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JEDIS: The JMP Experimental Design Iterative Solver[1]

JEDIS is an add-in for the JMP statistical software program that helps automate the Design of Experiments (DOE) process within JMP in a user-friendly manner.[2] JEDIS builds multiple test designs in JMP over user-specified ranges of sample sizes, Signal-to-Noise Ratios (SNR), and alpha (1-confidence) levels. It then automatically calculates the statistical power to detect an effect due to each factor and any specified interactions for each design.[3]

When finished, JEDIS presents the statistical power vs. design metrics in interactive plots and stores the data in an easy to use format. JEDIS supports generating factorial and optimal designs, but does not currently support generating split-plot designs.

The JEDIS Light feature can compute power for a pre-made design table, including pre-made split-plot designs, over ranges of SNR and alpha levels.

This document explains the basics of how to use JEDIS.

TIP: You can download a copy of JEDIS from https://testscience.org/JEDIS.

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1 This effort was conducted under IDA Task no. BD-9-229982.

2 This document assumes the reader is familiar with using JMP to create and analyze DOEs. If not, see https://www.jmp.com/support/help/13-2/Design_of_Experiments_Guide.shtml for JMP DOE guidance.

3 See Section III Part 2a for a description of the alternative hypotheses for which JEDIS calculates power.

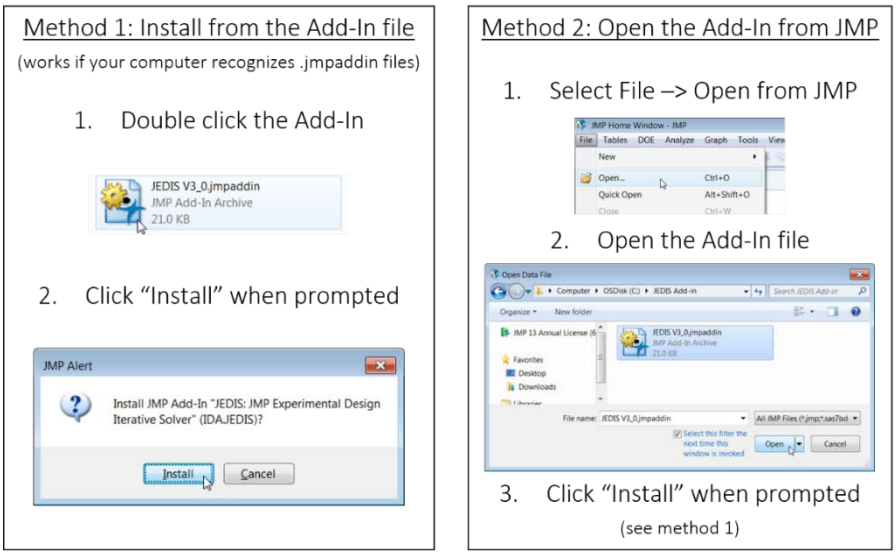
SECTION I – USING JEDIS

PART 1: Install JEDIS – Only necessary the first time you use JEDIS

JEDIS is distributed as a .jmpaddin file.

To install JEDIS in JMP:

- If your computer already associates .jmpaddin files with JMP, simply **double-click** on the JEDIS add-in file and then click Install when prompted.
- Otherwise, from within JMP, select File → Open, find and **open** the JEDIS add-in file, and then click Install when prompted.

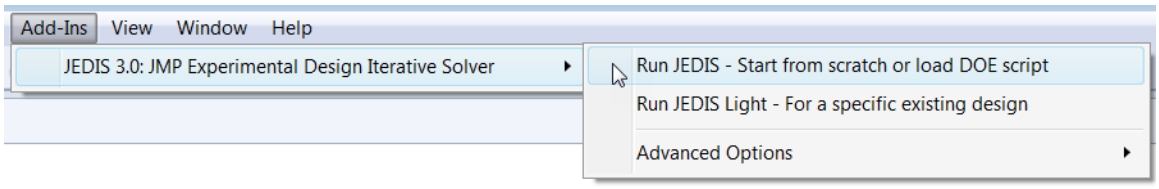


TIP: When you install JEDIS, JMP will save this documentation, default parameter files, button icons, and a copy of the GNU Lesser General Public License in your JMP/Addins folder. Modifying these files may cause JEDIS to crash. JMP will automatically remove them if you uninstall JEDIS.

