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Iterative Cancellation Of Non-Linear Distortion Noise In Digital Communication Systems

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ABSTRACT:

In this paper, an iterative receiver that performs nonlinear distortion noise cancellation is presented. The performance is assessed for time division multiple access (TDMA), orthogonal frequency division multiple access (OFDMA) and single-carrier frequency division multiple access (SC-FDMA) waveforms. Even though a return link setup is considered, the receiver is equally applicable in the forward link, taking into account the differences in the data multiplexing and the channel. Analytical modeling of the received electrical signal-to-noise ratio (SNR) is carried out for OFDMA with one iteration of non-linear distortion noise cancellation.

The performance is assessed in terms of power efficiency and spectral efficiency, where the total degradation (TD) of the received SNR in a non-linear channel is minimized. The modulation formats of the DVB-RCS2 satellite return link standard and a respective non-linear channel have been used. OFDMA shows the highest power efficiency gain of 1.1–2.5 dB with 2 iterations of non-linear noise cancellation across the different modulation orders. In SC-FDMA, the gain is in the range of 0.3–1.1 dB, while gains of 0.1–0.8 dB and 0.2–1.9 dB are presented in TDMA with 20% roll-off and 5% roll-off, respectively.

INTRODUCTION

NOWADAYS, broadband access is considered a commodity .To provide coverage to all households on the territory of the European Union and Turkey, the project on Broad band Access via Integrated Terrestrial and Satellite Systems (BATS) develops an integrated network solution, merging the benefits of terrestrial mobile networks, digital subscriber line (DSL)networks and satellite communication systems. In particular ,intelligent network and user gateways are designed which can classify the traffic of different types of applications and route it via low-latency terrestrial networks or high-bandwidth satellite links to maximize the quality of experience. Due to the ongoing shift towards more bandwidth demanding applications and services, next generation networks need to offer higher system throughput and user data rates, flexibility to adapt to traffic demand across the coverage area, and at the same time decrease the cost per transmitted bit. For this purpose, a higher spectral efficiency without a significant increase in the computational complexity of the air interface is imperative.

The utilization of larger pieces of bandwidth in the higherfrequency bands, such as Ka, Q and V radio frequency(RF) bands, imposes significant hardware implementation challenges,and imperfections cause signal distortion. Therefore,suitable signal processing techniques at the transmitter or receiverside that maximize the information rate of the link arestill an open issue. For example, communication over the satellitechannel suffers from linear and non-linear distortion. Thelinear distortion is attributed to mismatch of the signal spectrumand the spectral response of the filters along the chain, whilethe non-linear distortion originates from the non-linear transfercharacteristic of the high-power amplifiers (HPAs) onboardthe satellite and at the user terminal. These adverse effectsreduce the power and spectral efficiencies of the transmissionwaveform. Time division multiplexing (TDM) is the waveformof choice in the latest DVB-S2X standard for the satelliteforward link, while TDMA is employed in the return satellitelink according to the DVB-RCS2 standard.Waveforms suchas OFDMA and SC-FDMA are at the heart of terrestrial mobilelong-term evolution (LTE) networks due to their high spectralefficiency and flexible traffic allocation.

Existing Method:

This paper presents a detailed comparative study of two single-carrier frequency-division multiple access (SC-FDMA) schemes, namely localized FDMA scheme (LFDMA) and interleaved FDMAscheme (IFDMA), versus orthogonal FDMA scheme (OFDMA), for a satellite uplink. The air-interface of the latter is based on the digital video broadcasting (DVB) family of standards. Considering two state-of-the-art high power amplifiers (HPAs), operating in the K- and S-bands, the performance of synchronous and asynchronous LFDMA, IFDMA and OFDMA is evaluated in a multi-user environment. Systematic comparison results show that although for synchronous reception IFDMA outperforms the other twoschemes, for asynchronous reception it is the most sensitive to degradation caused by inter-block interference (IBI). Furthermore, due to its relatively large envelope fluctuations, OFDMA is the most sensitive scheme to non-linear distortion. Although for synchronous reception LFDMA shows only slightly inferior performance as

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compared to IFDMA, it outperforms the other two schemes for the asynchronous reception considered, especially for increased IBI distortion.

