

# Duet

Evoked Potentials and  
Otoacoustic Emissions  
in perfect harmony



many options, one smart system

# the clinical solution you've been waiting for

We've listened to you and have integrated your feedback into a powerful platform for EP and OAE. We are excited to introduce the Duet: a sleek, portable, and versatile clinical evoked potential and otoacoustic emissions system.

## stellar performance

Over 30 years of engineering design experience, combined with unsurpassed expertise in evoked responses, have culminated in the **next generation bio-amplifier** to bring you **superior data quality** for evoked potentials and otoacoustic emissions.

### Repeatable, reliable data you can count on

- High definition responses
- Cleaner, more robust responses
- Increased signal-to-noise ratio (SNR)
- Lower residual noise

### Reduced test times without compromising data quality

## dressed up for performance

The newest member of the Universal Smart Box family, the Duet's sleek design is both ergonomic and portable.

- It is lightweight, at less than 4 lbs (2 kg)
- Fits perfectly under a 15 inch notebook PC
- Maximize your workspace by using it with its companion stand
- Built-in isolation and shielding: it can be used in any location, including the NICU and OR

### Test in more places without sacrificing flexibility

## ready for the clinic

The Duet is available in two base packages: Duet 2 Channel AEP, or Duet 2 Channel AEP & OAE. Choose from a variety of add-on modules for the ultimate in flexibility and versatility. Upgrade anytime with minimal or no down time.

### Standard SmartEP modules:

- ECoChG
- ABR (click, tone burst, iChirp)
- MLR
- LLR/CAEP

### Optional SmartEP modules:

- P300/MMN
- eABR
- Chained-Stimuli ABR
- cVEMP, oVEMP
- ASSR

### Standard SmartOAE modules:

- DPOAE
- TEOAE
- SOAE

## flexible enough for research needs

### Advanced options for SmartEP:

- CLAD for high-rate stimulation
- Notched Noise Masking
- Advanced Auditory Research Module (AARM)
- Complex ABR
- Frequency Following Response
- Acoustic Change Complex
- CHIRP Stimulus Generation Module
- USB Development Kit

### Advanced options for SmartOAE:

- Contralateral, ipsilateral, and binaural TEOAE suppression
- Dual OAE probe system
- HF DPOAE for ototoxicity monitoring

designed for an improved clinical experience

# SmartEP

The ideal clinical tool for recording ECochG, ABR, and more.

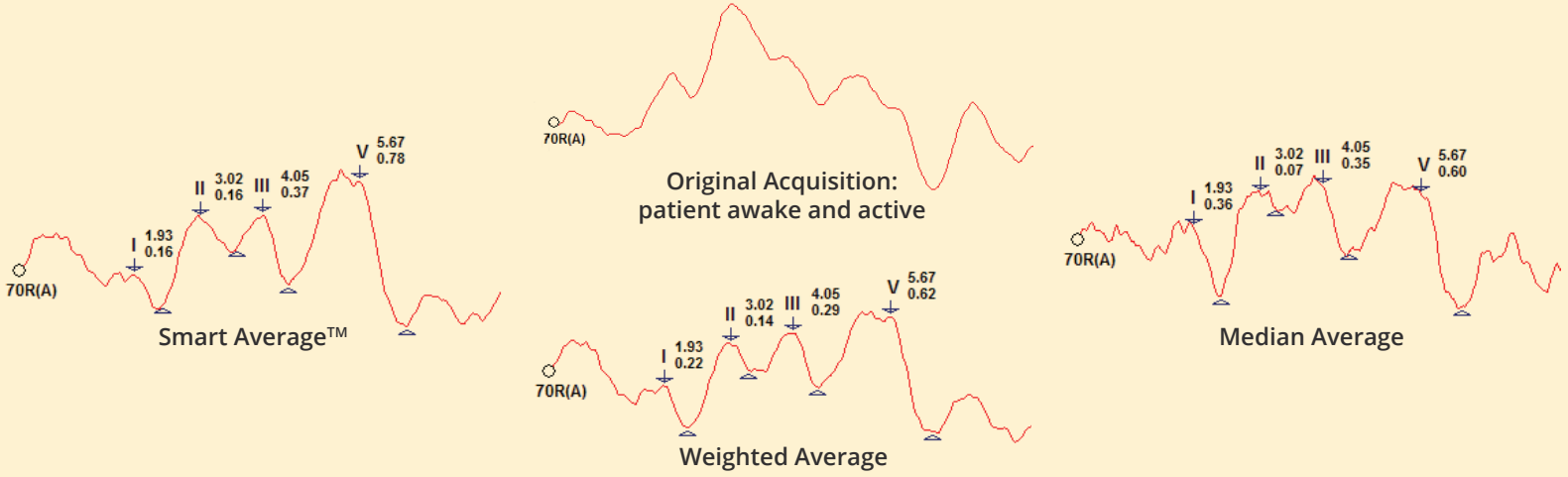
## new and improved user interface simplifies acquisition

- Improved toolbar and button design for fast access to key features
- Easy access to all parameters from a simplified control panel and streamlined menus
- Quickly load your own or preset protocols
- Easily view ongoing EEG display for quick assessment of patient state during testing
- Great variety of options allow you to perform the tests the way you want
- Choose from a variety of stimuli, or generate or import your own custom stimuli
- On-screen and remote impedance checking using patient response alert box



