Optoelectronic converter eoSense™ 4th generation

Make UWB EM-field measurement in time & frequency domains with optical RX antennas from 10 Hz up to 100 GHz

Optoelectronic converter compliant with eoProbe™ optical RX antennas

Constant AF (Antenna Factor) regardless of optical RX antenna position and temperature

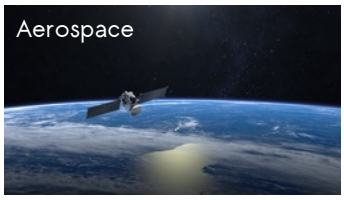
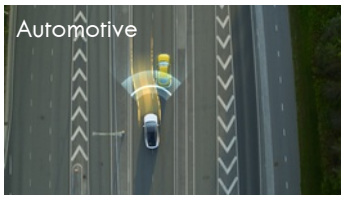
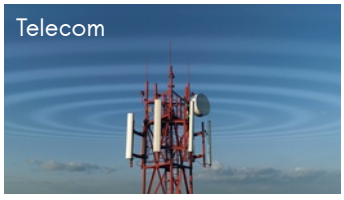
4th converter gen. with ultra high EMI shielding usable with both E-field & H-field probes

Optoelectronic converter line covering RF spectrum
from low frequency LF model (10 Hz → 50 MHz) up to high frequency
HF-25-40 model (25 → 40 GHz) & customized models

