△ DUALNOST VREMENSKOG I FREKVENCIJSKOG DOMENA

$$\mathcal{F}_t\{x(t)\} = \int_{-\infty}^{+\infty} x(t)e^{-j\omega t}\,dt$$

$$\mathcal{F}_t^{-1}\{X(j\omega)\} = \frac{1}{2\pi}\int_{-\infty}^{+\infty} X(j\omega)e^{+j\omega t}\,d\omega$$

$$\left.\begin{matrix} t \to \tau \\ \omega \to W \\ \hline t \to W \\ \omega \to \tau \end{matrix}\right.$$

$$\boxed{\mathcal{F}_t\{x(t)\} = X(j\omega)}$$

$$\mathcal{F}_t\{X(jt)\} = 2\pi x(-\omega)$$

$$\mathcal{F}_t\{X(-jt)\} = 2\pi x(+\omega)$$

KONAČNOG TRAJANJA — NEOGRANIČEN SPEKTAR

BESKONAČNOG TRAJANJA — OGRANIČEN SPEKTAR

△ PRIMER

$$g(t) = \frac{1}{4+t^2} \qquad G(j\omega) \qquad \Bigg| \qquad \mathcal{F}_t\{\underbrace{e^{-a|t|}}_{\boxed{a>1}}\} = \frac{2a}{a^2+\omega^2}$$

$$x(t) = \frac{1}{4}e^{-2|t|} \qquad X(j\omega) = \frac{1}{4}\cdot\frac{4}{4+\omega^2} = \frac{1}{4+\omega^2}$$

$$X(jt) = \frac{1}{4+t^2}$$

$$\mathcal{F}_t\{X(jt)\} = 2\pi x(-\omega)$$

$$\mathcal{F}_t\left\{\frac{1}{4+t^2}\right\} = 2\pi\cdot\frac{1}{4}e^{-2|-\omega|} = \frac{\pi}{2}e^{-2|\omega|}$$

$$G(j\omega) = \frac{\pi}{2}e^{-2|\omega|}$$

▽ $g(t) = \dfrac{1}{1+t^2}$ → PROBLEM SA PRIMENOM $x(t) = e^{-a|t|}$ ↑ a MORA DA BUDE > 1

△ VEZA F. TRANSFORMACIJE I F. REDOVA KONT. SIGNALA

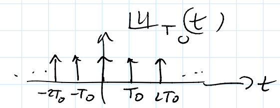
Δ VEZA F. TRANSFORMACIJE I F. REDOVA KONT. SIGNALA

$$x(t) = \sum_{k=-\infty}^{+\infty} X[k]\, e^{jk\omega_0 t} \qquad \omega_0 = 2\pi f_0 = \frac{2\pi}{T_0}$$

$$\mathcal{F}\{x(t)\} = \mathcal{F}_t\{\sum_k X[k]\, e^{jk\omega_0 t}\} =$$

$$\sum_{k=-\infty}^{+\infty}\left(X[k]\,\mathcal{F}_t\{e^{jk\omega_0 t}\}\right) = \sum_{k=-\infty}^{+\infty}\left(X[k]\, 2\pi\, \delta(\omega - k\omega_0)\right)$$

$$\boxed{= 2\pi \sum_{k=-\infty}^{+\infty} X[k]\, \delta(\omega - k\omega_0)}$$



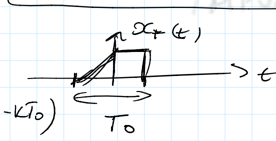
$$x(t) = \mathrm{COMB}_{T_0}(t) = Ш_{T_0}(t) = \sum_{k=-\infty}^{+\infty} \delta(t - kT_0)$$

$$\mathcal{F}_s\{Ш_{T_0}(t)\} = \frac{1}{T_0} = X[k]$$

$$\mathcal{F}_t\{Ш_{T_0}(t)\} = 2\pi \sum_{k=-\infty}^{+\infty} X[k]\, \delta(\omega - k\omega_0) = \frac{2\pi}{T_0} \sum_{k=-\infty}^{+\infty} \delta(\omega - k\omega_0)$$

↑ POVRŠINA ISPOD DIRAKOVIH IMPULSA

APERIODIČNI SIGNAL $\underline{x_F(t)}$
KONAČNOG TRAJANJA



$$x(t) = \sum_{k=-\infty}^{+\infty} x_F(t - kT_0) = x_F(t) * \sum_{k=-\infty}^{+\infty} \delta(t - kT_0)$$

$$x_F(t) * \delta(t - kT_0) = x_F(t - kT_0)$$

$$X(j\omega) = \mathcal{F}_t\{\sum_{k=-\infty}^{+\infty} x_F(t - kT_0)\} = \mathcal{F}_t\{x_F(t) * \sum_{k=-\infty}^{+\infty} \delta(t - kT_0)\} =$$

$$\mathcal{F}_t\{x_F(t)\} \cdot \mathcal{F}_t\{\sum_{k=-\infty}^{+\infty} \delta(t - kT_0)\} = X_F(j\omega) \cdot \frac{2\pi}{T_0} \sum_{k=-\infty}^{+\infty} \delta(\omega - k\omega_0)$$

