



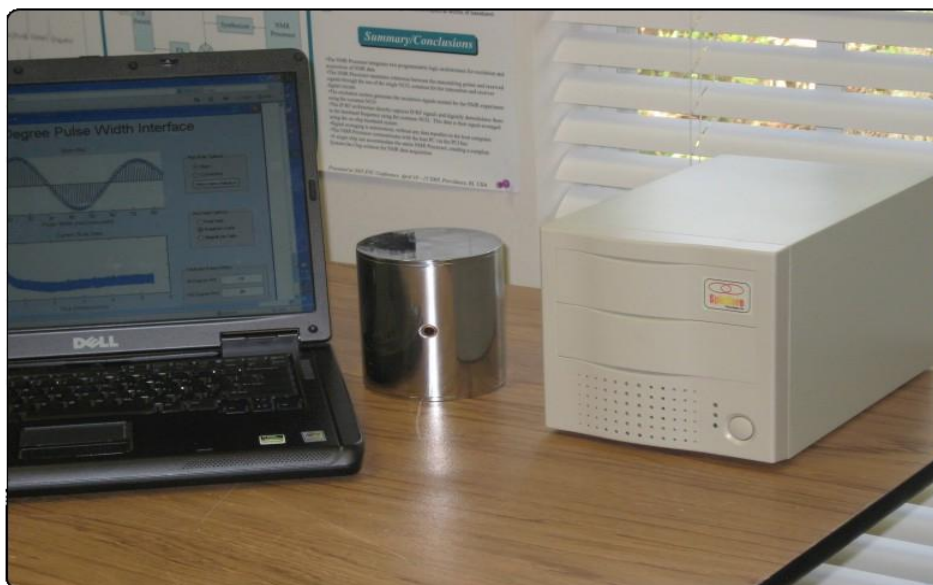
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## **iSpin-NMR™ Model GX-5**

**Part Number: GX-5-mk0 Rev1**

**Owner's Manual**

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**SpinCore Technologies, Inc.**  
<http://www.spincore.com>

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## **I. Introduction**

The iSpin-NMR™ is SpinCore's Portable Broadband NMR system. Built around the RadioProcessor board and SpinCore's NMR software, once connected to a probe the iSpin-NMR is instantly ready to perform NMR experiments from 0 to 100 MHz and beyond!\*

This manual provides all the information you need to get started with your iSpin-NMR system, and includes sections on typical applications with connection diagrams, detailed descriptions of the iSpin-NMR's internal components, connector information, testing and experiment procedures and more.

For more details about technical information pertaining to SpinCore's RadioProcessor board – the primary component of the iSpin-NMR system, responsible for all digital control and signal processing – or information about writing your own pulse programs and experiments, the user is encouraged to also read the SpinCore RadioProcessor user manual which can be found at the following location:

[http://www.spincore.com/CD/RadioProcessor/RadioProcessor\\_manual.pdf](http://www.spincore.com/CD/RadioProcessor/RadioProcessor_manual.pdf)

Should you have any questions that are not answered in either manual, please contact SpinCore Technologies, Inc. using the contact information section at the end of this document.

Thank you for choosing SpinCore Technologies, Inc. for your mobile NMR needs, and be sure to visit [www.spincore.com](http://www.spincore.com) for the latest information about SpinCore's products!

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\*Certain limitations apply (vide infra).

## **II. Warnings and Labels**

**Warning:** Use of this product in a manner other than intended can potentially cause damage to the product or result in injury or fire. Please familiarize yourself with the contents of this manual, as well as the labels on the exterior of the product enclosure prior to use. SpinCore Technologies, Inc. holds no responsibility for any damage or injury occurring as a result of product misuse.

### *Enclosure Labels Descriptions*



**CAUTION: 50 $\Omega$  Load  
MUST BE CONNECTED**

Indicates to have the need to have the properly tuned and matched probe attached at all times while operating. Failure to comply may cause damage to the equipment; however, this poses no safety risk to the user.



Indicates the protective earth ground terminal for the 100 – 240 VAC.



**DANGER:**  
High Voltage

Caution should be taken, 100 – 240 VAC present in the immediate area.

### III. Product Overview

The block diagram of the iSpin-NMR system is presented in Figure 1. The iSpin-NMR system console contains SpinCore's USB RadioProcessor board (Item #1), broadband power amplification unit (Item #2), and broadband pre-amplification unit (Item #3). The iSpin-NMR generates a NMR excitation pulse, amplifies that pulse, and then acquires data from a probe, performing digital detection, filtering and signal averaging autonomously. It connects to any PC or laptop via USB 2.0.

The iSpin-NMR system console is equipped with a universal AC input power supply (100 to 240 VAC) and consumes no more than 80 Watts. The iSpin-NMR system console is intended for operation in the range of temperatures from 15° C to 35° C. The GX-5 Magnet can operate the range of 15° C to 40° C but variations in temperature will cause changes to the field strength.

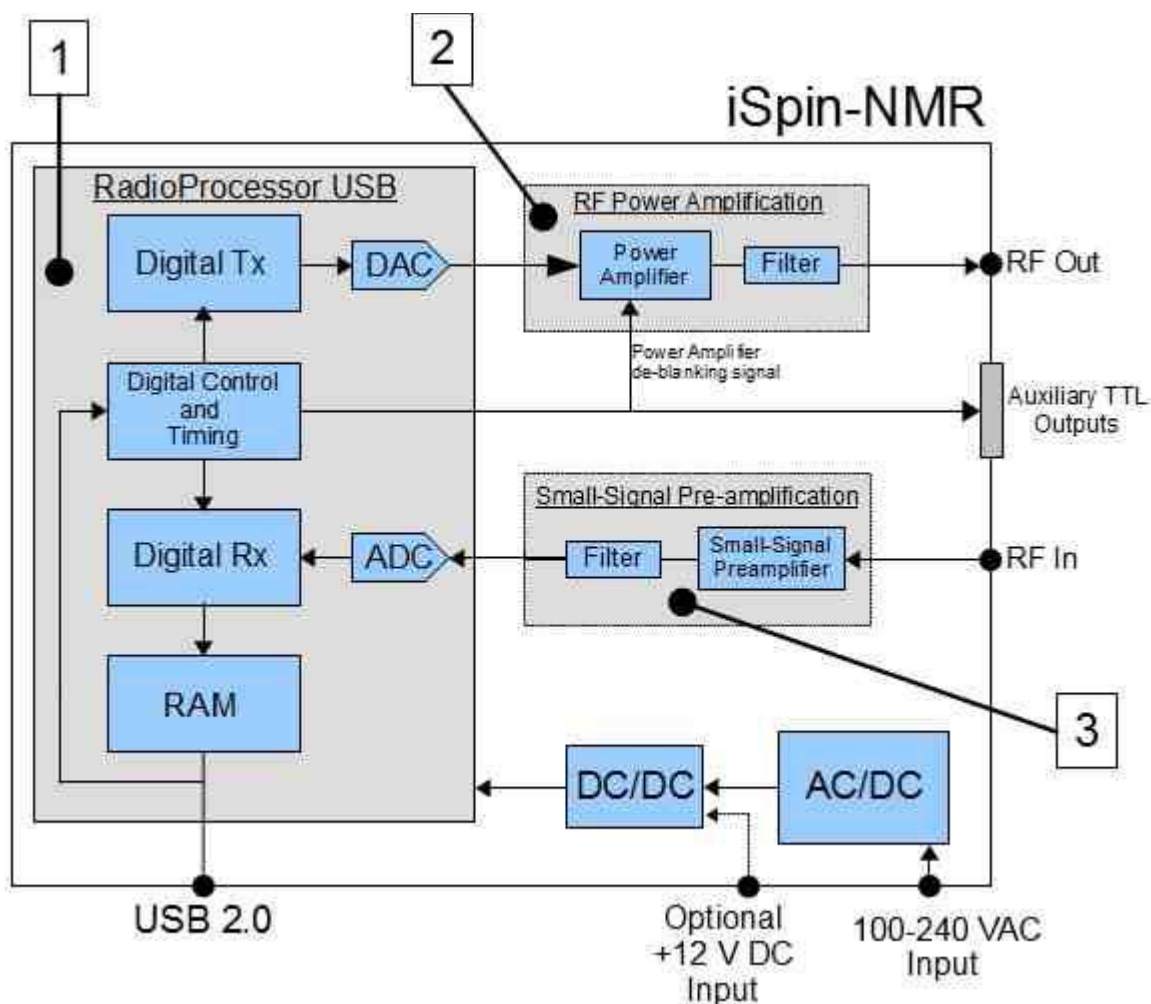


Figure 1: iSpin-NMR system block diagram.

