

100%



$$\frac{Z_2}{Z_1} = \frac{R_2 \parallel (1/j\omega C)}{R_1 R_2 + 1/j\omega C} = \frac{R_2}{R_1 j\omega R_2 C + 1}$$

$$-H(0) \frac{1}{1 + j\omega\tau} = -H(0) \frac{1/\tau}{1/\tau + j\omega} = -H(0) \frac{\omega_c}{j\omega + \omega_c}$$

[illegible]

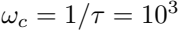


we are 100%

THESE ARE THE







$$\frac{Z_2(j\omega)}{Z_1(j\omega)} = \frac{R_2}{R_1 + 1/j\omega C} = \frac{R_2}{R_1} \frac{1}{1 + 1/j\omega R_1 C}$$

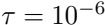
$$-\frac{R_2}{R_1} \frac{1}{1 + 1/j\omega\tau} = -\frac{R_2}{R_1} \frac{j\omega}{j\omega + 1/\tau} = -H(\infty) \frac{j\omega}{j\omega + \omega_c}$$



we are 100%

Handwritten text: "A B C D E F G H I J K L M N O P Q R S T U V W X Y Z"

2020



we are 100%



100 = 1





$$H_p(j\omega) = \frac{\omega_c}{j\omega + \omega_c},$$

$$H_{hp}(j\omega) = \frac{j\omega}{j\omega + \omega_c}$$

$$Z_1(w) = R_1 + 1/w, \quad Z_2(w) = R_2 + 1/w$$

ABP@w

$$\frac{Z_2(\omega)}{Z_1(\omega)} = \frac{R_2 || (1/j\omega C_2)}{R_1 + 1/j\omega C_1} = \frac{R_2/j\omega C_2}{(R_1 + 1/j\omega C_1)(R_2 + 1/j\omega C_2)}$$

$$\frac{j\omega R_2 C_1}{(j\omega R_1 C_1 + 1)(j\omega C_2 R_2 + 1)} = \frac{j\omega \tau_3}{(1 + j\omega \tau_1)(1 + j\omega \tau_2)}$$

$$\left(\frac{\omega_{c1}}{j\omega + \omega_{c1}} \right)$$

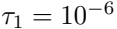
$$\left(\frac{\omega_{c2}}{j\omega + \omega_{c2}} \right)$$

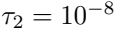
$$\left(\frac{j\omega}{\omega_{c3}} \right)$$

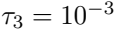
we are 1234567890

www.1234567890

we are 1234567890









$$-Im_{BP}(j\omega) = -20 \log |H_{BP}(j\omega)| = -20 \log \left| \frac{Z_2(\omega)}{Z_1(\omega)} \right| = 20 \log \left| \frac{Z_1(\omega)}{Z_2(\omega)} \right| = Im_{BS}(j\omega)$$

A pixelated, grayscale image of the text "21w". The characters are rendered in a blocky, digital font style. The "2" and "1" are on the left, followed by a space, and then the "w" on the right. The image has a low-resolution, pixelated appearance with various shades of gray and black pixels.



ABEWE

$$\frac{Z_1(\omega)}{Z_2(\omega)} = \frac{R_2 + 1/j\omega C_2}{R_1 || 1/j\omega C_1} = \frac{R_2 + 1/j\omega C_2}{R_1/j\omega C_1 / (R_1 + 1/j\omega C_1)}$$

$$\frac{(1 + j\omega C_1 R_1)(1 + j\omega C_2 R_2)}{j\omega R_1 C_2} = \frac{(1 + j\omega \tau_1)(1 + j\omega \tau_2)}{j\omega \tau_3}$$

W

o

Woo

A pixelated, grayscale image of the word "love" in a stylized, blocky font. The letters are composed of various shades of gray, giving it a textured, digital appearance. The "l" is on the left, followed by "o", "v", and "e" on the right. The image has a low-resolution, 8-bit aesthetic.

$$\frac{V_a - V_{in}}{Z_1} + \frac{V_a - V_{out}}{Z_3} + \frac{V_a - V_{out}}{Z_2} = \frac{V_a - V_{in}}{Z_1} + (V_a - V_{out}) \left(\frac{1}{Z_3} + \frac{1}{Z_2} \right) = 0$$

$$\frac{V_{out} - V_a}{Z_2} + \frac{V_{out}}{Z_4} = 0,$$

$$V_a - V_{out} = V_{out} \frac{Z_2}{Z_4},$$

$$V_a = V_{out} \frac{Z_2 + Z_4}{Z_4}$$

$$V_{out} \left(\frac{Z_2 + Z_4}{Z_1 Z_4} + \frac{Z_2}{Z_3 Z_4} + \frac{Z_2}{Z_2 Z_4} \right) = \frac{V_{in}}{Z_1}$$





$$\frac{V_{out}}{V_{in}} = \frac{Z_3 Z_4}{Z_1 Z_2 + Z_1 Z_3 + Z_2 Z_3 + Z_3 Z_4}$$





A pixelated, black and white representation of the text "100%". The characters are composed of various shades of gray and black pixels, giving it a retro, digital appearance. The "1" is a simple vertical bar with a horizontal base. The "0" is a circle with a small gap at the top. The "0" is a circle with a small gap at the top. The "%" is a standard percentage symbol with a diagonal slash.

$$H(j\omega) = \frac{\omega_p^2}{(j\omega)^2 + \Delta\omega j\omega + \omega_p^2}$$

$$\omega_n = \frac{1}{\sqrt{R_1 R_2 C_1 C_2}}, \quad \Delta\omega = \frac{1}{(R_1 || R_2) C_1} = \frac{1}{R_p C_1}, \quad R_p = R_1 || R_2 = \frac{R_1 R_2}{R_1 + R_2}$$

$$Q = \frac{\omega_n}{\Delta\omega} = \frac{\sqrt{R_1 R_2 C_1 C_2}}{(R_1 + R_2) C_2}, \quad \zeta = \frac{1}{2Q} = \frac{(R_1 + R_2) C_2}{2\sqrt{R_1 R_2 C_1 C_2}}$$





Q = 123











$$\omega_n = \frac{1}{\sqrt{C_1 C_2}},$$

$$\Delta \omega = \frac{1}{C_1}$$

1 = 10001

A pixelated, black and white representation of the text "100%". The characters are composed of various shades of gray and black pixels, giving it a retro, digital appearance. The "1" is a simple vertical bar with a horizontal base. The "0"s are formed by a series of connected pixels, with the top and bottom curves being more solid black. The "." is a small cluster of black and gray pixels. The "%" sign is a complex shape made of many small, overlapping gray and black pixels.





