**What is the PLL Digital Frequency**

**First let define a signal *x*(*t*) with frequency *fo* signal period *To*. The**

**digital sequence *x*[*k*] is sampled at discrete times = , where is the sampling period.**

**Now the signal can be written as:**

***x*(k) = *A* cos(ω+ *φ*) = *A* cos(ω+ *φ*)**

**If we define a new parameters called the digital frequency we can now write the above equation as:**

***x*(k) =*A* cos(+ *φ*) = *A* cos(+ *φ*)**

**In other word, we are simply normalizing the frequency of the physical signal to how fast it was sampled. Note also that the digital frequency Ω is the angular frequency (rad/s) times the sampling period (s/sample), so the units of digital frequency are rad/sample.**

**As a concept one major reason for using Ω instead of is that signal processing techniques fundamentally take in a sequence of numbers *x*[*n*] and operate on them in the same way regardless of the sampling period. By generalizing the sequences to the parameters k the time become an integer index and we can generalize signal processing techniques from that.**

**Going back to the equation of a second order ADPLL as presented in**

A close-up of a computer screen

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We have the following transfert fonction et parameters defined as:

A math equations and formulas

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Another aspect to consider for a ADPLL is that there is three frequencies of concern for system performance consideration. We have the resonance frequency , which appear directly as a parameters in the transfer function H(s), the 3 dB bandwidth and the noise bandwidth equivalent related to the measure in the energy of the noise at the output relative to a perfect windows type bandwidth this parameter (NEB) can be called Bn but it is generally better to define it as as to distinguish it from the parameter .The relation for or can be shown to be dependent of and the damping factor ζ as:

A mathematical equation with numbers and symbols

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**Or**

=

The reference from the equation above is R. Best, Phase Locked Loops - Design, Simulation and Applications (6th Edition), McGraw Hill, 2007

Also the the 3dB bandwidth can be approximated with this formula extractr from a visual graphic interpretation from ChatGPt:

# 3 dB Bandwidth vs. Damping in Second-Order ADPLL

This document presents an improved model for estimating the 3 dB bandwidth of a second-order analog or digital phase-locked loop (ADPLL) system as a function of the damping factor ζ.

## Measured Bandwidth Data

Measured 3 dB bandwidths (normalized by natural frequency fn):

|  |  |
| --- | --- |
| Damping Factor (ζ) | 3 dB Bandwidth / fn |
| 0.70 | 2.04 |
| 1.00 | 2.46 |
| 1.25 | 2.86 |
| 1.50 | 3.28 |

## Improved Analytical Fit

Rather than relying on a linear approximation, the following analytical model provides a better match:

f₃dB ≈ 2 · fₙ · (ζ + 1 / (4ζ))

This expression reflects the natural shape of the transfer function and improves accuracy across a wider range of damping factors compared to simple linear regression.

## Comparison Graph

The following graph compares the measured 3 dB bandwidths to values predicted by the improved formula:

A graph with a red line

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**Frequency Response Curves**

**This figure shows the frequency response of the second-order ADPLL system for different damping factors ζ. The 3 dB points are visually confirmed in each case.**

**A diagram of a frequency response

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