eoSense™

Patents EP2035845 EP2035846
US7769250 US8264685
CA2655034 CA2655447

MAIN FEATURES

- Analog signal output, true image of temporal evolution of E-field component of interest $E_x(t)$
- Perfectly suited both for time domain and frequency domain measurements
- Antenna factor given in real time by the instrument for absolute E field measurements
- Self-shielded instrument against any E field strength or permanent power density exceeding the damage threshold for the connected E-field probe
- Equivalent to UWB, EMI-free, ultra small antenna ($\lambda/10$ @ 60 GHz) with real time compensation of IL variations when used with E-field probe eoProbe™
- Intended for use with E-field probes eoProbe™
- 1 to 3 channels
- Recalibration service (recommended every 2 years)

TYPICAL APPLICATIONS

- Antennas characterization
- SAR assessment in phantoms
- Plasma characterization
- MRI compliance for electronic implants
- Field mapping of high voltage devices
- EMC malfunction diagnosis
- EMP measurement

Health
Science
Defence
Aerospace
Telecommunications

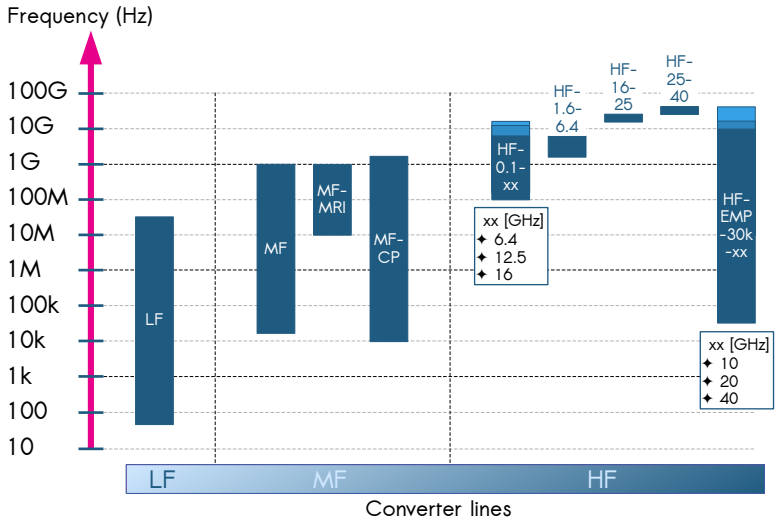
PRODUCTS LINE

Low frequency converters:
- **LF**-xx for **High Voltage** applications

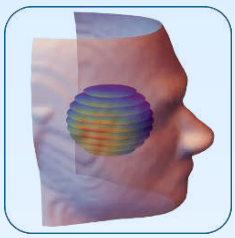
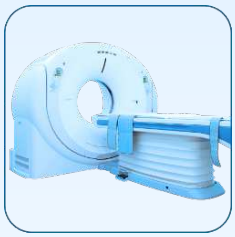
Medium frequency converters:
- **MF-CP**-xx for **Plasma** applications
- **MF-MRI**-xx for **MRI** applications
- **MF**-xx for general purposes

High frequency converters:
- **HF**-xx-xx for **Antennas** & **SAR** applications
- **HF-EMP**-xx for single shot **EMP** > 100 kV/m

