INT. J. ELECTRONICS, 1971, VOL. 30, NO. 6, 575-578

Research notes

A. PEDAR and P. E. SANKARANARAYANAN
National Aeronautical Laboratory, Bangalore 17, India

[Received 21 November 1970]

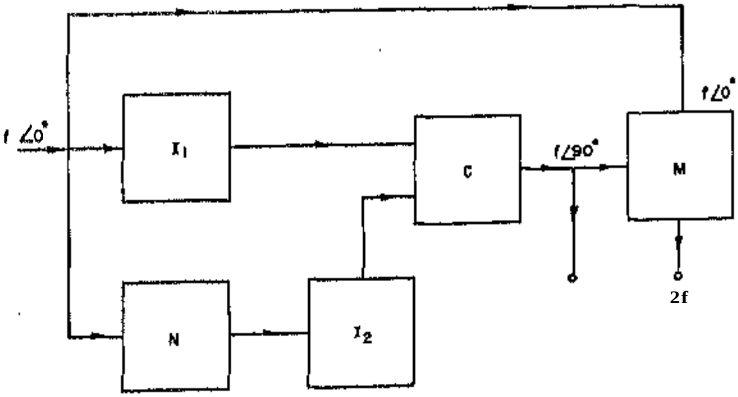
1. Introduction

In the field of electronic instrumentation there are many applications where a circuit is needed to shift the phase of square waves by 90°. In this paper a simple and novel scheme to achieve this end is proposed. This circuit, along with a modulo-two-adder, also enables one to obtain the double frequency component of the original input square wave. It is thus possible to have frequency multiplication by powers of two by cascading such circuits in tandem. The entire circuitry, excepting the time averaging capacitors, can be either integrated in one chip or fabricated in the module form.

2. Method of generation

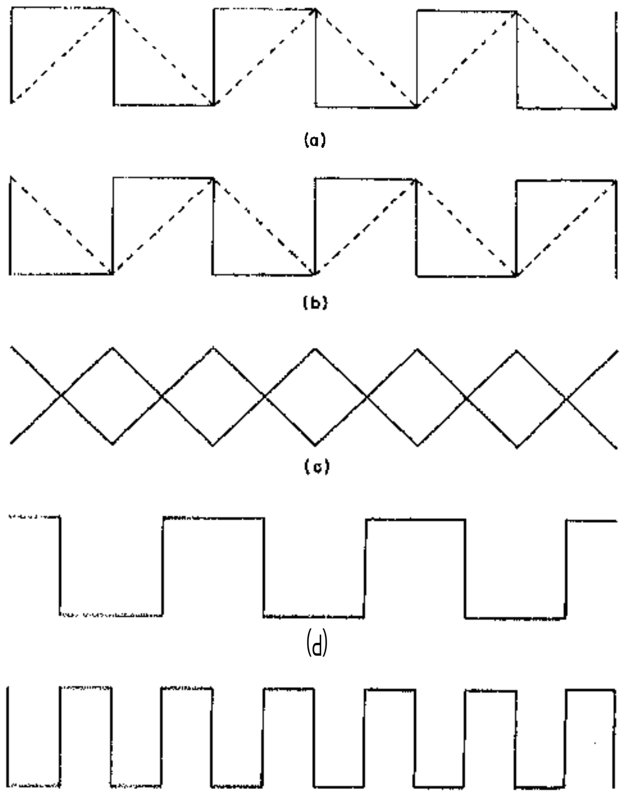
Figure 1 shows the schematic block diagram of the set-up. It comprises two integrators I_1 and I_2, a digital invertor N, a comparator C and a modulo-two adder M. The integrators provide an output that is proportional to the time integral of the square wave input signal. The wave shape at the output of these integrators will be triangular, corresponding to the integral of the non-inverted and inverted square wave. In figs. 2 (a) and 2 (b) the wave form drawn with the continuous line represents the non-inverted and the inverted square wave. They have the same amplitude. The wave form drawn in the same two figures with dotted line, represents respectively the integrated output of the two square waves. Figure 2 (c) explains the process of comparison done by

Fig. 1



Schematic block diagram.

Fig. 2



Method of generation.

