Interaction Impedance Measurements in Slow-Wave Structures via Nonresonant Perturbation Method

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Abstract: *In this work it is presented the results of the initial stage in the development of an automated measurement system for the dispersion and the interaction impedance characteristic of a slow-wave structure. The measurement technique is based on the nonresonant perturbation theory.*

Keywords: Microwave devices; slow-wave structures; traveling-wave tube, Interaction impedance measurements.

Introduction

The interaction impedance characteristic of TWT slow-wave structures (SWS) is a critical parameter for its design. An accurate measurement of this parameter is also essential to validate modelling tools that are in vogue nowadays. Especially interested in the measurement of the interaction impedance in TWT slow-wave structures, we present our recent progress in constructing a system for this kind of measurement. Following works [1] and [2] we are developing an automated measurement setup based on the nonresonant perturbation method, which we present here. A mobile carriage system is responsible for the perturbing mechanism and a vector network analyser (VNA) collects and stores the phase data of the transmitted wave which are used in the dispersion and the interaction impedance calculations.

The nonresonant perturbation method

The nonresonant measurement method (NRP) is based on the measurement of the reflected (or transmitted, that is our case) wave phase shift due to the displacement of a little perturber body into the SWS cavity. The background NRP theory [2][3] tell us that this phase shift $d\varphi$ can be associated with the axial phase constant β according to

$$\beta = -\frac{1}{2}\frac{d\varphi}{dz}, \tag{1}$$

from where we may find the phase velocity, using its definition $v_p = (\omega / \beta)$, as

$$v_p = -\frac{2\omega}{(d\varphi / dz)}, \tag{2}$$

$\omega = (2\pi f)$ where f is the microwave frequency.

From the variation of φ with the perturber position z along the axis of the structure, we may find $d\varphi/dz$. At this point we have the dispersion characteristic of the structure. For obtaining the interaction impedance Rao in [2] presented a way for extend expression from the resonant theory to nonresonant using the relation $\Delta\omega = -v_g\Delta\beta$, where v_g is the wave group velocity. We will use our own expression obtaining according to our analytical model related in [4].

The experimental setup

In the figure 1 is shown a (*a*) schematic representation of the measurement setup and (*b*) a 3D model of the mechanical apparatus that is under construction. It consists basically of a helical structure centered by dielectric support rods inside the circular waveguide. The structure will be excited using a rectangular waveguide similar to WR-90, however with a taper region with the goal of improving the structure coupling. A mobile carriage system driven by a stepper motor controlled by a PC is the responsible for the displacement of the SWS along a thin nylon wire which the perturber body is hold on. Computing the phase information of the transmitted signal for each z position of the perturber, we can obtain the dispersion relation using (1) and (2). To obtain a measure of the interaction impedance we perform the same procedure, however with a new pertubation that is a thin dielectric glass rod placed in the axis of the structure. With this new perturbation the measure of the phase information for each z position yields a new β' propagation constant that give us the quantity $\Delta\beta$ necessary to solve the interaction impedance K expression. A first order expression for the interaction impedance given by Rao in [2] is

$$\mathrm{K} = \frac{2}{(\beta')^2 \pi\varepsilon_0(\varepsilon_r - 1)r_p^2}\frac{\Delta\beta}{\omega}. \tag{3}$$

where r_p is the perturber rod radius and ε_r is its electric permittivity. The procedure of collecting the phase data from the VNA will be turn automatic by a computer code developed to control the measurement process.

