Thrane & Thrane

TT-7009A
Sailor 900

Above Deck Unit Documentation

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Contents

List of Figures

1 Introduction

1.1 Requested Documentation

Documentation on the Sailor 900 Above Deck Unit (ADU) has been requested in regard to the below-mentioned topics.

1. Side lobe performance.
2. Cross polarization performance: XPD at the -1dB contour must be greater than 30dB.
3. If the radome is included, please describe its effect on the side lobes and XPD performance. Are there any patterns measured both without and with radome at worst pointing position to assess the electrical effect, especially the radome joint effect?
4. Photos of the Sailor 900 ADU.
5. System diagram and description of how the system ensures that the off-axis PSD complies with the advised limits. Is it sold with integrated HPA and modulator?
6. A report showing that the tracking system can comply with the design tracking specification.
7. Documentation on quality control.

1.2 Performed Tests

The documentation to follow in this document is based on several tests of the Sailor 900 ADU. The tests pertain to radiation as well as tracking characteristics. Many of the above-mentioned topics are only referenced briefly in the present document since they are described thoroughly in other documents.

The gain of the Sailor 900 ADU has been measured at the Orange Labs test range in La Turbie, France. Measurements were carried out both with and without the radome. The radome was attached in different azimuthal orientations in order to assess the level of radome inhomogeneities. There were minor differences in the results for these measurements due to such radome inhomogeneities.

A comprehensive test of the tracking characteristics have been carried out using three independent means of assessing the pointing accuracy. Additionally the cessation of transmission has been verified.

2 Side Lobe Performance

Plots of the antenna gain at both Rx and Tx frequencies can be found in [1, Sec. 3-4], to which the reader is referred. Only the EIRP will be shown in this report. Thus 4 Tx frequencies are presented for, 13.75 GHz, 14.0 GHz, 14.25 GHz, and 14.5 GHz.

The Sailor 900 ADU uses a BUC with a maximum power of 8W. In the below calculations of the EIRP spectral density a bandwidth of 500 KHz is assumed. This corresponds to a maximum spectral power density of -1.93 dBW/40kHz. In Figure 1-4 the spectral EIRP density is shown for horizontal and vertical polarizations, respectively, based on the gain measurements. The EIRP spectral density is given in units of dBW/40kHz and is calculated as

$$EIRP_{sd} = 10\log_{10}(G) + 10\log_{10}(8\mathrm{W}) + 10\log_{10}\left(\frac{40\mathrm{kHz}}{500\mathrm{kHz}}\right) = 10\log_{10}(G) - 1.93\mathrm{dBW/40kHz}, \quad (1)$$

where G is the gain with respect to an isotropic antenna. For reference purposes, the Eutelsat EIRP mask has been superimposed on the respective EIRP pattern plot. The Eutelsat EIRP mask is defined as [2, Sec. 6.2.1]:

$$SL_{co} = \begin{cases} 31 - 25\log_{10}(\theta) & \mathrm{dBW@40kHz}, \quad \alpha \le \theta \le 7.0^{o} \\ 10 & \mathrm{dBW@40kHz}, \quad 7.0^{o} < \theta \le 9.2^{o} \\ 34 - 25\log_{10}(\theta) & \mathrm{dBW@40kHz}, \quad 9.2^{o} < \theta \le 48^{o} \\ -8 & \mathrm{dBW@40kHz}, \quad \theta > 48^{o} \end{cases}, \quad (2a)$$

for the co-polar polarization. For the cross-polar polarization it is

$$SL_{x} = \begin{cases} 21 - 25\log_{10}(\theta) & \mathrm{dBW@40kHz}, \quad \alpha \le \theta \le 7.0^{o} \\ 0 & \mathrm{dBW@40kHz}, \quad 7.0^{o} < \theta \le 9.2^{o} \end{cases}, \quad (2b)$$

where α is a frequency dependent number which for the Sailor 900 ADU takes a value between 2.3^{o} and 2.2^{o}. In the shown plots $\alpha = 2^{o}$ is used.

