Design for Internet of Things
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Lecture - 25
Lab Experiment

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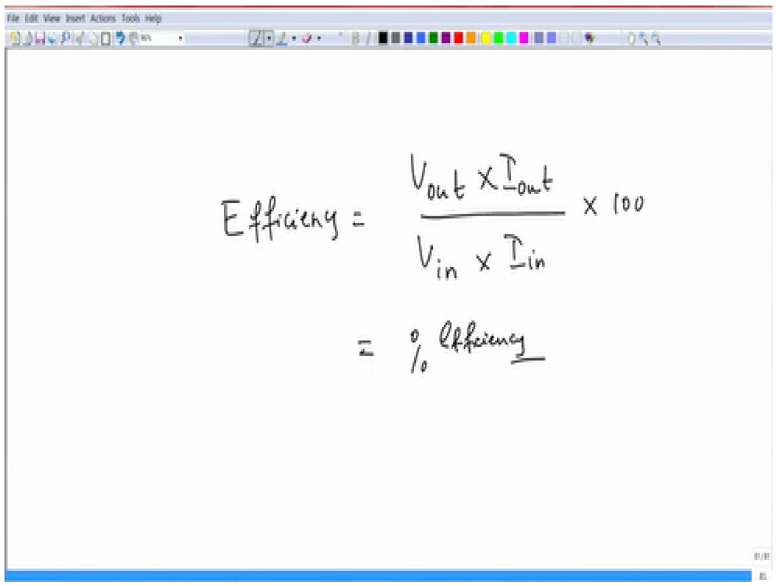

So, let us look at the efficiency calculations of a simple buck converter. So, this is a very simple expression that one can apply and you need to do these calculations all by yourself.

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So, what is the experiment and how do we go about? Please open the data sheet of TPS 54160. This is what we got from TI manufacturer and these are standard board. So, it is easy for us to explain what the setup is and I will show you what how the setup looks like.

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The experimental setup comprises off extreme left is the input voltage meter. The one next to that is the input current meter. Next to that are two pieces of equipment one is a power supply; this is a linear power supply. And down below is a electronic load where you can apply a certain amount of load current to the output of the buck converter and study its efficiency and performance and so on. Now, what you see on the right side?

Beyond this stacked up equipment is the output current meter and the one extreme right of the multi meter is the output voltage meter. So, you can think of all that you see in yellow is the output and all that you see on the black is essentially the input. And what I show you on the oscilloscope is a current switching current waveform, how I am getting the current waveform because I have used a current probe amplifier.

What you see next to the oscilloscope is TCPA 300? This is the current probe amplifier. Current probe amplifier is a piece of electronic. But you need an current probe in order to connect to the current probe amplifier and the current probe is TCP 312, you can also see that. So, you can now see it is all connected and this is the kind of infrastructure you may need to understand your complete system. The oscilloscope is TDS 5140 that is the make of the oscilloscope. So, having explained all these parts.

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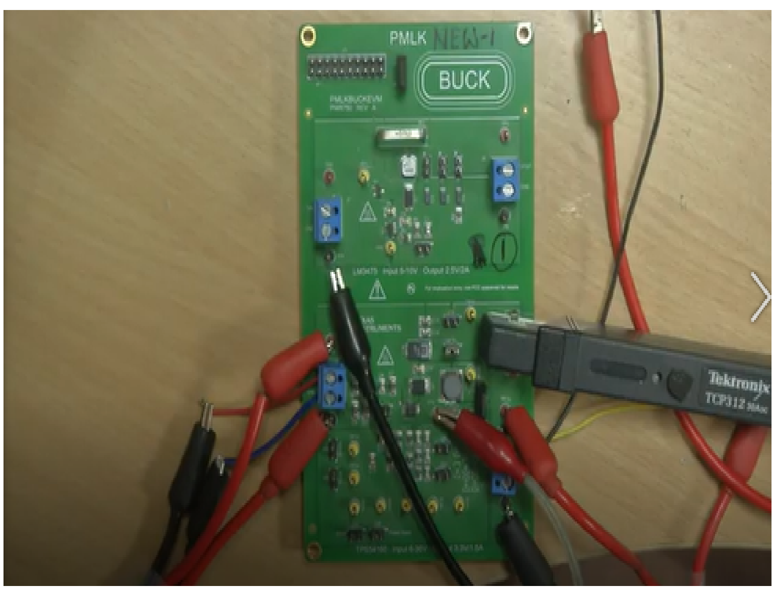

Let us begin the experiment where by setting the input voltage and the input power. And then let us see what actually happens at the output.

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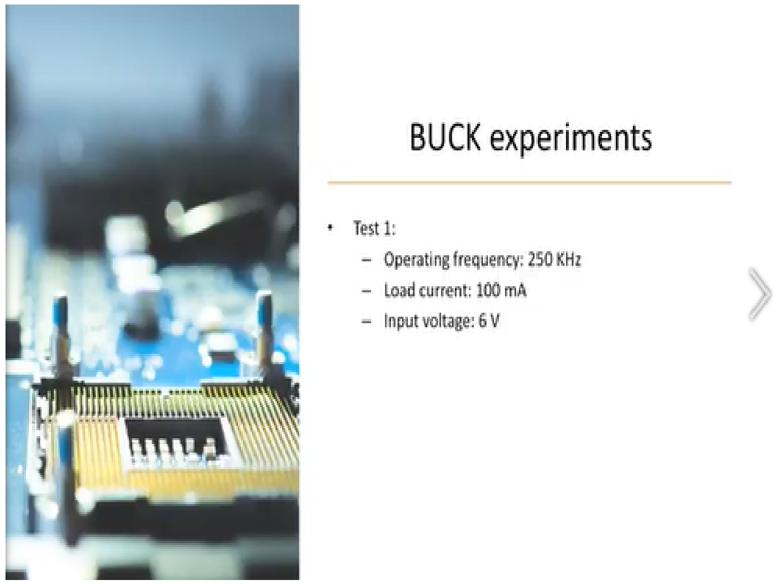

So, now we are setting the load current 100 milli amperes.

