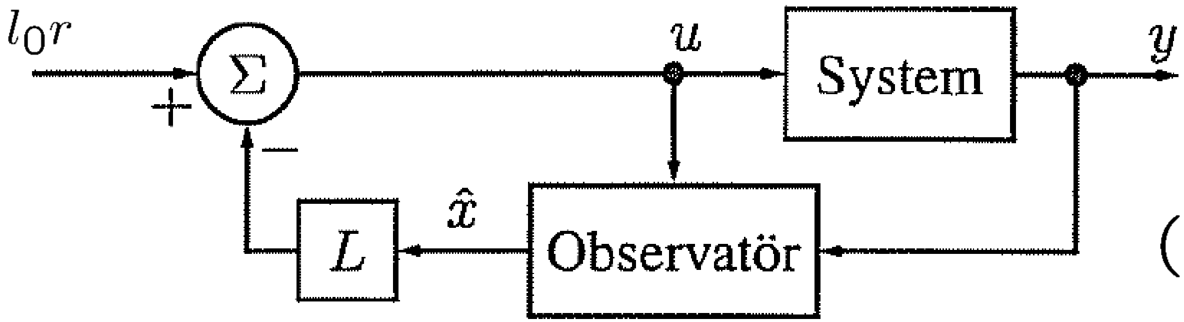
EL1000/1120/1110 Reglerteknik AK

Föreläsning 11:
Implementering

Innehåll

- Tillståndsåterkoppling med observerare (rep.)
- Kaskadkoppling, framkoppling och Smith-prediktorn (rep.)
- Implementering

Tillståndsåterkoppling med observerare



$(\tilde{x} = x - \hat{x})$

$$\begin{pmatrix} \dot{x} \\ \dot{\tilde{x}} \end{pmatrix} = \begin{pmatrix} A - BL & BL \\ 0 & A - KC \end{pmatrix} \begin{pmatrix} x \\ \tilde{x} \end{pmatrix} + \begin{pmatrix} B \\ 0 \end{pmatrix} l_0 r$$

$$y = \begin{pmatrix} C & 0 \end{pmatrix} \begin{pmatrix} x \\ \tilde{x} \end{pmatrix}$$

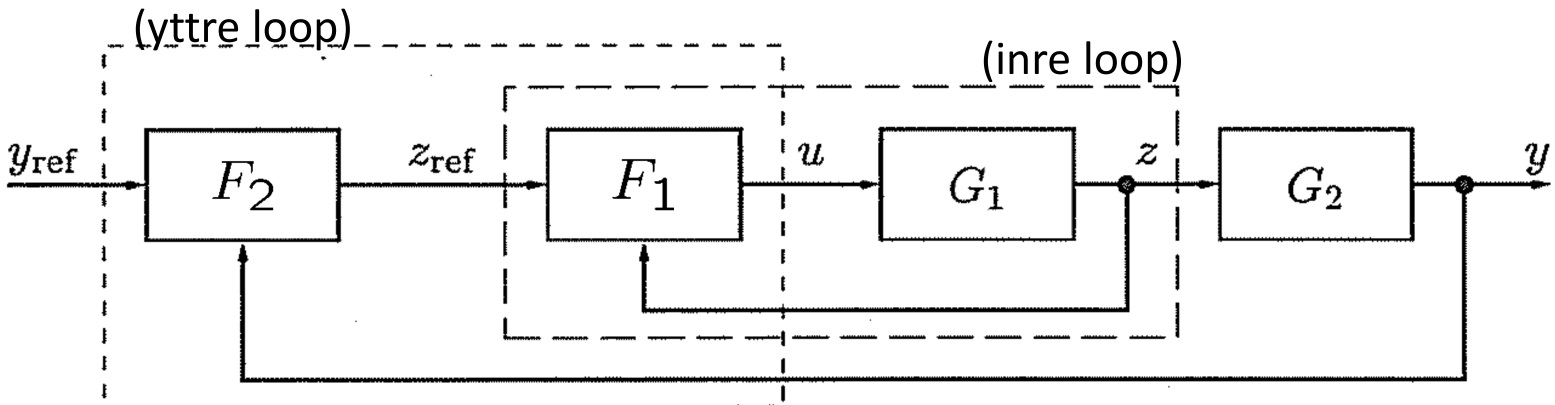
$$Y(s) = G_c(s) R(s)$$

$$G_c(s) = C(sI - A + BL)^{-1} B l_0$$

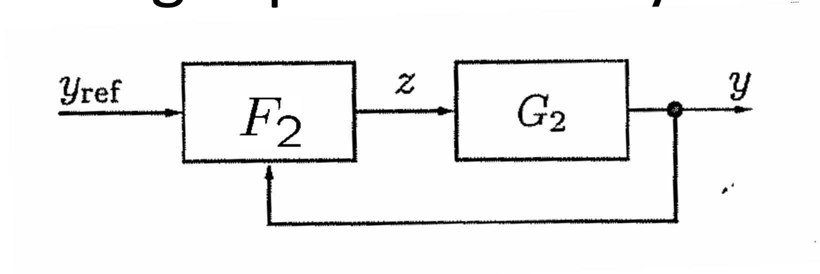
$G_c(s)$ samma som vid enbart tillståndsåterkoppling!

