PERFORMANCE RESULTS FOR THE BNL PSI DESIGNED FOR THE SNS AND IT'S APPLICATION TO OTHER ACCELERATORS *

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Abstract

Brookhaven National Laboratory has developed a Power Supply Interface (PSI) as part of the construction of the accumulator ring and transfer lines of the Spallation Neutron Source (SNS) that will be located in Oak Ridge, Tennessee. These units have now been constructed in production quantities. This paper will be in two parts. The first part reports the results of performance testing for it's application to the SNS. But the PSI can also be used for other applications, and is currently being used for another application at BNL, the Booster Application Facility (BAF). The second part of this paper will describe how the versatile PSI can be configured for other machines, and it's performance in ramping applications.

1 GENERAL PSI DESCRIPTION

The standard power interface between an SNS power supplies and the Input/Output Computer (IOC) is accomplished with two pieces of hardware - a Power Supply Interface (PSI), which is electrically connected to the power supply, and the Power Supply Controller(PSC), which is electrically connected to the IOC. A pair of fiber optic cables connects these two units for the communication link and electrical isolation. The PSI and PSC can be seen in Figure 1, with the PSC in a three slot VME crate with an IOC for testing.

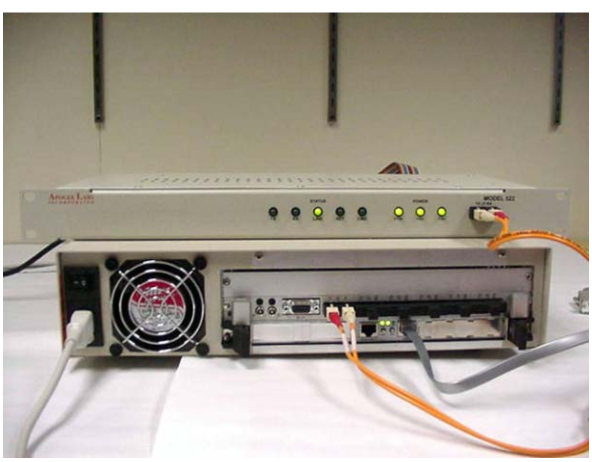

Figure 1. PSC and IOC in VME with Rack PSI

Together these two units provide analog and digital I/O communication. The PSC can send up to 15 digital command bits and one 16 bit analog reference to the power supply via the PSI, and receive back 16 status bits and four 16 bit analog readbacks.

There are several different features to this system, which have been described previously [1]. The primary purpose of this paper is to describe the performance of the analog portions as measured with production units.

2 TEST CONFIGURATION

The basic test configuration uses a standard personal computer (PC) running a LabView program to implement the test functions and data gathering. It communicates with a PSC, and then through the fibers to the PSI under test.

The single analog reference generated by the DAC in the PSI is wrapped around to all four analog inputs to the PSI. This wrapped around voltage is measured by a precision digital voltmeter (DVM). The DVM values are sent back to the PC via a GPIB link, where they are read by the LabView program.

For temperature stability tests, a temperature sensor is also recorded by the test software during the measurements.

Gains and offsets were calibrated before the tests were performed.

3 TEST RESULTS

3.1 Noise

Noise was measured both with and without integration. The results without integration is shown in Figure 2. The DAC was set to 5 Volts, and 1000 readings were taken from each channel.

It can be seen that one of the channels was offset by one bit from the other three, but in all four cases, every data point was within 3 LSBs of the central value, and most were within 2 LSBs.

The noise test was repeated with 10,000 samples, but every ten consecutive pulses were averaged to yield 1,000 data points again. The results are shown in Figure 3.

The results show the square root of N improvement that one would expect.

Any level of integration for noise improvement in system operation would be performed by the higher-level software. It is not implement in the PSI/PSC hardware.

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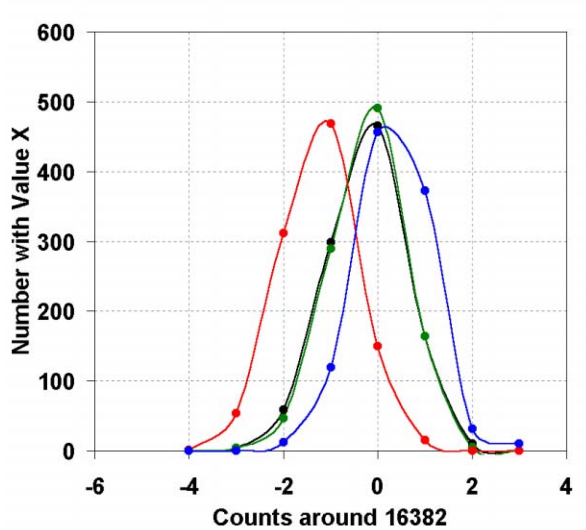

