CONTENT

GENERAL CATALOG

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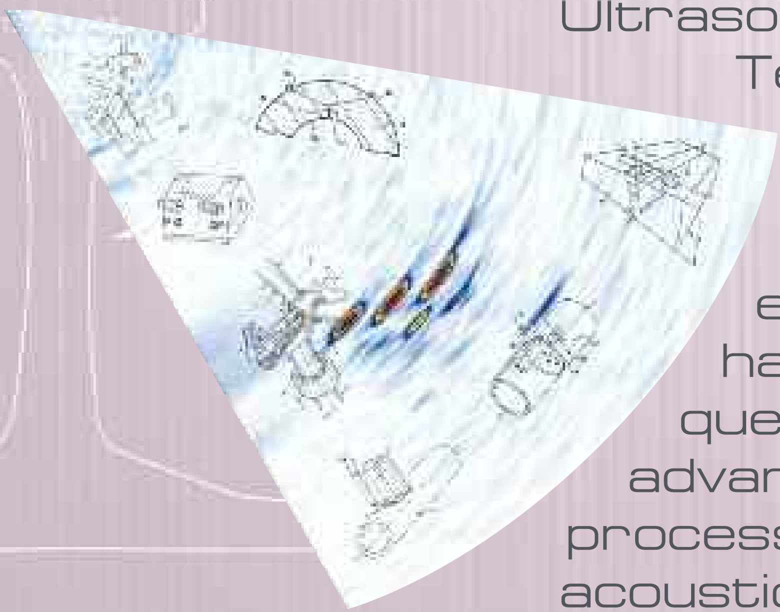
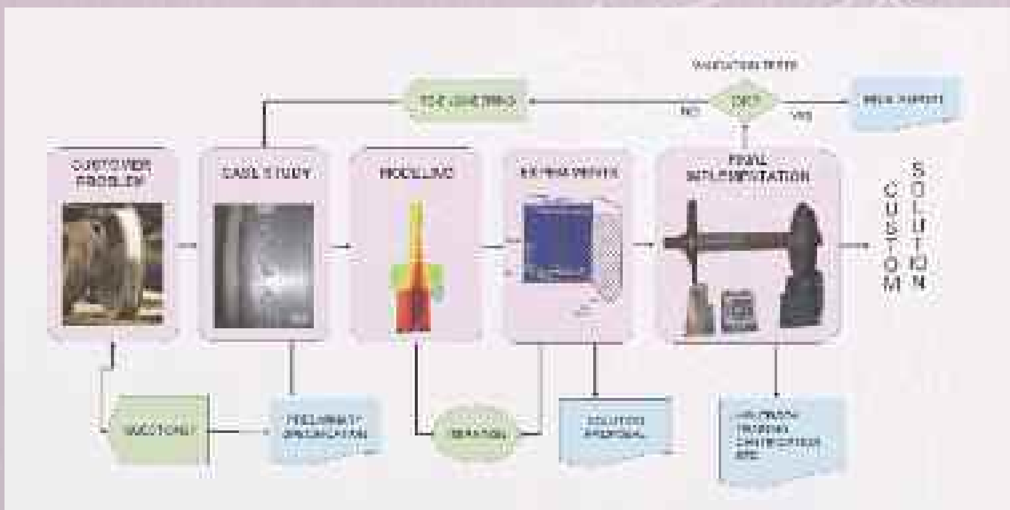
DASEL YOUR PARTNER IN PRODUCTIVITY & SAFETY



Ultrasonic Inspection Techniques are among the most commonly used for materials and components evaluation. Their use have become more frequent due to continuous advances in the processing and analysis of acoustic images.



Non Destructive Testing (**NDT**) has become an essential activity in certain industrial fields where the integrity of critical parts and components must be ensured, performing inspections during the manufacturing process as well as during the service. Nowadays, the customer is becoming increasingly aware of the profit he can get with a more versatile application instead of a closed solution. This is an important obstacle both for the large equipment manufacturers whose technology adaptation cost is high, and for the third party technology integrators that do not have the knowledge to properly modify the products.

Our choice is precisely the reverse: as we have all the knowledge about our technology and the capacity for its fast modification, **we can target a wide range of applications in a short period of time and at competitive prices.**

DASEL is a company specialized in the development of high-end ultrasound technology. We offer at the same time flexible solutions according to each customer requirements. Therefore the quality level of our products has the highest priority. Quality is a commitment that DASEL applies in all production areas to maintain traceability of its manufactured products. For this reason the company has been certified **ISO 9001:2008** by Bureau Veritas for equipments production and calibration.

ENGINEERING AT THE SERVICE OF ULTRASOUND SYSTEMS

Modular and Re-Configurable systems: The key to success in custom solutions.

DASEL develops all its products with a modular architecture and using high-density reconfigurable devices (**FPGAs**). Given the high cost for new hardware development, this design philosophy allows to adjust our systems to many different applications, with the incorporation of new functions or specific algorithms with no need to upgrade the equipment electronics.

PRODUCTS OVERVIEW

Dasel manufactures Conventional UT and Phased Array Systems. All our products include a set of innovative signal processing features, implemented in hardware for real-time operation.

Several of these algorithms are unique in ultrasound market, like Electromagnetic Interference Filter (**EMI**), Data Reduction without Peak Loss(**DRP**], the Grain Noise Reduction Filter (**GNR**) and autofocus phased array.

DASEL also offers a set of complete software applications (**ULTRAVIEW, SCANVIEW, TOFDVIEW, FOCALSIM**) and library functions for different programming environments as C++, LabView or MatLab, in order to ease the integration of our equipments into automatic inspection lines. Moreover, making use of these libraries, our systems become versatile and powerful ultrasound tools for scientific research.

Demonstrated ability to develop systems from a single channel to hundreds of channels

Conventional UT	Phased Array Systems	Multichanel
ULTRASCOPE USB	SITAU-MC series	DIFRASCOPE
ULTRAWOOD	SITAU-LF series	AIRSCOPE MX
AIRSCOPE TT	SITAU-FP series	MULTICHANNEL 32
ULTRASCOPE C	AIRSCOPE PA	
AMPLUS-32		

R&D ACTIVITIES

DASEL dedicates great effort in R&D with the objective of improving and adapting its products to the needs of its customers.

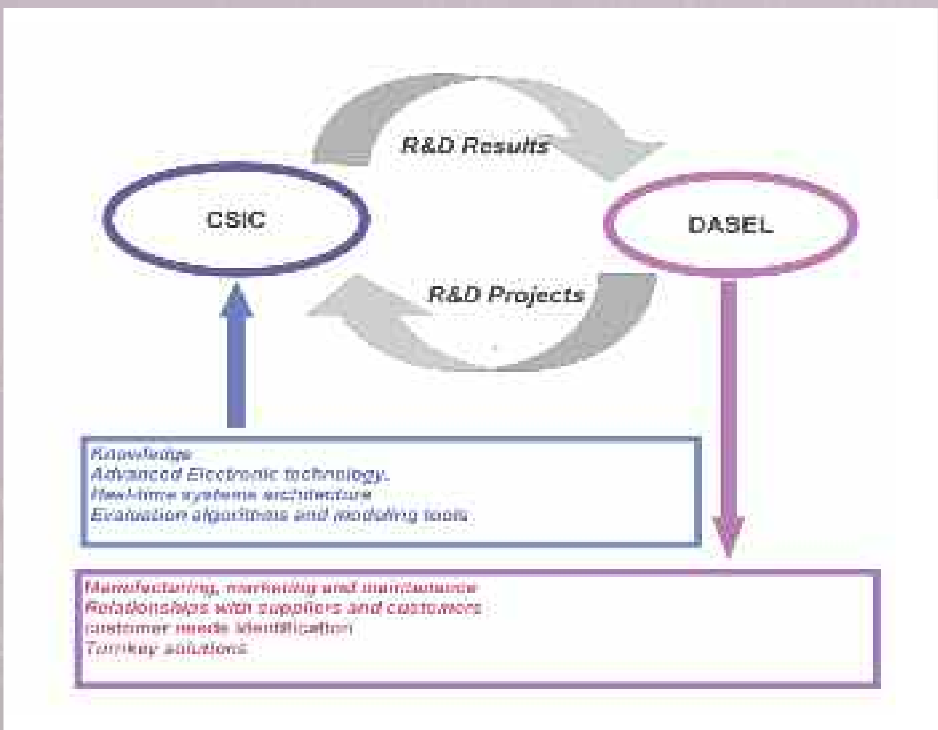
DASEL has a R&D department as well as a laboratory where the final assembly, the verification and the calibration of the manufactured systems is carried out. But most of the DASEL R&D needs are covered by research contracts agreed with the Spanish National Research Council (CSIC) and several Spanish Universities and Research Centers.

With these projects, DASEL receives the scientific knowledge and takes over the complementary tests of engineering, final product design, commercialization and maintenance.

On the other hand, the proximity of DASEL to the specific needs of its customers, together with the deep knowledge of the technology, opens new opportunities to start new projects, which are frequently undertaken in cooperation under R&D contracts.

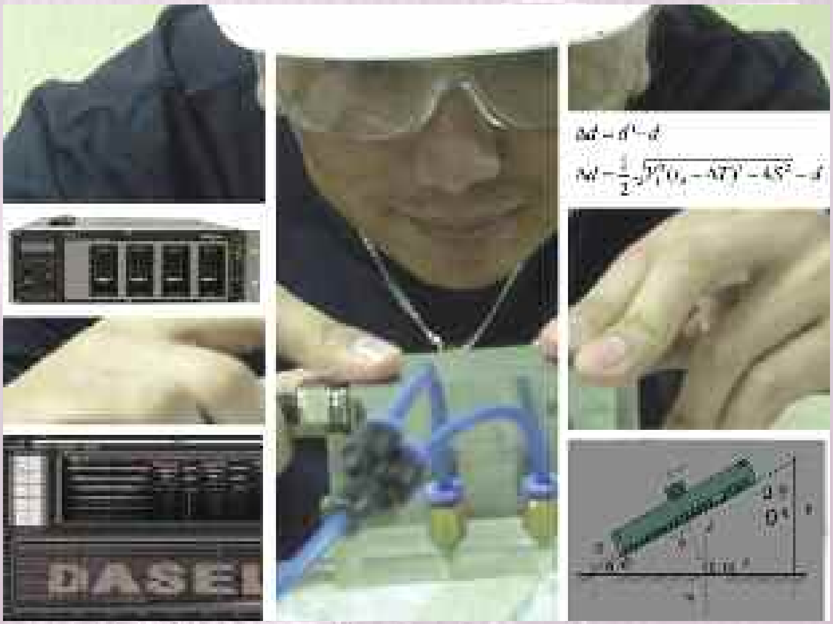
This way, the joint ultrasound skills of the CSIC and DASEL, has allowed to tackle many NDT problems from an innovative and original point of view. The result is the development of a high-performance technology with modular and reconfigurable design, which allows solving problems that stay out of the possibilities of competitors.

RESEARCH BACKGROUND



The consolidated relationship between CSIC and DASEL provides a permanent guarantee that will continue its research and innovation activities to get improved NDT systems and methods in the future, keeping the technology at the state-of-the art. This has been the pathway followed by the two institutions along their history.

ENGINEERING



Dasel has developed a flexible technology to provide their clients with tailored solutions according to their needs.

The engineering process usually starts with a feasibility study to check if the available ultrasonic techniques are able to obtain the desired results (resolution, repeatability, detectability, etc). Some times a deeper research work is required, which is accomplished by DASEL or CSIC depending of the project scope. In this last case, it is usual to formalize a specific R&D contract.

Once the feasibility study is finished, the design and manufacturing guidelines for the equipment are established. DASEL is proprietary of its ultrasound technology and has the knowledge to modify or redesign whatever part is needed, which is an important advantage over its direct competitors.

Some resarch works developed with DASEL equipments:

- J. Camacho, M. Parrilla, C. Fritsch “Phase Coherence Imaging” IEEE Transactions on Ultrasonics, Ferroelectrics and Frequency Control (TUFFC), 56, 5, 858-974, May 2009.

- J. Brizuela, A. Ibañez, C. Fritsch “NDE system for railway wheel inspection in a standard FPGA” Journal of Systems Architecture, Volume 56, Issue 11, November 2010, Pages 616–622.

- J. Ealo, J. Camacho, C. Fritsch “Airborne ultrasonic phased arrays using ferroelectrets: A new fabrication approach” IEEE Transactions on Ultrasonics, Ferroelectrics and Frequency Control (TUFFC), 56, 4, 818-858, April 2009.

- J. Villazón, A. Ibáñez, J. Camacho, J. Ealo “Evolutionary algorithms for optimal ferroelectret arrays design” 2009 IEEE International Ultrasonics Symposium,729-732, Rome, Italy, September 2009.

- M.Parrilla, P. Nevado, A. Ibáñez, J. Camacho, J. Brizuela, C. Fritsch “Ultrasonic imaging of solid railway wheels”, 2008 IEEE International Ultrasonics Symposium (IUS2009), 414-417, Beijing, China, 2008.

- J. Ealo, J. Camacho, F. Seco, C. Fritsch “Ultrasonic air-coupled inspection of textile materials using ferroelectret-based phased arrays”, 36th Annual Review of Progress in QNDE, Rhode Island, USA, 2009.

-Carlos J. Martín-Arguedas; David Romero-Laorden; Oscar Martínez-Graullera; Manuel Pérez-López; Luis Gómez-Ullate. An ultrasonic imaging system based on a new SAFT approach and a GPU beamformer.IEEE Trans on UFFC. Volume: 59 , Issue: 7.

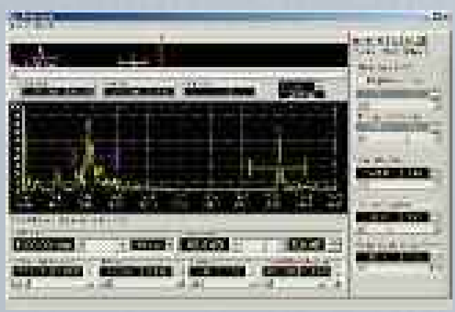
- B. Yelicich, J. Camacho y H. Gomez “Doppler transcraneal para monitoreo contínuo”, 7th Ibero-American Congress on sensors (Ibersensor 2010), Lisbon, Portugal, November 2010.

