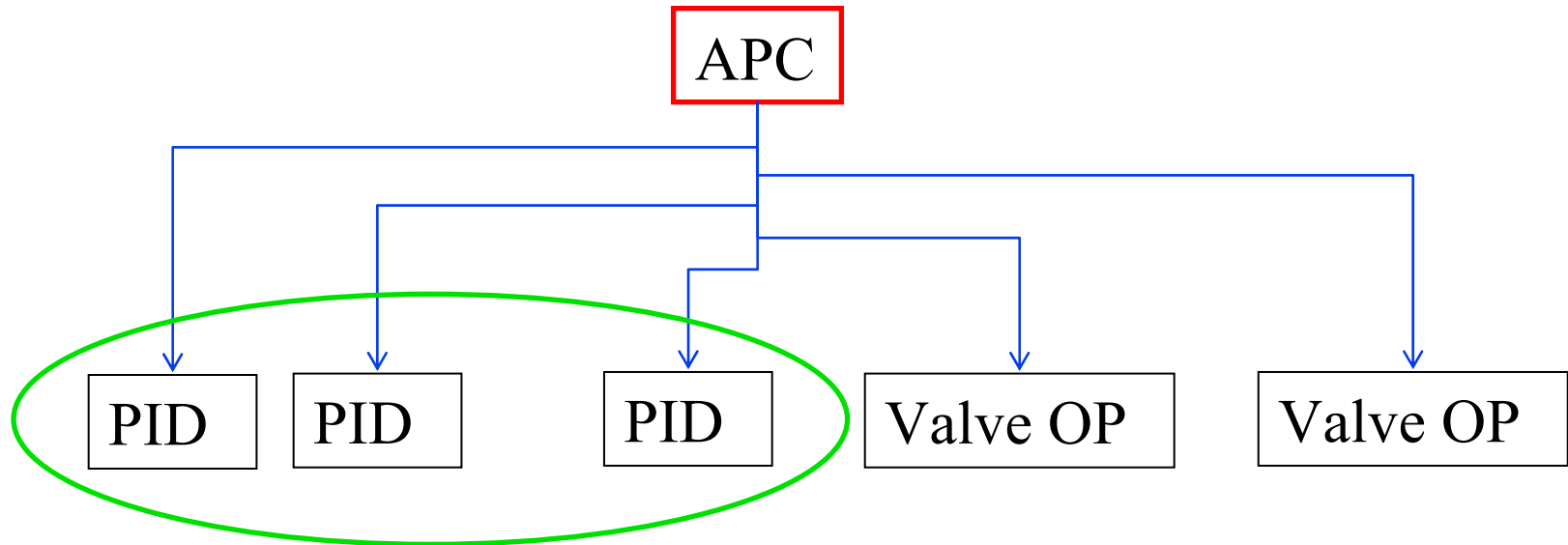


PID Tuning

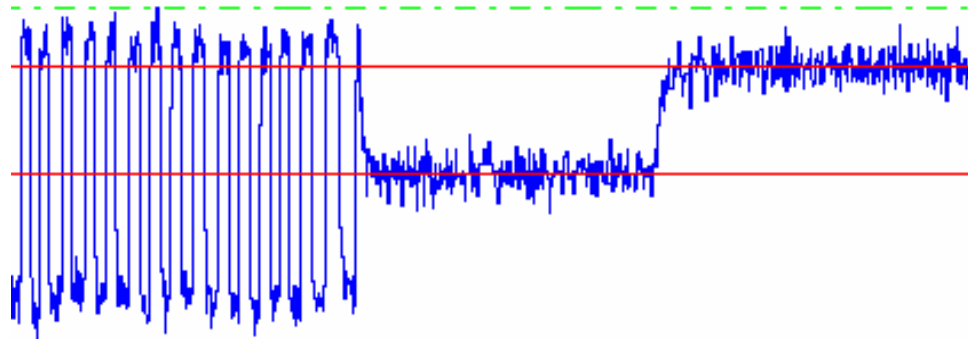
The Basis of APC

PID loops connected to APC



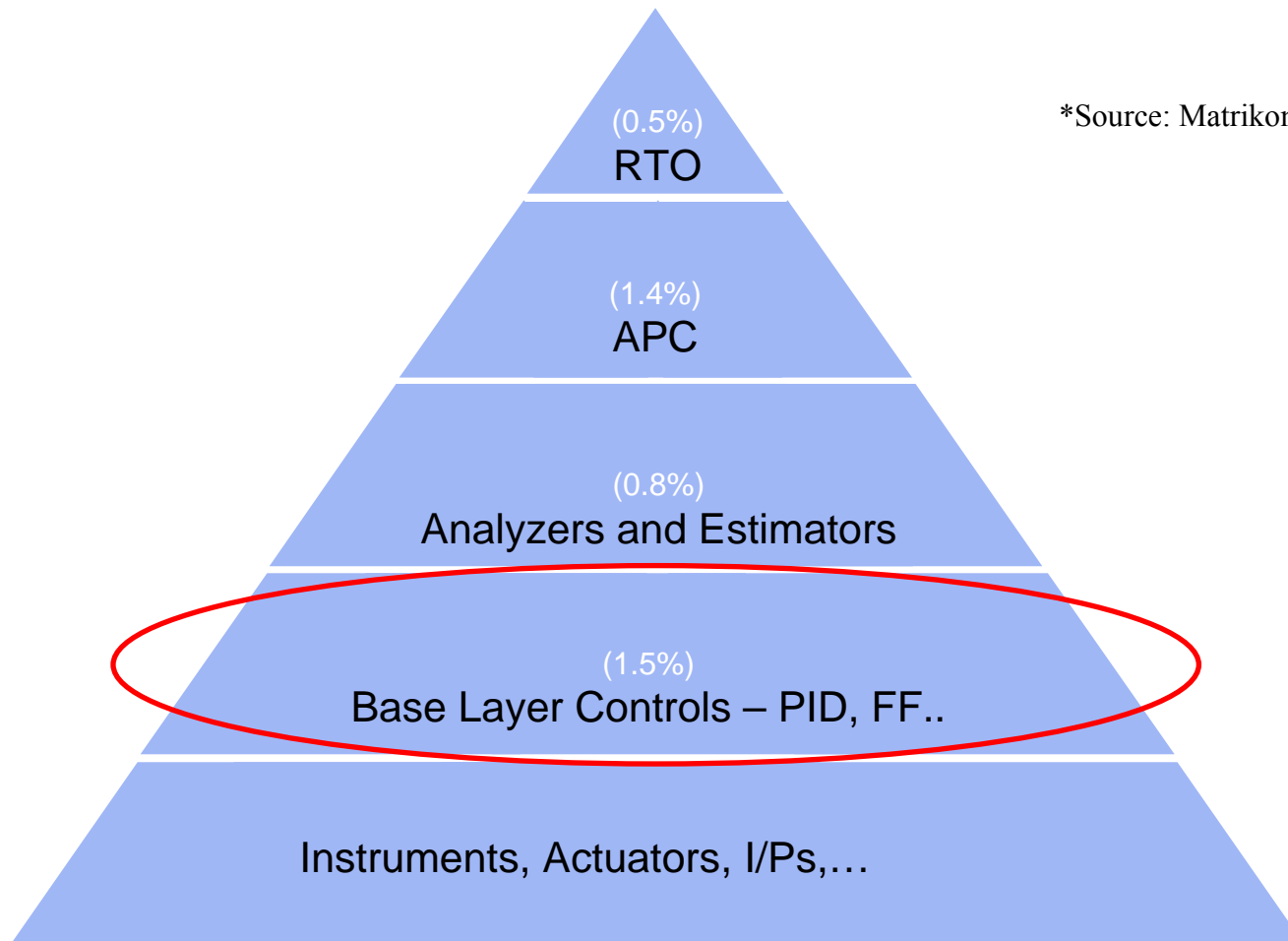
- Good basic PID performance is required
- Tuning affects the models of APC
- PID tuning before APC step testing

The benefit of PID tuning



- Better tuning: less PV oscillation, quick response to SP change
- Possibility to shift SP closer to limit
- Thus increase benefit

