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# Stepped frequency chirp signal imaging radar jamming using two-dimensional nonperiodic phase modulation

**Key words:** Radar jamming; Stepped frequency chirp signal; Nonperiodic phase modulation; Wideband radar

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# Motivation

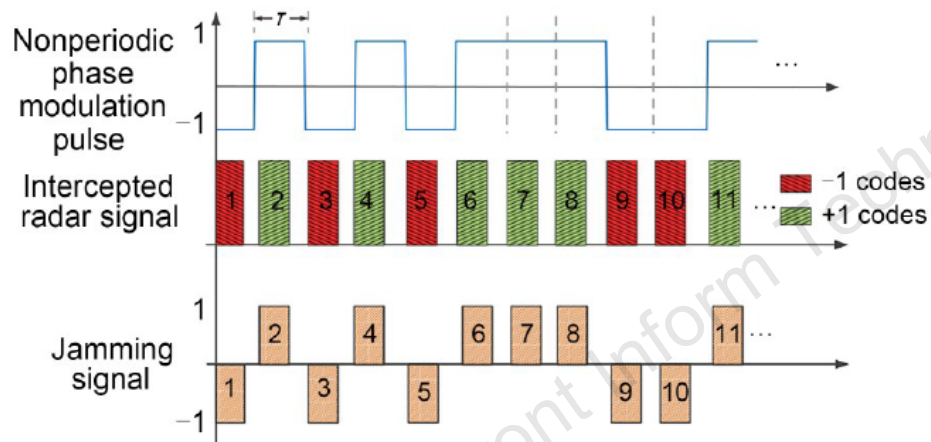
1. Stepped frequency chirp signal obtains high-resolution radar images by synthesizing multiple narrowband chirp pulses. It has been one of the most commonly used wideband radar waveforms due to its lower demand for radar instant bandwidth. Hence, it is of vital significance to explore target protection methods against stepped frequency chirp signal radar.
2. The jamming method using conventional interrupted-sampling repeater jamming (ISRJ) technique is the “0–1” modulation in the amplitude domain, which inevitably brings energy loss.

# Main idea

1. By nonperiodic phase modulation on the stepped frequency chirp signal in both fast and slow time domains, a flexible two-dimensional (2D) blanket jamming performance is obtained.
2. The proposed jamming method using “ $\pm 1$ ” modulation in the phase domain instead of the “0–1” modulation in the amplitude domain avoids the energy loss and makes a more efficient utilization of the jamming power.

# Method

## 1. Jamming mechanism



**Fig. 4** Subpulse nonperiodic phase modulation in the fast time domain

The nonperiodic phase modulation brings continuous frequency removal. By using this unique property, the jamming method is proposed using 2D nonperiodic phase modulation on the intercepted stepped frequency chirp signal, which can generate high-level sidelobes that perform as a special blanket jamming along both the range and azimuth directions and make the target unrecognizable.