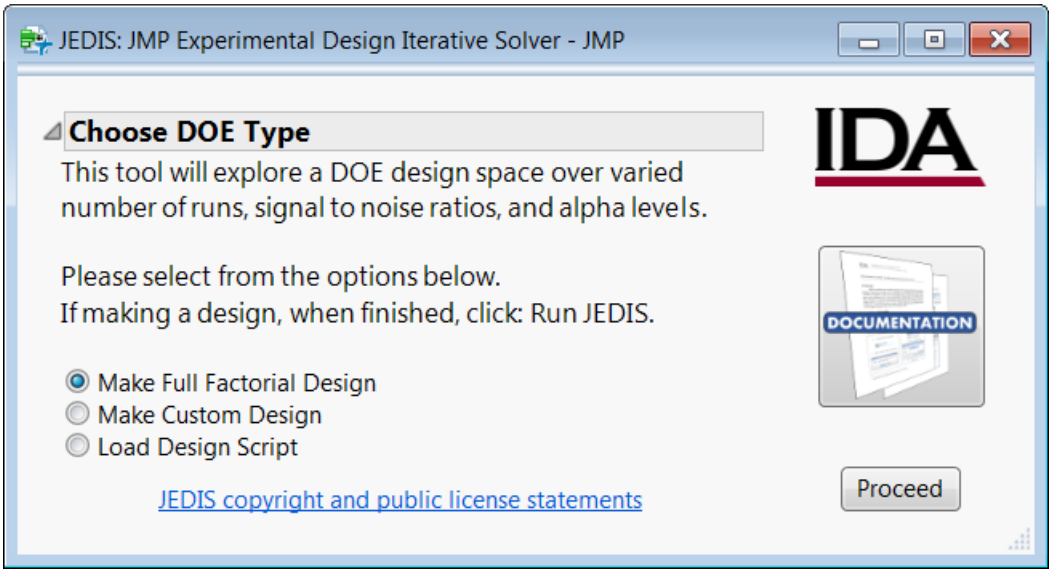
PART 2: Run JEDIS

After installation, JEDIS will be listed in the JMP **Add-Ins** drop-down menu.

To run JEDIS, select JEDIS from the list and then select Run JEDIS.

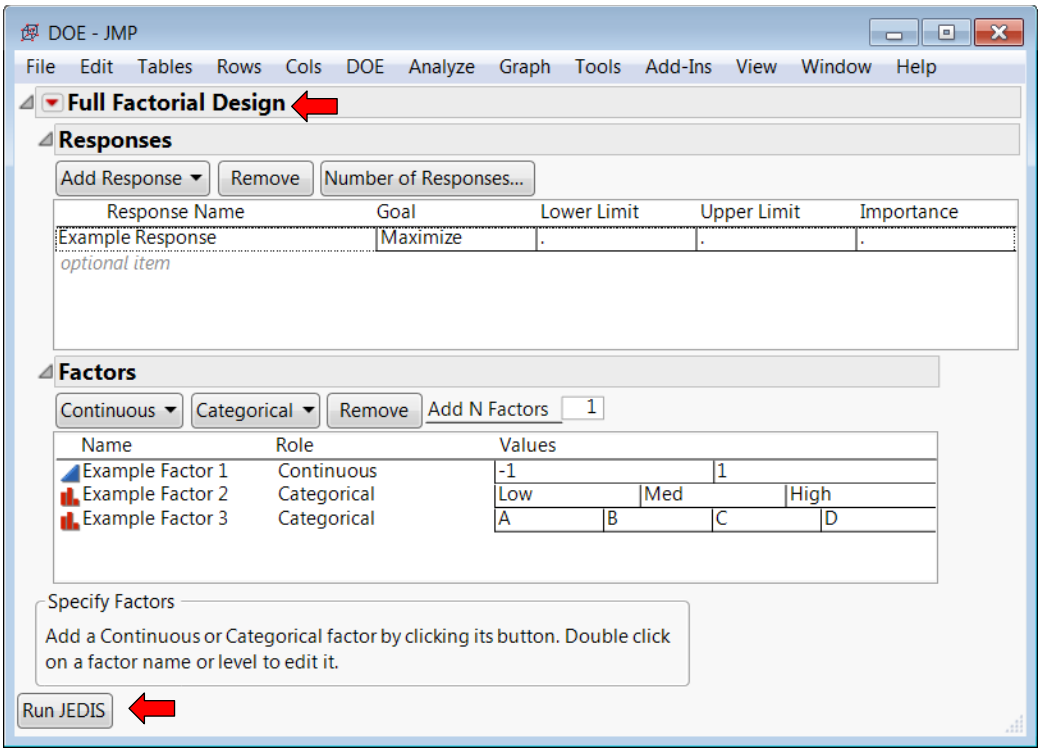


This will open the main menu of JEDIS, which has a choice of three options: 'Make Full Factorial Design', 'Make Custom Design', or 'Load Design Script'. This documentation is embedded on the right side in the main menu, should you want to open it again. You can also view the JEDIS copyright and public license statements by clicking the bottom link.



