FFT Frequency Resolution, Record Length and Window Bandwidth

Frequency resolution, record length, Nyquist frequency, usable lines and noise bandwidth of an FFT from the sampling rate, block size and window.

Method: Discrete Fourier transform resolution and window noise bandwidth

Input parameters

Unit system: SI

Parameter	Value	Unit
Sampling rate	25.600	kHz
Block size (samples)	4,096.0	
Window	Hann (1.50)	

Calculated results

Parameter	Value	Unit
Frequency resolution (bin width)	6.2500	Hz
Record length	160.00	ms
Nyquist frequency	12,800	Hz
Usable lines (N/2.56)	1,600.0	
Equivalent noise bandwidth	9.3750	Hz

Notes for this case

• An FFT of N samples at f_s resolves frequencies Δf = f_s/N apart and needs a record T = N/f_s long: fine resolution needs long records. Analysers show about N/2.56 lines, keeping clear of the anti-aliasing filter's roll-off below the Nyquist frequency f_s/2. A window reduces leakage but widens each bin's noise bandwidth by its ENBW factor (Hann 1.5, flat top 3.77); use the ENBW when converting a spectrum to power spectral density.

Formula and method

$$\Delta f = \frac{f_s}{N}, \quad T = \frac{N}{f_s}, \quad f_N = \frac{f_s}{2}, \quad ENBW = k_w \, \Delta f$$

Variables

f_s	Sampling rate	1/s
N	Block size (samples)	-
window	Window	-
Δf	Frequency resolution (bin width)	1/s
T	Record length	s
f_N	Nyquist frequency	1/s
n_L	Usable lines (N/2.56)	-
$ENBW$	Equivalent noise bandwidth	1/s

Method and standards

FFT resolution.

Assumptions and limits

- Single block; no zero padding.

References

Discrete Fourier transform resolution and window noise bandwidth

Report details

Report reference	FCC-RGTE-KY6E (the same inputs always give the same reference)
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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/fft-resolution-sampling

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.