Kaskadreglering

- Kan mäta "mellansignal" *z*

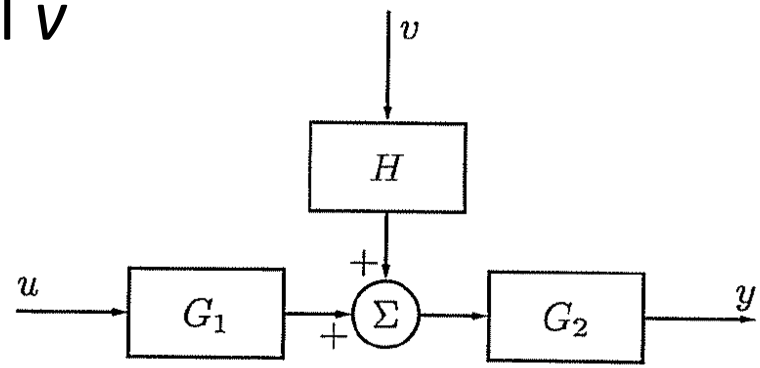


- Välj inre regulatorn F_1 så att $z(t) \approx z_{\mathrm{ref}}(t)$ (gör inre loopen tillräckligt snabb)
- Ger förenklat reglerproblem för yttre loopen:

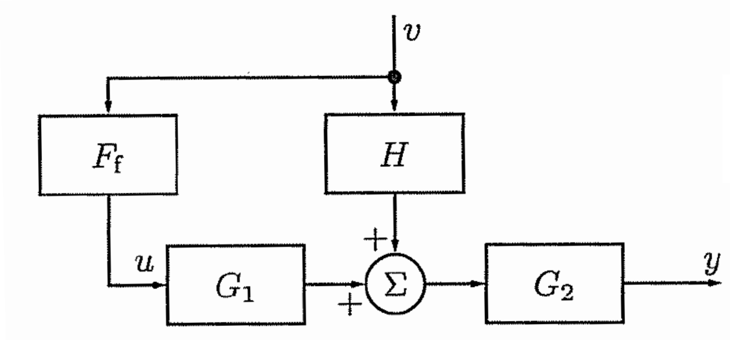


Framkoppling

- Kan mäta störsignal *v*



- Förkompensera innan störsignal ger fel i *y:*



$$Y = G_2(H + G_1 F_{\mathrm{f}})V$$

- Välj framkoppling

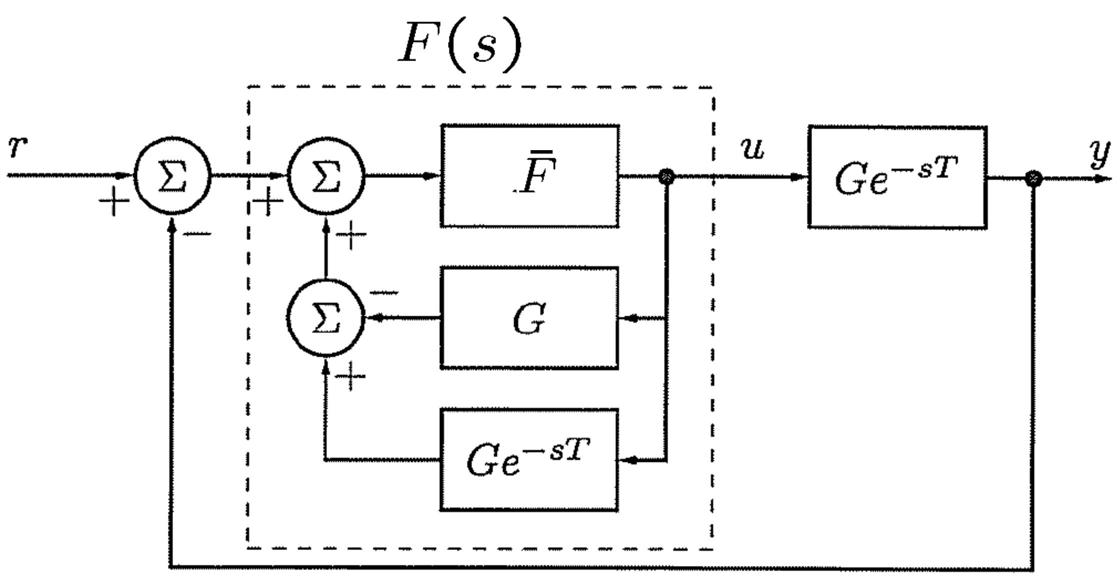
$$F_f(s) = -\frac{H(s)}{G_1(s)}$$

- Derivator i $F_f(s)$ måste approximeras

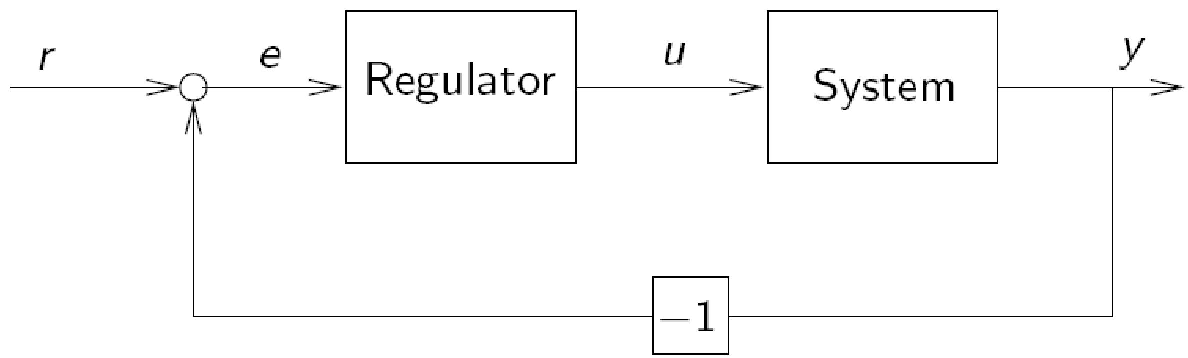
Smith-prediktorn

- Antag vi känner tidsfördröjningen *T*
- Designa $\bar{F}$ så att $\bar{G}_c = \dfrac{G\bar{F}}{1 + G\bar{F}}$ blir bra (PID, etc.)
- Smith-prediktorn $$F(s) = \frac{\bar{F}(s)}{1 + (1 - e^{-sT})\bar{F}(s)G(s)}$$

