1. DC-DC Fundamentals

XIANG FANG: Hello, everyone. I'm Xiang. Welcome to the DC-DC fundamentals. In this section, we will talk about linear regulator.

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2. What is a Linear Regulator?

So what is a linear regulator? The linear regulator is a DC-DC converter to provide a constant voltage output without using any switching components. The linear regulator is very popular in many applications for its low cost and low noise and simple-to-use features. But the linear regulator has limited efficiency and cannot boost the voltage.

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3. Pros and Cons

The pros and cons of linear regulators. The advantage of using a linear regulator is it has low output ripple and noise. So there's no EMI issues because there's no switching. And it's relatively low cost and simple to use. It has fast transient response, and it's easy to implement short circuit protection. The disadvantages of linear regulators is that it has low efficiency, especially when your V in is much higher than your V out. And also, you can run into thermal issues because all of the power dissipates within the linear regulator. And the V out has to be less than V in. That means you cannot increase your V out and your V in.

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4. How Does a Linear Regulator Work?

So how does a linear regulator work? The linear regulator and the output impedance, together they form a voltage divider network. And the regulator behaves like a controlled variable resistor. It's constantly adjusting itself according to the output load to maintain a steady output voltage. As you can see in the graph here, the output voltage is sent through the R1 and R2 resistor divider. The sent voltage is compared with the voltage reference, and the arrow signal is used to control the resistance in the past transistor. So in this way, the V out can be stable.

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5. Dropout Voltage

Dropout voltage. Dropout voltage is the smallest possible difference between the V in and the V out for a linear regulator to remain inside the regulator's intended operating range. That means if you have a V in too small, and the delta between V in and V out is too small, then the voltage regulator cannot work. And usually, we'll hear the word LDO. This type of linear regulator, the LDO, actually stands for Low Dropout Voltage.
6. Types of Linear Regulators

There’s a different type of linear regulator, depends on the pass element what's used in the regulator. So you can be a bipolar transistors or MOSFETs. And different configurations give you different dropout voltages. The bipolar linear regulators have higher dropout voltage and can support higher input voltage and have better transient response. The MOSFET LDOs can support very low dropouts, and use low quiescent currents, and improve the noise performance and has low power supply rejections.

7. More About LDO Dropout

So more about the dropout of LDO. In an LDO datasheet, dropout is only specific under max output current condition. And at other operating condition, the dropout can be calculated. The FET used in an LDO operates in a linear region. The FET has a minimum resistance at the saturation line, as you can see in the graph here. The LDO cannot operate at the left side of that saturation line. So on this graph, point A and point B is on the right side of the saturation line. So it's OK for the LDO to work at these two operation points. But the point C is on the left side, so it's not good for this type of LDO to operate at that point.

8. Other Key Specifications

And there's some other key specifications of LDO to keep in mind when you are choosing the right type of LDO. One is called a quiescent current. It's the current consumed by the regulator which doesn't flow to the output load. It's important for application that needs to run all the time, like the baseband and the real time clock. So for those applications, it needs a low quiescent current to prevent drawing too much current from the source. The other specification is called a power supply rejection ratio, PSRR. It's the ratio off the ratio of the regulated output voltage ripple to the input voltage ripple. These parameters are very important to applications with high noise rejection requirements, like the low noise amplifier or audio type or RF type applications. And the other one is called a broadband noise. It's defined as the total noise energy over a specific frequency range. It's important for those applications to have very high noise restrictions.

9. LDO Selection

And here, in this slide, we summarizes some typical LDO applications and their key care abouts in their specifications.

10. Summary
So in this section, we give you an introduction about a linear regulator. We briefly discuss how the linear regulator is going to operate, and discuss some key specifications of LDO.

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