Innovative Measurement Techniques for Next Generation Antenna & Payloads

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Abstract—**This paper describes various innovative measurement techniques proposed and successfully implemented in characterization of next generation antenna and payload system at spacecraft level in ISRO's compact range. Since its establishment in 2003, 33 spacecrafts and more than 160 devices under tests are characterized successfully over 200 MHz to 40 GHz. It is to be noted that nominal range of frequency of operation of the facility is from 1 GHz to 40 GHz. Some of the Innovative methods developed at ISRO's compact range are presented here viz. (i) Low frequency (<1GHz) antenna and Payload Measurement (ii) Transmit- mode Pattern measurement method for Navigational and Geostationary Satellites (iii) Transmit-Receive Combined pattern measurement. All these innovative measurement techniques are discussed in this paper.**

Keywords—Radiation pattern, payload antenna, payloads, compact range

I. INTRODUCTION

Performance of Geo spacecraft Antennas is critical for over all mission requirements. Measurement of various antenna parameters on before launch is mandatory for verify the conformance of design specifications. The prime objective of the ISRO's compact range test [1] [2] at S/C level is to validate by RF means the correct mounting of all antennas on the S/C, to observe the S/C body effects on the previously measured radiation patterns and also to ensure that there is no degrading impact on the antenna performance as well as payload performance, subjecting the S/C to Environmental tests. ISRO's compact range has rich experience in successful testing of 33 spacecrafts and more than 160 device under test. Each of these spacecrafts were unique in their own sense and demanded innovative measurement techniques to be developed to meet individual spacecraft requirements. Based on the test requirements innovative measurement techniques have been proposed and implemented successfully at S/C level with in the ambit of available facility and in a cost effective manner. Some of the most innovative methods are discussed in this paper.

In some of the spacecrafts there was a requirement to test low frequency (<1GHz) antennas for pattern and payload characterization. An innovative method has been proposed and successfully demonstrated for pattern and payload characterization in limited scan range, sufficient for spacecraft level testing. The detailed measurement method and results are discussed. Generally, spacecraft level antenna pattern measurements at ISRO's compact range will be done using on-board coupler in receive mode. Sometimes, due to constraints on size and mass of the couplers, transponder chain may not be able to accommodate couplers. Two methods have been proposed to address this problem based on on-board hardware. If the on-board reference is not available, a new method of pattern measurement of Transmit- Receive combined aantenna pattern is developed and successfully implemented in more than 5 spacecrafts.

II. INNOVATIVE MEASUREMENT TECHNIQUES FOR NEXT GENERATION ANTENNA PATTERN MEASUREMENT

A. Low Frequency (<1GHz) Antenna Testing in Compact Range

The nominal frequency of operation of ISRO's compact range is from 1GHz to 40 GHz. The lower frequency of operation of compact range is decided by length of serrations, reflector dimensions and absorber performance. An attempt has been made to test low frequency (<1GHz) antennas in ISRO's compact range by-passing reflectors and in standard far-field condition. Necessary changes in ISRO's compact range were carried out to suit for low frequency measurements. Initially, a test specimen low frequency array antenna (circular polarization) was tested in direct Line Of Sight (LOS) condition. The measured results have shown good agreement with simulated results both in terms co-pol and X-pol. The comparison of measured and simulated co-pol is shown in the figure. Further, measured and simulated axial ratio results are presented in table no: 1. with the confidence obtained from antenna level results, it was decided to proceed for S/C level measurements in LOS condition. It was observed that compact range can be used for limited angular ($\pm 10^0$) characterization of UHF antennas in direct LOS condition. Using this method, low frequency antenna pattern measurements and payload characterization was successfully carried out.

