Bo WANG, Jun-wei XIE, Jing ZHANG, Jia-ang GE, 2019. Dot-shaped beamforming analysis of subarray-based sin-FDA. *Frontiers of Information Technology & Electronic Engineering*, 20(10):1429-1444. https://doi.org/10.1631/FITEE.1800722

Dot-shaped beamforming analysis of subarray-based sin-FDA

Key words: Frequency diverse array; Subarray-based frequency diverse array; Decoupling; Dot-shaped beamforming

Corresponding author: Bo WANG
E-mail: wb_wangbo1991@163.com
ORCID: http://orcid.org/0000-0003-1434-0391

Motivation

- In contrast to PA, the frequency diverse array (FDA) is a potential solution to suppress range-related interference because of its time-range-angle-dependent beampattern. However, the range and angle of the FDA cannot be exclusively determined at the output of the array because of the range-angle-coupled transmit beampattern.
- The range-angle coupling inherent in the FDA transmit beampattern may degrade the output signal-to-interference-plus-noise ratio (SINR).

Main idea

- Introducing a sinusoidally increasing frequency offset into the FDAs and planar FDAs, which transmit multiple frequencies to achieve the dot-shaped beam steering to the desired range and angle pair.
- Proposing a cross SB-FDA to achieve the dot-shaped transmit beampattern.

Method

1. Analysis of the subarray-based FDA radar

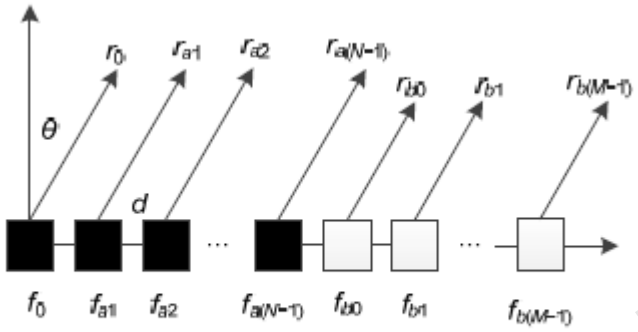

Fig. 6 Single-sided subarray-based frequency diverse array (SB-FDA)

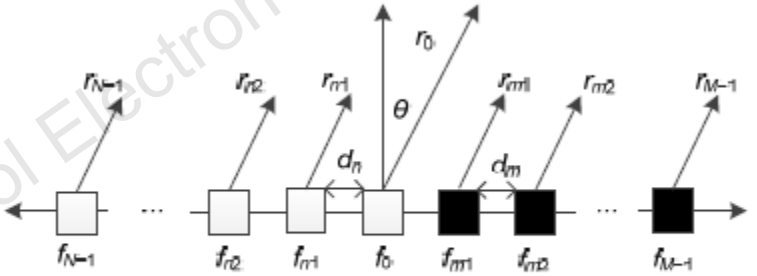

Fig. 7 Centrosymmetric subarray-based frequency diverse array (SB-FDA)

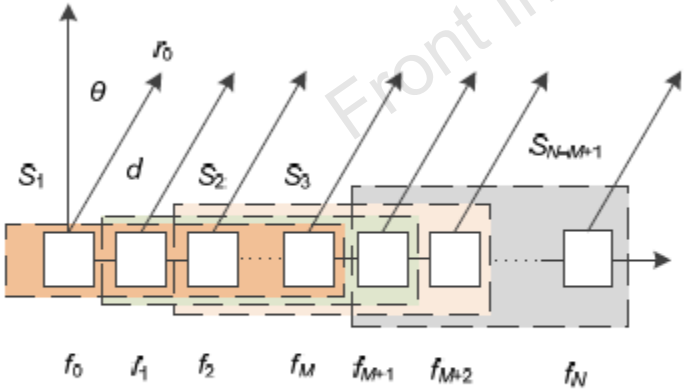

Fig. 8 Overlapping subarray-based frequency diverse array (SB-FDA)

