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Implementation of Seven Finger RAKE Receiver using MRC Technique

D. Sri Kavya, P.Siddaiah

Abstract: ***The radio receiver that counters the effects of the multipath fading is known as a rake receiver. Rake receiver used to combine the multipath signals by number of 'sub receivers' known as 'fingers'. Rake receiver uses a multipath diversity principle; it rakes the energy from the multipath propagated signal components. This paper gives the review on implementation of MRC (Maximal Ratio Combining) for the seven fingers rake receiver. It gives the same information to receiver as transmitter, it eliminates the multipath fading and the time offset estimation to seven fingers of rake receiver. In the simulation results we observed that both the signals that is input and output signal resembles the same with the help of MRC.***

***Keywords* : Rake receiver, multipath fading, multipath diversity principle, Maximal ratio combining.**

I. INTRODUCTION

When the signal travels from transmitter to receiver, due to the presence of obstacles in the middle of the path, the signal directs itself towards the receiver through different paths and finally reaches the receiver. It is called the multipath signal, which is to be combined efficiently to get back the original signal. One of the most efficient methods to combine such signals is RAKE RECEVIER implementation. Therefore the rake receiver is used to combine multipath signals in an efficient manner by using the required number of 'sub-receivers' which can also be called as 'fingers'. One finger is assigned to each path, so that the signal from each path is collected by those sub-receivers with respective to them. Later, the contributions from all the fingers are combined to get back the original signal with high signal to noise ratio. Since each path contains some or the other efficient information required, the received data from all the sub-receivers assigned to different paths are combined coherently to improve the reliability of data received.

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* Correspondence Author
D. Sri Kavya*, Dept. of ECE, University college of engineering and technology, Acharya Nagarjuna University, Nagarjuna Nagar, Guntur, India. Email: kavyadulla@gmail.com

Dr. P. Siddaiah, Principal, University college of engineering and technology, Acharya Nagarjuna University, Nagarjuna Nagar, Guntur, India. Email: siddaiah_p@yahoo.com

The receiver used for wideband code division multiple access systems (WCDMA) is rake receiver. All the users transmit in the same band simultaneously in a WCDMA system.

Each transmitted length of this code is called the spreading factor. Larger spreading factors give a better resistance against interference (interference of multiple users, multiple channels, and multiple paths). The receiver de-spreads the received signal by multiplication with exactly the same PN code. The results of all multiplications are added, this process is called correlation. A rake receiver has multiple fingers to correlate the received signals from different paths with different delays, and combines the results of the different paths to construct one output signal. For wideband code division multiple access systems (WCDMA) also rake receivers are used.

II. IMPLEMENTATION OF RAKE RECEIVER WITH SEVEN FINGERS

Implementation of the rake receiver with seven fingers is shown in figure.1 which mainly divided into three sections as transmitter, channel, and receiver. Transmitter section consists of spreading, modulation, filtering, up sampling and time offset. Channel is the place where the transmitted signal splits into different directions because of obstacles in the path and some factor of attenuation is applied to each path to mitigate the interference by reducing the strength of each signal. We can observe the signal splitted into seven paths in the figure below and corresponding attenuation is given to each finger. And the other section is the receiver section which is a rake receiver consisting of despreading block, the other block is used to combine the scattered signal to retrieve the original signal called maximal ratio combining, which makes the entire difference between the normal receivers and a rake receiver. Down sampling, filtering, demodulation, and despreading blocks follows the maximal ratio combining block respectively.

III. ALGORITHM FOR THE IMPLEMENTATION RAKE RECEIVER

A. TRANSMITTER

The PN sequence generated is maximal length sequence. Initial state of the register is considered as '10000', length of the initial state or shift register is '5'.

