NPTEL ONLINE CERTIFICATION COURSES

DIGITAL CONTROL IN SMPCs AND FPGA-BASED PROTOTYPING

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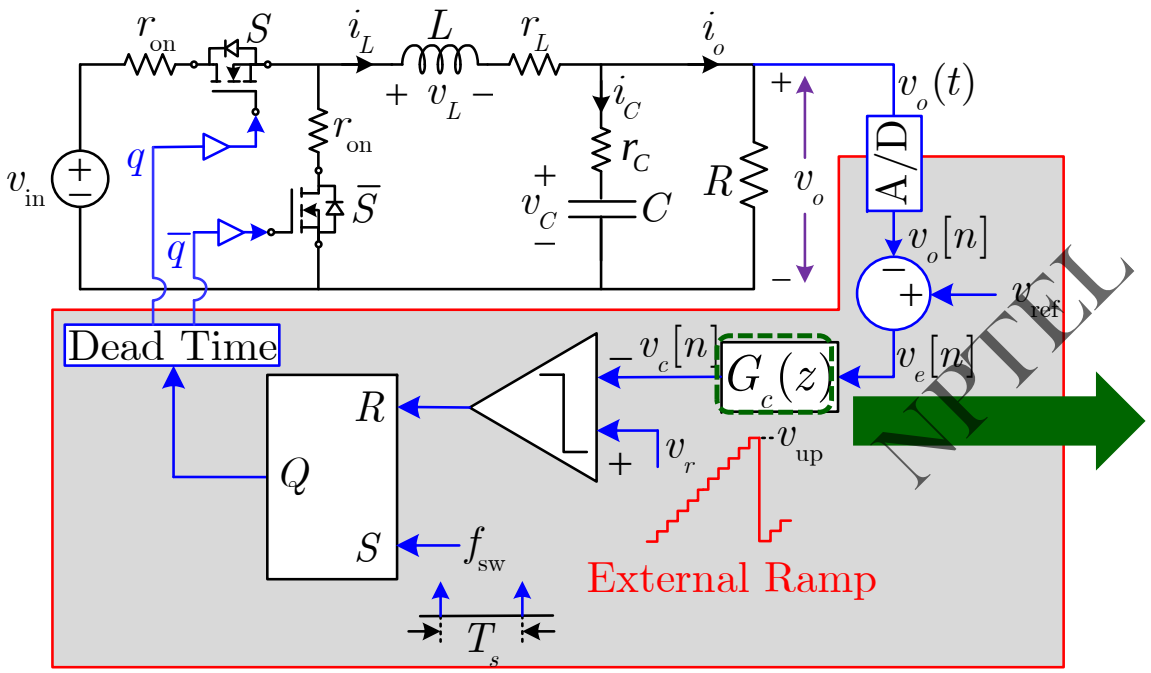
Module 03: MATLAB Custom Model Development under Digital Control

Lecture 24: MATLAB Models for Digital Controllers using Difference Equations

CONCEPTS COVERED

- Step-by-step custom MATLAB model development for digital controller
- Digital control implementation using difference equation
- MATLAB model of digital VMC

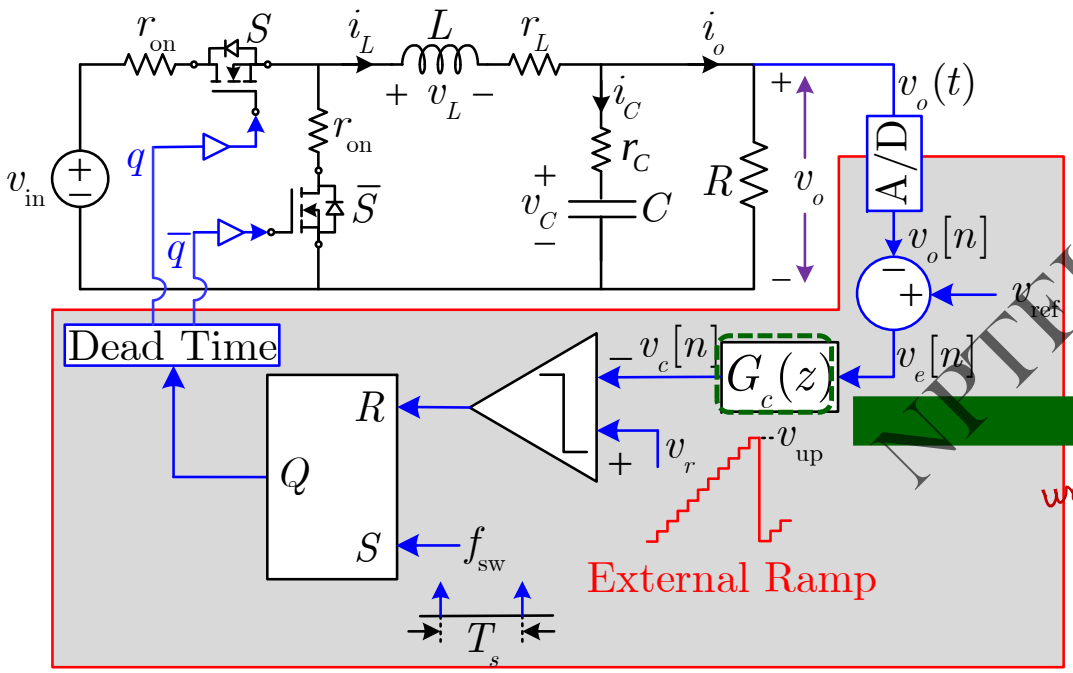
Digital Voltage Mode Control in a Buck Converter

