RE 204
Audio Analyzer
Operator Manual

re

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SAFETY PRECAUTIONS FOR LINE-POWERED EQUIPMENT

All line-powered equipment can be dangerous. Therefore, certain basic rules and precautions must be observed to ensure the best possible safety for users, service personnel, as well as third parties. At RE TECHNOLOGY AS we have taken great care during the design and production of our equipment. However, safety may be impaired by incorrect installation, handling, or intervention.

WARNING

Ensure that the line cable, connectors, and power outlet all have the correct configuration, to establish a protective earth. Disconnecting the protective earth conductor, inside or outside the equipment, may potentially be hazardous to the operator. Removing the covers may expose parts carrying potentially dangerous voltages.

INSTALLATION

This is a Safety Class I unit which requires protective earthing via the IEC power inlet. Before switching on, the unit must be connected via the third wire in the power cable to a protective earth contact in the line socket. The protective action must not be negated by using an extension cord (power cable) without a protective conductor (protective earth). Grounding one conductor of a two-conductor outlet is not sufficient protection. Ensure that the line fuse has the correct value according to the voltage and power consumption. If the unit requires separate signal grounding, through external connections to the unit chassis, do not disconnect the protective earth.

SERVICE

Only trained service personnel should attempt to dismantle and repair the unit. Take great care during the installation and service of the unit, especially when adjusting or measuring an open unit under voltage. Before removing any covers, switch off the unit and remove the line cable from the power outlet.
Capacitors inside the unit may hold dangerous charges for a considerable time after the unit has been switched off. If it is necessary to replace components in the line connected partition or area, use only new parts of the correct and approved type. Take special care to maintain or re-establish the protective earthing. The conductivity must be measured after the service or repair is finished. Do not remove any warning labels. Replace any damaged or illegible labels with new labels.

BACK-UP BATTERIES

For units with lithium back-up batteries, ensure, when replacing them, that they are of the same type and are correctly installed before you switch the power on to the unit. Do not recharge the batteries or expose them to temperatures above 100 °C (212 °F). Dispose of used batteries responsibly, according to your national/local guidelines. The batteries contain chemicals which are harmful to the environment. When you dispose of the unit itself, first remove the batteries and dispose of them separately.

SAFETY SYMBOLS

Warning. The unit will be marked with this symbol when it is necessary for the user to refer to the manual.

Ground terminal (sometimes used in the manual to indicate circuit common connected to the chassis).

Attention. Observe precautions for handling Electrostatic Sensitive Devices.

Danger. Live voltage exceeding 1000 V.

Warning label for laser radiation. The product is marked with this symbol if it is necessary to protect against laser radiation which is invisible and can cause permanent damage to the eye.

Use of Product Names. The product names mentioned herein are used for identification purposes only, and may be trademarks and/or registered trademarks of their respective companies.

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1 INTRODUCTION

1.1 Introduction

The RE 204 Audio Analyzer is designed for verification of performance of sound reproduction equipment. The instrument provides the following measuring capabilities:

* Four input channels - measuring in two channels simultaneously.
* True RMS - integration period selectable to suit the actual signal for maximum measurement speed.
* Weighted RMS, average or quasi-peak - different standard filters for noise measurements as well as user defined filters for specific application.
* Peak measurements.
* Two user defined filters may be downloaded via the IEEE488 interface.
* SINAD - distortion and noise in one measurement. A bandlimiting filter may be incorporated to reject undesired noise.
* Frequency measurements.
* DC measurements.
* Wow & Flutter - optional wow & flutter measurements according to DIN, NAB and JIS standards.

In addition, an Audio Generator option may be installed, thus obtaining:

* Two channels sine wave output; frequency and output level freely selectable for each channel.

Furthermore, an AM/FM stereo generator may be added to constitute a complete measurement system in two instruments: the RE 204 and an RF generator.

To the widest extent possible, the RE 204 performs its measurement by means of digital signal processing, implying that:

* Analog hardware is reduced to a minimum, thus increasing reliability and decreasing calibration requirements and hereby reducing production downtime.

* Drift problems are eliminated by means of software controlled calibration.

* Full flexibility is obtained - as all filters, including the notch filter for the SINAD measurement, are digital, the frequency characteristics may be easily changed.

* New measurements may be implemented with no other hardware change than a set of new PROMs for the CPU board.

The Audio Generator is also implemented digitally by means of a digital signal processor, implying:

* High stability and low drift.

* Fast frequency and level change.

* All signal changes are done in the zero crossing of the signal, thus reducing signal distortion during switching events.

1.2 Operating Manual

The present manual contains all information needed to operate the instrument, including all options.

The following sections are included:

Section 1 Introduction. A general description of the instrument.

Section 2 Installation information on the RE 204 itself as well as information regarding installation of options not supplied with the instrument at the time of purchase.

Section 3 Description of Front and Rear Panels.

Section 4 Description of the principles of operations, emphasizing information which is relevant from a programming point of view: Gain setting, filter selection, measuring principles for each measurement, auto-calibration scheme, wow & flutter detection principles - as well as descriptions of the audio and stereo generators.

Section 5 Programming. Detailed command descriptions as well as information on the IEEE488 bus implementation.

Section 6 Equipment and Accessories. A list of the accessories supplied with the instrument, available options and optional equipment and accessories.

Section 7 Specifications including filter characteristics and a list of typical measurement speeds at different instrument settings.

Section 8 Miscellaneous.

1.3 Servicing Manual

The Servicing Manual contains information relevant for a service technician, i.e. detailed circuit descriptions, dismantling information, procedures for maintenance and adjustments. Furthermore, parts lists, component location diagrams as well as schematic diagrams are included.

Section 1 Introduction.

Section 2 Principle of Operation.

Section 3 Circuit Descriptions.

Section 4 Dismantling the Instrument.

Section 5 Adjustments.

Section 6 Specifications.

Section 7 Parts Lists.

Section 8 Component Locations.

Section 9 Schematic Diagrams.

Section 10 Miscellaneous.

The Servicing Manual is not a part of the standard accessories. It must be ordered separately if required.

2 INSTALLATION

This section contains general instructions on the installation of the RE 204 Audio Analyzer. This section must be read in order to ensure correct installation.

Furthermore installation of the options:

* Audio Generator 906-129
* Stereo Generator 901-871
* Wow & Flutter 901-837

is described.

2.1 Installation of RE 204

Unpacking

When unpacking the RE 204, the instrument, the accessories and the packing material should be inspected for any damage. Please refer to section 6, Equipment and Accessories for a description. Should any item be damaged, please notify the carrier and your local RE TECHNOLOGY AS representative or the factory.

In case of complaint the packing material should be retained for inspection by the carrier.

When you have certified that no damage has occurred you can install the instrument. However, before you apply line power to the instrument you should study in detail the following section, Power Application, and section 3, Front and Rear Panels.

Power Application

The RE 204 operates on either 110 V or 220 V AC supplies. The required line voltage is selected by means of a code plug built into the mains adapter at the rear of the instrument. Make sure that the installed fuse has the correct value:

AC Voltage	Line Fuse
100 V to 130 V AC	2.0 A, slow blow
198 V to 260 V AC	1.0 A, slow blow

Table 2.1 - Line Fuse Ratings

CAUTION You should always make sure that the line voltage selector is set to the correct position, and that a fuse having the correct rating is installed in the fuse holder before you connect the RE 204 to any AC power source.

The following procedure should be used when applying power for the first time:

1. Check that the power switch is set to off.

2. Remove the code plug in the mains adapter and check that the correct fuse has been installed.

3. Install the code plug so that the correct text, 110 V/220 V, coincides with the white marking below the code plug.

4. Connect the power cord supplied with the instrument between the power connector and the AC power receptacle.

5. Set the power switch to on.

NOTE According to international safety regulations, the RE 204 is grounded via the third wire in the power cord. In case the RE 204 must be operated from AC outlets without a ground connector, the instrument must be grounded by means of the banana plug close to the mains adapter.

Battery Backup

Settings and setups in the RE 204 are retained during periods of power-down by means of a lithium battery on the CPU Board (901-870). In case of data loss during power-down, this battery should be checked and replaced if necessary. Please refer to the Servicing Manual for details.

Selftest

Following power-up, the RE 204 performs a complete selftest of all digital circuitries. This test comprises:

* EPROMs on CPU Board (901-870).
* Integrity of stored data.
* Signal Analyzing Processor (901-840).
* Detection of the presence of and test of the Audio Generator Signal Processor (901-867).
* Detection of the presence of the Stereo Generator (901-871).

Due to the lack of display, the result of the selftest can only be inspected from an IEEE488 controller by means of the command "TT" - refer to section 5, Programming.

2.2 Installation of Audio Generator Option

The Audio Generator Option comprises two printed circuit boards:

* Audio Generator Analog Board 901-868.
* Audio Generator Signal Processor 901-867.

Installation of Analog Board

The Analog Board should be mounted in the analog section of the instrument. This section is the leftmost part of the audio analyzer when seen from the rear. To gain access to the analog section, remove the screws shown in Fig. 2.1.

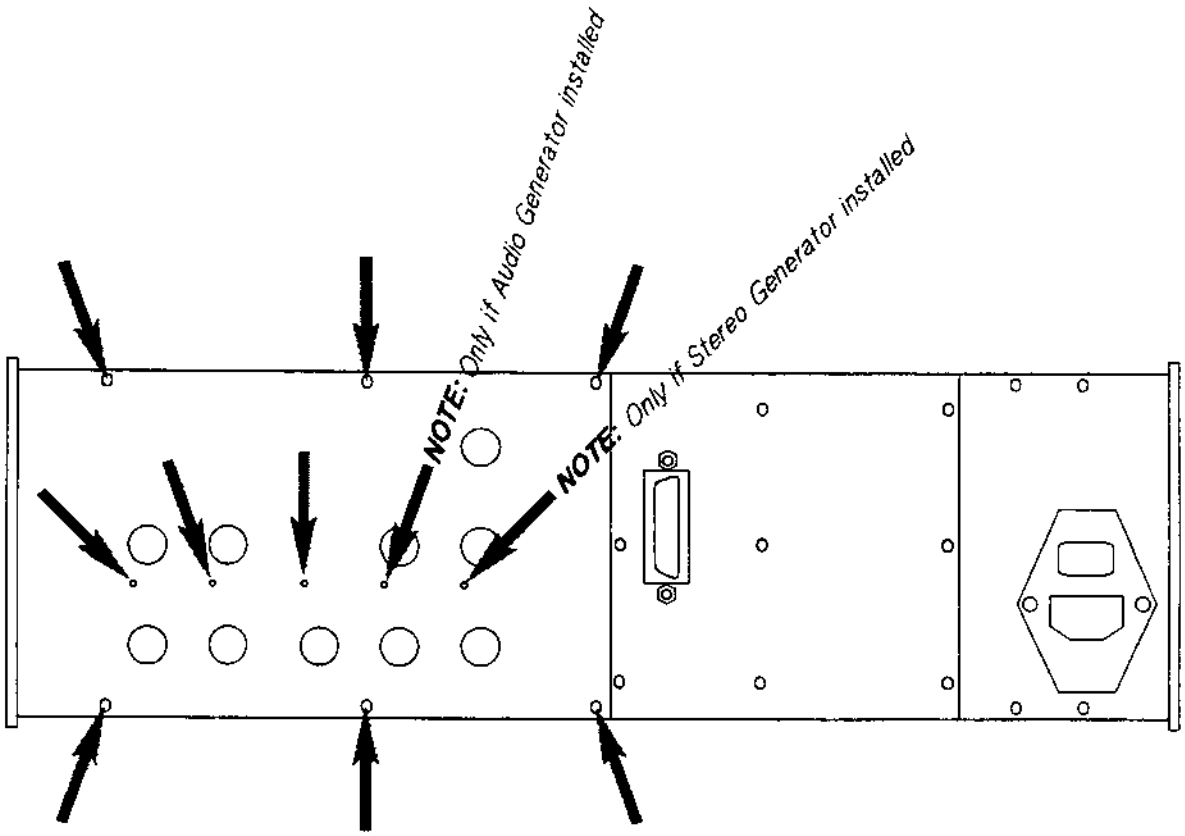

Fig. 2.1 - Removing the Analog Section Rear Panel

The Analog Board should then be inserted into the slot indicated in Fig. 2.3. Remove the screw and washer from the L-piece at the rear of the board. When remounting the rear panel, install the screw and washer as marked with a note in Fig. 2.1. It is important that you mount this screw as it is a vital part of the grounding system for the output circuitry of the Audio Generator.

Installation of Signal Processor Board

The Signal Processor Board is mounted in the digital section. This section is located to the right of the analog section when seen from the rear. To get access to the digital section, remove the screws indicated in Fig. 2.2.

Insert a screw driver into the slot between the rear panel and the chassis of the RE 204. Then you may remove the CPU Board and the rear panel of the digital section.

Then you install the Signal Processor in the slot next to the CPU Board, as indicated in Fig. 2.3 - use the rightmost groove. When reinstalling the CPU Board, please note that the leftmost groove in the box is to be used.

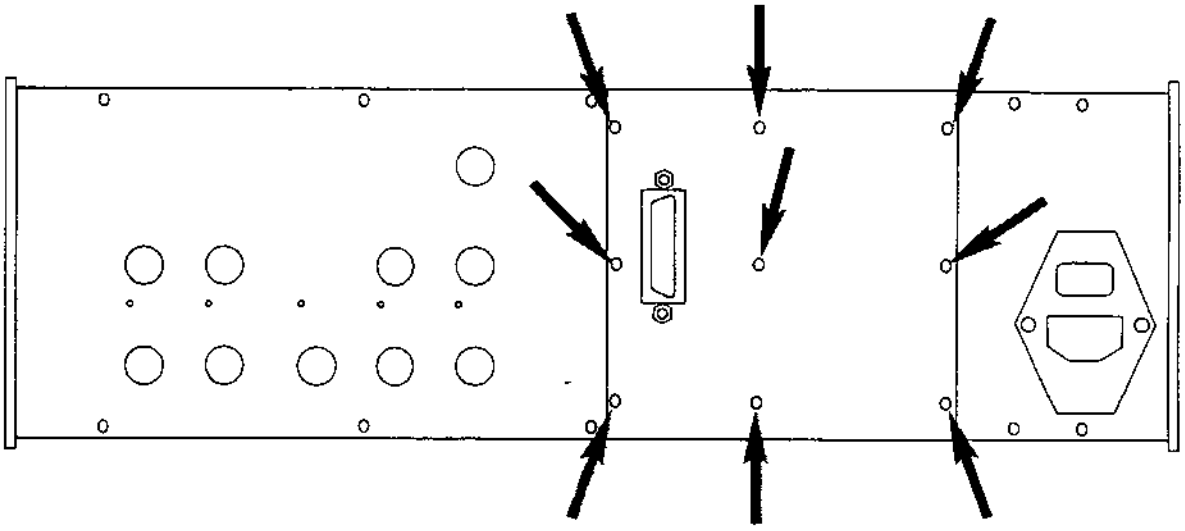

Fig. 2.2 - Getting access to the Digital Section

Selftest

The RE 204 automatically detects the presence of the Audio Generator Signal Processor - but not the presence of the Analog Board. The option should now be included in the answer to the ID query "ID?" as described in section 6, Programming.

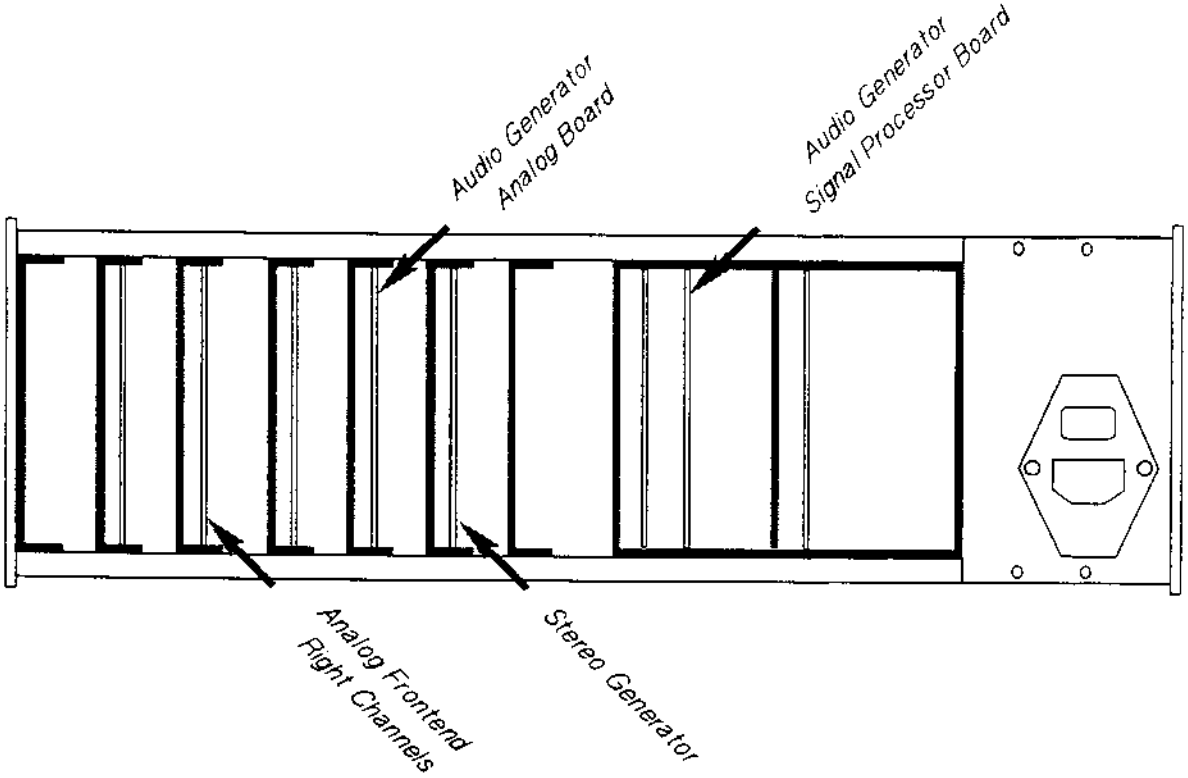

Fig. 2.3 - Board Positions

Connections

The two BNC output connectors are isolated connectors providing balanced outputs. For connections of shields, a separate ground plug is provided.

2.3 Installation of Stereo Generator Option

The Stereo Generator comprises one single printed circuit board which is to be installed in the analog section of the RE 204. Please refer to section 2.2 for a description of how to gain access to this section.

Then you insert the printed circuit board into the slot indicated in Fig. 2.3. Remove the screw and washer from the L-piece at the rear of the board. When remounting the rear panel, install the screw and washer as marked with a note in Fig. 2.1. It is important that you mount this screw as it is a vital part of the grounding system for the output circuitry of the Stereo Generator.

Selftest

The RE 204 automatically detects the presence of the Stereo Generator. The option should now be included in the answer to the ID query "ID?" as described in section 5, Programming.

Connections

Please refer to the descriptions of the rear panel in section 3. It should be noted, that the left and right signals are available at the Audio Generator output connectors in FM stereo mode. As the same connectors are used for the AM stereo signals L+R and L-R+Pilot, the left and right signals are not available in AM stereo mode.

FM Stereo Level Adjustment

By means of the potentiometer located just above the *COMP OUTPUT* connector you may adjust the output level for 100 % composite FM in the range 0 - 2 Vp.

Before you start the adjustment you must set up the RE 204 for FM stereo operation by sending the commands:

```
GF,FM AF,B,1000 AL,B,100% PE,0 FC,MN
AN,OFF PT,OFF CT,ON GE,FM
```

These commands will define an FM stereo generator setup with a 100 % L/R composite level with 1 kHz in both L and R, no preemphasis, no pilot and no auxiliary input signal. You may then adjust the level to suit the RF generator used.

AM Stereo

The functions for AM stereo are provided by the Audio Generator outputs:

L-R+25 Hz Pilot	Left Output
L+R	Right Output

The two outputs are connected to your signal generator. The L+R is used to create the AM modulation part of the Motorola C-QUAM signal and the L-R+Pilot the PM modulation.

2.4 Installation of Wow & Flutter Option

The Wow & Flutter Option comprises one single printed circuit board. The option is installed as a daughter board on the Analog Frontend Board providing the right channel inputs. The Analog Frontend Board is located in the analog section of the RE 204. Please refer to section 2.2 for a description of how to gain access to this board.

When you have removed the rear panel you pull out the Analog Frontend Board as indicated in Fig. 2.3. The Wow & Flutter printed circuit board is then mounted on top of this board with the four plastic stand-offs delivered with the option. The stand-offs have a snap lock that will activate when pressed firmly into the circuit board. Be careful not to bend the circuit boards to much. Excessive mechanical stress may damage the circuit boards.

