Transactions of the Korean Nuclear Society Spring Meeting
Pyeongchang, Korea, May 27-28, 2010

Development of Multichannel Eddy Current Testing Instrument

Hee Jong Lee, Chan Hee Cho, Min Woo Nam, Yoon Byung Sik, Yoo Hyun Joo
Korea Electric Power Research Institute, Nondestructive Evaluation Center, Nuclear Power Laboratory,
103-16, Munji-Dong, Yuseong-Gu, Daejeon 305-380, Korea
hjlee@kepri.re.kr

1. Introduction

Four main techniques of electromagnetic testing are used for commercial applications: eddy current testing, alternating current field testing, magnetic flux leakage testing and remote field testing. Eddy current testing is a nondestructive evaluation method, which makes eddy current flow on a specimen by applying driving pulse to eddy current probe coil, by using eddy current testing device, and makes the change of eddy current which is dependently caused by flaws, material characteristics, testing condition, receiving through eddy current, and analyzes material properties, flaws, status on the specimen. Application of EC instrumentation varies widely in industry from the identification of metal heat treatment to the inspection of steam generator tubing in nuclear power plants. In this study, we have designed multichannel EC instrument which can be applicable to the NDE of the tube in heat exchanger for electric power facility, chemistry, and military industry, and finally confirmed the proper function of EC instrumentation.

2. Methods and Results

2.1 Configuration of EC Instrument.

The eddy current instrument generally consists of five modules of excitation, modulation, signal preparation, demodulation, and analysis & display as illustrated in Fig. 1.

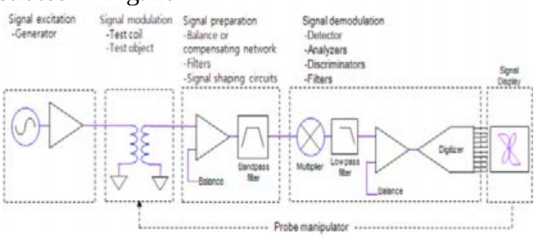

Fig. 1 Configuration of eddy current testing instrument.

2.2 Design of EC Instrument.

The excitation part of EC instrument consists of signal generation and amplifiers to drive the transducers. The signal generator provides sine wave excitation for the test coil. Multifrequency system is able to apply several frequencies simultaneously to provide multiple-parameter options. Magnetic fields are generated around the eddy current coil excited by the driving signal supplied from oscillator. Signal modulation occurs in the electromagnetic field of the EC coil. It is the primary magnetic field created by the coils that provide the energy transfer into the test specimen. This magnetic energy is modulated by the test specimen and the resultant signal is returned to the instrument for processing. The flaws in specimen and the change of physical properties induce the change of magnetic field in EC coils. In this study, developed EC instrument is able to generate simultaneously four frequencies .

After the modulation processed, the signal is amplified and extraneous noise is rejected. The test object data are extracted from the carrier signal. Demodulated signals are used to separate desired signals from undesired signals generated by the eddy current tester. Digitized data are generally displayed in a complex plane presentation with the strip chart and A-scan displays as required by the application.

If the signal contains low frequency components resulted from probe motion, in this case a high pass filter could be used to attenuate the low frequency component from the probe motion while still passing the high frequency component from the crack. Digital mixing, the combination of components from different test frequency, allows the suppression of unwanted parameters or signals from structures such as support plates in heat exchanges.

2.3 Verification of the signals from EC Instrument

A series of functional test was carried out to evaluate the proper operation of each module of the EC instrument. A bobbin probe was connected to the module of EC instrument, and the signals from the ASME calibration standard were acquired to assess the appropriate function of the frequency generator and receiver.

2.3.1 Signals from the EC frequency synthesizer

Output signals from the direct digital frequency synthesizer were generated as shown in Fig. 2(a),(b). Cosine signal at 100KHz is illustrated in Fig. 2(A), and sine signal at 100KHz is illustrated in Fig.2(b). The sine wave is also provided to the modulation module as a reference signal. Output signal of F1+F2, and F3+F4 sine summing wave on the DAC amplifier was verified as shown in Fig. 3(a),(b),(c). sine summing wave of F1+F2+F3+F4 at the DAC amplifier in Fig. 3(d) was also verified.