# Method

## 2. Jamming procedure

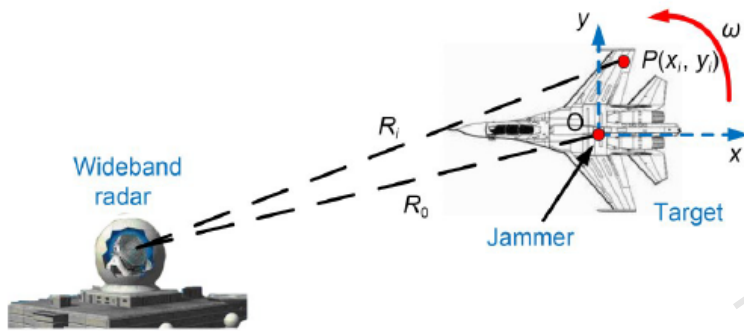


Fig. 5 Geometric relationship of the radar, target, and jammer

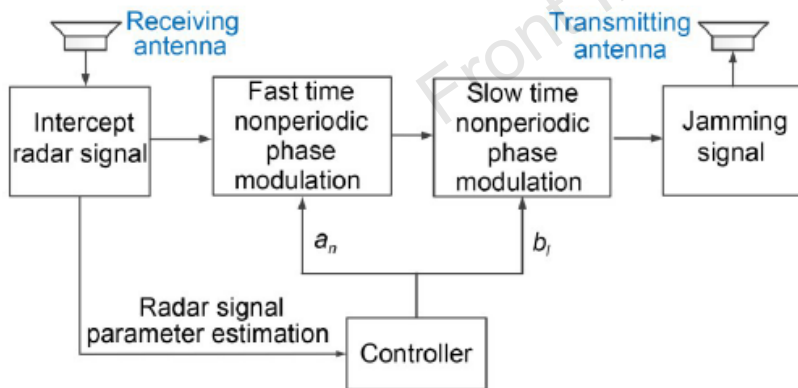


Fig. 6 The proposed jamming procedure

### Jammer assumption:

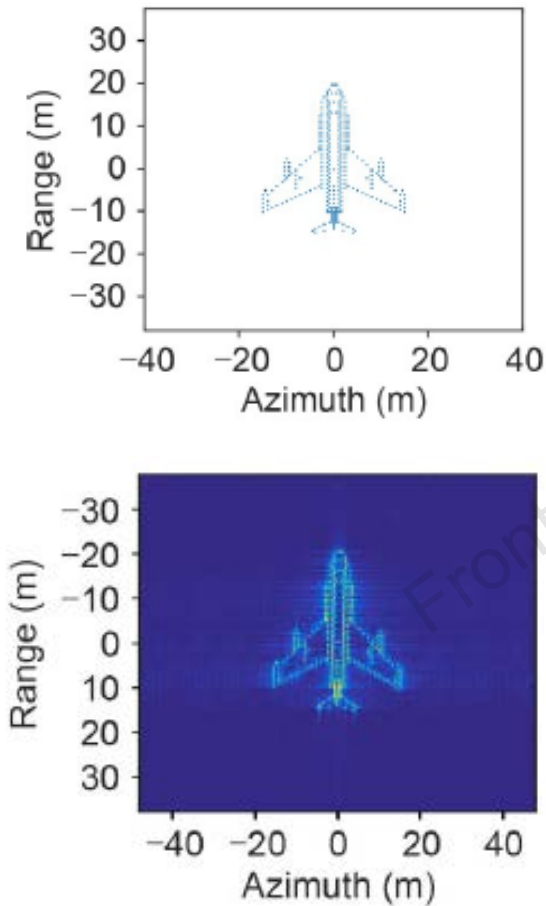
The jammer is fixed on the center of the target, which intercepts and modulates the radar signal and protects the target by transforming the target image feature.

