

# Audible Low-Battery Warnings: Standard or Optional?

Since the introduction of K-AMP hearing instruments in 1989, an estimated 2-3 million hearing instrument users throughout the world have known when their batteries were about to die. This is because a feature in K-AMP circuits, called LOBAT™, produces a steady, well-controlled audible sound when the battery voltage drops below 1.1V, a voltage level typically reached a few hours before the battery is expended completely.

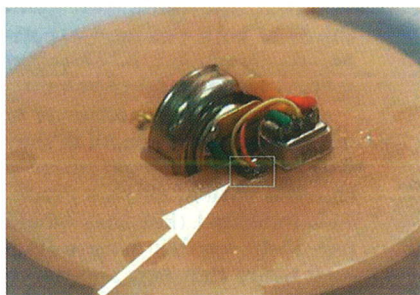
Hearing instrument users report that, when a hearing instrument goes dead without warning, they often don't think of the battery first. They know something is wrong, but cannot determine what it is. They worry that something has happened to their hearing, their hearing instrument, or their environment. Eventually, they realize that the problem is a dead battery, but many report disorientation, awkward moments or embarrassment while they troubleshoot.

When monaural hearing instruments were prevalent, it was more obvious when a hearing aid battery died. With binaural hearing instruments, it is easier to miss the problem at first. Knowing that a battery is about to die gives users an opportunity to change the battery at a convenient time, avoiding the uncertainty that occurs when a battery suddenly dies during an important conversation, business meeting or social situation.

## Operation

When battery voltage drops below about 1.1V, LOBAT injects tiny pulses into the microphone output. Above 1.1V, it is essentially disconnected from the microphone. The detector's warning sound starts as a slow ticking, which becomes faster and louder

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The tiny LOBAT circuit (the IC chip is 1.5 x 2.0 x 1.0 mm), which is connected to the battery terminals with the output coupled to the microphone output/amplifier input, acts as a low-battery detector. It introduces a ticking noise which becomes progressively faster and louder as battery voltage decreases.

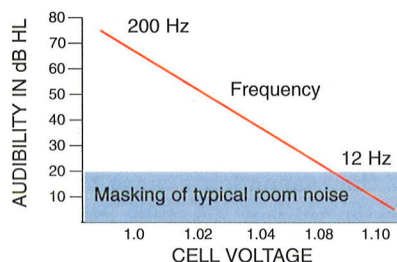


Fig. 1. Estimated audibility of LOBAT output versus battery voltage.

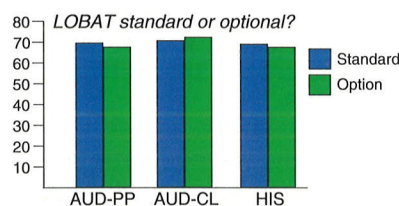


Fig. 2. Desirability of the circuit, as reported by dispensing professionals.

(like a motorboat) as the voltage drops. Because the chip is wired to the microphone output (or to the amplifier input, at the discretion of the manufacturer), it is compatible with any non-programmable or programmable, analog or digital instrument. The warning starts while the battery is still functioning, so the hearing instrument user has advanced warning up to several hours before the battery dies. There is little change in the performance of most hearing instruments during the warning period, which gives the user

sufficient time to change the battery at a convenient opportunity. Fig. 1 shows the audibility characteristics of the LOBAT signal. As the battery voltage drops below 1.1V, both the frequency and the intensity of the motor-boating sound increase.

## Survey Rationale

During the past 10 years, the author has dispensed thousands of K-AMP hearing instruments and found that LOBAT is important to most users. Many experienced hearing instrument users were disappointed when they subsequently purchased new devices without the detection system after having had the feature in their previous instruments. Some patients actually decided not to purchase new multi-channel, multi-memory or multi-microphone instruments solely because these devices did not have a low-battery warning.

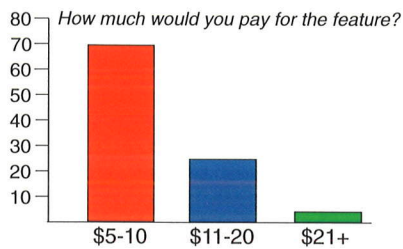
There appears to be a direct correlation between the degree of hearing loss and patients' expressed need to know when the battery is about to die. Individuals with moderately-severe and severe hearing losses often report more disorientation than those with milder losses when a battery dies suddenly. It is precisely this group that often needs the flexibility of multi-channel, multi-feature hearing instruments.

In 1996, a three-part study was undertaken to investigate the desirability of LOBAT for all hearing instruments. A 5-point rating scale was used on each questionnaire. The first survey was sent to 1500 dispensing professionals to determine the extent of their familiarity with the feature and their opinions about it. The second survey was sent to 442 patients who were currently using K-AMP hearing instruments (with the detection feature built-in) to determine their satisfaction with LOBAT. The third survey was sent to 75 users of digitally programmable, two-channel, two-memory wide dynamic range compression (WDRC) devices to determine whether they thought the detection system would be a desirable feature if it were available.

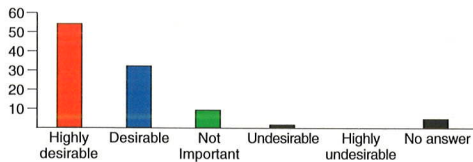
Results of these three surveys were withheld until LOBAT was available as an option for all hearing aids.