Figure 2. Non-Integrated Noise Results

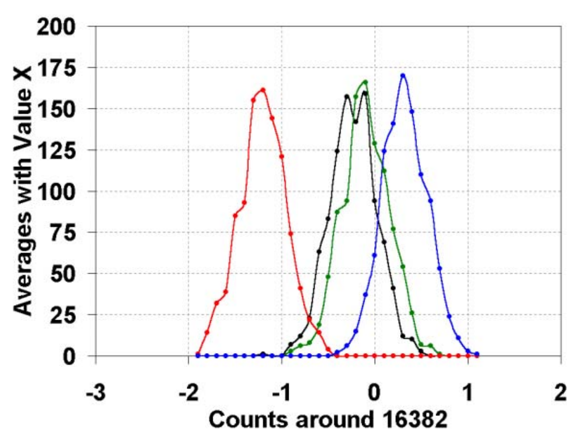

Figure 3. Integrated Noise Measurement

3.2 Linearity

The linearity tests were performed over the entire range of the ADC which spans from –10 Volts to +10 Volts. To make the results clearer to see, the four ADC channels are plotted on two graphs, Figure 4 and Figure 5.

In these linearity measurements, ten consecutive data points were averaged. In the graphs of Figures 4 and 5, the Y-axis division is 300 μVolts, which is one LSB. The difference between the ADC reading and the DVM reading is plotted, and can be seen to be within +/- one LSB.

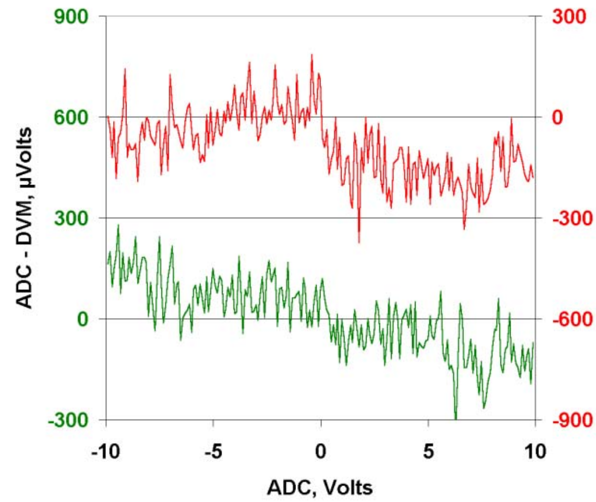

Figure 4. Linearity Results - Channels 1 and 2

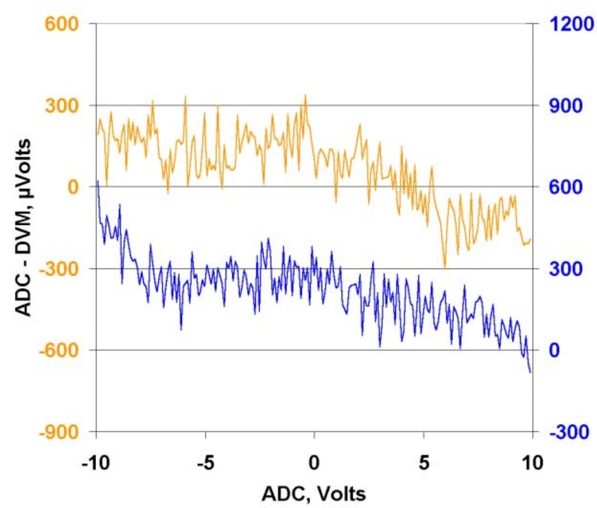

Figure 5. Linearity Results - Channels 3 and 4

3.3 Temperature Stability

Our temperature chamber was a room with a window left open overnight, in the winter. Since we were measuring the ambient temperature continuously, it didn't matter what it was, as long as we achieved a large enough swing in temperature to notice an effect.

The temperature stability of both the ADC and DAC was measured. Figure 6 shows the results for the DAC.

The top trace shows that over the 14 hour period that the test was run, the temperature in the room dropped 10°F. The right axis represents change around a nominal value of 76.4°F. During that same time, the DAC voltage dropped 120 μVolts, or about half an LSB. The left axis represents the change around a nominal value of 3 Volts.

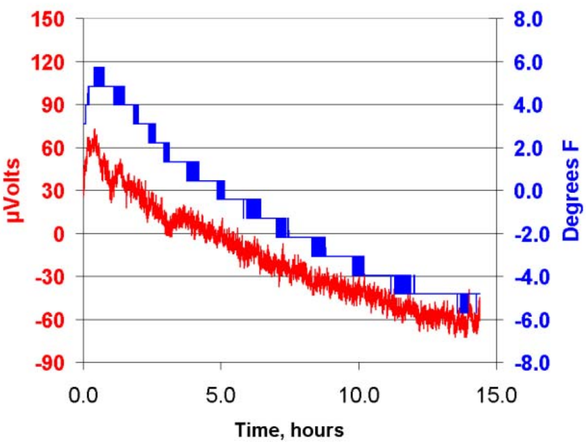

Figure 6. DAC Temperature Stability

During that same 14 hour period, data was taken from the four ADC channels. These results are shown in Figure 7.

