



D5000

Signal Analyzer

Hardware Description



02-107344-04



D5000

Signal Analyzer Hardware Description





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Guzik Technical Enterprises
2443 Wyandotte Street
Mountain View, CA 94043
TEL: 650-625-8000
FAX: 650-625-9325



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U.S. Patent Pending



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Table of Contents

Chapter 1 About this Document	1
1.1 Scope.....	1
1.2 Purpose	1
1.3 Audience.....	1
1.4 Revision History.....	1
1.5 References	1
1.6 Technical Support.....	2
Chapter 2 Introducing the D5000	3
2.1 Advantages of Digital Measurements.....	3
2.2 D5000 Features	7
2.3 D5000 Block Diagram.....	7
2.4 Integrating the D5000 with the RWA-2000 Series.....	9
Chapter 3 D5000 System and Specifications	11
3.1 D5000 Components and Specifications.....	11
3.1.1 ADC10K Data Acquisition Module.....	12
3.1.2 M5000 Memory Card.....	15
3.1.3 DP5000 Digital Data Processor.....	15
3.2 Boards and Connectors.....	17
3.3 D5000 Measurement Accuracy Specifications	17
3.4 PCI-to-CPCI Bridge	18
3.5 D5000 Physical Specifications.....	18
3.6 D5000 Environmental Specifications.....	18
Chapter 4 Installation	19
4.1 Before Installation Begins	19
4.2 Software Requirements, Installation and License.....	20
4.3 Hardware Installation Requirements.....	20
4.4 D5000 Front and Back Panels.....	20
4.4.1 PCI-to-CPCI Bridge Installation	23
4.4.2 Installation of Additional CPCI Boards (Optional).....	24
4.5 Cable Connections	24
4.6 Grounding	25
4.7 Starting the D5000.....	25
4.8 Powering-off the D5000.....	26
4.9 Functionality Verification.....	26
Chapter 5 D5000 Operational Basics	28
5.1 D5000 Synchronization.....	28
5.2 Hardware Channels	29
5.3 Measurements and Tests	29
5.3.1 Dual Analog–Digital Tests	34
5.3.2 Perpendicular Recording: Rise–Fall Time Replaces Pulse Width.....	34
5.3.3 Digital Parametric Tests.....	35
5.3.4 PRML Tests	35
5.3.5 Jitter Explorer Test.....	36
5.4 Capture Methods: Profile and One-Shot.....	36
5.5 TAA Calibration.....	38

D5000 CABLE DIAGRAM39

List of Figures

Figure 1: Absolute accuracy and relative error of digital parametric measurements 4
Figure 2: Positive and negative slope profiles at different noise levels (perpendicular recording) 5
Figure 3: Error rate for two PRML decoding algorithms (perpendicular recording) 5
Figure 4: Jitter Explorer test graphic output 6
Figure 5: Averaged signal (blue) and jitter values for each transition (red) 6
Figure 6: Eye diagram 7
Figure 7: D5000 block diagram 8
Figure 8: D5000 chassis with CPCI modules installed 9
Figure 9: Guzik D5000 with RWA-2000 series and V2000 spinstand 10
Figure 10: Guzik test system configuration 10
Figure 11: D5000 block diagram 11
Figure 12: ADC10K data acquisition module 12
Figure 13: ADC10K output signal spectrum (FFT) for input frequency 190.983 MHz and sampling clock 10 GHz 14
Figure 14: ADC10K output signal spectrum (FFT) for input frequency 2440.983 MHz and sampling clock 10 GHz 14
Figure 15: M5000 memory card 15
Figure 16: DP5000 digital data processor 16
Figure 17: D5000 boards and connectors 17
Figure 18: D5000 front panel (left) and back panel (right) 22
Figure 19: D5000 cable diagram. The spinstand (not shown) is not connected to the D5000 25
Figure 20: Hardware Features lists D5000 hardware 27
Figure 21: Synchronization for digitization 28
Figure 22: Hardware channels 29
Figure 23: One-shot method: shaded, low-amplitude pulses are ignored 37
Figure 24: Profile method: measuring parameters 37

List of Tables

Table 1: ADC10K specifications 13
Table 2: Accuracy of parametric measurements (repetitive pattern) 17
Table 3: D5000 physical specifications 18
Table 4: D5000 environmental specifications 18
Table 5: D5000 cable set 24
Table 6: Measurements that can be performed with analog or digital hardware 34
Table 7: Hardware compatibility of PRML-related tests 35
Table 8: Comparison of the One-shot and Profile methods 36

CHAPTER 1

ABOUT THIS DOCUMENT

1.1 Scope

This hardware description covers the D5000 Signal Analyzer. The control software is described in the *WITE32 Digital Measurements Test Descriptions Engineer's Reference*.

1.2 Purpose

Provide information to set up, configure, calibrate, and troubleshoot the D5000 hardware.

1.3 Audience

Hardware engineers responsible for the assembly and maintenance of a Guzik Technical Enterprises test system, including the set-up of the D5000. Knowledge of hard-disk test environments is a prerequisite.

1.4 Revision History

Revision 01 – initial release.

Revision 02 – minor update.

Revision 03 – includes the following updates:

- Section 4.7, Starting the D5000,
- Section 4.8, Powering-off the D5000,
- Section 5.5, TAA Calibration.

Revision 04 – removed references to multi-module configurations, such as multiple DP and multiple ADC configurations. These options are not supported.

1.5 References

The following Guzik Technical Enterprises test-system documentation is referenced in this document:

- *Read-Write Analyzer 2000 Series User's Manual*
- *V2002 Spinstand User's Manual*
- *Guzik PCI Host Adapter Installation Guide*
- *WITE32 Digital Measurements Test Descriptions Engineer's Reference*
- *WITE32 Installation User's Guide*
- *WITE32 System Configuration User's Guide*

- *WITE32 Standard Tests Descriptions Engineer's Reference*
- *WITE32 Servo User's Guide*
- *WITE32 Pattern Developer's Guide*

1.6 Technical Support

If you have any question about your Guzik product:

1. Read the printed documentation for this product and any online help provided within the software.
2. If you cannot find the answer, contact the Guzik Product Support Service.

Use the following links to contact the Guzik Product Support Service:

In the USA	Voice	(650) 625-8000	Between 9 A.M. and 5:00 P.M. Pacific Time, Monday through Friday excluding holidays
	Fax	(650) 625-9325	
	E-mail	support@guzik.com	

When you call:

1. You should be at your computer and have the appropriate product documentation at hand
2. Be prepared to give the following information to our product support service representative:
 - The revision number of the Guzik software
 - The type of spinstand, RWA and additional test-system hardware
 - What happened
 - What were you doing when the problem occurred
 - The exact wording of all error messages displayed on the computer
 - How you are trying to solve the problem

CHAPTER 2

INTRODUCING THE D5000

2.1 Advantages of Digital Measurements

The RWA-2000 series already provides measurements in real time using analog circuits. Why add or switch to digital measurements? There are three main reasons:

1. A digital system gives high accuracy for parametric measurements at a low signal-to-noise ratio (SNR) by averaging. For example, with SNR as low as 12 dB, you can measure TAA, pulse width, rise/fall time, *etc.*, with an error below 1% (Figure 1). Also, the slope measurements for perpendicular recording signals are stable in high noise (Figure 2). With such low SNR, analog circuitry typically does not work at all or errors exceed 20%; high noise causes a peak detector to report a TAA that is too high and a PW that is too low.
2. PRML decoders are implemented digitally. The decoding algorithm can be reprogrammed, for example, from perpendicular to longitudinal recording. This gives a unique opportunity to optimize the decoder. As an example, Guzik Technical Enterprises developed a new, self-adjustable algorithm for PRML signal decoding* with a lower error rate than traditional PRML decoders (Figure 3).
3. Jitter (transition-shift timing noise) can be analyzed in a number of ways.* The Jitter Explorer test can emphasize and suppress different types of jitter, for example media noise, read-channel noise, pattern-dependent noise (inter-symbol interference, ISI; non-linear transition shift, NLTS; hard and easy transition shift, HTS and ETS). Figure 4 shows the graphic output from the Jitter Explorer test. Figure 5 shows a close-up of the resampled signal and jitter track; Figure 6 shows a close-up of an eye diagram.
4. A digital system gives high repeatability of measurements.
5. DFT-based algorithms for frequency-domain analysis available on the digital system are faster compared with traditional frequency-domain measurements.

The known disadvantage of digital systems, compared to analog systems, is processing speed. To overcome this problem, Guzik Technical Enterprises developed a high-speed digital data processor with a data processing speed 2.5 Gs/sec. As a result, the D5000 executes PRML decoding and parametric measurements more than 100 times faster than currently available digital oscilloscopes. The D5000 has a 4 GByte memory card, which stores many revolutions of read-back data in real time. This buffer allows the data processor to continue calculations after the reading is finished—during head loading and unloading operations, *etc.* As a result, the D5000 has a near-real-time throughput.

* Patent pending

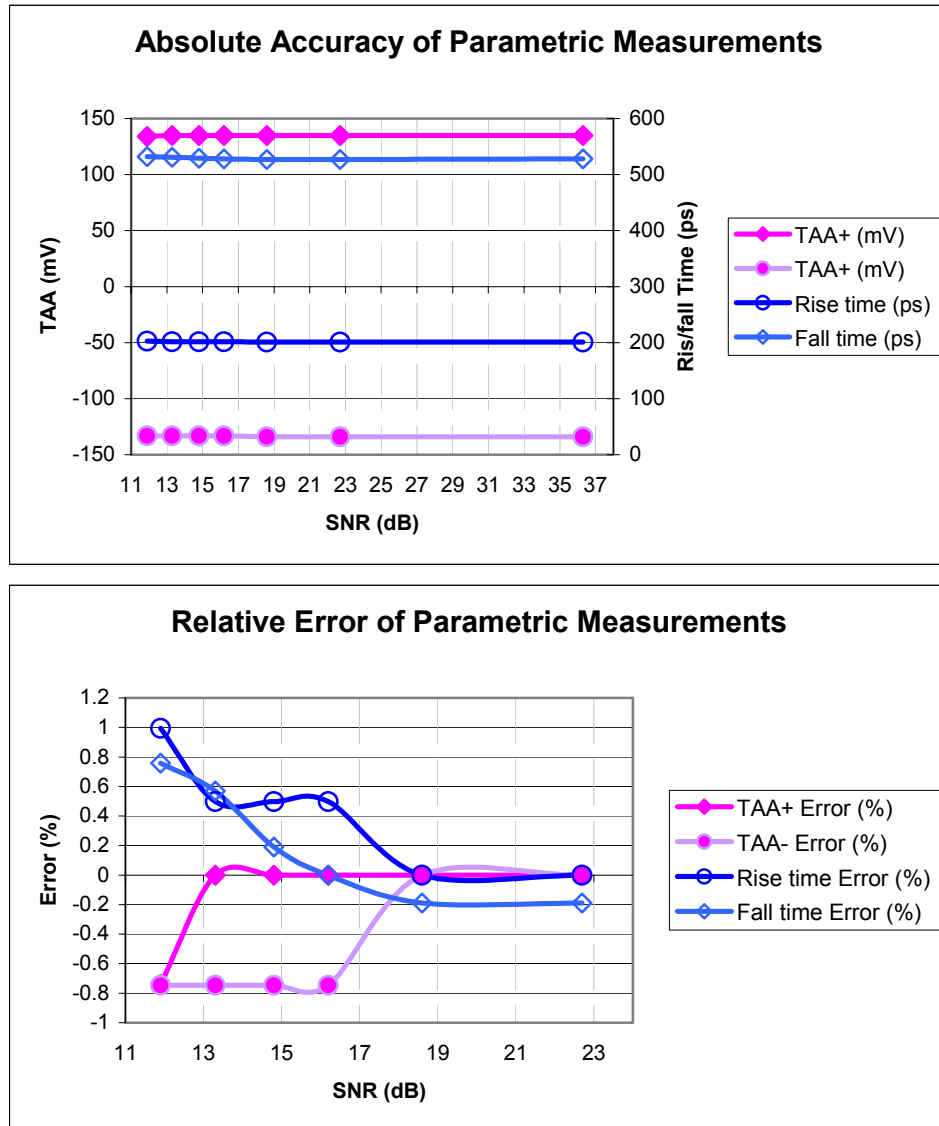


Figure 1: Absolute accuracy and relative error of digital parametric measurements