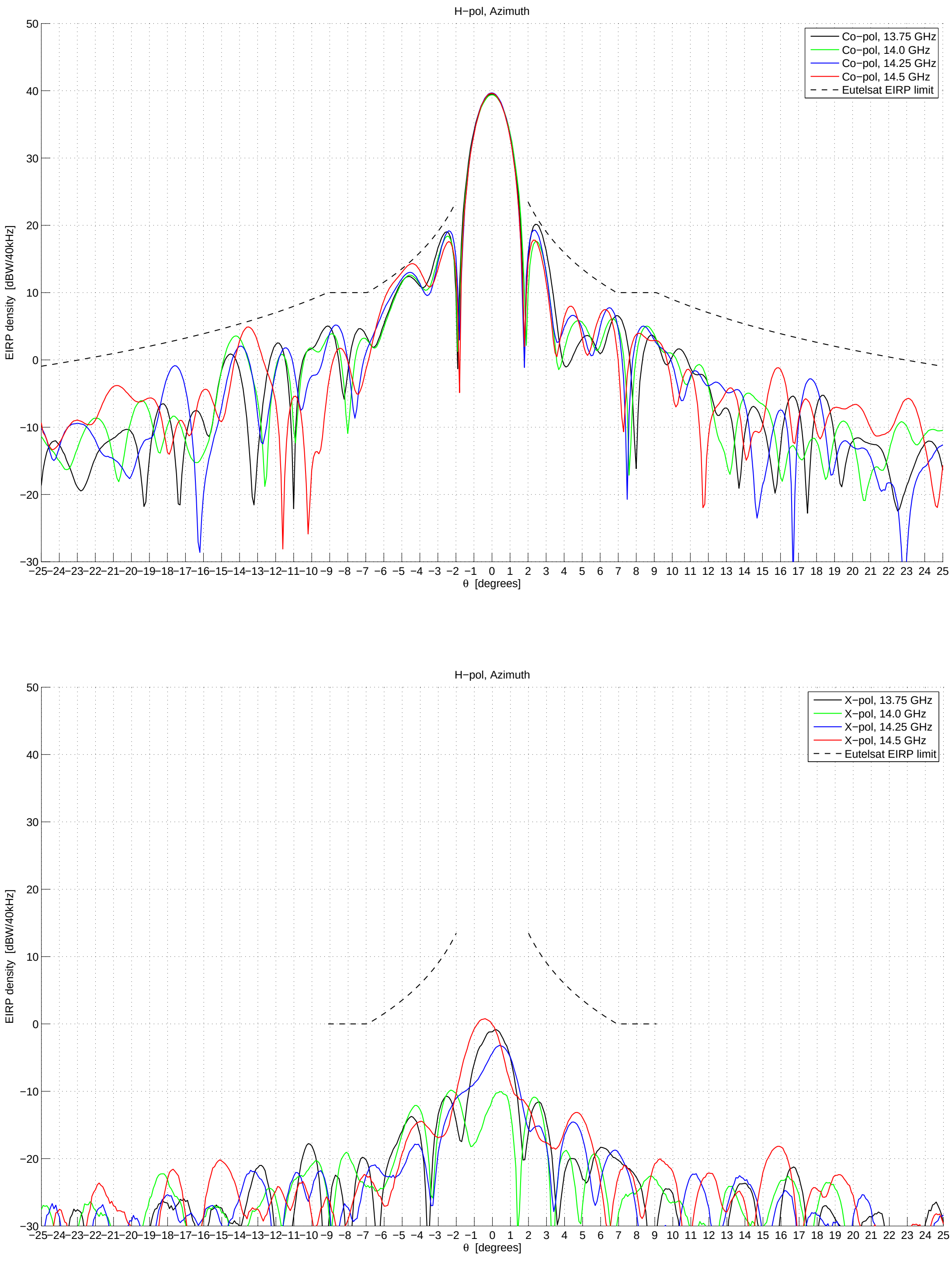
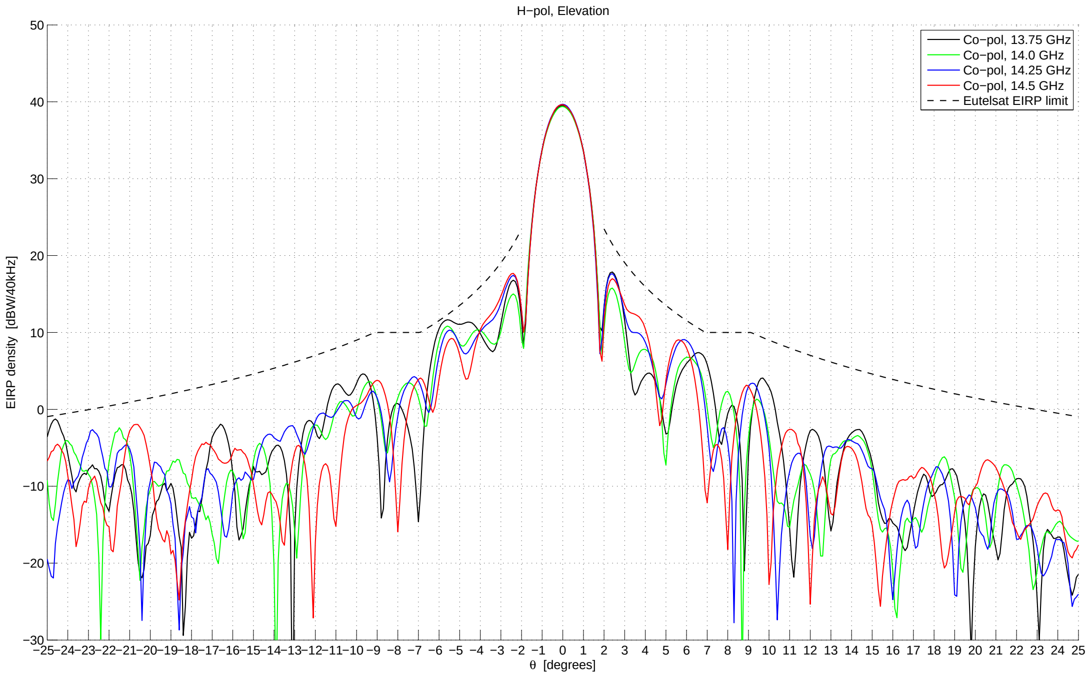


Figure 1: EIRP spectral density as function of θ for frequencies 13.75, 14.0, 14.25, and 14.5 GHz when the Sailor 900 ADU is transmitting 8W at 500 KHz and horizontal polarization, azimuth cut. For reference the Eutelsat EIRP mask is also shown. Top: Co-pol. Bottom: X-pol.



