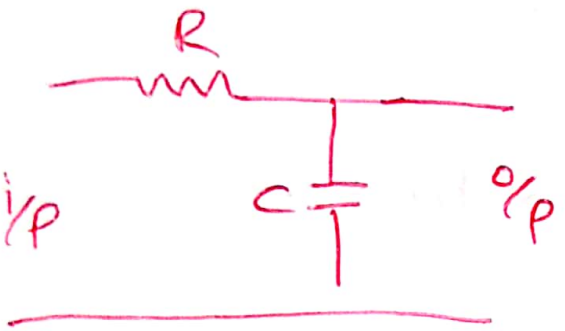
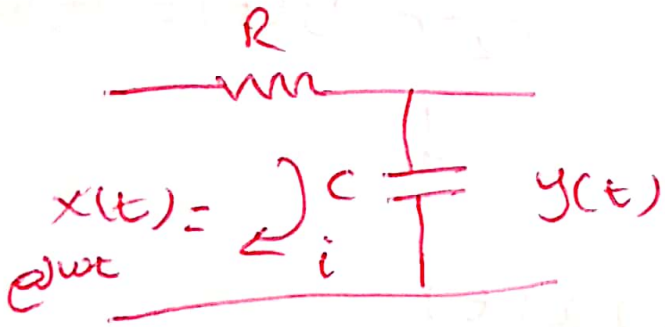


Find the transfer function of the n/w.



$$x(t) = iR + y(t) \quad \text{—— (1)}$$

$$i = C\frac{dy(t)}{dt} \quad \text{—— (2)}$$

$$y(t) = H(\omega)x(t) = H(\omega)e^{j\omega t} \quad \text{—— (3)}$$

$$\frac{dy(t)}{dt} = H(\omega)j\omega e^{j\omega t} = j\omega H(\omega)x(t) \quad \text{—— (4)}$$

$$i = C\cdot j\omega H(\omega)x(t)$$

$$x(t) = RCj\omega x(t)H(\omega) + H(\omega)x(t)$$

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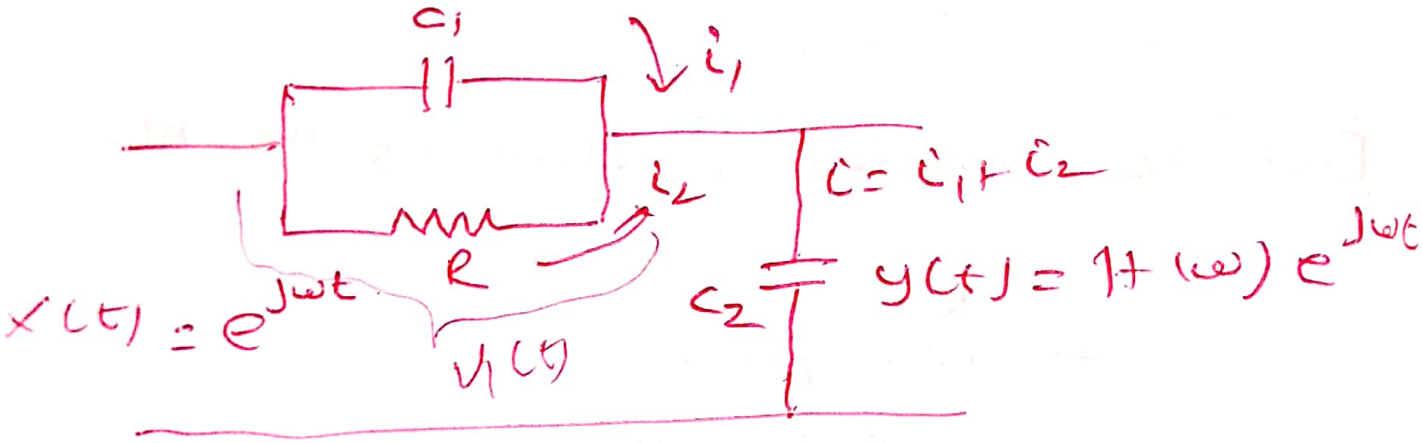
$$H(\omega) = \frac{1}{1 + j\omega RC}.$$

(2) Find the transfer function.



$$y(t) = H(\omega)\, x(t)$$

$$y(t) = H(\omega)\, e^{j\omega t}$$

$$\frac{dy(t)}{dt} = H(\omega) \cdot j\omega \left(e^{j\omega t}\right) = j\omega H(\omega) x(t) \quad \text{—— (1)}$$

$$i = C_2 \frac{dy(t)}{dt}$$

$$i_1 + i_2 = C_1 \frac{d}{dt}\left[x(t) - y(t)\right] + \frac{x(t) - y(t)}{R}.$$

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when the applied waveform is an ensemble member set $x(t)$ of random process $X(t)$.

