Owner's Manual for the

PulseBlasterPlus! Spin Decoupler™

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Section I: PulseBlasterPlus! Spin Decoupler™

1. Product Overview

The PulseBlasterPlus! Spin Decoupler™ system is an autonomous stand-alone pulse Radio-Frequency (RF) generator customized for NMR/MRI decoupling applications. The system integrates a precision timing engine and a dedicated Direct Digital Synthesis (DDS) core for generating continuous RF sequences for bi-level decoupling. To simplify the pulse-sequence programming, WALTZ and MLEV decoupling sequences are hard-coded via firmware and can be selected with an external TTL signal. The RF output frequency and pulse lengths can be controlled via a simple ASCII RS232 serial interface. The rf output power is approx. 10 dBm. The system is housed in a sturdy, shielded plastic enclosure with an integrated power supply.

Fig. 1 – A photograph of the PulseBlasterPlus! Spin Decoupler™

2. System Architecture

Figure 2 presents the general architecture of the PulseBlasterPlus! Spin Decoupler™ system. The four major sections of the design are as follows:

- Direct Digital Synthesis (DDS) core
- Precision Pulse Sequence Digital Timing (PP) core
- RF output (analog) circuitry, and
- RS-232 serial programming interface.

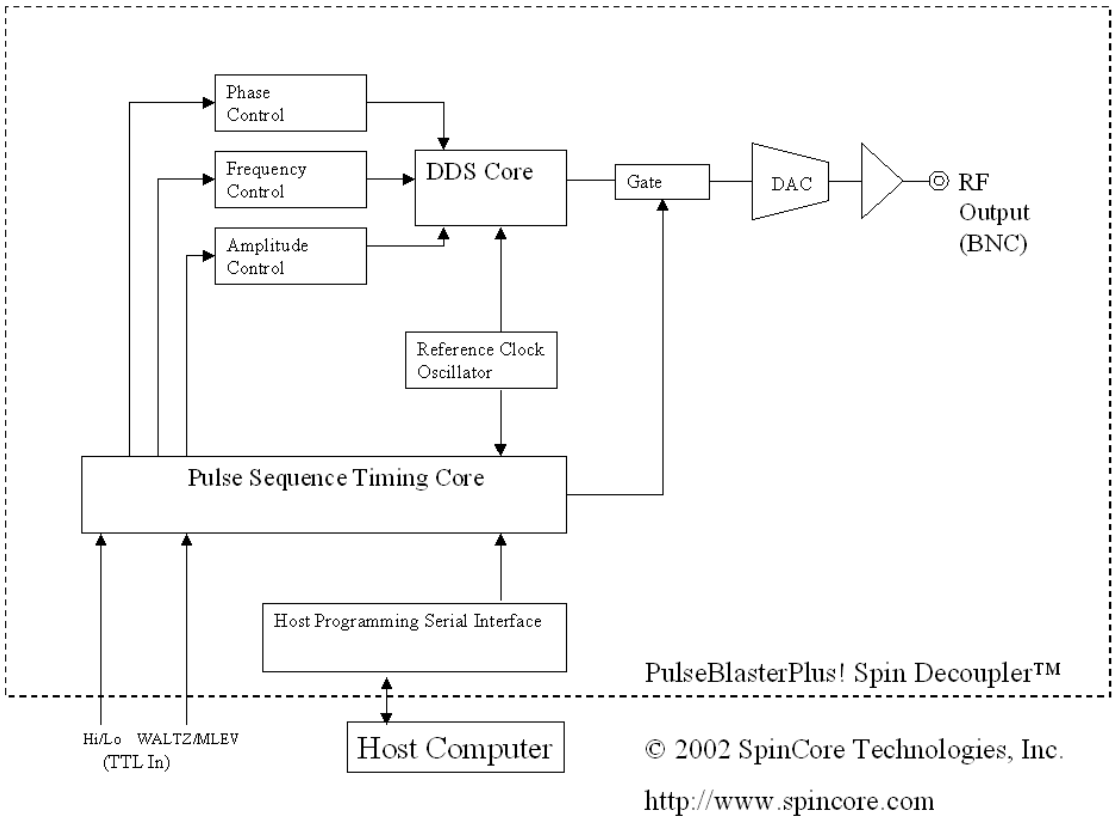

Fig. 2. PulseBlasterPlus! Spin Decoupler(tm) board architecture.

The DDS and PP cores run off a single, on-board reference clock oscillator. With a default 50 MHz clock oscillator, the DDS core allows for frequencies from 1kHz to 25MHz to be output, with a frequency resolution of 1kHz; the pulse-timing core allows for delay lengths of 1μs to 120ms, with a resolution of 1μs

The internal DDS core is a versatile digital frequency synthesizer with phase, frequency, and amplitude control registers to accommodate for broad requirements of RF pulse sequences used in NMR/MRI. A specific pulse decoupling sequence is produced via sequential control words generated

by the pulse-sequence timing core. The timing core is an implementation of SpinCore's PulseBlaster™ pulse program timing processor - a dedicated, programmable microcontroller based on a 80-bit Very Long Instruction Word (VLIW) architecture. To simplify pulse-sequence programming, pulse programs are hard-coded in an EPROM. Two most-commonly used decoupling sequences, WALTZ and MLEV, have been programmed as default sequences. An external TTL signal (level) can select one of the two sequences. A second external TTL signal (level) can select between the full RF output power and a –3 dB value.

