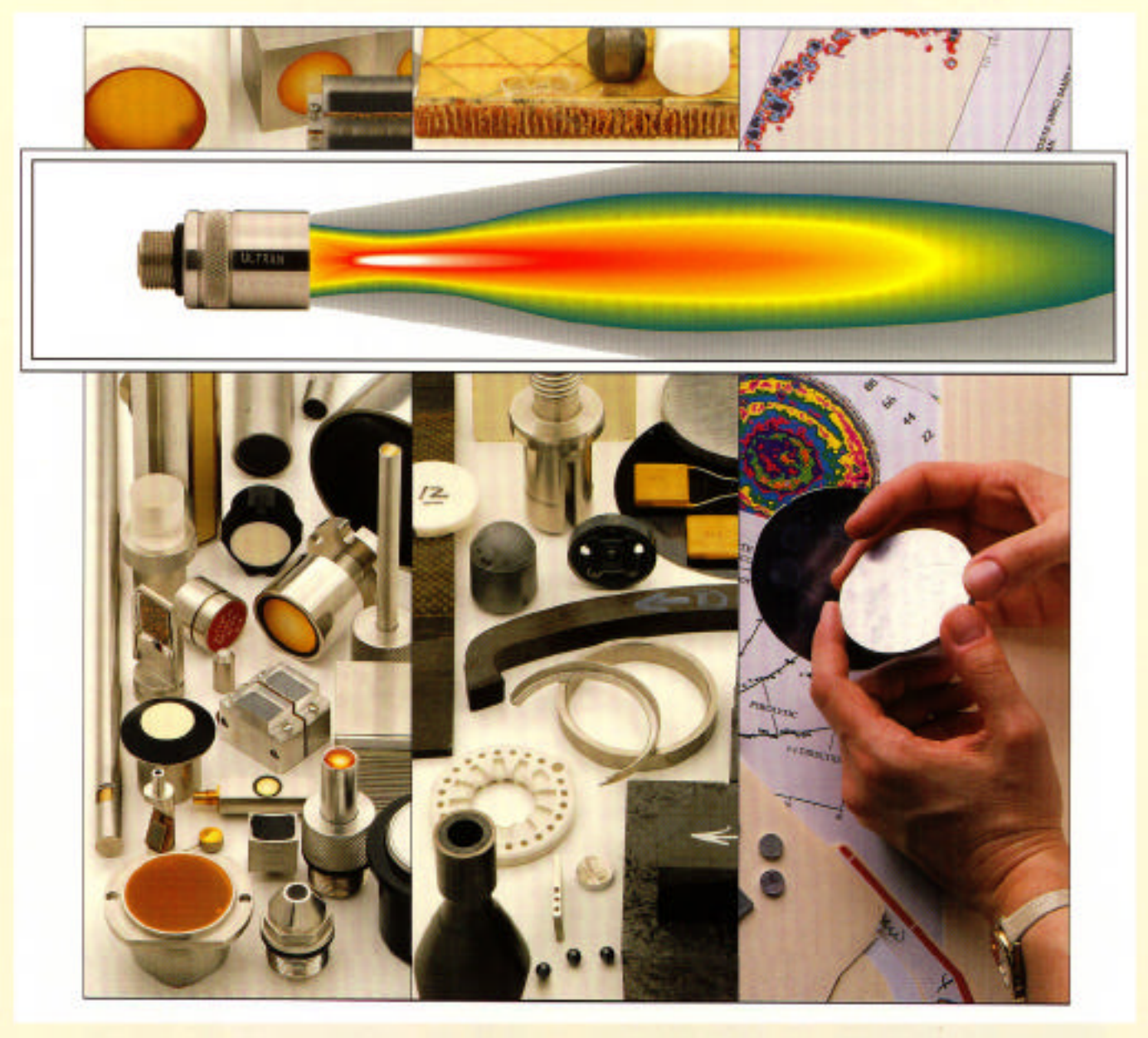
Modern Ultrasonic Transducers

Including Phenomenally High Sensitivity, High Frequency Non-Contact Transducers



Non-Destructive Analysis of Solids, Liquids, and Gases

ultran

Redefining the
limits of ultrasound

WELCOME TO ULTRAN

Ultran is a team of scientists and skilled technicians that works closely with our clients. Together we are dedicated to high quality and cost-effective materials production and applications through Ultrasonic Non-Destructive Characterization. Ultran accomplishes this by focusing on the heart of ultrasound: the transducer.

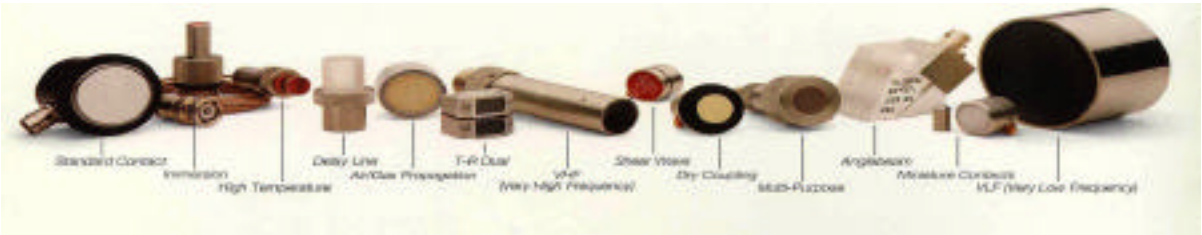
Long ago we realized that for ultrasound to rival other wave-based methods, we had to first develop the field. Proper acoustic characteristics are needed to achieve the desired materials test objectives. Proper techniques are essential to the test environment and the condition of a material. These goals are possible only through transducers with the right acoustics that perform under given conditions of testing.

Twenty years of non-stop R&D in transducers and applications allows us to share Ultran's milestones with you.

…a team of scientists, engineers, skilled technicians, and clients.

YEAR	MILESTONE
1977	Unipolar λ-series transducers for extremely high resolution and spectroscopy.
1978	Dual damping mechanism for high signal-to-noise ratios.
1979	Optimum development of broad-band (W-series), medium-band (P-series), and narrow-band (K-series) transducers from 500kHz to 25MHz.
1980	Very High Frequency (M-series) transducers from 30MHz to ~200MHz. 0° shear wave propagation transducers from 250kHz to 20MHz.
1983	Dry Coupling longitudinal and shear wave transducers from 250kHz to 25MHz. Introduction of air/gas propagation transducers from 100kHz to 5MHz.
1985 & 1992	High Temperature transducers from 250kHz to 5MHz for operation >800°C.
1986	Introduction of Wideband Ultrasonic Spectroscopy.
1988	Very High Numerical Aperture transducers up to 150MHz.
1989 to present	Very High Power transducers for biomedical and industrial applications from <500kHz to 100MHz. Introduction of transducer libraries for materials characterization.
1993	Very Low Frequency transducers from 30kHz to 250kHz.
1995 to present	Phenomenally High Air/Gas Transduction transducers from <100kHz to 10MHz for practical NON-CONTACT ULTRASOUND mode for industrial and bio-medical applications.
1988 to present	Guidance, education, and training for ultrasound users in industrial, medical, food, horticulture, construction and other fields.

Always labeled as being ahead of our time, we at Ultran continue to provide innovative solutions to very complex problems.



TECHNICAL SERVICES

Ultran has achieved an authoritative position in the ultrasonic industry by continually introducing innovative solutions to very complex problems. This is the result of combining two critical elements. The first element is Ultran's inter-disciplinary team of scientists and engineers in a comprehensive laboratory facility. Equally important is a very close and confidential working relationship with our customers.

Analytical & Feasibility Services

Ultran provides services for the ultrasonic nondestructive analysis of materials and components. We are equipped to perform analysis for defects, elastic and mechanical properties, micro-structure, interfacial, dimensional imaging and other test objectives. Each customer's inquiry is evaluated on its own merit and answered accordingly. We complete a project by providing a technical report describing objectives, techniques, observations, and results.

R&D Services & Transducer Prototyping

If your inquiry or problem requires in-depth analysis, new techniques, or a prototype transducer device, then our focus is on providing a practical solution by considering all operational factors. This is beneficial for establishing a strategy for assessing risk factors and cultivating a problem-solving mode. R&D projects include non-destructive characterization of special materials and processes, novel transducer designs, and other diagnostic or non-diagnostic uses of ultrasound.

We keep you up-to-date with the progress of your project. On completion of a project we give you a technical report describing objectives, techniques, observations, conclusions, and recommendations. As you would expect, science and technology transfer -- including education, training, and consultancy -- becomes an extremely significant part of our services.

…We are dedicated to exceeding the expectations of our customers.

A few of our special applications transducers

Customers & Publications

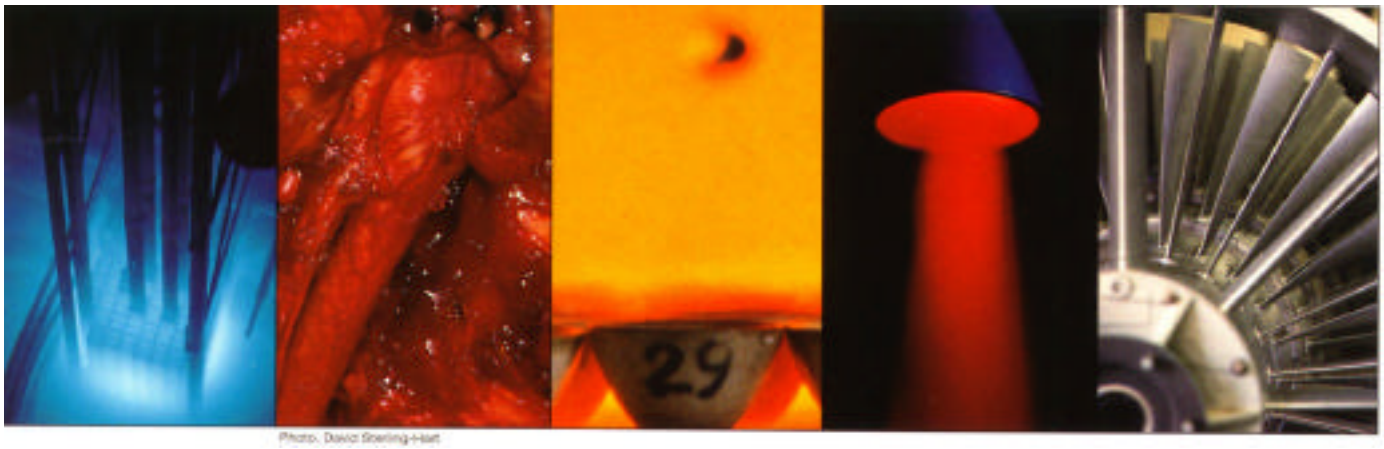


Photo: David Sterling-Hart

Some Customers

Westinghouse
Schlumberger-Doll
Bell Helicopter
ALCAN
BP America
Defelsko
Raytheon
Sofratest
Institute of Paper Science & Technology
Sofratest, France
NPL, UK
U.S. Air Force, Army, & Navy
Penn State University
University of West Virginia
Virginia Polytechnic Institute & University
Boeing
Katholieke Hogeschool, Belgium
Fraunhofer Institute, Germany
Siemens
Corning
General Electric
Hitachi
KAIST, Korea
Thiokol Propulsion
NASA
Lockheed-Martin
Weyerhaeuser
DOW Chemical
Johns Hopkins University
University of Penn
Smithkline-Beecham
Marion Composites
Electricite du France
Babcock & Wilcox
Framatome
CISE, Italy
EXXON

Some Publications

Our staff has authored or co-authored several important papers inspired by our novel advancements in ultrasound. Here is a partial list.