ULTRASCOPE USB

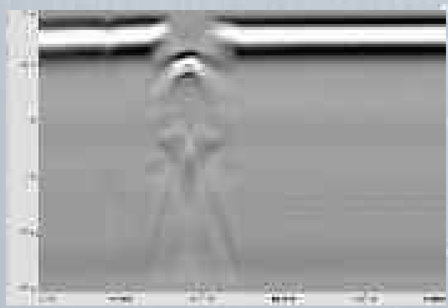
ULTRASCOPE USB, all the power of a high-end system in the palm of your hand.

Ultrascope USB is the single-channel ultrasound system with highest performance in its market range. Its easy to use and intuitive software (ULTRAVIEW) includes all the functionality (A-scan, B-scan ,C-scan, Peak detection,TGC,etc.) needed to take advantage of the equipment capabilities. The standard USB 2.0 connection along with its reduced size and height and a robust enclosure, make Ultrascope the ideal system for on field inspections. Furthermore, the possibility to control the equipment from several programming environments, makes it easy to customize and integrate in laboratory and industrial applications.

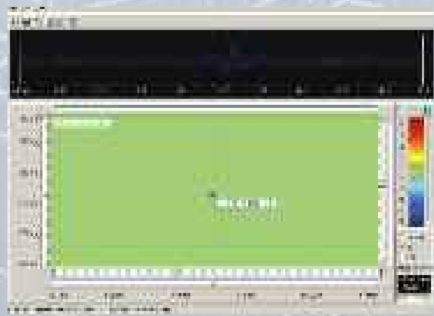
A-SCAN



TOFD



C-SCAN



ULTRAWOOD

ULTRAWOOD, moving forward beyond conventional applications.

ULTRAWOOD belongs to the ULTRASCOPE family and has been designed for the diagnosis of the structural condition of trees and processed woods. By using a non-destructive technique, the equipment is able to detect internal defects such as holes or cracks that disturb the sound propagation inside the sample. The system can work with both impact-induced waves or electrical excitation of a piezoelectric transducer. Unlike other equipments in the market that only gives the time-of-flight measurement, ULTRAWOOD can register the whole received signal (A-Scan) for being processed later, an essential feature for R&D in this field.

ULTRASCOPE C

Ultrascope C, the highest performance for low frequencies.

ULTRASCOPE C is a specialized equipment for **testing concrete** and is based on the Pulse –Echo and Through Transmission methods to detect cavities, cracks and other defects.

ULTRASCOPE C generates high energy pulses(> 4Kw) in the low frequency range and measures time of flight, echo amplitude and echo duration.

- Integral waveform display (A-scan, B-scan, C-scan)
- USB interface allows full remote control of all features.
- Direct data logging on the PC.
- Direct measurement: Ultrasonic Pulse Velocity, Poisson's Ratio, Modulus of Elasticity
- Wide range of transducers from 24 kHz up to 1000 kHz.

Meets the standards:

- ISO1920-7:2004 (International)
- EN12504-4 (Europe)
- ASTM C 597-02 (North America)
- BS 1881 Part 201 203 (UK)
- ASTM C 597
- ISO/DIS 8047

ULTRASCOPE - Technical features	USB	WOOD	C
Bandwidth	0.5MHz to 20MHz	10KHz to 500KHz	24KHz to 1MHz
Dynamic range	80 dB	80 dB	100 dB
Internal memory	1MB	1MB	1MB
Advanced signal processing	16 pulses (Max)	64 pulses (Max)	32 pulses (Max)
Tuned Squared Pulse	-20V to -400V	-20V to -400 V	-20V to -450 V
Encoder inputs	2		2
Synch output	1 (TTL)		1 (TTL)
External trigger input	1 (TTL)		
Alarm outputs	2 (TTL)		2 (TTL)
A/D Converter resolution	10 bits		
Software	UltraView	UltraWood	UltraC
Advanced signal processing	Programmable FIR, EMI filter, AVR		
Active protection	Yes		
Library of functions compatible with	C++, Visual Basic, LabVIEW®, MATLAB®		
Dimensions	150mm x 106mm x 38 mm.		
Weight	0.45 Kgrm		

DIFRASCOPE

Much more than a multi-channel TOFD system.

DIFRASCOPE is a high-end portable multi-channel system with superior processing capabilities. With up to 8 channels and 2 encoder inputs it can generate B and C-mode scans, improved with powerful post-processing algorithms like **SAFT** for better lateral resolution and **EMI** filter to suppress electromagnetic interference. **DIFRASCOPE** is an excellent choice for automated inspection of weldings simultaneously applying **TOFD**, pulse-echo and pitch-catch. Its intuitive and highly configurable software allows to tailor different applications quickly and to easily integrate the equipment into the industrial field or laboratory environments.

Difrascope - Technical features	
Number of channels	Configurable 2–32 chls.
A/D Converter resolution	12/14 bits
Sampling frequency	6,25 Ms/s to 100 Ms/s
Bandwidth (-3 dB)	0,5 MHz to 30 MHz
Internal memory for scans storage	48 MB
Connectivity	Ethernet (100 Mbit)
Digital signal processing, hardware implemented	SAFT(improves lateral resolution). Hyperbolic cursors, FIR, EMI-filter, Averaging, Envelope detector. Data compressor, Auto report capabilities
Gain dynamic range	100 dB
Time-gain compensation (TGC)	Yes
Signal-to-noise ratio	≤70 dB
Active protection	Yes
Tuned Squared Pulser	-20 V to -400 V
PC interface	Ethernet, Wi-Fi
Library of functions compatible with	C++, Visual Basic, LabVIEW®, MATLAB®
Software Program	TOFDView
Bateries life (case option)	+10 hrs
Case model	Compact Case & Peli Case model 1400NF (IP66)
Complies with	ASME Code Case 2235 BS 7706: 1993 EN583-5: 2001

Multi channel solution based on phased array technology

MULTI CHANNEL SOLUTION

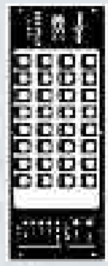
DASEL provides modular systems with up to 32 channels specifically designed for the **automated inspection of large structures** (tubes, shafts, large CFRP components, etc). While maintaining the performance of a high-end equipment, its modular architecture allows to easily address your actual requirements and also foresee future upgrades at lower cost. Its 4 parallel channels allows to increase inspection speed by using multiple-head systems. Integration with the inspection line is warranted by a complete set of software libraries (C++, Labview, etc.) and DASEL personalized support.

Standard models

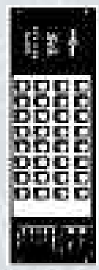
Model	Parallel channels	Multiplexed channels	Case option	Others
STM-132-63D-00	1	32	Desktop rack. 3U - 63HP	
STM-132-84R-PC-00	1	32	Industrial Rack for Cabinet mount 3U –84HP	Industrial Rack - On-board PC
STM-132-PRT-00	1	32	Rugged and Portable Case	Portable system Batteries and Tablet PC
STM-216-63D-00	2	16	Desktop rack 3U - 63HP	
STM-216-84R-PC-00	2	16	Industrial Rack for Cabinet mount 3U –84HP	Industrial Rack - On-board PC
STM-232-63D-00	2	32	Desktop rack 3U - 63HP	
STM-232-84R-PC-00	2	32	Industrial Rack for Cabinet mount 3U –84HP	Industrial Rack - On-board PC
STM-416-63D-00	4	16	Desktop rack 3U - 63HP	
STM-416-84R-PC-00	4	16	Industrial Rack for Cabinet mount 3U –84HP	Industrial Rack - On-board PC
STM-432-63D-00	4	32	Desktop rack 3U - 63HP	
STM-432-84R-PC-00	4	32	Industrial Rack for Cabinet mount 3U –84HP	Industrial Rack - On-board PC

Frontpanels case option

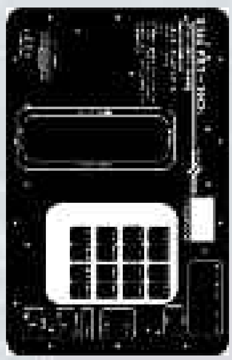
CASE 63D



CASE 84R



CASE PRT



Mean technical features

Exitation pulse	Programmable width	50 ns to 1.6 us, resolution of 6.25 ns
	Programmable amplitude	From -20 V to -190 V
Excitation modes		Single, Burst and Coded Excitation
A/D Converter resolution		12 bits
Maximum pulse repetition frequency		20 KHz
Bandwidth	OPT Standard	0.8 MHz to 16 MHz
	OPT LF (Low Frequency)	30 KHz to 2 MHz
Digital signal processing, hardware implemented		FIR filter, EMI filter, Envelope Detector, Non-peak-loss Data Reductor
Gain dynamic range		100 dB
Auxiliary inputs-outputs		4 Encoder inputs, External Trigger input and Synchronism output
Library of functions compatible with		MATLAB, LabVIEW, C++,Python,Visual Basic

AMPLUS-32

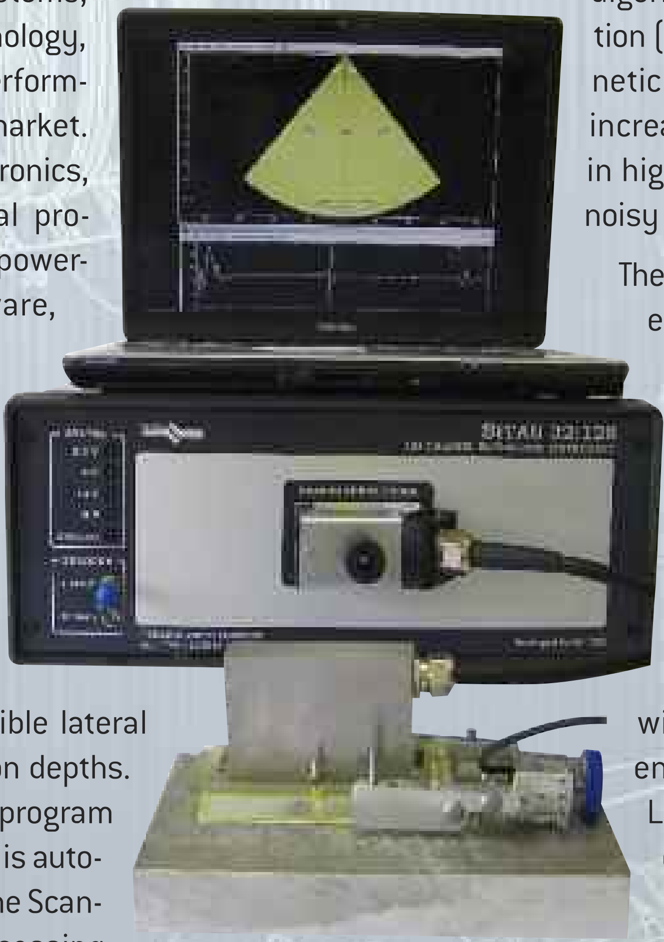
AMPLUS-32 is a broadband pre-amplifier fully compatible with ULTRASCOPE / DIFRASCOPE technology and capable to improve signal-to-noise ratio in the most adverse inspection environments.

ULTRASCOPE / **DIFRASCOPE** technologies provides a configurable gain up to 80 dB, which is usually enough for most common applications. However, for some techniques like **TOFD** higher gains are required, and cables up to 10 meter length are used. In those scenarios, **AMPLUS-32** improves signal-to-noise ratio adding up to **32 dB** of extra gain very close to the transducer. Its low size and weight and its internal battery make AMPLUS-32 the best option to mount on-board the inspection head. Furthermore, it is a valuable tool for laboratory tests with ultrasound transducers and hydrophones.

Amplus 32 - Technical features	TOFD	LF
Power supply sources	6 to 20 VDC adapter, 9V Battery, Self-powered	
Compatible with TOFD transducer	Krautkramer, Sonatest, Imasonic, Olympus	
Bandwidth	0.4 to 30MHz	0.05 to 1MHz
Power consumption	< 20 mA	
Input over voltage protection	≤ 500V (Max.)	
Gain	20 dB/ 32 dB	
Input impedance (f= 5 MHz/0.5MHz)	50 Ohm	50 Ohm
Output Noise (RS = RL = 50)	0.2 mVrms	0.15 mVrms
Signal-to-noise ratio	≤60dB	≤70dB
Maximum input signal (linear range)	70 mVpp	100 mVpp
Maximum output signal	2 Vpp	
Dimensions	88x56x26mm	
Weight	200 grs.	

PHASED ARRAY SYSTEMS

Phased Array systems, by using several transducer elements, are capable of obtaining real-time images.



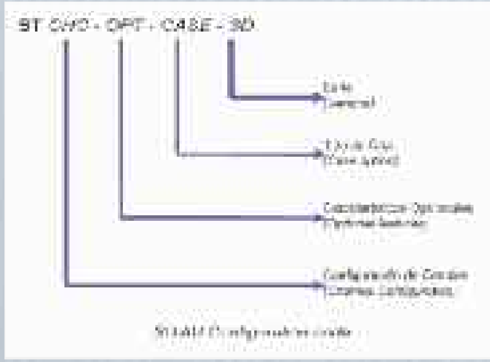
Our phased array systems, based on the **SITAU** technology, are among the highest performance equipments in the market. Their high resolution electronics, along with unique signal processing algorithms and powerful evaluation software, allows obtaining high quality images in any inspection condition.