The benefit of PID tuning



*Source: Matrikon CPM overview presentation

Tuning principles

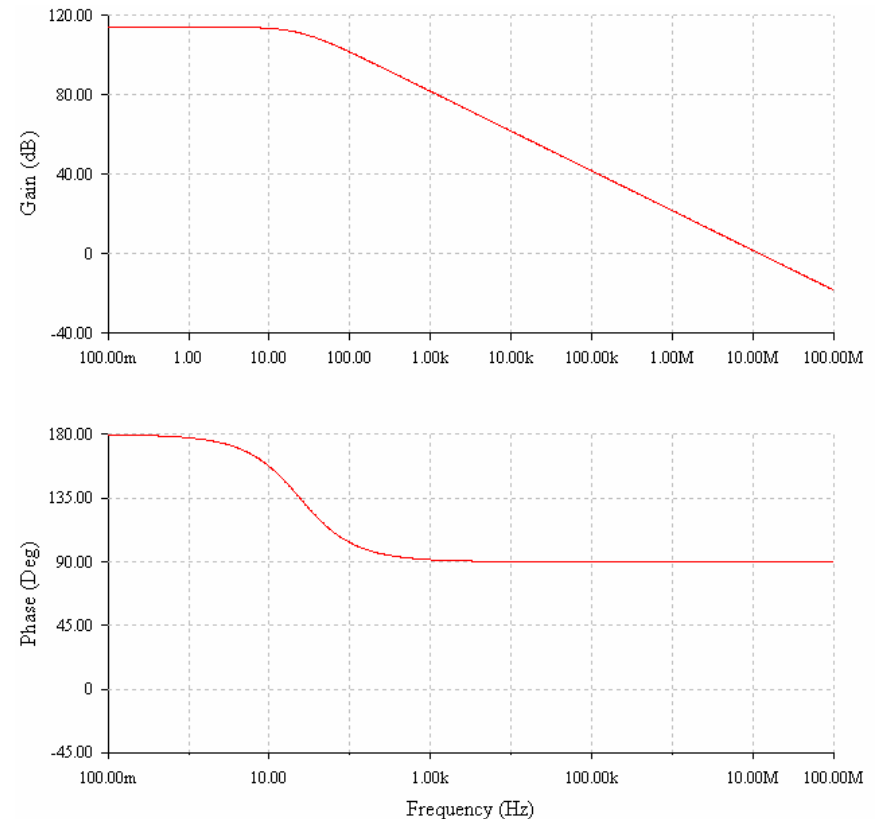
- Flow, temperature, pressure control loops
 - Quick response to SP change
 - Reduce oscillation, noise, offset error, etc...
- Level control loops:
 - Averaging control:
 - › allow oscillation of PV around SP
 - › Slow response to disturbance or SP change
 - › No sudden / big change on the OP ↔ stabilise downstream units
 - Tight control
 - › Faster response to disturbance or SP change
 - › Bigger OP moves

PID algorithm

- Serial compensation of a dynamic process
- Frequency / Laplace representation:
 $K*(1+1/sT_i+sT_d/(1+sT))$

PID algorithm

- Magnitude Bode diagram: define T_i and T_d in order to extend the -20 dB / dec. slope of the line
- Phase Bode diagram: define K in order to guarantee $> 60^\circ$ phase margin
- $\omega_c \leftrightarrow$ settling time
- Phase margin \leftrightarrow overshoot / stability



PID Tuning in Practice 1.

- Tune filter first
- (Closed loop tuning methods)
 - Ziegler-Nichols
- Open loop tuning methods
 - Ziegler-Nichols
 - Cohen-Coon
 - Louisiana State University
- List of typical parameters to start

PID Tuning in Practice 2.

- Computer-based tuning methods
 - Manual, open-loop „step test” & off-line tuning
for example: Profit Design Studio – Profit PID
 - Automatic open (or closed)-loop „step test” & on-line tuning
for example: Honeywell Opertune; Matrikon TaiJi PID
- Trial and Error tuning