ger $G_c(s) = \bar{G}_c(s)e^{-sT}$



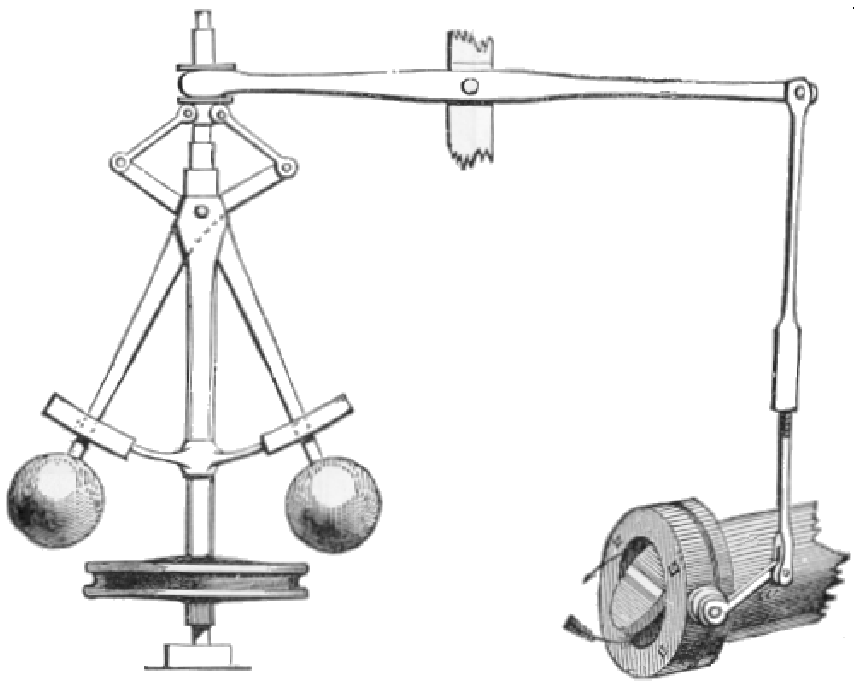
Implementering

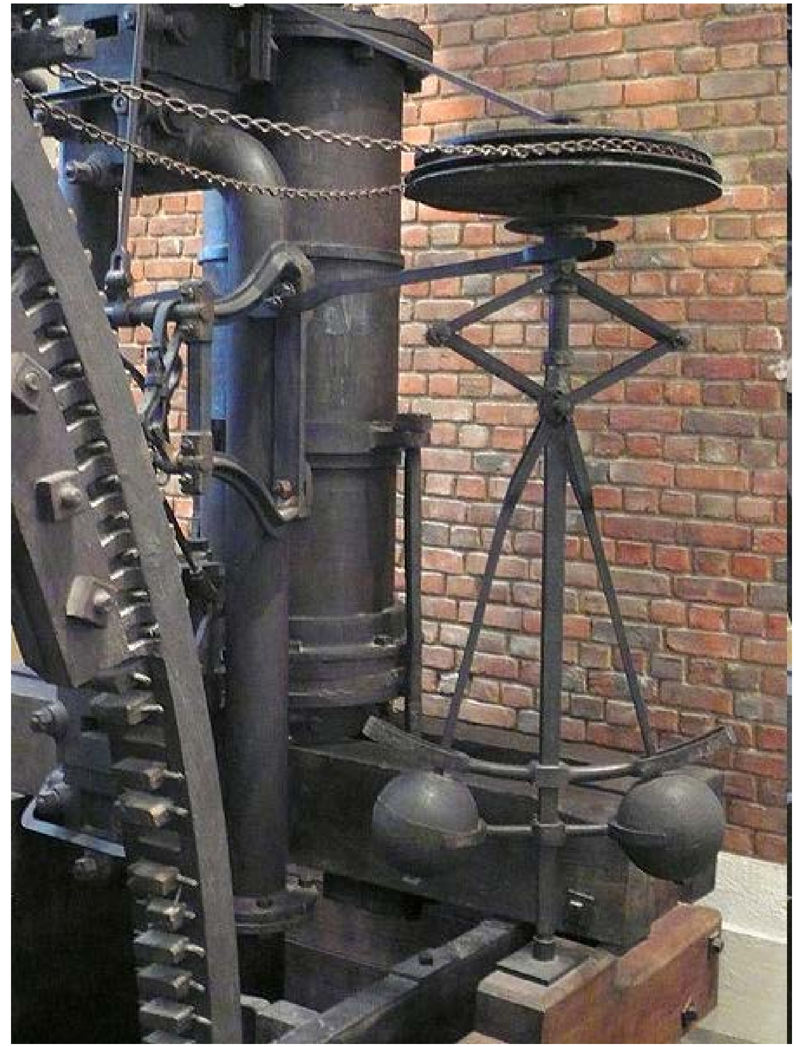


- Hur förverkliga sambandet mellan $e(t)$ och $u(t)$?
  - *Analogt:* mekanik, elektronik, pneumatik.
    Signaler representeras av spänning, tryck etc.
  - *Digitalt:* programmering.
    Signaler representeras av tal i en dator.