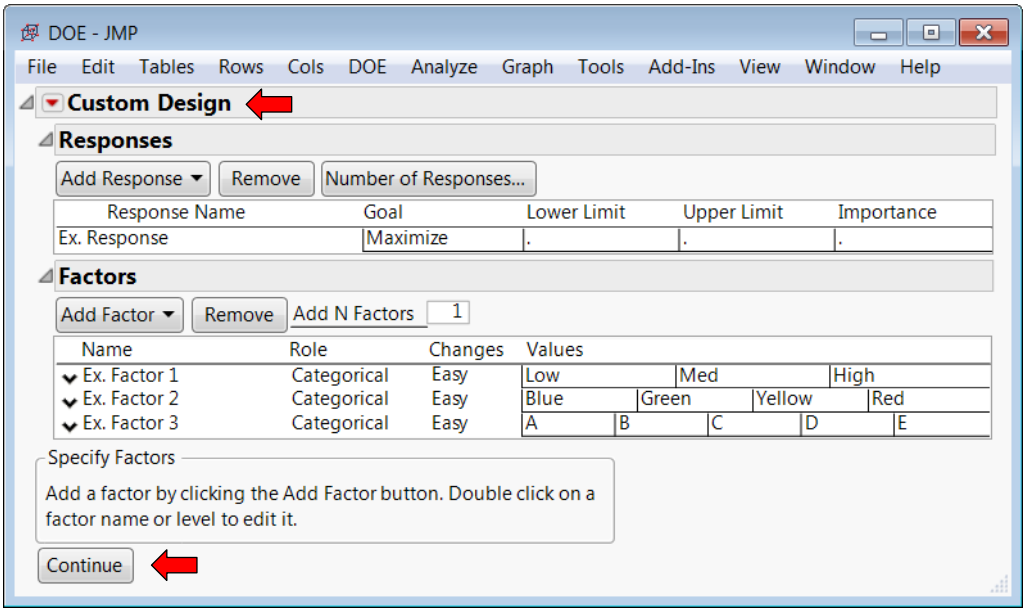
PART 2a: Make Full Factorial Design

Select Make Full Factorial Design and construct a DOE as normal in JMP, by adding the factors and levels appropriate for the design. Then click Run JEDIS.



PART 2b: Make Custom Design

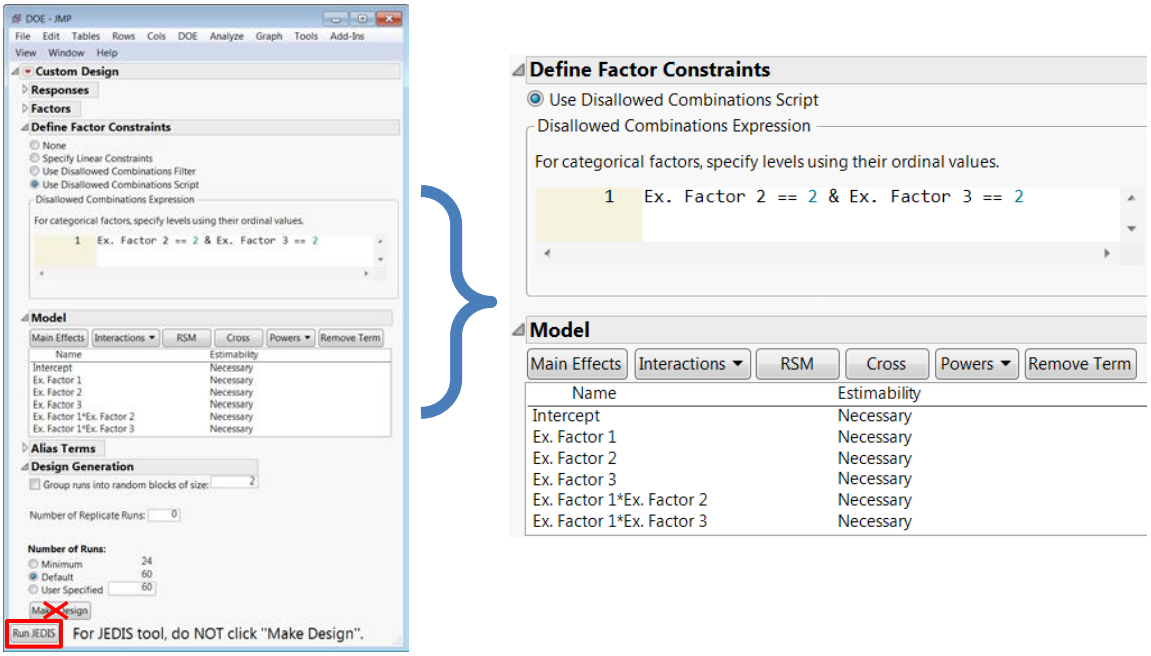
Select Make Custom Design and construct a custom DOE as normal in JMP, by adding the factors and levels appropriate for the design. Then click Continue.



TIP: JEDIS supports generating designs with Continuous, Discrete Numeric, Categorical, Blocking, Mixture, and Constant factors. JEDIS does not currently support generating designs with Covariate factors, Uncontrolled factors, or factors marked as 'Hard' or 'Very Hard' in the 'Changes' column (i.e., split-plot designs). JEDIS presents an error message if you include unsupported factors in your design. *Note: JEDIS Light supports evaluating pre-made split-plot designs (see Section II).*

On the second custom design screen, you can specify disallowed combinations of your factors and the terms in your model.

When you are finished specifying the design, click Run JEDIS.



TIP: Do NOT click the 'Make Design' button. Due to the nature of JMP programming, the 'Make Design' button cannot be removed from the Custom Design window. If you click it by mistake, simply click the 'Back' button and then click 'Run JEDIS'.

PART 2c: Load Design Script

Select Load Design Script to load a previously saved DOE script. For example:

```
DOE(
    Full Factorial Design,
    {Add Response( Maximize, "Example Response", ., ., . ),
    Add Factor( Continuous, -1, 1, "Example Factor 1", 0 ),
    Add Factor( Categorical, {"Low", "Med", "High"}, "Example Factor 2", 0 ),
    Add Factor( Categorical, {"A", "B", "C", "D"}, "Example Factor 3", 0 )}
);
```

TIP: To save a DOE script for later use, click the red downward triangle icon at the top of the DOE window, select Save Script to Script Window, and then click the save icon in the script window.

