



**NPTEL ONLINE CERTIFICATION COURSES**

# **DIGITAL CONTROL IN SMPCs AND FPGA-BASED PROTOTYPING**

**Dr. Santanu Kapat**

**Electrical Engineering Department, IIT KHARAGPUR**

**Module 03: MATLAB Custom Model Development under Digital Control**

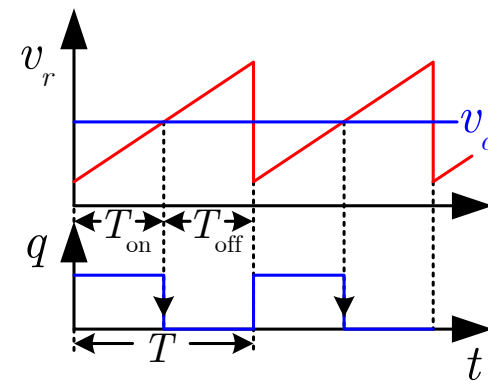
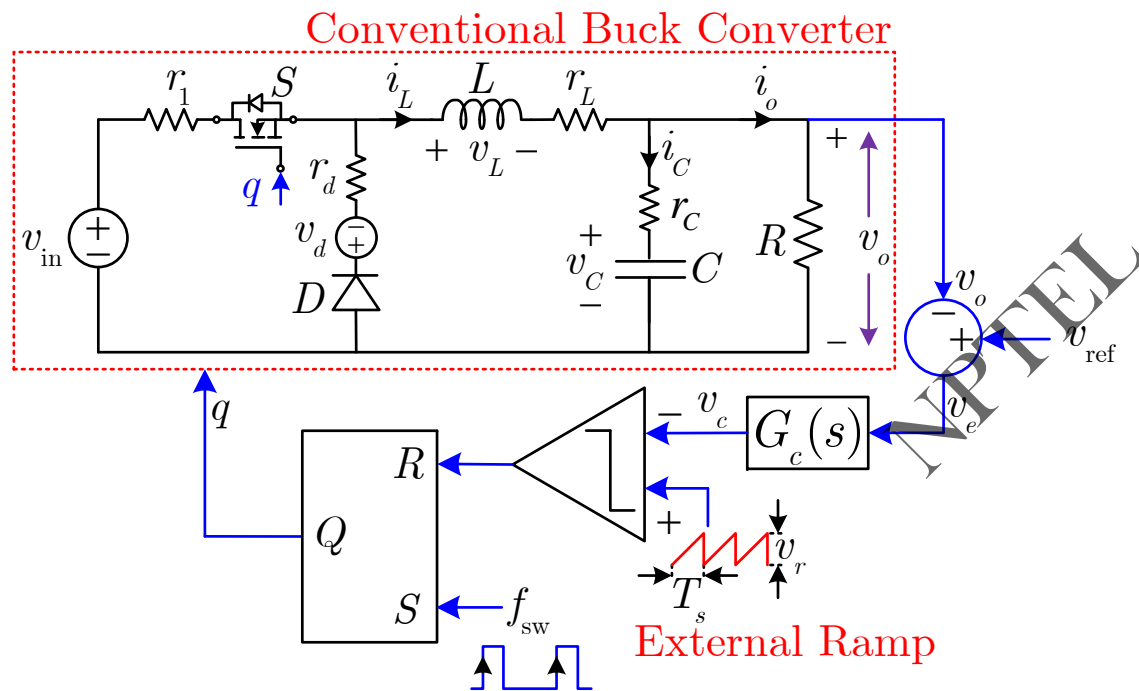
**Lecture 21: Recap of Voltage and Current Mode Control Implementation using MATLAB**



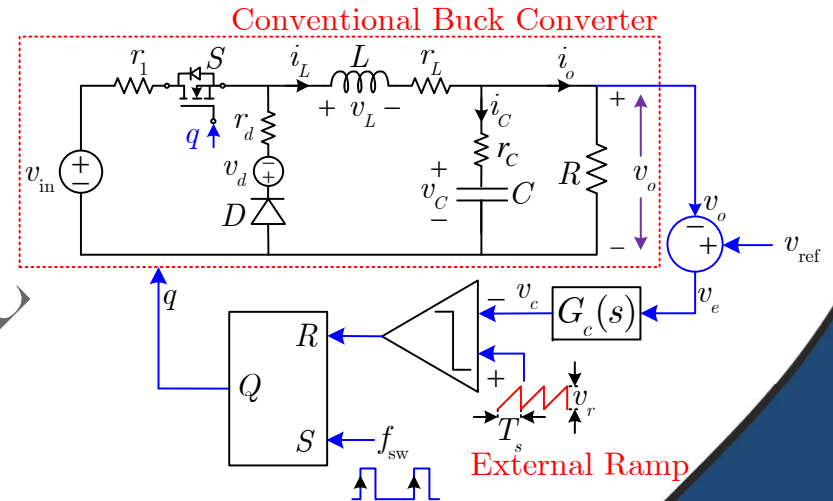
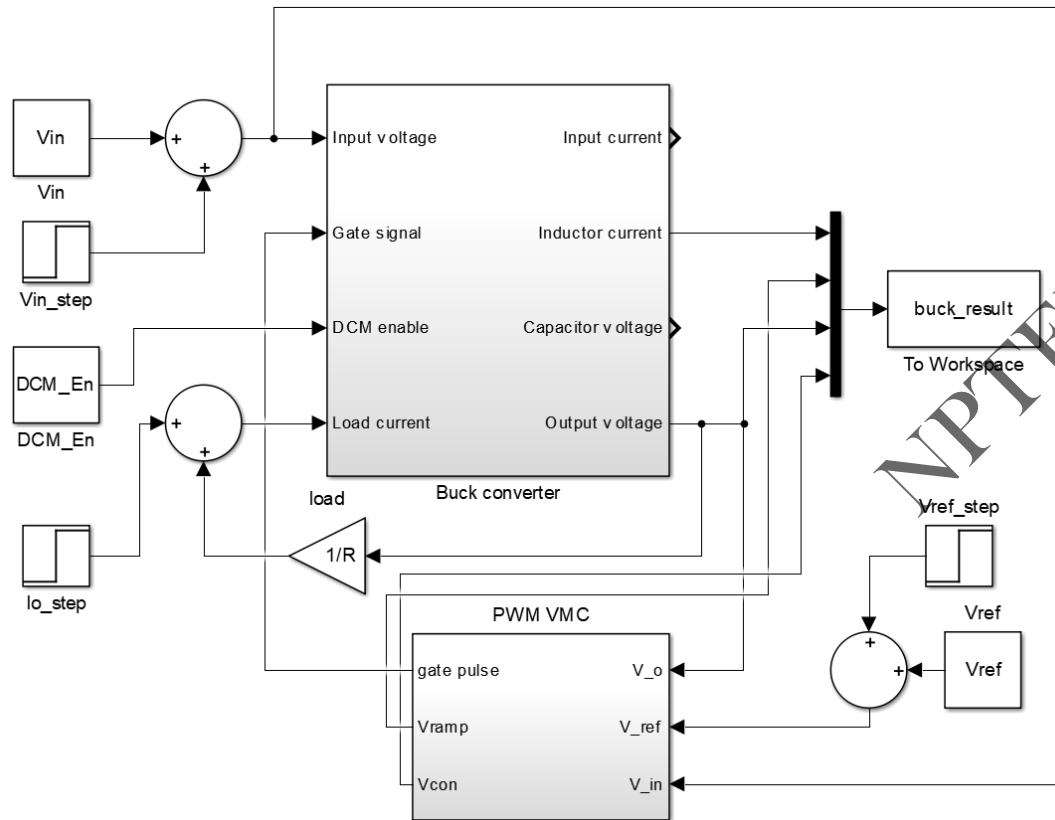
## CONCEPTS COVERED

