User Guide

Dual Channel Portable Signal Analyzers
Types 2148, 2144/7651

and

Portable Signal Analyzers
Types 2147, 2143/7669

Valid for

Dual Channel Portable Signal Analyzer Type 2148
from serial no. 1635506 with system software VP 7279,

Portable Signal Analyzer Type 2147
from serial no. 1623890 with system software VP 7361,

and for

Real-time Frequency Analyzer Type 2144
from serial no. 1614490 with Dual Channel FFT Option Type 7651
from serial no. 1673412

and

Real-time Frequency Analyzer Type 2143
from serial no. 1623846 with FFT Option Type 7669
from serial no. 1708537

September 1992

Safety Considerations

This apparatus has been designed and tested according to IEC Publication 348, *Safety Requirements for Electronic Measuring Apparatus*, and has been supplied in safe condition. The present User Guide contains information and warnings which should be followed by the user to ensure safe operation and to retain the apparatus in safe condition. Special note should be made of the following:

Powering the Apparatus

Before each use of the Power Supply ZG 0199 with the apparatus, check that it is set to match the available mains voltage and that the correct fuse is installed.

Safety Symbols

⚠ The apparatus will be marked with this symbol when it is important that the user refers to the associated warning statements given in the User Guide.

⊥ Chassis terminal ⏚ Safety earth terminal ϟ Hazardous voltage

Warnings

- Switch off all equipment before connecting or disconnecting their digital interface. Failure to do so could damage the equipment.
- Whenever it is likely that the correct function or operating safety of the apparatus has been impaired, the apparatus must be made inoperative and be secured against unintended operation.
- Any adjustment maintenance and repair of the open apparatus under voltage must be avoided as far as possible and, if unavoidable, must be carried out only by trained service personnel.

Contents

Chapter 1

Introduction

1.1 About Types 2148 and 2147

Dual Channel Portable Signal Analyzer Type 2148 and Portable Signal Analyzer Type 2147 are portable FFT analyzers for acoustics, electroacoustics and vibration measurements. Their light weight and water-protected cabinets make them especially well suited for use in the field, yet their measuring capabilities easily match those of a laboratory instrument. The analyzers feature 2048 sample transform size (801 lines), real-time zoom, advanced cursor functions, and a frequency range to 25.6 kHz in single- and (for Type 2148) dual-channel operation.

The analyzers are operated by means of user-interactive menus. This enables you to quickly become familiar with the use of the analyzer. Access to a system of on-screen help pages provides you with information about the use of the menus at any time and in any place.

A large internal non-volatile memory, together with back-up disk storage facilities, make the analyzer a powerful data-gathering device. The IEEE 488 and RS–232–C interfaces allow data-processing and external control.

1.2 About Types 7651 and 7669

Type 7651 is a dual-channel FFT software option for Real-time Frequency Analyzer Type 2144. Type 7669 is a single-channel FFT software option for Real-time Frequency Analyzer Type 2143. Both come on $3^1/_2''$ disks and are loaded using the analyzer's built-in disk drive. A software key must be installed in the analyzer to allow the program to be run.

Type 2144 plus Type 7651 offer identical functions and operation as the Type 2148.

Type 2143 plus Type 7669 offer identical functions and operation as the Type 2147.

1.3 About this User Guide

This guide is intended for use with both the dual-channel and single-channel analyzers. Since the majority of functions are common to both options, we simply refer to Type 2148. It can be assumed that:

- Dual-channel functions apply to Types 2148 and 2144/7651 only.
- Other statements concerning Type 2148 are equally valid for Type 2147, unless specifically stated otherwise.
- Except where the 7651 (or 7669) is specifically named, all references to the 2148 (or 2147) can be assumed to apply to both analyzers.

The guide introduces you to the operating principles of Type 2148 and gives you an overview of the analyzer's possibilities. Examples of measurement procedures and data processing are also given. You will find that the analyzer is very easy to use once you have become familiar with its working principles.

Summary of Contents

Chapter 2 contains information about electrical considerations and maintenance of the 2148. It also contains information on how to install the software key necessary to run the FFT option. It is important that you read this *before* you start using the analyzer.

Chapter 3 describes the buttons on the front panel and the connections on the rear panel.

Chapters 4 and 5 describe the set-up and calibration of the analyzer, give an overview of the menus, and show you how to make measurements.

Chapter 6 gives further details of some of the more important menu items.

Chapter 7 discusses how to save data and how to add identifying text.

Chapters 8 to 10 describe some of the analyzer's special functions with examples of use: preselected set-ups, autosequences and post-processing.

Chapter 11 contains the technical specifications and Chapter 12 is about service and repair.

Chapter 13, the appendix, describes different types of error messages and how to deal with them.

The index is in Chapter 14.

Use of the interfaces (serial and parallel) is described in Vol. 2: Interface.

Chapter 2

Installation and Maintenance

2.1 Power Supply

Type 2148 can be powered using internal batteries, an AC mains supply, or a car battery as an external DC supply.

2.1.1 Battery Installation

Suitable batteries for Type 2148 are 1.25V rechargeable NiCd batteries, type R20 ("D" size). These have Brüel & Kjær order numbers QB0008. Six QB0008s are supplied with Type 2148. Type 2148 will operate continuously for more than 4 hours (at 25°C) with a set of fully charged batteries. The operating time is reduced if the disk drive is used intensively or the temperature decreases.

Batteries are inserted into Type 2148 in the following way:

1. Remove the Battery Box ZG0146 by turning the release screw.
2. Remove the cover by turning the four corner screws.
3. Insert six batteries in the directions indicated inside the box.
4. Replace the cover and insert the battery box into Type 2148.
5. Secure the battery box by turning the release screw.
6. Label the battery box with the type of batteries contained.

Caution! It is possible for batteries to explode or leak if they are handled incorrectly, so:

- Never attempt to recharge non-rechargeable batteries.
- Never attempt to recharge batteries fitted the wrong way round.
- Never mix different makes or types of battery.
- Never mix charged and discharged batteries.
- Always label the outside of the battery box with the type of batteries contained.
- Always remove the battery box before storage or shipment.

2.1.2 Mains Supply

To power Type 2148 from the mains supply, Power Supply ZG 0199 (included as accessory) can be connected to the **External Power** 7-pin DIN plug on the rear panel via Cable AQ 0035. This arrangement is shown in Fig. 2.1. Alternatively, ZG 0199 can be inserted in place of the battery box.

⚠ **WARNING:** NEVER apply an external drive voltage to the analyzer when there are non-rechargeable batteries in it.

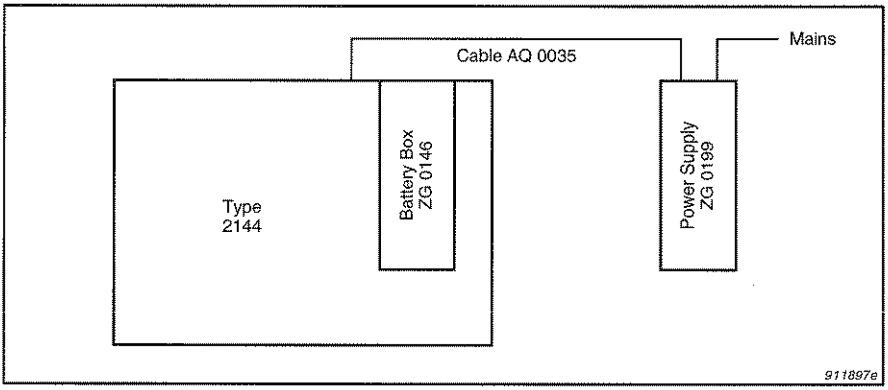


Fig. 2.1 Arrangement for powering or recharging

2.1.3 Recharging the Batteries

Power Supply ZG 0199 can be used to recharge the analyzer's NiCd batteries when the analyzer is switched off, for example overnight. The time taken to fully recharge the batteries is approximately 14 hours. The batteries can be recharged about 1000 times, provided they are not overcharged (i.e. not more than 16 hours). The arrangement for this is shown in Fig. 2.1.

Note: The switch on ZG 0199 must be in position **Drive Voltage "On"** for both powering and recharging. The charge LED does *not* come on.

Simultaneous Powering and Recharging

For simultaneous powering and recharging, use the arrangement shown in Fig.2.2. The switch on ZG0199 must be in position **Charge "On", Drive Voltage "On"**.

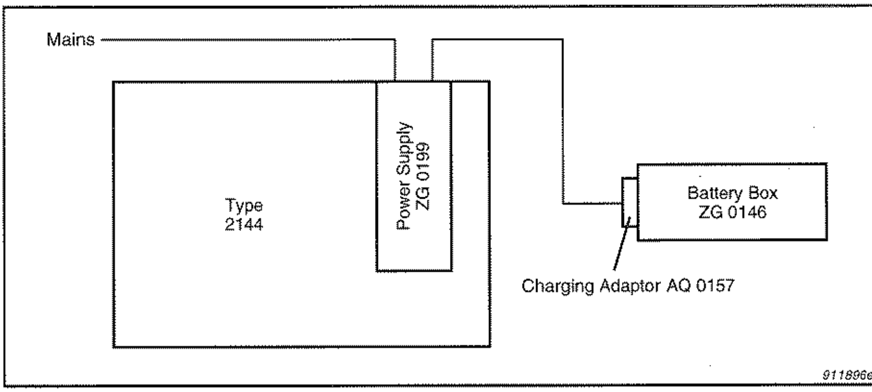


Fig.2.2 Arrangement for simultaneous powering and recharging

Note on Rechargeable Batteries

The batteries cannot be overcharged, but their lifetime can be reduced if a charging current is applied for too long a period. Likewise, NiCd batteries may exhibit a "memory effect" if used incorrectly. This effect leads to a decreased operating time, but can be avoided by letting the analyzer run to cut-off every time before recharging the batteries (it is a good idea to have an extra set of charged batteries ready). Your measurements are saved when the analyzer cuts off.

If, however, the operating time becomes considerably less than 4 hours, the "memory effect" problem can usually be overcome by deep discharging and recharging the batteries:

1. Discharge the batteries, for example by using them to power a flashlight until they are completely run down.
2. Charge the batteries for 20 to 24 hours.

2.1.4 Use of a Car Battery for External DC Supply

If a car battery is used as the external DC supply, and this is installed in a car, power should be taken at a point after the car's fuseboard, or, when the car is equipped with an electric lighter socket, power can be taken from here. To facilitate connection, the cigarette lighter should be replaced by a suitable adaptor-plug which has a built-in fuse. The plug should be mounted on a cable with a 7-pin DIN plug at the other end. For pin connections, see section 3.2. When possible, it is best to leave the car ignition switched off to avoid interference problems while using the analyzer.

The power supply in Type 2148 is isolated from its chassis and therefore cannot short-circuit the car battery if the analyzer's chassis (or the housing of a microphone) touches the chassis or bodywork of the car. However, if other instruments are used with the analyzer, ensure that they are also properly isolated, otherwise they can short-circuit the car battery.

2.2 Grounding Considerations

Indiscriminate grounding of instruments in a measurement system can introduce ground-loop interference from magnetic fields. Ground loops are created where multiple ground paths exist between two or more points in the measurement system, for instance where two instruments are interconnected by two separate signal lines. Circulating currents in these ground loops generate noise voltages which can lead to less accurate measurements. In extreme cases, the interference generated can also disrupt the digital communications in a bus-based system. Type 2148 terminology operates with three different ground symbols: signal ground, analogue ground, and chassis ground (rear panel). When the grounding switch on the rear panel is in **"Chassis"** position, analogue ground is connected to the chassis (see Fig. 2.3). In **"Floating"** position, analogue ground is disconnected to help break possible ground loops.

⚠ **WARNING!** Care must be taken to limit the Signal Ground current in order to prevent electrical hazards. Maximum is 50mA.

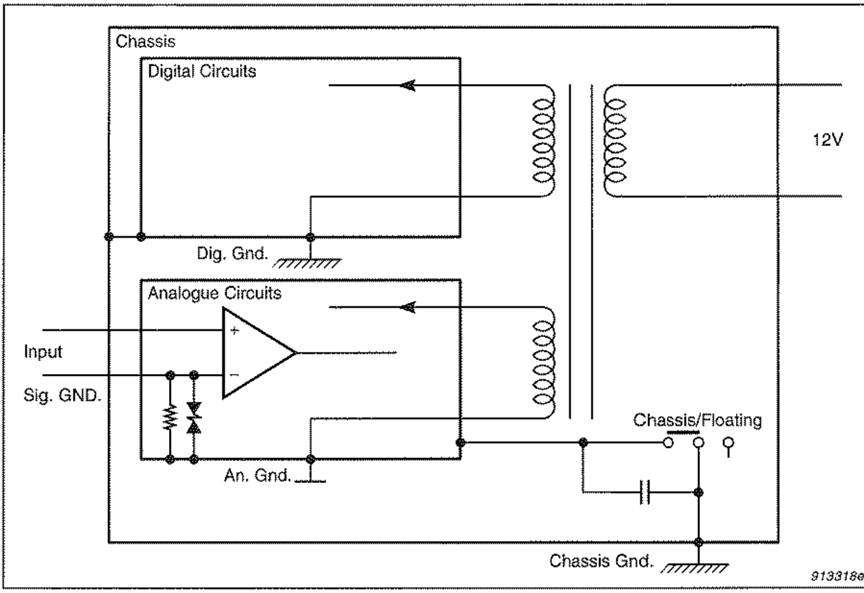


Fig. 2.3 Simplified circuit diagram showing the grounding principle of Type 2148 (one input channel shown)

If Type 2148 is part of a measurement system consisting of several instruments, use the following procedure to ensure that ground loops are eliminated without affecting the operating safety of the system.

1. Switch all instruments **"Off"** before making any changes to ground connections.

2. Connect together the Signal Ground lines of all the instruments in the system – this is done automatically through the screens of signal input/output connections. Make sure that the **Signal Ground** switch is **"On"** on any instruments equipped with such a switch.

3. If there is more than one signal cable connecting any two instruments together, break the signal ground connection in all but one of the interconnecting cables, either by switching **Signal Ground "Off"** or by disconnecting the signal ground lines in the cables. If this is not possible, use short cables and bunch the cables together to keep the area enclosed by cable loops as small as possible.

4. On all instruments which have a ground connection in their mains supply connector, connect the chassis to mains ground. Disconnect the signal ground from the chassis on all but one of these instruments.
5. In IEEE/IEC bus-based systems, disconnect the signal ground from the chassis on all but one of the instruments connected to the bus. Leave the signal ground connected to the chassis on an instrument with a mains ground connection, if any are included in the bus system. The bus cables provide a continuous chassis ground connection between the instruments.
6. Ensure that metal instrument cabinets do not touch each other, particularly if the chassis are connected to the signal ground. In rack-mounted systems, use isolating flanges to prevent ground loops being formed through the rack itself.
7. If transducers with metal housings are used, isolate the housings from grounded surfaces.

⚠ **WARNING:** Type 2148 is designed to be operated with its analogue ground and chassis ground at zero potential. Voltage between these two may be hazardous and must therefore be kept within the specified safety limits (see Specifications, Chapter 11).

2.3 Cleaning the Disk Drive

It is advisable to clean the heads of the analyzer's disk-drive at regular intervals – once a month is recommended – to avoid errors when reading to or from the disk. For cleaning, a $3^1/_2''$ Head Cleaning Diskette Kit is available (Brüel & Kjær part QA 0168). To clean the disk drive:

1. Prepare the cleaning disk according to the instructions included in the kit.
2. Insert the disk in the disk drive.
3. Press **"F7"** (`Memory`) on page 2 of the Main menu.
4. Set the `Select Memory` field to `Disk` using **"F1"**.
5. Press **"F7"** (`File List`).

6. Press **"F8"** (`Page 1`) to return to Memory menu, page 1.
7. Repeat steps 5 and 6 as required to give a total cleaning time of approximately 30s.

2.4 Installing the 7651 or 7669 Software Key

To run the 7651 FFT option on Type 2144, or the 7669 FFT option on Type 2143, a software key must be installed in the 2144. The key is a 24-pin integrated circuit which must be placed on circuit board 9 in the analyzer as described below (see Figs. 2.5, 2.4):

1. Make sure that the analyzer is switched off and disconnected from the mains.
2. Remove the battery pack or power supply.
3. Remove the four rubber feet.

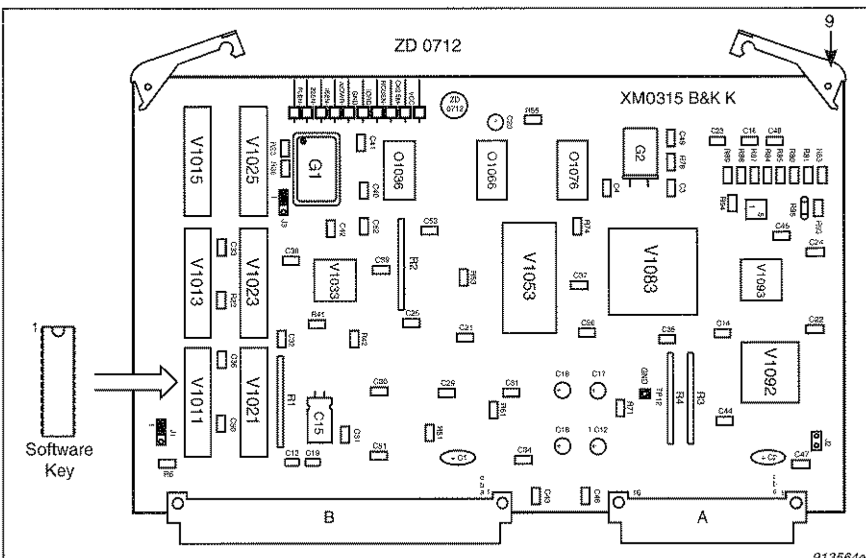


Fig. 2.4 Position of software key on circuit board 9

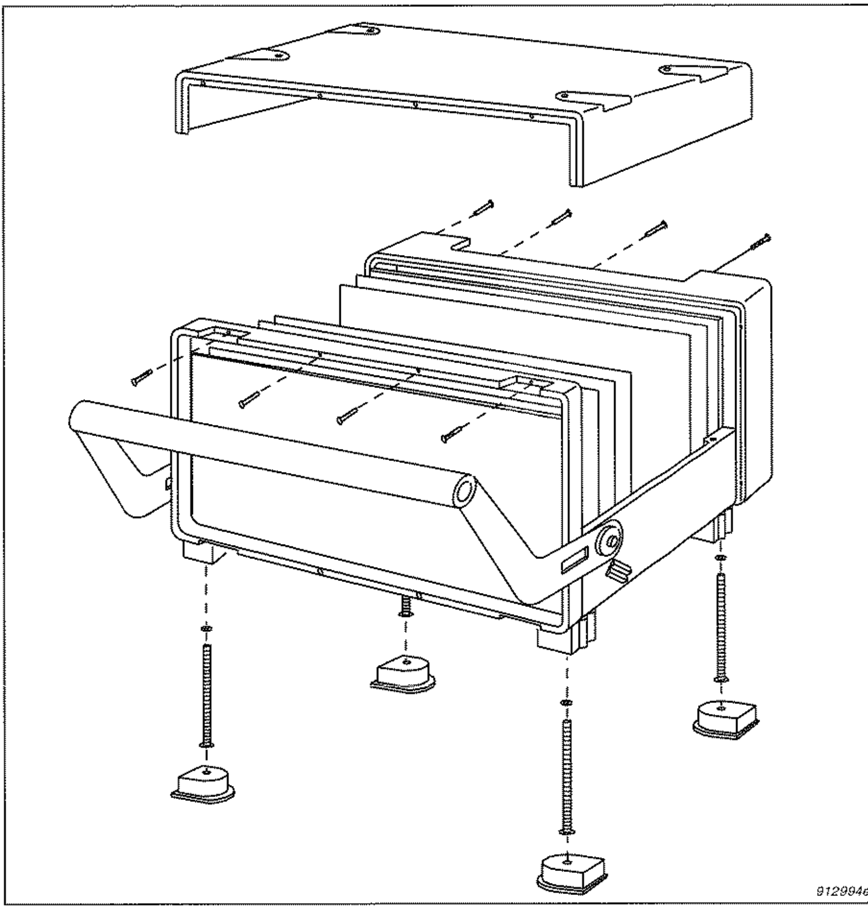


Fig.2.5 Dismantling the analyzer

4. Unscrew the eight short screws at the top of the front and rear panels.
5. Unscrew the four long screws at the bottom.
6. Remove circuit board 9 (ZD 0712).
7. Place the software key in one of the six sockets on the left-hand side of the circuit board as shown in Fig.2.4. Any free socket may be used.
8. Re-insert the circuit board and reassemble the analyzer.

Chapter 3

Controls and Connections

3.1 Front Panel

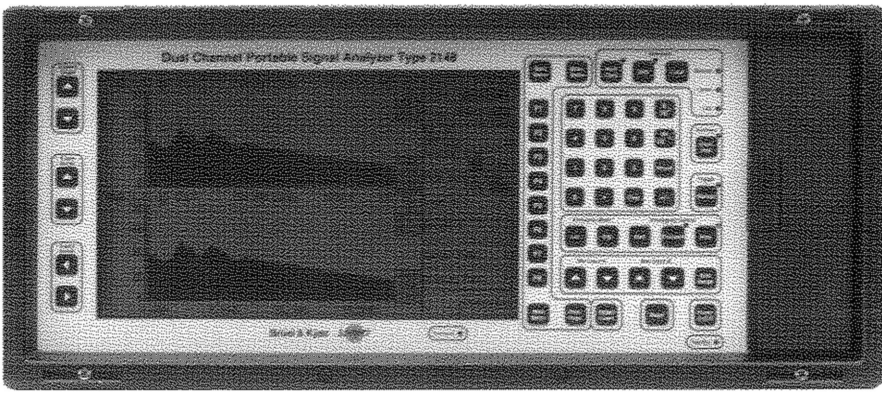


Fig. 3.1 Front Panel of Dual Channel Portable Signal Analyzer Type 2148

Screen Keys

Viewing Angle "△ / ▽ ": The analyzer's display contrast can be adapted to different vertical viewing angles using these keys.

Y-axis Scroll "△ / ▽ ": Step up and down the y-axis of the display selected with the **"Upper/Lower"** key.

X-axis Scroll "◁ / ▷ ": Step up and down the x-axis of the display. In dual and difference display modes both x-axes scroll.

Main Menu/Function/Meas. Mode Keys

"Main Menu": Displays page 1 of the Main menu, stopping any measurement in progress.

"Next Menu": Steps through the Main menu.

"Prev. Page": Steps backwards through the stack of previously used screen pages. The stack is 10 pages long. Note that if you are in measurement mode (see below), pressing **"Prev. Page"** will return you to the menu you were using before **"Meas. Mode"** was pressed. Therefore, you cannot use **"Prev. Page"** to move between the different menus in measurement mode.

"Meas. Mode": Puts the analyzer in measurement mode. To make a measurement, the analyzer must be in measurement mode.

"F1", ..., **"F8":** These are soft function keys. Their functions depend on the menu in use, and are described in the menu text. Where a ":" appears in the menu text, the setting can be obtained using the numeric keys.

Numeric Keys

These are used for entering numbers and prefixes into the echo field in the lower right-hand corner of the screen display. On entering numbers, see section 4.4.2.

Interface Keys

"SRQ": Sends a service request to the controller.

"Local": Sets the analyzer in local operation mode.

"Hard Copy": Sends a copy of the screen display to a printer via the interface.

The function of these keys is described in detail in Vol. 2 of the User Guide: Interface.

Averaging Keys

"Lin.": Sets the analyzer in linear averaging mode.

"Exp.": Sets the analyzer in exponential averaging mode.

"Start": Clears all four input buffers and starts a measurement if the analyzer is in Measurement Mode.

"Proceed": Continues an interrupted measurement without clearing the buffers.

"Stop": Stops any measurement in progress and freezes the display without clearing the buffers.

Autosequence Key

"Stop/Step": This key has three functions (see Chapter 9). It is used for terminating the programming of an autosequence, for stepping manually through the autosequence, and for executing it.

Trigger Key
"Manual": Triggers the analyzer.

Input Keys

2147 and 2143/7669:

Max. Input "△ / ▽ ": These keys fix the upper limit of the 80 dB dynamic range. The unit and reference depend on the input chosen.

2148 and 2144/7651:

Max. Input A "△ / ▽ ": These keys fix the upper limit of the A-channel's 80 dB dynamic range. The unit and reference depend on the input chosen.

Max. Input B "△ / ▽ ": Dual channel only. These keys fix the upper limit of the B-channel's 80 dB dynamic range. The unit and reference depend on the input chosen.

"Auto Range": Automatically sets the input attenuator of both channels to the optimal value according to the input levels. The input signal is measured over a period of time specified in the Averaging menu. If the level is too high, the signal is attenuated.

Upper/Lower Key (2148, 2144/7651 only)
"Upper/Lower": Toggles between the upper and lower display if two spectra are displayed at a time. All operations affect the display pointed out with the Upper/Lower Indicator (see section 5.2.3).

Reset Key
"Reset": Resets the analyzer to the user-defined settings without losing any set-ups or data already stored in the analyzer.

Power Key
"Power On/Off": Switches the analyzer on or off.

Note: If the **"Power On/Off"** key is pressed while the disk drive is active, the analyzer will wait until the disk drive has stopped running before switching off.

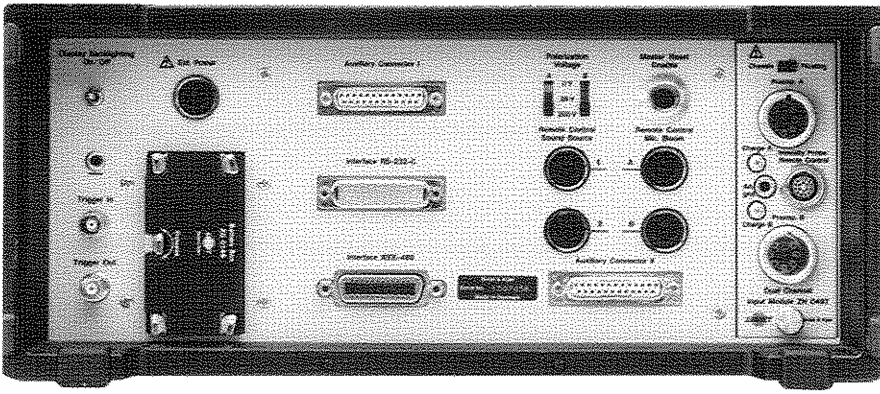


Fig. 3.2 Rear panel of Dual Channel Portable Signal Analyzer Type 2148

3.2 Rear Panel

Polarization Voltage

Selects a microphone polarization voltage of 0, 28, or 200V for each input as given on the microphone calibration chart.

Note: Always select the correct polarization voltage before switching the analyzer on. Otherwise, you may have to wait 10 to 15 minutes for the equipment to settle.

"Master Reset Enable"

This switch enables you to reset the analyzer to factory-defined settings. All saved data will be lost when a Master Reset is made. To master reset the analyzer:

1. Press **"Master Reset Enable"** and keep it pressed.
2. Press the **"Power On/Off"** key on the front panel.
3. Release the **"Power On/Off"** key.
4. Release **"Master Reset Enable"**.

Auxiliary Connector I

Reserved for future options.

Auxiliary Connector II

For input of an external sampling frequency to single-channel analyzers; otherwise reserved for future options.

With single-channel analyzers, external sampling is enabled in the Input menu.

The external sampling signal must be a series of CMOS logic-level (0 to +5 V) pulses with a maximum frequency of 65536 Hz

WARNING: Voltages outside this range can damage the input.

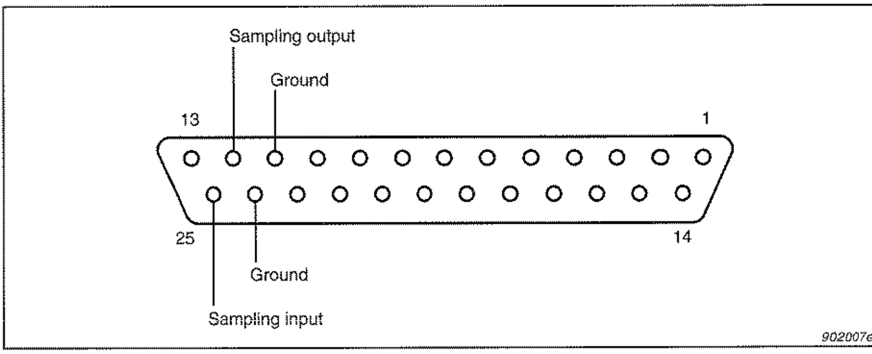


Fig. 3.3 Auxiliary Connector II (external view)

The external sampling signal is applied to pin 25 of Auxiliary Connector II, as shown in Fig. 3.3. The sampling output is only present on pin 12 when External Sampling is selected.

When the analyzer is controlled by external sampling, adequate precautions must be taken against aliasing. Note that the built-in antialiasing filter has a cut-off frequency of 25.6 kHz which cannot be disabled.

Interface RS-232-C

For controlling the 2148 from a computer. Also used for connection of the analyzer to graphics printers (see separate interface manual).

Interface IEEE–488

24-way socket for digital output of measurement results and for remote control of the analyzer (see separate interface manual) via the IEEE–488 interface. Also used for printers with IBM, HP or Epson print formats or for Brüel & Kjær Graphics Recorder Type 2313.

WARNING! Switch off all equipment before connecting or disconnecting their digital interfaces. Failure to do so can damage the equipment.

Remote Control Sound Source (7666 (1-ch.) or 7667 (2-ch.) required)

8-pin DIN connector(s) for remote control of Sound Source Type 4224. Pin designations are given in Fig. 3.4.

Remote Control Mic. Boom (7666 (1-ch.) or 7667 (2-ch.) required)

8-pin DIN connector(s) for remote control of Rotating Microphone Boom Type 3923 or Eight Channel Multiplexer Type 2811. Pin designations are given in Fig. 3.4.

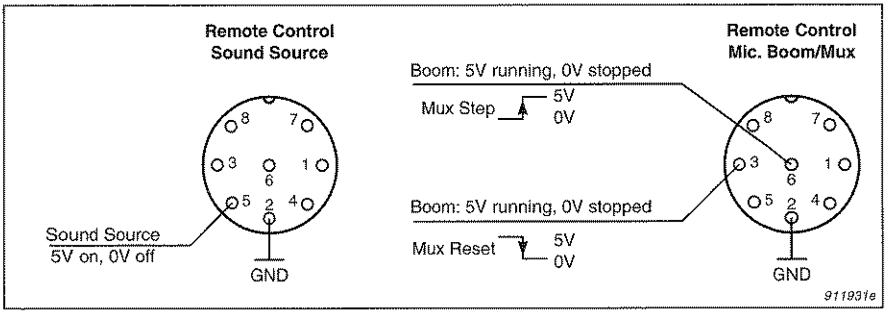


Fig. 3.4 Pin designations for Sound Source (left) and Microphone Boom / Multiplexer (right) connectors (outside view)

Preamplifier

7-pin connector(s) for Brüel & Kjær microphone preamplifiers. Pin designations are given in Fig. 3.5.

Direct

For Type 2148, Preamplifier-to-BNC adaptors JP 0736 (included as accessories) must be used for direct signals.

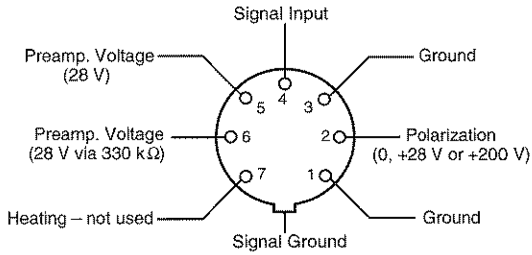


Fig. 3.5 Pin designation for 7-pin preamplifier connector (outside view)

For Type 2147 there is a BNC connector for connection of electrical signals.

Charge

For Type 2148, there are two 10–32 UNF micro-connectors for connection of Brüel & Kjær accelerometers to the built-in charge sensitive amplifiers.

For Type 2147, accelerometers are connected via a TNC connector.

Intensity Probe/Remote Control.

Dual-channel only. 18-pin LEMO socket for use with Brüel & Kjær Sound Intensity Probe Type 3548 including Remote Control Handle ZB 0017. Pin designations are given in Fig. 3.6.

Sound Intensity Probe Type 3545 may also be used with the 2148, but not all the remote control functions are available.

Trigger In/Out

For input of an external trigger signal, as provided, for example, by Photoelectric Probes MM 0012 and MM 0024, or output of a trigger signal from the analyzer.

Note: There is a risk of damage to the Trigger Input if the trigger signal is outside the range 0V to +5V.

0V to +0.9V is registered as *low* and +3.3V to +5V is registered as *high*. Triggering is on the *negative* slope of the trigger signal (see Fig. 3.7).

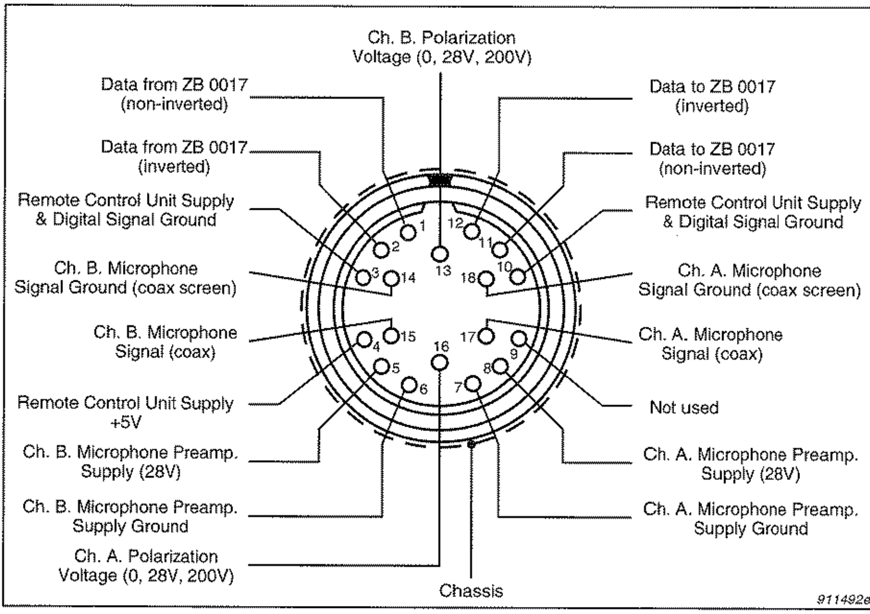


Fig. 3.6 Pin designation for 18-pin Intensity Probe / Remote Control connector (outside view)

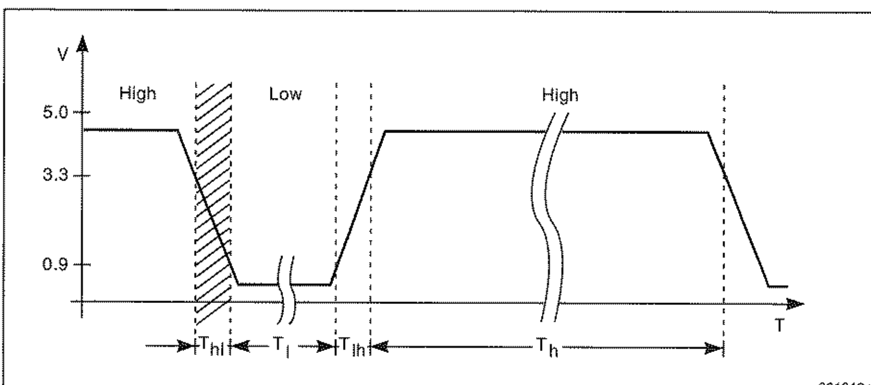


Fig. 3.7 Trigger signal used for external triggering. Triggering occurs in the cross-hatched area

The shift from high to low (T_{hl}, see Fig. 3.7) should be kept as short as possible (preferably less than 5µs) and the duration of time that the trigger signal is kept high or low (T_h or T_l) must be greater than 100ns to ensure that the signal stabilizes. The minimum time between two external triggers (T_{hl} + T_l + T_{lh} + T_h) is 2ms for exponential averaging, and the selected averaging time plus 1ms for linear averaging. If the pulses are sent at a faster rate, they are ignored.

Display Backlighting On/Off

Toggle switch for activating or deactivating the analyzer's backlighting mode.

Ext. Power

7-pin DIN socket for connection of an external power supply such as Power Supply ZG 0199 with Cable AQ 0035. Pin designations are shown in Fig. 3.8. The socket is also used when recharging NiCd batteries. Alternatively, the ZG 0199 can be plugged into the 2148 instead of Battery Box ZG 0146. When using an external power source, the voltage must be in the range 11V to 16V DC (see section 2.1).

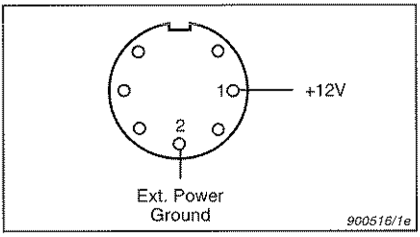


Fig. 3.8 Pin designation for 7-pin DIN external power connector (outside view)

⚠ **WARNING:** NEVER apply an external drive voltage to the analyzer when there are alkaline or other non-rechargeable batteries in it.

Chassis/Floating

⚠ **WARNING:** Connects/disconnects analogue ground to/from the chassis (rear panel) of the 2148. See section 2.2 for further information on grounding considerations.

Chapter 4

Getting Started

4.1 Switching On

Important: Ensure that you have read Chapter 2 (Installation and Maintenance) before you switch on the analyzer.

4.1.1 Normal Procedure

Press the **"Power On/Off"** key to switch the analyzer on.

When the analyzer is switched on, it goes through a three-step self-test:

- The power-on self-test looks for hardware failures.
- The program retention test checks if the different program parts are still in the analyzer's memory.
- The main program looks for errors in the internal memory (data memory, set-ups, autosequences, etc.).

Page 1 of the Main menu appears on screen when the self-tests have been successfully completed. This takes about 35 seconds.

In case of error messages, see the appendix, Chapter 13. This describes different types of errors and how to deal with them.

4.1.2 Loading Software

This procedure must be followed if you wish to reload the main analyzer program or to load any of the software options.

1. Select a program disk.
2. Insert the program disk in the disk drive.
3. Make a Master Reset (see section 3.2).

The procedure described above:

- Switches the analyzer on
- Loads the relevant software and help pages into the analyzer
- Resets the analyzer to its default (factory-defined) settings

Note: The interface settings are not changed when you make a Master Reset – they are kept from the program previously loaded. Also, most parameters from the Input menu and some of the calibration parameters remain as they were before the Master Reset.

4.1.3 Loading via the IEEE

If you have an IBM PC XT, AT, PS/2 or compatible fitted with a GPIB interface card, it is possible to boot the analyzer from the PC. Details are given in section 5.3 of Volume 2.

4.2 General Measurement Procedure

With a transducer connected (remember to set the polarization voltage if you use a microphone), making a measurement with the 2148 is extremely simple:

1. Switch the analyzer on and wait for the self-test to be completed.
2. Press the **"Meas. Mode"** key.
3. Press **Averaging Control "Start"** to start the measurement.

The measurement that you have just started is made with all parameters set as they were when the analyzer was last switched off. The way to change these settings is described in the following sections.

4.3 The Menu and Help Page System

The operation of the 2148 is based on a menu system. When the power-on self-test is completed, the first page of the Main menu is shown on the display. You can always get to this page by pressing **"Main Menu"**.

4.3.1 Set-up Mode/Measurement Mode

When using the 2148, it is important to remember that it has two operating modes, Set-up (or Main Menu) Mode and Measurement Mode, selected by pressing **"Main Menu"** and **"Meas. Mode"**, respectively. When the analyzer is in its Set-up Mode, it is not possible to make measurements. When the analyzer is in Measurement Mode, only the most important parameters of the set-up are accessible.

4.3.2 Getting Help

The first menu is called "Help". Each page of a menu has a help page associated with it. From any menu page (including Measurement Mode), you can go directly to the associated help page by pressing **"Main Menu"** and then **"F1"**. Pressing **"Prev. Page"** takes you back to the menu you came from.

4.3.3 Overview of Menus

To give you an idea of the possibilities of the 2148, let us first look briefly at the different menus and their use.

Current Set-up
Gives you an overview of the settings currently in use.

Measurement Type
With this menu you can choose between one- and two-channel analysis, or cross analysis with phase-matched inputs. For each Measurement Type the analyzer has a complete set-up which is saved internally. The three Measurement Types are described in section 5.1.

For Type 2147, this menu is locked on `1-CH ANALYSIS (Time, Auto)`.

Input
Input channels A and B can be set up separately, or locked together (`A&B`) as recommended for intensity measurements. The type of input (probe/preamp, direct, charge), low-pass filters,

maximum input, input protection and DC compensation are all set in this menu.

For Type 2147, only channel A is available.

Calibration

The A- and B-channel signal levels can be calibrated either one at a time or simultaneously. dB references and units can be entered from the front panel. For intensity measurements, the intensity and particle velocity levels can be verified and the pressure-residual intensity index can be measured (see section 4.5).

For Type 2147, only channel A is available.

Calibration is always made using a fixed set-up independent of the measurement mode. The set-up is: 12.8kHz frequency span, 400 lines, flat-top weighting and 0% overlap.

Time/Freq Parameters

This menu is used for setting the number of displayed lines (transform size) and the highest frequency for baseband analysis. Real-time zoom can also be selected together with centre frequency and frequency span (see section 6.4 to 6.6).

Averaging/Channel Delay

This menu is for selecting linear or exponential averaging. It also controls overlap, overload reject, and a "start averaging" delay from channel A to channel B (2148 only) (see section 6.3).

Display Set-up

One or two spectra can be displayed at a time. Also, the axes of the graphs in the frequency or time domain must be specified.

The display can be set up for both spectra and time records. This menu also controls frequency and time axis compression, differentiation, integration, bow-tie correction and the displayed phase and amplitude ranges.

Time Weighting Function

Five time weighting functions (time windows) are available: Rectangular, Hanning, Flat Top, Transient and Exponential. Transient and Exponential windows have selectable position and width (see section 6.7).

Trigger/Multimode

This menu allows the selection of single measurements or the measurement of normal, gated or matrix multispectra. Trigger conditions can be selected for each of these options (see section 5.4). A peak hold function is included with the internal trigger.

Memory

This menu can be used to display a list of files in the data memory or on the disk, format new disks, delete or rename files, transfer files between data memory and disk and create comma-delimited disk files for use with spreadsheet programs (see Chapter 7).

Measurement Text

In addition to the number used to identify a file in the memory, a name or a comment can be assigned to the file. This is a useful feature in the field, where paper and pencil are not always available.

Data View

The data view facility is mainly intended for displaying multispectra. You can view a multispectrum along either the frequency axis (`FREQ`) or the time axis (`INDEX`), or as an overload slice (`OVL`). All information about the analyzer set-up when the spectrum was measured is available in a measurement set-up. In addition, you can select the displayed function, e.g. `AUTO.A`, `H1` (2148), and select from a range of cursor functions, as described for Measurement Mode in section 5.3.

Hold

It is possible to hold the full display or the individual frequency bands of either channel when they exceed or fall below their previous level. Maximum or minimum hold, or both, can be chosen.

I/O Interface

The analyzer communicates with the outside world through its interfaces. Either serial (RS–232–C) or parallel (IEEE 488) interface can be selected. See Volume 2 for more information.

Spectrum Calculator

Spectra can be added or subtracted and constants can be added to or subtracted from spectra. Multispectra can be modified by substitution of one or more spectra. Weightings, either standard

A^{-1}, A, B, C or D, or user-defined, and sound power can be calculated. The Spectrum Calculator is described in Chapter 10.

Preselected Set-up

If you have any special settings that you want to use frequently, these can be saved in the analyzer's non-volatile memory. This facility is described in Chapter 8.

Autosequence

The analyzer can be programmed to make measurements without interference from an operator. Furthermore, it can be told to wake up at a particular time, make one or more measurements and then turn off again. See Chapter 9.

Real-time Clock

You can set the analyzer's internal clock. This is used for the wake-up facility and for time labelling the files.

Back Lighting

The LCD screen can be lit to make it visible in the dark. To save the batteries, the back lighting can be set to turn off automatically when the analyzer is not being operated.

Measurement Mode

Use of the Measurement Mode and its associated menus is described in Chapter 5.

4.3.4 Efficient Use of the Menus

Two other useful keys in Set-up Mode are **"Next Menu"** and **"Prev. Page"**. **"Next Menu"** is useful for stepping through the menus without having to return to the Main menu. It is particularly useful during the initial set-up of the 2148 where the menus follow each other in a logical sequence, starting with Input.

"Prev. Page" allows you to "backspace" up to ten pages from the current menu page. For instance, if you wish to go back to the last-but-one displayed menu page to change a parameter, it is often quicker to press **"Prev. Page"** twice rather than access it through the Main menu (particularly if that page belongs to a different menu). **"Prev. Page"** is also useful when used with

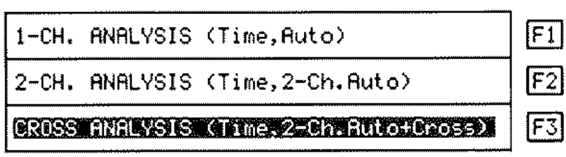
"Meas. Mode" for rapid switching back and forth between a menu page and Measurement Mode when setting up interactive parameters such as screen displays. Note, however, that it cannot be used to switch between the different Measurement Mode menus.

4.4 Changing Parameters in the Set-up

4.4.1 Changing Operating Parameters in a Menu

When the screen shows a menu selected from the Main menu, soft keys **"F1"**/.../**"F8"** are used to change operating parameters and, where the menu consists of more than one page, to move between the various menu pages. Operating parameters can be changed as follows:

- Where a soft function key controls a single parameter, pressing that key will select that parameter:



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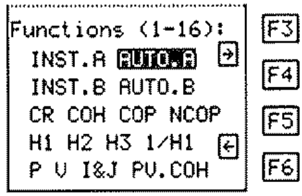
- Where a soft function key presents multiple choices, pressing that key will loop through the choices, an inverse video field indicating the selected choice. Alternatively, the number of the field can be entered into the echo field in the bottom right-hand corner of the screen from the numerical keypad and the parameter chosen by pressing the soft key:

- Some multiple-choice parameters are selected using more than one soft function key, allowing movement of the inverse video field indicating the selected choice to the left or right

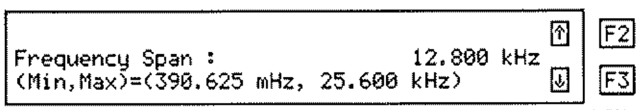


920784e

and/or up or down. Numerical selection (1 to 16 in the example), is also possible here:

4.4.2 Changing Numerical Parameters in a Menu

Where a ":" appears in a function field, it indicates that the function field controls a numerical parameter. The values of numerical parameters can be changed as follows:



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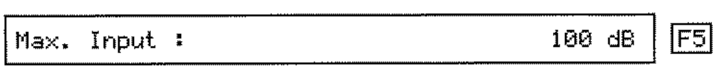
- Some numerical parameters can be incremented/decremented using increment/decrement soft keys shown above.
- All numerical parameters can be changed using direct numeric entry. For direct numeric entry, the numeric keys on the front panel are used to key the required value into the echo field in the lower right-hand corner of the screen, and then entered by pressing the soft key adjacent to the function field. If the entered parameter value is invalid, the echo field flashes and the numerical parameter is set to the nearest valid value:



- Entry of a suffix is done using the **"k/10^3"** and **"m/10^{-3}"** keys. These keys have repeat functions. For instance, to key in a value in pico-units, the suffix is entered by pressing **"m/10^{-3}"** four times.

If the 2148 indicates an invalid parameter value despite this being within its specified allowed range, it will be because the entered value is inconsistent with the setting of another parameter elsewhere in the set-up. In this case, the rest of the set-up must be checked.

4.5 Calibration

To calibrate the analyzer, a reference source must be used to apply a known signal level to its inputs. A reference source for sound pressure calibration could be Pistonphone Type 4228, Sound Level Calibrator Type 4230, or Sound Intensity Calibrator Type 3541. For vibration calibration, the source could be Calibration Exciter Type 4294.

