KLEIN + HUMMEL

# Measuring Procedure for K + H Studio Monitors with FIR Controllers to Correct Room Acoustics

Monitor parameter sets will be established in the anechoic chamber for each individual monitor before it leaves the factory. These parameter sets are calculated for a linear frequency response and also for a linear phase response of the complete system at anechoic conditions. They will then be loaded into the digital controller for an individual monitor system and can be recalled in the menu under „speaker select".

There are five alternatives to compensate frequency non-linearities of a regular listening environment caused by room acoustics and monitor location:

Compensation by
- rebuilding of the room
- analog EQ's
- digital IIR-EQ's
- digital FIR filtering technology
- active acoustical compensation.

The two KLEIN + HUMMEL digital controllers PRO C 28 and O 500 C (integrated into the monitor) provide FIR filter technology and IIR EQ's resulting in three different compensation features:

(1) a comfortable room EQ function
(2) a fully parametric 10 band EQ
(3) a compensation with individually calculated room specific system parameters as described in this leaflet

Equalization of (1) and (2) are carried out by digital IIR-filters and their resulting phase response is the same as with analog filters. Feature (3) - compensation with FIR filtering technology - is described in this leaflet.

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The use of digital IIR or analog filters will influence the phase response to become non-linear a fact that is not wanted when listening. This non-linearity will increase when the degree of equalization of the frequency response is increased.

With the K + H digital controllers PRO C 28 and O 500 C this would also appear when the factory set linear phase response is overruled by their built-in IIR filter equalization - trying to compensate acoustic room deficiencies.The phase response would become non-linear.

In order to avoid this effect K + H offers these controllers with FIR filtering technology: they have the power to compensate frequency response and to correct phase response such that the phase response will remain absolutely linear. For this purpose it is necessary to create a new parameter set which is specific to the studio or listening room.

To do this a special procedure must be carried out measuring the monitor system when installed in the studio. With the data received K + H will calculate a new parameter set for each monitor using a sophisticated proprietory software.

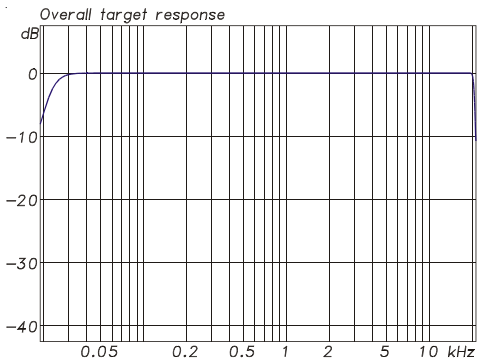
This individual parameter set will be loaded via a RS 232 interface into the K + H digital controller connected to the monitors. The controller will then execute the individual frequency and phase compensation according to the specific acoustic room conditions and monitor installation and will achieve the best acoustical results at the listening area.

This room specific parameter set calculation is offered by KLEIN + HUMMEL or authorized service companies as an option and will be charged at a minimal fee.

# 1. Generation of the Free Field Frequency Response Function

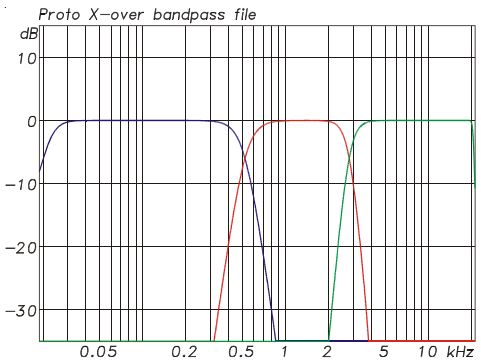
To understand the generation and the the functionning of the monitors' parameter set, the frequency response adjustment procedure carried out for every monitor at the factory is shown below. This procedure leads to an optimal linear frequency response curve of a monitor in an anechoic room.

