## Generating Digital Coefficients from the Modulator Transfer Function

Once you have measured (or modeled) the modulator transfer function, you can have the Venable System software generate the coefficients for the target processor to define the compensation for your desired loop. Here are the steps:

1. With the modulator (also called plant or control-to-output) transfer function displayed as a gain-phase graph and selected, click the Slide Bar icon or right-click anywhere on the open graph and click "Add Slide Bar". Note that data is "selected" by clicking anywhere on either curve of the data set or pressing the right- or left-arrow keys to toggle through the various data sets displayed. Also note that the Slide Bar option is not available if more than one data set is selected since the Slide Bar is keyed to a particular data set.
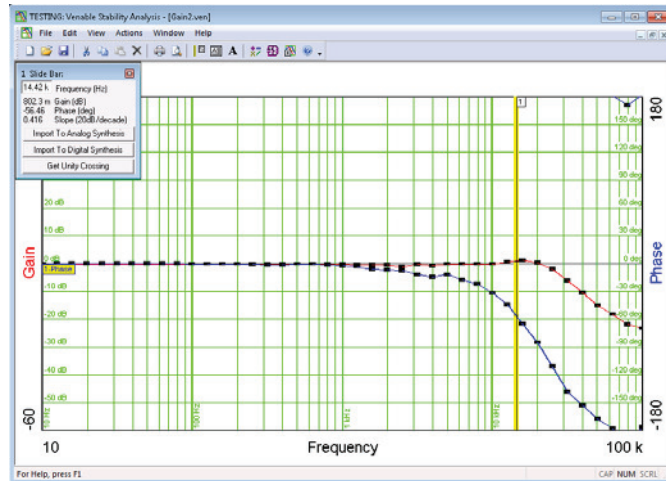
2. When the Slide Bar is added to the modulator transfer function data set, click and hold it with the left mouse button then move it to the desired loop bandwidth. In choosing loop bandwidth, remember that the response time of a system to a transient is approximately the reciprocal of the loop bandwidth. Also remember that the bandwidth limit of a switching data system is half the switching rate. As a practical matter, even though it is theoretically possible to cross the feedback loop over at half the switching or sampling frequency, a more achievable number will be in the range of 10-20% of the switching frequency.

3. After choosing the desired loop bandwidth and moving the Slide Bar to that frequency, note that the text box associated with the slide bar has a button labeled "Import to Digital Synthesis". Click that button. This will open the "Digital Compensator Synthesis and Analysis Menu" window and transfer the loop crossover frequency to that window together with the modulator gain and phase measurements at that frequency.

4. In the Digital Compensator Synthesis and Analysis Menu window there are a number of choices to make:

a) Phase margin – We recommend 60 degrees as a good starting point.

b) "Compensator is Inverting" check box – check this box if the modulator inverts (output is 180 degrees out of phase with the input) at low frequency. Leave it unchecked if the modulator output is in phase with the input at low frequency. If the gain is flat at low frequency (it should be), the circuit will be either inverting or non-inverting. It will not have some in-between phase value if the test was performed correctly.

c) Sampling Period – The sampling time of the PWM generator in the target processor is set in this box. It is the inverse of the processors PWM sampling frequency. This will also be the bandwidth constraint of the feedback loop circuit.

d) Input Voltage – This is the output voltage of the modulator or plant (which becomes the input voltage to the feedback divider).

e) Feedback Voltage – This is the voltage at the input of the ADC in the compensation processor.

f) Target Selection – This list will be populated with all supported processors that are licensed by Venable. The selection choice will control the algorithms that generate the coefficients in the Compensator Coefficients section of the menu.

g) "Scale Coefficients" check box – This check box will adjust the coefficients into the actual values to be coded into the target processors software. If PID is the selected stage 1 setting, then the PID coefficients will be rescaled instead of the primary coefficients. If left unchecked, raw algorithm coefficients are generated.

h) Stage 1 Compensator Type – Type 1 is a simple integrator, type 2 has a single zero-pole pair, and type 3 has two zero-pole pair. A PID is a compensator that has two zeros and no poles. It will generally be couple with a second stage pole filter. If the modulator transfer function is flat at the chosen crossover frequency, choose type 1.

Type 1   Type 2   Type 3
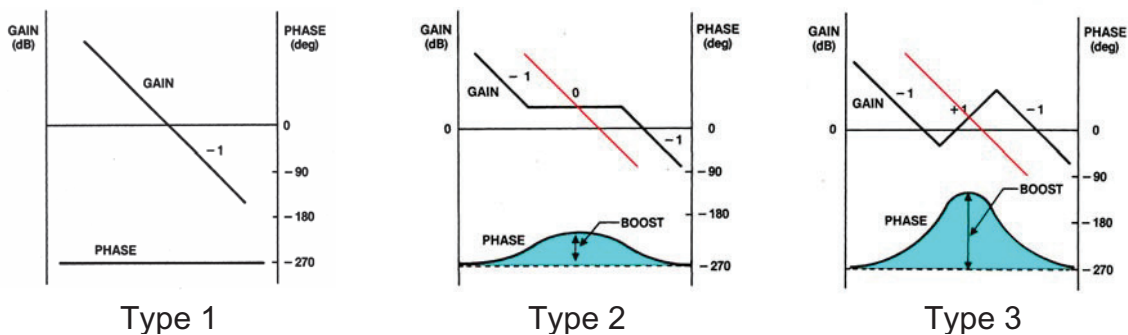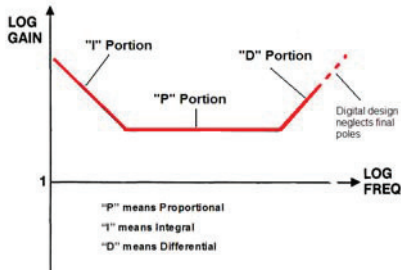
PID

If the modulator transfer function is falling at a -20 dB/decade slope at the chosen crossover frequency, choose type 2. If the modulator transfer function is falling at a -40 dB/decade slope at the chosen crossover frequency, choose type 3. The error message box will tell you if you chose an unachievable combination.

i) Stage 2 Type – This allows selection of a second stage filter for those processors that utilize them. Generally, this will consist of either a 1st order Low Pass Filter or 2nd order Low Pass Filter. The cutoff frequencies for these settings can be input for the poles. A "Custom" mode also is included with parameters set in the Custom parameters section. Refer to the Application Notes for your specific processor if you need to use the custom mode.

5. After you have entered in all the design values and choices, click the "Compensator Analysis" button. This will send you to the next (Compensator Analysis) tab.
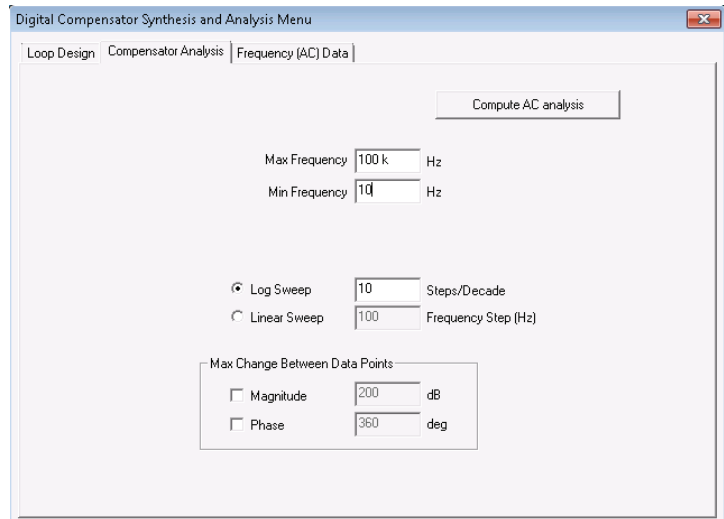
6. The Compensator Analysis tab is where you set up the parameters of the AC analysis of the computed coefficients. Choose the maximum and minimum frequency for the analysis sweep, whether you want a log or linear sweep and what the resolution of

the sweep is, and finally whether or not you want to activate the feature we formerly called "Max Delta Gain/Max Delta Phase". This feature measures the change in gain and phase from one analysis point to the next, and if the gain or phase change on any node is greater than the amount specified, will cut the frequency step size in half and try again. This can happen a maximum of 5 times (steps/decade x 32) up to a maximum resolution of 2000 steps/decade.

7. When the parameters of the analysis are set to your requirements, click the button labeled "Compute AC analysis". This will take you to the final tab, "Frequency (AC) Data". A brief description of the origin of the data will be at the top of the text display in lines starting with * (asterisk). Following the comment lines, the data will be displayed in Venable Standard Format which is 5 columns: Frequency, Node number, Voltage (volts), Voltage (dB), and Phase (degrees). There will be a row for each node selected at each frequency.
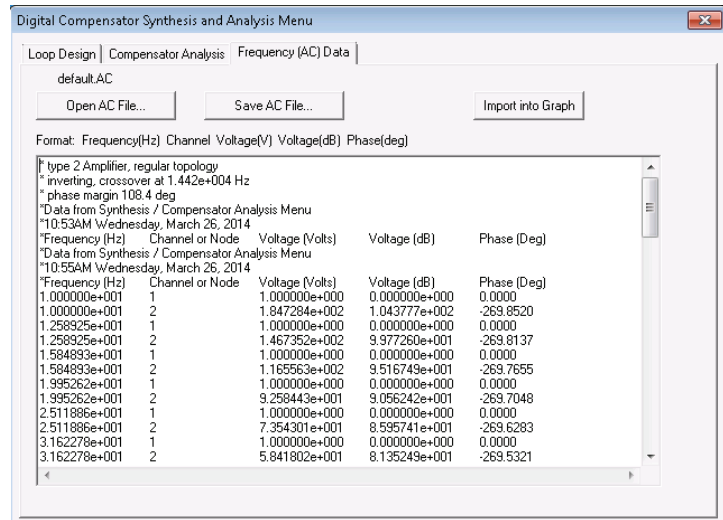
8. From the "Frequency (AC) Data" tab, click the "Import into Graph" button. If you have followed the steps up to here, a gain-phase graph of the modulator transfer function is already displayed and you will only see the second setup window asking you to confirm the output node, input node, and scale factor. Click OK to accept the default values of 2, 1, and 1.

9. After clicking OK, the setup menu will clear and you will see the graph with the compensator transfer function gain and phase superimposed on the original modulator transfer function.