Analog Circuits
Prof. Jayanta Mukherjee
Department of Electrical Engineering
Indian Institute of Technology - Bombay

Week 05
Module – 07
Tutorial No 06

Welcome back to next tutorial video, last in last tutorial we have stopped at designing Butterworth filter.

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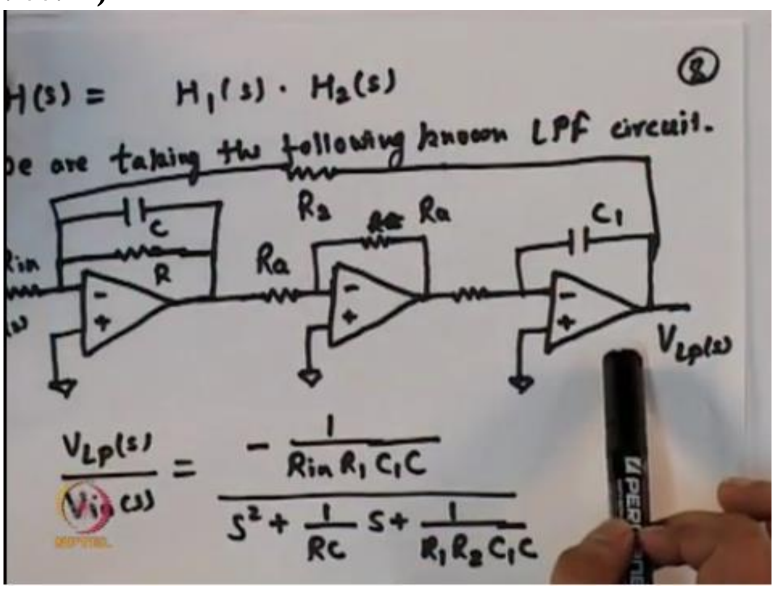

So, we have chosen 1 circuit that is this circuit and the transfer function of this circuit is given as this equation and from this equation we are having relation with the specifications like this, so I am continuing after this.

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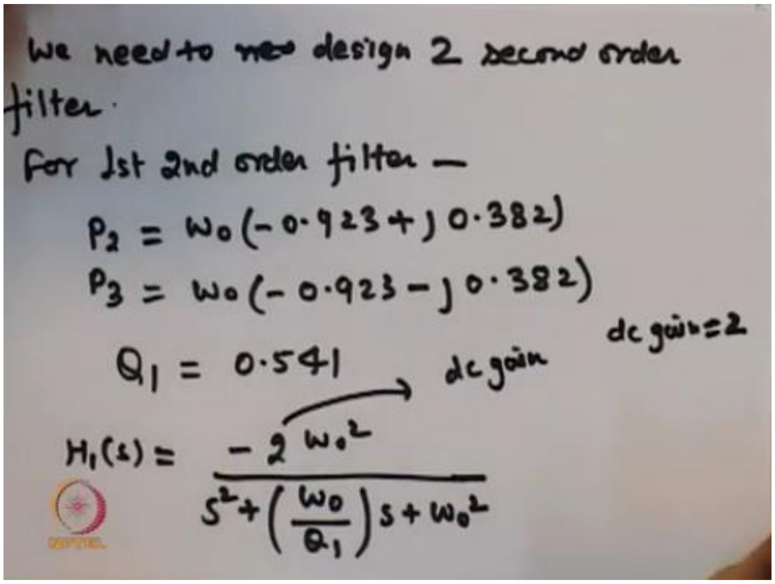

We need to design 2 second order filter, for first second order filter we take 2 poles that is P2, P3 which are that I have calculated earlier are - omega 0 - 0.923 + j 0.382, = 0.923 - j 0.382, so these are the complex conjugate of filters from that we are having Q1 = 0.541, Q1 we have derived equation earlier for Q1, so after finding Q1 we'll have transfer function like this.

H1S = - 2 omega o square upon S Square + omega 0 Q1 S + omega o square, here 2 is the DC gain so for this second order filter we are taking DC gain = 2 and for the next filter we will also take DC gain = 2 to maintain the symmetrical gain across 2 cascade systems from this circuit, now we need to find out the values of RC components.

