First-Order Digital Filter Coefficient and Response

Smoothing coefficient of a first-order digital filter for a time constant and sample time, in exact and backward-Euler forms, with cutoff and settling.

Method: Discretised first-order low-pass filter

Input parameters

Unit system: SI

Parameter	Value	Unit
Filter time constant	2.0000	s
Sample (scan) time	0.10000	s

Calculated results

Parameter	Value	Unit
Coefficient (exact discretisation)	0.048771	
Coefficient (backward Euler)	0.047619	
Cutoff frequency	0.079577	Hz
Samples to 95 % of a step	60.000	
White-noise reduction factor	0.15810	

Notes for this case

• y[k] = y[k−1] + α(x[k] − y[k−1]), α = 1 − e^(−T_s/τ) (or T_s/(τ + T_s) by backward Euler, close when T_s ⍰ τ). White noise is reduced by √(α/(2 − α)). Filtering a controlled variable adds lag; keep τ well below the loop's dead time.

Formula and method

$$\alpha = 1 - e^{-T_s/\tau}, \quad \alpha_{BE} = \frac{T_s}{\tau + T_s}, \quad \frac{\sigma_{out}}{\sigma_{in}} = \sqrt{\frac{\alpha}{2-\alpha}}$$

Variables

τ	Filter time constant	s
T_s	Sample (scan) time	s
α	Coefficient (exact discretisation)	-
α_{BE}	Coefficient (backward Euler)	-
f_c	Cutoff frequency	1/s
n_{95}	Samples to 95 % of a step	-
σ_{out}/σ_{in}	White-noise reduction factor	-

Method and standards

Digital filter.

Assumptions and limits

- Constant sample time; white input noise.

References

Discretised first-order low-pass filter

Report details

Report reference	FCC-HJTX-DNCN (the same inputs always give the same reference)
Generated	23 November 2026, 18:38 UTC
Calculator	First-Order Digital Filter Coefficient and Response
Method last reviewed	17 November 2026
Software release	FireCAD Calc, release of 22 November 2026
Release checks	3 reference cases of this calculator, computed independently, are checked on every release

Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

https://calc.firecad.com/instrumentation/signals-calibration/digital-filter-coefficient

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.