Measurement and Characterization of Precision 7 mm and 3.5 mm Coaxial Air Lines at NMC, A*STAR

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***Abstract* — This paper presents works on measurement and characterization of coaxial air dielectric transmission lines (air lines) at the National Metrology Centre (NMC) of the Agency for Science, Technology and Research (A*STAR) of Singapore. The air line is one of the realizable and calculable impedance standards directly traceable to the national standard of length. Diameters of two beadless air lines of 7 mm and 3.5 mm connectors are measured by using an automated air-gauging system established recently and their characteristic impedances are calculated from measured diameters.**

***Index Terms* — Precision coaxial air lines; characteristic impedance; impedance standards; measurement techniques**

I. Introduction

Precision coaxial air dielectric transmission lines (air lines) have been used as one of the realizable and calculable primary impedance standards, which can be directly traceable to the national length standard in RF, microwave, and millimeter-wave frequencies [1-2]. Characteristic impedance (Z_0) of coaxial air lines can be expressed with its own dimensional information [3] as described in Eq. (1):

$$Z_0 = \frac{1}{2\pi}\sqrt{\frac{\mu}{\varepsilon}}\ln\frac{b}{a}, \qquad (1)$$

where a is the outer diameter of the center conductor (ODCC) of a coaxial air line; b is the inner diameter of the outer conductor (IDOC) of the line; ε and μ are the permittivity and permeability of the air dielectric between the two conductors, respectively. Precise diameter measurements of air lines are required for establishment of national impedance standards for coaxial devices.

Recently, NMC has established an automated air-gauging system for measuring both the diameters of the outer and center conductors of air lines with the design and fabrication from the Korea Research Institute of Standards and Science (KRISS). This air-gauging technique makes the diameter measurements with a fast speed due to its physically non-contact measurement scheme. A preliminary comparison between NMC and KRISS has been carried out to validate the equivalence between their air-gauging systems and to demonstrate their measurement capabilities with three beadless Type-N air lines of different lengths in [4].

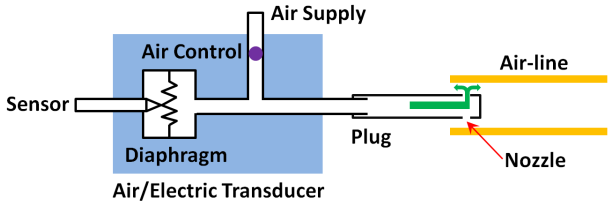
It is necessary to perform dimensional measurements of air lines of other line sizes. In this paper, performance evaluation for coaxial air lines of 7 mm and 3.5 mm connectors as in Table 1 will be reported by using the established air-gauging system.

Table 1. Air lines under evaluations.

Line size	7 mm	3.5 mm
Nominal length	100 mm	75 mm
Model number	2653S10	8043S7.5
Serial number	C187	B698

II. Air-Gauging Technique and Measurement System

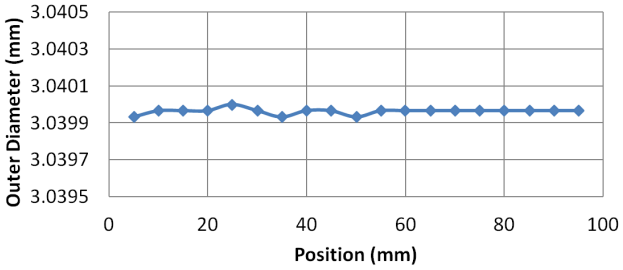
In air-gauging the diameters of a coaxial air line, a (ODCC) and b (IDOC) are determined by measuring the small variations in air pressure when a plug gauge moves inside the bore of an outer conductor or a ring gauge moves over the outside of a center conductor, respectively. Fig. 1(a) shows its basic principle with a plug gauge.



