ADDITIONAL CONTROLLER OF EXAMINATIONS
AU
CHENNAI
600 025

Roll No.

ANNA UNIVERSITY (UNIVERSITY DEPARTMENTS)

B.E. / B. Tech / B. Arch (Full Time) - END SEMESTER EXAMINATIONS, NOV/DEC 2023

ELECTRONICS AND COMMUNICATION ENGINEERING
V Semester

EC5006 RF MICROELECTRONICS

(Regulation 2019)

Time: 3hrs Max.Marks: 100

CO 1	Translate the top level wireless communications system specifications into block level specifications of the RF transceiver.
CO 2	Carry out transistor level design of the entire RF transceiver.
CO 3	Design and analyze CMOS LNAs , mixers, oscillators, PLL's, synthesizers and power amplifiers.

BL – Bloom's Taxonomy Levels

(L1 - Remembering, L2 - Understanding, L3 - Applying, L4 - Analysing, L5 - Evaluating, L6 - Creating)

PART- A (10 x 2 = 20 Marks)

(Answer all Questions)

Q. No	Questions	Marks	CO	BL
1	In Fit.1, a direct conversion receiver incorporates a voltage gain of 30dB from the LNA input to each mixer output and another gain of 40dB in the baseband stages following the mixer. If the LO leakage at the LNA input is -60dBm, find the offset voltage (DC) at the output of the mixer and at the output of the baseband chain. Assume 50ohm impedance at each stage.	2	CO1	L5
2	For Fig.2, compute the total noise at the output terminals for the given noisy network.	2	CO1	L1
3	List all the differences between a single balanced mixer and a double balanced Gilbert cell mixer.	2	CO2	L2
4	Explain briefly the principle of operation of the mixer shown in Fig.3	2	CO2	L4
5	Sketch the approximate spectrum of an ideal oscillator and that of an oscillator that exhibits phase noise	2	CO3	L2
6	Explain why a single common source stage shown in Fig.4 does not oscillate if it is placed in a unity gain loop?	2	CO3	L4
7	The quantity -174dBm/Hz represents the noise floor of a typical receiver. Suppose a GSM has a signal bandwidth of 200Khz and needs an input SNR of 10dB, what is the minimum input signal (specify in dBm) for which the receiver will operate correctly.	2	CO1	L5
8	Derive any one expression for the Q of a series RLC ciruit.	2	CO2	L2
9	Explain briefly any two differences between an integer N frequency synthesizer and fractional N synthesizer.	2	CO3	L2
10	Explain the difference between the 'Type' and 'order' of a PLL.	2	CO2	L2

PART- B (5 x 13 = 65 Marks)

(Restrict to a maximum of 2 subdivisions)

Q. No	Questions	Marks	CO	BL
11 (a) (i)	For the given Dual IF receiver sketch in Fig.5a the signal spectrum at various points B,C,D,E,F,G and H. The input signal spectrum at point A is given in Fig.5b .	10	CO1	L2
(ii)	Suppose the desired signal spectrum shown in Fig.6 is accompanied by an interferer in the adjacent channel. Plot the spectrum at the second IF if $\omega_{LO2}= \omega_{IF1}$.	3		
	OR			
11 (b) (i)	Draw the block diagrams of a typical heterodyne receiver and a homodyne	4+4	CO1	L2

