“Radio frequency interference at QUASAR Network Observatories”

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QUASAR radio telescopes RT-32 are equipped with high sensitive cryogenic receivers. Main frequency parameters of the receivers are presented in table1 [1]

Table 1. Main parameters of the QUASAR receivers.

Wavelength, cm	Frequency band	Bandwidth, GHz	LO freq. GHz	IF Bandwidth, MHz
18-21	L	1,38-1,72	1,26	130-470
13	S	2,15-2,50	2,02	130-480
6	C	4,60-5,10	4,50	100-600
3,5	X	8,18-9,08	8,08	100-1000
1,35	K	22,02-22,52	21,92	100-600

RFI is one of the factors reducing sensitivity of the radio telescopes.

It is well known, that all RFI affected on sensitivity of radio telescope can be divided by origin into two types: external and internal origin. The structure of most powerful RFI presented on fig.1.

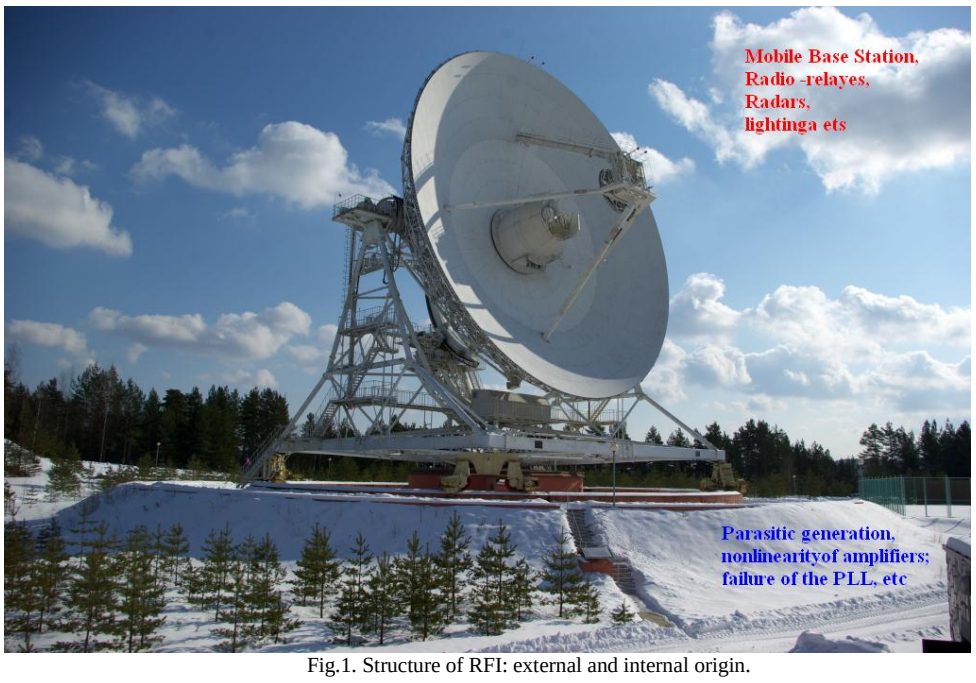

Fig.1. Structure of RFI: external and internal origin.

Most of external RFI’s are closely connected with human activities around the place of the QUASAR network observatories location. QUASAR radio telescopes were built in places remote from major settlements, but now this situation changed, and resulted in increasing RFI level especially in L and S-band.

For example, Svetloe observatory radio telescope was built in a valley, about 100km far from St. Petersburg, surrounded by hills, served as additional shield against RFI. Now these hills serve as a popular ski resorts. As a result we have powerful source of RFI from mobile phone base station transmitters installed near (2,5km away) radio telescope as infrastructure element of the resort.

The same mobile service recently appeared near the radio telescope of Badary and Zelenchukskaya observatory.

Practically RFI level in S- band is determined by radiation of the mobile phone base stations built near QUASAR observatories (look at frequency parameters of mobile communication links presented in Tab.2 and receiver parameters in Tab.1). Signals of these communication links can affect on IF directly (GSM-900) or generate RFI in L-band (GSM-1800) and S-band (UMTS) at the LNA’s inputs.

