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Optical E-field Sensor for E-field Measurement System

Yoshikazu TOBA †

† SEIKOH GIKEN Co.,Ltd. 415-2 Matsuhidai, Matsudo-shi, Chiba, 270-2214 Japan

E-mail: † yoshikazu.toba@seikoh-giken.co.jp

Abstract We have developed the Optical Electric Field Sensor utilizing the Pockels effect of lithium niobate ($LiNbO_3$), and proposed it for EMC measurement system.

This sensor can measure not only E-field strength but also frequency and phase. The feature of this sensor are: mitigating disturbance of the surrounding E-field, high-accuracy, elimination of common noise, small sensor head, measurement ability of any kinds of modulations such as AM, FM, CDMA and so on and wide frequency range such as 100kHz to 10GHz.

In this report, we introduce system configuration and product lineup of the optical E-field sensors. And we describe the efforts of some of the future.

Keywords Lithium niobate, Pockels effect, Isotropy, E-field sensor, Optical fiber link, EMC

1. Introduction

In recent years, the damage to other electronic devices by electromagnetic radiation has becomes a problem depending on spread to wireless devices. Therefore, Measurement technique which can accurately measure the electromagnetic wave is required.

We have developed Optical E-field Sensor and measurement technology using RoF (Radio over Fiber) technology. And we have introduced them for EMC (electro-magnetic compatibility) field [1]-[3].

Features of this sensor utilizing Pockels effect of lithium niobate are shown below:

a. Passive acquisition of signals, mitigating disturbances of the surrounding E-field.
b. Precise measurements of Frequency, Phase, and E-field.
c. High sensitivity and linear response over a broad frequency range.
d. Miniaturized sensor heads
e. Elimination of common noise

In the measurement of the Free-space E-field strength, the conventional method of using antenna had been degraded accuracy of E-field measurement by feed line (coaxial cable). Namely, the coaxial cable induce disturbance of the surrounding E-field. This Optical E-field Sensor with above features can be expected accuracy of E-field measurement improvement.

The radio waves are shortened by the high frequency of wireless device, so the sensor is required to minute spatial resolution.

The conventional method could not increase the resolution of the measurement. Optical E-field Sensor is formed antenna elements on the LN substrate, so sensor head can be reduced the dimension.

In this report, we introduce system configuration and product lineup of the optical E-field sensor. And we describe the efforts of some of the future.

References

[1] S.Torihata, et al, “A high accuracy Optical Electric Field Sensor for an EMC application” IEEJ Technical report, IM-00-54~58, pp.25-29, 2000.

[2] Y.Toba, et al, “Development of micro isotropy optical electric field sensor”, IEICE(C), Vol.J91-C, No.1, pp.84-92, 2008.

[3] S.Kurokawa,et al, “Optical Fiber Link for Antenna Measurement System”, IEICE(C), Vol.J91-C, no.1, p.64-74, 2008.

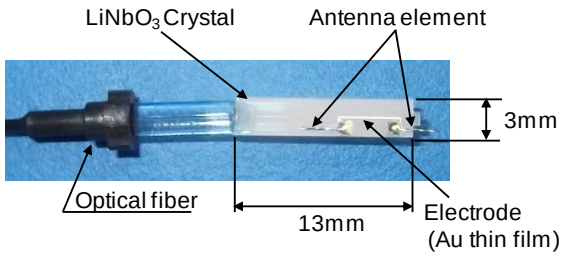

Fig.1 External view of sensor head

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Yoshikazu Toba

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Features of Optical E-field Sensor Using LN Optical Modulator

1. **No disturbance** of E-field from coaxial cable
2. **No power supply** for sensor head
   -miniaturized sensor head
   -mitigating disturbance of the surrounding E-field
3. **Precise measurements** of Frequency, Phase, and E-field

