

BRÜEL & KJÆR® Electroacoustic Solutions

Head and Torso Simulator Types 4128-C and 4128-D Handset Positioner for HATS Type 4606

Head and Torso Simulator (HATS)

Head and Torso Simulator Types 4128-C and -D are manikins with built-in mouth simulators and calibrated ear simulators (according to IEC 60318-4 and ITU-T Rec. P.57 Type 3.3) that provide realistic reproduction of the acoustic properties of an average adult human head and torso. They are ideal for performing in situ electroacoustic tests on, for example, telephone handsets (including mobile and cordless), headsets, audio conference devices, microphones, headphones, hearing aids and hearing protectors.

Handset Positioner for HATS

Handset Positioner Type 4606, with pressure/force and position read-outs, allows accurate, repeatable mounting of telephone handsets on HATS in both standardized and user-defined positions. This makes HATS into a state-of-the-art telephone test rig for measurement according to ITU-T recommendations.



Uses and Features

Uses

- Testing of headphones
- Evaluation of close-talking/noise-cancelling microphones
- Measurements on telephone headsets and hands-free communication devices
- Measurements on mobile and domestic telephones
- In situ/insertion measurements on hearing aids
- Testing of hearing protectors

Additional Uses When Using the Handset Positioner*:

- Accurate, repeatable positioning of telephone handsets on HATS for electroacoustic measurements
- Testing of almost all telephone handset designs
- Measurements in standardized positions according to ITU-T Rec. P.64

Features

- Provides accurate acoustic representation of the average human adult
- Complies with the acoustic requirements of ITU-T Rec. P.58, IEC 60318-7[†] and ANSI S3.36
- Highly representative mouth simulator based on ITU-T Rec. P.58
- Highly representative calibrated ear simulator based on IEC 60318-4[‡] and ITU-T Rec. P.57 Type 3.3
- Includes pinnae complying with ITU-T Rec. P.57 (harder pinnae are available)
- Adjustable neck angle to permit realistic posture
- Individual calibration data supplied

Additional Features When Using Type 4606

- Adaptable for a wide variety of telephone handset types
- Simple to configure for both standardized and user-defined mounting positions
- Graduated adjustment in three planes about the ear reference point
- Spring-loaded mounting of the handset against the ear with adjustable pressure force
- Positioning on both ears simulating right- and left-handed handset users (with Type 4159-C)

* Type 4128-D or Type 4128-C with optional Type 4606

[†] IEC 60318-7 formerly known as IEC 60959

[‡] IEC 60318-4 formerly known as IEC 60711

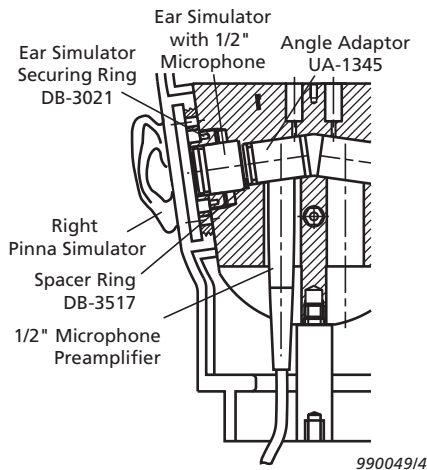
Head and Torso Simulator (HATS) Type 4128-C consists of a head mounted on a torso, representing the international average dimensions of a human adult. In airborne acoustic measurements it provides the correct simulation of the acoustic field around a human head and torso. You can use HATS free standing, fitted on a tripod, or on a turntable using a tripod mounting adaptor. HATS includes a mouth simulator and Right Ear Simulator Type 4158-C. Left Ear Simulator Type 4159-C is available for binaural measurements. HATS has an adjustable neck that allows you to position the head in a realistic posture for different positions of the torso. This is useful in real-life simulations, for example measurements in car seats.

Type 4128-D is HATS Type 4128-C with Handset Positioner Type 4606 included. The handset positioner is also available as a separate accessory. All head and torso simulators are delivered with individual calibration.