## IV. Typical Application

The iSpin-NMR is typically used for Nuclear Magnetic Resonance (NMR), Nuclear Quadrupolar Resonance (NQR) and Magnetic Resonance Imaging (MRI) applications. The typical connection diagram for those applications is depicted below in Figure 2

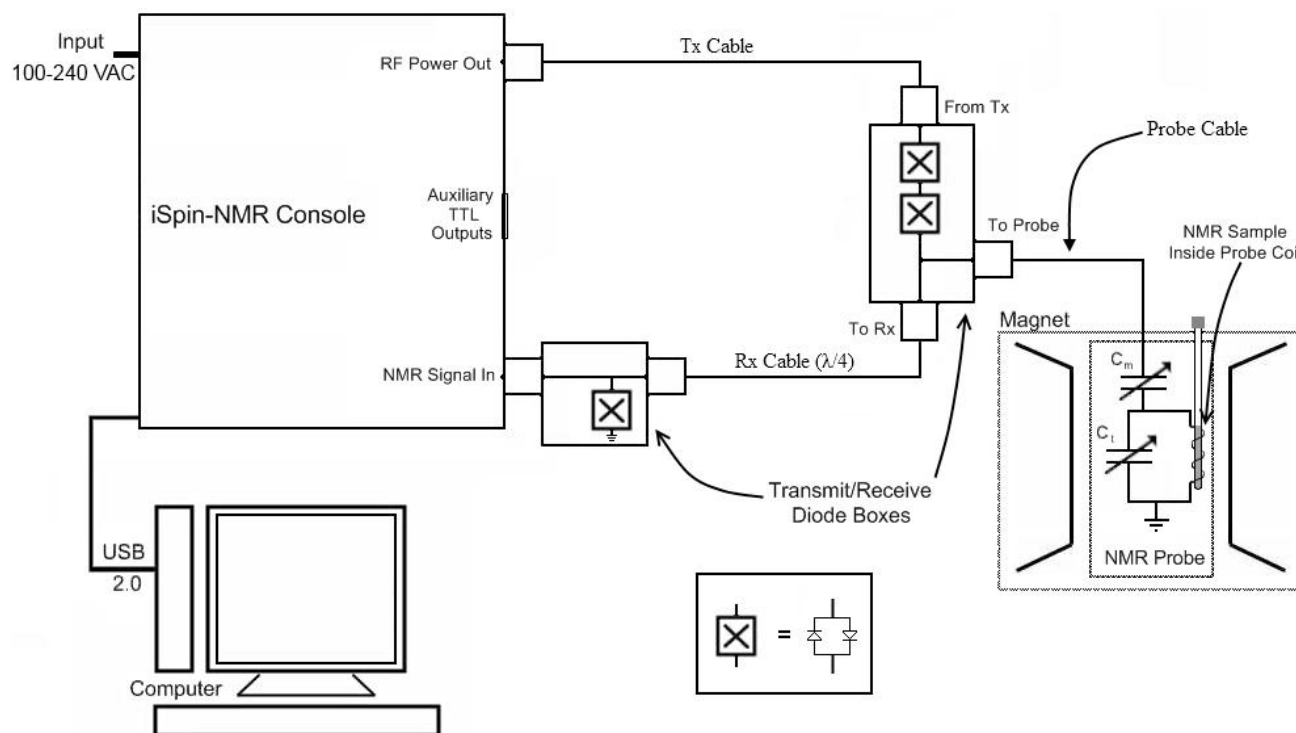


Figure 2: iSpin-NMR Connection Diagram for typical applications.

The sample being studied is placed in the RF coil (antenna) of the probe. The probe is connected to the iSpin-NMR system via the fast Transmit/Receive switch, comprised of appropriate RF coaxial cables and fast switching diodes.

The diodes and the  $\lambda/4$  cable protect the receiver of the iSpin-NMR system when excitation pulses are applied, while facilitating the isolation of the transmitter's circuitry from the receiver when acquiring the small-signal response from the sample.

NOTE: The GX-5-rev1 model iSpin-NMR system utilizes an alternative output configuration. This alternative output configuration has the switching diodes embedded within the enclosure, thus eliminating the need for a Tx cable.



## **V. General Operation Description**

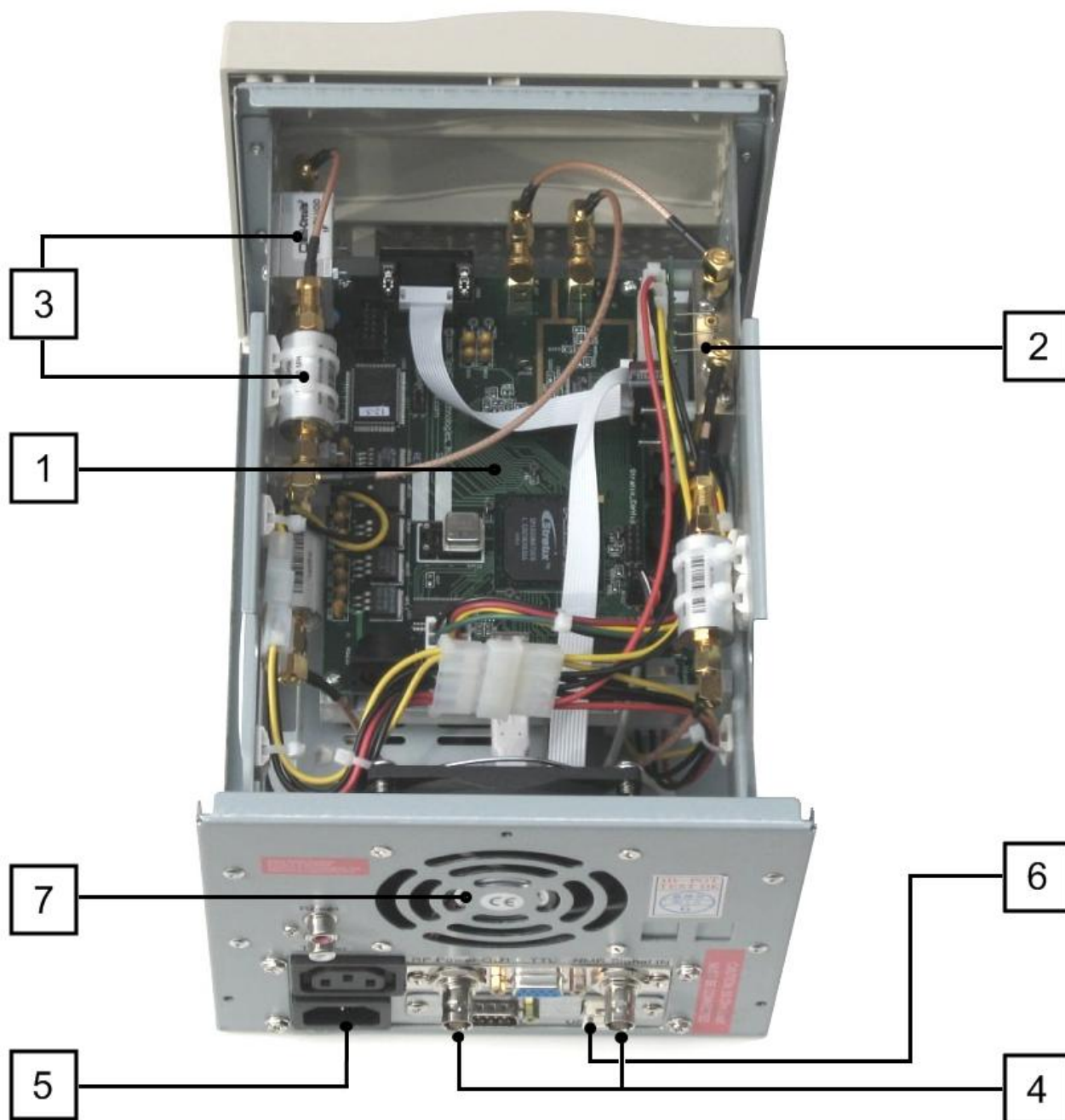
The iSpin-NMR is designed to be simple, intuitive and effective. The following is an outline of how the iSpin-NMR operates for typical NMR/NQR experiments.

1. The user inputs the necessary parameters into SpinCore's NMR GUI or alternative software program.
2. When the user begins the scan, the iSpin-NMR generates the NMR excitation pulses depending on the input parameters.
3. During specific intervals in the pulse sequence (typically after the excitation pulse in a single-pulse NMR experiment), the system will acquire the data returned from the sample in the sample probe. The iSpin-NMR system digitizes the signal and performs digital detection, filtering, and autonomous signal averaging. The processed digital values are stored on the iSpin-NMR console and are available for download to the host computer at the user's convenience.
4. Transmit/Receive Circuitry (sold as a separate component) will automatically switch between the excitation pulses and the signal input from the probe. The input signal from the sample probe is passed through a lambda-quarter cable (part of the Transmit/Receive switching circuit), fed into a pre-amplifier inside the iSpin-NMR system, and then follows to the digital receiver on the RadioProcessor board inside the iSpin-NMR system for digitization and digital signal processing.
5. The system continues to scan the specified number of times, automatically averaging the values stored on chip for each scan. Data may be downloaded to the host computer at any time for inspection, visualization, and processing, without interfering with the ongoing data acquisition. The user can download the data received from the RadioProcessor using SpinCore's NMR GUI, SpinCore's non-GUI C/C++ program, or alternative software tools.
6. NMR/NQR data are saved on the host computer in three different formats, including ASCII (plain text file) and JCAMP-DX, for post-acquisition processing, visualization, and analysis.

For a more detailed description of iSpin-NMR operation, please consult section VII, "Using the iSpin-NMR System," in this manual.

## **VI. Inside the iSpin-NMR**

A photograph of the internal components of the iSpin-NMR system is shown below in Figure 3, for descriptions of each component see the following page.



*Figure 3: Inside the iSpin-NMR system.*

## ***iSpin-NMR GX-5***

1. **USB RadioProcessor Board:** The heart of the iSpin-NMR system. The RadioProcessor board generates the completely formed excitation signals and then captures and digitally processes the NMR signals. Digital detection, filtering, and autonomous signal averaging are standard features, as well as shaped excitation pulses. For more information on RadioProcessor, including performance characteristics from 0 to 100 MHz, please visit:

<http://www.spincore.com/products/RadioProcessor/>.

The RF output of the RadioProcessor is connected to the Power Amplifier module, and the RF input is connected directly to the output of the small-signal preamplifier and filter.