Selftest

The RE 204 has to be told, that the Wow & Flutter Option is installed. This is done by setting switch no. 6 on the CPU Board to the ON position. The CPU Board is located in the digital section of the instrument. To gain access to the circuit board, please refer to the description in section 2.2.

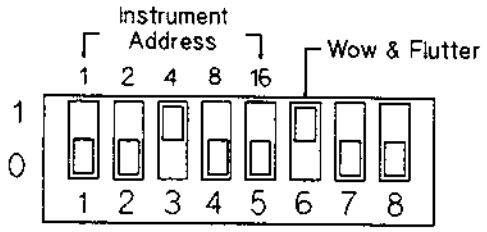

Fig. 2.4 - Wow & Flutter Switch Setting

3 FRONT AND REAR PANELS

3.1 Front Panel

The RE 204 front panel is shown in Fig. 3.1. The only display is the four bargraphs, indicating the input levels of all four input channels.

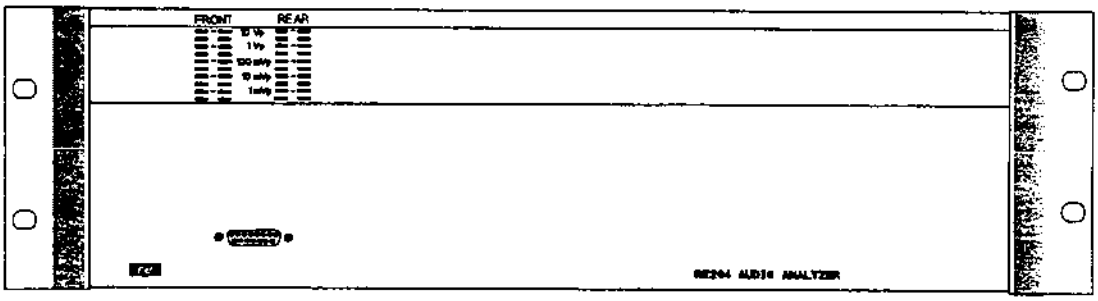

Fig. 3.1 - RE 204 Audio Analyzer, Front Panel

The meter may be used for monitoring of the input levels of all four channels simultaneously, regardless of the channels set active for measurements. The meter is switched on/off from the IEEE488 controller.

When the meter is deactivated, the upper- and lowermost bars are lit.

Each bargraph is composed of 10 LED bars, showing the peak input voltages logarithmically. A bar is lit as soon as the input level has passed the logarithmic middle of the distance between two bars. For example when having an input of 1 Vp, all the bars up to and including the 1 Vp bar are lit. In order to light the next bar i.e. the 3.16 Vp bar, the level has to pass the logarithmic middle between 1 Vp and 3.16 Vp i.e. 1.78 Vp. For a list of the meter ranges, please refer to section 4, Principle of Operation.

It should be noted, that an input, which is left open, normally will show a level of approx. 10 - 100 mVp. No filter is employed.

The 15-pole Sub-D connector on the front panel is for future use.

3.2 Rear Panel

The rear panel, as shown in Fig. 3.2, is divided into three sections. The leftmost holds the analog input/output BNC connector, the middle one the IEEE488 connector, and the rightmost the power inlet.

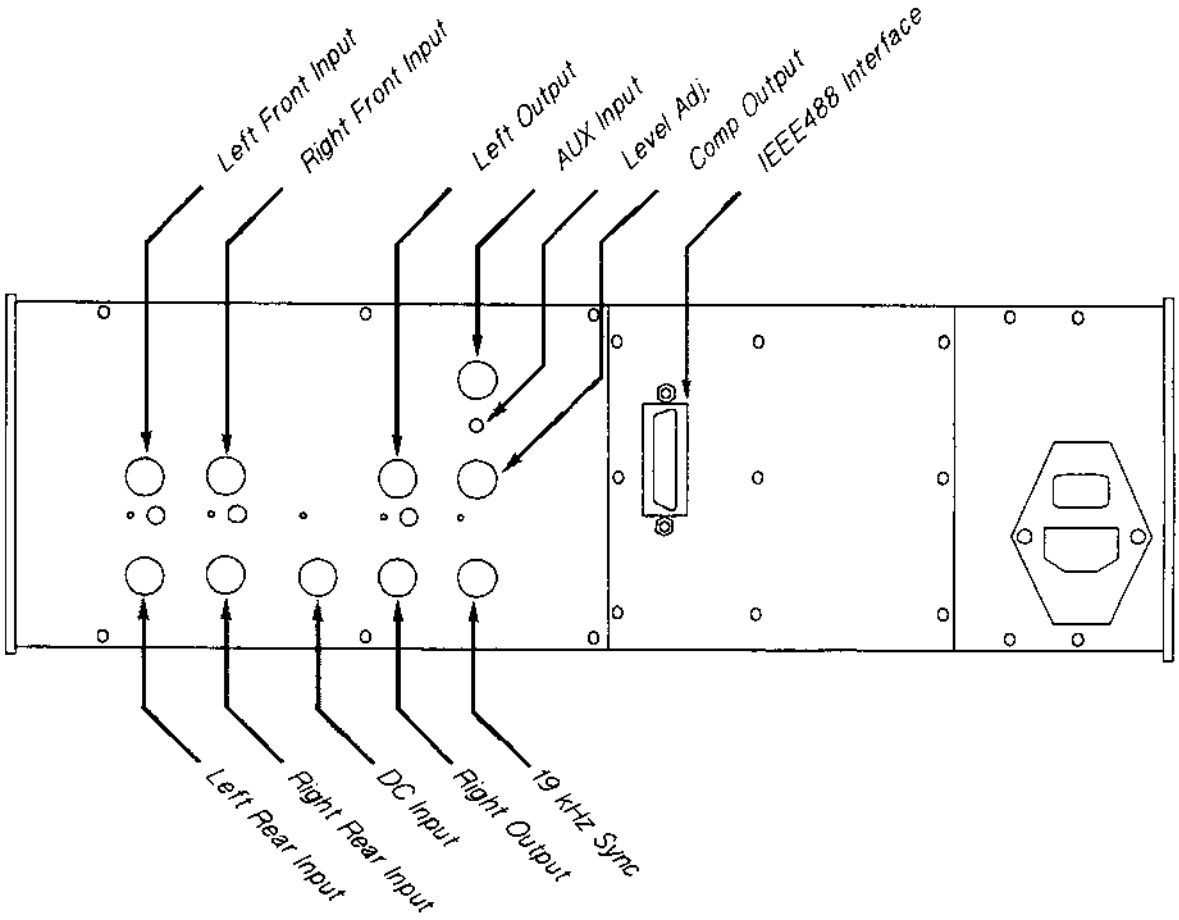

Fig. 3.2 - RE 204 Audio Analyzer, Rear Panel

Analog Input/Outputs

LEFT FRONT INPUT *RIGHT FRONT INPUT* *LEFT REAR INPUT* *RIGHT REAR INPUT*	Four identical floating inputs, configured as two times two channels. Both front inputs are measured simultaneously and then both rear inputs simultaneously. Isolated BNC connectors, with separate ground plug, for analyzer inputs.
DC	Isolated BNC connector for differential DC input. Two input ranges are provided, both use this connector.

LEFT OUTPUT
RIGTH OUTPUT

Audio Generator option outputs. Two identical balanced outputs. Also used for AM Stereo Generator:
Left Output: L-R+25 Hz Pilot
Right Output: L+R.
Isolated BNC connectors with separate ground plug.

AUX INPUT

Auxiliary input to the composite FM Stereo signal. May be used for e.g. SCA, ARI, RDS. This signal can be switched on/off.

19 KHZ SYNC

19 kHz FM pilot synchronization signal output from the Stereo Generator option. The signal is sinusoidal, having an amplitude of 775 mVpeak. This signal is present regardless of whether the pilot is switched on in the composite stereo signal and is therefore suitable for synchronization of e.g. an RDS generator.

COMP OUTPUT

Composite output signal from the Stereo Generator option i.e. a signal containing L+R, L-R, Pilot and the possible AUX input signal.

LEVEL ADJ.

Adjustment for absolute level of the composite FM stereo signal. Adjustable 0 - 2 Vpeak for 100 % composite level.

Remote Interface

IEEE488 INTERFACE

Standard connector for an IEEE488 controller. The interface has the capabilities:

SH1, AH1, T6, TE0, L4, LE0, SR1, RL0, PP1, DC0, DT1, C0, E2

Power Inlet

The RE 204 operates on either 110 V or 220 V AC supplies. The required line voltage is selected by means of a code plug built into the mains adapter.

In order to change the line voltage, pull out the code plug and reinstall it, so that the correct text, 110 V/220 V, coincides with the white arrow below the coding plug. Make sure that the installed fuse has the correct value before installing the code plug:

Nominal AC Voltage	Line Fuse
110 V	2.0 A, slow blow
220 V	1.0 A, slow blow

Table 3.1 - Line Fuse Ratings

*****CAUTION***** Always make sure that the line voltage selector is set to the correct position and that a fuse having the correct rating is installed in the fuse holder before connecting the RE 204 to any AC power source.

4 PRINCIPLE OF OPERATION

This section contains a description of the different parts of the RE 204 and how they work. The description is focused on the functional aspects that you have to consider when you want to program the instrument for optimum performance.

4.1 General Description

In order to obtain a high measuring speed, the RE 204 utilizes digital signal processing to the widest extent possible. The tasks of the analog circuitry are reduced to a minimum, i.e. preparation of the raw input signal prior to analog-to-digital conversion. Please refer to the block diagram shown in Fig. 4.1 on the next page.

All filtering and the various detectors offered by the RE 204 are implemented using digital filter techniques, employing a digital signal processor.

Before the A/D conversion, the input signal is band-limited through lowpass filtering and level-adjusted in order to utilize as much of the dynamic range of the A/D converter as possible.

The analog inputs are configured as two identical dual channel inputs. A separate input circuitry has been dedicated to each of the four inputs, while the gain section and the lowpass filter are common for two inputs.

The outputs of the Analog Frontends are routed to the 16 bit A/D converter via a multiplexer operating at a frequency which is the double of the sampling frequency. The sample values coming out of the converter are thus alternating between left and right channel. The data values are transmitted serially to the signal processor.

The A/D converter and the signal processor handle two input channels simultaneously. A four-channel measurement is accomplished by first measuring in the two front channels and then measuring in the two rear channels.

The Audio Generator option is comprised of a separate digital signal processor, interfacing to two D/A converters, one for each output channel.

The Stereo Generator option is a conventional analog modulator with the L/R modulation signals supplied from the audio generator. Preemphasis is handled by adjusting the L/R levels from the audio generator.

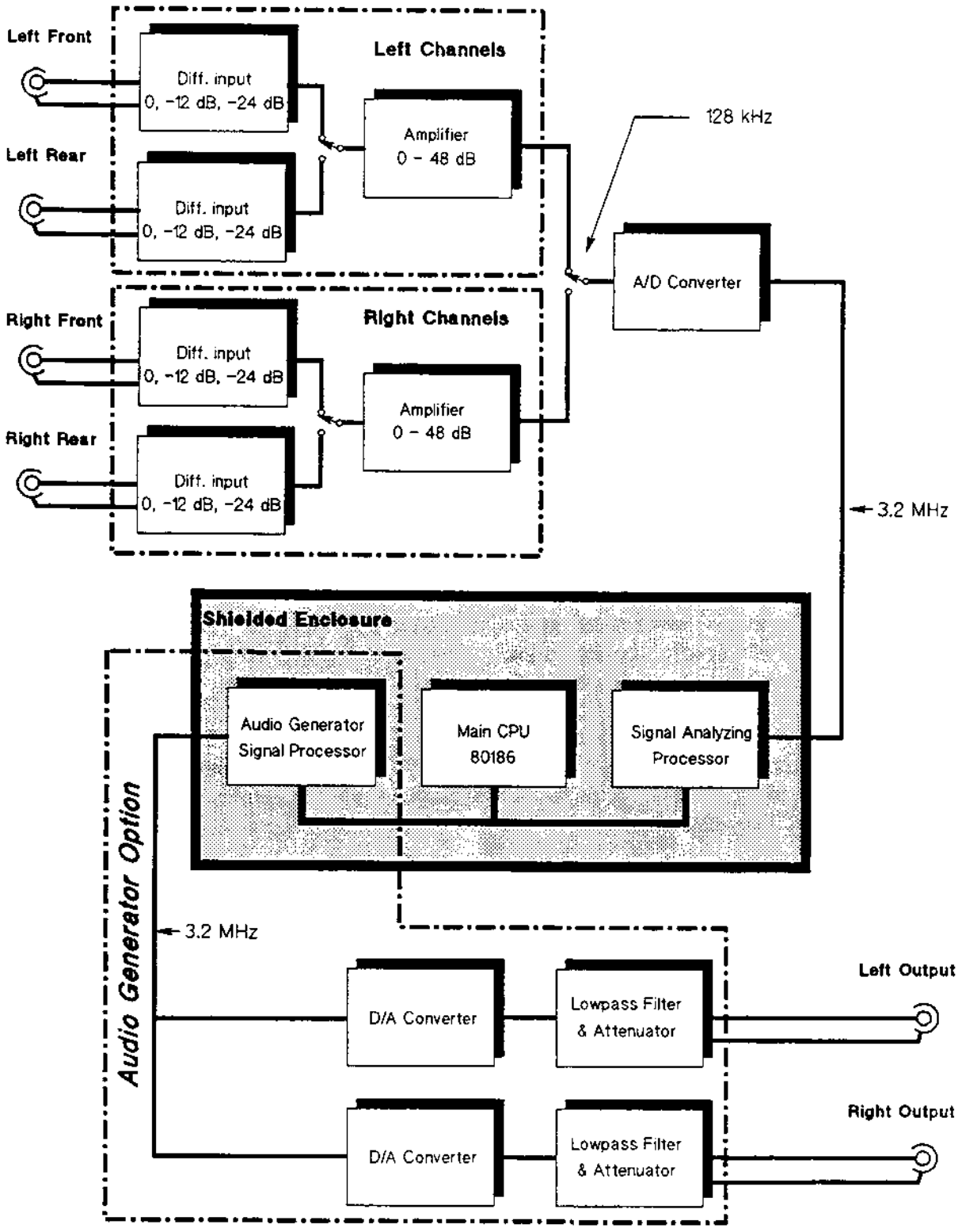

Fig. 4.1 - RE 204 Audio Analyzer, Block Diagram

An Intel 80C186 microprocessor is used to control the entire instrument and handle the interface to the IEEE488 bus. The tasks for the processor include:

* Setup of the analog circuitry.

* Loading of the appropriate digital filter and measurement specifications to the signal analyzing processor.

* Calibration of the measurement results obtained from the signal processor and calculation of frequency data for the audio generator.

Mechanically, the instrument is divided into two sections: An open frame structure holding the analog circuitries including the power supplies, and a shielded enclosure holding all digital circuitries. As some kind of filtering is a necessity for each connection to and from the shielded enclosure, the number of connections are held at an absolute minimum.

4.2 Input Ranges and Autoranging

As the dynamic range of a digital instrument is dependent on the number of bits utilized in the analog-to-digital conversion, it is essential that the full input range of the A/D converter is used. On the other hand, it is important, that the maximum voltage is not exceeded, as this will cause distortion and measurement errors.

Range control may be handled in different ways. The one yielding the optimum measurement speed is always to set the input range from the IEEE488 controller. However, in many cases this is not practically possible. The RE 204 therefore offers the possibility of selecting autoranging, meaning that the input range is automatically changed if the input peak voltage either overloads the A/D converter or passes the tolerated dynamic range limit.

During the measurement input overload is constantly monitored. For this purpose, analog peak detectors interfacing to a separate 8 bit A/D converter are included. The peak detectors are read by the 80C186 microprocessor while the Signal Analyzing Processor handles the measurement. When the measurement is completed, the input low condition is also checked.

If the level is inadequate to achieve the required measurement accuracy, the gain will be adjusted up- or downwards and the measurement restarted.

The autoranging procedure may also be disabled and the input range fixed for maximum measurement speed. In this case an input level outside the selected range will cause the RE 204 to report the error by means of a service request accompanied by a serial poll code indicating the nature of the error.

When a error occurs during a measurement and the RE 204 despite the service request issued is asked to output a measurement result, the result delivered will be exact 0, except for SINAD and Wow & Flutter where a result of 100 % indicates

error. For some level measurements, however, results will be delivered regardless of input low conditions. Therefore always interrogate the serial poll code to avoid measurement errors.

The peak voltages for full scale are given in Table 4.1 together with the corresponding gain settings.

Peak Voltage	Gain Setting
30 Vp	-24 dB
24 Vp	-18 dB
12 Vp	-12 dB
6 Vp	-6 dB
3 Vp	0 dB
1.5 Vp	6 dB
750 mVp	12 dB
375 mVp	18 dB
187 mVp	24 dB
93 mVp	30 dB
46 mVp	36 dB
23 mVp	42 dB
11 mVp	48 dB

Table 4.1 - Full Scale Ranges

When the range is changed across the borders 0 dB/-6 dB and -12 dB/-18 dB, a relay is activated/deactivated. In these cases a delay of approx. 10 ms is added.

The dynamic range, i.e. the difference between the actual input level and the full scale level, depends on the measurement type. The RE 204 operates with the following dynamic ranges:

Measurement	Dynamic Range
RMS or Average, without filter	18 dB
RMS or Average, with filter	12 dB
Peak	24 dB
Quasi-Peak	18 dB
Frequency	18 dB
SINAD, fine range	6.5 dB
SINAD, coarse range	12 dB
Wow & Flutter	18 dB

Table 4.2 - Dynamic Ranges

4.3 Filters

The only hardware filter in the RE 204 is a 25 kHz lowpass filter used to band-limit the input signal before A/D conversion. All other filters - weighting filters as well as the notch filter for the SINAD measurement - are created digitally by the digital signal processor.

It should be noted, that a given filter characteristics may be created using either single or double precision in the signal processor calculations. Single precision filters create additional noise through truncation errors in the filter calculation, but allow measurements to take place in two channels simultaneously. Consequently, measurements involving double precision filters will increase measurement time. At high input frequencies, however, the general measurement overhead will be the dominating factor for the measurement speed, implying that the difference between single and double precision measurements will not be significant.

Notch Filters

The notch filter is programmable, i.e. it may be tuned to any frequency between 20 Hz and 23750 Hz in steps of 1 Hz. For low notch frequencies, the filter may only be practically useable if it is allowed to operate in double precision, i.e. measurements only take place in one channel at a time.

Normally the RE 204 automatically selects between single and double precision depending on the selected notch frequency - a frequency below 700 Hz selects double precision, a frequency above 700 Hz selects single precision. It is possible, however, to govern the precision from the IEEE488 controller, e.g. if the notch depth at lower frequencies is not required to exceed 60 dB you can, through the filter command, force the RE 204 to use single precision and thus increase measurement speed. Selecting double precision at higher frequencies will increase the depth of the notch to more than 70 dB. Refer to fig. 4.2.

As is the case for the general-purpose notch filter, the SINAD notch filter may also be operated as a single or double precision filter. Double precision is mandatory for

frequencies below 700 Hz when measuring in the "fine" range and for frequencies below 440 Hz when measuring in the "coarse" range.

The use of a double precision weighting filter with a SINAD measurement demands the use of double precision notch filter. In this case, the "fine/coarse" selection is of no importance, as a double precision filter covers the entire range from 10 % and downwards.

