Soru 1:

$$V_I = \sqrt{\frac{2.I_{SS}}{k_N^{'}.\left(\frac{W}{L}\right)_1}} \qquad \left(\frac{W}{L}\right)_1 = \frac{2.I_{SS}}{k_N^{'}.(\Delta V_I)^2} = \frac{2x50x10^{-6}}{20x10^{-6}.(0.25)^2} = 80$$

$$K_V = g_{m1}.R_o \qquad g_{m1} = \sqrt{I_{SS}.k_N^{'}.\left(\frac{W}{L}\right)_1} = \sqrt{50x10^{-6}x20x10^{-6}.80} = 282\mu A/V$$

$$R_O = \frac{2}{(\lambda_N + \lambda_P).I_{SS}} = \frac{2}{(0.01+0.02)x50x10^{-6}} = 1.3M\Omega$$

$$K_V = 376$$

$$V_{D1} = V_{DD} - |V_{GS3}| = V_{DD} - V_{SG3}$$

$$V_{SG3} = -V_{GS3} = V_{DD} - V_{ICmaks} + V_{TN} = 1.5V - 1V + 0.7V = 1.2V$$

$$|V_{GS3} - V_{TP}| = \sqrt{\frac{2.I_D}{k_P^{'}.\left(\frac{W}{L}\right)_3}} = |-1.2V - (-0.7V)| = 0.5$$

$$\rightarrow \left(\frac{W}{L}\right)_3 = \frac{2.I_D}{k_P^{'}.|V_{GS3} - V_{TP}|^2} = \frac{50\mu A}{10x10^{-6}x(0.5)^2} = 20$$

Devrenin çalışması için gereken şartlar dikkate alındığında, verilen V_{ICmin} değerinde T1-T2 iletim yönünde kutuplanmalı ve transistorlar doyma bölgesinde kalmalı.

$$V_{GS1} = \sqrt{\frac{2.I_D}{k_N^{'}.\left(\frac{W}{L}\right)_1}} + V_{TN} = \sqrt{\frac{2x50\mu A}{20\mu A/V\ x\ 80}} + 0.7V = 0.95V$$

şartı yerine gelmeli. Verilen V_{ICmin} =-1V değerinde T1 transistorunun kaynak ucu gerilimi

$$V_{S1} = V_{IC\min} - V_{GS1} = -1V - 0.95V = -1.95V$$

bulunur.. V_{S1} <- V_{SS} olamayacağından, **devre bu son şartı yerine getiremez**!

Soru 2

$$K_V = B.g_{m1}.R_o$$

$$R_O = \frac{1}{(\lambda_N + \lambda_P).I_6} = \frac{1}{(0.01+0.02)x15x10^{-6}} = 2.2M\Omega$$

$$G = B.\sqrt{k_n'.I_A.\left(\frac{W}{L}\right)_{1-2}} = 134\mu A/V \Rightarrow K_V = 134\mu A/V\ x\ 2.2M\Omega = 297$$

$$f_d = \frac{1}{2\pi R_O(C_L + C_{n7})} = \frac{1}{2\pi\ x\ 2.2M\ x\ (11pF)} = 6.6kHz$$

$$GBW = K_V.f_d = 297x6.6kHz = 1.95MHz$$

$$\phi_5 = arctg\left(B.K_{V1}.\frac{C_{n5}}{C_L + C_{n7}}\right) = arctg\left(3x3x\frac{1}{11}\right) = 39.3^O$$

$$\phi_6 = arctg\left(\sqrt{\frac{B.(W/L)_1}{(W/L)_7}}.\frac{C_{n6}}{C_L + C_{n7}}\right) - arctg\left(\frac{1}{2}.\sqrt{\frac{B.(W/L)_1}{(W/L)_7}}.\frac{C_{n6}}{C_L + C_{n7}}\right)$$

$$= arctg\left(\sqrt{\frac{3x10}{10}}x\frac{1}{11}\right) - arctg\left(\frac{1}{2}x\sqrt{\frac{3x10}{10}}x\frac{1}{11}\right) = 4.43^O$$

$\phi_m = 90^O - 39.3^O - 4.43^O = 46.3^O$

Soru 3:

$$f_1 = \frac{I_1}{4.C.V_{BEon}}$$

$$V_K = V_{BE} + 2I_{E11}R_1 - V_{BE} - 2I_{E12}R_1 = 2R_1\left(I_{E11} - I_{E12}\right)$$

$$I_{E11} = \frac{1}{4}I_{C14} + \Delta I,\ \ I_{E12} = \frac{1}{4}I_{C14} - \Delta I$$

$$V_K = 4R_1.\Delta I \rightarrow \Delta I = \frac{V_K}{4R_1}$$

$$I_1 = I_{C5} + I_{C10} = I_T.\frac{R_B}{R_C} + \frac{1}{4}I_{C14} + \Delta I = I_T.\frac{R_B}{R_C} + \frac{1}{4}I_T.\frac{R_B}{R_D} + \frac{V_K}{4R_1}$$

$$I_1 = I_T.\left(\frac{R_B}{R_C} + \frac{1}{4}.\frac{R_B}{R_D}\right) + \frac{V_K}{4R_1} = I_T.(2+2) + \frac{V_K}{4R_1} = 4.I_T + \frac{V_K}{4R_1}$$

$$f_1 = \frac{I_1}{4.C.V_{BEon}} = \frac{1}{4.C.V_{BEon}}\left(4.I_T + \frac{V_K}{4R_1}\right)$$

$$I_T = \frac{V_{CC} + V_{EE} - V_{BE}}{R_A + R_B} = \frac{5V - 0.7}{11k} = 0.39mA$$

$$I_{C14} = \frac{R_B}{R_C}.I_T = 8.I_T = 3.12mA$$

$$I_{1maks} = 2.I_T + \frac{I_{C14}}{2} = 6.I_T = 2.34mA$$

$$I_{1\min} = 2.I_T = 0.78mA$$

V_K = 0 için osilasyon frekansı

$$f_o = \frac{4.I_T}{4.C.V_{BEon}} = \frac{4x0.39mA}{4x1nFx0.7V} = 0.417x10^6 = 557kHz$$

Üst sınır

$$f = f_{maks} \rightarrow I_{1maks} = 6.I_T$$

$$f_o = \frac{6.I_T}{4.C.V_{BEon}} = \frac{2.34mA}{4x1nFx0.7V} = 0.835x10^6 = 835kHz$$

Alt sınır

$$f = f_{\min} \rightarrow I_{1\min} = 2.I_T$$

$$f_o = \frac{2.I_T}{4.C.V_{BEon}} == 278kHz$$

$-3.12V \leq V_K \leq 3.12V$