## smarter averaging display options

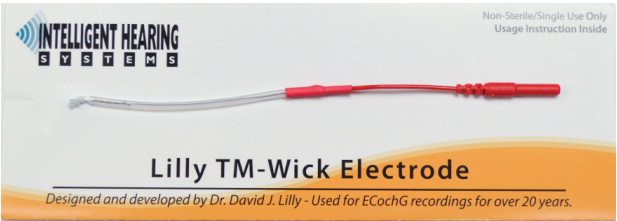
- Option to automatically acquire and store data in sweep blocks for more powerful processing
- Easily analyze acquired waveforms using additional averaging techniques for further noise reduction
- Averaging techniques includes traditional linear, median, and weighted



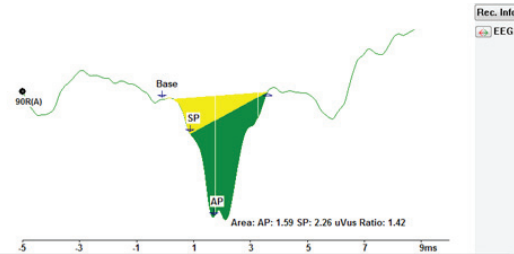
- Objective response measurements provide indicators of recording quality
- Automated averaging stopping rules using residual noise measures allow data to be acquired automatically with consistent quality and noise levels

## the perfect duet for electrocochleography

Our next generation amplifiers combined with the non-invasive IHS Lilly TM-Wick Electrodes produce more robust and repeatable ECochGs.



Improved SP/AP amplitude and area curve ratio analysis and automatic calculation.



## smart features

- Change most test parameters with a single click
- Set your own display scale
- Latency-Intensity graphs indicating normative data ranges are automatically generated from marked waveforms
- Quickly add, subtract, invert, time shift, or cross-correlate recordings
- Split-sweep view to visualize single recording repeatability
- 2D and 3D Spectral Analysis

## streamlined workflow

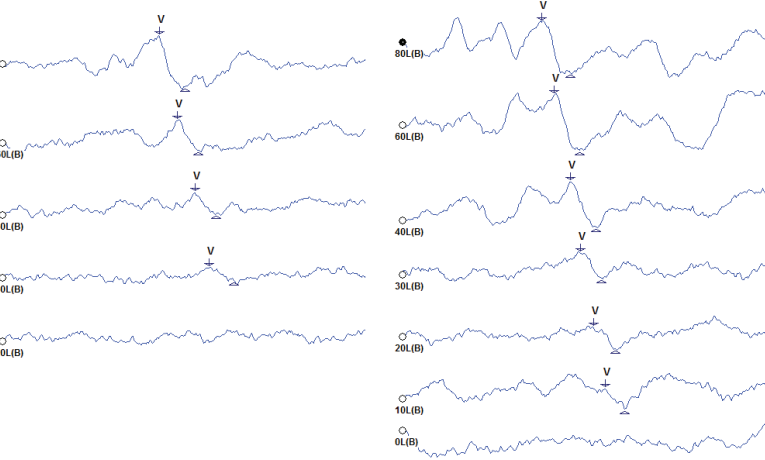
- Easily mark waveforms using over thirty pre-defined peak labels, or create your own custom labels. Easily adjust them using a mouse or keyboard
- View latencies and amplitudes of peaks directly on waveforms and in newly embedded recording information panel.
- Automatically arrange recordings by intensity, acquisition order, stimulus frequency, or rate
- Quickly resize the waveforms using the zoom in/out buttons
- Display or hide a subtle vertical grid or horizontal baseline
- Multi-page display and reports
- Easy PDF report generation
- Auto-save reports on program exit

## iChirp™ stimuli included

The intelligent Chirp for SmartEP and SmartEP-ASSR is included in the base package.

- Broad and narrow band (500, 1000, 2000, 4000 Hz)
- Improved threshold detection
- Robust amplitude responses
- Optimized wave V identification
- Optional, innovative custom chirp design utility

