THE MEASUREMENT RESULT OF E-FIELD DISTRIBUTION IN A TEM CELL USING OPTICAL E-FIELD SENSOR

Shinsuke Enomoto, Shigenori Torihata, Jun Ichijoh, Ryuji Osawa
NEC TOKIN Corporation, Broadband Devices Division, Optical Devices Group
E-mail: torihata@nec-tokin.com

Abstract: NEC-TOKIN developed an E-field measurement sensing system, using new principles. The sensor head of this system consists of $LiNbO_3$ crystal and optical fibre. No metal parts are used except for the antenna elements.
Because of this structure, this sensor has some benefit to measure the E-field in confined area.
The feature of this system is minimal disturbance of the surrounding E-field.
Key words: $LiNbO_3$ crystal, E-field sensor, TEM CELL, optical modulator

1. Introduction

The optical modulator made of $LiNbO_3$ crystal has been in use for optical telecommunications for higher rate modulation up to 40GHz. And some research has been done for E-field measurement. [1]
NEC-TOKIN have started the development applying LiNbO3 optical modulator to E-field measurement in 1990. Features of this sensor are shown below:

(1) This sensor needs no coaxial metallic cables for transmitting signals.
 -Minimal disturbance of or to the surrounding E-field.
 -Minimal signal attenuation and frequency deviation compared with the use of coaxial cable.
(2) The sensor head has no metal parts except for antenna elements.
 -Minimal disturbance of or to the surrounding E-field.
 -We can achieve precise isotropy because of precise directivity.
(3) This sensor head consists of only passive devices, and it needs no power supply.
 -Sensor head size is very small.

Because of this feature, We think that it may be useful for measuring E-field distribution in TEM CELL. We report the measured result of E-field distribution in TEM CELL with optical E-field sensor.

2. Sensor structure and performance

2.1 Structure of the optical E-field sensor head

The outline structure of sensor head is shown in figure 1. This figure explains the principle of the sensor of 1axis. This sensor head is composed of $LiNbO_3$ crystal, metal electrode for antenna and optical fibre with glass ferrule. The optical wave-guide is shaped on the $LiNbO_3$ crystal with Titanium thermal diffusion process. The layout of this wave-guide is called Mach-Zehnder interferometer. The $LiNbO_3$ crystal exhibits the Pockels effect. If an E-field is applied to this crystal, its refractive index is modulated. This modulation caused the speed of optical wave on the wave-guide to go faster or slower. The Mach-Zehnder interferometer converts this optical wave speed modulation to amplitude modulation. Because of this effect, we can observe the E-field signal as an optical amplitude modulation. To minimize the sensor head dimensions, we use the reflective type optical modulator structure. A non-modulated laser optical wave is guided from optical fibre to optical modulator, and this optical wave is modulated with E-field, then the modulated optical wave is reflected at the mirror, and returns via the same optical fibre to the detector unit.

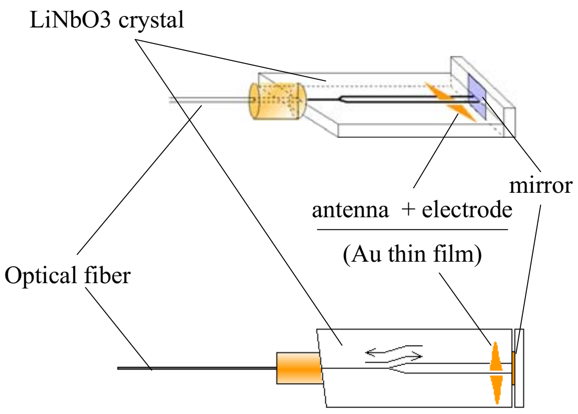

Figure1. structure of E-filed sensor head

2.2 Photograph of sensor head

Figure 2 shows the photograph of optical E-field sensor. Sensor chip length is 13mm. Width is 3mm. And the antenna element length are 1mm x 2.

2.3 system diagram of optical E-field sensor

Figure 3 shows the system diagram of optical E-field sensor system.

