All Things Digital

Amateur Radio for the 21st Century

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Resonant CW Speakers

Introduction

A few years ago, on a quite midnight shift, my co-worker Lori Bedford, VE3VAI was playing around with something that I've heard about but had never quite got around to building and trying. He had a short length of ABS pipe with a small speaker blocking one end with the other open; Morse code (CW) audio was being fed from his transceiver via a patch cord to the speaker (see Figures 1A and 1B, next page). His "something" is called a "resonant CW speaker" and the resulting monotone audio tone (beat note or side tone) coming out from the small speaker was booming through loud and clear, filling our Coast Guard radio operations room with amazing sound (amazing for those of us who enjoy listening to Morse code, that is). Its tuned or resonant frequency is peaked and reinforced (made louder) so that any noise and off-frequency (off-resonant) audio signals are reduced dramatically. By simply sliding a paper "trombone" sleeve over the ABS pipe, Lori could extend its length and shift the resonant frequency, turning it into a variable analog audio CW filter!

Figure 1A: Resonant CW Speaker with Trombone Sliding Sleeve
A small speaker blocks one end and the other is open. Varying the length of the cylinder with the slider changes the cylinder's resonant frequency.

Hooking it up to a laptop soundcard and using an audio tone generator program allowed him to sweep through a range of audio frequencies and adjust the sleeve to peak the preferred tone he likes to copy Morse code.

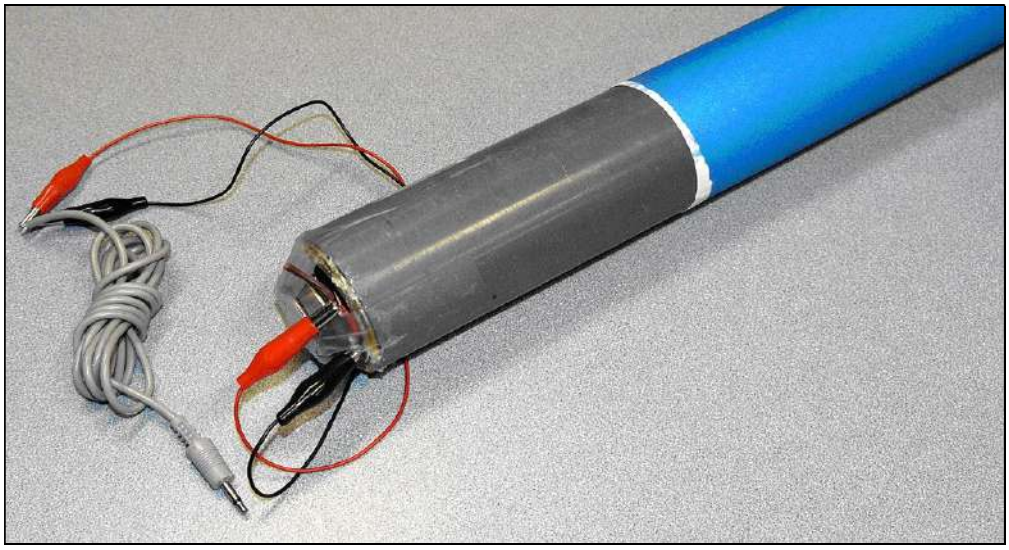

Figure 1B: Resonant Speaker with Trombone Sliding Sleeve (assembled)
The speaker end is sealed tightly to prevent air leaks because this affects the resonant frequency.

Using a receiver, you adjust its beat frequency oscillator (BFO) or receive incremental tuning (RIT) up or down to match that of the resonant CW speaker (see Figure 2). The use of resonant speakers has been around for a long time. Back in the 19th century green landline telegraphers would put snuff or tobacco cans lids up against their telegraph sounders to help identify theirs from others in a room full of similar sounding sounders. Old-time telegraphers sneered at those who did this and called them “lids”.

