Remote Controlled Satellite Ground Station

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***Abstract*-The fully remote controlled *AMSAT* Phase 3 satellites ground station was established at Institute of Radio Electronics, Brno University of Technology. Following text and figures illustrate hardware and software applied in this arrangement. The station provided daily hundreds of telemetry blocks to AMSAT archive. Also the Internet access to the AO-40 satellite is described.**

I. Introduction

A. Satellite Phase 3D

In November 2000 international organization AMSAT performed an experimental satellite Phase 3D. The satellite with a mass of 600 kg was launched by Ariane 5 rocket within geostationary transfer orbit (GTO) from space center ESA in Kourou, French Guyana. We participated on both the satellite integration in AMSAT facility Orlando (FL, USA) as well as during the launch campaign in Kourou.

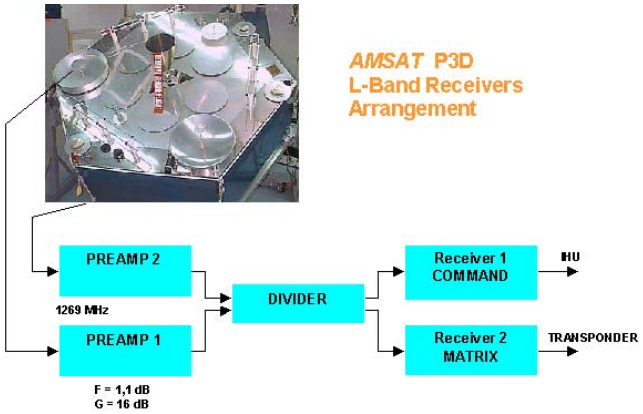

Figure 1. AMSAT Phase 3D satellite and L-band receivers arrangement.

Laboratories and individuals from a number of countries cooperated on this project under leadership of prof. Karl Meinzer from University of Marburg. The satellite carries equipment for several interesting experiments: matrix transponder, ability of spin and three-axis stabilization, momentum wheels with magnetic bearing, two color cameras, plasma engine, GPS (experiment NASA), laser for optical communication, etc. Two L-band receivers have been developed for this satellite in our laboratory. The first one is main command receiver and second one is a part of matrix transponder [1][2], fig. 1. At the end of January 2004 a defect of satellite power system happened, the command station is furthermore active and participates on the satellite recovery.

B. Satellite telemetry and command station

Development of basic equipment for the telemetry gathering and command station IREL BUT has been finalized at Brno University of Technology. The arrangement is suitable for the satellite on high elliptical (HEO) and low Earth (LEO) orbits. The goals were as follow:

- Telemetry data acquisition
- Fully remote control via Internet
- Command capability
- Long term telemetry data processing
- Analogue and digital communication
- Advanced hardware and software development

The equipment consists of antennae system for automatic satellite tracking, collection of receivers and transmitters, low noise amplifiers, down and up frequency converters, rf power amplifiers, modems and terminal node controllers. Frequency stability of microwave converters placed in outer environment is assured by GPS frequency standard. All these instruments are controlled by two servers where are running robust and complex software modules and a number of interfaces created in our laboratory.

II. Command Station Arrangement

A. Hardware and software

The remote control of the equipment is pursued by two HOST computers running on Microsoft Windows, fig. 2.

The first PC1 controls all the rotators and transceivers by standard interface. Satellite tracking is provided by TrakSat program written by Stacey Mills [3]. This program is extended by DDE coupling for our DDE client software. DDE client was developed especially for this application. The output of the receiver is processed by soundcard spectrum analyzer – AO40Rcv program by Moe Wheatley [4] and displayed on the screen in real time. This arrangement allows the accurate frequency setting of the receiver at the beginning of acquisition of signal (AOS) from the satellite. After this

