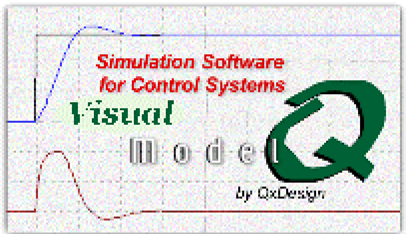
Visual ModelQ Training



Tuning a PI Controller

This unit discusses
- Zone-based tuning for a PI controller
- Adjusting gains with “Live Constants”
- Retuning the system from the Training unit “Building a PI Controller”

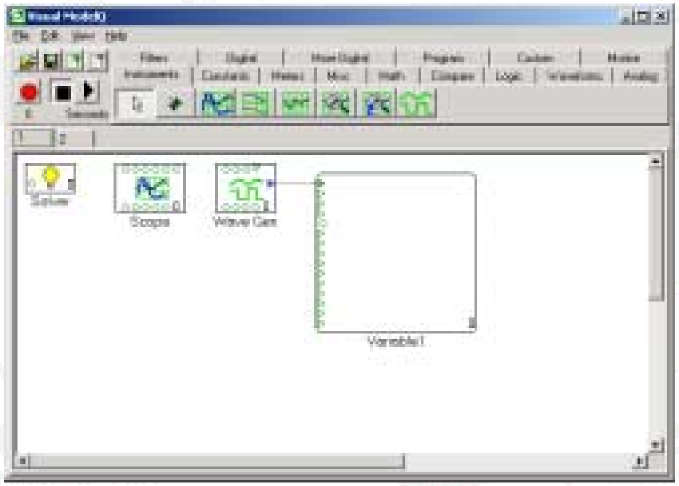
Install *Visual ModelQ*

To run *Visual ModelQ* the first time:

- Click here to visit www.QxDesign.com
- Download *Visual ModelQ***
- Run *Visual ModelQ* installation
- Launch *Visual ModelQ* using the Windows start button or clicking on the icon 

