Function Generator and Delta Modulator Circuits Using Current Tunable Technique

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ABSTRACT

This paper presents a low cost high performance of function generator and a delta modulator circuits using bidirectional tunable current technique. The tunable current technique accessed to be controlled the harmonic on output signal modulation and changing voltage across a capacitor to be linearity as ideal integrator of delta modulator model. This circuit is used to be either a square wave and triangle wave generator, it's can vary on 5 decades of frequency when it has zero input signal, or a delta modulation when there is sinusoidal wave input signal, Moreover, this circuit consisted a few component and another achieved these objective are minimized of circuit complexity. Both analytical and experimental verifications was carried out for function generator and a delta modulator circuits using bidirectional tunable current technique.

Keywords : Delta modulator, hysteresis, voltage to current converter.

I. INTRODUCTION

Recently, for advances of micro electronic semiconductor devies production technologies, 1 bit analog-to-digital (A/D) converters are able to be realized by using delta modulator circuit [1]. On the other hand,the topology of delta modulator with analog and digital circuit are complexity, expensive and limited application [1]-[5]. Thus, the delta modulator circuit with a low cost, high performance for wide rang of frequency, and versatile for applicability are proposed in this paper.

II. THE DELTA MODULATION TECHNIQUE

Figure 1 is a block diagram of delta modulator. Three basic components of the modulator are the comparator, hysteresis and ideal intregrator. For the system operating the input signal on modulator is a sinusoidal wave, and the output is the modulator wave.

The block diagram of economical delta modulator circuit is shown in Fig.1. The input signal to the modulator is Vr(t). Difference signal

Ve(t) (where, Ve(t) = Vr(t) - Vf(t) produced by comparision of Vr(t) and estimated signal Vf(t) is quantized to produce the modulated output.
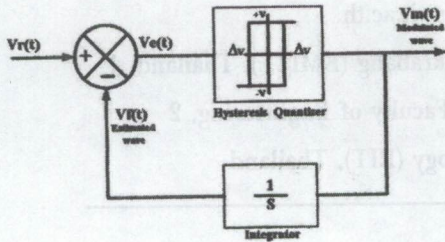

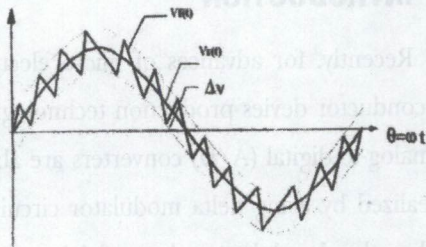**Fig. 1** Block diagram of delta modulator.

Fig. 2 Typical waveform of delta modulator.

The integrator performs the function of signal estimation form the output modulated wave by tunable current voltage across to be linearity. At the input this estimated signal is compared with the sinusoidal wave to produce an error signal as shown in Fig. 2. The error signal is quantized by quantizer producing the modulated output signal. In this type of modulators the ideal integrator of the delta modulation is allowes to charge with the tunable current of current source. For highest current tunable operation, the max slop of integrator in such a manner so as to increase the number of pulses of the modulated wave. This results increase of the ripple frequency of the estimated wave effective to reduction harmonic on output signal.

III. CIRCUIT ANALYSIS

The proposed delta modulator circuit is shown in **Fig.3.** The component circuit consisted of single op-amp, two resistors, single capacitor and two current sources.
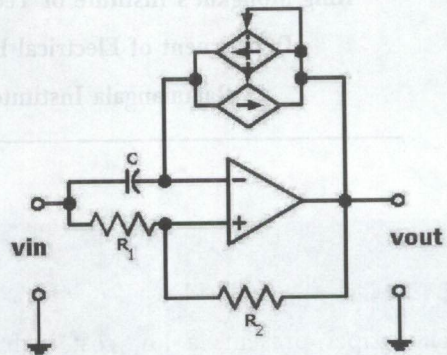

Fig.3 Proposed circuit configulation of delta-modulator.

A. Zero input signal

The voltage across Vc(t) is therefore a symmetrical triangular waveform extending between the limits of Vl to Vh for a total peak-to-peak excursion of Vh = Vh-Vl, as shown in Fig.4.
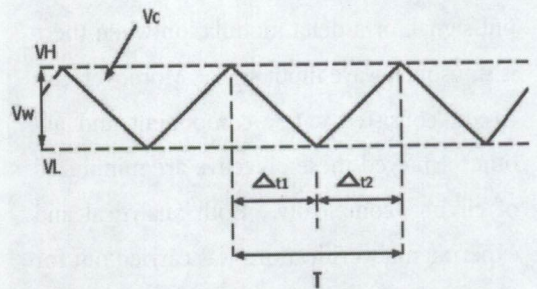

Fig. 4 Voltage waveform across a capacitor.

