extendsim

EXTENDSIM DATABASE

TUTORIAL & REFERENCE

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Acknowledgments

Extend was created in 1987 by Bob Diamond; it was re-branded as ExtendSim in 2007.

The contents of this document are the result of years of work by software architects, simulation engineers, and technical writers and editors of ExtendSim products.

ANDRITZ Inc • 13560 Morris Road, Suite 1250 • Alpharetta, GA 30004 USA
770.640.2500 • Info.ExtendSim@Andritz.com
www.ExtendSim.com

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ExtendSim Database Tutorial & Reference

Introduction

Welcome!

Thank you for using ExtendSim, the power tool for simulation modeling! We hope you enjoy using ExtendSim and that you find this document helpful.

About this document

The ability to create and use an internal relational database is an essential feature when building complex or data-intensive models. To enable this, the ExtendSim relational database is provided in, and fully integrated with, all ExtendSim products.

The purpose of this document is to get ExtendSim modelers knowledgeable about and familiar with the ExtendSim Graphical Simulation Database.

⚠ This document assumes you already know how to launch ExtendSim and build a model. If not, see one of the Quick Start Guides—Continuous Process, Discrete Event, or Discrete Rate.

Who should read this document

The ExtendSim Graphical Simulation Database (GSDB) is included in all ExtendSim products and is the best method for managing model information. This document is for:

- **All model builders**. Whether you think you will use the ExtendSim database in your models or not, you should at least read this introductory chapter. While it is entirely possible to create models without using it, the ExtendSim database provides a robust foundation for building scalable models. So unless your models are particularly simple or data-sparse, you will find the GSDB indispensable.
- **Modelers who currently use the database**. There's always something new to learn (plus there's a section starting on page 92 that describes what's new since release 9.0).

☞ The ExtendSim database provides a foundation for building complex and scalable models.

Chapters in this reference

1) Introduction to databases (this chapter of the document):
    * Definitions
    * About the ExtendSim Graphical Simulation Database (GSDB)

    * Databases and spreadsheets
    * Where to get more information

2) Basic information: exploring an existing ExtendSim database
3) Tutorial 1: building a simple database and linking model elements to it
4) Tutorial 2: other aspects of using databases
5) Tutorial 3: reading/writing and importing/exporting database information
6) Reference: using ExtendSim databases and their components; what's new since 9.0

Introduction to databases

Databases provide a well-organized mechanism for data storage and management. They are indispensable for capturing, manipulating, and analyzing information.

Since simulation is typically used to model complex systems, most simulation modelers use internal relational databases to store and manage information needed for and generated by the model.

What is a database?

A database is a structured repository of information—a centralized collection of information that is organized for convenient access, rapid search and retrieval, and efficient updating. To facilitate the entry, storage, and retrieval of large quantities of information, databases have:

- Data definitions—the ability to create, modify, and remove the structures that define how the information is organized
- Update and management features—to enable the insertion, modification, and deletion of the actual information
- Retrieval features—so information is provided in a form that is directly available, usable, and accessible from multiple locations

☞ A database is used to store and report inputs, results, and everything in between.

How are databases configured?

In a database, information is organized into one or more tables consisting of columns (called "fields" in database lexicon) and rows ("records").

For instance, the database table named Example Data, shown at right, has 2 fields and 5 records.

Example Data 2[2]

	Month[1]	Rainfall[2]
1	0	2.60
2	1	4.40
3	2	6.70
4	3	3.40
5	4	1.90

Storing data in table format means that new information and even new categories of information can be added without the need for re-organizing the tables. This allows information to be accessed or reassembled in a number of different ways.

Relational databases

If a database is relational, the records in one field can be linked to the records in another field (even a field in another table), establishing a relationship on the basis of the interactions between them.

Due to their efficiency, ease of use, and ability to perform a variety of useful tasks, relational databases are the dominant type of database for high performance applications such as simulation applications.

Advantages of using a relational database for simulation

There are many advantages to using a relational database when simulating. For instance, to:

- Organize information in a logical fashion, either within one database or across several databases.
- Separate the data from the model for scalability and for better project and experiment management.
- Provide a globally accessible repository of data that can be quickly read from and written to during the simulation run.
- Gather, view, and manipulate data by product type, location, components, or any other common characteristic.
- Support decision-making during the simulation run, through the use of Link Alerts.
- Provide a centralized location for information that is used in several parts of a model, getting easier access to different sets of data depending on model needs.
- Reuse common sets of data from one model to the next.
- Import model inputs from, or export results to, external applications.

While using a database to manage data is indispensable for large models, the user interface makes it convenient to use an ExtendSim database even for small models.

The ExtendSim database

☞ ExtendSim products include the ability to create and use ExtendSim databases.

What is the ExtendSim database?

The ExtendSim database is a relational database specifically designed to meet the needs of simulation modelers. It allows multiple databases per model and (as discussed below) has many advanced features to facilitate the entry, storage, and retrieval of information.

ExtendSim databases aren't just repositories of data.

- They provide model *builders* with a systematic way to manage information for the model, import information to the model from existing data repositories, and export model results to other applications for presentation or further analysis.
- They provide model *users* with a centralized location for information that can be accessed for use throughout a model without needing to be concerned about how or where the information is stored.
- Most importantly, the ExtendSim database provides a robust foundation when building complex and scalable models.

In addition to being used by model builders and users, the developers of ExtendSim use the database to manage data for the Scenario Manager, Advanced Resource Management (ARM), and Reports Manager. It is also the basis for other ExtendSim offerings, such as the Smart Block feature that provides a list of potential blocks to connect to when you right-click on a block's connector.

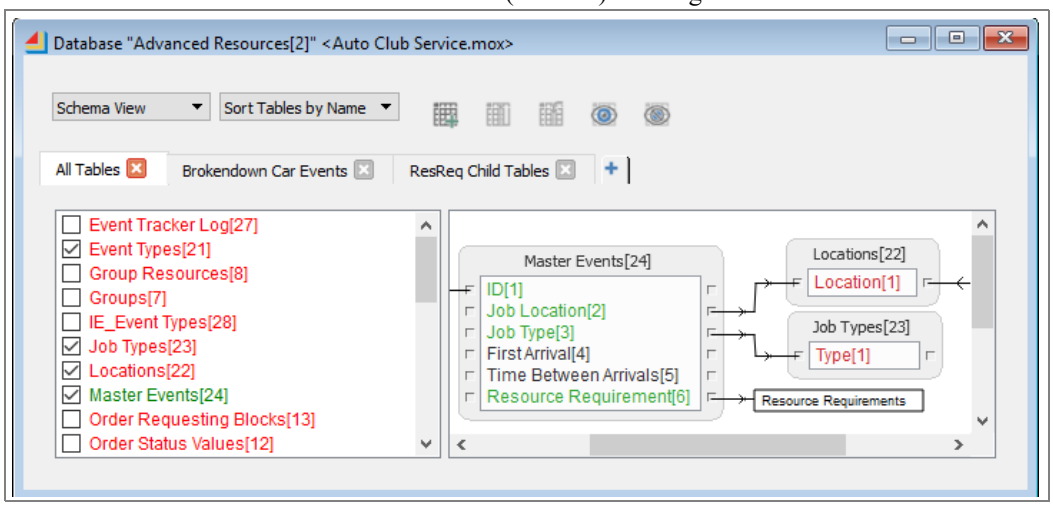
How is the database integrated with the model?

The ExtendSim database is fully integrated with the ExtendSim application. ExtendSim databases are saved as part of the model and interface with the model through:

- Dynamic data linking between block components and database tables
- Link Alerts, which automate the updating of information in real time
- Fast read and write during the simulation run

Example ExtendSim database

The screen shot below shows the structure (Schema) of a large ExtendSim database.



This database window is in Schema view. The database's tables are listed on the left and the structures for the selected tables, as well as parent (red) and child (green) relationships, are shown on the right. The components of an ExtendSim database are discussed fully in the next chapter.

ExtendSim database features

ExtendSim databases have several features that make them efficient and reliable components of simulation models, including:

Feature	Description	Advantage	Implementation in ExtendSim
Relational	A field can be linked to another field in the same table or to fields in another table.	Supports normalized database design and improves data integrity.	Parent/Child relations.
Components have a unique key	Every database, table, field, and record has an index. Cells have a DBAddress composed of those indexes.	Cells and other database components can be individually and separately addressed.	Read, Write, Data Import Export, and equation blocks can access information using the keys.

Feature	Description	Advantage	Implementation in ExtendSim
Linked	Parameters and data tables in ExtendSim models are easily linked to database cells and tables.	Blocks can access any information in a database; databases can access block data.	Dynamic Data Linking (DDL)
Name tracking	Automatically tracks database indexes and alerts model components if there is a change to a linked database component.	Model components point to the correct locations in the database even if structural changes have been made.	All blocks that interface with the database (Read, Write, Data Import Export, Equation, etc).
Integrated	The database is part of the ExtendSim application. Database structure and information is easily accessible and is saved with the model.	The database was developed specifically for use with simulation models. Read/Write access between the model and the database is fully supported. Database structure and information is retained with the model and can't be lost.	Simple access through the user interface (menu and right-click commands) or ExtendSim IDE (integrated development environment).
Automated real time updating of information	A model's linked parameters and data tables receive notifications whenever information changes in the database, and vice versa, even during the run.	As soon as the information at the source changes, the target is dynamically notified and can take the appropriate actions to react to the new value.	Link Alerts and the Link Alert block (Utilities library)
Scalable	Models can have 2 billion databases, 2 billion tables per database, 1,000 fields per table, and 2 billion records per table.	No imposed upper limit on the amount of information that can be stored or how complicated queries can be.	Database size is limited only by the computer's memory.
Resides in memory	Database structure and information are stored in memory.	Much faster response times and performance than using an external application.	Integrated with the application.
Querying	Searching the database and retrieval of specific information.	You can query for information during the run.	Query Equation blocks, equation-based blocks, and other blocks. Also through ExtendSim API which has many database-related functions.
Connectivity	Database information can be imported from and exported to external data sources including Excel workbooks, ODBC and ADO compatible databases, and FTP and text files.	Allows analysts who don't have ExtendSim to use Excel or other tools to configure the structure and contents of an ExtendSim database.	ExtendSim DB Add-In for Excel, Line Chart DB, Read/Write and Data Import Export blocks, and technologies such as OLE/COM, ODBC, ADO and more.

Using spreadsheets and databases

Spreadsheets are ubiquitous and most businesses use them extensively. They are easy to use, have many great features for displaying and analyzing information, and are extremely useful for simulation modeling.

While not as well known as spreadsheets, databases are ideal for storing large amounts of information that will be subject to the high-speed queries and changes that occur during a simulation run. Like spreadsheets, databases are very useful for simulation modeling.

☞ ExtendSim has extensive capabilities for interfacing with spreadsheets, as discussed in the User Reference. Also, it is common that a model would use both spreadsheets and databases.

When to use a database

Consider using a database for your model when:

- There is a lot of information, or the information is complex or messy.
- You want a centralized source of information for a model and reducing redundancy is important.
- Your model needs to have its information updated whenever the source information changes. Or vice versa, you want the database component to update whenever model information changes.
- The information would otherwise be stored in one very large spreadsheet or in multiple cross-referenced worksheets.

Where to get more information

The ExtendSim documentation, example models, and the video files and documents on the ExtendSim.com website provide comprehensive help.

User Reference

To learn about other ways that information is handled in ExtendSim, see the User Reference's chapter on Data Management. That chapter discusses a variety of standards-based options for managing and sharing information internally to ExtendSim and exchanging information between ExtendSim and other applications:

- Data import/export and read/write
- Global arrays and dynamic arrays
- Linked lists
- Standard communication technologies, such as ActiveX/COM/OLE, ODBC, ADO, DLLs and Shared Libraries, Mailslots, and FTP

Technical Reference

In most cases modelers will use the user interface to create ExtendSim databases and link model data with database information using ExtendSim blocks. However, the Technical Reference lists many functions that can be used to create, read, write, import, export, and delete databases and their components as well as programmatically establish links to the data.

Note that in addition to the programming interface and dialog editor, the ExtendSim integrated development environment (IDE) gives programmers access to sophisticated tools such as include files, a code editor, conditional compilation, a source code debugger, code completion, and external source code capabilities.

☞ To access these eBooks, see the Documents/ExtendSim/Documentation/folder or launch the books from the Getting Started "Quick Start" model that opens when ExtendSim launches. The User Reference and Technical Reference are also available if you select the Help menu when using ExtendSim.

Example models and videos show you how

ExtendSim includes numerous tutorial models as well as videos and example models that explain concepts discussed in the User Reference. For example models, see the Documents/ExtendSim/Examples folder. For videos, see the ExtendSim website.

ExtendSim Database Tutorial & Reference

Basics: Exploring a Database

Overview

This chapter discusses database terminology and describes database components while exploring an ExtendSim database.

Database basics

Before you open an ExtendSim database, it is helpful to understand the terminology.

Columns and rows/fields and records

While it is common in spreadsheets to refer to columns and rows, the equivalents in a database are called fields and records. The following table gives information on both of them from the perspective of how their data is organized.

In Data View mode§	Vertical Component§	Horizontal Component§
Spreadsheet§	Column§	Row§
Database§	Field§	Record§

Tables, fields, and records

As with all relational databases, an ExtendSim database is composed of tables which have fields, records, and cells.

- *Tables* represent one entity type (for example, customers, products, or processes). A table is the set of fields and records. Tables can be thought of as being similar to spreadsheet worksheets.
- Each *field* specifies an attribute or characteristic of that entity (for example, the last name of a customer, the shipping weight of a product, or a step in a process). Fields are named (First name, Last name, Company...). When looking at a table's Data view, fields are the vertical component, similar to columns in a spreadsheet.
- A *record* is the set of information that represents the single item (customer Sophia Lee at Oracle, 400 units of Widget A each weighing 1.5 pounds, a Lathing process that takes 3 minutes to setup...). Records have numbers rather than names. When looking at a table's Data

view, records are the horizontal component, similar to rows in a spreadsheet. (Records are also sometimes called *tuples*, but ExtendSim uses the more common term records.)

- *Cells* represent one piece of information about the item. Each cell is the intersection of one field and one record. And not to be confusing, but a cell in a database is the equivalent of what is called a field in a spreadsheet.

☞ Depending on the field type, a cell can hold numbers or strings, Boolean checkboxes (Yes or No), a DBAddress, or even a list of tables. So the word "information" can mean any of those.

Example

For example, a database might be composed of one or more of the following components:

Table	Fields	Records	Cells
Customers	First Name Last Name Company	1 to 10	Cells for the "First Name" field: Sofia, Noah, Zeynep, Benjamin, Seoyeon, Lucas, Louise, Bence, Junior, Olivia
Products	Product Name Shipping Weight (pounds) Inventory Level (units)	1 to 3	Cells for the "Shipping Weight" field: 1.5, 0.4, 3.9
Process steps	Step Setup Time (minutes) Operator	1 to 3	Cells for the "Step" field: Lathe, Drill, Press
Resources	Item Capacity (gallons) Pressurized?	1 to 2	Cells for the "Pressurized?" field: Yes, No

Exploring an ExtendSim database

This section uses a copy of the Reservoir 1 model to discuss databases and their components.

Open the example model

- Launch ExtendSim
- Open the **Reservoir 1** model located at Documents/ExtendSim/Examples/Tutorials/Continuous.

This model represents a reservoir that gets water from two sources during the year—rainfall and a stream.The estimated effect of rainfall on the reservoir's level is based on historical records. The stream's contribution to the reservoir level is determined by a random distribution with a minimum of 0 and a maximum of 1 inch of water per month.

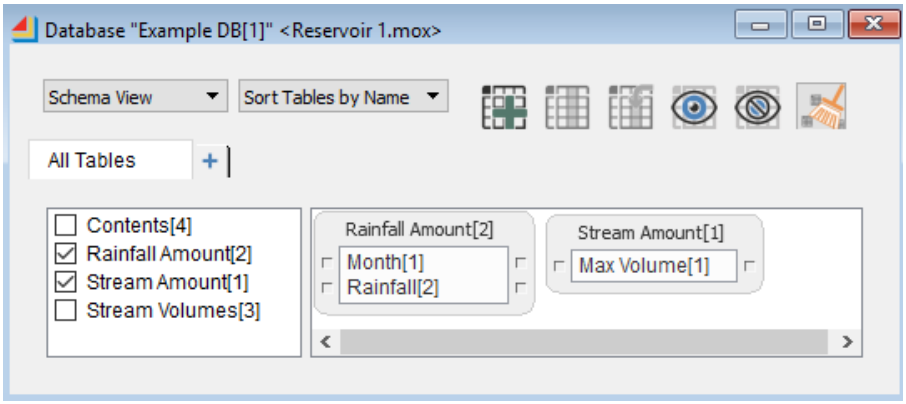
Open the model's database

- Go to the Database menu and, at the bottom of the menu, select the **Example DB** database

This opens the *database window*, shown below, for that database. By default, the window opens in *Schema* view.

The database window

The database window is where databases are created and configured.



A database window:

- Has in its title bar:
  - The word “Database” followed by the name of the database.
  - The database’s *index*, in this case “1”, in square brackets following its name.
  - The name of the model the database is attached to, in angle brackets.
- Provides a popup menu for viewing either the structure (Schema) of the database or its information (Data).
- Has a button for sorting database tables by name or by index number.
- Has toolbar buttons for performing common tasks, such as adding a table
- Has an All Tables tab and other tabs that display:
  - A list of tables on the left of the window (*Table List* pane)
  - The structure of the selected tables (showing their fields and relationships, if any) in a *Tables* pane on the right

By default, the *All Tables tab* is presented in front and lists all the tables in the database; other tabs can be added.

☞ Every database, table, field, and record has an index number (a unique key for identification) and each cell has a DBAddress that is the combination of those indexes. These are unique to that component sequence and are used for referring to databases and their components in equations or ModL code. More information is at “Indexes and data organization” on page 45.

Explore the Schema view

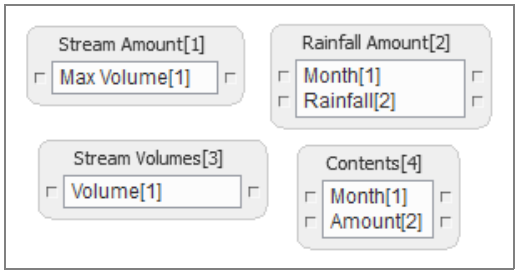
By default the database window opens in Schema view. This view shows the physical structure of a database, with all its tables and fields. It is also where parent/child relationships are established.

Toolbar buttons

Schema view has 6 buttons in its toolbar. They are used to add a table to the database, append or insert a field into a table, and show, hide, or reposition the tables in the Tables pane.

Tables

As seen in the All Tables tab, this database has four tables:



1) Stream Amount (with one field—Max Volume)
2) Rainfall Amount (with two fields—Month and Rainfall)
3) Stream Volumes (with one field—Volume)
4) Contents (with two fields—Month and Amount)

The numbers in brackets after the table and field names are their *indexes*. Tables can be sorted in the All Tables tab by index or by name.

Each field in a table has *connector points* on its left and right sides. As will be shown later, these are used to establish parent/child relationships between fields.

☞ Only tables that are checked in the Tables List pane will be shown in the Tables pane on the right.

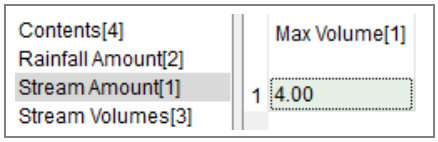
Explore the Data view

▸ In the database window, change the popup menu from Schema View to **Data View**

In Data view, the database window' shows the fields, records, and cells for the table selected on the left. This is also where you enter data for the table and can sort a table's data.

Stream Amount table

▸ In the Table List pane at the left, select the table named Stream Amount.



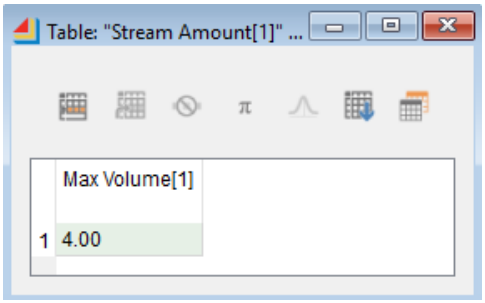
☞ If the font size is too small, use the *Zoom In* button in the ExtendSim toolbar to increase it. As long as *Auto Resize Column* is not selected, fields can be resized manually; this is discussed on page 58.

In Data view, selecting the Stream Amount table causes its field (Max Volume), record (1), and data (4.00) to be displayed in the *Data pane*, which is to the right of the Table List pane.

Toolbar buttons

Data view has 6 buttons in its toolbar. They are used to append or insert a record into a field, delete records, make a cell random or remove randomness, and sort data in the selected table.

Open and explore the Table Viewer



The Table Viewer is a separate window for each table, displaying the same information and toolbar buttons as shown in Data view mode of the database window.

☞ The Table Viewer is especially helpful when your model has multiple tables and you want to see the data view of each table separately, or see a table's data view at the same time as the database structure.

To open a table's Table Viewer, do one of the following:

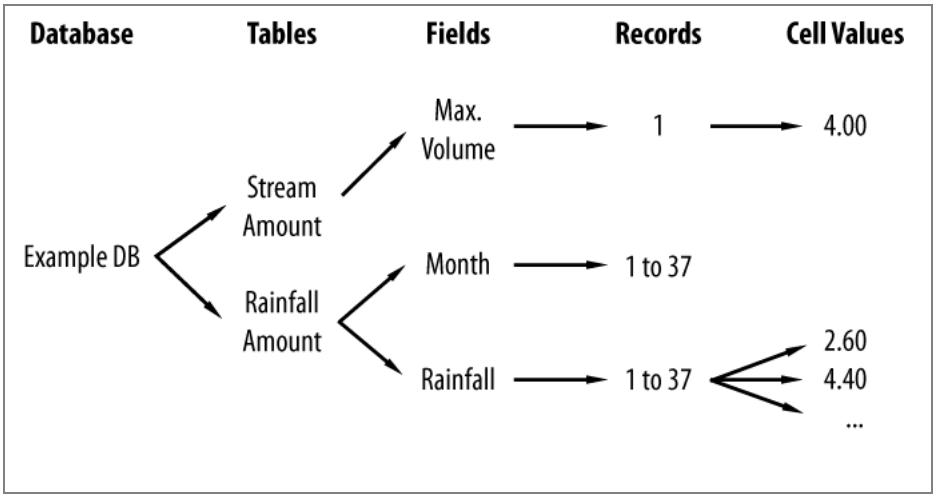
- Double-click the table's name in the list of tables
- Or, in Schema view, double-click the table's title bar in the Tables pane of the database window

Either method opens that table's Table Viewer, showing its fields (columns) and records (rows) with their data. You can have multiple Table Viewers open at the same time.

Toolbar buttons

The Table Viewer has the same toolbar buttons as the database window in Data view plus a button for opening the database window so you can see the Schema view separate from the table.

Summary

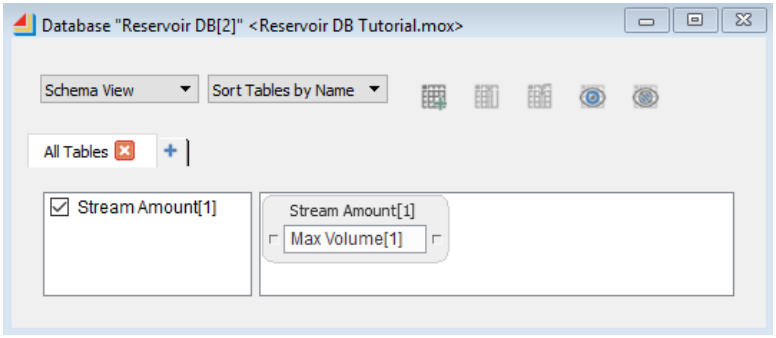


ExtendSim Database Tutorial & Reference

Tutorial 1: Creating a Database

Overview

This chapter shows how to use menu commands to build a simple ExtendSim database, shown below. The tutorial will also show how to dynamically link between the model and a database, by adding a two-way link between a model parameter and a database table and a one-way link between a block's data table and a database table..