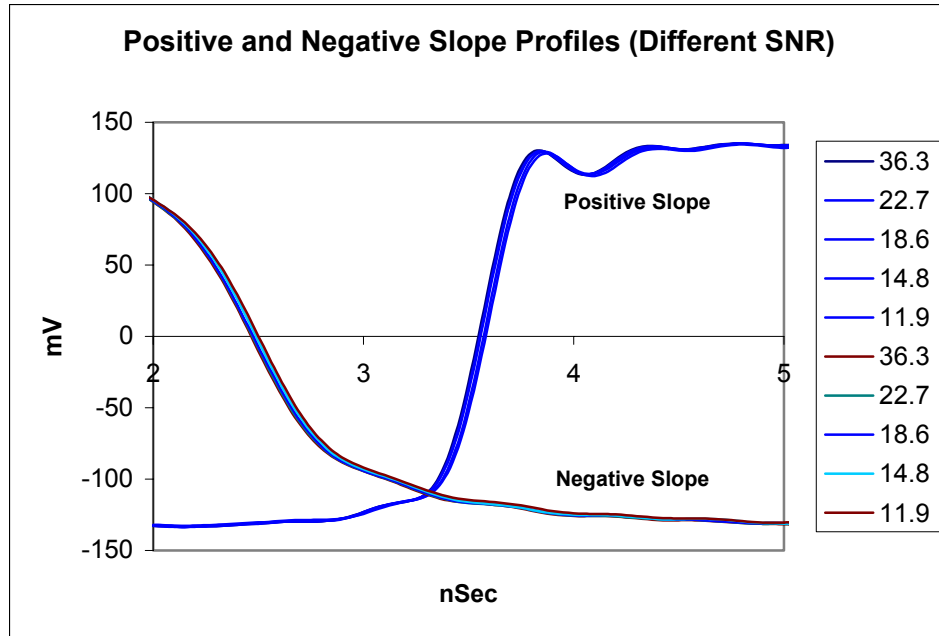


Figure 2: Positive and negative slope profiles at different noise levels (perpendicular recording)

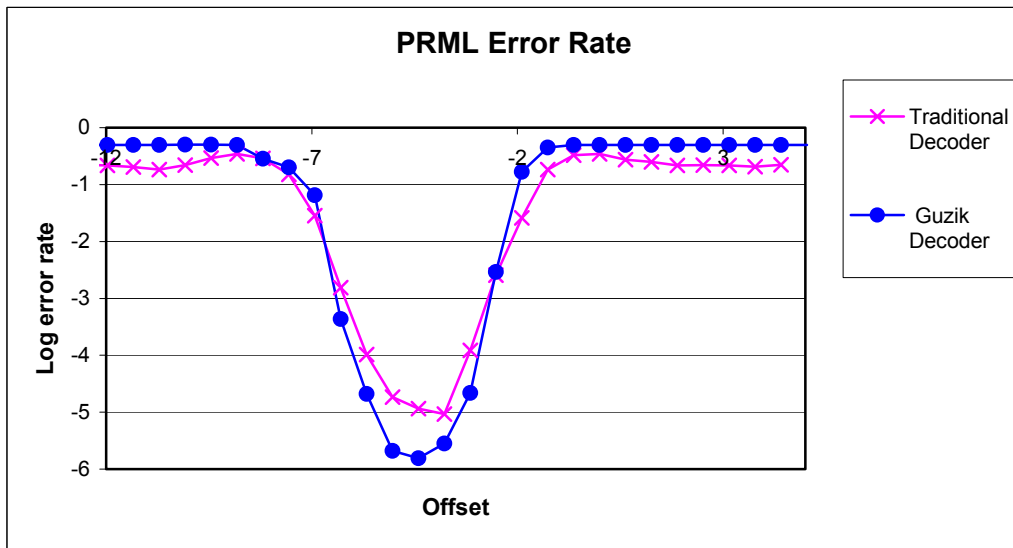


Figure 3: Error rate for two PRML decoding algorithms (perpendicular recording)

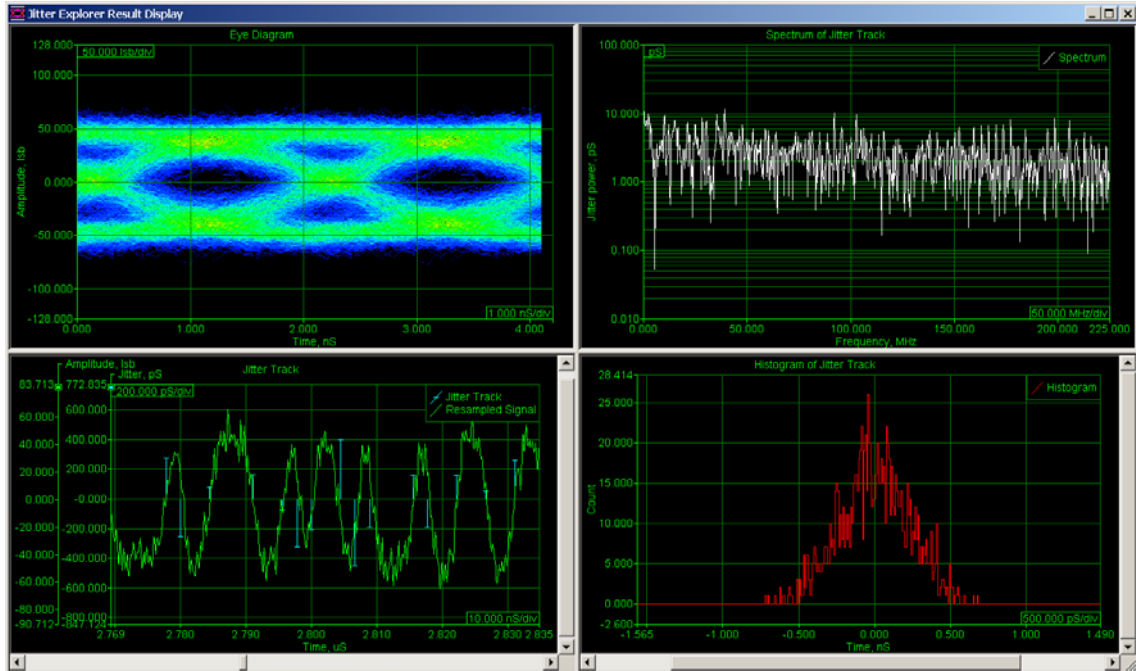


Figure 4: Jitter Explorer test graphic output

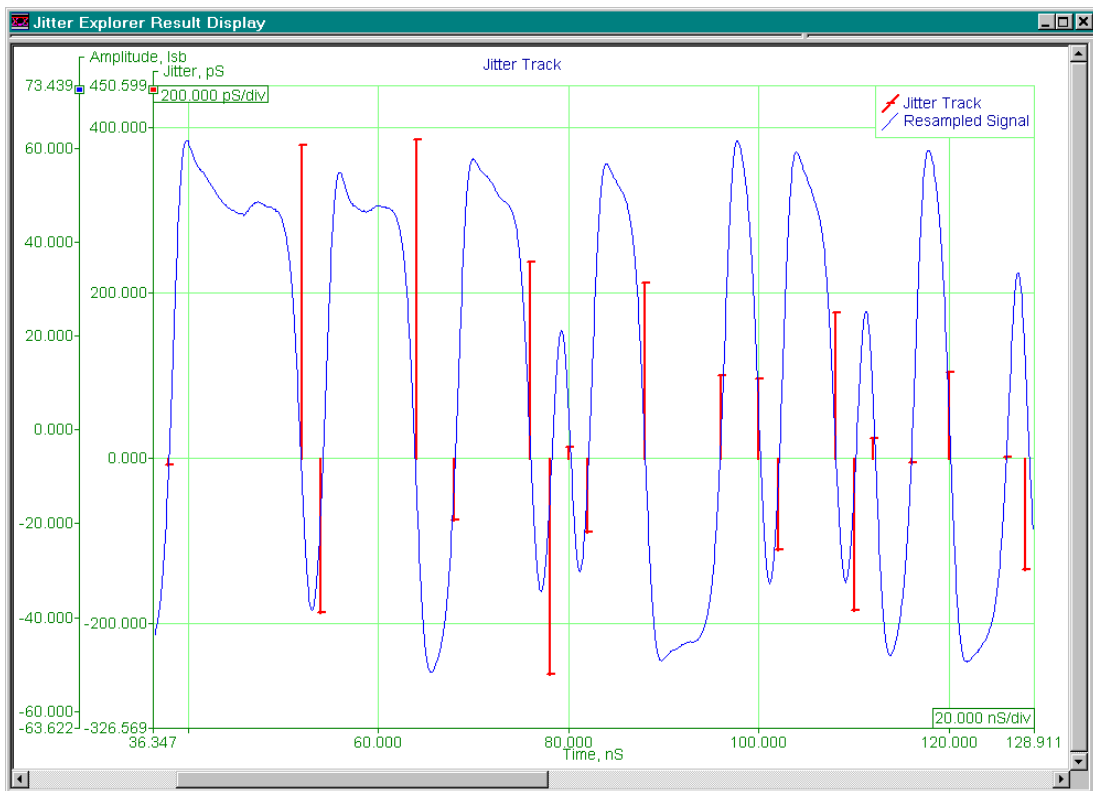


Figure 5: Averaged signal (blue) and jitter values for each transition (red)

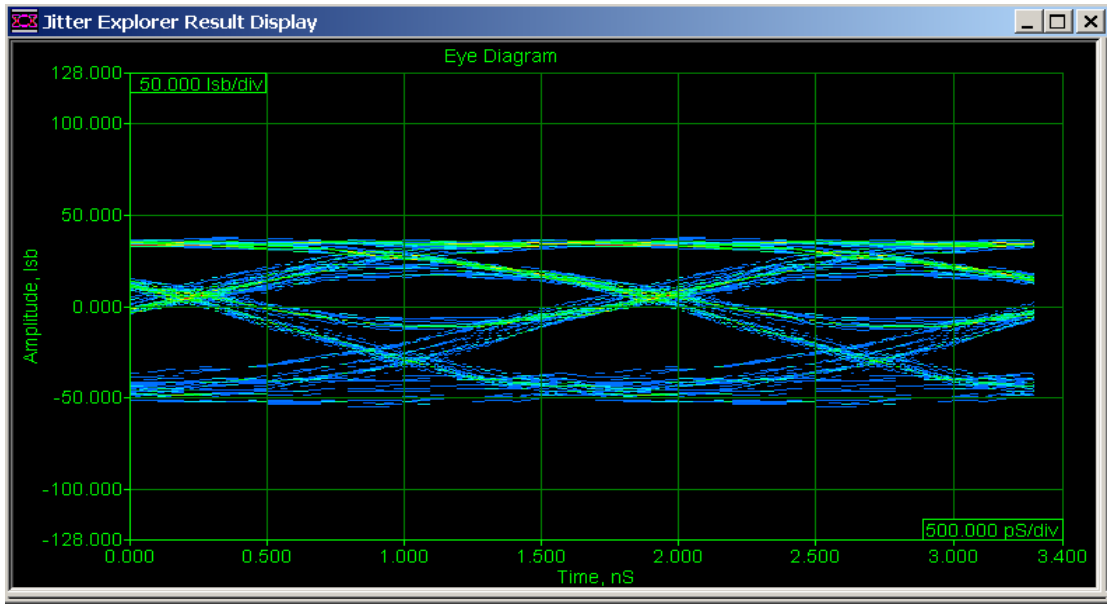


Figure 6: Eye diagram

2.2 D5000 Features

The Guzik D5000 Signal Analyzer has the following features:

- 10 Gs/sec acquisition speed
- 5 GHz analog bandwidth (typical)
- Full spectrum of digital parametric measurements and PRML measurements, including perpendicular recording and variable-target Viterbi detector
- FFT frequency-domain analysis
- Modular Compact PCI (CPCI) structure
- Open architecture
- Convenient front-panel interconnection

2.3 D5000 Block Diagram

Figure 7 shows a block diagram of the D5000.

