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A METHOD OF MEASURING PHASE DIFFERENCES WITH A DOUBLE FREQUENCY TRANSFORMATION

A.M. Vishnevskaya and B.V. Prosin

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At the present time, the phase difference of superhigh frequency signals is measured by means of various circuits, with /1, 2, 3/ or without /4, 5/ frequency transformation. The advantage of circuits having a transformation of the frequency into a comparatively low intermediate frequency is their wide range, high sensitivity and effective amplitude limitation. In a number of cases, however, and in particular when the signals to be compared are of the pulse type, difficulties arise owing to the fact that the frequency of the local heterodyne merges with the frequency of the measured signal. Such difficulties can be avoided if use is made of a 2-channel heterodyne whose signals have a fixed frequency difference and if the transformed signals in each channel are used for obtaining a signal of the second intermediate frequency. Double frequency transformation has been described in a slightly different circuit, in /6/ and in /7/. We describe below one of the variants of a phase-measuring system which, in particular, may be used for investigating the phase-frequency and phase-amplitude characteristics of superhigh frequency pulse amplifiers.

Figure 1 shows a block diagram of the system. The pulses from the equipment being studied first pass through balancing mixers (1) and (5), where by means of signals from the 2-channel heterodynes (2) and (3) they are transformed into signals of the first intermediate frequency. At the mixer output, the signals of the first intermediate frequency differ by the frequency difference of the heterodynes, which is controlled by a system of automatic phase adjustment of the frequency by means of a quartz reference generator (9). At the output of the mixer (10), the signal of the second intermediate frequency which contains information on the phase difference of the signals being investigated, after amplification in an intermediate frequency amplifier (11), arrives at the bilateral diode limiter (12), after which it is fed to a phase detector (13). The signal is then fed from the output of the phase detector to an oscillograph. From the output of the intermediate frequency amplifier (7) of the phase-amplitude transforming system a signal is fed into the phase detector to serve as a reference. The instability in the phase difference of the heterodyne signals in the confinement band has no effect on the output signal of the phase detector (13). If the arms of the phase meter have the same delay, and the delays from the heterodynes to the mixers are of equal length, the output signal of the phase detector (13) does not depend on a variation in the frequencies of the output signals and heterodyne signals. In this circuit, the second intermediate frequency always remains fixed, but the first intermediate frequency may vary over a comparatively wide range (units and tens of mHz depending on the band width of the mixer (1) and the matching of the circuit components). The phase shifter (4) can be located at the input of mixers (1) or (5), on the output of heterodynes (2) or (3), but the most convenient solution is to place it in the reference frequency circuit of the phase detector (13). In this case, the phase shifter (14) is always operating on a continuous signal of a fixed frequency, and its calibration - and if desired also a constant control of its phase shift - can be effected by means of the usual phase-meter.

This system can also be used for measuring the frequency instability within a pulse and from one pulse to the next. For this, both of its inputs are supplied with the signal under examination (for example by means of a 3-dB coupler, bridge etc.), whilst the delay line, a normal coaxial cable, is connected to the output of either mixer (1) or (5). As the signal attenuation in the cable is small on the first intermediate frequency, to improve the sensitivity of the system to frequency instabilities a comparatively long cable can be used (several tens of metres).

The phase-meter block diagram described above was used for investigation into the phase characteristics of superhigh frequency pulse amplifiers. The mixers (1) and (5) were of the standard type, E7-13.

The heterodyne used was a 2-channel generator with a phase-amplitude transforming system, type G4-54. The first intermediate frequency was selected in the 50-100 MHz range, whilst the second was 13 MHz, thus providing a phase fluctuation analysis band of up to 10 MHz. The balancing mixer (10) was made of four 3 dB directional couplers, similar to the KRT-2 type (8). Figure 2 shows the mixer circuit. The signal from input 1 reaches diode D_1 with a delay of 180° but it reaches diode D_2 without any delay. At the same time, the signal from input 2 reaches both diodes with the same delay. The decoupling between the inputs is $\sim$ 30 dB, whilst the voltage-standing wave ratio of each input does not exceed 1.1. To increase the sensitivity, a positive shift of $\sim$0.2 V was fed to the diodes. The mixer transformation losses were $\sim$15 dB. The minimum working level of input signals of the phase-meter was 5-10 mW. The resolving power, determined by the inherent noise of the system, did not exceed 0.3°. A 15 dB variation in the signal level at each input in relation to the other caused a parasitic phase-shift which did not exceed 1°. Figure 3 gives the oscillograms of the signal from the output of the phase detector during measurement of the internal pulse phase modulations in a KIU-12 amplifying klystron.

