QRM in VHF Contests

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presentation prepared for Polish VHF meeting in Zieleniec 2014

poor English translation made by author

Why to talk about VHF contesting? What consequence it have..

- Funny for participants and even a bit of adrenalin (OK, why not..)
- More activity on VHF bands and even few DX QSOs. And testing your gear…

- And what about: be ensured, that I'm better, than competitor, or event the best!?

THE BEST?.... TAKE CARE! => It is already more about PSYCHOLOGY!

- - Operator's EGO empowering through conquery of rival station in contest result?!

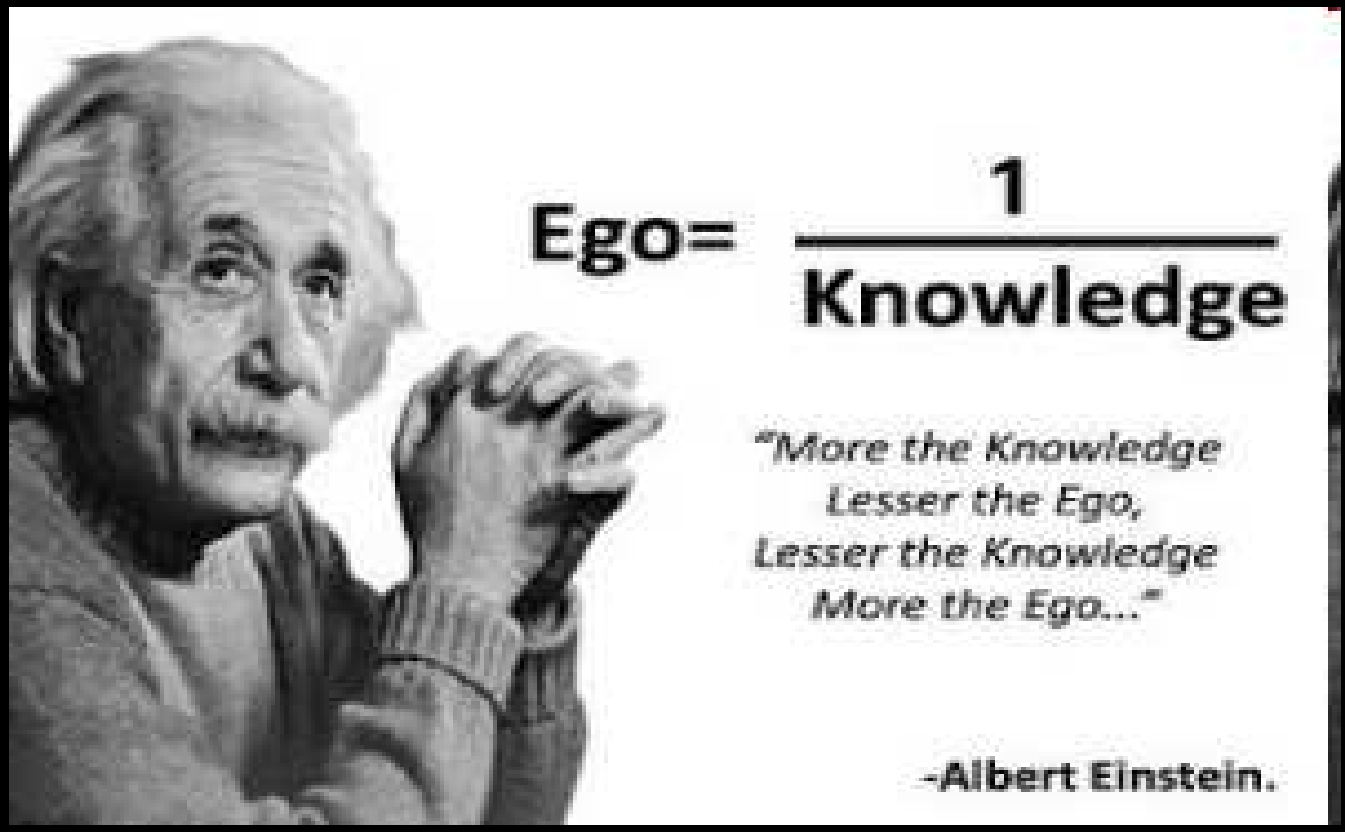
- - However nobody will winn always! Is you result worse, than expexted?
- Envy to competitor may bring decision to use unlegal tools (RF power, or even remote RX…)
- And it may create QRM, which fall off human relations. Where is a Hamspirit today?
- We have in OK operators, who – when they did not won a twice in VHF Contest – stop all VHF activity. Really it was a spoil for QRM only?

- If you can not be on second position in VHF contest, maybe just three other basic options are: to be always the first in EME contesting (or with first QSOs abroad), or even win always in SHF contest on super microwaves (above 100GHz)....

.... Or to learn what you can to improve and stay human....

Contesting on VHF bands is fun and it is a satisfaction for all of life. If you haven't EGO hypertrofy, I would suggest never be a surrender and learn, how to be better and what you make to improve for next.

