
HILL-SCAN 3XXX-Ultrasonic-PC- Boards for different Applications

Abstract

*In order to use the high performance resources of Personal Computers directly for ultrasonic inspections, PC-pulser/receiver boards were developed. A wide range of materials requires different pulser/receiver boards HILL-SCAN 30XX, which enable ultrasonic inspections from **30 kHz to 35 MHz** with a signal to noise ratio up to **60 dB**. Dependent on the application (manual testing or imaging), different ADC- boards with frequencies up to 400 MHz (single-shot) are used. Software is available for all inspections. Typical applications are: material characterization and -testing (concrete, components of nuclear power stations, welded joints, new materials and thin layers), ultrasonic imaging and transducer qualification.*

1. Introduction

The rapid development of the computer technique and the decreasing prices in spite of the increasing of performance have spread the use of personal computers (PCs) not only for industrial use but also for private use. Also, in spite of increasing requirements measurement and test systems become more and more economical , including NDT-systems.

In order to be able to reduce prices, even more and more test- and measurement systems are integrated on PC-boards. The powerful and inexpensive PC components can be directly used for these (virtual) instruments. The limited dimensions of the PC boards require a reduction to the absolute necessity of the electronic components. Analogue signal processing must be carried out by software as far as possible.

We decided already in 1994 to develop PC boards for ultrasonic inspections [1, 2].

2. Hardware Requirements

The requirements for an ultrasonic PC-board depend on the material and the dimensions of the component and on the type of inspection (manual or automatic inspection, with or without imaging).

Materials to be inspected are, for example: Concrete with test frequencies of about 50 kHz, sandwich components with 500 kHz, metallic materials up to 10 MHz and thin components up to 35 MHz. Apart from the difference of materials, variable thicknesses and attenuations require different amplifications and signal processings.

In order to obtain a high signal-to-noise ratio sufficient acoustical power is necessary. For special applications a programmable pulser (transmitter) is required in order to optimize the frequency spectrum.

Additional requirements have to be met, such as norm DIN 25450 for manual testing. This norm describes the requirements of transmitters, receivers and other parts of the system.

For ultrasonic imaging systems (B-, C- and C-scans) single-shot measurements, fast data recordings, and fast data transfer must be performed.

The ultrasonic hardware has to be designed to fit the PC boards. The length of the board should only be 160 mm for convenient installations because memory modules and processor cooler can be located behind the 160 mm long slot connector on the motherboard.

Apart from the technical data, the customer expects good price/performance-ratio.

3. Ultrasonic Flaw Detector for PCs

3.1 Conception

The developed PC flaw detector consists of a pulser/receiver board and a digitizer board. This separation enables a large flexibility for all applications. A single pulser/receiver board and a single digitiser board (also a single stand-alone flaw detector) cannot fulfil all requirements. Therefore, different HILL-SCAN 30XX pulser/receiver boards were developed, listed in Table 1. In addition, a programmable HILL-SCAN 3100 pulser was developed for materials with high sound-damping such as concrete or the testing with air coupling.

3.2 Design of the HILL-SCAN 30XX boards

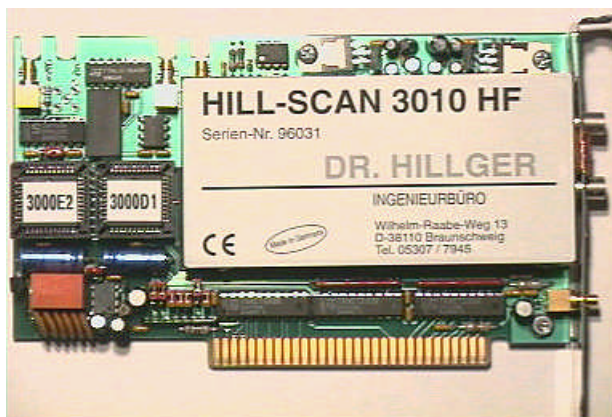
Special electromagnetic shieldings, high quality pulsers and amplifiers, and special power supplies provide excellent characteristics such as high dynamic range, high resolution and A-scans without PC-noise. Therefore, the PC boards are for some applications superior to stand-alone flaw detectors. The signal to noise ratio of up to 60 dB and the frequency range of 1 kHz to 35 MHz (-3 dB) establish new standards. Fig. 1 shows the HILL-SCAN 3010HF board with a length of 160 mm.

The HILL-SCAN boards contain the following subsystems:

- a pulser (transmitter) with selectable damping
- a low noise and broadband amplifier with a digital gain setting of 0 to 106 dB
- high and low pass filters
- an external trigger input with programmable divider
- a trigger unit for the pulse repetition frequency with external clock input

- a low noise power supply unit

- an interface to the PC-ISA-BUS.



