Toward Standardising PID Controllers in the Process Industry

Margret Bauer
HAW Hamburg, Germany
Nordic Process Control Workshop
17th August 2026

Process control runs on PID.

The world runs on PID.

„Since 1957, more than 7800 spacecrafts have been launched, among which more than 99% used PID as the main control strategy."

Xie, Y. C., Huang, H., Hu, Y., & Zhang, G. Q. (2016). Applications of advanced control methods in spacecrafts: progress, challenges, and future prospects. *Frontiers of Information Technology & Electronic Engineering*, *17*(9), 841-861.

„Good is good enough.“*

*Olaf Abel (BASF), keynote at the NAMUR-Hauptsitzung November 2025 focusing on pragmatism and cost during economic crisis mode.

The worst thing about PID control is its name*.

*TLA

Proportional

Integral

Derivative

Control is all about time.

Present
nuværende
حَاضِر
现在
भूतकाल

Past
datid
اَلْمَاضِي
现在
वर्तमान काल

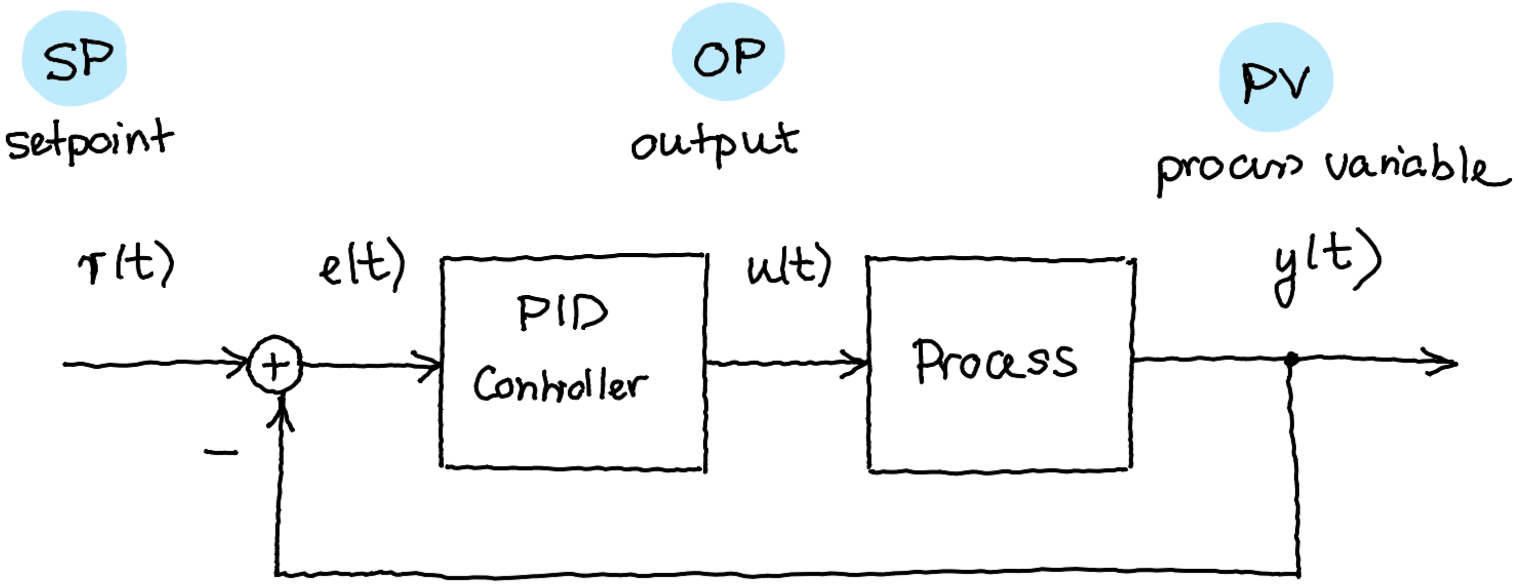
Future
fremtids
مُسْتَقْبَل
将来
भविष्य काल