$$H(j\omega) = \frac{(j\omega)^2}{(j\omega)^2 + \Delta\omega j\omega + \omega_n^2}$$

$$\omega_n = \frac{1}{\sqrt{R_1 R_2 C_1 C_2}}, \quad \Delta \omega = \frac{1}{C_s R_2}, \quad C_s = \frac{C_1 C_2}{C_1 + C_2}$$

$$Q \equiv \frac{\sqrt{R_1 R_2 C_1 C_2}}{(C_1 + C_2) R_1}, \quad \zeta \equiv \frac{1}{2Q} = \frac{(C_1 + C_2) R_1}{2\sqrt{R_1 R_2 C_1 C_2}}$$

$$V_2 = \frac{R_a}{R_a + R_b} V_{out} = k V_{out}, \quad \left(k = \frac{R_a}{R_a + R_b} \right)$$



$$\frac{V_1 - V_2}{Z_2} = \frac{V_2}{Z_4}, \quad \text{i.e.} \quad V_1 = V_2 \left(\frac{1}{Z_2} + \frac{1}{Z_4} \right) \quad Z_2 = V_2 \left(1 + \frac{Z_2}{Z_4} \right)$$



$$\frac{V_{in} - V_1}{Z_1} + \frac{V_{out} - V_1}{R_f} + \frac{V_2 - V_1}{Z_2} = \frac{V_1}{Z_3}$$

2021 + 2021

$$\frac{V_{in}}{Z_1} + \frac{V_{out}}{R_f} + \frac{V_2}{Z_2} = V_1 \left(\frac{1}{Z_1} + \frac{1}{R_f} + \frac{1}{Z_2} + \frac{1}{Z_3} \right)$$

$$V_2 \left(1 + \frac{Z_2}{Z_4} \right) \left(\frac{1}{Z_1} + \frac{1}{R_f} + \frac{1}{Z_2} + \frac{1}{Z_3} \right)$$

WAVE

$$\frac{V_{in}}{Z_1} + \frac{V_{out}}{R_f} = kV_{out} \left[\left(1 + \frac{Z_2}{Z_4} \right) \left(\frac{1}{Z_1} + \frac{1}{R_f} + \frac{1}{Z_2} + \frac{1}{Z_3} \right) - \frac{1}{Z_2} \right]$$

Van



21

$$K V_{out} \left[\left(1 + \frac{Z_2}{Z_4} \right) \left(\frac{1}{Z_1} + \frac{1}{R_f} + \frac{1}{Z_2} + \frac{1}{Z_3} \right) - \frac{1}{Z_2} \right] - \frac{V_{out}}{R_f}$$

$$v_{out} \left\{ k \left[\left(1 + \frac{Z_2}{Z_4} \right) \left(\frac{1}{Z_1} + \frac{1}{R_f} + \frac{1}{Z_2} + \frac{1}{Z_3} \right) - \frac{1}{Z_2} \right] - \frac{1}{R_f} \right\}$$

A $=$

$$\frac{V_{out}}{V_{in}}$$

$$1$$

$$Z_1 \left\{ k \left[\left(1 + \frac{Z_2}{Z_4} \right) \left(\frac{1}{Z_1} + \frac{1}{R_f} + \frac{1}{Z_2} + \frac{1}{Z_3} \right) - \frac{1}{Z_2} \right] - \frac{1}{R_f} \right\}$$

$$1/k$$

$$Z_1 \left[\left(1 + \frac{Z_2}{Z_4} \right) \left(\frac{1}{Z_1} + \frac{1}{R_f} + \frac{1}{Z_2} + \frac{1}{Z_3} \right) - \frac{1}{Z_2} \right] - \frac{Z_1}{kR_f}$$

$$1/k$$

$$1 + \frac{Z_1}{R_f} + \frac{Z_1}{Z_3} + \frac{Z_2}{Z_4} + \frac{Z_1 Z_2}{Z_4 R_f} + \frac{Z_1}{Z_4} + \frac{Z_1 Z_2}{Z_3 Z_4} - \frac{Z_1}{k R_f}$$

$$Z_1 = R_1, \quad Z_4 = R_2, \quad Z_2 = \frac{1}{j\omega C_2}, \quad Z_3 = \frac{1}{j\omega C_1}$$

$$\left(1 + \frac{R_b}{R_a}\right) \frac{1}{R_1 C_1} j\omega$$

$$(j\omega)^2 + \left(\frac{1}{R_2 C_1} + \frac{1}{R_2 C_2} + \frac{1}{R_1 C_1} - \frac{R_b}{R_a R_f C_1}\right) j\omega + \frac{R_1 + R_f}{R_f R_1 R_2 C_1 C_2}$$

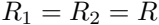
$$\frac{A j \omega}{(j \omega)^2 + \Delta \omega j \omega + \omega_n^2},$$

$$A = (1 + R_b / R_a) / R_1 C_1$$

$$\omega_n = \sqrt{\frac{R_1 + R_f}{R_f R_1 R_2 C_1 C_2}}$$

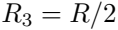
$$\Delta w = \frac{1}{R_2 C_1} + \frac{1}{R_2 C_2} + \frac{1}{R_1 C_1} - \frac{R_b}{R_a R_f C_1}$$













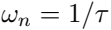
$$\frac{v_{out}}{v_{in}} = \frac{(j\omega)^2 + \omega_n^2}{(j\omega)^2 + 4\omega_n j\omega + \omega_n^2}$$

$$\frac{(j\omega)^2 + \omega_n^2}{(j\omega)^2 + \omega_n j\omega / Q + \omega_n^2} = \frac{\omega^2 - \omega_n^2}{\omega^2 - j\omega \Delta\omega - \omega_n^2}$$

$$w_n = \frac{1}{RC} = \frac{1}{\tau}$$

Q1415021





$$|H(j\omega)| = \begin{cases} H(0) = \omega_n^2/\omega_n^2 = 1 & \omega = 0 \\ H(j\omega_n) = 0 & \omega = \omega_n = 1/\tau \\ H(\infty) = \lim_{\omega \rightarrow \infty} H(j\omega) = \omega^2/\omega^2 = 1 & \omega \rightarrow \infty \end{cases}$$









$$V_1 = \frac{R_5}{R_4 + R_5}$$

$$V_{out} = 0V_{out}$$

Q = P + P

A pixelated, black and white graphic of the text "15 APRIL 1951" in a stylized, blocky font. The text is arranged in a single line, with the date "15 APRIL" followed by "1951". The font is reminiscent of early digital or video game typography, with thick strokes and a limited grayscale palette. The background is white, and the text is rendered in various shades of gray and black, giving it a retro, digital appearance.





