbers depicted from Fig.1 have to be corrected by a factor of 34 dB in order to cope with a bandwidth of 2.5 kHz.

2.3 Modulation Measurements

In addition to the pure phase noise measurements above spectra of the transmitted signal in the different operating (CW and SSB) modes have been recorded. Such spectra are for instance useful to check for problems resulting from key clicks or speech compressor settings.

frequency offset	bare K3	DF0MTL equ.
5 KHz	-94 dBc	-85 dBc
50 KHz	-104 dBc	-101 dBc
100 KHz	-103 dBc	-107 dBc

Tab. 1: Comparison of phase noise numbers for three different frequency offsets of the bare K3 [1, 2] and the DF0MTL equipment consisting of the K3 transceiver, TR144+40H transverter, and a HLV-600 power amplifier. The numbers are normalized for a bandwidth of 2.5 kHz.

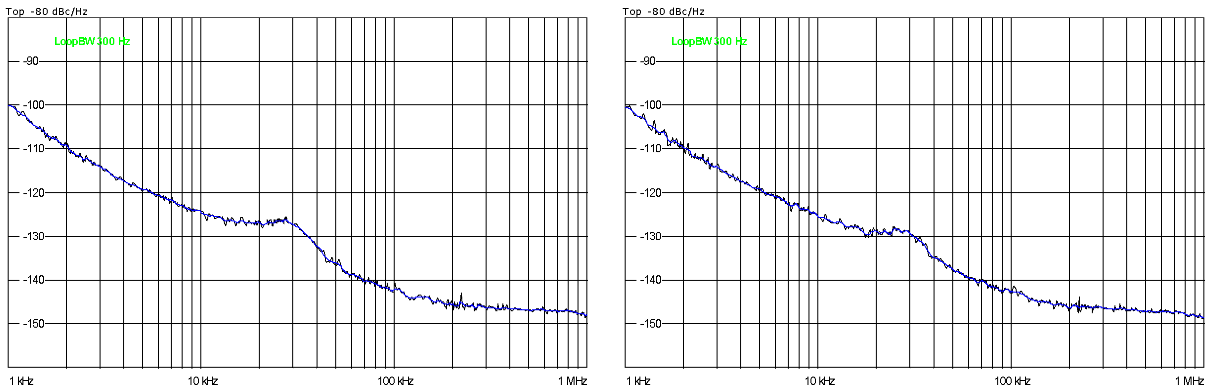

Fig. 1: Phase noise in units of [dBc/Hz] as function of the frequency offset for the setup of transceiver K3, transverter TR144H+40, and power amplifier BEKO HLV-600. The system power output has been about 400 W (left) and 550 W (right).

These measurements for SSB and CW have been carried out using the same setup as for the phase noise measurements. The transceiver has been set to the desired mode. The signal has been generated by actually speaking and whistling into the microphone or sending morse characters with an external paddle, respectively. The Signal Source Analyzer has been set to 'max-and-hold', i.e. the spectra consist of highest signal value recorded during the measurement time. When starting a measurement the base line of the noise is slowly moving up and eventually settling. A recording time of two minute has been found to be more than sufficient in order to obtain a settled spectrum.
The results of the measurements can be found in Fig. 2 and 3 for CW and SSB, respectively. Please note that the bandwidth for the measurements has been 3 kHz resulting in about 1 dB worse values when compared to 2.5 kHz. Again, the spectra do not show any particular problems or otherwise noticeable abnormalities besides some negligible spurii. When comparing the absolute values the signal-to-noise ratio is in the order of around 90 dB. At the first glance it seems that one looses more than 10 dB in comparison to the pure phase noise measurements. However, it should be noted that the spectra are worst case spectra and really move a couple of dB over the measurement period. Thus, it is most likely that compared with the pure phase noise measurements one is loosing a couple of dB. Nevertheless, the signal to noise ratio is still in excess of 90 dB with the setup used.