And to have a bit of mercy for other, who feels, that he must be always the best...



And now few words about QRM

Commercial products like a ICOM, YAESU, KENWOOD, ELECRAFT, TEN TEC, or even MIRAGE, BEKO etc. **<u>is not a professional equipment</u>!**

Due to it would be quite helpful to know a bit more about limits of your equipment, used in VHF Contests, than you may read in user manual...

QRM in contesting and EMC generally is quite complex issue. You never know, what may happen in contest, where strong RF field may have some influence. So you need not only knowledge but humility as well. EGO hypertrofy is not a good advisor!

Did you listen on VHF bands during Contest just other stations and noise?

- **Video QRM**
  - **https://www.youtube.com/watch?v=IgNncmA3RN0**
  - **https://www.youtube.com/watch?v=qbpPFezx8GM**
  - **https://www.youtube.com/watch?v=bZaC8eOewjY**
- Why we present Czech experience?
  - Compare for example: 3rd. subregional 144MHz Contest 2014:
  - Poland – 66 stations – 313000km2 – neighbours distance avg. 78km
  - Czech – 157 stations – 79000km2 – neighbours distance avg. 25km only!

What is a main reason of QRM:

- Operators faults
- Intermodulation of transmitter chain
- Sideband noise of local oscilators in both TX & RX gear
- Rough and unusual failures
- Troubles on RX side
- System troubles

Operators faults

- - overdrived PA - particularly SSPA – PEP measurment of PWR is missing!
  - http://www.ok2kkw.com/00003016/wattmetr/wattmeter_2_cz.htm
  - (or use at least LED bargraf with LM3914 IC! Or similar, to see the peaks!)

- transceiver ALC loop malfunction

http://lea.hamradio.si/~s53rm/IC275H.htm

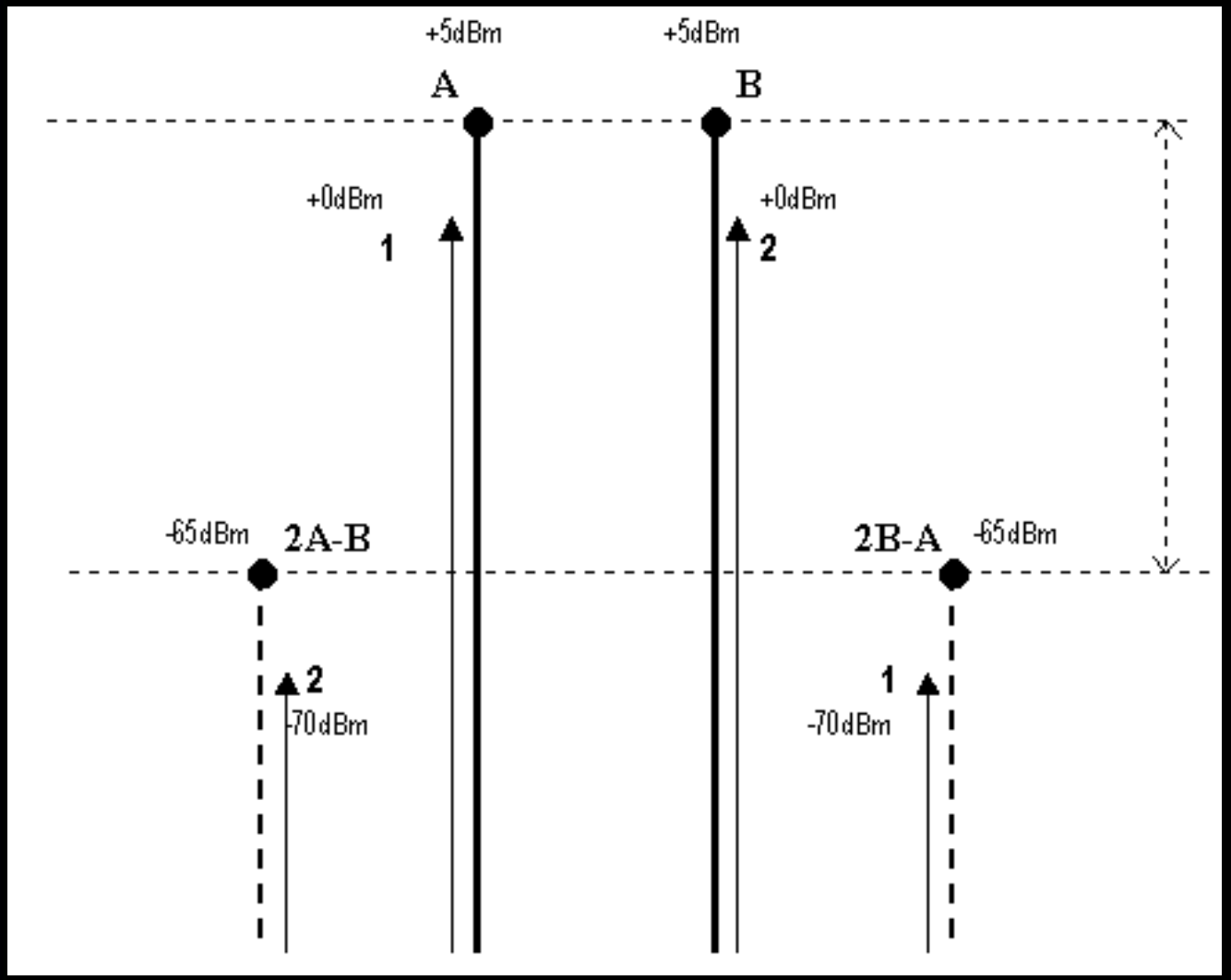
http://www.sm5bsz.com/dynrange/eme2004/eme2004.htm

