S-72.245 TRANSMISSION METHODS IN TELECOMMUNICATION SYSTEMS (4 CR)

Exam 31.1 .2005

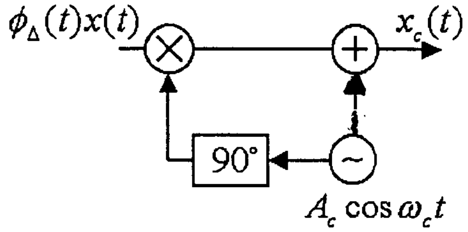
- Please see the formula collection overleaf of this paper/Huomaa, että tämän arkin kääntöpuolella on kaavakokoelma
- Return all answer papers – even empty ones/Palauta kaikki saamasi vastauskonseptit – myös tyhjät sellaiset
- All kinds of calculators are allowed/Voit käyttää millaista laskinta tahansa
- You can answer in English, Swedish or Finnish/Du kan svara på svenska/Voit vastata suomeksi
- Please show your identity when leaving papers to supervisor/Ole hyvä ja osoita henkilöllisyytesi jättäessäsi paperit valvojalle

This is closed-book exam – no handouts or other references can be present

1. Consider binary PCM transmission of a video signal with the sampling frequency of $f_s = 10$ MHz. Calculate the signaling rate needed to get $(S/N)_D \geq 50\ dB$ when $S_x = 1$.

2. Synchronous AM-detection with some local oscillator phase error results degradation of 3 dB in post detection SNR. Determine the respective local oscillator phase error.

3. Suppose the PCM quantization error ε_k is specified to be no greater than $\pm P\%$ of the peak-to-peak signal range in linear quantization. Obtain the corresponding condition on the number of bits ν in terms of number of quantization levels M and P.



4. Let us inspect the narrow band phase modulator shown in the figure above. Show that for large modulation indexes circuit works an nonideal way by determining output phase as the function of modulation index ϕ_Δ. Pinpoint how the nonideality of the device is indicated in your expression.

5. Consider matching of a communication channel with $Z_L = 30 + j2\pi fL, L = 10\,\text{nH}$ to the source having impedance $Z_g = 10 + 1/(j2\pi fC), C = 1\,\text{nF}$. Describe goodness of matching as a function of frequency. Is there a frequency where matching is optimized?

REMARKS / HUOMAUTUKSET:

Collection of formulas: There are many formulas on the same row!
Samalla rivillä voi olla monta kaavaa!

$d\phi(t)/dt = 2\pi f(t) = 2\pi[f_C + f_\Delta x(t)]$, $d\phi(t)/dt = [\phi(t) - \phi(t-t_1)]/t1$

$\phi(t) - \phi(t-t_1) = t_1 d\phi(t)/dt = 2\pi t_1[f_C + f_\Delta x(t)]$

$x_\delta(t) = x(t)s_\delta(t) = x(t)\sum_{k=-\infty}^{\infty}\delta(t-kT_s)$, $= \sum_{k=-\infty}^{\infty} x(kT_s)\delta(t-kT_s)$,

$X_\delta(f) = f_s \sum_{n=-\infty}^{\infty} X(f - nf_s)$, $F[\exp(-at)u(t)] = (a+j\omega)^{-1}, a>0$

$< v_i(t) >= \frac{1}{T}\int_{-T/2}^{T/2} v_i(t)dt, < v_i(t) >= \lim_{T\to\infty}\frac{1}{T}\int_{-T/2}^{T/2} v_i(t)dt$

$< v(t) >= \int_A x p_v(x)dx, < v_i^2(t) >= \int_A x^2 p_v(x)dx$

$< v_i^2(t) >= \frac{1}{T}\int_{-T/2}^{T/2} v_i^2(t)dt$

$\cos\theta = R_{tot}/Z_{tot} = R_{tot}/\sqrt{R_{tot}^{\ 2} + X_{tot}^2}$,

$X_{tot} = X_g + X_L, R_{tot} = R_L + R_g$

$\phi(t) = \begin{cases} \underbrace{\phi_\Delta A_m}_{\beta}\sin(\omega_m t), & \text{PM} \\ (\underbrace{A_m f_\Delta / f_m}_{\beta})\sin(\omega_m t), & \text{FM} \end{cases}$ $q = M^v$, $|\varepsilon_k| \le 1/q$, $P_{dB} = 10\log_{10}(P/P_{ref})$,

$\sin^2(x) = (1-\cos(2x)/2$, $\sin^3(x) = \frac{1}{4}[3\sin(x) - \sin(3x)]$,

$\sin(x)\sin(y) = [\cos(x-y) - \cos(x+y)]/2$

$\sin(x)\cos(y) = [\sin(x-y) + \sin(x+y)]/2$

$\frac{V_g}{V_i} = \frac{Z_g + Z_L}{Z_L}, P_L = V_i I_i \cos\theta$,

$\left(\frac{S}{N}\right)_D = 10log_{10}(3\times 2^{2n} S_x)$, $f_0 = (2\pi\sqrt{LC})^{-1}$

$y_D(t) \approx \begin{cases} K_{D,AM} A_v(t), \text{AM} \\ K_{D,PM}\phi(t), \text{PM} \\ K_{D,FM} d\phi(t)/dt, \text{FM} \end{cases}$, $\beta = A_m f_\Delta / f_m \big|_{A_m=1, f_m=W} = f_\Delta / W \equiv D$

$\cos(\beta\sin(\omega_m t)) = J_O(\beta) + \sum_{n\,\text{even}}^{\infty} 2J_n(\beta)\cos(n\omega_m t)$

$\sin(\beta\sin(\omega_m t)) = \sum_{n\,\text{odd}}^{\infty} 2J_n(\beta)\sin(n\omega_m t)$

$x_{PM}(t) = A_C\cos(\underbrace{\omega_C t + \underbrace{\phi(t)}_{\phi_\Delta x(t), \phi_\Delta \le \pi}}_{\theta_C(t)})$, $X_C(f) \approx \frac{1}{2}A_C\delta(f-f_C) + \frac{j}{2}A_C\Phi(f-f_C), f>0$

$\left(\frac{S}{N}\right)_D = \frac{S_x}{1+S_x}\gamma$, $S_x = S_R\cos^2\phi, \gamma = \frac{S_R}{N_0 W}$,

$C_{xy} = \int_A x(t)y(t-\tau)dt$ $, x(t)\otimes y(t) = \int_A x(t)y(\tau-t)dt$