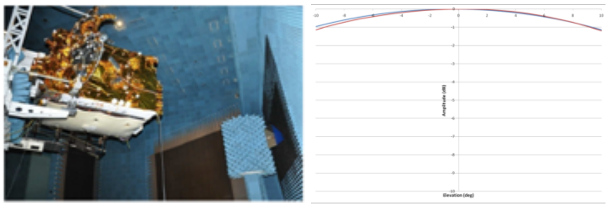

Figure 1: Antenna & S/C level UHF antenna measurements in LOS condition in compact range, comparison of measured and simulated results (Simulated: Blue, Measured: Reg)

B. *Transmit Mode-Antenna Pattern Measurement*

Generally, spacecraft level antenna pattern measurements will be carried out in Receive mode with the help of on-board coupler available in transponder chain. But, sometimes due to weight/size constraints coupler may not be able to accommodate in transponder chain especially at low frequencies (like in the case of IRNSS Class of satellites). In such cases we may have to de-mate the cable/waveguide sections to perform antenna pattern measurements and to assess the impact of S/C body on pattern performance. Since, compact range test is being final integrated level test before the launch pad it may not be wise solution (sometimes it may not be possible) to de-mate the cable/waveguide sections. Hence, new method has been proposed and successfully implemented for S/C level Transmit-Receive Combined Antenna Pattern measurement. During linear pattern measurements, phase information is not very important only amplitude information is sufficient. But, during circular antenna pattern measurements phase information is also important. To have accurate measurement synchronization between on-board source and CATF RF instrumentations is required. This is done by taping 10 MHz reference (which is going to S/C) and connecting to CATF RF instrumentation. This is possible in case of navigational series satellites where on-board clock can't be switched on at ground (due to constraints). So, external clock was used for on-board signal generation and same reference also was used to synchronize CATF range instrumentation. Test set-up is verified by performing pattern measurements in DUT Rx (with coupler) and DUT Tx mode. It was observed that results were in excellent agreement and is shown in following figure 2.

C. *Transmit-Receive Antenna Combined Pattern Measurement*

As mentioned in last section, that pattern measurements can be performed in DUT Tx mode directly for linear type of antennas and using on-board reference for circular antenna type pattern measurements. But, generally on-board reference is available only for navigational series of satellites only. In case of communication satellites employing either bent pipe or regenerative type transponders there will not be any on-board reference. So, in such cases, a new method has been proposed and used successfully to characterize Tx and Rx antennas simultaneously in transponder mode without de-mating cable or waveguide sections. Here, both uplink and downlink feeds were mounted on CATF feed positioner and transponder will be switched ON and measurements will be carried out.

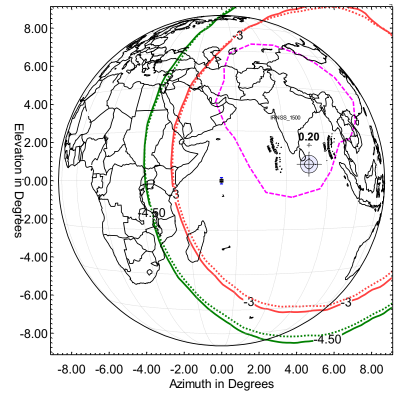

Figure 2: Comparison of S-band pattern measurement results (Solid: Tx mode Dotted: Rx mode using coupler)

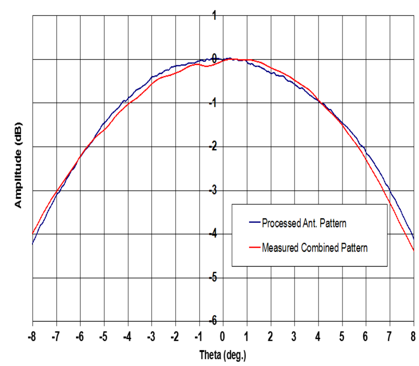

Figure3: Transmit-Receive Combined Azimuth cut comparison

It is to be noted that measured pattern is combined effect of both Transmit and Receive antennas. Individual sub-system measured data was processed accordingly and comparison was made w.r.t measured data. Due to paucity of space few innovative methods viz.: Pattern and payload measurement of Unfurable antenna, Effect of Micro-vibration on Unfurnable antenna, Multi-beam antenna payload characterization, PIM and auto-compatibility tests could not be presented and will be discussed during presentation.

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