1 Bhardwaj, M.C., "Principles and Methods of Ultrasonic Characterization of Materials, " Adv. Cer. Mat., v. 1, n. 4 (1986).
2 Bhardwaj, M.C., "Fundamental Developments in Ultrasonics for Advanced NDC," in Nondestructive Testing of High Performance Ceramics, A. Vary, Editor, Am. Cer. Soc., Westerville, OH (1987).
3 Bhardwaj, M.C., "Advances in Ultrasound for Materials Characterization," Ad. Cer. Mat., v. 2, n. 3A (1987).
4 Brunk, J.A., Valenza, C.J., and Bhardwaj, M.C., "Applications and Advantages of Dry Coupling Ultrasonic Transducers for Materials Characterization and Inspection," in Acousto-Ultrasonics, Theory and Applications, John C. Duke, Jr., Editor, Plenum Press, New York (1988).
5 Bhardwaj, M.C., "Modern Ultrasonic Concepts of NDC," Ad. Mat. Processes, v. 5 (1989).
6 Bhardwaj, M.C., "Simple Ultrasonic NDC for Advanced Ceramics Development & Manufacture," in Advanced Metal and Ceramic Composites, Bhagat, Clauer, Kumar, and Ritter, Editors, Minerals, Metals, and Materials Society, Warrendale, PA (1990).
7 Bhardwaj, M.C., "High-Resolution Ultrasonic Nondestructive Characterization," Cer. Bull., v. 69, n. 9, (1990).
8 Bhardwaj, M.C. and Bhalla, A., "Ultrasonic Characterization of Ceramic Superconductors," J. Mat. Sci. Lett., v. 10 (1991).
9 Bhardwaj, M.C. and Trippett, K., "Nondestructive Characterization of Green and Sintered Ceramics," Proceedings of the First International Symposium of Engineering Ceramics, eds. S. Kimura and K. Niihara, Koda, Aichi-Prefecture, Japan, October 21-25, 1991, The Ceramic Society of Japan.
10 Bhardwaj, M.C., "Evolution, Practical Concepts and Examples of Ultrasonic NDC," Ceramic Monographs, Supplements to Interceram 41 (1992) [7/8] #4.5 and 42 (1993) [1] #4.5 - Handbook of Ceramics, Verlag Schmidt GmbH, Freiburg, Germany.
11 Kulkarni, N., Moudgil, B. and Bhardwaj, M., "Ultrasonic Characterization of Green and Sintered Ceramics: I, Time Domain," Am. Cer. Soc., Cer. Bull, Vol. 73, No. 6, (1994).
12 Kulkarni, N., Moudgil, B. and Bhardwaj, M., "Ultrasonic Characterization of Green and Sintered Ceramics: II, Frequency Domain," Am. Cer. Soc., Cer. Bull, Vol. 73, No. 7, (1994).
13 Bhardwaj, M.C., "Innovation in Non-Contact Ultrasonic Analysis: Applications for Hidden Objects Detection," Mat. Res. Innovat. (1997) 1:188-196.
14 Jones, J.P, Lee, D, Bhardwaj, M., Vanderkam, V., and Achauer, B,, "Non-Contact Ultrasonic Imaging for the Evaluation of Burn-Depth and for Other Biomedical Applications," Acoust. Imaging, V. 23 (1997).
15 Bhardwaj, M.C., "Non-Contact Ultrasonic Characterization of Ceramics and Composites," Proceedings Am.Cer.Soc., V 89 (1998).
16 T. Carneim, D.J. Green & M.C. Bhardwaj, "Non-Contact Ultrasonic Characterization of Green Bodies," Cer. Bull., April 1999.
17 Bhardwaj, M.C., "High Transduction Piezoelectric Transducers and Introduction to Non-Contact Analysis," submitted to the Encyclopedia of Smart Materials, ed. J.A. Harvey, John Wiley & Sons, New York (1999).

ultran

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Modern Ultrasonic Transducers

Including Phenomenally
High Sensitivity and High Frequency
Non-Contact Transducers

"Ultran's transducers played a crucial role in our ability to characterize factors influencing directional moduli in the films."

Charles A. Nielson, Senior Sensor Specialist
Dow Chemical U.S.A.

"In many instances we discussed at length my problems and you were extremely free with your advice and comments, which I recognized as having deep foundations in both theory and practical experience."

Julius Frankel, Senior Scientist
U.S. Department of Army

"The help which Ultran provided for atherosclerotic plaque dissolution and to me is very typical of the work and support they give to their many clients and friends. It would be difficult to imagine a client not becoming Ultran's friend."

Joie P. Jones, Professor
Department of Radiology, UC, Irvine, CA

"Ultran has routinely been contacted by my office for support and consultations. Rarely have I had the opportunity to work with individuals like those of Ultran. Their goals, expectations of themselves, and high standards for delivering a quality product have always exceeded what is anticipated."

Paul Karner, Former Principal Engineer
Thiokol Propulsion

"I especially admire Mahesh for his entrepreneuer-ship in building a company, namely Ultran Laboratories, Inc., based on his own excellent research and in part on the needs of NASA and aerospace industry."

Alex Vary, retired Chief NDE Branch
NASA Lewis

Table of Contents page

1. INTRODUCTION TO ULTRASOUND, ULTRAN'S TRANSDUCERS & SERVICES

1.1 Introduction to Ultrasound

It is now well established that by propagating ultrasound in a given medium, useful information about the medium can be generated by analyzing the transmitted signals. This is analogous to all other methods of characterization and analysis also founded upon wave-material interaction phenomena. These are: Optics, X-ray, IR, Raman Spectroscopy, NMR, neutron, γ-ray, mass spectrometry, etc. Ultrasound differs from these methods because it does not require sample preparation, is non-hazardous, provides the means to determine mechanical properties, microstructure, imaging, & microscopy, is portable, and is cost-effective. Furthermore, ultrasound is applicable to all states of matter, with the exceptions of plasma and vacuum. Propagation of ultrasound in a medium is not affected by its optical opacity.

The following table provides a comprehensive introduction to ultrasound measurements and to the information revealed either directly or through correlation:

MEASUREMENT CATEGORY	MEASURED PARAMETERS	APPLICATIONS
Time Domain	Times-of-Flight and Velocities of Longitudinal, Shear, and Surface Waves	Density, Thickness, Defect Detection, Elastic and Mechanical Properties, Interface Analysis, Anisotropy, Proximity & Dimensional Analysis, Robotics, Remote Sensing, etc.
Attenuation Domain	Fluctuations in Reflected and Transmitted Signals at a Given Frequency and Beam Size	Defect Characterization, Surface and Internal Microstructure, Interface Analysis, etc.
Frequency Domain	Frequency-Dependence of Ultrasound Attenuation, or Ultrasonic Spectroscopy	Microstructure, Grain Size, Grain Boundary Relationships, Porosity, Surface Characterization, Phase Analysis, etc.
Image Domain	Time-of-Flight, Velocity, and Attenuation Mapping as Functions of Discrete Point Analysis by Raster C-Scanning or Synthetic Aperture Techniques	Surface and Internal Imaging of Defects, Microstructure, Density, Velocity, Mechanical Properties, True 2-D and 3-D Imaging.

1.2 Acoustics of Ultran's Transducers & their Classification

This catalog describes a wide variety of transducers spanning a frequency range from <50kHz to ~200MHz for longitudinal, shear, and surface wave measurements. We have provided graphical analysis of our transducers to help you make the selection best for your applications. We strongly suggest that you familiarize yourself with the acoustics series described in section 4 of this catalog. Since the acoustics of a transducer are the most critical part of ultrasound, we cannot overestimate their significance for your materials analysis objectives. If you are not sure about the suitability of acoustics to your needs, please feel free to consult with Ultran.

Our transducers are classified according to well-known physical styles: contact, immersion, delay line, etc. We have also decided to categorize them since we have added several new transducer types such as dry coupling, air/gas propagation, non-contact, 0° shear wave, very short pulse, very high & very low frequency, high temperature, etc.

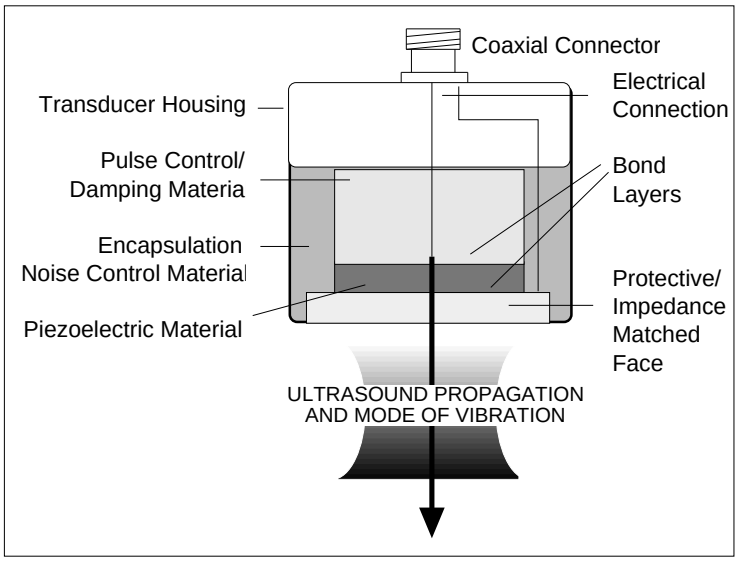
All attempts have been made to keep such classifications and terminology simple. If you need any assistance, please contact our technical services department.

1.3Physical Transducer Styles

After you have determined the acoustic series that is right for your application, you will need to select the most suitable physical transducer style. Ultran has any design you want – straight or delayed contact, immersion, oblique beam, dry coupling, high temperature, etc. If your application demands its own unique transducer style, we will create it. Especially for you!

1.4Precision Craftsmanship

Ultran has strict in-house quality control standards which result in flawless transducers for non-destructive materials characteri-zation applications. Each transducer features perfect alignment of acoustic and geometric axes and is encased in its own optimally shaped and sized housing with specially designed acoustically passive materials. Combined with our unique transducer-making technology, these features produce an optimum response from all our acoustic series. Our manufacturing "fussiness" offers you the ultimate in transducer reproducibility, whether your quantities are small or large.



ELEMENTS OF A PIEZOELECTRIC TRANSDUCER

A transducer can be as simple as a piezoelectric disc with leads attached to both faces.

Or, it can be a complex device intended to evaluate a number of materials and interfaces. In conjunction with the testing environment and a material's physical condition, a transducer device must be characterized by proper acoustics and mechanical construction. Therefore, the design of a modern transducer requires a knowledge of materials and the associated physics.

Ultran's years of experience have led to the evolution of an array of transducer designs suitable for a vast number of materials and test conditions.

1.5Customer Service

When you deal with Ultran, you are much more than a client. You are a partner. Our relationship with you underscores the fact that you may be testing something critical to human life. Therefore, we create our products as if OUR lives also depended upon them.

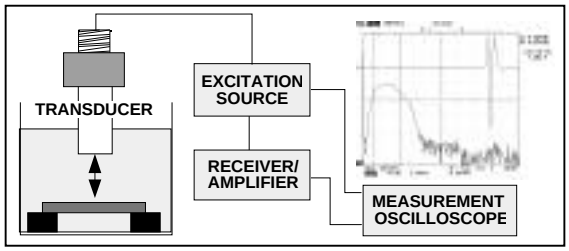
If you know what you need, it will be simple for you to order from this catalog. If you are not sure, we invite you to challenge us. Whether you are looking for a transducer or for the solution of a problem, our experts will give you forthright straight answers. You come to us for extraordinary standards. And we deliver. Ask anyone who has worked with us.

2. ACOUSTIC PARAMETERS OF A TRANSDUCER

Acoustic parameters of a transducer are described in the following table:

ACOUSTIC PARAMETER	DEFINITION
Nominal Frequency (F)	This is identified on the transducer housing.
Peak Frequency (PF)	This is the highest frequency response measured from the frequency spectrum.
Bandwidth Center Frequency (BCF)	This is an average of the lowest and highest points at a –6dB level of the frequency spectrum.
Bandwidth (BW)	This is the difference between the highest and lowest frequencies at a –6dB level of the frequency spectrum, also identified as the % of BCF or of PF.
Pulse Width (PW)	This is the time duration of the time domain envelope that is 20dB above the rising and decaying cycles of a transducer response.
Sensitivity (S)	S (dB) = -20 Log V_x/V_0, where V_0 is the excitation pulse in volts, and V_x is the received signal in volts. Sensitivity, also known as loop sensitivity or loop gain, is the function of the medium in which the test is performed.
Signal to Noise Ratio (SNR)	SNR (dB) = 20 Log V_x/V_n, where V_x is the received signal amplitude in volts, and V_n is the noise floor in volts. SNR is determined without signal processing. SNR measured in this manner also includes the noise associated with measuring instruments, cables, etc.

Acoustic parameters are measured by characterizing the reflected or transmitted ultrasound from a designated target or a reference medium. A specified pulser-receiver, toneburst or similar instrument excites the transducer and amplifies the signal.

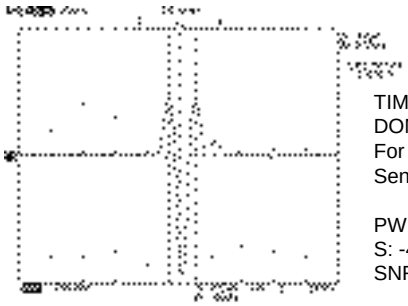


TRANSDUCER CHARACTERIZATION SCHEME

Water Immersion Example

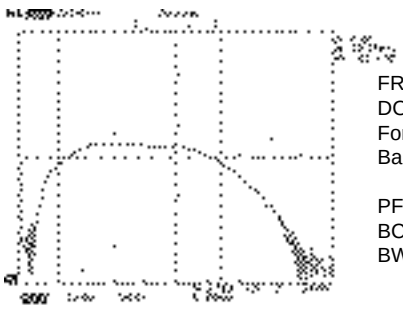
A transducer is also characterized by using hard, soft, or gaseous reference media depending upon its design and its intended applications – see section 5. The characterized information is significant for a user and for transducer producibility.

