NEUMANN
KH 750 DSP
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DSP-POWERED SUBWOOFER

With the KH 750 DSP, the Berlin manufacturer Neumann is launching its first subwoofer with an integrated DSP system. True to the motto “good things come to those who wait”, the new sub has a number of special features and unique selling points, which shall be examined in more detail.

Text & Measurements: Anselm Goertz  Photos: Anselm Goertz, Archive  Translation: Andreas Hau

The primary unique selling point, patented by Sennheiser/Neumann, is the ability to linearize the phase of the monitors connected to the KH 750 DSP by means of an FIR filter in the subwoofer. Matching filter sets are available for the Neumann KH 120, KH 310, and KH 420 monitors. So even the models that operate only with analog filter technology, which so far are all models with the exception of the KH 80 DSP, can enjoy a largely linear phase frequency response.

The KH 750 DSP can be used to supplement and relieve the monitors in a stereo arrangement or to reproduce the LFE channel in film sound. In order to be able to use the subwoofer as flexibly as possible, there are analog and digital inputs as well as an integrated Bass Management with four modes for operation in a 2.0 stereo setup or for three variants for joint use of the subwoofer for both the LFE and the signal of another channel. The “LFE Fullrange” setting bypasses all internal low pass filters and allows operation via external bass management. Further setting options concern the Subwoofer Gain, a Low Cut, Phase adjustment in 45° steps as well as some peripheral functions like Auto Standby, Ground Lift and Bass Management Disabled. The latter allows to deactivate the subwoofer for a direct comparison and to operate the normal stereo monitors full-range without subwoofer. All these settings relate to the stand-alone operation in back-plane mode. Another switch is labeled “Control Mode Local/Network” and makes it possible to adjust all the settings described above and many additional functions via network. The switches and pots on the back panel are then disabled. The network connection is a standard Ethernet connection which allows the subwoofer to be connected to the house network. Consequently, the audio signal will soon come in one of the usual formats for audio networks via the Ethernet connection. For operation via the network, Neumann provide an iPad app in the App Store free of charge. Currently, the app is only available for the iPad, which, given its widespread use, shouldn’t be a real problem. Details of the app can be found in the box on page 49.

In view of DSP technology, networking, iPad apps, and bass management, one might be inclined disregard the actual core competence of the KH 750 DSP, i.e. low-frequency reproduction. But of course, Neumann have devoted the greatest attention to this area.
in particular. The 10” driver with ELFF (Extremely Linear Force Factor) technology, developed specifically for the KH 750 DSP, operates in a sealed enclosure that has been designed to be particularly solid and low in resonance using modern design methods. In principle, a sealed cabinet for woofers always means some loss in maximum level, at least partially. On the other hand, there are fewer phase rotations and a less rapid roll-off of the frequency response towards the lowest frequencies. A sealed cabinet acts as a 2nd order acoustic high pass filter (12 dB/oct) and a bass reflex cabinet as a 4th order high pass filter (24 dB/oct). Moreover, with bass reflex systems the damping of the driver by the cabinet is almost completely lost below the tuning frequency. If, as in the case of the KH 750 DSP, you want to create a small cabinet with a deep bass response, then for the reasons mentioned above a sealed cabinet is the first choice for the woofer.

PROFILE NEUMANN KH 750 DSP

- **Frequency range:** 18 Hz - 732 Hz (±3 dB)
- **Ripple:** 1.4 dB (20 Hz - 200 Hz)
- **Bass capability:** 100.6 dB (10% THD 50 - 100 Hz) 4π
- **Dimensions/Weight:** 330 x 383 x 383 mm (WxHxD) / 19.5 kg
The driver itself is an extreme long excursion chassis of modern design, which was developed in cooperation with Neumann and is built exclusively for Neumann. The diaphragm can perform a very large linear excursion thanks to a huge surround and the optimized drive (thanks to Klippel). The latter is usually at the expense of sensitivity, but this can be compensated for by sufficient amplifier power. The KH 750 DSP uses a Class D amplifier rated at 250 W. The power amplifier, power supply and DSP are all located on the inside of the rear panel and can be easily removed for servicing. However, there is no separate inner housing for the electronics, which was probably a compromise in terms of enclosure size. In order to prevent the rear panel from vibrating, it is not a simple aluminum plate, but a solid folded steel plate. In addition, all speakers are tested in the QC lab for absolute tightness of the rear panel and rattle-free controls.

DSP and FIR filtering. On the subject of measured values, we first turn our attention to the filtering for the connected speakers. For the Neumann models mentioned above, there are ready-made FIR filters which leave the amplitude curve completely untouched and only equalize the phase. This is made possible by the ability of FIR filters to define amplitude and phase independently of one another. The only limit is the length or latency of the FIR filter. If, for example, you want to equalize the phase of a loudspeaker whose phase rotation causes the latency to increase to 30 ms at low frequencies, this can only be done with an FIR filter that delays all other signal components to this value and thus causes a latency of at least 30 ms. And that’s exactly the reason why Neumann have dispensed with phase equalization at very low frequencies, resulting in a total latency of the DSP system of only 3.15 ms, including ADC and DAC.

