Multiple Scattering Points Generator for Multi-Target

Hae-Chang Jeong, Gak-Gyu Choi, Dae Woong Woo, Jae Sik Kim, and So-Su Kim
Agency for Defense Development
Daejeon, Korea
hcjeong@add.re.kr

***Abstract*— A multiple scattering points generator for multi-target (MSPG-MT) is proposed to simulate multi-target engagement of a high-resolution radar (HRR) at an indoor testing. A multi-target signal generator provides to the MSPG-MT with multi-target signals generated by multiple direct-digital synthesizers (DDSs). The MSPG-MT provides to antennas with individual multiple scattering points of the multi-target generated by multiple divider blocks. The HRR receives the radiated signals from antennas and displays the multiple scattering points in the beat frequency domain. The validation of the proposed MSPG-MT was verified through a measurement using a Ku-band HRR and the MSPG-MT.**

Keywords—high resolution radar; multi-target engagement; multiple scattering points generator

I. Introduction

The advantage of a high-resolution radar (HRR) with wide bandwidth is that the target recognition can be performed by collecting and comparing reflectivity data versus range delays and viewing angles [1]. The reflectivity of the target is related to the physical scattering point of the target and multiple scattering points (MSP) may appear depending on the radar resolution.

A HRR for airborne target detection may have multi-target simultaneously within the radar beam width under certain circumstances. Figure 1 shows an example of a HRR detecting multi-target (number of targets, M=3). The transmission signal of the radar is a wideband chirp signal with a slope coefficient μ, and the received signals are echoes related to the velocity, distance, and reflectivity of each target. The obtained multi-target signal by heterodyning the transmitted signal and received echoes may have ambiguity in the separation of targets in the beat frequency domain. The ambiguity is expected to be solved by the modification of transmit signal without reducing the beam width.

Meanwhile, indoor test of a radar using a simulated target signal generator is essentially performed for reducing the radar development cost. In case of a HRR, a signal generator is needed to generate signals of MSP of a target for its indoor test. A MSP Generator (MSPG) [2], which was previously proposed and developed, has a limitation that it provides the simulated MSP only for single target. Therefore, a MSPG for multi-target (MSPG-MT) is proposed to simulate multi-target engagement of a HRR at an indoor testing.

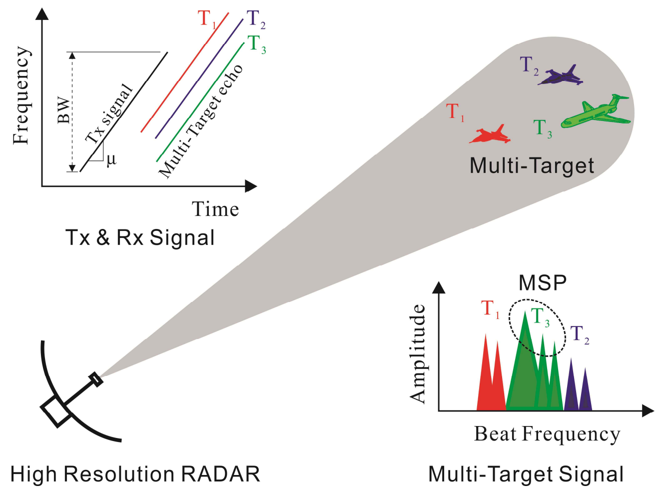

Fig. 1. An example of a High Resolution RADAR detecting multi-target. (*Number of targets, M=3*)

II. MSPG-MT configuration

Figure 2 shows the configuration of MSPG-MT and the indoor test concept of the HRR. The HRR and antennas installed in an anechoic chamber are connected to an external multi-target signal generator, an MSPG-MT, and a control computer as shown in Fig. 2. The multi-target signal generator has M channels consisting of direct digital synthesizer (DDS), frequency mixer and local oscillator (LO) per channel. The multi-target signal generator provides radar signal waveforms of the individual target using DDS with coherent signal of the HRR. The MSPG-MT is composed of M channels, in which N_M divider blocks per channel are connected in cascade. Each divider block consists of an amplifier, a time delay, a divider, and a variable attenuator. The MSPG-MT provides the multiple scattering points of each target using the time delay and the variable attenuator of the individual divider block with programmable control. Where, M is the number of targets, and N_M is the number of scattering points for M-th target, respectively. The number of ports (N_P) is the sum of N_1 to N_M. The outputs of the MSPG-MT are connected to the antennas in the chamber, and the antennas can be configured to be movable two-dimensionally in consideration of the moving targets. The signals radiated through the antennas are collected by the HRR and displayed in the beat frequency domain.

