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Synthesis of Time-Modulated Rotationally Symmetric Circular Arrays

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1. Introduction

Due to the use of radio frequency switches, time-modulated arrays have considerable interest in various applications. A new type of time-modulated circular planar array is designed in this paper. By optimizing the specific rotationally symmetric structure and the on-off time sequence of RF switches, time-modulated rotationally symmetric circular array (TMRSCA) is synthesized by the improved harmony search (ImHS) algorithm. Characteristic parameters of the TMRSCA are studied, such as sidelobe level (SLL), sideband level (SBL), and directivity.

2. Array Synthesis

Fig.1 shows the *N*-elements TMRSCA with uniform amplitude excitations and a circular aperture of radius *R*. Suppose time modulation period of the $U_i(t)$ is T_p, and the TMRSCA operates at the operating frequency f_0. Its radiation pattern can be formulated as

$$F(\theta,\varphi,t)=\sum_{h=-\infty}^{\infty} e^{j2\pi(f_0+h\cdot f_p)t}\cdot\sum_{p=0}^{P-1}\sum_{i=1}^{Q} a_{hi}\sum_{j=1}^{NS_i} e^{jkr_{i,j}\sin\theta\cos\left(\omega_{i,j}+p\Delta\varphi-\varphi\right)}$$

The directivity *Dir* of the array can be expressed by

$$Dir=\frac{4\pi\left|F_{h=0}(\theta_0,\varphi_0)\right|^2}{P\cdot\sum_{h=-\infty}^{\infty}\int_0^{2\pi/P}\int_0^{\pi}\left|F_h(\theta,\varphi)\right|^2\sin\theta\, d\theta\, d\varphi}$$