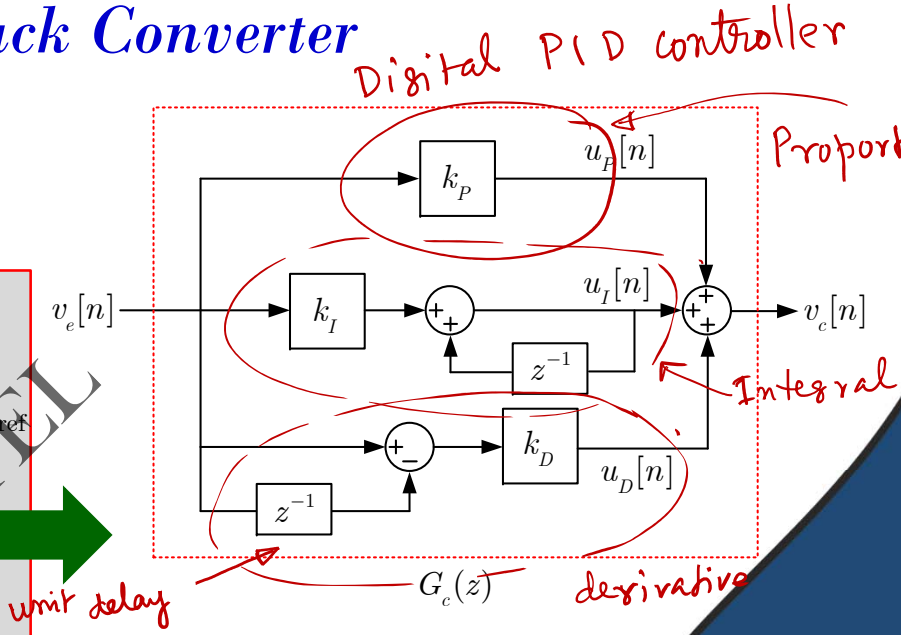


$$G_c(z) = k_p + k_i \frac{1}{1-z^{-1}} + k_d(1-z^{-1})$$

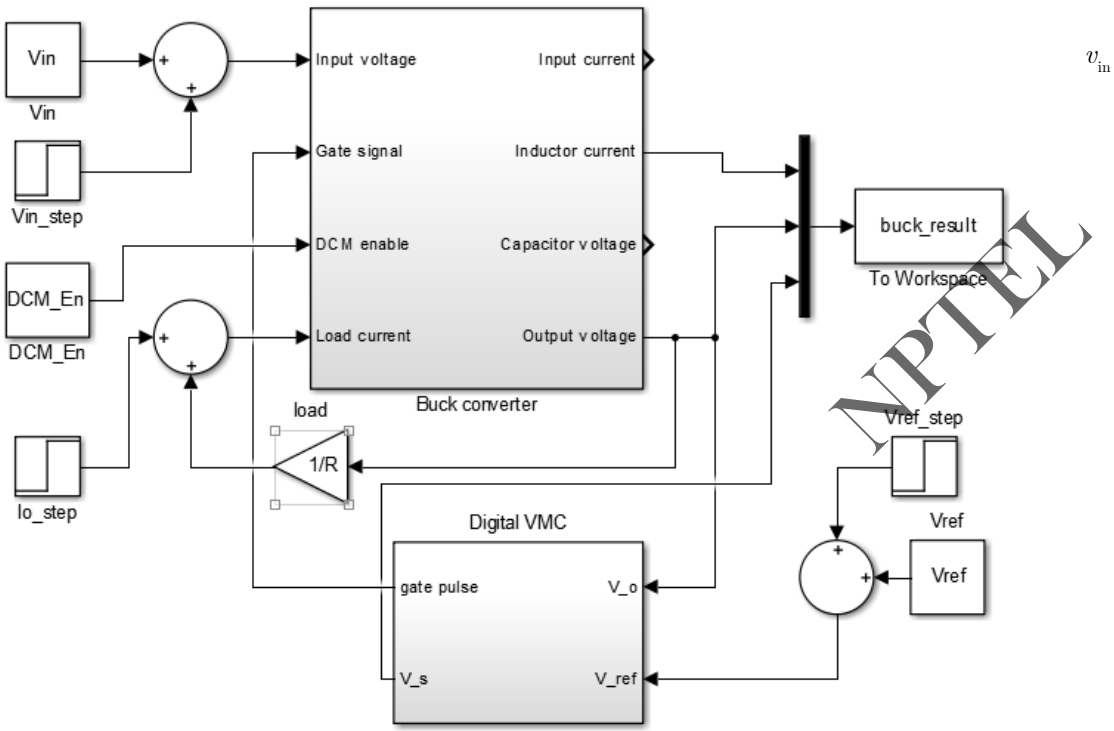
Digital PID controller

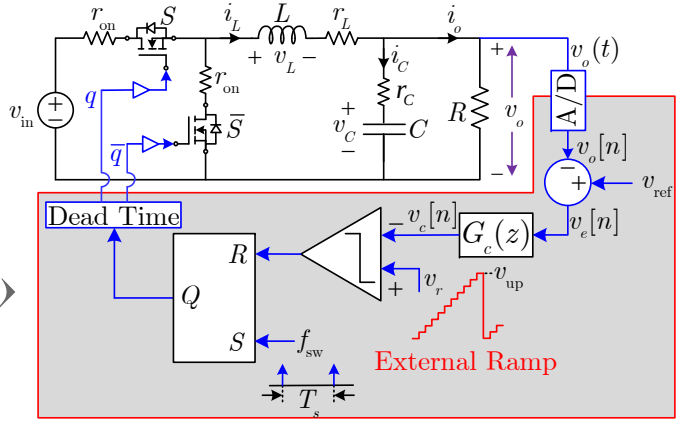
Digital Voltage Mode Control in a Buck Converter





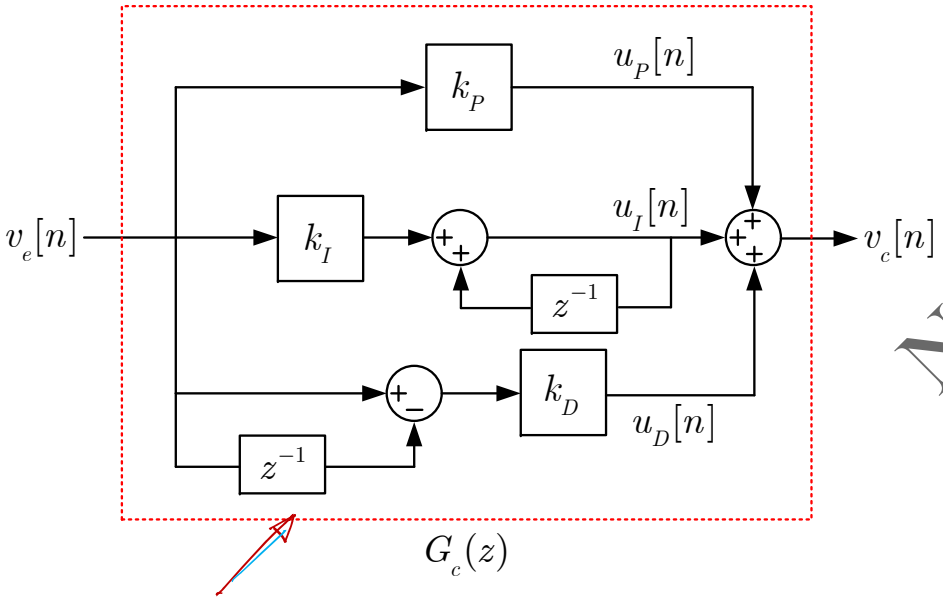
