802.3BZ 2.5G/5GBASE-T TF

EXTERNAL NOISE EVENT STUDY

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OUTLINE

1. Motivation.
2. Genie-aided decoder.
3. Simulator for the external noise events study.
4. Modeling the external noise events.
5. Simulation results.
6. Summary.

MOTIVATION

- For Alien Noise limited channels:
  - 10GBASE-T's DSQ-128 and LDPC code provide robust performance.
  - Performance is limited by LDPC code.
  - Euclidean distance does NOT limit performance.

- Questions asked for channels with high levels of external noise:
  - Is the Euclidean distance sufficient to protect the Euclidean distance protected bits?
  - Is the assumption correct, that the LDPC coded bits are NOT limiting performance?
  - Would FEC protection on the Euclidean distance improve performance?

- Objective of this study is to evaluate the performance of the Euclidean distance protection in the presence of external noise.

GENIE-AIDED DECODER

- **For our current channels, we observe two types of errors:**
  - CRC error only.
  - Syndrome error (w or w/o CRC error).
- **Syndrome errors will disturb the Euclidean distance protected bits during the DSQ de-mapping process. Distinguish the cause of the failure of Euclidean distance protected bits due to:**
  - the LDPC decoding fails and LDPC coded bits propagate errors to Euclidean distance protected bits in DSQ de-mapper or
  - the Euclidean distance protection that is overcome by noise.
- **A "genie-aided" decoder such that the encoder (genie) can pass the correct encoded bits to the decoder for the DSQ-demapping. Now the DSQ-demapper is independent of LDPC decoding.**
  - LDPC protection fails
  - Euclidean distance protection fails

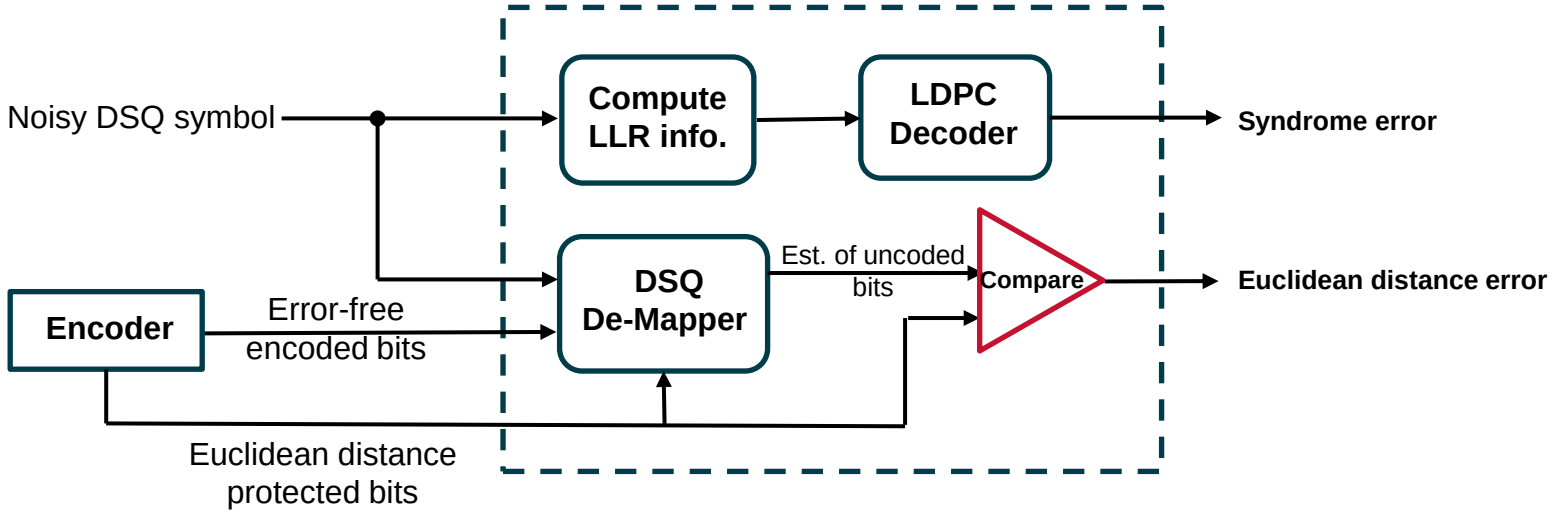


Figure 1. Genie-aided decoder

THREE TYPES OF ERRORS

- **Differentiate three types of errors:**
  - **Euclidean distance failure only** (Only Euclidean distance protected bits have errors)
  - **LDPC code failure only** (Only LDPC coding protected bits have errors)
  - **LDPC code & Euclidean distance failure** (Both LDPC coding and Euclidean distance protected bits have errors)
- **Red result bubbles increment, if both inputs are true.**

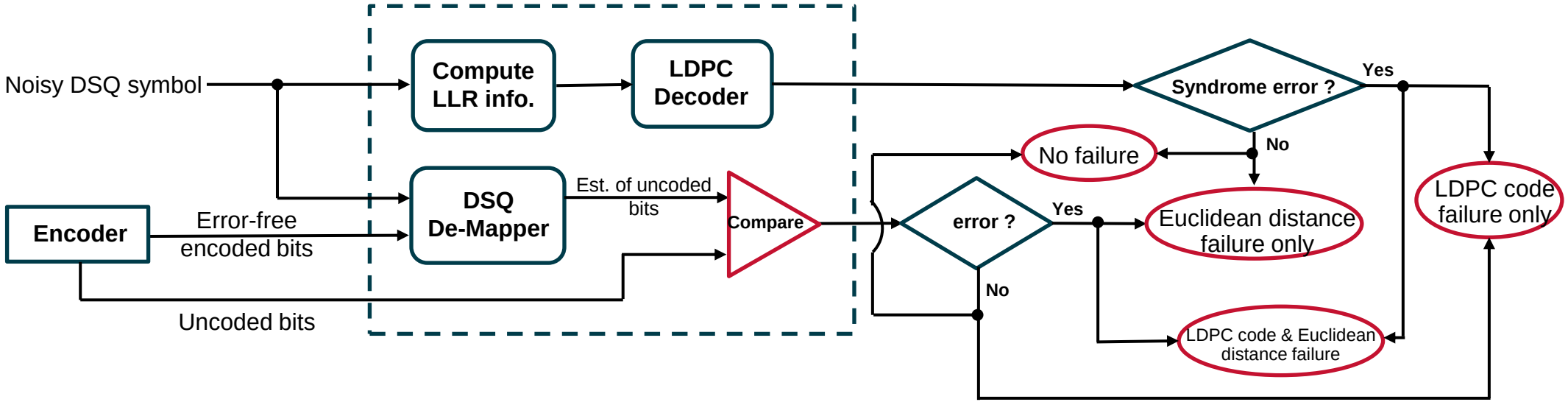


Figure 2. Genie-aided decoder that calculates three types of errors

SIMULATOR DIAGRAM

- **To study the impact of external noise events, we constructed the following simplified PHY system as shown in Figure 3.**
- **AWGN noise and external noise events (4X over-sampled) are added to all four channels.**