Description of Type 4128-C

The Ear Simulator

Fig. 1
Cross-section of the right ear with Right Ear Simulator Type 4158-C fitted



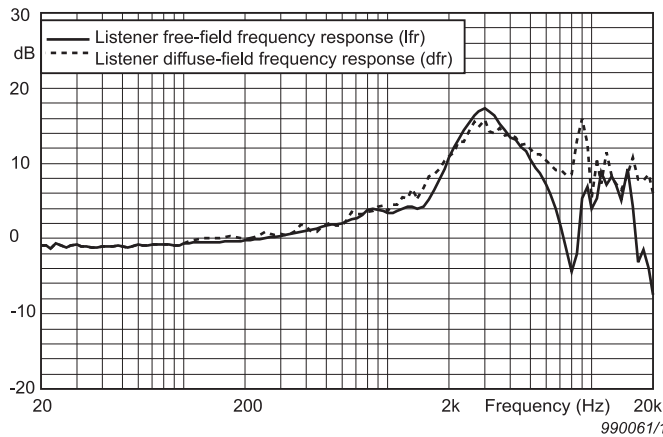
Each ear simulator consists of a removable silicon-rubber pinna joined to an ear canal. The ear canal ends in an occluded ear simulator that simulates the inner part of the ear canal according to the IEC 60318-4 standard. The ear simulator contains a 1/2" microphone and is connected to a microphone preamplifier with an adaptor. The ear simulator complies with ITU-T Rec. P.57 and ANSI S3.25.

Type 4158-C is the manikin's right ear simulator. Left Ear Simulator Type 4159-C is also available for binaural measurements*. Types 4158-C and 4159-C are each delivered with a calibration chart specific to their ear simulator and standard pinna. Sound Calibrator Type 4231 and Pistophone Type 4228 are suitable calibrators for these ear simulators.

Each ear simulator is delivered with a pinna corresponding to ITU-T Rec. P.57 (hardness rated at 35 on the Shore-00 scale).

This allows measurements on, for example, handsets using a realistic application force and obtaining a close simulation of an average human acoustic impedance to the handset. The pinna enables realistic deformation levels for measuring in open, semi-sealed or sealed conditions due to its specially designed human-like shape and stiffness. Another somewhat harder pinna is available when the pinna hardness matters less and conformance with P.57 is not required. This pinna's hardness is rated at 55 (on the Shore-00 scale) and is more durable than the softer pinna.

Fig. 2
Typical listener free-field and diffuse-field frequency responses of Type 4128-C



The combined influence of the torso, head, pinna and ear canal on airborne sound signals can be quantified by the acoustic free-field transfer function (the frequency response from free-field to the eardrum). This is called the listener free-field frequency response (lfr) or head related transfer function (HRTF) in telecommunications, and the manikin frequency response in technical audiology.

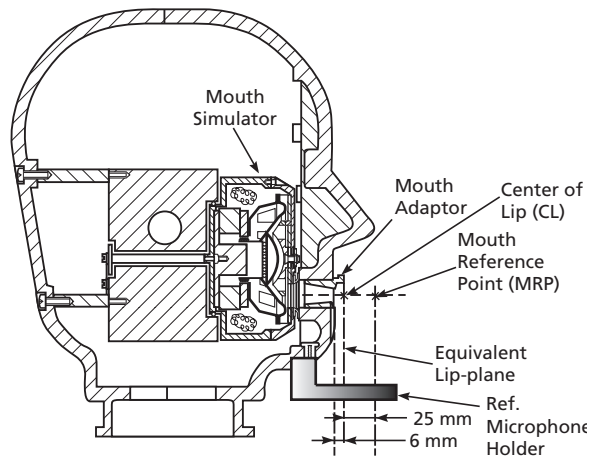
The typical listener free-field response of Type 4128-C for sound incidence at 0° (that is, coming from the front) is shown in Fig. 2. The listener diffuse-field frequency response (dfr) is also shown.

The frequency response data is provided with the HATS.

* Type 4159-C can be fitted to head and torso simulators with serial number 1947214 or higher (from February 1997). Type 4159-C cannot be retrofitted to earlier HATS units due to a re-design required for EMC conformance.