Any other custom-specified bandwidth on request **up to 110 GHz**

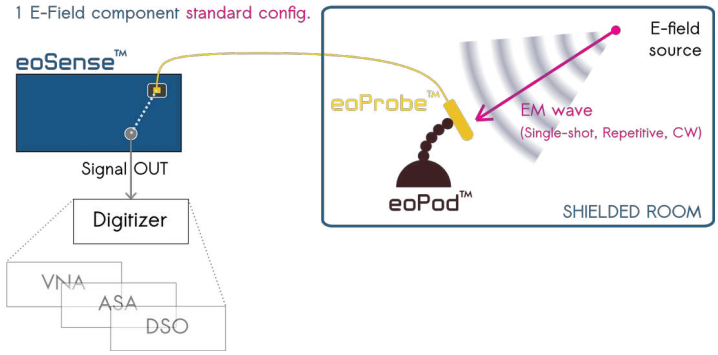
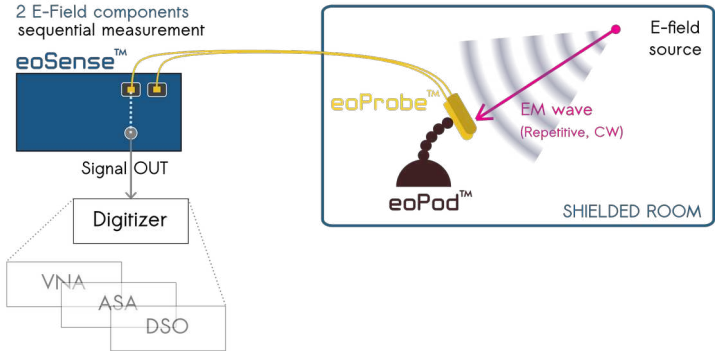
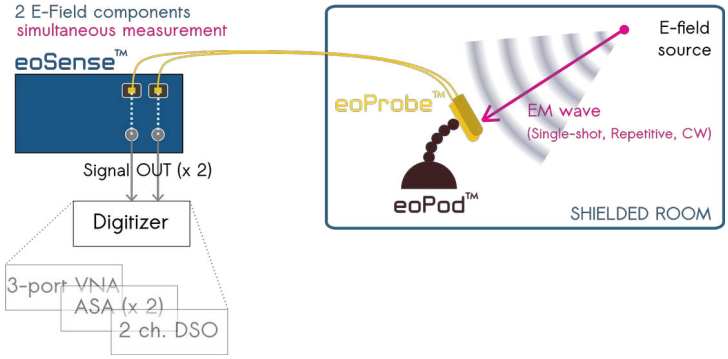
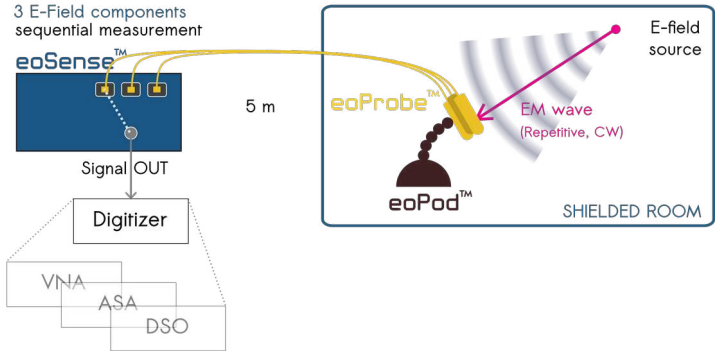
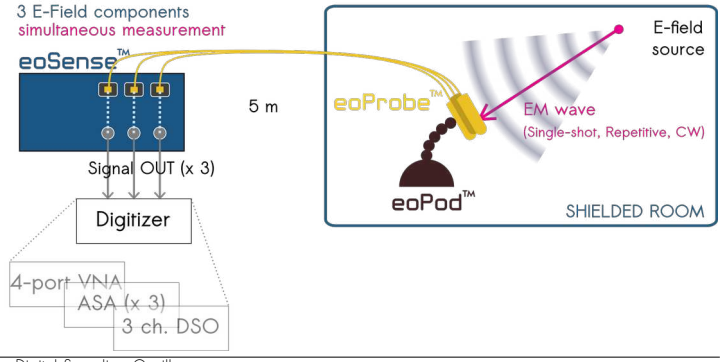




Your **key partner** for **electromagnetism** in **harsh environment**

VARIANTS

	xx	Use	Outline schematic
Single optical channel Single signal output	1S	1 E-field component meas. CW or repetitive signals single-shot signals	
Dual optical channel Single signal output	2S	2 E-field component meas. only CW or repetitive signals	
Dual optical channel Dual signal output	2D	2 E-field component meas. CW or repetitive signals ✦ 2-time faster ✦ 1-dB more sensitive single-shot signals	
Triple optical channel Single signal output	3S	3 E-field component meas. only CW or repetitive signals	
Triple optical channel Triple signal output	3T	3 E-field component meas. CW or repetitive signals ✦ 3-time faster ✦ 1-dB more sensitive single-shot signals	

VNA ≡ Vector Network Analyzer — ASA ≡ Automatic Spectrum Analyzer — DSO ≡ Digital Sampling Oscilloscope

