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wechacture - 4

Digital Signal Processing

Envis 114537/16339m

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z-Transform: Definition (Revisit)

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The z-transform of



$$\sum_{n=-\infty}^{\infty} x[n]z^{-n}$$

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- z is considered to be a complex variable Assignment Project Exam Help
 $z = re^{j\omega}$, where r is the radius, and ω is the phase

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- Notation $\mathscr{Z}\{x[\eta]\}$ 749389476
- https://tutorcs.com
 How can you evaluate the FT from the z-transform?
 - Evaluate the z-transform at $z = e^{j\omega}$ (unit circle on complex z-plane), to get the FT.



Region of Convergence (ROC)

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- For a given sequested by the set of z values for which the z-transform con the z-transform control called the Region of Convergence (ROC) of the z-transform control called the Region of Convergence (ROC) of the z-transform control called the Region of Convergence (ROC) of the z-transform control called the Region of Convergence (ROC) of the z-transform control called the Region of Convergence (ROC) of the z-transform control called the Region of Convergence (ROC) of the z-transform control called the Region of Convergence (ROC) of the z-transform control called the Region of Convergence (ROC) of the z-transform control called the Region of Convergence (ROC) of the z-transform control called the Region of Convergence (ROC) of the z-transform control called the Region called th
- Condition on convergence is

We Chat: cstutorcs $|X(x)| = \sum_{n=-\infty}^{\infty} \Pr[x] |Ex^n| = \sum_{n=-\infty}^{\infty} \Pr[x]$

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- ROC of the z-transform consists of all values of z such that the above inequality: 1003.89476
- If for some value of z on the circle defined by $|z| = |z_1|$ will also be in the ROC.



Poles and Zeros of z-Transform

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▶ Let the z-transf

 $X(z) = \frac{P(z)}{\text{WeChat: cstutor}Q(z)}$

where P(z) and A (z) range p of z (z) (z

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Poles and Zeros of z-Transform

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▶ Let the z-transf

fresented inside ROC as

$$X(z) = \frac{P(z)}{\text{WeChat: cstutor}Q(z)}$$

where P(z) and A (z) range polynomial Einarn Help

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The zeros are the roots of the numerator polynomial (i.e., P(z) = 0) and the poles are the roots of the denominator polynomial (i.e., $\frac{1}{100}$)/ $\frac{1}{100}$ rcs.com



Reminder: Sum of a Finite Power Series: $S_N = \sum_{n=0}^{N} b^n$ 柱厅代与代做 CS编程辅导



$$bS_N =$$
 WeChat: b^2 statistics ... + $b^N + b^{N+1}$ (2)

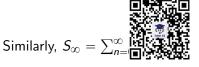
By subtracting (2) froms (1) ment Project Exam Help

$$(1-b)S_N \stackrel{\text{Email: tutorcs@163.com}}{=} 1-b^{N+1}$$

$$S_N \stackrel{\text{QQ: 749389476}^{N+1}}{=} \text{ provided } b \neq 1$$
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Reminder: Sum of a Infinite Power Series: $S_N = \sum_{n=0}^{\infty} b^n$ 程序代与代做 CS编程辅导



Sower hat + but $b^2 + b^3 + \dots$

Assignment Project Exam Help $bS_{\infty} = b + b^2 + b^2 + \cdots$

Email: tutorcs@163.com $S_{\infty} = \frac{\text{Email: tutorcs@163.com}}{\text{QQ:}749389476} |b| < 1$

Reminder: Sum of Power Series: $S = \sum_{n=N_1}^{N_2} b^n$



$$b^{N_1} + b^{N_1+1} + \ldots + b^{N_2}$$
 (3)

By subtracting (4) from ignment Project Exam Help

$$(1-b)S = \frac{\text{Email: tutorcs@163.com}}{b^{N_1} - b^{N_2+1}}$$

$$S = \frac{QQ: \frac{7b^{N_3}389b^{N_5}b^{1}}{1-b}}{\text{https://tutorcs.com}} \quad \text{provided } b \neq 1$$



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Then:

$$X(z) = \sum_{n=0}^{\infty} a^n u[n] z^{-n} = \sum_{n=0}^{\infty} a^n z^{-n}.$$
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For convergence, we need the series absolutely summable, i.e.,

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Then:

For convergence, we need the series absolutely summable, i.e.,

Above condition had a solution the ROC is the range of values for which $|az^{-1}| < 1$ or |z| > |a|. i.e., outside of the circle with radius |a| in the z-plane.