**1.1**



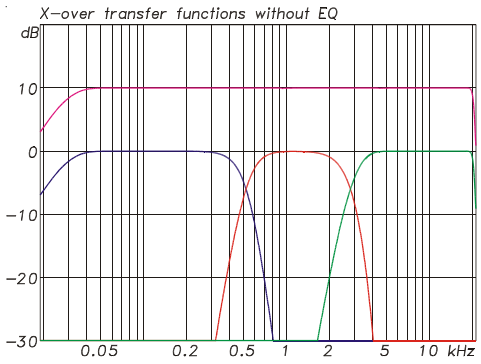

*Definition of target function:*
*Lower, upper cut off frequency, frequency run (here: flat)*

**1.2**



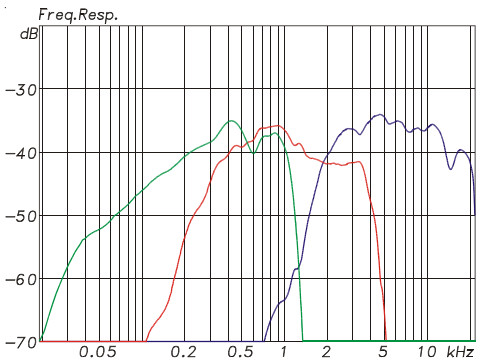

*Definition of target band passes:*
*Crossover points, slopes, filter character*

**1.3**



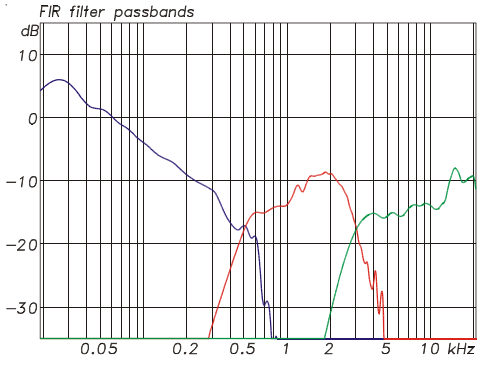

*Calculation of target band passes*
*considering frequency resolution*

**1.4**



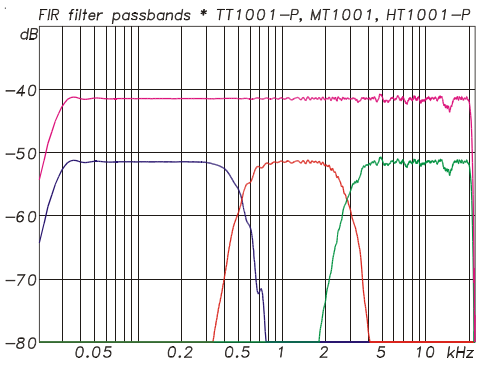

*Measured frequency self responses of each way*

**1.5**




*Calculation of corrective function: multiplication of self response function with corrective function to achieve the best possible target band passes*

**1.6**




*Measured resulting function of each way*
*and overall frequency response curve*

# 2. Step by Step Procedure to Gage a Specific Listening Room

There are two alternatives for the user to achieve phase corrected, room specific parameter sets for FIR controlled monitors.

**Alternative A**

**Measuring the listening room by K + H's or subcontractor's personnel at user location**

1. Installation of the complete system at user location (the complete system consisting of all monitors, PRO C 28 controller(s) and power amplifier(s) if requested)
2. Measuring frequency response curves around the listening area (determination of non-linearities caused by room reflections room or monitor positioning)
3. Evaluation of measurement results by K + H personnel
4. Definition of corrective frequency response function (curve?)
5. Correction of non-linearities with the IIR EQ function of the controller
6. Tonal verification: Using the controller's IIR EQs will create phase distortions like with an analog EQ. If this cannot be tolerated, proceed as below:
7. Calculation of a new combined room specific and phase corrected parameter set with FIR filters, including the IIR filter correction of (5)
8. Loading the new compound parameter set into the controller and cancelling the equalization of (5)

Estimated time for above iterative procedure for a stereo installation: approx. one working day

**Alternative B**

**Measuring the listening room by the user, calculation of new parameter set by K + H**

**User's procedure:**

1. Installation of the complete system at user location (the complete system consisting of all monitors, PRO C 28 controller(s) and power amplifier(s) if requested)
2. Measuring frequency response curves around the listening area (determination of non-linearities caused by room reflections room or monitor positioning)
3. Evaluation of measurement results by K + H personnel
4. Definition of corrective frequency response function (curve?)
5. Correction of non-linearities with the IIR EQ function of the controller
6. Tonal verification: Using the controller's IIR EQs will create phase distortions like with an analog EQ. If this cannot be tolerated, proceed as below:
7. The resulting IIR filter settings (with phase non-linearities)will be noted and relayed to K + H

**K + H's procedure:**

8. K + H will reproduce these IIR filter settings and calculate a FIR filtered parameter set for each monitor taking into account the specific room acoustics as described on page 1.
9. The customer receives the parameter set from K + H by e-mail or disk.

