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The Comparison and Performance Evolution of with and Without Rake Receiver in CDMA Technique

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Abstract: *RAKE receiver is used in CDMA-based (Code Division Multiple Access) systems and can combine multipath components, which are time-delayed versions of the original signal transmission. Combining is done in order to improve the signal to noise ration at the receiver. RAKE receiver attempts to collect the time-shifted versions of the original signal by providing a separate correlation receiver for each of the multipath signals. This can be done due to multipath components are practically uncorrelated from another when their relative propagation delay exceeds a chip period. This paper presents the basics of RAKE receiver technique, implementation, and design in cellular systems. Also the usage of RAKE receiver is introduced in CDMA-based systems such as IS-95 and WCDMA (Wideband Code Division Multiple Access).*

Index Terms: *RAKE receiver, CDMA, multipath, receiver.*

1. Introduction

In CDMA (Code Division Multiple Access) spread spectrum systems, the chip rate is typically much greater than the flat fading bandwidth of the channel. Where as conventional modulation techniques require an equalizer to undo the intersymbol interference (ISI) between adjacent symbols, CDMA spreading codes are designed to provide very low correlation between successive chips. Thus, propagation delay spread in the radio channel merely provides multiple versions of the transmitted signal at the receiver. If these multipath components are delayed in time by more than one chip duration, they appear like uncorrelated noise at a CDMA receiver, and equalization is not required. RAKE receiver, used specially in CDMA cellular systems, can combine multipath components, which are time-delayed versions of the original signal transmission. This combining is done in order to improve the signal to noise ratio (SNR) at the receiver. RAKE receiver attempts to collect the timeshifted versions of the original signal by providing a separate correlation receiver for each of the multipath signals. This can be done due to multipath components are practically uncorrelated from another when their relative propagation delay exceeds a chip period.

2. Rake Receiver

Due to reflections from obstacles a radio channel can consist of many copies of originally transmitted signals having different amplitudes, phases, and delays. If the signal components arrive more than duration of one chip apart from each other, a RAKE receiver can be used to resolve and combine them. The RAKE receiver uses a multipath diversity principle. It is like a rake that rakes the energy from the multipath propagated signal components.

3. Rake Receiver in Is-95 System

In the implementation of the IS-95 system, the mobile receiver employs a “searcher” receiver and three digital data receivers that act as fingers of a RAKE in that they may be assigned to track and isolate particular multipath components of a single cell site, a single base station in softer handover and multiple base stations in soft handover. The PN chip rate of 1,2288 MHz allows for resolution of multipaths at time intervals of 1,2288 x 10-6 s = 0,814 _s, which means that multipath difference in meters can be around 244 m.

A. Downlink

The searcher receiver scans the time domain about the desired signal’s expected time of arrival for multipath pilot signals from the same cell site and pilot signals and their multipaths from other cell sites. Searching the time domain on the downlink signals is simplified because the pilot channel permits the coherent detection of signals. The search receiver indicates to the mobile phone's control processor where, in time, the strongest replicas of the signal can be found, and their respective signal strengths. In turn, the control processor provides timing and PN code information to the tree digital data receivers, enabling each of them to track and demodulate a different signal. If a another cell site pilot signal becomes significantly stronger than the current pilot signal, the control processor initiates handover procedures during which the downlinks of both cell sites transmit at the same call data on all their traffic channels. When both sites handle the call, additional space diversity or macro diversity is obtained. The data from all three digital receivers are combined for improved resistance to fading. Different base stations or sectors are distinguished by different short PN code offsets. The downlink performs coherent post-detection combining after ensuring that the data streams are time-aligned; performance is not compromised by using post-detection combining because the modulation technique is linear. Coherent combining is possible because the pilot signal from each base station provides a coherent phase reference that can be tracked by the digital data receivers.

