Analysis of Interference Effects on UHF RFID Dense-Reader Environment

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Abstract – UHF RFID reader at 900MHz radio environment can be classified by two types of operation modes. These have been known to be stationary type reader within the dense reader mode, hand-held RFID readers and mobile RFID reader within the multiple reader modes. For avoiding these adverse interfering effects on stationary type reader within its specified environment, it is necessary to implement substantially effective channel utilization schemes. Dense modes including a number of similar types of Readers, which existing and thus commonly accessing a single stationary aimed channel, can be the issue of interference and is ought to be modified by zone planning. In this paper, we first present adverse interference effects among readers, and then effective channel utilization and efficient zone planning for resolving corresponding obstacles. To achieve more accuracy, we verified our experiment by employing MATLAB and ADS simulation tools in simultaneous use and settled path loss calculations by using Fourier Transform Formula

I. INTRODUCTION

UHF RFID reader at 900MHz radio environment can be classified by three types of operation modes. These have been known to be stationary type reader within the dense reader mode, mobile RFID within the multiple reader mode, and hand-held RFID readers. According to recent Frequency band assessment regulations for each nation, which basically support multiple reader mode, it becomes issue of compatibility for both dense and multiple reader mode in consequent use without any adverse correlation effect. The correlation effects can be caused by inappropriate allocation of mobile/hand-held type readers, which operate at identical frequency domain, within the pre-configured dense reader environment aimed to stationary type readers. For obtaining the stable Tag response, frequency band isolation for the Stationary-type and mobile/hand-held type readers needs to be performed. Since it is such inefficient to use the identical frequency bands for both stationary type reader and mobile reader, it is essential to configure the frequency bandwidth differently. In this paper, we introduce the outstandingly effective utilization formula of dense reader for obtaining both minimal adverse radio correlations and efficient frequency use. For verifying our experiment, we employed ancillary simulation systems such as MATLAB for baseband design and ADS (Advanced Design System) for RF.

II. SYSTEM MODEL

2.1 Dense-Reader Mode

Radio environment allowing a number of Readers commonly access into a single channel of UHF RFID, which can be called Dense-Reader Mode. By comparing with Multi-Reader Mode, it is necessary to use Guard Band between Reader and Tag aimed frequency channel. In addition, Zone Planning for obtaining minimized SNR (Signal to Noise Ratio) and Saturation avoidance is needed. Fig. 1 showing much modified and isolated channel with its utilization of Dense-Reader Mode. [1][2]

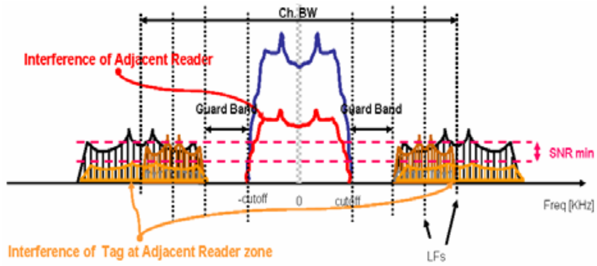
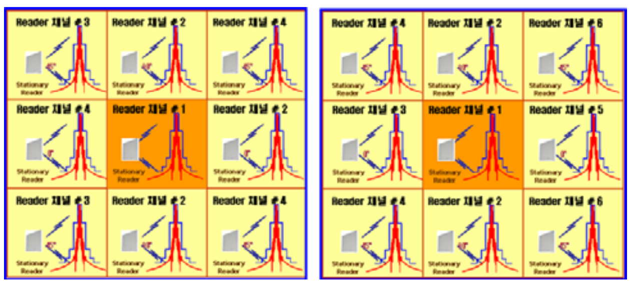


FIGURE. 1. CHANNEL DRIVING FOR DENSE-READER MODE

2.2 Multiple Interference Zone Planning and Noise Variation of Channels

Dense-Reader Mode, which is stationary type specified radio environment, allowing a number of readers commonly access into a single channel of UHF RFID. Thus it is necessary to build the effective zone planning for realizing comprehensive use of each reader and this can be seen in Fig. 2. The centre frequency of reader can be influenced by minimally 8 of adverse interferences. Further phenomena have been simulated by considering each antenna's LOS (Line Of Site) arrangement. Up/down cells of a central cell have 90˚ radiation patterns and diagonal cells of a central cell have 45˚ radiation patterns. Fig. 3 illustrates antenna gain. 45˚, 90˚ radiation patterns presented low antenna gain, and this again notice us the importance of effective zone planning. [2]