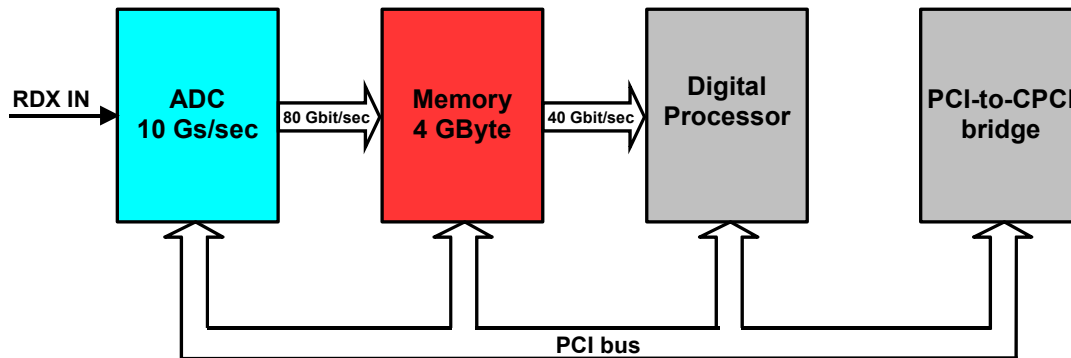


Figure 7: D5000 block diagram

The D5000 has four main modules:

- A data acquisition module with a high-speed, 8-bit, 10 Gs/sec analog-to-digital converter (ADC). A sampling rate of 10 GHz is sufficient to acquire a read-back signal with analog bandwidth of 5 GHz. The data speed at the ADC output is 80 Gbit/sec.
- A memory card, which stores up to 4 GByte of data in real time. The ADC is connected to the memory card via a high-speed bus with a data-transfer speed of 80 Gbit/sec. The back plane of the chassis provides this point-to-point connection.
- A digital data processor, which executes the algorithm selected by the user: parametric measurements, perpendicular recording decoding, longitudinal recording decoding, *etc.* The connection to the digital processor is 40 Gbit/sec.
- A PCI-to-CPCI bridge that connects to an external computer, which controls all modules over a PCI bus. The same computer is used to control the RWA hardware.

The platform for the D5000 is a customized 6-slot 6U Compact PCI (CPCI) chassis. The chassis is equipped with a power supply, a back plane, and a ventilation system. The chassis is a custom CPCI chassis, enhanced with a power supply that generates all voltages needed by the cards. The chassis and all installed Guzik CPCI boards are EMI shielded.

The D5000 CPCI modules *cannot* be installed inside a standard CPCI chassis, because the modules require additional power levels and high-speed interconnections. These additional interconnections are implemented with customized connectors in accordance with the CPCI standard.

Figure 8 shows the D5000 with the four CPCI modules.



Figure 8: D5000 chassis with CPCI modules installed

2.4 Integrating the D5000 with the RWA-2000 Series

The D5000 is an optional component within the Guzik test system (see Figure 9 and Figure 10), when integrated with a read-write analyzer (RWA) and a spinstand. The addition of the D5000 to the RWA-2000 series enhances the test system with a full spectrum of digital measurements, including digital parametric measurements, digital PRML, jitter and eye diagram measurements, and digital spectrum analysis. All digital tests are suitable for both engineering (R&D) and production applications.

A complete Guzik test system, with a D5000, consists of the following components:

- D5000 Signal Analyzer
- An RWA 2000 Series (consisting of an RWA and an ANA)
- V2002 Spinstand with control box
- Universal Preamplifier (UP8)
- Head amplifier set for HGA testing or head-stack amplifier for HSA testing
- HGA cartridges (CCW and CW) or head-stack tooling
- Host computer (with installed Guzik Host Adapter and PCI-to-CPCI bridge)
- System cable set
- Guzik control software (WITE32) running on the host computer

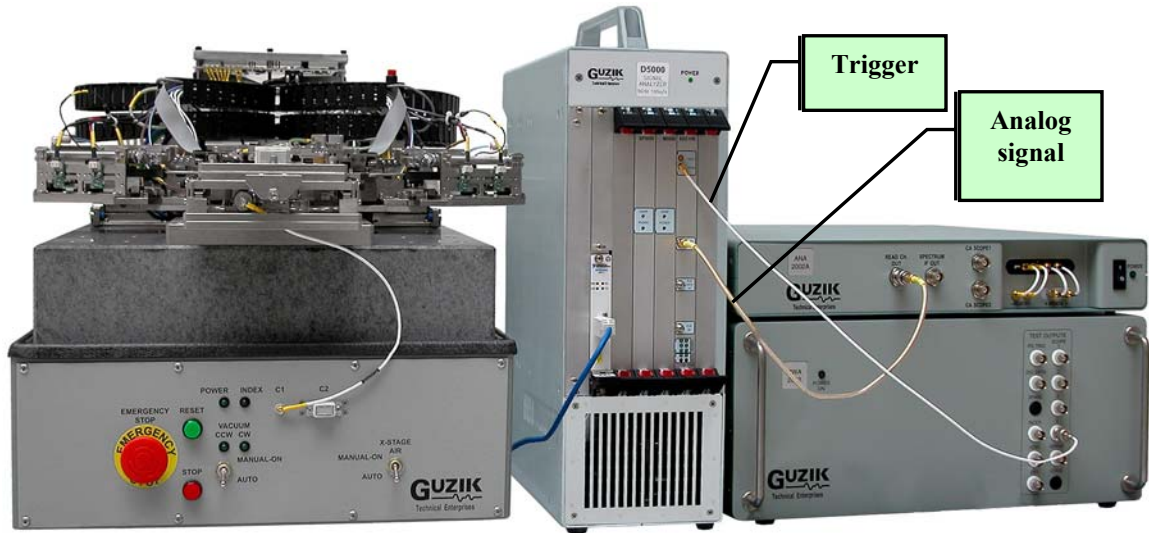


Figure 9: Guzik D5000 with RWA-2000 series and V2000 spinstand

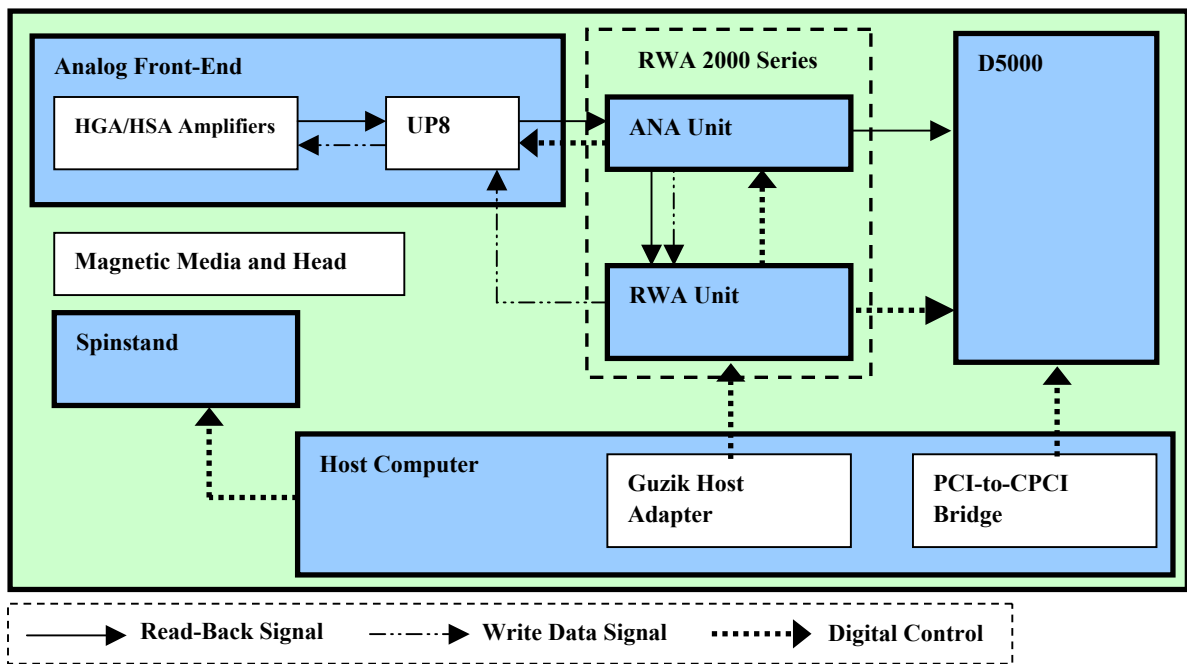


Figure 10: Guzik test system configuration

CHAPTER 3

D5000 SYSTEM AND SPECIFICATIONS

3.1 D5000 Components and Specifications

The D5000 contains four modules (Figure 11):

1. the ADC10K data acquisition module
2. the M5000 memory card
3. the DP5000 digital data processor
4. a PCI-to-CPCI bridge (not shown in Figure 11)

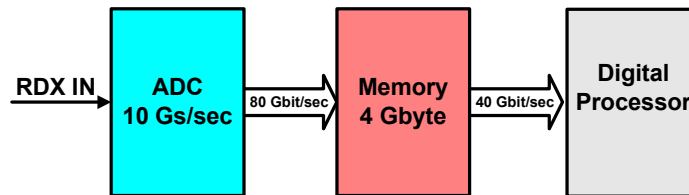


Figure 11: D5000 block diagram

3.1.1 ADC10K Data Acquisition Module

The ADC10K data acquisition module is shown in Figure 12.

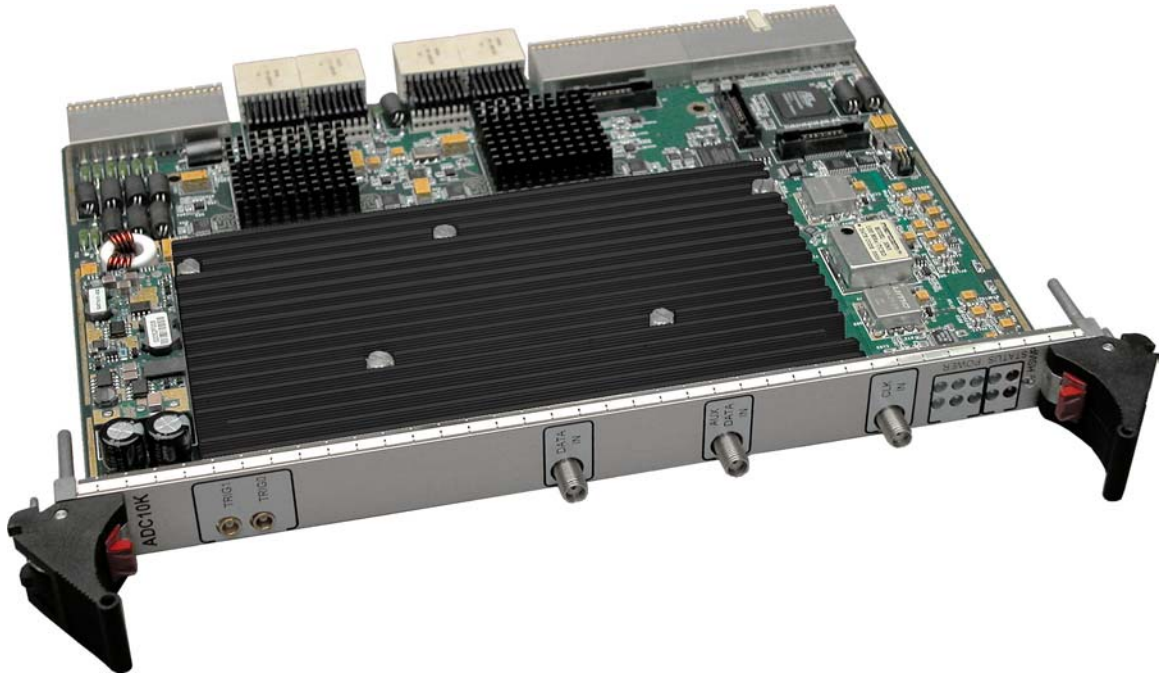


Figure 12: ADC10K data acquisition module

Table 1 shows the ADC10K specifications.

<i>Specification Type</i>	<i>Value</i>	
Sampling rate	10 Gs/sec	
Resolution	8 bits	
Analog bandwidth	5 GHz (typical)	
Flatness	± 0.5 dB (to 1 GHz) ± 2 dB (to 5 GHz, equalized to 0.5 dB by digital filtering)	
Nonlinear distortions	< 0.2 % at 200 MHz < 0.5 % at 2.4 GHz, see Figure 13 and Figure 14 for illustration	
Spurious components	– 50 dBc at 2.44 GHz, see Figure 13 and Figure 14 for illustration	
Analog input	Level	500 mV, peak to peak (max)
	Range for full-scale operation	100 mV – 500 mV, peak to peak
	Impedance	50 Ohm
	Return loss	Better than –12 dB at 6 GHz
Trigger input	Level	TTL
	Impedance	50 Ohm
	Maximum frequency	100 MHz
External clock input	Level	Minimum –6 dBm Maximum 6 dBm
	Impedance	50 Ohm
	Nominal frequency	1.25 GHz
Internal self-calibration	Yes	
Data interface to memory	80 Gbit/sec	

Table 1: ADC10K specifications

Figure 13 and Figure 14 illustrate the nonlinear distortions and spurious components at two frequencies.