Example of Measured Acoustic Characteristics



TIME DOMAIN
For Pulse Width, Sensitivity, SNR

PW: 40ns.
S: -45dB.
SNR: 36dB



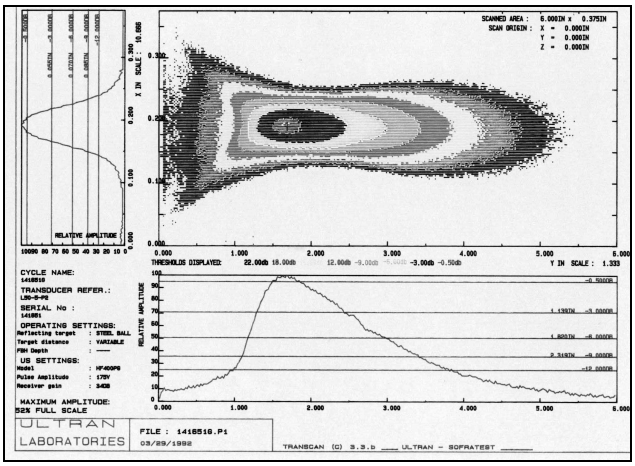
FREQUENCY DOMAIN
For Frequency & Bandwidth

PF: None.
BCF @ -6dB: 19MHz
BW @-6dB: 26MHz

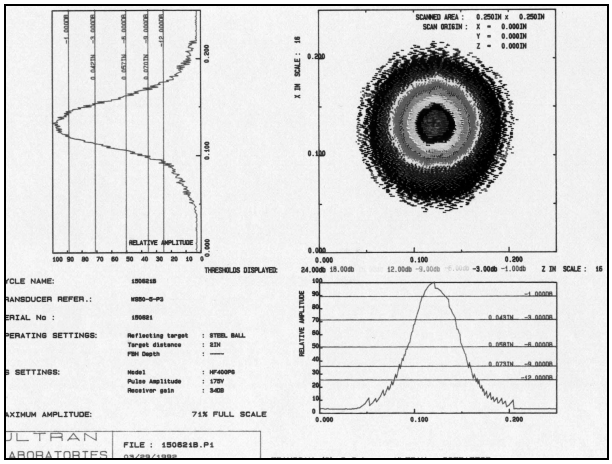
3 GEOMETRICAL PARAMETERS OF A TRANSDUCER

Geometrical parameters describe acoustic pressure variations in the axial and cross-sectional fields of a transducer. These parameters are generally produced by monitoring the reflected or transmitted signals from the lateral and axial motion of the transducer. Monitoring signals are functions of a fixed target or a receiving point hydrophone in a specified medium of ultrasound propagation. Geometrical characteristics of a transducer are normally determined with water as a reference medium. An illustration of this is shown below.

Example of Measured Geometrical Parameters



Axial beam profile in the direction of ultrasound propagation. For distance-amplitude relationships and for field symmetry.



Cross-sectional beam profile perpendicular to the direction of ultrasound propagation. For field symmetry and dimensions.

4. ACOUSTIC SERIES OF ULTRAN'S TRANSDUCERS

Ultran has perfected the art of ultrasonic transducers in order to improve the reliability of your materials testing and the accuracy of ultrasonic measurements. We achieved this by creating a number of possibilities based upon suitable combinations of frequencies, pulse widths, sensitivities, and acoustic impedance matching. These result from our expertise in materials science, electro-mechanical and wave-material interaction phenomena. We use a vast number of modern piezoelectric materials (Lead Meta-Niobates, Lead Zirconate-Lead Titanates, Lithium Niobates, Polycrystalline and Single Crystal Composites) in conjunction with our proprietary or patented transducer-making techniques.

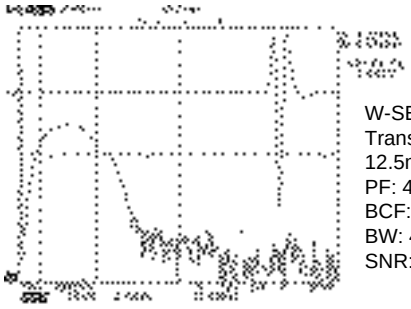
It may be of interest to note that a majority of our transducer designs were inspired by simple curiosity and a firm determination to advance ultrasound to new heights. We simply refused to tolerate the *status quo* that accepted transducer limitations. Long ago we created the shortest pulse and the broadest bandwidth λ-series transducers for high resolution and detectability. Then we produced the dry coupling mode for characterizing green and other liquid-sensitive materials. We were frequently labeled as being "well ahead of our time." In this section we provide details of our transducers according to their acoustic characteristics.

Ultran's transducers are classified according to acoustic series which define a specific combination of frequency ranges, bandwidths, pulse widths, and sensitivities. Ultran's acoustic series are the heart of our transducer know-how. You can choose a specific series that you consider optimum for the performance of your materials testing requirements. If you need any assistance, please contact Ultran's technical services department.

4.1Standard W and K Series (based upon PMN and PZT): For a majority of applications

ACOUSTIC SERIES	AVAILABLE FREQUENCY RANGE	BANDWIDTH (% of BCF @-6dB)	PULSE WIDTH (Periods)	SENSITIVITY/ SNR*	GENERAL APPLICATIONS
W	<100kHz to >25MHz	50 to 100	1 to 2	-36dB/ 40dB	Velocity, high resolution, defect detection, imaging, etc.
K	<100kHz to 20MHz	~30 to 40	2 to >4	-24dB/ 40dB **Approximate and subjective*	Very high sensitivity, attenuative & deep materials penetration

Examples of Typical W & K Series Acoustics



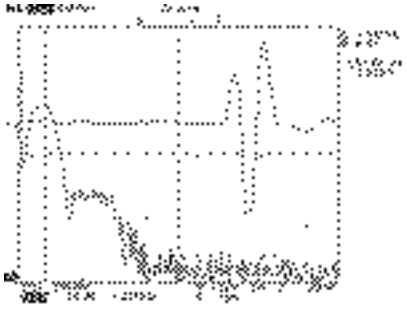
W-SERIES
Transducer: 5MHz,
12.5mm Active Diameter
PF: 4.4MHz
BCF: 4.5MHz
BW: 4.3MHz, S: -34dB,
SNR: 40dB

K-SERIES
Transducer: 5MHz,
12.5mm Active Diameter
PF: 5.4MHz
BCF: 5.1MHz,
BW: 3.2MHz, S: -26dB,
SNR: 40dB

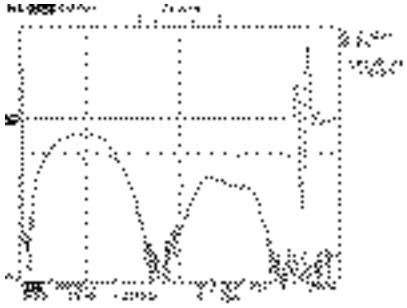
4.2Z-Series (based upon piezoelectric composites): For high sensitivity and high resolution

ACOUSTIC SERIES	AVAILABLE FREQUENCY RANGE	BANDWIDTH (% of BCF @-6dB)	PULSE WIDTH (Periods)	SENSITIVITY/ SNR*	GENERAL APPLICATIONS
Z	0.25MHz to 10MHz	50 to 100	1 to 2	-28dB/ 40dB **Approximate and subjective*	Velocity, high resolution, defect detection, imaging, and high sensitivity for attenuative and deep material penetration

Examples of Typical Z Series Acoustics: For high resolution and sensitivity.



Z-SERIES. Transducer: 1MHz, 12.5mm Active Diameter.
PF: 1.05MHz, BCF: 0.98MHz, BW: 1.1MHz, S: -24dB, SNR: 40dB



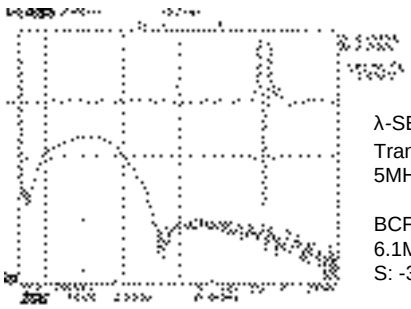
Z-SERIES. Transducer: 2MHz, 12.5mm Active Diameter.
PF: 2.1MHz, BCF: 2.0MHz, BW: 2.5MHz, S: -24dB, SNR: 40dB

Z-SERIES. Transducer: 5MHz, 12.5mm Active Diameter.
PF: 5.6MHz, BCF: 4.8MHz, BW: 5.4MHz, S: -28dB, SNR: 40dB

4.3λ and VSP Series (based upon PMN and $LiNbO_3$): For extremely high resolution, detectability, and spectroscopy.

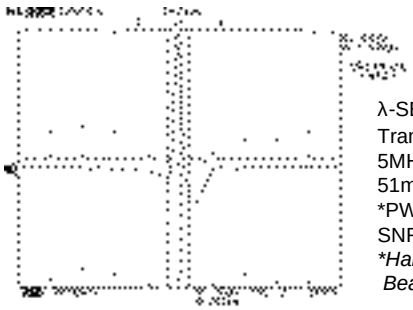
ACOUSTIC SERIES	AVAILABLE FREQUENCY RANGE	BANDWIDTH (% of BCF @-6dB)	PULSE WIDTH (Periods*)	SENSITIVITY/ SNR*	GENERAL APPLICATIONS
λ (Planar)	1MHz to >15MHz	100 to 150	1 to 1.5	-40dB/ 40dB	Velocity, high resolution, defect detection, imaging, spectroscopy
λ (Focused)	1MHz to >15MHz	100 to 300	0.5 to 1*	-40dB/ 40dB	Extremely high detectability & resolution
VSP --Special Very Short Pulse	15 to 100MHz	100 to 150	1 to 1.5 **For focused transducers with beam size ≤ a wavelength, then 0.5 period can be expected.*	-46dB/ 34dB **Approximate and subjective*	Extremely high resolution, spectroscopy, very thin and multi-layered materials

Examples of Typical λ Series Acoustics



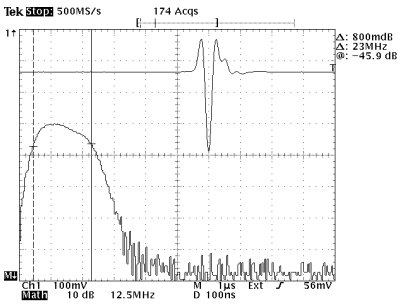
λ-SERIES (Planar)
Transducer:
5MHz, 12.5mm Diameter

BCF: 5.0MHz, BW: 6.1MHz, PW: 200ns, S: -36dB, SNR: 40dB.

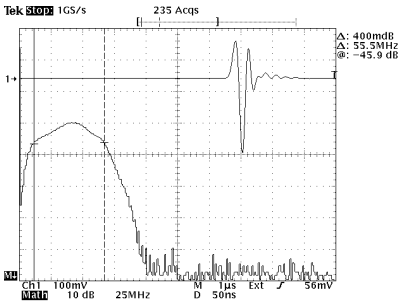


λ-SERIES (Focused)
Transducer:
5MHz, 12.5mm Diameter, 51mm point focus
*PW: 160ns, S: -40dB, SNR: 32dB
**Half Period when Beam Size ≤ 1λ.*

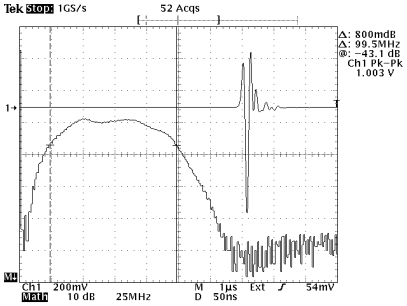
Examples of Typical VSP Series Acoustics



VSP-50
Transducer: 15MHz, 4.7mm Active Diameter.
BCF: 17MHz, BW: 23MHz,
PW: 48ns, S: -45dB, SNR: 30dB.



VSP-20
Transducer: 50MHz, 4.7mm Active Diameter.
BCF: 45MHz, BW: 55MHz,
PW: 22ns, S: -50dB, SNR: 30dB.

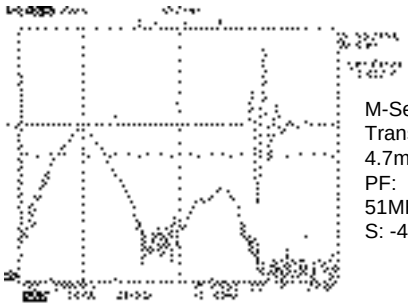


VSP-10
Transducer: 100MHz, 4.7mm Active Diameter.
BCF: 80MHz, BW: 100MHz,
PW: 11ns, S: -50dB, SNR: 30dB.