Proportional

Integral

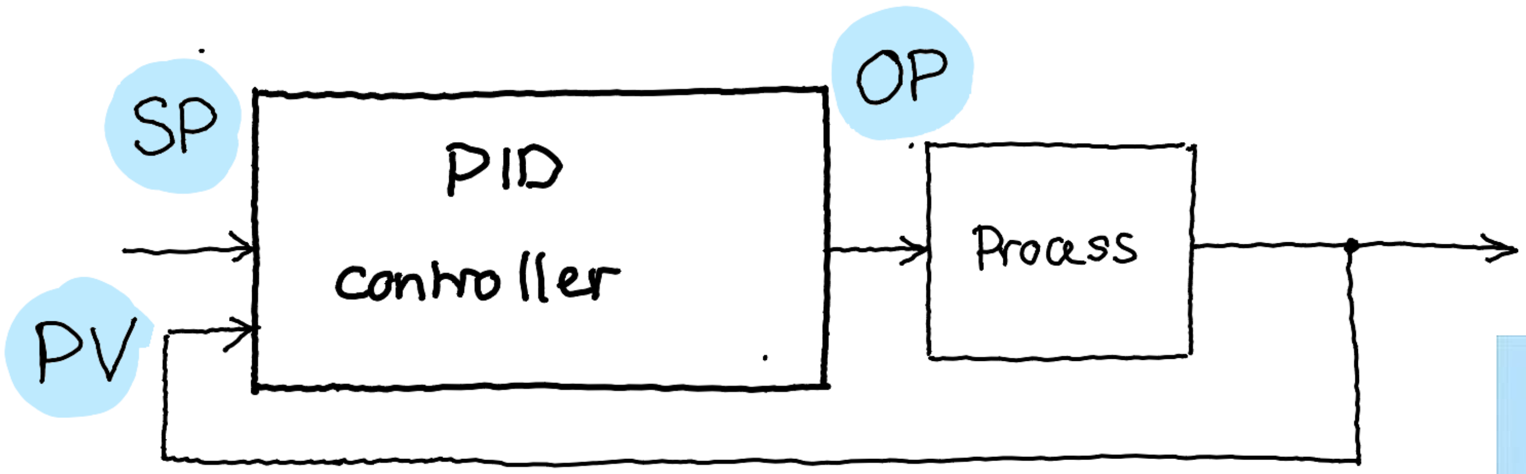
Derivative

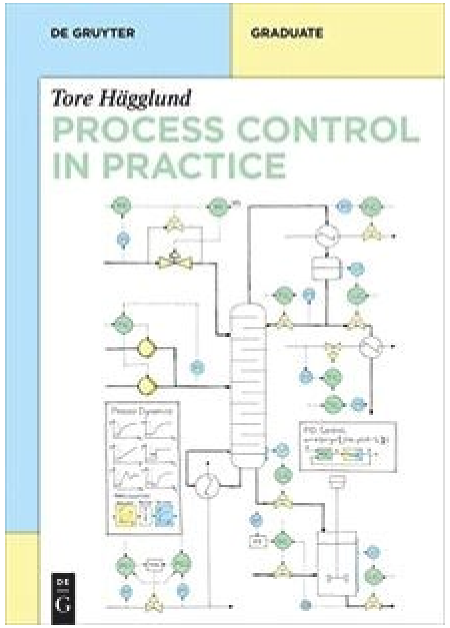
The basic PID control loop



$$u(t) = K\left(e(t) + \frac{1}{T_i}\int_0^t e(t)\,dt + T_d\frac{de}{dt}\right)$$

PID Control in Process Automation



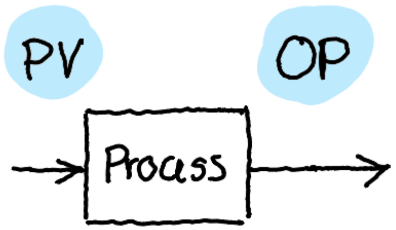


Block diagram

Process schematic

Automation Architecture

Block diagram



Process schematic

Automation Architecture

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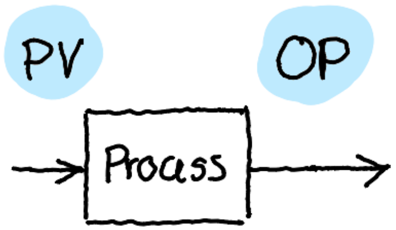

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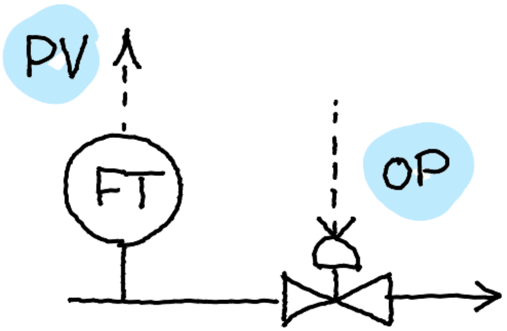

Automation Architecture

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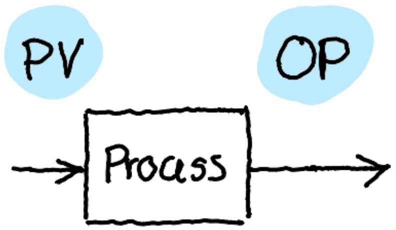

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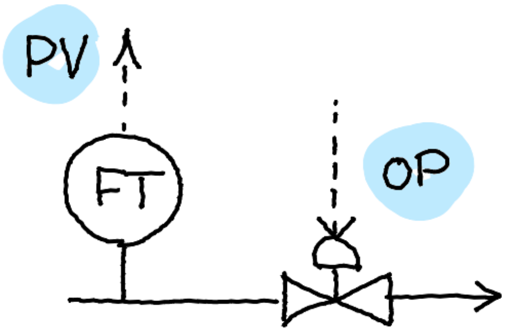

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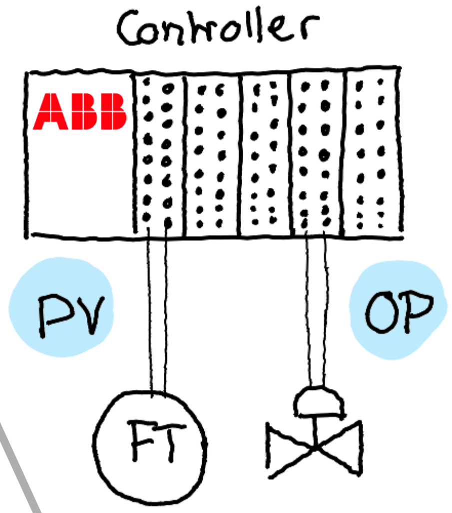

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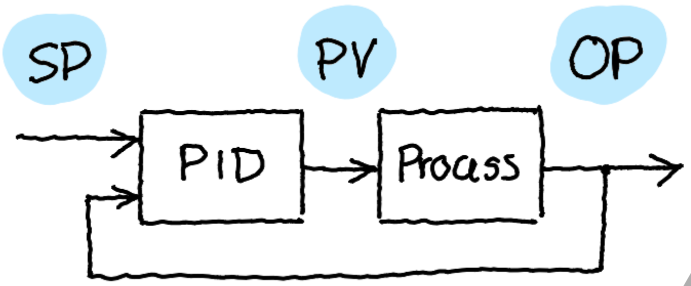

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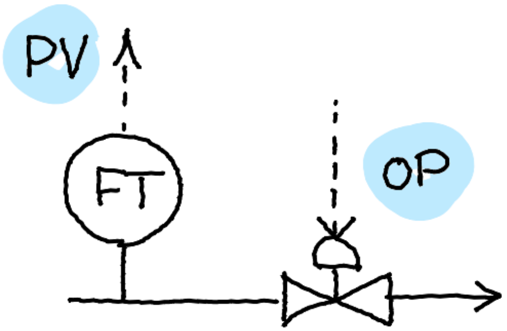