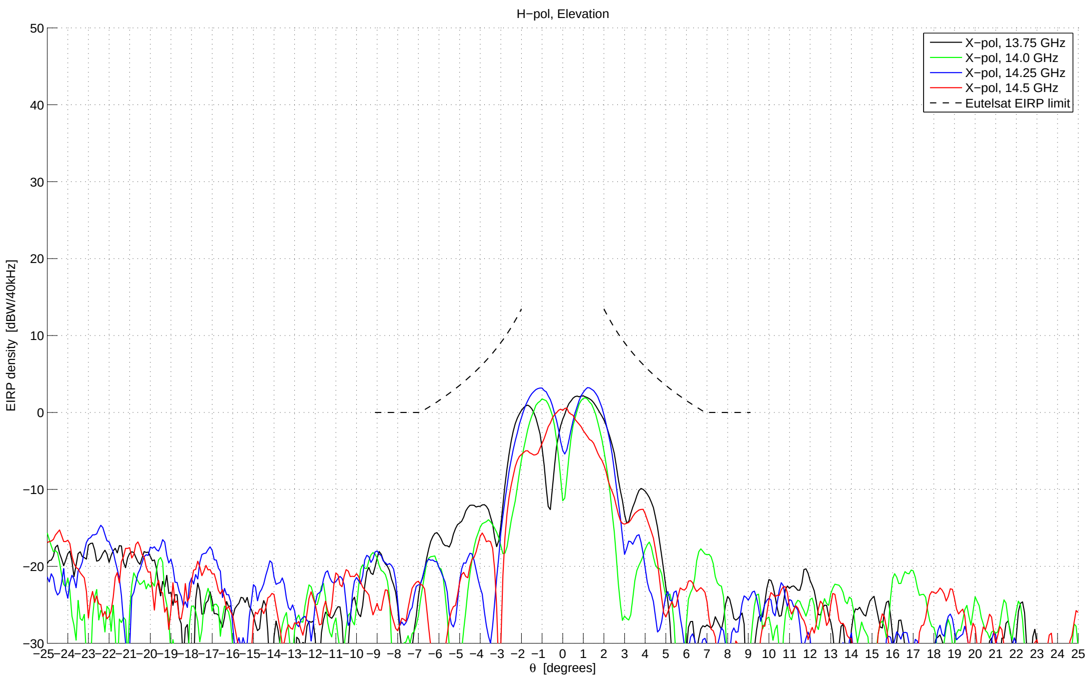


Figure 2: EIRP spectral density as function of θ for frequencies 13.75, 14.0, 14.25, and 14.5 GHz when the Sailor 900 ADU is transmitting 8W at 500 KHz and horizontal polarization, elevation cut. For reference the Eutelsat EIRP mask is also shown. Top: Co-pol. Bottom: X-pol.

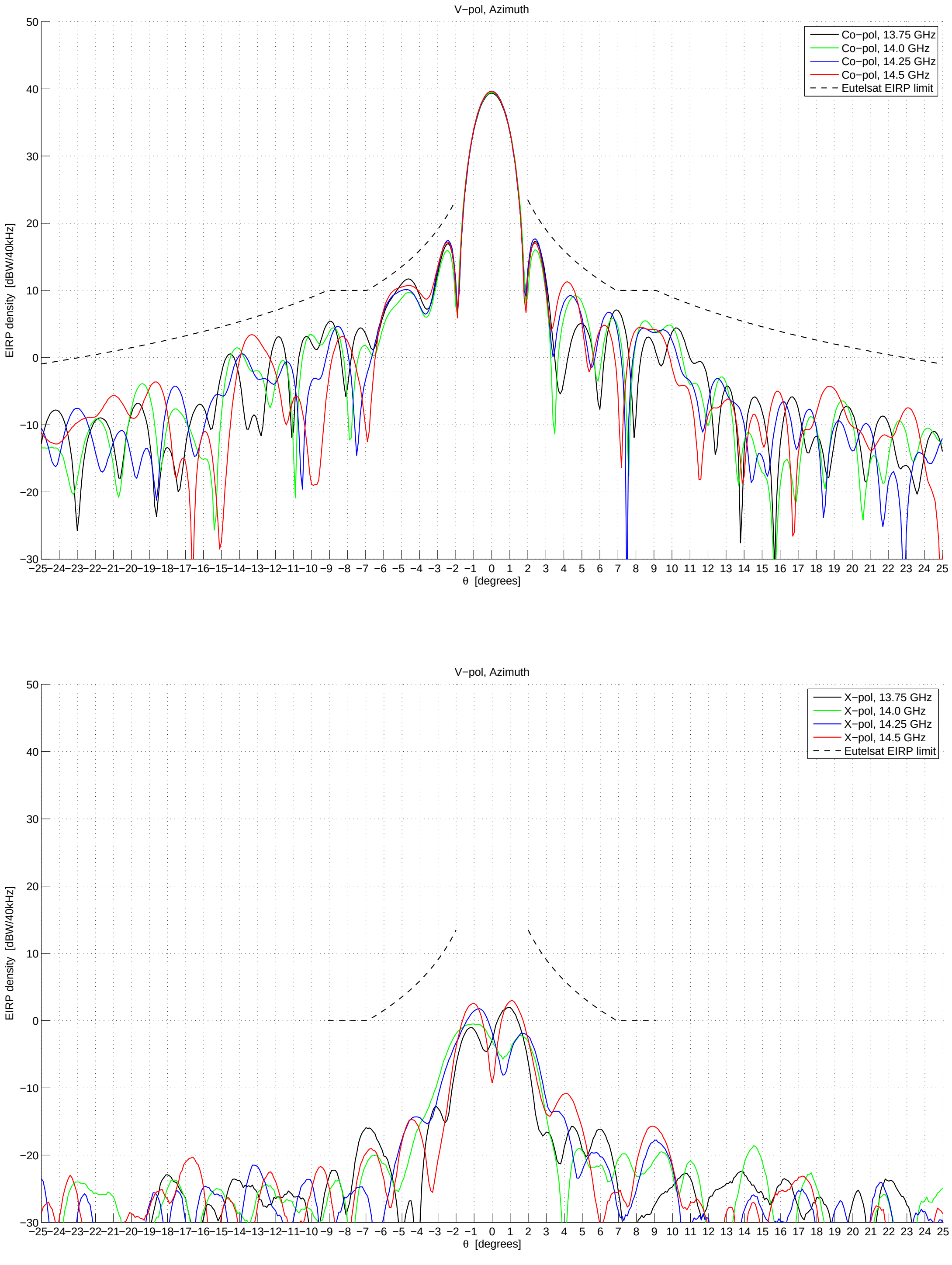
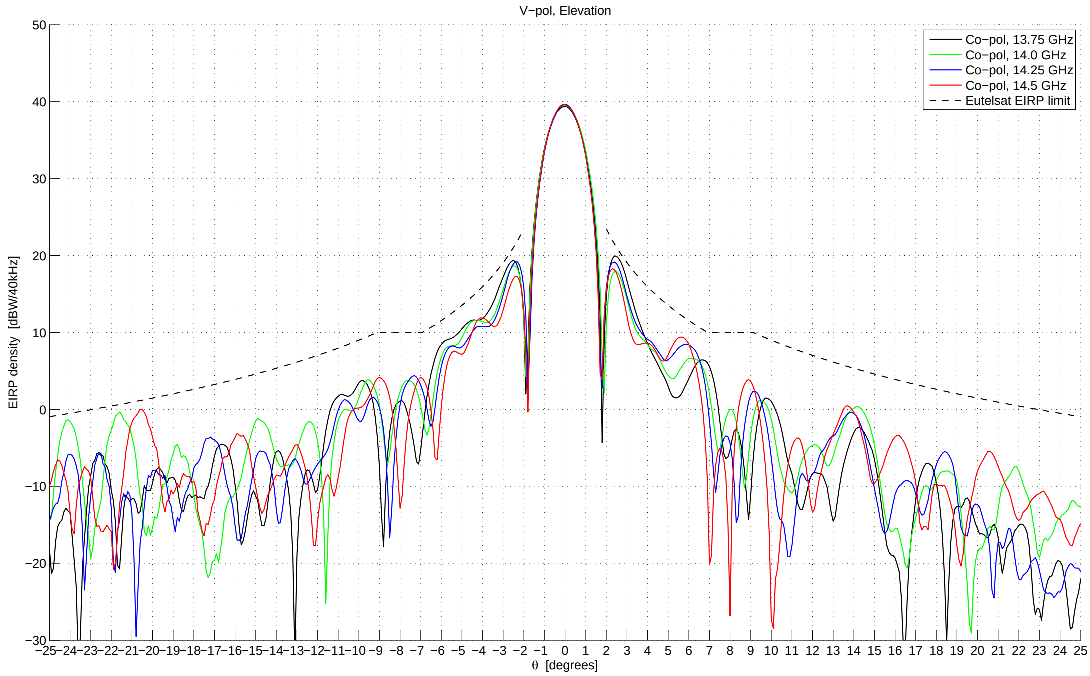


