WCDMA System using High Power Amplifier

Kavita Barange
Department of Electronics & Communication
LNCTS- Bhopal, India

Dr. Soni Changlani
Department of Electronics & Communication
LNCTS- Bhopal, India

Rahul Sharma
Department of Electronics & Communication
LNCTS- Bhopal, India

Abstract

This paper analyzes the performance of Wireless CDMA when high power amplifier use in the processing block of this. The simulation is carried out on MATLAB 7.8.1, the result shows the BER, MER comparison of WCDMA with using and without using high power amplifier. In this paper author analysis the WCDMA System without high power amplifier and with high power amplifier and the calculation of AWGN channel 15 db SNR, Received Signal via High efficiency power amplifier is plotted, AM/ PM response of resultant signal is plotted. BER, MER is calculated as a parameter to judge the performance of the proposed system.

Keywords: CDMA, WCDMA, OVSF, WH, DS-CDMA

I. INTRODUCTION

Wideband Code Division multiple Access (W- CDMA) is being used by Universal Mobile Telecommunication System (UMTS) as platform of the 3RD generation cellular communication system. W-CDMA uses noise-like broadband frequency spectrum where it has high resistance to multipath fading whereas this was not present in conventional narrowband signal of 2nd generation (2G) communication system.

High data rate signal transmission can be transmitted over the air by using W-CDMA system, thus enabling of multimedia rich applications such as video streams and high resolution pictures to end users. Thus, we need suitable modulation technique and error correction mechanism to be used in W-CDMA system. In 2G networks, Gaussian Minimum Shift Keying (GMSK) modulation scheme is widely used in GSM (Global System for Mobile) Communication.

Code Division Multiple Access (CDMA) based on Spread Signal (SS) has emerged as one of the most important multiple access technologies for Second Generation (2G) Third Generation (3G) wireless communication systems by its wide applications in many important mobile cellular standards. CDMA technique relies on spreading codes to separate different users or channels and its properties will govern the performance of the system. So many of the problems of communication systems based on CDMA technology stem from the spreading codes/sequences, which includes two sub-categories, one being the orthogonal codes, such as Walsh Hadamard (WH) codes and Orthogonal Variable Spreading Factor (OVSF) codes, and the other being pseudo-noise or Pseudo Random (PN) sequences, such as Gold sequences, Kasami sequences, m-sequences, etc

Third Generation (3G) wireless communication systems by its wide applications in many important mobile cellular standards. CDMA technique relies on spreading codes to separate different users or channels and its properties will govern the performance of the system. So many of the problems of communication systems based on CDMA technology stem from the spreading codes/sequences, which includes two sub-categories, one being the orthogonal codes, such as Walsh Hadamard (WH) codes and Orthogonal Variable Spreading Factor (OVSF) codes, and the other being pseudo-noise or Pseudo Random (PN) sequences, such as Gold sequences, Kasami sequences, m-sequences, etc

In this work a PN sequence generation based on Residue Arithmetic is investigated with an attempt to improve the performance of existing interference-limited CDMA technology for mobile cellular systems. This interference-limited performance is due to the fact that all the existing CDMA codes used in mobile cellular standards does not consider external interferences, multipath propagation, Doppler Effect etc. So the non-ideal correlation properties of the pseudo-random CDMA codes results in MAI when used in a multi-user system. The PN codes appear random yet they are completely deterministic in nature with a small set of initial conditions. Consequently this work focuses on CDMA code design approach based on Residue Number System (RNS) which should take into account as many real operational conditions as possible and to maintain a sufficiently large code set size.

First, the work will review RNS, DS-CDMA and CDMA codes that are already implemented in various mobile cellular standards. Then the new PN Sequence generator design based on RNS is discussed. Comparison of the generated PN sequence with respect to other standard sequence is done in terms of number of codes and correlation properties. Monte-Carlo simulations with the generated sequence are carried out for performance analysis under multi-path environment. The system has been evaluated in AWGN, Rayleigh Fading channel and different Stationary Multipath Channels for different cross-correlation threshold.
The world's first cellular network i.e., Advanced Mobile Phone System (AMPS) - based on analog radio transmission technologies was put into service in the early 1980s [1]. It uses separate frequencies, or "sub-channels" of the common channel for each user, see Figure 1.

![Fig. 1.1: Multiple Access Frequency Division Multiple Access Technique [2]](image)

Within few years of launching, the network began to hit a capacity ceiling as millions of new subscribers signed up for mobile voice services. To accommodate more users within a limited amount of spectrum, a new set of wireless technology called Time Division Multiple Access (TDMA) has been developed. Figure 1.2 shows how a TDMA system works. Several users share a common channel but they are separated by time. DAMPS (Digital AMPS) and Global System for Mobile (GSM) then came onto the stage [3].

