RF フロントエンド部適応制御を用いた携帯用低消費電力地上デジタルテレビ受信機

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あらまし　地上デジタルテレビ放送の携帯受信機では、筐体のサイズ限られており、バッテリーサイズを大きくすることができたいため、消費電力が厳しく制限されている．しかし，地上デジタルテレビ放送では，RF(Radio Frequency) front-end において要求されるアンプの線形性，Noise Figure(NF)などの条件が厳しく，この部分における低消費電力化が困難である．そこで，本報告では，RF-front end 部の低消費電力化を行うため，瞬時 CNR(Carrier-to-Noise power Raito)，フェージング遅延広がりや最大トップラー周波数といった伝搬路状況，変調方式や伝送モード，および，EVM (Error Vector Magnitude)などの伝送パラメータ応じて RF Front-end 部の適応制御を行う手法を提案する．計算機シミュレーションにより，その効果を明らかにする．

キーワード　地上デジタルテレビ放送，適応 RF front end，消費電力

Adaptive RF front end for low power consumption digital terrestrial television broadcasting receiver

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Abstract Reception of DTTB (digital terrestrial television broadcasting) based on OFDM (orthogonal frequency division multiplex) requires high power consumption RF (radio frequency) front-end in order to satisfy low NF (noise figure) and wide dynamic range amplification. However, the power consumption is strictly limited in mobile reception of DTTB because of limitation in its battery size. This paper proposes an adaptive RF front-end for reducing power consumption of the mobile DTTB receiver by making efficient use of channel state such as CNR (carrier to noise power ratio), EVM (Error Vector Magnitude), multipath delay spreading, and maximum Doppler shift as well as the transmission mode, modulation format. Computer simulation result shows that the proposed adaptive RF front-end receiver is capable of reducing the power consumption in multipath fading environment

Keyword DTTB, Adaptive RF front end, power consumption,

1. Introduction

Digital terrestrial television broadcasting (DTTB) service for mobile terminals has just begun on April, 2006 in major cities in Japan. The Japanese mobile DTTB service employs ISDB-T (Integrated Services Digital Broadcasting for Terrestrial) standard based on OFDM (Orthogonal Frequency Division Multiplex). Some mobile phone manufacturer has released the mobile phones with DTTB reception function.

In the mobile DTTB receiver, the power consumption is strictly limited because of its battery size. Manufacturers are now studying how to reduce power consumption of tuner, demodulator and display in mobile phone receivers. Among them, reducing power consumption of RF front-end block is not simple. Because, RF front-end must satisfy performances such as low noise, high linearity, and dynamic range, because OFDM based DTTB signal has wide dynamic range [1].

The efficiency of the reception antenna attached to mobile terminal is low because of antenna size limitation. Furthermore, the bit error rate performance is degraded due to multipath fading.

In general, RF front-end requires low noise amplifier (LNA) with high gain, high linearity and low power consumption. The reception performance is mainly determined by the NF (Noise Figure) of the LNA of the first block of the receiver [4]. Therefore, low NF LNA is required for improving the performance. In order to improve the RF front-end performance, however, it requires more power consumption. For example, the more the power consumption is, the less the NF.

In this paper, we propose an adaptive control scheme for reduction of power consumption in the RF font end. In the proposed scheme, the RF front-end is composed of a two amplifies with different performance and power consumption characteristics. The adaptive RF front-end chooses either choose either one of the amplifiers according to the channel CNR (carrier to noise power ratio), Error vector magnitude (EVM), multipath delay spreading, maximum Doppler shift.

The computer simulation result shows that the proposed adaptive scheme reduces power consumption while maintaining the bit error rate performance.

2. System Description

Fig. 1 illustrates the block diagram of the proposed DTTB receiver employing adaptive RF-front-end. The receiver is composed of two LNAs, received average power estimator, and selector followed by A/D (analog-to-digital converter), FFT (fast Fourier transform), QAM (quadrature amplitude modulation) demodulator, and FEC (forward error correction) decoder. LNA 1 provides the low NF performance while it consumes high power. On the other hand, LNA 2 gives higher NF than LNA 1, while its power consumption is lower than of LNA 1. Received average power estimator estimates the power and chooses either one of the LNAs according to the estimated received average power. In the following analysis, we assume that the receiver selects LNA 1 if received power is below the pre-defined threshold level, while it selects LNA 2 if received signal power is higher than the threshold.

