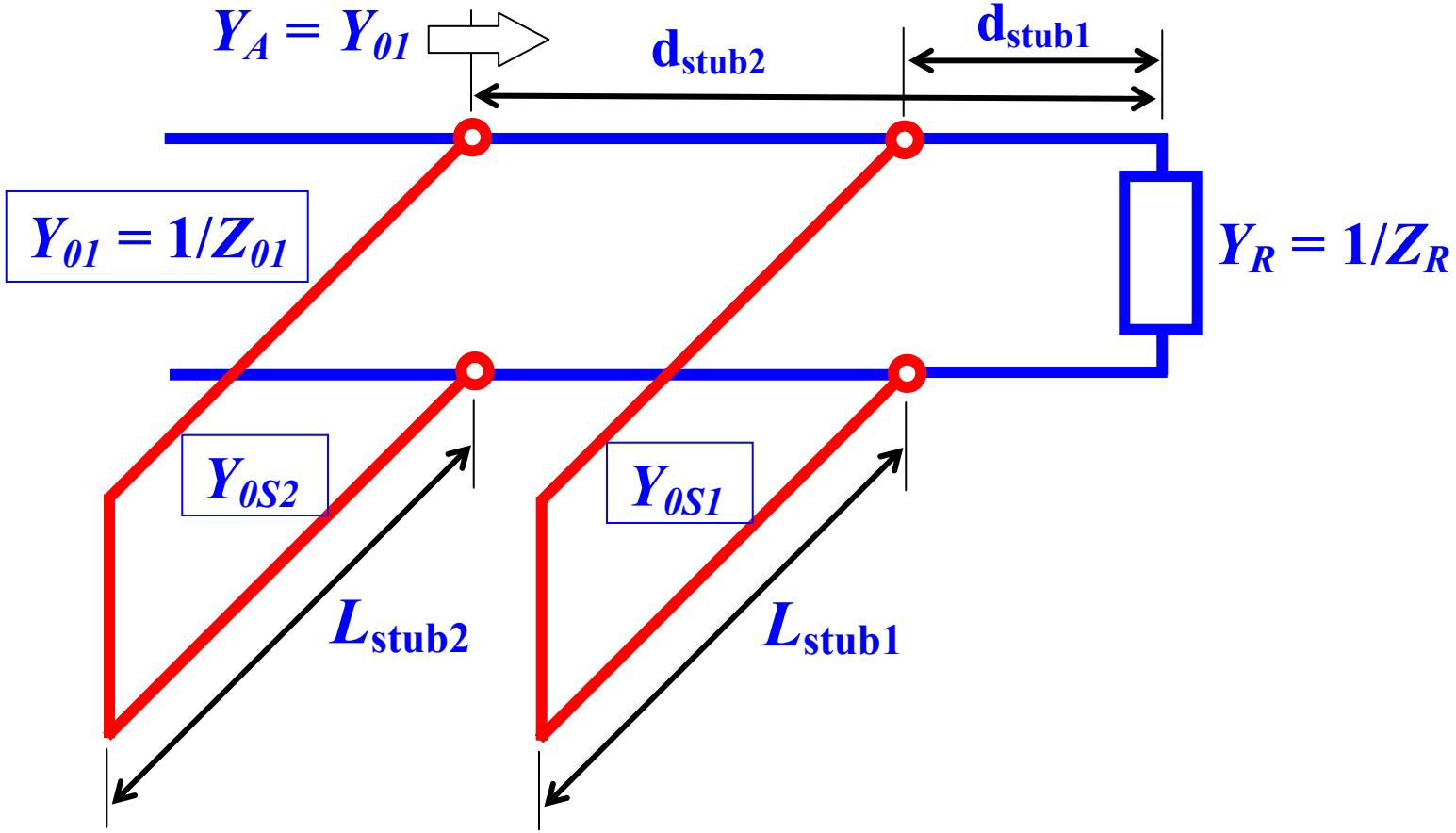
❑ Double stub impedance matching

Impedance matching can be achieved by inserting two stubs at specified locations along transmission line as shown below



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There are two design parameters for double stub matching:

- **The length of the first stub line L_{stub1}**
- **The length of the second stub line L_{stub2}**

In the double stub configuration, the stubs are inserted at pre-determined locations. In this way, if the load impedance is changed, one simply has to replace the stubs with another set of different length.

The drawback of double stub tuning is that a certain range of load admittances cannot be matched once the stub locations are fixed.

Three stubs are necessary to guarantee that match is always possible.

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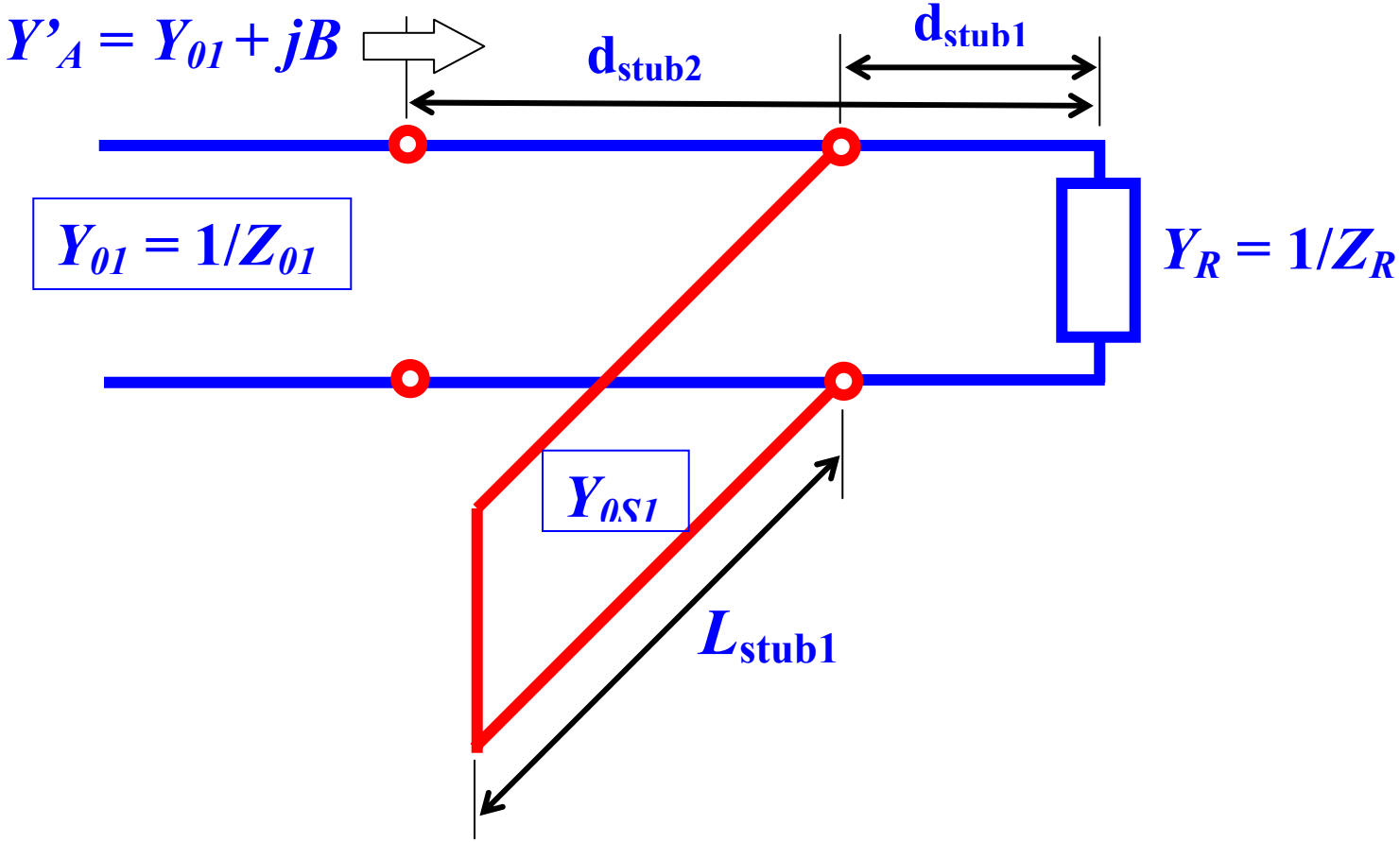
The length of the first stub is selected so that the admittance at the location of the second stub (before the second stub is inserted) has real part equal to the characteristic admittance of the line



