Frequency Offset Estimation for Satellite Communications with Adaptive Frame Averaging

Julian Webber, Masanori Yofune, Kazuto Yano, Naoya Kukutsu, Kiyoshi Kobayashi and Tomoaki Kumagai

Advanced Telecommunications Research International, 2-2-2, Hikaridai, Seika-cho, Kyoto, 619-0288, Japan

{jwebber, yofune_masanori, kzyano, kukutsu, kumagai}@atr.jp

Abstract-The modified Luise and Reggiannini (L&R) algorithm is one of the frequency offset estimation algorithms suitable for use with the Digital Video Broadcasting - Satellite (DVB-S2) standard. Recently we demonstrated an enhanced poly-polarization multiplexing (EPPM) system incorporating L&R frequency recovery as a hardware prototype in order to evaluate its high spectral-efficiency in a real satellite channel. In order to provide sufficient performance at low SNR, it is recommended to average the correlation estimates over 2048 frames. In high SNR regions however, such a large averaging size is unnecessary. In this paper, two techniques are proposed in order to reduce the averaging size. The first technique measures the average noise power and selects an efficient frame averaging length using a noise look-up-table (LUT). The second technique uses a cyclic redundancy check (CRC) to determine if sufficient performance is achievable with the averaging size. Performance results show that the size of the averaging window can be reduced whilst maintaining a target BER. The noise LUT adaptive scheme has been implemented in hardware and we describe the real-time behavior.

Keyword-satellite communications, polarization multiplexing, frequency offset estimation, latency reduction.

Julian WEBBER received the M.Eng. and Ph.D. degrees from the University of Bristol, UK in 1996 and 2004 respectively. From 1996-98, he was with Texas Instruments, Europe engaged on ASIC and DSP systems. From 2001-07 he was employed as a Research Fellow at Bristol University engaged in real-time MIMO-OFDM testbed implementation, and from 2007-12 he was a Research Fellow at Hokkaido University, Sapporo, Japan, working on MIMO signal processing & wireless communications. He is currently a researcher at ATR, Kyoto, Japan principally working on frequency recovery and spectrally efficient modulation techniques for satellite communications. His other current research interests include MIMO, high resolution direction of arrival estimation and M2M. He is a member of the IEEE and IEICE.

Masanori Yofune received the B.E. and M.S. degrees in systems engineering from Hiroshima City University, Hiroshima, Japan, in 2008 and 2010, respectively. In 2010, he joined Mobile Techno Corporation, Kawasaki, Japan, where he has been engaged in research and development on wireless communication systems. In 2012, he was assigned to ATR Wave Engineering Laboratories as a researcher and engaged in research and development on advanced techniques for frequency efficiency in satellite communication systems. His interest areas are wireless communication systems and digital signal processing. He is a regular member of the Institute of Electronics, Information and Communication Engineers (IEICE) of Japan.

Kazuto Yano received a B.E. degree in electrical and electronic engineering, M.S. and Ph.D. degrees in communications and computer engineering from Kyoto University in 2000, 2002, and 2005, respectively. He was a research fellow of the Japan Society for the Promotion Science (JSPS) from 2004 to 2006. In 2006, he joined the Advanced Telecommunications Research Institute International (ATR). Currently, he is a senior research scientist of the Wave Engineering Laboratories, ATR. His research interests include space-time signal processing for interference suppression, MIMO transmission, and PHY/MAC cross-layer design of cognitive radio for ISM bands. He received the IEEE VTS Japan 2001 Researcher’s Encouragement Award, the IEICE Young Researcher’s Award in 2007, the Ericsson Young Scientist Award 2007 and the IEICE 2007 Active Research Award in Radio Communication Systems. He also received 2010 Young Investigator Award in Software Radio from IEICE Technical Committee on Software Radio. He is a member of IEEE and IEICE.
Naoya Kukutsu received the B.E., M.E., and D.E. degrees in electrical engineering from Hokkaido University, Sapporo, Japan, in 1986, 1988 and 1991, respectively. His D.E. dissertation described research for a time-domain electromagnetic wave numerical analysis method. In 1991, he joined the Nippon Telegraph and Telephone Corporation (NTT), Applied Electronics Laboratories, and was engaged in developing high speed IC packages. From 2008-2013, he was a senior research engineer, supervisor at NTT Microsystem Integration Laboratories, and leader of the group that develops millimeter-wave and terahertz-wave radio transmission, as well as imaging systems. He is currently a senior research engineer at ATR Wave Engineering Laboratories and head of the department of Environment Communications. Dr. Kukutsu is a member of the IEEE MTT and COM Societies and a senior member of the Institute of Electronics, Information and Communication Engineers (IEICE).

Kiyoshi Kobayashi received the B.E., M.E. and Ph.D. degrees from Tokyo University of Science, Japan, in 1987, 1989 and 2004, respectively. He joined NTT Radio Communication Systems Laboratories in 1989. Since then, he has been engaged in the research and development of digital signal processing algorithms and their implementation techniques including modem, synchronization control and diversity for satellite and personal wireless communication systems. From 2011 to 2014, he was the director of ATR Wave Engineering Laboratories at Advanced Telecommunications Research Institute International, where he was engaged in research on advanced technologies for wireless communications. Currently, he is a senior research engineer, supervisor and a group leader of Satellite Communication Group in NTT Access Network Service Systems Laboratories, working on development of satellite communication systems. He is a member of IEEE and IEICE.

Tomoaki Kumagai received the B.E. and M.E. degrees in Electrical and Communication Engineering, and Ph.D. degree in Information Science from Tohoku University, Sendai, Japan, in 1990, 1992 and 2008, respectively. Since joining NTT in 1992, he has been engaged in research and development of personal communication systems and high-speed wireless LAN systems. Since 2014, he is the Director of Wave Engineering Laboratories, Advanced Telecommunications Research Institute International (ATR). He received the Young Engineer Award from the Institute of Electronics, Information and Communication Engineers (IEICE) in 1999. He is a member of the Institute of Electronics, Information and Communication Engineers (IEICE) and IEEE.