170 Triband (S, X, Ka) Antenna dual circularly polarized Monopulse feed for LEO satellite Auto tracking and Data reception.

170.1 Introduction

High-resolution satellite data containing more volume of information is need of the hour, but at the same time it causes a huge surge in satellite data rate. This calls for transmission and reception of huge data in a short period of satellite pass, increasing the data rate by many folds. To transmit/ receive such high-speed data, large bandwidth antennas with single/dual/multi-band operation is the fundamental requirement. To avoid spectral crowding in X-band, transmission at Ka-band is solution to enable high-resolution high data rate transmission. So, we have S/X/Ka Tri-band feed is indigenously designed and developed in-house to cater multiband data reception from single antenna system.

170.2 Salient Features:

Novel features of proposed system:

1. Frequency bands supported- – S, X and Ka band simultaneous RHCP and LHCP.
2. Monopulse Auto tracking Capability: – S band - RHCP & LHCP
    a. X band - RHCP & LHCP
    b. Ka band - RHCP & LHCP (switchable in feed)
3. G/T achieved: – S band: 17.0 dB/deg K
    a. X band: 31.5 dB/deg K
    b. Ka band: 34.5 dB/deg K
4. Multiband composite feed in a single cassegrain plane.
5. Ka band TE21 Monopulse auto tracking for LEO satellites.

170.3 Description:

The S/X/Ka Tri-band feed is indigenously designed and developed in-house. This tri-band feed configuration comprises of multimode Ka-band dielectric rod, 2×2 square array of dielectric rods for X and S-band. The developed and realized tri-band feed is very compact, cost effective and gives state of art performance in terms of optimum illumination of sub-reflector with symmetric low cross-polarized

radiation pattern. The designed feed is fabricated, assembled, tested at CATF and integrated in 7.5m cassegrain antenna system at IMGEOS, NRSC, Shadnagar. This will be useful in receiving data in all the three bands from remote sensing LEO satellites. Multimode Monopulse for Ka-band and Multi-element Monopulse in X & S-band is a novel approach to achieve a highly efficient multiband composite feed. Tri Band antenna system will be advantageous in receiving data from Remote Sensing Satellites in S, X and Ka bands satellites single antenna system. Multi-element Monopulse in S-band and X-band is achieved with square array of optimally designed dielectric rods.

170.4 Major components of the feed:

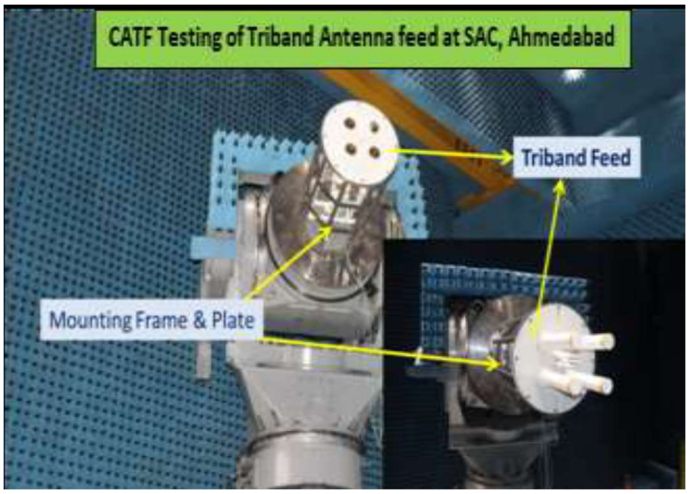
The proposed Integrated Triband feed design configuration is consisting of

1. multimode dielectric rod as Ka band feed element,
2. Ka-band TE21 mode coupler;
3. Ka-band tracking network;
4. 2x2 dielectric rod array for X band;
5. X-band MPC special waveguide;
6. X-band phase matched Auto Track network;
7. 2x2 dielectric rod array for S-band
8. S-band phase matched Auto Track network and
9. required RF uplink/downlink subsystems.

Fabricated S/X/Ka Triband Feed

Fabricated Ka band Components

Triband Feed installed in 7.5m Antenna



Testing of fabricated S/X/Ka Triband Feed at CATF Facility

171 S, X Dual band Antenna Feed for LEO satellite Auto tracking and payload data reception.

171.1 Introduction

Modern remote sensing satellites transmit information in different frequency bands. Therefore, the ground station antenna should be compatible enough to support multiple frequency bands using a single aperture antenna. So, Design and realization of a dual band, dual polarized composite Monopulse tracking feed, covering S-band (2.0-2.3 GHz) and X-band (7.8-8.5 GHz) is successfully accomplished by NRSC.

171.2 Salient Features:

Frequency bands: S and X simultaneous.

