

**UNIVERSITAT POLITÈCNICA DE CATALUNYA**

*Departament d'Enginyeria Electrònica*

**CONTRIBUCIÓN A LA MEJORA DE  
RESOLUCIÓN DE LOS SISTEMAS DE  
OBTENCIÓN DE IMÁGENES POR  
ULTRASONIDOS**

Autor: Jordi Salazar Soler  
Director: Miguel J. García Hernández

Diciembre de 1997

## Referencias

- [AULD83] B. A. Auld, H. A. Kunkel, Y. Shui and Y. Wang, "Dynamic Behavior Of Periodic Piezoelectric Composites", in *Proc. 1983 IEEE Ultrason. Symp.*, pp. 544-558.
- [BART75] D. K. Barton, *Pulse Compression. Radars Vol. 3*. Artech House, INC., 1975.
- [BENN90] A. Bennia and S. M. Riad, "An optimization technique for iterative frequency domain deconvolution", *IEEE Trans. Instrum. Meas.*, vol. 39, no. 2, pp. 358-362, April 1990.
- [CARP84] R. N. Carpenter and P. R. Stepanishen, "An Improvement To The Range Resolution Of Ultrasonic Pulse Echo Systems By Deconvolution", *J. Acoust. Soc. Am.*, vol. 75, no. 4, pp. 1084-1091, Apr. 1984.
- [CHAL90] P. Challande, "Optimizing Ultrasonic Transducers Based On Piezoelectric Composites Using Finite-Element Method", *IEEE Trans. Ultrason. Ferroelectr. Freq. Cont.*, vol. 37, no. 2, pp. 135-140, 1990.
- [CROM85] M. Van Crombruge and W. Thompson, Jr., "Optimization Of The Transmitting Characteristics Of A Tonpilz-Type Transducer By Proper Choice Of Impedance Matching Layers", *J. Acoust. Soc. Am.*, Vol. 77, pp. 747-752, 1985.

- [DESI78] C. S. Desilets, J. D. Fraser and G. S. Kino, "The Design Of Efficient Broadband Piezoelectric Transducers", *IEEE Trans. Sonics Ultrason.*, vol. SU-25, no. 7, pp. 115-125, July 1978.
- [GALL93] J. A. Gallego-Juárez, G. Rodríguez, J. L. San Emeterio, P. T. Sanz and J. C. Lázaro, "An acoustic transducer system for long-distance ranging applications in air", *Sensors and Actuators A*, 37-38, pp. 397-402, 1993.
- [GOLL75] J. Goll and B. Auld, "Multilayer Impedance Matching Schemes For Broadbanding Of Water Loaded Piezoelectric Transducers And High Q Resonators", *IEEE Trans. Sonics Ultrason.*, vol. SU-22, pp. 53-55, Jan. 1975.
- [GURU85] T. R. Gururaja, W. A. Schulze, L. E. Cross, R. E. Newnham, B. A. Auld and Y. J. Wang, "Piezoelectric composite materials for ultrasonic transducers applications. Part I: Resonant modes of vibration of PZT rod-polymer composites", *IEEE Trans. Sonics Ultrason.*, vol. SU-32, pp. 481-498, July 1985.
- [HARR76] *Proc. Workshop On Sonar Transducer Materials*, Guilford:IPC.
- [HASH86] K. Y. Hashimoto and M. Yamaguchi, "Elastic, Piezoelectric And Dielectric Properties Of Composite Materials", in *Proc. 1986 IEEE Ultrason. Symp.*, pp. 697-702.
- [HAYW84] G. Hayward and M. N. Jackson, "Discrete-time modeling of the thickness mode piezoelectric transducer", *IEEE Trans. Sonics Ultrason.*, vol. SU-31, pp. 137-150, May 1984.
- [HAYW89] G. Hayward and J. E. Lewis, "A Theoretical Approach For Inverse Filter Design In Ultrasonic Applications", *IEEE Trans. Ultrason. Ferroelec. Freq. Contr.*, vol. 36, no. 3, pp. 356-364, May 1989.
- [HEWL94] Generador de Funciones/Generador de formas de Onda Arbitrarias HP 33120A. Guía del Usuario, 1994.
- [HOLL84] A. C. Holly, "A Method For The Generation Of Broadband Acoustic Transmissions", *J. Acoust. Soc. Am.*, Vol. 75, no. 3, pp. 973-976, March 1984.