Centrifugalregulatorn

- Mekanisk P(I)-regulator
- James Watt, 1788

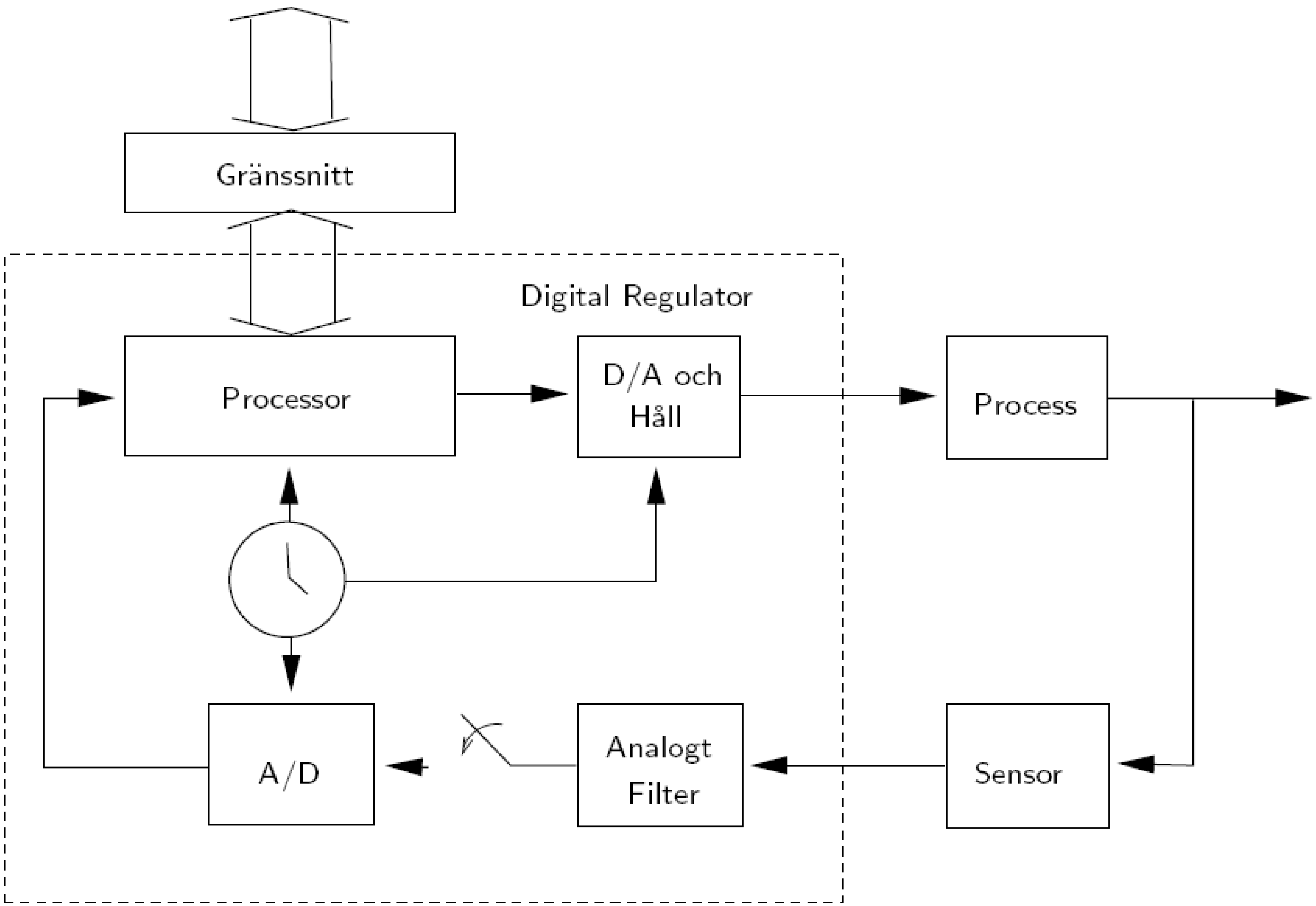




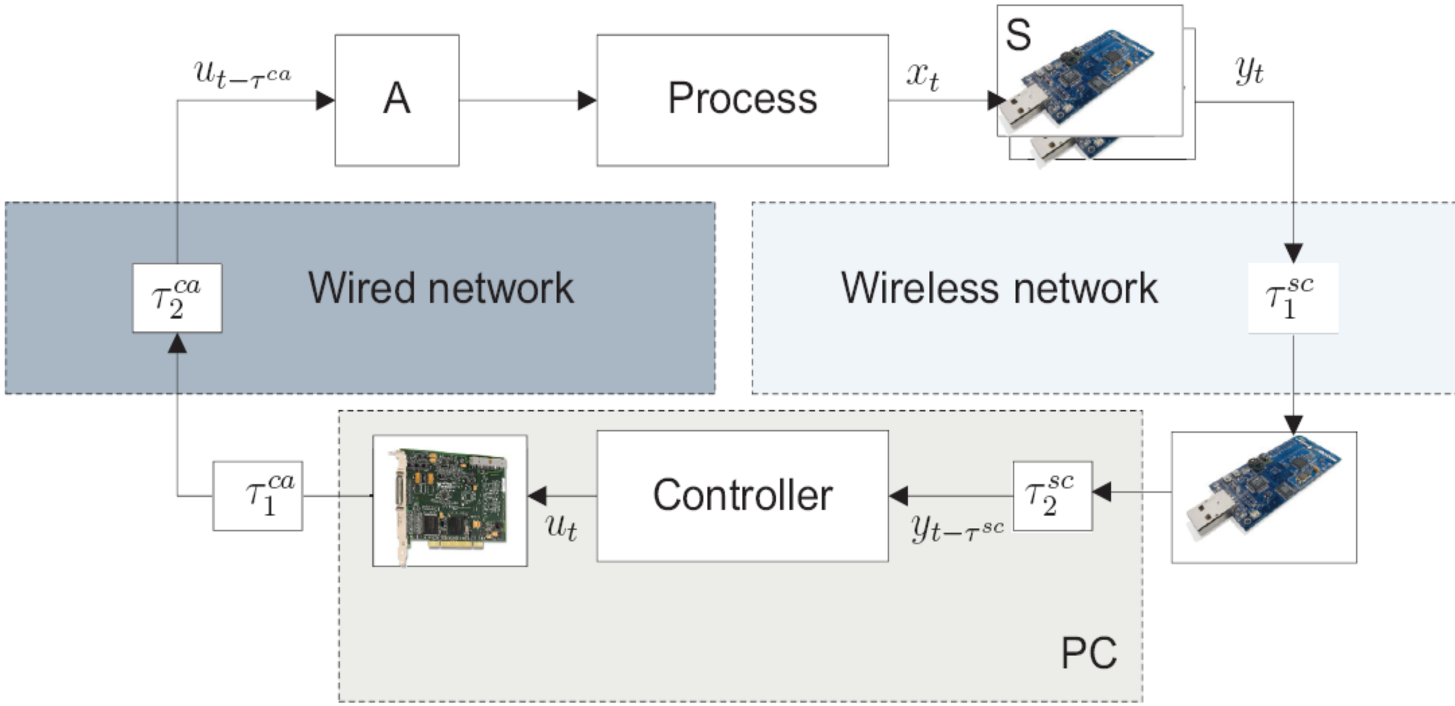
Varför digital implementering?