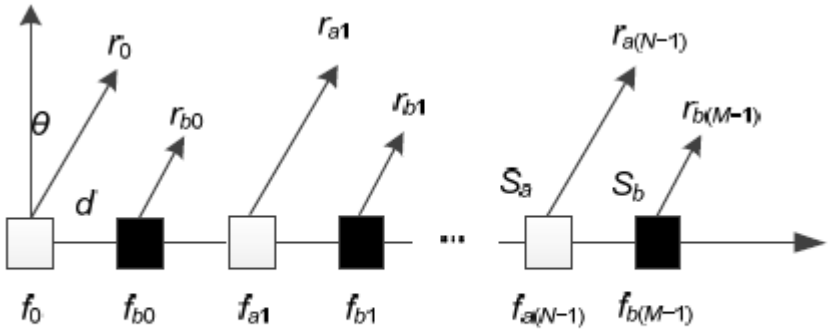

Fig. 9 Cross subarray-based frequency diverse array (SB-FDA)

2. Dot-shaped beamforming method based on nonlinear frequency offset and elements transmitting multi-frequency

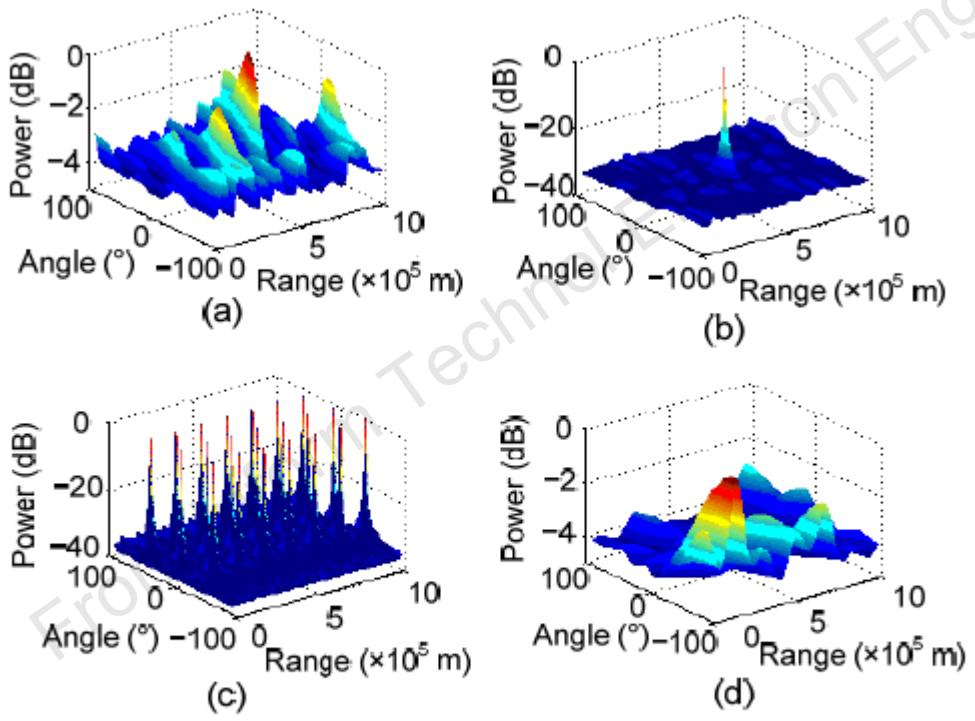

Fig. 10 MUSIC spectrum when θ=0° and R_0=500 km: (a) log-FDA; (b) sin-FDA; (c) cubic-FDA; (d) reciprocal-FDA

