

Passive radar – from target detection to imaging

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Tutorial topic

The topic of the tutorial is multistatic passive radar for target detection and imaging. In the first part of the tutorial the basics of passive radar will be presented. These include a review of possible illuminators of opportunity (e.g. FM radio, digital television, cellular telephony), and features of different signals from the point of view of radar detection. The bi/multistatic geometry will be presented, and passive radar equation will be analyzed.

The second part will be focused on detection and tracking of airborne targets using passive radar. A typical signal processing chain, consisting of clutter filtering, crossambiguity function calculation, detection, bistatic tracking and Cartesian tracking, will be described. Selected results and applications will be shown.

The third part will be devoted to target imaging using passive radar. This will be focused on ISAR (Inverse Synthetic Aperture Radar) mode, where images of targets are created.

The last part of the tutorial will outline possible future applications of passive radar. These include passive radar on moving platforms, e.g. airborne or seaborne. Terrain mapping in the SAR (Synthetic Aperture Radar) mode will be presented as one of the possible applications of passive radar on a moving platform. At the end, the concept of Deployable Multiband Passive/Active Radar will be presented, in which a combination of active and passive radars is used.

Intended audience and learning outcomes

Scientists and engineers working with general radar technology; understanding similarities and differences between passive and active radar technologies

Scientists and engineers working with passive radar technology; learning about practical aspects of implementation of passive radar technology

Representatives of the military, government and industry; understanding of the general principles and potential fields of applications of the passive radar technology, comprehension of the difference between passive and active radars, and their potential symbiosis

Prerequisites

Knowledge of radars' basics together with understanding of fundamentals of radar signal processing and familiarity with a few radar applications.

Presenters biography

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).



Prof. Piotr Samczynski received his B.Sc. and M.Sc. degrees in electronics and Ph.D. and D.Sc. degrees in telecommunications, all from the Warsaw University of Technology (WUT), Warsaw, Poland in 2004, 2005, 2010 and 2013 respectively. Since 2018, he has been the Associate Professor at the WUT; and since 2014 – a member of the WUT’s Faculty of Electronics and Information Technology Council. Prior to this, he was Assistant Profesor at WUT (2018-2010), a research assistant at the Przemyslowy Instytut Telekomunikacji S.A. (PIT S.A.) (2010-2005) and the head of PIT’s Radar Signal Processing Department (2010-2009).

Prof. Samczynski’s research interests are in the areas of radar signal processing, passive radar, synthetic aperture radar and digital signal processing. He is the author of over 200 scientific papers.

Prof. Samczynski was involved in several projects for the European Research Agency (EDA), Polish National Centre for Research and Development (NCBiR) and Polish Ministry of Science and Higher Education (MiNSW), including the projects on SAR, ISAR and passive radars. Since 2009 he has been a member of several research task groups under the NATO Science and Technology Organization, where he supports the research work in the fields of radar signal

processing, modern passive and active radars architectures and noise radars. Since 2018 he is a Chair of NATO SET-258 research task group (RTG) on Deployable Multiband Passive/Active Radar (DMPAR) deployment and assessment in military scenarios.

Prof. Samczynski is an IEEE member since 2003, and IEEE Senior member since 2016. He is a member of IEEE AES, SP, and GRS Societies and since March 2017 Prof. Samczynski is a Chair of the Polish Chapter of the IEEE Signal Processing Society. He received *IEEE Fred Nathanson Memorial Award* for outstanding contribution to the field of passive radar imaging, including systems design, experimentation and algorithm development in 2017.



Prof. Krzysztof 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 Publishers.

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.



Outline of the tutorial:

1. Passive radar technology basics
 - a. Illuminators of opportunity for passive radar
 - b. Bistatic geometry and radar equation
2. Passive radar for target detection
 - a. Signal processing for airborne target detection
 - b. Example results and applications
3. Target imaging with passive radar in ISAR mode
 - a. Introduction to radar imaging using ISAR techniques
 - b. Passive ISAR image creation algorithms
 - c. Example results and applications
4. Outlook on potential future developments and applications
 - a. Passive radars on moving platforms (airborne and seaborne)
 - b. Airborne and spaceborne SAR imaging
 - c. Deployable Multiband Passive/Active Radar (DMPAR) applications

Tutorial history:

1. "Signal Processing for Passive Coherent Location Radar", European Radar Conference (EURAD) 2011, 12 October 2011, Manchester, United Kingdom, conference tutorial, attendance: app. 50
2. "Recent Developments on Passive Radars", Ohio State University, 07 May 2013, Columbus, Ohio, USA, lecture on invitation by prof. Christopher Baker, attendance: app.30
3. "Recent Developments on Passive Radars", Air Force Research Laboratory, 08 May 2013, Dayton, Ohio, USA, a talk on invitation by Dr. Braham Himed, attendance: app.40
4. "Short Course on Passive Radar – Recent Developments in Passive SAR/ISAR Imaging", 15 May 2014, Rensselaer Polytechnic Institute, Troy, New York, USA, a 3h course on invitation by prof. Birsen Yazici, attendance: app.30
5. "Passive Radar Research", IEEE AESS Dayton Chapter Seminar, 29 May 2014, a talk given at Tec^Edge Collaboration Center, Dayton, Ohio, USA, attendance: app.40
6. "SAR/ISAR Imaging using Active & Passive Radars", conference tutorial, RadarConf 2016, 1-6 May 2016, Philadelphia, USA
7. "Passive SAR/ISAR Imaging – to be invisible and to catch invisible", tutorial accepted on International Conference on Radar Systems – RADAR 2017, 23-26 October 2017, Belfast, Ireland
8. "Passive imaging using SAR and ISAR technology", European Radar Conference (EURAD) 2017, 11-13 October 2017, Nurnberg, Germany
9. "Fundamentals of Active and Passive SAR/ISAR Imaging", IRSI-17: 11th International Radar Symposium India-2017, Nimhans Convention Centre, Bangalore, India, December 12-16, 2017, attendance: app. 100
10. "Advanced Multistatic Passive Radar - from Detection to Imaging", Radar Conference, 27-30 August 2018, Brisbane, Australia, attendance: app. 40
11. "Passive radar – from target detection to imaging", RadarConf 2019, Boston, MA, 22-26 April 2019, attendance: app. 20