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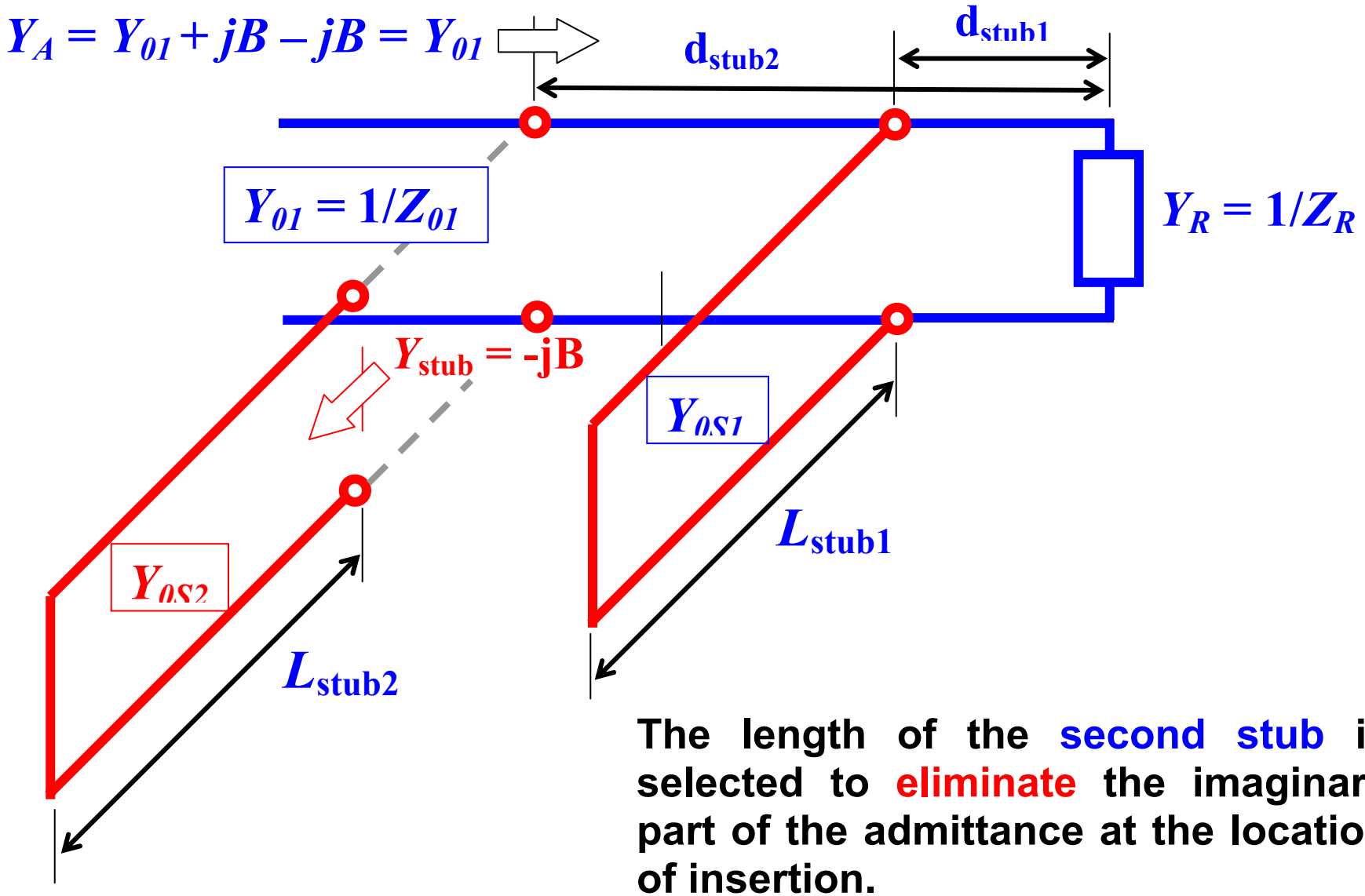

The length of the second stub is selected to eliminate the imaginary part of the admittance at the location of insertion.

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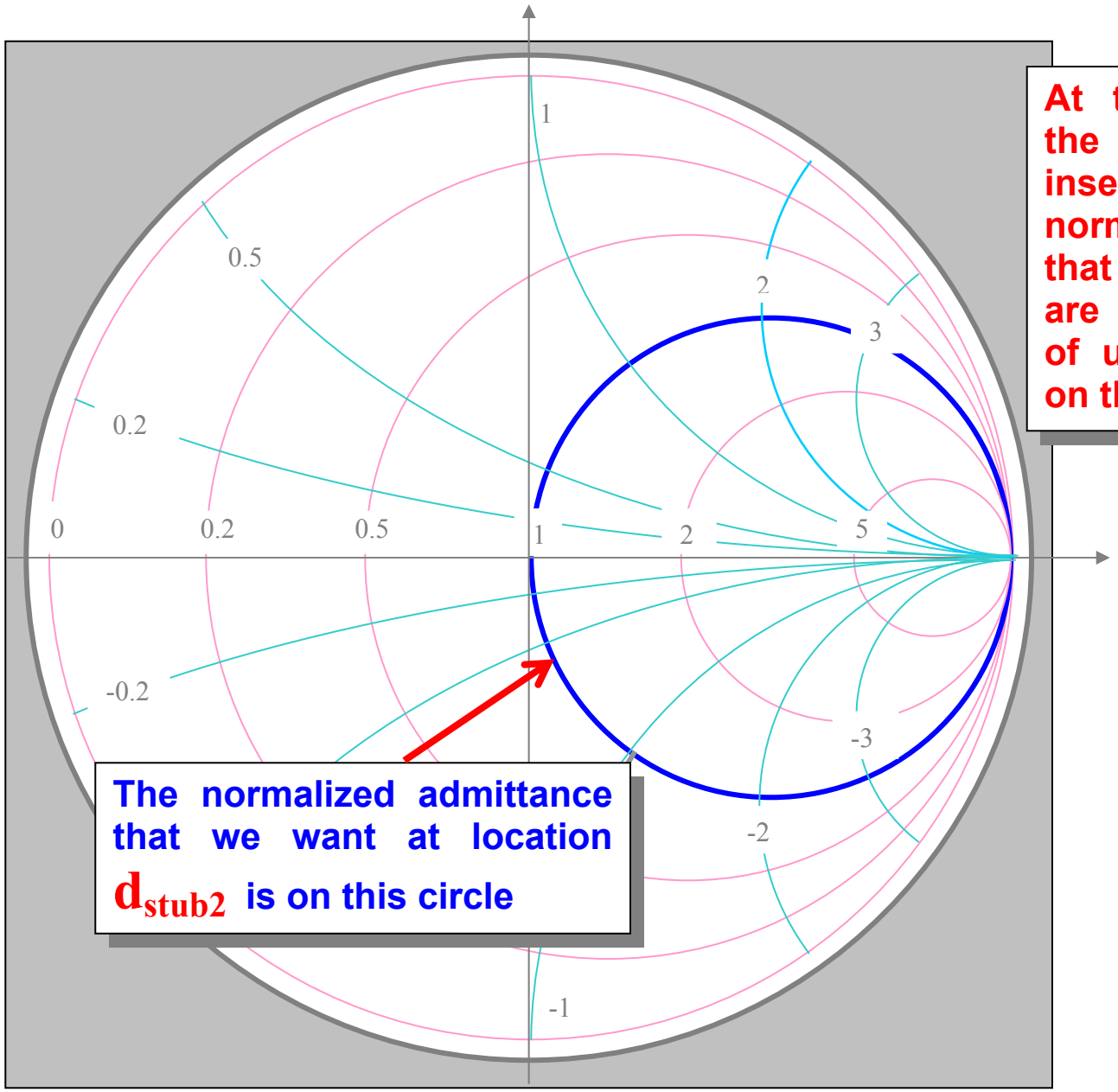

At the location where the second stub is inserted, the possible normalized admittances that can give matching are found on the circle of unitary conductance on the Smith chart.

