Application Note 1688

Author: Tamara Schmitz

Selecting Your First Op Amp

Selecting an op amp can be a daunting task, especially because a simple Google search won't get the job done. Most likely, you have designed your circuit using an ideal model and now you need to find an actual part to build your solution. There are many companies that provide amplifiers, and while I have my own loyalty, there are some practical reasons to choose a specific op amp from a particular company.

Sometimes it seems most comfortable to go with something familiar. Most every school uses a 741 op amp and many companies make an equivalent. Be aware that the design of the 741 was completed when supply voltages were large. It works well in a school setting where measuring gain, bandwidth, offsets and such can be made with the simplest of equipment at school lab benches (with offsets big enough to measure on that equipment). Caution, when some students tried to use it to drive a speaker, they found the output to be lacking in performance. Why would that happen? Doesn't the op amp provide whatever current is needed at the output? No, there are limitations. Different op amps have been designed to drive differing amounts of current. Some have been designed with different bandwidths in mind; others with different input bias currents. As you will see, there is a wide world of options and optimizations available beyond the op amps from lab class.

Where to Look

While there are a number of sources for op amps, I suggest choosing a company that provides helpful tools: a friendly website, parametric searches to ease your selection and simulation models for their parts. A friendly website may seem like a simple thing, but be sure to look for application block diagrams that are similar to your circuit. These block diagrams show you the typical structure of an application and, usually, which blocks this company provides.

Parametric searches are incredibly valuable, time-saving tools. They allow you to narrow your search of a company's parts and examine the differences between the remaining candidates. The better ones allow you to not only select the limits of each column, but also select which columns you wish to sort part by.

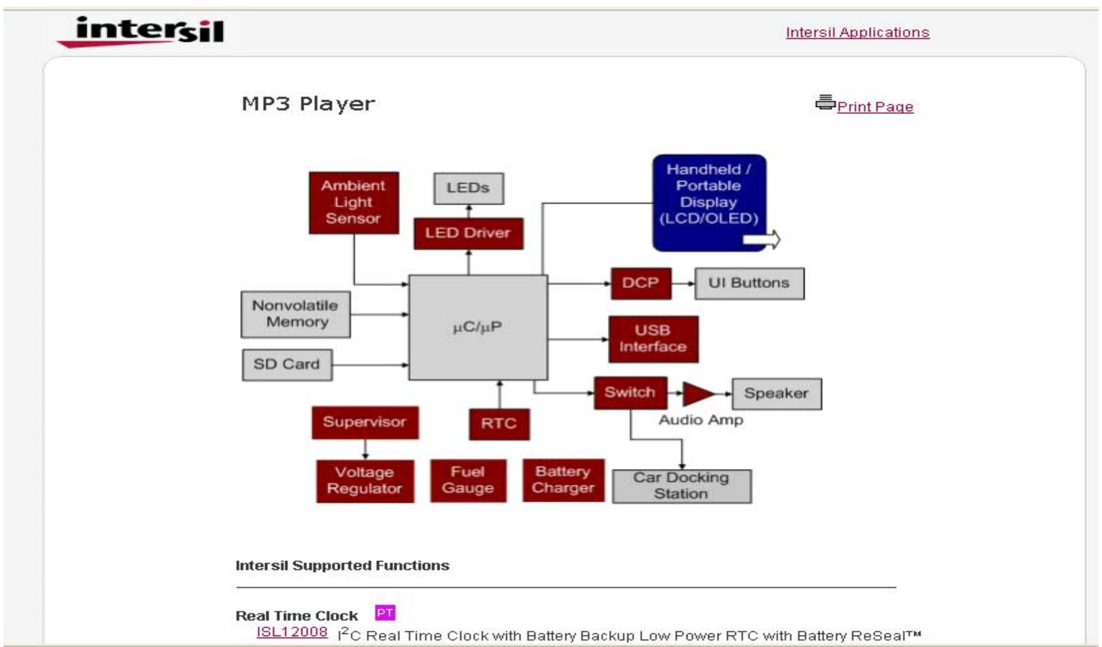

FIGURE 1. EXAMPLE APPLICATIONS BLOCK DIAGRAM OF AN MP3 PLAYER. INTERSIL SUPPORTS THE FUNCTIONS OF THE BOXES IN RED. SUGGESTED PARTS ARE LISTED BELOW THE BLOCK DIAGRAM