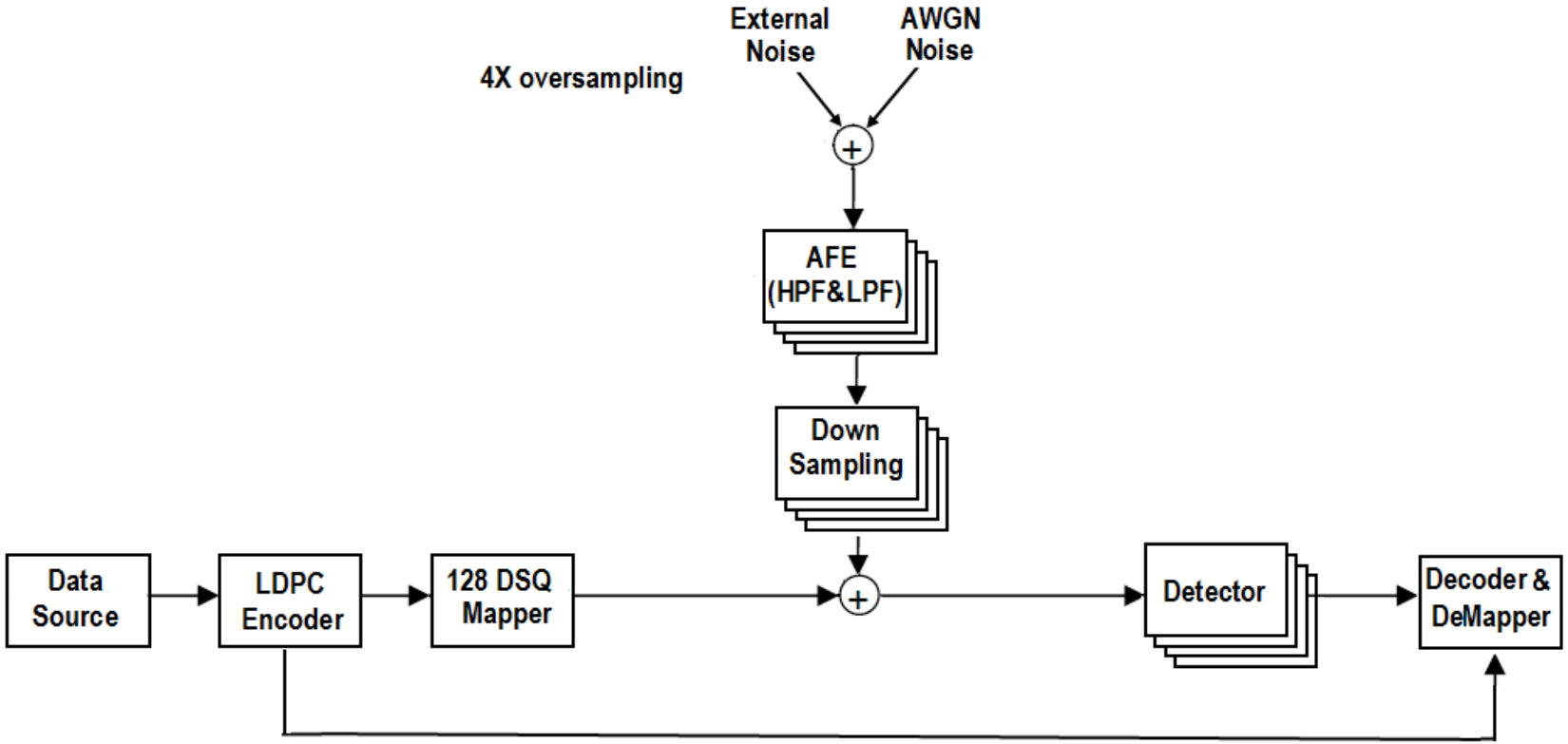
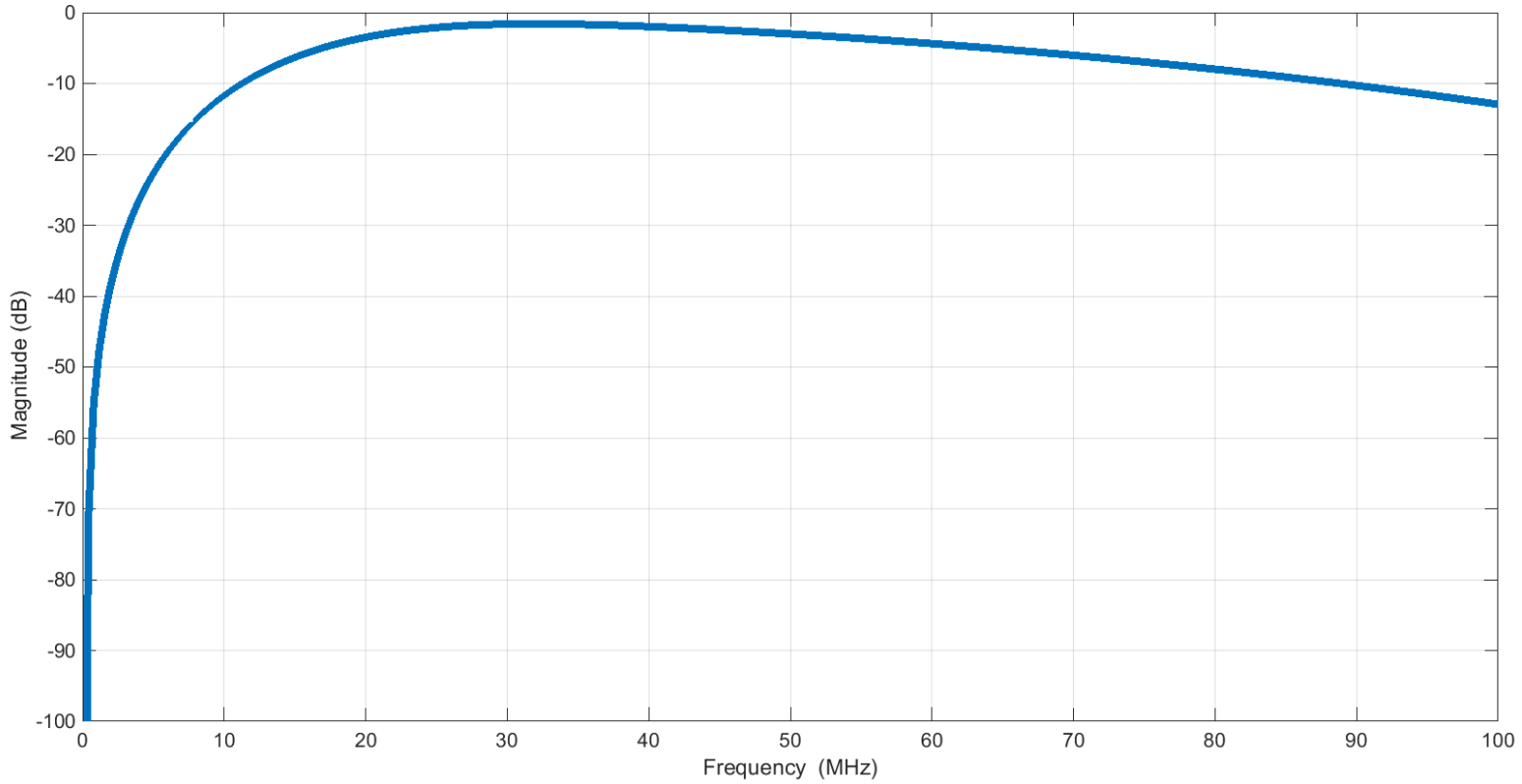


