OLYMPUS®

MultiScan MS5800

User's Manual

DMTA053-01EN — Rev. D
July 2017

This instruction manual contains essential information on how to use this Olympus product safely and effectively. Before using this product, thoroughly review this instruction manual. Use the product as instructed.

Keep this instruction manual in a safe, accessible location.

Olympus Scientific Solutions Americas, 48 Woerd Avenue, Waltham, MA 02453, USA

This document was prepared with particular attention to usage to ensure the accuracy of the information contained therein, and corresponds to the version of the product manufactured prior to the date appearing on the title page. There could, however, be some differences between the manual and the product if the product was modified thereafter.

The information contained in this document is subject to change without notice.

Part number: DMTA053-01EN
Rev. D
July 2017

Printed in Canada

Table of Contents

Labels and Symbols

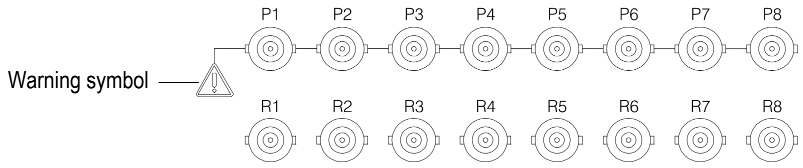
Safety-related labels and symbols are attached to the instrument. If any or all of the labels or symbols are missing or illegible, please contact Olympus.

Table 1 Content of the rating label

Content	
	The WEEE symbol indicates that the product must not be disposed of as unsorted municipal waste, but should be collected separately.
	The warning symbol indicates that the user must read the user's manual in order to find out the nature of the potential hazards and any actions to avoid them.
	Seller and user shall be noticed that this equipment is suitable for electromagnetic equipment for office work (class A) and it can be used outside home. The MSIP code for the MS5800 is the following: MSIP-REM-OYN-MS5800.
	The regulatory compliance mark (RCM) label indicates that the product complies with all applicable standards, and has been registered with the Australian Communications and Media Authority (ACMA) for placement on the Australian market.

CAUTION

To avoid the risk of electric shock, do not touch the inner conductor of the BNC (or LEMO) connectors. Up to 300 V can be present on the inner conductor. The warning symbol near the connectors warns of this electric shock risk.



Important Information — Please Read Before Use

Intended Use

The MS5800 is designed to perform nondestructive inspections on industrial and commercial materials.

WARNING

Do not use the MS5800 for any purpose other than its intended use. It must never be used to inspect or examine human or animal body parts.

Instruction Manual

This instruction manual contains essential information on how to use this Olympus product safely and effectively. Before using this product, thoroughly review this instruction manual. Use the product as instructed.

Keep this instruction manual in a safe, accessible location.

IMPORTANT

Some of the details of components and/or software images in this manual may differ from your instrument's components or software display. However, the principles remain the same.

Instrument Compatibility

The user must confirm that the MS5800 is compatible with any ancillary equipment being used.

CAUTION

Always use equipment and accessories that meet Olympus specifications. Using incompatible equipment could cause equipment malfunction and/or damage, or human injury.

Repair and Modification

The MS5800 does not contain any user-serviceable parts. Opening the instrument might void the warranty.

CAUTION

In order to prevent human injury and/or equipment damage, do not disassemble, modify, or attempt to repair the instrument.

Presence of Visual Interferences or Phantom Spots

IMPORTANT

Presence of strong electromagnetic interference could generate noise in the signal that is visually detectable. This interference is temporary and random in comparison with the signals generated by the physical features of the inspected part, which are coherent and persistent. This interference depends greatly on the nature, strength, and proximity of the electromagnetic source and it will only disappear when the source of the noise is no longer emitting signals.

Safety Symbols

The following safety symbols might appear on the instrument and in the instruction manual:

General warning symbol

This symbol is used to alert the user to potential hazards. All safety messages that follow this symbol shall be obeyed to avoid possible harm or material damage.

Shock hazard caution symbol

This symbol is used to alert the user to potential electric shock hazards. All safety messages that follow this symbol shall be obeyed to avoid possible harm.

Safety Signal Words

The following safety symbols might appear in the documentation of the instrument:

DANGER

The DANGER signal word indicates an imminently hazardous situation. It calls attention to a procedure, practice, or the like that if not correctly performed or adhered to will result in death or serious personal injury. Do not proceed beyond a DANGER signal word until the indicated conditions are fully understood and met.

WARNING

The WARNING signal word indicates a potentially hazardous situation. It calls attention to a procedure, practice, or the like that if not correctly performed or adhered to could result in death or serious personal injury. Do not proceed beyond a WARNING signal word until the indicated conditions are fully understood and met.

CAUTION

The CAUTION signal word indicates a potentially hazardous situation. It calls attention to a procedure, practice, or the like that if not correctly performed or adhered to may result in minor or moderate personal injury, material damage, particularly to the product, destruction of part or all of the product, or loss of data. Do not proceed beyond a CAUTION signal word until the indicated conditions are fully understood and met.

Note Signal Words

The following symbols could appear in the documentation of the instrument:

IMPORTANT

The IMPORTANT signal word calls attention to a note that provides important information, or information essential to the completion of a task.

NOTE

The NOTE signal word calls attention to an operating procedure, practice, or the like, which requires special attention. A note also denotes related parenthetical information that is useful, but not imperative.

TIP

The TIP signal word calls attention to a type of note that helps you apply the techniques and procedures described in the manual to your specific needs, or provides hints on how to effectively use the capabilities of the product.

Safety

Before turning on the instrument, verify that the correct safety precautions have been taken (see the following warnings). In addition, note the external markings on the instrument, which are described under "Safety Symbols."

Warnings

WARNING

General Warnings

- Carefully read the instructions contained in this instruction manual prior to turning on the instrument.
- Keep this instruction manual in a safe place for further reference.
- Follow the installation and operation procedures.
- It is imperative to respect the safety warnings on the instrument and in this instruction manual.
- If the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment could be impaired.
- Do not install substitute parts or perform any unauthorized modification to the instrument.
- Service instructions, when applicable, are for trained service personnel. To avoid the risk of electric shock, do not perform any work on the instrument unless qualified to do so. For any problem or question regarding this instrument, contact Olympus or an authorized Olympus representative.
- Do not touch the connectors directly by hand. Otherwise, a malfunction or electric shock may result.

- Do not allow metallic or foreign objects to enter the device through connectors or any other openings. Otherwise, a malfunction or electric shock may result.

WARNING

Electrical Warnings

- Before operating this instrument using mains electricity, you must connect the protective earth terminal of the instrument to the protective conductor (mains) of the power cord. The mains plug shall only be inserted into a socket outlet provided with a protective earth contact. Never negate the protective action by using an extension cord (power cable) without a protective conductor (grounding).
- Only use fuses with the required rated current, voltage, and specified type (normal-blow, slow-blow, quick-acting, etc.). Do not use repaired fuses or short-circuited fuse holders, doing so could cause electric shock or create a fire hazard.
- If there is any possibility that the ground protection could be impaired, you must make the instrument inoperative and secure it against any unintended operation.
- The instrument must only be connected to a power source corresponding to the type indicated on the rating label.

CAUTION

If an unauthorized power supply cord is used to power the instrument or charge the batteries, Olympus cannot guarantee the electrical safety of the equipment.

Equipment Disposal

Before disposing of the MS5800, check your local laws, rules, and regulations, and follow them accordingly.

Electrostatic Discharge Precautions

If, for any reason, you have to disassemble your instrument or touch any internal components, take all the necessary precautions against electrostatic discharges (ESD). Electrostatic discharges could damage or even blow electronic components in your system. Electrostatic damage to components can take the form of upset failures or system failures. In addition, failure to take appropriate precautions could void your warranty.

The basic rules of ESD control are as follows:

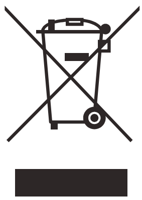
1. Only manipulate ESD-sensitive components in protected work areas. Always ground yourself when handling ESD-sensitive components or assemblies. Always use the proper maintenance and work procedures for the type of material.
2. Always use a conductive or shielding container when storing or transporting ESD-sensitive components or assemblies (for example, printed circuit boards). The materials used must create a Faraday cage, which will isolate the contents from electrostatic charges.
3. Only open ESD-safe containers at a static-safe workstation. Such a workstation shall include the equipment needed to perform these three critical functions: grounding, isolation, and neutralization.

At the static-safe workstation, follow the instructions below before beginning any work:

- Put on your wrist strap or foot grounding devices.
- Test your grounding devices to ensure that they are functioning properly.
- Check that all grounding cords are properly connected to the ground to ensure the effective dissipation of electrostatic charges.
- If you have an ion generator, turn it on. This will help dissipate static charges from any nonconducting materials.
- Make sure that your work surface is clean and clear of unnecessary materials, particularly common plastics.
- When handling electronic devices, hold the components by their plastic edges. Avoid touching the metal leads.
- When passing loaded boards or components between individuals, both individuals must be grounded to the same ground point.
- Do not allow components to come into contact with your clothing, hair, or other nonconducting materials.

The previous procedures are only a summary of the measures to be taken against electrostatic discharges. Please consult other literature dedicated to this topic for more details.

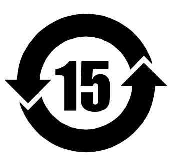
WEEE Directive



In accordance with European Directive 2012/19/EU on Waste Electrical and Electronic Equipment (WEEE), this symbol indicates that the product must not be disposed of as unsorted municipal waste, but should be collected separately. Refer to your local Olympus distributor for return and/or collection systems available in your country.

China RoHS

China RoHS is the term used by industry generally to describe legislation implemented by the Ministry of Information Industry (MII) in the People’s Republic of China for the control of pollution by electronic information products (EIP).



The China RoHS mark indicates the product’s Environment-Friendly Use Period (EFUP). The EFUP is defined as the number of years for which listed controlled substances will not leak or chemically deteriorate while in the product. The EFUP for the MS5800 has been determined to be 15 years.

Note: The Environment-Friendly Use Period (EFUP) is not meant to be interpreted as the period assuring functionality and product performance.

“ 中国 RoHS” 是一个工业术语，一般用于描述中华人民共和国信息工业部 （MII）针对控制电子信息产品 （EIP）的污染所实行的法令。

电气电子产品
有害物质
限制使用标识

中国 RoHS 标识是根据 " 电器电子产品有害物质限制使用管理办法 " 以及 " 电子电气产品有害物质限制使用标识要求 " 的规定，适用于在中国销售的电气电子产品上的电气电子产品有害物质限制使用标识。

注意：电气电子产品有害物质限制使用标识内的数字为在正常的使用条件下有害物质不会泄漏的年限，不是保证产品功能性的年限。

产品中有害物质的名称及含量

部件名称		有害物质					
		铅及其化合物 (Pb)	汞及其化合物 (Hg)	镉及其化合物 (Cd)	六价铬及其化合物 (Cr(VI))	多溴联苯 (PBB)	多溴二苯醚 (PBDE)
主体	机构部件	×	○	○	○	○	○
	光学部件	×	○	○	○	○	○
	电气部件	×	○	○	○	○	○
附件		×	○	○	○	○	○

本表格依据 SJ/T 11364 的规定编制。

○：表示该有害物质在该部件所有均质材料中的含量均在 GB/T26572 规定的限量要求以下。

×：表示该有害物质至少在该部件的某一均质材料中的含量超出 GB/T26572 规定的限量要求。

Korea Communications Commission (KCC)

이 기기는 업무용 환경에서 사용할 목적으로 적합성평가를 받은 기기로서 가정용 환경에서 사용하는 경우 전파간섭의 우려가 있습니다 .

EMC Directive Compliance

This equipment generates and uses radio-frequency energy and, if not installed and used properly (that is, in strict accordance with the manufacturer's instructions), may cause interference. The MS5800 has been tested and found to comply with the limits for an industrial device in accordance with the specifications of the EMC directive.

FCC (USA) Compliance

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:

1. This device may not cause harmful interference.
2. This device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy, and if not installed and used in accordance with the instruction manual, might cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference, in which case you will be required to correct the interference at your own expense.

ICES-001 (Canada) Compliance

This Class A digital apparatus complies with Canadian ICES-001.

Cet appareil numérique de la classe A est conforme à la norme NMB-001 du Canada.

Warranty Information

Olympus guarantees your Olympus product to be free from defects in materials and workmanship for a specific period, and in accordance with conditions specified in the *Olympus Scientific Solutions Americas Inc. Terms and Conditions* available at http://www.olympus-ims.com/en/terms/.

The Olympus warranty only covers equipment that has been used in a proper manner, as described in this instruction manual, and that has not been subjected to excessive abuse, attempted unauthorized repair, or modification.

Inspect materials thoroughly on receipt for evidence of external or internal damage that might have occurred during shipment. Immediately notify the carrier making the delivery of any damage, because the carrier is normally liable for damage during shipment. Retain packing materials, waybills, and other shipping documentation needed in order to file a damage claim. After notifying the carrier, contact Olympus for assistance with the damage claim and equipment replacement, if necessary.

This instruction manual explains the proper operation of your Olympus product. The information contained herein is intended solely as a teaching aid, and shall not be used in any particular application without independent testing and/or verification by the operator or the supervisor. Such independent verification of procedures becomes increasingly important as the criticality of the application increases. For this reason, Olympus makes no warranty, expressed or implied, that the techniques, examples, or procedures described herein are consistent with industry standards, nor that they meet the requirements of any particular application.

Olympus reserves the right to modify any product without incurring the responsibility for modifying previously manufactured products.

Technical Support

Olympus is firmly committed to providing the highest level of customer service and product support. If you experience any difficulties when using our product, or if it fails to operate as described in the documentation, first consult the user's manual, and then, if you are still in need of assistance, contact our After-Sales Service. To locate the nearest service center, visit the Service Centers page at: http://www.olympus-ims.com.

Introduction

The Olympus MultiScan MS5800 is a portable multitechnology NDT (nondestructive testing) instrument that is suitable for a number of applications, such as: tube inspection, weld inspection, and corrosion mapping.

The system may combine any of the following NDT technologies: eddy current testing (ECT), remote field testing (RFT), magnetic flux leakage (MFL), and ultrasonic testing (UT). Each one of the technologies offered provides unique capabilities and superior performance.

The MS5800 may also be used with probe pushers and scanners for automated inspections. The two built-in encoder inputs record the probe position, for accurate location of detected flaws.

Acquisition and analysis are both performed from a standard computer using Olympus MultiView software. This software allows for high volume data storage on any PC-compatible media.

1. MS5800 Features

The MS5800 offers the following features:

- Unique architecture expandable at any time to add ECT, RFT, MFL, rotating UT probes (IRIS), and multichannel UT options (up to eight channels available).
- Communication with the computer is done through an Ethernet cable.
- Lightweight: 12 kg, fully loaded.
- High speed ECT inspections: 2 meters per second.
- Very high immunity to ambient field interference. Some applications may be operated with 60 m (200 ft) probe cable extensions.
- Compatible with ECT, RFT, and UT probes from other manufacturers.
- Optional software (CARTO) for inspection planning and report generation on tube sheet diagrams.
- MultiView data acquisition and analysis software runs on standard computers, with or without the MS5800.
- Three coil-drive modes: non-multiplex, multiplex, and super-multiplex.
- Recording on any Microsoft Windows–supported storage devices.

Figure 1-1 on page 18 shows the MS5800 NDT applications.

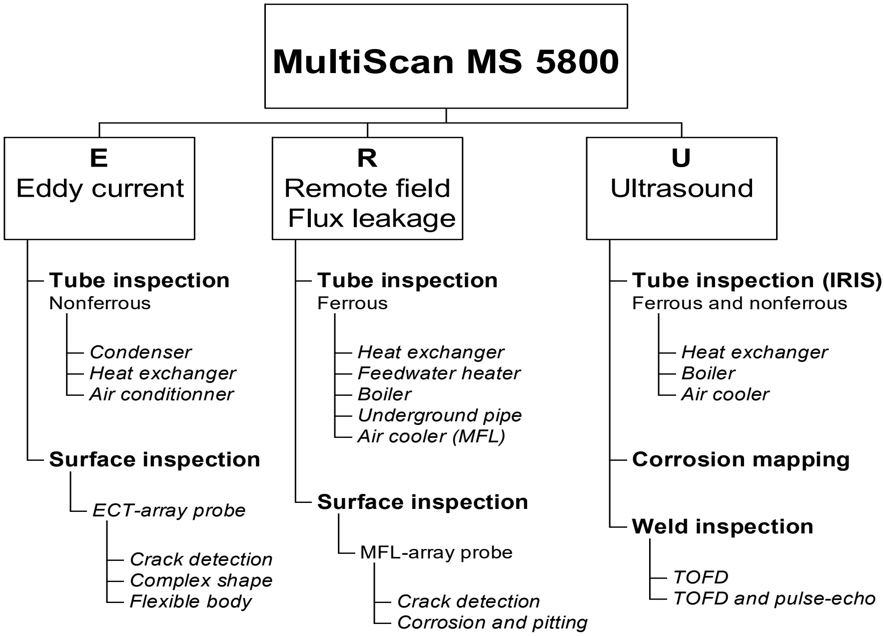


Figure 1-1 MS5800 NDT applications

NOTE

This manual describes the utilization of the MS5800 without external synchronization. If the system is synchronized by another computer, functioning details will be determined by the specific synchronization mode.

2. Instrument Overview

This chapter describes the MultiScan MS5800 front panel. As this instrument has a modular design, your model may be different from the reference model that is presented in this manual.

2.1 Possible Configurations of the MS5800

The MS5800 contains a number of boards, some of them being optional. Table 2 indicates the possible configurations of the instrument.

Table 2 MS5800 configurations

Number	Configuration
5800-E	MS5800 with ECT
5800-R	MS5800 with RFT and MFL
5800-1U	MS5800 with 1 UT channel (BNC)
5800-4U	MS5800 with 4 UT channels (BNC)
5800-8U	MS5800 with 8 UT channels (BNC)
5800-ER	MS5800 with ECT, RFT, and MFL
5800-E1U	MS5800 with ECT and 1 UT channel (BNC)
5800-E4U	MS5800 with ECT and 4 UT channels (BNC)
5800-E8U	MS5800 with ECT and 8 UT channels (BNC)
5800-R1U	MS5800 with RFT, MFL and 1 UT channel (BNC)

Table 2 MS5800 configurations *(continued)*

Number	Configuration
5800-R4U	MS5800 with RFT, MFL and 4 UT channels (BNC)
5800-R8U	MS5800 with RFT, MFL and 8 UT channels (BNC)
5800-ER1U	MS5800 with ECT, RFT, MFL and 1 UT channel (BNC)
5800-ER4U	MS5800 with ECT, RFT, MFL and 4 UT channels (BNC)
5800-ER8U	MS5800 with ECT, RFT, MFL and 8 UT channels (BNC)

ECT: eddy current
RFT: remote field
MFL: magnetic flux leakage
UT: ultrasound
BNC: BNC connectors for ultrasounds

2.2 Front Panel

The MS5800 front panel enables the user to perform the following:

- Connect the MS5800 to a network or other instruments
- Connect ECT, RFT, MFL, and UT probes
- Connect encoder signals and alarm

Figure 2-1 shows the front panel of a complete MS5800 (with ECT, RFT/MFL, and 8-channel US options). The permanent and optional elements of the front panel are described below.

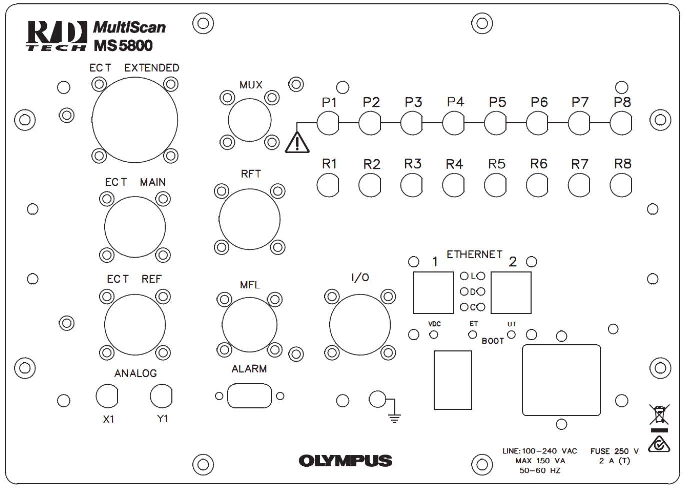


Figure 2-1 MS5800 front panel

2.2.1 Permanent Elements

The permanent elements of the MS5800 front panel are the following:

ANALOG X1, ANALOG Y1 These connectors provide real-time eddy current, remote field, or magnetic flux leakage signals from a channel selected by the user from the MultiView software. These connectors may be used to feed a strip chart recorder.

NOTE

These outputs are not enabled for the ultrasound (US) channels.

ALARM This connector provides open collector outputs for user-programmable alarms.

I/O This connector interfaces to: external trigger for acquisition, relay outputs, position encoders, and various synchronization signals.

ETHERNET 1, 2 RJ45 connectors for 10/100Base-T that allow the MS5800 communication via an Ethernet or Fast Ethernet network.

	Three indicator lights indicate the current communication state (see below).
L (green)	The letter L stand for link. When this indicator light is on, it indicates that the Ethernet link is connected.
D (green)	The letter D stands for data. When this indicator light is on, it indicates that data is transferring. When this indicator light is off, it indicates that there is no activity.
C (red)	The letter C stands for collisions. When this indicator light is on, it indicates that collisions are currently happening.
VDC	This indicator light, when turned on, indicates that DC power voltages are correctly applied to the MS5800 modules.
BOOT ET	This indicator light, when turned on, indicates that the acquisition module for the electromagnetic techniques (ECT, RFT, and MFL) is communicating with the user's computer.
BOOT UT	This indicator light, when turned on, indicates that the ultrasound acquisition module is communicating with the user's computer.
FUSE	A probe holder contains the MS5800 main fuse. This fuse is used to protect the MS5800 from an external power surge or internal short-circuit.
Power supply module	The power supply module allows connection of a standard three-lead power cord with a central ground. The power cord must be rated for at least 10 A. A power switch is used to turn the MS5800 on and off. The unit accepts voltages between 100 V and 240 V, operating at a frequency of 50 Hz to 60 Hz.
External ground (⏚)	This jack can be used to ground the MS5800 unit with an external cable. This plug is very useful for RFT inspections where it is recommended to ground the inspection system with the tube bundle under inspection.
Handles	The two handles located on each side of the front panel are used to disassemble and reassemble the unit.

