DIGITAL RECEIVER TECHNOLOGY FOR HIGH-SPEED NEAR-FIELD ANTENNA MEASUREMENTS

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ABSTRACT

High-speed receivers for near-field antenna and RCS measurements have traditionally been one-of-a-kind, expensive, difficult to interface and lacking in software support. Advances in digital signal processing, computer technology and software development now provide the means to economically solve these problems. NSI offers a high speed receiver subsystem, the Panther 6000 series, that allows multiplexed beam and frequency measurements at a rate of 80,000 independent amplitude and phase measurement points per second. The Panther 6000 receiver directly digitizes the 20 MHz IF test and reference input channels, and includes a high speed beam controller (HSBC) to sequence the measurement process. The HSBC receives an input trigger to initiate a measurement sequence of user-defined frequencies and beam or pol states.

NSI also offers a multi-channel all-digital receiver subsystem, the Panther 6500, to interface directly with Digital Beam Forming (DBF) antennas. The Panther 6500 allows up to 16 channels of I and Q digital input (16 bits each) with 90 dB dynamic range per channel. The all-digital DBF receiver reduces the cost, complexity and performance limitations associated with conventional instrumentation in DBF antenna measurement applications.

All Panther series receivers are fully integrated with the NSI97 antenna measurement software and operate with existing microwave sources, mixers and IF distribution equipment.

Keywords: Antenna Measurements, Near-field, Digital Receiver, Digital Beamforming, Digital Signal Processing, A/D Converters

1.0 INTRODUCTION

This paper describes the NSI Panther 6000 series digital receiver developed for high-speed near-field antenna measurements, and includes the following sections:

- Digital Receiver Applications
- Description of the Panther 6000 Receiver
- Description of the Panther 6500 DBF Receiver
- Panther 6000 Test Data
- Summary

2.0 DIGITAL RECEIVER APPLICATIONS

The contribution of receiver speed to overall antenna measurement throughput is well documented and varies from insignificant to critical depending upon the application [1]. For example, receiver speed is a minor factor in computing measurement time for single-frequency, single-beam antennas, but is very important for antenna measurements requiring many frequencies, multiple ports, dual polarization and beam switching. These applications will benefit greatly by incorporating a high-speed receiver. Since the receiver measurement is in the 'inner loop', and occur most frequently, improvements in speed have the greatest impact to overall measurement throughput [2]. Receiver speed and accuracy are interrelated and both should be considered when selecting a measurement system [3]. Technology advances in digital signal processing, A/D converters, computers and software allow highly accurate digital receiver implementation, while achieving a very high throughput. The Panther 6000 is an example of this technology applied to a direct IF sampling receiver with digital downconverter for high accuracy and throughput.

3.0 PANTHER 6000

The Panther Series 6000 High Speed Receiver and Beam Controller are designed specifically for high performance antenna testing where speed and accuracy are required. Applications that require high throughput, multi-frequency, multi-beam measurements with ease of setup are excellent candidates for the Panther 6000. The Panther 6000 High Speed Interface (HSI) and High Speed Beam Controller (HSBC) are shown in the photo below.

Figure 1 NSI Panther 6000 Receiver

The Panther 6000 Receiver and Beam Controller collect multi-port and multi-frequency data in user-specified order at rates up to 80,000 measurements per second. The Panther 6001 High Speed Interface (HSI) digitizes the 20 MHz test and reference IF signals from an external frequency downconverter such as the Hewlett Packard HP 85310A. The test and reference IF signals are amplified, digitized, digitally filtered and downconverted to baseband, then transferred from the Panther directly to the PC in real-time.

The Panther 6002 High Speed Beam Controller (HSBC) provides real-time control over the measurement process. During test setup, the NSI software transfers the user specified port, frequency and timing information to the HSBC. Once configured, the actual measurement process is controlled by the HSBC, freeing the measurement computer from critical timing requirements. The Panther 6002 provides simultaneous control of two frequency sources and will interface to a wide variety of sources including the HP 8360 series, HP E6432A series (VXI based), Gigatronics GT12520A, and Comstron FS5000. The Panther 6002 will also control a variety of multi-port PIN switches including the Hewlett Packard HP 85331A and HP 85332A series for high speed switching of RF signals up to 40 GHz. Specifications for the Panther 6000 are shown below.

