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A Freely Available Interactive PID Learning Module

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Background

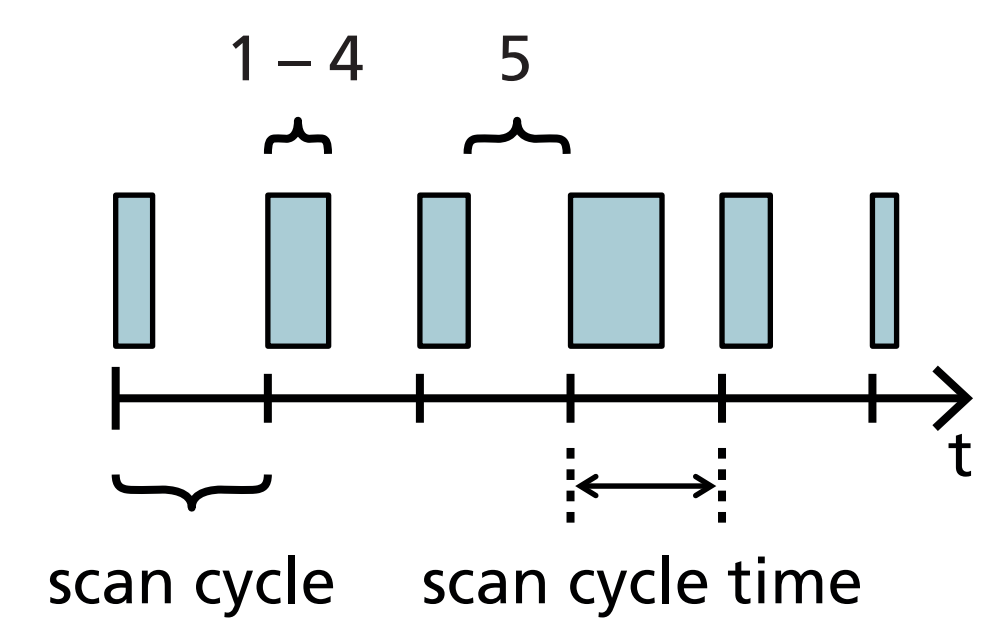
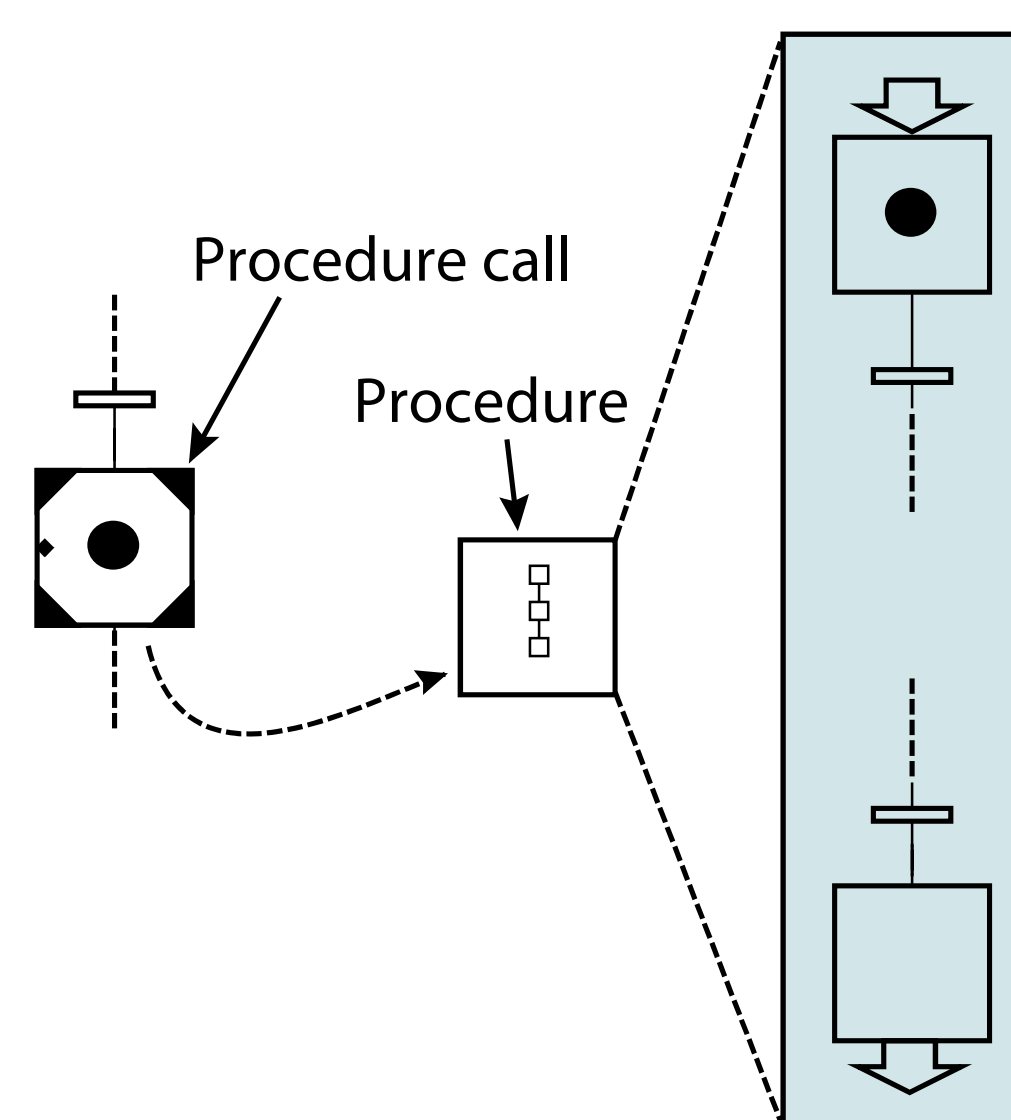
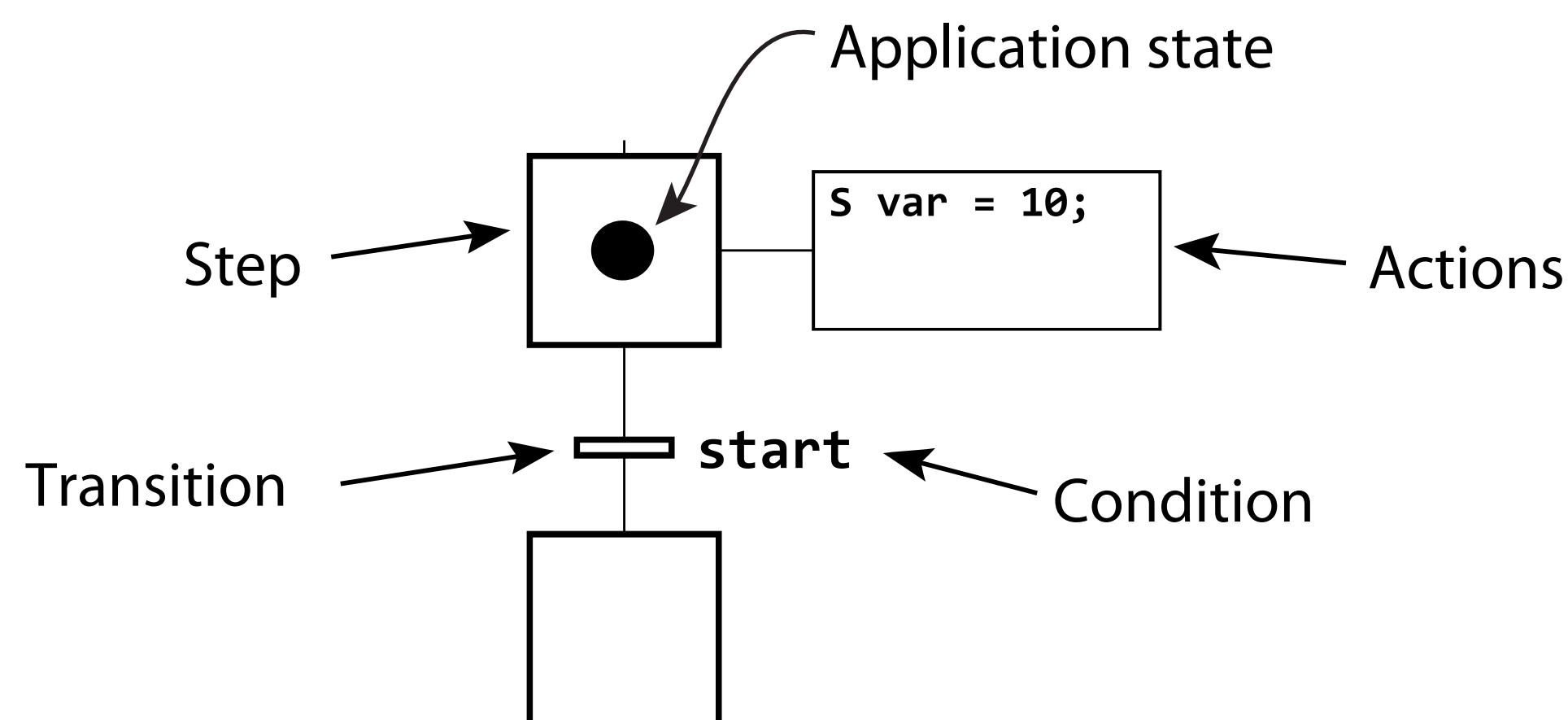
The PID is used in more than 95% of all the billions of control loops and a deep understanding of PID control is thus desirable. Interactive learning tools are great at providing students with hands on experience. One such learning module has been developed in Grafchart and it is freely available.