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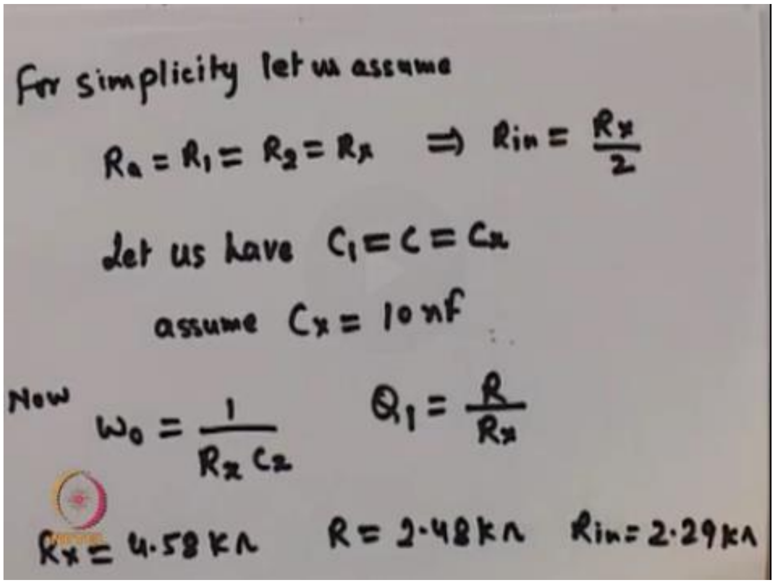

So, for simplicity, let us assume Ra = R1 = R2 = Rx which will give Rin equal Rx by 2 and from this circuit this is the R1 that I forgot this is the R1 value, now let us have C1 = C = Cx, assume Cx = 10 nano-farad, now omega o that is 3 DB cutoff frequency =1 upon RxCx Q1 = R upon Rx so the RX would have 4.58 kilo ohm R = 2.48 kilo ohms and Rin = 2.29 kilo ohms this values I have calculated and I am just putting it these values here you can calculate it offline.

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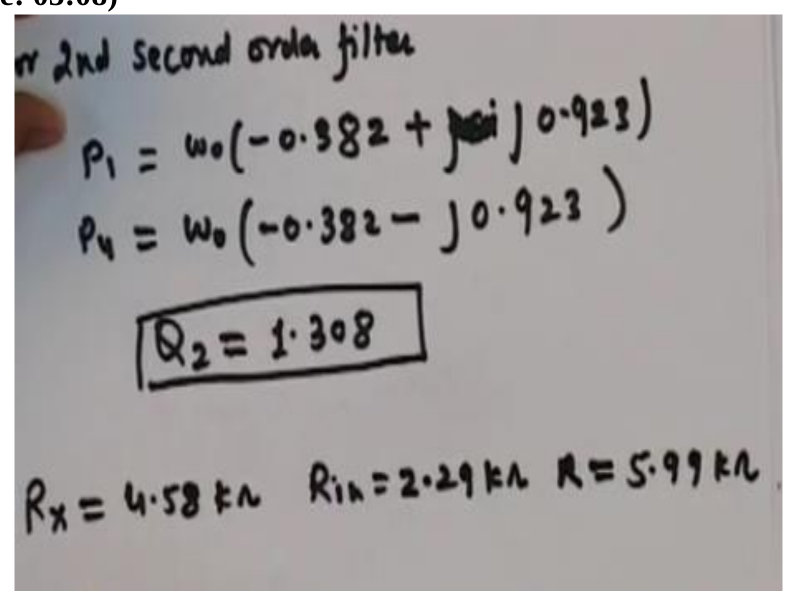

So, this is the first second order filter, now second order filter, we are taking poles P1 and P4, P1 is omega o - 0.382 + J Sin + sorry + J 0.923 P4 is complex conjugate that is omega o - 0.382 - J 0.923 from here we will calculate Q2 that from the formula that we discussed earlier Q2 will be

1.308, again we will be making the same assumptions like Ra = R1, R2 = Rx and the DC gain is again 2.

So, Rin will be Rx by 2 again assume C1 = C = Cx and Cx = 10 nano-farad and we are having this equations but the Q1 is Q1 here was 0.5 something But Q2 here is 1.308, so there will be changes in the values of Rx that will be so the Rx would be 4.58 kilo ohms that is same with the earlier value Rin = 2.29 kilo ohms and R = 5.99 kilo ohms, so these are the final values now finally we need to see what is the arrangement of filter.

