AIRBORNE RADAR WITH DIGITAL ACTIVE PHASE ARRAY FOR AN ADVANCED MULTIFUNCTIONAL AVIATION COMPLEX OF RECONNAISSANCE,WARNING, AND CONTROL

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Abstract

This paper deals with the principles of designing early warning airborne radar with "intelligent" digital active phased arrays for advanced Multifunctional Aviation Complex of Reconnaissance, Warning, and Control (hereinafter "Advanced AEW System"). The basic technical solutions for integration of hybrid active phased arrays (HAPA) in antenna assembly (phased slotted-guide array) of AEW aircraft radar are presented. Algorithms of HAPA radar and the evaluation of enhancing the radar's performance are under consideration.

Introduction

The main function of the present AEW Systems such as A-50 Aviation Complex (Russia) and AWACS (USA) is to provide radar information field, including IFF data, about air targets and surface ships in round zone. Both of these present AEW Systems use heavy carrier platforms with over fuselage rotary radomes of radar antennae with electronically beam control in elevation that is sufficient and closer to optimum. The application of rotary radome provides simply all-round coverage and makes it possible to use limited dimensions of antenna aperture in the best way [1,4].
We find it important to provide fulfillment of Advanced AEW System functions the main trends for enhancing radar's performance are as follows:

- enhancing the accuracy of target angular coordinates measurement;
- broadening zone of the elevation scanning;
- improving resolution of target's radial velocity;
- decreasing minimum value of radial velocity of detectable targets;
- application of the second radar channel, operating in decimeter wave band (L-band), for improving detection and tracking stealth targets and "usual" targets in jamming environment. The channel is also necessary for reconnaissance function of Advanced AEW System.

These problems can be resolved in the best way using active phased array located in a rotary radome and designed with the application of the recent achievements in microwave and digital technology. The recent achievements in the field of low noise microwave amplifiers with cross fields ("M"-type microwave amplifier) [2] as well as single chip high-speed ADC/DAC enable to design HAPA, using "intelligent" antenna receive-transmit modules (RTM) with high efficiency.
The structure of receive-transmit part of HAPA "intelligent" RTM is shown in Fig.1

1. HAPA structure

The structural chart illustrating integration of HAPA components with radiation elements of slotted-guide antenna inside rotary radome is shown in Fig.2.
Control and power supply units of HAPA including anode modulator for amplifiers should be arranged within rotary radome. Vacuum tubes (VT) with so-called cross-fields are supposed to be used as output microwave amplifiers of RTM. They are often called "M"- type VT.

