# Frequency Independent Phase Shifter

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***Abstract***: **A new simple and low cost frequency independent phase shifter is presented. The design is based on the simple op-amp phase shifter with programmable floating resistor and programmable capacitor. The phase shift can be varied using the programmable resistor. Compensation for the variation in the frequency is achieved using the programmable capacitor. Simulation results are also presented.**

***Index Terms- Phase shifter, C-multiplier***

## I. INTRODUCTION

Phase shifter are widely used in many areas this includes instrumentation, signal processing, communication and control. A frequency independent phase shifter that can provides a precise phase shift varying from 0 to 360 was developed in [1]. The disadvantages of this approach are the complexity of the system and hence the overall cost. A programmable phase shifter was reported in [2] and the circuit is shown in figure 1. Programmability is achieved by a programmable resistors using operational transconducatnce amplifier (OTA). This approach is suitable for single frequency application. If the frequency of the input signal is varying then there should be a way to compensate for the frequency variation. In this work a frequency independent phase shifter is proposed.. In section II the proposed system is presented. Simulation results are presented in section III. Section IV concludes the paper.

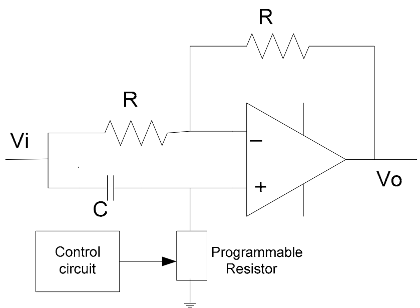


Figure1. Programmable phase shifter

## II. PROPOSED SYSTEM

The proposed system is shown in figure 2. Here both capacitor $C_e$ and resistor $R_e$ are implemented using OTAs reported in [3, 4] respectively.

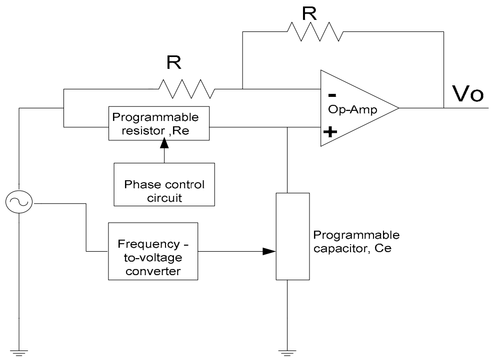


Figure.2. The proposed frequency-independent phase shifter

$R_e$ is programmable and it is used to control the phase via the control circuit where $C_e$ is used to compensate for the variation in frequency. If the frequency varies, the frequency to voltage converter output will change and hence adjust the value of $C_e$ to compensate for the change in frequency. The circuit diagram of the grounded C-multiplier developed in [3] is shown in figure 3, and the value of $C_e$ is given by:

$$C_e = C\frac{g_{m1}}{g_{m0}}, \quad g_{mi} = 2v_t / I_B \qquad (1)$$

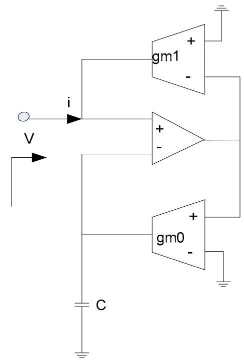


Figure.3. C-multiplier

Where $g_{m1}$ and $g_{m0}$ are the transconducatne of the OTAs that depends on the bias currents $I_{B1}$ and $I_{B0}$ respectively. If we set $g_{m1}$ to be $10g_{m0}$ then $C_e$ will be ten times the value of C.

Similarly, a floating programmable active resistor using OTA's developed in [4] is used and is depicted in figure 4

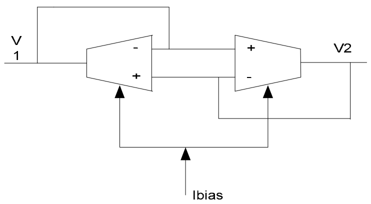


Figure.4. The programmable resistance

The equivalent resistance seen between $V_1$ and $V_2$ is given by:

$$R_e = \frac{1}{g_m} \qquad (2)$$

where $g_m$ depends on the bias current of the OTA's. By varying the bias current, a variable resistor is obtained.

With reference to figure2, it can be shown that the phase of the shifter is given by:

$$\Phi = -2\tan^{-1}\omega C_e R_e \qquad (3)$$

Substituting equations 1 and 2 in 3

$$\Phi = -2\tan^{-1}\frac{2\pi}{g_m}\frac{fg_{m1}}{g_{m0}} \qquad (4)$$

From equation 4, the value of $g_m$ is used to control the phase of the output while the term $\frac{g_{m1}}{g_{m0}}$ is used to compensate for the variation in the input signal frequency.

## III. SIMULATION RESULTS

The proposed approach was simulated using PSPICE simulator. As an example, the phase shift is set to 108° and the input signal frequencies are 10 KHz and 15KHz. Simulation results are shown in figures 5 and 6 respectively. The results confirm the functionality of the approach where the phase shift remains the same for the two frequencies.

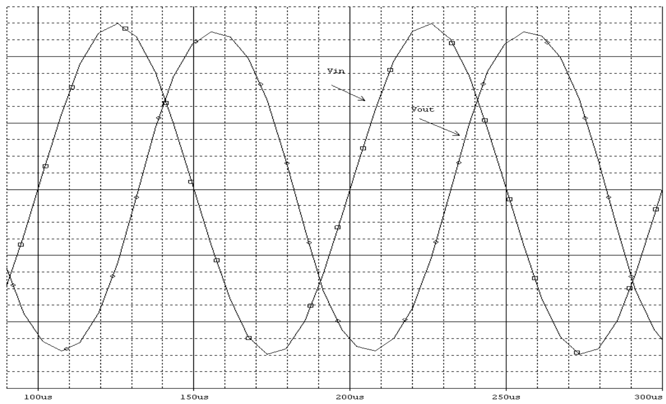


Figure.5. Input and output signals for 10 KHz signal

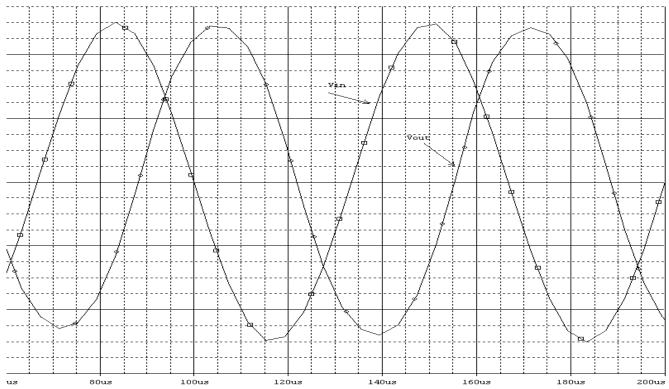


Figure.6. Input and output signals for 15 KHz signal

## IV. CONCLUSION

A low cost frequency independent phase shifter is achieved. The approach was verified by simulation results confirm the functionality of the approach. Further work is ongoing for more investigation.

## REFERENCES

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