Solid-State Pulse Compression Radars in Japan

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Abstract

We implemented the nonlinear frequency modulation (NLFM) waveform, which was developed by the Advanced Radar Research Center (ARRC) of Oklahoma University (OU).

The Optimized Frequency Modulation (OFM) waveform such as NLFM does not require mismatch filtering, thus increases the system sensitivity compared to a mismatched filtering pulse compression technique.

The result of experiment performed in early September 2013 is introduced.

Introduction

Weather radars must minimize their interference to neighboring bands due to strict reguration of electromagnetic emission in Japan. Since radio is limited public resources which should be shared efficiently, and demands of radio communication system is rapidly grown, it is just matter of time for bandwidth of weather radar will be regulated in all over the world.

In addition, the use solid-state based weather radar (SSWR) promises lower peak power, which reduces the operational costs of the weather radar, as the financial burden is directly proportional to the peak power in Japan. Using long transmit waveform and pulse compression, weather radars can achieve similar sensitivity performance of a high-power system, while linear solid-state amplifiers allows for minimal electromagnetic interference. In a joint effort between Toshiba Corporation and the Meteorological Research Institute (MRI), we developed parabolic dish-type C-band solid-state weather radar, which is currently installed at the MRI research facility in Tsukuba, Japan, in order to study the efficacy of a weather radar system using solid-state transmitter.

C-band SSWR installed in MRI facility

The first SSWR system installed in 2007

NonLinear Frequency Modulation

A waveform with non-linear frequency modulation (NLFM) was used. It should be noted that a minimal tapering is still being used for the transmit pulse shape in order to reduce interference to neighboring bands. Briefly, the waveform is optimized through an interactive process by adjusting the frequency chirp pattern until convergence to the desired performance metrics. A user-specified amplitude tapering is applied in the waveform synthesis step in order to minimize abrupt amplitude change in hardware. During the optimization process, a continuous chirp function is adjusted at each iteration, the corresponding waveform is synthesized and evaluated for the performance, which include several measurements on the ambiguity function of the waveforms, e.g. 3-dB resolution, peak sidelobes, etc. In the end, a waveform that simultaneously satisfies all the desired performance parameters are obtained, if achievable. The optimized waveform will be referred to as the optimized frequency modulation (OFM) herein. It should be emphasized here that the pulse compression scheme of the waveform is set to be match filtering so that the SNR is maximized. As such, there is no need for additional windowing at the later processing, which is advantageous compared to the windowed LFM method.

Major Components and Specification

Antenna

Advantages

- High-accuracy,
- Small size,
- Easier maintenance
- Low lifecycle cost
- Low spurious

Offline Processor

Power Distributor

Transmitter and Radar Processor

Specification

Item	Description
Observation range	230 km or more in radius
Frequency	5370 MHz
Pulse width	1 μs to 129 μs
Peak Power	3.5 kW per polarization
Receiver dynamic range	110 dB
Radome diameter	7 m or less
Antenna diameter	4 m or less
Antenna gain	42 dBi or more
Beam width	1 deg or less
Range resolution	150 m or less
Radar products	Reflectivity (ZH, ZV)
	Differential Reflectivity (ZDR)
	Doppler velocity V (m/s)
	Spectrum width W (m/s)
	Differential phase ΦDP (deg)
	Specific differential phase (KDP)
	Correlation coefficient (ρHV)
Manufacture	Toshiba Corporation