# The Communication Satellite Transponder Testing by EGSE System

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ABSTRACT

EGSE is used to check out satellite payload during the development prior to launch. The EGSE represented in this paper is a test system for Ka band communication transponder of COMS. The EGSE consist of two subsystems as CTS subsystem and PCTS subsystem. Communication Test subsystem (CTS) performs satellite transponder RF performance testing, data analysis and trending. Most of transponder RF performances are automatically tested by the CTS subsystem. Power, Command & Telemetry subsystem (PCTS) monitor telemetry messages from the transponder and send tele-commands to satellite transponder for the configuration change. PCTS also provide simulated S/C power to the transponder during the ground validation testing. The EGSE test functions are verified by the transponder simulator testing and will be used for the flight model transponders testing.

**Key Words** : EGSE, COMS, CTS, PCT

## I. Introduction

Communication, Ocean, and Meteorological Satellite (COMS) is a hybrid satellite will be launched on the middle of 2009. In the meantime, many of Korean research institutes and industries are participated in COMS program. The communication payloads in COMS spacecraft are developed by ETRI with Korean industries. The Ka band payload have RF switch matrix for beam switching and multi-beam antennas. The transponder performances are validated on ground by special testing system called Electrical Ground Support Equipment (EGSE). The EGSE for communication payload can configure transponder configuration and also performs RF performance testing of the transponder.

In this paper test concept and test configure-tion for Ka band multi-beam communication payload are described, and also EGSE configurations and test methods are described.

## 2. Communication Payload Overview

The Ka band communication payload provides 100MHz wide four channels for fixed satellite service. Three channels for on-board switching for multi-beam connection and one channel for bent pipe connection.

The uplink is frequency band is 30GHz and the downlink frequency band is 20GHz each. The multi-beam switching is performed at 3.4GHz band. Channel allocation and frequency plan of Ka band communication payload are shown in Figure-1. Figure-2 shows the functional block diagram of the Ka-band payload.

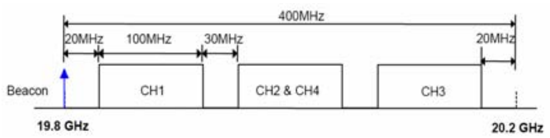

Figure-1. Ka band payload frequency plan

## 3. EGSE Overview

The main task of EGSE is to check out satellite systems, at system or subsystem level, during integration and validation phases of their life-cycle. Through a combination of hardware and software elements, EGSE supports manual, semi-automatic and fully automated testing. Automation is achieved by offering users simple, yet powerful means to write their own test application programs (test sequences) in high-level, test-oriented language and to run them in a strict real-time environment. The core of this environment is a user-configurable real-time database, containing all the information needed to calibrate acquired

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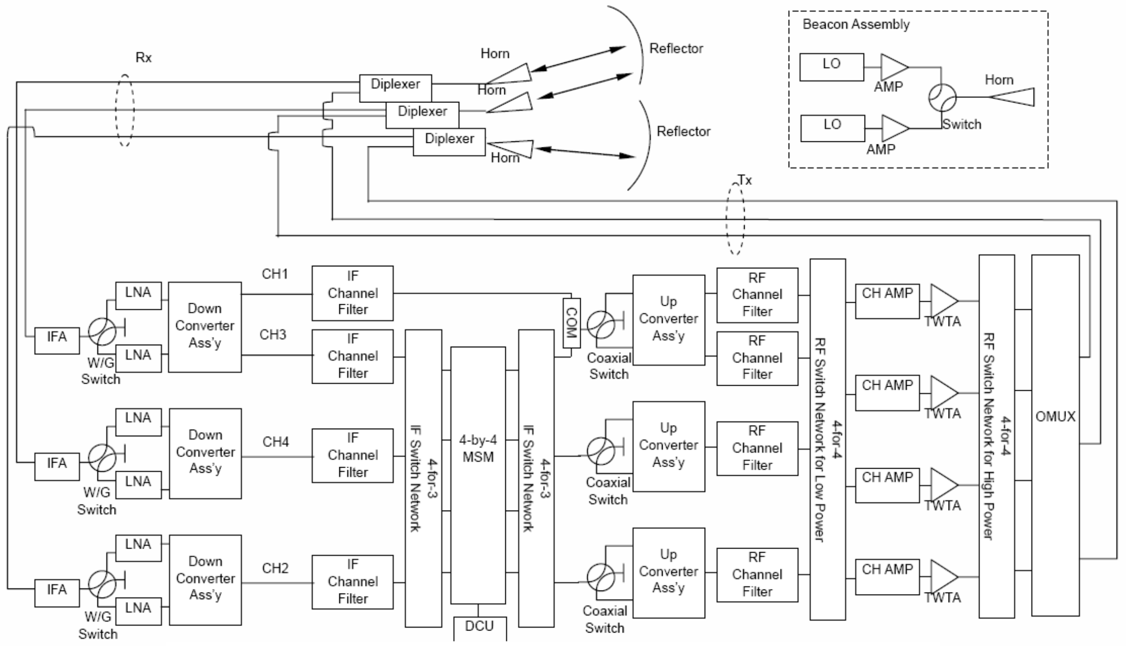


