MEASUREMENT EQUIPMENT FOR DETERMINATION OF Q AND RESONANCE FREQUENCY OF THE 200 MHz STANDING WAVE CAVITIES

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ABSTRACT

The measurement unit described has been built to determine the Q and f_o values of the standing wave cavities (200 MHz) before shipment from the factory in order to check the required specifications. The principle of operation is to use the cavity as the frequency determining element in an oscillating circuit and to tune this circuit by means of a mechanical phase shifter in such a way that it is very precisely symmetrical about the resonance frequency of the unperturbed cavity for two positions of a phase switch which inserts a known phase shift in the circuit. Afterwards the Q value is found by relating the difference between the two oscillation frequencies and the phase difference for these two symmetric frequencies.

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1. DESCRIPTION

The measurement set-up contains an amplifying branch with a variable phase shifter, a phase switch and a meter for determining the phase and amplitude ratio of the incoming (a) and transmitted (b) waves from the cavity under test, plus a counter to read the oscillation frequency (Fig. 1). Excitation and pick-up from the cavity is obtained by means of two small loops (ca 10 mm diameter) which are to be mounted with proper orientation into coupling holes on the equator of the cavity. The transmission attenuation (cavity, coupling loop 1 to coupling loop 2) amounts to approximately 32 dB. To meet the oscillation condition of the whole circuit with respect to phase, the connecting cable provided should not be changed , extended or modified. With the phase shifter set on mid-range for either position of the phase switch the circuit should oscillate after power on (counter reading ca. 200.5 MHz).

As a first step a tuning procedure (using the phase shifter) has to be performed to make sure that for both positions (1,2) of the phase switch (which inserts a known phase shift $\Delta\phi \simeq 92°$) the corresponding oscillation frequencies are symmetric ($\Delta\omega_+ = \Delta\omega_-$) to ω_o of the cavity

$$\omega_1 = \omega_o + \Delta\omega_+$$

$$\omega_2 = \omega_o - \Delta\omega_- \qquad (1)$$

$$\Delta\omega = \Delta\omega_+ + \Delta\omega_- = \omega_1 - \omega_2$$

This is achieved by mechanically adjusting the phase shift until the amplitude ratios B/A(1) and B/A(2) displayed on the vector voltmeter are equal. The loaded Q of the cavity (Q_L, loading due to coupling loops) results from

$$Q_L = 1/\Delta\omega \ast (\omega_1+\omega_2)/2 \ast \tan(\Delta\phi/2) \qquad (2)$$

using

$$Q_o = Q_\ell(1 + 2\beta)$$

where

$$|\tau| = 2\beta/(1 + 2\beta) = 10^{-1.6}$$

hence

$$2\beta = 0.026$$

$$1/Q_L = 1/Q_o + 1/Q_{ext} \quad (3)$$

and

$$Q_{ext}/Q_o = (1+\rho_{LOOP}(\omega_o))/(1-\rho_{LOOP}(\omega_o)) \text{ (one loop)} \quad (4)$$

one obtains here $Q_o \simeq Q_L \cdot 1.03$ for $\rho_{LOOP} = -0.97$.

2. OPERATING INSTRUCTIONS

1) Install the coupling loops into the small pick-up holes of the 200 MHz standing wave cavity. Make sure that the plane of the loops is perpendicular to Hϕ, i.e. writing "QUARTEX" should be readible from above. Connect the loop to the PICKUP and INJECTION plugs on the front panel of the test set by means of the two special connecting cables.

2) Switch on the main switch for the test set (upper left corner) and check that the counter and vector voltmeters are also switched on. Set counter to "high resolution". Set vector voltmeter amplitude range 0 dB, phase range ± 60 deg., phase offset -100 deg., frequency range 200 MHz and function switch to B. Now the counter should display some frequency around 200 MHz and the vector voltmeter should be locked to this frequency.

3) Toggle the phase switch and by adjusting the phase shifter, tune for equal amplitude for both positions of the phase switch.

4) Read frequencies (f_1, f_2) and phase (ϕ_1, ϕ_2) for both positions of the phase switch.

5) Determine f_o (eq. (1)) and Q_L (eq. (2)); $Q_0 \simeq Q_L.1.03$

6) Accuracy limits :

With $f_o \simeq 200$ MHz and $\Delta f = 4$ kHz an error of ±100 Hz due to the counter resolution leads to ±2.5 % deviation in Q_L. The resolution for f_o is ±50 Hz ($2.5.10^{-7}$ accuracy). The phase accuracy amounts to ± 1.5 % corresponding to roughly ± 1.7 % deviation in Q_L.

