Power System Frequency Analysis and Hardware Overview

Created with Smart Noter

Speaker 1 00:00

How to, how do they, you know, transmit? So that would be the communication part mainly.

Speaker 2 00:06

Okay.

Speaker 1 00:07

Which we will talk about. So let's talk about rate of change of frequency.

Speaker 2 00:12

Okay?

Speaker 1 00:13

So rate of change of frequency. We, we found out that frequency is nothing but change in the angle D PI by dt, right? And we calculated that by, you know, change in the angle from one window to the second window, okay? Divided by the time delta t, right? And we calculated the frequency using that, okay? So now we want to calculate the rate of change of frequency. So frequency, as we saw during the power system, it can change, you know, it's not constant. Let's say this is time and this is the frequency. Obviously it's constant if nothing happens in the power system, right? There is no disturbance in the power system. But if there is a disturbance, it can do many things. And we will look at that. You know, it can do like this. It can change on a linear scale, it can decrease on a linear scale and then come back to the normal value. Or it can oscillate like this.

Speaker 3 01:35

Right?

Speaker 1 01:37

So there are various aspects that, you know. So it's not constant and it's not linear.

Speaker 2 01:44

Okay?

Speaker 1 01:45

So what we are going to do is in order to calculate the rate of change of frequency, we are going to express this frequency in terms of nonlinear second order equation.

Speaker 2 01:56

Okay?

Speaker 1 01:57

So I am going to say frequency is nothing but at square.

Speaker 3 02:06

Right?

Speaker 1 02:08

Or angle, for that matter. We should say angle, you know, because frequency is rate of change of that angle.

Speaker 2 02:18

Okay?

Speaker 1 02:19

So angle is nonlinear. And we are going to express. And if it is highly nonlinear, you can always add the third term depending on your situation, right? You can always say it's highly nonlinear. I'm going to add that. But let's work with two. And usually two are enough up to square t squared. So what would be the frequency? The frequency will be D phi by dt.

Speaker 2 02:48

Okay?

Speaker 1 02:49

Actually we can follow along there, okay. And we can write down the frequency. But let's first express this angle, okay? Our aim is to find out these constants, okay? And I know the values of angle at various instants. So you have one window. You know how we do this? Voltage. We sample it.

Speaker 3 03:23

Right?

Speaker 1 03:23

We take, let's say full cycle. We calculate one value of phi. Then we move the sample along, right? We have the second window. We calculate value of phi. So this way at various times we will calculate the value of phi. So I can express this phi like this one, right? Which is nothing but phi naught phi one all the way up to phi N. Okay? Now you may Take only how many unknowns. We have only two. You may take two. So this is least error square.

Speaker 2 04:11

Okay?

Speaker 1 04:13

And then that's equal to at zero, zero. Then we have one delta T, delta T squared. I am just formulating the N delta T. N delta T square times A and sorry, one A and B.

Speaker 3 04:38

Right?

Speaker 1 04:39

One A and B.

Speaker 3 04:44

Right.

Speaker 1 04:50

So I can find, I can do the least error squared because I will know this value. This is matrix A. This is known. These are my measurements, right? So I will know the values of A and B.

Speaker 2 05:03

Okay?

Speaker 1 05:04

Just like we formulated the least error square. Okay, so let's follow along here. Angles are known. Matrix A is known because we know at what times we are taking the calculating the value of phi. Now we can calculate the frequency and rate of change of frequency. So let's go back to our polynomial where we will know A and B. Now, right? If I do the least error square of this and multiply with the the angles, I will know the values of A and B. Okay, so what is the frequency? The frequency is differentiation of one plus.

Speaker 2 06:02

At.

Speaker 1 06:04

Plus B T squared.

Speaker 2 06:07

Okay?

Speaker 1 06:07

So what is the frequency? It's equal to F naught plus delta F is equal to F naught plus one over two PI.

Speaker 2 06:25

Okay.

Speaker 1 06:30

Let'S call that A plus two times bt, right? Two times bt. That will be the value.

Speaker 2 06:43

Okay?

Speaker 1 06:43

And rate of change, differentiation of that which will be one over two PI into two times a two, which we can call B in our case.

Speaker 3 06:54

Right?

Speaker 1 06:55

So that's how we will calculate the rate of change of frequency.

Speaker 3 07:00

Right?

Speaker 1 07:00

So this was the little part that did not cover on last time. So once you know the angles, you can calculate the frequency. Ok. And once you know the frequency, you can calculate rate of change. Or you can do this, okay? You can formulate a least error square algorithm and calculate the values of frequency and rate of change of frequency frequency.

Speaker 2 07:30

Okay?

Speaker 1 07:31

So that will complete the four parameters that I talked about that are required in the power system, especially in the smart grid area.

Speaker 2 07:41

Okay?

Speaker 1 07:42

Voltage phases, current phases, frequency and rate of change of frequency.

Speaker 2 07:48

Okay?

Speaker 1 07:49

And later on we will talk about the IEEE thirty seven point one eight standard. Okay, so now we will talk about mainly two standards. Once we cover the hardware, IEEE thirty seven point one eight, which is synchro phasor standard and IEC sixty one eight hundred fifty which is the communication standard for substation operations. Okay, so those are the two parts that are left. Whatever time it takes, we will take that to cover those. But let's start with the hardware.

Speaker 2 08:47

It's.

Speaker 1 09:16

Okay, so in this One, I am going to give you a brief idea about the id.

Speaker 2 09:25

Okay.

Speaker 1 09:26

So it will be how we acquire the voltage and current signal from the power system. How do we sample it at a particular frequency and then convert to digital numbers and then store them one by one as we sample. Okay, so this will give you some idea about the hardware. Okay, so let's talk about the block diagram, the numerical relay. Yeah, so this is the general, you know, major parts of the, of the I D. Okay. The first part is signal conditioning, okay. Where we interface to the power system.

Speaker 2 10:15

Okay.

Speaker 1 10:15

So from the power system we get voltage and current signals from what we call voltage transformers and current transformers. We talked about that a little bit. Okay, so let's say you have a two hundred twenty KV system where the voltage is two hundred twenty kv and you want to sample that. Now you want to acquire the samples of that voltage. So what you will do is there will be voltage transformers, okay? We are sitting in the switch yard. So you will apply two hundred twenty volt to them and they will produce one hundred twenty volt. They are going to reduce it down, okay, without changing the waveform. The waveform will be maintained. Only the level will go down. And that one hundred and twenty volt will be brought into the control room. That is where this IED is. And it will be given to that ied, that ied. Within that they will have another small transformer which will go from one hundred twenty volt to maybe five volt and sometimes ten volt.

