Abstract
The demand for new bio instruments requiring higher capacities, data rates and different operating modes have motivated the development of new generation multi-standard wireless transceivers. In multi-standard design, sigma-delta based ADC is one of the most fashionable choices. A reconfigurable cascade sigma delta modulator has been presented on the system level. The modulator was based on single-bit quantizers and utilized feed-forward path to increase the dynamic range. The double-sampling technique was adopted to improve the over-sampling ratio (OSR) over a wide bandwidth range. The loop order and OSR were reconfigurable to meet the requirements of a wide range of standards. The modulator performance were modeled and analyzed in MATLAB/ SIMULINK for Global System for Mobile Communications (GSM) / Bluetooth / Wireless Body Area Network (WBAN) communication standards. The proposed modulator fulfills the performance requirements of biological devices.

I. INTRODUCTION
In the modern world, people are interested in using 4G wireless network. 4G is described as MAGIC — Mobile multimedia, anytime anywhere, Global mobility support, integrated...
wireless solution, and customized personal service. In telephony, 4G is the fourth generation of cellular wireless standards. It is a successor to 3G and 2G families of standards. A 4G system is expected to provide a comprehensive and secure all-IP based solution where facilities such as ultra-broadband (giga-bit speed such as 100+ MiB/s) Internet access, IP telephony, gaming services, and streamed multimedia may be provided to users.

In this paper, the design approach of a multi-mode sigma delta modulator for 4G mobile standard was proposed. A sigma delta modulator was presented to meet the requirements of GSM/Bluetooth/GPS/WBAN communication standards. The topology was based on 2-1-1 cascade sigma delta modulator with feed-forward paths. The double-sampling technique was employed to improve the OSR and the resolution of quantizers. The topology improves the order programmability and decreases the circuit’s complexity.

II. DELTA MODULATOR

Delta modulation (DM) is an analog-to-digital and digital-to-analog signal conversion technique used for transmission of voice information where quality is not of primary importance. DM is the simplest form of differential pulse-code modulation (DPCM) where the difference between successive samples is encoded into n-bit data streams. In delta modulation, the transmitted data is reduced to a 1-bit data stream.

To achieve high signal-to-noise ratio, delta modulation must use oversampling techniques, that is, the analog signal is sampled at a rate several times higher than the Nyquist rate. Derived forms of delta modulation are continuously variable slope delta modulation, delta-sigma modulation, and differential modulation. The Differential Pulse Code Modulation is the super set of DM.

![Figure 1: Delta Modulator](image1)

![Figure 2: Modulated Signal](image2)
The predicted signal is smoothed with a low pass filter. Delta modulators, furthermore, exhibit slope overload for rapidly rising input signals, and their performance is thus dependent on the frequency of the input signal. The spectrum of quantization noise of the prediction error is flat and the noise level is set by the 1-bit comparator. The signal-to-noise ratio can be enhanced by decimation processes.

Figure 3: Demodulator

![Demodulator Diagram](image)

Figure 4: Demodulated Signal

In delta modulation there is no restriction on the amplitude of the signal waveform, because the number of levels is not fixed. On the other hand, there is a limitation on the slope of the signal waveform which must be observed if slope overload is to be avoided. However, if the signal waveform changes slowly, there is nominally no limit to the signal power which may be transmitted.

III. SIGMA-DELTA MODULATOR

Sigma-delta modulation (SDM) was developed in 1960s to overcome the limitations of delta modulation. Sigma-delta systems quantize the delta (difference) between the current signal and the sigma (sum) of the previous difference. An integrator is placed at the input to the quantizer; signal amplitude is constant with increasing frequency; thus SDM is also known as pulse density modulation (PDM). Like PCM, SDM quantizes the signal directly, and not its derivative as in DM. Thus the maximum quantizer range is determined by the maximum signal amplitude and is not dependent on signal spectrum.

![Sigma Delta Modulator Diagram](image)

Figure 5: Sigma Delta Modulator
A first-order (single integration) sigma-delta modulation encoder is shown in Figure 5; the input to the quantizer is the integral of the difference between the input and the quantized output. The difference between the input signal and the output signal approaches zero; the average value of the clocked output tracks the input. There is little dc error in the output signal; the frequency spectrum of the quantizing error rises with increasing frequency (6 dB/octave). The integrator forms a low pass filter on the difference signal thus providing low frequency feedback around the quantizer. This feedback results in a reduction of quantization noise at low (in-band) frequencies. Unlike PCM and DM, the noise is not white, but shaped by a first-order high pass characteristic.

![Figure 6: Proposed Multimode Sigma Delta Modulator](image)

**IV. PROPOSED MODULAR TOPOLOGY**

**4.1 GSM Mode:**
GSM (Global System for Mobile Communications) is the most popular standard for mobile telephony systems in the world. The GSM Association, its promoting industry trade organization of mobile phone carriers. This ubiquity means that subscribers can use their phones throughout the world, enabled by international roaming arrangements between mobile network operators. GSM differs from its predecessor technologies in that both signaling and speech channels are digital. This also facilitates the widespread implementation of data communication applications into the system.

**4.2 Bluetooth Mode:**
Bluetooth is an open wireless technology standard for exchanging data over short distances (using short wavelength radio transmissions) from fixed and mobile devices, creating personal area networks (PANs) with high levels of security. It was originally conceived as a wireless alternative to RS-232 data cables. It can connect several devices, overcoming problems of synchronization. Today Bluetooth is managed by the Bluetooth Special Interest Group. Bluetooth uses a radio technology called frequency-hopping spread spectrum, which chops up the data being sent and transmits chunks of it on up to 79 bands (1 MHz each) in the range.
2402-2480 MHz. This range is in the globally unlicensed Industrial, Scientific and Medical (ISM) 2.4 GHz short-range radio frequency band.

