

## CHAPTER 10

# NETWORK SYNTHESIS

### 10.1. INTRODUCTION

In the preceding chapter we have been primarily concerned with the problem of determining the response, given the excitation in the network ; this problem lies in the domain of network analysis. In this chapter we will be dealing with the problem of synthesizing a network given the excitation and response.

### 10.2. ELEMENTS OF REALIZABILITY THEORY

The starting point for any network synthesis problem is the network function which is the ratio of response  $R(s)$  to the excitation  $E(s)$ , i.e.

$$T(s) = \frac{R(s)}{E(s)}$$

Our task is to synthesize a network from a given network function.

#### 10.2.1. Causality and Stability

The first step in a synthesis procedure is to determine whether  $T(s)$  can be realized as a physical passive network. There are two important considerations : causality and stability. By causality we mean that a voltage cannot appear between any pair of terminals in the network before a current is impressed, or vice-versa. In other words, the response of the network must be zero for  $t < 0$ .

In order for network to be stable, the following three conditions on its network function  $T(s)$  must be satisfied.

- (i)  $T(s)$  cannot have poles in the right half of  $s$ -plane.
- (ii)  $T(s)$  cannot have multiple poles in the imaginary ( $\omega$ )-axis.
- (iii) The degree of the numerator of  $T(s)$  cannot exceed the degree of denominator by more than unity.

#### 10.2.2. Hurwitz Polynomial

Another element of realizability is a class of polynomial known as Hurwitz polynomial which is, in fact, the denominator polynomial of the network function satisfying certain conditions.

In brief, A polynomial  $P(s)$  is said to be Hurwitz if the following conditions are satisfied :

- (1)  $P(s)$  is real when  $s$  is real.
- (2) The roots of  $P(s)$  have real parts which are zero or negative.

#### Properties of Hurwitz Polynomial

As a result of above conditions (1) and (2), Hurwitz polynomial  $P(s)$  have the following properties:

- (i) If the polynomial  $P(s)$  can be written as -

$$P(s) = a_n s^n + a_{n-1} s^{n-1} + \dots + a_1 s + a_0$$

then, All the coefficients  $a_i$  must be positive. A corollary is that between the highest order term in  $s$  and the lowest order term, none of the coefficients may be zero unless the polynomial is even

# Network Synthesis Volume 1

**Brendan G. Carr**



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