Identification of Active $\overline{URC}$ sinusoidal oscillator circuit

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Abstract :

Many sinusoidal oscillators can be represented by the structure RC - CR-Active Circuits (Wien-Bridge , Twin-T) . In this paper discusses a different approach is presented new structure Uniformly Distributed RC line ($\overline{URC}$) Active circuit in used oscillators may be also improved , extending their range of operation oscillator and reducing the harmonic distortion . The theory of operation of the device circuit , experimental verification of theory . This structure $\overline{URC}$ Active oscillator has the advantage of being very small , simple to fabricate and easy to use in conjunction with microelectronic integrated circuit or Thin-Film LSI Technology .

Keywords : DURC, Oscillator, Active Filter

1. Introduction

The Barkhausen's criterion sinusoidal oscillators in Fig.1 contain an active element with sufficient power gain at the oscillation frequency [1]-[4] , a frequency selective network, and an amplitude stabilizing mechanism. They are capable of producing a near-sinusoidal signal with good phase noise and high spectral purity.

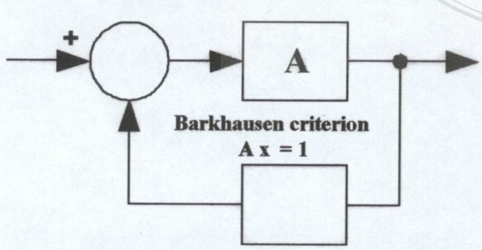

Fig 1. Block diagram basic structure of an sinusoidal oscillator

In a sinusoidal oscillator, positive feedback is used around a frequency selective circuit to drive the poles of the corresponding closed-loop linear system into the right-half s-plane. In the case to be considered in this paper , the structure Uniformly Distributed RC ($\overline{URC}$) used in network circuits. The Active $\overline{URC}$ extending their range of operation oscillator and reducing the harmonic distortion in sinusoidal signal.

2. The uniformly distributed RC ($\overline{URC}$) and Active Circuit

A structure of Uniformly Distributed RC line ($\overline{URC}$) is illustrated in Fig. 2(a) . the circuit symbol of Fig. 2(a) is illustrated in Fig. 2(b).

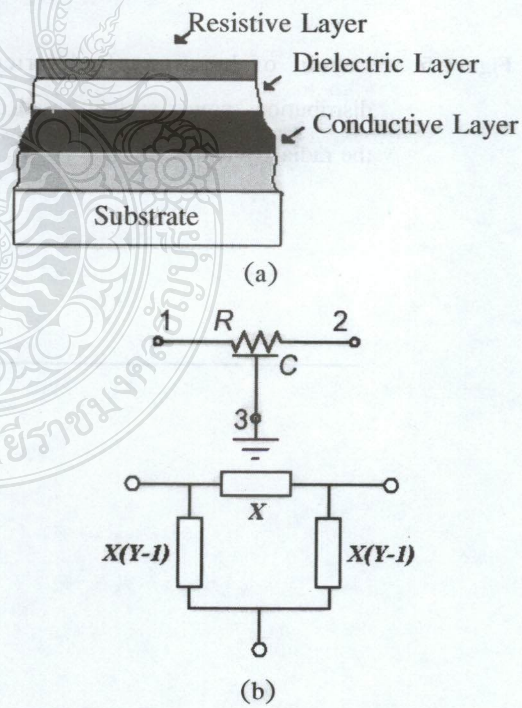

Fig 2. (a) A implementation uniformly distributed RC , (b) Symbolic and its equivalent circuits

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The admittance parameter [5,6] $[y_{ij}]$ of the $\overline{URC}$ in Fig 2 is given as follows:

$$\begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = X \begin{bmatrix} Y & -1 \\ -1 & Y \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \end{bmatrix} \quad (1)$$

when $X = \dfrac{P}{R\sinh P}$, $Y = \cosh P$ and $P = \sqrt{sRC}$

R and C are the values of the total resistance and capacitance of the $\overline{URC}$ respectively and S is the complex frequency.