Speaker 1 11:29

And then five volt signal or ten volt signal is the one we are going to sample. So you have to be, you know, now all those ratios have to be taken into account so that we can get the original value.

Speaker 2 11:43

Okay.

Speaker 1 11:43

Because we have done the scaling all along, right? So the first part is scaling and isolation. And the same thing is you have to isolate your ID from the power system, okay? Because power system is, you know, very harsh in terms of high voltage and transients and so on.

Speaker 3 12:03

Right?

Speaker 1 12:03

So you must isolate it. So that's the first part. Then we have anti aliasing filters. I will explain what they are because as soon as you do the sampling, you must have anti aliasing filters. Okay, we'll talk about that. And then there are parts related to data acquisition where once the signal is isolated and scaled down and passed through anti elastic filters, we are going to now sample it, okay. At a particular sampling rate.

Speaker 2 12:37

Okay.

Speaker 1 12:38

Then it will be also converted to digital numbers. Okay? And those digital numbers, those are the samples we are talking about now they will be brought into the microprocessor or DSP or whatever processor you are using. And then you implement your algorithm that we talked about voltage and current transformer phases. And you do that every time a new sample comes, continuously sampling this voltage and current. So that's the process. So this is what the block diagram looks like. It may change from I one ID to two second ied, but the general idea is the same.

Speaker 2 13:23

Okay?

Speaker 1 13:24

You got your signals coming from grant transformers and voltage transformers, okay? You got, you know, filters, you got buffers and A to D converters and so on, right? So this is the general block diagram. So let's talk about the first part which is the signal conditioning. Once you get ctbt, once you get the voltage and currents, okay? Before that there is a isolation and scaling. So the signal conditioning, what is the function of that? As I mentioned, it further steps down voltage and current transformers, voltages and current from the main voltage transformer and the main current transformer. So the main current transformer will bring down the current to either one ampere or five ampere. Let's say you have a current of normal current in the circuit is say two hundred amperes. So you will put a current transformer which is two, two hundred to one ampere or two hundred to five ampere.

Speaker 2 14:40

Okay?

Speaker 1 14:41

So it will bring it down to one ampere or five ampere.

Speaker 3 14:45

Right?

Speaker 1 14:47

So that's the first step. It will step down the signals from mains CT and pt. So you got main PT will give you one hundred twenty volt. You will further step it down to either five volt or ten volt. The main CT will give you either one ampere or five ampere.

Speaker 2 15:05

Okay?

Speaker 1 15:05

During normal condition, during fault it may be ten, twenty times more. So that means during fault, if it is one ampere CT output, you may get twenty amperes. Okay? And you have to bring it down further using, you know, auxiliary ctpt, okay? We call them auxiliary and they sit right within the ied.

Speaker 2 15:34

Okay?

Speaker 1 15:35

And then you have to perform the isolation. That means you have to isolate your IED from the power system and we will see how they do that. That's actually quite important. And then filter high frequency components and noise. That's anti eliasing because we are going to be sampling, so we must remove the high frequency components. Otherwise you are going to have errors in your calculation. So what are the components they use? Use auxiliary ctpts, okay? Those are really small ctpts that sit right within the id. And we use isolation amplifiers or some other means of isolation. We have to do and Optical isolators. If the inputs to ID are only digital and outputs are also digital, zero or one, you can just use optical isolators.

Speaker 2 16:36

Okay.

Speaker 1 16:40

So let's talk about isolation and scale. How do we do the isolation and scaling within that? So this is for voltage signals.

Speaker 2 16:51

Okay.

Speaker 1 16:52

By the way, how many of you are familiar with electronics? I think all of you, right, are familiar. So you are familiar with some of these components, right? Yeah. So as I said, one hundred twenty volt comes from the main voltage transformer. We will step it down to either five volt or ten volt. So this is your auxiliary pt. This one is your auxiliary pt.

Speaker 2 17:25

Okay.

Speaker 1 17:27

And the ratings, you have to be careful about its ratings.

Speaker 2 17:34

Okay.

Speaker 1 17:35

They vary from one volt ampere to twenty four volt ampere normally.

Speaker 2 17:40

Okay.

Speaker 1 17:44

Depending on the, you know, size of the circuit that you are monitoring.

Speaker 3 17:50

Right.

Speaker 1 17:51

It may be two hundred and twenty kv, but the amount of current flowing, say in a line could be thousand ampere, it could be two hundred ampere, it could be, you know, two thousand ampere. So you have to select your auxiliary PT accordingly. Right. And size is about one inch high. Just to give you an idea. It's not very big.

Speaker 2 18:15

Okay.

Speaker 1 18:16

So then we have metal oxide barrier strand.

Speaker 2 18:19

Okay.

Speaker 1 18:20

That's the component that goes in front of the primary of auxiliary pt.

Speaker 2 18:26

Okay.

Speaker 1 18:27

It basically acts as a surgical pressure.

Speaker 2 18:31

Okay.

Speaker 1 18:31

As soon as some transient comes, it's going to bypass it, right? It's going to bypass that. It doesn't allow it to go further.

Speaker 2 18:42

Okay.

Speaker 1 18:43

Transient or a high voltage.

Speaker 3 18:45

Right.

Speaker 1 18:46

It's going to pass, bypass that. So it acts as a surface pressure.

Speaker 2 18:51

Okay.

Speaker 1 18:52

So and primary and secondary are electrically isolated. So they, they are only magnetically coupled because remember, this is where your IB will be. So these parts are only magnetically coupled. They are electrically isolated from each other. This is one way of doing isolation and scaling. All the IED use auxiliary pts. They will use auxiliary pt. But isolation way of doing isolation may be different from one IED to another ied.

Speaker 2 19:30

Okay.

Speaker 1 19:31

This is one way of doing the isolation. And then we have the auxiliary ct. If you have a current signal that you are sampling, okay. You will pass it through your auxiliary ct, which as I said, will bring it down further. And then you will convert this into voltage because ieds cannot handle current.

Speaker 3 20:00

Right.

Speaker 1 20:00

Your A to D converters and all other electronics don't work on currents, they work on voltages. So you will make it equivalent voltage.

Speaker 2 20:11

Okay.