Digital Voltage Mode Control in a Buck Converter





Digital PID Controller

- Discrete-time PID controller



$$G_c(z) = k_P + \frac{k_I}{1 - z^{-1}} + k_D\left(1 - z^{-1}\right)$$

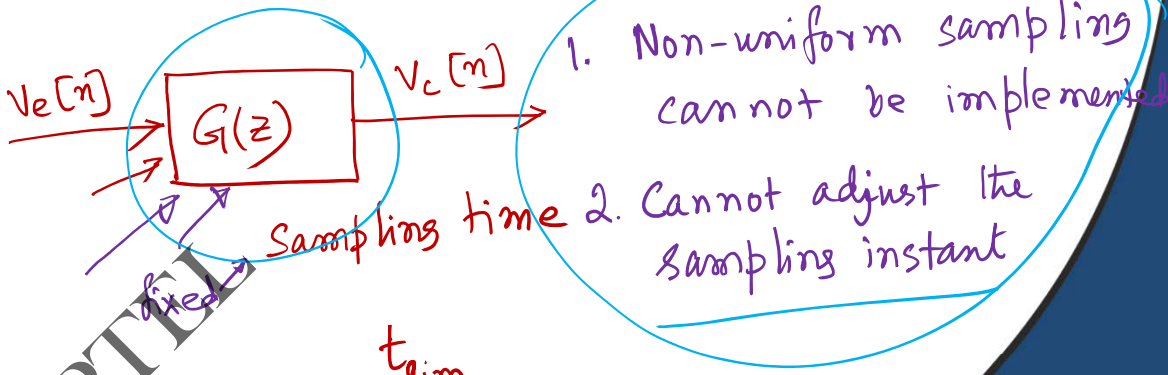
$$= k_p + k_i\left(\frac{z}{z-1}\right) + k_d\left(\frac{z-1}{z}\right)$$

