Design and Development of Pedestal Assembly for Medium Power Active Array Transportable Radar

Sandip Kumar[1], S Pazhanivel[1], K Ajit Kumar[1] and N M Athawale [2]
[1] Electronics and Radar Development Establishment,
Defence Research & Development Organisation,
Ministry of Defence,C V Raman Nagar,Bangalore-560093
[2] Larsen & Toubro Limited, SBU 2, WSAS,
Heavy Engineering Division, Powai Works, Mumbai- 400 072.
sandip.kumar@lrde.drdo.in

Abstract:

A Pedestal Assembly has been designed and developed for medium power transportable radar to deploy the 7ton antenna at required azimuth & elevation position by a combination of electromechanical and sliding actuators. The antenna can be brought down to horizontal position for transportation. It has been designed with the provision for mounting of rotary joint assembly and has been indigenized and validated through extensive tests.

Keywords: Pedestal Assembly, Drive Control

I. INTRODUCTION

A pedestal assembly was designed for deployment and stabilization of antenna for different operational modes of the medium power active array transportable radar. The deployment involves unfolding of four outriggers of the pedestal assembly and leveling the pallet assembly using the hydraulic actuators. On the leveled pallet assembly, the antenna which is initially kept at horizontal position will be brought to the required elevation angle. Keeping antenna at required elevation angle, the pedestal will rotate or position it at fixed azimuth angle depending on the operational mode. There are two operational modes namely surveillance and tracking. The pedestal assembly has the provision for mounting the rotary joint assembly. The rotary joint assembly transfers the power supply and signal cables, coolant line from the stationary part to the rotating part of the pedestal assembly and to the antenna. The antenna is brought back to the horizontal position to accommodate it within the transportable dimension. Tests were carried out to validate the design of the pedestal assembly.

II. DESIGN REQUIREMENTS AND CONSTRAINTS:

1 Requirements:

- *Platform leveling accuracy : < 0.3° (for ground slope up to 3°)*
- *Antenna to be deployed to 77.5° from horizontal position.*
- *Surveillance (Rotation) mode: Antenna shall rotate continuously at 7.5rpm and 15rpm.*
- *Tracking (Staring) mode: Antenna to be stopped at the required azimuth angle with an accuracy of 0.25 °*
- *Surveillance to tracking mode: within 12 sec*
- *Tracking to surveillance mode: within 8 sec*
- *The pedestal assembly shall be transported by standard 20 feet semi-trailer on road/rail and by air (IL-76 type of aircraft) using a low bed trailer*
- *Antenna deployment time : < 30 minutes (Includes pedestal leveling & antenna elevation)*
- *Antenna Elevation time : <10 minutes*

2 Constraints:

- *Weight of antenna: 7 ton*
- *Size of antenna: 6m x 2.4m x 0.9m*

III. CONCEPTUAL DESIGN

The pedestal assembly was conceptualized through detailed solid modeling and animation. Considering the requirements and design constraints, the overall dimension was finalized. The pedestal assembly has been conceptualized to be transported along with the antenna assembly on a trailer with a prime mover as shown in Fig. 1.

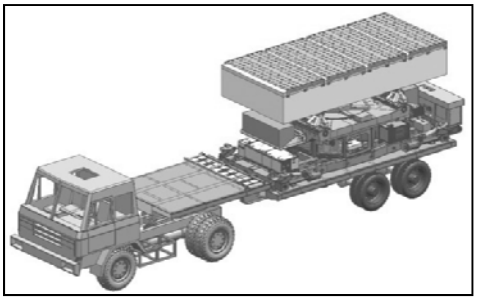

Fig. 1: Conceptual pedestal assembly with antenna - Transportation mode

The pedestal assembly has been configured in such a way that after deployment of the pedestal assembly, the prime mover along with the trailer can move out.

The pedestal assembly comprises of three main components as shown in Fig. 2 namely i. Pallet, ii. Drive control cabin and iii. Rotary Platform.

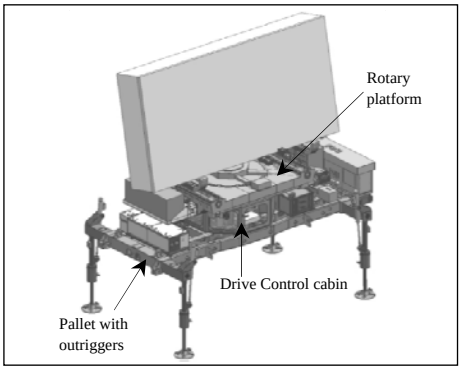

Fig. 2: Components of pedestal assembly

The pallet with outrigger assemblies will facilitate the deployment and leveling of the assembly along with the antenna. The drive control cabin houses the main drive mechanism, brake assembly, etc. It also has the provision for fixing the stationary part of slew bearing. The bearing is having internal teeth on its rotating part i.e. outer race which is driven by the main drive mechanism. The outer race of the slew bearing has the arrangement to mount the rotary platform on it. The rotary platform has two components: i. Rotary base and ii. Antenna elevation mechanism. The rotary table is fixed on the slew bearing and the elevation mechanism will bring the antenna to 77.5^{o} from horizontal position and back. The drive control cabin has the provision for mounting the rotary joint assembly.

