PRODUCT DATA

Voice Testing Software for Hands-free Equipment — Type 7909-S1

Voice Testing Software for Hands-free Equipment Type 7909-S1 provides a fast and efficient approach to voice testing of hands-free equipment used in connection with mobile phones. Whether the hands-free equipment is part of a mobile phone system integrated in a car or is connected to a common mobile phone, Type 7909-S1 can test the audio performance.

Type 7909-S1 has its origins in the dedicated test specifications outlined in the VDA standard (Verband der Automobilindustrie) for testing of hands-free equipment. With the software, the microphone system can be tested separately and under different conditions as outlined in the VDA standard, and the complete hands-free system can also be tested under the conditions outlined.

Type 7909-S1 is a powerful tool in the development of hands-free equipment. It is built on the PULSE™ platform, which also provides a wide range of analysis capabilities for the verification of acoustic design during development. Furthermore, it is a versatile platform for objective as well as subjective evaluation of specific components such as noise suppressors, echo cancellers, and so on. With PULSE there is a natural upgrade path for testing mobile phones according to international standards for measuring audio performance.

Uses and Features

Uses

- Testing of hands-free equipment according to the VDA standard
- Measurement of the complete transmit and receive signal path using an air interface
- Measurement of the acoustical performance of the microphone or the complete microphone system
- Research and development of hands-free equipment with focus on voice testing using advanced test signals
- Inspection and validation of hands-free equipment
- Quality assurance and sample testing of hands-free equipment

Features

- Pre-programmed test suites according to VDA test specifications
- Test suites that allow individual or complete sequences of tests with minimum operator interaction
- Flexible user-interface enabling users to modify parameters and tolerances in the individual test cases
- Supports the use of Head and Torso Simulator (HATS) as well as free-field microphone and mouth simulator
- Advanced test signals, such as the Composite Source Signal used for switching and echo measurements
- Automatic report generation
- Scalable system that can be configured depending on test required

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Introduction

The quality of hands-free equipment can only partly be characterised by means of the traditional parameters used for the characterisation of mobile phones. For the hands-free equipment, whether it is the microphone system, the loudspeaker system of the complete hands-free system, parameters such as frequency response, loudness rating, terminal coupling loss, and directivity response must be determined. However, other parameters such as duplex capability, transmission quality in the presence of background noise, switching, and echo cancelling have to be determined as these are known to have a close correlation with the perceived quality of hands-free equipment.

Voice Testing Software for Hands-free Equipment Type 7909-S1 is a comprehensive software package for testing the acoustical transmission performance of hands-free equipment according to the VDA standard. Furthermore, the system is designed to accommodate the needs for quality assurance testing, sample testing, incoming inspection and validation of hands-free equipment.

Voice Testing Software for Hands-free Equipment Type 7909-S1 together with a PULSE front-end constitutes a complete test system based on software-controlled instruments that allow measurements to be made consistently and with a minimum of operator interaction. Test suites delivered with the system allow tests to be run individually or as a sequence constituting the different sections of the VDA standard. Higher-level users can use the PULSE platform software interactively to develop their own tests and measurements to determine audio parameters not covered by standard test cases. This makes it easy to perform tests for research and development purposes.

All Type 7909-S1's control, measurement and report functions are software-based. The software is optimised to run under Microsoft® Windows®, its familiar interface making the system intuitive and efficient for inexperienced and experienced operators alike. Furthermore, extensive on-line help is always available to provide guidance if a question arises during test execution.
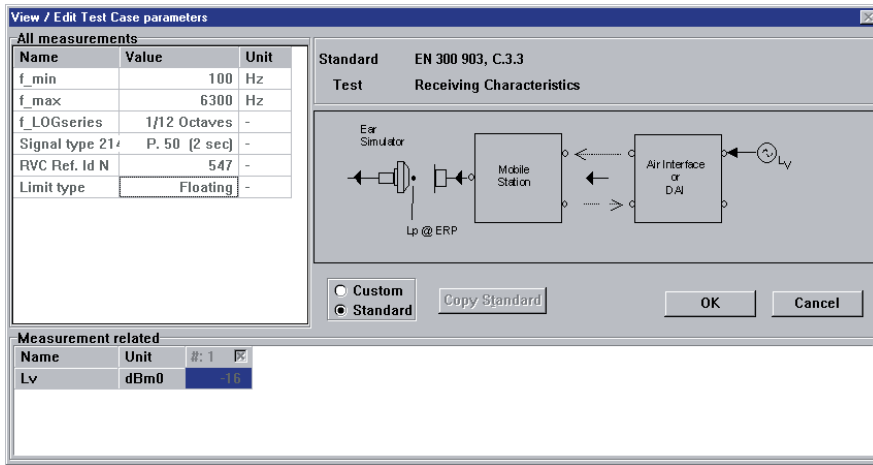
Performing Measurements