$x(t) - y(t) - v_1(t) = 0$

$x(t) - c_2$

white & colored noise

A sample function $n(t)$ of a WSS noise random process $N(t)$ is called white noise if the power density spectrum of $N(t)$ is a constant at all frequency.

$$P_{NN}(\omega) = N_0/2$$

N_0 is a real positive constant.

By inverse fourier transformation, the auto correlation function $N(t)$ is found to be

$$R_{NN}(\tau) = (N_0/2)\,\delta(\tau).$$

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Let jointly WSS processes $X_1(t)$ and $X_2(t)$ cause responses $Y_1(t)$ and $Y_2(t)$ respectively from a linear time-invariant system with impulse response $h(t)$. If the sum $x(t) = x_1(t) +$ is applied, the response is $y(t)$. Find $x_2(t)$ expressions in terms of $h(t)$ and characteristics of $x_1(t)$ and $x_2(t)$. for (a) $E[y(t)]$

(b) $R_{yy}(t, t+\tau)$

The system is linear

$$y(t) = y_1(t) + y_2(t)$$

$$\bar{y} = \bar{y}_1 + \bar{y}_2 = E[y(t)]$$

$$\bar{y} = (\bar{x}_1 + \bar{x}_2) \int_{-\infty}^{\infty} h(t)\, dt.$$

$$R_{yy}(t, t+\tau) = E[y(t)\, y(t+\tau)]$$

$$= E[\{y_1(t) + y_2(t)\}\{y_1(t+\tau) + y_2(t+\tau)\}]$$

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$$= R_{Y_1Y_1}(t, t+\tau) + R_{Y_1Y_2}(t, t+\tau)$$
$$+ R_{Y_2Y_1}(t, t+\tau) + R_{Y_2Y_2}(t, t+\tau)$$

$$\therefore R_{YY}(t, t+\tau) = R_{Y_1Y_1}(\tau) + R_{Y_1Y_2}(\tau)$$
$$+ R_{Y_2Y_1}(\tau) + R_{Y_2Y_2}(\tau)$$

Since

~~Here~~ $Y_1(t)$ and $Y_2(t)$ jointly WSS.

and i/p processes are also WSS.

interms of $h(t)$ and inputs

$$R_{YY}(\tau) = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} R_{X_1X_1}(\tau + \xi_1 - \xi_2)\, h(\xi_1)\, h(\xi_2)\, d\xi_1\, d\xi_2$$

$$+ \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} R_{X_1X_2}(\tau + \xi_1 - \xi_2)\, h(\xi_1)\, h(\xi_2)\, d\xi_1\, d\xi_2$$

$$+ \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} R_{X_2X_1}(\tau + \xi_1 - \xi_2)\, h(\xi_1)\, h(\xi_2)\, d\xi_1\, d\xi_2$$

$$+ \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} R_{X_2X_2}(\tau + \xi_1 - \xi_2)\, h(\xi_1)\, h(\xi_2)\, d\xi_1\, d\xi_2$$

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(2) Two separate systems have impulse responses $h_1(t)$ and $h_2(t)$. A process $x_1(t)$ is applied to the first system and its response is $y_1(t)$. Similarly, a process $x_2(t)$ invokes a response $y_2(t)$ from the second system. Find the cross-correlation function of $y_1(t)$ and $y_2(t)$ in terms of $h_1(t)$ $h_2(t)$ and the cross correlation function of $x_1(t)$ and $x_2(t)$. Assume $x_1(t)$ and $x_2(t)$ are jointly WSS.

