Model Solutions of Canada Ltd.

Tone Controls for R/C Sound Systems

And Why They Are Not a Good Idea

by

David Harrison of
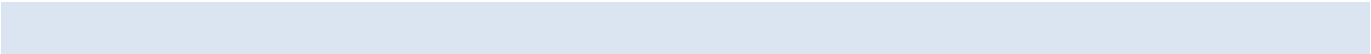
Model Solutions of Canada Ltd.

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INTRODUCTION

One manufacturer of sound modules for radio controlled models boasts that his sound module has bass and treble tone controls. Whilst this may sound like a good idea superficially, when you consider the effects this has on the rest of the system, they are definitely not a good idea as their use is quite limited and may lead to distortion or burnt out loudspeakers.

This is why the sound systems manufactured by Model Solutions of Canada Ltd. do not include tone controls.

This article seeks to debunk the mystery around tone controls for R/C sound systems.

WHAT DO TONE CONTROLS DO?

A Bass tone control works by boosting or cutting the lower frequency components of an audio signal and a Treble tone control works by boosting or cutting the higher frequency components of an audio signal – see Figure 1.

Figure 1 - Bass/Treble Tone Control Frequency Response
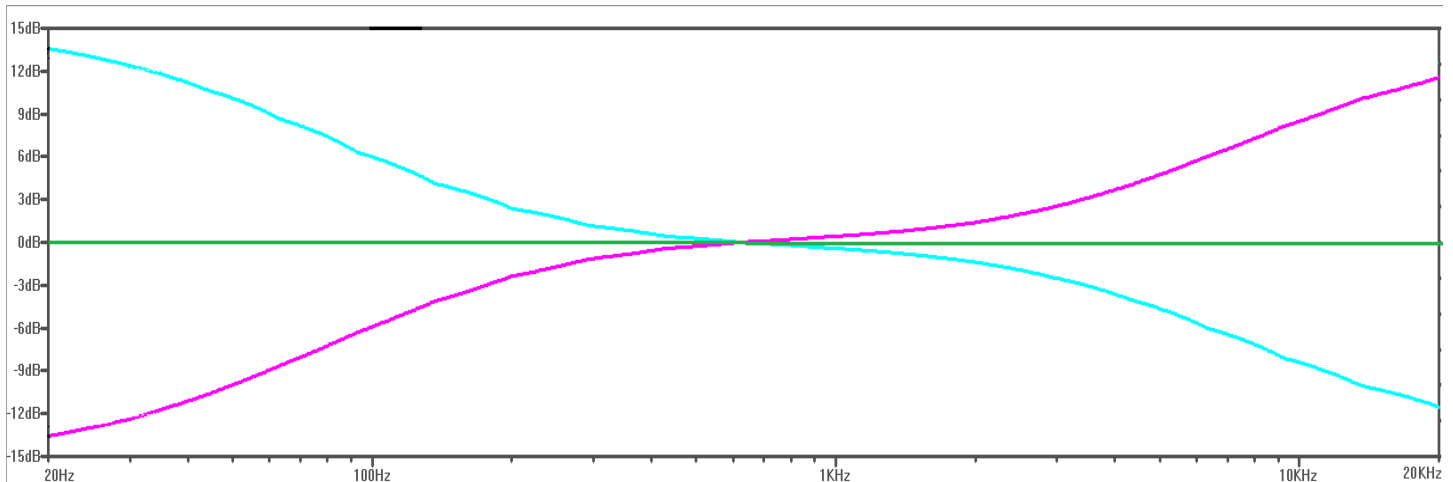
Legend : Aqua – Bass Boost and Treble Cut, **Magenta** - Bass Cut and Treble Boost, **Green** – Flat Response

Axes : Horizontal :   Logarithmic Frequency scale from 20Hz to 20KHz
**   Vertical :   Signal Level Amplitude in Decibels normalized to its 650Hz reference level**

This plot shows the frequency response of a typical tone control network with the tone controls set at their maximum boost or cut extremes. Only one of the three lines above are applicable at any given time. All three are superimposed on the one plot so you can see the overall effect.

OUTPUT AMPLITUDE AND MAXIMUM SIGNAL LEVELS

Radio controlled models, especially airplanes, can be some distance from their operators and, because Sound Pressure Level (SPL or Decibel level) is inversely proportional to the distance from the source, must usually be played as loud as possible to obtain a realistic sound level.

Therefore the volume level of an R/C sound module is usually set to its very maximum. This occurs when the amplitude of a digital signal reaches its maximum value (for 16 bit signals this is -32768 or + 32767), or once it has been converted to an analogue signal, represents the maximum amplitude the signal can reach when limited by the power supply voltage.

As can be seen in Figure 1 above, for effective and noticeable Bass or Treble boost (usually in R/C sound systems bass/treble cut is never employed), the amplitude of the signal of the lower/higher frequencies is amplified relative to the nominal midpoint value by more than 10dB. 10 Decibels represents a voltage difference of √10 times, or a power difference of 10 times.