- Fördelar:
  - \+ billigt
  - \+ flexibelt
  - \+ kan realisera komplicerade samband
- Nackdelar (ty tidsdiskret arbetssätt):
  - ÷ måste appoximera $F(s)$
  - ÷ kan ge sämre prestanda
  - ÷ kräver speciell teori

Hur ser den digitala implementeringen ut?

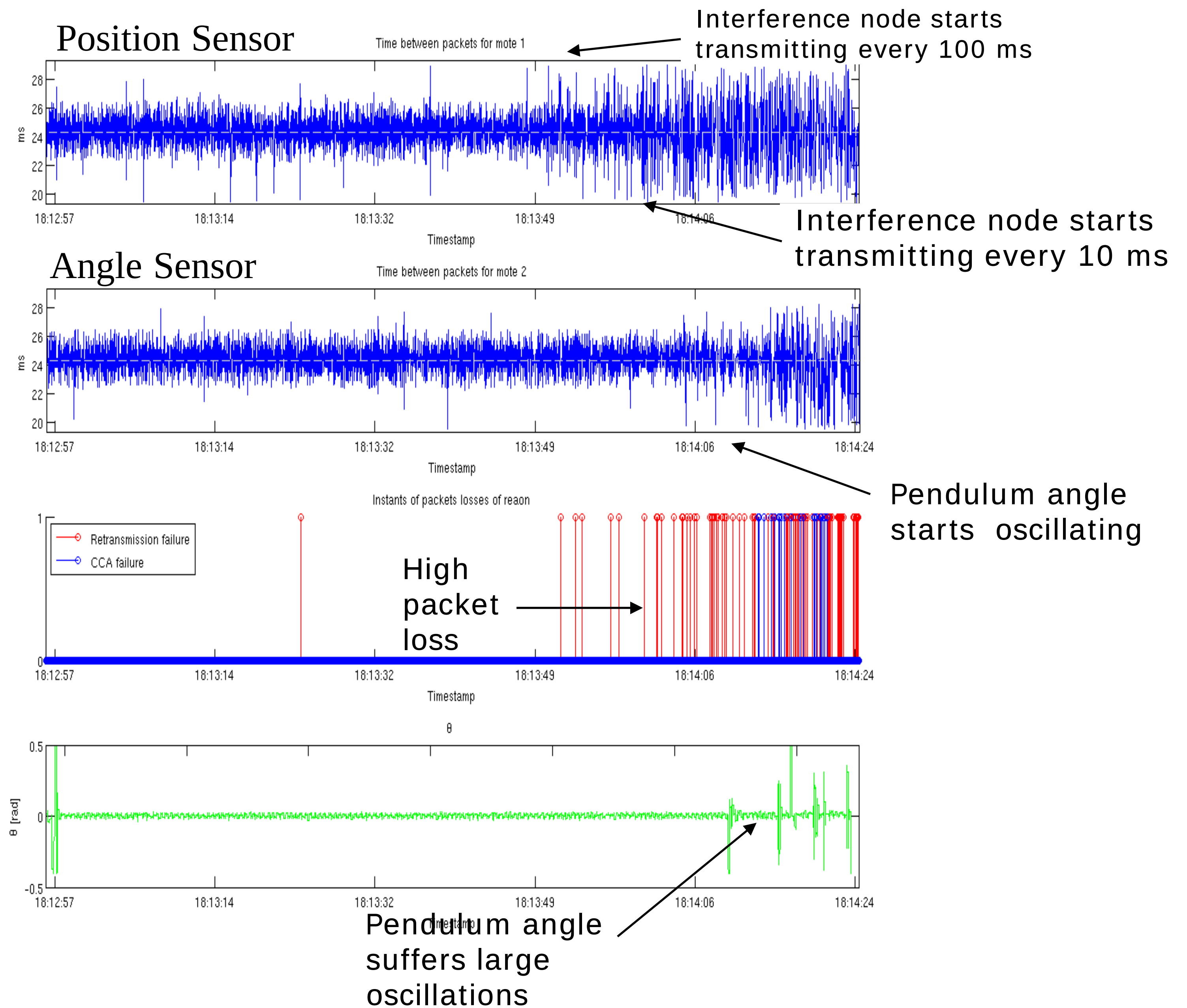


