

## **Technology Transfer -Two/Tri-axis Antenna Control Servo System(ACSS)**

### **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.

### **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:

- (a) 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.
- (b) 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.
- (c) 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.

### **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 Fig.1 as a sample.

Tri-axis Antenna Control Servo System (ACSS) block diagram as depicted in Fig.1:



Fig.1 Block diagram of the ACSS along with tri-axis antenna

**4. Salient features:**

- Tri axis Antenna control system was realized to meet the ka-band tracking accuracy requirements of 25 milli deg.

It was achieved through:

- Use of On-axis encoder in Elevation axis to avoid data pick-off errors from SRB.
- 7° Programmable tilt, axis and its control system.
- Implementation of adaptive control in Power PMAC.
- Optimum tilt axis orientation algorithm.
- Antenna Control application software.
- All axes with dual motor and dual drive control system to minimize back-lash.
- Safety features/ limits in both software and hardware domains.

## 5. ACSS Interface diagram

The ACSS interface diagram in Fig.2 shows how the different sub systems of ACSS are interconnected

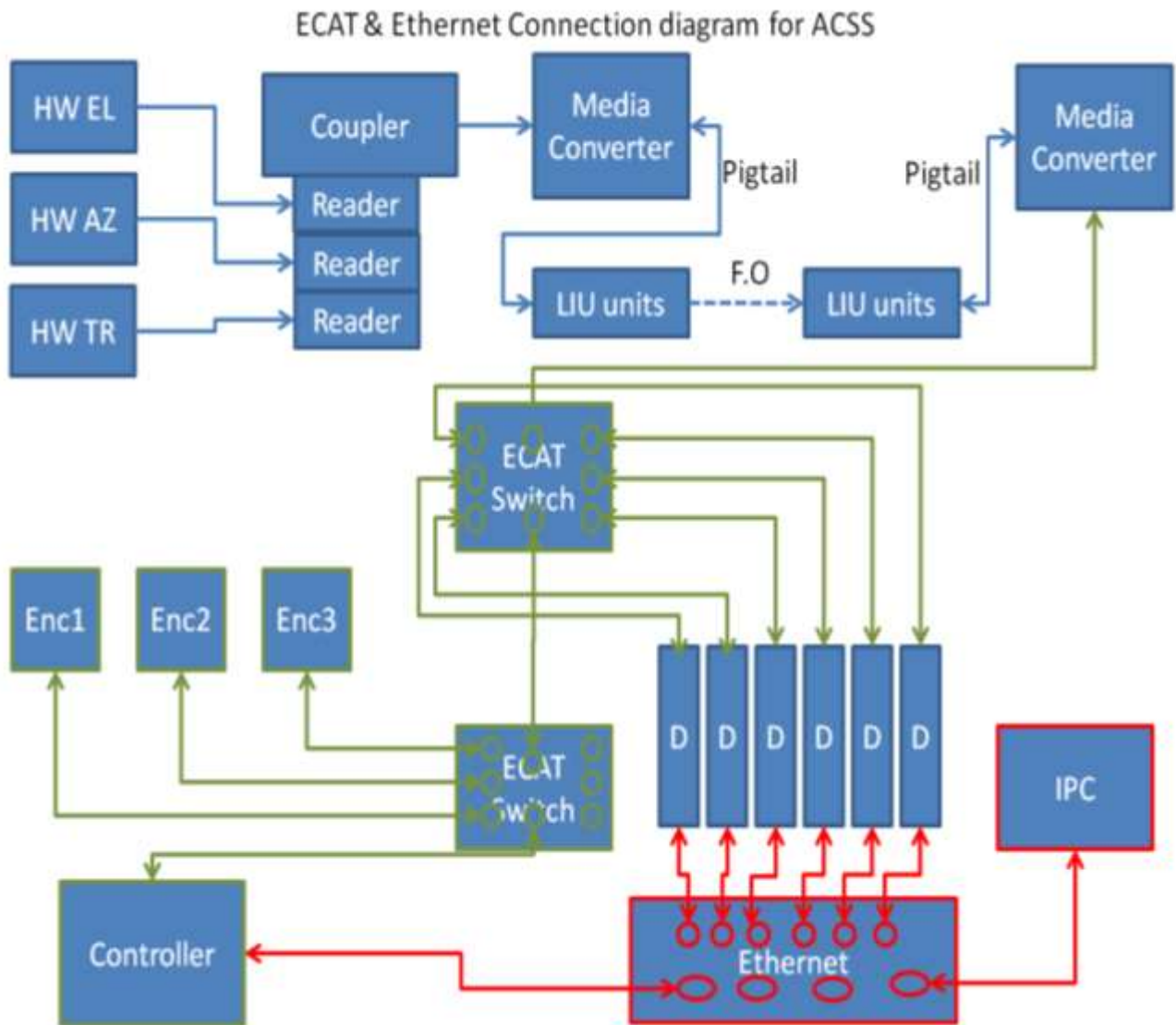


Fig.2 ACSS interface diagram

## 7. 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	7° 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	0.001°
8	Encoder Transducer	22 bit with SSI interface and hardware zeroing facility
9	Antenna Coverage limits	AZ ± 360°; EL -5° to +185°; Train ± 180°
10	Position loop bandwidth	1.0 Hz typical
11	Maximum Velocity	15°/sec in AZ, 6°/sec in EL, 6°/sec in Train.
12	Maximum Acceleration	6°/sec <sup>2</sup> in AZ, 3°/sec <sup>2</sup> in EL, 3°/sec <sup>2</sup> in Train.
13	Tracking accuracy	X band: 0.030° Ka band :0.025 deg
14	Pointing accuracy	0.05°
15	Operating wind velocity	60 KMPH

**8. Tracking accuracies of the system as achieved detailed in table 1:**

<b>Date</b>	<b>Mission/ Orbit</b>	<b>Max EL of pass</b>	<b>AZ RMS (deg)</b>	<b>EL RMS (deg)</b>	<b>BRE (deg)</b>	<b>Remarks</b>
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

Table 1 Tracking accuracy of the system

**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.**

**9. Technology Transfer from NRSC/ ISRO:**

NRSC/ISRO is willing to offer the know-how of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment, if any, and plans for diversification to the address given below:

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