100%

von 1846

Vorlesung

How do we

$$V_{out} + (H(j\omega) - 1)V_1 = V_{out} + (H(j\omega) - 1) \frac{R_5}{R_4 + R_5} V_{out}$$

$$\left(1 + (H(j\omega) - 1) \frac{R_5}{R_4 + R_5}\right) V_{out} = \frac{R_4 + H(j\omega) R_5}{R_4 + R_5} V_{out}$$

$$H_{\text{active}}(j\omega) = \frac{V_{\text{out}}}{V_{\text{in}}} = \frac{H(j\omega)(R_4 + R_5)}{R_4 + H(j\omega)R_5}$$

$$E(v) = (v^2 + v + 1) / (v^2 + v + 1)$$

How do we know?

$$(\omega_n^2 - \omega^2)(R_4 + R_5)$$

$$R_4(\omega_n^2 - \omega^2 + 1\omega_n j\omega) + (\omega_n^2 - \omega^2)R_5$$

$$(\omega_n^2 - \omega^2)(R_4 + R_5)$$

$$4\omega_n R_4 j\omega + (\omega_n^2 - \omega^2)(R_4 + R_5)$$

$$\omega_n^2 - \omega^2$$

$$j\omega R_4 \omega_n R_4 / (R_4 + R_5) + \omega_n^2 - \omega^2$$

$$\frac{\omega_n^2 - \omega^2}{\omega_n^2 - \omega^2 + \omega_n / Q_{\text{active}} j\omega} = \frac{\omega^2 - \omega_n^2}{\omega^2 - \Delta\omega_{\text{active}} j\omega - \omega_n^2}$$

$$Q_{active} = \frac{R_4 + R_5}{4R_4},$$

$$\Delta\omega_{active} = \frac{\omega_n}{Q_{active}}$$

$$\omega_n^2 - \omega^2$$

$$\omega_n^2 + 4j\omega\omega_n R_4 / (R_4 + R_5) - \omega^2$$

$$\frac{\omega_n^2 - \omega^2}{\omega_n^2 - \omega^2 + \omega_n / Q_{\text{active}} j\omega} = \frac{\omega_n^2 - \omega^2}{\omega_n^2 - \omega^2 + \Delta\omega_{\text{active}} j\omega}$$





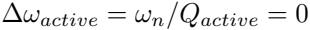


Quesada 145













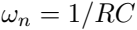
2014-2015

$$Z_3 = Z_3' \parallel Z_3'' = \frac{Z_3' Z_3''}{Z_3' + Z_3''} = \frac{2R(1 + j\omega RC)}{1 + j\omega RC + (j\omega RC)^2}$$

$$\frac{Z_2}{Z_2 + Z_3} = \frac{R + 1/j\omega C}{R + 1/j\omega C + 2R(1 + j\omega RC)/(1 + j\omega RC + (j\omega RC)^2)}$$

$$\frac{1/C}{1/j\omega C + 2R/(1 + j\omega RC + (j\omega RC)^2)} = \frac{1}{1 + 2j\omega RC/(1 + j\omega RC + (j\omega RC)^2)}$$

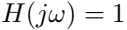
$$\frac{1 + j\omega RC + (j\omega RC)^2}{1 + 3j\omega RC + (j\omega RC)^2} = \frac{(j\omega)^2 + j\omega/RC + 1/(RC)^2}{(j\omega)^2 + 3j\omega/RC + 1/(RC)^2}$$



$$H(j\omega) = \frac{(j\omega)^2 + \omega_n j\omega + \omega_n^2}{(j\omega)^2 + 3\omega_n j\omega + \omega_n^2} = \frac{(j\omega)^2 + \Delta\omega_n j\omega + \omega_n^2}{(j\omega)^2 + \Delta\omega_d j\omega + \omega_n^2} = \frac{\omega_n^2 - \omega^2 + \Delta\omega_n j\omega}{\omega_n^2 - \omega^2 + \Delta\omega_d j\omega}$$



EXPERIENCE



1990

1995-1996

$$\frac{R_3}{R_4} = \frac{R_2 + 1/j\omega C_2}{R_1 || 1/j\omega C_1} = \frac{(j\omega R_1 C_1 + 1)(j\omega R_2 C_2 + 1)}{j\omega R_1 C_2} = \frac{1 - \omega^2 R_1 R_2 C_1 C_2 + j\omega(R_1 C_1 + R_2 C_2)}{j\omega R_1 C_2}$$

$$1 - \omega^2 R_1 R_2 C_1 C_2 = 0, \text{ i.e., } \omega = \frac{1}{\sqrt{R_1 R_2 C_1 C_2}}$$

$$\frac{R_3}{R_4} = \frac{R_1 C_1 + R_2 C_2}{R_1 C_2} = \frac{C_1}{C_2} + \frac{R_2}{R_1}$$

$$\omega = \frac{1}{\sqrt{R_1 R_2 C_1 C_2}} = \frac{1}{\sqrt{R^2 C^2}} = \frac{1}{RC}$$

$$\frac{R_3}{R_4} = \frac{C_1}{C_2} + \frac{R_2}{R_1} = 1 + 1 = 2, \text{ i.e. } R_4 = 2R_3$$

$$\frac{V_{in}}{R_4} + \frac{V_{out}}{R_3} + \frac{V_1}{R_2} = 0 \quad (1)$$

$$V_2 = \frac{R + 1/j\omega C}{R + 1/j\omega C + R/j\omega C / (R + 1/j\omega C)} V_1 = \frac{(j\omega\tau + 1)^2}{(j\omega\tau + 1)^2 + j\omega\tau} V_1,$$



$$V_1 = \left(1 + \frac{j\omega\tau}{(j\omega\tau + 1)^2} \right) V_2, \quad (2)$$

$$\frac{V_1 - V_2}{R_1} + \frac{V_{out} - V_2}{2R_1} = 0, \quad \text{i.e.} \quad V_{out} = 3V_2 - 2V_1, \quad (3)$$

$$V_{out} = 3V_2 - 2V_1 = 3V_2 - 2 \left(1 + \frac{j\omega\tau}{(j\omega\tau + 1)^2} \right) V_2 = V_2 - \frac{j\omega 2\tau}{(j\omega\tau + 1)^2} V_2 = \frac{(j\omega\tau)^2 + 1}{(j\omega\tau + 1)^2} V_2$$

$$V_2 = \frac{(j\omega\tau + 1)^2}{(j\omega\tau)^2 + 1} V_{out}$$

$$V_1 = \left(1 + \frac{j\omega\tau}{(j\omega\tau + 1)^2} \right) V_2 = \left(1 + \frac{j\omega\tau}{(j\omega\tau + 1)^2} \right) \frac{(j\omega\tau + 1)^2}{(j\omega\tau)^2 + 1} V_{out} = \frac{(j\omega\tau)^2 + 3j\omega\tau + 1}{(j\omega\tau)^2 + 1} V_{out}$$

$$\frac{V_{in}}{R_1} + \frac{V_{out}}{R_3} + \frac{(j\omega\tau)^2 + 3j\omega\tau + 1}{(j\omega\tau)^2 + 1} \frac{V_{out}}{R_2} = 0$$

$$\frac{V_{in}}{R_4} = - \left(\frac{1}{R_3} + \frac{(j\omega\tau)^2 + 3j\omega\tau + 1}{(j\omega\tau)^2 + 1} \frac{1}{R_2} \right) v_{out}$$