CAUTION

The front panel handles should not be used to carry the MS5800. Because the handles were not designed to transport the instrument, they may break off. Use the housing carrying handles to transport the instrument.

2.2.2 Elements Associated with the ECT Option

The front panel elements associated with the ECT option are the following:

ECT EXTENDED	Universal ECT probe connector. Interfaces with Olympus ECT probes. Interface to probes from other manufacturers may require an adapter.
ECT MAIN	4-pin probe connector used to connect the measure probe.
ECT REF	4-pin probe connector used to connect the reference probe for the creation of the absolute channel.

2.2.3 Elements Associated with the RFT/MFL Option

The front panel elements associated with the RFT/MFL option are the following:

MUX	Connector that provides the necessary signals for the use of a channel multiplexer.
RFT	RFT probe connector. Connector adapters may be required (optional).
MFL	MFL probe connector. Connector adapters may be required (optional).

2.2.4 Elements Associated with the UT Option

The front panel elements associated with the UT option are the following:

P1, P2, P3, P4…	These connectors are used to connect the ultrasound pulsers.

WARNING

If the instrument is equipped with BNC connectors for probe connections (p connectors), or if LEMO-to-BNC adapters are used to connect the probes to the p connectors, then the voltage present on the BNC connector is accessible and can cause an electric shock reaching 300 volts.

R1, R2, R3, R4… These connectors are used to connect the ultrasound receivers.

2.3 MS5800 Packaging

The MS5800 case (see Figure 2-2) is strictly a protection shell. The card cage and power supply are attached to the front panel, and the complete assembly may be pulled out as a single, fully functional unit. All electronics is on plug-in boards, with the exception of the modular power supply.

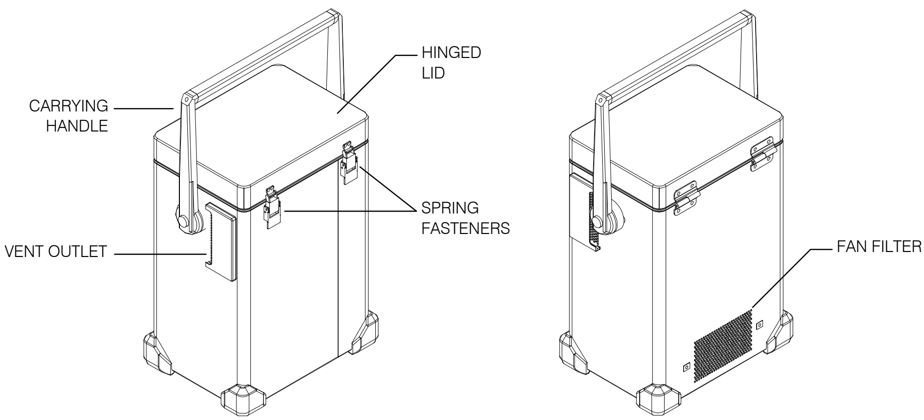


Figure 2-2 The MS5800 case

The MS5800 case includes the following elements:

Hinged lid	The removable hinged lid is used to close the MS5800 case and protect the front panel. Two spring fasteners keep the lid closed.
Fan filter	Mesh used to filter air drawn in by the fan. When necessary, the filter must be cleaned with a compressed-air jet (for details, see “Maintenance of the Fan Filter” on page 90).

2.4 Carrying Handle

The handle on the MS5800 unit (see Figure 2-2) can be used to lift and carry the instrument, but can also be used as a stand to support the instrument. When it is used as a support, the front panel end is slightly raised, for easier access and visibility.

WARNING

It is important for the handle to be locked into place when carrying or supporting the instrument. If it is not locked, the handle will not adequately carry or support the instrument.

Adjusting the handle on the MS5800

The MS5800 comes with a button on each side of the handle, which must be pressed simultaneously in order to release the handle. As you swing the handle to the desired position, it will click and lock into place at each one of the possible positions. Press the buttons on each side of the handle again to release it until it locks into the position you want. It is important that you hear a clicking sound to ensure that the handle is locked into place. If it is not locked, the handle will not adequately support the instrument.

3. Instrument Installation

This chapter explains the procedures to install the MultiScan MS5800 unit and to connect system components and peripherals to the main unit.

The MS5800 is operated through a standard computer set with Microsoft Windows NT or Windows 2000 or Windows XP Professional operating system, and running MultiView software. Both instruments communicate through an Ethernet cable. Thus, the computer must be specially configured to be compatible with the MS5800.

If your computer has been installed by Olympus, you will need to consult this chapter when starting MultiView, when assembling together the elements of the inspection system, and when upgrading MultiView.

The installation of the MS5800 is a Category II installation.

3.1 Standard Equipment and Options

The packing list should include the following items:

- MS5800 with the ordered internal options
- Power cord
- Ethernet cable
- MS5800 user's manual
- MultiView software installation CD-ROM
- Calibration certificate
- Protection key for MultiView options

The packing list may also include any or all of the following optional items:

- Probe adapter
- Computer with the ordered internal options
- User's manuals for the various MultiView software sets ordered by the client
- Installation disks for the various MultiView software sets ordered by the client

3.2 Installation Procedure

This section provides installation instructions for the MS5800.

To install the MS5800

1. Open the MS5800 case by proceeding as follows:
   a) Lift spring fasteners to open the hinged lid (see Figure 2-2 on page 24).
   b) When required, remove case lid by sliding it to the right (see Figure 3-1).
2. Install the MS5800 away from heat sources, leaving a minimum clearance of 5 cm (2 in.) to allow for heat dissipation. Stand the MS5800 on end, front panel facing upward.

CAUTION

The MS5800 must be properly ventilated so as to prevent overheating and ensure an appropriate operation. Make sure to use the instrument in a well-ventilated area while avoiding to obstruct the air inlet located on the lower part of the case as well as the air outlets located on both sides of the case.

3. Swing the handle to the desired position (for details, see "Carrying Handle" on page 25).

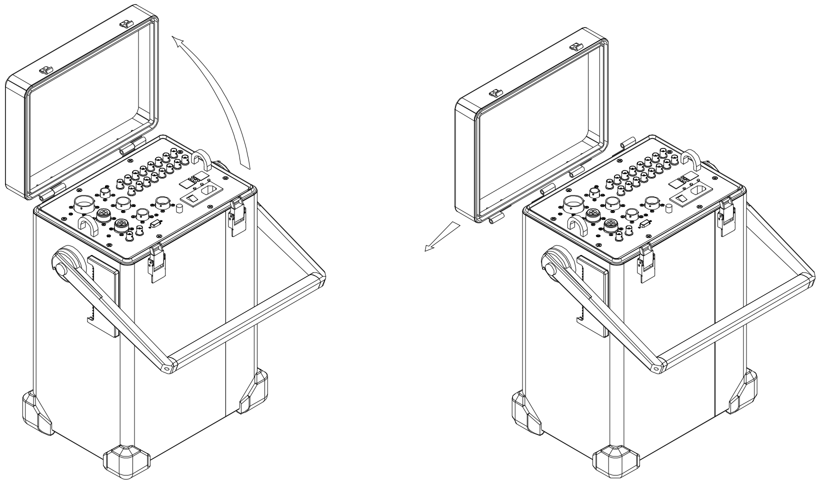


Figure 3-1 Opening the MS5800 case

3.3 Connection Procedure

This section explains the procedure to connect the MS5800. All of the connectors are located on the front panel of the unit.

WARNING

The instrument must be connected according to the manufacturer's instructions in order to prevent risks of electric shocks.

The instrument must always be used with its housing. The MS5800 must be completely inserted into the housing and the front panel screws properly tightened in order to ensure a appropriate grounding of the instrument. A bad grounding of the instrument may produce a short circuit that can damage the electronic components or cause electric shocks.

To connect the MS5800

1. Make sure that the instrument is disconnected from the power line.

2. Install the MS5800 away from heat sources, leaving a minimum clearance of 5 cm (2 in.) to allow for heat dissipation. Stand the MS5800 on end, front panel facing upward.
3. Using an Ethernet cable, connect the MS5800 ETHERNET 1 connector to the network board of the control and analysis computer.

CAUTION

Always ensure that the instrument is switched off when connecting or disconnecting a cable. Failure to do so may result in damage to the unit or to the modules.

---

4. Using the appropriate cables, connect each of the components required by your setup and your needs to the corresponding MS5800 connector.
5. Plug the power cord into the power entry module of the MS5800 front panel. Plug the other end of the power cord into a three-terminal grounded power outlet.
6. Turn on the MS5800 by setting the power switch to the position marked “ I ”.

NOTE

If you want the MS5800 to meet the expected specifications, let the instrument warm up at the ambient operating temperature for 15 minutes before using it.

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7. Turn on the control and analysis computer or computers.

   Depending on the case, Windows NT, Windows 2000, or Windows XP Professional will start.
8. Once the operating system booted, the BOOT ET and BOOT UT indicator lights turn on, according to the instrument configuration. If the MS5800 includes both the ECT or RFT/MLFL and UT technologies, it is important to wait until the two indicator lights turn on before proceeding to the next step.
9. Start MultiView on the control and analysis computer. For details, see “Starting MultiView” on page 30.

3.4 Starting MultiView

This section describes the procedure to start up MultiView.

To start up MultiView

1. On the Windows taskbar, click **Start** (lower-left corner), point to **Programs**, point to **RD Tech**, and then click **MultiView**.

   A dialog box appears, listing the various software options available on your protection key or on the MS5800.
2. Click the software application you want to use.

   The main window of the software option appears.
3. To quit MultiView, on the **File** menu, click **Exit**.

For further information on starting MultiView or connecting to the acquisition unit, refer to the *MultiView User's Manual*.

4. Operation Overview

The MultiScan MS5800 system is controlled by a computer called the “control and analysis station.” This station controls the acquisition process and analyses the data collected by the MS5800. The MS5800 may be integrated into complex inspection system including, for example, a control system for pusher-pullers or probe manipulators.

4.1 MS5800 Environment

The MS5800 has an open architecture that allows integration into a variety of configurations. However, in all configurations, the MS5800 has similar functions. This section describes the components of an MS5800 system.

The Ethernet configuration allows you to link the MS5800 to the control and analysis station through a standard Ethernet network. The simplest configuration will involve a monomodule MS5800 linked to a single computer with an Ethernet cable. At the opposite, the Ethernet network may be used to link the modules of a multimodule MS5800 to their respective analysis stations. The analysis stations can be different computers running each its own MultiView session, or a single computer running many separate MultiView sessions.

Figure 4-1 shows an example of configuration that uses the MS5800.

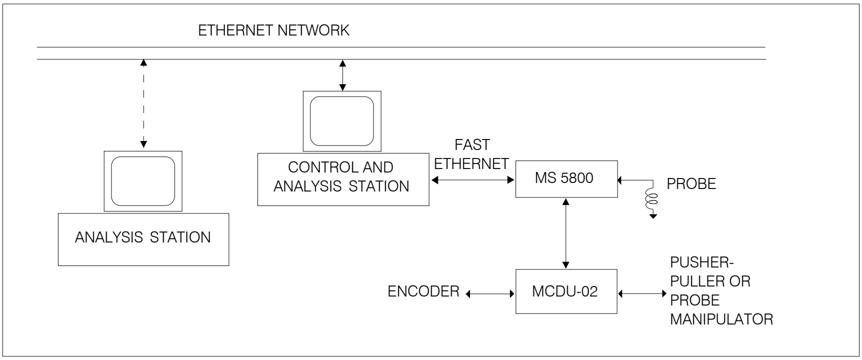


Figure 4-1 Example of configuration using the MS5800

This configuration requires a control and analysis station, as well as a drive unit to drive a robotic system, which includes a pusher-puller or a probe manipulator. The main functions supported by the elements of this system are described below.

MS5800

Eddy current, remote field, magnetic flux leakage, and ultrasound acquisition unit adapted for bidirectional communications via an Ethernet link.

- Generates the probe excitation signals as defined by the control and analysis station.
- Extracts eddy current, remote field, magnetic flux leakage, and ultrasound data from probe incoming signals.
- Acquires the position data.
- On request of the control and analysis station, sends data via an Ethernet cable.

Control and analysis station

PC-type computer adapted for bidirectional communications via a specific Ethernet link. This Microsoft Windows NT–, Windows 2000–, or Windows XP Professional–operated station hosts the Olympus MultiView software.

- Hosts the MS5800 configuration file.
- Controls the MS5800 and receives data from it through an Ethernet cable.
- Processes and displays data sampled by the MS5800.

- Can save, on disk, data files acquired for each item inspected.

Drive unit

Composed of power amplifiers and other controlling devices for various displacement systems.

Fast Ethernet link

The MS5800 is linked to the control and analysis station through a Fast Ethernet network. To make this link possible, the MS5800 comes equipped with two RJ45-type Fast Ethernet connectors and Ethernet cables.

4.2 MS5800 Functions

The MS5800 has an advanced architecture based on high-speed FPGA (field programmable gate array) and DSP (digital signal processing) technology.

The MS5800 main functions consist of:

- Generating multifrequency, multimode, and multiexcitation signals to allow simultaneous excitation of several probes.
- Carrying out a configuration process according to commands received from the control and analysis station.
- Processing the probe incoming signals in order to extract the data.
- Carrying out a self-calibration process upon request of the control and analysis station.
- Executing a self-diagnostic routine to verify circuit operation and to rapidly diagnose circuit failures.
- Exchanging messages with the control and analysis station through an Ethernet cable. Messages sent by the MS5800 to the control and analysis station include probe data, position data, robotics system status information, as well as synchronization signals and failure messages. Messages sent by the control and analysis station to the MS5800 include signals that initiate the acquisition, self-calibration, self-diagnostic, configuration, and probe balancing processes.

4.3 Circuit Description

The MS5800 is composed of two acquisition units: an electromagnetic unit (for the ECT, RFT, and MFL techniques) and an ultrasound unit. Even though these two acquisition units are independent one from each other, they share certain components: the MIM-HUB board and the interconnection board.

At instrument startup, both acquisition units log on the analysis station and wait for the activation signal. According to the inspection technique chosen by the user, one of the acquisition unit will be deactivated.

4.3.1 Electromagnetic Acquisition Unit

The electromagnetic acquisition unit is composed of two boards called **Electromagnetic-Generator** and **Electromagnetic-Acquisition**.

4.3.1.1 Electromagnetic-Acquisition Board

The Electromagnetic-Acquisition board manages the MS5800 internal operations:

- Performs calculations required to produce probe excitation signals and the corresponding demodulation signals, according to commands received from the analysis station.
- Configures the Electromagnetic-Generator board.
- Synchronizes the data acquisition process.
- Stores the data acquired by the acquisition boards in a transmission buffer.
- Upon request of the control and analysis station, sends the acquired data.
- Controls the probe balancing process, as well as the instrument self-diagnostic and self-calibration processes.

The Electromagnetic-Acquisition board plugs onto the Electromagnetic-Generator board.

4.3.1.2 Electromagnetic-Generator Board

The Electromagnetic-Generator board, also called the excitation board, provides four probe excitation signals, as well as the corresponding demodulation signals required for the Electromagnetic-Acquisition boards. This board also controls the built-in current source.

Injectors EC1, EC2, RF1, and RF2

- Generate sinusoidal signals that may contain up to eight superimposed frequencies and that may be time-multiplexed.
- The amplitude, frequency, and phase of these signals are user-adjustable via the MS5800 configuration file.
- The signals of each injector are amplified and sent to a Probe Interface Module (PIM) board in order to be applied to the probe excitation coils.
- The independent outputs of these injectors allow excitation of two probes with different signals.

Current source control

Circuit that generates a voltage to control the built-in current source. This source is mainly used to inject a current in a saturation coil, by means of an 8-bit digital-to-analog converter.

4.3.1.3 Probe Interface Module (PIM) Board

- The Probe Interface Module (PIM) board interfaces the MS5800 to most industry standard probes. It contains a multiplexer for selecting the inspection method to be used (ECT, RFT, MFL). Each channel has its own selection, so that it is possible to combine different inspection methods. According to the inspection method selected, the probe signals will get through an adapted amplifier circuit.
- Physically, the PIM board is located behind the MS5800 front panel. The connectors that transmit the input signals for the ECT, RFT, and MFL methods are directly soldered on the PIM board.

4.3.2 Ultrasound Acquisition Unit

The ultrasound acquisition unit is composed of two main components:

- Acquisition and Processing board
- 8-channel Pulser/Receiver board

4.3.2.1 Acquisition and Processing Board

The 8-bit digitizer (12-bit digitizer optional) contained on the Acquisition and Processing board is responsible for the acquisition and the real-time processing of ultrasound data. The features of this board include:

- Analog-to-digital conversion
- Real-time digital averaging
- Real-time multipeak processing
- Real-time C-scan processing
- Real-time position encoder acquisition
- Real-time alarm processing
- Real-time A-scan rectification
- Real-time DAC (distance-amplitude correction)
- Real-time compression per *n*
- Real-time digital smoothing

4.3.2.2 Pulser/Receiver Board

The Pulser/Receiver board has the following functions:

- Generates high voltages.
- Generates pulse widths.
- Allows for adjustable gains.
- Allows for a choice of low-pass and high-pass filters.
- Allows for an input booster of 25 dB.
- Offers the choice of a linear or logarithmic amplifier.

4.3.3 MIM-HUB Board

The hub circuit splits the Ethernet network cable into a set of separate cables, each connecting to a different MS5800 acquisition board. This allows each acquisition board to use a distinct Ethernet address (see the example shown in Table 3).

Table 3 Example of addresses used by acquisition boards

Slot	Board	Address
1	Electromagnetic-Generator	N/A
2	Electromagnetic-Acquisition	1.2.3.5
3	8-channel Pulser/Receiver	N/A
4	Acquisition and Processing (UT)	1.2.3.6
5	MIM-HUB	N/A

The MIM section interfaces the MS5800 with various types of robotic systems. The MIM is connected to the I/O and ALARM connectors on the front panel. According to the active acquisition unit (electromagnetic or ultrasound), the following functions will be available:

- Alarm output (8 for the electromagnetic unit and 3 for the ultrasound unit)
- Two quadrature inputs for encoder interface
- Input for encoder reset
- Input for index or rotation synchronization
- Input for acquisition start
- Input for external synchronization
- Two spare inputs
- Output for acquisition clock generated internally

4.3.4 Interconnection Board

The interconnection board is located at the back of the card cage. It can hold a maximum of five boards. The boards have a precise position to ensure the proper operation of the instrument (see Table 3).

5. Theory of Operation: Electromagnetic Techniques

This chapter is a reference guide for designers of applications based on the MultiScan MS5800 system. The MS5800 operating characteristics are presented so that the instrument may be configured for the planned application. In order to take advantage of the advanced capabilities of the MS5800, it is recommended to read this chapter from beginning to end.

5.1 Acquisition Triggering Modes

Two triggering modes can initiate the MS5800 acquisitions. The first mode uses a clock signal generated by an **MS5800 internal circuit**. The second mode uses **an external clock signal**, as that produced by a position encoder.

5.1.1 Acquisition Triggered by an Internal Clock Signal

In this mode, the signal generated by an MS5800 internal clock is used to clock the acquisition process. Each clock pulse initiates one acquisition. The clock signal frequency is adjustable using the MS5800 configuration file. The clock frequency, f_{clk}, ranges from 1 Hz to 40 kHz. This frequency can be limited by real-time processing performed on the data (filters, channel merging, alarms, gain, and rotation) or by the delays coming from the super multiplexed excitation mode.

5.1.2 Acquisition Triggered by an External Clock Signal

This mode requires an external clock signal, such as that produced by a position encoder. Encoder clock pulses are then used to initiate each acquisition.

5.2 Excitation Modes

Continuous excitation and frequency multiplexing excitation are operation modes currently used for inspections with electromagnetic techniques, particularly for eddy current testing. Manufacturers offering these excitation modes often emphasize their advantages without mentioning their drawbacks. Indeed, it is more advantageous to use continuous excitation for certain applications; while for some others, frequency multiplexing excitation is advisable. For this reason, Olympus designed an instrument offering these two modes simultaneously. A third excitation mode, called *context switching excitation*, provides most of the advantages of the two conventional modes, while eliminating several of their drawbacks.

5.2.1 Continuous Mode

Continuous mode consists of exciting a probe by continuously injecting one or several frequencies simultaneously. Figure 5-1 shows an example of an excitation signal generated in multifrequency continuous mode. This composite signal consists of four signals: 1 kHz, 10 kHz, 20 kHz, and 50 kHz. This excitation mode is available for both eddy current and remote field signals.

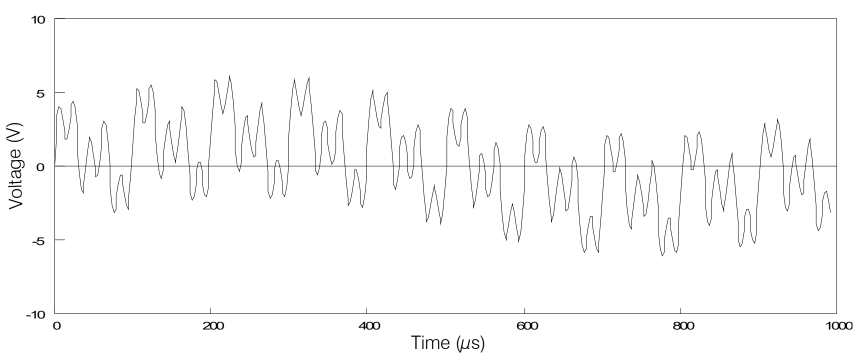


Figure 5-1 Example of probe excitation signal in continuous excitation mode

The first advantage of this method is that the acquisition rate is not limited by the excitation technique. Furthermore, all channels are sampled simultaneously at specific points of the inspected component, which provides excellent results when acquired signals are combined.

A limitation of this method is that frequency beats are likely to occur between excitation frequencies, or between the excitation frequencies and their harmonics, thus limiting frequency selection. In practice, this problem is minor in most applications.

Furthermore, it is often useful to interrupt excitation of some coils while keeping others excited to eliminate problems caused by mutual induction between adjacent or closed coils. This is rather difficult to achieve when operating in continuous excitation mode.