The following sections show an example of how to calibrate the analyzer for a sound intensity measurement. A 1/2″ two-microphone sound intensity probe (for example Type 3548) and Sound Intensity Calibrator Type 3541 are used in the example. Section 4.5.1 also applies to calibration of the 2147 using a microphone and pistonphone. The comments here also apply to calibration using accelerometers, hydrophones, or other transducers.

4.5.1 Calibration of the Sensitivity to Sound Pressure

1. Dual-channel only. Go to the Measurement Type menu (press **"Main Menu"**, **"F3"**) and select Cross analysis.
2. Dual-channel. Go to the Input menu (press **"Next Menu"**) and set Channel to `A&B` and Input to `PROBE/PREAMP`.

   Single-channel. Go to the Input menu and set Input to `PROBE/PREAMP`.
3. Press **"Main Menu"**, **"F5"** to go to the Calibration menu.

   Page 1 of the Calibration menu (see Fig. 4.1) is used for setting up the physical parameters valid at the calibration. A summary of these parameters is given on the left-hand side of the screen. It is possible to change the dB reference,

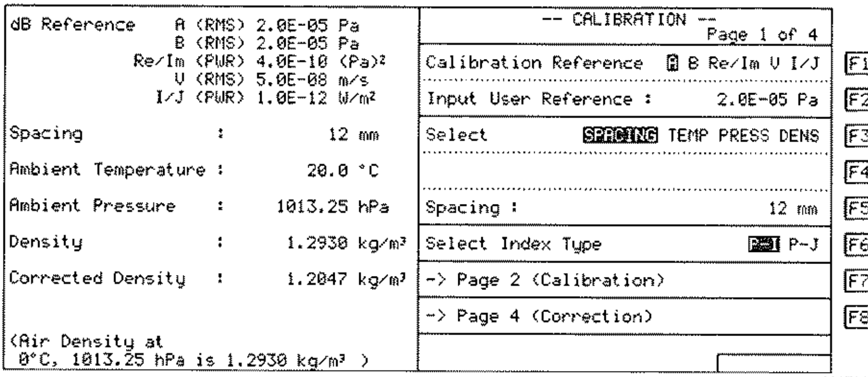


Fig. 4.1 Page 1 of the Calibration menu

but this should only be done when standards require it. Hydrophones, for example, use 1 µPa as reference.

4. Use soft keys **"F3"** and **"F5"** to enter values for microphone spacer, ambient pressure, and temperature. If you are not calibrating in air, enter the nominal density of the calibration media.

5. Press **"F7"** to go to page 2. Note that the (two) bar(s) on the left-hand side of the screen operate(s) in exponential averaging mode. This enables you to monitor the calibration signal prior to calibration.

6. Dual channel only. For simultaneous sound pressure calibration of both channels, arrange the microphones as described in the 3541 manual and set Mode to `A&B` (**"F1"**).

7. Enter the values for calibration level, calibration frequency and transducer sensitivity. If you do not know the sensitivity of the probe microphones, use 12.5 mV.

8. Key-in a number of linear averages and enter it by pressing **"F6"**.

9. Press **"F7"** to start the autocalibration.

The analyzer switches from exponential averaging to linear averages and starts a new measurement. When the calibration is completed, the indicator returns to `FINISHED`, exponential averaging starts again, and a gain factor for each channel is displayed in the Gain Adjustment field. This adjustment is added to all future measurements until the analyzer is re-calibrated (even if a Master Reset is made).

If no reference source is available and the sensitivity of the transducer is known from its calibration chart, an approximate calibration is possible by entering the sensitivity directly into the Calibration menu (**"F4"** on page 2).

Note: When acceleration is displayed, the default reference is 10^{-6} (RMS). When the integrated acceleration is displayed, the reference should be 10^{-9} (RMS), but it is not possible to select two references for an autospectrum for the two display modes. Therefore, in order to obtain the correct reference for integrated acceleration, it is necessary to change the reference in the calibration menu to 10^{-9}.

4.5.2 Verification of the Sensitivity to Sound Intensity/ Particle Velocity

To verify correct operation of the integrating circuit, the analyzer's sensitivity to sound intensity or particle velocity must be checked. This requires the use of Sound Intensity Calibrator Type 3541:

1. Place the microphones as described in the 3541 manual.
2. Go to page 3 of the Calibration menu. This page is only active if Cross Analysis has been chosen in the Measurement Type menu.
3. Set the `Mode` field to `I` or `V`.
4. Use **"F2"** to enter the intensity or particle velocity level (at reference conditions) as stated on the 3541's calibration chart.
5. Choose a number of linear averages (**"F3"**).
6. Press **"F4"** to make the verification.

No gain factors are added after the calibration. If, however, there is a large discrepancy between the measured and the entered calibration levels, check the instrument settings again and correct the faults.

4.5.3 Measurement of Residual Intensity

For sound intensity measurements, it is not enough to ensure that the sound pressure and intensity/particle velocity levels are correct; the phase matching of the channels is equally important. To measure this, Sound Source ZI 0055 (included in Type 3541) is used and the microphones are placed opposite each other in the coupler. With this arrangement, the two microphones pick up a signal with the same amplitude and phase. In theory, the amplitude of the intensity signal should therefore be zero over the whole frequency range. To measure the residual intensity:

1. Select whether you want to display `P-I` (active) or `P-J` (reactive) index. This is done on page 1 of the Calibration menu (**"F6"**).
2. Go to page 4 of the Calibration menu (this page is only active in Cross Analysis mode).
3. Use **"F3"** and **"F4"** to set the high and low end of the frequency range as required for the intensity measurement you want to make later on.
4. Select a number of averages (**"F5"**).
5. Press **Averaging Control "Start"** to start the measurement.

When averaging stops, the correction spectrum is saved in the analyzer's memory and the previous spectrum (if any) is overwritten. A file number can be given to the correction spectrum (by using **"F6"**), so that it is saved and can be recalled (**"F7"**) to the screen later on. A measurement text is automatically assigned to the correction spectra by the analyzer so that they can be identified in a file list. The measurement text reads `CORRECTION SPECTRUM`.

When Correction is set to `ON` (by pressing **"F8"**), the measured intensity spectrum is corrected using the correction spectrum shown on page 4 of the Calibration menu. The correction formula is shown in equation (4.1):

$$I_{cor} = I_m - \frac{p_m^2}{p_0^2} I_0 \qquad (4.1)$$

where

I_{cor} = Corrected active intensity

I_m = Intensity in measurement

I_0 = Residual intensity in coupler

p_m = Mean pressure in measurement (RMS value)

p_0 = Mean pressure in coupler (RMS value)

Note: Equation (4.1)* is only valid for small phase deviations. Also, a positive effect of this phase compensation is not guaranteed for all types of signals, so it should be used very carefully. Changing the number of lines automatically disables the correction algorithm.

If a corrected intensity spectrum is used for documentation, the pressure-residual intensity index spectrum must also be stated according to the ISO 9614–1 standard. The pressure-residual intensity index, Δ_{pI_0}, is defined as:

$$\Delta_{pI_0} = L_{p,0} - L_{I,0} \text{ dB} \qquad (4.2)$$

where

$L_{p,0}$ = SPL in coupler

$L_{I,0}$ = Intensity level in coupler

The pressure-residual intensity index spectrum is unique to the measurement system with which it was measured. This means that if, for example, the microphone spacing of the probe is changed, then a new spectrum must be measured.

* Equation (4.1) is shown for active intensity. Reactive intensity is corrected in the same way.

Chapter 5

Making Measurements

5.1 Measurement Types

		Measurement Type		
		1-ch.	2-ch.	Cross
Time Domain Functions	A/B channel time signal	A or B	•	•
	Complex time	•	•	•
	A/B channel autocorrelation	A or B	•	•
	Cross correlation			•
	Impulse response function h1			•
Frequency Domain Functions	A/B channel instantaneous spectrum	A or B	•	•
	A/B channel autospectrum	A or B	•	•
	Cross spectrum			•
	Mean sound pressure			•
	Particle velocity			•
	Complex intensity			•
	Frequency response function H1			•
	Frequency response function H2			•
	Frequency response function H3			•
	1/frequency response function H1			•
	Coherence between channels A and B			•
	Coherence between mean pressure and particle velocity			•
	Coherent output power			•
	Non-coherent output power			•

Table 5.1 Available display functions for each of the three measurement types. Type 2147 has only the 1-channel (A) functions

The 2148 has three Measurement Types, 1-channel, 2-channel and cross analysis. In effect it works as three different analyzers each with different set-ups of inputs, record lengths, frequency spans, numbers of averages, display modes, etc. Measurement type is chosen in the `Measurement Type` menu (selected from page 1 of the Main menu).

Different functions can be displayed depending on the measurement type. These are listed in Table 5.1. The display functions are selected in Measurement Mode on the `Display Func.` page (see section 5.3.1).

5.2 Screen Layout in Measurement Mode

"Measurement Mode" designates the state in which the analyzer is able to make measurements. In Measurement Mode, the analyzer screen is divided into two main parts: the display and the menu text. This section only describes the display; the menu text pages are described in section 5.3. The display includes one or two sets of the following:

- Frequency spectrum or time function with axes and cursor
- Display header
- Status fields

In addition, the display of dual-channel analyzers includes:

- Upper/Lower indicator (not in single display)

5.2.1 Displayed Ranges

In Measurement Mode, the 2148 always shows the position of its dynamic range in relation to its Y-axis display range, indicated by a thicker bar parallel to the Y-axis, as an aid to setting the Y-axis correctly.

For logarithmic scales (dB), the full scale value can be changed in Measurement Mode (but not the difference between the upper and lower limits) by using the **Y-axis Scroll** hard keys. For linear scales, the same keys change the range of the Y-axis.

With decibels on the Y-axis, the default value for the **Y-axis Scroll** keys is 5dB. If, however, you want to use a larger or smaller step, for example 50dB, simply press **"5" "0"** followed by one of the scroll keys and the display will be moved 50dB in the required direction. Any further scrolling will also step 50dB until a new value is entered or the analyzer is switched off. This procedure also applies when absolute values are displayed, but a value of 50 still shifts the axis by an amount equivalent to 50 dB. Remember, the spectrum does not change , only the Y-axis annotation..

The 2148 always analyses across the full frequency range specified in the Time/Freq Parameters menu. The *measured* frequency range is not always displayed, however. It can be controlled from page 1 of the Display Set-up menu which allows you to select whether or not to compress the frequency axes. If you select compressed frequency axis and then go to Measurement Mode, the frequency range is ordered as groups of lines where the highest value in a group is displayed.

5.2.2 Single, Dual and Difference Display

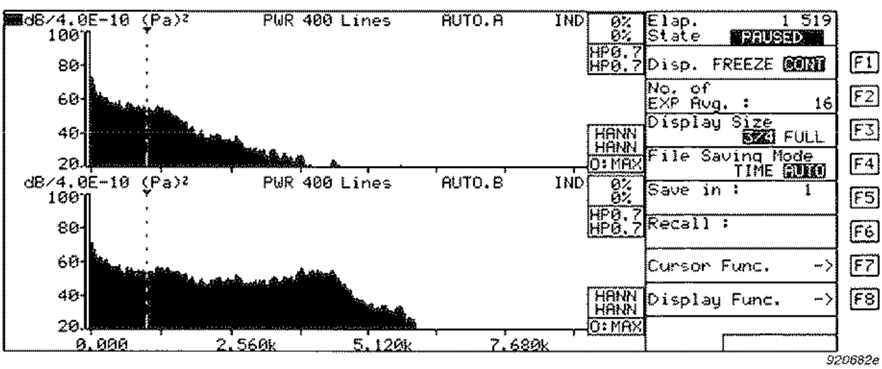


Fig. 5.1 A typical 2148 dual display in Measurement Mode

The Display Set-up menu permits the selection of three display modes: Single, Dual and Difference.

Single shows only one graph on the analyzer's screen. This is the upper display in Fig. 5.1 expanded to fill the screen.

Dual shows two graphs, upper and lower as shown in Fig. 5.1.

For Type 2148, difference shows two graphs, with the lower graph the same as for dual display, and the upper graph equal to the input, or a recalled file minus the lower graph. This mode cannot be used with time functions.

For Type 2147, the difference is always taken between the input signal and a saved spectrum shown in the lower graph.

5.2.3 Upper/Lower Indicator (2148, 2144/7651 only)

The black field on the far left of the display (Fig. 5.1) indicates which spectrum you are working with. In dual or difference display mode, this field toggles between the upper and lower spectrum when the **"Upper/Lower"** hard key on the front panel is pressed.

5.2.4 Display Headlines

The line of text over the display in Measurement Mode briefly describes the displayed data. This line consists of a number of fields, their functions dependent on whether full or 3/4 display is selected.

3/4 Display
Here the fields are:

1. The Y-axis unit (see section 5.2.5) shown in absolute units or as a dB/reference value and unit. The dB reference is chosen in the Calibration menu.
2. Integration or differentiation (double or single), as selected in the Display Set-up, page 2. If `1` has been chosen, this field is empty.
3. The spectrum unit selectable from PWR, RMS, ESD and PSD.
4. The number of lines, as specified in the Time/Freq Parameters menu.
5. The displayed function. This is chosen using soft keys **"F3"** to **"F7"** on the `Display Func.` page of the Measurement Mode menus.

6. The data source (input or memory) and measurement type:

   INA: Data from Input Module A, 1-channel analysis
   INB: Data from Input Module B, 1-channel analysis
   IND: Data from Input Modules A and B, 2-channel analysis
   INX: Data from Input Modules A and B, cross analysis
   RFD: Recalled data measured in the frequency domain
   RTD: Recalled data measured in the time domain
   CLC: Data which has been processed using the Spectrum Calculator menu

Full Display

For Full display, the fields are:

1. Cursor x-position.
2. Cursor y-value.
3. Displayed function (as in point 5 above).
4. Information on data (as in point 6 above).
5. Averaging control information (e.g. `WAIT/RUN`, `PAUSED`, etc.).

5.2.5 Units Philosophy

The 2148 allows you to select either relative (dB) or absolute units. If charge is selected in the Input menu, then absolute units can be further divided into metric or imperial. Imperial units are normally only used in the USA, where m/s^2, m/s and m are replaced by g ($9.81\,m/s^2$), inch/s and mil.

The philosophy for how metric units are used is described below. The description also applies to imperial units.

The units are displayed in the headline of the Measurement Mode screen. As spectrum units are chosen in the Display menu, some wrong combinations can occur, such as intensity measured in RMS. In such cases, **** is shown instead of the actual unit. If a legal but unlikely combination, such as the differentiation of m/s^2 to m/s^3, is chosen, then `unit` is written in the headline. If another transducer is used, for example a force transducer, the analyzer would normally display incorrect units (here m/s^2).

To avoid this, the Display Set-up menus allow you to select UNIT directly.

Note: For Direct Input, the analyzer operates with Units rather than Volts.

5.2.6 Status Fields

The status fields of the 2148 display are (top to bottom):

1. Overload percentages for channels A and B.
2. Analogue input filters for channels A and B. `HP` stands for high-pass filter followed by the lower 0.1 dB limit in Hz. `A` stands for A-weighting.
3. Trigger Mode. An empty field indicates that the Multispectrum Type in the Trigger/Multimode menu is `SINGLE`. `HOLD` indicates that Multispectrum Type is `SINGLE` and that the hold function specified in the Hold menu is active. `MULTI` indicates that Multispectrum Type is `GATED`, `NORMAL` or `MATRIX`.
4. Intensity correction. In the frequency domain, `CORR` is displayed if the intensity correction is active, otherwise the field is empty. For a time-domain display, the field reads `BOW-T` if bow-tie correction is on (correlation only).
5. Zero padding. The field shows to which channel(s) zero padding is applied: `EMPTY` means no zero padding; `Z-PA`, `Z-PB` and `Z-PAB` mean zero padding of channel A, channel B, and both channels, respectively.
6. Time weighting functions for channels A and B, as specified in the Time Weighting Function menu.
7. Overlap percentage. Both channels use the same overlap. The field is empty if overlap information is not relevant.

5.2.7 Getting Help in Measurement Mode

Help pages are also available in Measurement Mode. Each analysis mode (see section 5.4) has its corresponding help pages. They are obtained by pressing **"Main Menu"** and then **"F1"** (`HELP`). Pressing **"Main Menu"** stops any measurement in progress.

5.3 Measurement Mode Menus

The Measurement Mode menu has sub-menus. Fig. 5.2 shows the Measurement Mode menu structure and also gives an overview of the functions controlled in each menu.

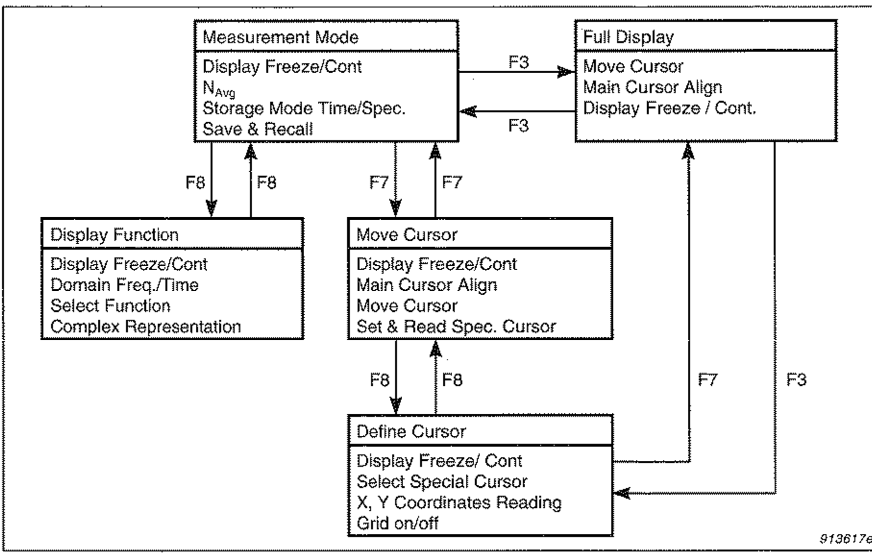


Fig. 5.2 Measurement Mode menu structure showing the functions controlled from each menu

5.3.1 Display Functions

The `Display Func.` page (see Fig.5.3) is used for selecting which functions to display. The functions are split up in two groups, one for the time domain and one for the frequency domain. **"F2"** is used to alternate between the two groups. The functions available (**"F3"** to **"F6"**) are closely related to the Measurement Types menu. Table 5.1 lists the available display functions for the different Measurement Types. Complex spectra, such as intensity, can be displayed as real part, imaginary part, magnitude or phase. Soft key **"F7"** is used to select these options.

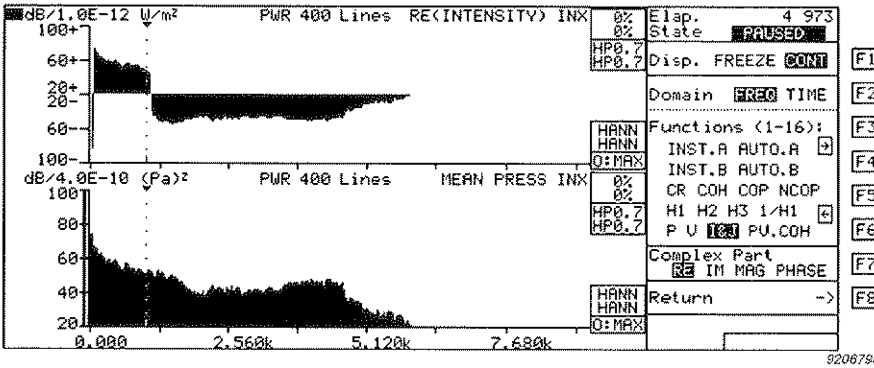


Fig. 5.3 Display Function page for selecting which functions to display in Measurement Mode

Note: Display Functions only applies to what you see on the screen, *not* what is actually saved in the memory. For Single and Normal modes you can choose between saving data as spectra or time records (using `File Saving Mode` on pages 2 and 3 of the Trigger/Multimode menu). For Gated and Matrix modes, data is always saved as spectra even though input data can be displayed in the time domain. This means that there are some limitations on which time domain functions can be displayed when data recorded in these modes is recalled.

Formulae

The display functions are calculated from the following formulae, where G_{AA} and G_{BB} are autospectra and G_{AB} is the complex cross-spectrum:

$$H1 = G_{AB}/G_{AA}$$

$$H2 = G_{BB}/G_{AB}$$

$$H3 = \frac{G_{AB}}{|G_{AB}|}\sqrt{\frac{G_{BB}}{G_{AA}}}$$

The coherence, γ, is calculated as

$$\gamma^2 = \frac{|G_{AB}|^2}{G_{AA} \cdot G_{BB}}$$

For intensity, γ_{pv} is given by

$$\gamma^2_{pv} = \frac{I^2 + J^2}{p^2 v^2}$$

where I is the active intensity, J is the reactive intensity, p is the mean pressure $(p_A + p_B)/2$, and v is the particle velocity.

5.3.2 Cursor Functions

Two pages in the Measurement Mode menu control the cursors.

The `Cursor Func.` (`Move Cursor`) page (Fig. 5.4, upper screen) is used for moving the main cursor to read the display values (**"F3"** and **"F4"**) and for aligning the main cursors of the upper and lower displays in Dual or Difference Display mode (**"F2"**) (in 2147, the cursors are always aligned and F2 has no influence). When the cursors are not aligned, the **"Upper/Lower"** key toggles the cursor control between the upper and lower displays. Another important function on this page is for setting the special cursor parameter (**"F5"** and **"F6"**). These parameters change with the special cursor selected as explained in section 5.3.3.

The `Define Cursor` page (Fig. 5.4, lower screen) is for selecting which special cursor to display (**"F2"** and **"F3"**). The cursors are explained below. In the time domain, only the Reference Cursor is available.

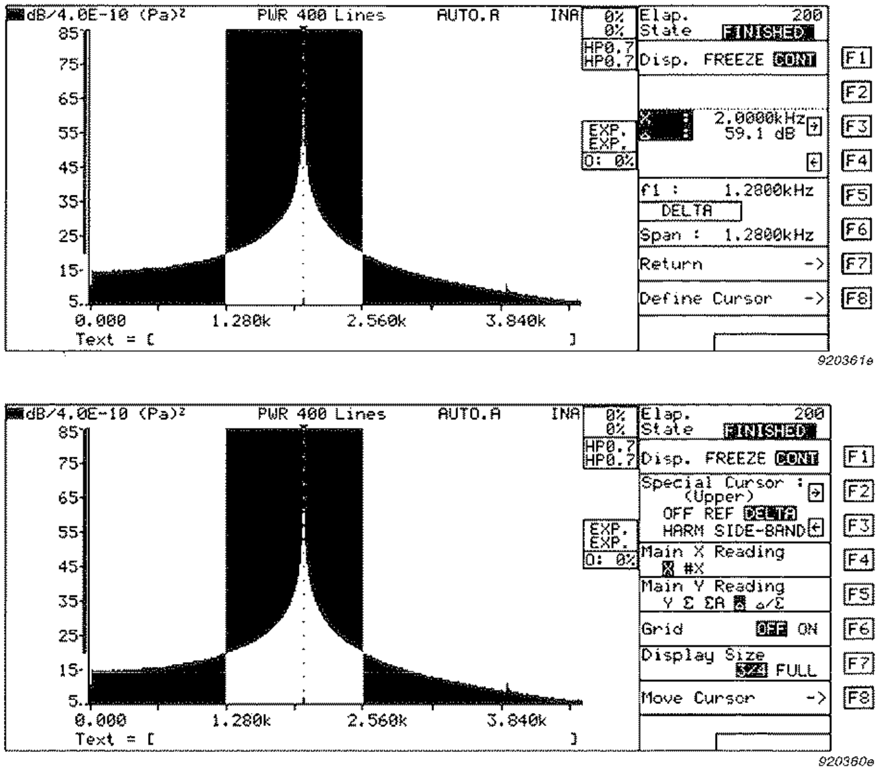


Fig. 5.4 Cursor Function sub-menus for controlling cursor movements and for selecting special cursors and cursor reading in Measurement Mode

Main Cursor

The Main Cursor is always displayed and, therefore, does not have to be selected. It is identified by a black triangle above the cursor line. The possible readings for the Main Cursor (when `Special Cursor` is `OFF`) are: `Y`, Σ or Σ`A` versus `X` or `#X` (see section 5.3.3).

Reference Cursor

When the Reference Cursor is selected, the Main Cursor Y-values are calculated and displayed relative to the Y-value at the Reference Cursor frequency or time, which is entered on the `Move Cursor` page in one of the following two ways:

- Key-in a value for the Reference Cursor frequency or time and enter it by pressing **"F6"**.
- Move the Main Cursor to the desired reference frequency or time and press **"F5"** to enter it as the Reference Cursor frequency or time.

The possible readings for the Reference Cursor are: Y, ΔY, Σ or ΣA versus X, #X, or ΔX (see section 5.3.3). Σ and ΣA are only available in the frequency domain.

Delta Cursor (frequency domain only)

The Delta Cursor is used for calculating power or energy in a part of a spectrum. The result of the calculation is read out on the `Move Cursor` page. The units for the value follow the setting of the Spectrum Unit (Display Set-up menu), which is also displayed in the Spectrum Header, in such a way that the sum over RMS and PWR do not change unit but ESD and PSD are converted to Energy and Power, respectively. The part of the spectrum defined by the Delta Cursor is shown in inverse video. The delta-band is set on the `Move Cursor` page in one of the following two ways:

- Move the Main Cursor to the start of the desired delta-band and press **"F5"**. Then key-in a numeric value for the frequency span and enter it by pressing **"F6"**.
- Move the Main Cursor to the start/end of the desired delta-band and press **"F5"**. Then move the Main Cursor to the end/start of the desired delta-band and press **"F6"** (without keying-in a numeric value) to define the band.

The possible readings for the Delta Cursor are: Y, Σ, ΣA, Δ, or Δ/Σ versus X or #X (see section 5.3.3).

Harmonic Cursor (frequency domain only)

The Harmonic Cursor is used to identify harmonics in a spectrum where the fundamental frequency is known. The analyzer displays cursor lines for all higher harmonics. 64 harmonics can be shown, the first 16 of which are numbered. The fundamental frequency is set on the `Move Cursor` page in one of the following two ways:

- Key-in a value for the fundamental frequency and enter it by pressing **"F5"**.

The possible readings for the Harmonic Cursor are: Y, ΔY, Σ or ΣA versus X, #X or #HRM (see section 5.3.3).

Side-band Cursor (frequency domain only)

The Side-band Cursor is used for identifying possible spectral side-band effects of modulated signals. The analyzer displays one cursor line at the centre frequency with equidistant cursor lines on both sides. The Side-band Cursor is set on the Move Cursor page in the following way:

Move the Main Cursor to the centre frequency and press **"F5"** (or key in a centre frequency). Then key-in a numeric value for the side-band "span" and enter it by pressing **"F6"**.

The possible readings for the Side-band Cursor are: Y, ΔY, Σ or ΣA versus X, #X or #SDB (see section 5.3.3).

5.3.3 Cursor Readings

Display Options for X-values

"F4" on the Define Cursor page selects the type of X-coordinate readings. The options are:

X: X-value as time or frequency

#X: X-value as display line number

ΔX: X-value as the difference in time or frequency between Main Cursor and Reference Cursor

#HRM: Decimal value of harmonic number

#SDB: Decimal value of side-band number

Display Options for Y-values

"F5" on the Define Cursor page selects the type of Y-axis reading. The options are:

Y: Y-level or -value as defined in the Display Set-up menu

Σ: Total power or energy across the entire frequency band. Power is calculated if the Spectrum Unit is PWR or PSD, and energy if the Spectrum Unit is ESD (see the Display Set-up menu)

ΣA: Same as Σ, but the spectrum is A-weighted

ΔY: REF: Main Cursor Y-value minus Reference Cursor Y-value; HARM: Main Cursor Y-value minus fundamental frequency Y-value; SIDEBAND: Main Cursor Y-value minus centre frequency Y-value

Δ: RMS power or energy in the delta band

Δ/Σ: RMS power or energy in the delta band divided by total RMS power or energy

Display Grid

The display grid is set to OFF as default to avoid interference with cursor lines. It can, if appropriate, be switched on by pressing **"F6"** on the Define Cursor page.

5.4 Trigger/Multimode

Type 2148 has four analysis modes: Single Measurement, Gated Multispectrum, Normal Multispectrum/Time Capture, and Matrix Multispectrum. These, together with the trigger conditions, are set up using the Trigger/Multimode menu.

5.4.1 Trigger Types

Type 2148 uses two types of trigger: Measurement Trigger which enables averaging (single/gated) or starts the collection of spectra in an opened file (normal/matrix), and Record Trigger which starts the collection of one block of data and average. The settings for these triggers are explained for each measurement mode in the following subsections. Note, however, that only one of the two triggers can be freely selected at any one time – the other depends on the measurement mode selected.

For the trigger which is freely selectable, the following settings are available:

- Internal
- External
- Clock
- Manual
- Free-run

Internal Trigger and Peak Hold

This trigger function works in the time domain. The trigger is specified on page 6 of the Trigger/Multimode Menu, where you can enter a trigger value in dB or metric/imperial absolute units (default is metric) and specify triggering on positive or negative slope.

The trigger resolution is $2\Delta T$ in baseband and ΔT in zoom.

A column on the left-hand side of the screen shows the peak of the signal. The analyzer starts measuring when you enter the menu. When a peak hold measurement is started, the peak value of the input signal (after the input filters) is detected and held. The measurement can be restarted, paused and proceeded using **Averaging Control**. To measure a new peak value, press **Averaging Control "Start"**. The peak value on the column has no sign.

External Trigger

The external trigger starts data collection when the down-going edge of a 5 V pulse appears at the **Trigger Input** socket on the rear panel of the analyzer. This trigger is described in section 3.2 and functions as illustrated in Fig. 3.7. With Single and Gated and a delay from trigger to ch. A ≥ 0, the resolution is $2\Delta T$ in baseband and ΔT in zoom. Otherwise, it is 1 ms.

Clock Trigger

This triggers data collection at a specific time. Use the Clock Trigger (page 6 of the Trigger Multimode menu) to select the time to start data collection and the time (repetition) interval between triggers.

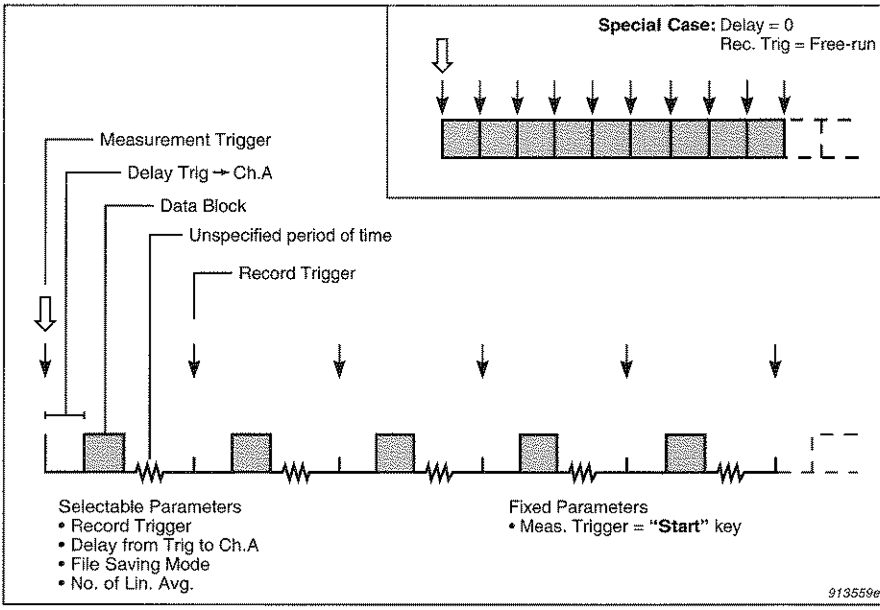


Fig.5.5 Selectable parameters for data collection in Single Measurement mode

Manual Trigger

Data collection starts when **Trigger "Manual"** is pressed on the front panel of the analyzer.

Free-run

Data collection starts when **Averaging Control "Start"** is pressed on the front panel of the analyzer.

5.4.2 Single Measurement

Fig. 5.5 illustrates data collection for a Single Measurement. The figure applies to the collection of both spectra and time records and shows only one channel.

In Single Measurement mode, the Measurement Trigger is always `START-KEY`. This means that the measurement starts when

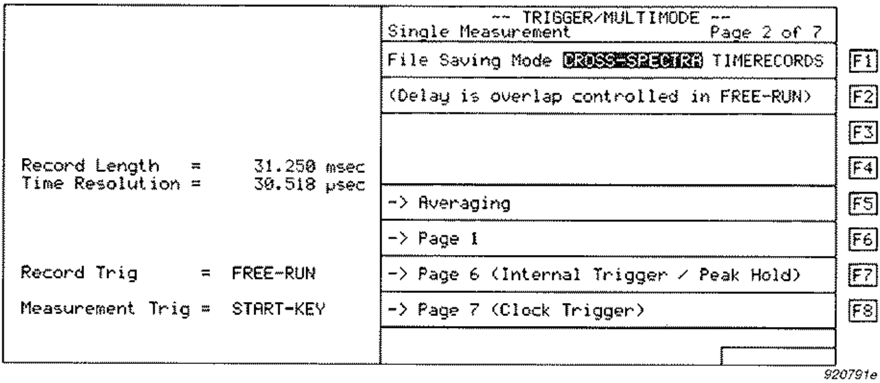


Fig. 5.6 Trigger / Multimode Single Measurement menu

the analyzer is in Measurement Mode and **Averaging Control "Start"** is pressed.

The Record Trigger is set using **"F2"** on page 1 of the Trigger/ Multimode menu. If Record Trigger is set to FREE-RUN, the data blocks are collected without other delay than the one specified. FREE-RUN is the only type of record trigger which allows an overlap to be set.

To make a single measurement:

1. In the Trigger/Multimode menu, select SINGLE using **"F1"**.
2. Use **"F2"** to select the required trigger.
3. Press **"F3"** to go to the Single Measurement menu (Fig. 5.6).
4. Use **"F1"** to specify whether you want to save cross- or autospectra (dependent on measurement type) or time records.

   Note: Saving data in 2-channel mode takes up twice as much memory space as in 1-channel mode since two parameters are measured simultaneously and saved with each measurement. Saving data as cross-spectra in cross mode takes up four times as much memory space as in 1-channel mode since four parameters are measured simultaneously and saved with each measurement. By saving the data as

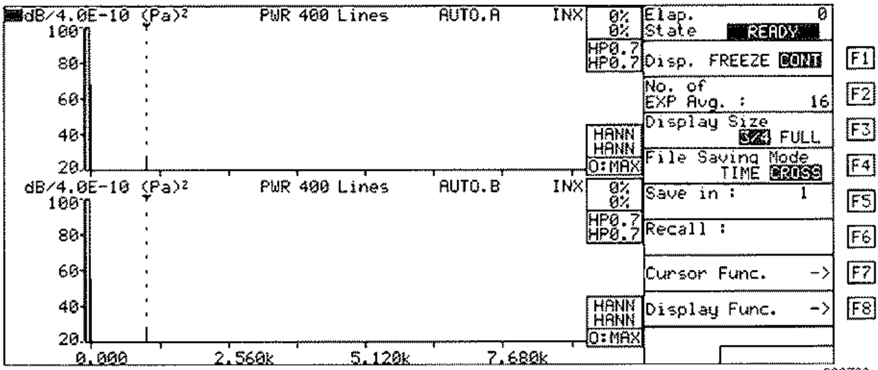


Fig.5.7 Measurement Mode – Single Trigger menu, page 1

time records instead, half the memory can be saved for other use.

5. If all other analyzer settings are as required, press **"Meas. Mode"** (Fig.5.7).

6. You can now make your measurements, save and recall files, select display and cursor functions, etc.

   Note: You can also change the file saving mode here, without going back to the Single Measurement menu.

5.4.3 Normal Multispectrum and Time Capture

Normal Multispectrum

Normal Multispectrum is mainly used for the analysis of non-stationary events. A series of spectra can be recorded versus time (or time-dependent parameter) and stored in a multispectrum. Fig. 5.8 illustrates the collection of a Normal Multispectrum. It applies to the collection of spectra (not time records) and shows only one channel.

The Record Trigger is always `FREE-RUN` in Normal Multispectrum mode.

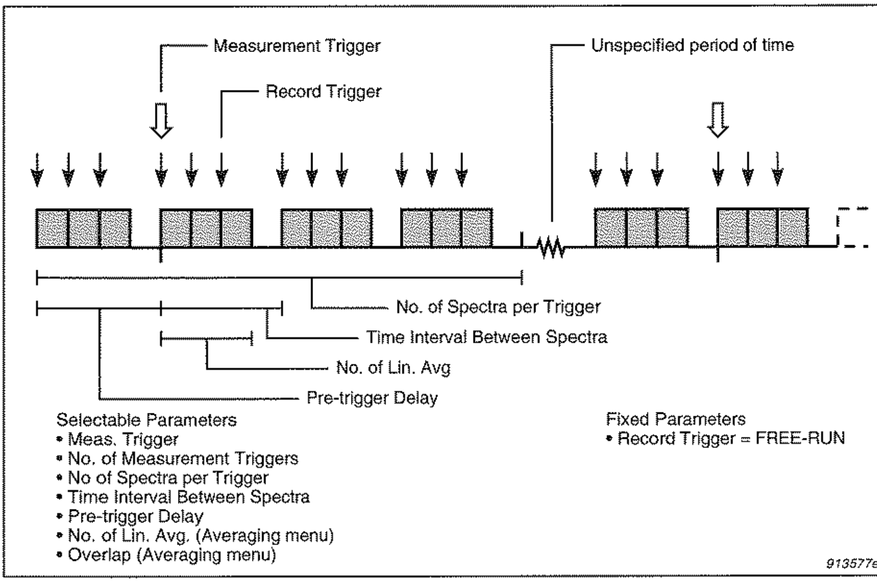


Fig. 5.8 Selectable parameters for data collection in Normal Multispectrum mode (pre-trigger delay shown)

The Measurement Trigger is defined on page 1 of the Trigger/ Multimode menu.

Time Capture

Time Capture is similar to Normal Multispectrum, except that time records are collected instead of spectra. Fig. 5.9 illustrates the Time Capture principle. The figure shows only one channel.

The Record Trigger is always `FREE-RUN` in Time Capture mode and Overlap is always 0%.

The Measurement Trigger is defined on page 1 of the Trigger/ Multimode menu.

Normal Multispectrum Menu

This menu, shown in Fig. 5.10, is page 3 of the Trigger/Multimode menu, and is selected by pressing **"F4"**.

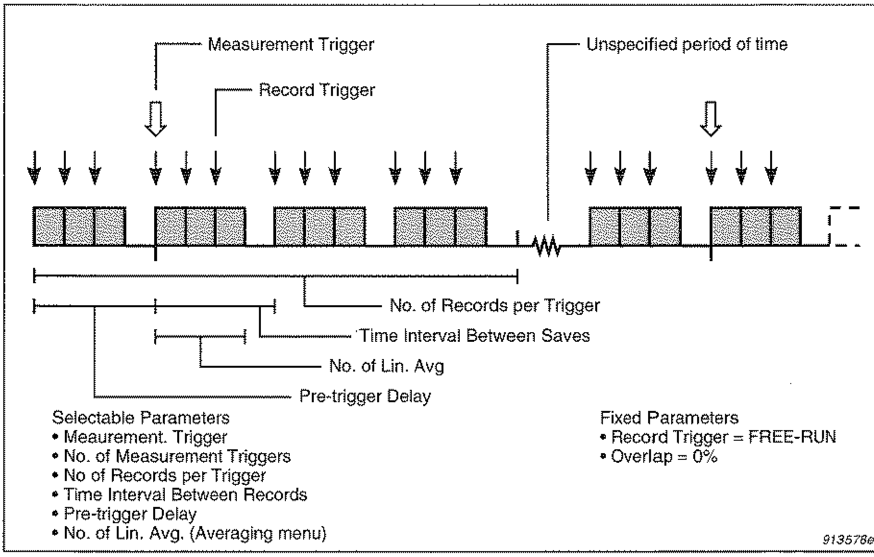


Fig.5.9 Selectable parameters for data collection in Time Capture mode (pre-trigger delay shown)

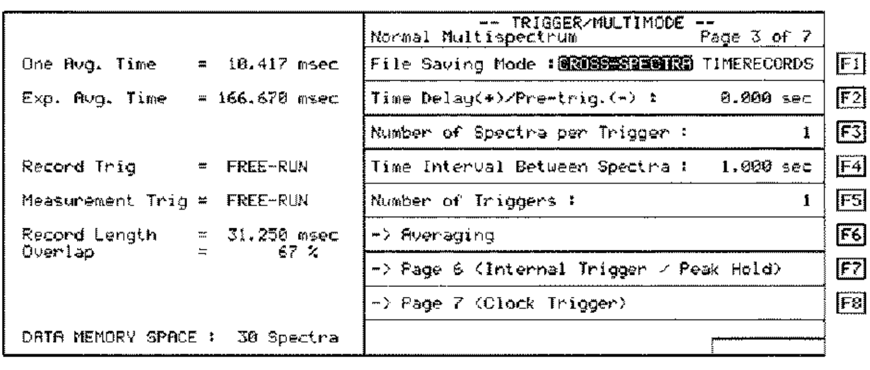


Fig.5.10 Page 3 of the Trigger/Multimode menu – Normal Multispectrum and Time Capture

Note that for this menu it is important to select whether you want to save spectra or time records *before* you go to Measurement Mode. As a guide, the bottom line on left-hand side of the screen indicates how much DATA MEMORY SPACE is free.

In order to be able to save a multispectrum, a file must first be opened by pressing **"F5"** Open File No. When the measurement is finished, the file is automatically closed and the field informs you how many spectra were saved.

Note that a file can only be opened when the measurement status is showing READY. If it does not, press **"F4"** (Terminate Averaging and File).

"F4" (Terminate Averaging and File) is used for interrupting the collection of a multispectrum. For example, you do not always know beforehand how many spectra you need in a multispectrum. Pressing **"F4"** during a multispectrum measurement causes the file to be closed immediately and the data to be saved.

The total number of spectra/records in a multispectrum file is "No. of Spectra/Records per Trigger" multiplied by "Number of Triggers".

If the record length is equal to the linear averaging time and the time interval between records, then one long time record is collected for each Measurement Trigger.

Viewing Multispectra

A single spectrum in a multispectrum can be viewed in Measurement Mode by keying-in its file number FFF.III (III is the index number, the position in the multispectrum) and using the Recall function ("F6").

A more convenient way, however, is to use the Data View menu. This menu allows you to recall a file, FFF, containing an entire multispectrum which can then be viewed in several ways: level versus frequency (you can scroll through the index numbers), level versus index (you can scroll through the frequencies), or overload percentage versus index (you can select channel A or B).

Hints for Setting Up Normal Multispectra

Many of the parameters used to set up normal multispectra are interactive. Therefore, where the 2148 will not allow you to enter the parameter value you wish, it might be because of some other parameter setting. In this case, you must check the rest of the set-up.

If linear averaging is selected, you may find that the 2148 will not let you enter the time interval you wish because it is shorter than the selected linear averaging time. If this happens, the analyzer displays the message `INTERVAL TOO SMALL`, and sets the time interval between spectra equal to the linear averaging time. If you want a smaller interval, you must reduce the averaging time first.

It is possible to check the functioning of a set-up for normal multispectrum collection by going to Measurement Mode and pressing **Averaging Control "Start"** without first opening a file. The collection will proceed but the results will not be saved. This gives you the opportunity to check trigger levels and so on. When the checks are complete, the measurement status can be returned to `READY` by pressing **"F4"**.

Gated Multispectrum

Gated Multispectrum is intended for use in the investigation of the variation of measurement parameters as a function of position in a repetitive cycle. Fig. 5.11 illustrates the collection of a Gated Multispectrum. The figure applies for collection of spectra and shows only one channel.

In Gated Multispectrum mode, the Measurement Trigger is always `FREE-RUN`. This means that the measurement starts when the **Averaging Control "Start"** key is pressed. Unlike normal multispectrum measurement, it is not necessary to open a file to receive the multispectrum.

The Record Trigger is set using **"F2"** on page 1 of the Trigger/Multimode menu. Usually, an external trigger is needed, for example from a photoelectric probe, to obtain good accuracy of the trigger timing.

The `Monitor Spectrum No.` field of the Measurement Mode menu is used if you wish to monitor one particular spectrum in a trigger cycle during measurements. The spectrum number is keyed-in and entered using **"F4"**. Otherwise, if nothing or "0" is entered for the spectrum number, you monitor the input buffer.

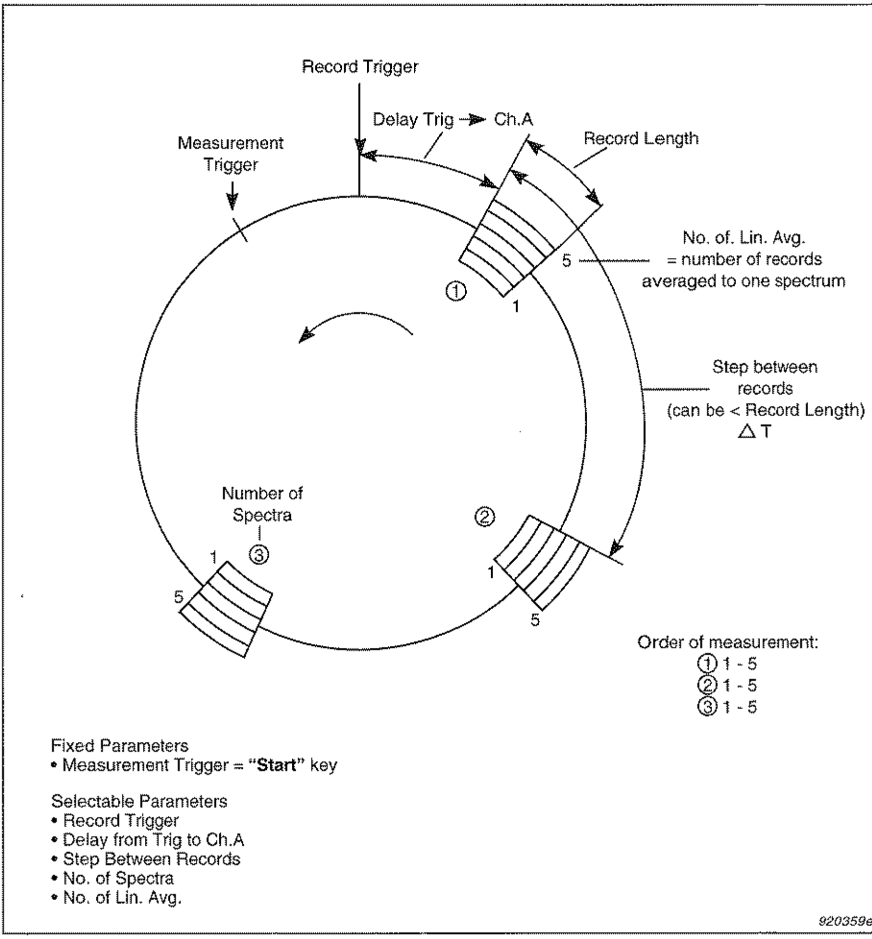


Fig. 5.11 Selectable parameters for data collection in Gated Multispectrum mode

Suppose, for example, that the analyzer is set up to measure a gated multispectrum on a machine. Five linear averages are made at each of three positions in a machine cycle (Fig. 5.11). When **Averaging Control "Start"** is pressed, the analyzer waits for the first Record Trigger. A Record Trigger is needed for each of the 15 spectra. First, five spectra are measured for position ① and these spectra are averaged into the first spectrum in the gated multispectrum. Then the analyzer steps to position

② and averages all the spectra there before stepping to position ③ to measure and average the final five spectra. The result of the operation is a gated multispectrum consisting of three spectra.