- Recap MATLAB customized model development
- Recap of fixed frequency analog voltage and current mode control implementation
- Recap of constant off-time analog current mode control
- Recap of constant on-time analog current mode control

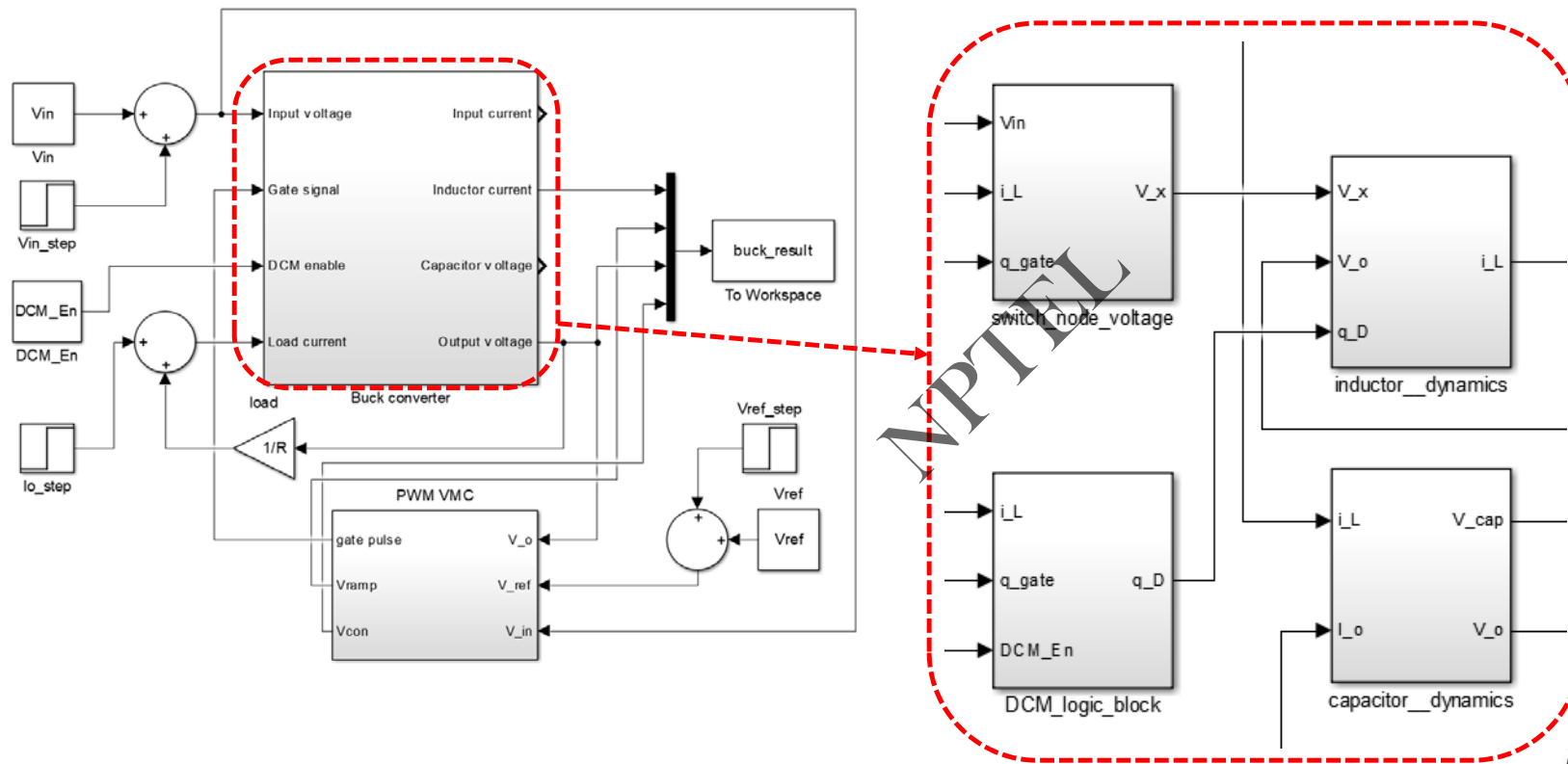
# Buck Converter Voltage Mode Control



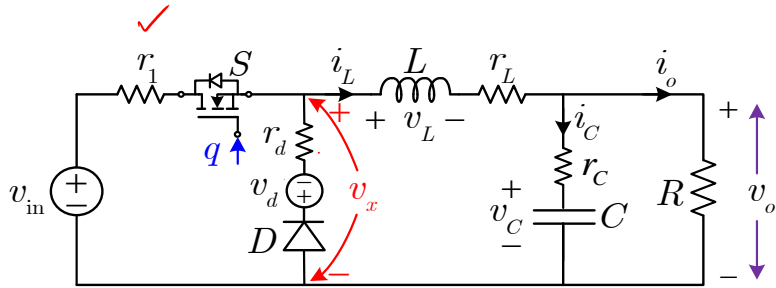
# Buck Converter VMC : Simulink Complete Implementation



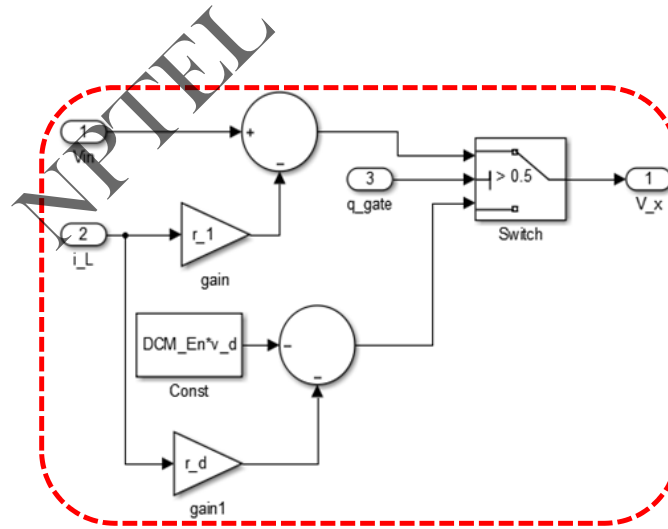
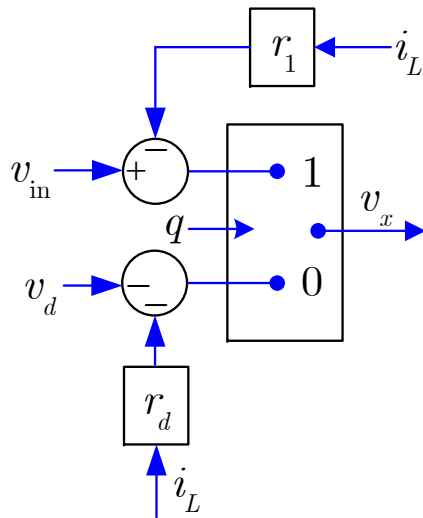
## Conventional Buck Converter : Inside Subsystem



