Applications of Techniques Described in U.S. Patent Pending 20070092101

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The following graphs document the performance changes caused by application of the targeted, material impedance changing techniques described in the above pending patent. The changes documented here are the result of embossing or impressing small “dimples” at critical regions in the material of the cone and dust cap (if used). The patent pending technique is applicable to any deformable diaphragm and dust cap material, especially plastic and paper.

The first example application is to a 10-inch advertised diameter transducer marketed as a subwoofer. The cone is pulp paper with a treated cloth dome style dust cap. The stock performance of the transducer is shown in graphs number one and two. Both the cone and the dust cap suffer from a significant material vibration mode. The dust cap mode frequency being only slightly higher than that of the cone.

Figure One. Impulse response of the stock 10-inch diameter, paper coned subwoofer.

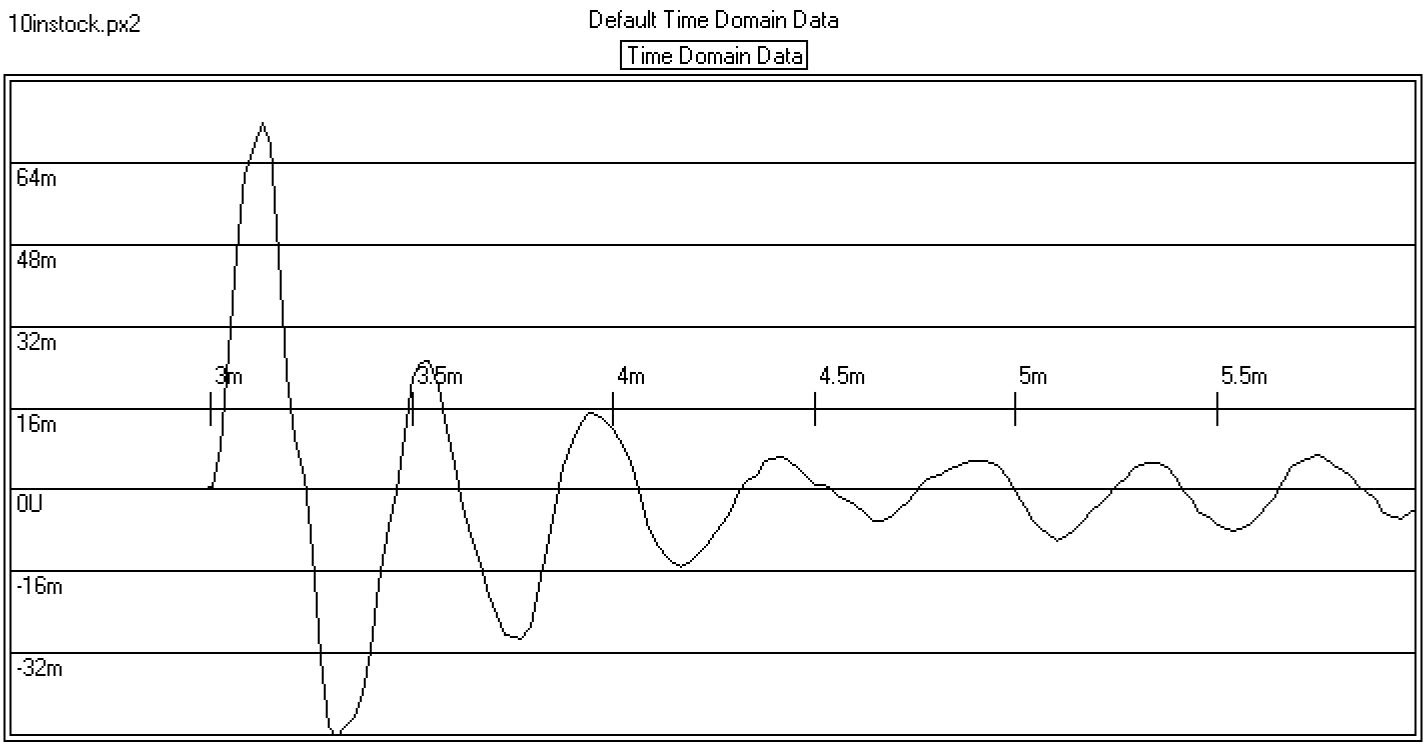
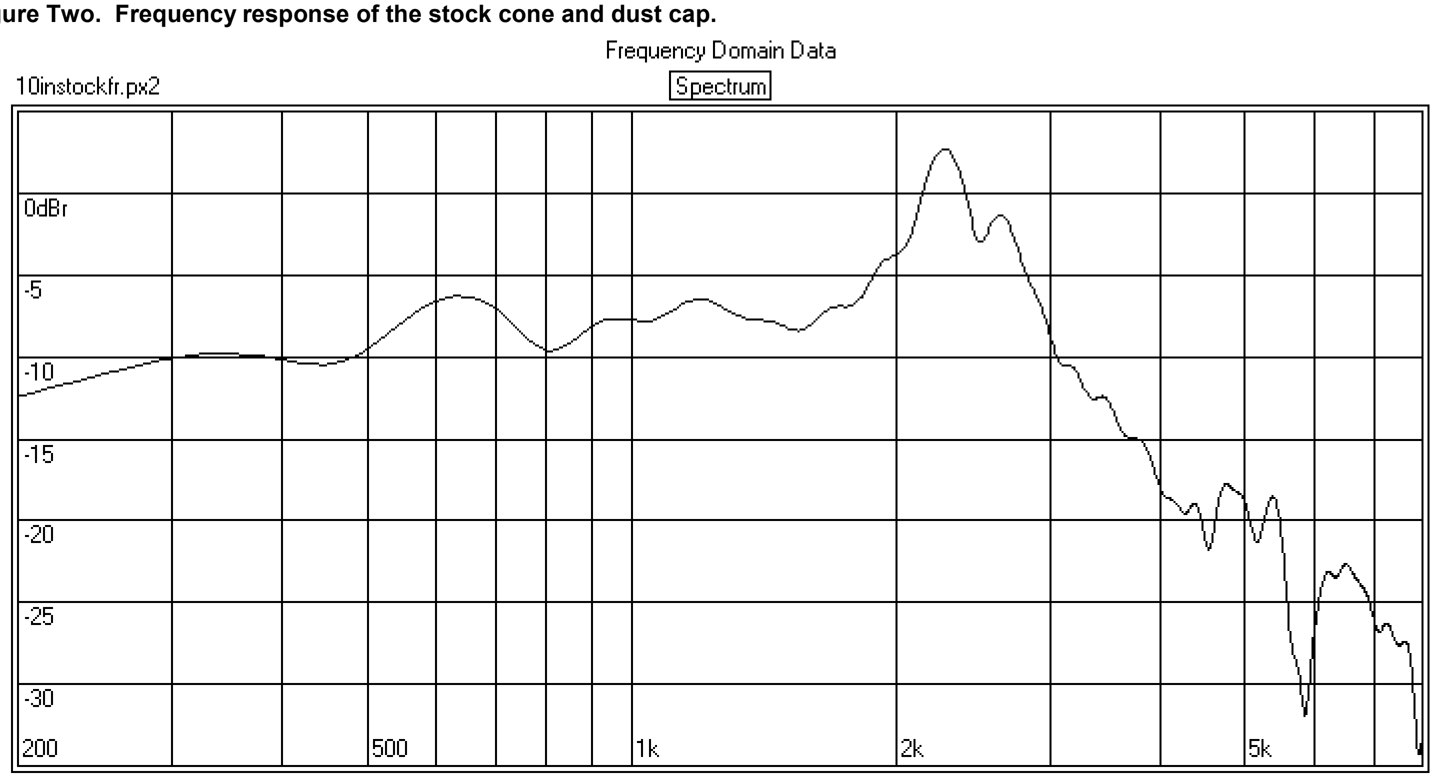


Figure Two. Frequency response of the stock cone and dust cap.



The performance change after application of targeted impedance changing techniques is shown in the two graph below on this page. The frequency response graph of the modified cone and dust cap also has the stock frequency response graph drawn on top in red for easy comparison.

A relatively tiny area of the cone and dust cap are treated to achieve control of the two vibration modes. For the cone, the critical area is located .91 inches in from the cone body OD, and is only a couple of tenths wide. For the 3.8 in diameter dust cap, the critical region runs from .4 to .88 inches in from the trim OD.

Figure Three. Dimpled cone and dust cap impulse response of paper coned 10-inch subwoofer.

