Power Management Integrated Circuits
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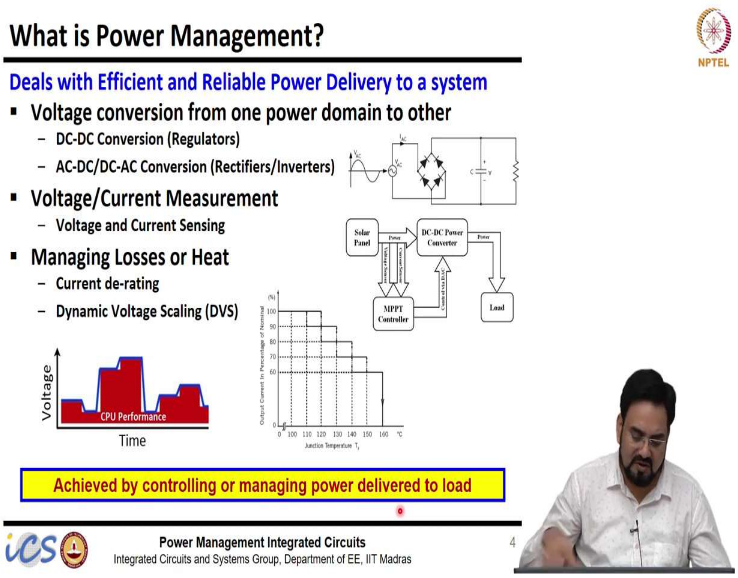
Lecture - 01
Introduction to PMIC - Part 1

Power management deals with the efficient and reliable power delivery to a system. It could be your voltage conversion from one power domain to another. Which means you have a DC input and you want to have a different DC output voltage. So, it is called DC-DC conversion. For example, let us say you have 5 V input and your system requires 1.2 V. So, you have to basically down convert from 5 V to 1.2 V.



It could be AC-DC or DC-AC conversion also, which we call rectifiers and inverters. Let us say you have AC input which could be coming from an AC line 220 V RMS at 50 Hz. So, you require a rectifier circuit which is shown in above figure. So, AC voltage gets converted to a DC and then all the ripples are filtered with output capacitor and you get a DC voltage. So, that is nothing but AC-DC conversion or rectifier.

Then DC-AC conversion: Consider a DC source let us say battery and you want to convert to AC. The example is your inverter which we use in our homes. That is nothing but a DC-AC converter which we call inverters. So, this is also a kind of power management.

Power management may also be associated with voltage and current measurement which is basically sensing of the voltage and current. One example could be your solar. In the solar when you harvest the energy from solar panels, it mostly requires something called MPPT, which is maximum power point tracking.

So, you need to measure the power. In order to calculate the power, you have to sense the voltage as well as current because power is nothing but product of voltage and current. So, we need to measure voltage and current in order to operate at maximum power point. And the MPPT controller drives nothing but your DC-DC converter. And based on the MPPT point, it decides what load current to be supplied or if you are charging a battery then at what current the battery should be charged.

Power management could also be associated with managing losses or heat. So, let us say your load is drawing few amperes of current and after some time it gets heated due to I^2R losses in that load. Most of the systems have a maximum temperature specification and we cannot operate beyond that because there is a risk of damaging that system.

One example could be your cell phone. Let us say you are charging your cellphone, the battery gets heated and the battery may explode or your cell phone may break. And if your phone has a metallic cover then it may get heated and you do not want your cell phone to heat like 60°C or 80°C because you cannot even hold your phone at that high temperature.

And there is a risk of damaging parts also which are inside your cell phone. So, what we do actually, when temperature goes beyond a certain range, let us say you have specified at 110°C and maybe let us 10 A current is 100%. So, when temperature reaches 110°C then you decrease the current by 10%, at every 10°C increase in temperature. So, by the time it reaches 160°C you will be at 60% of the total current which means instead of 10 A you will be supplying only 6 A. For example, let us say you are charging your battery with 1 A current then you will only be charging with 600 mA because you do not want your battery to heat up. So, this is also kind of power management, which is used in most of the systems especially in integrated systems like cell phones.

Another one is your dynamic voltage scaling. So, depending upon the performance required by the system, it changes the voltage dynamically. So, example is your CPU. When the CPU is running at a full performance, let us say you are running a lot of applications on your cell phone, let us say you are watching videos, listening to music or at the same time you are surfing the net. So, a lot of processing is going on in your processor and at that time it requires a lot of power. So, you increase the voltage and most of you would have heard of processor overclocking. So, you operate the processor at higher frequency.