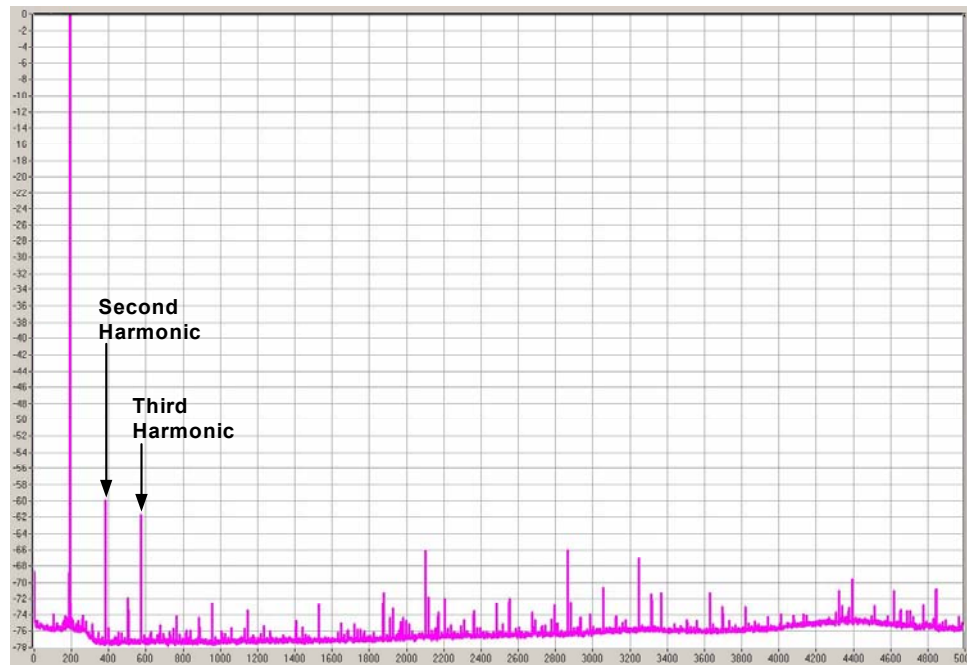


Figure 13: ADC10K output signal spectrum (FFT) for input frequency 190.983 MHz and sampling clock 10 GHz

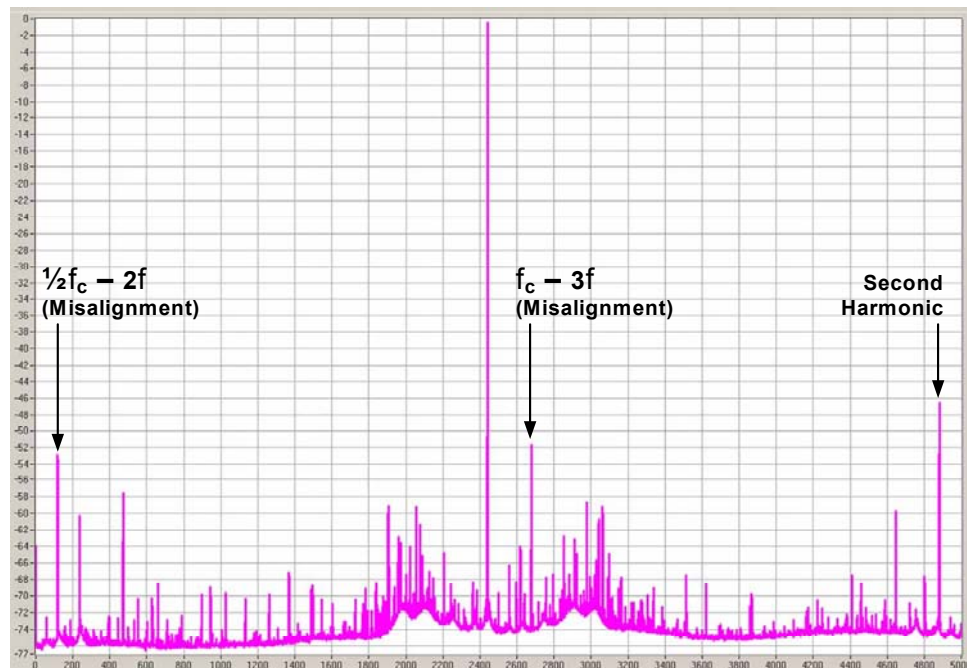


Figure 14: ADC10K output signal spectrum (FFT) for input frequency 2440.983 MHz and sampling clock 10 GHz

3.1.2 M5000 Memory Card

The M5000 memory card (Figure 15) has the following characteristics and features:

1. 80 Gbit/sec interconnection to back plane
2. Up to 4 GBytes of memory
3. Simultaneous write and read mode

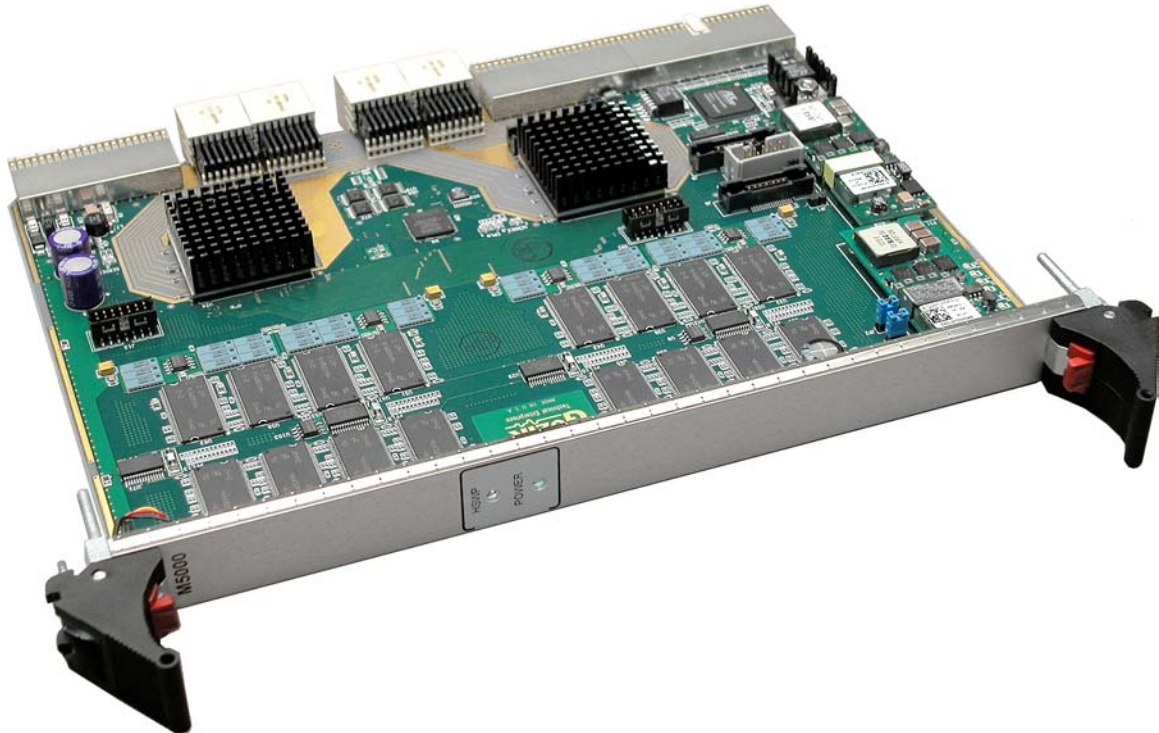


Figure 15: M5000 memory card

3.1.3 DP5000 Digital Data Processor

The DP5000 digital data processor (Figure 16) has the following characteristics and features:

1. Full spectrum of parametric and PRML measurements
2. 2.5 Gs/sec data processing speed for parametric measurements (per module). This is 100 times faster than the RWA2585 and more than 100 times faster than digital oscilloscopes
3. Parametric measurements based on average pulse profile: accuracy of 1% down to 12 dB SNR
4. Universal Viterbi decoder for variable-target decoding with both longitudinal and perpendicular recording
5. Digital filtering, digital equalization, digital clock recovery

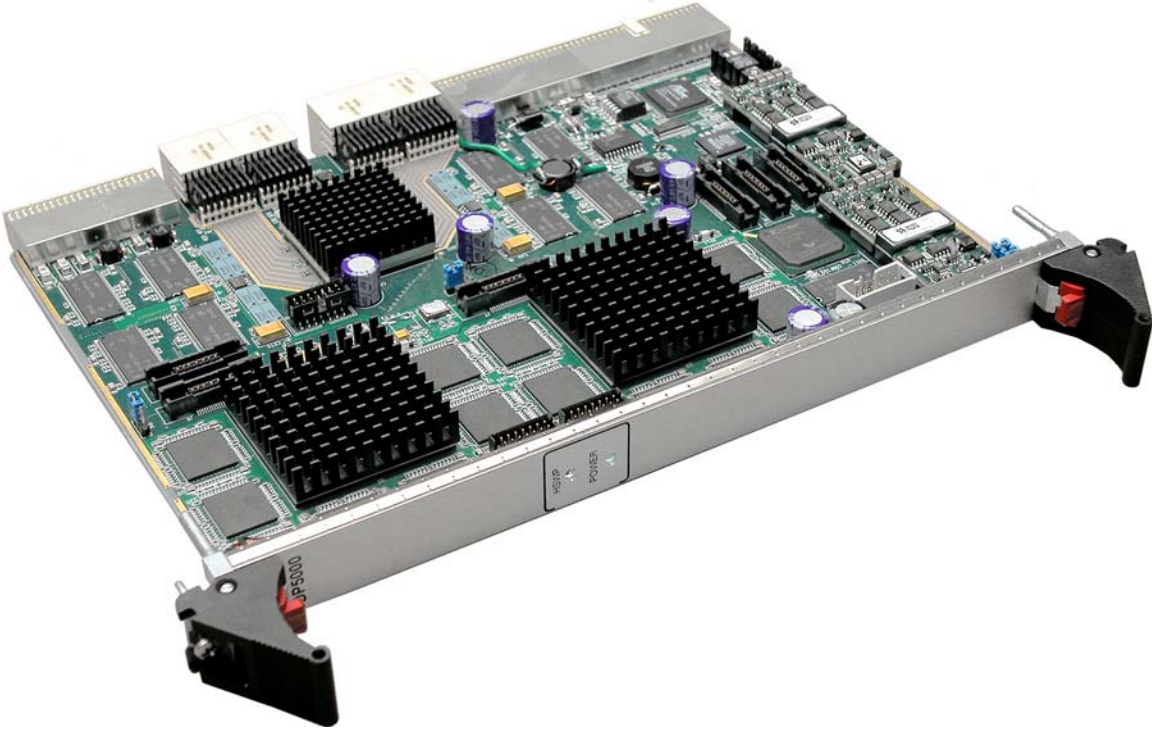


Figure 16: DP5000 digital data processor

3.2 Boards and Connectors

Figure 17 describes connectors on three front-panel boards (the PCI-to-CPCI-bridge is shown in Figure 18). For instructions how to connect the boards, see Section 4.5.

