Under normal circumstances, we are more interested in a correction formula to predict the true rate from the measured rate and the system dead time. Solving Eq. (4.39) for \( n \), we derive

\[
n = f \ln \left( \frac{f}{f - m} \right)
\]

(4.40)

Recall that this correction is valid only under the conditions \( T < \tau < (1/f - T) \).

In this case, the dead time losses are small under the condition \( m \ll f \). Expanding the logarithmic term above for this limit, we find that a first-order correction is then given by

\[
n \approx \frac{m}{1 - m/2f}
\]

(4.41)

This result, because of its similarity to Eq. (4.24), can be viewed as predicting an effective dead time value of \( 1/2f \) in this low-loss limit. Since this value is now one-half the source pulsing period, it can be many times larger than the actual physical dead time of the detector system.

**PROBLEMS**

4.1 Calculate the amplitude of the voltage pulse produced by collecting a charge equal to that carried by \( 10^6 \) electrons on a capacitance of 100 pF. (\( e = 1.602 \times 10^{-19} \) C).

4.2 Compare the characteristics of pulse, MSV, and current mode operations as they are applied in radiation measurement systems. Include a table that lists the advantages and disadvantages of each.

4.3 Derive Eq. (4.8).

4.4 A detector with charge collection time of 150 ns is used with a preamplifier whose input circuit can be represented by the parallel combination of 300 pF and 10,000 ohms. Does this situation fall in the category of small or large collection circuit time constant?

4.5 A scintillation counter operated at a given voltage produces a differential pulse height spectrum as sketched below:

(a) Draw the corresponding integral pulse height spectrum.

(b) Sketch the expected counting curve obtained by varying the voltage to the detector while counting above a fixed threshold.

4.6 Sketch both the differential and integral pulse height spectra (using the same horizontal scale) for the following cases:

(a) Pulses with single amplitude of 1 V.

(b) Pulses uniformly distributed in amplitude between 0 and 1 V.

(c) Pulses distributed around an average amplitude of 1.5 V with a pulse height resolution of 8%.

4.7 A gamma-ray spectrometer records peaks corresponding to two different gamma-ray energies of 435 and 490 keV. What must be the energy resolution of the system (expressed as a percentage) in order just to distinguish these two peaks?

4.8 In a detector with a Fano factor of 0.1 what should be the minimum number of charge carriers per pulse to achieve a statistical energy resolution limit of 0.5%?

4.9 A pulse-processing system operated over a long period of time shows a typical drift that broadens single-amplitude pulses into a distribution with pulse height resolution of 2%. If this system is used with a detector with an intrinsic pulse height resolution of 4%, what will be the expected overall pulse height resolution?

4.10 Find the solid angle subtended by the circular end surface of a cylindrical detector (diameter of 10 cm) for a point source located 20 cm from the surface along the cylindrical axis.

4.11 The diameter of the moon as seen from earth subtends an angle of about 0.5°. Find the probability that a laser beam aimed in a random direction from the earth's surface will strike the moon.

4.12 The detector of Problem 4.10 has an intrinsic peak efficiency at 1 MeV of 12%. The point source emits a 1 MeV gamma ray in 80% of its decays and has an activity of 20 kBq. Neglecting attenuation between the source and detector, calculate the number of counts that will appear under the 1 MeV full-energy peak in the pulse height spectrum from the detector over a 100 s count.
4.13 A source of $^{116m}$In (half-life = 54.0 min) is counted using a G-M tube. Successive 1-min observations gave 131,340 counts at 12:00 noon and 93,384 counts at 12:40. Neglecting background and using a reasonable model for dead time losses, calculate the true interaction rate in the G-M tube at 12:00.

4.14 Counters A and B are nonparalyzable with dead time of 30 and 100 $\mu$s, respectively. At what true event rate will dead time losses in counter B be twice as great as those for counter A?

4.15 A counter with negligible background gives exactly 10,000 counts in a 1-s period when a standard source is in place. An identical source is placed beside the first, and the counter now records 19,000 counts in 1 s. What is the count rate per dead time?

4.16 A paralyzable detector system has a dead time of 1.5 $\mu$sec. If a counting rate of $10^5$ per second is recorded, find the two possible values for the true interaction rate.

4.17 As a source is brought progressively closer to a paralyzable detector, the measured counting rate rises to a maximum and then decreases. If a maximum counting rate of 50,000 $1/\mu$sec/sec second is reached, find the dead time of the detector.

REFERENCES