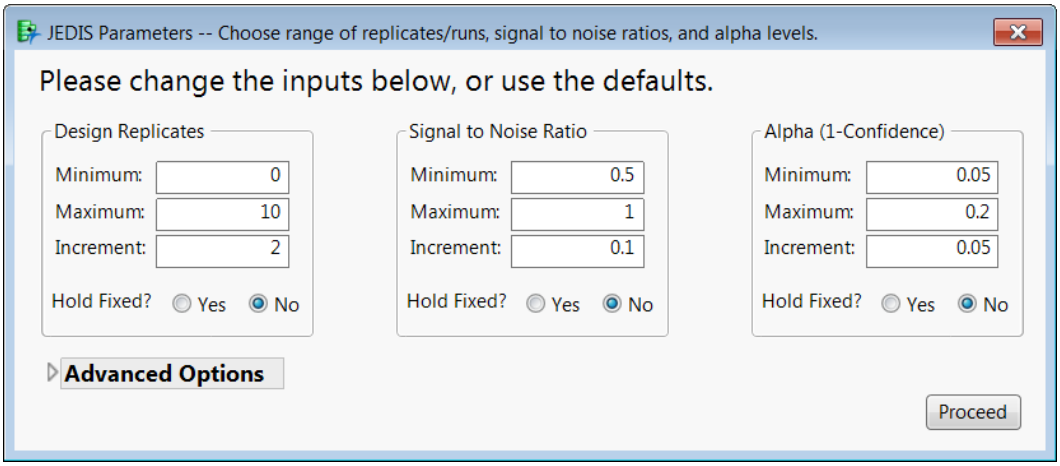
PART 3: Choose JEDIS Parameters

After making the design and clicking 'Run JEDIS', you will be presented with the JEDIS **Parameters** menu, which allows you to specify ranges for the number of design replicates (or runs),[4] SNR, and alpha.

Each variable can be held to a fixed value, instead of a range, with the 'Hold Fixed?' option.

Section III Part 2 discusses the 'Advanced Options' section of this menu.

When ready, click Proceed.



PART 4: Let JEDIS Run

JEDIS iterates through many different designs, which takes a varying amount of time[5] depending on the complexity of your factor space. Full factorial designs generally run very quickly, while custom designs can take longer amounts of time. SECTION III discusses ways to increase the speed of custom designs.

While JEDIS is running, it will print status messages to the JMP log, to keep you informed of its progress. For example:

```
"Welcome to JEDIS"
"This DOE has a custom design."
Current Iteration = "1 of 3";
Current Iteration = "2 of 3";
Current Iteration = "3 of 3";
```

[4] For full factorial designs, the JEDIS parameter window will ask for Design Replicates, while for Custom Designs, the JEDIS parameter window will ask for Number of Runs.

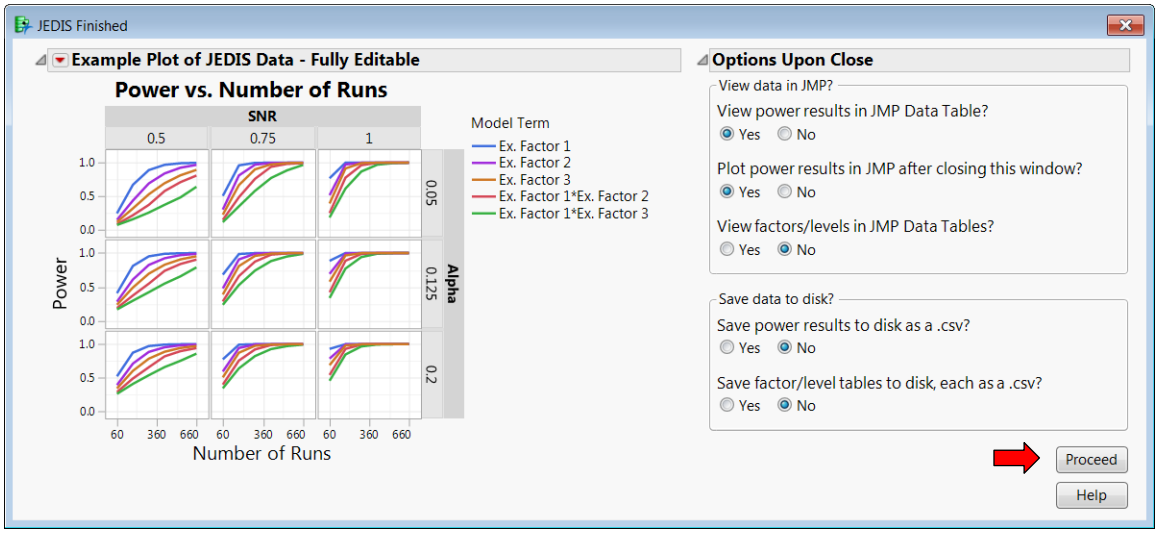
[5] The design replicate (or run) iterations is the primary variable that requires extra time for each iteration.

PART 5: View and Save the Results

When JEDIS has finished running, it presents your results,[6] as an editable plot, with a series of options for viewing the results in JMP and saving them to disk.

The options are:

THIS OPTION:	DOES THIS:
View power results in JMP Data Table?	Opens the power results in a JMP data table.
Plot power results in JMP after closing this window?	Recreates a larger version of the power plot in a separate window.
View factors/levels in JMP Data Tables?	Opens a factor/level table in JMP for each design iteration.
Save power results to disk as a .csv?	Allows you to pick a folder and filename to save the power results.
Save factor/level tables to disk, each as a .csv?	Allows you to pick a folder to save the factor/level tables.



When you have made your viewing/saving decisions, click Proceed.