$$= \frac{2\pi}{T_0} \sum_{k=-\infty}^{+\infty} X_F(j\omega)\, \delta(\omega - k\omega_0) = \underbrace{\frac{2\pi}{T_0} \sum_{k=-\infty}^{+\infty} \left(X_F(jk\omega_0)\, \delta(\omega - k\omega_0)\right)}_{X(j\omega)}$$

$$X(j\omega) = 2\pi \sum_{k=-\infty}^{+\infty} X[k]\, \delta(\omega - k\omega_0)$$

$$X[k] = \frac{1}{T_0} X_F(jk\omega_0)$$

$$\boxed{X[k] = \frac{1}{T_0} X_F(j\omega)\Big|_{\omega = k\omega_0}}$$

PERIODIČAN $x(t)$: $X[k]$

$$\mathcal{F}_t\{x_F(t)\} = X_F(j\omega)$$

ODBIRCI NA $\underline{k\omega_0}$

$x_F(t)$: SAMO JEDNA PERIODA $x(t)$, T_0

$$X_F(j\omega) = \int_{-\infty}^{+\infty} x_F(t) e^{-j\omega t} dt = \boxed{\int_{\langle T_0 \rangle} x_F(t) e^{-j\omega t} dt}$$

$$X[k] = \boxed{\frac{1}{T_0}\int_{\langle T_0 \rangle} x_F(t) e^{-jk\omega_0 t} dt} \qquad X[k] = \frac{1}{T_0} X_F(jk\omega_0)$$

FREKVENCIJSKA ANALIZA SISTEMA LTI SISTEMA

FREKVENCIJSKA ANALIZA LTI SISTEMA

- $h(t)$, STABILAN (BIBO) $\mathcal{F}_t\{h(t)\} = H(j\omega)$

$H(j\omega)$ — FREKVENCIJSKI ODZIV SISTEMA, FUNKCIJA PRENOSA SISTEMA

$x(t) \rightarrow \boxed{h(t)} \rightarrow y(t)$ | $X(j\omega) \rightarrow \boxed{H(j\omega)} \rightarrow Y(j\omega)$

$y(t) = x(t) * h(t) \;/\; \mathcal{F}_t\{\}$ | $Y(j\omega) = X(j\omega) \cdot H(j\omega)$

DC ANALIZA PSPICE, MATEMATIČKI EKSPERIMENTALNO

- ZA STABILNE SISTEME $H(j\omega)$

$x(t) \rightarrow$ AMPLITUDA A, UČESTANOST ω_0

$y(t) \rightarrow \underbrace{A \cdot |H(j\omega_0)|}_{\text{AMPLITUDA}}$ $\quad \boxed{\underbrace{\theta(\omega_0) = \arg\{H(j\omega_0)\}}_{\text{FAZNA KARAKTERISTIKA SISTEMA}}}$

$|H(j\omega)|$ AMPLITUDSKA KARAKTERISTIKA SISTEMA

$|H(j\omega_0)|$ POJAČANJE NA ω_0

$h(t) \leftarrow$ $\boxed{\delta(t) \rightarrow \boxed{h(t)} \rightarrow h(t) \leftarrow}$

$\left.\begin{matrix} |X(j\omega)| \\ \theta(\omega) \end{matrix}\right\}$ ANALIZATOR SPEKTRA dB

$$20 \log_{10} |X(j\omega)| = X(j\omega)|_{dB}$$

PSPICE: AC ANALIZA BODEPLOT | AC SWEEP ANALIZA

BODE PLOT

DIREKTNO ODREĐIVANJE $h(t)$, $H(j\omega)$ POMOĆU $\underline{\underline{\delta(t)}}$

$$\mathcal{F}_t\{h(t)\} = H(j\omega) = \frac{Y(j\omega)}{X(j\omega)}$$

$$H(j\omega) = \underbrace{|H(j\omega)|}_{\text{AMPLITUDSKA KARAKT.}}\, e^{j\overbrace{\theta(\omega)}^{\text{FAZNA KARAKT.}}}$$

$x(t) = e^{st}$, $h(t)$ $\Rightarrow$ $y(t) = x(t) * h(t)$

$$y(t) = \underbrace{\int_{-\infty}^{+\infty} h(\tau)x(t-\tau)\,d\tau}_{\text{KONVERGENTAN}} = \int_{-\infty}^{+\infty} h(\tau)e^{s(t-\tau)}\,d\tau =$$

