
Measurements on CD Players using the Audio Analyzers UPL or UPD and the Audio Test Disc UPA-CD

Application Note 1GA21_1E

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Rteplaces 1GPAN21E

Subject to change

Products:

Audio Analyzer UPL

Audio Analyzer UPD



ROPER SOFTWARE

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1. Conclusion

To analyse the quality of CD players, lots of measurements have to be done. This application note presents a program, which combines these measurements to an automatically running sequence and gives a printout of the results. A test CD is used for generating the test signals. Here the Audio Test Disc UPA-CD from Rohde & Schwarz is used, which holds all required signals in a sequence permitting automatic measurements to be carried out, without the need of controlling the CD player. In addition, this application note explains the measurements and informs about the different standards.

2. Introduction

With the Audio Analyzers UPL and UPD we have measuring instruments which are able to carry out practically all necessary audio measurements on analog and digital interfaces. In addition to single measurements, whole test sequences can be performed automatically with the aid of the Universal Sequence Controller UPL-B10 respectively UPD-K1, which is available as an option. The option is used in the present Application Note. With the aid of the Universal Sequence Controller also customized program functions not provided in the audio analyzer can be performed. As an example the converter nonlinearity is represented as an offset with reference to the ideal characteristic.

Operation of the universal sequence controller programs can be matched to the softkeys of the analyzer display in appearance and functionality. This has been done for the described application.

The application uses a BASIC program for automatic measurements on CD players. Results can be printed out or stored for further processing.

3. Preparation and Starting the Application Software

3.1. Required Instruments and Accessories

As regards the hardware, a basic model of the Audio Analyzer UPL or UPD will be sufficient to carry out all the measurements on analog interfaces described below. Normally, these measurements will cover all requirements. Although the data stream at the digital interfaces can be analyzed, it only provides information on the signal recorded on the CD which, however, is not changed by the CD player. Merely a protocol analysis of the auxiliary data transmitted in the digital data stream could prove to be of interest. This analysis can be carried out with the aid of the option UPD-B2 for the UPD, respectively the options UPL-B2 and UPL-B21 for the UPL.

In any case an external keyboard will also be required.

A test CD is used for generating test signals. Basically, any test CD could be used, but in this case the set would be required to select the correct tracks for the measurement in question. This disadvantage can be avoided by using the Audio Test Disc UPA-CD from Rohde & Schwarz. It holds all required signals in a sequence permitting automatic measurements to be carried out. Apart from starting the CD player no other action is required during the play of the CD. In addition to the signals for testing CD players, the CD from Rohde & Schwarz comprises signals and signal sequences for measuring other audio components, for instance tape recorders. The Audio Test Disc UPA-CD can be obtained from Rohde & Schwarz under the Order No. 852.8400.02.

The BASIC programs required for an automatic test run are stored on a floppy disk to be obtained from your local Rohde & Schwarz sales organization.

UPL/UPD should meet the following software requirements:

- UPD firmware version 3.00 or higher,
- UPL firmware version 1.00 or higher,
- Universal Sequence Controller built-in,
- Analyzer configured with 64-Kbyte program memory and 64-Kbyte data memory for Universal Sequence Controller (select setting 5 using configuration tool UPLSET/UPDSET).

3.2. Software Installation

The application software is installed with the aid of installation program CDINST.BAT which is on the supplied floppy disk:

- Quit the UPL/UPD software by pressing the SYSTEM key or Ctrl+F9 on the keyboard
- Insert supplied floppy disk
- Select disk drive (enter A:)
- Call up the installation program (enter CDINST)
- Return to UPL/UPD program

Program CDINST generates the directory C:\CDPLAYER in the UPL/UPD (if it does not yet exist) and copies the BASIC programs and the setups required for the application into this directory.

3.3. Starting the Application Software

The application program is run with the aid of the universal sequence controller. After the UPL/UPD program has been started, operation is switched to the universal sequence controller by means of key F3 (on the external keyboard).

Before switching over to the sequence controller make sure that the logging function is switched off. This is indicated by the message "logging off" displayed at the bottom righthand end of the screen. With the logging function on, commands entered during manual operation would be appended to the program and take up additional memory capacity. The logging mode is switched off by pressing key F2 on the external keyboard.

Application programs are to be called up via path C:\CDPLAYER as all program modules and setups are searched for in this path which may be changed either

- at the UPL/UPD level with the "Working Dir" command in the FILE panel,
- by calling up one of the setups required for measurements on CD players,
- at the UPL-B10/UPD-K1 level by means of the BASIC command line
UPD OUT"MMEM:CDIR\CDPLAYER",
- via the SHELL by entering CD CDPLAYER and pressing EXIT,
- at the DOS level by entering CD CDPLAYER.

The program disk comprises the BASIC program CDTEST.BAS for measurements at the analog interfaces of CD players. It is loaded and started by entering:

- LOAD"CDTEST"
- RUN

Loading and starting is also possible by means of the softkeys displayed at the bottom of the screen when the Universal Sequence Controller software is called up.