Fig. 3
Reference points of the
HATS mouth simulator

The Mouth Simulator



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The HATS mouth simulator has a high-compliance loudspeaker that gives powerful low-frequency response and low distortion. The acoustic transmission path from the loudspeaker to the mouth opening ensures an easily equalized frequency response of the sound pressure level in front of the mouth. The equivalent lip-plane containing the ITU-T centre of lip (CL) is 6 mm (.24") in front of the mouth opening. The usual calibration position is at the ITU-T mouth reference point (MRP), 25 mm (.98") in front of this plane. A holder is supplied with the HATS that will hold a ¼" reference microphone at precisely the correct distance for calibration at the MRP. This holder can also hold a microphone right at the opening of the mouth if you want to monitor or equalize the sound pressure at this point.

The mouth simulator produces a sound-pressure distribution around the opening of the mouth simulating that of a median adult human mouth, corresponding to the figures given in ITU-T Rec. P.58. An individual equalization procedure ensures a flat frequency response, enabling the mouth simulator to follow the frequency range of human subjects. Type 4128-C has the closest and most accurate human-matched behind-the-lip-plane* representation ideal for testing microphones in devices that pick up the sound between the mouth and ear, for example Bluetooth® headsets, modern mobile phones and professional theatre microphones.

Handset Positioner for HATS Type 4606

Fig. 4
Handset Positioner for
HATS Type 4606

Brüel & Kjær has developed Handset Positioner for HATS Type 4606 (see Fig. 4) for repeatedly accurate positioning of telephone handsets on the HATS for electroacoustic measurements. Type 4128-D includes Type 4606, which is also available separately as an accessory (upgrade) for Type 4128-C. The device screws directly into the top of the HATS and securely holds and positions mobile, cordless or conventional handsets. The handset mounts in the handset cradle, which is a multi-adjustable fixture capable of firmly holding practically any type of handset.



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Fig. 5
Alignment of receiver of
mobile phone in cradle

An alignment jig is supplied (see Fig. 5) that allows you to position the handset within the cradle, setting up the handset's ear reference point (ERP) and the ear cap plane. When the handset and cradle are mounted on the handset positioner, the ERP of the handset then corresponds to the nominal ERP of the HATS pinna. All the important fixing and positioning adjustments are accomplished via precision mechanisms equipped with graduated markings so that any position or adjustment is repeatable by simply setting all the positioning parameters to the appropriate values. To this end, HBS supplies a table for noting down these parameters (see [Handset Positioner Table](#)).

Once the cradle is mounted on the handset positioner, it can be adjusted in three different planes about the ERP, and the corresponding angles can be read off graduated markings. Additional cradles are available as accessories.



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* Celmer, Robert D., Beers, C., Miller-Klein, E., "Behind the Lip-Plane Acoustic Radiation Study of Human Subjects and Head & Torso Simulators", Audio Engineering Society 121st Conference, October, 2006.

The handset can be pressed against the HATS pinna with adjustable force (0 – 18 N) by the handset positioner. This is done using a screw adjustment that allows you to set the force via a scale graduated in newtons. The resulting deflection of the pinna and the movement of the handset ERP occur along the axis formed by the nominal ERPs of the left and right HATS pinnae. The deflection can be read off the handset positioner that is graduated in millimetres.

Type 4606 is also easy to set up for standardized measurements. A standardized position, the “HATS position” as defined in ITU-T Rec. P.64, is clearly marked on the handset positioner. This position takes into account the anatomy of the average human head. For exploring the effect of asymmetric transducers and simulating right- and left-handed users, it is possible to perform measurements on both ears. This is simply done by turning the transverse part of the handset alignment tool by 180°, and repeating all graduations of the adjustment screws for the left-hand position. A built-in quick release mechanism for the cradle makes it easy to change the handset or to change between measurements on the right and left ear.

