MATHEMATICAL QUESTIONS

Question 1

Consider an incoherent optical communication system with photo-diode multiplication feature.

(a) For an avalanche photo-multiplier, $F = \frac{\bar{g^2}}{\bar{g}^2} = 2+\gamma\bar{g}$. Find the optimum value of $\bar{g}$ that maximizes the achievable electronic SNR.

(b) For a general photo-multiplier tube, we can assume that $F = \frac{\bar{g^2}}{\bar{g}^2} = 1 + \bar{g}^q, 0 < q \leq 2$. Find the optimum value of $\bar{g}$ that maximizes the achievable electronic SNR.

Question 2

Consider the incoherent detector shown in Fig. 1, where the reciver has the capability of separately detecting each spatial mode and applying arbitrary deterministic photo-detection coefficient $q_i \geq 0$ to each mode i.

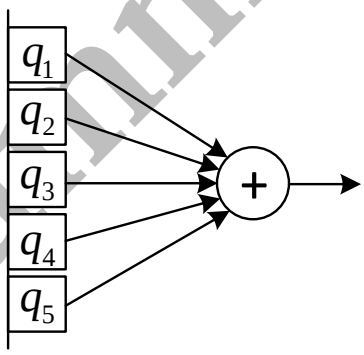

Figure 1: Focal-plane array processor.

(a) Show that the received shot noise-limited SNR is $\frac{\left(\sum_i q_i P_{s_i}\right)^2}{2\alpha F B_m \sum_i q_i^2 (P_{s_i}+P_{b_0})}$.

(b) Tunes the multiplication coefficients q_i to maximize the SNR.

Question 2 continued on next page...

(c) Find the maximum achievable SNR.

Question 3

An important processing operation following optical photo-detection is finite time integration. Let $y(t) = i(t) + i_n(t)$ represent the detector current, where $i(t) = \sum_{j=1}^{k(0,t)} h(t - t_j)$ is the shot noise current and $i_n(t)$ is a zero-mean thermal noise Gaussian process with the PSD N_{0c}.

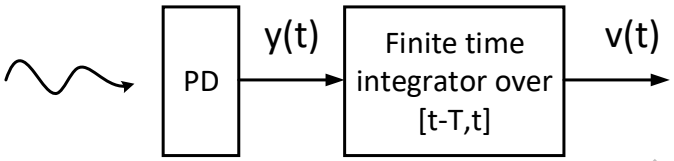

Figure 2: Photo-detector output integrator.

(a) Show that $\int_{t-T}^{t} i(\rho)d\rho \approx ek(t - T, t)$.

(b) Find the probability density function $p_{v_t}(v)$ of the integrator output at any time t.

(c) How is this integration processing used to evaluate the distribution of the current samples in a digital incoherent optical system?

Question 4

In a binary incoherent FSK system, two sinusoidal waveforms with different frequencies are used for transmitting the zero and one bits. Show that the optimal ML decoding can be approximately implemented using the block diagram shown in Fig. 3.

Question 4 continued on next page...

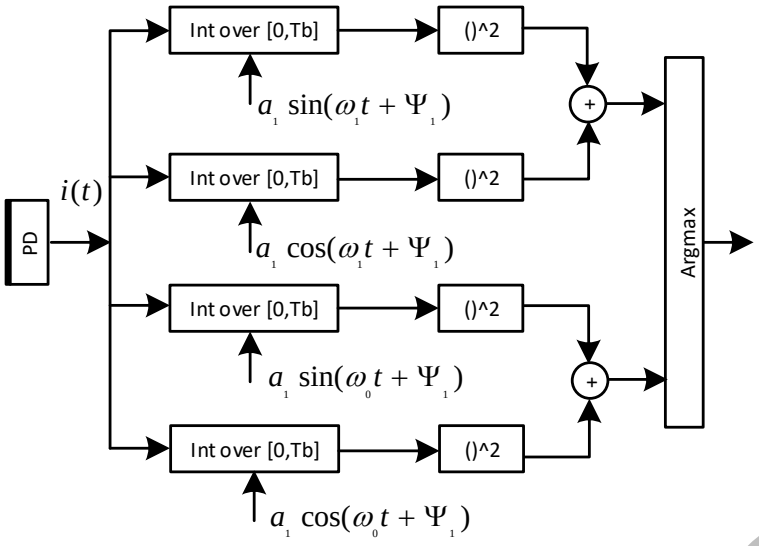

Figure 3: Binary incoherent FSK receiver.

Question 5

Find the optimal receiver structure and BER performance for a binary incoherent optical communication system with $n_0(t) = n_{s_0}, 0 \leq t \leq T_b$ and $n_1(t) = n_{s_1}, 0 \leq t \leq T_b$. Discuss the results for various values of n_{s_0} and n_{s_1}.

SOFTWARE QUESTIONS

Question 6

Simulate an OOK optical communication system and investigate its BER performance. You might use MATLAB or Python for the simulation.

BONUS QUESTIONS

Question 7

Simulate a binary PPM incoherent optical communication system and investigate its BER performance. You might use MATLAB or Python for the simulation.

Question 8

Return your answers by filling the LaTeXtemplate of the assignment.