Link-by-Link Coded Physical Layer Network Coding on Impulsive Noise Channels

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Abstract

- PNC: Physical-Layer Network Coding (PNC) employed on a conventional two-way relay channel (TWRC) is an active research area due to the potential doubling of the throughput compared with traditional routing. We investigate the effects of impulsive noise added at the relay of a TWRC employing link-by-link coded PNC, where the coding scheme of interest is the turbo code.
- GMM: Gaussian mixture model [1], to investigate the effects of impulsive noise added at the relay of a TWRC employing link-by-link coded PNC, where the coding scheme of interest is the turbo code.

$$p_{GMM}(x) = (1-\alpha)p_G(x) + \alpha p_I(x)$$

System Model

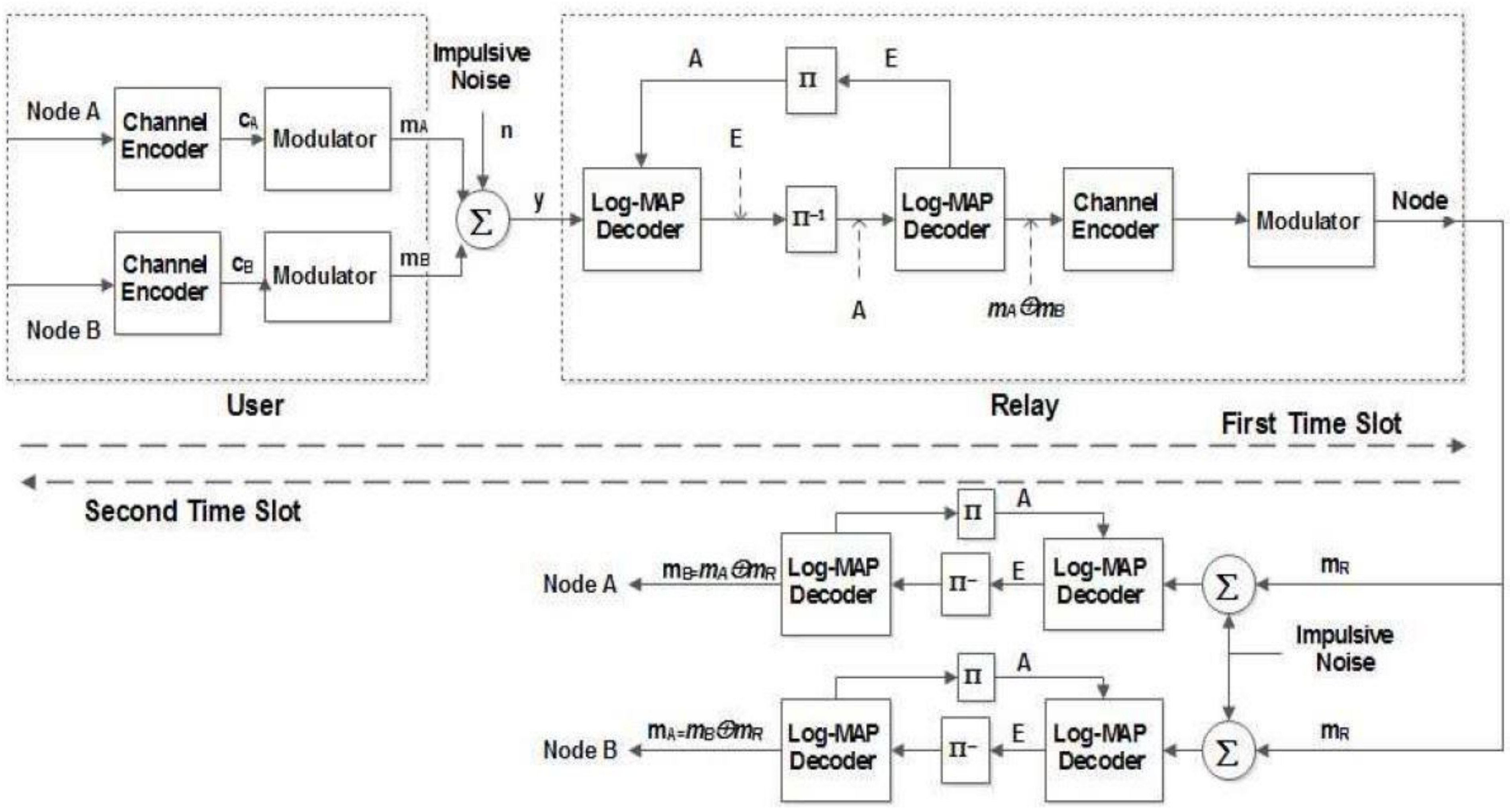


Fig.1 System model showing turbo encoder and iterative decoding processing of the PNC system

- Relay receive and add the transmitted symbol from Node A and B at the same time, where $m_R = m_A \otimes m_B$.[2]
- The decode message bits then encode again at relay, and broadcast back to Node A and B, where each node performs an XOR operation to extract the information bit, i.e. For Node A: $m_B = m_A \otimes m_R = m_A \otimes (m_A \otimes m_B)$.