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That is the load current. That means, on your yellow multi meter you should be able to measure roughly 100 milliampere. You may get 90 I suppose, that is what it is measuring. Now you can see the load current has been set to 100 milli amperes. The left black ones as I mentioned is you are coming close to 6 volts. Do not read the meters which are on top of the power supply, but read the multi meters that is important that is where the efficiency calculation can become easy. 5.8 volts is the input 63 milli ampere the input current.

That is what is the power at the input. Now what is happening at the output that is a switching current that you see. The switching current is at a frequency of 250 kilo hertz. It can also be changed to 500 and so on. So, we will see that subsequently, and now let us see what is happening at the load voltage and the load current. The load voltage is 3.3 always you want the buck converter to give you a fix to 3.3 volts in the output.

The current which we set for the load current was supposed to be 100 milli ampere. But it appears that it has taken about 90 milli amperes. So, that is also okay. So, that I now you know input and output it is easy for you to calculate the efficiency. Now, let us change the circuit and make the load current to 500 milli amperes. Now you have to observe very importantly the current waveform, switching frequency is what it is these are what they are.

We know them already; this is how this inductor current waveform is. If you can find out a simple expression to calculate the inductor current based on the voltages and the inductance value nothing like it. Please try that will be a great exercise for you, that is the inductor current. Now, the load current is changed to 1 ampere, and we repeat the same experiment and what is important is for you to look at the inductor current once again.

That is nothing but the load current, that is the load current. So, you can see this is the load current. Now the experiment can go on and you can make it, you can change the load requirement to 1.5 amps. So, we make it for 1.5 and that is what you read at the input. And you see that is what is at the output. And again, the inductor current waveform, which you can easily spot. And now you change the experiment to 24 volt input.

So, in other words, you are bucking heavily from 24, you are putting it back to 3.3. So, you can see now it is set to 24. Again, I urge you to look at the current waveform will start all over with 100 milliamperes. So, there you are 100 milli ampere load, 24 volt input, 3.3 at the output load current is 100 milli amperes. So, you can see 23.6 and that is the current which is 180 milliamperes and then you can see that, that is the inductor current, current waveform 3.3 and 90 milli amperes is what it is taking at the load current.

So, let us move on. Again, we will change this to the load current of 500 milli amperes, load current, again look at the input voltage and the input current. That is your input voltage, and that is your input current. And this is your inductor current at the load and voltage and currents are also mentioned accordingly. Again, we set it back to 1 and then repeat the experiment. Look at the inductor current. That is your input. This is your output, and that is the current waveform.

Again, you change it to 1.5. Look at the input voltage. Look at the output voltage and output current and then look at the current waveform. That is your output voltage and output current, and then that is the waveform. Now let me repeat all of this to 500 kilohertz, the way to do it is to put a jumper you put it, it becomes 500 kilohertz, I urge you to look at the switching current. Now, again, you go back set the input to 6 volts, 6 volts at the input load current is 100 milliampere.

Repeat the whole experiment to see what actually happens. So, you see this is your input, that is your output, and that the switching current. I know again, you set it back to 500 milliampere. This is the input. This is the output. And this is the switching current across the load. And now I set it to 1 amp. This is your input voltage and current that is your output voltage and current. And then that is the switching current. Now I switch it back to 1.5.

And repeat the same experiment at the input you see something, you see something at the output. Now we will set it to 24 volts and repeat the same experiment all over. So, input voltage input current can be seen load current is 100 milliampere. And repeat the whole thing to see what would happen at the output. That is input, that is output. Just look at the current waveform. This is your input. That is your output. And the current waveform is very, very critical.

Keep looking at the current waveform. Yes, so that is your current waveform. It is not held properly. That is perhaps the reason why the waveform is a bit shaky. This is 1.5. That is your input. And that is the output current waveform and that voltages which is hard to read.

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So, that is about what the experiment is being done. As we go along, we keep repeating this for different values of load currents. And this experiment actually shows that current waveforms are different for the two switching frequencies. The current waveform also changes drastically for different input voltages, given the same fixed output voltage that we want to measure. And please put down your inferences.

Put down your efficiency calculations to whatever you could read and understand. So, that it gives you a good grip on this area of buck converters. Why is this experiment important? Because all of this is being done inside the SOC, you have a huge choice to make between LDO and DC-DC converters particularly buck converters. And you will see this is the kind of waveforms that the output of the DC-DC will generate, which can be a lot of ripple current which comes.

And that is perhaps not all that required not at all desirable. Therefore, you have to use your own judgment on when to choose DC-DC converters inside and when to choose LDO which are inside the systems. That is all I have to say. Thank you very much.