Program :FY BSc. Subject :Physics,

Semester one , Paper code :PY C101

Paper title: Mathematical methods

and Mechanics and Electrical

circuit Theory (Section 2). Section

2: Electrical circuit theory.

Unit One: Circuit analysis.

Module name: Norton's

theorem Part 1. Module number 9.

Hello students, in this module we are

going to learn about Norton's theorem.

Outline of this module is Norton’s

theorem: Statement ,problem solving.

Learning outcome: the student will be

able to convert the given 2 terminal

network into its Norton's equivalent.

Norton's theorem, let us consider

the statement first. Statement:

Norton’s theorem states that any 2

terminal linear network with sources,

the sources can be current sources

or voltage sources and resistances can

be replaced by an equivalent circuit

consisting of a current source IN

in parallel with a resistance RN.

That is any 2 terminal linear network

like this containing voltage sources,

current sources and resistances,

we can say that it's a complex circuit,

can be simplified into an equivalent

circuit consisting of a current source

IN in parallel with the resistance RN.

The value of the current source IN

is the short circuit current between

the two terminals of the network.

How to calculate IN?

That is nothing,

but it is the short circuit

current between the terminals A&B.

So we have to remove RL and we

have to connect the terminals A&B.

Whatever current flows,

that is the short circuit current.

That is taken as Norton's current

IN. OK and the resistance,

RN is the equivalent resistance measured

between the terminals of the network,

when all the energy sources are

replaced by their internal resistances.

OK, what is RN?

It is the equivalent resistance

between the terminal A&B.

Here A&B when sources are replaced

by their internal resistances.

So we can see here,

Norton’s theorem is applied whenever in

a circuit where only one part is variable,

whereas the remaining part is fixed. OK,

similar to Thevenin's theorem,

Norton’s theorem can be applied

to a circuit where is one variable

and remaining part is fixed.

Like this we can simplify the complex

circuit into an equivalent circuit

consisting of a current source in

parallel with the resistance RN OK.

Let us try to understand Norton's

theorem from solving these examples.

OK, now consider example 1:

Calculate the load current IL

flowing through RL is equal to 6 ohm,

using Norton's theorem.

We are asked to find out the

current flowing through RL is equal

to 6 ohm using Norton’s theorem.

What is the step? We have to find out

IN, then we have to find out RN. To

find out IN what we have to do? To

find IN remove the load RL is equal

to 6 ohm and short the terminals A&B.

So remove it that has been done here,

and short the terminals A&B so

it has been shorted.

This short circuit current ISC is

equal to IN. OK you can note

here the whatever current flows

from here it will not go here.

It will take this path because

this is the easier path for it.

Current always takes the easy

path so it will not go here.

It will take this path and

complete the circuit.

Therefore IN is equal to E divided by 10.

ohm. OK. Current will not flow into 15 ohm,

it will take easier path

through A-B short.

This one.

OK so we got IN as 1 amps.

To find RN:

What is the procedure? We have to remove RL,

remove the load and replace the voltage

source with its internal resistance.

So what is the internal resistance of a voltage

source, of an ideal voltage source?

It is zero or we represent it by a short.

We have done this here right?

We have removed the voltage source

and we have shorted the terminals. OK.

And we have removed already the load.

OK So what is RN now?

It is the equivalent

resistance between the terminal A&B.

From the circuit we can say that

it is nothing but the parallel

combination of 10 ohm and 15

ohm. OK, therefore,

RN is equal to 10

parallel 15 that's equal to (10 x 15)

/ (10 + 15)that comes out to be 6 ohm.

Therefore RN is 6 ohms.

Therefore Norton’s equivalent circuit becomes

like this with a current source of 1 amp.

RN is equal to 6 ohm and we have

to connect RL back.

OK,

So let us write the equation

for the load current.

From here we can see ,

IN is dividing into two branches.

Right. Here some current is flowing

here some current is flowing.

So what is IL ? Using current divider

we can write IL is equal to input current

into resistance of the other branch.

In this case it is R N divided by (R N + RL).OK,

so IL is equal to,

(IN x R N)/ (R N + RL) .

I'm applying current divider here

right? That's equal to (1 x 6)

/ (6 + 6), that's equal to half. Or

that is also equal to 0.5 amps.

So we got the load current

equal to 0.5 amps,

using Norton’s Theorem.

OK, now consider one more example.

The statement is: Obtain Norton's equivalent of the given circuit at the terminals P&Q.