1. Monopulse Auto tracking Capability:
   a. S band - RHCP & LHCP
   b. X band - RHCP & LHCP
2. Data Reception Capability:
   a. S band and X-band: Simultaneous RHCP & LHCP
3. G/T achieved:
   a. S band: 17.0 dB/deg K @ 5 deg EL
   b. X band: 32.0 dB/deg K @ 5 deg EL

171.3 Description

X-band feed is a five element Monopulse feed, comprising a corrugated horn acting as the main or Sum element surrounded by four circular septum polarizers serving as tracking elements. S-band feed is a four element Monopulse feed consisting of square dielectric array arranged in 2 X 2 configurations. S/X composite feed is systematically designed, fabricated and experimentally characterized in LAB facility with network analyzer and at CATF for Radiation characteristics. The designed composite feed is fully operational in S/X Band Antenna at NRSC, IMGEOS. The specifications of G/T with 32.0 dB/K in X-band and 17 dB/K in S-band are achieved in Antenna System. The proposed feed is highly efficient, compact, simple and cost-effective. The realized Antenna Feed is perfectly suitable for ground station reflector antenna, meeting the stringent specifications for Auto Track and data reception.

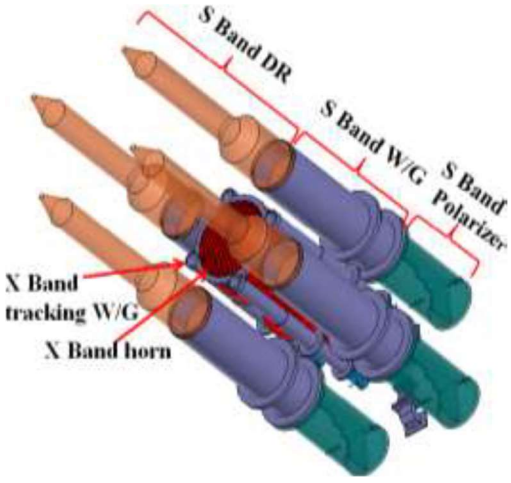
171.4 Antenna Feed Specifications:

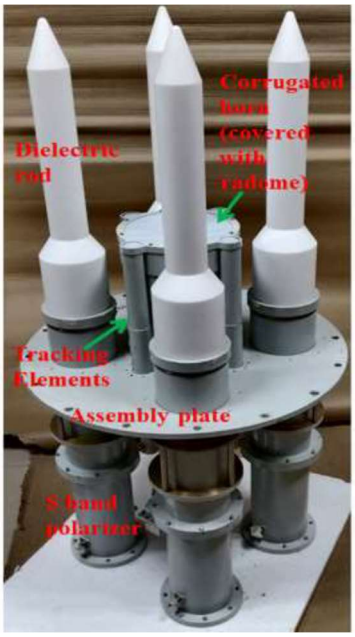
1.	Frequency Range (X Band)	: 7.8 to 8.5 GHz
2.	Frequency Range (S Band)	: 2.2 to 2.3 GHz
3.	Primary Feed Gain	: 21 dBi
4.	Polarization	: RHCP&LHCP
5.	Auto Track Capability	: RHCP/LHCP
6.	Axial Ratio (X Band)	:<1.0 dB
7.	Axial Ration (S Band)	:< 1.5 dB
8.	X band G/T	: 32.0 dB / deg K at 5 deg EL
9.	S band G/T	: 17.0 dB / deg K at 5 deg EL

171.5 Major components of the feed:

The proposed S-X band tracking feed consists of

1. X-band corrugated horn,
2. X-band tracking elements;
3. X-band Auto Track network;
4. S-band 2x2 dielectric rod array;
5. S-band phase matched tracking network
6. RF uplink/downlink systems





Designed model and Fabricated model of S/X Dual band Feed

172 Two/Tri-axis Antenna Control Servo System(ACSS)

172.1 Introduction:

This note describes the preliminary details of the Antenna Control Servo System for the S/X/Ka band Remote Sensing Data Reception System at National Remote Sensing Centre (NRSC), Indian Space Research Organization (ISRO).

NRSC has designed and developed Two axis/ Tri-axis antenna control servo systems for remote sensing data reception from IRS series of satellites. The Data Reception System is for providing payload data reception support for ISRO"s current & next generation remote sensing satellites for various applications. The satellites transmit data to ground in S/X/Ka bands. S&ASG (Servo & Automation Systems Group) has taken up the responsibility for in-house design and development of Antenna Control Servo Systems (ACSS) for ground stations based on their requirements. The Antenna Control Servo System will control the antenna position in AZ and EL axis with tracking accuracies of the order of 30mdeg. The antenna system is mounted on a three-axis tracking mount (elevation over azimuth over train) to point the antenna over full hemispherical coverage without any key hole. The tilt axis is programmable and will be utilized during a pre-pass activity. ACSS will support PTS mode &auto track mode using single channel mono-pulse technique with S/X/Ka band tracking. This report covers the configuration of the Antenna control servo system, architecture and details of main electronic modules such as controllers, motor drives and other subsystems, functions and interfaces with other systems.

