

# New Series of NMR Spectrometers JNM-ECZ

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## Introduction

New NMR spectroscopic methods continue to be developed for many different purposes, particularly for research. However, to achieve good results, the complex pulse sequences often require high precision RF control depending on the application or properties of the samples to be analyzed. At the same time, the demand for routine NMR measurements, for example in the fields of quality control and simple analysis, is remarkable, thus leading to requests for NMR to be a more 'user-friendly' technique.

Older, conventional NMR systems used analog technologies that would have led to relatively large instruments. However, the use of digital technologies has been advancing and this has enabled development of next-generated NMR systems with increased functionality, higher performance and greater expandability as well as providing improved general versatility.

In order to meet these demands and to anticipate future development of NMR measurements, JEOL RESONANCE Inc has developed a new NMR system, the JNM-ECZ series (\* Notice). Building on the experience of the JNM-ECAII/ECXII/ECS series, the JNM-ECZ series uses fully integrated cutting-edge digital technologies. In this report, some of the hardware features of the JNM-ECZ spectrometers (ZETA) are introduced.

## ECZ Series Spectrometers (NMR Spectrometer ZETA)

The ECZ series of spectrometers are equipped with Smart Transceiver System (STS), a new technology which achieves high-precision digital RF thus giving performance which greatly surpasses that of currently existing spectrometers. The basic design will enable the spectrometers to operate at ultrahigh frequencies exceeding 1.2 GHz. The high quality

performance is complemented by the cutting-edge design in black.

The ECZ spectrometers are controlled by the built-in Spectrometer Control Computer (SCC), and the SCC is controlled by the host computer connected through an Ethernet link. The host computer provides the direct user interface, but the SCC can operate stand-alone. This prevents the danger of measurement omission should a communication problem occur between the SCC and the host computer. The SCC incorporates a large memory and hard disk, thus emphasizing the secure reliability of the pulse-programmed and measured data.

## Two "Z" (ECZR/ECZS Series Spectrometers)

There are two spectrometers in the ECZ series. The spectrometers have customized features to meet different application needs.

### ECZR series spectrometer (Fig. 1)

The high-end model ECZR spectrometer is configured primarily for a research oriented workplace. With a highly flexible and expandable configuration to meet the demands of various NMR measurements, the ECZR is compact compared to currently available spectrometers, and achieves overwhelming performance.

### ECZS series spectrometer (Fig. 2)

The entry model ECZS spectrometer has the same basic functions, performance and capability of the ECZR spectrometer. Furthermore, the ECZS spectrometer is even more compact than the ECZR spectrometer and offers good general versatility. The main console of the ECZS spectrometer is amazingly small, less than 1/2 that of the current ECS series spectrometer.

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Fig. 1 ECZR series spectrometer (JNM-ECZ500R).



Fig. 2 ECZS series spectrometer (JNM-ECZ400S).

## STS (Smart Transceiver System)

The ECZ series spectrometers build on the highly successful system architecture of the ECAII/ECXII/ECS series spectrometers but are equipped with a highly advanced STS (Smart Transceiver System) developed using cutting-edge digital technologies. STS allows the construction of high-precision RF control with high-speed digital circuits mounted on a small logic device. Because of this, the ECZ series dramatically improves the digital functions and performance of the RF transmitter & receiver system. In addition, the ECZ series utilize a compact spectrometer that integrates the basic functions of the conventional NMR system into one board (Fig. 3).

### Multi-sequencer control

Each DDS (Direct Digital Synthesizer) for the RF transmitter & receiver system is independently controlled at high speed by the respective slave sequencers. This independent control by the slave sequencers is comprehensively managed by the master sequencer. This mechanism allows for highly flexible control, thus allowing the creation of versatile pulse sequences. For example, the ECZR series spectrometer can control over 30 sequencers,

that is, more than 3 times those of the ECAII series spectrometer. Thus, the ECZR series will be able to support many kinds of measurement methods that may be required in the future.

### High-precision digital control

The time resolution for each of frequency modulation, phase modulation and intensity modulation, which are simultaneously and independently controlled as digital RF signals by the sequencers, is as small as 5 ns. This ultimate high time resolution allows for the control of a duration (modulation time width) of 5 ns (minimum). This corresponds to approximately 10 to 20 times improvement when compared to that offered by currently available spectrometers. Moreover as each characteristic is accurately controlled, the overall performance is also improved (Fig. 4). This improved digital-control performance further enhances the effectiveness of phase and intensity modulation pulses such as adiabatic pulse schemes (frequently used nowadays). Also in order to make measurements requiring ultra-high speed control, e.g. in recent solid-state NMR, the STS of the ECZ spectrometers provides high accuracy in controlling the gate signals and the external input & output trigger signals.

