Using Multisim Video

Video Transcript

Hello, I'm Lois Gray from North Highland College and I'm going to show you how to create and simulate an inverting op-amp circuit using National Instruments Multisim electronics simulator. So to start Multisim - and you should be able to get this through my UHI - I'm just going to go into the Start menu/All programs and I'm using Multisim version 13. You may have a different version but it should be reasonably similar. So when Multisim runs up you'll see that there's three panes: there's the hierarchical menu where you could have a top level design and then various circuits below that. We're just going to use a single circuit so we're not really going to use that. We've got a page where we're actually going to build our circuit on and we've also got a command window down here which tells us what's going on or if there's any thoughts. Okay, now I need to make sure you have the same toolbars as me. The toolbars are going to use are these blue toolbars here, which are virtual components so that means that these are perfect components; they don't have any manufacturer tolerances built in. So the circuit we're going to build is purely to check the functionality; it's not to check things like how much effect does the offset voltage have, how much variation is there really from one out to another in gain. I's purely to check that the op-amp is working as an inverter and the other toolbar we need are these instruments down the right-hand side here. So to ensure that you have those same toolbars if you left click on View, scroll down to the toolbars selection and then you can check that the Instruments is ticked and the Virtual is also ticked.

Okay, so to put a component on our sheet you just select the menu or the box that you want and then left-click and drag the component. So we're going to start with our op amps, which are in this analog family. Left click on that we've got a choice of a three terminal op amp, which is just inputs and outputs, or a five terminal op-amp which also has the DC power supply connections. I'm going to go for the three terminal one to make it nice and easy to see. So left click on that, drag it onto your sheet and left click again. There's no need to hold the mouse button down while you're dragging. Okay, now we also need some resistors. You'll remember that for an inverting amplifier. So we get these from the basics family here: left-click on the basics family; these are your resistors here. Be careful because the inductors also look quite similar so you definitely want to pick resistors and just left-click and we'll just use the default value of 1 kiloohm. We need another one for the feedback resistor so we'll do the same again for feedback and I'm also going to put a resistor on the positive input to try and reduce the bias currents. So an easy way to do that is to use this in used ones. You've already put components on your sheet they come up they appear in this In Use list and you can just pick them from there. So there's a 1k resistor; let's put it down here. Ok now, just to tidy the circuit up I'm going to rotate this 1K here so if you left click on it and then right click, there's the option of rotating it. You can also flip it, but we'll rotate it here ok and now we want to connect everything up.

To connect you just hover over the terminal, left-click and drag. So if you want to corner left click again and then left click at the connection point and you should see a red wire like that showing that it's connected. Ok, I would strongly suggest you don't connect components by just hovering like that. Sometimes Multisim will connect them, sometimes it won't. It would really be better if you use a wire each time. Now you can clearly see the connection ok so let's continue connecting that up. If you want to just connect a different component that you don't have an obvious terminal for you can place a junction on your wire and that will give you a connection point as well. I'm not going to do that but that's an easy way of doing it. Right, so we're going to carry on wiring this up. That's not very tidy - it was too messy - but it doesn't look very tidy. Leave it at that plane and put that there.

Multisim circuits always need a ground point to work, so even though a circuit doesn't have a ground, you have to put one on somewhere for Multisim. This circuit does have a ground: this resistor here should be grounded, so we'll get our ground from the Power Source family and we use the analog ground here connect that and now we need an input so I think we'll have a sine wave input so we can see the effect on both phase and amplitude of the amplifier. So we'll get a function generator from our Instruments bar here, put that there so lets double left click on that to open up a component and you can see we've got choice of sine, triangle or square. We're going to pick the sine wave. We probably want a slightly higher frequency than one Hertz so you can type in a frequency here. You can use the buttons to scroll up and down and you can change the units here, so I'm going to change this to one kilohertz. Equally, ten volts is rather a large signal to be amplified so let's change that to one volt. So that seems to be set up correctly. We're only using the plus and the common terminals so close that. So we want to connect the plus point to our input resistor and we want – whoops didn't quite work- there we go now.

We want to connect the ground point to our common point here and we want to look at both amplitude and phase so let's use an oscilloscope on the output. So if we scroll down again on our Instruments bar here until we find an oscilloscope. Here is a four terminal one as well a four channel one. We only need the two channels so we'll stick with the two channel one. You'll see that each channel has two connections: this negative connection is your screen. If you're trying to simulate the effect of the circuit with a noise condition you might want to connect the screen but we don't need to do that. We're just going to look at functionality so let's just connect channel A to our input and channel B to our output, and just one more thing: the scope comes up with the same colour as the wires so it's quite hard to see the red wires on a black background scope. It's a black background so I'm just going to change the colour of these wires just by left-clicking the wire, right clicking and changing segment colour; so we'll go for maybe orange for input and maybe blue for our output. Blue that you can see on both screens that's good for maybe that one. Hopefully you can still see it out on the page.

