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I B I S C O N N E C T O R S P E C I F I C A T I O N
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Last Updated: 04-19-2001, AP
Generally, attempted "alignment with "IBIS-x" specification header
ADD "ARGUMENT" TO EVERY KEYWORD

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Specification Revision level 0.962
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Section 1

1.0 GENERAL INTRODUCTION
=====

This section gives a general overview of the remainder of this document.
Sections 2 to 5 contain general information about the IBIS versions and the general rules and guidelines.
The remaining sections describe the connector keywords and usage rules.

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Section 2

2.0 STATEMENT OF INTENT
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In order to enable an industry standard method to electronically transport IBIS connector modeling data between connector vendors, simulation vendors, and end customers, this template is proposed. The intention of this template is to specify a consistent format that can be parsed by software, allowing simulation vendors to derive models compatible with their own products.

One goal of this template is to represent the current state of IBIS data, while allowing a growth path to more complex models / methods (when deemed appropriate). This would be accomplished by a revision of the base template, and possibly the addition of new keywords or categories.

Another goal of this template is to ensure that it is simple enough for connector vendors and customers to use and modify, while ensuring that it is rigid enough for simulation vendors to write reliable parsers.

This template is meant to contain a complete description of the elements on an entire connector or family of connectors.

This template is intended to provide a basis for future versions which are expected to be backward compatibility with this initial version.

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Section 3

3.0 REVISION HISTORY
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02-28-2000, AP
Reformatted to IBIS-X `ish

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Section 4

4.0 GENERAL SYNTAX RULES AND GUIDELINES

- 1) The content of the files is case sensitive, except for reserved words and keywords. File names must be all lower case.
- 2) The following words are reserved words and must not be used for any other purposes in the document:
 - PWRGND- reserved model name, used with power or ground pins,
 - POWER - reserved model name, used with power supply pins,
 - GND - reserved model name, used with ground pins,
 - RET - reserved word indicating either power or ground used as a high-frequency return path.
 - NC - reserved model name, used with no-connect pins,
 - NA - used where data not available.
- 3) Each line in the file must be 120 characters or less excluding end of line characters.
- 4) Anything following the comment character is ignored and considered a comment on that line. The default "|" (pipe) character can be changed by the keyword [Comment Char] to any other character. The [Comment Char] keyword can be used throughout the file as desired.
- 5) Keywords must be enclosed in square brackets, [], and must start in column 1 of the line. No space or tab is allowed immediately after the opening bracket '[' or immediately before the closing bracket ']'. If used, only one space (' ') or underscore ('_') character separates the parts of a multi-word keyword.
- 6) Underscores and spaces are equivalent in keywords. Spaces are not allowed in sub-parameter names.
- 7) Valid scaling factors are:

T = tera	k = kilo	n = nano
G = giga	m = milli	p = pico
M = mega	u = micro	f = femto

When no scaling factors are specified, the appropriate base units are assumed. (These are volts, amperes, ohms, farads, henries, and seconds.) The parser looks at only one alphabetic character after a numerical entry, therefore it is enough to use a single character suffix to scale the parameters. However, for clarity, it is allowed to use full abbreviations for the units, (e.g., pF, nH, mA, mOhm). In addition, scientific notation is allowed (e.g., 1.2345e-12).
- 8) WARNING: use of TAB characters may make imported files invalid. The usage of TAB characters is legal but NOT RECOMMENDED. They should be avoided as far as possible. This is to eliminate possible complications that might arise in situations when TAB characters are automatically converted to multiple spaces by text editing, file transferring and similar software. In such cases lines might become longer than allowed causing a syntax error.
- 9) Currents are considered positive when their direction is into the component.
- 10) All temperatures are represented in degrees Celsius.
- 11) Important information is contained in the sample files provided with the specification and these should be referred to as a starting point for creating new models.