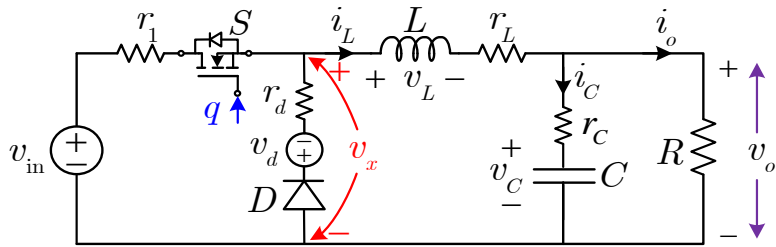
## Conventional Buck Converter : Switch Node Voltage



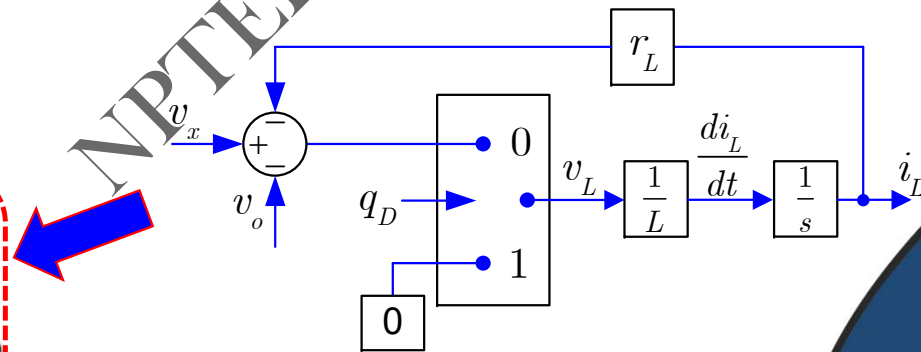
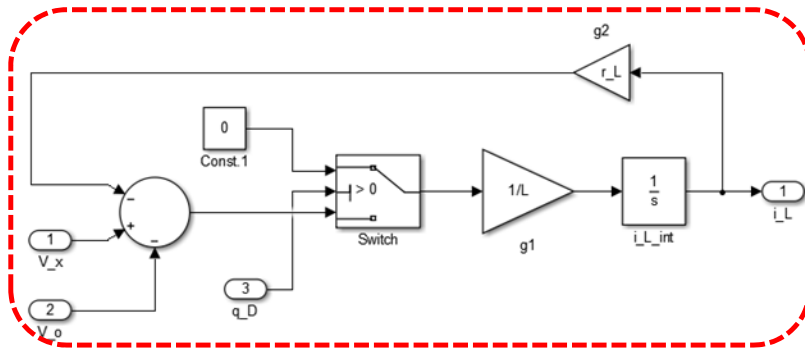
$$v_x = q(v_{in} - i_L r_1) + (1 - q)(-v_d - i_L r_d)$$



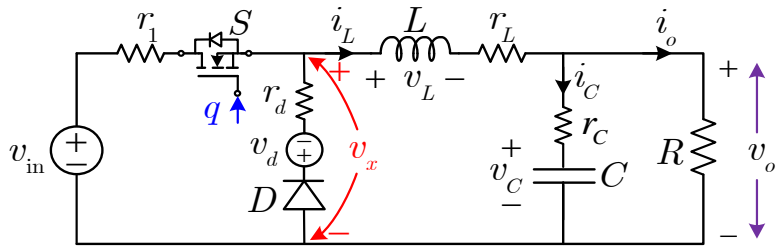
## Conventional Buck Converter : Inductor Dynamics



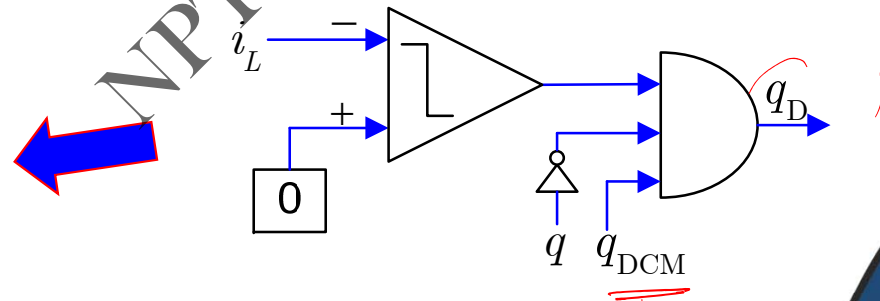
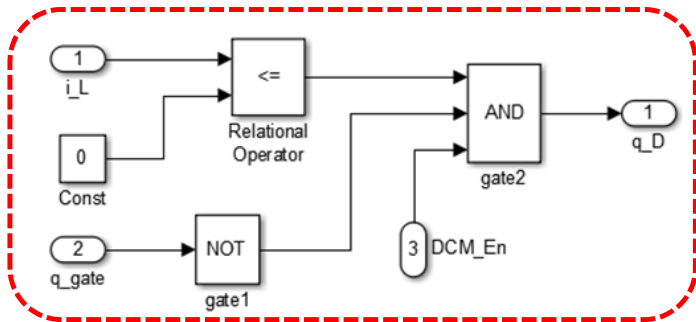
$$\frac{di_L}{dt} = \begin{cases} \frac{1}{L} \times (v_x - i_L r_L - v_o) & \text{for } i_L > 0 \\ 0 & \text{for } i_L \leq 0 \end{cases}$$



## Conventional Buck Converter : DCM Enable Block

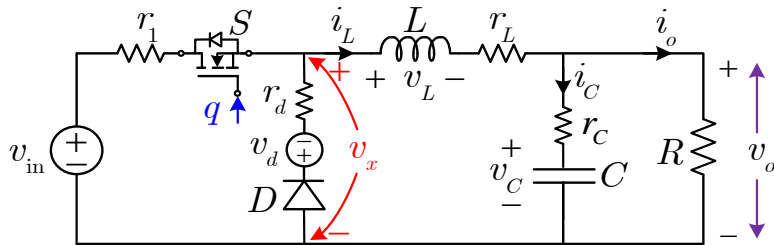


$$\frac{di_L}{dt} = \begin{cases} \frac{1}{L} \times (v_x - i_L r_L - v_o) & \text{for } i_L > 0 \\ 0 & \text{for } i_L \leq 0 \end{cases}$$