Fig. 1

Test Manager window for controlling the calibration procedures and test cases
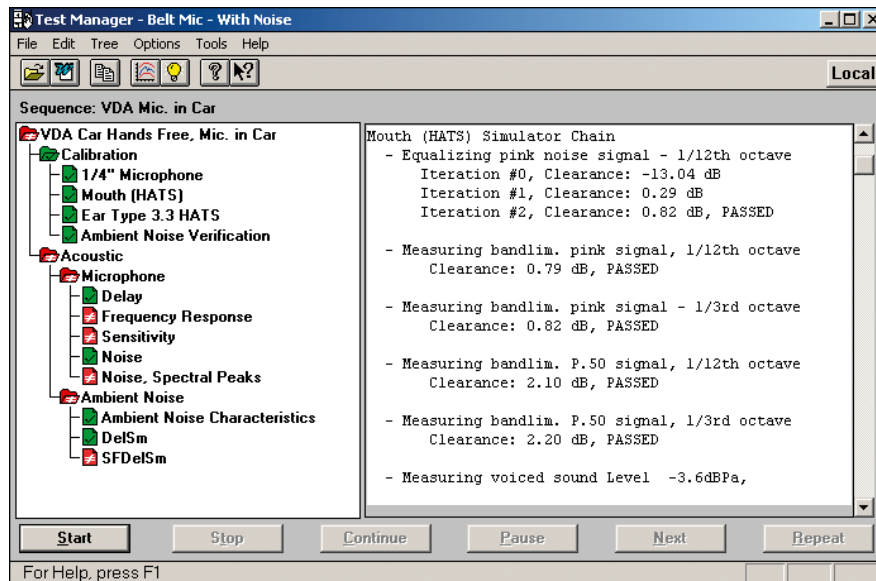
To control the actual measurements, the Test Manager (see Fig. 1) is used to start, pause and stop the testing of a specific telephone. The testing is performed in accordance with the selected session profile corresponding to a specific test suite or standard. When a session has been selected, the operator is presented with a hierarchical tree showing all the tests included in the session. By selecting the root of the tree, all tests are performed consecutively. It is also possible to select individual branches of the tree to do a limited range of tests, for example only sending characteristics. Test results are clearly indicated on the screen, making pass/fail judgements immediately obvious. Each test within a session can be performed according to the standard set down by the issuing authority. Alternatively, the operator can select different parameters and tolerances within the range of the hardware and software, allowing research and development testing to be conducted (see Fig. 2). As each test is performed, an information window shows the current state of the system and the results of the test in numeric form. Using the Data Browser, it is also possible to see the results of tests graphically during or after a test is performed.

Fig. 2
The software allows customisation of all relevant test-case parameters and requirements

Viewing, Storing and Retrieving Measurements

The Data Browser (see Fig. 3) is a versatile display for viewing measurements. Combined, the Data Browser and the Test Manager constitute a tool for instantly displaying the results of the current test or for viewing the previous tests. Several Data Browser windows can be opened at once, allowing direct comparisons to be made on-screen. Using the Windows® cut-and-paste facility, results can be copied to word-processing packages or spreadsheets.

Fig. 3
Speed and versatility are the main features of the Data Browser. The Data Browser displays the measurement results in graphical or tabular format
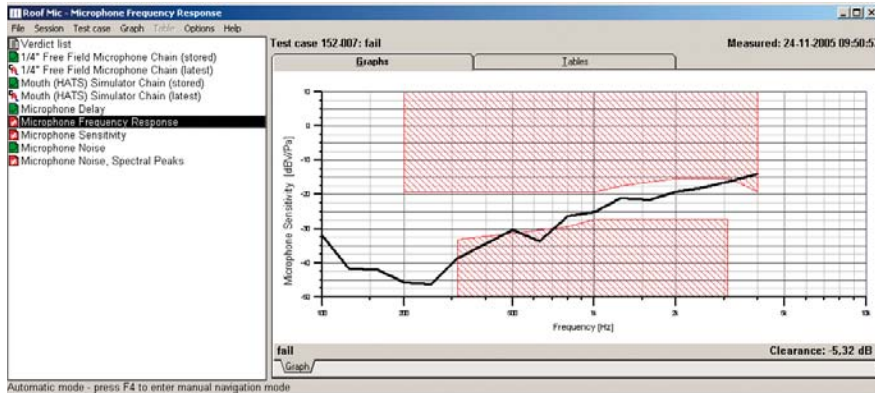
Using the Session Manager (see Fig. 4), the operator can gain access to the different sessions that hold the measurements. A session is a set of tests conducted on a telephone according to a specific standard and related measurement data produced during the test of the telephone. The Session Manager supports facilities to quickly find previous sessions and simple procedures to create new sessions. Commonly used sessions containing recurrent information, for example, the name of the test house or telephone manufacturer, are easily copied into new sessions, considerably reducing the time needed for test of similar telephones. Measurement results of stored sessions can be examined using the Data Browser and reports of stored sessions are easily produced with the report generator.