B. Uplink

On the uplink, the base station receiver uses two antennas for space diversity reception, and there are four digital data receivers available for tracking up to four multipath components of a particular subscriber's signal. The searcher receiver at the base station can distinguish the desired mobile signal by means of its unique scrambling long PN code offset, acquired before voice or data transmission begins on the link, using s special preamble for that purpose. During soft handover from one base station site to another, the voice data that are selected could result from combining up to eight multipath components, four at each site. The uplink transmission, not having a coherent phase reference like the downlink's pilot signal, must be demodulated and combined non-coherently; maximal-ratio combining can be done by weighting each path's symbol statistics in proportion to the path's relative power prior to demodulation and decoding decision.

4. RAKE RECEIVER IN WCDMA SYSTEM

A basic implementation of RAKE receiver presented in despreads data from different multipath components, combines the multipath components, and detects combined data to soft bits. A WCDMA base station RAKE receiver contains the following functions to enable the receiving of CDMA type of multipath signals.

1. Channel delay estimation for multipath components.

This can also called as Impulse Response (IR) Measurement.

2. RAKE receiver finger allocation based on the channel delay estimation

3. RAKE receiver fingers to perform the descrambling and despreading operations

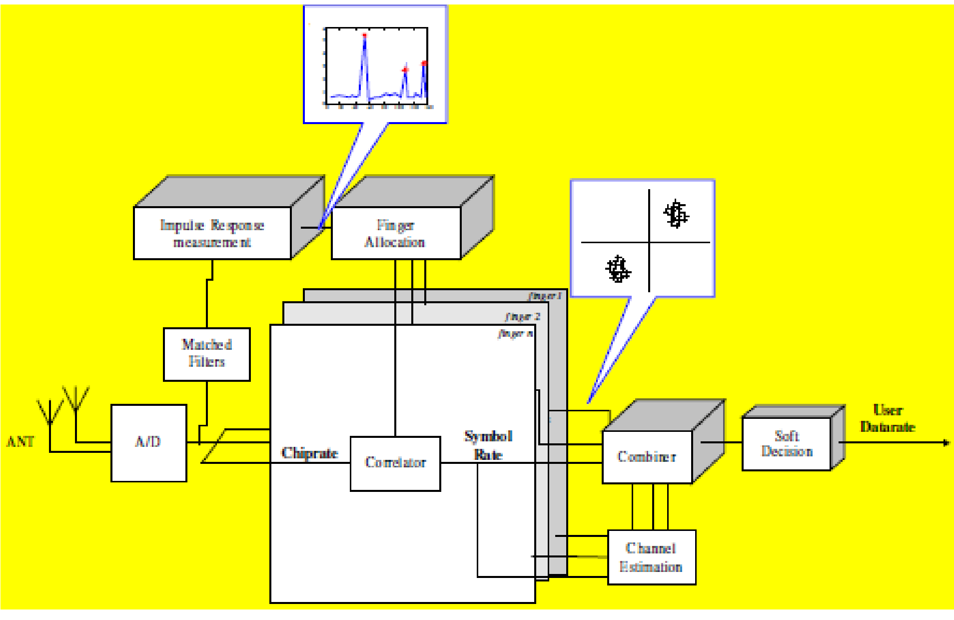

Fig 1. *RAKE RECEIVER WCDMA*

A. Channel Delay Estimation

The channel Impulse Response Measurement (IRM) is performed by using Matched Filter (MF) type of correlators that correlate the received signal with known reference code sequence such as pilot channel code. The MF resources contain shorter filters (length of 64 chips time period for RACH and 32 chips time period for DPCCH), which can be concatenated in time domain to enable the proper delay estimation also in large cells with large delay spreads (e.g. hilly terrain environments). To improve the delay estimation performance and to increase signal to noise ratio the results of MFs are further processed by coherent and non-coherent averaging. The length of the coherent IR averaging is typically one time slot while the noncoherent averaging is typically done over radio frames. The length of the averaging operations can be selected by parametrization. The accuracy of the IR measurement is ¼ chip (65,1 ns).

