A Radiation Measurement System by Using Optical Feeding

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1. Introduction

Recently, as wireless mobile devices become smaller and smaller, antennas used in the devices are required to be very compact. It becomes even more important to measure precisely such compact antennas for antenna development. However, an antenna must be fed when the antenna is to be measured and the feeding is generally made electrically by microstrip lines, coaxial cables, etc. Electrical feeding lines disturb the radiation pattern of the antenna due to their metallic bodies. In addition, there causes unbalanced currents on the feeding lines to excite unwanted radiation which interferes the original one. The influence becomes significant when the antenna under test is small. As a consequence, ripples or unwanted peaks appear in the radiation patterns of the antenna.

Using smaller feeding lines, setting a balun by ferrite chokes, cylindrical conductive caps on coaxial cables [1]-[2], or replacing the electrical feeding by optical feeding [3]-[4] are main solutions for suppressing the influence. However, a conventional balun is only available at narrow and low frequency band. The optical feedings proposed in [3]-[4] used expensive laser diodes and only results measured at frequencies lower than 2 GHz were presented.

In this paper, we propose a compact measurement system for radiation patterns by using optical feeding. We use direct modulation on a vertical surface emitting laser (VCSEL) and a graded-index (GI) optical fiber as transmission line so as we can realize a cost-effective system and extend the measuring frequency range up to 6 GHz easily. To show the validity of the system, a small antenna operating at ultra-wideband (UWB) is measured by the system. We investigate the influence of the feeding line by changing its wiring. Results are compared with those measured by an electrical feeding and it is demonstrated that our system can be used for precise measurement of small antennas.

2. Measurement Setup

The proposed measurement setup is schematically shown in Fig. 1. It replaces conventional electrical feeding line by E/O and O/E converters with a GI-fiber. The E/O converter is composed of a VCSEL which is directly modulated by RF source. The O/E converter is composed of a photodiode (PD) and an amplifier which amplifies the demodulated RF signal. The O/E converter which includes a tiny RF connector has a compact dimension of $10\times15\times5$ mm^3. A micro coaxial cable with a diameter of 0.8 mm is used to connect the O/E converter and the antenna under test. The length as well as the wiring of the cable can be arranged so that the influence on measured radiation patterns is minimized.

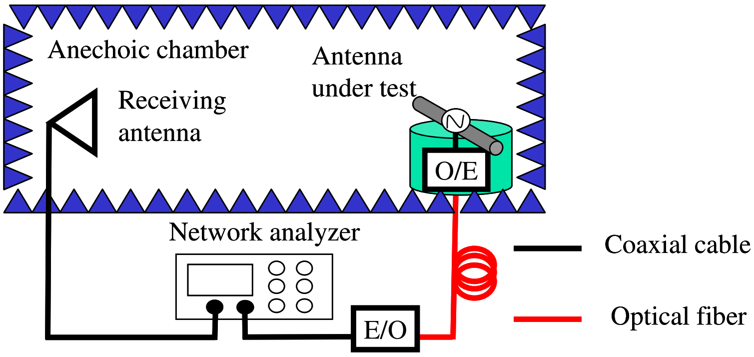

Figure 1: Measurement setup of optical feeding.

3. Experimental Results

In order to verify the validity of the optical measurement system, an UWB antenna shown in Fig. 2 is measured. The antenna is rolled from a flat film one so as it has omni-radiation patterns in its azimuth plane even at high frequencies [5]. A micro coaxial cable with a length of 200 mm is used to connect the antenna to the O/E converter. This long cable is used because we can separate the O/E converter from the antenna and try to investigate the influence of the cable by changing its wiring, as shown in Fig. 3. The antenna is also measured by electrical feeding, where the cable is electrically fed.

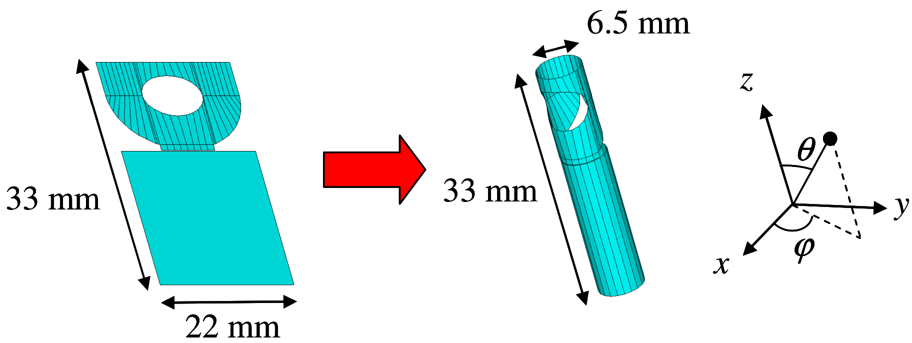

Figure 2: Rolled UWB antenna for measuring.

