Noise radar technology and noise waveform design – prospective solution for future SISO and MIMO systems

Krzysztof Kulpa , Mateusz Malanowski
Warsaw University of Technology, Warsaw, Poland

Tutorial topic

In the tutorial the concept of continuous-wave radar emitting noise or pseudo-noise waveform will be presented. Noise waveforms have significant advantages over the classical radar waveforms, as they do not have range nor Doppler ambiguities and can be used in dense electromagnetic environment without significant interferences with other devices using the same spectrum.

In the tutorial the basics of noise radar will be presented. Problems typical for noise radar, such as the masking effect, will be identified and solutions to those problems will be analyzed. Pulse noise radar will also be presented and compared with classical deterministic pulse radar. The possibilities of target identification using micro-Doppler, SAR and ISAR imaging will be discussed. The waveform design for noise radar will be shown, including sidelobe reduction and spectrum shaping. Operation of the noise radar in MIMO configuration, both using co-located and spatially separated antennas, will be analyzed.

In the tutorial numerous real-life result examples will be shown. Possible applications of noise radar will be analyzed.

Intended audience and learning outcomes

Scientists and engineers interested in novel noise radar technology; learning outcomes – better understanding of basic phenomena and problems related to noise radars.

Military forces, government and industrial representatives; learning outcomes – understanding the noise radar technology, potential fields of applications, understanding the difference between pulse, FMCW and noise radars and their cooperation.

Prerequisites

General knowledge about radars, radar signal processing and radar applications is assumed.

Presenters biography

Prof. Krzysztof S. Kulpa received his M. Sc., Ph.D. and D.Sc. degrees from the Warsaw University of Technology (WUT) in 1982, 1987 and 2009 respectively. Since 1990 he is with Institute of Electronic Systems (WUT), working on Radar Technology, including SAR, ISAR, passive and noise radars. Since 2011 he is of Scientific Director of the Defense and Security Research Center at WUT. In 2014 he obtained the title of State Professor.

He has had more than 250 published papers, and recently had his book “Signal Processing in Noise Waveform Radar” published by Artech House.

In his professional life he has always combined teaching, theoretical research and applications. He has been involved in several application projects and worked for the Polish radar industry for 15 years.

Prof. Mateusz Malanowski received his M.Sc., Ph.D. and D.Sc. degrees in Electrical Engineering from the Warsaw University of Technology, Warsaw, Poland, in 2004, 2009 and 2013 respectively.

He was a Research Scientist with FGAN (Forschungsgesellschaft fuer Angewandte Naturwissenschaften), Germany, and an Engineer with Orpal, Poland. Currently, he is an Associate Professor at the Warsaw University of Technology.

Prof. Malanowski is the author/coauthor of over 180 scientific papers. He is also an author of "Signal Processing for Passive Bistatic Radar" book, published by Artech House.

His research interests are radar signal processing, target tracking, passive coherent location, synthetic aperture radar and noise radar. For the last 14 years he has been involved in numerous national and international projects, focusing on passive radar, synthetic aperture radar and noise radar. He has been a member of several NATO Science and Technology Organization groups. Prof. Malanowski is currently managing a project, whose aim is to develop first Polish, and one of the first in the world, operational military (TRL9) passive radar system.

Prof. Malanowski is a IEEE Senior Member and a member of Institution of Engineering and Technology (IET) and European Microwave Association (EuMA).

Outline of the tutorial:

1. Introduction to noise radar: noise radar principle, continuous-wave versus pulse radar, noise radar range equation, basic physical phenomena
2. Target detection in noise radar: target motion models, correlation-based detection, ambiguity function computation, range and velocity walk problems and mitigation
3. Target identification in noise radar: micro-Doppler analyses, SAR and ISAR imaging, sparse imaging
4. Quasi-random signals: noise-like waveform design, reduction of sidelobes and residual fluctuations in time and Doppler frequency, using mismatched filtering
5. Spectrum allocation: wideband noise radar, sparse spectrum radar, illuminating signal shaping and side lobe control in crowded spectrum
6. MIMO noise radars: spatial diversity of illuminating signals, clutter cancelation in MIMO radars, waveform optimization. Collocated MIMO versus multi-static approach
7. Applications: surveillance radars, sector and forward scattering solutions, space applications, LPI, imaging

Tutorial history:

1. "Noise Radar: monostatic, multistatic and MIMO", EURAD 2014, 10 October 2014, Rome, Italy, about 25 attendees
2. "Noise Radar Systems", EURAD 2012, Amsterdam, 2.10.2012, The Nederland, about 20 attendees
3. "Noise Radar – New Challenges in SISO and MIMO Radars", 2016 IEEE Radar Conference Philadelphia, PA (given by P. Samczynski and J. Kulpa), number of attendees: app. 10
4. "Noise Radar – unlimited waveform diversity SISO and MIMO radars", 2017 IEEE Radar Conference Seattle (given by P. Samczynski and J. Kulpa), number of attendees: app. 15
5. "Noise radar technology and noise waveform design – prospective solution for future SISO and MIMO systems", RadarConf 2018, Oklahoma City, OK, 23-27 April 2018, attendance: app. 15