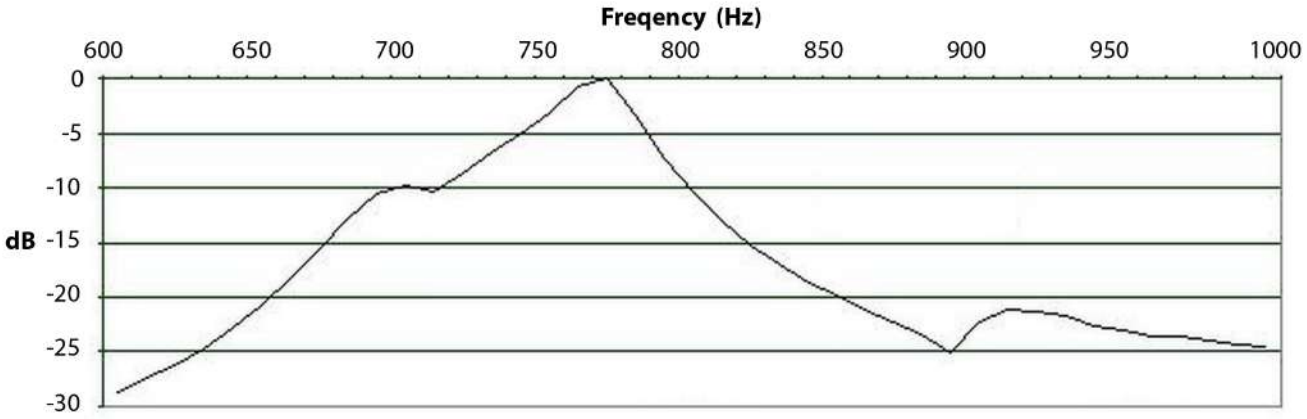

Figure 2: Resonant CW Speaker Audio Response Curve
Designed for an audio peak around 775 Hz. Credit: Edward Loranger, WE6W.

What's in a Wave?

Unlike radio or light waves, sound waves require an "elastic" medium in which to propagate, and they also create a pressure wave as they do so by physically pushing the atoms of the elastic medium out of the way. An elastic medium (flesh and blood, metal, air, water, wood, etc.) is one that can normally change its shape when impacted by a deforming force and then return to its original shape after the removal of the deforming force. Sound waves and their resulting pressure waves are deforming forces that can be both heard and physically felt in various degrees of intensity measured in decibels (dB) and deforming force measured in pascals (Pa). An explosion can be both very loud in sound and very destructive in pressure because both its sound and pressure waves travel rapidly outward from the centre at the "speed of sound", which in air is approximately 343 metres per second (m/s) at 20 °C. As a result, some elastic mediums can be destroyed by the sheer physical power of the forces involved if they are greater than the medium can withstand.

Rolling your Own

Speakers convert electromagnetic energy into mechanical energy by pushing against the surrounding elastic medium (air). In the specific case of a resonant CW speaker, the tube or cylinder attached to the speaker (called a waveguide) is cut for one quarter-wave length at the desired resonant frequency. Interestingly, it will also be resonant at all its odd order multiples (1, 3, 5, 7…); if the design resonant frequency is say 500 Hz then it will also resonant at 1500, 2500, 3500 hertz (Hz), etc. The general equation used to calculate the quarter-wave cylinder length is very easy to use. Expressed in its simplified form, and taking into account for the speed of sound at room temperature (20 °C) it's:

$$L = (122.4 / f) – (0.3d)$$

Where f is the desired resonant frequency in Hz; d is diameter of the cylinder, and L is the length of the cylinder both measured in metres (m). Reference: "An Electro-Acoustic CW Filter" *QST* April 1983. Example: Many Amateurs like to copy Morse code using a 500 Hz audio tone so let's calculate the required length of a cylinder using a 100 millimetre (mm) diameter speaker to create resonance at 500 Hz. First convert to whole metre units then rationalize the resulting value to easier to measure and units. Round-up to make the cylinder a tad longer then trim (tune) it to the final size:

$$L = (122.4 / 500) – (0.3 * 0.1)$$
$$L = 0.2448 – 0.03$$
$$L = 0.2148 \text{ m or } 21.5 \text{ centimetres (cm)}$$

But a cylinder of 21.5 cm is a bit too long to sit and stick out on a shelf; if only there was some way to make it less obtrusive. Well, there is! It can be stood upright or the cylinder can be folded back on itself (a folded waveguide). Sound waves are easily redirected (reflected) and guided by any smooth surface, and while a rounded waveguide is more preferable because this minimizes internal reflections, we can also use a square folded waveguide because it's so much easier to build into square speaker housings. Figure 3 depicts the plans for a resonant CW speaker cabinet; its dimensions will vary depending on the resonant frequency chosen and size of speaker used. The imperial measurements shown produce a resonance around 600 Hz. By sliding the speaker forward a bit you can shift the frequency down.