ExIT Chart

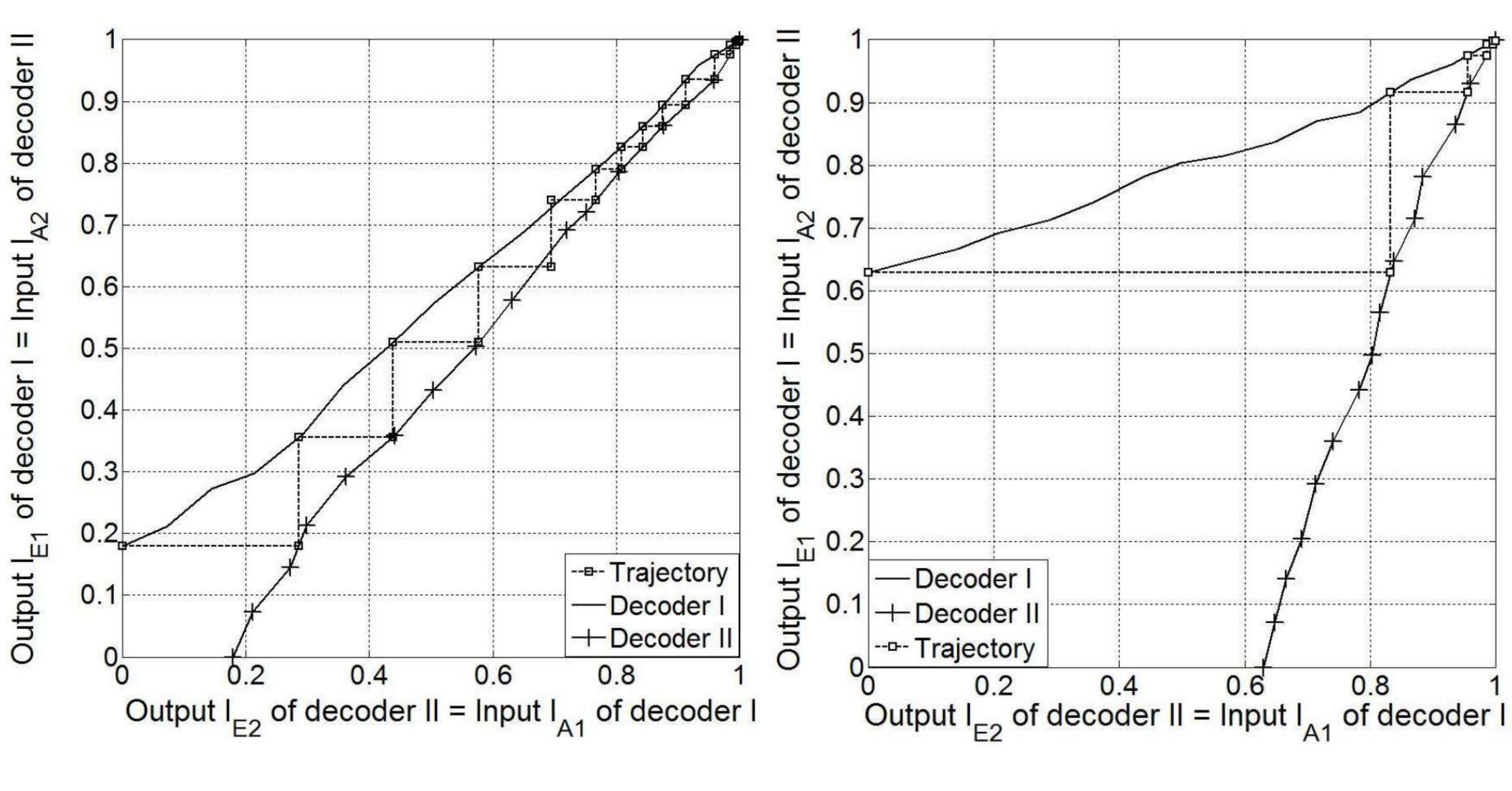


Fig.2 Rate $\frac{1}{2}$ Turbo code ExIT chart on PNC over Impulsive channel at relay, α=0.01 and 0.1, pinch-off SNR limit = 3.1dB and 16.5dB.

