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IMPLEMENTATION OF DIGITAL UP-DOWN CONVERTOR FOR WCDMA SYSTEMS

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Abstract: **This Project will discuss the design and implementation of the digital up down converter in MATLAB. Digital down convertor (DDC) and Digital up convertor (DUC) are extensively used in the radio systems. They are more popular than their analogue counterparts because of small size, low power consumption and accurate performance. DUC is a digital circuit which generates digital intermediate frequency (IF) signal from low complex digital baseband signal. The DUC provides pulse shaping, interpolation and frequency translation where the up sampled signal is shifted from centered frequency (0Hz) to intermediate frequency. The DUC is designed for digital signal processing applications and wireless communication systems along with capability of flexible digital filtering. The DDC converts the signal at the output of analog to digital convertor (ADC), centered at the intermediate frequency (IF), to complex baseband signal. In addition, DDC also decimates the baseband signal without affecting its spectral characteristics. The decimated signal, with a lower data rate, is easier to process on a low speed DSP processor. The introduction and proliferation of data network wireless access is a natural evolution in modern communication systems, stimulated by the promise of user mobility and freedom from wires and greatly encouraged by recent advances in portable wireless terminal technology. Just as already is the case of cellular voice communications, wireless data access is on the way of becoming a universal modern capability. For example, small and inexpensive PCMCIA modules, which readily attach to laptop computers, are available to make multi Mb/s wireless connections with access points strategically located within enterprise buildings, which further connect the users to wired LANs, intranets, etc. Likewise, in the home or in public places, wireless LANs will increasingly provide valuable data communication channels.**

I. INTRODUCTION

DUC are extensively used in the radio systems. They are more popular than their analogue counterparts because of small size, low power consumption and accurate performance. The DUC converts the signal at the output of digital to analog convertor (ADC), centered at complex Base band signal to the intermediate frequency in addition, DUC also interpolates the baseband signal without affecting its spectral characteristics. This paper discusses the DUC for the WCDMA system and implements them on the Mat lab. WCDMA is a leading choice of a data communication in the wireless industry nowadays and is selected as the air interface for the UMTS. WCDMA supports a higher data rate and is less susceptible to arrow band interferers and multipath. A fundamental part of many communications systems is Digital down Conversion (DDC). Digital radio receivers often have fast ADC converters delivering vast amounts of data; but in many cases, the signal of interest represents a small proportion of that bandwidth. A DDC allows the rest of that data to be discarded, allowing more intensive processing to be performed on the signal of interest. TI Wireless Radio Products devices provide digital signal processing functions for digital receiver, transmitter, and filtering functions.

Down Converter (DDC) and Digital Up Converter (DUC) fundamentals, and compares current products. The DDC provides signal selection, frequency translation, filtering, and decimation of digital input signals, and gives a baseband complex output. The DUC provides interpolation, filtering, frequency translation, and summing of DUC channel outputs to produce digital IF outputs. DDCs can be found in wireless base station receive electronics, specialized digital IF transmit-test equipment, and software defined receive-radio equipment. The number of DDC channels is based on the number of frequency carriers, number of phased or diverse antennas, and antenna delay calibration inputs. DUCs can be found in wireless base station transmits electronics, specialized digital IF receive-test equipment, cable TV modulators, and software defined transmit-radio equipment. The number of DUC channels is based on the number of frequency carriers, number of phased or diverse antennas, and antenna delay calibration outputs. Repeaters have one or two receive sections, and one or two transmit sections. Repeaters and smaller capacity base stations can have 2 or 4 DDC and DUC channels.