In most Active RC configuration, one is struck by the large number of passive element which far outstrip both the cost and the size of the active element, the operational amplifier. A potential advantage of using $\overline{URC}$ networks in active configurations is the reduction of the number of passive elements and substantial reduction which may be expected in the substrate area taken by the passive elements. For example, $\overline{URC}$ element combine both the capacitor and resistor function on the same substrate area. A simple active $\overline{URC}$ network which provide sharp cut-off lowpass characteristics [7,8] is shown in Fig. 3.

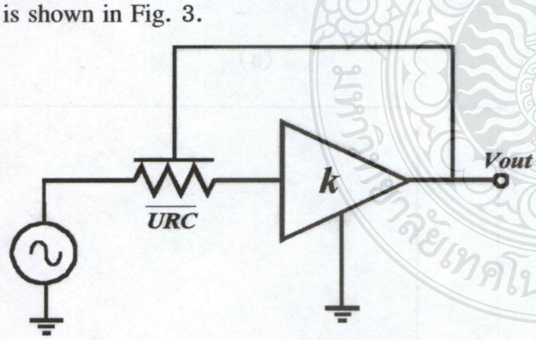


Fig 3. Active $\overline{URC}$ network lowpass filter

the transfer function matrix of the passive $\overline{URC}$ network, with its capacitive terminal grounded, is given by

$$F(s) = \begin{bmatrix} \cosh\sqrt{sRC} & \dfrac{R\sinh\sqrt{sRC}}{\sqrt{sRC}} \\ \dfrac{\sqrt{sRC}\sinh\sqrt{sRC}}{R} & \cosh\sqrt{sRC} \end{bmatrix} \quad (2)$$

It is simple to shown that the overall trans mission matrix of the active network is given by

$$F(s) = \cosh P \begin{bmatrix} (1-k) + k\,\mathrm{sech}\,P & \dfrac{R\tanh P}{P} \\ \dfrac{(1-k)P\tanh P}{R} & 1 \end{bmatrix} \quad (3)$$

The voltage transfer function of this network

$$T_v(s) = \frac{Vo(s)}{Vi(s)} = \frac{1}{k + (1-k)\cosh\sqrt{sRC}} \quad (4)$$

permits complex pole pairs to be realized rather readily. The first (dominant) pole are given by

$$sRC = \left(\log(M + \sqrt{M^2 - 1})\right)^2 \quad (5)$$

where $M = -k/(1-k)$

The dominant pole solutions, shown in Fig. 4 lead to real frequency responses as shown in Fig. 5, for several values of k from $k = 0$ to $k \cong 0.921$. Value of $k > 0.921$ result in oscillatory response.

