CRL712- RF and Microwave Active Circuits

Major Examination (Time: 3hr) 09-05-2021 Maximum Marks-65
Solve all questions.

Q1. Two GaAs MESFET amplifiers with S-parameters listed below are used in a balanced amplifier configuration:

(a) Draw schematic of the balanced amplifier using branch line couplers.
(b) Calculate the reflection coefficients and VSWRs at the input and output ports of the balanced amplifier.
(c) Calculate overall power gain of the amplifier in dB.

(4,4,2 marks)

A			B		
Parameter	Mag.	Angle	Parameter	Mag.	Angle
S_{11}	0.75	40°	S_{11}	0.82	30°
S_{12}	0.15	-30°	S_{12}	0.17	-32°
S_{21}	7	180°	S_{21}	7.5	170°
S_{22}	0.6	20°	S_{22}	0.75	40°

Q2. A GaAs FET has the following scattering and noise parameters at 8 GHz $\mathbf{S}_{11} = 0.68\angle -110^0, \mathbf{S}_{21} = 3.4\angle 60^0, \mathbf{S}_{12} = 0.00, \mathbf{S}_{22} = 0.82\angle -70^0$ (Z_0= 50 ohms): F_{min}=2.5 dB, $\Gamma_{opt}=0.70\angle 120^0$, R_N= 15 ohms. Calculate source and load reflection coefficients for obtaining noise figure=3 dB with maximum associated gain. Assume Z_0=50 ohms.

$$N = \frac{F - F_{min}}{4R_N / Z_0}\left|1 + \Gamma_{opt}\right|^2 \qquad C_F = \frac{\Gamma_{opt}}{N+1} \qquad R_F = \frac{\sqrt{N\left(N+1-\left|\Gamma_{opt}\right|^2\right)}}{N+1}$$

$$g_s = \frac{G_S}{G_{S\max}} \qquad C_S = \frac{g_S S_{11}^*}{1-(1-g_S)\left|S_{11}\right|^2} \text{ (Centre)} \qquad R_S = \frac{\sqrt{1-g_S}\left(1-\left|S_{11}\right|^2\right)}{1-(1-g_S)\left|S_{11}\right|^2} \text{ (Radius)}$$

(7,8 marks)

Q3. The scattering parameters of an FET device at 10 GHz for different bias conditions are given below:

$I_{ds}/I_{dss}\,\% = 20;$ $\quad S_{11} = 0.53\angle -60^0, S_{12} = 0, S_{21} = 4.3\angle 28^0, S_{22} = 0.75\angle -150^0$

$I_{ds}/I_{dss}\,\% = 50;$ $\quad S_{11} = 0.54\angle -50^0, S_{12} = 0, S_{21} = 4.8\angle 29^0, S_{22} = 0.78\angle -155^0$

$I_{ds}/I_{dss}\,\% = 100;$ $\quad S_{11} = 0.50\angle -45^0, S_{12} = 0, S_{21} = 5.0\angle 30^0, S_{22} = 0.8\angle -160^0$

We want to design an amplifier using this FET device to achieve maximum gain. The source and load impedances are both 50Ω.

(a) Determine if the maximum gain amplifier designed using the FET device will be stable.
(b) What is maximum gain obtained from the device in dB?
(c) Determine source match (Γ_s) and load match (Γ_ℓ) required for achieving maximum gain.
(d) Determine maximum gain contribution in dB from the input matching and output matching networks.
(e) What is the maximum gain possible using the above FET in dB?
(f) Design the input matching network using a piece of 50-ohm transmission line and a quarter wave transformer.
(g) Design the output matching network using a piece of 50-ohm transmission line and short circuit 50-ohm stub.

(Marks 2,2,3,3,2,4,4)

Q4. Show how resistive loading can stabilize a device whose S-parameters at f =750 MHz:

$$S_{11} = 0.69\angle 78^0, S_{12} = 0.033\angle 41.4^0, S_{21} = 5.67\angle 123^0, S_{22} = 0.84\angle 25^0$$

$$K = \frac{1+|S_{11}S_{22} - S_{12}S_{21}|^2 - |S_{11}|^2 - |S_{22}|^2}{2|S_{12}S_{21}|}; \Delta = S_{11}S_{22} - S_{21}S_{12}$$

$$C_L = \frac{(S_{22} - \Delta S_{11}^*)^*}{|S_{22}|^2 - |\Delta|^2} \text{ (Centre)}; R_L = \left|\frac{S_{12}S_{21}}{|S_{22}|^2 - |\Delta|^2}\right| \text{ (Radius)}$$

$$C_S = \frac{(S_{11} - \Delta S_{22}^*)^*}{|S_{11}|^2 - |\Delta|^2} \text{ (Centre)}; R_S = \left|\frac{S_{12}S_{21}}{|S_{11}|^2 - |\Delta|^2}\right| \text{ (Radius)}$$

Consider only two schemes of series resistive loading at the input and shunt resistive loading at the output of the device. Use Smith chart.

(Marks 5,5)

Q5. Two satellite receiver systems (a) and (b) have the following specifications for their components:

RF Amplifier:	F=5dB, G=10dB
Mixer:	L_c=5dB
IF Amplifier:	F=2dB, G=15dB
Band Pass Filter:	IL=2dB

Compare the two systems in terms of the overall gain and noise figure values.

(Marks 5,5)