Table2. Frequency parameters of mobile communications used in Russian Federation: GSM 900/1800, UMTS, (BS - Base Station, HS- handsets)

Transmission(up-down)	GSM-900	GSM-1800	UMTS
From HS to BS, MHz	890 - 915	1710 - 1785	1885- 2025
From BS to HS, MHz	935 - 960	1805 - 1880	2110 -2200

For estimation of RFI parameters, receiver intermediate frequency (IF) signals are controlled to measure RFI spectral characteristics: frequency, bandwidth, level (fig2). Spectrum analyzer GSP 827 is used for this purpose. Spectral measurements of the receivers IF signals are performed every three month in all QUASAR network observatories. Spectrograms obtained from these measurements fill RFI database.

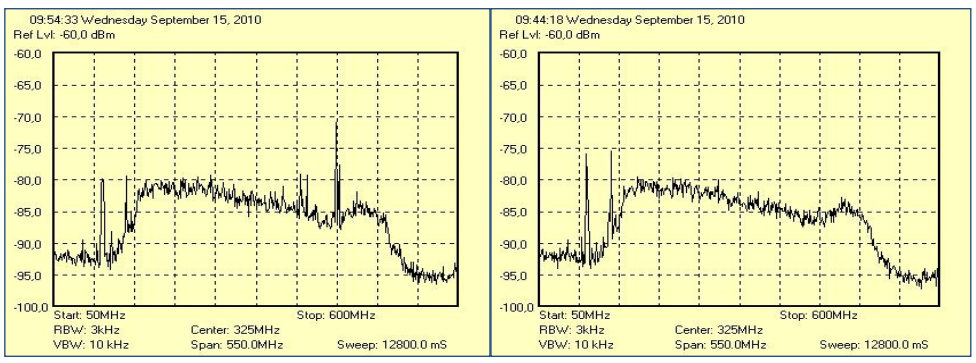

Fig2.Svetloe RT-32 reflector direction: Az=250°, El =20°, on the resort- left and in opposite direction- right. Main RFI: f_1=114.9 MHz, U=-80.1dBm; f_2=147.9 MHz, U=-80.9dBm; f_3=433.9 MHz U=-72.7dBm.

Using this technique we can register only relatively strong, stationary narrow band RFI.

Radio telescope also detects the presence of impulses of various origins, which do not plot on the spectrograms. Different types of narrow band RFI registered at QUASAR network observatories listed in Tab. 3-5.

All problems concerned electromagnetic compatibility (EMC) of radio equipment are regulated by the State Radio Frequency Center and its local territory departments. Most intensive EMC regulation process concerned mobile operators. Otherwise S-band can’t be used for VLBI observations, as it follows from Fig.3 - intermodulation products bring down the entire S-band receiver.

Table 3. RFI type and some characteristics. Badary observatory.

RFI	Source	Input frequency, MHz	Level , over system noise, dBm	Notes
L - band	Radionavigational satellite (GLONASS L1, GPS L1)	1598,0625-1608,75 1575,42	25-30	Maximum value
	DORIS	401,25	10	
	MOBILE SATELLITE (S-E)	1525-1560	5-7	
S - band	Mobile (UMTS)	2134-2139	15	Observed in three azimuths
C - band	DORIS	401,25	10	
X - band	Clear			

Table4. Svetloe observatory

RFI	Source	Input frequency, MHz	Level, over system noise, dBm	Notes
L - band	Radionavigational satellite (GLONASS L1, GPS L1)	1598,0625-1608,75 1575,42	25-30	Maximum value
	Fixed service	1532	25	Azimuth depended
S - band	Mobile (UMTS)	2134-2139	1-5	high-pass filter added
	Fixed service , MW oven	2400-2500	15	Direction on resort, 2km distance
C - band	Spurious harmonics PLL	4800, 4900	30	Will be removed after PLL upgrade
X - band	Clear			

Table 5. Zelenchukskaya observatory

RFI	Source	Input frequency, MHz	Level , over System noise, dBm	Notes
L - band	Radionavigational satellite (GLONASS L1, GPS L1)	1598,0625-1608,75 1575,42	25-30	Maximum value
	Fixed service	1532	25	Azimuth depended
S - band	Mobile (UMTS)	2134-2139	20	Maximum value, no intermods
	Fixed service	2400-2500	10	
C - band	Spurious PLL harmonics	4800, 5100		Will be removed after PLL upgrade
X - band	L-Clear, R:Spurious PLL harmonics			Will be removed after PLL upgrade
K - band	Clear			

Fig.2 demonstrates “compatible” UMTS BS signals (in low frequency part of spectrograms). Additional High Pass filter was used at the output of the LNA to attenuate UMTS signal. At the left plot MW - oven signal (f3) can be seen.

