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OLYMPUS BEACON RECEIVER

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A medium-size Beacon Receiving System for reception and processing of the B1 (20 GHz) and B2 (30 GHz) beacons from Olympus has been developed. Integration of B1 and B2 receiving equipments into one system using one antenna and a common computer for control and data processing provides the advantages of a compact configuration and synchronization of the two receiver chains. Range for co-polar signal attenuation measurement is about 30 dB for both beacons, increasing to 40 dB for B2 if the receivers are synchronized to B1. The accuracy is better than 0.5 dB. Cross-polarization discriminations of the order of 10 to 30 dB may be determined with an accuracy of 1 to 2 dB. A number of radiometers for complementary measurements of atmospheric attenuation from 13 to 30 GHz has also been constructed. A small multi-frequency system for operation around 22 GHz and 31 GHz is presently under development.

1. Introduction

For use in propagation experiments with signals transmitted from the upcoming ESA satellite Olympus, a dual-frequency Beacon Receiving System has been developed at ElektronikCentralen (EC), Denmark. It will receive and process the B1 (20 GHz) and B2 (30 GHz) satellite beacon signals.

The system is a self-contained equipment comprising an outdoor integrated antenna/receiver/detector part and a remotely placed computer. The compact configuration and rigid mechanical construction ensures safe transportation and easy installation. By tight temperature control of the receiver, stable and accurate operation is obtained even under extreme environmental conditions.

The computer and its dedicated software enables easy operation of the system and provides flexible data processing capabilities. Measured information on detected signals is displayed and printed out locally, and it may be transferred to a central computer for postprocessing, or to a data storage medium.

The system is primarily designed for measurement of B1 and B2 co-polar signal attenuation with large dynamic range and high accuracy. However, the crosspolarization discrimination of B1 - or rather the cross-polarization isolation - is also determined and reliable results for significant events are provided. The system can easily be expanded for measurement of the B2 cross-polar signal as well. Further, a high signal sampling rate makes the system well suited for investigation of scintillation phenomena.

Propagation experiments with beacons are usually complemented by parallel radiometer measurements. For this purpose, EC has developed a range of

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References

Barton, S.K., "Section 6.4 : Alternative Digital Receivers" in OPEX Handbook for Beacon Receiver Design, Issue 1, January 1985

radiometers for K_u-band and for 20 and 30 GHz. In the following sections the equipments are described.

2. Beacon Receiver

In the design of the Beacon Receiving System, it has been the objective to make a system which is compact, easy to install and operate, and suited for continuous, unattended operation - and which provides satisfactory measuring capability, e.g. dynamic range and accuracy, on the signals available.

Figure 1 shows the system configuration.

The antenna is comparatively small, 1.3 m diameter, so pointing will not be critical. The dual-frequency Cassegrain system has high efficiency and good polarization isolation properties, and it allows the receiver to be mounted on the back of the main reflector, close to the feed.

By imbedding the main reflector in a temperature controlled enclosure, the reflector may be heated and kept free from ice. At the same time the receiver and detector equipments which are mounted within the enclosure will be protected from exposure to extreme ambient temperatures. The internal temperature in the receiver and detector boxes is controlled to about $\pm 2^{\circ}\text{C}$ thereby eliminating the need for active gain drift determination by means of pilot signals.

The receiver comprises front end chains for the B1 and B2 signals. Each chain contains a low-noise preamplifier and provides double frequency conversion. The box containing the front ends is mounted directly on the feed assembly which can be rotated for precise polarization alignment.

The two front end chains are synchronized, the local oscillator signals being derived from a common reference oscillator. The local oscillator assembly has a performance similar to that of the satellite beacon generator as concerns frequency stability and phase noise. This means that the characteristics of the received beacon signals are not unduly degraded by the receiving system.

In the detector the received polarization-switched B1 signal is demodulated and co-polar and cross-polar signals detected. The VCO's of the B1 and B2 chains may be synchronized, either by locking to B1 or by locking to B2. This gives increased flexibility and extended dynamic range for B2 measurements.

Switching detectors produce I and Q components of the received signals. This will ensure maximum accuracy in the extraction of amplitude and phase information from the signals. I and Q components, as well as sensor and status signals are transmitted in digital form to a PC-type computer, which may be placed at a convenient indoor location.

The computer will provide efficient control and monitoring of the overall operation of the system and will give alarm in case of any malfunction.

It processes the data on received beacon signals and performs the transmission of the final results to a central computer or to a hard disk for storage. Local graphics display and printing of the results is made available.

The receiving system will have a G/T of 18 dB/K at 20 GHz and 20 dB/K at 30 GHz. In Europe this will ensure a dynamic range for attenuation measurements on co-polar signals of 29 dB for B1, and 31 dB for B2, if the two receivers are not synchronized. When B2 is synchronized to B1 its dynamic range is extended by about 10 dB. The accuracy is about 0.5 dB for maximum measurable attenuations, and 1-2 dB on the expected values of cross-polarization discrimination.