The MS5800 generates a maximum excitation amplitude of 10 V peak (20 V peak-to-peak). In multifrequency continuous mode, the sum of excitation amplitudes at different frequencies cannot exceed 10 V peak. Therefore, it is impossible to generate an excitation amplitude of 10 V for each excitation frequency.

5.2.2 Frequency Multiplexing Mode

Frequency multiplexing consists of exciting a probe with a signal whose frequency and variable in time remains fixed during a specific time interval, called a "time slot," to allow stabilization of eddy currents before recording. Figure 5-2 shows an example of a signal generated in frequency multiplexing mode. This signal is composed of three time slots during which the frequency is fixed. The frequency is equal to 5 kHz during the first time slot, to 20 kHz during the second one, and to 50 kHz during the third one.

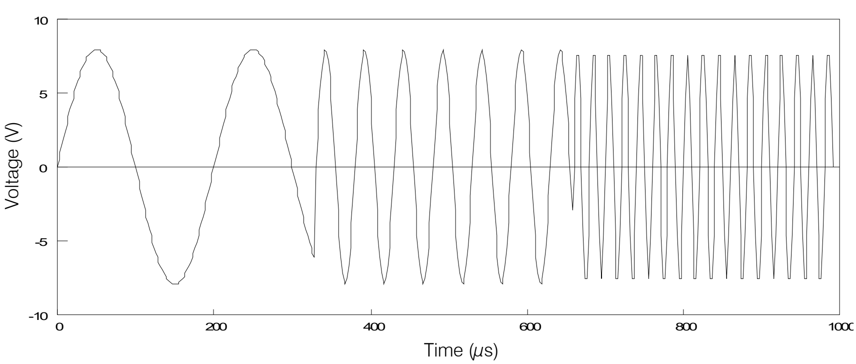


Figure 5-2 Example of probe excitation signal in frequency multiplexing mode

In frequency multiplexing mode, excitation signals of 10 V peak can be generated for each time slot and consequently for each frequency alone in a time slot. This particularity allows signal-to-noise ratio optimization.

Another advantage of this method is that frequency beats are unlikely to occur because only one excitation frequency is injected at a time.

A limitation of this method is that acquisition must be performed at a very precise moment with respect to the excitation signal. After transition from one time slot to the next, the excitation signal needs a specific time to reach a steady state. During this time, a residue of the preceding slot may exist. For this reason, measurements are not performed at the beginning of the slot, but after a certain delay. Furthermore, measurements must be performed during at least one complete cycle of the excitation signal.

The acquisition rate of the MS5800 is thus limited by the stabilization time required for the eddy current and by the delay allocated for measurements. The MS5800 automatically adjusts this measurement delay according to the user-selected frequencies. Therefore, in frequency multiplexing mode, the maximum acquisition rate of the instrument is function of the number of time slots and the lowest frequency. With this limitation, it is virtually impossible to use the frequency multiplexing mode with the RFT inspection technique, because the frequencies used with RFT are much too low (usually lower than 500 Hz). This excitation mode is mostly used for the ECT or MFL inspection techniques. As there is no excitation signal in the case of MFL, the acquisition rate is affected only by the number of time slots.

A limitation of the frequency multiplexing mode is that it provides less immunity to noise than the continuous excitation mode. The MS5800 bandwidth, in frequency multiplexing mode, is not adjustable and it will depend on the number of time slots, on the frequencies selected, and on the acquisition rate. In most cases, the bandwidth is quite large compared to the continuous excitation mode where you can adjust the bandwidth from 8 Hz to approximately 5.2 kHz, providing greater noise immunity (see “Digital Filters” on page 60).

Another limitation of this method is that the acquisition channels are not sampled simultaneously. Combination of these signals provides results that are not as good as when excitation signals at different frequencies are sampled simultaneously (see “Time Interpolation of Eddy Current Signals” on page 62).

5.2.3 Super Multiplexed Mode

The super multiplexed mode of excitation is similar to the frequency multiplexing mode in that it uses many time slots to produce different frequencies. However, this mode is much more versatile because it allows simultaneous injection of up to eight frequencies during the time slots (four frequencies per time slot). With this mode, time slots become “contexts,” for which the frequency, the amplitude and the phase of the signals generated by each injector may be modified. Moreover, the acquisition channels and the kind of processing performed on the eddy current data collected can be selected for each context. Figure 5-3 shows an example of excitation signal generated in context switching mode. This signal consists of three contexts. The first context combines two sinusoidal signals at 10 kHz and 50 kHz; the second one, two sinusoidal signals at 5 kHz and 10 kHz; and the third one, two sinusoidal signals at 5 kHz and 50 kHz.

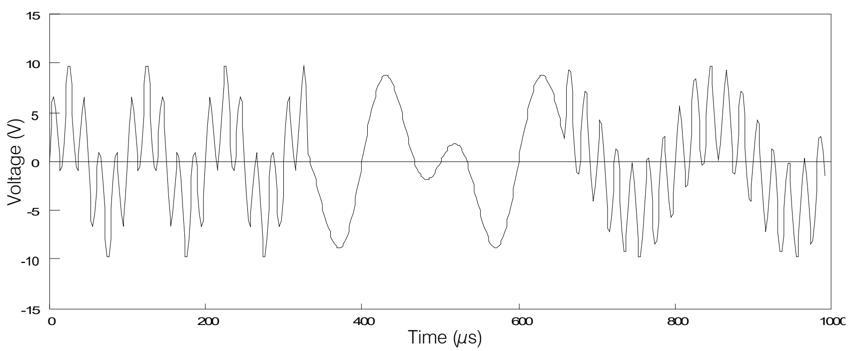


Figure 5-3 Example of probe excitation signal in context switching mode

5.2.4 Comparative Summary of Excitation Modes

This section presents a table containing a comparative summary of excitation modes.

Table 4 Comparative summary of excitation modes

		Continuous mode	**Frequency multiplexing mode**	**Super multiplexed mode**
Excitation frequency adjustment range	ECT	20 Hz to 6 MHz	500 Hz to 6 MHz	500 Hz to 6 MHz
	RFT	20 Hz to 250 kHz	500 Hz to 250 kHz	500 Hz to 250 kHz
	MFL	N/A	N/A	N/A
Number of acquisition channels per Electromagnetic-Acquisition board	ECT	16	Up to 64	Up to 256
	RFT	16	Up to 64	Up to 256
	MFL	4	Up to 64	Up to 64
Noise immunity		Excellent. The bandwidth ranges from 8 Hz to 5.2 kHz.	Not adjustable. Inversely proportional to the time slot duration. Lets through more noise than the continuous mode.	Not adjustable. Inversely proportional to the time slot duration. Lets through more noise than the continuous mode.
Are frequency beats likely to occur between excitation frequencies?		Yes	No	Yes, but this problem can be avoided.

Table 4 Comparative summary of excitation modes *(continued)*

	Continuous mode	Frequency multiplexing mode	Super multiplexed mode
Is the acquisition rate limited by the excitation mode?	No. Acquisition rates of 40 kHz can be reached in some applications.	Yes. The acquisition rate is limited by the number of time slots and by the lower frequency used (ECT and RFT).	Yes. The acquisition rate is limited by the number of time slots and by the lower frequency used (ECT and RFT).
Can maximum excitation amplitude be applied for each excitation frequency selected?	No	Yes	No. However, the maximum amplitude applicable in this mode is higher than in continuous mode.
Can coil excitation be momentarily interrupted?	No	Yes	Yes

NOTE

The frequency multiplexing excitation being, in itself, a context switching excitation with a single frequency in each context, only continuous and context switching modes will be considered until the end of this chapter.

5.3 Multigenerator Operation

The MS5800 allows simultaneous utilization of two independent generators for the ECT and RFT techniques. These generators operate independently, so they can generate signals having different amplitudes, phases, and frequencies. In the context switching mode, each generator combines up to eight signals whose frequency, phase, and amplitude are adjustable independently, with a maximum of four simultaneous frequencies per time slots.

Two generators are often useful to overcome specific problems and to increase system performance. The MS5800 multigenerator capabilities allow generators to be used to:

- Replace reference coils
- Increase probe spatial resolution
- Excite differential probes producing subtractive flux
- Overexcite various types of probes

5.3.1 Reference Coil Elimination

Usually, ECT measurements are performed using a reference coil and a test coil. Sometimes, the reference coil forms an integral part of the probe, and it is shielded to prevent interference by the tested piece.

If the probe does not incorporate a reference coil, one of the coils of a second probe may be used for this purpose. In this case, the reference probe is positioned in a sound area of a second test piece identical to the inspected one. Figure 5-4 shows the wiring diagram of an impedance probe with its reference probe.

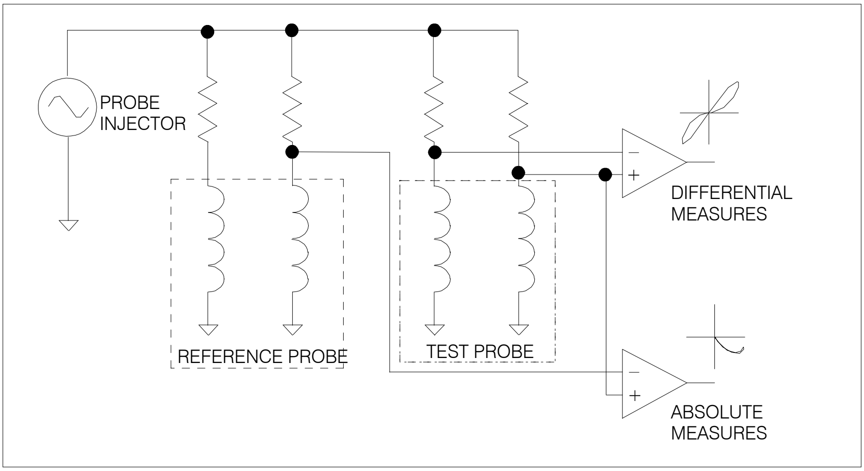


Figure 5-4 Wiring diagram of an impedance ECT probe with its reference probe

The MS5800 allows the replacement of the reference probe signal by a generator signal. In this case, a balancing process automatically determines the phase and amplitude of the reference signal required to balance each excitation frequency used. In context switching mode, this process is performed for all frequencies of each context. Figure 5-5 shows the wiring diagram of an impedance probe with its reference injector.

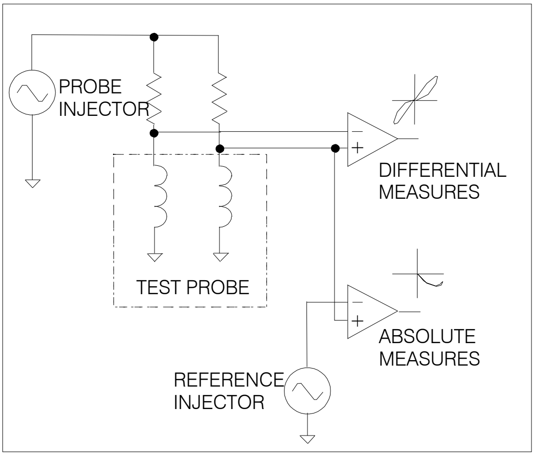


Figure 5-5 Wiring diagram of an impedance probe with its reference injector

Elimination of the reference coil, circuit simplicity, and higher reliability are the main advantages of this circuit.

With reference coil circuits, test and reference coils must often be paired because the impedance mismatch can cause saturation of the acquisition channels, resulting in clipped eddy current signals. With reference generator circuits, it is unnecessary to pair test and reference coils since the self balancing process accurately balances the absolute coil signal.

In some applications, replacing the reference coil with a reference generator can increase noise level. With reference coil circuits, noise and excitation signals present at the two inputs of the differential amplifier originate from a single generator. Because this amplifier subtracts its two input signals, noise is nullified. With reference generator circuits, unequal noise levels are present at the two amplifier inputs. Consequently, noise is not nullified at the amplifier output.

5.3.2 Increasing Probe Spatial Resolution

If two test coils are close enough to each other, a voltage will be induced in each coil because some of the flux of one coil will link the flux of the second coil. This phenomenon is referred to as mutual induction, and it reduces probe resolution.

In continuous excitation mode, the mutual induction problem can be overcome by exciting the coils with two different injectors. The injectors are configured to produce nearly identical signals having slightly different frequencies. The difference between frequencies must be higher than the system bandwidth so as the MS5800 can eliminate the mutual induction effects. According to the application requirements, this bandwidth can be manually adjusted. Hence, excitation of adjacent coils with frequencies separated by at least the instrument bandwidth will overcome problems due to mutual induction.

Figure 5-6 shows an example of an eight-coil probe. Initially, each coil should be excited with two frequencies at 100 kHz and 400 kHz, the instrument bandwidth being set at 2 kHz. To overcome the effects of mutual induction, coils A, C, E, and G will be excited by a generator adjusted to 99 kHz and 399 kHz, while coils B, D, F, and H will be excited by a second generator adjusted to 101 kHz and 401 kHz. Thus, parasitic signals induced, for example, in coil A due to mutual induction with coils B and H will be at 101 kHz and 401 kHz. These frequencies will be eliminated by the MS5800 because they are separated by 2 kHz from the A coil frequencies (101 kHz – 99 kHz, and 401 kHz – 399 kHz).

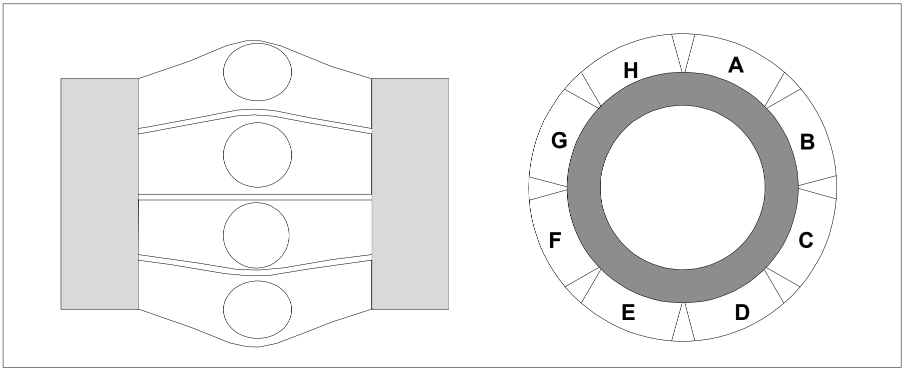


Figure 5-6 Example of mutually inductive coils in a probe

Figure 5-7 shows signals produced by coils H, A, and B as the probe approaches a crack facing coil A. All coils are simultaneously excited at the same frequency. Due to mutual induction between coil A and adjacent coils, parasitic signals are produced by coils H and B.

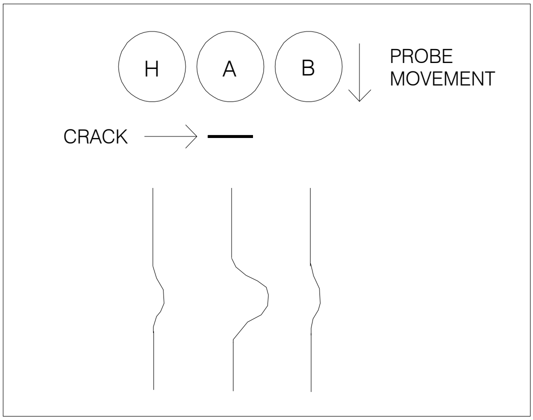


Figure 5-7 H and B coil parasitic signals due to mutual induction

Figure 5-8 shows the H, A, and B coil signals when adjacent coil frequencies are separated by 2 kHz, as described earlier.

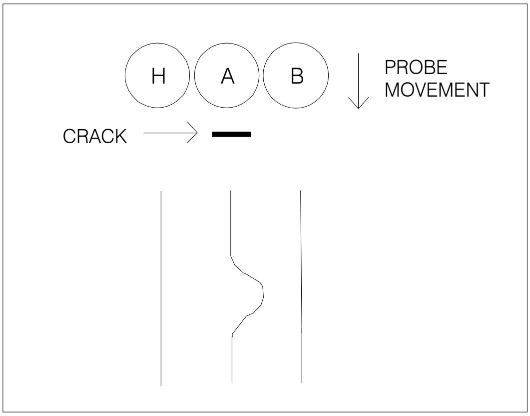
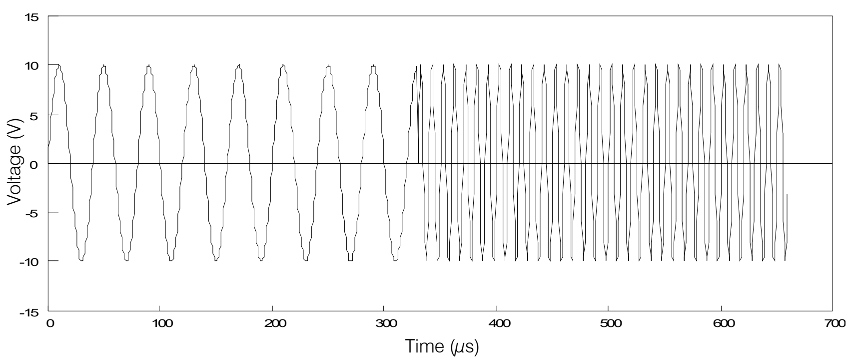


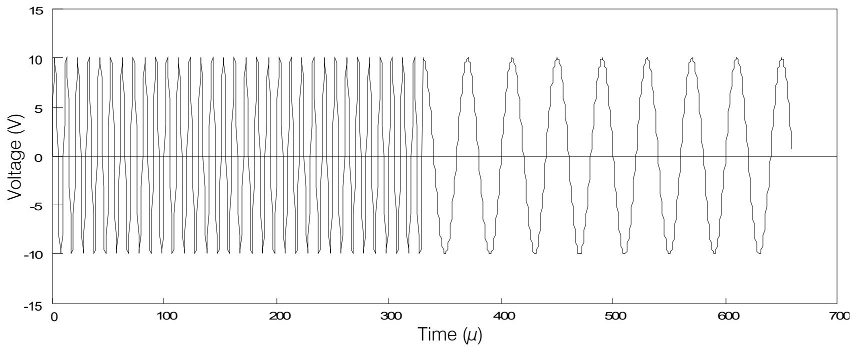
Figure 5-8 Signals obtained when adjacent coil frequencies are 2 kHz apart

The limitation of this method is that excitation frequencies used must be shifted on both sides of the excitation frequency initially desired. Generally, a difference less than 3% between the two shifted frequencies produces negligible effects on eddy current signals. In the example of Figure 5-8, the difference between the 99 kHz and 101 kHz frequencies is equal to 2%, and that between the 399 kHz and 401 kHz frequencies, to 0.5%, which is acceptable. However, if a low frequency application requires, for example, an excitation frequency of 25 kHz, the difference between the two shifted frequencies (24 kHz and 26 kHz) would be equal to 8%, which might be unacceptable. In this case, it is better to reduce the instrument bandwidth to 750 Hz in order to keep the difference less than 3% in comparison to the desired frequency. However, it is important to note that reducing the bandwidth forces a reduction of the inspection speed.

Another method for overcoming the mutual induction problem is in using several generators operated in context switching mode. Adjacent coils may be excited at the same excitation frequency, but during different contexts, which eliminates the need for using excitation signals that are more than 2 kHz apart. In the above example, coils A, C, E, and G could be excited at 100 kHz during the first context, and at 400 kHz during the second one; while coils B, D, F, and H could be excited at 400 kHz during the first context, and at 100 kHz during the second one. Figure 5-9 shows these excitation signals.



(a) Signal of injector 1, composed of two frequencies at 25 kHz and 100 kHz

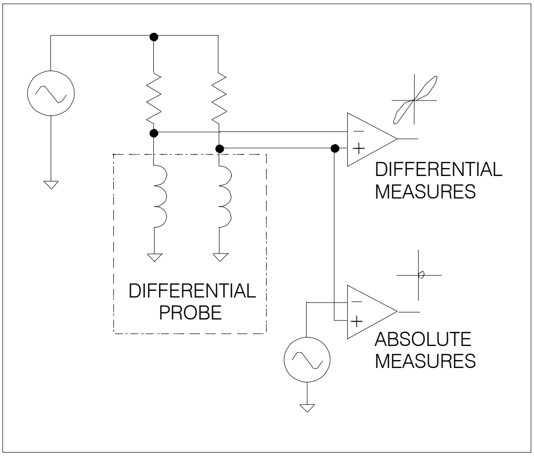


(b) Signal of injector 2, composed of two frequencies at 100 kHz and 25 kHz

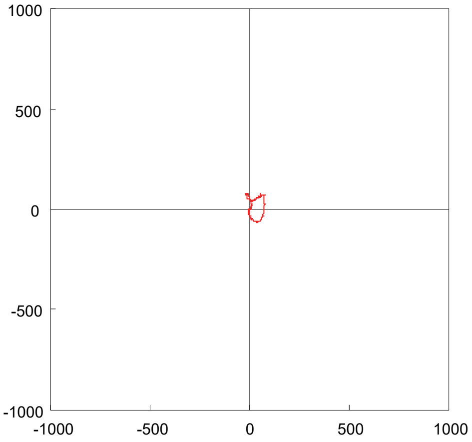
Figure 5-9 Example of excitation signals having two contexts

5.3.3 Excitation of Differential Probes

Certain types of differential probes offered on the market are designed in such a manner that if they are excited with a conventional, single generator circuit like the one shown on Figure 5-10 (a), the fields induced in the windings are subtractive rather than additive. When performing absolute measurements with these probes, subtractive flux result in an erroneous eddy current signal. Figure 5-10 (b) shows an erroneous eddy current signal resulting from the inspection of a support plate with a subtractive flux probe used in absolute mode. Absolute measurements must be performed by using one coil of the differential probe.