**Beneficial for recording ABR in awake and active patients.**

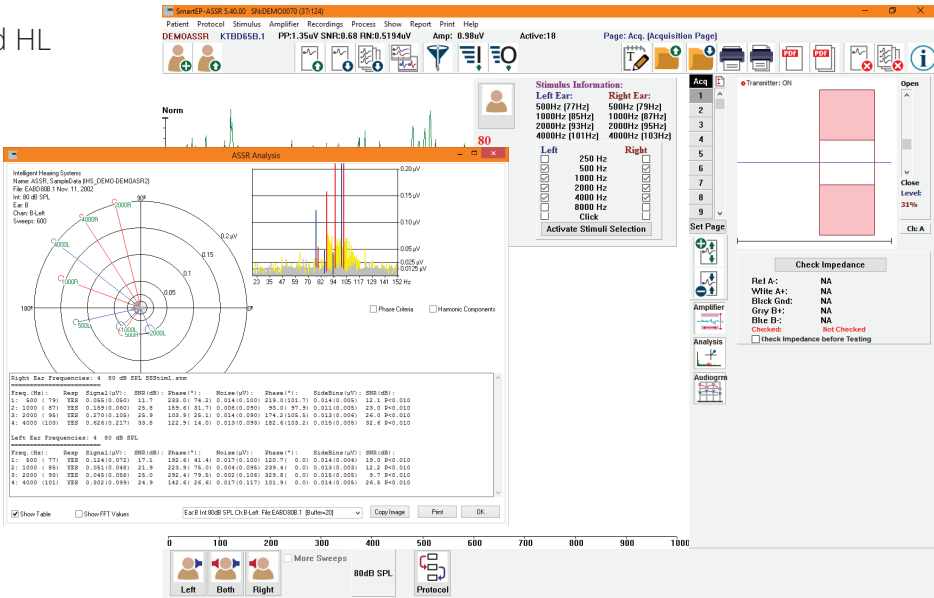
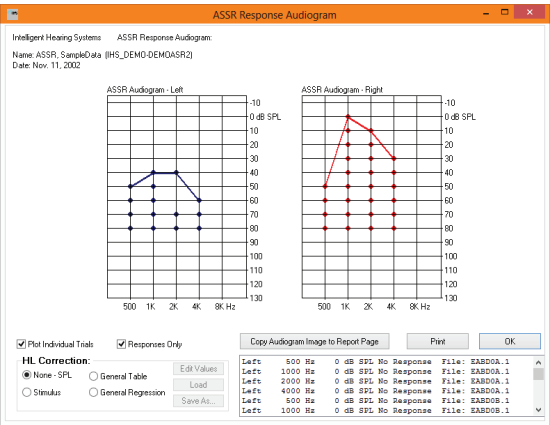


2000 Hz tone burst ABR (left) vs 2000 Hz iChirp ABR (right)

# SmartEP-ASSR

Full-featured screening and diagnostic Auditory Steady State Response System.

- Provides quick, accurate threshold detection using automated statistical analysis
- Test both ears at the same time, four frequencies per ear
- iChirp (broadband & frequency specific) for robust amplitudes and harmonic component analysis for improved threshold detection and reduced test times
- Automated audiogram generation in SPL and HL
- Cost effective add-on to SmartEP



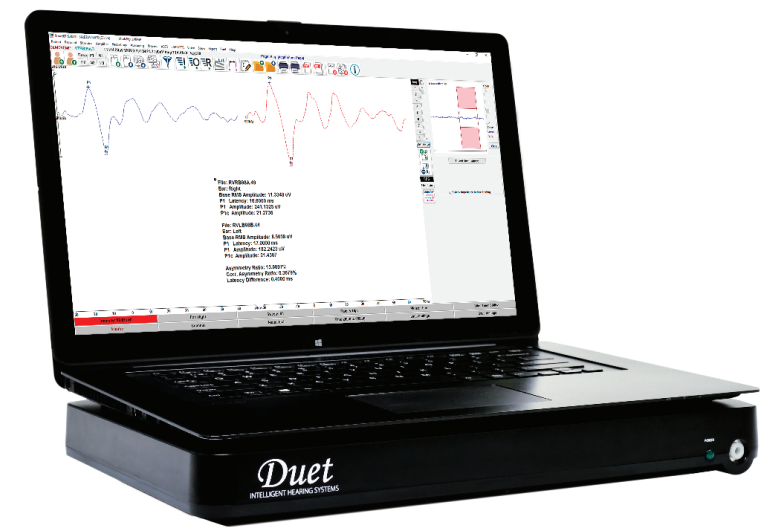


# SmartVEMP

innovative solution for cVEMP and oVEMP

## the VEMP solution you've been waiting for

The new & improved SmartVEMP option is the only device cleared by the FDA for oVEMP and cVEMP testing on patients of all ages (K163326). The most advanced VEMP module in the market has been enhanced to become the ideal clinical tool for recording oVEMP and cVEMP responses.



## integrated EMG monitoring

SmartVEMP includes the ability to monitor EMG activity with the same recording electrodes: no need for additional EMG monitoring electrodes.

The module also features a user-friendly interface to easily choose the target EMG levels for your patient.

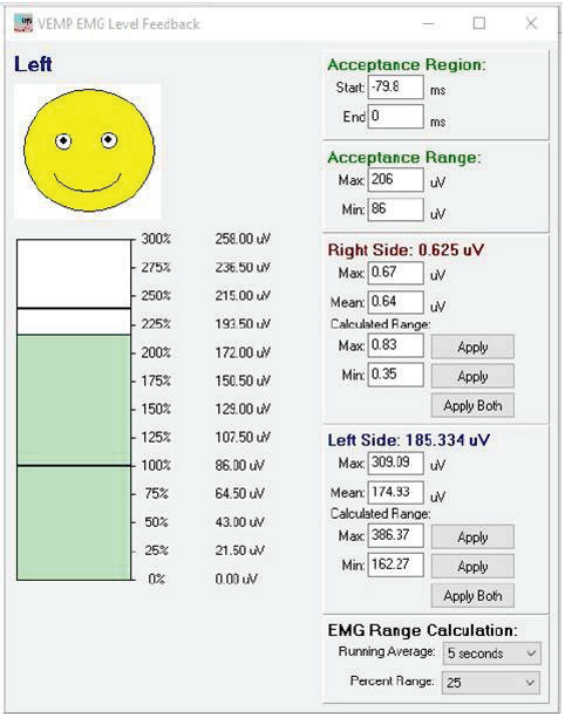
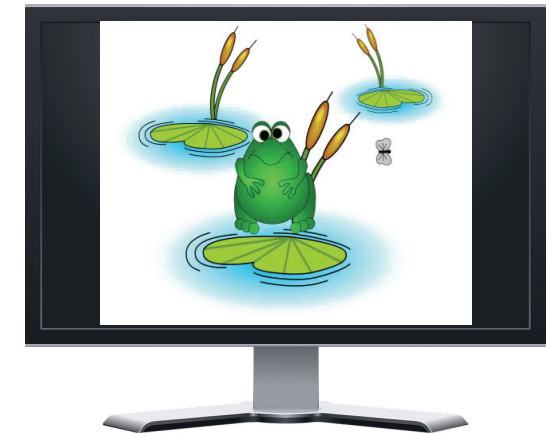
- Choose patient specific acceptance amplitudes for each side
- Automatically calculates the acceptance range
- User-defined acceptance and rejection regions
- Only averages sweeps with adequate EMG activity