Demo: Wireless Inverted Pendulum

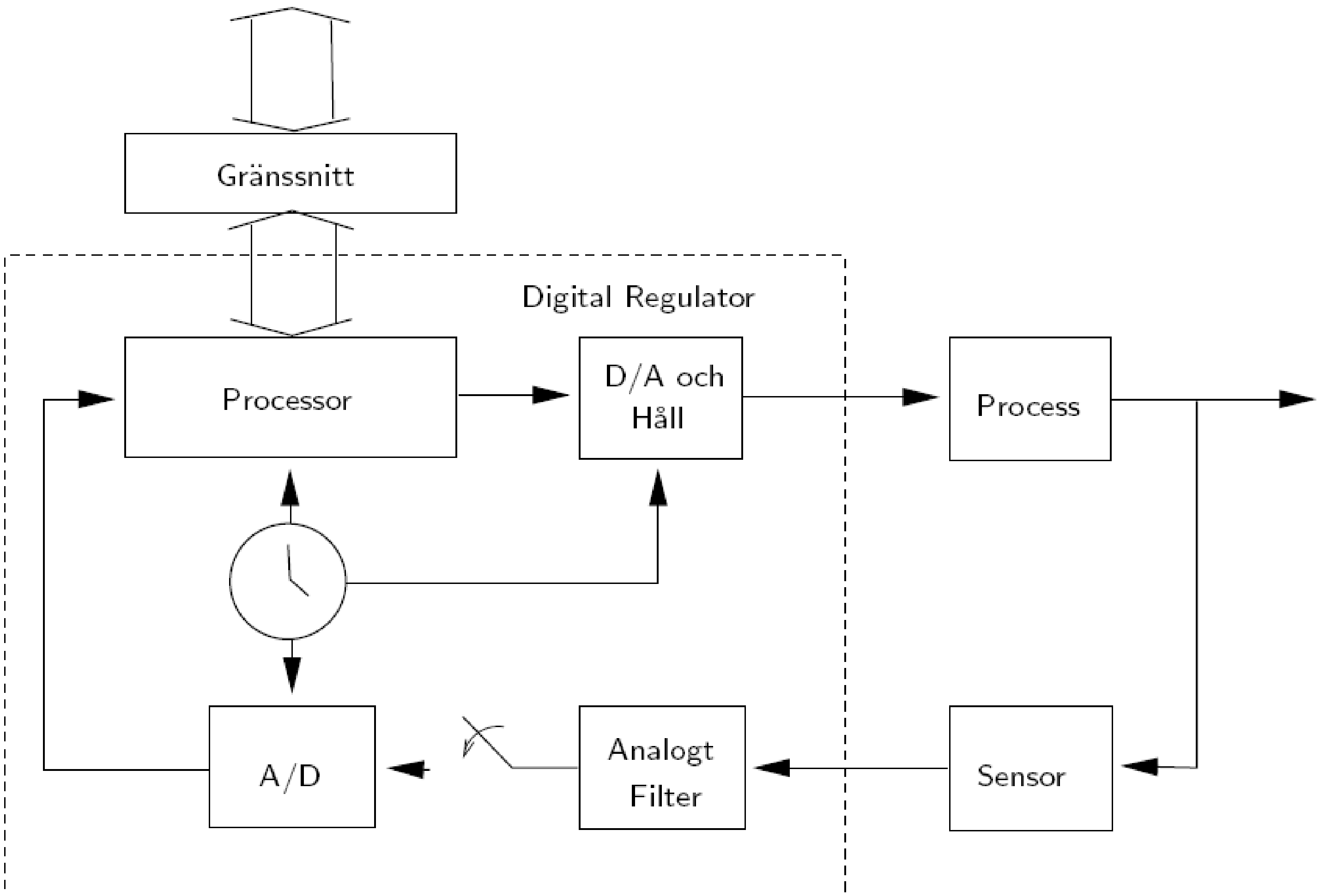


- Sampling period of 25ms (Real-Time Control)
- Delay of 50ms
- Controller = Linear Quadratic Controller and Kalman Filter
- System is of 4th order where the states are:
  – Position and velocity of the cart
  – Angle and angular velocity of the pendulum