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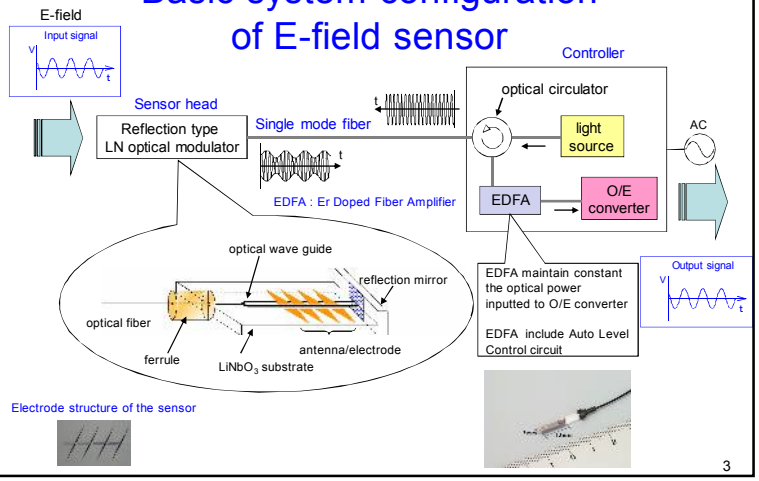
Basic system configuration of E-field sensor



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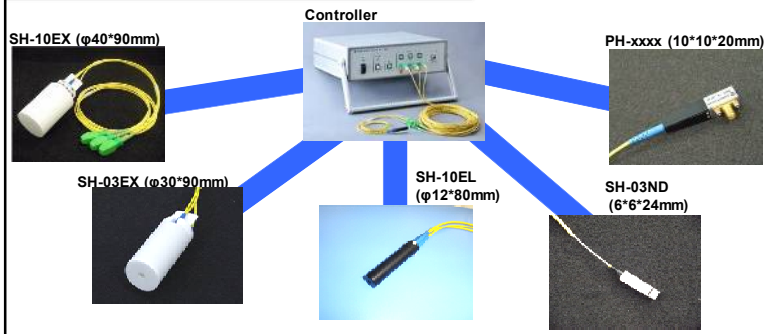
Products of optical E-field sensor



Type	Feature
SH-10EX	Standard
SH-03EX	High sensitivity
SH-10EL	Small & High strength

Type	Feature
SH-03ND	Ultra-small
PH-xxxx	SMA Connector type
C3-xxxx	Controller

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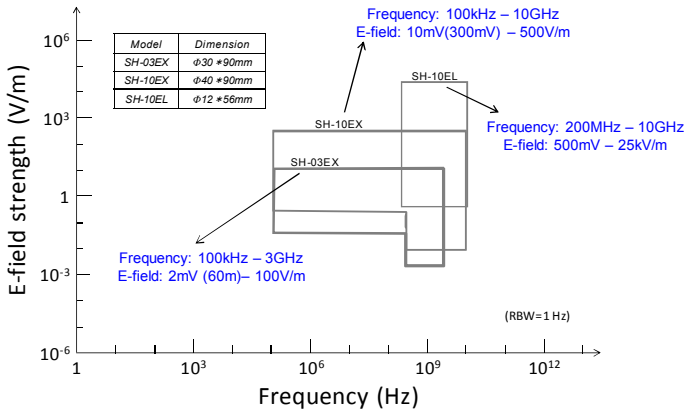
Dynamic range of the isotropic optical E-field sensors



Note) The measurement max E-field strength of SH-10EL is confirmed only 2.4GHz.

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Optical fiber link for EMC

～Insulation of the feeder line～

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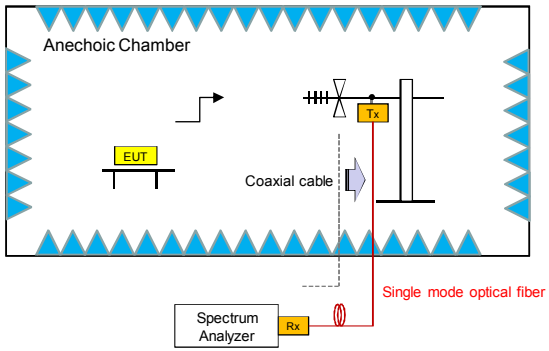
Application of optical fiber link