The normalized admittance that we want at location d_{stub2} is on this circle

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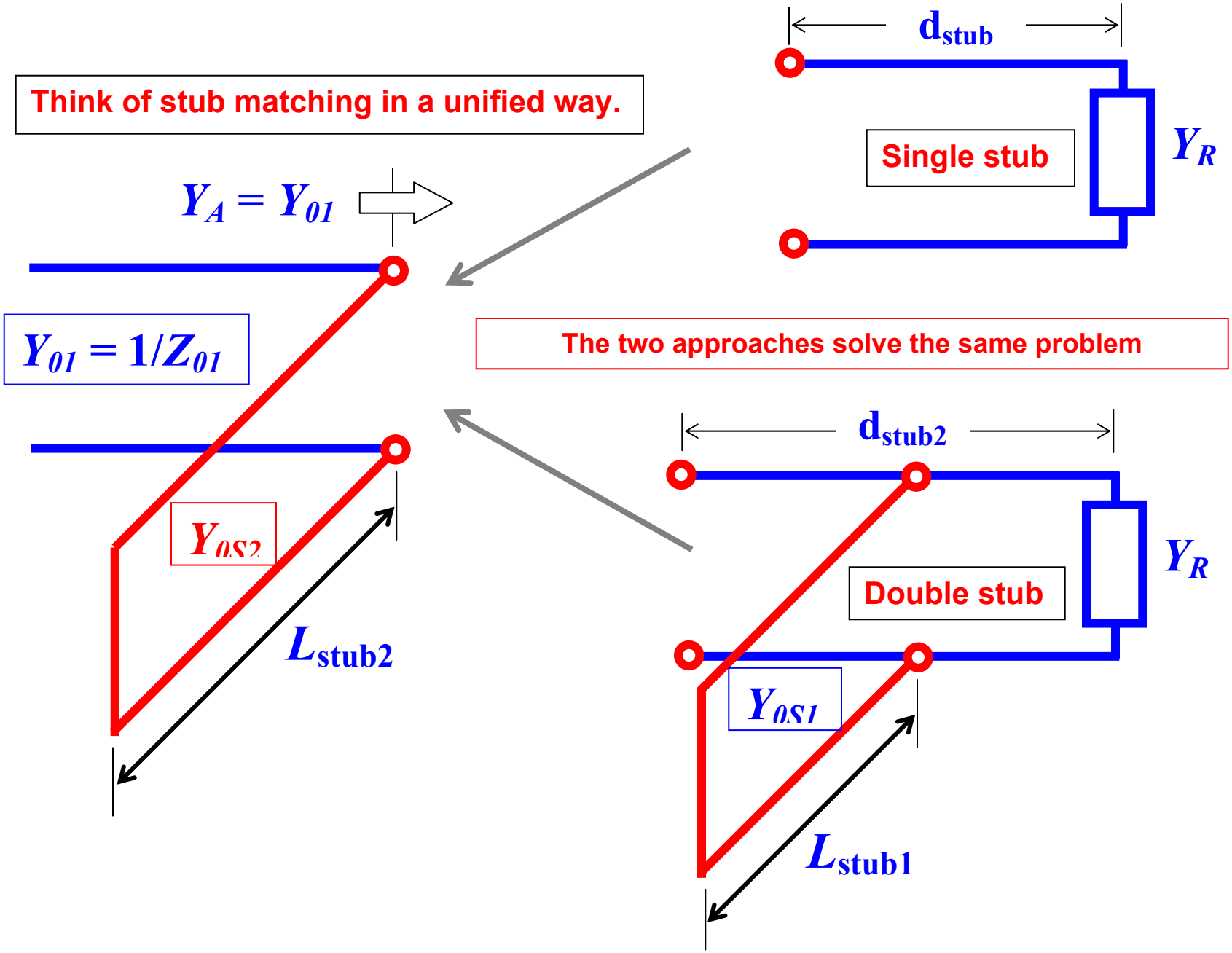

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If one moves from the location of the second stub back to the load, the circle of the allowed normalized admittances is mapped into another circle, obtained by pivoting the original circle about the center of the chart.

At the location of the first stub, the allowed normalized admittances are found on an auxiliary circle which is obtained by rotating the unitary conductance circle counterclockwise, by an angle

$$\theta_{aux} = \frac{4\pi}{\lambda}\left(d_{stub2} - d_{stub1}\right) = \frac{4\pi}{\lambda} d_{21}$$

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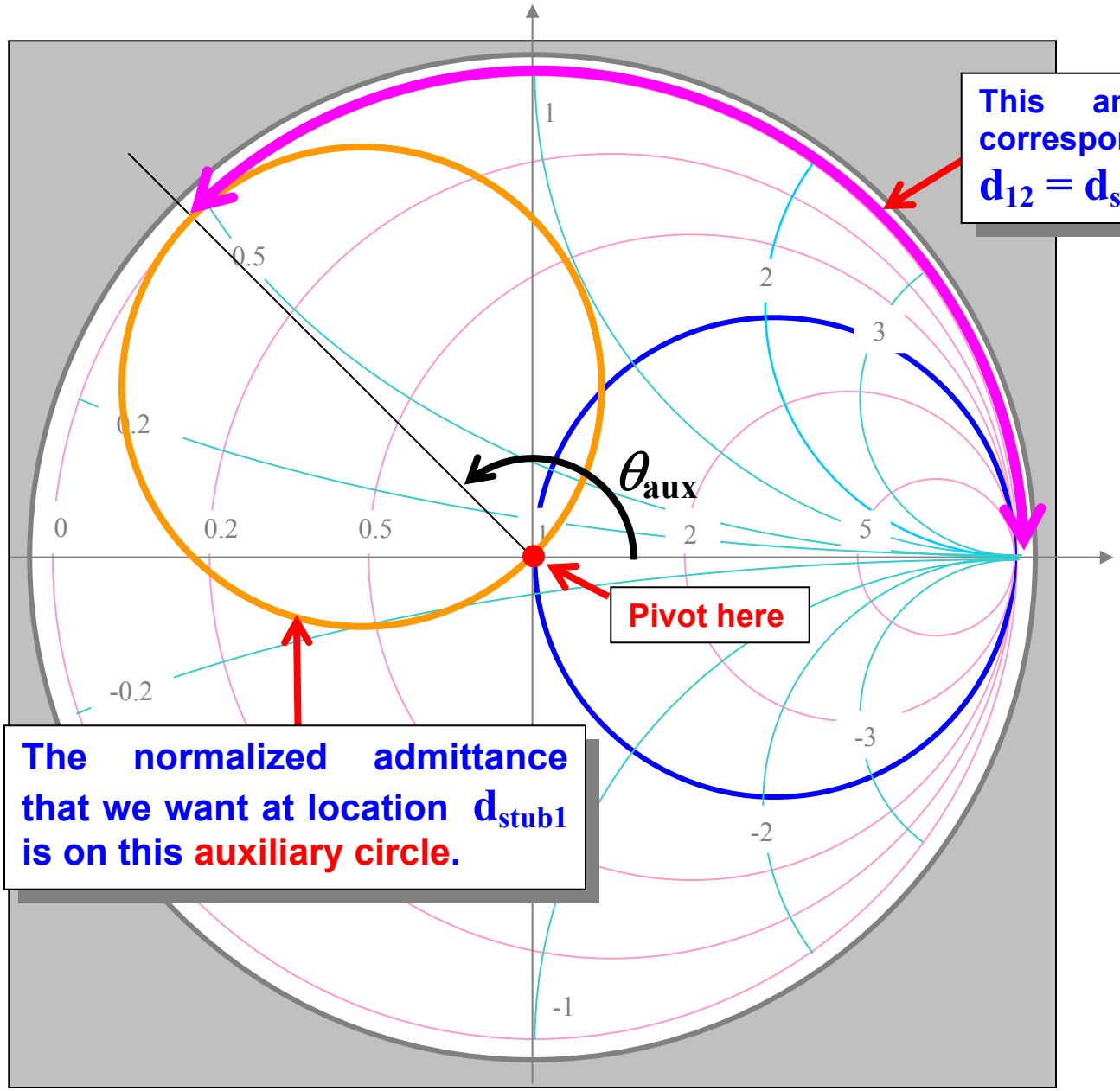

