Telemetry, Tracking, Command and Monitoring on Ground Station Parameters for Satellites

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Abstract: The main function of the ground station is to provide telemetry, tracking and command support to all ongoing and new satellites, and also provide mission support to the Launch missions namely, IRS and INTERPLANETARY MISSIONS. In order to qualify as a ground station , characteristics of the station in terms of its performance specifications and every system in the station is to be tested at regular interval of time to know the performance of the station. The ground station acts as an interface between the satellite and satellite controllers by providing the services and functions namely telemetry, tracking and command collectively called as TTC operations. In order to carry out the above functions effectively, ground station needs to be evaluated for its performance of critical parameters. The main objective of this paper is to perform thorough tests on the various systems that constitute the ground station, such as the Antenna system, Receiver system, Servo control system, Ranging & Doppler system and Timing systems. The results produced in these tests are used to indicate the credibility of the ground station to support satellites such as IRS and Interplanetary Missions.

Index Terms: GS-Ground Station, RAC-Remote Access Control, Telemetry, Tracking.

I. INTRODUCTION:

1.1 TTC &M SYSTEM:

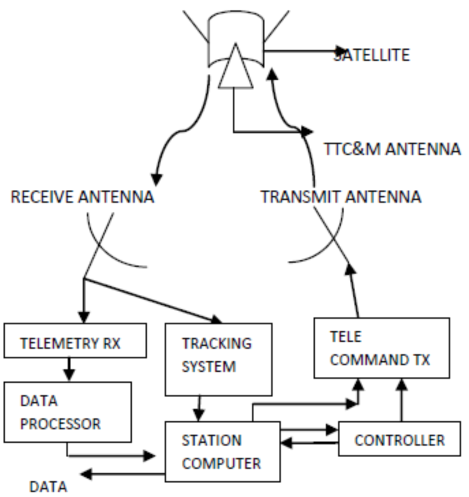


Fig 1.1 Block diagram of a typical TTC&M system

1.2 TELEMETRY & MONITORING SYSTEM:

The monitoring system collects data from many sensors within the satellite and sends these data to the controlling station. There may be several hundred sensors located on the satellite to monitor pressure in the fuel tanks, voltage and current in the power conditioning unit, current ran by each subsystem, and critical voltages and currents in the electronics communication. The temperature most of the subsystems is important and must be kept within predetermined limits; so many temperature sensors are fitted. The sensor data, the status of the each subsystem, and the positions of switches in the communication system are reported to the earth by the telemetry system. Telemetry data are usually digitized and transmitted as phase shift keying(PSK)of a low power telemetry carrier using time division techniques .A low data rate is normally used to allow the receiver at the earth station to have a narrow bandwidth and thus maintain a high carrier to noise ration. The entire TDM frame may contain thousands of bits of data and takes several seconds to transmit. At the controlling earth station, computer can be used to monitor, store and decode the telemetry data so that the status of any system or sensor on the satellite can be determined immediately by the controller onthe earth. Alarms can also be sounded if any vital parameter goes outside allowable limits.

1.3 TRACKING:

A number of techniques can be used to determine the current orbit of the satellite. Velocity and acceleration sensors on the satellite can be used to establish the change in orbit from the last known position, by integration of the data. The earth station controlling the satellite can observe the Doppler shift of the telemetry carrier or beacon transmitter carrier to determine the rate at which the range is changing. If a sufficient number of earth stations with an adequate separation are observing the satellite, its position can be established by triangulations from the earth station by simultaneous range measurements. With pressure equipment at the earth station, the position of the satellite is within 10m.

1.4 COMMAND:

A typical system of the type will originate commands at the control terminal of the computer. The control code is converted into a command code, which is sent back in a TDM frame to the satellite. After checking for validity in the satellite the word is sent back to the control station via the telemetry link where it is checked again in the computer. If it is found to have been received correctly, an execute instruction will be sent to the satellite so that the command is executed. The entire process may take 5 or 10 sec but minimizes the risk of erroneous command causing a satellite malfunction. During the launch and injection into geostationary orbit, the main TTC&M may be inoperable because the satellite doesn't have the correct attitude or has extended its solar sails. A backup system is used at this time, which controls only the most important sections of satellite.

II. ANTENNA:

The ground station has two S-band disc shaped parabolic antennas (east and west chain) each of10M diameter. Since there are two antennas, two spacecrafts can be independently tracked simultaneously. It can be revolved around 360deg in horizontal plane (azimuth angle) and about 90deg in vertical plane (elevation angle).

Fig 2. Cassegrain-antenna and its parts

2.1 SUBREFLECTORS:

Sub-reflector is an asymmetrically shaped cassegrain reflector that is a metal coated Carbon and honey comb design. It is 3.5m in diameter. It creates focusing points into the center of feed horns located in the feed cone. As sub-reflector moves in rotation this focusing point travels around the top of feed cone in circle. The sub-reflectors can also travel up or down in order to focus the signal into receiver located at base of feed horn.

2.2 FEEDHORN:

It is a device that collects the signal at the focus of the satellite dish and channels them to the LNA. It is used to convey radio waves between the transreceivers.