Major results

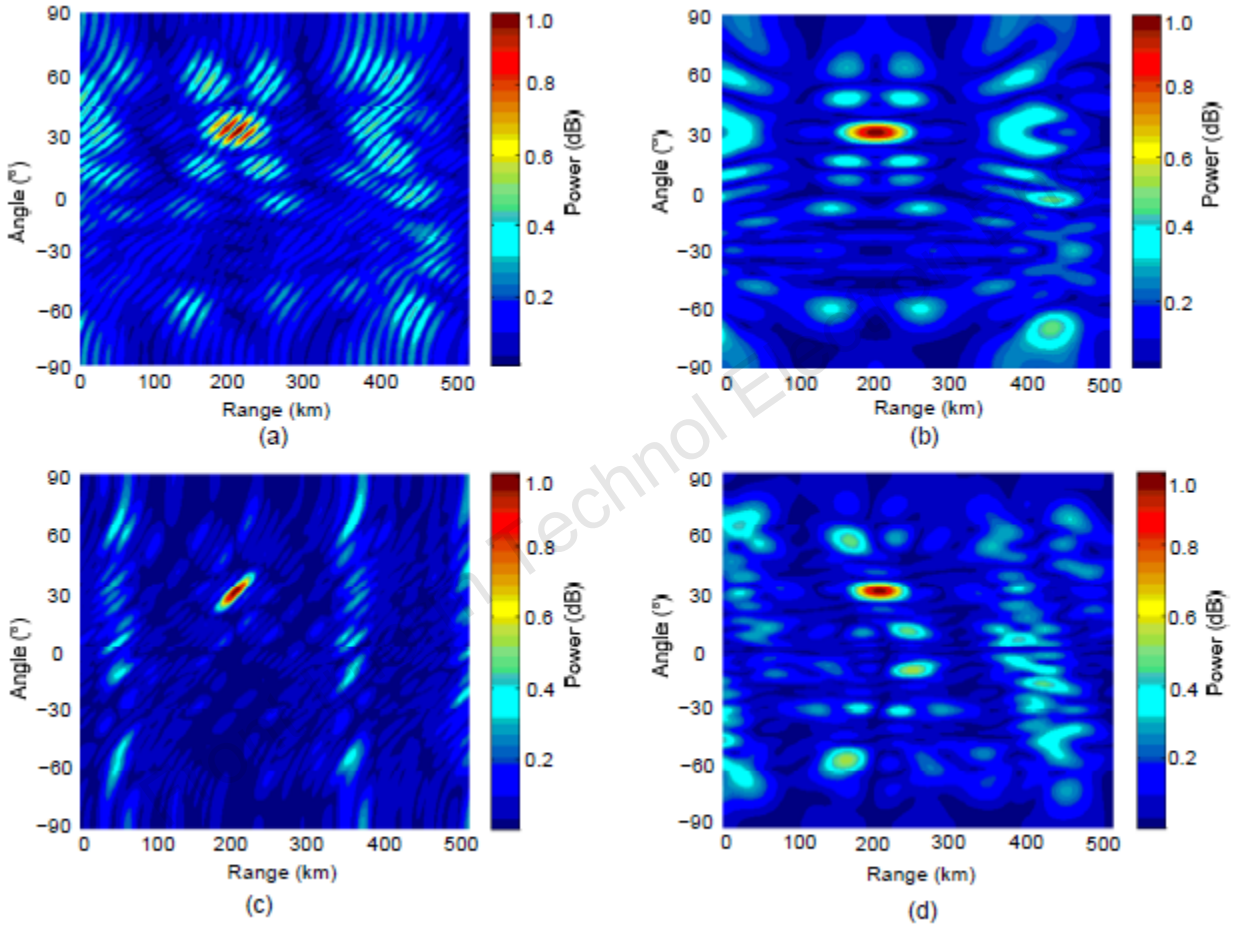

Fig. 18 Transmit beampattern of the four subarray-based sin-FDAs transmitting multiple frequencies: (a) single-sided SB-FDA; (b) centrosymmetric SB-FDA; (c) overlapping SB-FDA; (d) cross SB-FDA

It can be seen that there is only one single maximum at the target location, which can focus the transmit energy in a desired spatial region. The sidelobe disturbances of the cross SB-FDA, overlapping SB-FDA, and centrosymmetric SB-FDA are reduced.