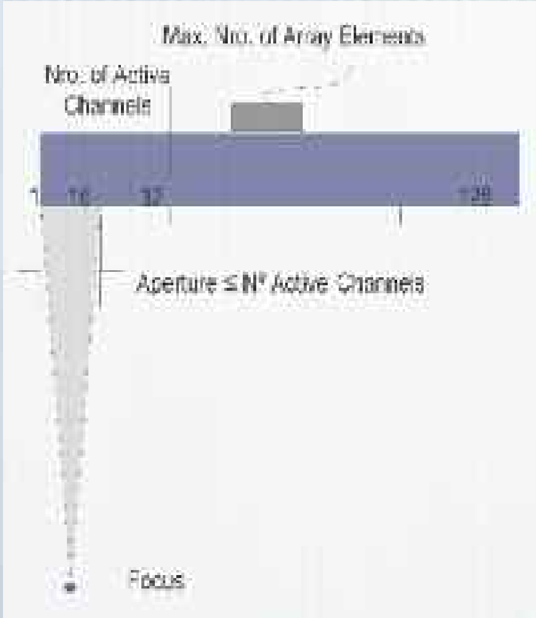
SITAU equipments are the only ones that integrate the **Progressive Focal Correction Technique** (**ProFoc**), achieving the best possible lateral resolution at all inspection depths. It also avoids the user to program the focus position, as this is automatically carried out by the ScanView software. Other processing algorithms such as Coded Excitation (**CoDex**), and the Electromagnetic Interference Filter (**EMI**) increase the signal-to-noise ratio in highly attenuating materials or noisy environments.

The **ScanView** software allows to easily program all the inspection parameters while being a powerful acquisition and defect evaluation tool. To easily integrate SITAU systems in automated inspection machines, **DASEL** provides a full set of software libraries compatible with most used development environments, such as C++, LabView, Python, Visual Basic or Matlab.

SITAU SERIES SELECTION GUIDE

SITAU, the phased-array solution that better fits your needs.





SITAU phased array technology offers you the flexibility of a custom-made system at a very competitive price. The number of active channels and encoder inputs, and the type of connector and case are some of the configurable parameters to better adapt the equipment to your inspection requirements. Some special featured models are: **MC** (with conventional channels), **LF** (for low frequency), **PC** (with embedded computer) and **TR** (with pitch-catch connector).

CHC	Channel Configuration		
Code	Number of Active Channels	Maximum Number of Array Elements	Number of Array Connectors
331	32	32	1
332	32	32	2
334	32	32	4
311	32	128	1
312	32	128	2
661	64	64	1
991	96	96	1
111	128	128	1
OPT	**Optional Features**		
LF	Adapted to operate with low frequency arrays		
TR	With array connector for Trough-Transmission or Pitch-Catch mode		
PC	With on-board Computer		
MCXX	Multi-channel (XX: Multiplexed channels number)		
CASE	**Case Option**		
63D	Desktop Rack 3U - 63HP		
84D	Desktop Rack 3U - 84HP		
84R	Industrial Rack for Cabinet mount 3U – 84HP		
PRT	Rugged and Portable Case (with batteries and touch-screen tablet PC)		
STP	**Customization Code**		
00	Standard Equipment		
others	Customized Equipment		
Connector Type			

SITAU TECHNICAL SPECIFICATIONS

DASEL offers four standard types of cases for the SITAU systems in all versions (MC, LF and PF) to fulfil your application requirements. Moreover, their modular architecture allows us to design custom-made cases under customer request.

TECHNICAL FEATURES OF SITAU SYSTEMS		
Excitation type	Negative square wave pulse	
Excitation voltage	[OPT ≠ MC]	100 V
	[OPT = MC]	Phased Array : 100 V
		Multi-channel : Programmable from 20 V to 190 V
Pulse width	[OPT ≠ LF]	Programmable from 50 ns to 1.6 us, with a resolution of 6.25 ns
	[OPT = LF]	Programmable from 50 ns to 25.5 us, with a resolution of 25 ns
Pulse repetition frequency (PRF)	≤ 20 kHz	
Burst mode	≤ 256 consecutive pulses	
Coded excitation	Programmable codes of 16 bits length	
RECEIVER AMPLIFIER		
Amplifier type	Wide-band and low-noise amplifier	
Gain	Programmable: 0 to 100 dB	
CAT (TGC)	Arbitrary Time-Gain-Compensation curve (2048 points)	
Bandwidth (-3 dB)	[OPT ≠ LF]	0.8 MHz to 16 MHz
	[OPT = LF]	30 KHz to 2 MHz
Anti-aliasing filter	[OPT ≠ LF]	Low-pass, fC = 16 MHz
	[OPT = LF]	Low-pass, fC = 2 MHz
Equivalent input noise	[OPT ≠ LF]	3.5 μV rms
	[OPT = LF]	1.1 μV rms
Input protection circuit	Low resistance MOSFET active circuit	
A/D Converter		
Resolution	12 bits	
Sampling frequency	40 MHz	
Hardware interpolation	160 MHz (Lagrange filter bank).	
Acquisition depth	Phased-Array	Programmable up to 20.000 samples per scan line.
	Parallel Acquisition	Programmable up to 4.096 samples per array element.
Beamformer		
Focusing delays	Programmable for each channel (up to 409μs, resolution of 6.25 ns). Independent for emission & reception.	
Real Time Dynamic Focusing	Focus at every image sample (hardware implemented).	
Focusing technique	Progressive Focal Law Correction (PFLC) with Lagrange interpolation.	
Delay resolution	± 3.125 ns -> timing resolution equivalent to 160 MHz.	
Dynamic aperture	Programmable per channel and scan line.	
Trigger modes		
Trigger modes by model	[CASE = 63D, 84D, 84R, PRT]	Software Trigger.
	[CASE = 63D, 84D, 84R, PRT]	Encoder Trigger.
	[CASE = 63D y 84D]	Ext. Input Signal Trigger.
Signal processing		
Signal processing features	Real-time signal processing of acquired scan lines (Hardware Implemented)	
Digital Filter	Band-Pass filter with programmable cutoff frequencies 63 coefficients FIR implementation).	
Envelope detection	Digital, implemented by Hilbert Transform	
Scan compression	Non-Peak-Loss compression algorithm, up to 128:1 compression rate	
Acquisition modes (GMR and Autofocus)	A-scan, B-scan, peak position and amplitude (gates), encoders count	
Other specifications		
Power consumption	[CHC = 311, 312, 331, 332, 334]	58 W
	[CHC = 661]	95 W
	[CHC = 991]	132 W
	[CHC = 111]	166 W
Power supply	100- 220 Volt 47- 63 Hz , Fusible 3 A.	
Batteries	[CASE = PRT]	2 lithium batteries of 6.6Ah each one.
Dimensions	[CASE = 63D]	360 x 150 x 390 mm
	[CASE = 84D]	470 x 150 x 450 mm
	[CASE = 84R]	480 x 130 x 420 mm
	[CASE = PRT]	490 x 230 x 400 mm
Approximately Weight	[CASE = 63D]	7.5 Kg
	[CASE = 84D]	8.5 Kg
	[CASE = 84R]	9.2 Kg
	[CASE = PRT]	4.5 Kg

GNR FILTER: SEE BEYOND STRUCTURAL NOISE

NO MATTER GRAIN NOISE PRESENT ON THE MATERIAL

GNR filter*: included in all SITAU models, reduces grain noise and improves flaw detection by increasing the signal to noise ratio.

GNR filter is an advanced image processing technique that reduces **grain noise** while preserving flaw indications:

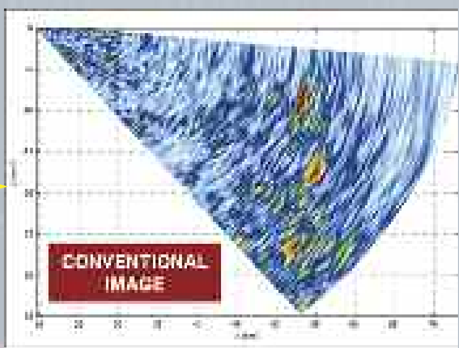
- Real time: no PRF reduction.
- Simple operation: no user defined parameters.
- Reliable: no missed defects.
- Specially designed for Fiberglass or Carbonfiber reinforced parts inspections and austenitic steel welds and parts.

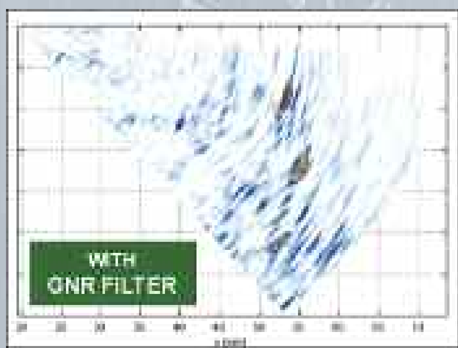
A valuable tool for most applications.

- Stainless steel welding inspections.
- Wind-blades **GFRP** inspections.
- Aerospace **CFRF** testing.

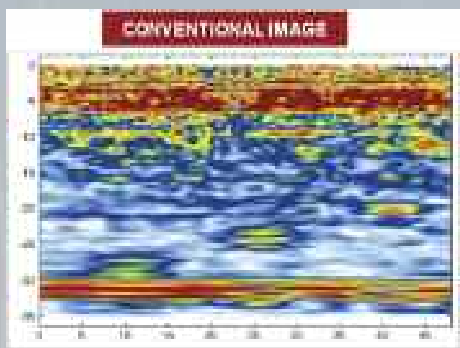
GNR filter feature:

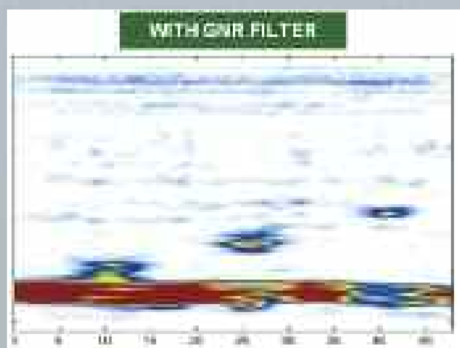
- Reduces grain noise.
- Improves contrast.
- Improves spatial resolution.
- Suppress grating lobes indications






Wind Mill Blade Sample





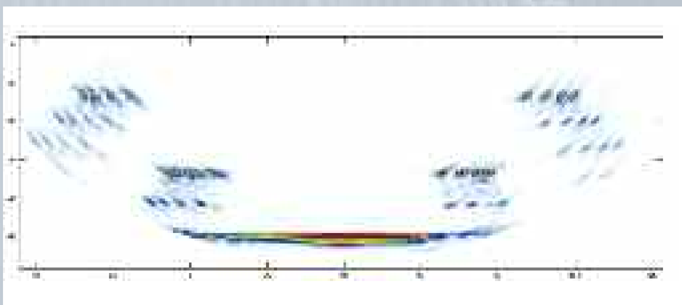
*GNR Filter is based on the patent "Phase Coherence Imaging Technique" (PCT/ES09/070303)

AUTOFOCUS: GET THE BEST IMAGE QUALITY WITH A SINGLE CLICK... NO MATTER HOW COMPLEX THE GEOMETRY IS

A fully automated process detects the surface profile of the part, calculates the focal laws and programs the equipment to get the best possible image. No matter how complex the geometry is, **Auto-Focusing** will set-up all parameters for you.

It not only saves you time, but also allows you to face challenging inspections where the part geometry is not accurately known or changes during the scan.

Auto-focusing algorithm, included in all SITAU models, simplifies the process of setting-up a phased-array inspection.



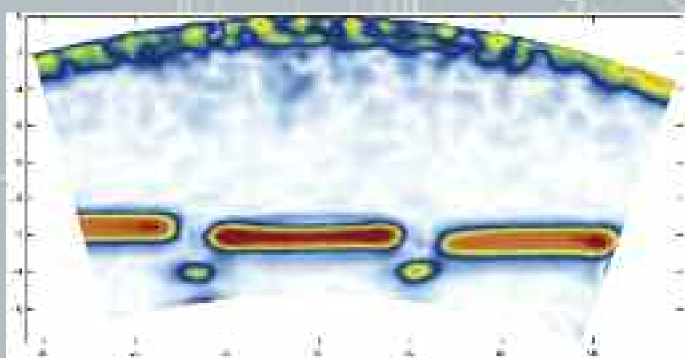
Auto-focusing is a fully automated 2-step process, carried out in less than 1 second:

1 - Part geometry detection: Using a few emission events, the geometry of the part is detected and estimated.

2 - Focal-Law calculation: With our patented Virtual-Array method, dynamic focal laws are calculated for the whole image, giving the best resolution at all depths.

Typical applications:

- Water-tank immersion inspections.
- Irregular surface parts.
- Custom-developed wedges.
- Automated inspection of shape varying components.



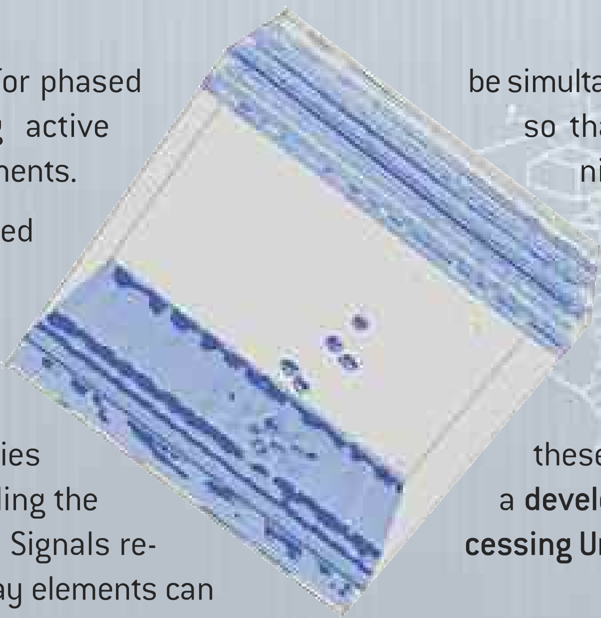
FULL PARALLEL PHASED ARRAY

SITAU FP (Full Parallel)

Undoubtedly the most advanced technology of the SITAU series, allowing simultaneous control of up to 1024 ultrasound channels

This is the ideal solution for phased array inspections requiring active apertures larger than 128 elements.

SITAU FP, along with provided Matlab, LabVIEW, C++, etc. libraries which can be interfaced with **GPU platforms; SITAU FP** becomes a powerful tool for Ultrasound Laboratories and **Research Centres**, providing the maximum possible flexibility. Signals received by each one of the array elements can be simultaneously acquired and stored, so that Synthetic Aperture Techniques (**SAFT**), Full matrix capture (**FMC**), total focusing method (**TFM**), Sampled Phased array, can be implemented.