Visual ModelQ

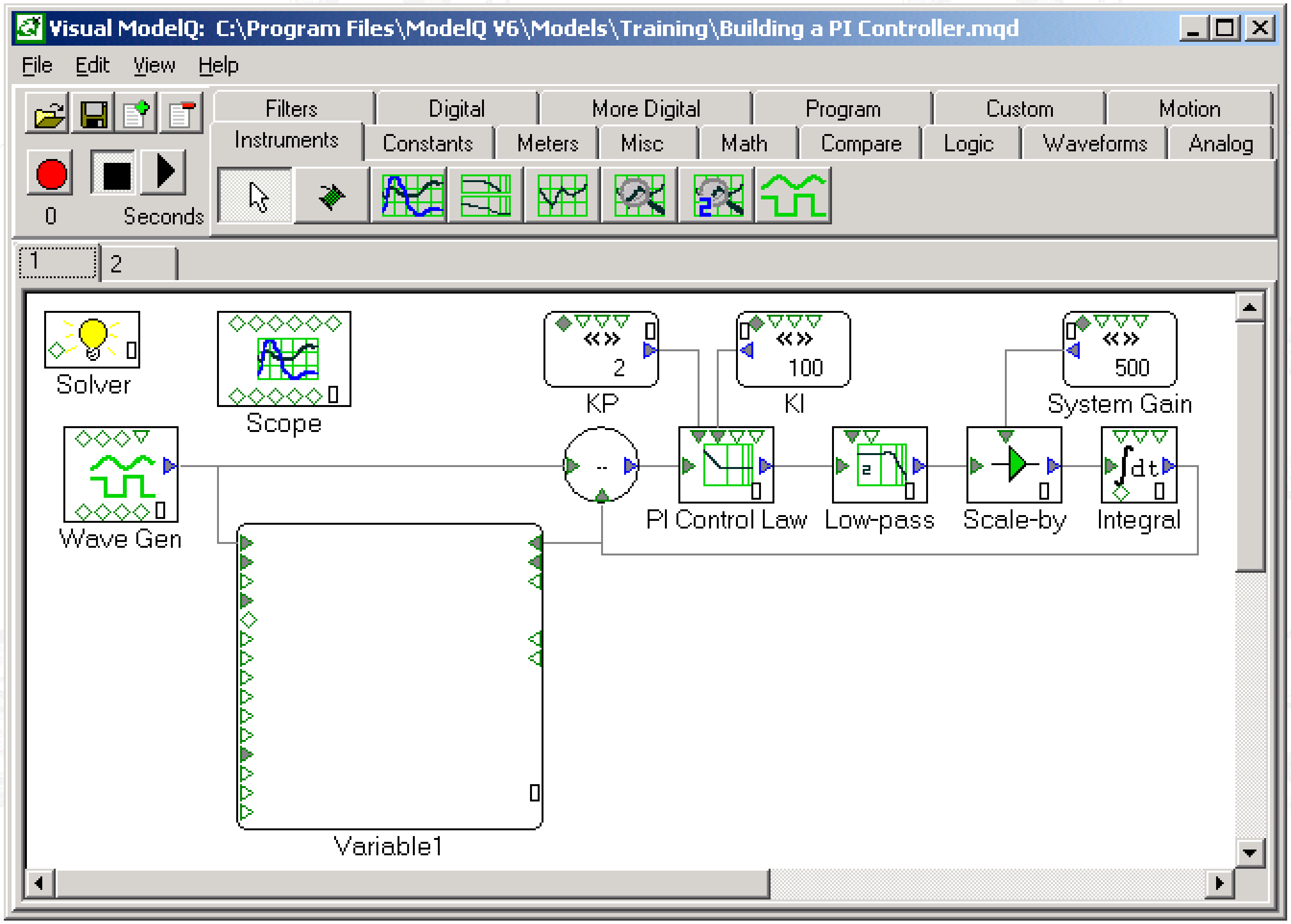
- The "default model" should appear



**This unit can be completed with a