KEY PARTNER FOR ELECTROMAGNETISM
kapteos

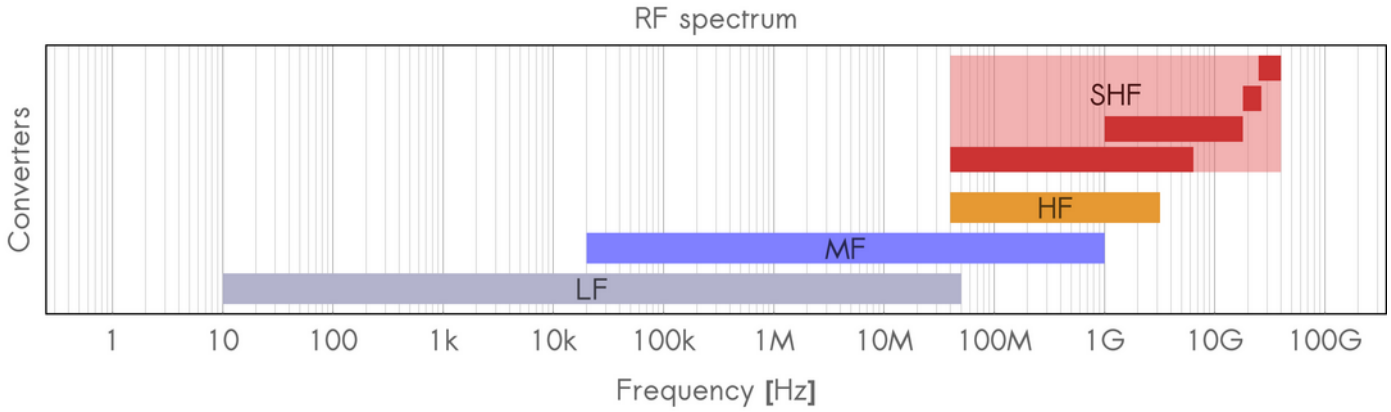
APPLICATIONS

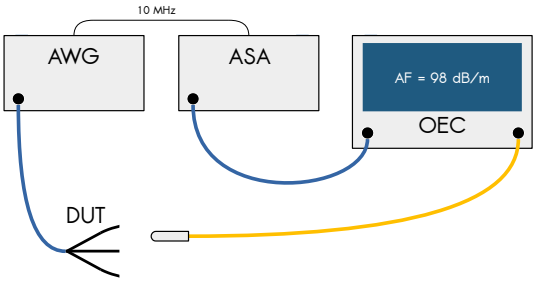
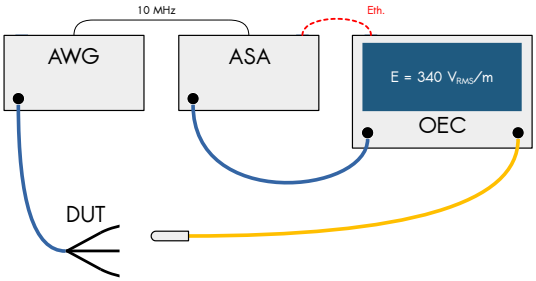
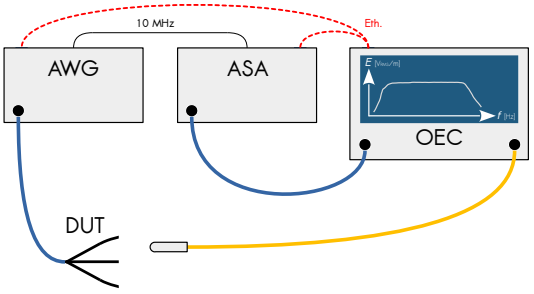
These optoelectronic converters combine state-of-the-art optoelectronics technology and EMI shielding. Three converters (LF, HF & SHF) are sufficient to cover 9.6 decades from 10 Hz up to 40 GHz. They are designed to be used in conjunction with EM-field probes eoProbe™ and their unique features make them ideal for use in a wide range of applications for various industries.

Industries	Applications
	Qualification ground test of: • Satellite antenna horns in T-VAC chamber • Satellite EM shielding in flight conditions • Plasma thrusters in T-VAC chamber
	• Qualification test of radar-based CAS (Collision Avoidance System) • Identification of EM interference • Localization of EM transients in electric vehicles
	Qualification test of: • EM pulse generators • Shielding against EM pulse • APAR (Active Phased Array Radar) in the near field • Exposure assessment to EM field
	• Localization of PD (Partial Discharge), DBD (Dielectric Barrier Discharge) in HV devices • Characterization of EM transients in HVDC converters • Quantitative measurements of lightning EM pulse
	Qualification test of: • Hyperthermia apparatuses • MRI safety of medical implants • Optimization of cold plasma sterilization/decontamination
	• Characterization of EM pulse generated by intense laser-plasma interaction • Absolute & time-resolved E-field mapping with sub-mm spatial resolution • Monitoring of particle beam position and shape
	• Identification of failed element(s) in antenna arrays • Qualification test of antennas and arrays • Assessment of human exposure to EM field • Acquisition of phase reference for antennas with no access to LO (Local Oscillator)

Implementation

Depending on the application, different types and configurations of optoelectronic converters can be used. RF spectrum is covered at 80% by standard converters. Extension to higher frequencies, up to 100 GHz, is achieved with customized converters. Standard converters embed their frequency response in their EEPROM so that any new calibrated probe can be directly plugged in and used instantaneously without any further step. SHF converter can embed up to 3 RF blocks, each RF block covering a specific sub-band.



Configuration	Frequency Domain	Use & features
Basic		3 apparatuses to operate • Set the frequency of interest on AWG • Set the center frequency on ASA • Set current operating frequency on OEC • Get the Antenna Factor on OEC • Get peak value at operating frequency on ASA • Calculate the E field strength
Automatic		2 apparatuses to operate • Set the frequency of interest on AWG • Set current operating frequency on OEC • Get the E field strength at operating frequency
Advanced		1 single apparatus to operate • Set frequency range of interest on OEC • Launch the frequency sweep on OEC • Get E-field strength versus frequency on OEC

Glossary of acronyms

AF	Antenna Factor
ASA	Automatic Spectrum Analyzer
AWG	Arbitrary Wave Generator
DUT	Device Under Test
OEC	Opto-Electronic Converter (eoSense™)

