Fiberoptic Electric Field Sensor

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Return to the Webpage

The EOFS Electric-field sensor provides an analog response to the electrical field from few tens Hz to 40GHz. It is based on packaging an electro-optical crystal with a dual fiber collimator, consisting entirely of non-metallic materials, having an ultra-high electrical damage threshold (>10 MV/m and 10W/cm^2 power density) and harsh environment compatibility, including temperature, pressure, liquid, X-rays, and gamma rays. Since it does not disturb the field, the measurement has high fidelity. We produce horizontal and vertical sensors to detect electrical fields in 3D. We offer several package configurations for general use, liquid immersion, vacuum chamber compatibility, permittivity matching, and 3D vector sensing in customization. Custom design is our specialty.

The readout unit (PEFS) is sold separately. The operation principle is launching a laser beam through optic fibers and detecting the optical intensity changes on function of E-field. The readout has a multichannel capability. The system is well suited to remotely and non-intrusively measure electric fields in demanding applications.

Features

- No metal parts
- Passive
- Miniature
- Optical fiber readout
- High shock/vibration resistance
- High sensitivity
- Wide bandwidth
- High damage threshold

Applications

- PAA radar tests
- Antennas characterization
- Plasma process control
- Military Active Denial Systems
- HPM, HRI and EMP systems

Specifications

Parameter		Min	Typical	Max	Unit
Frequency Bandwidth	Ultra-high		18	40	GHz
	High			7	GHz
	Low		250	500	MHz
Sensitivity [1]	Ultra-high frequency	500[2]	200		mV/m-Hz$^{1/2}$
	High frequency		100		mV/m-Hz$^{1/2}$
	Low frequency		60		mV/m-Hz$^{1/2}$
Cut-off Frequency	Ultra-high frequency		100	1000[2]	MHz
	High frequency		10		MHz
	Low frequency		30 [3]		Hz
Maximum detectable E-field [4]			200		kV/m
Damage E-field				5	MV/m
Package Dimension			See design		

Notes:

[1] Defined by measuring with the readout system (PEFS) @ 50MHz for low frequency and @1GHz for high frequency.

[2] Defined for 40GHz with PEFS.

[3] Sensitivity drops significantly at f < 50Hz.

[4] Possible to be increased up to 2MV/m, please contact us

Note: The specifications provided are for general applications with a cost-effective approach. If you need to narrow or expand the tolerance, coverage, limit, or qualifications, please [click this link]:

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Rev 09/26/25

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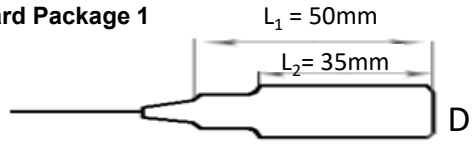
DATASHEET

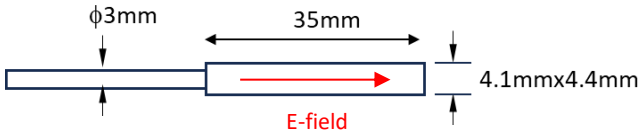
Mechanical Dimensions (mm)

Standard Package 1

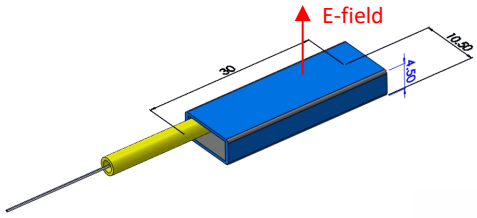


D (Standard) = 8mm in diameter

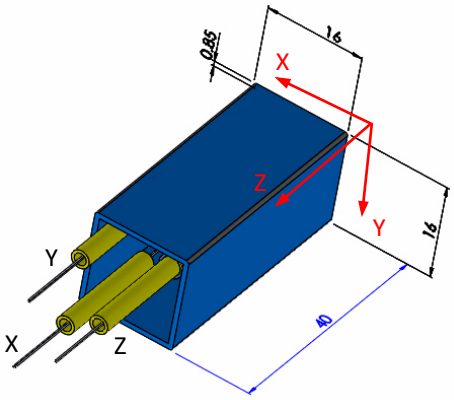
Mini Package 2 (Longitudinal E-field sensing)



