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Secure analysis on artificial-noise-aided simultaneous wireless information and power transfer systems

Key words: Artificial noise; Multi-antenna systems; Secrecy outage probability; Simultaneous wireless information and power transfer

Corresponding author: Qing-shan TANG
E-mail: cstqs001@126.com
ORCID: https://orcid.org/0000-0002-8797-7732

Motivation

1. Simultaneous wireless information and power transfer (SWIPT) systems are more and more popular in both theory and applications due to the fact that radio-frequency (RF) acts as the energy source and SWIPT can provide a convenient, safe, and green alternative for energy harvesting.
2. SWIPT systems have an eavesdropper-attack problem, especially when the source needs to transmit information signals and energy to different users.
3. By designing the signal structure to involve artificial noise in the eavesdropper side in the multi-antenna systems, a better secrecy outage performance can be achieved.

Method

1. A simple closed-form expression for the SOP is derived by using the Gauss-Laguerre quadrature (GLQ) method, where a few summation terms in GLQ can make a very tight approximation to the exact SOP.
2. By using the asymptotic result for the upper incomplete Gamma function in high SNR, we can derive the asymptotic expression for the SOP, where the secrecy diversity order and array gain are presented.
3. In view of the robust approximation method proposed and developed in some related works, a robust approximation for the SOP is easily derived, which has a very high accuracy in the low-SINR region of the eavesdropper.

Major results

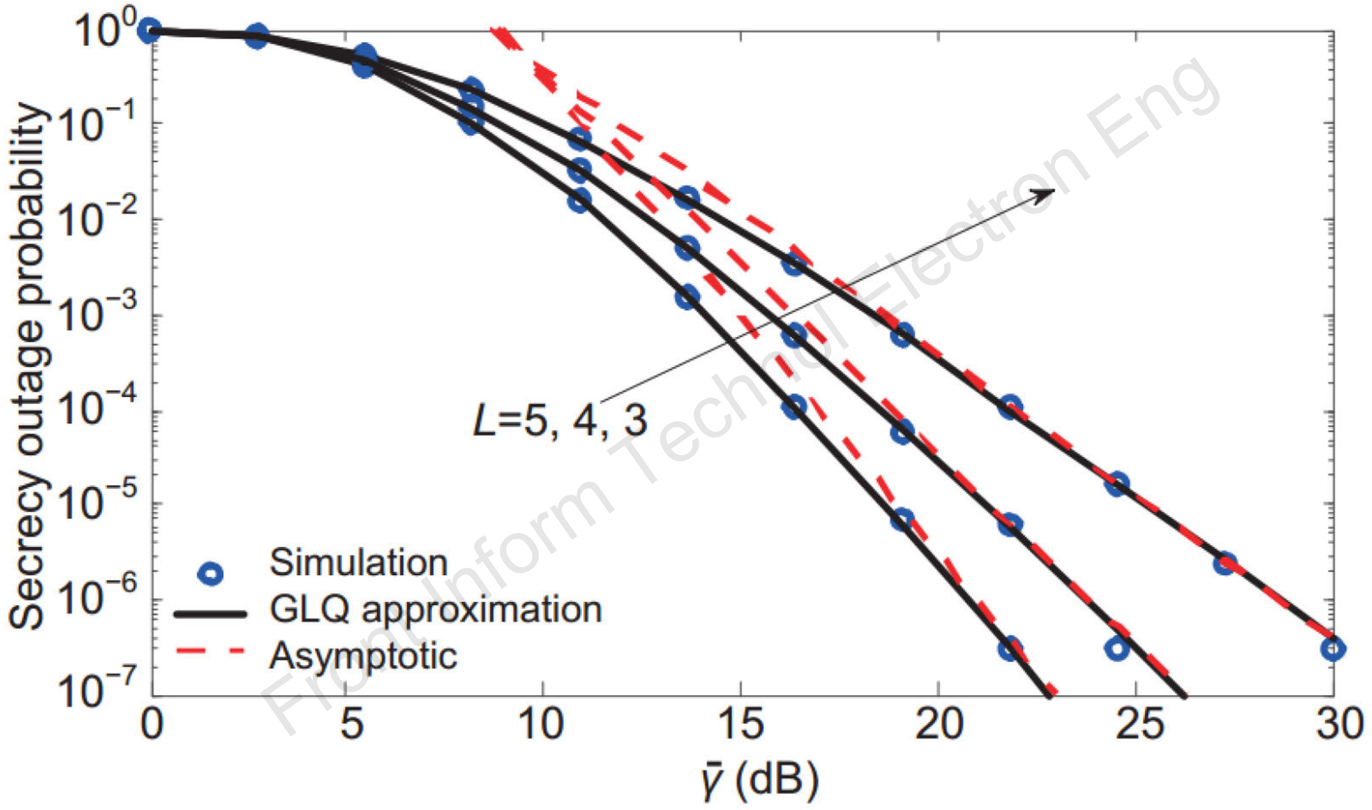

Fig. 2 SOP versus $\overline{\gamma}$ for $N_0 = N_E = 0$ dB and $\alpha = \beta = 0.5$