Fig. 4
The Session Manager supports viewing, storing and retrieving measurements

Documenting the Measurements

The Report Generator takes measurement data files, either singly, when selected from the Data Browser, or collectively when selected from the Session Manager or the Test Manager, and rapidly converts the stored results into pre-formatted Microsoft® Word documents. Each test can be presented in short form, showing only a graph and a table of the most important results, or in standard form, where parameters, tolerances and detailed measurement data are given. Once in Microsoft® Word format, the report can be printed, or the page layout modified to suit individual corporate standards.

Fig. 5
The Data Export tool for export of measurement results in different file formats
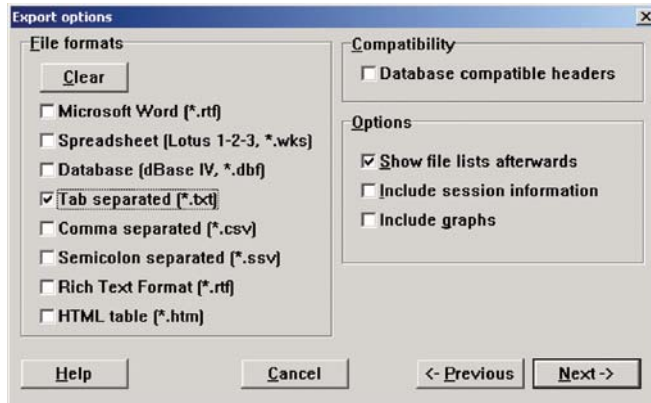
For customised documentation of measurements, the measurement data, etc., can be exported in a number of different file formats. This powerful export facility takes the measurement data and formats them into files that can be imported into a wide variety of standard data-processing programs (see Fig. 5). Measurement data can even be dynamically linked to enable automatic referencing and updating. The file formats currently supported are: ASCII (tab, comma, or semicolon separated), spreadsheet (support for Microsoft® Excel®), Rich Text Format (general and Microsoft® Word optimised), HTML table, and database format (Microsoft® Access).

Preparing for Measurements

Before making the actual measurements, the test system must be calibrated and, for measurements that involve a mobile phone, the radio link between the air interface and the mobile phone established. The software supports both these tasks.

The system needs to be calibrated at least once a day. During the calibration procedure, the ear simulator, mouth simulator and the electrical signal paths are measured, ensuring that any deviation can be digitally compensated for during the actual measurements. Calibration is valid for one day, i.e., 24 hours.

For measurements that involve a mobile phone, the radio link between the air interface and the mobile phone can be controlled manually or remotely. In remote mode, the air interface is controlled by the software via the IEEE−488 interface. The air interfaces that can be controlled remotely are HP-8922, CMD-55 and CMU-200. When controlled manually, the radio link is established from the front panel of the air interface. In manual mode, the operator must enter the send and receive gains at 1 kHz. Manual mode allows the use of air interfaces not supported by the control software. The manual mode also allows testing of other telephone technologies than the ones currently available for Type 7909-S1.

Fig. 6
Test System Configuration tool: Air Interface and Digital Audio Interface settings

System Configurations

Voice Testing Software for Hands-free Equipment Type 7909-S1 supports different hardware configurations. A configuration based on a PULSE Type 3560-C front-end and a configuration based on a PULSE Type 3560-E front-end are available. With these two configurations and associated options, a system for testing the relevant parts of the VDA standard can be defined. Whether the system should support the testing of microphones in the car and under anechoic conditions, or the testing of the complete hands-free device including the mobile phone, it all comes down to picking the suitable PULSE hardware platform and the proper options.