$$y_1(t) = \int_{-\infty}^{\infty} x_1(t-\xi_1)\, h_1(\xi_1)\, d\xi_1, \quad y_2(t) = \int_{-\infty}^{\infty} x_2(t-\xi_2)\, h_2(\xi_2)\, d\xi_2$$

$$R_{y_1 y_2}(t, t+\tau) = E\left[y_1(t) \cdot y_2(t+\tau)\right]$$

$$= E\left[\int_{-\infty}^{\infty} x_1(t-\xi_1)\, h(\xi_1)\, d\xi_1 \int_{-\infty}^{\infty} x_2(t+\tau-\xi_2)\, h(\xi_2)\, d\xi_2\right]$$

$$= \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} E\left[x_1(t-\xi_1)\, x_2(t+\tau-\xi_2)\right] h(\xi_1)\, h(\xi_2)\, d\xi_1\, d\xi_2$$

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$$= \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} R_{X_1X_2}(\tau+\xi_1-\xi_2)\, h(\xi_1)\, h(\xi_2)\, d\xi_1\, d\xi_2$$

$$= R_{Y_1Y_2}(\tau)$$

(3) A stationary random process $x(t)$ is applied to the input of a system for which

$$h(t) = 3u(t)\, t^2 \exp(-8t)$$

If $E[x(t)] = 2$. what is the mean value of the system's respons $Y(t)$

$$\overline{Y} = \overline{X} \int_{-\infty}^{\infty} h(t)\, dt$$

$$= 2 \int_{-\infty}^{\infty} 3u(t)\, t^2 \exp(-8t)$$

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$$6\int_0^\infty t^2 e^{-8t}\,dt$$

$$\frac{3}{512}$$

$$\int x^2 e^{ax}\,dx = e^{ax}\left[\frac{x^2}{a} - \frac{2x}{a^2} + \frac{2}{a^3}\right]$$

$$= 6 \times \left[e^{-8t}\left[\frac{t^2}{-8} - \frac{2t}{64} - \frac{2}{512}\right]\right]_0^\infty$$

$$= 6 \times \frac{2}{512} = 3/128$$

(4) Two identical networks are cascaded. Each has impulse response

$$h(t) = u(t)\, 3t \exp(-4t)$$

A wide sense stationary process $x(t)$ is applied to the cascade's input.

(a) Find an expression for the response $Y(t)$ of the cascade

(b) If $E[x(t)] = \bar{x} = 6$, find $\overline{Y}$

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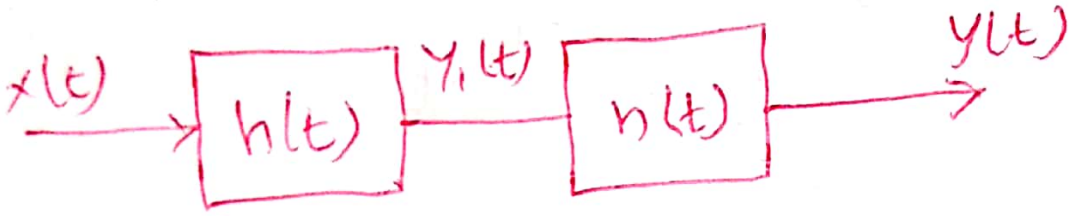

$$y_1(t) = \int_{-\infty}^{\infty} x(t-\xi_1)\, h(\xi_1)\, d\xi_1$$

$$y(t) = \int_{-\infty}^{\infty} y_1(t-\xi_2)\, h(\xi_2)\, d\xi_2$$

$$= \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} x(t-\xi_2-\xi_1)\, h(\xi_1)\, d\xi_1\, h(\xi_2)\, d\xi_2$$

$$= \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} x(t-\xi_1-\xi_2)\, h(\xi_1)\, h(\xi_2)\, d\xi_1\, d\xi_2$$

$$= \int_{0}^{\infty}\int_{0}^{\infty} x(t-\xi_1-\xi_2)\; 3\xi_1 e^{-4\xi_1}\; 3\xi_2 e^{-4\xi_2}\; d\xi_1\, d\xi_2$$

$$= 9\int_{0}^{\infty}\int_{0}^{\infty} x(t-\xi_1-\xi_2)\; \xi_1 \xi_2\, e^{-4(\xi_1+\xi_2)}\; d\xi_1\, d\xi_2$$