B. RAKE Receiver Finger Allocation

The purpose of the RAKE finger allocation procedure is to define the optimal finger delay positions that maximize the receiver performance. The allocation procedure defines the correct delay positions for despreading (in RAKE fingers) the received wideband signal to symbol level information. In the case of receiver antenna diversity the finger allocation procedure combines information from separate receiver antennas. In softer handover the allocation procedure defines the optimal finger delay positions by taking into account the information from all the sectors involved in the handover situation. The finger allocation procedure contains algorithms, which eliminate the unnecessary changes in the finger time positions between successive allocations. Thus the despreading of a certain multipath component is kept on the same RAKE finger as long as possible to maximize the performance of channel estimation and maximal-ratio combining. In the finger allocation procedure also the shape of the channel impulse response is taken into account when defining the optimum finger delay positions. It has been confirmed that the allocation must be done differently for the channels where the taps are very close to each others (so called "fat finger") than for channels with clearly separate taps. Typically the allocation frequency in normal operation mode is one allocation for a code channel in every 25 ms (accuracy of ¼ chip), which is enough for all the practical situations. Code tracking with accuracy of 1/8 chip is further used in RAKE fingers to track and compensate small delay deviations in multipath component timing. The change in the timing can be caused by the movement of the UE or by the transmission timing adjustment of the UE.

C. RAKE Receiver Finger Descrambling and Despreading

The despreading operation for DPDCH (Dedicated Physical Data Channel) and DPCCH (Dedicated Physical Control Channel) is performed in RAKE fingers to recover the receiver wideband signal to symbol level information - multiplying of incoming signal by complex conjugate of scrambling code and channelization code and accumulating the results over symbol periods. In the base station receiver 8 fingers are allocated for each code channel (i.e. 8 multipath components can be despread for a single user). Code tracking is used to track and compensate small deviations in multipath component delays i.e. the Code tracking performs the fine adjustment of the delay used in the despreading. The tracking is done for every finger and the accuracy is 1/8 chip. Like in the main finger allocation procedure the shape of the channel impulse response is taken into account when defining the despreading timings. Typically the delay updating by code tracking is performed once in each or every second 10 ms radio frame.

5. Purpose Of Simulator

The objective of this research is to simulate and evaluate the performance of deferent parameter and RAKE receiver performance for the CDMA. It is well known that CDMA simulator and the simulation software developed for this research implements RAKE and without RAKE methods in combination with CDMA standard.

This work will provide crucial information leading to the implementation of CDMA simulator in a real-world system. RAKE to multiple stages of interference cancellation. RAKE was used in this work along with receivers that used the information in the channel. For both rake and without rake, we compare them in multipath environment. It will be shown that the use of number of bit error in received data by the RAKE receiver is less than the received data of without RAKE receiver advantages of RAKE receivers.

6. Simulation Results

In the result of this project we will show once we give the input to the receiver, how the command window will simulate CDMA with and without Rake Receiver. Then it will show the convolution of BER towards the SNR. We will also show the transmitted data and received data for different attenuation factor and number of bit error in GUI, this project shows that the number of bit error in received data with the RAKE is less than the number of bit error in received data without the RAKE, and when we increase the attenuation factor the number of bit error is decreases.

A. GUI for simulation of CDMA with Rake receiver

When we run the w_rake.m then this will open this command window. This simulation shows the information about the no. of user, no. of finger, 15 bit transmitted bit data and 15 bit received bit data. In simulation with rake, it shows the user data and received data which is 15 bit in the form of having 15 columns.