Simulation Result

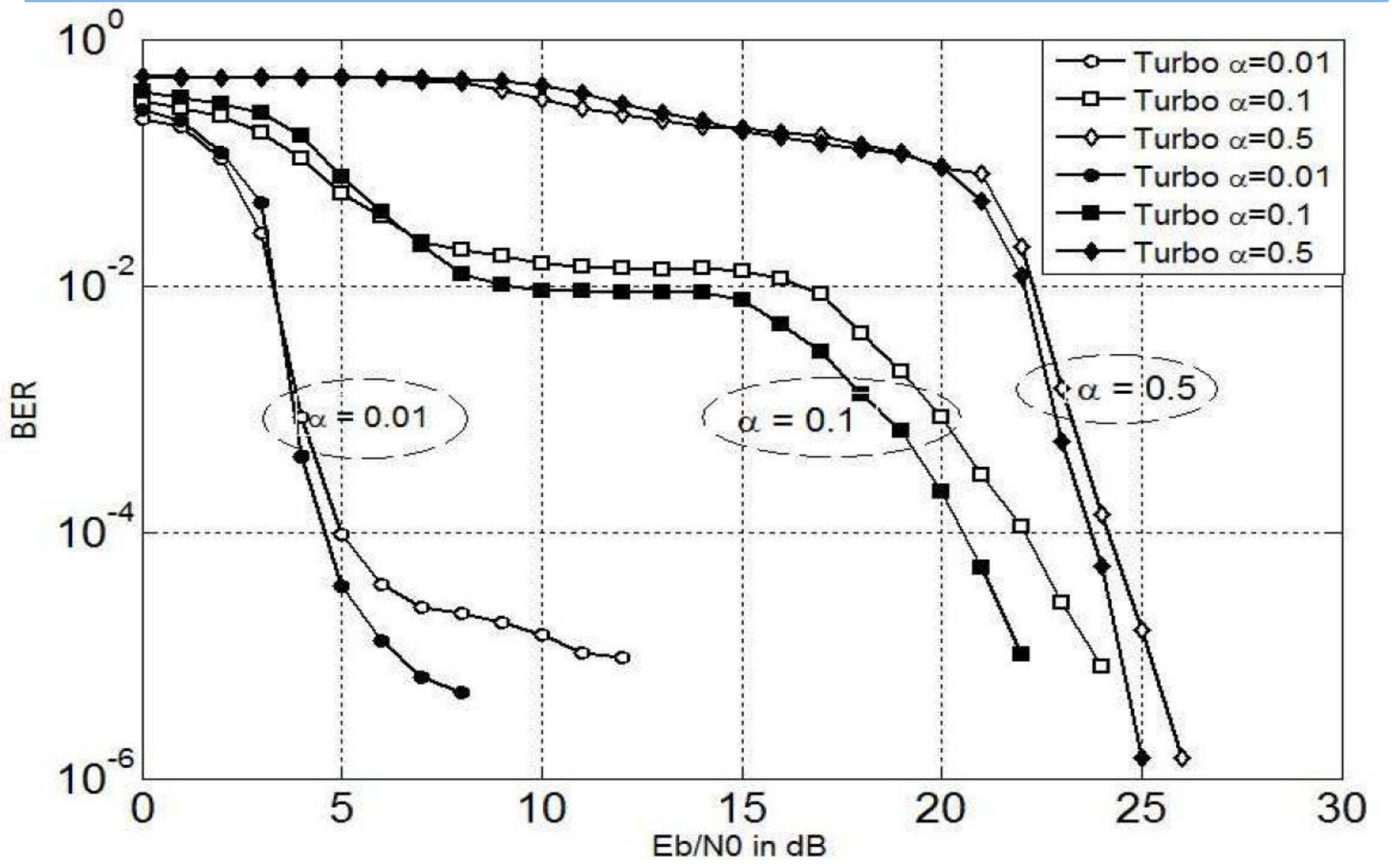