2.3 ADVANTAGES OF CASSEGRAIN-ANTENNA:

1. Low noise temperature.
2. Pointing accuracy.
3. Flexibility in feed design.
4. Greater mechanical stability (permits very accurate pointing of high gain, narrow beam antennas).

III. GROUND STATION:

Ground station is a network place, which acts as an interface between spacecrafts and operator (user). It establishes communication links with the satellites.

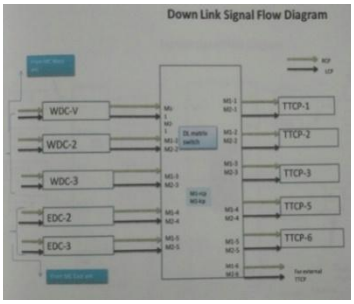


Fig 3(a) Down-link flow diagram

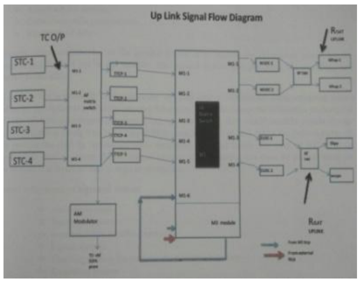


Fig 3(b) Up-link flow diagram

3.1 FUNCTIONS OF GS:

1. Receive satellite telemetry data
2. To collect data, format and transmit to mission computer for further analysis.
3. Control spacecraft by commanding.
4. Auto track the satellite.
5. Recording data.

IV. OBJECTIVE:

The main objective of the paper is to do the performance evaluation of the ground station parameters for the missions. One of the main objectives of the mission is to develop the technologies required for design, planning, management and operations. The ground station parameters are designed keeping in mind the requirements of the satellite. The requirements of satellite vary as per the objectives of the satellite. The evaluation of each component in the ground station is a very crucial process so as to maintain optimal level in the performance of each of the components. Performance measurements of the components are done to ensure that the measured performance values are within the tolerable variance range. Throughout the mission timeline the actual performance is tracked and compared to the values which are deemed acceptable at the projects outset. These comparisons are done to take corrective or preventive action whenever required to prevent failure or delays in the mission timelines. The performance measurements can be conducted by performing several tests on the system.

V. METHODOLOGY:

The following tabulation is based on the survey of ground station specification parameters of 10M antenna:

1	Band of frequencies	
	Downlink	2200-2300 MHz
	Uplink	2025-2120 MHz
2	No. of carriers	2
3	Type of antenna-main antenna	Main chain-cassegrain
		Geometry-10M diameters Acquisition chain-cluster of 4 horns
		Simultaneous Transmitting and Receiving
4	PSK modulation	
	Fixed frequency demodulation	25.6/32 KHz PSK sub, 128KHz PSK sub
	Tunable PSK demodulation	4000 bps
5	Bit synchronizer	10 bit to 2 megabits synchronization capacity
6	Timing	GPS based tuning
	Time accuracy	150ns
	Frequency stability	1*10-12 per day
7	Data recording	
	PC(STC) based AGC and error recording	6 channels

Parameters to be measured:

1. Automatic Gain Control (AGC)
2. Bit Error Rate (BER)

5.1 AUTOMATIC GAIN CONTROL (AGC):

AGC adjusts the gain of the IF and sometimes RF stages in 4response to the strength of the receives signal, providing more gain for week signals, it allows receiver to cope with very large variation in signal levels, the range may be more than 100dB for communication receiver.

Need for AGC:

The AGC is a very important part of the receiver since it must take the received signal and level out the variations. It does this by automatically adjusting the gain of the RF stage as needed to maintain the desired output level. AGC can be derived from AM diode detector by using additional low pass filter with longer time constant (about 1sec) the result in dc voltage varies with carrier amplitude and is used to adjust the bias on transistors in IF and sometimes RF amplifiers.

The various reasons for usage of AGC are:

1. To control phase locked loop bandwidth.
2. To avoid overload.
3. To provide an indicator of the signal level.
4. To aid in the providing as reliable indicator of the lock.

Test Description: AGC Calibration

Test equipment: HP Signal Generator E4421B

AGC Time Constant: 10ms

At 220MHz frequency,

S. No.	LEVEL(dBm)	AGC(volts)
1	-30	1.97
2	-20	0.94
3	-10	-0.09
4	0	-1.14
5	+10	-2.13

Table: AGC tabulation

5.2 BIT ERROR RATE (BER):

The figure of merit for a digital radio link is its bit error rate. BER plays the same role as important as an indicator of quality in a digital communication system that the signal to noise ratio plays in an analog link.BER is the percentage of bits that have errors relative to the total number of bits that have been transmitted or received in a given timeperiod. Bit error rate is the rate at which errors occur in a transmission system.

BER= number of errors / total number of bits transmitted.

BER is an indication of how often a packet or other data has to be retransmitted because of an error. Too high BER may indicate that shower data rate would actually improve overall transmission time for a given amount of transmitted data since the BER might be reduced by lowering the number of packets that has to be rest. BER can also be defined interns of the probability of error (POE).

