ADIsimPower Provides Robust, Customizable DC-to-DC Converter Designs

By Matt Kessler

Introduction

Designers of dc-to-dc converters, both novice and expert alike, are faced with an overwhelming number of options for power management ICs. Finding the best combination of features, performance, integration level, and price can be difficult enough—and the actual design work can be daunting. ADIsimPower is designed to both simplify the IC selection process and to provide the information required to build an optimized dc-to-dc converter.

While most dc-to-dc selection guides simply direct users to switching regulators, switching controllers, and linear regulators that will work with a given set of inputs—without providing the means to quantify the trade-offs made in selecting one part over another—ADIsimPower allows designers to investigate power-conversion trade-offs and navigate design complexities. An intelligent selection guide combined with a comprehensive design assistant, this new tool provides robust designs that are optimized to the user’s exact inputs for size, efficiency, cost, parts count, or some combination thereof.

The ADIsimPower selection and design process comprises four steps: 1. Enter Your Design Criteria, 2. View All Design Solutions, 3. View Solution Details, and 4. Build Your Design. At the end of the experience, the goal is for ADIsimPower to provide a customized schematic, bill of materials (BOM) with vendor part numbers and prices, efficiency plots, performance specifications, closed-loop transfer function, and the means to rapidly build the design.

Enter Your Design Criteria

The first page of ADIsimPower includes user input fields for minimum input voltage, maximum input voltage, output voltage, output current, and maximum ambient temperature; bounds for each parameter are shown below the corresponding text box. After filling in the boxes, choose Find Solutions to find recommended solutions for this application.

Or, users who know which Analog Devices power management part they would like to use can select choose the IC. This will activate a pull-down menu that displays a list of currently supported power management ICs. After selecting one of these parts, the user will be taken directly to View Solution Details.

View All Design Solutions

The second stage of ADIsimPower helps the user to choose the best part for the design. At the top, the design inputs from the first stage are repeated for clarity. Below this, the Recommended Solutions suggests ICs and topologies for solutions yielding the lowest cost, smallest size, fewest parts, and highest efficiency. The recommendations are based on the entire dc-to-dc converter design, including the power management IC, inductors, capacitors, resistors, MOSFETs, and diodes.

Below the Recommended Solutions, a table quantifies to the first order the solution cost, size, efficiency, and component count for every IC that works, allowing users to see the design trade-offs without having to do individual designs with each part. Each column can be sorted to highlight the most important trade-offs. A feature list can be found at the right of the table. To expand or collapse this list, click on Show all features or Show default features. Clicking on the associated check box selects or deselects a feature. Select all the features that are required for the application. ICs that do not include the selected features will be removed from the table and from the recommended solutions.

After selecting the IC that best balances features, performance, integration level, and cost, click on the corresponding View Solution button. If this button is not active, comprehensive design support is not yet available on ADIsimPower. Click on the IC name to see the data sheet and other information. Click Download Design Tool to get an Excel-based design tool that can be run locally.

View Solution Details

In this stage, ADIsimPower generates and displays the complete design, including a customized schematic, a well-documented bill of materials, and estimates of operational parameters, power
dissipation, and maximum temperature. Switching converter designs also show plots of efficiency, loss, and, in some cases, the closed-loop transfer function.

At the top of the page, the original inputs are repeated for clarity; they can be updated if the design parameters have changed. Click on **Modify Advanced Settings**, which will open up a window allowing the user to modify many settings, including, but not limited to, accuracy, maximum component height, peak-to-peak output voltage ripple, input filter requirements, load transient response, inductor ripple current, and MOSFET vendor preference (a subset of these features may be shown depending upon the part selection). The ability to modify these settings is one way in which ADIsimPower differentiates itself from other dc-to-dc converter design tools. Though understandable enough to make novice power supply designers feel comfortable, the advanced settings are exactly the kind of parameters expert power supply designers expect to control in their designs.

The next section on the page has several tabs that specify various important design parameters. Once again, the information in these tabs will vary depending upon the chosen IC, but common tabs include **Operational Estimates**, **Dissipation Estimates**, and **Temperature Estimates**. All parameters are shown at both minimum and maximum input voltage. The **Operational Estimates** tab includes parameters such as PWM duty cycle, peak-to-peak output voltage ripple, and peak inductor current. The **Dissipation Estimates** tab shows the power dissipated in each high loss component. The **Temperature Estimates** tab shows the temperatures of each of the components associated with loss in the **Dissipation Estimates** tab. Power dissipation and temperature calculations assume worst-case values for many of the parameters that dictate power loss to ensure a robust design.

The following section shows the complete customized schematic, including reference designations and pin numbers.

Next on the page is the **Bill of Materials**. This may have several components that can be edited, as indicated by an orange item number. Click on the item number to see a list of other components that are prequalified to work in the design. The column headings will vary depending upon the type of component. Typical headings include Manufacturer, Part Number, Loss (W), Area (mm$^2$), Hgt (mm), Cost ($), and other specifications that characterize the part and how it will work in the circuit. These allow the user to continue to make performance-vs.-size-vs.-cost trade-offs to fully customize the design. Each of these columns can be sorted, which makes quantifying gains and losses associated with changing parts easier. If a new part is selected, ADIsimPower will redesign with the selected component, ensuring that all specifications are still met.

Below the Bill of Materials is the **Graphs** section, which may include plots of efficiency, loss, and the closed-loop transfer function (Bode plot)—all at both minimum and maximum input voltages. The efficiency and loss curves correspond to losses associated with worst-case values for many high loss parameters. This worst-case analysis is common throughout the ADIsimPower design process. The goal is to give the user confidence that the designs provided by the tool are robust across component tolerances, ambient temperature range, and other circuit variances. This tool provides far more than a basic solution.

At the top of each section in the **View Solution Details** stage are radial buttons for each design criterion (**Lowest cost, Part count, Efficiency**, and **Size**). Selecting a new radial button will completely redesign the circuit according to the new design criteria, nullifying all BOM changes previously made. When the final design has been determined, click on **Build This Solution**!

**Build Your Design**

The first item on this page is a picture of the appropriate evaluation board for the IC chosen in the previous stages. Links to order the evaluation board and IC are to the right of the evaluation board picture. Below it is the schematic that corresponds to the entire evaluation board. Note that the schematic in this section of the tool corresponds to the evaluation board, which usually accommodates many different configurations. Next to each component on the schematic are value and package designators that will be helpful while building the board. Many of these will be designated **No Pop**, as they are not required in this specific design. Below the schematic is the bill of materials, which once again applies to the evaluation board. Each component is listed, allowing it to be checked off as the board is populated. The schematic and bill of materials in this section may be considerably longer and more complicated than the schematic and bill of materials in the **View Your Solution** section, which would be more representative of the final design. Below the bill of materials are pictures of the top assembly, bottom assembly, and all PCB layers of the evaluation board. In short, this stage provides everything one needs to build the design created in ADIsimPower.
Links allow the user to download or email all information found in the *Build Your Design* and *View Solution Details* sections in a format similar to that seen while interacting with the tool on the Web.

**Parts Database**

The parts database that ADIsimPower uses includes more than 3000 unique part numbers, including inductors, MOSFETs, diodes, capacitors, and power-management ICs. Each of these part types naturally has parasitic elements that cause them to behave in a nonideal fashion; they must be considered in order to do robust power supply design. Although many of these parasitic elements are not fully characterized on their data sheets, the architects and implementers of ADIsimPower have worked with manufacturers of these components to procure this unpublished information. The nonideal behaviors taken into account in the tool include, but are not limited to, the following:

- **Capacitors**: change of capacitance with applied voltage \(\frac{dC}{dV}\), change of ESR with switching frequency \(\frac{dC}{dT}\).
- **Inductors**: core loss and skin-effect losses as a function of switching frequency.
- **Diodes**: change of forward voltage with forward current \(\frac{dV_f}{dI}\), change of forward voltage with temperature \(\frac{dV_f}{dT}\), change of parasitic capacitance with applied voltage \(\frac{dC}{dV}\).
- **MOSFETs**: change of \(R_{ds(on)}\) with temperature \(\frac{dR_{ds(on)}}{dT}\), change of \(R_{ds(on)}\) with applied gate-to-source voltage \(\frac{dR_{ds(on)}}{dV_{gs}}\), change of parasitic capacitance \(C_{oss}, C_{rss}, C_{iss}\) with applied voltage \(\frac{dC}{dV}\).

These are just the most general of the many nonideal component behaviors that designs produced by ADIsimPower take into account. The result is that both frequent and first-time users of ADIsimPower find the designs are robust and as close to production-ready as one could expect from any design tool.

**Conclusion**

ADIsimPower helps designers, both novice and expert, find the right IC for a dc-to-dc converter design by providing the means to find the best combination of features, performance, level of integration, and price point for their applications. The intelligent selection guide in the *View All Design Solutions* section allows the user to see trade-offs that could otherwise only be seen by doing the whole design for each part individually. The third section of the tool, *View Solution Details*, allows users to further hone the robust and well-documented design shown by editing components and adjusting advanced features. The final stage, *Build Your Solution*, provides all the necessary information to build the evaluation board to evaluate the design. ADIsimPower differentiates itself as a dc-to-dc voltage regulator design and selection tool by providing robust designs for switching controllers, switching regulators, and LDOs that are truly optimized for each unique application.

**References**


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