



# An “Optimized” Platform for DSP Hearing Aids

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## ABSTRACT

Digital signal processing (DSP) hearing aids have been categorized to date as using either a “closed” or “open” platform. Typical of the closed-platform devices is a three-channel aid with slow-acting compression. Typical of the open-platform devices is an aid which can be configured in a one-, two-, or four-channel mode, running BILL, TILL, or WDRC algorithms. **SONIC innovations** has developed a third platform, one which combines many open- and closed-platform capabilities. This “optimized” platform offers the best features of earlier DSP configurations and is disclosed in this paper.

## INTRODUCTION

Manufacturers have a choice of design approaches when developing DSP hearing aids. First-generation DSP products (Section I) were developed with an algorithm hard-coded into the integrated circuit. Because the algorithm choice is preselected, the designers can use a dedicated architecture which generally results in smaller chips with lower energy requirements and translates into smaller hearing aids with longer battery life. This approach, termed "closed" platform, has been highly successful and represents the majority of DSP hearing aids worn today.

Second-generation DSP products (Section II) employ an alternate strategy. The integrated circuit contains computational blocks which can be configured by software to run various signal processing algorithms. An advantage to this approach is that the dispenser may choose from a library of algorithms to match hearing aid characteristics to a patient's needs. Because the algorithm decision is made and can be changed in the field, the designers must use general-purpose architecture for the integrated circuits. As a rule, general-purpose architecture results in larger chips with greater energy demands. This approach, termed "open" platform, is being introduced in many hearing aids in 1998.

The **SONIC innovations** DSP hearing aids have a hardware configuration that is closed platform in addition to software flexibility similar to open-platform systems. These hearing aids represent a third-generation DSP product (Section III), the "optimized" platform.

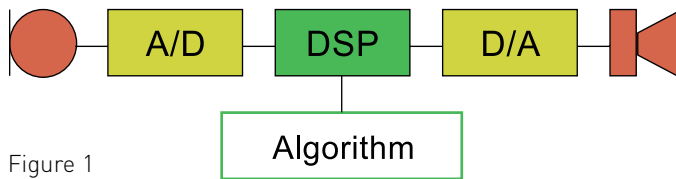


Figure 1

## I. CLOSED DIGITAL PLATFORM

Closed-platform systems (see Figure 1) have a signal processing scheme that is specified in the design of the integrated circuit<sup>1, 2</sup>. Like other dedicated-architecture aids, the **SONIC innovations** circuitry is closed-platform. The new system utilizes unique and patented DSP algorithms derived from a nonlinear auditory model<sup>3</sup>. The hearing aids employ nine-channel, narrowband signal processing; each channel has independent, fast-acting time constants. The input-output function for each channel can be configured using compression, linear, and expansion elements. The programming system efficiently combines threshold measurements, loudness contours, and *in situ* dynamic range verification to produce fast and accurate fittings. Two audiograms and corresponding fittings from our Auditory Research Laboratory are shown as Figure 2. Both fittings are using the recommended nine-channel WDRC mode. Electroacoustic curves are with 50, 60, 70, and 80 dB input signals.

