EM-field optical probe **eoProbe™**

Make accurate E-field measurement with an interference-free optical RX antenna from 10 Hz up to 100 GHz

Absolute E-field measurement from mV/m up to MV/m in time & frequency domains

Compliant with all media such as liquids, biological tissues, vacuum, plasma...

Ultra high damage threshold > 10 W/cm^2 & compliant with near-field measurement

Transverse, longitudinal and SAR probes for measuring E-field in low κ (gases, plasma, oils) or high κ media (aqueous liquids, biological tissues) and in harsh environment (vacuum, high pressure)

KEY PARTNER FOR ELECTROMAGNETISM

kapteos

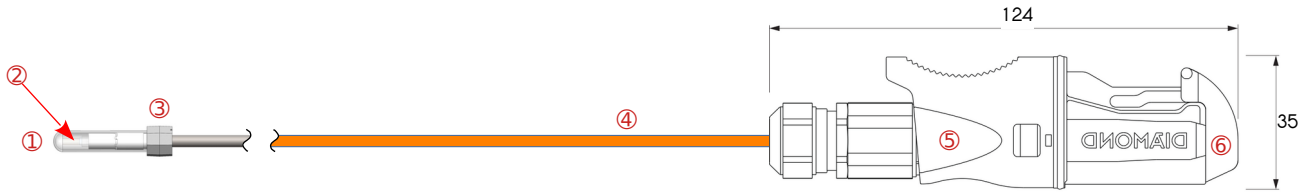
PERFORMANCE SPECIFICATIONS

	Model	Min	Typical	Max	Unit
Frequency bandwidth (cutoff freq. f_{low} & f_{high} ± 10%)	ET5, EL5 & ES5	10	12		GHz
	ET1, EL1 & ES1	50	60		
Dynamic range	All models	130	135		dB.Hz
Min. measurable E-field strength in Time Domain (E_{min})	EL5		16	20	$mV_{RMS}/m.\sqrt{Hz}$
(for f > 200 kHz)	ET5 high κ in H_2O		25	32	
	EL1		64	80	
	ET5 low κ in air		80	100	
	ET1 high κ in H_2O		100	125	
	ET1 low κ in air		320	400	
Min. measurable E field strength in Frequency Domain	EL5		40	50	$mV_{RMS}/m.\sqrt{Hz}$
(for f > 200 kHz)	ET5 high κ in H_2O		64	80	
	EL1		160	200	
	ET5 low κ in air		200	250	
	ET1 high κ in H_2O		250	320	
	ET1 low κ in air		800	1000	
Phase noise	@ 10 Hz from carrier			-65	dBc/Hz
Rejection of orthogonal E-field components		50	60		dB
Probe response isotropy defined by HPBW	Below 100 MHz	300			°
(Half Power Beam Width)	@ 20 GHz for ET5 low κ in air	70	80		
Damage threshold	E-field strength	10			MV_{RMS}/m
	Permanent power density	10			W/cm^2
Measurement repeatability	For $E \geq 100 \times E_{min}$		0.15	0.2	dB
Measurement voxel (cylindrical shape)	Diameter		0.5	1	mm
	Length for ET5, EL5 & ES5	4.8	5	5.2	
	Length for ET1, EL1 & ES1	0.8	1	1.2	
P1dB (1-dB compression point)	EL5	70			kV_{peak}/m
	ET5 high κ in H_2O	110			
	EL1	280			
	ET5 low κ in air	350			
	ET1 high κ in H_2O	450			
	ET1 low κ in air	1400			
Lower cut-off frequency	All models		10	40	Hz
Effective relative permittivity (@ 10 MHz)	Probes with low κ sheath	3.2	3.6	4.0	
	Probes with high κ sheath	XX	XX	XX	
Optical insertion loss	LF (f > 200 kHz)		6	9	dB
Antenna factor AF for HF-0.04-3.2/6.4 & HF-2.5-18	EL5		100	110	dB/m
	ET5 high κ in H_2O		105	115	
	EL1		110	120	
	ET5 low κ in air, ET1 high κ in H_2O		115	125	
	ET1 low κ in air		125	135	