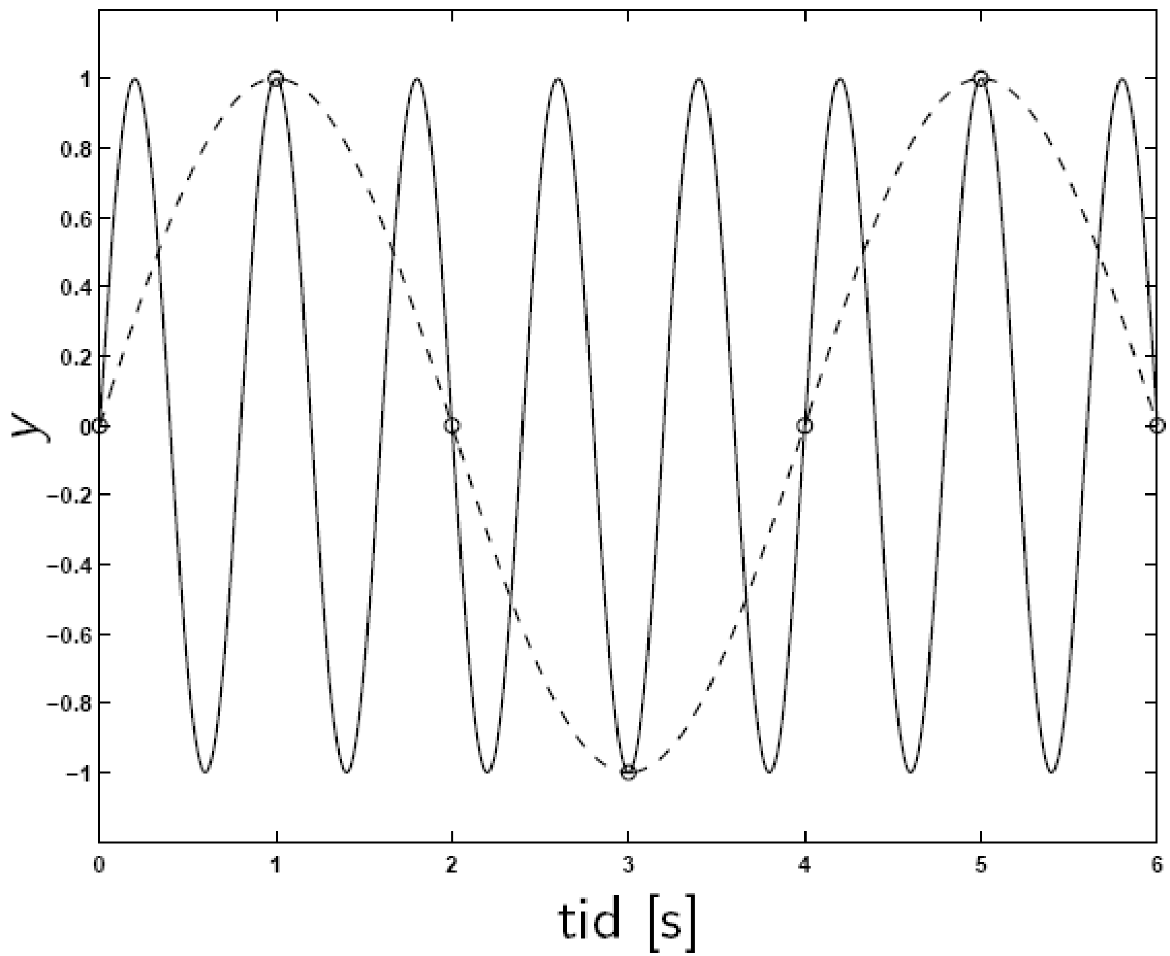
Wireless Inverted Pendulum



Hur ser den digitala implementeringen ut?



Aliaseffekt

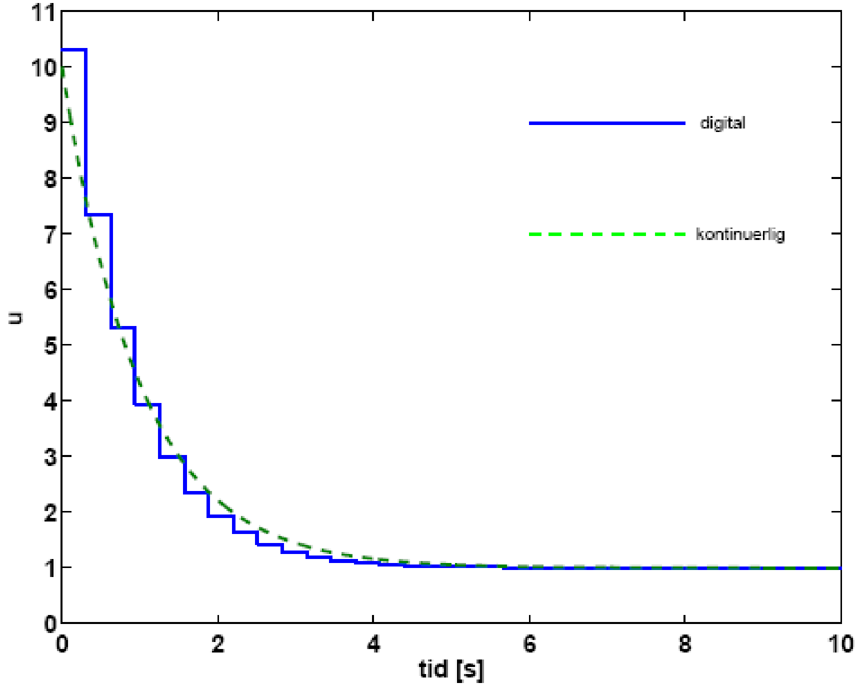


– Signal med frekvens $\omega = 2.5\pi$ uppfattas som signal med frekvens $\omega = 0.5\pi$!

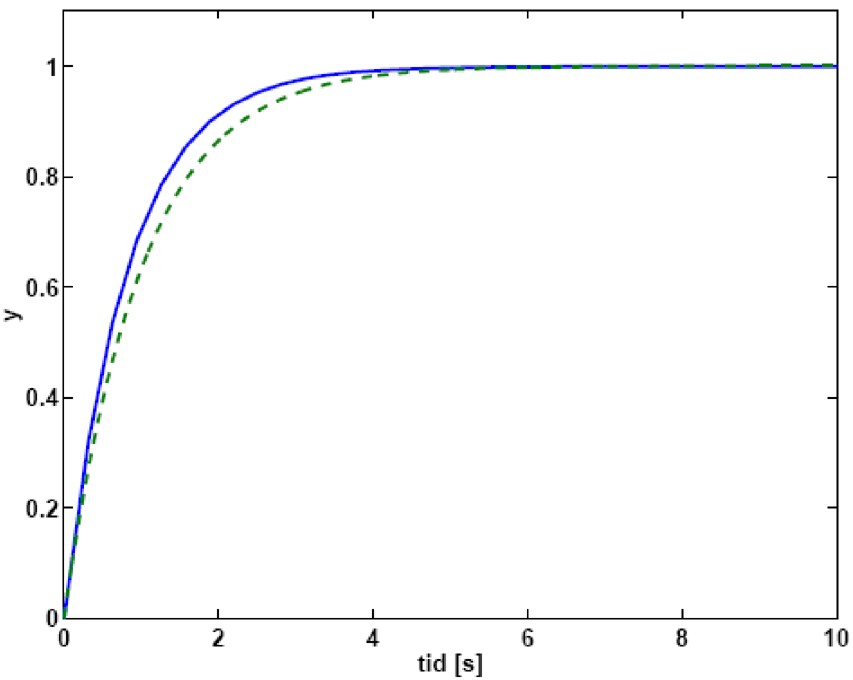
Digital implementering. Exempel

- Sampeltid $T = 0.3s$

styrsignal u:



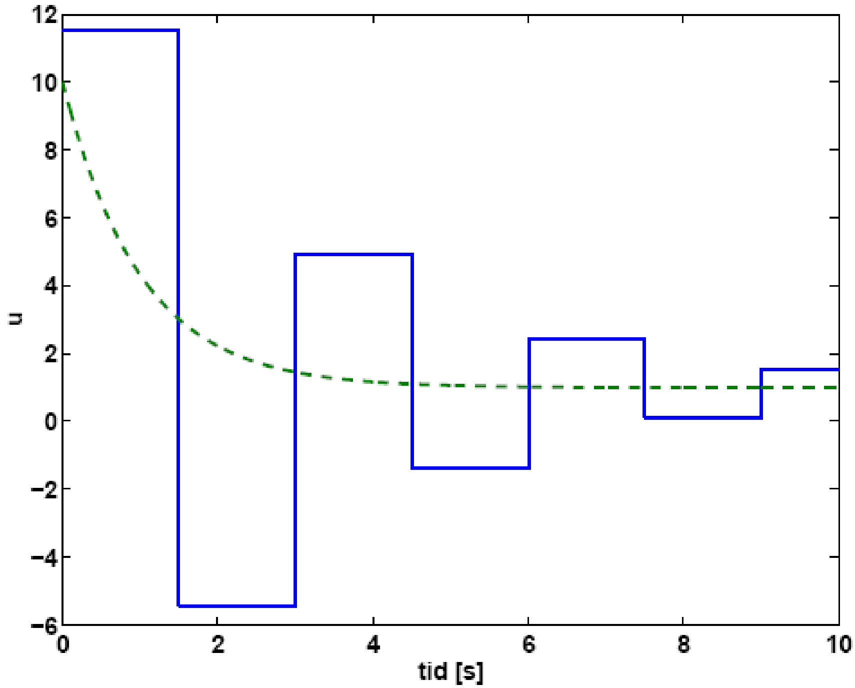
utsignal y:



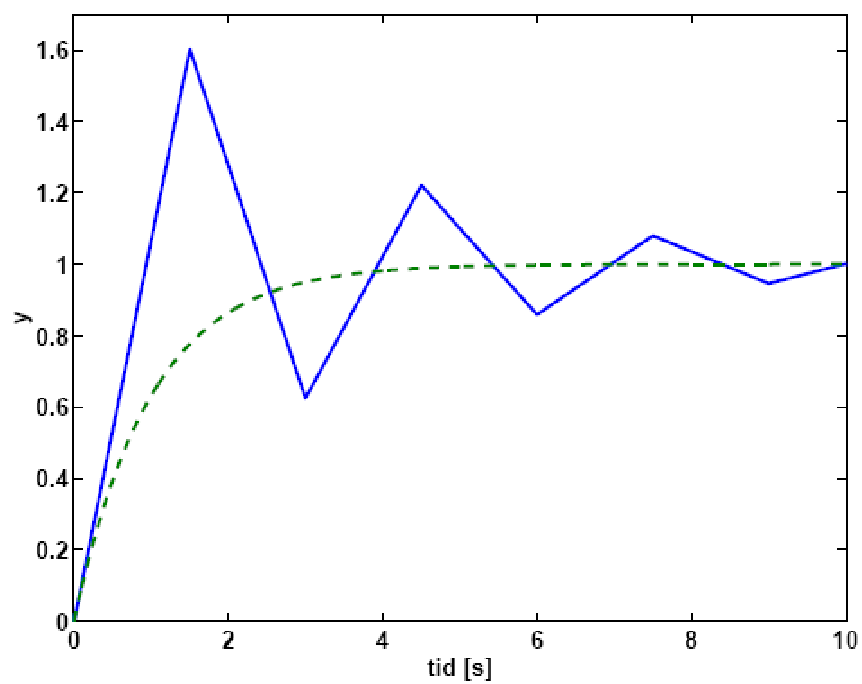
Digital implementering. Exempel

- Sampeltid $T = 1.5s$

styrsignal u:



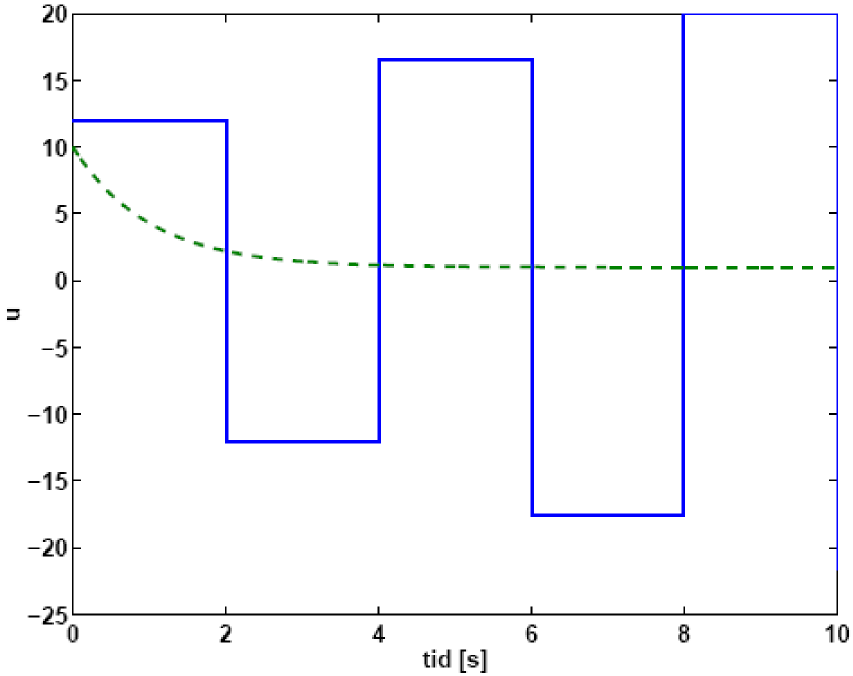
utsignal y:



Digital implementering. Exempel

- Sampeltid $T = 2.0s$

styrsignal u:



utsignal y: