1.6 Matching

A mismatched load \((Z_L \neq Z_0)\) means that power is reflected and is not delivered to the load. If this is undesirable, an impedance matching network can be used to make the load appear to be matched. There are many ways to do this:

- Stub tuning
- Quarter-wave matching
- Lumped element matching
- Matching transformers
- Multistage (broadband) matching networks
- Tapered transmission lines
- Isolators (non-reciprocal devices allowing only one-way power flow)

1.6.1 Shunt Single-Stub Matching

One type of matching network is a short section of transmission line placed in parallel with the main line at some distance from the load (Fig. 1.29). The stub is typically terminated with an open or short circuit. Since we are placing two elements in parallel, it is convenient to use admittances for the design procedure, since the admittance of two parallel elements is the sum of the admittances of the elements. The basic principle is to place the stub at a location where the input admittance on the main line is of the form \(Y_o + jB\), and then choose the length of the stub so that its input admittance is \(-jB\). The parallel combination of the stub and main line then has admittance \(Y_{in} = Y_o\), which represents a match.

![Shunt single-stub matching network.](image)

The goal is to find the length of the stub \(d_2\) and the distance of the stub from the load \(d_1\) such that the input impedance looking into the junction of the stub and main line is equal to \(Z_o\). The solution procedure is as follows:

1. Normalize the load impedance.
2. Plot $y_L$ on the Smith chart. On a single-color Smith chart, this is done by plotting $z_L$ and then rotating by $180^\circ$ to $y_L$.

3. Rotate towards the generator (clockwise) around the constant VSWR circle until the input impedance reaches the $g = 1$ circle. At this point, the normalized input admittance of the line is of the form $y_{d_1} = 1 + jb$. Read $y_{d_1}$ and $d_1$ in wavelengths from the Smith chart.

4. The input admittance of the sub must be $y_{stub} = -jb$, so that $y_{in} = y_{d_1} + y_{stub} = 1$. From the Smith chart, determine the length of the stub $d_2$ that gives this input admittance. The generator end of the stub is at the point $(0, -1)$. On a single color Smith chart, we flip this about the origin to the point $(1, 0)$. We then rotate towards the generator end until the admittance is $-jb$, and read off the length of the stub in wavelengths. The lengths can easily be converted to meters by multiplying by $\lambda$.

5. What would $d_2$ be if we want to use an open circuit stub?

There are other solutions for this matching problem. We could continue rotating away from the load until the main line input impedance hits the $g = 1$ circle again.

1.6.2 Series Single-Stub Matching

If the stub is in series, then the design procedure changes, so that we rotate from the load end of the main line to the $r = 1$ circle, and then add a series stub to cancel the imaginary part of the impedance.
Shunt Stub Matching Example 2

Figure 1.30: Shunt sub matching example.

1. Normalize the load impedance.

2. Plot $y_L$ on the Smith chart.

3. Rotate towards the generator (clockwise) around the constant VSWR circle until the input impedance reaches the $g = 1$ circle. Read $y_{d_1}$ and $d_1$ in wavelengths from the Smith chart.

4. The input admittance of the sub must be $y_{stub} = -jb$. For an open circuit stub, we start at $y_{L,stub} = 0$ and rotate towards the generator end until the admittance is $-jb$, and read off the length of the stub in wavelengths.

5. Find another solution to the problem: