Power Management Integrated Circuits
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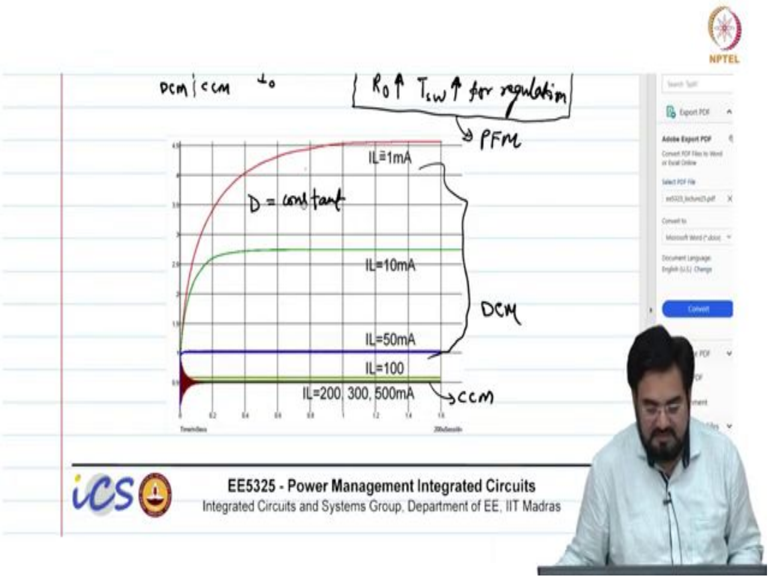
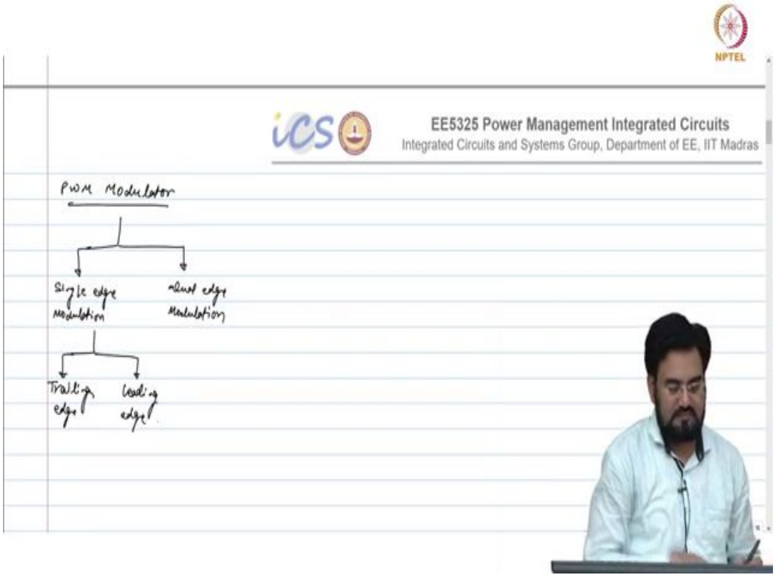
Lecture - 45
Classification of Pulse-Width Modulators

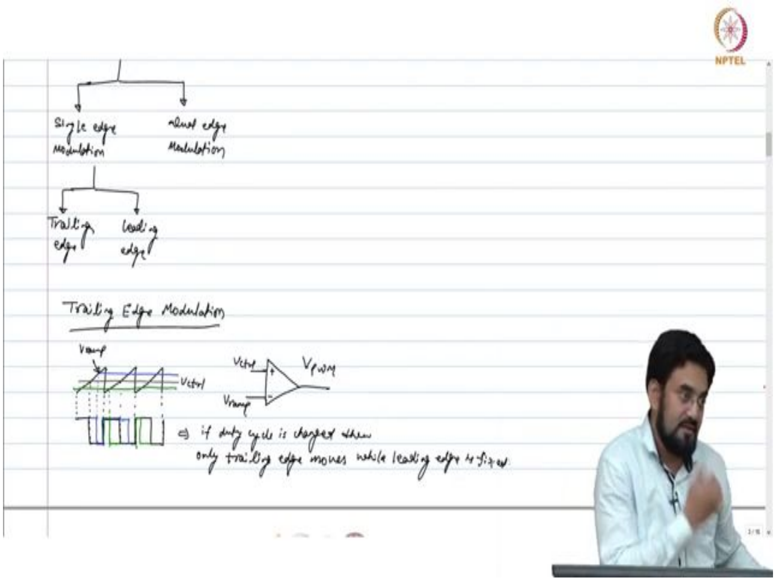


The above image shows the simulated result of the switching converter in both CCM and DCM. The simulation is done in an open-loop and keeping the duty cycle constant. If we keep the duty cycle constant and keep reducing the load current then at the moment when the switching converter enters into DCM, we can see that the output voltage will start increasing and start approaching V_{IN}. We can see there is hardly any voltage change in the output voltage in CCM and minor change is due to the IR drop.