Major results (Cont'd)

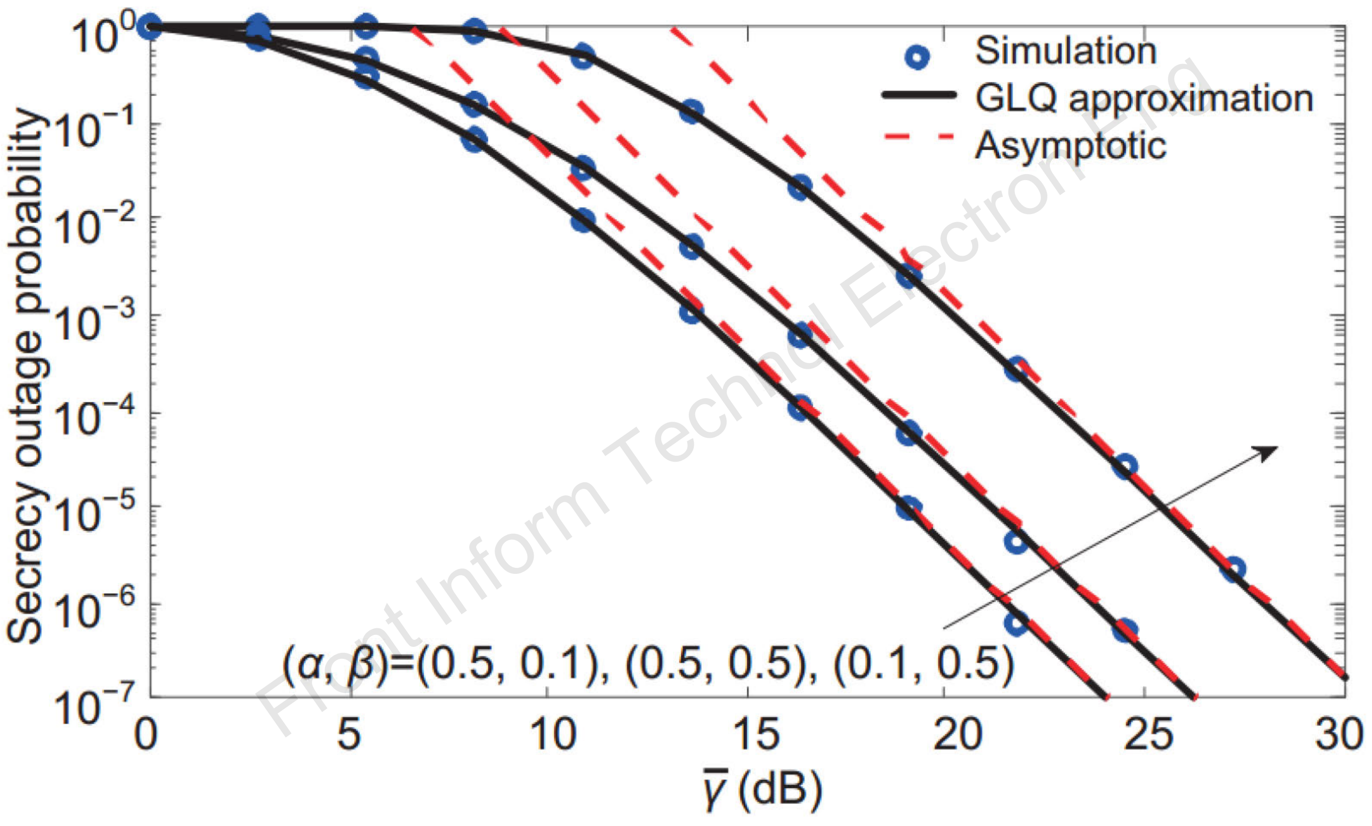

Fig. 3 SOP versus $\overline{\gamma}$ for $N_0 = N_E = 0$ dB and $L = 4$

Major results (Cont'd)

