



# Electron Paramagnetic Resonance

- Solutions for Life Science and Analytical Research

# ELEXSYS-II E780

## The World's First Commercial mm-wave 263 GHz EPR Spectrometer

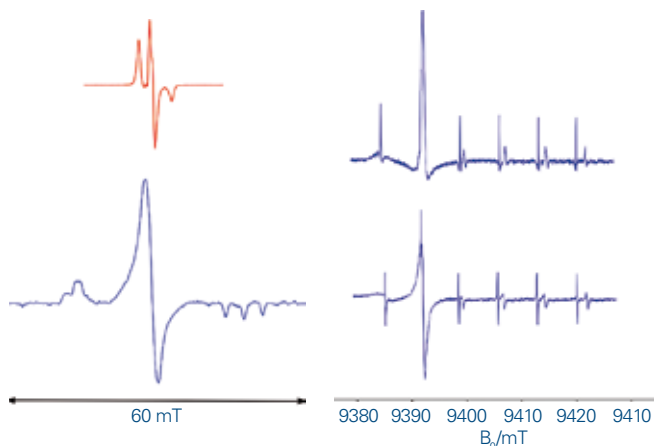


Bruker BioSpin has pioneered the world's first commercial mm-wave 263 GHz EPR spectrometer, ELEXSYS-II E780, representing a first step for Bruker's EPR division into quasi-optical microwave technology. It incorporates a unique superconducting magnet that can be ramped up to 12 T and is combined with new probe technology for optimum sensitivity, even on large samples up to 5 mm. Based on the well-proven Bruker ELEXSYS concept it provides multiple turn-key operation modes including, CW-, Pulse-EPR, ENDOR and ELDOR, thus enabling research groups for the first time, to routinely use very high frequency EPR technology.

### Features

- Enables mm-wave very-high field EPR at 263 GHz
- Quasi optical front-end featuring reflection and induction detection
- Superconducting EPR magnet incorporating 12 T main coil and 0.2 T sweep coil
- Multiple turn-key operation modes including CW-, Pulse-EPR, ENDOR and ELDOR
- High-sensitivity single mode resonator
- Non-resonant probe for samples up to 5 mm
- Variable sample temperature from 4 to 300 K
- Safe and robust operation
- Runs routine software package Xepr

### 263 GHz Examples



Tempol in polystyrene,  
2 mW microwave power,  
modulation 10 G / 100 kHz,  
 $5 \times 10^{15}$  spins

$Mn^{2+}$  in CaO, dispersion (top)  
and absorption (bottom) signal,  
sample volume 80  $\mu$ l, microwave  
power 0.2 mW, modulation  
1 G / 100 kHz

## ELEXSYS-II Series

### Redefining research level EPR

Introduced in 1997 the ELEXSYS has become the renowned research platform for modern EPR. Over the years a constant technical evolution has assured to keep track with new emerging demands of the EPR society. The second generation of the pulse devices SpecJet-II and PatternJet-II have been launched in 2006 and just recently DICE-II has become available.

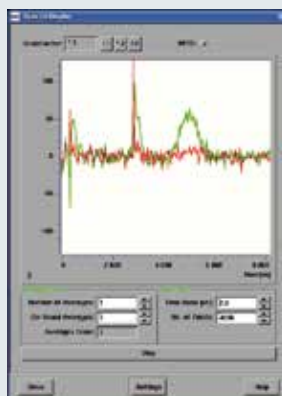
Yet another major development step has now created ELEXSYS-II. The OS9 acquisition server has been replaced and the SuperX microwave bridge has been redesigned with improved specifications. The new multi-purpose signal processing unit (SPU) plays a central role in the expanded capabilities of the ELEXSYS-II, replacing the signal channel, fast digitizer, and rapid scan with a single integrated unit offering unprecedented performance and specifications.