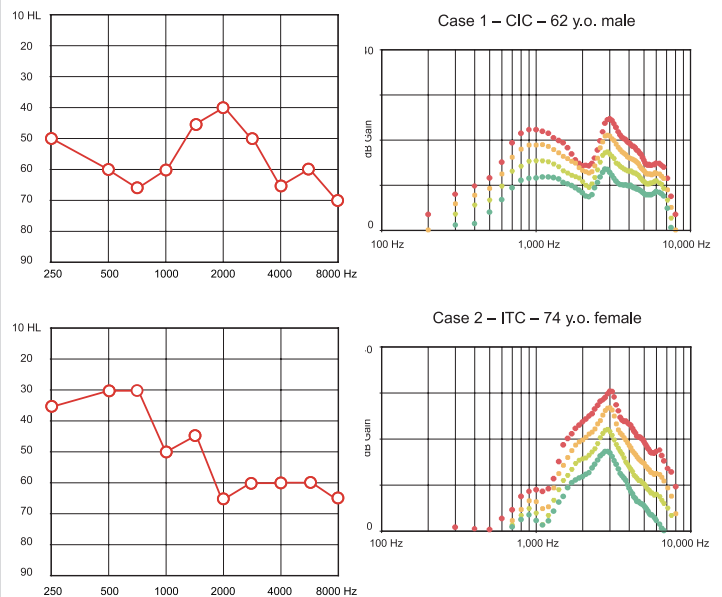


Figure 2

## II. OPEN DIGITAL PLATFORM

Open-platform systems (see Figure 3) require the dispenser to select from algorithms in a software library and load the desired algorithm into the DSP hearing aid<sup>1, 2</sup>. Software options also include prescriptive formulae and adaptive programs. Like general-purpose architecture systems, the **SONIC innovations** hearing aids are software-configurable and are not confined to a single operating mode. Previous work has demonstrated that the new hearing aids can conform to multiple prescriptive formulae with an unprecedented degree of accuracy<sup>4</sup>. The graphs in Figure 4 reveal that the system also can be configured easily to multiple adaptive programs such as BILL, TILL, and WDRC recommendations. Electroacoustic curves are with 50, 60, 70, and 80 dB input signals.

## III. OPTIMIZED DIGITAL PLATFORM

**SONIC innovations** has developed a new hearing aid that combines the benefits of first-generation closed digital platform and second-generation open digital platform devices. Typical of the closed platform, the new system runs multi-channel DSP on a small, energy-efficient circuit suitable for CIC and ITC devices. The choice of fast-acting, narrowband compression results from the auditory model and is designed to compensate for impaired cochlear function.

Consistent with the open platform, the new hearing aid is software-configurable to run multiple hearing aid prescriptions and adaptive programs, without the physical limitations of general-purpose architecture integrated circuits. Programming software and new algorithms are installed on a small, portable programmer via modem using telephone communications.

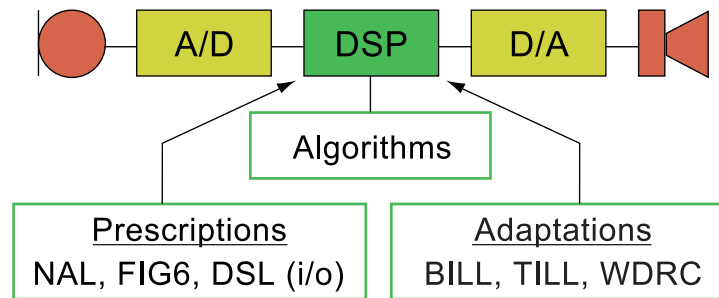


Figure 3

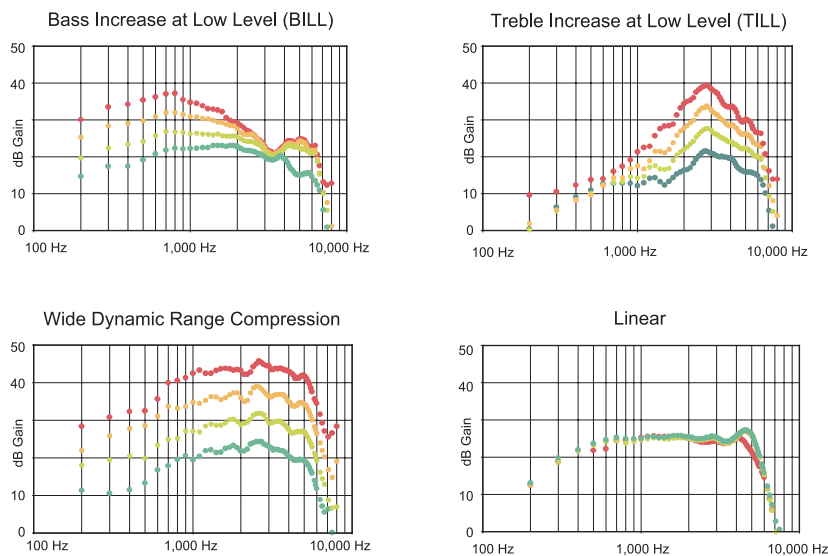


Figure 4