Speaker 1 20:12

So obviously on the secondary side, you have to put a load here. I have shown one. Ohm, but it may not be one ohm and across that you will get your voltage signal.

Speaker 2 20:25

Okay.

Speaker 1 20:26

So again the ratios have to be kept in mind. You have scaled. The current is scaled down by the main CT first and then by the auxiliary CT and then converted to equivalent voltage. So there are three ratios you have to be careful about, right? So that you can, you know, get the original value of current. So current is stepped down and converted to equivalent voltage signal.

Speaker 2 20:56

Okay.

Speaker 1 20:57

And MOV is on the secondary side here.

Speaker 2 21:01

Okay.

Speaker 1 21:02

So it will not again allow anything to go further to the idd.

Speaker 2 21:07

Okay.

Speaker 1 21:08

And power rating of the resistance that you use, it has to be, you know, sometimes it becomes an issue. Okay, let me give you an example. Let's say during the fault on the secondary side of your auxiliary ct, you get a grunt of pick a number ten ampere.

Speaker 2 21:31

Okay.

Speaker 1 21:32

What should be the rating of that one ohm resistor I square R. Right. So it has to be one hundred watt resistor.

Speaker 3 21:43

Right.

Speaker 1 21:44

Sometimes that becomes an issue.

Speaker 2 21:47

Okay.

Speaker 1 21:48

Sometimes you have to use a two pigeon resistor. So that's why the value, if you use five ohm, for example, five ohm resistor.

Speaker 2 21:58

Okay.

Speaker 1 22:00

And you get, you know, ten ampere. So now you're talking about five hundred watt resistor.

Speaker 3 22:09

Right.

Speaker 1 22:10

So you have to be careful while picking that. And in this case also, primary and secondary are isolated. They are magnetically coupled but electrically isolated. So this is one way of providing isolation.

Speaker 2 22:25

Okay.

Speaker 1 22:28

The other way is what they call isolation amplifiers. If you are interested, I can give you some idea about that.

Speaker 2 22:40

Okay.

Speaker 1 22:41

So these are used mainly in medical equipment.

Speaker 2 22:46

Okay.

Speaker 1 22:47

And you know, at one point they were very costly but prices have come down so now they have started using them in ID also.

Speaker 2 22:57

Okay.

Speaker 1 22:58

That's another way of providing the isolation. But as I said, majority of the relays I d use these kind of components because these are cost effective, not very expensive. Mop's are not very expensive.

Speaker 3 23:14

Right.

Speaker 1 23:14

They use this kind of circuitry. Yeah, I do have a blurb about isolation and amplifiers. So isolation amplifiers, they are basically like operational amplifier OP amps, but they have a galvanic discontinuity between their input and output planes. So this is what happens. They still use transformer.

Speaker 2 23:52

Okay.

Speaker 1 23:52

Let's say we are talking about voltage. They still use the transformer and then they have the circuitry on this side. Circuitry on this side.

Speaker 2 24:01

Okay.

Speaker 1 24:01

Just like operational amplifier. So what you will do is let's say I got a voltage signal, pick a number one hundred twenty volt, sixty hertz.

Speaker 2 24:13

Okay.

Speaker 1 24:14

That's the one I want to isolate and bring to the other side. So what they will do is they will lower the voltage, okay? They will lower the voltage. And that's done basically by dividing the signal, okay? There is no transformer there. So you can lower the voltage. Let's say you lower it to five volt, sixty hertz, okay? Then what they will do is they will transform this signal into a high frequency signal, very high frequency signal, okay? They will transform into very high frequency, maybe in megahertz, and then they will use the transformer. And the reason for transforming basin to high frequency is that, you know, the size of this transformer becomes very small, okay? If you go high frequency, the size becomes much smaller. So that they can put this transformer right on the chip, okay? So this one sits on the chip. And then they will bring down the voltage level, okay?

Speaker 1 25:27

And obviously use the output, okay. So and to fully isolate, they will even isolate the power supply on this side and on this side. So there are, you know, different isolation of power supplies also happens in that. So this is the basic concept of that isolation amplifier. They were originally used in medical devices so that patients get electrical shocks, right? Because this side is the patient, right? So that's where, you know, they were originally used. They were very expensive. I used it in my first design, when I designed the very first iv, I used these isolation amplifier. At that time, one isolation amplifier was something like over hundred dollars. So it was very expensive at that time. We are talking about thirty years back, right? But now, obviously prices have come down. So modern ied, some of them may.

Speaker 2 26:31

Be using that, okay?

Speaker 1 26:34

So they are, you know, mostly reduced in instrumentation amplifiers and so on. So as I mentioned, protecting patients undergoing medical monitoring or diagnostics, okay? So they completely break the ground loops by isolating even the power supplies, okay? So that's what happens with these isolation amplifiers, okay? But relays are. Majority of the relays are okay with this kind of circuitry, okay? And then there are optical isolators, okay. Which are basically transferring whether, you know, on off signals. So you can't use optical isolators there, okay? So they will provide very good isolation because you are basically converting your electrical signal into optical signal, passing the optical signal along and converting it back to electrical signal at the other end. And those chips are available actually, you know, very cost effective, very cheap, right?

Speaker 1 27:54

So they will block unwanted currents originating from one side. So they provide isolation, basically. And they also eliminate ground loops, right? And then there are optical eye leds. They can be used for, I think These ones are fairly common optical leds. So you can basically use them to. Because all you want is the switch status. Let us say circuit breaker is on or off, right? Zero or one. Okay, so they are basically digital output input and digital outputs. That's what you want. Okay, so this was the isolation and scaling. Just give you a very brief idea about that. We can. I have a much more detailed presentation on these but I think for this course this is enough for you to just understand the basics of IEP from the hardware. And then comes the anti elastic filter. Once you have isolated and scaled your voltage and current signal, obviously it will be converted to voltage signal.

Speaker 3 29:11

Right?

Speaker 1 29:12

Then you have clean signals in a way. Okay. Now you have to apply them to anti aliasing filters.

Speaker 2 29:23

Okay.

Speaker 1 29:28

So what is the purpose? So anti elapsing filter, wherever you are doing sampling you are going to need anti elapsing filters.

Speaker 2 29:38

Okay?

Speaker 1 29:39

And the reason for that is that the frequencies that are higher than half the sampling frequency when will look like lower frequencies and they will interfere. So that will obviously affect the accuracy of your estimation, voltage and current. So let me illustrate what I mean by that. Let's suppose I have a waveform of twelve sixty hertz and I am sampling at twelve hundred hertz.