172.2 Experience in developing and delivering digital Servo control Systems

Servo & Automation Systems group has the following experiences in developing in-house ACSS and delivered the systems, which are currently in operations as detailed below:

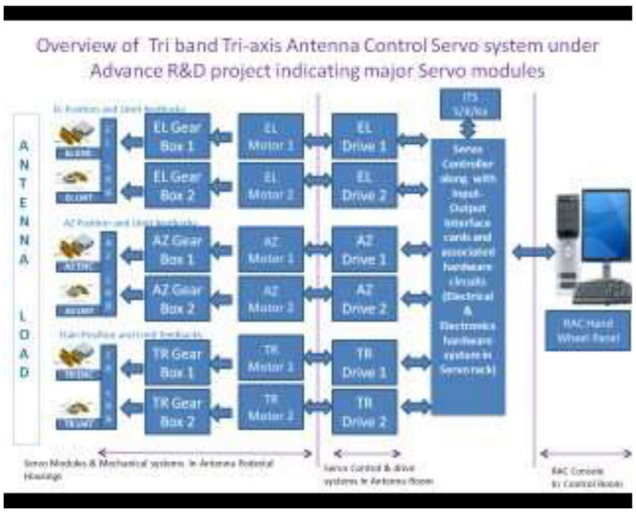
1. First, In-house digital ACSS is developed in 2018 –deployed @AS5 antenna, IMGEOS and regularly tracking non-IRS missions in auto track mode and it is currently in operation.
2. Second, In-house Design and Development of ACSS for INCOIS, S/X band Ground station, which was established in 2022 for OS3 data reception and currently in operation.
3. Tri-axis antenna servo system at IMGEOS Development & Commissioning done in July 2022 for S/ X band tracking and data reception. Which is later upgraded to Tri band (S/X/Ka) under Advance R&D in 2023 for S/X/Ka band tracking and data reception from C03. It is currently in operation.

172.3 Our Capabilities

a. Design, Modelling, Simulation and Analysis of Two axis and Tri axis Antenna Control Servo Systems for Satellite Ground stations

b. Design formulation, Servo algorithm, firmware, hardware, software development, System Fabrication, Implementation, Integration, Testing, Tuning, Optimisation and Commissioning of Two axis and Tri axis ACSS systems for Ground stations

One of the ACSS developed and operationalized in the IMGEOS antenna terminal is exhibited in below figure.



Block diagram of the ACSS along with tri-axis antenna

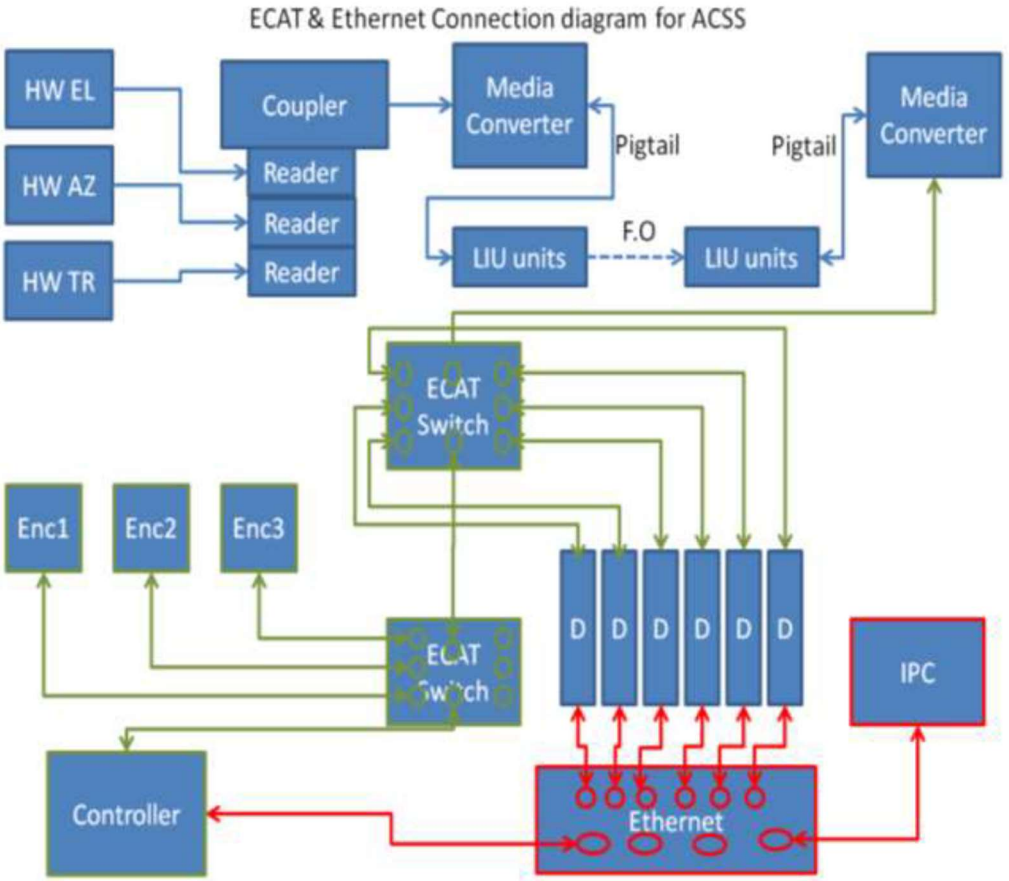
172.4 Salient features:

Tri axis Antenna control system was realized to meet the ka-band tracking accuracy requirements of 25 milli deg. – Use of On-axis encoder in Elevation axis to avoid data pick-off errors from SRB.

1. 7° Programmable tilt, axis and its control system.
2. Implementation of adaptive control in Power PMAC.
3. Optimum tilt axis orientation algorithm.
4. Antenna Control application software.
5. All axes with dual motor and dual drive control system to minimize back-lash.
6. Safety features/ limits in both software and hardware domains.

172.5 ACSS Interface diagram

The ACSS interface diagram in below figure shows how the different sub systems of ACSS are interconnected



ACSS interface diagram

172.6 Overall technical specifications of Tri-axis ACSS:

SL NO	Parameter	Description
1	Mount	Three axis, fully steerable EL over AZ over Train
2	Train axis tilt	70 Maximum programmable
3	Servo operating modes	Standby, Ready, Manual, Slew and Designate
4	Servo tracking modes	Program, S-Auto, XR-Auto, XL-Auto, Ka auto, Auto sequence
5	Type of Motor	Brushless AC servo motor with resolver feedback
6	Drive configuration	Dual drive in Counter-torque arrangement
7	Position Resolution	0.0010
8	Encoder Transducer	22 bit with SSI interface and hardware zeroing facility
9	Antenna Coverage limits	AZ ± 360₀; EL -5₀ to+185₀; Train ± 180₀
10	Position loop bandwidth	1.0 Hz typical
11	Maximum Velocity	15₀/sec in AZ, 6₀/sec in EL, 6₀/sec in Train.
12	Maximum Acceleration	6₀/sec² in AZ, 3₀/sec² in EL, 3₀/sec² in Train.
13	Tracking accuracy	X band: 0.030₀ Ka band :0.025 deg
14	Pointing accuracy	0.050
15	Operating wind velocity	60 KMPH

172.7 Tracking accuracies of the system as achieved detailed in below table:

Date	Mission/ Orbit	Max EL of pass	AZ RMS (deg)	*EL RMS (deg)*	BRE (deg)	Remarks
09.08.2023	C03_20513	25.00	0.007	*0.010*	0.012	Ka-band tracking is good
30.08.2023	C03_20831	36.72	0.004	*0.005*	0.006	Ka -band tracking is good
31.08.2023	C03_20846	20.15	0.004	*0.007*	0.008	Ka -band tracking is good
01.09.2023	C03_20862	21.09	0.005	*0.007*	0.009	Ka -band tracking is good
08.09.2023	C03_20968	58.00	0.007	*0.006*	0.009	Ka -band tracking is good
13.09.2023	C03_21051	18.26	0.003	*0.005*	0.006	Ka -band tracking is good
14.09.2023	C03_21059	78.14	0.010	*0.006*	0.012	Ka -band tracking is good
15.09.2023	C03_21082	74.49	0.007	*0.010*	0.012	Ka -band tracking is good
15.09.2023	C03_21074	54.81	0.005	*0.006*	0.008	Ka -band tracking is good
26.09.2023	C03_21241	54.02	0.004	*0.006*	0.007	Ka- band tracking is good
06.10.2023	C03_21393	81.6	0.008	*0.012*	0.012	Ka -band tracking is good
03.11.2023	C03_21818	64.33	0.005	*0.007*	0.008	Ka -band tracking is good
04.11.2023	C03_21833	36.49	0.005	*0.010*	0.011	Ka -band tracking is good
05.11.2023	C03_21848	23.31	0.004	*0.009*	0.010	Ka -band tracking is good
05.11.2023	C03_21849	22.45	0.006	*0.010*	0.012	Ka -band tracking is good
06.11.2023	C03_21864	34.41	0.005	*0.007*	0.008	Ka -band tracking is good

Conclusion: The achieved Ka-band tracking accuracy is 15mdeg.

Note: ACSS can be designed and fabricated for two axis/ Tri-axis antenna control systems based on requirements.