1. The signal component of a coherent binary PSK system is defined by

\[ s(t) = \pm \sqrt{\frac{2E_b}{T_b}} \cos(2\pi f_c t) \]

where \( 0 \leq t \leq T_b \). The plus sign corresponds to symbol 1 and the minus sign corresponds to symbol 0. The block diagram of the receiver is shown in Fig. 1.

If the correlator supplied with a phase reference that deviates from the exact carrier phase by \( \phi_0 \) radians, derive an expression for the average probability of error. The channel is an additive white Gaussian noise (AWGN) channel of zero mean and power spectral density \( \frac{N_0}{2} \).