Like that was ready to simulate now then you might want to save your file so we can go into this file button here. Click file. You've got choice of saving or save as. The name you give your file should not really have any spaces or strange characters but other than that you can save it in any way you want, as anything you want. I'm not going to bother - I'm going to just go straight to simulations so here is a Run button or a simulate button. If we click on that then the circuit is now simulating. You can tell it's simulating - there should be a little LED display down the bottom here that's flashing and we can see our scope traces by double clicking on (left clicking on) our oscilloscope. So this is like a normal oscilloscope; it's got a time per division along the x-axis and amplitude division on the y-axis and they can be adjusted. So lets decrease our time for divisions for the circuit. The signals a little slower. Looking at that seems not bad and we’ll also decrease our volts per division so the signals look a bit bigger. So I think that's our input signal, if I remember rightly, and this one is our output signal.

OK, I just realized something – that we still only have a gain of one. I’m going to change that to one millisecond per division now. Actually have a gain of one so then just stop that now. If you make any changes to your circuit you have to stop the simulation by clicking this red button. You can also pause the simulation with this button here but we're going to stop the simulation and I'm going to make this gain 5 so, again, remembering that it's an inverting amplifier, the gain is negative R2 over R1 so let's double click left click on R2 and you get a new pane comes up. We'll change this to 5k. Again you can do it with the arrow or you can just type in with a small k for kilohms. I'm also going to change the label. So a label is what the resistor name is. If you like, we're going to call that feedback resistor RF. Okay, we don't really need to do anything else. There are other things you can change but we’ll not do that just now. We’ll click OK and you can see now that our feedback resistor is now 5 Kilo Ohms and has been renamed as RF. All right, so let's start the simulation again. Double click left click on our scope to see the signal now. Of course you can see that the blue trace - the output of the amplifier - is much bigger, which is what it should be, so let's increase our volts per division so we can see the full signal and you'll notice it's flashing. That's because the scope is scanning across very quickly so probably the easiest way to stop that is to change it to a single trace and then we could also pause the simulation so that we can see the signals more clearly. So hopefully now you can see the blue traces - our output. The red trace is our input. We put in a 1 volt peak input so we're talking about 500 millivolts per division so that's half a volt = 1 volt - that's correct.

You could check the frequency as well. We won’t do that just now. I also put in our 2 volts per, so we're expecting an amplification of 5 so our 1 volt should become 5 at the output so we can check. We're on two volts per division on the output so we've got 2, 4 and probably

another half (divisions) in each direction would give us 5. 5 volts yeah, we can also measure those using this cursor things here. If you just left click on that and drag it up to somewhere near the peak we can see, down here, that our cursors are telling us channel A is minus nine eight millivolts near enough one volt, and channel B is four point nine four three volts which is near enough five volts. The other thing to note is that on channel B the output is a complete inversion of channel A. That's what we would expect for an inverting amplifier. Channel B should be a hundred and eighty degrees out of phase with channel A. I’ll maybe just expand that just a little so you can see that more clearly. Okay so hopefully that is very clear there and it is exactly 180 degrees out of phase. Of course this is because we're using perfect components.

Right, so that's pretty much the simulation of the inverting op-amp done. I just want to show you one more thing. What happens if we put too big an input signal in? Okay, so what do you think will happen? Well, what should happen is the amplifier should saturate and we won't get the five times game that we're expecting. So I'll stop my simulation so I can change my function generator. I'll make my function generator ten volts like we had originally and then we'll run the simulation with the green arrow and check what our scope is doing now. So all our signals are much bigger. We're going to have to change our volts per division to get to see them. To make that a bigger number, five volts per division. Yep, five ten that seems fair enough and let's change that as well so we're on five volts per division on both channels and you can quite clearly see that the blue trace has a flat area at the top and bottom where the amplifier is saturating. It's unable to give us any more voltage so the blue trace is nowhere near five times the gain of the red trace and that's because it's limited by the DC supplies. Even the three terminal amp has a DC supply limit. If we were to measure that in this blue, you'll see that that's probably around about twelve volts so this amplifier has a 12 or 13 volt DC power supply - plus or minus 12 or 13 volts. It cannot give out any more amplitude than that, so it's saturating. Okay, well that's what I wanted to show you. I hope that was interesting. I'll just turn off the recording and we'll see you again later.