Panther 6000 Specifications

Panther 6001 High Speed Interface	
Sensitivity (1 average)	-90 dBm
Measurement speed (max)	80,000 points per second
Receiver integration time (1 average)	8.4 usec
IF Bandwidth (minimum integration time)	160,000 kHz
No. Channels	2 (test and reference)
Buffer size (memory available for single cut)	2,000,000 points
IF Frequency (nominal, others available as option)	20 MHz
Dynamic Range (1 average)	68 dB
Size	1.75”H x 17”W x 12”D
Power Requirements	100 – 240 VAC, 47-63 Hz, 35W
Controls and Indicators	Power switch, DC Power, Test/Ref Overload & Trigger LEDs

Panther 6002 High Speed Beam Controller	
Measurement speed (max)	80,000 points per second
Beam setup time (min)	4.2 usec
Timing resolution	1.0 usec
Multiplexing capacity	9,000 measurements per trigger
Switch control unit ports	Three (3) ports, 8-bits per port, RS-422 differential outputs
Frequency control	Two (2) ports, 44-bits per port, RS-422 differential outputs
Trigger inputs	One (1) single-ended trigger input
Trigger outputs	Four (4) single-ended trigger outs Four (4) differential trigger outs
Size	3.5”H x 17”W x 12”D

Power Requirements	100 – 240 VAC, 47-63 Hz, 100W
Controls and Indicators	Power switch, DC Power, State, Trigger LED

A typical near-field application [4] using the Panther 6000 is shown in the figure below.

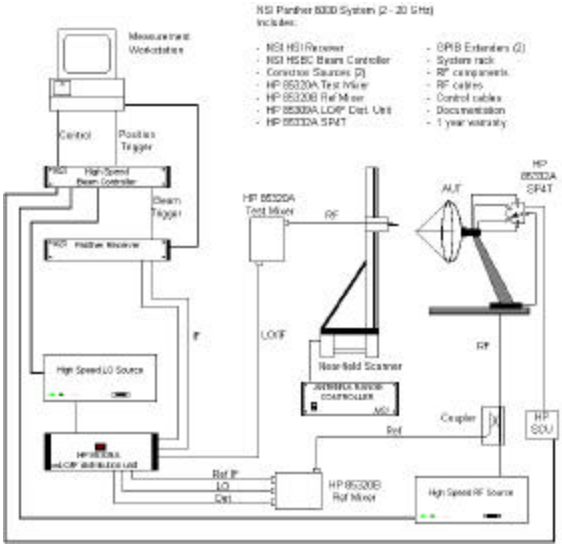

Figure 2 Near-field System with Panther 6000

4.0 PANTHER 6500 DBF RECEIVER

The Panther 6500 Digital Beam Forming (DBF) Receiver is designed specifically to test antennas that directly output digital data [5]. The Panther 6500 offers improved sensitivity, dynamic range, noise immunity and speed over most analog receivers available today, and eliminates many of the problems associated with conventional antenna measurement systems. An 8-channel model of the Panther DBF Receiver is shown below.

Figure 3 NSI Panther 6500 Receiver

The Panther 6500 DBF Receiver operating with the NSI 6002 High Speed Beam Controller is capable of receiving up to 16 channels of digital I (16-bit In-Phase) and Q (16-bit Quadrature) data in random order at rates up to 312,500 measurements per second. The digital input data is capable of being coherently clocked at rates up to 5 MHz. The I and Q channels are multiplexed into a High-Speed Digital Receiver module, which performs x16 integration, and then transferred from the Panther directly to the PC in real-time. A block diagram of the Panther 6500 signal flow is shown in Figure 5.