Me



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The Grafchart Language



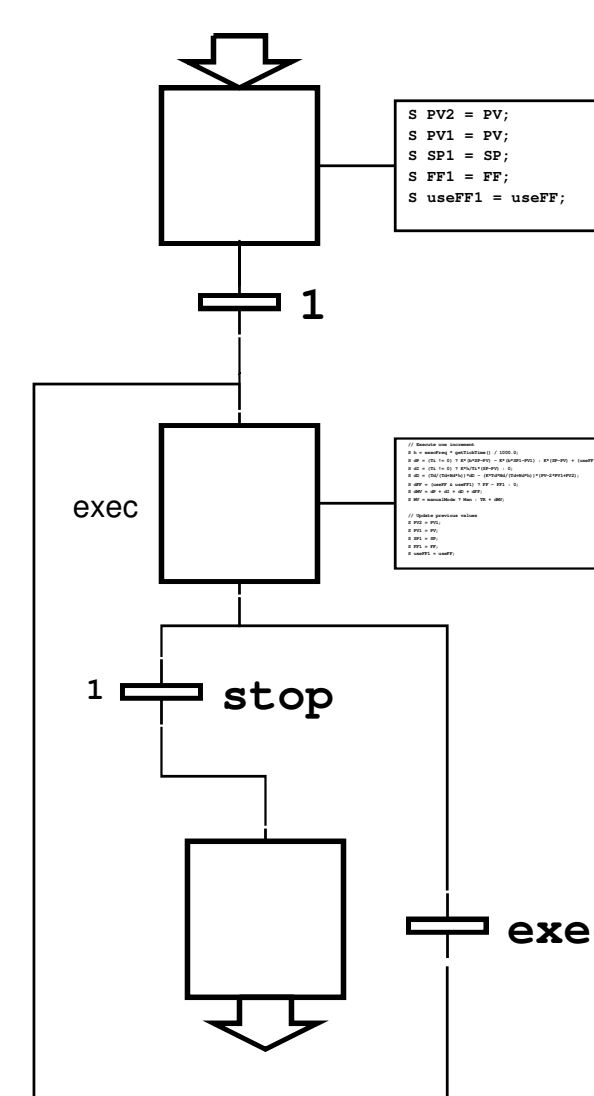
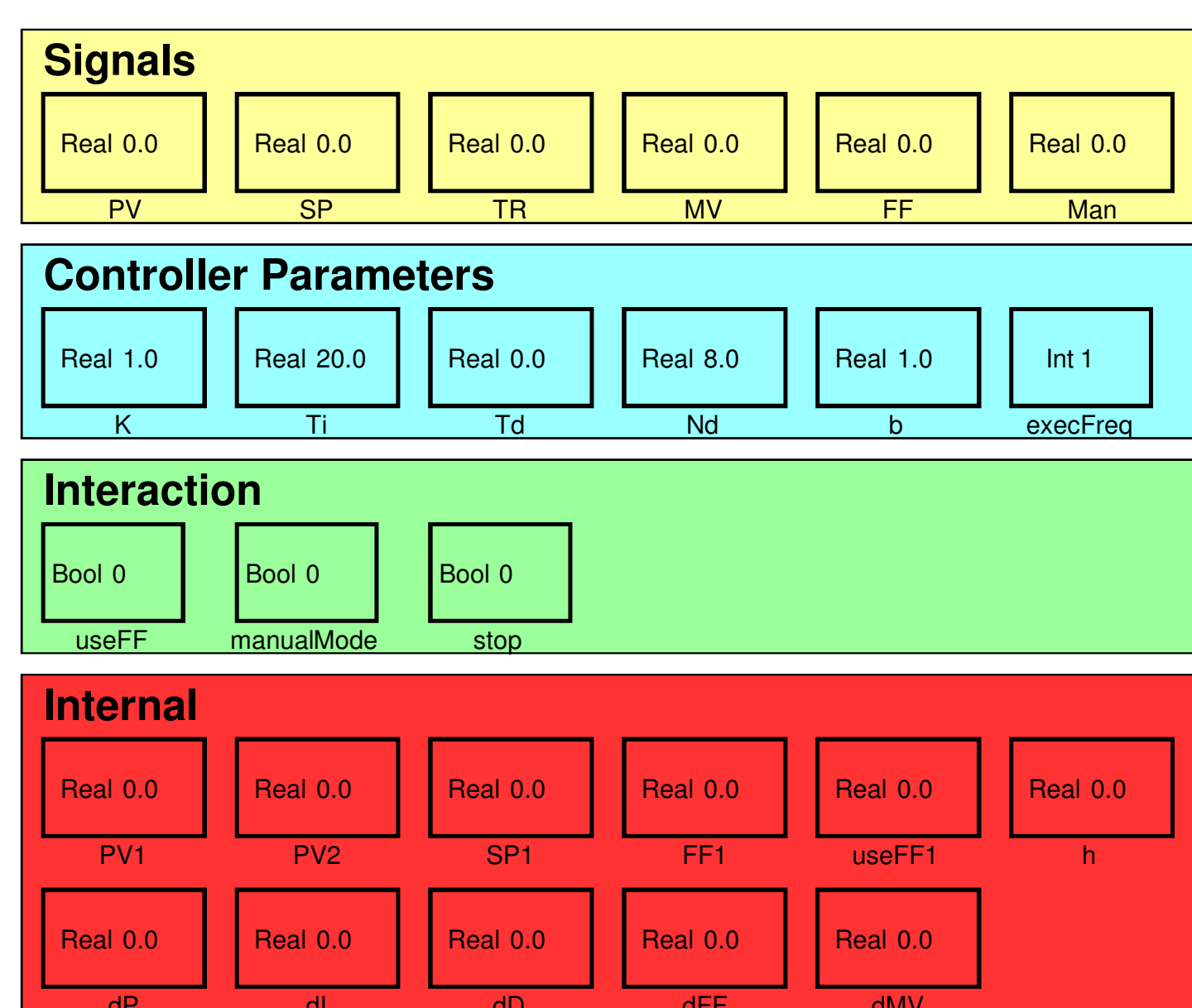
Execution model