3.4. Configuring the Application

Measurements are carried out with a number of setups stored on the application floppy. All setups for measurements on analog interfaces have the designation

CDA_XXXX.SAC

The code word under XXXX identifies the measurement function, eg "FREQ" stands for frequency response, "THDN" for THD+noise measurement, "CROS" for crosstalk, etc. Only the "actual setups" are used. Contrary to the "complete setups" they comprise settings for analyzer ANLG 22kHz used in the application as well as settings made in the DISPLAY, FILE and OPTION panels. The advantage of actual setups is that they can be called up in a considerably shorter time than complete setups which hold all the settings.

Upon delivery the setups are configured for printout of measurement results on a "default" printer. This means, the settings of the printer which have been used during the last operation of the UPL/UPD will be used again. The UPL/UPD screen is set to colour display and an external monitor is connected. These settings may, of course, be adapted to user requirements by modifying the settings in the OPTION panel.

Customers may wish to make other changes in the individual setups. In this case the respective setups are called up and after modification stored again under the same name. The following modifications can be made:

- Entry of a comment in the graphics display ("Comment" in the DISPLAY panel)
- Defining tolerance curves/values ("Limit Check" in the DISPLAY panel)
- Selection of settings to be displayed in the STATUS panel (marking)

IMPORTANT: If others than the above-mentioned settings are changed, a correct run of the software cannot be guaranteed.

3.5. Converting the Setups after Firmware Updates

Upon an update of the UPL/UPD firmware, setups may require to be converted. The conversion is carried out automatically every time the setups are loaded. However, this might extend the loading procedure to an extent that proper execution of the measurement sequence is no longer possible. For this reason the setups should be converted and stored before the application software is started. This can be done in two ways:

- At the DOS level by calling up the converter program
DO_CONV \CDPLAYER.
In this case all setups in the CDPLAYER directory are converted.
- At the UPL/UPD level by loading and restoring every setup after conversion.

IMPORTANT: In setups with READ ONLY, the "r" attribute has to be cleared first (at the DOS level by means of command ATTRIB -r).

4. Operating Concept

After starting the program, the user is prompted to enter the information items to be printed on the test report. These include the type designation of the CD player to be tested and the name of the person carrying out the test. Date and time will be taken automatically from the analyzer's system clock.

The display of a list of possible measurements follows. A selection can be made whether an automatic test sequence or single measurements are to be made. The single-measurement mode is required for carrying out measurements that are not included in the automatic measurement sequence.

The CONFIG softkey (corresp. to F11) is displayed together with the list of possible measurements.

When it is pressed, a menu is displayed where the units dB or % can be selected. This selection is valid for THD-N, intermodulation and difference frequency distortion measurements. Measurements are in most cases carried out at the unbalanced analog outputs of the CD player, but balanced outputs - as are required for professional CD players - can also be used. The selection can be made in the CONFIG menu as well.

After the return to the main menu the desired measurement is selected.

This is followed by the request:

Select track X and press PLAY,

"X" being the required track number on the test disc.

The program detects the start of the test CD automatically and begins with the measurements. Synchronization of individual measurements is also automatic. For synchronization, levels and frequencies on the CD are evaluated and the measurements are switched accordingly. For measurements that cannot be exactly assigned when the DUT is faulty, eg for linearity measurements, short sections with high level or other frequencies are stored on the CD for continuing the test program.

At various stages of the program, sequence softkeys are displayed at the bottom of the screen. With the aid of these softkeys, which correspond to the function keys on the external keyboard, the measurement sequence can be changed.

The following functions are available:

GOTO UPD (= F5)

stops the ongoing program and switches to manual operation of the UPL/UPD without terminating BASIC eg for evaluating a graphics display by means of a cursor or for entering a comment.

STOP (= F7)

interrupts the ongoing measurement. It is followed by

CONT (= F7)

for continuing the measurement.

CONFIG (= F11)

branches to the above-mentioned configuration routine.

HARDCOPY (= F12)

outputs the screen content or measurement results to the interface selected in the OPTIONS panel (for printer, plotter or file).

5. Measurement Procedure

5.1. Measurement Standards

Measurements are in line with the international standard IEC 1096:1992: Methods of measuring the characteristics of reproducing equipment for digital-audio compact discs, or with the European Standard EN 61096:1993: Meßverfahren für die Eigenschaften von Wiedergabegeräten für Digital-Audio-Compact-Discs.

The measurements

- max. power consumption
- frequency response with deemphasis and
- access times

are not part of the described sequence. The output polarity measurement is carried out in a slightly modified way because the test signal specified in the standard is not available on the Rohde & Schwarz test CD.

Tracking errors are measured in addition to the measurements prescribed by the standards.

5.2. Test Setup

Audio Analyzer UPL or UPD, a Test Disc UPA-CD and possibly a printer for result documentation are required.

The output of the CD player for the left channel is to be connected to UPL/UPD test input 1, the right channel to input 2.

The setup is to be properly earthed for the measurements, eg to avoid hum loops. Since CD players are normally provided with floating outputs, the inputs of UPL/UPD are grounded by selecting "Common GROUND" and has already been considered in the application setups.