For the implementation of these techniques, DASEL provides a **development kit for Graphics Processing Units (GPU) programming.**

Full Parallel Systems (SITAU FP)				
Model	Active Channels	Array Elements	Array Connectors	Others
STP1-84	128	128	1 pulse-echo	8 Encoders input Sinc Out Trigger In
STP2-84	256	256	2 pulse-echo	
STP3-84	384	384	3 pulse-echo	
STP4-84	512	512	4 pulse-echo	
STP5-84	1.024	1.024	8 pulse-echo	
STPX-84	Customizable	Customizable	X pulse-echo	

All SITAU FP models are also available for Low Frequency Arrays, see LF model features.

GPU DEVELOPMENT KIT

Complete your SITAU Phased-Array system with the power of GPU's.

SITAU GPUs package was developed for interfacing DASEL's technology with this powerful processing hardware using **PyOpenCL**, the most extended multi-platform programming language. Acquired data can be easily handled and plotted using Python packages, such as, Scipy, Numpy, etc.

SITAU Python's package also includes innovative procedures for **3D reconstruction** at high frame rates. This novel 3D imaging modality combines two techniques: Phased Array (PA) and Synthetic Aperture Focusing (SAFT), to get an accurate representation and quantification of flaws. The method uses conventional linear PA probes and a mechanical scanning to inspect the whole volume of the component with high resolution in all axes.

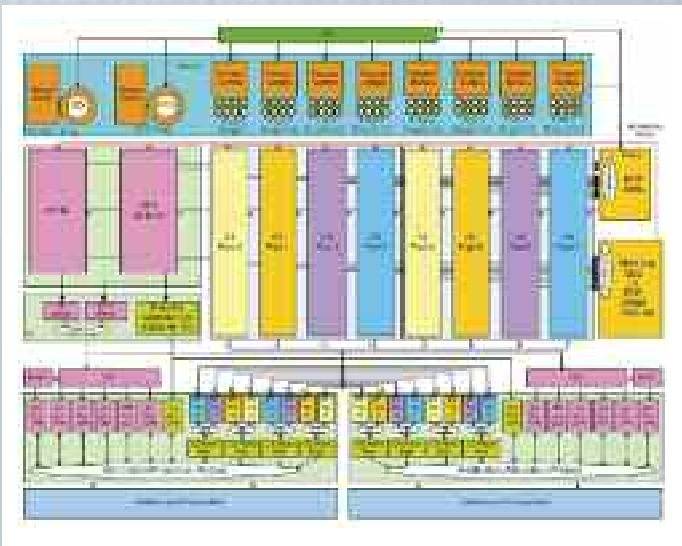
On SITAU Python's package you will find a complete set of example functions for ultrasonic imaging. These functions were used to obtain the 3D image of a "spring" showed on the right:

- Ultrasonic data was captured on SITAU-111-84D Full Parallel Phased Array system with 128 active channels using a Python script.

- Image reconstruction was performed on a GPU platform using PyOpenCL.

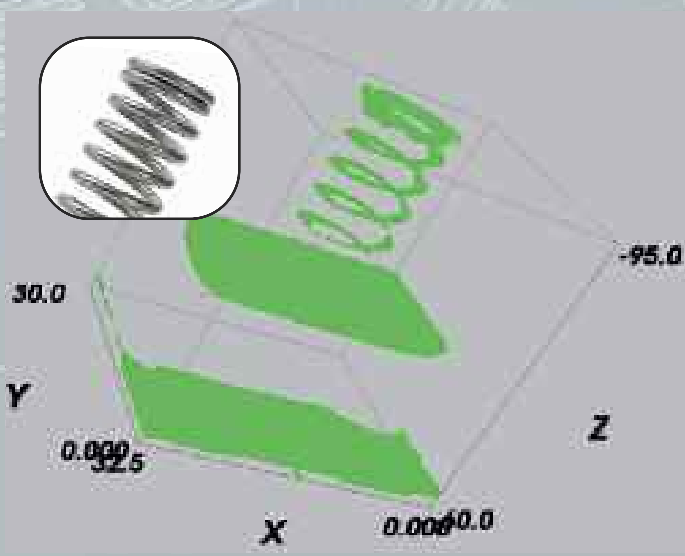
- Visualization was carried out on Mavayi embedded on Python.

You can use any Python IDE for Eclipse if you are familiarized with these tools and keep your project organized. These tools also provide many other features for authoring, modifying, compiling, deploying and debugging your software.



3D algorithms technical features

- Easy integration on your Python code
- Flexible hardware platform selection (CPU or GPU).
- 3D algorithm tested at 6 frames of 97x1860 pixels per second.



AIRSCOPE SOLUTIONS

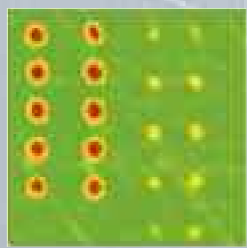
Main applications:
- Air-coupled NDT
- Positioning systems,
- Acoustic Vision
- Lamb waves
- Structural Health Monitoring.

AIRSCOPE - Technical features	
Bandwidth	30KHz to 1MHz
Dynamic range	80 dB
Tuned Squared Pulse	-20V to -800 V
Encoder inputs/trigger input	Yes
Advanced signal processing	EMI, AVR, FIR, etc
Airscope TT	1 channel
Airscope MX	Up to 8 channels
Airscope PA	Up to 64 channels

Available models:

- Airscope TT (Monochannel)
- Airscope MX (Multichannel)
- Airscope PA (Phased Array)

Main Applications
- Composites
- Plastics, Rubber & Foam
- Wood
- Aluminum

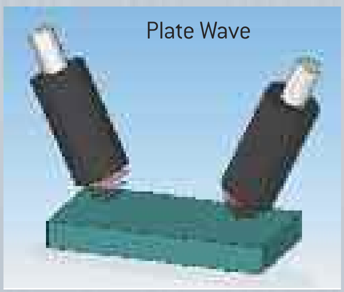


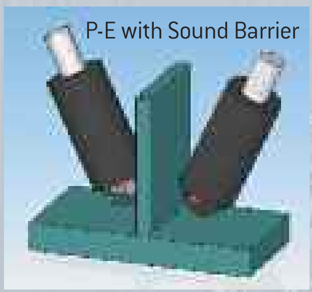
AIR-COUPLED TRANSDUCERS

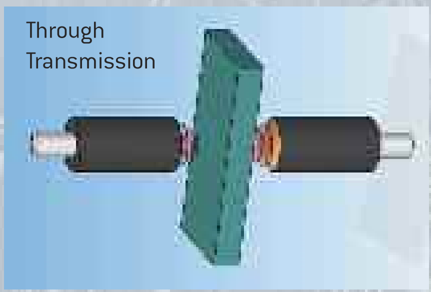
The air-coupled ultrasonic technique has shown to be very efficient and fast for the testing of large areas. The air-coupled technique avoids coupling problems like bubbles in water, but the large acoustic mismatch between solids and air must be solved with special transducers, a powerful excitation as well as hardware and software signal processing.

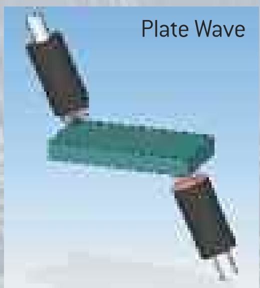
Features:

- Connectors: BNC / SMB / Lemo00.
- Housing: anodized aluminum.
- Electric Matching with Airscope series
- Crown to protect the radiant surface
- Each pair of transducers is identical and can be used without distinction as a sender or receiver. All transducers can also work in pulse-echo mode.
- Compatibility: The transducers have been successfully tested with DASEL devices (Airscope TT/MX/PA).



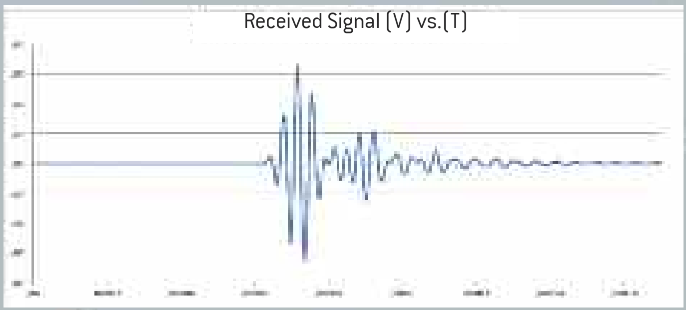


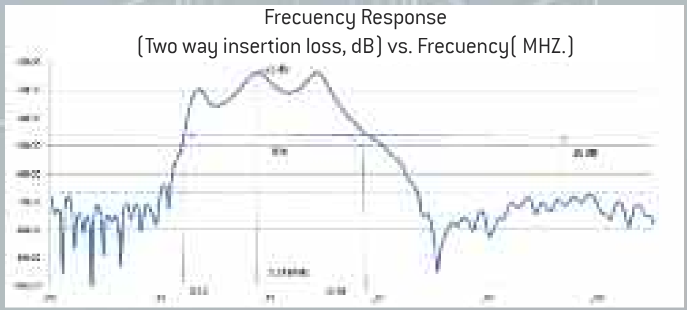




Transducers: planes, untargeted, piston radiation				
Transducer	Center Frequency (MHZ)	Active Diameter[mm]	Band Width (%)*	Focussed and Unfocussed
DS-25-D	0.25	25 / 50 / 100	65	NO / YES
DS-40	0.40	25 / 100	60	NO
DS-100	1	25	60	YES / YES
DS-XXX	Customizable	Customizable	Customizable	Customizable

* Tolerance: 5%





QUICK PRODUCTS GUIDE

MONOCHANNEL

STANDARD

ULTRASCOPE USB — PAG. 6


SPECIAL

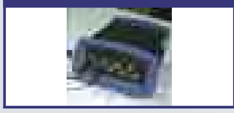
ULTRAWOOD — PAG. 6

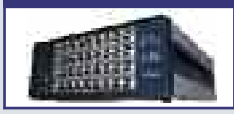

ULTRASCOPE C — PAG. 7


AIRSCOPE TT — PAG. 18


MULTICHANNEL

STANDARD

DIFRASCOPE — PAG. 8


SITAU STM-132 — PAG. 9


SPECIAL

AIRSCOPE MX — PAG. 18


SDP — PAG. 9


DSR — PAG. 9


DISFRASCOPE — PAG. 8

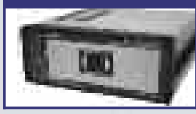

CASE PRT — PAG. 9


PHASED ARRAY

STANDARD

CASE — PAG. 11


PA STANDARD — PAG. 11


SITAU 311 — PAG. 11


SPECIAL

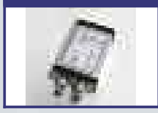
FULL PARALELL — PAG. 16


SITAU - 312 — PAG. 11

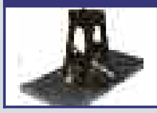

SITAUT- 311-MC24 — PAG. 12


OTHERS

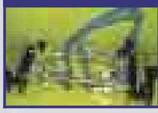
AIRBONE — PAG. 19


LIMITER — PAG. 10


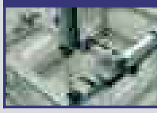
MOTORMOTION — PAG. 27


SCANNER — PAG. 21


AMPLUS — PAG. 10


SCANNER — PAG. 22


PA - SCANNER 2 — PAG. 21


UT TANK — PAG. 22


MANUAL AND AUTOMATED SCANNERS

DASEL provides high-quality solutions for their wide range of products, making easier inspection routines in field and at laboratory facilities.

MANUAL SCANNER

The manual scanner developed by DASEL can be used in TOFD, Conventional UT and Phased-Array inspections.

The design is simple and requires minimum training and setup time. Its high-quality materials and components make it suitable for industrial applications. Moreover, it has a coded axis allowing accurate data acquisition for faster and efficient inspections. The scanner supports two probes (single-element or phased array) and it is fully compatible with ULTRASCOPE, DIFRASCOPE and SITAU products.

SCANNER - Main features
Supports 2 / 4 probes for TOFD, phased array, or pulse-echo inspections.
High precision mechanics allows a constant scanning speed for smooth data acquisition.
Four industrial-strength magnetic wheels guarantee good coupling and reliable displacement on ferromagnetic surfaces.
Compatible with ULTRASCOPE, DIFRASCOPE and SITAU Systems.
Water injection input and uniform couplant delivery.
Room available to integrate AMPLUS-32 preamplifier for improved TOFD and Pitch&Catch inspections.
Minimal time needed for probe mounting.

IMMERSION INSPECTION TANKS

Immersion Systems are frequently used when the object under test and the probe are submerged in a liquid (usually water) that acts as coupling medium.

DASEL provides a wide range of immersion tanks for non-destructive testing in water bath, with standard dimensions or manufactured according to customer requirements.

The immersion systems can be supplied with any of the DASEL-NDT ultrasonic instrumentation (including mono or multichannels, preamplifiers, phased arrays systems, etc.) or interfaced to existing test equipment at the customer facilities. However, the capabilities of the system, such as operating modes, dynamic range, etc., are determined in function of the installed ultrasonic system.

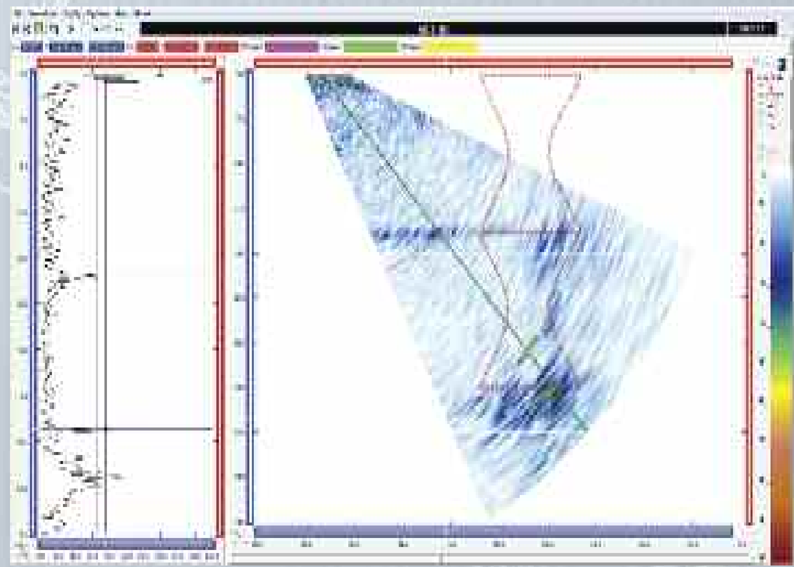
The immersion systems are totally automatized and can be controlled from a PC using the Motor-Motion software, or even more, they can be integrated in custom applications by using our LabVIEW, MATLAB or C++ toolboxes.

