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LOW FREQUENCY ACOUSTIC (IMPEDANCE) FLAW DETECTORS OF THE NEW GENERATION AND THEIR APPLICATION

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Multilayer constructions and objects made of polymer composite materials have found its application in aviation and space industries. Low-frequency acoustic methods are widely used for inspection, *viz* impedance and free oscillation method. "RII MSIA "Spectrum" has designed and has been manufacturing the AD-42IP and AD-64M flaw detectors operating on the basis of the above methods.

AD-42IP is the development of the impulse impedance flaw detectors AD-42I and AD-42IM. Its distinguishing feature is digital signal processing. The power of received signal, Db, is under monitoring. This is a portable device with battery power supply that allows inspection in hard-to-reach zones and closed space. To decrease power consumption we monitor the contact between the probe and an object that stops excitation of oscillation. Basic parameters and oscillogram are displayed.

The on-screen menu assists adjustment, previous operational parameters are stored automatically and an operator can start the inspection at once. The received signal can be stored and transferred to PC via IR unit.

AD-64M is a computerized system that comprises an electronic unit and PC connected to that via USB interface. Modifications feature the connection with a pocket PC via Bluetooth interface. AD-64M also employs the method of free oscillations that allows inspection of objects with soft external elements. Spectral data processing is used. The difference between the current and reference spectrum serve for a flaw. It enhances the sensitivity and informativeness. The device features many service options: storage, processing and representation of data and inspection parameters.

The above devices are certified and applied to inspect parts of aeronautical and space engineering (rotor and oar blades, plain elements and skin), pipeline isolation and others.

Key words: acoustic impedance, flaw detection, low frequency

1. Introduction

Multilayer constructions and objects made from polymer composite materials have found its application in air and space industry. To test them low frequency acoustic methods are often used – impedance and free oscillations method. JSC "RII MSIA "Spectrum" has developed and manufactured the AD-42IP and AD-64M flaw detectors based on the above methods.

2. Acoustic flaw detector AD-42IP

AD-42IP is the improved impulse impedance flaw detector AD-40IP and its modification AD-42IM.

Fig. 1. General view of the AD-42IP flaw detector

Its distinguishing feature is digital data processing. It is a portable device with autonomous power supply that allows testing in hard-to-reach and closed places. To decrease power consumption, the device monitors the transducer's contact to an object tested and switches off generation of excitation when the contact is lost. The basic operation parameters and signal oscillogram are displayed.

Figure 2. General view of the AD-42IP display

A LED on a transducer and alarm sound signal about a defect revealed. The device is calibrated through a display menu and previously set operation parameters are stored and when the device is switched on an operator can start testing at once. The measured signal stores into the devices memory and can be transferred to a PC.

The device is completed with three types of transducers:

PA-7R – transmit-receive transducer for laminated materials with defect depth up to 20 mm;

PA-5R - transmit-receive transducer for defect depth up to 10 mm;

PA-4S - combined transducer for undersurface defects.

The block diagram explains the device operation (see Fig. 3).

Fig. 3. Block diagram of the AD-42IP flaw detector

Depending on the transducer type, the electronic unit accordingly sets the mode of the digital filter (DF) and the pulse generator (PG). When contacted to a tested surface, the transducer turns on excitation through the micro switch. The excitation starts high-voltage transducer (HVT) and PG and excitation signal comes periodically to the transducer. The coming signal excites the radiating piezo-element of the vibrator of the combined (or transmit-receive) transducer. The vibrator generates pulses of damped elastic oscillations in a tested object, the amplitude and carrier frequency of the pulses being depended upon mechanical impedance of the object tested. The pulses affect the receiving piezo-element of the vibrator and they convert into electrical signals that go to the front amplifier (FA). When passed through the programmable amplifier (PA), high-cut filter the signal digitizes in ADC and goes to DF. DF processes ADC signals and automatically adjusts amplification (AAA) in PA and controls the excitation of PG. The central processor (CP) sends data to the display (D), receives commands from the keyboard (KB), stores the data in an energy-saving memory (ESM), and transfers data to PC via infrared channel. Automatic alarm defect system (AADS) is used to switch on the transducer's LED and sound alarm system when signal exceeds the lower or upper threshold of AADS.