disable ALC, or modify time response of ALC loop:
http://www.ok2kkw.com/00000104/ft847_alc_mod/alc_ft847_cz_2.htm
(or at least decrease in transceiver SW gain of TX chain!)

- break down of supply voltage for transceiver in case of use battery supply,
- unskilled operator, who has no VHF QRM experience (on HF it is different!)
- broadband noise of TX chain – bad system design of TX way – too many amplifiers in cascade are working with too low signal level

Intermodulations

- **Sometime on nonlinearities of active elements may be created new frequencies, which could be a QRM reason:**



Transmitter intermodulations

- - low voltage SSPAs – short linear response in case of 12V supply (linearity troubles with Mitsubishi hybrids), bad BIAS circuit for AB class

  http://www.ok2kkw.com/00003016/bias/bias_new.htm

  http://www.ok2kkw.com/zdroj_predpeti_elektronky.htm

  http://www.ok1baf.wz.cz/g2/g2.htm

  - bad input matching of tube PA, connected to SSPA output + even positive feedback of triode PA with common grid (mostly on 70cm)

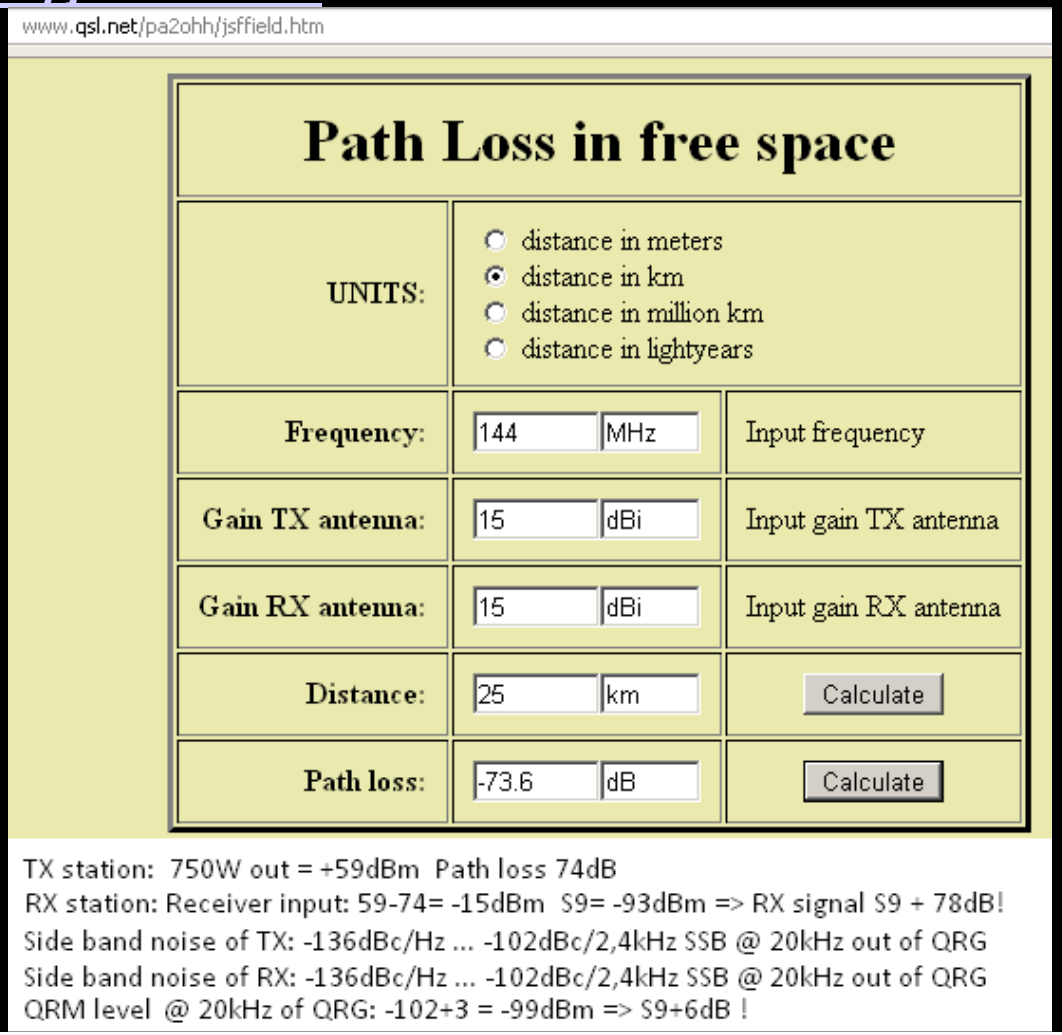
  http://www.ok2kkw.com/studnice/gi7b_neutralization.htm

  - bad matching on SSPA output – may create even malfunction of ALC
  - intermodulation of driver transceiver (for example FT1000) in case of use transverter low level output due to disconnected ALC in TRX.