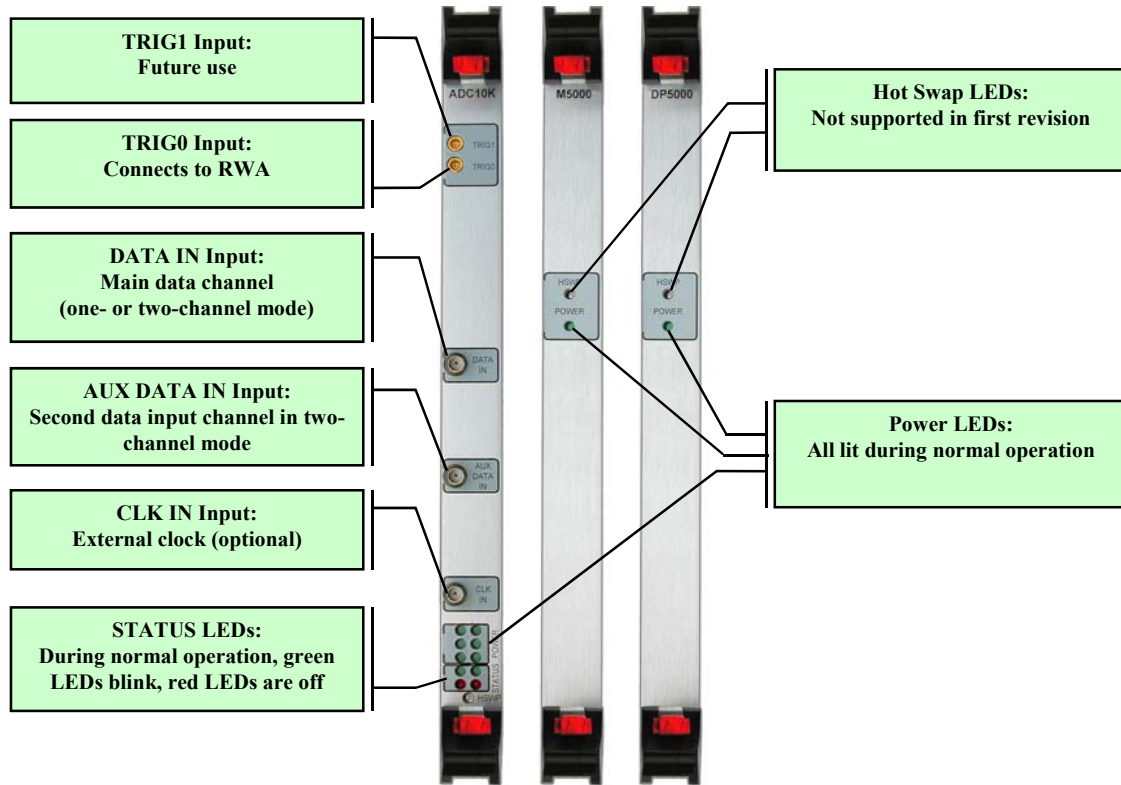


Figure 17: D5000 boards and connectors

3.3 D5000 Measurement Accuracy Specifications

Specification Type	Value
TAA	± 0.5 % (down to 12 dB SNR)
Rise–fall time	± 1.0 % (down to 12 dB SNR)
Pulse width	± 1.0 % (down to 12 dB SNR)
SNR	± 0.2dB (down to 12 dB SNR)
Modulation	± 1.0 %
Resolution	± 0.5 %
Crest factor	± 1%
Overwrite	± 0.2dB
TAA asymmetry	± 0.5 %

Table 2: Accuracy of parametric measurements (repetitive pattern)

3.4 PCI-to-CPCI Bridge

A host computer controls the entire test system, including the D5000, the RWA and the spinstand. A PCI-to-CPCI bridge must be installed in the host computer and connected to the D5000. See Section 4.2 for the host computer requirements and the PCI-to-CPCI bridge installation.

The back panel contains the SYSTEM POWER board, which powers the PCI-to-CPCI bridge. It shows four green LED indicators, all of which should be lit when power is on.

3.5 D5000 Physical Specifications

Table 3 provides the physical specifications for the D5000 in a 6-slot chassis.

<i>Specification Type</i>	<i>Value</i>
Dimensions (without handle)	19.5" x 12.1" x 6.2" (49.5cm x 30.7cm x 15.7cm)
Weight	25 lbs (11.3 kg)
Power consumption	110 VAC ($\pm 10\%$, 50/60 Hz, 2.5A approximately) 230 VAC ($\pm 10\%$, 50/60 Hz, 1.2A approximately)

Table 3: D5000 physical specifications

3.6 D5000 Environmental Specifications

Table 4 provides ambient air temperature and humidity requirements for the D5000.

<i>Specification Type</i>	<i>Value</i>
Temperature	15 °C to 40 °C
Relative humidity	90% with no condensation

Table 4: D5000 environmental specifications



CHAPTER 4

INSTALLATION

4.1 Before Installation Begins

This chapter assumes that other components of the Guzik test system — the spinstand, RWA and host computer — have already been installed and configured. See the *Read-Write Analyzer 2000 Series User's Manual* and the *V2002 Spinstand User's Manual*. To integrate the D5000 into the test system, perform the following steps:

- Unpack
- Install software
- Install CPCI-to-PCI bridge in host PC
- Connect the cables
- Power up

 WARNINGS 	
Disconnect the power cable before replacing fuses. For continued protection against fire, replace only with fuses of the same type and ratings (see label on the machine).	
To keep the D5000 in working condition, do not place it near anything that prevents adequate air circulation by blocking the ventilation holes. Do not place other objects on top or immediately underneath.	
This device is sensitive to electrostatic. Use a ground strap when handling boards.	
When the power is on, do not insert or remove any boards, nor make any connections between the boards. Otherwise, serious damage may occur.	
Never connect any cables between the D5000 unit and other components of the test system when the power is on. Serious damage to some or all of the system components may result.	

4.2 Software Requirements, Installation and License

The Guzik test system is controlled by Guzik's WITE32 software running on a host computer. The same software and host computer is used to control the optional D5000 Signal Analyzer described in this document. Installation of the WITE32 software is described in the *WITE32 Installation User's Guide*. The requirements for the host computer are described in the document *Read-Write Analyzer 2000 Series User's Manual*. Additional software modules must be loaded to take full advantage of the hardware. These modules are distributed with WITE32 version 3.40 and later; see the *Digital Measurements Test Descriptions Engineer's Reference*.



CAUTION: WITE32 version 3.40 or later is required. The D5000 series system is not supported by earlier WITE32 software releases. An earlier versions of WITE32 will not recognize the D5000 system.

You need a license to operate the D5000. Place the file *D5000.lic* in the installation directory. The license refers to the ADC10K board. If you purchase a new system, the license is typically pre-installed by Guzik Technical Enterprises. If the license is not installed, contact sales@guzik.com.



CAUTION: WITE32 version 3.40 or later must be installed before connecting and powering up the D5000 hardware. Failure to do so may complicate the software installation.

After software installation, connect and power up the D5000, then restart the computer. With most configurations, the Windows Hardware Wizard does not appear, and WITE32 is ready to launch. If the Windows Hardware Wizard does appear, follow these steps:

1. If you correctly installed WITE32 version 3.40 or later before connecting the D5000 hardware, go to step 7
2. In the Hardware Wizard, click *Cancel*
3. You need to install WITE32 version 3.40 or later. If you plan to install it to a directory containing a previous version of WITE32, first uninstall the previous version
4. Install WITE32 version 3.40 or later
5. Reboot the computer
6. If the Hardware wizard does not appear, go to step 10
7. In the Hardware wizard, select "No, not this time" and click *Next* (this step appears in Windows XP, but not in Windows 2000)
8. In the Hardware wizard, select "Install the software automatically (Recommended)" and click *Next*
9. In the Hardware wizard, click *Finish*
10. WITE32 is now installed and ready to launch

4.3 Hardware Installation Requirements

The D5000 operates on alternating current (AC) in the range 100 to 230 V at 50–60 Hz. There is no need to manually set the input voltage.

4.4 D5000 Front and Back Panels

On the D5000, all switches, connectors, and indicators are mounted on the front and back panels.

Figure 18 (left) shows the front panel of the system. It includes a green POWER indicator and a connector for the PCI-to-CPCI cable for connecting the D5000 to the host computer. It also include the connectors for the three main boards, which are described in Section 3.2.

Figure 18 (right) shows the back panel of the system. It includes a fuse-protected power input connector, a Power ON/OFF switch and a ground terminal. This terminal should be connected to a similar ground terminal on the RWA using the correct type of cable (Section 4.4.1). The SYSTEM POWER board powers the PCI-to-CPCI bridge; it displays four green LED indicators, all of which should be lit when power is on.

The unit is equipped with a cooling fan, in order to prevent the system overheating.



Figure 18: D5000 front panel (left) and back panel (right)

4.4.1 PCI-to-CPCI Bridge Installation

The host computer communicates with the D5000 via a PCI-to-CPCI bridge. This requires a PCI card to be installed in the host computer, a CPCI card in the D5000 chassis, and a cable connecting the two.

- 1) Install the PCI host card:
 - a) Install driver software
 - b) Turn off the power on the host computer
 - c) Unplug the host computer's power cord

Note: This step is required because certain PC motherboards retain stand-by power on the PCI bus even when the power switch is turned off.

- d) Remove the host computer's cover to provide access to the card slots
 - e) Locate a vacant PCI card slot in the host PC chassis
 - f) Insert the PCI host card into this slot and fasten the card in place with a mounting screw
 - g) Replace the host computer's cover and secure into place. Reconnect the host computer's power cord

- 2) Install the Compact PCI backplane controller card:

Note: The CPCI card in the D5000 is usually preinstalled at the factory.

- a) Turn off the power on the Compact PCI chassis
 - b) Insert the Compact PCI backplane controller card into the system slot of the Compact PCI chassis

Note: The system slot is labeled with the \triangle (triangle) capability glyph with the slot number inside the symbol. Typically, the system slot is slot 1. According to the Compact PCI specifications, the system slot of the Compact PCI chassis is indicated by red guide rails.

- c) Fasten the card in place with mounting screw(s)
- 3) Attach the bridge connection cable to the PCI host card and to the Compact PCI backplane controller card

4.4.2 Installation of Additional CPCI Boards (Optional)

You may choose to install additional CPCI cards in the D5000 chassis, such as the PG-5000 pattern generator and the WG-5000 waveform generator. After installation of the four standard cards, there are two slots available.

- 1) Turn off the power on the Compact PCI chassis
- 2) Locate a vacant slot in the Compact PCI chassis and insert the CPCI board in this slot and fasten the board with two mounting screws

4.5 Cable Connections

The D5000 requires three data cables for connecting with the other units of the Guzik test system, as well as cables for power and ground. Table 5 describes the cables and where to connect them. Figure 19 shows a cabling diagram of the D5000 in relation to a RWA 2000 series and a host computer.

<i>Cable name</i>		<i>Description</i>
Data cable	P/N:	30-461123-xx (BNC-to-SMA) 30-461161-xx (SMA-to-SMA)
	Connection:	1) D5000: DATA input 2) ANA: READ CH. OUT output
	Connector type:	1) D5000: SMA straight plug 2) ANA: BNC or SMA plug, depending on ANA revision
Trigger cable	P/N:	30-460488-xx
	Connection:	1) D5000: TRIG0 input 2) RWA: SCOPE 4 output
	Connector type:	1) D5000: MCX straight plug 2) RWA: BNC plug
PCI-to-CPCI cable	P/N:	30-461160-xx
	Connection:	1) D5000: CPCI bridge card 2) Host computer: PCI bridge control card
Power Cord cable	P/N:	30-101672-xx
	Connection:	1) D5000: power input 2) AC line: 100-240 VAC, ± 10%, 50/60 Hz
	Connector type:	1) D5000: IEC C13, three poles, straight connector 2) AC line: different plug types are available
Ground cable	P/N:	30-460620-xx
	Connection:	1) D5000: Ground terminal 2) RWA: Ground terminal
	Connector type:	1) D5000: Ring terminal, stud size ¼" 2) RWA: Ring terminal, stud size ¼"

Table 5: D5000 cable set

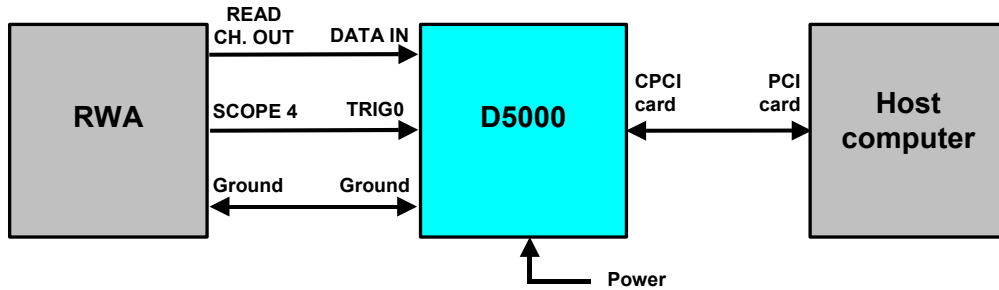


Figure 19: D5000 cable diagram. The spinstand (not shown) is not connected to the D5000

4.6 Grounding

The D5000 has a ground terminal. Guzik Technical Enterprises ships ground cables with every D5000 system. Use the cables (Guzik P/N 460620) to connect the ground terminal on the D5000 to a ground terminal on the RWA, the ANA, or the spinstand.



CAUTION: Do not form a loop in the ground connections.

4.7 Starting the D5000

The D5000 CPCI bus is the extension of the host computer PCI bus. Because of this, the operating system and the host computer BIOS treat the D5000 CPCI boards as regular PCI cards installed in the host computer. Therefore it is important to follow the exact sequence of powering on and powering off the D5000 and the host computer in order to ensure proper PCI bus operation.

To start the D5000, follow these steps:

- 1) Power-on the D5000 CPCI chassis first
- 2) Then power-on and boot the host computer



CAUTION: Always power-on the Compact PCI chassis *before* powering on the host computer. Otherwise, the Compact PCI bus may reset improperly and can cause the host computer to not recognize the cards installed inside the Compact PCI chassis.