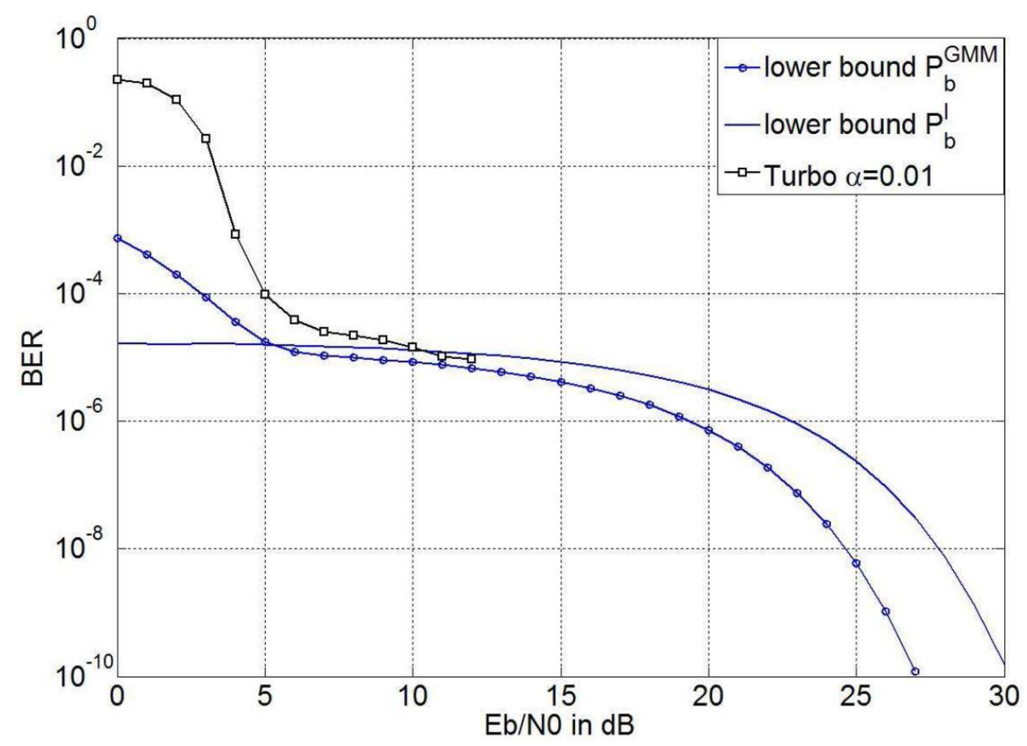
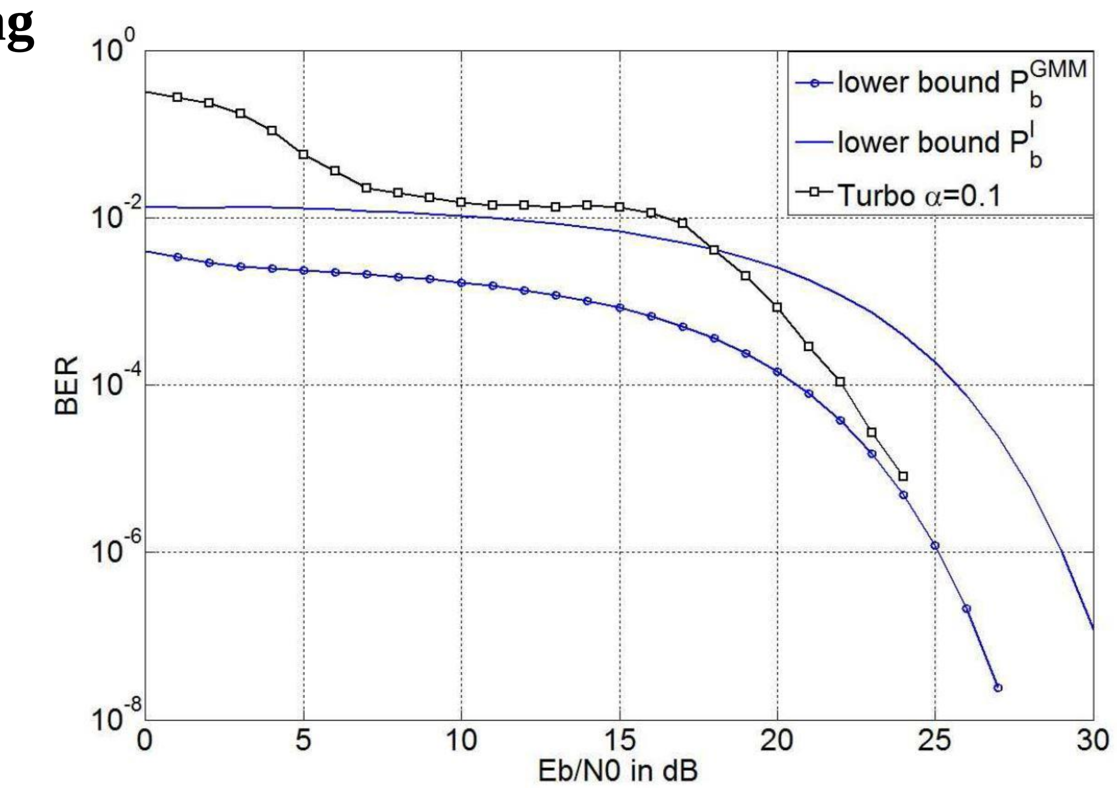


