A Fractal Audible Interface, Version 1.0

By R. G. Sparber

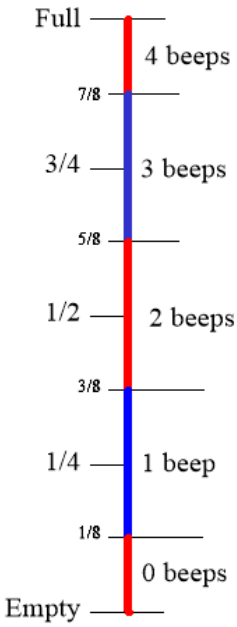
Protected by Creative Commons.[1]

Buried in my eGas Gauge design was a problem that I found devilishly hard to solve to my own satisfaction: the human/machine interface.

Only when I finally had a design I liked was I able to generate the requirements that it must meet.

1. Communicate a number via a series of beeps.
2. Require minimal training of the user.
3. Variable accuracy.

These requirements won't make much sense until you see my solution:



The number I need to convey to the user is the fraction of the remaining energy in my eBike's battery. Remember, requirement number 2 is to have minimal training of the user. In other words, the series of beeps should be painfully obvious.

The number of beeps represents the number of quarters. Duh…

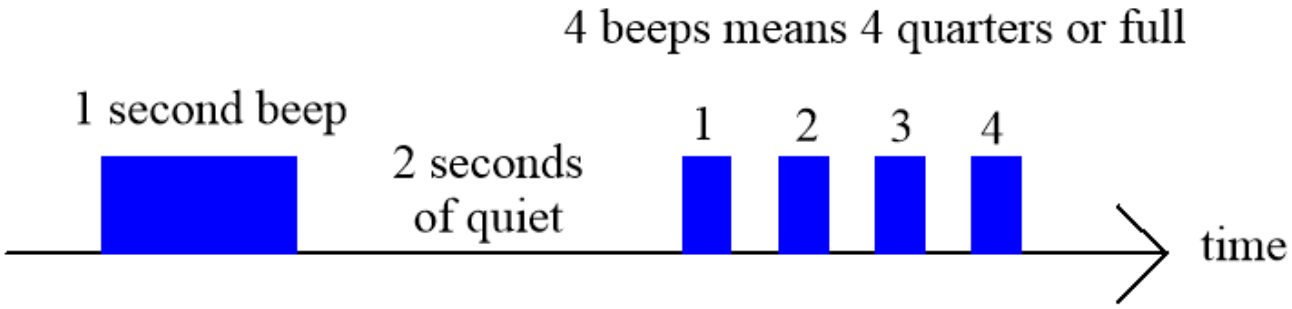
Looking a little closer, I had to decide where to put my transitions between quarters. For ¼, ½, and ¾, I spanned ± 1/8. So, for example, ¾ runs from ¾ - 1/8 = 5/8 to ¾ + 1/8 = 7/8.

This leaves me with an odd range for 0 and 4/4. Both are half the range. From Empty to 1/8, I call it 0/4. Think of 0/4 as Empty, but instead of ± 1/8, it is $^{+(\frac{1}{8})}/_{-0}$. Similarly, 4/4 is Full $^{+0}/_{-(\frac{1}{8})}$.

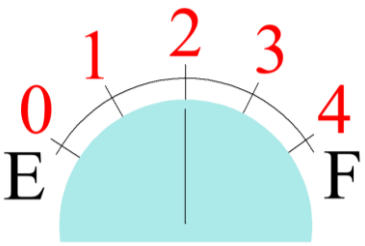
[1] This work is licensed under the Creative Commons Attribution 4.0 International License. To view a copy of this license, visit http://creativecommons.org/licenses/by/4.0/ or send a letter to Creative Commons, PO Box 1866, Mountain View, CA 94042, USA.

These boundaries must be clearly defined for the software, even though the user probably doesn't care.

To meet requirements 1 (Communicate a number via a series of beeps), I chose this pattern of beeps:



The 1-second beep gets my attention every time. Then I have 2 seconds to become prepared to count the following short beeps. It is easy to count 0 to 4 beeps, but that is about the limit. Counting, say, 10 beeps, would be too much to ask.