### ELEXSYS-II: The only commercial spectrometer series which covers all EPR techniques

	L-Band	S-Band	X-Band	K-Band	Q-Band	W-Band	mm-wave
CW-EPR	•	•	•	•	•	•	•
FT-EPR	•	•	•	•	•	•	•
CW-ENDOR			•		•		
Pulse-ENDOR			•		•	•	•
Pulse-ELDOR	•	•	•	•	•	•	•
Imaging	•	•	•				
Saturation recovery	•	•	•		•		
Rapid scan	•	•	•	•	•		
Transient EPR			•		•	•	
ODMR			•		•		

### A Complete System

The ELEXSYS-II E780 is equipped with a quasi-optical front-end, featuring reflection and induction detection with safe and robust operation. The front-end is interfaced with a single mode resonator for highest sensitivity, and with a non-resonant probe featuring a larger diameter for samples up to 5 mm, both of which allow low temperature measurements down to 4 Kelvin. As with all other ELEXSYS systems, the E780 is driven by the proprietary Intermediate Frequency (IF) concept for optimum phase stability and pulse precision, and runs the Bruker software package Xepr, for routine and assisted expert workflows.



Spin echo of the E' center in quartz:

- Single shot
- Non-resonant probe
- Pulse sequence: 0.7-2-0.7 us

### Very High-Field EPR Magnets

The ELEXSYS-II E780 is based on a unique superconducting magnet with specifications that match the needs of very-high field EPR applications.

- Vertical field
- 89-mm bore
- Main field 0–12 T in < 100 min (21 bit)
- Homogeneity 10 ppm in 10 mm dsv
- High-resolution sweep coil (19 bit)
- High-resolution range 0.2 T



Quasi optical front-end of ELEXSYS-II E780

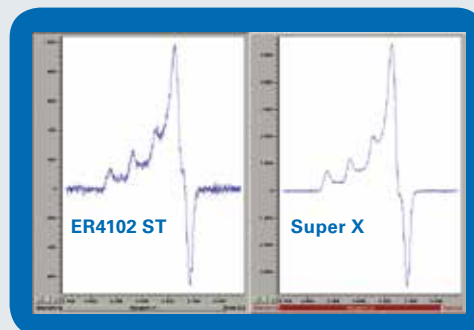
# ELEXSYS-II E500 CW-EPR

## SuperX: an ELEXSYS feature for the ultimate sensitivity in CW-EPR

The X-Band ELEXSYS instruments are equipped with the SuperX feature. SuperX comprises a selected high-power, ultra-low-noise Dual-Gunn source, and the super-high-Q cavity. The combination of these devices has resulted in an order of magnitude increase in sensitivity for CW-EPR in X-band. As one measure for sensitivity we specify a weak-pitch signal-to-noise of 3000:1 for the E 500 CW-EPR spectrometer.

## Xepr for experiment design and data handling

Unprecedented flexibility and ease of use are the attributes of the Xepr software. Whether you are dealing with a simple CW experiment or a complicated multiple-resonance 2D experiment, the graphical user interface of Xepr ensures easy instrument control, experiment definition and execution. .



Cu<sup>2+</sup> histidine at 20 K and 20 dB power

## E 500 Accessories

- Teslameter
- Field-Frequency lock
- N<sub>2</sub> and Helium VT systems
- automated goniometer
- DICE-II ENDOR system
- microwave frequencies from L- to W-Band
- numerous dedicated probeheads
- large selection of magnet systems

## E500 Highlights

- SuperX microwave units of world record sensitivity
- rapid scan module
- stationary and time resolved experiments
- multi purpose signal processing unit
- reference free spin counting

Standard super-high-Q cavity for ELEXSYS Systems



# ELEXSYS-II E580 FT/CW

Pulsed EPR was initially the pride of selected laboratories until a real breakthrough was made by Bruker with the introduction of the ESP380 spectrometer in 1987. This event marked the beginning of a new era and set the standard for all future technical developments in EPR. The new generation of ELEXSYS-II FT/CW spectrometers has now been extended in frequency range up to 263 GHz. With the recent introduction of the second generation pulse programmer and transient recorder, PatternJet-II and SpecJet-II, improvements in digital resolution and averaging capabilities have again pushed up the performance level of the E580.