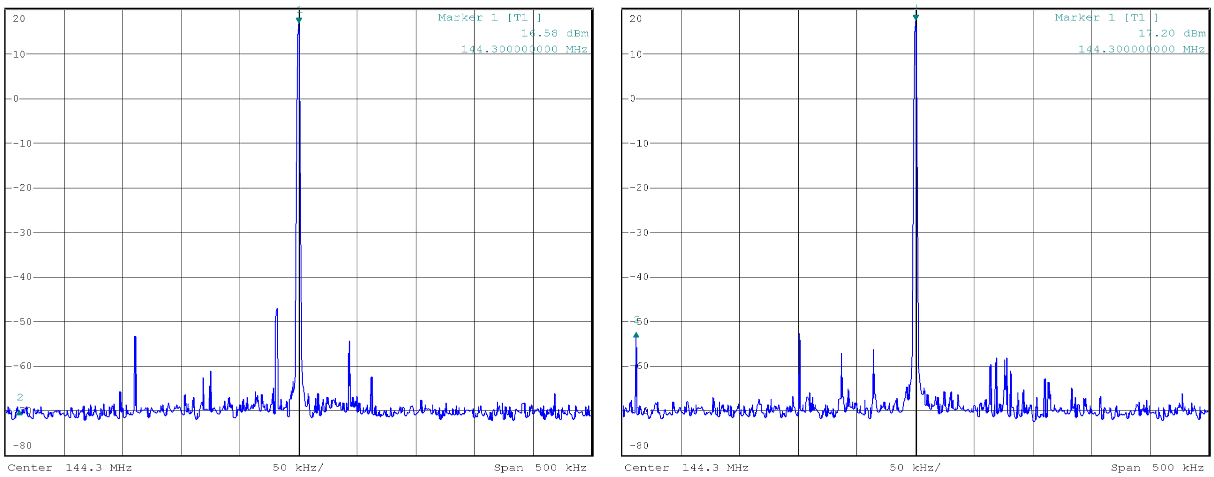

Fig. 2: Spectra of the transmitted signal amplitude in units of [dB] at 3 kHz bandwidth as function of the frequency offset when using mode CW for the setup of transceiver K3, transverter TR144H+40, and power amplifier BEKO HLV-600. The system power output has been about 400 W (left) and 550 W (right).

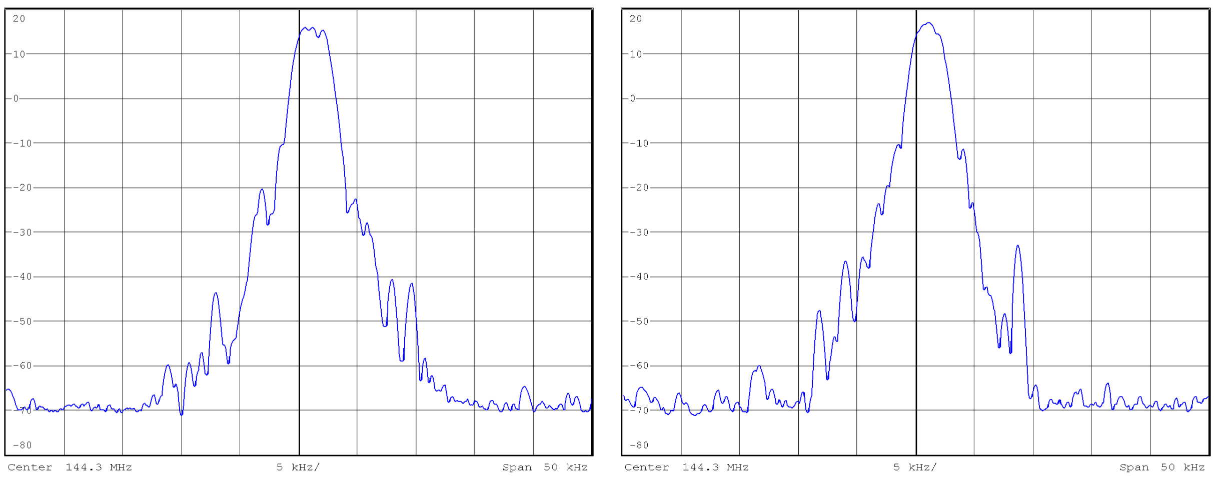

Fig. 3: Spectra of the transmitted signal amplitude in units of [dB]at 3 kHz bandwidth as function of the frequency offset when using mode SSB for the setup of transceiver K3, transverter TR144H+40, and power amplifier BEKO HLV-600. The system power output has been about 400 W (left) and 550 W (right).