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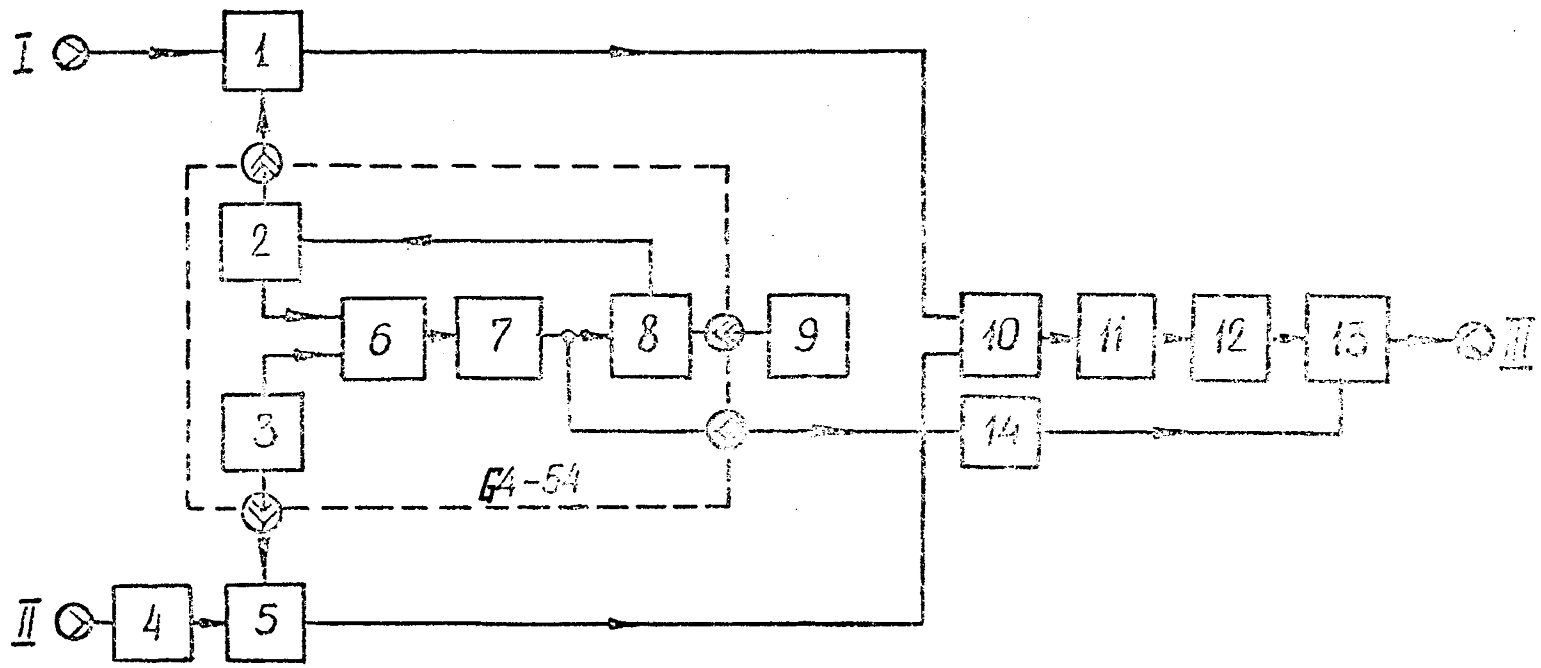

Fig. 1. Block diagram of the Phase Meter.

1 and 5 - superhigh frequency mixers,
2 and 3 - heterodynes,
4 - phase shifter,
6 - mixer,
7 - intermediate phase amplifier,
8 - phase detector,
9 - reference generator,
10 - mixer,
11 - intermediate frequency amplifier,
12 - amplitude limiter,
13 - phase detector,
14 - phase shifter,
I,II - signal input,
III - output to the oscillograph.