PWM Modulator

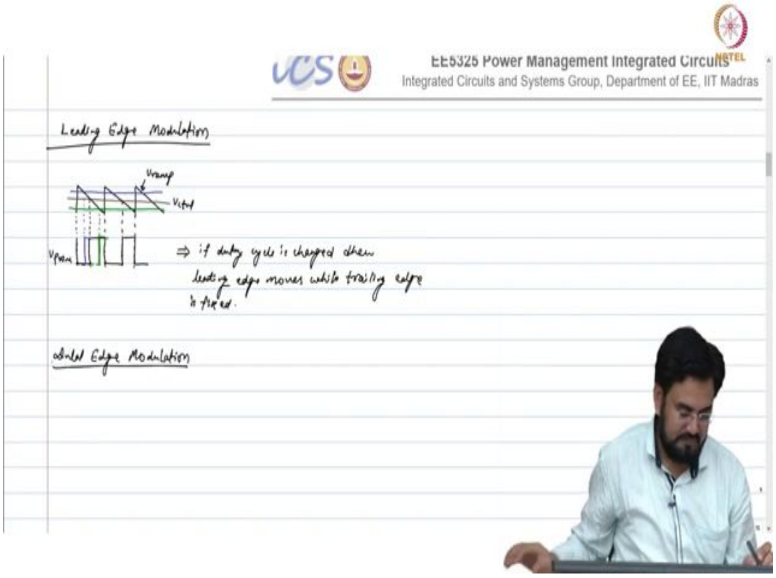
We know that the switching regulator works on the principles of the PWM. The control voltage from the feedback loop has to be converted to a PWM clock which will regulate the output. PWM modulator can be divided into two categories, single edge modulation, and dual-edge modulation. Single edge modulation can further be divided into trailing edge modulation and leading-edge modulation.



The connection of signals to the comparator is shown in the above image.

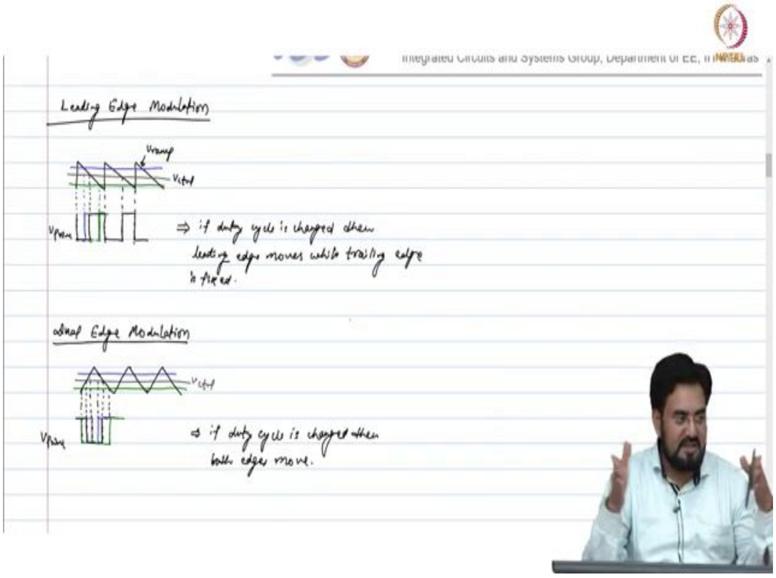
Trailing-Edge Modulation

Waveforms of V_{RAMP}, V_{PWM} for different values of V_{CTRL} are shown in the above image for Trailing-Edge modulation. As you can see, the duty cycle is proportional to the value of V_{CTRL} and only the trailing edge of the PWM signal moves upon changing the value of V_{CTRL} and the leading-edge remains fixed.



Leading-Edge Modulation

Waveforms of V_{RAMP}, V_{PWM} for different values of V_{CTRL} are shown in the above image for Leading-Edge modulation. As you can see, the duty cycle is proportional to the value of V_{CTRL} and only the leading-edge of the PWM signal moves upon changing the value of V_{CTRL} and the trailing-edge remains fixed.



Dual-Edge Modulation

Both trailing edge and leading edge moves in dual-edge modulation upon changing the V_{CTRL}. V_{RAMP} should be in a triangular shape for both edges of V_{PWM} to move when V_{CTRL} changes. Waveforms of V_{RAMP}, V_{PWM} for different values of V_{CTRL} are shown in the above image for Dual-Edge modulation. Off time decreases and the duty cycle increases on increasing the V_{CTRL}. The benefit of dual-edge modulation is that it is sampling V_{CTRL} at double rate compared to trailing edge modulation and leading-edge modulation. So delay is less in dual-edge modulation when V_{CTRL} changes. Frequency is changing in dual-edge modulation when instantaneous change occurs in V_{CTRL} and both edges move but go back to the original value in steady-state. If we are using a random load that is switching then duty cycle frequency will have a lot of harmonics which is not good for noise-sensitive applications. So if we are expecting output voltage ripple to be of fixed frequency then we prefer leading-edge modulation or trailing edge modulation rather than the dual-edge modulation.