Figure 4 shows measured radiation patterns for the antenna at 5 GHz in *xy*-plane with two wirings shown in Fig. 3, for the optical and electrical feedings. In Wiring A where the cable is parallel to the axis of the antenna, the difference between the optical and electrical feedings in the radiation patterns is small. However, the difference becomes significant for Wiring B where a part of the cable is perpendicular to the axis of the antenna. The level of E_φ becomes comparable to that of E_θ in the electrical feeding but keeps relatively low in the optical feeding. It can be explained that while unbalanced current in the cable is large in the electrical feeding and thus influences the radiation pattern but the current is effectively suppressed in the optical feeding.

Figure 5 shows the radiation patterns for total field at 3 GHz for both the optical and electrical feedings where Wiring A is applied. A calculated radiation patterns are also shown in Fig. 5. When calculating the radiation patterns, the antenna and the micro coaxial cable are modelled. The radiation patterns obtained by the optical feeding are better fit to the calculated ones. Null points and distortion can be recognized clearly and ripples appearing in the patterns obtained by the electrical feeding are almost suppressed for the optical feeding.

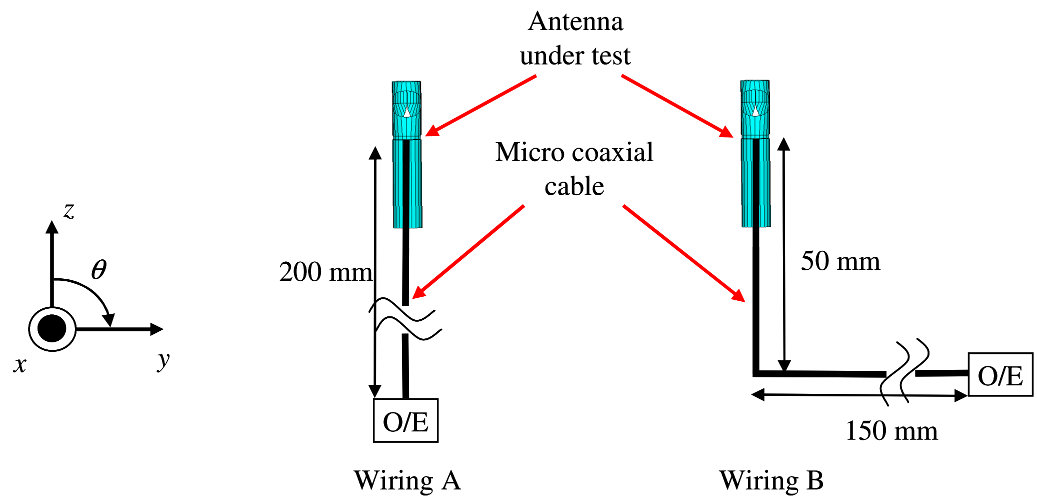

Figure 3: Antennas for optical and electrical feedings with different wirings of micro coaxial cable.