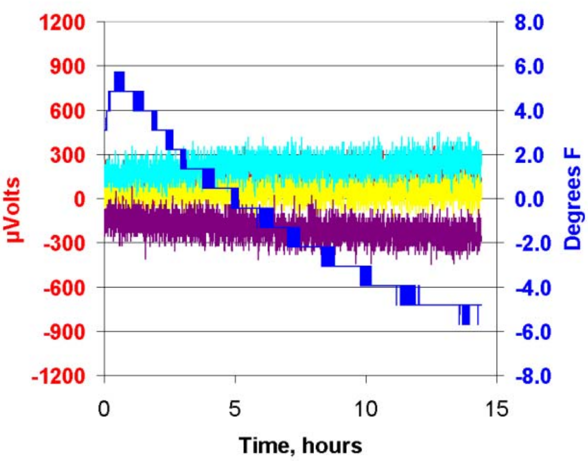

Figure 7. ADC Temperature Stability

In the ADC case, the same 10°F temperature range can be seen, as was the case with the DAC. In this case, the Y-axis is one LSB per division. It can be seen that the drift may be up or down, but in all cases less than one LSB.

4 APPLICATION BEYOND SNS

4.1 Timed Setting and Readings

The PSI/PSC system is suitable for applications well beyond SNS. Even though SNS is a DC machine, the waveform generation capabilities of this system allow for dynamic tuning and magnet cycling. The PSI/PSC system can produce waveforms, generated by the IOC, at rates of over 10KHz.

The waveform capture capabilities of this system allow for ripple and line disturbance recording, as well as FFT analysis.

Figure 8 Shows an example of an FFT analysis of ripple on a BAF power supply. The PSI and PSC collected data in the burst mode, and stored it in the circular buffer. That made it available for FFT computations.

Combined, the timed setting and reading features make the PSI/PSC suitable for ramp generation, waveform viewing or frequency component viewing.

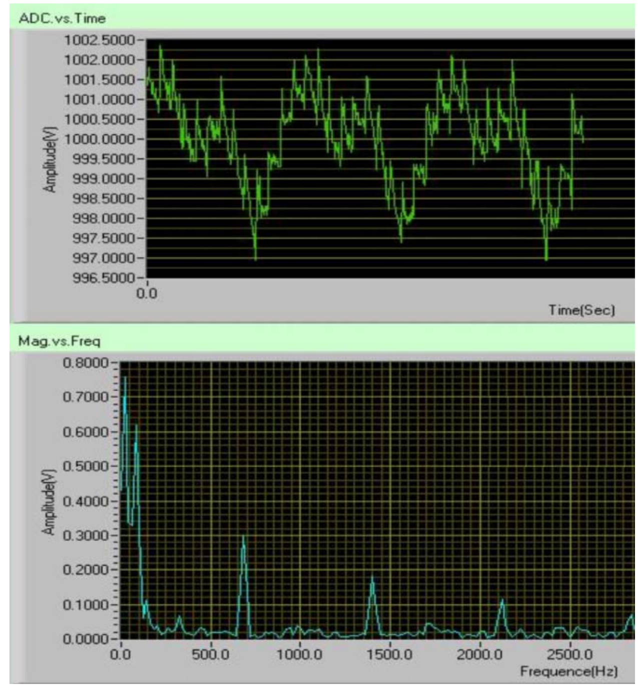

Figure 8. FFT Analysis

4.2 Standard Power Supplies

As power supplies are built to interface with this system, one can think of the combination of the PSI/PSC and a power supply as an "EPICS Ready" power supply. One example of this is our bipolar correction power supplies. Already in use at SNS and the Booster Application Facility at BNL, these units are likely to be used at least at one outside Laboratory.

Consider that while power supplies change very little from machine to machine, the interface can change widely. With the PSI/PSC, no modifications to the power supply are needed to interface with any EPICS based control system.

5 CONCLUSION

The BNL designed PSI/PSC, which has been developed for SNS has been shown to operate within specifications in all key analog measures of performance.

This versatile system can make power supply interfacing easier in a large class of machines with EPICS based control systems.

6 REFERENCE

[1] R. Lambiase, B. Oerter, S. Peng, J. Smith, "Power Supply Control And Monitoring For The SNS Ring And Transport System," PAC' 01, Chicago, June 2001.