AND9021/D

Automatic Directional Microphone

ON Semiconductor®

http://onsemi.com

APPLICATION NOTE

INTRODUCTION

ON Semiconductor's Adaptive Directional Microphone (ADM) algorithm is a two-microphone processing scheme for hearing aids. It is designed to automatically reduce the level of sound sources that originate from behind or from the side of the hearing-aid wearer without affecting sounds from the front. The algorithm accomplishes this by continuously adjusting the null in the microphone polar pattern to minimize the noise level at the output of the ADM (see Figure 1). The discrimination between desired signal and noise is based entirely on the direction of arrival with respect to the hearing aid. Sounds from the front hemisphere are passed unattenuated, whereas sounds arriving from the rear hemisphere are considered noise and are reduced. The angular location of the null in the microphone polar pattern is continuously variable over a range of 90 to 180 degrees where 0 degrees represents the front.

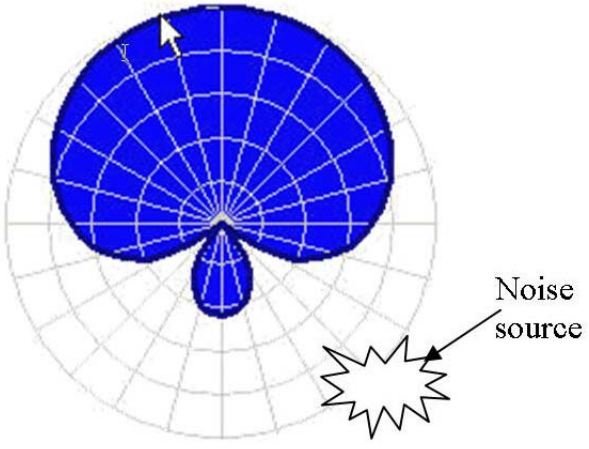

Figure 1. Sample ADM Polar Pattern

The location of the null in the microphone pattern is influenced by the nature of the acoustic signals (i.e., spectral content and direction of arrival) as well as the acoustical characteristics of the room. The ADM algorithm steers a single, broadband null to a location that minimizes the output noise power. If a specific noise signal has frequency components that are dominant, they will have a larger influence on the null location than a weaker signal at a different location. In addition, the position of the null is affected by acoustic reflections. The presence of an acoustic reflection may cause a noise source to appear as if it originates at a location other than the source location. In this case, the ADM algorithm will choose a compromise null location that minimizes the level of noise at the ADM output. Figure 2 shows a screen shot of the Interactive Data Sheet (IDS) with the Adaptive Directional Microphone front end mode selected. Figure 3 shows IDS with ADM mode disabled.

The ADM as it was implemented on Inspiria Ultimate, the GA3285, also has an Auto mode. In this mode, when the ambient sound level is above a threshold of approximately 55dBSPL and the polar pattern has adapted to something other than omni-directional, then the adaptive polar pattern is enabled. If the polar pattern adapts to omni-directional, then the algorithm will switch to single microphone, omni-directional mode to reduce current consumption.

MEASURING ADM ATTENUATION

The ADM attenuation can be measured by providing a steady sound source in the rear hemisphere and measuring the difference between the ADM on and off. The ADM should be allowed time to adapt before taking the ADM on measurement to ensure an accurate reading. By taking measurements at specific increments (e.g., 5 degrees), a polar plot can be created showing the measured attenuation at each angle. If these measurements are not taken in a free-field environment then the echoes in the room will cause acoustic reflections and make the noise source appear

to arrive from a different angle, which will affect the amount of attenuation recorded.

