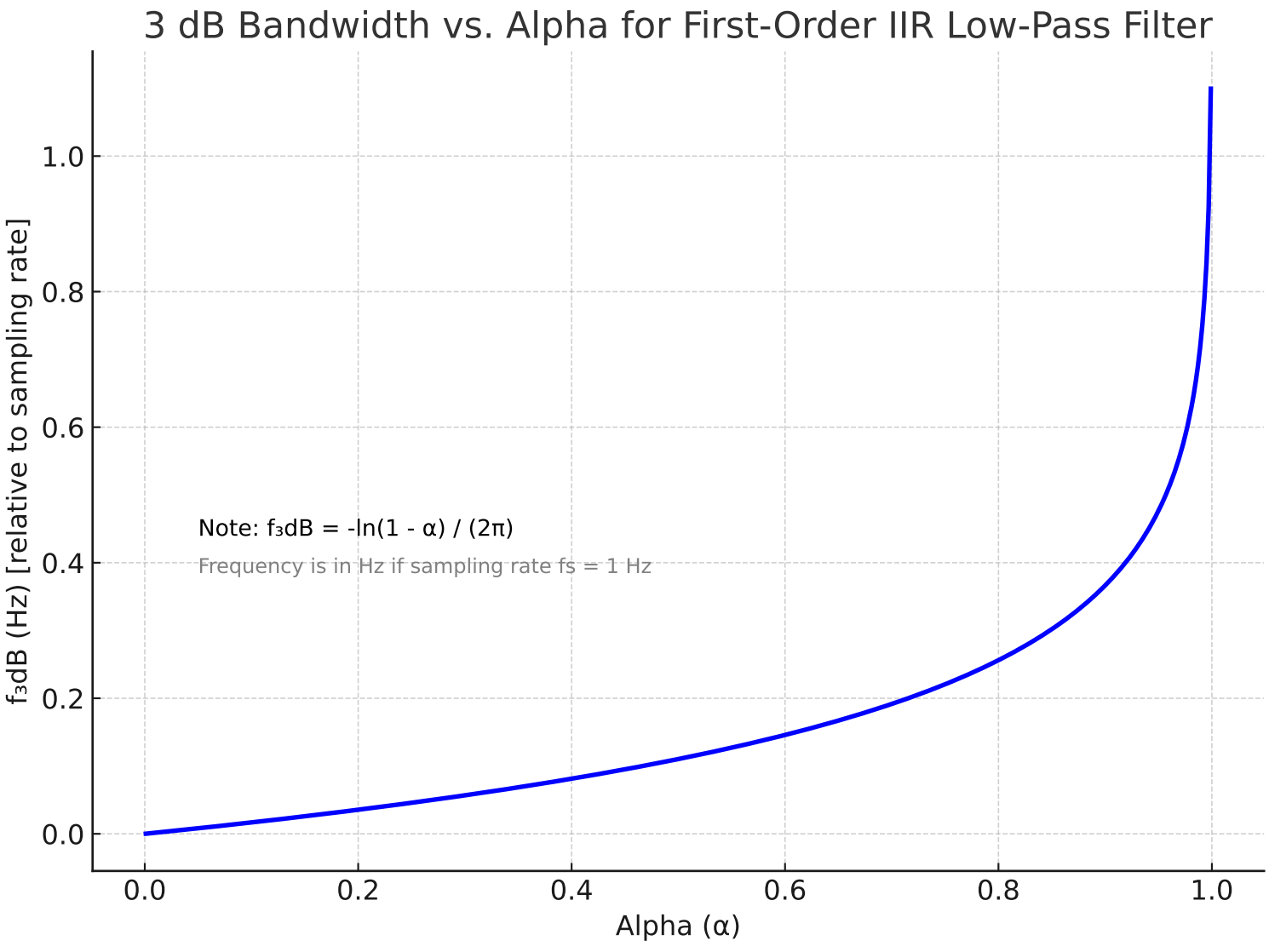
3 dB Bandwidth vs. Alpha for First-Order IIR Low-Pass Filter
f₃dB (Hz) [relative to sampling rate]
Alpha (α)
0.0
0.2
0.4
0.6
0.8
1.0
Note: f₃dB = -ln(1 - α) / (2π)
Frequency is in Hz if sampling rate fs = 1 Hz

IIR First-Order Low-Pass Filter: 3 dB Bandwidth Analysis (via ChatGPT)

Filter Equation:
$$y[n] = (1 - \alpha) * y[n - 1] + \alpha * x[n]$$
where $0 < \alpha < 1$

3 dB Bandwidth Formula:
$$f_{3dB} = -\ln(1 - \alpha) / (2\pi) * f_s$$

Explanation:
- This defines the cutoff frequency (in Hz) where the output power falls by half (-3 dB).
- The frequency is expressed relative to the sampling rate f_s (typically 1 Hz in time-based applications).
- As α increases, the filter reacts faster and allows more bandwidth through.

Observations:
- Small $\alpha \rightarrow$ slow response $\rightarrow$ narrow bandwidth
- Large $\alpha \rightarrow$ fast response $\rightarrow$ wide bandwidth
- When $\alpha \rightarrow 1$, the cutoff frequency approaches Nyquist ($0.5 * f_s$)

Use Cases:
- α is often tuned to match a desired cutoff frequency or smoothing behavior.
- This formula helps convert between intuitive "speed of reaction" and formal filter characteristics.

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