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New Proposed Second-Order ASDM Using OTAs

Farouq M. Al Taweel
Department of Electrical Engineering
Faculty of Engineering Technology, Al-Balqa' Applied University, Amman, Jordan

Abstract: In this work, we present a new proposal for the second-order Adaptive Sigma Delta Modulation (ASDM). The new proposed Adaptation scheme is based on using Operational Transconductance Amplifier (OTAs) as an Integrator and as an Amplifier to adapt the quantizer step-size to control the voltage gain by feedback the quantizer output through adaptation scheme. The step-size is changing up or down by the output voltage of the integrator for every clock period. A comparison with general second-order SDM proves that our idea about using OTAs to achieve a high resolution and confirm the signal-to-noise ratio is better than GSM.

Key words: ASDM, OTA, general SDM, adaptive step-size

INTRODUCTION

The over sampling Sigma-Delta modulation is very important subject in many modern communication systems. Different proposed systems are used to: quantize continuous amplitude signals into discrete amplitude sequences and deliver high-resolution analog-to-digital (A/D) conversion using low-precision analog components. The high-resolution can be achieved by increasing the clock speed or by limiting the bandwidth due to their over sampling nature[1, 2].

The high over sampling ratio is required to meet dynamic range requirement according to the tradeoff between order and over sampling ratio[3-5]. A general second order Sigma-Delta modulation is shown in Fig. 1; it consists of two integrators and a single bit analog to digital converter and feedback digital-to-analog converter. The large amplitude signal Y(KTs) usually integrated into the first and second integrator of the over sampling A/D converter. Then the modulated output consists of a noise shaping spectral and a single-bit quantization[6].

Proposed second order ASDM: The output noise shaping given by the Eq.1. For clarity of exposition Adaptive Sigma-Delta Modulator, we start to discuss Adaptation principle in many systems and papers as Adaptive Differential Pulse Code Modulation (ADPCM). There is many adaptation systems to adapt the quantization levels of the difference signal E(KTs). If E(KTs) is small, we increase the step size of the quantization levels and if the difference signal is large, we decrease the step size of the quantization levels. So, we can adapt the quantization level to the size of the input difference signal, using the output signal to perform the signal-to-noise ratio (SNR) that is uniform through the dynamic range of the difference signal. Mansour M. Aldajani[7,8] developed a new scheme for adapting the quantization step-size, based on estimating the amplitude of the quantizer input instead of the input signal itself and performed both stability and performance analysis. J. S. chiang and others[9,10] propose a new second order Sigma-Delta Modulator with extended dynamic range (DR) scheme which is accomplished by a dual-quantizer approach. The quantizers are in multi-bit architecture, but the feedback of the SDM is a dingle bit DAC.

$$Y(KTs) = P(KTs) + E(KTs) \quad (1)$$

In our work, we propose second order adaptive Sigma-Delta-Modulator as shown in Fig. 2, where the error signal E(z) is the difference between the input signal X(z) and the output signal Y(z). The first and second integrators are working as the noise-shaping filter. Our proposed technique is similar to the structure given in[7]. The output of second integrator is quantized by the low-bit quantizer Q(z) to produce the output Y(z).

$$Y(z) = \text{sign}\,[\,P(z)\,] \quad (2)$$

Where:

$$P(z) = X(z) - XP(z) \quad (3)$$

The output encoded signal is feededed back through the adaptation scheme which consists of low-pass filter, square low and Variable Voltage gain Operational Tranconductance Amplifiers (OTAs) to estimate the input signal.

Like companding Algorithm of continuously Variable slope Delta modulator/demodulator[11-14], if X(z) is increasing or decreasing rapidly the output pulses Y(z) is all 1s or all 0s. The magnitude of output of filter will be relatively large. This large value controls the amount of Amplifier bias current (I_{ABC}) which controls the transconductance (gm) and change the voltage gain (Av) where:

$$g_m = K\, I_{BIAS} \quad (4)$$

Corresponding Author: Dr. Farouq M. Al Taweel, Department of Electrical Engineering, Faculty of Engineering Technology - Al-Balqa' Applied University, Amman, Jordan