The printer is connected to the Centronics interface.

6. Measurements

The following sections describe the measurements in the sequence in which they are carried out in an automatic test run.

With some measurements a lowpass filter has to be used for eliminating signal components above 20 kHz. At 24.1 kHz the attenuation must be at least 60 dB, above 44.1 kHz at least 100 dB. The analyzer ANLG22kHz is used for this application. Up to 22 kHz it features a flat frequency response and suppresses all higher frequencies. This goes far beyond the IEC 1096 requirements.

Since only audio frequencies between 20 Hz to 20 kHz are evaluated, lowpass filters are required. However, because of the digital signal processing in the CD player, residues of clock pulses as well as mixer products and image frequencies inevitably occur. The 44.1 kHz - f_s image frequency of the CD player is more or less suppressed by the built-in anti-aliasing filter, but when it comes to higher frequencies, where signal and interference frequencies approach each other, an elaborate circuit would be required for the suppression. In practice such circuit is often left out for reasons of cost. For example, without additional filtering the distortion measurement would be falsified by the image frequencies. This is shown by an increase of the distortion factor towards higher frequencies. The lowpass filter ensures that correct measurement results are obtained.

6.1. Reference Output Voltage and Channel Asymmetry

During replay of the recorded reference level (at 1 kHz) the rms output voltage of the CD player is measured in both channels and stored as a reference value for further measurements. The measured value is indicated in Volt.

At the same time the level difference between the two channels is calculated and displayed in dB.

IMPORTANT: If a volume control is provided on the CD player, it should be set to nominal output voltage.

With top-quality instruments the level difference should not be much more than 0.1 dB.

6.2. Frequency Deviation

This measured parameter is also called pitch error. The frequency of the replayed signal is compared to the rated frequency of the test CD and the difference is indicated in %.

Normally, deviations from the rated frequency are minimal, as the frequency is determined by the accuracy of the built-in crystal. Measured values are in most cases about 0.1%. In some CD players greater deviations occur, eg in portable instruments using a simple ceramic resonator instead of a crystal. With some professional units the replay speed can be varied. In this case the described measurement can be used for checking the setting range.

6.3. Signal-to-Noise Ratio

According to IEC 1096, the measured signal-to-noise ratio (to IEC 268-1) is to be determined unweighted and weighted with an A filter. The measurement is carried out separately in each channel. For the present application the S/N ratio is also weighted to CCIR 468 as is common for professional equipment.

The ratio of the replayed reference level to the noise level of a replayed digital zero signal is measured. The test CD contains a digital zero signal, ie no signal is applied to the converter. Mainly the noise of the analog components and interference coupled into the output amplifiers affect the measurement results.

S/N values of 100 dB and above (with A-weighting) are expected of high-grade CD players.

6.4. Dynamic Range

Noise and distortion are measured in relation to the recorded reference level. The result is indicated in dB.

In addition to analog effects such as noise, signal quantization also limits the dynamic range of digital systems. With the 16-bit linear digitization of the CD, a theoretical dynamic range of approx. 98 dB is obtained (with an evaluation bandwidth of 20 kHz). CD players with 18-bit or even 20-bit converters cannot yield a greater dynamic range since the information on the CD is in the form of 16-bit words. What such converters attain is that the dynamic range is not impaired by additional resolution errors. Since it can be assumed that the quantization errors of the CD and the converter are not correlated, the theoretical limit of 98 dB can also be attained by top-class units with 16-bit converters.

For this measurement, IEC specifies a test signal with a level of 60 dB below the reference level. This is necessary in order to separate the effects of nonlinear distortions (caused by analog circuit sections) and quantization errors. As the measurement is carried out at low levels of approx. 2 mV, these distortions have practically no effect.

THD + noise is measured and not all distortion meters are able to measure at such low levels. For this reason IEC stipulates an amplifier which boosts the level to a value which can also be measured by

simple distortion meters. Audio Analyzer UPL and UPD does not require such auxiliary equipment since it is able to determine the dynamic range up to far above 100 dB without additional amplifiers. The result is related to the reference level. This means that the 60 dB by which the signal level has been reduced must be added to the THD+N values which are referenced to the output signal. This is taken into account by the present application program.

Before IEC 1096 came into force, the dynamic range was weighted with an A filter. To be able to compare current measurement results and those of previous measurements, the A-weighted dynamic range is also specified for the present application.

High-grade CD players attain values of 95 dB and better (measured without A weighting).

6.5. Level Nonlinearity

The level nonlinearity is the true deviation of the output signal from the level recorded on the CD. This measurement is frequently specified as converter nonlinearity. The differences between measured and recorded levels are specified for each measurement step in dB, separately for each channel and for all test signals up to 90 dB below the reference level at 1 kHz. These measurements are carried out selectively for suppressing noise and interference.

The Rohde & Schwarz test CD comprises test signals which are first reduced in 10-dB steps and later on in steps matching those of the bit structure. The signals (0 dB, 2 kHz) inserted between the individual steps are used for synchronizing the measurement sequence since, in the case of DUTs with a moderate converter linearity, measured levels are not accurate enough for a reliable step identification.