The database built in this chapter will be similar to the one seen in the previous chapter, except it will have only one table.

A sample model

☞ The ExtendSim database feature is included in all ExtendSim products. Since every ExtendSim product has continuous modeling capabilities, this tutorial creates a database for a continuous model. And while a database is obviously unnecessary for the Reservoir model, the purpose of the example is to show how to create and use an internal relational database.

- Open the model **Reservoir 1** from the Documents/ExtendSim/Examples/Tutorials/Continuous folder.
- So that you don't overwrite the original file, **Save** the model as **Reservoir Tutorial**.

The reservoir model has two sources of water flowing into it: rainfall and a stream.

- The amount of rainfall is based on historic averages and varies with the month, as shown in the data table in the dialog of the block labeled Rainfall (a Lookup Table block).

- The block labeled Stream (a Random Number block) contributes an amount that is calculated using a Uniform Real random distribution, with a minimum of 0 inches per month and a maximum of 1 inch.

Through the tutorials you will link the maximum parameter in the Stream block and the data table in the Rainfall block to a cell and a table, respectively, in an ExtendSim database.

⚠ For expediency, this tutorial adds a database to an existing model. However, it is more common for a modeler to create the database before building the model. This is best practice because arranging database tables for the expected inputs and outputs helps with developing the model.

Create the database

The following example creates a database through the user interface—menu and right-click commands.

☞ As discussed on page 50 there are other ways to create a database but this is the most common.

Assumption

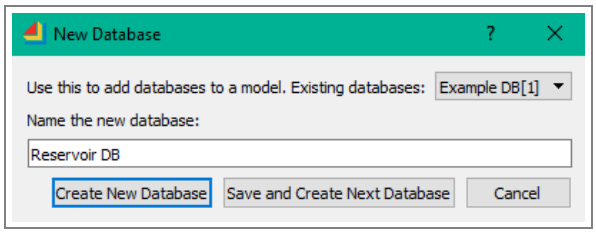
The database you create will have one table, one field, and one record, as shown below.

Database Name	Table Name	Field Names	# of Records	Links To
Reservoir DB	Stream Amount	Max Volume	1	"Maximum" parameter in the dialog of the Stream (Random Number) block

Create a new database and name it

- With the Reservoir Tutorial model worksheet active, choose the command Database > New Database.

The New Database dialog opens. As seen here, the model already has a database named *Example DB*.

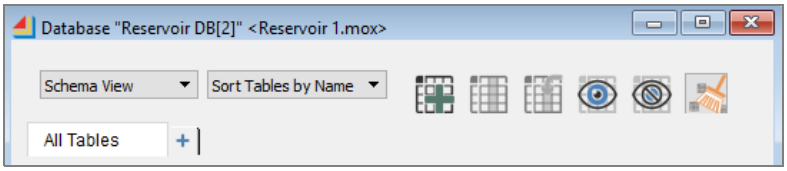


- However, you are creating a second database for this model. Name the new database **Reservoir DB**.
- Click **Create New Database**. This opens the database window for the Reservoir DB database.

☞ The database's name can be anything you want as long as it does not *start* with an underscore (_), is not used by another database in that model, and does not exceed 63 characters. Database names are not case sensitive and can contain spaces.

The database window

The database window is where you create database tables, add fields to the tables, and so forth. The window's title bar dis-



plays the name of the database and its associated model. The number 2 after the database's name indicates it was the second database added to this model.

The database window has two views, Schema and Data. By default, the window opens in Schema view, as shown here. The Schema view is the graphical depiction of the database's structure. This is where the database is logically configured with tables and fields and where relationships between fields are defined. The Data view is for adding and configuring records and data.

Save the model

- Save the model (you can leave the database window open)
- Notice that Reservoir DB is now listed at the bottom of the Database menu

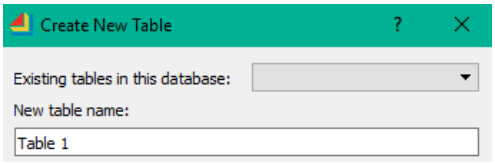
☞ Databases are stored with the model. Saving a model also saves the model's databases.

Add a table

Each table represents one entity type. In this case, the table will represent the maximum volume of water flowing in the stream.

Methods for adding a table

- With the database window active and in Schema view, create a database table using one of the following methods:
  - Give the command Database > New Table.
  - Or, right-click on the database window's Table pane (on the right) and choose New Table.
  - Or, click the New Table button in the database window's toolbar.



The Create New Table dialog opens with a popup list of existing tables (if any) and a field for naming the new table.

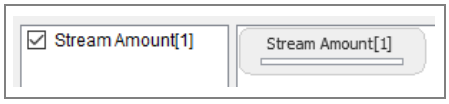
☞ If there are tables in the list of existing tables, you can select one of them and that name will appear as the *New table name*. Then append characters or otherwise change the name to create a unique name for your new table.

Name the table

This table will hold the maximum volume of water that the stream contributes to the reservoir.

- Name the table **Stream Amount**.
- Leave the options as is and click the **Create New Table** button. This closes the dialog and adds the table to the database.

The new table is placed in the All Tables tab of the database window. As shown here, *names* of the database's tables are listed in the *Table List pane* at the left and a physical view of the tables (the *database structure*) is shown in the *Tables pane* on the right.



Add a field to the table

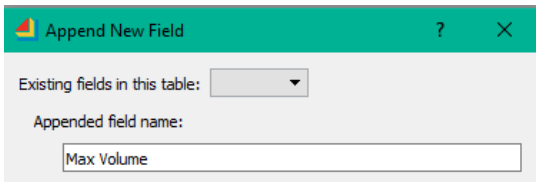
The next step is to add a field to the Stream Amount table. Fields are characteristics of the entity that the table represents; in this case, the maximum volume settings for the stream.

Methods for adding a field

- Create a field for the table using one of the following methods:
  - Select the table name (Stream Amount) in the Table List pane and give the command Database > *Append New Field*.
  - Or, right click the table's name and choose *Append New Field*.
  - Or, select the table's name and click the *Append New Field* button in the database's toolbar.

Name the field

In the Append New Field dialog (a portion of which is shown at right):



- Name the field **Max Volume**.
- Leave the default choices as they are.
- Since you only want one field, click the **Save Field** button to finish.

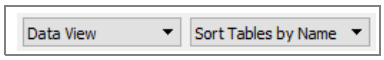
☞ Fields are formatted when created using the Append New Field or Insert New field dialogs. Their formatting can be changed using the Edit Field Properties dialog. See "Field Properties dialog" on page 61 for more information.

Add a record to the table

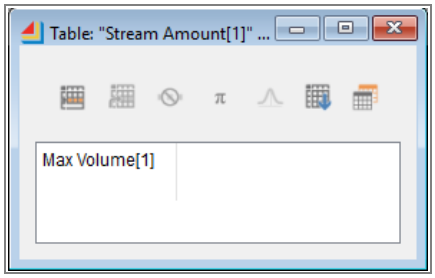
The record will hold the data for the maximum stream volume. Records are numbered, not named.

Where to add records

Records can be added to a database table either in the database window or by opening the table's Table Viewer:



- To use the database window to add a record, change its popup menu from Schema View to Data View.
- To use the *Table Viewer*, double-click the table's name (Stream Amount) in the Table List pane on the left or, in Schema view, double-click the table's title bar in the Tables pane on the right. The Table Viewer is shown at right.



Note that the Table Viewer has the same buttons as the database window in Data View plus an additional button for opening the database window in Schema View, so you can see the database structure along with the table structure.

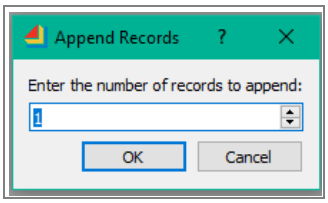
Change to the Data view to add a record

This tutorial adds records using the database window in Data View mode:

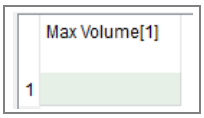
- In the database window's popup menu, change the database window from Schema to Data view.
- Select the table's name (Stream Amount) in the Table List pane on the left.

Methods for adding a record

- Create a record for the table using one of the following methods:
  - Right-click the field's name (Max Volume) and select Append New Record
  - Or, click the Append New Records button in the Data view's toolbar
  - Or, give the command Database > Append New Records
- Since you only want one record, in the Append Records dialog enter **1** for the number of records and click OK.



The field and record should look like the screen shot at the right.



Enter a value for the cell

In your Reservoir Tutorial model the dialog of the Stream block has a value of 1 as the maximum number of inches of monthly rainfall. For this tutorial, you will set the maximum to 4.

There is now one cell in the database, the intersection of the Max Volume field and record #1.

- Click on the cell and enter the number **4**.
- Close the database window and save the model to save your work.

☞ By default the values in cells are constants. While it wasn't done for this example, you can set a cell to use a random or empirical distribution. See "Set a database cell to use a random number" on page 25 for more information.

Dynamic data linking

Databases are used to store data for use in the model or to store model outputs before, after, and during a simulation run. A model can exchange information with a database by any of these methods:

- Dynamically linking a parameter or data table to the database
- Accessing database cells using specialized blocks (e.g. equation-based, Data Import Export, Read, or Write blocks)
- Through ModL programming.

☞ This section focuses on using dynamic data linking as a method for exchanging data. The other methods (e.g. data access and equation-based blocks) for exchanging information are discussed on page 45 and shown in Tutorial 2.

Dynamic data linking (DDL) is the proprietary method ExtendSim uses for creating live links between a model and an ExtendSim internal data structure. This application-level protocol tracks which dialog items (model parameters and data tables, including their clones) are linked to which internal data structures (ExtendSim database tables, global arrays, and dynamic arrays).

Dynamic data links are extremely powerful because they are live and bidirectional. This means that the value of a linked dialog item can change immediately when the value of the data source changes, and vice versa.

⚠ The same features that make dynamic linking so powerful mean it should be used judiciously. Avoid overloading models with dynamic links to data sources that get frequently updated; it could slow simulation performance as messages are sent to linked blocks every time their data source is modified. For alternatives such as using the Read, Write, and Data Import Export blocks, see "Read and Write blocks" on page 67.

Link a dialog parameter to a database table

Unless it is already linked for sensitivity analysis, a dialog parameter can be dynamically linked to a specific cell of an ExtendSim database. Parameter fields that are dynamically linked to a database are outlined in light blue.

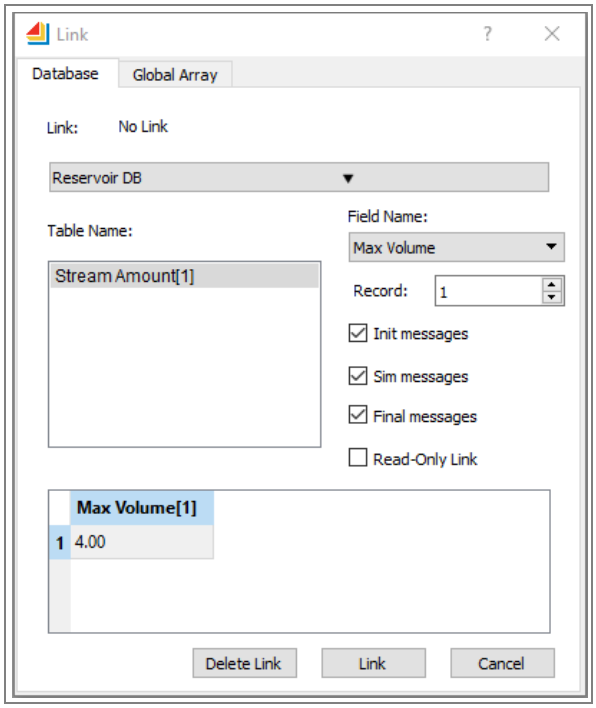
☞ Parameter fields are outlined in green for active sensitivity analysis and red for inactive sensitivity analysis; sensitivity analysis is discussed in the User Reference.

Overview

For this example, you will link the Maximum parameter from the Stream (Random Number) block's dialog to a cell in a database. This allows you to use the database, rather than the dialog parameter, to control the maximum amount of water coming from the stream.

Database Name	Table Name	Field Names	# of Records	Links To
Reservoir DB	Stream Amount	Max Volume	1	"Maximum" parameter in the dialog of the Stream (Random Number) block

Create the link



- In your Reservoir Tutorial model, open the dialog of the Random Number block (labeled Stream).
- Right-click in the *Maximum* parameter field (currently set to 1) and select **Create/Edit Dynamic Link**. (Note: don't select or left-click the parameter field first.)
- In the Link dialog that appears, select the **Database** tab at the top of the dialog, as shown at right.
- In the *Select a Database* popup, choose **Reservoir DB** (the database you created earlier) and click **Select Database**. This causes the table (Stream Amount), field (Max Volume), and record (#1) for that database to be displayed in the Link dialog.

☞ The Stream Amount table only has one field, Max Volume. If the database table had multiple fields, you would choose the field in the Field Name popup.

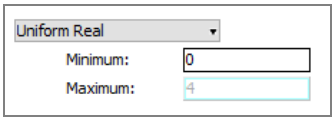
⚠ There are two databases in this model. Be sure to choose **Reservoir DB**, not Examples DB.

Configure the link

- In the Link dialog:
  - Leave the checkboxes as they are; they are explained at "Link dialog" on page 65.
  - Click the **Link** button; this establishes the dynamic link and closes the Link dialog.
- Save the model.

Results

In the dialog of the Random Number block (labeled Stream) the Maximum parameter will now be 4 and the parameter field will be outlined in light blue, indicating that it is linked to an internal data structure (ExtendSim database or global array).



Due to the ExtendSim link alerts (discussed on page 47), and since this is a two-way live link, the Maximum parameter field will get immediately updated every time a change is made in the database and vice versa. (To cause the database, but not the dialog, to have control over the parameter, you would choose Read-Only Link in the Link dialog, as discussed in "Configure and create the link" on page 22.)

☞ Hovering over a linked parameter displays the linking information.

Link a block's data table to a database table

⚠ Since you already know how to create a database and its components, this example uses a pre-built database named Example DB and its existing tables, rather than the Reservoir DB you built earlier.

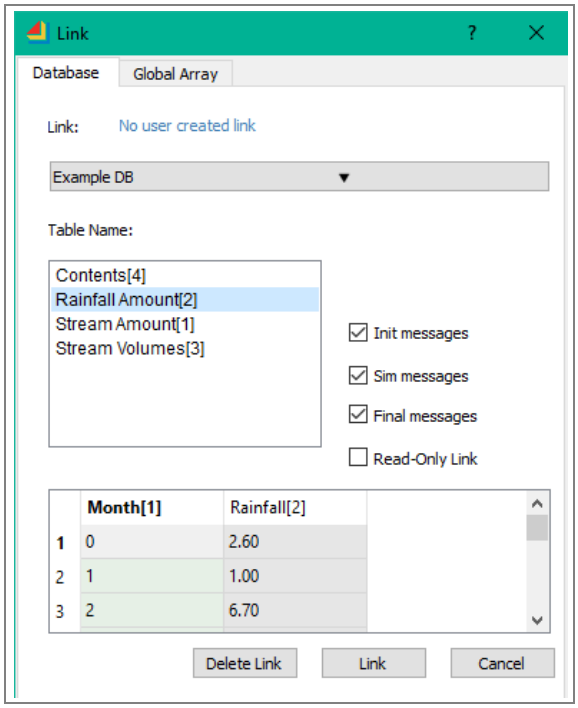
This section shows how to link from a block's data table to a database table. The data table contains monthly rainfall information covering a period of 3 years. The database table it will link to is in the database named "Example DB".

☞ This section focuses on dynamically linking between a block's data table and an ExtendSim database table. Tutorial 3 shows how the data in the database was obtained from Excel.

Database Name	Table Name	Field Names	# of Records	Links To
Example DB	Rainfall Amount	Month Rainfall	1-37	Data table in the dialog of the Rainfall (Lookup Table) block

Creating the link

- If the Reservoir Tutorial model you saved in the previous chapter isn't already open, open it.
- Open the dialog of the Lookup Table block labeled Rainfall.
- Click the *Link* button that is in the bottom left corner of the Months/Rain data table. A Link dialog appears, as shown here.
- In the Link dialog:
  - Select the *Database* tab at the top of the dialog
  - From the popup menu, choose the **Example DB** and click **Select Database**
  - From the list of table names, select the **Rainfall Amount** table as shown here



Configure and create the link

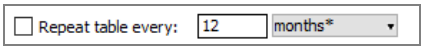
- In the Link dialog:
  - Check the "Read-only link" box. This configures the block's data table to be read-only, so that the value can only be changed through the database.
  - Leave the other checkboxes as they are; they are explained at "Link dialog" on page 65.
  - Click the *Link* button. This links the data table in the block's dialog to the database table named Rainfall Amount.

The dialog of the Lookup Table (Rainfall) block

In the dialog of the Lookup Table block (labeled Rainfall) the initials *DB* appear in a blue rectangle in the upper left corner of the data table. This indicates that the data table is linked to an ExtendSim database. Double-clicking those DB initials opens the database window in Data view, so you can see the database table's fields and records.

Since the database has three months worth of data, the data table it's linked to now also has three months of data. You want to be sure the Lookup Table block uses all the data from the database, and not just the first 12 values.

- Uncheck the box in the Lookup Table block's dialog that causes the table to repeat every 12 months



- Save the model to save your work.

Results

Due to the ExtendSim link alerts (discussed on page 47), the block's data table will get updated every time a change is made in the database. Since it is set to be Read-Only, the block's data table cannot be changed through the dialog; it can only be changed through the database.

⚠ Because dialog data tables are zero-based, but databases are one-based, a data table's cell at row 0, column 0 (the top, leftmost cell) is linked to the database table cell at field 1, record 1 (the top, leftmost cell).

Change a link to point to a different database table

In the previous section you linked the Maximum parameter from the Stream (Random Number) block's dialog to a table in the Reservoir DB database. There are times when you might want to change a link so that a parameter or data table exchanges data with a different table in the same database or even a table in a different database.

This section shows how to change a parameter link so that it goes to a table in different database—Example DB.

☞ A model can't have two databases with exactly the same name. However, as seen in this example, one database's tables, fields, and records can have the same names as are used by a different database.

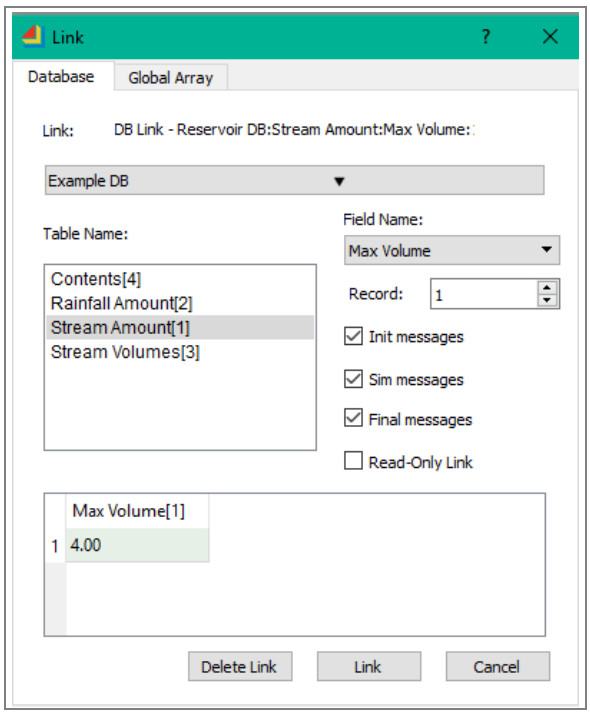
Database Name	Table Name	Field Names	# of Records	Links To
Example DB	Stream Amount	Max Volume	1	"Maximum" parameter in the dialog of the Stream (Random Number) block

- If your **Reservoir Tutorial** model isn't already open, open it.
- Open the dialog of the block labeled Stream. As indicated by its blue border, the parameter field for Maximum is already linked to a database table.
- Right-click in the Maximum parameter field (or go to the Model menu) and select **Create/Edit Dynamic Link**.

- In the Link dialog that appears, change the selected database from Reservoir DB to **Example DB**, then click *Select Database*.
- From the list of Table Names, select the **Stream Amount** table.
- In the box at the bottom, select the **Max Volume** field and click *Link*.
- Save the model to save your changes.

This changes the link from the Max Volume field in the Reservoir DB database to the Max Volume field in the Example DB database.

☞ Similarly, to change a linked data table, click its Link button to open the Link dialog and select a new database table.



ExtendSim Database Tutorial & Reference

Tutorial 2: Enhancing Your Database

Overview

This chapter shows how to do more with an ExtendSim database, such as assign random values to a cell, create a parent/child relationship, and use the DB Line Chart block. It also mentions blocks that are helpful when using the ExtendSim database.

Set a database cell to use a random number

A field's cells take on the formatting assigned to the field through the New Field or Field Properties dialog. While the numbers in the cells are constants by default, individual cells can be customized to use random distributions.

For simplicity, and so you don't have to build new database tables, this example uses an existing database (Example DB) and its components.

Database Name	Table Name	Field Name	Record #
Example DB	Rainfall Amount	Rainfall	2

Formatting cells

The tutorial titled "Create the database" on page 16 showed how to create a field using the default format options in the New Field dialog. That dialog's options, discussed more on page 61, allow you to specify a field type, set the number of decimals to display, and more.

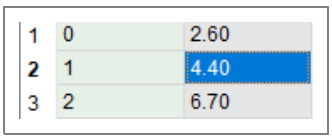
Whichever options are selected for the field are also assigned to its cells. And by default, all the cells for a field are formatted as constants. Instead of a constant value, you might want a cell's value to be a random number.

Making a cell random

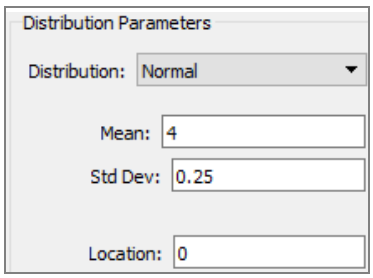
To cause a cell to use a random or empirical distribution:

- Open the **Example DB** database from the Database menu
- In its database window, select **Data** view

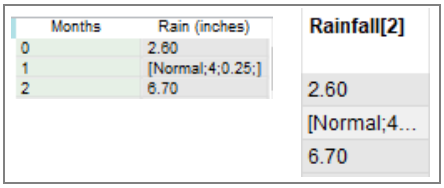
- In the Table List pane, select the **Rainfall Amount** table
- In the Rainfall field, select record #2 (value = 4.40)
- Either give the right-click or Database command **Make Cell Random**, or click the Make Cell Random button in the toolbar



- In the Database Random Distribution window that appears, for the Distribution Parameters choose:
  - **Distribution: Normal**
  - **Mean = 4**
  - **Std Dev = 0.25**
  - **Location = 0**
- At the top of the dialog, click **Submit to Cell**
- Save the model to save your changes



This creates a randomized value for that month's amount of rainfall. The setting will be shown in that cell of the database table (on the left side of the screen shot shown here) as well as in the Rainfall block's data table (on the right side of the screen shot).



☞ Depending on how you make the selection, you can randomize one cell, several, or an entire field.