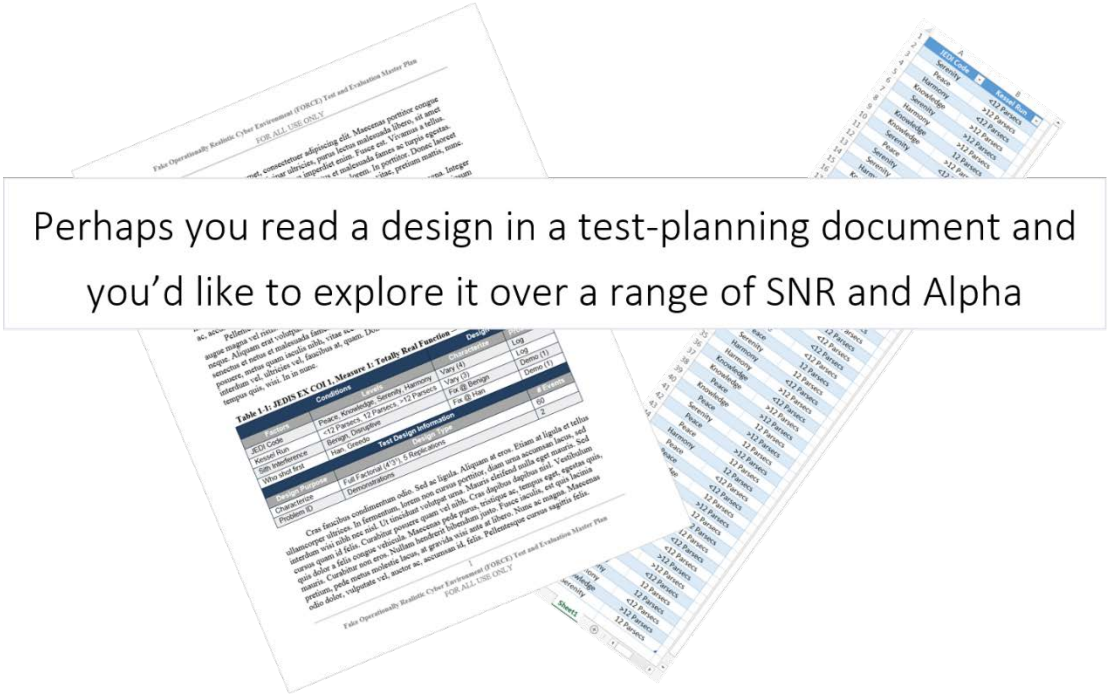
TIP: If you close the 'JEDIS Finished' window without clicking Proceed, or if you select all No responses, JEDIS will prompt you that you are about to delete your results and ask you to confirm.

[6] JMP automatically creates the 'Help' button on the 'JEDIS Finished' window and JEDIS cannot remove it. Clicking 'Help' will open a web page about plotting in JMP that is unrelated to JEDIS, but harmless.

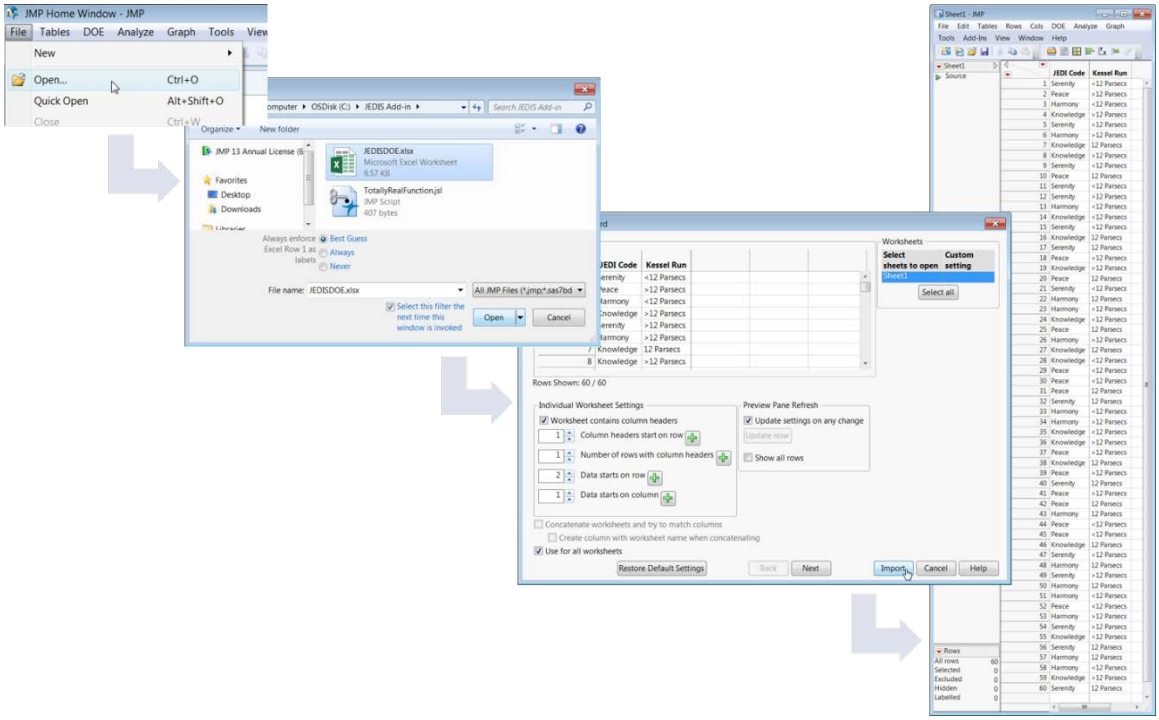
SECTION II – USING JEDIS LIGHT

PART 1: Open a Pre-made DOE Factor/Level Table in JMP

JEDIS Light is a tool for exploring pre-made designs over ranges of SNR and alpha.