Phase (sideband) noise of TX & RX Local oscillators

- Calculate path loss between two contest stations in 25km distance

- http://en.wikipedia.org/wiki/Free-space_path_loss
- http://www.qsl.net/pa2ohh/jsffield.htm



Phase (sideband) noise of TX & RX Local oscillators

- comparison of regular used transceivers and why the HF TRX with transverter has better performance

http://www.sm5bsz.com/dynrange/eme2004/eme2004.htm

Web www.sm5bsz.com/dynrange/eme2004/eme2004.htm

Model/ser.	Band	Noise floor in -dBc/Hz				
	(MHz)	5kHz	10kHz	15kHz	20kHz	50kHz
IC-765(02576)	14	121.3	126.7	128.4	129.0	130.1
FT-1000D(3G330126)	14	107.7	115.0	117.8	120.0	124.7
FT-736(9E260294)	144	115.7	123.7	126.7	128.4	130.8
FT-817(1D240059)	144	101.7	110.6	114.8	118.0	126.7
FT-817(1E270433)	144	101.0	109.6	114.2	117.4	126.0
FT-817(1E270433)	14	107.3	115.2	119.6	122.8	128.8
FT-847(81100231)	14	105.6	117.2	124.9	129.3	136.4
FT-847(81100231)	144	94.3	107.3	112.7	116.1	125.2
FT-897	14	109.9	120.2	125.8	128.4	127.3
Orion(03C10433)	14	128.2	127.1	126.2	125.2	119.8
TS-2000(30400028)	14	108.6	117.8	119.6	121.1	124.1
TS-2000(30400028	144	105.3	115.3	119.8	122.6	131.0

Table 1. *Noise floor at different frequency separations from a carrier.*

http://www.df9ic.de/tech/trxtest/trxtest.html

144 MHz Allmode Radios:TRX	Owner	IP3	TX sideband noise level in 2,5 kHz BW		
		dBm	20 kHz offset	50 kHz offset	200 kHz offset
IC275E	DF9IC	-7.5	-97	-104	-109
IC7000	DD9WG	-7.5	-87	-93	-93
IC706 - measured by DL2KCK	DL2KCK	-	-91	-95	-103
IC746	DJ0QZ / D	-7.5	-82	-91	-105
IC821H	DK9VZ	-9	-77	-88	-97
IC910H	DK9IP	-8.5	-78	-88	-98
IC202	DL3IAS	-14	-100	-102	-102
Hohentwiel	DL3IAS	-5.5	-96	-97	-101
FT225RD + MuTeK + mods	DK9VZ	7	-85	-92	-106
FT817	DK2DB	-12	-83	-91	-96
FT847	DK5UY	-12,9	-80	-91	-103
FT857D	DK9VZ	-2	-84	-93	-99
TS700G mod. with GaAsFET	DK8SG	-13	-102	-106	-107
TS700S (preamp off)	DB6IR	-7	-96	-102	-104
TS790E	DJ5IR	-14.5	-84	-94	-95
TS2000 (preamp on)	DK2GZ	-21.5	-85	-97	-107
DK2DB homemade 1976	DK2DB	-11	-103	-107	-110
DK2GR homemade	DK2GR	-2	-110	-114	-114