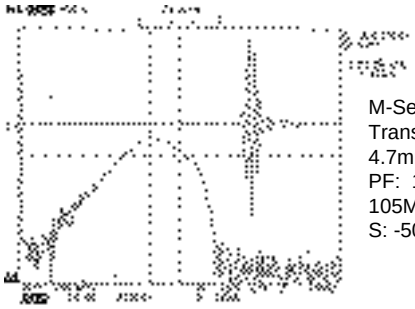
4.4M-Series (based upon $LiNbO_3$): For very high frequency applications

ACOUSTIC SERIES	AVAILABLE FREQUENCY RANGE	BANDWIDTH (% of BCF @-6dB)	PULSE WIDTH (Periods)	SENSITIVITY/ SNR*	GENERAL APPLICATIONS
M	30MHz to ~200MHz	>50	2 to 3	-50dB/ 30dB **Approximate and subjective*	Velocity, high resolution, defect detection, microscopy, imaging, spectroscopy

Examples of Typical M-Series Acoustics



M-Series
Transducer: 50MHz, 4.7mm =Diameter
PF: 50.5MHz, BCF: 51MHz, BW: 35MHz,
S: -45dB, SNR: 30dB.

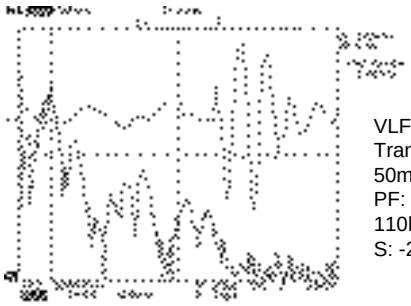


M-Series
Transducer: 100MHz, 4.7mm Diameter
PF: 100.5MHz, BCF: 105MHz, BW: 50MHz,
S: -50dB, SNR: 30dB.

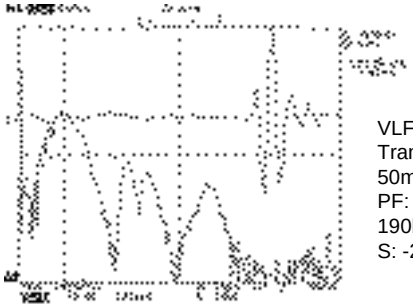
4.5VLF-Series (based upon multiple piezoelectric materials): For very low frequency applications

ACOUSTIC SERIES	AVAILABLE FREQUENCY RANGE	BANDWIDTH (% of BCF @-6dB)	PULSE WIDTH (Periods)	SENSITIVITY/ SNR*	GENERAL APPLICATIONS
VLF	<50kHz – 250kHz	30 to 70	2 to 6	-24dB/ 32dB **Approximate and subjective*	Velocity, defects, attenuative and very deep material penetration.

Examples of Typical VLF Series Acoustics



VLF-Series
Transducer: 125kHz,
50mm Diameter
PF: 125kHz, BCF:
110kHz, BW: ~75kHz,
S: -24dB, SNR: 32dB

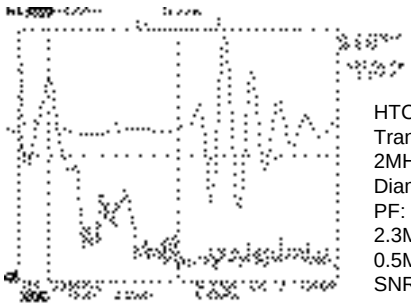


VLF-Series
Transducer: 200kHz,
50mm Diameter
PF: 180kHz, BCF:
190kHz, BW: 150kHz,
S: -22dB, SNR: 40dB

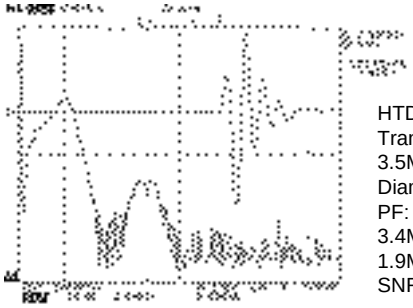
4.6HT-Series (based upon PMN): For high temperature applications

ACOUSTIC SERIES	AVAILABLE FREQUENCY RANGE	BANDWIDTH (% of BCF @ -6dB)	PULSE WIDTH (Periods)	SENSITIVITY/ SNR*	CONTINUOUS TEMPERATURE OPERATION
HTC (Direct Contact)	<500kHz to 5MHz	30 to 50	3 to 6	-50/20	~300°C
HTD (Delayed Contact)	<500kHz to 5MHz	40 to 70	2 to 4	-30/30	>600°C
				*Approximate and subjective	

Examples of typical HT-Series Acoustics



HTC-Series
Transducer:
2MHz, 6.3mm
Diameter @ 250°C.
PF: 2.3MHz, BCF:
2.3MHz, BW:
0.5MHz, S: -58dB,
SNR: 20dB

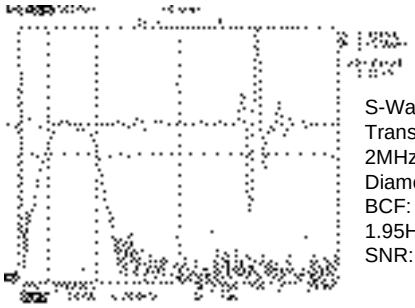


HTD-Series
Transducer:
3.5MHz, 12.5mm
Diameter @ 600°C.
PF: 3.5MHz, BCF:
3.4MHz, BW:
1.9MHz, S: -50dB,
SNR: 30dB

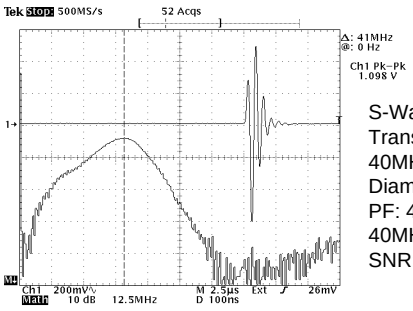
4.7S-SERIES (based upon $LiNbO_3$): For 0° shear wave measurement applications

ACOUSTIC SERIES*	AVAILABLE FREQUENCY RANGE	BANDWIDTH (% of BCF@ -6dB)	PULSE WIDTH (Periods)	SENSITIVITY/ SNR*	GENERAL APPLICATIONS
S *Shear vibration is in the horizontal plane of the transducer. Its direction of vibration is marked on the housing.*	<500kHz to 100MHz	40 to 80	2 to 4	-40dB/ 30dB *Approximate and subjective*	Shear wave velocity, shearography, anisotropy, and mechanical properties

Examples of Typical 0° Shear Wave S-Series Acoustics



S-Wave 2MHz
Transducer:
2MHz, 12.5mm
Diameter
BCF: 2.1MHz, BW:
1.95Hz, S: -40dB,
SNR: 30dB

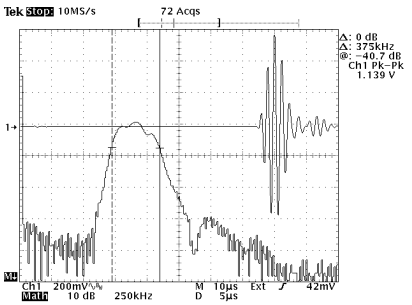


S-Wave 40MHz
Transducer:
40MHz, 3.2mm
Diameter
PF: 41MHz, BCF:
40MHz, S: -19dB,
SNR: 44dB

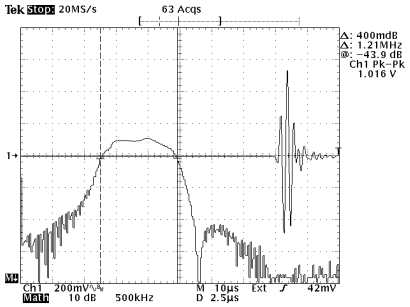
4.8 NCT-Series (based upon multiple piezoelectric materials): For non-contact applications. Please see sections 27 and 30 for more details.

ACOUSTIC SERIES	AVAILABLE FREQUENCY RANGE	BANDWIDTH (% of BCF @-6dB)	PULSE WIDTH (Periods)	SENSITIVITY/ SNR*	GENERAL APPLICATIONS
NCT	<100kHz to 5MHz	40 to >80%	1 to 5	-40dB/30dB **Approximate and subjective*	Liquid and contact sensitive, continuously rolled materials, proximity and dimensional analysis, etc.

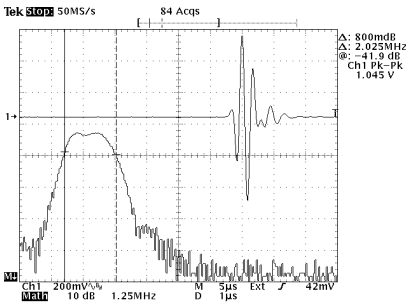
Examples of Non-Contact NCT-Series



NCT-Series 1MHz
Transmission Mode, T-R Separated by 10mm ambient air.
Active Diameter: 25mm, BCF: 0.93MHz, BW: 0.4MHz, S: -52dB,
SNR: 40dB.



NCT-Series 2MHz
Transmission Mode, T-R Separated by 10mm ambient air.
Active Diameter: 12.5mm, BCF: 1.9MHz, BW: 1.2MHz, S: -58dB
SNR: 32dB.



NCT-Series 3MHz
Transmission Mode, T-R Separated by 10mm ambient air.
Active Diameter: 12.5mm, BCF: 2.6MHz, BW: 2.0MHz, S: -62dB,
SNR: 26dB.

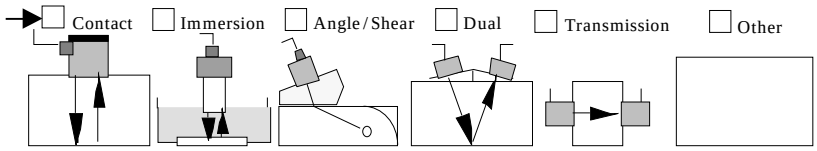
5. TRANSDUCER ACOUSTIC CHARACTERIZATION REPORTS

A comprehensive acoustic characterization report accompanies each Ultran transducer. This report consists of the transducer catalog number, serial number, nominal acoustic and dimensional characteristics, method of analysis, excitation, amplification, oscilloscope settings, analyzed parameters, and special instructions. Special instructions include information such as customer-specified frequency, dimensions, co-axial connections, direction of wave propagation or vibration, and other significant information. A typical example of Ultran's acoustic characterization report is illustrated below. These reports are provided at no extra cost with each ordered transducer.

Model # ZD50-2* **Frequency: 2.0MHz** **Serial # 220,498** **Customer/PO: ATK, Inc.**

Active area: 12.5mm diameter Cable: 1.0m RG174/u Other:

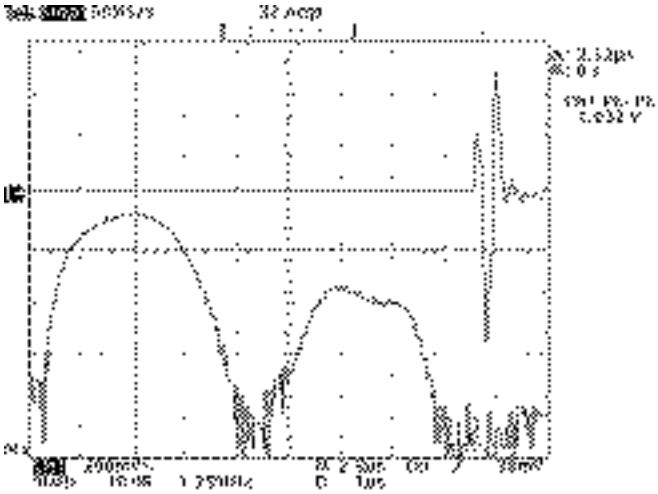
TEST METHOD



Test Material: 31mm Polystyrene. Reference Signal: Bottom Surface Reflection

INSTRUMENTS & SETTINGS

Pulser/Receiver:		**Oscilloscope**	**FFT SPECTRUM**
Volts: ~100 (-ve spike)	Gain: 22dB	VS: 200mv/D	VS: 10dB/d
Pulse Width: LOW	Attn:	HS: 1µs/D	HS: 1.25MHz/d
Damping: ~500Ω_	Bandwidth: 1kHZ-35MHz	Other	



OBSERVATIONS & RESULTS

Peak Frequency: 2.5MHz

Bandwidth Center Frequency: 2.3MHz

Bandwidth @ -6dB: 2.55MHz

Pulse Width @ maximum points: 450ns

Sensitivity: -32dB

Focal Length in WATER/AIR:

Other Characteristics:

*Special Observations/Instructions: DRY COUPLING. Please do not rub or abrade the

ANALYST: nsb **DATE: July 4, 1999**

6. TRANSDUCER SELECTION GUIDE*

We cannot overestimate the suitability of a transducer for a given application. The transducer *is* the heart of your application. Its selection depends upon the composition, texture, micro-structure, shape and the objectives of your materials testing. It also depends upon the mode by which you can physically couple the transducer to your test material. The following table provides a general guideline for transducer selection.

