GENERATION OF DIGITAL MODULATION FOR OPTICAL COMMUNICATION USING TUNABLE ACTIVE-R OSCILLATOR

D. PAL, S.K.SANYAL** & R.NANDI***
** Regional Science Centre,*
Bhopal-462 002
INDIA.
*** Department of Electronics and*
Telecommunication Engg
Jadavpur University
Calcutta-700 032
INDIA.

ABSTRACT

This paper describes the design of an active-R biphase oscillator using a pair of matched Operational Amplifier (OA) and a few resistors. The frequency of oscillation of such oscillator is tunable by a resistor (R_0). The oscillator can be readily extended to the digitally tunable version by replacing the tuner resistor with a Binary Weighted Switched Resistor Array (BWSRA). The digitally tunable oscillator can also be hooked up with microprocessor using CMOS CD 4066 switches. Generation of BFSK/BPSK wave modulations have then been considered using this oscillator. Subsequently, the BFSK/BPSK modulations are used to excite 4N25 Optoisolator. The received BFSK/BPSK signals from the Optoisolator are in full conformity with the corresponding transmitted ones. Experimental results are included.

Keywords:
active-R networks, oscillators, digital modulation,

1. Introduction

The elimination of discrete capacitors in active-R networks, utilising the finite bandwidth and the excess phase shift of internally compensated Operational Amplifiers (OA) makes it possible to design networks which are stable drift-free, low frequency-sensitive and which can be operated up to a relatively high-frequency with easy adaptability to monolithic IC fabrication [1],[2]. In Active-R oscillators, the frequency of oscillation depends on the Unity-gain bandwidth (B) of the OA used and on resistor ratio.

In this paper a tunable oscillator has been designed using a pair of matched OAs and three resistors. Replacement of the tunable resistor (R_0) by a Binary Weighted Switched Resistor Array (BWSRA) provides an easy compatibility between microprocessor and active-R oscillator. Replacement of R_0 by VVR [3] makes the oscillator, a voltage tunable configuration. BFSK modulation [4] can be obtained by selecting two values of the tuner resistor.

The two OAs provide biphase, 180-grade phase shifted outputs - a feature useful for the generation of BPSK modulation [5]. This is done by time multiplexing the two biphase OA output by a pair of non-overlapping switches ($\phi^{e,o}$).

The BFSK/BPSK signals generated from the tunable active-R oscillator are allowed to excite a 4N25 optoisolator which acts as an inbuilt light receiver, free from the effects of ambient light [6]. The output of the optocoupler after being amplified provides the BFSK/BPSK waveform in the CRO keeping full conformity with the corresponding transmitted ones.

2. Design of tunable oscillator

The proposed active-R tunable oscillator is shown in Fig. 1.

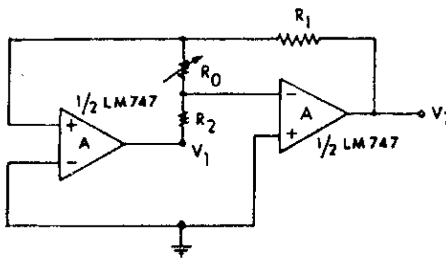


Fig.1
Active-R tunable oscillator

The two pole model expresses the open loop voltage gain of the OAs as

$$A(s) = \frac{A_0 \omega_1 \omega_2}{(s+\omega_1)(s+\omega_2)} \qquad (1)$$

where A_0 is the open loop d.c. gain of the OAs and ω_1 and ω_2 are the first and second corner frequencies of the OAs respectively.

For the commercially available internally compensated OAs, the second corner frequency (ω_2) is very larger than the first corner frequency (ω_1) as such the double pole model of OA effectively becomes the model of true integrator i.e.

$$A(s) \cong B/s \qquad (2)$$

where B is the unity-gain bandwidth of the OA. The frequency of oscillation of the oscillator may be shown to be,

$$f_0 = B\sqrt{R_0/(R_0+R_1+R_2)} \qquad (3)$$

Equation (3) shows that f_0 can be controlled by varying the tuner resistor (R_0).

3. Extension to digital tuning

The digital tuning of the oscillator can be achieved by replacing the tuner resister (R_0) by a binary weighted switched resistor array (BWSRA). A simulation scheme is shown in Fig. 2. The switches used are CMOS CD 4066 having low on resistance and relatively high off resistance [7]. The incorporation of simulated R_0 in Fig. 1 provides a digitally tunable active-R oscillator with biphase output. If the control voltages of SPST switches are supplied through the 8255 Programable Peripheral Interface (PPI) chip of an Intel 8085 based microprocessor system, the tunable oscillator can easily be interfaced with microprocessor.