On-screen EMG for easy viewing and monitoring patient state during testing

## improved bio-feedback options

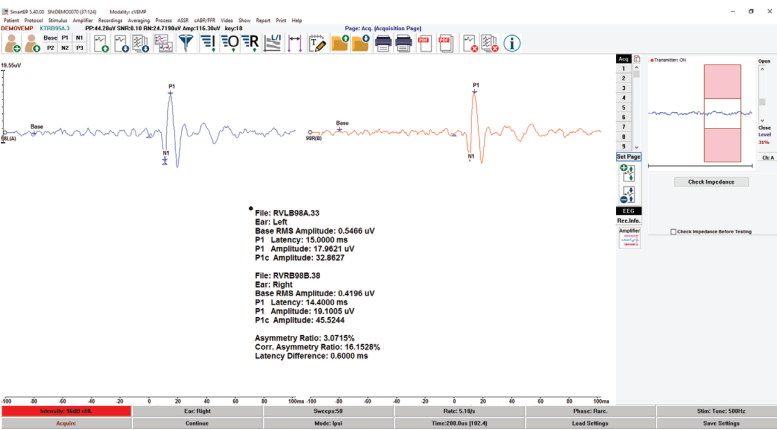
Patient-friendly options for visual bio-feedback:

- Feedback box with LED indicators
- On-screen EMG level display with happy/sad face
- Animated videos for pediatric testing

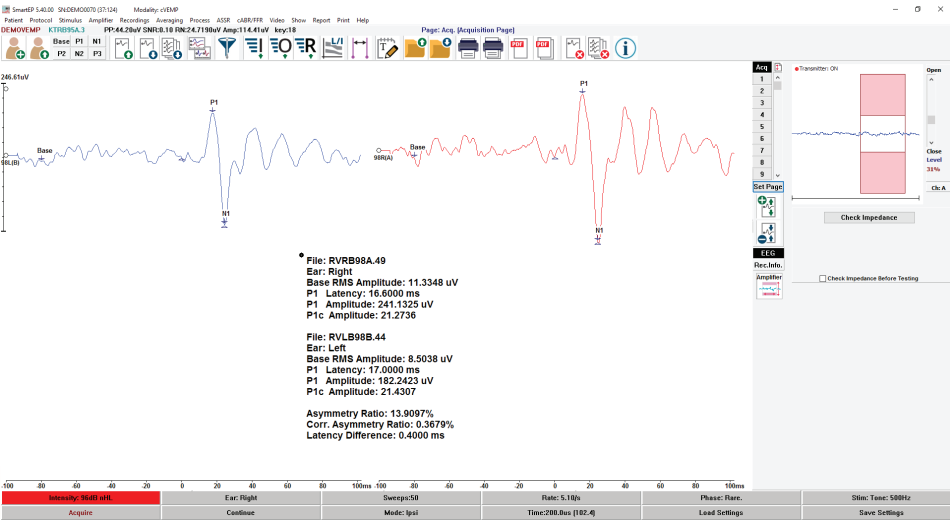


## smarter VEMP features

- Quickly load preset cVEMP and oVEMP protocols
- Easy to mark peak labels using mouse or keyboard
- Baseline automatically marked to the user-defined acceptance region
- Integrated baseline EMG response normalization
- Create a grand average using multiple recordings
- Easily compare left and right VEMP responses
- Automatic calculation of corrected amplitude and asymmetry ratios
- Amplitude corrections based on pre-stimulus EMG activity



Sample oVEMP Recordings



Sample cVEMP Recordings



# AAR/FFR

Advanced Auditory Research Module for Frequency Following Response and Acoustic Change Complex

## complete control of stimulus and acquisition timeline

This add-on module for SmartEP allows users to customize every aspect of acquisition and stimulation, using an advanced and easy to understand interface; making it an ideal tool for the acquisition of Frequency Following Responses (FFR). It permits the mixing of stimuli when the Notch-Noise masking hardware is installed and provides the user access to define times of acquisition by specifying delays and offsets for each stimuli selected.

- Use simple or complex stimuli, including tones, iChirps, speech stimuli, and noise.
- Define custom stimuli using the built-in conversion utility.
- Adjustable stimulus sampling rate: 40kHz, 20kHz, 10kHz, 5kHz.
- Use stimulus files up to 8 seconds in duration.
- Set stimuli to be presented at a specific time, or to be output continuously.
- Combine up to 2 stimuli per ear or present ipsilateral masking.