3 Signal Magnitude Model

The following table shows a rough estimation of the signal strength in-between the two interfering stations of OL4A and DF0MTL:

	DF0MTL → OL4A	OL4A → DF0MTL
Transmitter Power	500 W +57 dBm	1500 W 62 dBm
Transmit Antenna Gain	+15 dBd	+23 dBd
Path Loss	-115 dB	-115 dB
Receive Antenna Gain	+23 dBd	+15 dBd
Preamplifier Gain	+15 dB	—
Signal Strength at Receiver	-5 dBm $S9^{+68dB}$	-15 dBm $S9^{+58dB}$
Noise Level at Receiver (with 90 dB suppression)	-95 dBm $S5^{+2dB}$	-105 dBm $S3^{+4dB}$

DF0MTL uses a transmitting power of about 500 W whereas the power output for OL4A is according to private communications assumed to be in the order of 1500 W. The antenna gain (4×6 element) for DF0MTL and OL4A (6×22 element) has been estimated as 15 dBd and 23 dBd, respectively. Furthermore, OL4A is using a pre-amplifier according to their web site contrary to DF0MTL. Therefore, an additionally 15 dB receive gain has been assumed for that case. The path loss can only be roughly estimated. The free space propagation would give a value in the order of 100 dB for a frequency of 144 MHz and a distance of about 18 km. However, more sophisticated models incorporating the first Fresnel zone imply a higher value closer to 115 dB [4].
The results show the enormous signal levels both stations have to deal with. The signal strength of OL4A at DF0MTL is in the order of -15 dBm ($S9^{+58dB}$). The signal level of DF0MTL is even stronger with about -5 dBm ($S9^{+68dB}$). These signal levels alone are already a great challenge for all of the receiving equipment. Furthermore, the resulting phase noise will clearly be audible with S3 in the case of OL4A at DF0MTL. However, it should almost vanish when turning one antenna away. This has been indeed observed by DF0MTL. The direction towards OL4A is more or less unusable for any DX attempt. Nevertheless, almost any other direction but the antenna backside direction with limitations is fine. A completely different picture is seen by the OL4A side. When the antennas of both stations point to each other a noise level of more than S5 is encountered. It will drop to about S3 when the DF0MTL antenna is pointing away. Therefore, the direction towards DF0MTL is completely unusable except some additional 20 dB of isolation can be found.

4 Conclusion

Extensive tests of the 2 m transmit equipment of the DF0MTL contest team have been carried out in order to check for extensive phase noise and spurii. These measurements show that the equipment used has a signal-to-noise ratio of better than 90 dB at a bandwidth of 2.5 kHz. Thus, demonstrating that the equipment is behaving according to its specifications. The equipment used is well suited for contest operation even in close proximity to other stations.
The theoretical analysis supports the signal and noise strength of the DF0MTL signal as observed by the OL4A team. However, as can be seen the resulting interference is inevitable and a direct result of the close proximity as well as the enormous receive gain OL4A is using, especially by utilizing a pre-amplifier and multi-antenna systems. It is of course not our intention to interfere with the OL4A operation. However, we have to deal with an even stronger and permanent signal produced by the OL4A transmitter and have to make certain sacrifices, e.g. no pre-amplifier and unusable directions of operating.
It is our understanding — and we hope that is the understanding of all hams — that frequencies used, especially in contests, are a precious resource. It is of course the right of every ham to build his station as big as he wants to and where he wants to. However, this is true for everybody. The OL4A station is set up in a region of great interest for every VHF contest station. However, as far as we know there is no safety zone whatsoever around any qth. So, mutual respect and ham spirit of all of the stations involved is necessary to avoid interference and allow a jointly get on of everybody.

Acknowledgements

We would like to acknowledge the cooperativeness and ham spirit by Michael, DB6NT, and Vico, DG1NPV, of Kuhne Electronic for lending their equipment carrying out the measurements with us.
Additionally, we acknowledge the fruitful discussion with Bodo, DL7AFB and his help by visualizing the near-field theory in an Excel spread sheet. The later can be provided to everybody interested on request.

References

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