Figure-2 Functional block diagram of Ka band Communication payload

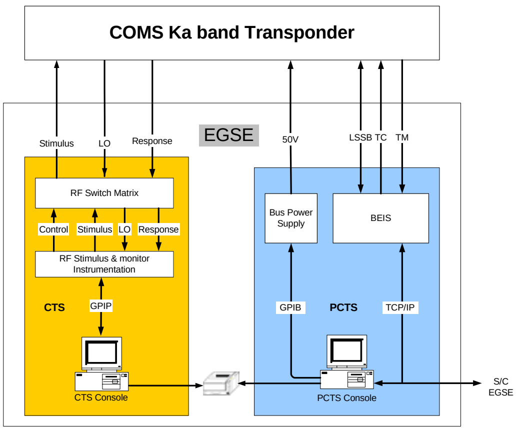


Figure-3 EGSE Configurations

data, check them against predefined thresholds, and automatically react to out-of-range conditions, displays data using animated graphics or synoptic windows, and so on.

Figure-3 shows the EGSE connections for Ka band communication transponder testing. EGSE comprises two parts, namely CTS[1] and PCTS[2]. CTS perform the function for accurate automatic testing of transponder RF performance. RF stimulus & monitor instrumentation module of CTS consists of signal generator and signal measurement device, which generates various signals required for transponder performance measurement, and analyzes the transponder output signals.

RF switch matrix routes and transfers the signal to the transponder generated from RF stimulus & monitor instrumentation suitable to each measurement item for automatic performance measurement, and simultaneously perform the function for routing the output signal to the measurement instrumentation. Transponder performance measurement can be executed accurately as well as fast by using this RF switch matrix. CTS controller has built-in program required for measurement, and appropriately sets the parameters for various instruments according to each measurement, and provides the function for automatic measurement by controlling the various switch operations of switch matrix. CTS controller stores the measurement results in the DB, and compares the results with the specification, and also printout the results.

PCTS controls the parameters of various transponder equipments as well as performs the

1. CTS: Communication Test system
2. PCTS: Power Command & Telemetry System

function for monitoring each equipment operation status. BEIS receives transponder control command generated from the PCTS controller, and transfers it to the transponder after transforming to the suitable command format. BEIS also receives the operation status as telemetry, and transfers this message to the PCTS controller by transforming to TCP/IP format. PCTS controller also provides operator GUI environment, and interfaces with BEIS for command generation and monitoring of transponder. PCTS also supplies DC power required for the operation of transponder equipments CTS controller and PCTS controller are connected by TCP/IP, for sharing various information required for test, control and monitor of transponder. The PCTS controller also has TCP/IP interface with spacecraft EGSE for the transponders testing on spacecraft level.

CTS H/W comprises three parts: RF stimulus & monitor instrumentation, CTS controller, and RF switch matrix. RF stimulus & monitor instrumentation consists of CW generator, Sweep generator, Spectrum analyzer, Vector network analyzer, Power meter, Attenuator & switch driver and Data acquisition unit. These equipments GPIB interfaced with CTS controller, and operation parameters of the equipments are controlled as well as monitored by the CTS controller.