free (unregistered) copy of *Visual ModelQ*

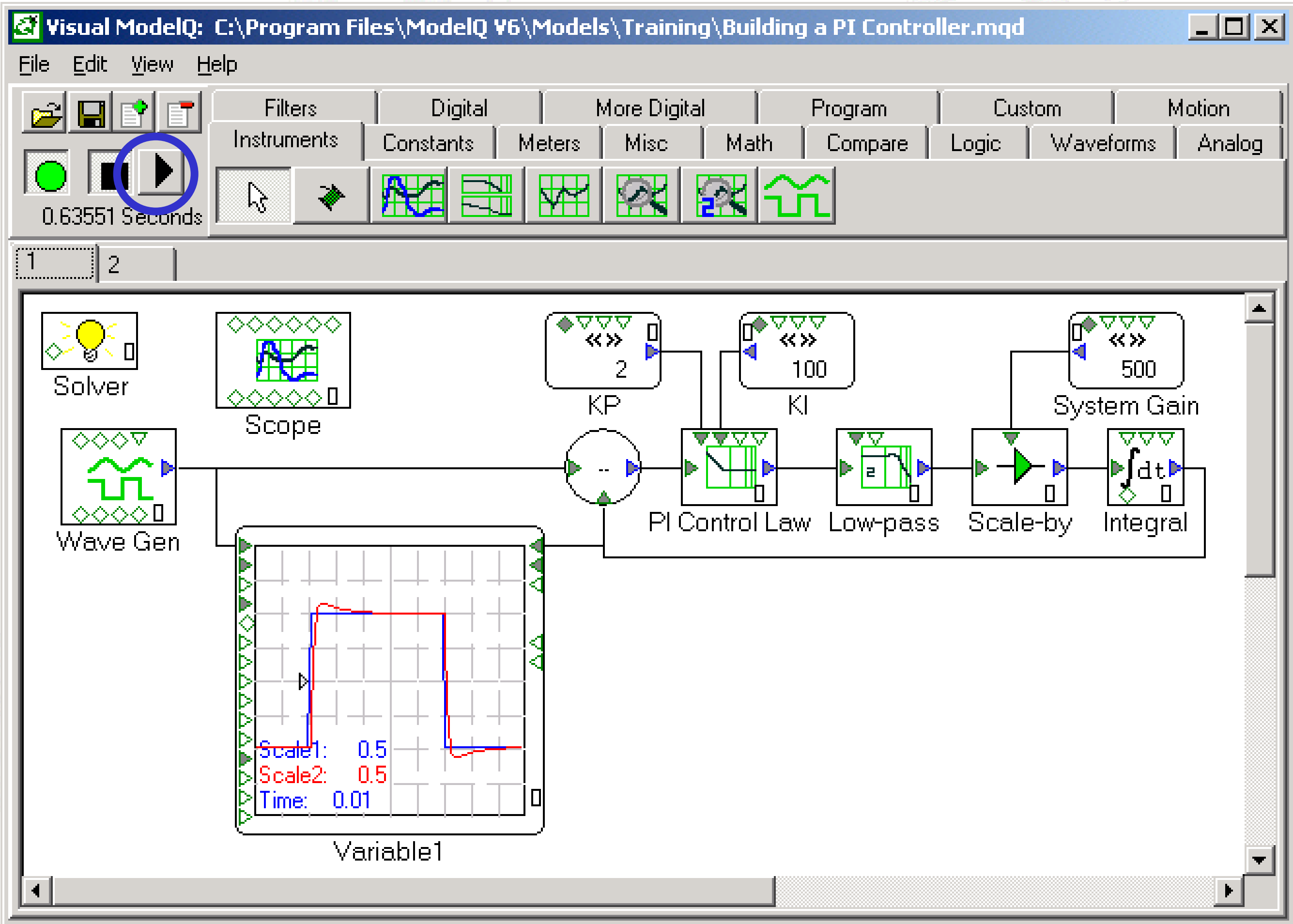
Start with the model “Building a PI Controller”