IV. DETAILED DESIGN

A detailed design of pedestal assembly was carried out using Finite Element Analysis and verified the structural rigidity. A deflection plot of pedestal assembly is shown in Fig. 3. The subsystems of pedestal assembly are described below:

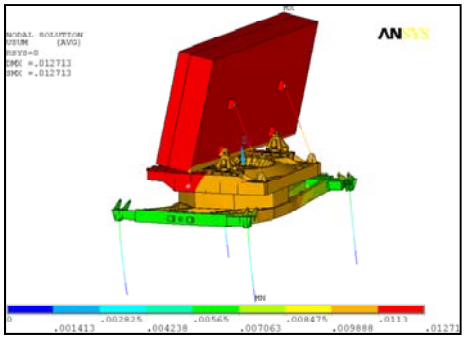

Fig. 3: Deflection plot of pedestal assembly

1. Pallet:

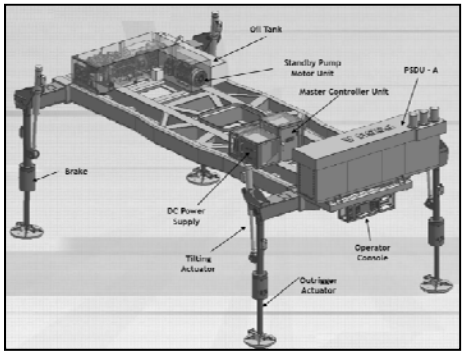

Fig. 4: Pallet with accessories

The pallet (Fig. 4) is designed with four outriggers to deploy the assembly. The outriggers are operated hydraulically to outreach position and can be retracted back. Each of these outriggers is having hydraulic stabilizing actuators which is controlled from the operator console independently. The actuators are provided with brake to arrest any slippage after leveling. The pallet is made of alloy steel and designed to withstand the static, quasi static loads during operation and the various dynamic loads during transportation. It is designed with mounting interface for drive control cabin and other accessories. It has four ISO corners to lock on a standard trailer during transportation. In order to maintain the pallet size suitable for transportation, the leveling actuators are folded back to horizontal position by hydraulic actuators and the outrigger is retracted back to its original position.

2. Drive control cabin:

The drive control cabin is a welded structure (Fig. 5) and it is designed to withstand the rotating load, dynamic loads due to rotation and wind. It is fixed over the pallet as shown in Fig. 2. It

supports the rotary platform and houses a main drive mechanism assembly. The main drive mechanism has been designed such that the required speed of 7.5 and 15 rpm from rest will be achieved with in 8 sec.

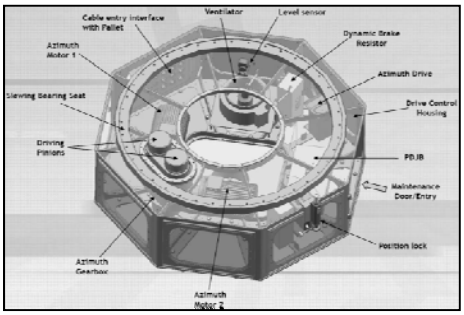

Fig. 5: Drive control cabin

The main drive mechanism consists of drive mechanism housing, drive controller, two drive motors and a gear box. The drive controller performs various operations like rotation to staring, staring to staring, staring to rotation and antenna elevation. Two drive motors are used to power the gear box. The gear box is having two pinions at top which drive the rotary platform through slew bearing. The inner race of the slew bearing is fixed on the drive control cabin concentrically. The bearing is having internal gear teeth on its rotating outer race. This gear is driven by the pinions of the main drive gearbox. The use of two pinions is aimed at achieving minimum backlash. The outer race of the slew bearing has the mounting arrangement for rotary platform on it. The gear box is provided with electromagnetic brakes. This enable the mechanism to stop the rotary platform along with antenna from rotation to the desired azimuth angle. The brake is capable of stopping the platform rotating at 7.5 and 15 rpm to the required azimuth angle with in 12 sec with an accuracy of 0.25^{o}.

The cabin also have mounting provisions for rotary joint assembly. The rotary joint assembly is having i. Stationary part and ii. Rotary part. This is used to connect the power supply and signal cables to the antenna from other parts of the radar. this assembly has a media channels which enables circulation of coolant from cooling unit through the antenna.

3. Rotary Platform:

The rotary platform (Fig. 6) is mounted on the outer race of slew bearing. The platform is consisting of a rotary base and an antenna elevation mechanism. The 7 ton antenna is mounted on the rotary base through the elevation mechanism. At bottom side, the antenna is fixed on two sliding pylons and at the rear side on two electromechanical actuators which forms a four bar mechanism. This mechanism is used to deploy the antenna to the required elevation angle.