3. Radiometers

3.1 K_u-band Radiometer

The K_u-band radiometer is intended for operation at a single frequency in the band 13 to 18 GHz. It is a compact, self-supporting system with an outdoor integrated antenna/receiver part and a remotely placed controller/computer. Data processing facilities for calculation of results such as sky noise temperature and atmospheric attenuation are provided.

The basic configuration of the radiometer encompasses a 1 m Cassegrain antenna, a radiometer receiver of the noise injection type, and a PC. Figure 2 shows a block diagram of the radiometer.

The Cassegrain antenna provides minimum distance from feed horn to receiver which means small feed loss corrections. The feed horn is mechanically integrated in the receiver subsystem which is mounted on the main reflector. This arrangement permits easy replacement of receivers and change of polarization without need for recalibration. An insulated heated enclosure houses the receiver and all associated equipment. The main reflector forms one of the faces of the enclosure and may thus always be kept above freezing level. Warm air will be blown onto the feed horn window in order to keep it free from water and ice.

The noise injection type receiver yields a maximum of independence of gain variations and mismatches within the noise injection feedback loop thus ensuring a high long-term stability. The measurement accuracy depends mainly on the precise knowledge of the temperature of the internal reference load, which is easily controlled.

The receiver front end and detector is installed in a temperature regulated box. This box also contains a datalogger which registers the temperature of the key microwave components in the front end and feed assembly as well as antenna surface temperature. A variety of house-keeping data is also measured.

The detected noise power from the receiver and the temperature and house-keeping signals are digitized and transmitted to the computer which per-

forms the calculation of the sky noise temperature. In this calculation the effects of losses and reflections in the feed waveguide and horn are corrected for, as well as the ground noise pick-up through the antenna sidelobes. In an initial measurement and calibration, the antenna pattern has been determined and the power distribution table introduced in the computer software.

From the sky noise temperature the apparent atmospheric attenuation at the measuring frequency is found. By means of a scaling formula the attenuation at any frequency in the range 10 to 22 GHz may be calculated. On the computer's screen the found results are presented in graphical form, and a list of housekeeping data are displayed. Also, results from several months are stored in the computer.

The radiometer system has proved high measuring accuracy and stability. The absolute accuracy in sky noise temperature is better than 4 K at 30 deg. elevation. A high-performance cryogenic load is used in initial receiver calibrations and in recalibrations which are only required at 8 to 12 months intervals. More frequent calibration checks are performed by use of a computer-controlled tip-curve method.

3.2 20/30 GHz Radiometer

EC has previously supplied single-frequency radiometers for 20 and 30GHz at the same configuration as described above. Now a new 20/30 GHz radiometer system is under development. It is intended for a range of applications in satellite communication (signal attenuation correction), satellite ranging (path delay correction), and in scientific investigations of atmospheric properties (content of water and water vapor).

This dual frequency, or multi-frequency, system will measure sky noise temperature at one or several frequencies around 22 GHz and at one frequency around 31 GHz. High accuracy is a prime performance objective which imposes strict requirements on the antenna system. Sidelobes shall be extremely low in order to avoid ground noise pick-up, and equal beamwidth at 20 and 30 GHz are desired. An offset reflector antenna with optimum performance will be developed. A compact selfcontained equipment with an absolute accuracy better than 4 K and great operational flexibility is aimed at.