## PatternJet-II

Virtually no experimental limits are imposed by the PatternJet Series of pulse programmers. Designed for the needs of EPR this pulse programmer features a dynamic range of  $10^9$ , i.e. ns resolution over a time scale of up to one second. The well established concept of our first generation PatternJet has been

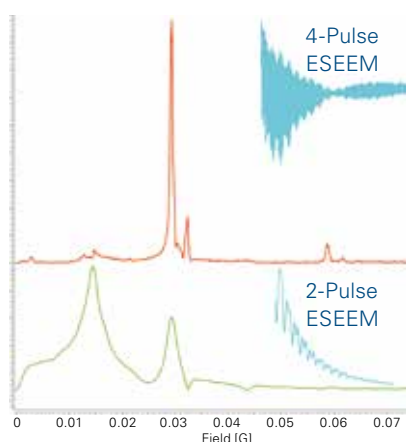
technically enhanced and carried on to the second generation PatternJet-II. A 1 GHz clock, ultra low jitter and increased memory size are the cornerstones for a further increase in experimental flexibility and precision in data acquisition.

## SpecJet II

With the first generation of SpecJet a dramatic improvement in pulse-EPR sensitivity could be achieved by high-speed signal averaging. The SpecJet-II now further enhances the abilities to capture fast and short lived transient signals. The real time display of the averaged echo/FID can now be toggled between time and FT mode and greatly facilitate spectrometer handling and signal optimization. With a sampling rate of up to 1 GHz and a pulse programmer with 1 GHz clock, the SpecJet-II is the perfect partner for meeting the evolving needs of pulsed EPR.



## ESEEM Application



Numerous ESEEM sequences are available for increased sensitivity and resolution: 4-pulse (top) vs. the 2-pulse (bottom) ESEEM spectrum of powder spin label.



# ELEXSYS-II E540 System

Biomedical research by EPR imaging is a rapidly growing field. Bruker's response to this development is the E540. Based on the proven ELEXSYS architecture, this instrument operates at 1 GHz and provides the seamless integration of imaging techniques into EPR spectroscopy. The imaging accessory can also be adapted to an X-band spectrometer for material science applications.

## Gradient and Magnet System

EPR imaging uses continuous microwave irradiation and stepped field gradients in 3 dimensions. The 3D gradient coils provide up to 40 G/cm and are mounted on the pole faces of a dedicated L-band magnet or an X-band magnet.

To assure optimum performance, we have developed a variety of probes dedicated to specific applications.

## E540R23

This probe has an access diameter of 23 mm, assuring a high-filling factor (sensitivity) for "small" animals.

## E540R36

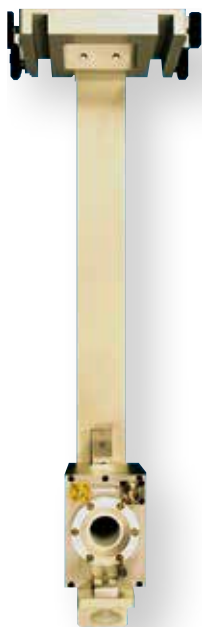
This probe has an access diameter of 36 mm and is well suited for whole body mice and rat brain applications. An electronic matching control compensates effects from animal motion.

## E540SC

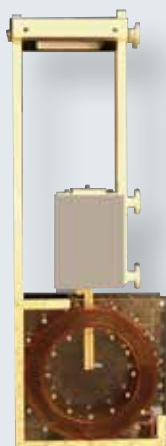
The surface coil is designed for localized spectroscopy with or without magnetic field gradients. An electronic auto-matching and auto-tuning circuit assures ease of handling and compensates the undesired effects of animal movement during data acquisition.

## Imaging Software

The graphical user interface provides a comprehensive, easy-to-use software package for all aspects of EPR imaging in 3 dimensions as well as spectral-spatial imaging in 4 dimensions. The ImageViewer supports further analysis and visualization of the images, and the oximetry software package allows precise determination of tissue oxygen levels.



E540R23



E540SC



E540R36



# ELEXSYS-II Multi-Frequency

Multi-frequency EPR is commonly understood in terms of its relation to CW-EPR spectroscopy. Bruker's commercial Multi-frequency/Multi-resonance EPR covers both, CW-EPR and FT-EPR as well as Pulse-ENDOR and Pulse-ELDOR at a multitude of microwave frequencies. Thanks to the ELEXSYS platform design and the advantageous intermediate frequency (IF) concept, every ELEXSYS spectrometer can be expanded for state-of-the-art multi-frequency experiments; now and in the future. All features of the X-Band CW/FT microwave bridge are transferred to the new operating frequency. For each frequency band a dedicated probe provides a maximum of sensitivity and ease of use.

