

Overview of A-Line32D Series AE Systems, Produced by INTERUNIS, Ltd.

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Abstract. INTERUNIS, Ltd has worked in the field of Non-Destructive Testing since 1988, it develops and produces Acoustic Emission (AE) equipment and complex diagnostic monitoring systems. The 18-year experience has allowed to create A-Line AE systems family for AE data acquisition and processing that has become the INTERUNIS Trade Mark.

A-Line 32D AE systems series innovations are overviewed in the paper. Several digital multi-channel AE systems are presented in new generation of A-Line 32D series. Along with A-Line 32D(PCI-8) AE system, which has a traditional design and an analog data transmission from preamplifier to the host computer over a coaxial cable, there is a new type of noise-immune A-Line 32D(DDM) AE systems – module systems for AE data acquisition and processing with a digital data transmission over a serial high-speed cable link or a wireless radio channel.

Introduction

INTERUNIS, Ltd has worked in the field of Non-Destructive Testing since 1988. It engages in development and production of Acoustic Emission (AE) equipment and complex diagnostic monitoring systems. INTERUNIS performs an expert examination of civil construction and industrial equipment for industrial safety. The company carries out its own scientific researches [1].

In 1992-1993 the first IBM PC based A-Line 8S and A-Line 16S multi-channel AE systems were produced. These systems initiated the A-Line family of multi-channel AE systems.

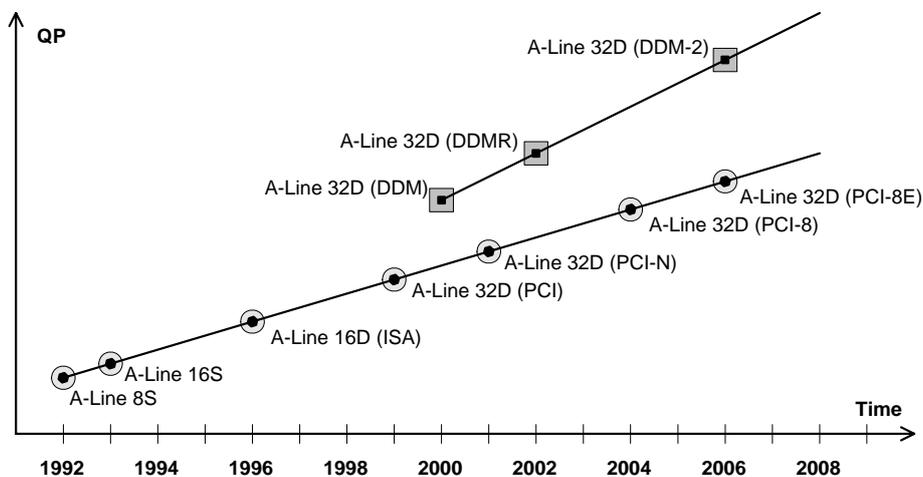


Fig. 1. A-Line AE Systems Family

The first software for AE systems appeared simultaneously with production of the first AE devices. It included the core set of functions required for AE data acquisition and further processing.

Fig. 1 shows the entire spectrum of AE hardware, produced by the company in different years.

Up to now INTERUNIS has produced more than 250 AE systems of the A-Line family and four generations of software. High quality and reliability are approved by ISO-9001:2000.

The last generation of AE systems is presented by A-Line 32D series. The A-Line 32D AE systems software is realized in Windows 9x, XP environment. It is easy to use and provides wide abilities for AE data processing.

1. A-Line 32D Series AE-Systems

1.1 Hardware

As it is evident from Fig. 1, the production of the multi-channel AE systems of traditional design has continued. In A-Line 16D(ISA), A-Line 32D(PCI), A-Line 32D(PCI-N) and A-Line 32D(PCI-8) AE signals are transferred from a preamplifier to the host computer in an analog form over a coaxial cable. Mostly these AE systems were developed evolutionary. Each new AE system model involved new technologies, it had the improved characteristics and additional functions.

In the end of 2000 in parallel with development of traditionally designed AE systems, A-Line 32D(DDM) AE system with digital data transmission was introduced. It was absolutely different from all previous representatives of the A-Line 32D family. The particular feature of this AE was a relocation of the AE measuring and processing hardware from the host computer to the devices to be installed directly on an object under testing. Such devices were named as an AE-module.

1.1.1 A-Line 32D(PCI, PCI-N, PCI-8)

Representatives of AE systems of the traditional design for installation into the host computer (Fig.2). They are complete multi-channel PC boards for AE data acquisition and processing.

