PulseBlasterDDS™

Model DDS-III

(PCI Board SP3)

Brief Application Note
SP3-APN001

SpinCore Technologies, Inc.
http://www.spincore.com

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I. Introduction

The PulseBlasterDDS series of intelligent pattern and radio frequency (RF) generation boards from SpinCore Technologies, Inc., couples SpinCore's unique intelligent pattern generation processor core, dubbed PulseBlaster, with Direct Digital Synthesis (DDS) for use in system control and pulse generation.

The PulseBlaster's state-of-the-art timing processor core provides all the necessary timing control signals required for overall system control and pulse synchronization. By adding DDS features, PulseBlasterDDS can now provide not only digital (TTL) but also analog output signals, meeting high-performance and high-precision complex excitation/stimuli needs of demanding users.

PulseBlasterDDS provides users the ability to control their systems through the generation of fully synchronized (digital and analog) excitation pulses from a small form factor PC board, providing users a compelling price/performance proposition unmatched by any other device on the market today.

Coupled with industry standard devices, PulseBlasterDDS makes the perfect nuclear magnetic resonance (NMR) system. Figure 1 represents a basic direct-detection (quadrature) NMR system with the use of PulseBlasterDDS-III.

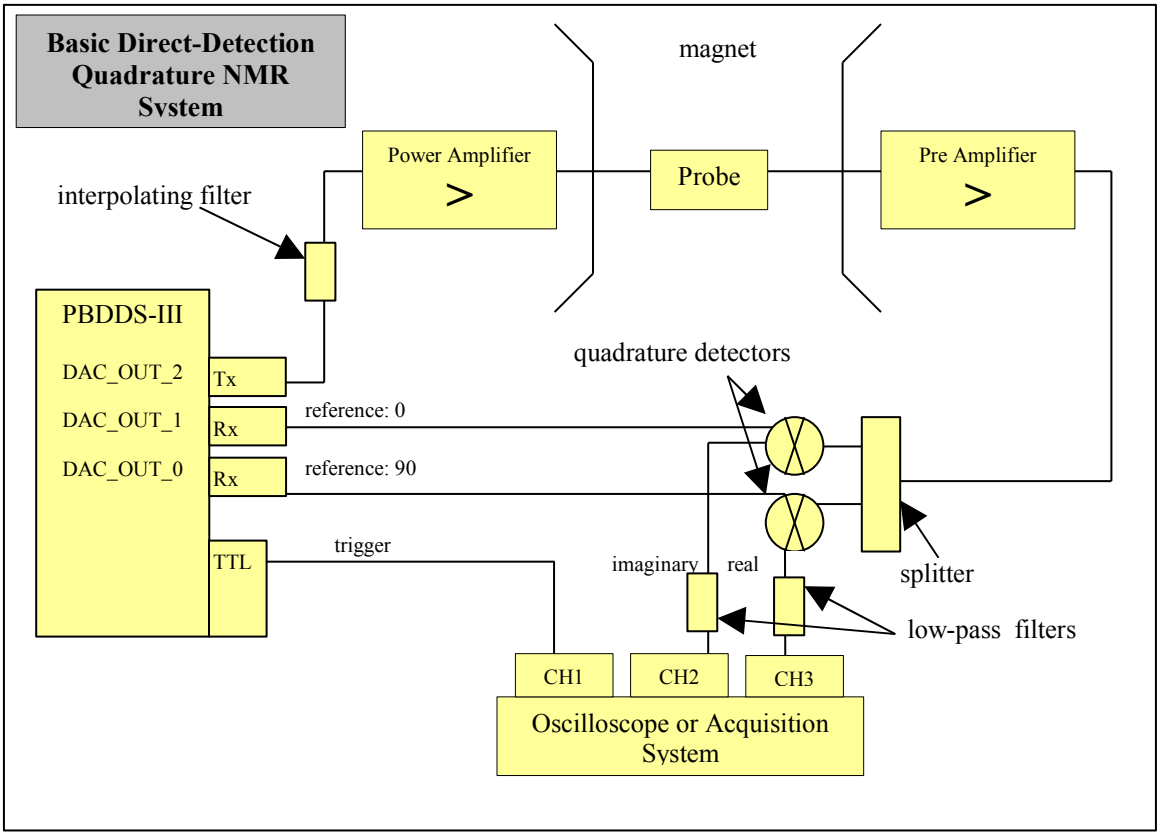

Figure 1: Basic direct-detection (quadrature) NMR system with the use of PulseBlasterDDS-III

II. NMR System Hardware Details

All information presented here is for reference and may not apply to your NMR situation. Properties of one item may depend on other items in the system.