Figure 3: EIRP spectral density as function of θ for frequencies 13.75, 14.0, 14.25, and 14.5 GHz when the Sailor 900 ADU is transmitting 8W at 500 KHz and vertical polarization, azimuth cut. For reference the Eutelsat EIRP mask is also shown. Top: Co-pol. Bottom: X-pol.



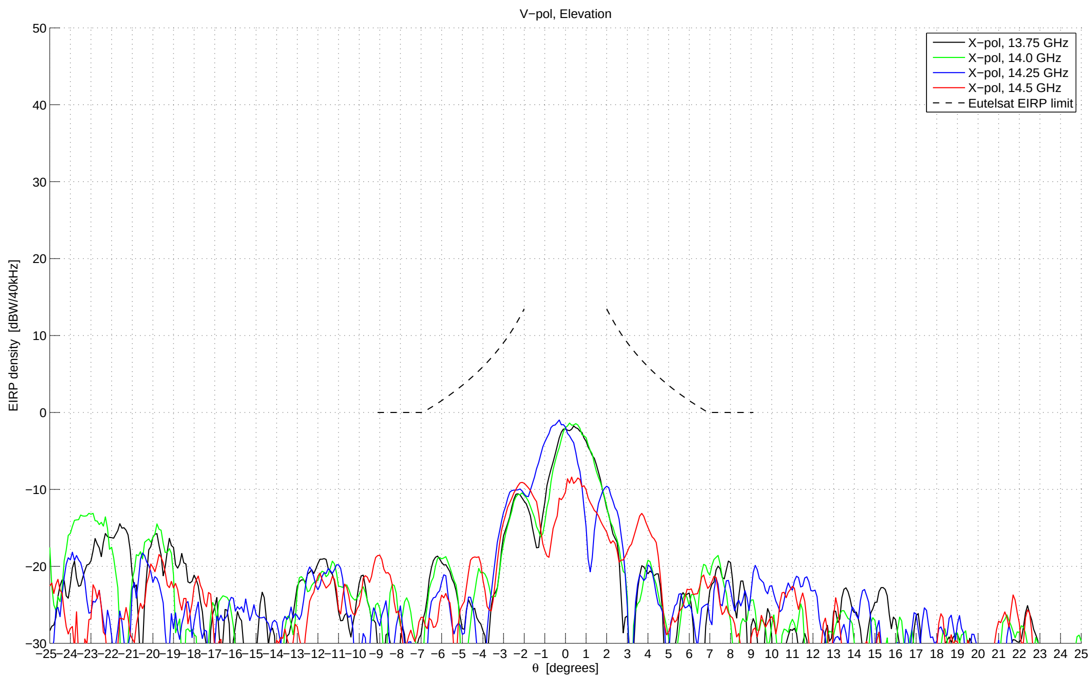


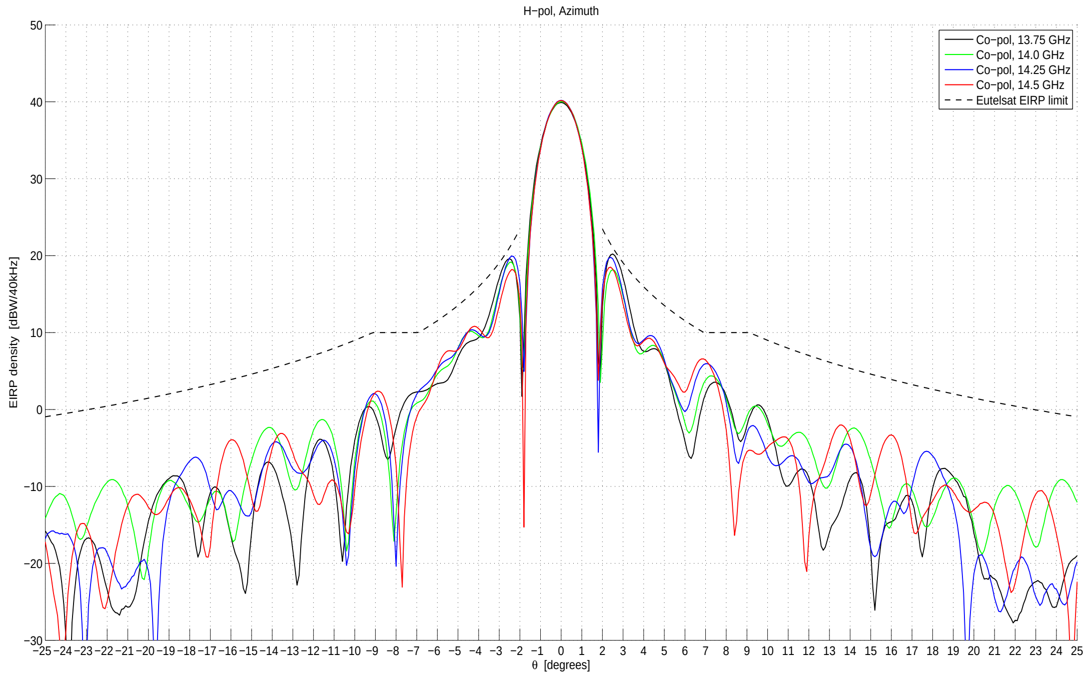
Figure 4: EIRP spectral density as function of θ for frequencies 13.75, 14.0, 14.25, and 14.5 GHz when the Sailor 900 ADU is transmitting 8W at 500 KHz and vertical polarization, elevation cut. For reference the Eutelsat EIRP mask is also shown. Top: Co-pol. Bottom: X-pol.

3 XPD Performance

The XPD level of the Sailor 900 is discussed in detail in [1, Sec. 6] to which the reader is referred. In [1, Sec. 6] it is demonstrated that the requirement of 30 dB XPD level is passed for all the Tx frequencies and polarizations.

4 Effect of Radome on Side Lobe and XPD Performance