## High-Frequency/High-Field EPR and ENDOR at 94 GHz

The ELEXSYS family of EPR spectrometers includes two W-band systems, the E600 and E680. The former is optimized for CW-EPR experiments at 94 GHz, while the E680 operates in both CW and FT-mode.

The variable-temperature W-band TeraFlex probehead operates from 4 K to 300 K. This resonator is available as an EPR and EPR/ENDOR version. Samples can be exchanged at any temperature.

## 6 T EPR SC

The second generation of W-band superconducting magnet features a horizontal field, a main coil with 6 T sweep range, permanent leads and a 2000 G high-resolution sweep coil. Easy and safe operation is accomplished conveniently by software only, which allows switching between the two operation modes just by a mouse click.

## SuperQ-FT

One building block, introduced in 2002, is called SuperQ-FT, a Pulsed EPR microwave bridge operating at Q-band (34 GHz). The SuperQ-FT can be configured as a stand-alone unit or as an upgrade for an X-band E580. The ER5107D2 resonator is available as an EPR and EPR/ENDOR version.



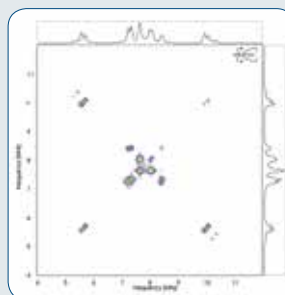
W-band magnet

## SuperL-FT

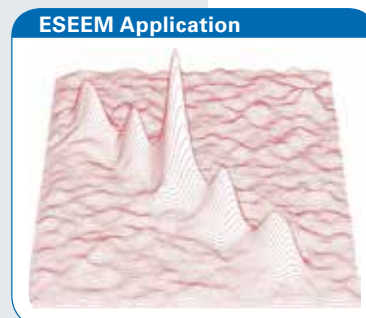
The Bruker IF Concept not only allows to up convert to higher frequency but also to down convert to a lower operating frequency. This is realized for the first time with the CW/FT microwave bridge SuperL-FT. Combined with a local oscillator at 8.5 GHz, all features of the X-Band CW/FT microwave bridge are transferred to a frequency range of 0.8 – 1.4 GHz.

## SuperS-FT

The latest addition to our IF multi-frequency pulse-EPR suite operates in S-band (3.4 – 3.8 GHz) in CW and pulse mode. The SuperS-FT is available as an add-on to an X-band E580 spectrometer for X/S dual band operation.



$^2\text{H}$  Q-Band single crystal HYSCORE



S-Band HYSCORE of BDPA

# Multi-Resonance Accessories

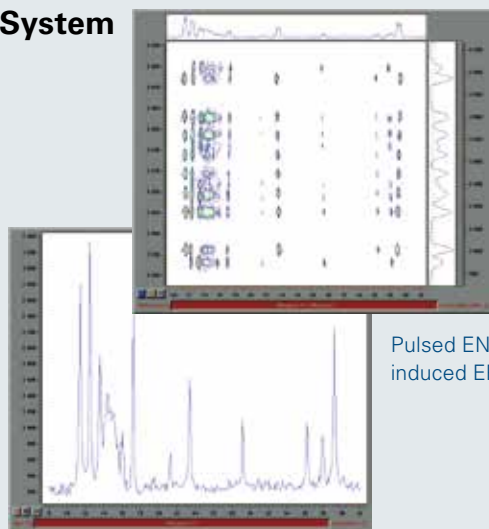


Flexline  
Pulse-ENDOR  
Resonator  
EN4118X-MD4

## E560D-P DICE-II Pulse-ENDOR System

The DICE unit has been the cornerstone of pulse-ENDOR applications over many years. Now the second generation, DICE-II, has been developed with numerous enhanced specifications. To mention just one, the frequency range is 1 - 650 MHz covered by two bands.

DICE-II supports all known pulse-ENDOR and related techniques and in addition opens the way to new applications and pulse sequences. Multi-frequency pulse-ENDOR is supported by probeheads in X-, Q-, W- and mm-wave-band .



