Indian Institute of Science

Design of Photovoltaic Systems

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NPTEL Online Certification Course

Let us now look at how we will transform a three phase waveform ABC to αβ coordinates.

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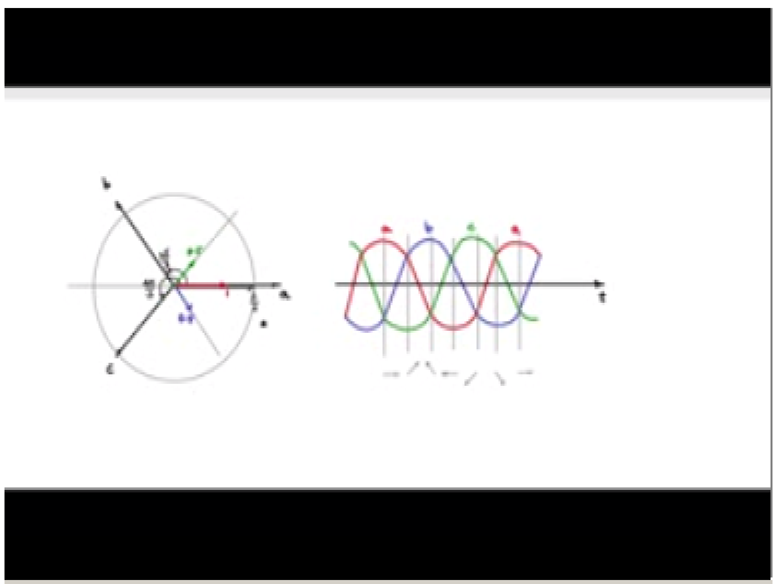

And from αβ coordinates to DQ coordinates that is the DC coordinates now consider this three phase wave form let me draw them now this is a three phase waveform along the time axis a phase B phase C phase so on so each is individually a time wave shape now this also can be represented in the spatial coordinates just like before now you can have three planes a phase can be in one plane let us say the horizontal plane B phase can be at 120 degrees plane C phase can be at another plane which is 240 degrees from the airplane.

So their projections will be on the spatial coordinates will look like this so let us say I have three axis A axis B axis and C axis they are distributed spatially 120 degrees apart are 2π/3 radians apart let me also draw the negative portions of the axis and in a light color B phase is 2π/ 3 radians apart from A C phase is 4π/3radians apart from e all measured anti-clockwise now consider a reference line like this at a given time instant at this instant a phase is at a maximum B phase and C phase are at negative 0.5.

So I will put the a phase value this is the a phase vector along the a phase line because this is the projection along the a axis horizontal axis and that has a value 1 let us say all these are sine waves of unit amplitude so this has amplitude 1 now the B phase and C phase both are at a meeting point here and they are at amplitude 0.5 now I will put C negative 0.5 so B phase axis is here negative 0.5 is here and C phase axis is here negative C phase axis is on that side so as I see point five.

Now these two contribute to the overall resultant vector this is 60 degree this60 degrees cos 60 is 0.5 so 0.5 into 0.5is 1/4 point five two point the one-fourth plus one-fourth so totally a point thing gets added to one so you will have a total amplitude of 3by 21.5 so you will see a vector resultant vector of 3 by 2 results if you are have all units signs now that said these are the phase as an example this could be phase voltage or phase currents if you move this reference line along the time axis smoothly along the time axis this vector here will transcribe as smooth circle of dude of radius 3/2.

So this is how it will come about just same like the two-phase system that we saw αβ system now this three-phase system we have to convert it into an αβ system so you will get it into a two-phase system orthogonal system and from the αβ system let us translate it into a rotating DQ reference frame observe that along this I have a resultant vector in this direction and then let us say I shift the time and at this point C is maximum negative so it is along this line so it will be like this the reference where a resultant vector then if I shift to another time here B is maximum B is along that one.

So you will see the resultant goes in that fashion and then negative and in this direction the resultant then here C is maximum you will see it is in this direction then here B is negative maximum it is in this direction and then again one cycle is complete so you see the resultant vector makes a complete rotation so it transcribes this circle in this manner.

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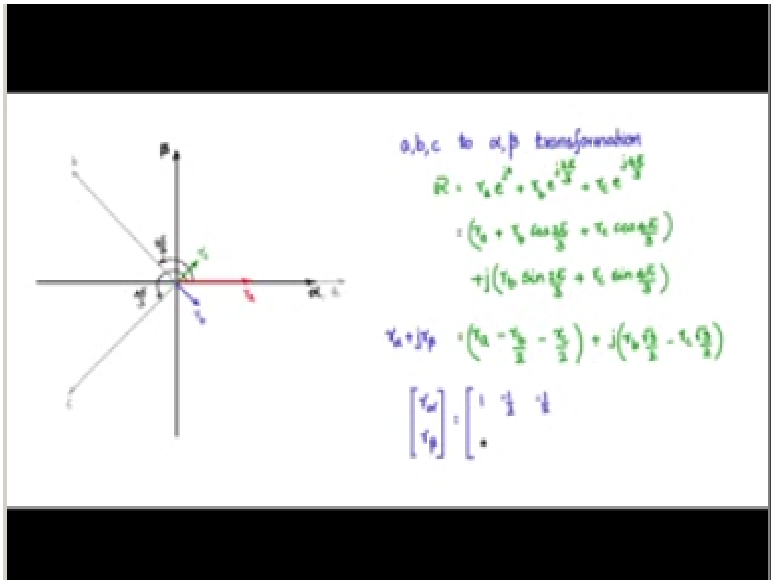

Now let me draw the αβ axis now I have αβ axis on that I will superpose the A B C axis and let me take a vector RA vector RB and RC in this fashion so this is just an arbitrary vector so Rea is along the y axis RB is along the B axis RC is along the C axis now our job is to convert the ABC vectors this could represent IA IB IC or VA VB VC so any arbitrary ABC vectors to αβ coordinate system.