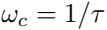
$$\frac{R_2}{R_4} = - \left(\frac{R_2}{R_3} + \frac{(j\omega\tau)^2 + 3j\omega\tau + 1}{(j\omega\tau)^2 + 1} \right) \frac{V_{out}}{V_{in}}$$

$$H(j\omega) = \frac{V_{out}}{V_{in}} = \frac{R_2 R_3}{R_4 (R_2 + R_3)} \frac{(j\omega\tau)^2 + 1}{(j\omega\tau)^2 + 3j\omega\tau R_3 / (R_2 + R_3) + 1}$$

$$H(j\omega) = A \frac{(j\omega)^2 + \omega_n^2}{(j\omega)^2 + \Delta\omega/Q j\omega + \omega_n^2} = \begin{cases} A & \omega = 0 \\ 0 & \omega = \omega_n = 1/\tau \\ A & \omega \rightarrow \infty \end{cases}$$

A R R R R + R R R R R





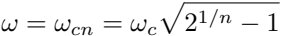


$$H(j\omega) = \frac{1}{j\omega\tau + 1} = \frac{1}{j\omega/\omega_c + 1} = \frac{\omega_c}{j\omega + \omega_c}$$

$$H(j\omega) = \left(\frac{\omega_c}{\omega_c + j\omega} \right)^n$$



$$\left| \frac{\omega_c}{\omega_c + j\omega} \right|^n = \left| \frac{\omega_c}{\sqrt{\omega_c^2 + \omega^2}} \right|^n = \frac{1}{\sqrt{2}} = 2^{-1/2}$$



wp4 2π1000=0.292x10⁹

$$\omega_c = \frac{\omega_{c4}}{\sqrt{2^{1/4} - 1}} = \frac{6.2832 \times 10^3}{0.435} = 1.445 \times 10^4$$

7-10-1910-5

Q&A 100%

$$R = \frac{\omega_c}{C} = \frac{6.92 \times 10^{-5}}{10^{-7}} = 6.92 \times 10^2 = 692 \, \Omega$$



$$|H_{lp}(j\omega)| = \frac{1}{\sqrt{1 + (\omega/\omega_c)^{2n}}} = \begin{cases} 1 & \omega = 0 \\ 1/\sqrt{2} & \omega = \omega_c \\ 0 & \omega = \infty \end{cases}$$

1992-1993





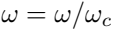


1992-1993

$$|H_p(j\omega)| = \frac{1}{\sqrt{1 + (\omega/\omega_c)^2}} = \frac{\omega_c}{\sqrt{\omega^2 + \omega_c^2}} = \left| \frac{\omega_c}{j\omega + \omega_c} \right|$$

$$|H_p(j\omega)| = \frac{1}{\sqrt{1 + (\omega/\omega_c)^2}} = \begin{cases} 1 & \omega < \omega_c \\ 0 & \omega > \omega_c \end{cases}$$

$$|H_{hp}(j\omega)| = \frac{1}{\sqrt{1 + (\omega_c/\omega)^{2n}}} = \frac{(\omega/\omega_c)^n}{\sqrt{1 + (\omega/\omega_c)^{2n}}} = \begin{cases} 0 & \omega = 1 \\ 1/\sqrt{2} & \omega = \omega_c \\ 1 & \omega = \infty \end{cases}$$

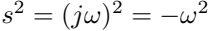




$$|H(j\omega)|^2 = H(j\omega)H(-j\omega) = \frac{1}{1 + (\omega/\omega_c)^{2n}} = \frac{1}{1 + \omega^{2n}} = \frac{1}{1 + (\omega^2)^n}$$







$$|H(j\omega)|^2 = H(j\omega)H(-j\omega) = \frac{1}{1+(\omega^2)^n} = \frac{1}{1+(-s^2)^n} = \frac{1}{1+(-1)^ns^{2n}} = |H(s)|^2 = H(s)H(-s)$$



$$1 + (-1)^n s^{2n} = 0, \quad \text{i.e.} \quad \begin{cases} 1 + s^{2n} = 0 & n \text{ is even} \\ 1 - s^{2n} = 0 & n \text{ is odd} \end{cases}$$



$$\begin{cases} s = (-1)^{1/2n} = (e^{j(2k+1)\pi})^{1/2n} = e^{j(2k+1)\pi/2n} & n \text{ is even} \\ s = 1^{1/2n} = (e^{j2k\pi})^{1/2n} = e^{jk\pi/n} & n \text{ is odd} \end{cases} \quad (k = 0, \dots, 2n-1)$$

$$s_k = e^{i(2k+1)\pi/2n}, \quad s_k = 0, \quad s_k = e^{i(2k-1)\pi/2n}$$

94211721



$$s_{2n-1-k} = e^{j(2(2n-1-k)+1)\pi/2n} = e^{j\pi(4n-2k-1)/2n} = e^{j2\pi} e^{-j(2k+1)\pi/2n} = s_k$$

$$\frac{(2k+1)\pi}{2n} > \frac{\pi}{2}, \quad \text{i.e.} \quad k > \frac{n-1}{2}$$



$$\frac{1}{\prod_{k=\lceil (n-1)/2 \rceil}^{n-1}(s-s_k)(s-s_{2n-1-k})}}=\frac{1}{\prod_{k=\lceil (n-1)/2 \rceil}^{n-1}(s-s_k)(s-s_k^*)}}$$

$$\frac{1}{\prod_{k=1}^{n-1} (s^2 - (s_k + s_k^*)s + s_k s_k^*)} = \frac{1}{\prod_{k=1}^{n-1} (s^2 - 2 \cos((2k+1)\pi/2n) + 1)}$$





$$s_k + s_k^* = e^{j(2k+1)\pi/2n} + e^{-j(2k+1)\pi/2n} = 2\cos((2k+1)\pi/2n), \quad s_k s_k^* = 1$$