SELECTION OF **ACOUSTICS SERIES**	**SELECTION OF FREQUENCY**	**SELECTION OF MODE OF COUPLING**	**SELECTION OF TRANSDUCER PHYSICAL STYLE**
Will depend upon the material composition and test objectives. For example: For high resolution, use W-Series For general purpose, high sensitivity and thick materials, use K-Series For high resolution and high sensitivity needs, use Z-Series For very high resolution and spectroscopy, use λ-Series For extremely high resolution and detectability, use M-Series For highly attenuative media, use VLF series For shear wave measurements, use S-Series	Will depend upon the material composition, micro-structure, and texture. For example: For super hard, dense, fine-grain ceramics, metals and composites, from 10MHz to >100MHz For non-porous, dense, and medium-grain ceramics, metals, polymers, composites, and liquids, from 1 to 15MHz For coarse-grain attenuative ceramics, construction, cellular and other materials, from <100kHz to 5MHz For air/gas propagation, from <50kHz to 10MHz	Will depend upon the material composition and the desired contact with material. For example: For impervious and liquid-resistant materials, use standard couplant or water immersion coupling For porous, green, fragile, and liquid-sensitive materials, use dry coupling or non-contact For continuous testing of impervious and liquid-resistant materials, use water (or other liquids) immersion For continuously rolled, liquid-sensitive, and other like applications, use non-contact transducers	Will depend upon the material shape, size, and test objectives. For example: For thick materials, use direct contact For thin materials and thickness gauging, use delay line contact For C-scanning and imaging, use focused water immersion For high temperature materials, use high temperature-resistant transducers For shear wave measurements, use 0° shear wave transducers

*This is a general guideline for transducer selection. Unique applications may require specific combinations of acoustics, mode of transducer coupling, and style. If you need assistance, please consult Ultran's technical services department.

ORDERING INFORMATION

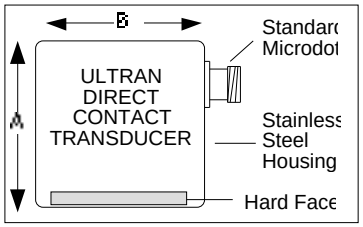
Sections 7 through 27 of this catalog provide specifications and ordering information for a variety of ultrasonic transducers in direct and delayed contact, immersion, and anglebeam types. These transducers are suitably classified according to Ultran's well-known W (broadband), K (high sensitivity and medium bandwidth), Z (broadband and high sensitivity), λ (extremely broadband and short pulse), and S (0° shear wave incidence) acoustic series. We have also included a number of our other major transducer developments in this catalog. These are: Very Short Pulse (VSP), Very High Frequency (VHF), Very Low Frequency (VLF), High Temperature (HT), and Non-Contact Transducers (NCT.) You may order any transducer you need. If you require custom made transducers or a solution to a specific problem, we suggest you contact Ultran's technical services department.

For pricing, delivery, and terms of sales, please contact Ultran's sales department or ask for a price list.

You can reach us by these means:

Toll Free: **800.226.1700**
Phone: **814.466.6200**
Fax: **814.466.6847**
Email: **ultranlabs@aol.com**
Web: www.ultranlabs.com

7. STANDARD MINIATURE CONTACT TRANSDUCERS: <500kHz to 25MHz. Featuring a hard protective face. Please see section 4.1 for W and K Acoustic Series Details



DIMENSIONS (mm)	TRANSDUCER ACTIVE DIAMETER (mm)					
	3.2	4.7	6.3	9.5	12.5	19.0
A	12.5	12.5	12.5	12.5	16.0	16.0
B	6.3	7.8	9.6	13.5	17.8	25.0

CATALOG NUMBER W-Series	CATALOG NUMBER K-Series	FREQUENCY (MHz)	ACTIVE DIAMETER (mm)
WC50-0.5		0.5	12.5
WC75-0.5	KC75-0.5		19.0
WC50-1	KC50-1	1.0	12.5
WC75-1	KC75-1		19.0
WC25-2	KC25-2	2.2	6.3
WC50-2	KC50-2		12.5
WC75-2	KC75-2		19.0
WC25-5	KC25-5	5.0	6.3
WC37-5	KC37-5		9.5
WC50-5	KC50-5		12.5
WC75-5	KC75-5		19.0
WC12-10	KC12-10	10.0	3.2
WC18-10	KC18-10		4.7
WC25-10	KC25-10		6.3
WC37-10	KC37-10		9.5
WC50-10	KC50-10		12.5
WC12-15	KC12-15	15.0	3.2
WC25-15	KC25-15		6.3
WC12-20	KC12-20	20.0	6.3

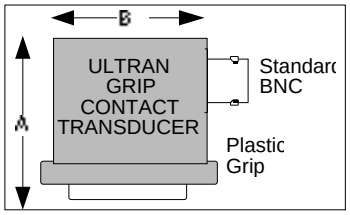
STANDARD MINIATURE CONTACT TRANSDUCERS

These are supplied with a side-mounted standard microdot co-axial connector.

For all other dimensions, frequency, connector and special needs, please contact Ultran.

All transducers are furnished with acoustic characterization reports at no extra charge.

8. STANDARD GRIP CONTACT TRANSDUCERS: <500kHz to 10MHz. Featuring a plastic grip and a hard protective face. Please see section 4.1 for W and K Acoustic Series Details.



DIMENSIONS (mm)	TRANSDUCER ACTIVE DIAMETER (mm)					
	12.5	19.0	25.0	28.5	38.0	50.0
A	32.0	32.0	32.0	32.0	32.0	32.0
B	22.2	28.6	35.0	38.1	47.6	60.3

CATALOG NUMBER W-Series	CATALOG NUMBER K-Series	FREQUENCY (MHz)	ACTIVE DIAMETER (mm)
WN100-0.5	KN100-0.5	0.5	25.0
WN50-1	KN50-1	1.0	12.5
WN75-1	KN75-1		19.0
WN100-1	KN100-1		25.0
WN50-2	KN50-2	2.2	12.5
WN75-2	KN75-2		19.0
WN100-2	KN100-2		25.0
WN50-5	KN50-5	5.0	12.5
WN75-5	KN75-5		19.0
WN50-10	KN50-10	10.0	12.5

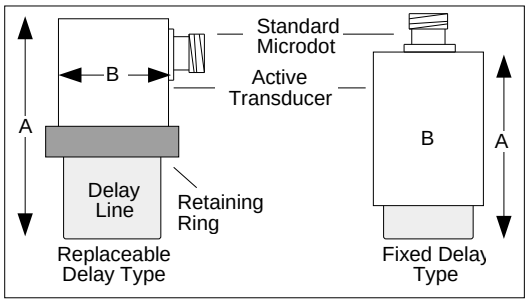
STANDARD GRIP CONTACT TRANSDUCERS

These are supplied with a side-mounted standard BNC co-axial connector.

For all other dimensions, frequency, connector, and special needs, please contact Ultran.

All transducers are furnished with acoustic characterization reports at no extra charge.

9. STANDARD DELAYED CONTACT TRANSDUCERS: <1MHz to 25MHz.
Please see sections 4.1 and 4.2 for W and Z Acoustic Series Details



DIMENSIONS (mm)	TRANSDUCER ACTIVE DIAMETER (mm)						
	3.2	4.7	6.3	9.5	12.5	19.0	25.0
A*	22.0	22.0	22.0	24.0	37.0	40.0	55.0
B	6.3	9.5	9.5	12.5	16.0	23.8	32.0
*Approximate							

CATALOG # Replaceable Delay[1] W-Series	CATALOG # Fixed Delay[2] W-Series	CATALOG # Replaceable Delay[1] Z-Series	CATALOG # Fixed Delay[2] Z-Series	FREQUENCY (MHz)	ACTIVE DIAMETER (mm)	ROUND-TRIP DELAY TIME (μs)
WRD50-1	WFD50-1	ZRD50-1	ZFD50-1	1.0	12.5	17
WRD75-1	WFD75-1	ZRD75-1	ZFD75-1		19.0	17
WRD100-1	WFD100-1	ZRD100-1	ZFD100-1		25.0	17
WRD25-2	WFD25-2	ZRD25-2	ZFD25-2	2.2	6.3	7
WRD37-2	WFD37-2	ZRD37-2	ZFD37-2		9.5	7
WRD50-2	WFD50-2	ZRD50-2	ZFD50-2		12.5	17
WRD75-2	WFD75-2	ZRD75-2	ZFD75-2		19.0	17
WRD25-5	WFD25-5	ZRD25-5	ZFD25-5	5.0	6.3	7
WRD37-5	WFD37-5	ZRD37-5	ZFD37-5		9.5	7
WRD50-5	WFD50-5	ZRD50-5	ZFD50-5		12.5	17
WRD25-10	WFD25-10	ZRD25-10	ZFD25-10	10.0	6.3	7
WRD37-10	WFD37-10	ZRD37-10	ZFD37-10		9.5	7
WRD50-10	WFD50-10	ZRD50-10	ZFD50-10		12.5	17
WRD12-15	WFD12-15			15.0	3.2	7
WRD18-15	WFD18-15				4.7	7
WRD25-15	WFD25-15				6.3	7
WRD12-20	WFD12-20			20.0	3.2	7
WRD18-20	WFD18-20				4.7	7
WRD12-25	WFD12-25			25	3.2	7
WRD18-25	WFD18-25				4.7	7

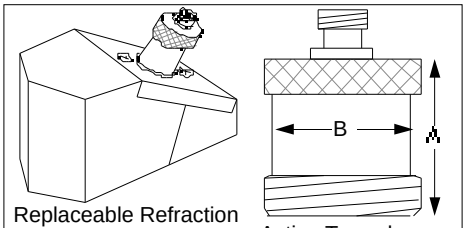
[1]Replaceable delay line transducers are supplied with a side-mounted standard microdot co-axial connector. These transducers come as a kit containing the main transducer, standard delay line, and delay retaining ring. Replaceable delay line transducers can be used with your choice of delay lines such as STANDARD, HIGH TEMPERATURE (300°C), or DRY COUPLING. Please see section 9.1 for details.
[2]Fixed delay line transducers are supplied with a top-mounted standard microdot co-axial connector.

9.1Delay Lines for Replaceable Delay Line Transducers. Classified according to the transducer's active diameter

CATALOG NUMBER Standard Delay	CATALOG NUMBER High Temp. Delay	CATALOG NUMBER Dry Coupling Delay*	SUITABLE FOR ACTIVE DIAMETER (mm)
DL12	HDL12	DCD12	3.2
DL18	HDL18	DCD18	4.5
DL25	HDL25	DCD25	6.4
DL37	HDL37	DCD37	9.5
DL50	HDL50	DCD50	12.5
DL75	HDL75	DCD75	19.0

*Dry coupling delay lines cannot be rubbed or abraded on test materials. For other dimensions, please contact Ultran.

10.STANDARD ANGLEBEAM/SHEARWAVE TRANSDUCERS: <500kHz to 10MHz. Offered with screw-on replaceable refraction wedges. Please see section 4.1 for W and K Acoustic Series Details.



Replaceable Refraction Wedge Anglebeam Type

Active Transduce

DIMENSIONS (mm)	TRANSDUCER ACTIVE DIAMETER (mm)			
	6.3	9.5	12.5	19.0
A*	14.3	14.3	17.8	20.0
B	9.5	12.5	16.0	23.8
*Approximate				

CATALOG NUMBER W-Series	CATALOG NUMBER K-Series	FREQUENCY (MHz)	ACTIVE DIAMETER (mm)
WT50-0.5 WT75-0.5	KT50-0.5 KT75-0.5	0.5	12.5 19.0
WT50-1 WT75-1	KT50-1 KT75-1	1.0	12.5 19.0
WT37-2 WT50-2 WT75-2	KT37-2 KT50-2 KT75-2	2.2	9.5 12.5 19.0
WT25-5 WT37-5 WT50-5	KT25-5 KT37-5 KT50-5	5.0	6.3 9.5 12.5
WT25-10 WT37-10	KT25-10 KT37-10	10.0	6.3 9.5

STANDARD ANGLEBEAM/ SHEARWAVE TRANSDUCERS

These are supplied with a top-mounted standard microdot co-axial connector.

Screw-on refraction wedges can be ordered separately. Please see section 10.1.

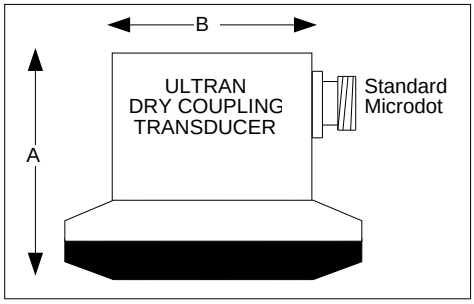
All transducers are furnished with acoustic characterization reports at no extra charge.

10.1 Refraction Wedges for Anglebeam Contact Transducers. Classified according to the refraction angle, active diameter, and wave type*.