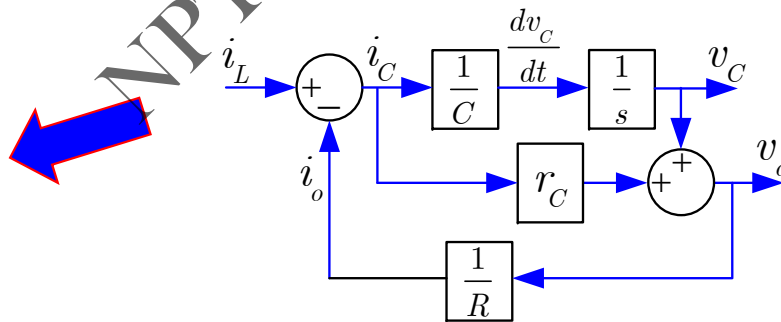
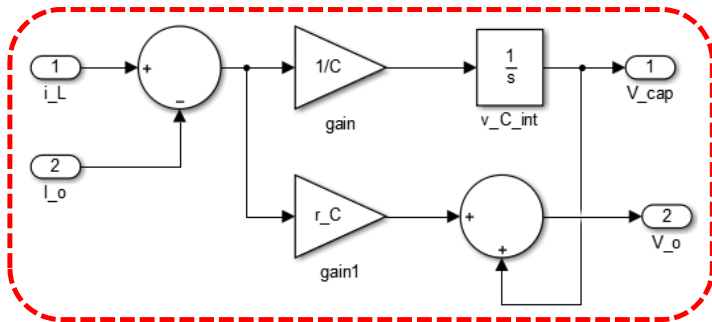


## Conventional Buck Converter : Capacitor Dynamics

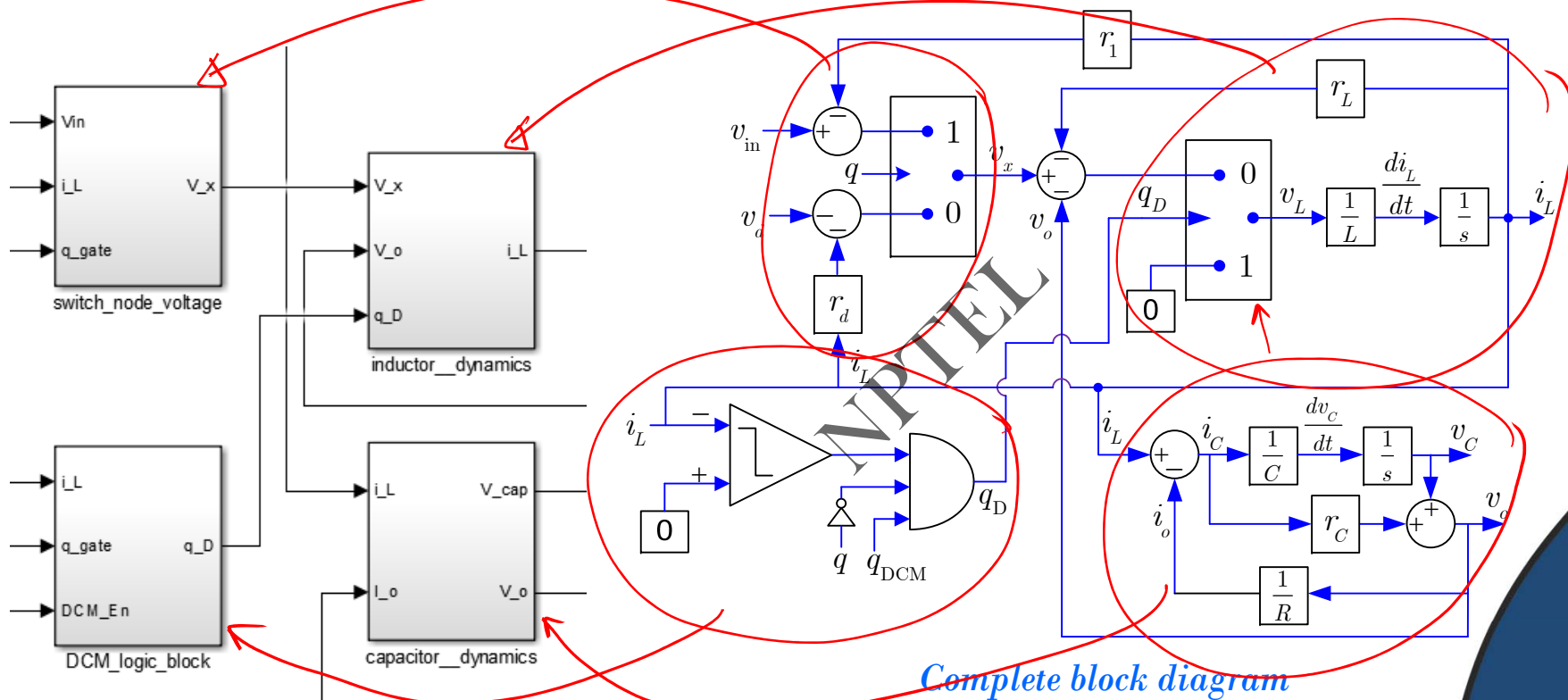


$$\frac{dv_C}{dt} = \frac{1}{C} \times i_C = \frac{1}{C} \times (i_L - i_o)$$

$$v_o = i_C r_C + v_C$$



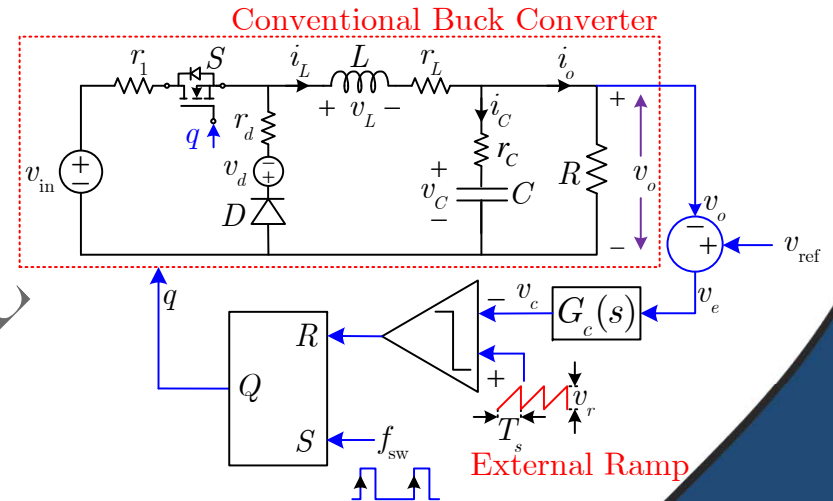
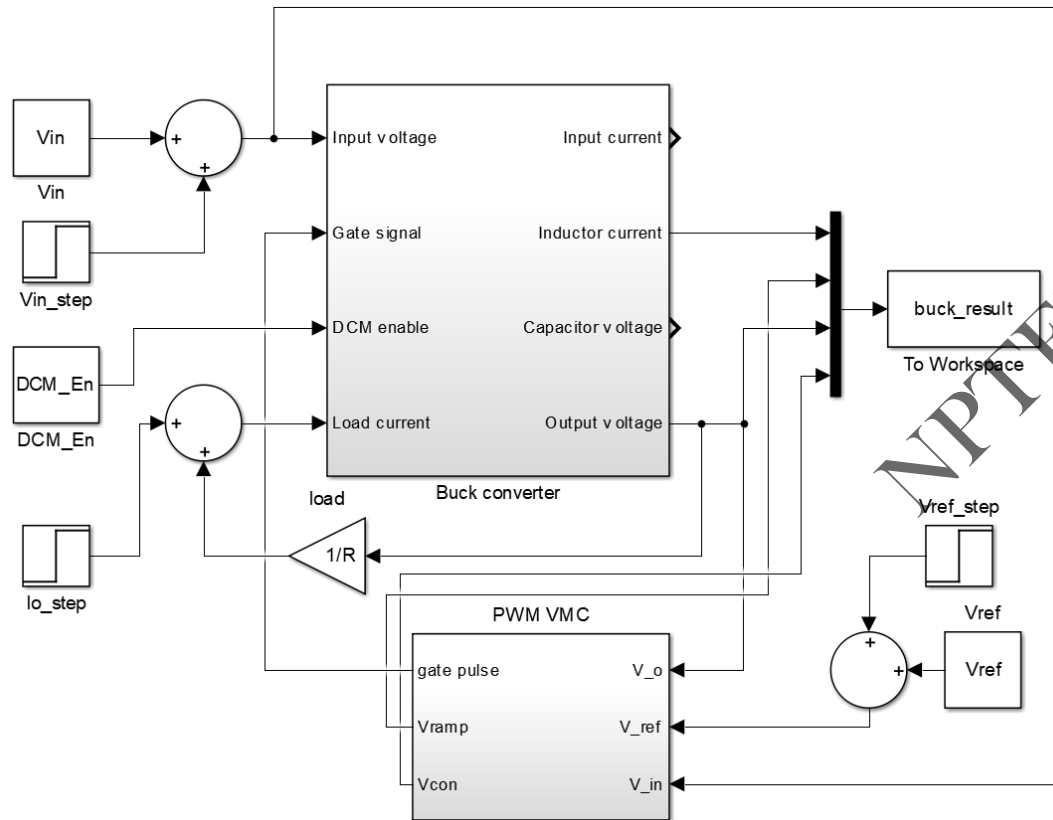
## Conventional Buck Converter : Complete Simulink Subsystem