Standard immersion inspection tanks			
Model	X [mm]	Y [mm]	Z [mm]
DIS-400	400	400	250
DIS-800	800	400	250
DIS-1000	1000	800	300
DIS-XXXX	Customizable	Customizable	Customizable
Main features			
Three motorized axis (x,y,z). A fourth motorized rotary axis is optional			
Adjustable scan index, vertical and horizontal scans. Optionally, revolution surface scans.			
Mechanical features			
Rugged aluminum structure with laminated structure.			
Ball screw drive with positioning accuracy of ± 0.1 mm			
Methacrylate independent tank			
Probe-holders manually adjustable (+90º TO -90º at XZ or YZ) and with fine adjust of orientation.			
Scan speed between 25 mm/s (Stepper motors) and 66 mm/s (Servos)			
Electrical features			
Stepper motors with independent power stages and USB for up to 4 motors (Standard)			
Position encoders in motors X and Y for acquisition synchronization (also in θ if an optional rotary axis is used)			
Low noise electronics. Limit switches, warning indicators and emergency stop control.			

EVALUATION AND CONTROL SOFTWARE

All the equipment manufactured by DASEL is supported by powerful software tools to easily configure the system parameters, display the signals and images and evaluate possible defects.

DASEL also provides a set of Library Toolboxes for different programming environments such as **C++, LabVIEW or MATLAB**, in order to facilitate the integration of their equipments into automatic inspection systems and R&D laboratories.

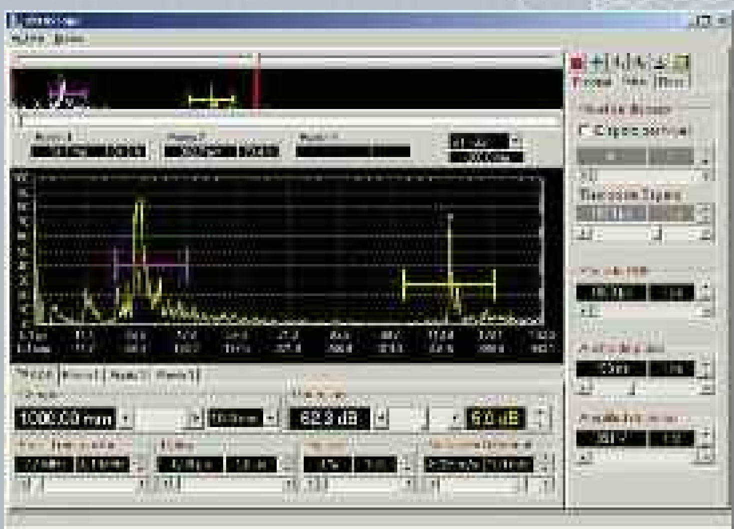


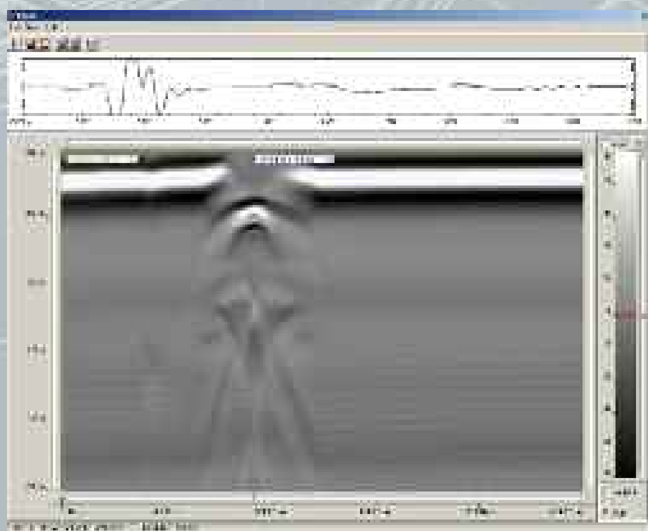
ULTRAVIEW

The software suite for ULTRASCOPE systems.

Being intuitive and easy to use, it allows taking most advantage of all features available in ULTRASCOPE systems. It is possible to display the captured A-scan and evaluate the possible defects in the material under test.

UltraView is also available in versions for air-coupling (Airscope-TT) and wood inspection (Ultrawood).





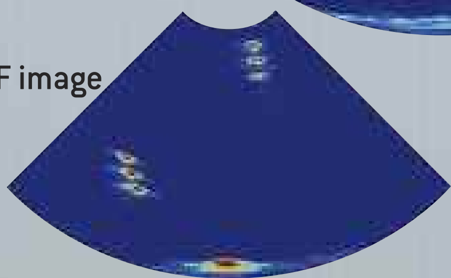
SCANVIEW

The software suite for SITAU Phased-Array equipments.

Its intuitive design reduces the learning curve, and so on, the time required to configure the equipment. Furthermore, it takes the maximum advantage of all functionality included in SITAU systems. For example: introducing wedge parameters, results presentation in all kind of views (A, B, C-scans) with measurement cursors of position, amplitude, attenuation and time-of-flight. Moreover, ScanVIEW includes a set of toolboxes for presenting, evaluating and sizing possible defects, save and export the captured data and create automated reports. The software also allows synchronizing acquisitions with the probe movement and position over the test material, which allows multiple stop-and-run interruptions during the inspection procedure while maintaining data integrity.

Conventional image

DDF image



Main features

- Advanced data analysis
- Fully customizable display
- Wizard menu
- Customizable and Flexible reporting
- Off-line peak gate calibration
- Easy wedge configuration and Auto-Focus mode
- Metric and US customary units
- Fast gain /range / focal point adjustment
- Ability to open multiple files simultaneously
- S-scan, L-scan, F-scan C-scan Display tool
- Off-line A-scan synchronization
- Off-line Scan/Index/Sound axis calibration
- Ability to import focal laws from other platforms

Advanced features

- Grain-Noise-Reduction Filter
- EMI reduction filter
- Intelligent data compression
- True Dynamic-Depth-Focusing

TOFDVIEW

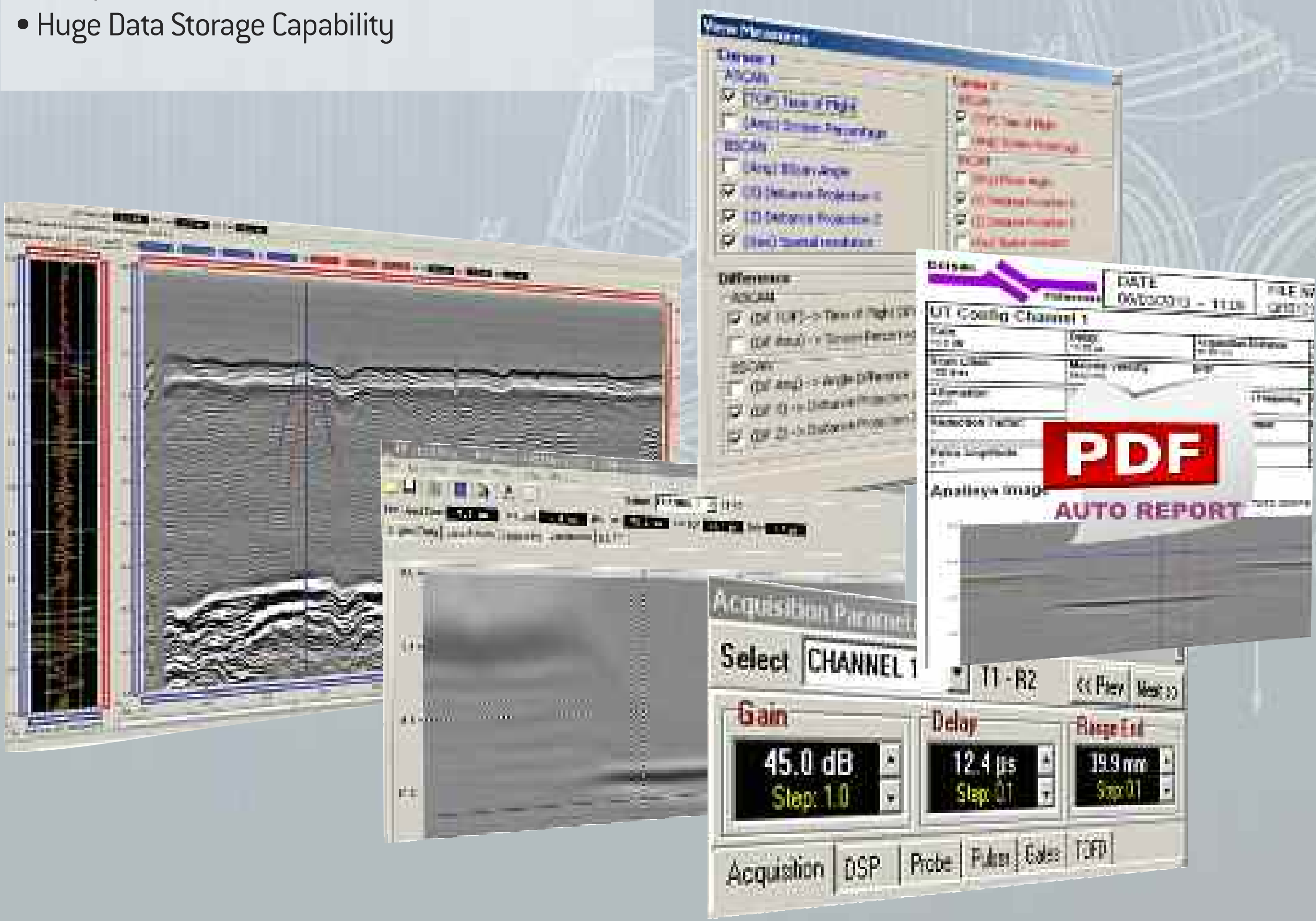
TOFDView is the ideal software solution for weld inspection by TOFD technique.

Features & Benefits

- Linearisation
- Lateral wave straightening
- SAFT
- XY Cursors (B-Scan+A-Scan)
- Depth Calculation
- Gray scale with threshold
- PCS Calibration wizard
- Hyperbolic Cursor Toolbox
- Lateral wave removal
- Up to 32 Channels
- Auto Report in PDF
- Single Channel and Multi-Channel
- Manual, Semiautomatic, and Automatic modes
- A-, B-, C-Scan, Amplitude / TOF
- 100% Open Raw Data Recording
- Compliance with ASME and UNE Procedures
- Huge Data Storage Capability

With this tool you can get the maximum performance of DIFRASCOPE systems. Its simple and easy to use interface, allows you to display images, save and export the acquired data and size possible flaws.

It includes many advanced processing techniques like lateral wave straightening and lateral resolution improvement by synthetic aperture (SAFT)

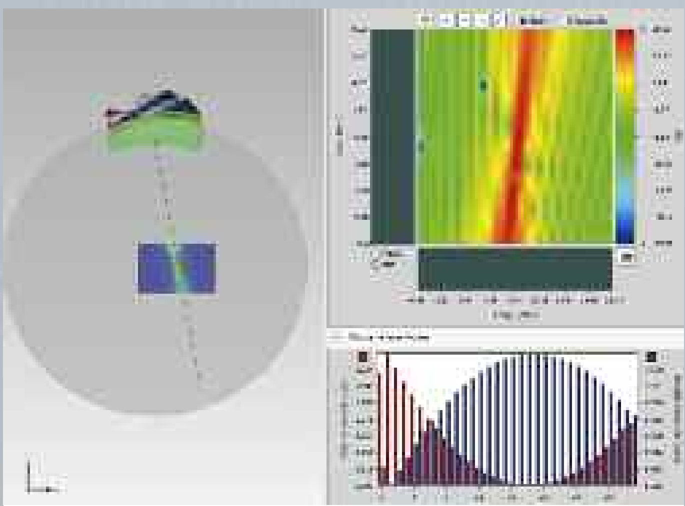


FOCALSIM: FAST ULTRASONIC SIMULATION SOFTWARE

FocalSim can handle complex geometries, as well as the latest developments in probes, inspection strategies and data-analysis techniques.

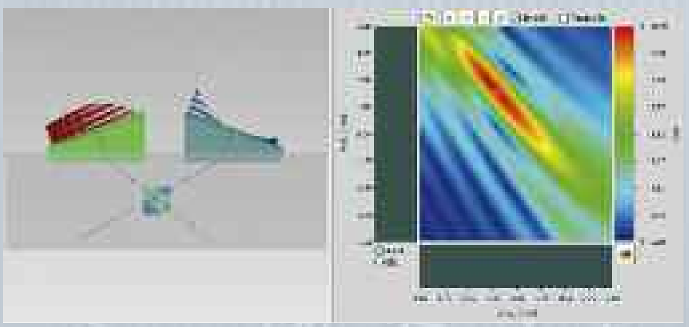
Being able to accurately simulate your inspection during the design process, it allows you to identify and account for critical issues. This procedure greatly reduces unforeseen problems, and thus, additional costs during operation.

DASEL has developed this powerful acoustic field simulation tool, based on the monochromatic wave equation solution in homogeneous media, and the Ray-tracing method for the focal law calculation, which allows the user to have a more precise idea of the behaviour, shape and distribution of the



ultrasonic beam into the specimen. The obtained focal laws can be exported to SITAU systems or to other Phased-Array equipments that accept these input parameters.

FocalSim makes it possible to understand and visualize the acoustic field radiated by any Phased Array probe in a NDT inspection. The simulation results are used to optimize inspection strategies, verify inspection parameters, and help in the analysis of results.