- 3) When the host computer is booted the first time after the PCI-to-cPCI bridge installation, or after the installation of additional cPCI boards, reboot the host computer one more time to ensure, that the PCI-to-cPCI bridge driver and cPCI boards drivers are installed properly.
- 4) Double-click the WITE32 icon on the Windows desktop to start the application



CAUTION: Do not power-off the Compact PCI chassis when the WITE32 software is running. It may lead to system instability and unpredictable behavior.

4.8 Powering-off the D5000

To power-off the D5000, follow these steps:

- 1) Exit from WITE32 software, close all other applications.
- 2) Shut down and power-off the host computer.
- 3) Power-off the D5000 CPCI chassis.



CAUTION: Do not power-off the Compact PCI chassis before powering off the host computer. It may lead to system instability and unpredictable behavior.

4.9 Functionality Verification

We recommend checking the D5000 functionality before operation, using the following steps:

1. Check all cables connecting the system units. Make sure the cable connectors are attached firmly and in the correct location
2. Check the LED indicators that electrical current is present in the power supply lines:
 - All green POWER indicators on the three front-panel boards of the chassis: ADC10K, M5000 and DP5000
 - All green POWER indicators on the back-panel SYSTEM POWER board
3. Start the WITE32 control software. Under the *Info* menu, select *Hardware Features* to display the *Hardware Features* dialog box (Figure 20). This box contains four labels that relate to the D5000:
 - *Guzik PRML Channel*
 - *Digital Read Signal Analyzer*
 - *Digital Parametric*
 - *Digital Spectrum*

When the D5000 is present and functioning correctly, all four labels are preceded by a green checkmark; otherwise they are preceded by a red 'X'.

4. After starting the WITE32 control software, the two green STATUS indicators on the ADC10K board should blink and the two red STATUS indicators should be off (Figure 17)

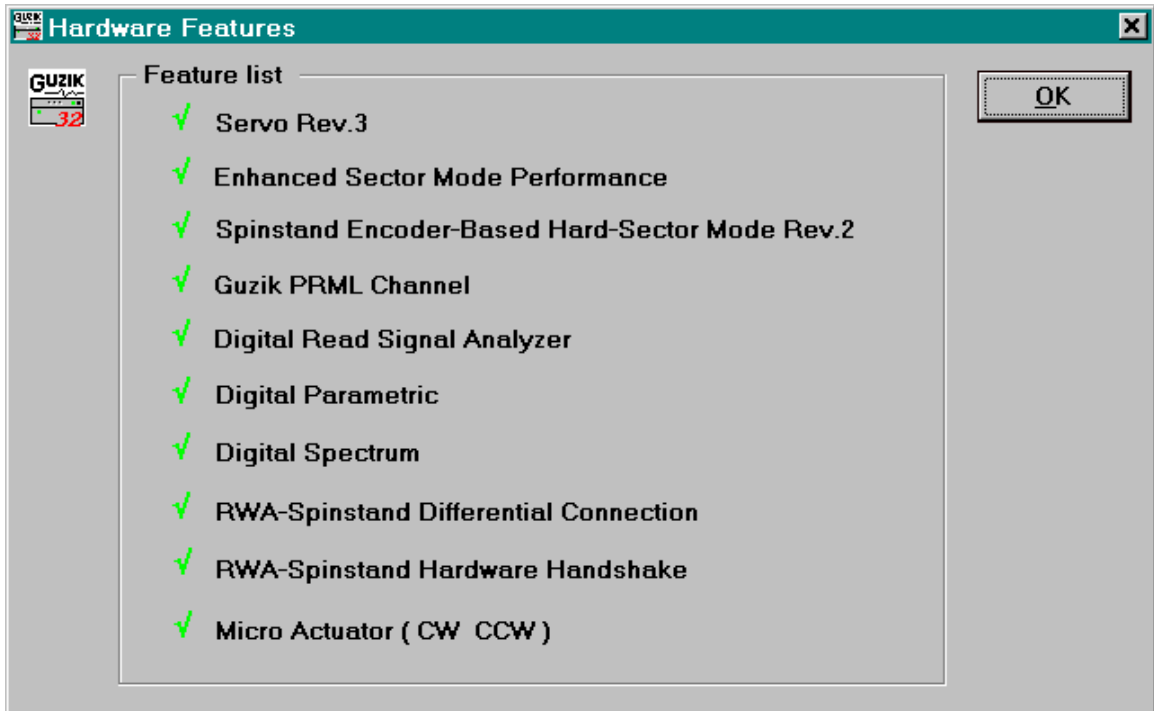


Figure 20: Hardware Features lists D5000 hardware

CHAPTER 5

D5000 OPERATIONAL BASICS

5.1 D5000 Synchronization

Each Guzik test system uses a set of signals for synchronization with the rotating media. These signals are called *time-base signals*, and they include *Index*, *Sector*, *Read Gate*, *Lock to Data* and *Write Gate*. For the D5000, the relevant signals are the *Read Gate* and *Lock to Data*. Depending on the test, one of these two signals is delivered to the D5000 on the TRIG0 input connector (see Figure 19 for a cable diagram.). When the TRIG0 input is active (positive polarity), the D5000 will digitize the analog signal that it receives on the DATA input connector, as illustrated below.

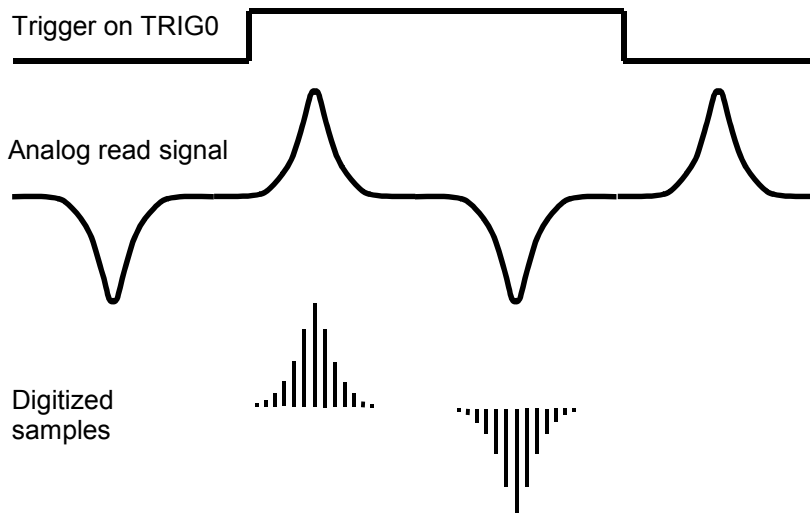


Figure 21: Synchronization for digitization

Note: See the *Read-Write Analyzer 2000 Series User's Manual* for more details on time-base signals.

5.2 Hardware Channels

Figure 22 shows how the read signal, after conditioning by the ANA unit of the RWA, is analyzed by hardware to produce measurements. The hardware can be classified into three types:

1. Analog hardware in the RWA: used for most traditional non-PRML tests
2. Commercial PRML chips installed in the RWA: used for PRML tests
3. Digital hardware in the D5000: used for many traditional tests and PRML tests, as well as for several new tests that require the D5000

While some tests require one type of hardware, many tests can execute on two types, as discussed in the next section. The user selects the type of hardware with the WITE32 control software; see the *Digital Measurements Test Description Engineer's Reference*.

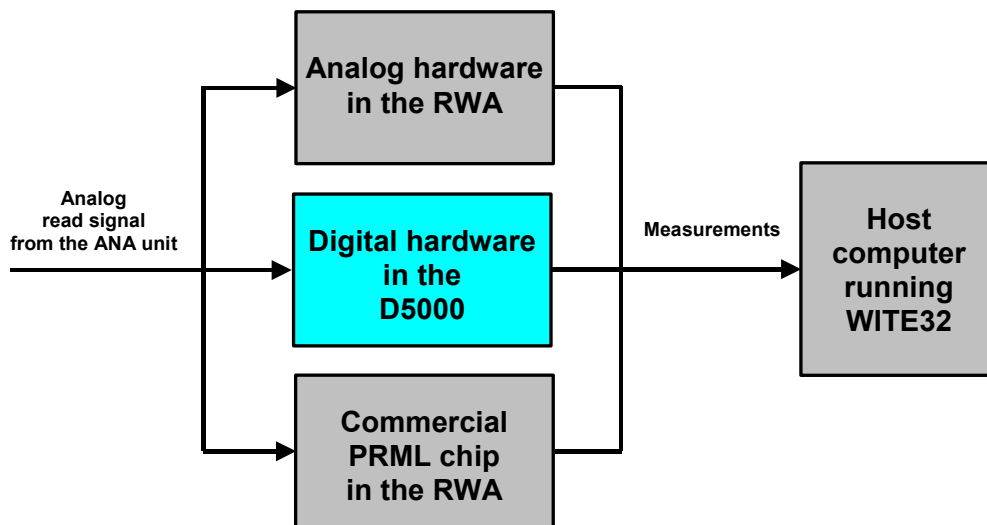


Figure 22: Hardware channels

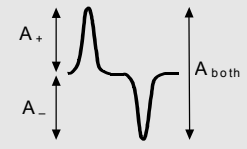
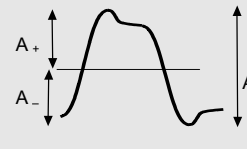
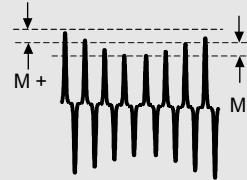
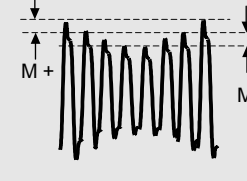
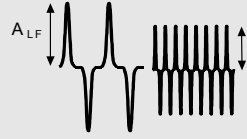
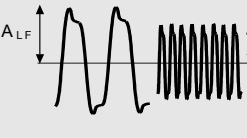
5.3 Measurements and Tests

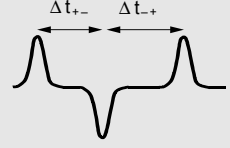
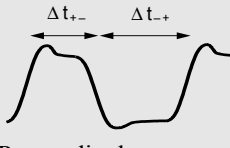

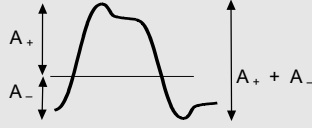
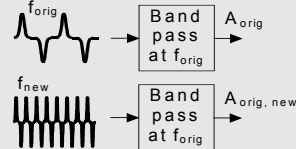
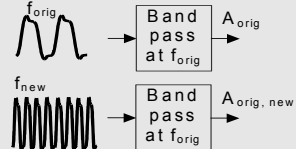
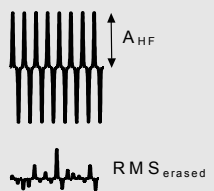
The WITE32 control software provides a large number of “tests” that measure one or more parameters. Many of these parameters are defined in Table 6. The same parameter may be measured in different tests under different conditions. For example, the pulse width (PW) is measured directly in the *Pulse Width* test; the variability of PW is measured in the *Pulse Width Stability* test; the PW as a function of write current is measured and plotted in the *Saturation* test, together with other parameters. Other tests plot parameters as a function of read-bias current, flux frequency or head offset.

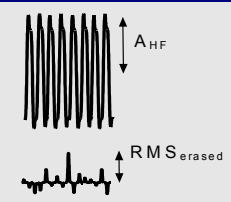
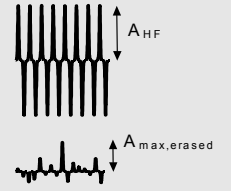
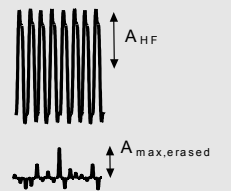
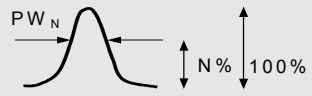
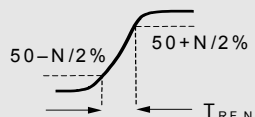
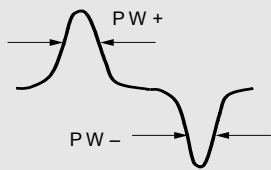
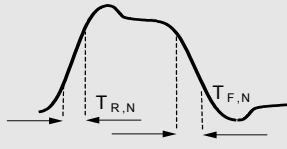
Pre-existing tests are described either in the *Standard Test Descriptions Engineer's Reference* or in module-specific manuals, such as the *747 Test Descriptions Engineer's Reference*.