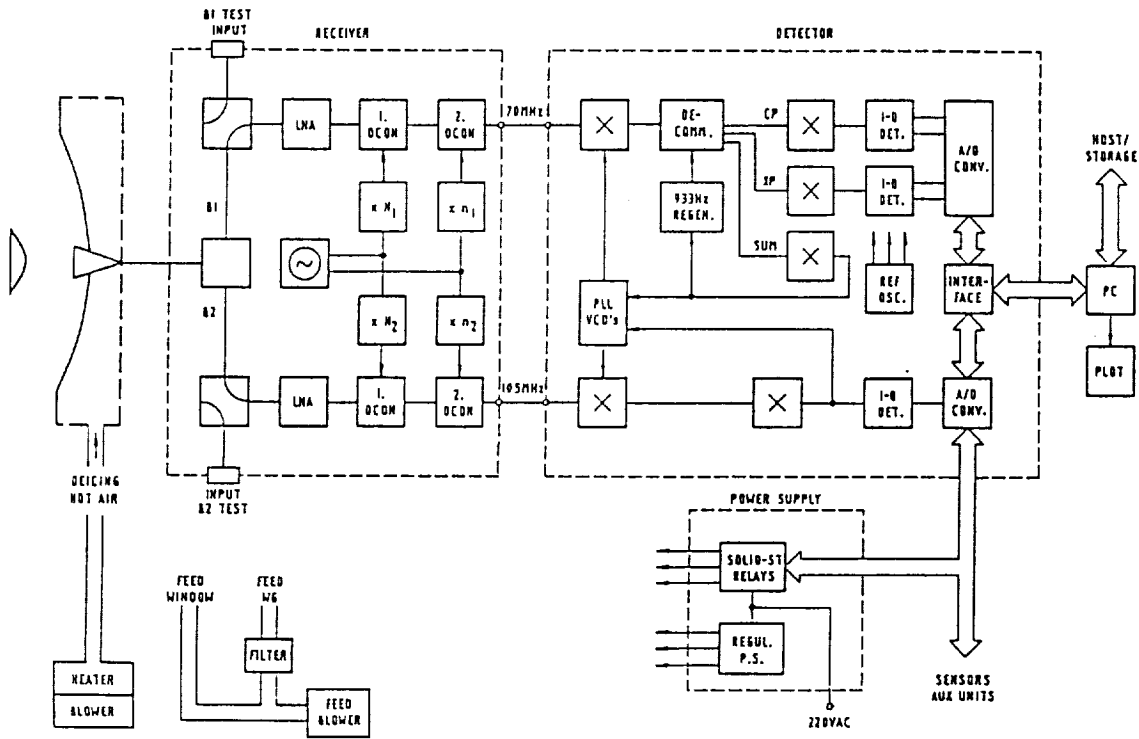


Figure 1 Simplified B1/B2 Receiving System, Simplified Block Diagram

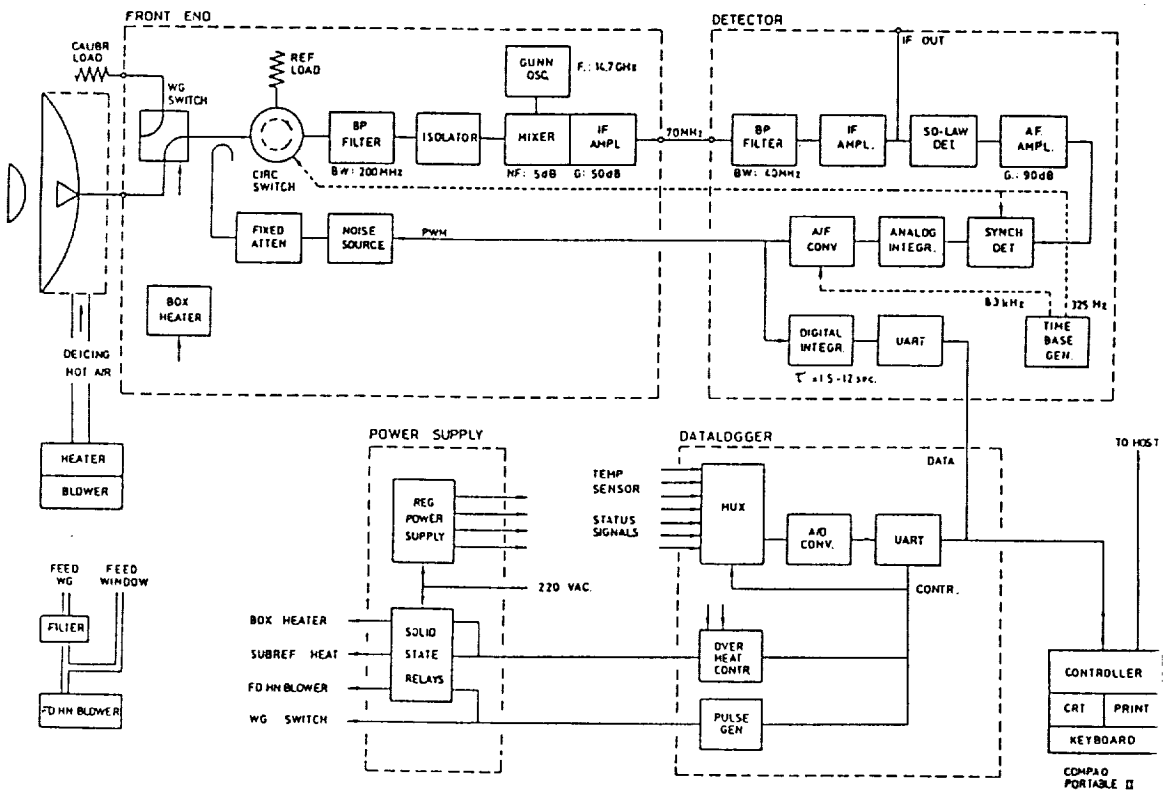


Figure 2 Ku-band Radiometer, Block Diagram.

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