According to running conditions, the device can reliably work at:

Temperature range: -10…40C
Relative humidity 80% at +25C
Atmospheric pressure 84,0…106,7kPa

3. The AD-64M acoustic flaw detector

The AD-64M acoustic flaw detector is a computerized system that consists of an electronic unit and a PC connected to it via USB interface.

Fig/ 4. General view of the AD-64M

There is an AD-64M electronic unit design that allows connection to a pocket PC via Bluetooth interface. Apart from the impedance testing method, the device employs the free oscillation testing method that covers testing of objects with soft outer elements. The device uses spectral data processing. The difference between the current and the reference spectra results in defect that enhances the sensitivity and reliability of inspection. The flaw detector provides wide range of options for data storage, data processing and displaying of data and test parameters.

The device is completed with two types of transducers:
PI-1 – for impedance testing method;
PS-2 – for free oscillation testing method.

The block diagram explains the device operation (see figure 5).

Fig. 5. Block diagram of the AD-64M flaw detector

When a transducer 1 is linked to the flaw detector, the transducer's code comes to the exciter 4 of the electronic unit 2. According to the received transducer's code, the exciter generates and sends driving pulses to the transducer, the frequency being set by the generator 5. As a result, the transducer excites acoustic pulses in a tested object. The acoustic signal from the tested object is received by a microphone (PS-1 transducer) and converted into an electrical signal. In case of the PI-1 impedance transducer, the receiver of the signal is the receiving piezo vibrator. The received electrical signal through the front amplifier 6, variable bandwidth filter 7 and programmable amplifier 8 comes to ADC 9 that quantizes it and converts it into a digital code of each sample capture. The code is sent through the interface 11 to a PC 3. The PC is capable to receive 256 measurements of the analog signal. The driving generator 5 synchronizes the operation of all elements of the flaw detector.

4. Conclusion

The above flaw detectors are certified and used to test parts and elements of air and space engineering (oar and rotor blades, airplane elements and skin), pipeline isolation, etc.

References:

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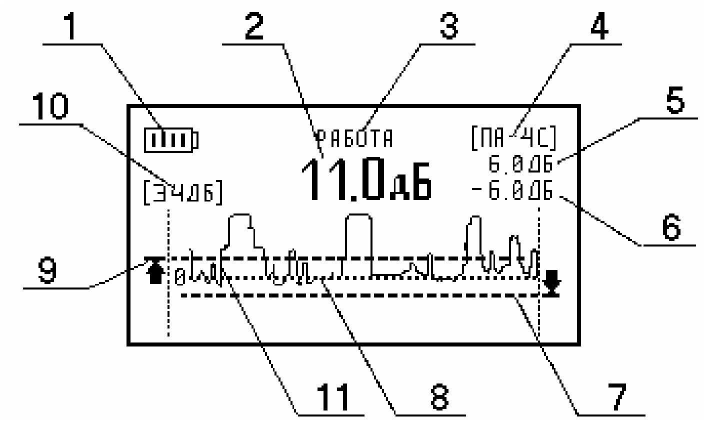
Fig. 1. General view of the AD-42IP flaw detector



1 – battery; 2 – signal; 3 – operation mode; 4 – transducer type; 5 – upper threshold; 6 – lower threshold; 7 – lower threshold line; 8 – reference level line; 9 – upper threshold line; 10 – scale; 11 – signal oscillogram.

