

Improving Television Signal Reception under Different Rainfall Conditions using Adaptive Equalizer

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Abstract

The transmission of an image signal, such as a television signal, through a transmission channel subjects the signal to a variety of disturbances that may alter desired parameters of the signal. A television signal reaching a TV receiver may be unstable due to interference caused by noise and heavy rainfall, which creates poor-quality reception. An adaptive equalizer was used to minimize the errors in the received signal. From the research findings, degradation in television signal reception (called fading) is a result of attenuation by heavy rainfall and other natural phenomena. This work aimed to improve television signal reception under heavy rainfall conditions using an adaptive equalizer. From the results obtained, the equalizer minimizes the error by altering its filter coefficients with an average result of 0.1 at step sizes of 0.01, 0.5, and 0.1 with the equalizer against 0.3 without the equalizer.

Keywords: Rainfall Conditions; Signal Reception; Adaptive Equalizers

Introduction

Adverse weather conditions have been known to affect the quality of TV signal reception. The most severe impact is caused by rain, and this is popularly called “rain fade”. The transmission channel in communication systems is defined as the medium through which the transferred information is sent from the transmitter end to the receiver end. The perfect situation can be obtained when the signal is received without any distortion or loss of the transmitted signal. Interested people and researchers have been working hard to attain a close to ideal situation, but until now, this target has remained difficult to achieve due to the difficulties that appear in the transmission medium. The radio signal propagation can be divided into two types: direct path (LOS signal) and multipath propagation. The direct path occurs when there is a straight path between the transmitter antenna and receiver antenna. This case is defined in the communication system as (line of sight), so no interference happens in the transmitted frame when passing through the channel (John G. Proakis, 2008).

The multipath propagation occurs when the transmission medium has obstacles which affect the transmitted frames like buildings, trees, cars and long distance. When the fading occurs in the channel because of signal attenuation, propagation by more paths, and dominate component exists because of optical visibility from transmitter to receiver. It has been found experimentally, that Nakagami distribution offers better fit for wider range of fading conditions in wireless communications (Ahmed, 2014). In wireless communication systems, various techniques for reducing fading effect and influence of shadow effect were employed. Such techniques are dynamic channel allocation, diversity reception and power control. Upgrading transmission reliability and increasing channel capacity without increasing transmission power and bandwidth and how to reduce the effect of signal fading due to heavy rainfall is the main focus.

Literature Review.

Robert A. Nelson (2014) studied on “effect of rain on communication link”. He explored the physical mechanism of rain degradation and the comparison of the relative effects in various frequency bands used for satellite communication. He discussed a variety of new satellite services which are being developed in the frequencies regime higher than the usual C and Ku bands due to the availability of spectrum. These systems include the broadband service planned for Ka-band. With the significant impact of rain on these systems, he discusses a mitigation technique such as site diversity or the allocation of spectrum sparingly at lower frequencies to ensure uninterrupted service. His work focused on the theoretical aspect, not statistical measurement.

Barhumi (2014) on Time-Varying FIR Equalization for Doubly-Selective Channels describes a least squares (LS) channel estimation scheme for multiple-input multiple-output (MIMO) OFDM systems based on pilot tones. First, the mean square error (MSE) of the LS channel estimate was computed. Then, the optimal pilot sequences and optimal placement of the pilot tones concerning this MSE were derived. Also, to enhance channel estimation, a recursive LS (RLS) algorithm is proposed, for which the optimal forgetting or tracking factor was derived. This factor is found to be a function of both the noise variance and the channel Doppler spread. It is also shown that a considerable gain in signal-to-noise ratio (SNR) can be obtained by using the RLS algorithm, especially in slowly time-varying channels.

The study concluded that diversity techniques are used to improve the performance of radio channel without any increase in the transmitted power. As higher as the received signal replicas are de-correlated, as much as the diversity gains can be achieved. The work finally suggested that much research is required to improve the performance in terms of fading in the next generation wireless networks. The TV signal is made up of two main parts: the sound and the picture. But it is far more complex than that. The sound is usually stereo, and the picture carries color information as well as the synchronizing signals that keep the receiver in step with the transmitter. The process involved in receiving a TV signal and recovering it to present the picture and sound outputs in a high-quality manner is complex.

An equalizer is a filter that is usually adjustable and is meant to compensate for the unequal frequency response of some other signal processing circuit or system. A typical equalizer allows the user to adjust one or more parameters that determine the overall shape of the filter's transfer function. It is generally used to improve the fidelity of sound, to emphasize certain instruments, to remove undesired noises. The purpose of this equalization was to undo the adverse effects on the signal and to remove interferences (Debashere et al, 2014). The equalizer attempts to build a system that has a ‘delay inverse’ of the digital model of the transmission channel, removing the interference while simultaneously rejecting the additive interferers that are uncorrelated with the source.

Methodology

Adaptive Equalizer; Adaptive Equalizers are equalizer that uses filters to automatically adjust and compensate for the unequal frequency response of a signal processing system. This adaptive equalizer model was designed to minimize the error between the transmitted signal and the output obtained by the equalizer filter. Since the desired output of the equalizer is nothing but the desired signal, i.e, the inverse of the received signal and linear phase, what the adaptive equalizer does is to minimize the output error and estimate the weights corresponding to each delayed signal using a training algorithm.