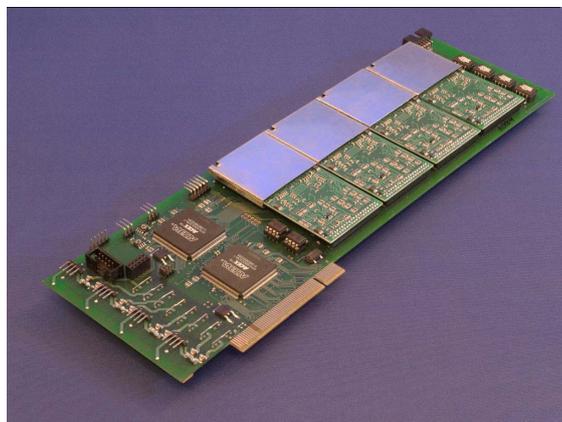


Fig. 2. A-Line 32D(PCI-8)

The multi-channel AE systems of such design have excellent characteristics, high

performance and are suitable both for field works and scientific researches.

Table 1 shows the progress of traditional AE systems characteristics and their distinctive features.

A single type of AE system of the traditional design – A-Line 32D(PCI-8) is in full-scale production now. However, the previous representative of this class – A-Line 32D(PCI-N) AE system with an extended frequency range (up to 1 MHz) is still in favour as a low-cost variant of the AE data processing board for scientific researches.

Table 1. Characteristics of Traditional AE Systems Produced by INTERUNIS,Ltd

AE system	A-Line 16D (ISA)	A-Line 32D (PCI)	A-Line 32D (PCI-N)	A-Line 32D (PCI-8)
Number of AE channels on PC-board	4	4	4	8
Maximum number of AE channels in one unit	32	32	32	64
Performance	> 4000 [Hits/sec]	>10000 [Hits/sec]	>20000 [Hits/sec]	>20000 [Hits/sec]
ADC resolution and sample rate	12-bit, 5 [MHz]	16-bit, 5 [MHz]	16-bit, 5 [MHz]	16-bit, 2 [MHz]
Maximum AE signal amplitude	92 [dB]	96 [dB]	100 [dB]	100 [dB]
Dynamic range	66 [dB]	78 [dB]	84 [dB]	84 [dB]
Frequency Bandwidth	10 – 500 [kHz]	30 – 500 [kHz]	1 – 500 [kHz]	1 – 500 [kHz]
Variable Gain Amplifier	0 ÷ -60 [dB]	-	-14 ÷ + 26 [dB]	-
Filters	analog	analog	analog, 4 HP and 4 LP	digital, programmable
Waveform	1 channel per system	1 channel per system	4 channels on PC-board	8 channels on PC-board

A-Line 32D(PCI-8) is a complete 8-channel AE system on one PCI board with a full-speed interface (up to 132 MBytes/sec). First of all it is intended for field testing.

The boards are equipped with high-performance DSPs, high-density FPGAs and a fast memory. It has made possible to obtain per-channel programmable high-quality digital filters with slope up to 60 dB/octave.

Among other advantages of A-Line 32D(PCI-8) it is possible to list the high accuracy of amplitude measurement, absolute energy dynamic range of 120 dB, time resolution of 1 μ s for AE parameters measurement.

A-Line 32D(PCI-8) has the possibility of waveform and spectrum real-time analysis for each channel.

Along with eight AE channels each A-Line 32D(PCI-8) PC board contains two 12-bit parametric inputs. One is intended for ± 5 V voltage measuring, another for $\pm (0 \div 25)$ mA current measuring.

1.1.2 A-Line 32D(DDM, DDM/R)

The multi-channel modular AE system with the serial high-speed digital data channel for distributed acquisition and processing of AE signals.

The A-Line 32D(DDM) AE system is shown in Fig. 3. It consists of the host computer and several measuring lines. Each measuring line is a set of serially connected AE-modules (one per channel) for acquisition and processing of AE signals. AE signals amplifying, filtering, analog-to-digital conversion and further digital processing and determination of AE parameters are performed in the AE-module, placed near the AE sensor directly on the tested object.