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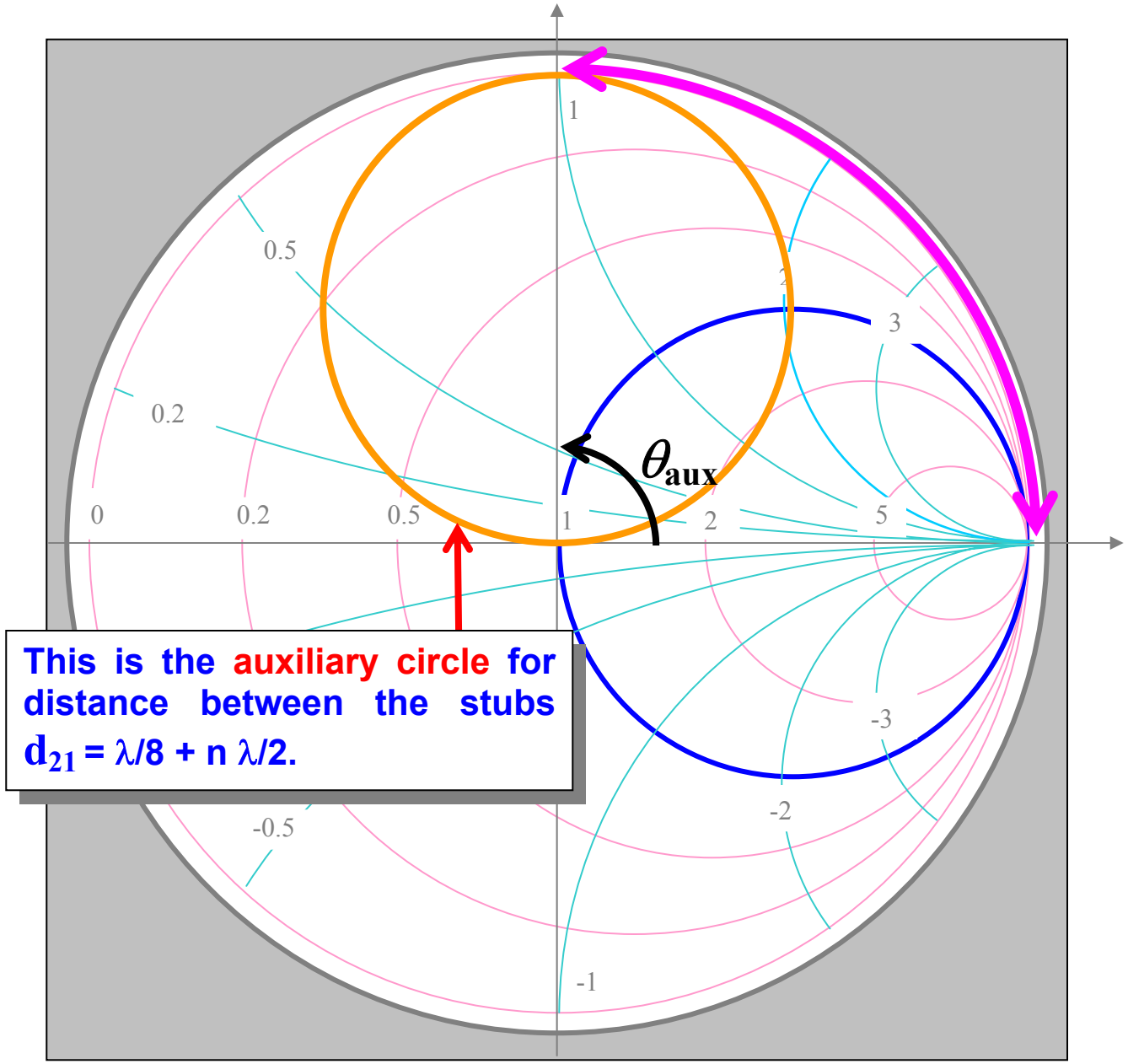

This is the auxiliary circle for distance between the stubs $d_{21} = \lambda/8 + n\,\lambda/2$.

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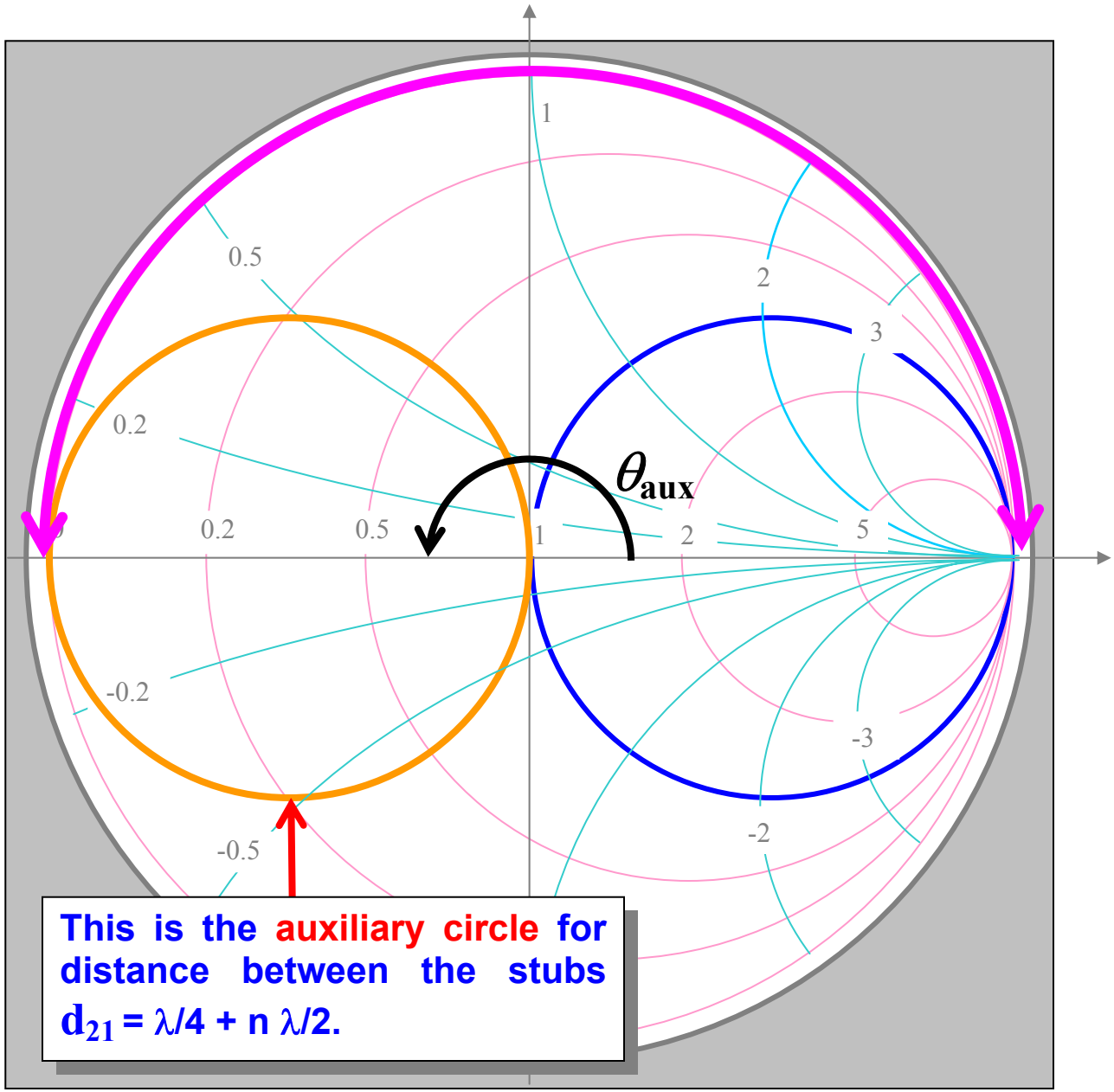

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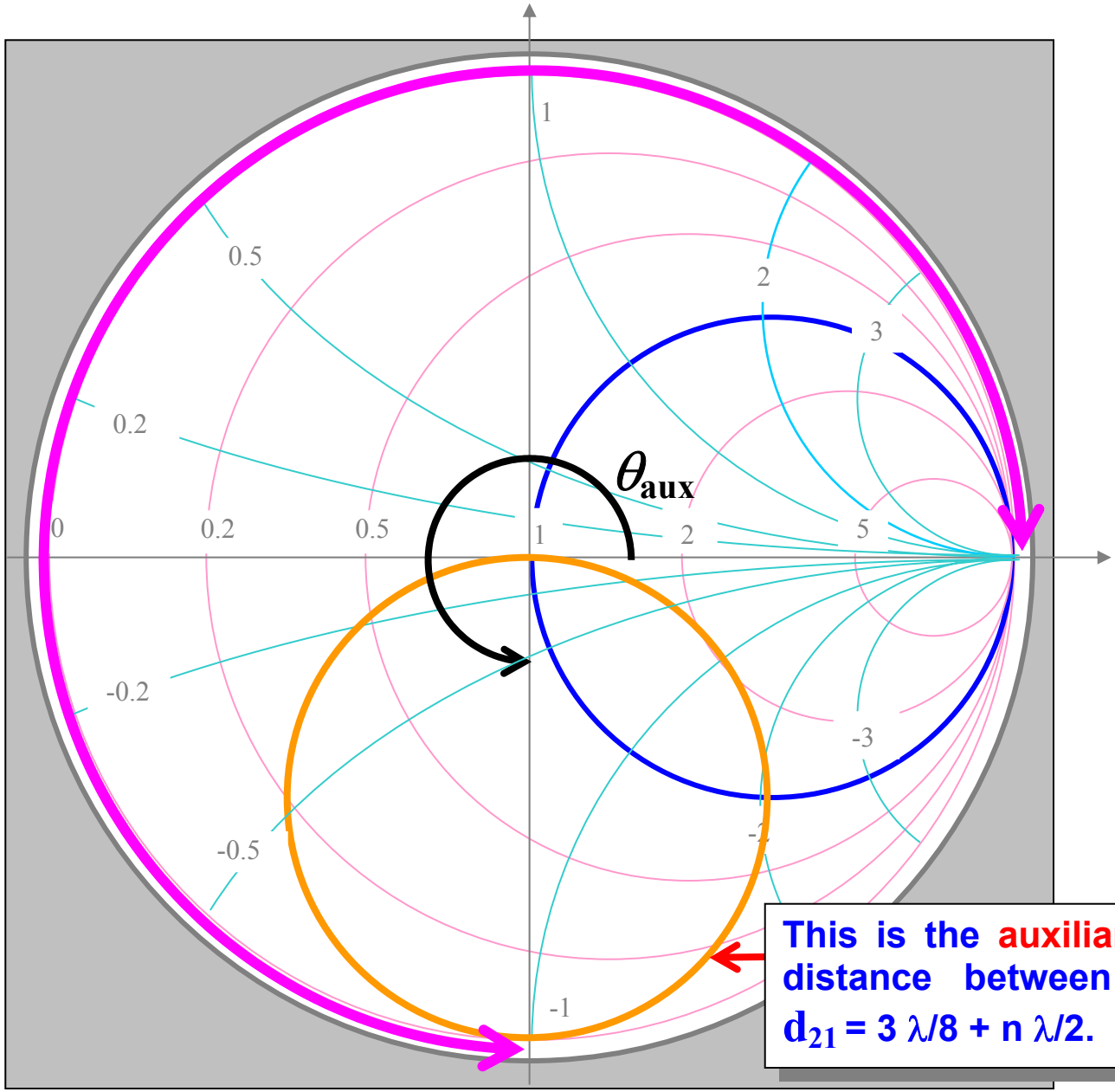

