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MIRA- Ultrasonic Concrete Tomography



Introduction

The MIRA uses a low-frequency linear ultrasonic antenna array to produce high resolution tomographical images of concrete.

The MIRA is suitable for imaging of the internal structure of objects constructed of concrete and reinforced concrete using pulse-echo technique of testing. This technique only requires access to one-side of the object in order to search for foreign inclusions, holes, flaws, cracks, honeycombs, positioning of ducts and other inside the material and also to assess the state of reinforcement bars in concrete.

Features

Real-time Imaging of the internal structure of the object for easier understanding of testing results.

Focusing antenna array of 48 elements (DDF-principle) – better resolution and higher sensitivity of the system, at that the focusing in every point of volume is provided.

Automatic calibration on the object

Automatic measurement of average ultrasonic velocity in the object

- Compensation of surface SH-wave providing clearer image in near surface area

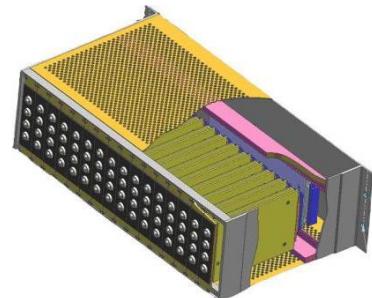
Tomographic data procession (SAFT-algorithm)

Special features

- Dry point contact (DPC) transducers
- Ultrasonic pulse-echo testing technology
- Adaptation of antenna array to the rough object surface.
- Synthetic Aperture Focusing Technique [SAFT]

Description of the system

The MIRA consists of 12 measuring units, combined into a focusing antenna array. Also included in the probe array is a control unit, data collection unit and internal computer for initial processing.



Each measuring unit consists of 4 low-frequency broadband DPC transducers with the nominal operation frequency of 50 kHz. These produce shear waves using only a dry point contact. The transducers have wear-resistant ceramic pins, which prolongs the lifetime of the transducer even when operating on rough, unprepared surfaces.



Each transducer features an independent spring load, which allows performing testing on uneven surfaces with 100mm of travel in each transducer.

A PC with the IDEAL Viewer software, can be used to create 2D or 3d Images of the collected tomographic scans scans.

Data acquisition from antenna array

The data received at one position of the array is an accumulation of signals collected from every pair of measuring units of antenna array. The received



