An Improved Method for Active Phased-Array Antennas Calibration

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Abstract – **Some problems of phased array antennas and its T/R modules calibration are considered. The main attention is paid to the problems and procedures of diagnostics and measurements of amplitude and phase distribution on aperture, to alignment and calibrations of phased array antennas, which take into account the peculiarities connected with its hardware implementation and service conditions.**

Keywords - **Calibration, active phased-array antenna, antenna measurements, alignment, calibration, fault diagnostics, performance monitoring, weighting functions, signal isolation, module failure, transfer matrix.**

I. INTRODUCTION

This paper discusses some possible solutions to phased array antennas (PAA) diagnostics and calibration in the operational environment using built-in-test equipment which can play a key role in reducing life cycle cost if accurately implemented.

II. MAIN PART

The built-in performance-monitoring systems (BPMS) are used for automatic diagnostics, performance monitoring and correction of the distortions in amplitude and phase distribution (APD) over aperture, caused by destabilizing factors (such as temperature gradient over the aperture, changes with ageing and different kind of elements failures in the channels) using compensatory techniques [1].

Advanced methods and practical aspects of active phased array antennas (APAA) performance monitoring and calibration are presented in this paper. The key questions of BPMS designing, such as the right choice the pilot signal injection system and transfer matrix calibration, are analyzed. The paper extends the rotating element field vector (REFV) method techniques for considering PAA performance in several limiting cases, including the case wherein switching on bits of PS inserts both amplitude and phase errors. It is shown, that inserted loss affects the phase estimation error that is the most considerable and vulnerable parameter for restoration of APD [2].

Here we propose an improved method of PAA diagnostic that gives more accurate results in estimation of APD over aperture of the APAA and describe the BPMS which for inputting the pilot signal in the channels of planar PAA employs several fixed probe antennas, placed on some distance from the corners of PAA and oriented in a direction to its center. Such construction takes into account all restrictions of APAA allocation on the ship or on the vehicle including demands to design of fixed probe system, which provides necessary rigidity, stability, and spatial orientation of pilot signal sources in relation to the aperture of PAA. The added circuit complexity is minimal. This approach has the advantage of low cost and easy implementation especially in the case when alignment is needed for TX and RX (sum, ΔAZ and ΔEL) channels, using only one PS for all channels. The proposed construction and method of performance monitoring and calibration of APAA were tested in field-operating conditions [3].

Several significant technological advantages were achieved. First, APD changes for receive and transmit modes of operation are observed and effects of mutual couplings with other radiating elements may be revealed. Next, the probes for injecting pilot signal are located in Fresnel zone of radiation and the level of a total signal in Tx and Rx modes during PAA monitoring may be considerably reduced (up to 25-50 dB). Furthermore, there were no problems with organizing and stability of reference channel.

The special attention was paid to some practical aspects of designing and application of the BPMS. A numerical model of BPMS has been developed and many cases, described in literature, were examined here to isolate and characterize errors commonly found in BPMS.

III. CONCLUSION

Here we propose an improved method of PAA diagnostic and discuss its practical aspects. The degradation is detected with low false alarm rate and the appropriate action initiated consistent with low life cycle cost. Both simulation and measurement results are presented to demonstrate the utility of the proposed measurement and monitoring techniques. Future research directions in BPMS designing are highlighted.

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