Figure 5.21   Cables added to a two-terminal-pair component

The fourth-order term $Y_1 Y_2 Z Z_1/2$ is again much smaller for moderate values of ω than the term just evaluated.

5.4.3   The effect of cables on a two-terminal-pair component

This case is shown in Figure 5.21, where the defining conditions are again to be fulfilled at the ends of added cables instead of at the internal defining points. From (3.7), we have $I = I'(1 + Y_2 Z_2/2)$, if Y_1 is small compared to $1/Z_2$. Since current flows through the original terminals where the potential was defined, we cannot use (3.8) to deduce the relationship between U and U'. We can carry out an approximate analysis, however. If Y_1 and Y_2 are less than or of the order of $1/Z$, then the current through Y_H is UY_H and the current through Y_1 is approximately UY_1. Therefore,

$$U' - U = \frac{Z_1(UY_1 + UY_H + I)}{2} + \frac{Z_1(UY_H + I)}{2}$$

or

$$U' = U\left(1 + \frac{Y_1 Z_1}{2} + Y_H Z_1 + \frac{Z_1}{Z}\right)$$

Since $Z = U/I$ and the apparent impedance of the component and added cables $Z' = U'/I'$,

$$Z' = Z\left(1 + \frac{Y_1 Z_1}{2} + Y_H Z_1 + \frac{Z_1}{Z}\right)\left(1 + \frac{Y_2 Z_2}{2}\right) \tag{5.8}$$

Hence, the correction to be made to the apparent impedance Z' to obtain Z depends to first order on the term Z_1/Z. This might have been anticipated since Z_1 is in series with Z. The correction is subject to the uncertainty in the connector impedance contained in Z_1. Either satisfactory corrections can be made to account for the other two terms, or the impedance can be regarded as having been redefined with the lengths of additional cable included (but take note of section 3.2.6 regarding the non-linearity of cable corrections if further lengths of cable are added to include the component in a measuring network). Because of these considerations, a two-terminal-pair definition is suitable only for high-impedances Z.

Since the way we define a three-terminal impedance is not different in principle from a two-terminal-pair definition, the above considerations apply to this definition also.