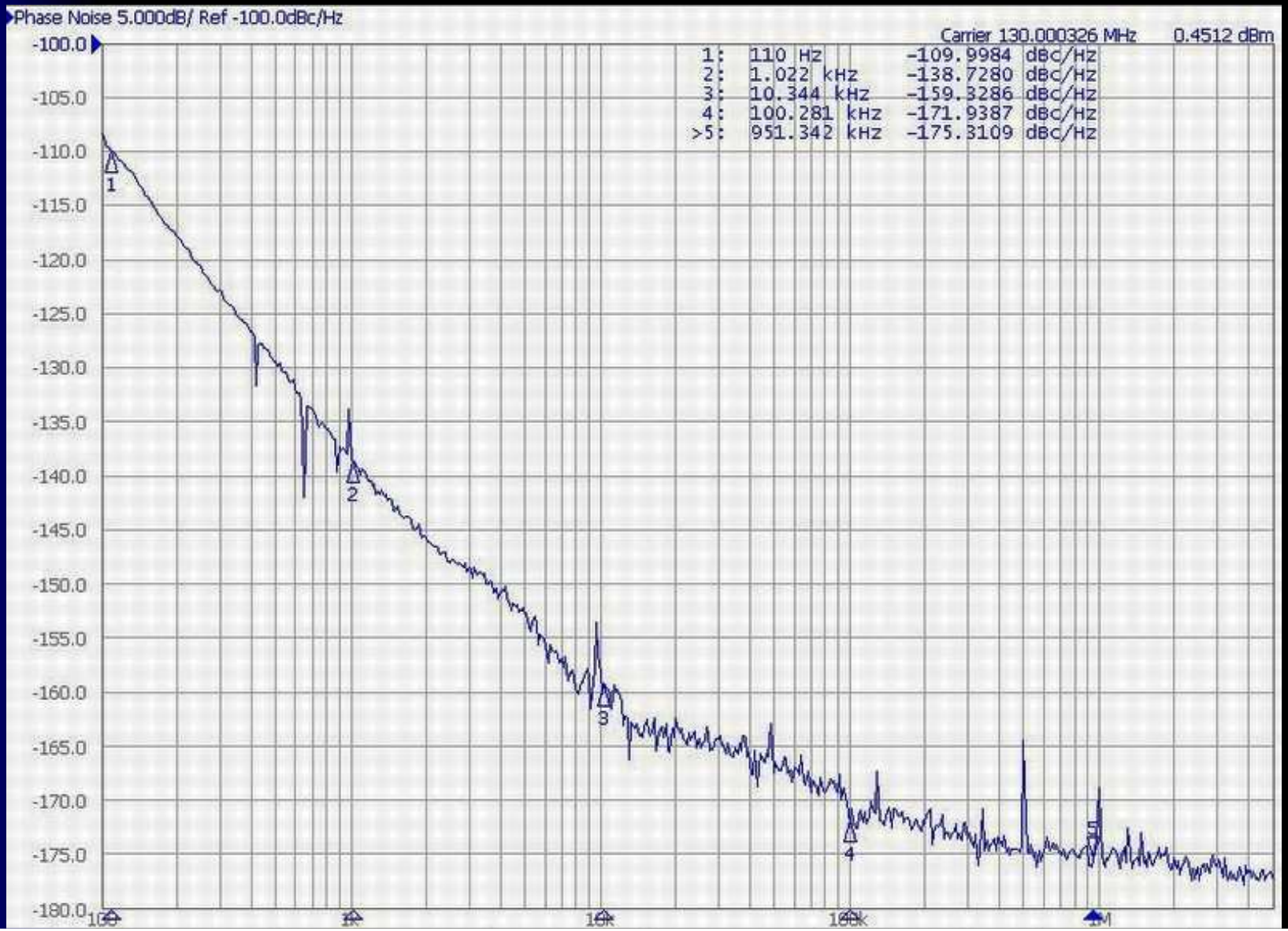
http://www.df9ic.de/tech/trxtest/trxtest.html

HF Allmode Radios with transverter:	IF	IP3	TX sideband noise level in 2,5 kHz BW		
	MHz	dBm	20 kHz offset	50 kHz offset	200 kHz offset
Elecraft K2 + XV144	28	-26	-93	-92	-93
Elecraft K2 + Kuhne TR144H+40	14	-9	-90	-95	-96
Orion main RX + Javornik	14	0	-93	-88	-99
TS850 (preamp off) + LT2S	28	-1,5	-93	-100	-103
TS870 (preamp off) + LT2S	28	-6	-95	-100	-104
TS870 (preamp off) + Javornik	14	-1,5	-92	-97	-99
IC756pro II (preamp off) + Kuhne TR144H	28	-5	-90	-100	-108
FT1000 M.V main RX (preamp off) + Kuhne TR144H	28	-8	-91	-99	-101
FT1000 Mark V main RX (preamp off) + Javornik	28	1	-98	-106	-110
IC7800 + Kuhne TR144H40	28		-98	-102	-108

- **Note: sideband noise level is ordinary presented in dBc/Hz (1Hz wide band), but in practice is used SSB filter 2,5kHz. In SSB case the sideband noise level is higher by 34dB!**

What about some improvement? X.O. by DC8RI!

http://www.ok2kkw.com/00000104/preselector/rmc/krystalove_oscilatory_sideband_noise.htm



And what about insert some X-tal filter into TX & RX IF chain?

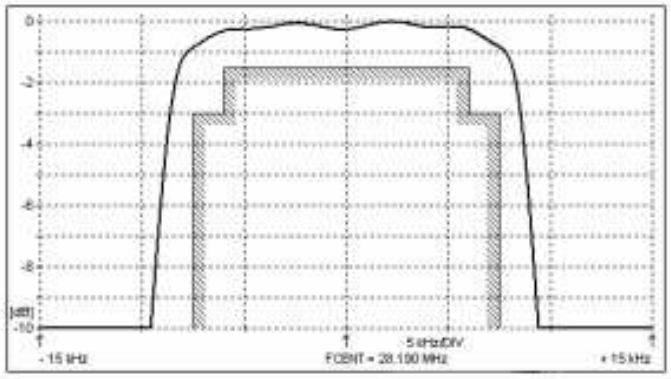
SPECIFICATION FOR CRYSTAL FILTER
MCF 28.190-15/06

