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*USA Standard
and
IEEE Test Procedure
for*

SEMICONDUCTOR RADIATION DETECTORS

(FOR IONIZING RADIATION)

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G. A. Morton, *Chairman*

L. Costrell, *Secretary*

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J. L. Blankenship	W. W. Managan
W. L. Brown	H. Mann
R. L. Butenhoff	G. L. Miller,
J. A. Coleman	<i>Project leader</i>
D. C. Cook	S. Wagner
F. S. Goulding	F. J. Walter
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Subsequently the proposal was reviewed and approved by USA Standards Committee N42, Nuclear Instruments. The membership of N42 at the time of balloting was:

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FOREWORD

Semiconductor radiation detectors have come into widespread use in recent years for detection and high-resolution spectroscopy of ionizing radiation. Both silicon and germanium detectors have been developed, with silicon finding its principal application in the detection and analysis of heavy charged particles. Germanium detectors with their relatively high atomic number (as compared with silicon) and with large sensitive volumes have come into widespread use in the detection and analysis of gamma radiation. The rapid development and utilization of these detectors have made desirable standard test procedures so that measurements may have the same meaning to all manufacturers and users.

This Test Procedure is not intended to imply that all tests described herein are mandatory, but only that such tests as are carried out on completed devices should be performed in accordance with the procedures given.

A companion document is "Test Procedure for Amplifiers and Preamplifiers for Semiconductor Radiation Detectors," IEEE Standards Publication No. 301.

*USA Standard
and IEEE Test Procedure
for*

SEMICONDUCTOR RADIATION DETECTORS

(FOR IONIZING RADIATION)

1 GENERAL

The definition of a semiconductor radiation detector herein will be: A semiconductor device that utilizes the production and motion of excess free charge carriers for the detection and measurement of incident radiation.*

Test procedures for the associated amplifiers and preamplifiers are described in "USA Standard and IEEE Test Procedure for Amplifiers and Preamplifiers for Semiconductor Radiation Detectors" (USAS N42.2 and IEEE 301).

The following general precautions and specifications are recommended for all the test procedures described herein. Maximum diode voltage, current, radiation flux ratings, and other specification limits should not be exceeded, or permanent changes of the device characteristics may result. All measurements shall be performed with the device in total darkness. The device ambient temperature and atmosphere shall be specified together with other relevant conditions. The values of the parameters measured should be reproducible, within the precision of the measurements, after the performance of any one or all of the tests performed. The ripple, hum, stability, etc., of the detector bias supply shall not substantially influence the resolution or other detector parameter measurements.

1.1 Symbols

a, b	Constants characterizing noise.
B	Bandwidth.
C	Electrical capacitance.
C_c	Calibrated capacitor used to couple pulse generator to circuit under test.
C_{in}	Effective input capacitance of a preamplifier.
C_f	Feedback capacitance in the charge-sensitive loop of a preamplifier.
C_t	Total capacitance at preamplifier input.
Δ	FWHM of a monoenergetic spectral peak.
Δ_E^D	FWHM, expressed in units of energy, due to amplifier noise.
Δ_N^D	FWHM, expressed in channels, due to amplifier noise.
Δ_Q^D	FWHM, expressed in units of charge, due to amplifier noise.

Δ_E^D	FWHM, expressed in units of energy, due to detector noise.
Δ_N^D	FWHM, expressed in channels, due to detector noise.
Δ_Q^D	FWHM, expressed in units of charge, due to detector noise.
Δ_N^O	FWHM, expressed in channels, due to all factors other than electric noise.
Δ_N^S	FWHM for monoenergetic incident radiation, expressed in channels, including all spectral broadening effects.
Δ_E^T	FWHM, expressed in units of energy, due to the combined effect of detector and amplifier noise.
Δ_N^T	FWHM, expressed in channels, due to the combined effect of detector and amplifier noise.
Δ_Q^T	FWHM, expressed in units of charge, due to the combined effect of detector and amplifier noise.
E	Energy of a particle or photon.
ϵ	Average energy required to form one hole-electron pair.
e	Electron charge.
e_{ni}	Equivalent root-mean-square noise voltage referred to the preamplifier input.
e_{no}	Root-mean-square noise voltage.
e_{qi}	Root-mean-square noise in units of charge at the amplifier input.
φ	Noise spectral power density.
i	Detector noise current.
I	Electric current.
I_d	Detector leakage current.
I_0	Diode equivalent Gaussian noise current in a specified frequency band.
k	Boltzmann's constant.
K	Constant relating FWHM in units of energy to FWHM in units of charge.
L_D	Differential nonlinearity of an amplifier.
L_i	Integral nonlinearity of a biased amplifier.
L_I	Integral nonlinearity of an amplifier.
N	Channel number corresponding to the maximum of a monoenergetic spectral peak.
N_{avg}	Average number of counts in all channels of a multichannel pulse-height analyzer spectrum.
N_X	Number of counts in channel X of a multichannel pulse-height analyzer spectrum.
Q	Electric charge.
R	Electrical resistance.

* The properties and performance of these detectors are discussed in detail in [C1], [D1], [G1], [M1], and [T1].