Disadvantage:

1. Not properly applicable on non-linear distortion noise
2. Hardware complexity will increase with high power amplifiers

Proposed Method:

In this paper, an iterative receiver that performs nonlineardistortion noise cancellation is presented. The performanceis assessed for time division multiple access (TDMA), orthogonalfrequency division multiple access (OFDMA) and single-carrierfrequency division multiple access (SC-FDMA) waveforms. Eventhough a return link setup is considered, the receiver is equallyapplicable in the forward link, taking into account the differencesin the data multiplexing and the channel. Analytical modeling ofthe received electrical signal-to-noise ratio (SNR) is carried out forOFDMA with one iteration of non-linear distortion noise cancellation.

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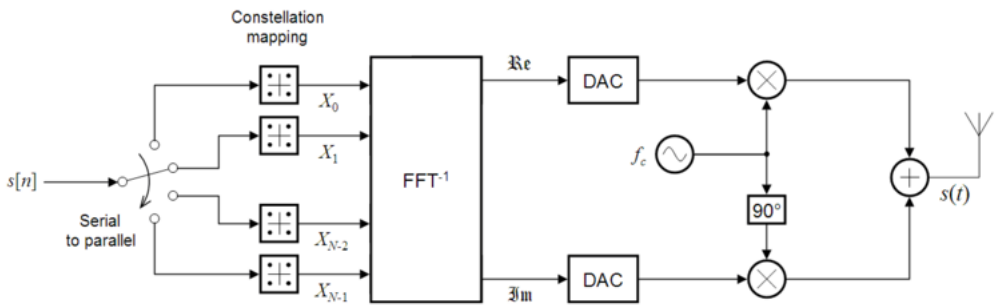
Advantages:

1. Applicable on non-linear distortion noise
2. Low Hardware complexity with DVB-RCS2

Disadvantage:

1. Congestion will occur with big intervals

Transmitter

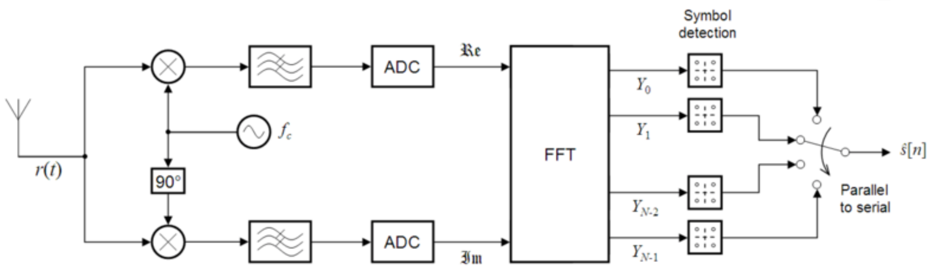


An OFDM carrier signal is the sum of a number of orthogonal sub-carriers, with baseband data on each sub-carrier being independently modulated commonly using some type of quadrature amplitude modulation (QAM) or phase-shift keying (PSK). This composite baseband signal is typically used to modulate a main RF carrier.

$s[n]$ is a serial stream of binary digits. By inverse multiplexing, these are first demultiplexed into N parallel streams, and each one mapped to a (possibly complex) symbol stream using some modulation constellation (QAM, PSK, etc.). Note that the constellations may be different, so some streams may carry a higher bit-rate than others.

An inverse FFT is computed on each set of symbols, giving a set of complex time-domain samples. These samples are then quadrature-mixed to passband in the standard way. The real and imaginary components are first converted to the analogue domain using digital-to-analogue converters (DACs); the analogue signals are then used to modulate cosine and sine waves at the carrier frequency, f_c, respectively. These signals are then summed to give the transmission signal, $s(t)$.

Receiver



The receiver picks up the signal $r(t)$, which is then quadrature-mixed down to baseband using cosine and sine waves at the carrier frequency. This also creates signals centered on $2f_c$, so low-pass filters are used to reject these. The baseband signals are then sampled and digitised using analog-to-digital converters (ADCs), and a forward FFT is used to convert back to the frequency domain.