This is the auxiliary circle for distance between the stubs $d_{21} = 3\,\lambda/8 + n\,\lambda/2$.

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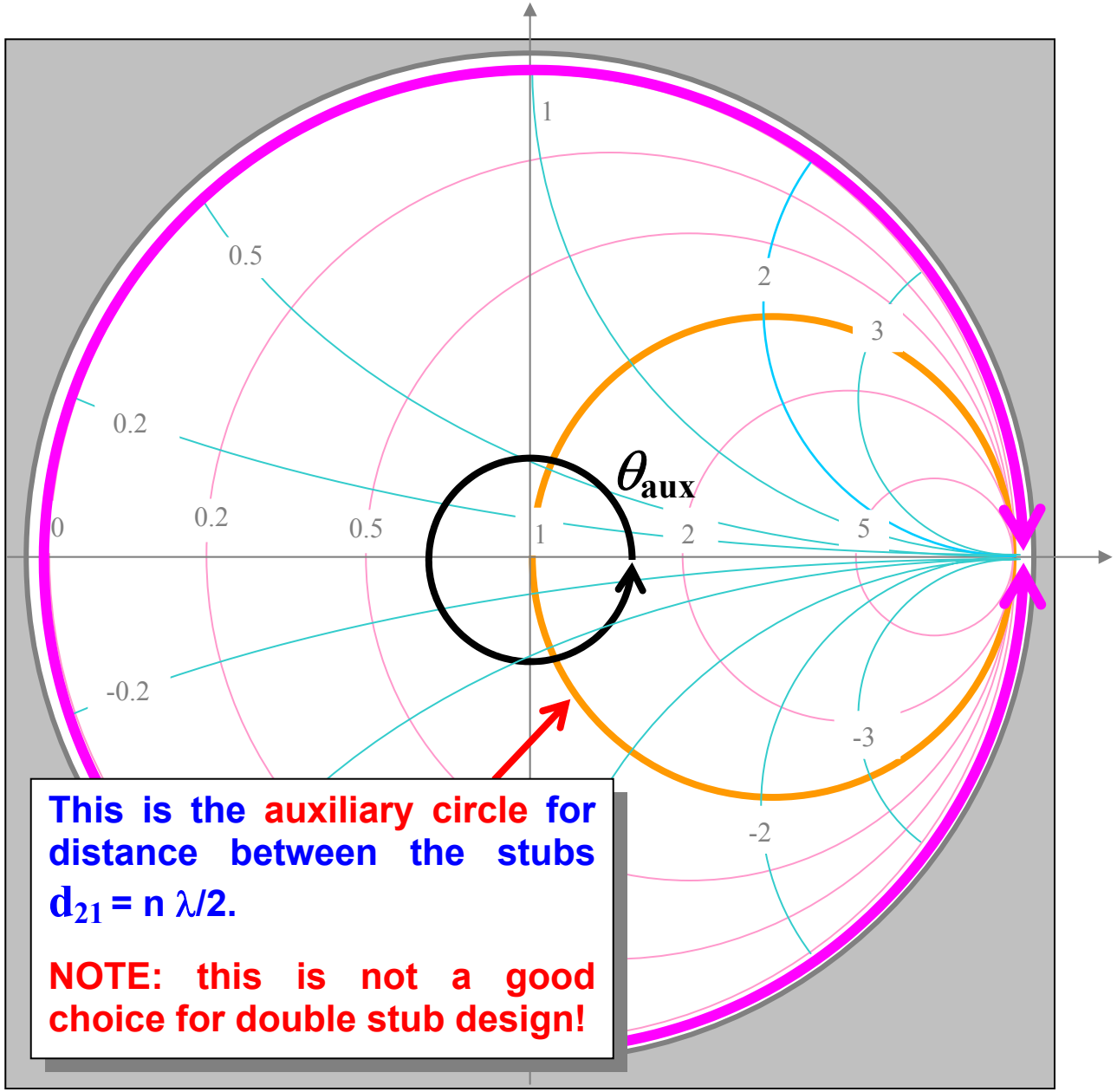
1
0.5
2
3
0.2
θ_{aux}
0
0.2
0.5
1
2
5
-0.2
-3
-2
This is the auxiliary circle for distance between the stubs $d_{21} = n \lambda/2$.
NOTE: this is not a good choice for double stub design!

Given the load impedance, we need to follow these steps to complete the double stub design:

(a) Find the normalized load impedance and determine the corresponding location on the chart.

(b) Draw the circle of constant magnitude of the reflection coefficient $|\Gamma|$ for the given load.

(c) Determine the normalized load admittance on the chart. This is obtained by rotating -180° on the constant $|\Gamma|$ circle, from the load impedance point. From now on, all values read on the chart are normalized admittances.

(d) Find the normalized admittance at location d_{stub1} by moving clockwise on the constant $|\Gamma|$ circle.

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(e) Draw the auxiliary circle

(f) Add the first stub admittance so that the normalized admittance point on the Smith chart reaches the auxiliary circle (two possible solutions). The admittance point will move on the corresponding conductance circle, since the stub does not alter the real part of the admittance

(g) Map the normalized admittance obtained on the auxiliary circle to the location of the second stub d_{stub2}. The point must be on the unitary conductance circle

(h) Add the second stub admittance so that the total parallel admittance equals the characteristic admittance of the line to achieve exact matching condition