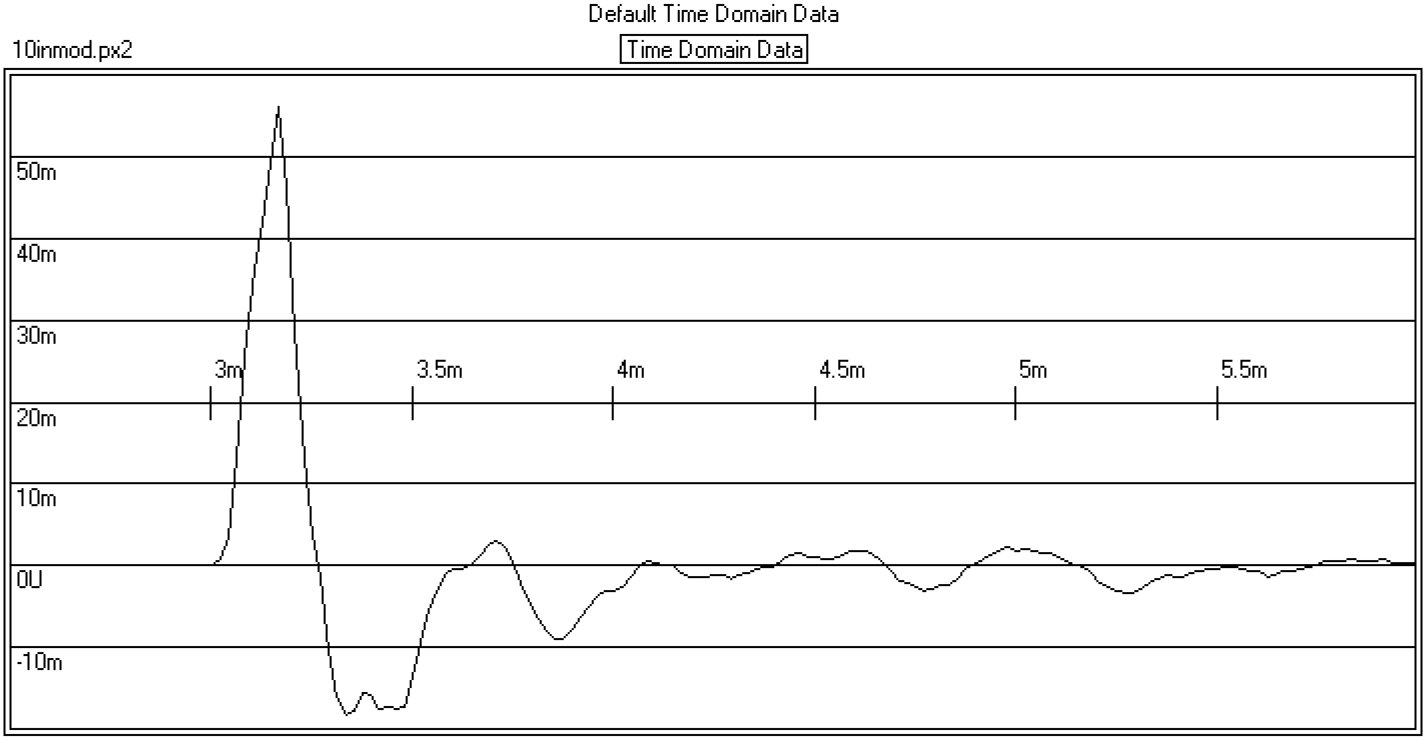
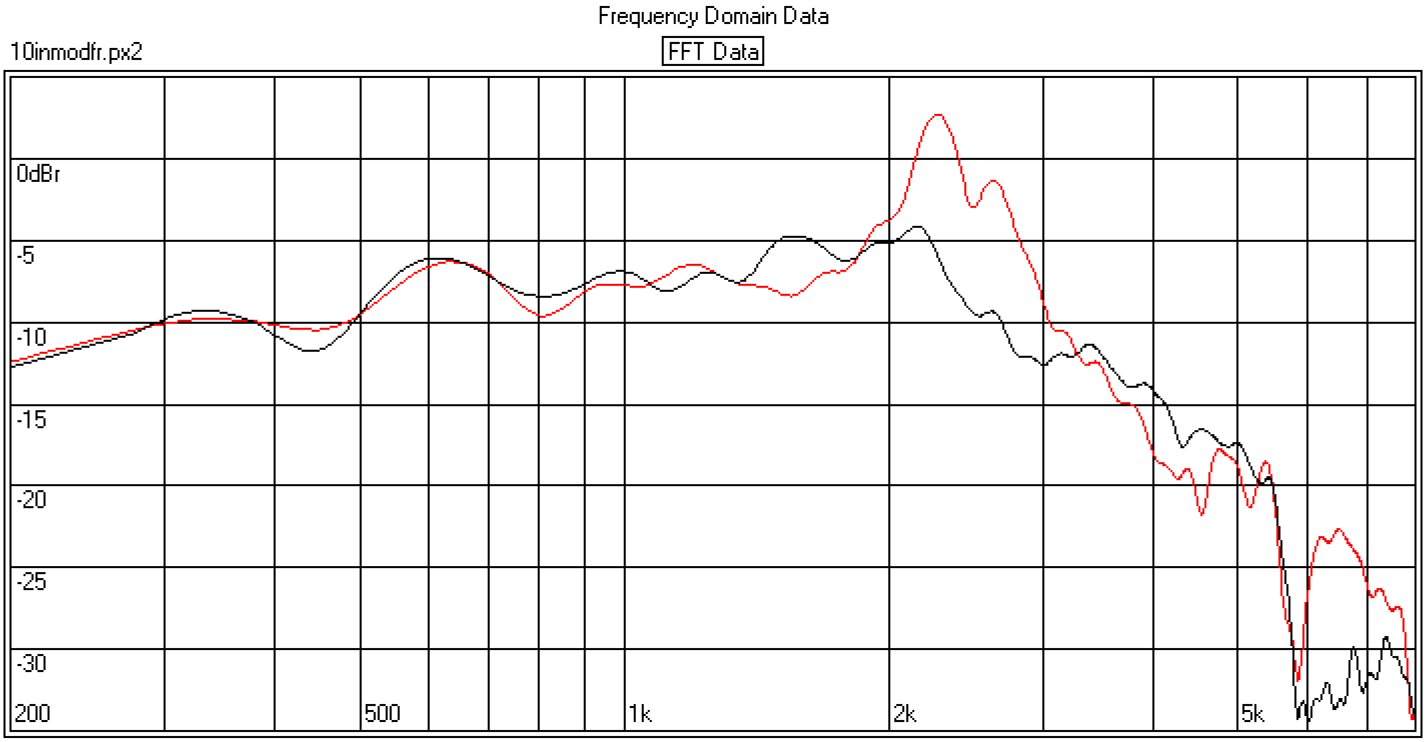


Figure Four. Frequency response of dimple modified 10-inch paper cone and cloth dust cap. Stock frequency response is overdrawn in red for easy comparison.



My purpose in including multiple examples in this document in addition to the examples in the patent application is to show that the technique is applicable to all diameter transducers. This second transducer is an advertised eight-inch basket diameter. The cone body and dust cap are made from polypropylene plastic. The voice coil inductance is low and the bandwidth is wider than most eight-inch transducers. This wide frequency response clearly shows how complex vibration modes can become.

The stock impulse and frequency response are shown in figures five and six.

Figure Five. Stock impulse response of a eight-inch diameter, polypropylene cone body with polypropylene dust cap.

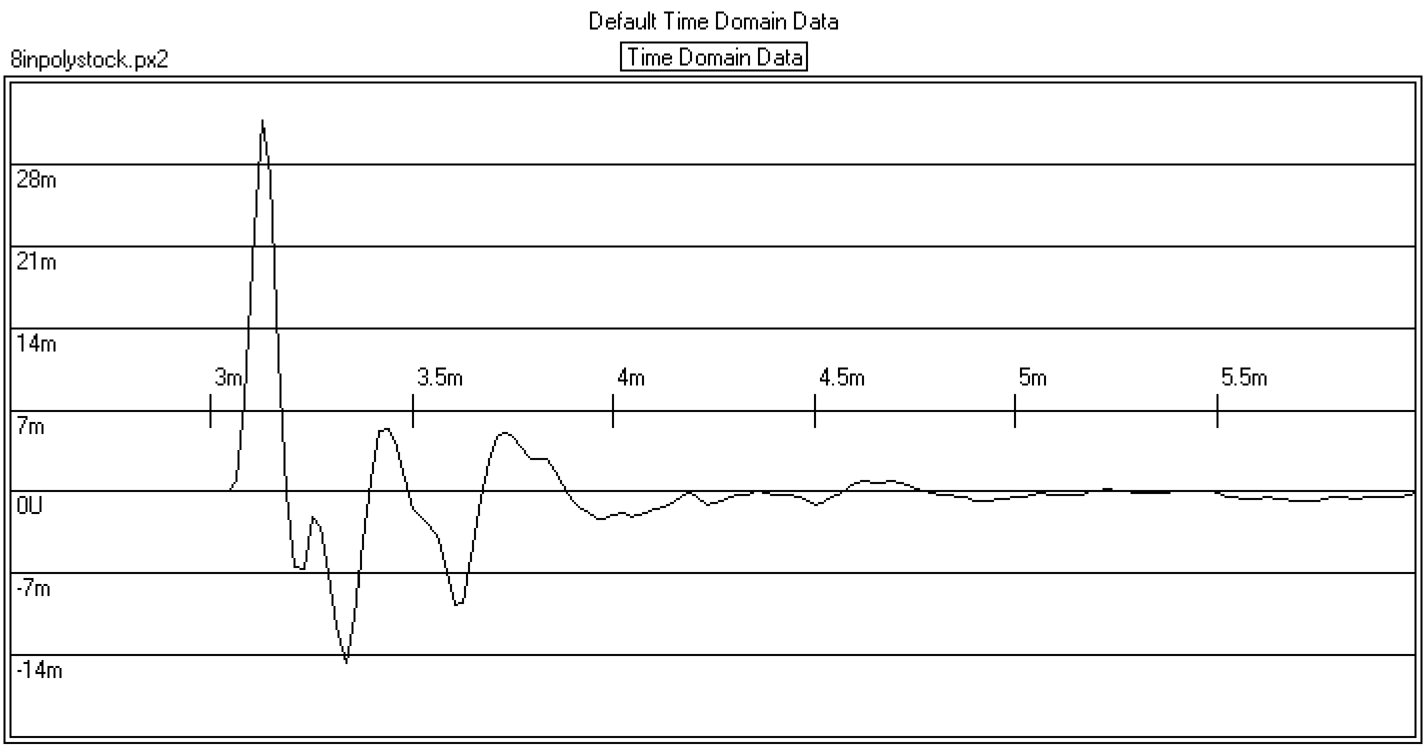
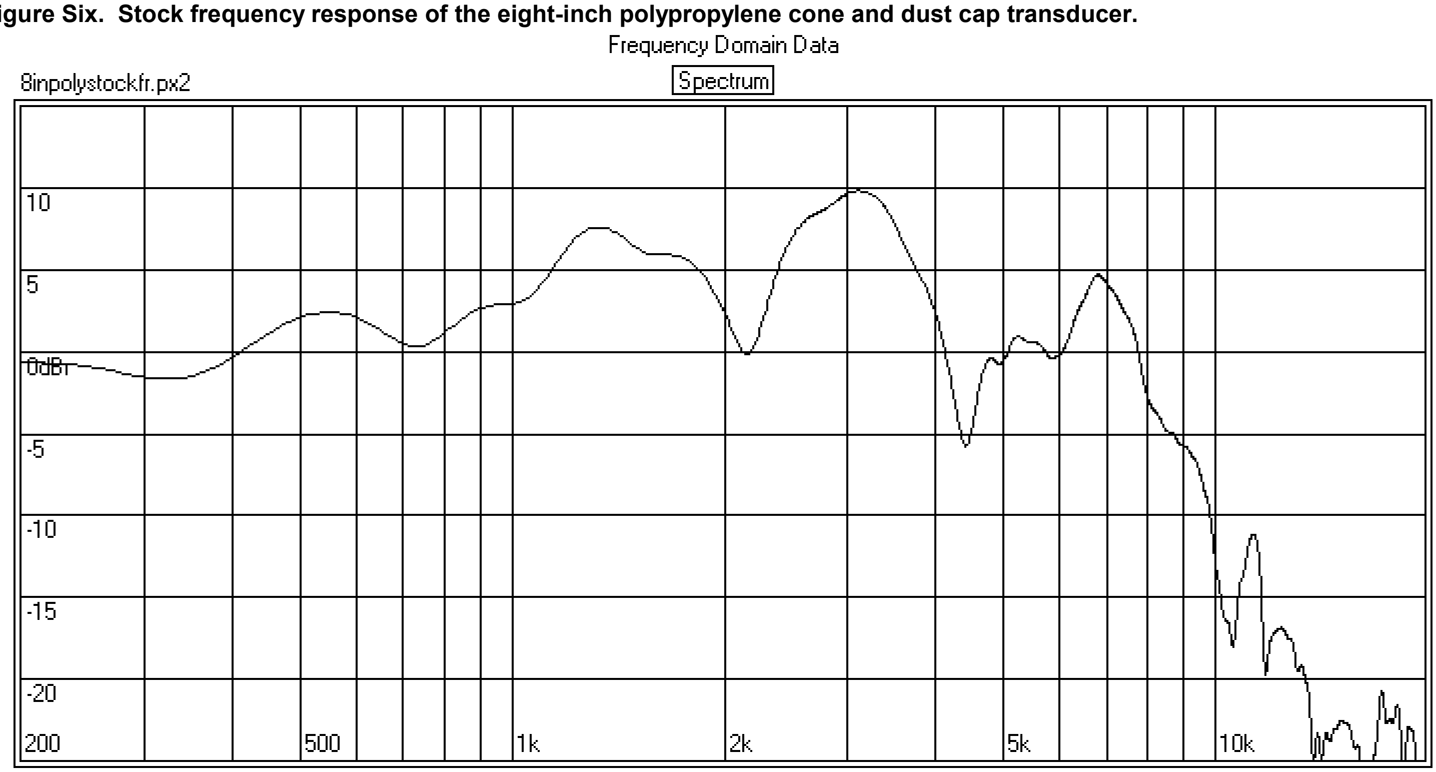


Figure Six. Stock frequency response of the eight-inch polypropylene cone and dust cap transducer.



One technique for simplifying vibration mode problems in transducers is to replace the dust cap with a plug (sometimes called a phase plug) where the application will allow. Figures seven and eight show the eight-inch polypropylene coned transducer with the dust cap replaced with a plug.

The response is much improved, but still more improvement is possible by dimpling the cone.

Figure Seven. Impulse response of the eight-inch polypropylene transducer with the dust cap replaced by a plug.