II. DIGITAL UP CONVERTERS

Digital Up-Converter (DUC) is a key component of digital front-end (DFE) circuits for RF systems in communications, sensing, and imaging. The function of the DUC is to translate one or more channels of data from baseband to a pass band signal comprising modulated carriers

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at a set of one or more specified radio orintermediate frequencies (RF or IF). It achieves this by performing: interpolation to increase the sample rate, filtering to provide spectral shaping an d rejection of interpolation images, and mixing to s hift the signal spectrum to the desired carrier frequencies. The sample rate at the input to the DUC is relatively low; f or example, the symbol rate of a digital communications sy stem, while the output is a much higher rate, generally th e input sample rate to a Digital-to-Analog Converter (DAC), which converts the digital samples to an analog waveform for further analog processing and frequency conversion. A generic architecture for a DUC is shown in Figure 1. A modulator (or other digital channel signa l source) feeds into a set of filters for pulse-shaping and in terpolation, and the filter output is then mixed with a vector of one or more carrier frequencies. Optionally, in adv anced systems, further filtering (interpolation), RF p rocessing (for example, Crest Factor Reduction (CFR), Digital Pre-Distortion (DPD), Modulation Correction, etc)., and frequency translation (to shift to a pa ss band centre frequency) may be performed. Finally, th e up-converted signal is converted to an analog sig nal for further processing and up-conversion to the RF ban d.

III. DIGITAL DOWN CONVERTERS (DDC)

A Digital down converter (DDC) is the counterpart component to the DUC an d is, therefore, equally important as a component in the s ame application systems. Its function is to translate a pa ss band signal comprising one or more radio or interme diate frequency (RF or IF) carriers to one or more baseba nd channels for demodulation and interpretation. It ach ieves this by performing: mixing to shift the signal spectrum from the selected carrier frequencies to baseband, decimation to reduce the sample rate, and filtering to r emove adjacent channels, minimize aliasing, and maximi ze the received signal-to-noise ratio (SNR). The DDC inp ut signal has a relatively high sample rate, generally, the output sample rate of an Analog-to-Digital Converter (ADC) which samples the detected signal (often after an alog frequency translation and pre-processing), while the output is a much lower rate, for example, the symbol ra te of a digital communications system for demodulation.

IV. WCDMA

DUC and DDC (Digital down Converter) are integral part of a communication system, which are used to convert the sample rate of the signal. Digita l up conversion is required when a signal is translated fro m baseband to intermediate frequency (IF) band. Digital d own conversion is required when a signal is converted from IF band to baseband. In addition to sampling rate con version, DUCs and DDCs typically include frequency shifting using mixers. The structure of a DUC or DDC depends mainly on the conversion ratio. For WCDMA systems, the conversion ratio is typically in the order of 8. DDC forWCDMA standard with deci mation factor of 8 is designed. Fig 2 shows the top leve l front end lock diagram of WCDMA.W-CDMA – the radio technology of UMTS - is a part of the ITU IMT-2000 family of 3G Standards. Both Frequency Division Duple x (FDD) and Time Division Duplex (TDD) variants ar e supported. W-CDMA is a spread-spectrum modulatio n technique; one which uses channels whose bandwidth i s much greater than that of the data to be transferred. Inst ead of each connection being granted a dedicated frequen cy band just wide enough to accommodate its envisaged maximum data rate, W-CDMA channels share a much l arger band. The modulation technique encodes each ch annel in such a way that a decoder, knowing the code, can pick out the wanted signal from other signals using t he 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 tech nology and W CDMA. W-CDMA specifications orig inate from the 3GPP Radio Access Network (RAN) gro up of 3GPP and were frozen in Release 99; Nearly 200 sp ecifications and reports reside mainly in the 25 series of 3 GPP specifications. In the late 1990s, W-CDMA was devel oped by NTT DoCoMo as the air interface for their 3G network FOMA. Later NTT DoCoMo submitted the spe cification to the International Telecommunication Union (ITU) as a candidate for the international 3G standard known as IMT-2000. The ITU eventually accepted W-CD MA as part of the IMT-2000 family of 3G standards, as an alternative to CDMA2000, EDGE, and the short rang e DECT system. Later, W-CDMA was selected as an a ir interface for UMTS.As NTT DoCoMo did not wait fo r the finalization of the 3G Release 99 specifications; their network was initially incompatible with UMTS. However, this has been resolved by NTT DoCoMo updating their network. Code Division Multiple Access communi cation networks have been developed by a number of