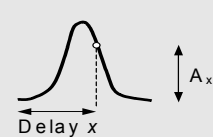
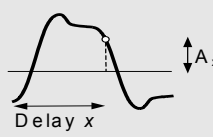
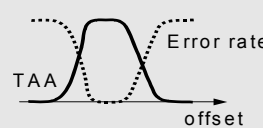


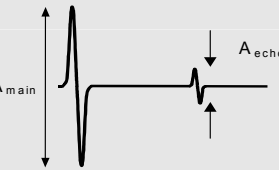
The *Digital Measurements Test Description Engineer's Reference* describes how to configure WITE32 to use digital hardware for pre-existing tests. It also describes new modules such as *Digital Tests*, *Jitter Tests*, and *PRML 2 Tests*, which are specific to the D5000. There, you will also learn how to get direct access to the digitally sampled signal and to display it using the Signal Display application.

The next three sections give a brief overview of pre-existing analog tests that can be executed in digital mode with the D5000 hardware and new PRML and parametric tests developed specifically for the D5000. For details, see the above-mentioned manual.

Measurement	Result Description	Illustration
Track average amplitude (TAA)	A_+ , A_- or A_{both} : average amplitude across a revolution A_+ : positive peak amplitude measured from baseline; A_- : negative peak amplitude measured from baseline; A_{both} : peak to peak	 <p>Longitudinal</p>
		 <p>Perpendicular</p>
Modulation	$M_+ = (A_{max} - A) / A \times 100\%$ (positive modulation) $M_- = (A_{min} - A) / A \times 100\%$ (negative modulation) The average amplitude, A , and maximum and minimum, A_{max} and A_{min} , are measured across a revolution	 <p>Longitudinal</p>
		 <p>Perpendicular</p>
Resolution	$R = A_{HF} / A_{LF} \times 100\%$ A_{HF} and A_{LF} are amplitudes measured at high and low flux frequencies, f_{HF} and f_{LF}	 <p>Longitudinal</p>
		 <p>Perpendicular</p>
Resolution delta	$R_1 - R_2$ R_1 and R_2 are the resolutions at two different write-current values	

Measurement	Result Description	Illustration
Amplitude stability	σ / A_{avg} σ is the standard deviation of the measured amplitudes. A_{avg} is the average value	
Timing asymmetry	$\Delta t_{+-} - \Delta t_{-+}$ — temporal asymmetry of transition positions Δt_{+-} is the time from a positive pulse (or rising slope) to the next negative pulse (or falling slope). Δt_{-+} is the time from a negative pulse (or falling slope) to the next positive pulse (or rising slope)	 Longitudinal
		 Perpendicular
TAA asymmetry	$(A_+ - A_-) / (A_+ + A_-) \times 100\%$	 Longitudinal
		 Perpendicular
Overwrite	$20 \log (A_{orig} / A_{orig, new})$ A_{orig} is the amplitude of the original pattern, before overwriting it. $A_{orig, new}$ is the amplitude, filtered at the frequency of the original pattern, after it has been overwritten by a new pattern	 Longitudinal
		 Perpendicular
Signal-to-noise ratio (SNR)	$SNR = 20 \log (A_{HF} / RMS_{erased})$ TAA_{HF} is the TAA of a high-frequency pattern; RMS_{erased} is the root-mean-squared value in the absence of transitions	 Longitudinal

Measurement	Result Description	Illustration
		 <p>Perpendicular</p>
Crest factor	$A_{max,erased} / A_{HF}$ $A_{max,erased}$ is the maximum amplitude in the absence of transitions. A_{HF} is the TAA for a high-frequency pattern	 <p>Longitudinal</p>
		 <p>Perpendicular</p>
Pulse width	$PW_N = t_2 - t_1$ t_1 and t_2 are the times at which a pulse reaches N % of the peak value. PW may be reported in nanoseconds, microinches or nanometers	 <p>Longitudinal</p>
Rise-fall time	$T_{RF,N} = t_2 - t_1$ t_1 and t_2 are the times at which a transition reaches $50 \pm N/2$ % of the peak value. For example, $T_{RF,80}$ measures the times that the transition reaches 10 % and 90 % of the amplitude. $T_{RF,N}$ may be reported in nanoseconds, microinches or nanometers	 <p>Perpendicular</p>
PW asymmetry	$(PW_+ - PW_-) / (PW_+ + PW_-) \times 100\%$	 <p>Longitudinal</p>
Rise-fall time asymmetry	$(T_{R,N} - T_{F,N}) / (T_{R,N} + T_{F,N}) \times 100\%$	 <p>Perpendicular</p>

Measurement	Result Description	Illustration
Pulse-width stability	σ_{PW} / PW_{avg} σ_{PW} is the standard deviation of the pulse width; PW_{avg} is the average pulse width	
Pulse stability	σ_x / A_x σ_x is the standard deviation of the read-signal amplitude at location x along the transition; A_x is the average amplitude at the same location	 <p>Longitudinal</p>
		 <p>Perpendicular</p>
Track profile	TAA and error rate <i>versus</i> read-head offset in the radial direction	
Pulse profile	Read-signal amplitude <i>versus</i> time for a pair of transitions, averaged over many transition pairs	 <p>Longitudinal</p>
		 <p>Perpendicular</p>
Saturation	Read or write current at which some parameter levels out	
Error rate	$\log_{10} (N_{errors} / N_{bits})$ N_{errors} is the number of incorrectly decoded bits; N_{bits} is the total number of decoded bits	
NLTS	$2 A_{echo} / A_{main}$ A_{echo} is the amplitude of an NLTS echo; A_{main} is the peak-to-peak amplitude of a dibit (two consecutive pulses of opposite polarity) or autocorrelation plot	
Amplitude reduction factor	$\alpha = 1 - V_{PE} / V$ V_{PE} is the reduced amplitude due to partial erasure; V is the amplitude in the absence of partial erasure	

Measurement	Result Description	Illustration
Third harmonic ratio	$V(3f, 1) / (3 V(f, 3))$ $V(3f, 1)$ is the third harmonic of a square wave at frequency f . $V(f, 3)$ is the fundamental of a square wave at frequency $3f$.	
SAM	The percentage sequenced amplitude margin value where a user-specified error rate is obtained (using a PRML decoder)	

Table 6: Measurements that can be performed with analog or digital hardware

5.3.1 Dual Analog–Digital Tests

Below is a list of WITE32 tests that can be performed using either analog or digital hardware. The tests are grouped in modules. Note that the modules typically contain additional tests that can be performed using only analog or only digital hardware.

- Tests in the *Parameteric* module: TAA, Asymmetry, Pulse Width, Parametric, Read-Only Parametric, Signal-to-Noise Ratio, Resolution Delta, Amplitude Stability, Pulse Width Stability, Spectral Integral SNR
- Tests in the *Composite* module: Frequency, Saturation, MR Saturation, Pulse Profile
- Tests in the *NLTS* module: Alternative Spectral Elimination, Third Harmonic Ratio, NLTS vs. Write Current
- Tests in the *MR* module: TAA Asymmetry, Pulse Width Asymmetry, Pulse Stability, Write/Read Offset

Table 6 lists a number of parameters of the read signal that can be measured using either analog hardware or the D5000 digital hardware.

Note that analog measurements sometimes add another step of processing. For example, to compute TAA, the analog hardware creates an internal envelope signal, and the user needs to set time constants for the envelope circuitry. The digital hardware does not need an envelope, as it can directly detect peak amplitude. In this case, you do not need to specify envelope time constants in WITE32; the time constants are ignored.

5.3.2 Perpendicular Recording: Rise–Fall Time Replaces Pulse Width

The shape of the read-back signal resulting from a transition depends on the recording method. For traditional longitudinal recording, the shape is a pulse. For the newer perpendicular recording, the shape is an S-shaped slope.

If you specify both digital measurement and perpendicular recording (see the *WITE32 Digital Measurements Tests Descriptions Engineer’s Reference*), all tests that measure the pulse width will instead measure the rise–fall time. Both measurements require one parameter, N. For pulse width, N is the percent of the peak amplitude at which the width is measured. For rise–fall time, the time between the two amplitudes $50 \pm N/2$ % is measured; for example, for N = 80, the rise–fall time between 10 % and 90 % is measured.

Note that when the rise–fall time is measured instead of the pulse width, the label of the reported result changes accordingly.

Note: When analog hardware is used, WITE32 assumes longitudinal recording for pulse-width measurements, regardless of the *Recording Method* setting. With digital hardware and perpendicular recording, pulse-width measurements are replaced by rise–fall time measurements of slopes.

5.3.3 Digital Parametric Tests

A new module requires the D5000: the *Digital Tests* module. It contains the *Digital Parametric* and *Signal Profile* tests.

The *Digital Parametric* test measures many standard parameters simultaneously: track average amplitude (TAA), modulation, pulse width (PW), rise–fall time, timing asymmetry, RMS, SNR and crest factor. These parameters, along with many others, are defined in Table 6.

The *Signal Profile* test digitizes and graphs the read-back signal. Optionally, preamble, address mark and inter-sector data are graphed in addition to the user data.

5.3.4 PRML Tests

Table 7 lists WITE32 tests that use a PRML channel. Note that some tests do not support all types of PRML channels. The new *PRML 2* module contains tests designed specifically for the D5000, including the PRML Optimization, PRML Explorer and Sequenced Amplitude Margin (SAM) tests.

Module	Tests	Supported PRML hardware		
		Commercial	Guzik other than D5000	D5000
Composite	Track profile, Comparator error rate, Off-track performance	Yes	Yes	Yes
Bit Error Rate Tests (BER)	BER 747A, BER Linear Density, BER Distribution, BER Performance	Yes	No	Yes ¹
Error	Comparator Error	Yes	Yes	Yes
747	747 Comparator Error	Yes	Yes	Yes
PRML	Guzik channel optimization, SAM, SVD	Yes	Yes	No
PRML 2	PRML Optimization, PRML explorer, SAM	No	No	Yes

Table 7: Hardware compatibility of PRML-related tests

¹ Not all tests are supported in WITE32 at the moment this document was released. Will be supported in the future WITE32 revisions.

5.3.5 Jitter Explorer Test

The *Jitter* module, which contains the *Jitter Explorer* test, also requires digital hardware.

The test measures transition shifts, using a patent-pending algorithm, and can suppress or highlight different types of timing noise: media noise (irregularities in the size, orientation and density of magnetic grains), read-channel noise, pattern-dependent noise (inter-symbol interference, ISI; non-linear transition shift, NLTS; hard and easy transition shift, HTS and ETS), variable rotation speed and baseline shift.

The test reports the transition-shift statistics and plots several diagrams, including the histogram and spectrum of transition shifts and an eye diagram of the resampled signal.

5.4 Capture Methods: Profile and One-Shot

The D5000 uses a large number of pulses to compute measurements. The user can choose the order of averaging and measuring:

- One-shot method: measure on single pulse pairs, then average the results
- Profile method: average many pulse pairs, then measure on the averaged signal

The One-shot method extracts two pulses at a time (one positive and one negative). Any bit pattern can be used as input. Because noise tends to be systematic, the results are more noise-sensitive than for the Profile method.

The Profile method can be used only with regular patterns (HF, LF, IS, *etc.*) and quasi-regular patterns (see definition below). The results are less noise sensitive, but this method does not support modulation measurements.

Note: For perpendicular recording, slopes replace pulses

A *quasi-regular* pattern is a pattern with constant distance from each even-numbered transition to the next odd-numbered transition, and constant distance from each odd-numbered transition to the next even-numbered transition. For instance, the pattern “1001000010010000...” is quasi-regular.