Speaker 2 30:12

Okay.

Speaker 1 30:13

Ideally I should eliminate everything above six hundred and thirty hertz. Half the, sorry, six hundred hertz half of the sampling frequency.

Speaker 2 30:26

Okay.

Speaker 1 30:27

I should, theoretically I should filter this signal and eliminate.

Speaker 2 30:31

Okay.

Speaker 1 30:32

So obviously if I did that, twelve sixty hertz will be gone. Okay, I'm eliminating everything above six hundred hertz, right? But let's say I don't do that.

Speaker 2 30:44

Okay?

Speaker 1 30:44

And I continue sampling at twelve hundred hertz and I have a signal of frequency twelve sixty in my waveform. So if I sample it, this is how it will look like the green waveform.

Speaker 2 31:02

Okay. Okay.

Speaker 1 31:04

If I sample it, all these at twelve hundred hertz, this is the waveform and this waveform appears like a sixty hertz.

Speaker 2 31:15

Okay?

Speaker 1 31:17

So if you have original sixty hertz in your signal and you have twelve sixty, you don't use anti aliasing filter. Your sixty hertz phasor calculation using the samples will be okay because you have interference from twelve sixty hertz. This is why you need to eliminate all the frequencies above half of six hundred half of your sampling rate. In this case that will be six hundred hertz.

Speaker 2 31:48

Okay?

Speaker 1 31:49

So you have to eliminate those. And for that we use anti aliasing and that has to be used everywhere, wherever you are doing sampling. It doesn't matter whether you know at any other system.

Speaker 2 32:03

Okay?

Speaker 1 32:04

So what are the functions of this? Because of that? So it will prevent aliasing. So that's why it's called anti aliasing. It's going to prevent aliasing.

Speaker 3 32:14

Right.

Speaker 1 32:16

And it will also at the same time filter out noise. So let's say twelve hundred hertz, you have sampling rate. Theoretically you should be eliminating everything about six hundred hertz, but you know, the filters, you know, let's say this is the frequency, okay? You want to eliminate everything above six hundred.

Speaker 3 32:42

Right?

Speaker 1 32:43

There is no. Everything else should be one and this should be zero. Here it should be all zero. Right? Above six, there is no such thing. There is no filter like that. Characteristic. This is ideal characteristic.

Speaker 2 33:00

Okay.

Speaker 1 33:00

Depending on the design of the filter, you may get, you know, if you take a cutoff of six hundred hertz, you may get something like this where it will become zero, maybe at eight hundred hertz, okay. Depending on the design.

Speaker 2 33:18

Okay.

Speaker 1 33:19

Order of the filter. Or if you want to cut at six hundred, then you may have to do something like this. So that means you don't have gain of one for these frequencies.

Speaker 2 33:33

Okay.

Speaker 1 33:34

So this is why, what. Theoretically it's six hundred hertz, but practically what they will do is they will maybe go down to four hundred hertz because of this. Because if you start at four hundred, it will eliminate everything above six hundred. Because your filter response is not a perfect right, where it's one and then suddenly it's zero. You can't get that kind of response from filter.

Speaker 2 34:03

Okay?

Speaker 1 34:04

So theoretically six hundred, but practically much less than six hundred, depending on the design of your filter.

Speaker 2 34:12

Okay.

Speaker 1 34:13

So it's designed to cut off at least frequency more than half the sampling rate. At least. But as I said, practically it will be much lower than half the sampling.

Speaker 2 34:26

Okay.

Speaker 1 34:28

I think you are all familiar probably with these. I don't have to go over this. There are various printer types. Band pass, which passes only band of frequencies.

Speaker 2 34:37

Okay.

Speaker 1 34:38

There is a band reject low pass. High pass. High pass, which are phase shift.

Speaker 2 34:44

They basically.

Speaker 1 34:46

So in relays in I. Ds we use either low pass or band pass. Majority of them use just low pass. This is a low pass filter. That means it passes only lower frequency. Because the aim is basically to eliminate higher frequency. So they use low pass filter most of the time. So this is the filter. It will allow frequencies below the cutoff to pass and then above cut off, it has to eliminate or at least the venuator and then make it zero at half the center.

Speaker 2 35:29

Okay.

Speaker 1 35:30

And then sometimes they use band pass also.

Speaker 2 35:33

Okay.

Speaker 1 35:34

So remember the algorithms which do not eliminate DC and decaying dc. So if you use that kind of algorithm, then make sure that you use a band pass filter.

Speaker 2 35:48

Okay?

Speaker 1 35:49

So now that brings me down to another point. These type of filters you choose and the cutoff frequency and you know, whatever characteristics you use, you have to decide this in conjunction with your phasor calculation algorithm, okay? They both have to work together. If your phasor calculation don't eliminate DC and decaying dc, then you have to use band positive.

Speaker 2 36:20

Okay?

Speaker 1 36:21

If they eliminate DC and decaying dc, then you can use low pass filter. But what would be the cutoff? Let's say you don't eliminate fifth harmonic in your phasor algorithm, which will be three hundred hertz. So you better use the low pass filter. That eliminates three hundred hertz.

Speaker 2 36:39

Okay?

Speaker 1 36:40

So it has to be used in combination at those when you design it.

Speaker 2 36:47

Okay.

Speaker 1 36:49

Now there are various forms of implementation. I don't know if you have done filter design. I think it's probably done in second year or third year using operational amplifier. So it's actually quite simple. So they use passive elements only. So combination of RL and C. Right. I'm not going to go into the details of that. Okay. How they do that, because that's really very simple stuff.

Speaker 2 37:18

Okay.

Speaker 1 37:19

And they do not use any external power source. That's why they are called passive.

Speaker 2 37:25

Okay.

Speaker 1 37:26

And then there are active filters which are basically made of operational amplifiers.

Speaker 2 37:31

Okay?

Speaker 1 37:32

Operational amplifiers. And they need to be powered externally. So they are going to need a power supply. The last one, I don't know how many of you know about these. Have you heard about switched capacitor filters? Anyone? Nobody have heard about those? Okay, let me just give you a brief idea what they are. So these are again operational amplifiers. The circuits are very similar to active filters which are operational amplifier.

Speaker 2 38:10

Okay?

Speaker 1 38:11

But remember, these filters, you cannot put them on a chip other than you can use operational amplifier. Then you have to add external components, rlc, okay? To get the filter. Whereas here what they have done is the same circuit, put it on a chip, okay? And once you put it on a chip, then what happens is you can actually control the values of those rlc, okay? By just. By controlling the frequency. Sampling frequency.