1. Read inputs
2. Fire transitions (execute **X** and **S** actions)
3. Execute **P** actions
4. Update variables subject to **N** actions
5. Sleep until next scan cycle

Grafchart is a graphical programming language. The basic building blocks are steps (application states) with actions (what to do when) and transitions (how and when to change application state).

Grafchart procedures enable code reuse.

The PID Procedure



```
// Execute one increment
S h = execFreq * getTickCount() / 1000.0;
S dP = (Ti != 0) ?
    K*(b*SP-PV) - K*(b*SP1-PV1) :
    K*(SP-PV) + (useFF ? FF : 0) - TR;
S dI = (Ti != 0) ? K*h/Ti*(SP-PV) : 0;
S dD = (Td/(Td+Nd*h))*dD -
    (K*Td*Nd/(Td+Nd*h))*(PV-2*PV1+PV2);
S dFF = (useFF & useFF1) ? FF - FF1 : 0;
S dMV = dP + dI + dD + dFF;
S MV = manualMode ? Man : TR + dMV;

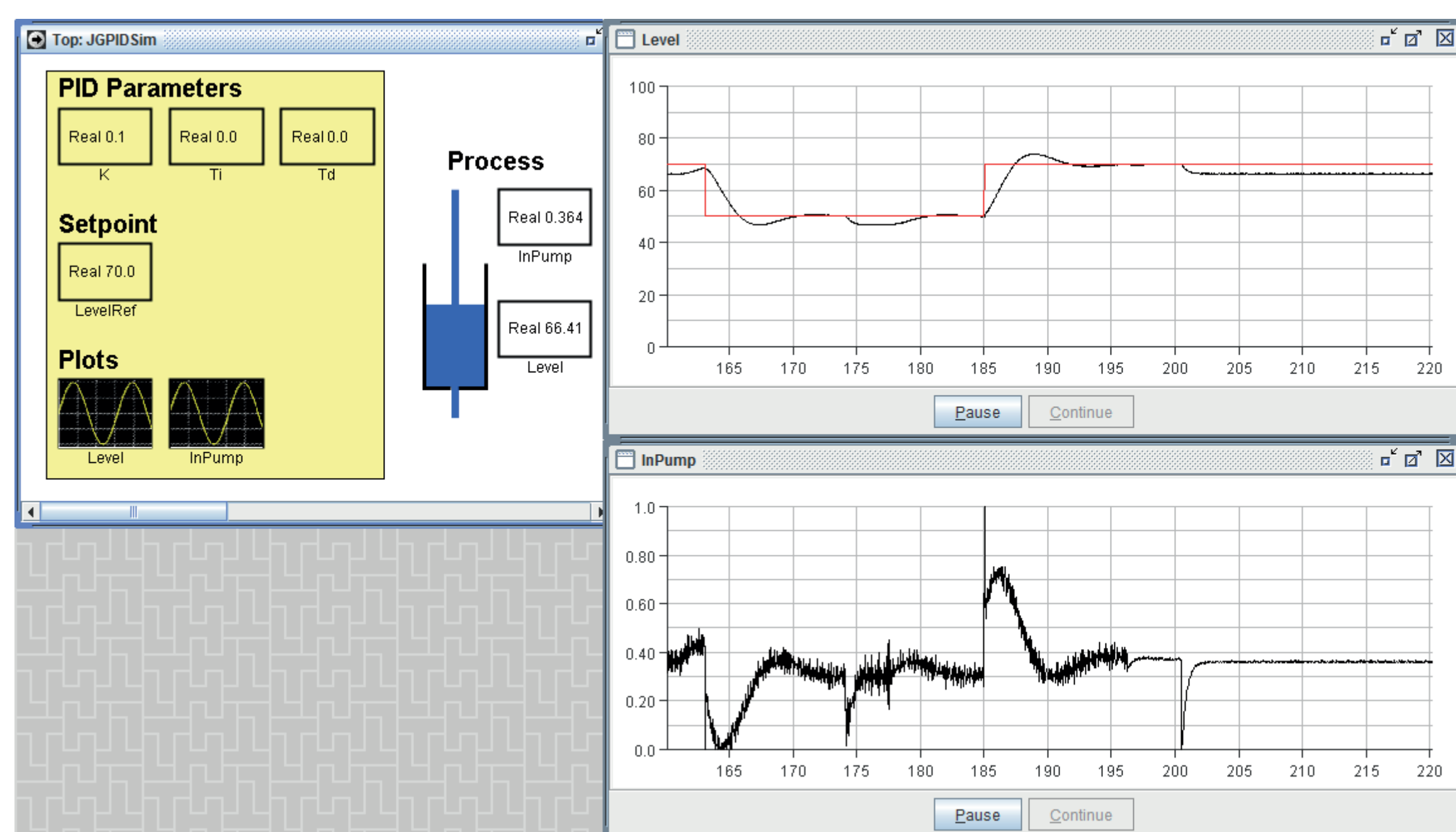
// Update previous values
S PV2 = PV1;
S PV1 = PV;
S SP1 = SP;
S FF1 = FF;
S useFF1 = useFF;
```

| | |
|------------|-------------------------|
| PV | Process Value |
| SP | SetPoint |
| TR | Tracking |
| MV | Manipulated Variable |
| FF | FeedForward |
| Man | Manual control signal |
| | |
| K | Controller gain |
| Ti | Integral time |
| Td | Derivative time |
| Nd | Maximum derivative gain |
| b | Setpoint weight |
| execFreq | PID sample time |
| | |
| useFF | Turn feedforward on/off |
| manualMode | Turn manual mode on/off |
| stop | Terminate call |

A full-fledged PID module has been implemented as a procedure. It supports anti-windup, auto/manual mode, feedforward, tracking, setpoint weighting, and bumpless mode and parameter changes.

It is implemented on incremental form which is easier to get right as most features come for free.

The PID Learning Module



A basic PID learning module has been created. To make it standalone it uses a simulated process. Since the PID procedure uses **S** actions, proper execution was ensured by limiting the control signal and then updating the simulated process with **P** actions in the same step.

To the left, setpoint and controller parameters can be changed during execution and a live animation of the process is shown. To the right, live plots are shown. The upper plot shows process value (black) and setpoint (red) and the lower plot shows the control signal.

Conclusions

The module will be included in future JGrafchart releases. Unlike other PID learning tools JGrafchart is free, based on an industrial control language, and can be used in industry-like environments. Future work includes using it for education as well as adding more features to the PID procedure, for example process value filtering or an auto-tuner.



Download: <http://www.control.lth.se/Research/tools/grafchart.html>

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