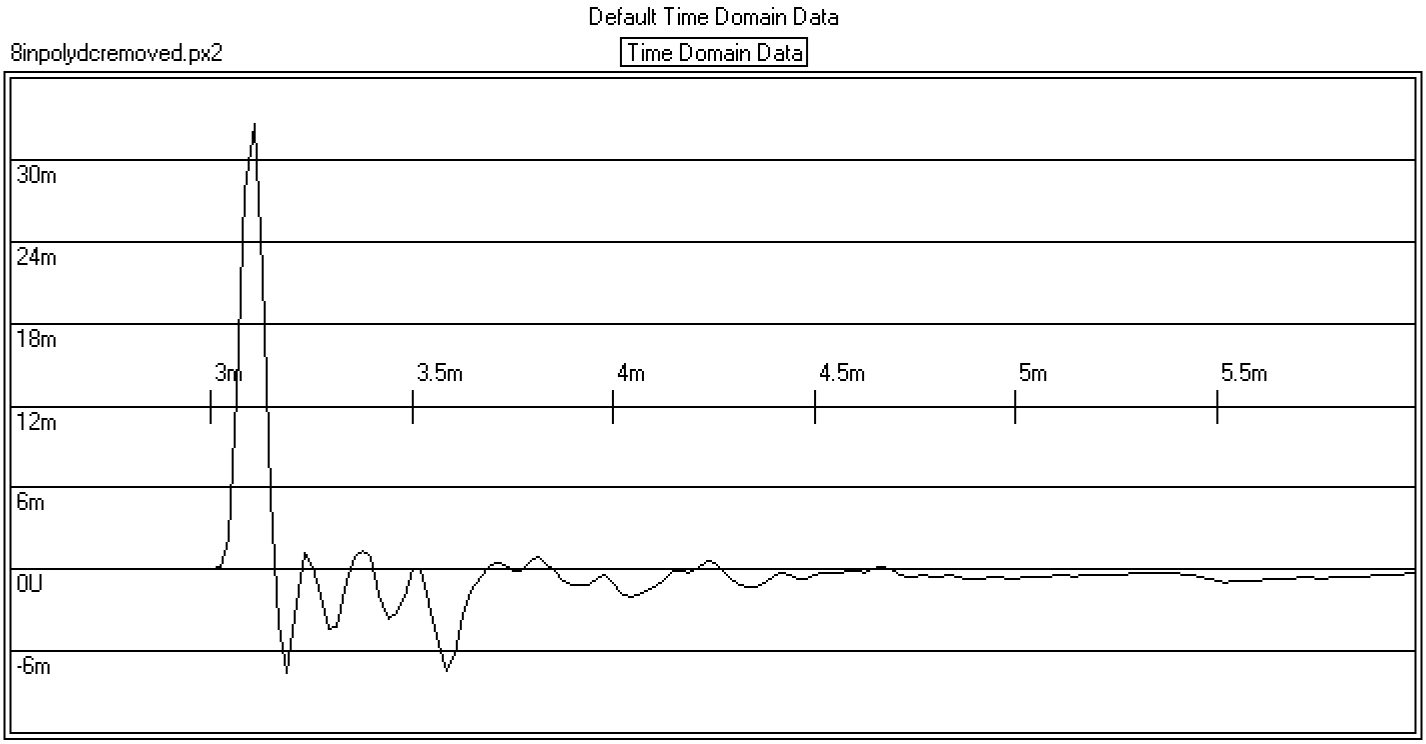
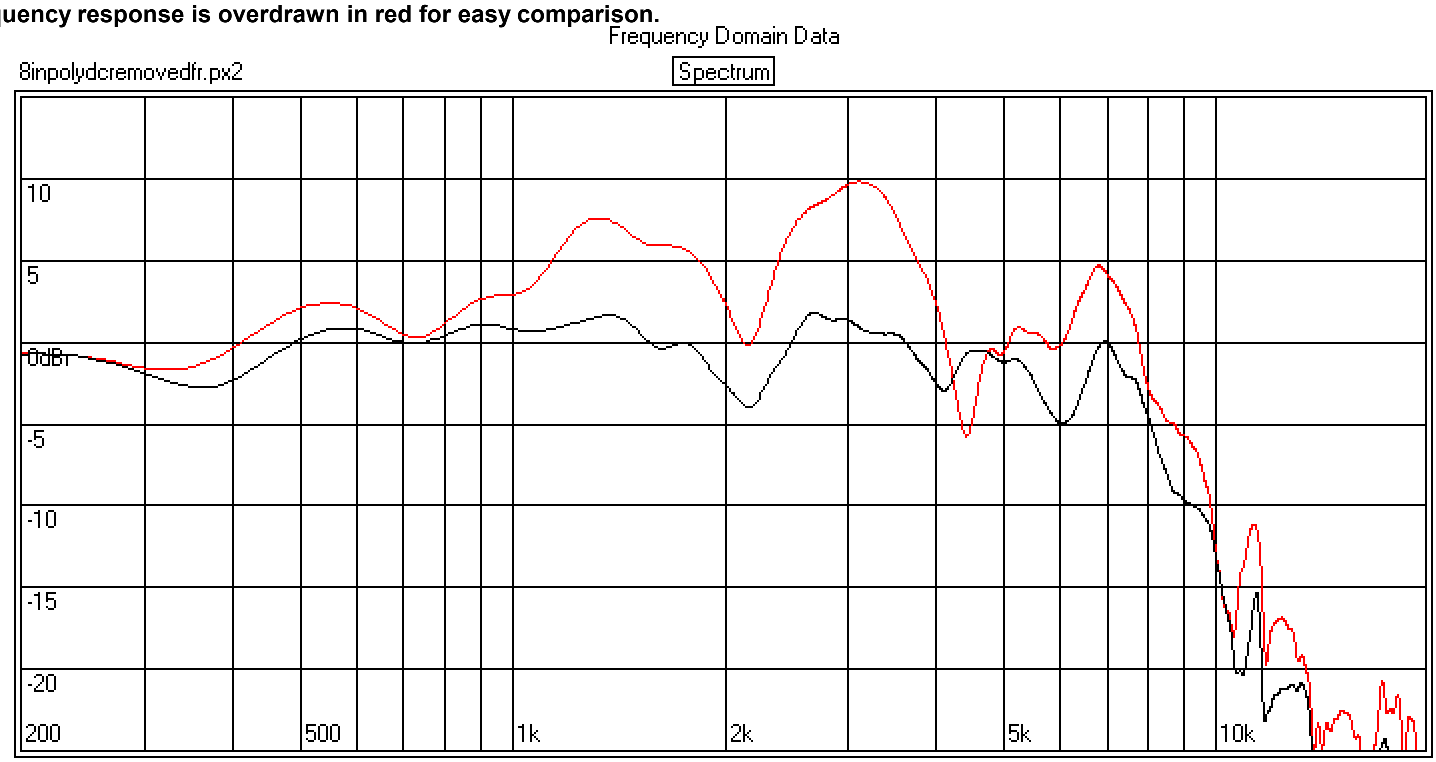


Figure Eight. Frequency response of the eight-inch polypropylene coned transducer with dust cap replaced by plug. Stock frequency response is overdrawn in red for easy comparison.



Figures nine and ten show the impulse and frequency response with the dust cap replaced with a plug and the cone dimpled. Only a tiny area of the cone needs to be treated to achieve this quality of performance.

Figure Nine. Impulse response of eight-inch polypropylene coned transducer with dust cap replaced with plug and cone dimpled.

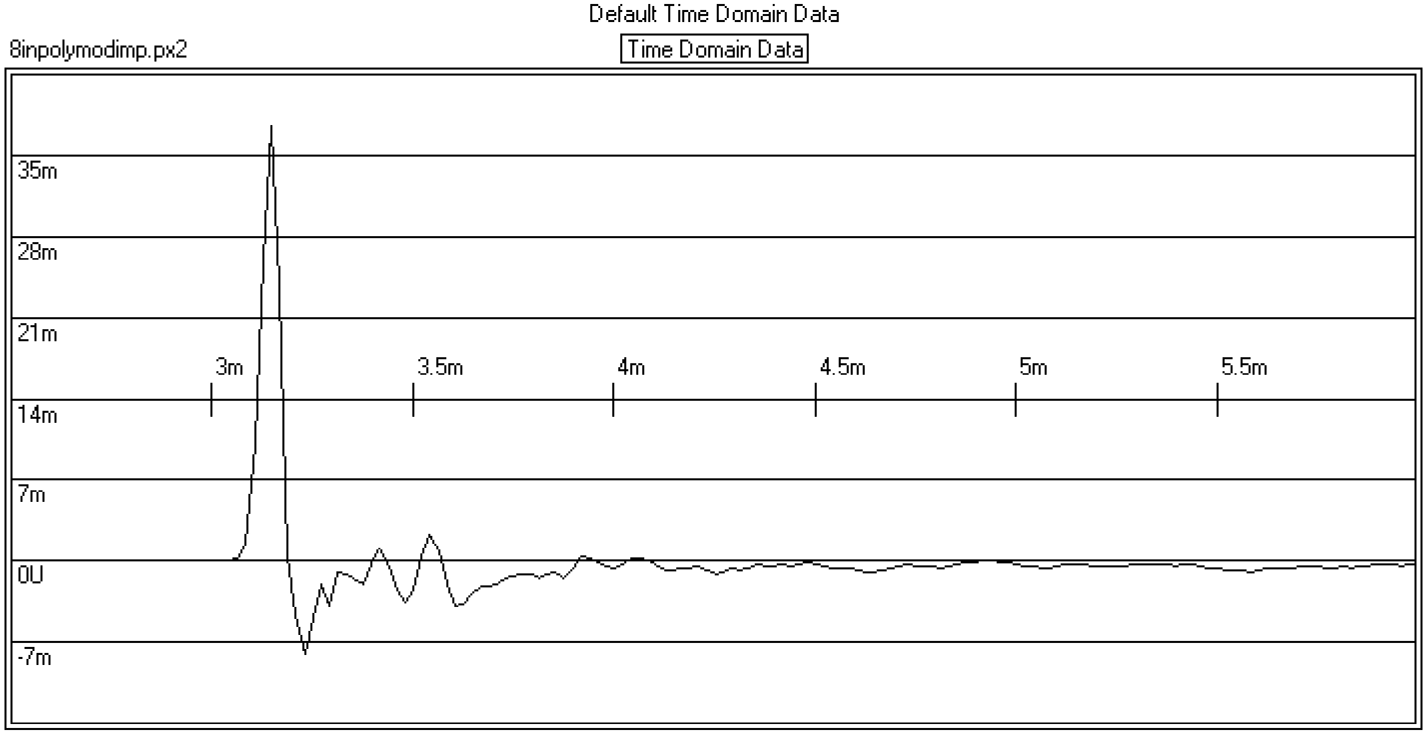
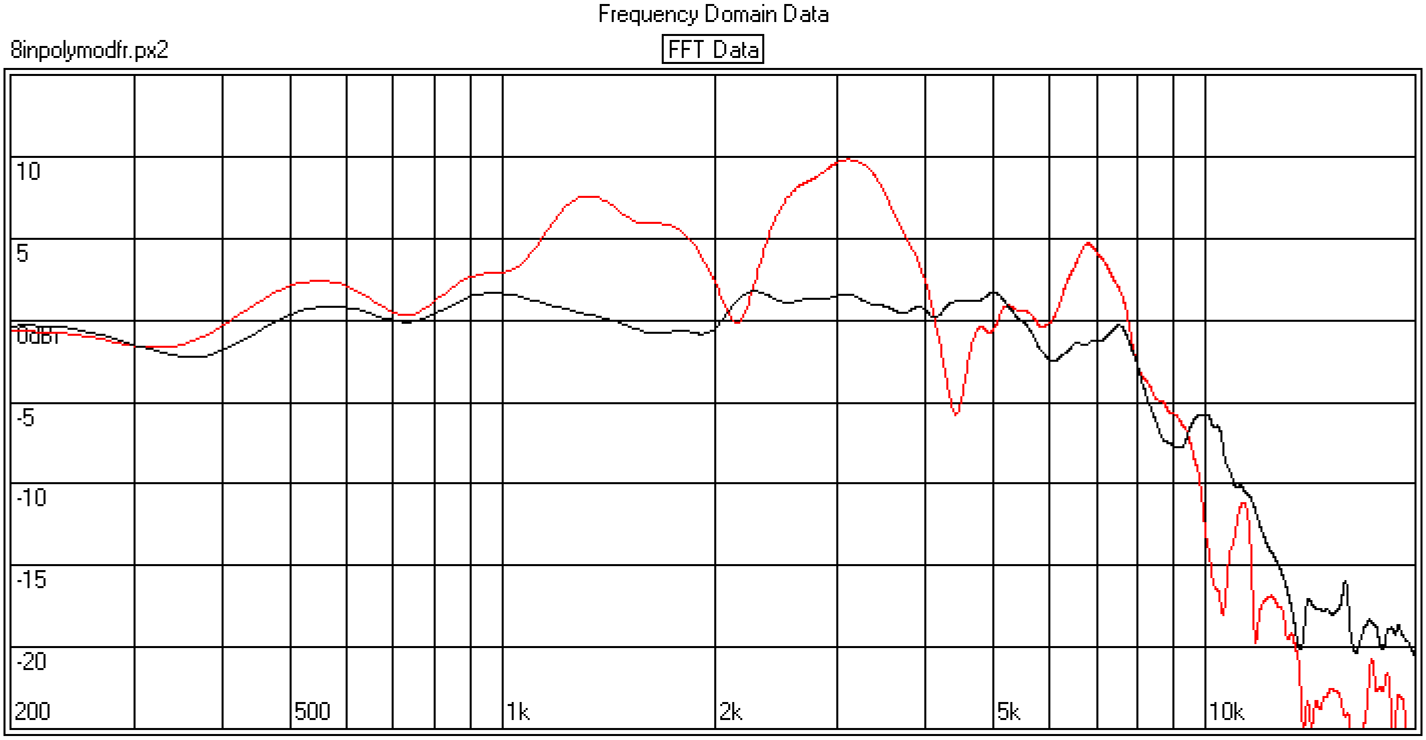