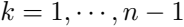
$$g_k = e^{i2k\pi/2n} = e^{ik\pi/n}, \quad (k = 0, \dots, 2n-1)$$







9 1 2 3 4 5 6 7 8





$$e^{2n-k} = e^{j(2n-k)\pi/n} = e^{-jk\pi/n} = e^{-k}$$



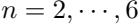
$$\frac{k\pi}{n} \geq \frac{\pi}{2},$$

i.e.

$$k \geq \frac{n}{2}$$

$$\frac{1}{(s-s_n)\prod_{i=\lceil n/2\rceil}^{n-1}(s-s_k)(s-s_{2n-k})}}=\frac{1}{(s+1)\prod_{i=\lceil n/2\rceil}^{n-1}(s-s_k)(s-s_k^*)}}$$

$$\frac{1}{(s+1)\prod_{i=\lceil n/2\rceil}^{n-1}(s^2-(s_k+s_k^*)s+s_k s_k^*)}=\frac{1}{(s+1)\prod_{i=\lceil n/2\rceil}^{n-1}(s^2-2\cos(k\pi/n)+1)}$$







341 = 324 + 14

1991-12-19

123456789

$$s_0 = e^{j\pi/4} = \frac{1+j}{\sqrt{2}}, \quad s_1 = e^{j3\pi/4} = \frac{-1+j}{\sqrt{2}}, \quad s_2 = e^{j5\pi/4} = \frac{-1-j}{\sqrt{2}}, \quad s_3 = e^{j7\pi/4} = \frac{1-j}{\sqrt{2}}$$





$$\frac{1}{(s - s_1)(s - s_2)} = \frac{1}{(s - (-1 + j)/\sqrt{2})(s - (-1 - j)/\sqrt{2})}$$

1



s^2

+

$\sqrt{2}s$

+

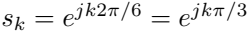
1

2023-2024





2021-2022





$$s_0 = e^{j0} = 1, \quad s_1 = e^{j\pi/3} = \frac{1 + j\sqrt{3}}{2}, \quad s_2 = e^{j2\pi/3} = \frac{-1 + j\sqrt{3}}{2}$$

$$s_3 = e^{j3\pi/3} = e^{j\pi} = -1, \quad s_4 = e^{j4\pi/3} = \frac{-1 - j\sqrt{3}}{2}, \quad s_5 = e^{j5\pi/3} = \frac{1 - j\sqrt{3}}{2}$$







$$\frac{1}{(s-s_2)(s-s_3)(s-s_4)} = \frac{1}{(s+1)(s-(-1+j\sqrt{3})/2)(s-(-1-j\sqrt{3})/2)}$$

$$1$$



$$(s + 1)(s^2 + s + 1)$$

2023-2024





921 = 921 + 1

2017-10-20



2009-10-20





2005-05-01

2009-09-19

$$H(s) = \frac{1}{(s^2 + 0.765s + 1)(s^2 + 1.848s + 1)}$$





[illegible]

$$g_k = e^{i(2k\pi)/10} = e^{i(k\pi)/5}, \quad g_k = 0, \quad , \quad 0)$$

— 2020 11 11

2024-05-20

2009-05-16

$$H(s) = \frac{1}{(s+1)(s^2+0.618s+1)(s^2+1.618s+1)}$$





912 12 11 21 + 11

$$g_k = e^{i(2k+1)\pi/12}, \quad k = 0, \dots, 11$$





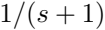
2009/12/25.05170

2009-12-14

2009-12-29

$$H(s) = \frac{1}{(s^2 + 0.5176s + 1)(s^2 + 1.4142s + 1)(s^2 + 1.9319s + 1)}$$

1992 + 92 + 19



$$H(s) = \frac{1/\tau}{s + 1/\tau} = \frac{\omega_c}{s + \omega_c} = \frac{1}{s + 1}$$

we are 123456789





$$H(s) = \frac{1/R_1C_1R_2C_2}{s^2 + s(R_1 + R_2)/R_1R_2C_1 + 1/R_1C_1R_2C_2} = \frac{1}{s^2 + \Delta\omega s + \omega_n^2} = \frac{1}{s^2 + as + 1}$$

WELCOME TO THE

$$\frac{201}{201} = \frac{201}{201}$$

Q1 = 20, Q2 = 100, Q3 = 20

$$H(s) = \frac{s}{s + \omega_c} = \frac{s}{s + 1}, \quad H(s) = \frac{s^2}{s^2 + \Delta\omega s + \omega_c^2} = \frac{s^2}{s^2 + as + 1}$$

$$H(s) = \begin{cases} s^n / (1 + s^{2n}) & n \text{ is even} \\ s^n / (1 - s^{2n}) & n \text{ is odd} \end{cases}$$









A pixelated, black and white graphic of the text "1. RINGE". The characters are rendered in a blocky, digital font style. The "1" is a simple vertical bar with a small horizontal base. The "R" and "I" are composed of thick vertical strokes and horizontal bars. The "N" is formed by two vertical strokes and a diagonal connecting line. The "G" is a simple open curve. The "E" consists of three horizontal bars of equal length. The "R" at the end is a stylized, blocky letter. The entire text is set against a white background.

Q1

—
—

Q1

Q1



100% Approved

$$\begin{cases} Y_3(s) = Y_2(s)/s \Rightarrow Y_2(s) = Y_3(s)s \\ Y_2(s) = Y_1(s)/s \Rightarrow Y_1(s) = Y_2(s)s = Y_3(s)s^2 \\ Y_1(s) = Y_0(s)/s \Rightarrow Y_0(s) = Y_1(s)s = Y_3(s)s^3 \end{cases}$$

$$V_0(s) = X(s) + K_1 V_1(s) + K_2 V_2(s)$$

$$Y(s) = Y_0(s) + K_1 Y_1(s) + K_2 Y_2(s) + K_3 Y_3(s) = s^3 + K_1 s^2 + K_2 s + K_3 Y_3(s)$$

$$H(s) = \frac{Y_3(s)}{X(s)} = \frac{1}{s^3 + k_1 s^2 + k_2 s + k_3}$$

$$\begin{cases} Y_2(s) = -c_2 Y_1(s)/s \Rightarrow Y_1(s) = -s Y_2(s)/c_2 \\ Y_1(s) = -c_1 Y_0(s)/s \Rightarrow Y_0(s) = -s Y_1(s)/c_1 = s^2 Y_2(s)/c_1 c_2 \\ Y_0(s) = k_0 X(s) + k_1 Y_1(s) + k_2 Y_2(s) \end{cases}$$

