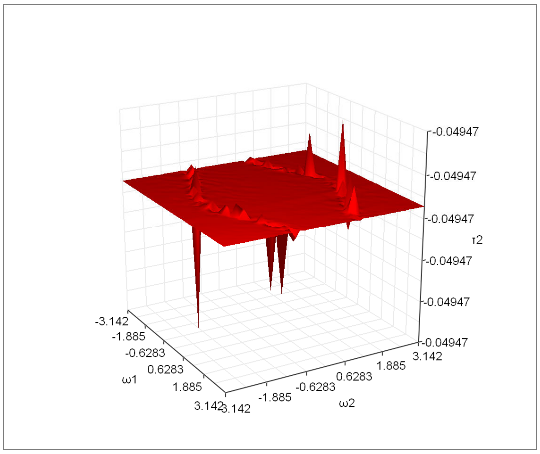

Fig.3.c 2nd Group Delay Response for the 2-D Comb Filter (2nd order)

4 Conclusion

A method for designing 2-D comb filters has been presented and illustrated through specific numerical examples. The method is based on the appropriate transformation $z^{-1} = \lambda z_1^{-1} + (1-\lambda) z_2^{-1}$ with $0 < \lambda < 1$. A Theorem regarding the stability of our 2-D Comb Filters is also stated and proven. Numerical examples illustrate the validity and the efficiency of the method. 2-D filters with several Comb frequencies can be easily implemented by cascade design, while by using further transformations like $z_1^{-1} = z_1^{-P_1}$ and $z_2^{-1} = z_2^{-P_2}$ where P_1, P_2 are positive integers, except the Comb frequencies $\omega_1 = \pm\omega_{10}, \omega_2 = \pm\omega_{20}$ the following comb frequencies are obtained $\omega_1 = \pm\frac{k_1}{P_1}\omega_{10}, \omega_2 = \pm\frac{k_2}{P_2}\omega_{20}$, $k_1 = 1,2,...,P_1$ and $k_2 = 1,2,...,P_2$

References:

[1] Sophocles J. Orfanidis, *Introduction to Signal Processing*, Prentice Hall. 1996.

[2] McEachen, J.C., II; Nehorai, A.; Duncan, J.S.; “Estimating cardiac motion from image sequences using recursive comb filtering” International Conference on Image Processing, 1995. Proceedings., P 496 - 499 vol.2, 1995

[3] Stubberud, P.A., "2-D linear phase frequency sampling filters and 2-D linear phase frequency sampling filters with fourfold symmetry” Proceedings of the 1996 IEEE International Symposium on Circuits and Systems, 1996. ISCAS '96.pp 356 - 359 vol.2

[4] Youn, Jae-Ho; Kim, Hyeong-Seok; Kang, Byeong-Gwon; Park, Jun-Seok; Kim, Sun-Hyung; Lim, Jae-Bong; "Design of Planer type Comb-Line Bandpass Filter And Design Parameter Extraction Using FE Analysis", Proceedings of the 32nd European Microwave Conference, pp.1-4, 2002.

[5] Cardells-Tormo, F.; Arnabat-Benedicto, J.; "Flexible hardware-friendly digital architecture for 2-D separable convolution-based scaling" IEEE Transactions on Circuits and Systems II: Express Briefs, pp.522 - 526, Vol.53 , Issue: 7, 2006

[6] N.E.Mastorakis, "A method for computing the 2-D stability margin based on a new stability test for 2-D systems", Multidimensional Systems and Signal Processing, Vol.10, pp.93-99, 1998.

[7] N.E.Mastorakis, "New Necessary Stability Conditions for 2-D Systems", IEEE Transactions on Circuits and Systems, Part I, Vol.47, No.7, pp.1103-1105, July 2000.

[8] N.E.Mastorakis, "A method for computing the 2-D stability margin", IEEE Transactions on Circuits and Systems, Part II, Vol.45, No.3, pp.376-379, March 1998.

[9] N.E.Mastorakis, "Recursive Algorithms for Two-Dimensional Filters' Spectral Transformations", IEEE Transactions on Signal Processing. Vol.44, No.10, pp.2647-2651, Oct.1996.

[10] V. Mladenov, and N. Mastorakis, “Design of 2-Dimensional Recursive Filters by using Neural Networks”, IEEE Trans. on Neural Networks.

[11] Mastorakis, N.E., Gonos, I.F., and Swamy, M.N.S., “Stability of multidimensional systems using genetic algorithms”, IEEE Trans. on Circuits and Systems, Part I: Fundamental Theory and Applications, Volume 50, Issue 7, July 2003, pp.962 – 965.

[12] Mastorakis, N.E. Swamy, M.N.S., "Spectral transformations for two-dimensional filters via FFT" IEEE Transactions on Circuits and Systems I: Fundamental Theory and Applications, Vol.49, Issue 6, pp.827 - 831, Jun 2002