The configuration based on PULSE Type 3560-C, VDA Lite, supports:
- Testing of hands-free terminals in cars
- Testing of microphones in cars
- Operator controlled application of pre-equalized background noise

The configuration based on PULSE Type 3560-E, VDA Advanced, supports:
- Testing of hands-free terminals in cars
- Testing of microphones in cars
- Fully automated equalization of pre-recorded background noise – see the description of the PULSE Background Noise Replay System below
- Automated start of equalized background noise during measurements – see the description of the PULSE Background Noise Replay System below

Both configurations require the addition of an option for HATS or for free-field microphone.

Fig. 7
Typical configuration for testing hands-free telephones and car hands-free terminals. The system is built on the PULSE VDA Lite configuration and can be expanded with several options to cover relevant parts of the VDA standard

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Options available for the PULSE VDA front-end configurations:

- **Air Interface CMU-200:** For interfacing to the mobile phone in the hands-free system, an air interface for accessing the audio path and establishing the radio link between the mobile phone and the air interface is required.
- **Anechoic Test Box:** Considering that the performance of the microphone must be evaluated under quiet conditions, an Anechoic Test Box with a built-in loudspeaker and a reference microphone can be supplied with the system.
- **Free-field Microphone Option[1]:** To provide an acoustical interface to the microphone system as well as the hands-free system, the Free-field Microphone Option is required. This option includes an ordinary measuring microphone for use in free-field conditions and a stand-alone mouth simulator. As an alternative to this option, the HATS Option could be chosen.
- **HATS Option[1]:** To provide a proper acoustical interface to the microphone system as well as the hands-free system, HATS is required. HATS, equipped with an ear simulator and a mouth simulator, constitutes an indispensable component of the VDA configurations. As an alternative to this option, the Free-field Microphone Option could be chosen.
- **PC Option:** A suitable PC is required for controlling the PULSE VDA configurations, executing the VDA application software and controlling the air interface.
- **Portable Background Noise Recording System:** For recording background noise under realistic driving conditions in car, a small portable system consisting of a binaural microphone, a laptop PC and a PULSE Type 3560-B front-end is available. Background noise can also be recorded using the PULSE Type 3560-C front-end included in PULSE VDA Lite, in which case the software required for recording background noise must be added.
- **PULSE Background Noise Replay System:** For determining the performance of the hands-free system as well as the microphone system in a noisy environment, the application of background noise is required. With the PULSE Background Noise Replay System, automated equalization of the background noise under specific acoustic conditions can be conducted. The system also ensures that the background noise is automatically applied in the relevant test cases.
- **Speech Quality:** When testing the complete hands-free system, the VDA standard outlines that speech quality is evaluated using methods based on perceptual models of hearing.

For detailed information regarding the tests covered by the different configurations, please refer to Overview of Software Options and VDA Test Specification on page 8. For more detailed information on the PULSE VDA configurations as well as the listed options, please refer to the Ordering Information at the end of this document.

Using PULSE as a General Research and Development Tool

PULSE provides access to analyzers, post-processing functions and display facilities for many applications within the area of electroacoustic testing. Using the FFT Analyzer, CPB (1/nth octave) Analyzer, Overall Level Analyzer and Signal Generators, PULSE can be set up to accommodate the vast amount of different measurements typically required for R&D of new electroacoustic devices. Furthermore, PULSE contains a task-oriented user interface (Fig. 8) that allows the tasks involved in the complete measurement process to be implemented in PULSE as individual tasks that can be performed one after another. This could typically include many different types of analysis that can easily be managed and documented. All the tasks can be stored together with the actual measurements, and reports can be stored as a PULSE project that can be restored in PULSE at a later stage. For displaying the measurements, PULSE has a large variety of different functions such as 3D waterfall display and contour display (Fig. 9). For documenting the measurements PULSE supports the use of either dynamic or static links to Word or Excel displays.

Additional software that enhances the analysis capability of PULSE and that could be useful during the development of new electroacoustic devices are:

- PULSE Electroacoustics Type 7907 for determining frequency response, distortion, directivity, impedance and calculation of Thiele Small parameters, etc.
- PULSE Time Data Recorder Type 7708 or Time Capture Type 7705 for recording of acoustical or electrical signals – recordings that can be exported from PULSE as wave files and then be loaded into the generator and replayed

For more information on PULSE software and hardware please refer to System Data Sheets BU 0229 (PULSE Software) and BU 0228 (PULSE Hardware).

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[1] Please note that either the Free-field Microphone option or the HATS option must be included in the VDA configuration.