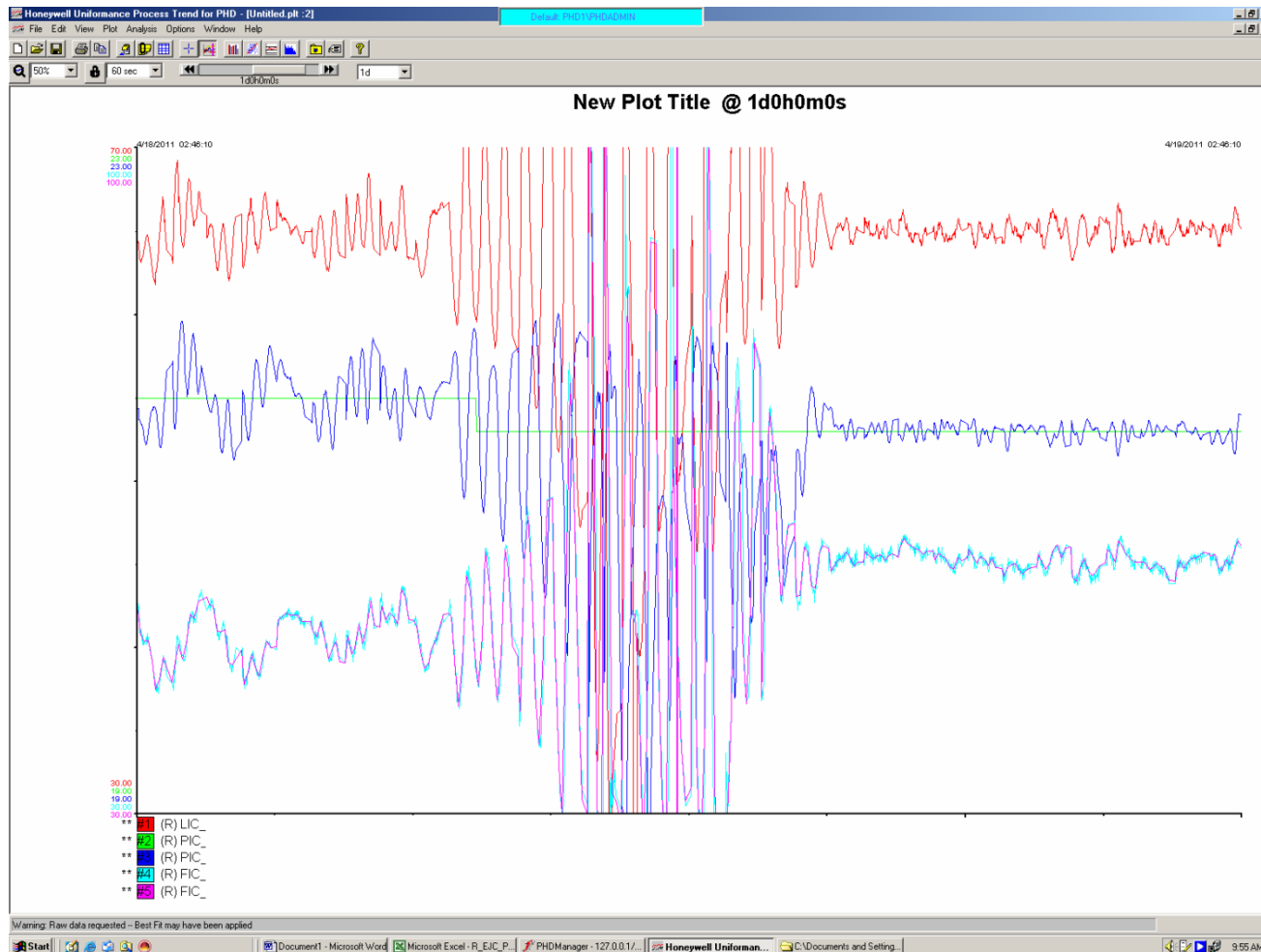
Advanced Regulatory Control

- For example:
 - Cascade
 - Feed forward
 - ...
 - SISO / MISO MPC (for example Profit Loop)
- Break it or keep it?
 - Is APC able to control it better?
 - Is APC fast enough?

Interacting PID loops – case study 1.

- Process: LPG plant, deethaniser column
- Interacting PID loops: column pressure and reflux drum level
- Loose / averaging control of the level:
 - Level and pressure are oscillating with the same frequency
- Solution: accelerate the level loop by tight control

Interacting PID loops – case study 1.