Optional ultra-shielded ER3 or ER2 insert earphones

SmartEP Advanced Auditory Research Module

|      |           |      |          |           |
|------|-----------|------|----------|-----------|
|      |           |      | 170.05ms |           |
|      |           |      |          | 500.00ms  |
| 1024 |           | 2048 |          |           |
|      | Zero Time |      | ArtRej   |           |
|      |           |      |          | 476.19 ms |

System Base Sampling Rate: 40 kHz

File Stim Info: BA.STM

Comment:

Right Ear - Channel 1 (Stimulus 1):  
☒ ON File: BA.STM Intensity: 80 Time Offset (us): 50000 ☐ Continuous ☐ Condensation ☐ Rarefaction ☒ Alternating

Right Ear - Channel 2 (Stimulus 2):  
☐ ON File: Intensity: 0 Time Offset (us): 0 ☐ Continuous ☐ Condensation ☐ Rarefaction ☒ Alternating

Left Ear - Channel 1 (Stimulus 3):  
☒ ON File: White\_40K.STM Intensity: 70 Time Offset (us): 0 ☒ Continuous ☒ Condensation ☐ Rarefaction ☐ Alternating

Left Ear - Channel 2 (Stimulus 4):  
☐ ON File: Intensity: 0 Time Offset (us): 0 ☐ Continuous ☐ Condensation ☐ Rarefaction ☒ Alternating

Data Buffer 1:  
☒ ON Zero Time (us): 50000 Start Time (us): 0 Sampling Rate (us): 150 (25us intervals) Data Points: 2048

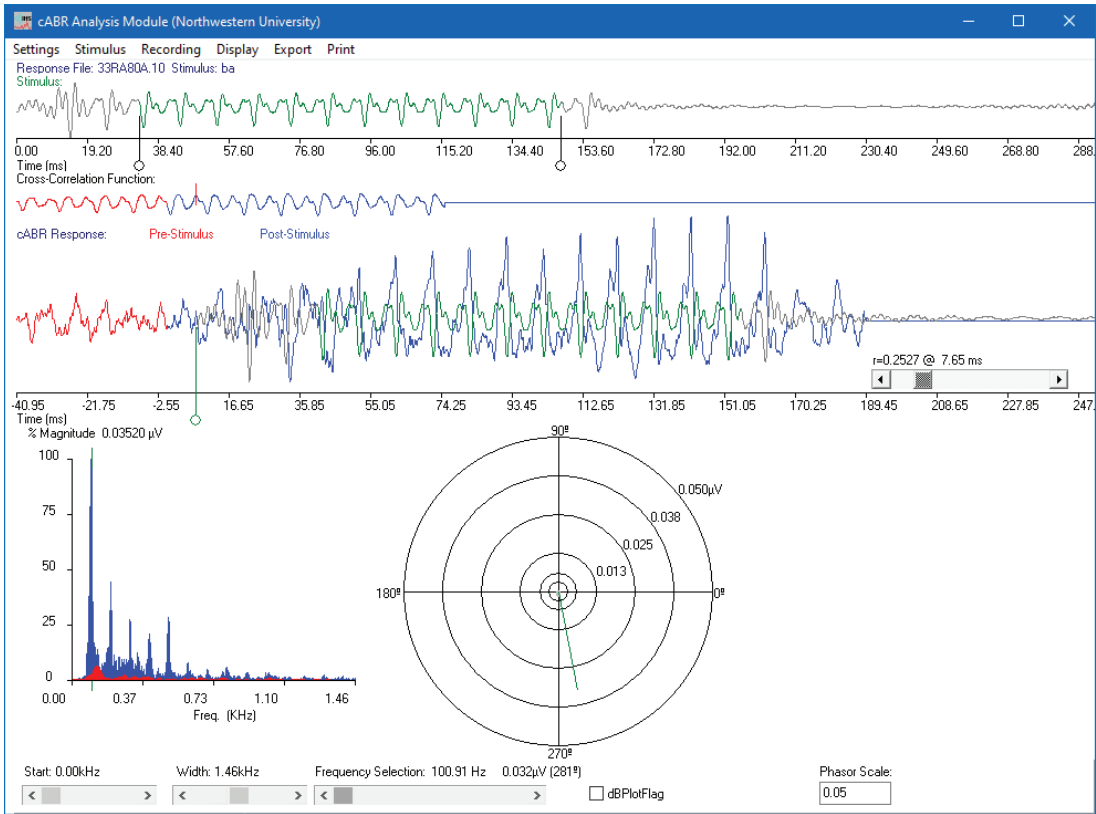
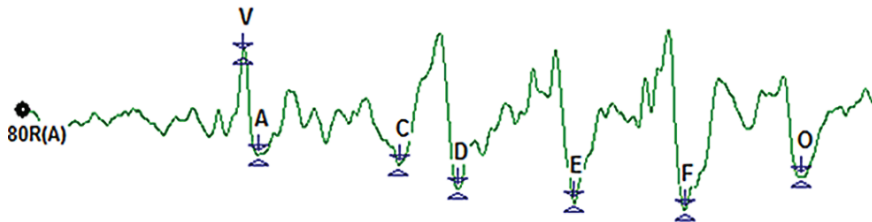
Main:  
☐ Right-Left Control Panel  
Rate: 2.10 /s  
Period: 19048 prnts  
Period: 476.19 ms  
EP Type: A-ABR  
☐ OAE Enabled  
Artifact Rejection (us):  
Start: 55000  
End: 200000  
Load  
Save  
Save as Default  
Note: Advanced Settings will also be saved when saving System Settings.  
OK