	receiver. Explain one main advantage and one main disadvantage of each. In your block diagrams, normally which individual block is expected to have the best Noise Figure and which one block is expected to have the best IIP3.	+2		
(ii)	An Engineer is to design a receiver for space applications with no concern for interferers. The engineer constructs the heterodyne front end as shown in the block diagram given in Fig.7, avoiding band select and image select filters. Explain with the help of spectrum why this design suffers from a relatively high noise figure.	3		
12 (a) (i)	Consider the resistor terminated amplifier diagram shown in Fig.8. Here, 'A' represents the voltage gain of the amplifier, and Vn represents the equivalent input noise of the amplifier. Vin represents the input signal source. Assume that the internal amplifier block shown as triangle has infinite input impedance. Compute the total meansquare noise voltage at the output. In order determine the NF of the system, compute the meansquare noise voltage at the output assuming only the Rs1 associated in Vin contributes noise (source contribution alone at the output). Based on these, write down the expression for the Noise Figure.	10	CO2	L3
(ii)	The circuit shown in Fig.9a is a fully differential version of the resistively terminated and its symmetric half equivalent ciruit is also shown in Fig.9b. Using the steps outlined part (i) above, etermine the expression for the overall Noise Figure of the fully differential system.	3		
	OR			
12 (b) (i)	Assuming the input output relationship of an amplifier is given by $v_o(t) = c_0+c_1v_i(t)+c_2(v_i(t))^2+c_3(v_i(t))^3$, determine the expressions for IIP3 and input P1dB of this system.	10	CO2	L3
(ii)	An amplifier has a small signal gain of 12dB and OIP3 of 13dBm. What is the IM3 at an input of -10dBm.	3		
13 (a)	Derive the frequency of oscillations for the Colpitts oscillator shown in Fig.10 and indicate the assumptions/approximations you need to make use of. Also sketch the expected drain current waveforms of M1 and give the possible expression for the possible amplitude of Vout.	8+5	CO2	L2
	OR			
13 (b) (i)	Draw the circuit diagram of a Gilbert cell mixer and determine the expression for its conversion gain.	7	CO2	L2
(ii)	Indicate all the sources of Noise in the above Gilbert cell. Explain which transistors of the Gilbert cell contribute to the nonlinearity of mixer and which ones contribute 1/f noise at the output.	6		
14 (a) (i)	Explain why a charge pump used along with the phase detector? Justify this with its phase response and transfer function.	7		L4
(ii)	Explain how an analog multiplier can be used as a phase detector. Sketch its transfer characteristic and give the expression for its K_{PD}.	6	CO3	
	OR			
14 (b)	The block diagram in Fig.11 represents the phase transformations from the input to the output of a certain synthesizer. Write down the expression for the phase transfer function and explain why this block diagram and associated synthesizer would not be of use unless it is modified. With justification, suggest any suitable modification to this block diagram to make the synthesizer work . Assuming the input reference frequency for such a PLL is f_{ref}, what is the minimum frequency step size one can get for the output of the synthesizer.	5+6 +2	CO3	L4
15 (a)	Consider the amplifier shown in Fig.12 for which the input to the gate terminals of M1 and M2 are as shown. Vth represents the threshold	13	CO2	L3

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<table>
<tr><td></td><td>voltage of the M1 and M2. With justification, state what class of power amplifier this circuit represents. Sketch the possible drain current waveforms of M1 and M2 and also waveform of the current through RL. Explain atleast two functions/tasks carried out by the transformer.</td><td></td><td></td><td></td></tr>
<tr><td colspan="5">OR</td></tr>
<tr><td>15 (b)</td><td>Draw the circuit diagrams of a differential LC oscillator and a ring oscillator. Explain the conditions necessary for establishing oscillations in each of these and give the expression for the frequency of oscillations.</td><td>3+3
+3+
4</td><td>CO2</td><td>L3</td></tr>
</table>

PART- C (1 x 15 = 15 Marks)

(Q.No.16 is compulsory)

<table>
<tr><th>Q. No</th><th>Questions</th><th>Marks</th><th>CO</th><th>BL</th></tr>
<tr><td>16. (i)</td><td>Consider two amplifiers A and B with the noise characteristics given below.
<table>
<tr><th></th><th>(I_n) (fA/√Hz)</th><th>(V_n) (nV//√Hz)</th></tr>
<tr><td>Amp A</td><td>50</td><td>10</td></tr>
<tr><td>Amp B</td><td>25</td><td>20</td></tr>
</table>
What is the optimum source resistance for each case. If the source resistance of 100K ohms, which amplifier is better.What is the minimum noise figure in each case.</td><td>2+2+2</td><td>CO3</td><td>L5</td></tr>
<tr><td>16 .(ii)</td><td>It is desired to downconvert the spectrum shown in Fig.13 using the different ideal LO frequencies. The figure shows the LO spectrum for $w_{LO} < w_1$. (i) Sketch the downconverted spectrum for this case $w_{LO} < w_1$, (ii) for the case when $w_1 < w_{LO} < w_1$ and also (iii) for the case when $w_2 < w_{LO}$.</td><td>4</td><td></td><td></td></tr>
<tr><td>16. (iii)</td><td>A load impedance of RL = 50 ohms is to be matched to a source impedance of Rs =5ohms. The centre frequency is 1GHz. Design a suitable impedance matching network.</td><td>5</td><td></td><td></td></tr>
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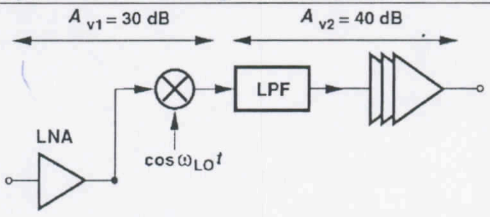

