

Power Line Communications for the Smart Grid

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Tutorial

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This tutorial covers recent advances in Power line communication (PLC) which is among the most interesting and important communication technology candidates for application in the Smart Grid since the grid is not only the information source but it also offers the infrastructure for the information delivery.

An overview of the various application scenarios of PLC (such as in-home, in-vehicle, and smart grids) and a summary about the evolution of PLC technology will be provided.

We will then discuss the important topics of channel and noise modeling and report up-to-date results about statistical channel modeling, MIMO channel modeling, and noise/disturbances modeling.

The main challenges of physical layer design for both narrow-band (NB-PLC) and broad-band PLC (BB-PLC) to encompass the presence of channel attenuation and frequency selectivity, interference, and various noise sources will be addressed. In particular, we will describe existing and emerging single carrier modulation approaches, filter bank modulation approaches (as OFDM, DWMT, FMT), and ultra wide band techniques. We will show that advanced modulation techniques, combined with coding and smart resource allocation algorithms are capable of granting robust performance and coexistence with other technologies.

We will then focus on the specific Smart Grid applications (as automatic meter management, grid monitoring, vehicle-to-grid communication, demand side management, home networking for energy management) and remark the similarity to those found in sensor and control networks. The role of PLC in HV, MV and LV networks will be discussed and in particular the relevant role of NB-PLC. MAC algorithms for sensing and control we will described as well as proposed relaying and cooperative schemes that grant range extension through the grid.

Finally, an overview of the main standards will be offered covering both NB-PLC and broad-band BB-PLC.

List of topics:

- Power line communication applications and evolution of PLC technology
- Channel modeling for narrow-band and broad-band communications, recent advances in statistical modeling and MIMO modeling.
- Noise modeling for broad-band and narrow-band PLC
- Physical layer techniques, single carrier modulation, filter bank modulation, coding and resource allocation algorithms.
- Smart Grid applications and the role of PLC.
- Narrow-band PLC and optimum modem algorithms design
- MAC protocols for sensing and control in the smart grid.
- Relaying and cooperative schemes.
- PLC standards.

Biographies :

Masaaki Katayama, Nagoya University, Japan

Masaaki Katayama, Prof. of Ecotopia Science Institute, Nagoya University, was born in Kyoto, Japan in 1959. He received the B.S., M.S. and Ph.D. degrees from Osaka University, Japan in 1981, 1983, and 1986, respectively, all in Communication Engineering. After working for Toyohashi University of Technology and Osaka University as a faculty member, in 1992, he joined Nagoya University as an associate professor, and has been a professor since July 2001. He also had been working at the College of Engineering of the University of Michigan from 1995 to 1996 as a visiting scholar. His current research interests are on the physical and media-access layers of radio communication systems. His current research projects include, Smart Grid and Energy Management Systems, Reliable Robust Radio Controls, Cognitive Radio, Power-Line Communications, Visible Light Communications, Next Generation Mobile Communications, and Satellite Communications. Dr. Katayama is a fellow of IEICE, a senior member of IEEE, and a member of Reliability Engineering Association of Japan.

Andrea M. Tonello, University of Udine, Italy

Andrea M. Tonello received the Doctor of Engineering degree in electronics (cum laude), and the Doctor of Research degree in electronics and telecommunications, both from the University of Padova, Italy in 1996 and 2003, respectively. On February 1997, he joined as a Member of

Technical Staff, Bell Labs – Lucent Technologies, where he worked on the development of baseband algorithms for cellular handsets, first in Holmdel, NJ, and then within the Philips/Lucent Consumer Products Division in Piscataway, NJ. From September 1997 to December 2002, he has been with the Bell Labs Advanced Wireless Technology Laboratory, Whippany, NJ. He was promoted in 2002 to Technical Manager, and was appointed Managing Director of Bell Labs, Italy. He conducted research on wireless systems, on air interface design and performance analysis. He was involved in the standardization of the evolution of 2G and 3G cellular technology.

In January 2003, he joined the Dipartimento di Ingegneria Elettrica, Gestionale, e Meccanica (DIEGM) of the University of Udine, Italy, where he is an Aggregate Professor and founder of the Wireless and Power Line Communication Lab. His research focuses on next generation wireless systems, infomobility and vehicular networks, power line communications including in-home and smart grids. He has been involved in several European coordinated actions through FP5-FP7 EU funded projects and within the Institutional Human Resources Strategy Group that aims at implementing the European charter for researchers and the code of conduct of the recruitment of researchers.

Dr. Tonello received several awards among which a Lucent Bell Labs Recognition of Excellence award in 2003, the 2007 Eurasip Journal on Advances in Signal Processing Best Paper Award. He co-authored the papers that received the best student paper awards at the IEEE International Symposium on Power Line Communications (ISPLC) in 2010 and in 2011, and the IEEE Vehicular Technology Conference 2011 Spring MIMO track best paper award. He was awarded a Distinguished Visiting Fellowship from the Royal Academy of Engineering, UK, in 2010. He held chairing positions at conferences and in particular he was the TPC Co-chair of IEEE ISPLC 2007, the Chair of the Workshop on Power Line Communications 2009, and the General Chair of IEEE ISPLC 2011.

He serves as an Associate Editor for the IEEE Transactions on Vehicular Technology, and he is in the editorial board of ISRN Communications and Networking. He is the Vice-chair of the IEEE Communications Society Technical Committee on Power Line Communications.

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