Package 4 (Lateral E-field sensing)



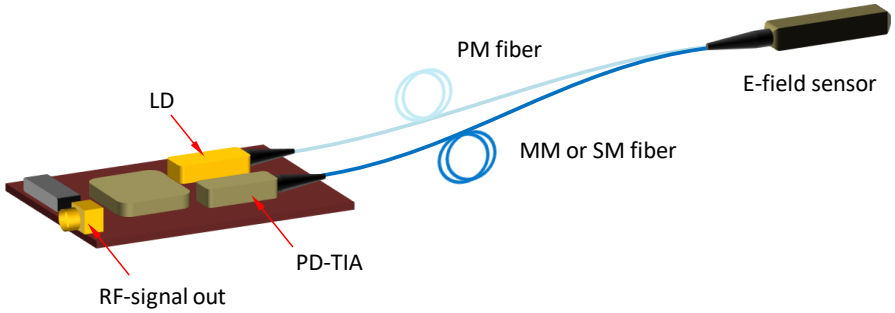
Package 5 for 3-axis sensor



Application Note

1) **System Configuration of E-field Measurements**

The E-field detection by using a fiber optic sensor (EOFS) and the readout system is straightforward, as shown below. The Photonic E-field measurement system (PEFS, sale separately) is composed of one laser diode (LD), one photodetector (PD) with the amplifier, and a customer own oscilloscope or RF spectrum analyzer (not shown in the following schematic diagram). For weak E-field measurement, RF spectrum analyzer is necessary.



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The fiber-coupled LD is connected to the fiber E-field sensor, and the output of the probing laser from the sensor is connected to the PD in the readout module (PEFS). The electric signal from PD should be connected to either the oscilloscope or the spectrum analyzer for measuring the E-field. Because the output electric signal is highly dependent on the laser power, PD, and TIA performances, the measurement set-up must be calibrated for the quantitative measurements.

2) EOFS Calibration

For characterizing/calibrating the fiber optic sensor EOFS and the module, the TEM cell or parallel electrodes must be used, as schematically shown in Fig.2 and Fig.3 respectively.