- 12) Use of connectors with more than 100000 pins is not recommended and should generate a warning by the parser indicating that CAE tools may not support this model.
- 13) The numeric accuracy used in the file should not be significantly greater than the accuracy of the model.
It is recommended that for numeric data the mantissa portion be less than or equal to 5 decimal digits. In no case shall more than 15 decimal digits be used.
For example:
 1.2345e-12 is considered acceptable
 1.23456789e-12 is allowed but not recommended
 1.234567890123456e-12 is not allowed
 The 5 digit recommendation will aid in human readability of files4 and reduce the file size.
- 14) Only ASCII characters, as defined in ANSI Standard X3.4-1986, shall be used in an IBIS file. The use of characters with codes greater than Hexadecimal 07E is not allowed. Also, ASCII control characters (those numerically less than hexadecimal 20) are not allowed, except for tabs or in a line termination sequence. As mentioned in item 10 above, the use of tab characters is discouraged.

=====
 Section 5

5.0 KEYWORD TREE DIAGRAM
 =====

- (ml) Indicates that keyword may occur multiple times at any location.
 (m) Indicates that keyword or sub-parameter may occur multiple times within the context for which it applies.

```

/-- Start of File
-----
|-- [Begin_Header]
|   |-- [IBIS_Cn_Model_Ver]
|   |-- [Comment Char]           (ml)
|   |-- [File Name]
|   |-- [File Rev]
|   |-- [Date]
|   |-- [Source]
|   |-- [Notes]
|   |-- [Disclaimer],[Copyright]
|   |-- [Manufacturer]
|   |-- [Support]
|   |-- [Redistribution]
|   |-- [Redistribution_Text]
|-- [End_Header]
-----
|-- [Begin_Cn_Model_Family]
|   |-- [Begin_Cn_Family_Description]
|   |   \-- [End_Cn_Family_Description]
|   |-- [Manufacturer]
|   |-- [Begin_Cn_Model_List]
|   |   \-- [End_Cn_Model_List]
|
|   |-- [Begin_Cn_Model]           (m)
|       |-- [Begin_Cn_Model_Description]
|       |   |-- [End_Cn_Model_Description]
|       |-- [Cn_Number_of_Conductors]

```

```

        |-- [Cn_Columns_of_Pins]
        |-- [Cn_Rows_of_Pins]
        |-- [Cn_Col_Swath]
        |-- [Cn_Row_Swath]
        \-- [End_Cn_Model]
|
|-- [Begin_Cn_Auto_Map]                                (m)
    |-- [Cn_Col_Range]
    |-- [Cn_Row_Range]
    \-- [End_Cn_Auto_Map]
|
|-- [Begin_Cn_Pin_Map]                                (m)
    \-- [End_Cn_Pin_Map]
|
|-- [Begin_Cn_Section]                                (m)
-----
    |-- [Derivation Method]    Lumped, Distributed
    |-- [Resistance Matrix]    Banded_matrix, Sparse_matrix,
                                Full_matrix, Diagonal_Matrix
-----
    |-- [Bandwidth]
    |-- [Row]                    (m)
|-- [Inductance Matrix]        Banded_matrix, Sparse_matrix,
                                Full_matrix, Diagonal_Matrix
-----
    |-- [Bandwidth]
    |-- [Row]                    (m)
|-- [Capacitance Matrix]      Banded_matrix, Sparse_matrix,
                                Full_matrix, Diagonal_Matrix
-----
    |-- [Bandwidth]
    |-- [Row]                    (m)
    \-- [End_Cn_Section]
|
\-- [End_Cn_Model_Family]
|
\-- [End]

```

Section 6

6.0 KEYWORDS

```

=====
Keyword:  [Begin_Header]
Required: Yes
Argument: None
Description: This keyword denotes the beginning of the file header section.
Usage Rules: [Begin_Header] must be the first keyword in any IBIS-X file.
              This keyword may be preceded by lines of general text and/or
              comments which should be treated as comments by the parser.
-----

```

[Begin_Header]

```

=====
Keyword:  [IBIS_Cn_Model_Ver]
Required: Yes
Argument: Text Block

```

Description: This keyword allows electronic parsers to immediately determine that this file contains an IBIS connector model. The version number is used to inform the parser what keywords are valid for this model and to allow backward support as new keywords are added.

Usage Rules: IBIS_Cn_Model_Ver] MUST BE THE FIRST KEYWORD in the file. It is normally on the first line of the file, but can be Receded by comment lines that must begin with a "|".

Context:

- 1) MUST BE THE FIRST KEYWORD in the file.
- 2) It is normally on the first line of the file, but can be receded by comment lines that must begin with a "|".