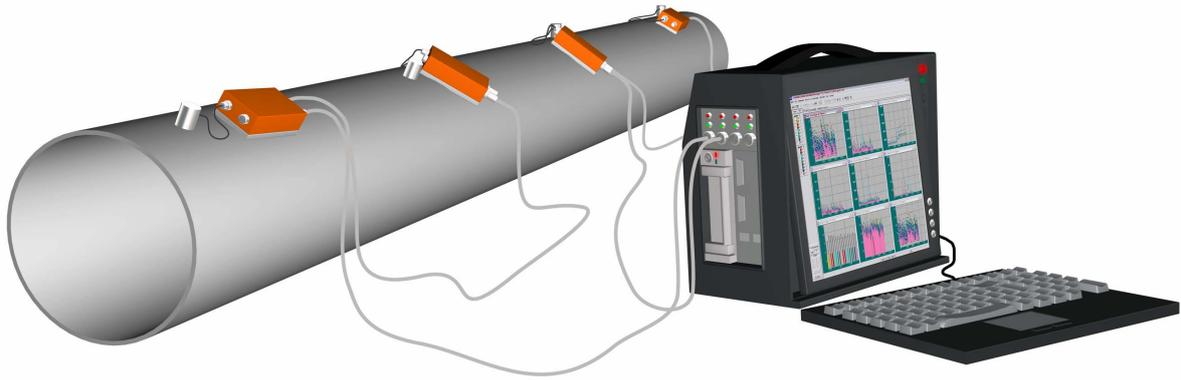


Fig. 3. A-Line 32D(DDM)

Every AE-module contains:

- Low-noise ($< 5 \mu\text{V}$) variable gain amplifier, 20 to 60 dB in 1 dB step;
- 5-th order 4 LP and 4 HP switchable filters;
- 14-bit, 1 MHz ADC;
- DSP, FPGA and memory.

Each AE-module is equipped with a pulse generator (10 to 140 V amplitude) for AE signal simulation and four 12-bit parametric inputs for connecting additional sensors.

One of A-Line 32D(DDM) advantages is a galvanic isolation of measuring channels.

AE signals' parameters and waveforms are transferred by the AE-modules to the measuring line controller in the host computer in a digital form.

One system unit may include up to 8 measuring line controllers, each servicing up to 12 AE-modules. 100-m segments of the data transmission cable result total measuring line length up to 1.2 km. The simultaneous use of two measuring lines allows to test a pipeline linear section having a length above 2 km at once. The digital data transmission makes it possible to avoid signal attenuation and interference, occurring during the analog signal transfer over the coaxial cable lines.

A-Line 32D(DDM) has a high performance of at least 1000 AE events for each channel and transfers AE signals waveforms simultaneously from all AE-modules.

Using the digital data transfer, INTERUNIS engineers could fit out the AE system A-Line32D(DDM) with the complete set of wireless communication.

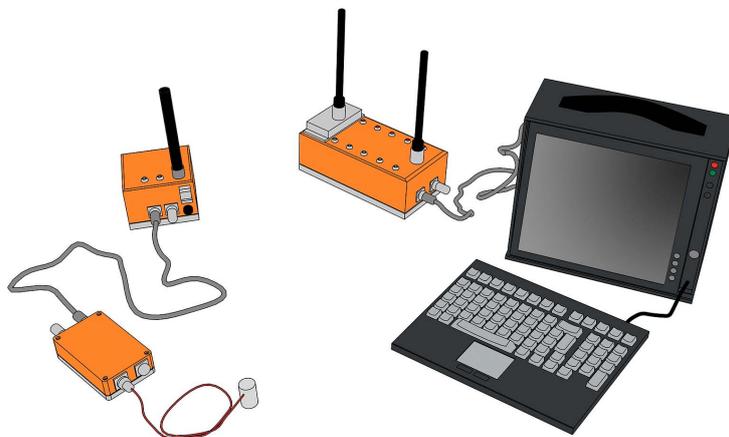


Fig. 4. A-Line 32D(DDM/R)

- built-in utilities for measuring velocity and attenuation of AE signals;
- various location schemes: linear, planar, zone, 3-dimensional (3D), vessel, sphere, tank bottom;
- AE sources location results can be applied to flat or 3-dimensional model of tested object;
- various methods for calculation of coordinates: AE arrival time or maximum amplitude time difference, triangular or rectangular algorithm with adjustable speed;
- object clusterization by a number of located AE events and AE-source calculated amplitude allows to evaluate the class of defect danger;
- weld map or even the whole object can be applied to any window in on-line and off-line mode for better representation of location results;
- control reliability can be increased by applying flexible criteria for automatic removal of false AE signals (such as electromagnetic noise, refraction of AE signals) in on-line and off-line modes;
- data files concatenation for off-line mode processing;
- AE data filtering based on any single parameter or complex formula, on location and clusterization data, on noise and parametric data, graphical filtration;
- representation of any AE parameter dependency versus any other AE parameter, time, location coordinates and parametric data, bar graph representation of any AE parameter distribution;
- classification of AE signals assigns a class number according to amplitude, location-dynamic and integral criteria;
- built-in spectrum analysis of AE signals;
- built-in correlation analysis of AE signals and their spectra registered by different sensors;
- export of all types of data to ASCII format for advanced processing.