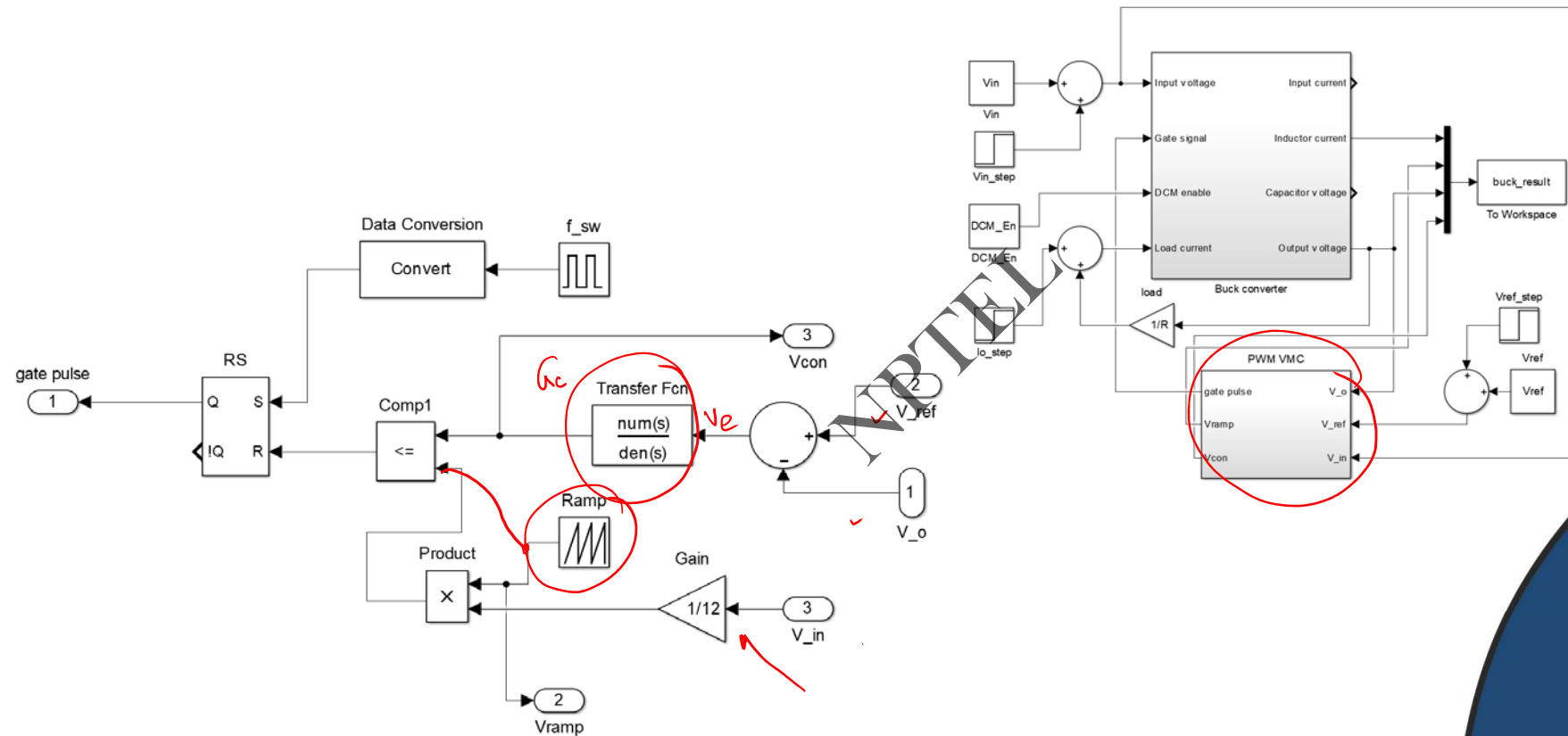
Complete block diagram

[ For details, refer to [Lecture~4, NPTEL "Control and Tuning Methods ..." course](#) ([link](#))