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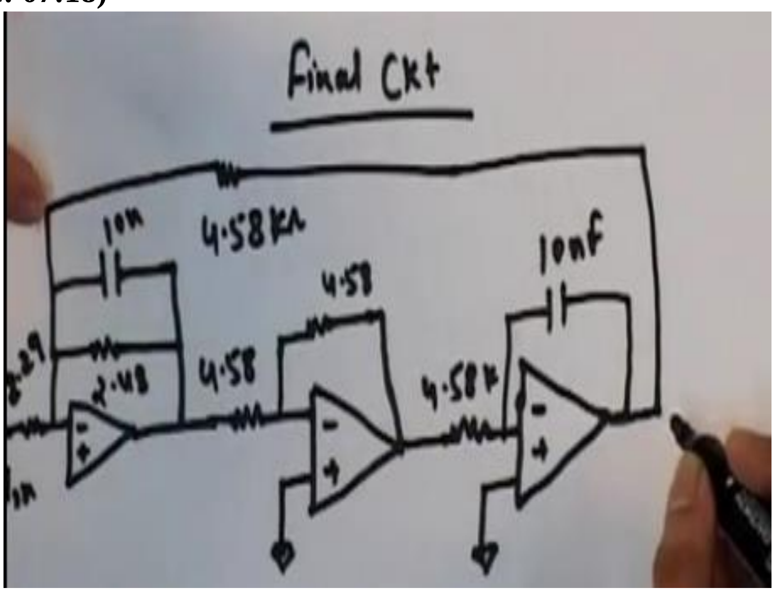

Final circuit this I will be drawing in small, so that it will cover in this page this is 2.29 Vin 2.48 10 nano, 4.58, 4.58 this is also 4.58, 4.58 kilo, 10 nano-farad, this is the first second order filter we need to cascade it another second order filter, so I will be writing like this so from here we will cascade like 2.29, so this is the final filter on the screen will be noticing 2 parts.

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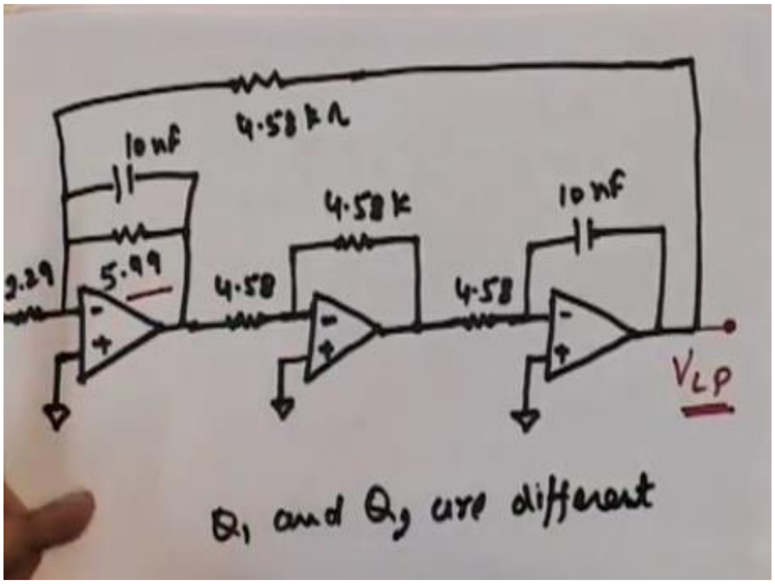

So, I will be covering like this, this is the first filter then you will cascade it and have it like this and the output would be here VLP output would be here VLP the difference in values are here like 5.99 and 2.48 these are because Q1 and Q2 are different, so this is the final realization of my fourth order Butterworth filter, so I have plotted this on (()) (12:27) tool and find out what is the transfer function, what is the magnitude response, what is the phase response of this filter, so that just to verify whether we have deriving the correct filter or not so this is the final plot of filter.

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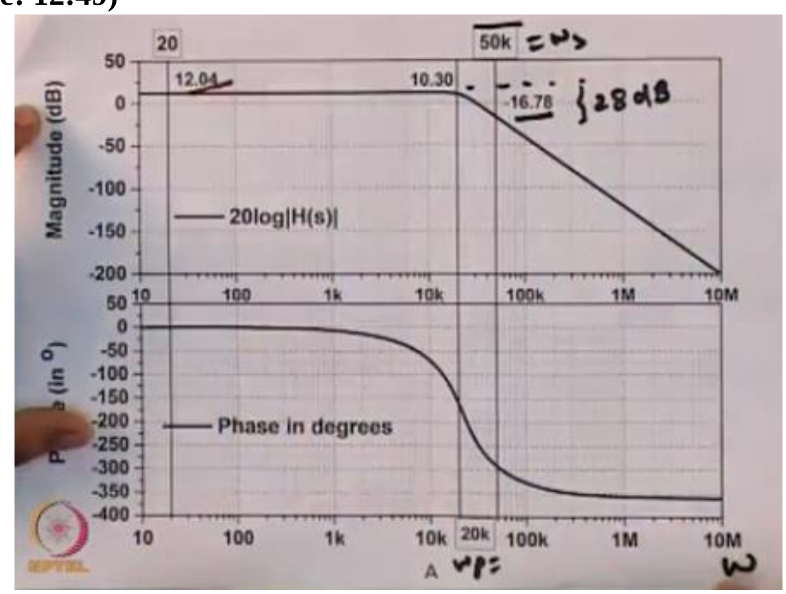