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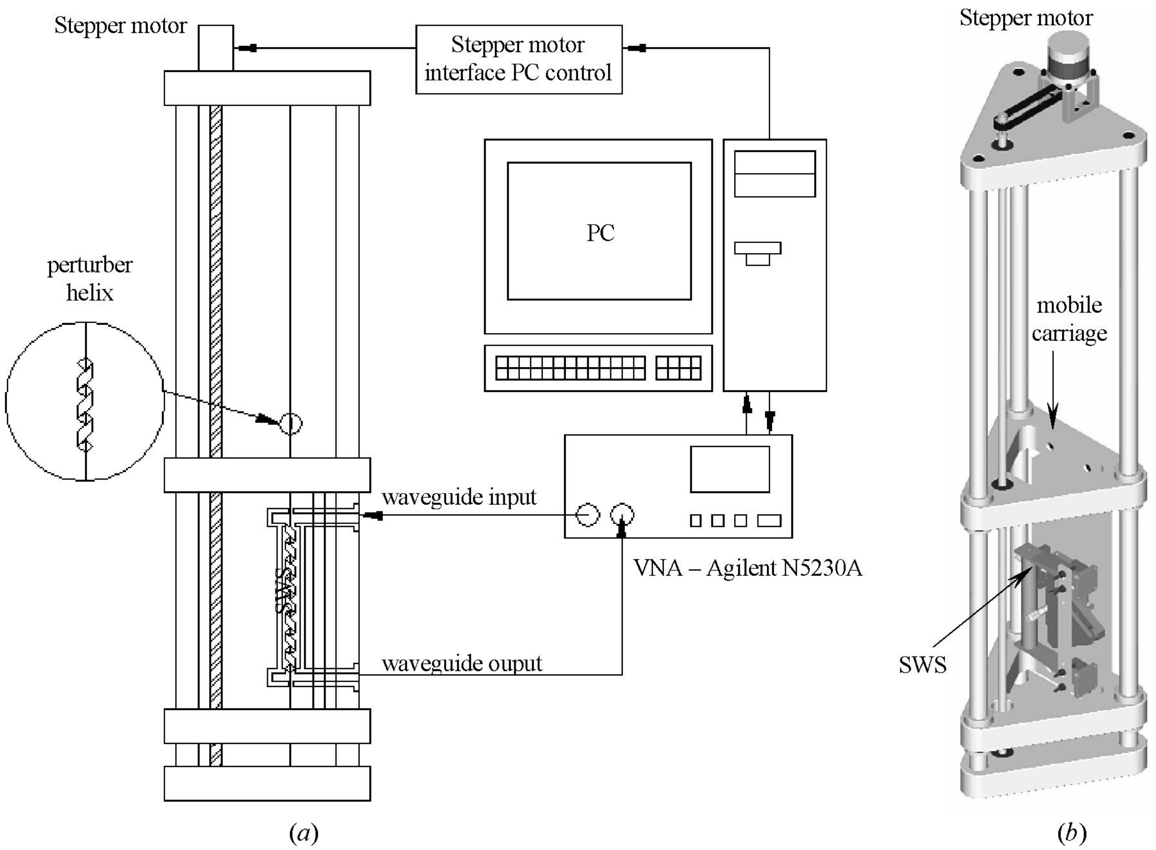

Figure 1. (*a*) Schematic illustration of the complete measurement system, (*b*) Measurement setup 3D view.

References

[1] S. M. Hanna, G. B. Bowden, H. A. Hoag, R. Loewen, A. E. Vlieks, J. W. Wang, "A semi-automated system for the characterization of NLC accelerating structures", Stanford Linear Accelerator Center, Stanford University, Stanford, CA 94309, USA.

[2] S. J. Rao, S. Ghosh, P. K. Jain, and B. N. Basu, "Nonresonant perturbation measurement on dispersion and interaction impedance characteristics of helical slow-wave structures," *IEEE Trans. Microwave Theory Tech*, vol. MTT-45, pp. 1585-1168, Sep. 1997.

[3] C. W. Steele, "A nonresonant perturbation theory," *IEEE Trans. Microwave Theory Tech*, vol. MTT-14, pp. 70-74, 1966.

[4] D. T. Lopes and C. C. Motta, "Theoretical loss determination of a TWT slow-wave structure using the sensiper's tape-helix model," *Proc. IVEC2005, WPP-246, pp 371-374, Apr* 2005.