Transmission Lines Model © 1994

There are usually long distances involved when electricity is transmitted from a power station to its destination (the consumer). The transmission of electricity over long distances can potentially result in unwanted wastage of some of the power (**P**) due to the resistance (**R**) of the transmission lines. This wastage of power is equal to the square of the current (**I**) multiplied by the resistance of the lines.

$$P = I^2 R$$

The power wastage in the lines may be minimised by keeping $I^2 R$ to a minimum.

- **R** may be minimised by using wires made from a material with low resistivity and a large cross sectional area.
- **I** may be minimised by using transformers to step up/down the voltage. As power is also equal to voltage (**V**) multiplied by current; thus if the voltage is increased, then to balance the equation the current must similarly decrease (resulting in a decrease in the significance of the I^2 component).

The *Transmission Lines Model* is able to easily and safely demonstrate the principles as to why electricity is stepped up to thousands of volts when transmitted over long distances. With no voltage step up, the power loss in the lines is significant and the consumer lamp doesn't glow. With voltage step up, the power loss in the lines is reduced and the consumer lamp glows.

The apparatus consists of a simulated power station generating approximately 2 volts AC, a step up transformer T_1 (steps the voltage up to a maximum of approximately 20 volts), two transmission lines (two lengths of wire with a small resistor in series to simulate the resistance of long distance lines), a step down transformer T_2 (steps the voltage back down), and a consumer load consisting of a light globe (2.5volt, 200mA). Two rotary switches (S_1 and S_2) enable the step up/step down ratio to be varied from 0x (transformers bypassed) and upwards in steps of 8x, 12x and 16x, so as to demonstrate the increased efficiency with which the electricity is transmitted as the voltage is increased. Diagram 1 shows a simple schematic of the model.

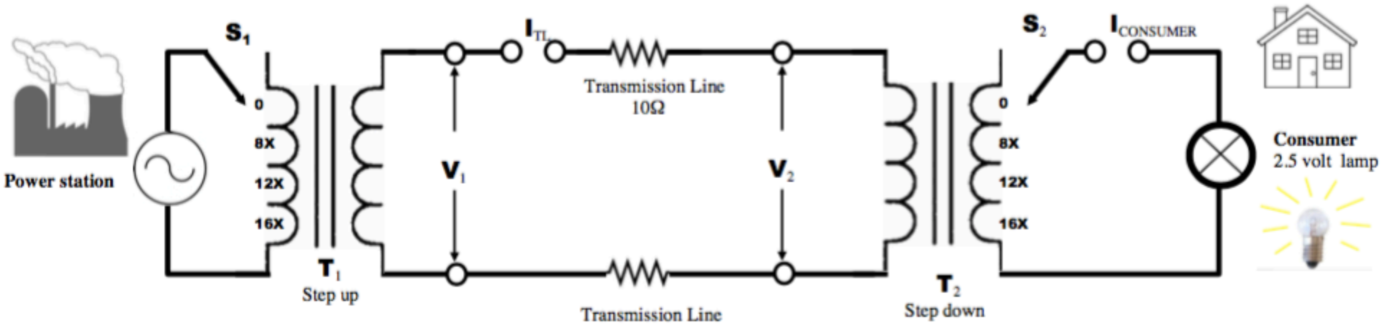


Diagram 1

Additional Equipment Required

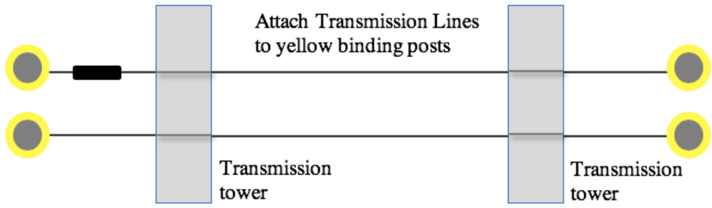
Four digital multimeters (2 used as AC ammeters, 2 as AC voltmeters) and good quality connecting leads are required for the *Transmission Lines Model* to be demonstrated to maximum effect.