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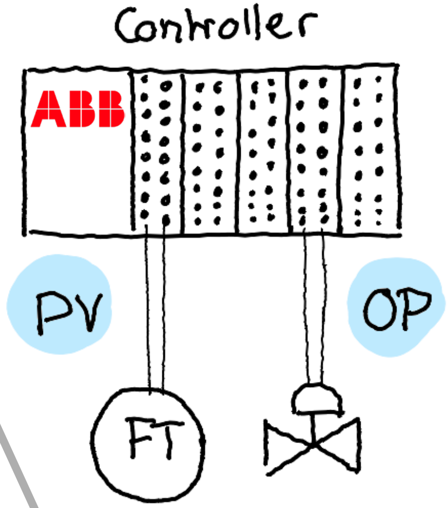

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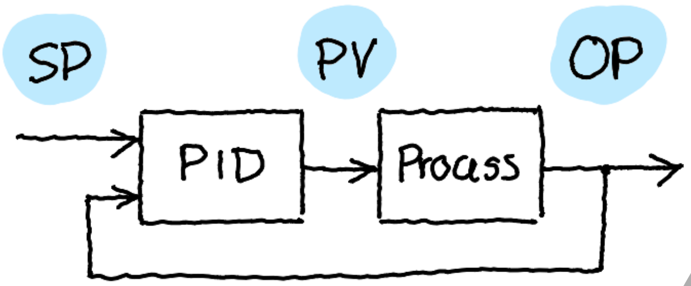

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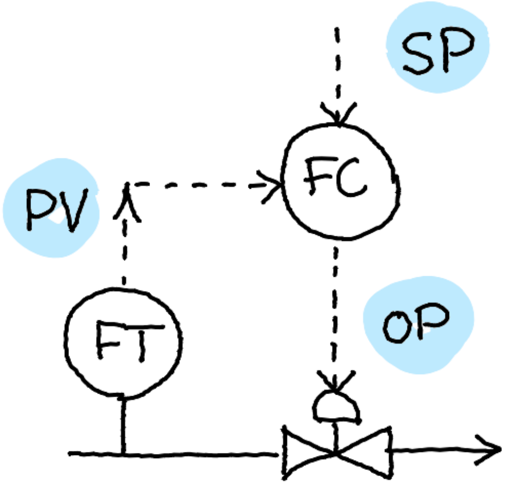

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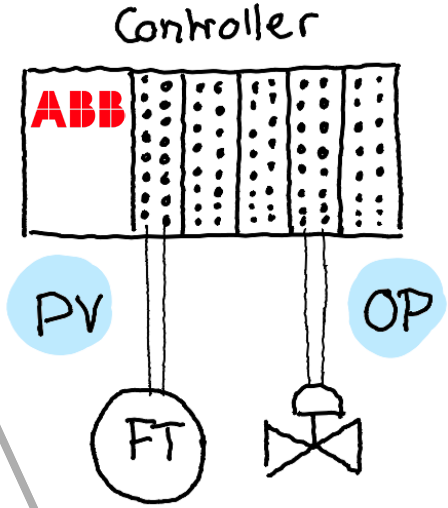

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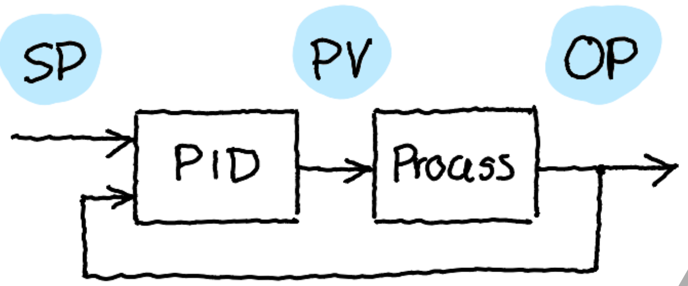

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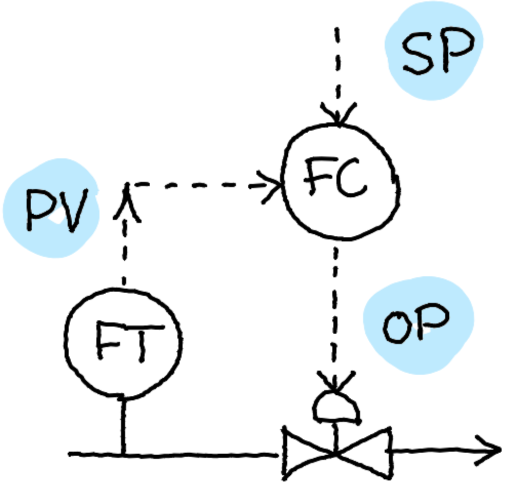