Fig. 8
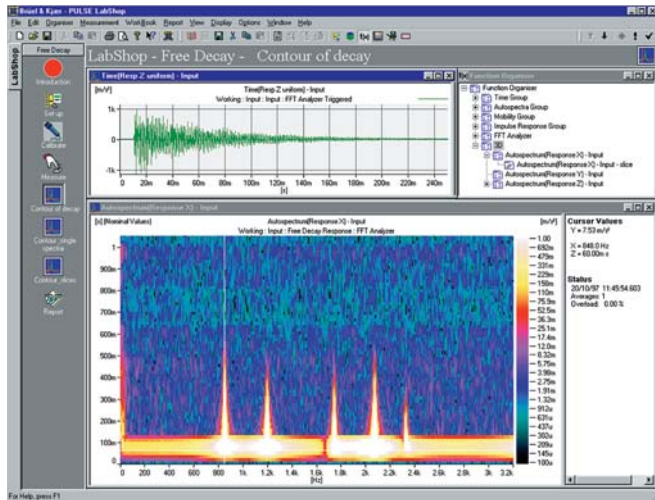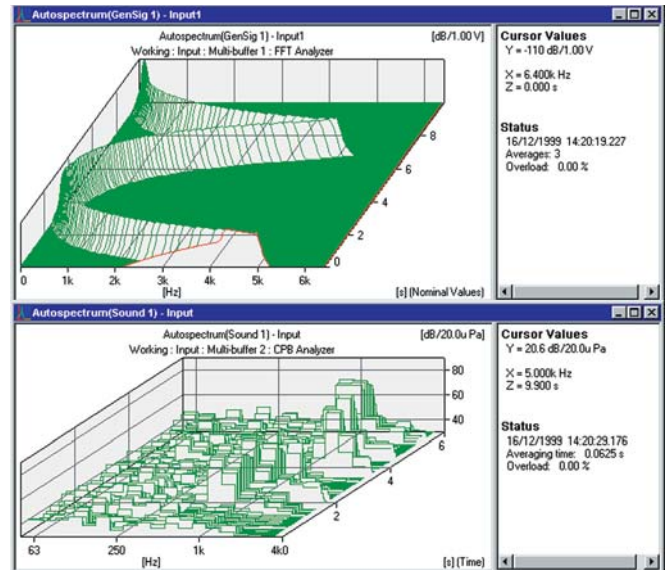*PULSE software showing task-oriented user interface*

Fig. 9
Waterfalls showing FFT and 1/3-octave acoustic response from multi-analysis using FFT and Real-time Digital Filter (CPB) analyzers


Using Sound Quality for Product Sound Evaluation

Using the Brüel & Kjær Sound Quality solution during the development of specific electroacoustic components enables useful sound quality parameters such as loudness, sharpness, fluctuation strength, roughness and related parameters to be determined.

The main features of the sound quality software allow recording, editing and replay of sounds using binaural techniques. It also supports Subjective Listening Tests or jury testing such as Semantic Differential and Paired Comparison. The actual way in which the tests are set up and presented to the person listening can be designed using the Sound Quality software.

Fig. 10
Recording with PULSE
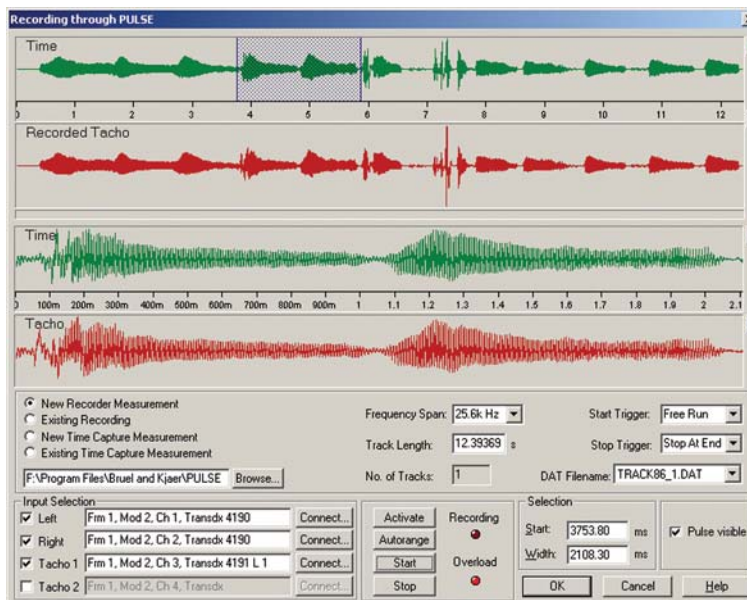
Besides the subjective test, the Sound Quality software also supports a wide range of Objective measurements. Objective measurements using Zwicker Loudness analysis allows the calculation of metrics for both stationary and non-stationary sounds revealing:

• Total Loudness vs. Time
• Specific Loudness
• Instantaneous Loudness vs. Time
• Statistical Instantaneous Loudness
• Sharpness vs. Time
• Specific Roughness

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- Specific Fluctuation Strength

The Sound Quality Software options available for PULSE are:
- PULSE Sound Quality Software Type 7698
- BZ-5265 Zwicker Loudness Option for Type 7698
- BZ-5301 Psychoacoustic Test Bench Option for Type 7698

For more information on PULSE Sound Quality software and hardware please refer to the Product Data for PULSE Sound Quality Software (BP 1589).

Overview of Software Options and VDA Test Specification

Four software packages have been developed for testing different types of hands-free equipment:

- **BZ-5137-033 Software for Testing Car Hands-free Terminals – HATS Option:**
  This software is intended for testing the performance of a mobile phone with hands-free capability either built into the mobile phone or enable through the attachment of hands-free accessories in the car. In addition, fully integrated hands-free car systems can be tested. The test cases that can be performed are marked with a "+" in Table 2.
- **BZ-5137-035 Software for Testing Car Hands-free Terminals – Microphone Option:**
  This software is intended for testing the performance of a microphone either built into the car or mounted by other means. In addition, a complete microphone system, for example, a system including noise reduction capability, can be tested. The test cases that can be performed are marked with a "*" in Table 2.
- **BZ-5137-034 Software for Testing Car Hands-free Terminals – Noise Option:**
  This software is intended for testing the types of equipment mentioned above under the influence of background noise, typically noise recorded during a real driving situation, but with the noise applied automatically during test execution. The test cases that can take advantage of this are marked with a "#" in Table 2. Note that BZ-5137-033 and BZ-5137-035 also support these measurements but require the operator to apply the noise manually when instructed by the software.
- **BE-5137-036 Software for Speech Quality Evaluation:**
  This software is intended for the evaluation of the speech quality of hands-free terminals. The software is based on PESQ – Perceptual Evaluation of Speech Quality – as outlined in ITU-T Rec. P. 862.

Table 1
Overview of software applications

Test Environment	Hands-free Equipment Under Test	
	Mobile Phone or Hands-free System	**Microphone or Microphone System**
Anechoic conditions	Not applicable	BZ-5137-035
In car – quiet conditions	BZ-5137-033 BZ-5137-036	BZ-5137-035
In car – noise (applied by operator)	BZ-5137-033 BZ-5137-036	BZ-5137-035
In car – noise (applied by software)	BZ-5137-034	

Table 2 shows how the PULSE VDA configurations and associated options enable testing of specific test cases defined in the VDA test specifications.

For specific information on software licenses and hardware configurations please see the Ordering Information.

Table2 *PULSE VDA configurations and associated options*

Ref.	Test Case	VDA Advanced	VDA Lite (Note 2)	Anechoic Test Box Option (Note 3)	PULSE Background Noise Recording System (Note 4)	PULSE Background Noise System (Note 5)
				Options for VDA Lite		
5.1.1	Microphone Sensitivity – Anechoic Condition*	X		X		
5.1.2	Microphone Sensitivity – In Car*	X	X			
5.2	Microphone Overload – Anechoic Condition*	X		X		
5.3.1	Microphone Distortion – Anechoic Condition*	X		X		
5.4	Microphone Frequency Response – In Car*	X	X			
5.5	Microphone Noise – Anechoic Condition*	X		X		
5.6	Microphone Noise Suppression – D-factor – In Car*	X			X	X
6.2.1	Sending Path Delay#	X	X			
6.2.2	Receiving Path Delay#	X	X			
6.3.1	SLR#	X	X			
6.3.2	RLR#	X	X			
6.3.2	RVC#	X	X			
6.4.1	Sending Response#	X	X			
6.4.2	Receiving Response#	X	X			
6.5.1	Sending Speech Quality+ (Note 1)					
6.5.2	Receiving Speech Quality+ (Note 1)					
6.6.1	Sending Noise#	X	X			
6.6.2	Receiving Noise#	X	X			
6.7.1	Out-of-band Sending#	X	X			
6.7.2	Out-of-band Receiving#	X	X			
6.8	Receiving Distortion#	X	X			
6.9.1	Echo Loss – TCLw#	X	X			
6.9.2	Echo Loss – Time Variations#	X	X			
6.9.3	Echo Loss – Spectral#	X	X			
6.9.4	Echo Attenuation vs. time#	X	X			
6.9.5	Echo Attenuation vs. time with background noise#	X			X	X
6.10.1	Sending – Build-up Time and Threshold Level#	X	X			
6.10.3	Sending – Hang-over Time and Attenuation Range#	X	X			
6.10.4	Receiving – Hang-over Time and Attenuation Range#	X	X			
6.11.1	Sending – Attenuation Range Double Talk#	X	X			
6.11.2	Receiving – Attenuation Range Double Talk#	X	X			
6.11.3	Talker Echo Loudness Rating Double Talk#	X	X			
6.12.1	D-factor#	X			X	X
6.12.2	Sending Noise Suppression during Call Establish#	X			X	X
6.12.3	Sending Noise Suppression following Far-end Talker#	X			X	X
6.12.4	Sending Noise Suppression following Near-end Talker#	X			X	X
6.13	Sending Noise Suppression during Far-end Talker#	X			X	X