*Fig. 1:
Ultrasonic pulser/receiver PC-
board*

3.3 Pulser

The VMOS-pulser with a rise time lower than 6 ns provides high axial resolution and high-frequency inspections above 10 MHz with an excellent signal-to-noise ratio. The output voltage amounts to about 228 V without load, and 194 V with a load of 75 Ω . A damping control from 75 Ω to 360 Ω matches the impedance to the transducer.

3.4 Receiver Amplifier

The pulser/receiver is completely shielded and therefore receives no noise coming from the PC components. The input connector is a Lemo 00 coupler. The extremely low noise amplifier with a maximum amplification of about 90 dB accommodates very small signals. A precise gain setting is possible up to 106 dB.

In order to get an extremely high resolution and a small „dead zone“ (after the transmitter pulse) single amplifier states must have a bandwidth up to 90 MHz (!), and a total bandwidth of 35 MHz (-3 dB) can be reached (HILL-SCAN 3010HF). High- and low-pass filters can be combined to band-passes and provide optimal A-scans. All parameters are controlled by software.

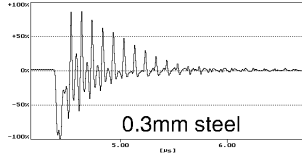
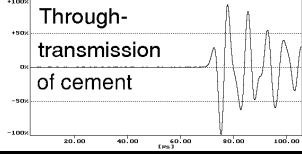
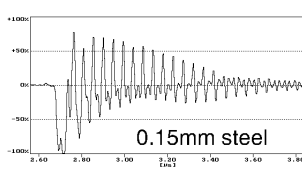
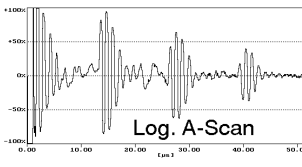
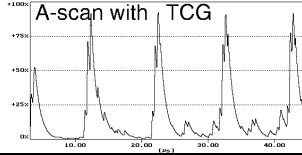
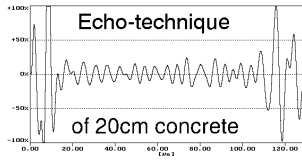
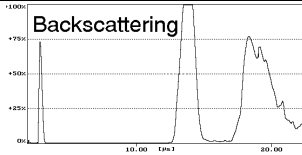
3.5 External Trigger Input

The external trigger input allows automatic inspections and ultrasonic imaging. The clock signal of an encoder or of stepper motors can be used as a trigger for the pulser. An internal software controlled divider allows different scan resolutions.

3.6 Programmable Pulser HILL-SCAN 3100

The transmitter board HILL-SCAN 3100 provides a higher acoustic energy than the usual spike pulsers. It generates rectangular pulses with programmable widths from 0,16 to 2,4 μ s, or rectangular burst signals from $n = 2$ to $n = 10$. Frequency and

bandwidth of the transmitter pulses can be set over a large range. The usable frequency range is about 50 kHz to 5 MHz.

HILL-SCAN Frequency range (-3 dB)	Highlights	Applications	
3010 < 0.1 to 20 MHz	<ul style="list-style-type: none"> • Inspection of metals, composites, general purpose 	<ul style="list-style-type: none"> • Damage detection in materials • Characterization of materials and probes 	 <p>0.3mm steel</p>
3011 NF < 0.01 to 10 MHz	<ul style="list-style-type: none"> • Optimized for materials with high sound damping 	<ul style="list-style-type: none"> • Inspection of mineral building materials • Characterization of concrete and cement 	 <p>Through-transmission of cement</p>
3010 HF < 0.1 to 35 MHz 3010 VHF < 0.1 to 70 MHz	<ul style="list-style-type: none"> • Extremely high resolution (0.15 mm steel) 	<ul style="list-style-type: none"> • High-frequency ultrasonic testing • Thickness measurements • Transducer characterizations • Inspection of thin layers 	 <p>0.15mm steel</p>
3020 LOG < 0.1 to 10 MHz	<ul style="list-style-type: none"> • Logarithmic amplifier with 100 dB dynamic range without gain setting 	<ul style="list-style-type: none"> • Components with different thickness 	 <p>Log. A-Scan</p>
3040 DAC < 0.1 to 20 MHz	<ul style="list-style-type: none"> • TCG up to 40 dB 	<ul style="list-style-type: none"> • Inspection of thick components 	 <p>A-scan with TCG</p>
3041 NF < 0.01 to 20 MHz	<ul style="list-style-type: none"> • Echo-technique for concrete • TCG up to 40 dB 	<ul style="list-style-type: none"> • Inspection of materials with high sound damping and thick components (Echo-Technique) • Characterization of concrete and cement 	 <p>Echo-technique of 20cm concrete</p>
3050 < 15 to 25 MHz	<ul style="list-style-type: none"> • Built-in video unit with peak holder 	<ul style="list-style-type: none"> • Measurement of backscattering in metals for the detection of the effective hardening depth 	 <p>Backscattering</p>
3100	Programmable pulser, delivers rectangular or burst- signals	provides high acustical power for materials with high sound attenuation, centre frequencies: 50 kHz to 6 MHz	The transmitter generates rectangle pulses with programmable duration from 160 ns to 2.4 μs (n=1) or bursts with n = 2 to 15 with the same duration.