Figure 3. Simplified PHY Block Diagram

SIMULATION SETUP

- Two high-pass filters and one low-pass filter are used in AFE.
  - Magnetics HPF: single pole
  - Analog HPF: single pole
  - Analog LPF: single pole
- Overall magnitude response below:



EXTERNAL NOISE EVENT MODEL

- **External noise event model based on Shirani_NGEABT_03_0315.pdf**
- **Model external noise as the product of an white uniform noise in the range of [-1, 1] with an envelope signal, i.e.,**

$$n_{external} = n_{uniform} \times s_{envelope}$$

- **Model parameters: *A* (amplitude or peak value of the envelope signal), T_r (rise time of the envelope signal), T_d (decay time of the envelope signal), frequency *f* (how often an external noise event occurs)**

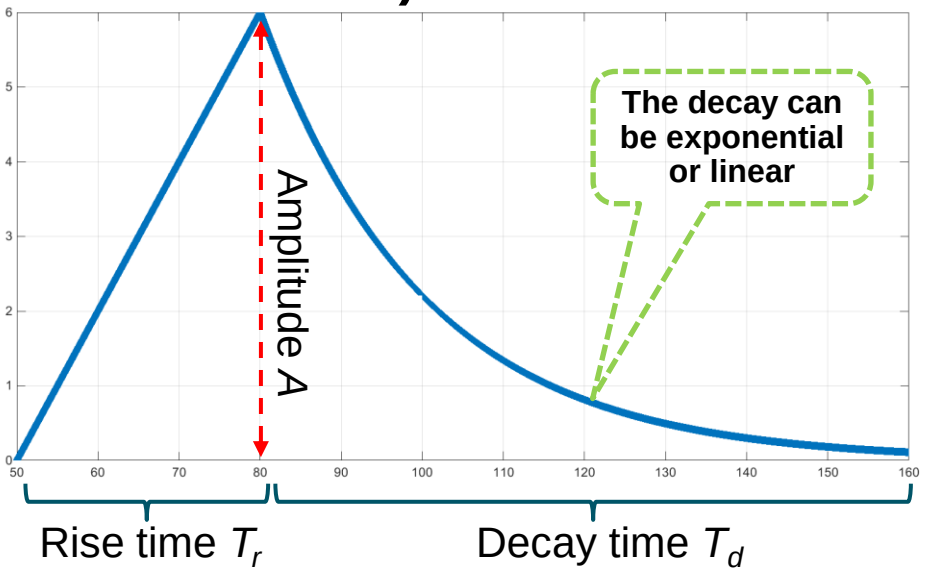


Figure1. Envelope signal

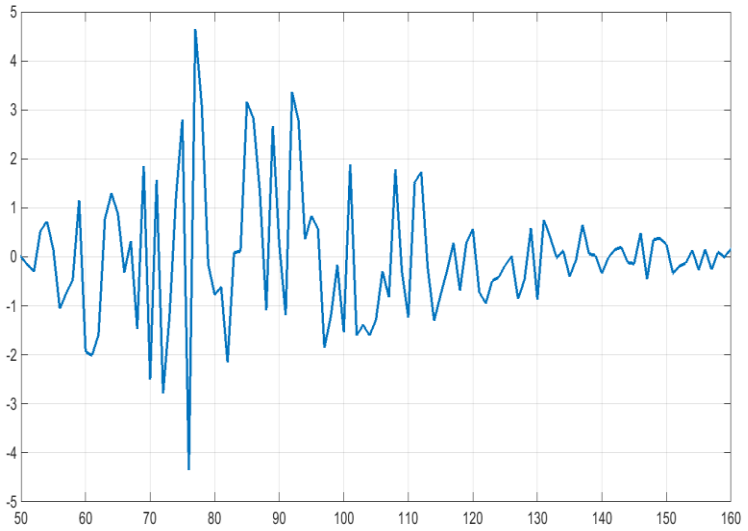
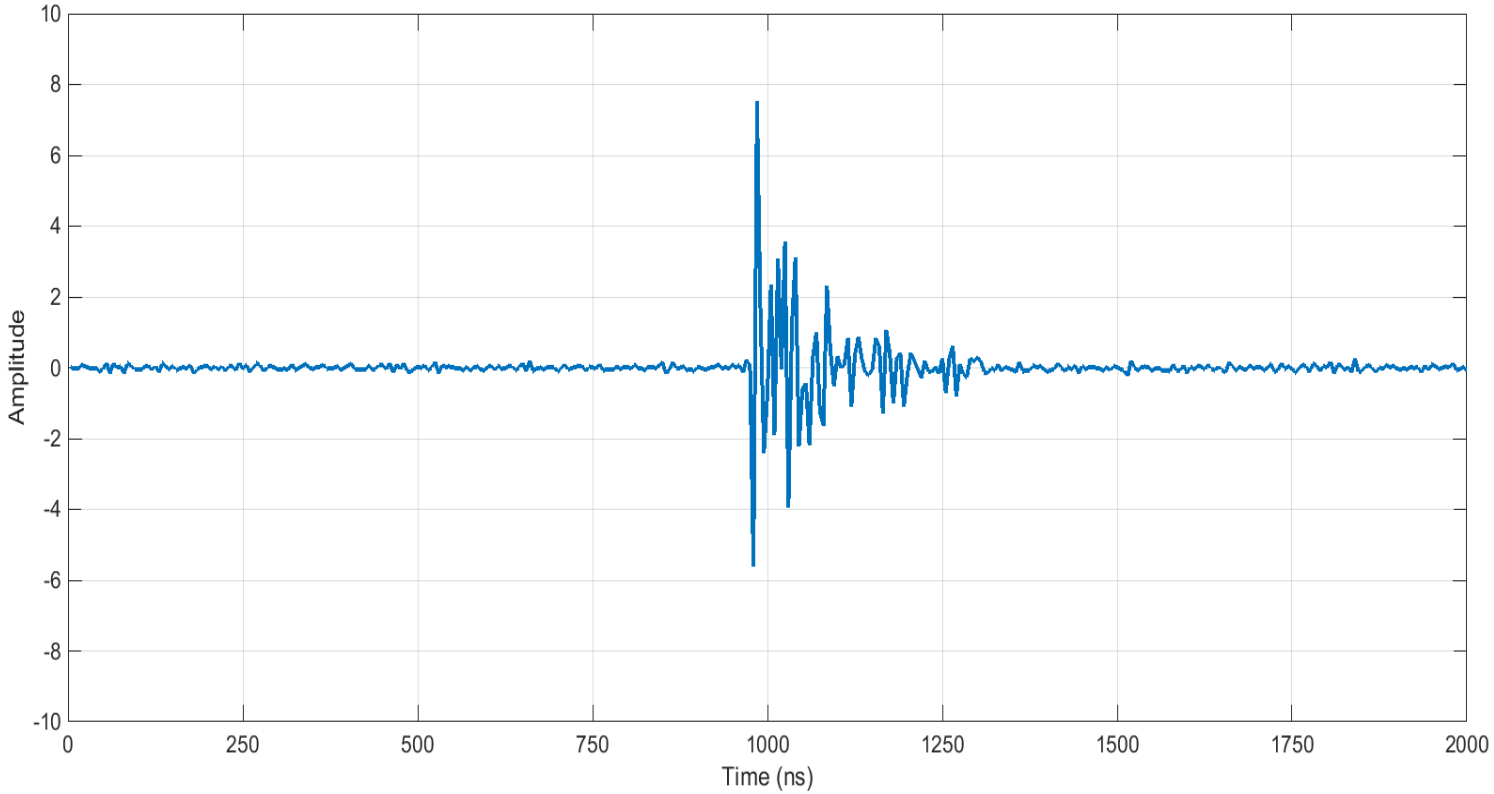