2. **Power Amplifier:** Used to amplify the NMR excitation pulses. The supplied Power Amplifier is broadband, and is able to supply continuous power at the desired frequency of operation. There are several available power amplifiers: the PA10W, capable of supplying 20 Watts Peak Envelope Power, the PA15W, capable of supplying 30 Watts Peak Envelope Power, and the PA75W, capable of supplying 150 Watts Peak Envelope Power. For more information, please visit <http://spincore.com/products/RFPA/>. If higher power is needed, a final Power Amplifier stage can be provided with output power ranging from 100 to 1000 Watts. Please contact SpinCore for more details.
3. **Preamplifiers and filters:** The supplied preamplifiers are broadband, 1-200 MHz, and provide ~60 dB gain. The preamplifiers are supplemented with band-pass (or low-pass) filters. When ordering, please specify your frequency of interest for the selection of appropriate filters.
4. **Input and output RF connectors:** SMA Connectors are used for RF signals, connecting with the Transmit/Receive Circuitry. An additional DB-9 type connector is used to output TTL signals for multi-system synchronization or control of any required peripheral devices.
5. **Universal AC Power Supply:** (TDK-Lambda model LS75 – 12) Accepts 100-240 VAC power, 50 - 60 Hz. A standard PC power cable can be used. Power entry module: Qualtek model 701W-X2/03. NOTE: The unit does not contain a manual ON/OFF switch and is always powered on whenever the power cord is connected to the AC power source.
6. **USB 2.0 Interface:** Contains the USB 2.0 interface hardware and software.
7. **Large-diameter fan:** Included for efficient heat dissipation and quiet operation.

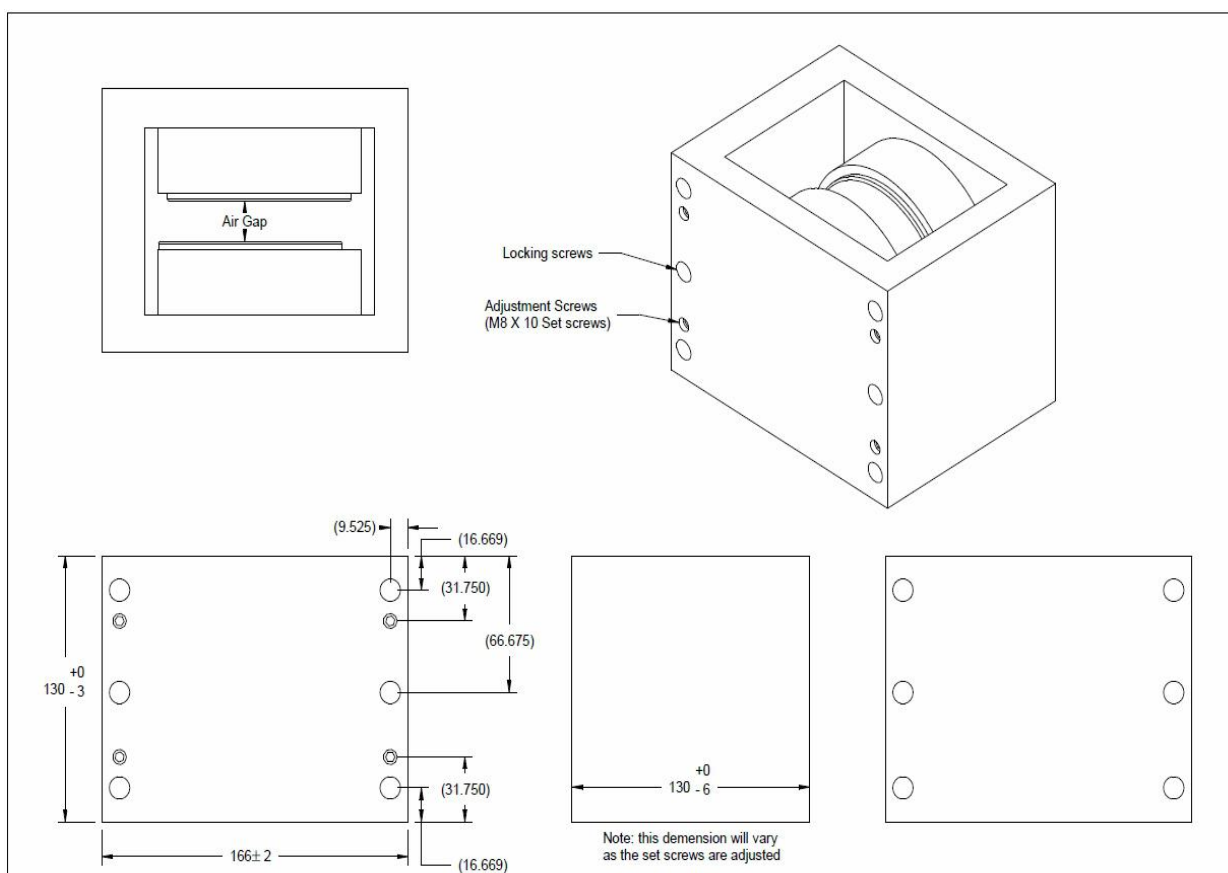
## VII. Magnet Overview

### Magnet Specifications

Figure 4 below shows the GX-5 Magnet's specifications. Figure 5 shows a mechanical drawing of the GX-5 magnet (with all dimensions in mm).

Parameter	Value
Pole face Diameter	100 mm
Air Gap	20 mm
Field Strength	0.51 T – 0.53 T
Minimum Field Uniformity	$10^{-4} \Delta T/T$
Size (L x W x H)	See Figure 1
Weight	15 kg

*Figure 4: GX-5 Magnet Specifications. The minimum field uniformity was found with a sample size of 3mm x 10mm*

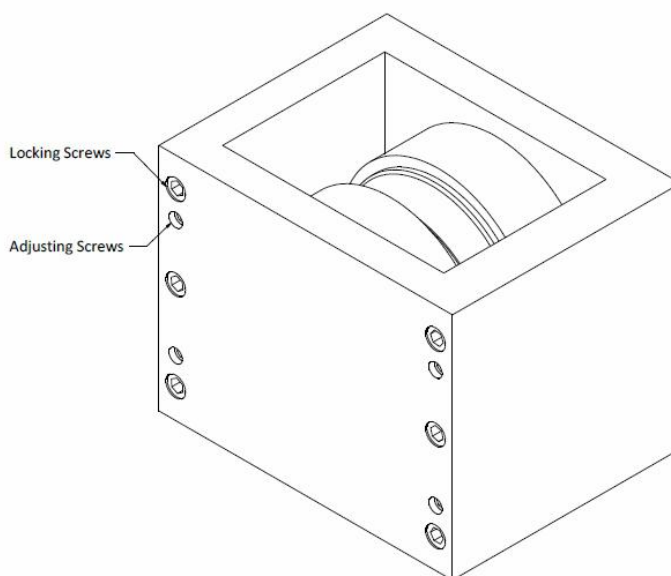


*Figure 5: Mechanical Drawing of the GX-5 Magnet*

## Magnet Shimming

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To adjust the pole position, loosen the locking screws. Then use the adjusting screws to calibrate the magnet. When you are satisfied with the properties of the magnetic field, re-tighten the locking screws to set the poles in place. Figure 6 indicates the locking and adjusting screws.



*Figure 6: The locations of of locking and adjusting screws on the model 3 magnet*

**Note:** Shimming is done on all magnets before they are shipped from SpinCore. Adjustments by the customer could damage the NMR signal quality and is not recommended. Contact SpinCore if you have a question about your magnet.

## VIII. Probe Overview

### Electrical and Mechanical Specifications

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Figure 7 below shows the schematic of the GX-5 Probe's circuit. The resonance frequency of the GX-5 Probe is approximately 5.5 MHz.  $C_m$  is the matching capacitor and  $C_t$  is the tuning capacitor. Both adjustable capacitors have a range of 1.5 to 19 pF with 20 pF and 33 pF capacitors in series, respectively. The inductance of the coil is approximately 11.4  $\mu$ H. A label on the probe's exterior indicates its exact tuned frequency and serial number.

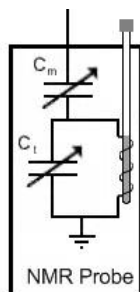


Figure 7: Schematic of the GX-5 Probe's circuit

Figure 8 shows a mechanical drawing of the probe (with all dimensions in inches)

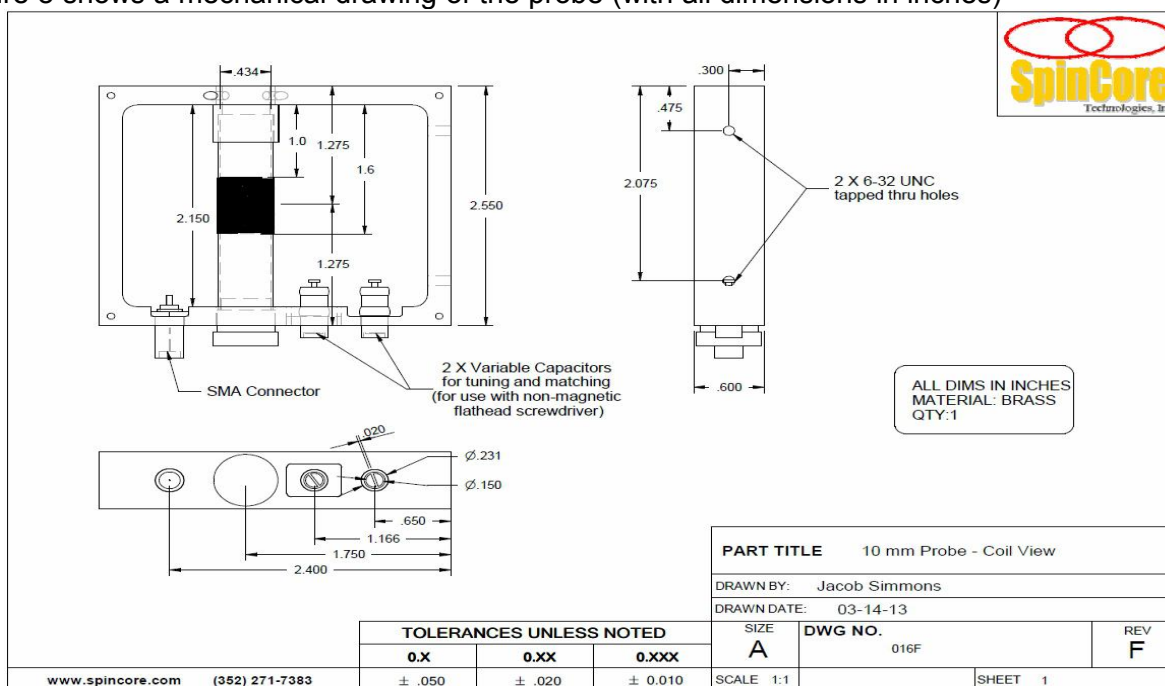


Figure 8: Probe Mechanical Drawing

## Probe Tuning

The GX-5 Probes are tuned by adjusting the two tuning capacitors seen in Figure 7. The probe is connected to a Vector Network Analyzer or to an Antenna Tuning Device. The capacitors are adjusted until the desired resonance frequency is obtained. Figure 9 shows a probe which has been tuned to 5.55 MHz. The impedance of this probe, after tuning, is  $Z=47.6+j0.5$  ohms.