Tab. 1: PC-boards for ultrasonic inspections

In testing materials with high sound damping, the burst transmitter increases the signal-to-noise ratio to, typically, 12 dB. Typical applications: honeycomb and concrete components, and air-coupled testing.

3.7 ADC-Boards

The sample frequency of the ADC (analogue to digital converter) should be 8 times higher than the test frequency (centre frequency of the spectrum). In dependence of the application, different ADC-boards are used. A standard board (20520) provides 8 bit resolution and up to 100 Msamples/s in single shot mode. For manual tests, up to 400 Msamples/s can be reached in the repetition mode. For scanning systems with high frequencies boards up to 400 Msamples/s (single shot) are available.

3.8 Software

The software WinHillgus provides all functions of a portable flaw detector and a powerful ultrasonic imaging in A-, B-, C- and D-scans. Not only motor driven scanners can be used, but also manual scanning systems with encoders.

Further documentation and test reports can be carried out with Windows™ software.

Special software (HILLGUS) was also developed for material characterizations such as the determination of the modulus of elasticity for building materials.

4. Applications

The HILL-SCAN 30XX boards can be used in different PCs. Desktop- and tower-PCs as well suited for laboratory uses. For in-field inspections rugged notebooks and portable PCs are advantageous. A typical portable system is shown in Fig. 2 (USPC 3010), used in MUSE (Mobile UltraSonic Equipment). This portable PC does not only contain the boards for ultrasonic testing but also a controller with power supply for stepper motors, so that a manipulator can be connected directly. The MUSE-system is enlarged with a water circulation system which enables a „local immersion technique“ for in-field inspections. A typical result is shown in Fig. 3, which presents a D-scan of a CFRP- component in RTM-techniques. The defect area caused by an impact is clearly indicated. The manipulator is described in [3].

Fig. 4 presents an A-scan of a 0,15 mm thick steel plate. The RF-A-scan (sampled with 400 MHz) clearly separates the backwall echoes and demonstrates the high resolution of the HILL-SCAN 3010HF with a 50 MHz transducer.

Fig. 5, also an A-scan, shows the possibility of the echo-technique for concrete. The interface and backwall-echo of a 20 cm thick concrete specimen are displayed (RF-

display). A HILL-SCAN 3041NF board and a broadband transducer (40mm element \varnothing) are used which enable optimal pulse parameters in a range of 50 to 150 kHz. Remarkable for concrete inspections is the high signal-to-noise ratio of about 18 dB.

Fig. 6, a B-scan of a 15 mm thick sandwich with Nomex cores and GFRP-skins, clearly shows the depth of the two defects in the core [4]. A HILL-SCAN 3010 board and a broadband probe (0,8 to 3 MHz) were used. In regions without defects, the backwall-echo is indicated.

5. Summary

In order to test a wide range of materials a serie of ultrasonic pulser/receiver boards has been developed. In combination with an ADC-board (analogue-to-digital converter) a PC can be converted to a high performance ultrasonic system not only for manual testing but also for automatic testing and imaging systems.

The HILL-SCAN 30XX boards enable ultrasonic inspections from 50 kHz (concrete inspections) to 35 MHz (inspection of thin layers) with a signal to noise ratio up to 60 dB. The gain setting range of the receiver is 106 dB. High- and low pass filters in the receiver can be combined to band-passes, so that optimal A-scans are displayed.



Fig.2: Portable PC used as ultrasonic system

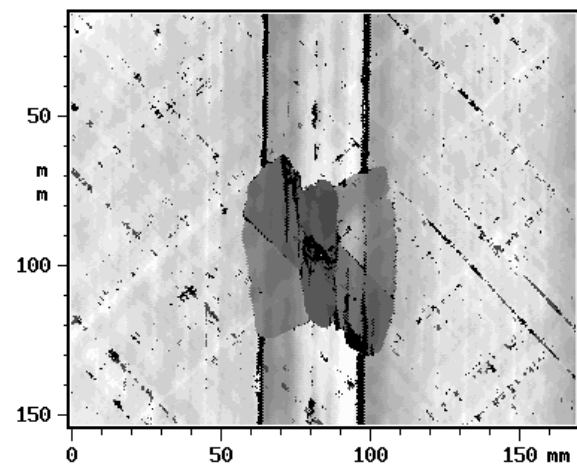
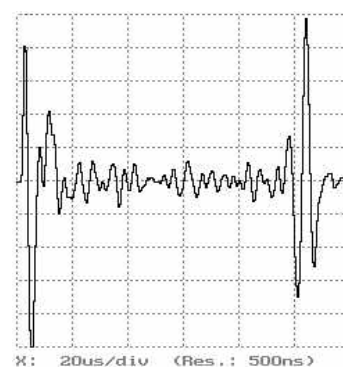


