Power Management Integrated Circuits

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Lecture - 28
Dynamic Offset Cancellation Techniques
(Chopping, Auto- zeroing)

The resistor setting used to cancel static offset will happen automatically, that is with automatically it will do, when you start your system, this will automatically, will start operating during when the system is started. It will be part of your design actually. So, initially when your; so, when your V dd is; V dd is settled then you operate this actually, during start up. So, that is the one way, other way so, then in that case, every time you start your system you have to do that. Another way is what do you do actually during testing, you do this and burn the code on the ROM and then it will fix your resistor value in that case.

So, both ways are used actually, if you do not have a ROM option then you have every time you have to do because those codes will be stored in the flip flop, ok, and every time you turn off your system that code will get reset. So, you have to do every time, but if it is stored in the ROM, then you do not have to repeat it again. So, and that is why if you stored in the ROM you mostly do it during testing.

So, whoever buys your chip that will get a burned code in that case; so, in that case it will not change, ok. So, both techniques are used, ROM as well as RAM. And, sometimes during testing, it is not burned in the ROM, still you want to store, so during testing you find what is the code, and that code is stored in your startup file, like a BIOS in computer you have. So, when your system starts, it will load those codes and then properly your phone or whatever computer will start up after that.

So, there are various techniques which are used in the software, hardware, everything whatever the requirement is, they apply that. So, during boot up you use; so, that is called you boot file you use, and the boot file will have an initialization code, and that will just write those codes to these flip flops and it will start with that. In that case you do not have to do every time that iteration, ok.

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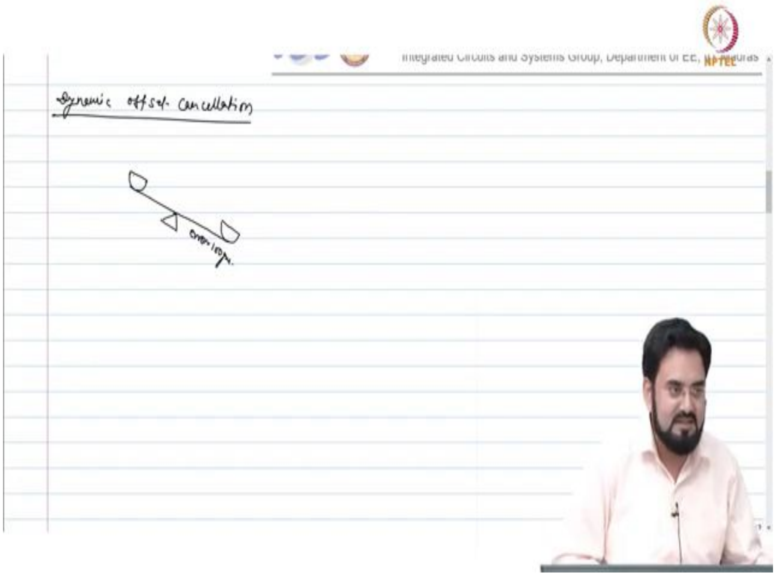

So, those were static offset cancellation, now, let us look at dynamic, ok. So, we will take the same example, your balance; so, we know my balance was faulty. Now, go back to the original, you do not shift the center because shifting the center means you have corrected. So, now, since we are using a dynamic offset cancellation, so, we will not do the correction. We just use that faulty balance and so, we know that let us say error is, 100 grams was the error. So, if we went to buy 1 kg fruit you will get 900 gram only, ok.

So, now, you go back to the again that shopkeeper and play a game with him. So, just tell him, I want to swap the my fruits and weights. So, he will not do that, he will say now he will have to give you 1.1 kg, ok. So, ask him you split into half kg's; one time half kg weigh from this side and other half kg weigh from this.

So, this half kg will give me 400 gram, other half kg will give me 600 gram. So, you will get perfect 1 kg, and that is what you do in dynamic offset cancellation, what do you do, you know your offset is in the one direction, either positive or negative. So, use a clock and keep swapping every clock cycle, the positive input and negative input, that is it. So, you apply a plus offset on the other side, then you apply a same offset on the other side in another cycle and they will get automatically canceled out on an average, ok.