The Sailor 900 has also been measured without the radome. The corresponding EIRP patterns for the case without radome is shown in Figure 5-8. By comparing with the case including the Radome (see Figure 1-4), it is seen that the peak gain decreases about 0.5 dB due to the radome. Also the first side lobes are slightly reduced by the radome. It is, however, also seen that side lobes at about $\theta = 5^{\rm o}$ increase slightly due to the radome. This does, however, not conflict with the EIRP requirements. There are no contour plots available for the case without radome, however, from the plots in Figure 5-8 the XPD level is seen to be similar to the case with the radome.



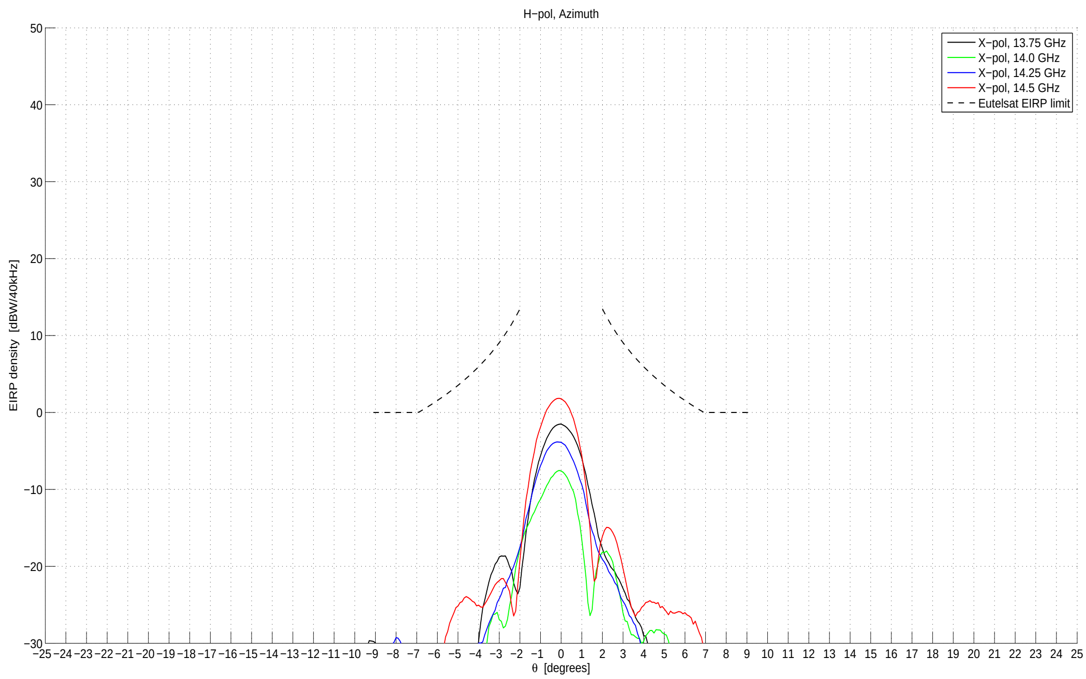


Figure 5: EIRP spectral density as function of θ for frequencies 13.75, 14.0, 14.25, and 14.5 GHz when the Sailor 900 ADU is transmitting 8W at 500 KHz and horizontal polarization, without radome, azimuth cut. For reference the Eutelsat EIRP mask is also shown. Top: Co-pol. Bottom: X-pol.