Preamplifier

40 to 50 dB, e.g., two (in series) - Mini-Circuits ZFL-500LN (http://www.minicircuits.com/dg03-172.pdf); Use a $\lambda/4$ cable with crossed diodes in front of the pre amplifier to act as Tx/R switch and to protect the circuit.

Splitter

One - Mini-Circuits ZFRSC-42 (http://www.minicircuits.com/dg03-122.pdf)

Quadrature Detectors

Two - Mini-Circuits ZFM-2 (http://www.minicircuits.com/dg03-94.pdf)

Power Amplifier

Output power 5 to 25 Watts, for probes 5 to 40 mm in diameter

Interpolating Filter

Filter depends on which frequency you are operating at. Possible filters include:

a) lowpass - Mini-Circuits SLP-5 (http://www.minicircuits.com/dg03-198.pdf)
b) bandpass - Mini-Cirucits BBP-10.7 (http://www.minicircuits.com/dg03-200.pdf
c) bandpass – Mini-Circuits BBP-30 (http://www.minicircuits.com/dg03-200.pdf)

Low-pass Filters

a) A 5MHz low-pass filter can be used, as above
b) For narrower bandwidth a custom RC filter would be required

III. Software – Pulse Program

A typical NMR pulse program consist of an RF pulse, a transient period, and an acquisition & repetition delay. The code presented below produces a simple pulse program consisting of these three stages. The output pattern can be seen in Figure 2. This code requires the spinapi package (http://www.pulseblaster.com/CD/spinapi/) and can be compiled using one of the freely available C compilers such as MinGW (http://www.mingw.org/).

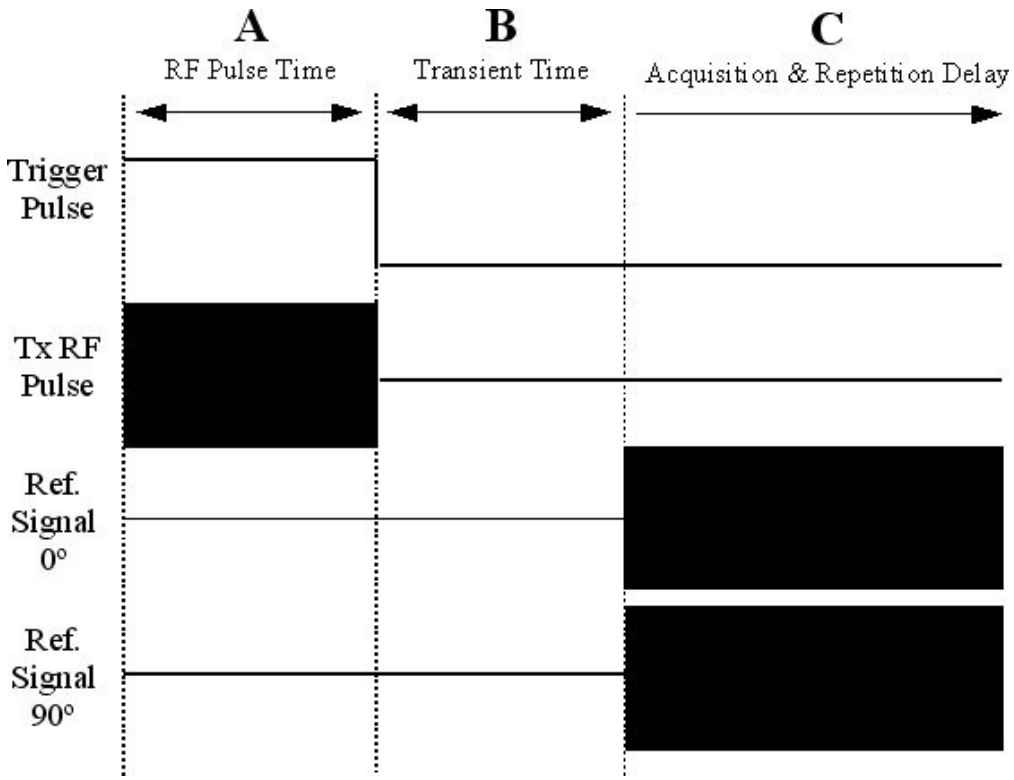

Figure 2: General timing diagram of Example Pule Program (not to scale). Trace 1 is the trigger pulse, trace 2 is the Tx RF pulse, trace 3 and 4 are the two 90 degree phase offset reference signals. Please refer to Figure 1 for RF connector assignments.