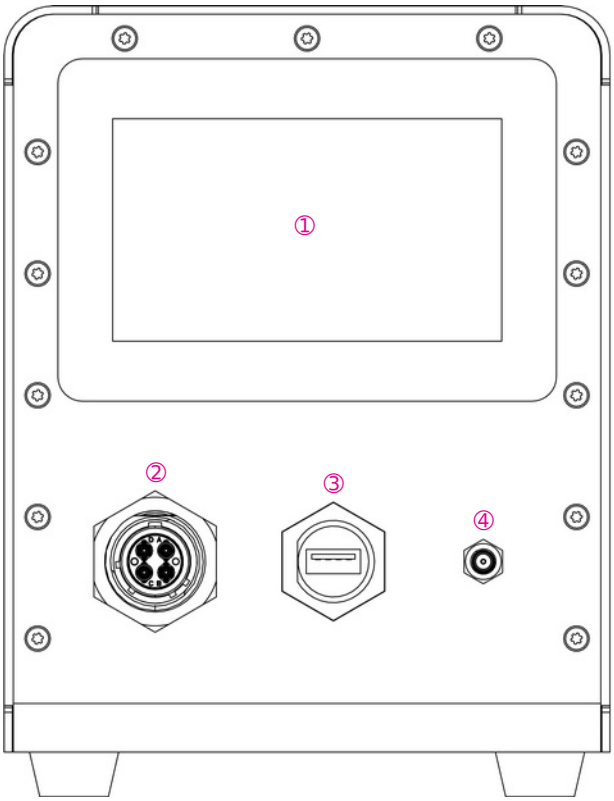
PERFORMANCE SPECIFICATIONS

	Type	Min	Typical	Max	Unit
Frequency bandwidth (cutoff freq. f_{low} & f_{high} ± 10%)	LF	10		50M	Hz
	MF	20k		1G	
	HF	40M		3.2G	
	SHF case & -0.04-6.4 RF block	40M		6.4G	
	SHF case & -1-18 RF block	1G		18G	
	SHF case & -18-26.5 RF block	18G		26.5G	
	SHF case & -25-40 RF block	25G		40G	
	Customized type	f_{low}		f_{high}	
P1dB (1-dB compression point) in Frequency Domain	LF	18	19		dBm
	MF	15	16		
	HF & -0.04-6.4 RF block	19	20		
	-1-18 RF block	20	22		
	-18-26.5 & -25-40 RF blocks	15	18		
Output voltage swing in Time Domain	LF	5.0	5.6		Vpp
	MF	3.5	4.0		
	HF & -0.04-6.4 RF block	5.6	6.3		
	-1-18 RF block	6.3	8.0		
	-18-26.5 & -25-40 RF blocks	3.5	5.0		
Output noise spectral density	LF (f > 50 kHz)		-120	-110	dBm/Hz
	MF (f > 10 MHz)		-110	-100	
	HF		-110	-100	
	-0.04-6.4 & -1-18 RF blocks		-110	-100	
	-18-26.5 RF block		-100	-90	
	-25-40 RF block		-90	-80	
Phase noise with use of any probe eoProbe™	@10 Hz from carrier			-70	dBc/Hz
Antenna factor AF for use with EL5-air probe	LF		115	125	dB/m
	MF		115	125	
	HF & -0.04-6.4 RF block		100	110	
	-1-18 RF block (for f < 10 GHz)		100	110	
Dynamic range in Frequency Domain	LF (f > 50 kHz)	130	140		dB.Hz
	MF (f > 10 MHz)	120	130		
	HF	120	130		
	-0.04-6.4 & -1-18 RF blocks	120	130		
	-18-26.5 RF block	110	120		
	-25-40 RF block	100	110		

