Introduction

L-band (1 - 2 GHz) microwave radiometry is an important remote sensing technique to monitor soil moisture over land surfaces at the global scale. The ESAL-Band SMOS radiometer mission aims at providing global maps of soil moisture, with accuracy better than 0.04 m$^3$ m$^{-2}$ every 3 days, with a spatial resolution better than 50 km.

To improve the used models and for verifying the accuracy of the aimed global soil moisture data product, ground based radiometer campaigns before launch, during the commissioning phase and during the operative SMOS mission are important. Furthermore, the availability of ground based L-band data simultaneously measured with the over flying SMOS satellite are required for calibration and validation purposes. To address these needs three ELBARA II radiometers are built by Gamma Remote Sensing (Gümligen, Switzerland) by order of ESTEC in the framework of the contract ESTEC 21013 / 07 / NL / FF “L-band Radiometer Systems to be deployed for SMOS Cal/ Val Purposes”.

The radiometer systems rely on the proven architecture of the ELBARA radiometer with improvements on the user interface, the mechanics, and the microwave electronics. The development of an Active Cold Load as cold reference power source is expected to improve the radiometric accuracy. Furthermore, the mitigation of Radio Frequency Interferences is improved by digitizing the signals after the detector and sampling with 800 Hz.

The ELBARA II systems will be operated by the successful applicants selected from the Announcement of opportunity for the use of an L-band radiometer from ESA SMOS Project. At the end of April 2009 the instruments will be supplied to the users, accompanied by a two-day workshop held at the Swiss Federal Institute WSL in Birmensdorf (Switzerland). This workshop allows the users to perform basic measurements with the ELBARA II system on a test site.

This poster presents the main characteristics of the ELBARA II system and presents examples of laboratory measurements performed on the electronics.

Mechanical Layout

The mechanical components of the ELBARA II system are shown in the figure below. The setup consists of:

i) The Picket horn antenna consisting of the antenna cone (dark yellow) and the antenna feed (red).
ii) The antenna holder (green).
iii) The tracker (yellow).
iv) The scaffold (blue).
v) The Peli-case containing the radiometer electronics (violet).

The antenna is highly directive with -3 dB beamwidth of 12° and provides H- and V-polarization and symmetrical and identical beams with small side lobes.

The base of the scaffold features several borings (for M16 screwing) allowing for most flexible deployment either on a tower platform or on the cantilever of a crane.

The present scaffold construction and the tracker allows for rotating the antenna from nadir to zenith direction corresponding to observation angles 35° ≤ α ≤ 315°. Observing two opposite field sites without rotating the instrument around its vertical axis is possible.

The construction weighs approximately 330 kg and can be mounted in any orientation (rectangular at a wall or even upside-down).
Design of the Electronics

The block diagram shown below is subdivided into the following subsystems: 1) microwave assembly (red), 2) power detector assembly (green), 3) calibration loads (orange), and 4) temperature control assembly.

Special attention has been directed to the block diagram and the mitigation and interception of possible RF Interference.

Mitigation: a) Highly directive antenna (8” at -3 dB).
   b) Narrow-band input band-pass (1413.5 MHz, 22 MHz).
   c) Frequency domain: two microwave channels (1407.5 MHz and 1419.5 MHz, 11 MHz bandwidth).
   d) Time domain: statistical analysis of the digitized signals after power detection.

Microwave Characteristics

Filters:
The figure below shows measured spectral responses of the four Band Pass (BP) filters along the microwave path:
   a) Input 4-section BP filter BPF-01. Bandwidth is 1413.5 MHz is 22 MHz at -3 dB. Insertion loss is 0.384 dB.
   b) Second BP filter BPF-01. Bandwidth is 22 MHz. Insertion loss is 0.627 dB.
   c) and d) The two 11 MHz BP filters BPF-3a and BPF-3b. Insertion losses at the center frequencies 1407.5 MHz and 1419.5 MHz are 0.798 dB and 0.731 dB, respectively.

Total transfer function:
The total measured transfer function of the low-frequency channel a) and of the high-frequency channel b) are shown below:

Antenna Match:
Return losses of the (sky looking) antenna feed measured for 1 - 2 GHz. The return losses measured for H- and V- polarization were clearly smaller than the specified -20 dB.

Controls

Two embedded computers are implemented, the Temperature and Power Controller (TPC) and the Instrument Computer (IC):
   1) The TPC monitors the power used by the radiometer, controls the Peltier heating and cooling element, and starts the IC.
   2) The IC controls the ELBARA II system, schedules the data acquisition, and permits the remote control.

Flash drive is used for data storage.
16-bit ADC PCI card is used for digitizing after the detectors with 600 Hz.
RS232 serial lines to control the servo drive of the elevation tracker.

The system can be controlled locally via a control panel or remotely via Ethernet.