$$\frac{s^2}{c_1 c_2} Y_2(s) = k_0 X(s) + k_1 \left(-\frac{s}{c_2} \right) Y_2(s) + k_2 Y_2(s)$$

$$H(s) = \frac{Y_2(s)}{X(s)} = \frac{k_o}{\frac{s^2}{c_1 c_2} + \frac{s}{c_2} - k_2} = \frac{k_o c_1 c_2}{s^2 + k_1 c_1 s - c_1 c_2 k_2}$$



$$H(s) = k_0 \frac{c^2}{s^2 + ck_1s - k_2c^2}$$

$$H(s) = \frac{\omega_n^2}{s^2 + 2\zeta\omega_n s + \omega_n^2}$$









$$v = v + jv = |v| \angle v = |v| e^{jv}$$

2023 + 2024 = 2024

$$\begin{cases} |v| = \sqrt{u^2 + v^2}, & \angle v = \tan^{-1}(v/u) \\ |z| = \sqrt{x^2 + y^2}, & \angle z = \tan^{-1}(y/x) \end{cases}$$

$$v_2 = (v + jv)(x + jy) = |v|e^{j\angle v}|z|e^{j\angle z}$$

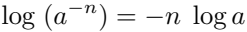
$$|vz| = |v|z, \quad e^j \angle v e^j \angle z = e^j \angle (v + z), \quad \text{or } \angle(vz) = \angle v + \angle z$$

$$\frac{w}{z} = \frac{x + jv}{x + jy} = \frac{|w|e^{j\angle w}}{|z|e^{j\angle z}}$$

$$\left| \frac{w}{z} \right| = \frac{|w|}{|z|}, \quad \frac{e^{j\angle w}}{e^{j\angle z}} = e^{j(\angle w - \angle z)}, \quad \text{or} \quad \angle \left(\frac{w}{z} \right) = \angle w - \angle z$$

log₁₀ = log₁₀

100% 100% 100%









1 = 2



$$Z = \frac{V}{I} = \frac{v_m e^{j\phi}}{i_m e^{j\psi}} = \frac{v_m}{i_m} e^{j(\phi - \psi)}$$









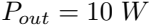
$$V e^{j\omega t} = L \frac{d}{dt} [I e^{j\omega t}] = j\omega L I e^{j\omega t} \text{ i.e. } Z_L = \frac{V}{I} = \frac{j\omega L I}{I} = j\omega L$$



$$Ie^{j\omega t} = C \frac{d}{dt} [Ve^{j\omega t}] = j\omega CVe^{j\omega t} \quad \text{i.e.} \quad Z_C = \frac{V}{I} = \frac{V}{j\omega CV} = \frac{1}{j\omega C}$$

$$Z_R = \frac{V}{I} = \frac{v_m e^{j\phi}}{i_m e^{j\phi}} = \frac{v_m}{i_m} = R$$

100%



$$L_B = \log_{10} \frac{P_{out}}{P_{in}} = \log_{10} \frac{10}{0.1} = \log_{10} 100 = 2 \text{ bel}(B)$$

$$L_B = \log_{10} \frac{P_{out}}{P_{in}} = \log_{10} 100 = 2 \text{ } B = 20 \text{ } dB, \quad \text{or} \quad L_{dB} = 10 \log_{10} \frac{P_{out}}{P_{in}} = 20 \text{ } dB$$

$$L_B = \log_{10} \frac{P_{out}}{P_{in}} = \log_{10} 10000 = 3 \text{ } B = 30 \text{ } dB, \quad \text{or} \quad L_{dB} = 10 \log_{10} \frac{P_{out}}{P_{in}} = 30 \text{ } dB$$



1990-2020

$$\frac{P_{out}}{P_{in}} = 10^{L_{dB}/10} = 10^{30/10} = 10^3, \text{ i.e. } P_{out} = 10^3 P_{in} = 1,000 P_{in}$$

W 202

10-12 WPA 2



102 W 30 St

THE UNIVERSITY OF CHICAGO

1234567890

123456789

$$L_{dB} = 10 \log_{10} \frac{V_{out}^2}{V_{in}^2} = 20 \log_{10} \frac{V_{out}}{V_{in}} \text{ dB}$$

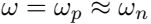
$$20 \log_{10} \frac{V_{out}}{V_{in}} = 20 \log_{10} \frac{1,0000}{10} = 40 \text{ dB}$$

$$20 \log_{10} \frac{V_{out}}{V_{in}} = 20 \log_{10} \frac{10,000}{10} = 60 \text{ dB}$$

1990-2020

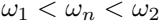
$$\frac{V_{out}}{V_{in}} = 10^{L_{dB}/20} = 10^{60/20} = 10^3, \text{ i.e., } V_{out} = 10^3 V_{in} = 1,000 V_{in}$$





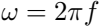






$$|H(j\omega_1)|^2 = |H(j\omega_2)|^2 = \frac{1}{2} |H(j\omega_p)|^2 \text{ i.e., } |H(j\omega_{1,2})| = 0.707 |H(j\omega_p)|$$

$$20 \log_{10} \left(\frac{|H(j\omega_{1,2})|}{|H(j\omega_p)|} \right) = 20 \log_{10} 0.707 = -3.01 \text{ dB} \approx -3 \text{ dB}$$



$$H(\omega) = |H(\omega)| \angle H(\omega) = |H(\omega)| \angle H(\omega)$$

1990





1992-2001



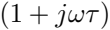


$$\left\{ \begin{array}{ll} Lm(H_1 H_2) = Lm H_1 + Lm H_2, & \angle(H_1 H_2) = \angle H_1 + \angle H_2 \\ Lm(H_1 / H_2) = Lm H_1 - Lm H_2, & \angle(H_1 / H_2) = \angle H_1 - \angle H_2 \\ Lm H^n = n Lm H, & \angle H^n = n \angle H \\ Lm(1/H) = -Lm H, & \angle(1/H) = -\angle H \end{array} \right.$$









$$\begin{aligned}
 & \left(\frac{1}{2} \frac{d^2}{dt^2} + \frac{1}{2} \frac{d^2}{dx^2} \right) \psi = \left(\frac{1}{2} \frac{d^2}{dt^2} + \frac{1}{2} \frac{d^2}{dx^2} \right) \psi \\
 & \quad + \frac{1}{2} \frac{d^2}{dt^2} \psi = \frac{1}{2} \frac{d^2}{dt^2} \psi + \frac{1}{2} \frac{d^2}{dx^2} \psi
 \end{aligned}$$

$$H(j\omega) = \frac{N(j\omega)}{1 + j\omega T}$$

$$H(j\omega) = \frac{N(j\omega)}{(j\omega)^2 + 2\zeta\omega_n j\omega + \omega_n^2} = \frac{N(j\omega)}{(\omega_n^2 - \omega^2) + j(2\zeta\omega_n\omega)}$$

$$\begin{cases} \text{If } k > 0, & k = |k|e^{j0}, & \operatorname{Lm} k = 20 \log_{10} |k|, & \angle k = 0 \\ \text{If } k < 0, & k = -|k| = |k|e^{j\pi}, & \operatorname{Lm} k = 20 \log_{10} |k|, & \angle k = \pi \end{cases}$$

$$\operatorname{Im} e^{j\omega T} = 20 \log_{10} |e^{j\omega T}| = 20 \log_{10} 1 = 0, \quad \angle e^{j\omega T} = \pm \omega T$$