Davies ENDOR spectrum

## E580-400 Pulse-ELDOR unit

Electron-Electron Double Resonance (ELDOR) has become a major tool in EPR applications over the last few years. The E580-400 ELDOR unit is available as an accessory to the E580 FT/CW-EPR system and transfers to all other bands generated by the IF concept.

### Typical experiments that can be performed with the ELDOR unit:

- Saturation Recovery ELDOR to measure molecular dynamics
- ELDOR-detected NMR to measure the ENDOR-equivalent nuclear-spin spectrum
- DEER to measure electron-electron spin distances
- Hyperfine Selective ENDOR to correlate the ENDOR and hyperfine spectrum



### Specifications

- Digitally controlled solid-state microwave oscillator
- Frequency range of 800 MHz
- Pulse switching unit with 80 dB isolation
- Amplitude control with 30 dB dynamic range
- Fully software controlled

In order to make full use of the 800 MHz frequency range the ELDOR unit is complemented by the ultra broad band Flexline resonator series.



# EMXplus

## The foundation of EPR

The EMXplus is the next generation of Bruker's successful EMX spectrometer line, well-known for its premium performance in CW-EPR research. The design of the EMXplus reflects its dedication to the heart of the matter: rapid and high-quality data.

Simply power-on the EMXplus and start your EPR journey. Following self-validation procedures, the EMXplus is ready to use via Bruker's WIN-ACQ software.

## The Perfect Duo I

The Signal Channel and Field Controller work together seamlessly to provide practically unlimited resolution on both axes: field and signal intensity.

## The Perfect Duo II

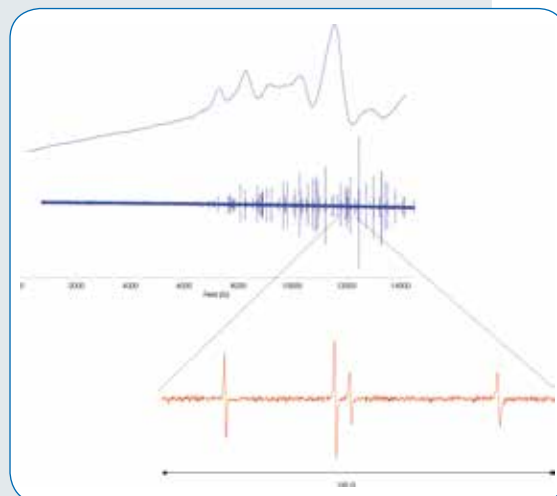
The EMXplus Signal Channel now offers two detection channels in one. Simultaneous quadrature and 1st & 2nd harmonic detection schemes are just a mouse click away.

## Accessories & Options

- The PremiumX microwave package for enhanced sensitivity
- The Variable Temperature Controller can be incorporated into the EMXplus console
- The ER036TM Teslameter ensures precise g-factor determination in combination with the integrated microwave counter
- The EMX-ENDOR package allows CW-ENDOR experiments to be performed on EMXplus Systems
- The full range of microwave frequencies from L- to Q-Band



## Ultra-high-resolution over large sweep

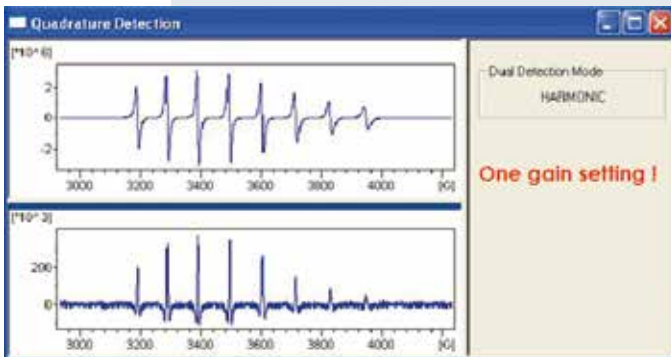


The spectra show oxygen in air at ambient pressure (top) and reduced pressure (middle) measured at Q-Band. A sweep range of 14 kG was recorded with 180000 points, resulting in a resolution of 80 mG, sufficient for the line width of 300 mG at reduced pressure.