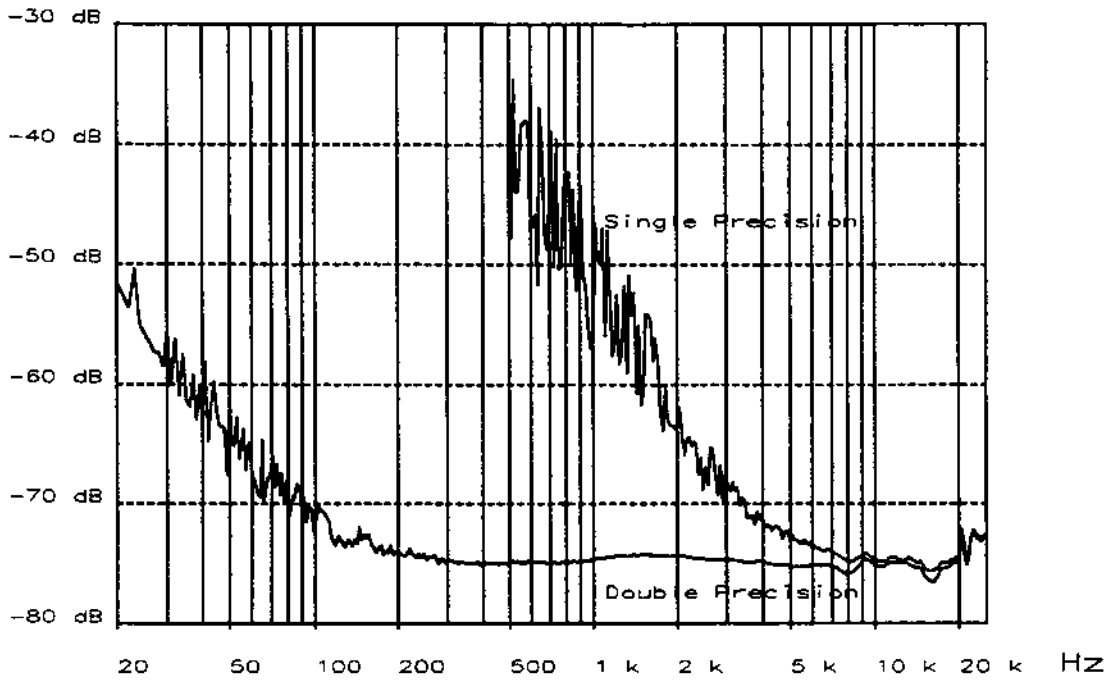

Fig. 4.2 - Notch Filter Depth

Bandpass Filters

The bandpass filter is programmable, i.e. it may be tuned to any frequency between 20 Hz and 23750 Hz in steps of 1 Hz. For low center frequencies, the filter may only be practically useable if it is allowed to operate in double precision, i.e. measurements only take place in one channel at a time.

Normally the RE 204 automatically selects between single and double precision depending on the selected center frequency: single precision for frequencies below 1 kHz and double precision for frequencies above 1 kHz. It is possible, however, to govern the precision from the IEEE488 controller, e.g. if the stop band attenuation at lower frequencies is not required to exceed 60 dB. In this case, selecting a single precision filter will increase measurement speed. Selecting double precision at higher frequencies will improve the stop band attenuation by several dBs. As an example,

the bandpass filter tuned to 1 kHz is shown for single and double precision in Fig. 4.3 and 4.4 respectively.

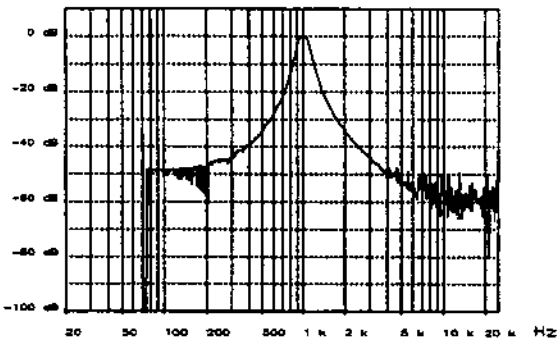

Fig. 4.3 - Single Precision Bandpass

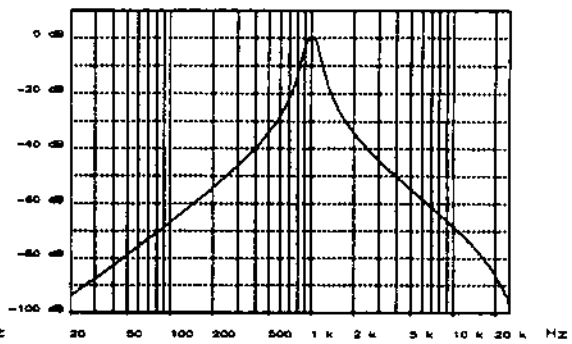

Fig. 4.4 - Double Precision Bandpass

User Filters

In order to satisfy the different needs for different applications, it is possible to define digital filters for the RE 204 externally and download them at any time. Through this feature the number of different filters that you can use in a test sequence becomes practically unlimited. The only thing you have to do is to download new user filter coefficients to the RE 204 when a filter change is required.

For most filters, especially filters with large attenuation at low frequencies and/or filters with tight frequency specifications, the definition of the coefficients is not a straight forward task, as topics such as internal filter gain, absolute gain, settling time, stability etc. all must be investigated.

Therefore, we do strongly recommend that this task is handled by RE TECHNOLOGY AS based on your filter description. The resulting filter parameters may then be downloaded as explained in the programming section of this manual.

4.4 SINAD Measurement

The SINAD measurement uses a separate programmable notch filter. Due to the fact that the input signal is known to have a dominant component, namely the fundamental frequency, it is possible for the RE 204 to obtain a better dynamic range compared to using the notch filter on an arbitrary signal. The penalty for this is that only a specific range of SINAD values can be covered by the same filter. Thus, it must be specified whether the SINAD value is expected to be "coarse" or "fine".

The "coarse" range covers 10 % down to 0.1 %, while the "fine" range covers 0.3 % and downwards. However, if the RE 204 finds that a given result is outside the

selected range, the range is automatically changed and the measurement repeated. Of course, this adds to measurement time, so selecting the correct range speeds up things.

If the fundamental frequency is below 700 Hz and/or if a double precision weighting filter is applied, the notch filter is always double precision. In this case, the "coarse/fine" selection is of no importance, since a double precision filter covers the entire range.

The fundamental frequency is measured and the notch filter calculated accordingly. If the frequency is identical to the last one used for this channel, the filter calculation is omitted. This will save approximately 150 ms of time.

If the signal used for the test is known to origin from the audio generator, either directly or via the AM/FM stereo generator, the actual measurement of the fundamental frequency may be omitted. It is assumed that left output from the audio generator is used for measurement in left front and left rear, and that right output is used for measurement in right front and right rear.

The SINAD value is calculated as:

$$\frac{\text{Signal excluding the fundamental}}{\text{Entire signal}} \cdot 100\ \%$$

In other words, the SINAD value is the output of the notch filter divided by the input to the notch filter. Both the signal and the signal excluding the fundamental frequency, i.e. noise and distortion, are thus measured simultaneously. It should be noted that a weighting or a band limiting filter used with a SINAD measurement only affects the measurement of noise and distortion and not the signal measurement.

If the measurement time is not specified, 10 times the period of the fundamental frequency is automatically used, except for frequencies above 10 kHz, as the measurement time cannot be set below 1 ms. It should be noted, however, that the noise and distortion measurement may call for a significantly higher measurement time for an accurate result. In this case, the measurement time must be specified in the SINAD command.

4.5 RMS, Average and Quasi-peak Measurements

All three detectors are implemented digitally, and weighting filters may be applied - the quasi-peak measurement, however, only accepts the CCIR468 filters CW and CB.

When measuring RMS or average, the measurement time is determined as follows:

1. If the measurement time is specified, this value is of course used.

2. If a frequency is given as parameter, i.e. the input frequency, the measurement time set to 10 times the signal period.

3. If the audio generator is known to be the origin of the test signal, possible via the AM/FM stereo generator, the measurement time is selected according to the following rules:

   a. If the frequencies in the two channels left and right differ, a measurement time of 10 times the largest signal period is selected.

   b. If the frequency is below 400 Hz, a measurement time equal to one signal period is selected, otherwise 3 times a signal period.

4. If no parameter is given, the frequency is measured and the measurement time set to 10 times the signal period. If no frequency is found, as for noise measurements, a period of 250 ms is selected. If different frequencies are found for the left and right input channels, the measurement time is determined by the lowest of the frequencies.

As the two front channels are measured simultaneously, and then the two rear channels, the measurement time may differ for the front/rear measurements.

In addition to the rules above, it should be noted, that a measurement time less than 1 ms is never used.

As the quasi-peak measurement is to be used for noise measurements, linking to a specific frequency is not a legal choice.

4.6 Peak Measurement

The peak measurements are done by means of analog detectors, preceded by fullwave rectifiers. As the antialiazing filter is not used, the bandwidth is extended to 75 kHz, and the ripple of 0.1 dB is eliminated.

4.7 DC Measurement

The DC voltage from the separate input connector is routed to the 16 bit A/D converter. The output from the converter is then averaged in 50 ms by the signal processor, the result is compensated for gain, (high or low range), and delivered to the IEEE488 interface.

It should be noted, that no autoranging between high and low range is implemented.

In order to facilitate implementation of different ranges, the gain factor may be defined, according to the actual hardware configuration.

4.8 Frequency Measurement

The frequency measurement is based on a zero-crossing detection, performed by the signal processor.

The frequency measurement algorithm searches for frequency, from the lower frequency range and upwards. If nothing is anticipated about the input, it is necessary to scan from 20 Hz and upwards. For accurate frequency determination, at least two periods of the signal is needed, so for an unknown input frequency, the minimum observation period is:

$$\frac{2}{20\ \text{Hz}} = 100\ \text{ms}$$

(in practise, 135 ms). This amount of time is not needed, if it is known, that the frequency is above a certain limit, e.g. 500 Hz. In this case, it is only necessary to observe the signal for a period of:

$$\frac{2}{500\ \text{Hz}} = 4\ \text{ms}$$

i.e. a speed improvement of 25 times. Such a known lower bond of the frequency, or alternatively an observation period, may be specified as part of the frequency measurement command in order to speed up the measurement.

High levels of noise on the input signal may disturb the zero-crossing detection and result in fluctuating results. This problem is more significant when measuring on low frequencies, due to the fact that the signal is in the area around zero for a longer period of time, where noise may cause the signal to cross the zero line more than once. In order to be able to measure low frequencies with a high noise contents a digital lowpass filter can be applied. In this way, stable readings are obtained even in the presence of rather large noise components.

The lowpass filter is a 2nd order Butterworth filter with a cutoff frequency of 2500 Hz. Enabling/disabling of this filter is a parameter for the frequency measurement command. However, if this parameter is omitted, the RE 204 automatically detects whether the lowpass filter is required or not: If the RMS level without the filter is more than 4 times the RMS level with the filter, i.e. the main component of the signal is below approx. 3 kHz, the filter is used during the frequency detection.

4.9 Meter Updating

The bargraph displays may be used for monitoring the input levels of all four channels simultaneously, regardless of the channels set active for measurements. No filter is employed.

Each bargraph is composed of 10 LED bars, showing the peak input voltages as shown in Table 4.3. A bar is lit as soon as the input level has passed the logarithmically middle of the distance between two bars. For example the 10 Vp bar is lit when input level is above 5.62 Vp, which is the logarithmic middle between 3.16 Vp and 10 Vp.

It should be noted, that an input, which is left open, normally will show a level of approx. 10 - 100 mVp.

When the meter is deactivated, the upper- and lowermost bars are lit.

Display	Input Level
10 Vp	>5.6 Vp
3.16 Vp	>1.7 Vp
1 Vp	>560 mVp
316 mVp	>170 mVp
100 mVp	>56 mVp
31.6 mVp	>17 mVp
10 mVp	>5.6 mVp
3.16 mVp	>1.7 mVp
1 mVp	>0.5 mVp

Table 4.3 - Meter Ranges

As shown in Fig. 4.5 on the next page, all four inputs are routed to analog peak detectors, which are allowed to charge for 50 ms. Then the voltage is read by the main computer by means of a four-input 8 bit A/D converter. The computer compensates the reading for the actual gain set in the programmable amplifiers and reads out the result to the bargraph displays. Autoranging may take place if the level is inappropriate, regardless of the enabling of the general autoranging feature.

It should be noted, that updating of the meters has a lower priority than making a measurement, i.e. when a measurement is started, updating of meters is suppressed. Consequently, if measurement commands are issued continuously by the IEEE488 controller, the display will never change. You can deal with this problem in two ways:

* Make your program halt for approx. 100 ms whenever an update is wanted, thus allowing the meter procedure to complete.

* Issue a new `MR,ON` command which forces the meter to update.

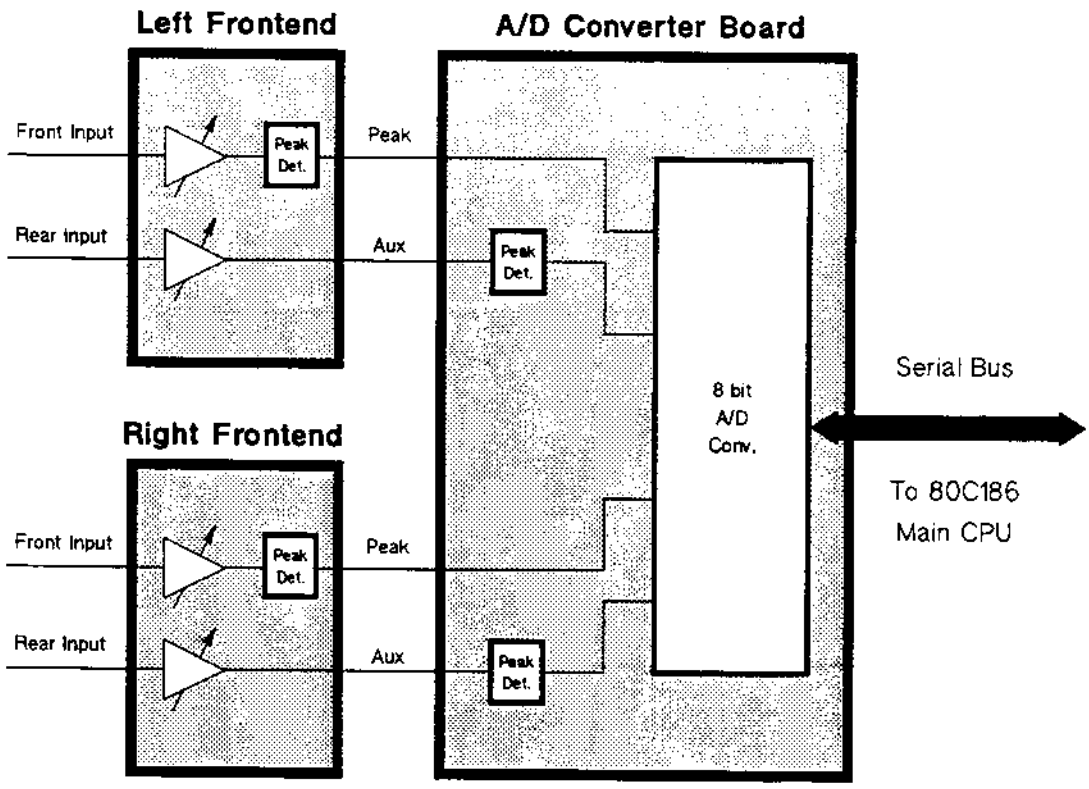

Fig. 4.5 - Meter Operation

4.10 Calibration

The fast measuring speed of the RE 204 is due to the DC coupling of the signal path. However, a DC-component originating from offset voltages due to aging, temperature changes etc. will inevitably be present. When measuring e.g. SINAD or very low RMS voltages without a highpass filter, this DC voltage may corrupt the measurements. Hence, it must be ensured, that it is always kept as low as possible. The hardware calibration feature handles this task.

The calibration may be performed either automatically or governed by the external controller. In case of automatic calibration the scheme is as follows:

* For the first 5 minutes, i.e. the initial warm-up period, no calibration is done

* During the next half hour, calibration takes place each minute. This is the final warm-up period.

* After the first half hour, calibration takes place for every 15 minutes.

Since calibration must be performed for each channel and for each gain step, it takes some time. It may therefore be recommended to disable the automatic calibration and let the IEEE488 controller initiate calibration during natural pauses in the test sequence.

The calibration interval necessary depends on the actual dynamic range needed. If SINAD for instance is only measured down to approx. 0.15 % and RMS down to 1 mV, it may not be necessary to calibrate so often. In this case a calibration once a week would probably be enough. The actual interval will depend the temperature cycle of your set up.

The calibration procedure, which is governed by the main computer, proceeds as follows:

* The external input is disconnected and a short circuit established.
* The DC voltage is measured, using the same signal path as during measurements.
* A compensation DC voltage is inserted by means of a D/A converter.
* The DC measurement is repeated in order to store the residual DC value together with the setting of the D/A converter.

The calibration procedure is repeated for each channel. Whenever gain and/or channel afterwards is changed, the correct DC compensation voltage is established from a stored table. When measuring small values of RMS, the RE 204 may corrected the result by subtracting the residual DC.

4.11 Wow & Flutter

When measuring wow & flutter, an optional board is installed in the right frontend channel. The purpose of this board is to remove amplitude variations from the input signal, by means of a clipper. The signal is then routed via the 25 kHz lowpass filter to the A/D converter. After digitalization, the following steps are performed digitally by the signal processor:

* 4.5 kHz lowpass filtering in order to remove harmonics of the carrier.
* FM demodulation.
* Filtering of the demodulated signal, 0.2 Hz to 500 Hz or 0.5 Hz to 200 Hz filters.
* Weighting according to DIN standard, if selected.
* Detection according to the selected standard:

  RMS for JIS standard
  Average for NAB standard
  Quasi-peak for DIN standard

* Lowpass filtering of the detector output in order to simulate a meter response with $\tau = 60$ ms.

* Calculation of mean value, sigma value and the result: mean + 2*sigma.

Before the wow & flutter measurement, the frequency is measured in order to tune the digital FM demodulator according to the actual frequency.

4.12 Audio Generator

The Audio Generator is composed of two boards:

* A Digital Board comprising a TMS320C10 signal processor and a sine wave look-up table.

* An Analog Board comprising two channels, each equipped with a 16 bit D/A converter, antialiazing lowpass filter, programmable level setting, and balanced output buffers.

The digital samples for a single sine wave are generated by the signal processor which reads samples from the look-up table and multiplies them by a level factor. This factor is determined by the 80C186 main computer and includes three compensations:

* As the gain on the Analog Board only may be programmed in steps of 3 dB, the finer gain adjustments are done digitally.

* The frequency response of a lowpass filter (not the antialiazing filter) is compensated.

* It is known from the sampling theory, that when using a staircase signal in the D/A conversion process instead of delta functions, the frequency response of the output signal will follow with a sin x/x function, $x = 2\pi fT/2$, where T is the sampling period. Thus, the level factor must compensate for this frequency dependency.

As the latter two compensations are frequency dependent, different settings of the analog attenuator may be seen for the same output level at different frequencies.

4.13 Stereo Generator

The Stereo Generator option offers two capabilities: FM stereo and AM stereo. In both cases, the L/R signals to be used must be supplied by the audio generator.

FM Stereo

The FM stereo generator is a conventional analog design with the exception of the preemphasis function, which is implemented as a digitally compensation of the left and right input signals.

The composite signal is generated by using the time multiplexing principle, the advantage of which is the completely uniform handling of the left and the right channel signals.

The modulator, operating at 38 kHz, is an integrated balanced switch modulator driven by a 38 kHz square wave. The modulator itself suppresses the 38 kHz carrier, but it produces unwanted sidebands at odd harmonics of 38 kHz.

The sidebands at the third harmonics of 38 kHz, i.e. 114 kHz, are balanced out by a signal from a 114 kHz modulator similar to and synchronized to the 38 kHz modulator. Higher sidebands, i.e. at 190 kHz and upwards, are removed by a composite filter with a linear phase response and a flat amplitude response up to 53 kHz, resulting in high L/R separation.

The sine wave pilot signal is generated by integration of a 19 kHz square wave derived from the same digital circuit which is generating the 38 kHz carrier. This results in a negligible pilot phase deviation in relation to the 38 kHz carrier.

The harmonics of the 19 kHz square wave are balanced out and removed by filters. The third and the fifth harmonics, i.e. 57 kHz and 95 kHz, are compensated by means of a 57 kHz and a 95 kHz square wave. The seventh harmonic is eliminated by a 133 kHz trap while the remaining harmonics are attenuated by the composite filter.

The pilot level can be set in steps of 0.5 % by means of an attenuator.

The left and the right signals are preemphasis weighted in the audio generator. Thus, the left and right output signals available at the audio generator output connectors incorporate this weighting. It should be noted, that the preemphasis weighting is implemented as attenuation of the lower frequencies instead of amplification of the higher frequencies.

Output level control is accomplished by adjustment of the L/R levels from the audio generator, which may be programmed in percent. The actual output level for 100 % composite signal may be adjusted by means of a potentiometer. Please refer to Section 3, Front and Rear Panels, for a description.

AM Stereo

For modulation an RF generator as e.g. the RE 122 Signal Generator, an AM stereo matrix is generated by means of the audio generator. The audio generator left output is used to generate L-R+25 Hz pilot, while the right channel is used for L+R. As all components are digitally calculated, the resolution for the L/R level as well as for the pilot is very fine.

5 PROGRAMMING

This section contains information on how to control the RE 204 from the IEEE488 interface.