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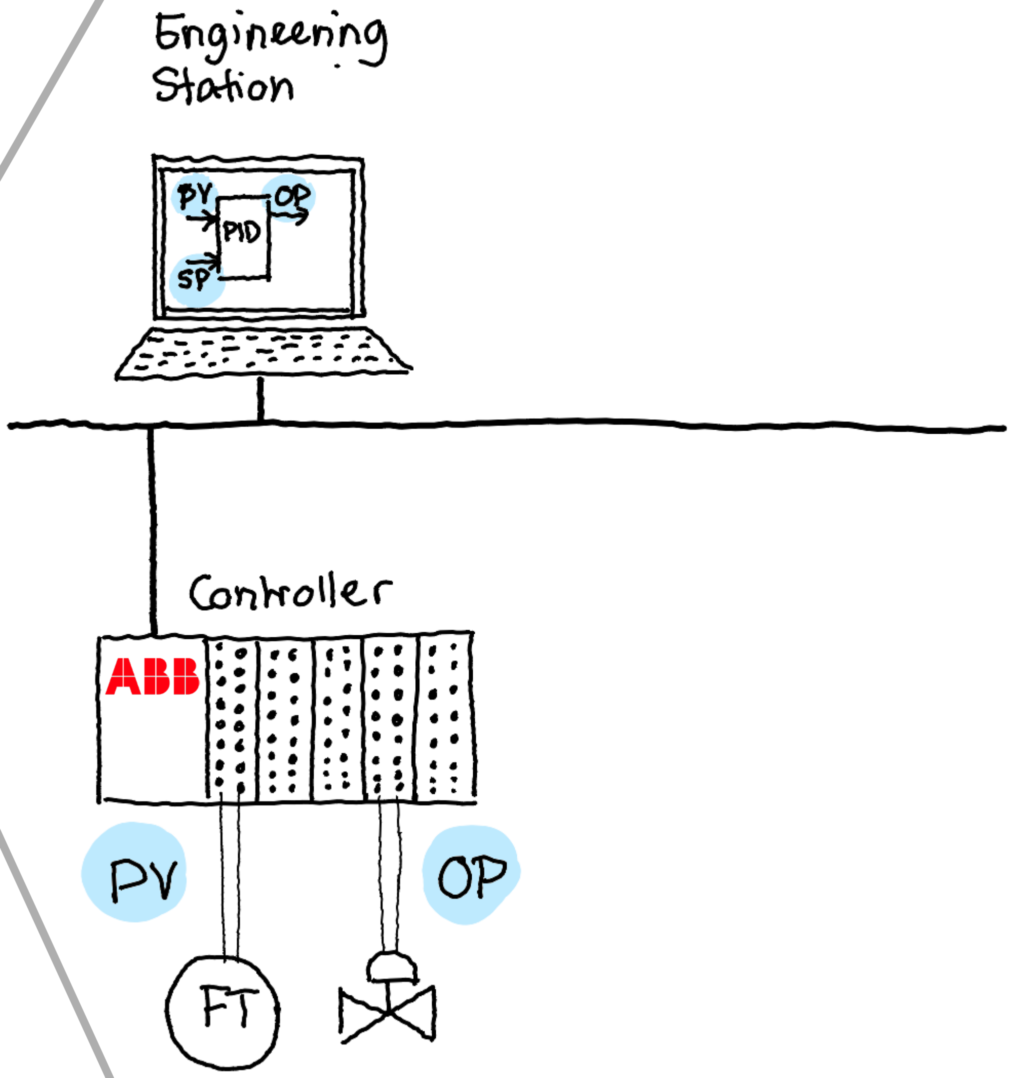

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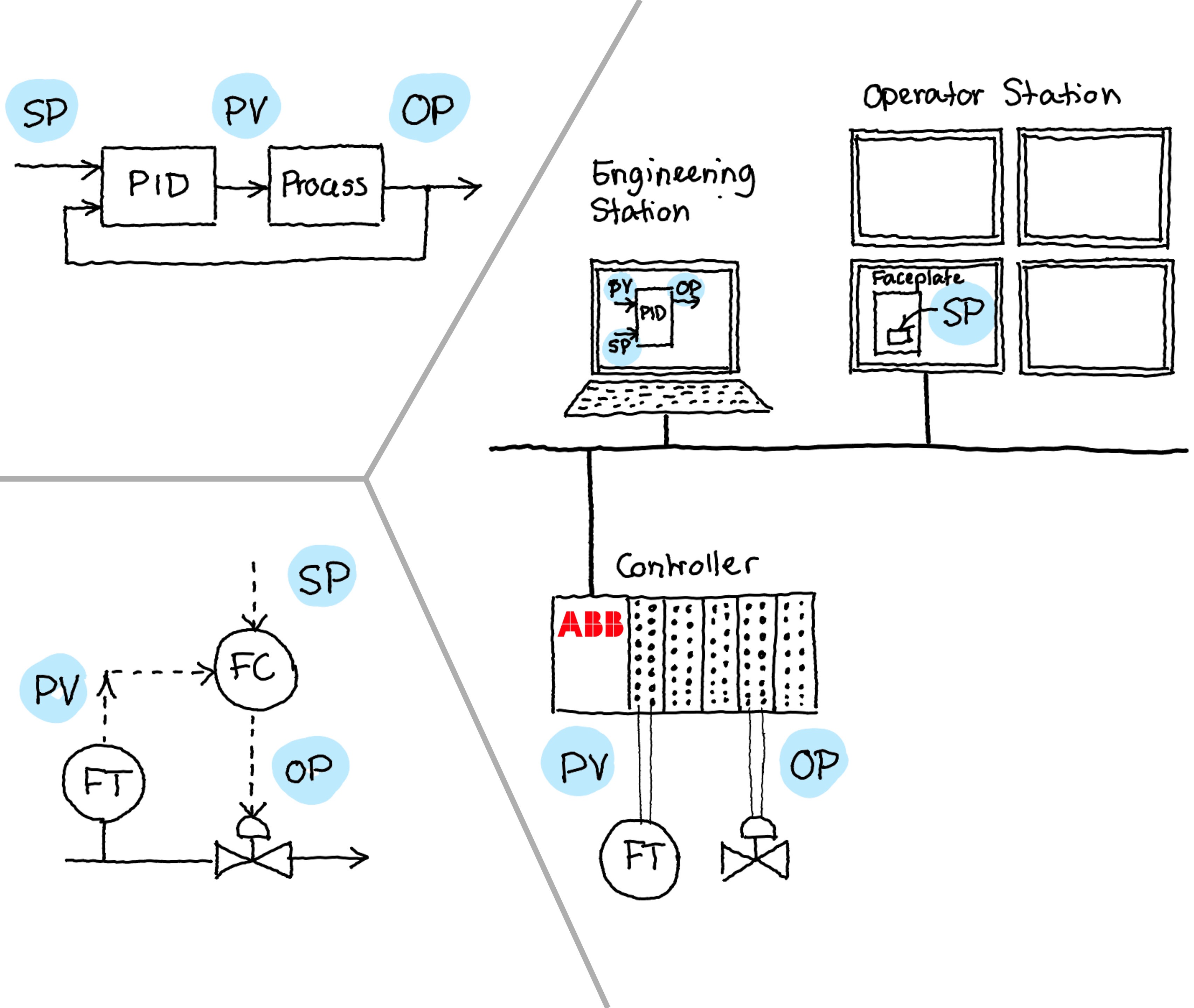
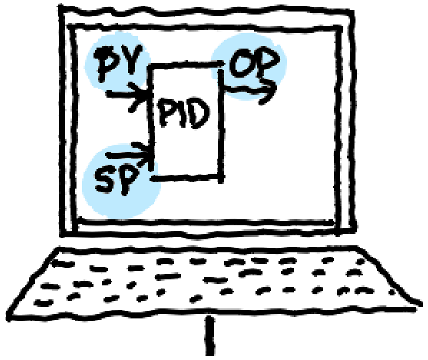