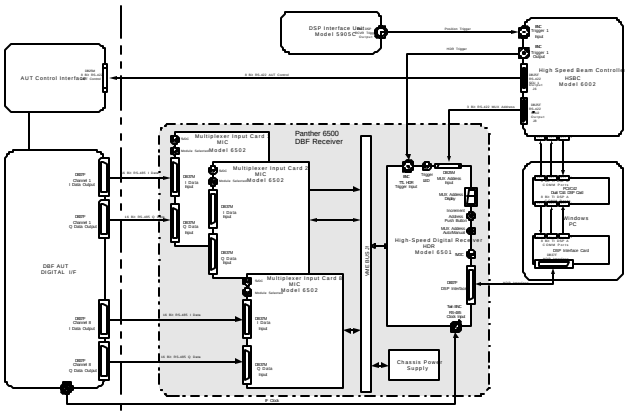

Figure 4 Panther 6500 Block Diagram

The Panther 6002 High Speed Beam Controller (HSBC) provides real-time control over the DBF measurement process in the same manner as for the Panther 6000. For the Panther 6500 application, the HSBC controls selection of the digital input multiplexer and provides 8-bits for AUT beam-forming control. Specifications for the Panther 6500 are shown in the following table.

Panther 6500 Specifications

Panther 6500 DBF Receiver	
Sensitivity (1 average)	AUT dependent
Measurement speed (max)	312,500 points per second (no averages)
Receiver integration time (1 average)	4.2 usec
IF Bandwidth (minimum integration time)	160,000 kHz
Number of Channels	2 (test and reference)
Buffer size (memory available for single cut)	2,000,000 measurement points
IF clock rate	5 MHz
Dynamic Range (1 average)	90 dB
Size	(9U) 15.75”H x 17”W x 15”D
Power Requirements	100 – 240 VAC, 47-63 Hz, 35W
Controls and Indicators	Power on/off switch, Mux Select Sw, Local/Auto Sw, Mux LEDs, IF Clk LED,

A typical system block diagram using the Panther 6500 is shown in the figure below.

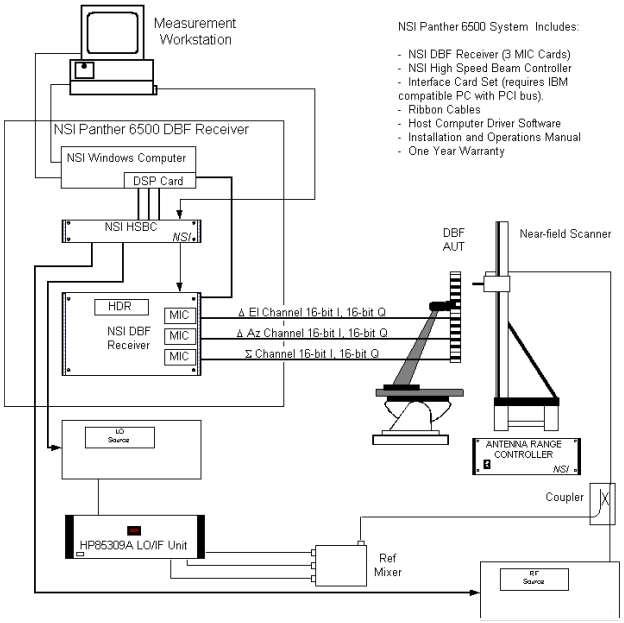

Figure 5 Near-field System with Panther 6500

5.0 TEST DATA

Test measurements for the Panther 6000 receiver and High Speed Beam Controller are shown in the figures below. Test data is measured using the HP 85320A/B mixers and HP 85309A LO/IF Distribution Unit.