5.1 Notation Used to Describe the RE 204 Command Language

Modified Backus-Naur notation has been used in the description of the commands:

Symbol	Meaning
=	is Defined to be
|	OR
.	End of Definition
[x]	0 or 1 Instance of x
{x}	0 or more Repetitions of x
(x|y|..|z)	Grouping: any one of x, y,.., z
"xyz"	the Terminal Symbol xyz
x-y-z	the Non-Terminal Symbol x-y-z

5.2 Syntax for RE 204 Communication

```
Command-string          =  set-of-commands {" "} ("CR"|
                           "LF" |"EOI with last byte").

Set-of-commands         =  Command {Command-separator
                           Command}.

Command-separator       =  {" "} " ".

Command                 =  Mnemonic {Parameter-separator
                           Parameter} |Command-query.

Mnemonic                =  "First_letter" {"Letter"}
                           "Last_letter".

Command-query           =  "?" | (Mnemonic [Parameter-
                           separator Parameter] "?").

Parameter-separator     =  {" "} "," {" "}.

Parameter               =  Alphabetical-parameter |
                           Numerical-parameter.

Alphabetical-parameter  =  "First_letter" {"Letter" |
                           "Digit"}
                           "Last_letter_or_digit".

Numerical-parameter     =  Number [Unit].
```

```
Number                  =  ["+"|"-"] {Digit} ("." |
                           Digit) {Digit} ["e"|"E"
                           ["+"|"-"] [Digit] Digit].

Unit                    =  ("First_letter" {"Letter"}
                           "Last_letter") | "%".

First_letter            =  "Letter".

Last_letter             =  "Letter".

Last_letter_or_digit    =  "Letter" | "Digit".

Digit                   =  "1"|"2"|"3"|"4"|"5"|"6"|"7"|
                           "8"|"9"|"0".

Letter                  =  "A"|"B"|"C"|"D"|"E"|"F"|"G"|
                           "H"|"I"|"J"|"K"|"L"|"M"|"N"|
                           "O"|"P"|"Q"|"R"|"S"|"T"|"U"|
                           "V"|"X"|"Y"|"Z"|"a"|"b"|"c"|
                           "d"|"e"|"f"|"g"|"h"|"i"|"j"|
                           "k"|"l"|"m"|"n"|"o"|"p"|"q"|
                           "r"|"s"|"t"|"u"|"v"|"x"|"y"|
                           "z"|"&"|"_".
```

All commands begin with a mnemonic, i.e. a two-letter abbreviation of the command name. Additional characters may be inserted between the two letters in order to facilitate reading of the programme, as only the first and the last letter are interpreted. Uppercase and lowercase letters may be used at random.

To set the input range, either `RE` or `Range` may be used.

Following the mnemonic, the parameters are given, separated by commas. Spaces (blanks) may be inserted. Some parameters may be alphabetical or numerical, and the numbers may be accompanied by unit specifier, such as Hz or kHz. A default unit is always assumed, if no unit is given - this is stated in the command syntax. Units or alphabetical parameters consisting of two letters may be extended by insertion of additional letters or digits.

To deselect autoranging, either `AUTO,OFF` or `AUTO,0` may be used.

To set the audio generator frequency, either of the following may be used: `AF,B,1000`, `AF,B,1000Hz`, `AF,B,1kHz`, `AF,B,1KZ`.

Numerical parameters may be given as integers, as reals, or as floating point numbers with exponents. This is regardless of whether the actual parameter actually is an integer or a floating point number. However, it should be noticed that numbers are truncated if more digits than the actual resolution is given.

`1, 1.0, 1.0E00, 0.1E+01, 100E-2` are all legal representations of the number 1.

The actual format of the results are generally floating point with exponent, which is easily read by a controlling computer.

5.3 The Commands

The commands for the RE 204 may be divided into the following groups:

Control Commands

These commands establish the general conditions for all of the measurements and are used in order to:

Control Autorange	(AO)
Select Channel(s)	(CH)
Control Calibration	(CL)
Calibrate the DC Channels	(DL)
Select Filter	(FR)
Control Meter Display	(MR)
Set Input Range	(RE)
Wait for Settling	(SE)
Select Wow & Flutter Detector	(WD)

Generator Commands

These commands set up the generators (if installed) and are thus used in order to:

Set Audio Generator Frequency	(AF)
Set Audio Generator Level	(AL)
Control Auxiliary Input	(AN)
Control the Composite Output	(CT)
Control Stereo Mode	(FC)
Change Generator	(GE)
Define a Generator Setup	(GF)
Set Pre-emphasis	(PE)
Switch Pilot On/Off	(PT)
Control Pilot Level	(PV)

Measurement Commands

All measurements are comprised in this group, i.e.:

Average Measurement	(AE)
DC Measurement	(DC)
Frequency Measurement	(FQ)
Peak Measurement	(PK)
Quasi-peak Measurement	(QK)
RMS Measurement	(RS)
SINAD Measurement	(SD)
Wow & Flutter Measurement	(WF)

Miscellaneous Commands

These commands are used in order to:

Define a User Filter Biquad	(BQ)
Recall a Setup	(EX)
Define User Filter Parameters	(FF)
Set Instrument Identity	(ID)
Set IEEE Address	(IR)
Reset Definitions	(RT)
Define a Setup	(SF)
Disable a Service Request	(SS)

5.4 Control Commands

The control commands are used to govern the general environment for the measurements.

Before starting the first measurement, the measuring conditions of the instrument must be selected. The order of the commands is quite arbitrary.

First, select the channels we want to measure:

`CH,F` Select front channels

Set the proper range:

`RangE,F,1` Set input range in both front channels to 1 V_{peak}

The range value is always given as peak values, either Vp or mVp. Selecting the range at forehand speeds up things, but the instrument is capable of autoranging. The autoranging may be selected/deselected for each channel individually:

`AutO,LF,ON AutO,RF,OFF` Enable autoranging in left front channel, but not in right front channel.

Select which filter is to be used, select allpass, AP, for no filter):

`FilteR,HP,100HZ` Select 100 Hz highpass filter

All the settings are maintained until changed, i.e. the highpass filter will now be applied to all measurements until a new filter command is issued. The range may though be changed if autoranging is enabled.

Autorange Control (AO)

"AO" Parameter-separator Alphabetical-parameter [Parameter-separator Alphabetical-parameter]

1st Parameter:	Channel	
Range:	"F"	The 2 front channels
	"R"	The 2 rear channels
	"A"	All 4 channels
	"LF"	Left front channel
	"RF"	Right front channel
	"LR"	Left rear channel
	"RR"	Right rear channel
Unit:	none	
Default Value:	none	
2nd parameter:	Autorange On/Off	
Range:	"OFF"	
	"ON"	
Unit:	none	
Default Value:	"ON"	

Example: `AutO,F,ON`

Explanation: The autorange feature of the RE 204 is activated in the 2 front channels.

Comments: Autoranging is only done when necessary, meaning that no overhead is added whenever the input signal is within acceptable limits - refer to the description in section 4.2.

Select Channel (CH)

"CH" Parameter-separator "F"|"R"|"A"|"LF"|"RF"|"LR" |"RR"

Parameter:	Channel	
Range:	"F"	The 2 front channels
	"R"	The 2 rear channels
	"A"	All 4 channels
	"LF"	Left front channel
	"RF"	Right front channel
	"LR"	Left rear channel
	"RR"	Right rear channel
Unit:	none	
Default Value:	none	

Example: `CH,R`

Explanation: The two rear channels are now active.

Comments: The channel(s) selected will be used for measurements until a new CH command is received by the RE 204. The actual setting may

be read back by issuing the command "CH?". Please note that the Wow & Flutter measurement will only take place in the RIGHT channel(s).

Start Calibration (CL)

"CL" [Parameter-Separator Alphabetical-parameter]

Parameter:	Automatic calibration on/off
Range:	"OFF" Auto calibration off "ON" Auto calibration on
Unit:	none
Default Value:	Without a parameter, a normal calibration will take place under computer control.
Example:	`CaL`
Explanation:	The auto calibration routine is activated.
Comments:	The calibration takes approx. 2 seconds. In case auto calibration is switched on, the RE 204 waits 5 minutes following power up, then calibrates every minute for half an hour to end up calibrating every 15 minutes. In order to ensure that no calibration takes place during normal measurements (which would prolong the measurement and could cause IEEE488 bus timeout), the auto calibration should be switched off and calibration performed under IEEE computer control. Refer to section 4.10.

Calibrate the DC Input (DL)

"DL" Parameter-separator [Alphabetical-parm] Parameter-separator (Number ["mV"|"V"] | Alphabetical-parm)

1st parameter:	High or low range
Range:	"LO" "HI"
Unit:	none
Default Value:	HI
2nd parameter:	Full scale input voltage
Range:	1 mV to 100V "C" | "CR" Clear calibration
Unit:	"mV" | "V"
Default Unit:	"V"
Default Value:	none
Example:	`DCcaL,LO,1V`
Explanation:	Max. reading on the low range equals 1V.

Comments: The DCcal-command allows the RE 204 to calculate DC values correctly and does not instigate any hardware calibration. Parameter 2 depends on the hardware installed in the RE 204. The standard version of the RE 204 operates with 1V and 30V low and high range, respectively.

Select a Filter (FR)

"FR" Parameter-separator Alphabetical-parm [(Parameter-separator Number ["Hz"|"kHz"] [Parameter-separator (Alphabetical-parm)) | (Number)]]

1st parameter:	Filter name or number	
Range:	"AP"	Allpass, i.e. no filter
	"CR"	CCIR/ARM
	"CW"	CCIR 468 weighting filter
	"CB"	CCIR 468 band pass
	"DA"	dB(A)
	"LP"	15 kHz low pass
	"BP"	Band pass
	"HP"	High pass
	"NH"	Notch
	"UR"	User defined filter
Unit:	none	
Default Value:	none	
2nd parameter:	Filter frequency - only allowed when using high pass, band pass or notch filters or - user filter number.	
Range:	100 | 400	High pass filter
	20 to 25000 Hz	Band pass or notch filter frequency
	1 to 2	User filter number
Unit:	"Hz" | "kHz"	High pass, band pass or notch filter frequency
	none	User filter number
Default Unit:	Hz	Filter frequency
	none	User filter
Default Value:	400 Hz	High pass filter
	1000 Hz	Band pass
	19000 Hz	Notch filter
	1	User filter number
3rd parameter:	Normally omitted, and only allowed for band pass and notch filters: Single or double precision.	
Range:	"SP"|"S"	Single precision
	"DP"|"D"	Double precision
Unit:	none	
Default Value:	"SP"	Band pass frequency > 1000 Hz Notch frequency > 700 Hz

	"DP"	Band pass frequency < 1000 Hz Notch frequency < 700 Hz

Example: `FilteR,UseR,1`

Explanation: Select the user defined filter, previously defined as number 1 by means of the "FF"-command.

Comments: The selected filter remains active until a new "FR"-command is issued. The filter setting may be read back by issuing the query-command "FilteR?". The filter only influences RMS, Average and SINAD measurements.

Control Level Indication Meter (MR)

"MR" Parameter-separator Alphabetical-parm

Parameter:	Meter control	
Range:	"OFF"	Bargraph display disabled
	"ON"	Bargraph display enabled
Unit:	none	
Default Value:	none	

Example: `Meter,on`

Explanation: Start updating the bargraph meter display

Comments: When a new measurement command is received by the RE 204, the bargraphs will "freeze" during the measurement in order to optimize measurement speed. Thus, if measurements are executed continuously, the bargraph displays will not be updated. This can be circumvented by issuing a new "MR,ON" command, thus forcing a bargraph display update to take place before the next measurement is started.

Set Input Range (RE)

"RE" Parameter-separator Alphabetical-parm [Parameter-separator Number ["mVp"|"Vp"]]

1st parameter:	Channel	
Range:	"F"	The 2 front channels
	"R"	The 2 rear channels
	"A"	All 4 channels
	"LF"	Left front channel
	"RF"	Right front channel
	"LR"	Left rear channel
	"RR"	Right rear channel
Unit:	none	
Default Value:	none	

2nd parameter:	Full scale input peak voltage
Range:	11 mVp to 30 Vp
Unit:	"mVp" | "Vp"
Default Unit:	"Vp"
Default Value:	3 Vp
Example:	`RangE,A,1.5Vp`
Explanation:	Set all channels to accept max. 1.5 Vp input signals
Comments:	The gain setting in all channels may be read back by issuing the command "RangE?" - please note that internally the RE 204 selects the nearest 6 dB step (0 dB = 3 Vpeak, refer to section 4.2). When autoranging is enabled, the range may be altered automatically - the new setting may then be read back by the "RE?" command.

Wait for Settling (SE)

"SE" [Parameter-separator Alphabetical-parm]

Parameter:	Settle on/off
Range:	"OFF" "ON"
Unit:	none
Default Value:	ON
Example:	`SE,OFF`
Explanation:	Automatic waiting for the frontend to settle is turned off.
Comments:	When settling is on, SINAD measurements are delayed if a change in frontend relay setting may damage the SINAD result. When settling is off, a special service request (104) is delivered with the SINAD result if "settle on" would have caused waiting.

Select Wow & Flutter Standard (WD)

"WD" Parameter-separator Alphabetical-parm Parameter-separator (Number ["Hz"|"kHz"]| Alphabetical-parm)

1st parameter:	W&F standard	
Range:	"DN"	DIN
	"NB"	NAB
	"JS"	JIS
Unit:	none	
Default Value:	none	

2nd parameter:	W&F filter	
Range:	500	500 Hz Low pass
	200	200 Hz Low pass
	"WT"	DIN weighted
Unit:	"Hz" | "kHz"	200 or 500 Hz Low pass
	none	DIN weighted
Default Unit:	"Hz"	200 or 500 Hz Low pass
	none	DIN weighted
Default Value:	none	
Example:	`W&F_std,DIN,WT`	
Explanation:	Following this command, W&F will be measured according to the DIN standard, including the weighting filter. The current detector for W&F measurements may be read back by issuing the query command "WD?".	

5.5 Generator Commands

The commands covered by this section are mainly related to the stereo generator option. The only commands applicable if no stereo generator is installed, are the AF and AL commands - audio generator frequency and level, respectively.

When a stereo generator is installed, the RE 204 operates 3 virtual generators: an LF generator, an FM stereo generator, and an AM stereo matrix generator, although the same physical audio generator is used in all cases.

The command GenmodE is used to switch between the 3 generators. Separate settings are maintained for each of the generators, e.g. the level of the audio signals. The command GendeF is used to define for which generator the commands that follow are intended.

Complete setups for the 3 generators may be established by means of the following command strings:

```
GENDEF,AG AUDIOF,L,1000HZ  AUDIOF,R,2000HZ  AUDIOL,B,30%

GENDEF,FM AUDIOF,L,1000HZ  AUDIOF,R,2000HZ  AUDIOL,B,30%
          FUNC,OFF  COMPOUT,ON  PILOT,ON  PILOTLEV,9.0%
          AUXIN,OFF  PRE,0

GENDEF,AM AUDIOF,L,1000HZ  AUDIOF,R,2000HZ  AUDIOL,B,50%
          FUNC,OFF  PILOT,ON  PILOTLEV,5.0%  PRE,0
```

It should be noted, that the GendeF command only defines the pertinent settings; to activate the relevant generator, use the "GenmodE" command.

If no GendeF is present at the start of the command string, the commands are routed to the generator presently selected.

Set Generator Frequency (AF)

"AF" [Parameter-separator [Alphabetical-parm] [Parameter-separator Number ["Hz" | "kHz"]]]

1st parameter:	Output channel	
Range:	"B"	Both channels
	"L"	Left channel
	"R"	Right channel
Unit:	none	
Default Value:	B	
2nd parameter:	Frequency	
Range:	20 to 25000 Hz in 1 Hz steps	
Unit:	"Hz" | "kHz"	
Default Unit:	Hz	
Default Value:	1000	
Generators:	All	
Example:	AF	
Explanation:	Output frequency in both channels set to 1 kHz.	

Set Generator Level (AL)

"AL" parameter-separator [Alphabetical-parm] Parameter-separator Number [Unit]

1st parameter:	Output channel	
Range:	"B"	Both channels
	"L"	Left channel
	"R"	Right channel
Unit:	none	
Default Value:	B	
2nd parameter:	Output level	
Range:	0 to 8.5 Vp	Audio Generator
	0 to 3Vp/100%	FM Generator
	0 to 1Vp/100%	AM Generator
Unit:	"mVp" | "Vp"	Audio Generator
	"mVp" | "Vp" | "%"	FM and AM Generators
Default Unit:	"Vp"	Audio Generator
	"%"	FM and AM Generators
Default Value:	none	
Generators:	All	
Example:	AudioleveL,R,1Vp	
Explanation:	Set output level in right channel to 1 Vp.	
Comments:	"%" is % modulation. In the AM Generator, 100% is equivalent to 1 Vp. In the FM Generator, 100% is equivalent to 3 Vp.	

The resolution is 1 mV; if more digits are presented, the number i truncated without a warning.

Auxiliary Input On/Off (AN)

"AN" [Parameter-separator Alphabetical-parm]

Parameter:	On/Off
Range:	"OFF" "ON"
Unit:	none
Default Value:	OFF
Generators:	FM
Example:	`AuxiN,ON`
Explanation:	The AUX input is switched on.

Composite Output On/Off (CT)

"CT" [Parameter-separator Alphabetical-parm]

Parameter:	On/Off
Range:	"OFF" "ON"
Unit:	none
Default Value:	ON
Generator:	FM
Example:	`CompositT,OFF`
Explanation:	The composite output is switched off.

Stereo Mode Control (FC)

"FC" [Parameter-separator Alphabetical-parm]

Parameter:	Stereo signal mode	
Range:	"OFF"	Mono and subchannel switched off
	"ST"	Stereo (L&R)
	"MN"	Mono (L=R)
	"SB"	Subchannel (L=-R)
	"L"	L only
	"R"	R only
Unit:	none	
Default Value:	OFF	
Generators:	FM, AM	

Example:	`FunC,L`
Explanation:	The Stereo Generator is set to "L only".
Comments:	The Pilot signal is not switched off in modes "MN" and "OFF". The Pilot signal must be controlled separately by means of the "PT" command.

Select Generator Mode (GE)

"GE" Parameter-separator Alphabetical-parm

Parameter:	Generator mode	
Range:	AG	Audio Generator
	FM	FM Generator
	AM	AM Generator
Unit:	none	
Default Value:	none	
Example:	`GeneratormodE,FM`	
Explanation:	The FM stereo generator is now active.	
Comments:	When another generator than FM is selected, the composite output is switched off. When FM is selected later, the previous output is reestablished.	

Define a Generator Setup (GF)

"GF" Parameter-separator (Number | Alphabetical-parameter) {command-separator command}

Parameter:	Generator	
Range:	"AG"	Audio Generator
	"FM"	FM Stereo Generator
	"AM"	AM Stereo Generator
Unit:	none	
Default Value:	none	
Example:	`GeneratordeF,FM Pilot,ON AuxiN,OfF`	
Explanation:	On the FM Stereo Generator, remove the Aux. input and set pilot on.	

Pre-emphasis Specification (PE)

FM Generator

"PE" Parameter-separator Number ["usec"]

Parameter:	Pre-emphasis time constant	
Range:	0	0 µsec
	25	25 µsec
	50	50 µsec
	75	75 µsec
Unit:	usec	
Default Unit:	usec	
Default Value:	0	
Generator:	FM	
Example:	`PrE,50usec`	
Explanation:	Pre-emphasis now set to 50 µsec.	

AM Generator

"PE" [Parameter-separator Alphabetical-parm]

Parameter:	Pre-emphasis On/Off	
Range:	"OFF"	Pre-emphasis off
	"ON"	Pre-emphasis on
Unit:	none	
Default Value:	OFF	
Generator:	AM	
Example:	`PrE,ON`	
Explanation:	Pre-emphasis is now turned on.	

Pilot On/Off (PT)

"PT" [Parameter-separator Alphabetical-parm]

Parameter:	On/Off
Range:	"OFF"
	"ON"
Unit:	none
Default Value:	OFF
Generators:	FM, AM
Example:	`PiloT,ON`
Explanation:	If generator mode is set to AM, the 25 Hz pilot signal is switched on. If generator mode is set to FM, the 19 kHz pilot signal is switched on.

Pilot Level (PV)

"PV" Parameter-separator Number [Unit]

Parameter:	Pilot level in %.
Range:	0 to 15.5% (resolution 0.5%)
Unit:	%
Default Value:	none
Generators:	FM, AM
Example:	`PilotleV,5%`
Explanation:	Pilot level is set to 5 %.

5.6 Measurement Commands

Each measurement command sent to the RE 204 results in **one** (set of) result(s). Depending on the last "CH"-command, the string will contain from one to four (up to eight for Quasi Peak) results separated by "," and terminated by <CR> and <LF>.

Measurement Integration Periods

When determining the proper measurement integration times, the following general rules may be applied:

1. To measure true RMS correctly (i.e. within 1%), at least 10 periods of the dominant frequency must be covered (but never less than 1 ms).

