**UNIT-II**

**RF AMPLIFIER DESIGN & MATCHING NETWORKS**

**Session - I**

Introduction:

* RF transistor



Presentation & discussion:

* RF amplifier - performance characteristics are

 Stability

 Gain

 Input and output impedance matching

 Reflection coefficient and standing wave ratio

* Equivalent circuit

Presentation & analysis:

* Single stage amplifier with frequency response



Conclusion & Summary: quiz

* What is RF? Radio frequency in Gigahertz
* Name some application of RF. Power amplifiers, radars, satellites
* What is need for RF circuit? High power analysis
* What is the need for RF amplifier? High power amplifications
* Why do we go for double stage circuit? More and controlled amplifications
* Drawbacks of RF circuit. Stability and gain
* What are performance characteristics of RF amplifier? Gain, stability, input & output imp

How gain & stability are important in RF circuit?

 In a two-port network, oscillations are possible ifthe magnitude of either the input or outputreflection coefficient is greater than unity, whichis equivalent to presenting a negative resistance atthe port. This instability is characterized by|Γin| > 1 or |Γout| > 1which for a unilateral device implies |S11| > 1 or|S22| > 1.

**Session – II**

Brainstorming:

* Power introduction



Derivation & analysis:

* Amplifier power relation





Derivation &anaylsis:

* Two port power gain



Transducer Power Gain 



Conclusion & summary: list by key words

* Transducer gain
* Power gain
* Available power gain
* Unilateral power gain
* Operating power gain

**Session – III**

Brainstorming:

* Stability :Stability circles determine what load or sourceimpedances should be avoided for stable or nonoscillatoryamplifier behavior Because reactive loads are being added to amp the conditions for oscillation must be determinedSo the Output Stability Circle determine the ΓL orload impedance (looking into matching networkfrom output of amp) that may cause oscillation Input Stability Circle determine the ΓS orimpedance (looking into matching network frominput of amp) that may cause oscillation

Presentation & derivation:

* Stability consideration & stability circle

 Unconditional Stability when amplifierremains stable throughout the entire domain

 of the Smith Chart at the operating bias and frequency. Applies to input and outputports

 |*Cin*| – *rin*| >1 and |*Cout*| – *rout* | >1with |*S11*| < 1 or |*S22*| < 1





Presentation & derivation:

* Test for unconditional stability

Stabilization methods can be used to foroperation of BJT or FET found to beunstable at operating bias and frequencyOne method is to add series or shuntconductance to the input or output of theactive device in the RF signal path to“move” the source or load impedances outof the unstable regions as defined by theStability Circles



Conclusion & summary: recall by key words

* Stability factor, Condition for stability at input port, Condition for stability at output port
* Equation of circle with radius &centre
* Circle diagram
* Stabilization methods

**Session – IV**

Recap:

* Questionnaires and discussion on gain factor

Presentation & derivation:

* Gain consideration – constant gain





Presentation & derivation:

* Specified gain

 Max gain imax =1/(1-|*Sii*|2) when i = *Sii\** ;gain circle center is at *dgi= Sii\** and radius *rgi*=0 Constant gain circles have centers on a lineconnecting origin to *Sii\**

 For special case i = 0, *gi*= 1-|*Sii*|2 and*dgi*= *rgi*= |*Sii*|/(1+|*Sii*|2) implying i = 1 (0

 dB) circle always passes through origin ofi plane

Conclusion & summary: recall by key words

* GSMAX
* GLMAX
* GTU, GS, G0, GL
* Condition for no feedback loop
* Bilateral design
* Unilateral figure of merit
* Matched source reflection coefficient
* Matched load reflection coefficient

**Session –V**

Introduction:

* Noise Figure – its importance

Having done a stability check and having met the gain requirementsof an amplifier, we shall consider the noise as our next milestone inactive circuit design considerations. In an RF/microwave amplifier, theexistence of the noise signal plays an important role in the overall design,procedure, and its impact needs to be grasped before a meaningful

design process can be developed.Noise power results from random processes that exist in nature.Those random process can be classified in several important classes,each generating a certain type of noise

Presentation & derivation:

* Noise Figure for two port network

 *F* = *Psi/PNi*

 *Pso/PNo*

 = *(SNR)i*

 *(SNR)o*

* *F* = *F*min+ *rn/gs*|*Ys*−*Y*opt|2

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Conclusion & summary: recall by key words

* Signal to noise ratio
* Expression for noise figure
* Optimum reflection coefficient
* Optimum source admittance
* Fmin

**Session –VI**

Brainstorming & discussion:

* T-Matching networks
* Need for matching networks

To achieve maximum power transfer, we need to match the impedanceof the load to that of the source. Usually this is accomplished by incorporatingadditional passive networks connected in between source andload. These networks are generally referred to as matching networks.