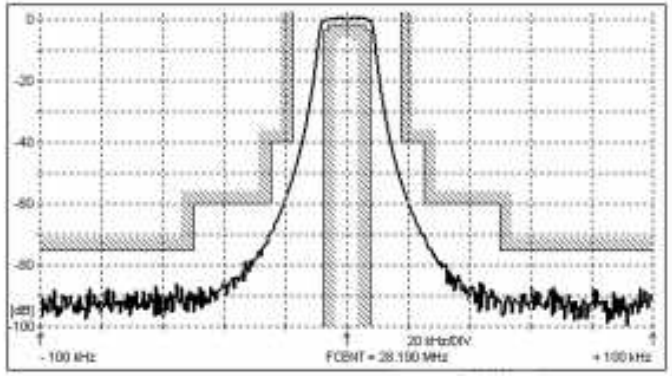
Number: 92 272
Drawing: 61 9578

1. Electric values

1.0 Number of poles :		6
1.1 Nominal centre frequency f_{nom} :		28.190 MHz
1.2 Bandwidth between 3 dB frequencies :		≥ ± 7.5 kHz
1.3 Ripple at f_{nom} ± 6.0 kHz :		≤ 1.5 dB
1.4 Insertion loss :		≤ 4.0 dB
1.5 Stop band	f_{nom} ± 17.5 kHz :	≥ 40 dB
	f_{nom} ± 25 kHz :	≥ 60 dB
	f_{nom} ± 50 .... 500 kHz :	≥ 75 dB (except spurious)
1.6 Terminating impedance (input and output) :		50 Ohm // 0 pF
1.7 Operating temperature range :		-25℃ to +70℃
1.8 Case :		KF 13 (25.1 x 14.1 x 10.5 mm)
1.9 Marking on the case :	KRYSTALY CZ YYWW 28.190-15/06	YY = year WW = week

2. Characteristics MCF 28.190–15/06



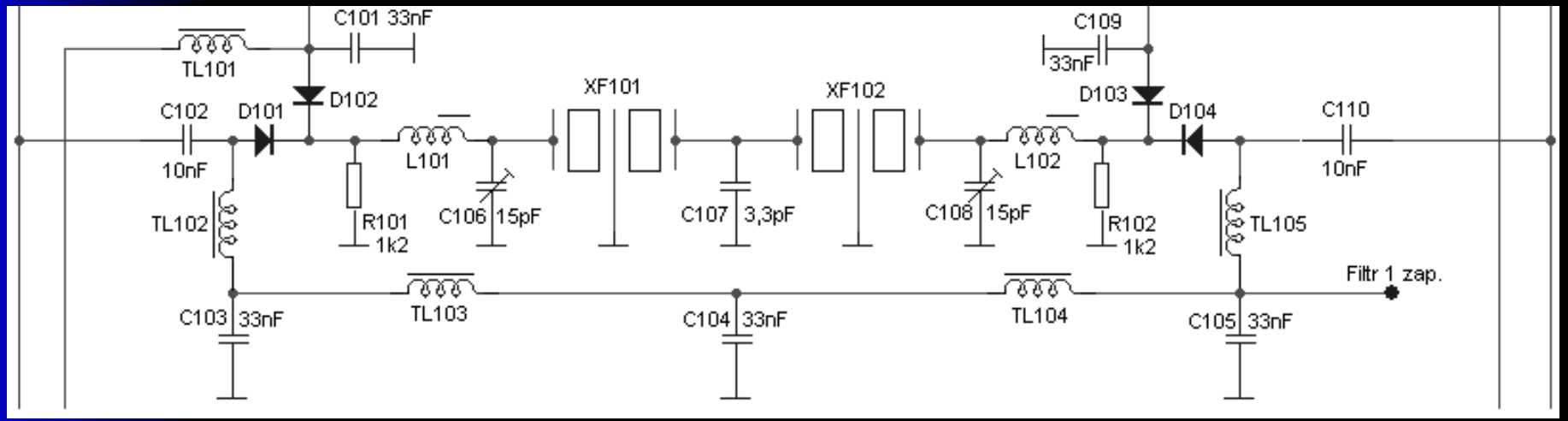


How to find a way to improvement? Look here!

http://www.ok2kkw.com/next/sideband_noise_ft5000mp.htm

http://www.ok2kkw.com/next/staronove_vyzvy.htm

http://www.ok2kkw.com/00000104/preselector/preselect_quarz_filter.htm



How to recognize different kind of QRMs?

Bad intermodulation in transmitter:

- very bad QRM in case of SSB
- slightly better when CW is used
- better if QRG distance is higher

Sideband (phase) noise of L.O. :

- worst in case of CW
- better in case of SSB
- better if QRG distance is higher

Broadband noise of transmitter chain:

- broadband noise does not related to a modulation
- does not comply with QRG gap

Corona RF arc: similar to sideband noise, but the same for SSB & CW

RF ingress: variable by TX stand constellation - for example antenna beaming

Bad switching PS and other reasons: create spurious modulated by transmitter

Clicks in case of CW, and many more…

Very often are combined two or even more QRM reasons..