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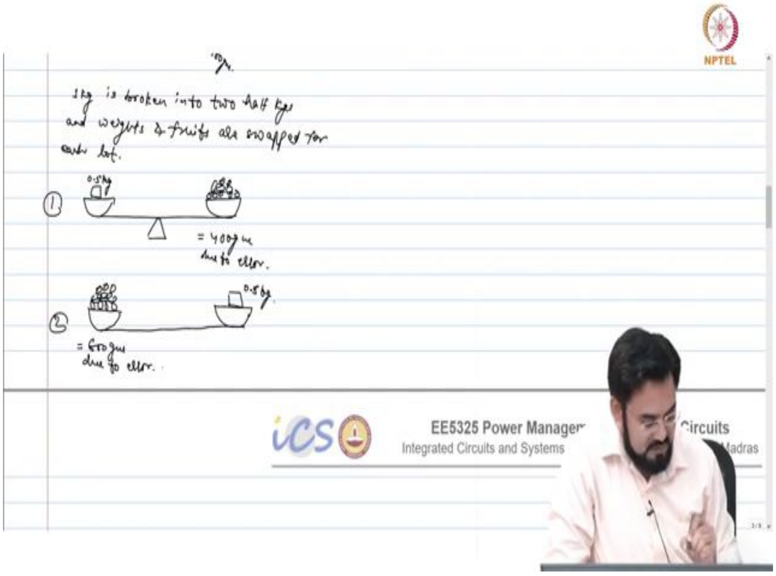

So, 1 kg is broken into two half kg's and weights and fruits are swapped for each lot, ok. So, this is your 0.5 kg weight and then you have your fruits. So, what do you get here, it will give me 400 gram due to error, correct. So, second part you just do this 0.5 kg, so, it will give me due to; so, total equal to 0.4 equal to 1 kg, ok so, your error is.

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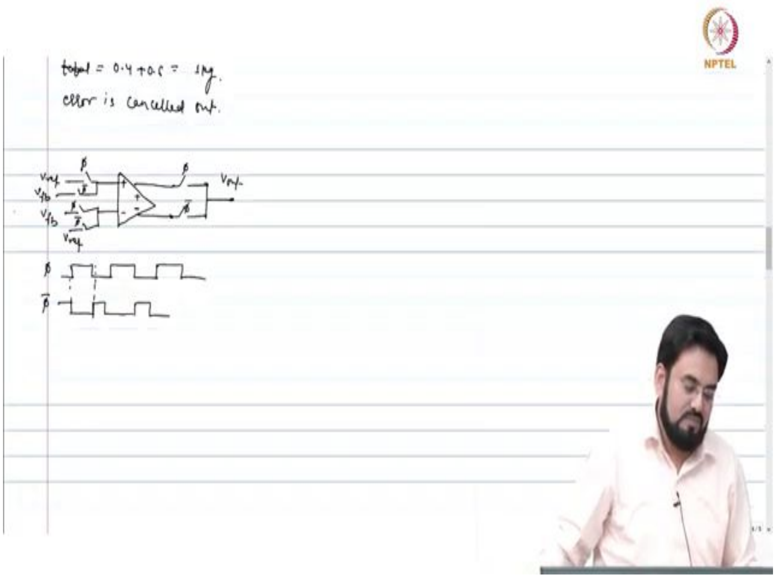

So, what you do in the amplifier? So, each amplifier has two inputs and two outputs; positive and negative, ok. And, since I am operating in the feedback, I have to ensure that when I change the inputs, it should still be operating in the negative feedback which means when you are changing the input you have to change the output also; so, that your negative feedback is maintained, otherwise this will not work.

So, if this is V ref and this is your feedback voltage let us say, then what do you have, you have two switches V f b and similarly you have two switches here; one will, other will V ref, and then you have two switches here. So, this is my plus and this is my minus output and this is your V out.

So, let us see at phi, this is V ref, this is V f b, at phi bar; this is V fb, this is V ref so, at phi this is V out and sorry, and at phi bar, you change inputs and outputs both. So, your negative feedback will be maintained and your offset will be cancelled out and usually these are non-overlapped clocks. So, what would happen at the output if you keep doing this, you know offsets.