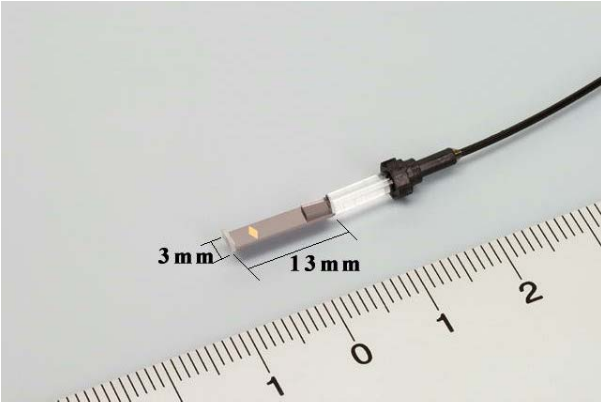

Figure 2. Photograph of optical E-field sensor head

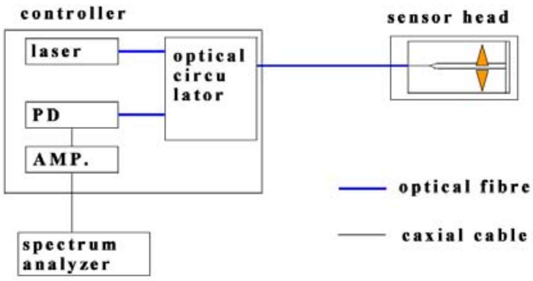

Figure 3. system diagram of optical E-field sensor

The non-modulated optical wave is generated by two laser diodes, combined to give the required power. A dual polarized optical wave is output by the optical combiner.
The optical wave is transmitted to the sensor head through a single mode optical fibre. The LiNbO3 sensor head is optical polarization sensitive, but a orthogonally polarized optical wave can supply the same optical power to the sensor head in any case of polarization rotation in the single mode fibre.
sensor head is optical polarization sensitive, but a orthogonally polarized optical wave can supply the same optical power to the sensor head in any case of polarization rotation in the single mode fibre.

3. Specifications of optical E-field sensor

3.1 Frequency response

A typical frequency response of the optical E-field sensor from 30MHz to 1GHz is shown in Figure 4. Because of the miniature size of the dipole antenna, the frequency response is very flat, within +/- 3dB from 40MHz to 1GHz. The lower sensitivity under 40MHz is caused by the frequency response of RF amplifier.

3.2 Directivity

A typical directivity of the optical E-field sensor at 300MHz is shown in Figure 5. It shows the three rotation axis of directivity of the optical E-field sensor. And figure 6 shows the rotation axis.

4. Measurement result in TEM CELL

4.1 Measurement setup

We have measured the E-field distribution with the measurement setup shown in figure 7.
We used spectrum analyzer to measure the E-field amplitude. The chamber size and scan direction of optical E-field sensor is shown in figure 8.
The chamber of TEM CELL is 30cm x 60cm x 60cm.

4.2 Measurement result

The measurement result is shown in figure 9.
On the condition of lower frequency such as 100MHz and center position in the TEM CELL, ration of Vertical and Horizontal is good enough more than 10dB. But at higher frequency such as 1GHz and wall side position in the TEM CELL, the Horizontal E-field amplitude is larger than that of Vertical.

5. Conclusion

We have measured the E-field distribution in TEM CELL with optical E-field sensor. With this measurement, we have verified that the optical E-field sensor is useful for measuring E-field in confined area.
And we have measured that TEM CELL has polarization change on the condition of higher frequency and near the wall side.
Next we will measure a GTEM CELL in near feature.

Acknowledgements

The following researchers are acknowledged for their contribution of the National Physical Laboratory, Teddington, UK.

References

[1] Kuwabara, N, Tajima, K, Kobayashi, R, Amemiya, F, 1992, "Development and analysis of electric field sensor using $LiNbO_3$ optical modulator.", *IEEE Trans. on EMC*, **34**, pp. 391 - 396.

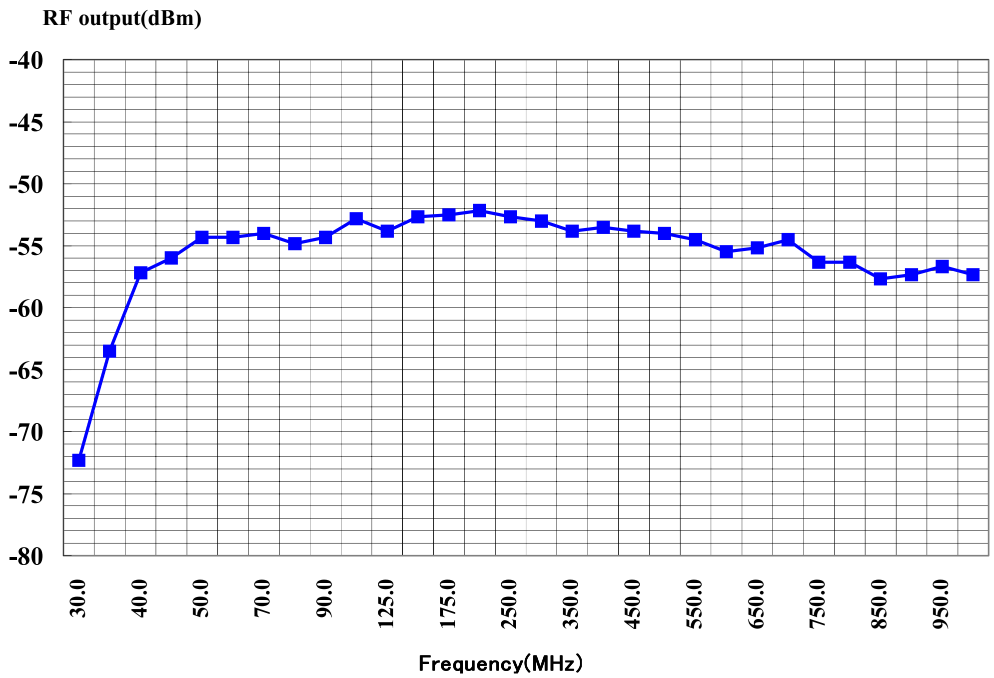

Figure 4. Frequency response.