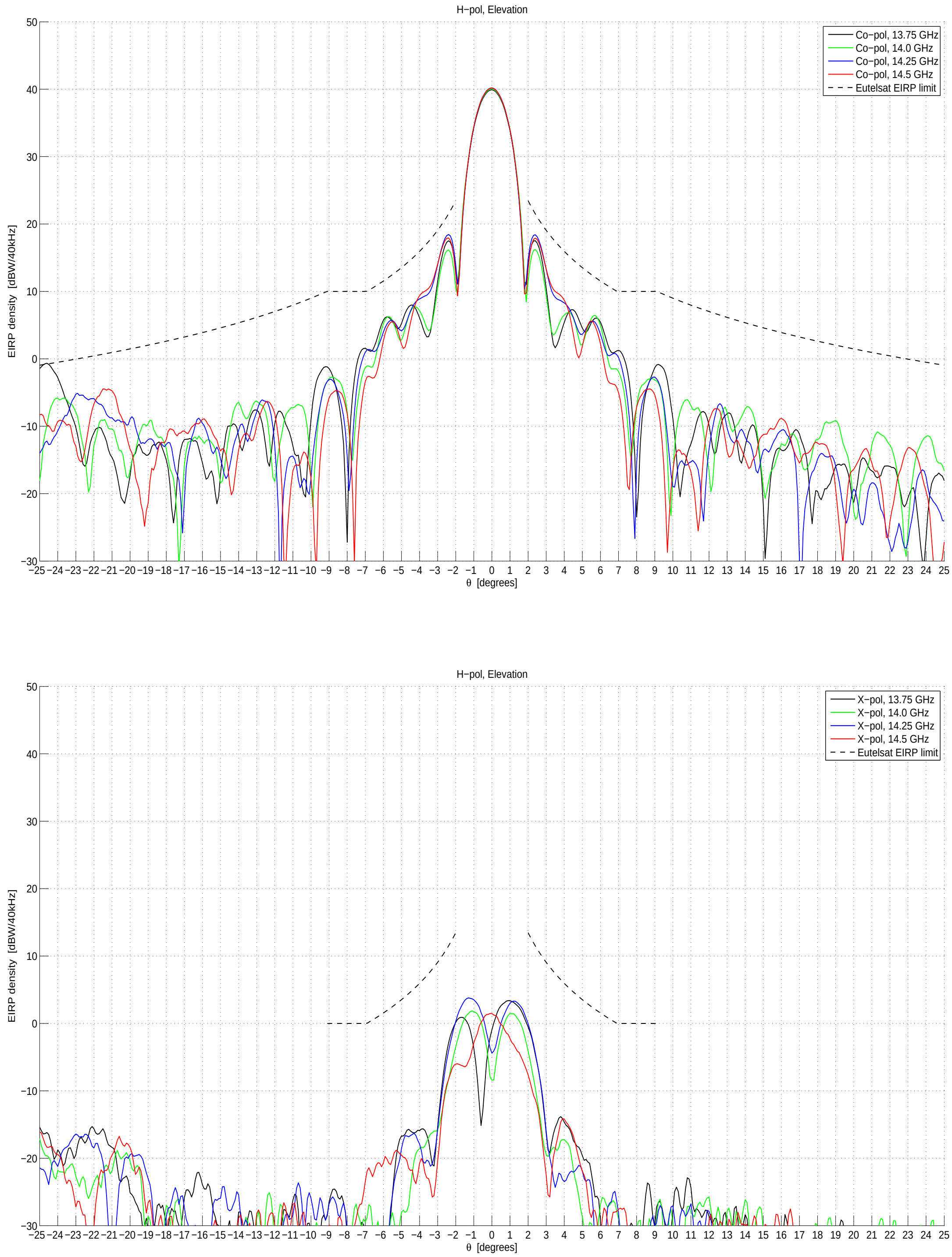
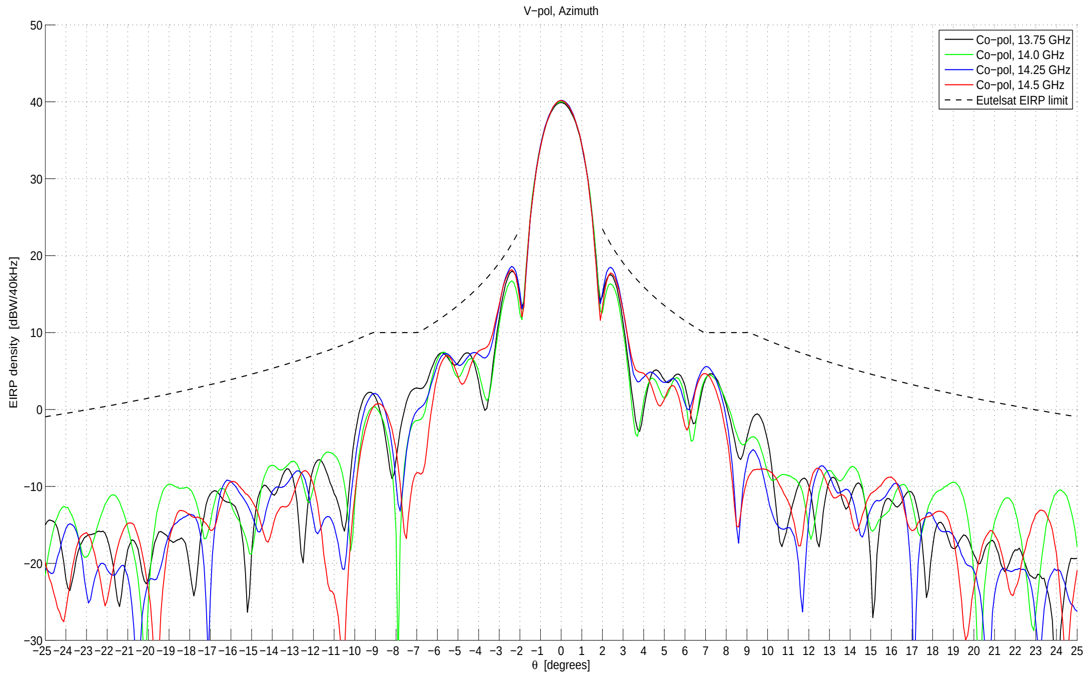