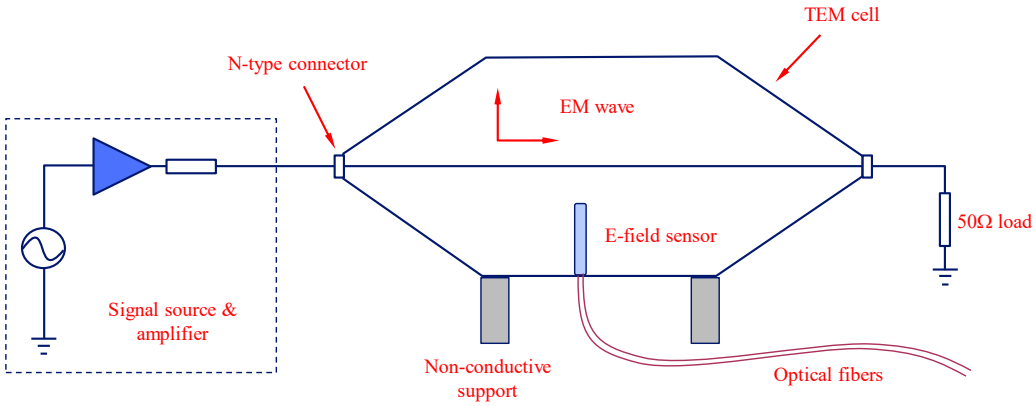

Figure 2: Schematic diagram of EOFS (high frequency) set up in TEM cell

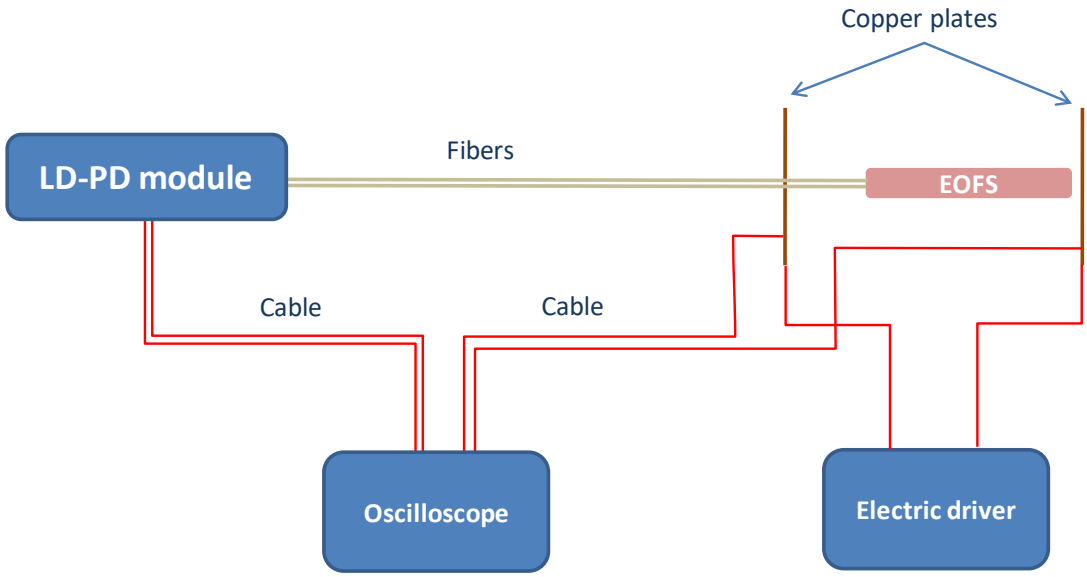

Figure 3: Schematic diagram of low frequency E-field measurement

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3) System Calibration

The sensor's responsivity highly depends on the frequency and the system parameters, such as the laser power, and the PD's responsivity and TIA gain in the laser readout module (PEFS). So, the onsite calibration in the measurement system of EOFS and PEFS is highly recommended to quantitively measure the E-field strength accurately, once the whole system is set up.

The electric signal measured on the oscilloscope can be expressed approximately on the function of E-filed strength as follows.

$$\Delta V(f) = \alpha E(f) + \beta E^2(f)$$

Where α, β are the coefficients to be determined through the calibration test, which depend on the input laser power and TIA gain. E is the electric field strength (V/m), f is the frequency of the E-field.

For the weak E-field, the RF spectrum analyzer must be used to measure the signal from PEFS. The signal level can be expressed on function of E-filed strength as following.

$$P_{OUT}(dBm) = \sigma \ln(E) + \gamma$$

Where σ, γ are the coefficients highly related to the laser power and the PD-TIA response in PEFS, and should be determined through the calibration.

Ordering Information (Part Number) System

	☐☐	☐	☐	☐	1	☐	☐	☐
Prefix	**Type**	**Configuration**	**Package [4]**	**Fiber Cover**	**Fiber Type (input)**	**Fiber Type (output)**	**Fiber Length**	**Connector [5][6]**
EOFS-	LNGITUD[2] 7GHz = 11 LNGITUD[2] 500MHz = 12 LNGITUD[2] 18GHz = 18 LNGITUD[2] 40GHz = 04 LNGITUD[2] Special = 00 LTRL[3] 7GHz = L1 LTRL[3] 500MHz = L2 LTRL[3] 18GHz = L8 LTRL[3] 40GHz = L4 LTRL[3] Special = L0 3-axis & 7GHz = C1 3-axis & 500MHz = C2 3-axis & 18GHz = C8 3-axis & 40GHz = C4	Ambient = 1 Liquid = 2 Vacuum = 3 Special = 0	Standard = 1 Small = 2 Package 4 = 4 Package 5 = 5 Special = 0	Bare fiber = 1 900μm tube = 3 Special = 0	Panda PM = 1 Special = 0	SMF-28 = 2 Special = 0	0.25m = 1 0.5m = 2 1.0m = 3 Special = 0	FC/PC = 2 FC/APC = 3 SC/PC = 4 SC/APC = 5 Special = 0

[1]. For frequencies ≥ 7GHz, the output fiber must be SMF-28.
[2]. Longitudinal E-field
[3]. Lateral E-field
[4]. Small package 2 for longitudinal EOFS; package 4 for lateral EOFS, package 5 for 3-axis EOFS.
[5]. Regular fiber connector has PER ~22dB. Connector with PER >27 dB is available using special process

Red is specially made with long lead time.