[IBIS_Cn_Model_Ver] 1.0

=====

Keyword: [File Name]

Required: Yes

Argument: Text String (file name)

Description: Specifies the name of the IBIS-X file.

Usage Rules: The purpose of this keyword is to document a single filename the file uses even if the file is transferred from one computer to another. The file name must conform to the rules given in section 4, "General Syntax Rules and Guidelines".

- 1) The file name must have the file extension .icm
Note: icm stands for "Ibis Connector Model"
- 2) The file name must be 40 characters or less in length.
- 2) The file name must be all lower case to avoid problems with certain operating systems.
- 4) This name must match the actual name used for this file.

Notes on file naming:

To make maintenance of libraries of connector models from different companies easier the following recommendations are made:

- 1) It is recommended that the first 8 characters or less of the file name indicate the name of the company creating the model. Typically the abbreviation indicating the connector company. It is recommended that manufacturing company names or abbreviations only be used when the model is created by said company or their representative. If a user creates a model then the name prefix should represent their company not the manufacturer of the part to avoid confusion of vendor created vs. user created models.
- 2) In the example below note the name of the company manufacturing the connector is "Ibis Connector Manufacturing" -> abbreviation = iconm

Usage Context:

- 1) MUST BE THE SECOND KEYWORD in the file.
- 2) It is normally on the second line of the file, but can be preceded by comment lines that must begin with a "|".

[File Name] iconm_hdi_202.icm

=====

Keyword: [File Rev]

Required: Yes
 Argument: Text String
 Description: Tracks the revision level of a particular .ibs file.
 Usage Rules: Revision level is set at the discretion of the engineer
 defining the file. The following guidelines are recommended:
 0.x silicon and file in development
 1.x pre-silicon file data from silicon model only
 2.x file correlated to actual silicon measurements
 3.x mature product, no more changes likely

 [File Rev] 1.0 Used for .icm file versions

=====

Keyword: [Comment Char]
 Required: No
 Argument: Text Block
 Description: Defines a new comment character to replace the default
 "|" (pipe) character, if desired.
 Usage Rules: The new comment character to be defined must be followed by
 the underscore character and the letters "char". For example:
 "|_char" redundantly redefines the comment character to be
 the pipe character. The new comment character is in effect
 only following the [Comment Char] keyword. The following
 characters MAY be used:

! " # \$ % & ' () * , : ; < > ? @ \ ^ ` { } ~

The [Comment Char] keyword can be used throughout the file, as
 desired.

 [Comment Char] |_char

=====

Keyword: [Date]
 Required: No
 Argument: Text String (Date)
 Description: Date this file was last modified.
 Usage Rules: This keyword is provided to insure the last changed date for
 this file is not lost if the file is transmitted between
 computer systems.

 [Date] July 1, 2000 The latest file revision date

=====

Keyword: [Source]
 Required: No
 Argument: Text Block
 Description: Records the originating source of model data.
 Usage Rules: Use this keyword to record how the model information was
 obtained (physical measurement of device, simulations, data book,
 etc.).

NOTE: It is recommended that the argument to the [Source]
 keyword be limited to a maximum of 24 lines of text.

 [Source] Put originator and the source of information here. For example:
 From silicon level SPICE model of from lab measurement.

Compiled from manufacturer's data book at "Company XYZ".

```
=====
Keyword:  [Notes]
Required:  No, unless the [Redistribution] keyword specifies the value
           "Specific" as its argument.
Argument:  Text Block
Description: Optional notes regarding the file.
Usage Rules: The keyword provides a place for the model maker to record
             important notes about the file or model data that are not
             included elsewhere. Such information may include notes on
             validation level, model limits, usage assumptions, etc.
```

NOTE: It is recommended that the argument to the [Notes] keyword be limited to a maximum of 24 lines of text.

If the required keyword [Redistribution] takes as its argument the value "Specific", then the [Notes] keyword must contain information on this model's licensing and redistribution requirements. Refer to the description of the [Redistribution] keyword for more details.