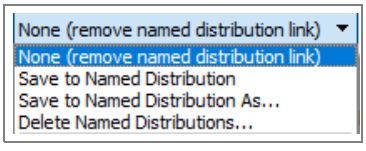
As discussed below, a distribution selection and settings can be saved as a named distribution.

Creating a named distribution

Distributions can be assigned a name and saved for use throughout the database. You can create a named distribution as you randomize a cell or afterwards.

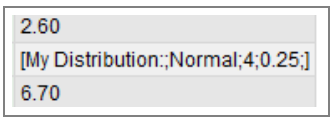
To save the distribution you created above as a named distribution:

- Go to the database window for the **Example DB** database and select Data view. Alternatively, open the Table Viewer for the Rainfall Amount table.
- To reopen the popup, select the database cell you randomized above and choose to **Make Cell Random** using the right-click or Database menu command or the Make Cell Random button in the toolbar.
- In the Database Random Distribution dialog that appears, choose **Save to Named Distribution** from the popup menu at the top of the window



- In the Save to Named Distribution dialog that appears, name the distribution **My Distribution**
- Click **Save** to close the dialog
- In the Database Random Distribution dialog, click **Submit to Cell**
- Save the model to save your work

That cell in the Rainfall Amount table and the corresponding field in the Rainfall block's data table now indicate the distribution is a named distribution.



Create a Parent/Child relationship

Establishing a parent/child relationship between database fields is optional but powerful. It is useful for many situations, such as providing a list of components for a specific product, a selection of custom colors for a particular model of car, or the properties of a material.

Having a parent/child relationship limits the child field's set of data to what is present in a designated parent field. Instead of entering data directly into the child field, you select the data from a popup data selector in the child field that shows all the possible values present in the parent field.

Relationships are established between fields, so you can even have one field in a table be related to another field in the same table.

☞ Parent fields have their names in red text and database tables that have parent fields are listed in the database window in red text. Child field names are in green text and tables that have child fields but no parent fields are listed in green text.

Assumptions

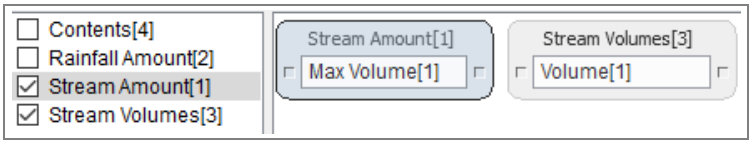
The following example creates a parent/child relationship, causing a field in one database table to get its values from a field in a different table.

As with the previous example, this example uses an existing database (Example DB) and its components.

Database	Table Name Child Field	# of Records in Field	Table Name Parent Field	# of Records in Field
Example DB	Stream Amount Max Volume	1	Stream Volumes Volume	4

Create a parent/child relationship

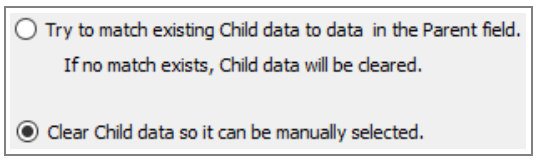
- Open the Reservoir Tutorial model you created in the previous chapter.
- Go to the Database menu and select the **Example DB**. This opens its database window.
- Go to Schema view and, if they aren't already checked, check the boxes in the All Tables tab so that the **Stream Amount** and **Stream Volumes** tables are visible in the Tables pane



- Use point and click to draw a line *from* a connector point for the Max Volume field (the child) in the Stream Amount table *to* a connector point for the Volume field (the parent) in the Stream Volumes table. In other words, from the child to the parent.

Since the child field has existing data (4.00), the Parent/Child Relationship dialog opens with options for how the data in the child field should be handled. In this case, you want to clear the data from the child field so that all data comes from the parent field.

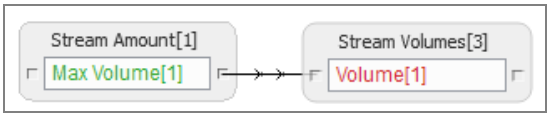
- In the Parent/Child Relationship dialog, choose that the data is cleared from the child field as shown here.



- Click *Set Relationship*.

☞ The Relationship dialog is discussed more at page 64.

This establishes the Volume field (Stream Volumes table) as the parent to the child field Max Volume (Stream Amount table). As shown here, the names of parent fields are in red text; the names of child fields that aren't also parents are in green text.

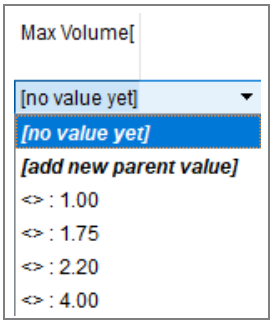


⚠ When establishing a parent/child relationship, always draw the line from the child to the parent, so the arrow points to the source of the data.

Select data for the parameter field

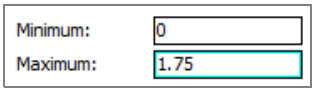
To select which record from the parent table that the Stream block will have as its Maximum amount:

- In Schema view, double-click the header for the Stream Amount table to open the Table Viewer. (Or, switch the database window to Data view and select Stream Amount in the Table List pane at the left.)
- For record #1, double-click the triangle on the right of the popup to expose the Child popup options coming from the parent field.
- In the selector, chose the value **1.75**.
- Close the window and save the model to save your work.



The child cell for record 1 of the Max Volume field in the Stream Amount table is now set to 1.75. It gets that value from the parent field in the Stream Volumes table. If the parent value changes, the child value will change (but not vice versa).

Note that whichever amount is selected in the child field is now shown as the Maximum value in the dialog of the Stream block, as shown here.



☞ In the Stream block's dialog, you can change the Maximum parameter from the choice made in the database's client field but only to one of the 4 values in the parent field. Entering any other number would result in an error message.

Dealing with strings in child fields

Database fields are often formatted as strings. On the other hand, a model's block connectors, dialog parameters, and attributes require numbers to perform calculations.

If a child field is linked using DDL to a model's parameter field (as was done above) or data table, and the child field is a numeric data type, the link is simply created. However, *if the child field is a string data type,* ExtendSim automatically handles the translation between string and number using the Parent Record Index (PRI) "behind the scenes" as discussed on page 48.

However, the translation must be handled *explicitly* if you:

- Use a block that reads or writes to an ExtendSim database, rather than use dynamically linking
- And, one or more of the linked database fields is a child field
- And, the field is of type "string"

In this case the translations is accomplished using the Parent Record Index (PRI). For more information, see "Fields with string data types; PRI and PRV" on page 48.

Use tabs to categorize tables

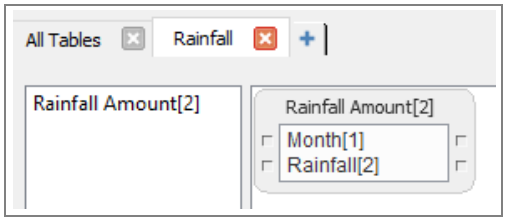
A database window's All Tables tab will always list all of the database's tables. This works fine since there are only 3 tables in the Example DB database. However, if a database has a lot of tables you might want to organize them onto different tabs. You do this by *cloning* the tables from the All Tables tab to tabs that you add.

As discussed in the Quick Start guides, clones are exact copies of parameter fields, text, tables, or graphs. Similar to a shortcut or alias, clones behave identically to the original. While you can't *move* a database table from the All Tables tab, you can *clone* the table onto another tab or tabs you designate. The table remains listed on the All Tables tab and its clone is displayed on some other tab.

Clone a table to a new tab

To add a tab to the database window and clone a table to that tab:

- Go to the Database menu and select the **Example DB**. This opens its database window.
- In the database window (Schema view), click on the plus sign to the right of the name All Tables; this opens a dialog for naming the new tab.
- Name the new tab **Rainfall**.
- With the database window in Schema view, select the name of the Rainfall Amount table in the Table List pane on the left or select the Rainfall Amount table in the Tables pane on the right.
- Give the command **Database > Clone Selected Tables to Tab**. (If you've selected the table in the Tables pane, you can right-click and give that command.)
- In the dialog that appears, select the Rainfall tab to clone the table to.

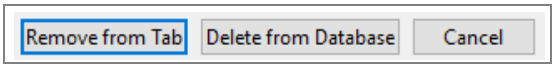


☞ A database table can be cloned to multiple tabs. Any changes made to a table on one tab will be reflected in that table's original and clones on all the other tabs.

Remove a cloned table from a tab

To remove a table from a tab:

- Select the table and give the command Edit > Clear Selected Tables or click the Delete or Backspace key.
- The Delete Tables from Tab dialog opens with the choices shown here.



- Click Remove from Tab

DB Line Chart block for viewing database data

The DB Line Chart block (Chart library) displays database data as a graph and reports that data in a table. You use the DB Line Chart block (Chart library) to:

- View data stored in one or more ExtendSim databases
- Monitor what happens to a database cell's value during a simulation run
- Compare sets of database data to each other— compare a cell, a record in a table, or a database table to another cell, record, or table respectively

Instead of reading values from input connectors as most of the chart blocks do, this block displays values from an existing ExtendSim database. It is shown below and discussed in detail starting on page 73.

☞ The DB Line Chart block is the best method for viewing a cell's data history.

Using the block in a model

The following example uses the DB Line Chart block in a continuous model. It can also be used in a discrete event or discrete rate model. In any case, the model must have an ExtendSim database.

Add the block to the model

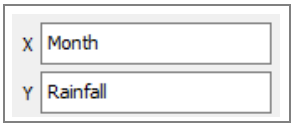
- Open the Reservoir Tutorial model you created in the previous chapter.
- Place a DB Line Chart block (Chart library) anywhere on the model worksheet

☞ Since the DB Line Chart block gets its information directly from the model's ExtendSim databases, it is not connected to other blocks and can be placed anywhere on the model worksheet.

Choose settings for the graph

The traces and graph for the DB Line Chart block can be customized in numerous ways, as explained in the User Reference. For this example, just set a few simple conditions.

- Double-click the DB Line Chart block's icon to open it. By default, the Graph tab opens in front.
- In the *Graph* tab:
  - Right-click on the graph to bring up the Graph Properties dialog
  - For the X value, change the name to **Month** and enter **6** for the intervals
  - For the Y value, change the name to **Rainfall (Inches)** and enter **7** for the intervals
  - Close the Graph Properties dialog



- Go to the *Dialog* tab, on the left side of the graph
- Select the *Display* tab at the top of the Dialog tab:
  - Choose **Graph: opens at end of simulation**
  - Choose **Autoscale: at end of simulation**
- Now, at the top of the Dialog tab, select the *Data Collection* tab

Choose the data collection options

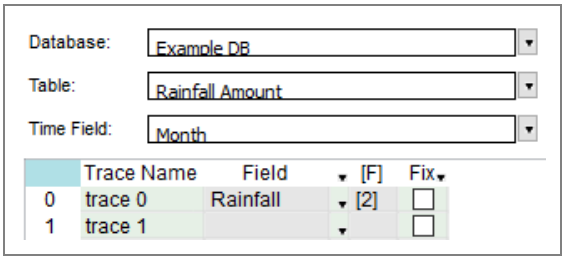
The next step is to choose what type of information should be reported, what should be plotted (a cell, a field, or a table), and when the data should be collected. This example will look at rainfall by month, so the DB Line Chart block should look at fields.

- In the section of the dialog for *Data collection type*:
  - Select the data source as **one field per trace**
  - Choose **Data Collection: at end of simulation**

Select the data source

For this example, you will trace two fields in the Rainfall Amount table of the Example DB database.

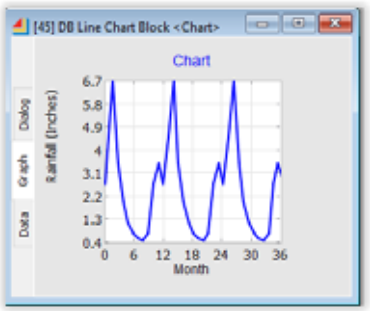
- In the *Data collection options* section of the Data Collection tab:
  - For the database, choose **Example DB**
  - For the table, choose **Rainfall Amount**
  - For the time field, choose **Month**
  - In the Trace Name table, select **Rainfall** as the name in the Field column



- Click OK to close the DB Line Chart's dialog
- Save the model to save your settings

Run the simulation

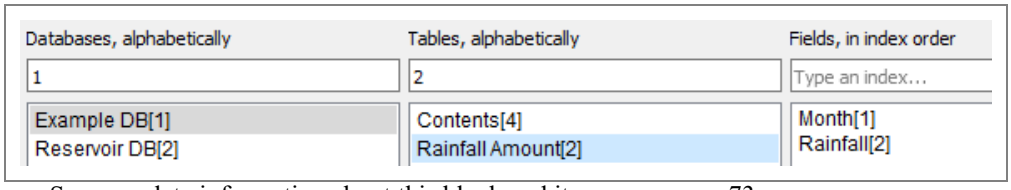
When the simulation ends, the DB Line Chart's graph is displayed. Since the example was simple by design, the DB Line Chart block reports and displays the same Rainfall information as seen in the Line Chart block.



Other information

Some other features of the DB Line Chart block to note:

- You don't need to run a simulation to use the DB Line Chart block. It is also useful when you just want to visualize and compare sets of data within a database or between one database and another. After selecting the data sources and options, use the Plot Now button in the Data Collection tab to graph the data. (Note that this option is not available if you are graphing one cell per trace.)
- If you choose "one cell per trace" for the data collection, the best way to drill down to the wanted cell is by clicking first in the Select column. This takes you to the Database Address Selector so you can choose the database, table, field, and record in one window.



• See complete information about this block and its uses on page 73.

Other blocks for use with the ExtendSim database

In addition to the DB Line Chart block, other blocks are useful when using the ExtendSim database.

Blocks for exchanging data with an ExtendSim database

The ExtendSim database is a very powerful tool used both by ExtendSim developers and model developers. Accordingly, ExtendSim includes blocks for exchanging data between the model and a database and between a database and external applications and files.

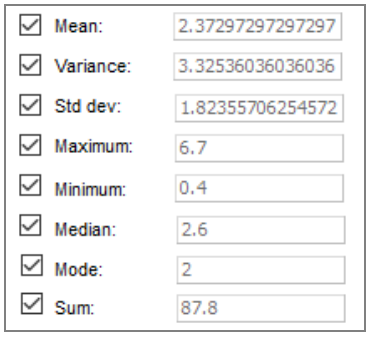
Tutorial 1 showed how to create a dynamic data link (DDL) between a model and a database. There are other and more powerful data exchange options when you don't want to, can't, or shouldn't link a dialog item or data table to a database table.

Block	Library	Purpose	See
Read and Write	Value	Value library blocks exchange data *between the model and ExtendSim databases* (as well as global arrays, Excel workbooks, or text files).	page 39
Read(I) and Write(I)*	Item	Item library blocks only exchange data between the model and ExtendSim databases.	page 41
Data Import Export	Value	Exchange data *between the ExtendSim database and external files* (Excel, text files, ADO and ODBC compatible databases, or files from the Internet via FTP).	page 35
Equation	Value	Create equations that use database information as part of their calculations and/or that output the results of calculations to a database. A powerful alternative to using the read/write blocks because equation blocks have full access to the ExtendSim API.	page 77
Equation(I)*	Item		
Queue Equation	Item		
Query Equation*	Value	Create an equation that, according to the criteria you specify, selects one record from an ExtendSim database table for use in the model. Has access to the ExtendSim API.	page 78
Query Equation(I)*	Item		
Your custom block	N/A	Use programming to create your own block for custom features and actions.	Technical Reference

* These blocks are not available in all products.

DB Statistics block

The DB Statistics block (Report library) calculates the mean, variance, standard deviation, minimum, maximum, median, and other information for a field in a database table.



Place the block anywhere on a model. It does not need to be connected to other blocks to capture the information.

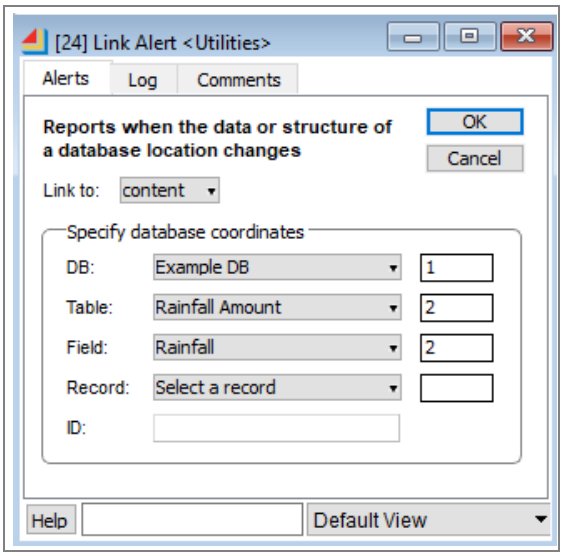
Select a field on the block's Database tab and the results will be calculated automatically and displayed on the Results tab. In the Database tab, choose to calculate statistics either *at the end of each run* (to calculate values as each run completes) or *at the end of all runs* (to calculate values after all of the simulation runs have completed).

Equation-based blocks

These blocks use database information as part of their calculations and/or output the results of calculations to a database. For more information, see "Equation-based blocks" on page 77.

Link Alert block

The Link Alert block (Utilities library) tracks and notifies when an ExtendSim database or one of its components changes either its contents or its structure during the simulation run.



Once you specify a database location to be monitored (database, table, field, or record), the block senses if there are any changes to the content of, or the structure at, that location.

Whenever a change occurs, the block's output connectors report the change as well as the Global Object ID of the block that caused the change. This block also has an option to log the information in a data table, capturing any changes that occurred during the run.

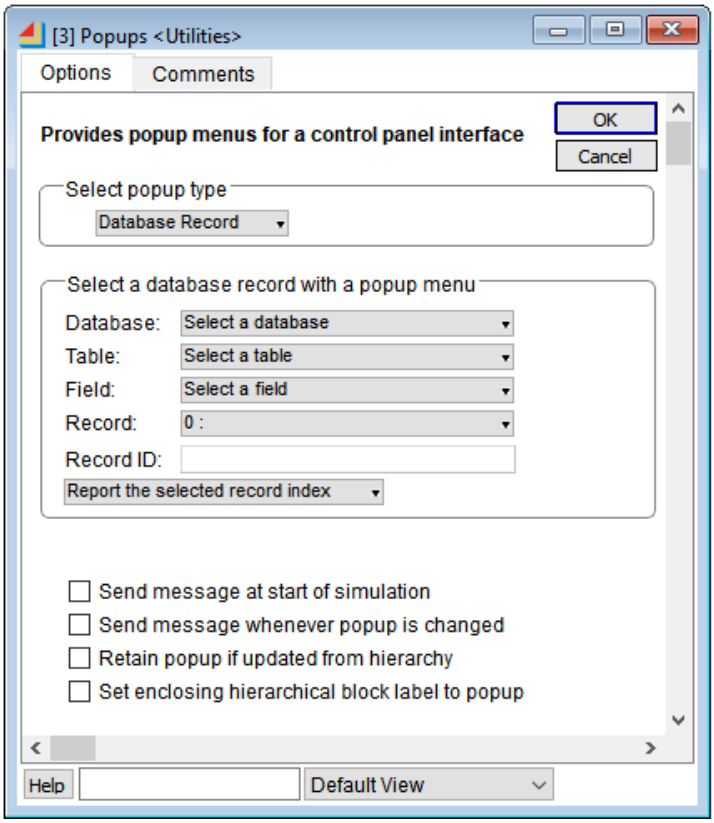
- Place the block anywhere on a model.
  It does not need to be connected to other blocks to log the information.

Popups block

Use the Popups block (Utilities library) to define a custom popup menu that you can clone to the model worksheet and use as a numeric input to the model.

To use this block to obtain the index of the selected record, select *Database Record* as the popup type and enter the database information.

It is common to connect this block's output to the *R* input on a Read or Write block (Value library), so you can manually change which record is being read or written to.



ExtendSim Database Tutorial & Reference

Tutorial 3: Data Exchange

Overview

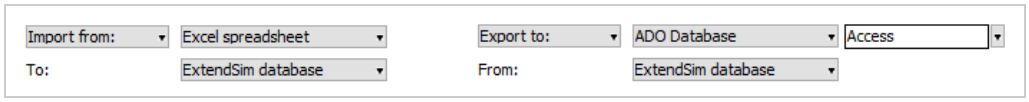
The previous chapter showed how to use the DB Line Chart block to see data stored in an ExtendSim database. This chapter shows how to use the:

- Data Import Export block to exchange data *between ExtendSim databases and external applications/ files*
- Read and Write blocks to exchange data *between a model and an ExtendSim database*

The Data Import Export block for automating data exchange

The Data Import Export block (Value library) controls the *automated exchange of data between ExtendSim databases and external applications and files.* It transfers the data from source to target and controls the timing of the data exchange.

The main advantages of using the Data Import Export block is that the data gets completely copied in a single operation and the exchange can happen at the beginning, during, or after the run.



The left side of the screenshot above shows importing from Excel to an ExtendSim database. The right side shows exporting to Access from an ExtendSim database.

The following examples show how to import data from Excel into a continuous model's ExtendSim database and export data from the database to Access.

☞ For a complete description of the Data Import Export block, see page 70.

Import data from Excel to an ExtendSim database

This example uses a continuous process model that all ExtendSim modelers have access to. An Excel worksheet is the source of the data and an ExtendSim database table is the target.

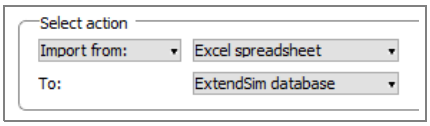
☞ The tutorial on page 22 dynamically linked a block's data table with an ExtendSim database table, causing the block to get its data from the database. The data in the database came from an Excel worksheet; this tutorial shows how the database got that data from Excel.

Configure the model

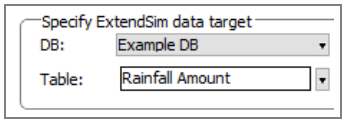
- If the Reservoir Tutorial model you created isn't already open, open it.
- Place a Data Import Export block (Value library) anywhere on the model worksheet
- Open the Data Import Export block's dialog to its Import Export tab

Choose the settings

- In the *Select action* section of the block's dialog:
  - In the first popup menu, choose **Import from Excel spreadsheet** (the default)
  - To: **ExtendSim database**



- In the *Specify ExtendSim data target* section of the dialog, choose:
  - DB: **Example DB**
  - Table: **Rainfall Amount**



View the information in the database

The information about this database table—its field names and each record's data—is now displayed in the Data Import Export block's *ExtendSim Data* tab. Use this to verify that you have selected the correct database location to get data from or, as in this case, send data to.

You can also click the Show Database and Show Table buttons in the block's Import Export tab to view the database structure and verify you've selected the correct data target or source, as applicable.

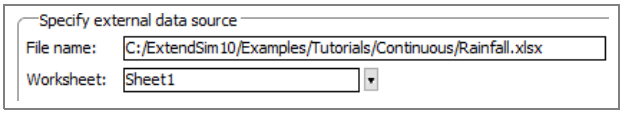
- Notice that there is already data in the Rainfall Amount table, and that the data for rows 13 to 24 is as shown at right. If you've completed the previous tutorials, that will be the same data in the block labeled Rainfall, since its data table is dynamically linked to the Rainfall Amount database table.

13	12	2.60
14	13	4.40
15	14	6.70
16	15	3.40
17	16	1.90
18	17	1.10
19	18	0.70
20	19	0.50
21	20	0.40
22	21	0.70
23	22	2.60
24	23	3.40

Importing data from Excel will overwrite the data in this table, changing what is available to the Rainfall block in the model.

Select the data source

- In the *Specify external data source* section of the Import Export tab:
  - Browse to File Name: **Rainfall.xlsx**, located at ExtendSim/Examples/Tutorials/Continuous



⚠ If Excel isn't already open, this step will launch Excel, open the appropriate workbook, and immediately minimize it. So you may see that window quickly open and close.