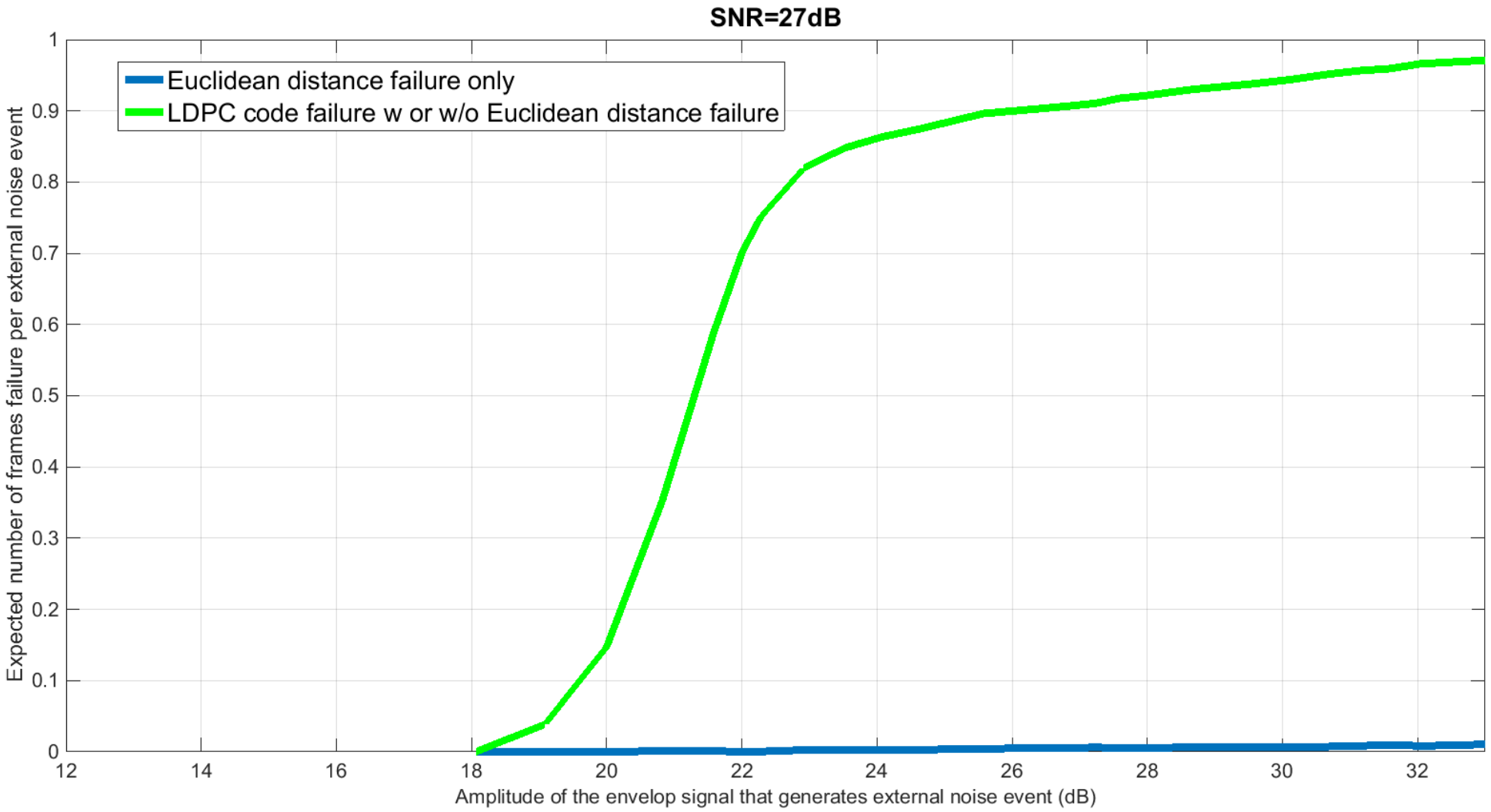
Figure 2. External noise generated from the envelope signal in Figure 1.

SIMULATION I (EXTERNAL NOISE EVENT)