Example Source Code

```
#include <stdio.h>
#define PBDDS
#include "spinapi.h"
#define CLOCK 100.0

int main(int argc, char **argv)
{
      int start;
      int status;

    printf ("Using spinapi library version %s\n", pb_get_version());
    if(pb_init() != 0) {
```

```
        printf ("Error initializing board: %s\n", pb_get_error());
        return -1;
    }

    // Tell the driver what clock frequency the board has
    pb_set_clock(CLOCK);

    // Program the frequency registers
    pb_start_programming(FREQ_REGS);
    pb_set_freq(10.791*MHz); // Register 0
    pb_stop_programming();

    // Program RX phase registers (DAC_OUT_1) [Units in degrees]
    pb_start_programming(PHASE_REGS_1);
    pb_set_phase(90);  // Register 0
    pb_stop_programming();

    // Program the TX phase registers (DAC_OUT_0 and DAC_OUT_2)
    pb_start_programming(PHASE_REGS_0);
    pb_set_phase(0);   // Register 0
    pb_stop_programming();

    // Send the pulse program to the board
    pb_start_programming(PULSE_PROGRAM);

    // Interval A
    // RF Pulse and Scope Trigger
   start = pb_inst(0, 0, TX_ANALOG_ON, 0, RX_ANALOG_OFF,
                   0x1FF, CONTINUE, 0, 10.0*us);
    // Interval B
    // Transient time
    pb_inst(0, 0, TX_ANALOG_OFF, 0, RX_ANALOG_ON,
          0x000, CONTINUE, 0, 30.0*us);
    // Interval C
    // Acquisition and Repetition Delay
    pb_inst(0, 0, TX_ANALOG_OFF, 0, RX_ANALOG_ON,
          0x000, BRANCH, start, 1000000.0*us);

    pb_stop_programming();

    // Trigger the pulse program
    pb_start();

    // Retreive the status of the current board.
    status = pb_read_status();
    printf("status: 0x%.2x\n", status);

    // Release Control of the PulseBlasterDDS Board
    pb_close();

    return 0;
}
```

IV. System Output

Figure 3 is an example of the possible free induction decay (FID) NMR signal that can be obtained using the pulse program described earlier.

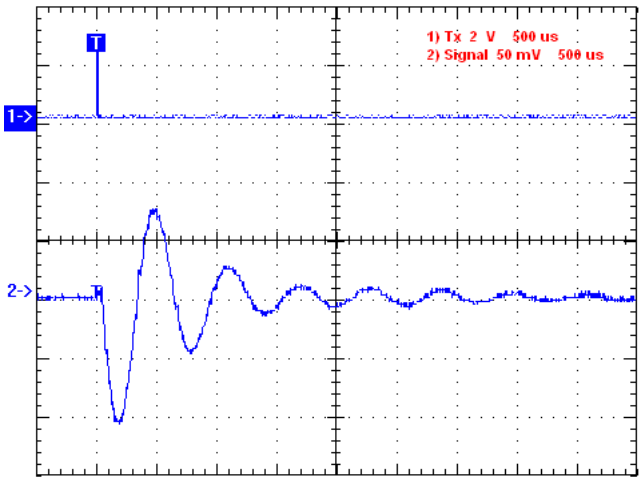

Figure 3: Oscilloscope (Tektronix TDS 224; 100MHz Bandwidth) screen shot of output signal of complete system. Trace 1 is the trigger pulse that also represents the width of the RF pulse and trace 2 is the NMR signal.

Signals can be captured with an oscilloscope or one of the many available general purpose dual-channel data acquisition boards. A complete system including a digital receiver is also available from SpinCore Technologies, Inc.. This product is called the RadioProcessor (http://www.pulseblaster.com/CD/RadioProcessor/) and is currently available.

V. Contact Information

Email: sales@spincore.com

Web: http://www.spincore.com

Product URL: http://www.pulseblaster.com/CD/PulseBlasterDDS/PCI/SP3/