Calculate the load current

IL for R L is equal to 5 ohm

and RL is equal to 20 ohm. For two values of RL,OK.

Consider this one.

OK, what we have to do? What is the step?

We have to find out first,

IN and then we have to find out RN. To

find IN remove the load RL and short the

terminals P&Q so it has been done.

Here we have removed load RL and

we have shorted the terminals.

So this short circuit current ISC

is equal to the Norton's current.

Calculate the short circuit

current ISC is equal to IN.

OK.

Apply, so this we can do

using Superposition theorem.

We know how to apply superposition theorem,

right? So apply superposition

theorem to calculate IN.

So we have to apply superposition theorem

how superposition theorem is applied?

We will consider one source at a

time and will replace the other

source with its internal resistance.

OK and will calculate what is the

current flowing through this P-Q?

because of this source then will

calculate the current flowing through this,

using this. OK second Source considering

second source and replacing first

with its internal resistance.

OK, then we'll calculate the total current

flowing through this PQ through PQ.

OK. Now consider source

E1, remove the voltage source E2 and

replace it with its internal resistance.

So it is short. We have to replace

it with short so that is done.

Here it is connected like this.

OK, now see the circuit here.

The current from this source

E1 is equal to 30 volt,

will not flow here.

It will take this easier path right?

Always it will take a easier

path as it is short.

There is no resistance so it will take

this path and continue the circuit.

OK it will not take this path.

Therefore IN1, that is current

due to source one that is E1 is IN1

 is equal to E1 divided by 10

ohm. Right, E1 divided by 10 ohm, that's

equal to 30 / 10 that's equal to 3 amp

which flows from P to Q. OK we got IN1.

is equal to 3 amps.

Now consider source E2. OK for

that what I have to do is remove

the voltage source E1 and replace

it with its internal resistance.

That has been done here.

I have shorted it because internal

resistance of voltage source is 0,

which is represented by a short. OK,

now see the circuit here.

The current from this voltage

source will go like this.

It will take this path

and complete the circuit.

It will not go this way because

it is a resistance, right?

It will always take an easier path, which is.

This is a short. Short, right?

So zero resistance, so it will take

this path and complete the circuit.

Therefore IN2 is equal to,

IN2 is equal to E 2 / 10 , this

resistance 10 that's equal to 10 / 10

is equal to 1 amps and the current

flows here from Q to P not from P to.

Q. Here from Q to P OK.

Therefore, the total current

because of both the sources,

we have to calculate this right?

I_{SC} which is Norton's current.

Therefore IN is equal to.

IN1

was flowing from P to Q whereas

IN2 is flowing from Q to P.

Therefore the resultant current

is IN 1 -- I N 2.

That's equal to 3 amp -- 1 amp, that's

equal to 2 amp in the direction P to Q.

OK like this.

OK to find RN OK what we have to do we have

to remove the load and replace the voltage

sources with their internal resistances.

Here both are voltage sources

so we have to replace,

we have to short it right?

We have to short it, that is done like this.

OK then we have to calculate the equivalent resistance between the terminals P&Q.

So from the circuit we can see what it is?

It is nothing but the parallel

combination of 10 ohm and 10 ohm.

OK straight away

I can say the equivalent is 5 ohm right?

When two equal resistances,

say R&R are in parallel,

then equivalent is R/2.

OK that we can calculate also.

So RN is equal to 10,

parallel to 10.

That's equal to (10 x 10)/ (10 + 10).

That's equal to 5 ohms.

So we got RN as 5 ohm.

Hence, Norton equivalent Circuit becomes

like this with IN is equal to 2 A,

then RN is equal to 5 ohm and we are

connecting back the load RL like this.

The general equation for the

load current is given by,

(IN x RN) divided by (RN + RL) OK.

Therefore when, so we have to

calculate for two values of RL right?

So when RL is equal to 5 ohm,

what I have to do?

I have to just replace here for RL by 5.

So it is (2 x 5)/(5 + 5), that's

equal to 1 amps. When RL is equal to

20 ohm IL is equal to I-20 is equal

to (INx RN) by(RN + 20) here

there for (2 x 5)/ (5 + 20), that comes

out to be 2 / 5 or it is 0.4 amp. OK.

So I have done here this.

I have shown this because

like Thevenin’s theorem,

we can calculate load current for

various values of load resistance,

I can calculate IL. OK.

So in such situation even we

can use Norton’s theorem.

This is the application of Norton’s theorem.

And these are the reference books.

Thank you.