

Circuit Analysis for Analog Designers
Prof. Shanthi Pavan
Department of Electrical Engineering
Indian Institute of Technology, Madras

Lecture - 15
MNA stamp of an ideal opamp

(Refer Slide Time: 00:16)

NPTEL

$$\lambda^T G_n^{-1} = (\hat{v})^T \quad (G_n)$$

$$\Rightarrow \lambda^T = (\hat{v})^T G_n$$

$$\Rightarrow \lambda = G_n^T \hat{v}$$

Inter-adjoint or Adjoint ← Measurement vector ← Adjoint equation

$$\frac{v_{out}}{i_s} = \lambda^T \begin{matrix} \uparrow \\ \downarrow \end{matrix}$$

Alright. The next small thing that I would like to mention is the following.

(Refer Slide Time: 00:23)

NPTEL

$v_1 = v_2$ $i_1 = 0$ $i_2 = 0$
 * Opamp is ideal
 * DC negative feedback is present

MNA Stamp

③	1	1	0	0	0
⑥	1	-1	0	0	0
	1	-1	0	0	0

i_1
 i_2

Is the MNA stamp of an op-amp did we discussed this before? Not in the context of MNA right. So, let us say you have an op-amp and we know that it is in negative feedback alright, if the op amp is in negative feedback. So, op-amp is ideal and DC negative feedback is present. Under these circumstances what comment can we make about the properties of the op-amp?

There is an op-amp embedded inside a network there is we know that the op-amp is ideal in the sense that you know the G_m is infinite or the voltage gain is infinite and we know that there is DC negative feedback around the op-amp. So, what does it mean as far as the network equations are concerned?

v_1 the virtual short so, v_1 equal to v_2 and what about; is that all?

$$v_1 = v_2$$

And i_1 is 0 and i_1 is 0 and likewise i_2 is 0, alright. And what about i_3 ?

$$i_1 = 0; \quad i_2 = 0$$

It can be anything and that is dictated by the rest of the network correct. So, therefore, what will be the MNA stamp of an ideal op-amp I mean how many unknowns will be do we need to have an extra unknown?

Well remember that the current flowing through the output of an op-amp is an unknown. So, we will need an extra unknown ok. And now can you tell me what the structure of the MNA stamp of the op-amp ideal op-amp should be?

Yeah, what do we have in the last row? 1 and minus 1 in which columns? Yeah. So, let me yeah ok 1 and 2 and you basically have 1 and minus 1 ok alright, what else?

The row corresponding to node 3 in the last column, plus 1 or minus 1? It is going outside. So, it must be yes Harshith. Plus 1 very good alright ok now we come to something interesting.

$$\left(\begin{array}{cc|c} & & \\ \hline 1 & -1 & 1 \end{array} \right) \begin{pmatrix} \\ \\ i_3 \end{pmatrix}$$

So, let us say we had a circuit with two op-amps in it right. So, we had a network with two op-amps. So, let me call this 1, 2, 3 let me call that 4, 5, 6 and again I am going to assume that there is these are ideal op-amps and that there is negative feedback around DC negative feedback around all the op-amps right.

So, to make things clearer I am going to basically call this I am going to make this op-amp in magenta alright. Now, can we how will the MNA matrix b for when we have both these op-amps in? We will have one more row, let us call that i 6 this is another unknown. So, we need another row and. So, what we do with that row?

Sorry 4 and 5 right 4 and 5; what we do?

1 I am going to put that in magenta again its 1 and minus 1 alright and then what else?

The 6th row plus 1 alright.

$$\left(\begin{array}{cccc|c} & & & & 1 \\ & & & & 1 \\ \hline 1 & -1 & & & \\ & & 1 & -1 & \end{array} \right) \begin{pmatrix} i_3 \\ i_4 \end{pmatrix}$$

Now I am going to do I am going I am going to drive your attention to something interesting right. If I showed you this matrix ok, I did not show you the picture of the op-amps of course, you already know what the MNA stamp of the op-amp is right. Now, if I say draw the circuit what would you do?

Do you understand the question? So far what we have done is gone from the circuit to the MNA matrix right. Now I am asking you here is the MNA matrix what is the circuit? If the magenta nodes were not there. 4 and 5 are if the black entries were not there I am sorry, what would you say?

4, 5 are the inputs. 6 is the output ok. Now when both are there? Exactly. So, basically when you have both present right it.

(Refer Slide Time: 07:38)

The slide features the NPTEL logo in the top left corner. It displays two circuit diagrams of an op-amp with nodes 1, 2, 3, 4, 5, and 6. The left diagram shows the op-amp with nodes 4, 5, and 6 connected. The right diagram shows the op-amp with nodes 1, 2, and 3 connected. A handwritten MNA matrix is shown in the center, with the matrix elements corresponding to the nodes. The matrix is:

$$\begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \\ v_3 \\ v_4 \\ v_5 \\ v_6 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

Handwritten notes include: "Opamp is ideal", "DC negative feedback is present", and "Both have the same MNA matrix". A video inset shows a lecturer speaking.

One obvious solution is I mean because we came up with it you know one obvious solution is to say oh well that is the network right, but it is entirely legitimate to say well what do I do? Well, it is perfectly ok to say this is 3 and this is 6 ok, both these circuits have the same MNA matrix ok. So, what is the moral of the story?

Yeah, if both have the same MNA matrix what comment can we make about you know the outputs at node 6 and node 3. Do you understand the question? Right. So, these are two I mean these are parts of a circuit, in one of them the op-amp the ideal op-amp is connected between 4, 5 and 6 right and the other one is between 1, 2 and 3. In the other circuit all I have done is cut off the output from 6 for the op-amp in magenta and connected it to 3 and vice versa ok. Both networks evidently have the same MNA matrix. So, therefore, as far as the voltages at node 3 and node 6 are concerned they will remain the same. They will remain the same because the MNA matrices are the same, correct. So, therefore, when you have. So, what is the you know design implication of this?

If you have a network with multiple identical, I mean ideal op-amps right you can actually cut off their outputs and switch them any which way you want and nothing will change. Do you understand this? Do you understand the you know the implication right? Let me prove that to you with an example.