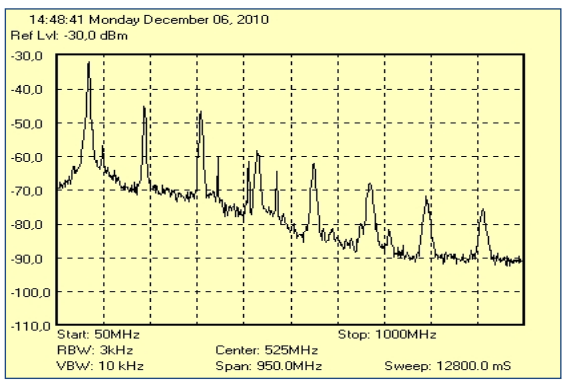

Fig. 3 - Spectrogram of Svetloe S-band receiver IF signal.

Intermods are produced UMTS BS (RT-32 reflector is directed to BS)

For more accurate estimation of RFI affect on VLBI observations, spectrograms obtained by IAA correlator can be used [2]. This technique was applied to estimate IF spectrum distortion caused by DORIS signal for the S and X-band receivers. DORIS 401.25MHz signal penetrate directly in to the IF band of all receiver, probably via the long cable wrap. Significantly attenuated DORIS signal do not overload amplifiers and can be registered in IF band with the help of low resolution GSP 827 spectrum analyzer [3]. For the experiment with correlator 16 MHz video convertors were tuned on frequency 401.25MHz.

Result of the data processing presented on Fig.4: components of DORIS 401.25MHz signal spectrum filled practically all 16MHz band of the video convertor. Thus we can conclude that DORIS transmitter has to be torn-off if 401 MHz signal is within bandwidth of signal registered, as it take place in some EVN observation sessions.

Otherwise, in standard IVS sessions this low frequency signal doesn’t impact on observations because this signal is out of video convertors band. DORIS high frequency signal (2036MHz) must be carefully filtered too when a wide-band receiver is used [3].

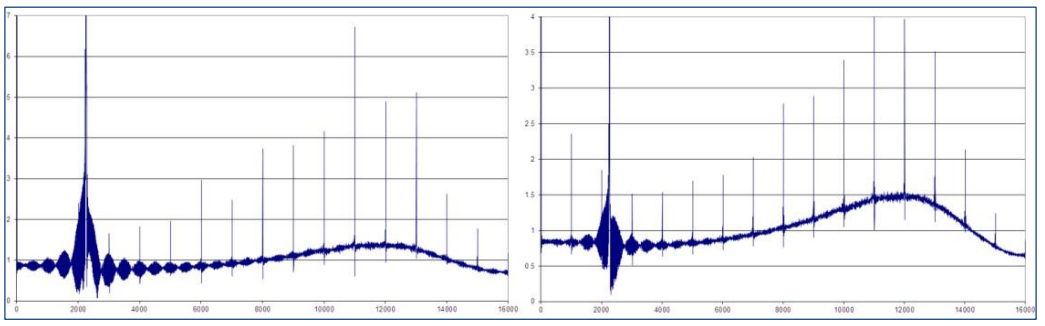

Fig.4. Spectrum of DORIS 401,25MHz (Badary observatory) and phase calibration signal generator on measured at16MHz bandwidth video convertor with frequency resolution 2KHz. S-band receiver –left and X-band-right. Signal processed by IAA correlator.

RFI and QUASAR network in the future

Now we can conclude that S-band receiver in QUASAR observatories substantially affected by RFI at the 2.15GHz frequency range.

At the end of 2010 Russian mobile operators announced intentions to obtain frequency range 2.5-2.7GHz for wide band communication service. This can create problems for VLBI2010 operating in low frequency range in the future. RFI- free frequency range will be narrower than expected or low frequency end of this range will be moved to 3GHz.

The impact of RFI on VLBI2010 discussed in many papers [4-6] and it is not the end. Problems are more complicated, than it can be seen for the first sight. One of them – how to combine demands of the receiver low noise, wide frequency range and it high dynamic range to ensure high linearity amplification of the signals and RFI received. Receiver design concept suggested in [7] looks more preferable, because of using several relatively narrow band amplifiers operating in RFI low level region. (On the other hand, such a solution provides limited possibilities for changing or tuning the frequency range of the receivers).

For the beginning, it is nesessary to determine RFI free bands taking into account very specific situation in observatories and RFI dynamic for a long period interval. These measurements planned to begin at the near future.

References

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