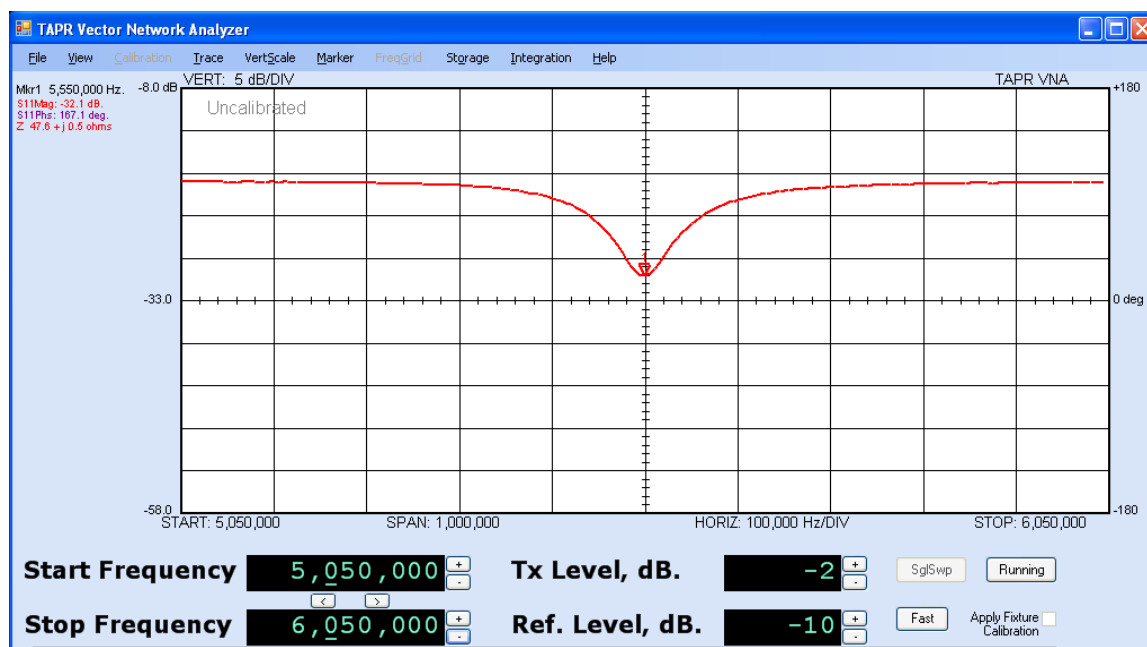


Figure 9: TAPR Vector Network Analyzer display of a 5.55 MHz tuned probe

## IX. Connector Information

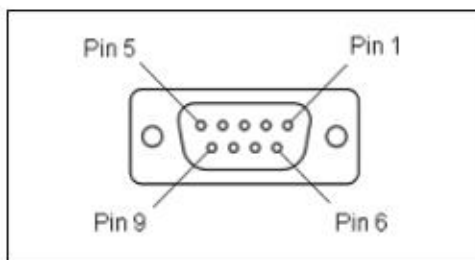
This section provides descriptions of the external connectors for the iSpin-NMR.

### RF Connectors

The system has three SMA jack (female) connectors. These three SMA connectors can be easily connected to via standard SMA cables. Two of the SMA connectors are labeled ' $\lambda/4$  Cable' and the third connector is labeled 'To Probe.'

### Digital (TTL) Connector

The digital, TTL-compatible, outputs of the iSpin-NMR are present on the bracket-mounted DB-9 (female) connector marked TTL. The pinout of this connector and the corresponding signal names are shown below in figure 10.



Pin number	Function
1	Flag bit 0
2	Flag bit 1
3	Flag bit 3
4	Flag bit 2
5	Reserved
6	Ground
7	Ground
8	Ground
9	Ground

Figure 10: TTL Output Connector (DB9-female) and signal list.

## USB Connector

The USB connector is a USB Type-B connector, and can easily be connected to a computer via a standard USB 2.0 cable.

## Hardware Reset/Trigger Connectors

Access to the hardware reset and hardware trigger lines of the RadioProcessor USB is provided via RCA jacks labeled 'Reset' and 'Trigger'. For more information about the function of these pins, please see the SpinCore RadioProcessor manual.

# X. Using the iSpin-NMR System

## Testing iSpin-NMR: Step-by-step Instructions

The iSpin-NMR is tested extensively before shipment and is ready to use for acquisition of NMR (or NQR) signals out-of-the-box, however, it is suggested that the user tests the iSpin-NMR upon delivery to make sure there were no damages during shipment and to become more familiar with the operation and performance of individual components.

The testing procedure for the iSpin-NMR system is described below:

1. Download and install the latest SpinAPI package available at:

<http://spincore.com/support/spinapi/>

Download and install the latest SpinAPI RadioProcessor Examples. The Examples are available at:

[http://spincore.com/CD/spinapi\\_examples/](http://spincore.com/CD/spinapi_examples/).



2. Connect your iSpin-NMR system as shown in figure 11 below. Note that pin-4 on the TTL output DB-9 connector is the blanking signal and can be used to trigger the oscilloscope.

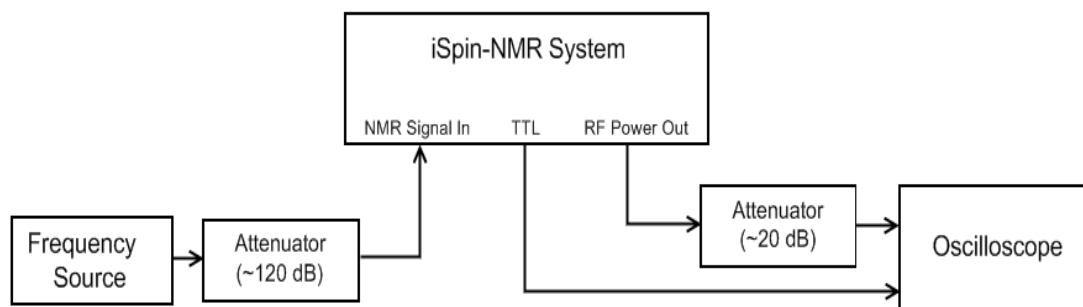


Figure 11: iSpin-NMR test setup.

Turn on your iSpin-NMR system only after making all connections.

The iSpin-NMR receiver is very sensitive and can detect signals less than 1  $\mu\text{V}$  peak-to-peak. The maximum *input* that can be received without distortion is approximately 2.5 mV peak-to-peak. Be sure to attenuate the signal going into the iSpin-NMR so it falls in this range. The RF *output* of the iSpin-NMR can be as high as 75 W, or 200 V peak-to-peak. This voltage is typically too large for an oscilloscope, so be sure to attenuate the output properly.

3. Create your own new working directory somewhere outside of the SpinCore directory and copy the contents of the SpinAPI RadioProcessor Examples to your new working directory. The SpinCore RadioProcessor directory can be found in the location you downloaded the SpinAPI Examples.
4. To test the **Transmitter**, edit the following parameters in the singlepulse\_nmr\_example.bat. This file can be edited by right-clicking and selecting 'edit'.
  - REPETITION\_DELAY = 0.5 (seconds)
  - NUMBER\_OF\_SCANS = 100
  - SPECTROMETER\_FREQUENCY = 20.001 (MHz)
  - PULSE\_TIME = 10.0 ( $\mu\text{s}$ )
  - FNAME = tx\_test (the output files can be ignored when only testing the transmitter)
  - BLANKING\_EN = 1
  - BLANKING\_BIT = 2
  - BLANKING\_DELAY = 3.0 (ms)

- AMPLITUDE = 0.1
5. After entering the parameters, save the singlepulse\_nmr\_example.bat file, then run it by double-clicking the file. On the oscilloscope you should see a 20.001 MHz sine wave that is on for 10.0  $\mu$ s. The amplitude of the sinusoid depends on the attenuation of the RF output signal. This will repeat 100 times every 0.5 seconds and then stop. The diagram in figure 12 shows what a typical oscilloscope output will look like for this test.
  6. Repeat this test a few times, increasing the amplitude setting until you reach your desired output power (up to a maximum of 1.0). The output power should not exceed 10W RMS for a PA10W, 15W RMS for a PA15W, etc.
  7. To test the **Receiver**, edit the following parameters in the singlepulse\_nmr\_example.bat file:
    - NUMBER\_OF\_SCANS = 1
    - NUMBER\_POINTS = 16384
    - SPECTROMETER\_FREQUENCY = 20.001 (MHz)
    - SPECTRAL\_WIDTH = 50 (kHz)
    - BYPASS\_FIR = 1
    - FNAME = rx\_test

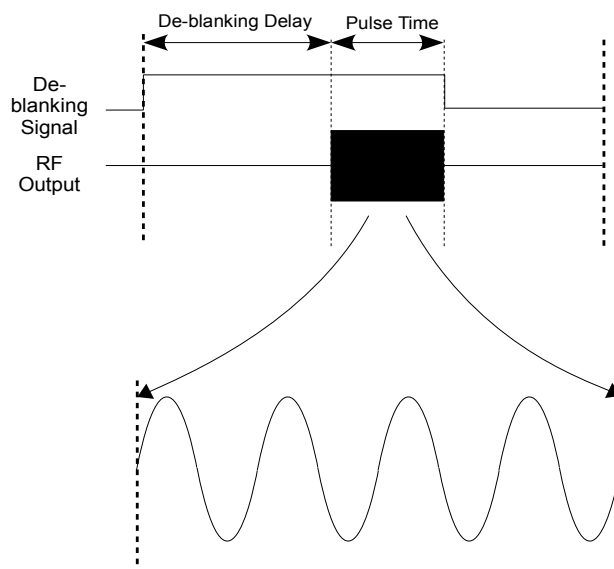


Figure 12: Representation of the oscilloscope output for the iSpin-NMR transmitter test. The iSpin-NMR's internal RF power amplifiers requires a specific de-blanking time, for each model, prior to the RF pulse for full output power. The de-blanking time for each power amplifier can be found in the RF power amplifier manuals, which can be downloaded at <http://spincore.com/products/RFPA/RF-Power-Amplifier.shtml>.