The [Notes] keyword can only be used once.

```
-----
[Notes]      Use this section for any special notes related to the file.
```

```
=====
Keyword:  [Disclaimer], [Copyright]
Required:  No
Argument:  Text Block
Description: Legal disclaimer and copyright information
Usage Rules: Because IBIS-X model writers may consider the information in
             these keywords essential to users, and sometimes legally
             required, design automation tools should make this information
             available. Derivative models should include this text
             verbatim. Any text following the [Copyright] keyword must be
             included in any derivative models verbatim.
```

NOTE: It is recommended that the arguments to the [Disclaimer] and [Copyright] keywords be limited to a maximum of 96 lines of text.

```
-----
[Disclaimer] This information is for modeling purposes only, and is not
             guaranteed.
[Copyright]  Copyright 2000, XYZ Corp., All Rights Reserved
```

```
=====
Keyword:  [Manufacturer]
Required:  Yes
Argument:  Text Block
Description: Clarifies the component's manufacturer.
Usage Rules: 1) The length of the Manufacturer's Name must not exceed 40
             characters (blank characters are allowed, e.g., Illinois
             Connector Corporation).
```

Usage Context:

1) It is recommended that this keyword appear shortly after the keyword [Begin Cn Model Family].

NOTICE: Each manufacturer should use a consistent name in all .icm files.

[Manufacturer] XYZ Corp.

=====
Keyword: [Support]
Required: No
Argument: Text Block (URL path name)
Description: Specifies a web site that can be visited to get the latest version of the file.
Usage Rules: Following the [Support] keyword is the URL of a web site the user may visit for more information on the model or model(s). If the URL given is the web site root then the .html or .htm extension is not required. The [Support] keyword may appear only once between the [Begin Header]/[End Header] keyword pair.

NOTE: It is recommended that a separate IBIS model web site (not page) be maintained to prevent accidental changes of page name from breaking this link.

[Support] www.VendorName.com\with\a\very\very\very\very\very\very\very\very\very\very\very\very\long\path.html |example with long path
[Support] www.VendorNameIbisModels.com |example ibis web site root

=====
Keyword: [Redistribution]
Required: Yes
Argument: Text String (Yes, No, Specific)
Description: Indicates to CAE tool companies and model users who may use and redistribute this file.
Usage Rules: Following the [Redistribution] keyword is one of three arguments: "Yes", "No" and "Specific".

An argument value of "Yes" means that a CAE tool vendor or end user may freely distribute the model as long as no fee is charged. A fee may be charged if authorized by the model creator.

An argument value of "No" means that the model may not be redistributed or retransmitted in any form.

An argument value of "Specific" means that specific license information is contained in the [Notes] field. Use of the "Specific" argument prevents automated redistribution.

[Redistribution] Yes

=====
Keyword: [Redistribution Text]
Required: Yes if [Redistribution] value is "Specific, otherwise it is optional
Description: Use this section for any special notes related to the redistribution. Allows model creator to supply specific redistribution information

Usage Rules: 1) It is recommended that a maximum of 24 lines of text be used for the [Redistribution Text] description. The end of this section is determined by finding the next keyword in square brackets.
2) This keyword may only appear more once in the file.

Usage Context:

1) May only appear after keyword [Redistribution].

[Redistribution Text] Your legal text goes here.

=====
Keyword: [End Header]
Required: Yes
Argument: None
Description: Marks the end of an IBIS-X header section.
Usage Rules: [End Header] must be the last keyword in any IBIS-X header section.

Argument: None

[End Header]

=====
Keywords: [Begin Cn Model Family] [End Cn Model Family]
Required: yes
Description: The name of the connector family in this file. These commands wrap the entire model in this file.
Usage Rules: 1) Only a single occurrence of each [Begin Cn Model Family] and [End Cn Model Family] is allowed in the file.

Usage Context:

- 1) It is recommended that [Begin Cn Model Family] appear shortly after the keyword [Source].
- 2) It is recommended that [End Cn Model Family] be the last line in the file.

[Begin Cn Model Family]
[End Cn Model Family]

=====
Keywords: [Begin Cn Family Description] [End Cn Family Description]
Required: Yes
Argument: Text Block
Description: Provides a concise yet easily human-readable description of this connector family.
Usage Rules: 1) It is recommended that a maximum of 4 lines be used. Each line must be 120 characters or less.
2) The end of this section is determined by finding the keyword [End Cn Family Description]
3) Only a single occurrence of each [Begin Cn Family Description] and [End Cn Family Description] is allowed in the file.
4) Do not put spaces or indent at the beginning of the line as this text will be formatted in text display controls by CAE tools.