- Visit www.QxDesign.com/VisualModelQ#Training
- Download “Building a PI Controller.mqd” or build the model yourself using the presentation “Building a PI Controller.pps”



Check performance with the initial values

- Click the run button to see the performance with the initial gains of KP = 100, KP = 2, and with a System Gain of 500.
- Looks good; feedback (red) responds fast, with little overshoot.



Zone-based Tuning Procedure

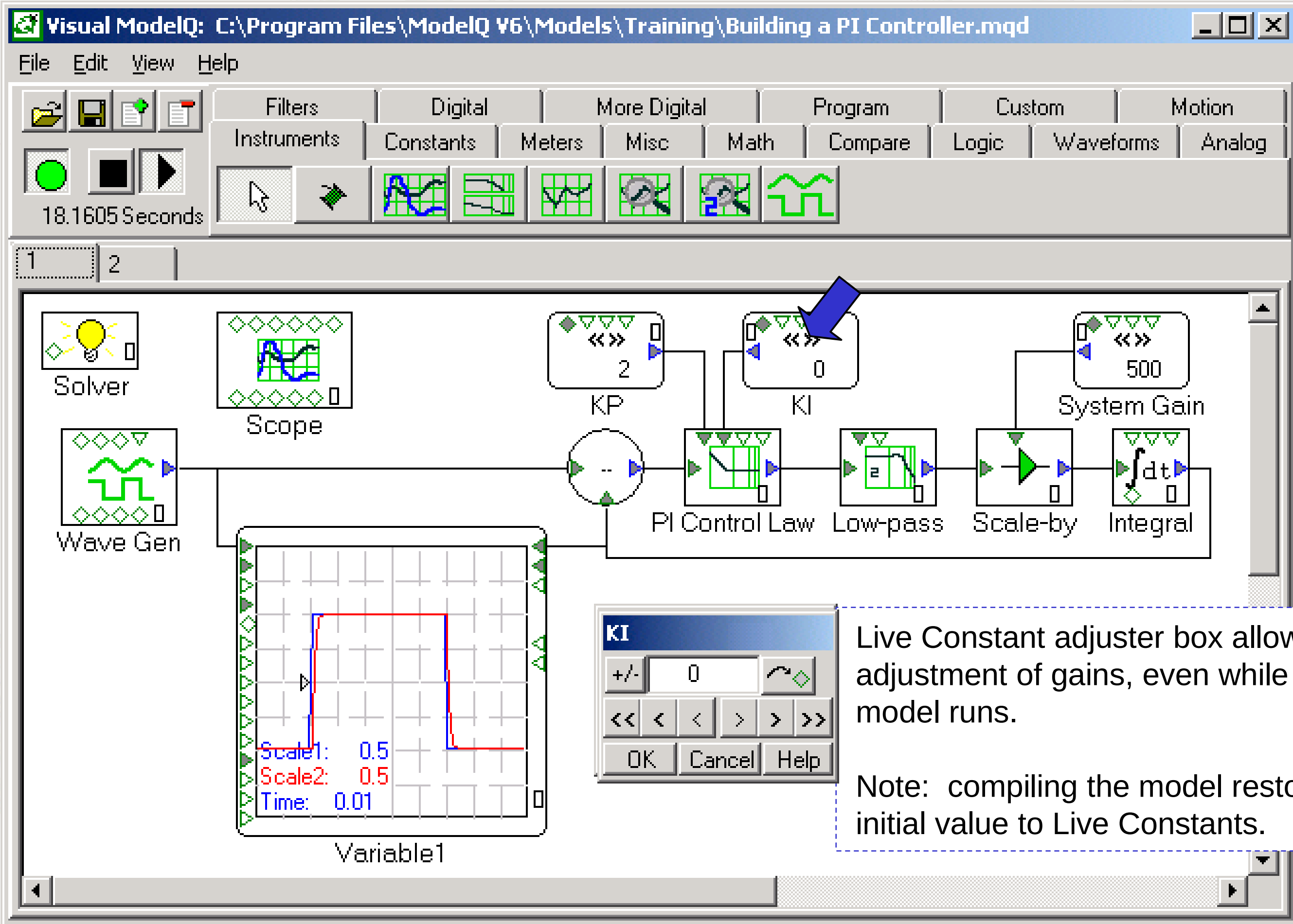
- An overview of the Zone-based Tuning Procedure for a PI (Proportional-Integral) controller:
  1. Set integral gain (KI) to zero**
  2. Set proportional gain (KP) low for system stability
  3. Apply a step command
  4. Increase KP to max value without overshoot to a step++
  5. Increase KI for ~10% overshoot to a step++
- The starting model is tuned with KP=2 and KI=100.
  Let's revisit, but ignore the fact that these values are known.
- For more detail on Zone-based Tuning see
  Control System Design Guide, 2nd Ed., Chapter 3.