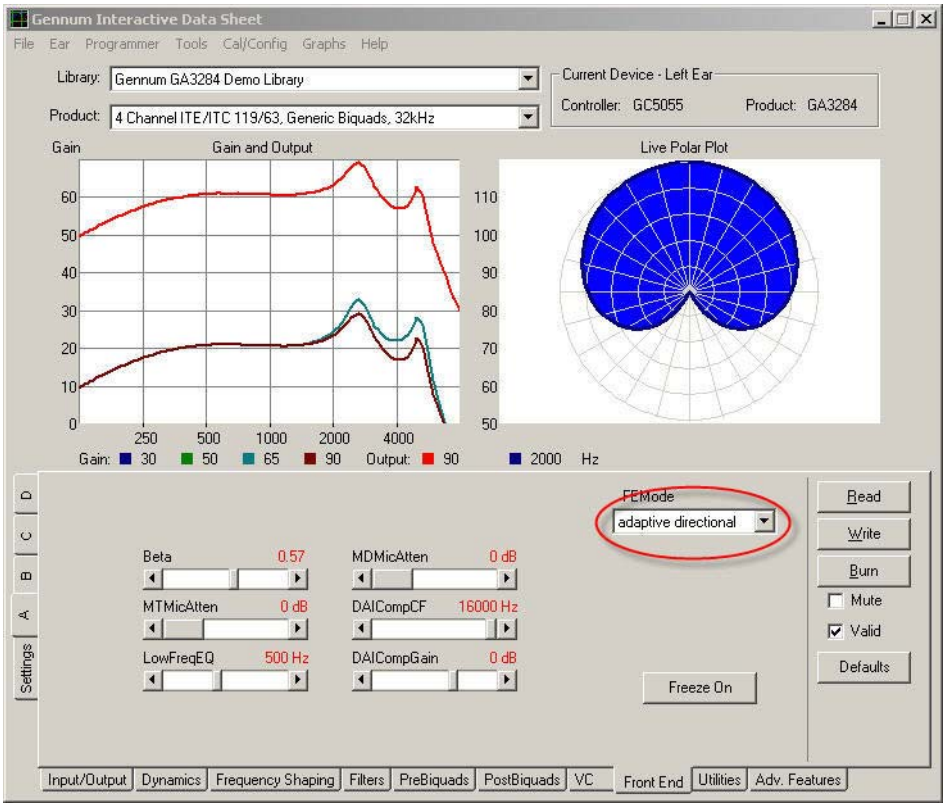

Figure 2. IDS Screen Shot of ADM Mode Enabled

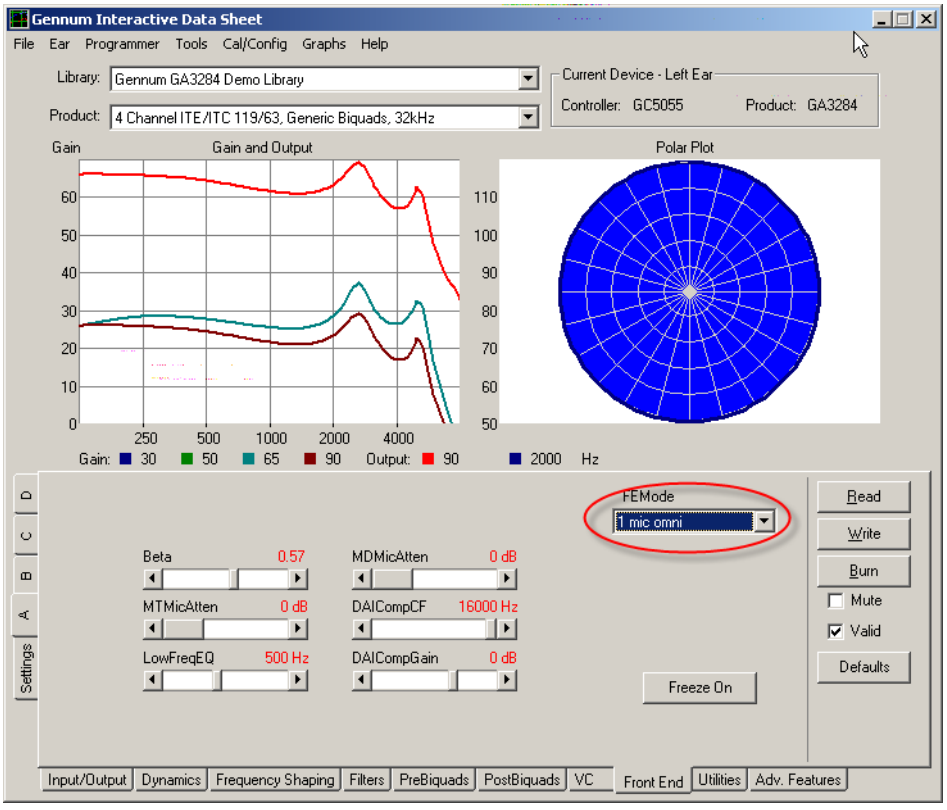

Figure 3. IDS Screen Shot of ADM Mode Disabled

MEASURING THE ADM POLAR PATTERN

The ADM polar pattern can be measured by providing a steady sound source in the rear hemisphere and allowing the algorithm time to adapt. After several seconds, the adaptation can be frozen using the software tools provided (see Figure 4) and the polar pattern can be measured using conventional directional measurement procedures. In a free-field (echo-free) environment, the measured angle of the microphone null and the angular location of the noise source should coincide. In some test chambers, however, acoustic reflections may be present that cause a shift in the null location away from the actual noise location, as described above. This is not a cause for concern since the null position is selected to minimize the level of noise in the microphone output including the effect of acoustic reflections.

