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MONOPULSE DIRECTION FINDER FOR HARMONIC RADAR SYSTEM

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Эта работа представляет первые результаты экспериментального амплитудного пеленгатора моноимпульса для гармонического радара. Связанные с диафрагмой антенные решетки используется для работы в диапазоне 1.5 ГГц с 10%-й пропускной способностью. Антенны с листовой характеристикой включают сектор с азимутом в 50 °. Проблемы с общей (круговой) поляризацией также были рассмотрены.

This paper introduces first results of experimental amplitude collation monopulse direction finder for harmonic radar. Aperture related patch antenna arrays are used for operation in 1.5 GHz range with 10% operation bandwidth. Antennas with leaf characterization enable 50° sector of operation in azimuth. Problems with common (circular) polarization are discussed.

Monopulse radar systems are able to obtain angle information on a single pulse [1]. While complete vector information has to be measured in phase-comparison systems, amplitude-comparison systems process only scalar information. This significantly simplifies direction of arrival estimation. Four antennas are used for true 3D measurement whereas two antennas suffice for measurement in a plane (Figure 1).

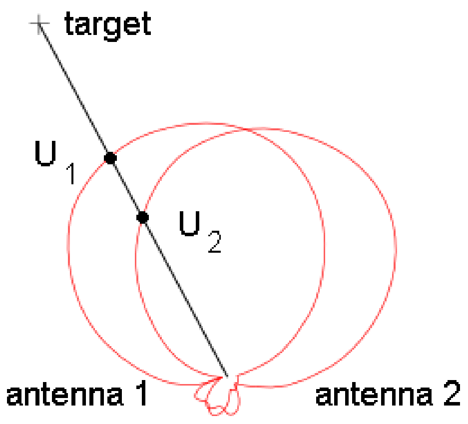

Figure 1. Monopulse tracking

Antenna beamwidth and mutual (relative) beamshift define monopulse System operation sector. Direction of arrival is taken from the monopulse system characteristic $\xi(\phi)$

$$\xi(\phi) = \frac{\Delta(\phi)}{\Sigma(\phi)} = \frac{f\left(\phi - \frac{\Phi}{2}\right) - f\left(\phi + \frac{\Phi}{2}\right)}{f\left(\phi - \frac{\Phi}{2}\right) + f\left(\phi + \frac{\Phi}{2}\right)}$$

where ϕ is angle of arrival, Φ is monopulse antenna beamshift and $f(\phi)$ is antenna radiation function.

Aperture coupled patch antenna array was chosen for operation in frequency band of 1.5 GHz with 10% bandwidth.

Double-layered (cascaded) antenna is printed on Rogers RT5880 and Arlon AD450 substrates with 10 mm air gap. Antenna's radiation patterns are in Figure 2. Antenna has 3dB beamwidth of 80° in the plane of azimuth and 20° in elevation.

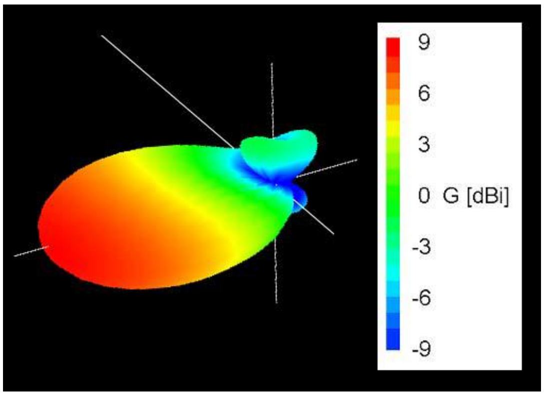

Figure 2. Antenna radiation characteristics

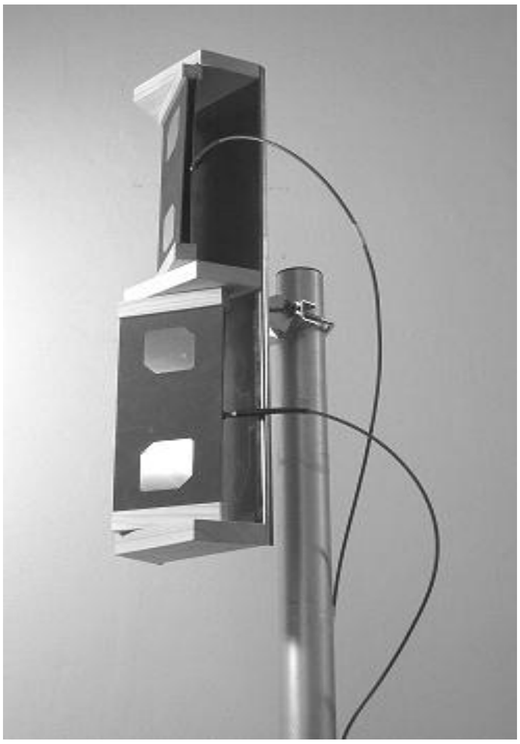

Figure 3. Monopulse tracking system antennas

The direction finder uses two arrays; both situated in the same vertical axis (Figure 3), which provide in-phase arrival of signal localized in the horizontal plane perpendicular to this axis. Reception out of this plane should be reduced – antennas must have leaf radiation characteristics.