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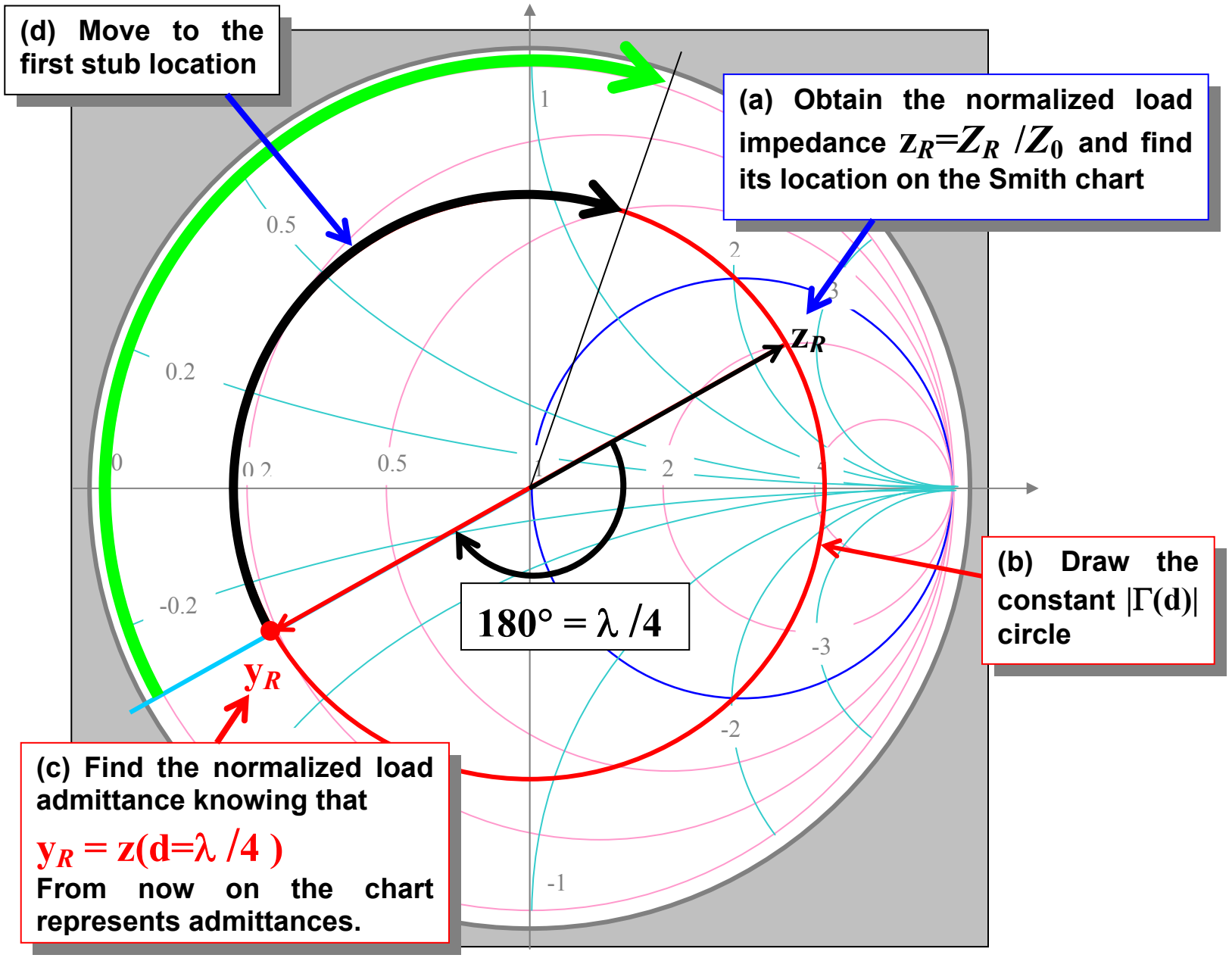

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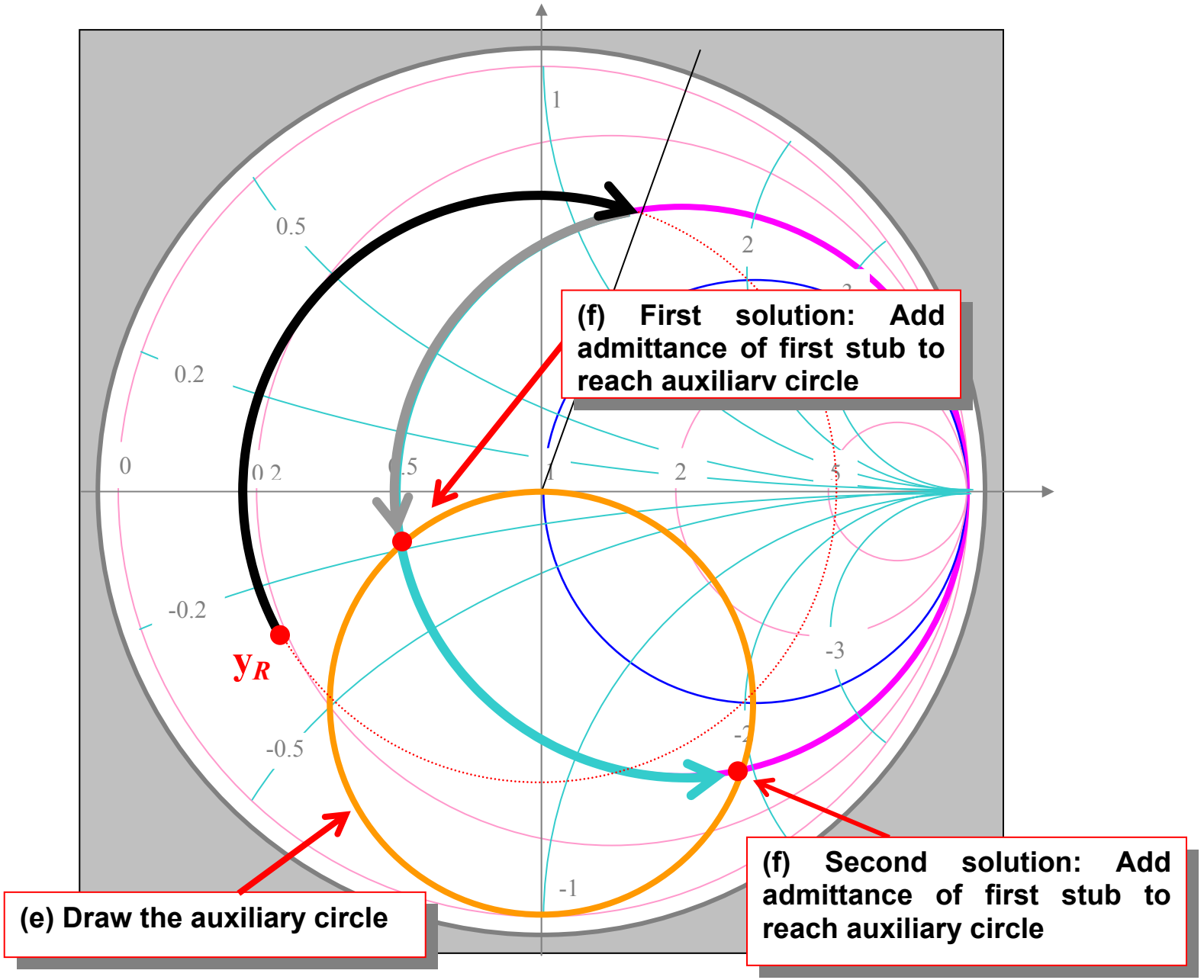