Fig.3: D- scan of an impacted RTM-panel (MUSE with HILL-SCAN 3010)



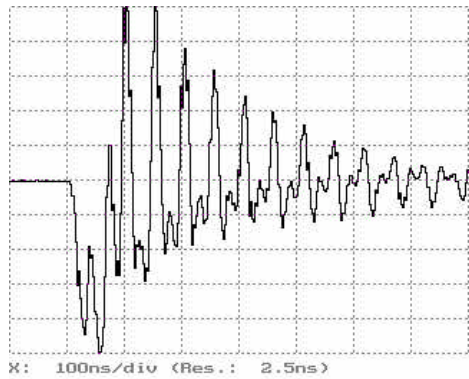


Fig. 4: A-scan of a 0.5 mm steel plate (RF-recording) with 400 MHz sample frequency (HILL-SCAN 3010HF), 0.1 V/div. and 100ns/div.

Fig. 5: Echo-technique for concrete inspections with HILL-SCAN 3041NF; interface- and backwall echo of a 20 cm thick concrete specimen, 0.1 V/div. and 20µs/div.

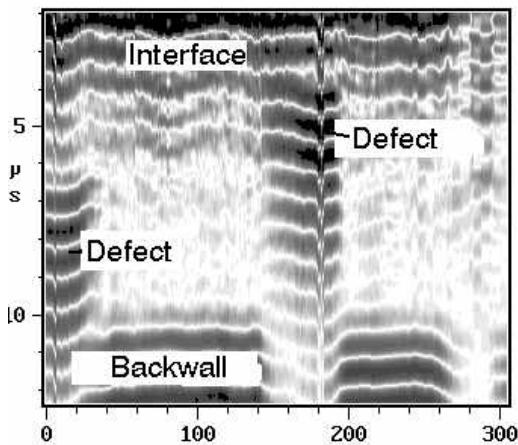


Fig. 6: Bt-scan of a sandwich specimen with defect (HILL-SCAN 3010)

The internal pulser generates an output voltage of 228 V with a rise time of lower than 6 ns, which provides high resolution for frequencies above 10 MHz. The external trigger input enables synchronization with manipulators.

The ADC boards used for the PC systems provide a resolution of 8 bit with single-shot sampling of up to 400 Msamples/s.

The HILL-SCAN 3020LOG with a logarithmic amplifier provides A-scans with a single-shot dynamic range of 100 dB.

The HILL-SCAN 3041NF board is optimized for low test frequencies so that materials with high sound damping such as concrete can be successfully inspected by the echo technique.

For special applications such as air coupled testing a special programmable transmitter board was developed. This transmitter generates rectangular and burst signals, which increase the acoustical power in an optimized frequency range, and provides a superior signal-to-noise ratio.

The great advantage of installing an ultrasonic system in a PC is that both the hardware (processor, graphics, power supply, ..) and the software (evaluation and documentation) are directly available for the inspections.

The pulser/receiver HILL-SCAN 30XX boards satisfy DIN 25450. Typical applications are: ultrasonic imaging systems for nuclear power stations and for aircraft, material characterization, transducer qualification, replacement of portable flaw detectors (inspections of welded joints), inspection of new materials, measurement systems with air coupling .

6. References

[1] Hillger, W.: Kann die PC-Karte das Ultraschallprüfgerät ersetzen?, 4. Kolloquium Qualitätssicherung durch Werkstoffprüfung, Zwickau, 7. und 8. 11. 1995, DGZfP-Berichtsband 49, S. 75-79. Vortrag P 17

[2] Hillger, W. : Anforderungen an Ultraschall-PC-Karten aus der Sicht von Hersteller und Betreiber, DGZfP-Seminar „Automatisierung der Ultraschallprüfung, Gerätetechnik und Regeln zur Anwendung und Auswertung“, DGZfP-Berichtsband 62, S. 29-35.

[3] Hillger, W.: Ultrasonic imaging of defects in Sandwich Composites -from laboratory reseach to in-field inspections, 7th ECNDT 1998, Copenhagen, Conf. Proc.

[4] Hillger, W.: Friederichs, B.: Ultrasonic Inspection of the Helicopter EH 101 Tail Unit, Brite Euram Project No. BE-5781, Document No. DAMTOS-WP-503-1.1/DLR, 1995