Labor of Fundamentals of Electronics and Power Electronics

Exercise No. 10

SINUSOIDAL WAVEFORM OSCILATOR (GENERATOR)

10.1 General information

The aim of the exercise is choice of a circuit elements for implementation of the sinusoidal generator based on operational amplifier with positive feedback. The RC passive filter plays a role of the phase shifter. The positive feedback can be realized basing on three or four single differential RC structures. The frequency characteristic can be shaped by modifying resistance R, while capacitance C can be chosen as described on the console in the lab (C=22nF, 47nF).

Additionally the laboratory console is equipped with integrated amplifier circuit. This element gives a possibility to build and test the sinusoidal generator with quartz-crystal resonator in the feedback loop.

The aim of the exercise is a proper choice of resistors and capacitors in the feedback loop to guarantee generation conditions (excitation and maintenance of electrical oscillation) in the circuit.

References:

Tse Chi Kong: Linear circuit analysis
http://en.wikipedia.org/wiki/Phase-shift_oscillator
http://pl.wikipedia.org/wiki/Generator_RC
http://en.wikipedia.org/wiki/RC_oscillator
Baranecki A.: Laboratorium układów elektronicznych. Cz. 1, Cz. 2
Kaźmierkowski M.P., Matysik J. T.: Wprowadzenie do elektroniki i energoelektroniki

10.2 Exercise description

The view of the console front panel is shown in Fig. 10.1.

Panel contains following circuits and elements:

- measurements and connection sockets,
- phase shifter capacitors: 4x22nF, and 4x47nF,
- two independent operational amplifiers ULY7741. First one gives a possibility to realize a sinusoidal generator with phase shifter in the feedback. The second one gives a possibility to realize and test generator with quartz-crystal resonator.

The operational amplifiers are supplied with ±12 V symmetrical voltage by internal connectors in main panel of the laboratory setup. Please, choose 12 V on the main control panel (both 12V buttons).

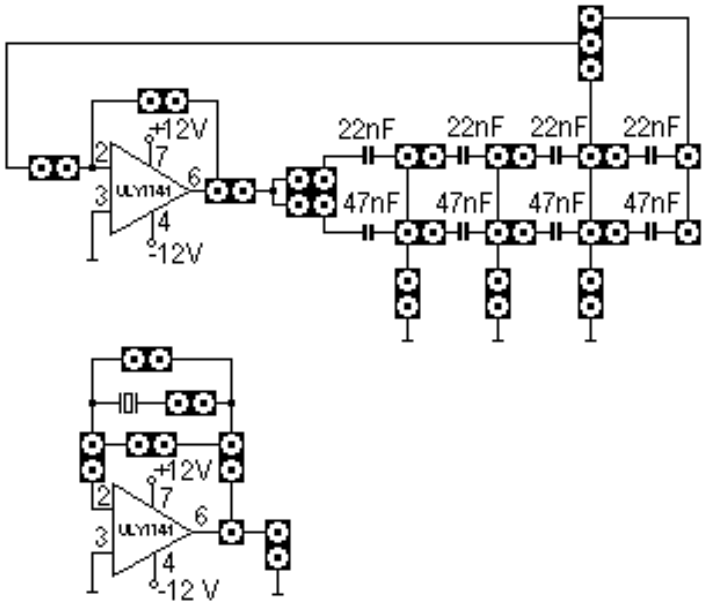


Fig. 10.1

10.3 Exercise program

10.3.1 Phase shifter tests(Fig. 10.2).

a) Choose the phase shifter topology (3 or 4 single RC structures),

b) Calculate R value. The output waveform frequency should be taken from 3kHz - 6kHz range. Chose one value for capacitors C (22nF or 47nF).

c) Connect functional generator to the phase shifter input. Set maximal sinusoidal waveform amplitude and frequency 50kHz.

d) Decrease the frequency and draw phase shifter frequency characteristic (amplitude and phase). Pay special attention to the shape of characteristics in the region close to frequency chosen in p. 10.3.1b.

For measurements use Lissajous curves method and/or direct method using two oscilloscope channels for input and output voltage waveforms observation.

Equivalent testing circuits are shown in Fig. 10.3, and Lissajous curve method for damping and phase shift measurement is presented in Fig. 10.4.

e) Draw the amplitude and phase characteristics and determine theoretically oscillation excitation conditions.