Fig.1

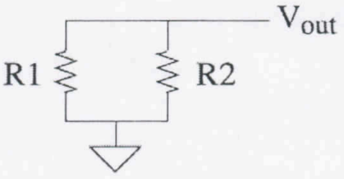

Fig.2

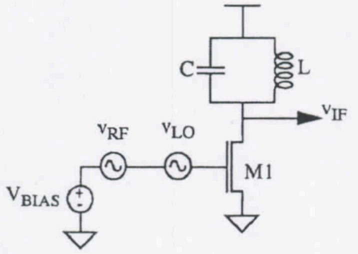

Fig.3

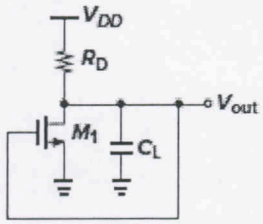

Fig.4

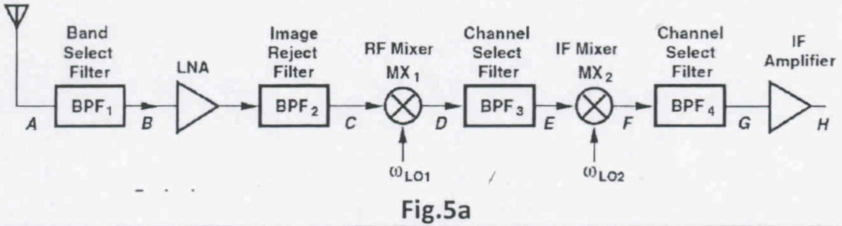

Fig.5a

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AU CHENNAI 600 025

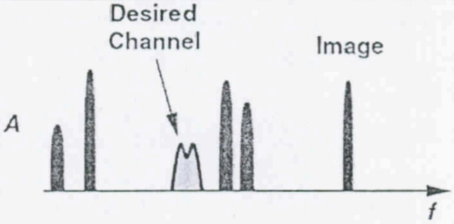

Fig.5b

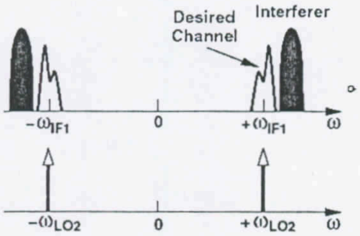

Fig6

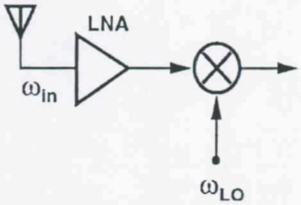

Fig.7

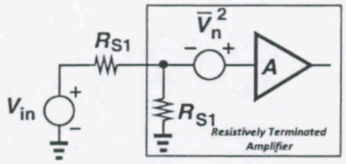

Fig.8

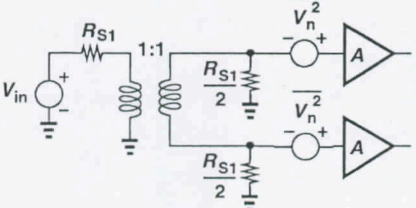

Fig.9a

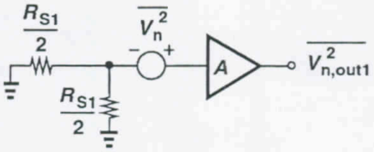

Fig.9b

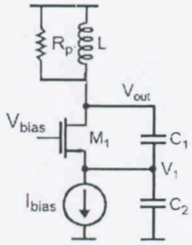

Fig.10

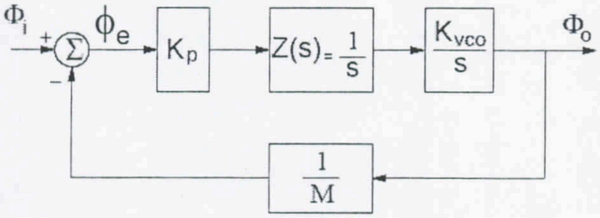

Fig.11

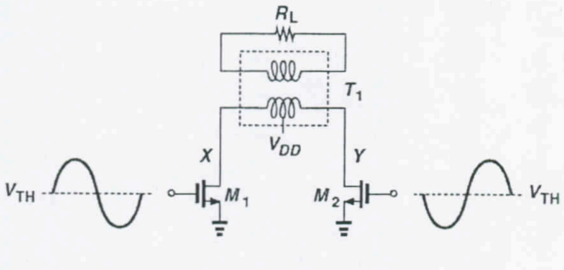

Fig.12

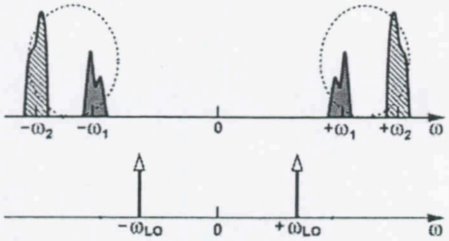

Fig.13

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