Presentation & derivation:

* T-matching network design using ZY Smith Chart
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Conclusion & summary: recall by key words

* Forbidden region
* Nodal Quality factor Qn
* ZY Smith Chart
* Movement of Shunt L,C & Series L,C

**Session –VII**

Brainstorming & discussion:

* Pi-matching network – need for it

Presentation& derivation:

* Pi-matching network design using ZY Smith Chart
* As already pointed out the loaded quality factor of the matching network can be estimated from the maximum nodal *Qn*. The addition of the third element into the matching network produces an additional node in the circuit and allows as controlling the value of *QL* by choosing appropriate impedance at that node.
* Example problem
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Conclusion & summary: recall by key words:

* Normalized input & load impedance
* Admittance circle
* Impedance circle
* SWR circle

**Session –VIII**

Brainstorming & introduction:

* Single & double matching networks

Presentation& analysis:

* Single stub matching network using ZY Smith chart

This is one of the step for the transition from the lumped to distributedelement networks in the complete elimination of all lumped components.This is accomplished by employing open/short circuit in stublines.In this a series transmission line is connected to a parallel opencircuit(or) short-circuit stub. It has two topologies.First one involves a series transmission line connected to a parallelcombination of load and stub. Second one involves a parallel stub connected to the series combinationof load and transmission line

The matching networks in Figure 2.21 posses four adjustable parameters,length*ls*, and characteristic impedance *Zos*of the stub and thelength*lL*and characteristic impedance *ZOL* of the transmission line.

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Presentation& analysis:

* Double stub matching network using ZY Smith chart

The single stub matching networks are quite versatile and allow matchingbetween any input and load impedances, so long as they have anon-zero real part.One of the main drawbacks of such matching networks is that theyrequire a variable-length transmission to between stub and input part(or) between the stub and load impedance. And this drawback can beavoided by double stub matching networks.In this double stub matching networks, two short (or) open circuitstubs are connected in parallel with a fixed length transmission lineplaced in between. The length *l*2 of this line is usually chosen to be oneeightthree-eight and five eights of wavelengths. The 3*/*8th and 5*/*8th

* are mostly used in the high frequency applications.
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Conclusion & summary: list by key words

* Stubs, Open circuited stub, Short circuited stub
* Length of stub, Location of stub

**Session – IX**

Questionnaires & discussion:

* Microstrip line

With increasingfrequency and correspondingly reduced wavelength, the influence of

parasitics in the elements becomes more noticeable as it providescomplications in the component value computations.As the discrete components are available only for certain values,limits their use in high frequency circuit applications. As on alternativeto lumped elements, discrete components are widely used as thewavelength becomes sufficiently small compared with the characteristiccircuit component length.



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Presentation :

* Quality factor Q of microstrip line matching networks In the mid GHz range, design engineers often employ a mixed approach by combining lumped and distributed elements. These types of matching networks usually contain a number of transmission lines connected in series and capacitors spaced in a parallel configuration as illustrated in

Inductors are usually avoided in such designs because they tend tohave higher resistive looses than capacitors. In general only one shuntcapacitor with two transmission lines are connected in series on bothsides as sufficient to transform any given load impedance to any inputimpedance.The arrangement of components in Figure 2.20 is very attractive inpractice. Since it permits tuning the circuit after it has been manufacturedchanging the values of the capacitors as well as placing them atdifferent locations along transmission lines offers wide range of flexibility.The tuning capability makes these types of matching networks avery popular for prototyping.

Conclusion & summary: recall by key words

* Lumped distributed components
* Discrete elements
* Parasitics
* Shunt open circuited/ short circuited stubs