V – curves of the Synchronous Motor

Object: The object of this experiment is to run the synchronous machine as a synchronous motor and determine the V – curves IL = f (Ie) at cos φ = 1 for different torque values.

Theory: If a synchronous motor is operated with over – excitation, it emits inductive reactive power to the mains, i. e. it acts as a capacitor and compensates inductive loads. As a result it improves the mains power factor. It makes no difference whether the motor is loaded or is operated on no – load. The synchronous motor can consume reactive power until the maximum permissible stator current IL is reached. If you trace this current for different constant active powers over the excitation you get the so – called V – curves, as shown in Figure (49). From Figure (49) it is seen that the bottom curve is a pure reactive current characteristic whereas the active current parts gets greater and greater upwards. The reactive power of the synchronous motor is controlled by the exciting current. At under – excitation the motor consumes inductive reactive power and at over – excitation it emits inductive reactive power and consumes capacitive reactive power. In practice synchronous motors are used for reactive power compensation. This is known as "phase advancer operation".

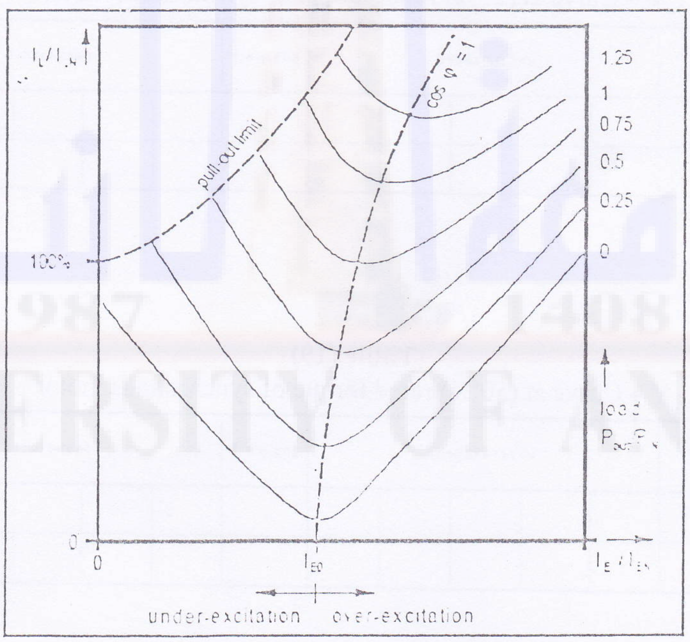

Figure (49)
V – curves of the synchronous motor

Necessary equipments:

1. Synchronous Machine (Type 2711).
2. Brake Unit (Type 2719).
3. Control Unit (Type 2730).
4. Universal Power Supply (Type 2740).
5. Power factor meter (10 A).
6. 2 Ammeters, range (0 – 5 A).

Procedure:

1. Connect the circuit shown in Figure (50).
2. Start up the system as already described in the previous experiment. The motor should rotate to the right (CW) with the rated speed (1500 rpm).
3. Calculate the rated torque (Mn) with the specifications on the name plate data, record as: Mn = ...Nm.
4. Set the excitation so that the power factor is unity.
5. Set the set point so that the motor is loaded with (0.25*Mn). Measure the exciting current (Ie) and load current (IL) and record the values in Table (18).
6. Over – excite and under – excite the motor step by step until reaching its stability limit and record the values in Table (18). Make sure not to exceed the rated excitation and rated load currents.
7. Repeat steps 5, 6 and 7 for (0.5 *Mn), (0.75*Mn) and (1.25 *Mn) respectively and record the values in Tables (19), (20), (21) and (22) respectively.
8. Set the excitation current to zero first, then switch *OFF* the Universal Power Supply and then the Control Unit.