Extension Method:

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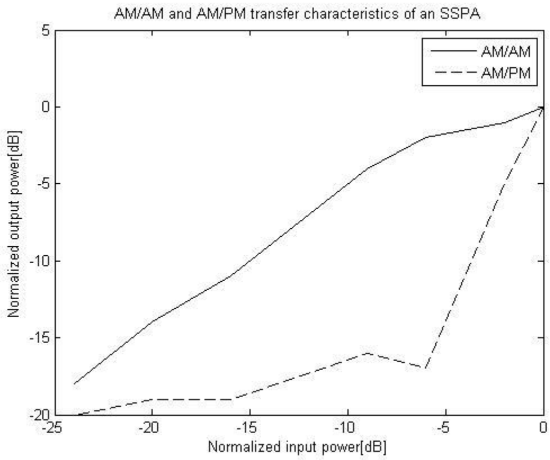
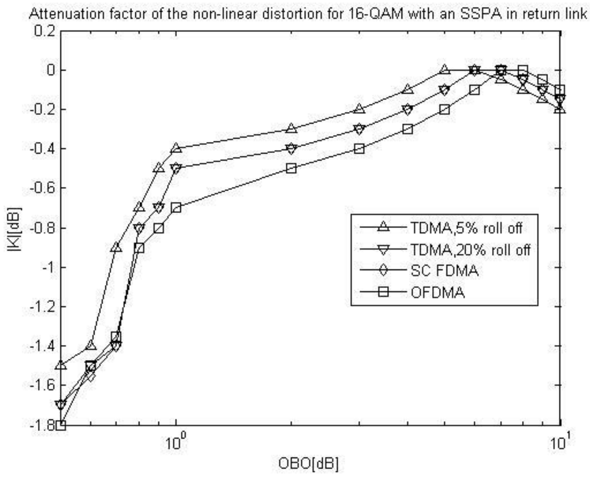
The next generation of interactive satellite terminals is going to play a crucial role in the future of DVBstandards. As a matter of fact in the current standard, satellite terminals are expected to be interactive thus offering apart from the possibility of logon signalling and control signalling also data transmission in the return channel with satisfying quality. Considering the nature of the traffic from terminals that is by nature bursty and with big periods of inactivity, the use of a Random Access technique could be preferred. In this paper

Random Access congestion control

In DVB-RCS2 is considered with particular regard to the recently introduced Contention Resolution Diversity Slotted Aloha technique, able to boost the performance compared to Slotted Aloha. The extensionanalyzes the stability of such a channel with particular emphasis on the design and on limit control procedures that can be applied in order to ensure stability of the channel even in presence of possible instability due to statistical fluctuations.