Major results (Cont'd)

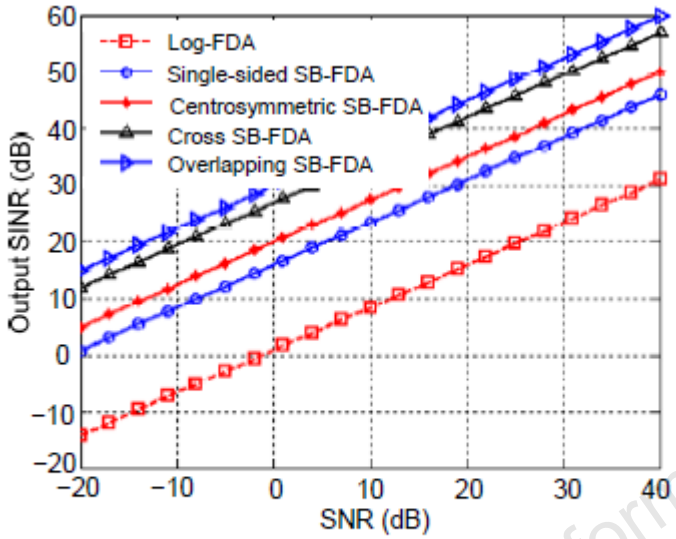

Fig. 20 Performance comparison of the SINR of different FDA radars

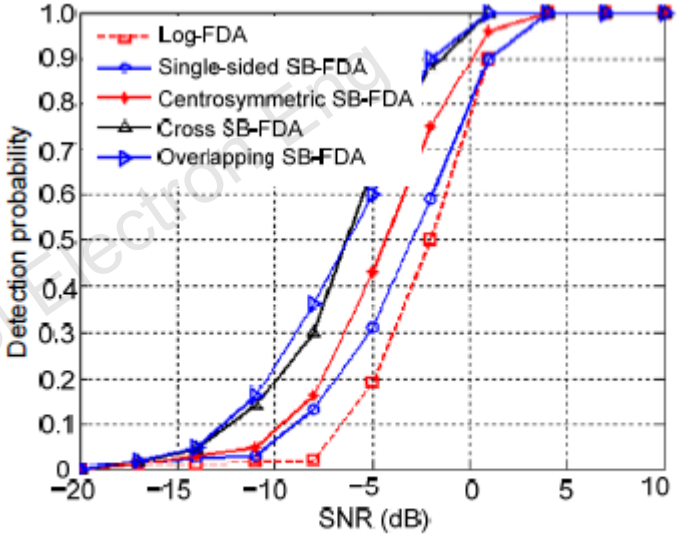

Fig. 21 Detection probability versus SNR

It can be seen in Fig. 20 that the signal-to-interference-plus-noise ratio (SINR) of the proposed SB-FDA is better than that of log-FDA. Thus, the proposed system has better robustness against interference. Fig. 21 shows the detection probability versus the signal-noise ratio (SNR) for the proposed SB-FDA and log-FDA. The proposed FDA exhibits better detection performance compared with log-FDA. The improvement in performance in terms of SINR and the detection probability can be attributed to the sinusoidal offset across the transmit array.

Conclusions

- A dot-shaped beam based on SB-FDA is realized.
- The subarray-based structure simplified the processing and assembly of the array, providing a wide signal bandwidth. It has wide application potential in the fields of range-angle joint estimation, front-view detection, and imaging of radar targets.
- To decouple FDA range-angle dependent beampattern, the best way is to form a dot-shaped beampattern without periodicity in the maximum.
- The FDA with sinusoidally increasing frequency offset, named sin-FDA, has remarkable performance advantages.