Rough and unusual QRM sources

- - RF ingress from your own antenna, or from near commercial transmitter (FM, TV, KV):
  - - into modulation, PLL, power supply regulation, other supportive circuits…

- switching PS for PA a TRX: operational frequency around 60 kHz:
  - creates birdies & spurios – additional filtration is needed, use just HQ PS!.

http://www.ok2kkw.com/00003016/pa70cm/im008884.jpg

- another QRM source: diffused magnetic field from PS, PC, second transceiver with the same IF, RF Corona arc in the cavity of tube PA,

and particularly: any bad PWR connection - for example not well tighten screw in AC wall socket…

Troubles on receiver side

- check intermodulation robustness of complete RX chain incl. LNA

- why the LNA with high IMD performance is so needed?

Particularly due to Out of band interference!

The whole RX chain would be fatefully overloaded by signals far away from reception band - even by signals hundred MHz away!

http://www.ok2kkw.com/ok1dak/ok1dak.htm

SW simulation of RX chain:

http://www.avagotech.com/pages/appcad

(keep the RX chain gain as low as possible!)

- Out of band interference - in case of use of QTH of TV & FM transmitters -> to prevent overloading of receiver, use on the output of LNA circulator, or long coax cable (RG58) and only then some BPF!

Use of BPF only directly on the output of LNA may create even worse QRM and not the improvement!

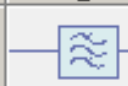
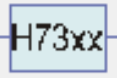
- sideband noise of receiver local oscillator – see the sideband noise issue of the transmitter...

AppCAD - [NoiseCalc Example: 1.9 GHz CDMA Handset Receiver]

File Calculate Application Examples Options Help

NoiseCalc

Set Number of Stages = 7 | Calculate [F4] | Clear | Main Menu [F8]

		Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Stage 6	Stage 7
Stage Data	**Units**							
Stage Name:		FBAR Duplexer	Agilent ATF-36xxx	Image Filter	Agilent MGA-72543	Agilent HPMX-7102	IF Filter	Agilent HPMX-730x
Noise Figure	dB	3,8	0,9	3,5	1,7	9	3,1	6
Gain	dB	-3,8	13,8	-3,5	14,1	13	-3,1	52
Output IP3	dBm	100	14,5	100	9,8	20	100	12
dNF/dTemp	dB/°C	0	0	0	0	0	0	0
dG/dTemp	dB/°C	0	0	0	0	0	0	0
Stage Analysis:								
NF (Temp corr)	dB	3,80	0,90	3,50	1,70	9,00	3,10	6,00
Gain (Temp corr)	dB	-3,80	13,80	-3,50	14,10	13,00	-3,10	52,00
Input Power	dBm	-50,00	-53,80	-40,00	-43,50	-29,40	-16,40	-19,50
Output Power	dBm	-53,80	-40,00	-43,50	-29,40	-16,40	-19,50	32,50
d NF/d NF	dB/dB	0,76	0,92	0,08	0,11	0,02	0,00	0,00
d NF/d Gain	dB/dB	-0,24	-0,08	-0,05	-0,02	0,00	0,00	0,00
d IP3/d IP3	dBm/dBm	0,00	0,00	0,00	0,00	0,00	0,00	1,00

Enter System Parameters:

Input Power	-50	dBm
Analysis Temperature	25	°C
Noise BW	1	MHz
Ref Temperature	25	°C
S/N (for sensitivity)	10	dB
Noise Source (Ref)	290	°K

System Analysis:

Gain =	82,50	dB
Noise Figure =	5,11	dB
Noise Temp =	651,32	°K
SNR =	58,86	dB
MDS =	-108,86	dBm
Sensitivity =	-98,86	dBm
Noise Floor =	-168,86	dBm/Hz

Input IP3 =	-70,50	dBm
Output IP3 =	12,00	dBm
Input IM level =	-9,00	dBm
Input IM level =	41,00	dBC
Output IM level =	73,50	dBm
Output IM level =	41,00	dBC
SFDR =	25,57	dB

Normal

Click for Web: APPLICATION NOTES - MODELS - DESIGN TIPS - DATA SHEETS - S-PARAMETERS

System faults…

Czech republic: Class „A“ license allowed use of transmitter with RF power limits:

- **750 W PEP for ordinary use**
- **1500 W PEP in case of international contests & EME**
- **3000 W PEP in case of international contests under the condition, that the station must be outside of urban area**

- **In case of use more parallel PAs, connected to one signal driver (“multibeaming design”) the output power of PA should be counted as a sum of PEP of all of them and the result can not exceed 3kW RF. But not always the OK QRO contest stations are comply with such limit..**