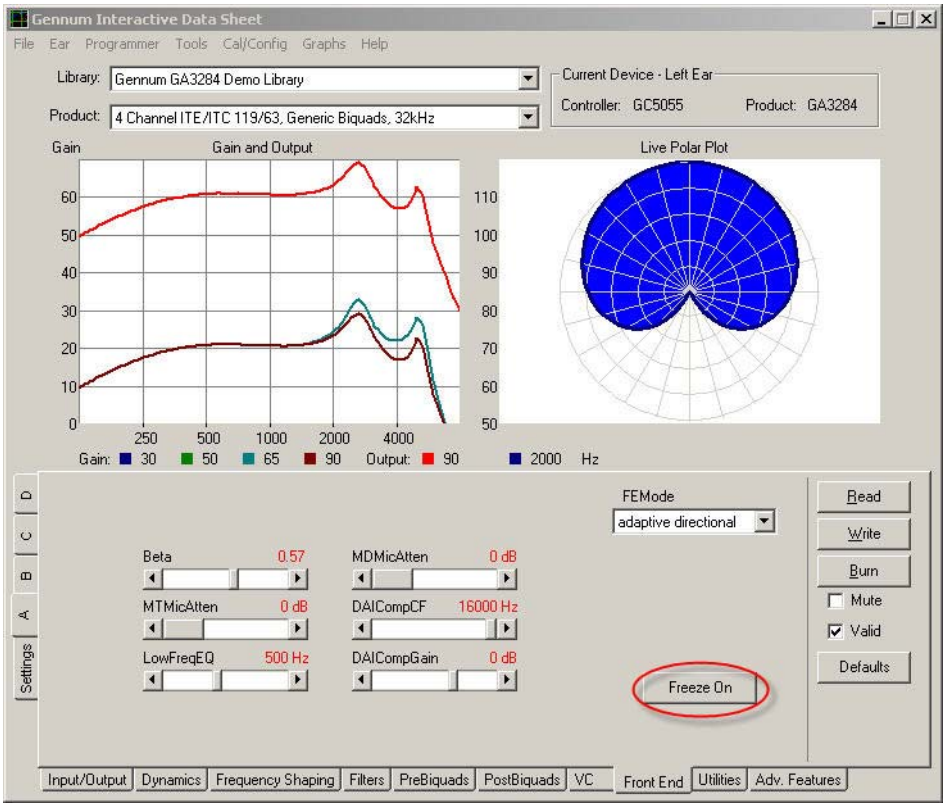

Figure 4. IDS Screen Shot Highlighting the ADM Freeze Button

TYPICAL MEASUREMENT SETUP

A block diagram of a typical measurement setup is shown in Fugure 5. Two loudspeakers are provided:

- Signal speaker should be situated in the front hemisphere (typically at 0 degrees) and represents the signal we want to hear.
- Noise speaker should be situated in the rear hemisphere. It should be moveable from 90 to 270 degrees and represents the noise or interference.

The distance between each loudspeaker and the hearing aid should be approximately 1 meter. The black circles on the hearing aid represent the microphone ports. Measurements on a mannequin are possible but, the location of the null and the measured polar pattern will be affected by the acoustic properties of the mannequin. In either case, the centre of the speakers should be at the same height as the hearing aid microphones.