# cABR

Complex ABR Research Module

## Acquisition and Analysis of cABR:

- Includes pre-defined settings for complex stimuli, including speech syllables BA, GA, DA, and more.
- Users can create customized settings and stimuli.
- cABR specific label markers.
- Easy comparison of marked recordings.
- Includes cABR analysis, spectrogram, and phaseogram tools.
- Analysis module includes a cross-correlation function, overlapping stimulus and response, and response power spectrum.
- Users can define the response analysis region, high pass, and low pass filters.
- Display of filtered and unfiltered spectrogram.
- Export data, cross correlation information, or power spectrum of recording for additional external analysis.
- Interfaces with MATLAB® modules for further analysis possibilities.



The Advanced Auditory Research Module, cABR Research Module, and Ultra-Shielded Insert Earphones are for research use only; they are not for use in diagnostic procedures.

Full functionality requires the Auxiliary Output Channel hardware and the Notched Noise Masking software option.

Visit the Auditory Neuroscience Lab website ([www.brainvolts.northwestern.edu](http://www.brainvolts.northwestern.edu)) for information about the research supporting the cABR technology and about upcoming scientific talks by the Lab.



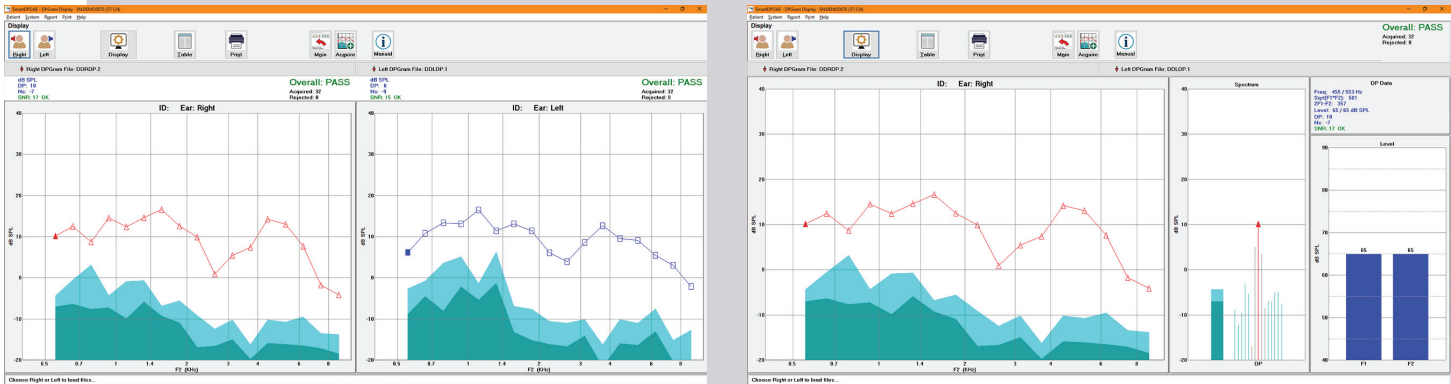
SmartDPOAE

complement your Duet

Screening and diagnostic distortion product otoacoustic emissions.

Expand your capabilities by adding either of the following audiometry options to your Duet.

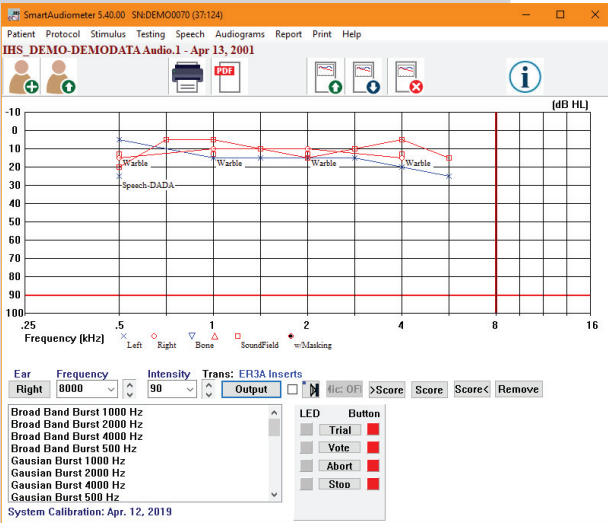
- Fast and easy setup with up to 41 frequencies per ear in a single test
- Automatic probe-fit check and in-ear calibration for increased accuracy
- Easy-to-interpret colorful DPGrams and detailed information for each frequency tested
- Clear Pass or Refer indications based on user-selected passing criteria
- User-customizable display of normative ranges on the DPGram facilitates response analysis
- High frequency option for ototoxicity monitoring
- Built-in scripting feature allows you to define sequences of frequencies and intensities for automated data collection
- Optional graphical display of noise standard deviation for improved interpretation



## Smart Audiometer

PC-based screening audiometer.