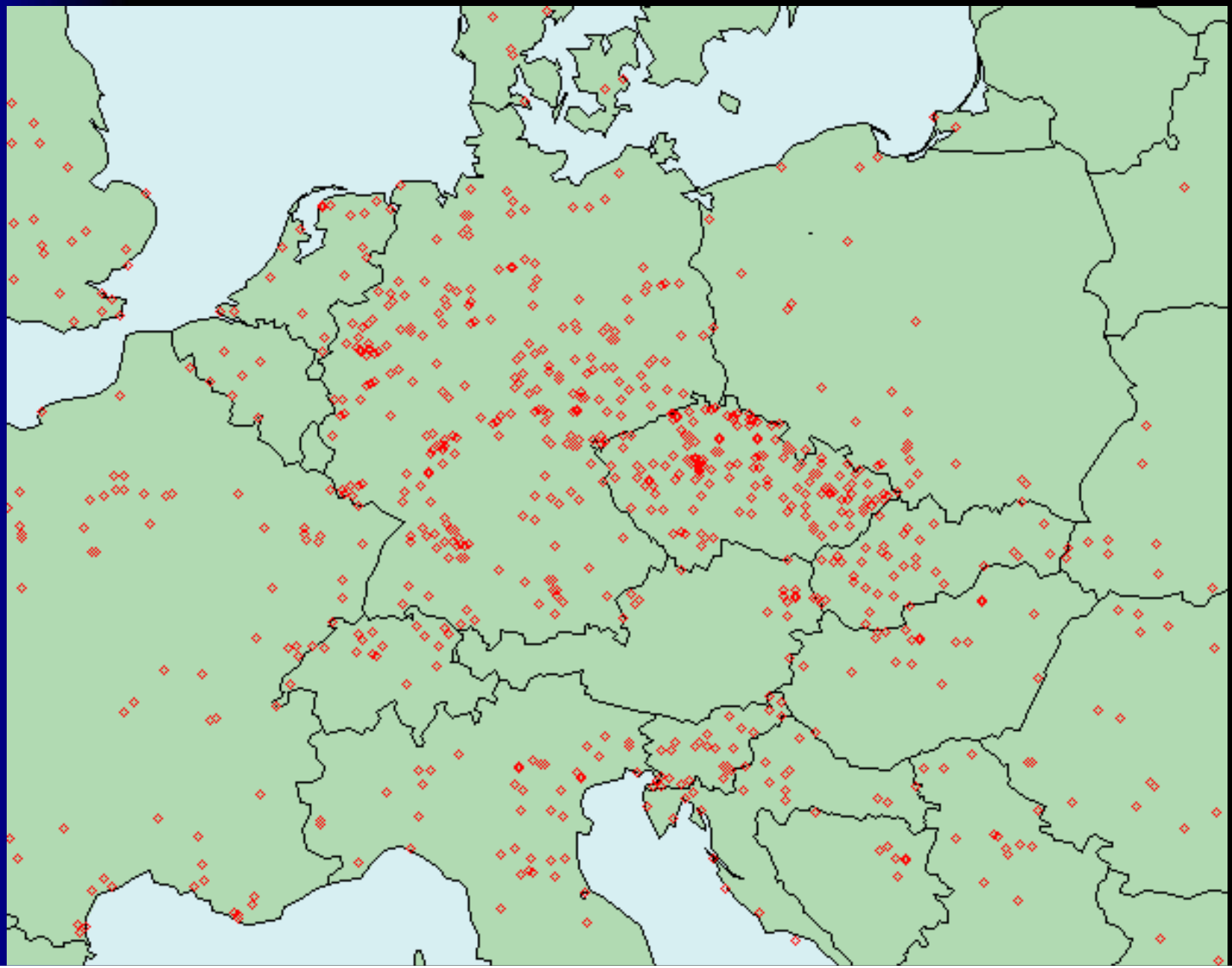
- **Because „multibeaming“ contest station transmit all the contest into all used directions (!) (only receiver is switching antenna by antenna to get the best RX), the other station on opposite hill has not chance for clean reception, because previous practice turn of the antenna from each to other directions of QRO station is not possible… The result of it are exceeded physical limits (particularly sideband noise), which does not give to other station chance for clean reception.. However the way back is probably not feasible any more ☹**

For final: how to win a VHF Contest in EU?

- - manage QRM free reception (close station far away more, than 50km)
- - Generate good enough RF field into all important directions
- - Use suitable EU QTH, from where the QRB into areas with high density of contest stations (DL, OK, S5, 9A, IK) is abt. 500 to 700km to maximize points
- - Find the hill with at least 300m elevation above the terrain around, without trees and TV & FM transmitters and where is possible to go there by car…
- - manage good and reliable equipment + experienced VHF operators

- Due to contest stations penetration in EU I would express my belief, that one of the optimal QTH for such station would be somewhere in SP3 area. What about fulfilment of the other conditions?

EU areas with the highest density of VHF contest stations (July 2014, 70cm)



No bad QRM in VHF Contests and a satisfaction from a nice result wish you on behalf of all OK2A / OK2KKW contest team

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