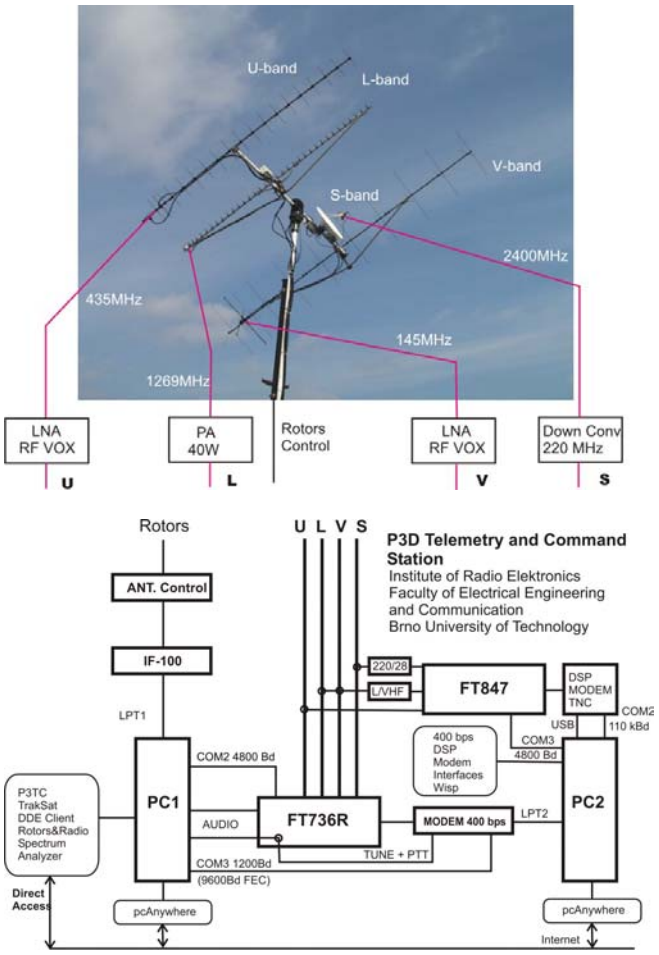

Figure 2. Telemetry and command station arrangement.

Figure 3. Main inner equipment of the telemetry and command station.

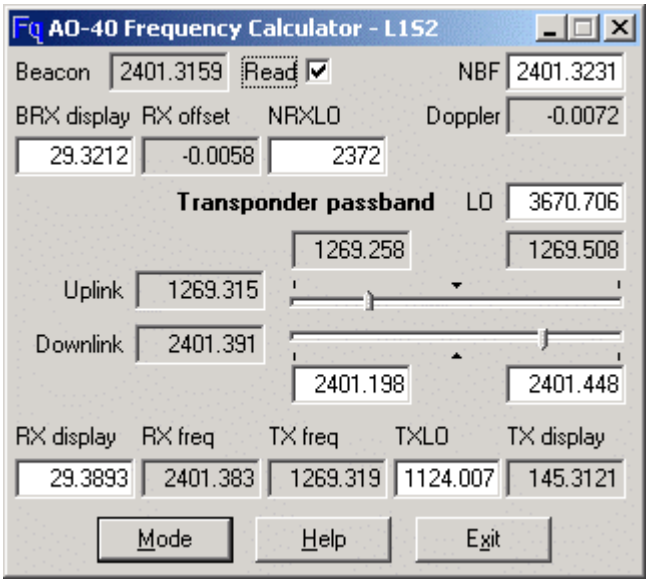

Figure 4. Frequency calculator.

procedure the CAT is switched off and transceiver is tuned automatically by MODEM. The simple calculator [5], is disposal for all frequencies calculation when the actual receiver frequency offset is found out at AOS and actual Doppler shift is sending by TrakSat via registers. The calculator screen is shown in the figure 4. On this computer is running also P3TC software (by Stacey Mills) for telemetry data acquisition and commands processing.

The second HOST computer PC2 controls 400 bps BPSK MODEM extended by interface to the parallel port (LPT) with suitable program for tuning bar, DATA, CLK and BLOCK LEDs indication as well as for the switches TUNE and PTT control.

The RF equipment allows operation in V,U, L, and S bands. The V and U bands can be used for both the uplink and downlink with LNAs and RF VOXs. The L band is arranged for uplink with PA that is shown in figure 5., and S band for downlink with down-converter. All these electronics unit are mast-mounted, figure 2. The transceiver FT736R contains also the 220 MHz module which is used for microwave down converters.

The communication equipment for other digital modes are under development. Transceiver FT847 is completed by down-converter (220/28 MHz) and up-converter (144/1269 MHz). The antenna relays box allows to choose actual rf mode. At present we are developing a new Terminal Node Controller with USB connection to the HOST as well as an advanced DSP modem.

B. Telemetry and command station operation

The both HOST computers are connected to the faculty Intranet network and next to the Internet. By means of pcAnywhere software are accessible really from any place

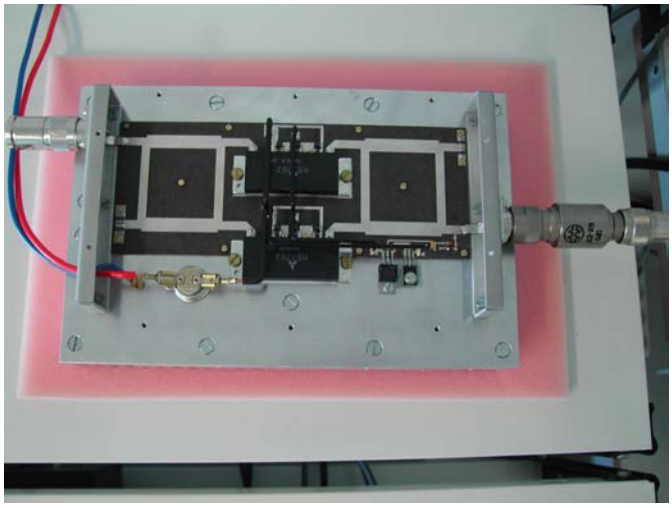

Figure 5. The home built L-band power amplifier.

where an Internet access is disposal. Of course, actual data rate of this connection influences a station remote control comfort. However, our experience shows that a standard phone line connection with data rate better than 33 kbps is useable even from a very distant location. The access via pcAnywhere allows general maintenance of the system. The ordinary access for real time telemetry gathering however is possible by TCP/IP console directly. If TCP/IP contact is established with an appropriate command station P3TC server, it is possible to control that server and uplink to the satellite. Of course, command mode is encrypted and permitted only for authorized command stations.