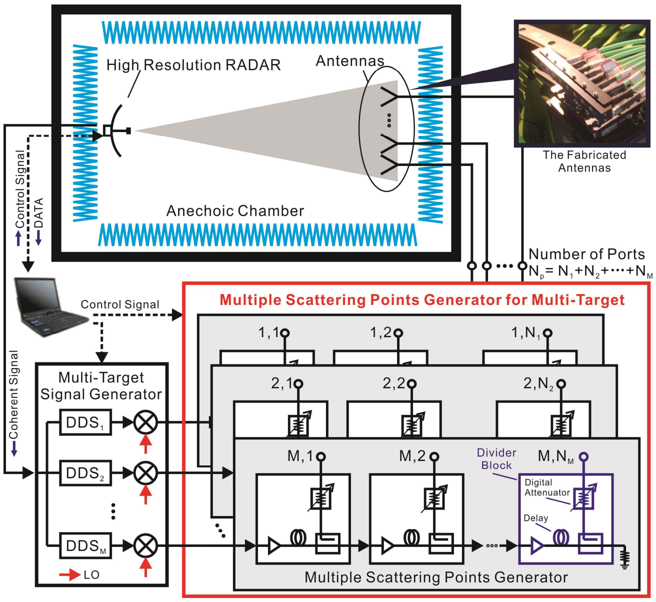

Fig. 2. A configuration of the MSPG-MT and the indoor test concept of the HRR (*M=the number of targets,* N_M*=the number of scattering points for M-th target*).

III. Measurement Result

The MSPG-MT was implemented by modifying the fabricated MPSG [2]. The series connection of the divider blocks was simply modified to be series and parallel connections considering M and N_M. The chosen factors are shown in Table I (M=2, N_1=2, N_2=3). The velocities and ranges of each target were determined to be close in the beat frequency domain by considering the performances of the HRR shown in Table II. The equation about the beat frequency (f_{beat}) is as follows [1] :

$$f_{beat}=2(vf \pm r\mu)/c \qquad (1)$$

TABLE I. MSP Profiles of Multi-Target for Indoor Test

Target No.	MSP Profile			
	Velocity	*(M, N_M)*	*Amplitude*	*Range*
#1	200 m/s	(1,1)	10 dB	1000 m
		(1,2)	8 dB	1000+3.5 m
#2	193 m/s	(2,1)	-10 dB	1040 m
		(2,2)	-10 dB	1040+3.5 m
		(2,3)	-4 dB	1040+9.5 m

TABLE II. Performances of HRR

Frequency Band	Ku Band
Resolution	≤ 1 m
Chirp slope, μ	≥ 15 GHz/s

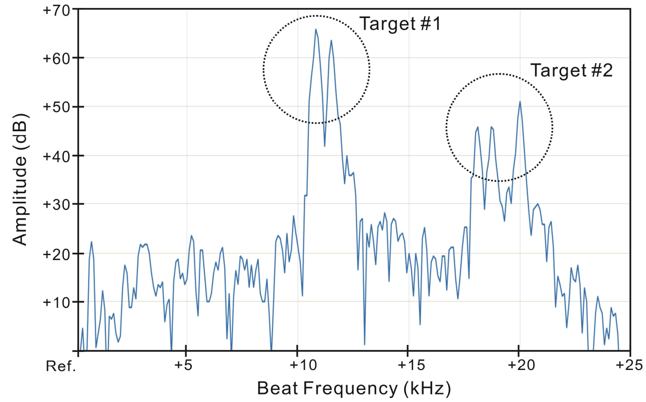

Fig. 3. The measurement result of using the HRR and the MSPG-MT (*Up-chirp spectrum*).

Here, v is velocity, f is center frequency, r is range, μ is chirp slope, and c is velocity of light. f_{beat} is calculated to be '+' for up-chirp and '-' for down-chirp.

Figure 3 shows the measurement result of using the HRR and the MSPG-MT. The measured result is the up-chirp spectrum. The MSPs of two targets in the spectrum were obtained similar to the MSP profile shown in Table I. Here, the values of amplitude axis and beat frequency axis are normalized to certain reference values.

IV. Conclusion

In order to simulate multi-target engagement of a HRR at an indoor testing, a MSPG-MT is proposed. The previously developed MSPG for single-target was simply modified to MSPG-MT. The MSP profiles defined for the two targets are similar to the measured data, the validity of the indoor test concept using the MSPG-MT was confirmed.

In the future, based on multi-target's MSP profiles of the actual engagement scenarios, MSPG-MT and multi-target generator will be fabricated. A HRR, which will be applied new algorithms or waveforms (eg, nonlinear chirp) for improvement of performances about multi-target engagement, is expected to verify experimentally using the proposed MSPG-MT.

References

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