This measurement, which is so important for testing the fidelity of sound reproduction, shows considerable differences between the various CD players. While high-quality equipment show linearity errors of <1 dB up to levels of -80 dB, deviations of more than 10 dB may well occur in the case of simpler units. A complete suppression of extremely low levels is possible. The measured values for S/N or the dynamic range can be improved by the intentional reduction or suppression of very small levels. Therefore these measured values must be evaluated critically whenever high linearity errors are involved. Figs. 1 and 2 show examples for measurements on high-quality and simple CD players.

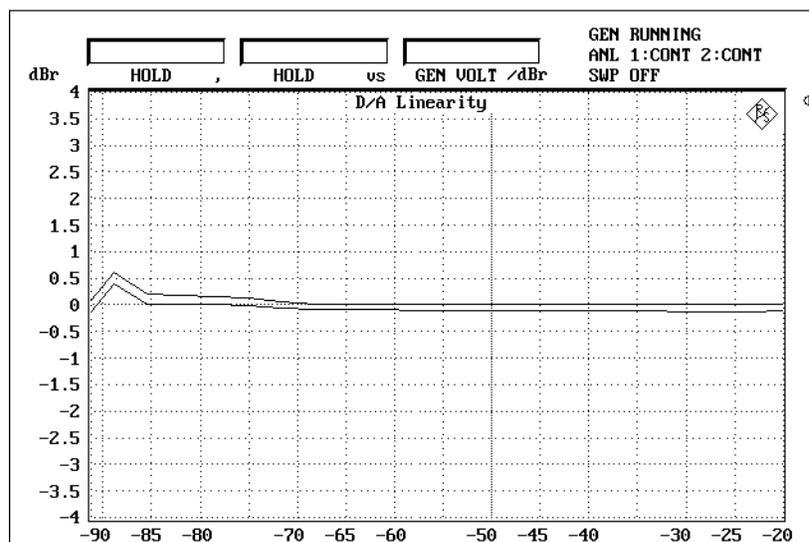


Fig. 1: Typical linearity curve of a well-aligned unit

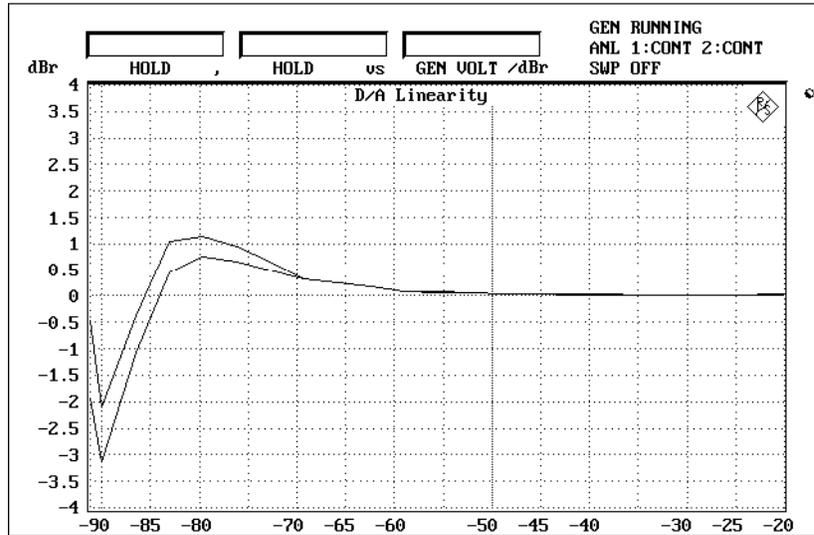


Fig. 2: Linearity curve of a CD player deviating considerably from the rated curve

6.6. Frequency Response

The output level of the two channels is displayed as a function of frequency.

Variable-frequency or fixed-frequency sweeps may be used for this measurement. More convincing results are obtained with the variable-frequency sweep. Sweeps from 20 Hz to 20 kHz are used on the test CD from Rohde & Schwarz and recorded consecutively for the two channels. Thanks to the high measurement rate of the UPL/UPD, frequency response can be determined with a resolution of 0.01 dB.