(A) 4 CHANNEL (B) 6 CHANNEL

FIGURE 2. CHANNEL FOR MULTIPLE INTERFERENCE

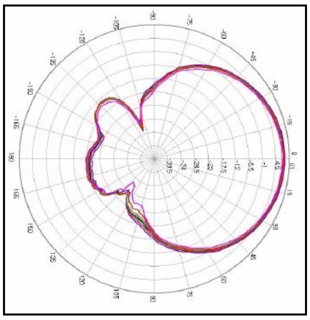


FIGURE 3. STATIONARY READER ANTENNA GAIN PATTERN

2.3 Building Simulation Environments

To achieve more accurate simulation data, detailed simulation environment is built as shown in Fig. 4. We extract informative data from simulation system of MATLAB, which is implemented to PIE codes for transmitter departs and Miller code for receiver departs, respectively. And these become referable data for designing ADS RF components of Mixer, Amplifier and Wave Filter. And additional designs of the Air-Interface including Spectrum Mask and Air-channel model which all intended to Dense-Reader Mode were also modified. [1]

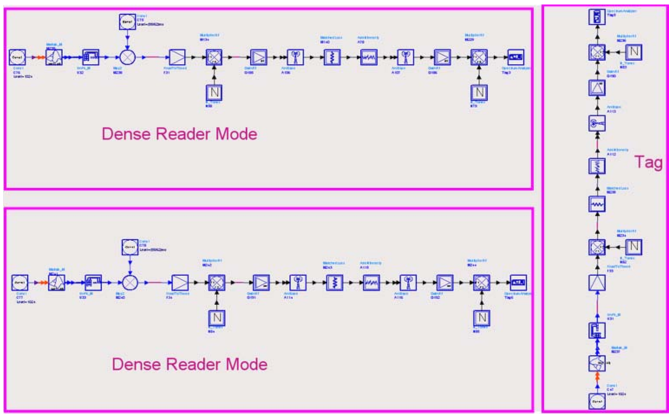


FIGURE. 4. BLOCK DIAGRAM OF ADS SIMULATION CONFIGURATION

2.4 Realization of Interference Air Channel

By considering signal attenuations through the lossy transmission path, it is much preferable to use Friis formula for calculating the size dimensions of the interference signals, which flows within the receiver departs. Friis formula here can be categorized by Transmitting Power, Antenna Gain, Distance, Wavelength as shown in Eq. 1. [3]

$$P_{rec} = P_{PA} G_{TX} G_{tag} \left(\frac{\lambda}{4\pi\pi} \right)^2 = P_{EIRP} G_{tag} \left(\frac{\lambda}{4\pi\pi} \right)^2 \qquad (1)$$

P_{rec} : Receiving Power $\quad$ P_{PA} : Transmitting Power

G_{TX} : Transmitting Antenna Gain $\quad$ G_{TAG} : Receiving Antenna Gain

λ : Wavelength $\quad$ d : Tx/Rx antenna distance

PEIRP : PPA X GTX

2.5 BER to SNR

SNR (Signal to Noise Ratio) of interferences and channel intervals, which can be simulated by supportive simulation tools of ADS (Advanced Design System). BER specification thereafter can be also calculated by completely measured SNR. And RCVR is designed by using orthogonal basis functions. Eventually verified BER can be seen in Eq. 2. In case of Tag Responses, which are derived by Miller-code, Eq.3 presents the mathematic principle of BER with factor of M. [4][5]

$$P_b(e) = 2Q\left(\sqrt{\frac{E_b}{N_0}}\right)\left[1 - Q\left(\sqrt{\frac{E_b}{N_0}}\right)\right] \qquad (2)$$

$$2Q\left(\sqrt{\frac{ME_s}{N_0}}\right)\left[1 - Q\left(\sqrt{\frac{ME_s}{N_0}}\right)\right] \qquad (3)$$

III. SIMULATION RESULT

3.1 Channel Bandwidth of Stationary Reader

For showing more effective frequency use and minimized interfering effects scheme, we simulated Dense-Reader Mode aimed channel bandwidth, which of 400kHz and 600kHz, and are presented in Fig. 5. In case of 400kHz, Tag response is locating at the edge of channel with 200kHz of Link Frequency and ignorable interferer can be occurred. Fig. 5 shows the worst case of Dense-Reader Mode interferer occurring at identical frequency and adjacent frequency, respectively. In this case, external interferer can be measured by 4W of output power levels with considering EIRP (Effective Isotropically Radiated Power) and almost 8m of interrogation range from the Tag has been obtained. We also have found that, the SNR (Signal to Noise Ratio) for Tag response of 600kHz of bandwidth is approximately 5dB improvement than that of 400kHz.

