ANSWERS

3B1 Radio Frequency Electronics 2005

1 (a) Miller effect multiplies effective capacitance from input:output by factor of (1+G) for an inverting amplifier. This combined with a finite source impedance gives rise to a longer input circuit CR time constant and lower roll-off frequency.

(b) Can use single transistor stage: eg. R1=270 Ω, R2 = 100 Ω, R3 = 39 Ω, R4 = 100 Ω, coupling C's = 1 nF (~ 1 Ω @ 600 MHz), Gain = 8 dB (x 2.5)

(c) Input cct. dominates roll-off, C'=4.3 pF, R' = 37 Ω, f_{-3dB} = 1.0 GHz

(d) eg. Use a pair of 25 Ω resistors from output to drive each 75 Ω line (both lines then matched to 75 Ω, but net loss of -6 dB) – or can match 100 Ω output impedance to 50 Ω using LC cct. and then split via two 25 Ω resistors (matching is not quite perfect, but net loss drops to -1 dB)

2 (a) Loop gain =1, phase shift around loop = 360n degrees (n = 0,1...)

(b) Describe NIC and how a pair are connected with R's and C to give effective $L = CR^2$ (standard from notes)

(c) Use op-amp. circuit to provide gain for LC oscillator – with FET as variable resistance to control op-amp. gain (similar to examples question). The L needs to be large, so use synthesised version from part (b). Alternatively, can use Colpitts cct. but distortion would be greater – synthesised L here too.

(d) Use PLL: divide 10 MHz down to 100 Hz ($\div 10^5$), divide oscillator down to 100 Hz ($\div 15$) and feed into XOR gate. Low pass filter and feed to a varactor across L to tune frequency.

3 (a) Standard description of PLL from notes.

(b) Use the VCO given with an XOR gate as a mixer and a low-pass (long time constant) RC filter. In the steady state, the input to the VCO will be 198/80 = 2.475 V. When the carrier changes phase by ± 22.5 ° and with 5 V/180 ° from the XOR, the dc component of the XOR will swing by ± 0.63 V. This can be separately smoothed with a faster RC filter and fed into a comparator / state machine to give 0 and 1 outputs.

4 (a) $\lambda = 5000$ m, $P = 1.72 \times 10^{-7}$ W/m^2, $H = 3.0 \times 10^{-5}$ A/m (E = 11 mV/m)

(b) $G = -76$ dB $\equiv 2.5 \times 10^{-8}$, $G = 4\pi A_e/\lambda^2$ therefore $A_e = 0.05$ m^2, $v = 1.5$ mV$_{rms}$

(c) $R_r = 3.26 \times 10^{-5}$ Ω (assuming ideal dipole), $\delta = \sqrt{(2/\omega\mu\sigma)} = 0.36$ mm hence assume full cross-section of wire conducts, $R_o = 0.61$ Ω, Efficiency = 0.005 %

(d) Q = 98.4, B/W = 610 Hz, C = 15 nF, $R_{parallel} \equiv 17.4$ kΩ

PART IIA 2005

3B1 Radio frequency electronics

Principal Assessor: **Dr P A Robertson**