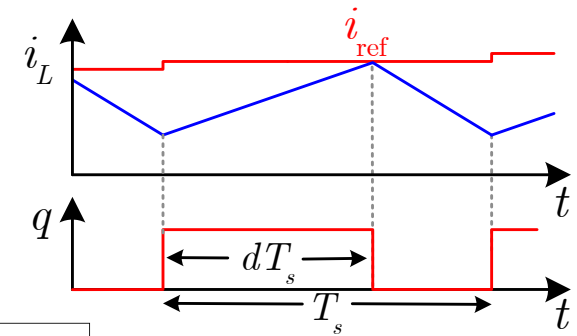
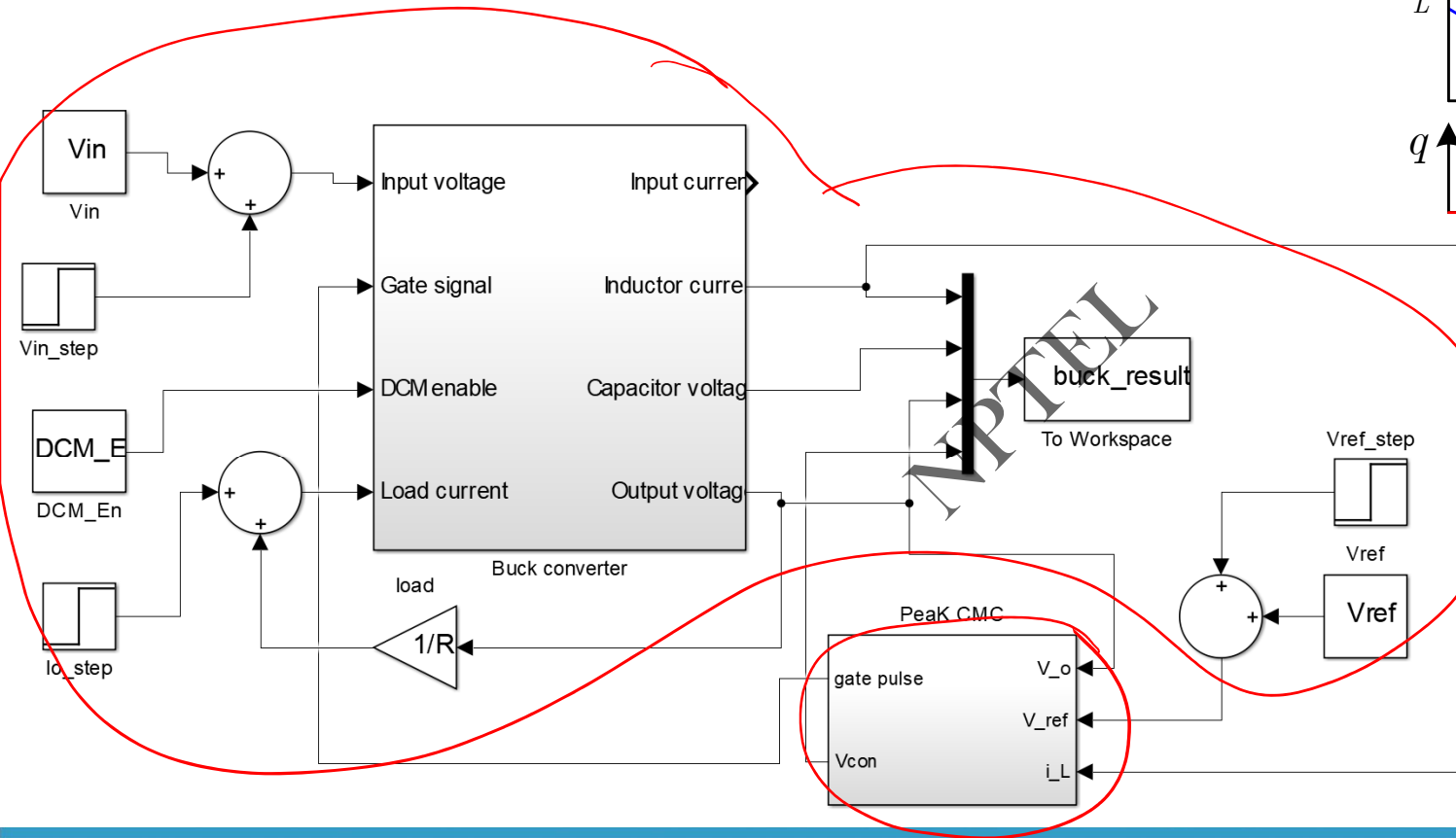
# Buck Converter VMC : Simulink Complete Implementation



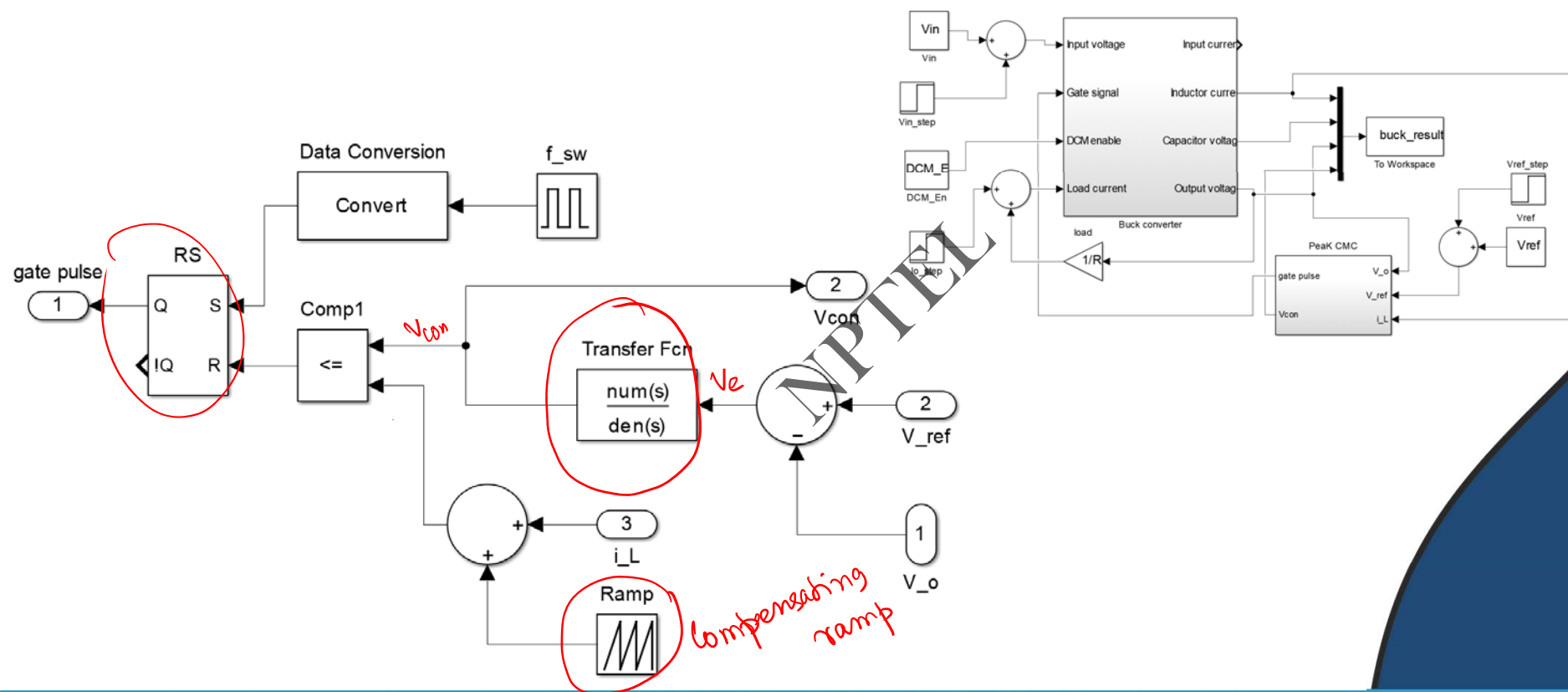
## Buck Converter Voltage Mode Control : Control Block