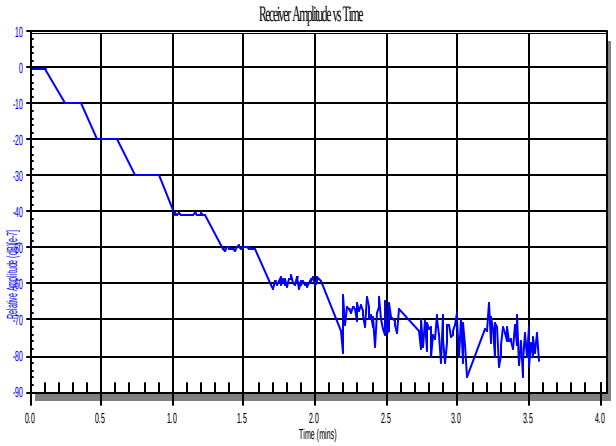

Figure 6 Panther 6000 Receiver Linearity

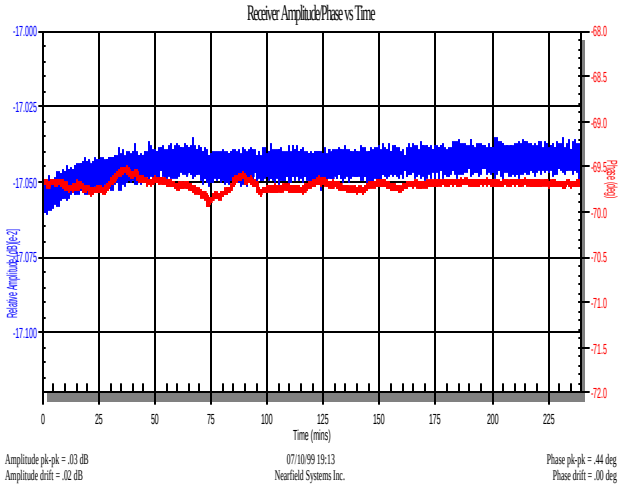

Figure 7 Amplitude & Phase Stability

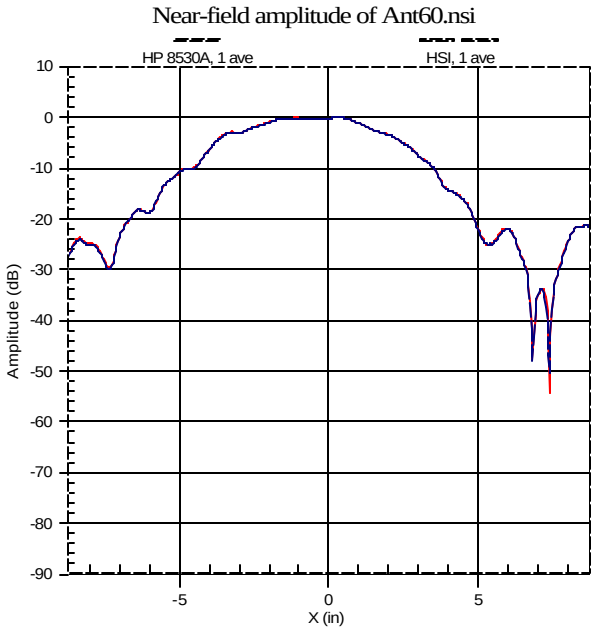

Figure 8 Near-field Amplitude Comparison with HP 8530A Receiver

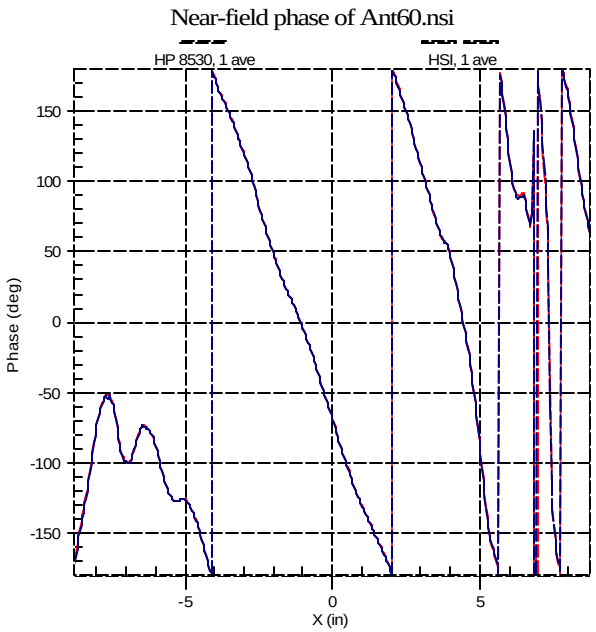

Figure 9 Near-field Phase Comparison with HP 8530A Receiver

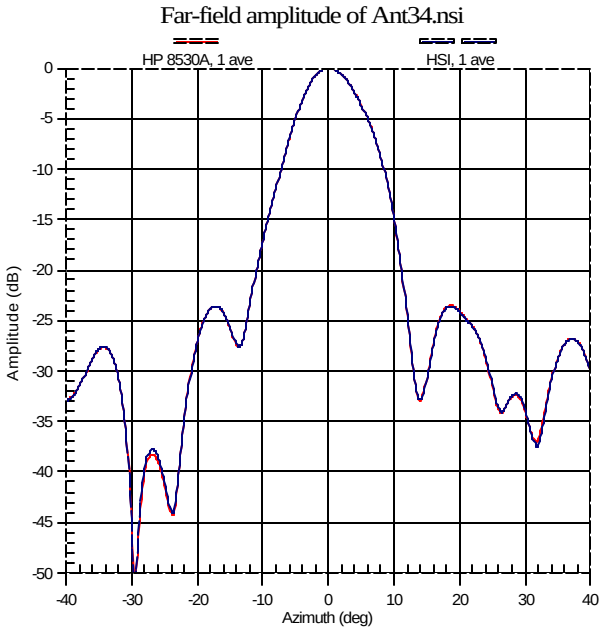

Figure 10 Far-field Comparison with HP 8530A

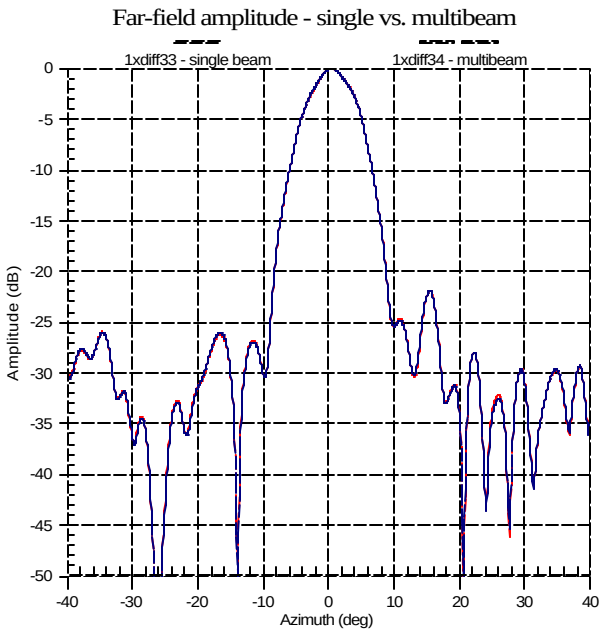

Figure 11 Single Beam to Multi-beam Comparison

