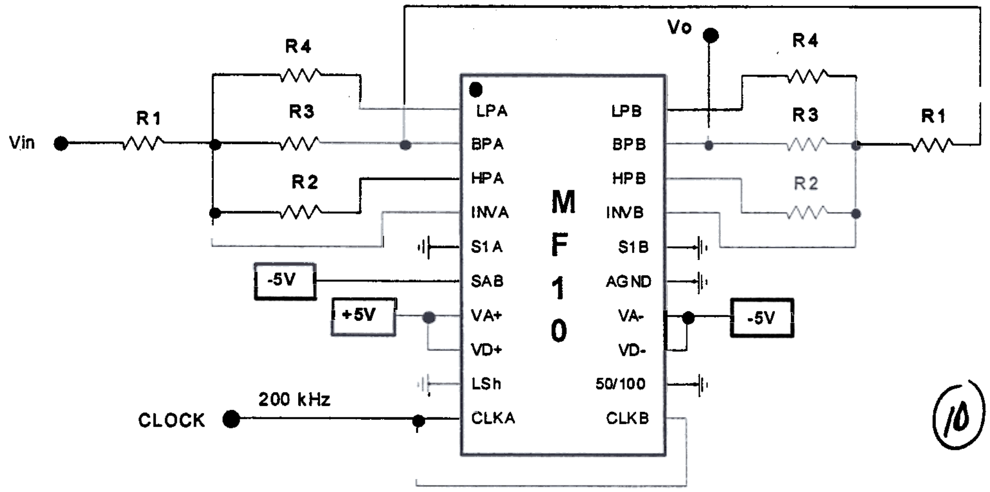
LINEAR CIRCUITS TEST –2 NOV 2002

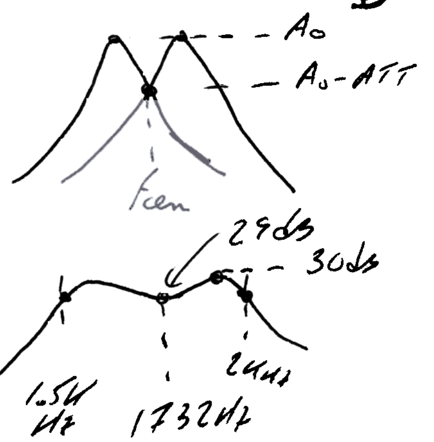
NAME: Solutions

No.1 (50 pts) $F_n = \frac{F_{clk}}{100} \times \sqrt{\frac{R_2}{R_4}}$ $Q = \frac{R_3}{\sqrt{R_2 R_4}}$ $A_{HP} = -\frac{R_3}{R_1} = -38.17\,v/v$

$$ATT(dB) = 10 \times LOG\left(1 + Q^2\left(\frac{F_n}{F} - \frac{F}{F_n}\right)^2\right) = 10 \cdot LOG\left(1 + 25.075^2\left(\frac{1995.3}{1732} - \frac{1732}{1995.3}\right)^2\right) = \underline{17.134\,dB}$$

5





(10)

$\omega_{cen} = 3.4641$ 5

$A_o = (29 + 2 \cdot 17.134)/2 = \underline{31.63\,dB}$

Design a band-pass filter that meets the following specifications:

Pass-band gain of 30 dB
Cutoff frequencies of 1500 Hz and 2000 Hz
Chebychev response with 1 dB ripple.
Normalised low-pass poles 0.99323 /±98.076° ~~0.52858 /±129.591°~~

$\bar{S}_{1,2} = 3.99062 \underline{/\pm 91.14257°}$

$\bar{S}_{3,4} = 3.00705 \underline{/\pm 91.14257°}$

$S_{1,2} = 12536.9 \underline{/\pm 91.14257°}$ $S_{3,4} = 9446.9 \;/\pm 91.14257°$ (18)

$Q_1 = 25.075$ $F_{n1} = 1995.344$ 3 $F_{n2} = 1503.54\,Hz$ $Q_2 = 25.075$

$A_o = 38.17\,v/v\ (31.634\,dB)$ $A_o = 38.17\,v/v$ 3

$\frac{R_2}{R_4} = \left(\frac{100 F_{n1}}{F_{clk}}\right)^2 = 0.9953$ 6 $\frac{R_2}{R_4} = 0.565128$ 6

$R_3 = 25.075\sqrt{R_2 R_4}$ 3 $R_3 = 25.075\sqrt{R_2 R_4}$ 3

$R_1 = R_3 / 38.17$ 3 $R_1 = R_3 / 38.17$ 3

(24)