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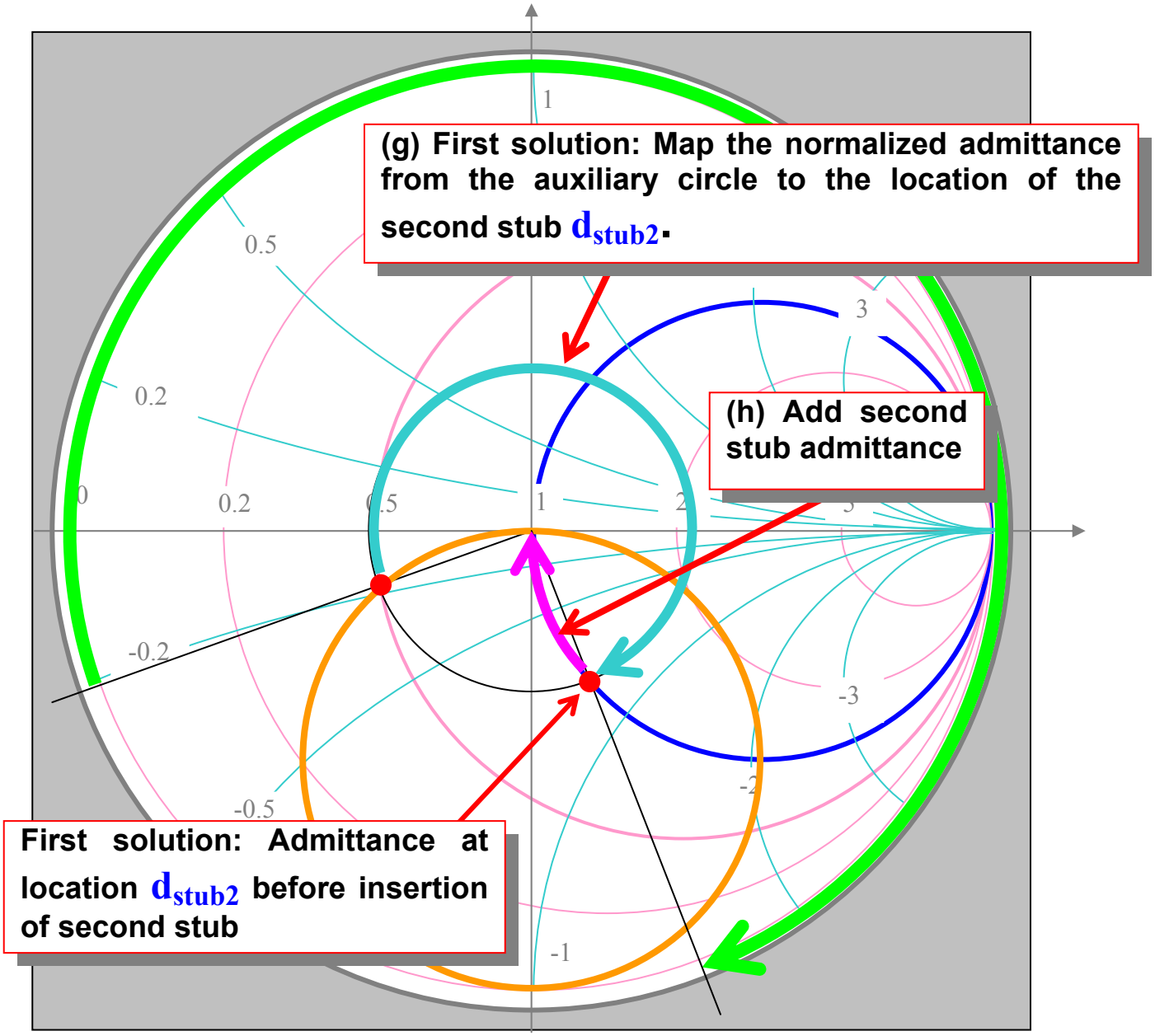
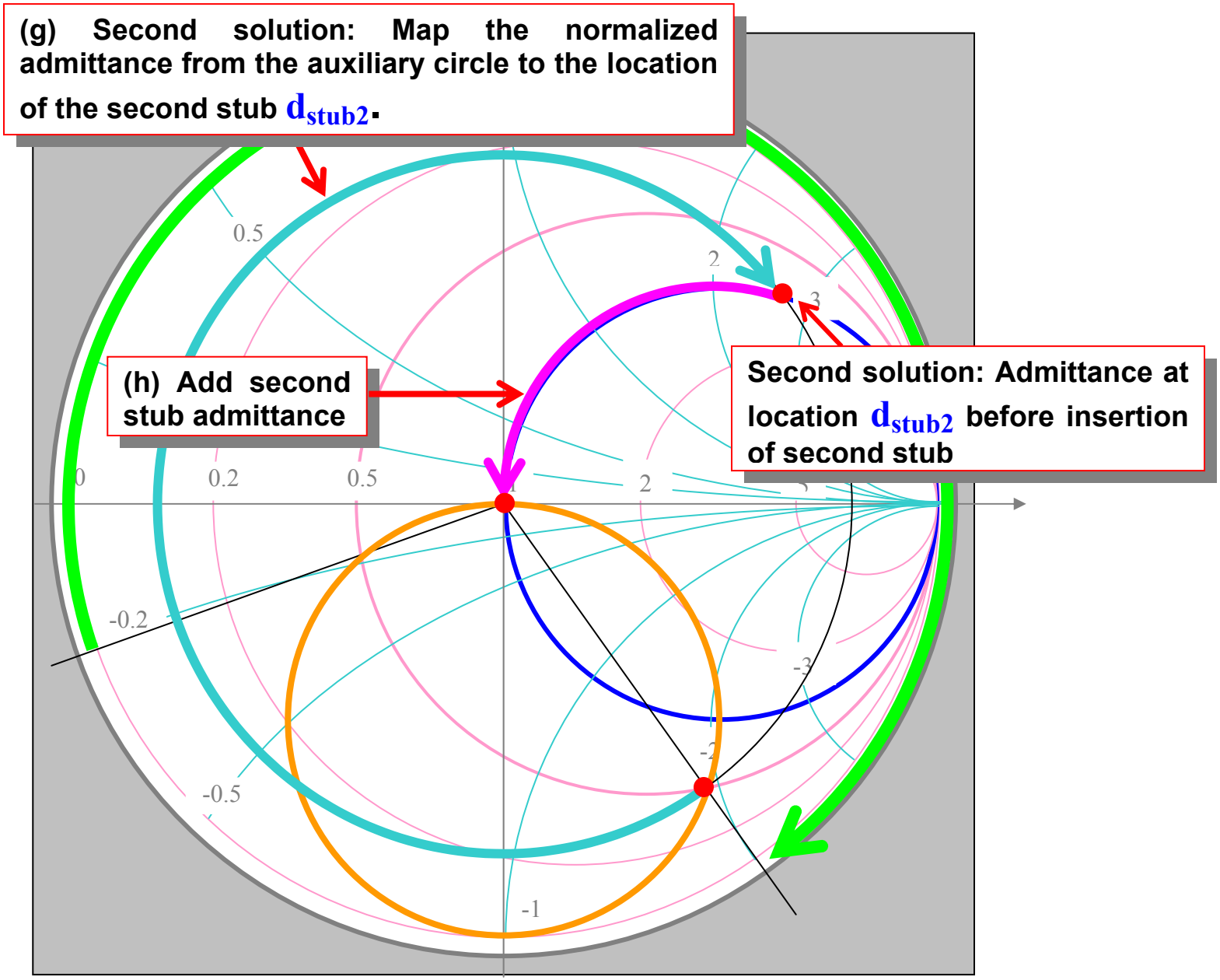

(g) First solution: Map the normalized admittance from the auxiliary circle to the location of the second stub d_{stub2}.
(h) Add second stub admittance
First solution: Admittance at location d_{stub2} before insertion of second stub
1
0.5
0.2
0
0.2
0.5
1
2
3
-0.2
-0.5
-1
-2
-3



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As mentioned earlier, a double stub configuration with fixed stub location may not be able to match a certain range of load impedances.

This is easily seen on the Smith chart. If the normalized admittance of the line, at the first stub location, falls inside a certain forbidden conductance circle tangent to the auxiliary circle (and always contained inside the unitary conductance circle), it is not possible to find a value for the first stub that can bring the normalized admittance to the auxiliary circle. Therefore, it is impossible to position the normalized admittance of the second stub location on the unitary conductance circle.

When this condition occurs, the location of one of the stubs must be changed appropriately. Alternatively, a third stub could be added.

Examples of forbidden regions follow.

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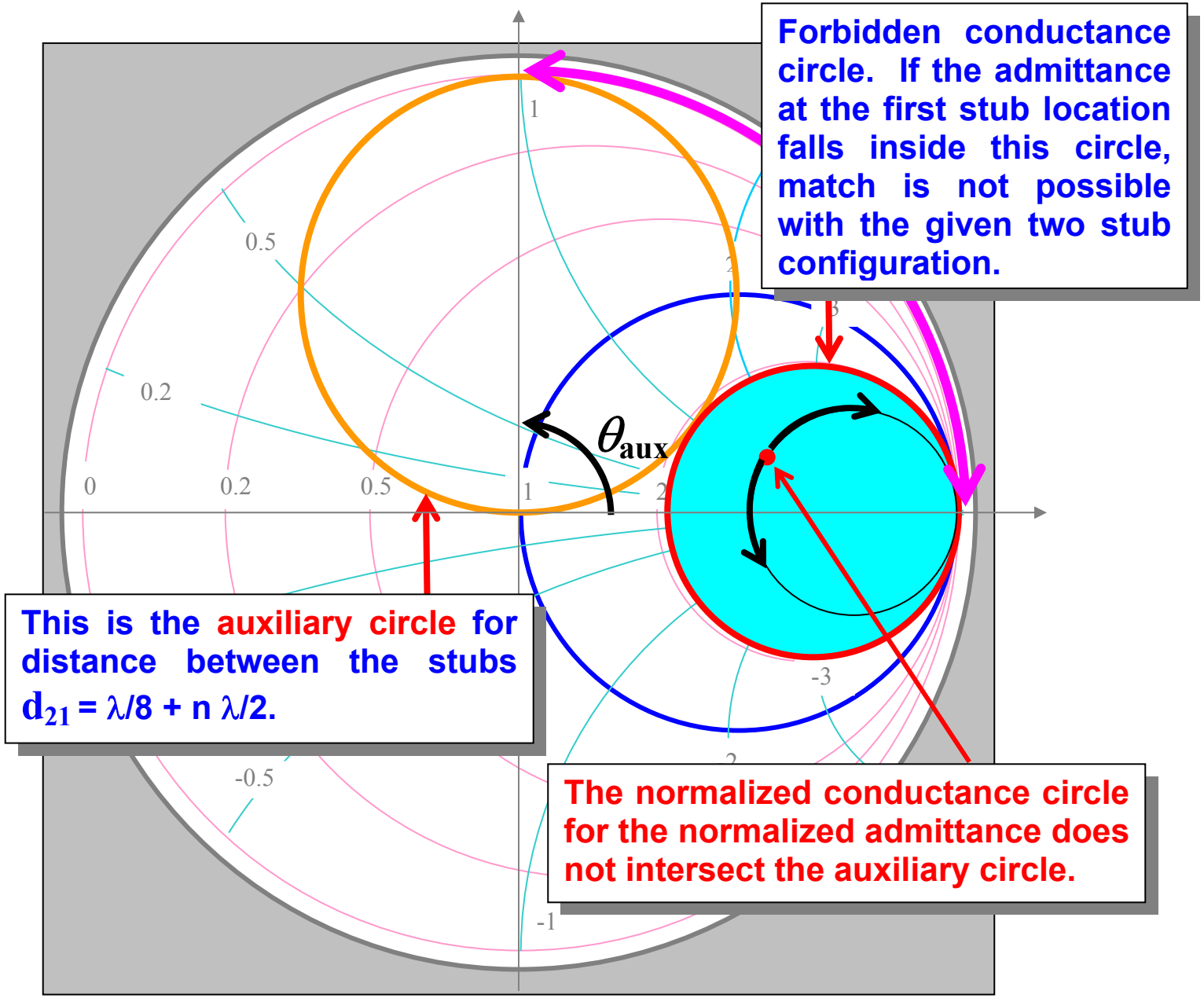