PERFORMANCE SPECIFICATIONS

		Min	Typical	Max	Unit
Frequency bandwidth for all variants lower & higher cutoff frequencies ± 10%	LF	50		32 M	Hz
	MF	16 k		1 G	
	MF-MRI	10 M		1 G	
	MF-CP	10 k		1.6 G	
	HF-1.6-6.4	1.6 G		6.4 G	
	HF-0.1-6.4	100 M		6.4 G	
	HF-0.1-12.5	100 M		12.5 G	
	HF-0.1-16	100 M		16 G	
	HF-16-25	16 G		25 G	
	HF-25-40	25 G		40 G	
	HF-EMP-30k-10	30 k		10 G	
	HF-EMP-30k-20	30 k		20 G	
	HF-EMP-30k-40	30 k		40 G	
Dynamic range for all variants	LF	125	135		dB.Hz
	MF-CP	120	130		
	MF & MF-MRI, HF line	100	110		
	HF-EMP line	140	150		
P1dB (1-dB compression point) for all variants for frequency-domain measurements	LF	12	14		dBm
	MF & MF-CP	15	16		
	MF-MRI	16	18		
	HF-1.6-6.4	12	14		
	HF-0.1-xx line	10	11		
	HF-16-25	10	15		
	HF-25-40	10	12		
	HF-EMP-30k-10	-7	-4		
	HF-EMP-30k-20	-7	-4		
	HF-EMP-30k-40	-10	-7		
Output voltage swing for all variants for time-domain measurements	LF	2.5	3.2		Vpp
	MF & MF-CP	3.6	4		
	MF-MRI	4	5		
	HF-1.6-6.4	2.5	3.2		
	HF-0.1-xx line	2	2.25		
	HF-16-25	2	3.6		
	HF-25-40	2	2.5		
	HF-EMP-30k-10	0.28	0.40		
	HF-EMP-30k-20	0.28	0.40		
	HF-EMP-30k-40	0.20	0.28		
Antenna factor *AF* for all variants for f < 10 GHz when optoelectronic converter used directly in combination with E-field probe eoProbe EL5-air	LF		95	105	dB/m
	MF-CP		115	125	
	MF & MF-MRI		95	105	
	HF line		95	105	
	HF-EMP line		140	150	
Output noise spectral density for all variants for f > 10 kHz	LF		-120	-110	dBm/Hz
	MF-CP		-120	-110	
	MF & MF-MRI		-100	-90	
	HF line		-100	-90	
	HF-EMP line		-145	-135	
Switching time	for 2S & 3S variants			20	ms

USEFUL EQUATIONS

	Equation[1]
Frequency domain	E [dBV$_{rms}$/m] = AF [dB/m] + $P_{eoSense}$ [dBm] - 13.01
Time domain	E [V/m] = AF [m^{-1}] x $V_{eoSense}$ [V]
Conversion of units	AF [dB/m] = 20 log$_{10}$(AF [m^{-1}])
	E [V$_{rms}$/m] = 10^(E [dBV$_{rms}$/m] / 20)

[1] $P_{eoSense}$: power delivered by optoelectronic converter - $V_{eoSense}$: voltage at output of optoelectronic converter

SOFTWARE

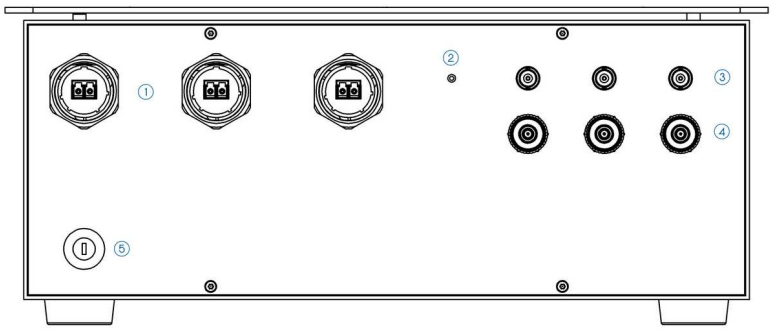
	Contents
Main features	multi-converter control embedded E-field strength calculator semi-automatic calibration when used with field applicator eoCal™ operating mode selection • **Standard mode** (control via eoSystem software) • **Instrumentation mode** (control via Eth eoSystem driver) • **Autonomous mode** (standalone converter)
Operating System	Windows 10 Linux Fedora 29 and future releases
Recommended hardware configuration	full HD display 4 GiB RAM 256 GiB HDD/SSD Intel Core i5 or higher