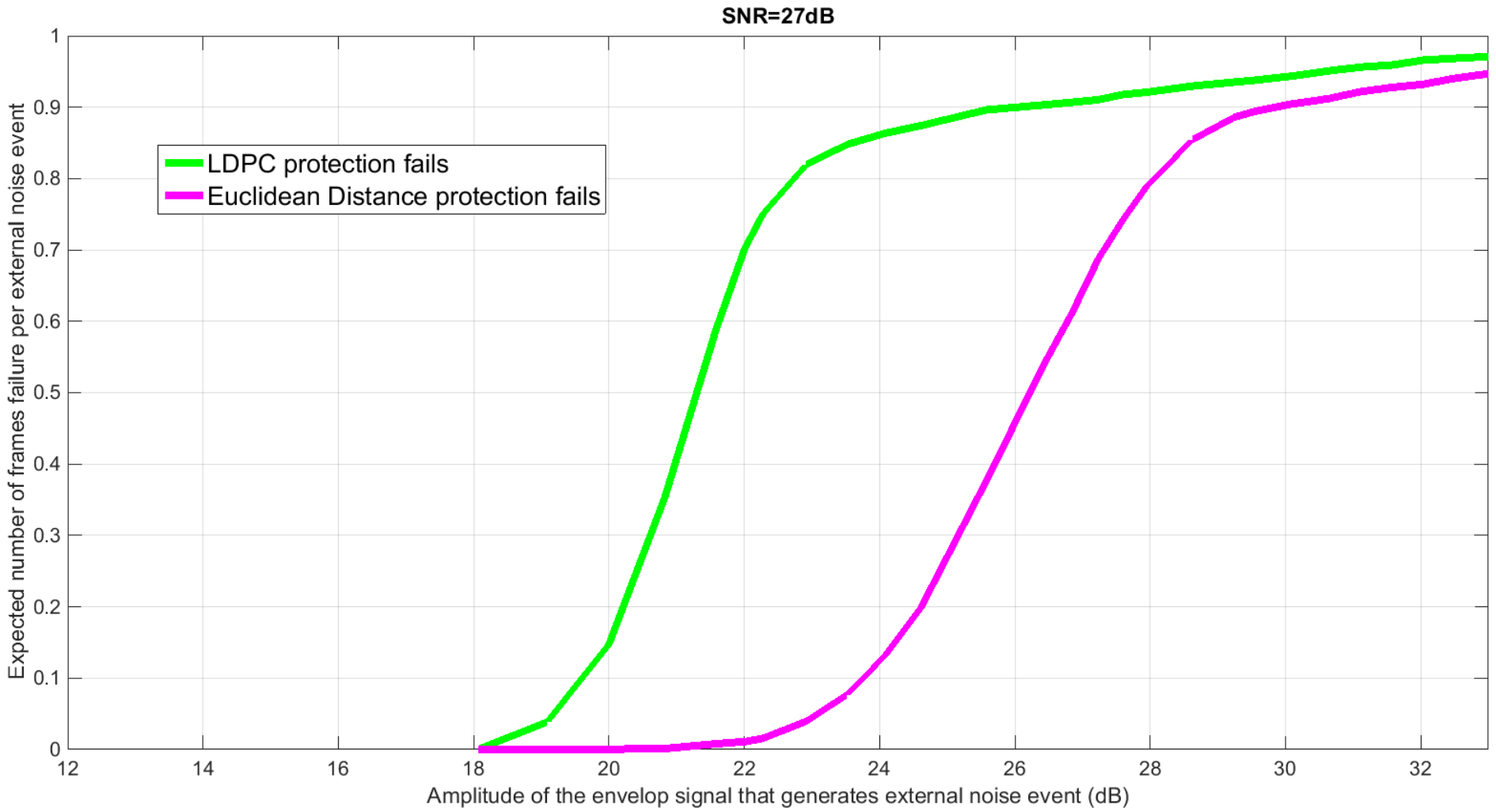
- **Rise time $T_r = 0$**
- **Decay time T_d = 64 symbol periods (320 ns), exponential decay.**
- **Frequency f = 0.2 (An external noise event occurs in every 5 consecutive data frames for each of the 4 channels)**
- **The starting times of external noise events for 4 channels are random, but time differences are within 50ns.**



SIMULATION RESULT I



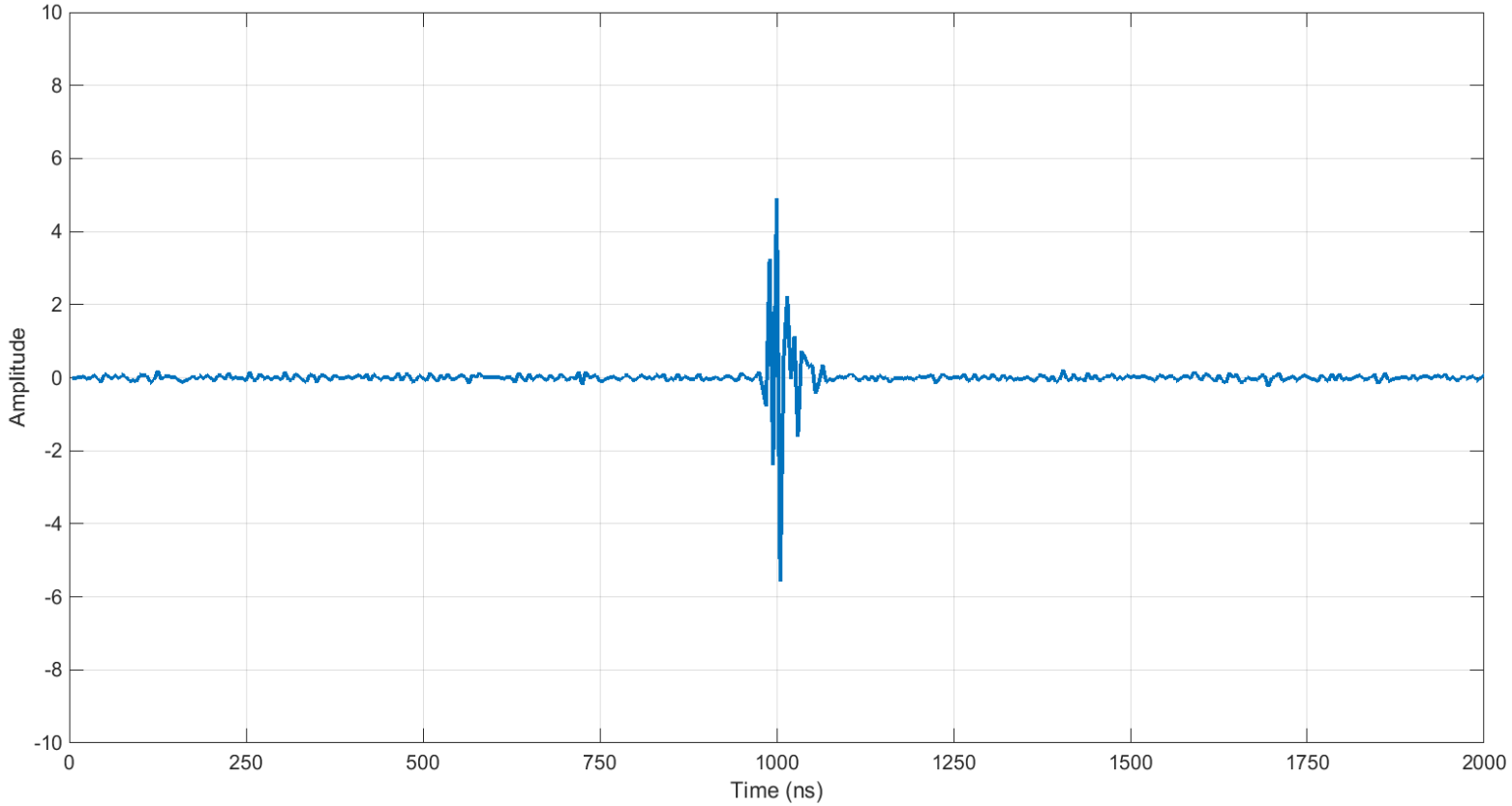
SIMULATION RESULT I (CONT.)