$$=$$

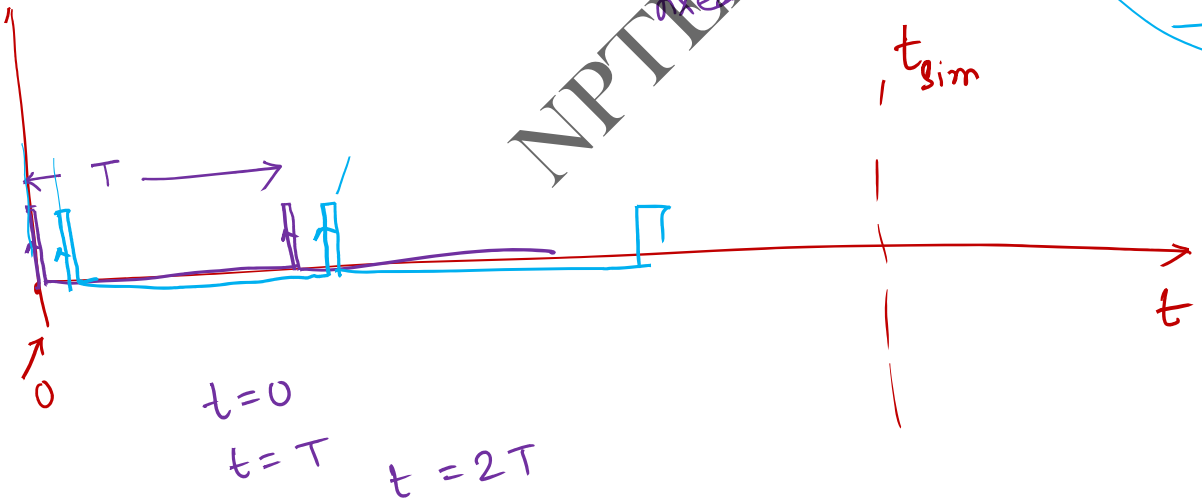
Difficulties in Direct Implementation of Digital PID Controller

