Aalto University
School of Electrical Engineering
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S-26.3120 Radio Engineering, laboratory course

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Transistor amplifier matching circuit design

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How to design a transistor amplifier matching network

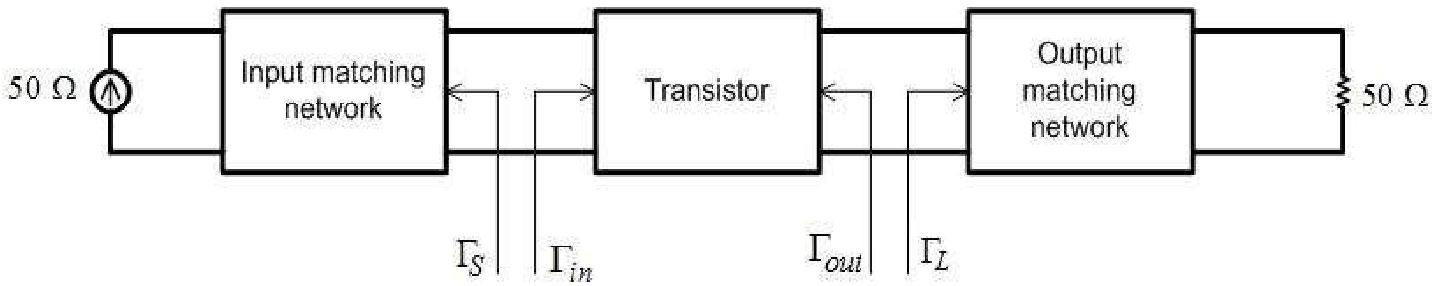

Fig. 1: Transistor amplifier matching network

First of all it is worth noting that in the Smith chart the terms "Toward generator" and "Toward load" are not related to the illustrated input source or 50-Ω load.

We now go through the amplifier matching circuit design in two different cases, i.e. to obtain

1. maximum transducer power gain
2. a certain transducer power gain below that in 1., or a certain noise figure

To obtain maximum transducer power gain the input and output of the transistor amplifier are matched conjugately to the other circuitry (to 50 Ohms). First we consider the input matching; the output is then done in the same manner. Matching can be made in two ways, either matching to Γ_{in}, or matching to Γ_s , it is mainly a matter of taste.

Matching to Γ_{in}

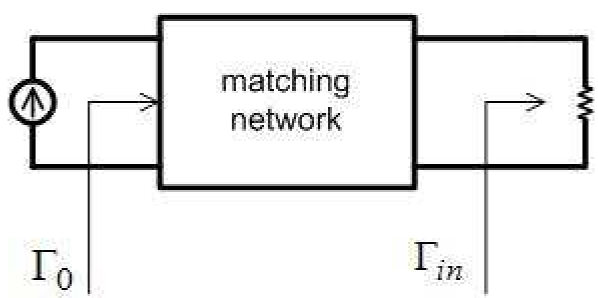

Fig. 2: Matching to the input impedance of the transistor

In Fig. 2 the generator and load now refer to the notations/transitions in the Smith chart, i.e. to the direction of the two reflection-coefficient arrows in Fig. 2. So, they have nothing to do with a real generator and load. We begin the matching process by drawing $\Gamma_{in} = \Gamma_S^*$ in the Smith chart.

Let's assume that $\Gamma_{in} = 0.3 - j0.8$ (see point ① in Fig. 3). Now we move "Toward generator" in such a way that we reach the mirror image of the unity circle (this is useful for the following jump to the admittance plane), i.e. to the point ② (0.18 - *i*0.38). This transition ①→② is now length l_1. Now we mirror this point ② on the mirrored unity circle to the admittance plane, i.e. to the real unity circle which is point ③ $(1.0 - j2.15)$. To achieve matching we have to add to this point a stub parallel to the transmission line, to eliminate the imaginary part of point ③. So, we want to connect the parallel admittance *i*2.15 This is achieved by a shorted stub with a length l_2 that can be read from the transition ④. Similarly, we could use an open stub, but then we would start the shift from 0-admittance, which would result in a quarter-of-a-wavelength longer stub.