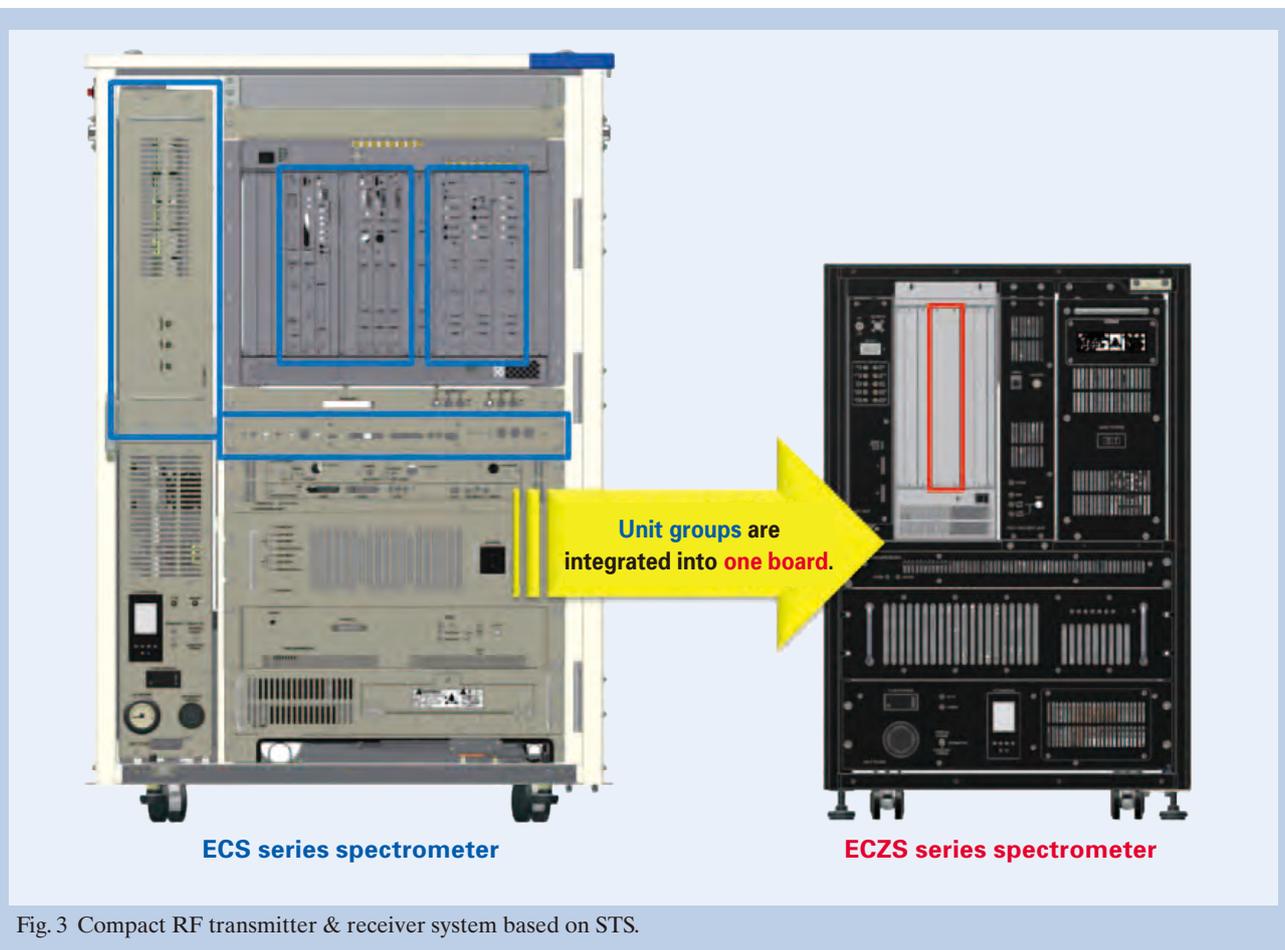


Fig. 3 Compact RF transmitter & receiver system based on STS.

## Digital RF control

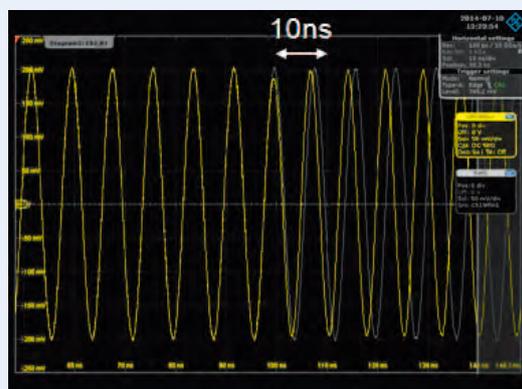
In this system, conventional RF oscillation and transmission functions are highly integrated. The new RF system can output up to 4 different frequencies for each RF transmitter channel. In addition, an expansion of the variable frequency offset range allows the ECZ spectrometers to support complicated measurements such as simple triple resonance within the standard configuration. The RF detection system is equipped with a sequencer control function comparable to that of the RF oscillation system. This makes it possible for the ECZ series spectrometers to carry out dynamic modulations of frequency and phase with or without synchronism, thus implementing important cutting-edge solid state NMR methods which have recently been published. In addition, DQD (Digital Quadrature Detection) provides a way to reduce artifacts including QD (Quadrature Detection) image and the centre 'spike' at 0 Hz, therefore, the improved digital RF control of the ECZ spectrometers makes the analysis of NMR spectra clearer.