☞ The Data Import Export block will browse first to the folder that contains the model. As best practice, keep any files that will be sources or targets in the same folder as the model. Otherwise, the *File name* field will show the entire path (as shown above) rather than just its name.

  - Select Worksheet: **Sheet 1**

- Check the box to **Import at beginning of simulation** (the default)
- Click OK to close the dialog and save its changes

Import the data and verify the results

- Run the simulation or click the Import Now button in the block's dialog
- Open the database window for the Example DB database
- With the window in Data view, select the *Rainfall Amount* table so that its data is displayed
- Compare the database table's data to what is in the Excel worksheet to verify that they are the same.
- Notice that the amounts in rows 13 to 24 of the Rainfall Amount table are not the same as what had been in the database prior to importing (shown on page 36). Also notice that the new amounts are immediately available for use by the Rainfall block, since its data table is dynamically linked to this database table.

13	12	1.20
14	13	2.40
15	14	3.70
16	15	1.20
17	16	1.90
18	17	1.10
19	18	0.30
20	19	0.50
21	20	0.40
22	21	0.70
23	22	1.20
24	23	1.40

☞ Excel will remain open until you close it.

Export data from an ExtendSim database to Access

⚠ The following example requires that a 64-bit compatible version of Microsoft Access be installed on your computer. Since ExtendSim is a 64-bit application, your version of Access and its drivers must be 64-bit compatible.

The Data Import Export block can be configured to export an ExtendSim database table, and even an entire ExtendSim database, to a selected ADO-compliant database. The following example shows how to export an ExtendSim database to Microsoft Access.

Create an Access database file

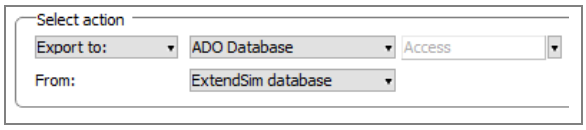
- Create an empty database file using Microsoft Access. The file will import its structure from the ExtendSim database.
- For best results, locate the Access database file in the same folder as the model you will export data from.

Configure the model

- If the Reservoir Tutorial model you created in the Tutorial 1chapter isn't already open, open it.
- Place a Data Import Export block (Value library) anywhere on the model worksheet
- Open the block's dialog to its Import Export tab

Choose the settings

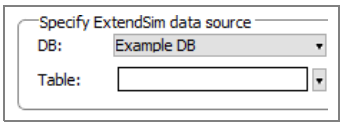
- In the *Select action* section of the dialog:
  - In the first popup menu, choose **Export to**



  - In the popup menu to its right, select **ADO database**
  - For the ADO database, choose **Access** (the default)

- For the *From* location, choose **ExtendSim database** (the default)

- In the *Specify ExtendSim data source* section of the dialog, choose:



  - DB: **Example DB**
  - To export the entire database, leave the table name blank, as shown above.

☞ Leaving the table name blank (or choosing *None* from the list of tables) causes the Data Import Export block to export the structure and data for an entire database.

Select the target

- Click the Show Database button in the block's Import Export tab to verify you've selected the correct data source.
- In the *Specify external data target* section of the Import Export tab:
  - For the *File name*, browse to the Access file you created for storing the data
  - Leave the *Table name* blank, since an entire ExtendSim database will be exported to Access
  - Check the box to **Export at end of simulation**

☞ If you were importing from, rather than exporting to, an ADO database, you would check the box to *Import at beginning of simulation*.

Export the data and verify the results

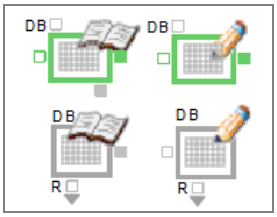
- Run the simulation or click the Export Now button in the block's dialog
- To verify the results, compare the tables and data in the ExtendSim database to what is in the Access database file.

Running the simulation, or clicking the Export Now button, causes the Data Import Export block to export all the data and database structure from the Example DB to the Access database file. A dialog table in the data target section displays the Field Name and Field Type for each table you select in the *Table* popup.

⚠ For ADO compliant databases, the path to the external source or target file varies depending on which database is selected. For Access it is specified by a file name. For MySQL and SQLServer the source/target is specified using a server name and a database name. For Oracle, a user name and database name must be specified.

Read and Write blocks

The the Read(I) and Write(I) blocks (Item library) shown at the top of this picture and the Read and Write blocks (Value library) shown at the bottom of the picture are typically used to exchange data *between model components while the simulation is running*. Since the ExtendSim database is part of the model, these blocks are often used to exchange data between the model and an ExtendSim database.



☞ The Read and Write blocks in the Value library have multiple data sources and targets; the Read(I) and Write(I) blocks (Item library) only exchange data between the model and ExtendSim databases.

Compared to using dynamic data linking (DDL) to link a model parameter or data table to an ExtendSim database, these blocks have some advantages:

- They allow you to *dynamically* control which database or table is accessed during a simulation run as well as when it is accessed
- The data can be more easily accessed at several places in the model

☞ For a complete description of the Read and Write blocks, see page 67

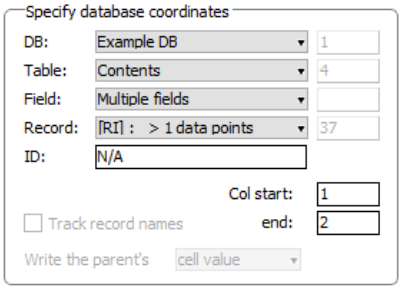
Use a Write block to send model data to an ExtendSim database

The following example uses a Write block (Value library) in the Reservoir DB model. This is obviously completely unnecessary for this small model and in fact requires the additional step of adding a System Variable block. However, the purpose is to show how to use a Write block to send data from a model to an ExtendSim database, and all ExtendSim modelers have access to continuous process models such as the Reservoir model.

In this tutorial you will write the contents of the reservoir to the Contents table in the Example DB database. That table has two fields, Month and Amount, and 37 records for holding data.

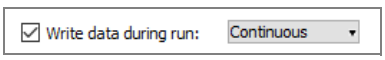
Open the model and add the block

- Open the Reservoir Tutorial model you created in the previous chapter
- If the model includes the Data Import Export block (from the tutorial above), delete it. You don't want ExtendSim to write to the database at the same time as the data is being exported from it.
- Place a Write block (Value library) on the model worksheet and label it **Write to DB**
- In the Write block's Write Data dialog, specify the database coordinates:
  - DB: **Example DB**
  - Table: **Contents**
  - Field: **Multiple Fields**
  - Leave the Record and other fields in the Write Data dialog as is



☞ If the block had been set up to write to a child field, the dialog would display the text "Write the parent's record" and give options for the record value (PRV) or index (PRI). This is discussed on page 48.

- In the Write block's Options dialog, define when writing will take place:
  - Check the box "**Write data during run**"
  - Choose **Continuous** (since the Reservoir Tutorial is a continuous model)



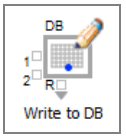
- Also in the Write block's Options dialog, to make sure there are enough records in the database table to hold all the generated data:
  - Check the box "**Expand number of records in the data destination, if necessary**"
- So that the connections are clearer, check the box to **Show connector numbers**

- Close the Write block's dialog and Save the model

☞ Notice that the database window does not need to be open to set the database coordinates in the Write block. The database is part of the model and all its information is known by the blocks in the model.

Connect the Write block to the model

There are now two input connectors in the left side of the Write block that correspond to the Month and Amount fields in the Contents table. The input connector on the top (#1) is for the month and the one below it (#2) is for the amount of water in the reservoir.



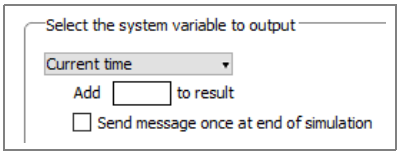
Months

To indicate which month each amount is getting reported for:

- Place a Simulation Variable (Value library) block on the worksheet and connect its output connector to the #1 input connector on the left side of the Write block.

☞ This is a perfect opportunity to right-click on the Write block's #1 input connector and use the Smart Block technique to add and connect a Simulation Variable block. If you don't know how to do that, see one of the Quick Start Guides.

- In the Simulation Variable's dialog:
  - Select **Current Time** (the default) as the system variable to output
  - Label the block **Month**



Amount

To get the information about the reservoir's contents from the model:

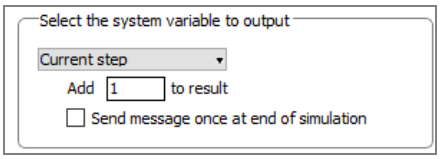
- Connect from the Contents output connector on the Holding Tank block (labeled Reservoir) to the second input connector on the Write block.

☞ This is a good place to use a named connection! If you don't know how to do that, see the User Reference.

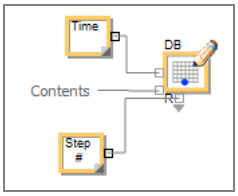
Write each piece of data to a record

Continuous models recalculate their data at each time step, and you want each piece of data to be written to a separate record in the database. To cause data to be written to a different record at each step of the simulation:

- Place another Simulation Variable (Value library) block on the worksheet, near the Write block
- Connect its output connector to the R (record) input connector at the bottom of the Write block
- In the Simulation Variable's dialog:
  - Select **Current Step** as the system variable to output
  - Since data tables are 0 based, and databases are 1 based (see "Indexes and data organization" on page 45), choose to **Add 1 to the result**



- Name the block **Write Each Step**



☞ This second Simulation Variable block was added in this model so that data calculated at each step would be recorded in a new record.

- Save your model. The affected part of the model should look like the segment shown here.
- Run the simulation

The data (Contents) has been written to the Example DB. In the dialog of the Write block, notice that the Write Data tab has a section that shows the Month and Amount, shown here. This is the same information recorded in the Contents table of the Example DB database and in the Data tab of the Line Chart block.

DB	Month [1]	Amount [2]
1	1	0.00
2	2	3.04
3	3	8.04
4	4	15.67
5	5	19.63
6	6	21.60

☞ One way to see the Contents database table is to click *Show ExtendSim Database* in the Write block's dialog. This will open the Table Viewer for the database table named Contents.

Use a Read(I) block to get data for the model from an ExtendSim database

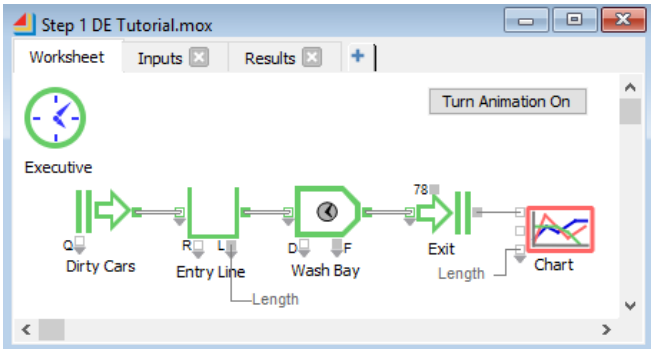
⚠ This part of the tutorial uses the Read(I) block from the Item library in a discrete event model. If you only have the ExtendSim CP product, you won't have the Item library and you won't be able to create or run the following example.

Unlike the Read and Write blocks in the Value library, the Read(I) and Write(I) blocks in the Item library only exchange data between a model and an ExtendSim database rather than also with Excel, text files, and global arrays. Furthermore, since they only do the exchange when an item passes through, the Read(I) and Write(I) blocks must be connected to the flow of items in the model.

About the model

- Open the model **Step 1 DE Tutorial**. It is located at ExtendSim/Examples/Tutorials/Discrete Event

This model simulates a simple system where cars enter a line to be washed. Cars arrive at the car wash facility randomly, as simulated by the Create block labeled Dirty Cars. They then wait in a single line until they can enter the Wash Bay. Each car takes 6 minutes to be washed before exiting the system.



The following tutorial will change the model so that each time a car item leaves the Entry Line and heads towards the Wash Bay, the Read(I) block will get a value from a cell in an Extend-

Sim database. That value will provide a random delay for the time it takes to wash the car. The database cell has been customized to use a random distribution, as was discussed on page 25.

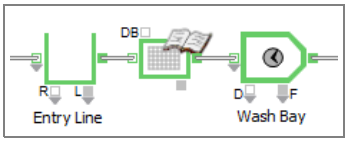
Make a copy of the Car Wash model

So that you don't overwrite the example model:

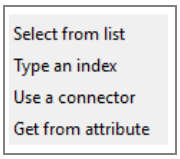
- Save the model under the name "**My Read Tutorial**"

Add a Read(I) block to the model

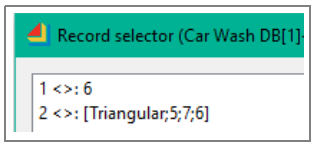
- Insert and connect a Read(I) block (Item library) between the Queue block labeled Entry Line and the Activity block labeled Wash Bay. (If you know how to use the Smart Blocks technique, separate the two blocks and right-click the output connector of the Entry Line to insert and connect the Read(I) block.)



- Save your model, because its the right thing to do
- In the Read(I) block's *Read Data* dialog tab, select **Database: Car Wash DB**. (By default, the first database in a model is automatically selected by default.)
- In the first column (*Read Name*) of the dialog table, enter the word **Delay**. This will be used to label the connector that outputs the values as they are read from the database.
- In the second column (*Table*) of the dialog table:
  - Click once on the down arrow in the cell to reveal the popup shown at right
  - Choose **Select from list**
  - From the popup list, select the table named **Wash Delays**



- In the third column (*Field*) of the dialog table:
  - Click once on the cell's down arrow to reveal the popup
  - Choose **Select from list**
  - From the popup list, select the field named **Delay Time**
- In the fourth column (Record) of the dialog table:
  - Click once on the down arrow in the cell to reveal the popup
  - Choose **Select from list**
  - From the popup list, select the **triangular distribution**, the second record



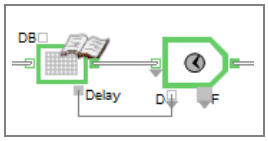
☞ Notice that the cell displays the information about the Triangular distribution—a minimum of 5, maximum of 7, and most likely value of 6. This is helpful if records have distributions with the same name.

- Leave the other columns in the dialog table in their default settings and go to the block's Options tab

Connect the data flow into the model

The Read(I) block is now prepared to get a value from the selected database cell each time an item arrives at the block. However, it still needs to be set up to transfer those values to the appropriate place in the model.

- In the Read(I) block's *Options* tab, check the box to **Show output connector labels**. This causes the word *Delay* (from the first column of the dialog table in the Read Data tab) to appear on the block's output connector
- Click OK to close the block's dialog and save changes
- In the model worksheet, connect from the Read(I) block's **Delay** output connector to the **D** input connector at the bottom left of the Activity labeled Wash Bay. Note: As seen in the Activity's Process tab, this automatically causes the Wash Bay to get its processing (delay) time from its D input connector, rather than from the constant (6) originally set in its dialog.

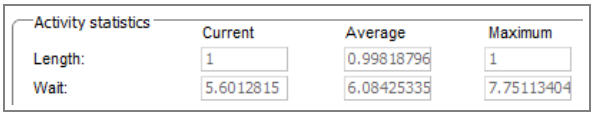


- Save the model

Conclusion

- Run the model

Before the change, the Wash Bay was taking a constant 6 minutes. Thus its Current, Average, and Maximum Wait times, as reported in the Wash Bay's Results tab, were all 6. Now the block's Results tab indicates that the Wait times are random.



To validate the model, compare the delay at each point to the data coming from the database:

- Connect from the Wash Bay's D output connector to an input on the Line Chart block. (You'll need to expand the variable connector at the bottom left side of the Line Chart.)
- Connect from the Read(I) block's Delay output to an input connector on the Line Chart block.
- Then run the simulation and look in the Line Chart's Data tab; the values from the Read(I) block (which come from the database) will be identical to the values for the delay in the Wash Bay.

☞ For more information about the Read and Write blocks, as well as some example models that use these blocks, see "Read and Write blocks" on page 67.

ExtendSim Database Tutorial & Reference

Reference

Overview

This section provides additional information about using and managing ExtendSim databases. It also has a section highlighting the changes and enhancements since ExtendSim 9.0.

Methods for exchanging data with an ExtendSim database

ExtendSim provides the following methods for exchanging data with its databases.

Method	Description	See
Dynamic Data Linking (DDL)	Establish live links between dialog items (parameters and data tables) and database tables	page 19
Read and Write blocks (Value and Item libraries)	Exchange data between a model and database tables. Compared to DDL this gives more control over when and how data is exchanged.	page 38 (tutorial) and page 67
Data Import Export block (Value library)	Exchange data between an ExtendSim database and an external file: Excel, ADO and ODBC compatible databases, text files, FTP	page 35 (tutorial) and page 70
Equation-based blocks (Value and Item libraries)	Use logic, equations, and code to call database functions	page 77
Programming	Use ModL and database functions to create custom methods	the Technical Reference

☞ In addition, the Query Equation and Query Equation(I) blocks search a database and locate specific records according to the criteria you specify. They are discussed on page 78.

Indexes and data organization

When interfacing between a model and an ExtendSim database, or between an ExtendSim database and an external application's files, it is important to know how data is organized and how data locations are indexed.

Indexes and organization by data type

An index is a numeric type of identifier, as opposed to a name used as an identifier. An address is a collection of indexes that can be used to identify a specific member or component within a hierarchical data structure.

Indexes and addresses are unique and make it faster to find components and easier to sort them. An index usually starts with 1 or 0. In addition, data sources are organized by rows and columns or some similar arrangement.

The following table lists indexing and organization conventions for different data source types.

Data Source Type	Indexing	How organized
ExtendSim Data Tables	0-based	Row/Column
Spreadsheets	1-based	Row/Column
ExtendSim Databases	1-based	Field (column)/Record (row)
External Databases	1-based	Field (column)/Record (row)
Arrays	0-based	Row/Column
Text Files	N/A	Row/Column

☞ When exchanging data, it is important to compensate for the fact that the data tables in ExtendSim blocks are 0-based, and ExtendSim databases are 1-based. Usually this is accomplished by adding 1 to the output from the data table to the database (as shown on page 40), or subtracting 1 from a database input going to a data table.

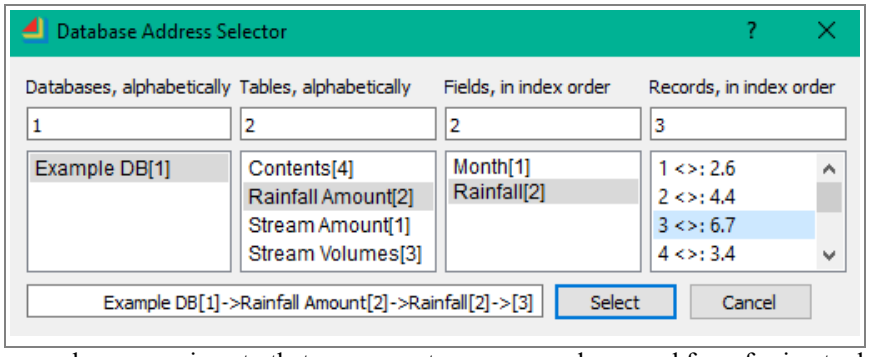
ExtendSim database indexes and addresses

ExtendSim assigns a unique index number to each database. As seen for the Example DB database discussed in the tutorials, that number is appended to the database name and enclosed in square brackets.

Likewise every database table, field, and record is assigned an index number that is displayed after its name. And each cell has a DBAddress that is the combination of those index numbers.

☞ A DBAddress is a single value that contains between 1 and 4 numbers—the index numbers for a specific database, table, field, and record as appropriate.

Database index numbers start with 1, such that the first database in a model has an index of 1, the first table in a database has an index of 1, and so forth. ExtendSim uses a database's index information to assign addresses to the database and to each of its components.



These numbers are unique to that component sequence and are used for referring to databases and their components from blocks or in equations or ModL code. For instance, every read/write operation in a block requires a fully qualified address that specifies a specific set of database components and hence the location of the targeted data.

☞ ExtendSim databases and their tables and fields have both name and index identifiers. By default, records only have index identifiers. However, through the Field Properties dialog, each table can have one Record ID field so that records can also have names.

Since they can change, indexes can be an unstable way to reference locations in a database. For example, a field index will change if you move the field's location. To avoid issues, database aware blocks such as the Equation and Read and Write blocks store names rather than index values. Then at the beginning of the run, the block does a one time lookup using the names to find the index values. This name tracking feature allows the block to track database addresses even if the indexes have changed.

Read/Write Index Checking command

This command in the Database menu is helpful if you program and use database read/write functions. It causes error messages to be displayed if a read/write function call has illegal indexes.

This is a good tool for finding illegal indexes, and enabling this option does not impact the speed of a simulation run. Leave it unchecked if it is preventing a legacy model from running. New models have this menu command checked by default.

Link alerts

Live update messages, called *Link Alerts*, are automatically sent to ExtendSim blocks and the ExtendSim databases or global arrays they are dynamically linked to. This means that as soon as the data at the source changes, an alert will be dynamically sent to all the blocks linked to that location so those target blocks can take actions to react to the new value.

For example, if you write to a location in an ExtendSim database, ExtendSim will send update messages to all the Read blocks in the model linked to that location. When the Read block receives the alert message, it will act on the fact that the data value changed.

⚠ Writing to a cell in an Excel spreadsheet or to a text file will not have the same live link effect.

Link alerts can significantly slow simulation speed if enabled during the simulation run. To control when they are sent, see:

- "Link dialog checkboxes" on page 66 for managing the alerts during the simulation run when block parameters and data tables are linked to an ExtendSim database or global array

- The checkbox *When receive database link alert msgs* in the Equation block (Value library)
- The *data source changes* check box in the Options tab of the Read block (Value library)

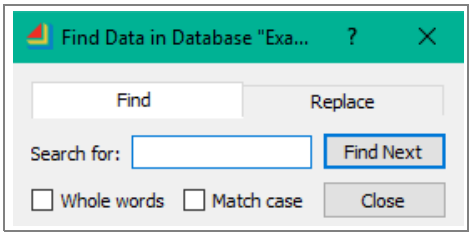
For the most part, link alerts will just make the blocks that have implemented them work as expected—when data changes, the blocks will respond appropriately. However, due to all the opportunities for response, link alerts are an especially powerful tool for those who use equation-based blocks or who create custom blocks.

If you are developing a block that needs to respond to changes in data in ExtendSim database or global or dynamic arrays, or you are creating sophisticated equations that need this, or you need to use the Link Alert block, go to the Technical Reference to understand more about how Link Alerts work.

☞ See also the Link Alert block discussed at page 33.

Finding a number or a string

Use the Edit > Find command (or the right-click menu) to find data (a number or string) within a database. With the database window open in Schema or Data view, give the command Edit > Find. This opens the *Find Data in Database* dialog, shown at right.



To only search within a specific table, open that table's Table Viewer before giving the Edit > Find command; the *Find Data in Table* dialog appears. The Table Viewer is discussed on page 13.

☞ To locate a table by name, click in the All Tables pane in Schema or Data view. Then type the first letter (or more) of the table's name. The first table with those initials will be highlighted. Repeat that letter (or set of letters) to go to the next table name with those initials.

Fields with string data types; PRI and PRV

Database fields are often formatted as strings. On the other hand, a model's block connectors, dialog parameters, and attributes require numbers to perform calculations. ExtendSim provides a mechanism for translating strings in the database into the numbers the model requires.

The translation is based on the fact that child fields have both an index value and a data value. This means that each child field can be referenced by one of those two values: either the data (which can be a number or a string) or the index (which points to the location of the data).

How the translation occurs depends on the circumstances, as discussed below.