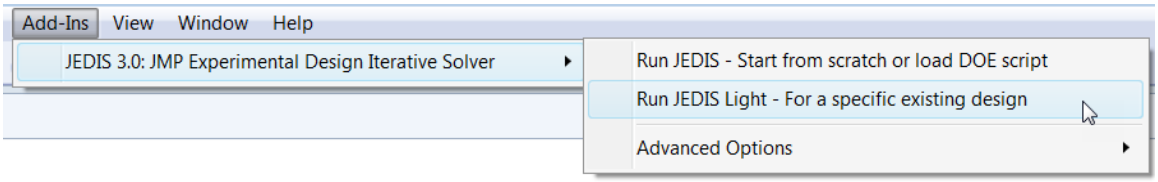


Before running JEDIS Light, you must read a design table into JMP (or have created one within JMP). You can open a design table by selecting File → Open, finding and opening the design table from the directory you saved it in, and clicking Import when prompted.

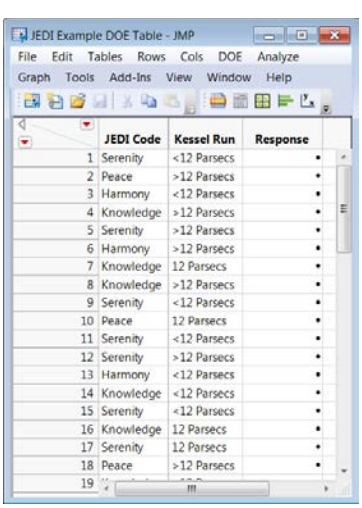


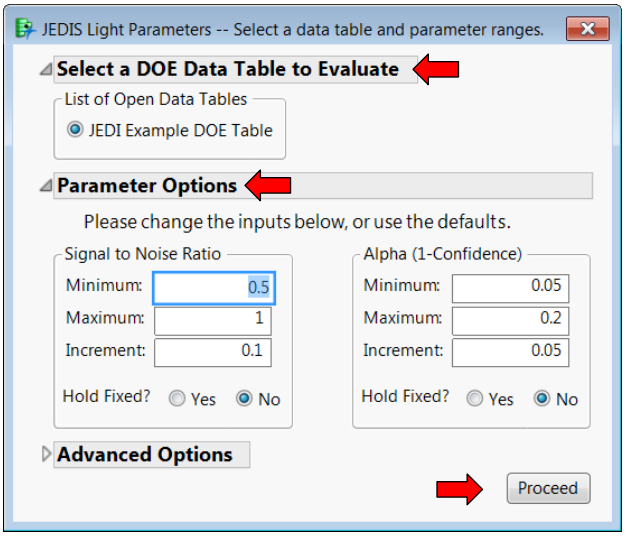
PART 2: Run JEDIS Light

Select JEDIS from the JMP Add-Ins list and then click Run JEDIS Light.



This will open the main menu of JEDIS Light, which has three sections: 'Select a DOE Data Table to Evaluate', 'Parameter Options', and 'Advanced Options'.





The 'Select a DOE Data Table to Evaluate' section asks you to select your data table from a list of all open data tables.

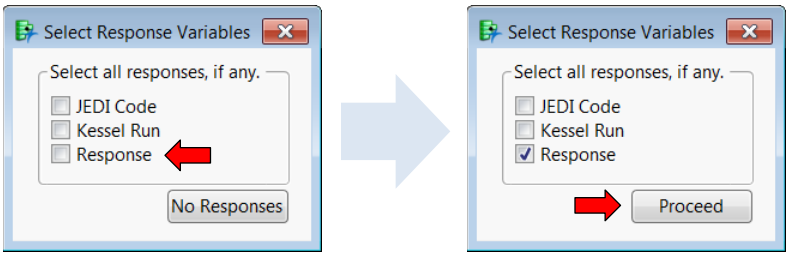
TIP: You must either open or create a DOE data table in JMP in order to run JEDIS Light. If you do not have any open data tables, JEDIS Light will not run, and will instead issue an error stating: *"You need a DOE data table to iterate over."*

TIP: If you are evaluating a split-plot design, your data table must include a 'Whole Plots' factor column (for 'Hard' to change factors), or both a 'Whole Plots' and a 'Subplots' factor column (for both 'Very Hard' and 'Hard' to change factors), as relevant.

The 'Parameter Options' section allows you to specify ranges for SNR and alpha. Each variable can be held to a fixed value, instead of a range, with the 'Hold Fixed?' option.