CATALOG NUMBER S (Shear Wave)	CATALOG NUMBER L (Longitudinal Wave)	REFRACTION ANGLE (C-Steel Reference)	SUITABLE FOR ACTIVE DIAMETER (mm)
45S25 45S37 45S50 45S75	45L25 45L37 45L50 45L75	45°	6.3 9.5 12.5 19.0
60S25 60S37 60S50 60S75	60L25 60L37 60L50 60L75	60°	6.3 9.5 12.5 19.0
70S25 70S37 70S50 70S75	70L25 70L37 70L50 70L75	70°	6.3 9.5 12.5 19.0
90S25 90S37 90S50 90S75	90L25 90L37 90L50 90L75	90°	6.3 9.5 12.5 19.0

*For all other refraction angles, including the type of refracting wave (longitudinal, shear, or surface), please contact Ultran.

11. DRY COUPLING DIRECT CONTACT TRANSDUCERS: <500kHz to 10MHz. Featuring an acoustically transparent solid compliant contact face. Please see sections 4.1 and 4.2 for W and Z Acoustic Series Details.



DIMENSIONS (mm)	TRANSDUCER ACTIVE DIAMETER (mm)			
	6.3	9.5	12.5	19.0
A	13.5	16.0	19.0	19.0
B	16.0	22.2	25.0	32.0

CATALOG NUMBER W-Series	CATALOG NUMBER Z-Series	FREQUENCY (MHz)	ACTIVE DIAMETER (mm)
WD50-0.25 WD75-0.25	ZD50-0.25 ZD75-0.25	0.25	12.5 19.0
WD50-0.5 WD75-0.5	ZD50-0.5 ZD75-0.5	0.5	12.5 19.0
WD50-1 WD75-1	ZD50-1 ZD75-1	1.0	12.5 19.0
WD25-2 WD37-2 WD50-2	ZD25-2 ZD37-2 ZD50-2	2.0	6.3 9.5 12.5
WD25-5 WD37-5	ZD25-5 ZD37-5	5.0	6.3 9.5
WD25-10	ZD25-10	10.0	6.3

DRY COUPLING DIRECT CONTACT TRANSDUCERS

These are supplied with a side-mounted standard microdot co-axial connector.

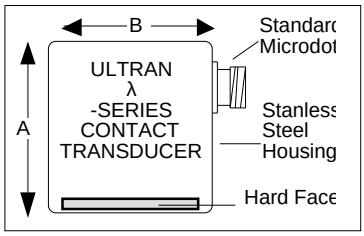
They cannot be rubbed or abraded on test materials.

All transducers are furnished with acoustic characterization reports at no extra charge.

DELAY LINE DRY COUPLING TRANSDUCERS

Please use the standard delay line transducers with an appropriate dry coupling delay line as described in sections 9 and 9.1.

12. λ-SERIES DIRECT CONTACT TRANSDUCERS: <500kHz to 15MHz. Featuring a hard protective face. Please see section 4.3 for λ-Series Acoustics Details.



DIMENSIONS (mm)	TRANSDUCER ACTIVE DIAMETER (mm)				
	4.7	6.3	9.5	12.5	19.0
A	12.5	12.5	12.5	16.0	16.0
B	7.8	9.6	13.5	17.8	25.0

CATALOG NUMBER	FREQUENCY (MHz)	ACTIVE DIAMETER (mm)
LC50-1 LC75-1	1.0	12.5 19.0
LC50-2 LC75-2	2.0	12.5 19.0
LC25-5 LC37-5 LC50-5	5.0	6.3 9.5 12.5
LC25-10 LC37-10	10.0	6.3 9.5
LC18-15	15.0	4.7

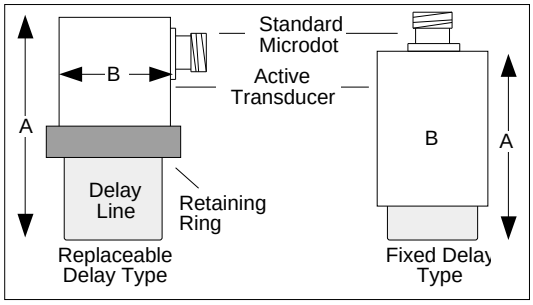
λ-SERIES DIRECT CONTACT TRANSDUCERS

These are supplied with a side-mounted standard microdot co-axial connector.

For all other variations, please contact Ultran.

All transducers are furnished with acoustic characterization reports at no extra charge.

13. LAMBDA SERIES DELAYED CONTACT TRANSDUCERS: <2MHz to 20MHz.
Please see section 4.3 for λ-Series Acoustic Details



DIMENSIONS (mm)	TRANSDUCER ACTIVE DIAMETER (mm)					
	3.2	4.7	6.3	9.5	12.5	19.0
A*	22.0	22.0	22.0	24.0	37.0	40.0
B	6.3	9.5	9.5	12.5	16.0	23.8
*Approximate						

CATALOG NUMBER Replaceable Delay[1]	CATALOG NUMBER Fixed Delay[2]	FREQUENCY (MHz)	ACTIVE DIAMETER (mm)	ROUND-TRIP DELAY TIME (μs)
LRD50-2	LFD50-2	2.0	12.5	17
LRD75-2	LFD75-2		19.0	17
LRD25-5	LFD25-5	5.0	6.3	7
LRD37-5	LFD37-5		9.5	7
LRD50-5	LFD50-5		12.5	17
LRD25-10	LFD25-10	10.0	6.3	7
LRD37-10	LFD37-10		9.5	7
LRD18-15	LFD18-15	15.0	4.7	7
LRD12-20	LFD12-20	20.0	3.2	7

λ-SERIES DELAYED CONTACT TRANSDUCERS

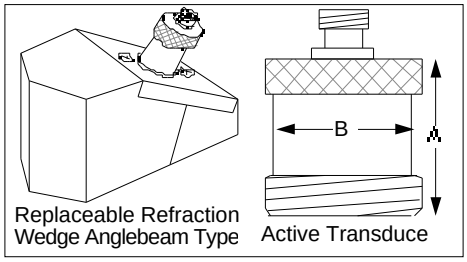
1. Replaceable delay types are offered with standard side microdot connector.

2. Fixed delay types are offered with a standard top microdot connector.

Please choose delay lines as described in section 9.1.

For other variations, please contact Ultran

14. LAMBDA ANGLEBEAM/SHEARWAVE TRANSDUCERS: 2MHz to 10MHz. Offered with screw-on replaceable refraction wedges. Please see section 4.3 for λ-Series Acoustics Details.



DIMENSIONS (mm)	TRANSDUCER ACTIVE DIAMETER (mm)			
	6.3	9.5	12.5	19.0
A*	14.3	14.3	17.8	20.0
B	9.5	12.5	16.0	23.8
*Approximate				

CATALOG NUMBER	FREQUENCY (MHz)	ACTIVE DIAMETER (mm)
LT50-2	2.0	12.5
LT75-2		19.0
LT25-5	5.0	6.3
LT37-5		9.5
LT50-5		12.5
LT25-10	10.0	6.3
LT37-10		9.5
LT50-10		19.0

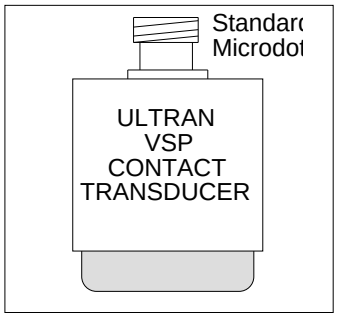
λ-SERIES ANGLEBEAM/ SHEARWAVE TRANSDUCERS

These are supplied with a top-mounted standard microdot co-axial connector.

Screw-on wedges can be ordered separately. Please see section 10.1

All transducers are furnished with acoustic characterization reports at no extra charge.

15. VERY SHORT PULSE TRANSDUCERS: 50ns, 25ns, and 10ns Pulse Widths. Featuring short, fixed acoustically transparent delay lines. Please see section 4.3 for VSP-Series Acoustic Details



The housing dimensions for VSP transducers are optimum, but vary as a function of the pulse width and active transducer diameter.

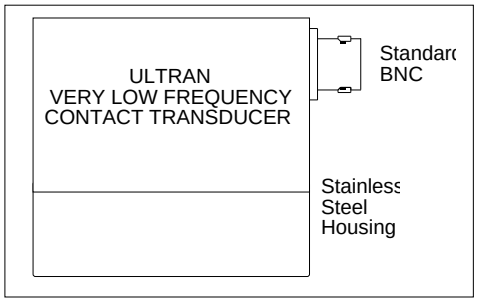
The housing is made of stainless steel.

These transducers are supplied with a top-mounted Microdot coaxial connector

All transducers are furnished with acoustic characterization reports at no extra charge.

CATALOG NUMBER	PULSE WIDTH (~ns)	FREQUENCY RANGE @ -6dB (~MHz)	ACTIVE DIAMETER (mm)	ROUND-TRIP DELAY TIME (μs)
VSP-50	50	5 to 30	4.5	6
VSP-25	25	15 to 70	4.5	4
VSP-10	10	30 to 125	3.2	4

16. VERY LOW FREQUENCY DIRECT CONTACT TRANSDUCERS (VLC): 50kHz to 250kHz. Featuring a hard protective face. Please see section 4.5 for VLF-Series Acoustic Details.



The housing dimensions of VLC transducers are optimum, but vary as a function of a transducer's frequency and active diameter.

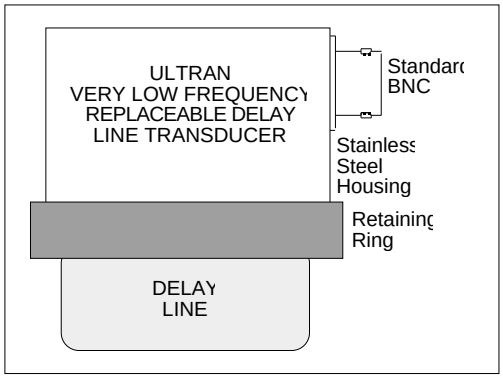
These transducers are supplied with a side-mounted standard BNC connector.

For all other variations, please contact Ultran.

All transducers are furnished with acoustic characterization reports at no extra charge.

CATALOG NUMBER	FREQUENCY (kHz)	ACTIVE DIAMETER (mm)
VLC100-0.05 VLC200-0.05	50	25 50
VLC100-0.1 VLC200-0.1	120	25 50
VLC100-0.15 VLC200-0.15	150	25 50
VLC100-0.2 VLC200-0.2	250	25 50

17. VERY LOW FREQUENCY DELAYED CONTACT TRANSDUCERS (VLR): 50kHz to 250kHz. Featuring replaceable delay line. Please see section 4.5 for VLF Acoustic Series Details.



The housing and delay length dimensions of VLR transducers are optimum, but vary as a function of the frequency and active transducer diameter.

These transducers come as kits containing the active transducer, standard delay line and the delay retaining ring.

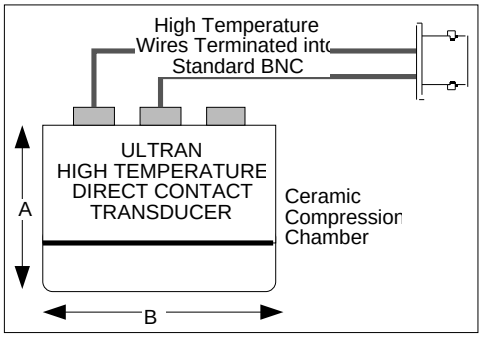
The housing is made of stainless steel.

These are supplied with a side-mounted BNC coaxial connector.

All transducers are furnished with acoustic characterization reports at no extra charge.

CATALOG NUMBER	FREQUENCY (kHz)	ACTIVE DIAMETER (mm)	ROUND-TRIP DELAY TIME (μs)
VLR100-0.05 VLR200-0.05	50	25 50	20
VLR100-0.1 VLR200-0.1	100	25 50	20
VLR100-0.15 VLR200-0.15	150	25 50	20
VLR100-0.2 VLR200-0.2	250	25 50	20

18. HIGH TEMPERATURE DIRECT CONTACT TRANSDUCERS (HTC, 300°C) from 500KHz to 5MHz. Featuring the patented compression-held piezoelectric assembly in a ceramic chamber. Please see section 4.6 for HT-Series Acoustic Details.



DIMENSIONS (mm)	TRANSDUCER ACTIVE DIAMETER (mm)	
	6.3	12.5
A	16.0	16.0
B	21.5	28.0

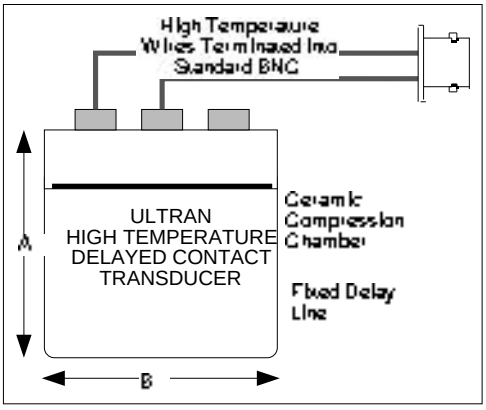
CATALOG NUMBER	FREQUENCY (MHz)	ACTIVE DIAMETER (mm)
HTC50-0.5	0.5	12.5
HTC50-1	1	12.5
HTC25-2 HTC50-2	2	6.3 12.5
HTC25-5	5	6.3

HIGH TEMPERATURE DIRECT CONTACT TRANSDUCERS

These transducers are supplied with special high temperature-resistant 2m wires terminated into a standard BNC connector.