For turntable measurements, care should be taken to ensure that the hearing aid rotates about an axis that passes between the microphone ports. This ensures that the microphone ports maintain a consistent distance from the loudspeakers and minimizes errors in the measured polar pattern. ADM polar patterns should be measured with the hearing aid in an acoustic free field. This means that the hearing aid should be mounted on its own (not on a mannequin) with both microphones the same distance from the floor (level) and away from any source of acoustic reflection, preferably in an anechoic chamber. To minimize reflections from a turntable, the hearing aid should be

attached to the end of a rod which is mounted to the centre of the turntable. Null-angle measurements taken when the hearing aid is free-field should line up very well with the position of the noise source.

If an anechoic chamber is not available or the hearing aid is mounted on a mannequin, then the acoustic reflections from the room and/or mannequin will have an affect on the measured null angles. In such cases, the measured null angles may not coincide with the exact position of the noise source.

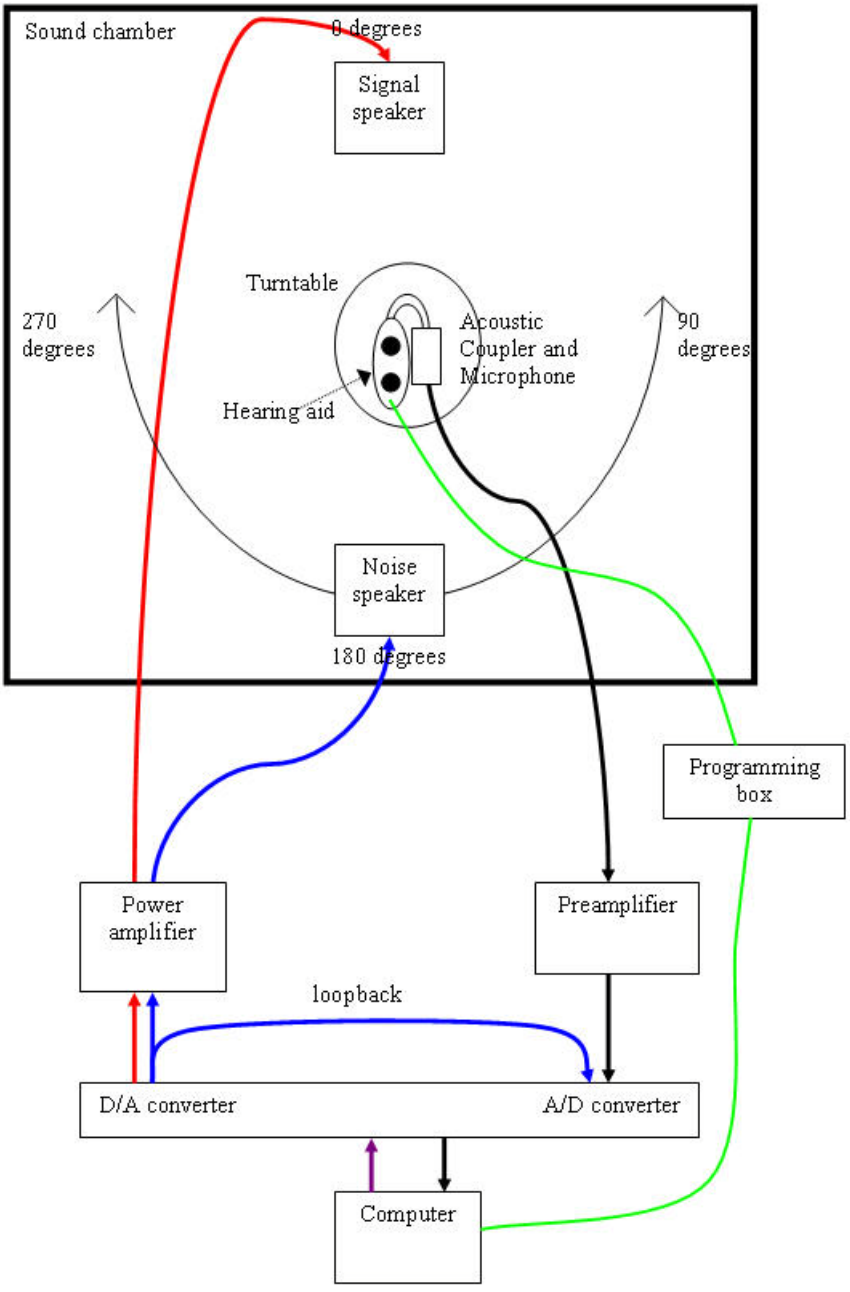

Figure 5. Typical Measurement Setup Diagram

LIVE POLAR PLOT

Another tool available for verifying the ADM functionality is the Live Polar Plot option in IDS (see Figure 6 and Figure 7). Using the Live Polar Plot enables real-time feedback on the polar pattern of the device at any given moment. For the Live Polar Plotter to work, the hearing device must be connected to a programming box such as the DSP Programmer or HiPro. The software will continuously monitor registers in the device and translate them to a polar pattern on the screen. As the environment around the hearing device changes (moving the noise source, for example), the display will show the null adjusting accordingly. The ability to freeze the polar pattern is available. Source code to implement the Live Polar Plot function in fitting or engineering software is also available.

