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Designing of a Quadrature Oscillator

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सार – देश में ही निर्मित उपकरणों का उपयोग करके कार्व्ड्रेचर दोलक के लिए इलेक्ट्रॉनिक परिपथ का डिजाइन तैयार करने और उसका विकास करने का इस शोध–पत्र में प्रयास किया गया है। इसका उपयोग भारत मौसम विज्ञान विभाग की 39 रेडियोसौंदे/रेडियो पवन प्रेक्षण प्रणाली के उपरितन वायु संजाल में 14 समीर रेडियोथियोडोलाइटों के संजाल के अनुरक्षण के लिए डिस्पले यूनिटों के रखरखाव हेतु किया जाएगा।

ABSTRACT. This paper is an attempt to design and develop an electronic circuit for Quadrature Oscillator, by using locally available components, to be used in servicing of display units for maintenance of a network of 14 Nos. of SAMEER R/Ts in IMD's upper air network of 39 radiosonde radiowind observation system.

Key words – Quadrature oscillator, Radiotheodolite, Sine wave, Radiosonde, Display unit.

1. Introduction

IMD has a network of 39 upper air stations taking RS/RW observations twice daily. For upper air observations balloons are released twice daily at 0000 UTC & 1200 UTC with a radiosonde (RS) transmitter system, which transmits meteorological data *i.e.*, temperature, humidity and pressure at different levels. This system is tracked for upper air wind data (wind direction and wind speed) with different types of ground equipments such as radar and radiotheodolites (R/T). At present different types of radiotheodolites are being used in IMD. Out of 39 RS/RW stations, 14 stations are equipped with SAMEER, Mumbai, make radiotheodolites. As the balloon drifts according to wind at a particular level, the balloon is tracked and its position (azimuth & Elevation) is noted down and by calculating its drift, the wind data is known. The balloon position is made available on the display unit, in two windows, one for azimuth and another for elevation by exact tracking of transmitter (Krishnan *et al*., 1999). For display of balloon position, SAMEER Mumbai make R/T system originally uses M/s Computer Conversion Corporation, USA, make display unit, which has two cards one each for azimuth and elevation windows. Both the cards are driven by a common quadrature oscillator. It has been noticed that most of the times these quadrature oscillator circuit becomes defective, causing complete unit to become un-serviceable. This is an effort to design and develop a quadrature oscillator circuit, by using locally available components, to be used in servicing of display units for maintenance of a network of 14 Nos. of SAMEER R/Ts in IMD's upper air network.

2. Circuit design and methodology

The circuit schematic is shown in Fig. 1. As its name implies, the quadrature oscillator generates two signals (Sine & Cosine) that are in quadrature, that is, out of phase by 90°. The actual location of sine & cosine is arbitrary, in the quadrature oscillator. The idea of the quadrature oscillator is to use the fact that the double integral of a sine wave is a negative sine wave of the same frequency and phase, in other words, the original sine wave is 180° phase shifted. The phase of the second inverter is then inverted and applied as positive feedback (Ron, 2003). In this circuit two Op-Amps and three RC combinations are used.

The following circuit elements are needed for the quadrature oscillator to operate at 400 Hz :

a. 741-IC (2 Nos.)

b. Resistances, 3.9 KΩ (3 Nos.)

c. Capacitances, 0.1 μF (3 Nos.)