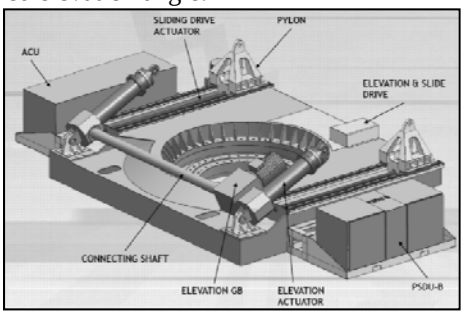

Fig. 6: Rotary Platform

Initially, the electromechanical actuators driven by a single motor and gear box elevates the antenna to an angle of 32^{o} from horizontal. Then the pylons mounted on a sliding drive actuator moves back and elevate the antenna further from 32^{o} to the required 77.5^{o}. Both the sliding actuators are connected through a common shaft which is driven by a single motor and gear box.

V. DEPLOYMENT OF PEDESTAL ASSEMBLY ALONG WITH ANTENNA

The process of deployment starts with unloading the pedestal assembly along with antenna from the trailer. The trailer is positioned at the required location. Then the outriggers are extended to the outreach position and stabilizing actuators are unfolded to vertical position from folded horizontal position. Then the actuators are operated to lift the pedestal assembly above the trailer and level the assembly to the required accuracy. Then the trailer can be moved out and the pedestal assembly is supported by four leveling actuators.

The antenna deployment sequence is shown in Fig. 7. The antenna is elevated to an angle of 32^{o} from horizontal by operating the electromechanical actuators. Further, the antenna is elevated to 77.5^{o} by moving the sliding pylons back by using the sliding actuators, there by the antenna is ready to operate.

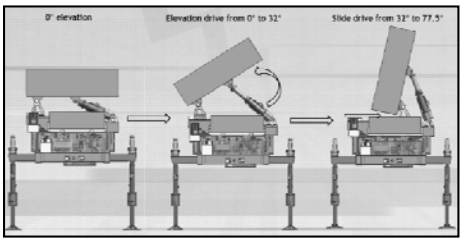

Fig. 7: Deployment sequence of antenna

VI. PEDESTAL ASSEMBLY REALIZATION AND VALIDATION

A detailed solid modeling and animation was carried out for finalizing the configuration of

pedestal assembly. After successful conceptual design, the pedestal assembly was realized indigenously. The realized pedestal assembly is shown in Fig. 8.

Fig. 8: Realized pedestal assembly with antenna

The rotary joint assembly consisting of media rotary joint, power and signal slip ring, fiber optic rotary joint and encoder was customized and integrated to the pedestal assembly. Coolant is circulated through a two channel media rotary joint to cool the antenna electronics.

Extensive tests were carried out to verify that all functional, structural, transportation, environmental and EMI/EMC requirements are met. The design of pedestal assembly is validated as per requirements.

VII. CONCLUSION

The design of pedestal assembly for medium power active array transportable radar was conceptualized through detailed solid modeling and animation. The pedestal assembly was realized and integrated with the antenna assembly, rotary joint and antenna pressurization system. The integrated pedestal assembly was tested extensively and qualified. Presently, the pedestal assembly is integrated with radar sub-systems and radar trials are being carried out.

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BIO DATA OF AUTHORS

SANDIP KUMAR, Sc 'D': Received his AMIE degree in Mechanical Engineering from Institution of Engineers, India in 2000 and M Tech degree in 2003 from Indian Institute of Technology, Madras. Presently, he is working as a scientist in Electronic and Radar Development Establishment (LRDE), Bangalore. Involved in the design and development of mechanical system and hardware for radars.

S PAZHANIVEL, Sc 'F': Received his BE degree in Mechanical Engineering from University of Madras in 1994 and ME degree in 1997 from College Of Engineering, Guindy, Anna University, Madras. Presently, he is working as a scientist in Electronic and Radar Development Establishment (LRDE), Bangalore. Involved in the design and development of mechanical system and hardware for radars. He is recipient of DRDO 'Laboratory Scientist of year' award in the year 2002 & DRDO Award for performance Excellance-2008.

K AJIT KUMAR, Sc 'G': Received his BE degree from College Of Engineering, Guindy, Anna University, Madras and M.Tech degree from IIT, Kharhagpur. Presently, he is working as a senior scientist in Electronic and Radar Development Establishment (LRDE), Bangalore. Involved in the design and development of mechanical systems and hardware for radar system. He is recipient of Agni Award-2007 & DRDO Award for performance Excellance-2008.

N M ATHAWALE, GM: Working in Larsen & Toubro Limited (L&T), Powai, Mumbai. Presently involved in the Aerospace and Defence projects.