The RF output section converts the digital samples generated by the DDS core to analog waveforms, and it includes a high-speed Digital-to-Analog Converter (DAC). The gate between the DDS core and the DAC is continuously opened for the WALTZ/MLEV decoupling sequences. The analog RF signals from the output of the DAC are amplified by a high-bandwidth amplifier delivering approx. 10 dBm of power; the output impedance is 50 ohm. The analog output signal is available on the external BNC connector.

The host programming serial interface, implemented as an RS-232 circuit operating at the fixed speed of 115 kBaud, allows the user to modify the output frequency and the pulse length of the generated pulse decoupling sequences. Any terminal/modem software capable of communicating via RS-232 communication channels (8-bit data, no parity, one stop bit) can be used to communicate with the system.

The system is NOT equipped with an interpolating filter. Thus, a step-like output signal will be observed, especially pronounced at high output frequencies. This is normal for non-filtered DDS-generated signals. To eliminate the step-like output, the user should use a low- or band-pass filter as appropriate for their application.

The system boots with the following parameters:

- Output frequency – 6.25 MHz
- Pulse sequence – WALTZ
- 90-degree pulse length – 2 ms
- RF output level – high (approx. 10 dBm).

By default, the system runs continuously once the board is powered.

3. User Guide

The PulseBlasterPlus! Spin Decoupler™ system is a stand-alone unit and is ready to use right out of the box. Upon receiving and unpacking the system, examine it for any damages that may have occurred in transit.

Attach a 50 ohm coaxial cable to the BNC output connector mounted on the box. For proper operation, the cable should be terminated with a 50 ohm impedance. Output signals can be evaluated with an oscilloscope with a 50 ohm input impedance. The observed signals will be in the range of approx. 3Vpp. Use an external filter, if desired, to eliminate the step-like output.

The PulseBlasterPlus! Spin Decoupler needs only to be powered. Connecting to a serial port on a host computer will allow the user to change the frequency and pulse length of the pulse sequence by a simple ASCII terminal interface.

To control the system using the serial interface, follow the steps below:

1) Configure your serial port or terminal software to use a 115200 bits per second transfer speed, 8 data bits, no parity bits, 1 stop bit, and no flow control.

2) Turn on the power switch of the PulseBlasterPlus! Spin Decoupler™.

3) Your terminal program should display the SpinCore Technologies' logo. At this point you are ready to begin controlling the frequency and pulse length of the sequence.

4) Press 'D' (*note this must be a capital letter) to change the value of the delay register. This value should be entered in μs, should not contain any commas, and the valid range of values is 1 to 120000. If you enter too many digits or an invalid value, the delay register will not be updated correctly.

5) Press 'F' (*note this must be a capital letter) to change the value of the frequency register. This value should be entered in kHz, should not contain any commas, and the valid range of values is 1 to 25000. If you enter too many digits or an invalid value, the frequency register will not be updated correctly.

6) To control the amplitude of the output signal, a TTL signal should be connected to the RCA connector labeled "Hi/Lo." A high TTL level signifies full-swing output, and a low TTL level signifies half-swing output. This connector has an internal pull-up resistor, so the default mode of operation is full-swing output voltage.

7) To control the sequence being used, a TTL signal should be connected to the RCA connector labeled "WALTZ16/MLEV16." A high TTL level signifies the WALTZ sequence, and a low TTL level signifies the MLEV sequence. This connector has an internal pull-up resistor, so the default mode of operation is WALTZ.