X: indicates that the test case is enabled   *: Test cases supported by BZ-5137-035

+: Test cases supported by BZ-5137-036   #: Test cases supported by BZ-5137-033

Note 1   For support of 6.5.1 and 6.5.2, VDA Advanced and VDA Lite must be equipped with the Speech Quality option.

Note 2   Test cases that are not marked with an X in this column can be performed by adding relevant options as outlined in Notes 3 – 5.

Note 3   The test cases marked with an X in this column are supported in the VDA lite configuration when measurements are made using the HATS or Free Field Microphone under anechoic conditions provided by means of an anechoic room or a quiet room. In situations where such conditions are not available, the Anechoic Test Box Option can be added to the PULSE VDA Lite configuration.

Note 4   The test cases marked with an X in this column are supported in the VDA lite configuration when the noise is recorded by other equipment. In situations where such equipment is not available, the PULSE Background Noise Recording System can be added to the PULSE VDA Lite configuration.

Note 5   The test cases marked with an X in this column are supported in the VDA Lite configuration when the noise are replayed equalized using other equipment, for example, CD player in car. However, for fully automated control of background noise replay, the PULSE Background Noise system is required.

Ordering Information

VOICE TESTING SOFTWARE FOR HANDS-FREE EQUIPMENT TYPE 7909-S1
This software includes the following PULSE Telephone Testing software options:
• BZ-5137: Telephone Testing Software
• BZ-5137-033: Software for Testing Car Hands-free Terminals – HATS option
• BZ-5137-034: Software for Testing Car Hands-free Terminals – Noise option
• BZ-5137-035: Software for Testing Car Hands-free Terminals – Microphone option
• M1-5137: Annual Software Maintenance and Support Agreement for BZ-5137
• M1-5137-033: Annual Software Maintenance and Support Agreement for BZ-5137-033
• M1-5137-034: Annual Software Maintenance and Support Agreement for BZ-5137-034
• M1-5137-035: Annual Software Maintenance and Support Agreement for BZ-5137-035

PULSE BUNDLES FOR VOICE TESTING SOFTWARE FOR HANDS-FREE EQUIPMENT
Type 6712-A-S04 PULSE Platform for VDA Advanced includes:
• 3 × Type 2716-C: Audio Power Amplifier, Stereo
• 4 × Type 3109: Generator, 4/2-ch. Input/Output Module
• Type 3560-E-E01: PULSE E-size Front-end
• Type 4231: Sound Calibrator
• Type 7700-N2: FFT & CPB Analysis
• Type 7705-N: PULSE Time Capture
• AO-0087-D-030: Screened Connection Cable BNC to BNC connector 3 m (10 ft)
• AO-0389: BNC−BNC Cable, 130 mm (5.1″)
• 2 × JJ-0152: BNC Adaptor
• M1-7700-N2: Annual Software Maintenance and Support Agreement for Type 7700
• M1-7705-N: Annual Software Maintenance and Support Agreement for Type 7705
• 6 × WL-1324: XLR−BNC Cable, 3 m (10 ft)
• 6 × WL-1325: Speakon®−Banana Cable, 5 m (16 ft)
• Type 7909-S1: Voice Testing Software for Hands-free Equipment

PULSE Platform for VDA Advanced has been designed to form a hardware platform for testing according to all sections of the VDA standard. The hardware platform holds all the analyzers and generators required for the VDA standard and can be upgraded with options mention under "Options for Voice Testing Software for Hands-free Equipment". Note, however, that the PULSE Background Noise System option is already included in the configuration.