Fig. 2. General view of the AD-42IP display

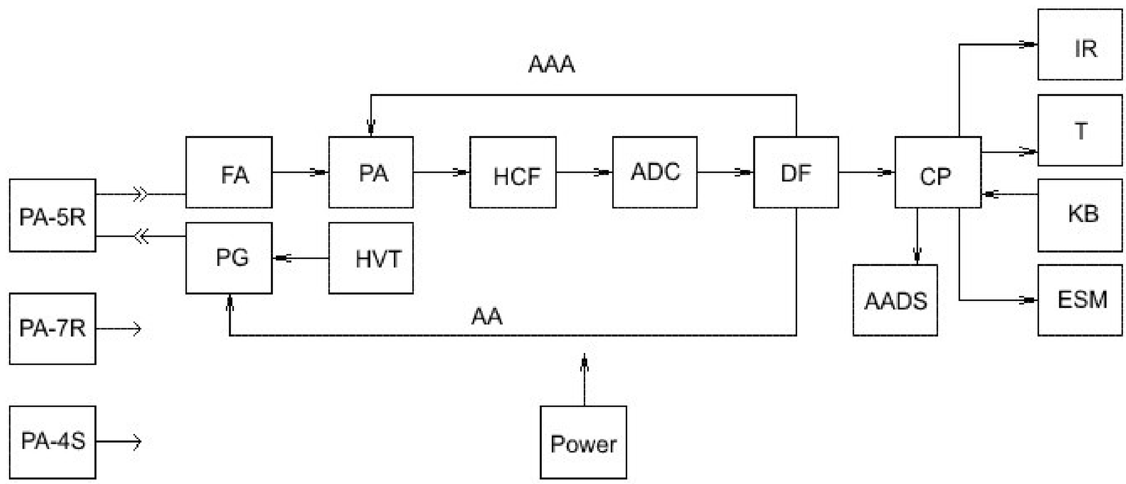
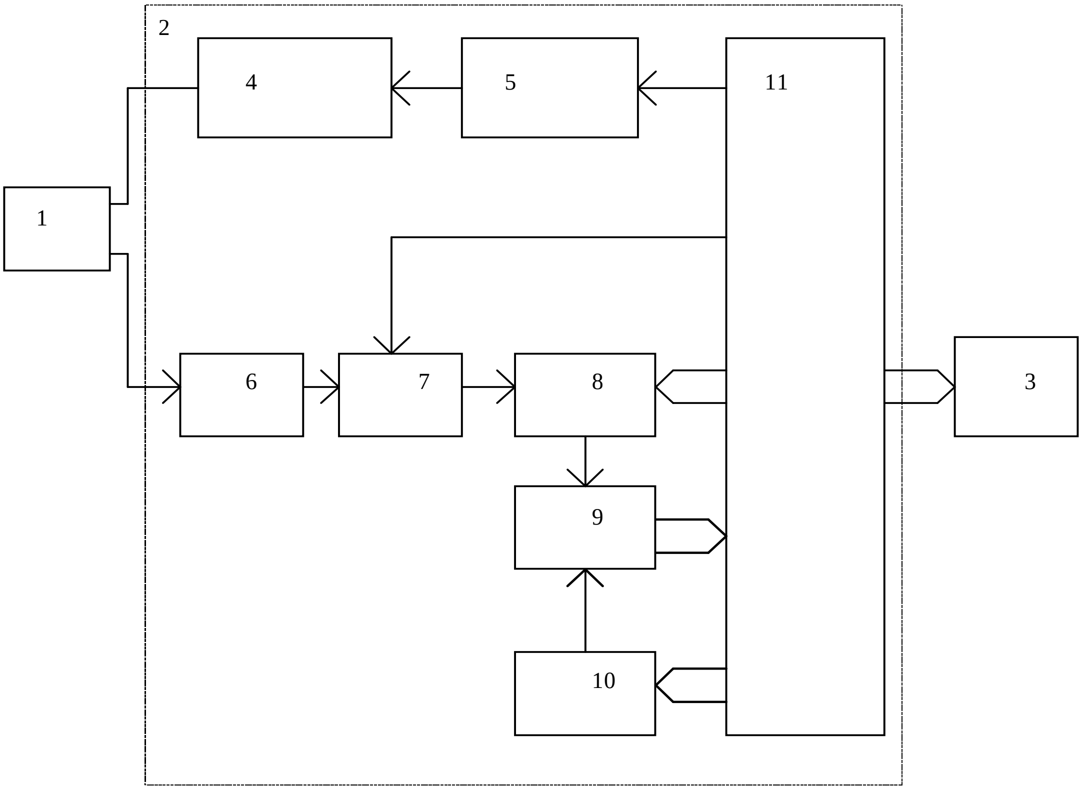


Fig. 3. Block diagram of the AD-42IP flaw detector

Fig. 4. General view of the AD-64M



1 – transducer; 2 – electronic unit; 3 – PC (laptop); 4 – exciter; 5 – driving generator; 6 – front amplifier; 7 – variable bandwidth filter; 8 – programmable filter; 9 – ADC; 10 – programmable timer; 11 – interface.

Fig. 5. Block diagram of the AD-64M flaw detector