Design Tools
Load Model & Loop Stability

4. Load Model & Loop Stability
Crossover Frequency, Gain Margin, Phase Margin, Output Impedance

This tool is used to configure the digital PID feedback loop. Acadia uses **real-time adaptive PID control** to automatically scale the coefficients and low-pass filters to maintain stability as phases are added and dropped.

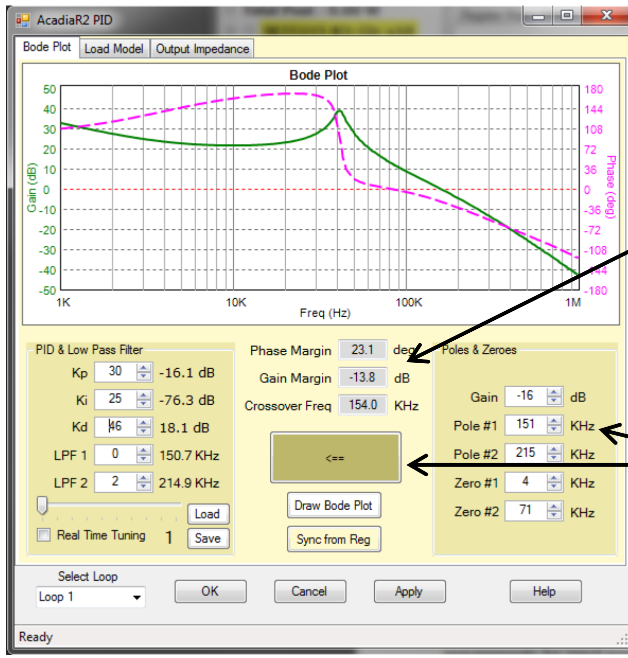
The Acadia PID control loops consists of two low pass filters, a proportional term, an integral term, and a derivative term. Its purpose is to modify the nominal pulse width so that error voltage between output voltage and target voltage is zero.

K_P term – proportional term that sets the mid band gain. It affects the instantaneous magnitude of the error voltage signal.

K_i term – integral term that sets the low frequency gain. It determines how quickly the loop responds to transient information.

K_d term – derivative term that sets the high frequency gain. It affects the slope of the error voltage and how well the loop respond to the start of a load transient.

LPF 1 – Pre-low pass filter
LPF 2 – Post-low pass filter. Combined with the PID terms they create a type 3 compensator with 2 zeroes and 3 poles.



The calculated Phase Margin, Gain Margin, and Crossover Frequency of the compensator.

User can set desired poles and zeros locations and low frequency gain for the tool to convert to K_p, K_i, and K_d terms.

The compensator follows this transfer function. ωp_1 and ωp_2 are configurable poles to filter noise and roll of the high frequency gain that the K_d term creates.

$$\left(K_P + \frac{K_i}{s} + K_d * s\right) * \left(\frac{1}{1 + {}^{s}/_{\omega p_1}}\right) * \left(\frac{1}{1 + {}^{s}/_{\omega p_2}}\right)$$

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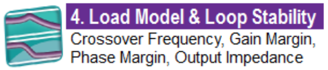

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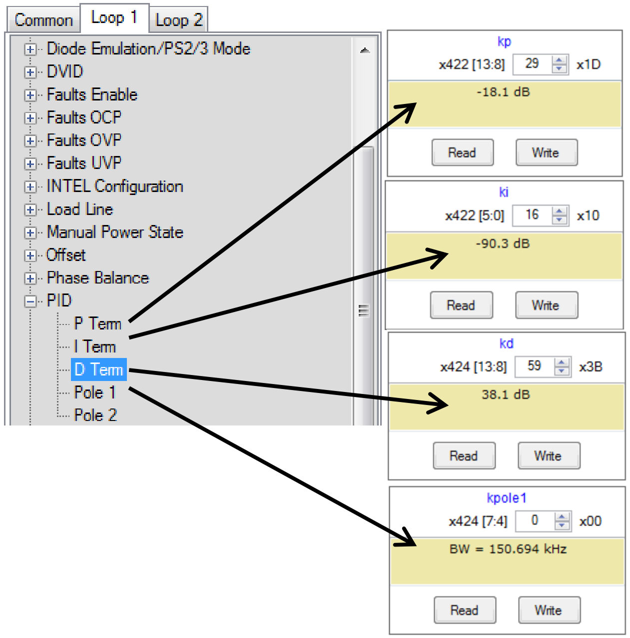

In Loop 1 and Loop 2 section, under **PID**

The K_p, K_i, and K_d terms can also be configured in the list of register map commands.

Design Tools
Recommendations for Designing a PID Feedback Loop

- The first zero should be placed on the left side of the LC filter's double poles, and the second zero placed on the right side of the double poles
- Zero frequencies are chosen to provide a phase boost at the LC double pole frequency.
- Pole frequencies are chosen to provide high frequency gain roll off/decay to reduce PWM jitter
- The cross-over frequency (fc) or bandwidth (BW) should not exceed 1/4 of the switching frequency
- The Gain should cross the 0dB threshold with a slope of -20dB /dec
- **Kp**/**Ki**/**Kd**/**Kfp** values are larger for lower phase-count than that for higher phase-count