2. When the RE 204 is informed that the Audio Generator is used to supply the signal, the measurement time may be reduced, as the generating and measuring devices are tightly synchronized.

The following notes to rule 2 above should be observed:

2a. If the frequencies in the LEFT and RIGHT channels differ, and the measurement is done in both channels, the measurement time will be 10 times the lowest frequency.

2b. The relationship between frequency and selected measurement time is as follows:

f >	10	kHz		always 1 ms
f >	1	kHz	- 10	periods
f >	400	Hz	- 3	periods
f <	400	Hz	- 1	period

For SINAD measurements, the measurement time should be determined with regards to the lowest noise component as well as the fundamental frequency, as the signal and the noise are measured simultaneously.

Measurement Command Example

As an example, initiate a level measurement:

`RMS`	The RMS level is measured in the selected channels, in this case both front channels. As no measurement integration time is given, the RE 204 will measure the input frequency and determine the appropriate measurement time. If no frequency is found, e.g. for noise measurements, a period of 0.5 second is selected.

Other formats of the command:

`RMS,1kHz`	The main frequency component is known - this speeds up the measurement, as a frequency determination is omitted.
`RMS,100ms`	The integration period is 'manually' selected - if the signal contains low-frequency components, it may be necessary to select a longer integration period than what is needed to measure the main signal component.
`RMS,AG`	The input signal originates from the audio generator, possibly via a stereo generator and/or an RF generator. This information speeds up things, because the generator and the analyzer frequencies in this case is tightly locked to each other. However, it is important, that LEFT channel output from the generator connects to LEFT channel input(s), and RIGHT channel output to RIGHT channel input(s). One audio generator channel may be used for all inputs, as long as both channels are programmed in parallel.

The Results

Results are delivered in the following order:

Left front (1), Right front (2), Left rear (3), Right rear (4)

The RE 204 delivers results from measurements in one of two different formats:

Integer - e.g.: 12500

Floating point with exponent - e.g.: 1.253E-02

All formats are compatible with formats found in IEEE-controllers thus facilitating data transfer from the RE 204 to the controller.

There are three ways to get the results:

1. When the command has been sent, simply initiate a read operation. Either read the results into a string, or read the results as (in this case) two numbers.

2. After sending the command, perform a serial poll while waiting for the result. While the RE 204 is measuring, a serial poll code '0' will be issued. When the result is ready, the poll code is changed to the actual measurement poll code.

3. The service request facility of the IEEE488 interface may be used. A service request is generated, when the measurement has completed, thus requesting the computer to fetch the results. service request is furthermore generated in case of errors. The serial poll code, which is presented at the time of the service request, is used to distinguish between the various causes for the request. It is possible to programme the RE 204 to generate service requests for results only, for errors only, or for both.

The three schemes outlined above have each their advantages and disadvantages. The first is the most simple; however, if an error has occurred - detectable by a result which is exact '0' - the cause of the error is not uncovered.

This is the case for the second approach. As error codes are less than 128 and result codes are greater than 128, it is easy to classify the codes. A list of the service request codes is given in section 5.10.

For the more experienced programmer, the third approach may be the most appealing. Using service request interrupts, error conditions may be handled by a separate error handler, invisible for the normal programme flow. As opposed to the second approach, it is not necessary to check for error conditions for each measurement.

Average Measurement (AE)

"AE" [Parameter-separator ((Number ["Hz" | "kHz" | "ms" | "s"]) | Alphabetical-parameter)]

Parameter:	Measurement time or approximate input frequency or Audio Generator is used		
Range:	1 to 1000 ms		Measuring time
	20 to 25000 Hz		Lowest frequency
	"AG"		Audio Generator used
Unit:	"ms"	"s"	Measuring time
	"Hz"	"kHz"	Input frequency
Default Unit:	"ms"		

Default Value:	In case parameter 1 is absent, the RE 204 measures the input frequency to determine the correct integration time. This measurement, of course, adds to the total time it takes to reach a result.
Service Request:	213
Result Range:	1 μV to 25V - the result is RMS calibrated
Format:	Floating point with exponent
Unit:	Volt
Example:	`AveragE,500ms`
Explanation:	Measure the (rectified) average value of the signal(s) present on the active input(s) ("CH"-command) using an integration time of 500 ms.
Comments:	Measuring speed is increased in case the Audio Generator is known to deliver the test signal.

DC Measurement (DC)

"DC" [Parameter-separator Alphabetical-parm]

Parameter:	High or Low input range
Range:	"LO" "HI"
Unit:	none
Default Value:	HI
Service Request:	209
Result Range:	Depending on DC calibration
Format:	Floating point with exponent
Unit:	Volt or percentage of full scale
Example:	`DC,HI`
Explanation:	Measure DC in the High range.
Comments:	If the DC channel has not been calibrated by means of the "DL"-command, results will be delivered as % of full scale reading with a trailing "%"-sign.

Frequency Measurement (FQ)

"FQ" [Parameter-separator Number ("Hz" | "kHz" | "ms" | s) [Parameter-separator Alphabetical-parm]]

1st parameter:	Measurement time or lower limit of frequency
Range:	3 to 250 ms — Measuring time 11 to 25000 Hz — Input frequency
Unit:	"ms" | "s" — Measuring time "Hz" | "kHz" — Input frequency
Default Unit:	None
Default Value:	In case parameter 1 is absent, the RE 204 uses a measurement time corresponding to a lower frequency limit of 20 Hz, i.e. 135 ms.
2nd parameter:	2.5 kHz lowpass filter on/off
Range:	"OFF" "ON"
Unit:	None
Default Value:	In case parameter 2 is absent, the RE 204 employs an automatic detection of whether the lowpass filter will improve the measurement.
Service Request:	202
Result Range:	20 to 25000 Hz
Resolution:	1 Hz
Format:	Integer
Unit:	Hz
Example:	`FQ,1000Hz,LP`
Explanation:	Measure the frequency in the channel(s) set up by means of the "CH"-command. The frequency is expected to be above 1 kHz and below 3 kHz.
Comments:	For accurate frequency determination, at least two periods of the signal is needed. The general relationship between measurement time and the lowest expected value of the frequency is: measurement time = 2750/frequency [msec] For unstable signals, longer measurement times may improve the accuracy. In order to remove the noise components which jeopardizes the zero-crossing detection scheme being used, it is possible to insert a (digital)

lowpass filter in front of the zero-crossing detector. Enabling/disabling of this filter is the second parameter. If this parameter is omitted, the RE 204 inserts the filter if the main component of the signal is below approx. 3 kHz.

Refer to section 4.8 for a description of the frequency measurement algorithm.

Peak Measurement (PK)

"PK" Parameter-separator (Number ["Hz" | "kHz" | "ms" | "s"] | Alphabetical-parameter)

Parameter:	Measurement time or approx. input frequency or Audio Generator used		
Range:	1 to 1000 ms		Measurement time
	20 to 75000 Hz		Input frequency
	"AG"		Audio Generator used
Unit:	"ms"	"s"	Measuring time
	"Hz"	"kHz"	Input frequency
Default Unit:	"ms"		
Default Value:	none		
Service Request:	194		
Result Range:	1 µV to 25V		
Format:	Floating point with exponent		
Unit:	Volt		
Example:	`PK,50ms`		
Explanation:	Measure the peak value of the signal(s) present on the active input(s) ("CH"-command) using an integration time of 50 ms.		

Quasi-peak Measurement (QK)

"QK" Parameter-separator Number ["ms" | "s"]

Parameter:	Measurement time		
Range:	0.1 to 30 s		Measurement time
Unit:	"ms"	"s"	
Default Unit:	"s"		
Default Value:	none		
Service Request:	214		

Result Range:	1 μV to 25V
Format:	Two floating point with exponent: peak reading and average reading of the output from the Quasi-peak detector.
Unit:	Volt
Example:	`QK,2s`
Explanation:	Measure the Quasi-peak value of the signal(s) present on the active input(s) ("CH"-command) using a measurement time of 2s.
Comments:	Quasi-peak can only be measured using the CCIR 468 weighting or band pass filters (CW or CB). In case another filter is selected the Quasi-peak measurement will return a zero result and issue the service request code 105. The Quasi-peak measurement returns 2 results per channel. The first result is a peak reading and the second an average reading.

RMS Measurement (RS)

"RS" [Parameter-separator (Number ["Hz" | "kHz" | "ms" | "s"]) | Alphabetical-parm]

Parameter:	Measurement time or approx. frequency or Audio Generator used.		
Range:	1 to 1000 ms		Measuring time
	20 to 25000 Hz		Input frequency
	"AG"		Audio Generator used
Unit:	"ms"	"s"	Measurement time
	"Hz"	"kHz"	Input frequency
Default Unit:	"ms"		
Default Value:	In case parameter 1 is absent, the RE 204 measures the input frequency to determine the correct integration time. This measurement, of course, adds to the total time it takes to reach an RMS result.		
Service Request:	195		
Result Range:	1 μV to 25V		
Format:	Floating point with exponent		
Unit:	Volt		
Example:	`RMS,500ms`		

Explanation: Measure the RMS value of the signal(s) present on the active input(s) ("CH"-command) using an integration time of 500 ms.

Comments: Measuring speed is increased in case the Audio Generator is known to deliver the test signal.

SINAD Measurement (SD)

"SD" [Parameter-separator [Number ["ms"|"s"]] [Parameter-separator [Alphabetical-parm] [Parameter-separator [(Alphabetical-parm|Number)] [Parameter-separator [Number ("Hz"|"kHz"|"ms"|"s")][Parameter-separator Alphabetical-parm]]]]

1st parameter:	Measurement time		
Range:	1 to 1000 ms		
Unit:	"ms"	| "s"	
Default Unit:	ms		
Default Value:	10 times the period of the notch frequency.		
2nd parameter:	Coarse/Fine selection (applies only to notch frequencies above 700 Hz)		
Range:	"C"	| "CE"	Coarse i.e. results >-60 dB
	"F"	| "FE"	Fine i.e. results <-50 dB
Unit:	none		
Default Value:	F		
3rd parameter:	Notch frequency determination		
Range:	"AG"		Audio generator used
	"FQ"		Frequency is measured
	20 to 23750 Hz		Fixed frequency
Unit:	"Hz"	| "kHz"	Fixed frequency
	none		AG or FQ
Default Value:	FQ		
4th parameter:	Only if 3rd parameter is FQ: Measurement time or lower limit of frequency		
Range:	3 to 250 ms		Measuring time
	11 to 25000 Hz		Input frequency
Unit:	"ms"	| "s"	Measuring time
	"Hz"	| "kHz"	Input frequency
Default Unit:	None		
Default Value:	In case parameter 4 is absent, the RE 204 uses a measurement time corresponding to a lower frequency limit of 20 Hz, i.e. 135 ms.		
5th parameter:	Only if 3rd parameter is FQ: 2.5 kHz lowpass filter on/off		
Range:	"OFF"		
	"ON"		

Unit:	None
Default Value:	In case parameter 5 is absent, the RE 204 employs an automatic detection of whether the lowpass filter will improve the measurement.
Service Request:	210 (or 104)
Result Range:	0.001 to 10%
Unit:	%
Format:	Floating point with exponent
Example:	`SinaD,100ms,Fine`
Explanation:	Measure SINAD in the active channel(s) using the fine range of the RE 204.
Comments:	Dividing the range in two allows the RE 204 to maximize throughput. In case an incorrect range is selected, the RE 204 automatically switches the range. This, however, increases the measurement time. Using the Audio Generator as test signal is another way of increasing throughput as the position of the notch frequency is known exactly. Refer to the description of the FQ command for further explanation of parameters 4 and 5. Refer to section 4.4 for a description of the SINAD measurement algorithm.

Wow & Flutter Measurement (WF)

"WF" Parameter-separator [Number ["s" | "ms"]] [Parameter-separator Number ["s" | "ms"]]

1st parameter:	Measuring time
Range:	1 to 20 seconds
Unit:	"s"
Default Unit:	"s"
Default Value:	5 s
2nd parameter:	Measuring time for frequency determination
Range:	1 to 20 seconds
Unit:	"s"
Default Unit:	"s"
Default Value:	Half the time used for measuring
Service Request:	204
Result Range:	0.01% to 3%
Unit:	%
Format:	Floating point with exponent

Example: `W&F,10s`

Explanation: Measure W&F according to the standard selected using the "WD"-command. 5 seconds are used for frequency determination (in addition to the 10 seconds of measuring Wow & Flutter).

Comments: The W&F measurement always uses the right channel(s):

`CH,RF` or `CH,F`	right front is measured
`CH,RR` or `CH,R`	right rear is measured
`CH,A`	Both front and rear are measured

It should be noted, that in the case of measurement in both front and rear, measurements are made sequentially, i.e. the total measurement time is twice that of a single measurement.

A SRQ code 106 is issued if none of the right channels are selected (i.e. either `CH,LF` or `CH,LR`).

5.7 Miscellaneous Commands

Define a User Filter Biquad (BQ)

"BQ" Parameter-separator Number [Parameter-separator Number Parameter-separator Number Parameter-separator Number Parameter-separator Number Parameter-separator Number Parameter-separator Number]

1st parameter: User filter number
Range: 1 to 2
Unit: none
Default Value: none

2nd parameter: Biquad number
Range: 1 to 5
Unit: none
Default Value: none

3rd to 7th parameter: Filter coefficients for a biquad in the user defined filter in format 2.14 for single precision filters **or** format 2.30 for double precision filters. The order is:

a2,a1,a0,-b2,-b1,

the 'a' coefficients being the nominator and the 'b' coefficients the denominator.

Range: -32768 to 32767 single precisidon

	-2147483648 to -2147483647 double precision
Unit:	none
Default Values:	Coefficients for an all-pass filter: 0,0,16384,0,0 single precision 0,0,536870912,0,0 double precision
Example:	`BQ,1,3,0,0,16384,0,0`
Explanation:	Biquad 3 in user filter 1 now set up as all-pass filter (single precision must be specified in the corresponding "FF" command).
Comments:	In case no coefficients are defined, i.e. parameters 3 to 7 are absent, the Biquad resets to all-pass. The actual precision of the Biquad coefficients is controlled by the "`FF`"-command. All coefficients for e.g. user filter 1 may be read back by the query command "`BQ,1?`". Refer to section 4.3 for a description of the use of user filters.

Execute a Setup (EX)

"EX" Parameter-separator Number

Parameter:	Setup number to be executed
Range:	0 to 99
Unit:	none
Default Value:	Without a parameter, the command may be used to store the current setting in a new setup during setup definition (ref. "SF" command)
Example:	`EX,2`
Explanation:	A setup defined previously using the "SF"-command will now be executed, i.e. all commands of the setup will be executed. In case the setup does not contain commands for say channel selection, the current channel(s) will be used during measurement(s).
Comments:	The query command "`EX?`" reports the current settings of the RE 204.

Define a Filter (FF)

"FF" Parameter-separator Number [Parameter-separator Number [Parameter-separator Number [Parameter-separator Number [Parameter-separator Number]]]]

1st parameter:	User filter number
Range:	1 to 2
Unit:	none

Default Value:	none
2nd parameter:	Filter gain
Range:	-3.4E38 to 3.4E38
Unit:	none | "dB"
Default Unit:	none, i.e. gain is not in dB
Default Value:	1
3rd parameter:	Filter precision
Range:	"SP" | "S" Single precision "DP" | "D" Double precision
Unit:	none
Default Value:	S
4th parameter:	Settling time (number of samples)
Range:	0 to 10000
Unit:	none
Default Value:	500
Example:	`FilterDef,1,,,250`
Explanation:	User filter 1 now set up with gain 1, using single precision biquads, and with a settling time of 250 samples.
Comments:	If all parameters (except filter number) are omitted, the entire filter, including the value of the Biquads, is reset to default, i.e. an all-pass filter with gain = 1, single precision coefficients and a settling time of 500 samples. Refer to section 4.3 for a description of the use of user filters.

Program Instrument Identity (ID)

"ID" Parameter-separator Number

Parameter:	ID number
Range:	0 to 255
Unit:	none
Default Value:	0
Example:	`ID,53`
Explanation:	This command transfers an identification number to the RE 204 in order to be able to track different units. The ID number may be read back by issuing the query command "ID?". The ID number is stored in non-volatile RAM.
Comments:	The query command "ID?" results in the following response from the RE 204 (items in [ ] only if the pertinent option is installed):

```
ID,nnn *
RE 204 AUDIO ANALYZER
SOFTWARE VERSION x.y yymmdd *
[AUDIO GENERATOR OPTION]
[WOW & FLUTTER OPTION]
[STEREO GENERATOR OPTION]
```

Set IEEE Address (IR)

"IR" Parameter-separator (Number| Alphabetical-parm)

Parameter:	IEEE address	
Range:	0 to 30	
	"S"	Use DIP switch setting on CPU Board
Unit:	none	
Default Value:	none	
Example:	`IR,4`	
Explanation:	Set the IEEE address to 4	
Comments:	The IEEE address is stored in non-volatile memory. In case of memory failure i.e. wrong check sum due to battery failure the RE 204 will use the IEEE address defined by the DIP switch on the CPU Board.	

Reset (RT)

"RT" [Parameter-separator Number]

Parameter:	Reset specification	
Range:	0	Reset current setting to the factory setting
	1	Reset, i.e. undefine all setups 0 to 99.
	2	Reset user filters to the defaults.
	99	Reset whole unit.
Unit:	none	
Default Value:	0	
Example:	`RT,99`	
Explanation:	This command clears all information stored in the RE 204 and performs a software restart.	
Comments:	The default for the current setting is listed in section 5.9.	

---

* "nnn" to be substituted by the actual ID code. "x.y yymmdd" to be substituted by the actual software revision and date

Store a Setup (SF)

"SF" Parameter-separator Number [Command-separator Command]

Parameter:	Setup number
Range:	0 to 99
Unit:	none
Default Value:	none
Example:	`SetupdeF,2 CH,R RangE,R,100mVp RMS,10ms`
Explanation:	Setup number 2 now contains the following commands: "`CH,R`", "`RangE,R,100mVp`", and "`RMS,10ms`". These commands will be executed when the RE 204 receives the command "`EX,2`".
Comments:	In case setup xx is recalled in the definition of setup yy, the contents of setup xx will be copied to setup yy, i.e. "`SF,3 FR,BP EX,2`" transfers the commands from setup 2 to setup 3 which adds a filter selection command to the setup. In case the command includes "`E`" or "`EX`", the current setting will be stored in the setup being defined. Generator setup commands (`AL, AF, FC, PT, PV, PE, AN, CT`) must always be preceded by a "`GF`" command. The following commands may **not** be included in setups: `BiQ, CaL, DccaL, FilterdeF, ID, IR, ReseT, SetupdeF, SrqdiS, TesT.`

Disable Service Requests (SS)

"SS" Parameter-separator (Number | Alphabetical parameter)

Parameter:	Service request to be disabled	
Range:	"EA"	Enable all SRQs
	"ER"	Disable SRQs from errors and warnings
	"RS"	Disable SRQs from results or queries
	"DA"	Disable all SRQs
Unit:	none	
Default Value:	none	
Example:	`SRQdis,DA`	

Explanation: Disable all service requests from the RE 204.

Test (TT)

"TT" [Parameter-separator Number]

Parameter:	Test to be performed
Range:	1 PROM test 2 Setup integrity 3 DC measurement calibration integrity 4 User filter coefficients integrity 5 Hardware calibration integrity 6 Signal analyzer DSP test 7 Audio Generator test
Unit:	none
Default Value:	Tests 1 to 7 executed
Example:	`TesT`
Explanation:	The RE 204 performs a complete selftest. The results are delivered as text strings.

5.8 Queries

In order to be able to inspect the setting of the instrument, it is possible to output all mnemonics succeeded by a "?". In response to this, the RE 204 will deliver a text string, accompanied by a Service Request and a serial poll code of 212. The text string is in a format allowing it to be downloaded to e.g. another RE 204. E.g., as a response to the query `"FilteR?"`, the answer may be `"Filter,HighP,100Hz"`.

Special cases of the query facility are:

? The configuration of the instrument, e.g.:

```
"RE 204 AUDIO ANALYZER"
"SOFTWARE VERSION x.y  yymmdd *"
"AUDIO GENERATOR OPTION"
"STEREO GENERATOR OPTION"
```

`SF,1?` The contents of setup no. 1, e.g.:

```
Setupdef,1 Filter,CCIR AF,B,1000Hz AL,B,1Vp
RS,AG.
```

`SF?` The contents of all setups (0 to 99).

---

* "x.y yymmdd" to be substituted by the actual software revision and date.

EX? The current setting of the instrument, corresponding to the commands which may be stored in a setup (i.e. excluding "CAL" etc.).