They are tested at 250°C for continuous operation and furnished with acoustic characterization reports at no extra charge.

19. HIGH TEMPERATURE DELAYED CONTACT TRANSDUCERS (HTD, >600°C): 500kHz to 5MHz
Please see section 4.6 for HT-Series Acoustics Details.



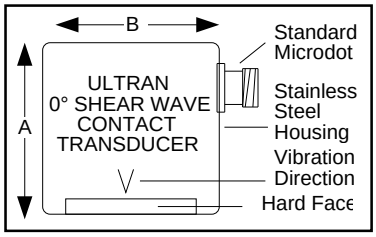
HIGH TEMPERATURE DELAYED CONTACT TRANSDUCERS

These are supplied with special high temperature-resistant 2m wires terminated into a standard BNC connector.

They are tested at 600°C for continuous operation and are furnished with acoustic characterization reports at no extra charge.

CATALOG NUMBER	FREQUENCY (MHz)	ACTIVE DIAMETER (mm)	ROUND-TRIP DELAY TIME (μs)
HTD50-0.5	0.5	12.5	12
HTD50-1	1.0	12.5	12
HTD25-2	2.0	6.3	12
HTD50-2		12.5	
HTD25-5	5.0	6.3	12

20. 0° SHEAR WAVE INCIDENT DIRECT CONTACT TRANSDUCERS: <500kHz to 10MHz
Please see section 4.7 for S-series Acoustics Details



DIMENSIONS (mm)	TRANSDUCER ACTIVE DIAMETER (mm)			
	6.3	9.5	12.5	19.0
A	12.7	12.7	16.0	16.0
B	9.7	13.5	17.8	25.0

CATALOG NUMBER	FREQUENCY (MHz)	ACTIVE DIAMETER (mm)
SWC50-0.5	0.5	12.5
SWC75-0.5		19.0
SWC50-1	1.0	12.5
SWC75-1		19.0
SWC25-2	2.0	6.3
SWC37-2		9.5
SWC50-2		12.5
SWC25-5	5.0	6.3
SWC37-5		9.5
SWC50-5		12.5
SWC25-10	10.0	6.3
SWC37-10		9.5

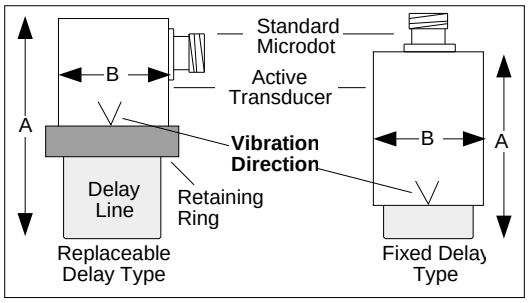
0° SHEAR WAVE DIRECT CONTACT TRANSDUCERS

These are supplied with a side-mounted standard microdot connector.

The shear wave vibration direction is in the horizontal plane and is marked on the housing.

All transducers are furnished with acoustic characterization reports at no extra charge.

21. 0° SHEAR WAVE INCIDENT DELAYED CONTACT TRANSDUCERS: <1MHZ TO 15MHZ. Please see section 4.7 for S-Series Acoustics Details



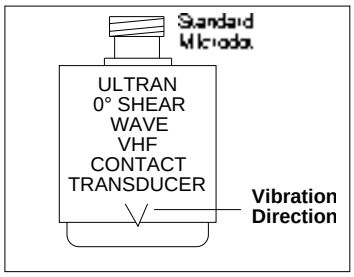
DIMENSIONS (mm)	TRANSDUCER ACTIVE DIAMETER (mm)			
	6.3	9.5	12.5	19.0
A*	22.0	24.0	37.0	40.0
B	9.5	12.5	16.0	23.8
*Approximate				

CATALOG NUMBER Replaceable Delay	CATALOG NUMBER Fixed Delay	FREQUENCY (MHz)	ACTIVE DIAMETER (mm)	ROUND-TRIP DELAY TIME (μs)
SRD50-1 SRD75-1	SFD50-1 SFD75-1	1.0	12.5 19.0	32 32
SRD25-2 SRD50-2	SFD25-2 SFD50-2	2.0	6.3 12.5	9 13
SRD25-5 SRD50-5	SFD25-5 SFD50-5	5.0	6.3 12.5	9 13
SRD25-10	SFD25-10	10.0	6.3	9

0° SHEAR WAVE INCIDENT DELAYED CONTACT TRANSDUCERS

The Replaceable delay type transducers are supplied with a side-mounted microdot co-axial connector.
The Fixed delay type transducers are supplied with a top-mounted microdot co-axial connector.
The Shear wave vibration direction is in the horizontal plane of the transducer and identified on the housing.
Please order replaceable delay lines separately as described in section 9.1
All transducers are furnished with acoustic characterization reports at no extra charge.

22. 0° SHEAR WAVE INCIDENT VERY HIGH FREQUENCY TRANSDUCERS: 20MHz to 100MHz Please see section 4.7 S-Series Acoustics Details.



The housing dimensions of these transducers are optimum, but vary as a function of the frequency and active diameter. They are furnished with short acoustically transparent fixed delay lines.

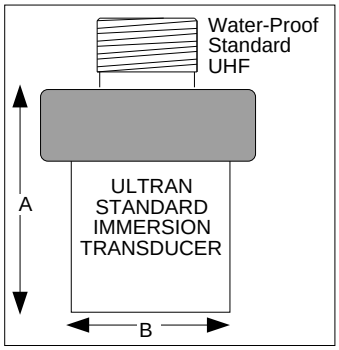
The housing is made of stainless steel.

The shear wave vibration direction is in the horizontal plane and is identified on the housing.

All transducers are furnished with acoustic characterization reports at no extra charge.

CATALOG NUMBER	FREQUENCY (MHz)	ACTIVE DIAMETER (mm)	ROUND-TRIP DELAY TIME (μs)
SFD18-20 SFD25-20	20.0	4.7 6.3	7
SFD12-25 SFD18-25	25.0	3.2 4.7	7
SFD12-50 SFD18-50	50.0	3.2 4.7	7
SFD12-100	100.0	3.2	4

23.STANDARD IMMERSION TRANSDUCERS: <500kHz to 25MHz. See sections 4.1 and 4.2 for Acoustic Series Details.



DIMENSIONS (mm)	TRANSDUCER ACTIVE DIAMETER (mm)						
	3.2	4.7	6.3	9.5	12.5	19.0	25.0
A	32.0	32.0	32.0	32.0	32.0	25.0	32.0
B	9.5	9.5	9.5	12.5	16.0	21.0	27.0

CATALOG NUMBER W-Series	**CATALOG NUMBER K-Series**	**CATALOG NUMBER Z-Series**	**FREQUENCY (MHz)**	**ACTIVE DIAMETER (mm)**
WS50-0.5	KS50-0.5	ZS50-0.5	0.5	12.5
WS75-0.5	KS75-0.5	ZS75-0.5		19.0
WS100-0.5	KS100-0.5	ZS100-0.5		25.0
WS50-1	KS50-1	ZS50-1	1.0	12.5
WS75-1	KS75-1	ZS75-1		19.0
WS100-1	KS100-1	ZS100-1		25.0
WS25-2	KS25-2	ZS25-2	2.0	6.3
WS37-2	KS37-2	ZS37-2		9.5
WS50-2	KS50-2	ZS50-2		12.5
WS75-2	KS75-2	ZS75-2		19.0
WS100-2	KS100-2	ZS100-2		25.0
WS25-5	KS25-5	ZS25-5	5	6.3
WS37-5	KS37-5	ZS37-5		9.5
WS50-5	KS50-5	ZS50-5		12.5
WS75-5	KS75-5	ZS75-5		19.0
WS100-5	KS100-5	ZS100-5		25.0
WS25-10	KS25-10	ZS25-10	10.0	6.3
WS37-10	KS37-10	ZS37-10		9.5
WS50-10	KS50-10	ZS50-10		12.5
WS75-10	KS75-10	ZS75-10		19.0
WS12-15	KS12-15		15	3.2
WS18-15	KS18-15			4.7
WS25-15	KS25-15			6.3
WS37-15	KS37-15			9.5
WS12-20	KS12-20		20	3.2
WS18-20	KS18-20			4.7
WS25-20	KS25-20			6.3
WS12-25			25	3.2
WS18-25				4.7

These transducers are supplied with a top-mounted WATER-PROOF STANDARD UHF co-axial connector.

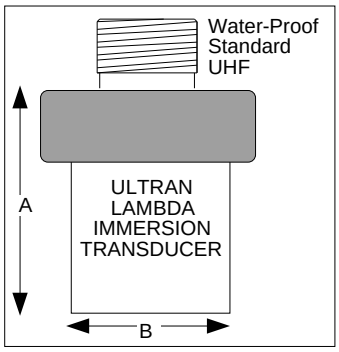
The above catalog numbers pertain to PLANAR beams. All transducers are also available with POINT or CYLINDRICAL FOCUS types. The available standard focal lengths in water are: 3.2, 4.5, 9.5, 12.5, 19, 25, 38, 51, 64, 76, 100, 125, 150, 200, 225, 250, 300, 400, 500, 600, and 1,000mm. If you need a focused transducer, simply identify the desired focus type and its value. For example, if you need the WS50-5 in a 76mm point focus, add the P76 suffix to create the WS50-5-P76. Similarly, if this transducer was desired in a cylindrical focus type, identify it as the WS50-5-C76.

All transducers are furnished with acoustic characterization reports at no extra charge.

For all other frequencies, dimensions, and focal types and lengths, please contact Ultran.

24. λ-SERIES IMMERSION TRANSDUCERS: <500kHz to 25MHz

Please see section 4.3 for λ-Series Acoustics Details



DIMENSIONS (mm)	TRANSDUCER ACTIVE DIAMETER (mm)						
	3.2	4.5	6.3	9.5	12.5	19.0	25.0
A	32.0	32.0	32.0	32.0	32.0	25.0	32.0
B	9.5	9.5	9.5	12.5	16.0	21.0	27.0

CATALOG NUMBER	FREQUENCY (MHz)	ACTIVE DIAMETER (mm)	FOCAL LENGTH/TYPE (mm)
LS100-0.5 LS100-0.5-P76	0.5	25	Planar P76
LS50-1 LS50-1-P76 LS75-1 LS75-1-P76 LS100-1 LS100-1-P100	1.0	12.5 19.0 25.0	Planar P76 Planar P76 Planar P100
LS50-2 LS50-2-P51 LS75-2 LS75-P76 LS100-2 LS100-2-P100	2.0	12.5 19.0 25.0	Planar P51 Planar P76 Planar P100
LS25-5 LS25-5-P25 LS37-5 LS37-5-P38 LS50-5 LS50-5-P51 LS50-5-P76	5.0	6.3 9.5 12.5	Planar P25 Planar P38 Planar P51 P76
LS25-10 LS25-10-P19 LS25-P25 LS37-10 LS37-10-P38 LS50-10 LS50-10-P100	10.0	6.3 9.5 12.5	Planar P19 P25 Planar P38 Planar P100
LS18-15 LS18-15-P12 LS18-15-P19 LS18-15-P25	15.0	4.7	Planar P12 P19 P25

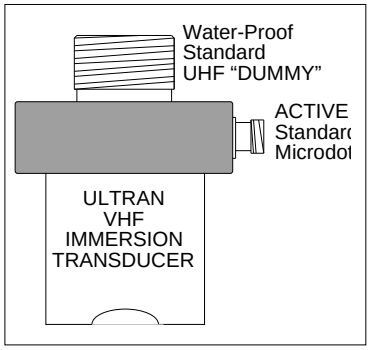
LAMBDA IMMERSION TRANSDUCERS

These are supplied with a top-mounted standard water-proof UHF co-axial connector.

All transducers are furnished with acoustic characterization reports at no extra charge.

For all other variations, please contact Ultran.

25. VERY HIGH FREQUENCY (VHF) FOCUSED IMMERSION TRANSDUCERS: 50MHz to 150MHz. Featuring acoustically transparent and optical quality clear fused silica glass delayed lens. Please see section 4.4 for VHF M-Series Acoustics Details.



All transducer dimensions are optimum, but vary as a function of the active diameter and the desired focal length.

These transducers are supplied with a top-mounted standard UHF "DUMMY" connector for mechanical fixturing. The ACTIVE connector is a side-mounted standard microdot. Both connectors are water-proof.

For all other variations, please contact Ultran.

All transducers are furnished with acoustic characterization reports at no extra charge.