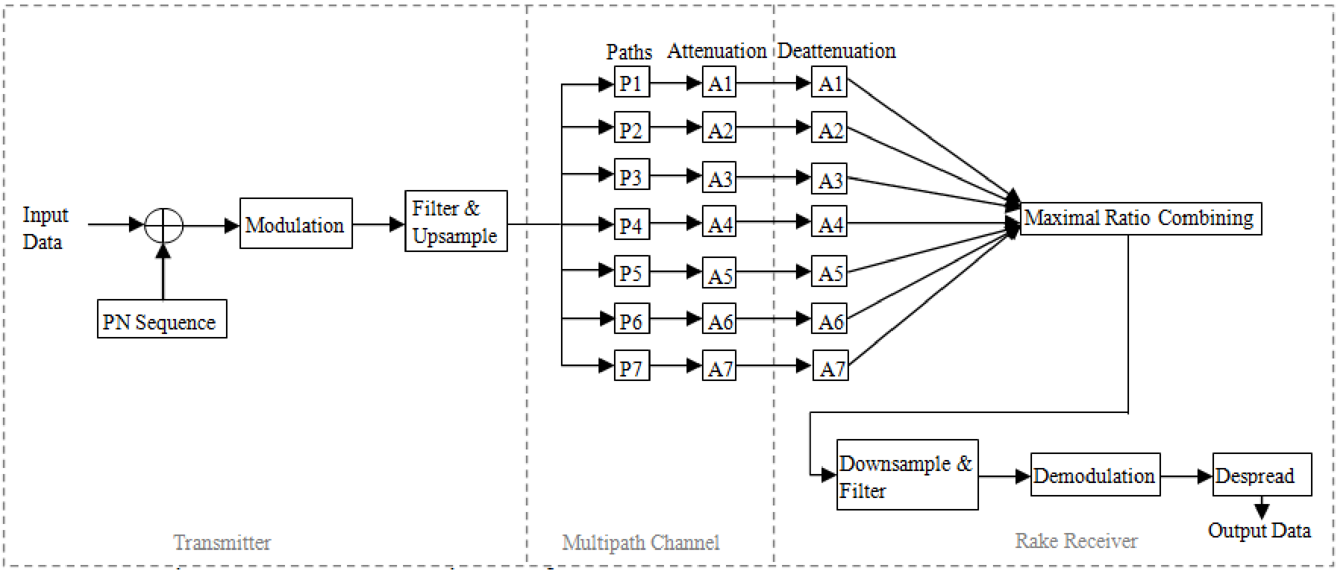

Figure 1: Block diagram of seven finger RAKE Receiver

According to maximal length sequence, for the initial state of 5 flip flops, total length of the PN sequence produced should be $\left(2^m - 1\right)$.Where 'm' is the length of the initial state i.e. 5. Therefore, length of the sequence is '31' for 5 flip flops. For 5 flip flops or shift register of length '5' the feedback taps taken are [5,2].

The PN sequence produced is of length 31. 16-bit binary data is produced to be used as user data. Random data is generated i.e. every time the program is run a new set of data is generated. Logic used to generate random data in mat lab. To generate random data, [0,1] is the interval of integers to be produced with the step size of '1'. Since we need to produce only binary data '0' is set as the maximum value in the interval and '1' as the maximum value. 1,16 give number of rows and number of columns respectively. Hence from the logic it is clear that the user data produced is 16-bit random binary data.

For the purpose of spreading the user data the PN sequence is generated. To spread the user data, modulo sum of user data with PN sequence is needed to be done. Each bit in user data is modulo added with 31 bits in PN sequence. Therefore 16-bit user data by spreading becomes 496 bits. Spreading provides resistance to interference, jamming etc. and also which cannot be decoded without the same spreading sequence. Modulation technique used is 16 QAM. The QAM is a modulation scheme where its amplitude is allowed to vary with phase.

The modulation techniques used in many digital data communication applications is QAM. The data rates beyond 8-PSK in a radio communication system are needed then the modulation scheme is extensively used is QAM, the main advantage of QAM is, by distributing the points are more distinct it achieves a greater distance between adjacent points in the I-Q plane and it reduces data errors.

The QAM modulation is more useful and efficient than the others and is almost applicable for all the progressive modems and microwave digital radio. When channel conditions are poor the energy efficient schemes such as BPSK or QPSK are used.

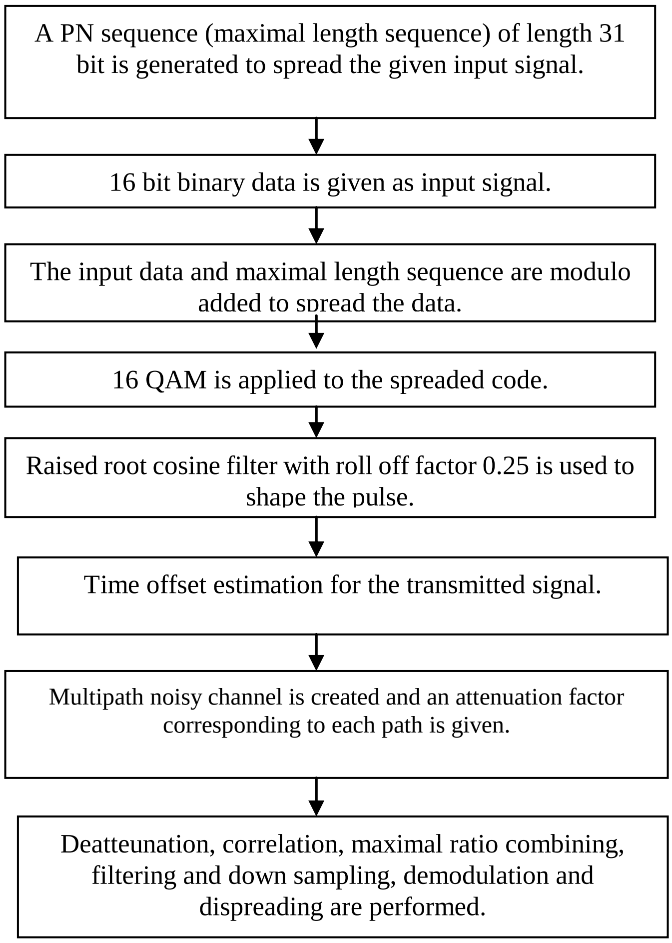

Figure 2: Algorithm of seven finger RAKE receiver

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For the better channel quality improvement, 16-QAM or 64-QAM is to be used. Pulse shaping is used to reduce or to remove the inter symbol interference. Filter used to perform this is raised cosine filter.

In consideration of better performance of bandwidth the filter used here is raised cosine filter. Even with maximum roll-off factor (β=1) the maximum bandwidth is only 1/T. T is the symbol period.

The QAM systems with smaller roll-off factors results in reducing the bandwidth. The 16 QAM modulated signal is filtered using root raised cosine filter with roll off factor 0.25 and the signal is up sampled by 4 samples and then the signal is transmitted.

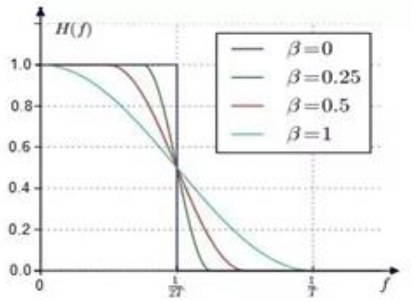

Figure 3: Raised cosine filter for some values of the roll-off factor

The lower value for roll-factor causes the filter to have a narrower transition band. Ideal raised cosine filters have infinite number of taps. Therefore, practical raised cosine filters are windowed. The window length is controlled using the filter span in symbols property. For pulse shaping of the modulated signal, the signal is up sampled by the raised cosine filter. Therefore, we also need specify the up sampling factor. The group delay is equal to 5. If the input signal is in the pass band of the filter, the output signal is approximately equal to the input signal delayed by the group delay of the filter.

The modulated signal is using as the reference signal for the time shift over the seven paths. The time delay is applied to the 16 QAM modulated signal for the seven paths as the time delay introduced in the first path is one-bit delay.

For the second path the time delay is two-bit delay and similarly for the remaining paths as three-bit delay, four-bit delay, five-bit delay, six-bit delay and seven-bit delay respectively.

B. MULTI PATH CHANNEL

Noisy channel with seven paths is created for the signal to diverge and transmit through and attenuation factor for each channel. Attenuation factors are used to reduce the signal strength in each path gradually, attenuation factors applied for each path are given respectively, they are, 1, 0.85, 0.7, 0.55, 0.4, 0.25, 0.1 respectively for path 1 to path 7. The received signal is multiplied with the array of attenuation factors to get the attenuated signal.

C. RAKE RECEIVER

In the receiver section the attenuated signal is deatteunated, then the received signals are correlated with the time delayed signal and these received signals from all the seven paths is combined by using the technique called maximal ratio combining (MRC).

From all the available diversity combining techniques each technique has its own unique advantage but in comparison to other diversity techniques, maximal ratio combining technique is superior to others in many aspects such as high diversity gain and high signal to noise ratio compared to other diversity techniques.

MRC weights are weighted to each path based upon their SNR's, highest SNR value is weighted the first and least SNR value is weighted least and all SNRs are combined to get the highest SNR. Then the combination of the signals according to their signal to noise ratios. Know the combined signal is applied to raised cosine filter and then down sampled by the factor of '4'.Filtered and down sampled signal is demodulated and then despread to retain back the original signal.

The same raised cosine filter that transmitter used earlier is used and then down sample the result by a factor of numSamplesPerSymbol. The first and last span symbols in the decimated signal are removed because they represent the cumulative delay of the two filtering operations.

IV. SIMULATION RESULTS

The simulation result for original bit sequence and pseudorandom bit sequence is in the figure 4.

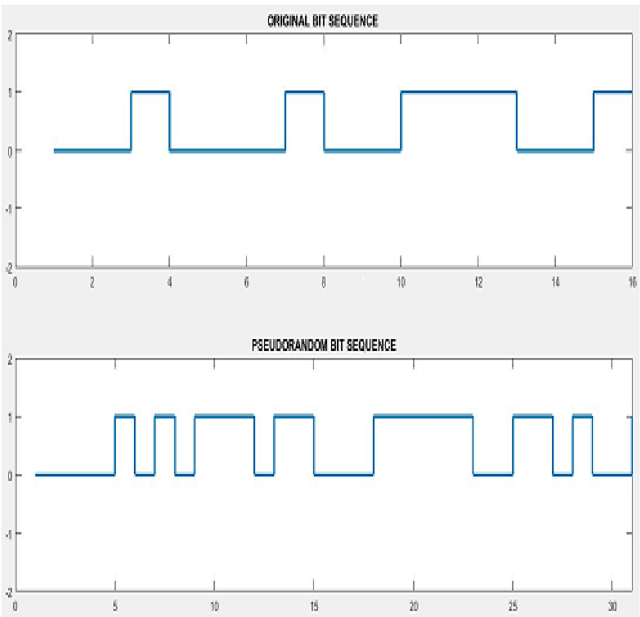

Figure 4: Input and pseudorandom bit sequence

The simulation result for spreaded code is given in figure 5.

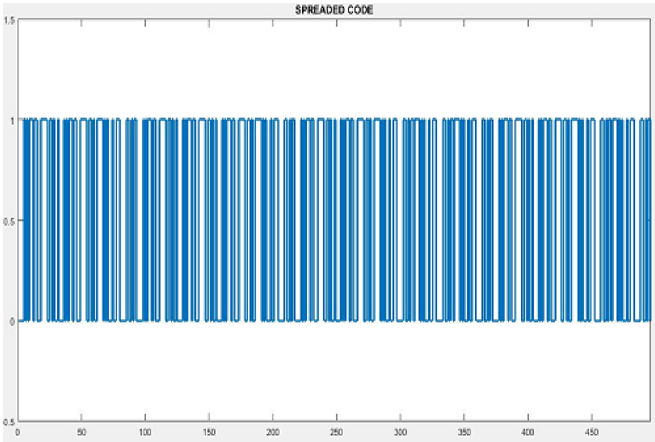

Figure 5: Spreaded code

The simulation result for 16 QAM modulated signals and transmitted signals are given in figure 6.