MECHANICAL SPECIFICATIONS

		Min	Typical	Max	Unit
Optical fiber cord	Length	4.5	5.0		m
Transducer	Tip diameter	5.4	5.5	5.6	mm
	Base diameter	7.9	8.1	8.3	
	Length	30		36	
	Weight		2		g
Probe axis marker	Angular deviation			3	°
	Resulting rejection of orthogonal E-field comp.	25			dB
Ingress Protection rating	Except optical connector		IP67		
Main components	Transducer	① tip	Quartz (low κ) / sapphire (high κ) sheath		
		② EO crystal			
		③ base			
	Optical fiber cord	④	3mm Ø PEEK / PVC fiber sheath		
	Optical connector Diamond HE-2000	⑤ base			
		⑥ dust cap			

Front view



Environmental specifications

		Min	Typical	Max	Unit
Fiber bending radius	Operating	40			mm
	Storage	50			
Temperature	Operating	10		50	°C
	Storage	10		40	
Pressure	Standard probes (**medium vacuum**)	10^{-3}		2000	hPa
	Harsh environment probes (**high vacuum**)	10^{-6}		7000	
	Storage for all models	690		1075	
Out-gassing properties (harsh environment probes only)	CVCM (Collected Volatile Condensable Material)			0.1	%
	RML (Recovered Mass Loss)			1	
Relative humidity	Non-condensing			90	%
Optical connector	Durability	10 000			mating
Storage	Only in its original case in a clean, dry environment				
Cleaning	Use cloth moistened with isopropyl alcohol (except for inner part of connectors) Specific tool for inner part of connectors (see § Options, customization and accessories)				

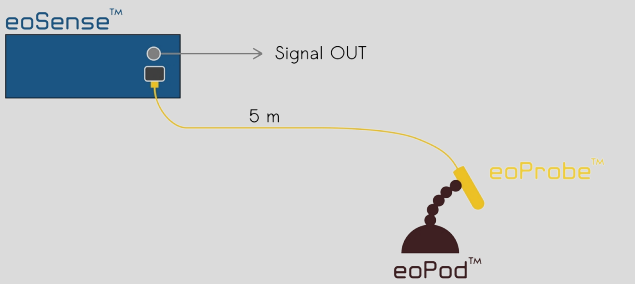
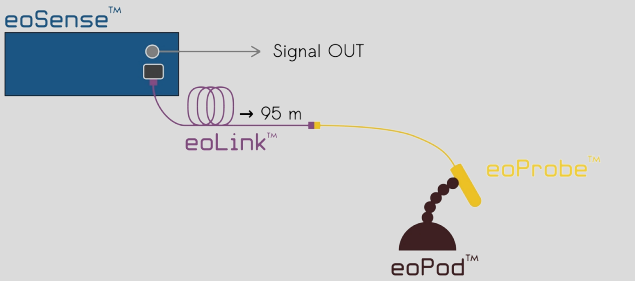
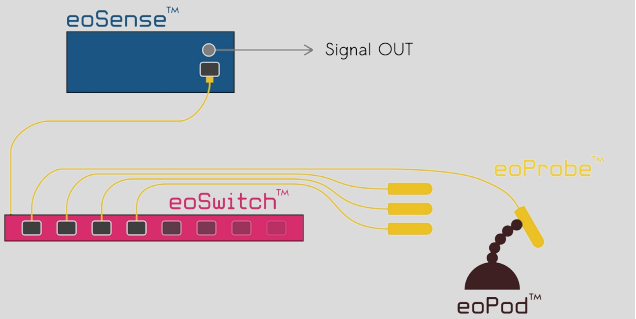
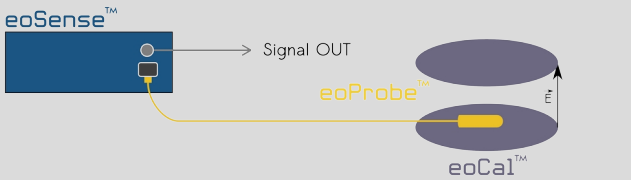
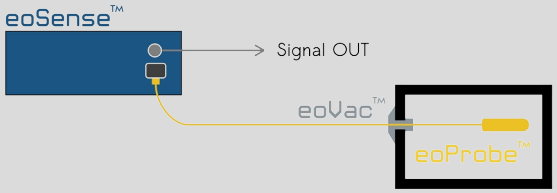
Standards compliance