Usage Context:

- 1) It is recommended that the keyword [Begin Cn Family Description] be the first keyword used in the file after the keyword [Begin Cn Model Family].
- 2) It is required that the keyword [End Cn Family Description] be the first keyword used after keyword [Begin Cn Family Description].

 [Begin Cn Family Description]
 High Density 0.1 center square pin connector designed for use on IEEE 99999 buses.
 [End Cn Family Description]

=====

Keywords: [Begin Cn Model List] [End Cn Model List]
 Required: yes
 Argument: Text Block
 Description: For each connector described in this file an entry is provided which names the connector specifies it's mating, maximum slew time (for which the model is valid), and provides a link to a picture of the connector.
 Usage Rules: 1) Defines which models are present in the file.
 2) Mating is required and describes the mating for this model,
 3) Mated means both halves of the connector are mated together for the model.
 4) Valid mating types are:
 Mated
 UnMated_Side_A
 UnMated_Side_B

- NOTES:
- 1: Using two unmated models in series DOES NOT provide a correct model of a mated connector.
 - 2: "UnMated_Side_A" MUST BE the back plane side if this applies to this connector.
 - 3: Unmated models should be provided for connectors that are likely to be used in backplanes, motherboards, or buses.
 - 4: At least one of these "Mating" choices is required
 - 5: Min_Slew_Time is required and specifies the minimum slew time (i.e. fastest edge) for any signal using this model. This is a 20% to 80% slew time.
 - 6: Image is optional and specifies an associated image file. The image file shall be either a .jpg or .txt (ASCII) formatted picture.
 - 7: It is suggested that CAE tools provide a viewer for the .jpg format and that model builders provide at least one picture for a connector.
 - 8: The same image file may be repeated for all model types if desired.
 - 9: Images if present should be maintained in the same directory with the connector model file or stored in the same compressed file with the connector to insure they files remained paired.
 - 10: Suggested .jpg image attributes:
 size = 160 horizontal by 120 vertical (pixels)
 color = 24 bit
 Image quality = 85%
 Larger or smaller images may be used but are not recommended. A standard image size will allow CAE tools to provide uniform look and feel for images from all vendors. The size was chosen to be a small disk file size and be useful as either a thumb-nail in a model selection window or scaled up to give a larger picture. The 160x120 was

chosen as a perfect 4:1 scale in both axis of a 640x480 picture.

- 11: The connector model MUST be considered valid by CAE tools even if an image file is specified but is missing.

Usage Context:

- 1) It is required that [Begin Cn Model List] appear shortly after the keyword [Begin Cn Model Family], but must appear before the keyword [End Cn Model Family].
- 2) It is required that the keyword [End Cn Model List] be the first keyword used after keyword [Begin Cn Model List].

```
-----
```

[Begin Cn Model List]	Name	Mating	Min_Slew_Time	Image
	HDI_TEST_202	Mated	100ps	HDI_TEST_202_Mated.jpg
	HDI_TEST_202_UnMatedA	UnMated_Side_A	100ps	HDI_TEST_202_UnMatedA.jpg
	HDI_TEST_202_UnMatedB	UnMated_Side_B	100ps	
	HDI_TEST_202_Mated_ThruHole_to_Cable	Mated	25ps	HDI_TEST_202_Mated.jpg
	HDI_TEST_202_Mated_SMT_to_Cable	Mated	25ps	HDI_TEST_202_Mated.jpg
	HDI_TEST_202_Mated_SMT_to_ThruHole	Mated	25ps	HDI_TEST_202_Mated.jpg

```
[End Cn Model List]
```

```
=====
```

Keywords: [Begin Cn Model] [End Cn Model]

Required: Yes

Argument: Text Block

Description: Used to define the start of single or multiple sections for a connector model as defined in the [Begin Cn Model List]. These sections define the R,L,C information making up the actual simulation data for the connector.