Note: The maximum number of spectra in the gated multispectrum is determined by the measurement type and by the number of lines. For example, if the analyzer is set up for single channel analysis, 400 lines, then the maximum number of spectra is 16.

5.4.4 Matrix Multispectrum

Matrix Multispectrum is a special version of Normal Multispectrum: Number of spectra per trigger is always 1, and the number of Measurement Triggers is determined by the specified number of row, columns, and directions. Record Trigger is FREE-RUN. Averaging is linear only.

Measurement Trigger can be chosen freely, but is usually set to MANUAL for this type of measurement. The total number of Measurement Triggers for a Matrix Multispectrum file is equal to Number of Rows × Number of Columns × Number of Directions.

When you key-in the number of directions for each measurement point (see Fig. 5.12), the corresponding directions are displayed on the left-hand side of the screen. The z-axis is perpendicular to the surface enclosing the measurement object.

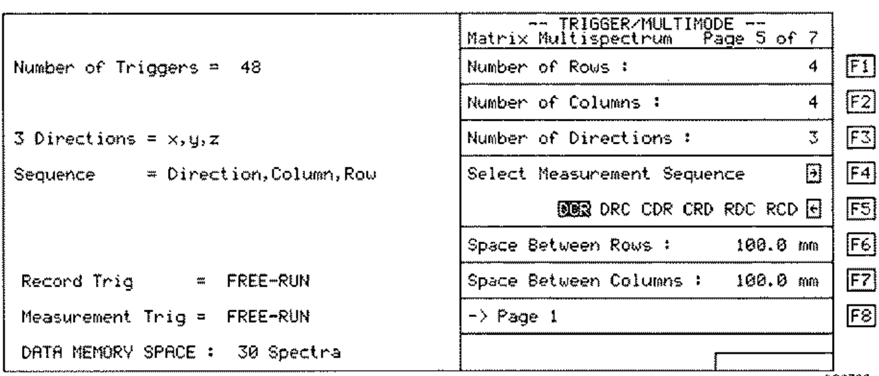


Fig. 5.12 Menu for setting up parameters for a matrix multispectrum

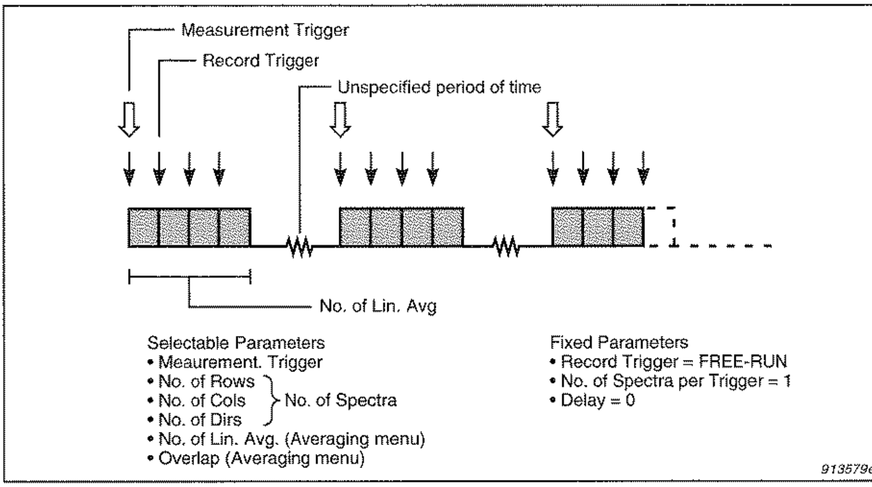


Fig. 5.13 Selectable parameters for data collection in Matrix Multispectrum mode

In Measurement Mode, the `Open File No.` and `Terminate Averaging and File` fields (described in section 5.4.3) include a special function: when a file is opened (by pressing **"F4"** in the Measurement Mode menu) the text `Open File No.` changes to `Delete Last Spec`. This gives a convenient way of deleting the last measured spectrum if a measurement fails. You cannot delete the last, for example, three spectra by pressing **"F4"** three times.

For single channel measurements, the lower half of the display gives information about which row, column and direction is to be measured next. The field is not interactive and is updated automatically as the measurement proceeds.

Fig. 5.13 illustrates the collection of a Matrix Multispectrum (one channel).

5.5 Sound Intensity Probe Type 3548

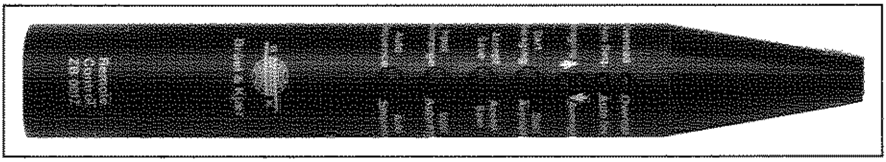


Fig. 5.14 Remote Control Handle ZB 0017 of Sound Intensity Probe Type 3548

Dual-channel Signal Analyzer Type 2148 (but not Type 2147) is designed to work with Sound Intensity Probe Type 3548 and has an 18-pin socket on the rear panel for single-cable connection (see section 3.2). Remote Control Handle ZB 0017, which is a part of Type 3548, is shown in Fig. 5.14.

ZB 0017 has four buttons which correspond to hard keys on the 2148:

"Start Averaging": If the analyzer is set up for Matrix Multi-spectrum with manual trigger, this button corresponds to the **"Manual Trigger"** hard key on the 2148.

"Accept Save": For matrix multispectra with manual trigger, this button has the same function as the **Averaging Control "Stop"** hard key on the 2148, but the saved spectrum will be frozen on the display if linear averaging is chosen.

"Input Autorange": Has the same function as the **"Auto-range"** hard key on the 2148.

"Autosequence": Corresponds to the **Autoseq. "Stop/Step"** hard key on the 2148 and is used for executing an autosequence.

Note: The LEDs on ZB 0017 are updated every 0.5 s.

Chapter 6

Details of Menus

6.1 Overload Indication

Instantaneous Overload

Instantaneous overloads for both input channels are indicated by the Overload LED on the front panel.

Cumulative Overload

Cumulative overloads for each input channel are shown on screen in the overload `A:` and `B:` status fields in Measurement Mode. Each overload is calculated as the percentage of the averaging time.

Common Mode Overload

Common Mode overloads are indicated by the message `COMMON OVL.` in the error field in the lower right-hand corner of the screen (just above the echo field). This type of overload occurs when the common mode input signal exceeds 2V (referred to analogue ground) and is likely to be caused by bad earth connections (see section 2.2).

Analogue Protection

Severe overloads, such as electrical shocks, are indicated by the message `PROTECT` in the display error field. The analyzer short-circuits the inputs to analogue ground to protect the input filters and amplifiers. To escape from protect mode you can either press "Reset" or go to the Input menu and press **"F6"** (`Input Protect`).

Overload Reject

If overload reject is switched on and an overload is detected, data will not be included in the averaging process for a period of time specified in the `Reject Hysteresis` field. You can enter your own values into this field (0 to 1000s), based on your knowledge of the input signal and the overload messages displayed in the measurement mode. Here the overload is given as a percentage of the averaging time.

6.2 Input

When a dual-channel analyzer is used in single-channel mode, the operational channel is selected by using **"F1"** in the Input menu.

In order to take care of any DC offset in the analogue input module, a pure digital DC compensation can be selected by pressing **"F7"** in the Input menu. When this is set to ON, the analyzer performs a running DC evaluation and compensation. The digital DC estimate is reset when the attenuators or Input Type are changed.

6.3 Averaging/Channel Delay

6.3.1 Averaging Mode

The Averaging Mode, linear or exponential, is set in the Averaging/Channel Delay menu using **"F1"**, or in Measurement Mode using the **Averaging Mode "Lin."** and **"Exp."** hard keys.

Number of Averages is set in the Averaging/Channel Delay menu using **"F2"** or in Measurement Mode (first page) using **"F2"**. Averaging "times" are given in number of averages rather than in seconds. The relation between these is given in equation (3.1):

$$T_{avg} = (N_{avg} - 1) \times (\frac{100 - OVLP}{100}) \times RL + RL \qquad (3.1)$$

where

T_{avg} is the averaging time in seconds

N_{avg} is the number of averages

$OVLP$ is the overlap percentage (see below)

RL is the record length in seconds. This parameter is calculated by the analyzer and displayed (as Record Time) in the Time/Freq Parameters menu.

6.3.2 Overlap

The overlap percentage is set in the Averaging/Channel Delay menu using **"F4"**. Fixed overlaps of 0%, 50%, 67%, and 75% are available. MAX overlap maximizes the overlap according to the analyzer's set-up. The overlap can be anywhere between 0 and 100%, depending on the settings of sampling frequency, zoom, and trigger mode. The analyzer calculates an estimate for the overlap percentage and displays it on the left-hand side of the menu display.

The setting of Record Trigger in the Trigger/Multimode menu controls the `Free-run Overlap` field of the Averaging/Channel Delay menu. If this field is empty or inactive, it is because Record Trigger is not set to `FREE-RUN`.

6.3.3 Averaging Delay

Delay: Trigger → Ch. A

A delay can be set so that channel A starts averaging a specified period of time after a trigger is detected. This delay is set in the Trigger/Multimode menu using **"F2"** in Single Measurement mode (page 2) or Normal Multispectrum mode (page 3), or using **"F1"** in Gated Multispectrum mode (page 4). This delay can also be negative, resulting in information prior to triggering being included in the measurement.

Delay: Ch. A → Ch. B

In dual-channel mode (2148), a delay can be set to start channel B averaging after channel A. This delay is set in the Averaging/Channel Delay menu using **"F3"**.

6.3.4 Autorange Time (2148, 2144/7651 only)

The default autorange time is 2s. In the Averaging/Channel Delay menu, it can be set to values ranging from 100ms to 1 min.

6.4 No. of Lines

The transform size (and consequently the frequency resolution) is determined by the selection of Number of Lines in the Time/Freq Parameters menu. The number of lines in the FFT can be set to 50, 100, 200, 400 or 800 using **"F1"**. A setting of 400 lines, for example, gives a spectrum with 512 lines of which 401 (400 plus DC) are displayed. This corresponds to a transform size of 1024 samples.

Usually, selecting the frequency resolution is a compromise between speed and accuracy. For the 2148 it is, however, a matter of memory space, since the spectrum recording rate is greater than 128 spectra per second, even for 400-line autospectra (1-channel). The number of autospectra or time records that the basic data memory (512kb) can hold is shown in Table 6.1.

No. of Lines	No. of Spectra			No. of Time Records		
	1 ch	2 ch	Cross	1 ch	2 ch	Cross
50	503	335	201	335	201	201
100	335	201	111	201	111	111
200	201	111	59	111	59	59
400	111	59	30	59	30	30
800	59	30	15	30	15	15

Table 6.1 Maximum numbers of spectra and time records in Data Memory as a function of Number of Lines for 1-ch, 2-ch and cross functions

If more memory is required, a memory extension to 2Mb total, WH 2921, is available. With this extension, the number of spectra and time records is increased by a factor of approximately 13.

6.5 Baseband Analysis

In baseband analysis, the upper frequency ranges from 0.7Hz up to 25.6kHz (both single and dual channel). The span can be stepped up or down in a binary sequence. Alternatively, you can step up or down the resolution, i.e. the line distance in Hz. The frequency resolution is determined by the size of the transform, i.e. the number of lines, and is equal to Frequency Span divided by No. of Lines. The time resolution, which is displayed on the left-hand side of the screen in the Time/Freq Parameters menu, is $1/f_s$, where f_s is the sampling frequency. With baseband analysis, the frequency resolution is increased by increasing the transform size (No. of Lines) or decreasing the frequency span.

6.6 Zoom Analysis

There are certain situations where baseband analysis does not provide the resolution necessary to analyse a spectrum. It is, however, possible to increase the resolution over a specific portion of the spectrum (without increasing the transform size) by applying the Zoom function.

Zoom is set to ON by pressing **"F4"** in the Time/Freq Parameters menu. Type 2148 uses real-time zoom (as opposed to non-destructive zoom). The number of lines in the magnified portion of the spectrum is the same as that selected for the whole transform.

The zoom function has a centre frequency range from 4Hz to 24.0kHz (the limit set by the analog input module). For centre frequencies f_c from 4Hz to 99Hz the frequency resolution Δf is at least 0.1mHz. From 100Hz to 999Hz it is at least 1mHz. For $f_c \geq 1$kHz, the minimum value of Δf is 100mHz for single channel analysis, and 4Hz for dual channel analysis in the range 12.0kHz to 24.0kHz.

Applying zoom to a spectrum reduces the dynamic range of the system in the vicinity of the zoom centre frequency. The reduction depends on the selected frequency span: the narrower the span, the greater the reduction. Typically, the reduction is about 3dB, but is always <7dB, even in worst cases.

6.7 Time Weighting

Five time weighting functions ("time windows") can be selected in the Time Weighting Function menu which is found on page 2 of the Main menu. The weighting functions are: Rectangular, Hanning, Flat-Top, Transient, and Exponential. Transient and Exponential windows have selectable position and length.

In dual channel mode, different windows can be used on each input. For example, a flat or transient window can be used to measure a transient input signal on channel A, while the exponential window is used to measure the system response on channel B.

6.8 Spectrum Weighting

Analogue A-weighting

An analogue A-weighting filter is selectable in the Input menu for probe, preamp. and direct inputs. This allows the analysis of signals which are A-weighted before FFT.

Digital A-weighting

Digital A-weighting can be applied to a spectrum just before it is shown on the display but it is not saved along with the measurement. It is selected as special cursor ΣA in Measurement Mode.

Digital A-weighting is also available on page 4 of the Spectrum Calculator menu.

6.9 Zero Padding and Bow-tie Correction

Zero padding and bow-tie correction are used to avoid circular folding in the calculation of correlation functions for continuous signals. The zero padding sets the second half of each time record to zero. The bow-tie correction is required to remove the ramp bias error caused by the zero padding (due to the decreasing amount of overlap between the two time records for increasing time shifts).

For transient signals (where the combined length of the A- and B-channel signals is shorter than one block of data) it is not necessary to use zero padding when calculating correlation functions. Note, however, that the bow-tie correction is never used without zero padding active.

Selecting Zero Padding and Bow-tie Correction

Zero padding is selected in the Time Weighting Function menu using **"F1"**. It can be applied to both input channels, simultaneously or individually. Default is NONE.

Bow-tie correction is specified for the upper and lower displays in the Display Set-up menu. It is only applicable to correlation functions in the time domain, i.e. pages 3 and 5 of the Display Set-up menu. Bow-tie correction is set ON or OFF using **"F5"** on these pages. Default is OFF.

6.10 Data View

Cursor Facilities

The Data View menus allow the same cursor facilities as are available for Measurement Mode. These are described in section 5.3.2.

Overload Slice

Type 2148 allows three choices of x-axis: FREQ, INDEX and OVL. OVL displays an overload slice.

When you have measured and saved a multispectrum, and recall the file for display in the Data View menu, you can use **"F2"** to toggle the x-axis to display an overload slice, OVL. For each of the individual measurements in the multispectrum, the slice displays the percentage overload during that measurement.

"F3" and **"F4"** are used to select whether the overload is to be displayed for channel A or channel B. **"F5"** and **"F6"** are used to select the index of a particular spectrum in the multispectrum.

The Y-value for that index, expressed as a percentage, can then be read from the box between F4 and F5.

Note: If you have measured, for example, a 4×4×1 matrix multispectrum, the indices of the slice will range from 1 to 16 and will always be in the same order as which you measured the multispectrum. It is therefore important to remember whether you have measured row, column, direction; column, row, direction; etc.

Chapter 7

Memory

7.1 Saving Measurement Data

7.1.1 Data Memory/Disk Memory

All measurement data can be saved in the internal data memory or on disk. The file structure used for saving data is common to both. Measurement data is first saved in the data memory (for example by pressing key **"F4"** in Measurement Mode) from which it can be transferred to disk. Likewise, measurement data can be transferred from disk to data memory.

The data memory and disk are controlled through the Memory menu which is accessed by pressing **"F4"** on page 2 of the Main menu. Page 1 of the Memory menu is common to both. Pages 2 and 3 apply to the memory type selected on page 1 (in the Select Memory field).

Note:

- The disk drive of the 2148 is designed for use with both high density (HD) and double density (DD) disks.
- In order to save power, the 2148 switches off the analogue input module when the disk drive is in use. When making measurements using a microphone requiring a polarization voltage, it is therefore advisable to wait for 1 or 2 minutes after any operation involving use of the disk-drive before proceeding with measurements.

Storage Capacity

2148 measurement data is saved into files. One file can contain a single spectrum or a multispectrum. The file also contains the measurement set-up used when the data was saved. Both the data memory and DD disks hold a maximum of 111 files, HD disks hold up to 223 files (when formatted on the analyzer). In addition, Table 6.1 gives details of the maximum number of spectra and time records which can be saved in the data memory.

The total capacity of the 2148 internal data memory depends on which limitation is reached first, the maximum number of files or the maximum number of spectra. The total capacity of the disk usually depends on the size of the files being stored, and could be anything from 223 spectra (1 spectrum per file) up to many thousands of spectra (many spectra per file).

7.1.2 File Management

Identifying Files in Data Memory or on Disk

A file list of the data memory or disk can be obtained by selecting page 2 of the Memory menu. When the `Select Memory` field on page 1 is set to `DATA`, the files in data memory are listed. If the field is set to `DISK`, the files on the disk are listed. In either case, each file is identified by its name (a 3-digit number), whether or not it is protected, the type of data in the file, the number of lines used in the analysis, the length of the file, and the time at which it was saved (according to the analyzer's internal clock). For a normal multispectrum, the time indicates when the measurement was started.

Deleting Files

The general method of deleting files is through page 2 of the Memory menu. Protected files (labelled with a `P`) cannot be deleted and must have their protection changed first.

All unprotected files in the data memory or on disk can be deleted at one time by pressing **"F5"** on page 1 of the Memory menu. The decision needs to be confirmed within about 5 seconds by pressing **"F6"**, otherwise nothing will happen.

7.1.3 Data Transfer

Transfer Between Data Memory and Disk

Data transfer between data memory and disk is controlled from page 3 of the Memory menu. When the `Select Memory` field on page 1 of the Memory menu is set to `DATA`, data is transferred from data memory to disk. When the field is set to `DISK`, data is transferred from disk to data memory. Single files can be transferred by placing the cursor on the required file and setting `No. of File(s) to Transfer` to 1. Blocks of files can be transferred by placing the cursor on the first file and specifying how many files are to be transferred. In either case, the transfer is made by pressing **"F4"** (`Copy to Data Memory/Disk`).

Copying Comma Delimited Files

Measurement data can be copied to disk in comma delimited format:

1. Select DATA memory by pressing **"F1"** on page 1 of the Memory menu.
2. Press **"F8"** to go to page 3 (data transfer).
3. Use **"F1"** and **"F2"** to select a file to copy.
4. Press **"F8"** to convert the file format and copy the file to disk.

The comma delimited file can be identified in a directory by its extension TXT, for example 001.TXT.

This format enables a computer to handle the data so that it can be presented in tabular or graphical form, such as spreadsheets. The format is compatible with Lotus 1-2-3.

Back-up of Measurement Data

No non-volatile memory is 100% non-volatile in all situations; electrical shocks, such as static electricity, can erase the memory or a part of it. Therefore: **always make a back-up of your results on disk** before you switch the analyzer off.

7.2 Measurement Text

Additional identification can be given to files using the Measurement Text menu on page 2 of the Main menu. This allows up to 8 different lines of alphanumeric text, each up to 40 characters long, to be defined. One of these lines can then be selected and appended to a particular file. The line of text is then displayed at the bottom of the screen when the cursor is placed on the corresponding file, see Fig. 7.1. It is also displayed in Measurement Mode below the x-axis of a single display. The addition of measurement text can only take place when the file in question is in the data memory. It will, however, be copied to disk (or back to the data memory) along with the rest of the file in a data transfer.

Entry of numeric values, for example measurement position numbers, is easy since the numeric keys on the front panel can

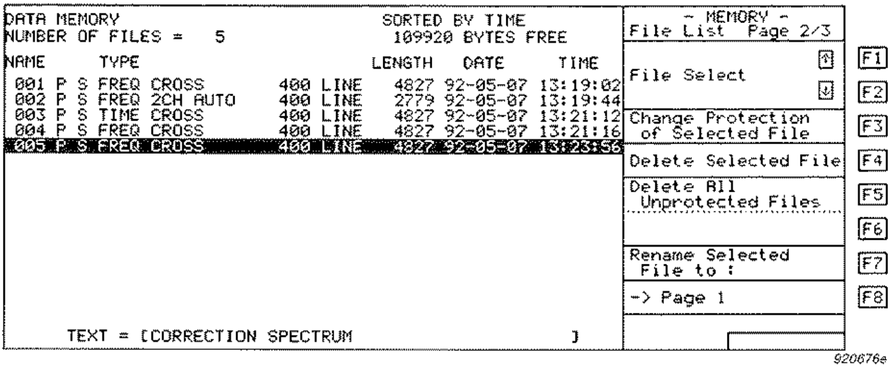


Fig. 7.1 A file list with measurement text being used to add identification

be used. Entering alphanumerics, however, can be a laborious process. In practice, it is easier to write the text on a PC and then read it in over one of the analyzer's interfaces. This can be done either before measurements or, where more than 8 text labels are required, during measurements, as shown in the following example.

Example: Field Use with Lap-top Computer

50 measurements must be made in the field and all data files must be labelled with different text. A lap-top computer set up to communicate with the 2148 is available. A convenient working procedure would be:

1. Call up the Measurement Text menu on the 2148.
2. Press **"Meas. Mode"**.
3. Make a measurement and save the file in the data memory.
4. Press **"Prev. Page"** to go back to the Measurement Text menu.
5. Write the text string on the computer and transfer it to the 2148 (consult the interface manual on how to do this). Use the same text field every time you do this.
6. Using the 2148, key-in the number of the file you saved in step 3 and press **"F7"** (`Copy text to file`).
7. Go back to step 2 and repeat the procedure for the rest of the measurements.

Chapter 8

Preselected Set-ups

8.1 Factory-defined Set-ups

Type 2148 has 3 complete factory-defined set-ups: 1 for each Measurement Type. Cross analysis is default after a Master Reset. Type 2147 has only one factory-defined set-up.

Selecting a Factory-defined Set-up

Set-ups are recalled from the internal memory in three parts: the MEASUREMENT set-up, the DISPLAY set-up and the CALIBRATION set-up. This allows you to decide how much of a particular set-up to recall. Only the activated parts of the preselected set-up override the current set-up. In this way you can use, for example, a standard calibration set-up *without* ruining the measurement set-up you are currently working with.

1. Go to the Preselected Set-up menu on page 3 of the Main menu.
2. Select DEFAULT using **"F3"**.
3. To activate the chosen set-up (or part of it), press **"F4"**, **"F5"**, and/or **"F6"** and leave the menu.

8.2 User-defined Set-ups

Up to 4 user-defined set-ups can be saved in the analyzer's non-volatile memory. Thus, you have instant access to complete set-ups that you use frequently.

Saving a Set-up

1. Specify the set-up parameters through the menu system.
2. Go to the Preselected Set-up menu on page 3 of the Main menu.
3. Press **"F1"** to select the location number at which you want to save the set-up.
4. Press **"F2"** to save the set-up.

Recalling a Saved Set-up

1. Go to the Preselected Set-up menu on page 3 of the Main menu.
2. Press **"F1"** to select the location number from which you want to recall the set-up.
3. Select `SAVED` set-up using **"F3"**.
4. To activate the chosen set-up (or part of it), press **"F4"**, **"F5"**, and/or **"F6"** and leave the menu.

Recalling a Set-up from Memory/Disk File

Whenever the 2148 stores data in memory or on disk, the current set-up used for the measurement is always stored along with the data. This therefore provides a means of storing set-up data on disk or in data memory. The set-up data stored as part of a memory/disk file can be called into the active set-up as follows:

1. If the data is on disk, transfer the file with the required set-up to data memory (see section 7.1.3).
2. Go to the Preselected Set-up menu on page 3 of the Main menu.
3. Set `Recall Reference Set-up` to `ACTIVE` using **"F7"**.
4. Go to Measurement Mode.
5. Key-in the file number of the set-up and enter it using **"F6"**.

When the **Averaging Control "Start"** key is pressed, the measurement is made using the recalled set-up.

Chapter 9

Autosequences

9.1 Autosequence Set-up

Measurements can be automated by using the pushkey autosequence facility in the 2148. A total of 4 autosequences, each consisting of maximum 200 keypushes, can be saved in the analyzer's memory. An autosequence can include any procedure that can be performed manually by using pushkeys on the front panel of the analyzer. Autosequences are used where a measurement procedure is very long, where a sequence of keypushes must be repeated many times, or where measurements must take place without the operator's presence.

The analyzer's set-up (including the field selector positions) is saved with the autosequence when you start the programming. You have the choice between using this "initial" set-up or the analyzer's current set-up when you run the autosequence. The way to do this is to set `Recall Current Autosequence Set-up upon Execution` to `ON` or `OFF`, respectively (**"F7"** in the Autosequence menu). In the first case, the autosequence always starts from the same set-up, which makes it easier to do the programming. Sometimes, however, it is more convenient to start a new autosequence where the previous one ended, especially where you want to execute a series of short sequences. The only exceptions to the above are the I/O Interface and Calibration set-ups which are not saved with the autosequence.

To make the autosequence as short as possible, the analyzer should always be set up for the first measurement before you start the programming.

9.2 Programming and Executing an Autosequence

The programming of an autosequence in the 2148 very much resembles that of a pocket calculator: first the sequence is executed manually, step by step, and then the analyzer is able to repeat it. The general procedure for programming an autosequence is this:

1. Select the Autosequence menu on page 3 of the Main menu.

2. Set `Learn Mode` to `ON` by pressing **"F1"** (the **Autoseq.** LED comes on).

3. Press the required steps for the autosequence (max. 200 steps).

4. After the last step, press **Autoseq. "Stop/Step"**.

   This terminates the programming, saves the sequence as the Current Autosequence and returns you to the Autosequence menu with Learn Mode `OFF`.

5. Use **"F7"** to choose whether the autosequence starts from its own set-up or from the analyzer's current set-up (see section 9.1).

6. Press **"F5"** to execute the current autosequence.

The Current Autosequence can also be executed by pressing the **Autoseq. "Stop/Step"** key (when Learn Mode is `OFF`). This means that you can execute an autosequence directly from any menu, including Measurement Mode.

Note: When you are programming (and editing, see section 9.3) an autosequence, soft key **"F5"** is not active in Measurement Mode (`Save` or `Open File No.`). Its function is, however, implemented when the autosequence is executed. Conversely, **Averaging Control "Stop"** is not implemented when the autosequence is executed, even if it is pressed while the analyzer is in Learn Mode. This is an advantage when a sequence includes measurements with long linear averaging times.

Type 2148 automatically waits for an operation to be completed before executing the next step in an autosequence.

Delay Before Execution

It is possible to delay the execution of the autosequence after **"F5"** or the **Autoseq. "Stop/Step"** hard key is pressed. The delay, which is entered using **"F6"**, can be up to 10 minutes long. The main purpose of this function is to allow the operator time to leave the measurement area before the measurements start. Another application is to allow the analyzer to settle after wake-up (see section 9.4).

Example: Use with Sound Intensity Probe Type 3548

The following autosequence can be used with a dual-channel analyzer with matrix multispectrum and manual trigger (see section 5.4.4) when one of the spectra is incorrectly measured (for example due to external noise). The autosequence deletes the last measured spectrum in a measurement sequence. It is assumed that the analyzer is in Matrix Multispectrum mode:

1. Set Learn Mode `ON` by pressing **"F1"** in the Autosequence menu.
2. Press **"Meas. Mode"**.
3. Press **"F5"** to delete the last spectrum (this key-press is not executed now but will be when the autosequence runs. Also, the text reads `Open File No.` now, but will read `Delete Last Spec.` when the file has been opened).
4. Press **Autoseq. "Stop/Step"** to exit Learn Mode and return to the Autosequence menu.
5. Set `Recall Current Autosequence Set-up upon Execution` to `OFF` by pressing **"F7"**.

This autosequence is used in Measurement Mode the following way:

1. Press **"F5"** to open a file. Note that the text changes to `Delete Last Spec.`
2. Make measurements by pressing the **"Start Averaging"** button on the remote control handle of the probe.
3. When an incorrect spectrum has been measured, execute the autosequence by pressing the **"Autosequence"** button.
4. Press the **"Start Averaging"** button to re-measure the spectrum.

9.3 Editing an Autosequence

The **Autoseq. "Stop/Step"** key can also be used for stepping through an autosequence. As **Autoseq. "Stop/Step"** is pressed, the screen pictures corresponding to each step appear on the display. This function is mainly used when you want to locate an error or want to edit the autosequence. The general procedure is this:

1. Go to the Autosequence menu on page 3 of the Main menu.
2. Press **"F1"** to switch Learn Mode ON.
3. Press **Autoseq. "Stop/Step"** repeatedly to locate the first step that you want to change.
4. Go to the step immediately before that by stepping through the sequence again, and re-enter the rest of the autosequence (see note below).
5. Press **Autoseq. "Stop/Step"** to terminate the programming.

Note: The **Autoseq. "Stop/Step"** key only works as a "step" key as long as no other key is pressed. As soon as another key is pressed, the **Autoseq. "Stop/Step"** works as a "stop" key. For this reason, it is not possible to re-enter a single step in the middle of a sequence and then step on to the end of the sequence.

Deleting the last step(s)

1. Go to the Autosequence menu on page 3 of the Main menu.
2. Press **"F1"** to switch Learn Mode ON.
3. Locate the step that you want to be the last by stepping through the sequence.
4. Go to the step immediately before that by stepping through the sequence again.
5. Repeat the step that you now want to be the last.
6. Press **Autoseq. "Stop/Step"** to terminate the programming.

9.4 Standby Mode

The 2148 can execute an autosequence at any pre-set time. The sequence can be repeated a maximum of 9999 times at fixed intervals.

The Wake-up Function

To prepare the execution of an autosequence in Standby Mode:

1. Go to the Autosequence menu on page 3 of the Main menu.
2. Recall the required autosequence to the Current Autosequence location.
3. Press **"F8"** to go to page 1 of the Real-time Clock menu.
4. Set the time for the first wake-up (remember to check that the analyzer's real-time clock is set correctly).
5. If more wake-ups are required, set the number of wake-ups and the time interval between them.
6. Press **"F7"** to activate the Wake-up function.

After approximately 10 seconds, the analyzer turns itself off and enters Standby Mode. This is indicated by the flashing **Standby** LED on the front panel.

Power-on After Wake-up

The 2148 switches itself on (wakes up) at the preset time and goes through the usual power-on self-test (this takes approximately 30 seconds). It then goes directly to the Autosequence menu and executes the Current Autosequence after any preset delay has elapsed. When the autosequence has been executed, the analyzer returns to page 1 of the Real-time Clock menu with Wake-up `ACTIVE`. Wake-up must be switched to `INACTIVE` within about 10 seconds if you do not want the analyzer to go back to standby mode.

If the 2148 is switched on manually when it is in wake-up mode, the message `"Wake up" is active` appears during power on self-test, and the analyzer goes directly to page 1 of the Real-time Clock menu with Wake-up `ACTIVE`. Wake-up must be switched to `INACTIVE` within about 10 seconds unless you want the analyzer to go back to standby mode.

Delay Before Execution

It is usually necessary to set a Delay Before Execution when the analyzer is to execute an autosequence in Standby Mode. This is to allow the analogue circuits time to stabilize. A delay of 2 minutes is appropriate.

Chapter 10

Post-processing

10.1 Spectrum Calculator Menu

The Spectrum Calculator menu has four main functions distributed over 5 menu pages. Page 1 (see Fig. 10.1) is used for multispectrum file modification, described in section 10.2, and gives access to the other menu pages and to the Data View menu (see section 6.10).

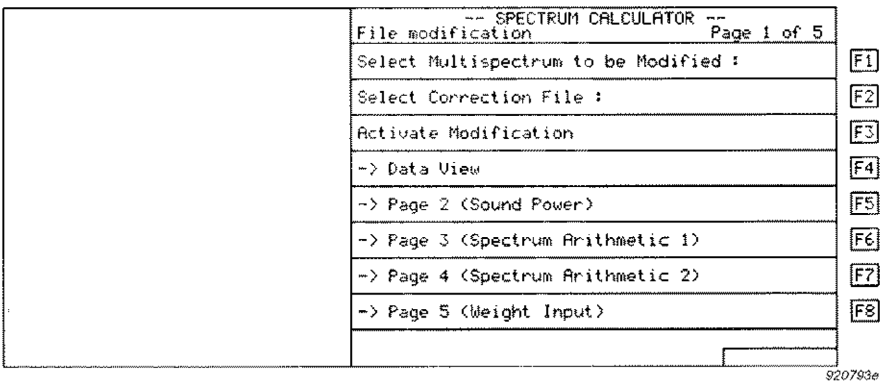


Fig. 10.1 Page 1 of the Spectrum Calculator Menu – File Modification

The second main function is sound power calculation. The calculation is based on either sound pressure or intensity data depending on the Measurement Type. Data must be arranged in a multispectrum (see section 5.4). Sound power calculation is described in section 10.3.

Pages 3 and 4 are intended for relatively simple arithmetic operations on measured data. Such operations could be background noise subtraction, calculation of attenuation, averaging of spectra (where the division by the number of spectra is made using dB subtraction), and so on. Spectrum arithmetic is described in section 10.4. Weightings can also be added to curves as described in section 10.5.

Finally, page 5 allows weightings to be defined, saved and recalled. Details are given in section 10.5.2.

10.2 File Modification

Page 1 of the Spectrum Calculator menu allows you to substitute spectra from one file to another. This is particularly useful if one of the measurements in a multispectrum fails, for example because of unwanted noise. If the measurement conditions allow it (that is, if they are the same as when the multispectrum was measured), then that particular measurement can be made afterwards and substituted for the "contaminated" spectrum.

To modify a multispectrum:

1. Key in the spectrum number of the spectrum to be modified, `FFF.III`, where `FFF` is the file number and `III` the index number, and press **"F1"**.
2. Key in the number (`FFF.JJJ`) of the new spectrum which will replace the original one, and press **"F2"**.
3. Press **"F3"** to activate the modification.

Note:

- The modification is only carried out if the original and replacement spectra were measured with exactly the same measurement set-up.
- Depending on the measurement type, there may be several spectrum types in `FFF.III`. All of them are modified.

10.3 Sound Power Calculation

Sound pressure and sound intensity data arranged in a multispectrum can be used as a basis for sound power calculations. The calculation is made on the whole multispectrum file or a specified part of it. While the calculation progresses, `CALCULATING` is displayed in the error field on the screen.

SPL Measurements

For SPL measurements, the analyzer calculates the sound power using the following equation:

$$L_W = \langle L_p \rangle + 10\log_{10}\frac{S}{S_0}\,\mathrm{dB}$$

where

$\langle L_p \rangle$ is the mean sound pressure level over the enclosing surface in dB re 20µPa

S is the enclosing surface area in m^2

S_0 is the reference surface area ($1\,\mathrm{m}^2$)

Area Correction

The term $10\log_{10}(S/S_0)$ in the equation above is called the Area Correction and must be set ON if you want to calculate sound power. However, setting the area correction OFF provides a convenient way of calculating the mean spectrum for a multispectrum.

Sound Intensity Measurements

For sound intensity measurements, the analyzer calculates the sound power using the following equation:

$$L_W = \langle L_I \rangle + 10\log_{10}\frac{S}{S_0}\,\mathrm{dB}$$

where

$\langle L_I \rangle$ is the mean intensity level over the surface in dB re $1\,\mathrm{pW/m^2}$

S is the enclosing surface area in m^2

S_0 is the reference surface area ($1\,\mathrm{m}^2$)

10.4 Spectrum Arithmetic

Although the Spectrum Calculator menu is intended for relatively simple calculations, it can also handle, through the use of autosequencing, much more complicated calculations where these can be broken down into a series of arithmetic operations and where they are of a repetitive nature. For details on autosequencing, see Chapter 9. If, during a calculation, a result is overrange or underrange, or, for instance, a negative power is obtained, the 2148 sets that result to the appropriate upper or lower limit.

Example: Background Noise Subtraction

Two spectra were measured and saved: one of a source signal contaminated with background noise and one of the background noise only. It is assumed that the background noise was stationary. To obtain the spectrum of the source signal:

1. Go to page 4 of the Spectrum Calculator menu.
2. Recall the spectrum containing the source signal to the upper display using soft key **"F1"**.
3. Press the **"Upper/Lower"** hard key.
4. Recall the noise spectrum to the lower display using soft key **"F1"**.
5. Select `PWR` as calculation mode by pressing **"F5"**.
6. Press **"F7"** (`Upper-Lower→Upper`) to subtract the spectra.

The result is displayed in the upper spectrum and can be saved in a file in the data memory by using the **"Upper/Lower"** key and **"F1"** on page 3 of the menu (for Type 2147, the function is always in "Lower"). The type "CALC." is assigned to the file and displayed in a file list.

Note: The reference used in dB calculation mode always follows the upper display. This means that if the upper and lower spectra have different dB references, then the result of an addition depends on which spectrum is the upper and which is the lower.

Maximum Level Difference

Situations may occur where, due to an insufficient input level, or to too low a value of the number of averages, the spectrum contains very large negative dB values (–256dB). Subtracting such a spectrum using dB subtraction, would render the overall result useless. To overcome this problem:

1. On page 3, select Upper or Lower display using the **"Upper/ Lower"** key (for Type 2147, the function is always in "Lower").
2. Key-in a value for Maximum Level Difference within the selected display (the allowed range is 0 to 100dB).
3. Enter the value by pressing **"F7"**.

This causes all the low levels of the present spectrum to be rounded up, so that the maximum level difference within the spectrum is equal to the specified value.

Reset Buffer

As long as transform size, frequency parameters, sampling frequency, etc. are the same for a number of files, any of these files can be recalled on page 4 of the menu. If however, you want to recall a file with different parameters, you will first have to go to page 3, press **"F2"** `Reset Buffer`, and then return to page 4 to recall the file.

10.5 Spectrum Weighting

Page 4 of the Spectrum Calculator menu allows you to select and add a weighting to or subtract it from the upper recalled curve. **"F3"** selects the type of weighting to be added, and **"F4"** adds the weighting.

There are three ways of obtaining a weight function in the Spectrum Arithmetic menu:

- User-defined weightings U1 to U4 can be entered on page 5 of the menu (section 10.5.2).
- Standard weightings A^{-1}-, A-, B-, C-, D- and L-weighting are permanently available from the internal memory (see Fig. 10.2). If L-weighting is selected, you can enter a constant to be added to the entire spectrum.

10.5.1 Standard Weightings

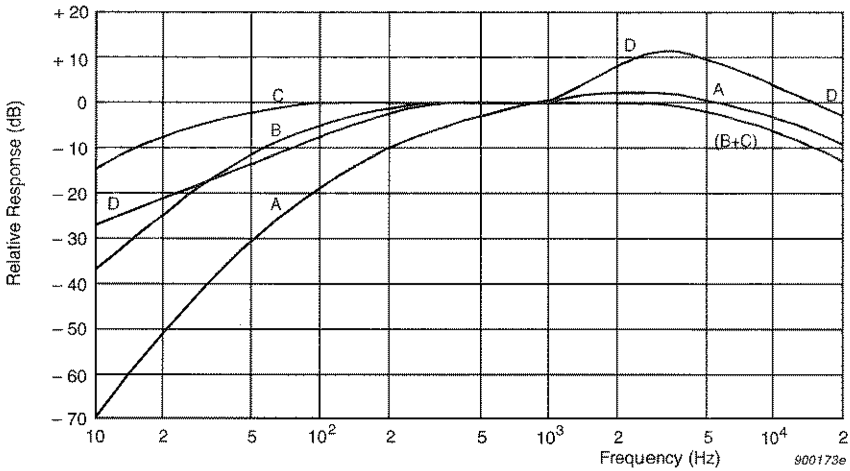


Fig. 10.2 Standard A-, B-, C-, and D-weightings

10.5.2 User-defined Weightings

Entering a User-defined Weighting

User-defined weightings are entered as a series of points, and the analyzer interpolates linearly between the points to produce the complete weighting function. Where required, user-defined weightings can be used as masks. A total of four user-defined weightings can be entered and saved in the non-volatile internal memory in the following way:

1. Select the Spectrum Calculator menu page 5.
2. Select the resolution at which weighting curves are displayed and the cursor is stepped using **"F1"**.
3. Select the frequency at which weighting is required using **"F2"**, **"F3"**, and/or numeric input.
4. Key-in the desired weight level and enter it using **"F4"**.
5. Repeat steps 3 and 4 until all weight levels have been specified.

6. Save the weighting by keying-in the weighting number (1...4) and entering it using **"F7"**.

Saving User-defined Weight Functions and Reference Spectra as Files

Up to four user-defined weighting functions or reference spectra can be saved in the non-volatile memory (as user weightings U1 to U4). If more weighting functions are required, or if it is necessary to store them on disk, they must be made into files. This is done as follows:

1. Create the weighting curve as described above.
2. Go to page 4 by pressing **"F8"**.
3. Use **"F1"** and the **"Upper/Lower"** key to call a dummy spectrum into both upper and lower display.

   The dummy spectrum can be any spectrum saved in the data memory having the same Measurement Type and Number of Lines as the user-defined weighting/reference spectrum.
4. Add the user-defined weighting/reference spectrum, defined in step 2, to the upper display by using **"F3"** and **"F4"**.
5. Use **"F5"** to select dB calculation mode.
6. Press **"F7"** to subtract the spectra and place the result in the upper display.

The contents of the upper display are now the user-defined weighting/reference spectrum. This can now be saved in data memory (and from there to disk) by going to return to page 3 of the Spectrum Calculator menu and using **"F1"**.

Recalling Weightings

Once you have created and saved a weighting (Spectrum Calculator page 5), you can recall it by entering its number (1 to 4) from the numerical keypad and pressing **"F6"**. Entering the number 0 clears the editing buffer.

Chapter 11

Specifications

11.1 Specifications 2147, 2143/7669

Input Characteristics

All inputs single ended. Choice of ground floating or connected to chassis

PREAMPLIFIER INPUT:
Via standard B&K 7-pin Preamplifier Input socket
Input Impedance: 1 MΩ || 130 pF (10 kΩ when not selected)
Input Ranges: Seventeen 80 dB ranges with a FSD from 10 mV to 100 V (RMS sine) selectable in steps of 5 dB (note the maximum input voltage)
Microphone Polarization: 0 V, 28 V, 200 V from 10 MΩ source
Power Supply: 28 V
Heater Voltage: None
High-pass Filter Cut-offs:
−0.1 dB at 0.70 Hz (−3 dB at 70 mHz). Slope 6 dB/octave
−0.1 dB at 20 Hz (−3 dB at 10 Hz). Slope 24 dB/octave
−0.1 dB at 100 Hz (−3 dB at 50 Hz). Slope 24 dB/octave
A-filter: According to IEC publication 651 type 0

DIRECT INPUT:
Via BNC socket
Input Impedance: 1 MΩ || 120 pF
Input Ranges: Seventeen 80 dB ranges with a FSD from 10 mV to 100 V (RMS sine) selectable in steps of 5 dB
High-pass Filter Cut-offs:
−0.1 dB at 0.3 Hz (−3 dB at 26 mHz).
Slope 6 dB/octave
−0.1 dB at 20 Hz (−3 dB at 10 Hz).
Slope 24 dB/octave
−0.1 dB at 100 Hz (−3 dB at 50 Hz).
Slope 24 dB/octave
A-filter: According to IEC publication 651 type 0

ACCELEROMETER INPUT:
Charge input via TNC connector
Input Impedance: 39 Ω || 220 pF
Input Ranges: Eighteen 80 dB ranges with a FSD from 4.5 pC to 80 nC (RMS sine) selectable in steps of 5 dB
High-pass Filter Cut-off:
−0.1 dB at 0.3 Hz (−3 dB at 51 mHz). Slope 12 dB/octave
Low-pass Filter Cut-off:
−0.1 dB at 1 kHz (−3 dB at 2 kHz). Slope −24 dB/octave

MAXIMUM INPUT VOLTAGE:
Type 2147 and 2143/7669 are safety class II instruments (IEC 348). For safe operation in accordance with IEC 348, the voltage of the signal ground relative to earth must not exceed 42 V RMS (sine). To ensure safe operation in accordance with IEC 348 at higher voltages, the user must limit all input currents to 0.7 mA peak
Maximum Input Voltage:
Direct: 200 V peak, 50 V DC
Preamplifier: 7.5 V peak, 50 V DC

MAXIMUM INDUCED COMMON MODE VOLTAGE:
42 V RMS, 100 V peak

COMMON MODE REJECTION:
0.4 Hz to 1 kHz > 80 dB
1 kHz to 25.6 kHz > 60 dB

OVERLOAD DETECTION:
Both analogue and A/D-converter overloads indicated.
Preamp. Input: Overload detection level is decreased to 7.5 V peak, to ensure detection of overload in the preamplifier.

CROSSTALK:
−60 dB

ATTENUATOR LINEARITY:
±0.1 dB

ANTIALIASING FILTER:
Cut-off Frequency: 25.6 kHz. Provides at least 80 dB attenuation of those input frequencies which can cause aliasing

INPUT SAMPLING:
Internal: 65 536 Hz
External: Maximum 65 536 Hz

A/D-CONVERSION:
14 bit

QUANTIZING ERROR:
Maximum 1/2 LSB

Fourier Transform

RESOLUTION:
51, 101, 201, 401 or 801 spectral lines corresponding to time records of 128, 256, 512, 1024 or 2048 samples

CALCULATION RATE:
Calculation of 801 line autospectrum takes < 5 ms including weighting, averaging and overlap

OVERLAP:
0%, 50%, 67%, 75% or maximum. Max. is, for example 67% with 25.6 kHz baseband analysis, 400 lines

WEIGHTING:
Rectangular, Hanning, Flat-top, Transient, Exponential. Transient and exponential windows have selectable position and length. Analogue A-weighting of the input signal is possible

FREQUENCY RANGE:
0.7 Hz to 25.6 kHz in a binary sequence. Baseband or zoom. 15 frequency spans from 1.56 Hz to 25.6 kHz. Resolution of zoom centre frequency setting is 4 Hz for all frequency spans (8 Hz in 1-ch. mode)
Real-time Frequency Range: > 25.6 kHz for 800 lines and 67% overlap (equivalent to 80 kHz single/dual channel for 800 lines and 0% overlap)

System Accuracy

DYNAMIC RANGE:
All distortion (intermodulation and harmonic) and spurious noise at least 80 dB below max. input voltage

OVERALL FREQUENCY RESPONSE:
±0.1 dB from lower frequency limit (0.3 Hz) to upper frequency limit

NOISE:
Voltage input: Measured in 1/3-octave bands in input range 10 mV with input short-circuited:
0.3 Hz to 20 kHz < 1 μV
Charge input: Measured in 1/3-octave bands in input range 4.5 pC with 1 nF transducer capacitance:

0.3 Hz to 2.0 kHz	< 1 fC
2.5 kHz to 4.0 kHz	< 1.5 fC
5.0 kHz to 8.0 kHz	< 2 fC
10.0 kHz to 20 kHz	< 3 fC

AMPLITUDE MEASUREMENT STABILITY:
±0.1 dB

AMPLITUDE LINEARITY:
±0.05 dB or ±0.005% of maximum input voltage, whichever is greater

FREQUENCY ACCURACY AND STABILITY:
0.01% without warm-up (no adjustment necessary)

Detectors

Digital true RMS detection. No crest factor limitation

CONTROL:
Start: Clears the average accumulator and starts an average
Stop: Stops the averaging process
Proceed: Continues an average without clearing the average accumulator
Averaging Gate: External or internal trigger signal for gating of the averaging process

LINEAR:
Averaging without truncation.
Max. number of averages is 32 767

EXPONENTIAL:
1 to 16 384 averages in a binary sequence.