The exported Focal Laws allows to configure SITAU® devices for the specific inspection.

MAIN FEATURES

- Fast focal laws calculation and acoustic field simulation.
- Exportable Focal laws for compatible devices.
- Exportable ray entry point for compatible devices.
- Acoustic field simulation in narrow band.
- Implements the most advanced Phased Arrays probes in the market.
- Multiple mediums.
- Dynamic Focusing Focal Law (DDF) calculator.
- Linear Scan.
- Angular Scan.

MOTORMOTION

MotorMOTION is the application software for controlling the immersion inspection tanks manufactured by DASEL.

MotorMOTION is a fully programmable stepper-motor control unit, capable of simultaneously controlling up to 3 axes, with configurable acceleration ramp and micro-steps. It also includes 6 limit switches and emergency stop switch control, and supports motor currents from 1.2A up to 5.6A. This unit is provided with an user software with B and C-Scan capabilities. It also includes a programming library for C++, LabView or Matlab.

MAIN CONTROL FUNCTIONS

- MC_Open()
- MC_Close()
- MC_VelocityConfig(value)
- MC_Move(axis, direction, steps)
- MC_GetStatus(*status)

COOPERATION PROJECTS

PAST PROJECTS

DASEL is a young company, whose technological base has been developed by the Spanish National Research Council (CSIC).

CSIC is the largest public institution dedicated to research in Spain and the third largest in Europe.

2004

New protocols for the industrial application of SENDAS and AMPLIA technologies. Project for knowledge transference from GEND-CSIC group to DASEL.

2006

Design of Non-Destructive-Evaluation applications and systems. Nº IDI 2006 0651, founded by CDTI for the consolidation of the company DASEL and the launch of Ultrascope, DSR and SITAU technologies.

2008

PIE 611/2008, Ultrasonic flaw detector by time of flight diffraction.

2008

INNO 129-2008.- Conceptual design and technical development of failures analyzer equipment by Ultrasonic technology SITAU, tool development product design based on customer needs.

2008

PET 2008_0116_01 DIFRASCOPE. Nondestructive Evaluation Technologies for time of flight diffraction. Ultra-compact multichannel system for ultrasonic weld inspection, TOFD based technology.

2009

PIE 306/2009 Development FOCAL-SIM tool for the calculation and simulation of focal laws, applied to the design of Phased Array inspections.

ACTUAL PROJECTS

As a result of this cooperation, the company has obtained R&D agreements and contracts of different magnitude and with several partners.

2010

HANDY, Portable System platform, open development platform for integrating various technologies with the characteristics of: High portability, Lithium-ion battery, touch screen of 10.4 ".

2010

Artemis Project (Advanced real time multimodality medical imaging), granted by Madrid government, to develop a multi-modal medical imaging technology. Achieving real-time acquisition and tomography reconstruction in a real surgical scenario.

2011

DOOME, Development and optimization of guided wave technologies for the monitoring of critical structures. Guided-wave system approach for inspection of pipes and longitudinal structures.

2012

EUROSTARS E!6771, SAPHARI. Synthetic aperture and phase coherence for ultrasound images in real time, applied to NDT. A new inspection standard based on the patent Nº ES/200802402

2012

Grant Agreement: 315130 CHAPLIN: The overall aim of CHAPLIN is to develop and demonstrate an integrated technology solution for the efficient and cost-effective inspection of high power overhead transmission line cables.

2012

Grant Agreement: 314913. SkinDetectorApplication of the innovative data fusion based non-invasive approach for management of the diabetes mellitus.

ULTRASOUND ANDROID SMARTPHONE APPLICATIONS

ULTRASOUND- CALC, PHASED ARRAY-WIZARD AND TOFD-CALC

A series of handheld tools for NDT, based on Android Operating System

Descriptions:

Ultrasound Calc, Phased Array Wizard and TOFD-Calc contains all calculations which are frequently required in industrial applications by NDT technicians of levels II and III.

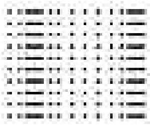
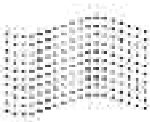
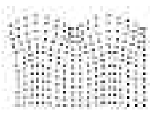
These applications turn your smart phone in a powerful calculator that simplifies the complexity of ultrasonic equations used to select a transducer or setup an inspection by menus of friendly interactive screens.

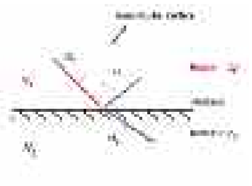
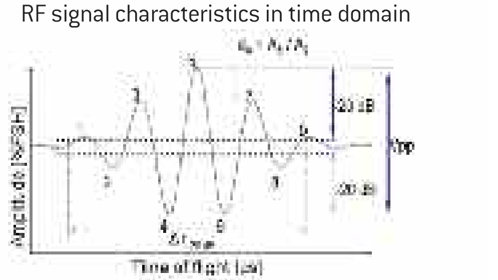
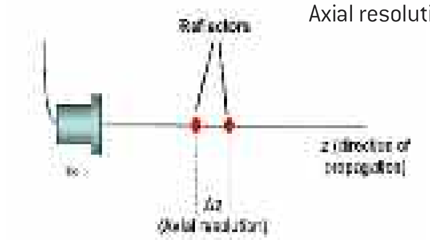
These applications have a database of material properties to look up longitudinal and shear wave velocity as well as impedance, density and wavelength for a given frequency

SPEED AND ATTENUATION OF WAVES IN SOLIDS

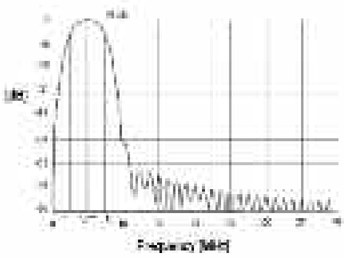
Materials	Speed of sound		Acoustic impedance
	c_L (Long.) 10^3 m/s	c_T (Trans.) 10^3 m/s	$Z = \delta$ cl 10^6 Kg/m^{2}s
Materials			
Aluminium	6.32	3.13	17
Berylium	12.87	8.90	23
Bismuth	2.18	1.10	21
Brass (58)	4.40	2.20	37
Cadmium	2.78	1.50	24
Cast iron	3.5 a 5.8	2.2 a 3.2	25 a 42
Constantan	5.24	2.64	46
Copper	4.70	2.26	42
German silver	4.76	2.16	40
Gold	3.24	1.20	63
Inconel	5.72	3.00	47
Stellite	6.8 a 7.3	4.0 a 4.7	77 a 102
Iron (steel)	5.90	3.23	45
Iron (cast)	4.80	2.60	33.2
Lead	2.16	0.70	25
Magnesium	5.77	3.05	10
Manganin	4.66	2.35	39
Mercury	1.45	-	20
Molybdenum	6.29	3.40	63.1
Monel	6.02	2.70	47.6
Nickel	5.63	2.96	50
Platinum	3.96	1.67	85
Silver	3.60	1.59	38
Steel, mild	5.92	3.23	46
Steel, stainless	5.80	3.10	45.4
Tin	3.32	1.67	24
Titanium	6.07	3.10	27.3
Tungsten	5.46	2.62	104
Uranium	3.37	2.00	63
Zinc	4.17	2.41	30
Non metals			
Aluminium oxide	9 a 11	5.5 a 6.5	32 a 43
Butyl	1.85	-	2.0
Epoxy resin	2.4 a 2.9	1.1	2.7 a 3.6
Glass, flint	4.26	2.56	15
Glass, crown	5.66	3.42	14
Ice	3.98	1.99	3.6
Paraffin wax	2.2	-	1.8
Acrylic resin (Perspex)	2.73	1.43	3.2
Polyamide (nylon, perlon)	2.2 a 2.6	1.1 a 1.2	2.4 a 3.1
Polystyrene	2.35	1.15	2.5
Porcelain	5.6 a 6.2	3.5 a 3.7	13
Plexiglass	2.76	1.10	3.1
Polyethylene	2.67	0.5	1.7
Polyurethane	1.90	-	1.9
Quartz glass (silica)	5.57	3.52	14.5
Rubber, soft	1.48	-	1.4
Rubber, vulcanized	2.3	-	2.8
Polytetrafluoroethylene (Teflon)	1.35	0.55	3.0
Liquids			
Glycerine	1.92	-	2.5
Methylene iodide	0.98	-	3.2
Diesel oil	1.25	-	1.0
Motor car oil (SAE 20 a. 30)	1.74	-	1.5
Water (20º C)	1.483	-	1.5

SUMMARY OF USEFUL FORMULAS

<table>
<tr><th colspan="4">Fundamental of ultrasound</th></tr>
<tr><th>Description</th><th colspan="3">Explanation</th></tr>
<tr><td>Ultrasonic waves</td><td colspan="3">Ultrasound can be defined as high frequency mechanical waves (>20Khz). In solids, ultrasound waves have different propagation modes, depending on of the way of vibration of the material particles.</td></tr>
<tr><td>Acoustic Impedance</td><td>Z=ρV [Kg/m²s]</td><td colspan="2">Resistance offered to the propagation of an ultrasonic wave by a material. It is obtained by multiplying the density ρ of the material and the velocity V of the ultrasonic wave in the material.</td></tr>
<tr><td>Acoustic pressure</td><td>P= Za</td><td colspan="2">Denote the amplitude of alternating stresses on a material by a propagating ultrasonic wave. It is related to the acoustic impedance “Z” and the amplitude of the particle vibration “a”.</td></tr>
<tr><td>Acoustic intensity</td><td>$I=P^2/2Z=Pa/2$</td><td colspan="2">The amount of energy per unit area in unit time.</td></tr>
<tr><td rowspan="4">Types of ultrasonic waves</td><td></td><td colspan="2">In longitudinal waves particles vibrates along the direction of travel of the wave. Such waves can propagate in solids, liquids and gasses.</td></tr>
<tr><td></td><td colspan="2">Shear Waves or Transverse waves: the particle movement is at right angle or transverse to the propagation direction. Sound velocity in a material is usually different for shear and longitudinal waves.</td></tr>
<tr><td></td><td colspan="2">Surface waves or Rayleigh waves: are produced in a semi-infinite material. They can propagate in a region no thicker than about one wavelength below the surface material. Particles vibrate following an elliptical orbit.</td></tr>
<tr><td colspan="3">Lamb waves are generated when a second Boundary surface is introduced, i.e. a plate. They can produce symmetric or antisymmetric vibrations in plates with a thickness of several wavelengths. The particles follow an elliptical orbit.</td></tr>
<tr><td rowspan="4">Wave parameters</td><td rowspan="4">λ= c/f = cT</td><td colspan="2">λ – Wavelength [mm]: Distance traveled during the time period.</td></tr>
<tr><td colspan="2">f – Frequency [MHz]: Number of cycles per second</td></tr>
<tr><td colspan="2">c – Velocity [mm/us]: Speed at which energy is transported between two points in a medium.</td></tr>
<tr><td colspan="2">T – Period [1/f]: oscillation time.</td></tr>
<tr><td rowspan="3">Velocity of ultrasonic waves</td><td>Longitudinal</td><td>$V_L = \sqrt{\frac{E(1-\mu)}{\rho(1+\mu)(1-2\mu)}}$</td><td rowspan="3">E = Young’s modulus of elasticity [N/m2].
ρ = material density [Kg/m3].
μ = Poisson’s coefficient = (E-2G)G
G = modulus of rigidity.</td></tr>
<tr><td>Transverse</td><td>$V_T = \sqrt{\frac{E}{2\rho(1+\mu)}}$</td></tr>
<tr><td>Surface</td><td>$V_S = \frac{0.87+1.12\mu}{1+\mu} \approx 0.92V_T$</td></tr>
</table>

Sound reflection Properties at an interface		
Description	Explanation	
	Reflection	When a wave reaches a medium of different acoustic impedance (interface), part of the wave energy is reflected into the incident medium. The angle of incidence and the angle of reflection are related by: $\alpha_{(incidence)} = \alpha_{(reflection)}$
	Refraction	When a wave reaches a medium of different propagation velocity, the transmitted wave undergoes an abrupt change in direction following the Snell's law: $\left(\frac{\sin(\alpha_1)}{V_1}\right)_{(incidence)} = \left(\frac{\sin(\alpha_2)}{V_2}\right)_{(refraction)}$
First critical angle	It is the angle of incidence that creates a 90º refracted longitudinal wave	
Second critical angle	It is the angle of incidence that creates a 90º refracted shear wave (or Surface wave)	
% Reflected energy (E)	$E = 100\left(\frac{Z_2 - Z_1}{Z_2 + Z_1}\right)^2$	Where Z1 and Z2 are the acoustic impedance of media 1 and 2 respectively. To calculate the % of transmitted energy, the reflected energy must be subtracted from 100%
Reflection coefficient	$R = \frac{(Z_2 - Z_1)^2}{(Z_2 + Z_1)^2}$	R is the reflection coefficient and it is a dimensionless numerical value.
Transmission coefficient	$T = \frac{4Z_1Z_2}{(Z_1 + Z_2)^2}$	T is the transmission coefficient and it is a dimensionless numerical value.
Attenuation	$Attenuation = \alpha_{absorption} f + \alpha_{scattering} f^4$	Reduction in energy as a result of friction absorption and scattering as the wave travels through a material.
Pulse width (PW)	$PW = \frac{1}{2 f_r}$	Duration of the high-voltage excitation pulse.
Characteristics of ultrasonic beam		
RF signal characteristics in time domain 		NP – Number of peaks CN – Number of cycles: CN = CP/2 Vpp – Peak-to-peak amplitude: Maximum deviation between peaks expressed in volts or % ΔT-20dB - Pulse duration or waveform length dA – Damping: relation between maximum amplitude and the adjacent peak.
Axial resolution 		Ability of an ultrasonic signal to distinguish two separated reflectors along the direction of the sound propagation (Δz).

