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About the Compatibility of DORIS and VLBI Observations

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Abstract

We investigated the compatibility of the DORIS and VLBI observations at Badary Observatory. The DORIS beacon stands at 100-m distance from the main radio telescope dish and transmits signals on two frequencies: 2036.25 MHz and 401.25 MHz. The latter frequency is modulated to send messages containing an ID number, timing information, data from the meteorological sensors, and engineering data (e.g., power). Both frequencies affect the S/X band radio telescope receivers. The parameters of the DORIS signals were measured at the outputs of the S/X band intermediate frequency amplifier. It was found that: (1) The level of RFI, produced by the DORIS beacon, practically corresponds to the level of the system (antenna plus receiver) noise signal and does not overload the S/X band receivers. (2) The DORIS 401.25 MHz signal is out of the frequency bands recorded during standard VLBI sessions. As a result, RFI from DORIS does not affect VLBI observations. This conclusion was confirmed after data correlations of actual VLBI observations that were conducted with the DORIS beacon turned on/off.

The Badary DORIS station ground-beacon is equipped with a Starec 52291 type antenna. This antenna was installed on 11.08.2004 (for details, see the logfile at http://ids.cls.fr/documents/doris/stations/log/archive/BADB200812.LOG).

Figure 1. Badary's DORIS Starec–type antenna and RT-32 radio telescope. View from control block.

The DORIS beacon stands on the cover of a control block, at a distance of about 100 m from the main radio telescope dish and transmits signals on two frequencies: $f_1 = 2036.25$ MHz and $f_2 = 401.25$ MHz. The latter frequency is modulated to send messages containing an ID number, timing information, data from the meteorological sensors, and engineering data (e.g., power). Signals f_1 and f_2 are classified as "NONE" and "15K0G1D", according to the recommendation ITU-R SM.1138. Thus we can observe narrowband signals in spectrograms, obtained with a GW Instek GSP-827 Spectrum Analyzer: signal f_1 as a sine signal spectrum and signal f_2 as a 15 kHz bandwidth one.

The Effective Isotropically Radiated Power (EIRP) values of the signals emitted on the f_1 and f_2 frequencies are 16.4 dB and 13.8 dB. Both of these strong signals affect the S/X band radio telescope receivers. In this paper we present results of DORIS and VLBI compatibility investigation.

The DORIS f_1 signal can affect the S band receiver, because the input frequencies of the receiver are 2.15–2.50 GHz and the LO is 2.02 GHz. As a result, the f_1 signal is attenuated and then converted to the intermediate frequencies (IF), producing radio frequency interference (RFI) at 16.25 MHz — near the lower end of the receiver IF bandwidth of 110–480 MHz.

The parameters of the DORIS RFI signals were measured for both S/X band receivers with a GW Instek GSP-827 Spectrum Analyzer. All measurements were taken at the outputs of more than 150 m coaxial phase stable lines, inside the control room, where the receiver IF signals are converted to the video frequencies (see Table 1) and registered.

Table 1. Video converter frequencies for R1 and R4 VLBI sessions, bandwidth 8 Hz, S/X band receivers.

Channel	Sky freq, MHz	LO freq, MHz	Video, MHz	Channel	Sky freq, MHz	LO freq, MHz	Video, MHz
01	2225.99	2020.00	205.99	04	2295.99	2020.00	275.99
02	2245.99	2020.00	225.99	05	2345.99	2020.00	325.99
03	2265.99	2020.00	245.99	06	2365.99	2020.00	345.99
01	8212.99	8080.00	132.99	05	8732.99	8080.00	652.99
02	8252.99	8080.00	172.99	06	8852.99	8080.00	772.99
03	8352.99	8080.00	272.99	07	8912.99	8080.00	832.99
04	8512.99	8080.00	432.99	08	8932.99	8080.00	852.99

The output signal spectrum of the S band receiver is presented in Figure 2. The RFI from the DORIS f_1 signal is marked by red letters. The level of RFI, produced by the f_1 signal (-93 dBm), is significantly lower than the level of the system (antenna plus receiver) noise signal of -75 dBm and does not influence the VLBI observations. For correct identification of RFI, the same spectrum is presented in Figure 3, when the DORIS beacon is turned off.

The DORIS f_2 signal is applied directly to the S/X band receivers' IF tract, and the long distance coaxial line probably serves as an antenna. The DORIS f_2 signal is effectively attenuated, practically to the receiver system noise signal level, as can be seen in Figures 4 and 5. The same spectrograms were obtained for the X band receiver.

Because of the small level and bandwidth (15 kHz) this signal can not significantly influence the VLBI observations at S/X bands. According to Table 1, the DORIS f_2 signal is outside of the

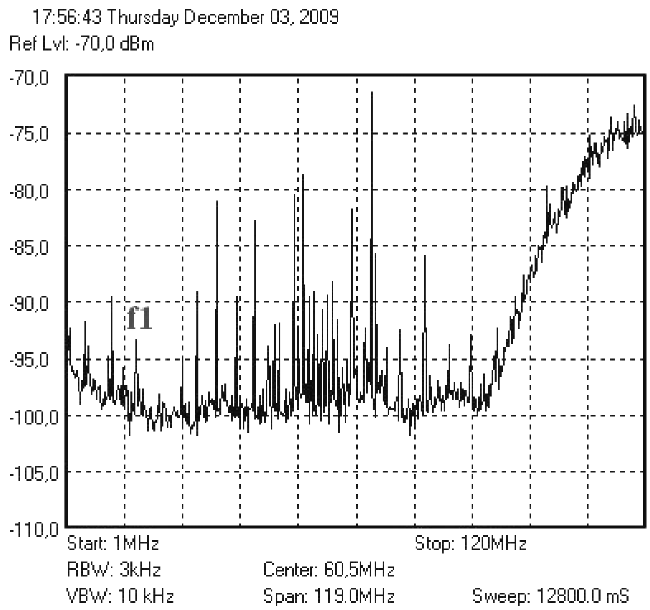

Figure 2. Output signal of the S band receiver with the DORIS beacon turned on.