Automation Architecture

ABB 800xA Function Block PID01A

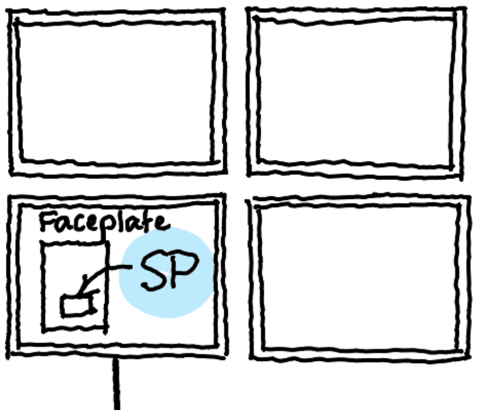
Engineering Station

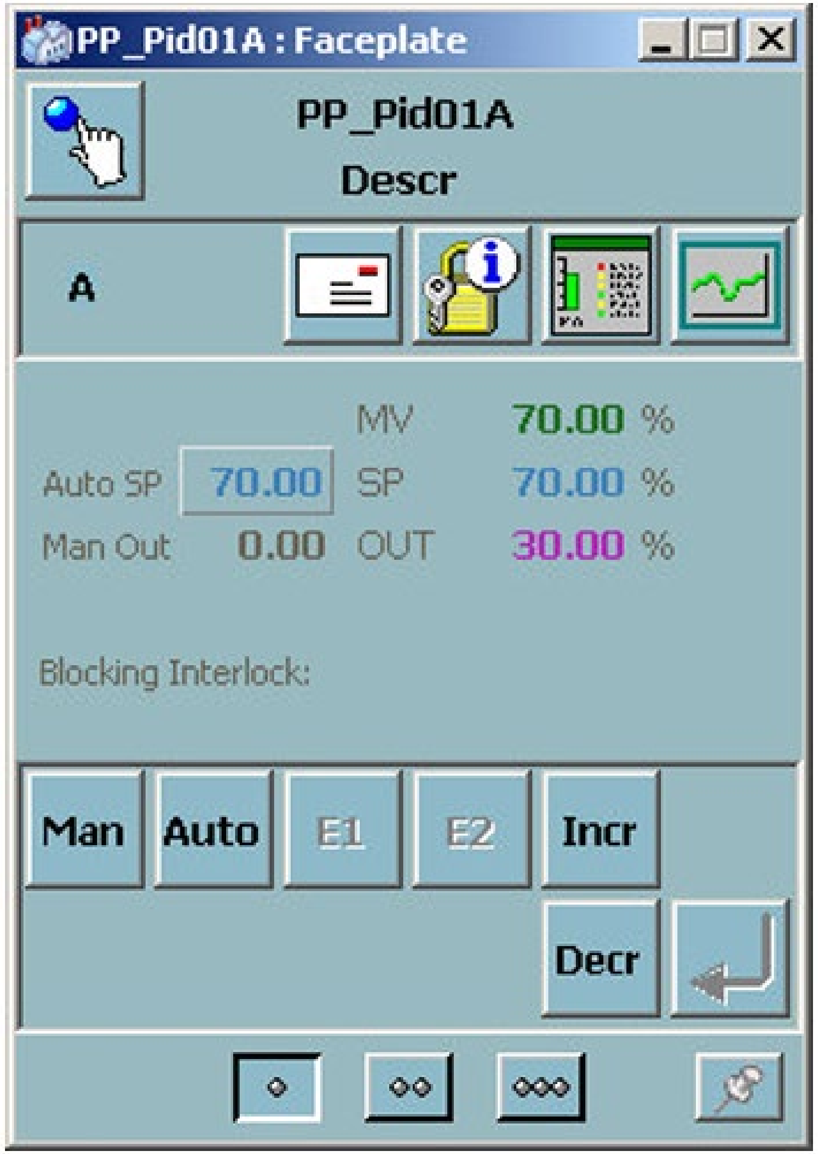


FUNCTION OF INPUT TERMINALS	PID01A		FUNCTION OF OUTPUT TERMINALS
Object name	Name	AutoSp	Setpoint in AUTO mode
Object description	Description	WSP	Working setpoint
Enable control	Enable	Dev	Deviation
Tracking A	TrackA	OutP	Output signal of the controller
Tracking B	TrackB	Bal	Control mode BAL
Tracking C	TrackC	Man	Control mode MAN
Direct or reverse control action	RevAct	ManFd	Control mode Man Forced
Derivation type	Deriv	Auto	Control mode AUTO
Input for hot init	HotInit	E1	Control mode E1
Feed Forward	FeedFwd	E2	Control mode E2
Measured value	MV	E3	Control mode E3
Input for status of analog input for MV	AIErr	BalOut	Control mode Bal, Man or Auto
Change rate in auto mode	Speed1	OutEqLL	Output signal limited
Change rate in manual mode	Speed4	OutEqHL	Output signal limited
Enable order MAN by operator	ManEnbl	SpEqLL	Setpoint at lower limit
Enable order AUTO by operator	AutoEnbl	SpEqHL	Setpoint at upper limit
Enable order E1 by operator	E1Enbl	MV_LT_L2	Measured value falls below limit L2
Enable order E2 by operator	E2Enbl	MV_LT_L1	Measured value falls below limit L1
Enable order E3 by operator	E3Enbl	MV_GT_H1	Measured value exceeds limit H1
External reference 1	ExtRef1	MV_GT_H2	Measured value exceeds limit H2
External reference 2	ExtRef2	Dev_LT_L	Deviation falls below alarm limit
External reference 3	ExtRef3	Dev_GT_H	Deviation exceeds alarm limit
Rate of reference E1	Speed2	OLimErr	Output limit error
Rate of reference E2	Speed3	NoInt	No interlock
Pulse input for control mode E1	SeqE1	Err	Parameter error
Pulse input for control mode E2	SeqE2	ExtParOut	Control data for Supervisory control
Pulse input for control mode E3	SeqE3		
Ordering of control mode BAL (LOC)	Local		
Ordering of control mode BAL	BalIn		
Pulse input for control mode MAN	SeqMan		
Pulse input for control mode AUTO	SeqAuto		
Balance reference	BalRef		
Block limit alarms for MV and Dev	AICBlk		
Ordering MAN with clamping	Clamp		
Clamp reference	ClampRef		
Enable output limit parameters	EOLim		
External output lower limit	EOLL		
External output upper limit	EOHL		
Interlock	IB1		
Interlock	IB2		
Reference for interlock IB1	IB1Ref		
Reference for interlock IB2	IB2Ref		
External Control	ExtCtrl		
Actuator Position	ActPos		
Ack. Alarm from logic	AlarmAck		