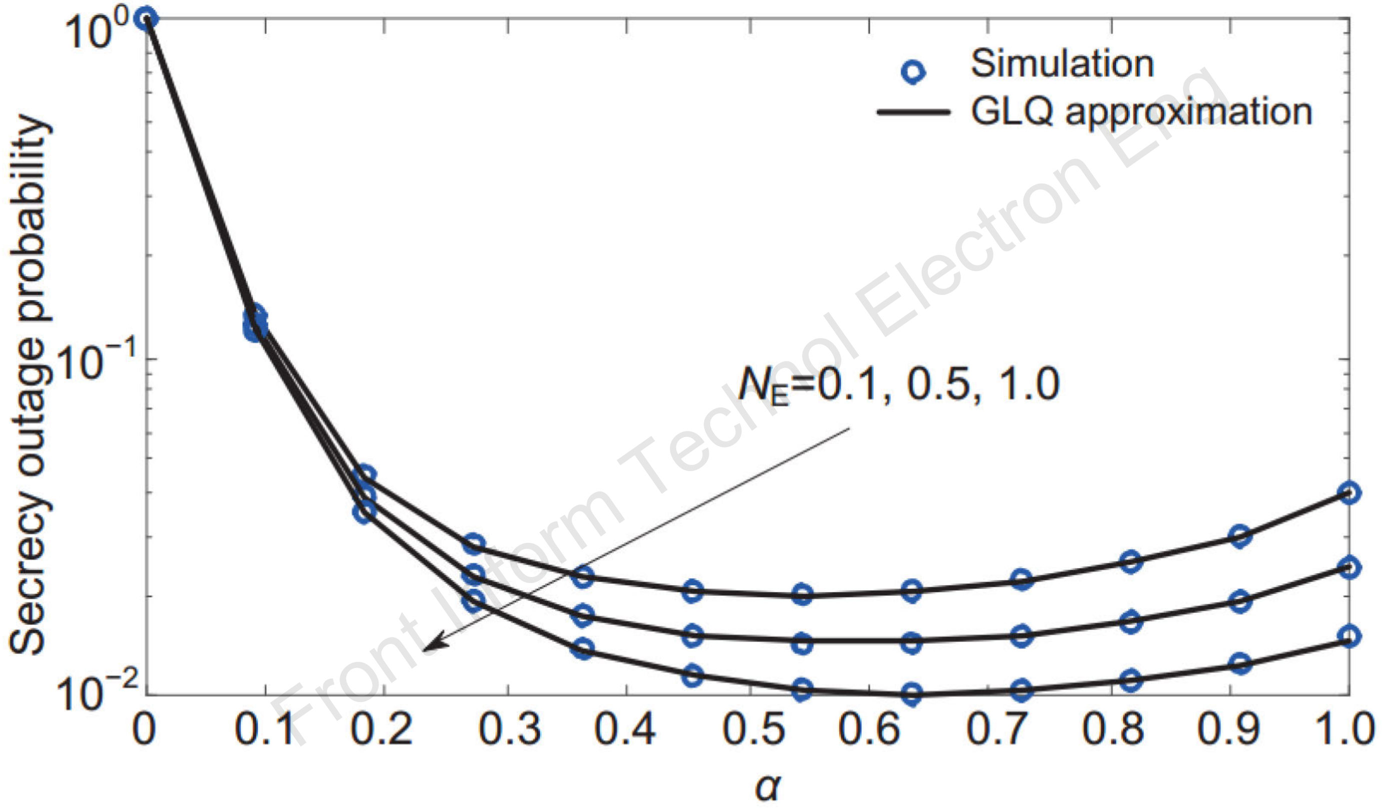

Fig. 4 SOP versus α for $\overline{\gamma} = 15$ dB, $N_0 = 0$ dB, $L = 3$, and $\beta = 0.8$

Major results (Cont'd)