MECHANICAL SPECIFICATIONS

		Min	Typical	Max	Unit
Overall dimensions (± 1 mm)	width		410		mm
	depth		283		mm
	height		170		mm
Overall weight	1S variant			8.5	kg
	2S / 2D variant			9	
	3S / 3T variant			10	
Ingress Protection rating	except optical connector		IP51		
Front panel I/O	optical probe		Souriau duplex LC/APC socket		
	signal output (Z = 50 Ω)		**LF** & **MF** lines: SMA		
			HF line: SMA or SMK (2.92 mm)		
	IL compensation signal (high Z, > 1MΩ)		SMA with dust cap		
	status indicator		LED		
	laser On/Off		Key		
Rear panel I/O	power entry connector with power switch		C14 socket		
	earthing stud (potential equalization)		POAG-S6		
	laser interlock		BNC socket		
	USB 2.0		Type A socket		
	Ethernet		RJ45 socket		

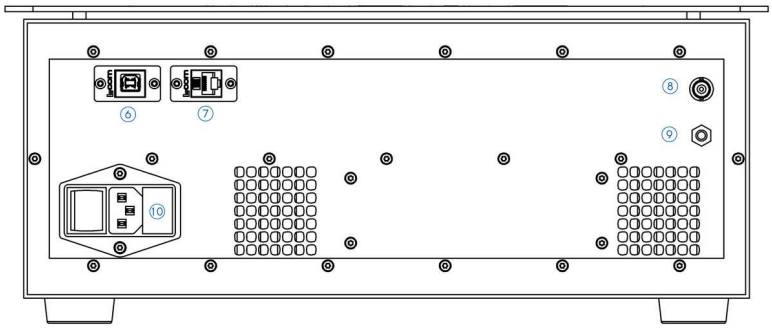
CONVERTER - Drawings at scale 1:4

front view



① optical probes
② status indicator LED
③ IL compensation signal (high Z, > 1MΩ)
④ signal output (Z = 50 Ω)
⑤ laser On/Off key

rear view



⑥ USB 2.0
⑦ Ethernet
⑧ laser interlock
⑨ earthing stud
⑩ power entry with power switch

ENVIRONMENTAL SPECIFICATIONS

		Min	Typical	Max	Unit
Power supply	voltage	90		260	VAC
	frequency	47		63	Hz
	power		40		W
Temperature	operating	15		30	°C
	storage	10		40	
Pressure		690		1 075	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)				

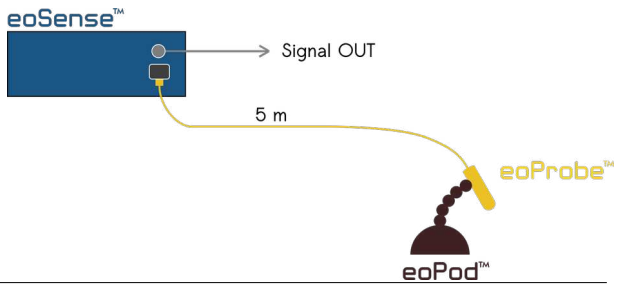
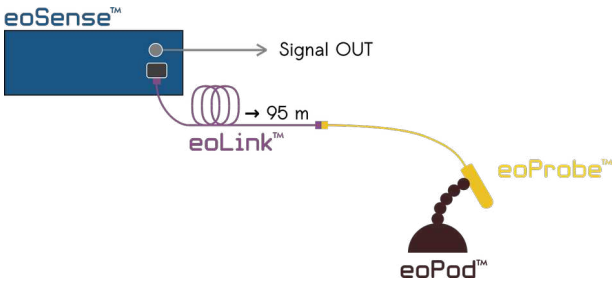
STANDARDS COMPLIANCE

	Contents
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

PACKAGING INFORMATION

	Contents
Converter	delivered with a routine test report
Software	on a USB key delivered with E-field probe(s)
Power cord	with CEE 7/7 plug (Europe, Asia) or with NEMA 5/15 plug (North America, Japon)
Transport case	drip-proof and dust-proof case (W x D x H = 490 x 390 x 230 mm - Weight: 3.5 kg)
Other parts	1 interlock BNC plug, 1 laser safety key, 1 A-B USB 2.0 communication cable
User guide	cf. eoSystem User Guide PDF file GU-eoSystem