d. D.C power supply, 15 V

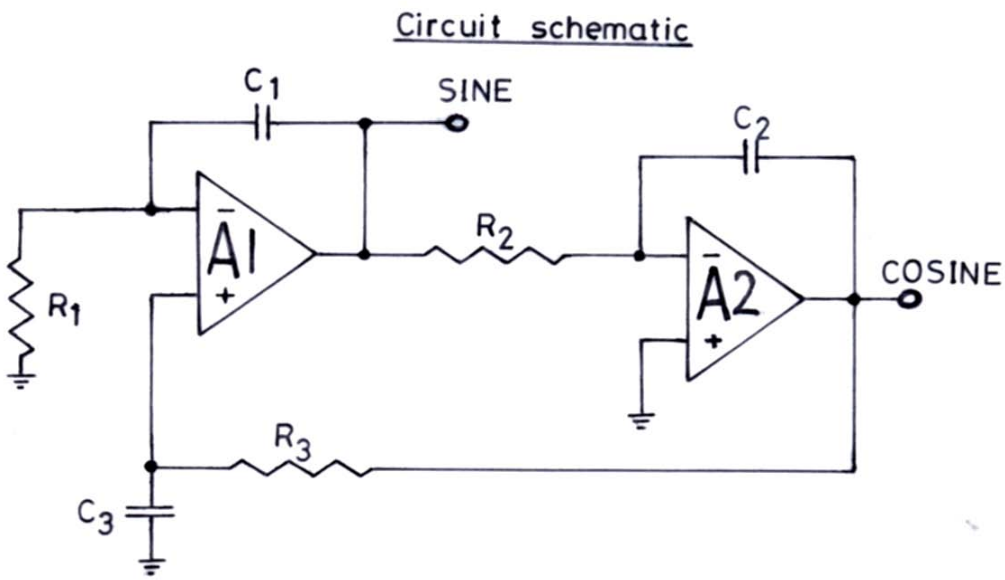

Fig. 1. Circuit schematic

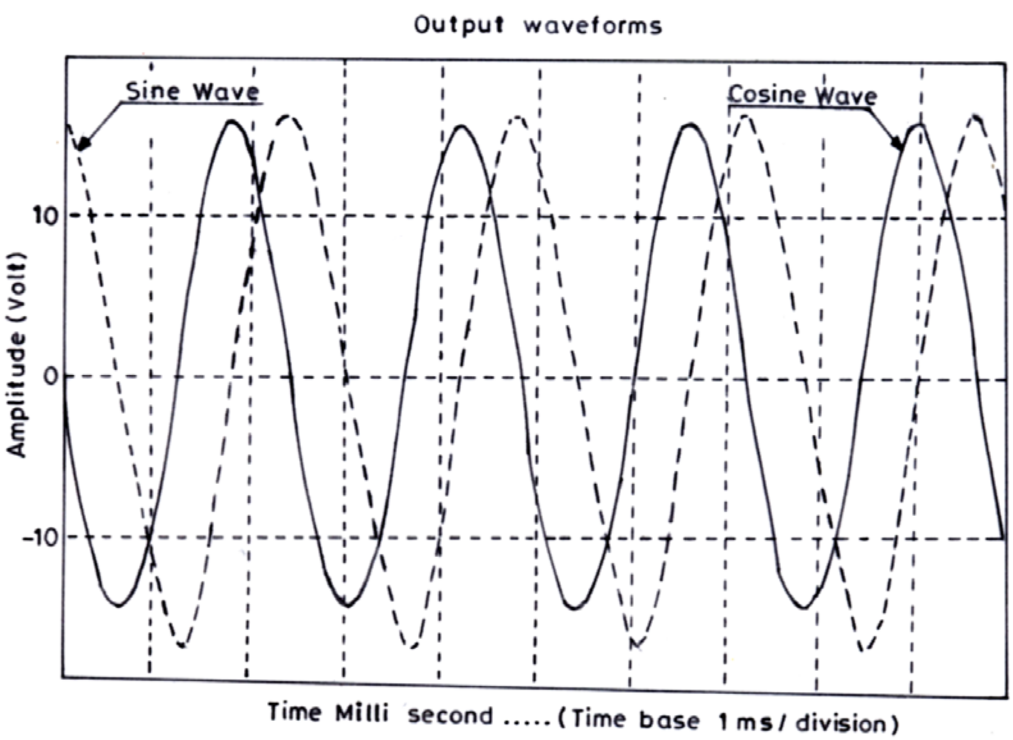

Fig. 2. Output wave forms

TABLE 1

Comparison of accuracies of designed circuit with original imported circuit

Angle position (Degrees)	Measured phase difference			Measured angle		
	Designed circuit	Original imported circuit	Error	Designed circuit	Original imported circuit	Error
000	000.0	000.0	0.0	000.0	000.0	0.0
090	090.1	090.0	0.1	090.1	090.0	0.1
180	180.1	180.0	0.1	180.1	180.0	0.1
270	270.1	270.0	0.1	270.1	270.0	0.1

3. Calculation

We require f_0 = 400 Hz, if we select the value of C=.1 µF, then the value of R can be easily calculated as follows:

We know, $f_0 = 1 / (2\pi RC)$, where C = 0.1 µF and f_0 = 400Hz

It implies that, R = 3.9 KΩ

The 5 kΩ potentiometer has been used in place of 3.9 KΩ resistance, which can be adjusted to 3.9 KΩ obtaining distortion-less outputs.

4. Working

The first op-amp is operating in the non-inverting mode and appears to be a non-inverting integrator. Further more A_2 is followed by a voltage divider network consisting of R_3 and C_3. The feedback network consists of a RC combination, whereas A_1 and A_2 are forming the amplifier stage. For proper oscillation two conditions are necessary, first, the total phase shift around the loop should be 360° and secondly the gain $A_v \beta = 1$. These two conditions are known as Barkhausen criteria (Choudhary, 2006; Ron, 2003). The op-amp A_2 is a pure integrator and inverter, hence it contributes -270° or 90° of the phase shift. The remaining -90° or 270° phase shift needed is obtained by voltage divider and the op-amp A_1. The total phase shift of 360° however is obtained only at one frequency called as frequency of oscillation f_0.

This frequency of oscillation is given by

$f_0 = 1/2\pi RC$

where, $R_1C_1 = R_2C_2 = R_3C_3 = RC$, at this frequency $A_v = 1/\beta$

This is the second condition for oscillation.

5. Results

The output sine and cosine waves are shown in Fig. 2. Both the waves are with a phase difference of 90° *i.e.*, both are in quadrature. The circuit is on a small PCB and can be fitted easily on the existing card of the display unit. The accuracy of the designed circuit has been compared with that of original imported circuit, at various measurement angles, which is tabulated in Table 1. The results are in good agreement with the performance of imported card.

6. Conclusions

The designed circuit has been useful in servicing of display units to be used for maintenance of a network of 14 Nos. of SAMEER R/Ts in IMD's upper air network. Three such circuits have been made on PCB and used in repair of display unit of SAMEER make radiotheodolites. All three repaired display units are working satisfactorily at different stations. For further refinement of the circuit high quality components may be used to increase the efficiency and stability of the circuit.

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