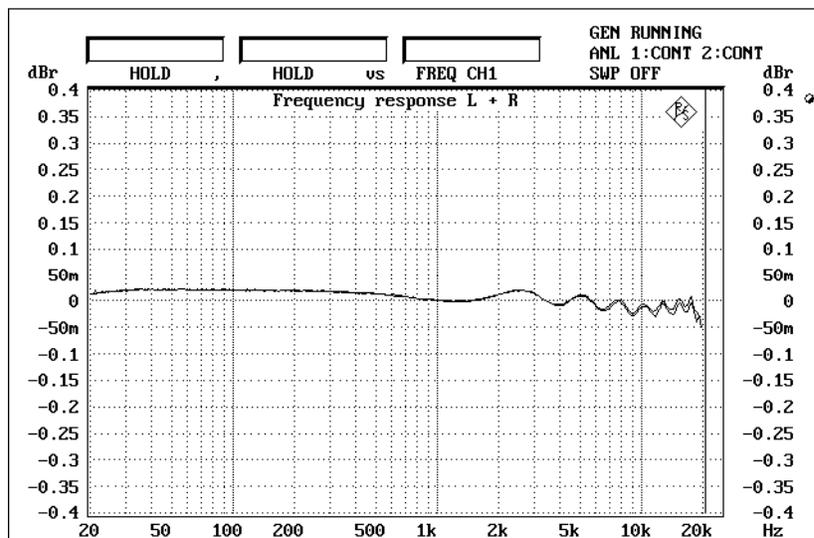


Fig. 3: Typical frequency response of a CD player with digital filtering

Normally, the frequency response of even simple CD players is far better than that of analog components. A wavy response is often shown at higher frequencies and results from the digital filtering in the CD player (Fig. 3). The higher the number of poles of the built-in filter, the flatter and smoother the frequency response. In the case of top-class units, the frequency response remains flat below 0.1 dB. Note that the frequency response is referred to the level at 1 kHz for the respective channel. For this reason level differences between the two channels, as are measured under section 5.1, cannot be derived from the frequency response display.

6.7. Distortion

A measurement of the THD+N value at fixed frequencies between 20 Hz and 20 kHz is prescribed, including a measurement at 1 kHz.

The test CD from Rohde & Schwarz includes 12 signal frequencies for this measurement and thus meets this requirement. Measurement results may be displayed in % or dB.

As a result of inadequate anti-aliasing filtering, mixture products occur through mixing harmonics of the signal frequency with the clock frequency or harmonics thereof. Even at low amplitudes, these products can be very disturbing. Typical mixture products are generated, for example, from the 1st and the 3rd harmonics of the signal frequency mixed with the clock frequency. As can be seen from Fig. 4, the products 24.1 kHz ($= 44.1 - 20$) and 15.9 kHz ($= 3 \times 20 - 44.1$) occur at a 20-kHz signal frequency. Fig. 5 shows a typical distortion curve as a function of frequency. The curve shows a slight rise up to approx. 10 kHz since up to this frequency the 1st harmonic of the signal is measured as well. Above 11 kHz the harmonic is suppressed by the lowpass filter, the distortion drops, but the mixture products described above cause the curve to increase again.

Top-class CD players achieve a distortion suppression of greater than 90 dB over the entire frequency range.

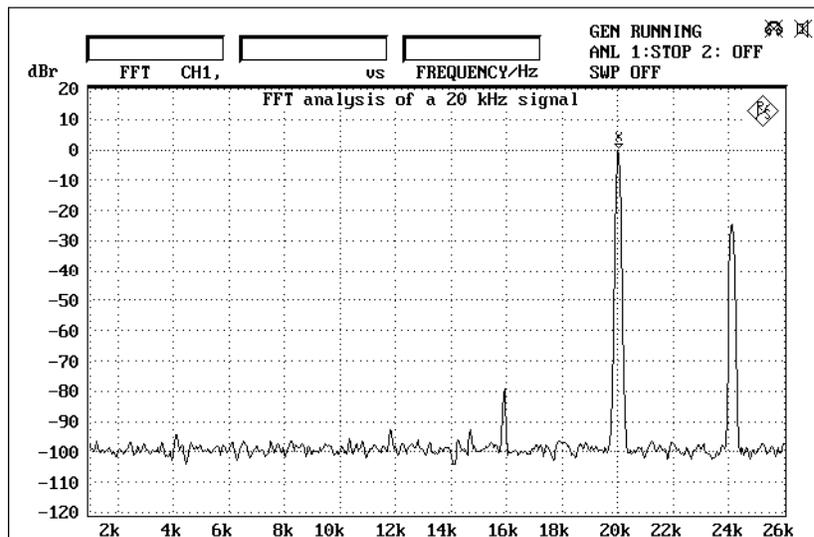


Fig. 4: Typical distortion curve showing mixture products at 24.1 kHz and 15.9 kHz

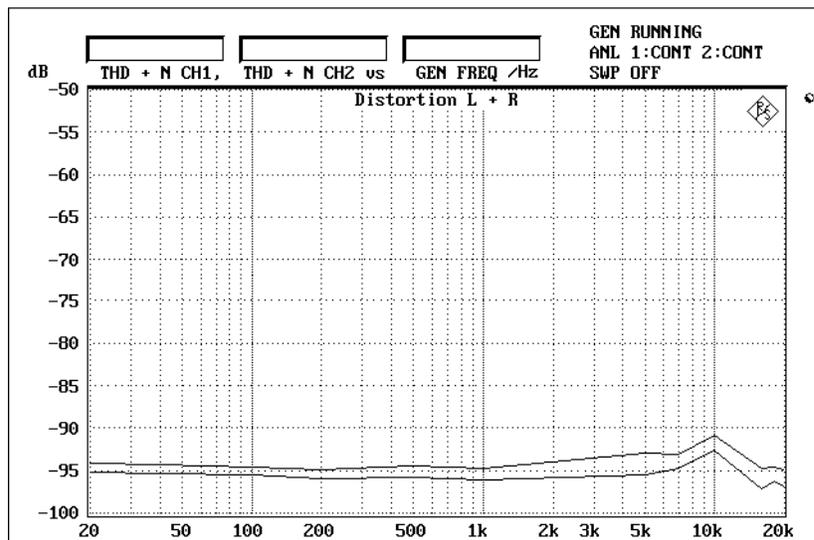


Fig. 5: Example of a distortion curve as a function of frequency

6.8. Phase Difference

The phase difference between the left and the right channel is measured at various frequencies. IEC 1096 prescribes measurements at 1 kHz and 20 kHz, measurements at other frequencies are voluntary.