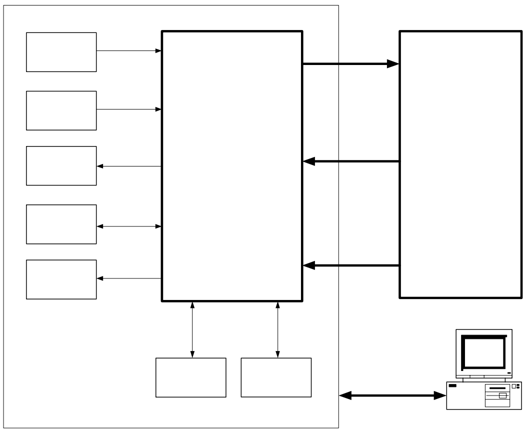

Figure-4 CTS subsystem diagrams

CTS controller configured with PC of windows98 environment. CTS controller has a built-in test sequence program for transponder performance testing, and provides functions for collecting and storing transponder measurement results, and printing out the results of comparisons with specifications. CTS controller interfaces with PCTS controller through the hub, and shares the data each other.

The RF switch matrix module located in the EGSE, will serve as a central interface between the measurement and stimulus equipment and the UUT (Unit Under Testing). All microwave connections to the UUT will be made through this switch matrix at all the test modes. The RF switch matrix will contain the necessary circuitry for switching and routing the UUT stimulus and response signal to and from the appropriate measurement instrumentations. It will also provide external auxiliary ports, where appropriate, for injection or monitoring of special signals. Figure-4 shows the CTS configuration.

## 4. Test by EGSE

Before start satellite transponder testing, EGSE verification was need to be performed with transponder simulator for the EGSE functional verification. After EGSE verification with simulator testing, EGSE will performs satellite transponder RF performance testing. The parameters of the satellite transponder RF performance testing by EGSE are as following,

- Input, output VSWR
- Noise figure
- Transfer response
- Saturation output power
- Phase shift
- AM/PM conversion coefficient
- Channel amplifier gain control functions
- LO frequency stability
- In band frequency response & group delay
- Out of band frequency response
- Inter-modulation characteristics
- Spurious output

Figure-5 shows the test result of frequency response and group delay of transponder simulator by the EGSE. The detailed test methods of EGSE are as follows;

### 4.1 transfer response

The center of each channel will be power swept using the VNA from small signal at~20dB nominal back off to 3dB nominal overdrive. When the channel amplifier is operated in linear mode, transponder maximum power is defined as the point in the knee where maximum output power is achieved. After the response is swept, the uplink signal will be 30% AM modulated with a 1 KHz sine wave. With the Spectrum Analyzer set up to measure the Am Modulated Carrier, The downlink signal will be connected to the spectrum analyzer and the uplink drive will be adjusted to achieve a null on the SA. The input power to determine this null will be the input level to achieve saturation. Measurement results will be graphed with markers indicating the saturation point and the SFD required producing saturation.