Use the amplitude you determined in step 5 above.

8. After entering the parameters, save the singlepulse\_nmr\_example.bat file.
9. Set your frequency source 20.000 MHz. Notice that this value is 1.0 kHz offset from the spectrometer frequency entered in step 6.
10. Run the singlepulse\_nmr\_example.bat by double-clicking the file. After the scan has completed, the program will generate three output files (rx\_test.fid, rx\_test.jdx, and rx\_test.txt).
11. Open the 'rx\_test.fid' file and verify the 1 kHz signal using Felix NMR software, which is available for 32-bit Windows systems at:

[http://www.spincore.com/support/RadioProcessor/Felix/Felix\\_Instructions.shtml](http://www.spincore.com/support/RadioProcessor/Felix/Felix_Instructions.shtml)

After doing the FFT, you should see a strong signal at 1 kHz. Figure 13 shows data captured by the iSpin-NMR system with a signal attenuated by over 100 dB. The time domain signal is on top (expanded) and the FFT is shown on the bottom.

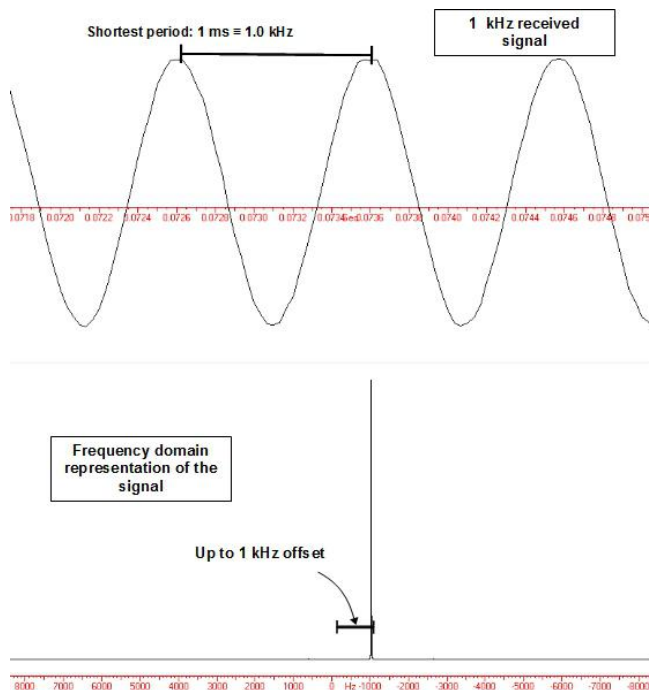


Figure 13: Data received by an iSpin-NMR system performing the Rx test. The input signal is attenuated by over 100 dB and is less than 18  $\mu$ V peak-to-peak.

## Conducting an NMR Experiment with the iSpin-NMR: Step-by-step Instructions

1. Download and install the latest SpinAPI package available at:

<http://spincore.com/support/spinapi/>

Download and install the latest SpinAPI RadioProcessor Examples. The Examples are available at:

[http://spincore.com/CD/spinapi\\_examples/](http://spincore.com/CD/spinapi_examples/).

2. Connect your iSpin-NMR system as shown in Figure 2 (page 8).
3. Check all connections and then power on your system. ***WARNING: A 50 Ohm load MUST be presented to the RF output port of the iSpin-NMR system. If no load/probe is connected, or if probe is not properly matched/tuned, you may damage the system. If you have any questions, PLEASE contact us.***
4. Create your own new working directory somewhere outside of the SpinCore directory and copy the contents of the SpinAPI RadioProcessor Examples to your new working directory. The SpinCore RadioProcessor directory can be found in the location you downloaded the SpinAPI Examples.
5. Edit the singlepulse\_nmr\_example.bat batch file by right-clicking and selecting 'edit' and save the batch file when finished. The timing values in the batch file correspond to those in figure 14, below.

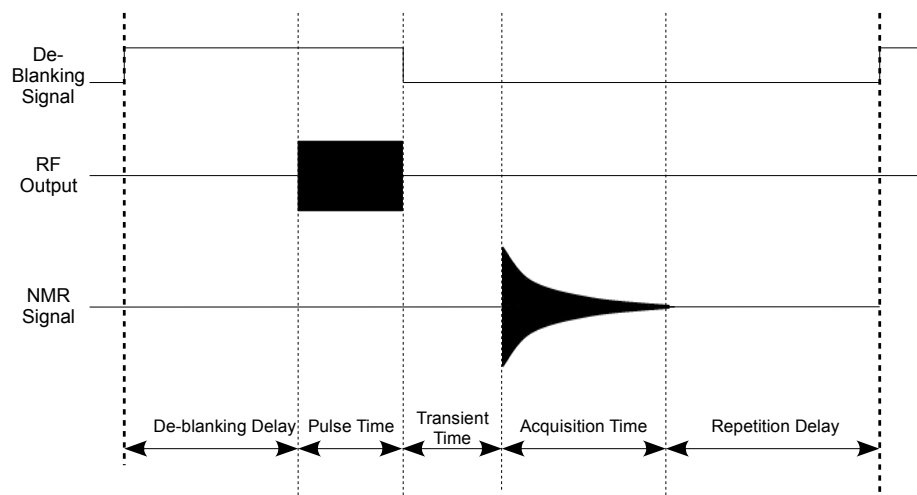


Figure 14: Timing diagram for one single pulse NMR scan (not drawn to scale).

6. Run the singlepulse\_nmr\_example.bat file by double-clicking. Once the singlepulse\_nmr.bat file has completed, three new files (\*.fid, \*.jdx, \*.txt) will be created in the directory from which the batch file was executed.

7. Load the Felix file (\*.fid) in Felix for Windows, or load the (\*.jdx) file in any program that supports JCAMP-DX. An easily parsed text file containing the NMR data will also be generated. For information on installing and using Felix to view your .fid files, go to [http://www.spincore.com/CD/RadioProcessor/felix/Felix\\_Instructions.html](http://www.spincore.com/CD/RadioProcessor/felix/Felix_Instructions.html)

The NMR data received should look something like that of the screenshots shown in sections VIII and IX. For information about specific control signals for NMR tests which would allow for custom NMR experiments, see the SpinCore RadioProcessor manual at [http://www.spincore.com/CD/RadioProcessor/RadioProcessor\\_manual.pdf](http://www.spincore.com/CD/RadioProcessor/RadioProcessor_manual.pdf)

## **XI. MATLAB GUI Interface**

### **Overview of SpinCore MATLAB GUI Interface**

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The SpinCore MATLAB GUI Interface is a series of programs created for the MATLAB environment that allows quick and easy interaction with the iSpin-NMR system. Specifically, this interface is designed to allow users to perform a variety of useful experiments with their system. Complete documentation for the SpinCore MATLAB GUI can be found here:

<http://www.spincore.com/support/RadioProcessor/MATLAB/Documentation.html>

#### **General Features:**

- Run NMR experiments with ease, including Single Pulse, CPMG, and 90 Degree Pulse-Width Determination
- Change experiment parameters quickly and easily
- Preview data in MATLAB immediately after the scan
- Combine the versatility of the RadioProcessor with the power of the MATLAB environment
- Quickly find resonant spectrometer frequency through automatic detection
- 90 Degree Pulse-Width Finder allows quick and simple detection of important pulse width parameters
- CPMG NMR now includes a feature to calculate T2 relaxation times for samples with a single exponential
- Continuous Scan setting for Single Pulse NMR

- Load and review data from previous Single Pulse NMR experiments within the interface.

Note: Versions prior to R5 do not have support for iSpin-NMR systems. Versions after R8g have full functionality for the iSpin-NMR for every function.

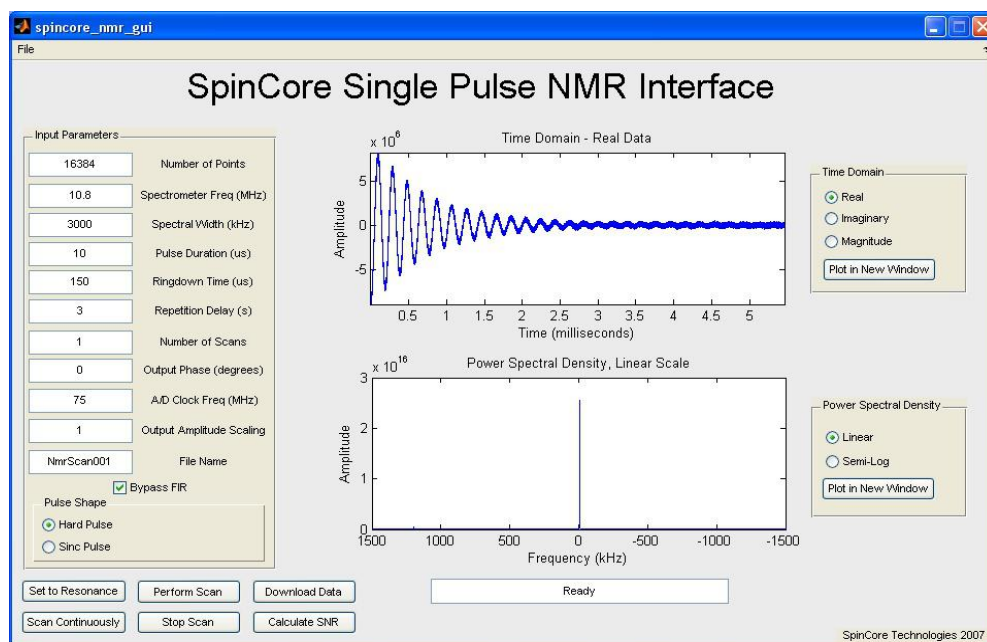


Figure 15: Sample output after running Single Pulse NMR experiment on household cooking oil.

