PHILIPS CTT Hogeschool van Utrecht

Systeem en Regeltechniek

FMT / Mechatronica

Deel 6: Extra regeltechniek

Blok 13: Digitale implementatie effecten

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Cursus Systeem en Regeltechniek

Overzicht

Deel 1	Blok 1. Inleiding
Wo. 14-04	Blok 2. Basisprincipes modelvorming massa-veersystemen
	Blok 3. De regelaar als veer-demper combinatie
Deel 2	Blok 4. Frequentie-domein beschrijving
Wo. 21-04	Blok 5. Basisconcepten in de regeltheorie
Deel 3	Blok 6. Verdere inleiding in de regeltheorie
Wo. 28-04	Blok 7. De PD regelaar als veer-demper combinatie
Deel 4	Blok 8. Stabiliteit van regelsystemen
Wo. 12-05	Blok 9. De PID regelaar in het frequentie domein
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	Blok 14. Terugblik / Evaluatie

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Digital implementation effects

How is a controller implemented?

?

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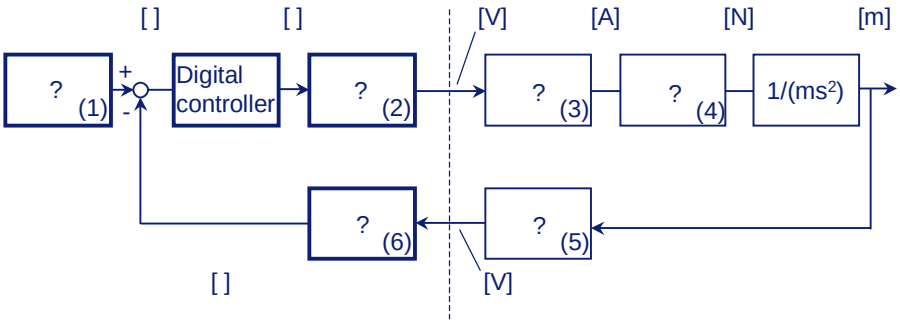
Digital implementation effects

Exercise: building blocks in digitally controlled system



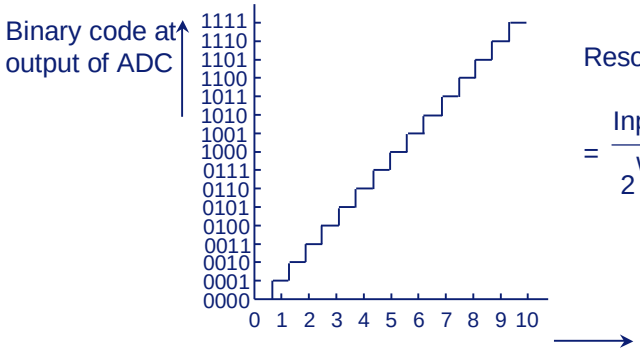
What elements do the question marks represent?

Contents of Sequel

- Digitizing a signal (ADC)
- Digital to analog conversion (DAC)
- Programming a digital controller
- Cause and effects of delay

Digitizing a signal (ADC)

Discretizing in magnitude



Resolution [V/bit]:

$$= \frac{\text{Input range}}{2^{\text{word size}}}$$

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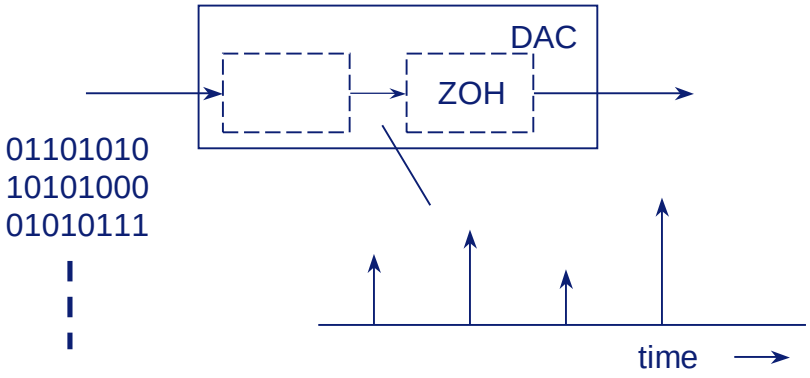
Digital to analog conversion (DAC)

Converting numbers into voltage



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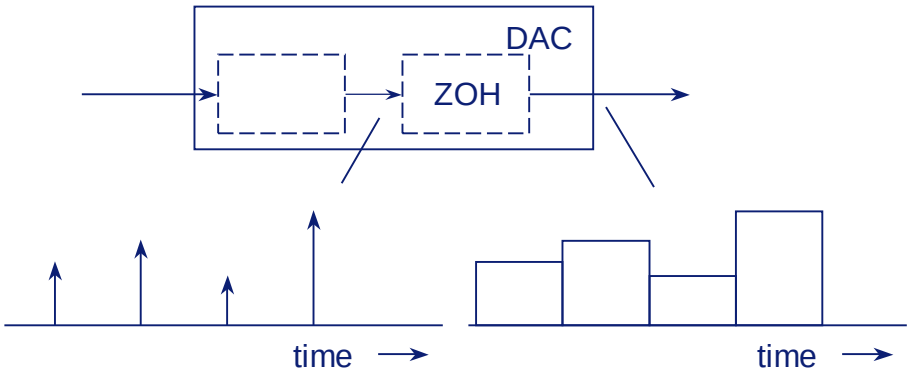
Digital implementation effects

