Signal Strength Based Distance Estimation of Passive Off-the-Shelf RFID Tags in the UHF Band

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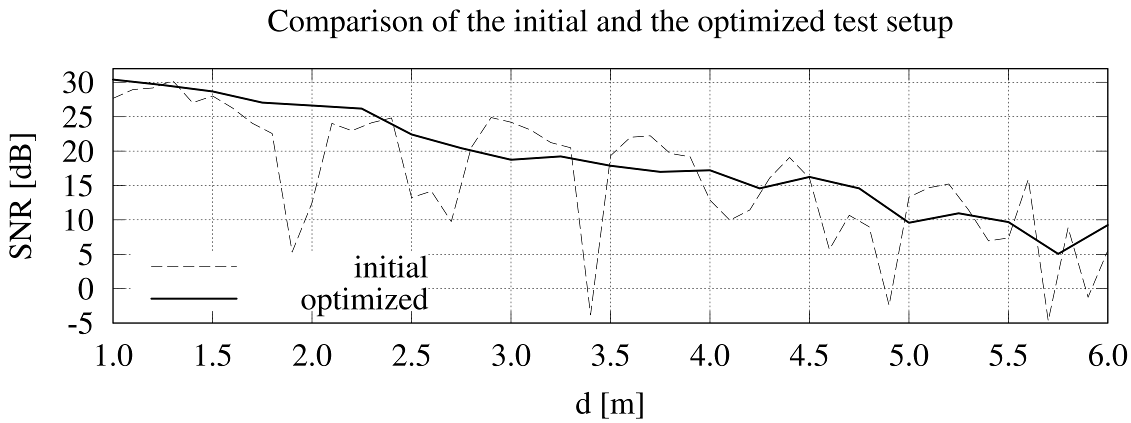
In this paper an evaluation system for the signal strength based distance estimation of passive Radio Frequency Identification (RFID) tags is proposed. One major demand imposed on the test system is the use of off-the-shelf tags, which require no modification to the tag hardware or the used communication protocol. Due to its relatively high range, for passive RFID systems, an Ultra High Frequency (UHF) system shall be used. Both the reader and the tags must therefore comply with the Class-1 Generation-2 UHF RFID Protocol, as specified by GS1 EPCglobal.

A test setup, utilizing a Software Defined Radio (SDR) system is developed. The SDR serves hereby as UHF RFID reader. With this single-input and single-output (SISO) system an initial measurement of the signal strength versus the tag-reader distance is performed. While a basic distance dependent trend is visible, the signal strength curve is largely dominated by various interfering effects, such as multi-path propagation. At certain distances, these effects lead to drops in the signal strength, which prevent reliable distance estimation.

For this reason an optimized test setup, which allows the addition of further transmit and receive channels, is proposed. Various methods to reduce the negative influence of multi-path propagation are utilized for the optimization of the system. By implementing a frequency hopping algorithm the best suited frequency for each tag-reader constellation may be selected. Furthermore, the test system is used as single-input and multiple-output (SIMO), as well as multiple-input and multiple-output (MIMO) reader. The influence of these antenna diversity techniques is discussed and illustrated by experimental measurements. As another form of antenna diversity the use of multiple tags is introduced. The influence of this tag diversity is also shown by an experimental measurement.



By implementing a combination of these proposed techniques, the test system can be optimized in order to allow the estimation of the tag-reader distance with a reasonable accuracy. However, the proposed system is limited to ideal laboratory conditions where a number of parameters, that would greatly influence the system in real-life scenarios, can be controlled. Such influences may for example be tag rotation, shadowing or non-stationary test environments.