**Note that in practice, some systems should not be operated with zero integral gain because external loading may cause undesirable consequences (example: in a motion-control system where an unbalanced load could fall with integral gain of zero).

++Note that steps 4 and 5 are "rules of thumb". The settings for KP and KI may be somewhat higher or lower for a given application. The point of Zone-based tuning is that, usually, having a fixed procedure with specific performance criteria speeds the tuning process and produces more consistent results.

Step 1: Zero Integral Gain

- While model runs, double-click in KI block; adjuster box appears.
- Click in edit box (initially “100”) and type “0” to disable integral.
- Press OK button and adjuster box will hide.

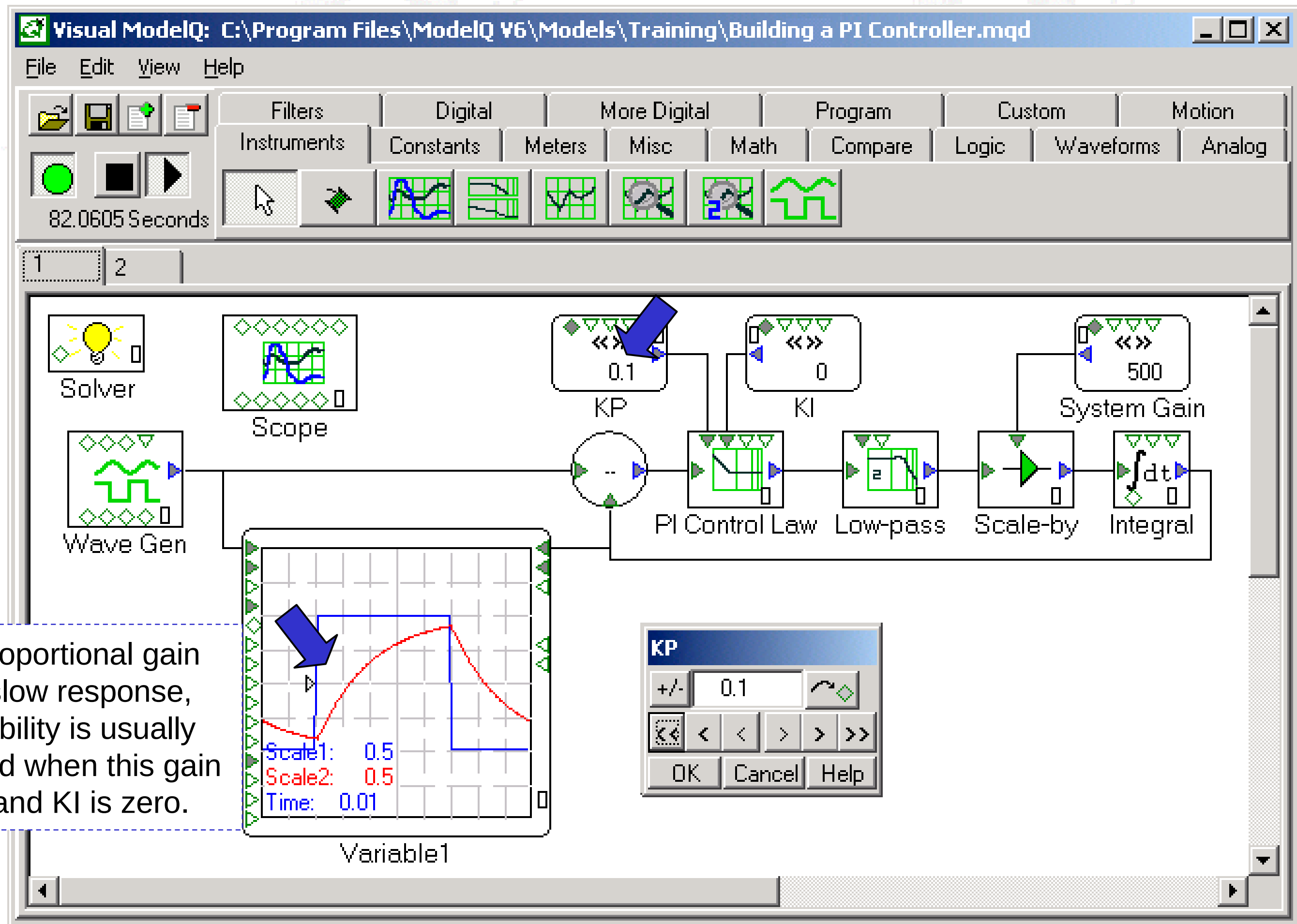


Live Constant adjuster box allows easy adjustment of gains, even while the model runs.

Note: compiling the model restores the initial value to Live Constants.