If you have simulated your op amp circuit, it will be a great advantage to return to that simulation with a model representing the part you intend to purchase. Many companies provide customers with simulation tools. These simulation tools vary greatly. Some are only available on-line while others are downloadable. Some are daunting to use with loads of options, yet that makes them more useful for advanced users. There are many other subtleties that make a more useful or less useful simulation tool. For example:

- Do they give a variety of application circuits?
- Do they set useful limits on the values of resistors, capacitors and inductors?
- Do they limit themselves to real values in their solutions?
- How easy is it to change a circuit value and resimulate?
- How fast does the simulator run?
- Do they provide any sort of useful report summarizing your work?

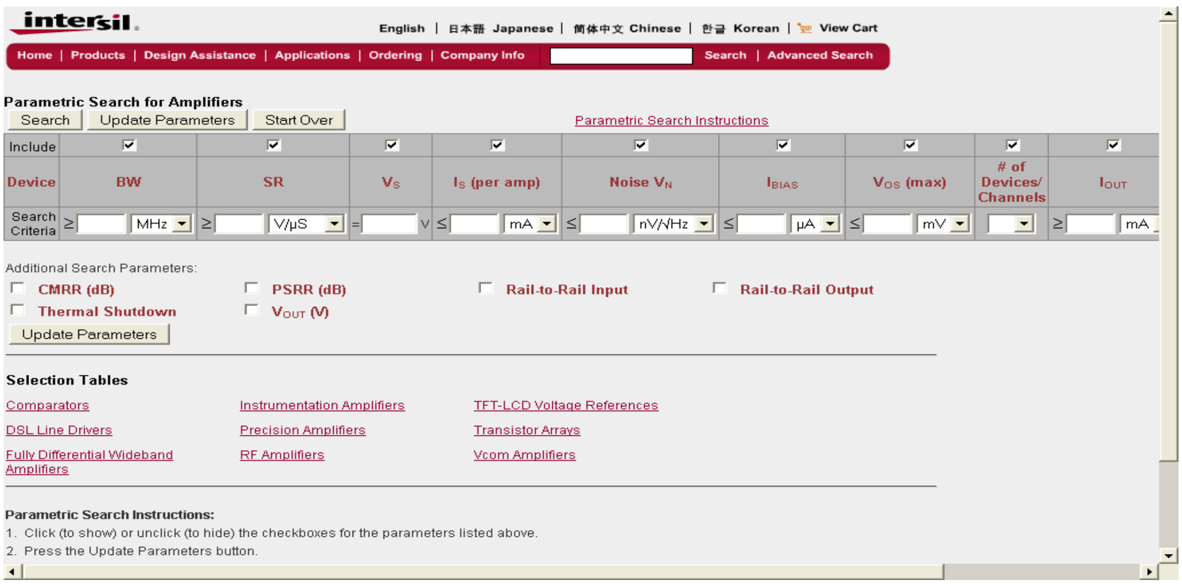

FIGURE 2. EXAMPLE OF PARAMETRIC SEARCH INTERFACE

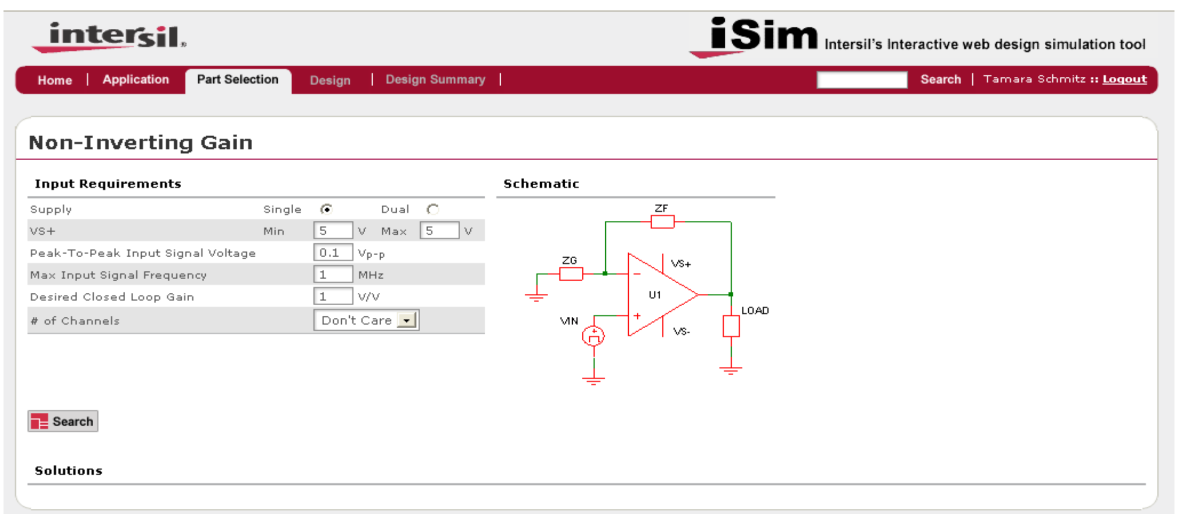

FIGURE 3. iSIM IS INTERSIL'S SIMULATION TOOL

A final consideration in choosing a company to patronize is accessibility. Do they contact information that is easy to find? Do they respond to customer requests in a timely manner? And do they provide samples of their product?

Diving into Datasheets

If you must start slogging through separate datasheets, it will help if you can identify a core set of parameters. My first suggestion is to identify whether or not you have dual or single supplies. Traditional operational amplifiers use dual supplies. In fact, in the ideal case, the supplies are positive infinite and negative infinite. On the other hand, single supply solutions are very practical. If you wanted a portable solution operating on a single battery, you will most likely have a single-supply system. (It is, of course, possible to create a virtual ground and use a dual supply.) Single-supply op amps are designed to operate with their negative supply pin connected to ground. It is noteworthy that op amps do not traditionally have a ground pin. Instead, their terminals are connected to references directly or through other devices. It is very convenient if that reference is ground, but it can be any voltage if the circuit is designed correctly.

My second suggestion is power supply range. The process in which an operational amplifier is made, as well as its circuit topology, will determine what power supply voltages can be used. The most typical supplies can be represented by ranges. The highest (and I'm assuming that you are not building a 480V circuit without knowing your parts well) range is typically 12V to 15V for industrial applications. There are a few hobby circuits at 9V because of the ease and simplicity of using the battery. The rise of digital circuitry made 5V circuits popular. Now, NiCad and Li ion batteries power a whole new set of systems from 3.3V down to a volt. Of course, op amps are available and optimized for each of these power levels.