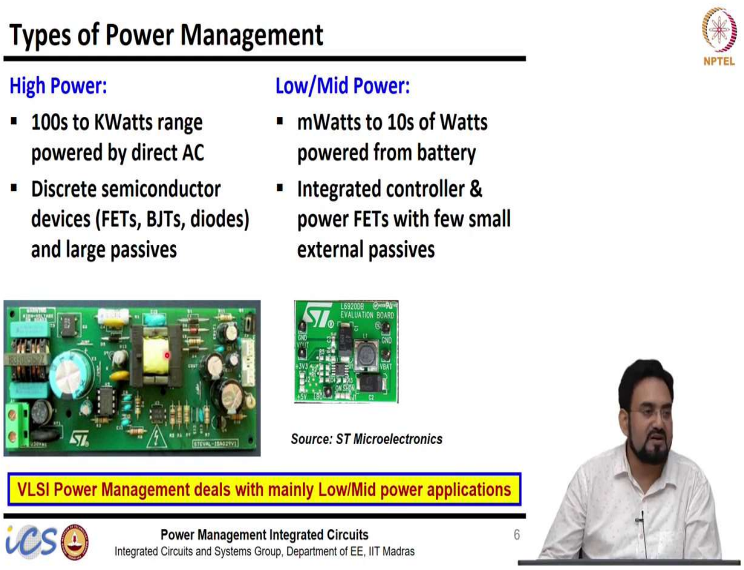
When you operate the processor at higher frequency, that means it has a more power consumption. So, increase the voltage also so that you can run your processor at higher frequency. And when performance requirement is very low, let us say you are not watching any video or your phone is in the silent mode and you are not surfing the net or a lot of processing is not going on, then you can reduce the voltage and at the same time reduce the frequency also for the processor. So, this is called dynamic voltage scaling (DVS).

Sometimes, it is also called as dynamic voltage frequency scaling (DVFS) where we scale both frequency and voltage. But in the processor most of the time we change both frequency and voltage. So, DVFS is used there. This is also a kind of power management technique which is used in integrated systems like cell phones, PCs and tablets.

So, this efficient power management is achieved by controlling or managing power delivered to the load. Depending upon the performance required, you basically change the power requirement or current. A lot of different control techniques are used in order to achieve this efficient power management.

<u>Types of Power Management:</u>

There are mainly two types of Power Management; high power and the other one is low or mid power. When we talk about high power, we talk about 100s of Watts to Kilo Watts range and most of these systems are directly powered by AC. Since at a such high power, it is very difficult to integrate everything on chip. So, they mostly use discrete semiconductor devices which are your power MOSFETs, BJTs or diodes and very large passive components like inductors and capacitors.



You can see in above figure that for high power a lot of passive components are there compared to your controller chip or your power FETs, which is a semiconductor. It looks like 90% of components here are passive. And even if you are using these semiconductors they are mostly discrete actually, except the controller. Your BJTs, diodes or MOSFETs everything is discrete; they are not integrated on the same chip where the controller is.

Low or mid power:

When we talk about low or mid power, its range is milli Watts to 10s of Watts and powered from battery. The example is your cell phone. It is powered by a single lithium-ion battery and these batteries have a capacity of 3000 mAh to 5000 mAh. In this case, we have integrated controller and power FETs with few small external passive components as shown in the figure on right side. So, your power management chip which integrates your controller as well as power FETs and outside you see the inductor and capacitor. You may have some resistors also for sensing purpose but mostly there is one inductor and one capacitor or maybe two capacitors for filtering both input and output supplies.

But the point here is the number of discrete components which are used in low power are much less compared to which are used in high power. And that is the main difference between your power electronics and your power management.

The power management deals with chip level design, while power electronics deal with discrete level design because they are dealing with very high power. So, they have a different requirement. The devices used in power electronics are completely different.

We are dealing with order of amperes of the current, they might be dealing with the 100s of amperes of current or if you talk about the power, they might be dealing with kilo Watts and we are dealing only with 10s of Watt. But slowly the integrated power management is moving towards high power. It is gaining some market from the power electronics and you can say there is a little overlap between power electronics and power management.

But if you know the power management then you can easily go and design an integrated system for power electronics requirement. But if you do not know the power management IC or you have taken any course on power electronics, that does not mean that you can do a power management IC because it requires all the chip level expertise.

Which means, you need to know the basics of transistor, you need to know how to design op-amp, how to design your controllers and everything at the chip level (transistor level) actually, which most of the time power electronics people do not know actually. They only deal with the discrete level design, so they do not know what is happening inside the controller or inside the chip.

From the theory point of view, you will find some overlap because the basic concept of regulators or DC-DC converters remain same but the difference is mainly at the implementation level because in the power management IC we mainly deal with chip level.