CATALOG NUMBER	FREQUENCY (MHz)	FOCAL LENGTH (mm)	BEAM SIZE (mm)	ACTIVE DIAMETER (mm)	ROUND-TRIP DELAY TIME (μs)
MDS12-50-P6	50.0	6.3	0.06	3.2	10
MDS12-50-P12		12.5	0.12		
MDS18-50-P-6	50.0	6.3	0.04	4.5	10
MDS18-50-P12		12.5	0.08		
MDS25-50-P4	50.0	4.5	0.03	6.3	10
MDS25-50-P6		6.3	0.04		
MDS25-50-P12		12.5	0.06		
MDS25-50-P25		25.0	0.12		
MDS12-100-P2	100.0	2.5	0.01	3.2	5
MDS12-100-P3		3.2	0.015		
MDS12-100-P6		6.3	0.03		
MDS18-100-P4	100.0	4.5	0.015	4.5	5
MDS18-100-P6		6.3	0.02		
MDS18-100-P9		9.5	0.03		
MDS12-150-P2	150.0	2.5	0.008	3.2	5
MDS12-150-P3		3.2	0.01		

26. VERY LOW FREQUENCY (VLF) IMMERSION TRANSDUCERS: 50kHz to 250kHz
Please see section 4.5 for VLF Series Acoustics Details.

CATALOG NUMBER	FREQUENCY (kHz)	ACTIVE DIAMETER (mm)
VLS100-0.05	50	25
VLS150-0.05		38
VLS200-0.05		50
VLS100-0.1	125	25
VLS150-0.1		38
VLS200-0.1		50
VLS100-0.15	150	25
VLS150-0.15		38
VLS200-0.15		50
VLS100-0.2	250	25
VLS150-0.2		38
VLS200-0.2		50

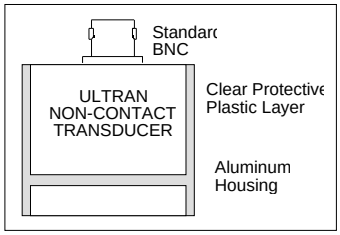
The housing dimensions of the VLS transducer are analogous to those of the standard immersion transducers. Their dimensions are optimum, but vary according to the desired frequency and the transducer active diameter.

These transducers are supplied with a top-mounted standard water-proof UHF co-axial connector.

They are also available in focused types. Please contact Ultran for any further questions.

All transducers are furnished with acoustic characterization reports at no extra charge.

27.NON-CONTACT TRANSDUCERS: <100kHz to 5MHz Please see section 4.8 for NCT Series Acoustics Details. For Systems and Applications Information, please see section 30.



DIMENSIONS (mm)	TRANSDUCER ACTIVE DIAMETER (mm)						
	3.2	6.3	12.5	19.0	25.0	38.0	50.0
A	27.0	27.0	27.0	27.0	27.0	~45	~45
B	10.0	13.5	21.0	27.0	34.0	46.0	58.0

CATALOG NUMBER	FREQUENCY (MHz)	ACTIVE DIAMETER (mm)
NCT-101	0.12	25.0
NCT-201		50.0
NCT-102	0.25	25.0
NCT-202		50.0
NCT-55	0.50	12.5
NCT-75		19.0
NCT-105		25.0
NCT-205		50.0
NCT-210	1.0	6.3
NCT-510		12.5
NCT-710		19.0
NCT1010		25.0
NCT-2010		50.0
NCT-220	2.0	6.3
NCT-520		12.5
NCT-720		19.0
NCT-1020		25.0
NCT-230	3.0	6.3
NCT-530		12.5
NCT-730		19.0
NCT-1030		25.0

NON-CONTACT TRANSDUCERS*

These are the newest addition to our long list of novel transducers. Non-Contact Transducers replace our 1983 AIR/GAS propagation transducers. The NCT are more than 20dB higher in sensitivity than our previous transducers of this type. Also the NCT are approximately 30dB lower in sensitivity when compared with the standard contact transducers. The combination of phenomenally high sensitivity and high frequency of our new transducers now make it practical to perform all applications where direct or liquid contact with the test materials is undesirable.

These transducers are also offered with our dedicated ultrasonic Non-Contact Analyzer, the NCA 1000 system. The NCA 1000 is suitable for thickness, time-of-flight, velocity or density, spectroscopy or microstructure, imaging and many other applications. This development supersedes all known “air-coupling” transducers and associated systems. For more details, see section 30. Any additional questions may be directed to Ultran.

For proximity, dimensional, distance/level and remote sensing applications our Non-Contact Transducers have no rival in the world! We will configure them to suit your needs. Please inquire about the details and the documented observations.

These transducers are supplied with a top-mounted standard BNC connector. Acoustic characterization reports are provided at no extra charge.

World-wide patents pending and in process.

28.SPECIAL APPLICATIONS AND TRANSDUCER PROTOTYPING

Ultran has helped a number of customers and researchers by providing solutions to problems through innovative transducer designs. Besides non-destructive materials evaluation, this also includes very high power and high frequency transducers for chemical reaction acceleration and for therapeutic and surgical applications. The list of our accomplishments is too large and beyond the scope of this publication. If you believe you have a problem that can be solved by ultrasound, please feel free to contact Ultran and consult with our materials and ultrasound experts. We will work with you in providing the simplest possible answer to your problem.

29.ACCESSORIES – CO-AXIAL CABLES

CATALOG NUMBER	DESCRIPTION
BB6-174	BNC-BNC, 2m RG174/u
BB6-58	BNC-BNC, 2m, RG58/u
BM6-174	BNC-MICRODOT, 2m, RG174/u
BU6-174	BNC-UHF, 2m, RG174/u
BU6-58	BNC-UHF, 2m. RG58/u
BL6-174	BNC-LEMO, 2m, RG174/u
ML6-174	MICRODOT-LEMO, 2m, RG174/u
BB6-HT	BNC-BNC, 2m, High Temperature

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Boalsburg, PA 16827 USA

phone: 1.814.466.2823
fax: 1.814.466.6847
email: noncontact@secondwavesystems.com
web: www.secondwavesystems.com

The NCA 1000 is the world's first and only high frequency non-contact non-destructive analyzer. Developed by VN Instruments of Canada, this system directly measures thickness, velocity, density, and defects in plastics, rubbers, tissues, composites, metals, ceramics, powders, green, sintered, and many other materials.

The NCA 1000 is a sophisticated tool for quality and process control in materials laboratories. It is also simple enough for on-line use. Calibration for any given application is a routine procedure for the NCA 1000. It is a production system performing successfully in the factories and laboratories of our customers.

The NCA 1000 is offered as a one channel (direct transmission mode) or as a four channel (direct transmission and reflection mode) system. All you need is a key-board and monitor.

Ideal solution for materials quality and process control

PARAMETERS MEASURED	MATERIAL INFORMATION	KEY SPECIFICATIONS
Time of Flight Thickness Velocity Attenuation Dispersion Phase relationships	Density Thickness Velocity Mechanical properties Microstructure Defect detection Internal & surface imaging Anisotropy, and more!	**NCA 1000** Dynamic range: >140dB Accuracy: ± 1ns (closed) and ± 50ns (open) **TRANSDUCERS** Sensitivity: Only 30dB below contact transducers Frequency range: <100kHz to >5MHz

Total freedom from touch or contamination

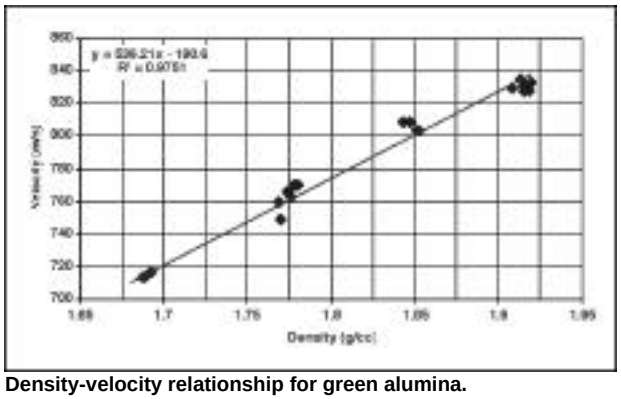
Digital output from the NCA 1000 is standard; the analog output module is available as an option. The NCA 1000 can be purchased with a horizontal or a vertical transducer alignment stage and a wide array of non-contact transducers from frequencies of <100kHz to >5MHz.

At the helm of the NCA 1000 are our phenomenally high transduction and broadband piezoelectric transducers. These devices, developed by Ultran Laboratories, are merely 30dB lower in sensitivity than the conventional contact transducers. This characteristic alone is being hailed as a great development in ultrasound.

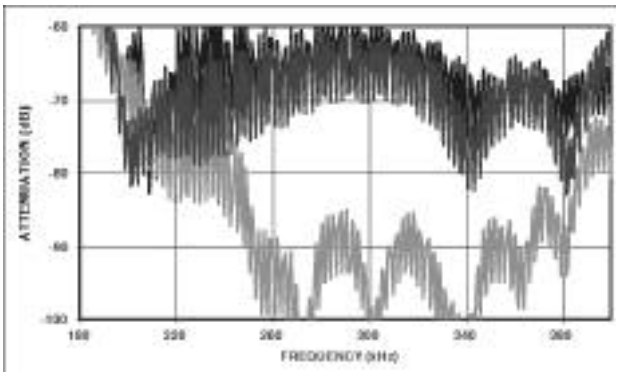
The NCA 1000, transducers, alignment stages, options, and accessories are marketed and supported by SecondWave Systems. This company uses the expertise of transducer, instrumentation, and application specialists with 50 combined years of experience. SecondWave personnel are ready to meet your testing and analysis needs in an efficient and cost-effective manner.

Please contact SecondWave for further information.

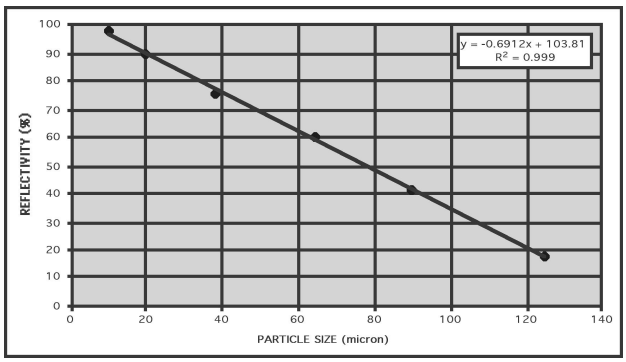
SELECTED NON-CONTACT ULTRASOUND APPLICATIONS



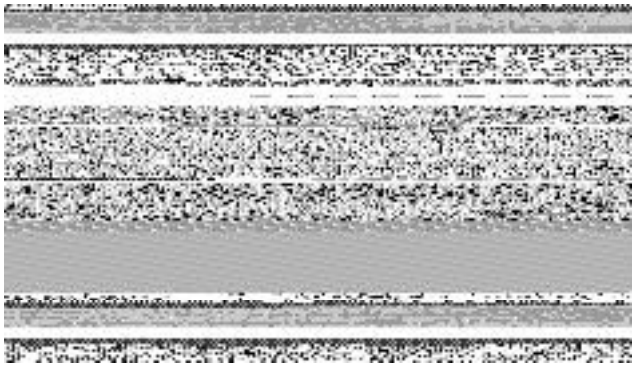
Density-velocity relationship for green alumina.



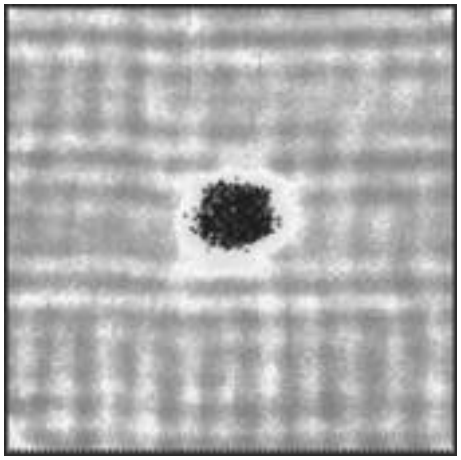
Transmission spectroscopy of extremely porous Material (Space Shuttle Tile). Top: 0.38g/cc, mid. 0.28g/cc, bot. 0.1g/cc.



Surface texture analysis.



Measurement of fat content in milk products with no contact to the container.



C-Scan image of an impact-damaged 6.4mm GFRP Composite.

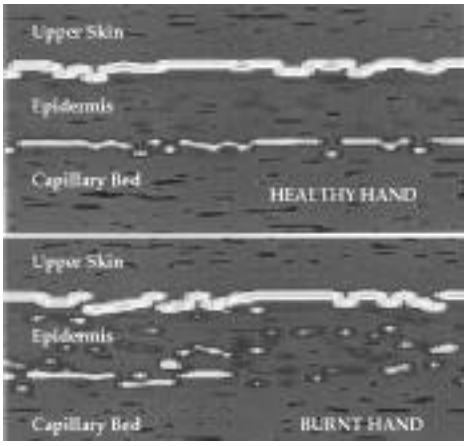


Image cross-sections of healthy and burnt human hands.

Please contact SecondWave for further information.

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