### Jamming procedure:

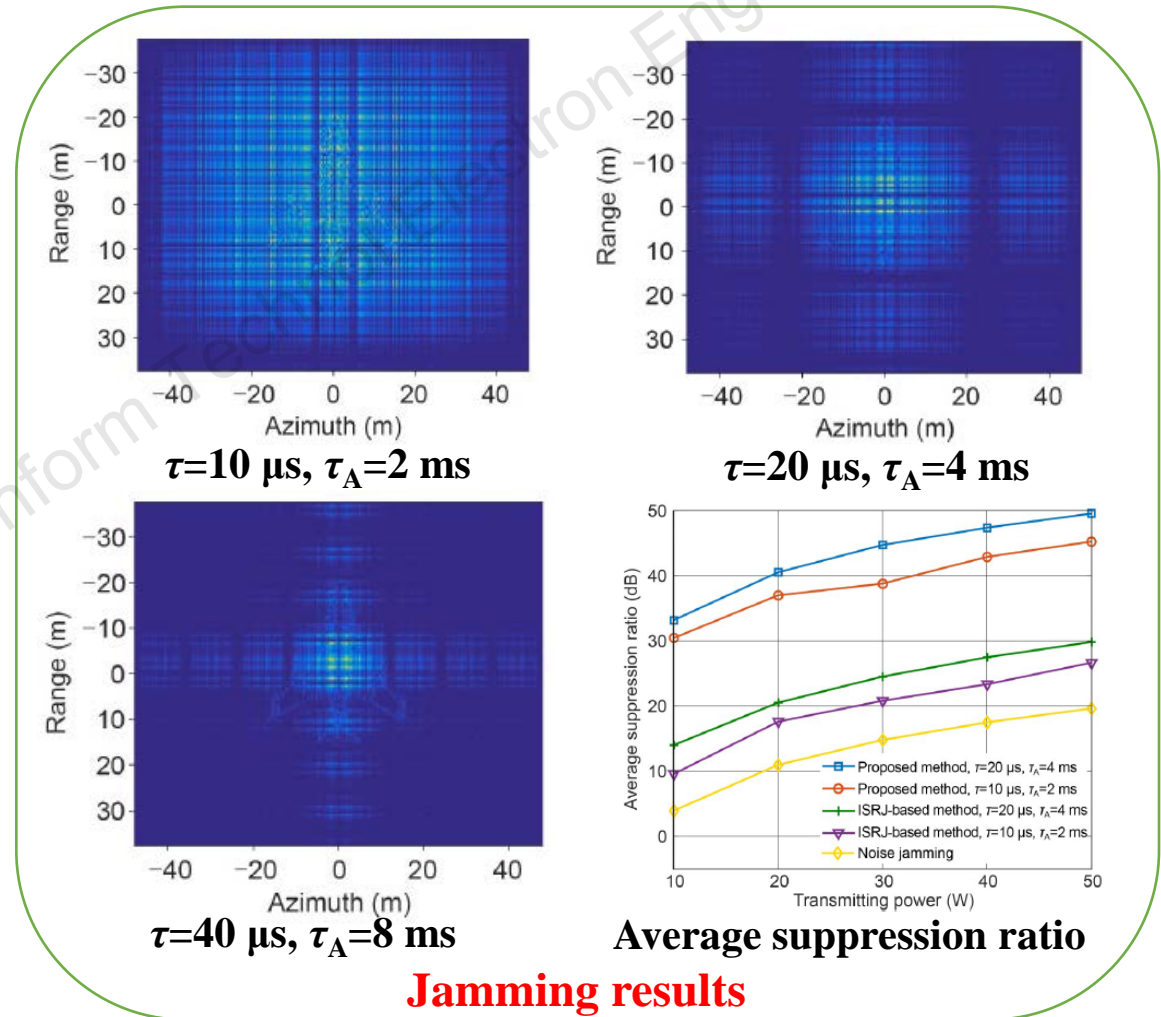
First, the jammer intercepts the radar signal by the receiving antenna. Then the controller analyzes the signal parameter and modulates the radar signal in both fast and slow time domains with the phase codes  $a_n$  and  $b_i$ , respectively. Finally, the jamming signal is retransmitted back to the victim radar after power amplification.