$$G_c(z) = k_P + \frac{k_I}{1 - z^{-1}} + k_D\left(1 - z^{-1}\right)$$

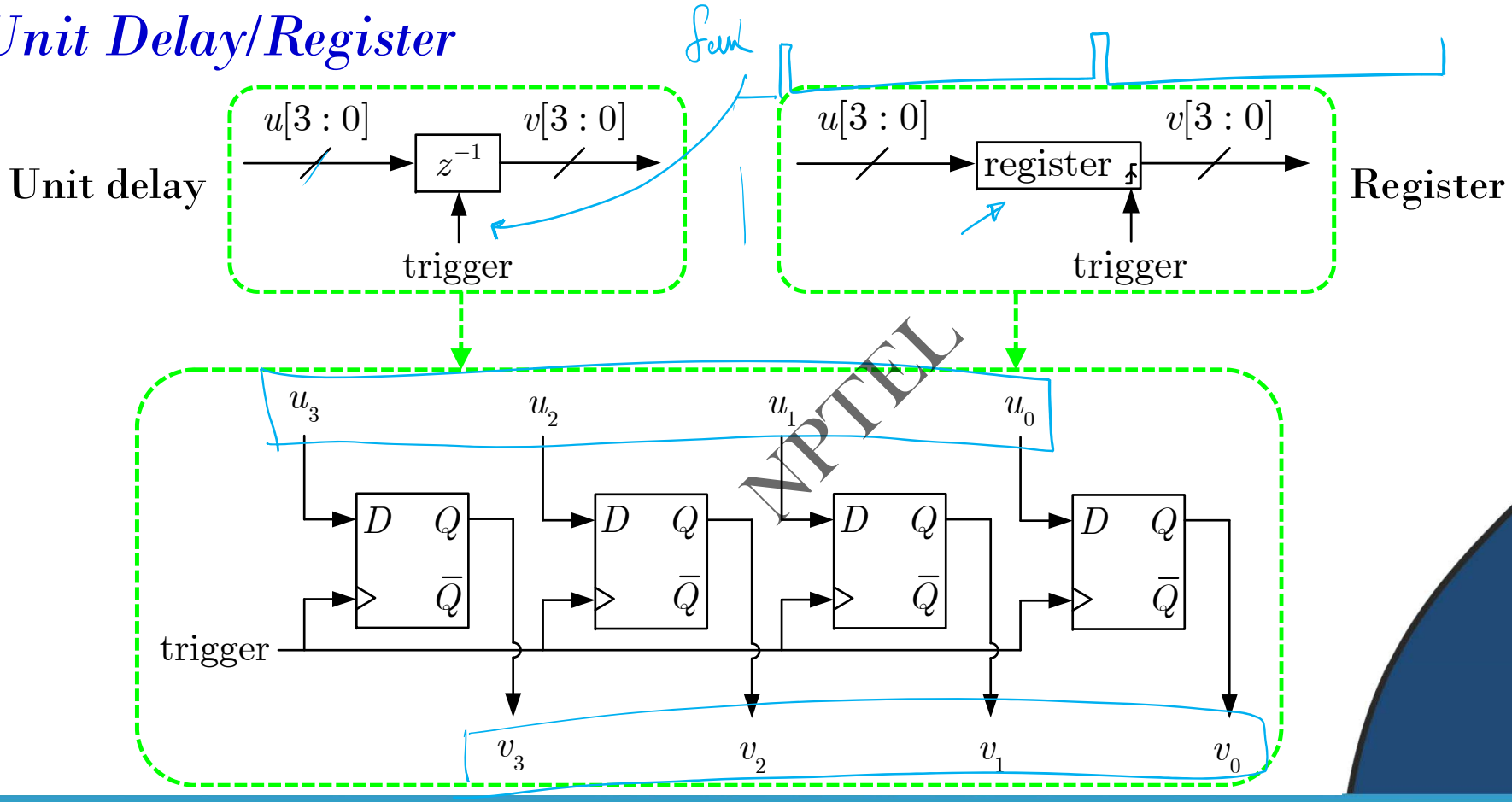
Start the simulation



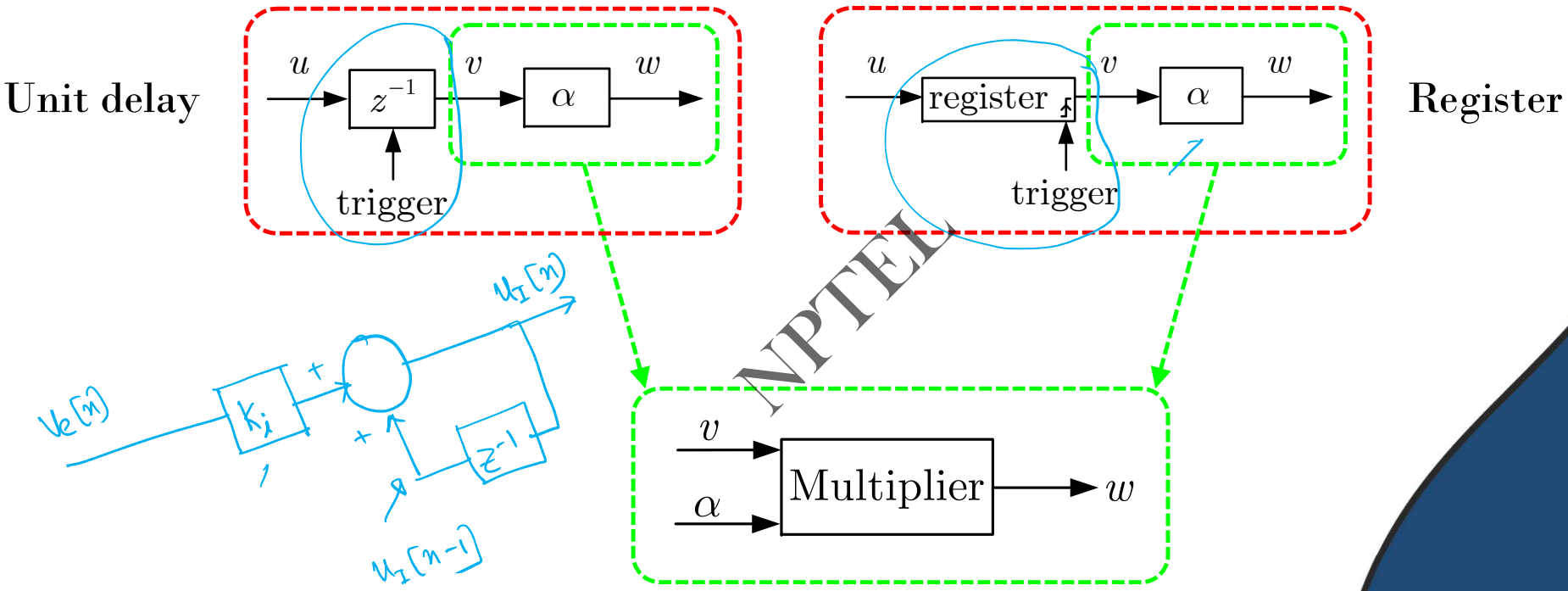
1. Non-uniform sampling cannot be implemented
2. Cannot adjust the sampling instant