The proposed adaptive RF front-end can reduce the power consumption from the non-adaptive receiver with LNA 1. This is because the proposed system chooses LNA 2, which consumes less power consumption than LNA 1, when the instantaneous received power is higher than threshold. However, it maintains the reception performance because it chooses high performance LNA 1 when required.

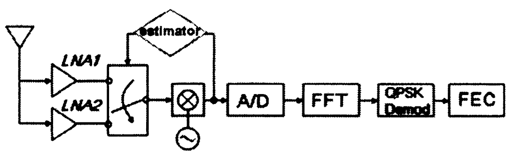

Fig. 1 Proposed System model switching LNAs depended on threshold

The bit error rate performance is deteriorated even if the received average power is higher than the threshold, when the frequency selective fading or the strong adjacent channel interference exits. In order to solve this problem, the proposed scheme can choose one of the LNAs according to the other measures which has direct link to bit error rate. So, we propose an adaptive control scheme employing the EVM, which is corresponds the average signal-to-noise power ratio.

Fig. 2 illustrates the block diagram of the proposed system 2, which uses two LNAs, can switch LNAs depend on EVM of the received signal at the output of the FFT.

In the analysis, when EVM power exceeds the threshold, we select LNA 1. However, when the EVM power is lower than threshold, we select the LNA 2. The proposed system 2 can reduce the power consumption of the RF front-end better than the case that the receiver uses only one LNA 1. Also, proposed system 2 can reduce the BER performance than proposed system 1.

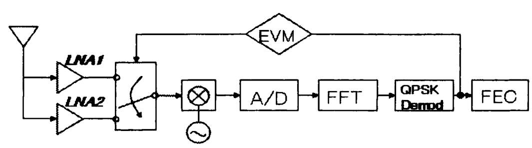

Fig. 2 Proposed System model switching LNAs depended on EVM

3. Simulation Results

In order to verify the performance of the proposed scheme, computer simulation is carried out. Computer simulation parameters, such as band-width, carrier spacing, number of carriers, effective symbol duration, and guard interval follow the ISDB-T standard mode3. In the following QPSK is assumed as a sub-channel modulation format. Exponentially decayed six-ray Rayleigh fading channel [2] is employed as a channel model.

In computer simulation, the propose system can switch LNA 1 and LNA 2 depended on reception qualities. Table 1 shows computer simulation parameter each LNAs

Table 1. Computer Simulation Parameters

LNA1	Noise Figure	1.9dB
	Power Dissipation	750mW
LNA2	Noise Figure	4dB
	Power Dissipation	400mW
Band Width		5.572MHz
Carrier Spacing		0.992KHz
FFT Point Size		8192
Number of Carriers		432
Effective Symbol Duration		1.008ms
Guard Interval		126us(1/8)
Propagation Model		Six-ray Rayleigh Fading

Fig 3 shows the BER performance of the proposed scheme in case of exploiting received average power as a selection criterion. As a received signal strength threshold, we assume 5, 10. 15. and 20dBμ. In the figure, LNA1 and LNA2 depict the BER performance of the conventional systems with LNA1 (NF=1.9dB) and LNA2 (NF=4.0dB), respectively. Other curves denote the BER performance of the proposed adaptive receiver, which exploits received average power as a selection criterion. That is, LNA 1 is chosen when the instantaneous received average power is less than threshold, otherwise, LNA 2 is chosen. The result shows that BER performance when the threshold is 25dBμ almost agrees with BER performance of LNA1.