In the present application, the phase measurement is carried out in parallel with the distortion measurement, ie distortion and phase are measured alternately during the test signal run. The result of the phase measurement is displayed as soon as the THD+N measurement is terminated.

Top-class CD players show a phase difference of less than 0.5°.

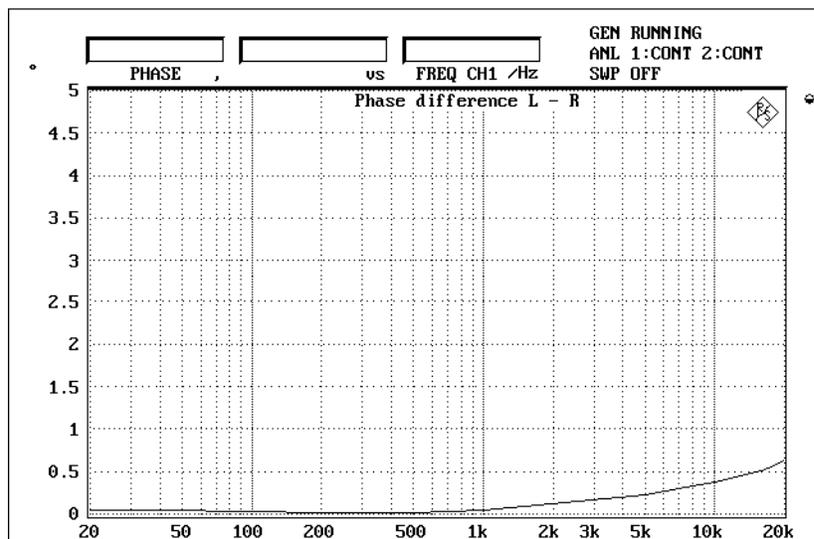


Fig. 6: Phase characteristic of a top-class CD player versus frequency

When CD players were introduced for the first time, also units with only one D/A converter operating in the multiplex mode were used. In the simplest case without oversampling, a phase difference of approx. 82° is obtained at a signal frequency of 20 kHz as a result of the shift in time by half a system clock. The phase difference can be reduced to about half the value with oversampling and compensation measures. This "economy configuration" can be identified by the typical rise of the phase angle as a function of frequency.

IEC 1096 refers to this time offset occurring with players using one converter in the multiplex mode. An example is shown in the diagram below.

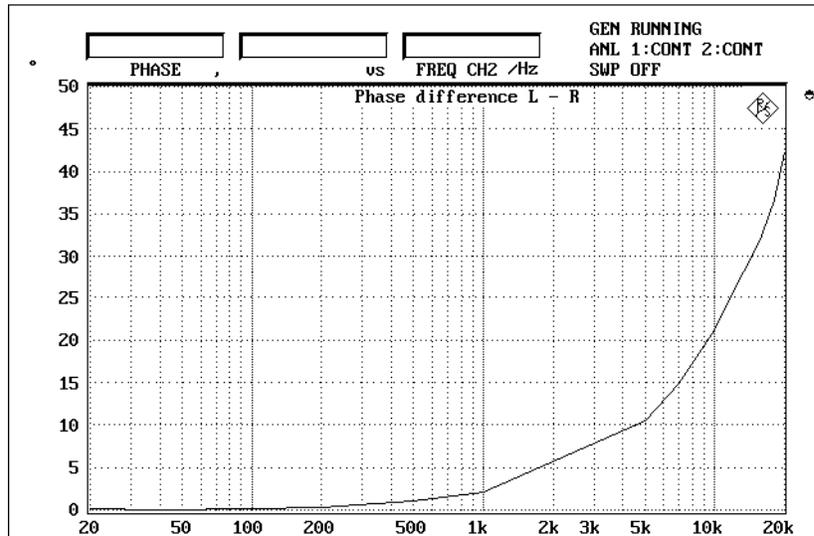


Fig. 7: Phase characteristic of a CD player using one D/A converter only

6.9. Crosstalk

The level difference between the wanted signal in one channel and the unwanted signal caused by the wanted signal in the other channel is measured. A measurement is prescribed for both directions at 1 kHz; measurements at other frequencies are voluntary.

In the present application, the crosstalk is measured at 1 kHz, 10 kHz and 20 kHz. Since the crosstalk level in top-class unit is relatively close to the noise level, the measurement must be carried out selectively.

Results from 90 dB to better than 100 dB are achieved by top-class CD players.