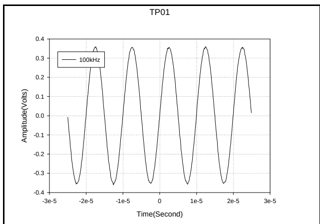

Fig. 2(a)DDS output signal (100kHz cosine wave)

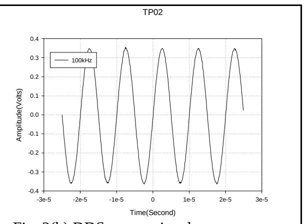

Fig. 2(b) DDS output signal (100kHz sine wave)

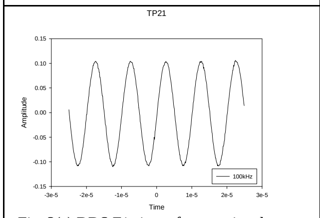

Fig. 3(a) DDS F1 sine reference signal

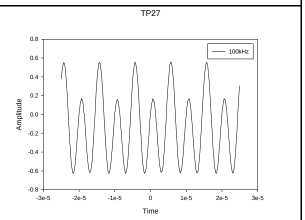

Fig. 3(b) F1+F2 sum sine signal

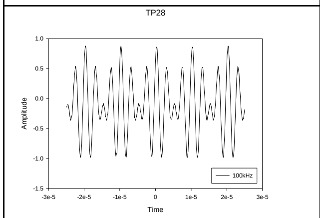

Fig. 3(c) F3+F4 sine sum signal

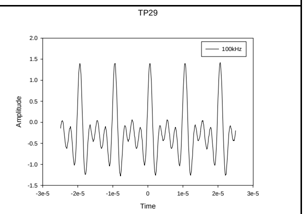

Fig. 3(d) F1+F2+F3+F4 sum sine signal

2.3.2 Signals from modulation , demodulation, and impedance balancing circuit

Signals of differential and absolute wave applied to probe coils were generated as shown in Fig.4(a),(b). Signals in Fig.5(a),(b) are balancing signals applied to balance the real and imaginary components of Lissajous signal in the impedance plane. Signals shown in the left side of Fig.6 are the strip chart of impedance change at 100 KHz, and the right side signal is the Lissajous display of the impedance change in probe coils.

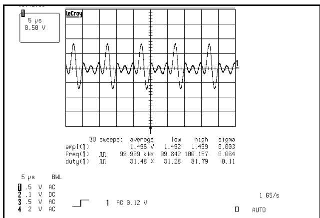
Fig. 4(a) differential input signal

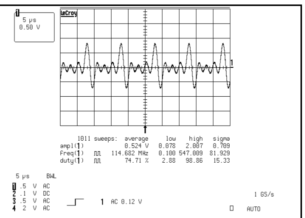
Fig. 4(b) absolute input signal

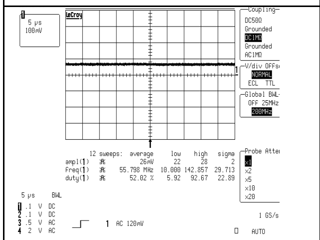
Fig. 5(a) DC signal for balancing of Lissajous X axis

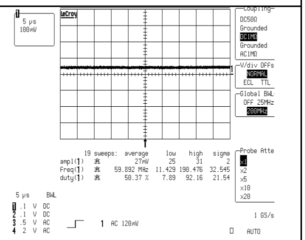
Fig. 5(b) DC signal for balancing of Lissajous Y axis

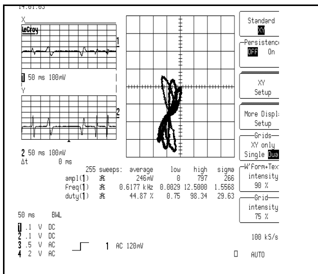
Fig. 6 X-Y strip chart and Lissajous signal

3. Summary

In this study, we have developed the eddy current signal generating and processing technology. To verify the suitable function of the designed module of the eddy current tester, an ASME calibration standard was used. As a result of the functional test, sine and cosine waves at four frequencies were verified at the output of the synthesizer. And we verified that the appropriate summing wave necessary to amplify the driving power was generated. Conclusively, we have successfully developed the eddy current signal synthesizer, modulator, and demodulator necessary to compose the eddy current tester.

REFERENCES

1. Hugo L. Libby, *Introduction to Electromagnetic Nondestructive Test Methods.* John Wiley & Sons, Inc (1971).
2. ASNT,"*Nondestructive Testing Handbook*" 4rd ed, : Vol.4, Electromagnetic Testing, Columbus, OH : American Society for Nondestructive Testing, 1982
3. EPRI, "*Electromagnetic NDE Guide for Balance-of-Plant heat Exchangers*", Rev. 2, pp. 3.2-21~4.0-30, (1997)