Program First year BSc ,Subject Physics

Semester one, paper code PY C101, paper

title Mathematical methods and Mechanics

and Electrical circuit Theory Section2.

Section 2: electrical circuit theory.

Unit One Circuit analysis.

Module name: Thevenin's theorem

Part 1. Module number 6.

Hello students, in this module we

are going to study about Thevenin’s

theorem. Outline of this module,

Thevenin's theorem, problem solving.

Learning outcome: the student will be

able to convert the given 2 terminal

network into its Thevenin's equivalent.

OK. Why Thevenin’s Theorem?

OK consider a simple example where

we want to calculate the current

flowing through RL is equal to 10 ohm.

Right here I want to use the mesh

analysis method and calculate the

current flowing through RL is equal to

10 ohms. Using mesh analysis; in mesh

analysis we have to write the mesh

equations for mesh 1 as well as mesh 2.

The sign convention what I follow

is the IR drop in the direction

of the motion of the mesh

current is taken as negative and the

voltage drop from negative to positive

is taken as plus in the direction

of the motion of mesh current.

OK, so let us write the mesh

equation for mesh 1, that is

--40 I1 -- 10(I1 -- I2) because

the current flowing through RL,

in the direction I 1, is I 1 -- I 2.

Therefore I have to write -- 10 into

(I 1 -- I 2) + 20 = 0 or

on simplification I get 5 I 1 -- I2

is equal to 2 as equation number 1.

Similarly for mesh 2, the equation

is -- 20 I 2 and the current

flowing in the direction of I2 in

RL is nothing but I 2 -- I 1.

Therefore I have to write -- 10 into

(I 2 -- I 1) that is equal to 0.

On simplification I get I 1 -- 3 I 2

is equal to 0 as my equation number 2.

Solving equations 1 and 2 we know that

I have to multiply equation number2 by minus

5 and on adding I'll get the solution.

So the equation number 3 is 5 I 1 -- I2 is equal

to 2 and equation number 4 is -- 5 I 1 + 15 I2

is equal to 0. From 3 and 4

we have 14 I2 is equal to 2

or I2 is equal to 2 / 14 or 1 / 7A.

And I 1 is equal to 3 I2.

From equation 2,

we can see that I1 =3 I2,

therefore I1 is equal to 3 into

1 / 7 that's equal to 3 / 7 amps.

Therefore, the current flowing through

RL is equal to 10 ohm is I 1 -- I 2 right?

So it is 3 / 7 -- 1 / 7.

That's equal to 2 / 7 amps,

which flows from A to B.

Now consider one more example where

only the RL value is changed to 30 ohm.

OK here I have changed RL from

10 ohm to 30 ohm. So again we

have to apply the mesh analysis here.

So we have to write mesh equations for

mesh 1 as well as mesh 2 and we

have to simplify it to get the mesh

currents I-1 and I2 in this situation.

So the equation for mesh 1 is 7 I 1 -- 3 I2.

is equal to 2 and

mesh equation for the second mesh is 3 I1

--5 I2 is equal to 0. Solving 1 and

2 we get I1 is equal to 5 /13

amps and I2 is equal to 3 /13 amps.

Therefore the current flowing through

RL will be, RL is equal to 30 ohm,

is I 30 that's equal to IL,

I1 -- I 2 that comes out to be 2 /13

amps, which flows from A to B. OK here I have

done only changes in the value of

RL from 10 ohm to 30 ohm,

whereas the remaining part is the same.

OK, in such situation,

if I want to find out again for

one more value of RL,

then I need to write the mesh equation,

simplify it and get the value

of load current.

In such situations we can

use the Thevenin’s theorem.

Thevenin’s Theorem: OK.

The statement of the theorem:

Thevenin's theorem states that any

2 terminal linear network having

a number of voltage sources,

current sources and resistances can

be replaced by a simple equivalent

circuit consisting of a single

voltage source V Thevenin in series

with the resistance R thevenin.