Speaker 3 38:49

Right?

Speaker 1 38:50

So you can put, you can, you can put C and L on a chip. You can't put R. You can't put resistance on a chip. So what they did was they used a switch and a capacitor. And by switching on and off, you can simulate the resistor. It behaves like a resistor. Just by switching it on and off.

Speaker 2 39:21

Okay.

Speaker 1 39:22

So that's what they have done. So replace the resistor with a capacitor and a switch. And now you can see by controlling the rate of switching, I can vary the value of the resistor. So that's what makes these switched capacitor filters in a way very, what should I say adapting. That means just by changing the switching rate I can change their cutoff frequency.

Speaker 3 39:54

Right.

Speaker 1 39:55

And I can even change the type of filter whether it's a band pass or low pass filter.

Speaker 3 40:02

Right.

Speaker 1 40:03

So those are again these are more modern type of implementations.

Speaker 2 40:09

Okay.

Speaker 1 40:10

But majority of the relay is actually jews passive filters because you can get very good filters just by using RLC combination modern ieds.

Speaker 2 40:23

Okay.

Speaker 1 40:23

Where you want to be adaptable, you want to change say the cutoff frequency. They use switched capacitor filters. And these are actually not very expensive. They're pretty cheap, right? So and they come on a chip. So if you really want to reduce the size of your ied, the total, you know, area hardware of the hardware, you can use these cluster filter because it's just one tiny chip, you can put everything on a small, very small, you know, footprint they have. Okay, so those are the filter anti aliasing filters.

Speaker 3 41:08

Right.

Speaker 1 41:11

Okay. So once you have your signal passed through these anti aliasing filters, now you are ready to acquire, sample them at a particular frequency and convert them into digital numbers.

Speaker 2 41:31

Right.

Speaker 1 41:32

So that's the data acquisition part.

Speaker 2 41:35

Okay.

Speaker 1 41:36

So converts the analog signals to analog data to numbers. So what are the main components in this part? The main components are the buffers which basically because if you're using switched capacitor filters, you need a buffer in between.

Speaker 2 41:54

Okay.

Speaker 1 41:55

Because their input output characteristics don't match very well with what we are going to use ahead of them. So you will end up using which is sample and hold amplifier. So we will use sample and hold, which will basically sample the signal, hold it till you convert it and then next time again sample it, hold it as you convert with A to B converter and then depending on how many A to B converted used you, which you need multiplexers.

Speaker 2 42:29

Okay.

Speaker 1 42:30

Nowadays A to D converters are cheap. So you know, Id use one A to D converter for every channel. So you don't need this multiplexer.

Speaker 2 42:40

Okay.

Speaker 1 42:41

So if you are using eight signals, there will be eight A to D converters. So very fast they will convert simultaneously at the same time. Okay, so why do we need buffers? These are basically unity gain and they need impedance matching because your input is coming from switched capacitor filters to this block and impedances don't match.

Speaker 2 43:08

Okay?

Speaker 1 43:08

So you need buffers, otherwise you are going to overheat your switch capacitor filters in that case, right? So they are basically unity gain operational amplifiers. So they have a high input impedance and low output impedance so that you can transfer the signal very well. Otherwise signals won't transfer very well from one stage to the other stage.

Speaker 2 43:36

Okay?

Speaker 1 43:43

And then we have sample and code. As I said, these components are going to sample and hold the signal. So a to D converter requires that the signal be steady. You can't, you know, apply a signal to A to B, because A to D converter takes time to convert. It's not instantaneous. It's going to take some time. So during that time the signal value must be held constant. It can't change, right? So and input voltage and current should be sampled at the same instant to preserve the phase relationship.

Speaker 2 44:27

Okay?

Speaker 1 44:27

And this is important, I think let's spend a little bit of time here because we are going to talk about this in synchro phases also.

Speaker 2 44:37

Okay?

Speaker 1 44:38

Let's say you got a voltage signal, okay, which is here at zero, and you have a current signal which is here. And this angle is say theta.

Speaker 2 44:51

Okay?

Speaker 1 44:52

This is all it. Now obviously you want to calculate the voltage phaser and current phasor using the sampled values, okay? Let's say voltage is here.

Speaker 2 45:05

Okay?

Speaker 1 45:05

And your front is lagging by thirty degrees. So it will look like, it will look like this, you know, something like that. It's thirty degrees. This is thirty degrees. So it's lagging by thirty degrees. Suppose now you use your algorithm. What you have done is you are sampling it and use your algorithm to, you know, so your time reference is zero here, right? You are using your algorithm, so you are sampling it.

Speaker 3 45:49

Right?

Speaker 1 45:51

And your time reference is zero here also. So you're sampling it and you use your algorithm. And let's say, you know, pick a number, it's one hundred and twenty angle zero.

Speaker 2 46:04

Okay?

Speaker 1 46:06

Now if you want to preserve this relationship, you must sample this current at the same instant at the same time. You must sample this current also. So it has to be sampled exactly at the same instant. Otherwise you are not going to be able to preserve that phase relationship, okay? You will have a different phase. If you don't do that, your current can be anywhere, okay? And having this preserving this phase relationship is important when you are working in power system, you want to know where your phases are with respect to each other, okay? So that's why it's extremely important all these voltages and currents has to be sampled at exactly the same time, okay? And this is why in ieds, we use one single sampling clock, okay? So, so that clock is going to produce the sampling pulse which will be given to sample and hold. So input voltage and current should be sampled at the same instant to preserve that relationship.

Speaker 1 47:28

And we are going to see that when we will talk about synchro phasers also, okay? And here in id, you have basically the local voltages and currents because all the signals come into ied. Let's say you have three voltages. This is your ied, right? You have three voltages and three currents coming in. These are voltage ABC currents. Abc. If you sample all of them at the same time, and in id, you can produce a sampling clock sampling pulse using a clock, simple clock, right? And you sample them exactly like this, all of them at the same instant, doesn't matter where they are, right? If you do that, their phase relationship will be maintained.

Speaker 2 48:18

Okay?