Digital to analog conversion (DAC)

Zero Order Hold



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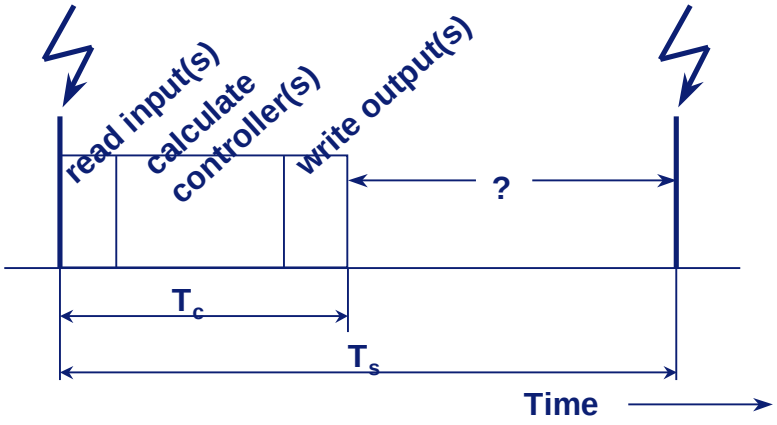
Programming a digital controller

Timing of the sample routine



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Digital implementation effects

Programming a digital controller

Example: PI controller

Continuous Time domain:

$$F_c(t) = K_p\, e(t) + K_i \int e(t)dt$$

Discrete Time domain:

$$F_c^{\,k} = K_p\, e^k + \boxed{K_i\,(e^0 + e^1 + \ldots + e^k)T_s}$$

$$F_c^{\,k+1} = K_p\, e^{k+1} + K_i\,(e^0 + e^1 + \ldots + e^k + e^{k+1})T_s$$

$$F_c^{\,k+1} = K_p\, e^{k+1} + \boxed{K_i\,(e^0 + e^1 + \ldots + e^k)T_s} + K_i\, e^{k+1} T_s$$

$$F_c^{\,k+1} = F_c^{\,k} + K_p\,(e^{k+1} - e^k) + K_i\, e^{k+1} T_s$$

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Digital implementation effects

Cause and effects of delay

Delay in digital system caused by:

- Time needed to calculate new actions (force) as response to new inputs (position errors), called T_c
- Lag effect in the DA conversion (ZOH)

So, in total delay complies to:

- $T_{delay} = T_c + 0.5 \cdot T_s$

Remark:

- Transfer function of delay with time T: $H_{delay}(s) = e^{-Ts}$
- FRF of delay with time T: $H_{delay}(\omega) = e^{-j\omega T}$

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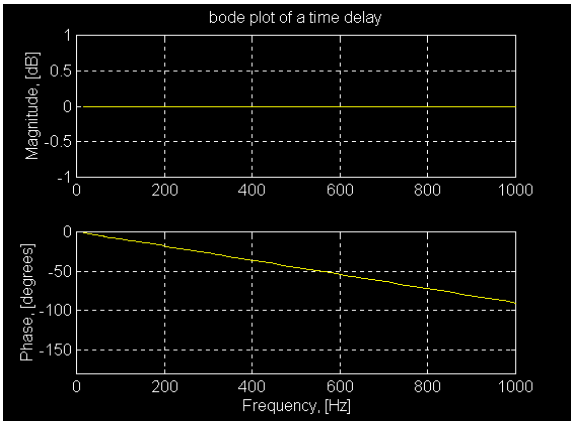
Digital implementation effects

Cause and effects of delay

$H_{delay}(\omega) = e^{-j\omega T}$

Amplitude = 1

Phase = $-T_{delay} \cdot f \cdot 360$



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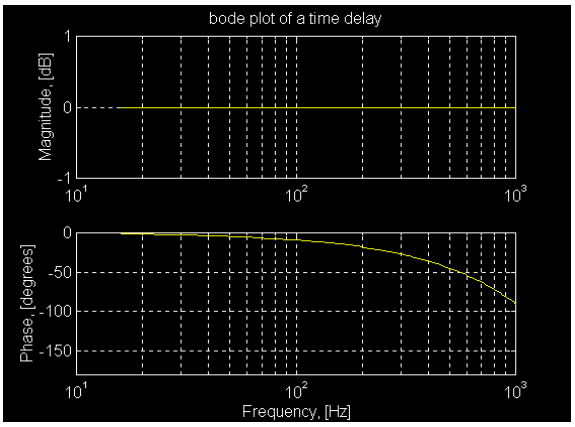
Cause and effects of delay