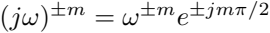
$$\operatorname{Im}(j\omega) = 20 \log_{10} \omega \text{ dB}, \quad \angle(j\omega) = \frac{\pi}{2}$$



1m1=20log1=0dB

$$\ln(w) = 20 \log_{10} w = 20 \log_{10} w = 20 \log_{10} w = \ln(w)$$





$$\ln(v) \pm n = \ln(v) \pm n = \ln(v) \pm n \pi / 2$$

120px



$$\ln v^2 = 40 \lg v^2 - \pi$$







1992-1993

$$\operatorname{Im}(j\omega)^{-1} = -\operatorname{Im}(j\omega) = -20 \log_{10} \omega \text{ dB}, \quad \angle(j\omega)^{-1} = -\angle(j\omega) = -\frac{\pi}{2}$$

1234



$$1 + j\omega\tau = \sqrt{1 + (\omega\tau)^2} e^{j \tan^{-1}(\omega\tau)} = \sqrt{1 + (\omega\tau)^2} \angle \tan^{-1}(\omega\tau)$$

$$\text{Im}(1+j\omega\tau) = 20 \log_{10} \sqrt{1+(\omega\tau)^2} = 20 \log_{10}(1+(\omega\tau)^2)^{1/2} = 10 \log_{10}(1+(\omega\tau)^2)$$

$$\frac{d}{dx} \left(x^2 + \frac{1}{x} \right) = 2x - \frac{1}{x^2}$$

$$\angle m(1+j) = 20 \log_{10} \sqrt{1^2 + 1^2} = 20 \log_{10} 0.707 \approx 3.01 \text{ dB}, \quad \angle(1+j) = \frac{\pi}{4}$$



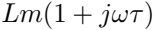


$$\ln(1+jv) \approx 10 \lg_{10}(1) = 0, \quad \angle(1+jv) \approx \angle(1) = 0$$



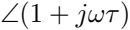


$$\angle m(1+j\omega\tau) \approx 20 \log_{10}(\omega\tau), \quad \angle(1+j\omega\tau) \approx \angle(j\omega\tau) = \frac{\pi}{2}$$















$$\frac{1}{1 + \exp(-x)} = \frac{1}{1 + \exp(-x)}$$

$$\ln(1+j\omega\tau)^{-1} = \ln(1+j\omega\tau) = -10 \log_{10}(1+(\omega\tau)^2)$$

$$\angle(1+\sqrt{w})-1=\angle(1+\sqrt{w})-1$$

1.1 + 2.2 = 3.3





$$H(j\omega) = \frac{1}{(j\omega)^2 + 2\zeta\omega_n j\omega + \omega_n^2} = \frac{1}{(\omega_n^2 - \omega^2) + 2\zeta\omega_n j\omega} = \frac{\frac{1}{\omega_n^2}}{1 - \left(\frac{\omega}{\omega_n}\right)^2 + j2\zeta\frac{\omega}{\omega_n}}$$

$$\Delta = b^2 - 4ac = 2^2 - 4 \cdot 1 \cdot (-1) \geq 0$$



$$p_1, p_2 = \left(\pm \sqrt{p_2^2 - 1} \right) \omega \pi \omega 0$$

$$H(j\omega) = \frac{1}{(j\omega - p_1)(j\omega - p_2)} = \frac{1/p_1 p_2}{(j\omega/p_1 - 1)(j\omega/p_2 - 1)} = \frac{\tau_1}{1 + j\omega\tau_1} \frac{\tau_2}{1 + j\omega\tau_2} = H_1(j\omega)H_2(j\omega)$$

1234567890

12345678

$$I_m(A_1A_2) = I_m(A_1) + I_m(A_2), \quad I(A_1A_2) = I(A_1) + I(A_2)$$

we are 121

A pixelated, grayscale image of the text 'wcl' in a stylized, blocky font. The characters are composed of various shades of gray and black pixels, giving it a retro, digital appearance. The 'w' is on the left, followed by the 'c', and then the 'l' on the right. The background is white.

Two horizontal bar charts showing the percentage of respondents who believe the U.S. should take more action to protect the environment. The top chart shows 85% for Democrats and 75% for Republicans. The bottom chart shows 85% for Democrats and 75% for Republicans.

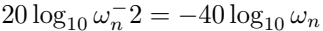
A pixelated, black and white graphic of the number 52. The digits are composed of a grid of squares, with varying shades of gray and black, giving it a retro, digital appearance. The number 5 is on the left, and the number 2 is on the right. The overall style is reminiscent of early computer graphics or video game sprites.

Figure 1 consists of two horizontal bar charts. The top chart, titled 'Internet use', shows the distribution of responses for 'How often do you use the Internet?'. The categories are 'Daily' (black), 'Weekly' (dark grey), and 'Monthly' (light grey). The bottom chart, titled 'Mobile phone use', shows the distribution of responses for 'How often do you use a mobile phone?'. The categories are 'Daily' (dark grey), 'Weekly' (medium grey), and 'Monthly' (light grey).

| Question | Response | Percentage |
|--------------------------------------|----------|------------|
| How often do you use the Internet? | Daily | ~15% |
| | Weekly | ~85% |
| | Monthly | ~0% |
| How often do you use a mobile phone? | Daily | ~85% |
| | Weekly | ~15% |
| | Monthly | ~0% |

A pixelated, black and white representation of the number 2. The number is formed by a grid of squares, with darker shades of gray representing the main body of the digit and lighter shades representing the background. The style is reminiscent of early digital art or a low-resolution scan of a printed number.