Speaker 1 48:20

Now this is, you can do that because sampling clock is right here within the ied, right? What about if you have one ID here and another ID somewhere in bed, okay? And they are measuring, you know, so this is your power system, this is here, this is in bed, right? So here obviously you got an ID which has its sampling clock. So all the local you can synchronize, you can measure, right? You can produce the same pulses. But how do you do this in bed? So you want exactly at the same point, okay? What we will do is we will use the GPS clock, okay? We will talk about that later on. And that way everything in the whole power system is going to be, say, synchronized because every single voltage and current is sampled exactly at the same time, okay? And the clock will be provided by the gps, okay? So we will talk about that later on. But at the local level, make sure that we use the same clock and, you know, sample them exactly at the same time, okay?

Speaker 1 49:53

So the function is basically the input appears. So you apply the input. This is the waveform I want to sample. You apply it to sample and hold, okay? So when you are in the track mode, in the sample mode, you get same output from your sample and hold exactly same. It follows it, okay? It output looks exactly like this. But as soon as you say hold, and that will happen when you want to sample. So this sampling pulse will come, you say hold, then the output will be held at that value, okay? So that's what happens. Circuit switches to the hold mode, and then that Signal is given to a to D converter for conversion because you want to sample that particular value. This is the value you will hold, for example, right? Whatever value is at that sampling interval.

Speaker 2 50:59

Okay?

Speaker 1 51:00

So this is the basic circuit of that. It's very simple. When you close the switch, the capacitor will charge and whatever voltage is in the input will appear at the output. So that's the sample or track mode. You are following the input voltage.

Speaker 2 51:20

Okay?

Speaker 1 51:21

As soon as you open that switch, you are in the hold mode. Whatever value was there on the capacitor, it will be held.

Speaker 2 51:33

Okay?

Speaker 1 51:33

And that's the value. That's a real sample value. And then you will convert that value to digital number. So this is the basic of that. But obviously basic circuit has issues which they have fixed using operational amplifiers. This is just to give you an idea how it works.

Speaker 2 51:55

Okay.

Speaker 1 51:56

What are the issues with the basic circuit? You can have too large a capacitor. So then the time, charging time will be very large, right? So it will take some time to track.

Speaker 2 52:12

Okay?

Speaker 1 52:14

But at the same time you need a large capacitor. But if you make it too small, then capacitor charges fast and also it will discharge fast. Remember, when you are doing A to B conversion, you want to hold this value constant, okay? And that voltage is held by your capacitor, right? So if capacitor starts discharging, eventually it will discharge. So that will be an error.

Speaker 2 52:43

Okay?

Speaker 1 52:44

So you have to kind of strike a balance.

Speaker 2 52:47

Okay?

Speaker 1 52:47

But they have very good sample and hold tips nowadays where, you know, they use operational amplifiers.

Speaker 2 52:58

Okay.

Speaker 1 52:58

Once the signal is held, then you choose a to D converter. You want to convert that value to a digital number.

Speaker 2 53:13

Okay?

Speaker 1 53:29

So we saw that, you know, our algorithm needs those samples in digital values.

Speaker 2 53:36

Okay?

Speaker 1 53:37

So function is basically to convert that to equivalent number.

Speaker 2 53:45

Okay?

Speaker 1 53:45

And then we will use those samples to calculate our phases. That's what we have started with.

Speaker 2 53:52

Okay?

Speaker 1 53:53

So the number that they convert is really the ratio between unknown input and the full scale voltage.

Speaker 2 54:02

Okay.

Speaker 1 54:04

Now the resolution of a to D converter is important. It depends on the number of bits, you know. And we have a large difference between load current and fault current. So we require a proper A to D converter. Okay, I'll give you an example why. So resolution depends on the number of bits and, and the bitcode.

Speaker 2 54:34

Okay?

Speaker 1 54:34

Let's suppose I have a eight bit A TO D converter.

Speaker 2 54:41

Okay?

Speaker 1 54:42

The range is between zero to two hundred and fifty six, right? So you can have zero zero zero eight zero s and then eight, one S. Okay. And the uncertainty in this case will be plus minus one over five twelve.

Speaker 3 55:01

Right?

Speaker 1 55:02

That's your unserved.

Speaker 3 55:05

Right.

Speaker 1 55:06

So let's suppose I have a full scale voltage of ten volt. Then the minimum change that I can detect or convert is going to be ten over two hundred fifty six, which is thirty nine millivolts.

Speaker 2 55:25

Okay?

Speaker 1 55:26

And remember, this is right at the ied. We have already scaled it many times. So if I. Let's say I have scaled it thousand times already, right? First was the main voltage transformer.

Speaker 2 55:45

Okay?

Speaker 3 55:46

Right.

Speaker 1 55:47

Which basically took from two hundred twenty K v two one hundred and twenty volt.

Speaker 3 55:53

Right.

Speaker 1 55:54

And then I went from one hundred and twenty volt to say five volt.

Speaker 3 55:58

Right?

Speaker 1 55:58

So there is that ratio. So what is the overall reduction I have done?

Speaker 3 56:04

Right?

Speaker 1 56:05

Two hundred twenty kv. I brought it down to, let's say, you know, for simplicity, ten volts.

Speaker 2 56:13

Okay?

Speaker 1 56:14

So what is the ratio here? Ten to the power three. Right. So the ratio is already ten to the power two. And then I further reduced it, you know, this ten volt. Yeah, I reduced it to ten volt.

Speaker 3 56:36

Right.

Speaker 1 56:37

So first, okay, let us take step by step. I reduced it to one hundred and twenty volt.

Speaker 2 56:44

Right?

Speaker 1 56:45

So what is that ratio?

Speaker 3 56:47

Right.

Speaker 1 56:48

And then that one hundred and twenty volt was reduced to say five volt, that ratio. So overall is this ratio multiplied by this ratio.

Speaker 2 56:58

Okay?

Speaker 1 56:59

So one hundred twenty volt is, you know, just say simplicity is two.

Speaker 2 57:06

Okay.

Speaker 1 57:06

This one is how much? Twenty four. So it's something like the overall is forty eight times ten to the power three. So multiply that by forty eight times ten to the power three.

Speaker 3 57:22

Right?

Speaker 1 57:22

So resolution is very, very poor in this case.

Speaker 3 57:28

Right?

Speaker 1 57:29

So that's why the number of bits you have to be careful about. So let me give you an example here. I have an example of current. Because voltage doesn't change that much. It's the current during fault you can have, you know, twenty times the normal current. So you have to be very careful about the resolution. So let's say I have a two hundred twenty KV level Fault current is twenty kiloampere.

Speaker 2 57:58

Okay?