Figure Ten. Frequency response of eight-inch polypropylene cone transducer with dust cap replaced with plug and cone dimpled. Stock frequency response is overdrawn in red for easy comparison.



Figures eleven and twelve show the stock impulse and frequency response of a second eight-inch advertised basket diameter transducer. This transducer features a Kevlar doped paper cone body and treated cloth surround. The second eight-inch transducer has a cone body measuring 5.25-inches OD. This transducer was designed for use with a plug instead of a dust cap. The testing of this transducer was done with a plug.

Figure Eleven. Impulse response of stock Kevlar doped eight-inch paper body cone transducer.

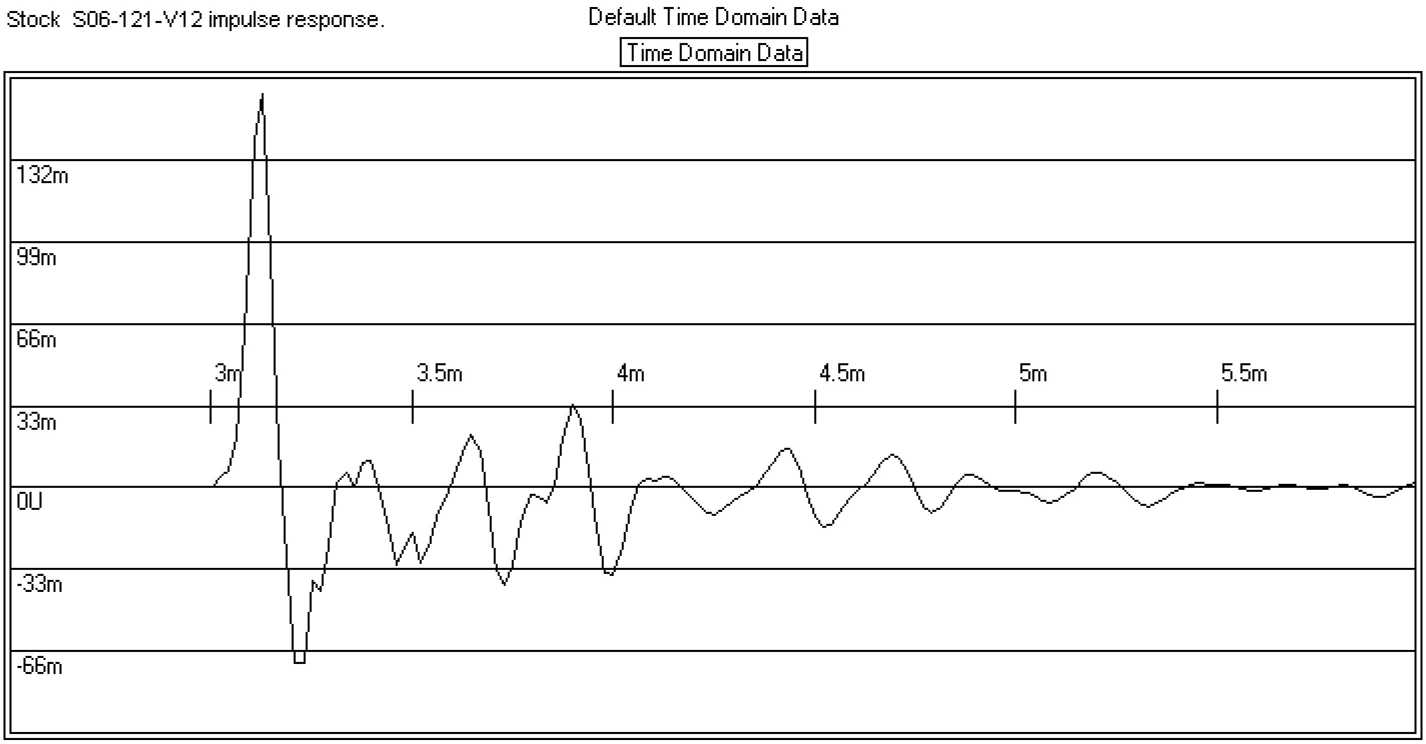
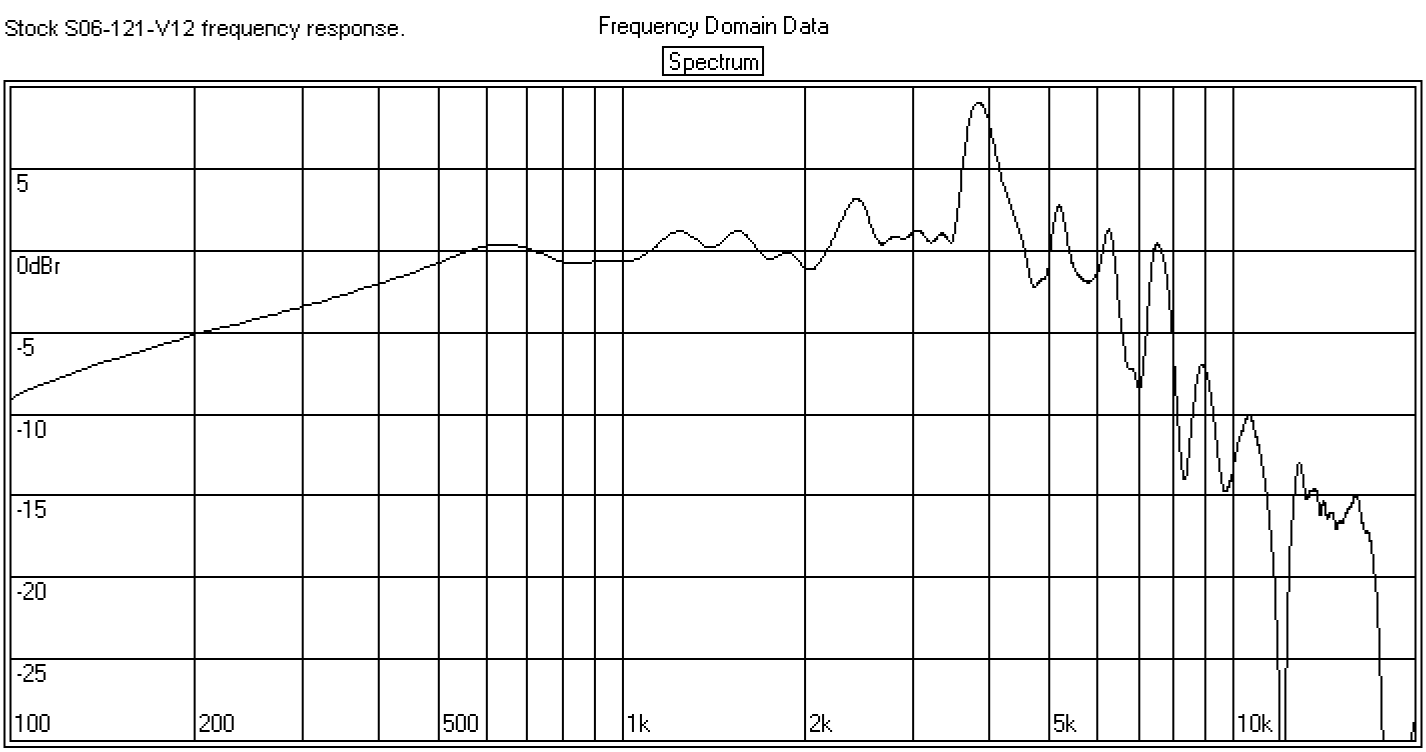


Figure Twelve. Frequency response of eight-inch Kevlar doped paper cone body transducer.



The dimple modified impulse and frequency response are shown in figures thirteen and fourteen. The critical point for the vibration mode mapped to a narrow, circular area of the cone approximately between 14 and 19 mm in from the cone OD. A total of ten rectangular dimples were used in the modification. Six dimples were three mm wide and six mm in length. Four dimples were five mm wide and six mm in length. The primary vibration mode was well controlled and as a bonus several other tightly coupled modes were also significantly improved.

Figure Thirteen. Impulse response of dimple modified Kevlar doped paper cone body.