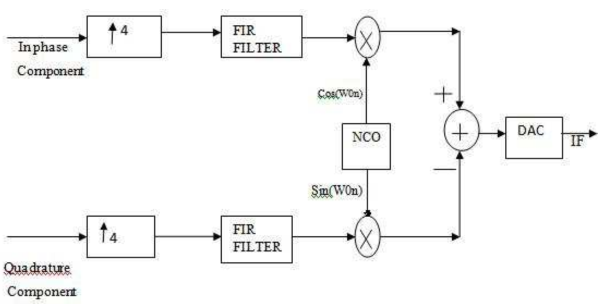

Figure 1: Block diagra m of digital up converter

The DUC has two identical data paths, one for the in phase and the other for qu adrature input. For this reason, it is also referred to as a complex DUC. The baseband signal at 23.04

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Msps is up sampled by 4 to 98.16 Mspsbefore mixing with the numerically cont rolled oscillator (NCO) output, to produce the spectrum centered around the desired modulation frequency. The low pas s FIR filter acts as an anti-aliasing filter after up sampling.

The filters are implemented in fix ed-point mode. The input/output word length and fraction length are specified. The sample rate change from 3.84MSPS to 61.44 is done. The designed model of DU C is shown in below figure 1.

V. DIGITAL DOWN CONV ERTOR

The DDC performs the reverse function of the DUC. It converts an IF signal to the baseb and signal. The DDC is built in a similar manner as DUC, b ut it uses down-sampling instead of up-sampling and they are connected in the reverse order compared to the DUC. A functional block diagram of the DDC is shown in Figure 2. This DDC does not require mixers or low pass filters

The IF signal *x (t)* is sampled at 98 .16 Msps by the ADC to create a digitized IF signal x (n) . This signal is demultiplexed into two data streams. One signal stream is down sampled by 4 to produce an in ph ase signal *I(4n)* ,while the other stream, delayed by a singl e sample, gives the quadrature component Q(*4n* -1) on d own sampling . The data rate of resultant in phase and quad rature signals is 23.04Msps.

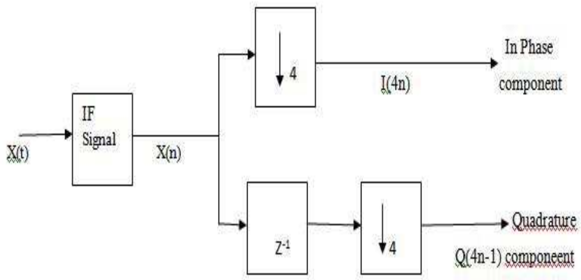

Figure 2. Block diagram of digital down c onverter

RESULTS

The DUC is designed using Matlab. The following results are concluded.

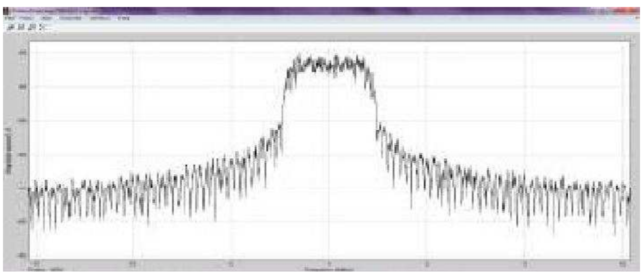

Figure 3. Input signal or WCDMA wav eform

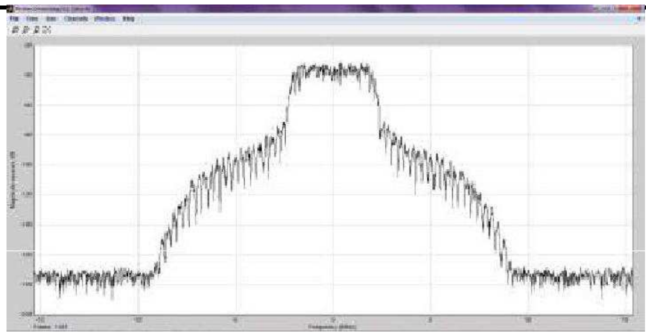

Figure 4. O utput of DUC

A. Down converter

The DDC is designed using Matlab. The following results are concluded.