A number of student projects contribute to these activities in our laboratory. Special hardware as the LNAs, down-converters, filters and interfaces has been developed. Figure 5. illustrates the finalizing of the L-band 40 W power amplifier, for example.

We have developed also software utilities for P3D telemetry data processing. Figure 6. shows the program for very big number of A-blocks processing which allows a long term studies of the satellite behaviour.

III. Conclusion

The briefly described remote controlled telemetry and command station for experimental satellites shows how an advanced satellite workplace can be done today. Several these stations can perform simple and cheap worldwide satellite network. At present we are developing a new flight hardware for *AMSAT* Phase 3E satellite and all this 'know how' will be applied and cultivated soon again.

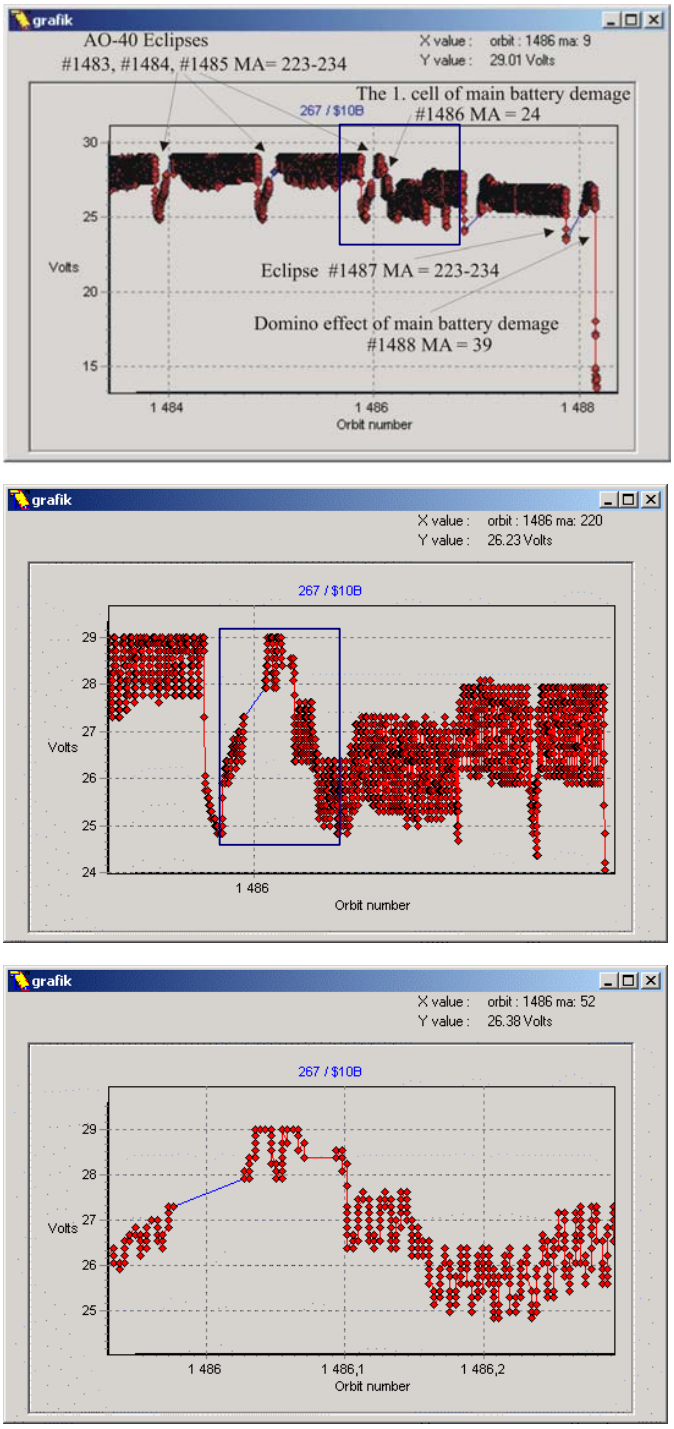

Figure 6. The program 'Grafik' allows a very big number of telemetry data processing and zooming. The telemetry of main baterry voltage at the incident is shown.

Acknowledgement

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