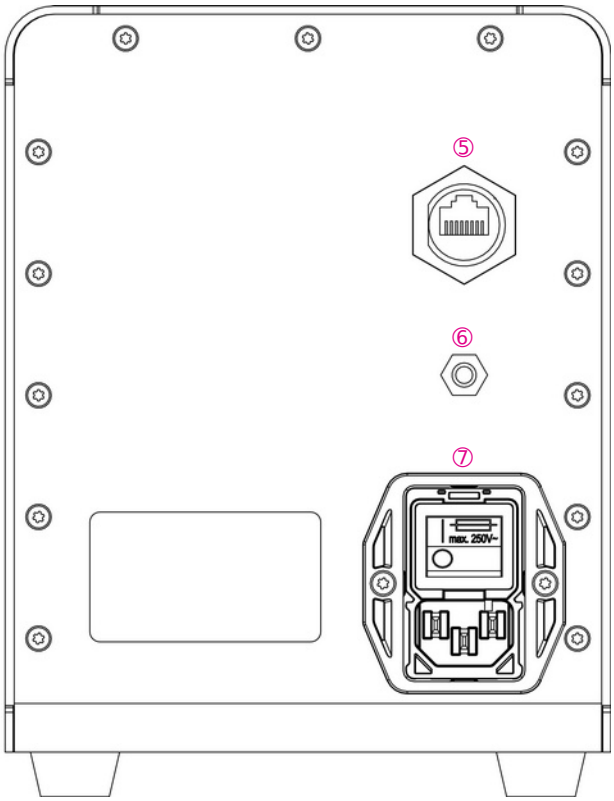
MECHANICAL SPECIFICATIONS

		Min	Typical	Max	Unit
Dimensions ± 1mm (cf. Max for overall dimensions)	Width		150	150	mm
	Depth		450	516	
	Height		185	195	
Weight	All types	6.7		7.4	kg
Ingress Protection rating			IP40		
Front panel I/O	① Human Machine Interface	4.3" capacitive touchscreen			
	② Optical probe	MIL-38999 connector			
	③ USB 2.0	Type A socket			
	④ Signal output (Z = 50 Ω)	SMA or SMK (2.92 mm)			
Rear panel I/O	⑤ Ethernet	RJ45 socket			
	⑥ Earthing stud	POAG-S6			
	⑦ Power entry connector	C14 socket			

Front panel



Rear panel



Environmental specifications

		Min	Typical	Max	Unit
Power supply	Voltage	90		260	VAC
	Frequency	47		63	Hz
	Power		65	130	W
Temperature	Operating	15		30	°C
	Storage	5		40	
Pressure		690		1075	hPa
Relative humidity	Non-condensing			90	%
Storage	Only in its original case in a clean, dry environment				
Cleaning	Use cloth moistened with clean water mixed with < 20% of isopropyl alcohol (only for outer part of connectors)				

Embedded computer specifications

Processor	Type	ARM Cortex A-8
	Frequency	1 GHz
	Architecture	32 bits
Operating system	Type	Linux
	Distribution	Debian
	Version	9.3 or higher
Connectivity	USB 2.0	Instrument front panel
	Ethernet 10/100M	Instrument rear panel
	Wireless	None

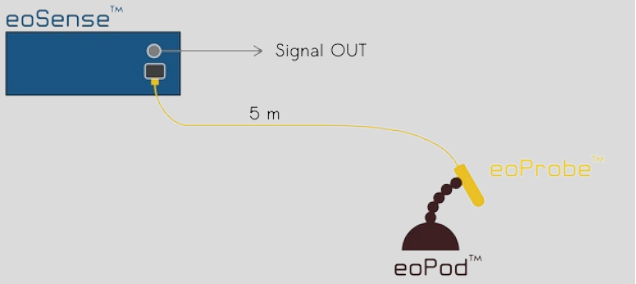
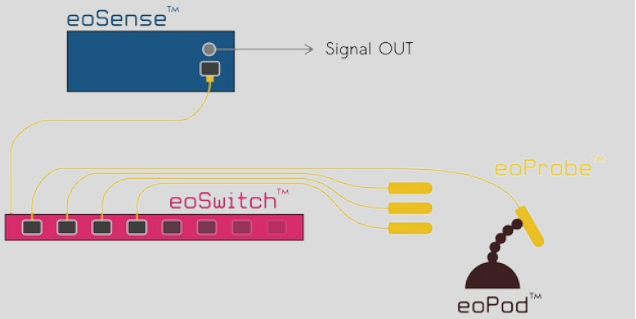
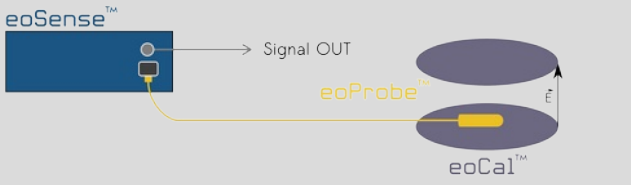
Standards compliance

EMC, emissions	IEC 60601-1-2 4th ed. EN 55032 class B
	IEC / EN 61000-3-2, class B
	IEC / EN 61000-3-3, class B
EMC, immunity	IEC / EN 60601-1-2
	IEC / EN 61000-4-2, 8kV/6kV perf. criteria A
	IEC / EN 61000-4-3, 20V/m perf. criteria A
	IEC / EN 61000-4-4, ± 2kV perf. criteria A
	IEC / EN 61000-4-5, ± 1kV/± 2kV perf. criteria A
	IEC / EN 61000-4-6, 20 Vrms perf. criteria A
Laser safety	IEC / EN 60825-1, class 1
	IEC / EN 60825-2, class 1

