POWER SYSTEMS LABORATORY

MEASUREMENTS OF ABCD CONSTANTS OF A TRANSMISSION LINE

Objective:

1. To determine the ABCD constants, characteristic impedance and propagation constant
2. To determine the shunt compensation to counteract the voltage rise on no load
3. To determine the voltage profile along the line with and without shunt compensation
4. To determine the reactive power required for zero regulation at different loads.

Introduction:

Long lines cause special problems in power systems. The voltage at the receiving end may rise, on no load or light load, beyond permissible limits; but on load the voltage may drop below normal. The phase shift may become excessively large and lead to stability problems. The no-load current may be large, if not compensated, and introduce some of the problems associated with long lines.
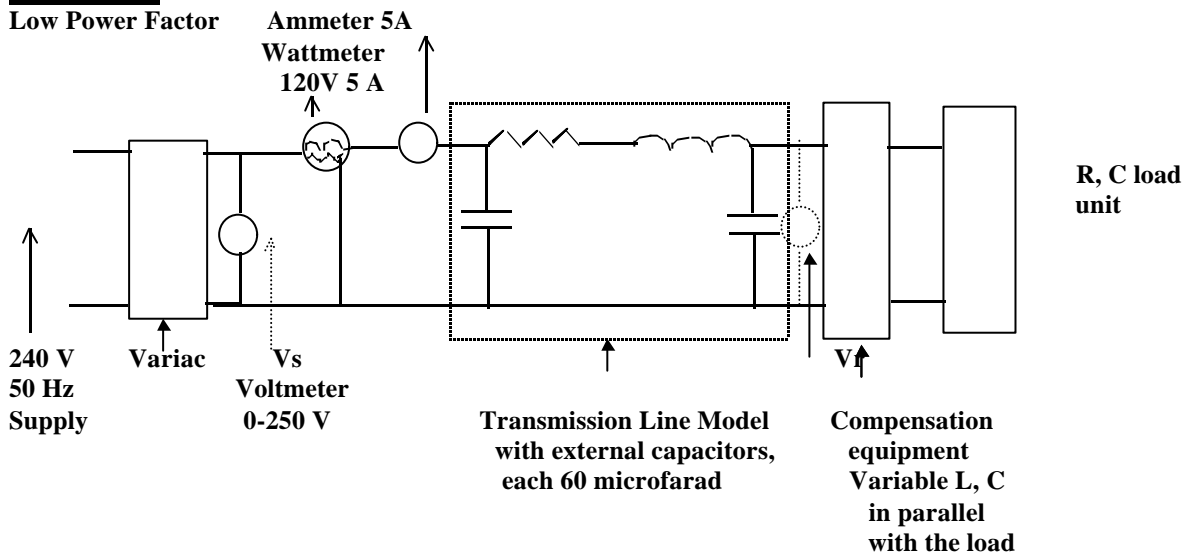
Procedure:

FIG. 1

Theory:

Since a transmission line is symmetrical, the measurement of the open circuit and short circuit impedances is enough to determine the ABCD constants.
Open - circuiting the load end of the line, the open circuit impedance is measured at the sending end as

Zoc = A/C   (1)

Short circuiting the load end of the line, the short circuit impedance Zsc is measured at the sending end as

Zsc = B/A (2)

For a symmetrical network,

A = D (3)

For a passive network,

AD-BC =1 (4)

Substituting equation (3) in equation (4),

A^2 **- BC** = 1 (5)

Using equations (1)-(5), we get

$$A = (\frac{Zoc}{Zoc - Zsc})^{1/2}$$ (6)

B = A.Zsc. (7)

C= A/Zoc (8)

Note that all parameters **A, B, C, D** and the measured quantities **Zoc** and **Zsc** are complex numbers

Part I

1. Connect the transmission line model as in Fig. 1 to represent a single-phase, long transmission line, by connecting two cable lengths in series and two 60-microfarad capacitors as shown.

2. Apply 110 V or less to measure **Zoc**

Zoc = $Zoc\angle\theta$ (9)

$Zoc = Vs/Is$ (10)

$Cos\ \theta = Ws/(Vs\ Is)$ (11)

(Note: A phase angle meter or an oscilloscope also can measure the phase angle if a low power factor wattmeter is not available)
Calculate **Zoc** as a phasor.
3. For measuring **Zsc,** pass a current of 6 A or less (Note: This requires low voltage!). Calculate **Zsc** as phasor from equations similar to (9)-(11).

4. Calculate **ABCD** constants as phasors from equations (6)-(8).
5. Determine the surge impedance **Zo** and propagation constant **γ**l as phasors from the following equations;
(Note that l is the length of the line, and, **γ=α +jβ**)

Zo = Sqrt (**B/C**)   (12)

γl= Cosh^{-1}(**A**)   (13)

6. Comment on the magnitude and angle of **A** and angle of **Zoc** and the total phase shift

Part II:

1. Open circuit the receiving end
2. Adjust the sending- end voltage to 110 V. Note the receiving - end voltage.
3. Introduce the compensation equipment and adjust its L and C till the receiving end voltage also reaches 110 V. (Vs = Vr)
4. Note the current taken by the compensator (which includes L and C in parallel) and determine its Var rating and its ohmic value

Part III:

1. With the adjustments as in 3 above, measure the voltages at the sending end, midpoint and receiving end of the line.
2. Disconnect the compensation equipment. Maintain Vs = 110 V.
3. Again measure the voltages at the sending end, midpoint and receiving end of the line.
4. Plot the voltage profiles with and without the compensation equipment and compare the results.

Part IV:

1. Disconnect the low power factor wattmeter at the sending end and connect a voltmeter, ammeter, and wattmeter and RC loading unit at the receiving end. (Note that an RL or an RLC loading unit may also be used.)
2. Adjust the loading resistor to take a power of 200, 300 and 400 W respectively.
3. For each value of power, adjust C (or L)of the compensation unit to make Vr =110 V
4. For each value of power, determine ± Qr, the reactive power to obtain the condition Vr = Vs = 110 V
5. Plot the results in the P-Q plane. What is the approximate shape of the curve?
6. Comment on the results
7. What are the uses of shunt reactors, capacitors and synchronous condensers in power systems?