Step 2: Set Proportional Gain Low

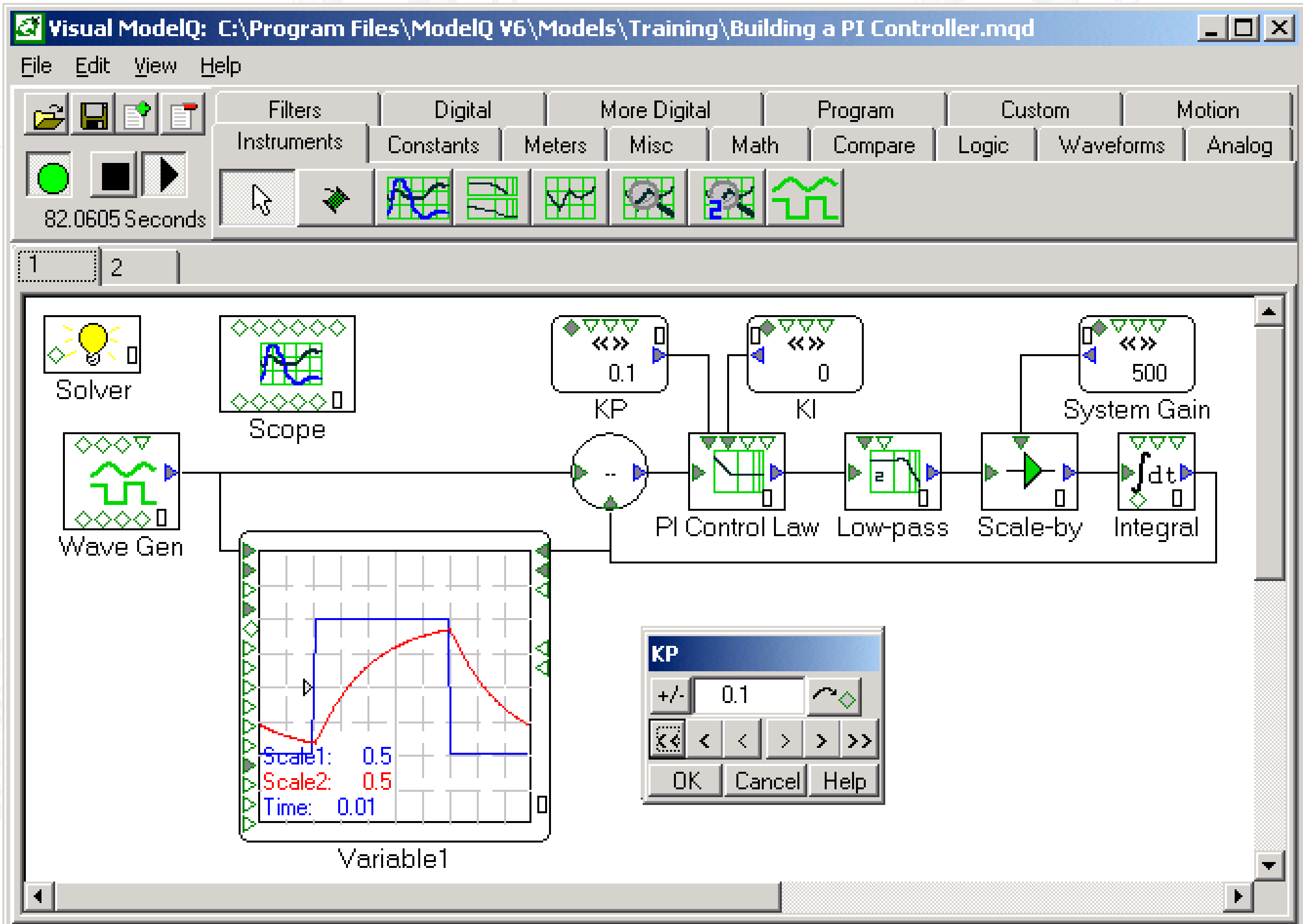
- Double-click in KP block; adjuster box appears.
- Click in edit box (initially “2”), type “0.1” and press Enter key. Note slow response; that’s okay…here, we just need stability.



Low proportional gain gives slow response, but stability is usually assured when this gain is low and KI is zero.

Step 3: Apply Step Command

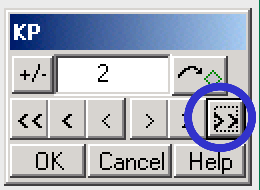
- Already done. This model is built with the step command applied.
- Now that the starting conditions are set, we can start tuning.



Step 4: Increase KP, avoid overshoot

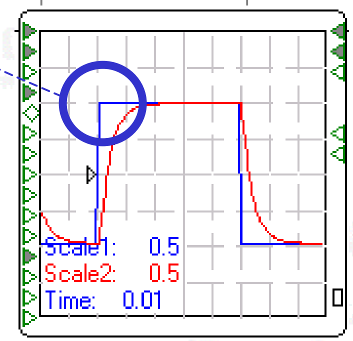
- Increase KP. Response improves up to KP ~2.0; KP > 3.0 makes overshoot. Several cases are shown below. Choose KP = 2.0.

TIP: Use adjustment such as ">>" (large increase) to quickly vary gains while the model runs

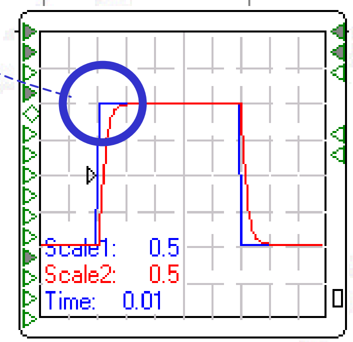


Slow Response

KP = 0.5

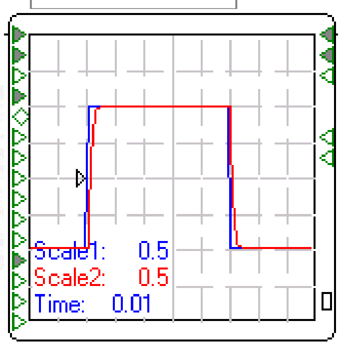


KP = 1.0



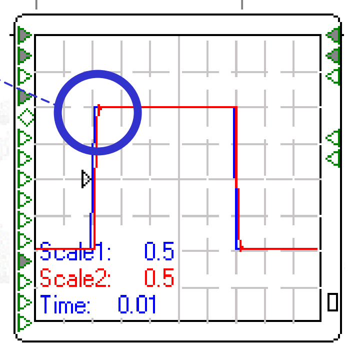
Choose this!