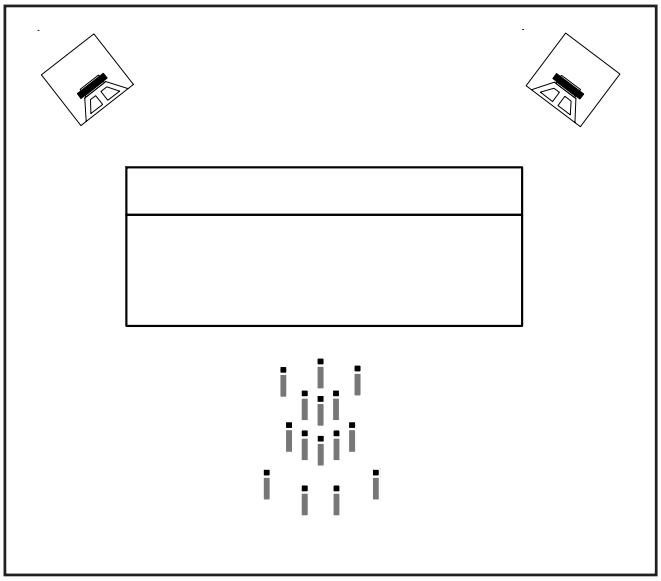
**User's procedure:**

10. Transfer of the parameter set via IBM-compatible PC into the controller
11. Cancel previous IIR EQ settings and recall the new room specific parameter set

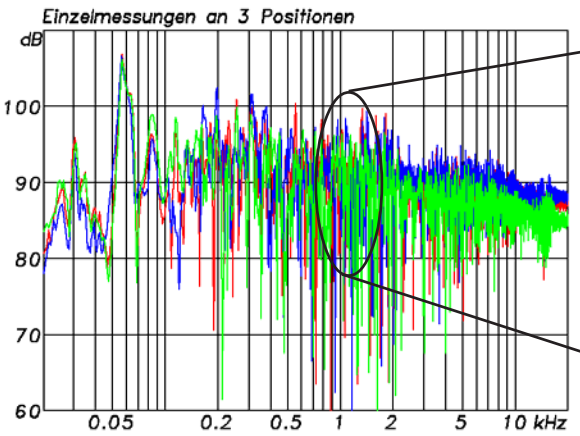
## 2.1 Installation and Startup of the Monitor System

Before starting the measuring procedure the user must take care that all acoustically relevant installations must be finalized, i.e. positioning and directing the monitors, positioning and paneling of mixing console, construction of the listening room with all walls and windows, all acoustical schemes, coverings and all racks and furniture must be finalized and in its final place.

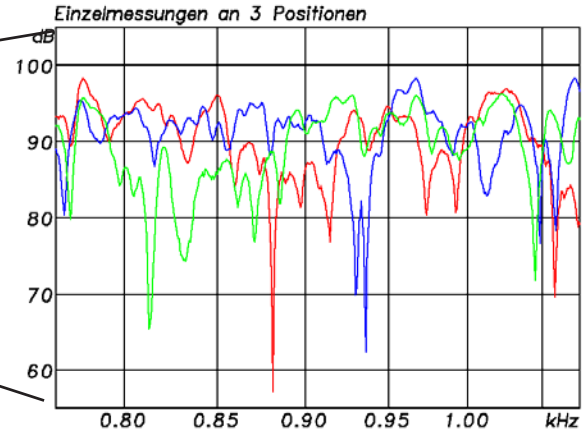
## 2.2 Measuring the Listening Room at Actual State



*Measuring of the monitors' frequency response after they are placed at their final position, recording the frequency response curve (without time window) at various microphone positions at and around the listening area.*
*The number of measuring positions depends on the geometry and size of the room, and the expected listening area.*

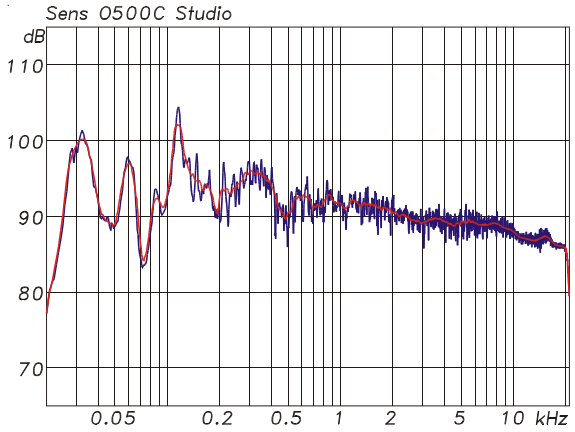



*Results of several measurements without time window around the listening position*