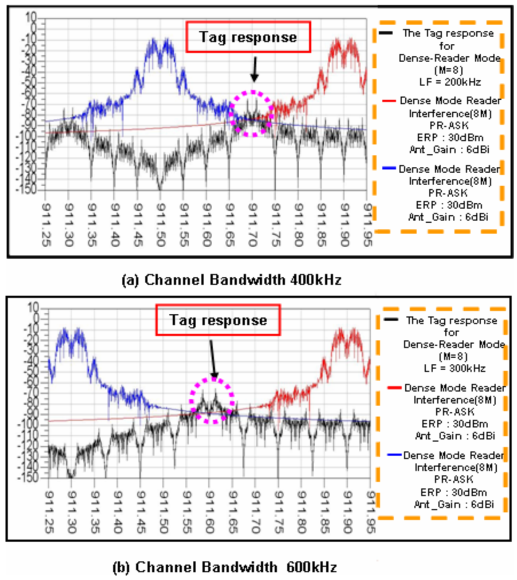


FIGURE 5 – DIFFERENCE OF THE TAG RESPONSE IN DENSE-READER MODE CHANNEL BAND

3.2 Effects of interferences on a single stationary reader

Fig. 5 shows the effects of interferences at 600kHz of bandwidth, which retards from stationary type reader, on the tag. Results from these effects were gained by assuming 8m of distance from reader. As illustrated below, tag can be affected by adjacent channel interferences. Fig. 6 presents the efficiency comparison of two different cases. One can be the adjacent channel interfering effects, which nearly known to be the worst. And the other is the channel difference, which adjusted by 2 of channel division index, from desirable signal. By observing these two simulated data, we can demonstrate that there much stabilized signal form is obtained, if substantial difference of channel exists. In case of inevitably chosen channel utilization of adjacent signals, readers need to be allocated in far distances to reduce noise effects. Statistical values of BER can be seen in Section 3.5.

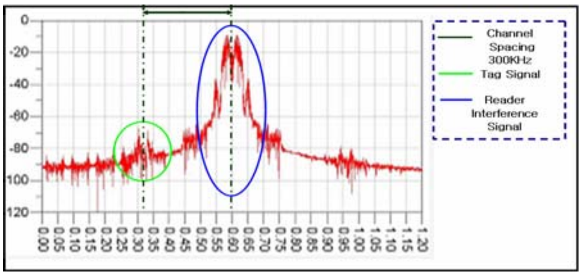


FIGURE 6. WHEN IT USED ADJACENT CHANNEL, INTERFERENCE SIGNAL AND TAG SIGNAL

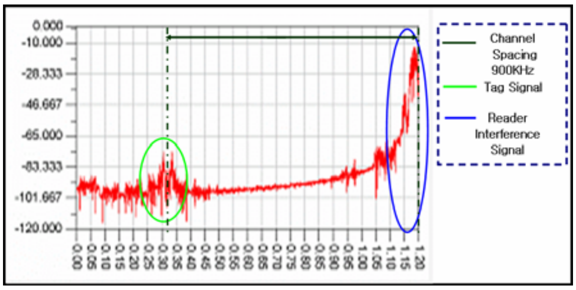


FIGURE 7. WHEN IT USED 2 CHANNEL SIDE CHANNEL, INTERFERENCE SIGNAL AND TAG SIGNAL

3.3 The effects of multiple interferences

It is necessary for Dense reader mode to be established with zone planning aimed to obtain stable tag response and effective frequency utilization. Fig. 8 displays the effects of multiple interferences on signal at 4channel and 6channel, respectively. This follows channel bandwidth of 600kHz. 4channel and 6channel must be secured by implementing link margin, and these for stable tag response. Fig. 11 shows SNR respecting the transmission ranges. Stationary-type reader should be satisfied not only guard bandwidth but also necessity of effective zone planning. . Statistical values of BER can be seen in Section 3.5.

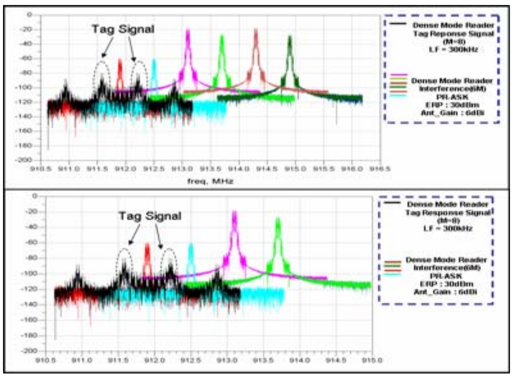


FIGURE 8. THE EFFECT TO MULTIPLE INTERFERENCE SIGNAL

3.4 Isolation of Stationary-type reader Frequency band and Mobile reader Frequency band

Fig. 9 is results which Mobile reader and Stationary-type reader with guard band utilizations. Without guard band, tag response of the stationary-type reader and mobile reader, are not visible. Guard band for obtaining stable tag response of stationary-type reader must be secured above 300kHz. For preventing correlative factors of stationary-type reader, it is essential to separate the frequency of the mobile/handheld-type and the stationary-type reader. Also, It gives guard band between the stationary-type reader and the mobile/handheld-type and must minimize interferences of the mobile/handheld-type reader. Fig. 11 shows BER by distance, if guard band is above 300kHz.