Figure 1 shows the Simulink model of the proposed adaptive equalizer.

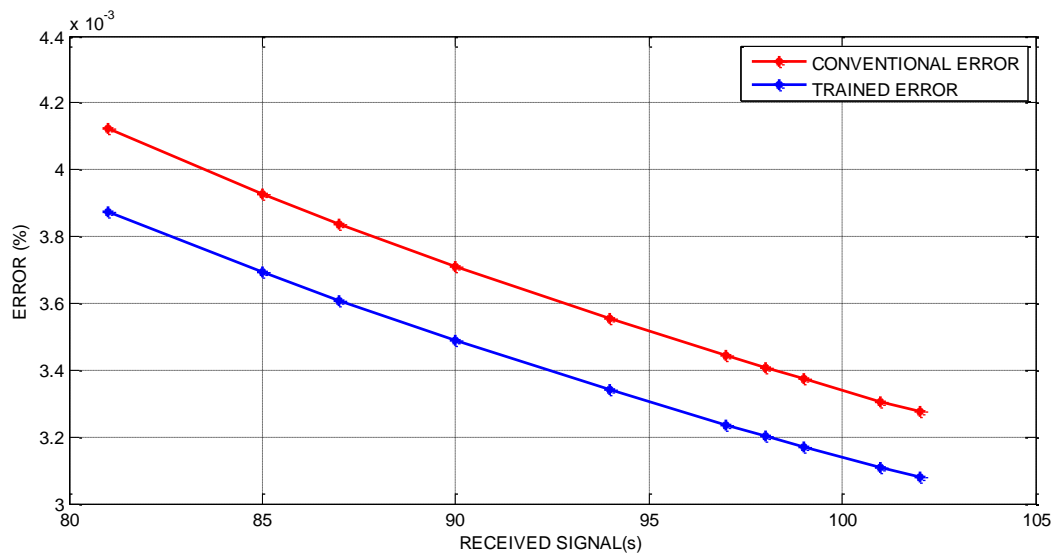


Fig. 2: Comparison plot of conventional errors with trained error.

From the result obtained in table 1 and figure 2 shows the conventional error against the characterized value when trained. Its co-ordinate is (-81, 0.004123) while that of trained error is (-81, 0.003876). with this result it shows that there is a decrease in error when trained than when the conventional method is used. The decrease in error when trained is at about 5.99%.

From figure 2; the result obtained shows the equalizer was able to bring the value down from -77dBm to -41.2dBm. This confirms that the system responds very well to the weather condition.

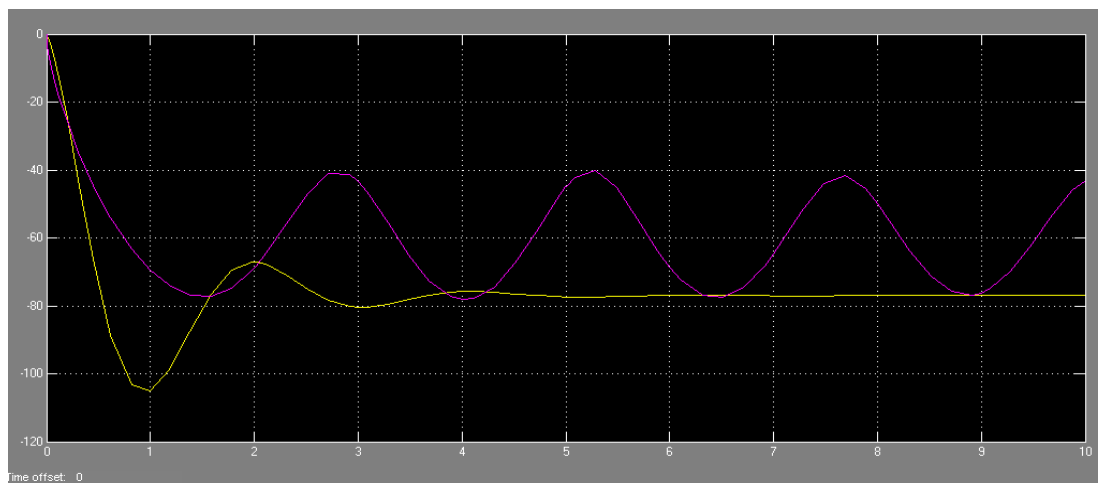


Fig. 3: Waveform of the equalized signal against the unequalized signal.

The waveform of the equalized signal in purple color and the unequalized signal in yellow color is presented in Figure 3 above. Here, the phase and amplitude of the attenuated signal were normalized after the signals had passed through the equalization process. Considering the rate of performance in a deep fading environment, from the result of simulations, the adaptive equalization performance was good.

Conclusion

In this work, the adaptive equalizer was meant to work in such a way that the bit error rate should be low and the signal-to-noise ratio should be high. This will give the inverse of the received signal and also give a flat frequency response and linear phase during variations in rainfall. The proposed adaptive equalizer was trained using the measured value during heavy rain, these were simulated using a modified version of the Simulink QPSK adaptive linear equalization block diagram with an embedded MATLAB equalization algorithm (least mean square) to get the desired signals. The simulations were based on two

test scenarios: with and without an adaptive equalizer. Finally, it is obvious that the adaptive equalizer reduces the errors on the received signal during heavy rainfall.

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