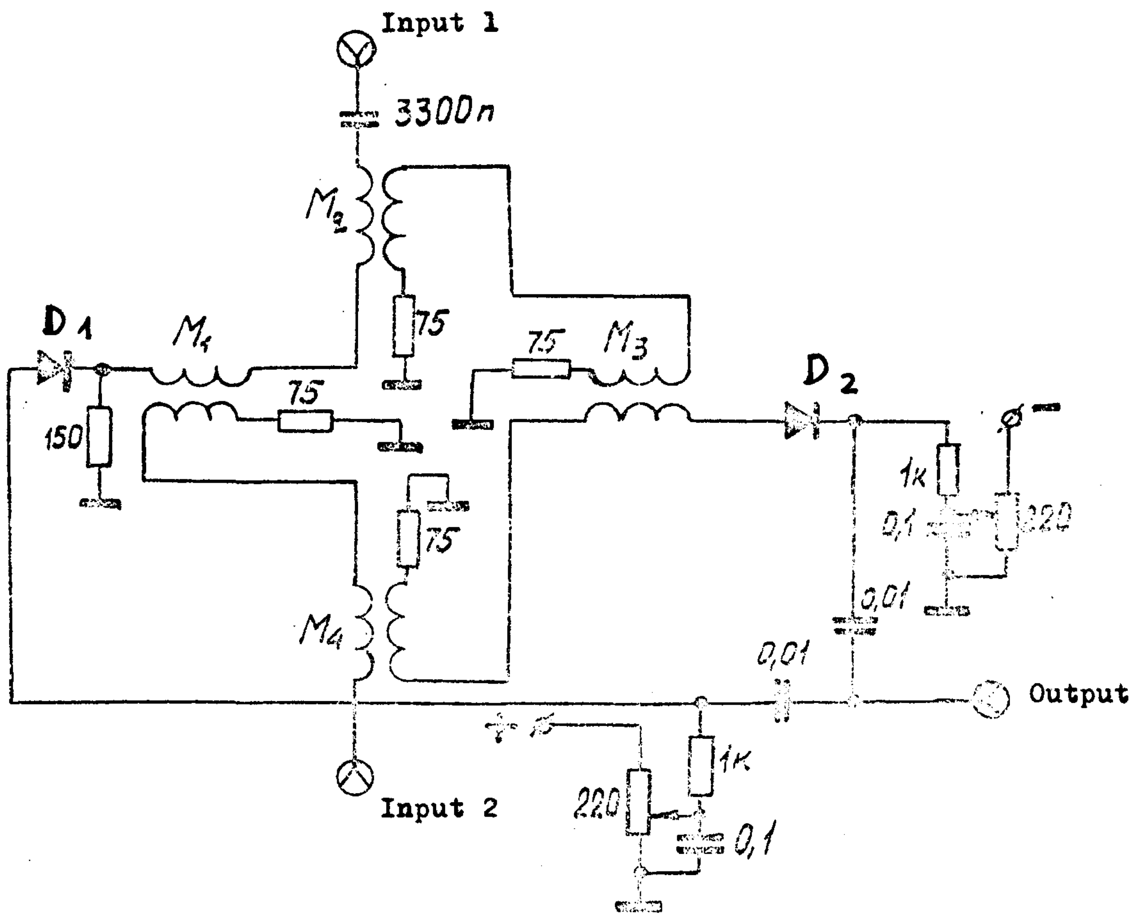

Fig. 2. Mixer circuit for the signals of the first intermediate frequency. $M_1 - M_2$ - directional couplers, $D_1 - D_2$ - D405BBP diodes.

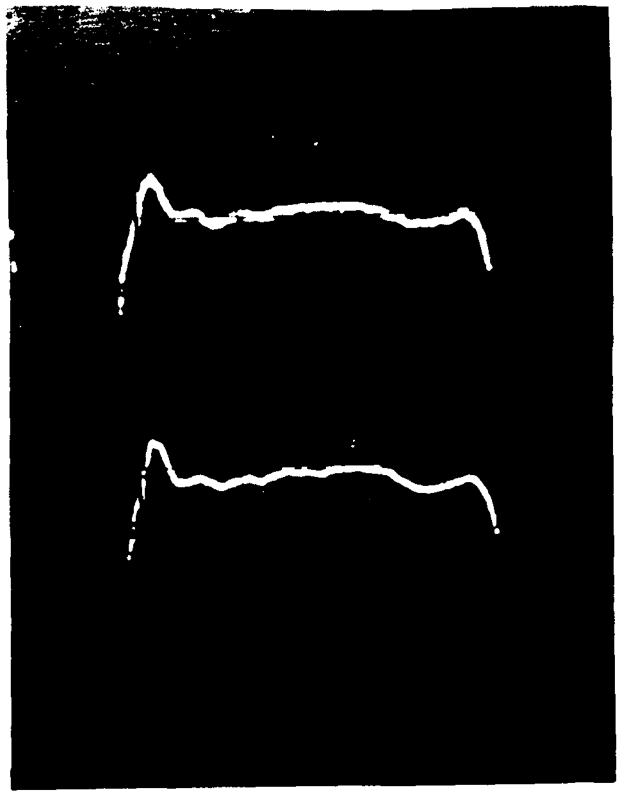

Fig. 3. Oscillogram of internal pulse modulation of a signal in a through-type KIU-12 klystron (2pulses are given from the series during a 5° change in the position of the phase shifter).