

## Chapter 262

# Balanced Incomplete Block Designs

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### Introduction

This module generates balanced incomplete block designs. Designs for up to ten treatments are available.

In order to make precise measurements of treatment means, uniform experimental conditions should be maintained when comparing a number of treatments. This insures that differences among the treatment means result from the application of the treatment and not from some extraneous factor. To achieve this, experimental trials are often grouped together into blocks. In such designs, conditions are kept constant within the blocks and allowed to vary between the blocks. The best known design of this type is the *randomized block* design. In this design, all treatments are present in each block.

Occasionally, the size of convenient blocks will not accommodate all the treatments of interest. For example, suppose you wanted to test four types of automobile tires for wear. An obvious choice for a block would be an automobile. You might select ten automobiles for the study. Assuming that the tires were rotated among the four positions, this experiment would control for differences in tire wear due to the type of automobile and the terrain that each traveled. However, what would you do if you wanted to test six types of tires. You could redesign the automobile, or you could adopt a *balanced incomplete block* design.

In a balanced incomplete block design, the treatments are assigned to the blocks so that every pair of treatments occurs together in a block the same number of times. This achieves the *balance* that is described in the title of the procedure. The balance means that all differences between treatments are measured with equal precision.

Following is an example of how four treatments are assigned to blocks with a natural size of three experimental units. Four blocks are required for this balanced incomplete block design.

<b>Block</b>	<b>Treatment</b>
1	A B C
2	A B D
3	A C D
4	B C D

Note that each treatment occurs three times in this experimental layout. Also note that each pair of treatments occurs twice. These are the basic properties of the balanced incomplete designs.

Box, Hunter, and Hunter (1978) point out the following rules when using such designs.

1. Randomly assign the numbers to the blocks.
2. Randomly assign the letters to the treatments.
3. Randomly assign the treatments within the blocks.
4. Randomly group blocks as replicates. A replicate is a complete set of all treatments.

If you take these steps, this design can be used effectively in those situations in which the block size and the number of treatments do not match.

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## Design Limits

These designs were taken from Cochran and Cox (1992). We have included designs with up to ten treatments. The following table shows what block sizes are available for each number of treatments.

<b><u>Number of Treatments</u></b>	<b><u>Block Sizes Available</u></b>
4	2, 3
5	2, 3, 4
6	2, 3, 4, 5
7	2, 3, 4, 6
8	2, 4, 7
9	2, 4, 5, 6, 8
10	2, 3, 4, 5, 6, 9

Note that some block sizes are not available for certain numbers of treatments.

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## Procedure Options

This section describes the options available in this procedure.

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### Design Tab

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

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### Experimental Setup

#### Block Size

This option contains the size of the blocks. That is, this is the number of experimental units that are contained in each block.

#### Treatment Values

The values used to represent the treatments are specified here. These values may be letters, digits, words, or numbers. The list is delimited by blanks or commas. The number of treatments is implied by the number of items in this list.

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### Data Storage

#### Store Data with the Dataset

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

#### Store First Factor In

The block identification numbers of each row of the design are stored in this column. The treatment identification numbers (or letters) are stored in the column immediately to the right.

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

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## Example 1 – Balanced Incomplete Block Design

This section presents an example of how to generate a balanced incomplete block design using this program.

**CAUTION: since the purpose of this routine is to generate (not analyze) data, you should always begin with an empty dataset.**

In this example, we will show you how to generate a design with four treatments in blocks of two experimental units 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 Balanced Incomplete Block 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 Balanced Incomplete Block Designs window.

- Using the Analysis menu or the Procedure Navigator, find and select the **Balanced Incomplete Block 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 Balanced Incomplete Block Designs window, select the **Design tab**.
- Set **Block Size** to **2**.
- Set **Treatment Values** to **1 2 3 4**.
- Check the box **Store Data with the Dataset**.

### 4 Run the procedure.

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

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## BIBD with Four Treatments in Blocks of Two

C1	C2
1	1
1	2
2	3
2	4
3	1
3	3
4	2
4	4
5	1
5	4
6	2
6	3

Two columns are filled with data. The first column, C1, contains the block identification number. The second column, C2, contains the treatment number.

We note that this design calls for six blocks of two experimental units each.

To use this design, you would follow the randomization rules discussed earlier to obtain your experimental layout. After running your experiment, you would place the response values in column 3 (C3) from your experiment. You would then analyze the data using the GLM procedure following the instructions for the randomized block design. You would specify blocks (C1) as Random and treatment (C2) as Fixed. The response variable would be C3. On the Model window of the GLM ANOVA procedure, you would set Which Model Terms to ‘Up to 1-Way.’ This forces the program to treat the block-by-treatment interaction as the error term.

## Balanced Incomplete Block Designs

## Analysis of Variance Table

### Expected Mean Squares Section

Source	DF	Term	Denominator	Expected
Term		Fixed?	Term	Mean Square
A (C1)	5	No	S(AB)	S+bsA
B (C2)	3	Yes	S(AB)	S+asB
S(AB)	3	No		S

Note: Expected Mean Squares are for the balanced cell-frequency case.

### Analysis of Variance Table

Source	DF	Sum of	Mean	F-Ratio	Prob	Power
Term		Squares	Square		Level	(Alpha=0.05)
A (C1)	5	489979.6	97995.91	0.41	0.820890	
B (C2)	3	132675.3	44225.08	0.18	0.900707	0.057179
S	3	719385.8	239795.3			
Total (Adjusted)	11	1256687				
Total	12					

\* Term significant at alpha = 0.05

Since you are using random numbers for the response, the values of the sum of squares, mean squares, and F-ratios will not match those displayed here. However, the number of degrees of freedom will match.

Also note that the Expected Mean Square values are generated for a complete model. Since the balanced incomplete model is not complete, these values are incorrect.