Franzis Fledermausdetektor (bat detector).

This document describes how you can put a frequency scale on the bat detector box.

For more information on the bat detector itself and its working please refer to
http://www.elektronik-labor.de/Lernpakete/Fledermaus3.html

The box of the bat detector kit.

The scale for the frequency on the box of the detector is given by equidistant marks, but no frequency values are given. The values probably depend on the exact component values, build quality and use of the kit and may vary between different detectors.

Some people may find a scale with actual frequency values an asset, so they can relate a frequency to a specific bat or any other ultrasonic noise they measure. A search on the internet into such a scale gave no results, so two experiments were defined and carried out to obtain the frequency values of the scale.

For the first experiment use is made of the working principle of the bat detector, as outlined in the section Binaural Beats in the manual. This involves generating an external acoustic signal with known frequency and measuring the response with the bat detector.
The second experiment involves a direct measurement of the oscillator frequency on the printed circuit board.
Both the experiments will be explained in more detail below.

Experiment 1: Ultrasonic measurement of the oscillator frequency.

Background to the experiment.
A stable ultrasonic sound can be generated with a wave generator attached to a tweeter.
Setting a specific input frequency on the wave generator for the tweeter, say 40 kHz, and turning the frequency knob on the bat detector, one can generate a well audible tone with the bat kit if you approach the input frequency. This tone is the difference of the input frequency (40 kHz in this case) and the oscillator frequency. If the oscilator frequency matches the receiving frequency, no tone can be heard. Just above and below this frequency a load tone is heard, so it is easy to obtain the frequency with some accuracy.

Equipment used.

- Bat detector from Franzis. On the box it shows version 2017/01.
- Wave generator: Rigol DG1032Z
- Tweeter: PT1-1012 manufactured by Kenford/McGee (rated for the range 3,5k....40kHz, but appears to work well over 100kHz)

Equipment setting.

On the wave generator (WG) a pure sine wave with amplitude 1Vpp was set as input for the tweeter. The WG was directly connected to the tweeter so low input voltage does not overload the WG. Volume of the bat detector speaker was set to half range up to about 60 kHz, and turned further up while approaching the 100kHz as the sound level decreases for higher frequencies. This setting does not affect the frequency at which the dip occurs but makes it better to distinghish at higher frequencies. Distance between tweeter and bat detector microphone was 20 centimeter.

Measurement procedure.

The knob on the bat detector was set at a specific mark, and the frequency of the sine wave was increased with steps of 100Hz until no sound was heard thru the speaker of the bat detector. The frequency was moved up and down around this point to be sure the dip in sound level was found. This frequency was noted down. The knob on the bat detector was then moved to the next mark and the procedure repeated. There are in total 17 marks on the scale. Full left starts at mark 1, full right is mark 17.

Note that you don't hear any sound directly from the tweeter as the frequency is too high for your ears.

Measurement results.

From full left turn to full right turn for each mark of the 17 marks the following frequencies were obtained (all values in kHz):

1 = 23.4 kHz
2 = 23.5
3 = 23.7
4 = 24.8
5 = 26.7
6 = 28.3
7 = 30.7
8 = 33.3
9 = 36.8
10 = 41.3
11 = 46.5
12 = 53.2
13 = 60.2
14 = 69.6
15 = 82.2
16 = 98.6
17 = 111.9

Values of the frequencies can be off by 100-200Hz (either higher or lower) but are considered more than accurate enough for the purpose the bat detector is used for. The measured frequency values range from 23.4 kHz to 111.9 kHz. The most interesting range for bat sound detection is roughly between 30 and 60 kHz, so this range is covered between marks 7 and 13.

As can be noticed, the scale is not linear. For the first 3 or 4 marks the frequencies are very close. Then the frequency steps become lager. You can now mark each scale mark with a frequency.

Experiment 2: Measurement of oscillator frequency on the printed circuit board.

To verify the oscillator frequencies, a second method can be used. But for this we have to dive a bit deeper in the actual circuit. This method works also if you don't have a waveform generator but only an oscilloscope or a frequency counter on your test bench.

Schematic.
The oscillator frequency is set with the frequency knob on the bat detector. This is a potentiometer with a value of 22K Ohm. The integrated circuit IC 555 with some components around it is responsible for generating the oscillator frequency. The frequency can be calculated from the resistors 2.2K, 3.3K plus potentiometer resistance and 1nF capacitor.
Use was made of the free program Electronics Assistant V4.31 which can be found at http://www.electronics2000.co.uk/
Under the menu entry Frequency -> 555 Timer Calculator. Select Astable circuit configuration, select variable to calculate frequency/Period, and input the values for C1, R1 and R2.
The Astable circuit shown on the right in the same tab looks similar to the schematic in the manual. C1 = 1nF (nanofarads), R1=2.2K, R2 ranges from 3.3K to 25.3K (fixed resistor of 3.3K plus pot resistor 22K). At 3.3K this yields 27kHz, at 25.3K this is 162kHz. The maximum oscillator frequency therefore ranges from 27 to 162kHz. This would be the ideal case if all components had their exact specified value. Since we measured a different frequency range during our acoustic test in experiment 1, some questions arise about the accuracy of the components, the frequency range of the tweeter, and what we actually measured during our first experiment.

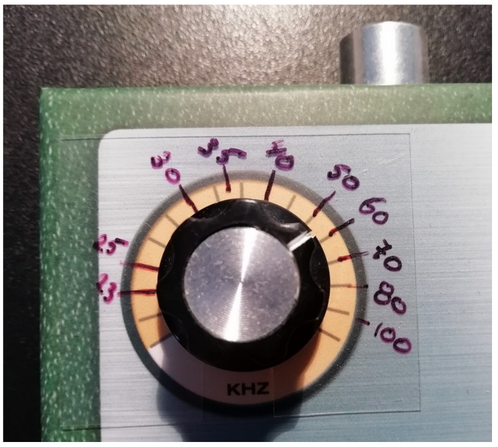
Measuring on pin 3 of the NE555 chip.
The oscillator frequency is output from pin 3 of the IC NE555. With an oscilloscope you can visualize the wave form and obtain the frequency (or use a frequency counter). Measuring at pin 3 shows a square wave with amplitude 2.5Vpeak-peak. For each mark on the scale measuring the frequency (in kHz) at pin 3 gives the following values (2nd column, note that the first column gives the values from the acoustic experiment 1):

	exp 1	exp 2
1 =	23.4	23.6
2 =	23.5	23.6
3 =	23.7	23.9
4 =	24.8	24.9
5 =	26.7	26.3
6 =	28.3	28.2
7 =	30.7	30.5
8 =	33.3	33.1
9 =	36.8	36.2
10 =	41.3	40.6
11 =	46.5	45.0
12 =	53.2	51.0
13 =	60.2	58.1
14 =	69.6	66.7
15 =	82.2	76.9
16 =	98.6	98.0
17 =	111.9	111.0

As can be seen, the output frequency from pin 3 is close to the frequency measured using the wave generator and tweeter (experiment 1), so we have some confidence that the acoustic test was performed correctly, and the component properties are deviating from their nominal values. This is probably also the reason that no scale is put on the box: for each bat detector it can be different and a fixed scale pretends more accuracy than actually present.

Result.

On the bat detector the values at the marks are finally rounded off to the closest 'neat' value which seem to be sufficient accurate for practical use.



Frequency scale (in kHz) on the bat detector.

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5 October 2018