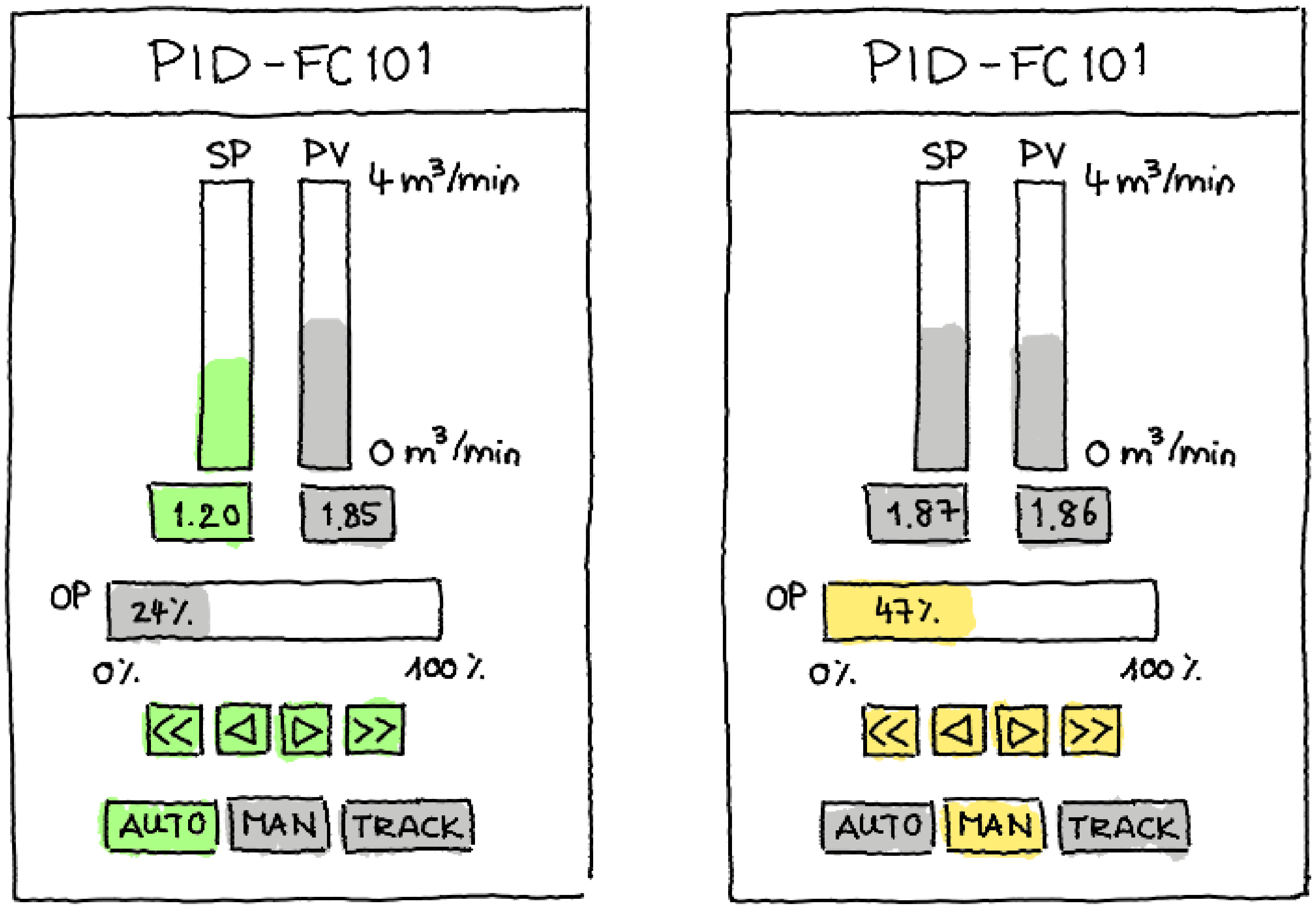
ABB 800xA Faceplate PID01A

Operator Station





Standardisation efforts: Faceplate in ISA101



Efforts to standardise the PID algorithm

$$u(t) = K\left(e(t) + \frac{1}{T_i}\int_0^t e(t)\,dt + T_d\frac{de}{dt}\right)$$

Laplace

$$U(s) = K\left(E(s) + \frac{1}{T_i s}E(s) + T_d s\, E(s)\right)$$

Discrete time with sampling time Δt

$$u[n] = K\left(e[n] + \frac{\Delta T}{T_i}\sum_{i=0}^{n} e[i] + \frac{T_d}{\Delta T}\left(e[n] - e[n-1]\right)\right)$$

NAMUR Standard PID-controller (2018, 2026)

$$Y = RD \frac{OP_{range}}{PV_{range}} GAIN \left(G_e \left(W - \frac{X}{1 + \tau s} \right) - G_x \frac{X}{1 + \tau s} \right)$$