$H_{delay}(\omega) = e^{-j\omega T}$

Amplitude = 1

Phase = $-T_{delay} \cdot f \cdot 360$



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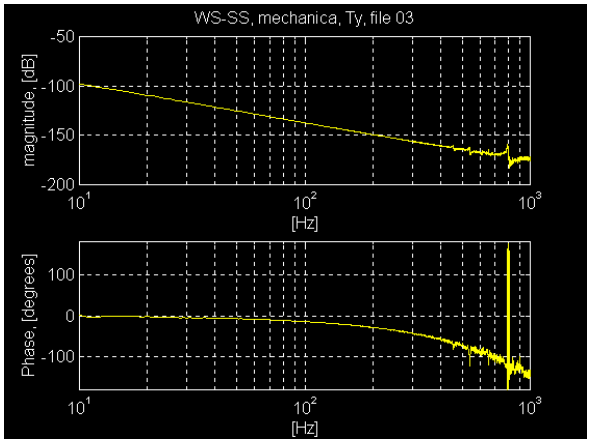
Digital implementation effects

Cause and effects of delay



What is the calculation delay if T_s = 400 μsec?

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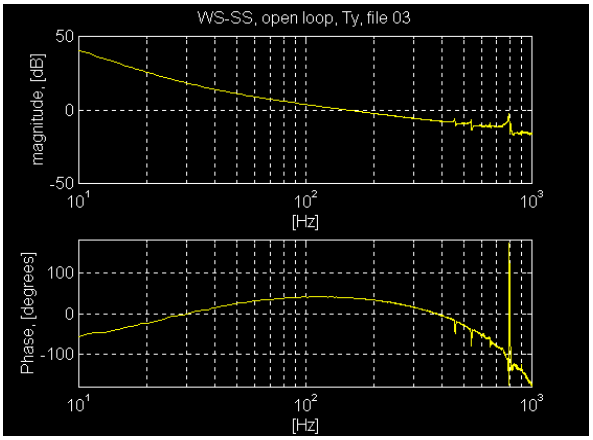
Cause and effects of delay



At what sample rate would the phase margin be 5 degrees larger?

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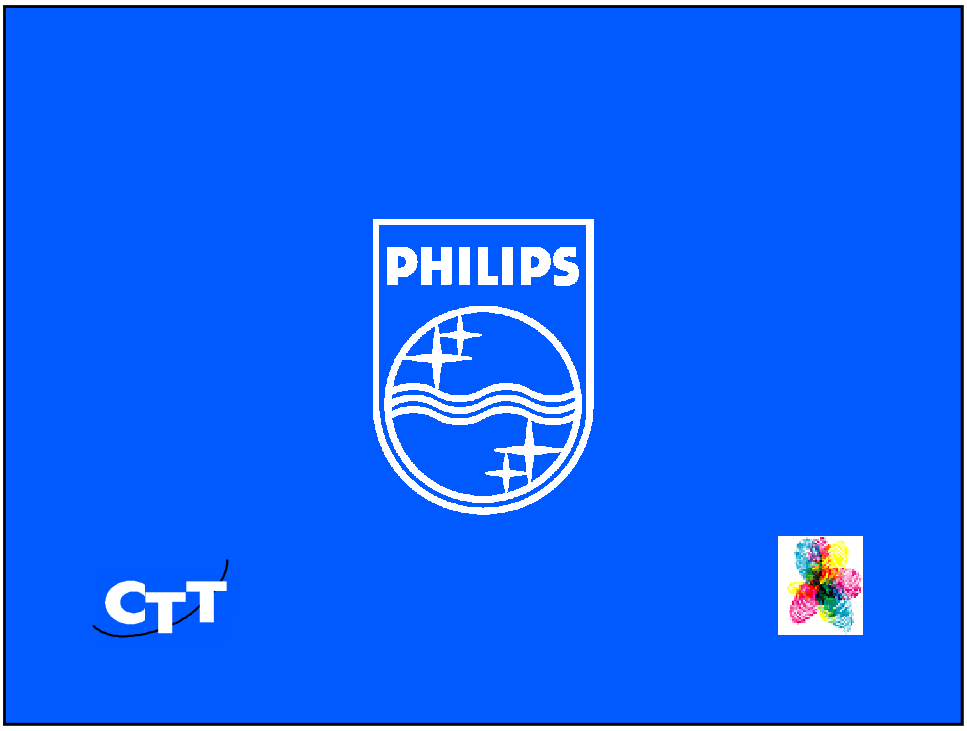
Summary

- Building blocks of control loop
- Digital controller implementation:
  - Digitizing the input signal (ADC)
  - Digital to analog conversion of output (DAC)
  - Programming a digital controller
  - Cause and effects of delay
- Delay is phase lag => reduced PM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