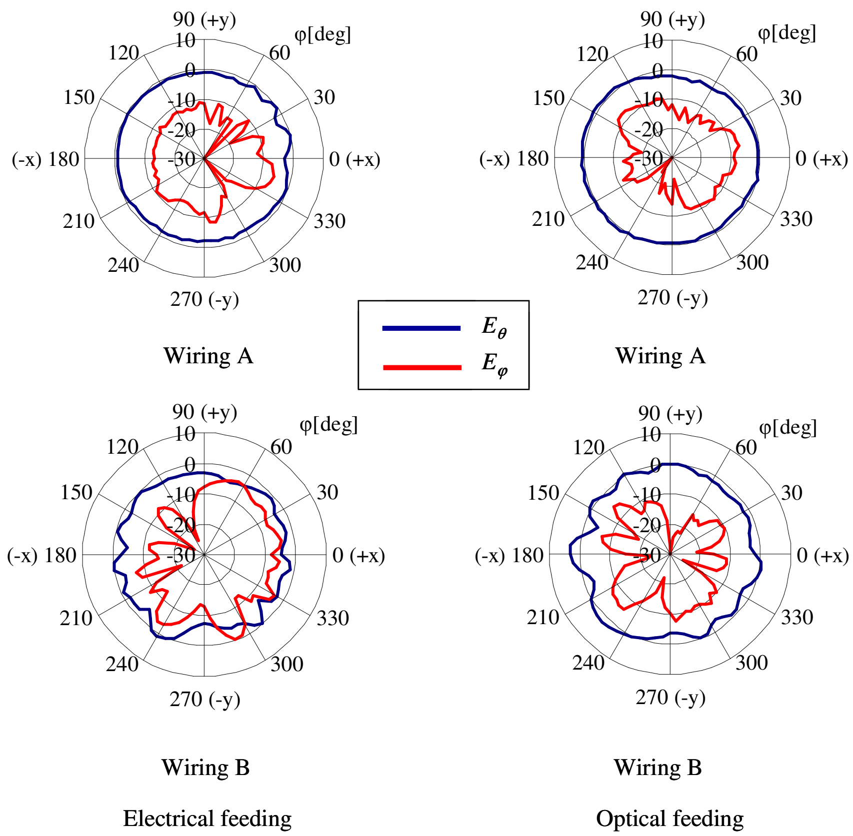

Figure 4: Measured radiation patterns in *xy*-plane at 5 GHz for optical and electrical feedings.

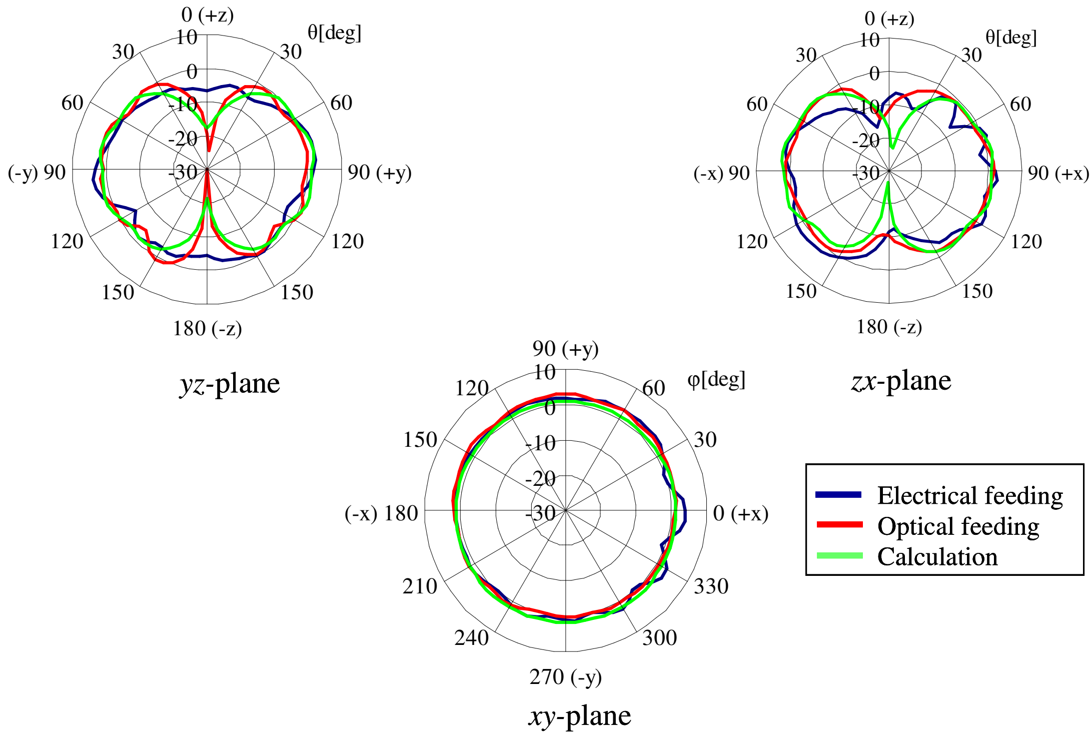

Figure 5: Measured and calculated radiation patterns for total field at 3 GHz.

4. Conclusion

We have developed a cost-effective radiation measurement system by using optical feeding. The system is composed of a VCSEL, a PD and a GI-fiber and provides measurement up to 6 GHz. It has a compact O/E converter which is connected to the antenna under test by a micro coaxial cable. It is experimentally demonstrated that the system successfully suppresses the unbalanced currents on the feeding line and the system can be used for precise measurement of radiation patterns. We will update the system to extend the measuring frequencies up to 10 GHz.

References

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