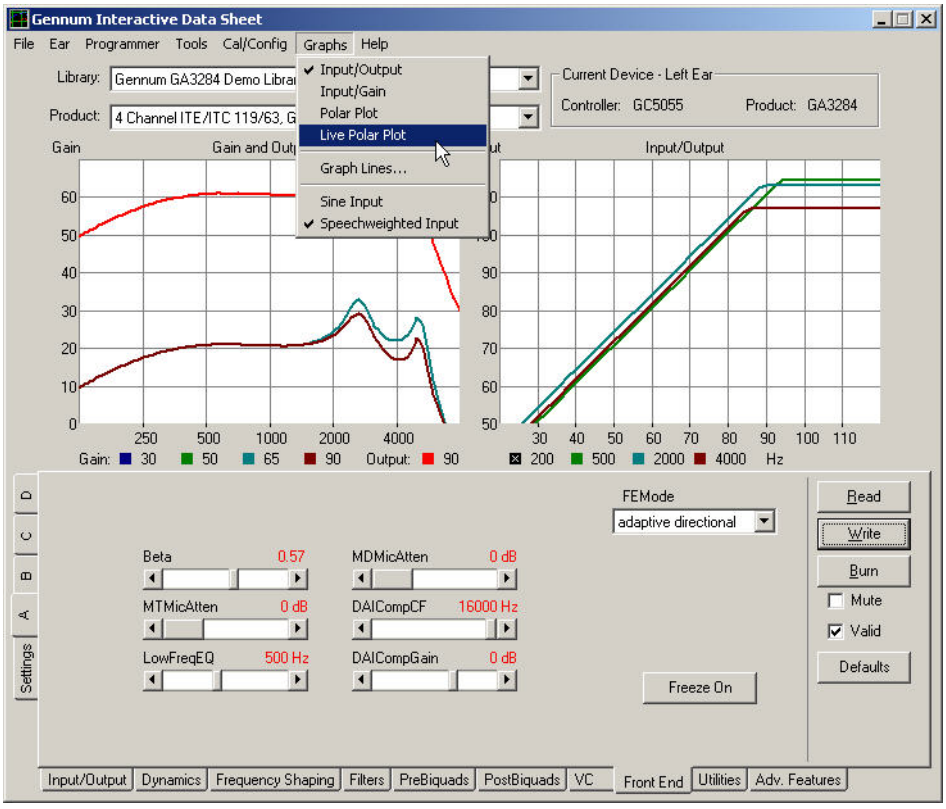

Figure 6. Enabling the Live Polar Plot Function

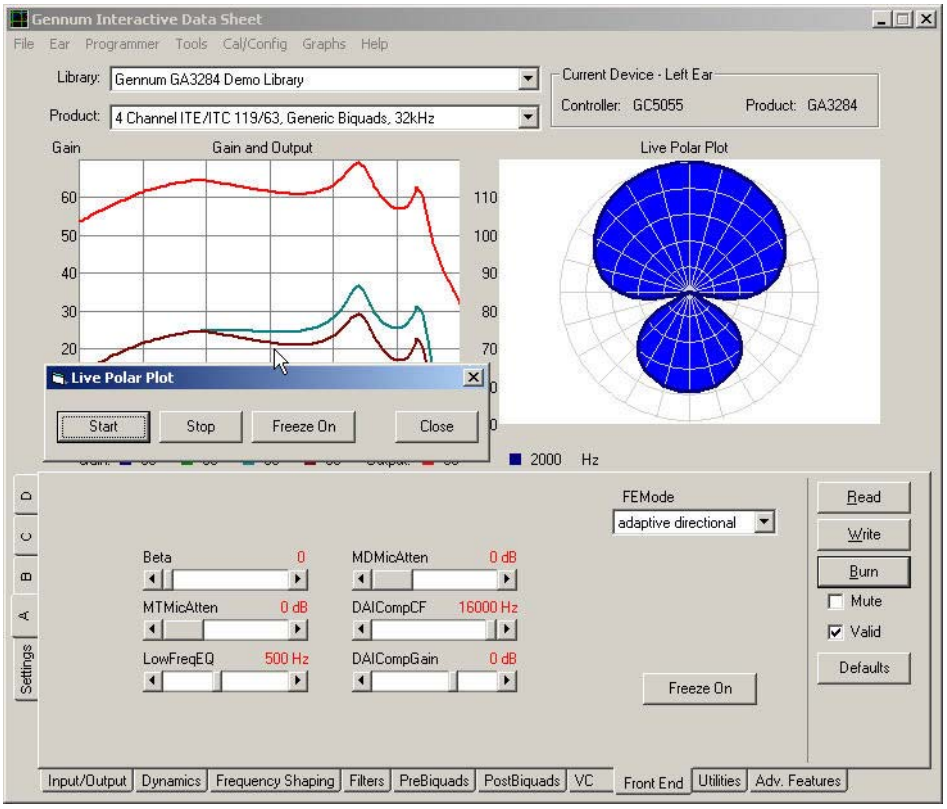

Figure 7. Polar Pattern on Live Device

CALIBRATION

To ensure that the deepest possible nulls, and therefore the best ADM performance, are attained, it is recommended that a hearing aid be calibrated (see Figure 8) before wearing or performing measurements. In IDS, you will need to select **Calibrate directional