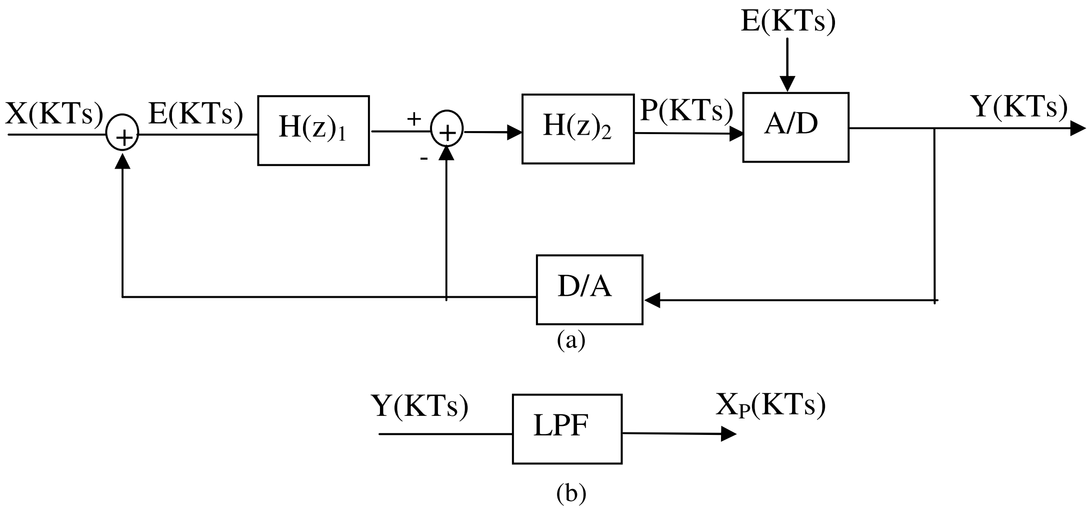

Fig. 1: General second-order (GSDM) a) Transmitter. b) Receiver

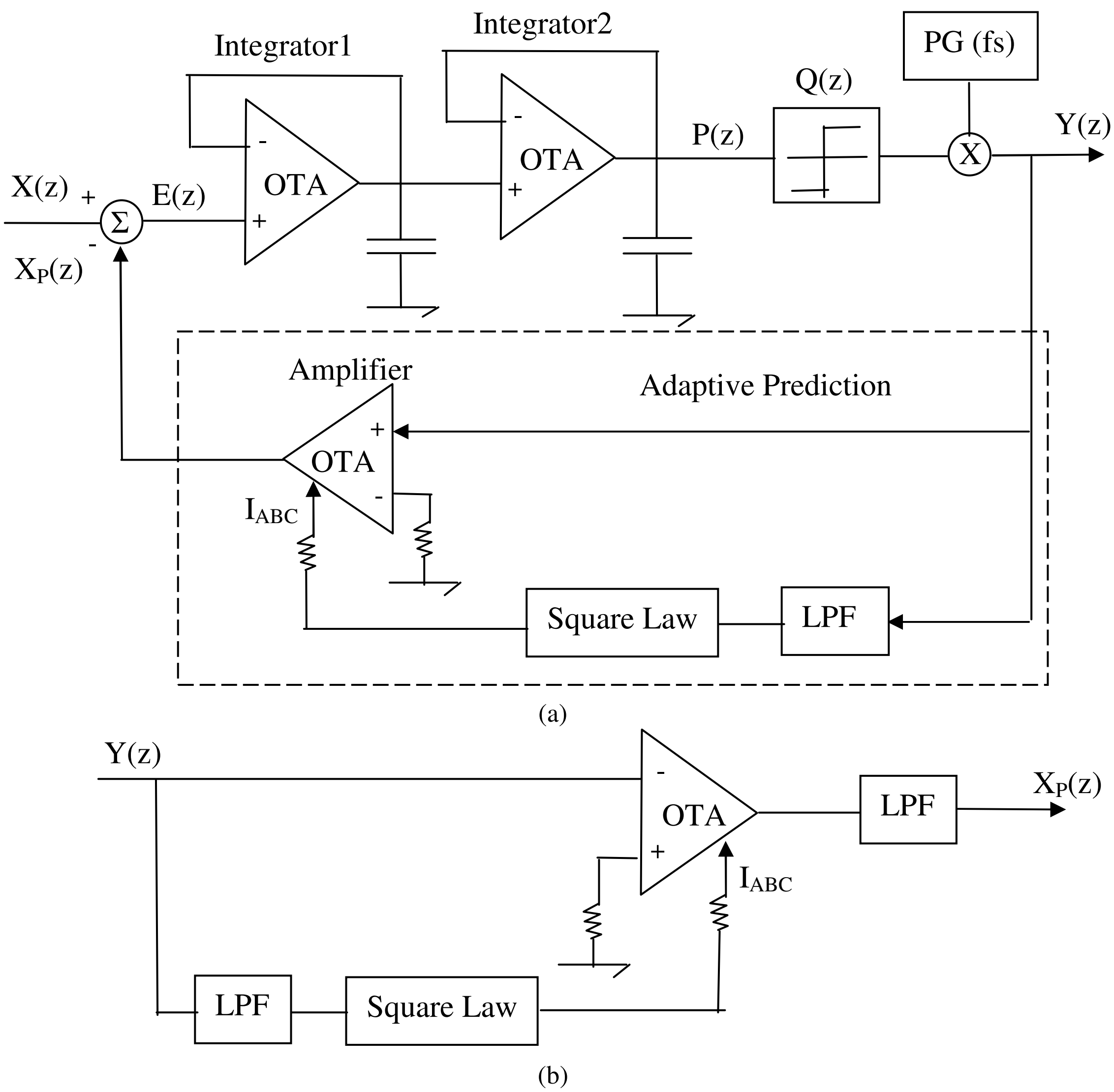

Fig. 2: Proposed second-order (PASDM). a) Modulator. b) Demodulator

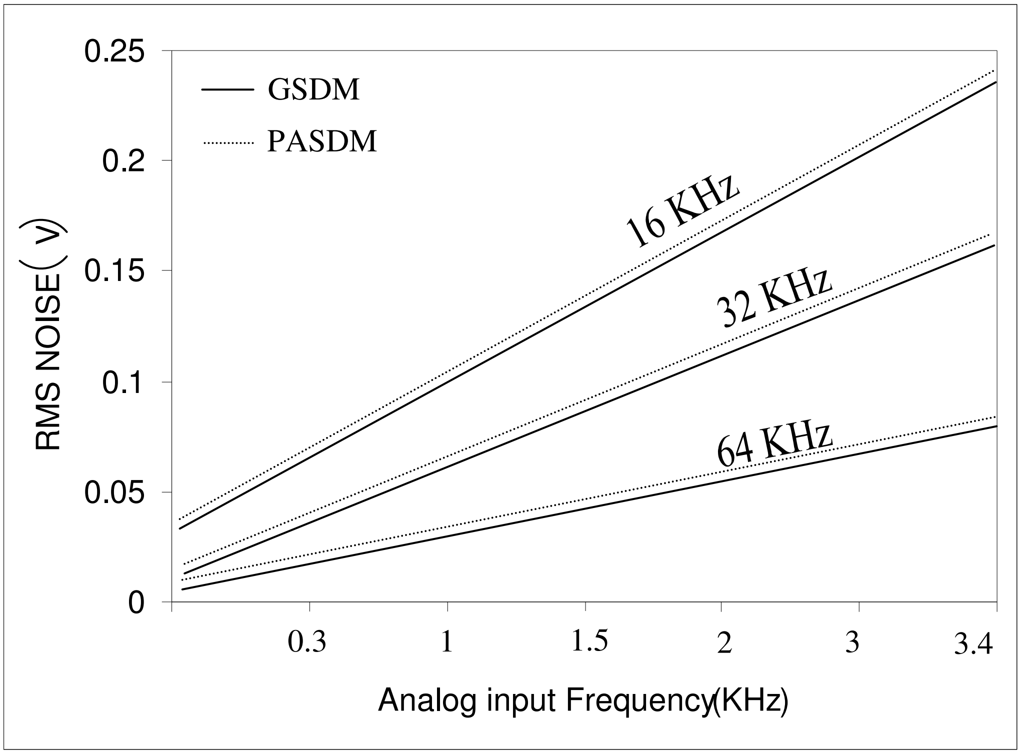

Fig. 3: Comparison of noise versus input frequency at several sampling frequencies

Where:
K is the constant of proportionality and K=16 for CA3080.

$Av = g_m R_L$ (5)

The square law is used to ensure that the control Voltage and the amplifier gain (Av) are always positive. If X(z) is small or alternate in sign. So the dc value, determined over the time constant of the LPF, is very small. This small value controls I_{ABC} and Av, thus the step-size is made small at the amplifier input making the Amplitude of the output small, this produces a reconstructed output that track the slop of the input, where the dynamic range is increased past that which would be possible with a controlled OTAs gain.

At the receiver shown in Fig. 2b, the step size is changing to match the same value at the modulator. Finally, the reconstructed signal is filtered using low-pass filter.

RESULTS

Laboratory testing the second order ASDM is shown in Fig. 3 and compared it with a general second-order SDM. The two OTAs integrators, which have the same output, were connected with the modulator which connected to a high-quality sinusoidal signal source and the initial digital filter. The output of filter controls the gain of OTAs.

The power spectrum of quantization error from Eq.1 can be assumed white and uncorrelated with X(KTs). So the power of quantization noise is calculated using Parevals theorem for fourier series[8].

$$P = \frac{1}{T_0}\int_0^T \left|E(WTs)\right|^2 dwTs \qquad (6)$$

and experimental quantizing SNR for the proposed second order ASDM was obtained by:

$$SNR(dB) = 20\ \log\frac{X(KTs)}{Y(KTs) - X(KTs)} \qquad (7)$$

Figure 3 shows the comparison of RMS Noise in volts versus the frequency for GSDM and PASDM.

CONCLUSION

A new proposed second-order ASDM using OTAs is building and demonstrated with reasonable results. The proposed ASDM is compared with general SDM to prove that the proposed ASDM performs better. Simulations and analytic results verify that the NPASDM give a high dynamic range and best SNR performance.

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