So ABC to αβ transformation let us do this now the vector R which is a composition of RA RB RC r EA e ^ j0 polar coordinates RB, RB is referred with respect to V axis which is at angle 2π/3 R b/a to the power of J 2π/ 3 and RC refer to the C axis which is RC in the power J 4π/3 so this is the vector resultant vector R now expand that you have re a plus RB cos 2π/3 plus RC cos 4π/3+ j RB sine 2 π/3+RC sine 4 PI by 3 this is the imaginary part now put the values for the COS on the signs RA-RB/2- RC/2+cos 2π/ 3-1/2 cos 4π/ 3-1/2 so this would be the real part plus j RB.√3/2sine 2π/3-RC√ 3/2 sine4π/3-√3/2.

So this will be the imaginary part so this is of the form Rα+Jβ so this will be our alpha this will be our beta now let us when I present this in a matrix form Rα+Jβ so our αβ goes through a transformation matrix which is now re a1 minus half this is minus half and then for our β there is no contribution from Rea that is zero contribution from our B is √3/2 contribution from our C -√3/2 and then you multiply it with this vector area RB RC.

So this is our transformation so from this we see that we can get our αβ so this is the vector R alpha beta which is representing the alpha beta coordinates and the inputs are RA RB RC and pass it through this transformation matrix you will get R α R β in the αβ coordinate system so this is ABC 2 αβ transformation.

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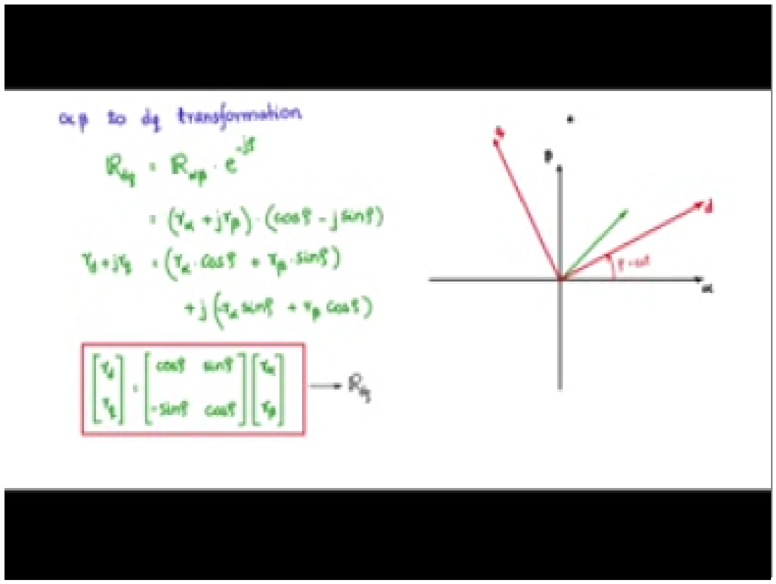

Now let us convert the αβ coordinate vector to DQ so αβ to DQ transformation DQ is the synchronous reference frame which is rotating αβ is fixed stationary so let us say our DQ visa is equal to R αβ e^{-J} ρ where ρ is the angle between the αβ coordinate and the DQ coordinate system so this is our αJβ cos ρ-J sine ρ so you expand that you will see that you will get it in this fashion now this is our D and this is our Q.

So that we are d + gr q so what is already and our Q I can put it in the matrix form our D is this one cos ρ will come in sine ρ will come in our Q- sine ρ and cos rope and I can put in the input vectors which is R α R β so this thing has been put into this compact matrix form and this will be the αβ to DQ transformation and this is a vector can say is in the DQ reference frame so let us have a look at that DQ reference frame this is the αβ coordinate system let us take an arbitrary vector like that.

And this red line is the D axis of the DQ reference frame this is the Q axis orthogonal and the DQ axis is shifted from the αβ axis by an angle ρ if this angle ρ is a varying angle let us say it is varying at who a make our T where ω represents the Radian frequency so if it is rotating at50 Hertz then 2π 50 Hertz into T will be this angle and this angle will be rotating increasing at the 50 Hertz rate and this DQ coordinate system is rotating if this vector is representing current or voltage again rotating at 50Hertz then this DQ reference frame will be synchronized with the voltage or current vector.

And any projections onto the DQ axis reference frame will be constant fix it and there will be DC in this DQ coordinate system therefore if you place the controller circuits and controller large algorithms in the DQ reference frame all the parameters will appear DT so if I project this vector onto the DQ reference frame our Q and RD this relative values of our QR r D will always be fixed however if this vector is projected with respect to the fixed and αβ axis now with respect to αβ axis this vector is rotating this vector is moving.

And therefore α value and β value will change sinusoidal if it is a sinusoidal wave shape and as this DQ reference frame is also rotating with the green vector here already and our curve will be constant and so therefore in the DQ reference frame everything will appear DC now this is the concept so this is how we have converters ABC sine waves three-phase sine waves into αβ to phase rotate a sine wave quantities and from the αβ we are converted into the DQ reference frame quantities that is RDR Q which are DC in nature if you are setting in the DQ reference frame and looking at the vector.