- [HOSS91] J. A. Hossack and G. Hayward, "Finite-Element Analysis Of 1-3 Composite Transducers", *IEEE Trans. Ultrason. Ferroelect. Freq. Contr.*, vol. 38, no. 6, pp. 618-629, 1991.
- [KINO87] G. S. Kino, *Acoustic waves: Devices, Imaging, and analog signal processing*. Englewood Cliffs, N J: Prentice Hall, 1987.
- [KOCH96] Š. Kociš and Z. Figura, *Ultrasonic Measurements and technologies. Sensor Physics and Technology* 4. Chapman & Hall, 1996.
- [KOSS66] G. Kossoff, "The Effects Of Backing And Matching On The Performance Of Piezoelectric Ceramic Transducers", *IEEE Trans. Sonics Ultrason.*, vol. SU-13, pp. 20-30, Mar. 1966.
- [KRIM70] R. Krimholtz, D. Leedom, and G. Matthaei, "New Equivalents Circuits For Elementary Piezoelectric Transducers", *Electronics Letters*, vol. 6, no. 13, pp. 398-399, June 1970.
- [LEAC94] W. M. Leach, "Controlled-Source Analogous Circuits And SPICE Models For Piezoelectric Transducers", *IEEE Trans. Ultrason. Ferroelec. Freq. Contr.*, vol. 41, no. 1, pp. 60-66, Jan. 1994.
- [LOCK94] G. R. Lockwood and F. S. Foster, "Modeling And Optimization Of High-Frequency Ultrasound Transducers", *IEEE Trans. Ultrason. Ferroelec. Freq. Contr.*, vol. 41, no. 2, pp. 225-230, March. 1994.
- [MAND88] B. Mandersson and G. Salomonsson, "Weighted Least-Squares Pulse-Shaping Filters With Application To Ultrasonic Signals", *IEEE Trans. Ultrason. Ferroelec. Freq. Contr.*, vol. 36, no. 1, pp. 109-113, Jan. 1988.
- [MASO48] W. P. Mason, *Electro-mechanical Transducers and Wave Filters*, 2nd ed., Princeton, N. J.: Van Nostrand, 1948.
- [MATL92a] MATLAB<sup>TM</sup>, *High-performance numeric computation and visualization software. Reference guide*, The MathWorks Inc., 1992.
- [MATL92b] MATLAB<sup>TM</sup>, *Signal Processing TOOLBOX. For use with Matlab<sup>TM</sup>*, The MathWorks Inc., 1992.
- [MATL92c] *MATLAB Reference Guide*, The MathWorks, Inc., August 1992.

