Indian Institute of Science

Design of Photovoltaic Systems

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NPTEL Online Certification Course

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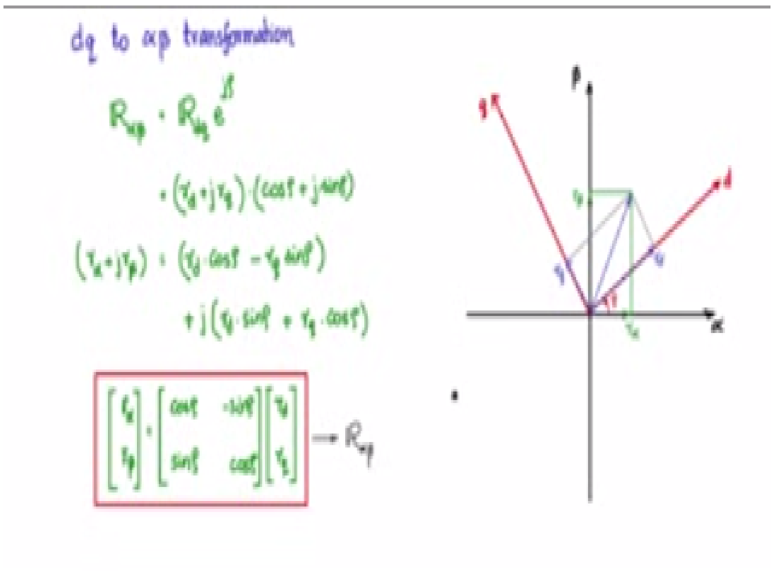

We have discussed the three phase abc ac signals to α ß ac signals and we have also discussed transforming α ß that is the two phase ac signals to the dq domain dq dc signals now we should be able to transform the reverse direction d_q to α ß α ß to abc so we will see look at that a reverse transformation, so first let us see how to go about doing d_q to α ß that is dc domain to two phase ac remain we know that a vector in the α ß coordinate is given by vector in the d_q coordinate system.

Multiplied by a transformation factor ej δ is the angle between the δ ß coordinate system and then d_q coordinate system this can be expanded as rd + jr3 Cos δ + j Sin δ and expanding it further you have already Cos δ – rq Sin δ this will be the real part and the imaginary part rd Sin δ + rq Cos δ so this will represent r ß and you can say r α + jrß and therefore in the matrix form I can write r_α r_β as follows and rd Cos δ, so Cos δ will come in minus Sin δ for the second term here.

And for r ß and put in Sin δ and Cos δ and the vector input vector r_d r_q so knowing r_d r_q I can get r_α $r_ß$ using this transformation matrix, so this will provide you with a vector representation in the α ß coordinate system knowing the vector representation in the d_q coordinate system you can visualize this let me draw the two coordinate system α ß coordinate system like this is α and the ß and I will also draw the d_q axis is the d and the orthogonal q now the d_q coordinate system is this place from the α ß coordinate system by an angle ρ this ρ can be a varying ρ let us say it is varying.

At ρ = ωt that 50h frequency now consider that I have two vectors 1 rd along the d axis as shown and another rq along the q axis as shown now these two vectors rd and rq can be composed and you will get the resultant in this fashion, now this resultant can be decomposed along result along the α ß coordinate axis so if you resolve it along the α axis project the resultant on to the α axis you will get r_α project this along the ß axis you will $r_ß$ so this r_α $r_ß$ is what they want as the output having rd and rq as the input.

So that is what this transformation has done rd and rq is the input knowing these we will use this transformation and find out r_α and $r_ß$ for this ρ the angle between the d and d_q coordinate system and α ß coordinate system should be known.

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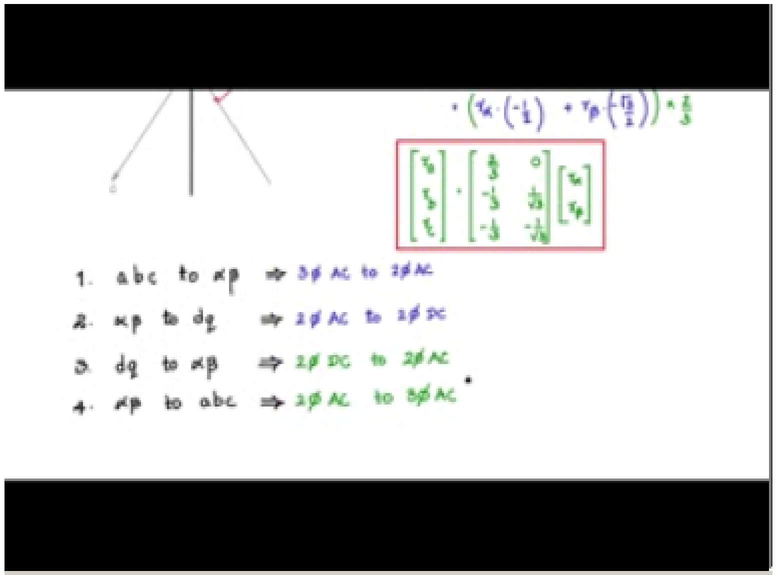

Now let us discuss how we transform a vector in the α ß coordinate to the three phase abc coordinate system now let us go by the graphical means it is easier to understand that we draw these two orthogonal axis α axis and the ß I will also draw the a b c coordinate axes the 3 axes which are displace 1200 apart so this is the a axes in line with the α axes this is the b axes this is the c axes so the b axes is 1200 or 2 π / 3 displace from the a axes c axes is 4π/ 3 or 2400 displaced from the a axes. Now you take an arbitrary vector, and this vector let us resolve it around the α β coordinates and you have here α and β as shown.