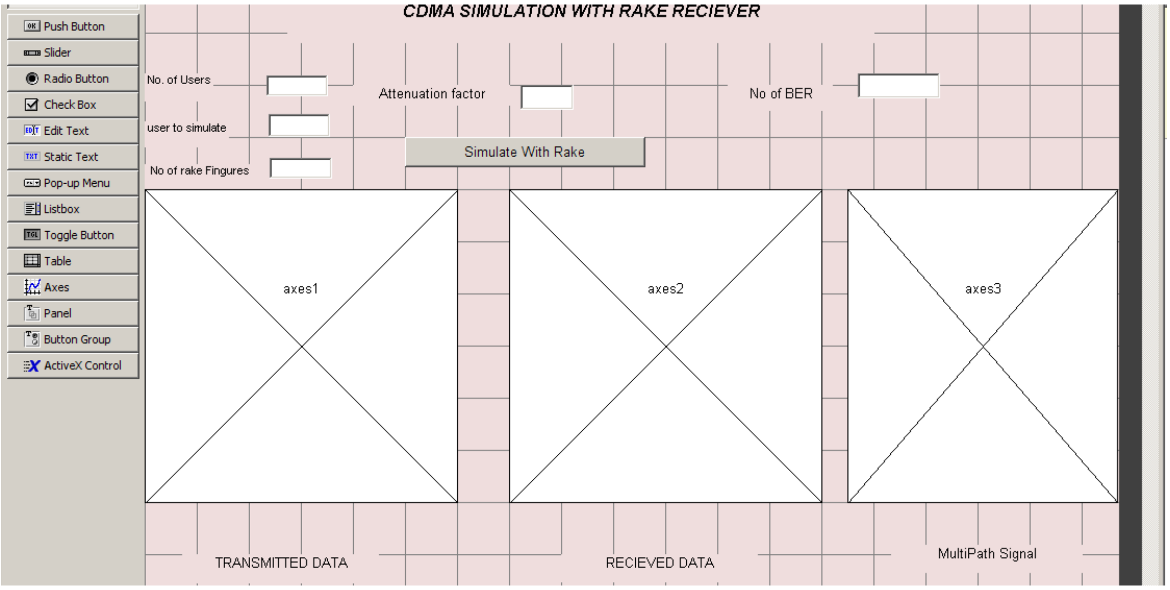

Fig 2. *GUI Implementation For CDMA Simulation with Rake Receiver*

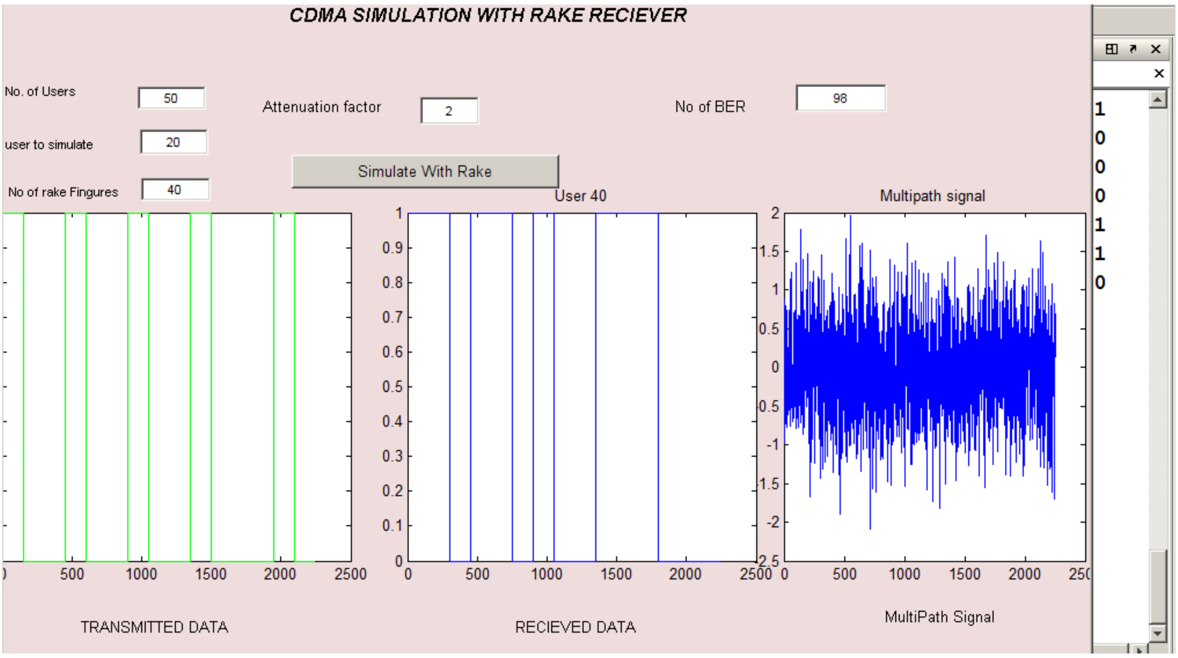

Fig 3. *GUI Simulation Analysis for CDMA with Rake Receiver*

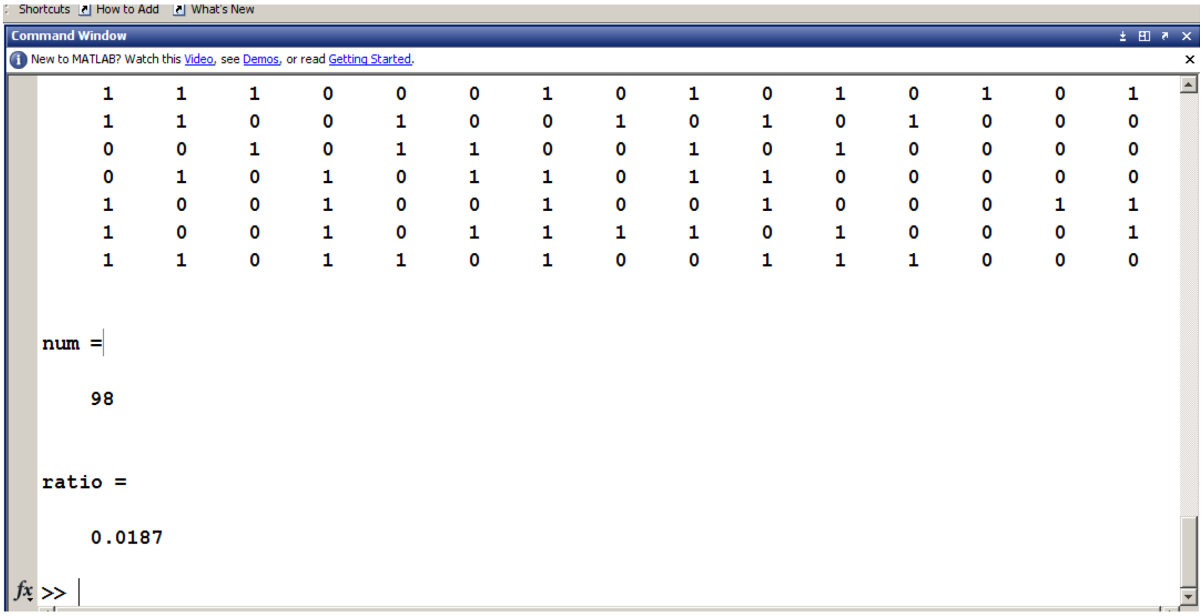

Fig 4. *Command window analysis for CDMA with Rake Receiver*

B. GUI for simulation of CDMA without Rake receiver

When we run the w_rake.m then this will open this command window. This simulation shows the information about the no. of user, no. of finger, 15 bit transmitted bit data and 15 bit received bit data. In simulation with rake, it shows the user data and received data which is 15 bit in the form of having 15 columns.

