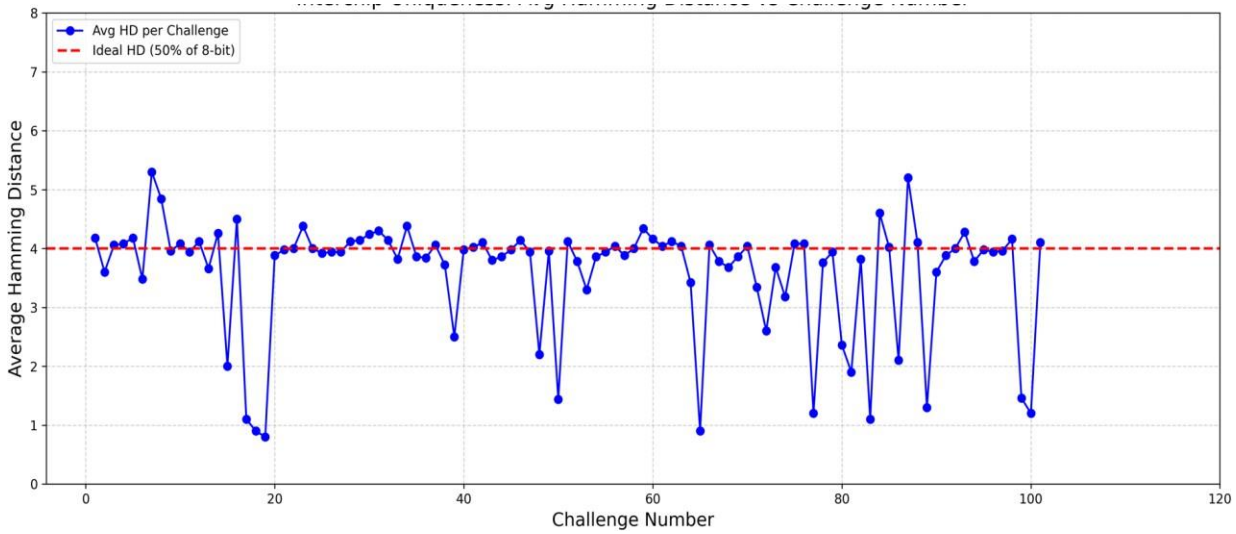
Hamming Distance-Based Inter-Chip Response Analysis



The interchip uniqueness graph shows how differently two chips respond to the same set of 100 challenges. For each challenge, 10 responses were taken from one FPGA board and 10 from another, giving a total of 100 response pairs (10 × 10). For each pair, the Hamming Distance (HD) between the two 8-bit responses was calculated. These 100 HD values were then averaged to get one average HD per challenge. This process was repeated for all 100 challenges, and the average HD values were plotted to observe the variation across challenges.

The graph follows a consistent trend, with most values clustering around 4, which is the ideal HD for 8-bit responses (50% bit difference). This trend confirms that the responses from the two chips are sufficiently different and that the RO-PUF design achieves good interchip uniqueness. A few challenges show HD values slightly below 2 or above 5, but the majority fall in the desired range of 3 to 5, indicating reliable and distinct behavior across devices.

The overall interchip uniqueness was calculated by averaging all the average HD values across the 100 challenges. This resulted in an interchip uniqueness of **45.009901%**, which is close to the ideal 50%, confirming strong device-level separability.

The interchip HD for a challenge is:

$$\text{Avg\_HD}_{\text{challenge}} = \frac{1}{100} \sum_{i=1}^{10} \sum_{j=1}^{10} \text{HD}(R_i^{(A)}, R_j^{(B)})$$

The formula used for interchip uniqueness is:

$$\text{Interchip Uniqueness (\%)} = \left(\frac{\text{Sum of Average HD over all challenges}}{8 \times \text{Number of Challenges}} \right) \times 100$$