So, here you can see that the DC gain of the filter is 12.04 DB that is closed to for that we have assumed that 4 would be the filter DC gain and here we are having this X-axis as omega this is magnitude response, this is phase response so at omega P = 20 K we are having 10.30 DB gain that is approximately 2 DB down from our low frequency value.

Why it is this is less than 2? Because we have over designed the filter and similarly at the omega is = 50 k we are having this response magnitude as - 16.78 DB that is approximately 28 DB down from the DC value but in the specification we have targeted 28 DB but since we over designed the filter it comes out to be 28 DB attenuation at 50 K omega S.

So, from this plot we can say that we have achieved our specifications and we have designed a good filter which is maximally flat in pass band and alternating in the stop band with our specification, so this problems are easier, so now moving to the next problem that is based on diodes circuit that is a simple circuit but just to have a quick inside in to the diode system I am introducing this problem, so the problem is there is a circuit given.

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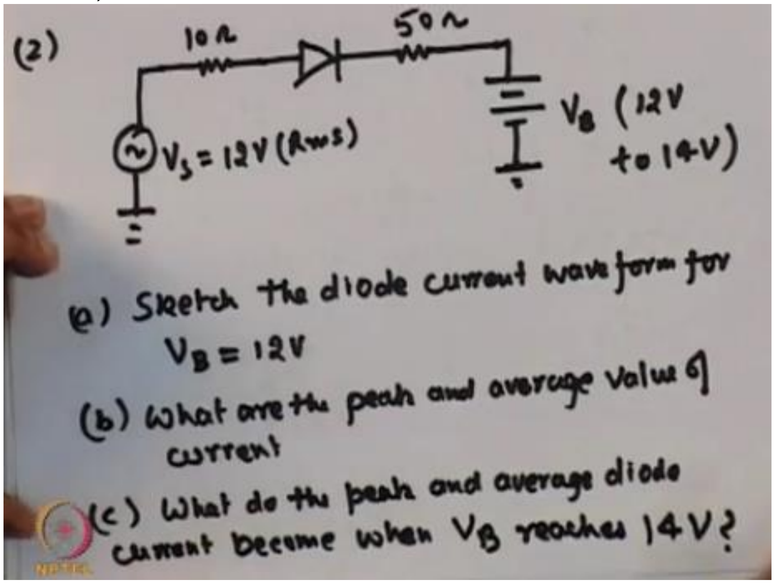

So, this is the given circuit in this circuit there is a AC source which is having at 12 volt Rms value and there is battery which is charging from 12 volt to 14 volt from this AC source, so here we need to find out A part: sketch the diode current wave form for VB = 12 volt then B part would be what are the peak and average value o f current and C part would be what do the peak and average diode current become when VB reaches 14 volt, so this is our problem.

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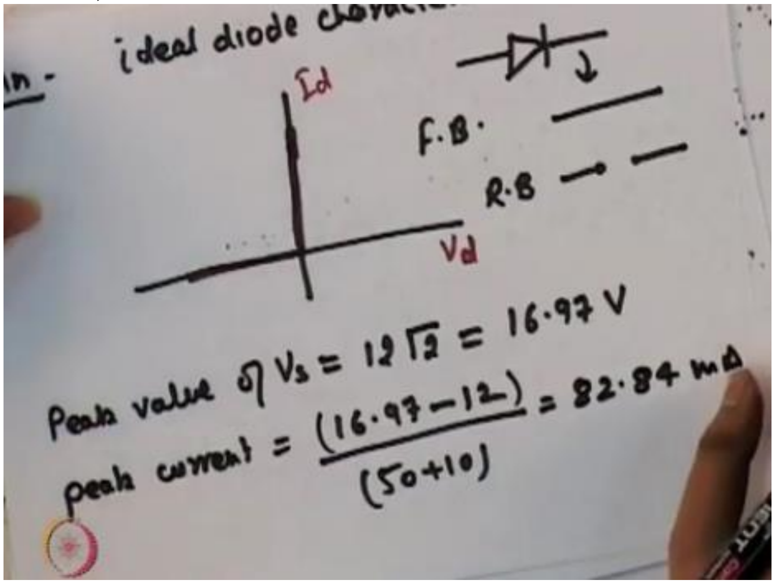