OK, in this box it is written

2 terminal linear network.

This network may contain many resistances,

current sources or voltage sources.

We can consider it as a complex circuit.

OK, then it is connected to a load.

This 2 terminal network can be replaced

by an equivalent circuit having only

one voltage source Vth in series

with the resistance Rth.

OK, how to find the value of Vth?

the value of voltage source

Vth is equal to the open circuit voltage

across the two terminals of the network.

OK, that is how to get the open circuit?

We have to remove the load from here

then it becomes open circuit OK.

The voltage across the terminal

A&B is then taken as V th.

Now how to find out Rth?

The resistance Rth is equal to

the equivalent resistance measured

between the terminals, with all

the energy sources replaced by

their internal resistances.

OK,

the resistance Rth is found

removing RL and we have to replace

whatever energy sources are there;

suppose here voltage sources are there,

current sources are there.

We have to replace them with

their internal resistances.

Then we have to calculate

the resistance across ,equivalent

resistance across A&B.

That is Rth.

OK, let us consider

the previous example only.

That is in the previous example,

only RL value was varying.,

so we can draw the general

circuit as like this.

So I have shown a symbol variable

saying that RL value is varying. OK.

This is the general circuit. To Thevenize

this circuit we have to find.

Vth and Rth. To

find Vth, remove the load RL.

Remove the load RL and calculate the

open circuit voltage across A-B. OK.

What we have done? we have removed the

load and we have we have to calculate

the voltage Vth , across A-B.

Using voltage divider method

Vth is equal to nothing but V AB OK.

We can use a voltage divider method

according to which the voltage

across this 20 ohm resistor is given

as ,Vth,

that's equal to V_{AB},

that's equal to (20 x 20) / (40 + 20),

that is 400 / 60.

Or that's equal to 20 / 3 volts.

To find R th,

remove the load RL and replace the voltage

source with its internal resistance.

OK,

we know that the internal resistance

of a voltage source is zero, of

an ideal voltage source is 0.

We represent that by a short.

OK, so I've done here.

I have removed the voltage source here

and I have connected the terminals.

OK,

now we have to calculate the

resistance, equivalent resistance

between the terminal A&B. From the circuit,

we can see that, that is nothing,

but it's a parallel

combination of 40 ohm and 20 ohm right?

So Rth is 40 ohm parallel with

20 ohm, that is (40 x 20) / (40 + 20)

that's equal to 800 / 60 or 40 /3 ohm.

So we got R thevenin

as 40 / 3 ohm.

OK now Thevenin’s equivalent

circuit becomes like this.

We have got V th with 20/3 V,

and Rth is 40 /3 ohm,

and we have to connect

the load back. OK from this equivalent

circuit we can get the general

equation for the load current

as I L is equal to V th

divided by(Rth + RL).

Here we have just applied Ohm’s law.

OK so IL is Vth

divided by(R th + RL) amps.

OK, now let us calculate the current

flowing through RL when it is 10 ohm

and when it is 30 ohm. Ok, that we

did in the previous examples, right?

So I 10 is equal to IL,

so Vth divided by (Rth+RL) ,

that comes out to be 2 by 7 amps. OK.

Similarly,

I30 is equal to IL, that's equal to Vth

divided by (Rth + RL).

Here I'm replacing RL with 30

so it is 20 / 3

divided by(40 / 3 + 30) that

comes out to be 2 / 13 amps.

OK that these results are same which

we got from mesh analysis right?

So using Thevenin's theorem we can

easily find load current IL for

any value of load RL. OK so easily

now I can find out if I want

to change R L to 40 Ohm.

What I have to do is I have to just

replace RL with 40 here whereas

Vth and Rth are the

same for that particular circuit.

OK,

so in such situations Thevenin’s

theorem becomes very useful.

Note: in many circuits it is required

to calculate current, voltage

or power in only one resistor,

say load resistor RL.

In such circuits Thevenin's

theorem is very useful.

Thank you.