OVERLOAD REJECT:
Any block of data related to overload can be rejected from an average. The hysteresis time after detection of overload can be set in seconds

Hold

Peak Hold: Measures and holds the max. value of the input signal in one channel
Max/Min. Hold: Holds on selected line

Multifunction Trigger

Mode Options: Single measurement (time record or spectrum), Normal Multispectrum/Time Capture, Gated Multispectrum, Matrix Multispectrum.
Trigger Types: Internal, External, Clock, Manual, Free-run
Internal Trigger: On channel A after digital low-pass filtering. Trigger slope selectable
Measurement Start: One measurement trigger starts a measurement process
Record Trigger: One record trigger starts collection of one block of data

Data Memory

Non-volatile internal memory for 111 single spectrum or multispectrum files each labelled with up to 40 characters of user-defined text. The text label is stored together with data and is shown in the file list
Memory Size: 512 kbytes. 128 992 bytes Data Memory corresponding to, for example, 59 801-line spectra or 30 time records 2048 samples long.

Mass Storage

Built-in disk-drive for storage of measured data and optional programs
Data Media: Removable 3 1/2″ double sided, high density micro floppy disk
Data Format: Compatible with PC/MS-DOS from version 3.2. PC-DOS is a trademark of International Business Machines Corporation. MS-DOS is a trademark of Microsoft Corporation
Formatted Capacity: 1440 kbytes
File List: Contains disk identification, user-definable volume label and file list sorting key. Each file is identified by user-definable file number, data type, size and start time of the measurement

Hard Copy

Graphics Printer: Any display on Types 2147 and 2143/7669, including graphics and all notation, can be printed on graphics printers with IBM, HP or Epson print formats or on Brüel & Kjær Graphics Recorder Type 2313

Autosequence

Allows the user to specify an autosequence of front panel keypushes, the functions of which can be executed on command. Maximum 200 keypushes per autosequence. Up to 4 autosequences can be saved in non-volatile memory

Display

Liquid Crystal Display (dot matrix super twisted nematic) with back-light and resolution 480 x 200 points

DISPLAY FORMATS:
Single: A single spectrum showing pressure, acceleration, velocity or displacement
Dual: Two spectra (input spectrum and recalled spectrum) displayed in upper and lower parts of the display, respectively
Difference: Two spectra. The upper is the difference and the lower is the recalled
Slice: A time slice through a multispectrum
Menu: The text shown relates to the soft key control

DISPLAY MODES:
Autospectrum: Display shows autospectrum with 50, 100, 200, 400 or 800 lines
Time Record: Display shows time record which is 128, 256, 512, 1024 or 2048 samples long
Display Size: Display in Measurement Mode extendable from 288 lines (3/4 display) to 801 lines (full display)

Y-AXIS:
Annotation: Absolute units or relative units (dB). Selectable dB reference
Calibration: Direct entry of transducer sensitivity or autocalibration with an appropriate calibrator
Spectrum Type: RMS, power, power spectral density, energy spectral density or energy
Amplitude Scroll: Hard key controls to shift the display up and down.

X-AXIS:
Spectrum Display: Linear frequency scale with annotation in mHz or Hz depending on the setting of Highest Frequency. Upper range from 781.25 mHz to 25.6 kHz in full display
Time Display: Time scale annotated in ms or s, depending on the settings of Highest Frequency and No. of Lines: axis 6.1 ms for 25.6 kHz frequency range and 400 lines, and 1600 s for 0.8 Hz and 50 lines
Slice Display: Linear axis annotated with index numbers from 1 up to a maximum of 853 (representing time, points, etc.)
Frequency Scroll: Hard key controls to shift the display left and right

CURSOR:
Main: Reads level versus frequency for autospectra, level versus time for time records, or level versus index number for slice display
Delta: Defines lower and upper frequency limit for any part of an autospectrum and calculates the power or energy within that frequency range
Harmonic: Identifies harmonics in the spectrum of a signal for which the fundamental frequency is known

Operation

Menus: User-interactive menus are used to set-up the analyzer for measurements. 4 user-defined measurement set-ups can be saved and recalled from non-volatile internal memory
Measurement Mode: For enabling measurements
Spectrum View: For looking at spectra and slices in the internal non-volatile memory

Help Pages: Each user-interactive menu is provided with a corresponding page of help text

IEC/IEEE Interface

Conforms to IEEE 488.1 and IEC 625-1 standards. Any function shown on display (including measured data, post-processed result, measurement set-up, display set-up or calibration set-up) can be transmitted to and from the analyzer

FUNCTIONS IMPLEMENTED:

Source Handshake	SH1
Acceptor Handshake	AH1
Talker	T5
Listener	L3
Service Request	SR1
Remote/Local	RL1
Parallel Poll	PP1
Device Clear	DC1
Device Trigger	DT0

COMMAND SET:
Simple and easy to remember standard engineering English. Resistant to operator error

CODE:
ASCII (ISO 7-bit) code, or binary

INTERFACE TERMINATOR:
Can be specified in the Interface Menu

DEVICE ADDRESS:
Can be specified in the Interface menu

RS–232–C Interface

Conforms with the EIA Standard RS–232–C (equivalent to CCITT V24). Allows remote activation of the front panel key functions via a non-intelligent terminal, either directly or via a modem

Input/Output

Trigger Input: BNC connector for external trigger to start an average instantaneously or with user-defined delay

External Sampling: The sampling frequency can be externally controlled via the Auxiliary II connector (rear panel)

Power Supply

Battery: 6 rechargeable NiCd cells (QB 0008) operate the system for >4 hrs continuous use at 25°C. The operating time is reduced if disk-drive or interface bus is used and decreases with decreasing temperature.

Mains: An external source or filtered DC power in the range of 11–16 V DC will power the analyzer continuously. Brüel & Kjær Power Supply ZG 0199 fits into the slot normally occupied by the battery pack and is powered from 100, 115, 127, 220 or 240 V AC mains supply

Power Consumption: 900 mA during measurements at a typical battery drive-voltage of 7.5 V (back lighting off)

Environmental

OPERATING TEMPERATURE:
Analyzer: –10°C to +55°C (+14°F to +131°F)
Disk-drive: +5°C to +50°C (+41°F to +122°F)

STORAGE TEMPERATURE:
–25°C to +70°C (–13°F to +158°F)

HUMIDITY:
90% RH (non-condensing at 40°C/104°F)

ELECTROMAGNETIC COMPATIBILITY:
Complies with requirements for class B computing device of the American FCC Rules

Cabinet

DIMENSIONS:
Height: 175 mm (6.89")
Width: 356 mm (14.02")
Depth: 293.5 mm (11.56")
Weight: 9.3 kg (20.46 lb.)

11.2 Specifications 2148, 2144/7651

Input Characteristics

All inputs pseudo difference. Choice of analogue ground floating or connected to chassis. Individual set-up for each channel

PREAMPLIFIER INPUT:
Pseudo Difference Input: Two standard Brüel & Kjær 7-pin Preamplifier sockets or one 18-pin socket (for sound intensity probes)
Input Impedance (signal to signal ground): 1MΩ ‖ 100pF
Signal Ground to Analogue Ground Impedance: 50Ω ‖ 10nF
Frequency Range: 0.7Hz to 25kHz, ±0.1dB
Noise Floor: 1μV, measured in 1/3-octave bands
Max. Input Voltage: 15V peak
Attenuator: FSD from 10mV to 3.16V (RMS sine) in steps of 5dB
Microphone Polarization: 0V, 28V, 200V from 10MΩ source
Power Supply: 28V
Heater Voltage: None
High-pass Filter Cut-offs:
−0.1dB at 0.7Hz (6dB/octave)
−0.1dB at 20Hz (12dB/octave)
−0.1dB at 100Hz (12dB/octave)
A-filter: According to IEC publication 651 type 0

DIRECT INPUT:
Pseudo Difference Input: Two BNC sockets (via preamplifier-to-BNC adaptors)
Input Impedance (signal to signal ground): 1MΩ ‖ 100pF
Signal Ground to Analogue Ground Impedance: 50Ω ‖ 10nF
Frequency Range: 0.7Hz to 25kHz, ±0.1dB
Noise Floor: 1μV, measured in 1/3-octave bands
Max. Input Voltage: 15V peak
Attenuator: FSD from 10mV to 3.16V (RMS sine) in steps of 5dB
High-pass Filter Cut-offs:
−0.1dB at 0.7Hz (6dB/octave)
−0.1dB at 20Hz (12dB/octave)
−0.1dB at 100Hz (12dB/octave)
A-filter: According to IEC publication 651 type 0

ACCELEROMETER INPUT:
Pseudo Difference Input: Two micro connectors, 10–32 UNF
Input Impedance (signal to signal ground): 39Ω ‖ 220pF
Signal Ground to Analogue Ground Impedance: 50Ω ‖ 10nF
Frequency Range: 0.3Hz to 25kHz, ±0.1dB
Noise Floor: 10fC, measured in 1/3-octave bands
Max. Input Charge: 14nC peak
Attenuator: FSD from 56pC to 10nC (RMS sine) in steps of 5dB
Low-pass Filter Cut-off:
−0.1dB at 1kHz (18dB/octave)
High-pass Filter Cut-offs:
−0.1dB at 0.3Hz (12dB/octave)
−0.1dB at 20Hz (12dB/octave)
−0.1dB at 100Hz (12dB/octave)

CHANNEL–TO–CHANNEL MATCH:
Max. Gain Difference: 0.1dB from lower frequency limit (0.3, 0.7 or 20Hz) to upper frequency limit (12.8 or 25.6kHz)
Max. Phase Difference:

50 to 315Hz	<0.017°
315 to 630Hz	<0.021°
630 to 1.25kHz	<0.042°
1.25 to 2.5kHz	<0.083°
2.5 to 5kHz	<0.166°
5 to 15kHz	<0.333°

MAXIMUM VOLTAGE RATINGS:
Input: 15V peak, 50V DC for direct and preamplifier inputs
Signal Ground/Chassis Ground: Type 2148 and 2144/7651 are safety class II instruments (IEC 348). For safe operation in accordance with IEC 348, the voltage between signal ground and chassis ground (in "floating" mode) must not exceed 42V RMS. To ensure safe operation in accordance with IEC 348 at higher voltages, the user must limit all input currents to 0.7mA peak
Signal Ground/Analogue Ground: 5V peak. If this limit is exceeded, the user must limit the ground current to 50mA. If the voltage exceeds 1V peak, the dynamic range is decreased

MAXIMUM INDUCED COMMON MODE VOLTAGE:
42V RMS, 100V peak

COMMON MODE REJECTION:
Floating input, 50Ω source impedance:
0.4Hz to 1kHz > 80dB
1kHz to 25kHz > 50dB

DIFFERENTIAL COMMON MODE REJECTION:
50Ω source impedance:
DC to 250Hz > 35dB

OVERLOAD DETECTION:
Both analogue and A/D-converter overloads indicated.

CROSSTALK:
−60dB

ATTENUATOR LINEARITY:
±0.1dB

ANTIALIASING FILTER:
Cut-off frequency: 25.6kHz (single channel), 12.8kHz (dual channel). Provides at least 80dB attenuation of those input frequencies which can cause aliasing

SAMPLING RATE:
1×65536Hz or 2×32768Hz

A/D-CONVERSION:
Resolution: 16 bit
Quantizing Error: Maximum 1/2 LSB

System Accuracy

DYNAMIC RANGE:
All distortion (intermodulation and harmonic) and spurious noise at least 80dB below max. input voltage

OVERALL FREQUENCY RESPONSE:
±0.1dB from lower frequency limit (0.3Hz) to upper frequency limit

NOISE:
Voltage input: <1μV with input range 10mV (80dB FSD) and input short-circuited:
Charge input: < 10^{-2}pC with input range 5.6pC and 1nF transducer capacitance

AMPLITUDE MEASUREMENT STABILITY:
±0.1dB

AMPLITUDE LINEARITY:
±0.05dB or ±0.005% of maximum input voltage, whichever is greater, measured using a sine wave input

FREQUENCY ACCURACY AND STABILITY:
0.01% without warm-up (no adjustment necessary)

Fourier Transform

See 2147 specifications

Averaging

See 2147 specifications

Hold

Peak Hold: Measures and holds the max. value of the input signal in one channel
Max/Min. Hold: Two different hold functions can be applied simultaneously

Multifunction Trigger

Mode Options: Single measurement (time record or spectrum), Normal Multispectrum/Time Capture, Gated Multispectrum, Matrix Multispectrum.
Max. Multispectrum Update Rate: 512 spectra/second (1 average between spectra)
Trigger Types: Internal, External, Clock, Manual, Free-run
Internal Trigger: On channel A or B after digital low-pass filtering. Trigger slope selectable
Measurement Start: One measurement trigger starts a measurement process
Record Trigger: One record trigger starts collection of one block of data
Delay, Trig → Ch.A: Single and Gated mode: T* to 9999s. Resolution is ΔT† for zoom, 2ΔT for baseband (up to T for some set-ups). Normal mode: −16ms (or up to several sec.) to 9999s. Resolution is T/2
Delay Ch.A → Ch.B: 0 to 999s. Resolution is ΔT for zoom, 2ΔT for baseband
Trigger Accuracy: Internal and External in Single and Gated: resolution is ΔT for zoom, 2ΔT for baseband. All other modes: resolution is 1ms

Memory

Memory Size: 512kbytes. 128992 bytes Data Memory corresponding to, for example, 15 801-line cross spectra or 30 time records 2048 samples long.

Mass Storage

See 2147 specifications

Hard Copy

See 2147 specifications

* T is the length of one block of data
† ΔT is the sampling time interval

Autosequence

See 2147 specifications

Display

Liquid Crystal Display (dot matrix, super twisted nematic) with back-light and resolution 480×200 points

Measurement Types: 1-channel, 2-channel, auto and cross analysis

Functions Calculated and Displayed:

Time domain: Time Record A & B, Complex Time, Autocorrelation A & B, Cross Correlation, Impulse Response h1

Frequency Domain: Inst. Spectrum A & B, Autospectrum A & B, Cross Spectrum, Mean Sound Pressure, Particle Velocity, Complex Intensity, Frequency Response H1, H2, H3, 1/H1, Coherence, Pressure-Velocity Coherence and Non-coherent Output Power. Single or double differentiation and integration

A-weighting: Analogue A-weighting of input signal in both channels possible

Bow-tie Correction: Correlation function can be displayed with or without bow-tie correction

Y-AXIS:

Annotation: Absolute (metric or imperial) or relative units (dB). Selectable dB reference

Spectrum Scaling: RMS, PWR, PSD or ESD

Coordinates: RE, IM, MAG, PHASE

Units: V, V^2, V^2/Hz, V^2s/Hz, W/m^2, Deg or Unit related to units defined in the measurement set-up

Log. Range: 10, 20, 40, 80 or 160 dB

Phase Range: 0.2°, ±1°, ±5°, ±45°, ±90°, ±180°, +0°/−360°

Amplitude Scroll: Hard key controls to shift the display up and down.

X-AXIS:

Spectrum Display: Linear scale with annotation in mHz, Hz or kHz. Upper range from 781.25 mHz to 25.6 kHz in full display

Time Display: Scale annotated in ms or s. Length from 6.1 ms to 1600 s

Slice Display: Linear axis annotated from with index numbers from 1 up to a maximum of 999 (representing time, points, etc.)

Frequency Scroll: Hard key controls to shift the display left and right

CURSOR:

Cursor Types: Main, Harmonic, Sideband, Delta, Reference. Individual or aligned control of cursors on upper and lower graphs

X-readings: Time, frequency or line number (#X). Harmonic or Sideband Number. Difference between main and reference cursor positions

Y-readings: Calibrated and scaled, absolute or relative units (as y-axis). Total or A-weighted power or energy. Power or energy in delta cursor band or on harmonics. Delta band/Total. Level difference between main and reference, harmonic or sideband cursors.

Operation

See 2147 specifications

IEC/IEEE Interface

See 2147 specifications

RS−232−C Interface

See 2147 specifications

Input/Output

Trigger Input: BNC connector for external trigger to start an average instantaneously or with user-defined delay

Power Supply

See 2147 specifications

Environmental

See 2147 specifications

Cabinet

See 2147 specifications

11.3 Accessories

Accessories Included

Types 2147 and **2148** Portable Signal Analyzers **include the following accessories:**

ZG 0199:	Power Supply
AQ 0035:	7-core DIN Cable (1.5m)
ZG 0146:	Battery Box
6×QB 0008:	1.25V NiCd Batteries, type R 20 ("D" size)
JP 0312:	3-pin Plug
JP 0808:	8-pin DIN Plug
2×VF 0087:	5A Fuses
DH 0541:	Shoulder Strap
AQ 0157:	Charging Adaptor
2×JP 0736:	Preamp-to-BNC Adaptors (2148 only)
BZ 5064:	2 Program Disks for Type 2147
BZ 5075:	2 Program Disks for Type 2148

Optional Accessories

TRANSDUCERS:

Type 3548:	Sound Intensity Probe (2148, 2144/7651)
Type 4165:	General-purpose 1/2" Measuring Microphone
Type 2639:	Microphone Preamplifier
Type 4371:	General-purpose Accelerometer

Brüel & Kjær supplies a wide range of microphones and accelerometers. Please ask for more information regarding the different types and their uses.

CALIBRATION:

Type 3541:	Sound Intensity Calibrator
Type 4226:	Multifunction Acoustic Calibrator
Type 4228:	Pistonphone
Type 4230:	Sound Level Calibrator
Type 4294:	Calibration Exciter

ENHANCEMENTS (2147):

UA 1213:	Kit for Upgrading to 2148

APPLICATION PROGRAMS:

Type 7638:	Zwicker Loudness Option
Type 7666:	Real-time Frequency Analysis Option for Type 2147
Type 7667:	Dual Channel Digital Filter Software for Type 2148

COMPUTER SOFTWARE:

WT 9393:	Utility Program for Types 2144, 2148
WT 9362:	Non-stationary Signal Analysis Software

INTERFACE:

AO 0195:	Adaptor to convert IEEE 488 connector to IEC 625-1 (25-way)
AO 0264:	Interface Cable (2m), IEC 625-1 (25-way) to IEEE 488
AO 0265:	Interface Cable (2m), IEEE 488
UA 0814:	IEEE 24-way Bus Connector Kit

MISCELLANEOUS:

QB 0008:	1.25V NiCd Battery, type R 20 ("D" size)
QR 1102:	10 Micro Floppy Disks (Double Density)
QR 1105:	10 Micro Floppy Disks (High Density)

Chapter 12

Service and Repair

The analyzers described in this guide are designed and constructed to provide you with many years of reliable operation. However, if a fault occurs which impairs the analyzer's correct function, then remove the battery pack and/or disconnect the power supply to prevent risk of further damage. For repair, contact your local Brüel&Kjær service representative. Under no circumstances should repair be attempted by persons not qualified in the service of electronic instrumentation.

Chapter 13

Appendix

13.1 Error Messages

When reporting an error to your Brüel & Kjær service office, it is important that you always state:

1. The type of error as written on the display
2. The VP-number and program version numbers as written on the display
3. The serial number of your analyzer (stated on the rear panel)

13.1.1 Errors in the Power-on Self-test

The power-on self-test looks for errors in parts of the hardware in the analyzer. In some cases, it is possible to use the analyzer even though a self-test error has been detected, and the message `Press <Main Menu> to continue` is displayed. All saved files will, however, be marked `HWF` (hardware failure) to indicate that data may not be reliable. Please report the error to your local Brüel & Kjær office.

13.1.2 Errors in the Program Retention Test

This type of error is usually not fatal. If the analyzer is not used for a long time, the back-up battery may lose its power and the memory, including the program, is lost. A typical error message is:

```
Retention test completed with ERROR status!

err 9304 : Main program not valid
Ready for program load
```

If there is no disk in the disk drive, the message `err 9106 : No disk` is displayed. When you insert the program disk, or if the disk is already in the disk drive, the analyzer automatically starts reading the disk, and displays the message `Loading program from floppy disk`.

13.1.3 Errors in the Internal Memory

After the retention test, the main program looks for errors in the internal memory. The possible errors are listed below:

```
Hardware error detected during self-test.
Error in current set-up. Initialized.
Error in set-up no. 1 2 3 4. Initialized.
Error in interface parameters. Initialized.
Error in calibration parameters. Initialized.
Error in current auto-seq. Initialized.
Error in auto-seq. Initialized.
Error in wake-up parameters. Initialized.
Error in user-weight no. 1 2 3 4. Initialized.
Error in data memory directory.
Error in data memory.
Error in data memory measurement texts.
  Data memory initialized.
```

The error messages can usually be removed by pressing “Reset” or by making a Master Reset (see section 3.2). It is, of course, important to understand that removing the *symptom* of the error does not remove the error itself. If, for example, part of the memory directory is overwritten, the memory is initialized by the analyzer. All files in the data memory are lost, but the analyzer apparently works normally again after a reset. However, what *caused* the overwriting was probably a hardware error and it may cause problems again if the error is not removed. If an error turns up repeatedly, please report it to your local Brüel & Kjær office.

Note: `Last usage terminated by power failure` is not an error message as such, but a warning to tell you that the analyzer was not switched off using the “Power On/Off” key. Press the “Reset” key to remove the warning.

13.1.4 Run-time Errors

If a run-time error occurs and causes an internal stop, a screen picture showing the latest key-pushes appears on the display. Usually, saved files remain intact.

The information on the screen is divided into three groups:

- The VP number is the program version number and is displayed in the upper left-hand corner of the screen.
- CODES, in the upper right-hand corner, tells the service engineer what type of error caused the run-time error and where it occurred in the program.
- The latest key-pushes are shown so that, if necessary, it is possible to provoke the error again.

When reporting a run-time error to a Brüel & Kjær office, it is important that you give *all* the above information to the service personnel; this saves time for both you and the service engineer. The easiest way to document the error is to print the screen picture out on a printer by pressing "Hard Copy". This requires that the printer is already connected and that the interface parameters are set correctly. The interface is automatically activated if a run-time error occurs. If no printer is available, write down at least the VP-number, the codes, and the last 5 key-pushes.

13.2 Provoked Errors and Other Messages

When using the analyzer, you might sometimes provoke errors, for example by making an illegal choice. This results in a message from the analyzer appearing in the lower right-hand corner of the screen. Many of these messages are just to tell you that you have made a mistake and are often self-explanatory. The table below lists the messages and shows any action which may be necessary.

Message	Cause	Action
`ACCUM. OVERFLOW`	Numeric overflow when the attenuation is changed	Data unreliable. Make a new measurement
`ACCUM. UNDERFLOW`	Numeric underflow when the attenuation is changed	Data unreliable. Make a new measurement
`AUTO RANGE`	Autorange in progress	
`BAD DIRECTORY`	Logical error on the directory	Transfer whatever possible and reformat the disk
`BAD DISK`	Logical (CRC) error on the disk	Transfer whatever possible and reformat the disk
`BAD FILE TYPES`	File types are incompatible	
`BAD FILENAME`	An illegal file name has been used	Use file names in the range 1 to 999
`BAD SPECTRUM NO.`	Wrong spectrum number has been specified for the file	
`BAD STATE`	Test message – should not occur	Contact B & K
`BATTERY`	Batteries cannot supply enough current	Change or recharge the batteries
`BREAK`		Contact B & K
`BUFFER EMPTY`	The buffer is empty. For example when recalling to spectrum calculator	
`BUFFER FULL`	The weighting input buffer has a capacity of 100 points	

Table 13.1 Provoked error messages and other operating messages

Message	Cause	Action
CALCULATING	A long calculation is in progress	
CH A_B NOT LOCKED	Channels A & B are not locked together when displaying an input signal as P, V, I/J	Lock channels in input menu
COMMON OVERLOAD	Common mode input voltage > 2 V	Check earthing. Reduce common mode input voltage
COMPLETED	Operation is complete	
COPYING	Files are being copied to/ from disk	
CRC FAULT	A logical error was detected during a data transfer	Transfer whatever possible and reformat the disk
DATA SPLIT ERR	Data is split when a long file is copied from the floppy disk	Initialize the Data Memory and try copying again. If the error occurs again, contact B & K
DIFFERENT SETUPS	Attempt, for example, to modify a multispectrum from a file with a different set-up	
DIRECTORY FULL	Attempt to open more than 223 files on disk or 111 files in memory	Use new disk or initialize the memory
DISK ERR	Physical error on the disk	Transfer whatever possible and throw the disk away
DISK FULL	There is not enough room on the disk	
DISK-JOB ERR	Main Program error	Contact B & K
DISK PROTECTED	The disk is write protected	Write enable disk
DISK REMOVED	Disk was removed during read/write	Insert disk and try again
DISK USE LOCKED	Software key does not permit use of disk	Contact B & K
DISP. FUNCTION ERROR	Attempt to subtract different spectrum types, or, e.g., to recall a file for which the chosen spectrum type does not exist	

Table 13.1 Provoked error messages and other operating messages

Message	Cause	Action
DISPLAY FROZEN	Attempt to change domain, complex part, etc. when input signal or display is frozen	Unfreeze display and try again
FILE ALREADY EXIST	The specified file already exists	Specify new file name
FILE ALREADY OPEN	The specified file is already in use	Close file and open new file
FILE NOT FOUND	The specified file does not exist	
FILE NOT SPECIF.	A file has not been specified	Specify a file
FILE PROTECTED	The specified file is write protected	Change protection
FORMATTING	Formatting is in progress	
FREQ.PARM.MISMATCH	Attempt to recall a file with different centre frequency, zoom or transform size	
|GAIN|>10dB	Calibration level more than 10 dB different from expected level	Check specified calibration level, calibrator switched on, connections, pol. voltage, etc.
GAIN<0.316	Calibration signal too low (absolute units)	
GAIN>3.16	Calibration signal too high (absolute units)	
HARDCOPY FAULT	Error during print out of the screen. The screen picture cannot be transferred from the display processor	Contact B & K
ILL. IN ZOOM MODE	Not allowed in zoom mode	Deactivate zoom
ILL. MEAS TYPE	Software key does not allow the selected measurement type	If you need to make that type of measurement, you must buy a software key
INTERVAL TOO SMALL	Conflict between "Repetition time" and "Time interval between spectra/records" for normal multispectrum with clock trigger	

Table 13.1 Provoked error messages and other operating messages

Message	Cause	Action
MEAS. NOT COMPLETE	A normal triggered measurement is not complete, or memory is full	
MEMORY ERR	Error in Data Memory	Copy as much as you can from the data memory and initialize it
MEMORY FULL	Data memory is full	Copy data memory to disk and initialize the memory
NO ANALOGUE MODULE	Analogue module or software key missing	Insert the analogue module. If you need a software key, contact B & K
NO CALC. TIME REC.	You cannot calculate from a stored time record, only from spectra	
NO DATA	Spectrum does not exist in file	Check spectrum number specification
NO DISK	There is no disk in the drive	Insert disk
NO KEY	Software key is required for the measurement	Contact B & K
NO. NOT SPECIFIED	Recall of file without specifying file number	
NO SLICE STORE	A slice of a multispectrum cannot be stored	
NO VOLUME LABEL	Attempt to read volume label of disk which does not have one	Contact B & K
PROTECT	Severe input overload. Input is protected by a short circuit	Remove the protection by switching protect mode off in input menu, or press "Reset"
RECORD LENGTH ERR	Data is split when a long file is copied to disk	Press "Reset" and try copying again. If the error occurs again, contact B & K
REC. NOT DELETED	Failure to delete a spectrum	Check protection. Try again
SET-UP IS CHANGED	Measurement type changed when learning or executing an autosequence	
SPEC. MEM. EMPTY	Attempt to delete a file from empty memory	

Table 13.1 Provoked error messages and other operating messages

Message	Cause	Action
SPEC. NOT FOUND	Spectrum does not exist in file	Check spectrum number specification
SPECT. UNIT = RMS	Attempt to display PWR, PSD or ESD spectrum on RMS display	
STEP TOO LARGE	Conflict between “Step between records” and “Repetition time” for gated measurements using clock trigger	
TIMEOUT	Communication fault between main processor and signal processor	Press “Reset” or make a Master Reset. Contact B & K if still occurs
TOO MANY FILES	Attempt to store more than 111 files in memory	Copy memory to disk and initialize memory
TOO MANY RECORDS	Attempt to open a time capture file when not enough memory	Copy memory to disk and initialize memory
TOO MANY SPECTRA	Attempt to open a normal multispectrum file when not enough memory	Copy memory to disk and initialize memory

Table 13.1 Provoked error messages and other operating messages

Chapter 14

Index

User Guide

Dual Channel Portable Signal Analyzers Types 2148, 2144/7651

and

Portable Signal Analyzers Types 2147, 2143/7669

Valid for

Dual Channel Portable Signal Analyzer Type 2148
from serial no. 1 635 506 with system software VP 7229,

Portable Signal Analyzer Type 2147
from serial no. 1 623 890 with system software VP 7361,

and for

Real-time Frequency Analyzer Type 2144
from serial no. 1 614 490 with Dual Channel FFT Option Type 7651
from serial no. 1 673 412

and

Real-time Frequency Analyzer Type 2143
from serial no. 1 623 846 with FFT Option Type 7669
from serial no. 1 708 537

September 1992

Brüel & Kjær

BB 0860-11

Safety Considerations

This apparatus has been designed and tested according to IEC Publication 348, *Safety Requirements for Electronic Measuring Apparatus*, and has been supplied in safe condition. The present User Guide contains information and warnings which should be followed by the user to ensure safe operation and to retain the apparatus in safe condition. Special note should be made of the following:

Powering the Apparatus

Before each use of the Power Supply ZG 0199 with the apparatus, check that it is set to match the available mains voltage and that the correct fuse is installed.

Safety Symbols

⚠ The apparatus will be marked with this symbol when it is important that the user refers to the associated warning statements given in the User Guide.

⊥ Chassis terminal ⏚ Safety earth terminal ϟ Hazardous voltage

Warnings

- Switch off all equipment before connecting or disconnecting their digital interface. Failure to do so could damage the equipment.
- Whenever it likely that the correct function or operating safety of the apparatus has been impaired, the apparatus must be made inoperative and be secured against unintended operation.
- Any adjustment maintenance and repair of the open apparatus under voltage must be avoided as far as possible and, if unavoidable, must be carried out only by trained service personnel.

Contents

Chapter 1

Introduction

1.1 About this Volume

This volume describes the programming and operation of the serial and parallel interfaces of the Type 2148 Analyzer. It is intended as a reference guide for IEEE 488/RS-232-C programmers and users. It is assumed that users are familiar with manual operation of the analyzer, described in Volume 1 of this User Guide, and have some experience of interface programming.

This guide is intended for use with both the dual-channel and single-channel analyzers. Since the majority of functions are common to both options, we simply refer to Type 2148. It can be assumed that:

- Dual-channel functions apply to Types 2148 and 2144/7651 only.
- Other statements concerning Type 2148 are equally valid for Type 2147, unless specifically stated otherwise.
- Except where the 7651 (or 7669) is specifically named, all references to the 2148 (or 2147) can be assumed to apply to both analyzers.

1.2 Summary of Contents

The following chapters describe the operation of the 2148 IEEE-488/RS-232-C interfaces.

Chapter 2 describes the specifications and the setup procedure for the IEEE-488 interface, while Chapter 3 gives a similar description of the RS-232-C interface. Chapter 4 describes the interface message formats and some features common to both interfaces. Chapters 5, 6, 7 and 8 describe how the individual messages are used in the control of data flow between the 2148 and an interface controller. Chapter 9 lists the interface error messages, while Chapter 10 describes data formats for transfer over the IEEE-488/RS-232-C interfaces and storage in disk files. Chapter 11 is the index.

Chapter 2

The IEEE–488 Interface

2.1 Interface Specifications

2.1.1 Interface Functions Implemented

The interface of the 2148 implements the following functions as specified in IEEE Std 488–1978 — "IEEE Standard Digital Interface for Programmable Instrumentation". The sections referred to are the relevant sections of the IEEE standard. The equivalent clauses of IEC Publication 625–1 are given in parentheses.

Section 2,3	Source Handshake (SH) Interface Function (Clause 6) SH 1—complete capability
Section 2,4	Acceptor Handshake (AH) Interface Function (Clause 7) AH 1—complete capability
Section 2,5	Talker (T) Interface Function (Clause 8) T 5—complete capability
Section 2,6	Listener (L) Interface Function (Clause 9) L 3—complete capability
Section 2,7	Service Request (SR) Interface Function (Clause 10) SR 1—complete capability
Section 2,8	Remote Local (RL) Interface Function (Clause 11) RL 1—complete capability
Section 2,9	Parallel Poll (PP) Interface Function (Clause 12) PP 1—remote configuration
Section 2,10	Device Clear (DC) Interface Function (Clause 13) DC 1—complete capability
Section 2,11	Device Trigger (DT) Interface Function (Clause 14) DT 1—complete capability
	All other functions—no capability

For further details of the above functions refer to the relevant sections of the IEEE or IEC standards.

2.1.2 Interface Connections

Up to 15 devices can be interconnected in an IEEE–488 bus system. The maximum permitted cable length of the bus is 2metres (6ft) × the number of instruments in the system, up to a 20metre (60ft) maximum. Also, it is recommended that cable lengths between individual instruments connected to the bus be no greater than 4metres (12ft).

The IEEE interface connector of the 2148 is a 24-way female "micro-ribbon" connector, as specified in IEEE Std 488. The analyzer can be connected to other instruments fitted with this type of connector using the 2m long Brüel&Kjær IEEE Interface Cable, AO0265. Cable AO0265 has screw-locking stackable connectors, allowing a number of connections to be made at the same point during system interconnection.

Brüel&Kjær also supply cables and adaptors for interface bus connections to instruments fitted with the older IEC-625 standard connector (Brüel&Kjær part nos. AO0264 and AO0195).

2.1.3 Interface Addresses

Each device in an IEEE interface bus system has at least one listener and/or talker address depending on its function. When an interface controller contacts a device over the interface, it sends a device address which contains the appropriate talker or listener address. This address is in ASCII (ISO 7-bit) code; bit 8 is not used for addressing and is ignored.

The 2148 analyzer uses one interface bus address. On delivery, the address is set to the factory default value 15 (decimal). If you wish to change the device address, see section 2.3 for details.

2.1.4 Interface Management Lines

The REN Line

The interface REN or Remote ENable line is used in conjunction with other signals to select between manual operation via the front panel controls of the analyzer and remote operation via the interface bus. The REN line is controlled by the device cur-

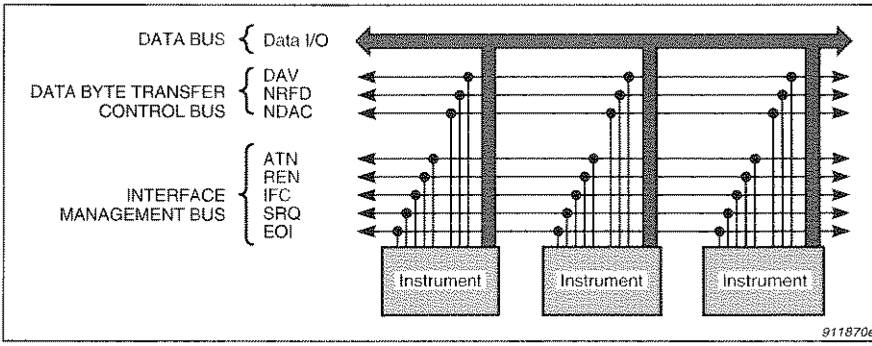


Fig.2.1 Overview of the IEEE bus lines

rently specified as the system controller. Most system controllers set the REN line to its "true" state immediately on taking control of the bus. For further details of how this function is implemented in the 2148, see section 2.5 and 7.12.

The IFC Line

The Interface Clear line resets the interface circuitry to a known operational state. This IFC line is used by the System Controller to place talkers and listeners in an unaddressed state.

The SRQ Line

A service request is generated by setting the interface Service Request (SRQ) line. For details of the service request system of the 2148, see section 7.1.

The EOI Line

The End Or Identify (EOI) line is used to indicate the last byte of a data transfer over the bus, or to initiate a parallel polling sequence, when used in combination with the Attention (ATN) line. The analyzer terminates all data transfer sent over the bus by setting the EOI line simultaneously with the transmission of the last Data Byte (DAB) of a message.

Note:
When the analyzer senses the EOI line set during reception of a data byte (DAB), reception is terminated.

2.2 How to Activate the IEEE Interface

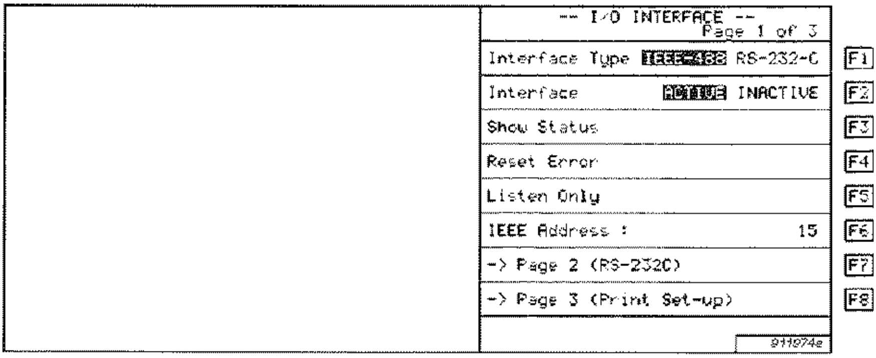


Fig. 2.2 I/O Interface menu, page 1

To activate the IEEE interface, display page 1 of the I/O Interface menu (see Fig. 2.2), then:

1. Select `Interface INACTIVE`, using soft key **"F2"**.
2. Select `IEEE-488` in the `Interface Type` field, using soft key **"F1"**.
3. Select `Interface ACTIVE`, using soft key **"F2"**.

Note:
The I/O Interface parameters cannot be changed with the interface `ACTIVE`.

2.3 How to Select the Device Address

You can set the 2148 IEEE device address using soft key **"F6"**, on page 1 of the I/O Interface menu and the numeric entry keys. Any integer value from 0 to 30 can be chosen. The factory default setting is 15).

2.4 Using the SRQ Key

When you press the "SRQ" key, the analyzer sends a Service Request if:

- The IEEE interface is set to ACTIVE in the I/O Interface menu, and
- This function is enabled in the SRQ mask (see section 7.1).

The **SRQ** LED indicates that the analyzer is waiting to be serviced by the controller. It is lit when one or more of the conditions defined in the SRQ mask are satisfied. It is switched off again when the controller carries out a serial poll on the analyzer. For details of the 2148 Service Request system, see section 7.1.

2.5 Local and Remote States

When a controller addresses the analyzer as a LISTENER, it can put the analyzer into the **Remote** state. It does this if the REN (Remote Enable) line was set to TRUE prior to the addressing. When this happens the **Remote** LED is lit and the normal operation of the front panel keys is inhibited. When the analyzer is in **Remote** mode, all the analyzer keys are inoperative, with the exception of: **"Local"**, **"Reset"**, **"Power On/Off"**, **"Viewing Angle"**, **"X-axis Scroll"**, **"Y-axis Scroll"**, **"SRQ"** and **"Display Backlighting On/Off"** (rear panel).

The analyzer returns to **Local** mode when:

- The **"Local"** key is pressed, or
- The REN line is (re)set to FALSE

The **Remote** LED is then switched off, and all the manual keys work normally again.

Notes:

- If the controller, using the bus command LLO (Local Lock-Out), has put the analyzer into the LOCAL LOCKOUT mode, then the **"Local"** key has no effect. In this case the controller, using the bus command GTL (Go To Local), can put the 2148 into the LOCAL WITH LOCKOUT mode. In this mode the front panel operates normally.

- The RS–232–C has no REN line, and the bus command LLO cannot be used. In this case the **Remote/Local** function is implemented using the messages **REMote** and **LoCKout**. See section 7.12 for further details.

2.6 Listening and Talking

The **Listen** LED lights when the analyzer is addressed as a Listener. It happens when:

- The analyzer is addressed by a controller, or
- Soft Key **"F5"**, `Listen only`, on page 1 of the I/O interface menu is pressed.

The **Listen** LED is switched off again when the 2148 is unaddressed. This can occur in several different ways:

- A controller sets the IFC (interface clear) bus line.
- Unaddress is received from a controller (address 31).
- The analyzer is addressed as a **Talker**.
- The **"Hard Copy"** key is pressed a second time (see section 4.3).
- The interface is made `INACTIVE`.
- The soft key **"F5"** on page 1 of the I/O interface menu is pressed a second time.

The **Talk** LED lights when the 2148 is addressed as a **Talker**. It happens when:

- The analyzer is addressed by a controller, or
- When a printout is started by using the **"Hard Copy"** key.

The **Talk** LED is switched off again when the 2148 is unaddressed. This can occur in several different ways:

- A controller sets IFC.

- Another talk address is received from a controller.
- The analyzer is addressed as a **Listener**.
- The **"Hard Copy"** key is pressed for a second time.
- The interface is made `INACTIVE`.

Note:
The Listen and Talk functions are used differently with the RS–232–C interface. This is described in section 3.3 and 7.12.

2.7 IEEE–488 Reset Levels

The interface has three levels of reset. The controller resets the interface by sending one of the following messages:

- **Interface Clear (IFC)** - All devices connected to the bus are unaddressed.
- **Device Clear (DCL)** or Selected Device Clear (SDC) - Parsing is restarted and interface errors are cleared.
- **RES**et - This has the same effect as a manual reset.

Note:
Parsing is the compiler operation of identifying the elements of instructions in terms of the programming language.

Chapter 3

The RS–232–C Interface

3.1 Hardware/Functional Specifications

This section describes the physical level of the interface. The serial interface of the 2148 conforms to EIA standard RS−232−C, which is equivalent to the CCITT V.24 recommendation.

The interface of the 2148 is coupled as "Data Terminal Equipment" (DTE), and it operates in full duplex mode, which means that the interface is capable of operating in both directions simultaneously.

3.1.1 RS-232-C Interface Connector

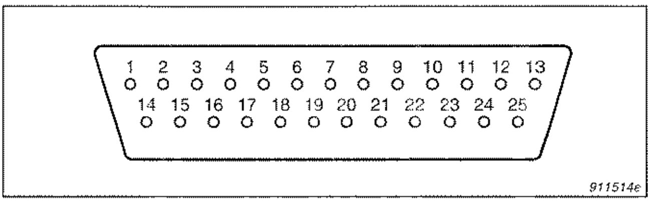


Fig. 3.1 The RS−232−C interface connector of the 2148

The interface connector is a 25-pin D-range male connector. It is located on the rear panel of the 2148, see Volume 1 of this User Guide (section 3.2) for details. Fig. 3.1 shows the numbering of the pins on the connector. Pin definitions are given in Table 3.1.

Pin NO.	RS−232−C	CCITT V.24	Description	Mnemonic	Direction
1	AA	101	Protective Ground	P GND	—
2	BA	103	Transmitted Data	TxD	From 2148
3	BB	104	Received Data	RxD	To 2148
4	CA	105	Request to Send	RTS	From 2148
5	CB	106	Clear to Send	CTS	To 2148
6	CC	107	Data Set Ready	DSR	To 2148
7	AB	102	Signal Ground	S GND	—
8	CF	109	Data Carrier Detect	DCD	To 2148
20	CD	108.2	Data Terminal Ready	DTR	From 2148

Table 3.1 Pin definitions for the RS−232−C interface

3.1.2 Data Lines

Pins 2 and 3, Transmitted Data and Received Data, are data lines. For data lines, RS–232–C specifies that:

- A voltage below –3 V signifies a binary 1
- A voltage above +3 V signifies a binary 0
- When a data line is passive, it is held in the binary 1 condition.

Data transmission is asynchronous as illustrated in Fig.3.2.

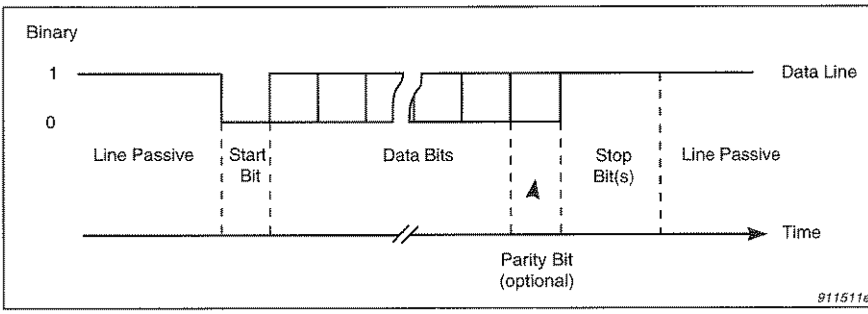


Fig. 3.2 Asynchronous transmission of 1 byte of data

3.1.3 Control Lines

Pins 4, 5, 6, 8 and 20 are the connections for the control lines. For control lines, the RS–232–C standard specifies that:

- A voltage above +3 V signifies the on state
- A voltage below –3 V signifies the off state.

The use of the control lines is described further in section 3.2.6.

3.1.4 Cables

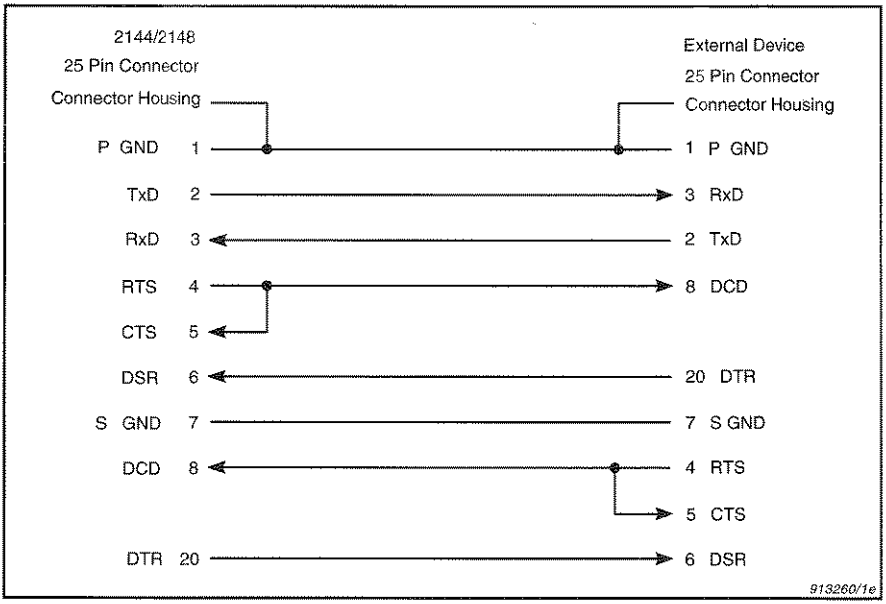


Fig. 3.3 Null-modem cable with 25-pin connectors at both ends (Brüel&Kjær order numbers WL0946 and WL0947)

A null-modem cable must be used to interface the 2148 to another DTE-coupled device (computer or printer). Fig. 3.3 shows the connections of a null-modem cable with 25-pin connectors at both ends. Fig. 3.4 shows the connections of a null-modem cable equipped with a 25-pin connector at one end and a 9-pin connector at the other end.

Interface cables can be ordered from Brüel&Kjær. Table 3.2 shows order numbers and usage of cables.