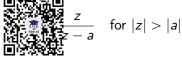


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Inside the ROC, |z|series converges to X(z)Wæ€0hat: cstutorcs As ignarient Project Exam Help Email₁ tutorcs@163.com = $\frac{1}{2}$ (Geometric series) QQ:749389476 https://tutorcs.com

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▶ Thus, $x[n] = a^n u[n]$ has a closed form z-Transform:



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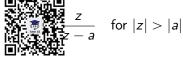
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▶ Thus, $x[n] = a^n u[n]$ has a closed form z-Transform:



Recall: The zero We like roots of the denominator.

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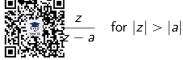
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▶ Thus, $x[n] = a^n u[n]$ has a closed form z-Transform:



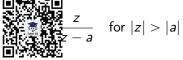
- Recall: The zerowe@the roots of the denominator.
- Note that there is a zero at z = 0 and a pole at z = a.
- If |a|<1 then ROGacortteinschle Lock coincle, and hence, the FT of the sequence converges to: QQ: 749389476

$$X(e^{j\omega})_{ttps://tugergs.com}$$
 1 (Table 2.3 Prop. 4)



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▶ Thus, $x[n] = a^n u[n]$ has a closed form z-Transform:

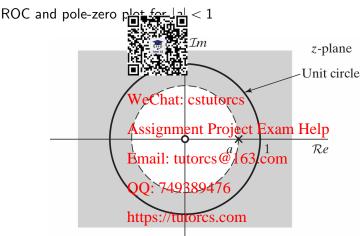


- Recall: The zerowe@the roots of the denominator.
- Note that there is a zero at z = 0 and a pole at z = a.
- If |a| < 1 then ROGacorttainscale look coincle, and hence, the FT of the sequence converges to: QQ: 749389476

$$X(e^{j\omega})_{ttps://tupergs.com}$$
 Table 2.3 Prop. 4)

▶ However, if $|a| \ge 1$ then ROC does not contain the unit circle, and hence, the FT of the sequence does not converge.

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The symbol ' \circ ' denotes the zero and ' \times ' denotes the pole.



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Since the sequence is nonzero for $n \le -1$, this is a left-sided sequence. Assignment Project Exam Help

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Since the sequence is nonzero for $n \le -1$, this is a left-sided sequence. The *z*- transform.

$$X(z) = -\sum_{n=-\infty}^{\infty} a_7^n y \left[\frac{1}{3} g_9 - \frac{1}{4} \right] z^{-n} = -\sum_{n=-\infty}^{\infty} a^n z^{-n}$$

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$$X(z) = -\sum_{n=1}^{n-1} a^n z^{-n} = -\sum_{n=-\infty}^{-1} a^n z^{-n}$$

We need to change the entering the from zero and increase to infinity.

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$$X(z) = -\sum_{\substack{n=1 \\ n=1}}^{n} a^n z^{-n}$$

$$n-1]z^{-n} = -\sum_{n=-\infty}^{-1} a^n z^{-n}$$

We need to change the entering the from zero and increase to infinity.

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Change of index $n = \frac{\text{Email}}{m}$, we write where $\frac{\text{@ 163.com}}{\text{om}}$

$$X(z) = -\sum_{m=\infty}^{1} a \frac{\text{QQ: 749389476}}{\text{https://tutorest}} (a^{-1}z)^{m} = 1 - \sum_{m=0}^{\infty} (a^{-1}z)^{m}$$

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The z-Transform:

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$$X(z) = 1 - \sum_{m=0}^{\infty} (a^{-1}z)^m$$

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The series converges in (at:12) occ1@.16,3 2 pm |a| which is the ROC.

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Using the formula for sum of the geometric series

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$$X(z) = 1 - \sum_{m=0}^{\infty} (a_{AS}^{-1}z)_{\text{ignntent}}^{m} = 1 + \frac{1}{\text{Project Exam Help } z} = \frac{z}{z-a}$$

We can see that there is a zero at z = 0 and a pole at z = a.

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The z-Transform: The properties if $|(a^{-1}z)| < 1$, i.e., |z| < |a|. The z-transform

$$\frac{z}{z-a}$$

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The z-Transform: The z-transform onverges if $|(a^{-1}z)| < 1$, i.e., |z| < |a|. The z-transform $|z| = \frac{z}{z}$

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Note that if |a| Askighenethte Project relaison blelp ROC and the FT of the sequence does not exist.

