

Evaluation of Material Characterization Systems that Utilize a Two-Wire Transmission Line

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Engineers in many disciplines use the electromagnetic properties of materials to evaluate and predict the performance of systems. Microwave engineers use these properties in the design of high frequency devices. Civil, mechanical, and biomedical engineers use the properties, either directly or indirectly, as indicators of the performance of structures and mechanical systems, e.g, in the evaluation of water-to-cement ratio (Mubarak, K. et al., Instrumentation and Measurement, IEEE Trans, v50, no.5, pp.1255—1263, Oct. 2001).

A two-wire transmission line system for material characterization has been previously introduced by the authors (Temme, et al., 2014 North American Radio Science Meeting, Memphis, TN). This paper presents a continuation of that work. Examined in this paper are various system configurations, analysis of various applications, and theoretical limits of a two-wire transmission system.

Being an unshielded transmission structure, the fields of a two-wire transmission line extend into the surrounding environment, and under some circumstances, may radiate into the environment. The transmission line may be configured to either increase or decrease the radiation and field interaction by adjusting the termination of the transmission line. This paper examines the effects of various terminations (short, open, matched, $Z_0/2$, etc.) on the fields of the system.

The field structure of the system determines the extent to which the transmission line can interact with the surrounding environment. This paper considers the setup of a two-wire transmission line for monitoring material samples in various practical scenarios such as liquid monitoring in a pipe, gel evaluation in a vat, or plasma diagnostics in a chamber. For such scenarios, this paper evaluates system design and considerations such as wire spacing, sample size, and mounting options. Effects of the sample container on the two-wire transmission line are considered and evaluated.