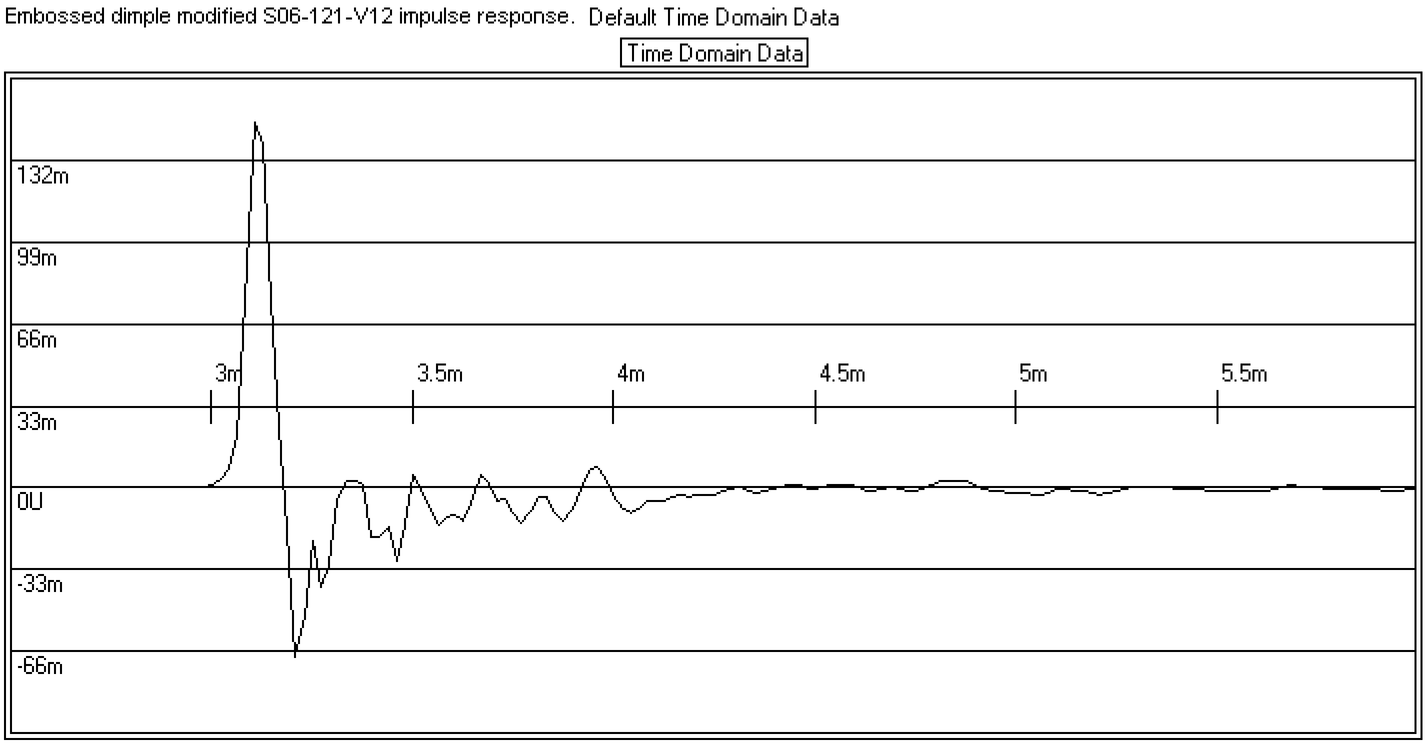
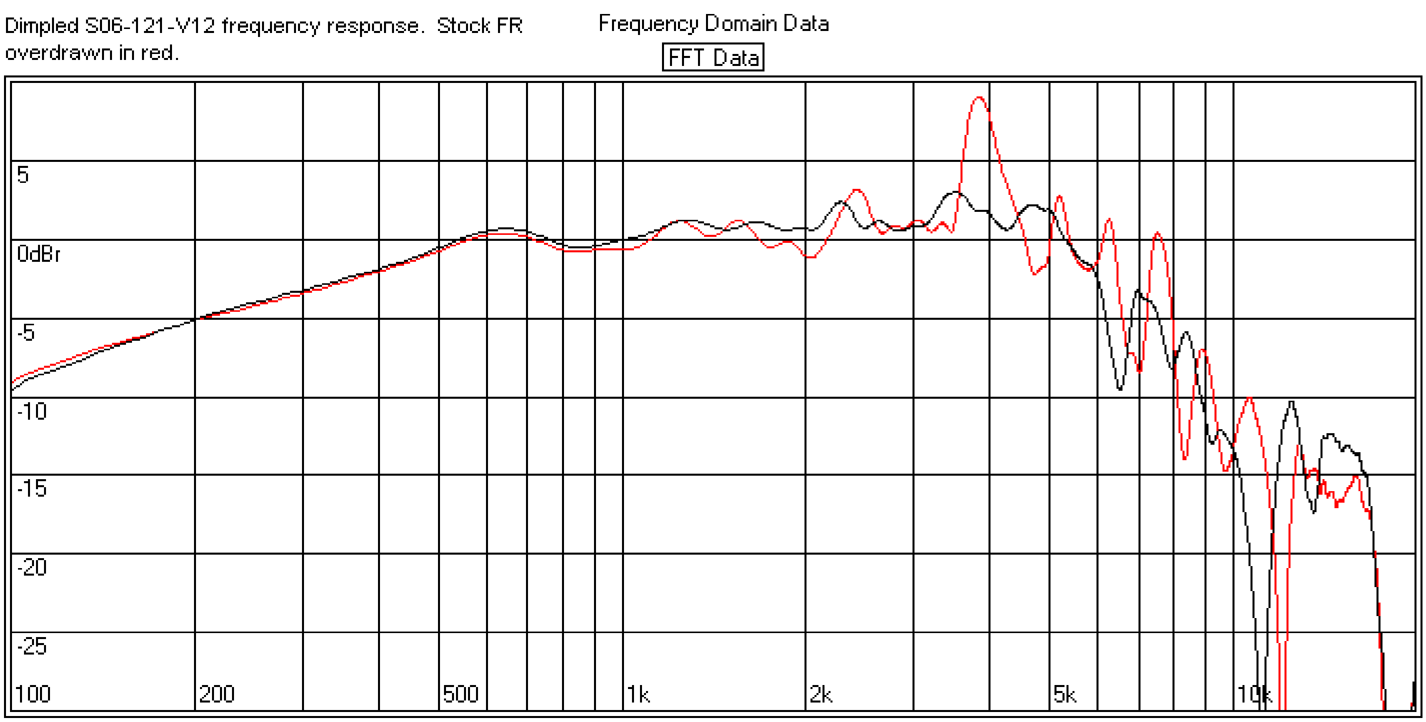


Figure Fourteen. Frequency response of dimple modified Kevlar doped paper cone body. Stock frequency response is overdrawn in red for easy comparison.



Figures fifteen and sixteen show the stock impulse and frequency response for a typical paper cone body 5.25-inch transducer. The upper limit if its bandwidth is defined by a prominent diaphragm material vibration mode (cone breakup). In this application, the vibration modes for the dust cap are well into the transducer's stop band and are not critical.

Figure Fifteen. Stock impulse response for 5.25-inch diameter paper cone body transducer with rubber half-roll surround and light-weight treated cloth dust cap.

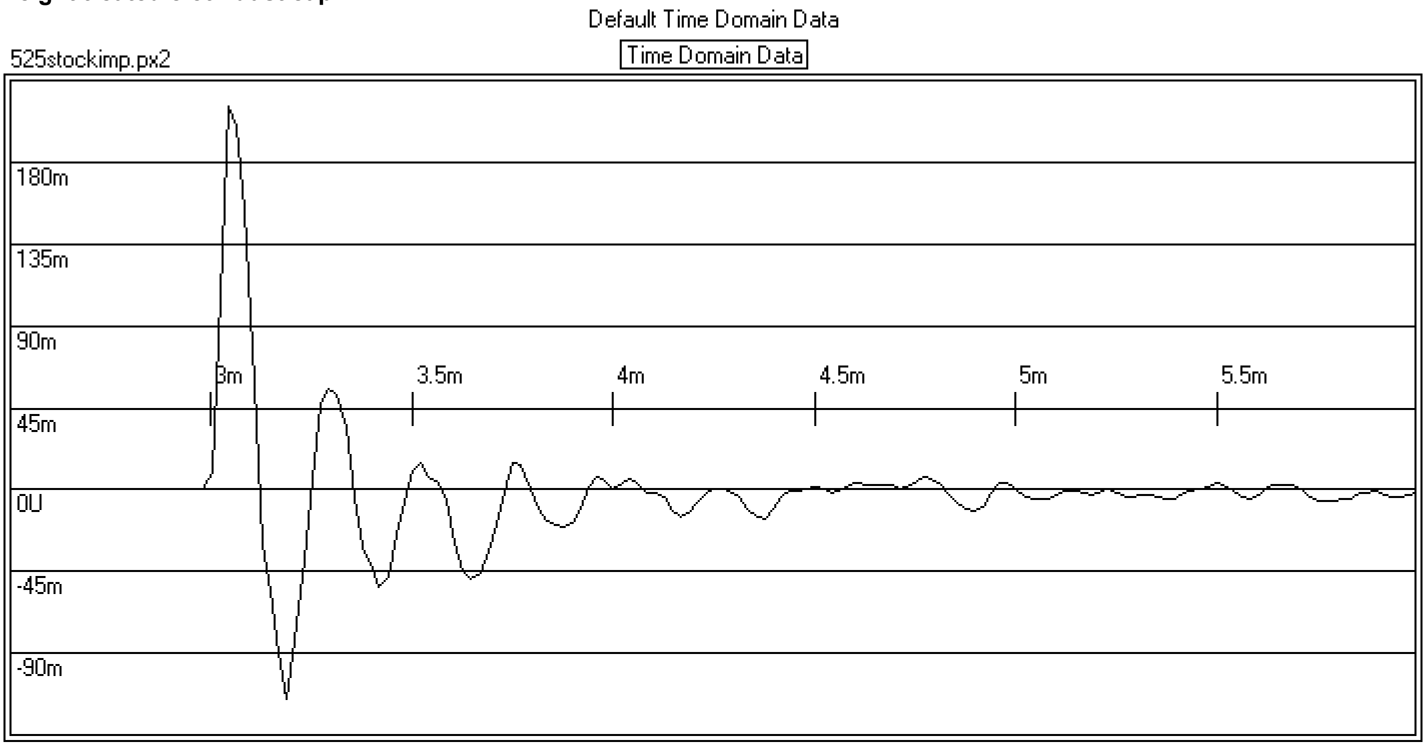
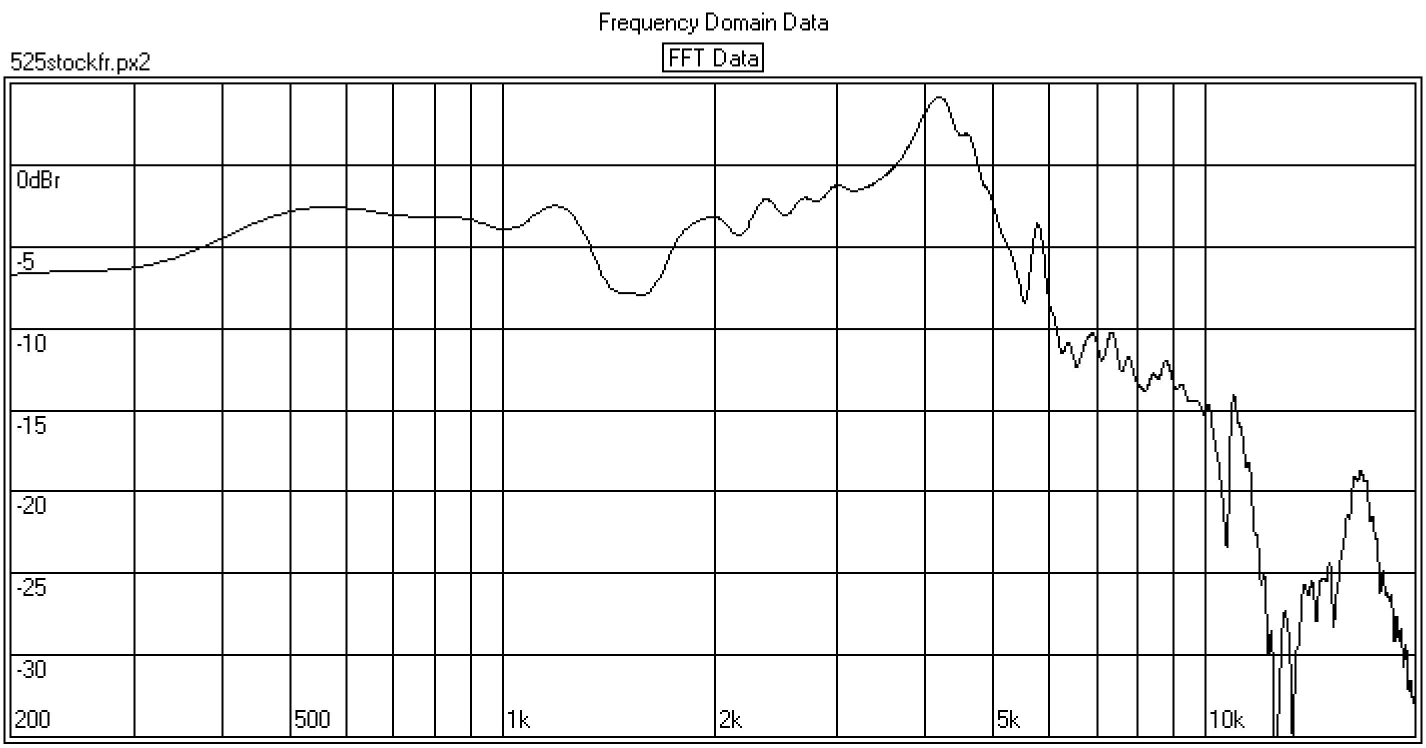


Figure Sixteen. Stock frequency response for 5.25-inch diameter paper cone and treated cloth dust cap transducer.