![Fig. 1.2: Multiple Access Time Division Multiple Access Technique [2]](image)

The most important milestone in the application of CDMA technologies is the time when IS-95 - the first CDMA-based civilian mobile cellular communication standard was successfully developed by Qualcomm in the 1990s. Since then, CDMA-based mobile cellular has become the fastest growing of all wireless technologies. Since then, it has been successfully demonstrated that a CDMA system based on the direct sequence (DS) spreading technique can in fact offer a higher bandwidth efficiency than its predecessors, with additional advantages such as low probability.

II. BACKGROUND AND LITERATURE SURVEY

RNS were introduced in field of DS-CDMA by many researchers as early as late 90s by Lie Liang Yang and Lajos Hanzo. In conventional systems, due to the carry forward required by the weighted number system, a bit error may affect all the bits of the result. In they proposed a parallel communication scheme based on RNS, which is a non-weighted carry-free number system. The symbol to be transmitted is transformed to RNS representation, mapped into a set of orthogonal sequences and are transmitted in parallel. Error control was also incorporated in this paper using redundant RNS (RRNS) code. Performance of the
same system over bursty communication channels is done by Madhukumar and Chin [8]. They have also proposed a modulation technique by combining RNS representation, PSK/QAM modulation and orthogonal modulation for bandwidth efficiency in [9].

The error control properties of RRNS were exploited in [10] to be used as channel codes for protecting the speech bits. In [11] residue arithmetic is used for representing the symbol to be transmitted. Redundant residue arithmetic system based multi-carrier DS-CDMA (MC/DS - CDMA) dynamic multiple access scheme has been proposed in [12] for dynamically accessing the frequency spectrum available for Cognitive Radio communication. All references basically points to a parallel communication scheme where the symbol to be transmitted by each user is represented in residue arithmetic and an inverse RNS transform block is used at the receiver to get back the symbol. But generation of PN sequences by exploiting the properties of RNS and use of these to spread message signals for multiple user transmission has never been investigated. Wideband Code Division Multiple Access (WCDMA), the air interface technology for third generation (3G) systems specified by 3rd Generation Partnership Project (3GPP) applies DS-CDMA technique with Orthogonal Variable Spreading (OVSF) Code as Channelization code for multiplexing different users [13].

The WCDMA downlink transmission is prone to self interference caused by the loss of orthogonality between spreading codes due to multipath propagation. There are several techniques for interference cancellation and multuser detection that improves the performance and capacity of the downlink WCDMA system. Most of these techniques are designed at the expense of higher receiver complexity and with OVSF codes derived from Walsh-Hadamard code. Construction methods of OVSF-ZCZ sequences have been proposed in to mitigate interference due to multipath propagation. Since the number of OVSF-ZCZ sequences is limited, various assignment algorithms are required to meet the demand of large number of users. The use of Orthogonal Variable Spreading Code (OVSF) code requires that a dedicated rate matching algorithm to be used in the transceivers [1]. This algorithm consumes a great amount of hardware and software resources and increases computation load and processing latency.

In the OVSF code generation tree structure, the codes in the upper layer with lower spreading factor blocks the codes in the lower layer with higher spreading factor. i.e. fewer users can be accommodated in a cell. These issues indeed demand for the existing code replacement. In this context this theses presents a Channelization code based on Residue Arithmetic which counter the said limitations. RNS is already used in the design of decimation filters for WCDMA receivers.

A. Some Referred Literature Papers Are As:

Bhadada, R et al., “Performance investigation modeling for modulation employable in WCDMA over AWGN fading channel” 2nd International Conference on Emerging Technology Trends in Electronics, Communication and Networking (ET2ECN), Dec 2014

Bhadada, R et al., works on the challenge of increasing demand for data transfer speed and consequently bandwidth. Digital modulation techniques have contributed a lot to increase the capacity, data rates and quality of network WCDMA is a high potential technique being rapidly adopted by the industry. Author presents a simulation technique to enable select better digital modulation scheme for WCDMA. The paper highlights the results of this simulation for BPSK, QPSK, 8-PSK modulation models over AWGN fading channel for WCDMA.