6.10. Intermodulation Distortion

Intermodulation distortion is the ratio of all intermodulation products referred to the useful signal. Measuring the intermodulation distortion of CD players is prescribed by IEC 268-1, section 7.2.8. Two test tones with an amplitude ratio of 4:1 are used for the measurement. Measuring the difference-frequency distortion to IEC 268-2, section 7.2.11, is voluntary. In this case two test tones of identical level and spaced by 1 kHz are superimposed.

Contrary to the test frequencies for intermodulation measurements of 60 Hz for the noise and 7 kHz for the wanted signal specified by IEC 1096, the test CD from Rohde & Schwarz uses a 400-Hz noise signal.

This makes practically no difference for the measurement result. The reason for using the frequency combination 400 Hz + 7 kHz is that in this case a more simple and accurate measurement can be carried out with the analog Audio Analyzer UPA. The frequency combination 60 Hz + 7 kHz can be found on track 42 of the test CD. This test signal can also be used for single-shot measurements with the UPL/UPD.

Since the sum signal of the wanted and the noise signal must not exceed the dynamic range of the CD, a low-frequency signal of -2 dB and a high-frequency signal of -14 dB are recorded. When using simple instruments for measuring the intermodulation, the measurement result for intermodulation suppression is limited by the quantization noise of the CD player. For this reason and because the value is referred to the 7-kHz signal, measured values of up to approx. 85 dB are possible. This limitation is avoided in the audio analyzers UPL and UPD by a selective measurement of intermodulation products, ie independent from the quantization noise.

Also the difference-frequency distortion at various frequency combinations may be determined by means of a single-shot measurement. In this case tracks 39 to 41 of the test CD are used. 2nd and 3rd order intermodulation is measured.

According to IEC 1096, all measured intermodulation values are indicated in %. In the UPL/UPD indication in dB is also possible.

Top-class CD players achieve an intermodulation suppression of approx. 90 dB and a difference-frequency suppression of approx. 100 dB.

6.11. Output Polarity

The influence of the CD player on the polarity of the output signal is determined by measuring the pulses on replay.

According to IEC 1096, 0-dB pulses with a width of one data word should be used for these tests. Such signals are not provided on the Rohde & Schwarz test CD. The purpose of this measurement is to determine whether pulses recorded with equal phase are output by the CD player in-phase and with correct polarity. Pulse-inverting channels are to be indicated.

In the present Application Note, a slightly different single-shot measurement is used, which yields the same results, however.

A pulse inversion can be determined by means of the burst signals on track 47. If the replayed pulse begins with a positive rise, no inversion is performed.

Here IEC 1096 points out that the tested CD player may be equipped with only one D/A converter in the multiplex mode. This can be determined by measuring the phase difference as described under 5.8.

6.12. Tracking Error

A test method for determining the behaviour of CD players in the case of defective discs is being discussed at present by the standardization committees.

The present application also offers a way of measuring the tracking error in addition to all the mentioned measurements. However, special test CDs with simulated faults are required in this case. Before the test is performed, the user is prompted by the application program to insert a respective CD. The Test Disc CDT-016, Order Designation SZZ P1054 from Panasonic, is used in this case. It simulates two different error sources:

- Surface defects of the CD:
Dirt and scratches on the surface may lead to errors when digital data are read. Such defects are simulated by painted dots of different diameters.

- Defects of the information layer of the CD
For simulating this error source, certain areas of the information layer inside the CD have been destroyed.

The response of CD players may be quite different regarding the two types of errors. It is possible for a CD player to correct one type perfectly and unnoticed by the listener while audible signal changes are produced when correcting the other. For this reason both tests should be carried for examining both types of errors.

The information on the CD has redundancy so that error handling routines may be able to regenerate the original code free of errors provided that not more than 1.2 mm of the track is lost. However, not all CD players are able to cope with incurred errors in that way. Despite an error-free reconstruction it may happen that correction errors are produced which impair the original signal and generate an audible clicking noise. In the event that the CD player is not able to retrieve the missing signal, the output signal of the many CD player is muted for the period of the fault. It may also happen that the servo circuit for tracking can no longer find the track to be read and the disc gets stuck. Since the above-mentioned characteristics provide important information on the suitability of a CD player in everyday use, sufficient importance should be attached to the measurement of the tracking error.

The measurement is based on the fact that even the slightest signal changes become evident by a rise in THD. Thus the distortion factor is measured and recorded with time whilst the faulty track is running. In the event of insufficient error correction of the CD player, the periodic reading of the faulty area causes a peak in the distortion as shown in Fig. 8. A constant, low THD indicates a correctly functioning error correction (Fig. 9). In the event that the signal of the CD player is briefly muted, the Audio Analyzers UPL and UPD records a sudden level change. In the diagram muting is shown by gaps in the curve.

A top-class CD player should be able to correct both, surface and information layer errors. In this case the tracks with the largest interruptions (0.9 mm) are used. Playing other tracks with smaller interruptions can exactly reveal the error correction capabilities of the DUT.