Packaging information

	Contents
Converter	Delivered with a routine test report
Dust caps	3 attached shielded dust caps: 1 for optical probe ②, 1 for USB ③ and 1 for Eth ⑤
RF Termination	50 Ω load for signal out connector ④
Optic connector cleaner	1 fiber optic cleaner for connector MIL-38999 (> 500 cleans)
Power cord	with CEE 7/7 plug (Europe, Asia) or with NEMA 5/15 plug (North America, Japon)
Ground strap	1 m length, 4 mm^2 cable cross-section
Transport box	Double-wall cardboard (W x D x H = 565 x 215 x 315 mm) with protective foam
Firmware update	See website https://en.kapteos.com/
User guide	See website https://en.kapteos.com/

Compatible devices and accessories

Device	Associated data sheet	Use	Outline schematic
EM-field probe	eoProbe-FT-23.12.pdf	Recommended setup in most cases	
Optical multiplexer	eoSwitch-FT-23.12.pdf	Recommended setup to sequentially connect up to 16 probes	
EM-field probe calibration cell	eoCal-FT-23.12.pdf	Required setup for probe calibration in air or in any fluid	

Hardware options, customization and accessories

Field of activity	Issue	Options and/or accessories
MRI	Ultra narrowband signals	-3T Ultra narrow external filters for 0.55T, 1.5T, 3T, 4.7T... MRI machines
High Voltage	Partial discharge assessment	-PD External diplexer with two channels: 10 Hz → 50 MHz and 2 kHz → 50 MHz
Antennas	RF spectrum coverage	**Single-band**, **dual-band** or **triple-band** for SHF converter only
	Automotive radar characterization	-DC75 76-81 GHz converter with embedded frequency down-conversion linked to LO at 75 GHz giving output signal spectrum from 1 to 6 GHz

Software options

Option	Function	Requirements
-ASA	**E-field strength display** through direct control of end customer spectrum analyzer through Ethernet cable.	Recent Automatic Spectrum Analyzer with Ethernet remote control
-AWG+ASA	**E-field strength display versus frequency** through direct control of both end customer synthesizer & spectrum analyzer through Ethernet cables	Recent Arbitrary Waveform Generator & Automatic Spectrum Analyzer with Ethernet remote control
-CRF	Correction of the Response Flatness of the EM-field measurement system (OEC + EM-field probe) to get a **flat response on the frequency range of interest**	Factory calibration of the OptoElectronic Converter (OEC)

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	Hardware options (for SHF OEC only)			Accessory	Software option
		1st option	2nd option	3rd option		
eoSense	LF				-PD	-CRF
	MF				-3T	
	SHF	-0.04-6.4	-1-18			-ASA
		-1-18	-18-26.5	-25-40		-AWG+ASA
		-75-85	-DC75			

Examples:

Optoelectronic converter for 10 Hz-50 MHz frequency range with diplexer for partial discharge assessment and correction of response flatness → 3 items: **eoSense LF**, **eoSense -PD**, **eoSense -CRF**