$POE=1/2(1-erf)\sqrt{Eb/No}$

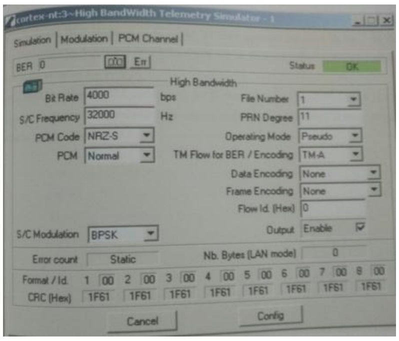
Where, erf=error function

Eb= energy in one bit

No=noise power spectral density.

Cortex TTCP settings:

1. Click on the simulator icon.
2. Following screen will get open. Set the parameters as shown in the screen.



3. Ensure that the IF receiver, Telemetry units are configured as required.

4. The required screens for this as shown in section 6, part D (TTCP operations) of operation manual.

5. Select “Flow for BER encoding” as TM-A for HK data & TM-B for PB data. Select operating mode as “Pseudo”.

6. Now enable the simulator o/p. Ensure that the “TMS” (Modulating Signal part) is enabled in IF modulator.

7. Connect TTCP output to UPC and set the correct frequency required for simulation (2245.68MHz)

8. Also set required down link frequency in the down converter used in simulation chain. Now make the simulation ON for the station.

9. Observe the TTCP Rx, PSK and Bit sync lock for TM-A/TM-B.9. Go to the simulation screen and observe the BER readings. If all errors are zero, decrease the LNA i/p by 1dB and record the errors. Decrease the LNA i/p till we get some errors in the range of 1x 10^-6.

10. Initially calculate the BER individually for IF channel-A (RCP) and Channel-B (LCP). Then enable the combiner. The combiner improvement can be directly observed in terms of increase in Eb/No in TM-A / TM-B page.

5. 2. 1. ALGORITHM:

This algorithm calculates the Bit error rate measurement.

BER calculation:

Step 1: Start

Step 2: Read values of mi, ml, br, T

Step 3: Calculate the Noise Temperature, N

N= 10log (k*T*10^-23) dBm

Step 4: Substitute N in Signal Power formula,

S= [10log (br) +12 + ml + N]

Step 5: Calculate BER

BR=S/N

Step 6: Print the BER value calculated

Step 7: Stop

VI. ADVANTAGES:

1. Simultaneous Transmitting and Receiving of signals.
2. Good sensitivity to detect in a given bandwidth.
3. Exclusive coverage to unreachable destinations (like island, sea, desert, ice covered areas).
4. Independent of environmental effects.
5. More reliable.
6. Wide area coverage.
7. Wireless communication.
8. Uniform installation characteristics.
9. Community service.
10. Mobile ground station is possible.
11. Point to multi-point communication.

VII. APPLICATIONS:

1. Mobile services.
2. General and commercial usage.
3. Military purpose.
4. Experimental purpose.
5. Weather conditions.
6. Automobile usage.
7. Agricultural land survey.
8. Natural resource survey.
9. Forestry and Ecology.
10. Oceanography.
11. Observe prominent landmarks, countries of World etc.,
12. Broadcasting of T.V.

VIII. RESULT AND EXPERIMENTAL ANALYSIS:

8.1 AGC:

It is the automatic gain control. It is the plot between time and power. It helps us to determine the satellite anomalies.

8.2 BER:

The figure of merit for a digital radio link is its Bit Error Rate (BER).

Measured BER for 4000 bps: **9.57*10^-6.**

IX. CONCLUSION:

“Known is a drop, unknown is an ocean”. True to the old saying, the area of satellite communication has spread its wings over a wide range of applications and our paper is an attempt to learn a few measurements involved in the

Ground Station. The project paved a useful tool in understanding some important parameters that decides the performance of the ground station. Practical viewing of the measurements and the plots obtained there in were instrumental in successfully completing the paper.

The measurements AGC and BER were recorded to verify the performance of theground station and these values are compared with station specifications.

REFERENCES:

[1] Jack K. Kreng, Michelle M. Ardeshiri, Oscar C.Barbosa, and Yogi Y. KrikorianT&C "Link Considerations for a LEO Sat123" .

[2] Alisha, Ritambara Pandey "TTC&M system in Geostationary satellite" by, IJEE Journal, vol no.6, issue no.02, July-December 2014.

[3] Dennis Roddy, "Satellite Communications" , 3rd edition, McGraw-Hill, 2001.

[4] Nimit Hongyim and Somak Mitatha, "Building Automatic Antenna Tracking System for LEO Satellite Communications",IEEE Journal 2015.

[5] J.N.Pelton, "Satellite Communication, Springer Briefs in space development", D0110.1007/978-1-2614-5-2,2012.

[6] Timothy Pratt, Charles Bostian, and Jeremy Allnutt, John Wiley, "Satellite Communications", 2003.

[7] Bruce Elbert, "Introduction to Satellite Communications", 2nd edition, Artech House, 1999.

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