[6]. The default connector configuration uses fiber with 0.9 mm buffer protection. The connector cannot be installed directly onto bare fiber because the bare fiber is prone to damage during shipping. However, the connector can be assembled on bare fiber if a 3 cm protective loose tube is added for reinforcement. The customer may remove this protective tube after testing. The optical power handling of a standard connector is less than 0.5 W for SMF-28 fiber and decreases further for smaller-core fibers.

Note:

1) Additional fiber cable extensions can be purchased through this link: https://agiltron.com/category/optical-fiber-patch-jump-cables/ or
2) The extended length of fibers in one protection cable is available too, please call us.

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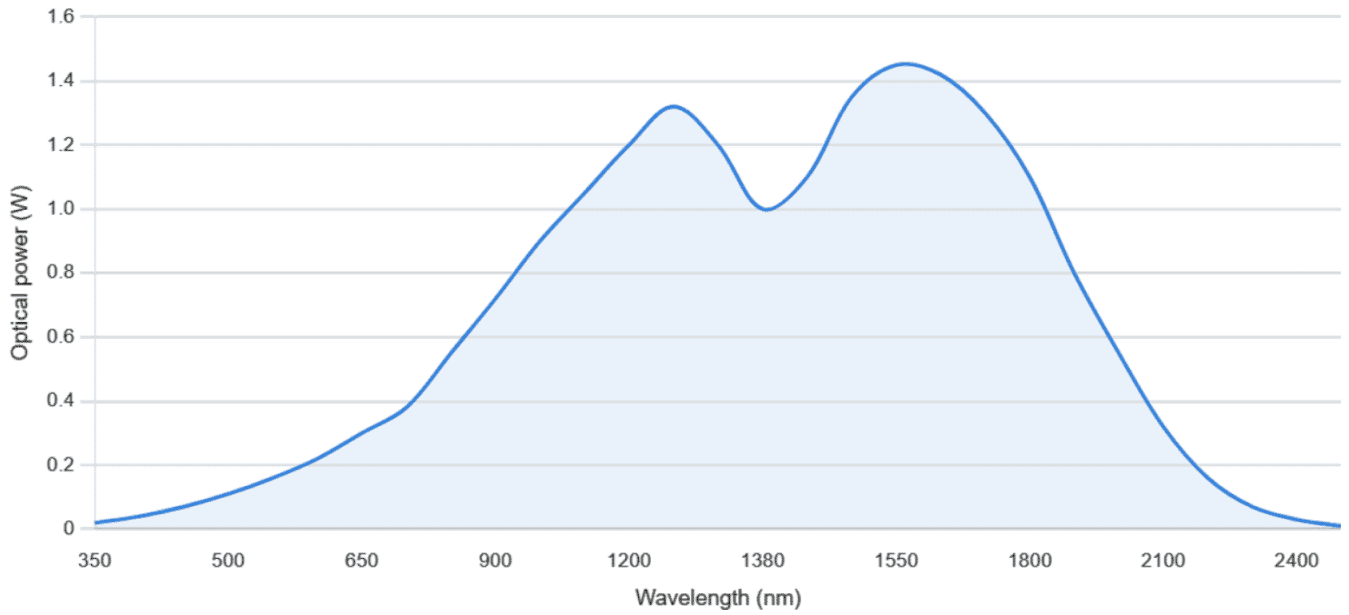
Regular Single Mode / Polarization Maintaining Fiber Optical Power Handing vs Wavelength



Single mode fiber optical power is limited by nonlinear effects in addition to absorption that increase loss and generate heat. The curve shows the approximate safe CW power envelope for standard single-mode fiber. Actual limits depend on fiber design, core size, length, and laser characteristics. Specialty fibers can significantly increase the power limit.

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