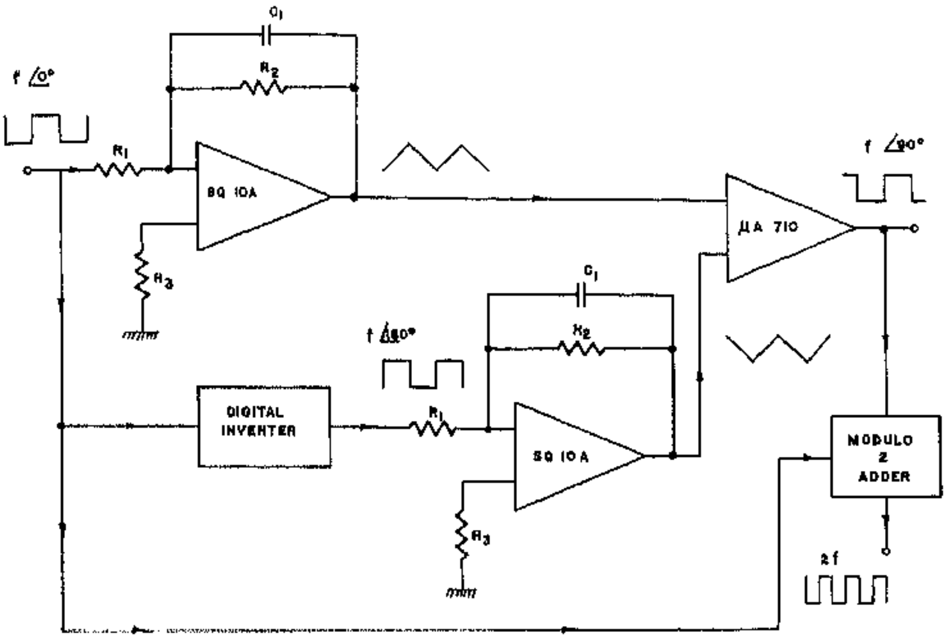
the comparator. When, at a given instant, the two inputs to the comparator are equal in magnitude, the output level of the comparator changes in sign. If the integrator output, i.e. the sides of the triangular wave, is linear with time, then the points of intersection in fig. 2 (c) occur at times equal to $T/4$, $5T/4$, $9T/4$, etc., where T is the period of the original square wave signal. Thus the output of the comparator will be a train of square waves having the same frequency as the original one, but shifted in phase by 90°. Figure 2 (d) shows the output of the modulo-two-adder, which is also a square wave signal but of double the frequency. This block has the original non-inverted square wave and the output of the comparator (90° shifted version) as its two inputs.

3. Experimental verification

The scheme described above has been verified experimentally by constructing a circuit as shown in fig. 3. The operational amplifier block SQ10A (Nexus), along with the associated components, forms the integrator. Resistor R_2 is included in the feedback path to provide d.c. stabilization. This also limits the gain of the amplifier and minimizes the output drift. The frequency f_0 above which this circuit functions as an integrator is given by

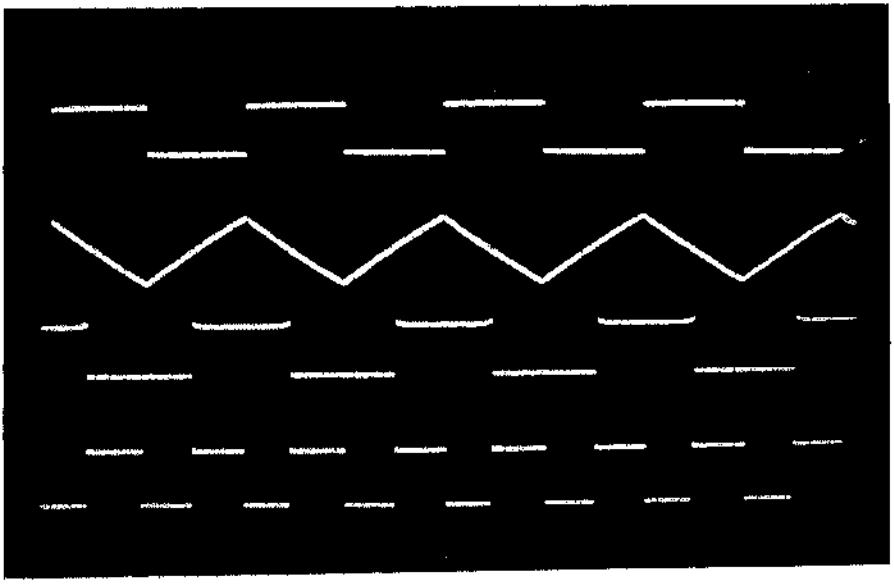
$$f_0 = \frac{1}{2\pi R_2 C}.$$

Fig. 3



Circuit diagram.

Fig, 4



To have optimum linearity f_0 is chosen as 1/10 of the lowest frequency to be handled as the input signal. The digital invertor employed is a simple 'not' circuit. Integrated circuit chip μA 710 has been used as the comparator. The modulo-two-adder performs the function $(A\bar{B} + B\bar{A})$, where A and B are the two inputs.

It has been found that 90° phase shift and doubling of frequency occur in the frequency range of 1 kHz to 10 kHz. The C_1R_1 value used in the experiment is 1 msec. This range can be varied by changing the value of C_1. Oscillograms of the input square wave, the integrator output, the 90° phase-shifted waveform and the double frequency component are shown in fig, 4.

4. Conclusions

In this paper a scheme, as well as the circuit to obtain 90° phase-shifted version of a square wave and its double frequency component, have been given. This circuit can be used as a, counterpart of the well-known frequency divider using flip-flops. Total integration or manufacture in the modulo form provides one simple device for 90° phase shifting and frequency multiplication by a factor two. However, depending on the range of frequencies employed, a proper integrating capacitor has to be connected externally. Use of such circuits in tandem enables frequency multiplication by powers of two.

In the circuit diagram shown in fig. 1 the digital inverter, and the following integrator, may be omitted, if the square wave at the input is symmetrical with respect to ground. Then one input end of the comparator is earthed. Now comparison is done with respect to ground potential only. Also, if the input square wave is obtained from a flip flop, then the outputs taken from the two collectors of the flip-flop constitute the non inverted and inverted square waves as such, the digital inverter is not needed.

Acknowledgment

The authors thank the Director, National Aeronautical Laboratory, Bangalore, India, for permitting them to publish this paper.