AG?,
FM?,
AM? The current setting of a generator.

MS? All measurement related settings, i.e.:

CH, RangE, AutO, FilteR, WD.

5.9 Default Settings

The factory default settings listed below is obtained when a RT command is issued, or if a general memory failure has occurred.

Measurements	CH,F RangE,A,3.000Vp AutO,A,ON FilteR,AllP W&fstD,NAB,500Hz,2 GenmodE,AudioG
Audio Generator	GendeF,AudioG AudioF,B,1000Hz AudioL,B,1.000Vp
FM Stereo Generator	GendeF,FM AudioF,L,1000Hz AudioF,R,2000Hz AudioL,B,30% FunC,OFF CompouT,ON PiloT,ON PilotleV,9.0% AuxiN,OFF PrE,0
AM Stereo Generator	GenDef,AM Audiof,L,1000Hz AudioF,R,2000Hz AudioL,B,50% FunC,OFF PiloT,ON PilotleV,5.0% PrE,0

Miscellaneous	MeteR,OFF SettlE,ON FreQ,100ms

Table 5.1 -Default Settings

5.10 Service Request Codes

The service request codes are divided into three classes according to priority (errors, results and status), meaning that a SRQ from a higher priority class overwrites a SRQ from a lower priority class.

Class	Hex	Decimal	Description
Error	50	80	Syntax error
	51	81	Illegal parameter count
	52	82	Parameter limits exceeded or unit error
	53	83	Missing option - wow & flutter, audio generator or stereo generator
	57	87	Incomplete command
	58	88	Command type error
	59	89	Parameter type error
	5A	90	Unit error
	5B-60	91-96	Signal processor errors
	61	97	Input low
	62	98	Overload
	63	99	Sinad coarse/fine range changed in vain
	66	102	Unable to calibrate hardware - wait for the instrument to warm up or perform an HW calibration.
	67	103	Fundamental frequency out of range for SINAD or Wow & Flutter measurements
	68	104	SINAD measurement too soon after relay change. Settle is off.
	69	105	Wrong filter (i.e. not CW or CB) used with Quasi-peak measurement, or too long a user filter used for SINAD measurement
	6A	106	None of the RIGHT channels are selected during a wow & flutter measurement
	FF	255	Fatal error - RE 204 clears all and resets

Results	C2	194	Peak measurement
	C3	195	RMS measurement
	CA	202	Frequency measurement
	CC	204	Wow & Flutter measurement
	D1	209	DC measurement
	D2	210	SINAD measurement
	D4	212	Text string ready (query)
	D5	213	Average measurement
	D6	214	Quasi-peak measurement
	DC	220	Calibration completed
Status	00	0	Busy - measurement in progress
	01	1	Calibration in progress
	80	128	Idle state
	82	130	Audio Generator not ready

Table 5.2 - Service Request Codes

6 EQUIPMENT AND ACCESSORIES

This section contains a list of the accessories supplied with the RE 204 Audio Analyzer and lists of available options and optional equipment and accessories.

6.1 Standard Equipment and Accessories

The following equipment and accessories should be found when unpacking the RE 204 Audio Analyzer:

Code	Type	Description
380-311	RE 204	Audio Analyzer
450-020	1.0 A	Fuse, slow blow
450-123	2.0 A	Fuse, slow blow
615-303	220 V	Line cord, 2.5 m
615-403	110 V	Line cord, 2.4 m
983-308		Operating Manual
983-705		Installation Instructions

Table 6.1 - Standard Equipment and Accessories

6.2 Available Options

The following options are available for the RE 204 Audio Analyzer:

Code	Description
901-837	Wow & Flutter Option
901-871	Stereo Generator Option
906-129	Audio Generator Option

Table 6.2 - Available Options

6.3 Optional Equipment and Accessories

Optional equipment and accessories to be used with the RE 204 Audio Analyzer:

Code	Description
901-805	96-pole DIN Extender Board to be used with: CPU Board, 901-870 Signal Analyzing Processor, 901-840 Audio Generator Signal Processor, 901-867
901-864	48-pole DIN Extender Board to be used with all other plug-in boards
983-402	Servicing Manual

Table 6.3 - Optional Equipment and Accessories

7 SPECIFICATIONS

This section contains a full specification for the instrument. The listed data are guaranteed data.

7.1 Audio Analyzer

Audio Analyzer	
Full scale range	11 mVp to 30 Vp
Range selection	Autoranging or manual in 13 ranges, steps of 6 dB
Residual noise	
CCIR 468-3 weighted	< 15 μVRMS
25 kHz bandwidth	< 30 μVRMS
Flatness	$\pm$ 0.1 dB

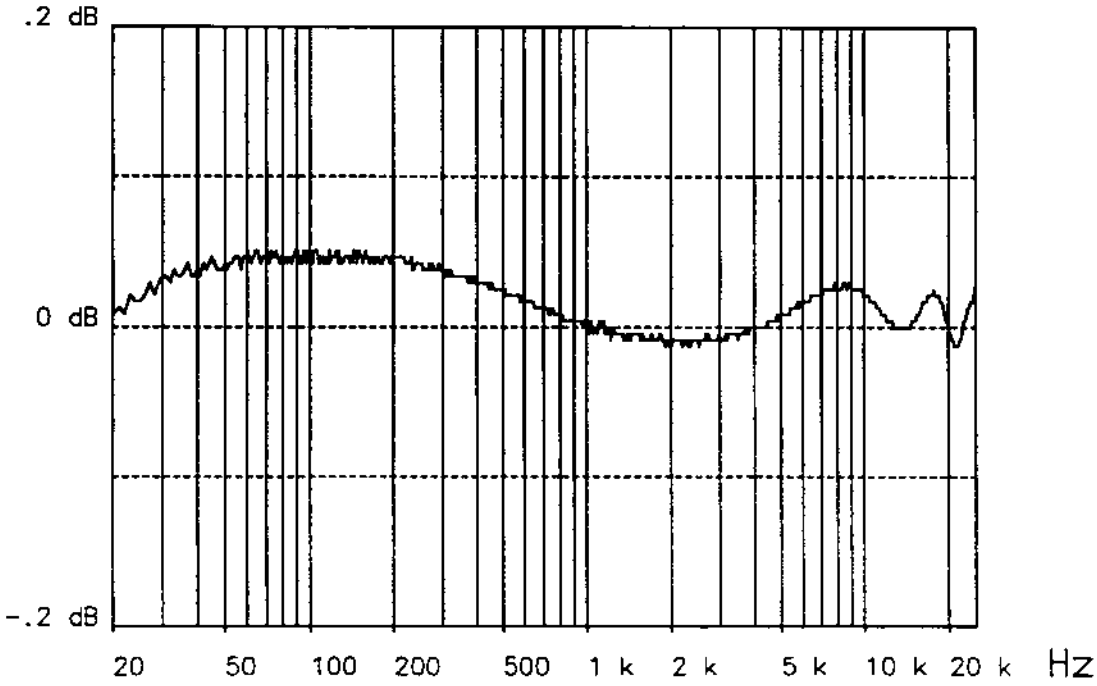

Fig. 7.1 - Flatness, Typical,
Combined Audio Analyzer and Generator

Input circuit	Balanced floating inputs, transformerless, overload protected to 50 Vp
Common mode rejection ratio	> 70 dB at 1 kHz
Maximum common mode input	± 7 V
Channel separation	> 110 dB at 1 kHz, 600 Ω generator impedance
Input impedance	100 kΩ shunted by 100 pF
Type of connectors	Isolated BNC with ground plug

Filters

Noise measurements	CCIR/ARM, Dolby Labs Bulletin No. 19/4
	CCIR 468-3, DIN 45404, weighted and unweighted
	DIN 45633, IEC 651, A weighting
Bandwidth limiting	100 Hz highpass with 25 Hz notch > 75 dB attenuation, 4th order elliptic with < 0.2 dB ripple[1)]
	400 Hz highpass, approximated 6th order Butterworth, 36 dB/octave
	15 kHz lowpass with 19 kHz notch > 50 dB attenuation, 6th order elliptic with < 0.1 dB ripple[1)]
Bandpass/notch	Programmable 20 Hz to 25 kHz with 1 Hz resolution
	Bandpass, 6th order Butterworth, 3 dB points are 0.9 f0 and 1.1 f_0
	Notch, > 70 dB attenuation, < 0.2 dB ripple[1)] exluding the band from 0.5 f_0 to 2 f_0
User filters	2 user specified filters may be downloaded via the IEEE488 interface
Measurements	Average, RMS, Quasipeak, SINAD

[1)] Ripple specification including flatness of analyzer and generator

Distortion and Noise - SINAD

Fundamental range	20 Hz to 23750 Hz
Noise bandwidth	25 kHz or any of the filters
Residual SINAD	< -70 dB at 1kHz, 3 Vp
Accuracy	± 1 dB
Time to result[2)]	150 msec

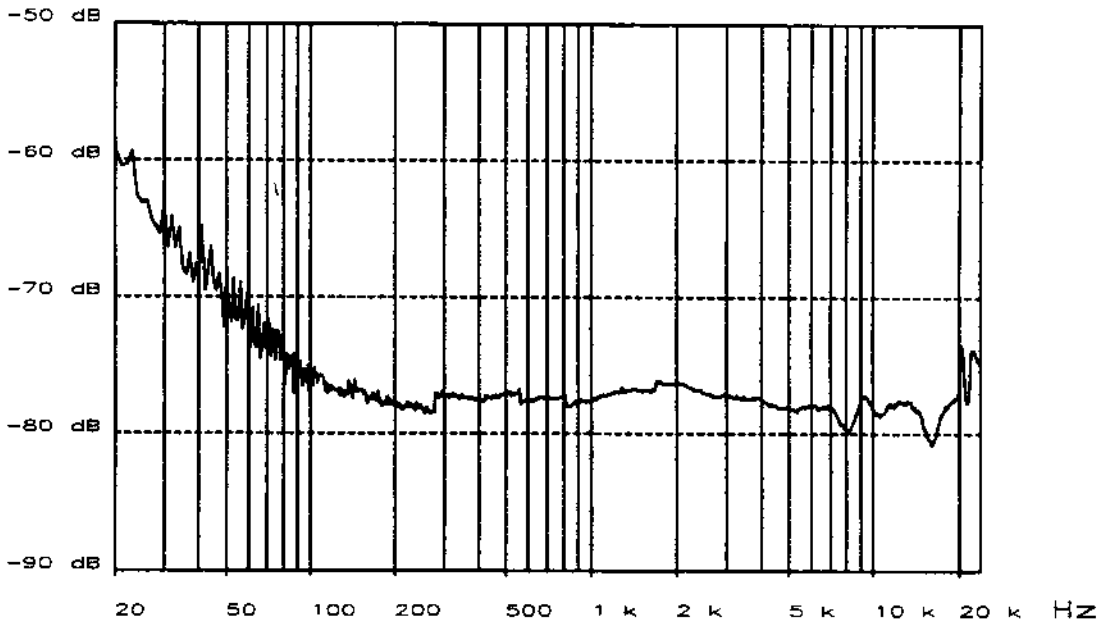

Fig. 7.2 - SINAD versus Frequency, Typical,
Level 3 Vp, 25 kHz bandwidth
Audio Generator and Analyzer Combined

2) Typical time from command is received until results for all 4 channels are available. Measured on a 1000 Hz, 1 Vp signal with autoranging disabled and no filtering. For average and quasi-peak, a noise measurement time of 100 msec is used. All other measurements use minimum measurement time for specified accuracy.

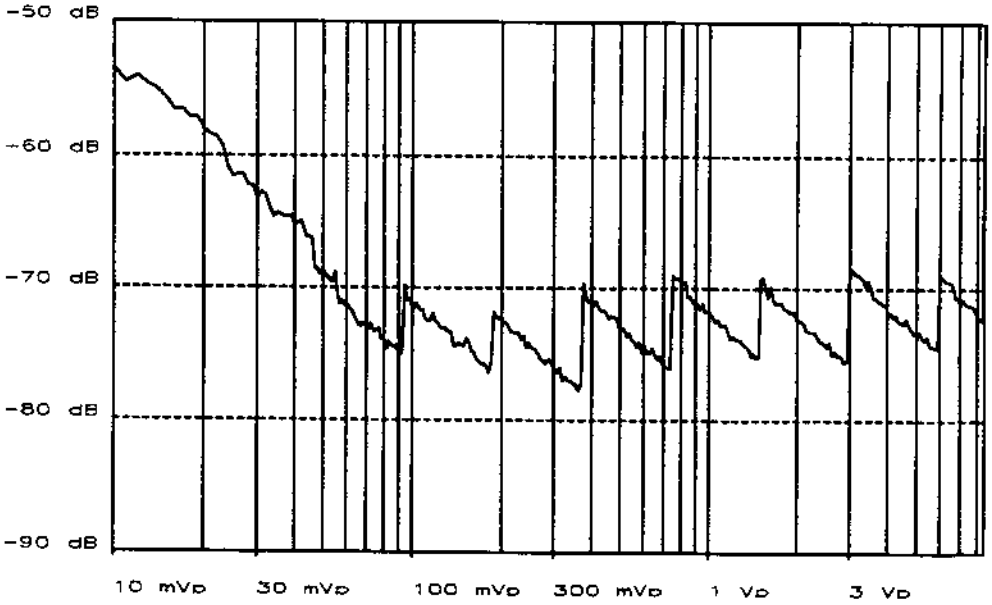

Fig. 7.3 - SINAD versus Level, Typical, Frequency 1000 Hz, 25 kHz bandwidth, Audio Generator and Analyzer Combined

RMS	
Frequency range	20 Hz to 25 kHz
Accuracy	± 3 %
Crest factor	
Without filter	8 at full scale
With filter	4 at full scale
Time to result[2)]	30 msec

Average	
Calibration	RMS calibrated
Frequency range	20 Hz to 25 kHz
Accuracy	± 3 %
Time to result[2)]	290 msec

Peak

Frequency range	20 Hz to 75 kHz
Accuracy	± 3 %
Flatness	± 0.05 dB, 20 Hz to 25 kHz ± 0.1 dB, 25 kHz to 75 kHz
Time to result[2)]	35 msec

Quasi-peak

Standard	CCIR 468-3
Calibration	RMS calibrated
Frequency range	CCIR 468 Weighted CCIR 468 Unweighted
Accuracy	± 3 %
Time to result[2)]	6.5 sec

Level Indication Meter

Range	1 mVp to 10 Vp
Resolution	10 dB

Frequency

Range	20 Hz to 25 kHz
Resolution	1 Hz
Accuracy	± 0.2 %
Time to result[2)]	55 msec

DC

Full scale ranges	1 V and 30 V, other ranges available on request
Accuracy	± 0.5 % ± 3 mV
Time to result	95 msec
Input circuit	Differential
Common mode rejection ratio	
30 V range	> 70 dB at 1 kHz
1 V range	> 50 dB at 1 kHz
Maximum common mode input	± 30 V
Input impedance	100 kΩ
Type of connector	Isolated BNC

7.2 Wow & Flutter Option

Range	0 to 3 %
Residual Wow & Flutter	0.001 %
Accuracy	± 0.5 %
Reference frequency range	2400 Hz to 3750 Hz
Detector modes	Quasi-peak, DIN 45507, IEC 386, CCIR 409-2 Average, NAB 1965 RMS, JIS C5551
Statistical detection	2 σ
Filters	Weighted, DIN 45507
	0.5 Hz to 200 Hz, 6 dB/octave rolloff below 0.5 Hz, 24 dB/octave rolloff above 200 Hz
	0.2 Hz to 500 Hz, 6 dB/octave rolloff below 0.2 Hz, 24 dB/octave rolloff above 500 Hz
Measurement time	1 to 20 sec with 1 sec resolution

7.3 Audio Generator Option

Principle of operation	AF synthesizer
Number of outputs	2, independently programmable
Frequency range	1 Hz to 25 kHz
Output level	0 to 8.5 Vp
Resolution	
Frequency	1 Hz
Level	1 mV
Distortion	> 80 dB, SINAD > 86 dB, THD
Flatness	± 0.05 dB, 20 Hz to 10 kHz ± 0.1 dB, 10 kHz to 25 kHz
Accuracy	
Frequency	± 25 ppm
Level	± 0.1 dB + flatness

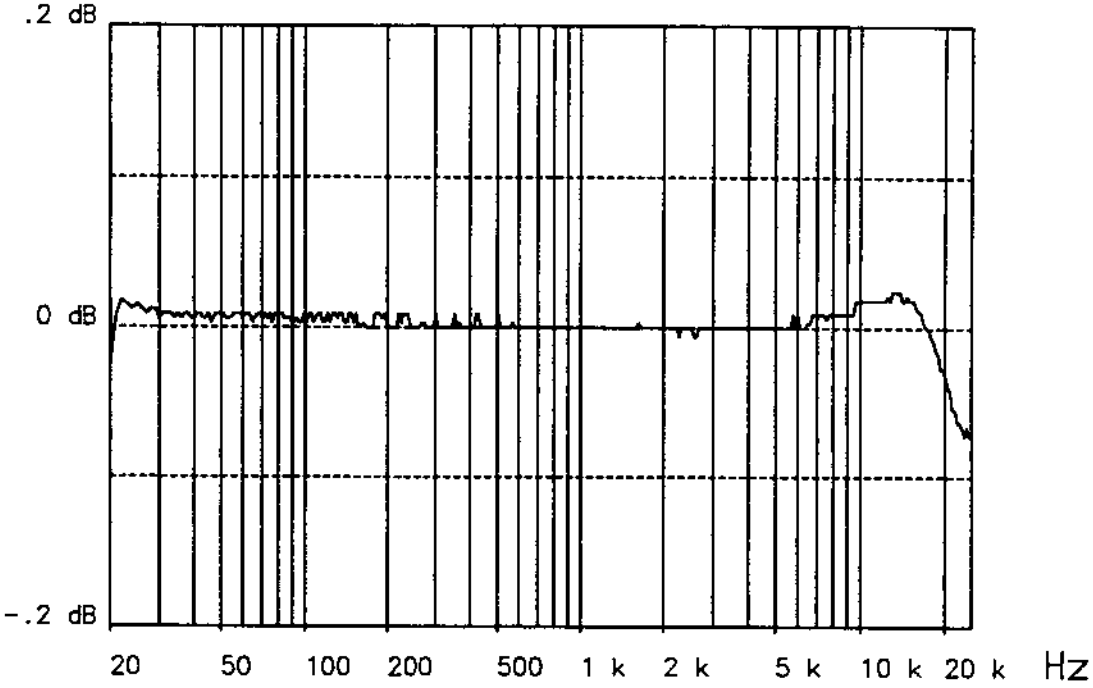

Fig. 7.4 - Audio Generator Ripple, Typical

Output circuit	2 balanced floating outputs, transformerless, shortcircuit protected
Output impedance	< 10 Ω
Type of connectors	Isolated BNC with ground plug

7.4 Stereo Generator Option

FM Stereo

General	
Functions	L&R, Stereo L=R, Mono L= -R, Subchannel L only R only
Bandwidth	20 Hz to 15 kHz, ± 0.1 dB
Distortion	< 0.02 % THD, 100 % composite level

Separation

Stereo separation	> 65 dB, 80 Hz to 5 kHz > 60 dB, 40 Hz to 8 kHz > 55 dB, 22 Hz to 15 kHz
M-S separation	
L=R, Mono	> 66 dB, 70 Hz to 3 kHz > 61 dB, 40 Hz to 5 kHz > 55 dB, 20 Hz to 10 kHz
L= -R, Subchannel	> 66 dB, 70 Hz to 1.5 kHz > 61 dB, 40 Hz to 3 kHz > 55 dB, 20 Hz to 5 kHz

Hum and Noise[3)]

Unweighted S/N ratio	
DIN 45300, Bandpass	> 86 dB, Mono > 83 dB, Stereo
CCIR 468-3, Bandpass	> 82 dB, Mono > 80 dB, Stereo
Weighted S/N ratio	
DIN 45300, A curve	> 86 dB, Mono > 83 dB, Stereo
CCIR 468-3	> 80 dB, Mono > 77 dB, Stereo
38 kHz suppression	< -64 dB
Spurious above 53 kHz	< -60 dB

L and R signals

Inputs	Audio Generator
Level	0 - 150 % continuously programmable
Level accuracy	As Audio Generator
Distortion	As Audio Generator
Outputs	L and R signals available at Audio Generator connectors. Note: Pre-emphasis weighted

3) Relative to 100 % composite level

Pilot

Frequency	19 kHz ± 1 Hz
Level	0 to 15.5 %
Resolution	0.5 %
Level accuracy	
Level ≥ 4 %	± 0.5 % of setting
Level < 4 %	± 1 % of setting
Phase deviation	< 0.3° rel. to 38 kHz
Distortion	< -70 dB