Now let us say this vectors α Rα Rβ, now these vectors have to be transformed in the a b c coordinate system and they have to be converted in to Ra Rb and Rc vectors, vectors are along these three axes, so how do you shift R α Rβ to Ra Rb Rc. So now let us take first Ra, Ra is a vector along a axes now what are the components of Rβ and R α that are contributing to vectors along the a axes R α is contributing completely because α and r aligned the β axes is orthogonal to the α axes and therefore orthogonal to the a axes there is no component of r β along the a axes.

Therefore it is 0, so component of β is 0 so R a is = R α, now what is the component along the b axes Rb, now R α component along the b axes now let us say your project R α on to the b axes, so this will be the projected value on the b axes, now this component here as I am showing in the cursor will be the component contributed by r α by its projection on to the b axes, it is falling on the negative portion of the b axes.

Now this angle is 600, how it is 600? You see that we know that be is displaced from the a axes this angle is 1200 therefore the remaining angle will be 600, so therefore I can say the contribution of r α- because it is on a – axes – r α cos π / 3 or cos 60, now we take the Rβ, Rβ drop a perpendicular to the b axes so this component will be the R β components projection of the b axes it is on the positive side so you can write Rβ, and this angle is 300 because this is this overall is 1200 b axes from a axes β is at 90 so this will be 30.

So that is cos π/ 6, so R α – cos π / 3 is – ½ π / 3 is $\sqrt{}$ 3/ 2, now Rc, what is the Rc vector? So let us take the projection of R α on to the c axes so this is the, and this angle is 600, so R α cos π/ 3. Now this is falling on the negative part of the c axes, so therefore the minus then projection of R β on to the c axes this is the Rβ component, and that is again falling on the negative apart of the axes minus Rβ cos π/6 because this portion is 30 degrees so now when you put the values for cosπ/3 and cosπ/6 where rα-1/2+rβ-$\sqrt{3}$/2.

Now there is another important point that you have to know remember that while we converted while we transformed the vectors from the abc to $\alpha\beta$ and when the a, b, c amplitudes are let us say unit amplitudes that is the sine waves the 3 120degree sine waves area ,b or c having unit amplitude then the amplitude that resulted was 3/2 in the $\alpha\beta$ domain.

So we have to make when you do the reverse transformation when you are having a value 1 in the $\alpha\beta$ domain it will be 2/3 in the a b c domain so to make that correction you can multiply each of the vectors by 2/3 because now if rα if it is one amplitude then it is multiplied by 2/3 so each of them is multiplied by 2/3 to bring in that factor of 3/2 which comes in and when you transforming from abc to $\alpha\beta$ domain because of the algebraic addition are unit sign will become 3/2 amplitude sign in the $\alpha\beta$ coordinate system likewise when we do the inverse transformation a unit sign in the $\alpha\beta$ coordinate system will become 2/3 times the amplitude in the a, b, c coordinate system.

So now when you put it into the matrix form so what I need is RA,RV,RC and what is the transformation matrix you can look at it now rα.2/3 so I will put 2/3 Rβ component 0 now -1/2/3 will be -1/3 and $\sqrt{3}$/2.2/3 will be 1/$\sqrt{3}$ this will be -1/3 and -1/$\sqrt{3}$ so this multiplied by $\alpha\beta$ so this will be our transformation matrix for converting a vector in the $\alpha\beta$ quadrants the resolved components are Rα and Rβ can be converted into the three case is quantity is Ra, Rb, Rc using this transformation matrix.

So now summarizing we can say first we know a how to do a,b, c to αβ transformation abc is 3 phase sign αβ is two phase ac value spaces ac to two phase ac transformation next αβ to DQ so what do we do αβ is two phase ac DQ is rotating along with the vector keeping in phase with the vector therefore the vectors projected on the DQ coordinate system will appear DC so it becomes two phase DC domain so this is the forward transformation can also have the reverse transformation DQ to αβ that DC quantities in the DQ coordinate system get converted to two phase ac quantities in the αβ coordinate system.

So it is two phase DC to two phase AC transformation now the fourth one is from αβ to abc that is what we just last day αβ is two phase AC to three phase AC so if you take set of variables signals let us say sinusoidal signals 3 phase sinusoidal signal 120 degrees apart you can go through the whole process of going to two phase, two phase to DC and then DC to two phase A, two phase AC to 3 phase AC back by using this transformation now these are the transformation these are the core transformation that will be used in the DQ axis control for grade connection we will now go back to the grid connected inventor three fill grid connected inverter and see how we will apply this transformation there.