APPLICATION OF RL GENERATORS AS FREQUENCY CONDUCTOMETRIC TRANSUDERS

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Sensing elements of frequency conductometric transducers are made of contactless capacitive (C) and inductive (L) electrolytic cells which are normally connected to the tuned circuit of an LC generator. The impedance of the tuned circuit varies with the losses contributed by the tested conducting solutions to the capacitive and inductive elements of the tuned circuit. Changes in the real and imaginary components affect, respectively, the amplitude and frequency of oscillations. The value of the generator's relative frequency variations (frequency sensitivity $S_f = \Delta f / f_{AV}$) are limited by the self-excitation conditions within the range of changes in the tested solution's concentration and for LC generators are relatively small (0.01-0.004).

It has been shown in [1] that it is possible to raise the transducer's frequency sensitivity by a factor of the order of 1-2, if one or several reactive components of an RC generator's phase-shifting network are replaced by a C cell. In addition to RC generators, it is also possible to use RL generators [1, 2]. In this case, the reactive components of the phase-shifting network are replaced by an L cell.

The main advantages of RC and RL generators over LC generators when they are used as frequency conductometric transducers consist of the self-excitation condition being attained over a wide frequency band with a corresponding selection of the amplifier gain and the circuit parameters, and of the possibility of using contact R cells in addition to the L and C cells. By meeting the self-excitation conditions over a wide frequency band, it becomes possible to work with highly sensitive cells or connect them in series, i.e., substitute cells for several active or reactive components of the phase-shifting circuit.

Moreover, an increasing number of such components raises, within definite measurement limits of the solution's concentration, the deviation frequency $\Delta f$ and the frequency sensitivity of transducers.

Below we describe the design of multisectional L and R cells and methods for substituting them for resistive and reactive components of various multisectional phase-shifting RL networks (ladder, T-type, and L-type), in corresponding generators. Examples are provided of the utilization of these cells in specific RL generator circuits, as well as the metrological characteristics and specific features of their application in conductometric circuits as compared with R and C cells in RC generators.

Schematics of RL networks are shown in Fig. 1. Two types of three-sectional networks were investigated, consisting of R-parallel (Fig. 1a) and L-parallel (Fig. 1b) circuits. The first network replaces three reactive components and consists of an L cell with three sections (Fig. 1c), the second network replaces three resistive components and consists of an R cell with three sections (Fig. 1d). Only one kind of a T-type network with grounded resistors was examined (Fig. 1e). This network replaces two reactive components and consists of an L cell with
two sections (Fig. 1f). By replacing two reactive components in an L-type network (Fig. 1g) an L-cell network with two sections was obtained (Fig. 1h), and by replacing two resistive components an R-cell network with two sections was obtained (Fig. 1i). A ladder network with three sections was used in the negative feedback of a four-stage wide-band amplifier with cathode followers at its output (Fig. 2). Self-excitation conditions were met in the range of 500 to 8000 kHz (with a gain of K \approx 30).

A T-type network was used in the negative feedback circuit of a two-stage wide-band amplifier with cathode followers at its output (Fig. 3). The generator operates in the frequency range of 400 to 11,300 kHz (K \approx 5).

The L-type network was used in a positive feedback circuit of a three-stage wide-band amplifier with cathode followers at its output (Fig. 4). The generator provided continuous oscillation in the range of 150-4000 kHz (K \approx 10).

Cathode followers were used at the amplifier outputs in order to raise their stability and reduce the effect of external loads on frequency. The anode circuits of amplifying tubes were provided with correcting inductances in order to extend the frequency range. In all instances, terminal 1 of the network was connected to the amplifying tube and terminal 3 to the cathode of the cathode follower, with terminals 2 and 4 grounded.

The selection of the type of the phase-shifting network in the RL generator circuit and the design of the electrolytic cell depends on the requirements specified for the frequency transducer with respect to sensitivity, measurement precision, and operating conditions.

The L-cell consisted of a solenoid with a tightly wound 1.0-1.2 mm PEL (enamelled, tinned) wire over a glass tube with a diameter in the range of 10-33 mm and a thickness of approximately 1 mm. The width of the winding was determined by the required inductance for maximal sensitivity and usually amounted to 75-100 mm with a spacing between coils of a few millimeters. The contact R cells consisted of 1-mm platinum wires 10 mm long fused in glass tubes at distances of 150 mm (circulating system).

All the experiments were carried out with aqueous solutions of potassium chloride with concentrations in the range of 0.001 to 3.0 N.

In order to examine both patterns observed in operations with multisectional L and R cells, let us refer to Fig. 5, which shows graphically the relationship of frequency to the logarithm of conductivity \( \kappa \) or concentration \( c \) of the tested solution. The segment of the curve shown between points a and b on the graph is virtually symmetrical with