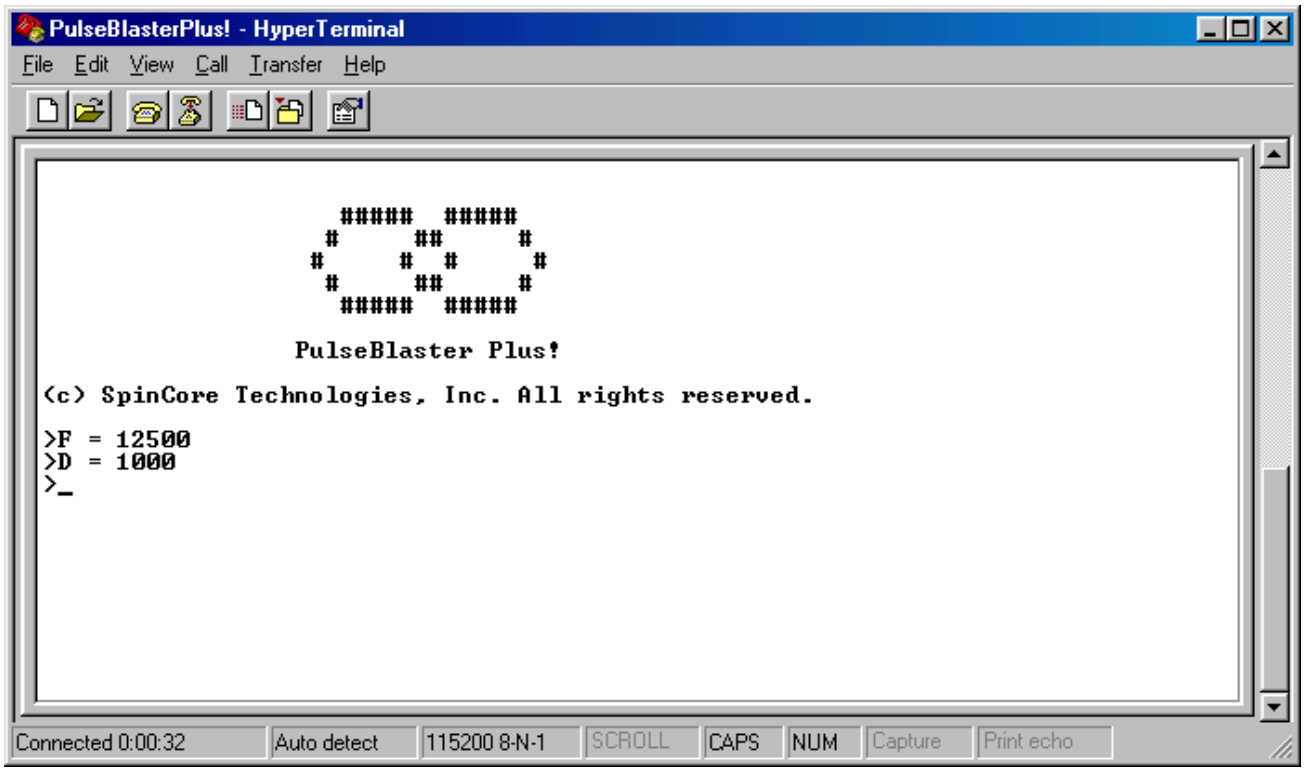

Fig. 3 – Microsoft Windows' HyperTerminal software can be used to control PulseBlasterPlus! Spin Decoupler™. Terminal settings: 115 kBaud, 8N1.

4. Connector Information

All input-output connectors are mounted on the back of the PulseBlasterPlus! Spin Decoupler™. A sketch depicting the available connectors is presented in Figure 4, below.

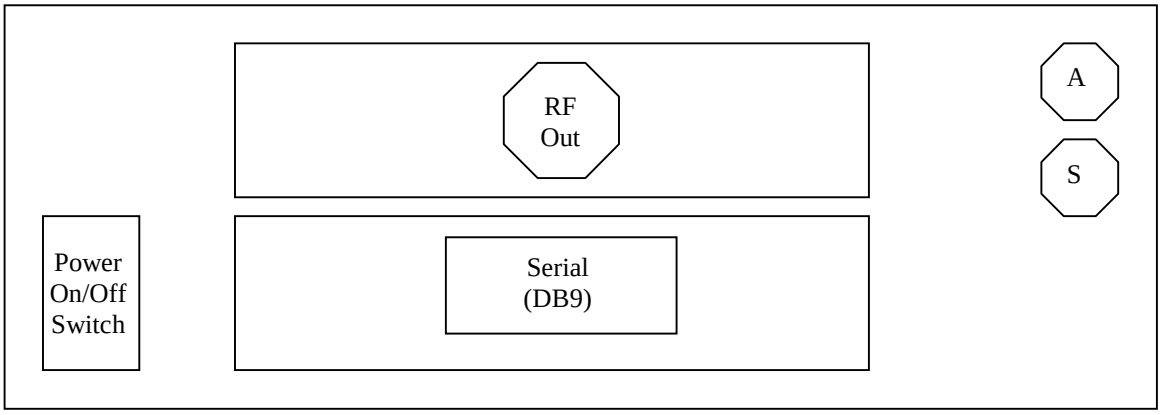

Figure 4 – Back view of PulseBlasterPlus! Spin Decoupler™

- RF Out – BNC connector for RF pulse sequence output signal; 50 ohm impedance, approx. 10 dBm.
- Serial (RS232 115kb) – DB9 connector to host computer serial port.
- A – RCA Jack Input TTL Level Amplitude Control (labeled Hi/Lo).
- S – RCA Jack Input TTL Level Sequence Control (labeled WALTZ/MLEV).

Appendix

1. Available Options

The PulseBlasterPlus! Spin Decoupler™ system can be customized. The following is a sample list of available options:

1. Reference clock frequency – any custom value of up to 100 MHz.
2. External gating.
3. Other pulse decoupling sequences.
4. Up to 8 additional TTL signals synchronized with the rf pulses.
5. Internal interpolating filter.
6. Internal power amplifier 30 dBm.
7. External power amplifier.

Please contact SpinCore Technologies, Inc., http://www.spincore.com, or sales@spincore.com, for more information.