Inevitably, the question arises why only the phase is equalized and not the amplitude, if you do have the option. The answer may sound a bit arrogant at first: it’s not necessary. All the monitors mentioned have a perfectly straight frequency
The following measurements of frequency response, dispersion behavior and distortion values were performed in the measurement laboratory under anechoic conditions. The Class 1 measurement room allows measurement distances of up to 8 m and offers free-field conditions from 100 Hz upwards. All measurements were made with a B&K 1/4"-4939 measurement microphone at 96 kHz sampling rate and 24-bit resolution using the Monkey-Forest audio measurement system. Measurements below 100 Hz were made as combined near-field-far-field measurements.

01 Frequency response of a KH 310 measured directly (blue curve) and via the KH 750 DSP (red curve). There is no change in the amplitude response.

02 Phase response of the KH 310 measured directly (blue curve) and via the KH 750 DSP (red curve). The phase response of the KH 310 is linearized using the FIR filter. Its total latency, including ADC and DAC is only 3.15 ms.

03 Frequency responses of the KH 310 (blue) and KH 750 DSP (red) in interplay with a crossover frequency of 80 Hz. The green curve shows the sum function.

04 Phase responses of the KH 310 (blue) in combination with the KH 750 DSP (red) as subwoofer. The green curve shows the sum function.

05 Frequency response of the KH 750 DSP without low pass filter. The lower –3 dB corner frequency is at an impressive 18 Hz. The blue curves show the low cut realized as a bell filter for settings from -3 to -12 dB.

06 Filter functions in the KH 750 DSP. The low pass filter for the subwoofer (red curve), the high pass function for the main speakers (dark blue curve) and the filter function for the main speakers in full-range mode without subwoofer. The separation to the subwoofer is done at 80 Hz using 4th order Linkwitz-Riley filters. In full-range mode the filter for the main speakers does not influence their amplitude.

07 Maximum levels of the KH 750 DSP measured with sine bursts for a maximum of 1% (green), 3% (blue) and 10% (red) distortion (THD). The levels refer to 1 m distance in free field under full room (4π) conditions.

08 Measurement of intermodulation distortion using a multitone signal with 12 dB crest factor for a maximum of 10% distortion. With reference to 1 m in the free field, a level of 105 dB is achieved as Lpk. The red curve shows the total level, the blue curves show the distortion components as FFT lines and summed for 1/12 octave bandwidth.

09 Averaged frequency response measurement over 30 positions each for the left and right speaker around the listening position. Non-smoothed response without EQ (green) and with EQ (blue). The red curve shows the frequency response of the filter setting.
response that can hardly be improved upon.

To test how well this phase linearization for the connected speakers has been implemented in the KH 750, a somewhat older pair of KH 310s from the lab inventory was used. Fig. 1 shows the frequency response of the KH 310 without and with filtering from the subwoofer. The curves are completely identical except for the roll-off above 20 kHz. The unfiltered KH 310 shows the well-known 270°+2x360° phase rotation of a 3-way system. With filtering, only the 270° phase rotation at the lower end of the frequency range remains, which is not equalized because of the resulting latency, as was explained above. Above 200 Hz, the KH 310 now works almost perfectly linear phase. If the subwoofer in Fig. 3 and 4 comes into play, then the crossover with corresponding high and low pass filters causes another 360° phase rotation. The idea of using linear phase FIR high and low passes here seems tempting, but again fails because of the latency involved. The frequency response of the combination of KH 310 and KH 750 DSP shows very nicely how the lower corner frequency of 34 Hz for the KH 310 alone shifts down to about 18 Hz. Whether you need this largely depends on the audio material being processed. For film sound or EDM, a bass extension of about an octave should be relevant. Regardless of the lower cutoff frequency, there are other important arguments for the subwoofer, which relieves the main speakers of the low frequencies and thus provides less distortion or allows higher levels. There is also the general advantage of having a greater degree of freedom in positioning the main speakers and the subwoofer within the room. Further measurements: Another laboratory measurement of the KH

**IPAD APP**

The Neumann Control iPad app allows a complete configuration of the KH 750 DSP. If the subwoofer is in Network Control mode, all settings can be made using the app. This applies not only to the configuration of the components, but also to their complete room alignment with level, delay and various filters. By means of the app, the user is guided step by step through the parameterization. If necessary, the app also shows which settings need to be made on the connected monitors and advises on a favorable speaker setup.

Once all settings have been made, you get the message “Setup done! For best results please align your system now.” Afterwards there are the two possibilities of a “Guided Alignment” or a “Manual Alignment”. The latter requires you to make your own measurements. In the Guided Alignment, the room dimensions, the volume, the acoustic behavior (reverberant, dry, ...) or alternatively the average reverberation time are entered. Next parameters such as the distance to the wall, the distance to the listening position, the placement behind or on a desk and other details for each loudspeaker in the setup are queried, and the filter settings are derived from this. With this procedure, the software determines an alignment specifically adapted to the listening situation for the respective loudspeaker model. If necessary, this can then be individually edited, e.g. to specifically address room resonances.