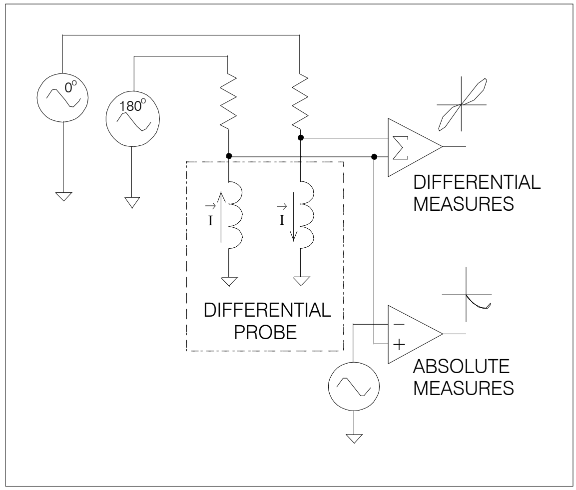
(a) Wiring diagram of the differential probe



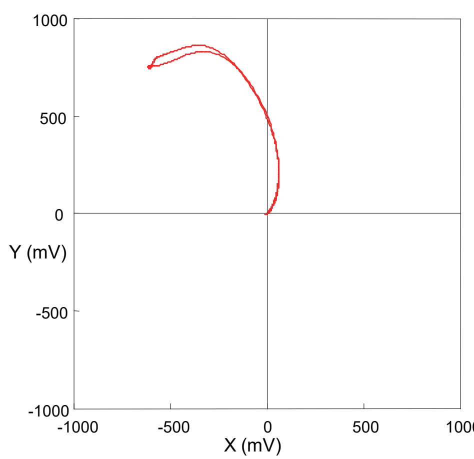
(b) Erroneous eddy current signal obtained with a subtractive flux differential probe

Figure 5-10 Conventional excitation of a differential probe

Fortunately, the MS5800 overcomes this problem by using two injectors that provide inverted signals (out of phase by 180°) to produce additive flux in differential probes. Figure 5-11 (a) shows the wiring diagram used, and Figure 5-11 (b), the eddy current signal obtained in absolute mode under the conditions previously described.



(a) Wiring diagram of the differential probe

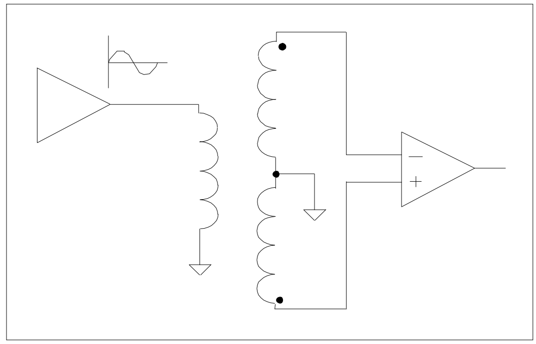


(b) Eddy current signal obtained with a subtractive flux differential probe

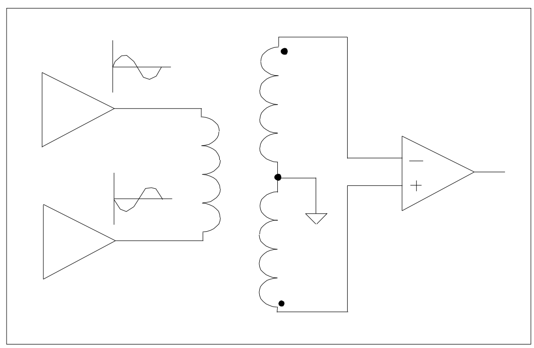
Figure 5-11 Excitation of a subtractive flux probe with two inverted signals

5.3.4 Probe Overexcitation

Overexcitation consists of doubling probe excitation amplitude to increase system sensitivity and to enhance signal-to-noise ratio. Two generators providing inverted signals (out of phase by 180°) must be used. When bridge type probes are used, the common point of probe coils must be connected to the second generator output rather than to ground. When send-receive probes are used, the excitation coil end connected to the common point of the coils must be connected to the second generator output rather than to ground. To obtain good results, the second generator must not be connected to the shield of the coaxial cables. This excitation mode is often used with the RFT application to double the signal excitation level or to drive a dual-exciter probe. Figure 5-12 shows the wiring diagram of a send-receive probe, with and without overexcitation.



(a) Conventional excitation



(b) Probe overexcitation using two injectors

Figure 5-12 Conventional excitation and overexcitation of a send-receive probe

5.4 Optimization of Signal-to-Noise Ratio

In most applications, it is important to obtain an excellent signal-to-noise ratio. This section explains how to optimize the MS5800 signal-to-noise ratio using the various features of the instrument.

In the following paragraphs, the term “noise” designates not only thermal noise produced by electronic components, but all undesired signals obscuring the signal of interest. Here is a list of potential sources of noise:

- Generators produce relatively low noise levels that add to signals generated.

- Probes may pick up electromagnetic noise originating from various sources close by (such as motors, electric welders, etc.).
- Probe mechanical vibrations may create noise because ECT probes are sensitive to slight air gap variations.
- The eddy current signal acquisition and amplification circuit produces an inherent noise level due to thermal agitation in its electronic components.

5.4.1 Excitation Amplitude and Amplification Gain Setting

The excitation amplitudes and the gain of the signal amplification circuits are user-adjustable. The level of the data sent by the MS5800 to the workstation depends directly on these adjustments.

Obviously, increasing the gain of the amplification circuits increases amplitude levels sampled at acquisition. However, this also increases noise produced by the probe in the same proportion. Therefore, increasing the gain does not increase signal-to-noise ratio by much.

It is much more advantageous to increase the excitation signal level in order to optimize signal-to-noise ratio. This increases the voltage levels sampled at acquisition, without increasing noise picked up by the probe and noise generated by the generators and the measuring circuits. Consequently, the signal-to-noise ratio is significantly increased.

To adjust excitation amplitudes and amplification circuit gains

1. Set the gain of the amplification circuits to the minimum value.
2. After making sure that the probe will not overheat, set the drive amplitudes to the maximum values.
3. If the MS5800 self balancing process cannot succeed in balancing the probe (see next section, “Electronic Probe Balancing”), this means that probe unbalance is too great to be compensated. In this case, decrease the amplitude of the excitation signals corresponding to the acquisition channels that reach saturation level.
4. Make sure that the defect producing the strongest signal does not cause saturation of the MS5800 acquisition channels. Saturation causes signals to be clipped as they are displayed on the Lissajous figure. Should this case arise, decrease the amplitude of the excitation signals corresponding to the acquisition channels that reach saturation level.

5. Increase the gain level to just under the point where the strongest signal (normally produced by the greater defect) would cause saturation of the acquisition channels.

Optimization of signal-to-noise ratio relies on successfully performing each of the above steps.

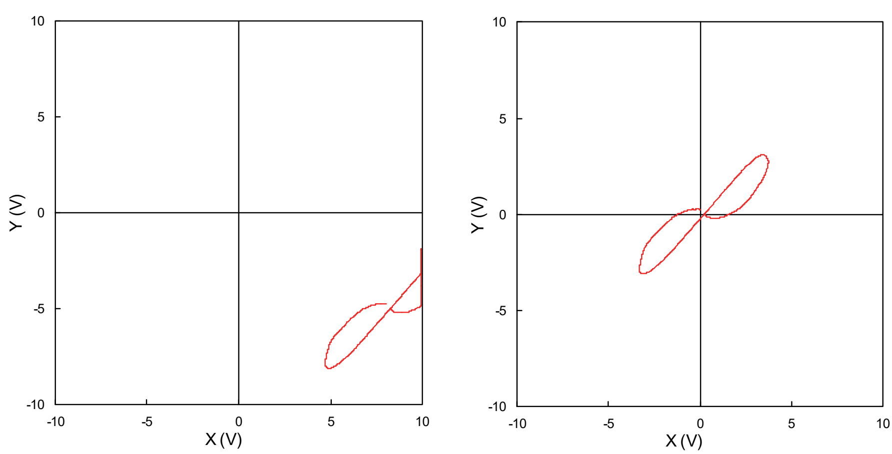
5.4.2 Electronic Probe Balancing

Since probe coils never have equal impedances, the MS5800 integrates an electronic balancing function that matches the coil impedance vectors, thus bringing back the operating point in the center of the Lissajous figure.

To perform probe balancing

1. Position the probe in a sound area of the piece to be inspected.
2. Start up the balancing process.

This process brings back the displayed eddy current signal in the center of the Lissajous figure, allowing utilization of the entire dynamic range of the instrument. Figure 5-13 (a) is an example of clipped eddy current signal displayed when probe unbalance causes saturation of the acquisition channels. Figure 5-13 (b) shows this signal, once the probe has been balanced with the probe balancing function.



(a) Before probe balancing **(b) After probe balancing**

Figure 5-13 Eddy current signal before and after probe balancing

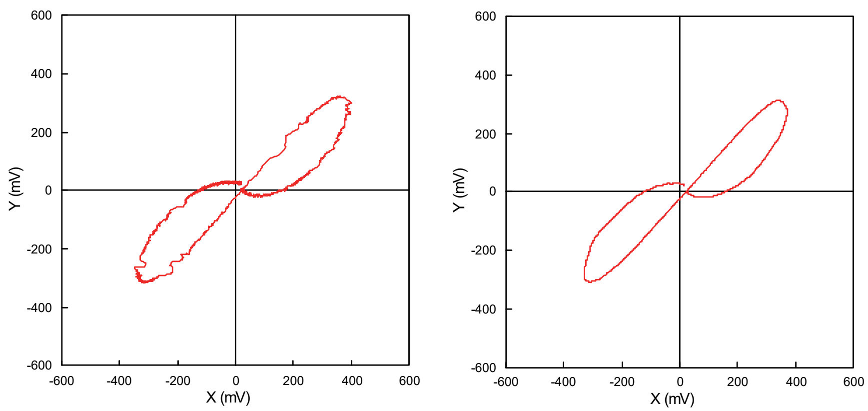
In order to maintain the optimum inspection dynamic range, certain types of probes are hardware-balanced by pairing the coils with capacitor blocks, which makes the probes costly. The MS5800 electronic balancing function eliminates the need for blocks.

This function can compensate for unbalanced voltages reaching up to 125 mV peak (250 mV peak-to-peak), for each excitation frequency used. If, however, the unbalanced voltage is greater than 200 mV for one of several excitation frequencies, the probe must be replaced, or the excitation voltages must be decreased.

5.4.3 Digital Filters

Increasing the probe displacement speed also increases the frequency of the signal produced by a defect. A large bandwidth allows for an increase in probe speed without attenuation of the signal. It should be noted, however, that noise levels increase proportionally with system bandwidth. In several applications, the instrument bandwidth is much larger than actually required. Therefore, digital filters may be useful to select a specific bandwidth in order to reduce the level of noise accompanying the eddy current signals. For these applications, the MS5800 is provided with low-pass filters.

Figure 5-14 shows an eddy current signal before and after applying a low-pass.



(a) Before applying filter **(b) After applying filter**

Figure 5-14 Effect of a low-pass filter on the eddy current signal

As Figure 5-14 shows, the filter smooths the eddy current signal displayed and increases signal-to-noise ratio.

The MS5800 filters are used when the bandwidth is larger than required by the application. They are especially useful for the RFT application, which is very sensitive to ambient noise and harmonics of the current supply frequency (60 Hz, 120 Hz, 180 Hz, for example). Moreover, the low-pass filter for the RFT channels has a much more rapid cutoff compared with the low-pass filter for the ECT channels.

To quickly estimate signal bandwidth at the probe amplifier output

1. Inspect a localized defect at normal probe speed and acquisition rate.
2. Estimate the half-cycle of the signal produced by the defect:

   On the time base display of the workstation, measure the time interval separating the positive and negative peaks of the eddy current signal displayed during which the fastest variation (highest frequency) normally occurs. Figure 5-15 indicates how to measure the half-cycle of a signal produced by a localized defect. In this example, the half-cycle measured is equal to 30 ms.

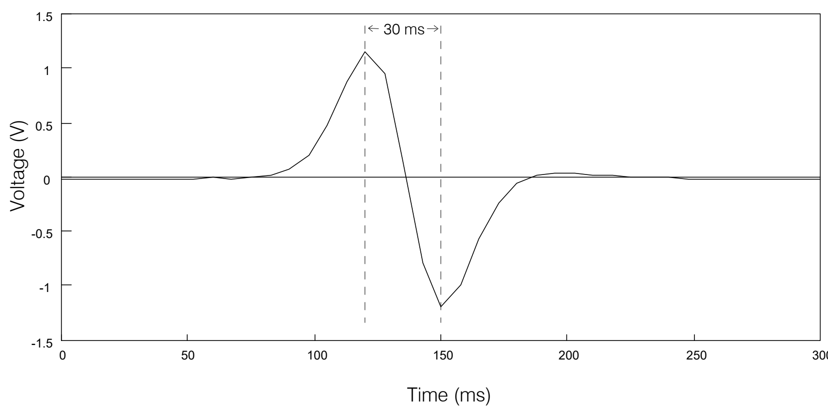


Figure 5-15 Measuring the half-cycle of eddy current signal on time base display

3. Calculate the cutoff frequency f_c required for the filter, using the following equation:

   $f_c = 1 / t$

   where:

   t = time interval between the positive and negative peaks (seconds)

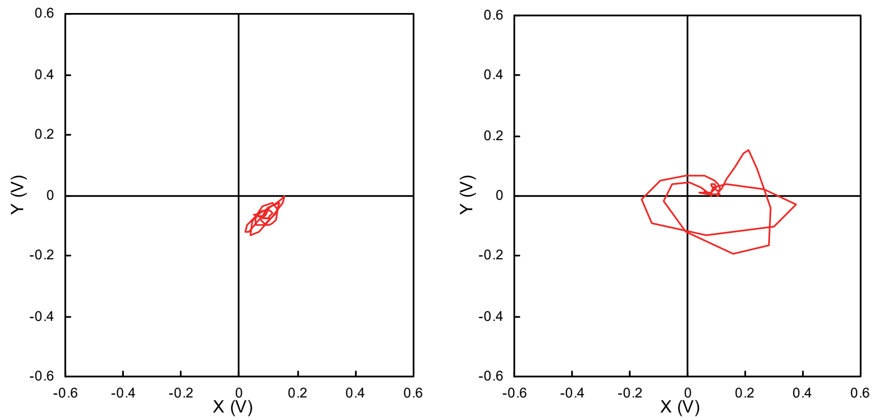
Note that the cutoff frequency obtained is equal to twice the highest signal frequency, to take into account the 3 dB attenuation produced by the filter at f_c.

In the example of Figure 5-15, a filter cutoff frequency of 33 Hz would be required since the half-cycle of the signal displayed is equal to 30 ms. However, this value is a quick approximation of the actual value required, and it may be necessary to modify it after trials in order not to attenuate or distort the signal. Generally speaking, the higher the filter cutoff frequency, the lesser the attenuation or distortion produced on the signal.

5.4.4 Time Interpolation of Eddy Current Signals

Multifrequency systems often combine signals sampled on each acquisition channel to attenuate one or several undesired signals. In some systems, however, the acquisition channels are not sampled simultaneously, causing time-shifting of the signals. This may be fairly annoying when operating in frequency multiplexing mode, because combination of time-shifted signals do not enhance signals as much as in absence of a time-shift. Effects of time-shifting on signal-to-noise ratio depend on shift duration, probe inspection speed, and probe resolution.

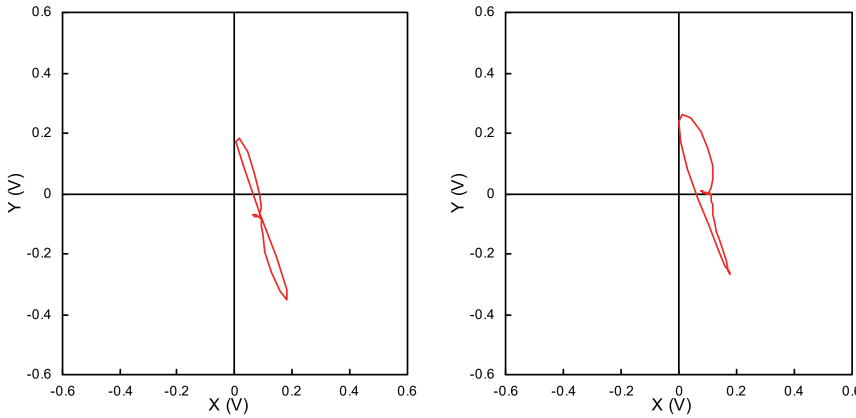
Figure 5-16 (a) shows the residual signal of a heat-exchanger support plate obtained when combining two acquisition channels that were sampled simultaneously. Figure 5-16 (b) shows the signal when the two combined channels were sampled successively with a sampling delay of 1.5 ms between channels. In this case, the residual parasitic signal is much greater because the sampled signals are time-shifted.



(a) Sampled channels not shifted **(b) Shifted sampled channels**

Figure 5-16 Residual signal obtained when combining eddy current channels

Figure 5-17 (a) shows the eddy current signal of a defect obtained when combining two channels that were sampled simultaneously. Figure 5-17 (b) shows this signal when the two combined channels were sampled successively with a sampling delay of 1.5 ms between channels. In this case, the distortion of the eddy current signal is obvious.



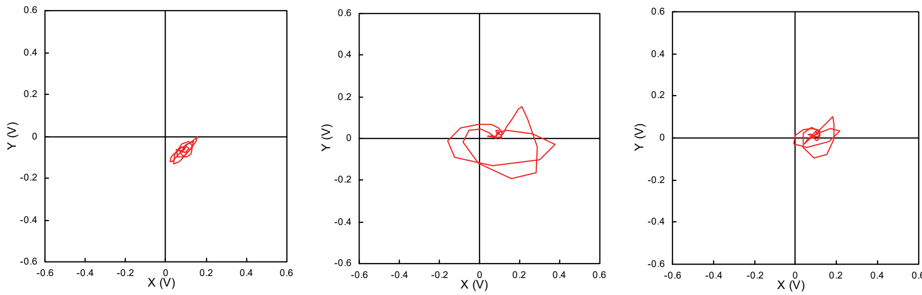
(a) Sampled channels not shifted **(b) Shifted sampled channels**

Figure 5-17 Signal obtained when combining eddy current channels

In context switching mode, there is no delay between the sampling of signals generated within the same time slot, because they are sampled simultaneously. However, a delay elapses between the sampling of two successive time slots.

The MS5800 is provided with an interpolation function that estimates the eddy current channel voltages that would have been measured if the channels had been sampled simultaneously. This function estimates the eddy current signal voltage at a given instant using voltages measured at sampling points immediately preceding and following the interpolated point. The interpolation is linear and uses two known values.

Figure 5-18 (a) shows a residual parasitic signal obtained when combining two simultaneously sampled acquisition channels.

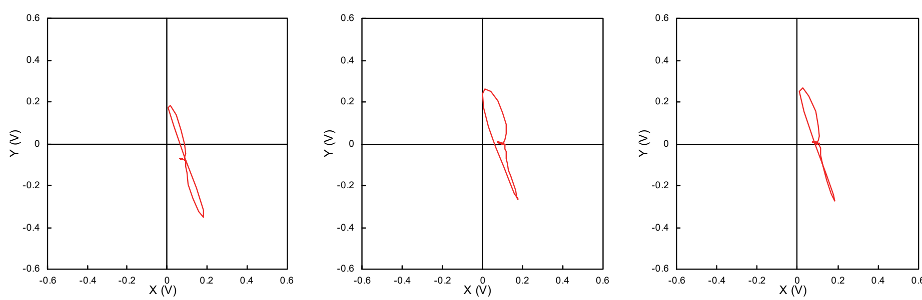


(a) Without delay **(b) With a 1.5 ms delay** **(c) With interpolation**

Figure 5-18 Effect of interpolation on a parasitic residual signal

Figure 5-18 (b) shows this signal when two combined channels were sampled successively with a sampling delay of 1.5 ms between channels. The residual signal is greater because sampled signals are time-shifted. Figure 5-18 (c) shows the attenuation effect of interpolation on the residual signal level.

Figure 5-19 (a) shows examples of eddy current signal obtained when combining two simultaneously sampled acquisition channels.



(a) Without delay **(b) With a 1.5 ms delay** **(c) With interpolation**

Figure 5-19 Effect of interpolation on an eddy current signal

Figure 5-19 (b) shows the signal when two combined channels were sampled successively with a sampling delay of 1.5 ms between channels. The eddy current signal is distorted because sampled signals are time-shifted. Figure 5-19 (c) shows distortion reduction of interpolation on the eddy current signal displayed.

In conclusion, the interpolation function greatly improves signals displayed when the user chooses to combine time-shifted signals. However, it is usually advisable to combine signals that were sampled simultaneously, or to minimize time-shifting of the signals to be combined. For example, the continuous mode produces negligible shifting on sampled channels. In context switching mode, combining signals that were sampled within the same time slot eliminates signal shifting.

The only limitation of the interpolation function is that it may decrease the maximum acquisition rate attainable in continuous mode.

5.5 Selection of Frequencies

The excitation frequencies are specified during the MS5800 configuration process. The selection must be done while taking two factors into account: the excitation mode and the number of frequencies used. A set of selected frequencies is stated "invalid" when frequency beats may occur between frequencies, or between these frequencies and their harmonics. The MS5800 is provided with a special program that checks for the invalid frequency sets. Should this case arise, the program will find a valid combination by shifting the frequencies selected by the user in the MS5800 configuration file.

The delay required to find a valid frequency set may be long because there is a large number of combinations. In some cases, the number of possible combinations is so great that several seconds may elapse before a valid set is found.

Constraints limiting the excitation frequency selection depend on the excitation mode used. The following describes applicable constraints in continuous and context switching modes.

Continuous mode

When operated in this mode, the MS5800 can generate excitation signals between 20 Hz and 6 MHz for the ECT applications, and between 20 Hz and 250 kHz for the RFT applications. The frequencies are adjustable with a 0.5% resolution, using the MS5800 configuration file.

When the MS5800 operates in multifrequency continuous mode, it automatically adjusts the bandwidth so it is four times smaller than the lowest difference between two frequencies. For example, if you are using frequencies of 10 kHz and 12 kHz, then the bandwidth will be set to 500 Hz.

Super multiplexed mode

When the MS5800 operates in multifrequency context switching mode, where each time slot contains several excitation frequencies, the frequency sets must be multiples of a common denominator to all frequencies. For example, you can use 10 kHz, 20 kHz, and 30 kHz (common denominator of 10 kHz). The acquisition rate will affect the value of the lowest common denominator available. In the previous example, 1 kHz, 2 kHz, and 5 kHz are other common denominators that could be used. The lower is the acquisition rate, the lower could be the frequency separation. For example, with an acquisition rate of 500 Hz, the system will allow a common denominator of 2 kHz, so 10 kHz, 20 kHz, and 22 kHz make up a valid frequency set. If you increase the acquisition rate to 1 kHz, then the lowest common denominator allowed by the system is at 5 kHz (10 kHz, 20 kHz, and 25 kHz make up a valid frequency set).