For this relatively soft pulp paper cone, four radial, rectangular shaped dimples effectively controlled the major cone vibration mode. The dimples are 3 mm wide and 10 mm long. Each begins 9 mm in from cone OD.

Figure Seventeen. Impulse response for modified 5.25-inch paper cone body with light-weight treated cloth dust cap.

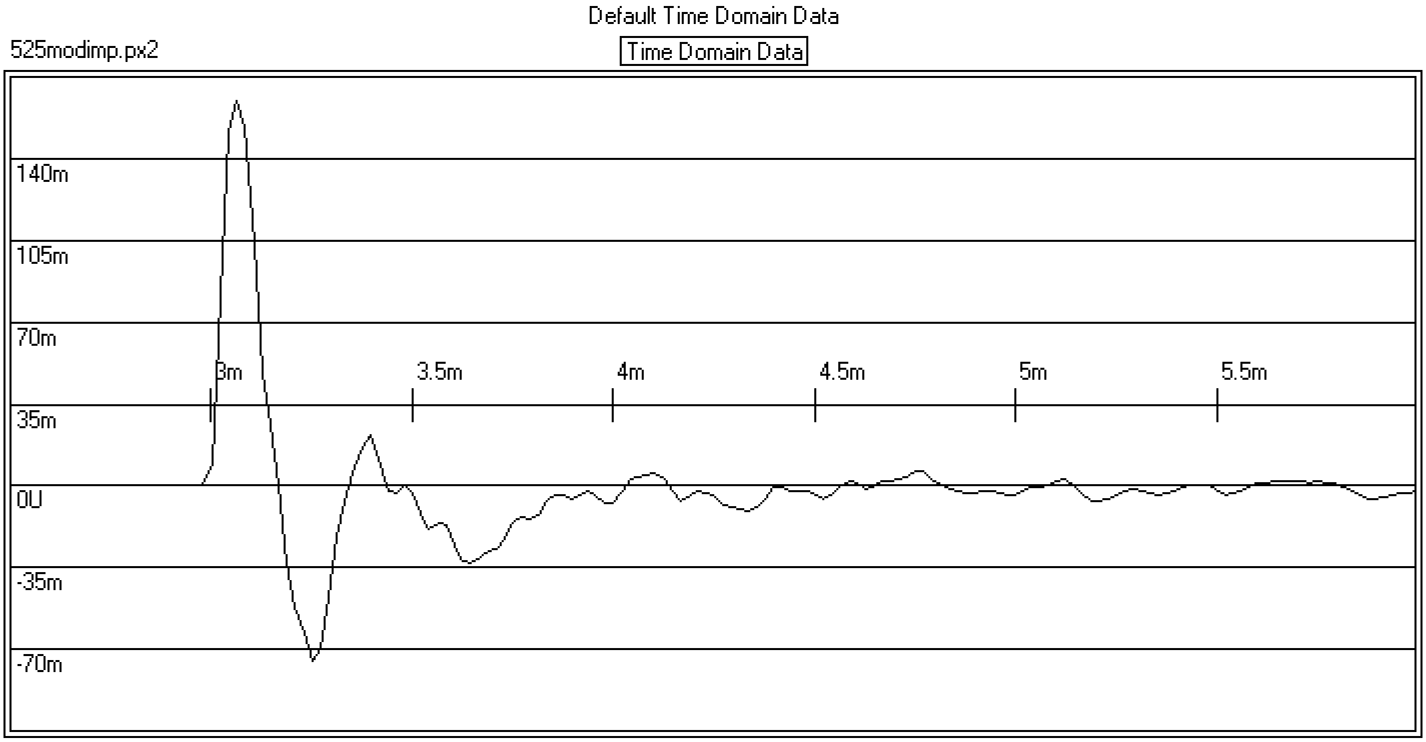
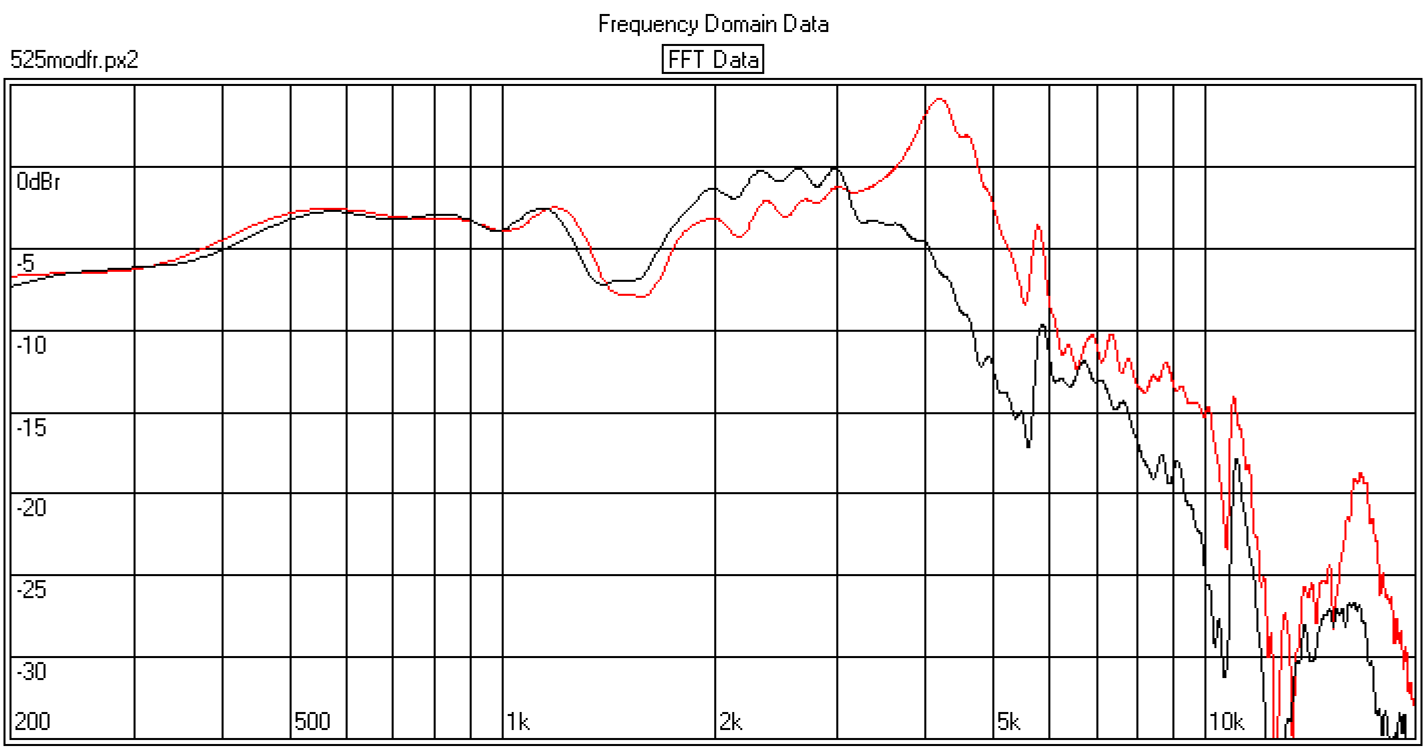


Figure Eighteen. Frequency response for modified 5.25-inch paper cone body with light weight treated cloth dust cap. Stock frequency response is overdrawn in red for easy comparison.



The next example is a transducer with an advertised basket dimension of 4.5 inches and a cone diameter of 3.188 inches, and featuring a stiff paper dust cap. The transducer is claimed full range and the stock performance impulse response and frequency response are shown in figures nineteen and twenty. This transducer has a paper cone body with treated cloth surround and features a small rigid paper dust cap attached directly to the voice coil former.

Figure Nineteen. Stock impulse response of 4.5-inch advertised basket diameter full range transducer featuring a paper cone body, treated cloth surround and small rigid paper dust cap attached to the top of the voice coil former.

