Development of Hardware and Software for Automated Ultrasonic Testing

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1. Introduction

Nondestructive testing (NDT) for the construction and operating of NPPs plays an important role in confirming the integrity of the NPPs. Especially, Automated ultrasonic testing (AUT) is one of the primary nondestructive examination methods for in-service inspection of the welding parts in major components in NPPs. AUT is a reliable nondestructive testing because the data of AUT are saved and reviewed with other examiners.

Korea Hydro & Nuclear Power-Central Research Institute (KHNP-CRI) has developed an automated ultrasonic testing (AUT) system based on a high speed pulser-receiver. In combination with the designed software and hardware architecture, this new system permits user configurations for a wide range of user-specific applications through fully automated inspections using compact portable systems with up to eight channels.

This paper gives an overview of hardware (H/W) and software (S/W) for the AUT system to inspect welds in NPPs.

2. Development of a new AUT system

A new AUT system permits user configurations for various applications through a fully automated inspection. This system assists examiners in performing the inspection by using the AUT system, which permits fast data acquisition followed by accurate offline data evaluation. This AUT system consists of three subsystems: pulser/receiver (KU-815), scanner, and AUT S/W called SonicWizard.

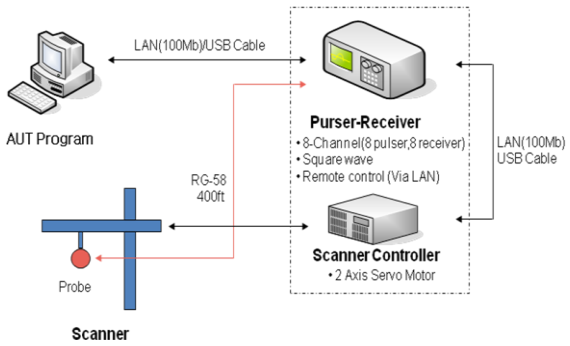

Fig. 1 Automated Ultrasonic Testing System

2.1 Hardware

A pulser/receiver of AUT is core hardware. The pulser/receiver (KU-815) is developed which is based on microelectronic components, such as digital signal processors (DSPs), field-programmable gate arrays (FPGAs), and a Complex Programmable Logic Device (CPLD) with a Serial Peripheral Interface (SPI) communications protocol. Highly integrated electronic circuits and the powerful processing capabilities of the AUT systems allow examining the welds of the components and piping in the fields through a fully automated inspection system with up to eight channels.

The pulser/receiver is composed of a square wave generator and a receiver-amplifier. The pulser provides the high voltage that is needed to excite the transducer to transmit an ultrasonic pulse. The receiver amplifies the output of the transducer to a level suitable for A/D conversion (ADC). It has a maximum gain of 70 dB and a uniform frequency response from 0.1 kHz to 35 MHz. The ADC has a selectable sampling rate of 12.5, 25, 50, 100, or 200 MHz and a resolution of 12 bit. The main processor of the AUT system is ARM 9 which has a 666 MHz clock. The master clock generates all the timing signals: the transmitting/receiving timing signal to excite the transducer and start ADC of the received signals, scanner controller signals to start the transducer scanning and to acquire the position data, and a signal to start the display of the received data. Signals from all the channels are processed in real-time. Each channel is equipped with eight gates and thresholds. Gates and thresholds can be set individually for each channel. A fast programmable distance amplitude correction (DAC) is implemented and compensates for the acoustic damping for increasing travel time. The DAC can also be programmed differently for each channel.

The automated scanner moves the transducer in two dimensions with a precision of better than 0.1 mm. The maximum scanning speed is 200 mm/s. A scanner controller is responsible for receiving the control signals from the motor controller unit and controlling the scanner for automatically examining the piping. The scanner can be manufactured for the inspecting piping with various diameters and thicknesses.

2.2 Software

The SonicWizard allows convenient operation of the entire AUT system. The on-line display of the AUT signals with respect to the specimen position is shown

on the SonicWizard. The signal amplitudes are clearly visible and help the examiner to supervise the current examination.

The SonicWizard contains modules for setup, examination, analysis, and reporting. Various database modules provide substantial information on inspection parameters, such as procedures, component geometry and images, material characteristics, probes, AUT H/W and S/W. All system functions are controlled from the SonicWizard using the keyboard and/or mouse.

The SonicWizard, running under Windows XP or 7, is suitable for a large variety of laboratory and field applications. The user interface layout can easily control the AUT H/W and S/W to examine the piping welds. The database of the SonicWizard provides support for managing the inspection parameters, such as search units, examination ranges, scanner settings, and calibration information, such as search units, examination ranges, scanner settings, and calibration information. The A-scan can be displayed and recorded in a full-wave mode and a positive or negative half-wave mode. Echo dynamics can be recorded and the signals can be averaged for a maximum of 32 consecutive individual A-scans. The number of data files is only limited by the available space on the hard disks.

Pitch/catch, pulse/echo, and time of flight diffraction (TOFD) mode can be selected to correspond to the requirements of the individual inspection task. Analysis of the acquired ultrasonic data is performed using the A/B/B'/C-scan display; composite top, side, and end view images help the inspector during data evaluation. The A/B/B'/C-scan display for the AUT system is shown in Fig. 2.

The A-scan displays the horizontal and vertical sweeps proportioned to the time or distance and the magnitude of the UT signal for a given probe position. In order to display a given cross section of a specimen, it is necessary to shift the probe with a raster scan on the specimen. The B/B'-scan displays the one direction and depth sweeps proportioned to the maximum magnitude of the A-scan for a given probe position. The C-scan displays the inspected plane on a specimen proportioned to the maximum magnitude of the A-scan for a given probe position.

The SonicWizard can provide a three-dimensional view of the inspected zones for various cross sections. This menu helps the qualified examiners to accurately determine type, location, and size of detected material discontinuities.

For reporting examination results, SonicWizard provides hard copies including the A/B/B'/C-Scan image, current system settings and the complete result data, including the examiner's comments. Previous system settings as well as inspection data can be recalled at any time.

The S/W contains modules with the DBMS that manages the information of examinees, probes, equipments, etc.

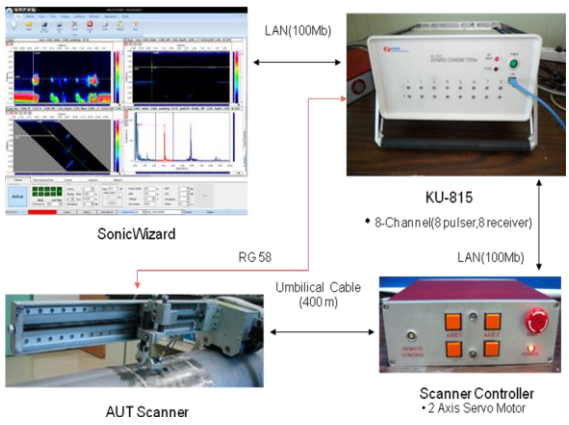

Fig. 2 Newly developed the AUT system

3. Conclusions

This paper gives an overview of the newly developed AUT system which is composed with H/W and S/W for the inspection of welds in NPPs.

In combination with the designed H/W and S/W architecture, the new AUT system developed by KHNP. The new AUT system permits user configurations for various applications through a fully automated inspection system with up to eight channels.

The technologies related with the developed H/W and S/W will give a chance to develop other automated NDE equipments in KHNP.

Acknowledgement

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