Database field>>>	Numeric Type, Not a Child Field	String Type, Not a Child Field	Numeric Type, Child Field	String Type, Child Field
Dynamic Data Link	Link is created	Error message	Link is created	Automatic translation when the link is created
Read/Write	Read/write is established	Error message	Read/write is established	Tell block to use PRI when reading/writing

Dynamic link between a model and a non-child field

As shown on "Field type popup menu" on page 62, field data types can be numeric or string; except for *String,* all of the data types are numeric.

If a parameter or data table is dynamically linked to a **non-child** field in a database using DDL (discussed in "Dynamic data linking" on page 19), and:

- The field has a numeric data type (that is, not a string)—the link will, of course, get created
- The field has a string data type—the link will be rejected with an error message because it doesn't make any sense

Dynamic link between a model and a child field

If a parameter or data table is dynamically linked to a **child** field in a database using DDL (discussed in "Dynamic data linking" on page 19), and:

- The field has a numeric data type—the link will get created normally
- The field has a string data type—ExtendSim *automatically* handles the translation of the string value into the appropriate numeric value. This is discussed in "Dealing with strings in child fields" on page 28.

Read/write exchange between a model and a non-child field

If data is exchanged between blocks that read or write and a **non-child** field in a database, and:

- The field has a numeric data type—the exchange will happen normally
- The field has a string data type—the exchange will fail with an error message because it doesn't make any sense

Read/write exchange between a model and a child field

If data is exchanged between blocks that read or write and a **child** field in a database, and:

- The field has a numeric data type—the exchange will happen.
- The the field has a string data type—you must select the parent record index (PRI) in the block's dialog, as discussed below.

PRI and PRV

The following blocks exchange data with ExtendSim databases:

- Read (Value library) and Read(I) (Item library)
- Write (Value library) and Write(I) (Item library)
- Equation-based blocks
- Query Equation (Value library) and Query Equation(I) (Item library)

Whether you are reading from the database or writing to it, when you specify database coordinates in those blocks, you tell the block to read or write the value(s) at the designated location in the database.

If the value at the designated location is numeric and does not come from a child field, there are no issues. However:

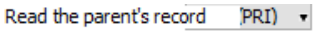
- If the value is a string and the location is a child field, the string must be translated into a numeric value.

- If the value is numeric, the location is a child field, *and the parent field contains a lot of data*, searching for that value throughout all the parent cells can slow performance.

ExtendSim provides a mechanism that performs a string to numeric translation for the first situation and improves performance when in the second situation. Since, as mentioned on page 48, child fields have both data values and index values, ExtendSim does this using the parent record index, or PRI.

- The Parent Record Value (PRV) is the actual value that you see in the child field. (It is also one of the values in the parent field.)
- The Parent Record Index (PRI) is the index *at the parent's location* for the PRV

For example, if a Read block is set up to get data from a child field that has a string, the block's dialog will display the *Read the parent's record value(PRV)/index(PRI)* option. If you choose PRI, ExtendSim will automatically translate a cell's string into a numeric value that can be used in the model.



☞ It is best practice to use PRI whenever you're doing a read/write and there is a parent/child relationship. In most cases there is a lot of parent data and PRI will increase reliability and enhance performance.

Databases

ExtendSim databases are created and managed through the:

- Database menu
- Right-click (context/shortcut) menu
- Database window
- Database List window

Creating an ExtendSim database

There are several ways to create an ExtendSim database:

1) The most common method is through the user interface—using a menu command to create a new database as illustrated on page 16,
2) Using the ExtendSim DB Add-In for Excel, as shown starting on page 85.
3) Importing a database text file from an already-existing ExtendSim or SDI database as discussed in "Importing or exporting an ExtendSim database" on page 52.
4) Using database functions in an equation-based block from the Value or Item library. These blocks are discussed in "Equation-based blocks" on page 77.
5) Programming with ModL code. For more information, see the Technical Reference.

Upon creation, every database is assigned an index, a unique key for identification. A database's index number is displayed in square brackets after its name.

Naming and saving a database

ExtendSim databases are named when created or imported; they can be renamed as discussed below. The database's name can be anything you want as long as it does not start with an underscore character (_), is not used by another database in that model, and does not exceed 63 characters. Database names are not case sensitive and they can contain spaces.

Databases are part of the model and are saved when the model is saved.

Opening a database window

The database window is for viewing and changing its structure (schema) or data. To open a database's window do one of the following:

- Select the database from those listed at the bottom of the Database menu.
- Or, give the command Window > Database List. when the list appears at the bottom of the library window tiles, double-click the name of the database in the list to open it.

The database window is shown and discussed starting on page 10.

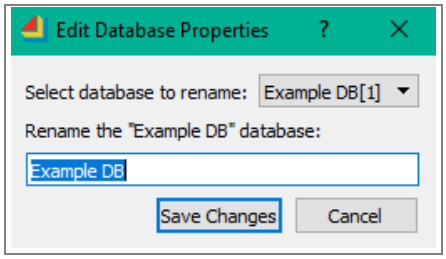
Editing a database's properties

☞ The only property of a database that can be changed is its name.

Accessing the Edit Database Properties dialog

To access the Edit Database Properties dialog:

- Either make a model that has one or more databases the active window, then going to the Database > Edit Database Properties command
- Or, give the Window > Database List command and right-click on the database's name in the list that appears at the bottom of the library windows area



Renaming a database

To rename a database:

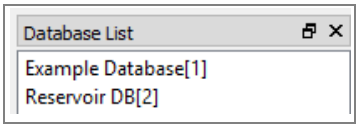
- Use one of the methods above to access the Edit Database Properties dialog
- From the popup menu, select the database to rename

☞ The database's name can be anything you want as long as it does not *start* with an underscore (_), is not used by another database in that model (although see "Overwriting an existing database" on page 53), and does not exceed 63 characters. Database names are not case sensitive and they can contain spaces.

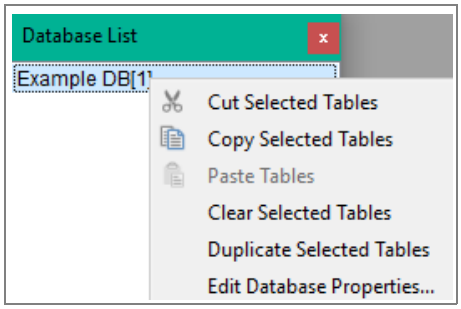
Copying or deleting a database

As is true for the Database menu, the Database List displays all the model's databases and is useful for opening and renaming databases. However, unlike the list in the menu, the Database List also lets you copy and delete a database.

To access the Database List, give the command Window > Database List. This places the list of databases at the bottom of the same area as the library windows.



Copy, duplicate, move



To copy or duplicate a database, select it in the Database List and either use the right-click menu shown here or give the command Edit > Copy (or Edit > Duplicate) Database in the menu bar.

You can paste a database into the current model or into a different model. You can paste into the Database List or onto a model worksheet.

Duplicating, or pasting into the current model's Database List, places a copy of the database into that Database List. It will be under a different index number and a modified name so as to not overwrite the existing database.

Pasting into a different model's Database List or onto a different model's worksheet copies the database into that model with the same name as the original database.

☞ Giving the Paste command on the model worksheet places a copied ExtendSim database in the Database menu and the Database List and makes it available to that model. It does not put a visual representation of the database on the worksheet.

To move a database from one model to another, select the database in the Database List and right-click to cut the database, then paste the database into the other model.

Delete

To delete an entire database:

- In the Database List, select the database to be deleted
- Use the Delete or Backspace key or right-click and choose Clear

Importing or exporting an ExtendSim database

☞ Unless they are exported as text files and translated using the language of a target application, exported ExtendSim databases can only be imported to an ExtendSim model or to the ExtendSim DB Add-In for Excel.

Export an entire database

The Database > Export Database command exports the entire ExtendSim database—all tables, fields, records, and so forth—into a specially formulated database text file.You export a database so you can do one or more of the following:

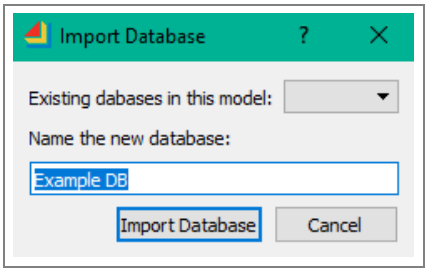
- Import the entire database into another model
- Send the database as a text file to another ExtendSim user so they can import it
- Prepare a database text file for use by the ExtendSim DB Add-In for Excel (discussed on page 85)

☞ The command Database > Export Database is only active when an ExtendSim database window is active.

To export only specific tables from a database, see the discussion on page 57.

Import an entire database

The Database > Import Database command creates a new ExtendSim database by importing a database text file that was exported using the Export Database command.



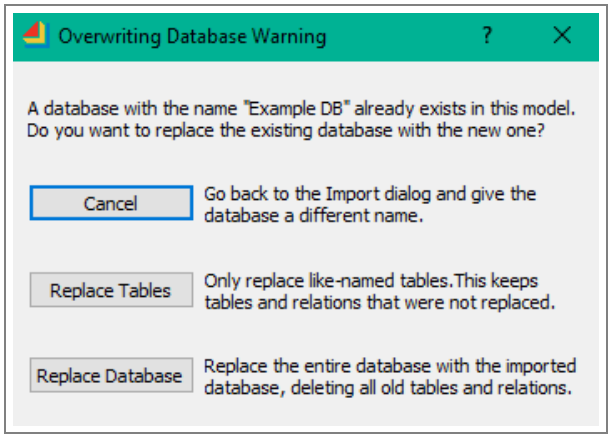
In the dialogs that appear, select the database text file to import then name and import the database. This command imports all the tables, fields, records, relations, and data from the exported file and creates a new database.

If the imported database is named the same as an existing database in the model, see "Overwriting an existing database" below.

To instead import tables to an existing database, see "Importing and exporting database tables" on page 53. See also "Excel Add-In" on page 85.

Overwriting an existing database

Databases can have the same name as long as they are in different models. They are not allowed to have the same name in the same model. Importing a database with the exact same name as an existing database can overwrite the contents of the existing database.



If the name you give while importing a database is the same as a database that already exists in the model, ExtendSim will automatically append a 1 to the name before the database is imported as well as give you the opportunity to change the name.

Alternatively, you can choose that the name of the new database is the same as the name of an existing database. If you do that, when you click the *Import Database* button a dialog appears for choosing how the import should be handled.The dialog allows you to:

- Cancel and give the database a new name
- Or, only replace tables that have the same name as the imported tables
- Or, to entirely overwrite the existing database, deleting any tables and relations that aren't in the import

Importing and exporting database tables

The Import Database command creates an entire new database in the model. You can instead import selected tables from one ExtendSim database into another ExtendSim database.

With the database window for an existing ExtendSim database active, the *Import Tables to Database* command opens a dialog for selecting a database text file that was exported using the

Export Selected Tables command. This imports the tables in the text file and adds them to the selected database. If you end up with unneeded tables, you can delete them.

Reserved databases

An underscore character (_) as the first character of a database name designates that database as a Reserved database. Reserved databases are used by developers and are purposefully hidden from the model user. If you want more information, see the Technical Reference.

Tables

Database tables represent one type of entity, such as Customers, Products, Process Steps, or Resources, as shown in the table on page 10.

Creating and naming a table

There are three ways to create a database table and add it to the database:

1) Through the Database menu using the New Table command
2) By right-clicking on a blank area in the Tables pane while in Schema view
3) By selecting the New Table button in the database window's toolbar

See more information in the tutorial, starting on page 17.

Upon creation, every table in a database must be given a unique name. Each table is also automatically assigned a unique index for identification. A table's index number is displayed in square brackets after its name.

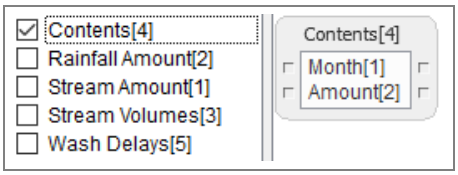
☞ The table's name can be anything you want as long is not used by another table in that database. Table names are not case sensitive and they can contain spaces.

Opening and viewing tables

If a database window is open, the database's tables are open but they might not be displayed. To see how the table fits into the database's structure, check the box to the left of the table's name in the Tables List pane when in Schema view. To see a table's structure, open its Table Viewer.

In the database window

A database window's All Tables tab lists all the tables for the database.



In *Schema* view the database window shows the structure of the database, with its tables and fields as well as any parent/child relationships.

In *Data* view it shows the fields, records, and cells for each selected table.

In the Table Viewer

When your model has multiple tables, it's helpful to see the data view of each table separately, or see a table's data view at the same time as the database structure. This is accomplished by opening Table Viewers.

To open a table's Table Viewer, do one of the following:

- Double-click the table's name in the Tables List pane at the left of the database window
- Or, double-click the table's title bar in the Tables pane of the database window

Either method opens that table's Table Viewer, showing its fields (columns) and records (rows) with their data. You can have multiple Table Viewers open at the same time.

If you've "lost" the database window, use the Open Schema button in the Viewer to bring the database window to the front.

☞ The Table Viewer is a separate window for each table, displaying the same information and toolbar buttons as if the table were selected in the database window in Data view mode.

Showing and hiding tables

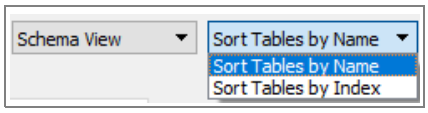
With the database window in Schema view, you can show and hide the table structure displayed in the Tables pane.

- To show or hide a specific table, use the checkbox to the left of its name in the Table List pane of the database window. Checked tables will appear in the Tables pane.
- To show or hide all the tables, use the *Show All Tables* or *Hide All Tables* buttons in the database window's toolbar. Selecting Hide All Tables clears the checkboxes at the left of every table's name in the Table List pane.

☞ If there are a lot of tables and you only want to show certain ones, use the Hide All Tables button. Then select the tables you want to display using the checkboxes in the Table List pane.

Sorting tables

Whether in Schema or Data view, a popup menu in the database window allows you to choose how tables are listed in the Tables List pane—by name or by index.



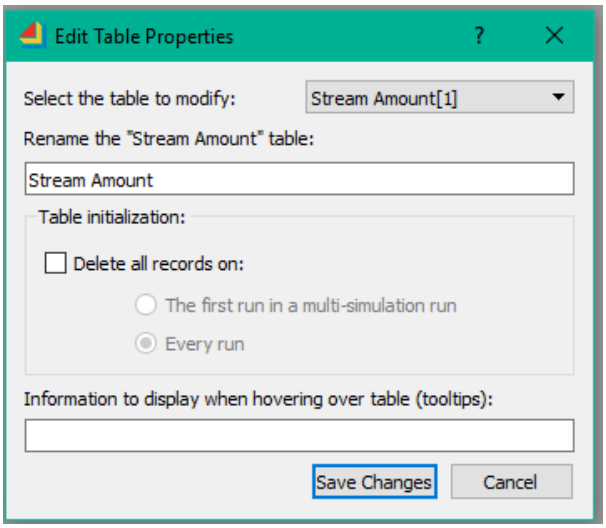
As discussed on page 46, an index is a unique key for identification that is assigned to each ExtendSim database, table, field, and record when it is created. For a table, its index number is displayed in square brackets after its name.

☞ No matter which sorting choice is selected in the database window, it does not affect how database tables are presented in selector windows throughout ExtendSim. Selector windows always present table names alphabetically.

Editing table properties

To access the Edit Table Properties dialog:

- Open the database window
- Select a table's name in the Tables List pane and either:
  - Go to the Database > Edit Table Properties command
  - Or, right-click on the table's title in the Tables pane (database window in Schema view) and select Edit Table Properties.



The editing options are:

- Choose a different table to modify
- Rename the selected table
- Initialize the table so that all records are deleted only on the first run of a multi-run simulation or on every run
- Enter text for tooltips to display when hovering over the table

Copying, renaming, or deleting

Database tables can be copied or moved from one database to another and duplicated within the same database.

Copying and moving

To copy a database table, with the database window in Schema view do one of the following:

- Either select the table name in the Tables List pane and give the command Edit > Copy Selected Tables. Then give the Edit > Paste Tables command
- Or, right-click on the table's title in the Tables pane and choose Copy Selected Tables. Then give the Paste Tables command.

The table can be pasted into the same database's window or into a different database's window.

To move tables from one database to another, use the Edit > Cut Tables command instead of the Copy Tables command. This removes the table from one database and places it in the Clipboard so it can be pasted into the database window of other database.

☞ Tables cannot be moved from the All Tables tab to a different tab. However, they can be cloned to new tabs as discussed in "Use tabs to categorize tables" on page 29.

Renaming and deleting

To rename a database table, access the Edit Table Properties window as shown on page 56.

To delete a table, use the Delete key, the Edit > Cut Selected Tables or Edit > Clear Selected Tables commands, or right-click to the commands.

Importing and exporting tables

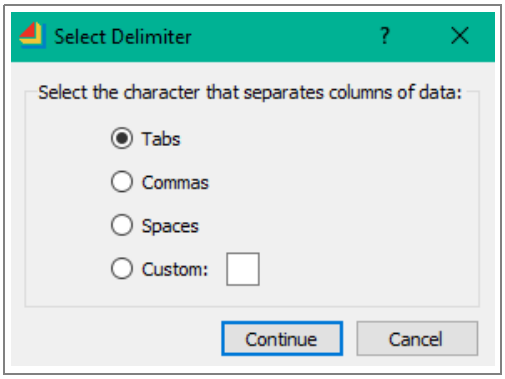
There are types of files for imported/exported ExtendSim database tables:

- As database text files for use by an ExtendSim database or the ExtendSim DB Add-In for Excel. See “Importing and exporting database tables” on page 53.
- As delimited files for use in other applications, as discussed below

⚠ The main purpose of exporting a table as a delimited text file is so the file can be read by Excel or some other application. And the main purpose of importing a delimited file is to use a file created in Excel or some other application. However, delimited files are not automatically formatted as an ExtendSim database table as would be generated using the Export Selected Tables or Import Tables to Database commands. If you want to work on ExtendSim databases in Excel, a better method would be to use the ExtendSim DB Add-In as discussed on page 85.

Exporting a delimited file

With a database window open, export the selected table by giving the command Database > Export Table to Delimited File. After you give the file name, ExtendSim puts up the column separator dialog (shown here), so you can specify which type of separator to use in the text file. You can read the text file in ExtendSim (however, see warning above) or in a word processing or spreadsheet application.



Importing a delimited file

With a database window open and a database table selected, import a table into the current database by giving the command Database > Import Delimited File to Table. This imports a text file that has been exported from an external application such as a word processing or spreadsheet application.

☞ See also “Excel Add-In” on page 85. The Add-In is a better method for working on ExtendSim databases in Excel compared to importing/exporting delimited text files.

Fields

As shown on page 10, each field specifies some attribute or characteristic of whatever the database table represents, for example:

Table	Fields
Customers	Last Name, First Name, Company
Products	Product Name, Shipping Weight (pounds), Inventory Level (units)
Process Steps	Step, Setup Time (minutes), Operator
Resources	Item, Capacity (gallons), Pressurized?

Every field has a name, an index, and a defined data type—integer, string, date/time, and so forth—that defines the structure of the information or data. Fields can also have parent/child relationships with each other.

☞ The field's name can be anything you want as long is not used by another field in that table and is less than 64 characters. Field names are not case sensitive and can contain spaces.

Creating a field

There are several methods for creating a field. See "Methods for adding a field" on page 18.

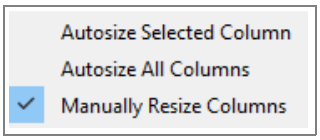
Upon creation, every field is assigned an index, a unique key for identification. A field's index number is displayed in square brackets after its name.

☞ To create a field with a mixed format (for instance, with both strings and numbers), set the field as a string type in the Field Properties dialog. Enter numbers or strings into the cells.

Formatting and editing a field

- Fields are formatted using the Field Properties dialog discussed in "Properties and other dialogs" on page 60. To access the Field Properties dialog for an existing field, with the database window in Schema view double-click or right-click the field, or select the field and use the Edit Field Properties menu command.
- Each cell in the field takes on the formatting assigned to the field through the *Field type* setting shown on page 62. (As discussed in "Formatting" on page 60, by default cells are constants but can be changed to be random.)
- To reorder fields in a table, with the database window in Schema view click and drag the fields.
- Use the ExtendSim Zoom In tool to cause fields to be larger; the zoomed setting is saved with the model.
- To resize a field's column width, put the database window in Data view. Then hover the cursor over the column divider until it turns into a resize cursor and click and drag to resize.

☞ If the column has been set in the Field Properties dialog to *Autosize column width* (see page 61), you won't be able to resize by dragging the column divider. To turn off auto resizing, right-click somewhere within the column (in Data View or Table Viewer mode) and select Manually Resize Column.



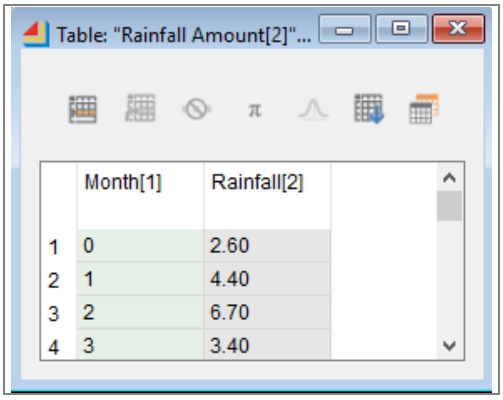
Creating parent/child relationships

See "Create a Parent/Child relationship" on page 27 for how to establish relationships between fields.

Editing data

To access data for editing, in the database window do one of the following:

- Double-click a table's name in the database window's Table List pane to open the Table Viewer window, shown here.
- Or, change the database window from Schema to Data view, select the table in the Tables pane, and edit the cells.



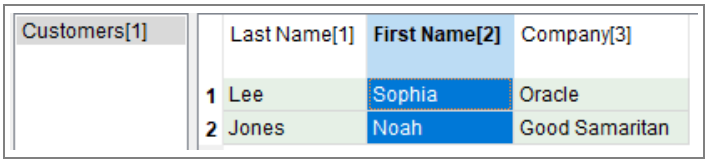
The records and fields for the selected table will be displayed.

Records

Each *record* is the set of information (cells) that represents the single item. Records are composed of one or more fields, each of which contains one piece of information. For example:

Table	Fields	Records	Cells
Customers	Last Name First Name Company	1 to 10	Cells for the "First Name" field: Sofia, Noah, Zeynep, Benjamin, Seoyeon, Lucas, Louise, Bence, Junior, Olivia
Products	Product Name Shipping Weight (pounds) Inventory Level (units)	1 to 3	Cells for the "Shipping Weight" field: 1.5, 0.4, 3.9
Process Steps	Step Setup Time (minutes) Operator	1 to 3	Cells for the "Step" field: Lathe, Drill, Press
Resources	Item Capacity (gallons) Pressurized?	1 to 2	Cells for the "Pressurized?" field: Yes, No

When looking at a table in the database window's Data view, records are the horizontal component, similar to rows in a spreadsheet. For example, the records shown here are #1 and #2.



Creating a record

Records can be added to a database table either when the database window is in Data view or by when the database's Table Viewer is opened. See "Add a record to the table" on page 18 for more information.

Upon creation, each record is assigned an index number, a unique key for identification.

By default, new records are appended to (placed below) any other records in the field. Records can also be inserted using the Insert New Records command, right-click, or button.