The option “Manual Alignment” opens a controller window, whose default settings are neutral, in which level, delay and filter can be set for all speakers involved. The filter bank per path consists of one low and one high shelf as well as eight freely configurable filters that can be defined as bell, shelf, notch, high or low pass. Unfortunately, the filter parameters can only be entered via small faders next to the graphics. Numerical input of the filter parameters is not possible. Even though it is considered modern to use a stylus or finger on the touch display of an iPad, this is rather a hindrance when setting the filters according to concrete numerical values. When setting the filters, it should be noted that the filters are not set as EQs in the inputs for left and right channel, but in the outputs for the subwoofer and for the left and right monitors.

Once the system configuration is complete and the alignment is done, the setup is saved in the system. The functions Dim, Mute, Solo, Bass Management active and the level can be set via the app. Since the parameters are permanently stored in the subwoofer, the connection to the network can also be disconnected after the alignment, because the settings remain in the subwoofer.
750 DSP in Fig. 5 shows the KH 750 DSP in full-range mode without low pass filter. For this measurement, the LFE setup with external bass management was selected. The curve speaks for itself. The frequency response is almost perfectly straight from 18 Hz to just over 700 Hz, based on a ±3 dB tolerance band; between 20 Hz and 150 Hz, even a ±0.8 dB tolerance band would suffice. Fig. 6 shows the frequency responses of the filter functions for the 80 Hz crossover between subwoofer and main speakers. The maximum level measurement for the KH 750 DSP was carried out with 680 ms long sine burst signals from 20 Hz to 200 Hz and in a second measurement with a special multitone signal for subwoofers. The measurement signal is composed of 40 sine signals from 20 Hz to 200 Hz in 1/12-octave intervals with random phase. The crest factor of this multitone signal is approx. 12 dB and thus comes quite close to a real music signal. In the classic measurement method using sine bursts, the KH 750 DSP achieves a maximum level of 100 dB referred to a distance of 1 m in the free field under full-room conditions. Standing on the floor and thus in half-space, 6 dB higher values are achieved. The curves in Fig. 7 show that the sound pressure level of 100 dB is achieved for a maximum of 10% THD from 38 Hz and for a maximum of 3% THD from 50 Hz. The multitone measurement yields a peak level Lpk of 105 dB at 10% THD, also referenced to 1 m distance in the free field under full-room conditions. If one compares these values with those of the Neumann monitors, then the KH 750 DSP is a well-suited complement to the KH 80 DSP, KH 120 and KH 310 models. However, the KH 750 DSP cannot quite reach the maximum level of the large KH 420.
For the listening test, the KH 750 DSP was used together with the two KH 310. All settings were made using the iPad app. The alignment was made in manual mode with the support of a measurement system. The filter settings derived from the measurement are shown in Fig.9. The measurement procedure was such that 30 measurements were first taken for each loudspeaker in the vicinity of the listening position and then averaged energetically. If the curves for the left and right loudspeaker agree sufficiently, the curves can then be used together for the filter settings. In the case of larger deviations, individual filtering may be necessary, but this should always be implemented with a certain degree of caution. If large differences occur between left and right, possible causes should be investigated and, if possible, eliminated. Since the filters in the KH 750 DSP are located in the outputs, all filters of the top speakers should be set identically for the subwoofer at lower frequencies (<800 Hz).

In the test setup, the subwoofer led to a clear improvement in the KH 310s’ delivery, which became more relaxed and precise in the bass and also reached lower with the subwoofer, which of course is only noticeable if the signal contains relevant low-frequency content. Independently of the bass reproduction, the KH310 also benefits from the phase equalization provided by the FIR filters in the KH 750 DSP, which improves the monitors’ imaging focus to some degree. Conclusion: With the KH 750 DSP, Neumann present a subwoofer that has very good acoustic properties as a subwoofer, but also offers considerable added value because of its filter functions and bass management. All current Neumann monitors can be equalized for linear phase using the filters in the KH 750 DSP. In the interplay with the Neumann.Control app, the setup of the monitoring system is also facilitated, thanks to the DSP system in the subwoofer, which opens up the possibility of individual filtering and adjustment. In addition to its qualities as a subwoofer, the KH 750 DSP thus is a highly recommended purchase for all users of the current Neumann monitors in particular.

In relation to what the KH 750 DSP has to offer, and considering Neumann’s well-known perfection in development and manufacturing, the list price of 1,495 euros is an offer that can hardly be refused, especially if you already own a pair of the aforementioned Neumann monitor models.

Further possibilities arise with the currently newly introduced MA 1 system for automatic calibration of the filters in the KH 750 DSP. The MA 1 set for 249 euros includes the associated software for macOS or Windows 10 and a measurement microphone. Using a computer and a high-quality sound card, individual measurements can be performed. A first field report on the MA 1 will follow shortly.