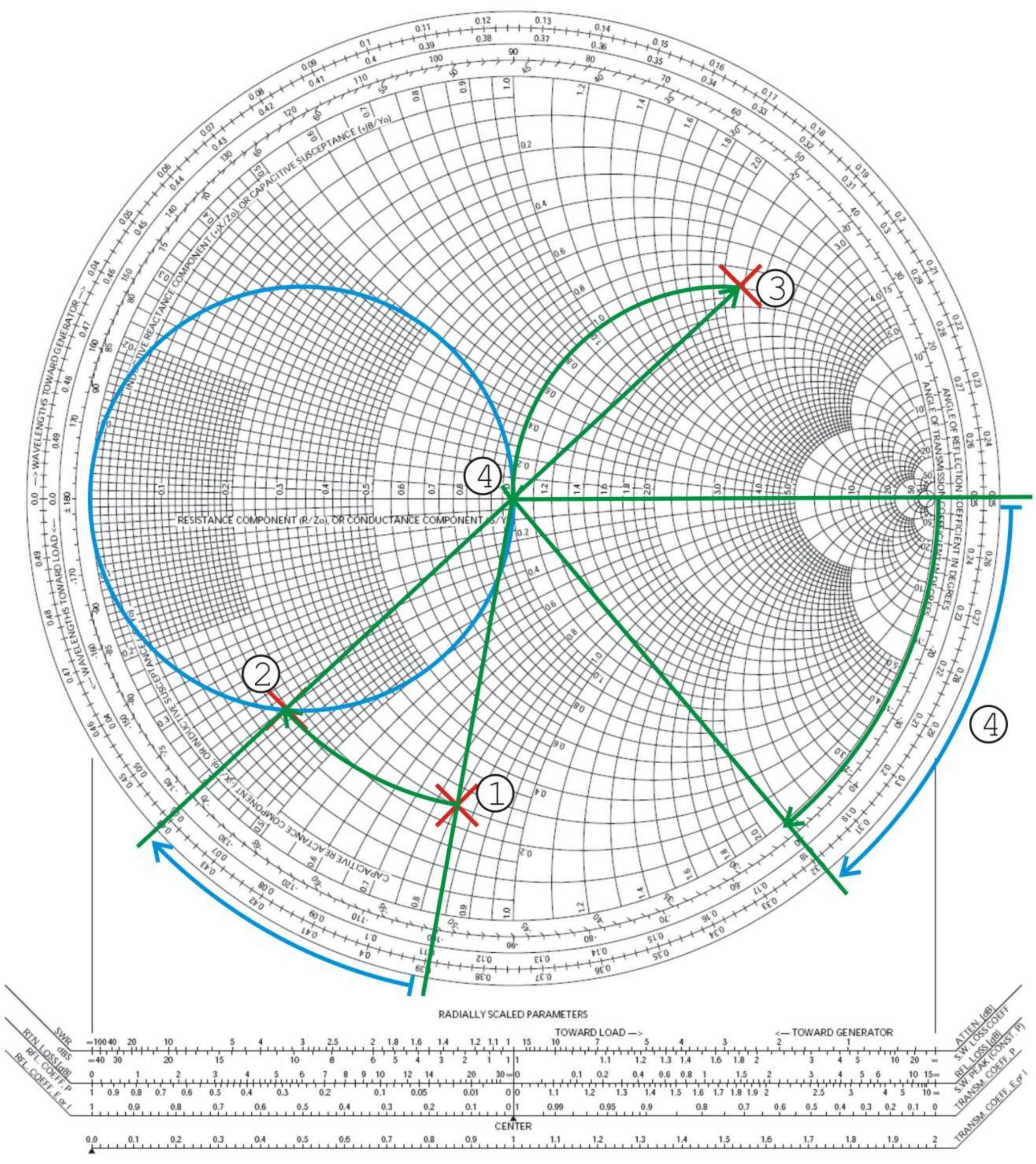

Fig. 3: Matching to the input impedance of the transistor

Matching to Γ_s

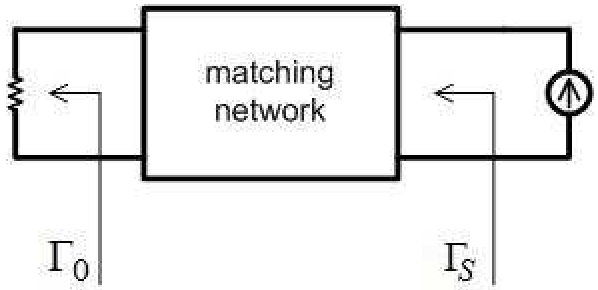

Fig. 4: Matching to the circuit impedance seen by the matching network

The generator and load in Fig.4 are now the other way around than the actual generator and load, indicating the direction of the reflection-coefficient arrows. We begin the matching process by drawing Γ_S in the Smith chart. Let's assume that $\Gamma_S = 0.45 - j1.1$ (point ④ in Fig. 5). Then we plot the circle going through this point on the Smith chart. Now we begin from the left side of Fig. 4, i.e. from the matched point ① $(1.0 + j0.0)$, the center of the Smith chart. Initially we are in the admittance plane. We move "Toward generator" in such a way that we reach the unity circle in point ② $(1.0 + j2.0)$, through which the previously drawn Γ_S circle passes. The transition ①→② is now the imaginary part, which is to be realized with a parallel stub whose admittance is -j2.0. The length of this stub l_2 is measured from the Smith chart the same way as in the previous section. Point ② two is now mirrored from the unity circle to the impedance plane, to point ③ $(0.21 - j0.42)$ on the mirror unity circle. All we still need is the stub length l_1 of transition ③→④ to Γ_S, and the matching circuit is complete.