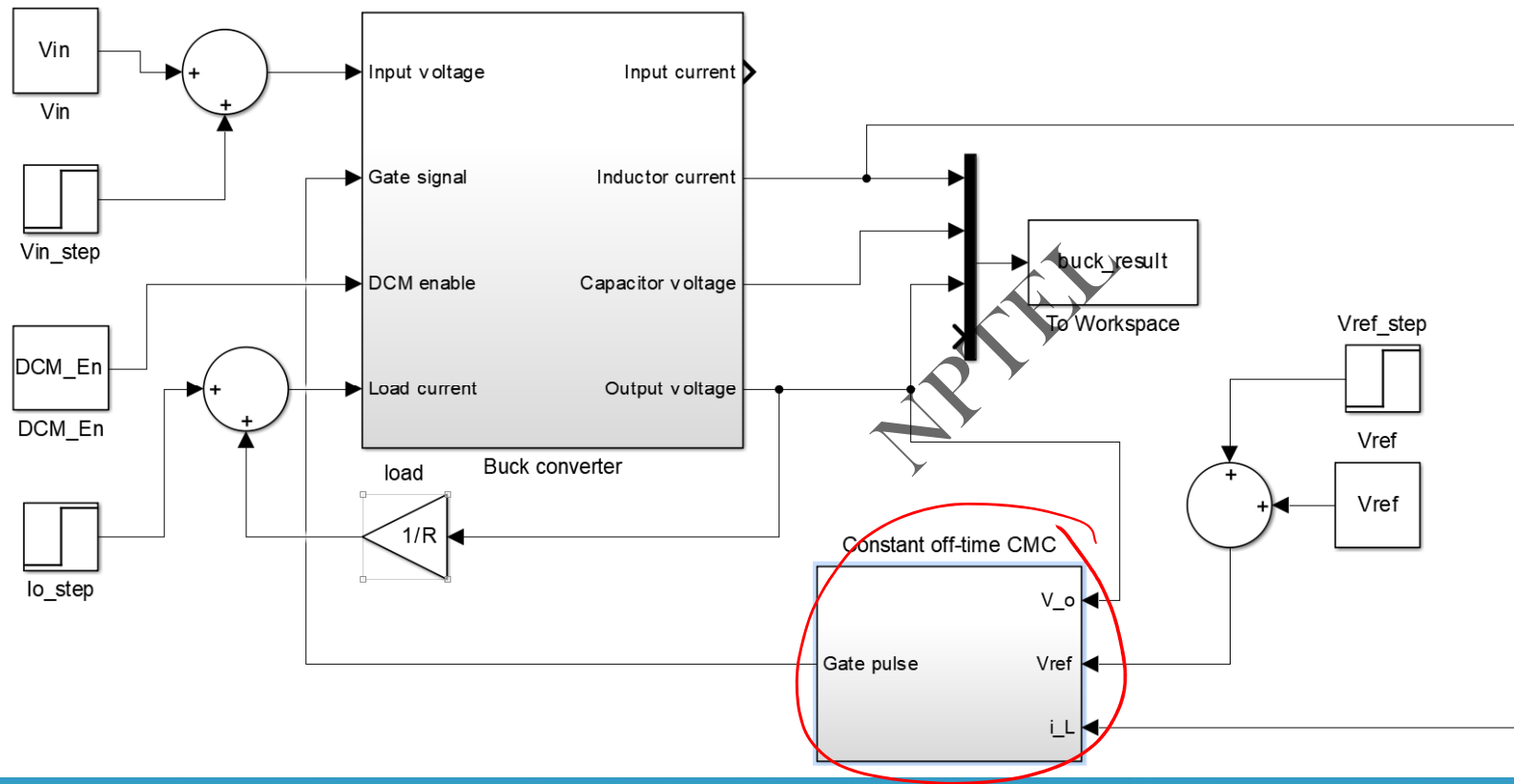
# Peak Current Mode Control



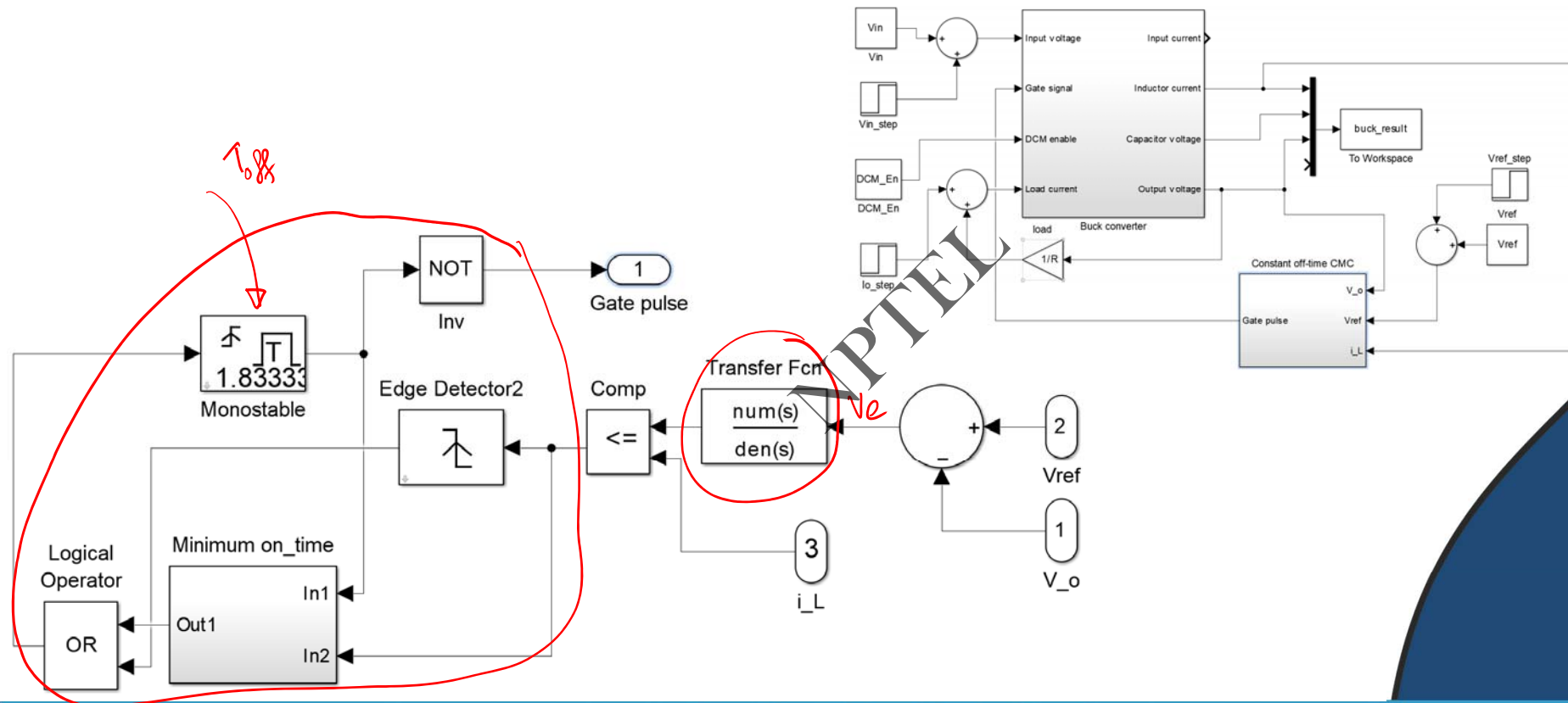
# Peak Current Mode Control : Simulink Complete Implementation



