Performance Analysis of the Power Splitting Simultaneous Lightwave Information and Power Transfer (PS-SLIPT) Architecture

Sumali Saumya Morapitiya

(188111E)

Thesis submitted in partial fulfillment of the requirements for the degree
Master of Philosophy

Department of Electronic and Telecommunication Engineering

University of Moratuwa
Sri Lanka

December 2021

Declaration

I declare that this is my own research proposal and this proposal does not incorporate without acknowledgement any material previously published submitted for a Degree or Diploma in any other university or institute of higher learning and to the best of my knowledge and belief, it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

Signature of the Student:..... *Date:.....*

I have read the proposal and it is in accordance with the approved university proposal outline. I am willing to supervise the research work of the above candidate in the proposed area.

Signature of the Supervisor:..... *Date:.....*

Prof. Dushantha Nalin K.Jayakody, Sri Lanka Technological Campus (SLTC), Sri Lanka.

Signature of the Supervisor:..... *Date:.....*

Prof. L.W.P. R Udayanga, University of Moratuwa, Sri Lanka.

Abstract

Recent studies done on Simultaneous Lightwave Information and Power Transfer (SLIPT) has become a hot topic among the research community. The importance of the SLIPT is to harvest energy using light sources while decoding the information. In this thesis work, we present the mathematical framework for the Power Splitting (PS) based SLIPT system and study the performance of the PS-SLIPT and Time Splitting (TS)-SLIPT architectures. Moreover, we quantitatively study the harvested energy with different Field of View (FoV) angles of the Light Emitting Diode (LED) and the Photodiode (PD). In addition, analyze the important parameter of the Visible Light Communication (VLC) system to achieve maximum received power and we consider the amount of harvested energy for different Direct Current (DC) values. Overall, concludes that the Field of View (FoV) and DC bias signals are directly affected by SLIPT systems. Using numerical simulations, we demonstrate the performance of the both architectures to enhance the QoS of information decoding data rate, amount of harvested energy and trustworthiness of the information.
Further, our research work extend to Simultaneous Wireless Information and Power Transfer (SWIPT) technique is introduced in Radio Frequency (RF) communication to carry both information and power in same medium. In this approach, the energy can be harvested while decoding the information carries in an RF wave. Recently, the same concept apply in VLC namely SLIPT, which is highly recommended in an indoor applications to overcome the problem facing in RF communication. Thus, the SLIPT is introduce to transmit the power through a Light Emitting Diode (LED) luminaries. In this work, we compare both SWIPT and SLIPT technologies and realize SLIPT technology archives increase performance in terms of the amount of harvested energy, outage probability and error rate performance.

Index terms - Outage Probability, Simultaneous Lightwave Information and Power Transfer (SLIPT), Simultaneous Wireless Information and Power Transfer (SWIPT), Visible Light Communication (VLC), Energy Harvesting (EH), Light Emitting Diode (LED), Information Decoding (ID)

List of publications

1. **Sumali S. Morapitiya**, Mohammad Furqan Ali, Samikkannu Rajkumar, Sanika K. Wijayasekara, Dushantha Nalin K. Jayakody and R.U.Weerasuriya "A SLIPT-Assisted Visible Light Communication Scheme" *IEEE International Conference on Distributed Computing in Sensor System (DCOSS)*, California, USA, 15^{th} June 2020.

2. **Sumali S. Morapitiya**, TWW Leelarathna, Dushantha Nalin K. Jayakody and RU Weerasuriya "Performance Analysis of the SLIPT Architectures" *10th IEEE International Conference on Information and Automation for Sustainability 2021 (IEEE ICIAFS 2021)*, Sri Lanka, 15^{th} August 2021.

Acknowledgements

I would like to extend my gratitude to my supervisors, Prof. L.W.P. Ruwan Udayanga, Department of Electronic and Telecommunication Engineering, University of Moratuwa and Prof. Dushantha Nalin K. Jayakody, Head - School of Postgraduate Research, Sri Lanka Technological Campus (SLTC), Padukka, Sri Lanka and professor at the School of Computer Science & Robotics, National Research Tomsk Polytechnic University (TPU), Russia for their academic advice, continuous guidance and the tremendous support given to me throughout my research study. I am extremely grateful that you took me on as a student and continued to have faith in me over the years.

I am fortunate to have been a part of the Center for Telecommunication Research (CTR) committee member - SLTC. Your encouraging words and thoughtful, detailed feedback have been very important to me. My appreciation also goes out to my family and friends for their encouragement and support all through my studies.

Contents

List of Figures

List of Tables

List of Abbreviations

Abbreviation	Description
AC	Alternative Current
AF	Amplify and Forward
APD	Avalanche Photo Diode
AWGN	Additive White Gaussian Noise
BER	Bit Error Rate
CSK	Colour Shift keying
DC	Direct Current
DCN	Data Center Network
DF	Decode and Forward
dLoS	direct Line of Sight
DPSK	Differential Phase Shift keying
EH	Energy Harvesting
FCC	Federal Communication Commission
FF	Fill Factor
FoV	Field of View
FPGA	Field Programmable Gate Array
FSO	Free Space Optics
ID	Information Decoding
IM/DD	Intensity Modulation/Direct Detection
IoT	Internet of Things
IR	Infrared
LAN	Local Area Network
LED	Light Emitting Diode
LoS	Line of Sight
OWC	Optical Wireless Communication
MAN	Metropolitan Area Network
MIMO	Multiple Input Multiple Output

MSN	Minimum Shift Keying
NRZ	Non-Return Zero
OFDM	Orthogonal Frequency Division Multiplexing
OLED	Organic LED
OOK	On-Off Keying
PD	Photo-diode
PPM	Pulse Position Modulation
PWM	Pulse Width Modulation
PS	Power Splitting
QoS	Quality of Service
RAT	Relay Assisted Technology
RF	Radio Frequency
SLIPT	Simultaneous Lightwave Information and Power Transfer
SPPM	Spatial Pulse Position Modulation
SSK	pace-Shift-Keying
SNR	Signal to Noise Ratio
SPAD	Single Photon Avalanche Diode
SWIPT	Simultaneous Wireless Information and Power Transfer
TDMA	Time Division Multiple Access
TS	Time Splitting
UV	Ultra Violet
UWAV	Underwater Autonomous Vehicle
VLC	Visible Light Communication
VPPM	Variable Pulse Position Modulation
V-to-V	Vehicle to Vehicle
WHO	World Health Organization