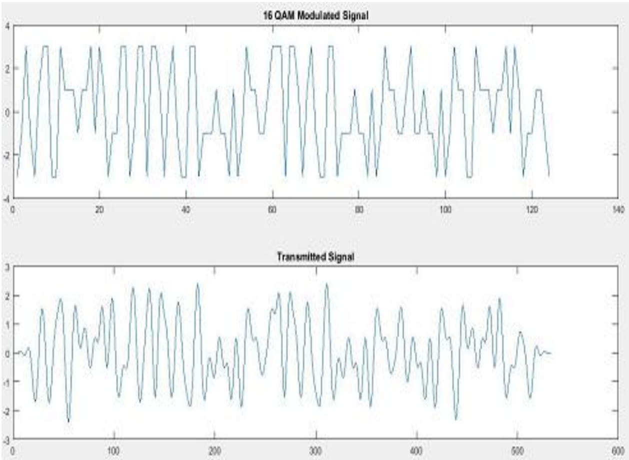

Figure 6: 16 QAM modulated signal and transmitted signal.

The simulation result for the time delay of seven fingers is given in figure 7.

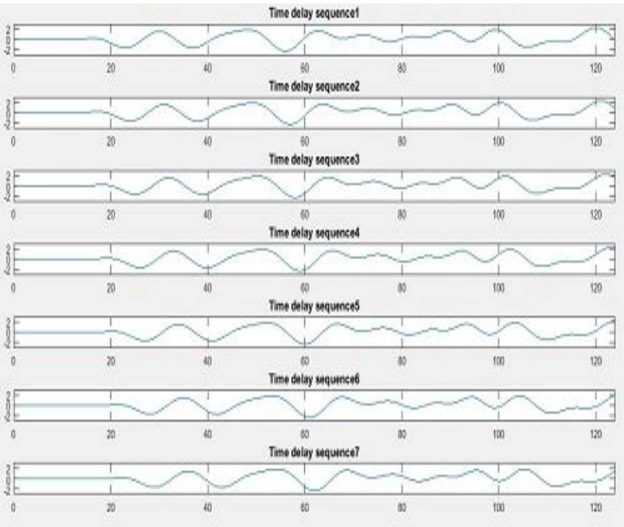

Figure 7: Time delay for seven fingers.

The simulation result for AWGN in seven fingers is given in figure 8.

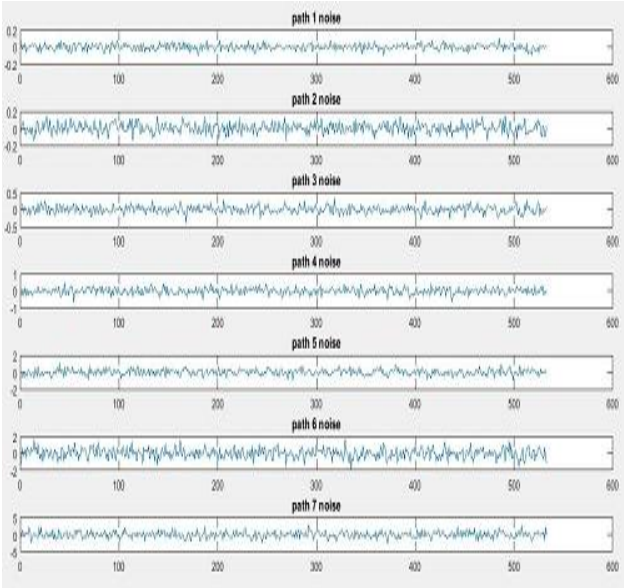

Figure 8: AWGN in seven fingers.

The simulation result for MRC is given in figure 9.