In this paper, a dual-band outphasing transmitter (able of operating either at 770 MHz or 960 MHz frequency bands) is presented. Two broadband RF power amplifiers (PAs) have been designed over packaged GaN HEMT devices, switching close to the nominal zero-voltage and zero-voltage-derivative class E conditions. A reactive combiner, using transmission lines of appropriate electrical lengths at both bands, together with compensating reactances, allows positioning the drain impedance loci to produce high efficiency and good dynamic range profiles. Average drain efficiency figures over 68% and 38% have been measured for WCDMA signals with a peak-to-average power ratio (PAPR) of 5.1 dB and 8.4 dB, respectively.

Yunjie Wan et al., “Uplink performance in 3G networks”, IEEE Workshop on Advanced Research and Technology in Industry Applications (WARTIA), 2014

In this paper, the WCDMA and CDMA’s uplink broadband performance was measured in Nanjing. Content of the measuring include throughput, packet loss, delay and receiving interval. Through testing, Author identifies the relationship between uplink packet loss, delay and receiving interval with throughput. Author observed that the maximum throughput values are quite away to the advertised throughput for both WCDMA and CDMA2000 uplink. Through multi-path test, we found that when using two-path with the same 3G will not interfere with each other within a certain transmission rate, but three-path will. Furthermore, different 3G cannot interfere with each other.

Liang Lin et al., “Shielding cover effects on the RF performance of LDMOSFET power amplifier for WCDMA application”, Asia-Pacific Microwave Conference Proceedings (APMC), 2013

Shielding cover effects on the RF performance of LDMOSFET power amplifier (PA) is investigated in this research. In the measurement, the PA cover is made of aluminum, with its height adjusted from 8.4 to 14.4mm which are widely used in current wireless communication application. The input-output responses of several PA samples with cover are measured and compared for different cover heights. Both experiment and simulation show that as the cover height is reduced, the PA performance is degraded, but its power efficiency and linearity are not varied approximately. Further, it is found that, even the cover height is decreased, but through careful optimizing of its internal impedance matching networks consisting of multiple bonding wires, the
PA performance can be improved effectively. This research can provide some useful design guidance for the development of compact and miniaturized PA module with high performance.

Clifton, J.C. et al., “Wideband high efficiency multi-band, multi-mode (LTE/WCDMA/GSM) power amplifier for mobile terminals”, European Microwave Conference (EuMC), 2013

Author proves that, it is currently the widest frequency range multi-mode PA available for such applications -with the ability to cover 698-915MHz with just one “Low-Band” PA for all possible band allocations below 1GHz. A similar “High-Band” PA was able to cover many of the mobile bands above 1GHz: 1710-2050MHz with the ability to also support the 3GPP 1400MHz band. Despite the wide bandwidth, a high efficiency level -of a similar order to the best-in-class conventional narrow-band PAs, was achieved. Furthermore, it is shown that the architecture deployed has a number of additional powerful benefits compared with conventional PAs such as the ability to provide higher efficiency across the typical HSPA and LTE transmit power distribution characteristics and also the ability to integrate post-PA components such as switches onto the same PA due to the characteristically high output impedance associated with the architecture.


This paper presents a direct model structure for describing class-D outphasing power amplifiers (PAs) and a method for digitally predistorting these amplifiers. The direct model structure is based on modeling differences in gain and delay, nonlinear interactions between the two paths, and differences in the amplifier behavior. The digital predistortion method is designed to operate only on the input signals' phases, to correct for both amplitude and phase mismatches. This eliminates the need for additional voltage supplies to compensate for gain mismatch. Model and predistortion performance are evaluated on a 32-dBm peak-output-power class-D outphasing PA in CMOS with on-chip transformers. The excitation signal is a 5-MHz downlink WCDMA signal with peak-to-average power ratio of 9.5 dB. Using the proposed digital predistorter, the 5-MHz adjacent channel leakage power ratio (ACLR) was improved by 13.5 dB, from -32.1 to -45.6 dBC. The 10-MHz ACLR was improved by 6.4 dB, from -44.3 to -50.7 dBC, making the amplifier pass the 3GPP ACLR requirements.

III. PRINCIPLE OF OPERATION

WCDMA networks have recently seen a rapid growth all over the world. The reason for this lies in its technological advantages over second generation systems. However, since the newly rolled out networks have often not yet reached their normal operation conditions, the effects of varying traffic load on coverage and capacity still need to be investigated. Additionally soft capacity leads to a description of the term coverage that differs from its conventional usage. Unlike conventional systems like FDMA or TDMA where coverage is purely determined by radio frequency RF aspects the cell coverage in WCDMA is extremely sensitive to the customers that are supplied in the cell. Due to the soft capacity nature of WCDMA networks the coverage of a cell depends on several factors, the transmission characteristics of the terrain is the dynamics of the power control procedure to the desired quality of service in term of sustainable interference level and the spatial customer distribution and corresponding time dependent customer traffic intensity. From previous studies it is known that the coverage area of a CDMA cell is of an elastic nature of Veeravalli Sendonaris and Jain as the number of customers in the cell increases the area of coverage may shrink. This effect indicates that the customer population and its spatial distribution has to be taken into account carefully in the context of CDMA network planning especially in the design of connection admission control CAC, and overload control algorithms. Looking e.g. at the CAC the impact of accepting new calls is that those at the fringe of the cell would face a deteriorating service. Therefore both coverage and capacity of a cell need to be planned in such a way that all calls are sufficiently supplied i.e. power controlled according to the quality of service W-CDMA – the radio technology of UMTS - is a part of the ITU IMT-2000 family of 3G Standards. Both Frequency Division Duplex (FDD) and Time Division Duplex (TDD) variants are supported.

W-CDMA is a spread-spectrum modulation technique; one which uses channels whose bandwidth is much greater than that of the data to be transferred. Instead of each connection being granted a dedicated frequency band immediately wide enough to accommodate its envisaged maximum data rate, W-CDMA channels share a much larger band.

The modulation technique encodes each channel in such a way that a decoder, knowing the code, can pick out the wanted signal from other signals using the same band, which simply appear as so much noise.

UMTS uses a core network derived from that of GSM, ensuring backward compatibility of services and allowing seamless handover between GSM access technology and W-CDMA.

The choice of third generation radio technology employed by 3GPP in implementing UTRA - Universal Terrestrial Radio Access - was decided upon after a long period of technical discussion in ETSI's SMG Technical Committee during the 1990s. These discussions involved interested parties from the wider cellular community and eventually resulted in the formation of the 3rd Generation Partnership Project (3GPP). The basic technology chosen was Wide-band Code-Division Multiple Access (W-CDMA), with several sub-flavours:
- Direct Sequence, Frequency-Division Duplex
- Direct Sequence, Time-Division Duplex
- Multi-Carrier.

Within the Time-Division Duplex category the initial specifications were augmented shortly afterwards by a low chip-rate version developed largely at the initiative of the Chinese partner. Subsequently, a high chip-rate version has also been specified.
B. Spread Spectrum:
W-CDMA is a spread-spectrum modulation technique; that is, one which uses channels whose bandwidth is much greater than that of the data to be transferred. Instead of each connection being granted a dedicated frequency band just wide enough to accommodate its envisaged maximum data rate, W-CDMA channels share a much larger band. The modulation technique encodes each channel in such a way that a decoder, knowing the code, can pick out the wanted signal from other signals using the same band, which simply appear as so much noise.

Using a wide frequency band makes the system inherently resistant to many of the aspects of radio communication which plagues narrow band systems, such as bursty noise, multipath reflections, and other interfering transmissions. Since all information shares the same band, and channels can only be distinguished with knowledge of the spreading codes used, W-CDMA is also very secure from eavesdropping, even before employing encryption algorithms. Also, unlike systems which use a fixed number of discrete channels in a given frequency band, with W-CDMA there is no fixed number of simultaneous communications links which can be supported. The effect of adding more active links to a given cell will eventually result in the need for data rates for all links to be reduced in order that the wanted signals can be picked out of the ever increasing noise, but this is generally preferable to allowing access of a first-come, first-served basis, with later users simply being denied access.

IV. RESULT AND CONCLUSION

Fig. 4.1: Signal Generated at Transmitter End

Fig. 4.2: QAM Modulated Signal
Fig. 4.3: Scatter Plot of the signal

Fig. 4.4: Response of the system with, and without HPA

Fig. 4.5: Constellation Plot of the Data
Fig. 4.6: AM/PM response of the data in both condition

- Mean Error Rate = -25.1649 dB
- Bit Error Rate = 5.2356e-005 dB
- Modulation = -25.1649 QAM
- IFFT Size = -25.1649 Points
- Guard Interval Size = -25.1649 Points
- Saturation Level = -25.1649 dB relative to AM Avg

The core of the next generation CDMA technology lies in CDMA code design approach which should take into account as many real operational conditions as possible and to maintain a sufficiently large code set size. In this context, this thesis work contributed a little towards the evolution of next generation CDMA technology because the generated PN sequence based on Residue arithmetic:

- Offers provision to vary correlation threshold based on the channel properties and error tolerance thus providing real operational conditions for spreading code design unlike any existing techniques.
- Inherits high dynamic key range to maintain large code sets such that large number of users can be accommodated.

REFERENCES