All the features listed above are included into the base A-Line 32D software.

Fig. 6 shows the specialized software for continuous AE monitoring system with multi-level access to settings and testing results depending on operator access rights.

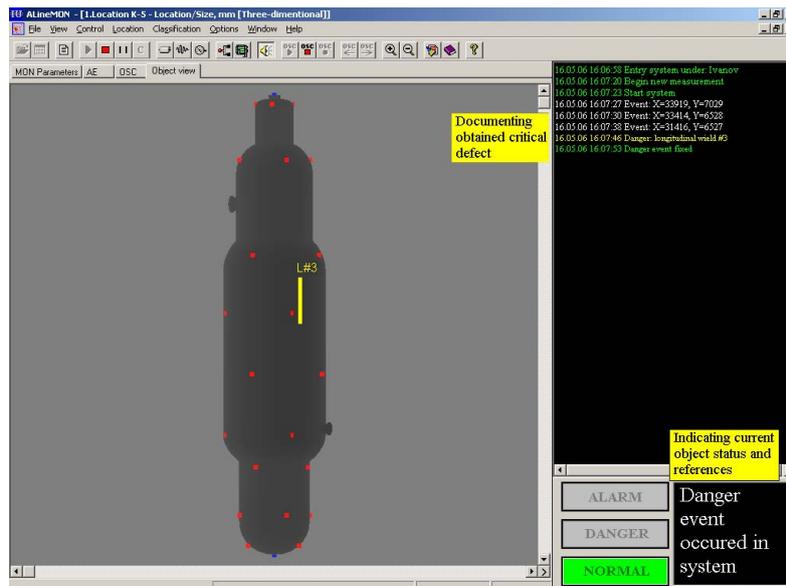


Fig. 6. Monitoring Software

AE monitoring software provides continuous acquisition, processing and storing of data from a large number of sensors. It logs the detailed report about system events and personnel activity. Multi-factor data analysis provides impartial results of diagnostic monitoring. In case of danger, the AE monitoring system will turn on sound and light alarms, and will suggest the way to eliminate hazard.

AE monitoring software also provides statistical processing and database maintenance.

2. Announcements

INTERUNIS, Ltd continues development of the AE hardware. In 2006-2007 some new representatives of A-Line 32D family will appear.

A-Line 32D(PCI-8E). Multi-channel AE system of the traditional architecture with improved characteristics: the 16-bit, 5 MHz ADC on a single 8-channel PCI board, better digital filters and new algorithms of data processing due to increased DSP power and FPGA capacity.

A-Line 32D(DDM-2). The result of development of modular AE system with the digital data transfer. A-Line 32D(DDM-2) will keep the existing design and all positive properties of this type of AE systems. Furthermore, A-Line 32D(DDM-2) will have better characteristics and a number of new features.

The AE-modules will use 16-bit ADC with 2 MHz sample rate for the AE channel. They will have programmable digital filters. Due to optimization A-Line 32D(DDM-2) will have reduced power consumption and weight.

Among new functions of the AE-modules the following ones can be also listed:

- 3 additional low-frequency channels for connecting 3-component sensors;
- 2 inputs for direct connection of strain gage bridges;
- 2 parametric inputs for current and voltage measurement;
- built-in pulse generator with 2 operation modes for the AE-module self-testing and for checking arrangement of other channels' AE sensors.

A-Line 32D(DDM-2) will be able to handle up to 16 AE-modules on one measuring line. It will extend the simultaneous testing zone above 3 km. AE-modules will be equipped with a jack for the wireless headset connection for a voice communication with the host computer operator to make the work easier under field conditions.

A-Line 32D(DDM/R2, DDM-2/R2). A new set for wireless data transfer. While keeping the former operation period and communication range, it has smaller dimensions and weight.

A-Line 32D(DDMR-C). A combined version of the AE-module and receiving-transmitting device in a common case for special applications.

References

[1] <http://www.interunis.ru/>

[2] Kharebov, V. G., Trofimov, P.N., Aljakritsky, A.L., 2004, MULTI-CHANNEL ACOUSTIC-EMISSION SYSTEM FOR TESTING INDUSTRIAL OBJECTS, Pat. № RU 2267122.