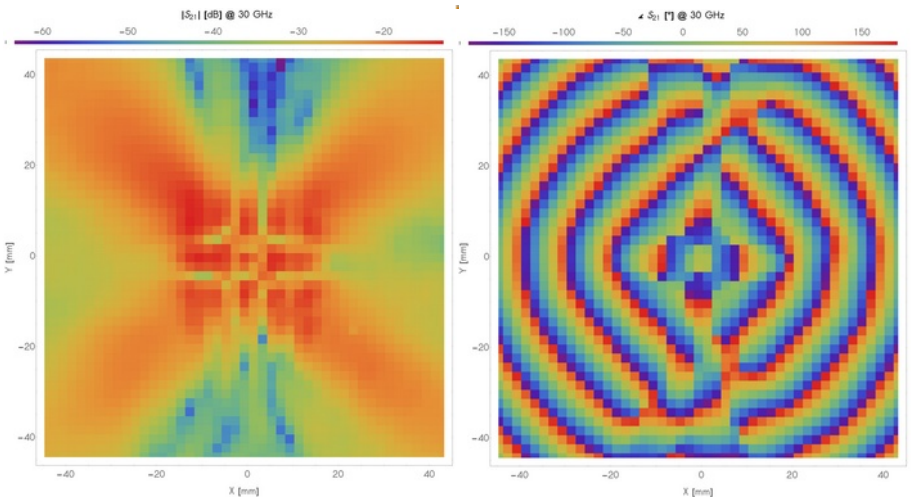
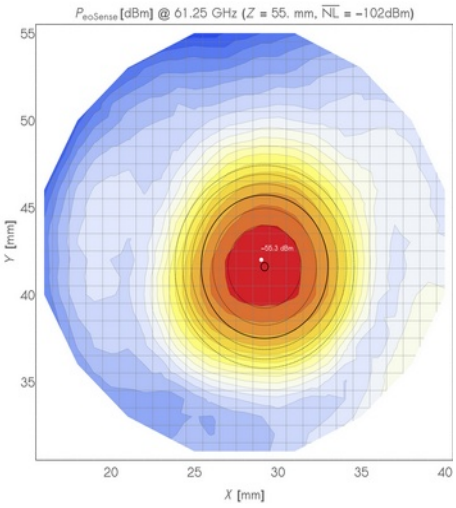
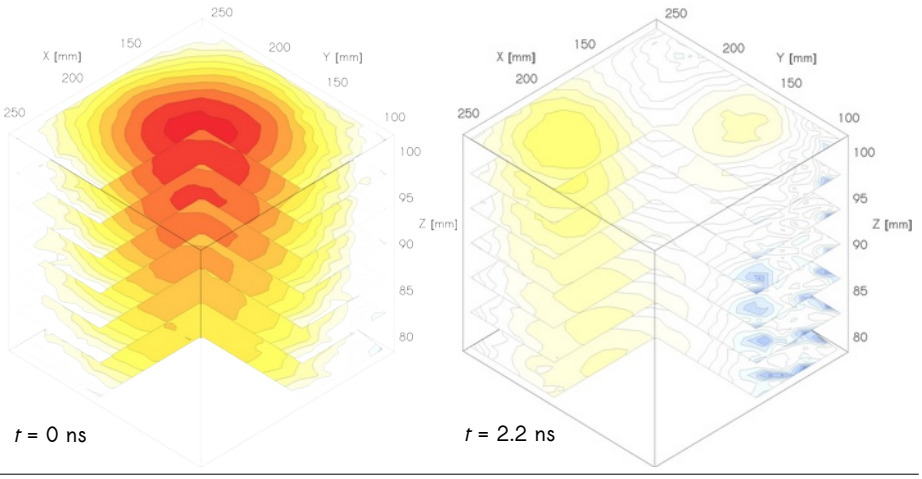
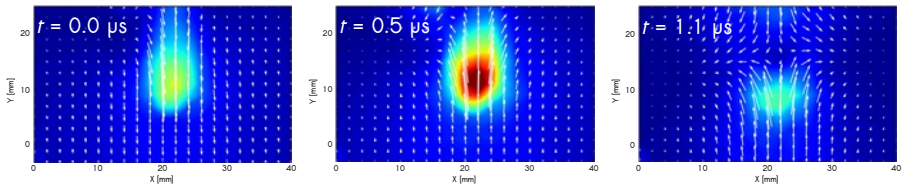
Optoelectronic converter for 20 kHz-1 GHz frequency range with ultra narrow band filter for use with 3T MRI machine → 2 items: **eoSense MF**, **eoSense -3T**

