## Chapter 261

# Fractional Factorial Designs

## Introduction

This program generates two-level fractional-factorial designs of up to sixteen factors with blocking. Reports show the aliasing pattern that is used. The design rows may be output in standard or random order.

When generating a design, the program first checks to see if the design is among those listed on page 410 of Box and Hunter (1978). These designs are especially good. If the requested design is not listed in the above book, the design pattern is determined using the standard procedure in which the highest-order interactions are confounded first, and so on. The program makes certain that main effects are not aliased with each other.

An introduction to experimental design is presented in Chapter 83 on Two-Level Factorial Designs and will not be repeated here.

## Procedure Options

This section describes the options available in this procedure.

## Design Tab

This panel specifies the parameters that will be used to create the design values.

### Experimental Setup

#### Runs

The desired size (number of rows) of the experiment. This number must be a power of two. This number determines what fraction of a complete replicate is run. For example, suppose you are contemplating an experiment with seven factors and have budget for sixteen runs. A full replication would take $2^7 = 128$ runs. Hence, this design is a 1/8th rep (note that 16/128 = 1/8).

#### Block Size

The number of experiments (runs) per block. This determines the number of blocks. This number must be a power of 2 (2, 4, 8, 16, etc.). Of course, the block size must be less than or equal to one half the number of runs.

#### Sort Order

The order of the generated rows. The rows may be in random or standard order.

- **Random**

  The rows are randomly ordered (random blocks and random rows within blocks). Use this option when the order of application to experimental units is governed by the row number.

- **Standard**

  The rows are not randomly ordered. Instead, they are placed in standard order. Use this option when you want to quickly see the structure of the design.

### Factor Values

Each factor has two possible values (levels) which are specified here. These are the values that will be written to the database. The first value is used to represent the low value. The second value represents the high value. You may use both text and numeric values.

The number of variables created depends on how many of these boxes have values in them.

## Data Storage

### Store Data to the Dataset

Check this box to generate the design data on the dataset. The data stored to the dataset will be identical to the design data generated on the output window.

### Block Column

The column to contain the block identification numbers. The blocks are numbered from one to B, where B is the number of blocks. This variable is optional. If this option is left blank, no blocks will be generated.

### First Factor Column

This is where the group of columns that is to contain your design begins. The K-1 columns after this column are also filled with data. The number of columns used is determined by the number of Factor Values boxes that contain data.

Warning: The program fills these columns with data, so any previous data will be lost.

# Reports Tab

These options designate the columns to contain the design and the values that will be placed in those columns.

## Select Reports

### Design Info Report

Specifies whether to display this report.

### Aliases Report

Specifies whether to display this report.

## Report Options

### Aliases

One of the reports shows the confounding pattern among the columns of the design. However, when several factors are confounded, the number of terms aliased with each other gets huge. This option lets you limit the amount of information that the program displays.

# Example 1 – Fractional Factorial Design

This section presents an example of how to generate an experimental design using this program. **CAUTION: since the purpose of this routine is to generate data, any existing data will be replaced. For this reason, you should begin with an empty dataset.**

In this example, we will show you how to generate a six-factor design using sixteen runs separated in blocks of four runs each. You may follow along here by making the appropriate entries or load the completed template **Example 1** by clicking on Open Example Template from the File menu of the Fractional Factorial Designs window.

**1 Open a new (empty) dataset.**

- From the File menu of the NCSS Data window, select **New**.
- Click the **Ok** button.

**2 Open the Fractional Factorial Designs window.**

- Using the Analysis menu or the Procedure Navigator, find and select the **Fractional Factorial Designs** procedure.
- On the menus, select **File**, then **New Template**. This will fill the procedure with the default template.

**3 Specify the design parameters.**

- On the Fractional Factorial Designs window, select the **Design tab**.
- Select **16** in the **Runs** box.
- Select **4** in the **Block Size** box.
- Set **six of the Factor Values boxes** equal to **-1, 1**.
- Enter **1** in the **Block Variable** box.
- Enter **2** in the **First Factor Variable** box.

**4 Run the procedure.**

- From the Run menu, select **Run Procedure**. Alternatively, just click the green Run button.

## 1/4 Rep of a Six-Factor Design in Blocks of 4 Runs

| C1 | C2 | C3 | C4 | C5 | C6 | C7 |
|---|---|---|---|---|---|---|
| 1 | -1 | -1 | 1 | 1 | 1 | -1 |
| 1 | 1 | 1 | -1 | -1 | -1 | 1 |
| 1 | -1 | -1 | -1 | -1 | -1 | -1 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 2 | -1 | 1 | -1 | -1 | 1 | 1 |
| 2 | -1 | 1 | 1 | 1 | -1 | 1 |
| 2 | 1 | -1 | -1 | -1 | 1 | -1 |
| 2 | 1 | -1 | 1 | 1 | -1 | -1 |
| 3 | -1 | -1 | 1 | -1 | 1 | 1 |
| 3 | -1 | -1 | -1 | 1 | -1 | 1 |
| 3 | 1 | 1 | 1 | -1 | 1 | -1 |
| 3 | 1 | 1 | -1 | 1 | -1 | -1 |
| 4 | 1 | -1 | -1 | 1 | 1 | 1 |
| 4 | -1 | 1 | 1 | -1 | -1 | -1 |
| 4 | -1 | 1 | -1 | 1 | 1 | -1 |
| 4 | 1 | -1 | 1 | -1 | -1 | 1 |

Notice that C1 contains the four block indices, and variables C2 through C7 contain the generated design values.

Note that since we selected the *random* order, your data may not appear in the same order as this example.

You would now proceed with your experiment, obtain the response values, and analyze the data using one of the analysis of variance programs or the Two-Level Design - Analysis program.

## Design Information Section

**Design Information Section**

**Design:**
1/4 replication of 6 factors in 4 blocks of 4 experiments.

**Defining Contrast:**
i = ABCE = BCDF = ADEF

**Design Construction:**
Generate a reduced model of the factors [ A B C D ].
The remaining factors are aliased with interactions
of this reduced model as follows:
E = ABC
F = BCD

**Blocking Section**

**Block:**
Blocks were generated by confounding them with the
following interactions from the reduced model:
ABCD, CD

This report provides technical information about the design that was generated.

## Aliases Section

**One-Factor Aliases Section**

A+BCE+ABCDF+DEF
B+ACE+CDF+ABDEF
C+ABE+BDF+ACDEF
D+ABCDE+BCF+AEF
E+ABC+BCDEF+ADF
F+ABCEF+BCD+ADE

**Two-Factor Interaction Aliases Section**
AB+CE+ACDF+BDEF
AC+BE+ABDF+CDEF
AD+BCDE+ABCF+EF
AE+BC+ABCDEF+DF
AF+BCEF+ABCD+DE
BC+AE+DF+ABCDEF
BD+ACDE+CF+ABEF
BE+AC+CDEF+ABDF
BF+ACEF+CD+ABDE
CD+ABDE+BF+ACEF
CE+AB+BDEF+ACDF
CF+ABEF+BD+ACDE
DE+ABCD+BCEF+AF
DF+ABCDEF+BC+AE
EF+ABCF+BCDE+AD

This report lists the aliases of the main effects and low-order interactions. The number of aliases listed is controlled by the Aliases Shown option. This report provides technical information about the design that was generated.

From the first line of the report, we find that factor A (factor 1) is confounded with interactions BCE, DEF, and ABCDF. If any of the three-factor interactions are known to be real, this design would not be useful.

Note that no two-factor interactions (like AB or CD) are aliased with the main effects.