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NUMERICAL CALCULATION OF THE GLOBAL AND LOCAL COMPONENTS OF THE NEUTRON NOISE FIELD IN BWR's*

F. C. Difilippo[1]
P. J. Otaduy[2]

Oak Ridge National Laboratory
Oak Ridge, Tennessee 37830

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[1]Consultant, Nuclear Engineering Department, University of Tennessee.

[2]Nuclear Engineering Department, University of Florida.

MASTER

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F. C. Difilippo

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On the basis of separability of the local and global components of the neutron noise field,[1] it is readily shown that the cross-power spectral density (CPSD) of the signals from two neutron detectors at two points Z_1, Z_2 in the same string in a BWR is given by,

$$\mathrm{CPSD}(\omega, Z_2, Z_1) = \phi(Z_2)\phi(Z_1)\Big[|G(\omega)|^2 \langle|\delta\$(\omega)|^2\rangle + k(Z_2)k(Z_1)\langle\delta\alpha(Z_2,\omega)\delta\alpha^*(Z_1,\omega)\rangle\Big] \quad (1)$$

where

$\phi(Z)$ = the neutron flux ,
$G(\omega)$ = the point kinetics reactivity to power transfer function ,
$\delta\$(\omega)$ = the reactivity perturbation ,
$\delta\alpha(Z,\omega)$ = the void fraction perturbation, and
$k(Z)$ = a parameter related to the localized perturbation induced in the detector by void perturbations within its volume of influence, i.e.,

$$k(Z) = \frac{1}{\phi(Z)} \frac{\partial\phi}{\partial\alpha} \quad (2)$$

From one group diffusion theory

$$k(Z) = -\frac{g(\alpha)}{1 - \alpha(Z)} \quad (3)$$

where $g(\alpha) \approx 1$.

The parameters $\alpha(Z)$, $\langle\delta\alpha(Z_2,\omega)\delta\alpha^*(Z_1,\omega)\rangle$ and $\langle|\delta\$(\omega)|^2\rangle$ can be calculated with a thermal-hydrodynamic computer code. Then using eq. 3, the CPSD can be obtained by means of eq. 1.

Calculations for the Hatch 1 BWR were performed using a modified version of the computer code LAPUR-3.

Fig. 1 shows the calculated phase-lag of the CPSD between detectors in string #36 at Z_1 = 88.8 cm and Z_2 = 138.7 cm, with the reactor operating at

80% flow rate and 83% power. These conditions are close to those corresponding to the measurements of Atta et al.[3]

The straight line corresponds to a complete dominance of the local component of the noise. The points of intersection with the straight line correspond to the buble transit harmonics, i.e., $f = \frac{n}{2\gamma}$ where $n = 0,1,2,\ldots$ and γ is the transit time of a buble between the two detector positions.

Agreement with the experimental results[3] is excellent above 6Hz frequency. The discrepancy at lower frequencies indicates the inadequacy of the point kinetics model to describe the global component of the neutron noise in large BWRs.

REFERENCES

1. Wach D., Kosaly G., *Atomkernenergie*, 23 244 (1974).
2. Otaduy P. J., "LAPUR-3. A Frequency Domain Dynamic Code for BWR," to be published as an ORNL-TM memo.
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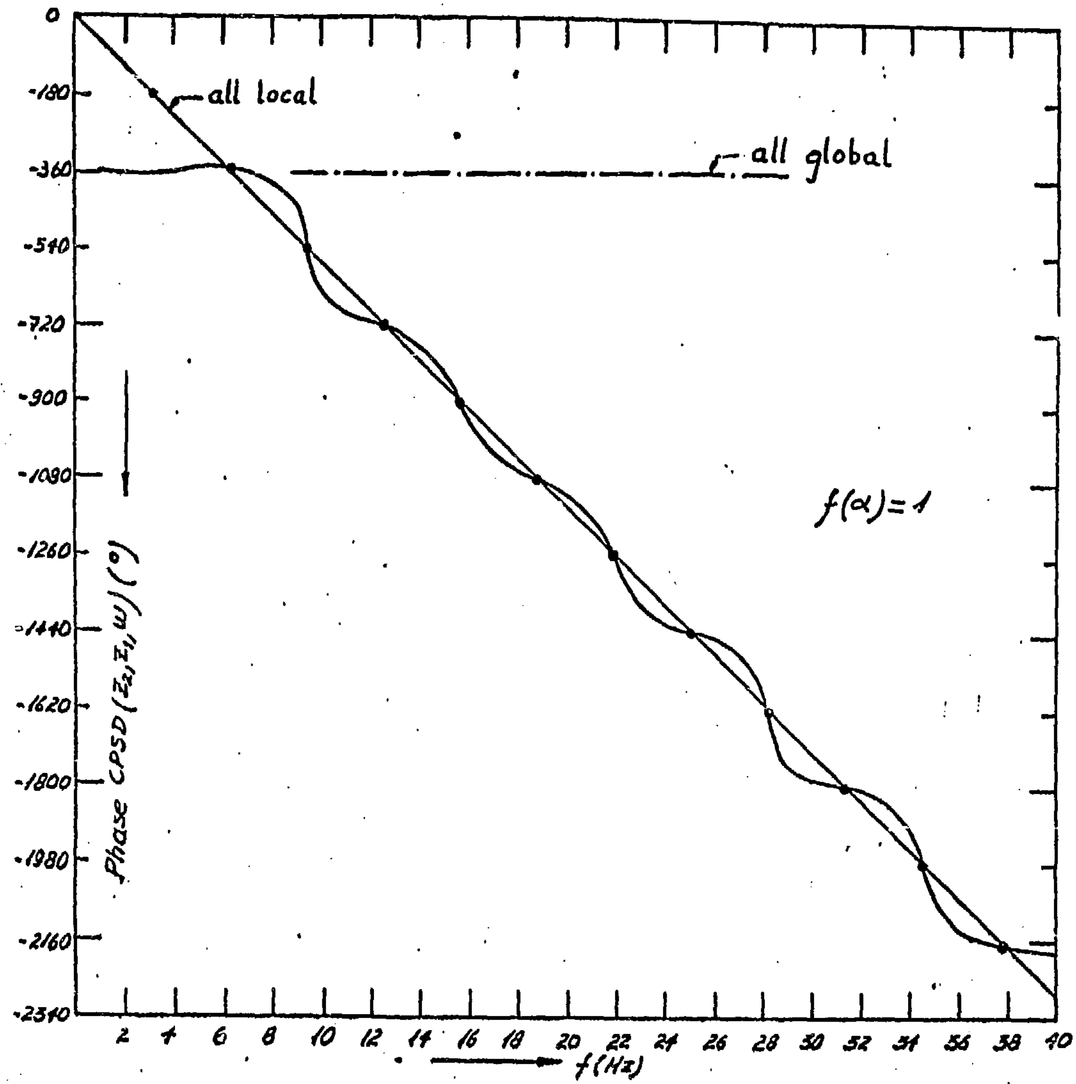
FIGURE CAPTIONS

1. Phase in degrees of the CPSD between positions Z_1 and Z_2 vs. frequency in Hz.



0
-180
-360
-540
-720
-900
-1090
-1260
-1440
-1620
-1800
-1980
-2160
-2340
Phase CPSD(z_2, z_1, ω) (°)
all local
all global
$f(\alpha) = 1$
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
f(Hz)

FIGURE 1