Since the slope of the voltage across Vc is $dv(t)/dt = d(Q/C)/dt = (1/C)(dQ/dt) = \pm IQ/C$, the time required to change the capacitor voltage from Vl to Vh and vice versa, is given by

$$\frac{V_H - V_L}{\Delta t_2} = \frac{I_Q}{C} \text{ and } = \frac{V_L - V_H}{\Delta t_1} = \frac{I_Q}{C}$$

Therefore, we have that

$$\Delta t_1 = \Delta t_2 = \frac{(V_H - V_L)C}{I_Q} = \frac{V_W C}{I_Q}$$

so the period of oscillation T is given by T $= \Delta i_1 = \Delta i_n = (2V_W C/Io)$ .The following frequency oscillation equation fo are obtained from output voltage signal of Fig.7(a)

$$f_0 = \frac{1}{T} = \frac{I_Q}{2V_W C} = \frac{S_C}{4\Delta V} \qquad (1)$$

where Se is slop of the integrator by tunable current a capacitor effective to reduction harmonic on output signal and Δv is hysteresis window.

B. Sinusoidal wave input signal

Control scheme of a delta modulated dc-ac inverter suggests asymmetrical variation of the modulator window widths for the inverter output voltage. Consider the encoding of an arbitrary reference signal $V_r(t)$ as shown in Fig. 5.
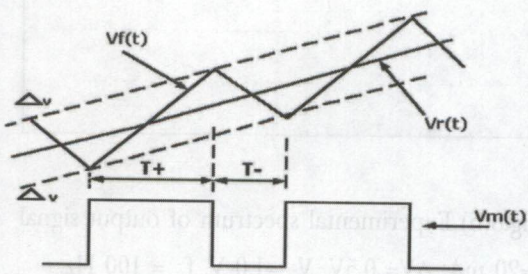

Fig.5. Typical estimated waveform, modulate waveform and hysteresis window of instantaneous.

The following frequency oscillation equation (f_1) are obtained from voltage output of Fig.

$$f_1 = \frac{1}{T} = \frac{S_C}{4\Delta V}\left[1 - \left(\frac{S_R(t)}{S_C}\right)^2\right] \qquad (2)$$

Thus, the input signal is. Also, slop of instantaneous of input signal is the frequency of modulated wave is therefore

$$f_1 = \frac{S_C}{4\Delta V}\left[1 - \left(\frac{\omega V_R}{S_C}\right)^2 \cos^2\omega t\right] \qquad (3)$$

The maximum switching frequency modulation is given by $S_C/4\Delta V$ with $\omega t = k(\pi/2)$, k was an integer and odd number, which the resulted pulse width have a lest narrow as given in Eq.(1) and the alternathing, minimum switching frequency modulation is given by $(S_C/4\Delta V)$ (1-ω $V_R/S_{C)_2}$ with ωt = , k(π/2) was an integer and even number, which the resulted pulse with have a widest.

C. Harmonic elimination using current tunable

Fig. 6. depicts a PWM pulse train with 5 notches and 5 triggering angles Cl_1, Cl_2 ..., Cl_5 , ,...
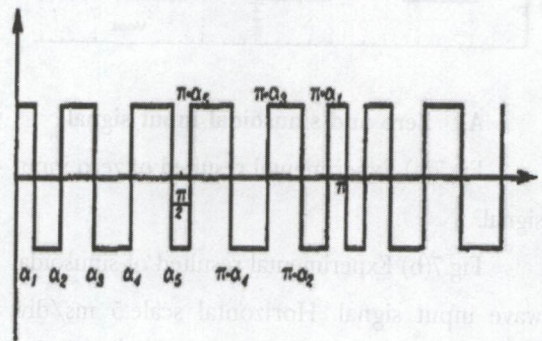

Fig. 6. Principles of harmonic elimination scheme.

in a half cycle. By proper selection of these five angle, a desired fundamental component can be determined and 4 harmonics can be eliminated [6].

This forms the foundation of the harmonic elimination scheme [4]. The Fouries Series of the pulse train in Fig. 6. is expressed as Eq. (4).

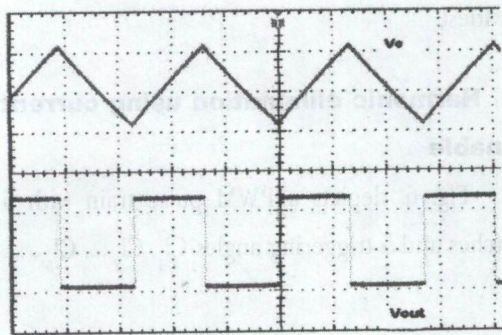$$Va(t) = \sum_{n=1}^{\alpha} bn\sin\omega t \qquad (4)$$

Where :

$$bn = \frac{4}{n\pi}[1+2(-\cos\alpha 1 + \cos\alpha 2 -... +\cos n\alpha k]$$

$$bn = \frac{4}{n\pi}[1+ \sum^{k} (-1)^k \cos n\alpha k]$$

Where : n = 1,2,3 and k is number of angle

IV. EXPERIMENTAL RESULTS

Fig.7 shows the experimental waveforms when zero input and sinusoidal wave input signal respectively.