Speaker 1 57:59

I use five hundred to one ratio ct. So during fault current at the output of the main ct I am going to produce forty ampere rms, which means fifty six ampere peak value.

Speaker 3 58:18

Right?

Speaker 1 58:19

Root two, right?

Speaker 2 58:21

Yeah.

Speaker 1 58:23

Fault current twenty kiloampere, five hundred to one ratio CT output will be forty ampere rms, which is fifty six ampere peak.

Speaker 2 58:34

Okay?

Speaker 1 58:35

So let's say I use level reduction two to one ratio to allow for DC Offset. Don't forget, you know, the current will have a DC offset also. And it can be the same value as the main current. So I need to reduce it further, two to one ratio.

Speaker 2 58:57

Okay?

Speaker 1 58:58

Then I convert this current to voltage. I say twelve ampere is one volt, okay? So then it becomes how much? Fifty six divided by twelve. So many volts.

Speaker 2 59:14

I will put.

Speaker 1 59:15

And let's say I go plus minus five volts.

Speaker 3 59:19

Right?

Speaker 1 59:20

So if I use twelve bit A to D converter, right? I can go between twenty forty seven and minus twenty forty eight.

Speaker 2 59:30

Okay?

Speaker 1 59:30

So twenty forty eight should represent sixty kiloampere peak approximately. It came out to fifty six. So I have rounded it to sixty. So resolution will be thirty ampere.

Speaker 2 59:46

Okay?

Speaker 1 59:47

So it can only measure thirty or sixty or ninety.

Speaker 3 59:54

Right?

Speaker 1 59:55

So that's the resolution. If I use eight bit only, the resolution is under sixty five amperes.

Speaker 2 01:00:03

Okay?

Speaker 1 01:00:04

So you have to be very careful about that. The good news is nowadays, you know, the A to D converters have become cheaper. So you can actually go up to twenty bits. So the resolution is actually very good. But whenever you are designing this, you have to be very careful about that, you know? Exactly. So this is the ideal characteristics of an A to B converter.

Speaker 2 01:00:33

Okay?

Speaker 1 01:00:39

So this is the eight bit, right? So if your ADC voltage is maximum, you are looking at one volt. For example, this will be one eight two eight three eight four eight and so on. And those are the values. So anything from zero to half of that you will get zero, right? So those are the levels. So you basically get that many levels.

Speaker 2 01:01:07

Okay?

Speaker 1 01:01:07

But then there are a bunch of errors. You have to be careful about quantization error because of that, that you have fixed levels. You get this error, which is plus minus half, what we call least significant bit. So you will get that as that's the quantization error. So the correct voltage is read only for the input voltage at the center of each step. That's it. All around it, you will have that error. And the maximum can be plus minus half lsd. It will go like this. You can be anywhere. So this is the quantization error.

Speaker 2 01:01:53

Okay?

Speaker 1 01:01:55

So this is another example.

Speaker 2 01:01:58

Okay?

Speaker 1 01:01:58

One volt, you will have one LSV as zero point one two five volt.

Speaker 2 01:02:04

Okay?

Speaker 1 01:02:05

Your whole range is zero to one volt, right? So you can only go to one LSV zero point one two five volts. So plus minus half LSV will be.

Speaker 2 01:02:16

Your L. Okay.

Speaker 1 01:02:21

That was ideal. A to D converter. Sometimes A to D converters, they will Miss a code, okay, that happens, okay? There will be a code missing, right? So that will give you another error because all code transitions do not fall on a straight line like this one. We had ideal situation, that's not the case. You know, you may be missing. Here you have half LSV linearity error there you have one full lsv, one full code is missing, okay? That happens in A to D converters.

Speaker 2 01:03:01

Okay?

Speaker 1 01:03:01

I have actually seen that happen. Then, you know, so that's basically transition error or missing codes.

Speaker 2 01:03:12

Okay?

Speaker 1 01:03:13

Then there is a differential linearity error which is the step size. Okay, step size, step size could be different, right? So you could have half or you could have one full lsd. Okay, we talked about the missing code already. And then there is another type of error which is integral linearity, okay? Deviation of the code transition point from the fitted line, right? So those are various errors. And then calibration, which is not a big deal now because you, when you start, you do the calibration. So what they do is they will apply a known voltage. Then see what is the output from A to D converter. So you can then calibrate it. You can do that in software, actually you can do that, right? So a really good converter will have less than half LSV linear error, no missing codes. And with temperature also it changes.

Speaker 2 01:04:38

So you have to be careful about that, okay?

Speaker 1 01:04:41

And you will always have the quantization error. Nothing can be done about that.

Speaker 2 01:04:47

Okay?

Speaker 1 01:04:48

Plus, minus half lsd, that will be minimum that you will have.

Speaker 2 01:04:54

Okay?

Speaker 1 01:04:55

So the most majority of the relays use what I will describe as a successive approximation. A to D converter. Okay, so what is the basic conversion method? Let's talk about that. The basic scheme is basically to use a comparator.

Speaker 2 01:05:15

Okay?

Speaker 1 01:05:16

You are, you are comparing the voltage to a known signal.

Speaker 2 01:05:22

Okay?

Speaker 1 01:05:23

Let's say you got eight. You know, I had eight levels, zero to one volt. Each level is zero point one two five volt.

Speaker 2 01:05:33

Okay?

Speaker 1 01:05:34

What I will do is I'm going to say this is my unknown signal that I want to convert to eight bits, okay? And, and to pick a number, let's say this is zero point five volt.

Speaker 2 01:05:50

Okay?

Speaker 1 01:05:51

So these are the levels and so on, right? I will have these eight ladders, okay? So the corresponding. This is three bits, right? Eight levels will be three bits, yeah. And so on, right? So what I will do, this is my unknown signal. All I will do is generate a signal corresponding to these and compare this signal with that. That's it. Okay, so this Signal happens to be exactly like this, so the output will become one, zero, one. This is the simplest way to explain how A TO D converters work, okay? So we will compare, okay? Now there are various ways of doing that, okay? And obviously I have to produce these voltages too, right? So there are various ways of doing that. That's why we have different type of A TO D converters, okay? The very fast ones are what we call flash converters, okay? They are basically used in videos where we need very fast outputs.

Speaker 1 01:07:34

So what they will do is they will parallel do all these voltage levels and wherever it matches, that's the output. So just in one shot they will do that, okay? Those are flash converters. And then in id's we use what we call successive approximation.

Speaker 2 01:07:58

Okay?