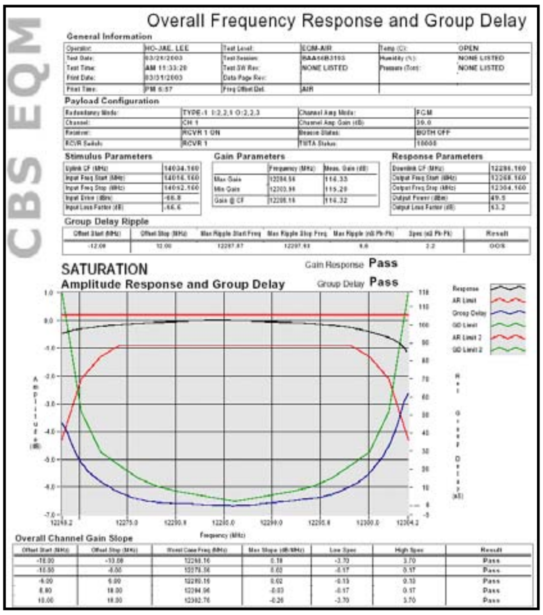


Figure-5 Test result of frequency response and group delay by EGSE

4.2 Phase shift, AM/PM conversion

The downlink signal is evaluated for excess PM created by the non-linearity of the system. The input drive is set to the AM Null Input drive with the AM turned ON. The uplink is switched to the spectrum analyzer, and the AM Input into the system is measured in a spectral analysis. An average of the upper side band and the lower side band is used to achieve the best results. The side band measured in dBc is then converted to AM in dB. The Downlink is then switched to the spectrum analyzer, and the output PM is measured in a spectral analysis. Because the transponder is at the AM Null point, the contributing AM is removed as a contributing spectral component. Again, and average of the upper side band and the lower side band is used to achieve the best results. The side band measured in dBc is then converted to PM in Degrees using the standard equation the PM(Deg)/AM(dB). The results are tabulated and annotated.

4.3 Frequency response & group delay

The uplink signal from the VNA can be sampled at Sensor 2A and adjusted using the calibration data so that the payload will receive the desired input signal level. The input drive will be maintained at the input power for saturation (at channel center) as measured during transfer response. This leveling technique will prevent the TWTA from being pulled out of saturation if substantial loss fluctuations over frequency are present in the uplink circuit. Port 2 will measure the output power of the payload. About 1,202 measurements will be performed to characterize each channel across frequency by alternately sampling uplink power then downlink power and incrementing the frequency.

4.4. Inter modulation

Two tone inter-modulation distortion measurements will be input carrier balanced. Each carrier will be adjusted independently for the required ISL. Third order products will be measured and plotted across the input signal range. The carrier separation is 20MHz, 10MHz on either side of the channel frequency. The integrated carrier power is referenced to the saturation point determined during transfer response. IMD will be measured at the following input back-off values: -3dB, -10dB, -17dB. IMD will be calculated the worst case method the ratio of the highest third order product to the lowest carier.

4.5 Spurious output

The specifications for spurious response will be specified in terms of dBc in a 4KHz BW. The search will be performed with the spectrum analyzer set to a resolution BW that satisfies both of the two conditions first, RBW<4kHz second, The analyzer noise floor is >6dB below the search specifications. The noise bandwidth for each point in the trace will be assumed to be identical to the spectrum analyzer RBW. Each point in the trace will then be normalized to a 4kHz bandwidth and compared to the specification.

## 5. Conclusion

The EGSE described on above, is a self contained semi-mobile test station for the COMS communication transponder testing. It has capability of performing several different tasks. First, EGSE can perform automated RF performance testing for the COMS communication transponder. It also has capability of monitor status and control commands for the transponder configure. The EGSE will be used for the COMS communication transponder verification on ground before satellite launch.

## Reference


[1] Nicklaussen, D., "The `Abrixas' EGSE Architecture and EGSE Software Development Approach," ESA report to the ... COSPAR meeting, Vol. 409, 1997, pp. 37-42.
[2] Kaufeler, J.-F., "ESA Committee for Operation & EGSE Standardization: Its Contribution to ECSS," ESA report to the ... COSPAR meeting, Vol.394, No.3, 1996, pp. 1153-1160.
[3] Jones, M. Melton, B. Bandecchi, M., "TEAMSAT's Low-Cost EGSE and Mission Control Systems," ESA bulletin. Bulletin ASE, No 95, 1998, pp. 152-157.
[4] Chiroli, P. Martinelli, E., "ECHO: A "Core EGSE SW" Running on Windows-NT," ESA report to the COSPAR meeting, Vol. 457, 2000, pp. 439-446.
[5] La Rosa, G. Gianotti, F. Fazio, G. Segreto, A. Stephen, J. Trifoglio, M., "The EGSE Science Software of the IBIS Instrument On-Board INTEGRAL Satellite," AIP conference proceedings, No. 510, 2000, pp. 693-697.
[6] Tri T. Ha, Digital Communication System, 2nd ed., New York: McGraw-Hill, 1990.
[7] T. Pratt and C. W. Bostian, Satellite Communications. New York: Wiley, 1986.


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