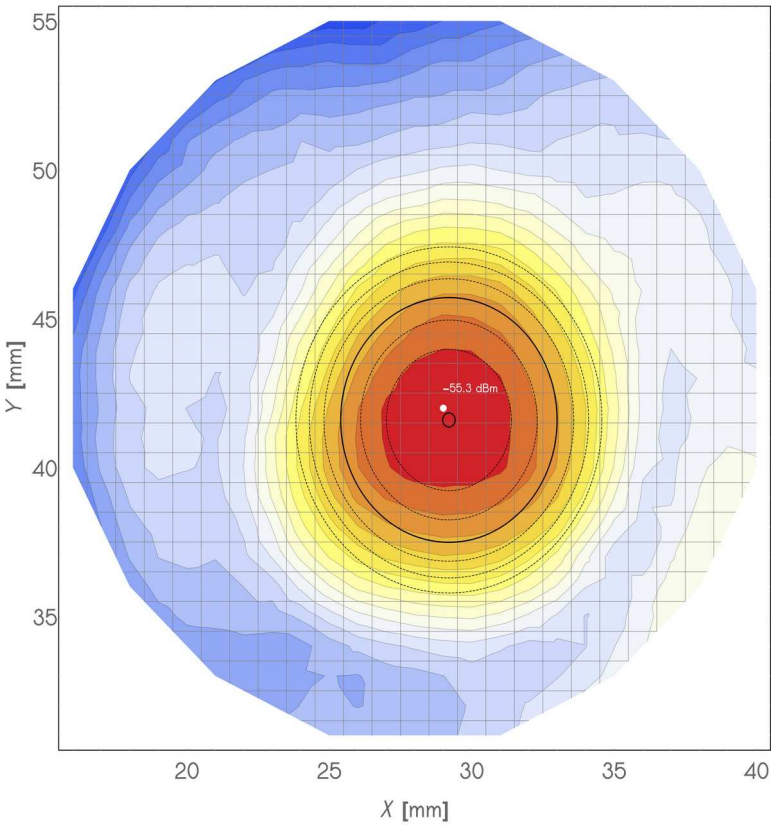
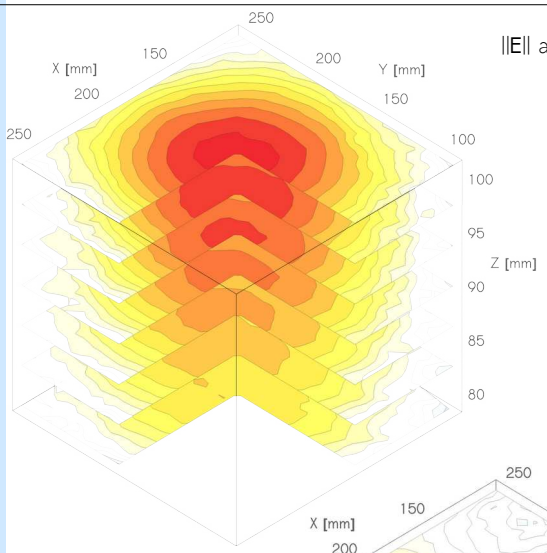
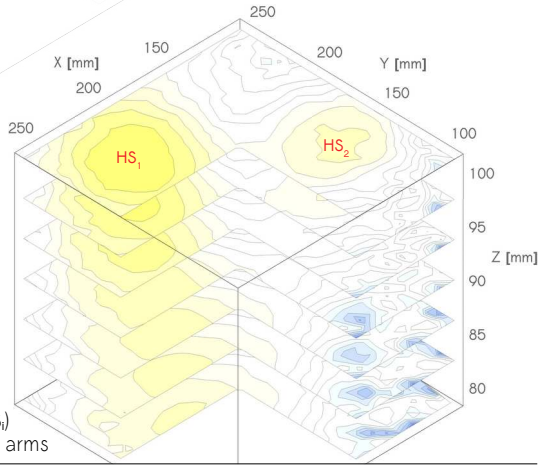
COMPATIBLE DEVICES & ACCESSORIES

	Device-related data sheet	Use	Outline schematic
E-field probe eoProbe™	FT20-eoProbe-05.pdf	Recommended setup in most cases	
Optical fiber extension cord eoLink™	FT20-eoLink-05.pdf	Required setup for measurements over great distances, like outdoor conditions	
Probe calibration cell eoCal™	FT20-eoCal-05.pdf	Required setup for probe calibration in air or in any fluid	

OPTIONS AND CUSTOMIZATION FOR SPECIFIC APPLICATIONS

Application	Issue	Solution
Plasma	Narrow bands in the 10 MHz - 12 GHz range	Dual-band instrument ✦ 1 MF channel: 16 kHz ↔ 1 GHz ✦ 1 HF-0.1-12.5 channel: 0.1 GHz ↔ 12.5 GHz

