Novel 11 m S-/X-/K-Band Remote Sensing Ground Station Antenna

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ABSTRACT

Modern geospatial techniques enable the provision of up-to-date imagery to the public through the media and internet. Improvements to earth monitoring satellites, such as SAR, and the very high resolution data received from these satellites, result in very large data files or a wide band pipe required for the transmission to the receiving earth stations. These large bandwidths cannot be provided by the regular allocated slot in X-Band. The only way to increase the bandwidth of the downlink is the exploitation of K-Band (25.5–27 GHz).

Vertex Antennentechnik (VA) has developed a triband full motion Antenna System with 11.5 meter diameter which incorporates S-, X- and K-Band. In conventional multiband Antennas, it is difficult to optimize Antenna parameters such as aperture efficiency and sidelobe performance in all three bands simultaneously. This paper discusses some advantages and design considerations and highlights the overall performance of a novel triband Antenna system for Remote Sensing (RS) applications which has been commissioned in 2016.

Key words: Reflector Antennas, Remote Sensing, Ground Station, S-/X-/K-Band, Monopulse tracking.

INCREASING BANDWIDTH REQUIREMENTS

Remote Sensing applications within the domain of natural hazards and disasters have become extremely important. In order to monitor actual weather or earth surface conditions in near real time, visual High Resolution images are required by national emergency services. This results in very large data files or wide band pipes for the transmission to the receiving earth stations. These large bandwidths cannot be provided by the regular allocated slot in X-Band (7.8 - 8.5 GHz) even when both polarization are exploited.

UTILIZATION OF K-BAND FOR RS

The remedy for this limited bandwidth is to utilize K-Band (25.5–27 GHz) which includes 2.5 GHz of continuous bandwidth in each polarization. This natural development is similar to the exploitation of Ka–Band in commercial satellite communication which started a decade ago.

For newly planned ground stations, the TM/TC chains will mostly remain in S-Band (Rx=2200-2300 / Tx=2025-2120MHz) whereas high speed data are down linked in X- or K–Band. In addition to the TM/TC transmit and receive chains in S-Band, the Antenna System requires autotrack, hence the feed system of the Antenna supports monopulse tracking in all three bands in order to precisely track the LEO or MEO spacecraft with an accuracy of a few tenths of a millidegrees. Simultaneous tracking in S and K-Band enables to utilize these large Antennas for acquisition aid support.

K-BAND READY

It is expected that in the near future operators of RS ground stations will require an upgrade from S-/X-Band to S-/K-Band or even S-/X-/K-Band.

In order enable to upgrade an existing S-/X-Band Antenna to S-/K- or S-/X-/K-Band, the mechanical properties of the Antenna are required to meet stringent requirements for mechanical stiffness, pointing error and reflector surface accuracy.

In addition, the Servo & Drive system should be able to support precise monopulse tracking as the tracking accuracy requirements for K-Band are much more stringent compared to X-Band.

VA delivers full motion Antennas which are suitable for K-Band operations, as various analyses are conducted

during the design phase such as wind,- temperature,- gravity changes, pointing and tracking accuracies. Internal design optimization routines and tools result in a very rigid mechanical structure which is required to comply with the K-Band requirements.

These Antennas are inherently “K-Band Ready”.

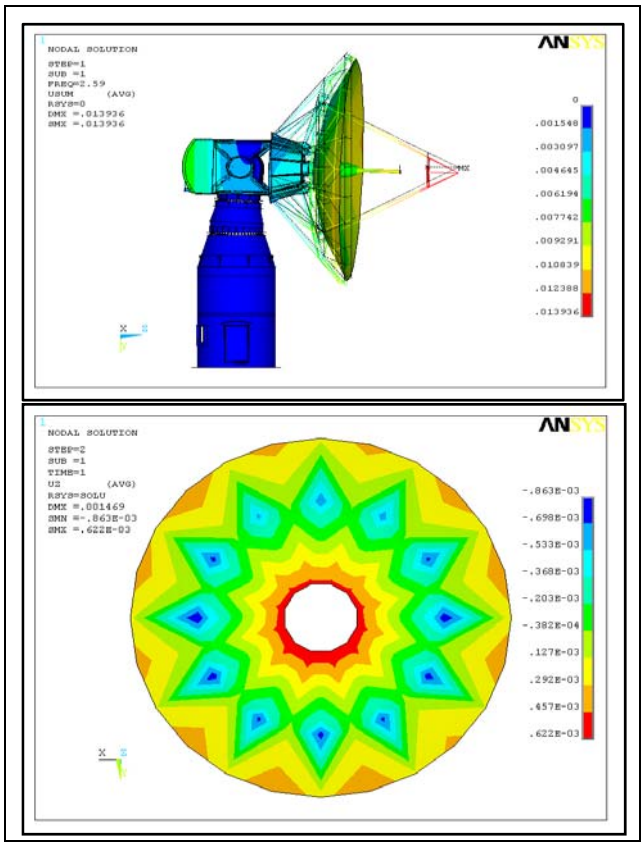

Figure 1. Examples of structural analyses

A VA Antenna initially equipped for S-/X-Band operation can be converted into S-/X-/K-Band by changing only the feed system and LNA`s; no further improvements or upgrades of the mechanics or Servo & Drive system or top the reflective surface are required.

FEED SYSTEM DESIGN

The feed system has a coaxial architecture. It comprises an optimized junction for S- and X-band with TE11-Mode (sum) / TEM-mode (difference) and a conventional K-Band waveguide network with a TE21 tracking coupler. The X-Band network has been integrated as waveguide solution. An integrated waveguide to coax transition in S-Band leads to a compact and highly integrated coaxial S-Band network solution.