It seems that everybody's favorite op amp parameter is gain-bandwidth product. In mid to high frequency circuits, it is, indeed, important. It would be a mistake, however, to assume that the op amp will function properly in your circuit. Make sure you take into consideration the load.

If a load is composed of a small resistor, it is considered to be a “heavy” load, since it takes a large amount of current to create the desired output voltage. Conversely, a large-value resistor requires a smaller amount of current and is considered a “light” load. (If this concept seems counter-intuitive, remember that a large-value resistor is closer to infinite than the small-value resistor. An infinitely-sized load would be the same as having no load at all.) The parameter for considering the output drive capability is slew rate.

Earlier I mentioned that a 741 op amp couldn't drive a speaker. Speakers have equivalent impedances of 4 or 8Ω. Let's choose 8Ω. If we wanted one watt out of a speaker, we would need:

Power (1 watt) = I2 * R

I = squareroot (P/R)

I = 0.35A !!

While some op amps are designed to handle high currents (greater than 100mA), many would melt under these conditions. Sadly, the 741 can only provide a maximum of 25mA through its output (that's only 7% of the current we wanted). So, you can choose to place 14 parts in parallel or choose a more appropriate op amp (this latter suggestion not only saves board space, but is probably cheaper in the long run). For instance, take a look at the ISL54000.

A final hint I have for the beginning op amp shopper is to pay attention to stability. Volumes have been written on the subject, so I can barely do it justice in one paragraph. Look for phrases like “gain of 2 stable”. That means this op amp is stable when configured in a gain of 2 or higher. It will not be stable in a unity-gain, or buffer, configuration. Lack of stability will cause the op amp to oscillate, most likely an unwanted new feature in your circuit.

While selecting the best op amp for your circuit can feel overwhelming, I've shared a few simple guidelines to help you forge your path. Follow your instincts, check Wikipedia and web searches. Remember, though, that these sources are fallible. Only the datasheet is a contract to the customer from a manufacturer about an op amp's performance.