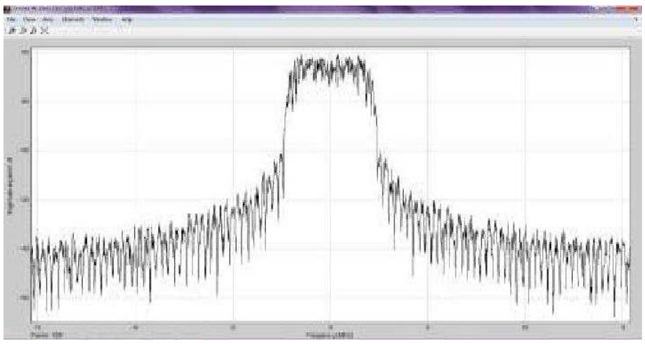

Figure 5. Input signal

The input DDC is shown i n fig 5.The input DDC is a 1 carrier WCDMA composite signal whose bandwidth is of 5 MHz in Fig below figure

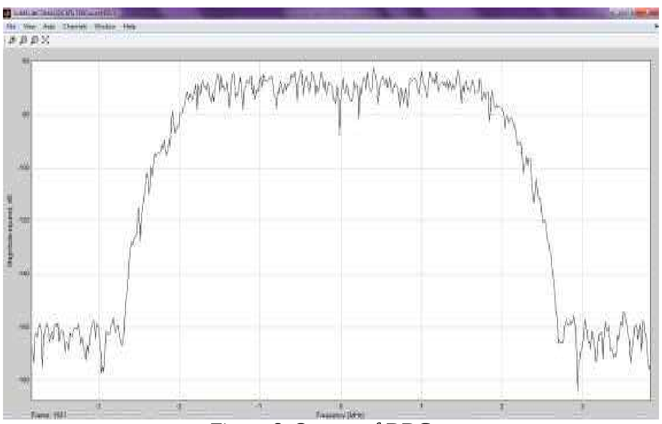

Figure 6. O utput of DDC

This plot estimates the p ower consumption with the frequency. The power cons umption has been estimated in terms of db and the frequen cy has been estimated in terms of

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MHz.

CONCLUSION

According to WCDMA standards, WCDMA systems can be designed for channel bandwidth 5 MHz As higher bandwidth can lead to more data rate and also design of digital systems at large bandwidth is of great challenge. So, in these paper interpolator stages of WCDMA DUC is designed for 5 MHz bandwidth. So, the design of WCDMA DUC results in an efficient system. The various parameters are evaluated after simulating the design. EVM factor evaluates the modulation quality of transmitter. The measured RMS EVM value is 8.01%. The ACLR values for offset frequency 5MHz and 10MHz are obtained. WCDMA is a rapidly growing wireless communication system that can provide broadband access with large coverage area. In the present work an effort is made to reduce the complexity of WCDMA system. From the study of literature related to WCDMA systems, it is concluded that DDC is the integral part of a WCDMA system. Study also shows that decimator filters are major part of DDC. As higher bandwidth can lead to more data rate and also design of digital systems at large bandwidth is of great challenge. So, in these thesis decimator stages of WCDMA DDC is designed for 5 MHz bandwidth According to WCDMA standards, for 5 MHz channel bandwidth, DDC need to be designed for decimation factor of 8, and during their design, the spectral emission standards should be strictly followed

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