Simulation Results





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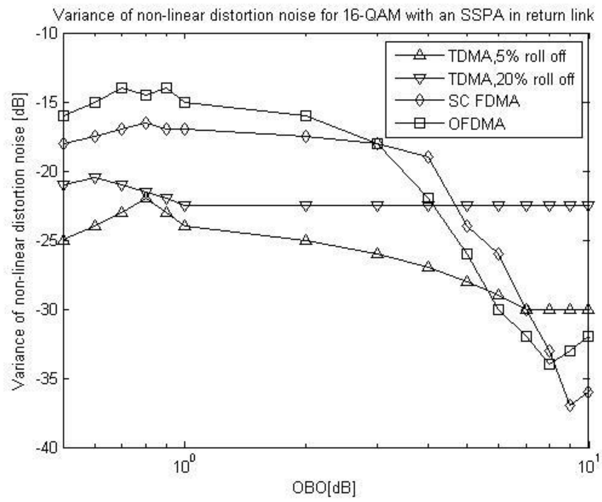
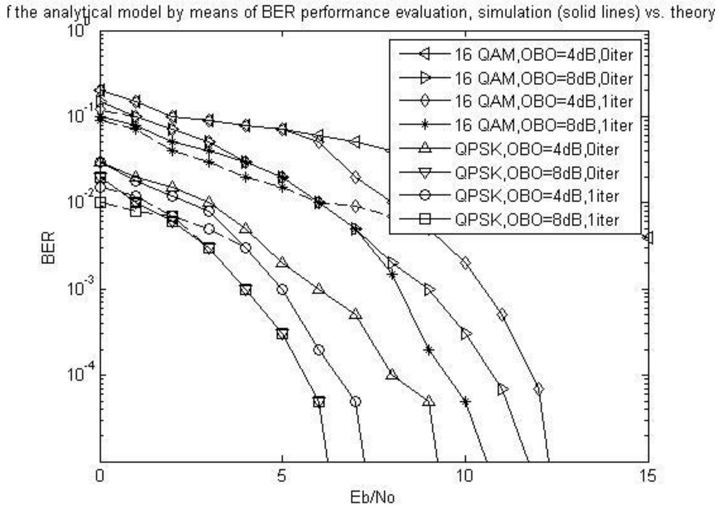
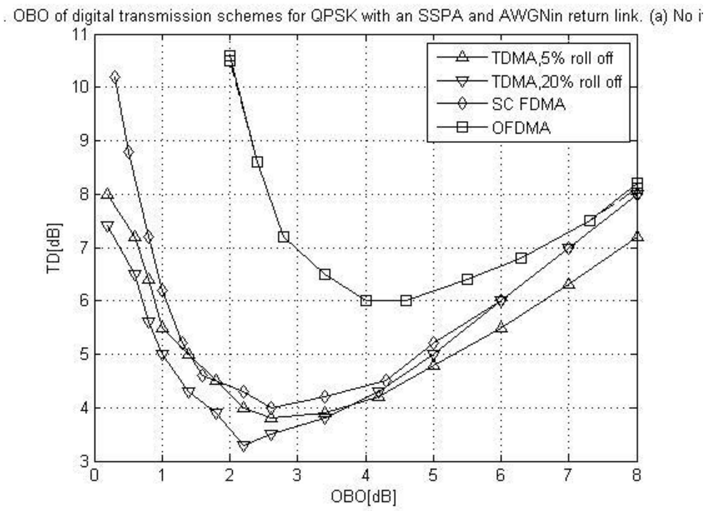
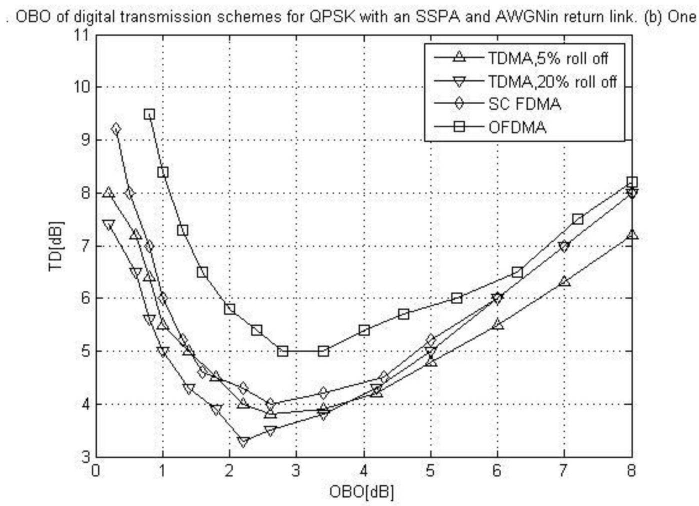





. OBO of digital transmission schemes for QPSK with an SSPA and AWGNin return link. (a) No i
TDMA,5% roll off
TDMA,20% roll off
SC FDMA
OFDMA
TD[dB]
OBO[dB]


. OBO of digital transmission schemes for QPSK with an SSPA and AWGNin return link. (b) One
TDMA,5% roll off
TDMA,20% roll off
SC FDMA
OFDMA
TD[dB]
OBO[dB]