The two methods are compared in the following table:

<i>Method</i>	<i>Pattern</i>	<i>Averaging</i>	<i>Noise sensitivity</i>	<i>Modulation measurement</i>
One-shot	Any	Averages parameters, after computing them from the read signal	More sensitive	Available
Profile	Regular or quasi-regular	Averages read signal, before computing parameters	Less sensitive	Not available

Table 8: Comparison of the One-shot and Profile methods

In the one-shot method, peak positions are identified using two criteria: the read-signal amplitude exceeds a threshold, and the derivative of the read-signal is zero. Figure 23 illustrates the method:

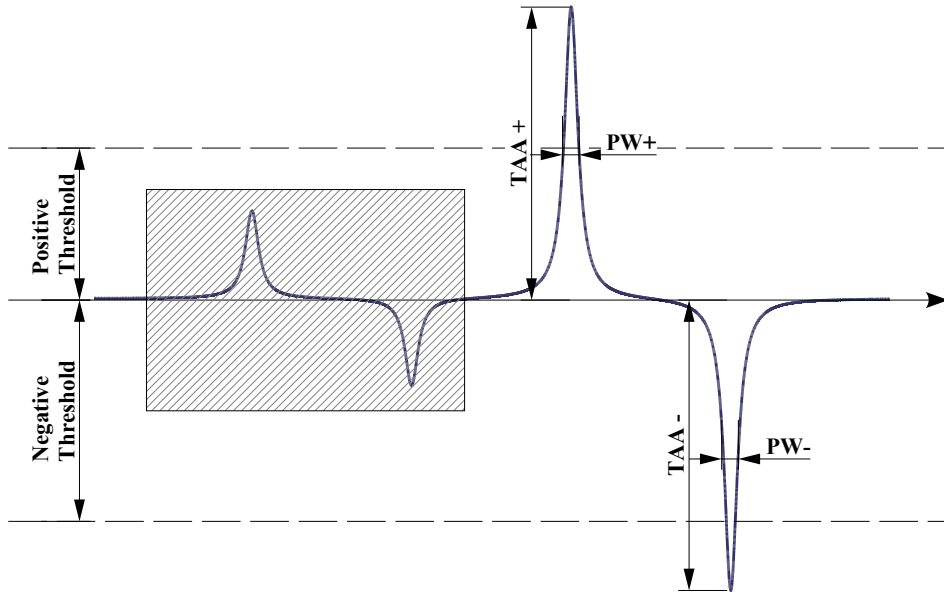


Figure 23: One-shot method: shaded, low-amplitude pulses are ignored

The pulse-profile calculation consists of the following steps:

- Locate the exact peak positions at points where the amplitude exceeds 50% of the maximum signal power and the derivative is zero
- Supply the peak position to a phase-locked loop, which removes noise in the peak-position calculation
- Input the peak positions to a histogrammer module, which accumulates two separate pulse profiles, one for the average positive pulse and one for the average negative pulse. The module averages over consecutive pulses, centered at the zero position.
- Calculate parameters such as TAA and PW from the averaged signal; see Figure 24 below:

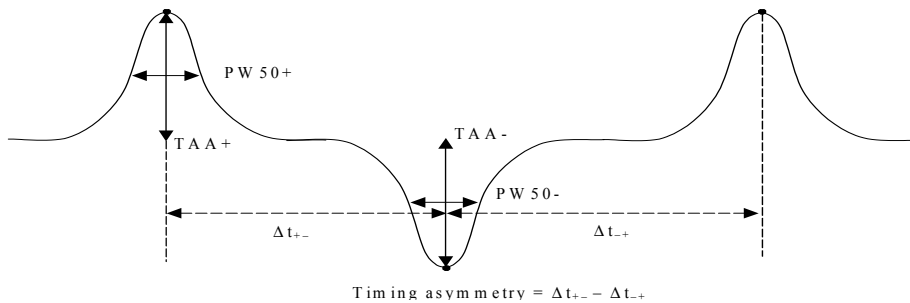


Figure 24: Profile method: measuring parameters

5.5 TAA Calibration

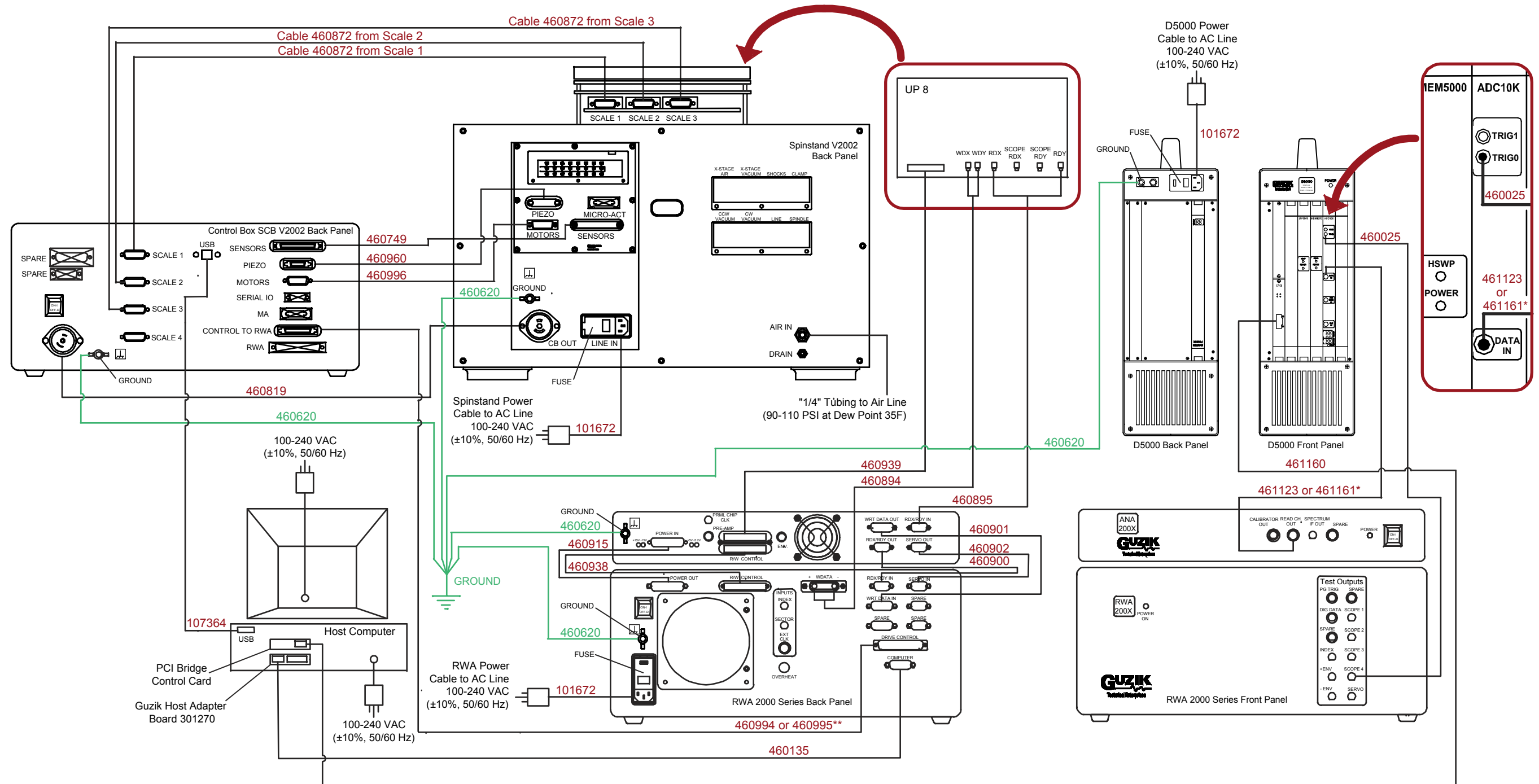
In order to provide accurate amplitude measurements, TAA calibration is performed by injecting a known signal from a generator to the input of the headamplifier. The objective is to calibrate the gain of the entire read channel, starting with the analog front-end, so that the TAA voltage read through the D5000 and RWA equals the actual peak voltage at the input. (Please refer to *WITE32 System Configuration User's Guide* for more information about the TAA calibration).

The WITE32 TAA calibration procedure, when performed on the Guzik test system equipped with D5000 Signal Analyzer, calibrates the gains of both analog peak detector (RWA) and digital read channel (D5000) and computes the analog-to-digital calibration factor in order to match the amplitude measurements performed by analog and digital channels.

The digital TAA in TAA calibration procedure is measured by the *One-shot* digital parametric measurement method (see Section 5.4). Because different methods of the TAA measurements, such as Analog Peak Detector, Digital One-shot, or Digital Profile, have different sensitivity to noise, the results of the TAA calibration may be affected, if the calibration is performed on noisy signals. In order to get accurate results of TAA measurements, it is recommended to use for calibration the clean sine-wave signal from a test generator. The signal amplitude should be close to the maximum amplitude allowed at the input of the head amplifier in order to minimize the influence of noise. The signal-to-noise ratio of the calibration signal measured at the analog box input should not be less than 30 dB. In this condition the accuracy of analog and digital channels amplitude matching will be within one percent range.

It is not recommended to calibrate TAA using the signal coming from the head under test, because in this case the relatively high level of noise present in the signal will distort the TAA measurements and will provide inaccurate calibration results.

D5000 CABLE DIAGRAM



* P/N 461123 for ANA model with BNC connector; P/N 461161 for ANA model with SMA connector
 ** P/N 460994 for RWA model with 3M Mini-D connector (50 pins); P/N 460995 for RWA model with D-Sub connector (37 pins)

INDEX

- Accuracy
 - crest factor, 17
 - overwrite, 17
 - pulse width, 17
 - resolution, 17
 - SNR, 3
 - TAA, 17
 - TAA Asymmetry, 17
- ADC10K, 8
 - features, 12
 - photograph, 12
- Amplitude reduction factor
 - definition, 33
- Amplitude stability
 - definition, 31
- ANA unit, 9
- Block diagram
 - cabling, 25
 - D5000, 8
 - D5000 components, 11
 - Guzik test system, 10
 - hardware channels, 29
- Cable diagram, 25
- Cable set, 9, 24
- Chassis, 8
- Compact PCI chassis, 8
- CPCI boards
 - installation, 24
- CPCI chassis, 8
- Crest factor
 - accuracy, 17
 - definition, 32
- D5000
 - block diagram, 8
 - features, 7
 - integration with Guzik test system, 9
 - photograph, 9
 - starting, 25, 26
- D5000 components
 - block diagram, 11
- DDP5000
 - features, 15
- Digital measurements
 - advantages, 3
 - illustration of accuracy, 4
 - slope stability, 5
- DP5000, 8
 - photograph, 16
- Engineering (R&D) applications, 9
- Error rate
 - definition, 33
- Ground terminals, 21
- Guzik software. *See* WITE32
- Guzik test system
 - block diagram, 10
- Hardware channels, 29
- Head amplifier. *See* MR5
- Headstack amplifier, 9
- HGA testing, 9
- Host Adapter, 9
 - installation, 18
- Host computer, 9, 18
 - installation, 20
 - requirements, 18
- HSA testing, 9
- Installation, 19
 - cabling, 24
 - CPCI boards, 24
 - functionality verification, 26
 - ground terminals, 21, 25
 - host computer, 20
 - PCI-to-CPCI bridge, 23
 - requirements, 20
 - software, 20
- LED indicators
 - functionality verification, 26
- M5000, 8
 - features, 15
 - photograph, 15
- Measurements, 29
 - definitions, 34
- modulation
 - accuracy, 17
- Modulation
 - definition, 30
- MR5, 9
- NLTS
 - definition, 33
- One-shot method, 36
 - algorithm, 36
 - comparison to Profile method, 35, 36
 - illustration, 37
- Open architecture, 7
- Overwrite
 - accuracy, 17
 - definition, 31

- Parameters
 - definitions, 34
- PCI-to-CPCI
 - bridge installation, 23
- PCI-to-CPCI bridge, 18
- Peak detection, 36, 37
- PRML
 - commercial chips, 29
 - digital implementation, 3
 - Guzik implementation, 29
 - tests, 29
- Production applications, 9
- Profile method, 36
 - algorithm, 37
 - comparison to One-shot method, 35, 36
- Pulse profile
 - definition, 33
- Pulse stability
 - definition, 33
- Pulse width
 - accuracy, 17
 - definition, 32
- Pulse-width asymmetry
 - definition, 32
- Pulse-width stability
 - definition, 33
- Read-gate signal, 28
- Resolution
 - accuracy, 17
 - definition, 30
- Resolution delta
 - definition, 30
- SAM
 - definition, 34
- Saturation
 - definition, 33
- Sequenced amplitude margin (SAM)
 - definition, 34
- SNR
 - definition, 31
 - high accuracy, 3
- Synchronization, 28
 - illustration, 28
 - time-base signals, 28
- TAA
 - accuracy, 17
 - calibration, 38
 - definition, 30
- TAA asymmetry
 - definition, 31
- TAA Asymmetry
 - accuracy, 17
- Technical Support, 2
- Test system, 9, 18
 - photograph, 10
- Tests, 29
 - Composite module, 34
 - Digital module, 29, 35, 36
 - Digital parametric test, 35, 36
 - dual analog–digital, 34
 - MR module, 34
 - new, 29
 - NLTS module, 34
 - Parametric module, 34
 - pre-existing, 29
 - PRML, 35
 - PRML 2 module, 29
- Third harmonic ratio
 - definition, 34
- Time-base signals, 28
- Timing asymmetry
 - definition, 31
- Track profile
 - definition, 33
- UP8, 9
- WITE32, 9