4.3 GPS and WCDMA mode

GPS is considered a dual-use technology, meaning it has significant military and civilian applications. GPS has become a widely used and useful tool for commerce, scientific uses, tracking and surveillance. GPS's accurate timing facilitates everyday activities such as banking, mobile phone operations, and even the control of power grids. Farmers, surveyors, geologists and countless others perform their work more efficiently, safely, economically, and accurately.

WCDMA air interface, referred also as UMTS terrestrial radio access (UTRA), developed by the third-generation partnership project (3GPP). WCDMA has two modes characterized by the duplex method: FDD (frequency division duplex) and TDD (time division duplex), for operating with paired and unpaired bands, respectively. For the channel coding three options are supported: convolutional coding, turbo coding, or no channel coding. Channel coding selection is indicated by upper layers. Bit interleaving is used to randomize transmission errors. The modulation scheme is QPSK.

The output of the second quantizer is given by:

\[ Y_2(z) = \frac{B}{D_1} z^{-3} V_m(z) + B z^{-1} (1 - z^{-1})^2 Q_1(z) - \frac{2a_2b_1}{b_2} z^{-2} Q_1(z) + z^{-1} (1 - z^{-1}) Q_2(z) \]

\[ B = \frac{2a_2b_1}{b_3} - \frac{b_2}{b_3} \]

Where, \( Q_2(z) \) is the quantization error of the 2nd stage.

The output of the 2nd stage is:

\[ \text{out}_2(z) = \text{STF}_2(z)V_m(z) + p_1(z) Q_2(z) \]

Where \( \text{STF}_2(z) = \frac{2a_2b_1 D_2}{b_3 D_1} z^{-3} \)

\[ p_1(z) = D_2 z^{-1} (1 - z^{-1})^3 \]

The output of 2\text{nd} stage can be reduced as \( 2a6b1D3 = b3D1, D2 = -D3B / D1 \) are satisfied.

\[ \text{out}_2(z) = z^{-3} V_m(z) + D_2 z^{-1} (1 - z^{-1})^3 Q_2(z) \]

In the conventional cascade modulator structure, there is no the D2 branch. Introducing D2 branch can improve the freedom of b1 and b2 effectively, which enhances the modulator’s performance.

4.4 WLAN and WiMAX mode

WLAN: IEEE 802.11 is a set of standards carrying out wireless local area network (WLAN) computer communication in the 2.4, 3.6 and 5 GHz frequency bands. They are created and maintained by the IEEE LAN/MAN Standards Committee (IEEE 802). The base current version of the standard is IEEE 802.11-2007. The 802.11 family includes over-the-air modulation techniques that use the same basic protocol. The most popular are those defined by the 802.11b and 802.11g protocols, which are amendments to the original
standard. The segment of the radio frequency spectrum used by 802.11 varies between countries.

WiMAX (Worldwide Interoperability for Microwave Access) is a telecommunications protocol that provides fixed and fully mobile Internet access. The current WiMAX revision provides up to 40 Mbit/s with the IEEE 802.16m update expected to offer up to 1 Gbit/s fixed speeds. The name "WiMAX" was created by the WiMAX Forum, which was formed in June 2001 to promote conformity and interoperability of the standard. The forum describes WiMAX as "a standards-based technology enabling the delivery of last mile wireless broadband access as an alternative to cable and DSL".

The output of the 3rd quantizer can be denoted as:

\[ Y_3(z) = STF_3(z)V_m(z) + p_3(z)Q_1(z) + p_4(z)Q_2(z) + p_5(z)Q_3(z) \]

Where \( Q_3(z) \) is the quantization error of the 3rd stage.

\[ STF_3(z) = \frac{B(b_3c_1-c_2)}{c_3D_1}z^{-4} \]

\[ p_3(z) = \frac{B}{c_3}(-c_2+b_3c_1)z^{-3}(1-z^{-1})^2 + \frac{2a_1b_3}{c_3}(c_2-c_1)z^{-3} \]

\[ p_4(z) = \frac{-c_2}{c_3}z^{-2} + \frac{c_2-c_1b_3}{c_3}z^{-3} \]

\[ p_5(z) = z^{-1}(1-z^{-1}) \]

Under the conditions \( c_2 = c_1b_3 \), formula can be simplified as:

\[ Y_3(z) = \frac{-c_2}{c_3}z^{-2}Q_2(z) + z^{-1}(1-z^{-1})Q_3(z) \]

The output of the 3rd stage can be expressed as:

\[ out_3(z) = \frac{2a_1b_3D_4}{b_3D_1}z^{-4}V_m(z) + D_2z^{-1}(1-z^{-1})^4Q_3(z) \]

where \( D_4 = \frac{c_2}{c_3} \), \( D_5 = D_3 \).

V. ANALYTICAL RESULT

Figure 8: Sigma Delta Modulator output
VI. CONCLUSION AND FUTURE WORK

The design approach of a multi-mode sigma delta modulator for 4G mobile terminals is proposed on the system level. The reconfigurable modulator adopts a cascade 2-1-1 double-sampling single-bit topology with a feed-forward path. The topology improves the order programmability and decreases the circuit’s complexity. The non-ideality analysis validates the efficiency of the proposed topology and the feasibility of the circuit realization. The simulation results meet the requirements of 4G mobile communication standards.

VII. REFERENCES


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