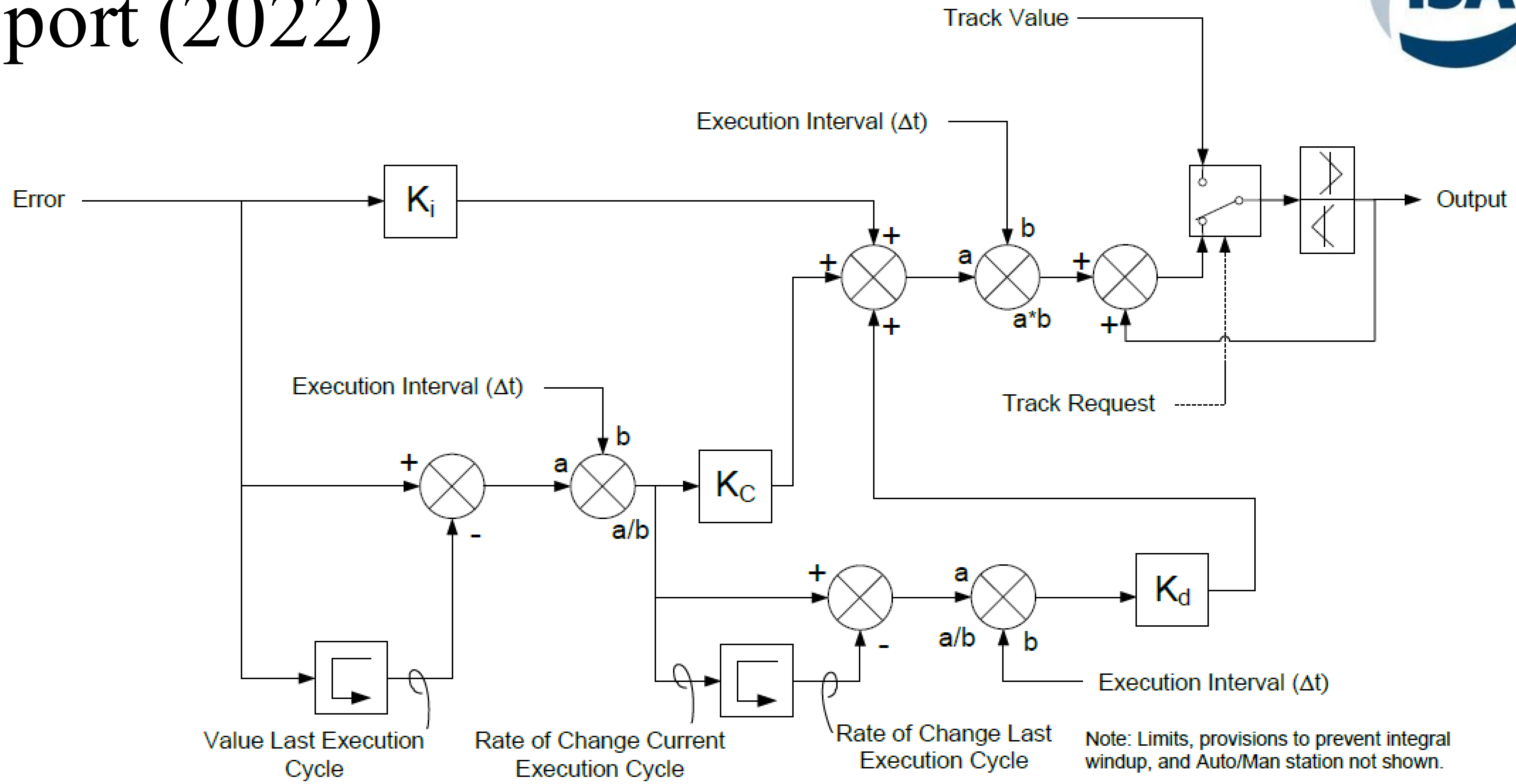
where

$$G_e = P_{on}(1 - P_{fb}) + I_{on} \frac{1}{T_I s} + D_{on}(1 - D_{fb}) \frac{T_D s}{1 + \frac{T_D}{\alpha} s}$$

and

$$G_x = P_{on} P_{fb} + D_{on} D_{fb} \frac{T_D s}{1 + \frac{T_D}{\alpha} s} .$$

Standardisation efforts: ISA5.9 technical report (2022)