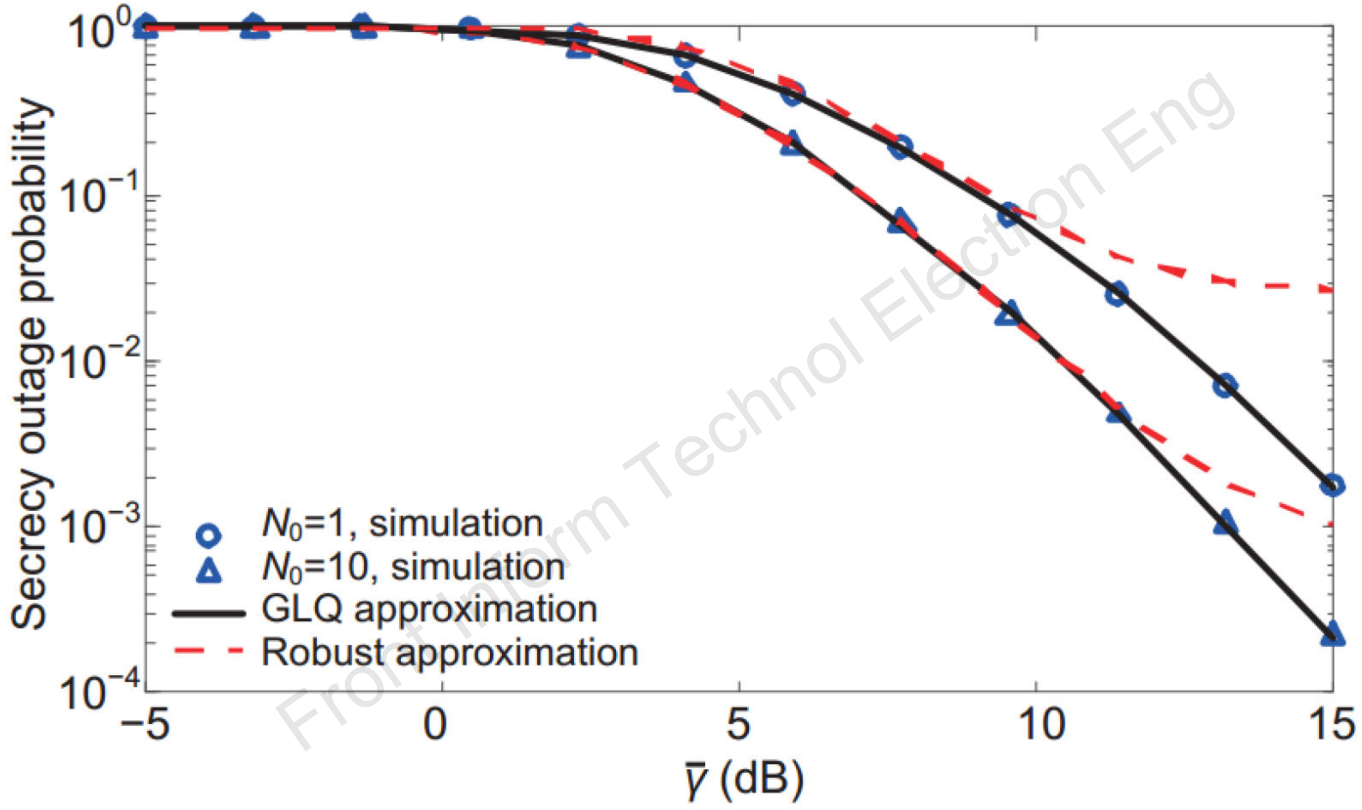

Fig. 5 SOP versus $\overline{\gamma}$ for $N_{\mathrm{E}} = 0$ dB, $L = 4$, and $\alpha = \beta = 0.5$

Conclusions

In this paper, a closed-form expression for the SOP in an artificial-noise-aided SWIPT system has been derived via the GLQ approximation method.
To obtain the secrecy diversity order and secrecy array gain of this system, asymptotic analysis for the SOP has been performed, where the derived ASOP was almost identical to the exact SOP in the high SNR region of the source–Bob link. Building on the works of Holtzman (1992), Pan et al. (2016*a*), and Zhao et al. (2019c), we also derived a robust approximation for the SOP when the variance of SINRs at Eve was not large. Monte-Carlo simulations have been conducted to demonstrate the correctness of the derived closed-form expressions, presenting the impacts of some parameters of interest on the SOP.

Wei-min HOU received his B.S. degree in Electrical Engineering from Chongqing University, China, in 1994, and Ph.D. degree in Signal and Information Processing from Institute of Acoustics, Chinese Academy of Sciences, China, in 2007. He joined the School of Information Science and Engineering, Hebei University of Science and Technology, in 2007. He is currently an associate professor. His research interests include array signal processing, wireless communications, and image processing.

Qing-shan TANG received his B.S. degree in Electrical Engineering from Xiangtan University, China, in 2000, and Ph.D. degree in Signal and Information Processing from Institute of Acoustics, Chinese Academy of Sciences, China, in 2009. He joined School of Physics & Electronic Science, Changsha University of Science & Technology, in 2009. He is currently an associate professor. His research interests include array signal processing, image processing, and high-speed interconnect technology.