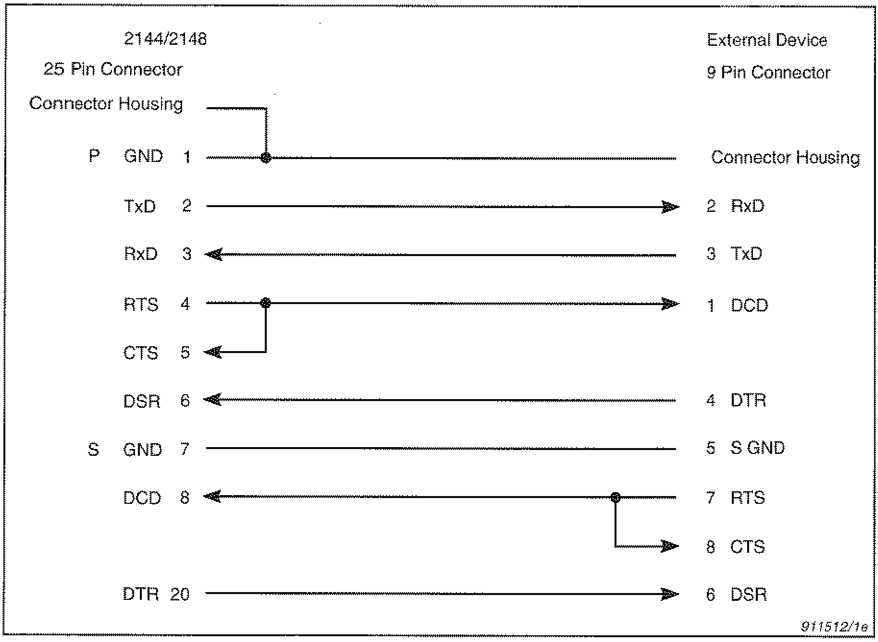


Fig. 3.4 Null-modem cable with one 25-pin connector and one 9-pin connector (Brüel & Kjær order number WL 0945)

Order No.	Connectors	Used to Interface to
WL 0945	25-pin female 9-pin female	Computer or printer with 9-pin male RS-232-C connector
WL 0946	25-pin female 25-pin female	Computer or printer with 25-pin male RS-232-C connector
WL 0947	25-pin female 25-pin male	Computer or printer with 25-pin female RS-232-C connector

Table 3.2 Brüel & Kjær RS-232-C null-modem cables

3.2 RS–232–C Interface Set-up

3.2.1 How to Activate the RS–232–C Interface

To activate the RS–232–C interface, display Page 1 of the I/O Interface Menu (see section 2.2), then:

1. Select `Interface INACTIVE`, using soft key **"F2"**.
2. Select `RS-232-C` in the `Interface Type` field, using soft key **"F1"**.
3. Select `Interface ACTIVE`, using soft key **"F2"**.

Note:
The I/O Interface parameters cannot be changed with the interface `ACTIVE`.

To set up the RS–232–C interface, first select page 2 of the menu (using soft key **"F7"**).

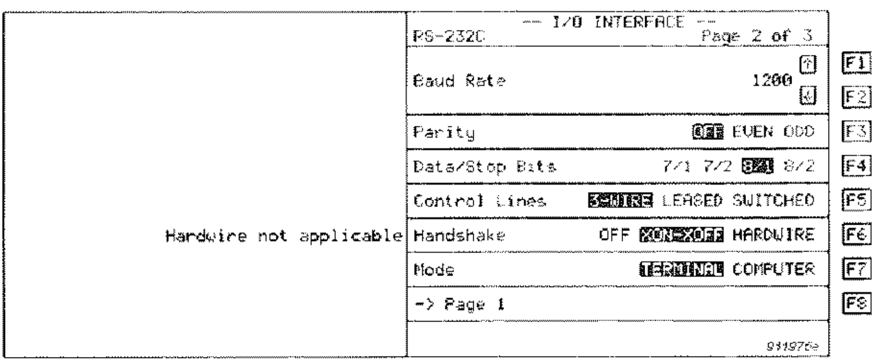


Fig.3.5 Page 2 of the I/O Interface menu (RS–232–C)

To change the interface setup parameters, use soft keys **"F1"** to **"F7"**. Soft key **"F8"** is used to return to page 1 of the I/O Interface menu. The setup parameters are described in the following sections.

3.2.2 Baud Rate

The baud rate is the speed of data transmission. The baud rate options are 300, 600, 1200, 2400, 4800 and 9600 bits/second.

3.2.3 Parity

Checking the parity of a transmitted byte is a means of detecting transmission errors. Even (odd) parity means that a transmitted byte must contain an even (odd) number of binary 1's. To achieve this, one extra bit — the parity bit — is added to each byte transmitted. When `None` is selected, no parity check is performed.

You can select from the following options:

- Even
- Odd
- None

3.2.4 Data/Stop Bits

The number of data bits determines how many bits are transmitted for each character. You can select 7 or 8 data bits to a character.

Note: You must use 8 data bits to transmit block data.

The number of stop bits determines for how long the data line must be in the passive state before the transmission of a new byte can begin. The 2148 can use 1 or 2 stop bits.

3.2.5 Handshaking

Handshaking is the method used by the 2148 and the external device to synchronize their transmissions. You can select one of three options:

- **X-On/X-Off handshake:** The 2148 transmits the X-Off character (ASCII 19) when it can handle no more input data. When the 2148 is once again ready to receive data, it transmits the X-On character (ASCII 17) over the interface. Similarly, when the 2148 receives an X-Off character during a transmission, it stops transmitting until it receives the X-On character.
- **Hardwired handshake:** The 2148 sets the DTR control line (pin 20) off when it will accept no more data. When it is ready to receive more data, the DTR line is set on. When the external device sets the DSR control line (pin 6 of the 2148) off, the 2148 stops transmitting until DSR goes back on.
- **None:** Handshaking is disabled.

3.2.6 Control Lines

This parameter determines how the 2148 uses the control lines of the interface. There are three options:

- **3-Wire:** In 3-wire mode, only the data lines are used. All control lines are ignored. This means that the only handshake method available is X-On/X-Off.
- **Switched:** In switched line mode, the CTS and DSR control lines are monitored. If one of the two control lines is set to off, data transmission from the analyzer is blocked. It is recommended that the external device uses the DSR line for handshaking.
- **Leased:** In leased line mode, the CTS, DSR and DCD control lines are monitored. CTS and DSR have the same effect as in switched line mode. If the DCD input control line goes off, the 2148 ignores all incoming data.

3.2.7 Terminal and Computer Modes

The `COMPUTER` or `TERMINAL` modes may be selected using soft key **"F7"**, on page 2 of the I/O Interface menu.

Terminal Mode

In this mode, which is intended for use with a "dumb" terminal, every printable character is echoed as soon as it is received. A prompt is transmitted whenever the analyzer is ready to receive a new message.

This prompt is: "<CR><LF>$"

There is also a simple screen editor.

Example:
When the RS-232-C interface is activated, the prompt is sent, and the terminal screen shows:

```
$ ▓
```

After executing the message "S_R_E? <CR><LF>", the screen shows:

```
$ S_R_E?
          S_R_E 0

$ ▓
```

Editing Functions

In Terminal mode, the analyzer stores input data (characters) in its input buffer. When the buffer is full (132 characters), or when a <LF> is received, the buffer contents are processed and the buffer is cleared. The buffer can also be cleared manually.

The last character received in the buffer can be deleted by sending <BS> or <DEL> to the analyzer. When this happens the cursor on the terminal screen moves one space to the left, but does not delete the character on the screen. This can be repeated as many times as there are characters in the buffer.

Notes:

- If a character string is typed in which is so long that it runs onto a new line on the terminal screen, then the cursor cannot be moved back to the previous line by using <BS>. However, a character is still deleted in the input buffer for each subsequent keystroke.
- Entering block data in terminal mode is not recommended. However it is possible, provided that the data does not contain <LF>, <BS> or <DEL> and the total length of the input string <132 characters.

Computer Mode

In this mode the analyzer is connected to an intelligent controller. Neither echo nor prompt are transmitted and it is not possible to edit transmitted data.

3.3 Listening and Talking

The **Listen** LED lights when the analyzer is receiving data over the interface i.e. it is addressed as a "listener". It is turned on when the first character of a message header is received, and is switched off when:

- The analyzer begins to send a response message, or
- The interface is made `INACTIVE`.

The **Talk** LED lights when the analyzer is sending a response message via the bus i.e. when the analyzer is functioning as a "talker". This occurs when:

- A query message has been received from the controller, and the analyzer starts to transmit a response message, or
- A printout is started using the **"Hard Copy"** key.

The **Talk** LED is switched off again when:

- The response-message transmission/printout is completed, or
- The **"Hard Copy"** key is pressed a second time, or
- The interface is made INACTIVE.

3.4 RS–232–C Interface Reset Levels

The RS–232–C Interface has two levels of reset:

- Sending a <Break> to the analyzer via the RS–232–C interface will restart parsing.
- Sending a **RES**et message to the analyzer has the same effect as a manual Reset (see section 5.1).

Notes:

- A <Break> is detected when the analyzer senses the RXD line held at binary 0 for a whole character, including parity and stop bits (A <Break> normally lasts for >100ms).
- There may be a delay after receiving the <Break> until execution stops, depending on the internal operations taking place in the analyzer at the time.

Chapter 4

Messages and Common Functions

4.1 Formats for Interface Messages

4.1.1 Terminology for Interface Messages

The data transmitted to and from the Type 2148 analyzer conforms to a subset of the ANSI/IEEE Standard, IEEE 488.2 (1987), "IEEE Standard Codes, Formats, Protocols and Common Commands".

Both the IEEE and RS-232-C interfaces are used to transfer data to and from the analyzer. This transferred data is referred to as a "message". Two types of message can be sent to the analyzer, "command" and "query" messages. Messages output by the analyzer replying to a query message from a controller are referred to as "response" messages.

Messages to the Analyzer

All messages sent to the analyzer start with a "header". A header consists of one or more "words". The simplest messages are made up of a single word header,

e.g. `HOLD`

If a header requires more than one word, the words are joined by "word concatenators". The underline character (_) is used as the word concatenator.

e.g. `RESET_STATUS_BYTE`
`SERVICE_REQUEST_ENABLE?`

Headers that end with a question mark (query messages) will cause the analyzer to output data (response message). Headers without question marks (command messages) are used to set up the analyzer or input data to the analyzer.

Headers may be followed by one or more data fields. The header is separated from the data fields by a "header separator" which is a space (SP). Data fields that consist of more than one word are joined by word concatenators.

e.g. `AVERAGING LIN_AVG_TIME,5M`
`MEASUREMENT_TYPE ONE_CHANNEL`

A single header can be used to define a number of data fields in the analyzer. If the message contains several data fields, then the data fields are separated by a "data separator", which is always a comma.

e.g. `HOLD HOLD_FUNCTION,1,TYPE,MAX,MODE,INACTIVE`

Several messages can be sent together, joined by a message separator, which is a semi-colon.

e.g. `ERROR_STOP YES;UPDATE UPDATE_MEAS`

Messages from the Analyzer

The structure of the response messages returned by the analyzer depends on the nature of the query from the controller. The messages will be in minimum code (mnemonics) see section 4.1.4.

4.1.2 Use of Syntax Diagrams

In this manual syntax diagrams are used to explain the individual messages. Syntax diagrams use three types of symbols, refer to Fig. 4.1.

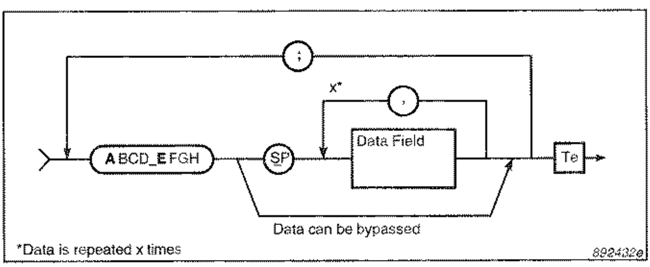


Fig. 4.1 General message syntax

Rectangular symbols indicate that the enclosed data must be replaced by a data item defined elsewhere or chosen by the user. The name of the data item is quoted in the upper left-hand corner of the symbol. The type of the data item, and its allowed length in parenthesis are, where appropriate, given in the lower right-hand corner. Circular symbols enclose single character literal data that must be included in the message. Elongated, round ended symbols indicate literal word data. These round ended symbols are usually used to illustrate message headers.

Data items that may be by-passed, are indicated by angled lines to and from the main flow line. Data items that **may** be repeated, are indicated by lines that loop vertically from the main flow line back over the data item and back to the main flow line. If an item of data **is** repeated, then the number of repetitions is indicated by a number above the flowline. Flow is from left to right unless arrows indicate otherwise.

Note:
For the 2148, all setup message commands (described in Chapter 6) change the display to the menu containing the data fields used in that particular message. If only the header is sent and the data fields are bypassed (see Fig. 4.1), then the analyzer displays the first page of the relevant menu.

4.1.3 General Rules for Constructing an Interface Message

The 2148 allows you to input the message headers and any character type data fields in full. For ease of use, the data field names used correspond to those used on the analyzer's front panel pushkeys and screen texts wherever possible.

In order to reduce coding and transmission time, mnemonics for each of the message components which use character type data can be entered. The mnemonics are derived from the names of the individual headers or data fields. The general syntax of these mnemonics is the same for headers and character type data fields. Throughout this manual a message's minimum allowable mnemonic is given in bold upper case text, for example **DISP**LAY_**MODE** **MODE_OPT**IONS,**DU**AL. In addition, the following rules apply:

1. All entries can always be written out in full. For example,

   ```
   DISPLAY_MODE MODE_OPTIONS,DUAL
   ```

2. Both upper and lower case letters are recognized and are equivalent:

```
DISPLAY_MODE MODE_OPTIONS,DUAL
display_mode  mode_options,dual
dIsPlay_MODe  mODe_oPtiONs,dUAl
```

3. All headers and character type data fields can be truncated down to the mnemonic.

```
DISPLAY_MODE  MODE_OPTIONS,DUAL
DISP_MOD  MOD_OPT,DUA
D_M  M_O,DU
```

4. All mnemonics are unique and consist of from one or more words, with each word consisting of one to three characters, plus the word concatenators.

5. The character type data parts of messages received by the analyzer are checked only with the mnemonic. Therefore, any misspelled words are undetected, provided that the mnemonics are correctly entered.

6. The analyzer returns only the mnemonics when transmitting data containing headers and character type data fields over the bus.

7. Between the header and the first data field, a header separator is entered. The header separator is a space (SP).

8. Between each of the data fields, the data separator (a comma <,>) must be entered. See section 4.1.1.

9. Some headers allow data to be both sent to and requested from the analyzer (commands and queries). Where this is the case, you can convert a command header into a query by appending a "?".

Command message:	Query Message:
D_M M_O,DU	D_M?

4.1.4 Mnemonic Codes

The following general rules apply to help you understand the construction of the mnemonics (minimum codes). The rules apply for all headers and data fields which use character type data.

1. If taking the first letter of every word gives a unique code, then this is the mnemonic. For example, the header

SERVICE_REQUEST_ENABLE becomes S_R_E
MEASUREMENT_TYPE becomes M_T

2. If the first letter of every word does not give a unique mnemonic, then include two or more characters of one or more words until the mnemonic is unique. For example, the message

   AVERAGING_CONTROL START becomes A_C STA
   AVERAGING_CONTROL STOP becomes A_C STO

Notes:

- Word concatenators are always required in mnemonics which include more than one word, except immediately before the question mark (?) in an input message header. Here, the inclusion of the word concatenator is optional.
- Only the minimum code is recognized internally. In the tables and syntax diagrams throughout this interface manual, the mnemonics are the characters appearing in bold within the headers and character type data fields.
- Headers are always output in mnemonic form by the analyzer.

4.1.5 Message Terminators

Note:
The following rules for the use of message terminators, including the EOI line, only apply to the IEEE-488 interface. The EOI line is not available with RS-232-C.

The message terminator is the last byte transmitted **at the end of an IEEE message** to signify the end of the transmitted data. Fig. 4.2 lists the possible terminators.

By default, the line feed character (LF) is defined as the terminator and is transmitted from the analyzer simultaneously with the End Or Identify line (EOI). This terminator can be redefined to any ASCII character decimal value between 1 and 31, with the exception of 13. These available user-defined terminators are

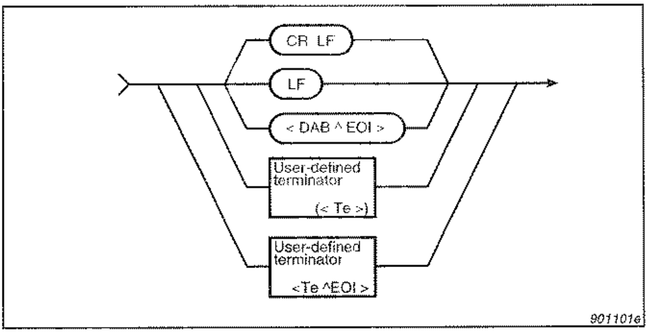


Fig.4.2 Syntax for valid message terminators

given in Table 4.1. Throughout this manual the user definable message terminator is referred to as "Te".

You can set the terminator using the message "Define_Terminator" (see section 7.2). The bold text below offers examples of valid terminators.

RESET_STATUS_BYTE**CR LF**
RESET_STATUS_BYTE**LF**
RESET_STATUS_BYT**<E^EOI>**
RESET_STATUS_BYTE**<Te>**
RESET_STATUS_BYTE**<LF^EOI>**

When information is output from the analyzer, the user-defined terminator (Te) will always be sent simultaneously with the EOI line. Data output from the analyzer is transmitted as in the following example.

S_R_E 129**<Te^EOI>**

<table>
<tr><th>Bit Numbers b_7 b_6 b_5
b_4 b_3 b_2 b_1</th><th>0 0 0</th><th>0 0 1</th><th>0 1 0</th><th>0 1 1</th><th>1 0 0</th><th>1 0 1</th><th>1 1 0</th><th>1 1 1</th></tr>
<tr><td>0 0 0 0</td><td>NUL</td><td>●DLE</td><td>SP</td><td>0</td><td>@</td><td>P</td><td>‘</td><td>p</td></tr>
<tr><td>0 0 0 1</td><td>●SOH</td><td>●DC1</td><td>!</td><td>1</td><td>A</td><td>Q</td><td>a</td><td>q</td></tr>
<tr><td>0 0 1 0</td><td>●STX</td><td>●DC2</td><td>“</td><td>2</td><td>B</td><td>R</td><td>b</td><td>r</td></tr>
<tr><td>0 0 1 1</td><td>●ETX</td><td>●DC3</td><td>#</td><td>3</td><td>C</td><td>S</td><td>c</td><td>s</td></tr>
<tr><td>0 1 0 0</td><td>●EOT</td><td>●DC4</td><td>$</td><td>4</td><td>D</td><td>T</td><td>d</td><td>t</td></tr>
<tr><td>0 1 0 1</td><td>●ENQ</td><td>●NAK</td><td>%</td><td>5</td><td>E</td><td>U</td><td>e</td><td>u</td></tr>
<tr><td>0 1 1 0</td><td>●ACK</td><td>●SYN</td><td>&</td><td>6</td><td>F</td><td>V</td><td>f</td><td>v</td></tr>
<tr><td>0 1 1 1</td><td>●BEL</td><td>●ETB</td><td>’</td><td>7</td><td>G</td><td>W</td><td>g</td><td>w</td></tr>
<tr><td>1 0 0 0</td><td>●BS</td><td>●CAN</td><td>(</td><td>8</td><td>H</td><td>X</td><td>h</td><td>x</td></tr>
<tr><td>1 0 0 1</td><td>●HT</td><td>●EM</td><td>)</td><td>9</td><td>I</td><td>Y</td><td>i</td><td>y</td></tr>
<tr><td>1 0 1 0</td><td>●LF</td><td>●SUB</td><td>*</td><td>:</td><td>J</td><td>Z</td><td>j</td><td>z</td></tr>
<tr><td>1 0 1 1</td><td>●VT</td><td>●ESC</td><td>+</td><td>;</td><td>K</td><td>[</td><td>k</td><td>{</td></tr>
<tr><td>1 1 0 0</td><td>●FF</td><td>●FS</td><td>,</td><td><</td><td>L</td><td>\</td><td>l</td><td>|</td></tr>
<tr><td>1 1 0 1</td><td>CR</td><td>●GS</td><td>–</td><td>=</td><td>M</td><td>]</td><td>m</td><td>}</td></tr>
<tr><td>1 1 1 0</td><td>●SO</td><td>●RS</td><td>.</td><td>></td><td>N</td><td>^</td><td>n</td><td>~</td></tr>
<tr><td>1 1 1 1</td><td>●SI</td><td>●US</td><td>/</td><td>?</td><td>O</td><td>_</td><td>o</td><td>DEL</td></tr>
</table>

Table 4.1 List of allowed user–defined message terminators (Te)

4.2 Types of Data

A message can contain one or more data fields, or none. The type of allowed data varies for each individual message, but the available types are:

- character data
- numeric data
- string data
- block data

The data separator used between all data fields is a comma (,). See Fig. 4.3 for the general syntax of a message containing all legal data types.

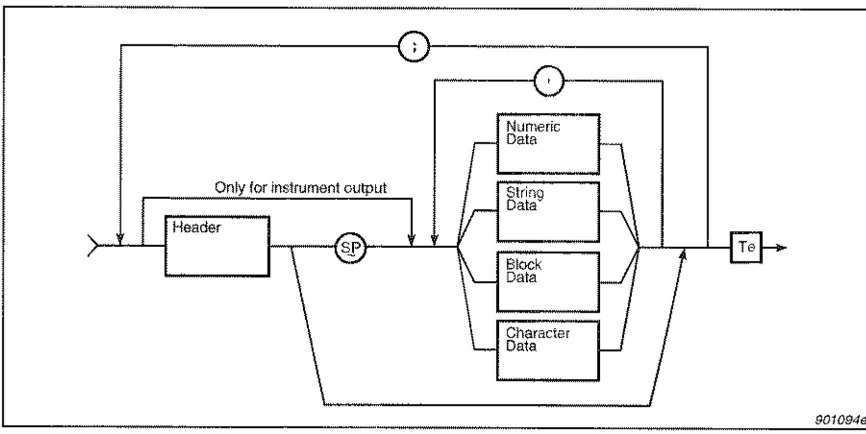


Fig. 4.3 General format for a message with all legal data types

4.2.1 Character Data

Character data must begin with an alphabetic character, either upper or lower case. This initial alphabetic character can be followed by any printable ASCII character, with the exception of a space (SP), a comma (,), a semi-colon (;), or the delete character (DEL). The valid ASCII characters are 33 through 126

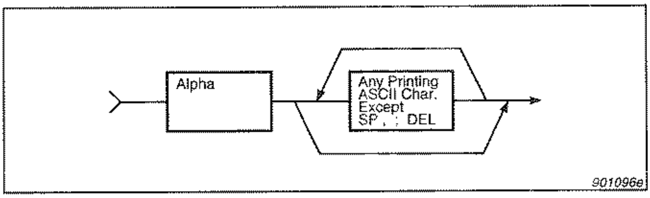


Fig. 4.4 General syntax for character data fields

(Decimal), with the exception of 44 (Decimal), and 59 (Decimal). Fig. 4.4 shows the valid form of entry for character data.

All headers and most setup field names are character data, as are many of the setup field settings. In the syntax diagrams, character data is represented by "Char.". When character data **must** be included, the data is written out in full in the syntax diagrams.

4.2.2 Numeric Data

Numerical data that is entered through the interface closely follows the format defined in the ANSI/IEEE 488.2-1987 Standard, "IEEE Standard Codes, Formats, Protocols and Common Commands" and the ISO 6093-1985 Standard, "Representation of numerical values in character strings for information interchange". The types of numeric data are represented in the syntax diagrams by NR1, NR2 and NR3, conforming to the above mentioned standards. The data is checked for illegal numbers not conforming to the above standards. The analyzer accepts in most cases the full NR3 (explicit point scaled representation, see Fig. 4.8), except where syntax diagrams state that NR1 or NR2

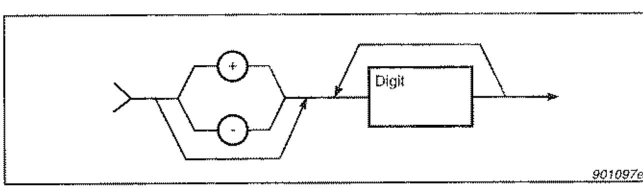


Fig. 4.5 Syntax for numerical data of type NR1 (implicit point representation)

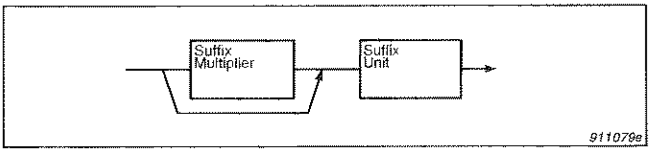


Fig. 4.6 Syntax for suffixes

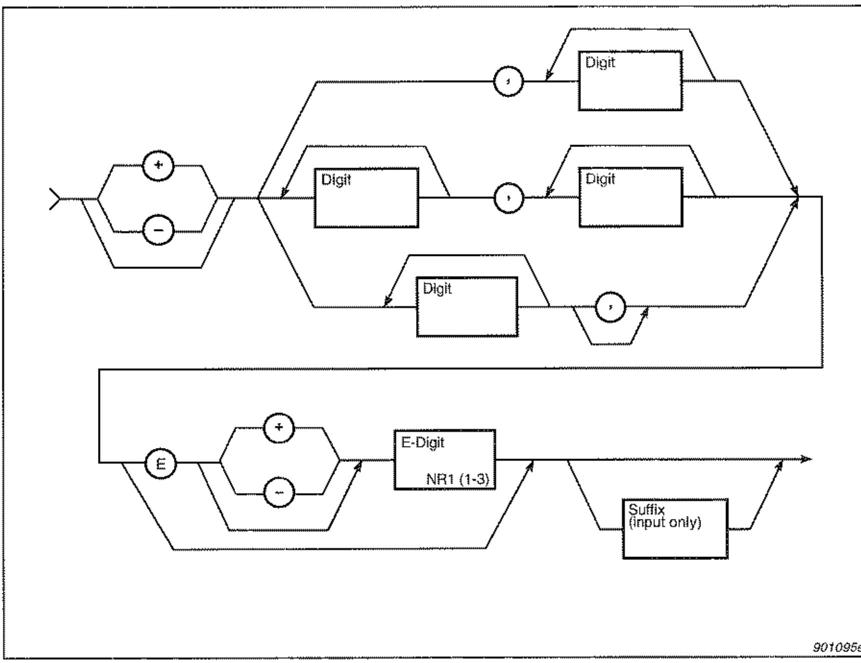


Fig. 4.7 Syntax for numerical data of type NR3 (explicit point scaled representation with exponent). NR2 is NR3 without exponent

is required. The syntax for numerical entry, NR1, NR2 and NR3, is shown in Figs. 4.5, 4.6 and 4.7.

A digit is any of the 10 number symbols, 0 through 9.

The following suffixes are available for entry through the interface.

`k` or `K` representing `kilo` and equivalent to `E+3`

m or M representing milli and equivalent to E-3
u or U representing micro and equivalent to E-6

When information containing any of these non-numeric suffixes is output from the analyzer, it is expressed in exponential notation. The analyzer writes out certain numerical values in a fixed format for easier interpretation in the controller. This depends on which message is used. In the following text, most messages to be output from the analyzer are illustrated with examples or syntax diagrams.

Note:
The maximum number of significant digits recognised by the analyzer is 29 (including exponent).

4.2.3 String Data

String data is the format used to enter a text in a message. In addition, it is used to enter special characters not allowed in character data fields.

String data is always enclosed in quotation marks. To include one quotation mark in the string data field, two quotation marks need to be entered. Fig. 4.8 gives the syntax for entering string data. The length in characters of a fixed length string data is given in parenthesis after the data type name.

Example:

```
"This is the text."
"This text contains "" one quotation mark."
```

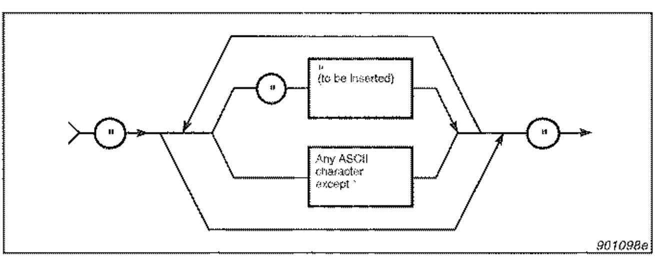


Fig. 4.8 Syntax for entering string data

4.2.4 Block Data

This describes the way block data is transmitted over the bus by the analyzer. The block data fields conform to the general format for "definite length arbitrary block data" as defined by IEEE Standard 488.2-1987. See Fig. 4.9 for the syntax of block data.

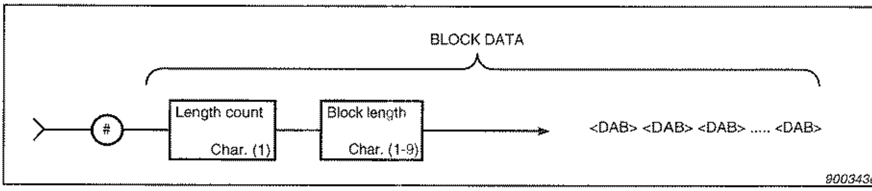


Fig. 4.9 Syntax for valid entry of block data

The length count gives the number of characters in the block length field. The length count is a number in the range 1 to 9. The block length gives the number of data bytes (<DAB>) in ASCII form found after the block length field (See section 7.14).

Example:

```
#3158<DAB><DAB><DAB>...<DAB>
```

158 bytes

Note:
When block data is received, only the block preface must be interpreted. For example, if <LF> is used as the terminator, an ASCII(10) in the block data will be regarded as the terminator. When using the IEEE interface, it is recommended only to use EOI (End_Or_Identify).

4.3 How to Make a Hard Copy

You can print out the information on the analyzer screen on a connected printer using the **"Hard Copy"** key on the analyzer front panel. Before printing you must select the correct print format for your printer, on page 3 of the I/O Interface menu (see Fig. 4.10). Press **"Hard Copy"** to print out a true raster copy of the analyzer screen. In Measurement Mode, there are three options for printing out your measurement data. You can select either GRAPHIC, GRAPHIC&TABLE, or TABLE, on page 3 the I/O Interface menu.

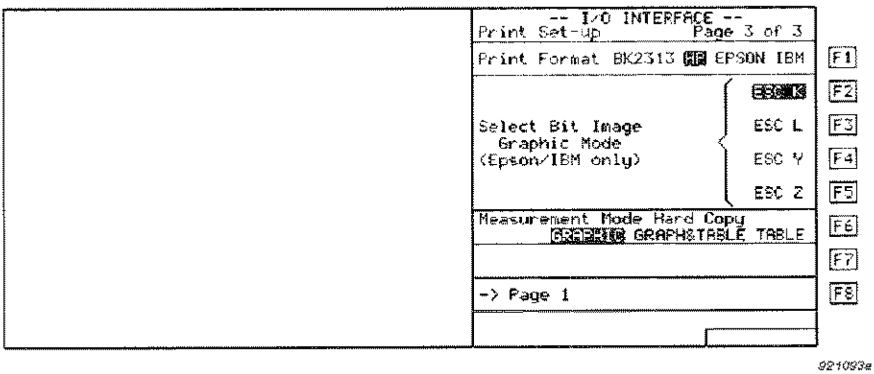


Fig. 4.10 Page 3 of I/O interface menu

Notes:

- If you select GRAPHIC, the read-out is a true raster copy of the current analyzer screen, see Fig. 4.11.
- If you select TABLE, the screen information is output in tabular form.
- If you select GRAPHIC&TABLE, the printout includes both of these options.

When **"Hard Copy"** is pressed the analyzer goes into talk mode, and lights the **"Hard Copy"** and **"Talk"** LEDs (Unless the **"Hard Copy"** LED is already lit, or the analyzer is addressed over the interface).

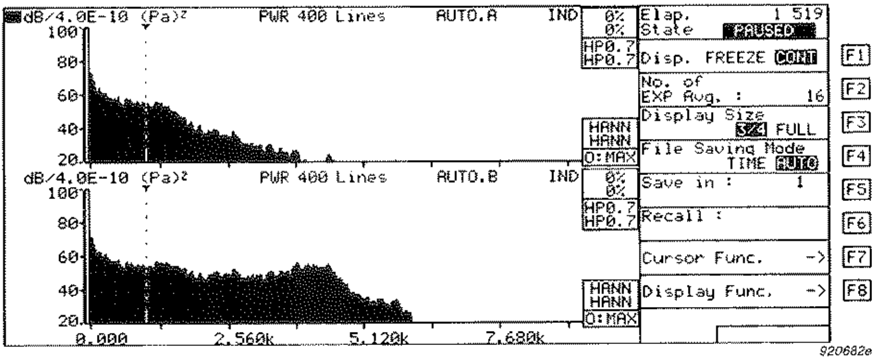


Fig. 4.11 Printout of Measurement Mode with the GRAPHIC option selected

The data is then read out to the printer via the IEEE–488 interface (or the RS–232–C, depending on which of them is currently selected). If **"Hard Copy"** is pressed again while the LED is still lit, the read-out is interrupted and the analyzer leaves talk mode.

When the read-out is complete, or if it is interrupted, the **"Hard Copy"** and **"Talk"** LEDs are turned off. Pressing **"Hard Copy"** again after this starts a new read-out.

Notes:

- If the interface is `INACTIVE` when **"Hard Copy"** is pressed, then it is activated automatically, and deactivated again when the printout is completed.
- For options `GRAPHIC&TABLE` and `TABLE` it is the Upper/ Lower selection which determines which set of spectrum values is printed out.

4.4 The Show Status Function

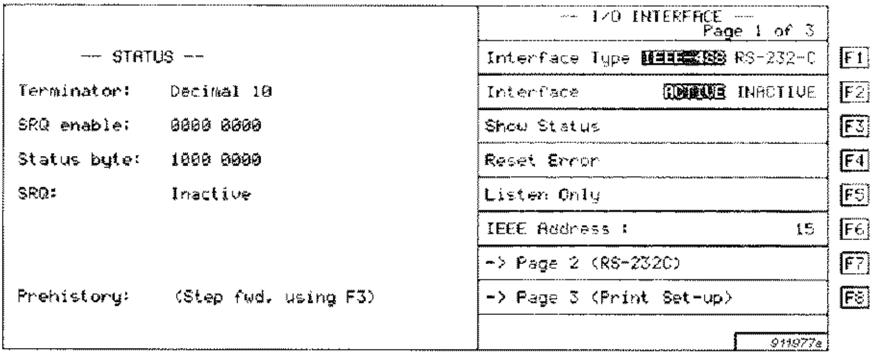


Fig. 4.12 Page 1 of I/O Interface menu after soft key F3 is pressed

Refer to Fig. 4.12.

`Terminator:` Shows the decimal value of the chosen terminator (default = 10, i.e. ASCII <LF>). See section 7.2 for the Define_Terminator message.

`SRQ enable:` Shows the current bit pattern for the status mask. See Service_Request_Enable, section 7.1.

`Status byte:` Shows the current bit pattern for the status byte.

`SRQ:` Can be either Active or Inactive.

`Prehistory:` (Step forward using **"F3"**). This is only displayed if **Error_Stop Yes** is chosen. See **Error_Stop**, section 7.3.

Chapter 5

Reset, Key Control and Boot/Load

5.1 RESet (RES)

RESet (command only) is used to reset the analyzer via the interface. This has the same effect as manual resetting the analyzer, i.e. the interface is unaddressed and is placed in Local state. To reset the IEEE interface only, the IEEE **DCL** or **SDC** command is used. See sections 2.7 and 3.4.

Note:

This Reset can result in noise on the bus. The bus will be stable again after 10 s.

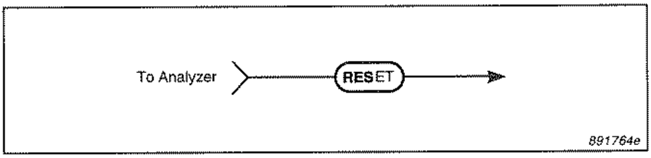


*Fig.5.1 Syntax for the **RES**et message*

5.2 Key_Control (K_C)

The **Key_Control** command message is used to perform one of more of the "remote keystrokes" listed in Table 5.1. This has the same effect as pressing the corresponding key(s) on the front panel of the analyzer.

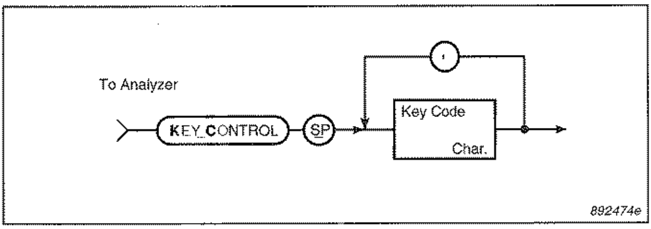


*Fig. 5.2 Syntax for the **K_C** command message*

The query message, **K_C?**, returns a read-out of the code for the last front-panel key operation, and the number of keys pressed since the last read-out or reset (via the front panel or the bus).

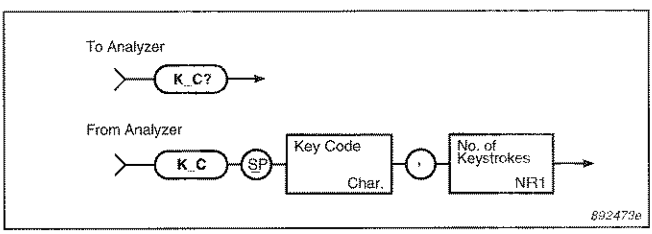


*Fig. 5.3 Syntax for the **K_C?** query message and analyzer response*

Key Control Codes	
Key	**Code**
Main Menu Meas. Mode F1 to F8 Next Menu Prev. Page	**MA_M** **ME_M** **F1** to **F8** **N_M** **P_P**
0 1 2 3 4 5 6 7 8 9 . Clear Recall k m +/−	**N0** **N1** **N2** **N3** **N4** **N5** **N6** **N7** **N8** **N9** **D_P** **CL** **REC** **K** **M** **C_S**
Autoseq. Stop/Step	**A_S_S**
Trigger Manual	**T_M**
Averaging Mode Lin. Averaging Mode Exp. Averaging Start Averaging Proceed Averaging Stop	**A_M_L** **A_M_E** **A_STA** **A_P** **A_STO**
Max. Input A Up Max. Input A Down Max. Input B Up Max. Input B Down Auto Range	**M_I_A_U** **M_I_A_D** **M_I_B_U** **M_I_B_D** **A_R**
Upper/Lower	**U_L**
Viewing Angle Up Viewing Angle Down	**V_A_U** **V_A_D**
Ampl. Scroll Up Ampl. Scroll Down	**A_S_U** **A_S_D**

Table 5.1 K_C pushkeys and codes

Key Control Codes	
Key	**Code**
Freq. Scroll Up Freq. Scroll Down	**F_S_U** **F_S_D**
Back Lighting On/Off	**B_L**
Hard Copy	**H_C**①
SRQ	**SRQ**
Local	**L**
Reset	**RES**

①Use the Print_Screen? query. The following errors will occur if the command K_C H_C is sent:
IEEE-488: "IN ADDR MODE"
RS-232-C: "IN LISTEN MODE"
"Hard Copy" is for manual use only and cannot be used when the interface is already in use. K_C H_C is retained as a command because the analyzer can still respond to K_C? with Hard_Copy as the last keypush.

Table 5.1 K_C pushkeys and codes

5.3 BOOT and LOAD

5.3.1 Syntax

Note:
BOOT(?) and **LOAD** can only be sent using the IEEE interface

The **BOOT(?)** and **LOAD** messages used in combination provide an alternative method of loading a new program and re-starting the analyzer. They have the same effect as a **"Master Reset"**, described in Volume 1 of this User Guide. Before attempting to load a program, you should send the **BOOT?** query message (see Fig. 5.4), to ensure that the analyzer is ready.

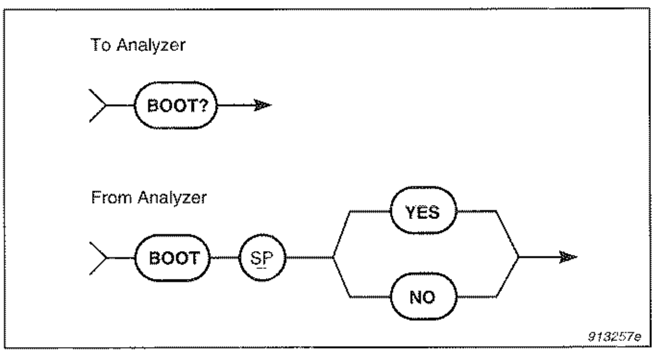


*Fig. 5.4 Syntax for the **BOOT?** query message and analyzer response*

If the analyzer responds with **YES**, then you can transfer the new program immediately, using the **LOAD** command message (see Fig. 5.6). If the response to **BOOT?** is **NO** then you must send the **BOOT** command message (Fig. 5.5), before sending **LOAD**.

Note:
The **BOOT(?)** and **LOAD** messages must be sent in full, there are no mnemonic codes.

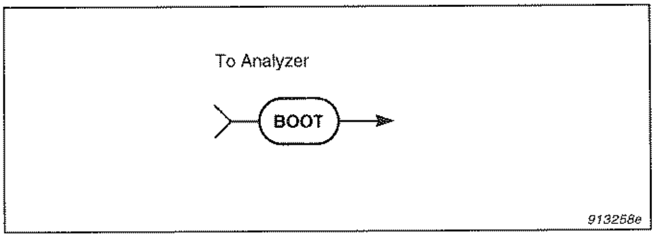


*Fig. 5.5 Syntax for the **BOOT** command message*

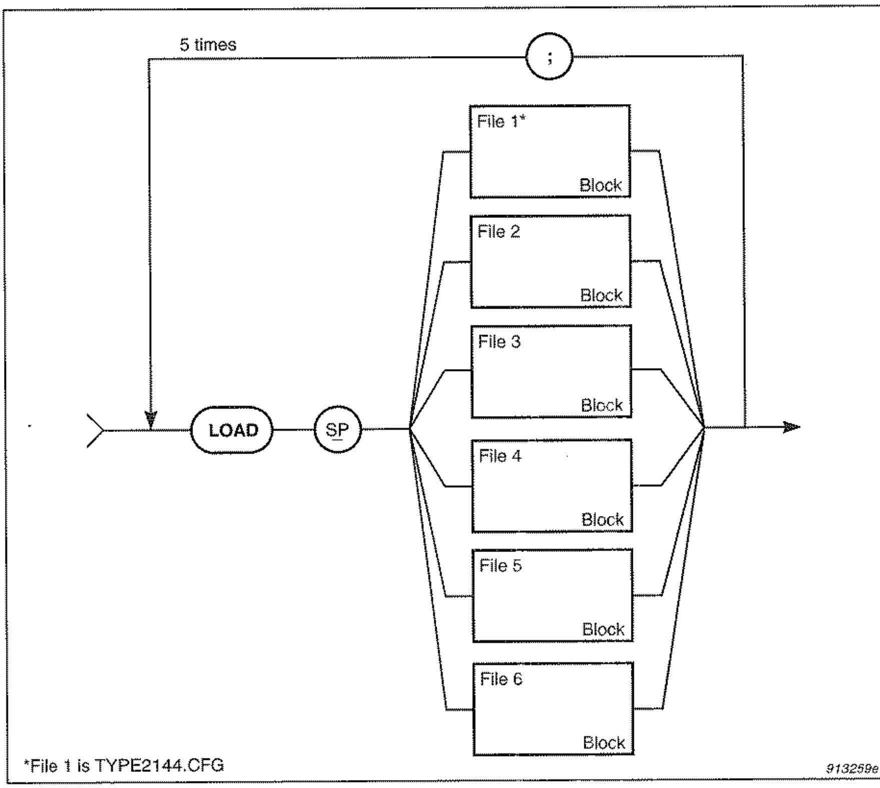


*Fig. 5.6 Syntax for the **LOAD** command message*

Notes:

- File 1 in Fig. 5.6 is the "Bootload Configuration File", named TYPE2144.CFG. This file **must always** be sent to the analyzer first. The remaining five files, described in the configuration file LOAD lines, are then sent. All six files **must** be sent to the analyzer in the order specified.
- When you load a new program you delete the existing contents of the data memory.

5.3.2 Loading the Program from an IBM PC

If you have an IBM PC XT, AT, PS/2 or compatible computer, fitted with a GPIB interface card from National Instruments, the analyzer program can be loaded in the following way:

1. Make a directory on your hard disk named, for example, 2148, by typing:

   `MD 2148 <Enter>`

2. Change to directory 2148 by typing:

   `CD 2148 <Enter>`

3. Copy all the files from the program disk supplied with/for your analyzer into this directory (the files occupy approximately 1 Mbyte), by typing:

   `COPY A:*.* <Enter>`

4. Store the program disk in a safe place.
5. Type `BOOTLOAD <Enter>`.
6. The program now prompts you to enter the IEEE device address you wish to assign to the analyzer. The factory default setting is 15, so if you have not altered it from the front panel of the analyzer, type:

   `15 <Enter>`

   Otherwise enter the desired number. The program will then load automatically. While loading, the **"Listen"** LED on the front panel of the analyzer is lit.

7. When all data has been successfully transferred, the message

   `BOOTLOAD TERMINATED SUCCESSFULLY`

   is displayed, and the program starts automatically. If this fails to happen , see section 5.3.3.

8. Normally, you will only need to download the program once. If, however, the back-up battery becomes discharged, you may have to repeat the procedure. The analyzer should then be left switched on for at least 15 hours to ensure full recharge.

Loading the program from another controller

If you are using any other system as your controller, you will need to write your own start-up program. To assist you in this, the program disk contains the file `BOOTLOAD.PAS`. You can adapt this program to meet the requirements of your system. The general procedure is described below. The start-up information is stored on the program disk in the files:

```
TYPE2144.CFG
RPXXXX.COF
FPXXXX.COF
HTXXXXGB.COF
DPXXXX.COF
HPXXXX.COF
```

where `XXXX` is 7651 or 7669.

The program is loaded using the BOOT(?) and LOAD messages.

1. First send `BOOT?`

   This asks the analyzer if it is ready to load a program. The first time it is switched on , the analyzer responds with:

   `BOOT YES`

   If the response is `NO`, then the analyzer already has a program loaded and is in measurement or set-up mode. If you still wish to load the program, you must send the `BOOT` command message to force the analyzer into bootload mode before carrying out step 2:

   `BOOT`

2. If the response to BOOT? is YES, you can transfer the new program immediately using the LOAD command messages (which must be in the order listed):

```
LOAD  <TYPE2144.CFG>
LOAD  <RPXXXX.COF>
LOAD  <FPXXXX.COF>
LOAD  <HTXXXXGB.COF>
LOAD  <DPXXXX.COF>
LOAD  <HPXXXX.COF>
```

3. You should ensure that your program contains enough error checking procedures to alert you if a fault occurs during loading. If the progeram develops a fault after loading, see the list of error messages in section 5.3.3.

5.3.3 Bootload Error Messages

After the last file has been transmitted, the loaded measurement program starts automatically. If the analyzer cannot load the program for some reason, an error message is displayed on the screen. The bootload error messages are listed in Table 5.2.