Formatting and editing a record

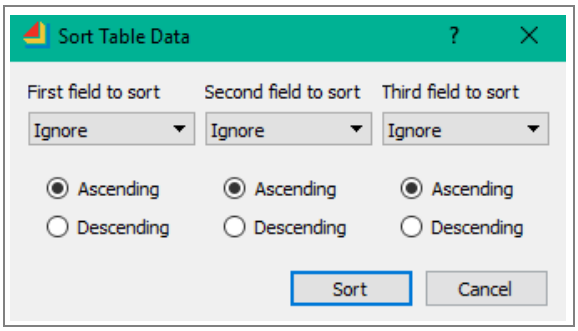
Records take on the formatting assigned to the fields through the "Field type popup menu" on page 62. (Note that individual cells are constant by default, but can be set to use a random distribution, as discussed in "Cells" on page 60.) Records are deleted using a menu command or a button in the Data view's toolbar.

Sorting data

With the database window in Data view, use the Sort Data button in the toolbar to sort a table's data by numeric or string values.

The dialog lets you choose up to three fields where each field can be sorted in either ascending or descending order.

For example, use this to sort a table's records first by last name, then by first name, and then by city.



Cells

Each cell is the intersection of one field and one record.

Definition

Cells represent one piece of information, such as a customer's last name, a product's weight, or a process step.

Cells can be:

- Required—information needs to be manually entered or needs to be imported from some other place
- Optional—the cell can be left empty
- Calculated—the cell's information is calculated based on a formula involving one or more other cells.

Formatting

Each cell in a field takes on the formatting assigned to the field through the *Field type* popup shown on page 62.

By default cells formatted as numerics are constants. Individual cells can be made random by selecting a cell and using a menu command, right-clicking, or using the Make Cell Random button in the Table Viewer or the database window's (Data View) toolbar. Making a cell random allows it to access any of the ExtendSim built-in distributions or even a named distribution. For more information, see the "Database Random Distribution dialog" on page 63.

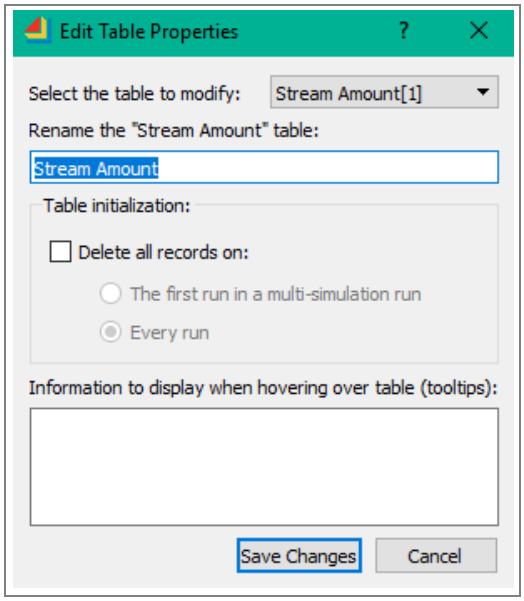
☞ See "Formatting and editing a field" on page 58 for information about manually resizing a record or having the record auto resize to accommodate large numbers in cells.

Properties and other dialogs

Most of the database dialogs are self-explanatory. The following require some explanation.

Table Properties dialog

When they're created, ExtendSim database tables have a Create New Table dialog. After creation, a table's properties can be viewed or changed in the Table Properties dialog. The two dialogs have the same options.



In the database window, access the Edit Table Properties dialog by selecting a table and giving the command Database > Edit Table Properties or by right-clicking a database table (Schema view of the database window) and selecting Edit Table Properties.

The Table Properties dialog allows you to:

- *Rename the selected table*.
- *Delete all the records*. If selected, the initialization is done at the beginning of each run or at the beginning of a multi-run simulation. Always check this if you are doing multiple runs and the number of records could change.
- *Enter a Tooltip*. This is the same as entering text in the field at the right side of the Database window's header. The text will be displayed in the Table Viewer or when a cursor is hovered over the table.

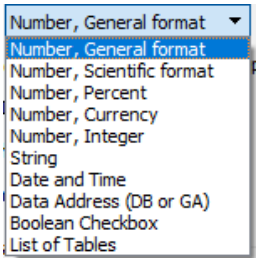
Field Properties dialog

When you append or insert a field in a database table, the Append New Field or Insert New Field dialogs present formatting and other options. These options are the same as shown in the Field Properties dialog, described below.

To open the Field Properties dialog for an existing field:

- Double-click the field's name while in the database window's Schema view.
- Or, select the field in the database window's Data view and give the command Database > Edit Field Properties. (Note: the field must have at least one record to be selectable.)
- Or, right-click the field name while in the database window's Data view..

Options

Option	Description
Field name	Enter any unique name, up to 63 characters. Spaces and special characters are allowed. Duplicate field names are not allowed in the same table. In the Edit Field Properties dialog you can rename the field.
Autosize column width	When checked, causes columns to automatically resize depending on the maximum width of cells. You can also manually resize columns using the right-click menu.
Field type	Format for the field. For details, see "Field type popup menu" on page 62. 
Display decimals/sig-Figs	Displayed only for certain field types. For general format or scientific numbers, the number of digits to display. For currency and percent, the number of digits to the right of the decimal point.
Use separators	Displayed only for certain field types. Inserts commas and periods to separate digits.
Record ID field	Used when you want the records in a table to have an identifier, such as a name. Similar to a key field in other databases.
Each value unique	When checked, the number or string for each record in this field must be unique.
Read only	When checked, prevents the data in a linked dialog parameter field from being changed.
Initialize every record in this field to:	If checked, initializes the data for all the records in the selected field to the parameter value entered in the field. If the parameter is left blank, initializes the field's records to a blank.
First run...Every run	Specifies when the record initialization takes place.
Information to display	For displaying important information about the field.

Field type popup menu

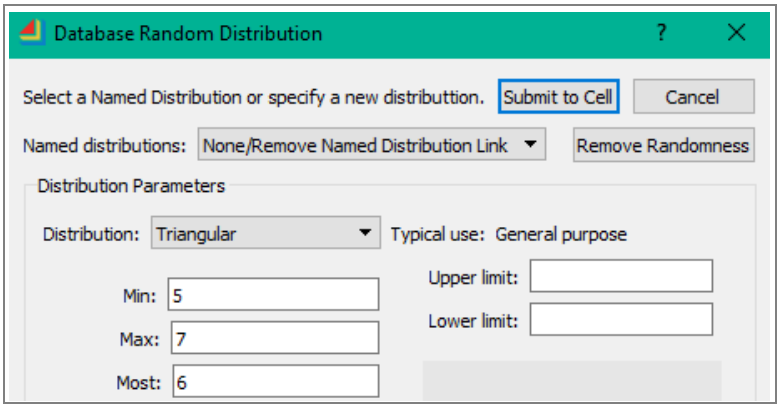
This table describes the options for the "Field type" popup menu in the Field Properties dialog, discussed above.

Field type	Description
Number	An integer or double-precision floating point number. Choose general, scientific, percent, currency or integer.

Field type	Description
String	An alphanumeric string up to 255 characters
Date/Time	Calendar date and time
Data address	Describes the coordinates of a cell in a database table
Boolean checkbox	Places a checkbox to indicate yes or no, true or false, on or off, etc.
List of tables	Provides a popup menu of all the tables in the database, so you can select a table.

Database Random Distribution dialog

By default all database cells are constant. They can be formatted as random numbers as shown on page 25.

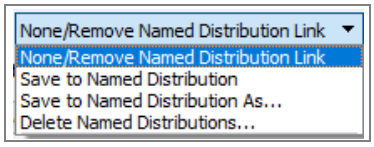


To make one or more cells random, select the cells and choose the Make Cell Random button in the toolbar. Or right-click the cell and choose Make Random. This opens the Database Random Distribution dialog, shown at right.

The random distributions in this dialog are the same as for the Random Number block (Value library). For a complete list and short description of those distributions, see the User Reference.

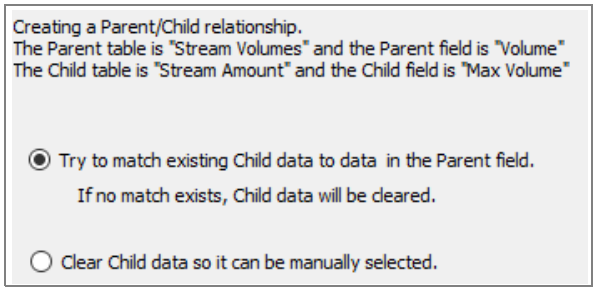
Named distributions

A special feature of the Random Distribution dialog is that you can assign a custom name to a distribution you've specified, allowing that distribution and its arguments to be selected by name elsewhere in the database.



For example, enter typical values for an empirical table and name it Machine Time Distribution. Or give a custom name to an exponential distribution with specific arguments.

Relationship dialog



When a parent/child relationship is created and the field that will become the child already has data, this dialog opens and allows you to arbitrate what happens. If there is no existing data, the dialog does not open.

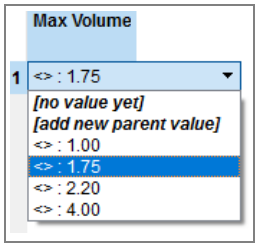
The options are:

- Try to match existing data in the Child field to a record in the Parent field. If existing data in the child matches data in the parent, the data is left unchanged. Otherwise, it is cleared and the record is left blank so the value can be manually selected using the Child popup selector
- Clear Child data. This option clears all the existing data in the child so the choice can be manually selected using the Child popup selector.

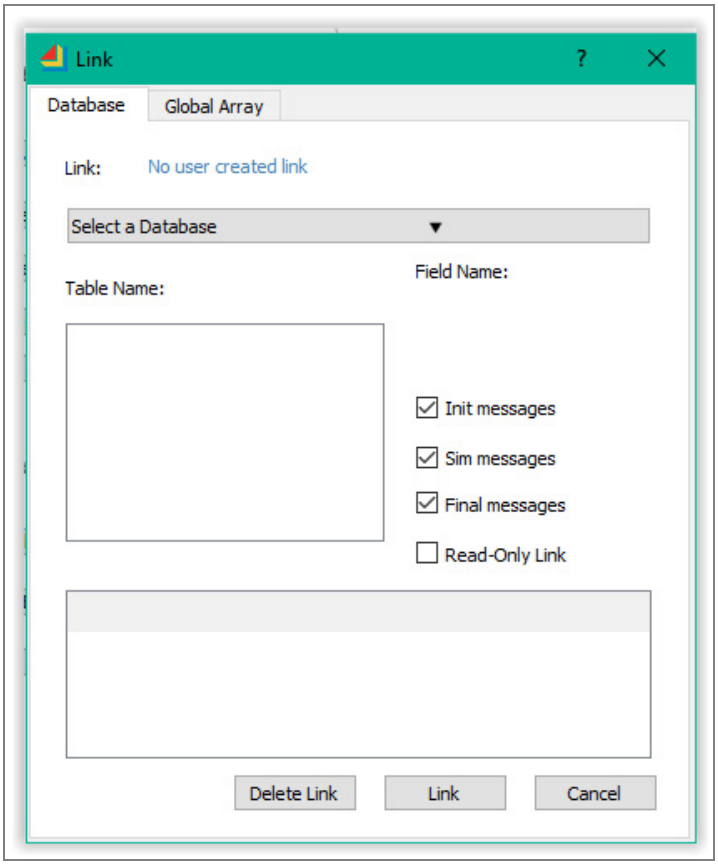
Child popup selector

When you click the down arrow in a Child cell it displays a popup menu with 3 types of options. The choices are to:

- Choose No value yet, which leaves the cell blank.
- Add a new parent value, which gets appended to the parent field
- Select one of the numbers listed in the popup
- Using this selector is discussed in “Select data for the parameter field” on page 28



Link dialog



This dialog opens if you click a data table's Link button or (by using the menu command or right-click) select Create/Edit Dynamic Link for a dialog parameter.

Use the Link dialog to create a dynamic link between a block's parameter or data table and a database or global array. It can also be used to delete a link, change link settings, and even change between linked data structures.

Dialog structure

As shown here, the Link dialog opens with two tabs: Database and Global Array.

- If the data table or parameter is already linked to a database or global array, the dialog will display information about the existing link. For example: *Link: DB Link - Reservoir DB:Stream Amount:Max Volume*. You can change or delete the link.
- If the data table or parameter is already linked to a dynamic array, the Link dialog will display *Link: No user created link*. (A dynamic array is an internal data structure only accessible through programming.) You can create a link to a database table or global array.
- If the data table or dialog parameter is not linked to anything, the dialog will display *Link: No link.* You can create a link to a database table or global array.

☞ See also "Finding linked dialog items" on page 67.

Delete Link button

The Link dialog is also used to delete a link.

⚠ A parameter or data table can only link to one data structure. If you change any of the components, such as linking to a different database table, the previous linkage will be automatically deleted.

Deleting a linked parameter

To delete a link between a dialog parameter and a database:

- Right-click in the linked parameter field and select **Create/Edit Dynamic Link**. (Note: don't select or left-click the parameter field first.)
- In the Link dialog that appears, click the **Delete Link** button.

Deleting a linked data table
To delete the link to a model's data table:

- Click the Link button at the bottom left of the data table
- In the Link dialog that appears, click the **Delete Link** button.

☞ ExtendSim knows which link is being deleted, so you don't need to select the table the parameter or data table is linked to before deleting the link.

Link dialog checkboxes

When the Database Table or Global Array option is selected in the Link dialog, it displays four checkboxes that allow you to control the link's behavior:

- Init messages
- Sim messages
- Final messages
- Read-Only link

Alert messages
As discussed on page 47, link alert messages are sent whenever the dynamically linked data changes at the source, whether the simulation is running or not. Outside of a simulation run, those alert messages are available to the Link Alert block (Utilities library; see page 33), equation-based blocks, and blocks you create. You can then use the alerts to detect changes or cause something to happen in the linked blocks.

However, it is most common to want alerts about data changes during the simulation run. The Link dialog's *Init messages, Sim messages,* and *Final messages* check boxes control whether or not all blocks receive link alert update messages when linked values change during specific points in a simulation run. For example, the "Init messages" option determines whether a block receives a message if a linked value changes during the InitSim message.

- These three options default to on. Turning an option off prevents ExtendSim from sending data update messages to the linked blocks if the data source is updated during that phase of the simulation.
- To maximize simulation speed you may not want these update messages sent during certain phases of a run. For example, if you know the dynamic link only updates during the FinalCalc message, it will reduce the messaging and speed up the simulation to uncheck the Init messages and Sim messages options.
- When the Init messages and Final messages options are checked, linked blocks will receive an additional message during InitSim and/or FinalCalc, causing an update of the linked dialog items during those phases.

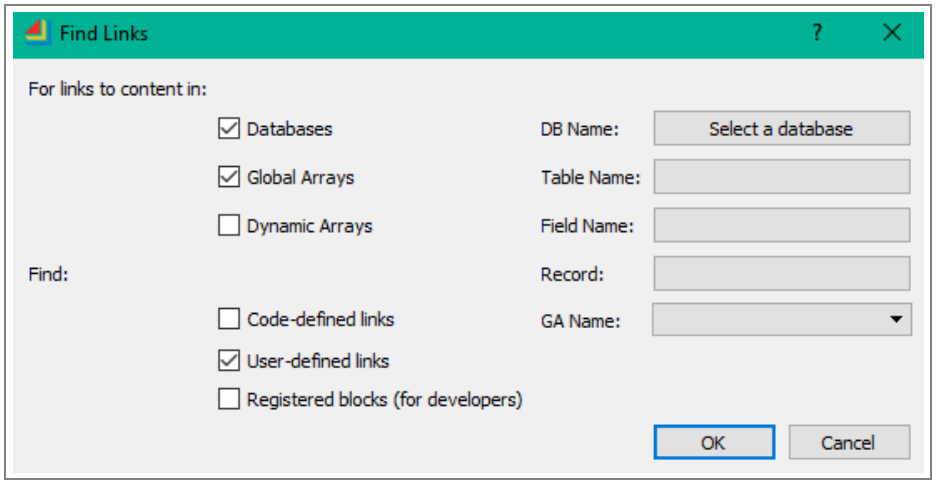
⚠ Use these options carefully and consider your objective (get the most up-to-date data, get a consistent set of data, etc.) since they can dramatically affect runtime performance and results.

Read-Only link

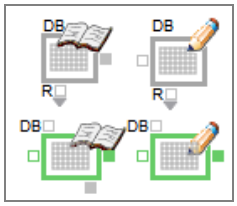
The fourth checkbox is the *Read-Only* link option, which is off by default. If checked, the linked data can only be changed from the internal data structure (database or global array). In that case, you will not be allowed to edit the parameter or the data table in the block's dialog and the live link is only one-way (from the database or global array to the data table or parameter).

Finding linked dialog items

The Model > Open Dynamic Linked Blocks command opens the Find Links dialog. This is useful for examining and locating linked dialog items, and the options in the dialog allow you to selectively choose which types of links you want to open.



Read and Write blocks



The Read and Write blocks (Value library) and the Read(I) and Write(I) blocks (Item library) make it easy to get data into or send data out of model components.The blocks are typically set to transfer data during a simulation run.

☞ An earlier chapter showed how to use these blocks. See "Use a Write block to send model data to an ExtendSim database" on page 39 and "Use a Read(I) block to get data for the model from an ExtendSim database" on page 41.

About the blocks

☞ The Read and Write blocks in the Value library have multiple data sources and targets; the Item library blocks only exchange data between the model and ExtendSim databases.

Name tracking

Since they can change, indexes can be an unstable way to reference locations in a database. For example, a field index will change if you move the field's location. To avoid issues, database aware blocks such as the Read and Write blocks store names rather than index values. Then at the beginning of the run, the block does a one time lookup using the names to find the index values. This name tracking feature allows the block to track database addresses even if the indexes have changed.

Reading

The two Read blocks look up information found at a specified data source:

- For the Read block (Value library) the data source could be an ExtendSim database or global array, Excel workbook, or a text file
- For the Read(I) block (Item library) the only source is an ExtendSim database.

The blocks then report that information through their value output connectors. The Read(I) block can also store the information as an attribute on items passing through, so the information can be used by other blocks in the model.

Writing

The two Write blocks send information to a specified data target or destination:

- For the Write block (Value library) the data target could be an ExtendSim database or global array, Excel workbook, or text file
- For the Write(I) block (Item library) the data target is an ExtendSim database.

The information to be sent can come from their value input connectors. The Write(I) block can also send the attribute information that has been found on items passing through.

Link alerts in Read and Write blocks

The link alert feature makes the Read, Read(I), Write, and Write(I) blocks especially powerful when used to exchange data between blocks in the model and an ExtendSim database or global array. When either the target or the source is an ExtendSim database or global array, the read/write blocks can create a one-way *live link* between the target and the source. Writing to a cell in an Excel spreadsheet or to a text file will not have the same live link effect.

See “Link alerts” on page 47 for more information.

Compared to DDL

Dynamic data linking (DDL) is discussed on page 19. Instead of dynamically linking data from a block’s dialog parameter or data table to a database cell or table, you can use the blocks that read or write to access the cells in a database for use throughout a model.

The advantages of using blocks that read and write rather than dynamic data linking (DDL) are:

- These blocks allow more control over which database values get used, and where and when they are used.
- Database usage is clarified visually. Instead of a blue outline around a parameter field inside a block’s dialog, it is more obvious when a database value is coming from a Read block.
- Dynamic linking is limiting because it is fixed point-to-point. While you can change the value at the data source, you can’t dynamically change which database cell is accessed during a simulation run or in a series of runs.
- Rather than setting up a dynamic link for each parameter or data table, data can be more easily accessed at several places in the model.
- The read/write blocks support *name tracking* whereby blocks are alerted if there is a change to the structure of a ExtendSim database component, such as the insertion or deletion of a record. DDL does not support name tracking.

- In some blocks there is no dialog parameter or data table you can directly link to.
- It is often easier to perform mathematical calculations on the database values.
- It is more convenient for hierarchical blocks, allowing access to a different record for each instance of the hierarchical block in a model.

Compared to importing/exporting

Rather than using the Data Import Export block (described on page 35), which exchanges the entire set of data at a time, the Read and Write blocks are usually used to exchange data piece-by-piece as required during the run. Even though it may slow simulation speed, models may need to write and read data while the simulation is running. For example, it is common that the data that is written is in turn read and used in another part of the model.

See page 72 for some advantages of importing/exporting compared to reading/writing.

⚠ A potential disadvantage of using the Read and Write blocks is that reading and writing the data each time the block is calculated can impact simulation speed. If the data to be read or written will not change over the course of the simulation, you should import/export the data as a local copy in the block before or after the run. If the data is not going to change at all, consider using another method, like a one-time copy/paste or import/export.

Where to get more information

- For a tutorial showing how to use these blocks in a model, go to page 38
- For an example of how the blocks are used, explore the Monte Carlo and DB Job Shop models discussed below
- Since the Read and Write blocks in the Value library have uses beyond interfacing with databases, they are also discussed in the How To: Data Management chapter of the User Reference.

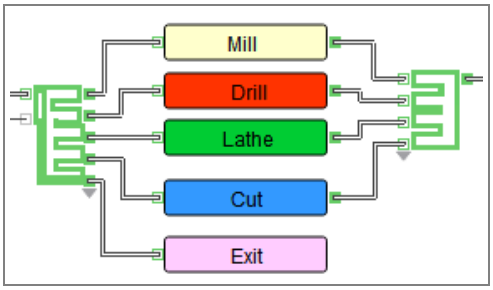
Monte Carlo model

The Monte Carlo model (located at ExtendSim/Examples/Continuous/Standard Block Models) is a continuous model that uses an ExtendSim database named “Scenarios” to store the model’s inputs and results. Using a database allows the model to experiment with alternative scenarios.

Rather than dynamically linking specific dialog parameters and data tables to a database, the model uses Read and Write blocks (Value library) to provide the interface to the database. The Read blocks get random values from the database and use them to represent model parameters where the actual values are not known with certainty. The Write blocks capture and report results to a database table that displays the results of the base case as well as each of the 23 scenario options.

DB Job Shop models

☞ These models use blocks from the Item library. They cannot be opened using the ExtendSim CP product.



The DB Job Shop Read(I) and DB Job Shop Read(I) Lookup models are located at ExtendSim/Examples/Discrete Event/Routing. These models simulate three parts, each with their own process sequence, being routed through five potential processes (milling, drilling, lathing, cutting, and exiting).

Depending on the part, a process sequence is made up of some combination of the processes. For example, the process sequence for part 100-3 is cut, mill, lathe, drill and then exit, while the sequence for part 100-1 only contains a milling step before exiting. Each step in the process has a random delay that is unique to each part type.

The purpose of these models is to demonstrate how the ExtendSim database can be used to control a discrete event model. In particular the database in these job shop models is used to:

- List the different products being made (in this case there are 3)
- Create a production schedule database table that is used by the Create block
- Describe the different routes or process steps required to build each of the three products
- Define processing delay times for each process step in each product's process sequence

One advantage of using a database for these models is that more products can be added to the database and the production schedule can be changed without having to change the structure of the model. Also, if this were a real model, production statistics would also be kept in the database.

☞ See also the “DB Job Shop Query model” on page 84. That model uses the Query Equation block to find the current part's next process step and its associated delay.

Data Import Export block

Simulation models require input data and generate output data. This data is often derived from one or more sources that reside in applications such as Excel, relational databases, SAP, and from files residing on remote computers. The management of this data is an integral component of the simulation modeling process.

As the complexity and fidelity levels of simulation models increase, the amount of data that has to be managed increases as does the time devoted to model configuration and data management. As the volume and complexity of data being managed increases, it becomes more desirable to automate as much of the data management process as possible.

Automation reduces data input errors, scenario setup time, and output data management time. Consequently, it is highly desirable to automate the direct exchange of data between simulation models and data management applications.