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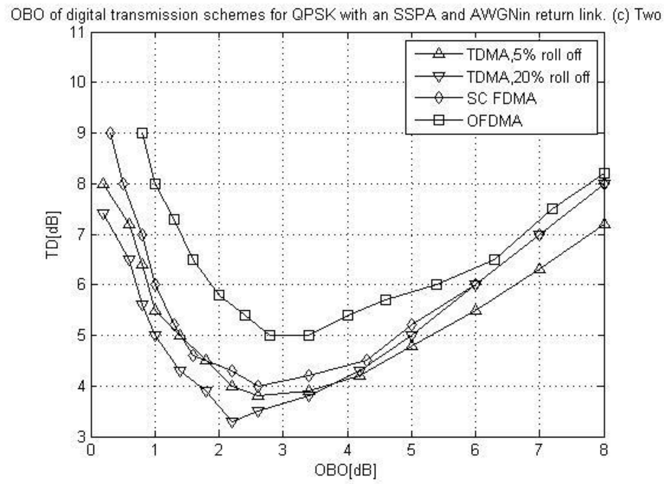
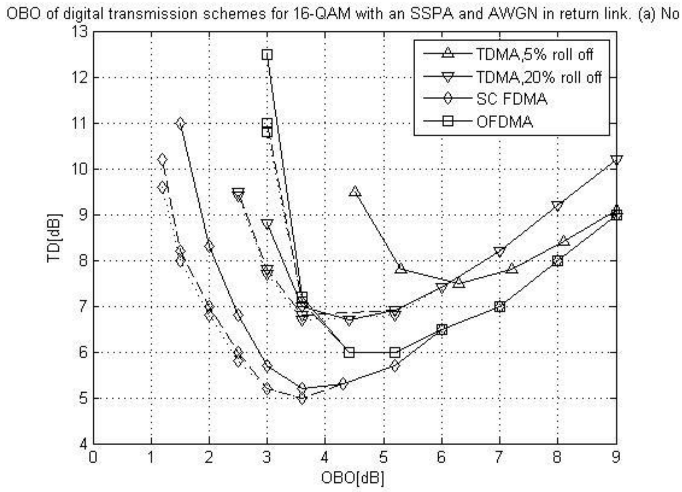
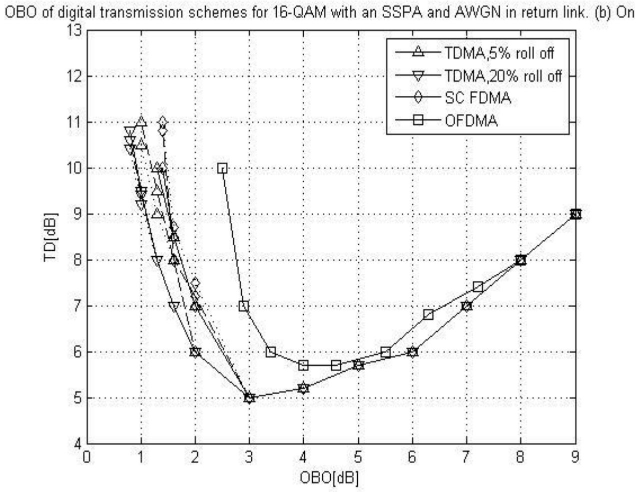
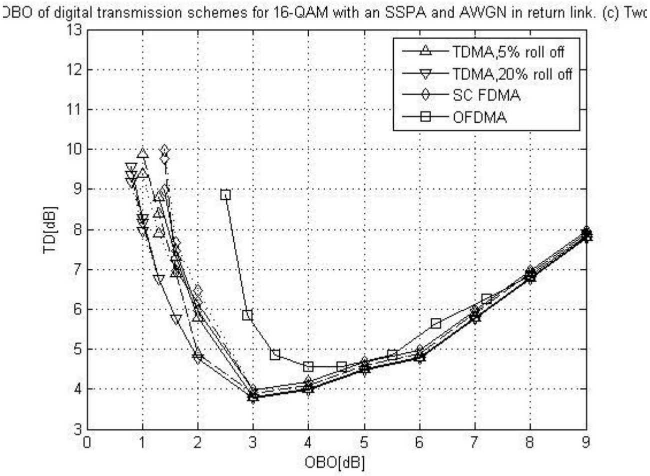
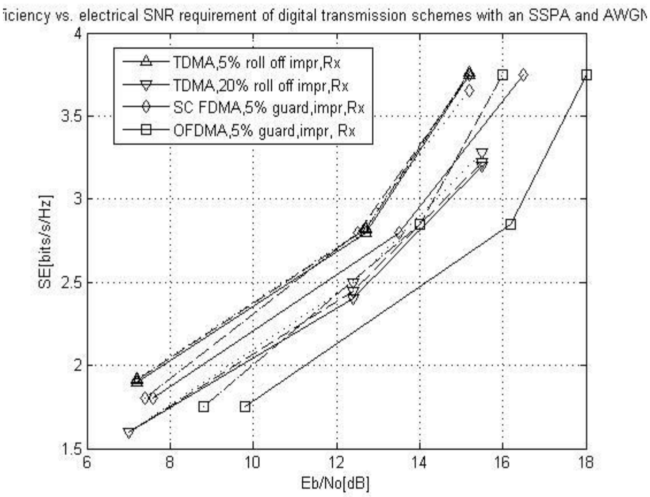
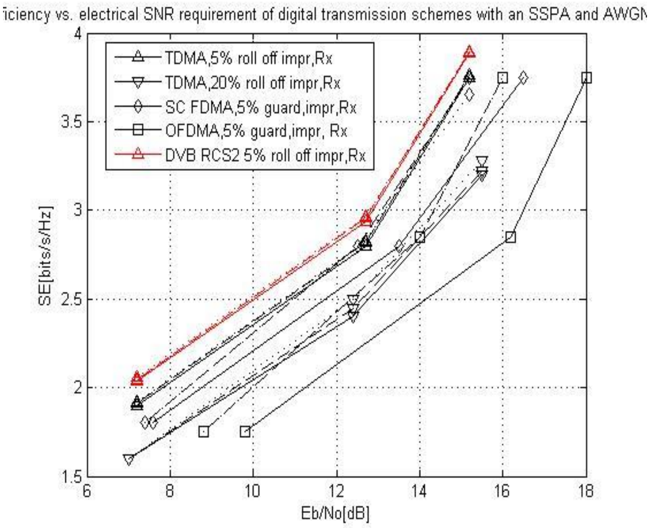