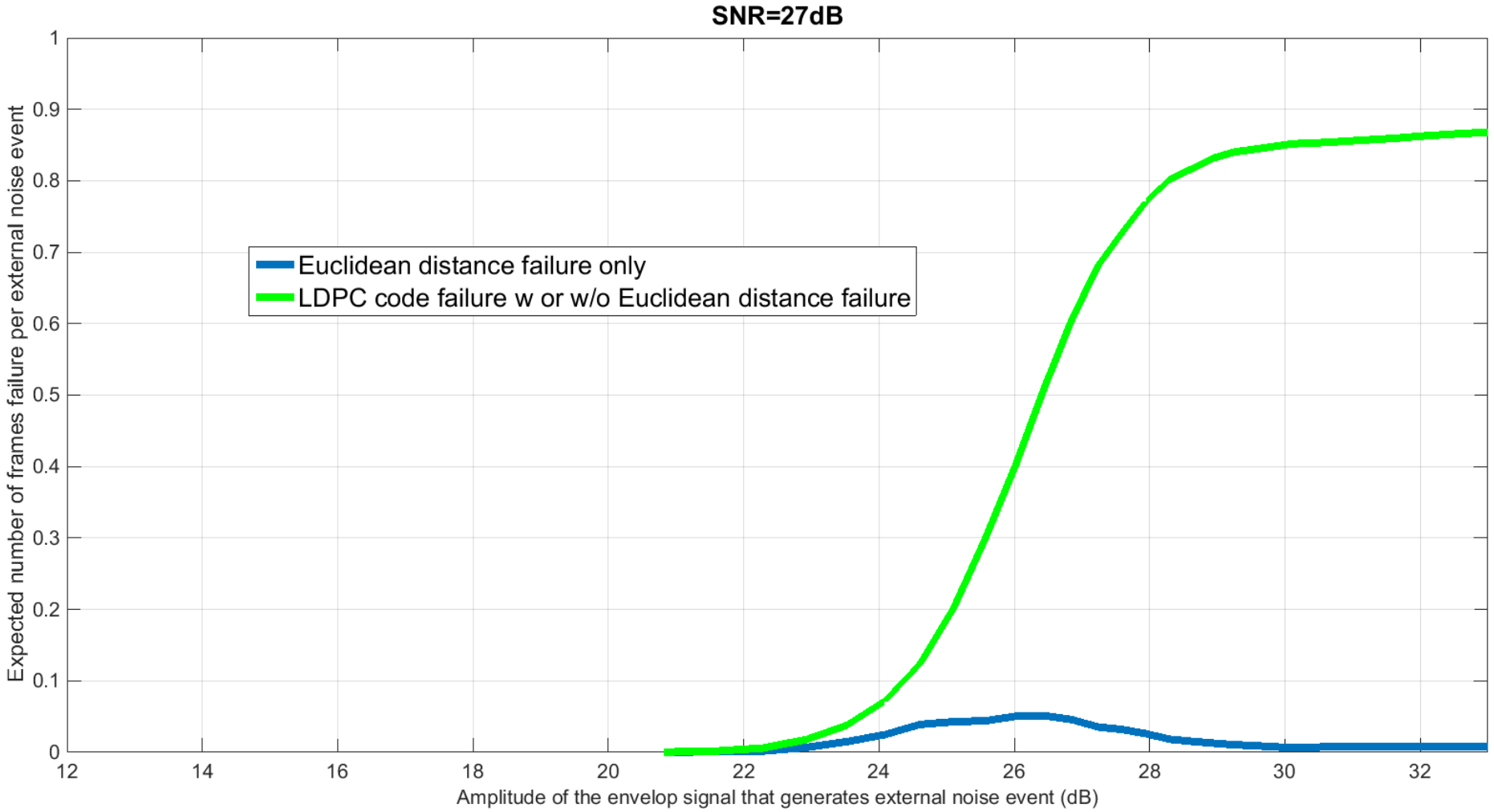
- LDPC protection fails at lower noise amplitude when compared with Euclidean Distance protection failure.

SIMULATION II (SHORT EXTERNAL NOISE EVENT, E.G., EXTERNAL NOISE FROM MESH DESK CHAIR INTERNAL ESD AT 2M (CAT 5E UTP))

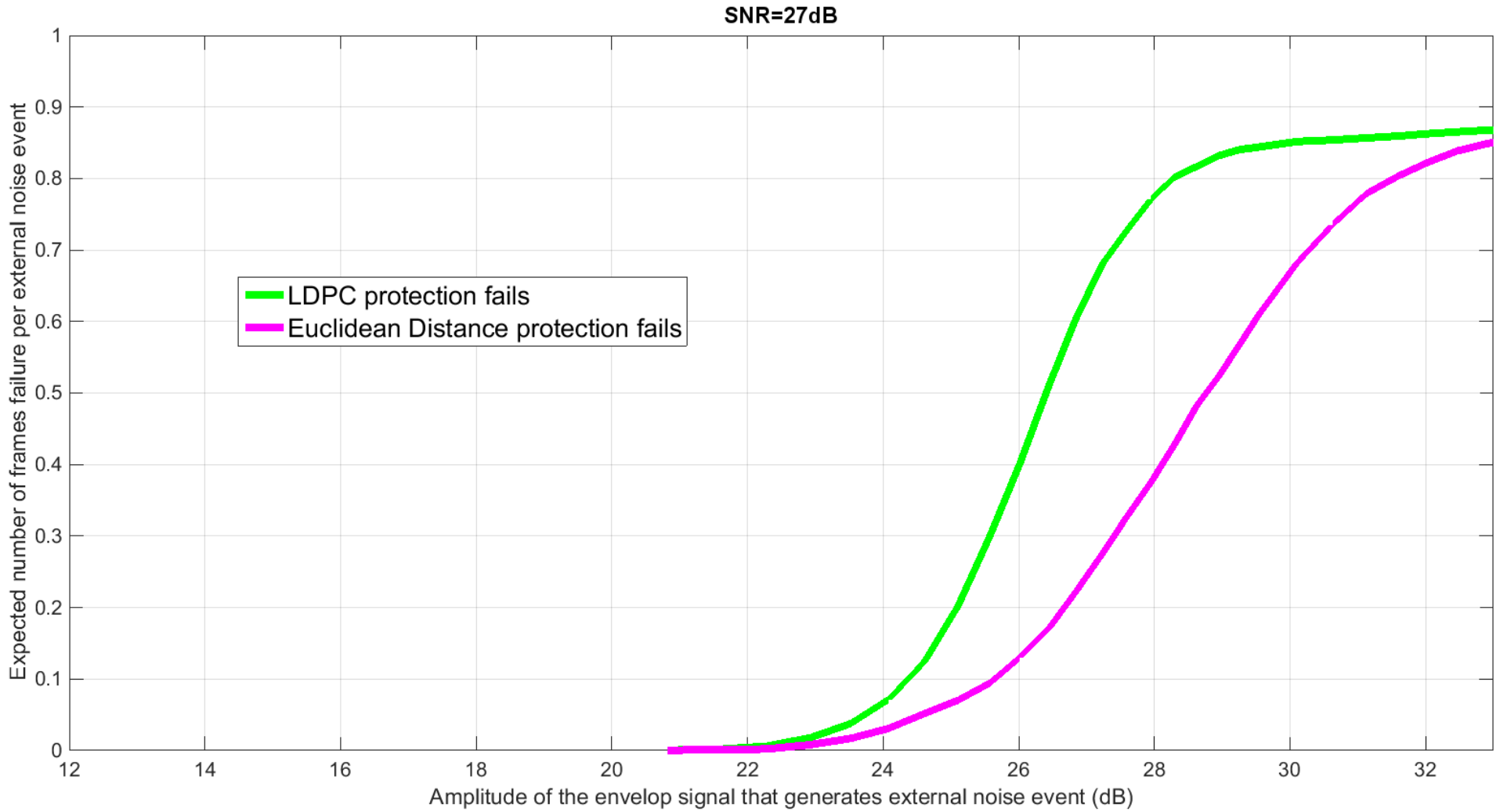
- Rise time T_r = 4 symbol periods (20 ns)
- Decay time T_d = 12 symbol periods (60ns), exponential decay.
- Frequency f = 0.2 (An external noise event occurs in every 5 consecutive data frames)
- The starting times of external noise events for 4 channels are random, but time differences are within 50ns.