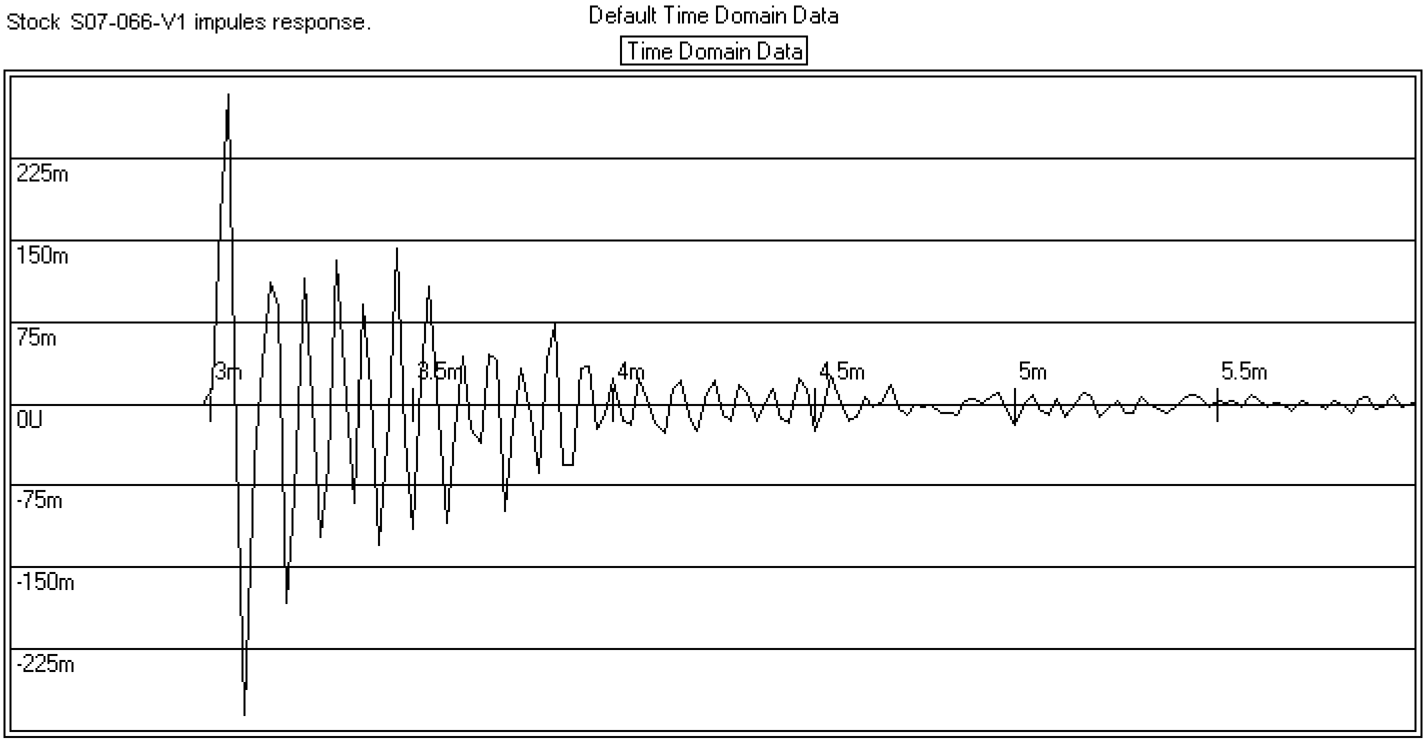
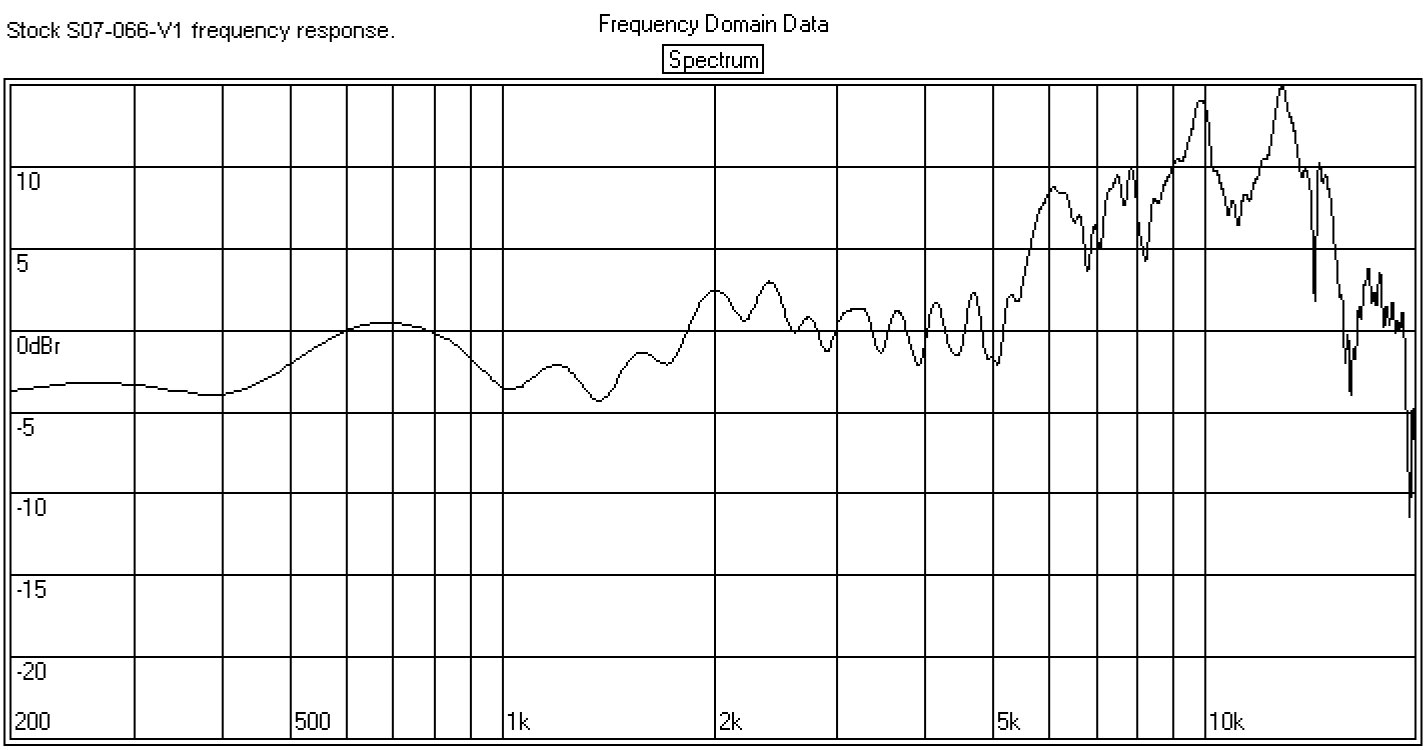


Figure Twenty. Stock frequency response of paper cone body and dust cap 4.5-inch diameter transducer.



For this example, both the cone body and the dust cap are dimpled. The vibration modes in this example were very complex and produced response problems of great complexity requiring more complex dimpling. The dimpling to the paper cone consisted of 10 rectangular dimples between three and four mm wide and varying from five to ten mm in length. The dust cap treatment consisted of very narrow dimpled areas only one mm wide and varying from two to six mm in length.

The performance change is shown in figures twenty-one and twenty-two. There is no change in the mass or suspension of the transducer and the only changes in response are those in the areas dominated by the material vibration modes (breakup) in the cone and dust cap.

Figure Twenty-one. Dimple modified impulse response of 4.5-inch diameter paper cone body and paper dust cap full range transducer.

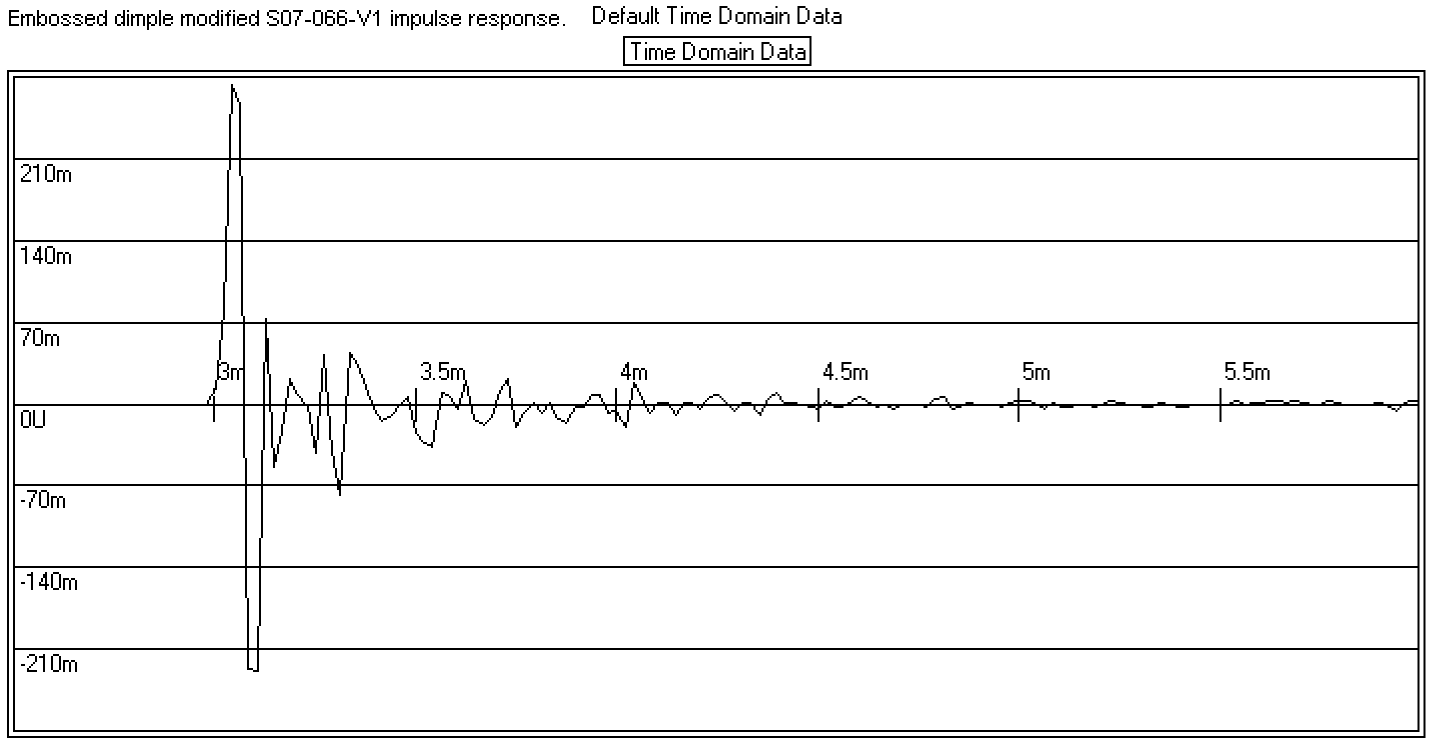
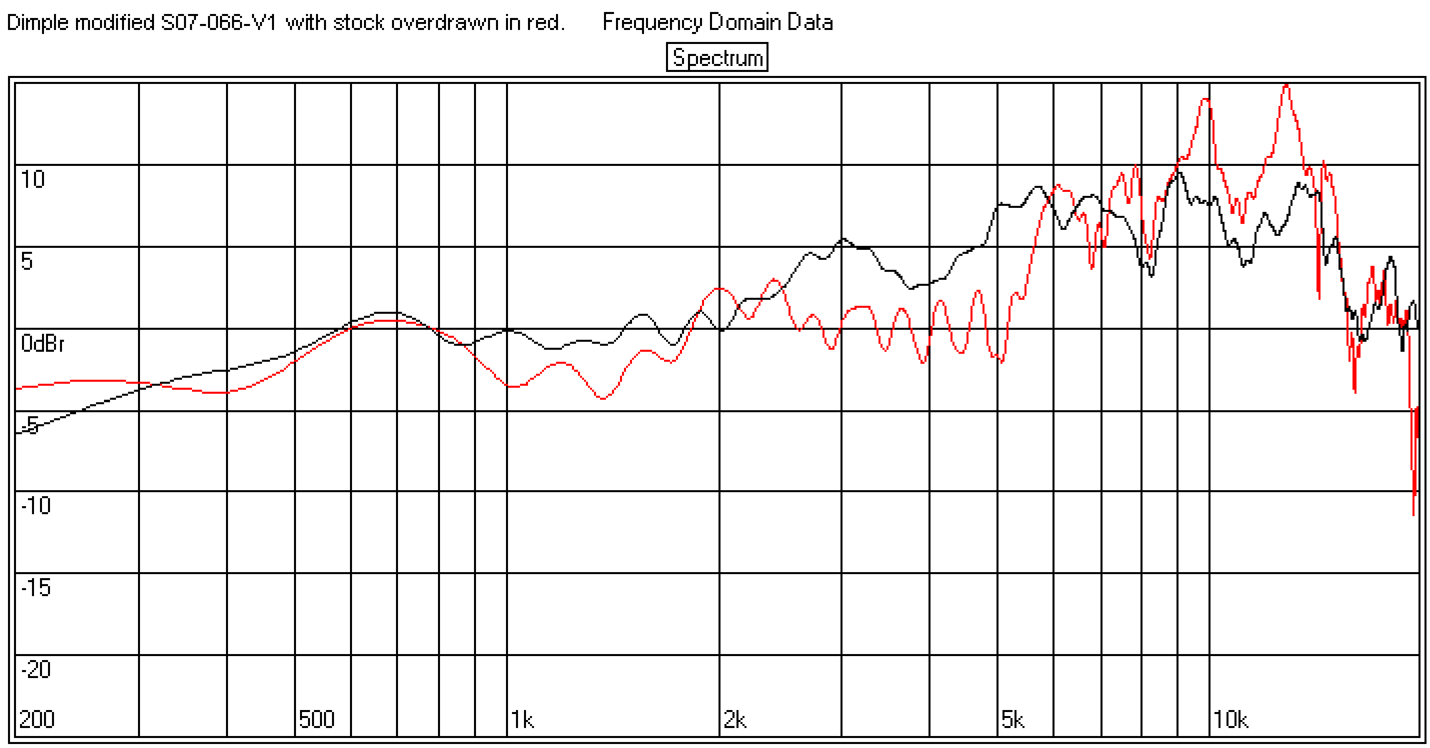


Figure Twenty-two. Dimple modified frequency response of 4.5-inch diameter, paper cone body and paper dust cap full range transducer. Stock frequency response is overdrawn in red for easy comparison.



