

Region of convergence

RoC in the Z domain

The region of convergence (RoC) is defined as the set of z for which the z-transform (and by extension, its infinite series representation) of the signal converges/exists.

The ROC cannot include a pole, so any possible regions of convergence exclude the circles $|z| = |p|$ for all poles p . As a result, regions of convergence look like donuts (between two poles), circles (less than the smallest pole), or the entire z-plane excluding a circle (greater than the largest pole).

The actual region can be found by reducing the Z-transform formula to an infinite geometric series whose common ratio includes z . Recall that the absolute value of the common ratio must be less than one.

Different signals can have the same Z-transform. Two signals must have the same Z-transform and region of convergence to be identical.

Choosing RoC from given constraints (Z)

- A **causal** system, which is right-sided ($h[n]=0$ for $n < 0$) has a region of convergence that extends to infinity.
- A left-sided system has a region of convergence that includes $z=0$.
- A **BIBO stable** system has a region of convergence that includes the unit circle ($|z| = 1$).

RoC in the Laplace domain

The region of convergence in the Laplace domain is similar.

In the Laplace case, the possible regions of convergence exclude the lines $\operatorname{Re}\{s\} = \operatorname{Re}\{p\}$, for all poles p . These lines divide the complex s plane into possible regions of convergence.

Choosing RoC from given constraints (Laplace)

- A **causal** system has a region of convergence that extends to positive infinity.
- A **BIBO stable** system has a region of convergence that includes the imaginary axis $\operatorname{Re}\{s\} = 0$.

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