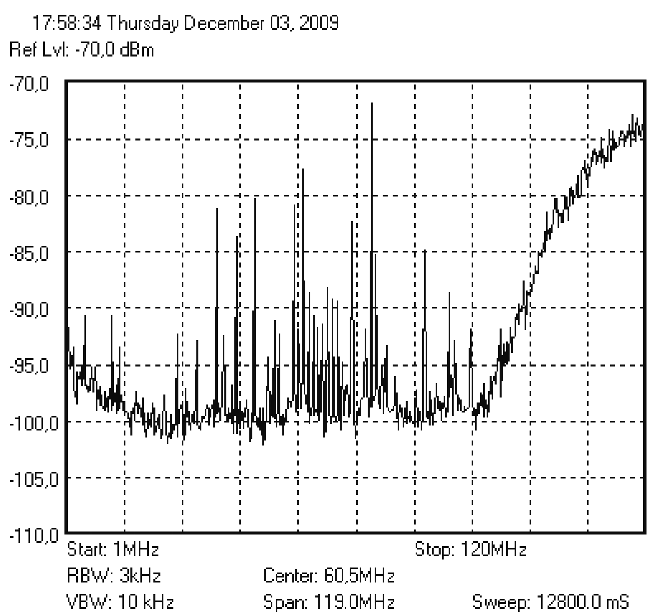

Figure 3. Output signal of the S band receiver with the DORIS beacon turned off.

frequency bands recorded during standard VLBI R1 and R4 sessions.

In summary, RFI from the DORIS beacon does not affect standard VLBI observations. This conclusion was confirmed after data correlation of actual VLBI observations that were conducted with the DORIS beacon turned on/off.

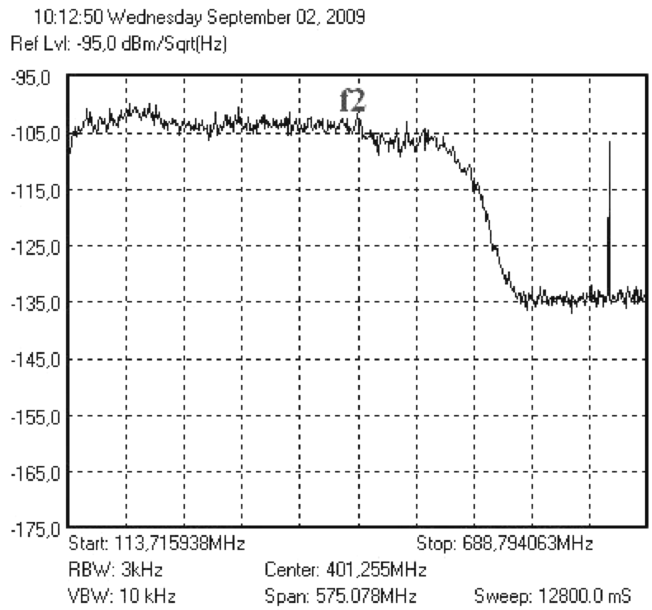

Figure 4. *S* band receiver output signal spectrum with small f_2 RFI (DORIS – turned on).

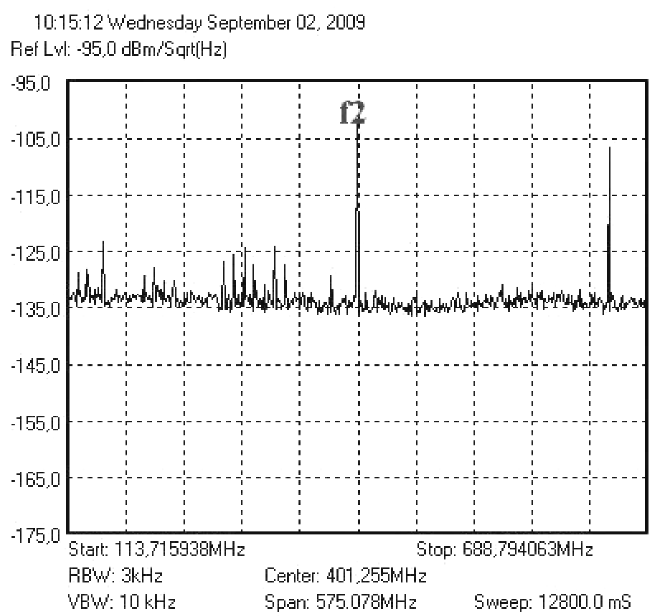

Figure 5. *S* band receiver output signal spectrum with f_2 RFI (DORIS – turned off).

The DORIS beacon f_1 signal must be carefully filtered when a wide-band receiver is used—as is planned for the VLBI2010 system. In this case the DORIS–VLBI compatibility will be a real problem!