be considered as an element of any high-speed digital tracking system. It replaces a reversible motor. Hence, it is only the extremal detector and modulator which comprise the additional equipment required for designing ac digital bridges. In many instances these two units can be partially combined, which leads to a simplification of the circuit.

The automatic ac digital bridges should be sufficiently simple and reliable. New design methods should not be used if they lead to undesirable complication of the circuit or of the instrument design. At first glance it would appear that the application of extremal control methods to automatic digital bridges would result in this case in excessively complicated circuits and construction. In fact, this is not so. Let us take as an example the above digital bridge. For single parameter balancing the extremal detector and modulator are provided with an additional five transistors, three AND circuits and two differentiating networks. For simultaneous balancing of two parameters the number of additional elements is approximately doubled. The extremal detector and modulator use transistors and crystal diodes and their circuits are simple.

From the above it will be seen that automatic digital ac bridges can possess adequately high dynamic and metrological characteristics with relatively simple control and balancing circuits.

LITERATURE CITED


PRECISION, TRANSISTORIZED SUMMING AMPLIFIER

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Precision in Transmitting Signals. In designing precise summing amplifiers it is possible to select correctly a circuit which would provide the required precision of signal transmission. In order to evaluate the latter let us use an equivalent circuit of a summing amplifier, shown in Fig. 1.

It is more convenient to use current amplification factors if the amplifier comprises transistors.

It is easy to obtain the transfer coefficient for the m-th channel $K_{mp} = -\frac{e_{out}}{e_m} (1 \leq m \leq n)$ by solving a system of Kirchhoff's 1st law equations for nodes 1 and 2 (Fig. 1) and taking into consideration the expression for the current amplification factor $K_i = -\frac{i_{out}}{i_6}$.
Let $K_{mi} = Y_{tm}/Y_2$ be an ideal transfer coefficient for the $m$-th channel and let $\Delta K_m = K_{mi} - K_{mp}$ be the absolute error of the transfer coefficient for the $m$-th channel. Then the relative error of the transfer coefficient will be
\[
\frac{\Delta K_m}{K_{mi}} = \frac{e_1}{1 + e_1},
\]
where
\[
e_1 = \left( \sum_{1}^{n} Y_{1s} + Y_2 + Y_3 \right) \left( Y_0 + Y_2 + Y_3 \right)
\]
\[
= \frac{Y_2 \left( K_1 Y_3 - Y_2 \right)}{Y_2 \left( K_1 Y_3 - Y_2 \right)}.
\]

Let us note that in practice $e_1 \ll 1$, hence
\[
\frac{\Delta K_m}{K_{mi}} \approx e_1.
\]

Since $K_1 Y_3 \gg Y_2$, we have
\[
\frac{\Delta K_m}{K_{mi}} \approx e_1 \approx e_2 = \frac{\left( \sum_{1}^{n} Y_{1s} + Y_2 + Y_3 \right) \left( Y_0 + Y_2 + Y_3 \right)}{Y_2 Y_3 K_1}.
\]

Expression (1) leads to the following conclusions about the effect of amplifier parameters on the value of $K_m/K_{mi}$:

1) $\frac{\partial e_2}{\partial Y_2} < 0$, \( \lim_{Y_2 \to \infty} e_2 = \frac{Y_0 + Y_2 + Y_3}{Y_2 K_1} \), i.e., a reduction in the input resistance $R_s$ decreases the error monotonically down to a certain limit.

2) $\frac{\partial e_2}{\partial Y_0} > 0$, \( \lim_{Y_0 \to -\infty} e_2 = \frac{Y_2 + Y_3}{Y_2 Y_3 K_1} \), i.e., it is advisable to increase the output resistance $R_o$ in order to reduce the error.

3) $\frac{\partial e_2}{\partial K_i} < 0$, \( \lim_{K_i \to -\infty} e_2 = 0 \), i.e., the relative error tends monotonically to zero with a rising $K_i$.

The effect of the number of channels and of the transfer coefficients for each of them on the relative error can easily be seen from a slightly different formulation of (1):
\[
e_2 = \frac{\left( \sum_{1}^{n} K_{si} + \frac{Y_2}{Y_2} + 1 \right) \left( Y_0 + Y_2 + Y_3 \right)}{Y_2 K_i}.
\]

A circuit for a summing amplifier with three common emitter stages has been selected on the basis of the above considerations. This circuit in a simplified form is shown in Fig. 2. Bias voltages $E_b$, $E_{b1}$, and $E_{b2}$ and resistor $R_4$ are used in order to operate the transistors under the required conditions. It is desirable that the internal resistances $R_{b1}$ and $R_{b2}$ of the bias sources should not exceed the differential resistance of the emitter junction, since the value of $K_i$ will otherwise be reduced.