Pre-emphasis

Standard	25 µs, FM Dolby 50 µs, European standard 75 µs, American standard
Accuracy	Digitally calculated on Audio Generator L and R signals

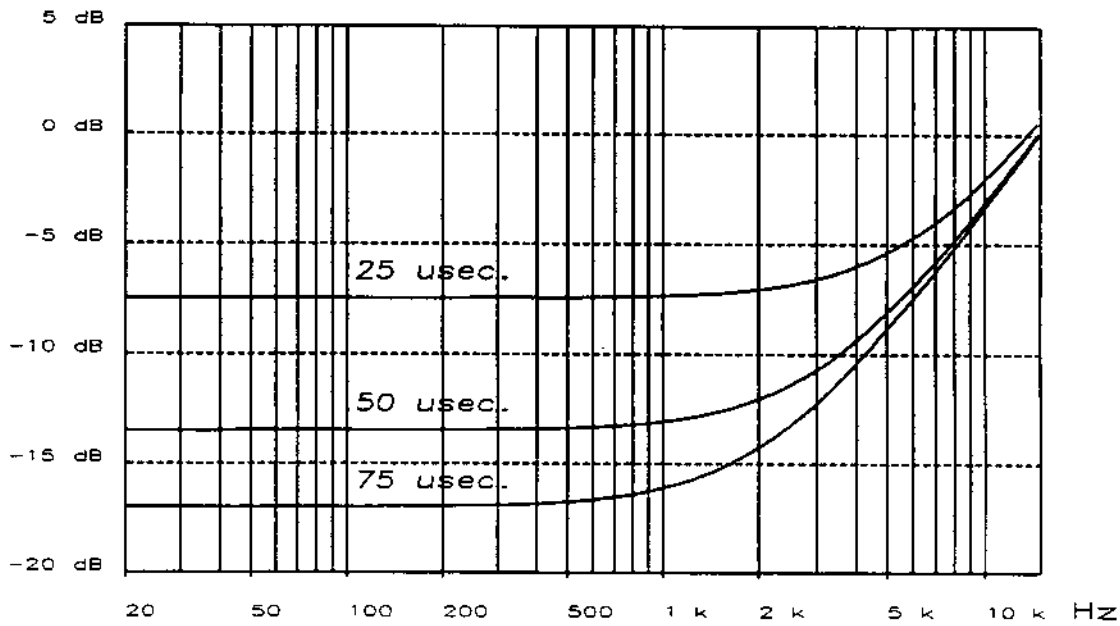

Fig. 7.5 - FM Stereo Preemphasis Weighting

Composite Output

Output level	0 - 2 Vpeak, adjustable for 100 % composite level
Output impedance	< 10 Ω
Load	> 500 Ω, < 500 pF
DC level	< 10 mV
Type of connector	BNC

Pilot Sync Output

Output level	775 mVp
Output impedance	< 10 Ω
Load	> 500 Ω, < 500 pF
Type of connector	BNC

AUX Input

Frequency range	10 to 100 kHz
Flatness	± 0.1 dB, 50 kHz to 75 kHz ± 0.3 dB, 50 kHz to 100 kHz
Sensitivity	100 mVp for 1 % composite level at 57 kHz
Maximum input	5 Vp
Input impedance	1 MΩ
Type of connector	BNC

AM Stereo

General

Stereo system	Motorola C-QUAM
Functions	L&R, Stereo L=R, Mono L= -R, Subchannel L only R only
Distortion	< 0.01% THD, 100 % L/R levels
Stereo separation	> 55 dB, R/L level 30 %, 1 kHz > 50 dB, R/L level 30 %, 20 Hz to 10 kHz

L and R Signals

Inputs	Audio Generator
Level	0 - 150 % continuously programmable

Level accuracy	As Audio Generator
Distortion	As Audio Generator
Outputs	L+R and L-R signals available at Audio Generator connectors. Note: Pre-emphasis weighted

Pilot

Frequency	25 Hz ± 25 ppm
Level	0 to 15.5 %
Resolution	0.5 %
Level accuracy	1 % of setting

Preemphasis

Standard	NRSC Interim Voluntary National Standard, 75μs AM Broadcast Transmission Pre-emphasis
Accuracy	Digitally calculated on Audio Generator L and R signals

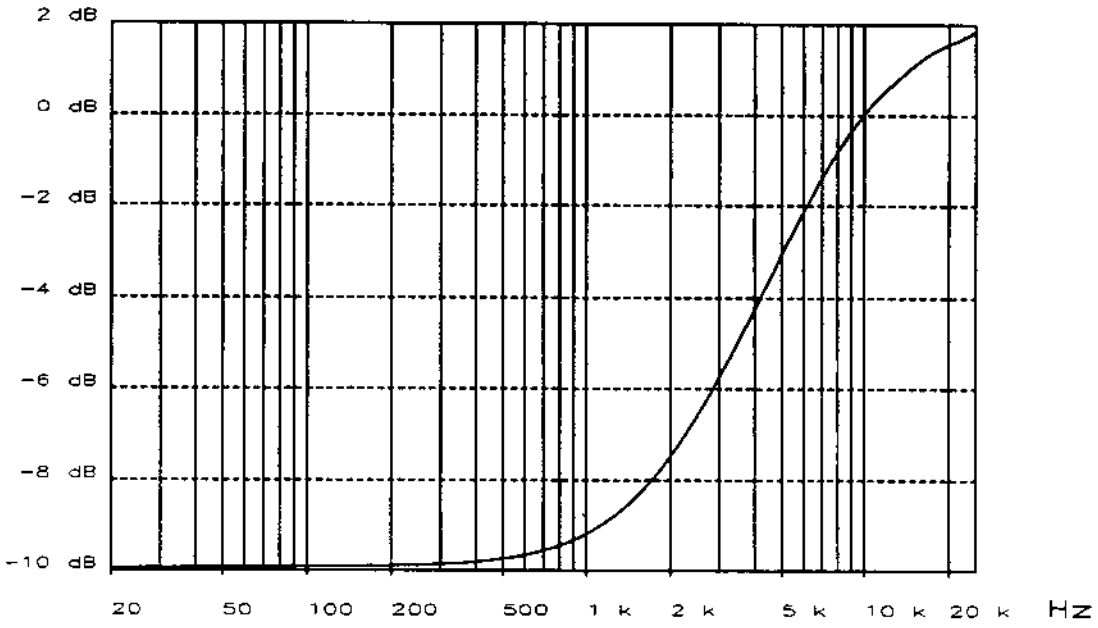

Fig. 7.6 - AM Stereo Preemphasis Weighting

7.5 General

Remote Programming and Operation

IEEE488 Bus	
Functions controlled	All except power on/off
Interface functions	SH1, AH1, T6, TE0, L4, LE0, SR1, RL0, PP1, DC1, DT1, C0, E2
Instrument setups	100 complete setups and 2 user defined filters can be store in nonvolatile memory

General

Temperature	
Operating temperature	5° to 50° C (41° to 122° F)
Storage temperature	-40° to 70° C (-40° F to 158° F)
Relative humidity	20 % to 80 %, non-condensing
Line	
Voltage	100 V to 130 V AC, 190 V to 260 V AC
Frequency	47.5 Hz to 63 Hz
Power consumption	70 VA including all options
Dimensions and Weight	
Height	133 mm (5.2")
Width	440 mm (17.3")
Depth	437 mm (17.2")
Net weight	11 kg (24.3 lbs)
Shipping weight	16 kg (35.3 lbs)

7.6 Filter Characteristics

Below are given filter characteristics for the built-in filters. Please note, that all filter characteristics are typical. The ripple plots include flatness of Audio Analyzer and Generator, and are all relative to 1 kHz.