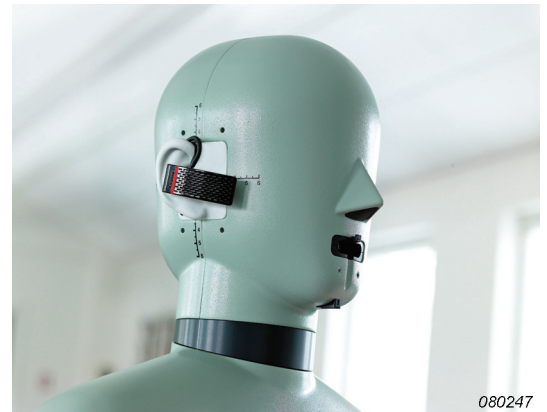
For users of the table-top Telephone Test Head Type 4602-B, when it is fitted with the HATS positioning jig it corresponds directly to the HATS position of Type 4606.

Applications

*Fig. 6
Headset mounted on right
pinna simulator of HATS*

Headset Measurements

The ear simulator in Type 4128-C allows accurate measurements to be made on the receiver part of a wireless or corded communications headset. The characteristics of the transmitting part can be measured thanks to the mouth simulator. Having both a mouth and an ear simulator, Types 4128-C/D can also be used for sidetone measurements.



*Fig. 7
Headphones mounted on
HATS*

Headphone Measurements

You can use Types 4128-C/D to determine a variety of headphone characteristics in situ. The influence of the pinnae is taken into account and the ear simulators provide the correct acoustic loading, so realistic evaluation of open, closed and insert headphones can be made. Simulated insertion responses are measured referring to either the equivalent free-field or diffuse-field response. Types 4128-C/D can also be used to determine the left/right tracking and background noise insertion loss of headphones.



*Fig. 8
HATS being used for
microphone and
hands-free communication
measurements*

Microphone and Hands-free Communication Measurements

When measuring on microphones, Types 4128-C/D can closely simulate the interaction between the mouth, head, body and microphone.

Its mouth simulator is an ideal sound source for the research, development and evaluation of a variety of microphones. In particular, you should use Types 4128-C/D with close-talking, noise-cancelling and lavalier types of microphones, in which the characteristics of the human voice must be reproduced accurately and the acoustic influence of the head and body is important.



Likewise, the quality of hands-free applications such as video conference and laptop VoIP call technologies can be measured intensively for codec optimization, sidetone tracking, noise cancellation, etc.

Types 4128-C/D enable full duplex operation (simultaneous receive and transmit) for simulation of real-life communication situations.

Fig. 9
Hearing aid fitted in left ear mould simulator

Hearing Aid Measurements

Both in-the-ear and behind-the-ear hearing aids can be evaluated with Types 4128-C/D. Two ear mould simulators are supplied with Types 4128-C/D for testing hearing aids where individually made ear moulds are normally used. The mouth simulator in Types 4128-C/D is useful for developing multi-microphone noise-cancelling hearing aids. Simulated insertion gain, simulated directional responses and in situ maximum output can be measured using HATS, as described in IEC Publication 60118-8, "Methods of Measurement of Performance Characteristics of Hearing Aids under Simulated In-situ Working Conditions".



Fig. 10
HATS being used for in-vehicle measurements

In-vehicle Measurements

The sound field in cars and other small enclosures is influenced to a great extent by the physical presence of people in the enclosures. Types 4128-C/D greatly simplifies representative acoustical measurements under these conditions, enabling more realistic evaluation of vehicle audio systems and mobile telephones, and the effectiveness of measures taken for noise control.



Fig. 11
HATS can also be used for evaluation of integrated helmet systems

Helmets/Masks

Previously, evaluation and testing of integrated helmet systems, for example communications equipment in crash helmets and gas masks, have been difficult to do realistically. With Types 4128-C/D, such systems can be thoroughly and realistically investigated with respect to both signals and noise. The mouth simulator of Types 4128-C/D replicate the sound field generated by the human mouth even with respect to the frequency-dependent motion of the acoustic centre in the frequency range important for high-end, noise-cancelling microphones.



Fig. 12
Stereo earphone mounted in HATS pinnae

Earphone Measurements

The artificial pinnae of the ear simulators enable mounting and testing of small in-the-ear earphones supplied with modern portable players, telephones, etc.