The number of time slots will also have an impact on the minimum common denominator allowed by the system; however, the impact of this parameter is less important than the acquisition rate.

6. Theory of Operation: Ultrasound Techniques

The MultiScan MS5800 is a powerful UT acquisition system that accepts 1, 2, or 8 physical channels. A physical channel corresponds to a circuit with a pulser and a receiver.

NOTE

This chapter describes what the MS5800 ultrasound option can achieve, but it does not mean that the application software (example: MultiView) supports all these features.

6.1 Description of the Acquisition Chain

This section provides a description of the acquisition chain.

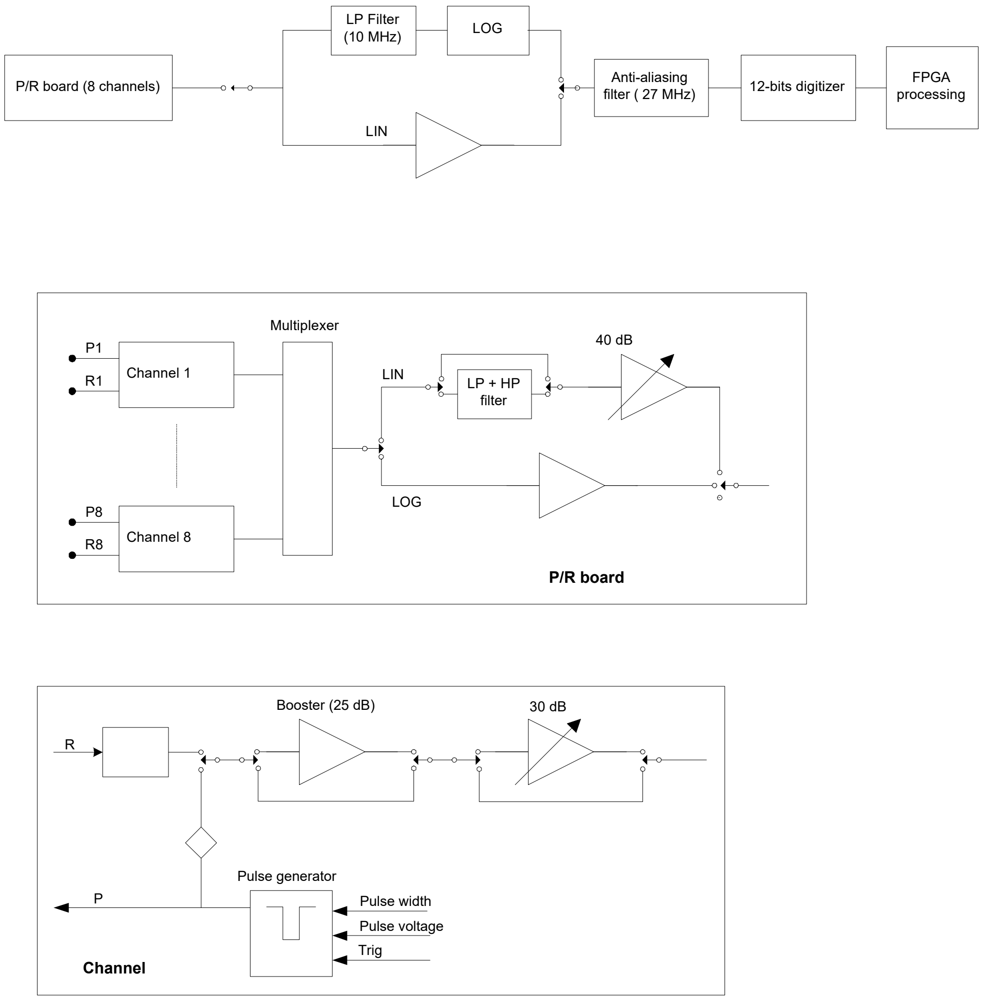


Figure 6-1 RF chain on an MS5800

Figure 6-1 provides a diagram of the RF chain on an MS5800. Different paths can be taken according to the type of amplification used:

Linear (LIN)
: This path allows you to apply 70 dB of gain and to add filters (low-pass and high-pass).

Logarithmic (LOG)
: This path is intended to provide the best signal-to-noise ratio possible (no gain and no filters).

Logarithmic with DAC (LOGDAC)
: This path is similar to the LOG path but filters can be added (high-pass and low-pass) and gain of 30 dB.

Description of the Analog Chain

- The acquisition board is configured with all the parameters of the logical channel. An acquisition board processes one channel at a time.
- A pace is generated either on the internal clock, on an encoder, or on an external clock. Following the pace, a negative square pulse is emitted on the PX output (a pulse of which length and voltage can be configured).
- Reception on the R (receiver) or P (pulser) input. For example, a signal can be pulsed through P2 and it can come back through P5; however, there is a 2 dB sensitivity loss when a signal is received through P*x* versus R*x*.
- At this point, a booster of 25 dB can be applied or not. Because this booster is located at the beginning of the chain, it is better to use it (better signal-to-noise ratio) than to add a 25 dB DAC. This booster is available for LIN, LOG, and LOGDAC.
- Then, there is a varying amplifier that can produce up to 30 dB, available in LIN and in LOGDAC modes only.
- Further on, there is a multiplexer. On the pulser/receiver board, there are 8 pulser/receivers. There is only one multiplexer because the rest of the chain is common.
- In LIN mode, a low-pass filter can be activated (2, 5, 10, 20 MHz).
- In LIN mode, a high-pass filter can be activated (1, 2, 5, 10 MHz).
- In LIN mode, there is a varying amplifier where it is possible to add up to 40 dB in gain (for a total of 70 dB).
- Next, there is the acquisition board.
- If you are functioning in LOG or LOGDAC mode, use a low-pass filter of 10 MHz. This limits the bandwidth to 10 MHz. This filter is there to improve the signal-to-noise ratio.
- Then, the signal goes through an anti-aliasing filter of 27 MHz.

- Next, the analog signal goes through the 12-bit digitizer at 100 MHz.
- Once the digitizing completed, the signal is processed by the field-programmable gate array (FPGA). Figure 6-2 shows the principal processes.

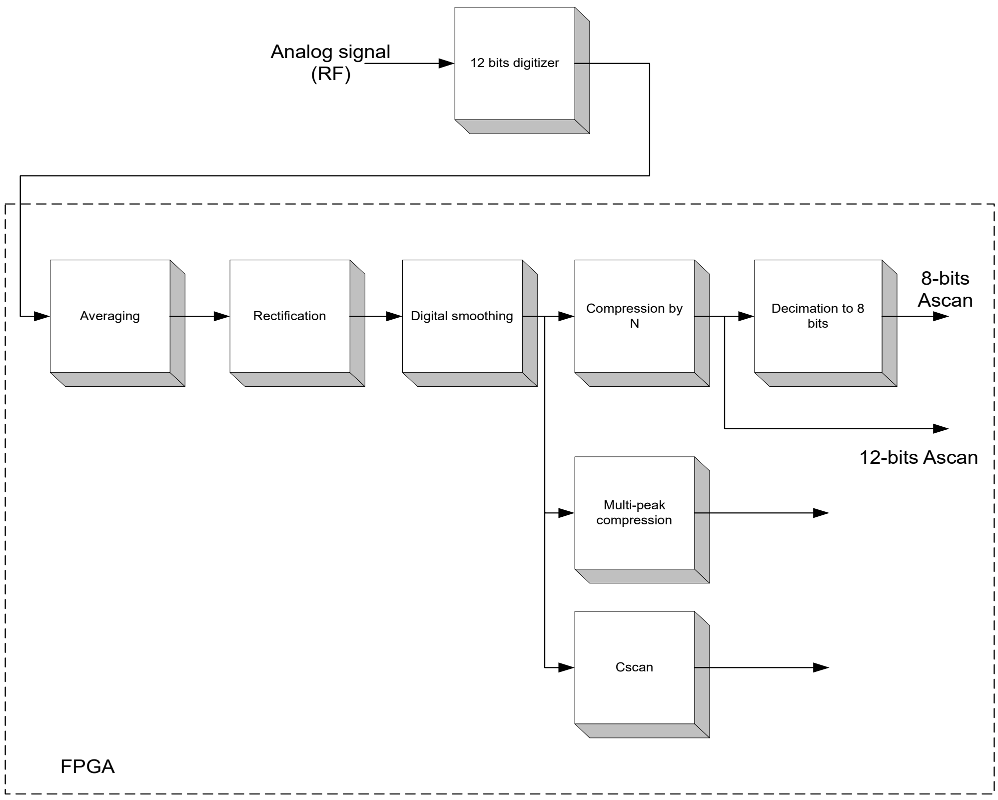


Figure 6-2 Digital processing

6.2 Description of the MS5800 Ultrasound Data

In this section, you will find a description of the various types of data produced by the MS5800.

6.2.1 Synchronization Modes

- **On pulser.** In this mode, the user defines one zone (delay after main bang, digitizing length) where the signal is digitized and processed, which means that the user can extract the A-scan, the C-scan, the multipeak, and the A-scan video.
- **On echo.** In this mode, the user defines an echo search gate. This gate is defined as delay after main bang, search length, echo detection threshold. Then the user defines a zone (delay after echo or pretrigger, digitizing length) where he will digitize and process the signal, this means that the user can extract the A-scan, the C-scans, the multipeak, and the A-scan video. In MultiView software, gate 0 is called synchronization gate.
  - If no echo is found in the search gate, the A-scan will be white (0%).
  - There can be a pretrigger; this means that the user can start the acquisition before the echo.
  - There can be a delay after the echo.

A-scan

The A-scan is the digitized section of the ultrasound analog signal as a fixed size array of samples. Its length corresponds to the digitizing length. The A-scan may have 12 bits or 8 bits, according to the options installed on the instrument. In the case of 12 bits, each sample uses 16 bits. The four extra bits are not used at this moment, but could be used later to increase time resolution when compression is used. In the case of 8 bits, the 12-bit amplitude is decimated to keep the 8 most significant bits. Only the A-scan and the A-scan video data may be decimated to 8 bits. The choice of 8 or 12 bits is done per channel.

A-scan Video

This type of data is similar to the A-scan. The only difference is that it is not produced synchronous, which means that it is not necessarily produced at every trigger (contrary to the A-scan). An acquisition board produces a maximum of 20 A-scan videos per second (20 Hz) on all channels where the A-scan video is requested. The A-scan video can be produced of round-robin manner or from a specific channel. For example, in a round-robin manner with a configuration where the A-scan video is required on the logical channels 1, 4, and 5, then the A-scans video will be produced in the following order: 1, 4, 5, 1, 4, 5, and so on. This mode is usually used for the applications when only the C-scans are kept (high acquisition rate) and when the user wants to check the couplant.

Remanence

The remanence is applied only to the A-scan video. When the remanence is not applied, A-scan video is produced at 20 Hz maximum. When the remanence is applied, the resulting A-scan is produced from *n* A-scan, where each point in time is the maximum value for each A-scan at that time. For example, if there is only one context and that the acquisition rate is 1000 Hz, with the remanence mode, each A-scan produced will be done from 50 A-scans (1000 Hz/20 Hz = 50), where the maximum value will have been kept for each point in time.

Multipeak

A multipeak is a variable array of pairs (12-bit amplitude, time of flight of 15 bits) representing peaks on the analog ultrasound signal. The criterion used for peak search is that there should be a difference of at least 6 dB on the amplitude between two peaks. This means that a new peak is not searched for as long as there is not an amplitude difference of 6 dB compared with the last peak found. The search algorithm of the peaks works only with a rectified signal on which a digital smoothing has been applied. These parameters are automatically applied on the channel when the multipeak is requested. As well, the following specific parameters are found:

- Number of peaks kept: This quantity is configurable and can be from 3 to 127 peaks.
- Peak threshold: Any peak under this threshold is not kept.
- Search range of the peaks: The peak search can be taken on the digitized length (length of the A-scan) from one C-scan gate (gate 1, 2, 3, or 4) or on all C-scan gates.

NOTE

It is important to know that only the first peaks found are kept (starting at the beginning of the selected ultrasound path). On a high level signal at the beginning of the acquisition gate (for instance the main bang or an interface echo), it is possible to reach the maximum quantity of peaks requested without covering the complete acquisition gate length. This problem can be solved by setting the appropriate starting point and range for gate 1, 2, 3, or 4.

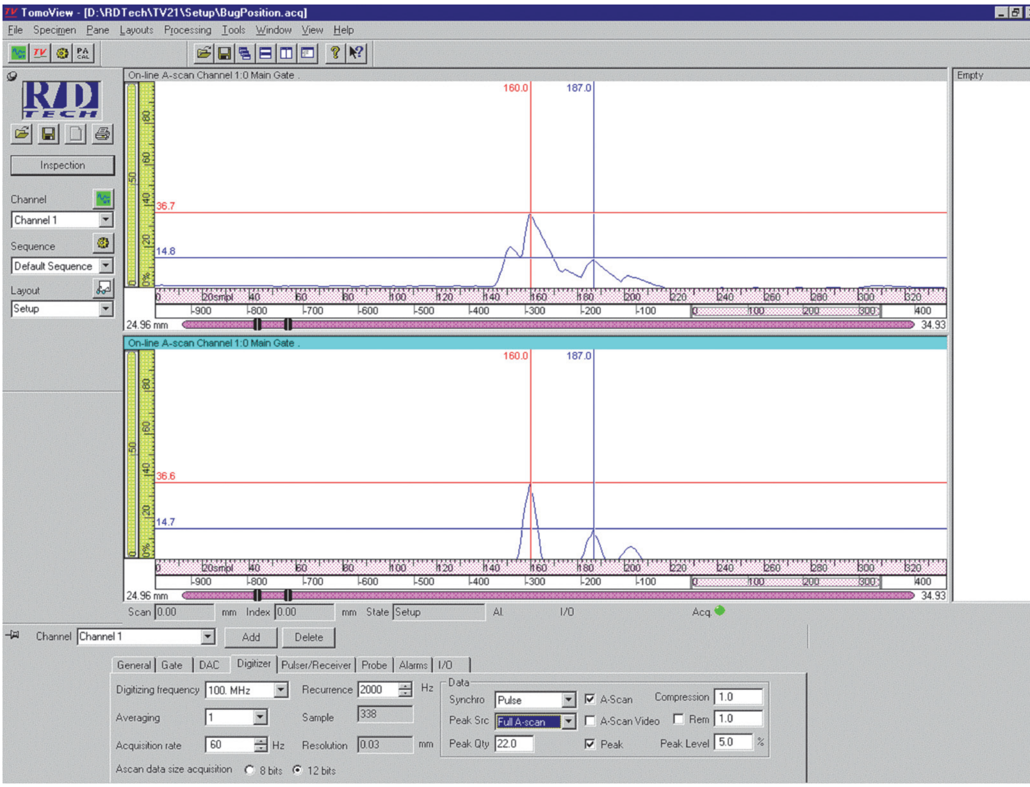


Figure 6-3 Comparison between an A-scan and a multipeak

In Figure 6-3, there is a comparison between the A-scan (top pane) and the multipeak (bottom pane) on the same ultrasound signal. The search algorithm of the peaks has found three peaks on the digitized length. This technique allows the diminution of the quantity of data saved compared to the A-scan. Figure 6-4 shows another example that compares the A-scan and the multipeak. With the A-scan peak, the user finds the same information than the A-scan but it takes only four pairs (amplitude, time of flight) instead of 1864 samples.

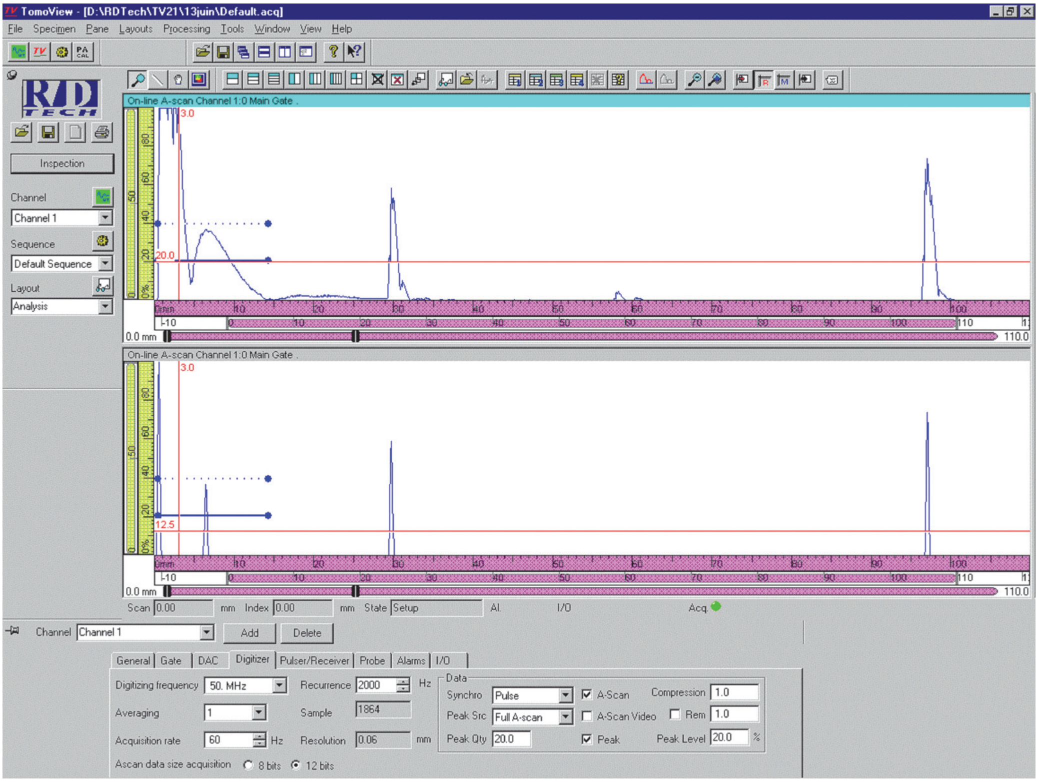


Figure 6-4 Another comparison between an A-scan and a multipeak

C-scan

A C-scan gate gives a pair (12-bit amplitude, 15-bit time of flight) representing a single point on the analog ultrasound signal. A gate is defined by a beginning, a length, and a threshold. There are up to four C-scan gates (P1, P2, P3, and P4) and one synchronization gate (P0). Here is a list of the different types of C-scan:

- **Maximum.** Provides the maximum amplitude found in the gate and the time of flight where the maximum amplitude is found. If the signal has not exceeded the threshold, a message stating that no maximum was found comes back.
- **Crossing.** Sends the time of flight where the signal has crossed the threshold.
- **Synchro.** When the user sets the channel in the echo mode, a gate showing where to look for the echo is defined. The synchronization gate (Gate 0 in MultiView)

sends back the time of flight where the echo was found in this gate. For this C-scan, the amplitude is not sent back but other types of information like the alarm status, etc.

The times of flight are relative compared with the definition of the gate.

6.2.2 Real-Time Processing

The MS5800 offers the following data processing functions: averaging, rectification, digital smoothing, data compression by *n*, and multipeak detection. These functions can be combined and performed in real time. Their activation does not jeopardize the global system performance.

Averaging

Real-time averaging is the first process applied on the "raw" RF signal. This allows for optimum noise reduction since the phase information of the signal is maintained, even when rectification is applied. The noise reduction factor is given by:

$$\text{(SNR) after averaging} = \text{(SNR) before averaging} \cdot n^{1/2}$$

with n = 1, 4, 8, or 16.

Rectification

Because the real-time rectification process is purely digital, it does not introduce any deformation (non-linearity) to the signal and assures the optimum use of the dynamic range of the 12-bit A/D converter.

Digital smoothing

Real-time digital smoothing is applied on the rectified signal. The smoothing process creates an envelope of the signal making analysis easier since the color palette will not be "crossed" by each cycle of the rectified signal. The smoothing parameters are automatically based upon the applied digitizing frequency and require no specific settings of the operator.

Smoothing consists in keeping the maximum value between the value of the found sample and the value of the previous peak found, multiplied by a distance factor. This factor is 15/16 for the first following sample, 14/16 for the second following sample, 13/16 for the third, 12/16 for the fourth, and so on to reach 1/16 for the fifteenth sample.

Table 5 presents an example of a hypothetical signal. The **Sample value** column presents the digitized value before smoothing, while the **Value kept** column presents the value obtained after smoothing.

Table 5 Example of a hypothetical signal

Sample number	Sample value (%)	Compared value (%)	Value kept (%)
1	0	0	0
2	2	$0 \times 15/16$	2
3	5	$2 \times 15/16$	5
4	17	$5 \times 15/16$	17
5	32	$17 \times 15/16$	32
6	28	$32 \times 15/16$	30
7	25	$32 \times 14/16$	28
8	20	$32 \times 13/16$	26
9	23	$32 \times 12/16$	24
10	27	$32 \times 11/16$	27
11	43	$27 \times 15/16$	43
12	48	$43 \times 15/16$	48
13	44	$48 \times 15/16$	45
14	40	$48 \times 14/16$	42
Etc.	Etc.		

