Optimized Passband Impedance Matching Synthesis with Nonuniform Transmission Lines

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A fundamental question about passband matching sections has been investigated since the 1940s: designing an "optimized" non-uniform transmission line to match two purely resistive and frequency-independent impedances over the band. The definition of optimization is here taken to mean that for a given taper length the reflection is minimized over the passband, or equivalently that for a given tolerance on the reflection coefficient the taper length is minimized. A well-known taper was designed by Klopfenstein, which performs as a high pass filter. This taper is optimized in the sense that it yields an equal ripple frequency response that has minimum reflection from the cutoff frequency to infinity for a specified taper length or vice versa. However, from the engineering point of view, an infinite bandwidth is seldom demanded, and we investigate here whether we can improve the optimization by sacrificing unused bandwidth.

A number of researchers have proposed methods to solve this problem since the 1950s. Although this problem has already been investigated extensively, we present an approach that will treat this problem by using a straightforward optimization criterion, the least-squares method, for the reflected power over the passband. The impedance profile is then modeled using a Fourier series as the basis function expansion. Our method is a direct one that gives a closed-form solution for the coefficients of the optimized impedance profile. This passband optimization generally yields an oscillating impedance profile. Therefore, microstrip lines are an appropriate choice for implementing this kind of taper.

Results from this technique exhibit some interesting physical phenomena. This method can also be used to investigate either an extremely broad bandwidth design from zero to infinite frequency, or an extremely short taper length for single narrow band transformers. Proceeding with a similar derivation, we can easily expand this method to arbitrary multi-band applications. Our results are verified by comparison to results from an ordinary differential equation solver, the ABCD-matrix method and Ansoft Designer.