SIMULATION RESULT II

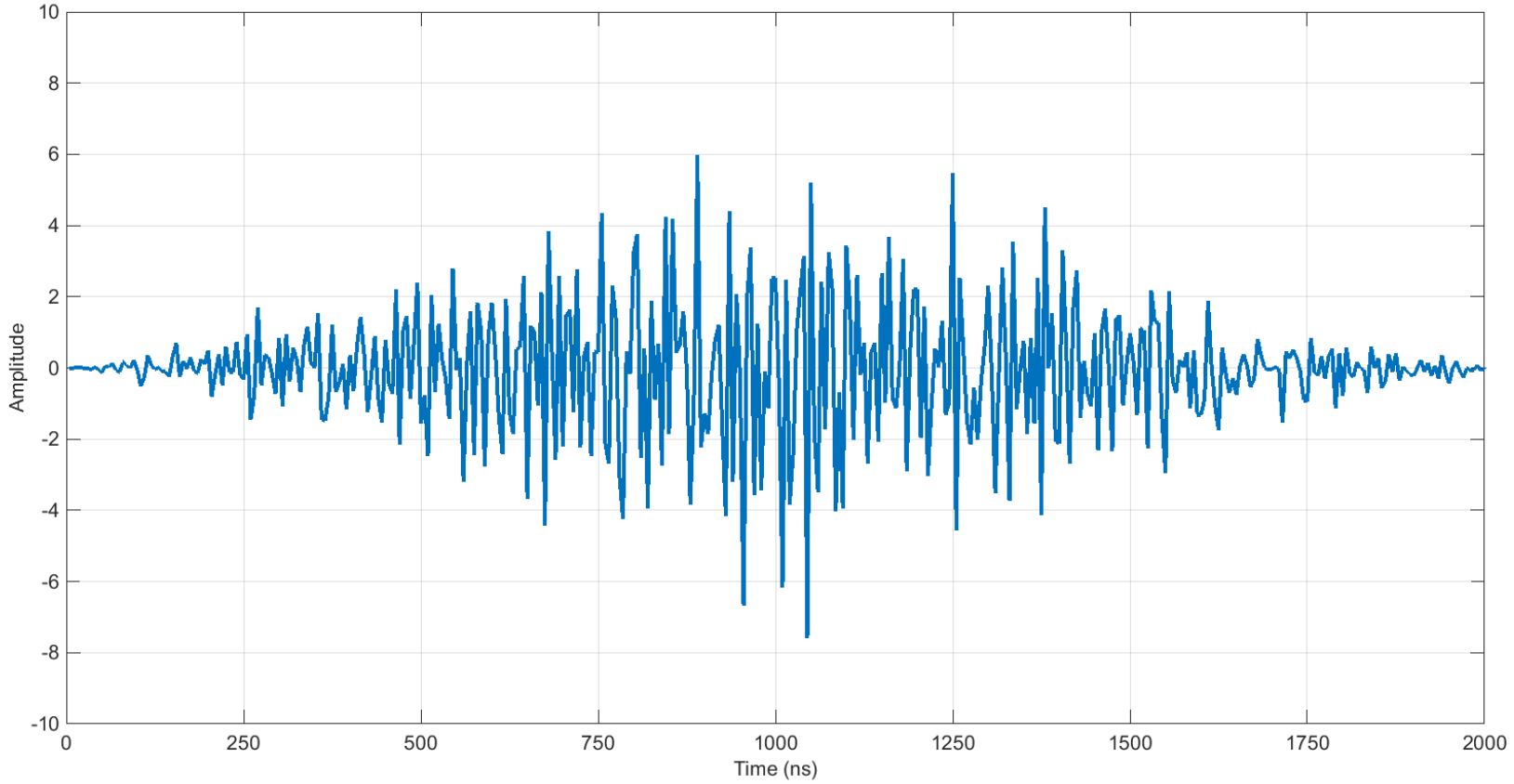


SIMULATION RESULT II (CONT.)