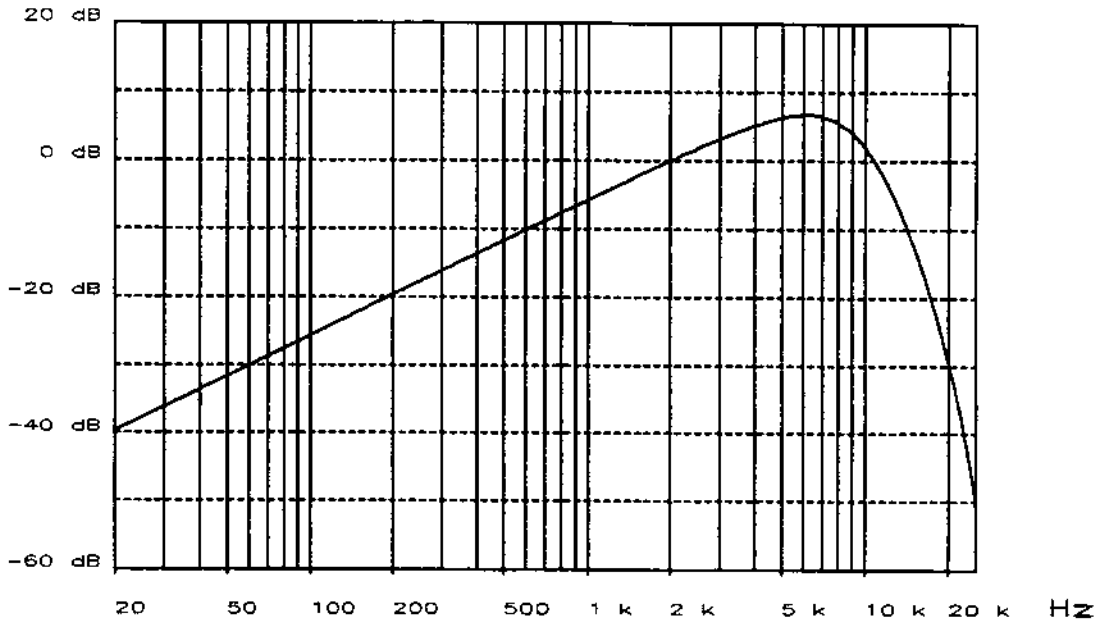

Fig. 7.7 - CCIR/ARM, Dolby Labs

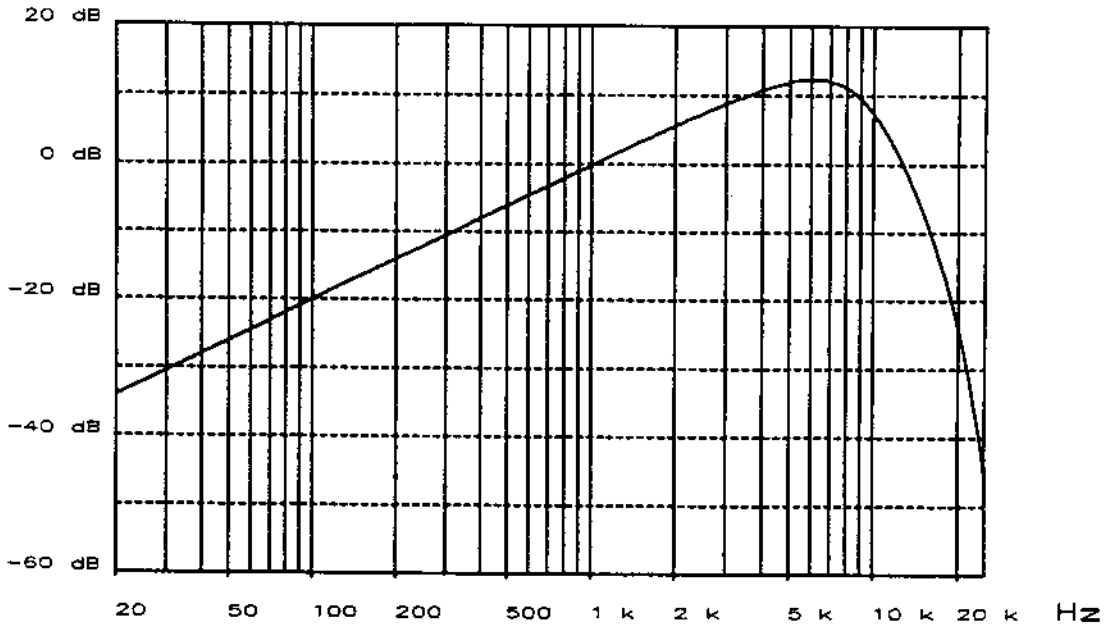

Fig. 7.8 - CCIR468-3, Weighted

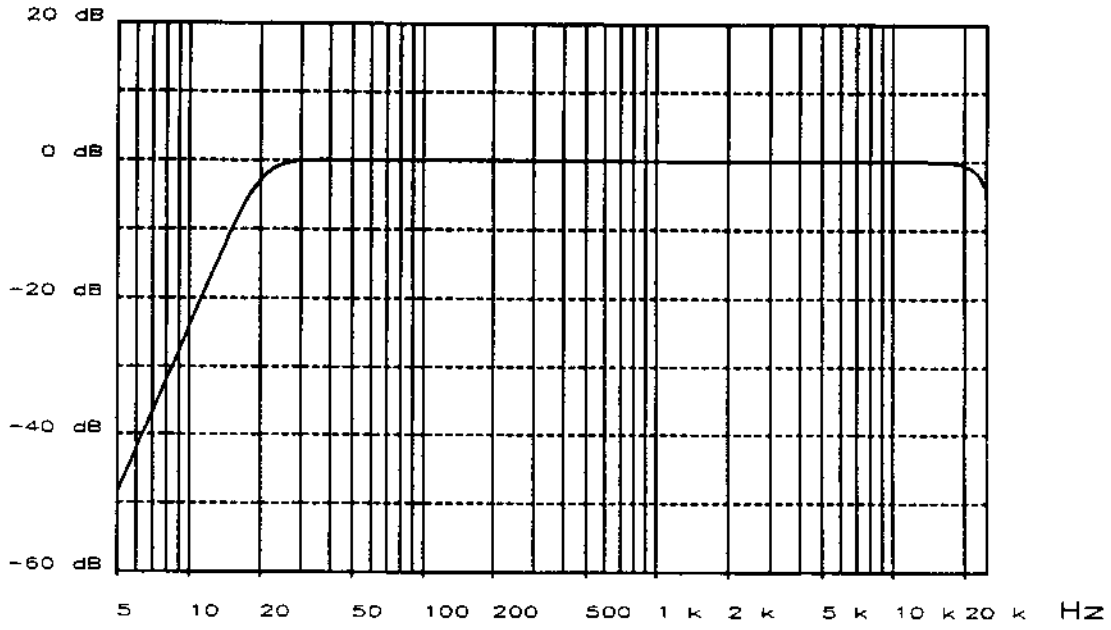

Fig. 7.9 - CCIR468-3, Unweighted

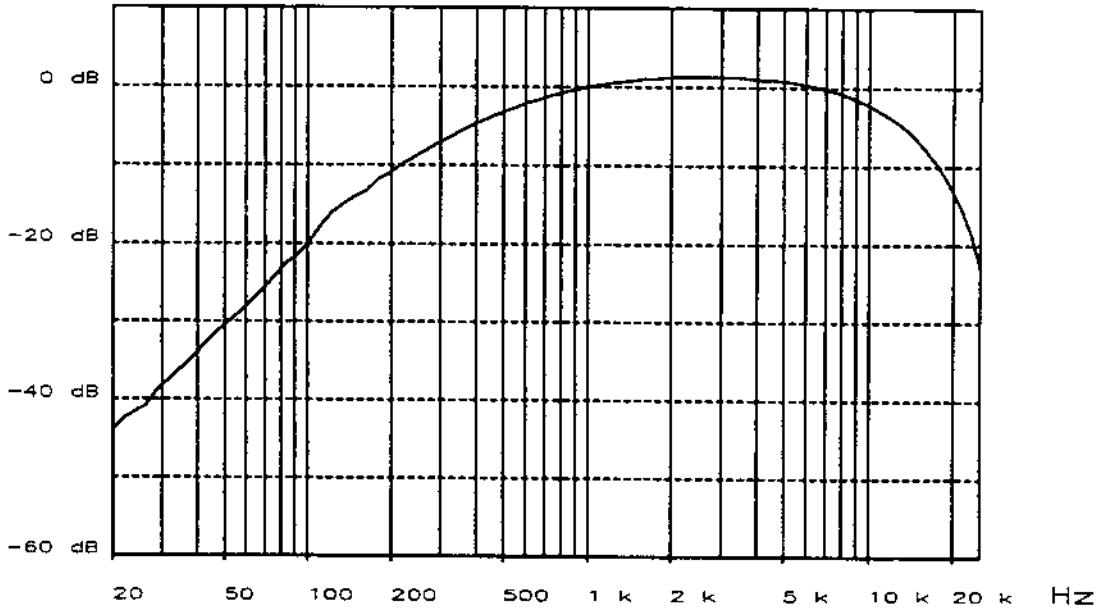

Fig. 7.10 - dB(A), DIN 45633/IEC 651

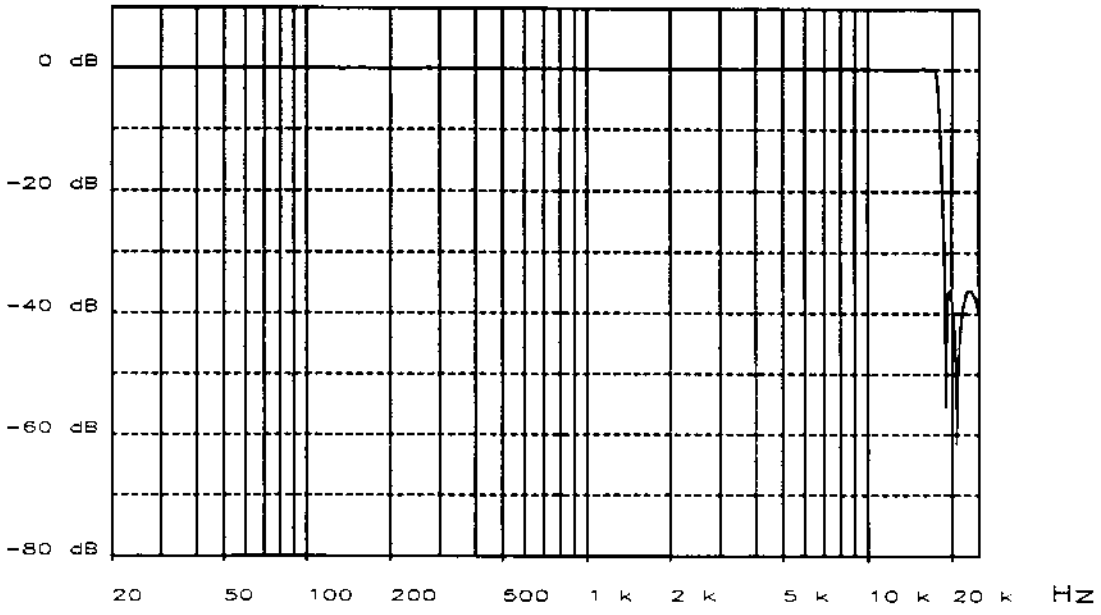

Fig. 7.11 - 15 kHz Lowpass with 19 kHz Notch

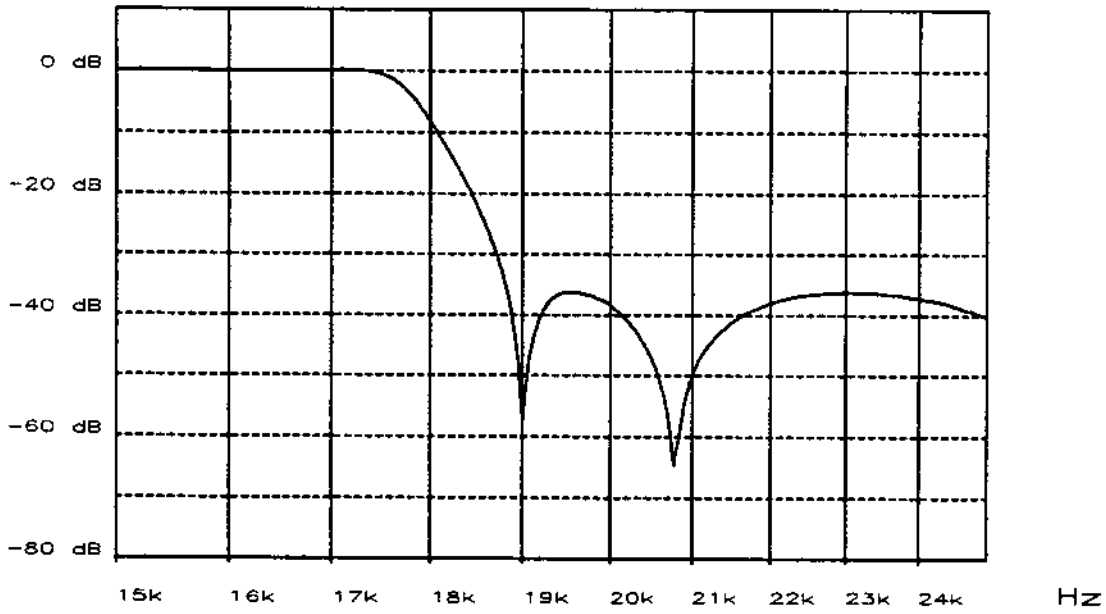

Fig. 7.12 - 15 kHz Lowpass, Stopband Characteristic

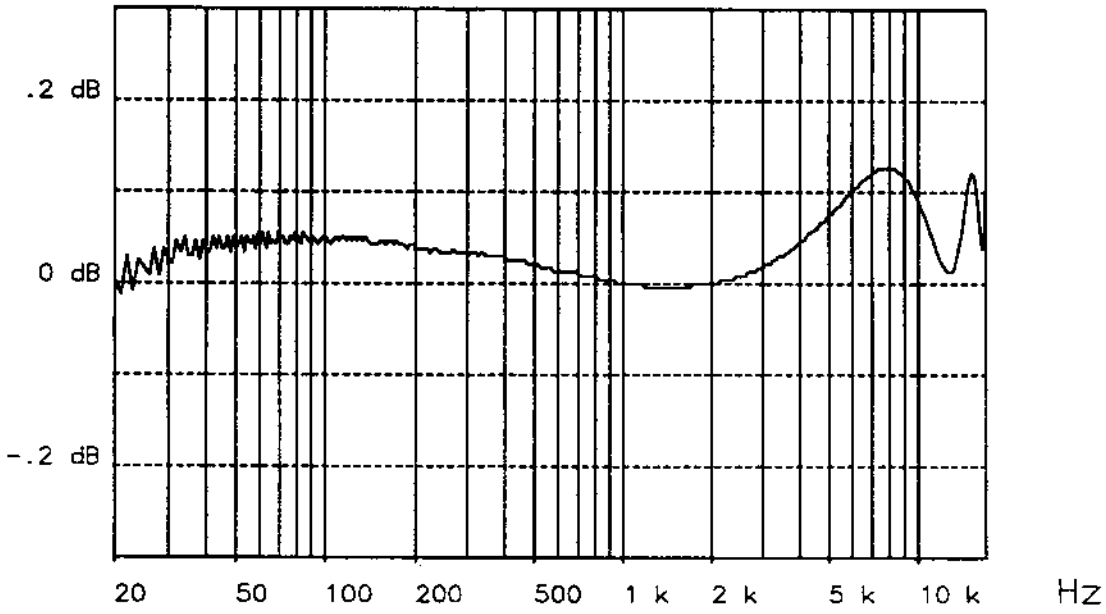

Fig. 7.13 - 15 kHz Lowpass Ripple

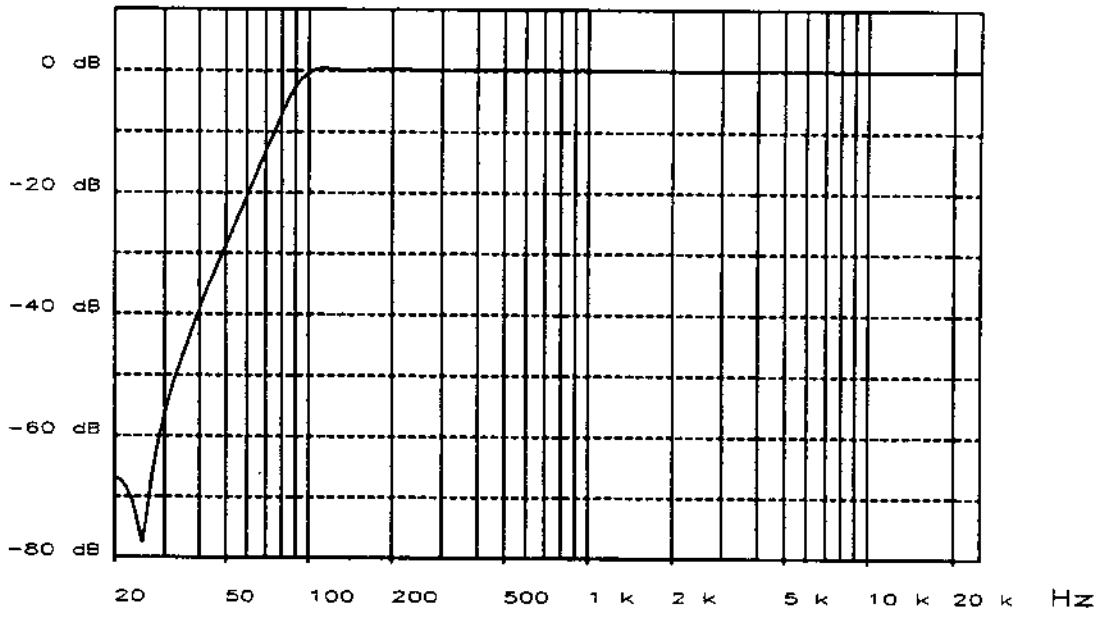

Fig. 7.14 - 100 Hz Highpass with 25 Hz Notch

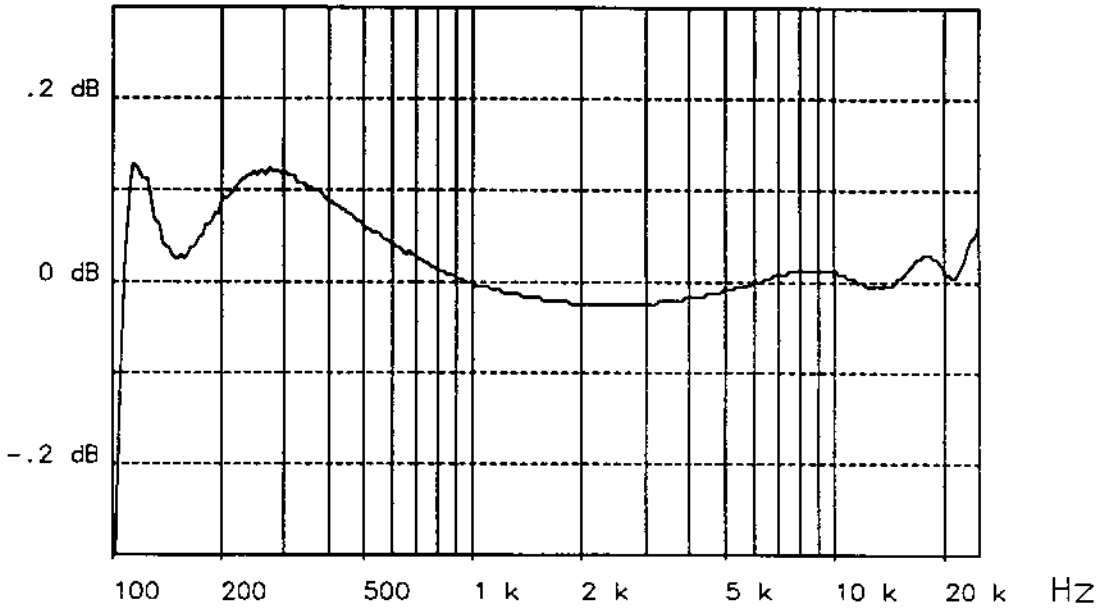

Fig. 7.15 - 100 Hz Highpass Ripple

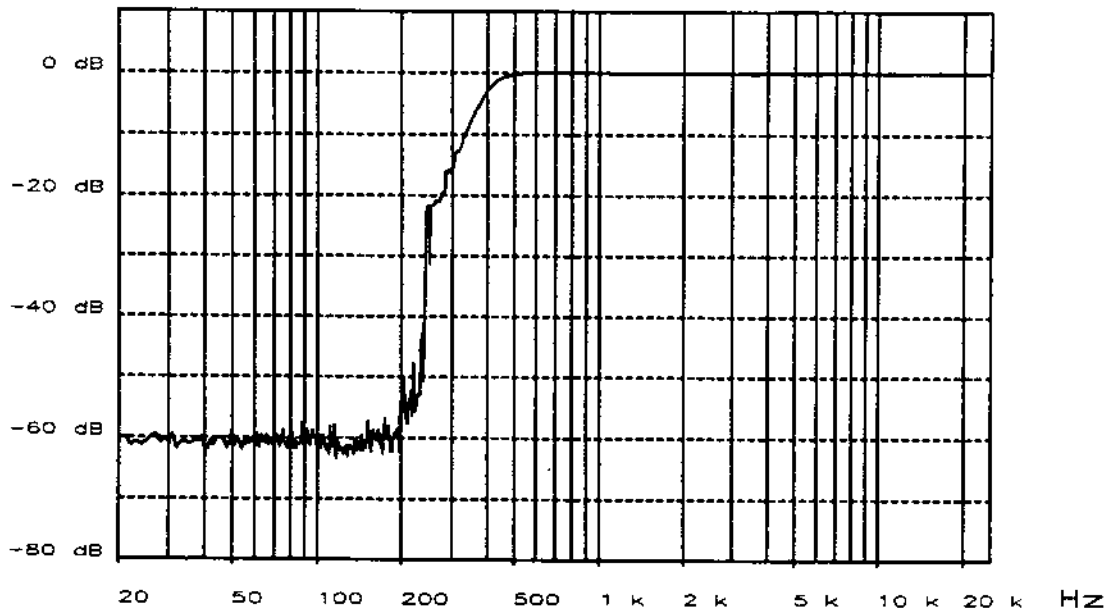

Fig. 7.16 - 400 Hz Highpass

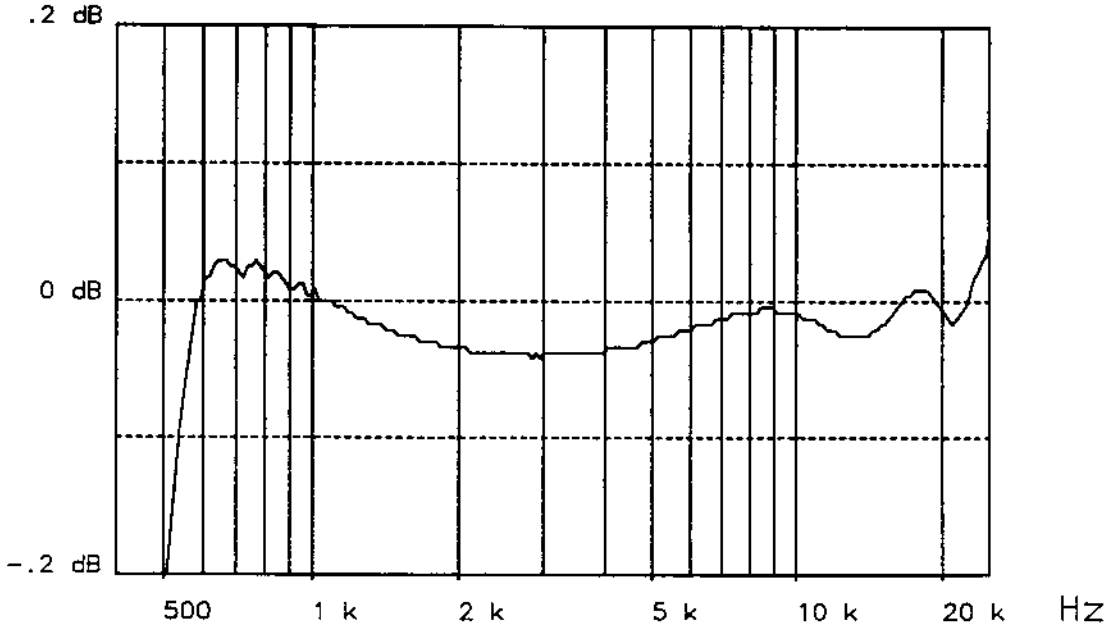

Fig. 7.17 - 400 Hz Highpass Ripple

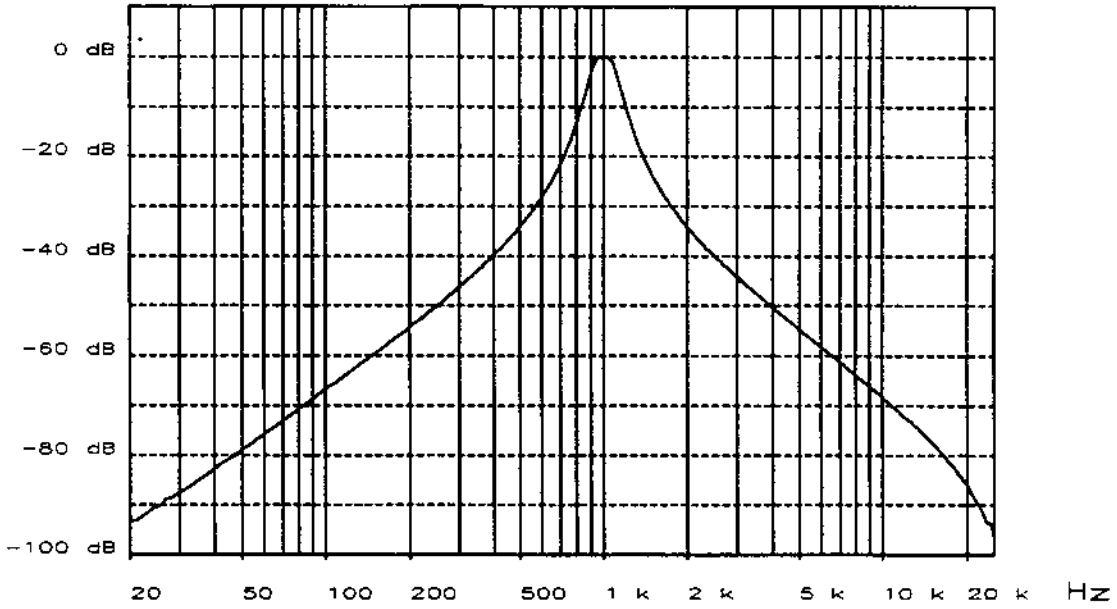

Fig. 7.18 - Double Precision Bandpass, 1 kHz

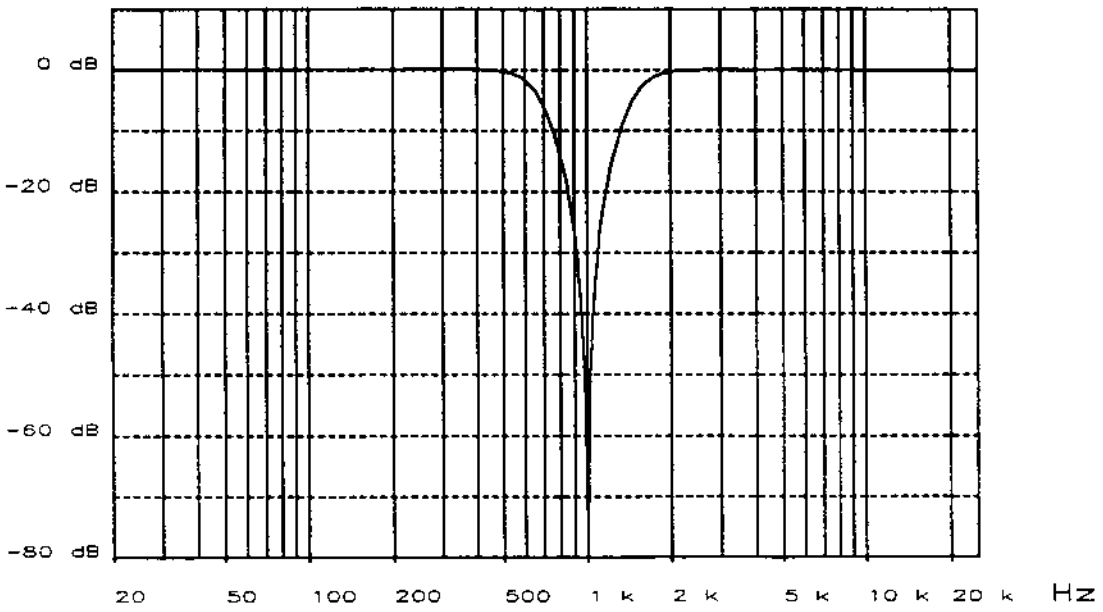

Fig. 7.19 - Notch Filter, 1 kHz

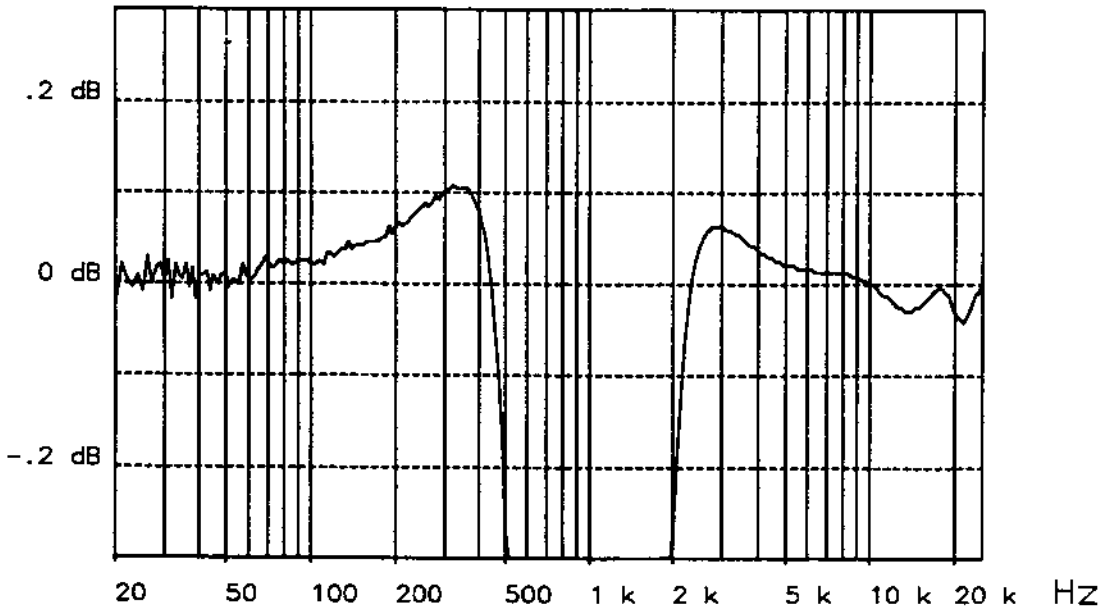

Fig. 7.20 - Notch Filter Ripple

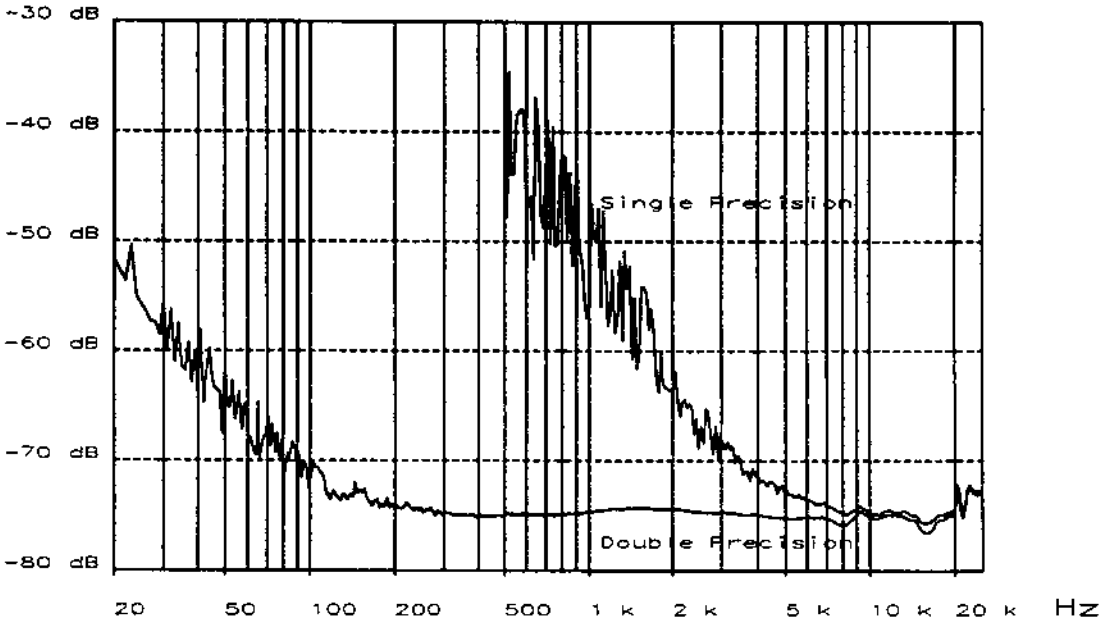

Fig. 7.21 - Notch Filter Attenuation at Notch Frequency

8 MISCELLANEOUS

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