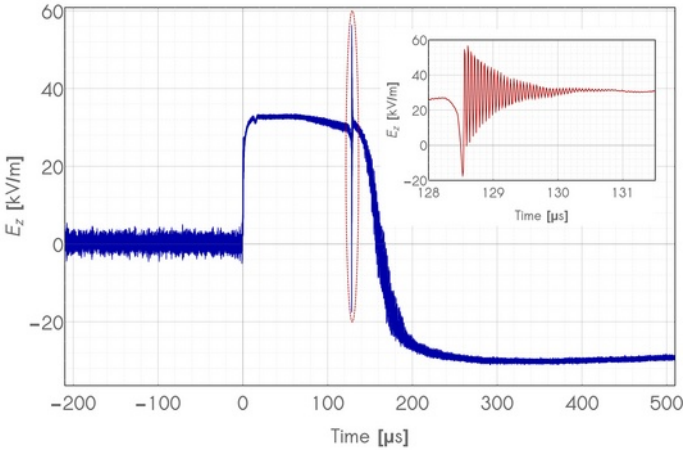
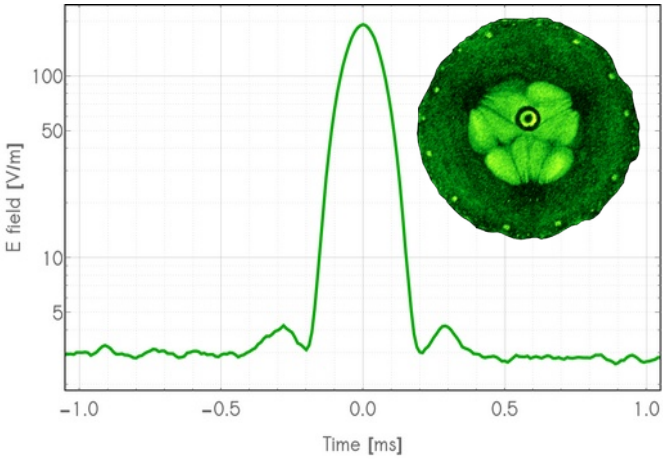
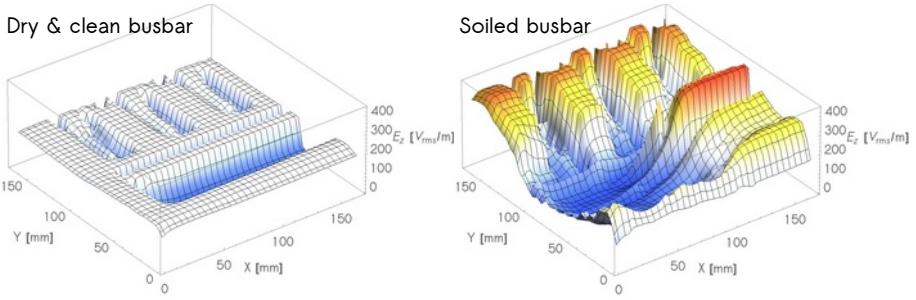
Optoelectronic converter for 40 MHz-18 GHz frequency range in two RF bands with direct control of spectrum analyzer → 4 items: **eoSense SHF**, **eoSense -0.04-6.4**, **eoSense -1-18**, **eoSense -ASA**

Optoelectronic converter for 1 GHz-40 GHz frequency range in three RF bands with direct control of arbitrary wave generator and spectrum analyzer → 5 items: **eoSense SHF**, **eoSense -1-18**, **eoSense -18-26.5**, **eoSense -25-40**, **eoSense -AWG+ASA**

Customized optoelectronic converter for 75 GHz-85 GHz frequency range with down conversion linked to LO at -75 GHz giving output signal spectrum from DC to 10 GHz → 3 items: **eoSense SHF**, **eoSense -75-85**, **eoSense -DC75**

Typical applications

Application	Device Under Test	Result
Near E-field mapping (@ 0.3 **λ**)	**Frequency Domain**: Patch antenna array @ 30 GHz	
E-field mapping of co-polarization	**Frequency Domain**: Free-space test bench @ 60 GHz	
3D SAR mapping	**Time Domain**: Phantom liquid during hyperthermia @ 115 MHz	
E-field mapping in a symmetry plane	**Time Domain**: Plasma bullet in a plasma plume	

E-field assessment in artificial lightning	**Time Domain**: lightning generated in a 1MV, 40kA tip-plane configuration	
Dosimetry in a 4.7-T MRI machine	**Freq/Time Domain**: Cucumber (time-resolved down-converted signal)	
Mapping of pollution and ageing effects	**Time Domain**: Laminated busbar @ 50 Hz, 500 V_{RMS}	
Near E-field mapping	**Frequency Domain**: Double ridge antenna @ 10 GHz