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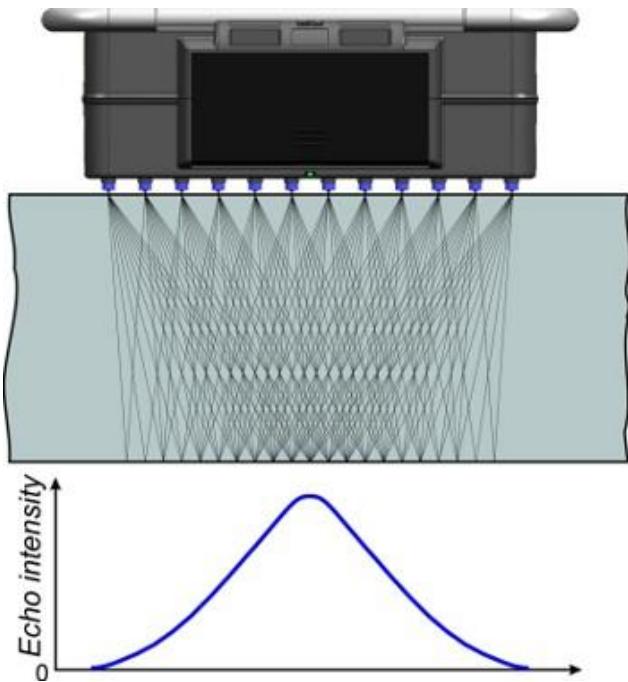
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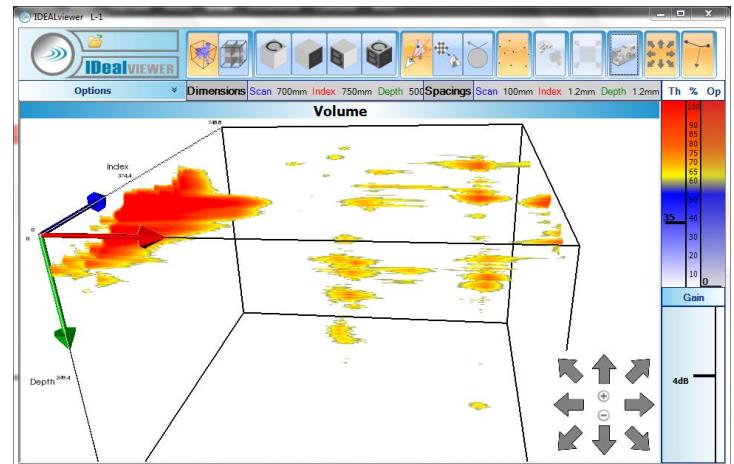
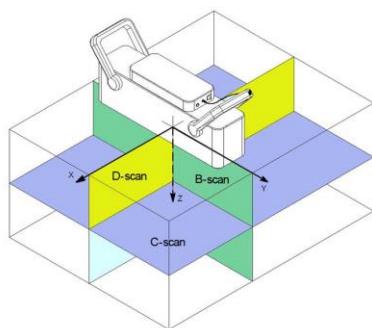
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signals are processed in controlling unit, visualized in 2D and then can be transmitted to PC, where special software constructs a 3D image of the internal structure of the object. This operation principle provides focusing in every point of the half-space. The time for data collection, processing and image reconstruction is only 3 seconds.



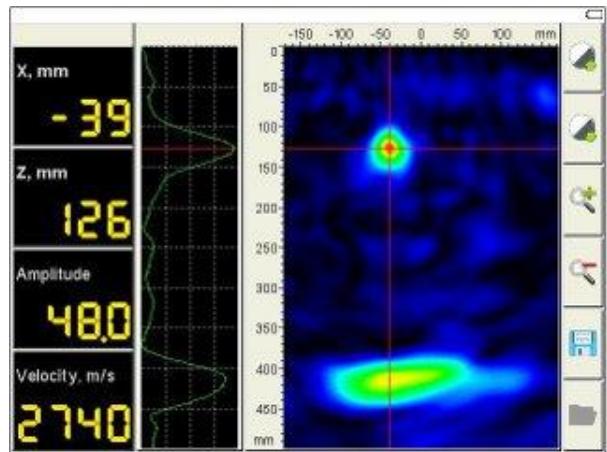
SOFTWARE Capabilities

- Imaging of internal structure;
- Data representation as B-Scan, C-Scan, D-Scan, 3D volume image reconstruction;
- Localization of defects;
- Measurements of signal levels in any point of tomogram;
- Threshold and smoothing filtering of tomogram;
- Color representation of signal levels;
- Manual or automatic modes of threshold image processing;
- Choice of tomogram on 3D image of reconstructed volume;
- Printout.



Operation modes

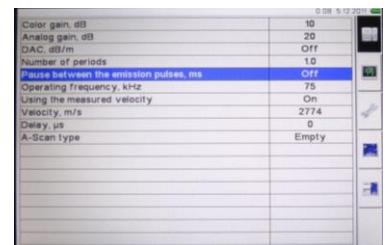
Investigation Mode



This mode is for quick data acquisition and spot checks, a single measurement is taken and can be recorded as an Image file. This mode is used to change settings to provide clear imaging of the internal structure of the concrete and to work quickly onsite.

Settings Mode

This mode is used to adjust the setting of the device, both signal gain and colour gain can be adjusted, DAC processing toggled and operating frequency and other parameters changed such as the assumed speed of sound in concrete.