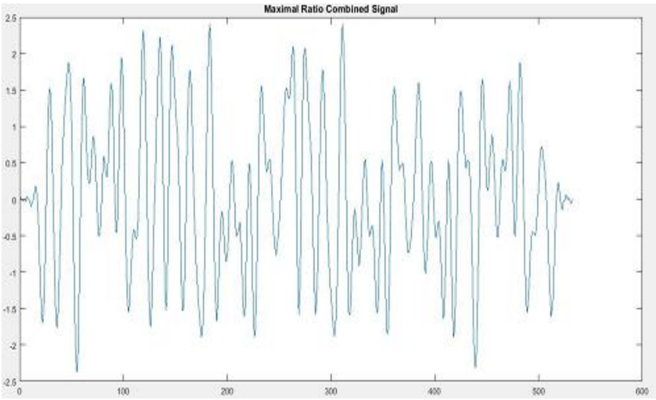

Figure 9: MRC signal.

The simulation result for 16-QAM demodulated signal is given in figure 10.

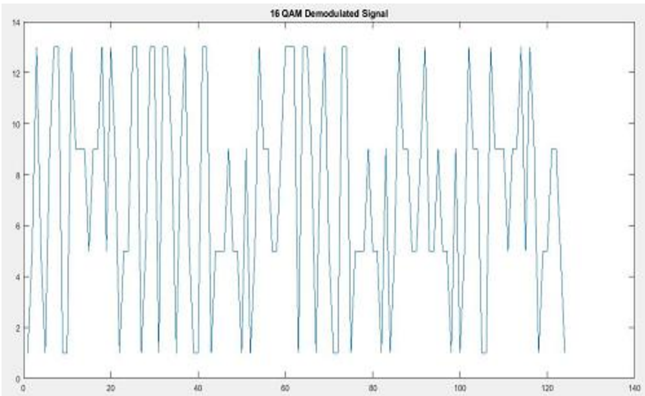

Figure 10: 16 QAM demodulated signal.

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The simulation result for the despreading output in comparison with input original data is given in figure 11.

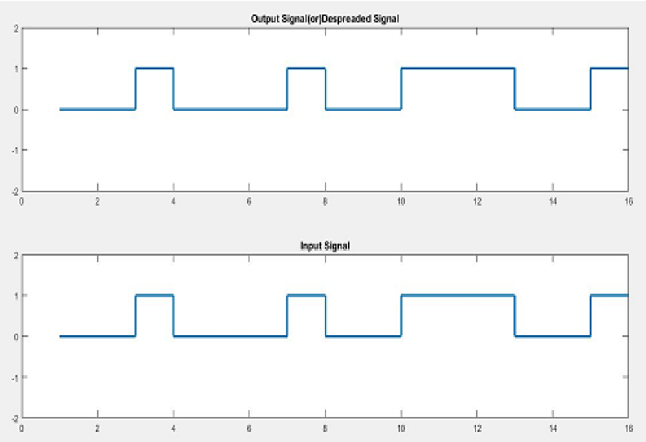

Figure 11: Comparison of output signal and input signal.

V. CONCLUSION

The one of the multipath fading effects is eliminated by the time offset implementation for a seven finger rake receiver. The received signal is extracted same as the input transmitted signal, which shows there is no multipath fading over the signal. Rake receiver improves SNR, efficiency, information reliability and the reception quality in the fading conditions. The efficient way of multipath signal reception in CDMA and WCDMA is rake receiver.

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AUTHORS PROFILE

D. Sri Kavya is pursing M. TECH with the stream of Communication & Signal Processing in ANUCET, Acharya Nagarjuna University. She did his B. TECH from Narayana Engineering College in the year 2013-2017. Her interesting areas are Communications, VLSI and Antennas.

Dr. P. Siddaiah obtained B.Tech degree in Electronics and communication engineering from JNTUA College of engineering in 1988. He received M.Tech degree From SV University Tirupati. He did Ph.D program in JNTU Hyderabad. He is currently working as Professor & Principal of ECE in university college engineering and technology, Acharya Nagarjuna University, Guntur, India. His interesting areas are Antennas, Communications and Signal processing.