

## Establishment of the In-service Test Management System for Nuclear Power Plants Using Database System

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### 1. Introduction

As a part of a Department of Energy-Nuclear Engineering Research Initiative (NERI) Project, we at OSU and our Westinghouse Electric Corporation (WEC) subcontractor colleagues are investigating SiC semiconductor detectors as power monitors for Generation IV power reactors. To have a better knowledge of the SiC detector response and the electronic channel requirements for neutron monitoring, a mathematical model of the detector channel has been developed. This model is described herein, from the SiC detector to the discriminator at the channel's end, and representative results of the model calculations are presented.

### 2. Methods and Results

In this section some of the techniques used to model the detector channel are described. The channel model includes a SiC detector, cable, preamplifier, amplifier, and discriminator models.

#### 2.1 Detector Model

The WEC co-authors of this Transactions have developed designs for the SiC diode detectors that are to be used in the neutron monitoring channel [1,2]. A four-layer configuration of such a diode detector, consisting of LiF, Al, Au and SiC, has been simulated with TRIM to find the response of the SiC detector to neutrons coming from the reactor core. TRIM [3] calculates, on a particle by particle basis, the energy loss of tritons coming from (n, alpha) reactions in the LiF converter as the tritons pass through the SiC layer [4]. From the calculated triton energy loss spatial distribution, a MATLAB code calculates output current pulses of the detector as a function of time [4,5]. In addition to the TRIM code output data, the MATLAB code uses as input the detector bias voltage, doping concentrations of the semiconductor, and electron and hole mobilities. As an illustration of the calculation, the output current is shown as a function of time in Fig. 1, for three particles that have been simulated as interacting in the detector randomly in time, with an average event rate of 10.8 events/s.

Besides the output current, the MATLAB detector code calculates the detector capacitance. The calculated output current is the input for the rest of the detector channel and the detector capacitance is an important input parameter.

#### 2.2 Cable Model

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The output of the detector model is input to the cable model. The cable is modeled using the code PSpice and includes the cable characteristics of capacitance, resistance, characteristic impedance, and length. Although the effect of cable on the shape of the output signal of a detector is usually negligible, in our application to high-rate counting, its effect is significant. For our application, we found a distributed parameter model was necessary for accurate modeling of the cable.

#### 2.3 Preamplifier Model

For our analysis, two major types of preamplifiers (charge sensitive and voltage sensitive) were modeled using MATLAB by supplying their transfer functions in s-space. The transfer function of the voltage sensitive preamplifier was specified based on the manufacturer's published bandwidth characteristics. The transfer function for the charge sensitive preamplifier was calculated based on the published rise time, fall time and sensitivity of the preamplifier.

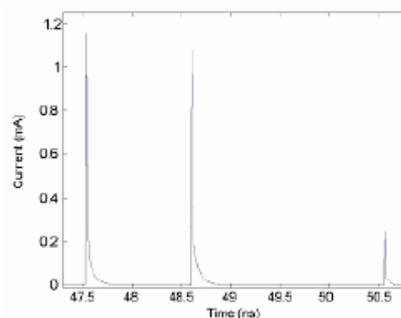


Fig. 1. Output current of the SiC detector for three particles that have been simulated as interacting in the detector randomly in time, with an average event rate of 10.8 events/s.

#### 2.4 Shaping Amplifier Model

The output of the charge sensitive preamplifier is an exponentially decaying tail pulse. At relatively high count rates, the large decay time constant of a charge sensitive preamplifier causes severe pulse pile-up, as pulses are superimposed on the tails of the previous

pulses [6]. A shaping amplifier is used to reduce pile-up. A bipolar amplifier was modeled in MATLAB as a circuit with two differentiators and an integrator.

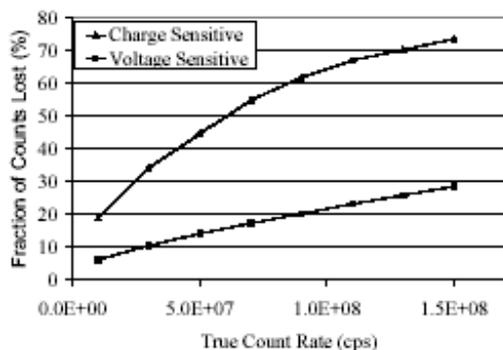


Fig. 2. Fraction of counts lost with voltage and charge sensitive preamplifiers as a function of the true count rate.

Table I: Problem Description

	Thermal conductivity (W/cm-K)	Radius (cm)
Kernel		
Buffer		
Inner Pyc		
SiC		

### 2.5 Single Channel Analyzer (SCA) Model

A SCA is required to distinguish the pulses induced by neutrons from those arising from gamma-ray interactions. A MATLAB SCA model was written that simply records those counts which are above the discrimination level. A discriminator dead time is an important parameter for the SCA and is a limiting factor establishing the system count rate. The output of the discriminator model is presented in Fig. 2, as a graph of the fraction of counts that are lost versus the true count rate, with voltage and charge sensitive preamplifiers. As can be seen from the figure, due to the dead time associated with the SCA, even with a voltage sensitive preamplifier, accurate dead time corrections are necessary to achieve large and accurate count rates.

### 3. Conclusions

Simulation techniques using TRIM, MATLAB, and PSpice can be useful tools for designing detector channels. Thus far TRIM, MATLAB and PSpice have been used to calculate the detector current output pulse for SiC semiconductor detectors and to model the pulses that propagate through potential detector channels. This model is useful for optimizing the detector and the resolution for application to neutron monitoring in the Generation IV power reactors.

### REFERENCES

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