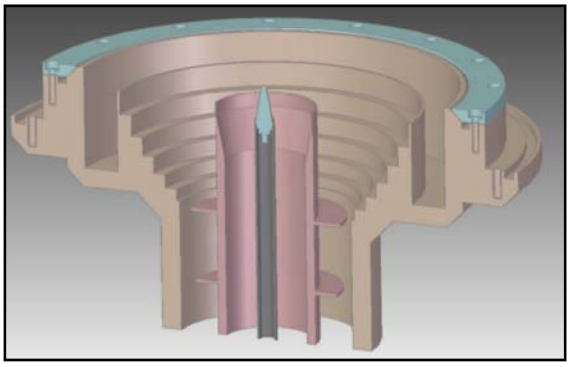

Figure 2. Coaxial S-/X-/K-Band Horn structure

The feed components such as the diplexers, OMT`s and monopulse couplers are housed inside the feed cone. The S-Band diplexers are folded in order to keep the physical length as small as possible. The feed system incorporates S-Band 2Tx/2Rx plus MP port; X-Band 2Rx plus MP port, K-Band 2Rx plus 2MP ports in total 12 ports.

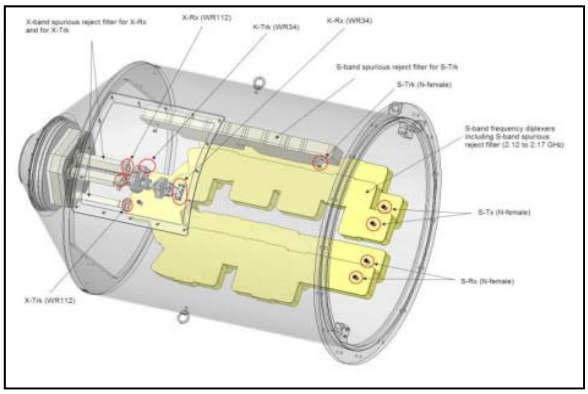

Figure 3. S/X/K-Band Feed System with 12 ports

Fig. 2 and 3 are shown with courtesy of Mirad microwave AG.

ANTENNA GEOMETRY

The geometry of the Antenna System utilizes a ring focus design which allows for a very compact arrangement of the radiating horn and subreflector. Another advantage of a ring focus design is that the Antenna can simultaneously achieve high efficiency values in all three bands.

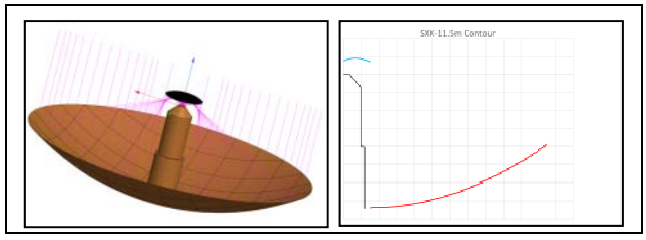

Figure 4. Ring focus geometry and shaping

MEASURED RF - PERFORMANCE

Due to the fact that the performance of the Antenna can be modeled and optimized in all three bands individually without compromising each other, the Antenna efficiency in all three bands is quite high. The measured results of the 11.5 meter tri-band Antenna System are depicted in the next table.

- RX Frequency	2.200	2.300			8.025	8.400	25.500	27.500	GHz
- TX Frequency			2.025	2.110					GHz
Antenna Gain at Feed output	45.8	46.1	45.2	45.2	57.7	58.0	66.5	67.1	dBi
Figure of Merit (G/T)	23.5	24.2			37.2	37.3	41.9	42.5	dB/K

Table 1. Measured RF values of 11.5 m S-/X-/K-Band Antenna System

The Receive patterns in X-Band for the sum and delta signals have been measured with a beacon of a geostationary satellite which was outside of the receive band hence the dynamic range of the measurement was poor.
All patterns in show excellent symmetry and the sidelobes are well below the 29-25log (theta) envelope. Some examples of pattern measurements are depicted here:

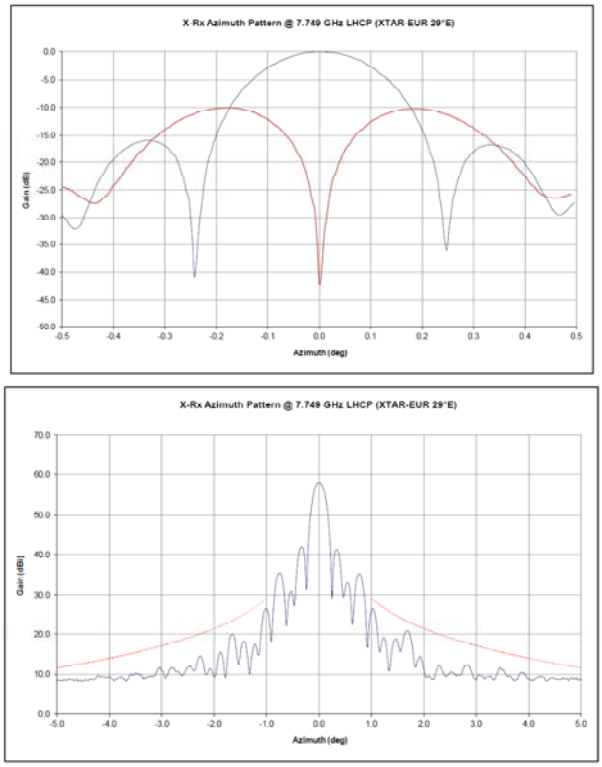

Figure 5. Some Antenna patterns

Figure 6. 11.5 m S-/X-/K-Band Antenna System installed and ready for operation