RF signal characteristics in frequency domain



fL – lower frequency

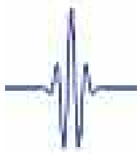
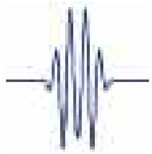
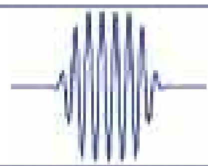
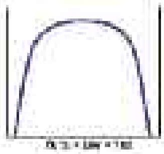
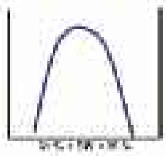
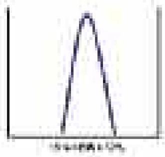
fU – upper frequency

fC – centre frequency: (fU-fL)/2

BW6dB[%] – Bandwidth: 100 *(fU-fL)/fC

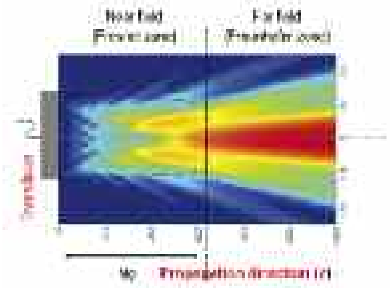
Transducer classification by its bandwidth

The transducer transforms electrical energy into mechanical vibrations and vice versa. Due to mechanical damping of the transducer element a damped oscillation is also produced -in the material.

High damping pulse – Wide band transducer 1 - 3 cycles	Medium damping pulse – Medium band transducer 3 - 5 cycles	Low damping pulse – Narrow band transducer 5 - 7 cycles
		
		
Axial resolution improves when pulse duration decreases	Reference Axial Resolution (Δz)	Axial resolution decreases when pulse duration increases

Ultrasonic field

Ultrasonic field



Transducer

Parameters:
D = Diameter, f = frequency V = velocity, λ=wavelength

Near field z<No (Circular Transducer)

The field intensity is irregular and the beam width is smaller than the transducer diameter.

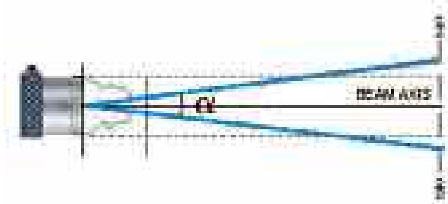
$$N_0 = \frac{D^2}{4\lambda} = \frac{D^2 f}{4V}$$

Near field z<No (Rectangular Transducer)

$$N_0 = \frac{1}{\pi\lambda}(a^2 + \lambda^2)\left(1 - \frac{a}{2\lambda}\right)$$

where "a" is the shorter size of the transducer and "b" the largest size of the transducer

Beam spread
The beam spread can be reduced by selecting a transducer with a higher frequency, a larger element diameter or both



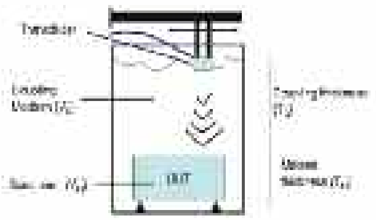
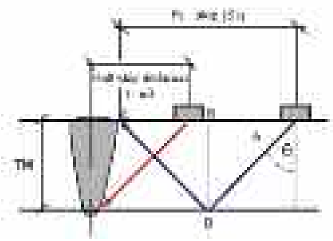
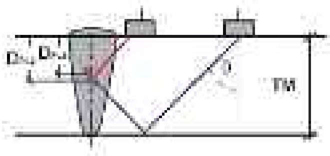
For flat transducers, the pulse-echo beam spread angle is given by:

$$\frac{\alpha}{2} = \sin^{-1}\left(k\frac{\lambda}{D}\right)$$

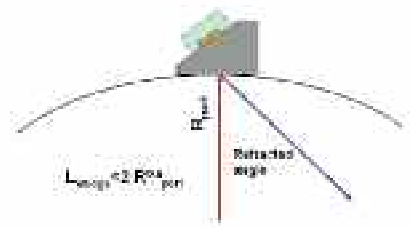
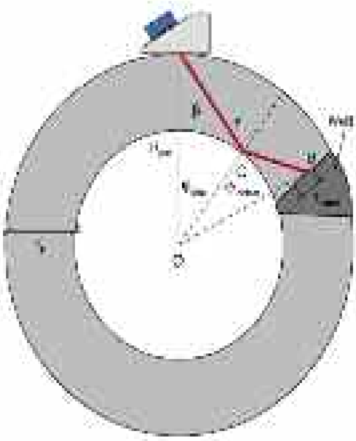
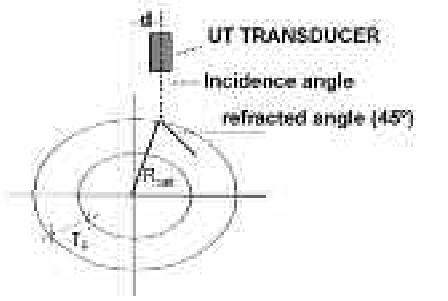
where: α/2 = Half angle spread.
"k" = constant value which depends on where the beam edge is defined

"k" = 0.51 gives the half beam width at -6dB drop in pulse-echo mode.

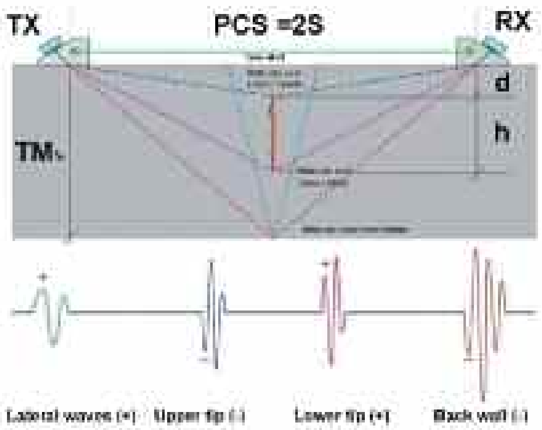
	"k" for Transmission mode	
Drop % dB	Circular transducer	Rectangular transducer
10% (20 dB)	1.08	0.60
50% (6 dB)	0.54	0.91
	"k" value for Pulse-echo	
10% (20 dB)	0.87	0.74
50% (6 dB)	0.51	0.44

Focused sound fields	The beam width can be reduced by focusing in the near-field zone using a lens $z_{foco} < N_0$ => zfoco: actual focal depth The focus position (zfoco) for a given lens radio is: $z_{foco} = \frac{R}{1-(V_M / V_L)}$ => VM: means de sound velocity in the specimen => VL: sound velocity in the lens material => R: lens curvature radius	
Focusing factor	A focused beam is characterized by: $S_{ac} = \frac{z_{foco}}{N_0}$	A focused beam can be classified by Sac as: 0.1 ≤ Sac ≤ 0.33 => strong focusing. 0.33 ≤ Sac ≤ 0.67 => medium focusing. 0.67 ≤ Sac ≤ 1.0 => weak focusing. Most of the industrial applications use: Sac < 0.6
Focusing Depth	$L_{-6dB} = 7\lambda\left(\frac{z_{foco}}{D}\right)^2$	The formula is only valid for Sac < 0.6
Focused beam diameter	$\Phi = S_{ac}\frac{D}{4} = \frac{z_{foco} D}{4 N_0}$	The beam diameter in mm at -6dB drop
Inspection techniques		
Maximum thickness of specimen	$T_M = \frac{T_C V_M}{V_C}$	The maximum thickness of material (TM) that can be inspected is limited by coupling medium height (Tc), such as water, plexiglass, etc. VC => Sound velocity in coupling medium. VM => Sound velocity in specimen. 
Skip distance (SD)		The “skip distance” is the surface distance from the probe "index point" where the sound beam returns to the surface. This distance must be calculated to determine the probe distance to the weld to provide full inspection coverage for the component thickness. Probe angle => θ TM => Thickness material. $S_D = 2T_M tg(\theta)$
Half skip distance (HSD)		The “half skip distance” is the surface distance from the “probe index point” to the point on the surface above the point where the sound beam reaches the backwall of the component. $H_{SD} = T_M tg(\theta)$ Half-skip-beam-path length (HSBPL) = AD = TM/cos θ Full-skip-beam-path length (FSBPL) = AD + DC = 2TM/ cos θ
Flaw identifications		DPL1 => Flaw depth from the surface, considering the first leg SP => Sound path - without reflection on the backwall $D_{PL1} = S_P \cos(\theta)$
		DPL2 => Flaw depth from the surface, considering the second leg SP => Sound path, including the reflection on the backwall TM => Material thickness $D_{PL2} = 2T_M - S_P \cos(\theta)$

Testing round parts

Relationship between wedge length and part radius		It is recommended, for contact inspections, that if the wedge is not shaped, the wedge length (LWedge)meets the following condition $R_{part} > \frac{L^2_{Wedge}}{4}$ => R_{part}: Outer radius As a rule of thumb, the height between the wedge extremes and the round part must be ≤ 0.5mm
Ultrasonic examination of an axial weld pipe		The ultrasonic beam path and the reflected angle on the inner surface change when performing an inspection of an axial weld on a pipe. $\beta_{max} = \sin^{-1}\left(1 - \frac{T_p}{2R_{part}}\right)$ $\sin\alpha = \left[\frac{1}{(1-2T_p/R_{part})}\right]\sin\beta$ $\varphi = \pi - (\beta + \alpha)$ $h_{defect} = OB - 0.5(R_{part} - 2T_p)$ TP => Pipe thickness RPart => Outer radius βmax => Maximum probe angle φ => Radial angle hDefetc => Defect height OB => The distance from the tube center to the top of the defect
Offset distance for generation of a 45º shear beam	$d = 0.707 R_{part}\frac{V_W}{V_T}$ 	The inspection procedure must be carried out by immersion. d => Offset distance from the centerline. Rpart => Outer radius. VW => Ultrasound longitudinal velocity in water. VT => Velocity of refracted shear beam in the test material. TP => Material thickness.

Time-of-flight difraction technique



$$T_{latwave} = \frac{PCS}{V_L} = \left(\frac{2S}{V_L}\right)$$

$$T_{uppertip} = \frac{2\sqrt{(S^2+d^2)}}{V_L}$$

$$T_{lowertip} = \frac{2\sqrt{(S^2+(d+h)^2)}}{V_L}$$

$$T_{BW} = \frac{2\sqrt{(S^2+TM^2)}}{V_L}$$

PCS => Probe center separation.

TLat.Wave => Time-of-flight lateral wave.

S => Distance from the probe index point to the weld center.

d => Upper ligament.

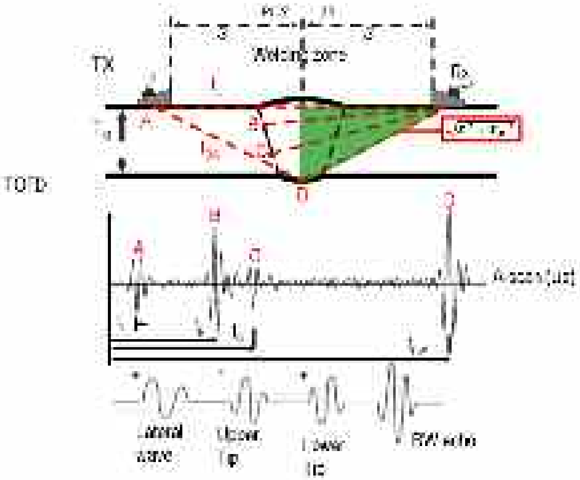
h => Defect height.

VL => Ultrasound longitudinal velocity.

TPP => Time-of-flight to the backwall.

TM => Material thickness.

Time-of-flight difraction technique



PCS => Probe center separation.

TM => Material thickness.

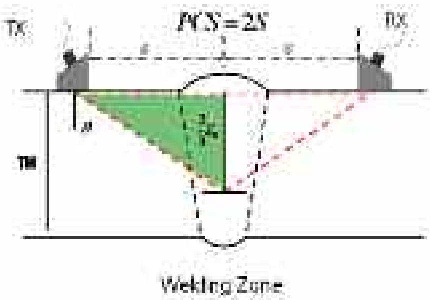
VL => Velocity of propagation of longitudinal waves in test material.

VT => Velocity of propagation of shear waves in test material.

* The time-of-flight of the lateral shear wave must be greater than the backwall time-of-flight.