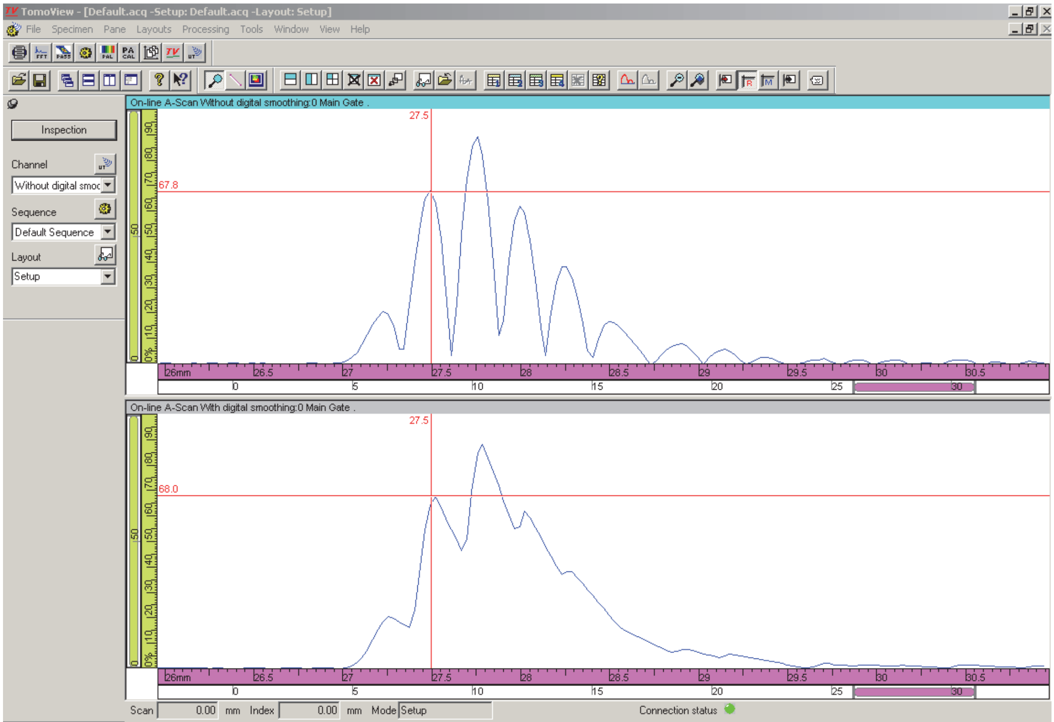


Figure 6-5 Digital smoothing

In Figure 6-5, the upper pane shows the signal without digital smoothing, and the lower pane shows the signal with digital smoothing.

Compression by *n*

The MS5800 offers a real-time data compression scheme that can provide a reduction of file sizes and an increase of performance without loosing relevant signal information for a variety of applications. This data reduction factor is user-selectable and can be as high as 64:1.

In Figure 6-6, the data compression is set to 4. Every 4 samples of the initial waveform are replaced by one sample with the maximum amplitude found in the flour samples. The resulting sample interval is thus 4 times longer than the initial sample interval, but the maximum amplitude is preserved.

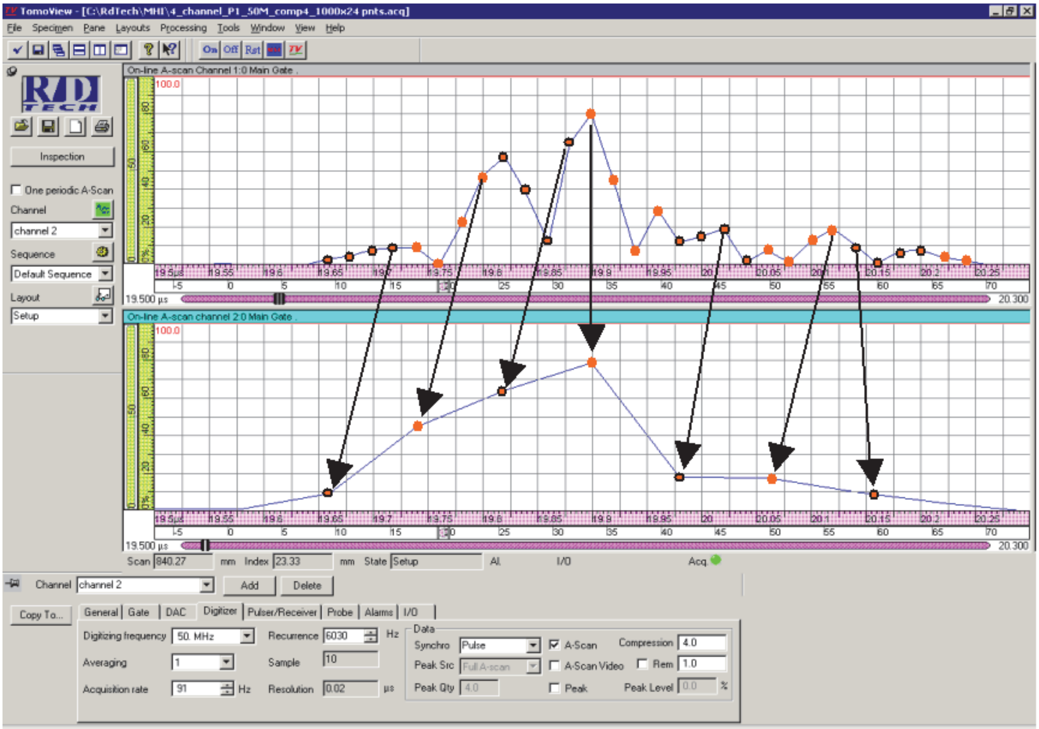


Figure 6-6 Example of data compression

The advantage of this technique is the reduction of the number of data points and thus the reduction of the number of data that has to be transferred to the PC system through the Ethernet link. Secondly it reduces the size of the acquisition file. This allows for the inspection of larger areas and improves the file handling time for analysis. Although the time resolution increases, the peak amplitude information is preserved.

This method can be applied to a rectified signal (unsigned) or to a non-rectified signal (signed). For a rectified signal, the technique consists in keeping a sample on *n* (the sample kept is the one with the maximum amplitude). For a non-rectified signal, two samples are kept on *n*. The samples kept are the one with the maximum positive amplitude and the one with maximum negative amplitude. If on *n* samples, no negative samples are found, then simply keep two times the maximum positive sample. If on *n* samples, no positive samples are found, then simply keep two times the maximum negative sample. Keeping two samples on *n* on the non-rectified signal allows the user to keep the phase information on very compressed signal.

Figure 6-7 is an example of two channels with the same parameters, except that the bottom channel is compressed 8 times (in this real reduces the amount of data by 4). This example was done with the digitizing frequency of 100 MHz and a 5-MHz probe.

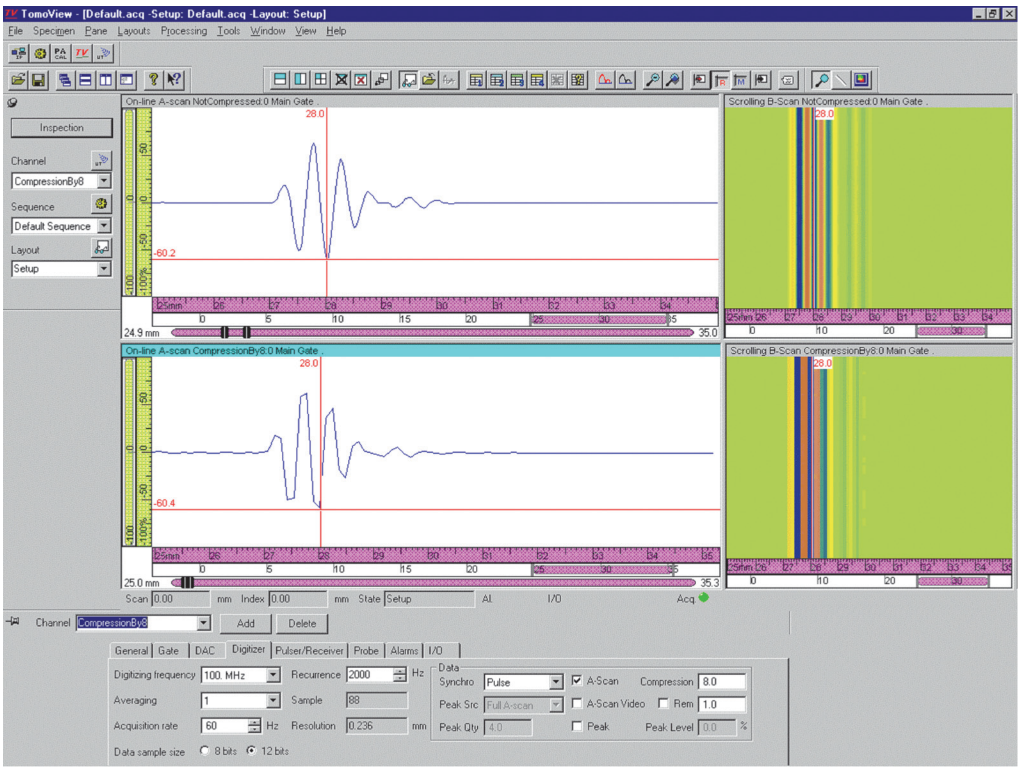


Figure 6-7 Example made with 100 MHz digitizing frequency and 5-MHz probe

6.2.3 Acquisition Rate Information

The following is some useful information about the acquisition rate of the MS5800.

Acquisition rate

In the embedded software of the MS5800, a cycle is the set of logical channels, or contexts, defined for an acquisition board. For each pace, the MS5800 fires each channel. The time required to determine the acquisition rate is as follows:

$$\text{Acquisition rate} = \frac{1}{\text{Sum of the context length}}$$

Context length

A context length is the necessary time to fire one channel. It is defined with the following formula:

$$\text{Context length} = \frac{1}{Recurrence} = [\text{Averaging quantity} \times (Ta + Td + Tt + Tu)] + Tf$$

Definition:

Ta	Acquisition time. This time is equal to 0 for digitizing frequencies 50 MHz and 100 MHz. In fact, this time is included in the processing time.
Td	Delay before acquisition. For the digitizing frequencies of 100 MHz, the formula uses double of the programmed delay. This is due to the support of the pretrigger function and to the process inside the FPGA that is done at 50 MHz (20 ns).
Tt	Processing time. This time is expressed as the quantity of samples´ 20 ns. The sample quantity is chosen according to the length of the acquisition and to the digitizing frequency.
Tu	Each context has its specific parameters (example: digitizing frequency, acquisition length, etc.). After the acquisition on a context is done, the hardware updates the parameters for the following context; this update time is equal to 8 µs.
Tf	For most configurations, this time is equal to 0. However, if the DMA does not have enough time to take the data out of the FIFOs, then time has to be added. The DMA needs 185 ns per byte, and there is a maximum transfer rate of 5.5 MB/s.

Example:

- Delay before acquisition = 5 µs

- Acquisition time = 20 μs (2000 samples with 100 MHz; 1000 samples with 50 MHz; 500 samples with 25 MHz)
- Averaging = 4

Table 6 Example of context length calculation

Digitizing frequency	Average quantity	*Ta*	*Td*	*Tt*	*Tu*	*Tf*	Context length	Recurrence
25 MHz	4	20 μs	5 μs	500 × 20 ns	8 μs	0	172 μs	5814 Hz
50 MHz	4	0	5 μs	1000 × 20 ns	8 μs	0	132 μs	7575 Hz
100 MHz	4	0	2 × 5 μs	2000 × 20 ns	8 μs	0	232 μs	4310 Hz

NOTE

As this formula shows, to obtain maximum speed performances, it is better to use a digitizing frequency of 50 MHz even if it means compressing the data by n afterward.

The embedded software of the MS5800 calculates the context length. The formula shown earlier indicates the minimum time, but the user can increase this period (for example, in order to avoid phantom echoes). When there are many contexts, the next context is not fired as long as the time of the previous context has not expired.

In MultiView software, the context length is indicated in the **Recurrence** text box. (Context length = 1/recurrence)

6.3 Input and Output Data

A cycle of data is produced after a pace signal. The pace signal can be produced:

- On the internal clock (timer)
- On encoder
- On the external clock (In this case, the signal comes from the pace pin of the DIGITAL I/O connector.)

However, the pace signal comes from only one source at a time. When the pace signal is produced on encoder or on the external clock, a pace limiter is applied. In MultiView software, this limiter is programmed from the acquisition rate text box. This means that if an acquisition rate of 100 Hz is requested, the MS5800 limits the quantity of pace signal to 100 Hz.

With each pace signal, the system reads the active input (encoders, alarms, etc.), updates the outputs (analog output, etc.), and produces all the contexts.

7. Theory of Operation: Encoder Inputs

The encoder inputs record position data from the robotics system and synchronizes data sampling according to probe position. The MultiScan MS5800 unit acquires and processes position encoder data by using up to two counter channels and one index channel.

Digital Position Encoders

The digital position encoders usually provide two signals, that could be phase quadrature signals or clock and direction signals. These signals are passed through digital low-pass filters to attenuate noise (essentially caused by contact rebound of robotics relays). The filter cutoff frequency, which is user-adjustable, must be equal or higher than the maximum encoder signal frequency. For example, if the maximum rotation speed of a motor is 1 revolution/s and its position encoder has a resolution of 1 pulse/0.5°, the signal generated will have a maximum frequency of 720 Hz. In this case, a cutoff frequency equal to or higher than 2 kHz would be a reasonable choice. The filtered signals are sent to a state detector, or to two 32-bit counters configurable into quadrature counters, or into “CLK-DIR” counters.

Quadrature counter

This type of counter is used with position encoders producing two phase-quadrature signals, often called ϕA and ϕB signals. The quadrature counter is clocked by each transition of ϕA and ϕB signals, and the counting direction depends on the phase relationship of these signals, as shown in Figure 7-1. The counter counts up when ϕA leads ϕB; it counts down when ϕA lags ϕB. Counter output data is stored into memory in a 32-bit format.

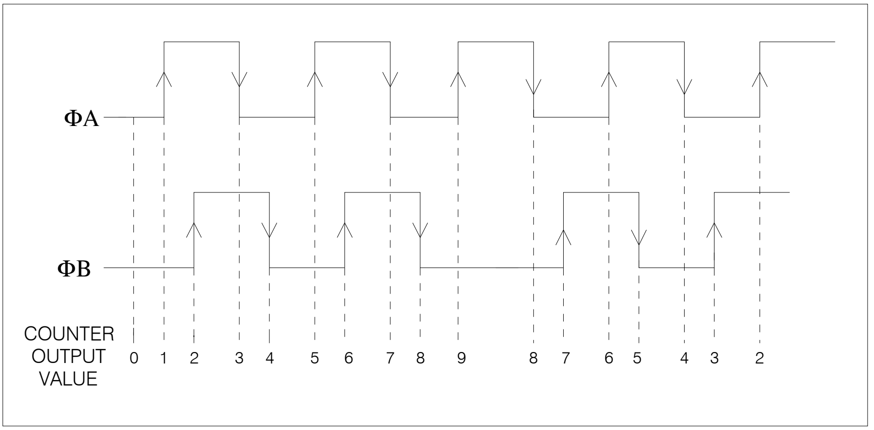


Figure 7-1 Quadrature-counter timing diagram

CLK-DIR counter

This type of counter is used with position encoders providing clock and direction signals, or clock signal only. The counter is clocked by each positive transition of the clock signal. The counting direction is controlled by the logic level of the direction signal, as shown in Figure 7-2. When this signal logic level is low, the counter counts up. When the logic level is high, the counter counts down. If the encoder provides a clock signal only, the counting direction may be software controlled through the setup dialog box. In this case, the counter may be configured into a CLK/UP or a CLK/DOWN counter. The counter output data is stored in memory with a 32-bit format.

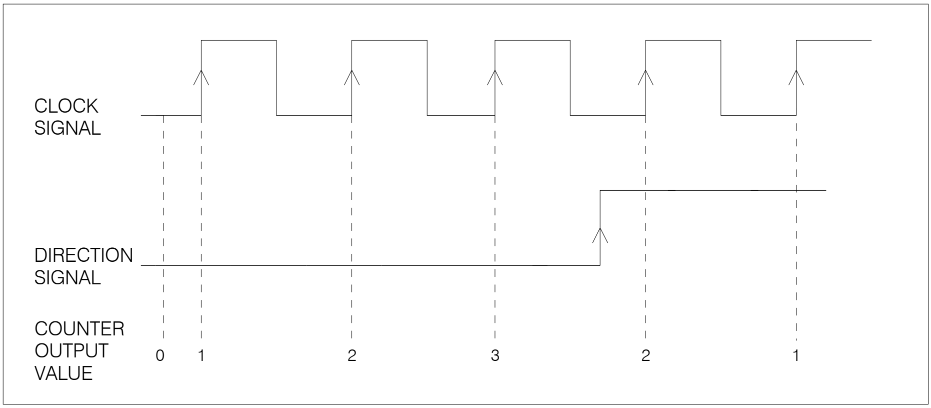


Figure 7-2 CLK-DIR counter timing diagram

8. Maintenance and Troubleshooting

This chapter deals with the basic maintenance that an operator can apply to the MultiScan MS5800 unit. The maintenance operations explained below allow you to keep the instrument in good physical and working conditions. Due to its design, the MS5800 requires only a minimum of maintenance. The chapter covers the following four topics: preventive maintenance, instrument cleaning, maintenance of the fan filters, and troubleshooting for common problems.

8.1 Preventive Maintenance

As the MS5800 has no moving parts, it does not require preventive maintenance. Only a regular inspection of the instrument is recommended to make sure that the MS5800 has a good grounding. To do this, verify that the MS5800 is completely inserted into the housing and the front panel screws are properly tightened.

WARNING

The instrument must always be used with its housing. The MS5800 must be completely inserted into the housing and the front panel screws properly tightened in order to ensure a good grounding of the instrument. A bad grounding of the instrument may produce a short circuit that can damage the electronic components or cause electric shocks.

8.2 Instrument Cleaning

The MS5800 external surfaces, that is, the casing and the front panel, can be cleaned when needed. This section provides the procedure for the appropriate cleaning of the instrument.

To clean the instrument

1. MAKE SURE THE INSTRUMENT IS TURNED OFF AND THE POWER CORD IS DISCONNECTED.
2. To bring the instrument back to its original finish, clean the casing and the front panel with a soft cloth.

WARNING

Do not clean the instrument with a water jet, spray can, or spray bottle. Liquid could seep in and damage the instrument, or the connector contacts could stay wet and produce a short circuit when plugging cables.

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3. To get rid of persistent stains, use a damp cloth with a soft soapy solution. Do not use abrasive products or powerful solvents that might damage the finish.
4. Wait until the instrument dries completely before plugging in the power cord and cables.

8.3 Maintenance of the Fan Filter

The MS5800 is equipped with an air inlet located on the lower part of the case (see Figure 8-1) and two air outlets located on both sides of the assembly (see Figure 2-2 on page 24). A grill plate protects the vent inlet, while two partial covers protect the vent outlet. A filter, located under the grill plate outside the case, filters the air drawn in by the internal fan. To allow a good airflow, this filter must be cleaned or changed periodically, according to your MS5800 utilization and the quality of ambient air. If you have to clean or change the filter, use the procedures that follow.

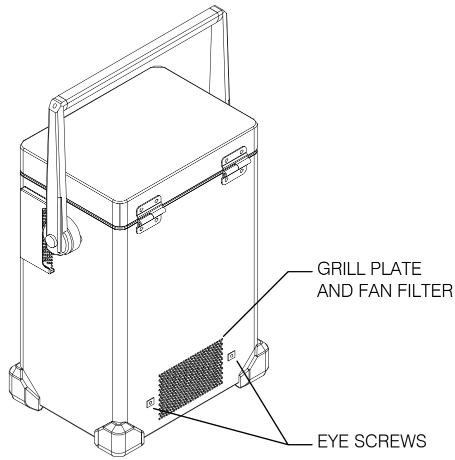

Figure 8-1 Fan filter location

To clean the fan filter

1. Place the MS5800 in its vertical position, that is, front panel facing upward.
2. Unscrew the two eye screws that hold the grill plate to the case (see Figure 8-1).
3. Take off the grill plate to access the fan filter, which is just underneath.
4. Remove the filter from its slot.
5. Using a compressed-air jet, clean the filter on both sides.
6. Put the filter back in the appropriate position.
7. Put the grill plate back on the filter. If needed, change the gasket seal that makes a tight joint between the grill plate and the casing.
8. Screw back the two eye screws that hold the grill plate to the case.

To change the fan filter

1. Place the MS5800 in its vertical position, that is, front panel facing upward.
2. Unscrew the two eye screws that hold the grill plate to the case (see Figure 8-1).
3. Take off the grill plate to access the fan filter, which is just underneath.
4. Remove the filter from its slot.
5. Put a new filter in place (Olympus part number: 26AB0023).

6. Put the grill plate back on the filter. If needed, change the gasket seal that makes a tight joint between the grill plate and the casing.
7. Screw back the two eye screws that hold the grill plate to the case.

CAUTION

The MS5800 must be properly ventilated so as to prevent overheating and ensure an appropriate operation. Make sure to use the instrument in a well-ventilated area while avoiding to obstruct the air inlet located on the lower part of the case as well as the air outlets located on both sides of the case.

8.4 Troubleshooting

This section will help you solve light problems that could occur during the operation of your MS5800. The troubleshooting guide (see Table 7) has been developed assuming that the instrument has not been modified and that the cables and connectors are those provided and documented by Olympus.

Table 7 Troubleshooting guide

Problem	Cause	Solution
The unit does not turn on.	The fuse is blown.	Check the fuse and replace it if applicable with a fuse of the correct rating. For the detailed procedure, see "Changing the Fuse" on page 93.
Communication problems occur between the PC and the MS5800.	The computer and the MS5800 are not connected with the proper type of Ethernet cable.	Make sure you use a crossover-link Ethernet cable for the connection.

8.5 Changing the Fuse

The fuse protects the MS5800 from external or internal power overload. If the unit does not turn on, check the fuse.

To change the fuse

1. MAKE SURE THAT THE MS5800 IS OFF AND THE POWER CORD IS DISCONNECTED.
2. Using a flat-head screwdriver, remove the module as shown in Figure 8-2.
3. Remove the fuse receptacle.

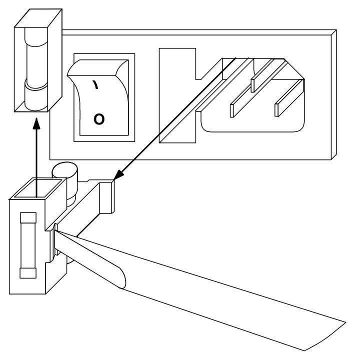

Figure 8-2 Changing the fuse in the MS5800

4. Replace the fuse with a fuse of the correct rating as shown below in Table 8.


WARNING

Use only 250 V slow-blow fuses that meet IEC 127 standards. Using fuses that are not recommended could cause an electric shock or fire hazard.

5. Put the receptacle back in place, and then insert the module.

   The fuse is now replaced and the MS5800 is ready for operation.

Refer to Table 8 to match the correct fuse with the power supply being used with the MS5800.

Table 8 Type of fuse to use according to power supply voltage

Power supply	Type of fuse	
100–240 V	250 V	2 A, slow-blow

9. Specifications

This chapter describes the MultiScan MS5800 specifications. It includes the specifications of the system and its options.

9.1 General Specifications

This section presents the MS5800 system general specifications.