## Sample Screenshots

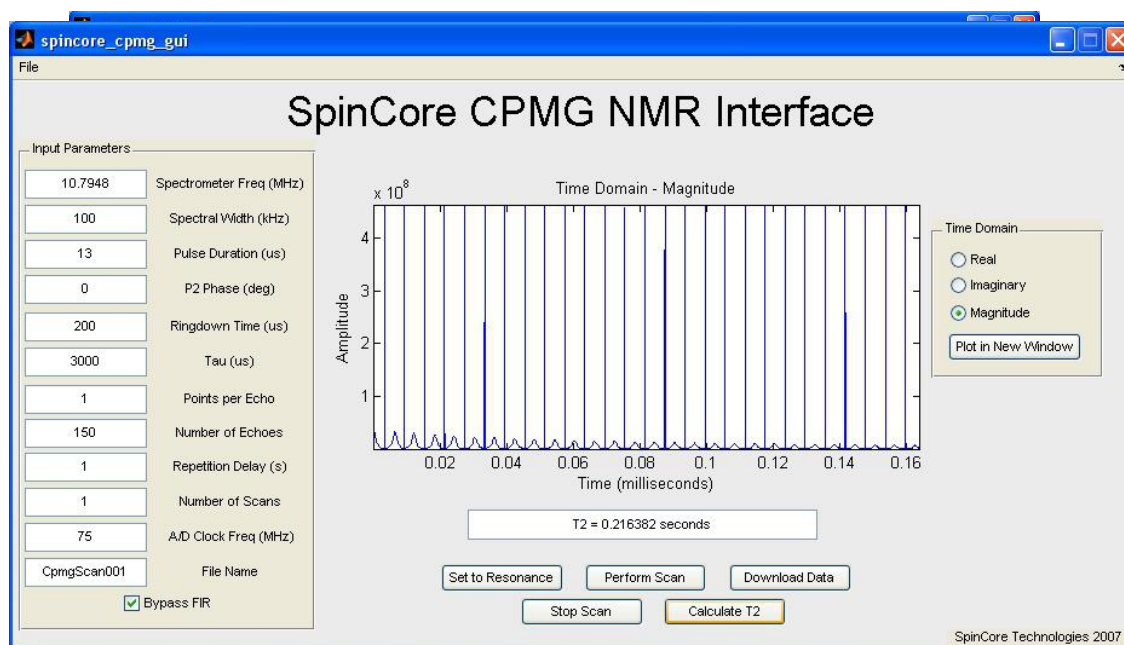


Figure 17: Sample output after running CPMG NMR experiment on household cooking oil.

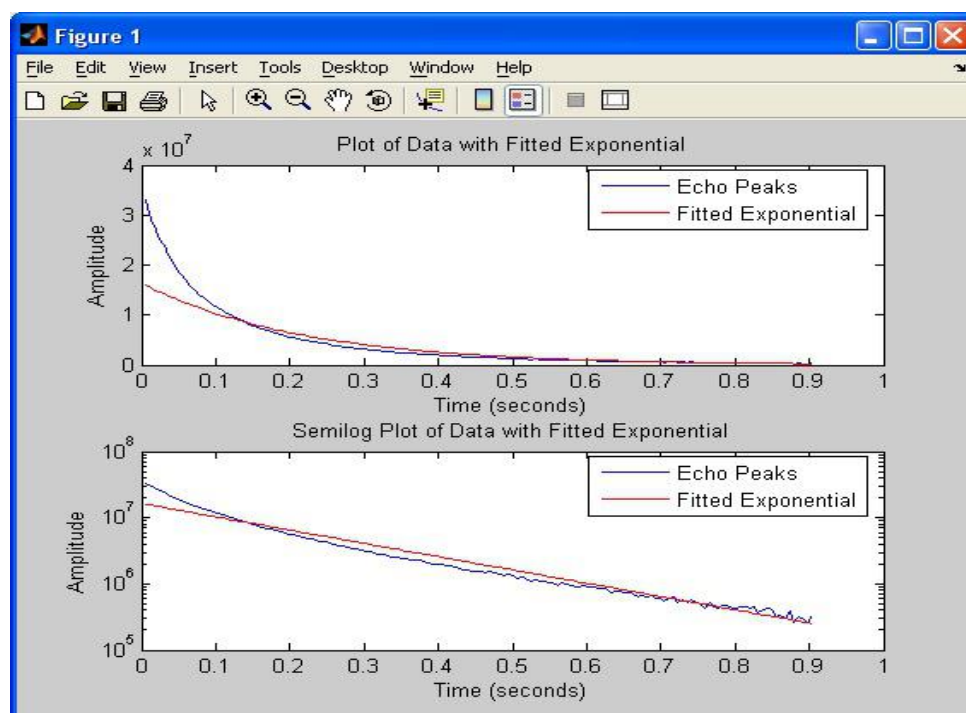


Figure 18: Sample T2 calculation and curve fitting.

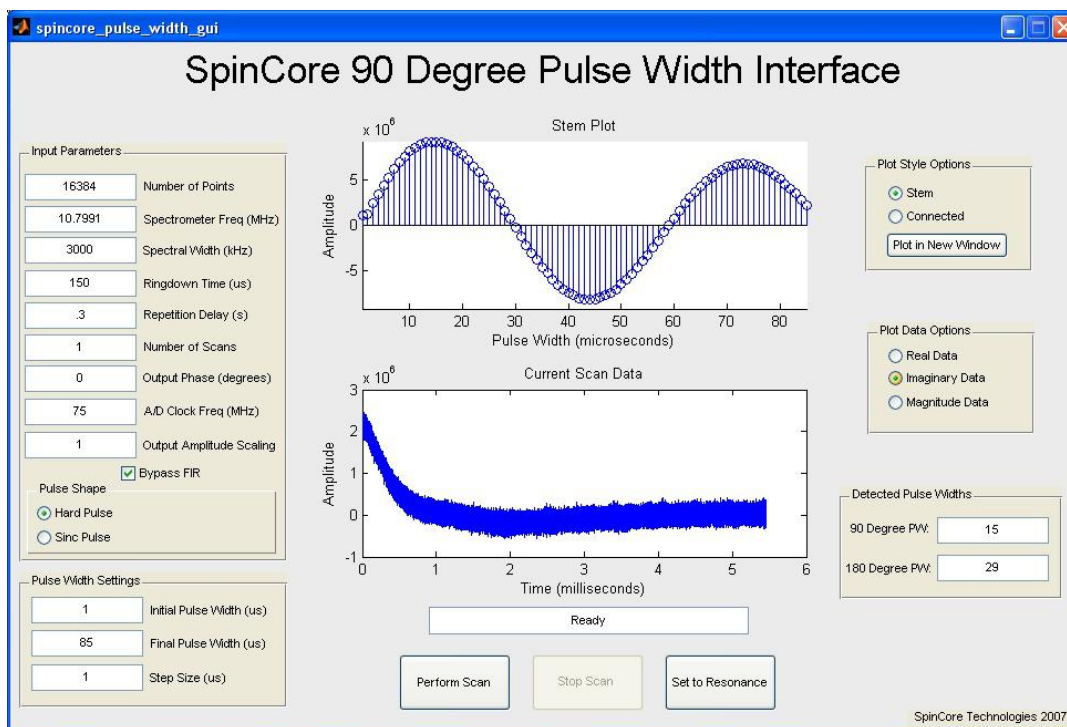


Figure 19: Automatic 90 Degree Pulse Width Determination.



## XII. LabVIEW NMR Interface

### Overview of SpinCore LabVIEW GUI Interface

SpinCore has developed an easy-to-use LabVIEW Graphical User Interface (GUI) that combines the Single Pulse NMR, T1 Inversion Recovery, and CPMG interfaces into one interface. It allows the user to run basic NMR experiments by simply setting the experiment parameters as described elsewhere in this manual. Extra features in LabVIEW GUI include lightning-fast resonance finder, built-in FFT and phasing, CYCLOPS phase cycling experiments, 90 degree pulse width finder, and continuous scan mode. The following two figures are screenshots of the LabVIEW NMR Interface:

For more information see the LabVIEW manual at:

[http://www.spincore.com/support/PBLV/PBLV\\_RP\\_NMRinterface\\_Manual.pdf](http://www.spincore.com/support/PBLV/PBLV_RP_NMRinterface_Manual.pdf)

NOTE: A National Instruments license is not required to run the LabVIEW interface.