Figures twenty-three and twenty-four show the stock response of a three-inch advertised basket transducer of similar design to that used in a couple of mass market satellite systems. The cone body is made from a relatively thin, soft, and smooth paper pulp. The dust cap is large in relation to the size of the cone and is attached to the cone body. While significantly different in size and construction to the ten-inch transducer of the first example, the performance errors are similar. Both the cone and the dust cap show significant cone vibration modes, the dust cap with a center mode frequency just slightly higher than the cone. The relatively large dust cap is also providing stiffening to the cone to reduce cone flex.

Figure Twenty-three. Impulse response of stock three-inch paper cone body with relatively large rigid paper dust cap.

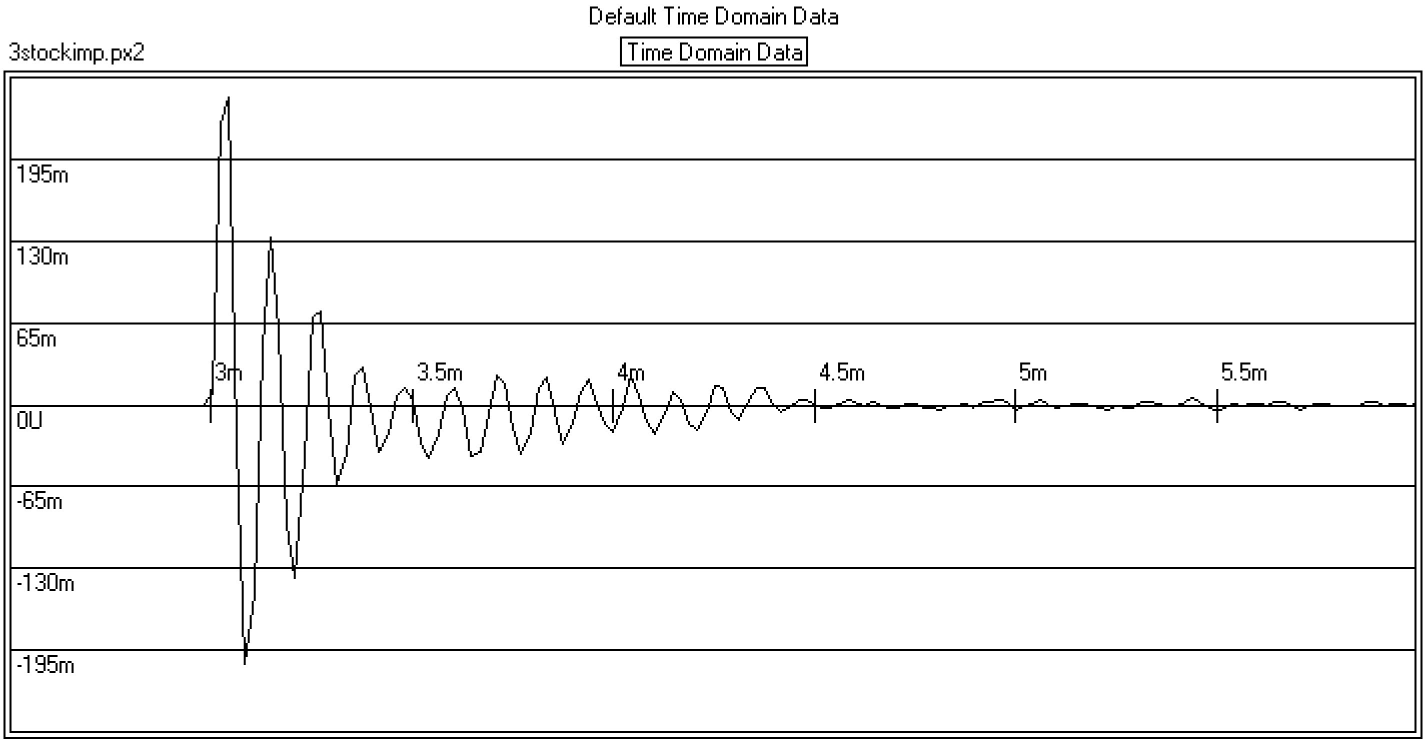
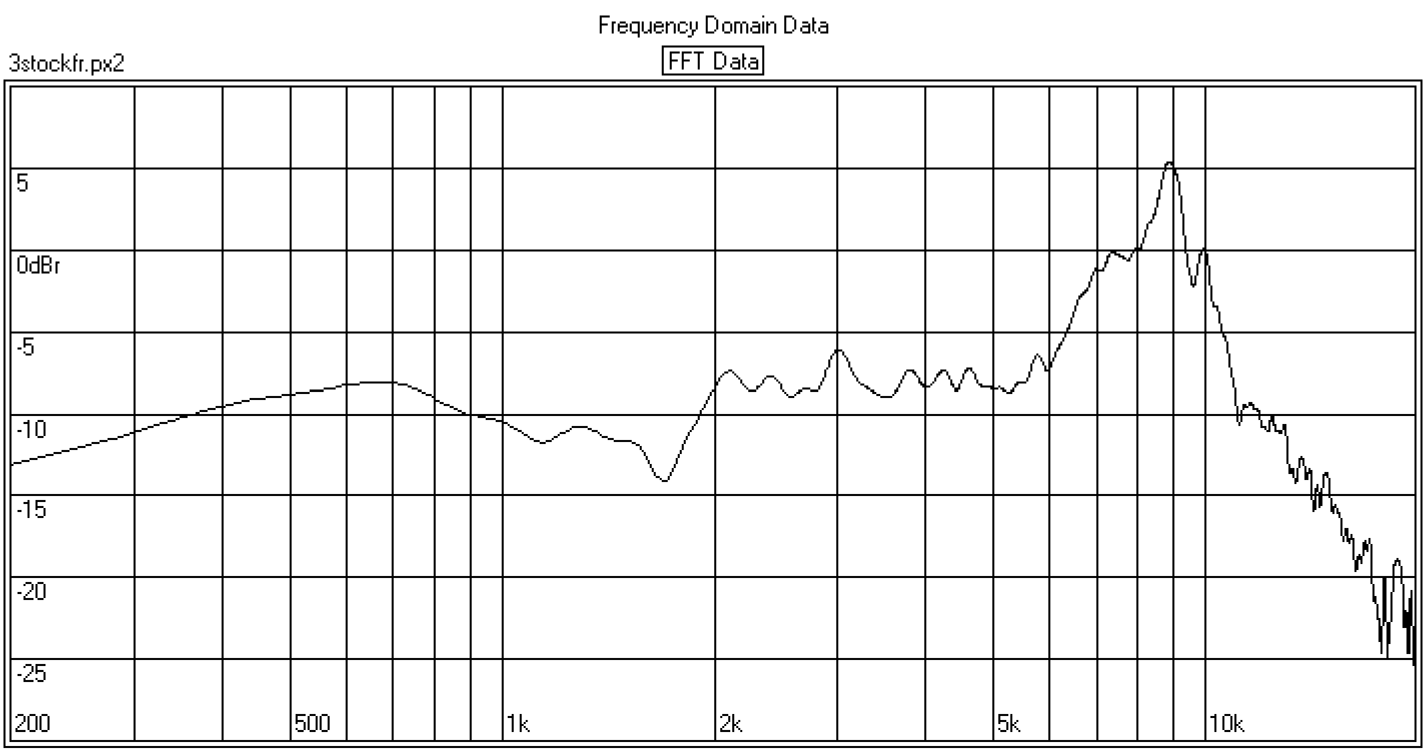


Figure Twenty-four. Frequency response of stock three-inch paper cone body with large rigid paper dust cap.



A series of very narrow dimples were used to modify the cone and the dust cap. The dimples on the dust cap are considerably longer than those on the cone. The modified performance is shown in figures twenty-five and twenty-six. The peak magnitudes of both vibration modes are reduced around 10 dB. As a result, the need for crossover compensation is reduced and ultimately the loudspeaker manufacturer using this transducer would benefit from reduced parts and labor cost.

Figure Twenty-five. Dimple modified three-inch transducer impulse response. Both cone and dust cap feature dimple modifications.

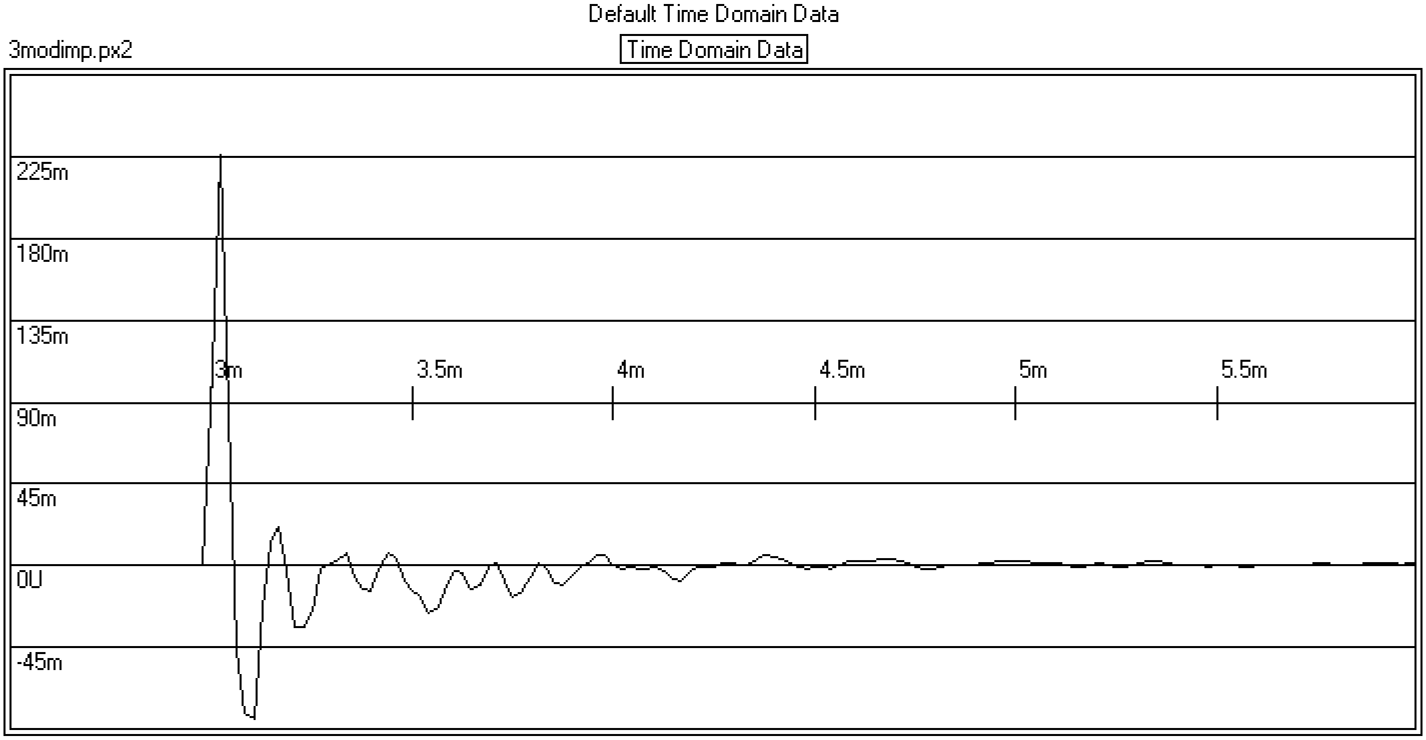


Figure Twenty-six. Dimple modified frequency response. Both cone and dust cap feature dimple modifications. Stock response is overdrawn in red for easy comparison.