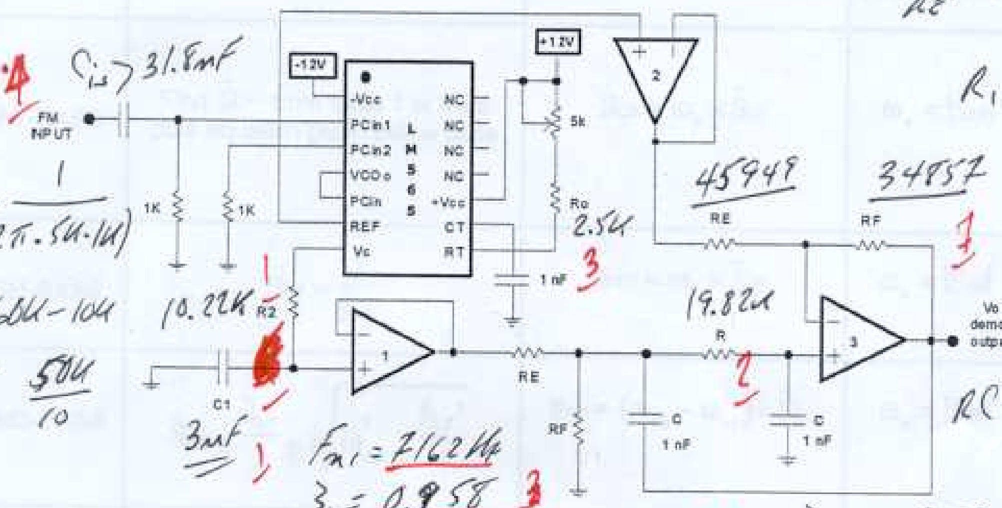
No.2 (50 pts) $F_{cen} \approx 0.3 / ((R_o + P_o)C_o)$ $K_d \approx 0.68 \frac{V}{rad}$ $K_o = \frac{\Delta\omega_{in}}{\Delta V_{C(Thev)}} \approx \frac{49.4 F_{cen}}{\Delta V_{CC}}$ = 123.5K

$R_1 = 3.6K$ $\tau_1 + \tau_2 = \frac{K_O K_d}{\omega_n^2}$ $\tau_2 = \frac{2\zeta}{\omega_n} - \frac{1}{K_O K_d}$ = 30.67 μs τ_1 = 10.8 μs

41.47 μs

6

Sallen-Key stage: $A_o = \frac{R_F}{R_E}$ $\omega_n = \frac{1}{RC}$ if $R = R_E \| R_F$ $\zeta = 1 - \frac{R_F}{2R_E}$ ⇒ $\frac{R_F}{R_E} = 2(1-\zeta) = 0.7586$



4 $C_{in} > 31.8$ nF

$C_{in} > \frac{1}{2\pi \cdot 5K \cdot 1K}$

F_{min} = 60K − 10K

$F_{Cin} < \frac{50K}{10}$

10.22K R2 1

3 nF 1

R_1 = 3.6K → C_1 = 3 nF

R_2 = 10.22K

45949 RE 34857 RF 7

2.5K Ro 3

19.82K R 2

F_{n1} = 7162 Hz

ζ_1 = 0.958 3

(18)

RC = 19.82 μs = $\frac{1}{\omega_{n2}}$

ζ_2 = 0.620696

F_{n2} = 8829.7 Hz 3

A(10) Design the above PLL to meet the following specs: 6

FM input: F_{car} = 60 kHz ΔF = 0 to 10 kHz F_{mod} = 0 to 2,5 kHz

PLL demodulator response: 4 th order low-pass Bessel with 5 kHz bandwidth.

Normalised poles: 1,43241 /±163.332° 1,60594 /±128.367°

45000 $\angle \pm \Phi_1$ 50452 $\angle \pm \Phi_2$

$\frac{1}{19.92K} + \frac{1}{0.7586 R_E} = \frac{1}{19.82K}$

R_E = 45949

B(10) Calculate the demodulated signal amplitude and explain the function of the Sallen-Key stage.

$\Delta V_C = 2\pi \cdot 10K / 123.5K = 0.5088$ Vp $\Delta V_{demod} = 0.386$ Vp 6

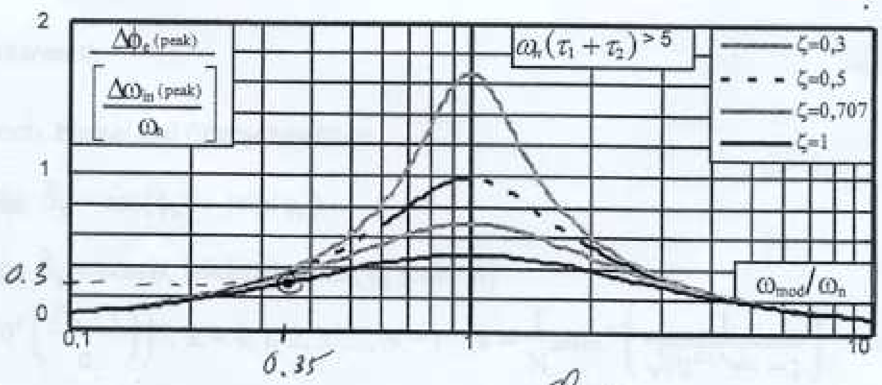
C(10) Determine the phase error signal when ΔF of carrier is maximum and F_{mod} is 2,5 kHz

Sketch signal showing max, min and average value of phase error.

4 Eliminate DC component. Attenuate HF ripple

Normalised phase error for FM sinusoidal modulation

$\omega_n(\tau_1 + \tau_2) = 1.866$



Use the following expression $\omega_n(\tau_1 + \tau_2) = K_O K_d / \omega_n$ to find out if the graph shown beside applies.

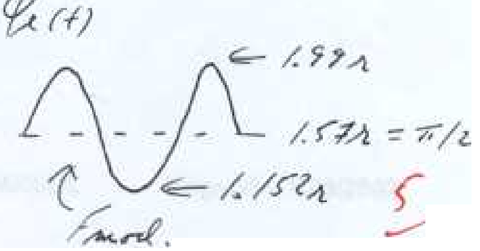
Graph does not apply but let's assume it does 1

(10)

$\frac{F_m}{F_{n1}} = \frac{0 \to 2.5K}{7162} =$

$\frac{F_m}{F_{n1}} = 0 \to 0.35$ 2

$\Delta\phi_e(\phi) = 0.3 \times 10K / 7162 = 0.419$ r 2



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