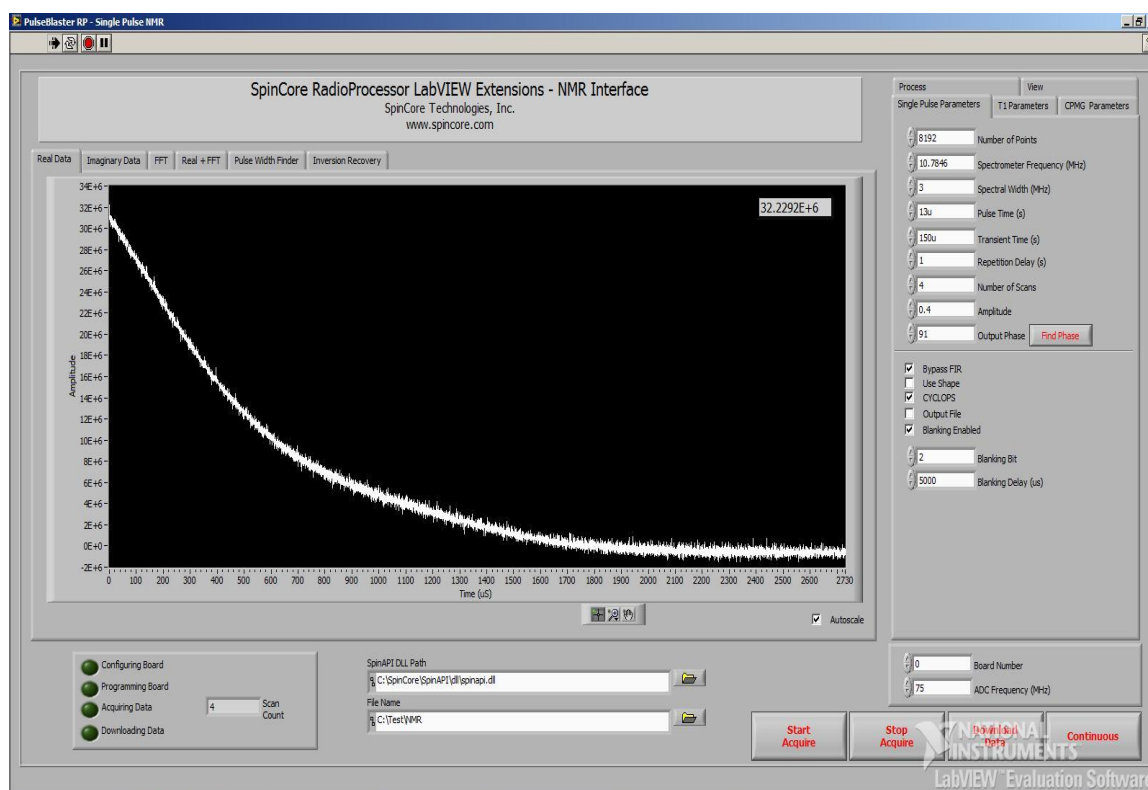


Figure 20: Example of RadioProcessor LabVIEW Extensions User Interface.

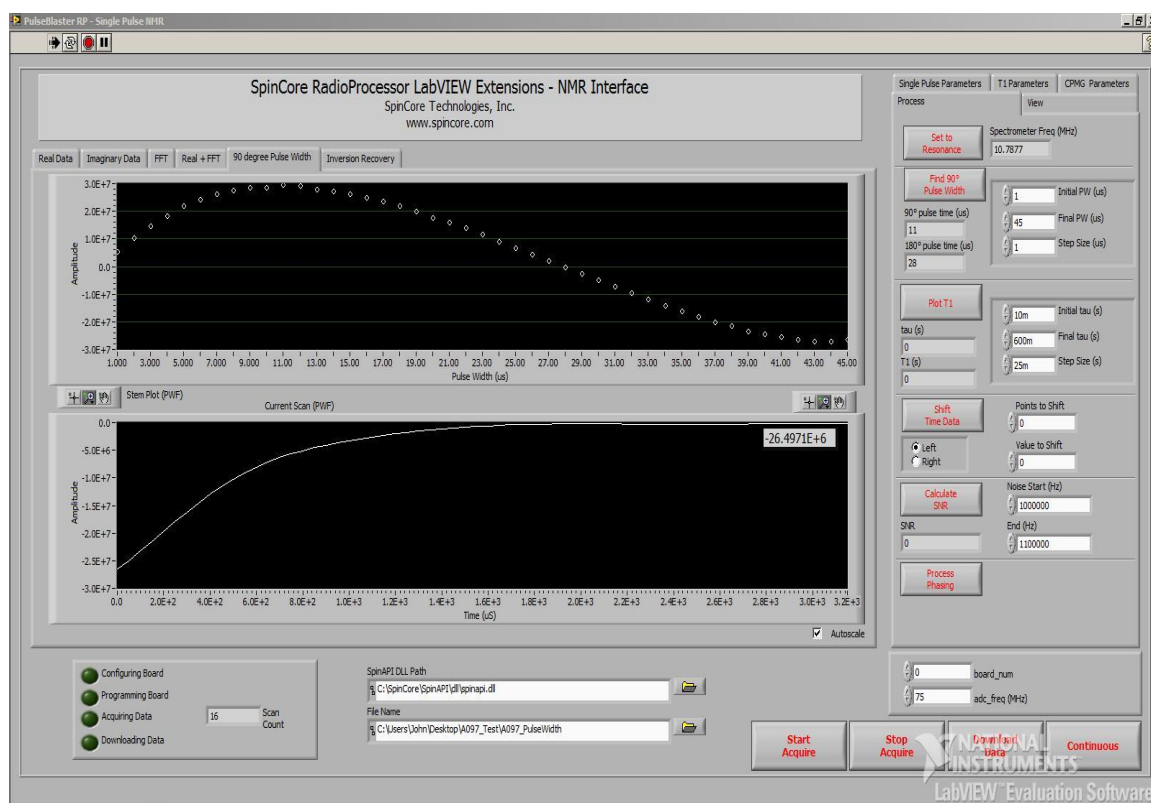
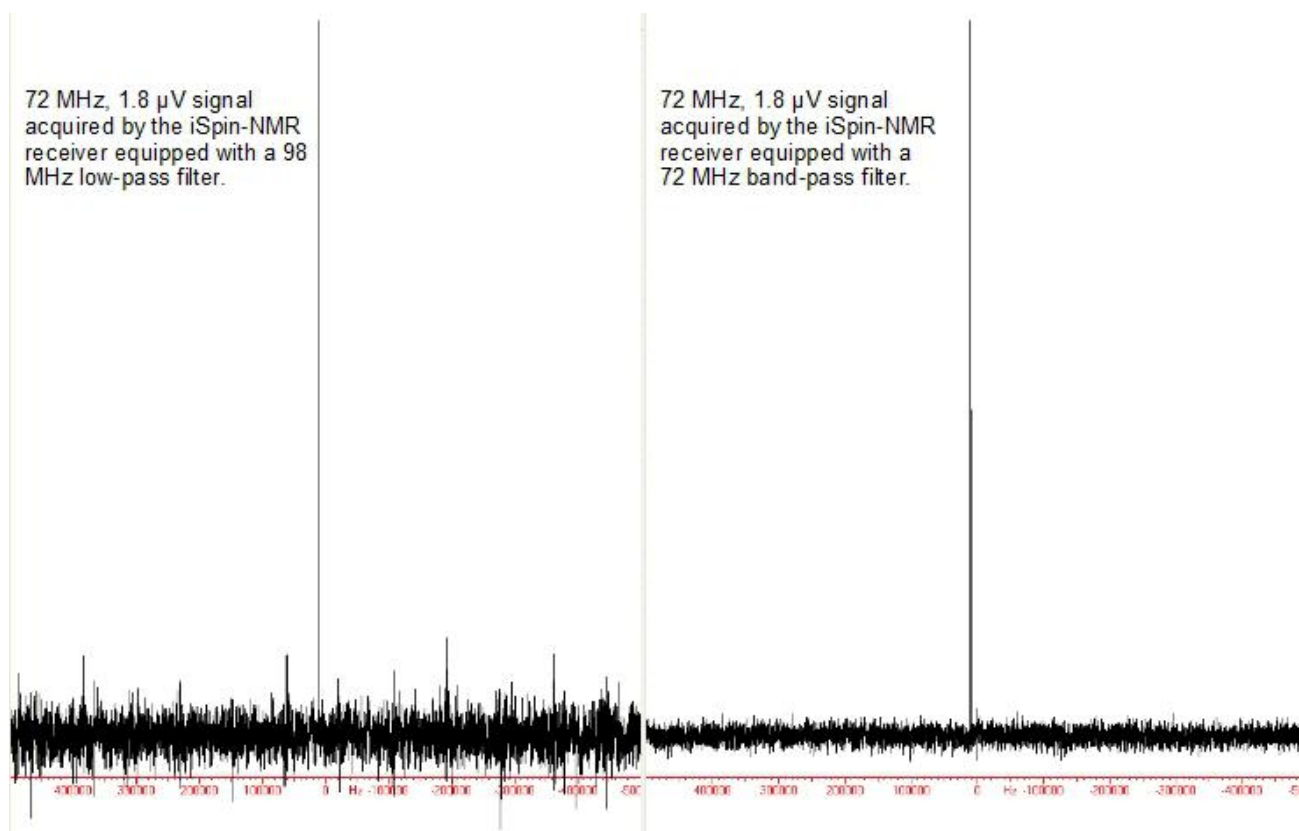


Figure 21: Example of Pulse Width Finder for LabVIEW NMR Interface.

### **XIII. Pre-amplifier Filter Considerations**

The iSpin-NMR receiver is very sensitive to small signals and has a broad input frequency range for maximum versatility. While this feature can be very useful, the broadband receiver may capture unwanted noise if not used correctly. At SpinCore we customize your iSpin-NMR system to your specific operating frequency and can provide custom band-pass filters at those specific frequencies. Contact SpinCore Technologies, Inc. for more information.

Figure 22, on the following page, shows the iSpin-NMR receiver sensitivity when connected to a 72 MHz RF signal that is attenuated by 120 dB down to less than 1.8  $\mu\text{V}$  peak-to-peak. The left side shows received data using a 98 MHz low-pass filter, and the right side shows received data when using a 72 MHz band-pass filter. The performance benefits of the band-pass filter are clear.