【feature】
- Compact design
- Battery drive (9hour, 3 AA battery)
- Low transmission loss (0.5dB/km typ.)
- Precise measurements of frequency, phase, and E-field

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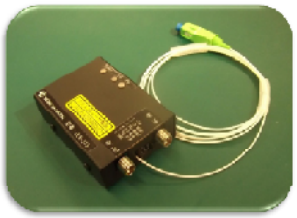
Photographs of the appearance

1way type

93*51*45mm

2way type



44*62*17mm

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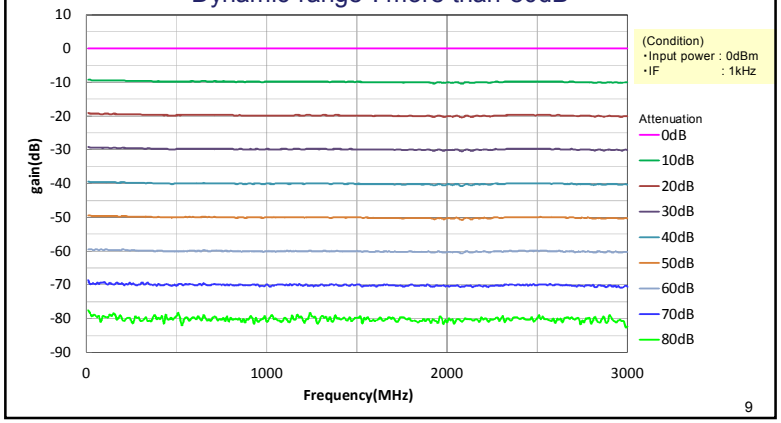
Linearity

(one way type Tx/Rx)

Dynamic range : more than 80dB



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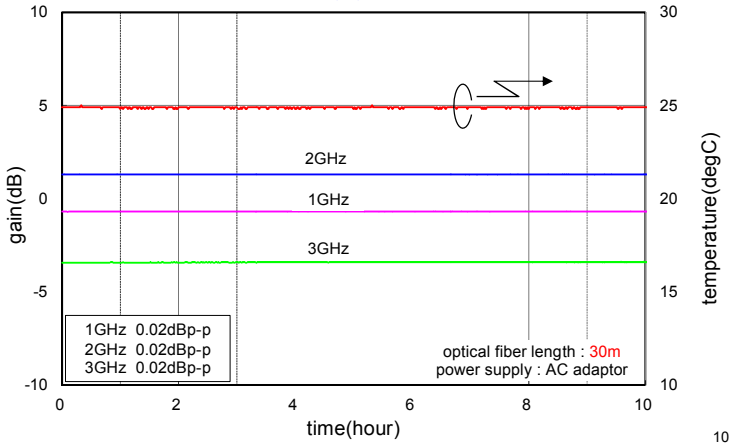
Stability(gain)

(one way type Tx/Rx)



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Products of Optical Fiber Link

Parameter	Low-frequency type (underdevelopment)	3GHz type	6GHz type
Modulation Bandwidth	10kHz～40MHz	40～3,000MHz	40～6,000MHz
RF Return Loss	8dBmin		
1dB Comp. Level	0dB typ.		-10dB typ.
Input Damage Level	20dBmin		
RF Link Gain	0dBtyp.		+10dBtyp.
Noise Figure	26dB typ.		17dB typ.
I/O RF connector	N-P 50ohm		
I/O Optical connector	SC/PC		
Operating Temperature	0-40℃		
Battery Drive Time	9hour(AA battery×3)		7hour(AA battery×3)
Fiber used	SMF/1port		

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Conclusion

Optical probe and optical E-field sensor using Pockel's effect

- Miniaturized sensor heads
- Broadband / wide dynamic range
- Precise measurements of frequency, phase, and E-field
- Passive acquisition of signals, mitigating disturbances of the surrounding E-field

-By improving the stability of the optical E-field sensor, we are trying to establish of the E-field measurement technology.
-By proposing the optical fiber link, we are trying to introduce the optical fiber instead of coaxial cable for E-field measurement.