System

Warm-up time	15 min
Workstation link	Ethernet 10/100Base-T
Transfer rate on Ethernet cable	10 Mbps or 100 Mbps (megabits per second), depending on the Ethernet board of the workstation

Power requirements

Voltage	100–240 VAC, ±10%
Frequency	48–63 Hz
Fuse	250 V, 2 A, slow-blow
Maximum input current	1.5 A

Environmental conditions

Operating temperature	5 °C to 45 °C
Storage temperature	–20 °C to 60 °C
Relative humidity	95%, no condensation

Safety	EN61010-1

Housing

Outline dimensions (H × W × D)	465 mm × 380 mm × 255 mm (18.3 in. × 15 in. × 10 in.) **Note:** The outline dimensions include the handle.
Net weight	12.8 kg (28.2 lb)
Protection	Static proof case

Ethernet cable

Type	Category 5, shielded
Maximum length	100 m (328 ft)

9.2 Encoder Specifications

This section presents the MS5800 encoder-related specifications, which include the encoder as such, the auxiliary input, and the auxiliary output.

9.2.1 Encoders

Number of encoder axes	2
Encoder type	Quadrature or Clk/Direction
Quadrature resolution	4 counts/cycle
Input type	TTL
Counter size	32 bits (from –2147483648 to +2147483648 counts)
Maximum frequency input	200 kHz
Immunity to noise	Programmable filter from 8 Hz to 250 kHz
Sample rate control	Programmable axis selection and resolution
Input protection	Over voltage protection and ±15 V continuous

9.2.2 Auxiliary Inputs

Type	Index, reset encoder, external clock, enable acquisition, and spare input
Index input	Used for C-scan index or rotation synchronization
Preset encoder	Used to preset encoder counter; programmable selection of preset counter
External clock	Used to control sample rate by external signal
Enable acquisition	Used to start/stop acquisition
Input type	TTL
Input protection	Overvoltage protection and ±15 V continuous

9.2.3 Auxiliary Outputs

Type	External clock, relay outputs, and spare output
External clock	Used to synchronize the sample rate of other equipment with the MS5800
Relay outputs	Defined by the synchronization mode
Spare outputs	Defined by the synchronization mode

9.3 Alarms

This section contains the specifications for the MS5800 alarms.

Type of data	Eddy current, remote field, magnetic flux leakage, or ultrasound raw data
Setting of alarms	Programmable
Maximum response time	Smaller than the sampling period
Number of alarm outputs	8 for electromagnetic techniques 3 for ultrasound techniques
Output type	Open collector

9.4 Electromagnetic Board Options

This section presents the specifications of the MS5800 electromagnetic board options. These options consist of eddy current (ECT), remote field (RFT), and magnetic flux leakage (MFL).

9.4.1 Eddy Current Option (ECT)

This section presents the MS5800 eddy current option specifications.

Coil drive signals

Number of coil drivers	2 independent
Level range	0 V to 20 V p-p
Frequency range	1 kHz to 6 MHz
Output impedance	<0.5 W at 600 kHz, limited current
Output load	>10 W or 10 W maximum
Output amplifier protection	Protected against short-circuits
Output drive	1 A peak

Acquisition channels

Acquisition modes	Non-multiplexed mode: monofrequency or multifrequency Super-multiplexed mode: monofrequency or multifrequency
Non-multiplexed mode	16 channels maximum (4 inputs × 4 frequencies)
Multiplexed mode	256 high-frequency channels maximum (4 inputs × 4 frequencies × 16 time slots)
Gain	
Range	32 dB to 62 dB, 1 dB resolution
Time stability	0.1%/h
Temperature coefficient	1%/°C
Accuracy	±2%

Bandwidth	
Non-multiplexed mode	Programmable from 8 Hz to 5 kHz
Multiplexed excitation mode	Inversely proportional to the time slot duration; set by the instrument
Linearity	
Amplitude	±1% over frequency range
Phase	±1° over frequency range
A/D converter	16-bit resolution
Digital filters (all modes)	Programmable low-pass, high-pass, and spatial filters
Acquisition triggering	Internal clock, external clock, or on encoders
Acquisition rate	1 Hz to 40 kHz, programmable. The rate can be limited by the instrument processing capabilities or the delays set by the multiplexed excitation mode.

9.4.2 Remote Field Option (RFT)

This section presents the MS5800 remote field option specifications.

Coil drive signals

Number of coil drivers	2 independent
Level range	0 V to 20 V p-p
Frequency range	20 Hz to 250 kHz
Output impedance	<0.5 W at 600 kHz, limited current
Output load	>10 W or 5 W maximum
Output amplifier protection	Protected against short-circuits
Output drive	1 A peak

Acquisition channels

Acquisition modes	Non-multiplexed mode: monofrequency or multifrequency Super-multiplexed mode: monofrequency or multifrequency

Non-multiplexed mode	16 channels maximum (4 inputs × 4 frequencies)
Multiplexed mode	64 channels maximum (4 inputs × 4 frequencies × 4 time slots) This mode is available only for frequency higher than 500 Hz and a limited acquisition rate.
Gain	
Range	56 dB to 86 dB, 1-dB resolution
Time stability	0.1%/h
Temperature coefficient	1%/°C
Accuracy	±2%
Bandwidth	
Non-multiplexed mode	Programmable from 8 Hz to 5 kHz
Multiplexed excitation mode	Inversely proportional to the time slot duration; set by the instrument
Linearity	
Amplitude	±1% over frequency range
Phase	±1° over frequency range
A/D converter	16-bit resolution
Digital filters (all modes)	Programmable low-pass, high-pass, and spatial filters
Acquisition triggering	Internal clock, external clock, or on encoders
Acquisition rate	1 Hz to 40 kHz, programmable. The rate can be limited by the instrument processing capabilities or the delays set by the multiplexed excitation mode.

9.4.3 Magnetic Flux Leakage Option (MFL)

This section presents the MS5800 magnetic flux leakage option specifications.

Acquisition channels

Acquisition modes	Non-multiplexed mode: monofrequency Super-multiplexed mode: monofrequency

Non-multiplexed mode	4 channels maximum (4 inputs × 1 frequency)
Multiplexed mode	64 channels maximum (4 inputs × 16 time slots)
Gain	
Range	12 dB to 52 dB, 1 dB resolution
Time stability	0.1%/h
Temperature coefficient	1%/°C
Accuracy	±2%
Bandwidth	
Non-multiplexed mode	Programmable from 8 Hz to 5 kHz
Multiplexed excitation mode	Inversely proportional to the time slot duration; set by the instrument
Linearity	
Amplitude	±1% over frequency range
Phase	±1° over frequency range
A/D converter	16-bit resolution
Digital filters (all modes)	Programmable low-pass, high-pass, and spatial filters
Acquisition triggering	Internal clock, external clock, or on encoders
Acquisition rate	1 Hz to 40 kHz, programmable. The rate can be limited by the instrument processing capabilities or the delays set by the multiplexed excitation mode.

9.5 Ultrasound Option (UT)

This section presents the MS5800 UT option specifications, which include the pulser, the receiver, the digitizer, the data type, the DAC, and the signal-to-noise ratio (SNR).

Pulser

Number of pulsers	8 independent pulsers
Impulse width	25 ns to 500 ns; accuracy depending on the lowest value between 5 ns or 10%

Voltage	Unipolar, adjustable from 1 volt to 300 volts, by 1-volt steps
Active damping	50 W
Output impedance	<10 W (typical 4–5 W)
Acquisition triggering	Internal clock, external clock, or on encoders
Repetition frequency	>25 kHz (1.4 kHz maximum with a 500-ns pulse at 300 V)

Receiver

Bandwidth	0.5 MHz to 24 MHz ±10%
High-pass filter	None, 1, 2, 5, 10 MHz ±15%
Low-pass filter	None, 2, 5, 10, 20 MHz ±15%
Maximum input voltage	2 V p-p on the receiver connector, 2 dB less on the pulser connector
Input impedance	50 W
Gain	Linear (LIN): 0 dB to 70 dB, 0.1-dB steps Logarithmic (LOG): 0 dB Logarithmic with DAC curve (LOGDAC): 0 dB to 29 dB, 0.1-dB steps
Input booster	25 dB
Input noise	<–83 dBm (16 μV_{RMS}/50 W)
Rectification	Unipolar+, unipolar–, bipolar

Digitizer

Digitizing rate	3.125, 6.25, 12.5, 25, 50, 100 MHz
Digitizing resolution	8 bits (12 bits optional)
A-scan length	20 to 16 328 samples
Acquisition delay	0 ms to 2.6 ms
Acquisition mode	Internal clock (free running), encoder position, external signal
Synchronization	Pulse, surface echo, external trigger
Real-time averaging	1, 4, 8, and 16
A-scan recording	9600 A-scans/s (512 samples of 8 bits) or 4800 A-scans/s (512 samples of 12 bits)

A-scan peak data	25000 peaks per second
C-scan data	25 kHz (four gates)
Data transfer	4800 12-bit A-scans per second or 9600 8-bit A-scans per second

Data type

A-scan	RF, rectified, rectified video
Multipeak data	Maximum of 127 peaks per waveform
C-scan type	4 gates (amplitude and time of flight for maximum and crossing C-scan), and a synchronization gate (time of flight of the echo)

DAC

Dynamic range	Maximum 70 dB with 0 dB of gain, ±0.1 dB
Exploitable range	70 dB for SNR >20 dB, with 0 dB gain setting
Maximum slope	20 dB/μs
Resolution	0.1 dB
Trigger	Pulser, echo

Signal-to-noise ratio (full scale)

Linear (LIN)	48 dB p-p (54 dB RMS)
Logarithmic (LOG)	68 dB p-p (74 dB RMS), 63 dB p-p with booster enabled (69 dB RMS)
Logarithmic with DAC curve (LOGDAC)	60 dB p-p (66 dB RMS)

NOTE

The peak noise is measured on a time lapse of 20 s on the produced A-scan view, the gain being set at 0 dB. The given RMS value is the obtained peak value increased by 6 dB.

10. Technical References

This chapter presents the technical description of the MultiScan MS5800 front panel connectors. It provides information regarding general connectors, as well as information pertaining to the connectors of the eddy current option, remote field and magnetic flux leakage option, ultrasound option, to the digital inputs and outputs, and to the alarm option. For each connector, you will find the following information: a brief description; the manufacturer number; the number of the corresponding cable connector; an illustration; and a table giving the specifications or the signal pinout for the connector. The chapter contains the following sections:

- General Connectors
- Connectors Specific to the Electromagnetic-Acquisition Board
- Connectors Specific to the UT Board

10.1 General Connectors

This section contains a description of the general connectors, their parameters as well as their specifications.

- ETHERNET 1 and ETHERNET 2 Connectors
- I/O Connector
- ALARM Connector

10.1.1 ETHERNET 1 and ETHERNET 2 Connectors

The ETHERNET 1 and ETHERNET 2 connectors are used to connect the MS5800 to the computer via an Ethernet or Fast Ethernet link.

Description	RJ45, female connector
Manufacturer, number	Stewart Connector, SS-65810SAFLS Olympus, 21AI0080
Suggested cable connector	Stewart Connector, 940SP-360808 Olympus, 21AI0079

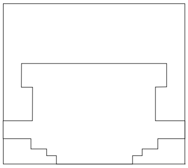

Figure 10-1 The ETHERNET connector

Table 9 Pinout for the ETHERNET 1 and ETHERNET 2 connectors

Pin	I/O	Signal	Description
1	Output	TX+	Data transmission
2	Output	TX–	Data transmission
3	Input	RX+	Data reception
4	–	NC	No connection
5	–	NC	No connection
6	Input	RX–	Data reception
7	–	NC	No connection
8	–	NC	No connection

The MS5800 must be linked to the computer with a category 5, shielded, twisted pairs Ethernet cable. The same cable can be used for 10Base-T or 100Base-T speeds; however, the maximum cable length depends on the link speed (see Table 10).

Table 10 Ethernet cable parameters and specifications

Parameters	Specifications
Description	Crossover-link Ethernet cable
Olympus number	EWTX525A
Cable types:	
EIA/TIA, category 5, shielded	150 Ω
Maximum cable length	
10Base-T	185 m (607 feet)
100Base-T	100 m (328 feet)

Precautions to be taken with the Ethernet cable

To ensure the proper functioning of the Ethernet cable, you must keep the twisted pairs to a maximum of 12.7 mm (0.5 in.) from the connector's end (see Figure 10-2).

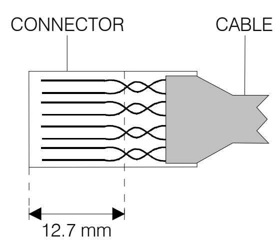

Figure 10-2 The twisted pairs in an Ethernet cable

10.1.2 I/O Connector

The MS5800 I/O connector allows the instrument to send and receive various signals, such as acquisition start and stop commands, encoder and rotation synchronization signals, relay outputs, etc.

NOTE

The spare input and output signals are available only if the MS5800 is equipped with an electromagnetic option (ECT or RFT/MFL).

Description	18-pin, female, shell 14 connector
Manufacturer, number	ITT Cannon, KPT02A14-18S Olympus, 21AN0005
Suggested cable connector	ITT Cannon, KPT06B14-18P Olympus, 21AN0011

Table 11 I/O connector parameters and specifications

Parameters	Specifications
All inputs	
Detection levels	TTL, (V_{IH} = +2 V, V_{IL} = +0.8 V)
Relay output 1, 2, and 3	Standard
Relay contacts	
Maximum commutation voltage	220 V p-p, 250 V
Maximum commutation power	60 W, 125 VA
Maximum commutation current	1 A
Maximum admissible current	3 A
Acquisition clock output	Digital, open collector
Maximum voltage	40 V
Maximum current	100 mA

Table 11 I/O connector parameters and specifications *(continued)*

Parameters	Specifications
+5 V supply voltage	Polyswitch 0.9 A
Encoder inputs Maximum voltage Maximum frequency	 +24 V 250 kHz

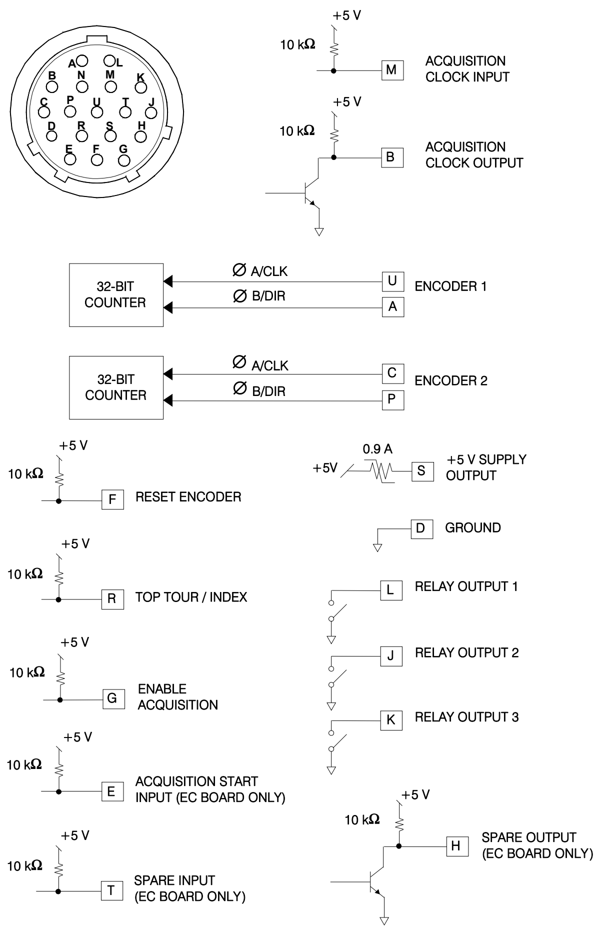

Figure 10-3 The I/O connector

Table 12 Pinout for the I/O connector

Pin	I/O	Signal	Description
A	Input	Encoder 1	Receives the signal from the first position encoder.
B	Output	Acquisition clock output	Sends the acquisition clock signal generated internally.
C	Input	Encoder 2	Receives the signal from the second position encoder.
D	–	GND	Power supply common of the instrument and casing
E	Input	Acquisition start	Input controlling the acquisition start defined by synchronization mode (on ECT board only)
F	Input	Reset encoders	Input controlling the encoder reset
G	Input	Enable acquisition	Input that enables or disables the acquisition (a low-level signal disables the acquisition)
H	Output	Spare output	Signal output defined by synchronization mode (on ECT board only)
J	Output	Relay output 2	Relay output defined by synchronization mode
K	Output	Relay output 3	Relay output defined by synchronization mode
L	Output	Relay output 1	Relay output defined by synchronization mode
M	Input	External acquisition clock	Receives an encoder signal to generate the acquisition clock, if the **acquisition clock** is **external clock**.
N	–	NC	No connection

Table 12 Pinout for the I/O connector *(continued)*

Pin	I/O	Signal	Description
P	Input	Encoder 2	Receives signals from second position encoder.
R	Input	Top tour / Index	Receives the top-tour (or index) signal to increment a scan axis on each pulse (low-level).
S	–	+5 V supply output	+5 V supply voltage, with a 0.9 A polyswitch limitation
T	Input	Spare input	Signal input defined by synchronization mode
U	Input	Encoder 1	Receives signals from first position encoder.

Table 13 Connection of encoders to I/O connector

Pin	Encoder type		
	Clock-up / clock down	Clock/Direction	Quadrature
U	Encoder 1	Encoder 1, clock	Encoder 1, ϕA
A	–	Encoder 1, direction	Encoder 1, ϕB
C	Encoder 2	Encoder 2, clock	Encoder 2, ϕA
P	–	Encoder 2, direction	Encoder 2, ϕB

10.1.3 ALARM Connector

The MS5800 ALARM connector is used only to send alarm signals. This connector does not provide a power supply voltage, it provides only the common that is used as a reference.

Description	DB-9, female connector
Manufacturer, number	ITT Cannon, DE-9S Olympus, 21AE0014
Suggested cable connector	ITT Cannon, DE-9P Olympus, 21AE0015

Table 14 ALARM connector parameters and specifications

Parameters	Specifications
Analog outputs	
Maximum output voltage	100 V
Maximum current	0.04 A

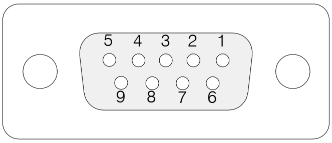

Figure 10-4 The ALARM connector

Table 15 Pinout for the ALARM connector

Pin	Signal	Description
1 to 4	Alarm outputs 1 to 4	Alarm condition detected = Open collector
5	Ground	Power supply common of the instrument and casing
6 to 9	Alarm outputs 5 to 8	Alarm condition detected = Open collector

NOTE

For the ultrasound option, only outputs 1 to 3 are available for the alarms.

10.2 Connectors Specific to the Electromagnetic-Acquisition Board

This section contains a description of the connectors specific to the MS5800 Electromagnetic-Acquisition board, their parameters, and their specifications. The MS5800 is equipped with an ECT board only if it has the Eddy Current (ECT) option or the Remote Field (RFT) and Magnetic Flux Leakage (MFL) option.

- ANALOG X1 and ANALOG X2 Connectors
- Connectors Specific to the ECT Option
- Connectors Specific to the RFT and MFL Option

10.2.1 ANALOG X1 and ANALOG Y1 Connectors

The ANALOG X1 and ANALOG Y1 connectors provide demodulated signals of the horizontal (X) and vertical (Y) components of an ECT board channel. The channel can be assigned by MultiView, and can come from the ECT, RFT, or MFL options. The signals provided by the ANALOG X1 and ANALOG Y1 connectors can be used to feed a strip char recorder or an “X-Y” table.

Description	BNC, female connectors
Manufacturer, number	Kings Connectors, KC-19-152 Olympus, 21AJ0030
Suggested cable connector	Amphenol, 31-320 Olympus, 21AJ0005

Table 16 ANALOG X1 and ANALOG Y1 connector parameters and specifications

Parameters	Specifications
Analog outputs	
Maximum output voltage	20 V p-p
Maximum current	0.04 A

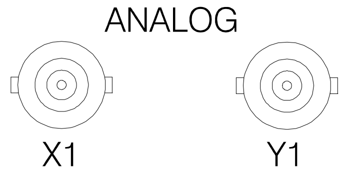

Figure 10-5 The ANALOG X1 and ANALOG Y1 connectors

Table 17 Pinout for the ANALOG X1 and ANALOG Y1 connectors

Connector	Contact	Signal	Description
ANALOG X1	Center	X analog output	Analog output, horizontal component
	Shell	Ground	Power supply common of the instrument and casing
ANALOG Y1	Center	Y analog output	Analog output, vertical component
	Shell	Ground	Power supply common of the instrument and casing

10.2.2 Connectors Specific to the ECT Option

This section contains a description of the connectors specific to the MS5800 ECT option, their parameters, and their specifications.

- ECT EXTENDED Connector
- ECT MAIN Connector
- ECT REF Connector

10.2.2.1 ECT EXTENDED Connector

The MS5800 ECT EXTENDED connector is used to connect the eddy current (ECT) probes. The signals contained in the ECT EXTENDED connector are the EC generator outputs, the eddy current channel amplifier inputs, the multiplexing outputs, and a DC power supply.