$s = j\omega \rightarrow \mathcal{F}_t\{\ \}$

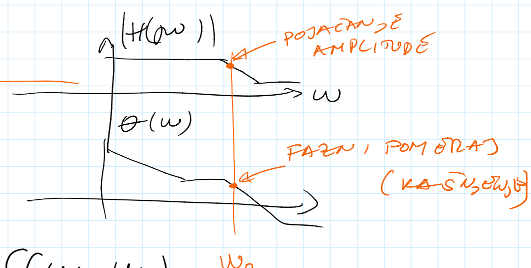
$s = \sigma + j\omega \rightarrow \mathcal{L}\{\ \}$

$$= e^{st}\boxed{\int_{-\infty}^{+\infty} h(\tau)e^{-s\tau}\,d\tau} \qquad s = j\omega_0$$

$$y(t) = e^{j\omega_0 t}\underbrace{\int_{-\infty}^{+\infty} h(t)e^{-j\omega_0\tau}\,d\tau}_{H(j\omega_0)} = e^{j\omega_0 t}H(j\omega_0)$$

$$= e^{j\omega_0 t}\underbrace{|H(j\omega_0)|}_{\text{AMPLITUDSKO POJAČANJE}}\, e^{j\theta(\omega_0)} = e^{j\omega_0 t}\,|H(j\omega)|\Big|_{\omega=\omega_0}\cdot e^{j\theta(\omega)}\Big|_{\omega=\omega_0}$$

FAZNI POMERAJ



$x(t) = e^{j\omega_0 t}$ $\qquad X(j\omega) = 2\pi\delta(\omega - \omega_0)$

$H(j\omega) = \mathcal{F}_t\{h(t)\}$

$$Y(j\omega) = X(j\omega)\cdot H(j\omega) = H(j\omega)\cdot 2\pi\delta(\omega-\omega_0)$$

$$= H(j\omega_0)\cdot 2\pi\delta(\omega-\omega_0)$$

$$y(t) = \mathcal{F}_t^{-1}\{Y(j\omega)\} = H(j\omega_0)\cdot e^{j\omega_0 t}$$

$x(t) = \boxed{A}\cdot \underset{(\sin)}{\cos}(\omega_0 t + \varphi)$ $\qquad |H(j\omega)|$

$\theta(\omega) = \arg\{H(j\omega)\}$

$$\boxed{y(t) = A\cdot|H(j\omega_0)|\cos(\omega_0 t + \varphi + \theta(\omega_0))}$$

USTALJENI PROSTOPERIODIČNI REŽIM

$$\boxed{x(t) = A\cdot e^{0\cdot t}}$$

$$\boxed{\begin{array}{l} s=j\omega \quad \mathcal{F}_t\{h(t)\} \\ H(s) = \mathcal{L}\{h(t)\} \\ s=\sigma+j\omega \end{array}}$$

$P(D)\,y(t) = Q(D)\,x(t)$

FUNKCIJA

$$P(D)\,y(t) = Q(D)\,x(t)$$

$$y(t) = \frac{Q(D)}{P(D)}\,x(t) = H(D)\,x(t)$$

FUNKCIJA PRENOSA

$$Y(j\omega) = H(j\omega)\,X(j\omega) \qquad Y(s) = H(s)\cdot X(s)$$

GRUPNO KAŠNJENJE $\quad \tau_g(\omega) = \underbrace{-\frac{d}{d\omega}\theta(\omega)}$

GENERALIZOVANA IMPEDANSA

$$\mathcal{F}_t\{i(t)\} = I(j\omega) \qquad \left(I(s) \right)$$

$$\mathcal{F}_t\{u(t)\} = U(j\omega) \qquad \left(U(s) \right)$$

$$\boxed{Z_C = \frac{1}{j\omega C}} \qquad \boxed{Z_C = \frac{1}{sC}}$$

$$\boxed{Z_L = j\omega L} \qquad \boxed{Z_L = s\cdot L}$$

$$\boxed{I(s) = \boxed{H(s)}\cdot V_G(s)} \qquad \boxed{\begin{aligned} s &= \sigma + j\omega \\ s &= j\omega \end{aligned}}$$

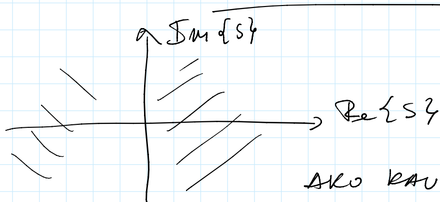
$$I(D) = H(D)\cdot V_G(D) = \frac{Q(D)}{P(D)}\cdot V_G(D)$$

$$\boxed{P(D)\,I(D) = Q(D)\cdot V_G(D)}$$

$H(s)$ $\quad \boxed{s = j\omega}$ $\qquad H(s) = \frac{Q(s)}{P(s)}$ ← NULE PRENOSNE FUNKCIJE; ← POLOVI PRENOSNE FUNKCIJE

— NULE, POLOVI
- REALNI $\neq 0$
- IMAGINARNI $\neq 0$
- KONJUGOVANO KOMPLEKSNI

UKOLIKO JE REALNI DEO NULE ILI POLA U DESNOJ POLURAVNI KOORDINATNOG SISTEMA $\boxed{\text{KOMPLEKSNE PROMENLJIVE } S}$



AKO KAUZALAN SISTEM IMA POLOVE U DESNOJ POLURAVNI ONDA JE NESTABILAN
