The Digitalization Scheme of Ex-Core Wide Range Signal Processing

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1. Introduction

The ex-core NIS(Nuclear Instrumentation System) provides a wide range signal and a narrow range signal.

Through preamplifier/filter, discriminator circuit, Logarithmic Count Rate(LCR) circuit, MSV(Mean Square Voltage) circuit, and combination circuit, the wide range power signal is generated to represent the actual power level 2×10^{-8}% to 200% power[1],[2].

In this paper, the digitalized wide range signal processing procedure of an ex-core NIS of an Integral Reactor is presented.

2. Suggested signal processing method

The digitalized signal processing mechanism for a wide range signal will be realized under analog and digital equipment bases.

Preamplifier/filter, discriminator circuit, and the bandpass filter of the MSV circuit will be realized using analog equipment, and the other functions will be realized using digital equipment.

In this section, only the digital portions of the ex-core NIS are described.

2.1 LCR Module

Through a preamplifier/filter and discriminator, the background noises such as the alpha particle and beta particle are blocked, and the TTL level pulses generated from the neutron reactions are obtained.

These pulses are provided as input signals to the counter card, and the output signals from the counter card are applied to the LCR module of the DSP(Digital Signal Processing) card.

In the LCR module, the obtained counting rates are converted to the voltage leveled values, and then the percent rated values are derived from the voltage leveled values.

The derived formulas are depicted as below.

$$V_1 \approx \log_{10}(CPS) + 1.69897$$

$$\%\ power \approx 2\times10^{V_1-8.00}$$

One has to denote that these formulas are reasonable over the range of 2×10^{-2} CPS through 2×10^{5} CPS.

2.2 MSV Module

Concerning the wide range signal generation, when one measures the pulse signals from the detector using the LCR module, the saturation phenomenon arises at around 200,000CPS[1]. To avoid the saturated condition, the MSV module is applied.

At the MSV circuit of the built plant, the Campbelling theorem[3] is adopted to obtain the voltage signal proportional to the reactor power [1].

In this scheme, the signals passed through a bandpass filter and a rectifier/filter are transmitted to an analog/digital conversion card. And then, the digitalized signals are applied to the MSV module of the DSP card.

In the MSV module, the following arithmetic operations are performed.

$$V_2 \approx 2\times\log_{10}(V_{rms}) + 11.00$$

$$\%\ power \approx 2\times10^{V_2-8.00}$$

For the above formulas, V_{rms} denotes the output value of a bandpass filter.

To fully complete the wide range signal processing, a combinational circuit is also realized under a digital basis.

2.3 Combination Module

The combination module in this paper has the same functions as the combinational circuit of the operating plants[1] .

Generally, in the combinational circuit, the outputs from the LCR circuit and the MSV circuit simultaneously contribute to the total output [1].

Figure 1 simply shows the expected signal flow of this system, and the quadrilateral portion of Figure 1 illustrates the operation logic of the combination module. The terminology “Lower_Volt” and “Upper_Volt” in figure 1 denotes the minimum value and the maximum value of the operating range of the combination module.

To derive these formulas, the following assumptions are defined :

- Maximum Neutron Flux Range : $\approx 1\times10^{9}$nv
- Counting Sensitivity : 0.2 CPS/nv
- AC Neutron Sensitivity : 1×10^{-10} V^2/nv

Through the MSV module, the LCR module and the combination module, the processed signals are transmitted to the network interface card to provide the neutron flux power signal for a related MMIS(Man Machine Interface System).

3. Conclusion

The digitalization scheme of wide range signal processing of an ex-core NIS of an Integral Reactor is proposed.

To generate the reliable and desirable signals, the wide range signal processing shall be performed by considering the signal characteristics, and to obtain such signals, the suggested digital signal processing scheme shall be applied.

REFERENCES

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[2] Timothy N. Chessman, Neutron Flux Monitor Training Course, Thermo Gamma-Metrics, 2001

[3] Glenn F. Knoll, Radiation Detection and Measurement, John Wiley & Sons, New York, 2000.

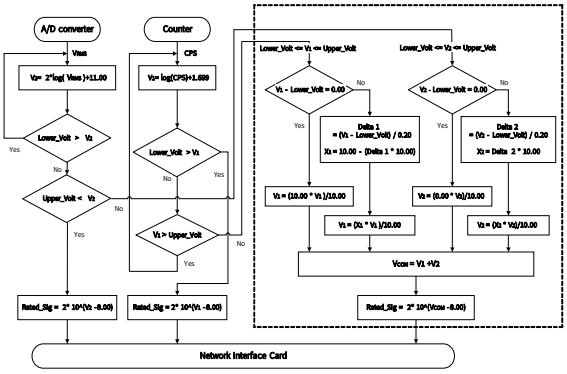

Fig 1. The signal flow

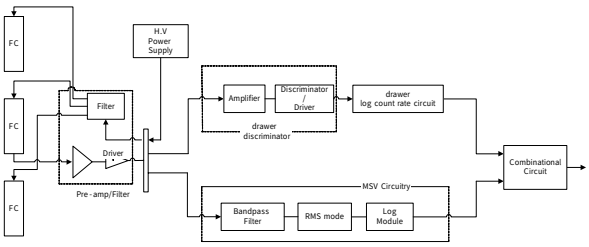

Fig 2. The simplified signal processing block diagram of built plant

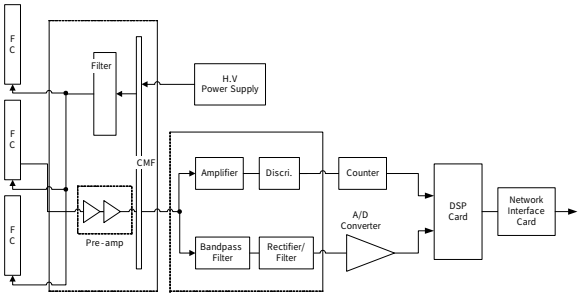

Fig 3. The simplified signal processing block diagram of Integral Reactor