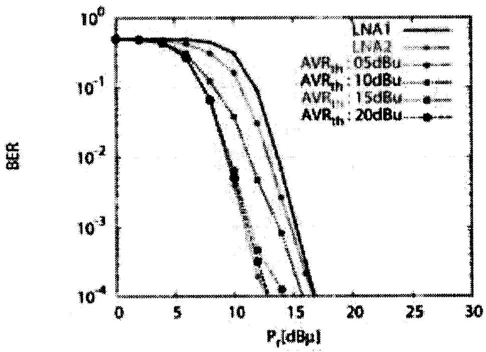

Fig. 3 Bit error rate performance of the proposed scheme based on signal strength against the average received power

Fig 4 shows the power consumption performance of QPSK in the exponentially decayed six-ray Rayleigh fading channel against the average received power. As a received signal strength threshold, we assume 5, 10. 15. and 20dBμ. The lower the threshold is the less the power consumption. According to Figs 3 and 4, we can conclude that the proposed scheme is capable of reducing power consumption by 20% at average received signal power is 20dBμ while it maintains the bit error rate performance in case of non-adaptive receiver with LNA 1.

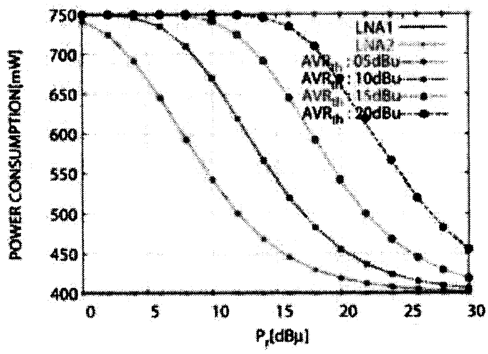

Fig. 4 Power consumption performance of the proposed scheme against the average received power

Fig. 5 shows the BER performance of the proposed scheme in case of exploiting EVM as a selection criterion. The result shows that BER performance almost agrees with BER performance of LNA1 when the EVM threshold is 15dB.

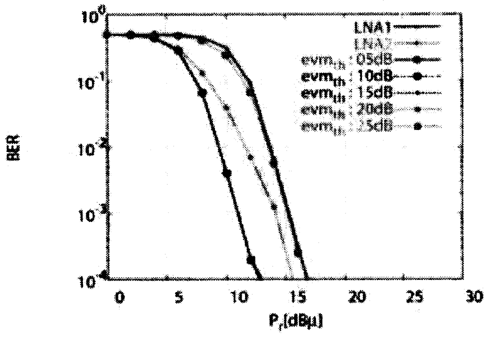

Fig. 5 Bit error rate performance for the proposed scheme employing EVM against the average received

Fig 6 shows the power consumption performance of the proposed scheme. The lower the threshold is the less the power consumption as well as the performance shown Fig. 4. According to Figs 5 and 6, we can conclude that the proposed scheme is capable of reducing power consumption by at average received signal power 25dBμ while it maintains the bit error rate performance.

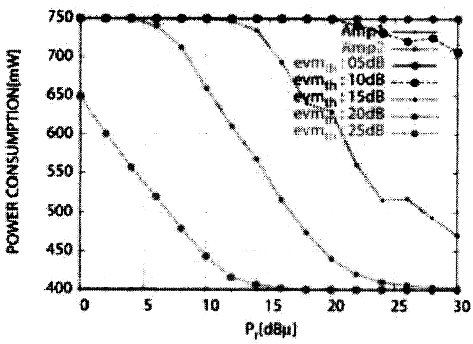

Fig. 6 Power consumption performance of the proposed scheme employing EVM against the average received power

4. Conclusion

In this paper, we have proposed the adaptive RF front-end for reduction of power consumption of the mobile DTTB receiver. The RF front-end of the proposed receiver is composed of two LNAs and controller. In order to reduce the RF-frond end power consumption, RF front-end is composed of two LNAs with different performances. It chooses either one of the two LNAs according to channel state as well as the transmission mode and modulation format. Computer simulation result shows that the proposed receiver can reduce power consumption while it maintains the bit error rate performance, in comparison to the conventional RF front-end exploiting one high performance and high power consumption LNA.

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