Now going to A part, so A part is asking sketch the diode current wave form for VB = 12 volt. so first let's see and there is one thing given in this circuit assume ideal diodes rather ideal diode**,** so what is ideal diode characteristics which is like this, so this is sVd this is Id so this is the line graph which means if this is diode in forward bias condition this will be this will be at as short circuit and reverse bias condition this will act as op amp.

First peak value of VS which is 12 root 2 = 16.97 volts, now what is the peak current, peak current = this 16.97 - 12 upon 50 + 10, so look at this circuit so we are assuming forward bias this will be short total resistance will be 50 + 10 and battery is having as given VB = 12 volt so the current would be given by this equation that is 82.84 milliamperes. Now let us see when diode starts conducting.

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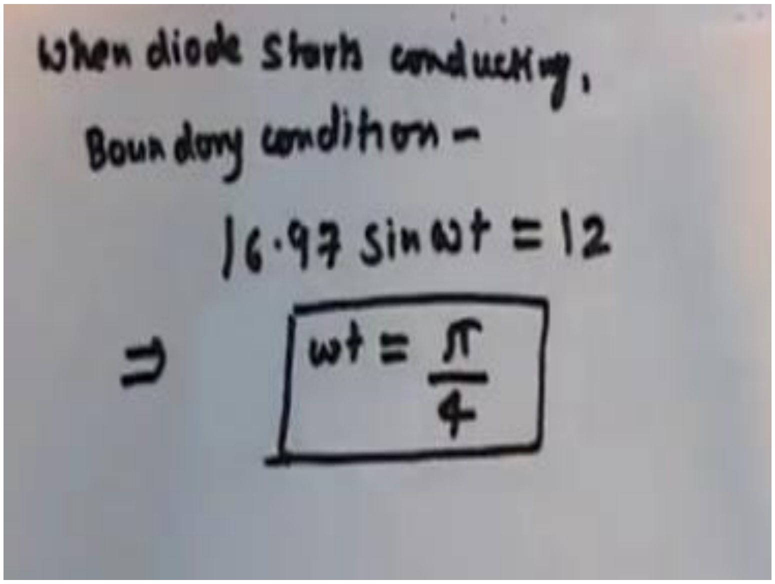

For that boundary condition would be 16.97 Sin omega t = 12 after this means when this value is greater than or = 12 the diode will start conducting because it will be forward bias so from here will get omega t = Phi by 4 now the input wave form is like this input voltage wave form.

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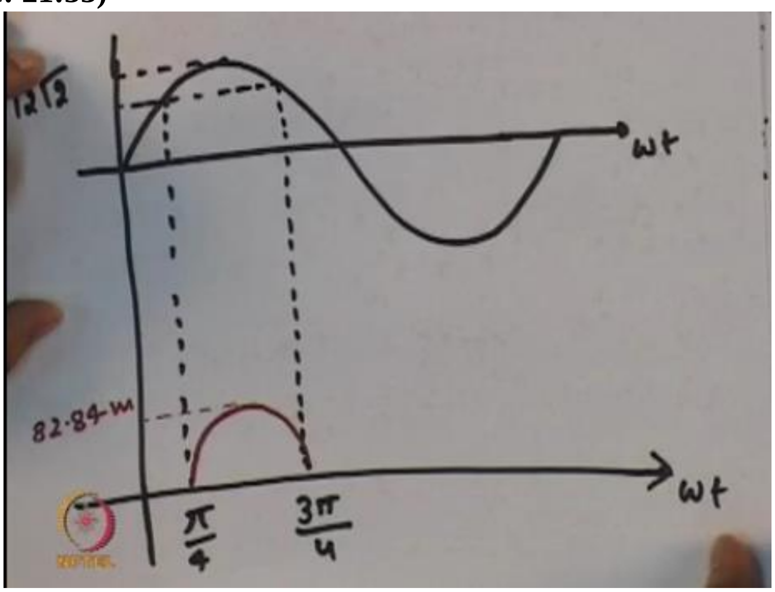

Peak value is 12 root 2 and I am drawing current wave form, so you are having this because this the diode start conducting after Phi by 4 this is the omega t omega t, so the current wave form would be this, this value would be the peak value and all other areas diode will be reverse biased conducting so this is the wave form of current now what is the average value?