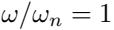




$$|H(j\omega)| = \left[\left(1 - \left(\frac{\omega}{\omega_n} \right)^2 \right)^2 + \left(2\zeta \frac{\omega}{\omega_n} \right)^2 \right]^{-1/2}$$

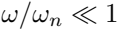
$$\text{Im} H(j\omega) = 20 \log_{10} |H(j\omega)| = -10 \log_{10} \left[\left(1 - \left(\frac{\omega}{\omega_n} \right)^2 \right)^2 + \left(2\zeta \frac{\omega}{\omega_n} \right)^2 \right]$$

$$\angle H(j\omega) = -\tan^{-1} \frac{2\zeta\omega/\omega_n}{1 - (\omega/\omega_n)^2}$$



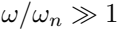
1920-1921

$$\operatorname{Im} H(j\omega) = -20 \log_{10} 2\zeta, \quad \angle H(j\omega) = -\frac{\pi}{2}$$





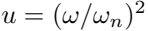
$$\ln A(\omega) - 10 \log_{10}(1) = 0, \quad \Delta A(\omega) = 0$$



$$\operatorname{Im} H(j\omega) \approx -10 \log_{10} \left[\left(\frac{\omega}{\omega_n} \right)^4 \right] = -40 \log_{10} \frac{\omega}{\omega_n}$$

$$\angle H(j\omega) \approx -\tan^{-1} 2\omega/\omega \approx -\tan^{-1}(-0) = -\pi = -180^\circ$$

$$|H(j\omega)| = \frac{1}{\sqrt{\left(1 - \frac{\omega^2}{\omega_n^2}\right)^2 + 4\zeta^2 \frac{\omega^2}{\omega_n^2}}} = \frac{1}{\sqrt{(1-u)^2 + 4\zeta^2 u}}$$







$$|H(j\omega_n)| = \frac{1}{2\zeta} = Q$$





$$\frac{d}{dv} [v^2 + (4c^2 - 2)v + 1] = 2v + 4c^2 - 2 = 0$$

$$u = \frac{\omega^2}{\omega_n^2} = 1 - 2\zeta^2, \text{ i.e., } \omega = \omega_n \sqrt{1 - 2\zeta^2} < \omega_n$$



$$|H(j\omega_p)| = \frac{1}{2\zeta\sqrt{1-\zeta^2}} > \frac{1}{2\zeta} = |H(j\omega_n)|$$







$$H_C(j\omega) = \frac{V_C}{V_{in}} = \frac{Z_C}{Z_R + Z_C} = \frac{1/j\omega C}{R + 1/j\omega C} = \frac{1}{j\omega RC + 1} = \frac{1}{j\omega\tau + 1}$$



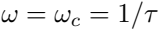
$$H_R(j\omega) = \frac{V_R}{V_{in}} = \frac{Z_R}{Z_R + Z_C} = \frac{R}{R + 1/j\omega C} = \frac{j\omega RC}{j\omega RC + 1} = \frac{j\omega\tau}{j\omega\tau + 1}$$

1992

$$H_R(j\omega) = \frac{1}{j\omega\tau + 1} j\omega\tau$$

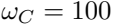


$$\ln H_R(j\omega) = 20 \log_{10} \left| \frac{1}{j\omega\tau + 1} \right| + 20 \log_{10} |j\omega\tau| = \ln H_C(j\omega) + 20 \log_{10}(\omega\tau)$$



$$\angle H_R(j\omega) = \angle \left(\frac{1}{j\omega\tau + 1} \right) + \angle j\omega\tau = \angle H_c(j\omega) + \frac{\pi}{2}$$







1990-1991



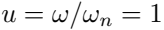
$$\frac{V_c}{V_{in}} = \frac{Z_c}{Z_L + Z_R + Z_c} = \frac{1/j\omega C}{j\omega L + R + 1/j\omega C} = \frac{1}{(j\omega)^2 LC + j\omega RC + 1}$$

$$\frac{1/LC}{(j\omega)^2 + j\omega R/L + 1/LC} = \frac{\omega_n^2}{(j\omega)^2 + 2\zeta\omega_n j\omega + \omega_n^2} = \frac{1}{\left(1 - \frac{\omega^2}{\omega_n^2}\right) + j2\zeta \frac{\omega}{\omega_n}}$$

$$\omega_n = \frac{1}{\sqrt{LC}},$$

$$\zeta = \frac{R}{2} \sqrt{\frac{C}{L}}$$

$$|H_c(j\omega)| = \frac{1}{\sqrt{\left(1 - \frac{\omega^2}{\omega_n^2}\right)^2 + 4\zeta^2 \frac{\omega^2}{\omega_n^2}}} = \frac{1}{\sqrt{(1-u)^2 + 4\zeta^2 u}}$$



1992

$$\frac{V_R}{V_{in}} = \frac{Z_R}{Z_L + Z_R + Z_C} = \frac{R}{j\omega L + R + 1/j\omega C} = \frac{j\omega RC}{(j\omega)^2 LC + j\omega RC + 1}$$

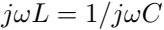
$$\frac{j\omega R/L}{(j\omega)^2 + j\omega R/L + 1/LC} = \frac{2\zeta\omega_n j\omega}{(j\omega)^2 + 2\zeta\omega_n j\omega + \omega_n^2} = H_0(j\omega) 2\zeta\omega_n j\omega$$

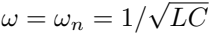
$$\ln H_R(j\omega) = \ln H_c(j\omega) + \ln(2\omega/\omega_n) \quad \angle H_R(j\omega) = \angle H_c(j\omega) + \angle(2\omega/\omega_n)$$

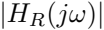
2010 2010



2 + 2 = 4









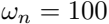


$$\frac{V_L}{V_{in}} = \frac{Z_L}{Z_L + Z_R + Z_C} = \frac{j\omega L}{j\omega L + R + 1/j\omega C} = \frac{(j\omega)^2 LC}{(j\omega)^2 LC + j\omega RC + 1}$$

$$\frac{(j\omega)^2}{(j\omega)^2 + j\omega R/L + 1/LC} = \frac{(j\omega)^2}{(j\omega)^2 + 2\zeta\omega_n j\omega + \omega_n^2} = H_0(j\omega) \frac{(j\omega_n)^2}{(j\omega_n)^2}$$

$$\ln H(j\omega) = \ln H_c(j\omega) + \ln(j\omega)^2 = \angle H_c(j\omega) + \angle(j\omega)^2$$

2010s 2010s





2019-2020 = 2019-2020

2019-2020
2019-2020

$$H(j\omega) = \frac{Z_2(j\omega)}{Z_1(j\omega)} = \frac{R_2 || 1/j\omega C_2}{R_1 + 1/j\omega C_1} = \frac{R_2/(1 + j\omega R_2 C_2)}{(1 + j\omega R_1 C_1)/j\omega C_1} = \frac{j\omega \tau_3}{(1 + j\omega \tau_1)(1 + j\omega \tau_2)}$$