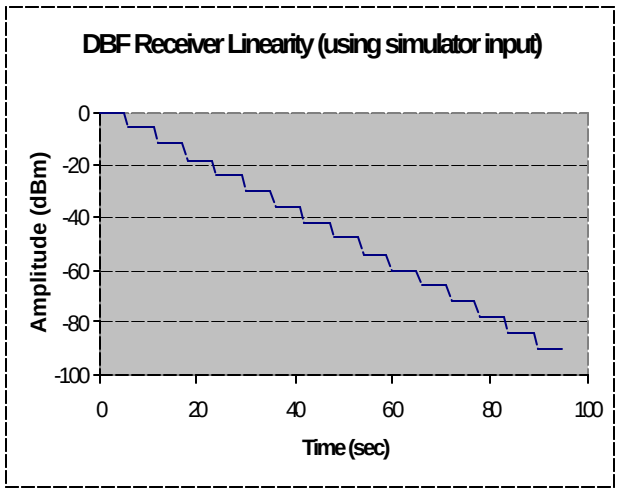

Figure 12 Panther 6500 DBF Receiver Linearity

6.0 SUMMARY

The Panther 6000 family of digital receivers represent a significant improvement in receiver technology for high-speed antenna measurements. Far-field, near-field and RCS applications can take advantage of the high throughput and performance of these receivers. The Panther 6500 DBF Receiver with its all-digital implementation offers unequaled performance for digital beam forming applications.

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