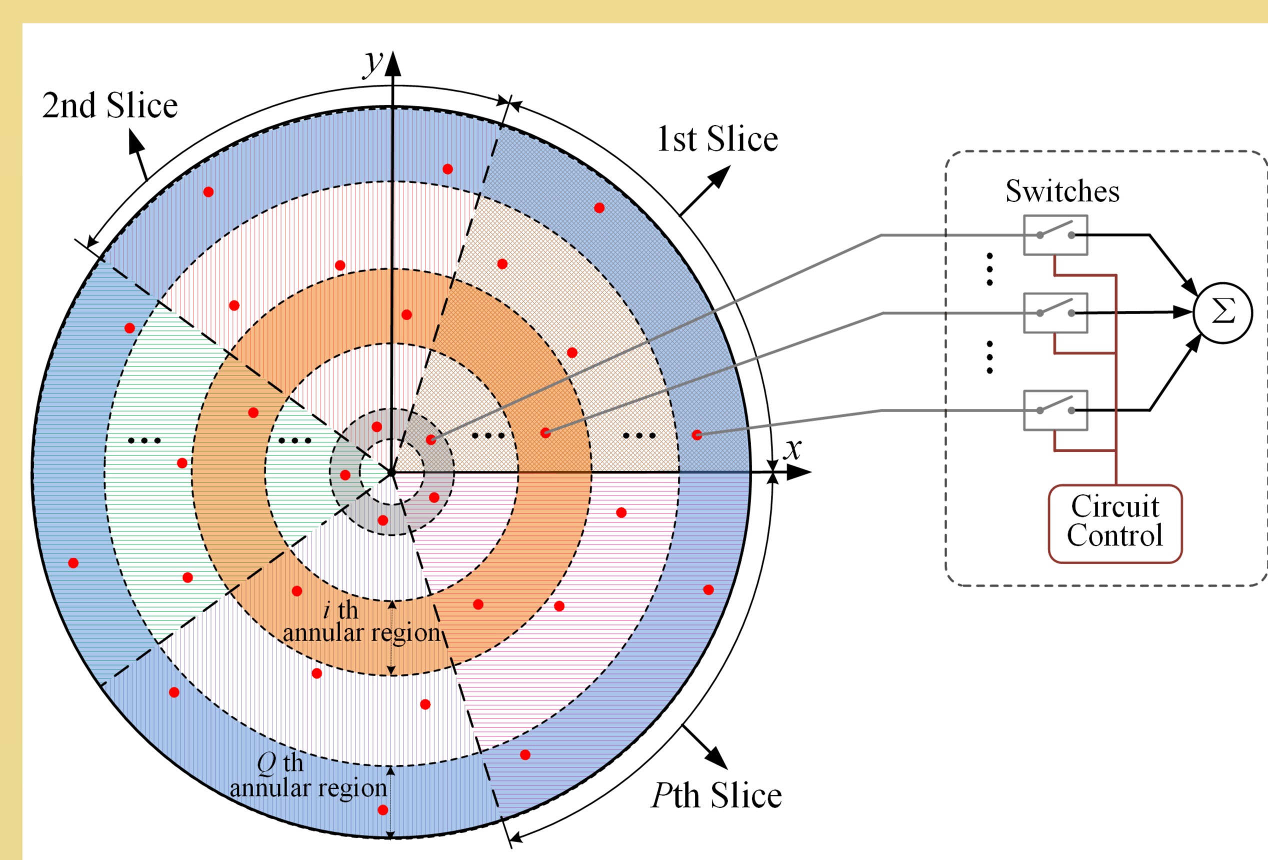

Fig. 1 Geometry of the TMRSCA in *xoy* plane.

3. Result

The element number in each annular sector, the specific time sequence in each annular sector, and all the element positions are optimized by the improved harmony search algorithm. Fig. 2(a) and 2(b) show the time sequence and the array layout of the 80-element. Some geometry and radiation properties are summarized in Table I. The 3-D radiation pattern at the operating frequency f_0 and the 3-D harmonic pattern at the first order sideband frequency f_0+f_p are given in Fig. 2(c) and 2(d).

TABLE I. Comparative Performance Of Designs

Array	*N*	*R*(λ)	SLL at f_0 (dB)	Directivity (dB)	SBL at $f_0 \pm f_h$ (dB)
Uniform A	223	4	−17.4	28.3	
Design B	80	3.8	−19.6	25.6	
Design C	80	3.8	−20.8	25.1	
Example 1 (TMRSCA)	80	3.8	−22.49	25.2	−31.46

4. Conclusion

A new design for the synthesis of time-modulated circular planar array is proposed in this letter. Comparing with other existing circular planar arrays, the TMRSCA achieves lower sidelobe level and suppressed sideband level.

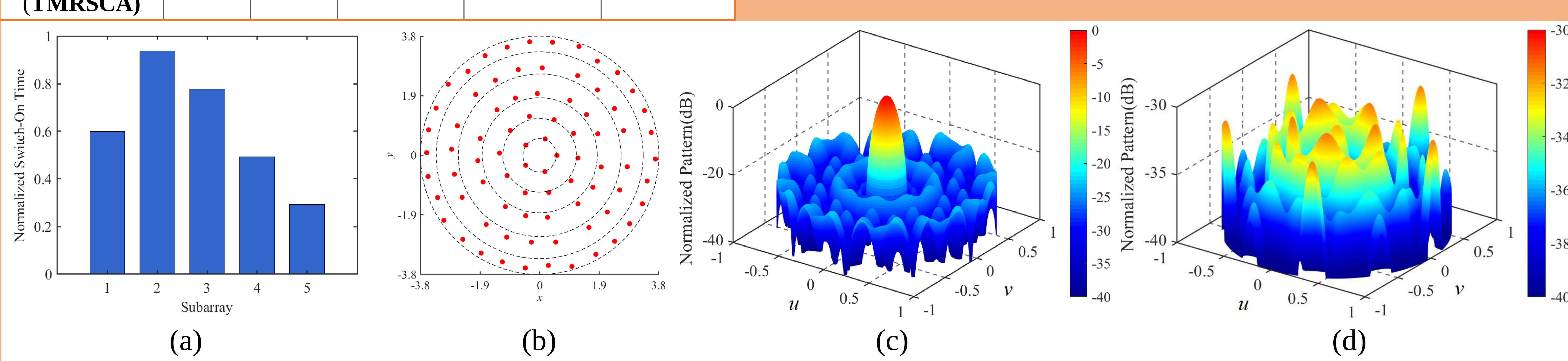

Fig.2 Results of Example 1. (a) Time sequence; (b) Array layout; (c) 3-D radiation pattern at f_0 (u=sinθcosφ, v=sinθsinφ). (d) 3-D harmonic pattern at f_0+f_p (h=1).