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A three-phase function generator in Power Systems

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ABS TRACT:

A variable frequency and variable phase function generator with three outputs of (1) 2, is described in this paper. TheÆ1 and (3) lag phase fO – Æ reference fO (2) lead phase fO + 1 is continuously adjustable over 0 to 180ºÆ leading phase difference by an input control 2 is also continuously adjustable over 0 to -Ævoltage VC1 and the lagging phase difference 180o by an another input control voltage VC2, independent of frequency of operation of the function generator which can be set by a third control input dc voltage –VI .

Introduction:

Using function generators with phase-shifted and referenced outputs is crucial for designing and testing contemporary control and instrumentation circuits. One such is the phase-sensitive detector [1], which is crucial for measuring power, impedance, instrument transformer error, and other things. A sine wave generator and an extra phase shifter are a common tool for testing phase-sensitive detectors and phase-measuring circuits. Using this technique, the phase difference θ between the two outputs is obtained using an all-pass filter. When the values of R and C vary because of their tolerances, the phase difference is altered along with the sine wave's frequency, and θ is also affected. By using an astable multivibrator and a divide by three logic network, followed by a divide by two logic network with a synchronization gate, [2] created a variable frequency fixed phase sequence. Variable phase sequence cannot be obtained with this method. By using a technique described by [3], millimeter wave signals with phase shifts ranging from 0 to 360 degrees can only be created at a constant frequency. A perfectly adjustable phase difference between the outputs that is unaffected by drift in component values and operating frequency would be very advantageous. Only dual phase applications can benefit from a variable frequency and variable phase function generator with dual outputs [4]. This study describes an enhancement on circuit [4] as a three-phase function generator for three-phase applications.

Circuit Analysis:

The circuit diagram of the proposed three phase function generator is shown in Fig. 1 and its associated waveforms in Fig. 2. A sawtooth wave with peak value VR is generated by opamps OA1,OA2 and a switch SW1. Let us assume that at start, the charge and hence voltage at the output terminal of opamp OA1 is zero. Since the inverting terminal of the opamp OA1 is at virtual ground, the current through R, namely VI /R amps, would flow through and charge the capacitor C. During the capacitor being charged (till the output of OA1 reaches a voltage level of VR) the output of opamp OA2, configured to work as comparator, will be at the LOW state and switch SW1 is kept open (OFF). As soon as the output of OA1 crosses the level of

VR, say after a time period T, the output of comparator OA2 goes high and the switch SW1 is closed (ON). The switch SW1 would then short the capacitor C and hence the output of integrator OA1 Vs drops to zero volts. During the time period T we have, 1 I I V Vs V dt t RC RC ò = = (1) After a very short delay time Td, required for the capacitor to discharge to zero volts, the comparator output returns to LOW and switch SW1 is opened, thus allowing C to resume charging. This cycle, therefore, repeats itself at a period (T+Td). From the equation (1) and the fact that at time t = T, Vs = VR , we get R I V T RC V = (2) A short pulse VP1 is generating at the output of comparator OA2 and is given to a toggle flop FF A. A square wave „X" of period 2T is obtained at the output of toggle flip FF A. This wave is called as reference square wave. The sawtooth waveform VS generated at the output of integrator OA1 is compared with a control voltage VC1 by the comparator OA3, a rectangular waveform VP2 whose OFF time is proportional to the control voltage VC1 is obtained at the output of comparator OA3 and is given to the toggle flip flop FF B. The output of this toggle flip flop FF B is a square wave „Y" of period 2T and this wave is called phase lead square wave. 1ÆLead phase difference ( ) = C1 R V V 180o (3) The sawtooth wave Vs is also compared with another control voltage VC2 by the comparator OA4. A rectangular waveform VP3 whose OFF time is proportional to the voltage VC2, is generated at the output of comparator OA4 and is given to the toggle flip flop FF C.