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The z-Transform: The property of |z|<|a|. The z-transform |z|<|a|. The z-transform |z|<|a|. The z-transform |z| |z|

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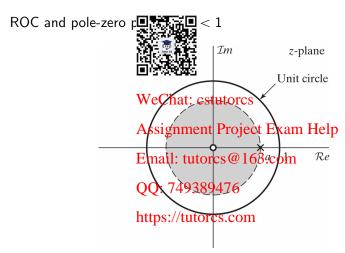
- Note that if |a| AskighenethteProjectrEleason blelp ROC and the FT of the sequence does not exist.

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- ▶ But if |a| > 1 then the unit circle is in the ROC and the FT is

$$\frac{\text{https://tutorcs.com}_1}{X(e^{j\omega})} = \frac{1}{1 - ae^{-j\omega}}$$



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- Important: Note algebraic expressions for Example 3.1 and 3.2 (right-sided and left-sided sequences) are the same. Also, their pole-zero locations are the same. However, the regions of convergence are relifered am Help
- Thus, the ROC Fandiltouter and 63. conter to understand the convergence of each sequence.
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$$x[n] = \left(\frac{1}{2}\right)^n u[n] + \left(\frac{E - \frac{1}{3}}{3}\right)^n u[n] CS$$
 $\frac{E}{4}$

The z-transform is

$$X(z) = \sum_{n=-\infty}^{\infty} \left(\left(\frac{z}{z}\right)^n u[n] + \left(-\frac{1}{3}\right)^n u[n] \right) z^{-n}$$

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$$= \sum_{n=-\infty}^{\infty} \underbrace{\text{High larges to 1}_{n=-\infty}^{\infty} 1.53}_{\text{QQ: 749389476}} .c(\text{m} \frac{1}{3})^n u[n] z^{-n}$$

$$=\sum_{n=0}^{\infty} \left(\frac{\ln \operatorname{ttps}}{2}\right) + \sum_{n=0}^{\infty} \left(-\frac{1}{3}z^{-1}\right)^{n}$$



Example 3.3: Sum of Two exponential Series $x[n] = \left(\frac{1}{2}\right)^n u[n] + \left(\frac{E-F_1}{2}\right)^m u[n] \times CS \%$

The z-transform is

$$X(z) = \sum_{n=0}^{\infty} \left(\frac{1}{z}z^{-1}\right)^n + \sum_{n=0}^{\infty} \left(-\frac{1}{3}z^{-1}\right)^n$$
When that: cstutores

Assignment Project $\pm \bar{x}$ and Help $|z| > |\frac{1}{2}|$

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$$x[n] = \left(\frac{1}{2}\right)^n u[n] + \left(\frac{E - \frac{1}{3}}{3}\right)^n u[n]$$
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The z-transform is

$$X(z) = \sum_{\text{Weighat: cstutors}} (\frac{1}{2}z^{-1})^n + \sum_{\text{minimal}} (-\frac{1}{3}z^{-1})^n$$

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Convergence requires both summations to converge, i.e., $|z| > \frac{1}{2}$ and $|z| > \frac{1}{3}$.

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Thus the ROC is the region of overlap, which is $|z| > \frac{1}{2}$.



$$x[n] = \left(\frac{1}{2}\right)^n u[n] + \left(\frac{EF_1}{3}\right)$$
 写 $u[n]$ CS编程辅导

$$X(z) = \sum_{n=0}^{\infty} \left(\sum_{n=0}^{\infty} \sum_{n=0}^{\infty} \left(-\frac{1}{3} z^{-1} \right)^{n} \right)$$

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$$= \frac{\frac{1}{\text{Assignment}} \frac{1}{\text{Project}} \text{(ExametHel peries)}}{1 - \frac{1}{2}z^{-1}} \frac{1 + \frac{1}{3}z^{-1}}{1 + \frac{1}{3}z^{-1}}$$
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$$= \frac{z}{z - \frac{1}{2}} \frac{QQ}{z + \frac{1}{3}} = \frac{2}{z + \frac{1}{3}}$$
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$$=\frac{2z(z-\frac{1}{12})}{(z-\frac{1}{2})(z+\frac{1}{3})}$$



$$x[n] = \left(\frac{1}{2}\right)^n u[n] + \left(\frac{E - 1}{3}\right)^n u[n] CS \%$$



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Example 3.5: Two-sided Exponential Sequence

$$x[n] = \left(-\frac{1}{3}\right)^n u[n] \stackrel{\text{def}}{=} \binom{1}{2} \stackrel{\text{def}}{=} \binom{\text{CS}}{n} \stackrel{\text{def}}{=} \frac{\text{def}}{n} \stackrel{\text{def}}{=} \frac{\text{def}$$

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Homework

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- 1. Read and understand Chapter 3 (Sections 1 to 2) of the textbook
- 2. Related Problems sign nontage of Esan Help 19, 3.20, 3.54

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