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(h) $E[y(t)] = 9 \times \left[\int_0^\infty \xi e^{-4\xi} d\xi\right]^2$

$$\int x e^{ax} dx = e^{ax}\left[\frac{x}{a} - \frac{1}{a^2}\right]$$

$= 9 \times 6 \times \left[\frac{1}{16}\right]^2$

$= 9 \times \cancel{6}^{3} \times \frac{1}{\cancel{256}\,128} = \frac{27}{128}$ //

(5) Find $\overline{y^2}$ for a system having white noise at inputs

$$R_{xx}(\xi_1 - \xi_2) = (N_0/2)\,\delta(\xi_1 - \xi_2)$$

where N_0 is positive real constant.

Also find cross correlation function $R_{xy}(\tau)$ and $R_{yx}(\tau)$.

$$\overline{y^2} = E[y^2(t)] = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} R_{xx}(\xi_1 - \xi_2)\, h(\xi_1)\, h(\xi_2)\, d\xi_1\, d\xi_2$$

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$$\overline{Y^2} = \underbrace{\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} N_0/2\ \delta(\xi_1 - \xi_2)\, h(\xi_1)\, d\xi_1\, h(\xi_2)\, d\xi_2}_{\xi_1 = \xi_2}$$

$$= N_0/2 \int_{-\infty}^{\infty} h^2(\xi_2)\, d\xi_2$$

O/p power become proportional to the area under the square of $h(t)$.

$$R_{XY}(\tau) = \int_{-\infty}^{\infty} R_{XX}(\tau - \xi)\, h(\xi)\, d\xi$$

$$R_{YX}(\tau) = \int_{-\infty}^{\infty} R_{XX}(\tau - \xi)\, h(\xi)\, d\xi$$

$$R_{XY}(\tau) = \int_{-\infty}^{\infty} N_0/2\ \delta(\tau - \xi)\, h(\xi)\, \underline{d\xi}$$

$$\xi = \tau$$

$$= N_0/2\ h(\tau)$$

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$$R_{YX}(\tau) = \int_{-\infty}^{\infty} (N_0/2)\, \delta(\tau - \xi_2)\, h(-\xi_2)\, d\xi_2$$

$$= N_0/2\, h(-\tau)$$

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(i) A wide sense stationary process $x(t)$, with mean value 5 and power spectrum

$$S_{xx}(\omega) = 50\pi\,\delta(\omega) + \frac{3}{1+(\omega/2)^2}$$

is applied to a network with impulse response

$$h(t) = 4\exp(-4|t|)$$

(a) Find $H(\omega)$ for the network.

Determine (b) the mean $\bar{Y}$

(c) the power spectrum of the response $Y(t)$

(a)

$$e^{-\alpha|t|} \longleftrightarrow \frac{2\alpha}{\alpha^2+\omega^2}$$

$$H(\omega) = \frac{4\times 2\times 4}{16+\omega^2} = \frac{32}{16+\omega^2}$$

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(b) $\bar{Y} = \bar{X} \int_{-\infty}^{\infty} h(\xi)\, d\xi$

$$= 5 \int_{-\infty}^{\infty} 4 e^{-4|\xi|}\, d\xi$$

$$= 20 \left[\int_{-\infty}^{0} e^{4\xi}\, d\xi + \int_{0}^{\infty} e^{-4\xi}\, d\xi \right]$$

$$= 40 \times \left[\frac{e^{-4\xi}}{-4} \right]_{0}^{\infty}$$

$$= 40 \times \frac{1}{4} = 10$$

(c) $S_{YY}(\omega) = S_{XX}(\omega) |H(\omega)|^2$

$$= \left(50\pi\, \delta(\omega) + \frac{12}{4+\omega^2} \right) |H(\omega)|^2$$

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$$= 50\pi\,\delta(\omega)\,|H(0)|^2 + \frac{12}{4+\omega^2} \times \frac{32^2}{(16+\omega^2)^2}$$

$$S_{YY}(\omega) = 200\pi\,\delta(\omega) + \frac{12{,}288}{(4+\omega^2)(16+\omega^2)^2}$$

(2) A Stationary random signal $x(t)$ has a auto-correlation function $R_{XX}(\tau) = 10\exp(-|\tau|)$. It is added to white noise [independent of $x(t)$] for which $N_0/2 = 10^{-3}$ and the sum is applied to a filter having a transfer function

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

(a) Find the signal component of the o/p power spectrum and the average power in the output signal.