Fig. 1 Circuit diagram of three phase function generator

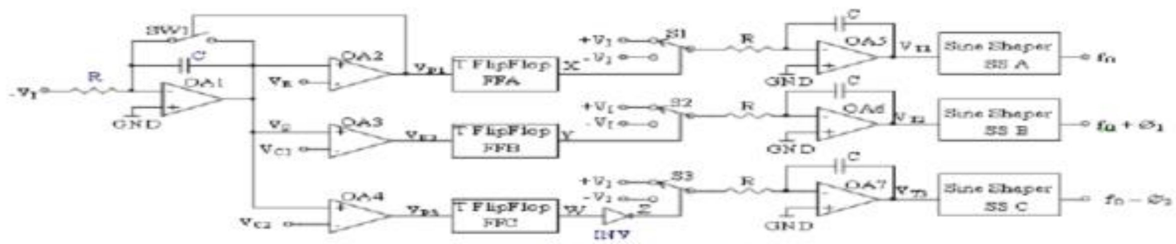
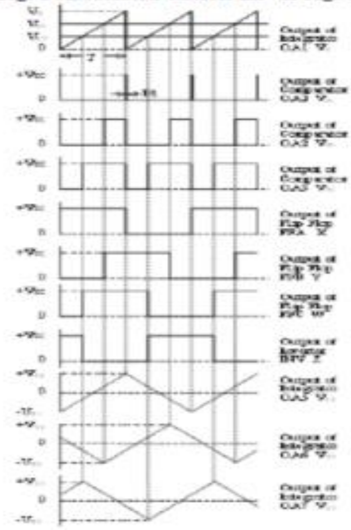


Fig. 2 Associated waveforms of Fig. 1



Hence a reference triangular waveform is generated at the output of integrator OA5 with peak to peak value of ± VT1 or ±VR/2). In similar way (1) phase lead triangular wave VT2 with peak to peak value of ±VT2 from the phase lead square wave „Y‟ is generated at the output of the integrator OA6 by the switch S2 and (2) phase lag triangular wave VT3 with peak to peak value of ±VT3 from phase lag square wave „Z‟ is generated at the output of integrator OA7 by the switch S3. The reference sine wave fO is converted from the reference triangular wave VT1 by the sine shaper SS A [5]. In similar way (1) phase lead sine wave fO + Æ1 is converted from phase lead triangular wave VT2 by the sine shaper SS B and (2) phase lag sine wave fO - Æ2 is converted from the phase lag triangular wave VT3 by the sine shaper SS C.

Experimental Results

The proposed circuit diagram was wired and tested in our Laboratory. OP 07 IC was used for all opamps. CD 4016 IC was used for switch SW1 and CD 4053 IC was used for the other switchs S1- S3. CD 4013 IC was used as T Flip Flops. A power Supply of ±Vcc = ±7.5V was chosen for the circuit. LM 336 2.5V voltage reference was used for VR. ie VR = 2.5V. R = 1MW 1% resistors were chosen. VC1 and VC2 were kept constant voltage of 1V and -VI was varied from 0.5V to 5V by selecting C as 10nF, 1nF and 100pF for three decade ranges. The waveforms in the circuit were observed in Philips PM 3206 Dual Trace CRO and verified as given in Fig. 2. The output frequency was measured with HIL 2722 universal counter. The readings were taken. Then Frequency was kept constant (–VI =2.5V, C = 10nF), VC1 was varied from 0.1V to 2.4V, the time delay between the reference and lead phase square waves was measured in HIL 2722 universal counter. Then VC2 is varied from 0.1V to 2.4V, the time delay between the reference and lag phase square waves was measured in HIL 2722 universal counter. The readings were taken. It is observed from the readings that the (1) Frequency Error in the range 10Hz - 100Hz = 0.5%, 100Hz - 1KHz = 1% and 1KHz - 10KHz = 2% (2) Phase error in all frequency ranges is found to be less than 0.1%.

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