Overview

The Data Import Export block (Value library) provides modelers with a mechanism for controlling the automated exchange of data between ExtendSim models and external data sources and targets. It performs two primary functions:

1) Transfers data from specified data sources to specified data targets where either the source or the target can be an external application or file

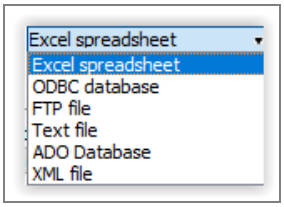
2) Controls the timing of when data exchanges occur—at the beginning, during, or after the simulation run

☞ The main advantage of using the Data Import Export block is that information is exchanged as one piece rather than step by step during the simulation run. Thus it is typically used to load the model with data before the simulation run and export results at the end of the run.

Import and Export modes and interfaces

The Data Import Export block can be configured to operate in either *import* or *export* mode. It exchanges data between an ExtendSim database and:

- A Microsoft Excel workbook (specified by rows and columns, named ranges, or by workbook table)
- External databases that are ODBC or ADO compliant (Microsoft Access, Oracle, MySQL, SQLServer; Windows only).

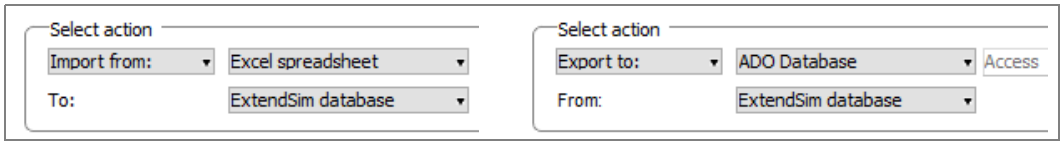


☞ The Oracle and SQLServer databases are useful as automated bridges between ExtendSim databases and ERP programs such as SAP.

⚠ If you use the Data Import Export block to exchange data with an ODBC or ADO database such as Access, the database and its drivers must be 64-bit compatible.

- An FTP (file transfer protocol) data source type, where the file resides on a remote machine and access to it requires a user name and password.
- Text files such as those generated by Notepad or Excel or any other applications where the modeler has read access to a file that resides on the local computer or a local area network (LAN).
- An XML (extensible markup language) file, a flexible way to share structured data with external databases, the World Wide Web, intranets, and elsewhere.

☞ The Data Import Export block even allows you to export an entire ExtendSim database to an ADO-compliant database, such as Access.



Configuring the block for external applications and files

Each of the allowed applications and file types above have their own set of requirements for a successful import or export and the Data Import Export block changes settings and fields accordingly.

For example, the tutorial on page 37 showed that, when exporting from an ExtendSim database to an Access database file, the block presents a field for the name of the Access file. However, depending on the external application or file type selected, the fields for specifying it as a source or target will vary. In addition, for server-based applications such as SQL Server and Oracle, you will need access to the server and/or a user name and password.

☞ For ADO compliant databases, the path to the external source or target file varies depending on which database is selected. For Access it is specified by a file name. For MySQL and SQL

Server the source/target is specified using a server name and a database name. For Oracle, a user name and database name must be specified.

If information other than a file name and location is required, the block's Options tab will be enabled. The Options tab is helpful for configuring tables, entering a data source name (DSN) data structure, and so forth. As is true when files are selected and configured on the Import Export tab, the fields on the Options tab will vary depending on the external application or file. If there is nothing additional to configure, the Options tab will be disabled.

☞ See "Fields with string data types; PRI and PRV" on page 48 if the block will exchange data with an ExtendSim database's child field.

Import and export timing

The Data Import Export block provides three options for when the external source or target exchanges data with the ExtendSim database:

- Manually whenever the Import Now or Export Now button is clicked, even if the simulation is not running.
- During the simulation run, when the block's input connector gets a value greater than 0 (zero).
- During a specified phase of the simulation run:
  - If the *Import at beginning of simulation* checkbox is checked, data is automatically imported at pre-CheckData. The Options tab offers alternative import points.
  - If the *Export at end of simulation* checkbox is selected, data is automatically exported at EndSim.

Compared to reading/writing data

The advantages of using blocks that read/write, rather than import/export, to exchange data between a model and a database are discussed on page 69.

The advantages of using import/export compared to reading and writing data include:

- Import/export might be faster than reading and writing data because the data gets completely copied in a single operation. Whether the exchange happens before, during, or after a simulation run, all the data is made available to the target at the same time, rather than transferring piece by piece during the simulation run.
- The information can be accessed even if it originated on a different computer or an external device.

For example, simulations often run faster because the data is exchanged as one piece—all the data is made available to the target at the same time rather than transferring piece by piece during the simulation run. This is true whether the data is imported/exported before, during, or after a simulation run.

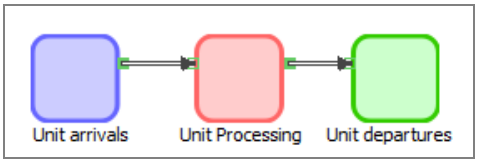
Where to get more information

- For a tutorial showing how to use this block in a model, go to page 35
- For an example of how the block is used, explore the Dynamic Resource Qualification model discussed below

☞ Since the Data Import Export block has uses beyond interfacing with ExtendSim databases, it is also discussed in the How To: Data Management chapter of the User Reference.

Dynamic Resource Qualification model

☞ This model uses blocks from the Item library. It cannot be opened using the ExtendSim CP product.



The Dynamic Resource Qualification model is located at ExtendSim/Examples/Discrete Event/Resources and Shifts/Advanced Resources. It uses stochastic distributions to represent the frequency and duration of resource down events.

A database table named Step Qualification Rules specifies, as a function of the number of units processed by a given resource, which process steps that resource is qualified to perform. As items pass through the unit processing loop in the Unit Processing hierarchical block, Equation block [30] checks the count of the number of units processed by each resource allocated to a unit item. When this count crosses one of the thresholds specified by the Step Qualification Rules database table, the Equation block updates the Qual Matrix table entries for the associated resource based on the new set of process step qualifications for the new Units Processed between PMs Level value.

Where to get more information

- For a tutorial, go to page 35
- For an example of how the block is used, explore the Dynamic Resource Qualification model discussed above

DB Line Chart block

The DB Line Chart block (Chart library) displays database data as a graph and reports that data in a table. You use the DB Line Chart block (Chart library) to:

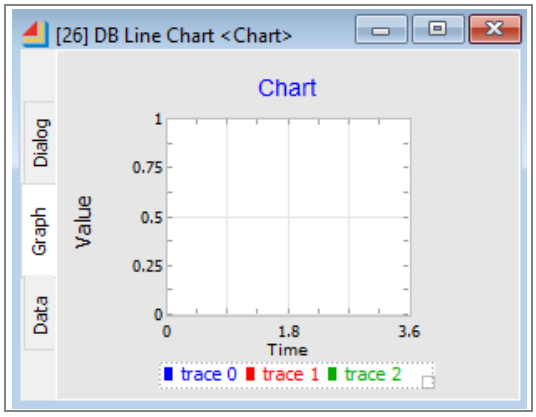
- View data stored in one or more ExtendSim databases
- Monitor what happens to a database cell's value during a simulation run
- Compare sets of database data to each other— compare a cell, a record in a table, or a database table to another cell, record, or table respectively

Instead of reading values from input connectors as most of the chart blocks do, this block displays values from an existing ExtendSim database. To see how it is used in a model, go to page 30.

☞ The DB Line Chart block is the best method for viewing a cell's data history.

Block structure

When the DB Line Chart's icon is double-clicked on the model worksheet, it opens with the Graph tab being front most. There are three tabs along the left side—Dialog, Graph, and Data.

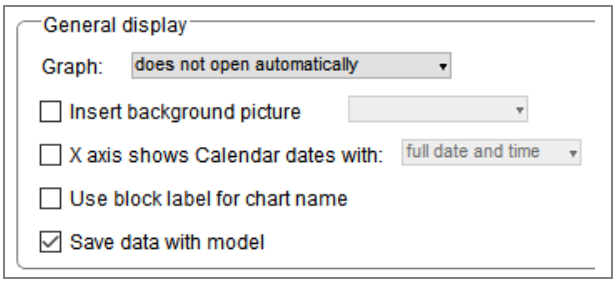


The Data tab is for recording data, and the Graph tab is for displaying data, during the simulation run. The Dialog tab is for entering settings for the block. As shown below, additional tabs appear if the Dialog tab is the active window.

⚠ See the User Reference for complete information about the Trace Editor and Graph Properties dialogs that appear when you right-click the Graph tab in Chart library blocks.

Dialog tab

When the Dialog tab on the left side is selected, the block shows three tabs across the top: Data Collection, Display, and Comments.



- The *Display* tab is much the same for all the blocks in the Chart library. Use it to set general options such as whether the graph opens automatically, how autoscaling is handled, and so forth. For example, you might not want to see the graph until the end of the simulation or until you manually open the block's dialog. Or you might clone the graph onto the model worksheet and never need the block's dialog to open. See the User Reference for more information about the options in the Dialog tab's Display tab.
- The modes and options in the Dialog tab's *Data Collection* tab, shown and discussed below, are specific to graphing database data. In addition to having options for what exactly gets graphed and when, the tab has options that limit the amount of recording time and the amount of data that gets recorded.

Data Collection tab

On the Dialog tab, the Data Collection tab is for specifying what data should be collected and when it should be displayed.

What should be shown on the graph

The *Data collection type* frame at the top of the Data Collection tab is for deciding what should be shown on the graph and when. The options are:

- *One cell per trace*. This is the easiest way to view the history of one or more database cells. The values for each selected cell are displayed on a separate trace in the block's Graph tab and reported in a separate column in the Data tab. The source cells can be from the same or different databases. The block reports and displays the values of the cells during the simulation run such that each point on the graph's trace represents the value of the cell at that specific time.

- *One field per trace.* For graphing data from different fields of the same database table. This choice gets the time information from one (and only one) of a table's fields and gets the data information from one or more other fields in that database table. All the fields must come from a single specified database table and that database table must have a time field. The block will report and display the value of each field's records at the associated times in the time field. Thus each record is a point on the graph and a value in the block's data table. The display can occur during or after a simulation run or whenever the graph is manually plotted.

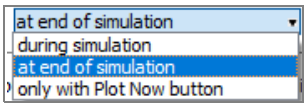
- *One table per trace*. Used to chart data coming from fields in different database tables. For this option, each table must have its own time field as well as at least one data field and each trace will represent one time field and one data field from one database table. If all the fields come from the same database table, it is similar to what happens if you choose "one field per trace".

☞ Each DB Line Chart block has a limit of 20 traces that it can display.

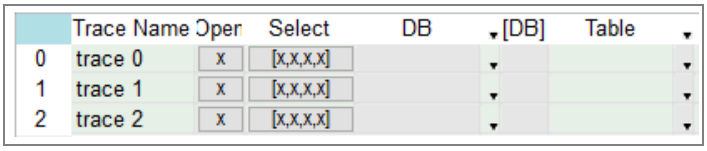
When the source data is collected

The options for when the data is collected are:

- For the "One cell per trace" mode, the data is always collected during the simulation run.
- For the "One field per trace" and "One table per trace" modes, the data collection options are:
  - During the simulation. Note: this option can slow the run because data will be constantly collected.
  - At the end of the simulation.
  - Only when the Plot Now button is clicked. Use this option if you just want to view what is currently in the database. For example, when you don't want to run a simulation or you have paused the simulation and want to view intermediate results.



Where the source data is located

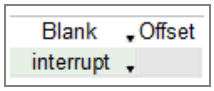


The *Data collections options per trace* frame in the middle of the DB Line Chart's Data Collection tab is for selecting the location that holds the data to be graphed, one row per trace. Most of the option headers are self-evident; the rest are explained here.

☞ Depending on what data is collected and whether the model is continuous or not, some of the following options may not appear in the dialog's Data Collection tab.

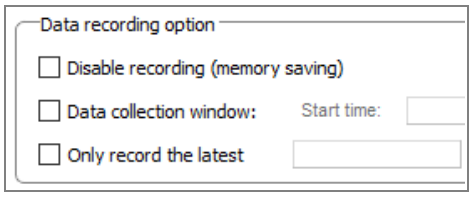
- *Open*. After the complete data source location (address of database, table, field, and record, as appropriate) has been entered, click the button in the Open column to open the Table Viewer. Until then, the button won't be able to open the Table Viewer.
- *Select*. If present, use the Select column to quickly specify the exact database address, rather than selecting each component of the address from the other columns. See the next page for a picture of the Database Address Selector.
- Checking the box for the *Fix* column (shown to the right) causes the trace to take the same name as the identifier (the cell ID or the name of the field or table) for the component that is being traced.

- *Blank*. Depending on the option selected, if a Blank value is received the block can ignore it or interrupt the line.
- *Offset*. Adds the entered number to the trace's Y or Y2 value, offsetting where on the graph the trace gets displayed. Use this if many traces could lie on top of or too close to others. (This option is not available in continuous process models.)



Data recording options

The bottom frame in the Data Collection tab allows you to either:



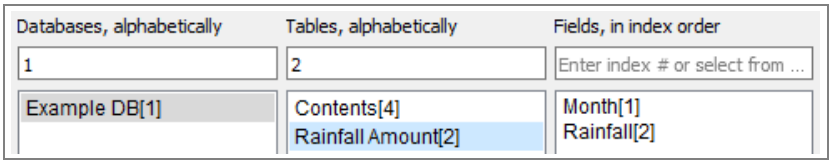
- Completely turn off data recording (saves recalculating time and memory)
- Only collect data during a specific window of time
- Record only the latest specified number of points ("worm chart")

Miscellaneous

Some other features of the DB Line Chart block to note:

- Each DB Line Chart block has a *maximum of 20 traces*.
- You can graph multiple database cells, **or** fields, **or** tables on separate traces in a DB Line Chart block, but you cannot mix cells, fields, and tables in the same block. Instead, use separate blocks for each component.

- You don't need to run a simulation to use the DB Line Chart block. It is also useful when you just want to visualize and compare sets of data within a database or between one database and another. After selecting the data sources and options, use the Plot Now button in the Data Collection tab to graph the data. (Note that this option is not available if you are graphing one cell per trace.)
- If you choose "one cell per trace" for the data collection, the best way to drill down to the wanted cell is by clicking first on a cell in the *Select* column. This takes you to the Database Address Selector so you can choose the database, table, field, and record in one window.



- To increase the number of available rows, and hence the number of traces, in a table in the dialog's Data Collection tab, click the +/- button (as shown to the right) in the lower right corner of the table. Unused rows will appear as empty columns in the Data tab.

Equation-based blocks

The equation-based blocks calculate values for, and perform operations in, models based on formulas and ModL code entered in their dialogs.

Overview

There are five equation-based blocks:

Block	Library	Purpose	See
Equation	Value	Computes user-defined equations and outputs the results	User Reference, How To: Math and Statistics
Equation(I)	Item	Computes user-defined equations when an item arrives, then outputs the results	User Reference, How To: Math and Statistics
Queue Equation	Item	Stores items and releases them based on the results of user-entered equations.	User Reference, How To: Math and Statistics
Query Equation	Value	A user-defined equation selects one record from an ExtendSim database table	page 78
Query Equation(I)	Item	A user-defined equation selects one record from an ExtendSim database table when an item arrives	page 78

☞ The Buttons block (Utilities library) is also equation-based but is used for more specific purposes. It is discussed in the User Reference.

These blocks provide access to over 1,200 ExtendSim ModL functions of the ExtendSim API; you can also use operators to enter logical statements, write compound conditions, and specify loops. The most common use of equation blocks is to write if-then-else logic statements.

The equation can be as simple as performing a mathematical operation on the value from an input connector or it could be as complex as a full programming segment. You can use include files (See *Include Files* in the Technical Reference) within your equation to reuse your own functions among many equation blocks, and you can use the source code debugger (see the User Reference) to check the equation if you have a problem.

The components of an equation are the input variables, the equation, and the output variables. An equation-based block takes input variables, uses those values in the equation, and outputs the results of the calculation. There are several pre-defined input and output variables with static variables you can use in equations and several of them relate to the ExtendSim database. For example, *DB address*, *DB database index*, *DB table index* are pre-defined input variables while *DB write value* and *DB write value using attribute* are output variables.

Use with ExtendSim databases

In addition to the Read/Write blocks from the Value and Item libraries, equation-based blocks also allow you to perform read/write database operations. And while equations require more effort to access the database, sometimes the added control and flexibility they provide are needed. For example:

- Searching. Combine reading and looping logic by searching an entire field (reading one record at a time) for a particular value by calling DBGetDataAsNumber() inside the “for” loop.
- Reading. Specify a DB Read Value as the input variable in the block, then use the read value to influence the if-then-else logic in the equation.
- Writing. Use the value of an input connector variable to write different kinds of information to a database using if-then-else logic.

☞ The Equation, Equation(I), and Queue Equation blocks are used extensively whether a model has a database or not. They are discussed fully in the **How To: Math and Statistics chapter of the User Reference**. Since the two Query Equation blocks are only used to perform ExtendSim database queries, they are discussed below.

Query Equation and Query Equation(I) blocks

☞ Unlike the Read/Write, Data Import Export, and equation-based blocks which have multiple uses, the Query Equation and Query Equation(I) blocks are unique blocks that are only used with the ExtendSim database. Therefore, these two blocks are discussed fully here rather than in the User Reference.

A query finds records in a database according to the criteria you specify. The Query Equation blocks are used to search an ExtendSim database, rank the records, and intelligently select one record based on a ranking rule. A user-defined equation in the block’s dialog is calculated once for each record in the table; the results are used to assign a ranking for each record. The record with the best ranking is the one that gets selected.

The query blocks are used when a database holds information that is required for making decisions in a model. While the querying and ranking behavior could be accomplished using the

Equation blocks, the equations would be long and complicated. Furthermore, the query blocks provide critical pieces of information that support writing more powerful queries.

There are two query blocks:

- Query Equation (Value library)
- Query Equation(I) (Item library)

The major differences between these two blocks is presented in the table on page 83.

⚠ The Query Equation blocks are advanced modeling tools. They are not available in all ExtendSim products.

How the blocks work

A *query cycle* is the point in time when a query block executes its equation to pick the next "winning" record.

- In the case of the Query Equation(I) block in the Item library, this occurs every time an item passes through.
- For the Query Equation block in the Value library, its Options tab has choices for controlling the initiation of the query cycle.

Importantly, only the results of the equation for the winning record are used for that particular query cycle. For example, if the query table has 10 records, the equation will be calculated 10 times, and 10 individual sets of equation results will be collected. However, only the equation results from the record with the best ranking are used and the results from the other 9 records are discarded.

The blocks' input and output variable types are specifically designed to help modelers write equations that will properly rank the records and select the winning record. So that each record will have a ranking, the user-defined equation is calculated once for each record.

The records are ranked according to the ranking rule selected in the block's Options tab; the rules are listed on page 82. The block's internal data structure keeps track of the ranking and any other results of the equation for each record.

☞ At least one *DBQ record rank* output variable is required so that each record can have a ranking.

Spawned items

A feature unique to the Query Equation(I) block is the ability to optionally create additional items. These *spawned* items can then be used for special purposes in the model. This is an independent and parallel system to how the items that pass through the block got created.

☞ A spawned item essentially represents a record that has been "spawned" as an item.

Typically items are created outside of the block and pass through the block. These items are called *pass-through items*. In some instances, you might want to create additional action items, called *spawned items*, based on equation logic and what has been found in the query table. If a spawn is created for a particular record, an equation can be defined in such a way that results particular to the spawned record may be saved as attributes on the spawned item.

To use this feature, enable spawning on the Options tab. This causes a new item output connector to appear on the top edge of the block's icon. It also causes some additional equation variable types, with the prefix DBQS (for database query spawn), to be available. Those variables are shown in the table on page 81.

☞ The equation results for pass-through items are calculated independently from those for spawns.

Pass-through results are associated with the pass-through item and spawn results are associated with the spawned item. For example, results for the pass-through item might get taken from record 6 (because 6 possessed the best pass-through record rank), while the spawn might use results from record 2 (because 2 possessed the best spawn record rank).

When a spawned item is created, it represents a record from the query table. Consequently, you can think of this newly created item as a "spawned record".

☞One pass-through item can result in anywhere from 0-n spawns being created, where n is the number of records in the query table. The number is determined by spawn settings and the equation results.

Variables

The Query Equation blocks have several types of input and output variables. Most of those variables are the same as shared by other equation-based blocks. However, the following variables are unique to the query blocks.

☞ See the How To: Math and Statistics chapter of the User Reference for a list of the input and output variables that are shared by all equation-based blocks.

To modify the number of rows used in the variable tables:

- Change the number of rows in the table by clicking the green +/- resize button in the table's bottom right corner and entering the number of rows desired.
- Delete rows by first selecting the rows you wish to delete, clicking the green +/- resize button, and then selecting the option to "delete selected rows"
- Duplicate any rows by first selecting the row you wish to duplicate, clicking the green +/- resize button, and then selecting the option to "copy selected row."

Input variables

This list is only for variables that are unique to the query blocks; see the How To: Math and Statistics chapter of the User Reference for descriptions of the other input variables.

Input Variable	Query Equation	Query Equation(I)	Uses
DBQ read value	X	X	Requires the user to choose a field in the query table. As the query block starts to loop through each record, this variable automatically takes on the value found in that field for the current record. (This is easier than calling DBDataGetAsNumber() to reference information residing in the query table for the current record.)

Input Variable	Query Equation	Query Equation(I)	Uses
DBQ read PRI	X	X	The Parent Record Index value from the specified field for the current record. See note below.
DBQ start record	X	X	The record to start the query cycle. (The default behavior is to start at record 1.)
DBQ num records	X	X	The number of records in the query table.
DBQ current record index	X	X	The index of the record currently being evaluated in the query cycle.
DBQ static query init	X	X	A static input variable that gets initialized at the beginning of every query cycle.
DBQ current best rank result	X	X	Current best record rank result in the current query cycle.
DBQ current best record	X	X	The record index with the best rank at this point in the current query cycle. If the value of this input is < 1, then no record has yet to be given a ranking.
DBQ num non-blank ranks	X	X	Number of non-blank ranked records at this point in the current query cycle.
DBQS current best rank result		X	Current best spawn rank result in the current query cycle. (Only enabled if spawning is enabled.)
DBQS current best record		X	The record index with the best spawn rank at this point in the current query cycle. If the value of this input is < 1, then no record has yet to be given a ranking. (Only enabled if spawning is enabled.)
DBQS num non-blank ranks		X	Number of non-blank spawn ranked records at this point in the current query cycle. (Only enabled if spawning is enabled.)

☞ The notation PRI (Parent Record Index) is used in blocks that interface with the ExtendSim database. It describes the type of value that is being read or written when dealing with a Child field. See “Fields with string data types; PRI and PRV” on page 48.

Output variables

This list is only for variables that are unique to the query blocks; see the How To: Math and Statistics chapter of the User Reference for descriptions of the other output variables.

Output Variable	Query Equation	Query Equation(I)	Uses
DBQ record rank	X	X	Rank result for the current record
DBQ halt query	X	X	A True value halts the current query cycle
DBQ next record	X	X	Tells block which record to query next
DBQS record rank		X	Spawn rank for the current record
DBQS attribute		X	For assigning attribute values to a spawned item. If the record's spawn rank is good enough to merit a spawning, then results from that record can be attached to the spawned item in the form of *DBQS attributes*. See "Spawned items" on page 79.
DBQS item quantity		X	Item quantity to be placed on spawned item. Also see DBQS attribute, above.
DBQS item priority		X	Item priority to be placed on spawned item. Also see DBQS attribute, above.
DBQS 3D object ID		X	3D object ID to be placed on spawned item. Also see DBQS attribute, above.