## Analog RF control

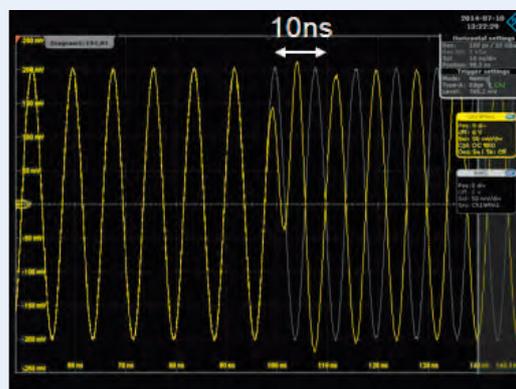
In the RF transmitter & receiver system, a hybrid system that combines under-sampling with super-heterodyne and over-sampling with direct conversion is achieved using a high-speed D/A (Digital to Analog) converter operating at 800 Msps and high-speed A/D (Analog to Digital) converter operating at 100 Msps. This makes the transmission and receiving efficient depending on the RF signals and linked by an optimized filtering mechanism.

## PFG control and Digital-lock control

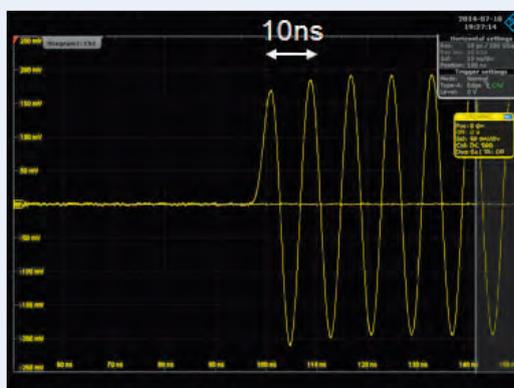
STS is also used for both PFG (Pulse Field Gradient) and lock control, and provides digital high performance comparable to that of oscillation and detection of RF signals. In particular, the ECZ spectrometers allow for lock-control with higher precision and better flexibility provided by a lock-feedback mechanism based on digital control technologies. This digital-control design enables the ECZ spectrometers to provide magnetic-field correction according to the environment of the



Frequency modulation (0 to 10 MHz)



Phase modulation (0 to 180 degrees)



Intensity modulation (0 to 100%)

Fig. 4 RF waveforms generated by modulation control.

instrument and samples. The ECZ spectrometers can also use the lock transmitter & receiver system in application measurements.

## Touch panel display (Head amplifier chassis)

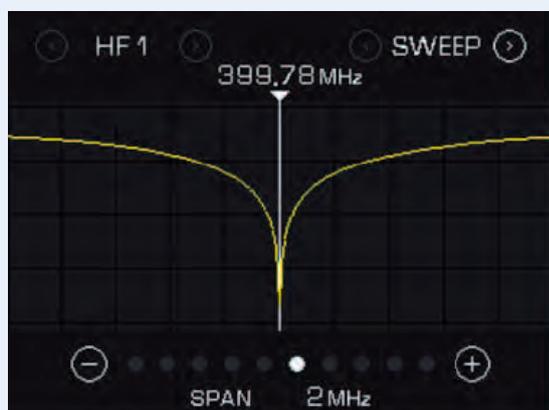
The head amplifier chassis displays functions related to the super conducting magnet (SCM) and the probe mounted in the SCM. On top of the head amplifier chassis, a large-screen (5") touch panel display is mounted, providing an intuitive multi-functional user interface. The spectrometer can display the RF reflection dip or a reflection value (bar display) during probe tuning, and the residual level of magnet cryogenics can be displayed in real time (Fig. 5). This function improves visual usability as well as operability.

## Summary

The new JNM-ECZ series of spectrometers has been developed with basic design concepts that

supports excellent functionality, high performance, are highly expandable and offer high general versatility. Furthermore, the JNM-ECZ series has extremely high potential that supports flexible applications for the future development of NMR measurements. We expect that our innovative JNM-ECZ series will meet and exceed a wide range of demands in various scientific fields and to serve in cutting-edge research around the world as well as in general-purpose analyses.

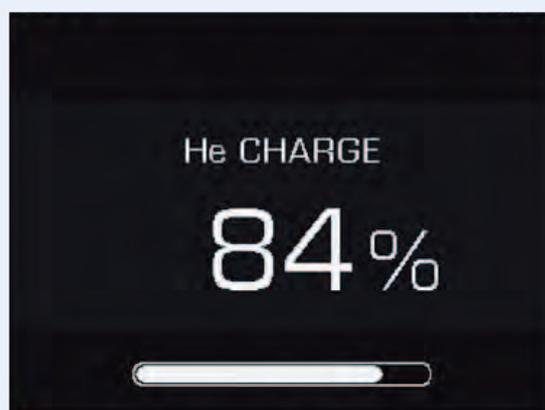
\* Notice  
Instrument specifications are subject to change without notice.



Reflection dip display



Reflection level (bar) display



Current He level display

Fig. 5 Touch panel-displays on the head amplifier chassis.