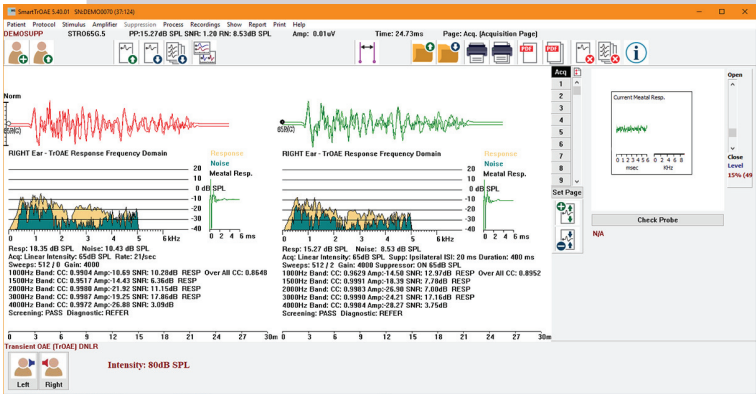
- Automatic generation of pure tones from 250 Hz to 16 kHz, depending on stimulator used
- Includes a wide array of stimulus files at 500, 1000, 2000, and 4000 Hz: warble tone, narrowband burst, small band burst, broadband burst, Gaussian burst, pure tones
- Ability to use custom stimuli
- Includes standard clinical ‘5-up/5-down’ Adult Self-Test automated routine using the response box accessory
- Print detailed reports with sequence information, frequency tables, and threshold information
- Built in audiogram markers for different stimulator types
- Optional speech discrimination module



## SmartTrOAE

Screening and diagnostic transient evoked and spontaneous otoacoustic emissions.

- Fast and easy test setup and data analysis
- Automatic probe-fit check and in-ear calibration
- Clear Pass or Refer indications based on user-selected passing criteria
- Displays of the OAE time signal, frequency analysis and the ear canal response
- Use clicks, tones, or user-defined stimulus files
- Time-Frequency plots can be used to illustrate how the frequency composition of transient OAE responses, Noise, and SNR change over time



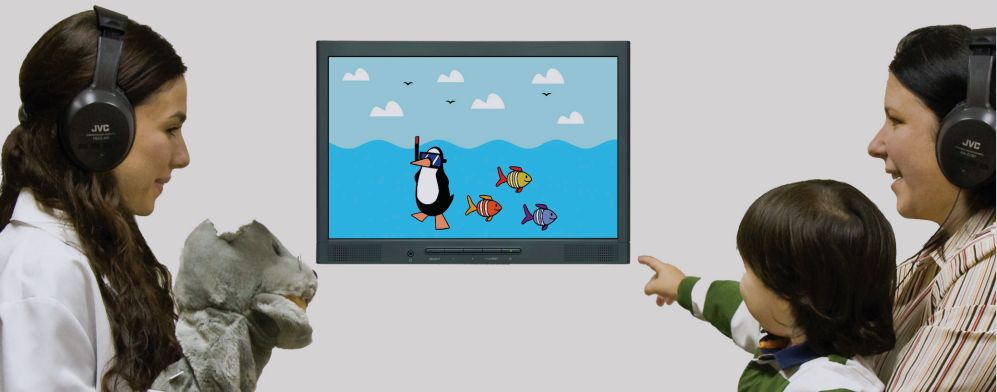
Available in the Duet is a dual-probe option that allows for the acquisition of contralateral, ipsilateral, and binaural TEOAE suppression recordings.

This option includes a Suppression Analysis module for temporal and spectral comparison of control and suppression data.

## Intelligent VRA

Automated visual reinforcement audiometry.

- Increased reliability & accuracy by a single examiner
- Choose from our variety of 4 and 10 second colorful, animated wide-screen video clips, or use your own video clips
- Use one of our three automated test routines, administer a speech discrimination paradigm (IVRISD), or run a VRA test manually
- Probe Trials maintain patient attention while testing near threshold
- Control Trials allow you to determine the reliability of a test
- Trial-by-trial reports include detailed information for each test sequence
- Final report includes audiogram and threshold for each frequency tested



### CAST™

Classification of Audiograms by Sequential Testing selects the best-fitting audiogram from 9 patterns, for fast and efficient screening.

### OHTA™

Optimized Hearing Test Algorithm is designed to test four frequencies, non-sequentially in an intensity staircase fashion.

### 5-up/5-down

Automated ‘step-up, step-down’ intensity staircase procedure for testing thresholds at up to four selected frequencies.

# Specifications

## EP Amplifier

Two channels  
A/D Converter: 16-bit  
Sampling rate: 200 to 40000 Hz (adjustable)  
Recording Window: -2.5 s to 2.5 s (max)  
User definable in AARM up to 10 s  
Data points per waveform 1024  
Up to 4096 in AARM  
Adjustable Gain: 5,000 - 200,000  
Adjustable High Pass and Low Pass filters  
HPF: -6 dB/Oct, -24 dB/Oct @ 70 Hz  
LPF: -6 dB/Oct, -24 dB/Oct @ 500 Hz  
High Pass: 0.1 - 300 Hz  
Low Pass: 30 - 5000 Hz  
Digital Filters: Finite Impulse Response (FIR/Smoothing), Band Pass, Notch.  
Adjustable artifact rejection level (0-100%) and any region within the analysis time window  
Line Frequency Notch Filter:  
50 or 60 Hz (-12 dB/Oct)  
Common Mode Rejection:  $\geq 110$  dB @ 1 kHz,  
 $\geq 110$  dB @ 60/50 Hz, notch filter off  
Noise Level:  $\leq 0.27$   $\mu$ V RMS  
Input Impedance:  $> 10$  MOhms  
Electrode Impedance: measuring frequency  
1000 Hz, measuring range 1 - 25 kOhms