Description	41-pin, female, shell 20 connector
Manufacturer, number	ITT Cannon, MS3470L20-41S Olympus, 21AN0023
Suggested cable connector	ITT Cannon, KPT06B20-41P Olympus, 21AN0052

Table 18 ECT EXTENDED connector parameters and specifications

Parameters	Specifications
Coil drive outputs	
Maximum output voltage	20 V p-p
Output impedance	0.5 Ω at 600 kHz
Output load	>10 Ω
Output amplifiers protection	Protected against short-circuits
Output drive	1 A peak

Table 18 ECT EXTENDED **connector parameters and specifications *(continued)***

Parameters	Specifications
Input amplifiers (in differential mode)	
Input impedance	11 kΩ
Maximum input voltage	450 mV p-p/coil drive frequency
Maximum differential input voltage	250 mV p-p/coil drive frequency
Maximum input voltage that must not be exceeded to make the balance possible	200 mV p-p/coil drive frequency
Spare analog output	
Maximum voltage	±10 V
Maximum current	5 mA at 10 V
±15 V output	Polyswitch 1.6 A

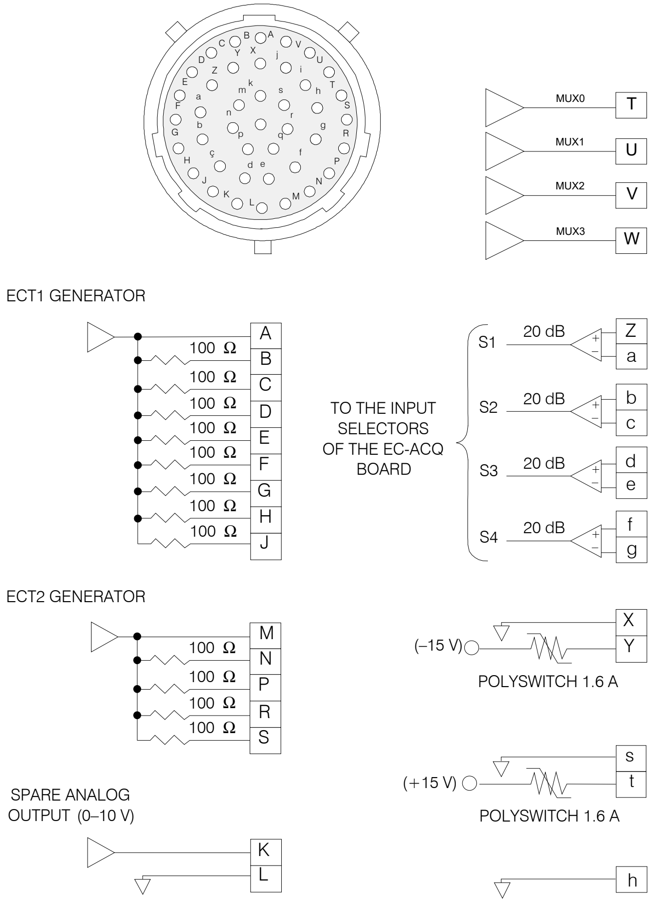

Figure 10-6 The ECT EXTENDED connector

Table 19 Pinout for the ECT EXTENDED connector

Pin	I/O	Signal	Description
A	Output	ECT1 generator	ECT1 eddy-current generator output
B, C, D, E, F, G, H, J	Outputs	ECT1 Generator / 100 Ω	ECT1 eddy-current generator outputs through 100 Ω
K	Output	Spare analog output	Spare analog output adjustable for saturation coil
L	–	Ground	Power supply common of the instrument and casing
M	Output	ECT2 generator	ECT2 eddy-current generator output
N, P, R, S	Outputs	ECT2 Generator / 100 Ω	ECT2 eddy-current generator outputs through 100 Ω
T	Output	MUX 0	Multiplexing signal output (bit 0)
U	Output	MUX 1	Multiplexing signal output (bit 1)
V	Output	MUX 2	Multiplexing signal output (bit 2)
W	Output	MUX 3	Multiplexing signal output (bit 3)
X	–	Ground	Power supply common of the instrument and casing
Y	Output	+15 V supply	+15 V supply voltage, with a 1.6 A polyswitch limitation
Z	Input	S1 + input	S1 input amplifier positive input
a	Input	S1 – input	S1 input amplifier negative input
b	Input	S2 + input	S2 input amplifier positive input
c	Input	S2 – input	S2 input amplifier negative input
d	Input	S3 + input	S3 input amplifier positive input
e	Input	S3 – input	S3 input amplifier negative input

Table 19 Pinout for the ECT EXTENDED connector *(continued)*

Pin	I/O	Signal	Description
f	Input	S4 + input	S4 input amplifier positive input
g	Input	S4 – input	S4 input amplifier negative input
h	–	Ground	Power supply common of the instrument and casing
i, j, k, m, n, p, q, r, s	–	NC	No connection
t	Output	–15 V supply	–15 V supply voltage, with a 1.6 A polyswitch limitation

10.2.2.2 ECT MAIN Connector

Many eddy current probes have a 4-pin connector. These probes can be connected directly onto the MS5800 front panel. The ECT MAIN connector is used to connect the inspection probe.

Description	4-pin, female, shell 14 connector
Manufacturer, number	Amphenol, 97-3102A-14S-2S Olympus, 21AC0020
Suggested cable connector	Amphenol, 97-3106A-14S-2P Olympus, 21AC0092

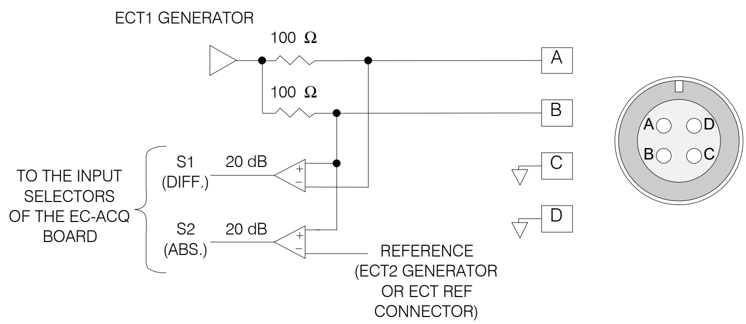

Figure 10-7 The ECT MAIN connector

Table 20 Pinout for the ECT MAIN connector

Pin	I/O	Signal	Description
A	Input	Coil 1	—Drive signals generated by Generator 1 of the EC-Generator board through 100 Ω. —Input signal (from impedance-bridge probe) for differential measure on S1 input amplifier of ECT board.

Table 20 Pinout for the ECT MAIN connector *(continued)*

Pin	I/O	Signal	Description
B	Input	Coil 2	—Drive signals generated by Generator 1 of the EC-Generator board through 100 Ω. —Input signal (from impedance-bridge probe) for differential measure on S1 and absolute measure on S2 input amplifier of ECT board.
C	–	Ground	Power supply common of the instrument and casing
D	–	Ground	Power supply common of the instrument and casing

10.2.2.3 ECT REF Connector

The ECT REF connector is used to connect the reference probe with a 4-pin connector.

Description	4-pin, female, shell 14 connector
Manufacturer, number	Amphenol, 97-3102A-14S-2S Olympus, 21AC0020
Suggested cable connector	Amphenol, 97-3106A-14S-2P Olympus, 21AC0092

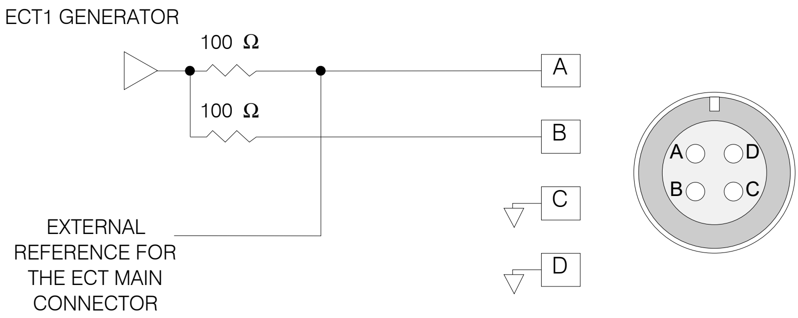

Figure 10-8 The ECT REF connector

Table 21 Pinout for the ECT REF connector

Pin	I/O	Signal	Description
A	Input	Coil 1	—Drive signals generated by Generator 1 of the EC-Generator board through 100 Ω. —Input signal (from impedance-bridge probe) for differential measure on S2 input amplifier of ECT board.
B	Input	Coil 2	—Drive signals generated by Generator 1 of the EC-Generator board through 100 Ω.
C	–	Ground	Power supply common of the instrument and casing

Table 21 Pinout for the ECT REF connector *(continued)*

Pin	I/O	Signal	Description
D	–	Ground	Power supply common of the instrument and casing

10.2.3 Connectors Specific to the RFT and MFL Option

This section contains a description of the connectors specific to the MS5800 RFT and MFL option, their parameters, and specifications.

- RFT Connector
- MFL Connector
- MUX Connector

10.2.3.1 RFT Connector

The MS5800 RFT connector is used to connect the remote field (RFT) probes. The signals contained in the RFT connector are the RFT generator outputs, the RFT channel amplifier inputs, and a DC power supply.

Description	19-pin, female, shell 14 connector
Manufacturer, number	ITT Cannon, KPT02A14-19S Olympus, 21AN0008
Suggested cable connector	ITT Cannon, KPT06B14-19P Olympus, 21AN0012

Table 22 RFT connector parameters and specifications

Parameters	Specifications
Coil drivers	
Output impedance	<0.5 Ω to 5 Ω
Maximum output voltage	1 coil driver: 20 V p-p, 2 coil drivers: 40 V p-p
Maximum current	1 A peak
RF input amplifiers	
Input impedance	51 kΩ
Maximum input voltage	100 mV p-p (total for both frequencies)
±15 V supply	1.6 A limited by polyswitch

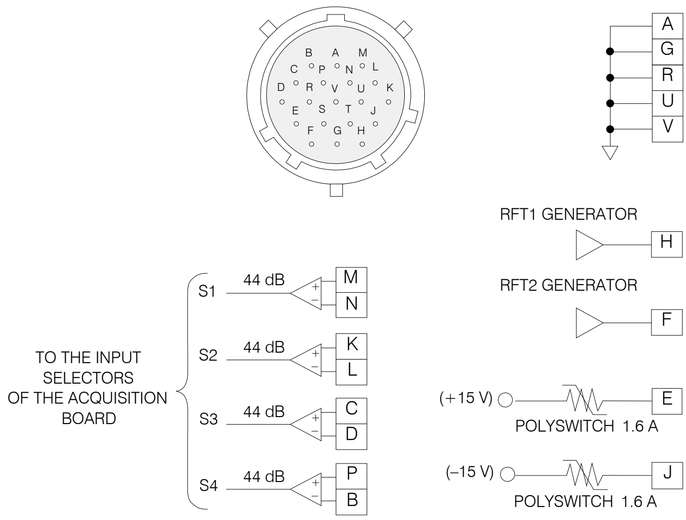

Figure 10-9 The RFT connector

Table 23 Pinout for the RFT connector

Pin	I/O	Signal	Description
A	–	Ground	Power supply common of the instrument and casing
B	Input	S4 – input	S4 input amplifier negative input
C	Input	S3 + input	S3 input amplifier positive input
D	Input	S3 – input	S3 input amplifier negative input
E		+15 V supply	+15 V supply voltage, with a 1.6 A polyswitch limitation
F	Output	RFT2 generator	RFT2 remote field generator output
G	–	Ground	Power supply common of the instrument and casing

Table 23 Pinout for the RFT connector *(continued)*

Pin	I/O	Signal	Description
H	Output	RFT1 generator	RFT1 remote field generator output
J		–15 V supply	–15 V supply voltage, with a 1.6 A polyswitch limitation
K	Input	S2 + input	S2 input amplifier positive input
L	Input	S2 – input	S2 input amplifier negative input
M	Input	S1 + input	S1 input amplifier positive input
N	Input	S1 – input	S1 input amplifier negative input
P	Input	S4 + input	S4 input amplifier positive input
R	–	Ground	Power supply common of the instrument and casing
U	–	Ground	Power supply common of the instrument and casing
V	–	Ground	Power supply common of the instrument and casing

10.2.3.2 MFL Connector

The MS5800 MFL connector is used to connect the magnetic flux leakage (MFL) probes. The signals contained in the MFL connector are the MFL channel amplifier inputs and a DC power supply.

Description	8-pin, female, shell 12 connector
Manufacturer, number	ITT Cannon, KPT02A12-8S Olympus, 21AN0067
Suggested cable connector	ITT Cannon, KPT06B12-8P Olympus, 21AN0071

Table 24 MFL connector parameters and specifications

Parameters	Specifications
MFL input amplifiers	
Input impedance	10 kΩ
Maximum input voltage	5 V p-p
±15 V supply	1.6 A limited by polyswitch

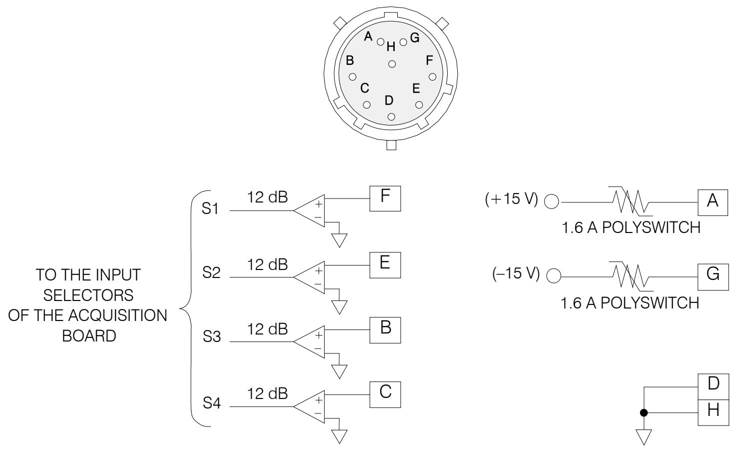

Figure 10-10 The MFL connector

Table 25 Pinout for the MFL connector

Pin	I/O	Signal	Description
A		+15 V supply	+15 V supply voltage, with a 1.6 A polyswitch limitation
B	Input	S3 + input	S3 input amplifier positive input
C	Input	S4 + input	S4 input amplifier positive input
D	–	Ground	Power supply common of the instrument and casing
E	Input	S2 + input	S2 input amplifier positive input
F	Input	S1 + input	S1 input amplifier positive input
G		–15 V supply	–15 V supply voltage, with a 1.6 A polyswitch limitation
H	–	Ground	Power supply common of the instrument and casing

10.2.3.3 MUX Connector

The MS5800 MUX connector is used to connect the remote field (RFT) and magnetic flux leakage (MFL) probes that require multiplexing signals. The signals contained in the MUX connector are the multiplexer outputs and a DC power supply.

Description	7-pin, female, shell 10 connector
Manufacturer, number	FCI Framatome Connectors, 851-02A10-7S50-A7 Olympus, 21AN0202
Suggested cable connector	FCI Framatome Connectors, 851-06EC10-7P50 Olympus, 21AN0203

Table 26 MUX connector parameters and specifications

Parameters	Specifications
Multiplexing outputs	
Output voltage	0 V to 5 V, TTL
Maximum current	0.04 V
±15 V supply	1.6 A limited by polyswitch

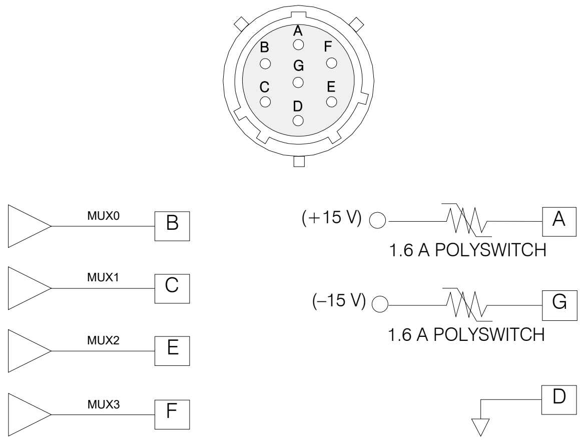

Figure 10-11 The MUX connector

Table 27 Pinout for the MUX connector

Pin	I/O	Signal	Description
A		+15 V supply	+15 V supply voltage, with a 1.6 A polyswitch limitation
B	Output	MUX 0	Multiplexing signal output (bit 0)
C	Output	MUX 1	Multiplexing signal output (bit 1)
D	–	Ground	Power supply common of the instrument and casing
E	Output	MUX 2	Multiplexing signal output (bit 2)
F	Output	MUX 3	Multiplexing signal output (bit 3)
G		–15 V supply	–15 V supply voltage, with a 1.6 A polyswitch limitation
H	–	Ground	Power supply common of the instrument and casing

10.3 Connectors Specific to the UT Board

This section contains a description of the connectors specific to the MS5800 UT board, their parameters, and their specifications. The MS5800 is equipped with an UT board only if it has the ultrasound (UT) option.

- P and R Connectors

10.3.1 P and R Connectors

Description	Female, BNC connector
Manufacturer, number	Kings Connectors, KC-19-152 Olympus, 21AJ0030
Suggested cable connector	Amphenol, 31-320 Olympus, 21AJ0005

Table 28 P and R connector parameters and specifications

Pulser output (P1 to P8)	
Output impedance	<10 Ω, typical 5 Ω
Output voltage	0 V to 300 V
Pulse width	25 ns to 500 ns
Maximum output power	2.5 W
Receiver input (R1 to R8)	
Input impedance (pulse/echo mode)	35 Ω
Input impedance (pitch-and-catch mode)	50 Ω
Maximum input signal	±1 V

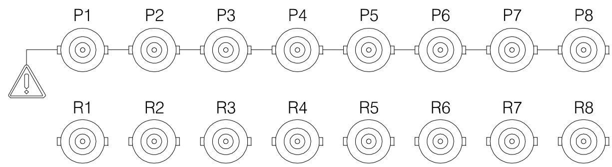

Figure 10-12 The P and R connectors

Table 29 Pinout for the P and R connectors

Connector	Contact	Signal	Description
P1 to P8	Center	Pulser outputs / receiver inputs	Ultrasound pulser outputs and/or ultrasound receiver inputs
	Shell	Ground	Power supply common of the instrument and casing
R1 to R8	Center	Receiver inputs	Ultrasound receiver inputs only
	Shell	Ground	Power supply common of the instrument and casing

11. Failure Messages

This chapter covers the different types of failure messages that can be sent by the MultiScan MS5800 unit to the computer and displayed by the MultiView software.

11.1 Introduction

The MS5800 is provided with a sophisticated failure detection system that detects circuit failures, as well as operator's incorrect manipulations. When a problem is detected, one or several failure messages are displayed by the computer (in MultiView software) to indicate the nature of the problem to the operator.

This chapter lists the MS5800 failure messages. A short procedure is given to the maintenance technician in order to correct the problem.

NOTE

Each time an MS5800 component must be replaced, specific instructions provided for the MS5800 maintenance must be followed. When a board is replaced, MultiView software must be restarted to initialize the board.

11.2 Format of the Failure Messages

The failure messages returned by the MS5800 are categorized according to their severity level. The following list describes the three different categories that are applied on fault to determine the fault severity.

- Warning: the message calls attention to an unexpected system condition.

- Error: the system may continue operation.
- Fatal error: the system must be restarted.

The message text may include a variable replaced on the screen by the number of a defective board, the number of the error detected, an illegal identification number, etc. These variables appears as ellipsis points (. . .) in the messages listed below.

11.3 Warning Messages

This section presents the warning messages that can be sent by the MS5800. Warning messages call attention to an unexpected system condition. The left column in the table lists the messages, and the right column indicates the action to be carried out for each message, if applicable.

Message	Action
The number of frequencies requested by the configuration . . . is higher than the maximum allowed. Quantity has been set to . . .	Verify and correct your configuration parameters.
The number of time slots requested by the configuration was 0. Quantity has been set to 1.	Verify and correct your configuration parameters.
The number of time slots requested by the configuration was too high. Quantity has been set to 16.	Verify and correct your configuration parameters.
At least one frequency is under the minimum value. Frequency has been set to . . . Hz.	Increase the frequency value.
At least one frequency is over the maximum value. Frequency has been set to . . . Hz.	Decrease the frequency value.
There are not enough acquisition boards in your system to meet the numbers of demodulators requested by your configuration. May fail if not all frequencies are demodulated.	Decrease number of demodulators in your configuration or add acquisition boards to your system.
With the current acquisition rate, the digitizing time is not long enough to have a good signal level and the signal/noise ratio is low (poor ratio).	Decrease the acquisition rate.

Message	Action
At least one frequency is not demodulated, the balance process may fail if not all frequencies are demodulated.	Make sure that every input (which demodulates frequency) uses every frequency generated by, at least, one generator for every time slot.
Selected channels are unavailable on mixed channel	Use a known channel.
Selected channels are unavailable on melted channel . . .	Use a known channel.
The channel selected for analog output is not available in the channel list.	Use a known channel.
Saturation occurs on the physical input . . . on the time slot channel list.	Decrease generator output voltage or input gain.
There is a harmonic problem with the selection of these 2 frequencies (. . . / . . .).	Increase difference between these frequencies
The requested channel for alarm is not available. It has been replaced automatically by the first valid one.	Use a known channel.
The quantity of defined melted channels for one board exceeds the board capacity. See melted . . ., board	Move melted channel to another board.

11.4 Error Messages

This section presents the error messages that can be sent by the MS5800. With error messages, the system may continue operation. The left column in the table lists the messages, and the right column indicates the action to be taken for each message, if applicable.

Message	Action
Transmission error happens on socket.	Application needs to reconnect socket.
Invalid state error.	
Invalid configuration has been downloaded to DSP. A new configuration must be downloaded.	Download a new configuration.
DSP overrun error.	
DSP internal timer error.	
DSP internal DMA error.	
Board . . . did not boot.	Report this problem to Olympus.
Your frequency selection needs a very long time for stabilization and for digitizing, time greater than MS5800 memory capacity. Reduce the number of time slots, reduce the frequency range, or increase the lowest frequency.	
Lost communication with RPC server on the board. System must be rebooted.	
Cannot download and start the DSP on the board.	System must be rebooted. If error persists, the hardware must be changed or repaired.
The DSP cannot process every requested task. Disable low-pass filter or decrease bandwidth (in continuous mode).	

11.5 Fatal Error Messages

This section presents the fatal error messages that can be sent by the MS5800. With fatal error messages, the system must be restarted. The left column in the table lists the messages, and the right column indicates the action to be taken for each message, if applicable.

Message	Action
Fatal error from the operating system. A call from the acquisition unit (MS5800) to the operating system has failed.	Report this problem to Olympus.
Cannot open the TCP/IP socket. The passive connection (TCP/IP socket on Ethernet) cannot be opened. This operation is logical and is not network-dependent.	Report this problem to Olympus.
A memory allocation error happened. This is a fatal condition.	Quit MultiView and turn the instrument off. Turn the instrument on again, and then start MultiView after the boards are booted and ready to perform data acquisition (the BOOT indicator light is steadily turned on). If this message continues to appear, report this problem to Olympus.
Cannot download the last firmware file requested.	Verify if you have every LPTX126*.BIT and LPTS136*.BIT files in your boot directory (pointed by the bootp server). If not, re-install MultiView.
Undefined error.	Report this problem to Olympus.

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