The giftie

Robert Burns, Scotland's best-loved poet, penned the following lines to begin the last verse of one of his most famous poems:

O wad some Pow'r the giftie gie us

To see oursels as ithers see us!

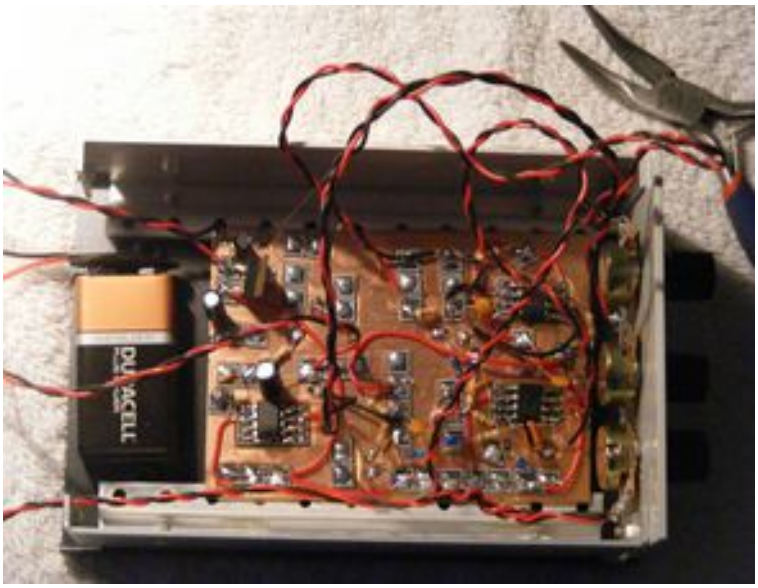
The events of a few nights ago were to provide me with an unexpected, and not altogether welcome, reminder of the phrase.

I have always been rather fascinated by bats and, in the summer dusk, I often stand in the lane outside my house to watch Pipistrelles dashing about above my head in search of incautious moths. Or, when I am able to get away on my ancient narrow-boat, I often see Daubenton's bats skimming low over water as evening morphs into night. In the tunnels of the English canal system it is even possible to watch them hunt by day for the insects that dance in the beam of the boat's headlight, as it shines in the smoky darkness. Space in these tunnels is very limited and the bats often fly so low over my head, as I stand at the tiller, that I feel the rapid beat of air from their wings as they pass. Unlike birds, which are generally wary of people, bats on the wing seem remarkably unbothered by humans and seem to fly as close to us as they do to bushes and trees. On a quiet night it is possible to hear them squeek in the manner of mice, but not to hear their famous ultrasonic echo-location. I felt I wanted to and, one wet Sunday afternoon, I decided to do something about it.

In principle, there are two simple ways to render the ultrasonic audible, both of which begin by using an ultrasonic microphone to turn sound into an electrical signal. The first method involves digitizing the signal (so that, for example, a rounded sine wave is turned into something more like square battlements), then using a digital divide-by-10 counter to reduce a wave spectrum between, say, 20kHz and 100kHz, beyond human hearing, to one between 2kHz and 10kHz, well within human hearing. This approach has the advantage of covering almost the whole 'batty' spectrum so is suitable for all species, but it compresses the frequency variation of each bat so that a 1kHz change in frequency would become only a 100Hz one. The digitization process would also erase any loudness information: the bat would either be loud enough to hear strongly or not loud enough to be heard at all, with nothing in between. The other method uses transposition, combining the output from the microphone with the output of an oscillator in a non-linear mixer, to generate new signals

at the sum and difference of the bat's and oscillator's frequencies. Listening to the difference frequency has the advantage that a 1kHz swoop from the bat between, say, 30kHz and 31kHz would still be a 1kHz swoop, but would appear, if the oscillator were set to run at 25kHz, as a swoop between 5kHz (ie 30kHz-25kHz) and 6kHz (ie 31kHz-25kHz) at the loudspeaker. This is well within the normal range of human hearing. Analogue transposition also has the advantage that variations in loudness are preserved. The disadvantage is that with a human hearing range of, say, 100Hz to 15kHz, only a 15kHz wide chunk of the ultrasonic spectrum can be monitored at a time. As different bats use different frequencies, the oscillator would need to be tunable across a range from about 20kHz to 85kHz. Obviously there are also more complicated solutions to the problem methods that would use computers and digital signal processing, but I was intending to knock something up from components kicking about in my attic and wanted to keep it simple.

Comparing the two techniques, I went for the second: my old analogue heart rebelled too strongly against the idea of turning the beautifully shaped, complex waves of a bat click into ugly, square digital pulses. I found an ultrasonic receiver to use as a microphone in a bargain bag of robot parts, and finding parts to use for a preamplifier for the ultrasonic signal, for the oscillator, and for the final amplifier was easy because all of these things can be knocked together from all kinds of standard components with no great need for accuracy in performance. Building the thing was easy - if you want one too, see the link section for instructions. It looked ugly, though (as most of my circuits do), so I quickly rammed it into an aluminium box, with volume and tuning knobs on the front and the microphone on the back, and did up the lid to hide the scruffy contents.



The innards of the bat detector in their messy glory. Production engineers used to printed circuit boards will be horrified by the construction style but, for a one-off project, this way is much quicker, especially when testing reveals that changes have to be made.

As I was messing around inhaling solder smoke and stabbing my fingers with stray bits of wire, the weather had set about clearing up and the evening was fine with hardly any wind by the time the semi-darkness, that is as close to night as Scotland gets mid-summer, fell. I picked up the bat detector and ventured out across the lane and into the field beyond. With unassisted hearing, I could already hear some mousy squeaks and occasional wing beats above me and, against the weak light in the sky, could see the outlines of fast-moving bats hunting for prey. I switched on the detector, set the gain up fairly high, and slowly tuned the oscillator. Nothing at first, then 'pa-pa-pa-pa', just detectable when a bat was about 100 feet away and really loud when it was above me. I tried to follow the animals' flight, pointing the box up high and listening. Soon it was apparent that the pa-pa-pa turned into a sort of brrrrrrrrrrp, with each 'r' being a falling note, just as the bat closed in on smaller flying objects that I assume to be moths. It was fascinating listening to them, and all the more satisfying to so so on a 'junk-box' device.

The evening was, as I mentioned, windless and quiet and I was listening very hard as I whirled about, tracking the bats as well as I could, and pointing the box of tricks aloft at the end of my outstretched arm. It is for perhaps this reason that I heard, from an unfamiliar, elderly sounding female voice in a nearby house or garden, the softly spoken words

I see yon professor's doing something peculiar…. again.

Thank you, whoever you were, for your little Burnsean 'giftie'.

Jamie Davies,
Edinburgh,
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Links:

Instructions for building the bat detector: http://golgi.ana.ed.ac.uk/Davieslab/batsnooper.pdf