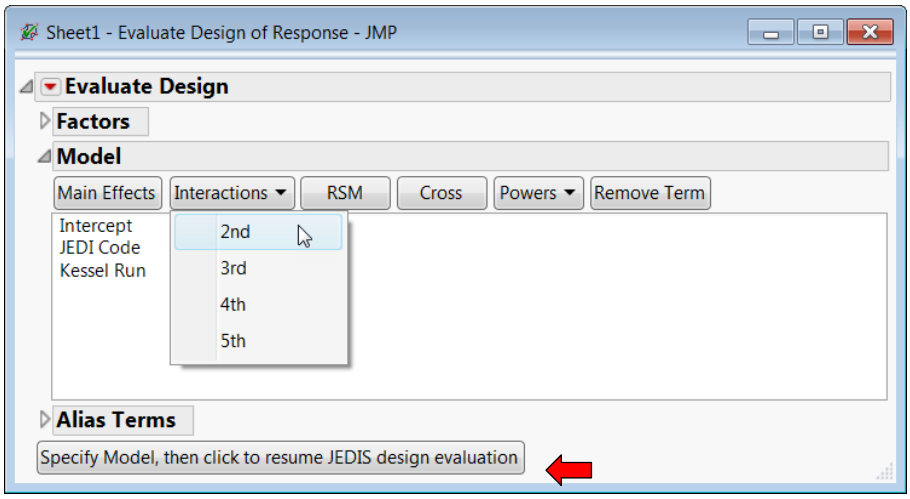
Section III Part 2 discusses the 'Advanced Options' section.

When ready, click Proceed. JEDIS will prompt you to identify response variables in your data table, if any. Do so, and then click No Responses or Proceed, as relevant.



PART 3: Specify the Model

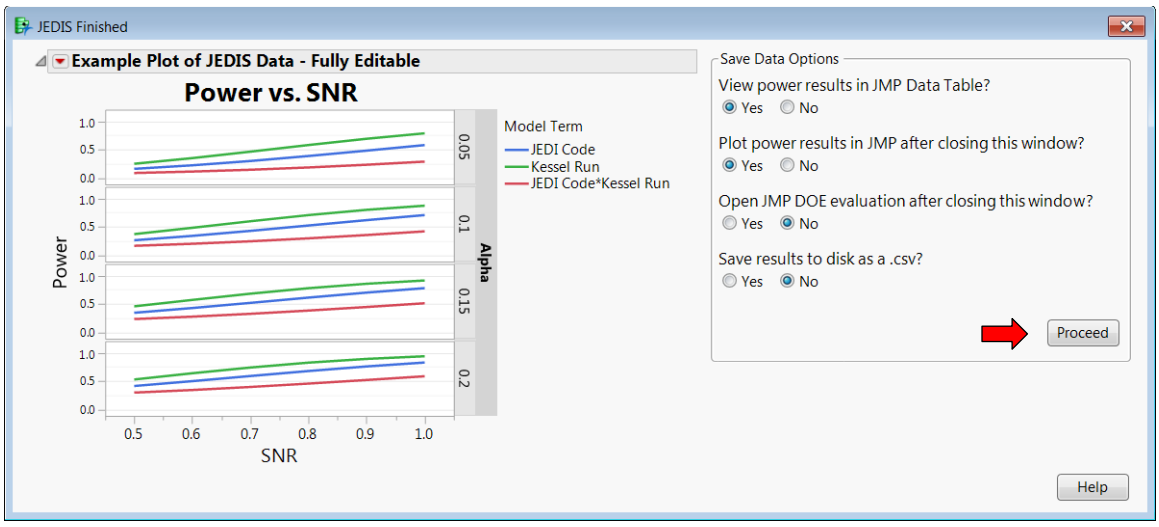
When using JEDIS Light with a design table that was loaded into JMP, the DOE model will be a main effects model by default.[7] JEDIS Light allows you to specify extra model terms (interactions, higher order powers, etc.) before evaluating your design.



When ready, click Specify Model, then click to resume JEDIS design evaluation.

PART 4: View and Save the Results

When JEDIS Light has finished running, it presents your results, as an editable plot, with a series of options for viewing the results in JMP and saving them to disk. The options are the same as in JEDIS (see Section I Part 5) except for *Open JMP DOE evaluation after closing this window?*, which will open the DOE evaluation function used to generate the JEDIS Light results, since JEDIS Light only uses a single DOE table (unlike JEDIS).



When you have made your viewing/saving decisions, click Proceed.

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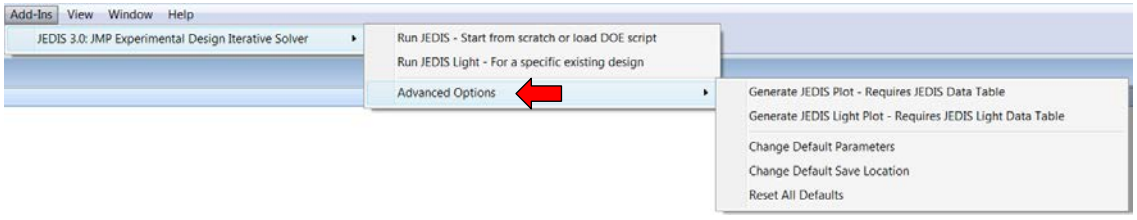
[7] Instead of loading a table from outside of JMP, you could also create a table for JEDIS Light within JMP. In this case, the evaluate design menu will inherit the model from the original DOE.