Error no.	Error Message	Description
	IEEE-488 LOAD ABORTED BY DEVICE CLEAR COMMAND	Load cancelled because SDC or DCL was received. Not a device error.
9001	UNEXPECTED END OF IEEE-488 TRANSMISSION	More data needed to complete load
9003	UNKNOWN IEEE HEADER	A header other than Boot(?) or Load was received
9004	IEEE SYNTAX ERROR	Check the syntax of the last IEEE message sent
9101	DISK ERROR	The disk contains a physical error
9103	FILE PROTECTED	Internal error – please report to B & K
9104	DISK PROTECTED	
9105	NO DISK SPACE	Internal error – please report to B & K
9106	NO DISK	Check that the disk is in the disk drive
9107	BAD DISK	Not a DOS disk

Table 5.2 Bootload error messages

Error no.	Error Message	Description
9108	FLOPPY JOB ERROR	Internal error – please report to B&K
9109	NO DIRECTORY SPACE	
9110	DUPLICATE FILE NAME	
9111	NO VOLUME LABEL	
9112	BREAK	
9113	DISK REMOVED DURING USE	Check that the disk is in the disk drive
9114	BAD DIRECTORY	Directory is incorrect or non-existent
9115	INVALID FILE NAME	The configuration file is corrupted
9116	UNKNOWN ERROR FROM FLOPPY	Internal error – please report to B&K
9200	EOF	
9201	ERROR IN CONFIG FILE, WRONG SYNTAX IN A LOAD LINE	The configuration file is corrupted
9202	COMMENT LINE OR DESCR LINE	Internal error – please report to B&K
9203	CRC_TABLE TOO SMALL	
9204	ERROR IN CONFIG FILE, DEST_ID IS TOO LONG	The configuration file is corrupted
9205	ERROR IN CONFIG FILE, FILE NAME IS TOO LONG	
9206	ERROR IN CONFIG FILE, UNKNOWN COMMAND	
9207	ERROR IN CONFIG FILE, UNKNOWN DEST_ID	
9208	ERROE IN PROGRAM FILE, NOT IN B&K COFF FORMAT	A program file is corrupted
9209	TOO MANY SECTION HEADERS	Internal error – please report to B&K
9210	EXIT WITH UNEXPECTED STATE	
9211	ERROR IN CONFIG FILE, ILLEGAL CHARACTER	The configuration file is corrupted
9212	PASSED LINE LGT IN CONFIG FILE	Internal error – please report to B&K
9213	ERROR ON INTERFACE PARAMETERS - INITIALIZED	Interface parameters have been lost – replaced with default values
9214	NO DISK - PLEASE INSERT SYSTEM DISK	Insert program disk

Table 5.2 Bootload error messages

Error no.	Error Message	Description
9215	NON SYSTEM DISK	
9215	SOFTWARE KEY IS MISSING	You cannot run the program without the correct software key fitted. See Vol. 1
9300	DSP LOADED	Internal error – please report to B&K
9301	NO CODE LOADED FOR DSP	
9302	NO SPACE IN GLOBAL_DATA_BUFFER	
9303	CRC ERROR IN DSP CODE	
9304	MAIN PROGRAM NOT VALID	The last program loaded has been corrupted. Load a new program
9305	UNABLE TO LOAD DSP1	Hardware error – please report to B&K
9306	UNABLE TO LOAD DSP2	
9312	DP WRITE TIMEOUT	Internal error – please report to B&K
9313	ERROR IN COMM. WITH DP - INITIALIZED	
9314	DEST_ID OUT OF RANGE	
9315	HP CRC_TABLE TOO SMALL	
9316	HT CRC_TABLE TOO SMALL	
9317	TOO MANY CRC_ELEM TO DP	
9318	ODD COUNT IN HP CRC BLOCK	
9319	ODD COUNT IN HT CRC BLOCK	
9320	"NO LOAD" DSP CHECK_SECTION NOT ALLOWED	
9321	INVALID DEVICE NAME	
9322	DEST_ID OUT OF RANGE	
9323	SOURCE OVERRUN	
9324	DEST. OVERRUN	
9325	ID ERROR	
9400	REACHED EOF BEFORE THE SPECIFIED BYTE COUNT	
9401	FILE NOT FOUND	A file named in the configuration file cannot be found

Table 5.2 Bootload error messages

Chapter 6

Set-up Messages

6.1 Measurement_Type (M_T)

The command message is used to set the **M_T** data field and display the **M**easurement_**T**ype menu. The query message returns a read-out of the current **M_T** data field.

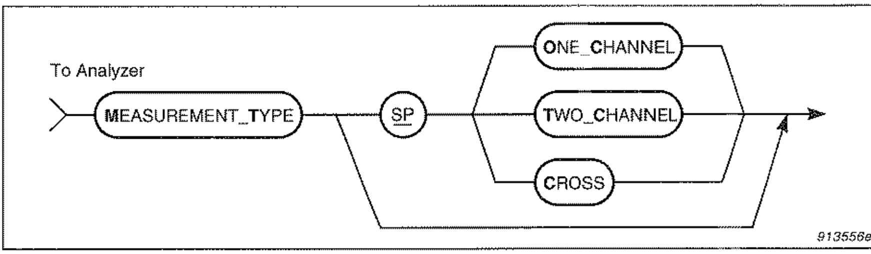


*Fig. 6.1 Syntax for the **M_T** command message*

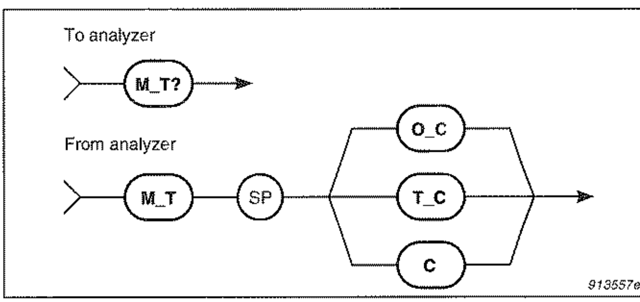


*Fig. 6.2 Syntax for the **M_T?** query message and analyzer response*

6.2 INput (IN)

The command message is used to set one or more of the **IN** data fields and display the **IN**put menu. The query message returns a read-out of all current **IN** data fields. The data fields and their settings are listed in Table 6.1.

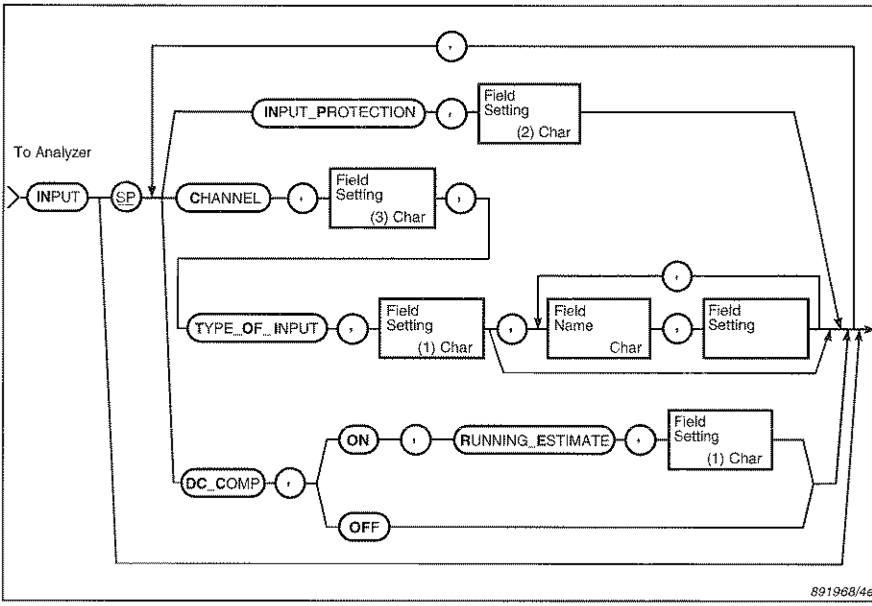


*Fig. 6.3 Syntax for the **IN** command message*

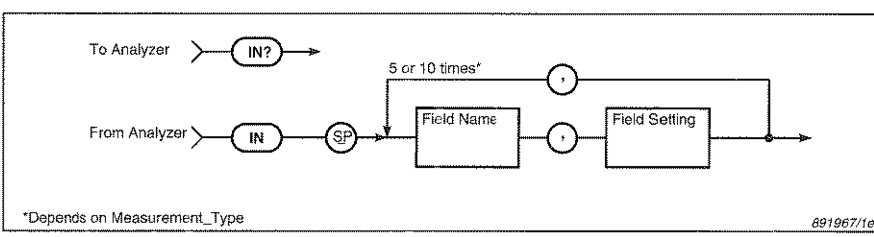


*Fig. 6.4 Syntax for the **IN?** query message and analyzer response*

Field Name	Field Setting	Data Type	Comments
Channel	**A_C** **B_C** **A_B**	Char.	 Cross mode only
Type_Of_Input	**Pr**obepreamp **D**irect **C**harge	Char.	 Not with **A**_Weighting[1]
Filter	**H**igh_**P**ass_**0.3** **H**igh_**P**ass_**0.7** **H**igh_**P**ass_**20** **H**igh_**P**ass_**100** **A**_Weighting	Char.	Only with charge Not with charge
Low_**P**ass	**ON** **OF**f	Char.	Only with charge
Max_**I**nput	<numeric>	NR 1/3[2] with suffix[3]	
Input_**P**rotection	**ON** **OF**f	Char.	
DC_**C**ompensation	**ON** **OF**f	Char.	
Running_**E**stimate	**Y**es **N**o	Char.	Only with **DC**_**C**ompensation **ON**

[1] It is recommended to set the Filter setting before setting the Type_Of_Input
[2] Depends on whether Y-axis unit is dB or Absolute
[3] When the suffix unit is dB or Absolute, Max Input is dependent on the Y-axis unit

Table 6.1 INput data fields and codes

6.3 Time_Freq_Parameters (T_F_P)

The command message is used to set one or more specified **T_F_P** data fields and to display the Time/Frequency Parameters menu. The query message returns a read-out of the current **T_F_P** data fields. The data fields and their settings are listed in Table 6.2.

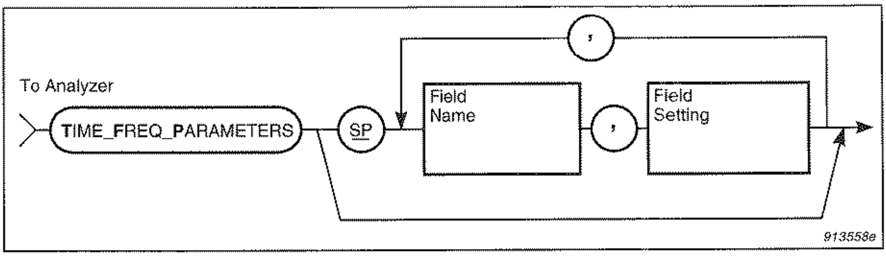


*Fig. 6.5 Syntax for the **T_F_P** command message*

Field Name	Field Setting	Data Type	Comments
Numberof_Lines	50; 100; 200; 400; 800	NR1	
Frequency_Span	<numeric>	NR3 (with suffix)	
Zoom	**OFf** **ON**	Char.	
Zoom_Center_Freq	<numeric>	NR3 (with suffix)	Only with Zoom on
Xaxis Sequence_Select	**R**esolution **S**pan	Char.	Only available with WH 2846

Table 6.2 Time_Freq_Parameters data fields and codes

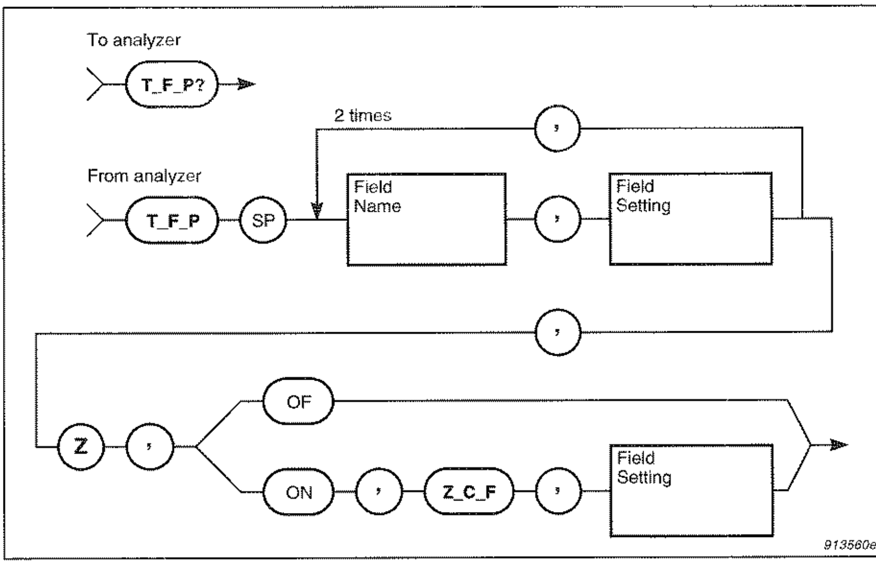


*Fig. 6.6 Syntax for the **T_F_P?** query message and analyzer response*

6.4 Calibration (CA)

The command message is used to set one or more specified **CA** data fields and display the Calibration menu. The query message returns a read-out of the current **CA** data fields for all inputs (with the exception of Auto_Calibration). The data fields and their settings are listed in Table 6.3.

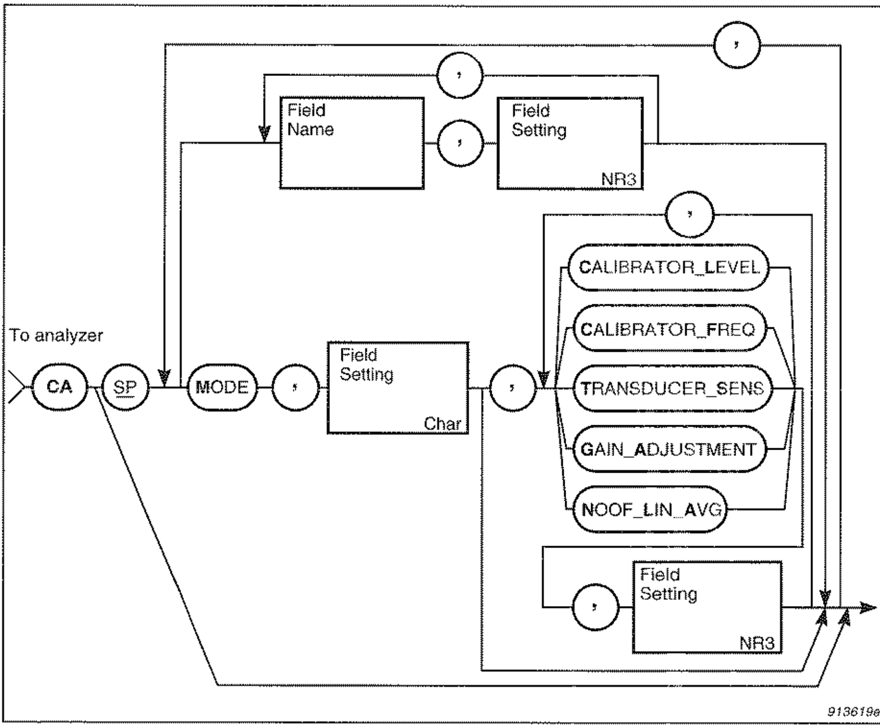


*Fig. 6.7 Syntax for the **CA** command message*

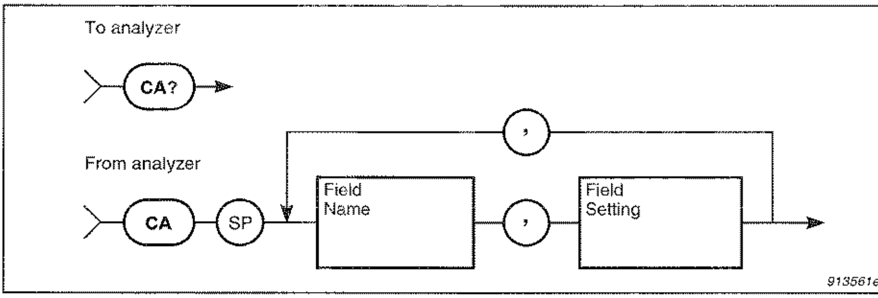


*Fig. 6.8 Syntax for the **CA?** query message and analyzer response*

Field Name	Field Setting	Data Type	Comments
Reference	**A** **B** **Re_Im** **V** **I_J**	Char.	 Cross mode only } Intensity
User_**R**eference		NR3	
Nominal_**S**pacing		NR1	
Ambient_**T**emperature	-25 to 100	NR2	Degrees Celsius
Ambient_**P**ressure	650 to 1100	NR1	Default unit hPa
Air_**D**ensity		NR3 (with suffix)	Default unit kg/m^3
User_**D**ensity		NR3 (with suffix)	
Mode	**A** **B** **A_B** **I** **V**	Char.	In 1-ch. mode depends on input channel Cross only I and V for verification of intensity calibration
Calibrator_**L**evel		NR3	See note in the Input message for Max_Input
Calibrator_**F**requency		NR3	
Transducer_**S**ensitivity		NR3	
Gain_**A**djustment		NR3	See note in the Input message for Max_Input
Noof_**L**in_**A**vg	128; 256; 512; 1024	NR1	
Auto_**C**alibration		Char.	Input only
Auto_**V**erification		Char.	

Table 6.3 CAlibration data fields and codes

6.5 COrrection (CO)

The command message is used to set one or more specified **CO** data fields and display the Correction menu (page 4 of the Calibration menu). The query message returns a read-out of the current **CO** data fields. The data fields and their settings are listed in Table 6.4.

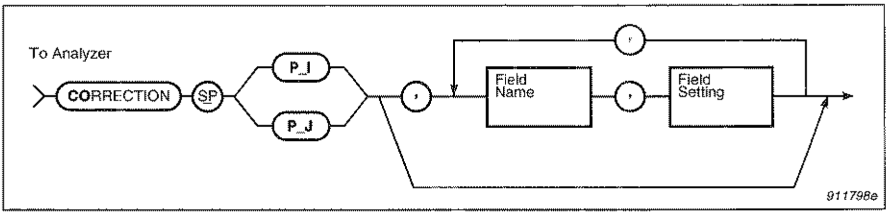


*Fig. 6.9 Syntax for the **CO** command message*

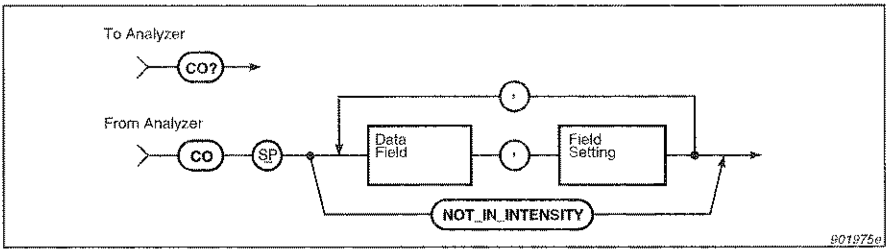


*Fig. 6.10 Syntax for the **CO?** query message and analyzer response*

Field Name	Field Setting	Data Type	Comments
Range_High_Frequency		NR3	
Range_Low_Frequency		NR3	
Noof_Averages		NR1	
Correction	**ON** **OFf**	Char.	
Save_Correction	1–999		Input message only

*Table 6.4 **COrrection** data fields and codes*

6.6 AVeraging (AV)

The command message is used to set one or more specified **AV** data fields and display the Averaging/Channel Delay menu. The query message returns a read-out of the current **AV** data fields. The data fields and their settings are listed in Table 6.5.

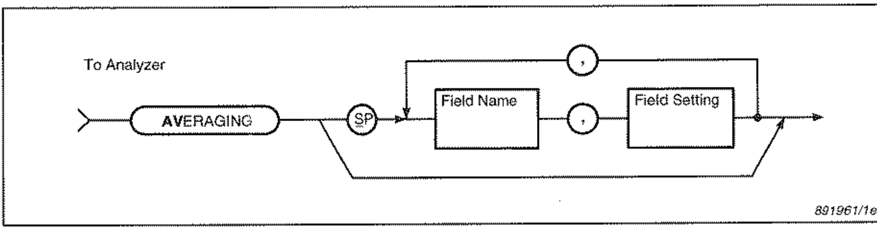


*Fig. 6.11 Syntax for the **AV** command message*

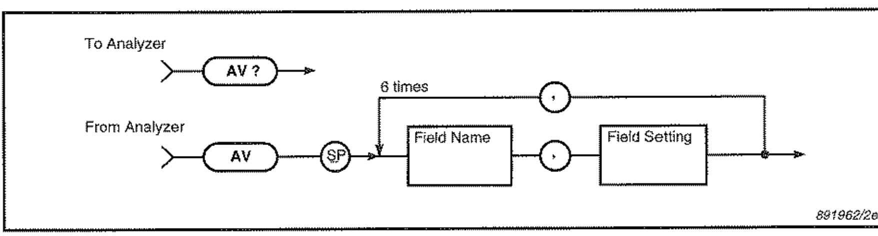


*Fig. 6.12 Syntax for the **AV?** query message and analyzer response*

Field Name	Field Setting	Data Type	Comments
Average_Mode	Linear Exponential	Char.	
Numberof_Averages		NR1	
Free_Run_Overlap	0; 50; 67; 75; Max	NR1 Char.	Percent
Delayfromch_Atoch_B		NR3	
Overload_Reject	ON OFf	Char.	
Reject_Hysteresis		NR1	
Auto_Range_Time		NR3	

Table 6.5 AVeraging data fields and codes

6.7 Display_Set_Up (D_S_U)

The command message is used to set one or more specified **D_S_U** data fields and to display the Display Set-up menu. The query message returns a read-out of the current **D_S_U** data fields. The data fields and their settings are listed in Table 6.6.

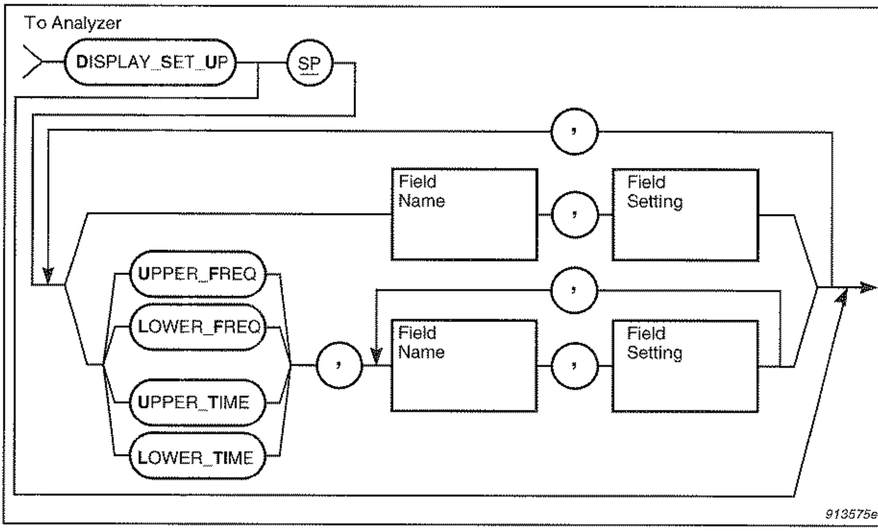


*Fig. 6.13 Syntax for the **D_S_U** command message*

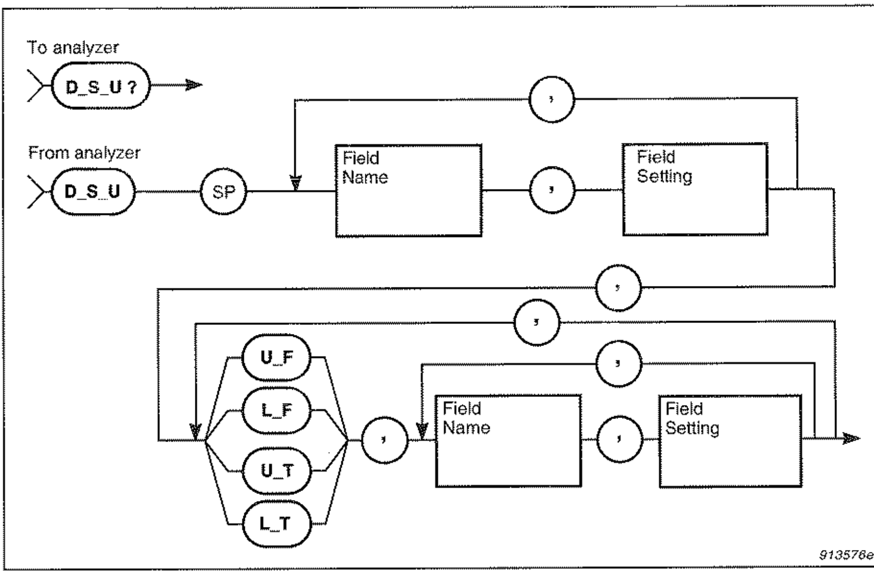


*Fig. 6.14 Syntax for the **D_S_U?** query message and analyzer response*

Field Name	Field Setting	Data Type	Comments
Mode_Options	Single DUal DIfference	Char.	
Freqdomain_Y_Axis	Absolute DB	Char.	
Timedomain_Y_Axis	Linear Absolute DB	Char.	
Y_Axis_Unit	Metric IMperial	Char.	
Freq_Axis_Compression	ON OFf	Char.	
Time_Axis_Compression	ON OFf	Char.	
Unitin_Headline	DEfault Unit	Char.	
Full_Scale	<numeric>	NR3	①
DISplayed_Amplitude_Range	10; 20; 40; 80; 160	NR1	Always in dB Only Freq.
Spectrum_Unit	PWr Rms PSd Esd	Char.	Only Freq.
Differentiationor_Integration	Diff_Twice DIfferentiated None INtegrated Integrated_Twice	Char.	Only Freq.
Bowtie_Correction	ON OFf	Char.	Only Time
Displayed_Phase_Range	0.2; 1; 5; 45; 90; 180; 360	NR1/NR2	
Displayed_Range_LOg	10; 20; 40; 80; 160	NR1	Only Time Always in dB
Displayed_Range_LIn	1.6; 3.2; 6.3; 12.5; 25; 50; 100	NR1/NR2	Only Time
DIFference_Ampl_Range	1; 5; 10; 20; 40; 80; 160	NR1	Only Freq./Upper Always in dB

①See note in the INput message for Max_Input

*Table 6.6 **Display_Set_Up** data fields and code*

6.8 Hold (H)

The command message is used to set one or more specified **H** data fields and display the Hold menu. The query message returns a read-out of the current **H** data fields. The data fields and their settings are listed in Table 6.7.

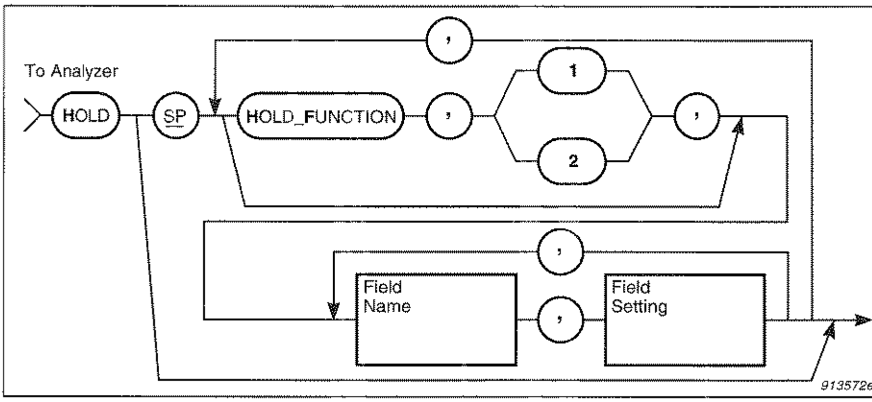


*Fig. 6.15 Syntax for the **H** command message*

Field Name	Field Setting	Data Type	Comments
Hold_Function	1 or 2	NR1	Ignored in 1-ch.
Type	**MA**x **MI**n	Char.	
Spectrum	**A**uto_**A** **A**uto_**B** **C**ross_**R**e **C**ross_**I**m	Char.	Ignored in 1-ch. } Cross only
MOde	**I**nactive **A**ll **L**ine	Char.	
Line_Frequency		NR3(with suffix)	Only in Line **MO**de

Table 6.7 Hold data fields and codes

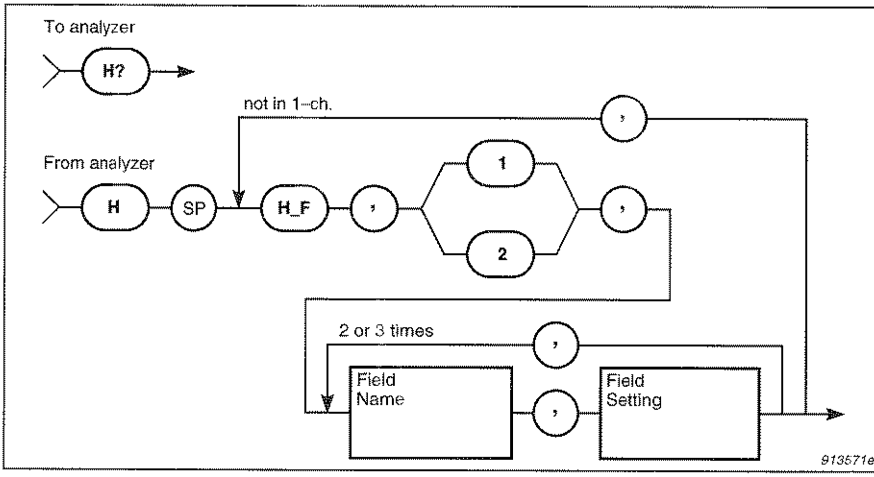


*Fig. 6.16 Syntax for the **H?** query message and analyzer response*

6.9 Time_Weight_Function (T_W_F)

The command message is used to set the **T_W_F** data fields and display the Time Weighting Function menu. The query message returns a read-out of the current **T_W_F** data fields. The data fields and their settings are listed in Table 6.8.

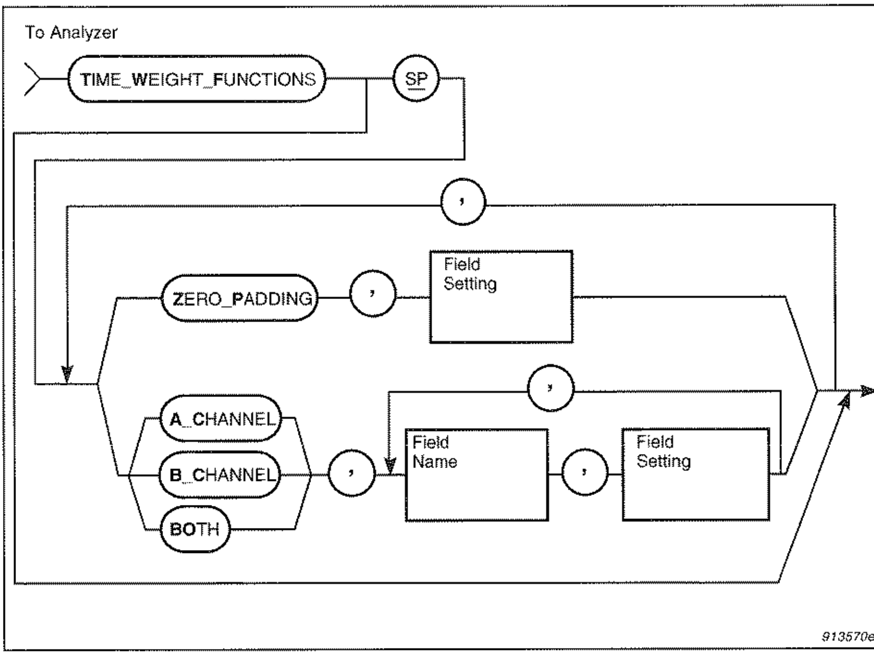


*Fig. 6.17 Syntax for the **T_W_F** command message*

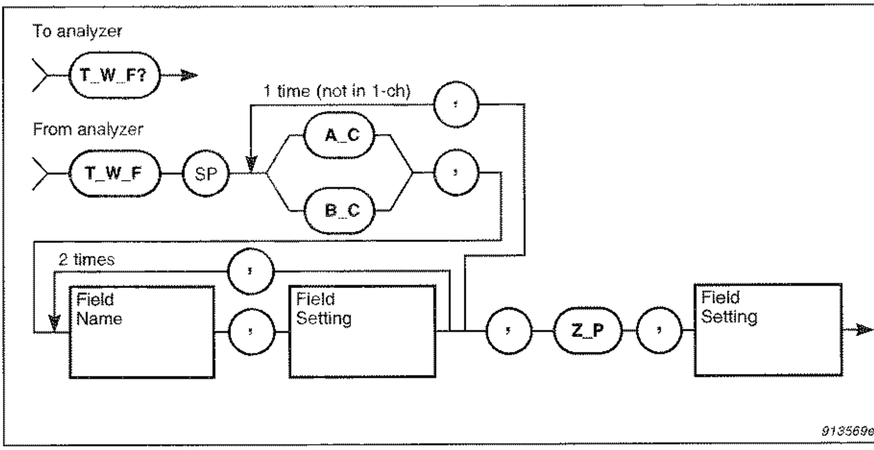


*Fig. 6.18 Syntax for the **T_W_F?** query message and analyzer response*

Field Name	Field Setting	Data Type	Comments
Zero_Padding	**N**one **A_C**hannel **B_C**hannel **BO**th	Char.	 Only 2-ch & Cross
Weighting	**R**ectangle **H**anning **F**lattop **T**ransient **E**xponential	Char.	
Window_Shift	<numeric>	NR3	Only Transient and Exponential
Window_Length	<numeric>	NR3	Only Transient and Exponential

Table 6.8 Time_Weight_Function data fields and codes

6.10 Real_Time_Clock (R_T_C)

The command message is used to display page 2 of the **Real_-Time_Clock** menu and set the 'Clock' data fields. The **R_T_C?** query message reads out all current Clock data fields. The data fields and their settings are listed in Table 6.9.

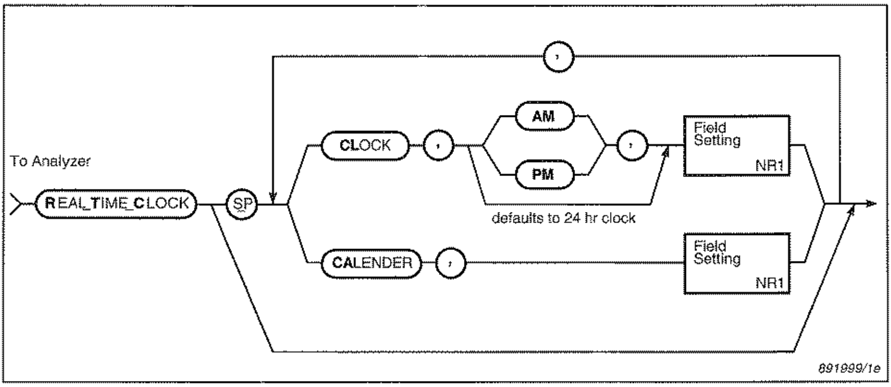


*Fig. 6.19 Syntax for the **R_T_C** command message*

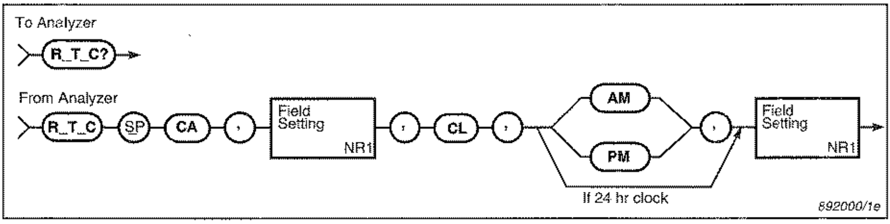


*Fig. 6.20 Syntax for the **R_T_C?** query message and analyzer response*

Field Name	Field Setting	Data Type	Comments
CAlendar	<integer>	NR1	YYYYMMDD
CLock	**A**m, <integer> **P**m, <integer> <integer>	Char. NR1	HHMMSS Integer on its own defaults to 24 hr clock

Table 6.9 Real_Time_Clock data fields and codes

Notes:

- Sending the **R_T_C** header without any data fields displays Page 2 of the Real_Time_Clock menu.
- Data fields concerned with **Wake_Up** functions are described in section 6.11.

6.11 Wake_Up (W_U)

The command message is used to set the **W_U** data fields in the **Real_Time_Clock** menu and display Page 1 of the menu. The query message returns a read-out of all **Wake_Up** data fields. The data fields and their settings are listed in Table 6.10.

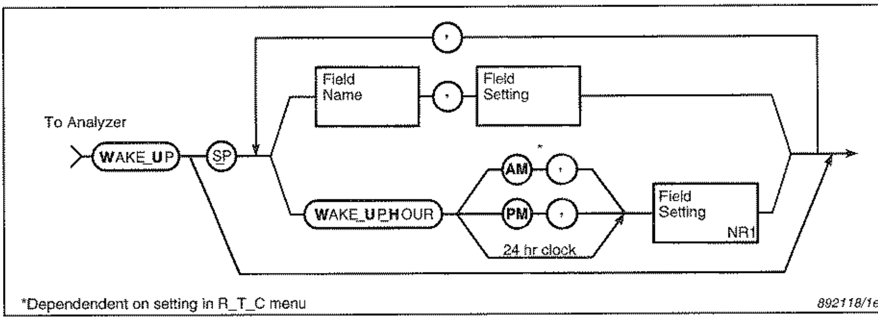


*Fig. 6.21 Syntax for the **W_U** command message*

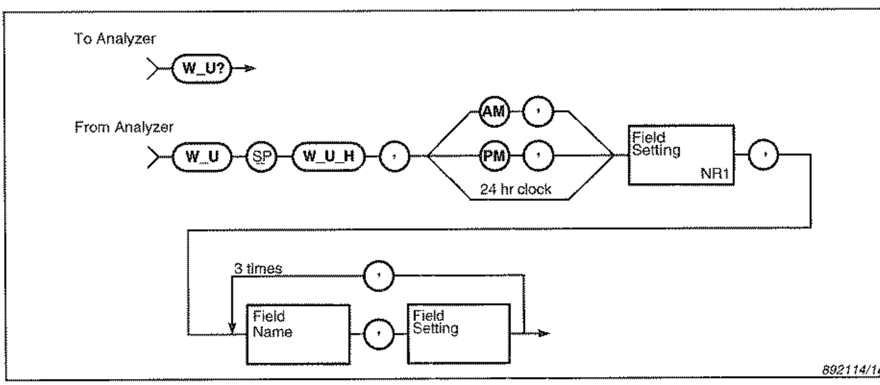


*Fig. 6.22 Syntax for the **W_U?** query message and analyzer response*

Field Name	Field Setting	Data Type	Comments
Wake_Up_Hour	**Am**, <integer> **Pm**, <integer> <integer>	Char. NR1	HHMM Depends on R_T_C setting. Omission defaults to 24 hr clock
Wake_Up_Interval	1 Minute to 24 Hours	NR2 (with suffix)	Minutes expressed as decimal fractions of an hour, e.g., 1.5H = 1 hr 30 min 90M = 1 hr 30 min Default is hours
Numberof_Wake_Ups	1–9999	NR1	Sets no. of "wake-ups"
Wake_Up	**AC**tive **I**nactive	Char.	See note
Elapsed_Numberof_Wake_Ups	0–9999	NR1	Exists as input message but has no effect

Table 6.10 Wake_Up data fields and codes

Note:
If the interface is active and **Wake_Up** is set to **AC**tive, 10 seconds elapses, then the analyzer switches itself off and consequently deactivates the interface. When the analyzer "wakes up" again it will automatically reactivate the interface.

6.12 Measurement_Text_Predefine (M_T_P)

The command message is used to edit the numbered texts in the **M**easurement_**T**ext menu, and to display Page 2 of that menu. The query message returns a read-out of all numbered texts in the **M**easurement_**T**ext menu. The **M_T_P** data fields and their settings are listed in Table 6.11.

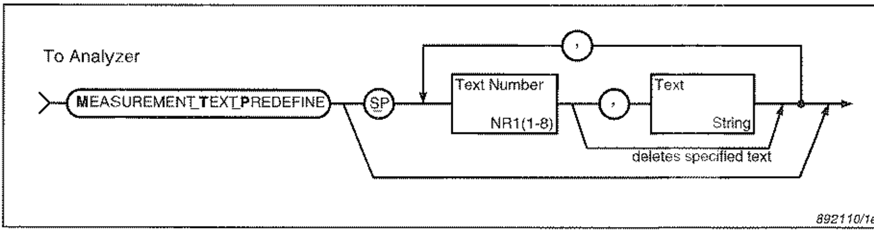


*Fig. 6.23 Syntax for the **M_T_P** command message*

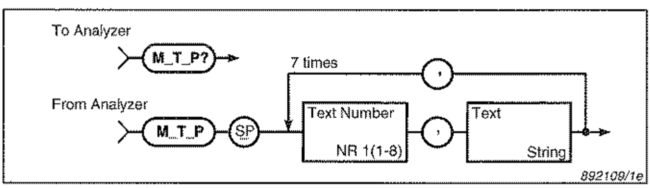


*Fig. 6.24 Syntax for the **M_T_P?** query message and analyzer*

Example:
To enter the first text field, the controller sends:

```
M_T_P 1,"ABCDEF"
```

Data Field	Data Type
Text No.	NR1
Text	String①

①Max. 40 char.

Table 6.11 Measurement_Text_Predefine data fields

Example:
To obtain a read-out of the text fields, the controller sends:

```
M_T_P?
```

The analyzer responds with (for example):

```
M_T_P 1,"ABCDEF   ",2,"GHIJKL   ",3,"...
```

6.13 Measurement_Text_Select (M_T_S)

The **M**easurement_**T**ext_**S**elect command message is used to select one of the predefined texts from the **M**easurement_**T**ext menu, and to display Page 1 of that menu.

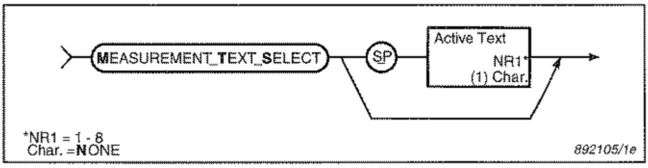


*Fig.6.25 Syntax for the **M_T_S** command message*

6.14 Trigger (T)

The command message is used to set one or more specified **T** data fields and to display the Trigger/Multimode menu. The query message returns a read-out of the current **T** data fields. The data fields and their settings are listed in Tables 6.12 to 6.14.

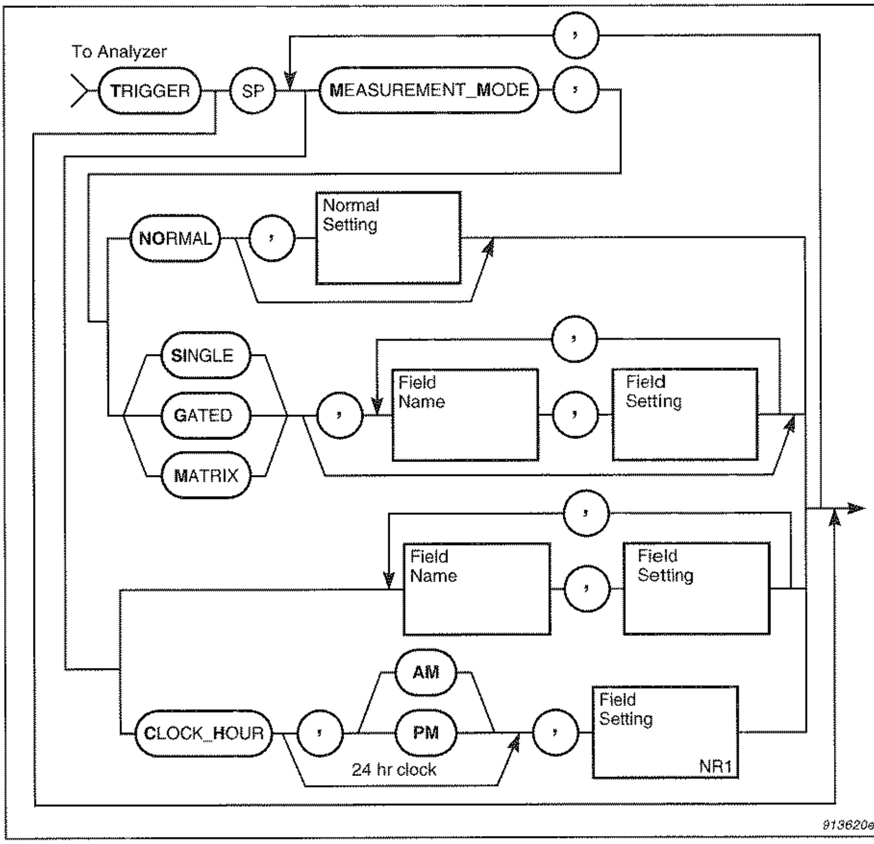


*Fig. 6.26 Syntax for the **T** command message. For Normal Setting see Fig. 6.31*

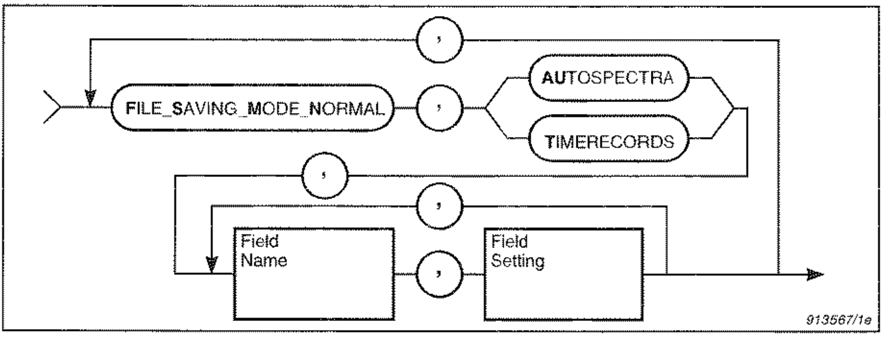


Fig. 6.27 Syntax for the Normal setting

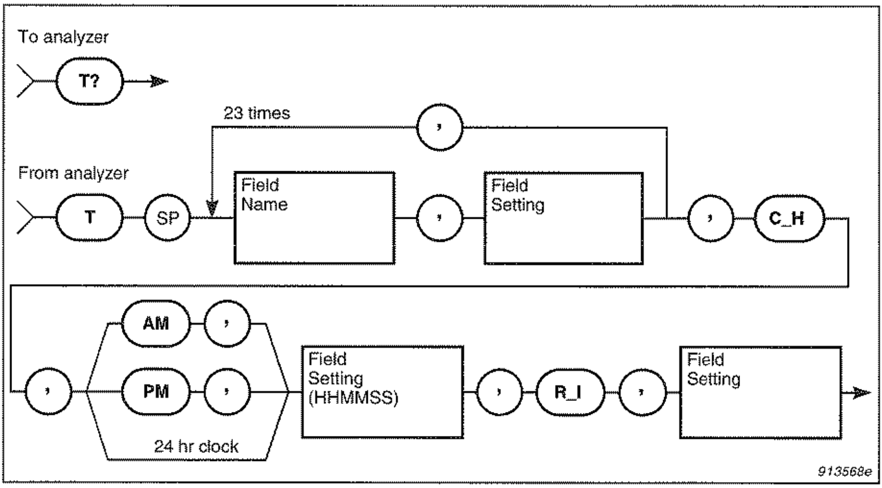


*Fig. 6.28 Syntax for the **T?** query message and analyzer response*

Field Name	Field Setting	Data Type	Comments
Measurement_Mode	SIngle Gated NOrmal Matrix	Char.	
Trigger_SElect	Internal External CLock Manual Free_Run	Char.	
Trigger_Value	<numeric>	NR3	①
Trigger_SLope	POsitive NEgative	Char.	
Clock_Hour	Am, <integer> Pm, <integer> <integer>	Char. NR1	HHMMSS Integer on its own defaults to 24 hr clock
Repetition_Interval	<numeric>, MIn <numeric>, Sec	NR2 (with suffix)	Default is seconds

①See Note in the INput message for Max Input

Table 6.12 Trigger data fields and codes

Field Name	Field Setting	Data Type	Comments
Data fields and codes for Single Measurement			
Delayfrom_Triggerto_ Channel_Single		NR3	Seconds
File_Saving_Mode_ Single	AUtospectra Timerecords	Char.	
Data fields and codes for Gated Measurement			
Delayfrom_Triggerto_ Channel_Gated		NR3	Seconds
Stepbetween_REcords		NR3	Seconds
Numberof_Spectra		NR1	

Table 6.13 Trigger data fields and codes for Single and Stepped mode

Field Name	Field Setting	Data Type	Comments
Data fields and codes for Normal Measurement			
File_**S**aving_**M**ode_**N**ormal	**AU**tospectra **T**imerecords	Char.	
Time_**D**elay_**A**utospectra		NR3	A negative value = pretriggering
Numberof_**S**pectraper_**T**rigger		NR1	
Time_**I**nterval_**B**etween_**S**pectra		NR3	
Numberof_**T**riggers_**A**utospectra		NR1	
Time_**D**elay_**T**imerecords		NR3	A negative value = pretriggering
Numberof_**R**ecordsper_**T**rigger		NR1	
Time_**I**nterval_**B**etween_ **R**ecords		NR3	
Numberof_**T**riggers_**T**imerecords		NR1	
Data fields and codes for Matrix Measurement			
Numberof_**R**ows	1 to 99	NR1	
Numberof_**C**olumns	1 to 99	NR1	
Numberof_**D**irections	1 to 3	NR1	
Measurement_**S**equence	**DCR** **DRC** **CDR** **CRD** **RDC** **RCD**	Char.	
Spacebetween_**RO**ws		NR3	Default is mm
Spacebetween_**C**olumns		NR3	Default is mm

Table 6.14 Trigger data fields and codes for Normal and Matrix modes

6.15 Preselected_SEtup (P_SE)

The command message is used to send a Preselected Setup to the analyzer in block data (binary) format and to change between the different Preselected Setups. You can activate a **M**easurement setup, **D**isplay setup or the **C**alibration setup from either default values or a set of stored values. The query message returns a read-out of a specified setup in binary or ASCII format. The data fields and their settings are listed in Table 6.15.