When we want to obtain a given transducer power gain or a certain noise figure we would produce a suitable mismatch at the input or output of the amplifier. Conjugate matching is done only either at the input or the output, with either of the above methods. The second port, which will be mismatched, can now only be matched with help of Γ_L or Γ_S. So, of the above presented methods only the latter is suitable, since $\Gamma_L \neq \Gamma_{Out}^*$ or $\Gamma_{in} \neq \Gamma_S^*$. Now, Γ_L or Γ_S only have to be calculated and selected from the constant gain circles or constant noise-figure circles. There are other ways to use the Smith chart in matching circuit design, and also other realizations than matching stubs are allowed. This manual is intended to provide one possible design of a matching circuit for a transistor amplifier.

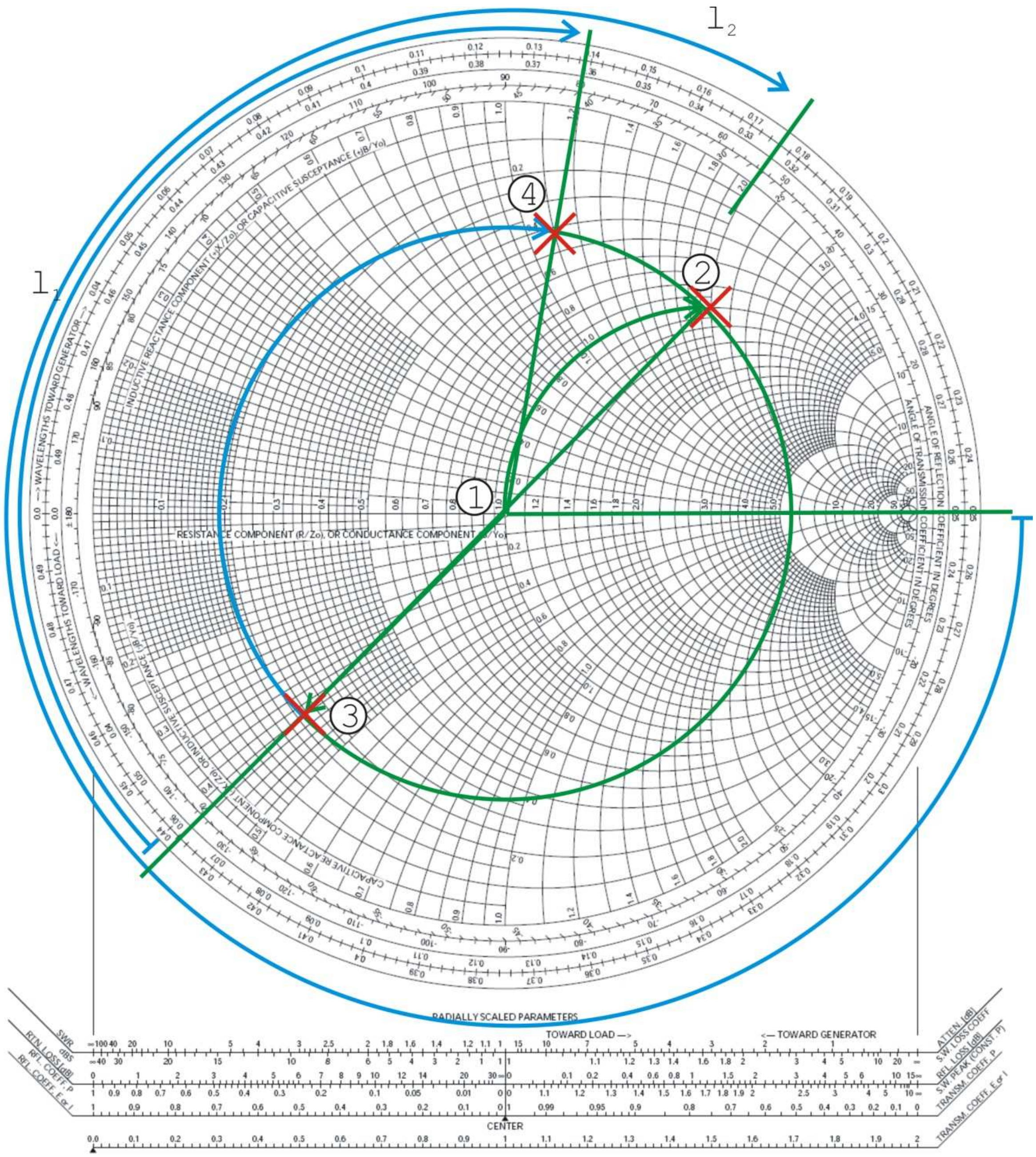

Fig. 5: Matching to the circuit impedance seen by the matching network