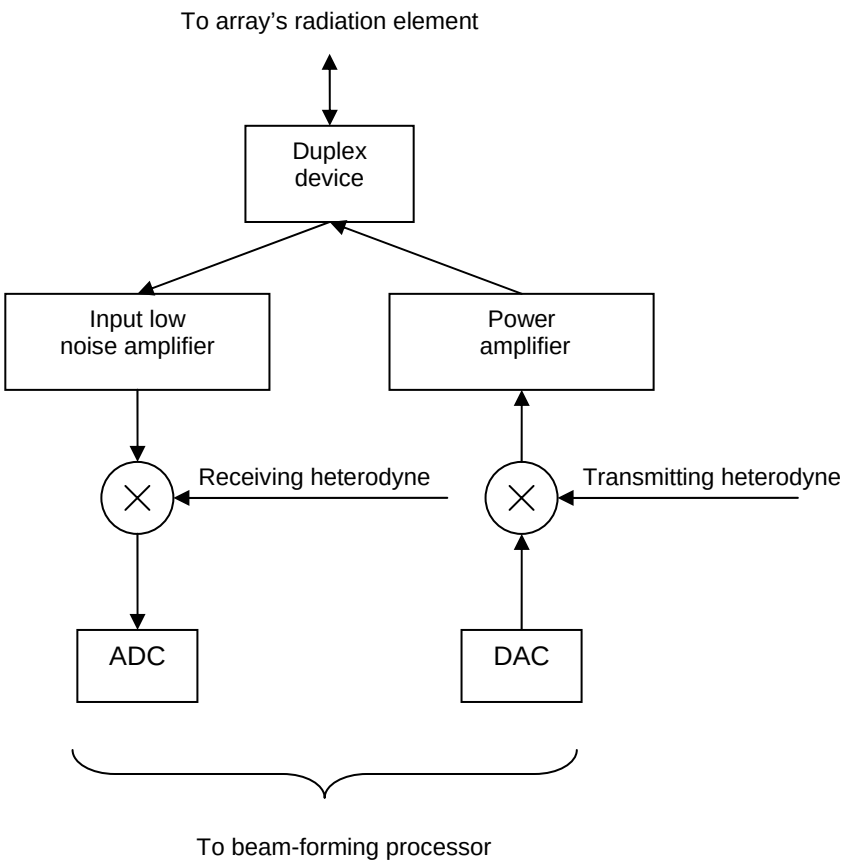

Figure 1. The structural chart of receiving-transmitting part of an "intelligent" RTM

The recent important achievement of "M"- type VT developers has resulted in reducing noise and collateral phenomena. At present the actual integral noise is reduced up to minus 80...90 dB that can be found acceptable for high coherent radars [2].

Preliminary research works indicate that it would be advisable to develop "intelligent" RTM as shown in Fig.1.

RTMs will use beam-forming processors for forming direction pattern of HAPA. For that RTMs will perform all essential functions. They are as following:

- producing probing signal with digital "signature" using transmitting coherent microwave heterodyne and high speed DAC;
- amplification of probing signal;
- Receive\Transmit duplex isolation and low noise-factor amplification of receiving signals;
- transformation of the receiving signals frequency to intermediate frequency using receiving coherent microwave heterodyne and further conversion of the resultant signals into digital form by high-speed ADC;
- exchange of digital data with beam-forming processors;
- producing output signals of RTM built-in sensors to perform operational check.

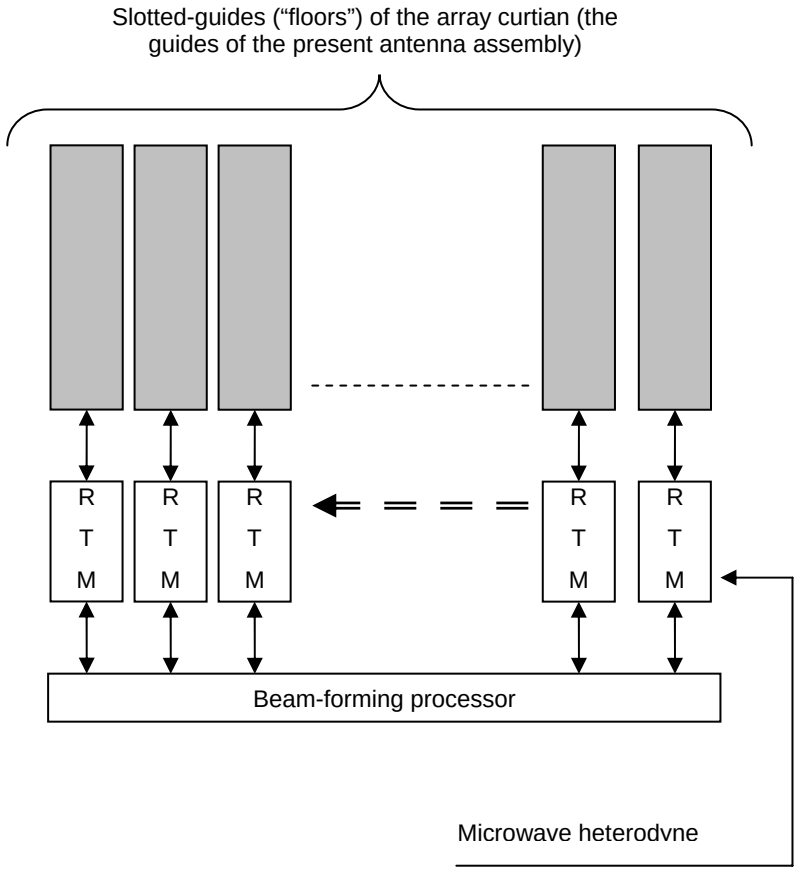

Figure 2.TheHAPA structural chart

2. The L-band radar channel

In the Introduction we noted the advisability to use the radar channel in L-band to improve detection and tracking for high-speed and stealth targets Fig.3 and "usual" targets in jamming environment. We find it advisable for Advanced AEW aircraft to have the second SAR channel in decimeter wave band to detect ground targets under foliage as well as a number of objects under foliage layer absorbing centimeter radio waves efficiently and not too thick to absorb decimeter radio waves (see Fig.4).