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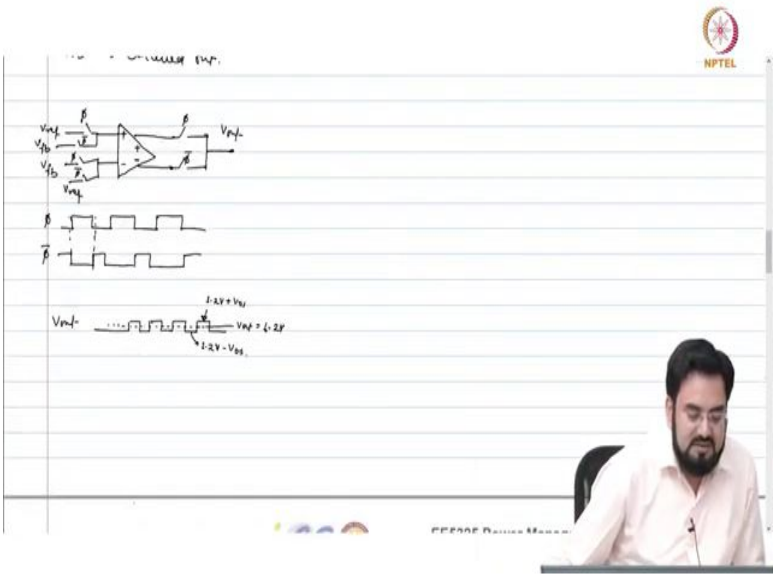

So, output will be looking like this instead of constant dc. So, let us see you had a offset. So, depending on whether offset is positive or negative, your output will be a DC, whatever your desired output is minus or plus V off ok, but now you are basically shifting the offset in both the sides. So, it will keep doing this, and average will be whatever let us say V out is 1.2 volt and this will be 1.2 volt plus V offset and, this will be 1.2 volt minus V offset correct, but average will be, so, you will get a ripples. So, your ripple will be plus minus twice of offset, peak to peak ripple. So, if you can afford to have that ripple then it is fine, if you cannot then this method will not work in that case. So, the only way it will work, you have to filter out these ripple by putting a low-pass filter at the output and then you can get it work. So, use a low bandwidth, low-pass filter and filter this, and if your system is very slow.

Let us say this output is going to some next stage, which by default has a very low bandwidth then that will automatically filter it out, but if you do not then you have to apply some filtering. So, for most of the time you are, it is good enough, your static offset cancellation is good enough for regulator application.

This is mostly used for very high accuracy application in the instrumentation and all those like ADC's ok; so, other ways you combine the both. So, let us say your offset is 10 millivolt. So, I would be seeing like plus minus 10 millivolt ripple which is quite huge. So, what do you do, 10 millivolt you can brought it down to 1 millivolt by using offset, a static offset cancellation and now you apply this. So, your ripple will be only plus minus 1 millivolt so, that is another way to reduce this ripple.

Student: (Refer Time: 12:40) using static here reducing the.

With the static so, if I want to reduce let us say with the static I want to reduce by a 100 times, then I know it will require very high resolution DAC for all those resistors, which will make it very complicated huh. So, what do you do, you just use a 3 or 4 bit resolution there. So, you know that your maximum offset can be 10 millivolt, with 3 to 4 bit, you can bring it down to, or with the 4 bit bring it down to less than 1 millivolt, ok.

So, now, after that if you apply this dynamic offset cancellation on top of that your ripple will be only plus-minus 1 millivolt or less, but if you do not use a static offset cancellation then all the offset is now getting corrected by this dynamic. So, your ripple will be larger in that case, ok. So, most of the time we use, combine the two techniques, you first cut do the static offset cancellation bring it down to; I mean, whatever easily you can do with the design one millivolt or so, and then on top of that you apply this dynamic offset cancellation, ok.

So, I mean, this technique is also called chopping actually because they are chopping the input. Now, it is not a continuous, but you are chopping the input basically, sampling the input and just swapping the input. What could be the other way, any other way of doing this dynamic offset cancellation?

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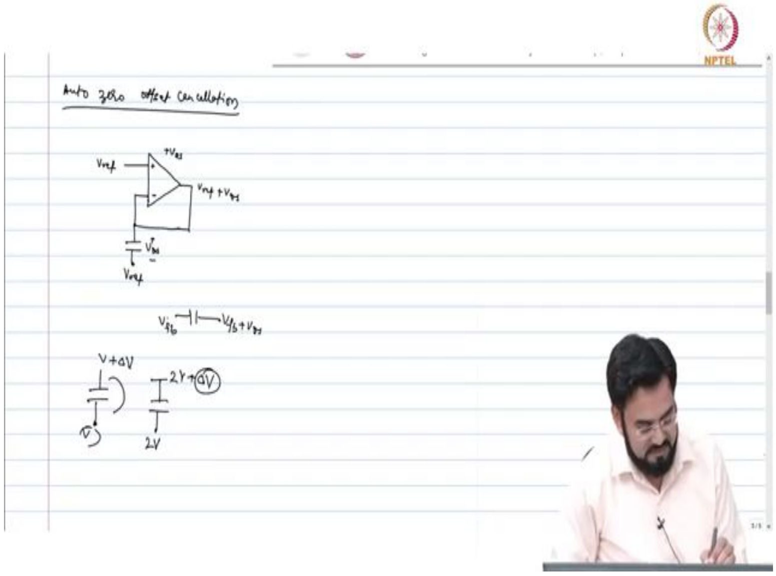

So, let us say I have this plus, minus; I apply V ref here and I apply V fb here in the feedback. So, if it has a offset of let us say plus V os and if I connect it in the feedback, what would happen? Where will this output go? This will go to V ref plus.