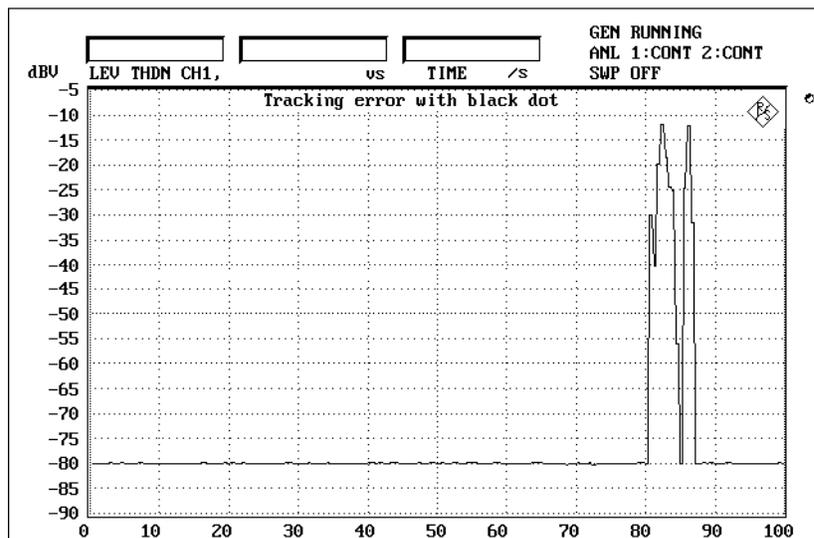


Fig. 8: Disturbance caused by faulty restoration of missing data

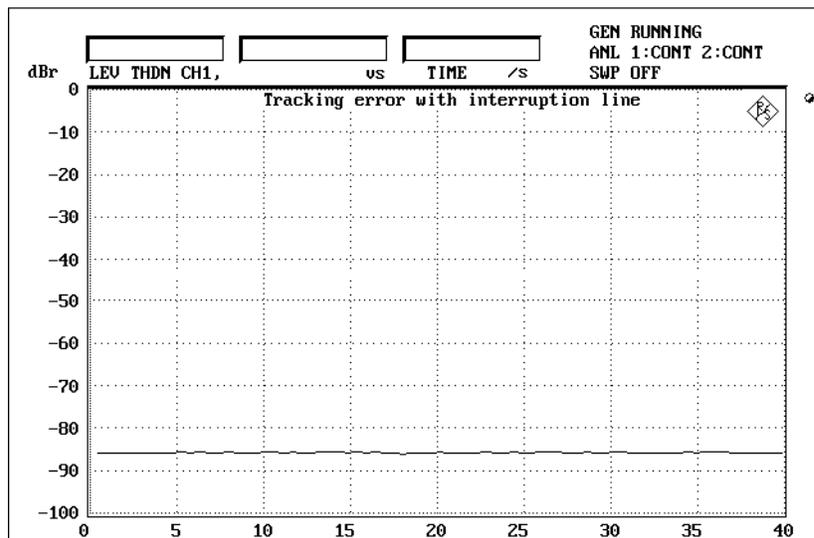


Fig. 9: Faultless error correction

7. Subsequent Processing of Measurements

Subsequent processing is only possible when single-shot measurements have been carried out. In this case manual operation has to be selected on the UPL/UPD so that modifications, eg changes in the graphics display, can be performed.

7.1. Change of Task Universal Sequence Controller / manual operation

Upon completion of a single-shot measurement, the "GOTO UPD" softkey (F5) is displayed permitting switchover to manual UPL/UPD operation without the BASIC program being terminated. The program may still be used for procedures such as

- changing the graphics scale,
- moving the graphics cursor or switching it on and off,
- entering a comment to the graphics display,
- configuring the printer interface,
- printing a section of the diagram with a modified status panel,
- displaying measured values or limit violations in tabular form.

Pressing function key F3 on the external keyboard causes a return to the location in the application program at which the BASIC program was quit.

This interruption cannot be made during automatic testing of the CD player. Although it would be possible to stop the program the test CD would continue to run.

7.2. Printout

After the test sequence has been completed a menu is displayed permitting the whole test report to be output to a printer or to a memory for storing.

After a single-shot measurement has been carried out, the HARDCOPY softkey (F12) is displayed so that the screen can be printed if it contains a diagram.

Of course, the hardcopy function can also be activated at the UPL/UPD level. In this case also trace data or limit violations can be printed.

7.3. Restarting the Measurement

The application can be restarted any time by entering the BASIC command RUN.

7.4. Interruption or Continuing a Measurement

The program can be interrupted by pressing the STOP softkey (F5). The softkey label then changes to CONT so that the measurement can be continued.

8. Terminating the Application

Pressing the ESC key on the external keyboard or the CANCEL key on the UPL/UPD causes a return to the previous menu level. Pressing one of these keys at the top level terminates the program, ie by pressing a key several times the program can be terminated from any menu level. To avoid the program from being ended inadvertently, a query is displayed prior to the termination of the program.

The software can be aborted any time by pressing CTRL+BREAK. After the entry of CONT the program is continued whereas RUN triggers a restart.