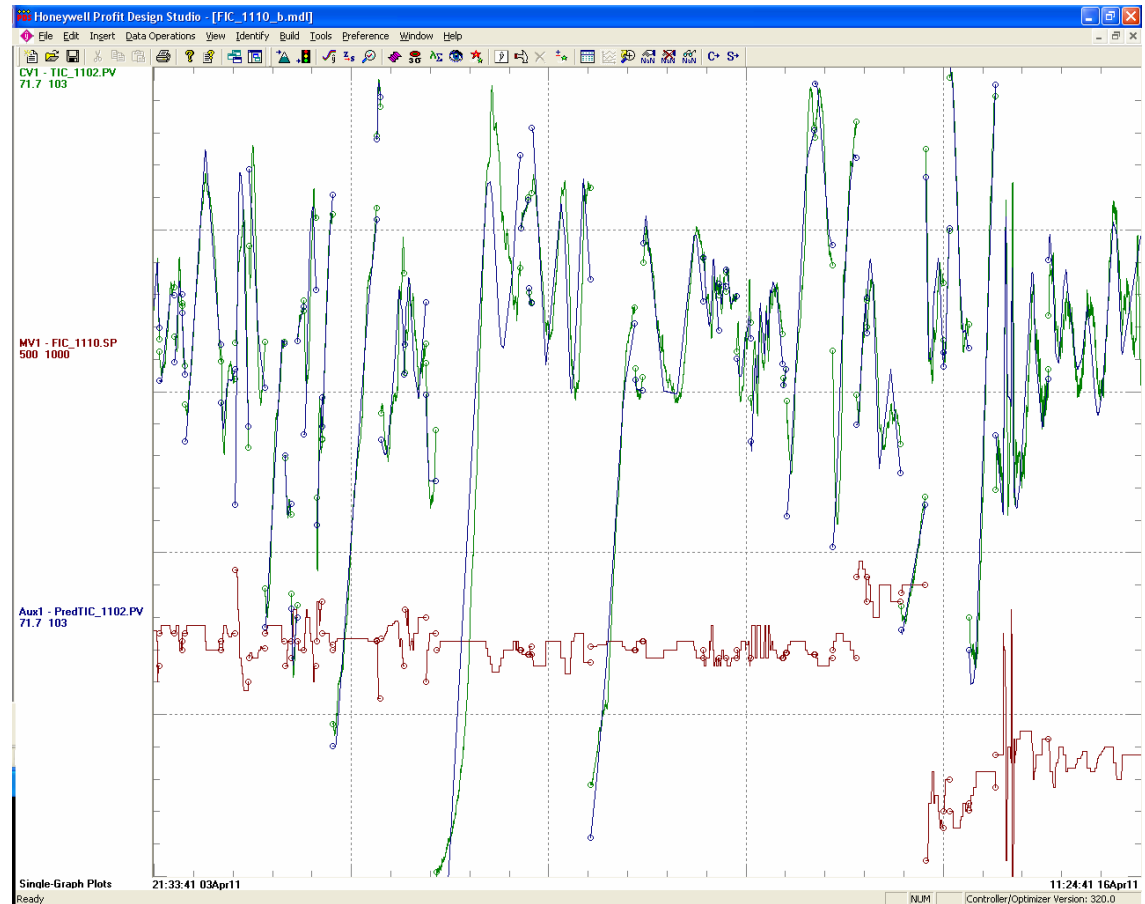
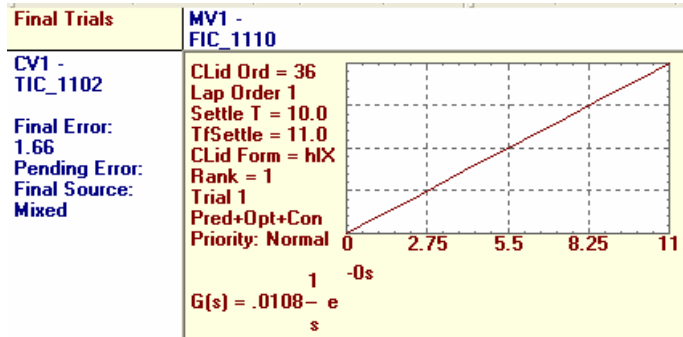
Big time constant / integrator-like process – case study 2.

- Even temperatures can behave like integrators
 - VCM plant: HCl column top temperature
 - LPG plant: fractionator bottom temperature
- Huge time constant, unmeasured disturbances have significant effect on the PV → difficult to control
- Tight control option: big gain, eliminates the error, large and quick OP moves, cause stability problems when SP changed
- Loose control: small gain, constant oscillation, slow response to SP change

Big time constant / integrator-like process – case study 2.

- This control behavior is not acceptable for a loop to be used for APC
- We want:
 - small OP moves
 - Fast response to SP change
 - Reduce disturbance
- Solution: SISO / MISO MPC (for example Profit Loop) or add the PV as CV and the OP as MV to the APC
- Why? Use of prediction and state estimator.