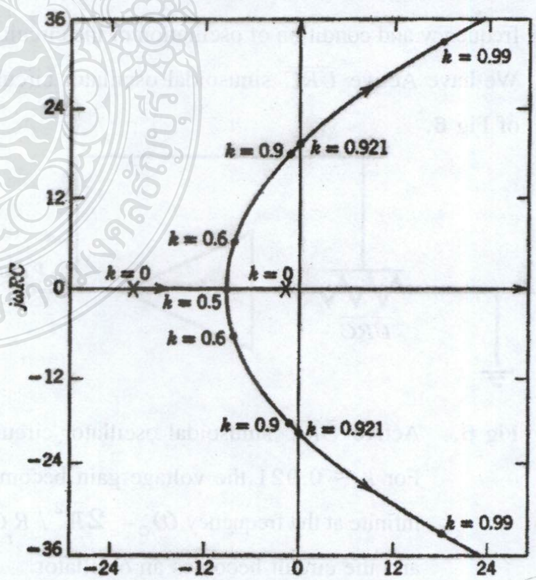


Fig 4. First dominant pole root locus of Figure 3 as function of k

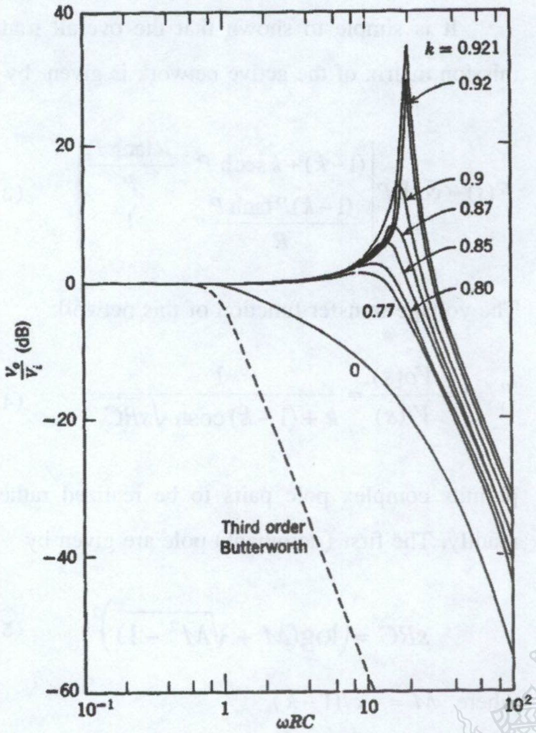


Fig 5. Active $\overline{URC}$ frequency response curves

3. Active ($\overline{URC}$) Sinusoidal Oscillators

By equating the real and imaginary part of (4) to zero i.e., using the Barkhausen criterion, the frequency and condition of oscillation of the circuit. We have Active $\overline{URC}$ sinusoidal oscillator circuit of Fig 6.

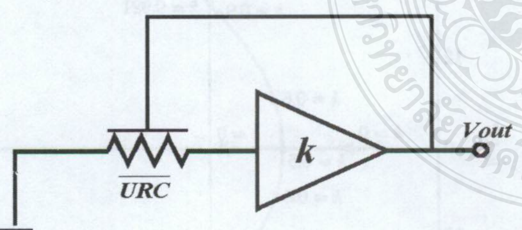


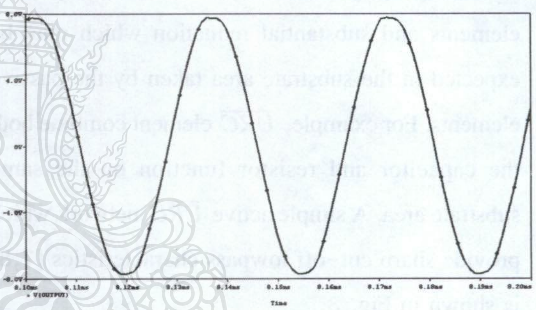
Fig 6. Active $\overline{URC}$ sinusoidal oscillator circuit

For $k \approx 0.921$, the voltage gain become infinite at the frequency $\omega_O = 2\pi^2 / R_t C_t$ and the circuit becomes an oscillator.

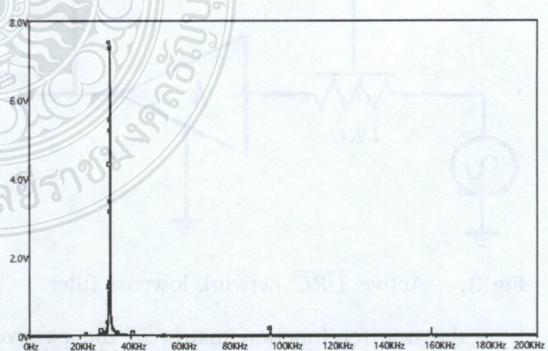
$$f_0 = \frac{\pi}{R_t C_t} \qquad (6)$$

4. Simulation and Experimental results

The circuit of Fig 6. was simulation, using the OrCAD PSpice AD, built and tested using the LF353 operational amplifier, with $\overline{URC}$ network at R_t = 1 kΩ and C_t = 1 nF. The representative simulation results are shown in Fig 7, and experi mental results signal circuit are shown in Fig 8. Fairly good quality sinusoidal oscillations has been obtained in all cases and very low the harmonic distortion (see spectrum waveform). In Fig 9 shown the output waveform of the simulates and experi mental circuit, taken across the $\overline{URC}$ conditions test The simulated and experimental results are reasona bly good agreement with the theoretical predications.