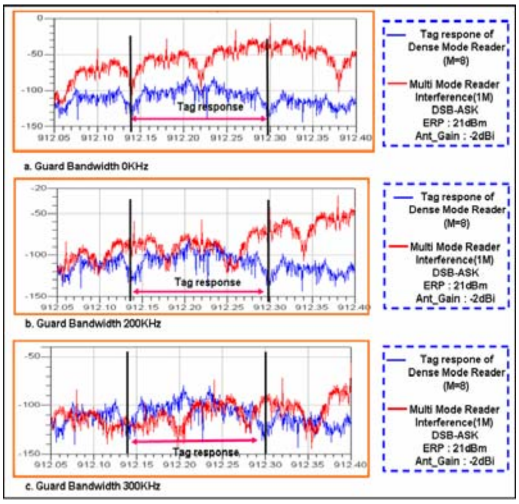


FIGURE 9 – GUARD BAND BUILDING BETWEEN THE MOBILE READER AND STATIONARY READER

3.5 BER variance respecting each case of interfering stationary type reader

It requires nearly 1.5dB SNR in ideal case of Miller M=8. In realistic case of channel and system circumstances demanding 3dB of marginal value, it eventually requires 4.5dB. When it comes to channel bandwidth of 200kHz, it only allows the case of M=1 and following SNR requirement shows almost 13-14dB. Fig. **10** displays further PER (Packet Error Rate) of 10^{-4} and Fig. 11 shows BER per communication ranges. Over the minimal range of 3m is needed to ensure the solely existing interference, and it also is possible to include link margin when 2m in case of 2channel differently allocated frequencies. Planning 4 channels within the zone requires minimal 4m of isolated range and 2.2m for 6 channels with link margin guaranteed. And as long as guard band of 300kHz allocated between stationary type reader and mobile reader aimed frequency, it ought to be over 2.2m of isolated range.

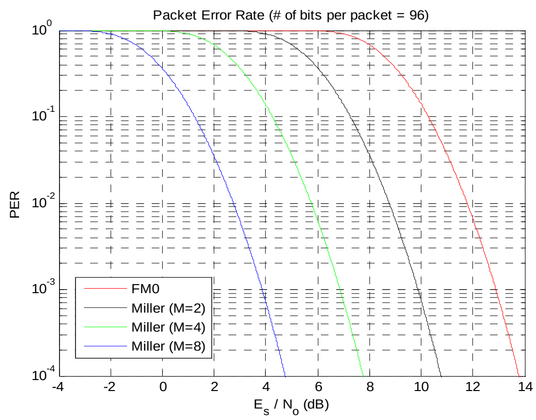


FIGURE. 10. PACKET ERROR RATE BY E_S/N_O

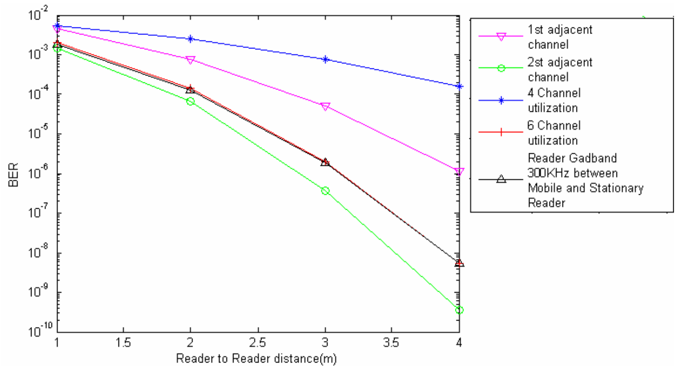


FIGURE. 11. BER BY READER TO READER DISTANCE

IV. CONCLUSION

This paper represented the effective channel utilization schemes and its simulated data of dense reader modes by considering with possible interference minimization schemes. Also, we proposed the minimal distance for securing the link margins, in case of adjacent channel and adjusted by 2 of channel. For multiple interference signals, it is possible to measure states of tag responses, which depend on Zone planning and number of channels. We additionally introduced the Guard band of Stationary-type reader and mobile /hand-held type readers which also secure the link margin and effective frequency utilization. This paper is expected the plan for the frequency of efficient use and a prevention of minimum interference.

ACKNOWLEDGEMENTS

This research has been supported by MIC(Ministry of Information and Communication) IITA(Institute for Information Technology Advancement) and IT Research Center (IITA-2006-(C1090-0602-0011))

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