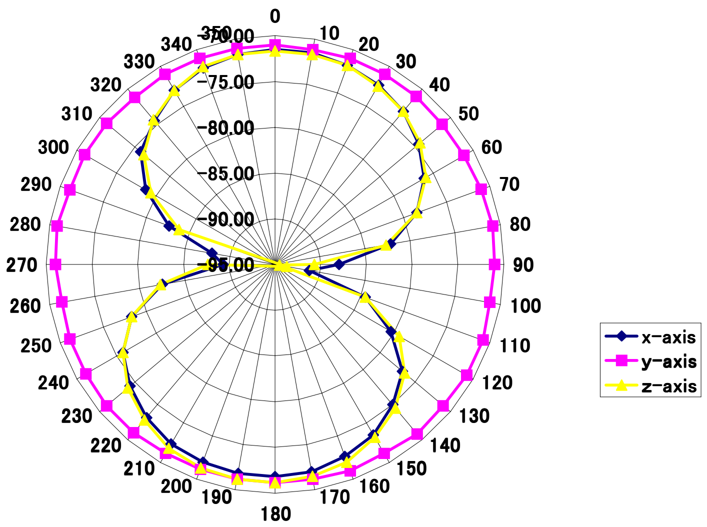

Figure 5. Directivity

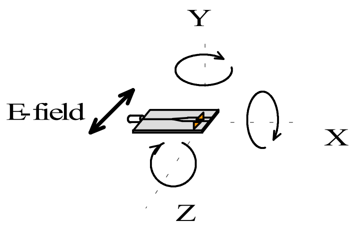

Figure 6. Rotation axis

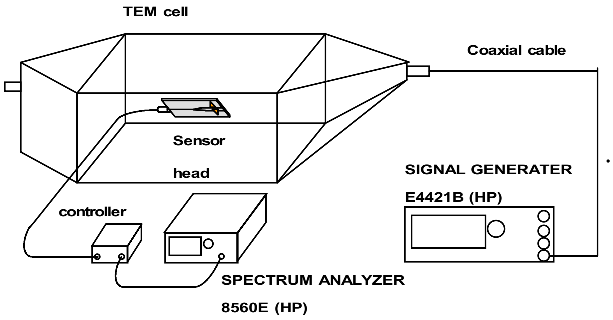

Figure 7. Measurement setup

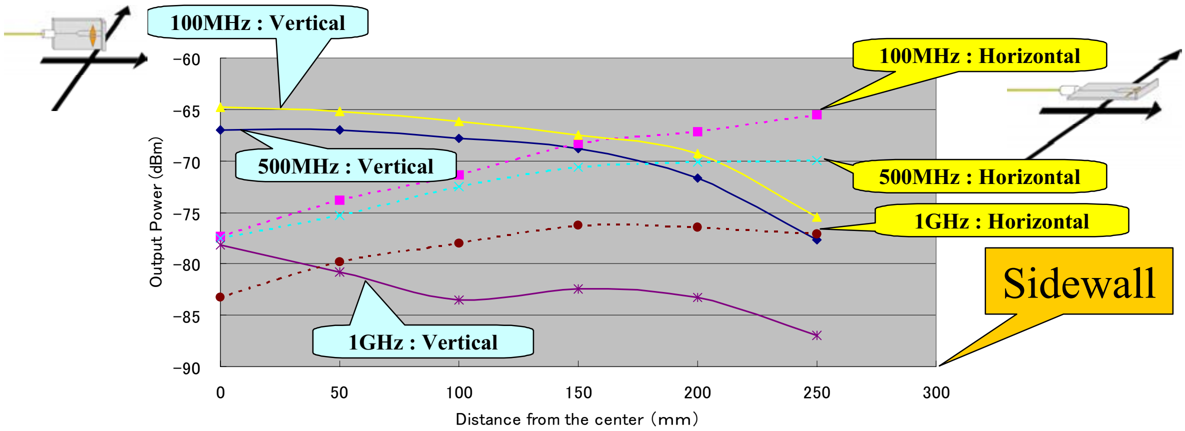

Figure 9. Measurement result of E-field distribution in TEM CELL

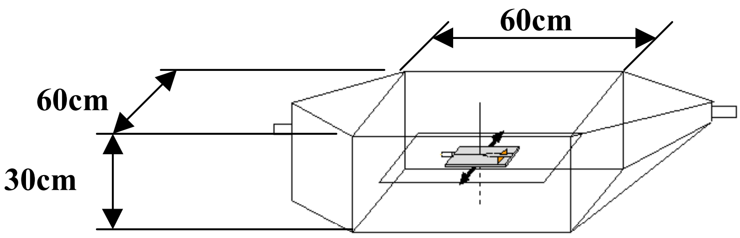

Figure 8. The size of chamber and scan direction