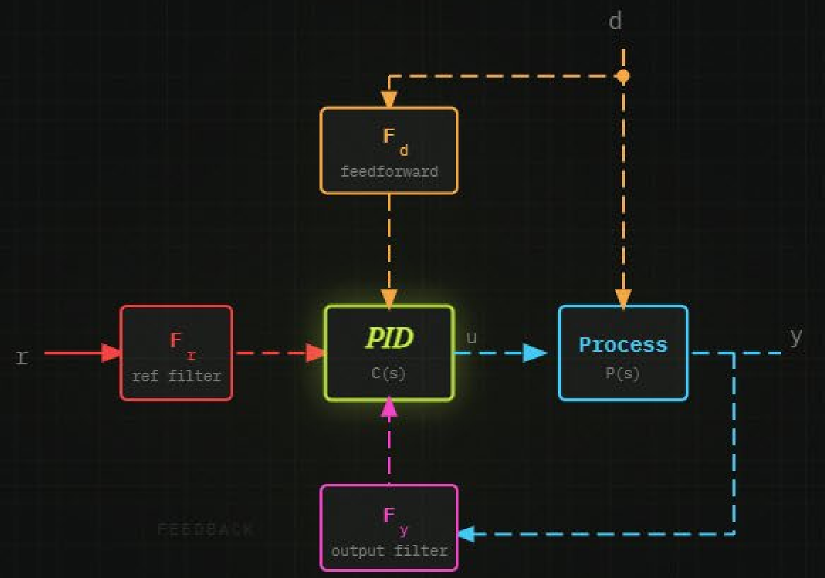


E. Sundström, M. Bauer, J. L. Guzmán, T. Hägglund, K. Soltesz
arXiv:2604.15918

RESEARCH ARTICLE · ARXIV:2604.15918

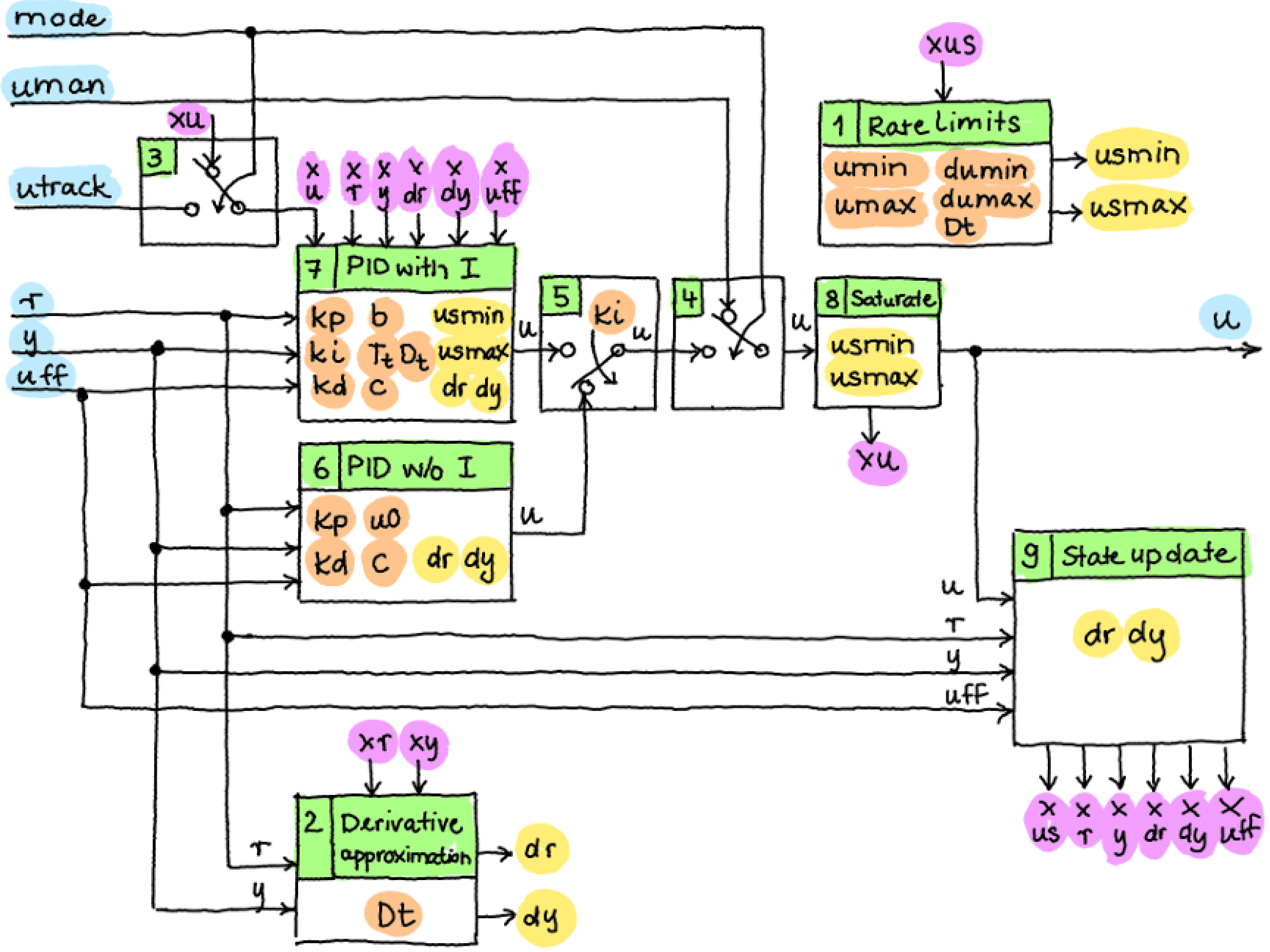
A Practical Guide to PID Controller *Implementation*

Beyond the classical control law. A comprehensive reference addressing the real-world problems that arise when taking a PID controller from theory to practice.



Listing 3: Combined form PID controller.

```
function u=control(r,y,uff,uman,utrack,mode)
  % 1 Rate limits
  usmin=max(umin,xus+Dt*dumin)
  usmax=min(umax,xus+Dt*dumax)

  % 2 Derivative approximation
  dr=(r-xr)/Dt
  dy=(y-xy)/Dt

  % 3 Tracking mode
  if mode==TRACK
    xu=utrack
  end
   % 4 Manual mode
  if mode==MAN
    u=uman
    % 5 Integral switch
  elseif ki==0
    % 6 PID without I
    u=u0+kp*(r-y)+kd*(c*dr-dy)+uff
  else
    % 7 PID with I
    % Signal increment
    Dr=r-xr
    Dy=y-xy
    Ddr=dr-xdr
    Ddy=dy-xdy

    % Control increment
    Dup=kp*(b*Dr-Dy)
    Dui=ki*Dt*(r-y)
    Dud=kd*(c*Ddr-Ddy)
    Duff=uff-xuff

    % Nominal control signal
    u=xu+Dup+Dui+Dud+Duff

    % Integrator anti-windup
    us=max(min(u,usmax),usmin)
    u=u-Dt/Tt*(u-us)
  end

  % 8 Saturate
  xu=u
  u=max(min(u,usmax),usmin)

  % 9 State update
  xus=u
  xr=r
  xdr=dr
  xy=y
  xdy=dy
  xuff=uff
end
```



PID implementation complexities

- Control with and without integral action
- Setpoint handling (weights)
- Feed-forward control
- Controller output limitation
- Anti-windup
- External setpoint tracking
- Bumpless mode changes and parameter changes
- Sampling rate variations and jitter
- Process variable and setpoint filtering

SOUTH AFRICAN
COUNCIL FOR AUTOMATION
AND CONTROL

Guest lecture

A Practical Guide to PID Controller Implementation

4 September 2026
1pm CET
SACAC Chair: Tobi Louw (Stellenbosch University)

- PID is everywhere
- PID is complex.
- Every vendor uses their own naming.
- Some features are not correctly implemented (e.g. anti-windup, feedforward)
- It‘s confusing to the operators.
- It‘s confusing to the automation engineers.
- Let‘s standardise it.