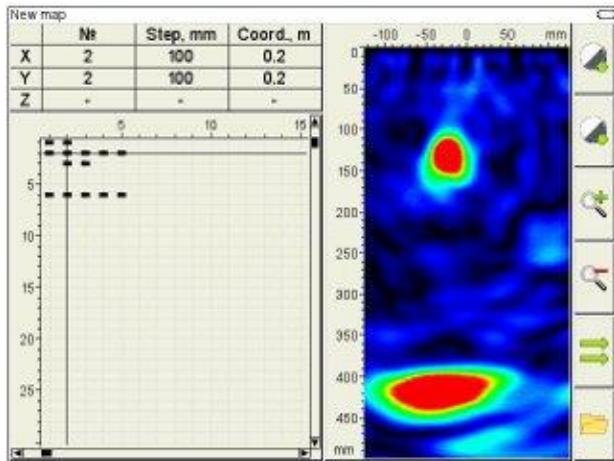




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Grid Collection Mode



This mode is used to take multiple scans over a proscribed Grid. This data can be processed into 2D or 3D images with Ideal Viewer. Each scan is displayed as a 2D image similar to that produced by Investigation Mode.

Application example

Testing object

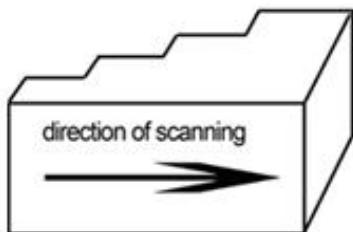
Concrete slab below was made in the form of steps with different thicknesses:

- Length of each step along the testing line - 500 mm. The total length of the object – 2000 mm
- Slab thickness of steps – 210, 330, 450 mm
- Scanning step - 50 mm
- Velocity, measured at calibration – 2872 m/sec

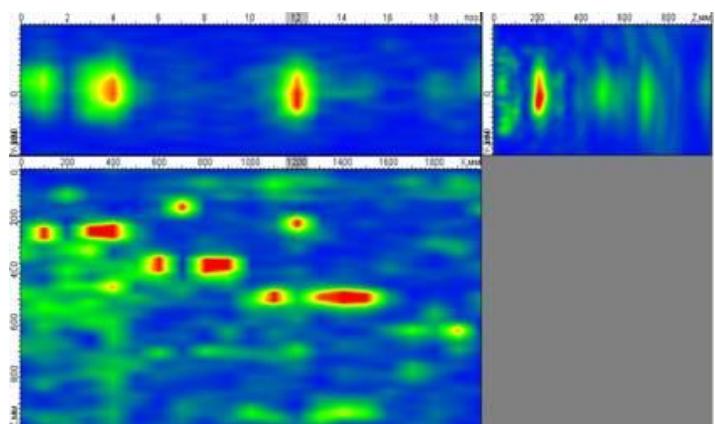


Results of testing

Testing was made along the length of the object with the constant step of 50 mm.



On the D-scan of reconstructed image all four steps and of three ducts in each step. The forth duct is also on the tomogram, though its image is not so clear. At the same time the forth duct can be seen and studied on the B-scan (the corresponding B-scan is given below the main tomogram). On the D-scan the back-wall reflection is disappearing in the area below ducts. This shows that this is not a local though prolonged reflector.



Specifications of the System

Parameter	Value
Minimum Thickness of Testing Object	50 mm
Maximum Thickness of Testing Object	2 m
Size and Type of Display	14.4cm TFT, colour
Built in Memory	Flash Memory
Power Source	Built in Quick Detachable Battery/ AC Adaptor
Battery Life	5 Hours
Computer Connection	USB
Operating Temperature Range	-10°C to 50°C
Size	380 * 130 * 140 mm
Weight	4.5 kg

Transducer Specifications

Parameter	Value
Nominal Operating Frequency	50kHz
Bandwidth by the level- 6dB in the emission/receiving mode	25-80 kHz
Ultrasonic Wave Type	Shear Waves