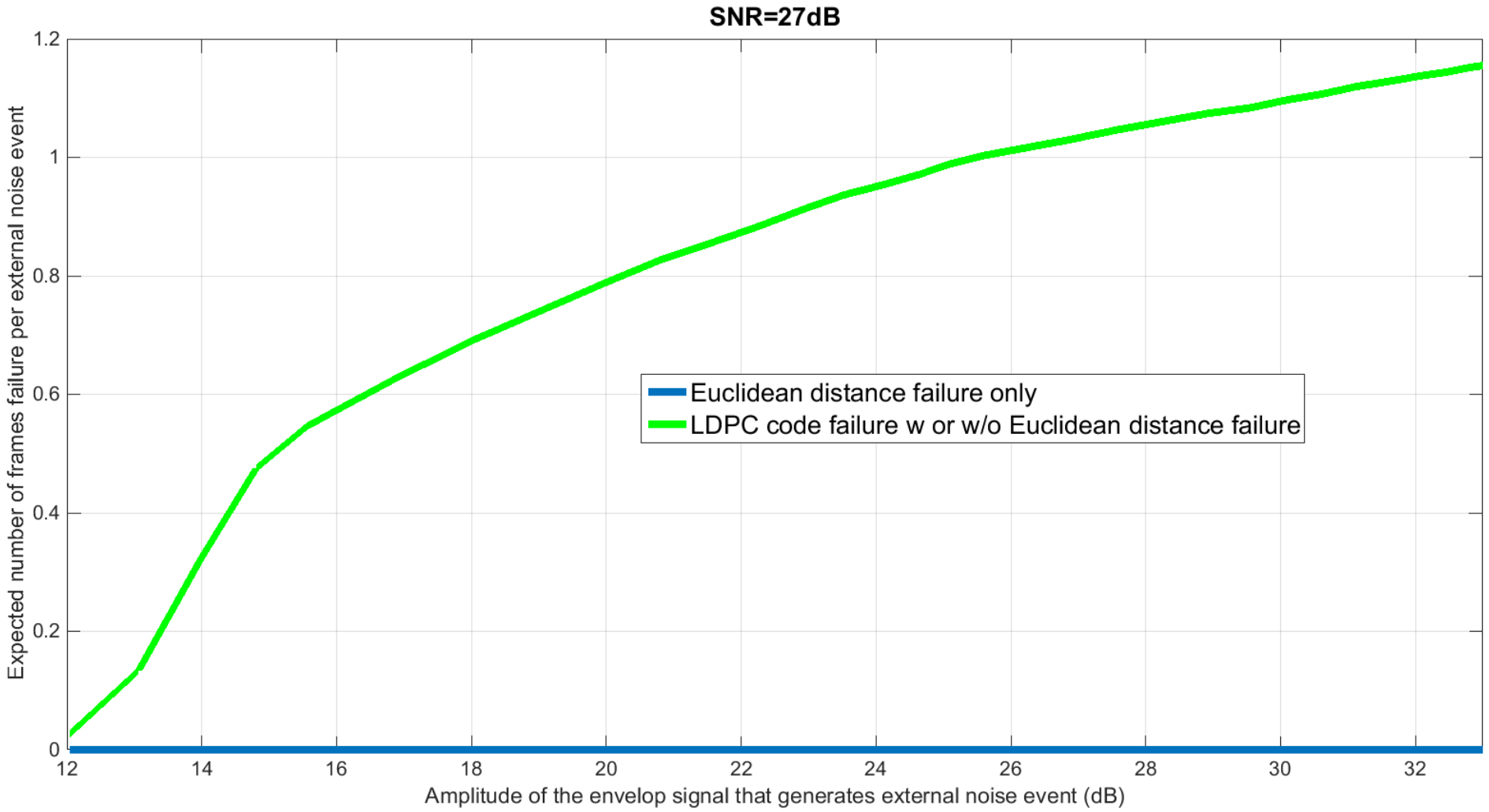


SIMULATION III (LONG EXTERNAL NOISE)

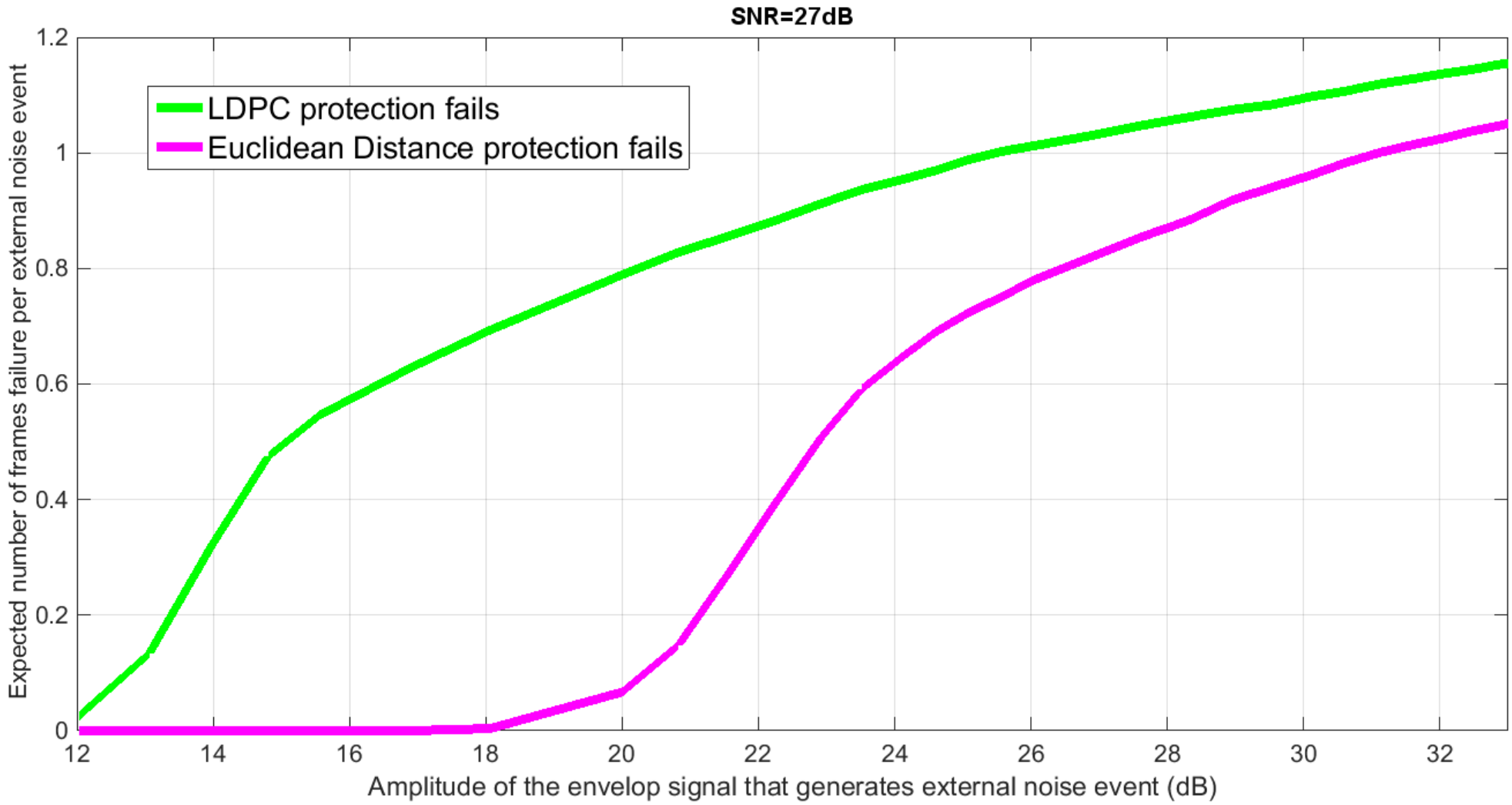
- Rise time T_r = 200 symbol periods (1000 ns)
- Decay time T_d = 200 symbol periods (1000 ns), linear decay.
- Frequency f = 0.2 (20% time we encounter external noises)
- The starting times of external noise events for 4 channels are random, but time differences are within 50ns.



SIMULATION RESULT III



SIMULATION RESULT III (CONT.)



EXTERNAL NOISE EVENT STUDY SUMMARY

- Model of 2.5G/5GBASE-T PHY used to study the impact of external noise events
- External noise event model based on Shirani_NGEABT_03_0315.pdf
- For each external noise event model, vary:
  - Noise event amplitude and
  - Envelope
- For each external noise event model, quantify:
  - Euclidean distance protection failure
  - LDPC code protection failure
- For all external noise events modeled, the simulation results show:
  - LDPC code protection failures far more dominant than Euclidean distance protection failures
  - Broadcom modulation / coding proposal NOT Euclidean distance limited