Hearing Protector Measurements

Evaluating hearing protectors is straightforward using HATS instead of human subjects. The most important characteristic for hearing protectors is airborne insertion loss. This is found by measuring the free-field response of Types 4128-C/D with and without the hearing protectors in place and comparing the results. Types 4128-C/D can be placed in situ, so the actual noise sources for which the hearing protector is designed can be used in tests. The effectiveness of hearing protectors on noise from different angles is also easy to investigate.

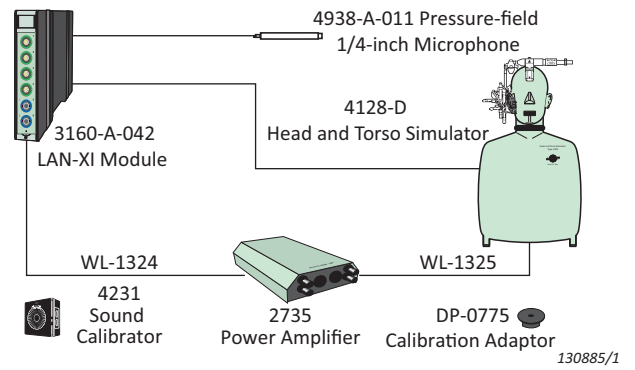


Fig. 13
Example of setup for
telephone testing

Telephone Measurements

HATS can be used as a representative manikin for in situ evaluation of telephone equipment including handset telephones, hands-free telephones, and group audio terminals or headsets. With both an ear simulator and mouth simulator, you can investigate, receive, and transmit acoustic sidetone and background noise characteristics for the full range of audio terminal devices. Full duplex operation is possible.

Several telephone test software and hardware solutions are available; for up-to-date descriptions see [our website](#).







References to Standards

Please note that generic references to standards have been used in this document. The specific revisions of these standards are listed in the table below:

STANDARD	DATE REVISION WAS PUBLISHED
ITU-T Rec. P.57	June 2021
ITU-T Rec. P.58	June 2021
ITU-T Rec. P.64	June 2019
IEC 60318-4	January 2010
IEC 60318-7	April 2017
ANSI S3.25	2009
ANSI S3.36	1985

Compliance with Standards

   	<p>The CE marking is the manufacturer's declaration that the product meets the requirements of the applicable EU directives</p> <p>RCM mark indicates compliance with applicable ACMA technical standards – that is, for telecommunications, radio communications, EMC and EME</p> <p>China RoHS mark indicates compliance with administrative measures on the control of pollution caused by electronic information products according to the Ministry of Information Industries of the People's Republic of China</p> <p>WEEE mark indicates compliance with the EU WEEE Directive</p>
Safety	EN/IEC 61010-1: Safety requirements for electrical equipment for measurement, control and laboratory use. ANSI/UL 61010-1: Safety requirements for electrical equipment for measurement, control and laboratory use.
EMC Emission	EN/IEC 61000-6-3: Generic emission standard for residential, commercial and light industrial environments. CISPR 32: Radio disturbance characteristics of information technology equipment. Class B Limits. FCC Rules, Part 15: Complies with the limits for a Class B digital device.
EMC Immunity	EN/IEC 61000-6-1: Generic standards – Immunity for residential, commercial and light industrial environments. EN/IEC 61326: Electrical equipment for measurement, control and laboratory use – EMC requirements. Note: The above is only guaranteed using accessories listed in this product data sheet.
Temperature	IEC 60068-2-1 and IEC 60068-2-2: Environmental Testing. Cold and Dry Heat. Operating Temperature: -5 ° to +40 °C (+23 ° to +104 °F) Storage Temperature: -25 ° to +70 °C (-13 ° to +158 °F)
Humidity	IEC 60068-2-78: Damp Heat: 90% RH (non-condensing at 40 °C (104 °F))
Mechanical	Non-operating: IEC 60068-2-6: Vibration: 0.3 mm, 20 m/s ² , 10-500 Hz IEC 60068-2-27: Shock: 1000 m/s ² IEC 60068-2-29: Bump: 1000 bumps at 250 m/s ²

Specifications – Head and Torso Simulator Types 4128-C and 4128-D

LISTENER FREQUENCY RESPONSE

Conforms to ITU-T Rec. P.58 up to 16 kHz for measurements on telecommunication devices and to IEC 60318-7 and ANSI S3.36 for measurements on air conducting hearing aids

EAR SIMULATOR

IEC 60318-4 and ITU-T Rec. P.57 Type 3.3-based calibrated ear simulator complying with ITU-T Rec. P.57, IEC 60318-4 and ANSI S3.25 standards. Output from the ear simulator is via a 7-core 3 m (9.8') cable (2.3 m (7.5') from the bottom of the torso) terminated with a Lemo® (1B) plug.