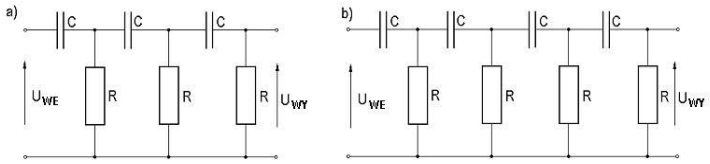
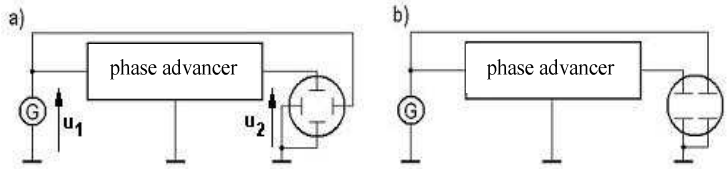
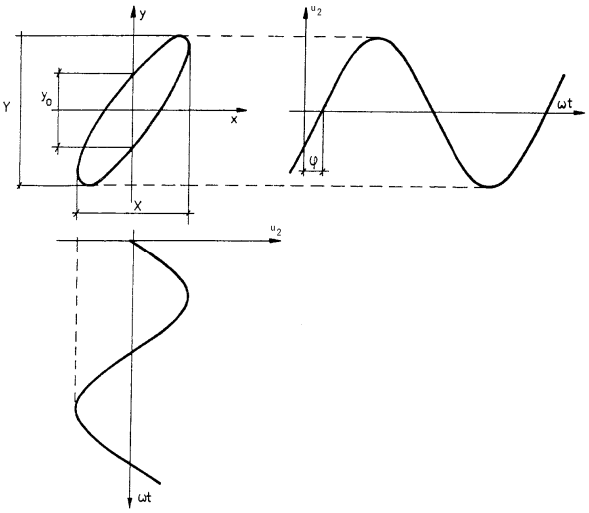


Fig. 10.2

Fig.10.3





If voltage $\mathbf{u_2 = U_2 sin(\omega t - \varphi)}$ **is** supplied to vertical deflector plates,
and voltage $\mathbf{u_1 = U_1 sin\omega t}$ **is** supplied to horizontal deflector plates,
and **ω** is a measured waveform pulsation,
than on the oscilloscope screen a picture appears,
its height **Y** is proportional to $\mathbf{U_2}$ amplitude,
and width **X** is proportional to $\mathbf{U_1}$ amplitude.
Damping (gain less than unity) is equal to:
$\mathbf{k_U = U_2/U_1 = n \cdot Y/X}$,
and $\mathbf{sin\varphi = u_0/U_2 = y/Y}$.
$\mathbf{n = n_Y/n_X}$, where $\mathbf{n_Y}$ i $\mathbf{n_X}$ scale coefficient,
i.e. $\mathbf{n_Y = U_2/Y}$, $\mathbf{n_X = U_1/X}$.

Fig. 10.4

10.3.1 Oscillator (Generator) with phase shifter tests (Fig. 10.5).

a) Calculate resistance R_S value in operational amplifier negative feedback ($R_S \approx 30R$ for 3 RC structures, $R_S \approx 18R$ for 4 RC structures). Connect the circuit. Pay attention when connecting to operational amplifier inverting input the resistor R from the last phase shifter's RC structure (Fig. 10.5).

b) Turn-on the operational amplifier supply voltage. Set the calculated resistance R_S on a decade resistor – start up the oscillator.

c) Measure output voltage waveform amplitude and frequency.

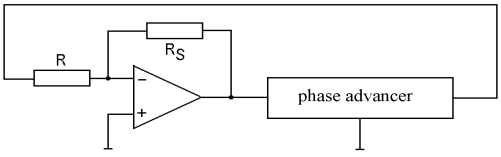


Fig. 10.5

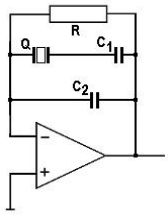


Fig. 10.6

10.3.2 Generator with quartz-crystal resonator tests. The circuit scheme is show in Fig. 10.6.

a) Turn-on the circuit with C1 – short-circuiter, C2 = 22 nF, R = 2 MΩ

b) Varying R (if necessary) to excite the generator. Measure output voltage frequency.

c) Connect C1 = 1 nF and repeat actions as in 10.3.2b.

c) Connect C1 = 2.2 nF and repeat actions as in 10.3.2b.

c) Connect C2 = 10 nF and repeat actions as in 10.3.2b.