TYPICAL CHARACTERISTICS

Application	DUT and Conditions[2]	Measurement
Antennas: E-field mapping ✦ pixel size: 1 mm x 1 mm (see gray mesh) ✦ contours lines every 1 dB from max value in white ✦ linear interpolation ✦ dotted lines: Gaussian beam fit ✦ thick lines: HPBW & beam center ✦ signal wavelength: λ = 4.9 mm	*Probe:* **ET1-air** *Converter:* **HF-50-75** *Digitizer:* **ASA** *E-field source:* **V-band** pyramidal horn **antenna** + 2 dielectric lenses	$P_{eoSense}$ [dBm] @ 61.25 GHz (Z = 55. mm, $\overline{NL}$ = −102dBm)  NL ≡ Noise Level
SAR: Time-resolved E-field magnitude in a phantom ✦ elliptical section phantom filled with muscle-equivalent saline solution ✦ antenna power supply: 115 MHz, 100 W ✦ spatial sampling: 5 mm in Z and 10 mm in X & Y ✦ contours lines every 1 dB ✦ max(‖E‖) = 120 V_{rms}/m (center of red area)	*Probes:* 1 x **EL5-bio** + 2 x **ET5-bio** *Converter:* **MF-MRI** *Digitizer:* **DSO** (4 Ch.) *E-field source:* **Spiral antenna for hyperthermia** (Ø 150 mm)	‖E‖ at its maximum for $t = t_0$  ‖E‖ for $t = t_0 + T/4$ Positions of hot spots (HS_i) close to the end of spiral arms 

HPBW ≡ Half Power Beam Width

[2] All measurements provided above were performed at the following conditions:
- Temperature of 22 ± 2 °C — Pressure of 985 ± 15 hPa — Relative humidity of 55 ± 20 %
- DUT warm up time of 30 min — Test equipment warm up time of 1 hour

High Voltage: E-field generated by a lightning

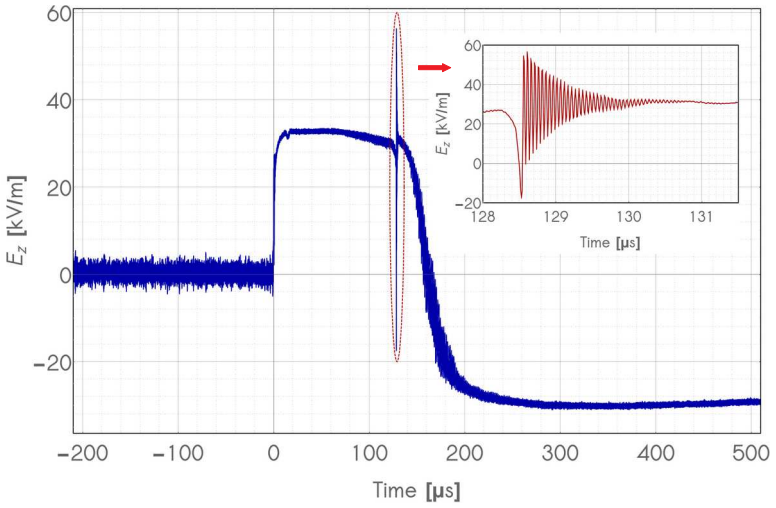
- single-shot measurement
- absolute measurement of vertical E-field component
- ~3-m long electric arc in a tip-plane configuration
- probe to electric-arc distance ~ 0.5 m
- 100 MS/s sampling rate

Probe: **EL5-air**

Converter: **LF**

Digitizer: **RTO**[3]

E-field source: **lightning** test bed (1 MV, 40 kA)



Plasma: Time-resolved 2D E-field vector mapping in a plasma plume

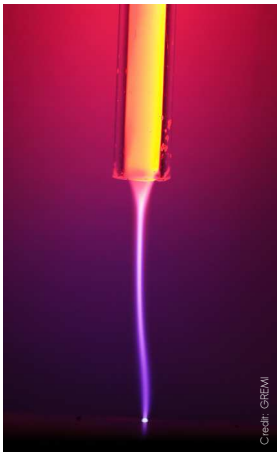
- spatial sampling: 2 mm
- absolute measurement of the E-field vector projection on a plane
- repetitive signals
- E field strength up to 4.5 MV/m
- E field polarity reversal at 0.5 µs