Speaker 1 01:07:58

So flex is the approximation, okay? It's much more efficient. And this is the one that's widely used, most cost effective, okay? What we will do is we will generate the voltage and use a successive approximation logic, okay? I don't know if you remember as kids, you know, somebody has asked you to, you know, give a number or something, right? You say, think of a number and then you say, is it less than this? Is it more than this? And then in two, three tries, they could tell you that this is the number you are thinking. Successive approximation is exactly that, okay? It will. Let's say this is. This is zero point four volt. I want to, you know, compare. So what I will do is I will start with the middle of this, okay? And let's suppose the middle of this is one, two, three, four, five, six, nine. Let's say it's here. Let's say middle is here. I'll compare this value with the middle and then see if it is more or less.

Speaker 1 01:09:26

Then I will say it's less, right? Less than zero point five. Then I will go to half of this, which is zero point two five. The middle of the. So I know it's not there, it's in the upper range. I'll go to the half and then I will say, is it less or more? Obviously it's more. So I will go to this value and that's the conversion, okay? So three tries, and generally that is related to number of bits. If you have three bits in three tries, I can find out the value. If you have twenty bits, then in twenty tries I will find that, okay? This is the successive approximation logic that we use in these conversions, okay? So what they will do. So you see the clock and successive approximation logic, which is this logic. So clock is basically when in one pulse you do one comparison. Second pulse you do the second. Third pulse you do the third comparison. So depending upon the speed of the clock, the speed of conversion happens.

Speaker 1 01:10:50

So that's what we do. And then we compare. That's the comparator and we have n bet d to a convert. That means we produce those voltages, okay? So this is the one that's very widely used, okay? So we basically perform what we call a binary search.

Speaker 2 01:11:15

Okay?

Speaker 1 01:11:16

This is the binary search. That's the same logic, okay? So that's our input at the top to a comparator. And then we basically produce a signal, compare it, and based on that we produce the next signal, compare it. And as I said, depending on the number of bits, if it is three bit, as I showed you, in three tries I will have the output digital output, which I can then capture. Okay, so, so we start with the half. D to A converter is set to the half value, right?

Speaker 2 01:12:00

So.

Speaker 1 01:12:03

This is again a, you know, same interpretation of that in three pulses we are able to find out the value of that.

Speaker 2 01:12:13

Okay?

Speaker 1 01:12:16

So let's just give you one more example. Consider a four bit converter, okay? Full scale voltage of sixteen volt, okay? And I have a signal of eight point six which correspond to binary output of one, zero zero zero. How does it happen? How do we start? Okay, Generates the number at the center of the sequence, okay? So it will compare, okay? And it doesn't stop there. It has to come back to. So it will say, okay, it is higher. So I generate middle of the higher range, which is eleven hundred, okay? And then come back, now it's higher. So I'll come down to the middle of the. So I have narrowed it one zero zero zero one zero one zero. Then again I will go to one zero zero one and then one zero zero zero four tries, right? So this is how it works basically. And this is the very widely used A TO D converter in ieds.

Speaker 2 01:13:34

Okay?

Speaker 1 01:13:34

And I'll give you some specifications later on. What are their conversion rates and so on. So advantages are it's very fast, popular logic, okay? And very cost effective. That's why they could use now one for each channel. You don't even need, you know, multiplex. So one voltage, take a voltage signal, isolate it, anti aliasing filter, hold it using sample and hold and then convert. And you do the same, sample and hold, same fault for every channel and immediately convert. You know, if you have eight channels in your I, then you use eight A to DC inversions like that, and you Got eight outputs. The disadvantage is, you know, it's not very fast. It's not extremely fast. But we don't need extremely fast. Also because in our id's we are not using very high sampling rates.

Speaker 2 01:14:45

Okay.

Speaker 1 01:14:46

You can, you know, they can handle all the way up to eight thousand, eight thousand hertz, which is the higher end in our case. And during that time inputs should remain fairly constant. So you have to use very good sample inputs in this case.

Speaker 2 01:15:06

Okay.

Speaker 1 01:15:07

So that.

Speaker 2 01:15:11

Okay.

Speaker 1 01:15:12

And application. As I said, it's the most widely used A TO D converter because we are, you know, sample and holes are good and we don't need very fast conversion. So they are pretty good for this.

Speaker 2 01:15:32

Okay.

Speaker 1 01:15:32

So as I said, nowadays we are using up to twenty bit. Okay, thirty two bit are available but they are expected. And we use only for very high frequency. May be for metering purposes. We use that because we need very high accuracy there. Ok. By the way, metering uses the same algorithm. Voltage and current phases and then you compute the power. The only difference is you need very high accuracy. And that's why they use thirty two bit components version. So this is the process. You got your signal, you have sampling pulse. You will hold. At each sampling pulse you will hold the signal.

Speaker 2 01:16:20

Okay.

Speaker 1 01:16:21

You will hold the signal. Right. And then convert this value to digital numbers. And those are your data that we used in our calculations.

Speaker 2 01:16:37

Okay?

Speaker 1 01:16:39

Okay. So why don't we take a break here, come back and continue. I think we will finish the hardware today. Whatever I wanted to talk about. So let's take come back at eleven fifteen, you know, take a ten minute break.

Speaker 2 01:16:58

Okay.

Speaker 1 01:17:25

The day before yesterday.

Speaker 4 01:18:17

Dragon Ball Festival. Right? Dragon Ball. Dragon Ball Festival Singapore. Very very. These are the way the office all buy and eat. As I'm so happy today I sell you all my notes. Always I'm doing heavily. I think it's a little poor. Hey. Hi.

Speaker 1 01:19:20

How are you?

Speaker 4 01:19:23

Yeah, I'm good.

Speaker 1 01:19:26

So sleepy.

Speaker 4 01:19:29

Day morning. So sleepy. Have you guys submitted? Yeah, but. Yeah, today is a today show you my nose. Okay. So many. Hello.

Speaker 2 01:20:05

SA.

Speaker 1 01:22:53

No banana.

Speaker 4 01:22:56

Egg yolk and meat. No meat. Egg yolk. Egg yolk, egg Y lotus. Also some peanut and the how to say that. I know that's the rice. Glutinous rice. Normie. Yeah, Glutinous rice. Yeah. And the date and peanut. That's it. I know. Oh, it's different. Huh? It's different. The south and South. I see pork lotus me and you have egg yolk inside lotus lot. There's a big one inside. I forgot the name of that. What is it?