*Figure 22: iSpin-NMR Receiver performance using low-pass filters (left) and band-pass filters (right).*

## **XIV. Related Products and Accessories**

1. RadioProcessor: Complete RF Acquisition and Excitation System with Digital Detection, Real-Time Signal Processing and Signal Averaging. For more information, please visit <http://spincore.com/products/RadioProcessor/>
2. RF Power Amplifiers PA10W, PA15W, PA75W and PA100W. For more information, please visit <http://spincore.com/products/RFPA/>
3. PulseBlaster: Programmable TTL Pulse Generator / Digital Word Generator and Timing Engine. For more information, please visit <http://spincore.com/products/PulseBlaster/>
4. SpinCore also offers the following to supplement the iSpin-NMR system.
  - [NMR Magnets](#) and Probes.
  - Duplexer (Transmit/Receive) Circuitry.
  - Custom RF Filters and Cables.
  - iSpin-NMR in Rack Mount Enclosure.
  - Oven controlled oscillators with sub-ppm stability.
5. All components of the iSpin-NMR system may be ordered separately. For custom designs, modifications or software development, please inquire with SpinCore Technologies through our contact form, which is available at <http://spincore.com/contact.shtml>.
6. The iSpin-NMR system can also be delivered in a Rackmount enclosure.

## **XV. Contact Information**

**SpinCore Technologies, Inc.**  
**4631 NW 53rd Avenue, SUITE 103**  
**Gainesville, FL 32653**  
**USA**

**Telephone (USA):**           **352-271-7383**  
**Fax (USA):**               **352-371-8679**

**Website:**                   <http://www.spincore.com>  
**Web Contact Form:**      <http://www.spincore.com/contact.shtml>

## **XVI. Document Information**

Revision history available at SpinCore.

## **Appendix I. Applicable Regulations**

### **Measuring Instruments Directive**

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These products conform with the requirements of council directive 2004/22/EC concerning measuring instruments when they bear the following mark of conformity:



### **Restriction of Hazardous Substances**

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All SpinCore products are assembled entirely from RoHS compliant components and materials. A bill of materials substantiating this claim is available from SpinCore upon request.

### **Manufacturers**

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All SpinCore products are designed and manufactured at SpinCore Technologies Inc.

SpinCore Technologies, Inc.  
4631 NW 53rd Avenue, SUITE 103  
Gainesville, FL 32653  
USA

Telephone (USA): 352-271-7383  
Fax (USA): 352-371-8679

Website: <http://www.spincore.com>  
Web Contact Form: <http://www.spincore.com/contact.shtml>

## Appendix II: QC Testing Information

### Quality Control Testing Overview

1. **Rx and Tx Bench Testing:** RF input and output testing follows the procedures described in section IX of this manual. Rx tests are performed at a frequency determined by the expected operation frequency of a given system. RF output power testing is done at a variety of output levels from 100% to 40% total output in order to establish the output linearity of the system. Linearity Calculations are made using a standardized spreadsheet available at SpinCore.
2. **NMR Testing:** All NMR testing is done using SpinCore's LabVIEW NMR interface with post-processing done using Felix and a specifically written SNR calculation Python script available upon request from SpinCore. All QC tests are done with a standard sample described in figure 23.

Name	Purpose	Specification
13C QC Methanol Standard		10 mm NMR tube (sealed)
		0.65 mL MeOH + CrAcAc solution
	Provide signal to set 90 degree pulse and measure SNR at 13C frequencies.	Solution:
	Chromium added to shorten relaxation times.	98.8 % 13C methanol
		CAS 14742-26-8
		1.2 % Chromium (III) Acetylacetonate
		CAS 21679-31-2

Figure 23: C13 Standard Sample Specifications

### Abridged Testing Procedures

**Note:** Performing any of these QC tests using line-broadening will skew the results. Perform all tests and analysis without line-broadening.

1. **RF Output Power:** Set the RF output to 100 %. Connect the RF Coil output port on the system to a suitable calibrated oscilloscope or RF pulse power meter. Measure the peak envelope power on a 50 microsecond square pulse (< 5% duty cycle).
2. **RF Output Linearity:** Record peak envelope power from the "RF Coil" output port into 50 ohm with TX power set to 100, 90, 80, 70, 60, 50 and 40 percent. Measured value shall be within 5 % of the expected value. The expected value shall be the power measured at 100% power level, multiplied by the percent power level being tested.

3. **90 Degree Pulse Determination:** Using the "Find 90" test parameters determine the pulse width corresponding to a 90 degree pulse.
4. **Signal to Noise Ration Determination:** **Signal:** Using the "SNR" test parameters, acquire a data set. Perform an FFT without line broadening. Select the absorption spectrum and correct the zero order phase. Measure the height of the center of the peak. **Noise:** Remove the sample and repeat the measurement. Perform an FFT without line broadening in the same manner as before. Select the absorption spectrum and calculate the standard deviation across the middle 50% of points. **SNR:** Divide the signal peak height by the standard deviation of the noise.
5. **Line Width Determination:** Using the "Linewidth" test parameters, acquire a data set. Perform an FFT without line broadening. Select the absorption spectrum and correct the zero order phase. Measure the line width using the built-in determination feature in Felix. A copy of this spectrum should be attached to the QC certification form
6. **NMR Frequency Determination:** Using data from the SNR test, verify that the NMR frequency is set such that the <sup>13</sup>C signal peak is centered in the spectrum at zero hertz. Record the NMR center frequency and magnet temperature. Verify that the frequency is within the upper and lower specification limits for the test temperature.

NMR parameters for the above tests are given in figure 24.

Parameter	Find 90	SNR	Linewidth
Frequency (MHz)	Centered at 0Hz	Centered at 0Hz	Centered at 0Hz
Spectral Width (kHz)	200	200	200
Pulse Width (us)	Varied	90-deg optimized	90-deg optimized
TX Power (%)	100	100	100
Points	2048	2048	2048
Averages	40	20	20
TXPhase (deg)	0	0	0
RX Delay (us)	60	60	60
Rep Delay (s)	5	5	5
Unblank pre-delay (us)	12	12	12
Unblank post-delay (us)	2	2	2
Phase Cycling	Cyclops	Cyclops	Cyclops
Additional Notes:			Double point number with zero-padding

Figure 24: NMR testing parameters



**Quality Control Certification Form (S/N:\_\_\_\_\_)****General Information:**

RadioProcessor	Power Amplifier	Pre-Amplifier	Filters:
S/N: EPROM Code:_____ R811: R812:	S/N:_____  Type:_____	S/N:	Type:

DC/DC	Magnet	Probe	$\lambda/4$ Cable
S/N:_____  Type:	S/N:	S/N:  Tuned Freq:	Freq:

**RF Output:**

Attenuation used:

	40.00%	50.00%	60.00%	70.00%	80.00%	90.00%	100.00%
V Pk-Pk							
% Error							N/A

**NMR:**

Tolerance Checklist:				
Test:	Results:		Tolerance:	Circle:
Rx Test Run	N/A		N/A	Pass/Fail
RF Output Power	Dbm @ full power		34.0±0.2 dBm	Pass/Fail
RF Output Linearity	% max error		< 5% max error	Pass/Fail
RF Frequency	MHz	Magnet Temp: °C	See table	Pass/Fail
90° Pulse Time	µs		Between 20 & 25 µs	Pass/Fail
SNR			No less than 50	Pass/Fail
Line Width	Hz		No more than 750 Hz	Pass/Fail
Additional Notes:				

**A printout of the spectrum (using linewidth test specs) is attached to this document.****Tester's Signature:\_\_\_\_\_Date:**

A detailed QC data folder as well as more detailed documentation of testing procedures for this product are available from SpinCore upon request.

RF Frequency:			
Temperature /C	Nominal /MHz	LSL /MHz	USL /MHz
15.0	5.590188	5.450434	5.729943
15.5	5.587948	5.448249	5.727646
16.0	5.585707	5.446064	5.725350
16.5	5.583466	5.443880	5.723053
17.0	5.581226	5.441695	5.720756
17.5	5.578985	5.439510	5.718460
18.0	5.576745	5.437326	5.716163
18.5	5.574504	5.435141	5.713866
19.0	5.572263	5.432957	5.711570
19.5	5.570023	5.430772	5.709273
20.0	5.567782	5.428587	5.706977
20.5	5.565541	5.426403	5.704680
21.0	5.563301	5.424218	5.702383
21.5	5.561060	5.422034	5.700087
22.0	5.558820	5.419849	5.697790
22.5	5.556579	5.417664	5.695493
23.0	5.554338	5.415480	5.693197
23.5	5.552098	5.413295	5.690900
24.0	5.549857	5.411111	5.688603
24.5	5.547616	5.408926	5.686307
25.0	5.545376	5.406741	5.684010
25.5	5.543135	5.404557	5.681714
26.0	5.540895	5.402372	5.679417
26.5	5.538654	5.400188	5.677120
27.0	5.536413	5.398003	5.674824
27.5	5.534173	5.395818	5.672527
28.0	5.531932	5.393634	5.670230
28.5	5.529691	5.391449	5.667934
29.0	5.527451	5.389264	5.665637
29.5	5.525210	5.387080	5.663340
30.0	5.522970	5.384895	5.661044
30.5	5.520729	5.382711	5.658747
31.0	5.518488	5.380526	5.656450
31.5	5.516248	5.378341	5.654154
32.0	5.514007	5.376157	5.651857
32.5	5.511766	5.373972	5.649561
33.0	5.509526	5.371788	5.647264
33.5	5.507285	5.369603	5.644967
34.0	5.505045	5.367418	5.642671
34.5	5.502804	5.365234	5.640374
35.0	5.500563	5.363049	5.638077
35.5	5.498323	5.360865	5.635781
36.0	5.496082	5.358680	5.633484
36.5	5.493841	5.356495	5.631187
37.0	5.491601	5.354311	5.628891
37.5	5.489360	5.352126	5.626594
38.0	5.487120	5.349942	5.624297
38.5	5.484879	5.347757	5.622001
39.0	5.482638	5.345572	5.619704
39.5	5.480398	5.343388	5.617408
40.0	5.478157	5.341203	5.615111