(a)



(b)

Fig 7. Simulated results for the output of the circuit of Fig. 6. (a) sinusoidal waveform (b) spectrum signal output

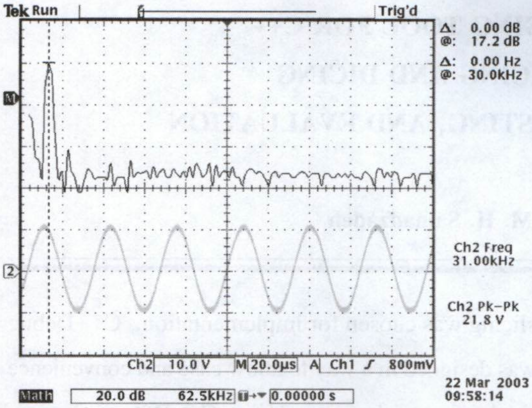


Fig 8. Experimental results signal circuit at $\overline{URC}$ network at R_t = 1 kΩ and C_t = 1 nF

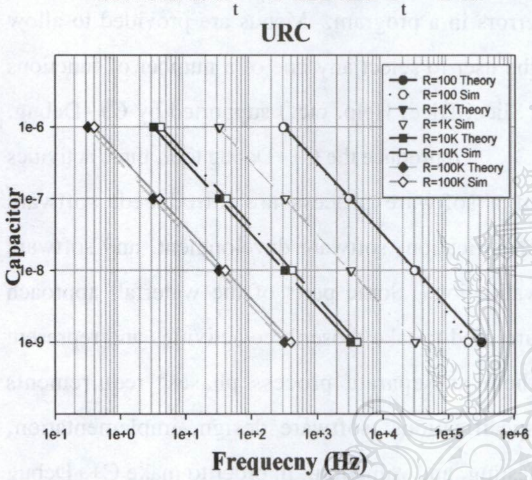


Fig 9. Simulated and experimental results variation of frequency of oscillation with the Active $\overline{URC}$ circuit

5. Conclusions

It has been shown, in this paper ,that the conventional Active $\overline{URC}$ sinusoidal oscillator can produce sinusoidal oscillations at relatively wide variable range frequency by proper selection of the $\overline{URC}$ element. The simulation and experimental results are in reasonably good agreement with the theoretical , and very low harmonic distortion .The proposed circuit can be suitable for fabrication by LSI process. It will be useful for sinusoidal signal circuit oscillator.

References

[1] A. Budak and K. Nay, "Operational Amplifier Cir-cuits for The Wien-Bridges Oscillator". *IEEE Trans. Circuit and Systems*, vol.CAS-28, pp.930-934, Sep. 1981.

[2] S. Awad, "Extending the Frequency Range of a Wine-Bridge Oscillator using Composite Operational Amplifiers". *IEEE Tans. on Inst.and Measurement*, vol.38, no.3, pp.780-744, June 1989.

[3] R.senani, "On the transformation of RC-active oscillators". *IEEE Trans. Circuits and Systems*, vol. 34, no.9, pp.1091-1093, Sept. 1987.

[4] A. S. Sedra and K. C. Smith, *Microelectronic Circuits. Philadelphia*, PA: Saunders,1991.

[5] M. S. Ghauasi and J. J. Kelly, "Introduction to distributed parameter Networks", Holt Rinchart and Winston, Inc. 1968.

[6] M. Teramoto, S. Sudo and K. Janchitrapongvej, "Realization of the active Low pass filter using URC lines", ICEE, October 1989.CAs 89-54.

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