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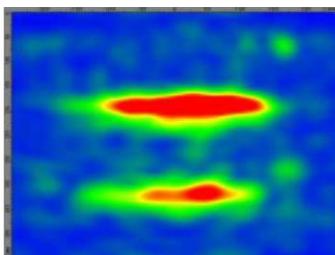
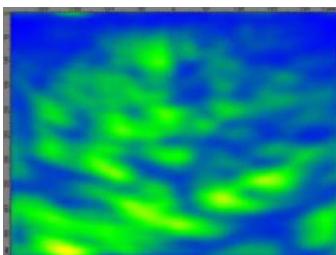
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Other Applications

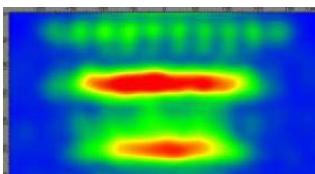
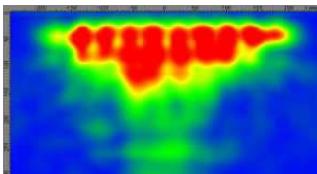
Quality Assurance & Detection of Voids

The Mira is ideal for confirming proper consolidation of concrete pours, the image on the left below shows a honeycombed structure and the image to the right a solid wall section.



Bond strength

Bonding of tiles, stone slabs or precast panels can be tested with the MIRA, a bad bond will show an intense reflection from the bonded point and no back wall reflection. The left image shows a debonded panel and the right one with a good bond.

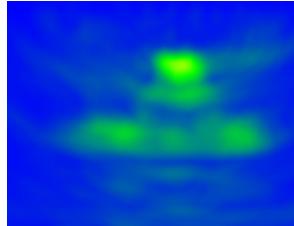
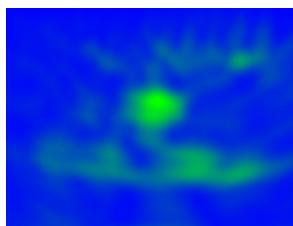


Locating ungrouted post tensioning ducts.

"In a well grouted region of the duct, the part of ultrasonic waves penetrating in the duct is also reflected from the back side of the duct. So it will be imaged in the SAFT reconstruction additionally to the upper side of the duct. The badly grouted areas can be localised, because here the reflection from the back side is not apparent."

O. Paris, J. M. Rambach, G. Nahas, 2003, 'Study of phased array techniques for cracks characterization in concrete structures', Non-Destructive Testing in Civil Engineering 2003, 2003, viewed 12 October 2011, <<http://www.ndt.net/article/ndtce03/papers/v051/v051.htm>>

The left image below shows an un-grouted section, note there is no reflection from the back wall of the duct and the reflection from the slab's base is attenuated, the right image shows a correctly grouted duct with the characteristic second reflection from the duct and clearer rear wall image.



Form supplied

- A1040 MIRA-tomograph ultrasonic unit
- Detachable battery
- Charging unit
- USB connection cable
- Transportation Case

Recommended Technical Specifications for Ideal Viewer Software

- Intel Core2 Quad 2GHz or better
- 2Gb or more of Ram
- 150Gb or greater Hard Disk or SSD
- Nvidia Graphics card with 512mb ram and CUDA 2.0 or greater
- 1024 * 768 or greater screen resolution

About PCTE

PCTE have over 30years experience in the measurement and testing of concrete. With experience in research, consulting and construction they are able to assist you in reviewing the issues and developing solutions. PCTE can provide more than just the equipment. They can provide leading technical support for your business.

Other Equipment

Acsys also offer the Eyecon Monolith, a smaller handheld DPC ultrasonic array and the Surfer dpc surface ultrasonic tester and crack analyser.

The Olson Instrument range includes the CTG, Freedom Data PC and DAS as well as the resonance tester.

The full Proceq range of equipment is available for insitu non destructive concrete measurement, including Schmidt Hammers, Covermeters, Half Potentials, Resistivity, Ultrasonics and Permeability.

We also supply Intelli-Rock maturity, temp and humidity logging systems, corrosion rate monitoring equipment, Ground Penetrating Radar.