Monopulse system characteristics for different mutual beamshift are in Figure 4. Antennas receive linearly polarized signal with horizontal polarization. With 20° beamshift system has the most wide operation sector while with the 60° beamshift system has the most linear characteristic within 120° sector.

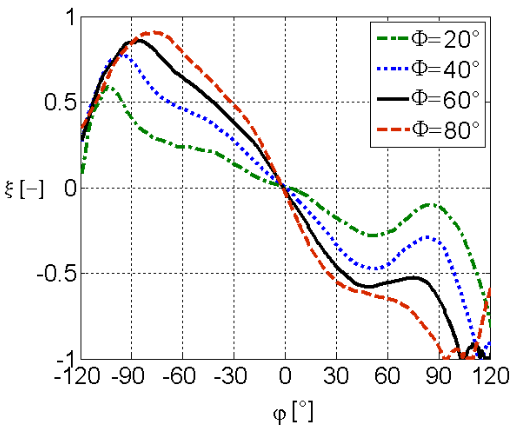

Figure 4. Monopulse characteristics for different beamshift (horizontal polarisation).

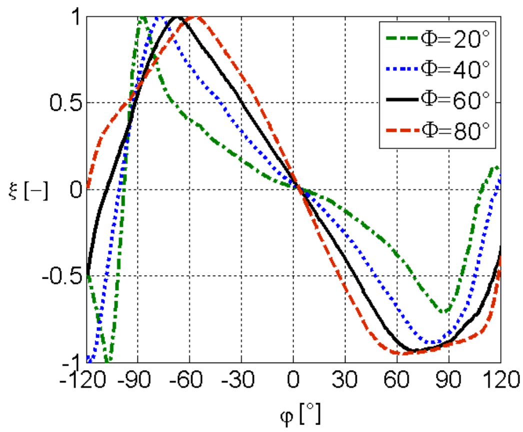

Figure 5. Monopulse characteristic for different beamshift (vertical polarisation).

Figure 5 shows system characteristics for the same beamshifts and vertically polarised incoming signal. System has the best performance (unique estimation) with 80° beamshift.

The requirement for common polarization reception limits the operation sector width the most. Unique prediction of the direction of arrival is the most important attribute of the system, therefore 80° mutual beamshift was chosen for the realization. System characteristics with 80° beamshift and both polarizations are in Figure 6.

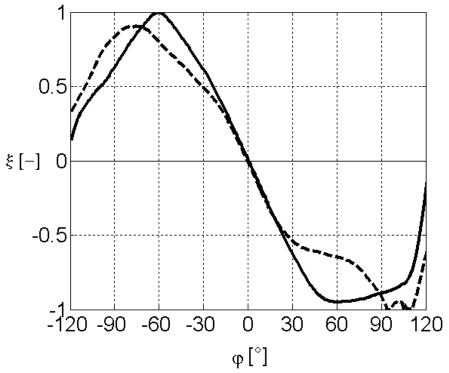

Figure 6. Monoplse characteristics both polarization, 80° beamshift.

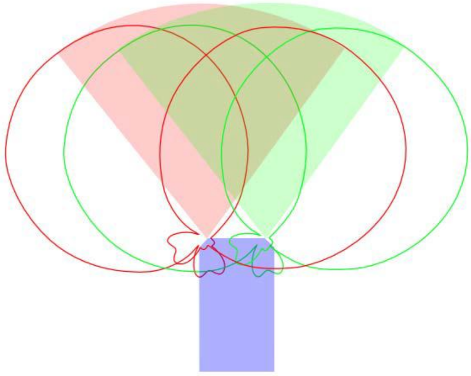

Figure 7. Dual unit monopulse direction finder.

Sector of operation is more than 60° wide with 10° error of permissible value and direction of arrival estimation is unique in the sector of 120°. This problem brings specific requirement on antennas to have ideal axial ratio (the same radiation characteristics) in the whole operation sector.

For compensation of direction of arrival error, dual unit (balanced) system is designed (Figure 7). The second system has axially symmetric antenna structure, which enables reception of signal with both circular polarizations. Monopulse system antennas have mutual beamshift 80° giving system operating sector of approximately 60°. Systems themselves have the same orientation, but can be shifted outwards or inwards.

Aperture coupled patch antenna arrays as a candidate for monopulse direction finder system was tested. Its circular polarization as well as broadband performance enables its operation at experimental harmonic radar system in 1.5 GHz band.

Monopulse amplitude comparison direction finder properties were investigated. Excellent axial ratio and the same shaped radiation characteristics for all polarizations are the major problems in antenna design. They can be partly overcome using dual unit device with post processing.

References

1. M. Skolnik, Radar Handbook. McGraw-Hill, 2008.
2. Kim Hyungrak, Moo Byoung, Young Lee, Yoon Joong, “A single-feeding circularly polarized microstrip Antenna with the effect of hybrid Feeding”, IEEE Antennas and Wireless Propagation Letters, vol. 2, no. 1, pp. 74-77.
3. I. Hertl, M. Strýček, “Broadband, circularly polarized patch Antenna Arrays”, in proceedings of “2009 International Conference on Electromagnetics in Advanced Applications ICEAA 09”, pp. 384-387.