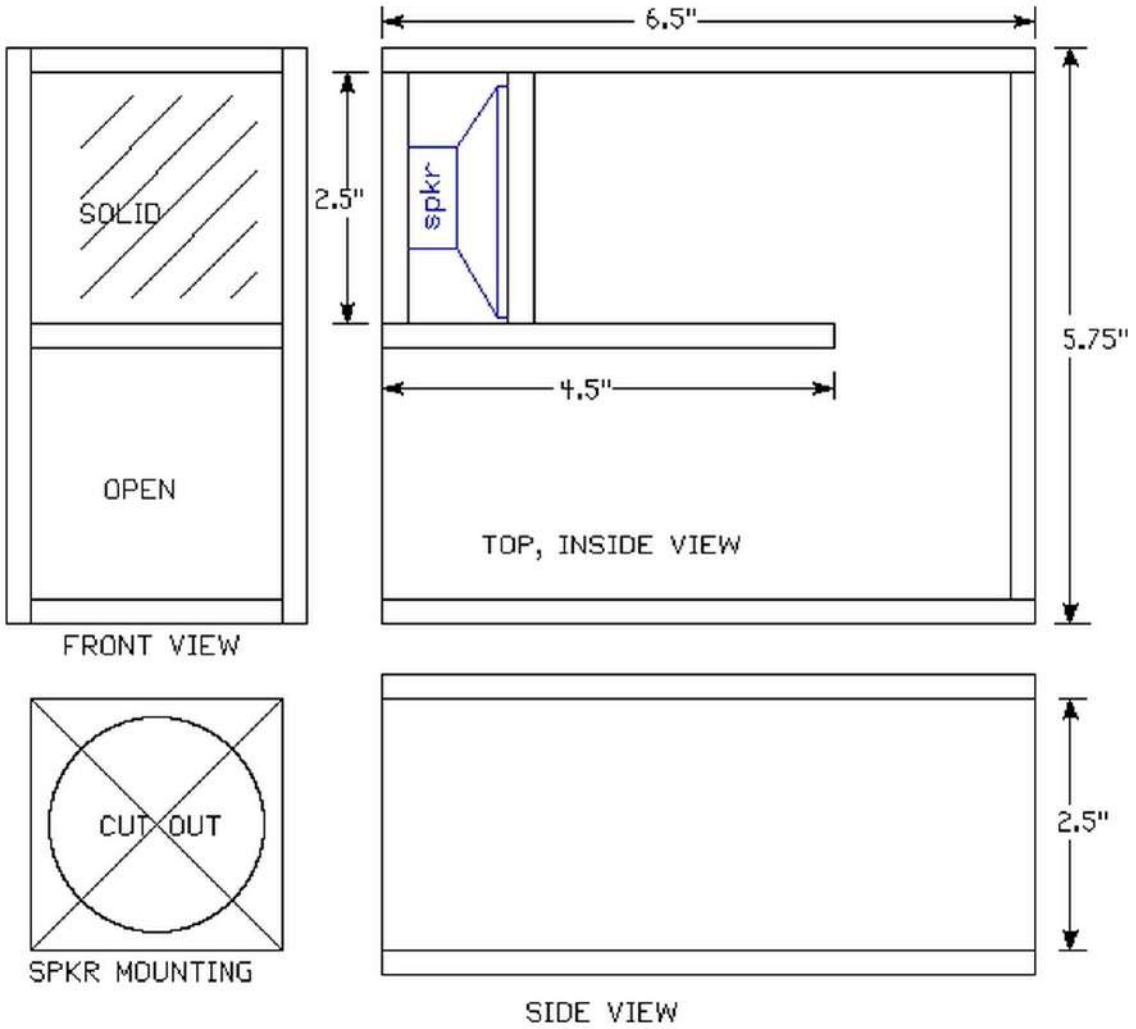

Figure 4: Resonant CW Speaker Cabinet (folded waveguide design)
Designed by Steven Weber, KJ1VD. If you are handy at woodworking a very handsome looking utility speaker can be added to enhance your enjoyment of listening to Morse code. Credit: Steve Weber, KJ1VD.

Why? Why Not!

Okay, so why would anyone want to bother with all this in the first place? Don't radios already have built-in analog or digital CW filters? If you have a modern radio or don't do the code, or prefer using headphones ("cans") then you definitely won't be interested in experimenting with this type of speaker. But even high end radios produce a lot of "white" speaker noise across the audio spectrum and this causes something called "listener fatigue", and a resonant CW speaker reduces white noise and its side affects!

If you want to do demonstrations for groups of listeners then you can use external speakers to compare the differences between the non-resonant and resonant design. I like to listen to the W1AW code practise transmissions while puttering around my basement radio shack and my workshop on the other side, and listening to a resonant CW speaker is more preferred over using a really long headphone extension cable!

There were commercial versions made and sold from the 1970's (Skytec CW-1) into the late 2010's (Alaskit, see Figure 5), but they are no longer available except on the used market. On a whim, I contacted Alaskit Educational and Scientific Resources and the chief engineer (well, the only engineer) Eric Nichols, KL7AJ and told me that he's resurrecting the Alaskit version and it should be available for sale later this year.

Figure 5: Alaskit CW Speaker
Marketed in the mid 2010's and perhaps will be once again.
Credit: Dan Romanchik, KB6NU.

My Final

I'm not much of a carpenter, but if I can find someone who is I'm going to have him/her build Steve, KJ1VD's design. It would be a nice addition to go with an old-school tube (or solid-state) CW only radio. And it would also make for a great club/group/class project because you can easily mass produce the cabinet pieces from sheets of plywood then use some classic dark cherry or mahogany wood stain to finish it for that antique classic radio look.—73