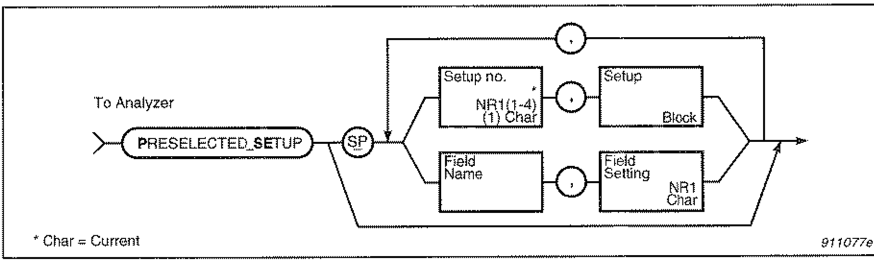


*Fig. 6.29 Syntax for the **P_SE** command message*

Header/Field Name	Field Setting	Data Type	Comments
Select	**1** **2** **3** **4** **D**efault	NR1 Char.	
Activate	**M**easurement **D**isplay **C**alibration	Char.	

*Table 6.15 **Preselected_SEtup** data fields and codes*

Examples:

The controller sends:

```
P_SE? C
```

The analyzer responds with:

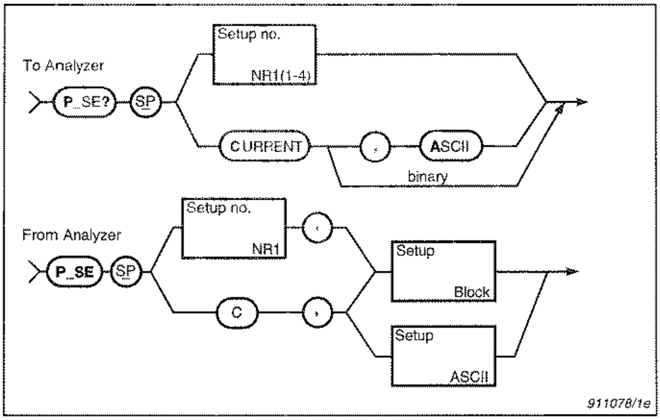


*Fig. 6.30 Syntax for the **P_SE?** query message and analyzer response*

```
P_SE C,#3883<block data>
```

The controller sends:

```
P_SE? C,A
```

The analyzer responds with:

```
P_SE C<CR><LF>
M_T C<CR><LF>
etc
```

Details of the data format for storage of block data in analyzer files are given in Chapter 10.

Note:
When the RS-232-C interface is used to transfer binary block data, 8 data bits are needed

6.16 Memory_Data (M_D)

6.16.1 M_D Command Message

The command message is used to set one or more specified **M_D** data fields and to display the Memory menu. The syntax for the command message is given in Fig. 6.31.

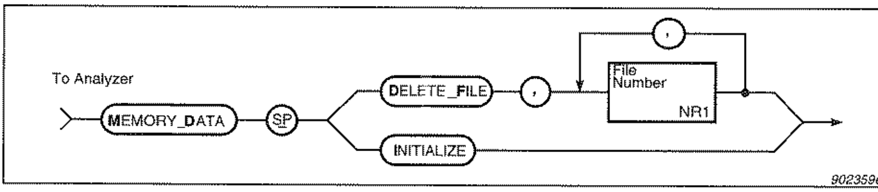


*Fig. 6.31 Syntax for the **M_D** command message*

6.16.2 M_D? Information Query Message

This query message is used to read out general information about the status of the spectrum memory over the interface. This information is also displayed on page 2 of the Memory menu.

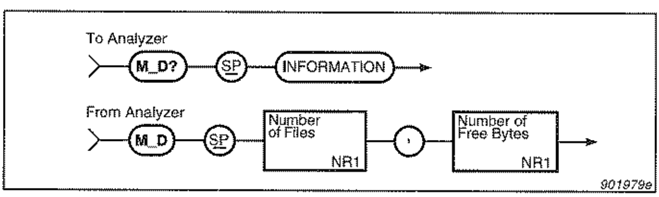


*Fig. 6.32 Syntax for the **M_D?** Information query message and analyzer response*

6.16.3 M_D? File List Query Message

In response to this query message, the analyzer lists all the files stored in the data memory, sorted according to which data field is specified.

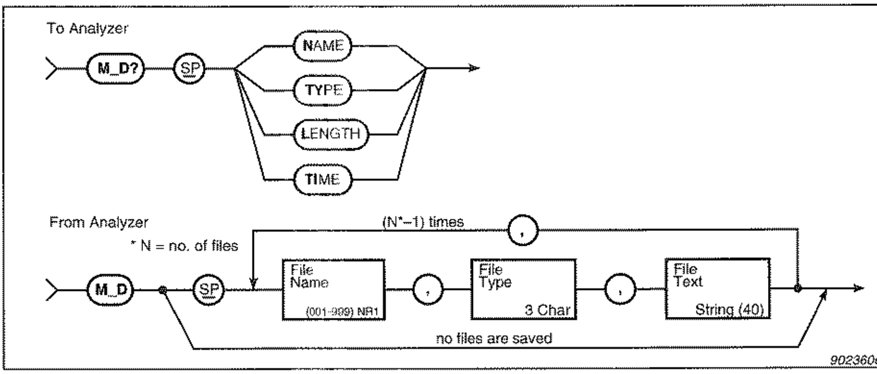


*Fig. 6.33 Syntax for the **M_D?** file list query message and analyzer response*

6.16.4 M_D? Overload Query Message

This query message is used to determine whether a particular file contains an overload. This could be used after a multispectrum measurement, to determine whether an overload has occurred in one of the spectra.

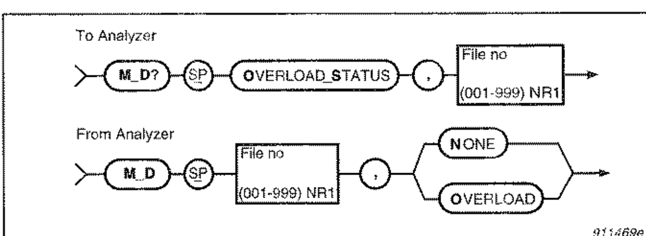


*Fig. 6.34 Syntax for the **M_D?** Overload query message and analyzer response*

Chapter 7

Device Control Messages

7.1 Service_Request_Enable (S_R_E)

Note:
This message is only available with IEEE-488

The **S**ervice_**R**equest_**E**nable command message is used to define the SRE mask. This determines which events generate a service request. The query message (**S_R_E?**) reads out the current decimal value of the SRQ mask. Table 7.1 describes the 8 bits of the 2148 status byte. Table 7.2 lists the SRQ functions which relate to these, along with a brief explanation of their use.

Bit no.	8	7	6	5	4	3	2	1
Binary Weighting	128	64	32	16	8	4	2	1
Designation	key pressed	service request	abnormal	busy	input overload	trigger accepted	global warning	data available

Table 7.1 The Status Byte

Note:
When the interface is made ACTIVE, all bits are disabled.

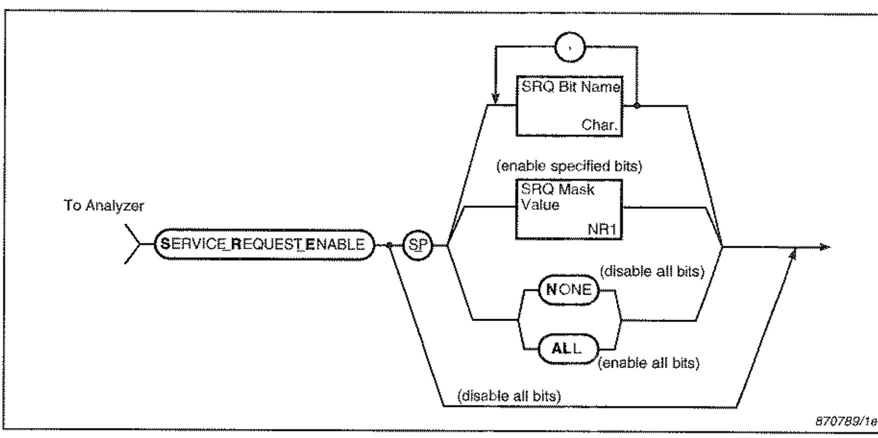


*Fig. 7.1 Syntax for the **S_R_E** command message*

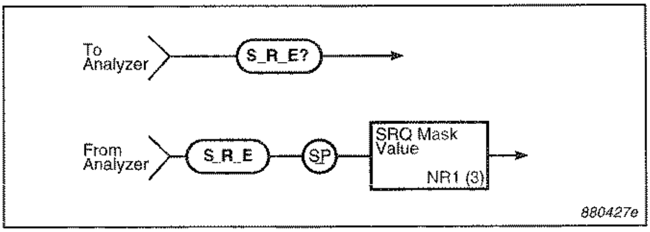


*Fig. 7.2 Syntax for the **S_R_E** query message and analyzer response*

Examples of Use:

```
S_R_E DATA_AVAILABLE,KEY_PRESSED
```

```
S_R_E 129
```

These two messages are equivalent, both set the mask bit pattern "10000001". The second message uses the decimal value of the bit pattern (1+128=129).

In this example the analyzer generates a service request:

- When it has finished processing the current data, and
- Whenever a key is pressed.

SRQ Function			
Bit No.	**Bit Name**	**Data Type**	**Status Indication**
1	**D**ata_**A**vailable	Char.	Set when RMS processor finished① and latest data received by display
2	**G**lobal_**W**arning	Char.	Set when power supply (battery) voltage is low or analogue module is protected
3	**T**rigger_**A**ccepted	Char.	Set when triggering conditions are satisfied
4	**I**nput_**O**verload	Char.	Set when an analogue or digital input overload occurs
5	[Busy]②		Set if the analyzer has not finished processing the previous message③
6	**AB**normal	Char.	Set when an error condition occurs
7	[SRQ]②		Set by the analyzer if one of the other bits is set③ (except bit 5)
8	**K**ey_**P**ressed	Char.	Set if one of the analyzer's pushkeys has been pressed④
(1 to 8)	**AL**l **N**one	Char.	Enable all bits in the status byte Disable all bits in the status byte
—	[Bit Pattern]②	NR1	Sets a selected combination of the above – NR1 is the decimal value of the bit pattern

①In the case of a multispectrum, Data_Available is set when the last spectrum is finished
②Not codes
③Cannot be enabled by the user
④In REMote without local LoCKout (LLO), this bit is set only when Local or SRQ keys are pressed. In REMote with LLO, the bit is set only when the SRQ key is pressed

Table 7.2 SRQ Functions

7.2 Define_Terminator (D_T)

The **Define_Terminator** message (command only) is used to define the ASCII character with which the analyzer terminates output messages, and which it recognises as the terminating character of input messages. See section 4.1.5 for further information.

By default, i.e. unless user-defined, the terminator is the line feed character<LF>.All the ASCII control characters, with the exception of 13, or <CR> can be used as terminators. See Table 7.3.

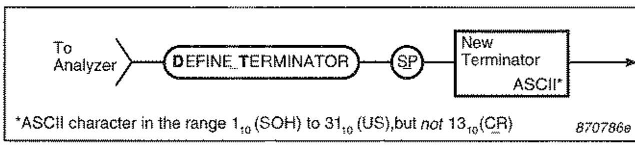


Fig. 7.3 Syntax for the D_T command message

Bit Numbers b_7 b_6 b_5 / $b_4\,b_3\,b_2\,b_1$	0 0 0	0 0 1	0 1 0	0 1 1	1 0 0	1 0 1	1 1 0	1 1 1
0 0 0 0	NUL	•DLE	SP	0	@	P	‘	p
0 0 0 1	•SOH	•DC1	!	1	A	Q	a	q
0 0 1 0	•STX	•DC2	“	2	B	R	b	r
0 0 1 1	•ETX	•DC3	#	3	C	S	c	s
0 1 0 0	•EOT	•DC4	$	4	D	T	d	t
0 1 0 1	•ENQ	•NAK	%	5	E	U	e	u
0 1 1 0	•ACK	•SYN	&	6	F	V	f	v
0 1 1 1	•BEL	•ETB	’	7	G	W	g	w
1 0 0 0	•BS	•CAN	(	8	H	X	h	x
1 0 0 1	•HT	•EM	)	9	I	Y	i	y
1 0 1 0	•LF	•SUB	*	:	J	Z	j	z
1 0 1 1	•VT	•ESC	+	;	K	[	k	{
1 1 0 0	•FF	•FS	,	<	L	\	l	|
1 1 0 1	CR	•GS	–	=	M	]	m	}
1 1 1 0	•SO	•RS	.	>	N	^	n	~
1 1 1 1	•SI	•US	/	?	O	_	o	DEL

Table 7.3 ASCII characters. The allowed terminators are indicated by •

Note:
With RS–232–C operation it is not advisable to use <DC3>, ASCII 19, as the message terminator, as this provides the RS–232–C X-Off function.

7.3 Error_Stop (E_S)

The **Error_Stop** message (command only) is used to determine what action the 2148 takes when an error is detected. The data field following the **E_S** header can be **Yes** or **No**, determining whether or not the **Error_Stop** function is active.

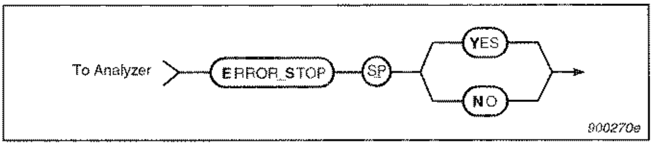


Fig. 7.4 Syntax for the E_S command message

Error_Stop works differently for the two interfaces. When **Error_Stop Yes** is selected:

- **IEEE 488** - when an error is detected, the 2148 stops the handshake with the bus, indicating to the controller that there is an error. After receiving a Device Clear (DCL) or Selected Device Clear (SDC), the analyzer resets the parser and resumes data reception. The parser is also reset and data reception resumed if the controller executes a serial poll or if the 2148 is requesting service.
- **RS-232-C** - when an error is detected, the 2148 discards any character received except BREAK. After receiving a BREAK, parsing is restarted.

When **Error_Stop No** is selected:

- **IEEE 488** - handshaking continues but all subsequent data is ignored until an End message (Char∧EOI). Parsing is then restarted.
- **RS-232-C** - when an error is detected, the 2148 discards all subsequent data until it receives a <BREAK>. After receiving a <BREAK>, parsing is resumed.

Note:
Error_Stop is automatically set to **No** in the following cases:

- The interface is manually switched from `INACTIVE` to `ACTIVE`

- The analyzer has been reset, either manually, or via the interface
- The analyzer has been switched OFF and ON again.

7.4 Reset_Status_Byte (R_S_B)

Note:
This message is only available with IEEE–488.

The **Reset_Status_Byte** message (command only) is used to return the status byte to its default setting. In this way a service request can be cancelled without performing a serial poll. All the status byte bits are set to zero.

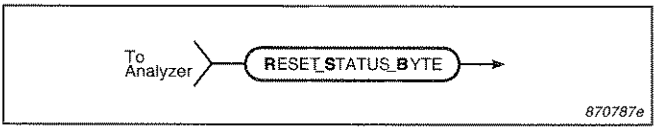


*Fig. 7.5 Syntax for the **R_S_B** command message*

7.5 IDentify? (ID?)

The **IDentify?** message (query only) returns a read-out of the instrument/software type. If version B of the message is sent, then the input module identification (analog type) and the software version number are also returned.

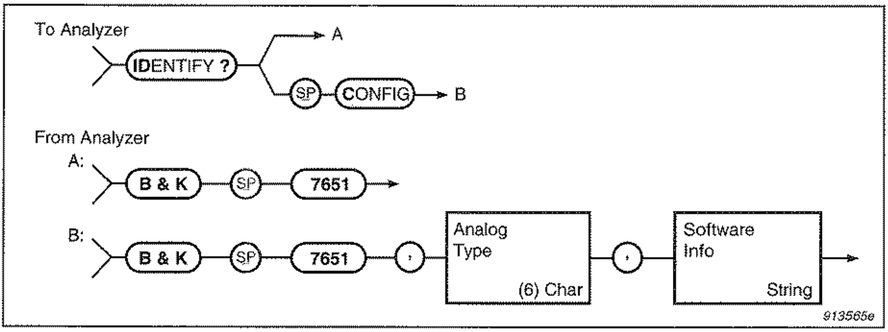


*Fig. 7.6 Syntax for the **ID?** query message and analyzer response*

7.6 Update (U)

Update (command only) is used to choose the update mode for the 2148 display. The alternatives are listed in Table 7.4.

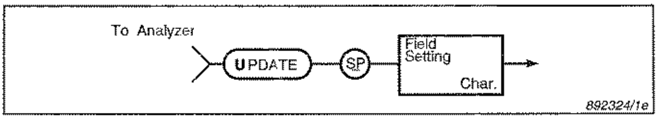


*Fig. 7.7 Syntax for the **U** command message*

Field Setting	Data Type	Comments
Update_Meas	Char.	Only displays changes in the Measurement menus, i.e. Measurement Mode, Calibration and Internal Trigger
Update_All	Char.	Displays all changes and the 'affected' menu. This is the default setting

Table 7.4 Update data fields

Note:
When changing the update mode, the analyzer always ends up in measurement mode.

7.7 AWait (AW)

AWait (command only) locks the IEEE interface until a particular event occurs. NRFD (Not Ready For Data) is held back until the specified event occurs (NRFD hold). The events are specified in the syntax diagram below.

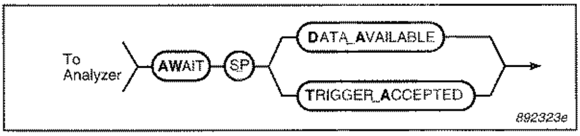


*Fig. 7.8 Syntax for the **AW** command message*

Notes:

- **AW**ait cannot be used with the RS–232–C interface
- NRFD hold is not active for any Universal or Addressed bus commands sent by the controller e.g. DCL, SDC, GET, etc.

7.8 Averaging_Mode (A_M)

Averaging_Mode (command only) is used to choose between linear and exponential averaging.

Note:
A_M can also be set up using the **AV**eraging message.

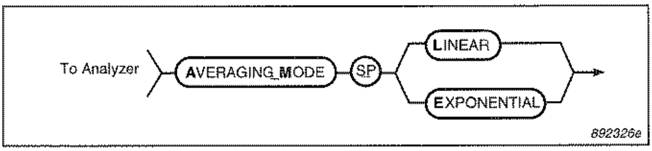


*Fig. 7.9 Syntax for the **A_M** command message*

7.9 Averaging_Control (A_C)

Averaging_Control (command only) is used to start, continue and stop an averaging operation.

Note:
If **A_C STArt** is received when the analyzer is not in measurement mode, it switches to measurement mode automatically, and then starts the measurement.

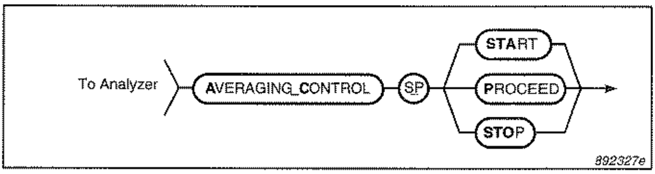


*Fig. 7.10 Syntax for the **A_C** command message*

7.10 Measurement_Mode (M_M)

Measurement_Mode is used to set one or more specified **M_M** data fields and to display the Measurement Mode menu. The command data fields and their settings are listed in Tables 7.5 and 7.6. The query message returns a read-out of the data fields listed in Tables 7.7 together with their current settings.

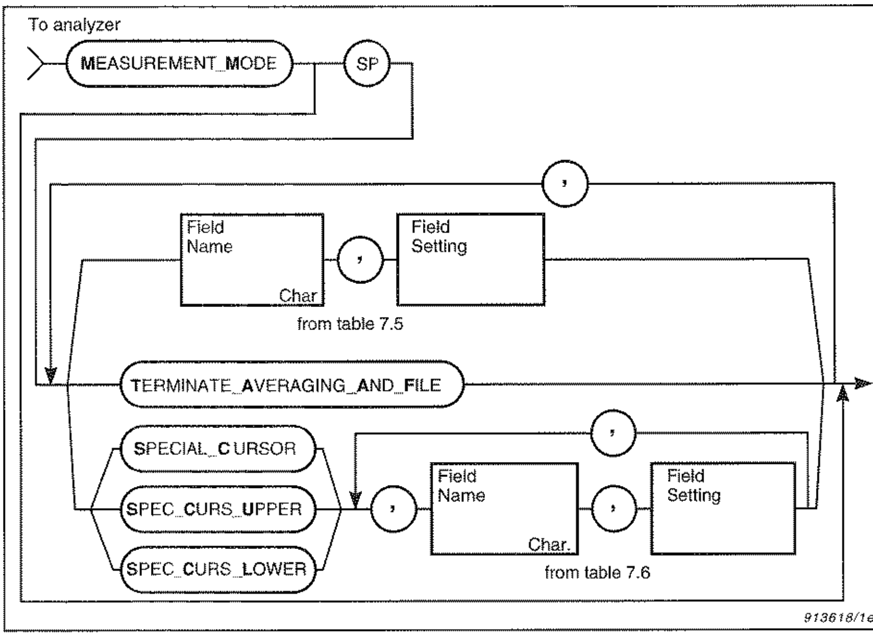


*Fig. 7.11 Syntax for the **M_M** command message*

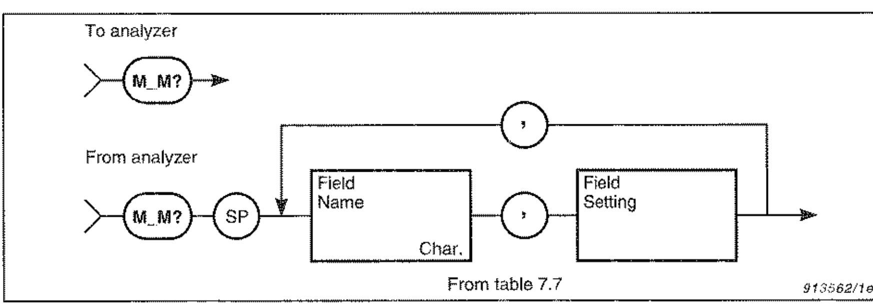


*Fig. 7.12 Syntax for the **M_M** query message and analyzer response*

Field Name	Field Setting	Data Type	Comments
DIsplay	**FREE**ze **CON**tinue	Char.	
No_**O**f_**A**verage	1 – 32767	NR1	
Display_**S**ize	**T**hree_**Q**uarters **FU**ll	Char.	
Storage_**M**ode	**TI**me **AU**to_**C**ross	Char.	Only in Single
Terminate_**A**veraging_**A**nd_**F**ile	[none] (not a setting)		Only in Normal or Matrix
Monitor_**S**pectrum_**N**o	1 – 999	NR1	Only in Gated
SAve	1 – 999	NR1	Only in Single or Gated
Open_**F**ile	1 – 999	NR1	Only in Normal or Matrix
RECall **R**ecallto_**U**pper **R**ecallto_**L**ower	1.001 – 999.999	NR1 NR2	For Multispectrum
Display_**D**omain	**FREQ** **TI**me	Char.	
Display_**F**unction **D**isplay_**F**unction_**U**pper **D**isplay_**F**unction_**L**ower	**I**nstant_**A** **I**nstant_**B** **A**uto_**A** **A**uto_**B** **CR**oss **COH**erence **COP** **N**cop **H1** **H2** **H3** **R**eciprocal_**H1** **PR**essure **V**elocity **I**_**J** **P**v_**C**oh		Frequency Domain (Hz)
	Time_**R**ecord_**A** **T**ime_**R**ecord_**B** **C**orrel_**AA** **C**orrel_**BB** **C**orrel_**AB** **I**mpulse_**R**esponse		Time Domain (s)

Table 7.5 Measurement_Mode data fields and settings (command)

Field Name	Field Setting	Data Type	Comments
Display_Complex_Part_Upper Display_Complex_Part_Lower	**REAL** **IM**aginary **MA**gnitude **PH**ase		Must be set *after* Display_Function[1]
ALign_**C**ursor	**ON** **OF**f	Char.	
Cursor_**P**osition **C**ursor_**P**osition_**U**pper **C**ursor_**P**osition_**L**ower		NR3	Hz for frequency Seconds for time
GRid	**ON** **OF**f	Char.	
Y_**R**eading **Y**_**R**eading_**U**pper **Y**_**R**eading_**L**ower	**L**ine_**V**alue **TO**tal **T**otal_**A** **D**elta_**Y** **S**um_**S**pan **S**um_**S**pan_**D**iv_ Total	Char.	Not Delta } } Only Delta } Only Spec_Curs

[1]There is one Complex_Part for each Display_Function (if relevant). Changing Display_Function therefore recalls the Complex_Part (if any) previously used with the new Display_Function

Table 7.5 Measurement_Mode data fields and settings (command)

Field Name	Field Setting	Data Type	Comments
Special_**C**ursor_**F**unction	**OF**f **REF**erence **DE**lta **HA**rmonic **S**ide_**B**and	Char.	} Not for time domain
Special_**C**ursor_**S**pan[1]	<numeric>	NR3	For Delta or Side-band cursor
Special_**C**ursor_**P**osition[1]	<numeric>	NR3	For Ref or Harmonic cursor

[1]In Hz for frequency domain and in seconds for time domain

Table 7.6 Measurement_Mode data fields and settings for special cursors (command)

Field Name	Field Setting	Data Type	Comments
Averaging_**S**tatus	**U**ndef **READ**y **RU**nning **PA**used **FI**nished **W**aiting **SE**ttling **GA**thering **A**uto_**R**ange		This field can also be read out using the Actual_Status message
Averaging_**E**lapsed		NR1	
DIsplay **D**isplay_**U**pper **D**isplay_**L**ower	**FREE**ze **CON**tinue	Char.	
SAve①		NR1	
ALign_**C**ursor	**ON** **OF**f	Char.	
Display_**D**omain	**FREQ** **TI**me	Char.	
Display_**F**unction_**U**pper **D**isplay_**F**unction_**L**ower	**I**nstant_**A** **I**nstant_**B** **A**uto_**A** **A**uto_**B** **CR**oss **COH**erence **COP** **N**cop **H1** **H2** **H3** **R**eciprocal_**H1** **PR**essure **V**elocity **I_J** **P**v_**C**oh **T**ime_**R**ecord_**A** **T**ime_**R**ecord_**B** **C**orrel_**AA** **C**orrel_**BB** **C**orrel_**AB** **I**mpulse_**R**esponse		
Display_**C**omplex_**P**art_**U**pper **D**isplay_**C**omplex_**P**art_**L**ower	**REAL** **IM**aginary **MA**gnitude **PH**ase		

①This is the figure displayed after 'SAVE IN' on the screen of the analyzer

Table 7.7 Measurement_Mode? data fields and settings (query)

7.11 Max_Input (M_I)

The **Max_Input** command message is used to set the input attenuator, either in single steps or by selecting a specified setting. The query message returns a read-out of the current setting.

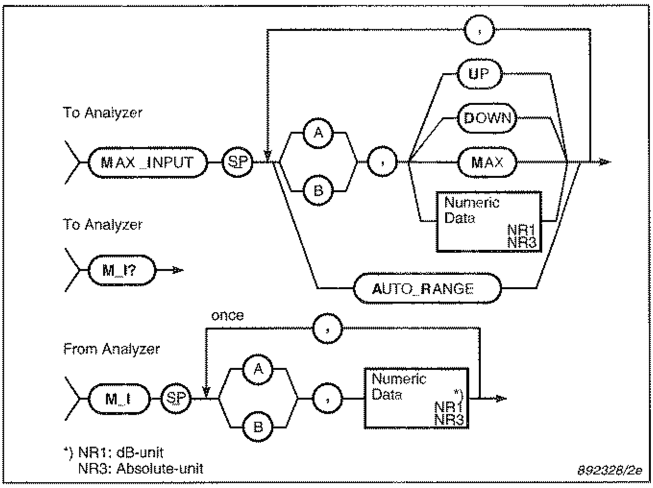


*Fig. 7.13 Syntax for the **M_I** messages*

7.12 REMote/LoCKout (REM/LCK)

Note:
These messages are only available with the RS-232-C interface.

REMote and **LoCKout** are used to control the Remote/Local function of the analyzer via the RS-232-C interface. Fig. 7.16 shows the relationship between the remote and local states.

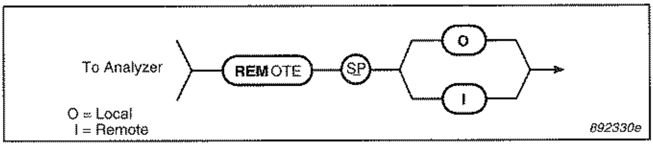


*Fig. 7.14 Syntax for the **REM** command message*

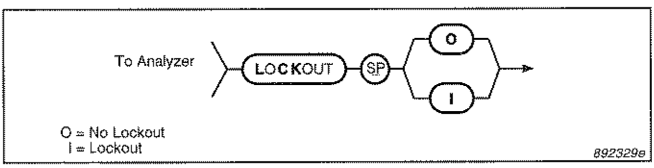


*Fig. 7.15 Syntax for the **LCK** command message*

Front Panel States

There are four states. Refer to Fig. 7.16.

1. **LOCS** – Local state: front-panel keys all work normally.
2. **REMS** – Remote state: limited front-panel operation (see section 2.5).
3. **RWLS** – Remote with lockout: similar to **REMS**, but the LOCAL key is inoperative.
4. **LWLS** – Local with lockout: front-panel keys all work normally.

Note:
When the interface is made ACTIVE, the analyzer is automatically set to the local state (LOCS).

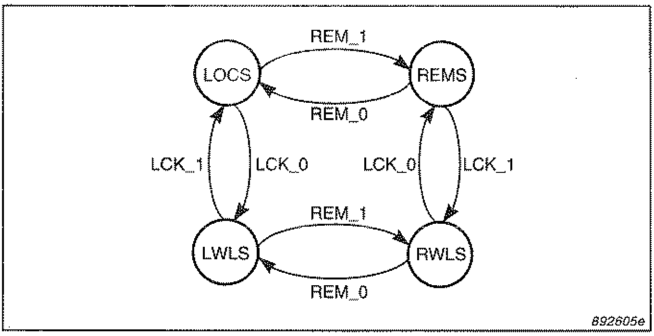


Fig. 7.16 Remote / Local state diagram

7.13 Group_Trigger (G_T)

Note:
This message has not effect when the RS–232–C interface is selected.

The Group_Trigger message allows you to enable the IEEE bus command "Group Execute Trigger" (GET). When GET is **Ena**bled, the analyzer responds to a GET command from a controller by generating a 1 µs pulse from the "Trigger Out" socket on the rear panel.

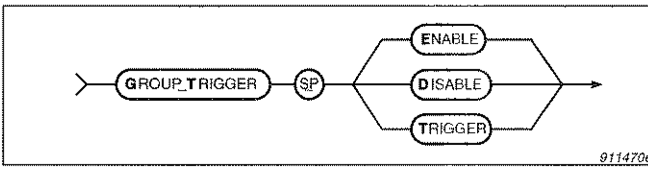


*Fig. 7.17 Syntax for the **G_T** command message*

You can also make the analyzer generate its own trigger pulse by sending the message **G**roup_**T**rigger **T**rigger. This allows you to trigger via the RS–232–C interface, though the trigger pulse will be delayed.

7.14 Block_Preface_Length (B_P_L)

The **B**lock_**P**reface_**L**ength command is used to define the length of the block preface. The **B_P_L** header defines the number of characters before the first data byte of a block. Block data is preceded by block length characters which specify the number of data bytes in the block. The length of the block preface must be greater than, or equal to 2 + the number of characters required to describe the length of the block. The block length count is a single numeric digit which defines the number of digits in the block length.

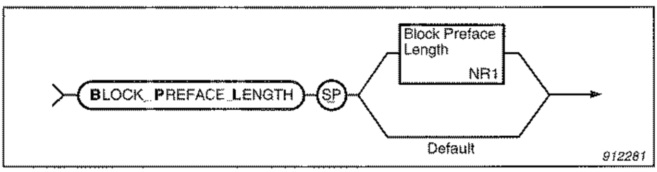


*Fig. 7.18 Syntax for the **B_P_L** command message*

Example:
If the block contains 1251 data bytes then the **B**lock_**P**reface_-**L**ength must be set to at least six.

```
Block Preface
 ______|______
# 4 1 2 5 1  <DAB> <DAB> <DAB> . . . <DAB>
  |  ___|___  ____________|_____________
  |   Block            Data bytes
  |   Length
  |______________ Block Length count
```

If the **B_P_L** is not large enough, the analyzer will generate an error. If it is not specified by the user or set to **D**efault the analyzer will automatically calculate the correct value. The block length characters are padded with zeros if **B_P_L** is greater than required.

Note:
The number of Block Length characters will always be **Block_-Preface_Length** minus two, as two characters are always required for the "#" and the Block Length character.

B_P_L will always be set to default after:

- A reset, either manual or via the interface.
- The Interface is made ACTIVE.
- The analyzer is turned on.

Chapter 8

Status, Result & Display Messages

8.1 ERror? (ER?)

ERror? (query only), returns information concerning the most recent analyzer error. This error record comprises the error number (see Chapter 9 for a full list of 2148 interface error messages and section 13.2 of Vol. 1 for non-interface errors) and a brief description of the error. It is in the form of a character string of up to 80 characters. The error record is described below, with examples. Fig. 8.1 shows the syntax for the **ERror?** message.

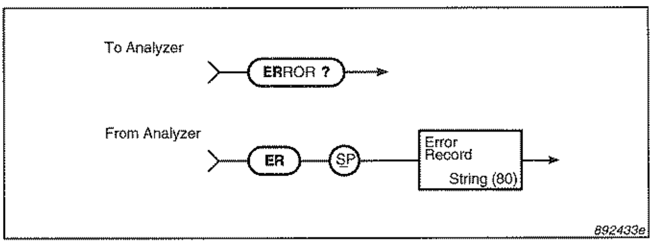


*Fig. 8.1 Syntax for the **ER?** message*

After the error record is read out, the record is deleted. If no error has occurred since the last read-out of **ER?**, the analyzer returns the message:

```
ER "ERR 000:-NO INTERFACE ERROR"
```

Error Record:

<">
Header: 4 char (1–4)
Error_Number: 4 char (5–8)
Error_Trail: 2 char (9–10)
Error_Text: 20 char (11–30)
Message_Header: 7 char (31–37) [*†]
Error_Buffer: 43 char (38–80) [*#]
<">

* Message_Header and Error_Buffer are left out if the error is the result of a manual operation. **Example:** "ERR 0060: UNKNOWN INDEX"

† Message_Header is left out if the error occurs on receipt of a header, in which case Error_Buffer is located from 30 to 44. **Example:** "ERR 0060: UNKNOWN INDEX g_b"

\# Left out if Error_Stop No is chosen. **Example:** "ERR 0060: UNKNOWN INDEX F_B:"

8.2 Status_Byte? (S_B?)

Status_Byte? (query only) returns a read-out of the 2148 status byte. This is similar to the effect of a serial poll performed via the IEEE interface, except that Busy (bit 5) will always be set. The value read out is the decimal value of the bit pattern.

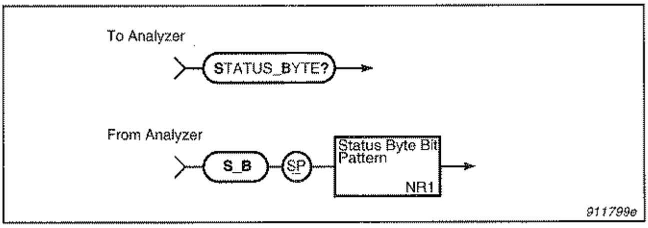


Fig.8.2 Syntax for the S_B? message

Example:

If you send:

```
S_B?
```

the analyzer responds (for example) with:

```
S_B 144.
```

This represents 10010000, i.e. bit 5 (busy) and bit 8 (key pressed) are set.

8.3 Actual_Status? (A_S?)

Actual_Status? (query only) returns a read-out of the status of one of the three **A_S** data fields, as listed in Table 8.1.

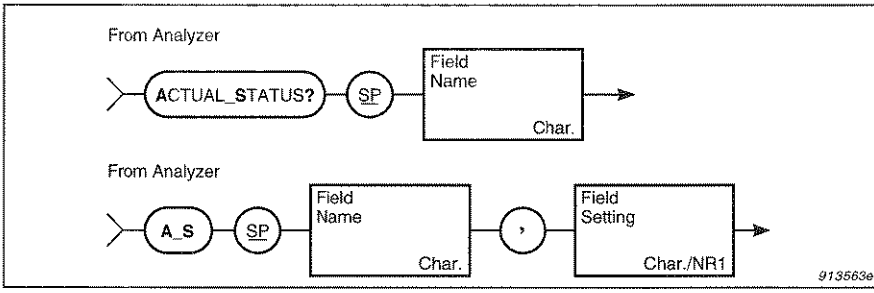


Fig. 8.3 Syntax for the A_S? message

Field Name	Field Setting	Data Type	Comments
Averaging	Undef **READ**y **RU**nning **PA**used **FI**nished **W**aiting **SE**ttling **GA**thering **A**uto_**R**ange	Char.	If **U**ndef occurs, please contact B & K
Input_**O**verload		NR1	8-bits status Bit 1 (LSB) common Bit 2 Channel A Bit 3 Channel B Bits 4–8 not used
Global_**W**arning	**L**ow_**P**ower **I**nput_**P**rotection **N**one	Char.	

Table 8.1 Actual_Status? data fields and codes

8.4 Measurement_Data_Transfer (M_D_T)

The **M_D_T** command and query messages are used to load files into and read files out of the 2148 memory. The files are input and output as binary block data.

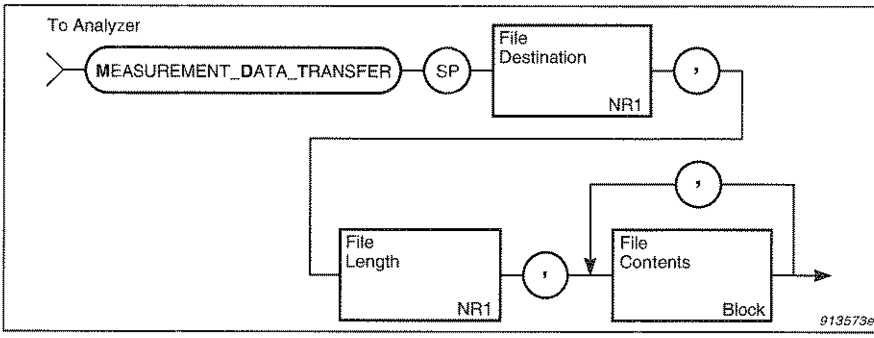


*Fig.8.4 Syntax for the **M_D_T** command message*

Examples

Current Measurement
To obtain a read-out of the current measurement, the controller sends:

```
M_D_T? C
```

The analyzer responds with (400 lines, autospectrum):

```
M_D_T #48320<data contents>
```

Numbered File
To obtain a read-out of file number 1, the controller sends:

```
M_D_T? 1
```

The analyzer responds with (400 lines, cross mode):

```
M_D_T 1,8955,#48955<set-up contents>
 <data contents>
```

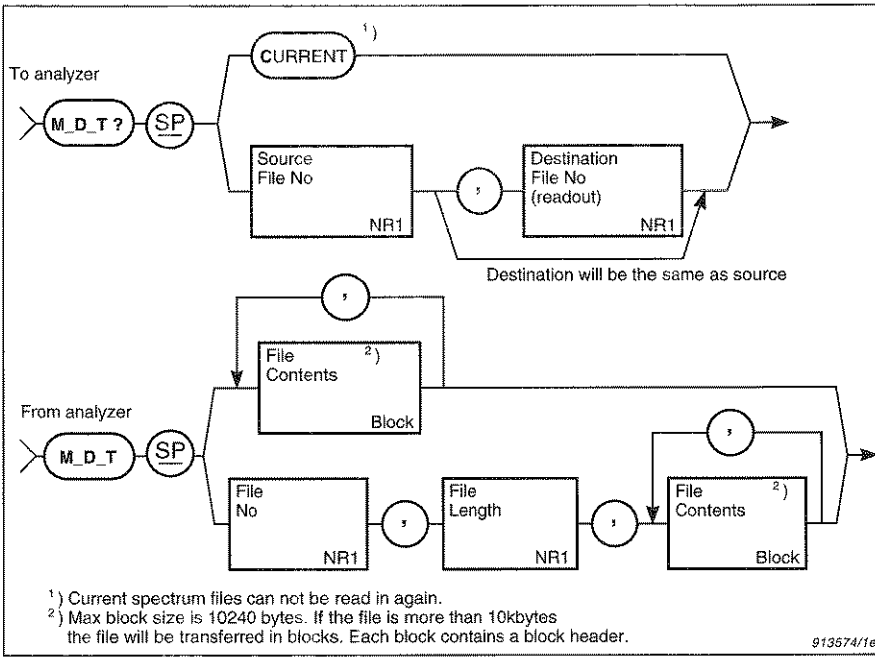


*Fig.8.5 Syntax for the **M_D_T?** query message and analyzer response*

Change File Number

To read-out of file number 1 as file number 100, the controller sends:

```
M_D_T? 1,100
```

The analyzer responds with (400 lines, cross mode):

```
M_D_T 100,8955,#48955<set-up contents>
  <data contents>
```

For further details of the block data format, see section 4.2.4 and Chapter 10.

Notes:

- If you attempt to read in and save a file using a file number which already exists (or an illegal file number), the file is not saved. The analyzer generates an error message, and sets the ABnormal bit in the status byte. If you want to use an existing file number, then first rename or delete the existing file.

- If a non-existent file number is specified for output, the analyzer generates an error message, and the ABnormal bit in the status byte is set.
- The current measurement may be read out. It cannot be loaded back into the 2148, however, as it does not contain the disk memory format. With Current measurement, all available spectra are read out.
- With RS-232-C operation, 8 data bits must be used.
- With the IEEE, use the EOI (End_Or_Identify) line as the end of the message and never the terminator. This is because the block format might contain something that could be misunderstood as the terminator.

8.5 Data_Memory_Read? (D_M_R?)

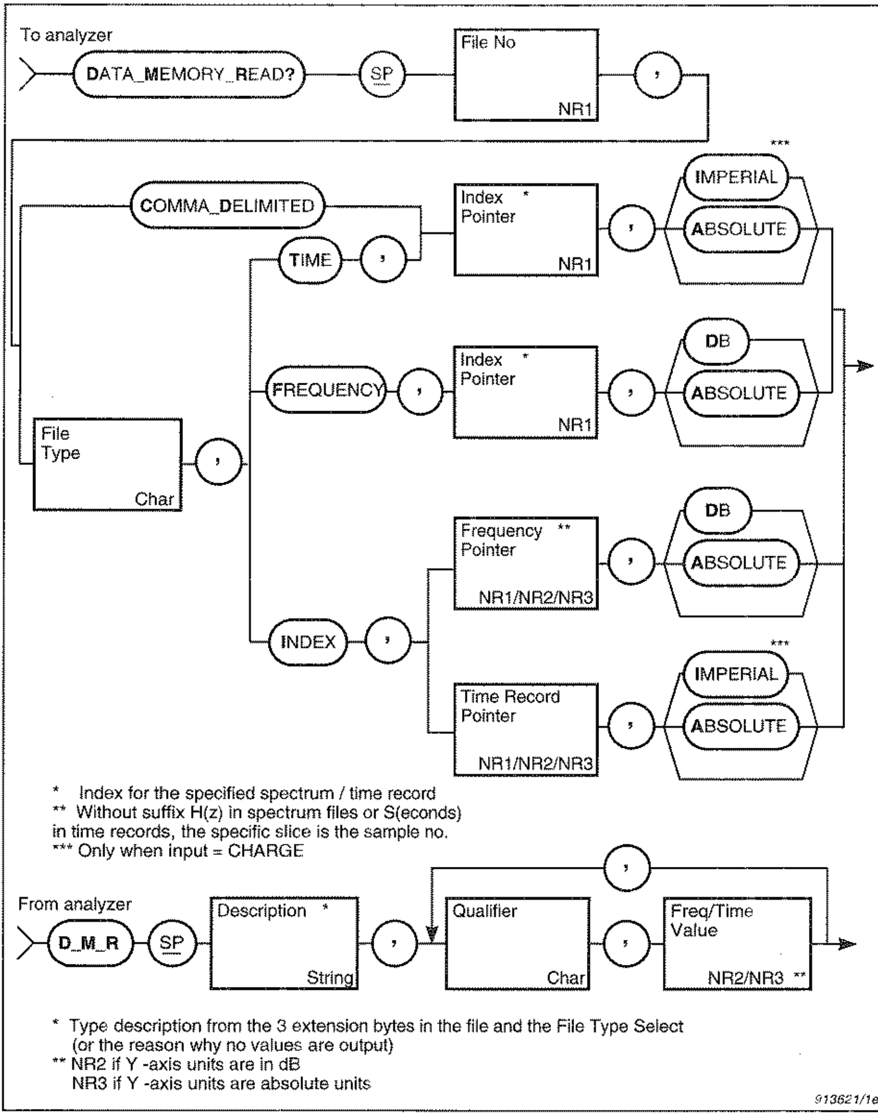


*Fig.8.6 Syntax for the **D_M_R?** query message and analyzer response*

The **D_M_R?** message (query only) returns a read-out of a specified spectrum or time record from memory. This read-out comprises a description followed by a number of Y-values (dB or absolute units).

The qualifier can be:

V=Valid

O=Overload

N=Negative

P=Positive

File Type

File Type is determined by the domain (frequency/time) and measurement type with which the file was saved.

When saved as 1-channel time record, File Type can be `A` or `B`

When saved as 2-channel time record, File Type can be `A` and `B`

When saved as 1-channel autospectrum, File Type can be `Auto_A` or `Auto_B`

When saved as 2-channel autospectrum, File Type can be `Auto_A` and `Auto_B`

When saved as 2-channel cross-spectrum, File Type can be `Auto_A`, `Auto_B`, `Cross_Real`, and `Cross_Imaginary`

Example

To obtain a read-out from memory, the controller could send:

```
D_M_R? 1,A_A,F,1,DB
```

The analyzer responds with (for example):

```
D_M_R "SINGLE,CROSS SPECTRUM,
 400 LINES,AUTO-A",
 "V",0.00,"V",12.34,"V",2.50,"V",3.45,...
```

8.6 Current_Measurement_Read? (C_M_R?)

The **C_M_R?** message (query only) returns a read-out of results from the currently displayed spectrum or time record. The start line of the read-out, the spectrum, and the number of values read out can be specified. The read-out may be in dB or absolute units. The data fields and associated codes are listed in Table 8.2.

