Jadavpur University

Master of Nuclear Engineering, 2nd semester, 2019

Nuclear and Reactor Instrumentation

Time: 3 hours

Full marks:100

Answer any 10 questions

1) (a) Suggest a scenario where the mean square voltage mode (MSV) is useful.
(b) On what factors does the fractional standard deviation of the MSV output depend? Derive an expression for it.
(c) On what factors does the mean square output in MSV mode depend? Derive an expression for it.
(d) Define or quantify the concept of "trial" in case of an event involving a radioactive process and what is the probability of success in each trial?
(e) Which statistical distribution is suitable for describing the randomness in the interval between two successive radioactive emissions and why?

2+2+2+2+2

2) (a) Explain the I-V characteristics of a typical ion chamber.
(b) What is the utility of the guard ring in an ion chamber?
(c) Why quenching is not required in an ion chamber?

4+3+3

3) (a) Compare the quenching phenomena between proportional counters and Geiger counters.
(b) What are the compositions of quench gases in both the case?
(c) Why the Geiger counter is not used in current mode?

5+3+2

4) (a) What is the working principle of a single channel analyzer?
(b) What are the advantages of a "preset count" counter over a "preset time" counter?
(c) On what factors does the fractional standard deviation of a diode pump circuit depend?

4+3+3

5)(a) With a suitable diagram explain the interface between the ADC and memory in a 16K channel MCA.
(b) What is the root cause of differential nonlinearity (DNL) in a nuclear ADC and how to determine DNL experimentally?

6+4

6) (a) Why the semiconductor detectors have a better energy resolution compared to gas filled and scintillation detectors?
(b) What are the desirable properties of the active material used in a semiconductor detector?
(c) In which way the pulse formation mechanism in a semiconductor detector is different from that in a gas filled detector?

3+4+3

7) (a) What type of detector you would use for a nuclear reactor (PHWR) star up after a prolonged shut down for more than 70 days?

(b) What are the preferred locations for these detectors?

(c) Under such operating conditions what information are needed from the instrumentation system to operate the reactor in safe condition and why?   2+2+6

8) (a) What is the difference between paralyzable and nonparalyzable dead times in a radiation detector?

(b) If n = true event rate, m = recorded event rate and τ = dead time, find out the relations between m and n in both the cases.

(c) Plot the typical curves between m vs. n in both the cases.   3+4+3

9) (a) What is the scope of radiation monitoring system in a nuclear power plant?

(b)Zone wise or location wise how many categories of radiation monitors are used in a nuclear power plant and why?   4+6

10) (a) What is the primary function of a preamplifier and what is its preferred location with respect to the detector?

(b) Derive the expression for gain of a charge sensitive preamplifier and clearly state the assumptions made.   4+6

11) (a) What type of device would you prefer to use at the input stage of a charge sensitive preamplifier and why?

(b) Draw an equivalent circuit showing various noise sources for a charge sensitive preamplifier using the device you have chosen in 11(a) at the input stage of the preamplifer and justify the reasons for the inclusion of each of the noise sources?   4+6

12) (a) What role does the linear amplifier play in a nuclear instrumentation system?

(b) What are the defects in a linear amplifier that can affect the energy resolution of a nuclear instrumentation system?   4+6