## Constant Off-Time Peak Current Mode Control

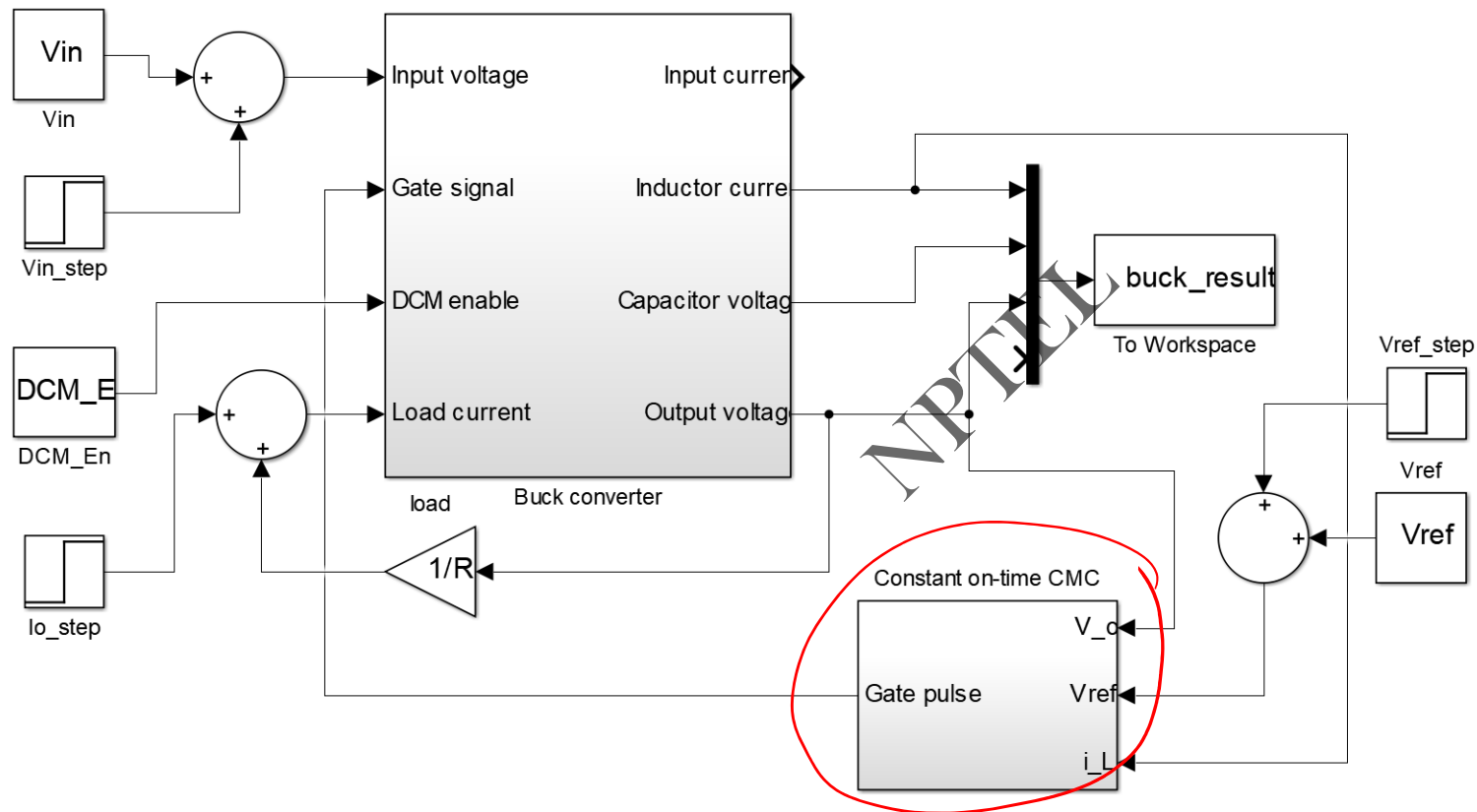


## Constant Off-Time Peak Current Mode Control

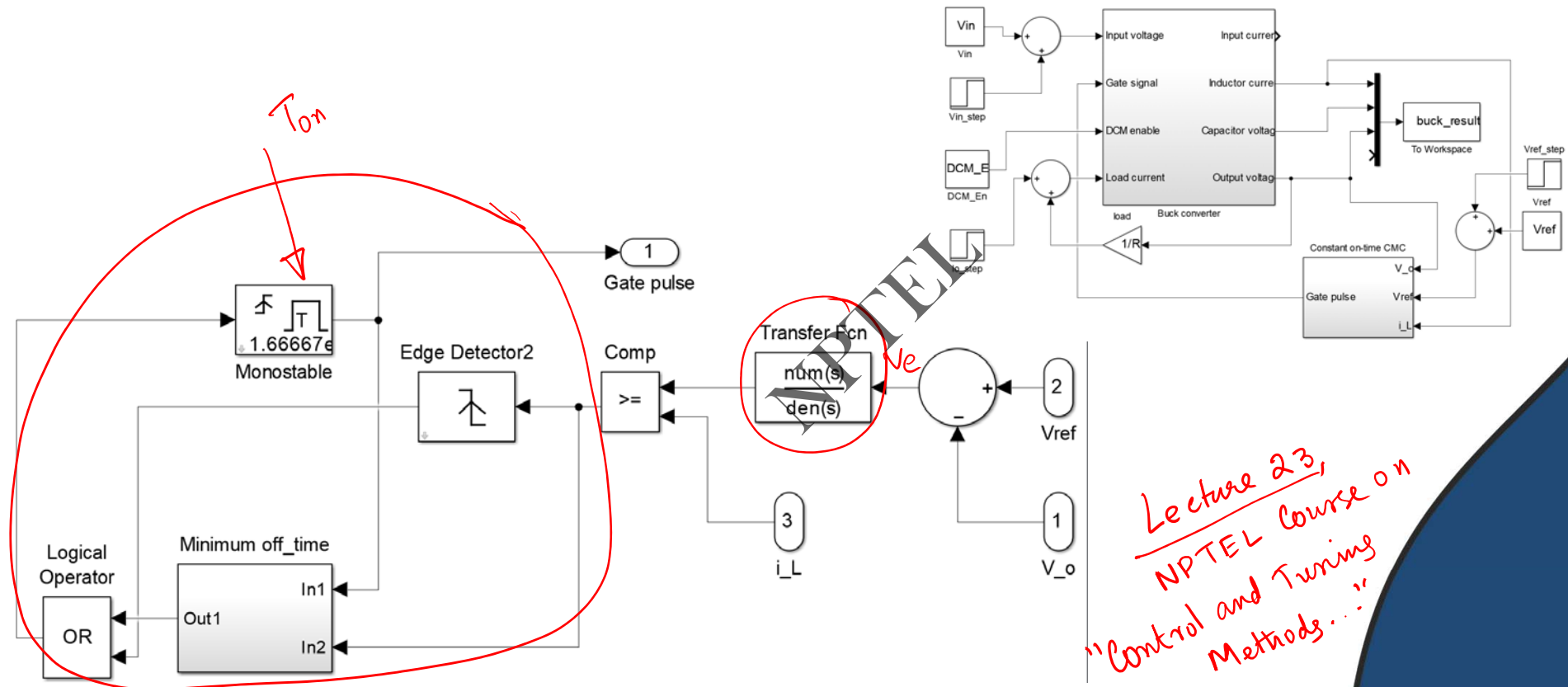




## Constant On-Time Valley Current Mode Control

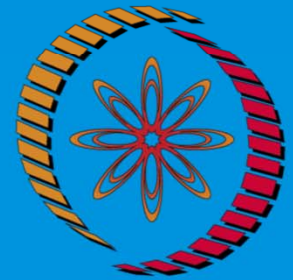


# Constant On-Time Valley Current Mode Control



# CONCLUSION

- Recap MATLAB customized model development
- Recap of fixed frequency analog voltage and current mode control implementation
- Recap of constant off-time analog current mode control
- Recap of constant on-time analog current mode control



**THANK  
YOU !**