(b) find the power spectrum of and average power in the noise.

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(c) what is the ratio of the output signal's power to the o/p average noise.

$$10 e^{-|\tau|} = \frac{20}{1+\omega^2} = S_{xx}(\omega)$$

$$S_{xx}(\omega) \cdot |H(\omega)|^2$$

$$\text{signal}_{out}(\omega) = \frac{20}{1+\omega^2} \frac{4}{(1+\omega^2)^3} = \frac{80}{(1+\omega^2)^4}$$

$$\cancel{P_{signal\ out} = \frac{1}{2\pi} \int_{-\infty}^{\infty} S_{xx}(\omega)}$$

$$P_{signal\ out} = \frac{1}{2\pi} \int_{-\infty}^{\infty} \frac{80}{(1+\omega^2)^4} d\omega$$

$$\int \frac{dx}{(a^2+x^2)^4} = \frac{x}{6a^2(a^2+x^2)^3} + \frac{5x}{24a^4(a^2+x^2)^2} + \frac{5x}{16a^6(a^2+x^2)}$$

$$+ \frac{5}{16a^7} \tan^{-1}\left(\frac{x}{a}\right)$$

$$= \frac{1}{2\pi} \times \frac{5}{16} \times 80 \times \pi = 12.5$$

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(b) $S_{noise\,out}(\omega) = \frac{N_0}{2} \frac{4}{(1+\omega^2)^3} = \frac{2N_0}{(1+\omega^2)^3}$

$$P_{noise\,out} = \frac{1}{2\pi} \int_{-\infty}^{\infty} \frac{2N_0}{(1+\omega^2)^3} d\omega$$

$$\int \frac{dx}{(a^2+x^2)^3} = \frac{x}{4a^2(a^2+x^2)^2} + \frac{3x}{8a^4(a^2+x^2)}$$

$$+ \frac{3}{8a^5} \tan^{-1}(x/a)$$

$$= \frac{1}{2\pi} \times 2N_0 \times \frac{3}{8/4} \times \pi$$

$$= 3/4 \left(\frac{N_0}{2}\right)$$

$$\frac{N_0}{2} = 10^{-3}$$

d

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(c) $P_{signal\ out} / P_{noise\ out}$

$$= \frac{12.5 \times 4 \times 10^3}{3}$$

$$= 50000/3 = 16,667 //$$

(3) A random noise $x(t)$ having power spectrum

$$S_{xx}(\omega) = \frac{3}{49+\omega^2}$$

is applied to a differentiator that has a transfer function $H_1(\omega) = j\omega$. The differentiator's output is applied to a network for which

$$h_2(t) = u(t)\, t^2 \exp(-7t)$$

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The network's response is a noise denoted by $Y(t)$

(a) What is the average power in $x(t)$?

(b) Find the power spectrum of $Y(t)$.

(c) Find the average power in $Y(t)$.

(a) $$P_{xx} = \frac{1}{2\pi}\int_{-\infty}^{\infty} S_{xx}(\omega)\, d\omega$$

$$= \frac{3}{2\pi}\int_{-\infty}^{\infty} \frac{d\omega}{49+\omega^2}$$

$$= \frac{3}{2\pi} \times \frac{1}{7} \times \pi = 0.2143$$

(b) $$h_2(t) = u(t)\, t^2 e^{-7t} \longleftrightarrow \frac{2}{(7+j\omega)^3} = H_2(\omega)$$

$$S_{YY}(\omega) = S_{XX}(\omega)\, |H_1(\omega)\, H_2(\omega)|^2$$

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$$= \frac{12\omega^2}{(49+\omega^2)^4}$$

(c) $$P_{YY} = \frac{1}{2\pi}\int_{-\infty}^{\infty} \frac{12\omega^2}{(49+\omega^2)^4}$$

$$\int \frac{x^2}{(a^2+x^2)^4} = \frac{-x}{6(a^2+x^2)^3} + \frac{x}{24a^2(a^2+x^2)^2} + \frac{x}{16a^4(a^2+x^2)}$$

$$+ \frac{1}{16a^5}\tan^{-1} x/a$$

$$= \frac{\cancel{12}^{\,3}}{\cancel{16}_{\,4}} \times \frac{1}{2\cancel{\pi}} \times \frac{1}{7^5} \times \cancel{\pi}$$

$$\boxed{P_{YY} = \frac{3}{134{,}456} = 2.231 \times 10^{-5}}$$

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Noise B.W

Consider a system having low pass transfer function $H(\omega)$.

