Great Expectations Come From Basic Understandings

Q: What should I do when my circuit performance falls short of my design expectations?

A: A recent college graduate was surprised when the amplifier he selected failed to meet his circuit needs. He reviewed the datasheet plots and specification tables, and although his exact circuit performance curves were not there, he thought the data shown was “close enough,” so his circuit should work. Unfortunately, he didn’t understand the concept of *gain-bandwidth product* (GBWP).

While looking at the large-signal bandwidth plot, he noted that the gain curves only went up to 10, but because the front page of the datasheet specified much more bandwidth than he needed, he figured the amplifier would also work at a gain of 20. What he didn’t know was that front page of the datasheet showed the small-signal bandwidth (the response to a very small sine wave). What he really wanted to know was the large-signal bandwidth, as his application used a signal greater than 2 V p-p. Large-signal bandwidth is typically measured as the response to a 2 V p-p sine wave. Note that small-signal and large-signal bandwidths can differ by as much as 2× or more depending on supply voltages and test conditions, so beware.

If he had known that the GBWP is a fixed quantity for any voltage-feedback amplifier (this is not true for current-feedback amplifiers as they do not have an associated GBWP), he could have avoided his mistake. The GBWP can be determined from the open-loop gain plot found in a datasheet. Simply pick a point on the linear portion of the open-loop gain response after the –3 dB point, multiply the gain (in V/V, not dB) by the corresponding frequency, and you have the GBWP. You and also use the unity-gain crossover as the GBWP if there are no parasitic poles, but high-speed amplifiers tend to have parasitic poles close to the unity-gain crossover, so we tend to stay away from those when calculating the GBWP. Once the GBWP is calculated, the bandwidth for a given gain or the gain for a given frequency can be determined.

In this case, the solution was to select an amplifier with higher bandwidth, one that had enough GBWP to meet the circuit needs. The fundamentals, which seem so… fundamental, sometimes get overlooked and can cause many headaches. The good thing about a case like this is that it only takes one or two of these types of design faux pas to permanently etch the solution in your brain, never to be repeated again.