Typical Sensitivity: 11.6 mV/Pa = -38.7 dB (±1.5 dB) re 1 V/Pa @ 250 Hz

Pressure-field Response:

±1 dB from 5 Hz to 7 kHz
±3 dB from 3.15 Hz to 20 kHz
(Individually calibrated)

3% Distortion Level: 162 dB re 20 µPa at eardrum position

Typical Noise Level: 19 dB SPL(A) re 20 µPa at eardrum position

TYPICAL LEFT EAR TO RIGHT EAR TRACKING

±1 dB up to 5 kHz, ±3 dB up to 8 kHz (measured using the same ear simulator)

PINNA SIMULATORS

Compliant with ITU-T Rec. P.58, IEC 60318-7 and ANSI S3.36. Types 4158-C and 4159-C are supplied with calibrated pinna simulators. An additional pair of uncalibrated hard pinna simulators are available as accessories

MOUTH SIMULATOR

Input to mouth simulator via 0.75 m (2.46') cables (0.2 m (0.66') from the bottom of the torso) terminated with banana-sockets

Sound Pressure Distribution: Conforms to ITU-T Rec. P.58

Mouth Opening: W = 30 mm (1.18"), H = 11 mm (0.43")

Equivalent Lip-plane Position, CL: 6 mm (0.24") in front of the sound radiation opening

Mouth Reference Point, MRP: 25 mm (0.98") in front of mouth CL

Continuous Output Level at MRP:

- Min. 110 dB SPL, 200 Hz to 2 kHz
- Min. 100 dB SPL, 100 Hz to 8 kHz

Typical Sensitivity at 1 kHz: 80 dB SPL 2 V/500 mm

Distortion (Harmonic Components up to 10 kHz) at 94 dB SPL:

- <14% from 100 Hz to 200 Hz
- <2% from 200 Hz to 250 Hz
- <1% above 250 Hz

Max. Average Input Power: 10 W max. continuous average power (at 20 °C (68 °F))

Max. Pulsed Input Power: 50 W for 2 seconds



CAUTION: If the mouth simulator is excited with pulses of more than 50 W, damage may occur before the protection circuit reacts

Loudspeaker Impedance: 4 Ω

DIMENSIONS AND WEIGHT

The main dimensions comply with the dimensional requirements of ITU-T Rec. P.58 and the reports from IEC 60318-7 and ANSI S3.36

Total Height, Head and Torso: 695 mm (27.4")

Torso: Height: 460 mm (18"), Width: 410 mm (16"), Depth: 183 mm (7.2")

External Neck Diameter: 112 mm (4.4")

Head Angles: Vertical or tilted 17° forwards

Weight: 9 kg (19.8 lb)

Specifications – Handset Positioner for HATS Type 4606

SPEAKING POSITION

Standardized Position: HATS position as defined in ITU-T Rec. P.64
 $\angle A = 21.2^\circ$, $\angle B = 12.9^\circ$, $\angle C = 2.3^\circ$

Variable Positions: $\angle A$ adjustable from $+15^\circ$ to $+35^\circ$, $\angle B$ adjustable from $+30^\circ$ to -10° , $\angle C$ adjustable from $+20^\circ$ to -20°

Angle Resolution: 0.5°

Precision: Once mounted the handset ear reference position (ERP) can be positioned within 1 mm relative to the nominal ERP of the HATS pinna

HANDSET THICKNESS

Min: >0 mm ($>0''$)

Max: 44 mm (1.73'')

HANDSET WIDTH

Min: 26 mm (1.02'')

Max: 92 mm (3.62'')

HANDSET WIDTH WITH OPTIONAL CENTRING FORK UA-1537

Min: 26 mm (1.02'')