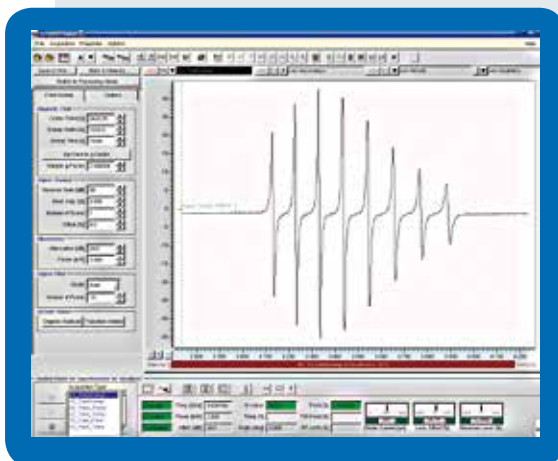
# EMX*micro*

The EMXmicro completes the EMX family and features an electronics cabinet with the footprint of a PC tower. The instruments micro cabinet can be combined with all electromagnets and microwave bridges from L- to Q-Band.

The standard software of the EMX series for data acquisition and processing is provided by WinACQ and WinEPR



Dual-mode simultaneous detection of 1st and 2nd harmonic EPR spectrum of a vanadyl sample



Xenon user interface

## Xenon

This new software package is an option for the EMXmicro/plus series. It features a Linux® front end PC with a new graphical user interface integrating acquisition and processing in a user friendly environment. Xenon features numerous novel tools for data acquisition and processing, e.g. the direct spin counting method without reference sample.

# e-scan

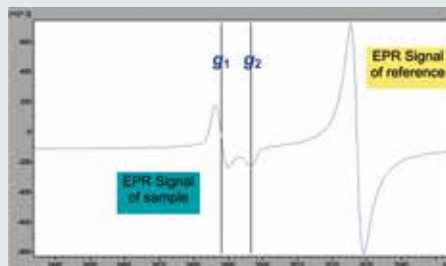
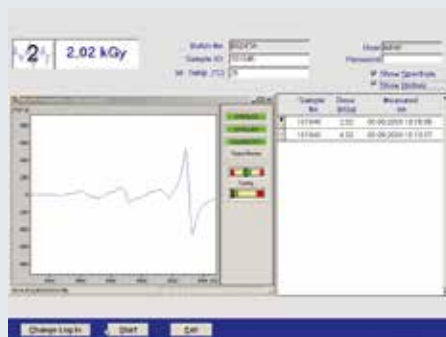
Bruker BioSpin's e-scan product line of table-top EPR (ESR) readers offer dedicated and tailored turn-key systems for specific Quality Control applications as well as systems for medical and pharmaceutical R&D applications of Reactive Oxygen Species (ROS) and Reactive Nitrogen Species (RNS). All e-scan systems have been designed for and have proven rock-solid in 24/7 operation with the best possible price-performance ratio available today.

## A few example applications fields for e-scan:

- Irradiation Dosimetry with Alanine Dosimeters (ISO/ASTM method)
- Food Irradiation Control (EU standard methods)
- Beer Shelf Life: flavour stability and antioxidant stability (patented application)
- Biomedical EPR research: ROS and RNS detection and quantification



e-scan food control inserts (left) and the cavity template. (right).



EPR spectrum of an irradiated chicken bone recorded with the e-scan Food Analyzer.



# Bruker BioSpin, your Solution Partner

Bruker BioSpin provides a world class, market-leading range of analytical solutions for your life and materials science needs.

Our ongoing efforts and considerable investment in research and development illustrates our long-term commitment to technological innovation on behalf of our customers. With more than 40 years of experience meeting the professional scientific sector's needs across a range of disciplines, Bruker BioSpin has built an enviable rapport with the scientific community and various specialist fields through understanding specific demand, and providing attentive and responsive service.

Our solution-oriented approach enables us to work closely with you to further establish your specific needs and determine the relevant solution package from our comprehensive range of instruments, or even collaborate with you on new developments.



● **Bruker BioSpin**

epr@bruker-biospin.de  
epr@bruker.com  
www.bruker-biospin.com