- Usage Rules:
- 1) The keyword [Begin Cn Model] must be followed by five required parameters in the following order: ModelName, ModelPinMap_A, ModelPinMap_B, Model Type. An optional SGR (signal to ground ratio) parameter may be included if the ModelType is SLM.
e.g. [Begin Cn Model] ModelName ModelPinMap_A ModelPinMap_B ModelType SGR
 - 2) The field ModelName is required and must be less than 40 characters. The ModelName MUST appear after the [Begin_Cn_Model] and may optionally appear as a parameter following the [End_Cn_Model] keyword.
 - 3) The field ModelPinMap_A and ModelPinMap_B are required and must be less than 20 characters. The ModelPinMap_A MUST appear after the ModelName. ModelPibMap_B must appear after ModelPinMap_A. The names must correspond exactly to the names following [Begin_Cn_Pin_Map] defined in this file. These two fields are used to name the two ports of each connector terminal. Under most conditions, these will be the same name, however two variables are required to address crossover pin mapping.
 - 4) The field ModelType is required and must be either SLM or MLM
SLM indicates this model is a "single-line model" i.e. non-coupled.
MLM indicates this model is a "multi-line model" i.e.

coupled.

SPECIAL NOTICE:

If ModelType is SLM then ALL sections MUST be specified using a matrix method that describes only the diagonal of a matrix. For SLM models it is recommended that all sections use only

Diagonal_matrix descriptions.

If ModelType is SLM then simulators should use this data to create a non-coupled fully distributed transmission line model. It may be also be used to create a multi-section ladder RLC-LCR model as is often used with SPICE simulators.

If a ladder network is substituted for a fully distributed transmission line model the simulator vendor should insure enough sections are provided to insure the bandwidth specified by the Min_Slew_Time of this model is achieved. The symmetric RLC-LCR method should be used as opposed to the non-symmetric RLC-RLC method if a ladder network is used.

The "SGR" Signal-Ground-Ratio value is optional. The SGR value is only allowed for use with type SLM. For example: 3:1 would indicate there is one (power or ground pin) for every 3 signal pins. No spaces are allowed between the numbers and ":". Valid range of signal number is 1 to 100. The number after the colon must always be "1". The number before the colon may include a decimal if desired. (e.g. 2.5:1)

The SGR value is the signal-to-ground ratio that was assumed when the model was created. The simulator may use this value to provide a warning if the model is being used with a higher or lower SGR. If the simulator provides such a warning then a mechanism should be provided to allow a user defined amount of tolerance. For example some areas may have 4:1 and others 2:1 with the nominal value being 3:1. It is recommended that the simulator make an average SGR display available to the user if the Model type is SLM.

MLM indicates this model is a "multi line model" and is a coupled or partially coupled model.

Any combination of Diagonal_matrix, Sparse_matrix, Banded_matrix, or Full_matrix may be used in an MLM model. The SGR value MUST NOT be present if the connector is an MLM model.

- 5) The model is composed of sections of RLC matrices either in series or as "Tee" sections called stubs. The following sub-parameters are used for this purpose:
 - Cn_Section - defines a "straight through" section
 - Cn_Stub - defines a "Tee" section
- 6) Simulators SHALL automatically replace all pins in an SLM connector used for power or ground with the following values:
 - R = 0.0 ohms,
 - L = 0.0 nH
 - C = 0.0 pFThe connector model creator SHALL create an SLM models with the knowledge that the simulators shall follow the above rules.

For example a 2 row by 10 column pin field connector would have a matrix with 20 rows to define it. Every diagonal (i.e. (pin) could have a corresponding R,L,C value that was created

assuming an SGR of say 1:1. When used by the simulator those that are grounded would be considered as ideal grounds and R,L,C values of 0.0 used. In this way an SLM model could be created that would allow either the top or bottom row to be grounded or every other pin of each row to be grounded and the same SLM model used for all cases.

Usage Context:

- 1) It is required that [Begin Cn Model] appear after the keyword [Begin Cn Model List], but must appear before the keyword [End Cn Model Family].
- 2) It is required that the keyword [End Cn Model] be the first keyword used after keyword [Begin Cn Model].
- 3) This keyword pair may appear more than once in the file.
- 4) Only the following list of keywords and sub-parameters are allowed within the context of the [Begin Cn Model] and [End Cn Model] keywords:
[Begin Cn Model Description], [End Cn Model Description]
[Cn Number of Conductors]
[Cn Columns of Pins]
[Cn Rows of Pins]
[Begin Cn Swath], [End Cn Swath]
Cn_Section, Cn_Stub

=====

Sub-parameters: Cn_Section, Cn_Stub

Required: Yes
Argument: Text Block
Description: Used to define either a straight or tee section of a connector model. A matrix sections are interconnected, scaled and may be re-used to form a connector model using these two keywords.