Assume white noise is applied at the input.

The power density of white noise $N_0/2$

$$P_{YY} = \frac{1}{2\pi}\int_{-\infty}^{\infty} S_{XX}(\omega)\,|H(\omega)|^2\,d\omega \quad \text{—(1)}$$

$$= \frac{1}{2\pi}\int_{-\infty}^{\infty}\left(\frac{N_0}{2}\right)|H(\omega)|^2\,d\omega \quad \text{—(2)}$$

$|H(\omega)|^2$ is even function.

$$P_{YY} = \frac{1}{2\pi}\,\cancel{2}\int_{0}^{\infty}\frac{N_0}{\cancel{2}}\,|H(\omega)|^2\,d\omega \quad \text{—(3)}$$

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$$P_{YY} = \frac{N_0}{2\pi} \int_0^{\infty} |H(\omega)|^2 \, d\omega. \quad \text{—(4)}$$

Now consider a idealized system that is equivalent to the actual system

i.e both produce the same output average power when both are excited by the same white noise.

So Both have same value of power transfer function at midband i.e $|H(0)|^2$

The principal difference b/w the two system is that

the idealized one has regularly shaped power transfer function $|H_I(\omega)|^2$

$$|H_I(\omega)|^2 = \begin{cases} |H(0)|^2 & |\omega| < \omega_N \\ 0 & |\omega| > \omega_N \end{cases} \quad \text{—(5)}$$

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W_N is a positive constant selected to make o/p power in the two system equal.

The o/p power in the idealized system is

$$\frac{1}{2\pi}\int_{-\infty}^{\infty}\left(\frac{N_0}{2}\right)|H_I(\omega)|^2 d\omega = \frac{N_0}{2\pi}\int_{0}^{W_N}|H(0)|^2 d\omega$$

$$= \frac{N_0|H(0)|^2 W_N}{2\pi} \quad \text{—— (6)}$$

$$W_{op} = \oint$$

equating (6) & (3)

$$W_N = \frac{\int_0^{\infty}|H(\omega)|^2 d\omega}{|H(0)|^2} \quad \text{—— (7)}$$

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Minimum Mean Squared Error

MSE of the optimum filter

$$E[\epsilon^2(t)]_{min} = \frac{1}{2\pi}\int_{-\infty}^{\infty} \frac{S_{xx}(\omega)S_{WW}(\omega) - |S_{Wx}(\omega)|^2}{S_{WW}(\omega)}$$

i/p

The signal and noise are uncorrelated.

$$S_{WW}(\omega) = S_{xx}(\omega) + S_{NN}(\omega)$$

$$S_{Wx}(\omega) = S_{xx}(\omega)$$

$$H_{opt}(\omega) = \frac{S_{xx}(\omega)}{S_{xx}(\omega) + S_{NN}(\omega)} e^{j\omega_0}.$$

$$E[\epsilon(t^2)]_{min} = \frac{1}{2\pi}\int_{-\infty}^{\infty} \frac{S_{xx}(\omega)\, S_{NN}(\omega)}{S_{xx}(\omega) + S_{NN}(\omega)}\, d\omega.$$

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A random signal $x(t)$ and additive un-correlated noise $N(t)$ have respective power spectrums.

$$S_{xx}(\omega) = \frac{9}{9+\omega^4} \quad \text{and} \quad S_{NN}(\omega) = \frac{3}{6+\omega^4}$$

(a) Find the transfer function of the Wiener filter for the given signal & noise

(b) Find the minimum value of the error in predicting $x(t+t_0)$

$$H_{opt}(\omega) = \frac{S_{xx}(\omega)\, e^{j\omega t_0}}{S_{xx}(\omega) + S_{NN}(\omega)}$$

$$= \frac{\frac{9}{9+\omega^4}}{\frac{9}{9+\omega^4} + \frac{3}{6+\omega^4}}\, e^{j\omega t_0}$$