A. Zero and sinusoidal input signal

Fig.7(a) Experimental resulted of zero input signal.

Fig.7(b) Experimental resulted of sinusoidal wave input signal. Horizontal scale:5 ms/div; vertical scale:5 V/div

Fig.7.is the experimental asynchronization delta modulator circuit in which R_1 = 10 kΩ, R_2 = 100 kΩ, C = 1µF and two current sources (LM334).

B. Experimental spectrum

Fig.8. is the experimental spectrum of output signal in which condition ΔV= 0.5V, V_{in} = 1.0 V, f_{in} = 100 Hz using tunable current sources.
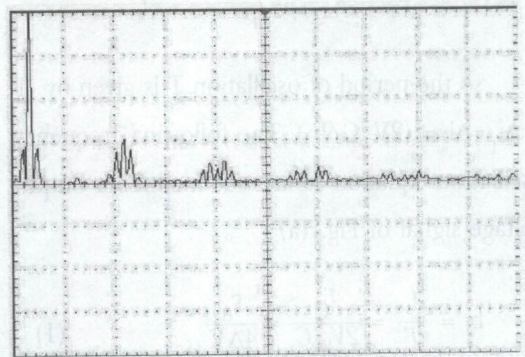
Fig.8(a) Experimental spectrum of output signal I=2 mA ; ΔV = 0.5V, V_{in} =1.0 V, f_{in} = 100 Hz.
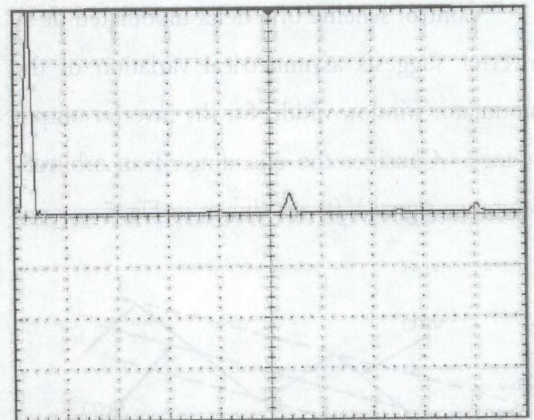
Fig.8(b) Experimental spectrum of output signal I=20 mA; ΔV= 0.5V, V_{in} =1.0 V, f_{in} = 100 Hz.

C. Half-bridge inverter

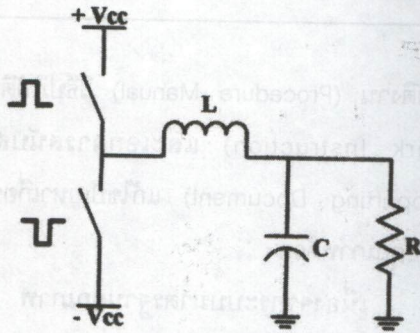A half-bridge inverter with two power supplies is shown in Fig. 9.

Fig.9. Circuit of half-bridge PWM inverter.

It is similar to a standard half-bridge PWM inverter with a single power supply. The output filter of the half-bridge inverter was constructed using a 100-UH inductor, a 100-UF capacitor, and a 1-kΩ resistor. The experimental result of output voltage waveform in the dc-ac power inverter is shown in Fig.10.

Fig.10. Output voltage waveform with resistive load.Horizontal scale:5 ms/div;vertical scale: 0.2 V/div.

V. CONCLUSION

In this paper, a low cost high performance function generator and delta modulation has been proposed for control signal dc-ac inverter operation as applications using current tunable technique. The tunable technique accessed to be controlled the harmonic on output signal and charging voltage across a capacitor to be linearity. Moreover, there is still potential to further reduce the harmonic using current tunable technique.

VI. REFERENCE

[1] G.L.Baldwin, and S.K. Tewksubury, " Linear delta modulator integrated circuit with 17 - Mbit /sampling rate", IEEE Transactions on Circuit and Systems, July, 1974.

[2] M. Azizur Rahman, Ali R.D. Esmail and Mohammed A. Choudhury," Analysis of delta PWM static AC-DC converters", IEEE Transactions on Power Electronics,vol.,10.No.4 July pp.494-502 1995.

[3] A.I. Maswood, M.A. Rahman," Performance of 3-phase induction motor fed from improved delta PWM voltage source inverter," IEEE Proceeding 2000.

[4] Alan J. Frazier and Marian K. Kazimierczuk, "DC-AC Power Inversion Using Σ-Δ Modulation," IEEE Transactions on Circuit and Systems,vol.47,No.1 pp.79-82,January 2000.

[5] R.E. Zimer, W.H. Tranter, " Principles of Communications System, Modulation and Noise" 4 th Edition pp. 224-228 1995.

[6] B.K. Bose, Power Electronics and AC drives, New Jersey,Prentice-Hall, 1986