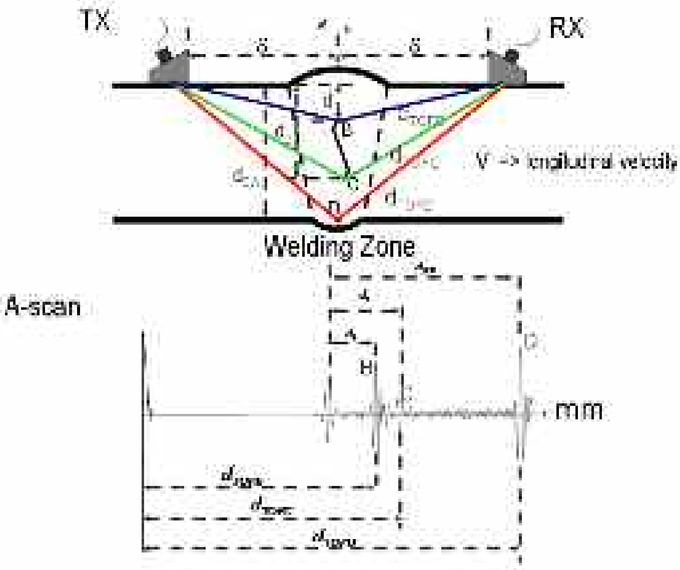
$$t_t\,(Transversal) > t_{BL}\,(Longitudinal)$$

$$\left.\begin{array}{l} \dfrac{2S}{V_T} = \dfrac{2\sqrt{S^2+T_M^{\ 2}}}{V_L} \\ V_L \approx 2V_T \\ PCS = 2S \end{array}\right| \Rightarrow PCS > \frac{2T_M}{\sqrt{3}}$$



The beam is incident at the selected input angle – θ - , in two-thirds of the material thickness - TM -

$$\left.\begin{array}{l} \tan\theta = \dfrac{S}{\frac{2}{3}T_M} \\ PCS = 2S \end{array}\right\} \rightarrow PCS = \frac{4}{3}T_M\tan\theta$$



VL => Velocity of propagation of longitudinal waves in test material.

tB=> Time-of-flight echo coming from point B.

tC => Time-of-flight echo coming from point C.

tD => Time-of-flight echo coming from the backwall - point D.

dTOFB => Distance from B to the receiver transducer.

dTOFC => Distance from C to the receiver transducer.

dTOFD => Distance from the backwall to the receiver transducer.

d1=> Depth of point B.

d2=> Depth of point C.

dBW=> Depth of point D.

$$d_{TOFB} = \frac{V_L t_B}{2}$$

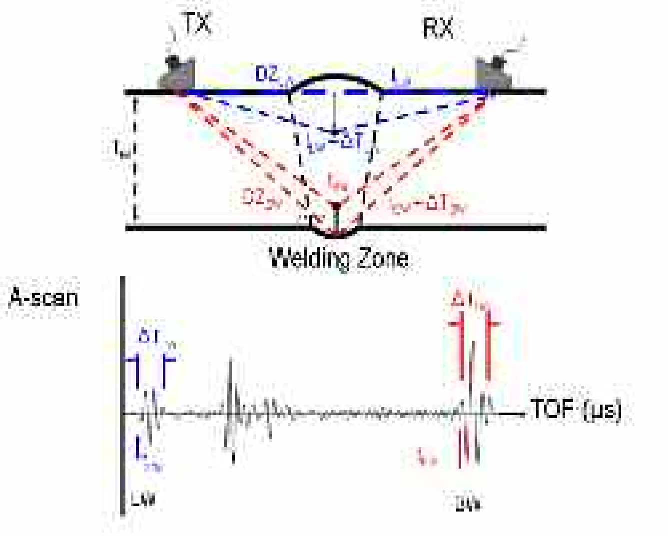
$$d_{TOFC} = \frac{V_L t_C}{2}$$

$$d_{TOFD} = \frac{V_L t_D}{2}$$

$$d_1 = \frac{1}{2}\sqrt{V_L^2 t_B^2 - 4S^2}$$

$$d_2 = \frac{1}{2}\sqrt{V_L^2 t_C^2 - 4S^2}$$

$$d_{BW} = \frac{1}{2}\sqrt{V_L^2 t_D^2 - 4S^2}$$



f => Emitting frequency of wide band transducers with a duration pulse of ∆TLW = 1.5/f.

TM => Material thickness.

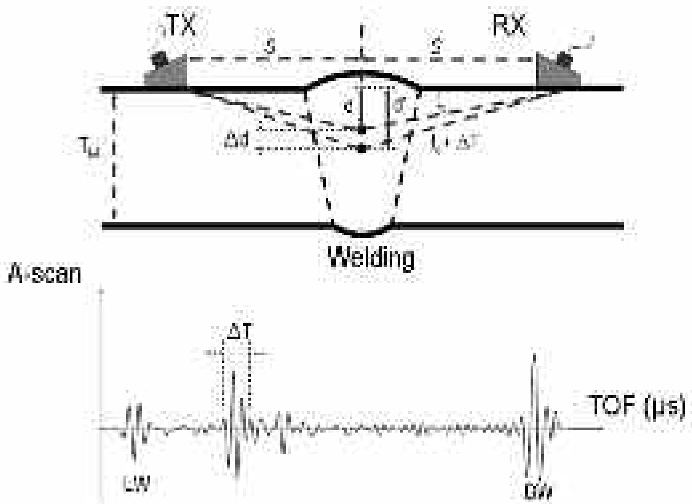
VL => Velocity of propagation of longitudinal waves in test material.

DZLW => Dead zone of the lateral wave INCREASES when frequency (f) DECREASES.

$$DZ_{LW} = \frac{1}{2}\sqrt{V_L^2\left(\frac{2S}{V_L}+\frac{2}{f}\right)^2-4S^2}$$

DZBW => Dead zone of the backwall echo INCREASES when frequency (f) DECREASES.

$$DZ_{BW} = \sqrt{V_L^2\left(\frac{\sqrt{S^2+T_M^2}}{V_L}+\frac{1.5}{2f}\right)^2-S^2}-T_M$$



The spatial resolution (∆d) is the ability of the ultrasonic signal to distinguish two separate reflectors along the depth of the test material. The spatial resolution (∆d) is a function of pulse duration (∆T) that INCREASES as the depth (d) INCREASE.

$$\Delta d = d' - d$$

$$\Delta d = \frac{1}{2}\sqrt{V^2(t_d+\Delta T)^2-4S^2}-d$$

$$\Delta T = \frac{1.5}{f}$$

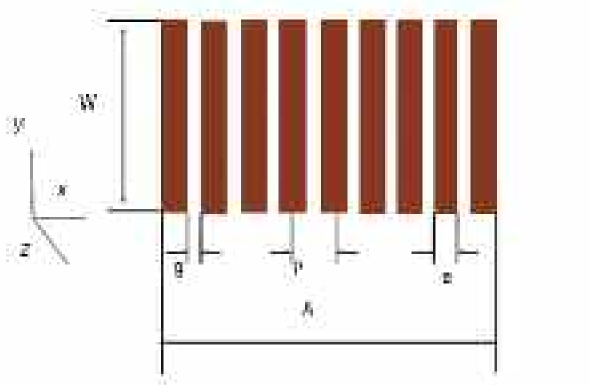
Phased array

Active aperture

$$A = (n-1)p + e$$

$$p = e + g$$

$$W = 1.4\sqrt{\lambda(F_{min}+F_{max})}$$



The Active Aperture is the total probe active length

A => Active aperture.

g => Gap between two adjacent elements

e=> Width of a single piezocomposite element, its typical value is ≤ λ/2.

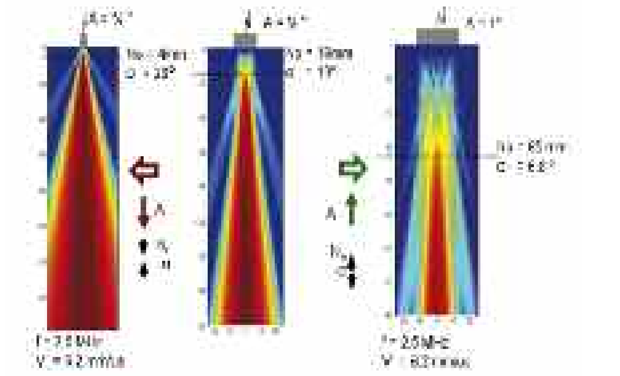
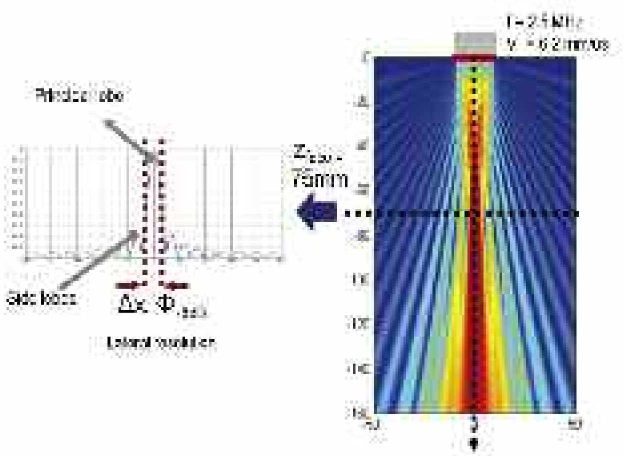
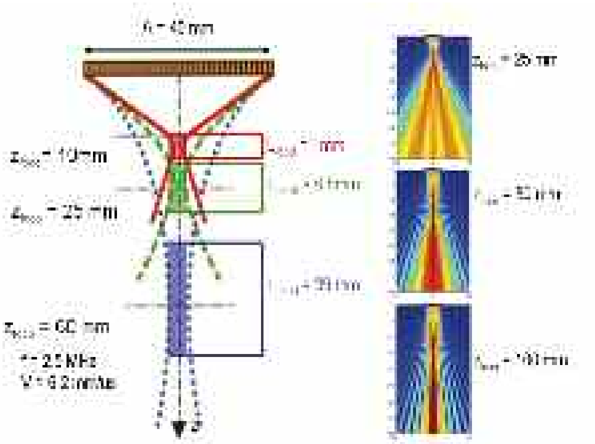
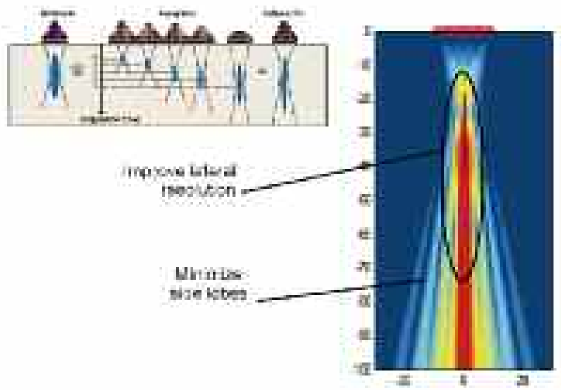
n => Number of elements.

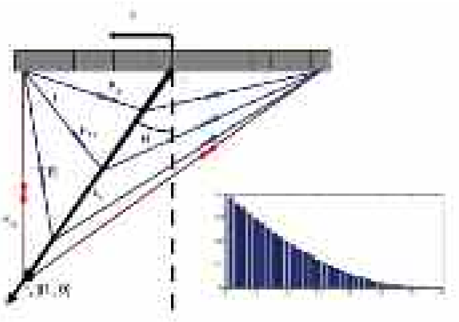
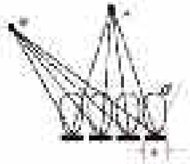
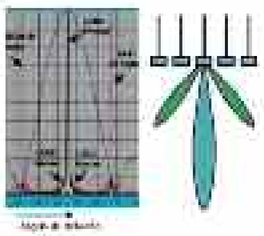
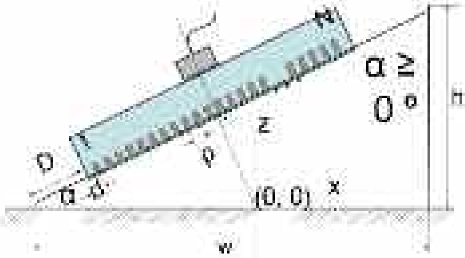
λ => Wavelength.

p (pitch) => It is the elementary distance between the centers of two adjacent elements.

W => Passive aperture is the element length or width. It determines the focal length on y-axis.

Fmin – Fmax => Maximum and minimum focal depths.

Near-field		The near field depends on the aperture size. $No = \frac{A^2}{4\lambda}$ A => Active aperture. No => Near field.
Beam width		The beam width depends on the focal depth and the active aperture size. $\Phi_{-6dB} = K_{BW} \frac{z_{foco}\lambda}{4 No}$ zfoco => Focal depth. κBW => Constant that depends on width criteria: κBW => 1 (Rayleigh criteria) κBW => 1.22 (FWHM - Full Width at Half Maximum - criteria) κBW=> 1.33(Sparrow criteria) Δx => Lateral resolution is defined by the beam width. Δz => Axial resolution is given by $\Delta z = \frac{V \Delta T_{-20dB}}{2}$ ΔT-20dB - Echo duration at a -20dB drop-off. V=> Sound velocity in the test material.
Focus depth		For a given aperture (A), the focus length (L) DECREASES as the focal distance (zfoco) DECREASES. $L_{foco} = 7\lambda\left(\frac{z_{foco}}{A}\right)^2$ The maximum focal distance (zfoco(MAX)) must be inside the near-field No. $z_{foco(max)} < No$ A => Active aperture. V => Velocity of propagation.
Dynamic Depth Focusing (DDF)		The DDF dynamically changes the focal distance as the signal returns to the phased array probe. It significantly increases the depth-of-field, resolution and SNR.

Calculation of emitting focal law – angular sweep	 $DLE = \frac{1}{V_M}\left(R_E - \sqrt{R_E^2 + x_i^2 - 2x_i R_E \sin\theta}\right)$ $DLR = \frac{1}{V_M}\left(r_{in} - \sqrt{r_{in}^2 + x_i^2 - 2x_i r_{in} \sin\theta}\right)$	DLE => Emission delay time. DLR => Reception delay time. θ => Steering direction. xi => Position of the element "i". FE => Distance from the array centre to the emitting focal point in polar coordinates (RE,θ). FR1, FR2, FR3, ...=> Distance from the array centre to the reception focal point "n". rin => Distance from the reception focal point "n" to the element "i" - round-time-of -flight VM=> Ultrasound velocity in the test material.
Max. steering angle	 $\sin(\theta_{STmax}) = 0.5\frac{\lambda}{e}$	Maximum steering angle depends on the element size θSTmax => Maximum steeering angle at -6dB. e => Width of a single array element. λ => Wavelength.
Grating lobes	 $\beta_{Grating} = \sin^{-1}\left(\frac{m\lambda}{p}\right)$ $m = \pm1, \pm2, \pm3, ...$	Grating lobes are generated by sub-sampling across the probe elements. Grating lobe amplitude depends on pitch size, number of elements, frequency and bandwidth. βGrating => Location of grating lobes. p => Pitch. λ => Wavelength.
Wedge Calculation	 	αi => Incident angle for a specific refracted angle from snell's law. Eh => Height of the middle of the phased array probe – virtual emitting point. Pw => Ultrasound path in the wedge. Dw [μs] => Time-of-flight for specific angles in the wedges. Ii => The index point length is the distance from teh back – or front – of the wedge to the exit point of a specific angle. ω => Wedge angle. Hi => Height in the middle of the first element. Hw => Wedge height –back. βi => Refracted angle in the test material. p => Pitch. L1 => Distance from the middle of the first element to the emitting point. L2 => Distance from the emitting point to the intersection with the horizontal line – wedge contact surface. VW=> Ultrasound velocity in the wedge. VM=> Ultrasound velocity in the test material.
Data size	$Data = K_s \times D_L \times R_s$ $\frac{I_s}{S_{AR}} < A_R$	KS => Number of samples per line – S-scan length. DL => Number of acquired lines. RS => Number of triggers – C-Scan length. IS => Inspection speed [mm/s]. SAR => Scan axis resolution [mm]. AR => Acquisition rate [B-scan/s].