SECTION III – ADVANCED OPTIONS

PART 1: Advanced Options from JMP Add-Ins Drop-Down Menu

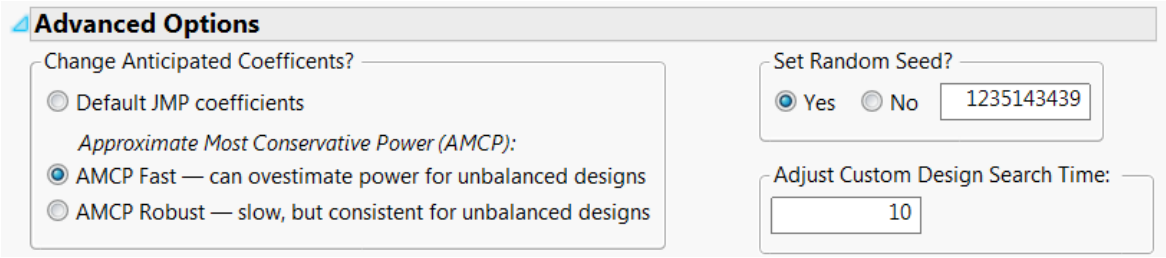
The 'Advanced Options' at the bottom of the JEDIS menu in the JMP Add-Ins list allow you to 1) generate the default JEDIS plot for a given JEDIS or JEDIS Light data table and 2) change/reset to default all of the default JEDIS parameters. The plotting options are useful if you originally chose not to generate the JEDIS plot, but changed your mind, or if you closed the original plot and want to recover it. The default parameters include ranges for design replicates, SNR, and alpha, and the custom design search time.



PART 2: Advanced Options from within JEDIS

The bottom of every JEDIS or JEDIS Light Parameters window has an 'Advanced Options' menu with three options. These display only when relevant:

- Change Anticipated Coefficients? – Displays for all JEDIS and JEDIS Light DOEs
- Set Random Seed? – Displays for JEDIS DOEs, but not for JEDIS Light
- Adjust Custom Design Search Time: – Only displays for JEDIS custom designs



PART 2a: Change Anticipated Coefficients

The 'Change Anticipated Coefficients' option allows you to select the alternative hypotheses with which JEDIS will test your DOE. This option exists because, for any DOE model containing terms with more than two levels, specifying the effect size does not uniquely determine an alternative hypothesis. In these cases, there exists a family of alternative hypotheses producing the same effect, but not necessarily the same power. The size of the effect of a factor or factor-interaction term is the largest difference between any two levels of that term.

By default, JMP's alternative hypothesis is that the levels of a factor or factor-interaction are all equal in magnitude (half the specified effect size) but alternate in sign, so the difference between any two levels is either the specified effect size or zero. This approach is a straightforward means to generating an alternative hypothesis of a specified

effect size, but it can result in an optimistic estimate of the power to distinguish between a factor's levels.

The Most Conservative Power (MCP) alternative hypothesis is the hypothesis that results in the least power for a specified effect size. A given design and model have an exact coefficient set that produce MCP,[8] but JMP and JEDIS do not have a method implemented to compute them.[9] Instead, JEDIS uses two Approximate MCP (AMCP) methods.

The first AMCP method, AMCP Fast, implements the method presented in Freeman et al.,[10,11] with a modification that doubles the coefficients for even powers of continuous factors.[12] This method provides a fast approximation for MCP, but it occasionally overestimates power for some terms, especially for unbalanced designs.

The second AMCP method, AMCP Robust, is a slower, iterative method of approximating MCP. AMCP Robust computes the power for every possible pair of coefficients for a given factor or interaction, with the other coefficients for that factor or interaction set to zero, and finds the pair with the lowest power for that factor or interaction. Because it is iterative, AMCP Robust takes longer for large designs, but it will always produce close estimates to MCP. AMCP Robust also doubles the coefficients for even powers of continuous factors.[12]

PART 2b: Set Random Seed

The 'Set Random Seed?' option allows you to specify the random seed used for DOE design generation, which is important for reproducibility of results. The random seed is generally only used when generating custom designs that are not replicates of the full factorial design, but it would also be used if the DOE requires any other random numbers.

PART 2c: Adjust Custom Design Search Time

By default, JMP will spend 10 seconds searching for an optimal solution to a custom design.[13] Most of the time, JMP needs far fewer than 10 seconds, but it will always spend the full amount of time you allocate it. The 'Adjust Custom Design Search Time:' option allows you to change the 10 seconds to something else. If you set the search time too low, your design will not converge. In that case, adjust the design search time until your designs converge, or until a reasonable about of time has passed.

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8 Thomas H. Johnson, Laura J. Freeman, Jim R. Simpson, & Colin E. Anderson: "Power Approximations for Generalized Linear Models using the Signal-to-Noise Transformation Method", February 2017.

9 A future version of JEDIS may implement the exact MCP method.

10 Laura J. Freeman, Thomas H. Johnson, & James R. Simpson: "Power Analysis Tutorial for Experimental Design Software", November 2014.

11 The AMCP Fast source code in JEDIS is based on code from AFOTEC's Conservative Power Tool JMP add-in, originally written by Susan Sorenson and Nicholas Garcia in HQ AFOTEC A2/9 March 2016.

12 By default, JMP underestimates the effect size for even powers of continuous factors, because it uses the same range of -1 to 1 for all factors. With the range of -1 to 1, an even power of a continuous factor can only take values from 0 to 1, so their effect size is halved. JEDIS corrects this in the AMCP methods by doubling the effect size of all even powers of continuous factors.

13 See https://www.jmp.com/support/help/13-2/Design_Search_Time.shtml for design search time details.