*Magnified section of frequency amplitude curves showing craggy runs of three measuring positions*

## 2.3 Averaging of Measured Curves

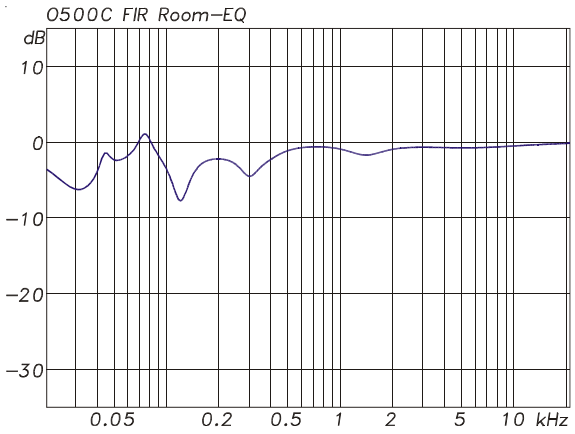



*Energetic averaging of the measured frequency curves without consideration of the phase. With this method the fine interference pattern will be averaged out.*

*The resulting frequency response curve is the interaction curve of the room characteristics, frequency response and dispersion characteristics of the monitors at or around the listening position (blue curve: without, red curve: with 1/6 octave smoothing).*

*Please note that the curve must show a steady decline towards high frequencies which is the result of the room's increasing absorption behavior and the monitors' increasing bundling ratio at higher frequencies.*

## 2.4 Producing the Corrective Curve




*Calculated corrective curve. The degree of the correction will depend (1)on the respective frequency and (2)on the origin of the non-linearity such as reflections, acoustic room modes, and sound absorption of the room. The degree of correction can vary between 30 % and 75 %.*

*The correction can be described with standard filter characteristics, e.g. high/low shelving, high/low pass and peak filters.*

## 2.5 Loading the Corrective Curve into the IIR Controller

The curve calculated in 2.4 must now be loaded into the parametric EQ of the controller's IIR section. There are 10 parametric EQ bands available.

## 2.6 Verifying theTonal Balance

With the following step the tonal balance will be verified and can be corrected with the controller.

The corrective function can be switched on/off in the EQ menue under „EQ ON/OFF“.

If necessary, steps 2.2 to 2.4 must be repeated.

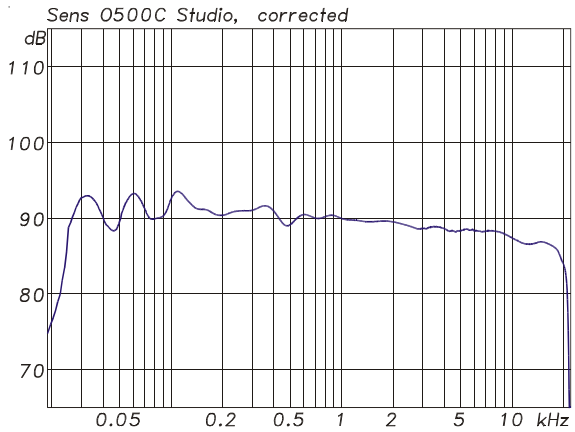
Please note that this type of correction is effecting the impulse behavior of the signal because a correction with IIR filters will shift the signal’s phase.

## 2.7 Calculating the new FIR-Filtered Parameter Sets

With the final corrective curve for the IIR EQ the new compound FIR parameter set can be calculated. This requires the „Monkey Forest“ measuring software. This software will assimilate the corrective curve into each original individual driver parameter set in order to achieve the new target function. The result will be the compound curve which is phase linear and frequency response corrected for the listening position.

## 2.8 Uploading into the Controller

Finally, the new parameter set calculated with the „Monkey Forest“ software must be uploaded into the controller via a RS232 interface.




*Resulting final frequency response curve with room compensation. A 100 % linearisation is not recommended because the ratio of direct to diffuse sound would be shifted by such a degree that an objective assessment of the program material cannot be ensured.*



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