Fig.3 BER performance of rate $\frac{1}{2}$ (white square) and $\frac{1}{3}$ (black square) turbo code over Impulsive noise at the relay

Error Floor Analysis

Fig.4
Comparison of rate $\frac{1}{2}$ turbo code on PNC at relay, α=0.01 and 0.1 with lower bound P_b^{GMM} and the higher impulsive lower bound P_b^I





On the GMM impulsive noise channel, the lower BER bound for turbo codes at the relay is:

$$P_b^{GMM} \leq \frac{3}{2K}\sum_{w\geq 2} w n_w \left((1-\alpha)\sqrt{2R_C d_{w,min}\frac{E_b}{N_G}} + \alpha\sqrt{2R_C d_{w,min}\frac{E_b}{N_I}} \right)$$

Conclusion

The performance of turbo codes is seriously affected on the GMM noise channel when the mixture is high, the error floor is determined solely by the impulses of the GMM noise channel at low SNRs, but this effect quickly reduces with increasing SNR and the Gaussian noise part of the GMM noise channel has more of an effect on the performance.

Reference

- [1] Middleton D. Procedures for determining the parameters of the first-order canonical models of Class A and Class B electromagnetic interference [10][J]. Electromagnetic Compatibility, IEEE Transactions on, 1979 (3): 190-208.
- [2] Zhang S, Liew S C, Lam P P. Hot topic: physical-layer network coding[C]//Proceedings of the 12th annual international conference on Mobile computing and networking. ACM, 2006: 358-365.