A PORTABLE MEASUREMENT SYSTEM FOR SUBCRITICALITY MEASUREMENTS BY THE CF-SOURCE-DRIVEN NEUTRON NOISE ANALYSIS METHOD

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A portable measurement system consisting of a personal computer used as a Fourier analyzer and three detection channels (with associated electronics that provide the signals to analog-to-digital (A/D) convertors) has been assembled to measure subcriticality by the ^{252}Cf-source-driven neutron noise analysis method.[1]

The ^{252}Cf-source-driven neutron noise analysis method for obtaining the subcritical neutron multiplication factor of a configuration of fissile material requires measurement of the frequency-dependent cross-power spectral density (CPSD), $G_{23}(\omega)$, between a pair of detectors (Nos. 2 and 3) located in or near the fissile material and CPSDs $G_{12}(\omega)$ and $G_{13}(\omega)$ between these same detectors and a source of neutrons emanating from an ionization chamber (No. 1) containing ^{252}Cf, also positioned in or near the fissile material. The auto-power spectral density (APSD), $G_{11}(\omega)$, of the source is also required. A particular ratio of spectral densities, $G_{12}^{*}G_{13}/G_{11}G_{23}$, (* denotes complex conjugation), is then formed. This ratio is related to the subcritical neutron multiplication factor and is independent of detector efficiencies.[1]

The portable measurement system (Fig. 1) consists of a parallel-plate ionization chamber containing ^{252}Cf, two ^{3}He proportional counters and their associated electronics, and a small computer containing anti-aliasing filters and A/D convertors. The system Fourier analyzes the digitized data and forms the appropriate APSD and CPSDs. These spectra are used to form the ratio, $G_{12}^{*}G_{13}/G_{11}G_{23}$, from which the subcriticality can be determined. The system is capable of sampling signals at rates up to 80 kHz and processing these data at rates (to form the appropriate spectra) of 2 kHz. As presently configured, it is a two-channel system requiring that measurement of G_{12}, G_{13}, and G_{23} be done sequentially before the ratio of spectral densities is calculated.

The appropriate signals from an ionization chamber containing ^{252}Cf and a pair of detectors placed near a submerged (in water) High Flux Isotope Reactor fuel element were recorded on an FM instrumentation grade tape recorder. The signals were analyzed on line with a large commercially available HP 5451 four-channel Fourier analyzer. After the experiment the data recorded on tape were analyzed by the portable system. Pairs of channels were sampled sequentially for ~20 minutes by the portable system and the cross power spectral densities G_{12}, G_{13}, G_{23} and the auto power spectral density G_{11} obtained. The magnitudes of the spectral densities and the ratio of spectral densities as a function of frequency obtained by the portable system
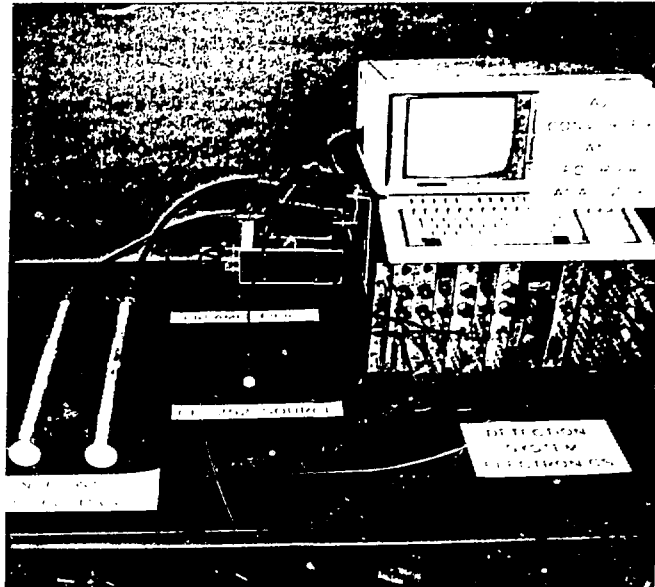
Fig. 1. Portable measurement system.

are shown in Fig. 2 and 3. The ratio of spectral densities averaged up to 300 Hz was 0.0623 ± 0.0013 and agreed with the value from the large commercial Fourier Analyzer, 0.0618 ± 0.0008.

The development of a portable measurement system makes the application of this method more practicable. Future improvements of the system will allow simultaneous measurements of all spectra while retaining portability. Further reductions in size and increased portability could be achieved with a special-purpose computer design.

Some of the potential applications of this method for which experiments have been performed and the usefulness of the method demonstrated are (1) initial fuel loading of reactors,[1] (2) refueling of reactors,[3] (3) fuel- preparation facilities,[4] (4) fuel-processing facilities,[5] (5) fuel-storage facilities,[6] (6) zero-power testing of reactors,[7] and (7) verification of calculational methods for assemblies with $k_{eff} < 1$.[8] In these experiments, the subcritical neutron multiplication factors, k_{eff}, were determined for systems whose k_{eff} values varied from ~0.5 to ~0.99 utilizing a large, elaborate research measurement system. The portable system is capable of measuring a variety of fissile systems conveniently, and at a relatively low cost.

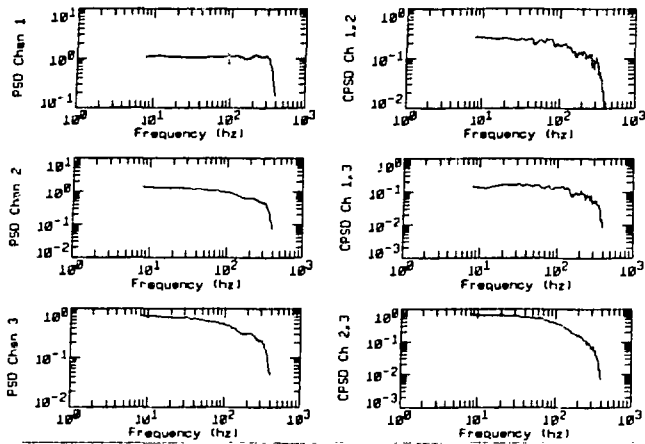**MASTER**

SPECTRAL DENSITIES VS FREQUENCY

Fig. 2. Plots of magnitudes of spectral densities for HFIR core 251.

SPECTRAL RATIO VS FREQUENCY

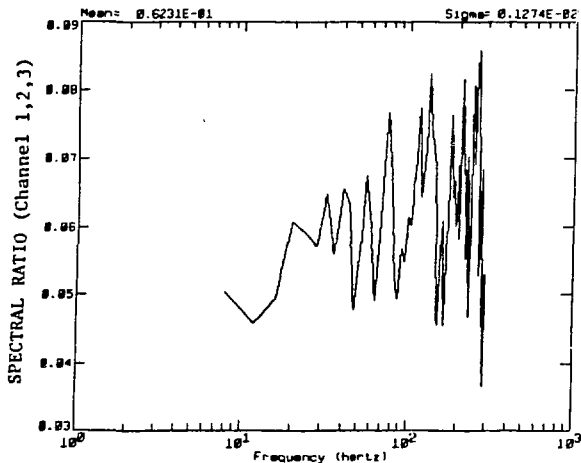
Fig. 3. Ratio of spectral densities for HFIR core 251.

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