Type 6712-A-S05 PULSE Platform for VDA Lite includes:
• Type 2716-C-001: Audio Power Amplifier, Stereo
• Type 3560-C-T62: PULSE Telephone Handset and Hands-free Test System (2 In/2 Out)
• Type 4231: Sound Calibrator
• Type 7705-N: PULSE Time Capture
• AO-0087-D-030: Screened Connection Cable BNC to BNC connector 3 m (10 ft)
• AO-0389: BNC−BNC Cable, 130 mm (5.1″)
• 2 × JJ-0152: BNC Adaptor
• M1-7705-N: Annual Software Maintenance and Support Agreement for Type 7705
• WL-1324: XLR−BNC Cable, 3 m (10 ft)
• WL-1325: Speakon−Banana Cable, 5 m (16 ft)
• BZ-5137: Telephone Testing Software
• BZ-5137-033: Software for Testing Car Hands-free Terminals – HATS option
• BZ-5137-035: Software for Testing Car Hands-free Terminals – Microphone option

• M1-5137: Annual Software Maintenance and Support Agreement for BZ-5137
• M1-5137-033: Annual Software Maintenance and Support Agreement for BZ-5137-033
• M1-5137-035: Annual Software Maintenance and Support Agreement for BZ-5137-035

PULSE Platform for VDA Lite has been designed to constitute an optimised hardware platform sufficient for testing according to the Hands-free Terminal part of the VDA standard or the Microphone parts of the VDA standard. It is assumed that background noise can be established manually in test cases where this is required or that these test case are considered irrelevant for the specific application. It can, however, be upgraded with the options mentioned under "Options for Voice Testing Software for Hands-free Equipment" to support testing as for PULSE Platform for VDA Advanced.

OPTIONS FOR VOICE TESTING SOFTWARE FOR HANDS-FREE EQUIPMENT
Air Interface option for CDMA requires:
UA-1694	Rohde & Schwarz CMU-200 for CDMA
2 × WL-1368	Antenna Cable for Air Interface
WL-3162-A	Audio Cable for R&S CMU 200-CDMA 2000
2 × WQ-2358	BNC Jack to N Plug adaptor

Other CMU-200 configurations are available on request.
Accessories for remote control of Air Interface:
AO-0265	Interface Cable, IEEE−488 to IEEE−488, 2 m (6 ft)

and one of the following IEEE interface cards:
WQ-1270	IEEE−488 Interface Card, PCI-GPIB
WQ-1290	IEEE−488 Interface Card, PCMCIA
WQ-2464	IEEE−488 Interface Card, USB

Anechoic Test Box option requires:
Type 4232	Anechoic Test Box
Type 4191	½″ Free-field Microphone, 3 Hz to 40 kHz, 200 V Polarization
Type 2669-001	½″ Microphone Preamplifier for use with Type 4232

Free-field Microphone option requires:
Type 2669-L	½″ Microphone Preamplifier, tapered, including Cable AO-0419, 7-pin LEMO Connector
Type 4191	½″ Free-field Microphone, 3 Hz to 40 kHz, 200 V Polarization
Type 4227	Mouth Simulator

HATS option requires:
Type 4128-C	Head and Torso Simulator
Type 4938-A-011	¼″ Pressure-field Microphone, incl. Preamplifier Type 2670 with TEDS
DP-0775	Adaptor for calibrating ¼″ microphones on Calibrator Type 4228 or 4231
Type 4159-C	Left Ear Simulator for Head and Torso Simulator Type 4128-C (required for recording noise)
UA-1324	Positioning Frame for HATS

Portable Background Noise Recording System option requires:
Type 3560-B-T33	Time Data Recorder
Type 4101	Binaural Microphone
Type 7789-A	PULSE Time

PULSE Background Noise System option requires:
2 × Type 2716-C	Audio Power Amplifier, Stereo
3 × Type 3109	Generator, 4/2-ch. Input/Output Module
Type 3560-D-E01	PULSE D-size Front-end
Type 7770-N1	FFT Analysis
M1-7770-N1	Annual Software Maintenance and Support Agreement for Type 7770-N2
WL-1324	XLR−BNC Cable, 3 m (10 ft)
WL-1325	Speakon−Banana Cable, 5 m (16 ft)

BZ-5137-034	Software for Testing Car Hands-free Terminals – Noise option
M1-5137-034	Annual Software Maintenance and Support Agreement for BZ-5137-034

Speech Quality option requires:

BZ-5137-036	Software for Speech Quality Evaluation
M1-5137-036	Annual Software Maintenance and Support Agreement for BZ-5137-036
Type 7705-N	PULSE Time Capture

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