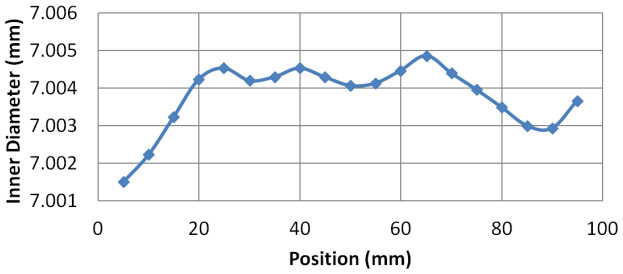
(a) Air-gauging measuring principle

(b) Measurement system

Fig. 1. Automated air-gauging measurement system at NMC.

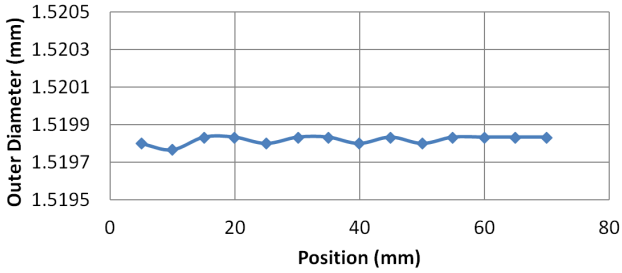


(a) Outer diameter of the center conductor

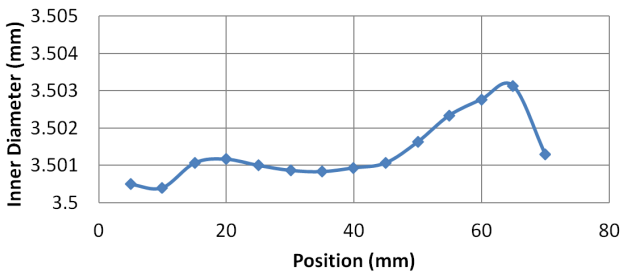


(b) Inner diameter of the outer conductor

Fig. 2. Averaged diameters for a 7 mm air line.



(a) Outer diameter of the center conductor



(b) Inner diameter of the outer conductor

Fig. 3. Averaged diameters for a 3.5 mm air line.

KRISS has developed an air-floating system for self-centering the plug and ring gauges in practical measurements. This is to make the centers of the moving air-gauging probes (i.e., plug and ring gauges) concentric with that of conductors of air line under evaluations. NMC has established such an air-gauging system recently with KRISS fabrication, as shown in Fig. 1(b). This measurement system is capable of axially and angularly air-gauging coaxial air lines. In the work, its performance for coaxial air lines of 7 mm and 3.5 mm connectors will be evaluated.

III. Performance Evaluations

A. Measurement Settings

As reported in [2], the diameters near both the ends of an air line are significantly different with respect to its nominal values. Therefore in this study, we ignored a section of approximately 5 mm from both the ends of air lines. The axial diameters of two air lines were measured at three angles (0^o, 120^o, 240^o) with a 5 mm step.

B. Results and Analysis

Fig. 2 and Fig. 3 show the measured diameters of 7 mm and 3.5 mm air lines respectively. The results indicate that there is larger variation along the axial direction for inner diameter of the outer conductor for both the air lines as comparing to their outer diameter of the center conductor. Similar observations can be found in [4].

The characteristic impedance Z_0 is then calculated using (1) for both air lines and is shown in Fig. 4. From Fig. 4, it can be found that the calculated impedance Z_0 from the measured diameters is very close to the theoretical value of 50 Ω.

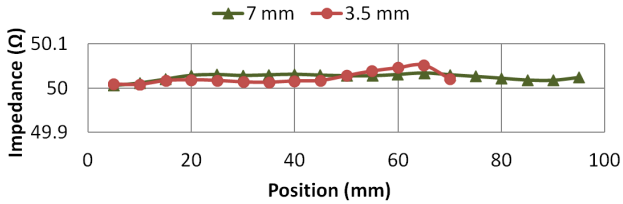


Fig. 4. Calculated impedances for 7 mm and 3.5 mm air lines.

IV. Summary

This paper reports diameter measurements of coaxial air lines of 7 mm and 3.5 mm connectors. The measured results were preliminarily analyzed. Detailed uncertainty evaluations and comparison will be discussed in the near future.

References

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