system** and set the **Mic Spacing** on the Directional tab in the Cal/Config Setup window. If you are not familiar with IDS or Cal/Config, refer to the Getting Started with the ARK™ Software information note (Document #27217) and Cal/Config User's Guide for mARK2™ application note (Document #27350).

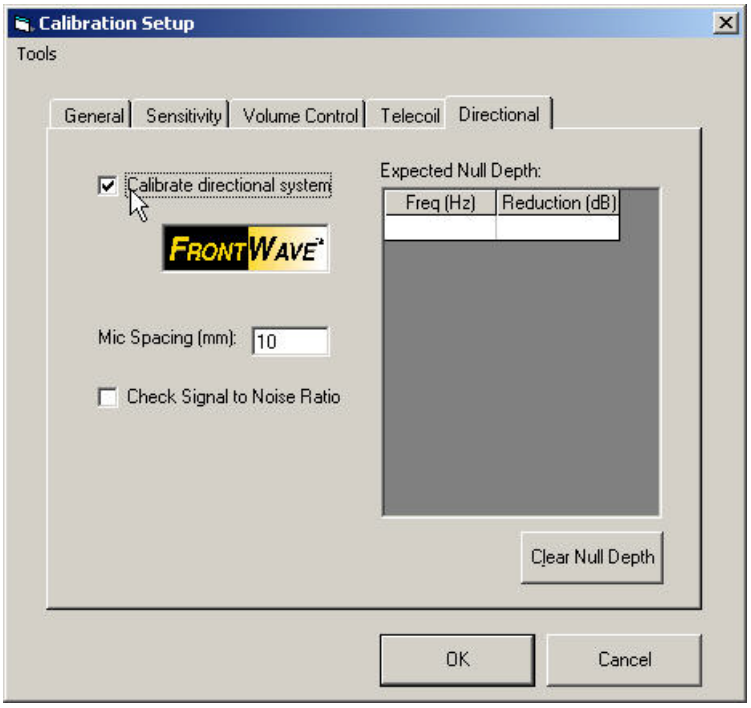

Figure 8. Directional Tab under Cal/Config Setup in IDS

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