HAPA should be developed for L-band radar channel too. One of the possible variants under consideration is the L-band HAPA integrated with antenna assemblies of IFF and command transmission system.

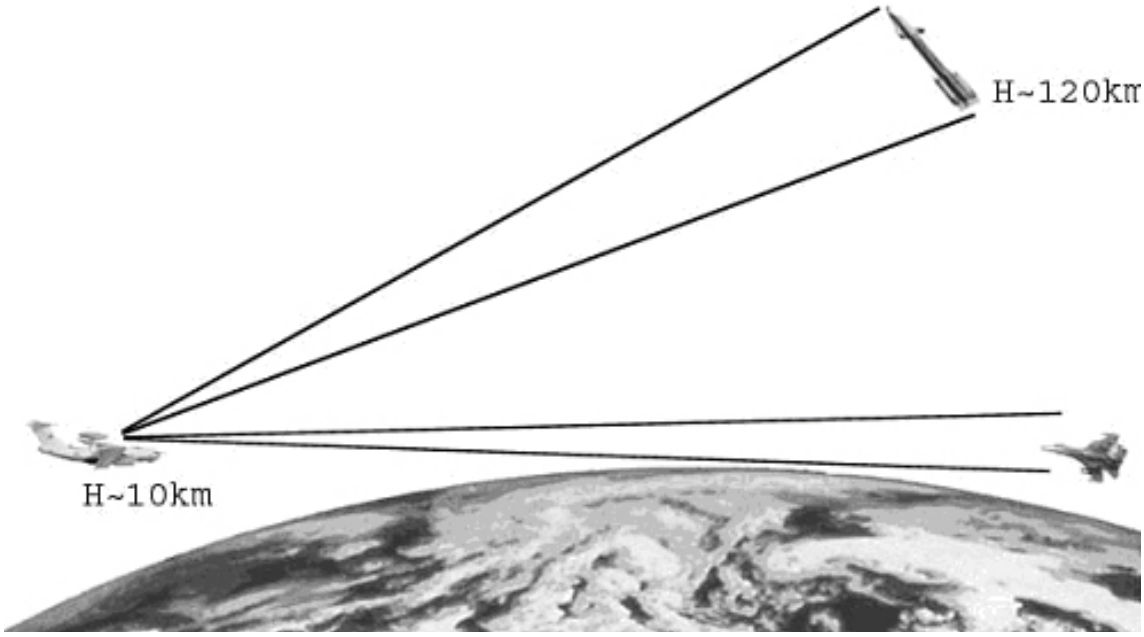

Figure 3. Detection of the high-speed and stealth targets by over radiohorizon L-band channels

Conclusions:

1. The analysis of antenna systems for Advanced AEW Aircraft shows that the most advisable trend of AEW airborne radar modification, taking into account development cost, is "intellectual" digital HAPA, located in rotary radio-transparent radome on heavy carrier platform.
2. We find it quite reasonable to use the integration of HAPA (with comparatively small number of RTM) with the present antenna system of AEW aircraft.
   New VT (M-type) providing necessarily low level of a noise and collateral phenomena are the most suitable for implementation of the RTM functions.
3. The "antenna intellectuality" is significant requirement for development of Advanced AEW System HAPA, where complex and bulky analog beam-forming devices to be replaced with high precise digital devices, based on updated digital technology.
   The "intellectual antenna" will enable by reprogramming to change antenna directivity diagram quite easily, including during in-flight missions directly.
4. Enhancing radar's performance by way of «intellectual" digital HAPA application permits to change over to development of Advanced AEW System of a new generation.

Figure 4. The surface surveillance by L-band airborne radar

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