# Major results

## 1. Simulation results with 330-point Yake-42 data



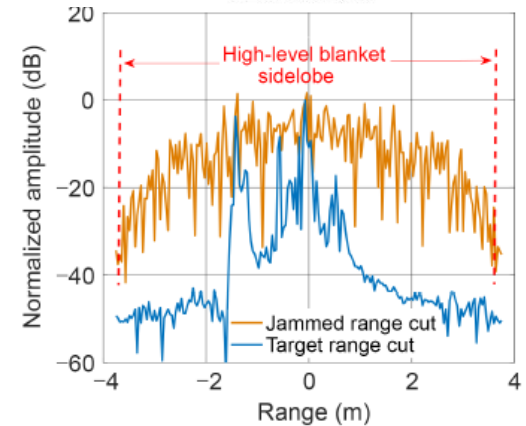
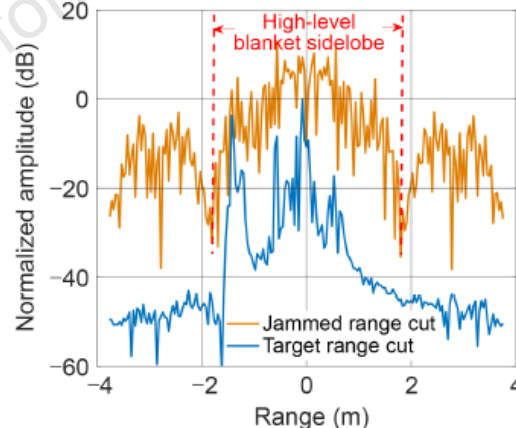
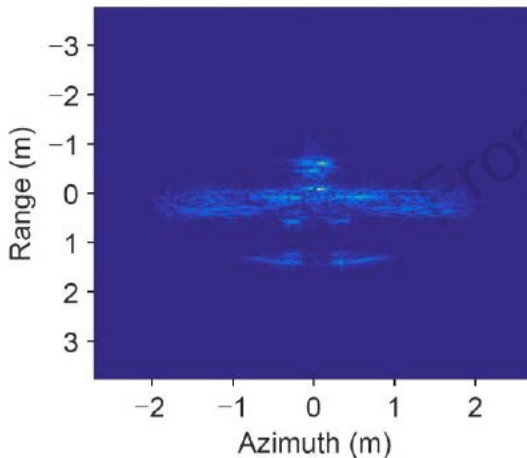
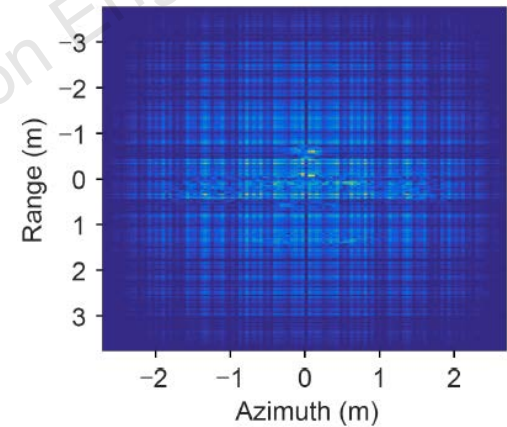
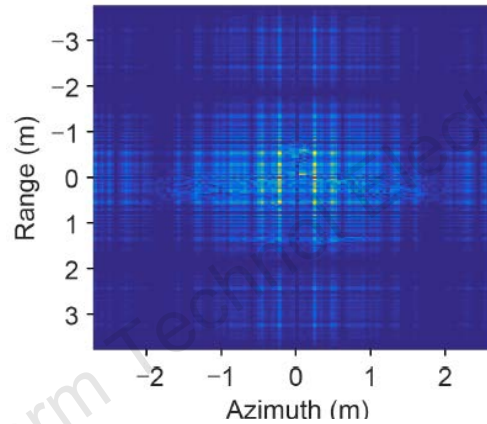
Original unjammed image



Jamming results

# Major results

2. Jamming performance with the measured unmanned aerial vehicle (UAV) data.



$\tau=20 \mu\text{s}, \tau_A=6 \text{ ms}$

$\tau=10 \mu\text{s}, \tau_A=4 \text{ ms}$

Original unjammed image

Jamming results

# Conclusions

1. In this paper, a novel blanket jamming method against stepped frequency chirp radar is proposed using two-dimensional nonperiodic phase modulation.
2. By intercepting and modulating the radar signal with a nonperiodic phase modulation pulse, the radar image will be covered by high-level blanket sidelobes spreading along both the range and azimuth directions.
3. Both the Yake-42 plane data simulation and measured UAV data experiment results demonstrate the validity of the proposed method.



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