WARNING - CAUTION

- **THE 16 VOLT AC MAINS PLUG PACK ADAPTOR THAT IS SUPPLIED WITH EACH APPARATUS MUST BE USED. THERE IS A RISK OF ELECTRIC SHOCK IF AN ADAPTOR WITH A HIGHER VOLTAGE OUTPUT IS USED.**
- **THE APPARATUS SHOULD ONLY BE USED AS DESCRIBED IN THESE INSTRUCTIONS AND MUST NOT BE MODIFIED OR USED IN ANY OTHER MANNER.**

Directions

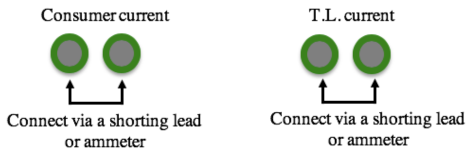
Thread the two transmission line wires through the holes of the transmission towers and then through the small side holes of the 4 yellow binding posts. Firmly secure the lines for good electrical contact.



Screw the supplied light globe (2.5volt, 200mA) into the lamp socket on the 'Consumer' cabinet. Adjust both rotary switches to the '0x' position (transformers T_1 and T_2 are bypassed). Plug in the mains plug pack adaptor (16 VAC max).

Demonstrate power losses within the lines:

To demonstrate power losses in the lines and the increase in power transmission efficiency when the voltage is stepped up, connect a shorting lead (banana plug type) to the pair of green ammeter sockets at the rear of the Power Station cabinet. Then similarly connect a shorting lead to the pair of green ammeter sockets at the rear of the Consumer cabinet.



Adjust both rotary switches to the '0x' position (no step up, transformers are bypassed), the electricity will not be transmitted in an efficient manner due to the power losses in the lines and the consumer's lamp will not be glowing. Now simultaneously adjust both rotary switches to step up/step down the voltages on either side of the transmission lines in ratios of 8x, 12x, and 16x, to observe the lamp glowing with increasing brightness.

Investigate power losses within the lines

To measure actual power losses within the lines - measure step up/down voltages and currents as follows:

- Connect digital multimeters (set to AC Amps) to both pairs of green ammeter sockets I_{TL} and $I_{Consumer}$. Use the Amp settings on the multimeters rather than mA settings (internal resistances of the multimeters may affect the brightness of the lamp).
- Connect digital multimeters (set to AC Volts) to both sets of yellow voltmeter sockets.
- With both rotary switches set to the '0x' position (transformers T_1 and T_2 are bypassed), measure voltages V_1 and V_2, and currents I_{TL} and $I_{Consumer}$. As both transformers are bypassed, the electricity will not be transmitted in an efficient manner and the consumer's lamp will not be glowing. Measurements should indicate a relatively large drop in voltage between V_1 and V_2, and a significant current in the transmission lines.
- Now simultaneously adjust both rotary switches to step up and step down the voltages on either side of the transmission lines in ratios of 8x, 12x, and 16x, and measure the corresponding voltages and currents.
- Calculate power losses within lines, and with each increasing increment note the increased efficiency with which the electricity is transmitted by the increased brightness and current through the lamp. Typical results are shown in the following table:

Step up	**V_1 volts**	**V_2 volts**	**I_{TL} mA**	**$I_{Consumer}$ mA**	**Lamp**
0 x (transformers bypassed)	1.5	0.5	92.0	92.0	Not visible
8 x	9.3	9.1	14.0	96.0	Barely visible
12 x	15.3	15.2	12.0	110.0	Brighter
16 x	21.2	21.1	10.0	115.0	Brightest

Possible causes of erratic results

- Check that shorting leads or ammeters are in place. The apparatus will not function if the green ammeter sockets are not connected via either ammeters or shorting leads.
- Ammeter set to mA setting (internal resistance of ammeter may affect the performance of the apparatus). Use Amp setting.
- Shorting or connecting leads do not make good contact. Good quality leads should be used. Use a multimeter to check 0Ω.
- Incorrect lamp being used. A 2.5volt, 200mA lamp should be used.