Unit Delay/Register

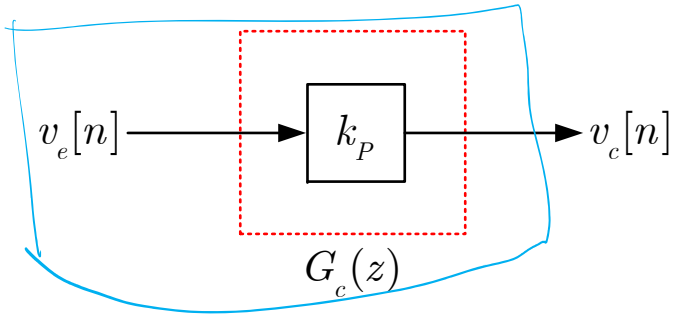


Unit Delay/Register Cascaded with Gain



Digital Proportional Controller

- Proportional Controller



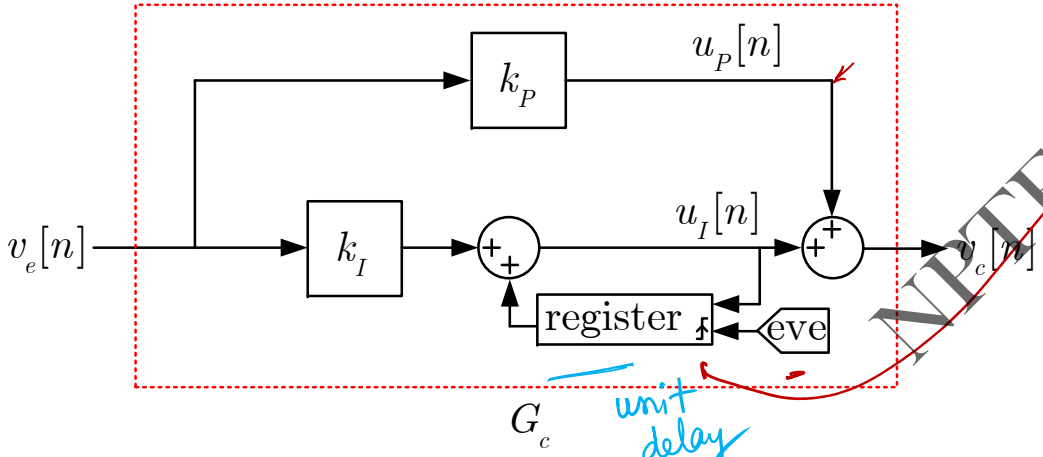
Uniform sampling

Difference equation: $v_c[n] = k_P v_e[n]$

$$G_c(z) = k_P$$

Digital PI Controller

- Proportional-Integral Controller



Clock driven sampling

$u_P(n) = k_P v_e[n]$

$u_I(n) = u_I(n-1) + k_I v_e[n]$

Difference equations:

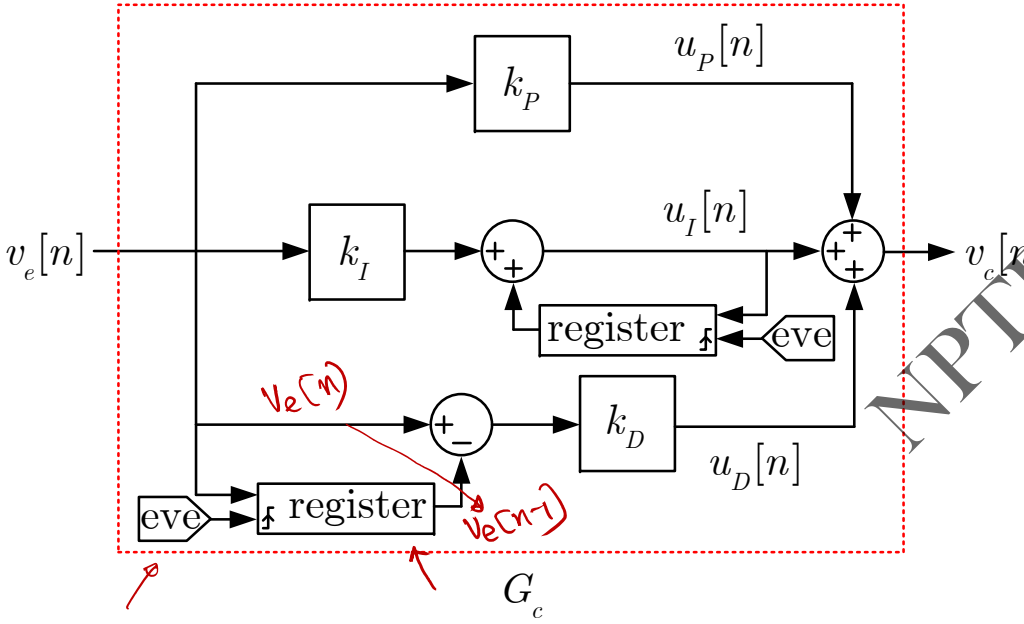
$$v_c[n] = k_P v_e[n] + u_I[n]$$

$$u_I[n] = k_I v_e[n] + u_I[n-1]$$

delayed version of $u_I(n)$

Digital PID Controller

- Proportional-Integral-Derivative Controller



Clock driven sampling

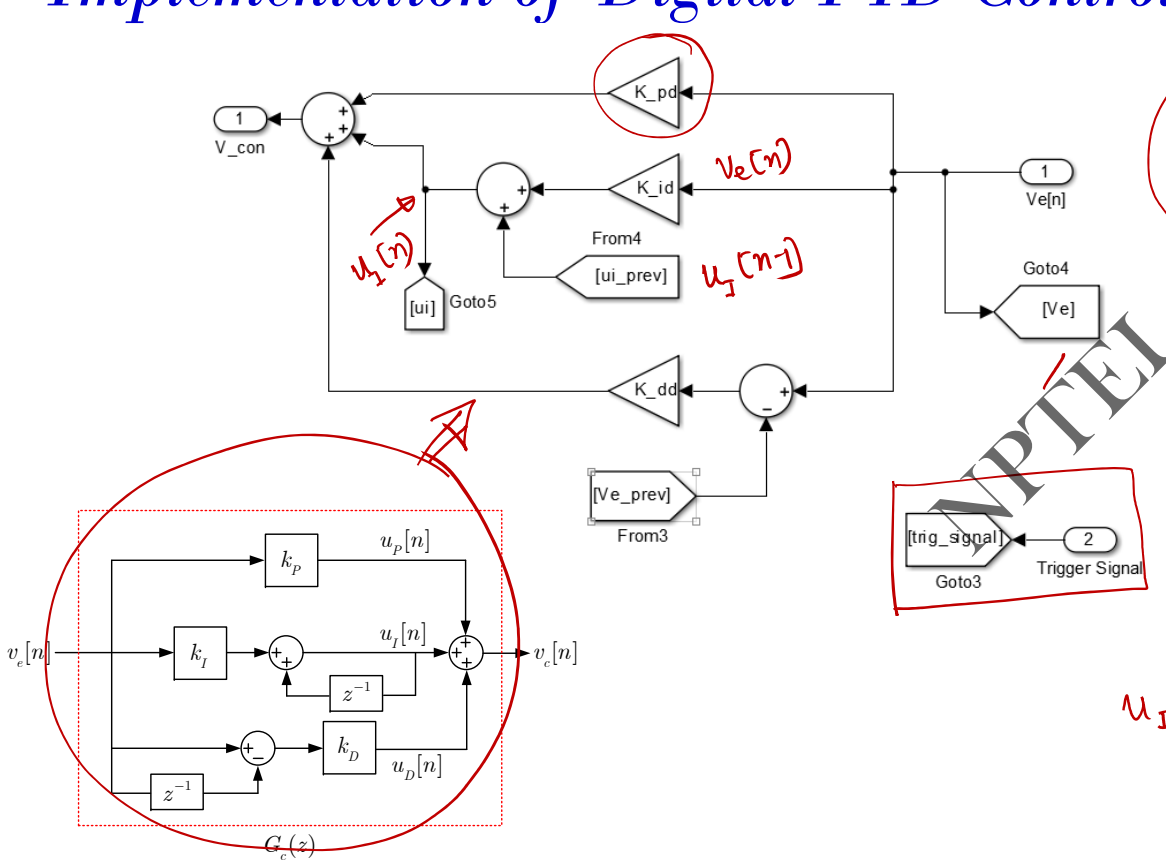
Difference equations:

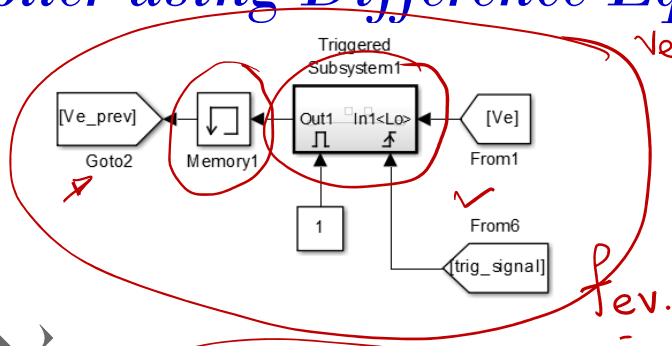
$$v_c[n] = k_P v_e[n] + u_I[n] + u_D[n]$$