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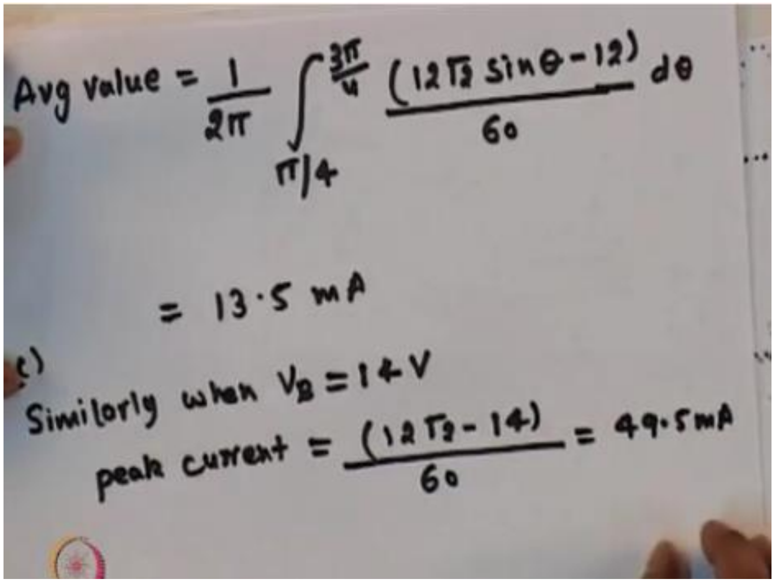

The average value is normal integration over divided by the total period Phi by 4 3 Phi by 4 12 root 2 Sin theta - 12 upon 60 d theta = 13.5 milliamperes similarly when VB = 14-volt peak current = 12 this is c part current = 12 root 2 - 14 upon 60 = 49.5 milliampere are the condition.

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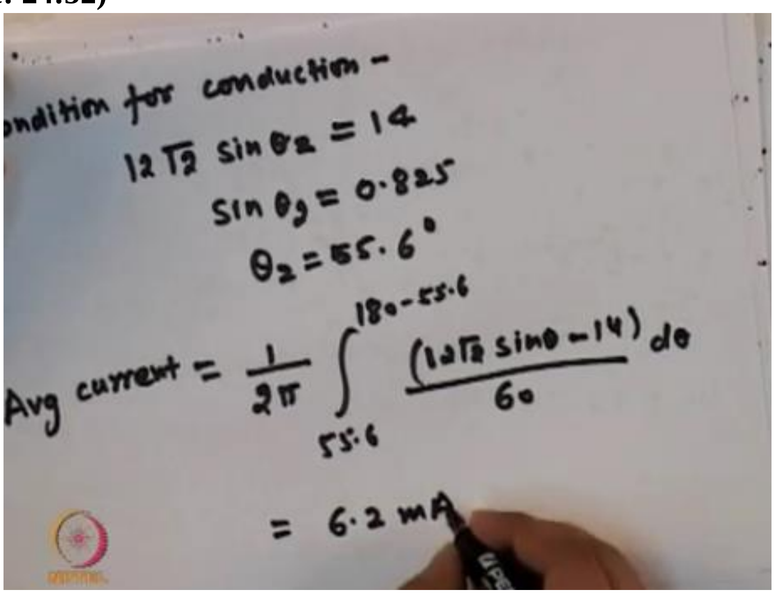

When condition for conduction 12 root 2 Sin theta 2 = 14 Sin theta 2 = 0.825 theta 2 = 55.6 degrees so the average current = 1 upon 2 Phi 55.6 to 180 - 55.6 12 root 2 Sin theta - 14 upon 60 d theta = 6.2 milliamperes this was our problem.

So, this simply illustrates the diode characteristics and when we are assuming ideal diode assuming ideal diode shows the way to find out the problem solution so today in this tutorial we have covered 2 problems 1 is Butterworth filter design it was having design of filter from specification given in terms of RC components then we solved one 1 simple problem during the ideal diode characteristics the same can be solved with different diode characteristics given in the, let’s talk in the class which is constant voltage signal model and so in this tutorial end here.