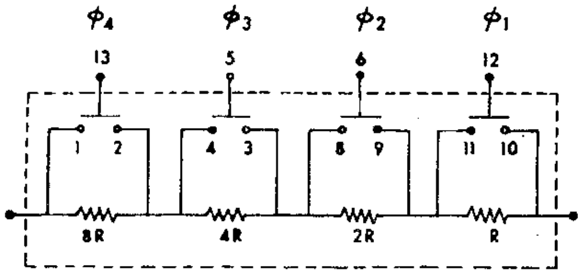


Fig.2
BWSRA simulating R0

The switching function in Fig. 2 may be defined as

$$\phi_j = \begin{cases} 1 & (switch\ on) \\ 0 & (switch\ off) \end{cases} \qquad 4)$$

The law for digital tuning can be expressed in terms of ϕ_j (j = 1 to 4) as

$$n = decimal\{\bar{\phi}_4 \bar{\phi}_3 \bar{\phi}_2 \bar{\phi}_1\} \qquad (5)$$

The performance of the tunable oscillator under digital control is shown in Table-1.

4. BFSK wave generation

Selection of any two combinations from Table-1 provides two different values of oscillation frequency and BFSK wave modulation. However instead of using microprocessor, a different scheme as shown in Fig. 3, for the generation of BFSK wave using standard 555 as table circuit [8] is used. Such scheme utilises only the first and last combination of Table-1.

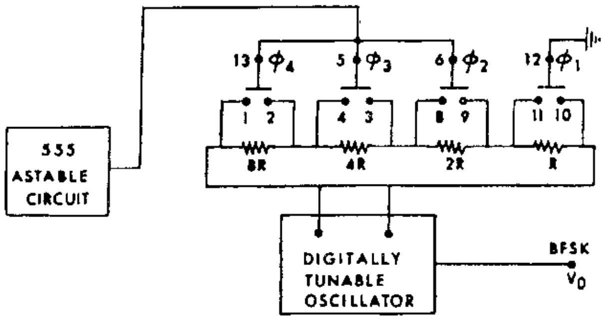


Fig.3
BFSK wave generation scheme

The astable output from 555 circuit provides the digital base band signal and two different frequencies are obtained.

5. BPSK wave generation

The availability of biphase oscillation in the digitally tunable oscillator suggests the applicability of such oscillator in BPSK wave modulator as a basic building block. The two outputs from the OA are time multiplexed using the multiplexing switches ϕ^e and ϕ^o as shown in Fig. 4.

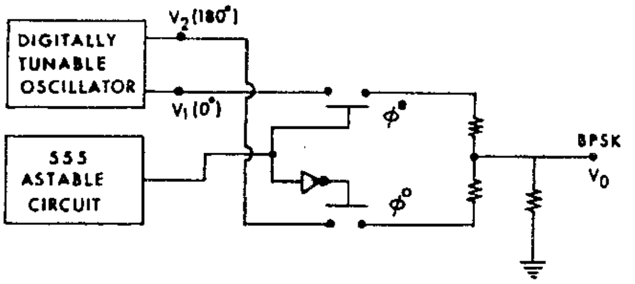


Fig.4
BPSK wave generation scheme

TABLE 1: Performance of the digitally tunable oscillator

ϕ_4	ϕ_3	ϕ_2	ϕ_1	n	R_0	f_0 in kHz	
						Theo.	Prac.
1	1	1	0	1	R	577	570
1	1	0	1	2	2R	707	700
1	1	0	0	3	3R	774	760
1	0	1	1	4	4R	816	800
1	0	1	0	5	5R	845	835
1	0	0	1	6	6R	866	860
1	0	0	0	7	7R	881	880
0	1	1	1	8	8R	894	890
0	1	1	0	9	9R	904	900
0	1	0	1	10	10R	912	910
0	1	0	0	11	11R	919	915
0	0	1	1	12	12R	925	920
0	0	1	0	13	13R	930	930
0	0	0	1	14	14R	935	940
0	0	0	0	15	15R	939	950

6. Transmission and detection using optoisolator

The next design is to develop a means for the transmission and detection of BFSK/BPSK wave using optical method. For this purpose a 6-pin DIP Optoisolator of 4N25 type has been used. The scheme is shown in Fig. 5.

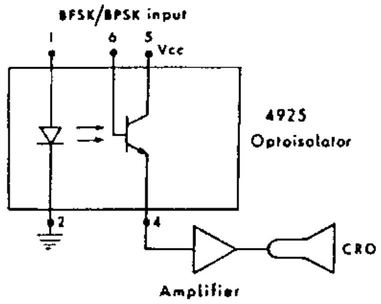


Fig.5
BFSK/BPSK transmission/detection

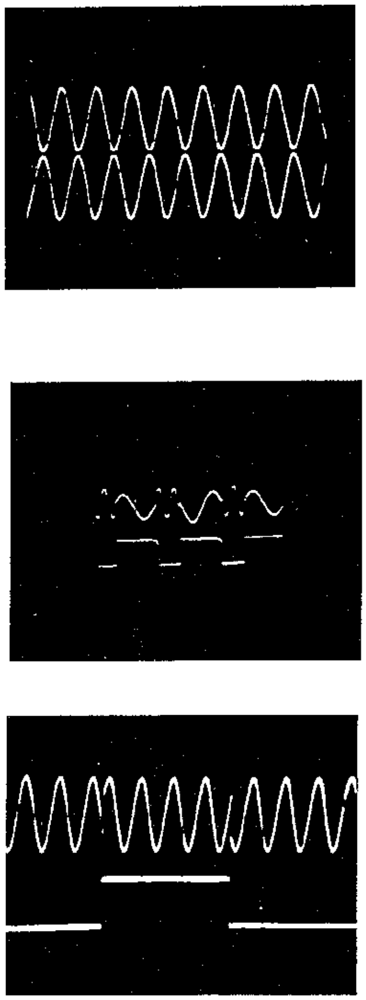
The LED and the transistor within 4N25 Optoisolator are properly biased so that ac signals can be handled without much distortion.