Table (18)

V – Curve at (25%) rated torque of synchronous motor

$0.25 \times M_N$	stability limit	under-excited					$\cos\varphi = 1$	over-excited				
I_E / A												
I_L / A												

Table (19)

V – Curve at (50 %) rated torque of synchronous motor

$0.5 \times M_N$	stability limit	under-excited					$\cos\varphi = 1$	over-excited				
I_E / A												
I_L / A												

Table (20)
V – Curve at (75 %) rated torque of synchronous motor

0.75 x M_N	stability limit	under-excited					cos φ = 1	over-excited				
I_E / A												
I_L / A												

Table (21)
V – Curve at rated torque of synchronous motor

M_N	stability limit	under-excited					cos φ = 1	over-excited				
I_E / A												
I_L / A												

Table (22)
V – Curve at (125 %) rated torque of synchronous motor

1.25 x M_N	stability limit	under-excited					cos φ = 1	over-excited				
I_E / A												
I_L / A												

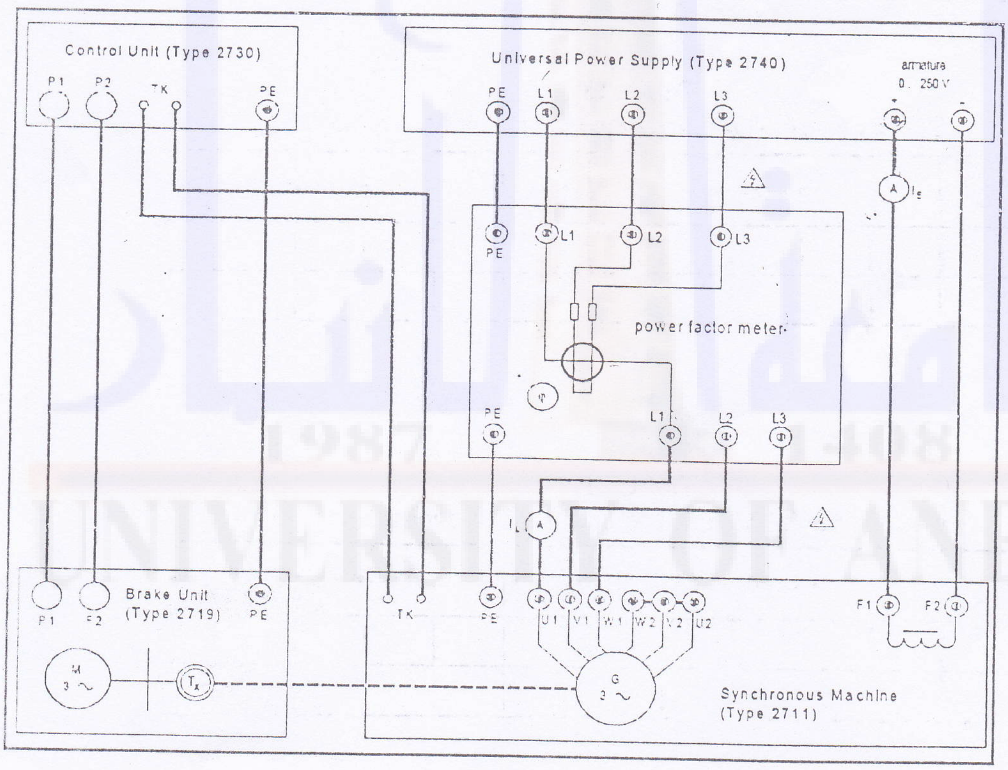

Figure (50)

Connection circuit diagram for determining the V – curves of a synchronous motor

Notes:

- If the synchronous motor does not start up, the excitation must be increased slowly as a starting aid.
- Make sure that the stability limit or the pull – out torque are not exceeded because otherwise the motor falls "out of step" and comes to a standstill.
- Carry out the measurements without delays if possible. If the machine heats up too much, the measuring results will deviate and the machine must cool down.
- Observe the setting of the torque attenuator.

Report & discussion:

1. Draw the V – curves from the results recorded in tables (18, 19, 20, 21 and 22).
2. On the same graph, draw the stability limit and the connecting line at unity power factor. What do you learn from the V – curves obtained in the graph?
3. How does exceeding the pull – out torque affect the synchronous motor?
4. How can a self – start up be achieved in synchronous motor?
5. What advantages and disadvantages does synchronous motor have in comparison with asynchronous motor?