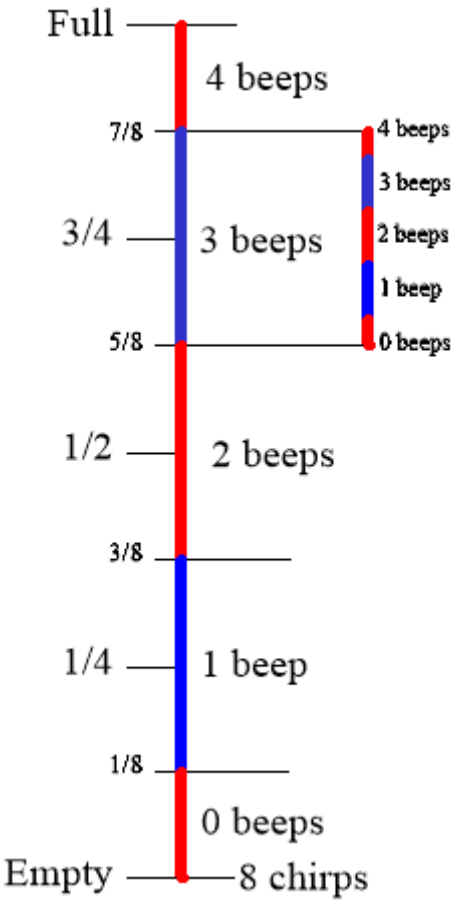


In support of requirement 2 (Require minimal training of the user), I found it easy to visualize a gas gauge with tick marks every quarter.

I lived with this design for a while and had no trouble with it, but the precision was not always good enough.

After many false starts, I ended up thinking about Fractals. Consider a tree as viewed from a distance. It is formed from many individual large branches. Just as these branches extend from the trunk, smaller branches extend from each of these large branches. Look at each smaller branch, and the pattern repeats. Eventually, you will get down to an individual leaf. It has veins that mirror the same pattern. This repeating and ever-smaller pattern is an example of a Fractal.

My tree is formed from having zero to four quarters. Once I know which quarter, I can repeat the pattern and tell the user which quarter of a quarter. I could have as many of these sequences as desired, but two is enough in this application.



Say you first hear 3 beeps. Ah, that means ¾. If that is all the precision you desire, stop listening. But if you want more, wait for the second set of beeps. This satisfies requirement 3 (Variable accuracy).

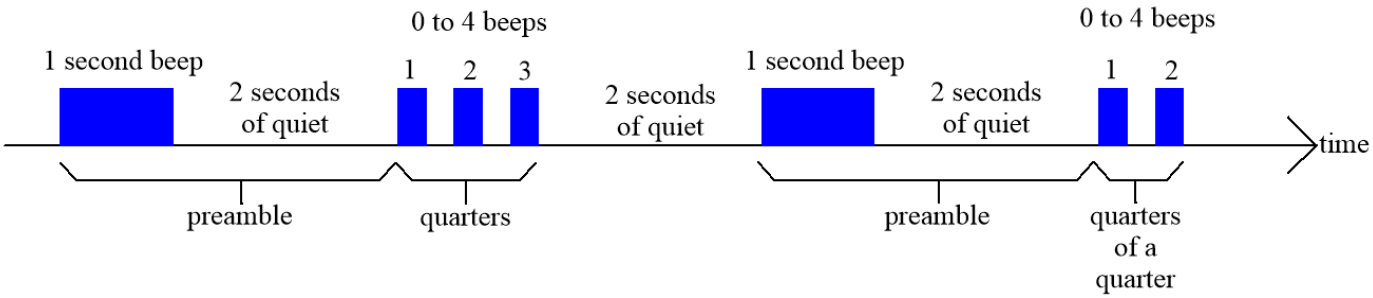
You hear 2 more beeps. This means 2/4, or ½. But since it is in the second set, it means ½ way up ¾. In other words, in the center of the ¾ zone.

If you just want a sense of where you are, it isn't hard to visualize that second set of beeps moving you around the known quarter. But if more precision is desired, a bit of mental math will give it to you.

First, convert the quarter to eights and subtract 1/8. Then convert that number to 16^{ths}. The second set of beeps are the number of 16^{ths} in this quarter so add them in. The result is ± 1/32 or about ±3%.

Example: **3 beeps and then 1 beep**
3 beeps mean ¾. Converting to eighths gives me 6/8. Subtract 1/8 brings me to 5/8. Convert that to 16^{ths} gives me 10/16. That second beep means 1/16, and I add that in to get 11/16. With a little practice, I found that this wasn't hard to do in my head. However, I rarely wanted to know the energy level to this precision.

Consistent with requirement 2 (Require minimal training of the user), the second set of beeps uses the same format as the first set of beeps:



This design experience reminds me of a saying from Mark Twain: “I didn’t have the time to write you a short letter, so I wrote you a long one instead.” It takes a lot more effort to make something simple. At least I *think* it is simple 😉.

I welcome your comments and questions.

If you want me to contact you each time I publish an article, email me with “Subscribe” in the subject line. In the email body, please tell me if you are interested in metalworking, software plus electronics, kayaking, and/or the Lectric XP eBike so I can put you on the right distribution list.

If you are on a list and have had enough, email me “Unsubscribe” in the subject line. No hard feelings.

Rick Sparber
Rgsparber.ha@gmail.com
Rick.Sparber.org