## Survey 1

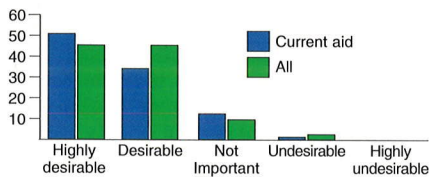
A list of 1500 dispensing professionals was purchased from a hearing industry journal's circulation list.



**Fig. 3.** Most dispensing professionals say they would pay \$5-10 for the feature.



**Fig. 4.** Desirability of low-battery warning system as rated by K-AMP hearing instrument users.



**Fig. 5.** Desirability as rated by users of digitally programmable devices.

Names were obtained from three categories in the same proportion that occurred on the mailing list: Audiologists in private practice (AUD-PP, 23%), audiologists in clinical settings (AUD-CL, 36%) and hearing instrument specialists (HIS, 41%). All practitioners were asked their opinions about: 1) the desirability of LOBAT as a standard feature on all hearing instruments; 2) how often they would order the system if it were an option available at no charge on all hearing instruments; 3) how helpful existing low-battery detection systems were for new users and for experi-

► **Results:**

1. Over 70% of respondents considered LOBAT desirable or highly desirable as a standard feature on all hearing instruments. The responses from the three groups were essentially the same (Fig. 2).

2. Over 70% of all dispensers stated that they would order LOBAT as a free option very frequently or frequently.

3. Dispensers from all groups reported that approximately two-thirds of both new and experienced users found the detection system very helpful or helpful.

4. More than two-thirds of dispensers indicated that they would order the system as a charged option. Of this group, 71% indicated that they would pay \$5-10 for this feature (Fig. 3), a figure that now appears to be a reasonable estimate of the likely dispenser cost (\$10-15) for the option.

**Survey 2**

The second survey was sent to 442 K-AMP users to determine how much they valued the LOBAT feature (would they miss it if they did not have it?) and whether they felt if all hearing instruments should have this low-battery warning signal. The response rate was 53%.

► **Results:** Eighty-seven percent of the respondents were binaural users, which is the same percentage of binaural users in the author's practice. The distribution of respondents was evenly divided between males (50%) and females (50%), as well as between first-time users (49%) and experienced users (51%) who were using K-AMP hearing instruments with the built-in detection system.

1. 86% rated the feature as highly

desirable or desirable (Fig. 4).  
 2. 82% reported that they would consider the feature highly desirable or desirable if it were available on all hearing instruments.

**Survey 3**

The third survey was sent to 75 users of digitally programmable two-channel, two-memory WDRC instruments. This group was asked whether it was desirable to have LOBAT on their own instruments and if they thought it was a desirable feature for all hearing instruments.

► **Results:** The response rate was 72%. Fifteen percent were new users, 85% were experienced hearing instrument users and 83% were binaural users. Eighty-seven percent considered the detection system highly desirable or desirable for their own digital-programmable devices, and 87% rated it as highly desirable or desirable for all instruments (Fig. 5).

**Discussion**

From 1997-1999, during the development of a stand-alone LOBAT circuit, several of the author's patients had non-K-AMP hearing instruments retrofitted with prototype LOBAT circuits. The circuit was successfully installed in full-shell, canal and CIC instruments, all of which were programmable.

In 1996, there was only one audible low-battery warning for hearing instruments, and it was proprietary to the K-AMP circuit. In 2000, there are six low-battery warning circuits with different frequency, audibility and temporal characteristics. Hearing instrument performance does not change during the warning period for these circuits except in Prisma; however, the audible sound and the duration of the warning period before shutdown vary significantly (see Table 1).

**Conclusion**

Three 1996 surveys corroborated the author's clinical experience that patient satisfaction with LOBAT is high, and practitioners in all surveyed groups judged the device to be a desirable feature. ♦

**Acknowledgements**

*During the design phase of the K-AMP circuit, one of the prototypes made a sudden motor-boatting sound when the battery voltage dropped too low for normal operation. Special recognition goes to audiologist Mary Cay Chisholm for realizing the value of this warning for hearing instrument users, and for encouraging the transformation of a prototype defect into a circuit feature in the original K-AMP. Thanks to Karen Briskey and Catherine Penn for assistance in questionnaire development and statistical analysis of results.*

Instrument	Audible warning	Time sequence	Activated	Warning time
Prisma (Siemens)	Gain drops	3 gain reductions of 6 dB each	Unknown	20 mins-2 hrs
Signia (Siemens)	Programmable beep	4 beeps/minute	Unknown	20 mins-2 hrs
InteliVenience (Siemens)	Steady motorboating	Faster+louder as V drops	At 1.1V	1-8 hrs
Danalogic (GN ReSound)	Beeps ≤ 750 Hz	Beeps every 15 sec	2 mins to shutdown	2 mins
Digital 5000 (GN ReSound)	Beeps @ 750 Hz	Beeps every 45 sec	5 mins to shutdown	5 mins
K-AMP w/ LOBAT	Steady motorboating	Faster+louder as V drops	At 1.1V	1-8 hrs

**Table 1.** Circuits with low-battery warnings.

enced users; and 4) how much they would pay for the system as an option. The survey return rate was 40%, with almost equal representation from each of the three groups.