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$$= \frac{\frac{\cancel{9}^{3}}{\cancel{9+\omega^4}}}{\frac{\cancel{3}\left(3(6+\omega^4)+(9+\omega^4)\right)}{\cancel{(9+\omega^4)}(6+\omega^4)}} e^{j\omega t_0}$$

$$= \frac{3(6+\omega^4)}{27+4\omega^4} e^{j\omega t_0}$$

(b) $$E\left[\varepsilon^2(t)\right]_{min} = \frac{1}{2\pi}\int_{-\infty}^{\infty} \frac{\frac{9}{9+\omega^4} \times \frac{3}{6+\omega^4}}{\frac{9}{9+\omega^4} + \frac{3}{6+\omega^4}} d\omega$$

$$= \frac{1}{2\pi}\int_{-\infty}^{\infty} \frac{\frac{\cancel{27}^{9}}{\cancel{(9+\omega^4)(6+\omega^4)}}}{\frac{3(6+\omega^4)+(9+\omega^4)}{\cancel{(9+\omega^4)(6+\omega^4)}}}$$

$$= \frac{9}{2\pi}\int_{-\infty}^{\infty} \frac{d\omega}{27+4\omega^4}$$

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$$= \frac{9}{2\pi} \int_{-\infty}^{\infty} \frac{dw}{4\left(\frac{27}{4} + w^4\right)}$$

$$= \frac{9}{8\pi} \int_{-\infty}^{\infty} \frac{dw}{\frac{27}{4} + w^4} \simeq 0.19$$

$$\boxed{\int \frac{dx}{a^4 + w^4} = \frac{1}{4a^3\sqrt{2}} \ln\left(\frac{x^2 + ax\sqrt{2} + a^2}{x^2 - ax\sqrt{2} + a^2}\right) + \frac{1}{2a^3\sqrt{2}} \tan^{-1}\left(\frac{ax\sqrt{2}}{a^2 - x^2}\right).}$$

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① A signal $x(t) = u(t)\,5t^2 \exp(-2t)$ is added to white noise for which $N_0/2 = 10^{-2}$ W/Hz. The sum is applied to the matched filter.

(a) what is the filter's transfer function.

(b) Find $\left(S_0/N_0\right)$

* $u(t)\,t^2 e^{-\alpha t} = \dfrac{2}{(\alpha + j\omega)^3}$

$$u(t)\,5t^2 \exp(-2t) = \frac{2 \times 5}{(2 + j\omega)^3} = \frac{10}{(2 + j\omega)^3}$$

$$H_{opt}(\omega) = \frac{1}{2\pi C}$$

given white noise.

$$H_{opt}(\omega) = K\, X^*(\omega)\, e^{-j\omega t_0}$$

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$$= \frac{k e^{-j\omega t_0}}{(2-j\omega)^3}$$

k is an arbitrary real constant.

For non white

$$H_{opt} = \frac{1}{2\pi C} \frac{X^*(\omega)}{S_{NN}(\omega)} e^{-j\omega t_0}$$

$$= \frac{1}{2\pi C} \times \frac{10}{(2-j\omega)^3} \times \frac{e^{j\omega t_0}}{S_{NN}(\omega)}$$

$$k = \frac{10}{2\pi C (S_{NN}(\omega))}$$

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$$\left(\frac{S_o}{N_o}\right) = \frac{1}{2\pi\,(N_o/2)} \int_{-\infty}^{\infty} |X(\omega)|^2 \, d\omega$$

$$= \frac{\overset{50}{\cancel{100}}}{\cancel{2}\pi} \int_{-\infty}^{\infty} \frac{100}{(4+\omega^2)^3} \, d\omega$$

$$\int \frac{dx}{(a^2+x^2)^3} = \frac{x}{4a^2(a^2+x^2)^2} + \frac{3x}{8a^4(a^2+x^2)}$$

$$+ \frac{3}{8a^5} \tan^{-1} x/a .$$

$$= \frac{50}{\cancel{2}\pi} \times \frac{3}{8 \times 2^5} \times \cancel{\pi} \times 100$$

$$= \frac{15000}{2^8} = 58.5938 .$$

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