If the volume level of the overall signal is already at its maximum level, then attempting to boost the lower or higher frequencies will simply lead to those components being "clipped" as the amplifier is already delivering its maximum power and cannot go any higher. Therefore those frequencies will be considerably distorted and will sound "rough".

The only way a tone control can be used with any meaning or decent result is to lower the overall amplitude of the signal by 10 dB or more. This then will allow some "headroom" for the amplifier to deliver more at the lower or higher frequencies.

However, a power level drop of 10dB, or 10 times, is a very significant drop in perceived loudness, all achieved just for the sake of a bit of bass or treble boost.

At Model Solutions of Canada Ltd,. Our philosophy is to present the maximum average power possible to the loudspeaker(s) in order for the perceived loudness to reach its maximum.

DRIVING LOUDSPEAKERS INTO DISTORTION

Every loudspeaker, and especially the smaller loudspeakers used in R/C models have a limited frequency response. Figure 2 shows the manufacturers quoted frequency response for the 4inch, 20Watt loudspeakers that we sell.

Figure 2 – over page …

Figure 2 - Frequency Response of A Typical R/C Model Loudspeaker
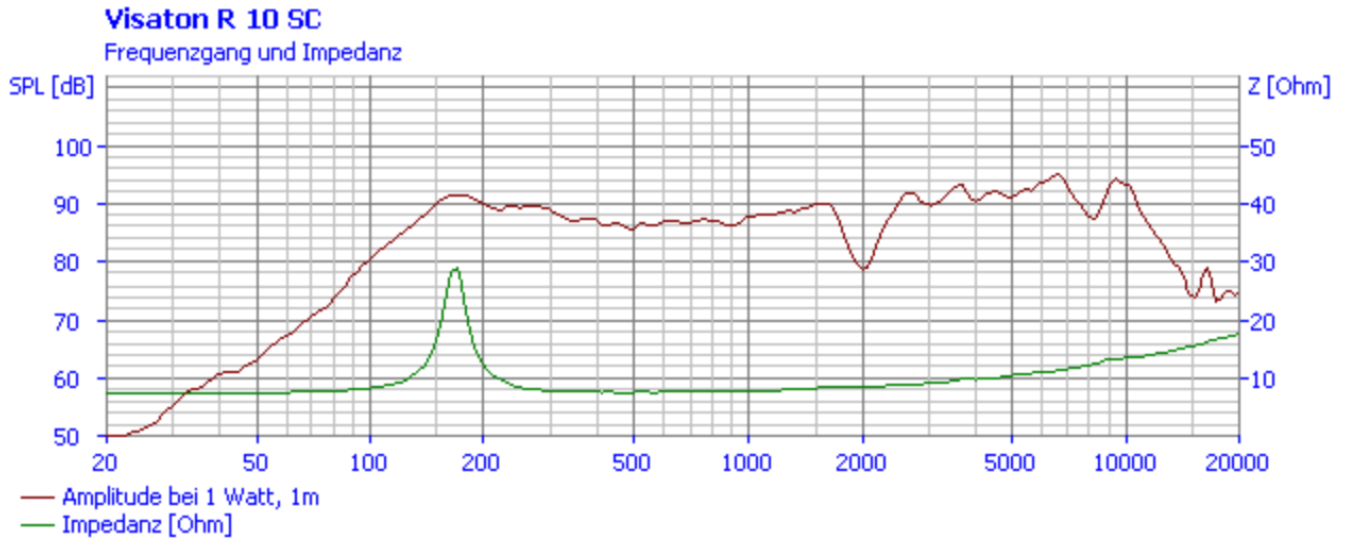
It can be seen that over the range from 150Hz to 10KHz, the frequency is relatively uniform within +/- 4dB, with a dip at 2KHz. The loudspeaker impedance varies from 8 Ohms at 20Hz to 18 Ohms at 20KHz with a spike at 170Hz. This latter spike is due to the self-resonant frequency of the loudspeaker occurring at this frequency and makes it difficult to drive significant power into the loudspeaker at this frequency.

The main point of this graph is to show that below the loudspeaker's self-resonant frequency, the response falls off fairly rapidly and the cone will not respond as vigorously as at higher frequencies.

Some people believe that this can be compensated for by applying Bass boost and driving more power into the loudspeaker. However, driving higher power into a loudspeaker at low frequencies like this may well exceed the power rating capacity of the speaker (which is the power capacity averaged over its frequency range) and cause the speaker to burn out.

Furthermore, overdriving a loudspeaker at any frequency may cause the cone and voice coil to move beyond the normal range of excursion causing severe distortion and roughness in the sound.

CONCLUSION

The above discussion illustrates how tone controls work and the limitations their use puts on the overall perceived loudness of the sound system. It further demonstrates that use of tone controls with typical small loudspeakers used in an R/C model can lead to severe distortion and may cause the speaker to burn out.

For these reasons, at Model Solutions of Canada Ltd., we believe that leaving tone controls out of our sound systems is the right design decision.