- [MONT96] R. E. Montgomery and C. Richard, "A Model for the hydrostatic pressure response of a 1-3 composite", *IEEE Trans. Ultrason. Ferroelectr. Freq. Contr.*, vol. 43, no.3, pp. 457-466, May 1996.
- [MORR86] S. A. Morris, C. G. Hutchens, "Implementation of Mason's Model on circuit analysis programs", *IEEE Trans. Ultrason. Ferroelectr. Freq. Contr.*, vol. UFFC-33, no. 3, pp. 295-298, May 1986.
- [NEWN78] R. E. Newnham, D. P. Skinner and L. E. Cross, "Connectivity And Piezoelectricity-Pyroelectric Composites", *Material Res. Bull.*, vol. 13, no. 5, pp. 525-536, 1978.
- [PARR83] B. Parruck and S. M. Riad, "An optimization criterion for iterative deconvolution", *IEEE Trans. Instrum. Meas.*, vol. IM-32, pp. 137-140, March 1983.
- [PERS81] H. W. Persson, "Electric Excitation Of Ultrasound Transducers For Short Pulse Generation", *Ultrasound in Medicine and Biology*, vol. 7, no. 7, pp. 285-291, 1981.
- [PHIL91] J. W. Waanders, *Piezoelectric Ceramics. Properties and Applications*, Philips Components, 1st Edition, Eindhoven, April 1991.
- [PIQU92a] J. C. Piquette, "Method For Transducer Transient Suppression. I: Theory", *J. Acoust. Soc. Am.*, vol. 92, no. 3, pp. 1203-1213, Sep. 1992.
- [PIQU92b] J. C. Piquette, "Method For Transducer Transient Suppression. II: Experiment", *J. Acoust. Soc. Am.*, vol. 92, no. 3, pp. 1214-1221, Sep. 1992.
- [PIQU93] J. C. Piquette, "Applications Of The Method For Transducer Transient Suppression To Various Transducers Types", *J. Acoust. Soc. Am.*, vol. 94, no. 2, Pt. 1, pp. 646-651, Aug. 1993.
- [PROA92] J. G. Proakis, D. G. Manolakis, "Digital Signal Processing. Principles, Algorithms, and Applications", Maxwell Macmillan International Editions, 2nd ed., 1992.
- [PÜTT97] A. Püttmer, P. Hauptmann, R. Lucklum, O. Krause and B. Henning, "SPICE Model For Lossy Piezoceramic Transducers", *IEEE Trans. Ultrason. Ferroelec. Freq. Contr.*, vol. 44, no. 1, pp. 60-66, Jan. 1997.

- [RAMO86a] A. Ramos, P. T. Sanz, F. R. Montero de Espinosa, "Control de arrays ultrasónicos de AF. Aplicaciones en ecografía de alta resolución", *Mundo Electrónico*, no. 167, pp. 167-172, 1986.
- [RAMO86b] A. Ramos, P. T. Sanz, F. R. Montero de Espinosa, E. Riera, "Generación eficiente de impulsos ultrasónicos breves con MOSFET", *Mundo Electrónico*, no. 168, pp. 117-124, 1986.
- [REDW61] M. Redwood, "Transient performance of a piezoelectric transducer", *J. Acoust. Soc. Am.*, vol. 33, no. 4, pp. 527-536, April 1961.
- [RHYN93] T. H. Rhyne and S. Panda, "Design Implications Of Using Transducer Noise Figure As The Basis Of Sensitivity", in *Proc. IEEE Ultrasonics Symp.*, 1993, pp. 1167-1170.
- [SALA96] J. Salazar, A. Turó, G. Espinosa, M. García, "A Theoretical Approach For Short Pulse Generation Using The Double-Pulse Excitation", in *Proc. IEEE Instrum. Meas. Tech. Conf.*, vol. 1, pp. 394-398, Brussels, 1996.
- [SALA97] J. Salazar, A. Turó, G. Espinosa, M. J. García, "Factor de mérito como estimador de la excitación óptima pulsada de transductores de ultrasonidos", *Actas de XII Simposium Nacional de la URSI*, pp. 521-524, vol. 2, Set. 1997.
- [SELF81] A. R. Selfridge, R. Baer, B. T. Khuri-Yakub and G. S. Kino, "Computer Optimized Design Of Quarter-Wave Acoustic Matching And Electrical Matching Networks For Acoustic Transducers", in *Proc. IEEE Ultrasonics Symp.*, 1981, pp. 644-648.
- [SHUI95] Y. Shui, X. Geng and Q. M. Zhang, "Theoretical Modeling Of Resonant Modes Of Composite Ultrasonic Transducers", *IEEE Trans. Ultrason. Ferroelectr. Freq. Cont.*, vol. 42, no. 4, pp. 766-773, July 1995.
- [SILK84] M. G. Silk, *Ultrasonic Transducers For Nondestructive Testing*, W & G Baird Ltd, Antrim, 1984.
- [SMIT85] W. A. Smith, A. Shaulov and B. A. Auld, "Tailoring The Properties Of Composite Piezoelectric Materials For Medical Ultrasonic Transducers", in *Proc. 1985 IEEE Ultrason. Symp.*, pp. 642-647.