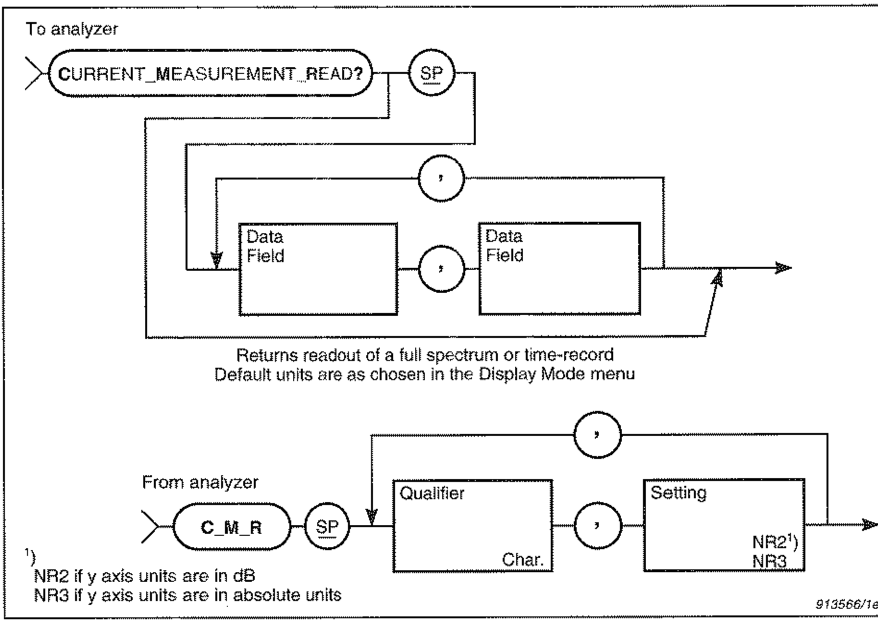


*Fig.8.7 Syntax for the **C_M_R?** query message and analyzer response*

Field Name	Field Setting	Data Type	Comments
Start		NR3	Default is the first line (=0)
Number	<numeric> Max	NR1 Char.	Default is 1 line[1]
Y_Axis_Unit	Db Absolute	Char.	
Measurement	Upper Lower	Char.	Defaults chosen in measurement mode

[1] Too great a value is interpreted as Max

Table 8.2 Current_Measurement_Read? data fields and codes

The qualifier can be:

V=Valid

O=Overload

N=Negative

P=Positive

Examples

Full measurement read-out

To obtain a read-out of the current measurement in full, the controller sends:

```
C_M_R?
```

The analyzer responds with (for example):

```
C_M_R V,79.76,V,81.97,V,66.13,V,...
```

Partial measurement read-out

To obtain a read-out of a specified part of the current measurement, the controller might send:

```
C_M_R? S,100,N,3,Y_A_U,DB
```

The analyzer responds with (for example):

```
C_M_R V,32.45,V,45.67,V,58.73
```

8.7 Print_Screen? (P_SC?)

Print_SCreen? (query) reads out a copy of the current analyzer screen to a hard-copy printer. This message has the same function as manual operation of the **"Hard Copy"** push key on the analyzer front panel (see also section 4.3).

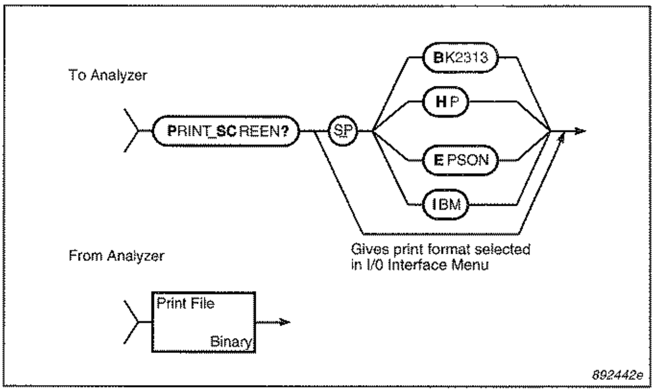


*Fig. 8.8 Syntax for the **P_SC?** query message and analyzer response*

Chapter 9

Interface Error Messages

9.1 Introduction

Error messages are displayed at the bottom of the right-hand side of the analyzer screen, or read out over the interface using the **ER**ror? query message (see section 8.1). Error cancellation is described in section 9.2, and all the interface error messages are listed in section 9.3, with a brief explanation.

9.2 How to Cancel an Error

9.2.1 Manual Cancellation

You can cancel an interface error manually by:

- Pressing soft key **"F4"** `RESET ERROR` in page 1 of the I/O Interface menu
- Setting the interface to `INACTIVE` by pressing soft key **"F2"** in page 1 of the I/O Interface menu
- Pressing the **"Reset"** hard key on the analyzer front panel

9.2.2 Cancellation by a Controller

A controller can cancel an interface error over the interface by:

- Sending a Device Clear (DCL) or Selected Device Clear (SDC), (IEEE–488 only)
- Conducting a serial poll if the SRQ Abnormal mask bit has been set (IEEE–488 only)
- Sending a <Break> (RS–232–C only).

9.3 List of Error Messages

Error no.	Error Message	Description
0000	NO ERROR	No interface error detected since last read-out of ERror?
0001	NO LISTENERS	The IEE−488 interface is addressed to talk, but no connected device is addressed to listen
0002	MESSAGE CANCELLED	The previous interface query message was cancelled because a) data reception was started, or b) a Device Clear (DCL or SDC) command was received
0003	IN REMOTE	Manual (un)addressing① was attempted with the analyzer set to Remote by a controller
0004	IN ADDR MODE	Manual (un)addressing① was attempted while the analyzer was addressed by a controller
0006	IN TALK MODE	Manual (un)addressing① was attempted with the analyzer in talk mode
0007	IN LISTEN MODE	Manual (un)addressing① was attempted with the analyzer in listen mode
0008	USER DATA ONLY	Internal Error — report to B & K
0010	NOT IN JDTS	
0011	NOT IN JNRS	
0012	NOT IN JRYS	
0013	NOTHING TO SEND	A query message was sent but no data was generated
0014	HANDSHAKE ERROR	The interface is addressed to talk by a controller, but no listener is active on the bus
0022	OVERRANGE	A numeric (NR*x*) with an absolute value >32 767 has been received
0023	NOT A COMMAND	A "query only" was received without a "?"
0024	NOT A QUERY	A "command only" was received with a "?"
0026	TOO MUCH DATA	Too many data items were received for the command message

①The analyzer is manually addressed to listen when the Listen Only key in The I/O INTERFACE menu is pressed.
Manual Addressing to talk is performed by pressing the "Hard Copy" key.
Manual unaddressing is performed by pressing one of the above-mentioned keys a second timed

Table 9.1 2148 interface error messages

Error no.	Error Message	Description
0027	MORE DATA EXPECT.	More data items are needed for this command or query message
0028	ILLEGAL DATA TYPE	Another data type expected with this message
0029	ILLEGAL DATA	Unspecified error in a data field or setting
0030	NOT A CONTROLLER	Internal Error — report to B&K
0032	AUTOSEQ. ACTIVE	Interface operation is illegal during the learning or execution of an autosequence
0033	CHAR EXPECTED	Char. data was expected with current command/query or data field
0034	INTEGER EXPECTED	Integer (NR1) was expected with current command/query or data field
0035	NUMERIC EXPECTED	Numeric data (NR*x*) was expected with current command/query or data field
0036	STRING EXPECTED	String data was expected with current command/query or data field
0037	BLOCK EXPECTED	Block data was expected with current command/query or data field
0038	ILL. INPUT VALUE	Numeric input value outside allowed range
0039	NOT SELECTABLE	Attempted selection is not possible with current instrument set-up
0040	BAD FILE NAME	File name is incorrect or outside limits (000 to 999)
0041	FILE NOT FOUND	File with the specified file name does not exist
0042	DIRECTORY FULL	The data memory directory already contains 111 files
0043	ALREADY EXISTS	Specified file name has already been allocated to an existing file
0044	NO MEMORY SPACE	The data memory is full
0045	DATA MEMORY ERROR	Error occurred during data memory operation
0046	IEEE INACTIVE	An attempt was made to execute an "IEEE only" message[2] via the RS–232 interface
0047	SYNTAX ERROR	The syntax diagram has not been followed correctly
0048	ILLEGAL FILE	File contents do not match files generated with this analyzer

[2] A few command/queries can only be used via the IEEE

Table 9.1 2148 interface error messages

Error no.	Error Message	Description
0052	NOT IMPLEMENTED	Internal Error — report to B & K
0053	WRONG TERMINATION	A wrong terminator or separator (or an illegal char. in numeric data) was received
0054	ILLEGAL CHARACTER	A character illegal in current command/query or data type was received
0055	MISSING CHARACTER	The END message[3] was received before the message was completed
0056	BUFF OVERFLOW	Receive buffer "overflowed" by a numeric input which was too long
0057	NOT ALLOWED	Internal Error — report to B & K
0060	UNKNOWN INDEX	Character data not legal with the current command/query or parameter
0061	DUPLICATE INDEX	Internal Error — report to B & K
0062	UNKNOWN TABLE	
0063	ILLEGAL NR1	Numeric data received did not conform to correct NR1 syntax
0064	ILLEGAL NR2	Numeric data received did not conform to correct NR2 syntax
0065	ILLEGAL NR3	Numeric data received did not conform to correct NR3 syntax
0066	EXPONENT OVERFLOW	Max. 2 digits are allowed in an exponent
0067	ILLEGAL STRING	Incorrect syntax for string data
0068	BAD BLOCK SPEC	Message included a block length specification >32 759
0069	ILL. BLOCK TYPE	An indefinite block length specification was received via the RS–232 interface
0071	BLOCK UNCOMPLETED	An END message[3] was received before the complete block was received
0072	BLOCK OVERRUN	Internal Error — report to B & K
0073	PREFACE RANGE ERROR	A bad block-preface specification was received
0074	PREFACE LGT. ERR.	The previously specified block preface does not match the current query message
0081	PARITY ERROR	Parity error was detected during RS–232 reception

[3] The End or Identify line — EOI set TRUE

Table 9.1 2148 interface error messages

Error no.	Error Message	Description
0082	FRAMING ERROR	A framing error was detected during RS−232 reception
0083	PAR. & FRAM. ERR.	Both parity and framing errors were detected during RS−232 reception
0084	RS-232 OVERRUN	A 1 byte hardware buffer overrun error was detected during RS−232 reception
0085	PAR.ERR. & OVERRUN	Both parity and overrun errors were detected during RS−232 reception
0086	FRAM.ERR. & OVERRUN	Both framing and overrun errors were detected during RS−232 reception
0087	PAR.& FRAM.& OVERRUN	Parity, framing and overrun errors were detected during RS−232 reception
0090	CTS OFF	Internal Error — report to B&K
0091	DSR OFF	The DSR line of the RS−232 interface was detected OFF
0092	CTS ON	Internal Error — report to B&K
0093	RS-232 RX OVERRUN	An overrun of the RS−232 software receive buffer has occurred. Use proper handshaking
0094	8 DATABITS NEEDED	7 data bits cannot be used for block data transfer

Table 9.1 2148 interface error messages

Chapter 10

Data Formats

10.1 Introduction

In the following the term 7651 is used for both the 2144 software, Type 7651 and the 2143 software, Type 7669. If it is necessary to distinguish between the two, the difference is described.

The purpose of this chapter is to present information which, combined with a reasonable amount of knowledge of the PASCAL programming language (e.g. TURBO PASCAL), enables you to construct a computer program for accessing data files from the 7651 software. The reader is assumed to possess knowledge of the way the PASCAL programming language physically handles enumerated types and RECORDS. Therefore, PASCAL syntax is used for the description, which can then easily be used for constructing a computer program. It is also included on the 7651 program disk supplied with the analyzer in a file named TYPE7651.DEF.

This chapter describes the parameters in a data file from the 7651, represented by a file stored on disk or the block data part of a bus file transfer (IEEE or RS-232-C). The response to an Measurement_Data_Transfer? Current bus command is not a file transfer because no set-up is included, only the data part of the 'file7651_t' (described later) is transferred.

A data file is transferred (using IEEE-488 or RS-232-C) in compliance with IEEE standard 488 as a number of blocks. Each of these is preceded by an IEEE block header, which **must** be removed in order to obtain the content of the data file. A description of the IEEE block format is found in section 4.2.4.

This chapter contains information on the location and size of the parameters. Although it may be difficult to read and understand, all possible values of all parameters in the measurement set-up are presented. However no information on the logical relations between these parameters is included.

10.2 Conventions for Filenames

The names of files stored on a disk conform to PC/MS-DOS conventions. Subdirectories are not supported by the 7651 software. The filenames are constructed according to the following system:

Filename: klm.xyz, where

k, l, m are integers (0 to 9), but k = l = m = 0 is illegal,

x = A for simple trigger measurement data files
B for multi trigger (normal/gated/matrix) measurement data files.

y = A for 50 line measurements
B for 100 line measurements
C for 200 line measurements
D for 400 line measurements
E for 800 line measurements

z = see Table 10.1

Measurement Type	Frequency Spectrum	Calculated Frequency Spectrum	HWF Frequency Spectrum	Time Record	HWF Time Record
1 ch. Auto	A	E	I	M	Q
2 ch. Auto	B	F	J	N	R
Cross	C	G	K	O	S
Cross + Corr.	D	H	L	P	T

Table 10.1 Values of z

Notes:

- The term HWF is used for indicating a non-fatal hardware failure in the analyzer. If the built-in self-test (executed when the analyzer is switched on) detects this kind of failure, all measurement files subsequently stored will then have a modified last character in the file extension (see Table 10.1).
- Corr. means "correction".

10.3 Description of the Parameters

10.3.1 General Information

Storage of Measurement Data

Frequency spectra
The dB-value of a specific frequency line (data_value) is stored as a SIGNED INTEGER and the wanted REAL value is found by multiplying by 0.01176 dB (calculated as 10/256 log(2) dB). The resolution is twice this value. For cross measurements the right-most bit (the least significant bit) is used for indication of existence of negative sign before dB conversion.

If a user-defined dB reference is selected, the corresponding dB_offset must be taken into account. The appropriate formula in this case is (data_value + dB_offset*2)*0.01176 dB. The dB_offset is located in the calibration_setup and possible values are within the range −512 to 512 dB.

There are two ways of obtaining the absolute value:

- data_value*0.01176 dB relative to the standard dB-reference.
- (data_value + dB_offset*2)*0.01176 dB relative to the user-defined dB reference.

Time records
A sample in a time record is stored as a SIGNED INTEGER. In order to obtain the value of this sample, it must first be shifted "no_of_weight_shifts_acc" bits to the left, then multiplied by one of the elements in "time_data_scale" in "meas_setup_data_t" (described later). NOTE: for one-channel measurements you should always use "time_data_scale[ch_a]" and "no_of_weight_shifts_acc_a" even if channel B is used for input.

INTEGER Terminology

The term INTEGER is used for a variable occupying two bytes. This does not imply any information whether it is signed, unsigned or in any way 'special'.

Storage of INTEGER

An INTEGER is stored the INTEL-way, i.e. the least significant byte first, i.e. on the lowest address.

Storage of BOOLEAN

Possible values for a BOOLEAN are TRUE or FALSE. The representation of FALSE, TRUE are bytes valued 0, 1 respectively.

Alignment

None, the parameters are “aligned” at byte boundaries.

Storage of “Enumerated Types”

Example:

TYPE

```
direction_type = (north, east, south,  west)
distance_type = ARRAY [direction_type] of INTEGER
```

A variable of an enumerated type is stored in one byte (see preceding example) where north, east, south and west are represented by 0, 1, 2 and 3 respectively. The distance_type shown thus occupies $4 \times 2 = 8$ bytes of storage.

Calculation of CRC

The CRC (Cyclical Redundancy Check) checksum is calculated by the CRC-16 algorithm (polynomial x**16 + x**15 + x**2 + 1) with the hexadecimal starting value 5555. The CRC value always occurs as the last field in a record and is obtained by using the algorithm on the preceding fields starting at the first byte of the first field. A detailed description of the CRC-16 algorithm used is found in “Byte-wise CRC Calculations”, Aram Perez, IEEE Micr., June 1983, pp. 40–46.

Intensity Correction

When the cross measurement type is selected, it is possible to activate intensity correction on page 4 of the Calibration menu. This changes the data file slightly because a correction spectrum (never a time record) is stored just after the set-up part and immediately preceding the data part. This enables the possibility of later application of an intensity correction to the stored data (the necessary formula is found in volume 1 of the User Guide). The content of the correction spectrum is [P-I, P-J, dummy, dummy] stored instead of [A, B, Re, Im], see the description of the data part of a data file.

BINARY Data Files

A data file from 7651 is BINARY and consists of two parts:

- set-up
- data

organized as in the example below (the right-hand column is used for calculation of the size in bytes):

Example:

```
file7651_t = RECORD
  setup         :file_head_t;                                635
  data          :ARRAY[1..#s] of
                   DataRecordType;             #s*(128+2*#a*#c)
END;                            total  635+#s*(128+2*#a*#c) bytes
```

#s equals the number_of_data_records in file_head_t. The constants #a, #c depend on the number of lines and the type of measurement and are discussed in section 10.3.3).

10.3.2 Set-up Information

The set-up part consists of a number of nested RECORD types using enumerated types. Each of the RECORDs at second level consists of related parameters corresponding to a menu in 7651. The units of the parameters are the same as in the menus.

```
file_head_t                    = RECORD
  source_id                    :file_name_t;                  8
  version_no,                                                 2
  wh_no                        :INTEGER;                      2
  total_file_size              :longint;                      4
  number_of_data_records       :INTEGER;                      2
  data_record_byte_size        :INTEGER;                      2
  clock                        :time_descr_t;                 4
  file_comment                 :file_text_t;                 40
  measurement_setup            :meas_setup_data_t;          569
  crc                          :INTEGER;                      2
END;                                            total 635 bytes

file_name_t                    = ARRAY [1..8] OF CHAR;        8

file_text_t                    = ARRAY [1..40] OF CHAR;      40
```

```
longint                    = RECORD
  lsword,                  :INTEGER;                            2
  msword                   :INTEGER;                            2
END;                                                total  4 bytes

time_descr_t               = RECORD
  hour_min_sec             :INTEGER;                            2
  year_mon_day             :INTEGER;                            2
END;                                                total  4 bytes

meas_setup_data_t          = RECORD
  data_id                  :data_id_t;                          1
  meas_type                :meas_type_t;                        1
  input                    :input_setup;                       54
  calib                    :calibration_setup;                 78
  time_freq                :time_freq_setup;                   18
  averaging                :averaging_setup;                   18
  display                  :display_setup;                     36
  weight_func              :weight_func_setup;                 35
  trigger                  :trigger_setup;                     67
  hold                     :hold_setup;                        22
  meas_mode                :meas_mode_setup;                  120
  external_sampling        :BOOLEAN; (Only relevant for 7669)   1
  time_data_scale          :ARRAY [input_ch_t] OF longreal;    16
  internal_use             :ARRAY [1..100] OF byte;           100
  crc                      :INTEGER;                            2
END;                                              total 569 bytes

byte                       = -128..127;                         1

data_id_t                  = (A_or_B_1ch_freq,
                               AB_2ch_freq,
                               cross_spectrum,
                               cross_corr_spectrum,
                               calculated_A_or_B_1ch_freq,
                               calculated_AB_2ch_freq,
                               calculated_cross_spectrum,
                               calculated_cross_corr_spectrum,
                               hwf_A_or_B_1ch_freq,
                               hwf_AB_2ch_freq,
                               hwf_cross_spectrum,
                               hwf_cross_corr_spectrum,
                               A_or_B_1ch_time,
                               AB_2ch_time,
                               cross_time,
                               cross_corr_time,
                               hwf_A_or_B_1ch_time,
                               hwf_AB_2ch_time,
                               hwf_cross_time,
                               hwf_cross_corr_time);            1

meas_type_t                = (one_ch,two_ch,cross);             1

input_ch_t                 = (ch_a,ch_b);                       1
```

```
input_setup                     = RECORD
  input_ch                      :input_ch_t;                       1
  input                         :ARRAY [input_ch_t] OF input_sel_t; 2
  input_set                     :ARRAY [input_sel_t,input_ch_t]
                                    OF input_setup_ch;            48
  analogue_ground,                                                 1
  DC_compensation               :BOOLEAN;                          1
  ana_smpl_frq                  :smpl_frq_t;                       1
END;                                                  total 54 bytes

input_sel_t                     = (preamp,direct,charge);          1

smpl_frq_t                      = (k2,k4,k8,k16,k32,k64);          1

input_setup_ch                  = RECORD
  input_filter                  :input_filter_t;                   1
  low_pass_filter_on            :BOOLEAN;                          1
  attenuator_level,             :INTEGER;                          2
  max_level                     :REAL;                             4
END;                                                   total 8 bytes

input_filter_t                  = (hp03,hp20,hp100,A);             1

calibration_setup               = RECORD
  calib                         :ARRAY [input_ch_t] OF
                                    calib_setup_ch;               32
  dens_param                    :dens_param_t;                     1
  nominal_spacing               :INTEGER;                          2
  temperature,                                                     4
  air_pressure,                                                    4
  nominal_density,                                                 4
  user_density                  :REAL;                             4
  dB_offset                     :dB_offset_t;                     10
  calib_level_ab,                                                  4
  corr_high_range,                                                 4
  corr_low_range                :REAL;                             4
  corr_time                     :time_descr_t;                     4
  corr_spect_on                 :BOOLEAN;                          1
END;                                                  total 78 bytes

calib_setup_ch                  = RECORD
  ref_level,                                                       4
  ref_ch_freq,                                                     4
  trans_sens,                                                      4
  gain_adj                      :REAL;                             4
END;                                                  total 16 bytes

dens_param_t                    = (air_dens,user_dens);            1

dB_offset_t                     = ARRAY [dB_offset_spec_type_t]
                                      OF INTEGER;                 10

dB_offset_spec_type_t           = (offset_AA,offset_BB,offset_AxB,
                                      offset_VV,offset_IxJ);       1
```

```
time_freq_setup          = RECORD
  no_of_lines            :line_no_t;                       1
  sample_freq            :ARRAY [BOOLEAN] OF REAL;         8
  zoom_on                :BOOLEAN;                         1
  centre_freq            :REAL;                            4
  sequence_select        :sequence_select_t;               1
  internal_use           :byte;                            1
  no_of_freq_units       :INTEGER;                         2
END;                                         total 18 bytes

line_no_t                = (150,1100,1200,1400,1800);      1

sequence_select_t        = (resolution,span);              1

averaging_setup          = RECORD
  averaging_mode         :averaging_mode_t;                1
  no_of_lin_avg          :longint;                         4
  exp_avg_index          :byte;                            1
  overlap                :overlap_t;                       1
  delay_a_to_b           :REAL;                            4
  reject_time            :INTEGER;                         2
  overload_reject_on     :BOOLEAN;                         1
  estimated_overlap      :REAL;                            4
END;                                         total 18 bytes

averaging_mode_t         = (lin,exp,peak);                 1

overlap_t                = (pcnt_max,pcnt_0,pcnt_50,
                              pcnt_67,pcnt_75);            1

display_setup            = RECORD
  display_mode           :display_mode_t;                  1
  y_axis                 :ARRAY [domain_t] OF y_axis_t;    2
  y_axis_unit            :y_axis_unit_t;                   1
  x_axis_compress        :ARRAY [domain_t] OF BOOLEAN;     2
  full_scale_dB          :ARRAY [display_sel_t,
                              domain_t] OF INTEGER;        8
  full_scale_lin_time    :ARRAY [display_sel_t] OF byte;   2
  ampl_range             :ARRAY [display_sel_t,
                              domain_t] OF dB_range_t;     4
  spectrum_unit          :ARRAY [display_sel_t,domain_t]
                              OF spectrum_unit_t;          4
  spectrum_mode          :ARRAY [display_sel_t,domain_t]
                              OF byte;                     4
  bow_tie                :ARRAY [display_sel_t] OF BOOLEAN; 2
  phase_range            :ARRAY [display_sel_t,domain_t]
                              OF phase_range_t;            4
  dB_diff_range          :dB_range_t;                      1
  head_unit              :head_unit_t;                     1
END;                                         total 36 bytes

display_mode_t           = (single_display,dual_display,
                              difference_display);         1

domain_t                 = (freq_domain,time_domain);      1
```

```
y_axis_t                  = (decibel,abs_unit,linear);          1

y_axis_unit_t             = (metric,imperial);                  1

display_sel_t             = (upper,lower);                      1

dB_range_t                = (db1,db5,db10,db20,
                               db40,db80,db160);                1

spectrum_unit_t           = (PWR,RMS,PSD,ESD);                  1

phase_range_t             = (dg02,dg1,dg5,dg45,
                               dg90,dg180,dg360);               1

head_unit_t               = (default_unit,user_unit);           1

weight_func_setup         = RECORD
  weight                  :ARRAY [input_ch_t] OF
                               weight_setup_set;               34
  zero_padding            :zero_padding_t;                      1
END;                                                total 35 bytes

weight_setup_set          = RECORD
  w_type                  :weight_t;                            1
  window_shift,                                                 8
  window_length           :ARRAY [transient..exponential]
                               OF REAL;                         8
END;                                                total 17 bytes

weight_t                  = (rectangle,hanning,flattop,
                               transient,exponential);          1

zero_padding_t            = (none_zero_pad,a_zero_pad,
                               b_zero_pad,both_zero_pad);       1

trigger_setup             = RECORD
  mode                    :trig_mode_t;                         1
  select                  :trig_select_t;                       1
  time_store_mode_simple  :BOOLEAN;                             1
  time_delay_simple,                                            4
  time_delay_stepped,                                           4
  stepping_width          :REAL;                                4
  no_of_spec_stepped      :INTEGER;                             2
  delay_normal_auto       :REAL;                                4
  no_of_spec_normal       :INTEGER;                             2
  time_between_spec       :REAL;                                4
  no_of_trig_auto         :INTEGER;                             2
  delay_normal_time       :REAL;                                4
  no_of_records_normal    :INTEGER;                             2
  time_between_records    :REAL;                                4
  no_of_trig_time         :INTEGER;                             2
  time_store_mode_normal  :BOOLEAN;                             1
  rows,                                                         2
  columns                 :INTEGER;                             2
  directions              :byte;                                1
  sequence                :trig_sequence_t;                     1
```

```
  row_space,                                                  4
  column_space,                                               4
  level                    :REAL;                             4
  slope                    :trig_slope_t;                     1
  pos_sign                 :BOOLEAN;                          1
  hours,                                                      1
  min,                                                        1
  sec                      :byte;                             1
  rep_sec                  :INTEGER;                          2
END;                                             total 67 bytes

trig_mode_t              = (simple,normal,stepped,matrix);    1

trig_select_t            = (int_trig,ext_trig,clock_trig,
                              manual_trig,free_run);          1

trig_sequence_t          = (dcr,drc,cdr,crd,rdc,rcd);         1

trig_slope_t             = (negative,positive);               1

hold_setup               = RECORD
  setup                  :ARRAY [1..2] OF hold_setup_set;    22
END;                                             total 22 bytes

hold_setup_set           = RECORD
  maximum                :BOOLEAN;                            1
  mode                   :hold_mode_t;                        1
  line_freq              :ARRAY [BOOLEAN] OF REAL;            8
  spec_select            :hold_disp_func_t;                   1
END;                                             total 11 bytes

hold_mode_t              = (inactive_hold,all,linefreq,
                              peakhold);                      1

hold_disp_func_t         = (autoA_mag,autoB_mag,cross_re,
                              cross_im);                      1

meas_mode_setup          = RECORD
  display_freeze         :BOOLEAN;                            1
  disp_selector          :display_sel_t;                      1
  domain                 :domain_t;                           1
  disp_func              :ARRAY [display_sel_t,domain_t]
                              OF display_function_t;          4
  complex                :ARRAY [display_sel_t,dis-
                              play_function_t] OF
                              complex_function_t;            44
  display_x_low          :ARRAY [domain_t] OF REAL;           8
  cursor                 :cursor_setup;                      61
END;                                            total 120 bytes

display_function_t       = (fftA,fftB,timeA,timeB,autoA,
                              autoB,correlA,correlB,
                              cross_spec,correlAB,H1,H2,H3,
                              inv_H1,impuls_respon,coherence,
                              coh_power,none_coh_power,
```

```
                                      meanpress,velocity,intensity,
                                      PV_coherence);                  1

complex_function_t                 = (re,im,mag,phase);               1

cursor_setup                       = RECORD
  align_cursors                    :BOOLEAN;                          1
  cursor_set                       :ARRAY [domain_t,display_sel_t]
                                      OF cursor_set_t;               60
END;                                                    total 61 bytes

cursor_set_t                       = RECORD
  main_curs_xcoor                  :main_curs_xcoor_t;                1
  main_curs_yread                  :main_curs_yread_t;                1
  special_curs                     :special_curs_t;                   1
  main_curs_value,                                                    4
  special_curs_set,                                                   4
  special_curs_span                :REAL;                             4
END;                                                    total 15 bytes

main_curs_xcoor_t                  = (x_value,line_no,dx_value,
                                      line_sc);                       1
main_curs_yread_t                  = (y_value,dy_value,tot,dtot,
                                      dtottot,dtotA);                 1

special_curs_t                     = (spcurs_off,spcurs_ref,spcurs_d,
                                      spcurs_harm,spcurs_sb);         1
```

10.3.3 Data Information

The data part consists of these RECORD types :

```
DataRecordType                     = RECORD
  drh                              :DataRecordHead;                 126
  data                             :ARRAY [1..#a] OF Data_t;   2*#a*#c
  crc                              :INTEGER;                          2
END;                                          total 128+2*#a*#c bytes

DataRecordHead                     = RECORD
  total_word_size,                                                    2
  head_word_size,                                                     2
  data_word_size                   :INTEGER;                          2
  time_stamp                       :time_descr_t;                     4
  elapsed_timeslots_since_proceed,                                    4
  total_elapsed_avg                :longint;                          4
  exponential_time_index,                                             2
  internal_use_1,                                                     2
  data_word_size_pr_acc,                  {=#c}                       2
  overload_pct_A,                                                     2
  internal_use_2,                                                     2
  internal_use_3,                                                     2
  internal_use_4,                                                     2
  zoom_ch_offset,                                                     2
```

```
    overload_pct_B,                                                   2
    peak_hold_on                  :INTEGER;                           2
    start_freq,                                                       4
    delta_freq                    :longint;                           4
    freq_sampling,                                                    2
    rms_gain_aa,                                                      2
    rms_gain_bb,                                                      2
    rms_gain_re,                                                      2
    rms_gain_im,                                                      2
    delta_cursor_val,                                                 2
    pre_weight_val,                                                   2
    delta_minus_preval,                                               2
    meas_mode,                                                        2
    no_of_data_acc,                      {=#a}                        2
    transform_size,                                                   2
    no_of_125_fir_flt,                                                2
    no_of_disp_ch_pr_acc,                                             2
    density_space_corr,                                               2
    record_time,                                                      2
    min_time_between_records      :INTEGER;                           2
    time_resolution,                                                  4
    time_pr_timeslot,                                                 4
    elapsed_time_since_proceed    :longint;                           4
    window_type_a,                                                    2
    window_type_b,                                                    2
    window_a_shift_offset,                                            2
    window_a_length,                                                  2
    window_b_shift_offset,                                            2
    window_b_length,                                                  2
    zero_pad_on_a,                                                    2
    zero_pad_on_b,                                                    2
    rms_gain_window_a,                                                2
    rms_gain_window_b,                                                2
    rms_noisebw_window_a,                                             2
    rms_noisebw_window_b,                                             2
    internal_use_5,                                                   2
    internal_use_6,                                                   2
    no_of_weight_shifts_acc_a,                                        2
    no_of_weight_shifts_acc_b,                                        2
    internal_use_7,                                                   2
    sum_post_weight_val           :INTEGER;                           2
  END;                                                    total 126 bytes

  Data_t                          = ARRAY [1..#c] OF INTEGER;      2*#c
```

Explanation of some Parameters in DataRecordHead

- word_size: size of DataRecordType is twice this value.
- head_word_size: size of DataRecordHead is twice this value.
- data_word_size: #a*#c equals this value.
- overload_level_A, overload_level_B: the overload %s are these values/100.

#s equals the number_of_data_records. The constants #a, #c depend on the number of lines, domain and type of measurement as shown in Tables 10.2 and 10.3.

<table>
<tr><th rowspan="2">Measurement Type</th><th colspan="5">Frequency Domain</th><th colspan="3">Time Domain</th></tr>
<tr><th>Value</th><th colspan="4">Order of Storage</th><th>Value</th><th colspan="2">Order of Storage</th></tr>
<tr><td>1 ch. auto</td><td>1</td><td colspan="4">A/B</td><td>1</td><td colspan="2">A/B</td></tr>
<tr><td>2 ch. auto</td><td>2</td><td colspan="2">A</td><td colspan="2">B</td><td>2</td><td>A</td><td>B</td></tr>
<tr><td>Cross</td><td>4</td><td>A</td><td>B</td><td>Re</td><td>Im</td><td>2</td><td>A</td><td>B</td></tr>
</table>

Table 10.2 Values of #a

Number of Lines	Frequency Domain	Time Domain
50	64	128
100	128	256
200	256	512
400	512	1024
800	1024	2048

Table 10.3 Values of #c

Arrangement of Stored Data within Data_t

- frequency domain, base band: only the first #c elements of Data_t are valid.
- frequency domain, zoom: only the 'middle' #c elements of Data_t are valid (skip the first 'zoom_ch_offset' elements).
- time domain, base band: Data_t contains #c real data elements (samples).
- time domain, zoom: Data_t contains #c/2 complex data elements stored REAL1,IMAG1,REAL2,IMAG2 ... .

10.4 Set-up Parameters

Set-up Parameter				Size
SOURCE_ID				8
VERSION_NO				2
WH_NO				2
TOTAL_FILE_SIZE				4
NUMBER_OF_SPECT_RECORDS				2
SPECT_RECORD_BYTE_SIZE				2
CLOCK	HOUR_MIN_SEC			2
	YEAR_MON_DAY			2
FILE_COMMENT				40
MEASUREMENT_ SETUP	DATA_ID			1
	MEAS_TYPE			1
	INPUT	INPUT_CH		1
		INPUT[CH_A]		1
		INPUT[CH_B]		1
		INPUT_SET [PREAMP,CH_A]	INPUT_FILTER	1
			LOW_PASS_FILTER_ON	1
			ATTENUATOR_LEVEL	2
			MAX_LEVEL	4
		INPUT_SET [PREAMP,CH_B]	INPUT_FILTER	1
			LOW_PASS_FILTER_ON	1
			ATTENUATOR_LEVEL	2
			MAX_LEVEL	4
		INPUT_SET [DIRECT,CH_A]	INPUT_FILTER	1
			LOW_PASS_FILTER_ON	1
			ATTENUATOR_LEVEL	2
			MAX_LEVEL	4
		INPUT_SET [DIRECT,CH_B]	INPUT_FILTER	1
			LOW_PASS_FILTER_ON	1
			ATTENUATOR_LEVEL	2
			MAX_LEVEL	4

Table 10.4 Set-up Parameters

<table>
<tr><th colspan="4">Set-up Parameter</th><th>Size</th></tr>
<tr><td rowspan="33">MEASUREMENT_ SETUP (cont.)</td><td rowspan="11">INPUT (cont.)</td><td rowspan="4">INPUT_SET [CHARGE,CH_A]</td><td>INPUT_FILTER</td><td>1</td></tr>
<tr><td>LOW_PASS_FILTER_ON</td><td>1</td></tr>
<tr><td>ATTENUATOR_LEVEL</td><td>2</td></tr>
<tr><td>MAX_LEVEL</td><td>4</td></tr>
<tr><td rowspan="4">INPUT_SET [CHARGE,CH_B]</td><td>INPUT_FILTER</td><td>1</td></tr>
<tr><td>LOW_PASS_FILTER_ON</td><td>1</td></tr>
<tr><td>ATTENUATOR_LEVEL</td><td>2</td></tr>
<tr><td>MAX_LEVEL</td><td>4</td></tr>
<tr><td colspan="2">ANALOGUE_GROUND</td><td>1</td></tr>
<tr><td colspan="2">DC_COMPENSATION</td><td>1</td></tr>
<tr><td colspan="2">ANA_SMPL_FRQ</td><td>1</td></tr>
<tr><td rowspan="22">CALIB</td><td rowspan="4">CALIB[CH_A]</td><td>REF_LEVEL</td><td>4</td></tr>
<tr><td>REF_CH_FREQ</td><td>4</td></tr>
<tr><td>TRANS_SENS</td><td>4</td></tr>
<tr><td>GAIN_ADJ</td><td>4</td></tr>
<tr><td rowspan="4">CALIB[CH_B]</td><td>REF_LEVEL</td><td>4</td></tr>
<tr><td>REF_CH_FREQ</td><td>4</td></tr>
<tr><td>TRANS_SENS</td><td>4</td></tr>
<tr><td>GAIN_ADJ</td><td>4</td></tr>
<tr><td colspan="2">DENS_PARAM</td><td>1</td></tr>
<tr><td colspan="2">NOMINAL_SPACING</td><td>2</td></tr>
<tr><td colspan="2">TEMPERATURE</td><td>4</td></tr>
<tr><td colspan="2">AIR_PRESSURE</td><td>4</td></tr>
<tr><td colspan="2">NOMINAL_DENSITY</td><td>4</td></tr>
<tr><td colspan="2">USER_DENSITY</td><td>4</td></tr>
<tr><td colspan="2">DB_OFFSET_TYPE[OFFSET_AA]</td><td>2</td></tr>
<tr><td colspan="2">DB_OFFSET_TYPE[OFFSET_BB]</td><td>2</td></tr>
<tr><td colspan="2">DB_OFFSET_TYPE[OFFSET_AXB]</td><td>2</td></tr>
<tr><td colspan="2">DB_OFFSET_TYPE[OFFSET_VV]</td><td>2</td></tr>
<tr><td colspan="2">DB_OFFSET_TYPE[OFFSET_IXJ]</td><td>2</td></tr>
<tr><td colspan="2">CALIB_LEVEL_AB</td><td>4</td></tr>
<tr><td colspan="2">CORR_HIGH_RANGE</td><td>4</td></tr>
</table>

Table 10.4 Set-up Parameters

Set-up Parameter				Size
MEASUREMENT_ SETUP (cont.)	CALIB (cont.)	CORR_LOW_RANGE		4
		CORR_TIME	HOUR_MIN_SEC	2
			YEAR_MON_DAY	2
		CORR_SPECT_ON		1
	TIME_ FREQ_ SETUP	NO_OF_LINES		1
		SAMPLE_FREQ[FALSE]		4
		SAMPLE_FREQ[TRUE]		4
		ZOOM_ON		1
		CENTRE_FREQ		4
		SEQUENCE_SELECT		1
		INTERNAL_USE_2		1
		NO_OF_FREQ_UNITS		2
	AVERAG- ING_SET- UP	AVERAGING_MODE		1
		NO_OF_LIN_AVG	LSWORD	2
			MSWORD	2
		EXP_AVG_TIME_INDEX		1
		OVERLAP		1
		DELAY_A_TO_B		4
		REJECT_TIME		2
		OVERLOAD_REJECT_ON		1
		ESTIMATED_OVERLAP		4
	DISPLAY	DISPLAY_MODE		1
		Y_AXIS[FREQ_DOMAIN]		1
		Y_AXIS[TIME_DOMAIN]		1
		Y_AXIS_UNIT		1
		X_AXIS_COMPRESS[FREQ_DOMAIN]		1
		X_AXIS_COMPRESS[TIME_DOMAIN]		1
		FULL_SCALE_DB[FREQ_DOMAIN,UPPER]		2
		FULL_SCALE_DB[FREQ_DOMAIN,LOWER]		2
		FULL_SCALE_DB[TIME_DOMAIN,UPPER]		2
		FULL_SCALE_DB[TIME_DOMAIN,LOWER]		2
		FULL_SCALE_LIN_TIME[UPPER]		1

Table 10.4 Set-up Parameters

Set-up Parameter				Size
MEASUREMENT_ SETUP (cont.)	DISPLAY (cont.)	FULL_SCALE_LIN_TIME[LOWER]		1
		AMPL_RANGE[FREQ_DOMAIN,UPPER]		1
		AMPL_RANGE[FREQ_DOMAIN,LOWER]		1
		AMPL_RANGE[TIME_DOMAIN,UPPER]		1
		AMPL_RANGE[TIME_DOMAIN,LOWER]		1
		SPECTRUM_UNIT[FREQ_DOMAIN,UPPER]		1
		SPECTRUM_UNIT[FREQ_DOMAIN,LOWER]		1
		SPECTRUM_UNIT[TIME_DOMAIN,UPPER]		1
		SPECTRUM_UNIT[TIME_DOMAIN,LOWER]		1
		SPECTRUM_MODE[FREQ_DOMAIN,UPPER]		1
		SPECTRUM_MODE[FREQ_DOMAIN,LOWER]		1
		SPECTRUM_MODE[TIME_DOMAIN,UPPER]		1
		SPECTRUM_MODE[TIME_DOMAIN,LOWER]		1
		BOW_TIE[UPPER]		1
		BOW_TIE[LOWER]		1
		PHASE_RANGE[FREQ_DOMAIN,UPPER]		1
		PHASE_RANGE[FREQ_DOMAIN,LOWER]		1
		PHASE_RANGE[TIME_DOMAIN,UPPER]		1
		PHASE_RANGE[TIME_DOMAIN,LOWER]		1
		DB_DIFF_RANGE		1
		HEAD_UNIT		1
	WEIGHT_ FUNC	WEIGHT[CH_A]	W_TYPE	1
			WINDOW_SHIFT[TRANSIENT]	4
			WINDOW_SHIFT[EXPONENTIAL]	4
			WINDOW_LENGTH [TRANSIENT]	4
			WINDOW_LENGTH[EXPONENTIAL]	4

Table 10.4 Set-up Parameters

Set-up Parameter				Size
MEASUREMENT_ SETUP (cont.)	WEIGHT_ FUNC (cont.)	WEIGHT[CH_B]	W_TYPE	1
			WINDOW_SHIFT[TRAN-SIENT]	4
			WINDOW_SHIFT[EXPO-NENTIAL]	4
			WINDOW_LENGTH [TRANSIENT]	4
			WINDOW_LENGTH[EX-PONENTIAL]	4
		ZERO_PADDING		1
	TRIGGER	TRIG_MODE		1
		TRIG_SELECT		1
		TIME_STORE_MODE_SIMPLE		1
		TIME_DELAY_SIMPLE		4
		TIME_DELAY_STEPPED		4
		STEPPING_WIDTH		4
		NO_OF_SPEC_STEPPED		2
		DELAY_NORMAL_AUTO		4
		NO_OF_SPEC_NORMAL		2
		TIME_BETWEEN_SPEC		4
		NO_OF_TRIG_AUTO		2
		DELAY_NORMAL_TIME		4
		NO_OF_RECORDS_NORMAL		2
		TIME_BETWEEN_RECORDS		4
		NO_OF_TRIG_TIME		2
		TIME_STORE_MODE_NORMAL		1
		ROWS		2
		COLUMNS		2
		DIRECTIONS		1
		SEQUENCE		1
		ROW_SPACE		4
		COLUMN_SPACE		4
		LEVEL		4

Table 10.4 Set-up Parameters

Set-up Parameter				Size
MEASUREMENT_ SETUP (cont.)	TRIGGER (cont.)	SLOPE		1
		POS_SIGN		1
		HOURS		1
		MIN		1
		SEC		1
		REP_SEC		2
	HOLD	SETUP[1]	MAXIMUM	1
			MODE	1
			LINE_FREQ[FALSE]	4
			LINE_FREQ[TRUE]	4
			SPEC_SELECT	1
		SETUP[2]	MAXIMUM	1
			MODE	1
			LINE_FREQ[FALSE]	4
			LINE_FREQ[TRUE]	4
			SPEC_SELECT	1
	MEAS_ MODE	DISPLAY_FREEZE		1
		DISPLAY_SELECTOR		1
		DOMAIN		1
		DISP_FUNC[UPPER,FREQ_DOMAIN]		1
		DISP_FUNC[UPPER,TIME_DOMAIN]		1
		DISP_FUNC[LOWER,FREQ_DOMAIN]		1
		DISP_FUNC[LOWER,TIME_DOMAIN]		1
		COMPLEX[UPPER,FFTA]		1
		COMPLEX[UPPER,FFTB]		1
		COMPLEX[UPPER,TIMEA]		1
		COMPLEX[UPPER,TIMEB]		1
		COMPLEX[UPPER,AUTOA]		1
		COMPLEX[UPPER,AUTOB]		1
		COMPLEX[UPPER,CORRELA]		1
		COMPLEX[UPPER,CORRELB]		1
		COMPLEX[UPPER,CROSS_SPEC]		1

Table 10.4 Set-up Parameters

Set-up Parameter			Size
MEASUREMENT_ SETUP (cont.)	MEAS_ MODE (cont.)	COMPLEX[UPPER,CORRELAB]	1
		COMPLEX[UPPER,H1]	1
		COMPLEX[UPPER,H2]	1
		COMPLEX[UPPER,H3]	1
		COMPLEX[UPPER,INV_H1]	1
		COMPLEX[UPPER,IMPULS_RESPON]	1
		COMPLEX[UPPER,COHERENCE]	1
		COMPLEX[UPPER,COH_POWER]	1
		COMPLEX[UPPER,NONE_COH_POWER]	1
		COMPLEX[UPPER,MEANPRESS]	1
		COMPLEX[UPPER,VELOCITY]	1
		COMPLEX[UPPER,INTENSITY]	1
		COMPLEX[UPPER,PV_COHERENCE]	1
		COMPLEX[LOWER,FFTA]	1
		COMPLEX[LOWER,FFTB]	1
		COMPLEX[LOWER,TIMEA]	1
		COMPLEX[LOWER,TIMEB]	1
		COMPLEX[LOWER,AUTOA]	1
		COMPLEX[LOWER,AUTOB]	1
		COMPLEX[LOWER,CORRELA]	1
		COMPLEX[LOWER,CORRELB]	1
		COMPLEX[LOWER,CROSS_SPEC]	1
		COMPLEX[LOWER,CORRELAB]	1
		COMPLEX[LOWER,H1]	1
		COMPLEX[LOWER,H2]	1
		COMPLEX[LOWER,H3]	1
		COMPLEX[LOWER,INV_H1]	1
		COMPLEX[LOWER,IMPULS_RESPON]	1
		COMPLEX[LOWER,COHERENCE]	1
		COMPLEX[LOWER,COH_POWER]	1
		COMPLEX[LOWER,NONE_COH_POWER]	1
		COMPLEX[LOWER,MEANPRESS]	1

Table 10.4 Set-up Parameters

Set-up Parameter					Size
MEASUREMENT_ SETUP (cont.)	MEAS_ MODE (cont.)		COMPLEX[LOWER,VELOCITY]		1
			COMPLEX[LOWER,INTENSITY]		1
			COMPLEX[LOWER,PV_COHERENCE]		1
			DISPLAY_X_LOW[FREQ_DOMAIN]		4
			DISPLAY_X_LOW[TIME_DOMAIN]		4
		CURSOR	ALIGN_CURSORS		1
			CURSOR_SET [FREQ_DOMAIN, UPPER]	MAIN_CURS_XCOOR	1
				MAIN_CURS_YREAD	1
				SPECIAL_CURS	1
				MAIN_CURS_VALUE	4
				SPECIAL_CURS_SET	4
				SPECIAL_CURS_SPAN	4
			CURSOR_SET [FREQ_DOMAIN, LOWER]	MAIN_CURS_XCOOR	1
				MAIN_CURS_YREAD	1
				SPECIAL_CURS	1
				MAIN_CURS_VALUE	4
				SPECIAL_CURS_SET	4
				SPECIAL_CURS_SPAN	4
			CURSOR_SET TIME_DOMAIN, UPPER]	MAIN_CURS_XCOOR	1
				MAIN_CURS_YREAD	1
				SPECIAL_CURS	1
				MAIN_CURS_VALUE	4
				SPECIAL_CURS_SET	4
				SPECIAL_CURS_SPAN	4
			CURSOR_SET [TIME_DOMAIN, LOWER]	MAIN_CURS_XCOOR	1
				MAIN_CURS_YREAD	1
				SPECIAL_CURS	1
				MAIN_CURS_VALUE	4
				SPECIAL_CURS_SET	4
				SPECIAL_CURS_SPAN	4
	EXTERNAL_SAMPLING				1
	TIME_DATA_SCALE[CH_A]				8

Table 10.4 Set-up Parameters

Set-up Parameter		Size
MEASUREMENT_ SETUP (cont.)	TIME_DATA_SCALE[CH_B]	8
	INTERNAL_USE	100
	CRC	2
CRC		2

Table 10.4 Set-up Parameters

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