Figure 6: EIRP spectral density as function of θ for frequencies 13.75, 14.0, 14.25, and 14.5 GHz when the Sailor 900 ADU is transmitting 8W at 500 KHz and horizontal polarization, without radome, elevation cut. For reference the Eutelsat EIRP mask is also shown. Top: Co-pol. Bottom: X-pol.



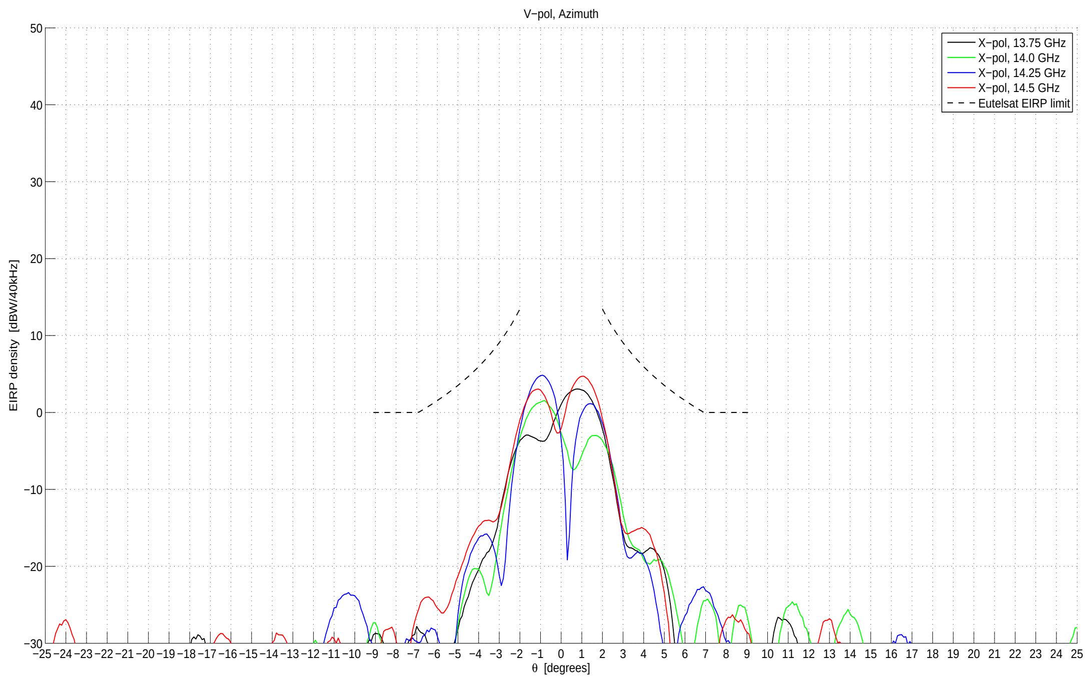
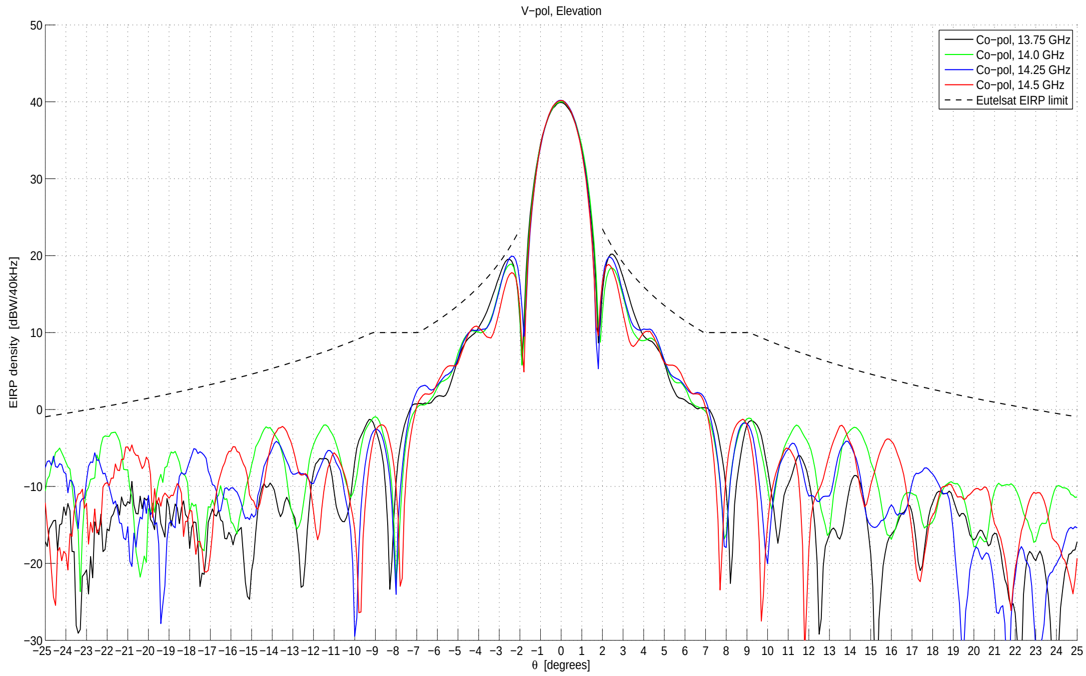