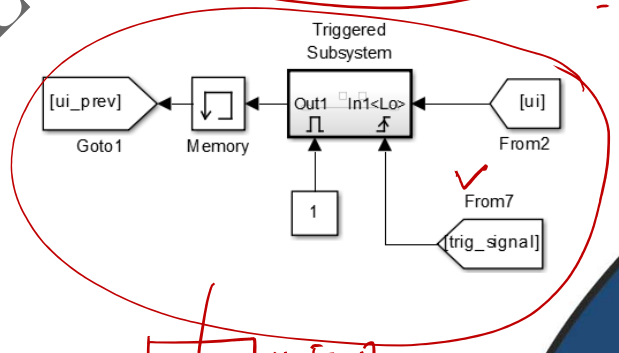
$$u_I[n] = k_I v_e[n] + u_I[n-1]$$

$$u_D[n] = k_D(v_e[n] - v_e[n-1])$$

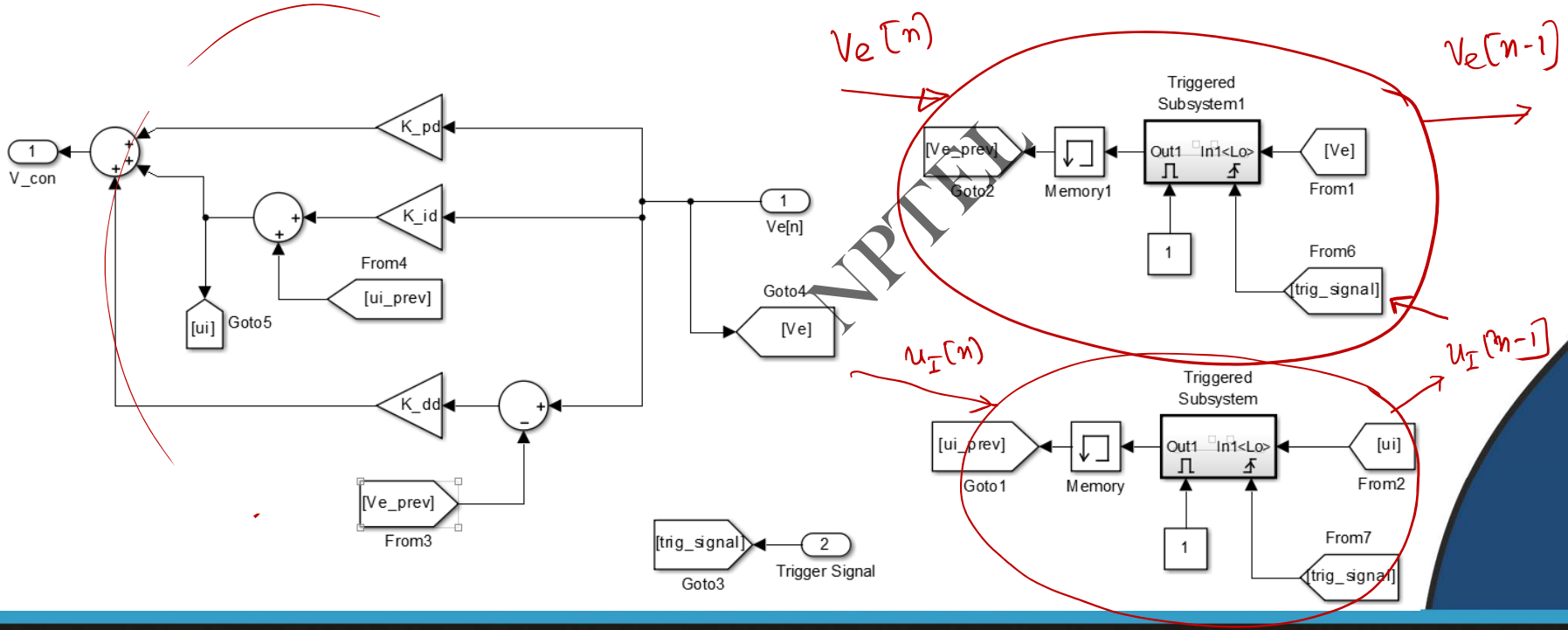
Implementation of Digital PID Controller using Difference Equation



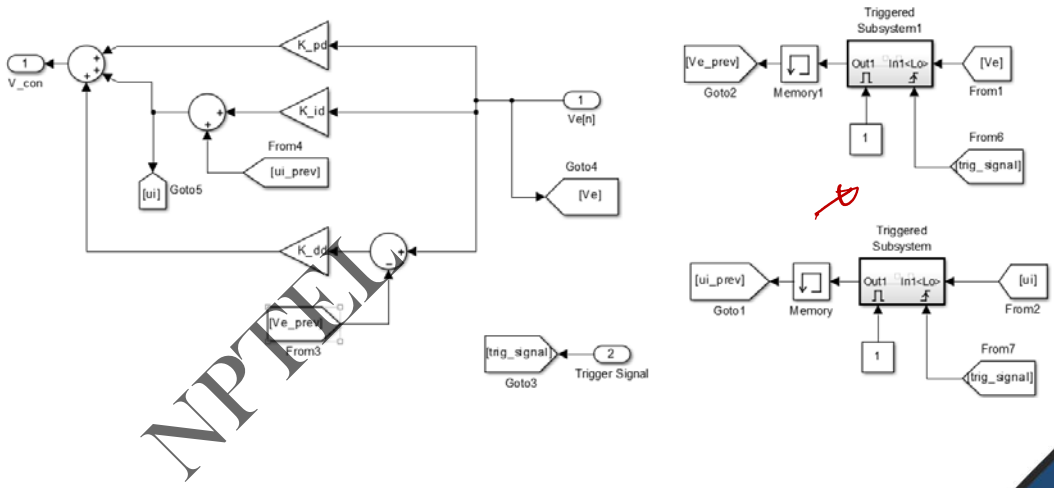




Implementation of Digital PID Controller using Difference Equation



Implementation of Digital PID Controller using Difference Equation



CONCLUSION

- Step-by-step custom MATLAB model development for digital controller
- Digital control implementation using difference equation
- MATLAB model of digital VMC

THANK YOU !