V os. So, now, if we had a cap here, this will store V ref plus V os. So, you had a plus V os which means at a positive terminal instead of V ref it was looking at V ref plus V os, correct; so, which means if I apply the, instead of V ref plus V os, if I apply the.

V ref minus V os, then.

But, how will you do V ref minus V os with this, or what could be the other way. So, you apply V ref minus V os or you apply a V ref, sorry, V in plus, or whatever V fb we are applying, you add that offset in the V fb, both are same, either you subtract there or add on the other side, ok. So, what we do actually, we connect this terminal to V ref; now, where will this go, V ref plus V os? It does not matter how, where the bottom plate disconnected.

So, now, how much voltage is stored? Now, if I take this capacitor and apply a V in here, or V fb, where will this go?

V fb plus V os. Because, capacitor voltage does not change, whatever is stored, it will it will remain stored. So, what do you are changing, only changing the common mode level on which this is floating, correct, that is how switch cap works actually. So, any cap if it is connected to any V voltage and if this is V plus delta V. So, no matter what you apply here, if you give a 2 V here then this side will go to 2 V plus delta V, because this delta V will be maintained by the cap, ok.

The common mode voltage will keep moving, but that capacitor whatever capacitor is storing it will remain stored across the cap because it cannot change for a floating cap, until unless you connect the other side to ground. If you hard connect to ground then whatever you charge it, it will, that charge will be stored and that is what you are doing here; when you are connecting in the unity feedback, this other side is considered as good as ground V ref. So, you charge it to fully, at V ref plus V os and then you change the other plates. So, this will change. So, in the next phase we apply a V fb plus V os and that offset will get cancelled out, ok. So, the same thing you require here, I am not showing the phi and phi bar, but you require switches and this capacitor.

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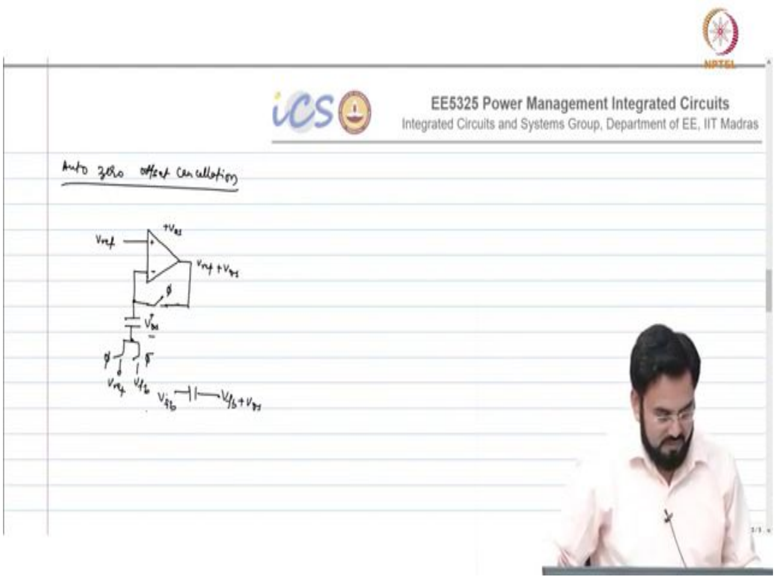

So, one switch will connect to here for unity feedback. So, let us say phi and then this capacitor output also needs to be changed, so, you will have again 2. So, phi will connect to V ref and phi bar will connect to V fb. So, this is called auto-zero actually. So, you connect it in the unity feedback, store the offset and then in the next cycle you cancel that by adding or subtracting that offset from your feedback voltage, ok.

So, if you are doing on the V ref side, you have to subtract instead of adding. So, in the switch capacitor circuit, most of the time use this because by default switch capacitor circuit has a clock, it is a switching circuit. So, you can easily apply these concepts there, but in a continuous time this is some extra overhead you have to add.