Laser safety	IEC / EN 60825-2, class 1

Packaging information

	Contents
E-field probe	Delivered with a routine test report
Probe protection for handling	Removable protective foam (red color)
Attached USB stick	Probe calibration file supplied on USB stick (if calibration ordered)
Transport case (up to 4 probes)	drip-proof and dust-proof case (W x D x H = 430 x 335 x 115 mm - Weight: 2.2 kg)
User guide	See website https://en.kapteos.com/

Compatible devices and accessories

Device	Associated data sheet	Use	Outline schematic
Optoelectronic converter Probe holder	eoSense-FT-23.07.pdf eoPod-FT-23.07.pdf	Recommended setup in most cases	
Optical fiber extension cord	eoLink-FT-23.07.pdf	Required setup for measurements over great distances, like outdoor conditions	
Optical multiplexer	eoSwitch-FT-23.07.pdf	Recommended setup to sequentially connect up to 16 probes	
EM-field probe calibration cell	eoCal-FT-23.07.pdf	Required setup for probe calibration in air or in any fluid	
Vacuum feed-through	eoVac-FT-23.07.pdf	Recommended setup in most cases	

Hardware options, customization and accessories

Field of activity	Issue	Options and/or accessories
SAR	Use in high κ liquids	-HK High κ sapphire probe tip sheath & 3mm Ø PVC probe fiber sheath
Antennas, MRI, Plasma, HPEM, EMC, High Voltage	Use in low κ media: gases, oils	-LK Low κ quartz probe tip sheath & 3mm Ø PVC probe fiber sheath
Harsh environment (high vacuum, high pressure)	$P < 10^{-3}$ hPa $P > 2000$ hPa	-HE Specific 3mm Ø PEEK probe fiber sheath (compliant with both high κ and low κ models of probe)
EMP generated by laser-plasma interaction using PW lasers	Intense UV, X and γ rays	-LPI Additional protective sheath for harsh environment probe
HPEM, High Voltage, MRI, Antennas	Large distance from DUT and digitizer	-Xm (X = 10, 15, 20, 30, 40, 50) Extra fiber length to get a fiber cord length of X meters
RF measurement in ultra small enclosure	Specific packaging	Customized probe tip sheath

Useful equations

P_{OEC} → Power delivered by the optoelectronic converter
V_{OEC} → Voltage generated by the optoelectronic converter

Equation	
Frequency domain	E [dBV_{RMS}/m] = P_{OEC} [dBm] + AF [dB/m] - 13.01
Time domain	E [V/m] = V_{OEC} [V] x AF [m^{-1}]
Conversion of units	AF [dB/m] = 20 $\log_{10}$(AF [m^{-1}]) E [V_{RMS}/m] = 10^(E [dBV_{RMS}/m] / 20)

Ordering information

Model	Type	(Option)
eoProbe	EL5	-HK
		-LK-HE-20m
		-LK-HE-LPI-10m

Examples: Transverse EM-field optical probe with 5-mm EO crystal for high κ liquids → **eoProbe ET5-HK**

Longitudinal EM-field optical probe with 1-mm EO crystal for low κ media with a fiber cord length of 20 m
→ **eoProbe EL1-LK-20m**

Transverse EM-field optical probe with 1-mm EO crystal for low κ media, harsh environment with extra protective sheath for EMP generated by intense laser-plasma interaction with a fiber cord length of 15 m
→ **eoProbe ET1-LK-HE-LPI-15m**