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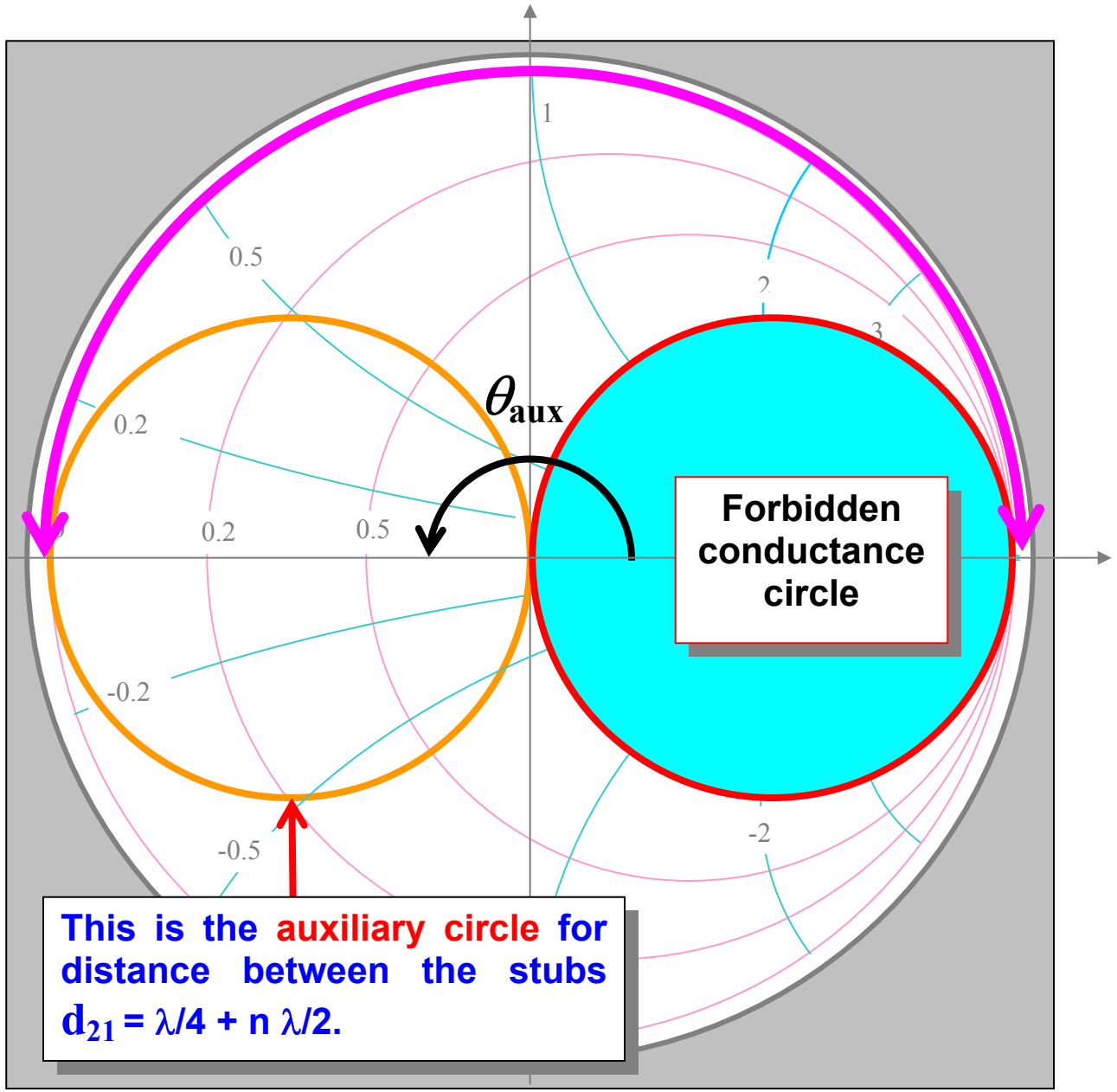

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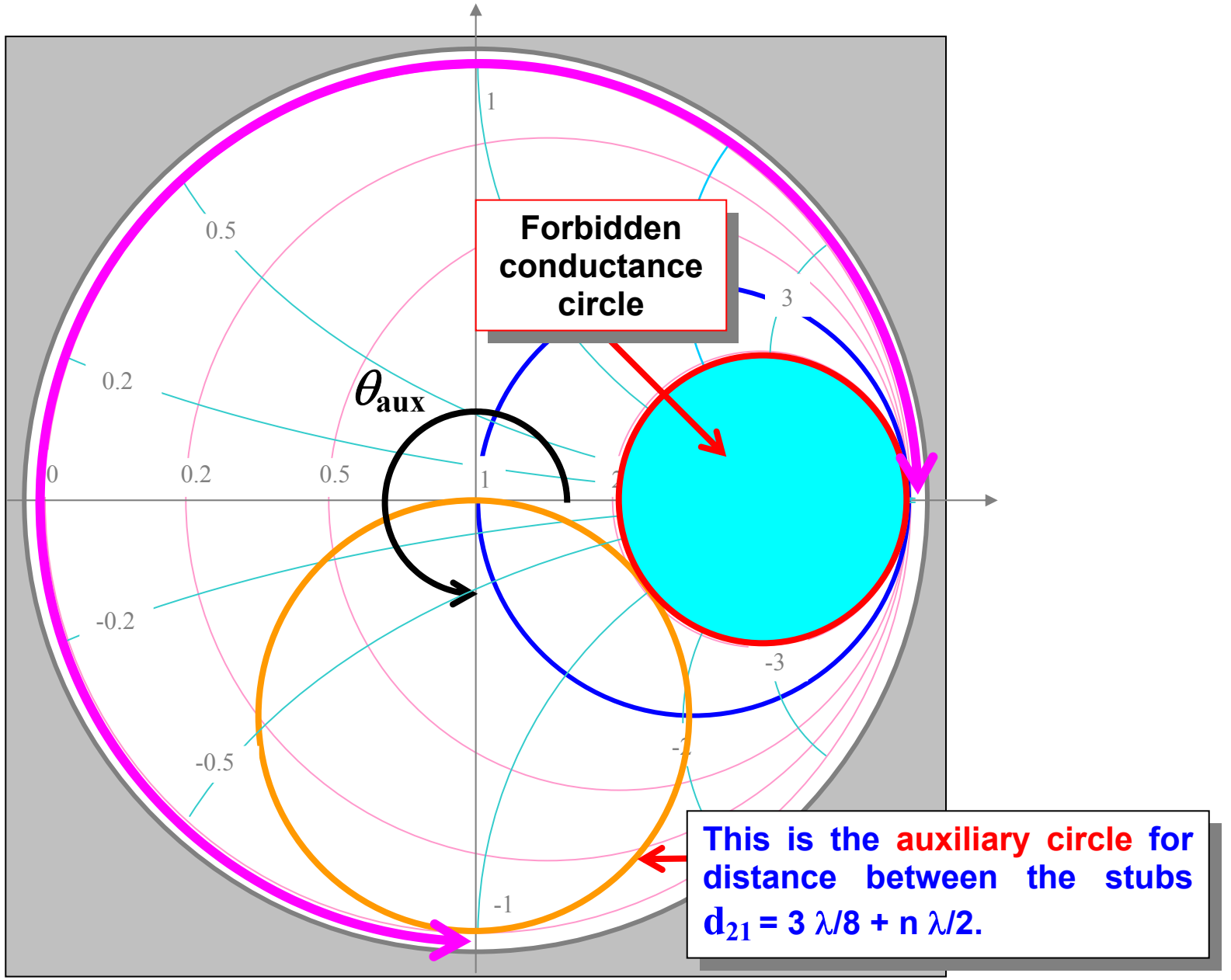

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