## OAE Amplifier

Sampling Rate: 40 kHz  
A/D Converter: 16-bit  
Frequency Accuracy: 0.01% from selected

## SmartDPOAE

Stimulus: 2 Pure Tones, user defined start, end and F2/F1 ratio  
375 - 12000 Hz, Standard  
375 - 16000 Hz, High Frequency  
Levels: 65/55 (user defined L1, L2, 0-80 dB SPL)  
Response Points per Octave: 1-10 (user defined), up to 41 frequencies per DPGRAM  
Frequency Analysis (FFT) points: 4096  
FFT Frequency Resolution: 9.8 Hz Standard, 15.6 Hz High Frequency  
Acquisition Time: 102.24 ms  
DP I/O Function

## SmartTrOAE

Stimulus: click, 75  $\mu$ s default (adjustable); or tones  
Stimulus Frequency Range: 250 to 6000 Hz  
Presentation: Linear or non-linear train  
Level: 0 - 95 dB SPL (adjustable)  
Stimulus Rate: 1-50/s (user defined)  
Response analysis frequencies: 300 - 6000 Hz  
Frequency Analysis (FFT) points: 1024  
FFT Frequency Resolution: 39.1 Hz  
Acquisition Time: 25.56 ms  
Contralateral, Ipsilateral, and Binaural Suppression  
Dual probe option

## SmartEP

Stimulus: Clicks, Tones, Broadband iChirp and Octave Band iChirps, Complex, Speech, and user-defined files  
Stimulus duration in  $\mu$ s or cycles  
Click: 100  $\mu$ s default (adjustable)  
Tones: up to 500 ms (adjustable); up to 4 seconds using AARM  
Stimulus Envelopes: Rectangular, Blackman, Exact Blackman, Cosine, Cosine Squared (Hanning), Cosine Cubed, Extended Cosine (Rise/fall time), Triangular (Bartlett), Trapezoidal (Rise/fall time), Gaussian  
Stimulus presentation:  
Continuously or only while acquiring  
Rarefaction, Condensation, Alternating  
Stimulus Rate: 0.1 - 200 per second, (dependent on stimulus duration)  
Rates  $> 200$ /s available in CLAD  
Level Accuracy:  $\pm 1$  dB  
Attenuation Range: 150 dB  
Frequency Accuracy:  $\pm 1$  percent  
Masking Level: up to 125 dB SPL  
Masking Frequency Response: Flat to 20 kHz (transducer limits determine roll off)  
Masking Types:  
Specific level or relative to stimulus level.  
Contralateral or Ipsilateral  
White Noise or Notched Noise  
SAL

## Transducers

ER-3C Insert Earphones:  
Intensity: up to 132 dB SPL  
Frequency Range: 125 - 10000 Hz  
ER-2 Insert Earphones:  
Intensity: up to 118 dB SPL  
Frequency Range: 125 - 16000 Hz  
TDH Headphones:  
Intensity: up to 120 dB SPL  
Frequency Range: 125 - 12000 Hz  
B71 Bone Conductor:  
Intensity: up to 125 dB SPL  
Frequency Range: 250 - 4000 Hz  
B81 Bone Conductor:  
Intensity: up to 138 dB SPL  
Frequency Range: 250 - 8000 Hz  
ER-10D OAE Probe:  
Intensity: up to 100 dB SPL  
Frequency Range: 125 - 16000 Hz  
Sound field amplifier and speakers intensity and frequency range dependent on individual model  
Auxiliary output channel for ipsilateral masking and stimulus mixing

## Quality System

Manufactured, designed, developed, and marketed under ISO 13485 certified quality systems.

## SmartEP-ASSR

Gain: 100K  
High Pass Filter: 30 Hz  
Low Pass Filter: 300 Hz  
Stimulus: Clicks, Tones, Broadband iChirp and Octave Band iChirps, and user-defined files  
Frequencies: 250, 500, 1000, 2000, 4000, and 8000 Hz  
Simultaneous testing of both ears  
Test up to four frequencies per ear

## Power Requirements

115-230 VAC, 560-350 mA  
30W, 50/60 Hz  
Fuse Type: Time Lag (Slow-Blow) Fuses  
2A, 250V~ (IEC 60127-2 compliant)

## Operating Environment

Portable Equipment  
Indoor use  
Operating temperature: 15 °C - 35 °C  
Relative humidity: 15% to 90% at 40 °C non-condensing  
Altitude: 0 - 3000 m  
Ambient Pressure: 98kPa -104 kPa

## Storage

Temperature: 0 °C - 50 °C  
Atmospheric Pressure: none specified

## Standards Compliance

Safety: IEC 60601-1 Class II, Type BF  
EMC: IEC 60601-1-2  
EP: IEC 60601-2-40  
Medical Device Directive: Class IIa 93/42/EEC  
Protection from Fluids: IPX0 - Ordinary equipment

## Computer Requirements

Windows 10 operating system  
Minimum 4 GB RAM  
Minimum 5 GB hard drive space  
Min display vertical resolution of 900 px, Full HD recommended.  
Grounded, 3-prong power supply  
Compliant with IEC 60950  
Mouse or other pointing device  
One available USB Port  
Removable media, network drive, or secure Internet storage site for data backup (recommended)  
Printer (optional)