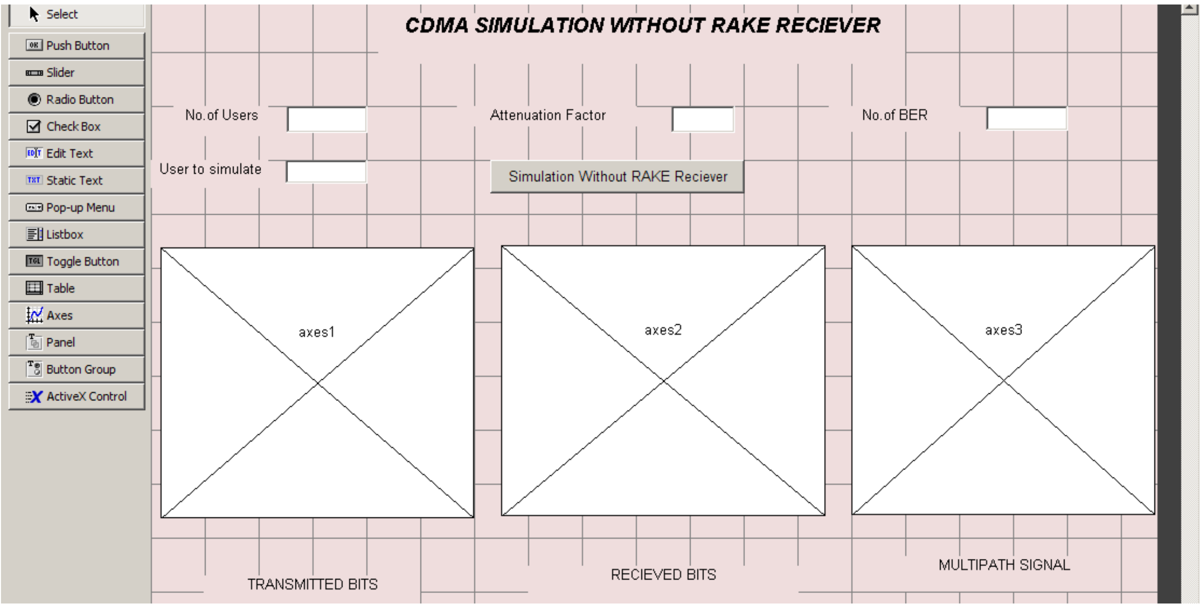

Fig 5. *GUI Implementation for CDMA Simulation without Rake Receiver*

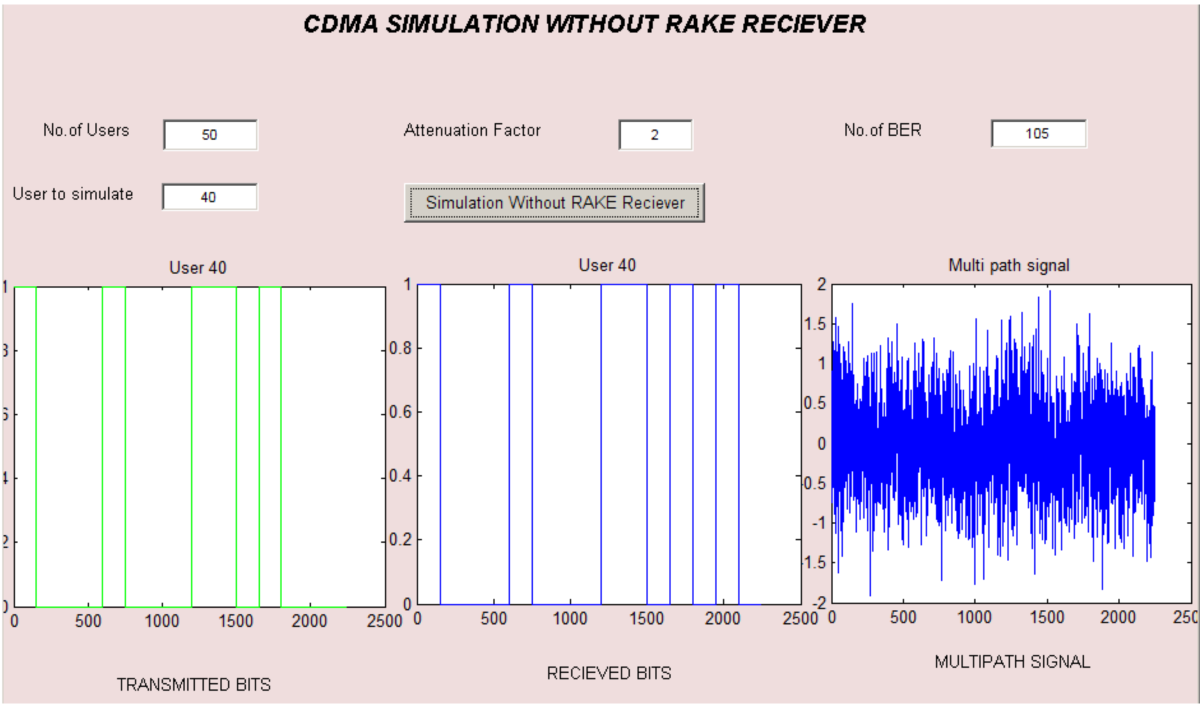

Fig 6. *GUI Simulation analysis for CDMA without Rake Receiver*

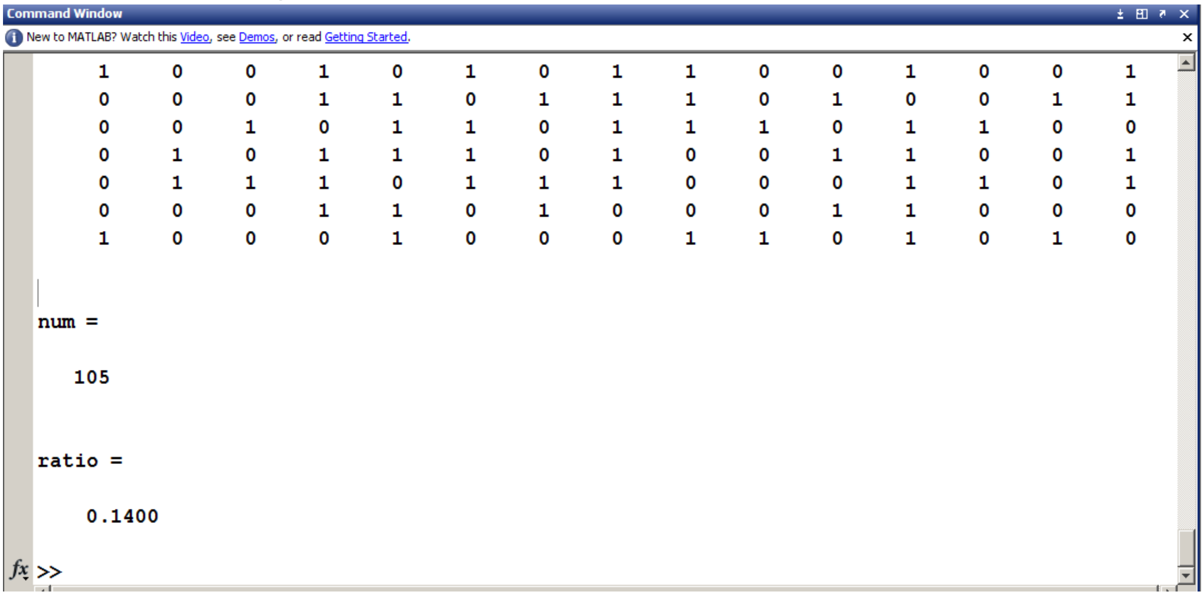

Fig 7. *Command window analysis for CDMA without Rake Receiver*

7. Conclusion

The system which can be efficiently reduce the bit error rate is introduced in this paper i.e. DS-CDMA technique. It is also putting the impact on the wireless system that how we increase or decrease the attenuation factor and hoe it affect on the wireless system while applying the multiple inputs.

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