OBO of digital transmission schemes for 16-QAM with an SSPA and AWGN in return link. (b) On
TDMA,5% roll off
TDMA,20% roll off
SC FDMA
OFDMA
TD[dB]
OBO[dB]


OBO of digital transmission schemes for 16-QAM with an SSPA and AWGN in return link. (c) Two
TDMA,5% roll off
TDMA,20% roll off
SC FDMA
OFDMA
TD[dB]
OBO[dB]





CONCLUSION

In this paper, an iterative receiver has been presented whichperforms cancellation of the IMI that originates from the nonlineardistortion in the channel. The performance of singlecarriertransmission schemes such as TDMA and SC-FDMAis maximized by the joint application of ML detection withrespect to the received constellation centroids and non-linearnoise cancellation using individual scaling factors for the detectedsymbols. The proposed receiver can be applied in alltypes of commercial digital communication systems. Theseinclude terrestrial mobile wireless communications, DSL andcable communications, satellite communications and opticalwireless communications such as infrared communications andVLC. In addition, it can be applied in both the forward andthe return links.

The receiver has been tested with TDMA, SCFDMAand OFDMA transmission formats, and it has demonstratedsignificant

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gains in the power efficiency. An analyticalmodel has been developed for 1 iteration of IMI cancellation inOFDMA. It has been shown that even 1 iteration is sufficientto present the majority of the gain of IMI cancellation inthe tested transmission schemes. In the considered modulationsetup, gains of up to 2.5 dB are expected for OFDMA, 1.1 dBfor SC-FDMA, 0.8 dB for TDMA with 20% roll-off and 1.9 dBfor TDMAwith 5% roll-off. The receiver is particularly suitablefor application with higher order modulation formats which aremore vulnerable to non-linear distortion, and as a result highergains are expected. Consequently, higher spectral efficiency canbe achieved which can be translated into higher throughput andlower cost per transmitted bit.

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