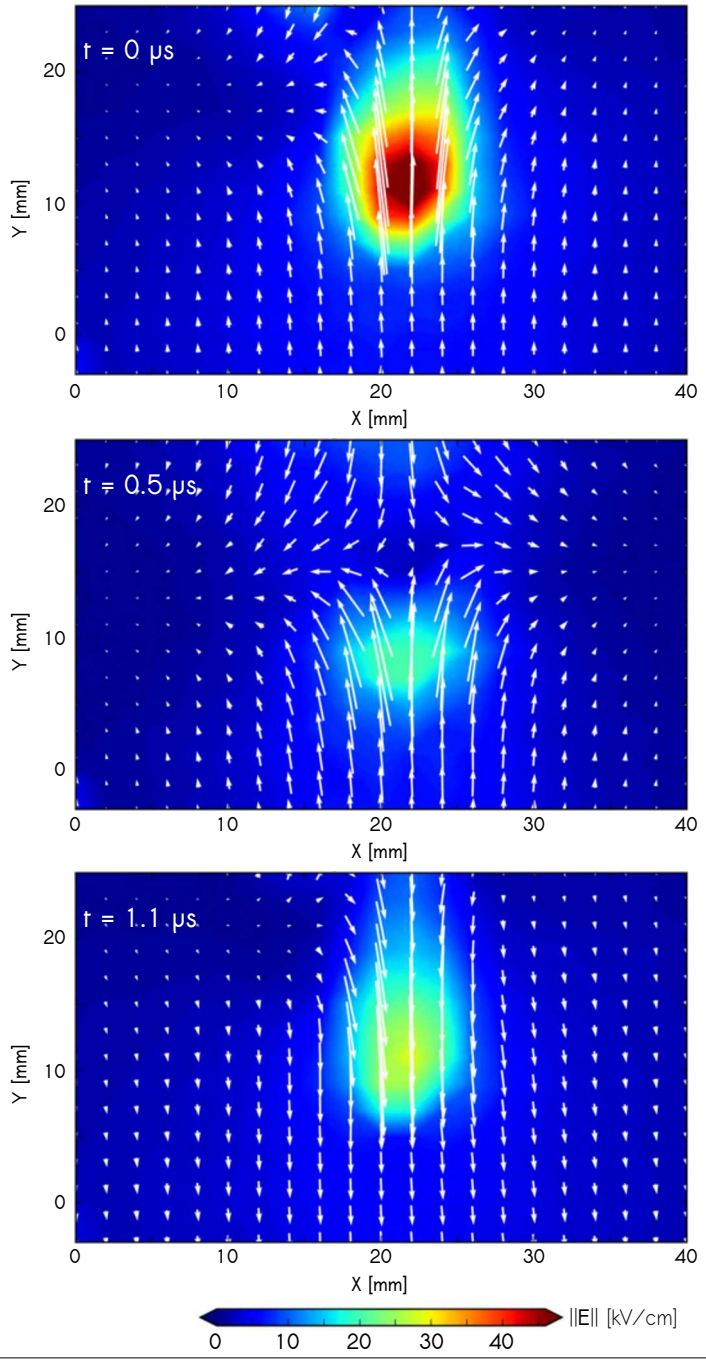
Probe: **ET1-air**

Converter: **MF-CP**

Digitizer: **DSO**

E-field source: **plasma**

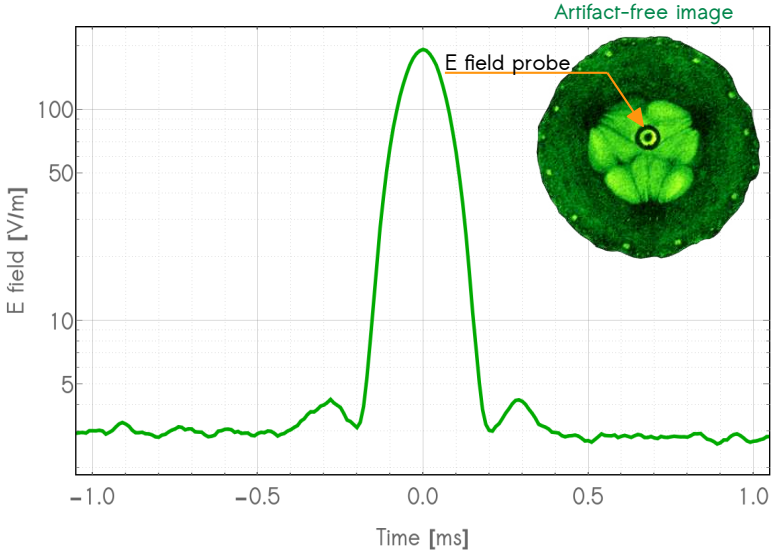
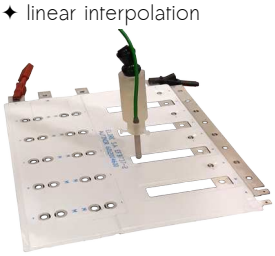
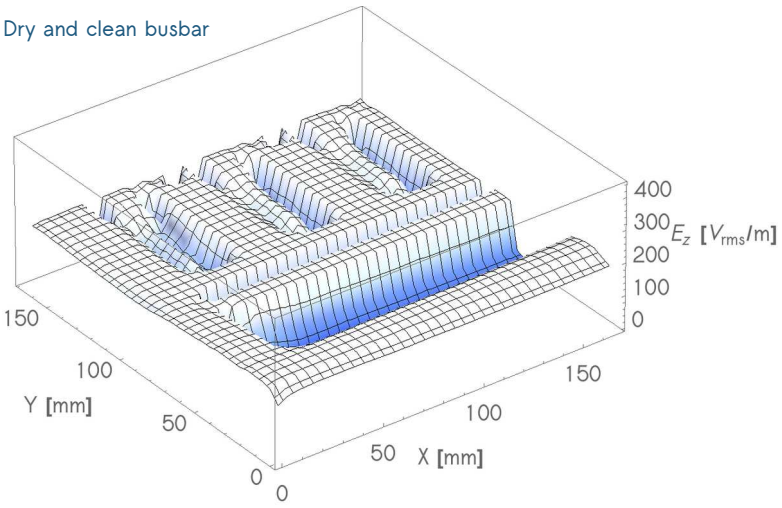
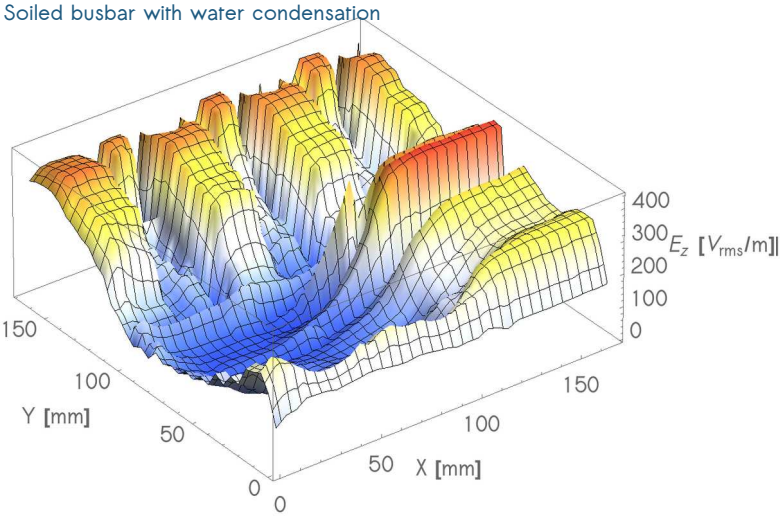




Credit: GREMI UMR7344 CNRS/Univ. Orléans

[3] RTO ≡ Real-Time Oscilloscope

TYPICAL CHARACTERISTICS

Application	DUT and Conditions[2]	Measurement
MRI: E-field measurement inside cucumber @ 4.7 T ✦ 200 MHz freq. carrier ✦ MRI FLASH sequence ✦ envelope measurement using spectrum analyzer ✦ RBW = 100 kHz ✦ E-field component perp. to cucumber axis  RBW ≡ Resolution Band Width	*Probe:* ET5-bio *Converter:* MF *Digitizer:* ASA + DSO *E-field source:* **birdcage antenna** for 4.7 T MRI	Artifact-free image 
EMC: Pollution & aging effects on laminated busbar ✦ pixel size: 5 mm x 5 mm (see black mesh) ✦ rms E-field strength from 0 V_{rms}/m (blue) to 430 V_{rms}/m (red) ✦ linear interpolation 	*Probe:* EL5-air *Converter:* LF *Digitizer:* DSO *E-field source:* **50 Hz mains voltage** (500 V_{rms})	Dry and clean busbar  Soiled busbar with water condensation 

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