Max: 66 mm (2.6'')

TABLET DIMENSIONS SUITABLE WITH OPTIONAL UA-1541-W-001

Length: 190 mm to 257 mm (7.48'' to 10.12'')

Width: 85 mm to 190 mm (3.35'' to 7.48'')

Depth: Up to 18 mm (0.71'')

OFFSET ADJUSTMENT

For asymmetrical handsets the offset perpendicular to the handset can be adjusted in the range \pm half the handset width minus 8 mm

END STOP ADJUSTMENT

The end stop can be adjusted from 8 to 36 mm (0 mm is located at the ear reference point (ERP) of the handset)

APPLIED EAR FORCE

The force that a handset exerts against the HATS pinna can be adjusted from 0 to 18 N

WEIGHT

Handset Positioner (incl. cradle, excl. handset): 1.4 kg (3.09 lb)

Alignment Jig (excl. cradle): 2.4 kg (5.29 lb)

Ordering Information

Type 4128-C-001 Head and Torso Simulator with Right Ear Simulator and Mouth Simulator

Type 4128-C-002 Head and Torso Simulator with Right Ear Simulator, Left Ear Simulator and Mouth Simulator

Type 4128-D-001 Head and Torso Simulator Type 4128-C-001 with Handset Positioner for HATS Type 4606

Type 4128-D-002 Head and Torso Simulator Type 4128-C-002 with Handset Positioner for HATS Type 4606

Overview of included parts:

	TYPE 4128-C- 001	TYPE 4128-C- 002	TYPE 4128-D- 001	TYPE 4128-D- 002
Right Ear Simulator Type 4158-C	•	•	•	•
Left Ear Simulator Type 4159-C		•		•
Mouth Simulator	•	•	•	•
Handset Positioner Type 4606			•	•

All Types 4128-C and 4128-D include the following accessories:

- BC-5000-C: Calibration CD
- DZ-9769: Right Pinna, soft (Shore-00 35)
- DZ-9770: Left Pinna, soft (Shore-00 35)
- DB-2902: Ear Mould Simulator, short
- UC-0199: Ear Mould Simulator, long
- UA-1546: Adaptor for Calibration
- QA-0167: Ear Mounting Tool
- QA-0223: Preamplifier Mounting Tool
- UA-1043: Support Feet
- UA-2127: Ref. Microphone Holder

- UC-5290: Adaptor for Tripod

Optional Accessories

Type 4606	Handset Positioner for HATS with 2 × Centring Forks for Wide Handsets UA-1587 (included with Types 4128-D-001 and 4128-D-002)
UA-1537	Centring Fork for Type 4606 (for handsets with width between 26 mm and 66 mm)
UA-1541-W-001	Cradle for Tablet, with forks, feet and end stop (for Type 4606)
UA-1642	Deep Cradle (for Type 4606)
Type 4159-C	Left Ear Simulator (included with Types 4128-C-002 and 4128-D-002)
Type 4231	Sound Calibrator
Type 4938	¼" Pressure-field Microphone
Type 2670	¼" Microphone Preamplifier
UC-5345	Torso with adjustable neck ring – Upgrade
DZ-9771	Right Pinna, hard (Shore-00 55)
DZ-9772	Left Pinna, hard (Shore-00 55)
DZ-9773	Right Pinna with tapered ear canal, soft (Shore-00 35)
DZ-9774	Left Pinna with tapered ear canal, soft (Shore-00 35)
AO-0419	Microphone Cable
WQ-2701	Heavy Duty Tripod
WA-1647	HATS Car Seat Fixture
WE-0195	Flight Case
AO-0414	Extension Cable

Services

4128-CFF	Factory Standard Calibration
4128-EW1	Extended Warranty for Head and Torso Simulator Type 4128-C, one year extension
4606-TCF	Conformance Test (mounting and testing of Type 4606 on Type 4128-C)

Skodsborgvej 307 · DK-2850 Nærum · Denmark
 Telephone: +45 77 41 20 00 · Fax: +45 45 80 14 05
 www.bksv.com · info@hbkworl.com
 Local representatives and service organizations worldwide

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