KP = 2.0



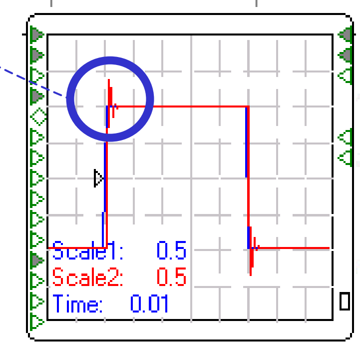
Slight overshoot

KP = 3.0



Overshoot and ringing

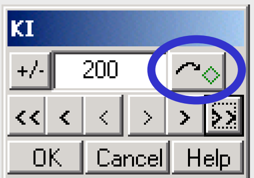
KP = 5.0

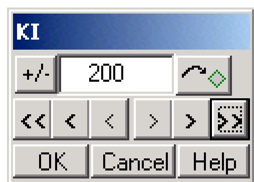


Step 5: Set KI for ~10% overshoot

- Start with KI low (say, 1)
- Increase KI for ~10% overshoot. Choose KI = 200.

TIP: To save a value so it isn’t reset by each compile, click the “save as initial value” button right of the value.

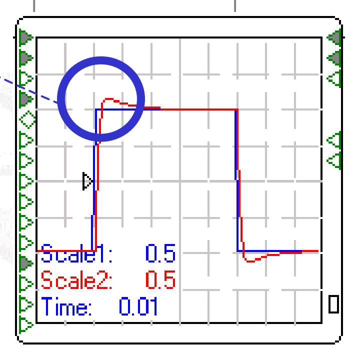




Choose this!

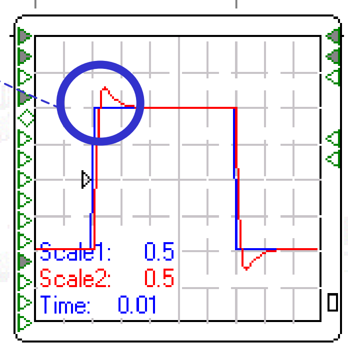
~5% overshoot

KI = 100



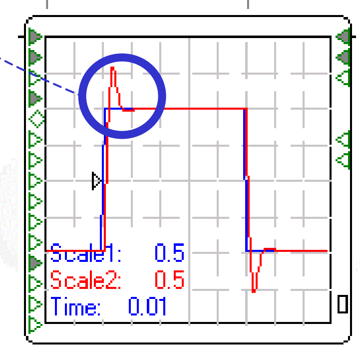
~10% overshoot

KI = 200

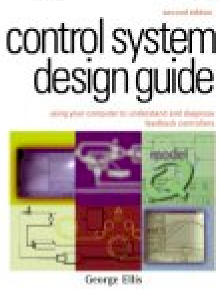


25% overshoot

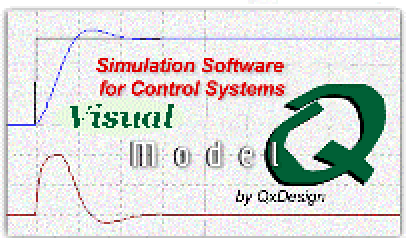
KI = 500



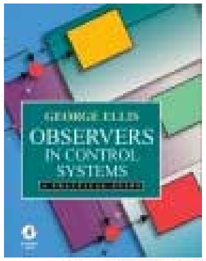
Visit www.QxDesign.com for information about software and practical books on controls.



Click here for information on <u>Control System Design Guide (2nd Ed.)</u>, published by Academic Press in 2000



Click here for information on *Visual ModelQ*



Click here for information on <u>Observers in Control Systems</u>, published by Academic Press in 2002