Figure 7: EIRP spectral density as function of θ for frequencies 13.75, 14.0, 14.25, and 14.5 GHz when the Sailor 900 ADU is transmitting 8W at 500 KHz and vertical polarization, without radome, azimuth cut. For reference the Eutelsat EIRP mask is also shown. Top: Co-pol. Bottom: X-pol.



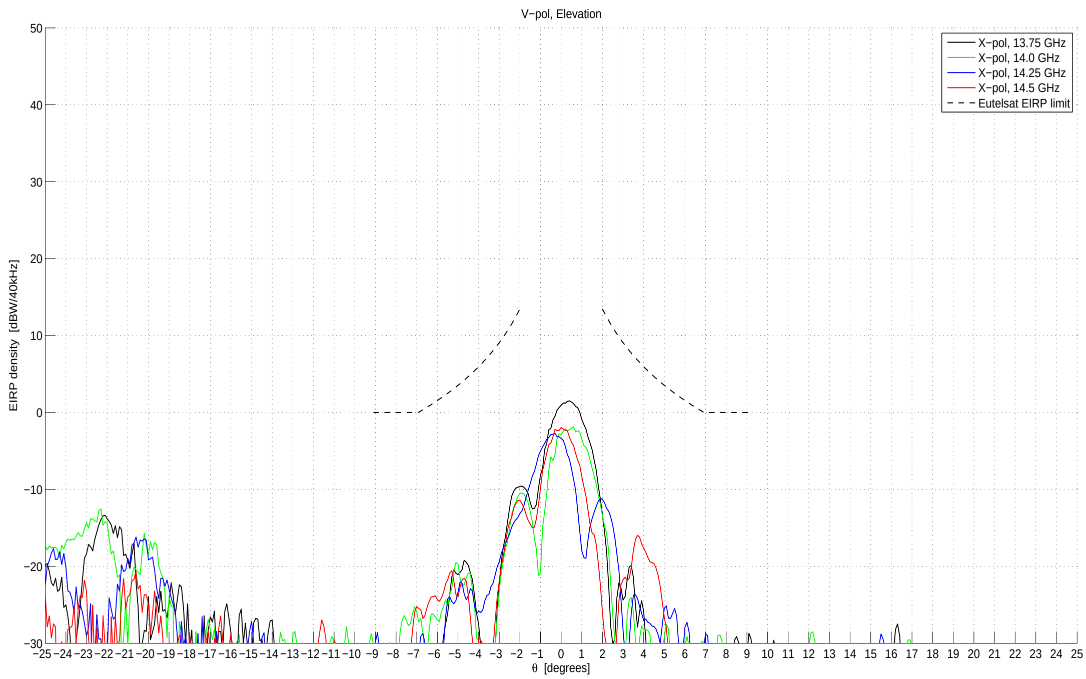


Figure 8: EIRP spectral density as function of θ for frequencies 13.75, 14.0, 14.25, and 14.5 GHz when the Sailor 900 ADU is transmitting 8W at 500 KHz and vertical polarization, without radome, elevation cut. For reference the Eutelsat EIRP mask is also shown. Top: Co-pol. Bottom: X-pol.

5 Photos of the Sailor 900 ADU

Photos of the Sailor 900 ADU are available in [1, Sec. 1].

6 System Diagram, Ensuring Off-Axis PSD Compliance, and HPA and Modem Types

6.1 System Diagram

Please see the system diagram [3]. The diagram shows the Sailor 900 inside the broken lines. Exterior to this are optional equipment.

6.2 BUC, LNB and Modem

The Sailor 900 ADU comes with a BUC from NexGenWave rated at 8W and an LNB from Philtech. The modem is not included in the Sailor 900. The Sailor 900 is compatible with a range of modems.

6.3 Ensuring Off-Axis PSD Compliance

With the assumption of a BUC with an applied power spectral density of -1.93dBW/40 kHz, as detailed in Section 2, and the measured gain (see Figure 1-4) it is apparent that the Sailor 900 never violates the Eutelsat EIRP density mask.

7 Tracking System and Compliance with Specifications

Please see the report on the Sailor 900 ADU tracking system and accuracy [4].

8 Documentation on Quality Control

Please see the attached Quality Certificate [5].

9 References

[1] Thrane & Thrane A/S, Doc. No. 99-134686, *TT-7009A Sailor 900, Above Deck Unit, Sailor 900 Gain Measurements*, October 2011.

[2] Eutelsat, *Earth Station Minimum Technical and Operational Requirements, Standard M, EESS 502, Issue 11 - Rev.0*, October 2007

[3] Thrane & Thrane A/S, Sailor 900 System Diagram, File: *TT92-134253A.pdf*, October 2011

[4] Thrane & Thrane A/S, Doc. No. 99-134756A *TT-7009A Sailor 900, Above Deck Unit, Pointing Error Test Report*, November 2011.

[5] Det Norske Veritas, Management System Certificate, No. 16342-2005-AQ-DEN-DANAK, File: *QA Certificate.pdf*, November 2010