7) Troubleshooting :

In case of a malfunction during steps 1-3 disconnect the cavity from the PICKUP and INJECTION plugs and connect the "self test" cable instead. For any position of the phase shifter and the phase switch the vector voltmeter should lock and the counter should display a frequency between 188 and 202 MHz.

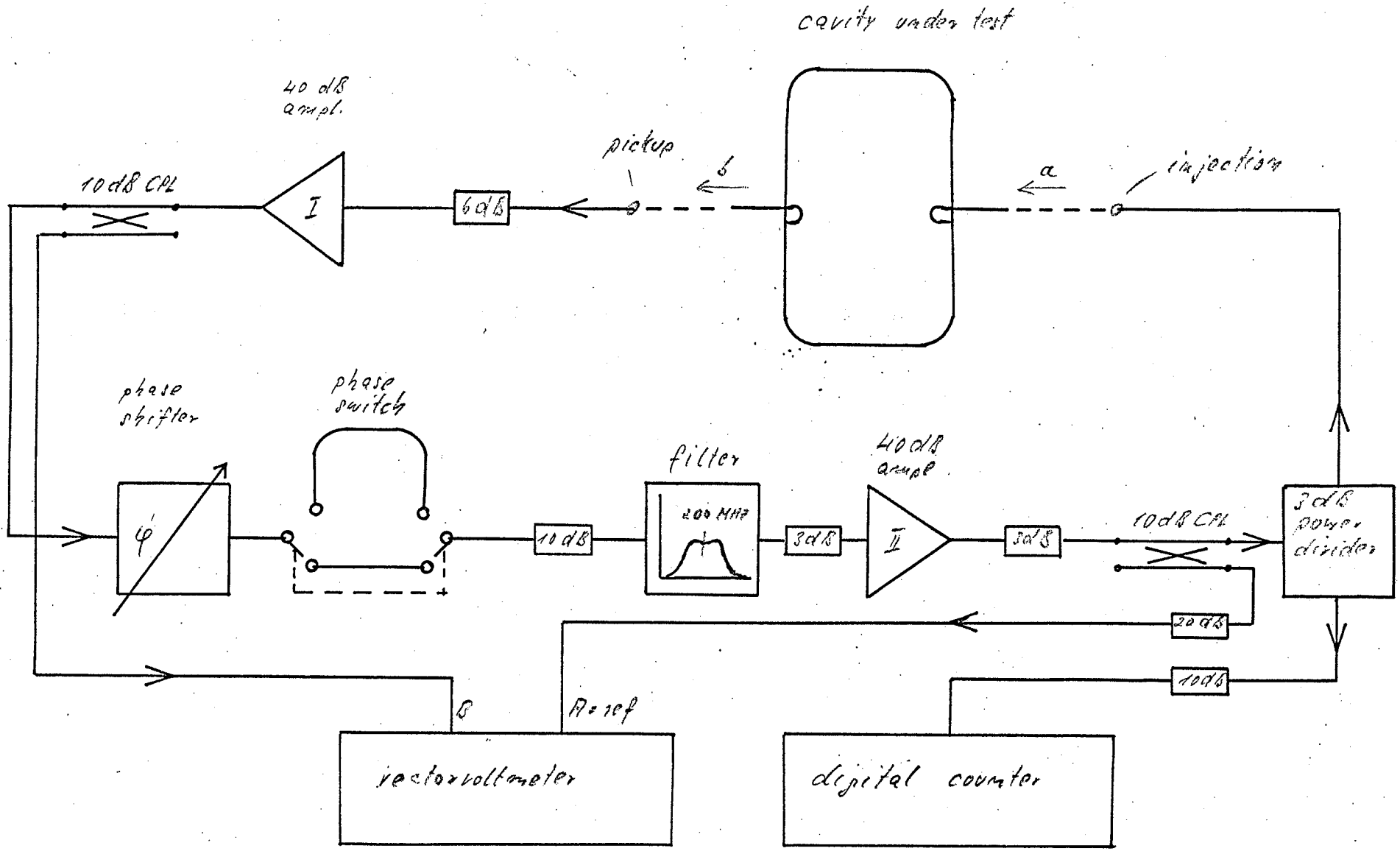

Fig 1. Block diagram for β, Q measurement test set.