7. Experimental results

The tunable active-R oscillator has been designed using matched dual OA LM 747 chip. The digital tunability has been incorporated by interfacing the oscillator with a SDA-UNI-01 microcomputer system based on Intel 8085 microprocessor. The digital code is taken out via the port B of 8255 PPI chip. Good quality biphase oscillation is produced over the range of frequencies as depicted in Table-1. The output of the digitally tunable oscillator is shown in Fig. 6 (a).

BFSK wave modulation utilises the two frequencies of 570 kHz and 950 kHz at V_0 output which is the either output (V_1 *or* V_2) of the tunable oscillator. The experimentally observed waveform is shown in Fig. 6 (b).

BPSK wave modulation si shown in Fig. 6 (c); the time multiplexed switches used are also CD 4066 CMOS switches.



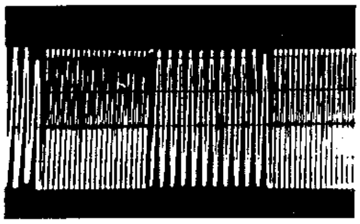
a

b

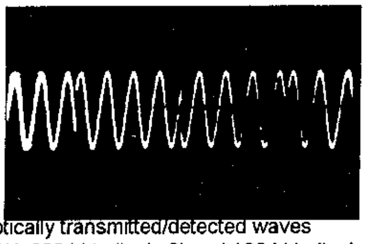
c

Fig.6
The experimentally observed wave form
a) Biphase oscillation at 800 kHz
b) BFSK wave: 1 represents 570 kHz, 0 represents 950 kHz
c) BPSK wave at 900 kHz

The optically transmitted BFSK/BPSK waves are shown in Fig.7.



a



b

Fig.7
The optically transmitted/detected waves
a) BFSK: 200 kHz (logic 0) and 100 kHz (logic 1)
b) BPSK at 250 kHz

8. Conclusion

A simple active-R tunable sinusoidal oscillator design is discussed. The tunability can be achieved digitally by the incorporation of the BWSRA. The dependency of the oscillation frequency on the unity-gain bandwidth (B) suggests a means of high-frequency operation of the circuit by the use of OAs with high values of B; such as AD 848: B = 175 MHz. The digital modulations like BFSK/BPSK are generated from such oscillator with good quality waveforms. Finally a simple scheme of optical communication link is established for the transmission and detection of digitally modulated signals using optoisolator. The received signals are in full conformity with the corresponding transmitted ones. This suggests the applicability of the designed modulator for use in optical fibre communication system.

9. References

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About authors, ...

D. Pal received the Bachelor's degree in Electrical Engineering. He served as Project Engineer in the Regional Science Centre at Bhopal, India. Presently, he is working towards his Ph.D. (Engg) thesis in the areas of mixed analog/digital mode integrated circuits design. His research interests include the design of analog/digital signal processing and communication engineering.

S. K. Sanyal received the B.E.Tel.E. (Hons), M.E.Tel.E. and Ph.D. (Engg) degrees from Jadavpur University, India in 1977, 1979 and 1990 respectively. Until 1982 he served as a Senior Research Fellow in the ETCE Department, Jadavpur University under the CSIR Scheme. He si currently a Senior Lecturer in the same department. His research interests include switched-capacitor circuits, Design of phased arrays, microprocessor controlled signal conditioning/generation networks suitable for digital communication, and design of programmable circuits with applications in optical communication. Dr. Sanyal is a Senior Member of IEEE, U.S.A.

R. Nandi received the B.Sc. (Hons) degree from Burdwan University, India, in 1965, and the B.Tech. (Hons) M.T.Tel.E., and Ph.D. degrees in engineering from Jadavpur University, India, in 1969, 1971 and 1982, respectively. He joined Jadavpur University as a Lecturer in 1973 and became a Reader in 1981. He is now a Professor at the ETCE Department, Jadavpur University. He served as a Visiting Research Associate Professor at the National Tsing-Hua University, National Science Council, Taiwan, during 1985-86. He also served as a Visiting Professor at the Cukurova Univ. Adana, Turkey during 1991-92. He has published more than 90 research papers in various international journals in the fields of active filters and communication circuits. His research interests include the design of integrable analog/digital signal processing/ conditioning circuits and programable filters suitable for application to instrumentation/communication systems. Dr. Nandi is a Senior Member of IEEE, U.S.A.