As mentioned earlier, while you can specify other equation results, at least one of the output variables has to be of the type *DBQ record rank*. Furthermore:

- Only the results for the record ranked best will be output.
- You can use more than one *DBQ record rank* variable; the secondary ranking variable will be used to arbitrate in the case of tied ranking. This is useful if you are concerned with tie breaking for two or more records having the same primary. What constitutes a tie can also be defined on the Options tab with the parameter *Records ranked within +/- X are equal*.
- If the Spawning option is enabled, at least two output variables are required – one variable of *DBQ record rank* type plus one variable of *DBQS record rank* type.

Ranking rules

The rules that determine which record is selected are given on the block's Options tab:

For a pass-through item

- **Highest pass-through record rank**. Each record's rank value is calculated by the equation. The one with the highest rank is chosen.
- **Lowest pass-through record rank**.Each record's rank value is calculated by the equation. The one with the lowest rank is chosen.
- **First True record rank**. The equation will be calculated once for each record until either:

- A record receives a True ranking
- Or, there are no records left to evaluate

For a spawned item

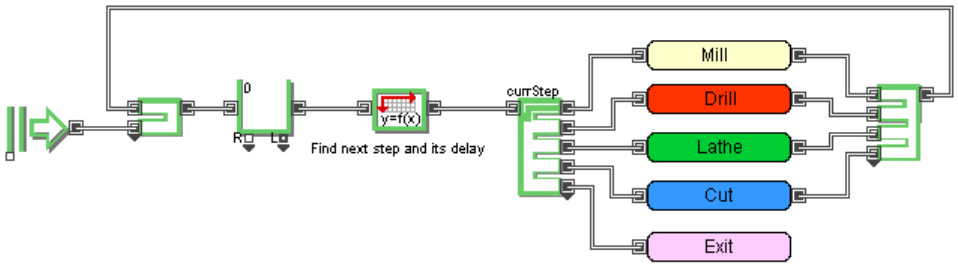
- **Highest spawn record rank**. Each record's rank value is calculated by the equation. The one with the highest rank is chosen.
- **Lowest spawn record rank**.Each record's rank value is calculated by the equation. The one with the lowest rank is chosen.
- **First True spawn record rank**. The equation will be calculated once for each record until either:
  - A record receives a True ranking
  - Or, there are no records left to evaluate
- **True spawn record ranks**. Any record receiving a spawn rank ≥ 0.5 will be spawned. This makes it possible to create any number of spawned action items for one pass-through item.

Differences between the query blocks

Description	Query Equation	Query Equation(I)
Query cycle initiated only when an item arrives (similar to the Equation(I) block).		*X*
Query cycle initiation is controlled using options on the Options tab (similar to the Equation block).	X	
Supports Spawning		X
Works in continuous models	X	
Works in discrete event models	X	X
Works in discrete rate models	X	X

DB Job Shop Query model

The DB Job Shop Query model is located at ExtendSim/Examples/Discrete Event/Routing.



DB Job Shop Query model

The model simulates three parts, each with their own process sequence, being routed through five potential processes. Depending on the part, a process sequence is made up of some combination of milling, drilling, lathing, cutting, and exiting. For example, the process sequence for part 100-3 is cut, mill, lathe, drill and then exit, while the sequence for part 100-1 only contains a milling step before exiting. Each step in the process has a random delay that is unique to each part type.

All the information needed to drive this model is located in the ExtendSim database named Database 1. The table structure of that database is shown here.

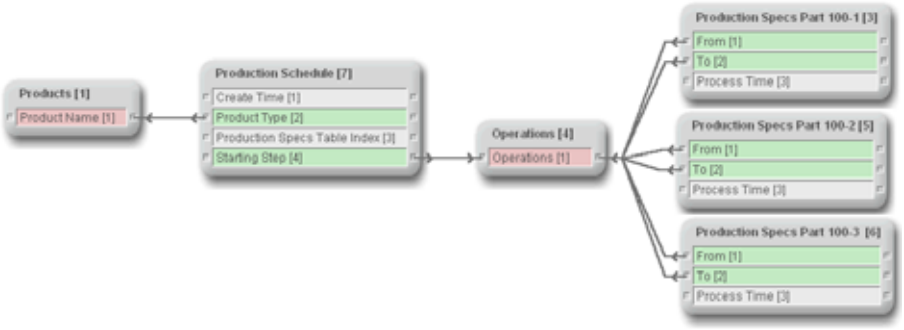


Table structure of Database 1

- The Products table contains the names of the three parts that are modeled.
- The Production Schedule table is used by the Create block (through linking) to create parts by schedule.
- The Operations table contains a list of the five different potential operations – mill, drill, lathe, cut, and exit.
- Each of the three part types has an associated Production Specs table. This is used to define the steps in a part's production sequence and the delays associated with each step. The From and To fields are used to define the appropriate destination given a particular origin: “If you come from here, go to there next.”

In the model, one Query Equation(I) block is used to find the current part's next process step and its associated delay. Both pieces of information are then stored as attributes on the pass-

through item. When the next item/part arrives, the query block starts looping through the Production Specs table associated with that part.

In this example, the query block is looking for the record whose *From* value matches the *currStep* attribute found on the item. Once that is found, the block then finds the associated *To* and *Process Time* values for that record and stores them as attributes on the item.

The equation in the query block is:

```
if(currStep == fromField)
     {
     rank = True;
     currStep = toField;
     activityDelay = delayField;
     }
else
     {
     rank = False;
     }
```

Given the complexity of what the query block is doing, the code is very simple.

Excel Add-In

The ExtendSim DB Add-In is a tool for externalizing the modification and construction of ExtendSim databases.

Uses

Use the Add-In to:

- Import an ExtendSim database text file into Excel for editing, then export it back to ExtendSim.
- Create new, fully structured, ExtendSim database files within Excel, then export those files for use within ExtendSim.
- Let Excel be the master for documenting the data and database structure. For instance, charts and data tables can be added in Excel to help explain or analyze inputs to the database. (Any tables that do not start on row 20 can be used because they are not considered ExtendSim database tables and will be discarded when the file is exported to ExtendSim.)

The data and structure of an ExtendSim database can thus be edited or created in Excel, separate from, and even in the absence of, the ExtendSim application. For example, analysts can structure or edit database files for use in models without knowing anything about ExtendSim.

☞ The DB Add-In for Excel is included only in specific ExtendSim products; it can also be purchased separately by those who have other ExtendSim products or who don't have ExtendSim.

Using ExtendSim versus the DB Add-In to create or modify a database

Depending on which environment you feel more comfortable in, you can choose to create database files in Excel or in ExtendSim. There are some things to note though:

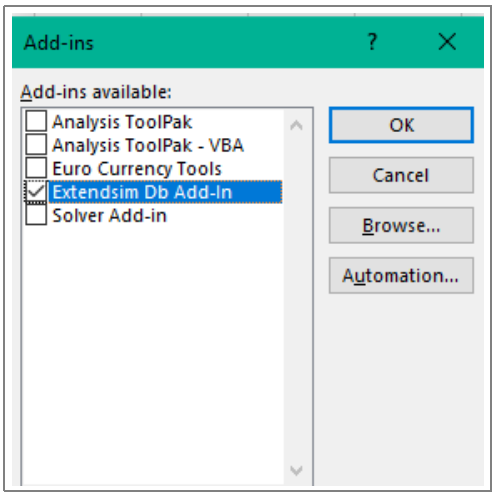
- There is no undo in the Add-In.

- In ExtendSim, database tables can exist on multiple tabs. In Excel, a database table can only exist on one worksheet.

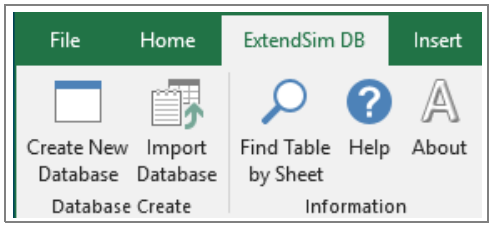
Installing the Add-In

⚠ The DB Add-In only works on Windows operating systems and requires Office 2007 or better.

To install the Add-In into Excel:



- Follow the Excel instructions for installing an Add-In. These will differ depending on the version of Excel and the platform you're installing on. For example, in Excel you might go to Insert > My Add-ins. Then from the My Add-ins popup choose Manage Other Add-ins > Manage Excel Add-ins > Go...
- In the Add-ins dialog, click the **Browse** button.
- Navigate to the **ExtendSim DB Add-In.xlam file**; it is located in the Documents/ExtendSim/Extensions folder.
- Select the ExtendSim DB Add-In.xlam file and click OK. This puts ExtendSim DB Add-In in the list of available Add-Ins as shown here. (Make sure the checkbox next to ExtendSim DB Add-In is checked.)
- Click OK to close the Excel Add-Ins dialog.



This action installs a new menu into Excel named "*ExtendSim DB* with commands (shown here) for creating a new database, importing a database, and so forth as shown here.

After a database text file has been imported or when a new database file is being created, other commands appear in the ExtendSim DB menu for adding a table, making a cell random, editing parent/child relations, and so forth.

⚠ If you have an older version of the Add-In (the older extension is .xla), uncheck the existing Add-In in the Add-Ins dialog, then browse to the newer DB Add-In and follow the above process. *You must restart Excel to finish the update.*

Importing and exporting database files

If the Add-In is used, the files exchanged between ExtendSim and Excel are formatted as database text files.

Exporting from ExtendSim

To export a database file from ExtendSim so that Excel can import it, see "Importing or exporting an ExtendSim database" on page 52. The exported file will be in a special database text file format.

Importing to Excel

To import a database text file into Excel, give the command ExtendSim DB > Import Database. Then choose a database text file that has been exported from ExtendSim using the Export Database command, as mentioned above.

During importing, the Status bar at the bottom of the workbook reports the current table as well as the number of the record being imported and the total number of records that will be imported.

After the file has been opened, you will be given the opportunity to perform a database consistency check, discussed on page 91.

If some or all of the database tables had been organized onto different tabs in the database, as discussed in "Use tabs to categorize tables" on page 29, Excel will populate the workbook with worksheets that correspond to those tabs. Thus each worksheet is the equivalent to one of the tabs in the imported database.

Exporting from Excel

To export a database file from Excel so that ExtendSim can import it, give the command ExtendSim DB > Export Database. The workbook will be exported as a database text file.

The DB Add-In will not allow you to export a database from a workbook until the database structure and content have been successfully validated, as discussed on page 91. During export, the Indexed Fields table (Data Relationship tab) in the workbook will be erased and repopulated with the current data from the workbook.

☞ Only ExtendSim formatted tables, those with fields present on row 20 of the worksheets, will be exported. If you use tables or pivot tables in the workbook to help explain or analyze input, start those on rows other than row 20.

Importing to ExtendSim

See "Importing or exporting an ExtendSim database" on page 52.

Creating a new database in Excel

The ExtendSim DB Add-In can be used to fully specify an ExtendSim database in Excel, including parent/child relationships, formatting, data validation, and more.

To create a new ExtendSim database in Excel, install the ExtendSim DB Add-In and give the command ExtendSim DB > Create New Database. This opens a new workbook with three tabs:

- All Tables
- Tab 1
- Data Relationships

The All Tables and Data Relationships tabs are discussed in "Required and protected worksheets" on page 88.

The All Tables and Tab 1 worksheets are for creating ExtendSim database tables. Add more worksheets as desired.

⚠ Any tables that you want registered as ExtendSim database tables must have their fields present on row 20. Any other tables will be discarded upon export.

Required and protected worksheets

Depending on the file's contents, a new or newly imported database file will have two or three worksheets that are required for the database's internal structure:

- *All Tables* is similar to the ExtendSim database's All Tables tab. However, because Excel database tables can only exist on one worksheet at a time, the only tables that show on this worksheet are those that don't appear on other worksheets. You can rename or, if empty, delete this worksheet. If this worksheet is not present when the file is exported from Excel, the Add-In will create it and ExtendSim will populate it with a duplicate reference to all the tables in the Excel database.
- *Data Relationships* has an Indexed Fields table for storing all parent-child relationships in the database. This worksheet is placed after any imported worksheets.
- *Named Distributions* stores a list of the named distributions used in the model, if any. If present, this worksheet is placed after the Data Relationships worksheet.


Do not delete or rename the Data Relationships or Named Distributions worksheets. Furthermore, do not place any other tables on those worksheets.

Creating or modifying database components


Use the Add-In commands to create or delete tables, add/delete/modify fields, and so forth. Do not use the regular Excel menu commands.

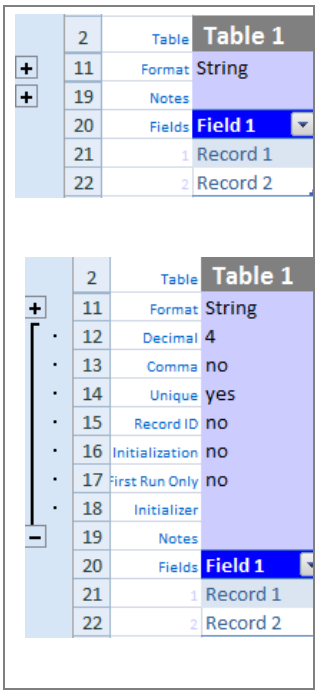
Adding a table

- Click in any column of the worksheet and give the command ExtendSim DB > Add Table.
- In the dialog that appears, name the table and indicate how many fields it should have. (See note below about renaming a table.)

The new database table will be added to the worksheet with its field name(s) on row 20.

Modifying table or field characteristics

- To modify table or field characteristics, click one of the Ungroup (+) buttons at the far left of the worksheet. The top Ungroup button is for table properties; the lower Ungroup button is for field properties. As shown at right, clicking these buttons expands the header rows above row 20 so you know which rows govern which properties.
- To change a property, select the cell associated with that property and make the change. Some properties, such as Decimal, are changed by entering the desired number. Other properties, such as Comma and Unique, are changed using the cell's Yes/No popup. Format has a popup that allows the same options as the ExtendSim database.



⚠ To change a table's name, double click the name and make the change in the Rename a Table dialog that appears. Do not change table names using the Excel formula bar.

Modifying the table size

To add a field (column) to a table:

- Select an existing field's name at row 20 so that additional Add-In menu commands are enabled.
- Then give the command ExtendSim DB > Insert New Field (to place the new field to the left of the selected field) or ExtendSim DB > Append New Field (to place the new field to the right of the selected field).

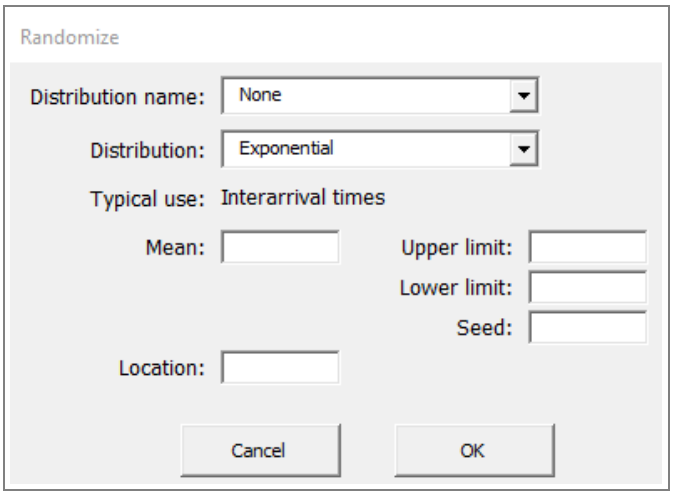
☞ You must select a field's name in row 20 to enable the Add-In menu commands.

To add more records (rows) to a table:

- Click the bottom right corner of the table until the cursor changes to a resize arrow.
- Then drag to get the correct number of records. The screen shot above shows two records below the Field 1 identifier.

Cell randomization
To make a data cell random:

- Select the cell and choose the command ExtendSim DB > Make Random.
- In the Randomize dialog that appears, select the distribution and enter required values.



Empirical tables must be named and require additional information. In the Randomize dialog's "Distribution name" popup select *Save to Named Distribution*, then give the table a name. Choose if the values are discrete, stepped, or interpolated. Then click the Set Values button and enter values and probabilities on the Empirical Table Data worksheet that appears. Be sure to enter probabilities that total 100 for all the rows you want values in, then click OK. To view the table, go to the Named Distributions worksheet.

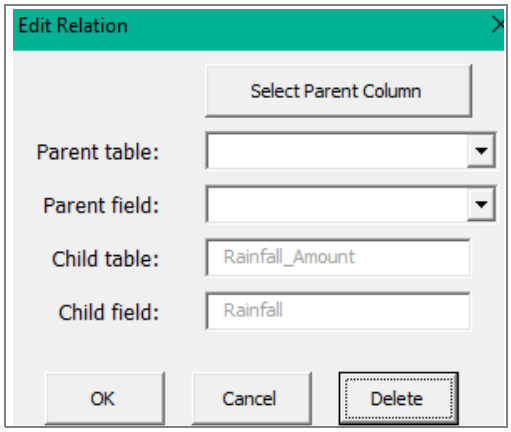
- Other than for the empirical table, it is optional to name the distribution. However, named distributions appear on the Named Distributions worksheet and are made available to other cells when Make Random is clicked.
- You can only randomize cells with an appropriate format, such as general. If the Make Random command is not enabled, check the field format.

Parent/child relationships

Parent and child fields are color-coded in the workbook. This matches the parent/child color coding in ExtendSim – red text for parent fields and green text for child fields. All relations are stored on the Data Relationships worksheet.

☞ A parent field must be designated as Unique and must have Record ID enabled. Make those changes in the parent's field properties header before creating a relationship.

- To create a parent/child relationship, right-click the name of the proposed child field to get the Edit Relation dialog shown at right. Then either:
  - Click the Select Parent Column button and select the column that contains the field you want as the parent.
  - Or, use the popups to choose the parent table and field.
- To change relationships, go to the Data Relationships worksheet and select the pertinent cell in the Indexed Fields table. Then give the command ExtendSim DB > Edit Parent Child Relations and enter the correct table and field names into the Edit Parent-Child Relations dialog.



Child field names are hyperlinked to their parent fields. For example, clicking on a child field's green header takes you to the linked field in the parent table. This allows use to quickly find parent tables and view the list of valid child values.

Check Database Consistency

One of the ExtendSim DB Add-In menu options is "Check Database Consistency". This command performs validations of the database and its parent/child relations, ensuring that the database structure and data content are internally consistent and valid.

Database consistency is checked every time a database file is exported from Excel and (optionally) when a database file is imported to Excel. You can also click the button to check consistency at any time.

If errors are found a message is displayed at the completion of the check and the errors are recorded in an Errors Summary worksheet. The Errors Summary worksheet will have hyperlinks to the errors so they can be fixed.

The Check Database Consistency command performs the following checks.

3) Parent/child data content. For each child field, the contents are checked to ensure that corresponding values exist in the parent fields of the parent tables.
4) Parent/child relations. The user-defined parent/child relations in the Indexed Fields table are validated. This check ensures that each child and parent table and each parent and child field referenced in the Indexed Fields table actually exists in the database workbook.
5) Table and field name uniqueness. This ensures that each table name in this specific workbook is unique and each field name is unique for the given table.
6) Each value unique. This looks at the record contents for each field where the field property named Unique is designated as Yes. The validation ensures that all values in the corresponding tables are unique.
7) The database is checked for any required unique fields. If some parent fields are not marked as unique, the Add-In will resolve any parent/child conflicts by linking the child to the first appropriate parent field it locates.

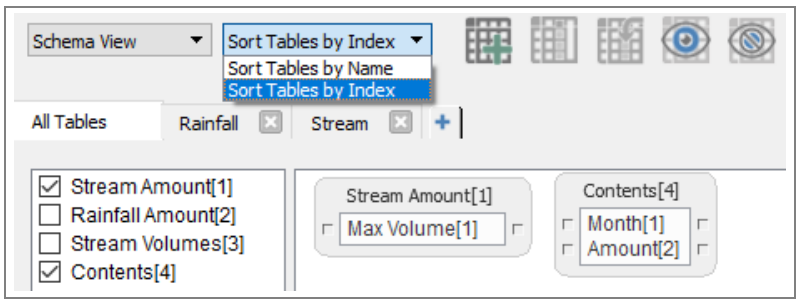
Any errors are reported on an Excel worksheet with hyperlinks to each error and an appropriate error message.

Find Table by Sheet

This command allows users to quickly find and go to a database table in their workbook. Selecting the command opens a dialog that displays a list of all the worksheets for the database and all the tables in the selected worksheet.

What's new in the database since release 9.0

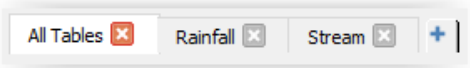
The ExtendSim internal relational database has been completely rewritten for release 10. In addition to all the capability of the previous iteration, this 3rd generation release is more powerful, easier to use, and has a new interface.



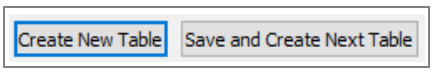
The new features include:

- Sort the list of tables by name or by index in Schema or Data view, as shown above.
- Use the ExtendSim toolbar buttons to zoom in or out on database tables, fields, and records. Zoomed appearances are saved with the database.

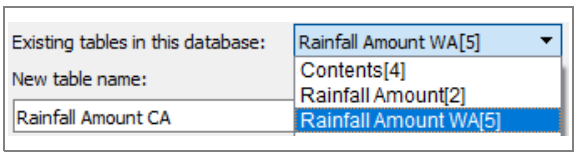
- Rename a database using either the new Database > Edit Database Properties command or the Window > Database List command.
- Click to add, delete, or rename a tab in the database window.



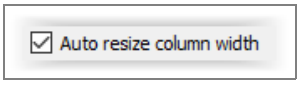
- Store a virtually unlimited amount of data in tables due to the ExtendSim 64 bit capability.
- Create multiple new databases, tables, and fields from the same window using the *Save and Create New* buttons.



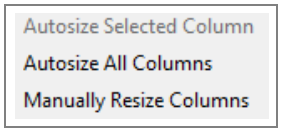
- When creating a new database, table, or field, selecting an existing name in the popup menu will cause that name to appear as the *New name*. Append characters or otherwise change that name to create a unique name for your new database, table, or field.



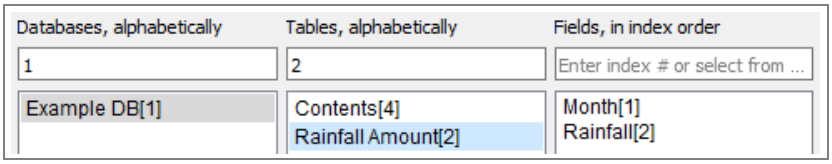
- When creating a new field, choose *Auto resize* to have the column automatically minimize based on the size of its largest cell. To select *Auto resize a*fter creating the field, select the field in Schema view using the Edit Field Properties command or right-click menu.



- To autosize or manually resize a column, in Data view or the Table Viewer select a field and right-click for the menu shown here.



- In blocks that access an ExtendSim database, such as the DB Line Chart block (Chart library), quickly capture an entire database address by selecting components or by entering names or indexes in the database address selector.



- When editing properties, select a database, table, or field to modify by scrolling through the popup list at the top of the dialog.

- Find a number or a string using the Find Data in Table or Find Data in Database commands.
- Open Schema view, or bring it forward if already open, using a new Open Schema View button in the Table Viewer.

- The new Clean Up Tables button allows you to cause visible tables to reposition so they don't overlap.
- As discussed starting on page 73, there is also a new **DB Line Chart** block (Chart library) that either traces the history of values received over time during the simulation or reports the content of database tables. The Chart can display up to 20 lines; each line gets its values from an ExtendSim database. The block can be used in discrete event, discrete rate, and continuous process models.

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