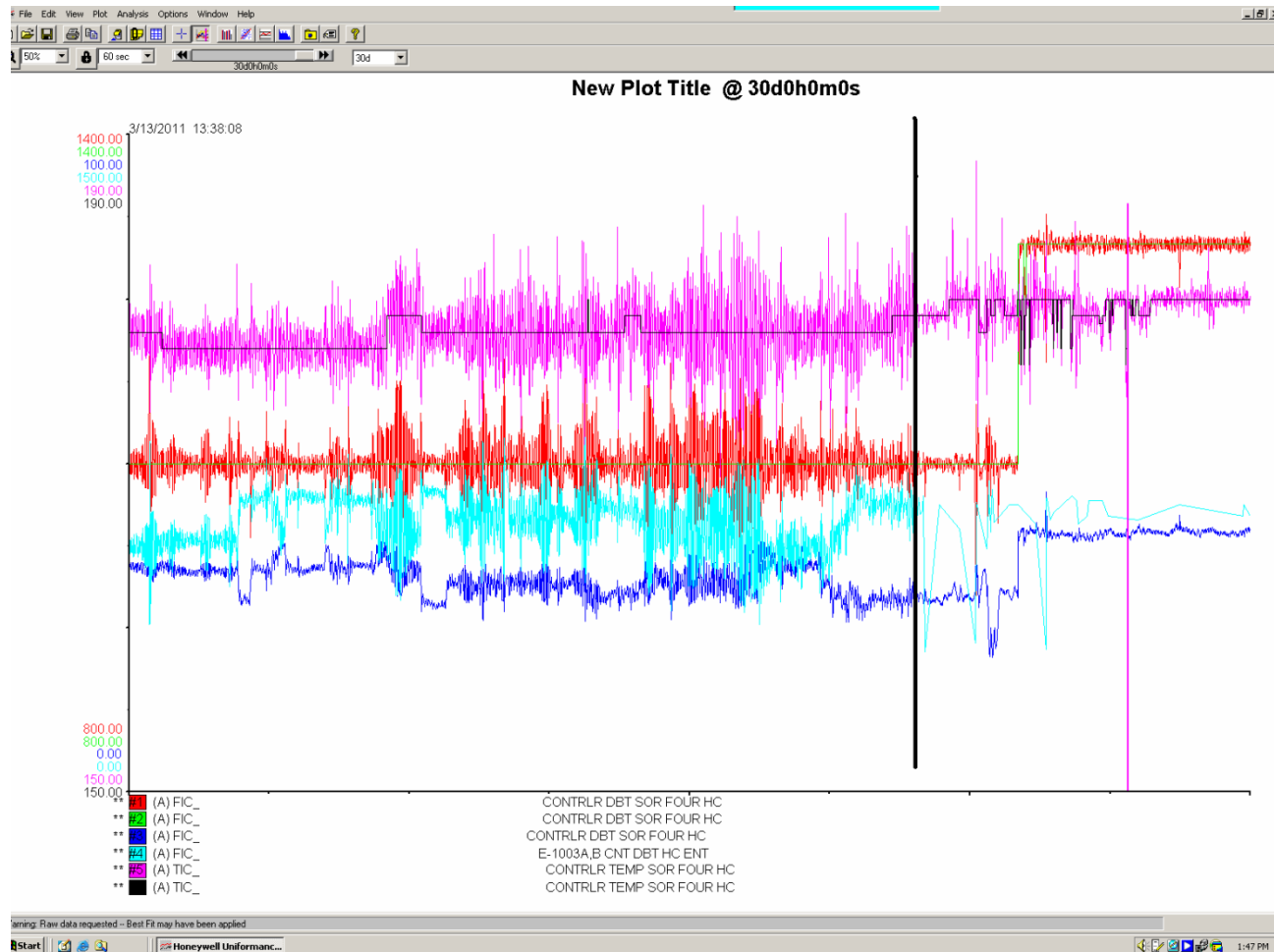
Big time constant / integrator-like process – case study 2.



Break a cascade loop – case study 3.

- Process: LPG plant, fractionator, hot oil reboiler
- Column bottom temperature cascade loop makes significant disturbance on the hot oil furnace which perturbs the whole unit
- Solution: break the cascade.
Add reboiler hot oil flow as MV and column bottom temperature as CV to APC

Break a cascade loop – case study 3.



Thank you!

Any questions?