- [SMIT93] W. A. Smith, "Modeling Of 1-3 Composite Piezoelectrics: Hydrostatic Response", *IEEE Trans. Ultrason. Ferroelectr. Freq. Cont.*, vol. 40, pp. 41-49, 1993.
- [SOME74] J. C. Somer and W. J. Kooij, "Double-Pulse Excitation Of Piezoelectric Transducers", *Progress Rep 4*. Institute of Medical Physics, TNO, Utrecht, Netherlands, 1974.
- [SOUQ79] J. Souquet, P. Defranould and J. Desbois, "Design Of Low-Loss Wide-Band Ultrasonic Transducers For Noninvasive Medical Applications", *IEEE Trans. Sonics Ultrason.*, vol. SU-26, no. 2, pp. 75-81, Mar. 1979.
- [THOM88] D. O. Thompson and D. K. Hsu, "Technique For Generation Of Unipolar Ultrasonic Pulses", *IEEE Trans. Ultrason. Ferroelec. Freq. Contr.*, vol. 35, no. 4, pp. 450-456, July 1988.
- [TORM97a] X. Tormo, "Caracterización de un transductor de ultrasonidos mediante la respuesta impulsional y técnicas de filtrado para la mejora de resolución en imágenes de ultrasonidos", Proyecto Final de Carrera, UPC, ETSETB, Director del Proyecto: J. Salazar, Junio 1997.
- [TORM97b] X. Tormo, J. Salazar, A. Turó, G. Espinosa, M. J. García, "Caracterización de un transductor de ultrasonidos mediante la respuesta impulsional y estudio de su dependencia espacial", *Actas del Seminario Anual de Automática y Electrónica Industrial (SAAEI'97)*, Valencia, pp. 431-435, vol. 2, Sept. 1997.
- [TURO96a] A. Turó, J. Salazar, G. Espinosa, M. J. García, "Sensor Inteligente para la detección de profundidad en un medio líquido", *Actas del Seminario Anual de Automática y Electrónica Industrial (SAAEI'96)*, Zaragoza, pp. 80-83, vol. 1, Sept. 1996.
- [TURO96b] A. Turó, J. Salazar, G. Espinosa, X. Martínez, M. J. García, "Gestión remota de un sistema de sensores inteligentes para la inspección automática del fondo de una canalización de agua", *Actas del Seminario Anual de Automática y Electrónica Industrial (SAAEI'96)*, Zaragoza, pp.187-190, vol. 1, Set. 1996.

- [TURO97] A. Turó, J. Salazar, G. Espinosa, M. J. García, "Modelo eléctrico de transductor piezoelectrónico para aplicaciones de diatermia", *Actas de XII Simposium Nacional de la URSI*, pp.525-528, vol. 2, Set. 1997.
- [YAÑE96] C. Yañez, "Implementación de un entorno de captura y representación de señales de ultrasonidos", Proyecto Final de Carrera, ETSETB, Director del Proyecto: J. Salazar, Oct. 1996.
- [ZHAN94] Q. M. Zhang, W. Cao, J. Zhao and L. E. Cross, "Piezoelectric Performance Of Piezoceramic-Polymer Composites With 2-2 Connectivity – A Combined Theoretical And Experimental Estudies", *IEEE Trans. Ultrason. Ferroelectr. Freq. Cont.*, vol. 41, pp. 556-563, 1994.
- [ZHAN95] Q. M. Zhang, J. Chen, H. Wang, J. Zhao and L. E. Cross, "A New Transverse Piezoelectric Mode 2-2 Piezocomposite For Underwater Transducer Applications", *IEEE Trans. Ultrason. Ferroelectr. Freq. Cont.*, vol. 42, no.4, pp. 774-781, July 1994.