- Usage Rules:
- 1) Sub-parameter multiplier-name pairs must follow the Cn_Section or Cn_Stub sub-parameters. The first parameter of the multiplier-name pair is a scale factor. The second parameter of the pair is the name of the section.
 - 2) The multiplier may be used to scale any named section. The multiplier may be any positive value greater than zero. The multiplier allows a matrix section to be re-used as a scaled value. The scale factor is applied to each parameter of all matrices resulting in scaled R,L, and C matrices.

Usage Context:

It is required that sub-parameters Cn_Section and Cn_Stub must appear after the keyword [Begin_Cn_Model] and before the keyword [End_Cn_Model].

NOTICE: Named sections are NOT specified in per-unit-length. They are specified as unit-less total R,L,C values for the given section.

Example 1:

A named section represents a 0.01 inch section of a connector and the model developer feels there is one section that is 0.015 long and another that is 0.020 long the same matrix could be used with a multiplier of 1.5 and 2.0.

Example 2:

A named section represents a 1 meter section of a connector and the model developer feels there is one section that is 0.015m long and another that is 0.009m long the same matrix could be used with a multiplier of 0.015 and a multiplier of 0.9e-3.

Example 3:

A named section represents an electrical section of a connector with no length known and the model developer feels there is one section that has two times the electrical characteristics of another section. The same matrix could be used in this case with multipliers of 1.0 and 2.0.

- 3) The named section must reference the name specified in a later usage of the keyword [Begin Cn Section].
- 4) Multiple sub-parameter pairs are allowed after either the Cn_Section or Cn_Stub keywords.
- 5) Any number of Cn_Section or Cn_Stub keywords may be used however only one keyword is allowed per line.
- 6) Each scale factor and section name MUST be separated by at least one space. Each sub-parameter pair MUST be separated by at least one space.
- 7) Each Cn_Section is connected in series with the previous Cn_Section.
- 8) The first Cn_Section or Cn_Stub sub-parameter after [Begin Cn Model] is connected to the side A connector pin. The last Cn_Section or Cn_Stub sub-parameter after [Begin Cn Model] is connected to the side B connector pin.
- 9) (Line continuation) The number of sub-parameter pairs on a line is limited by the 120 character length requirement. The sub-parameter pairs may be continued by using a "/" character at the end of the line. There is no limit to the number of multiplier-name pairs that may be used.
- 10) The last multiplier-name pair used with the Cn_Stub sub-parameter is open circuit at the far end.

=====

CONNECTOR MODEL EXAMPLES

=====

Example 1: (a simple single line model with one section)

```
[Begin Cn Model] MyModel MyModelPinMap_A MyModelPinMap_B SLM 3:1
Cn_Section 1.0 Diagonal_matrix1
[End Cn Model] MyModel
```

Example 2: (5 sections straight through)

```
          SectionA      SectionB      SectionC      SectionD      SectionE
Pin >-----< >-----< >-----< >-----< >-----< Pin
```

```
[Begin Cn Model] TestName1 TestName1Pin_A TestName1Pin_B SLM 3:1
Cn_Section 1.0 SectionA
Cn_Section 1.0 SectionB
```

```
Cn_Section 1.0 SectionC
Cn_Section 1.0 SectionD
Cn_Section 1.0 SectionE
[End Cn Model] TestName1
```

Example 3: (5 sections straight through with line continue)

```

      SectionA      SectionB      SectionC      SectionD      SectionE
Pin >-----< >-----< >-----< >-----< >-----< Pin

[Begin Cn Model] TestName1 TestName1Pin_An TestName1Pin_B SLM 3:1
Cn_Section 1.0 SectionA 1.0 SectionB 1.0 SectionC 1.0 SectionD \
Cn_Section 1.0 SectionE
[End_Cn_Model] TestName1
```

Example 4: (2 series sections with one stub)

```

      SectionA      SectionB
Pin >-----< >-----< Pin
      StubSection1

[Begin Cn Model] MyModel MyModelPinMap_A MyModelPinMap_B MLM
Cn_Section 1.0 SectionA
Cn_Stub 1.0 StubSection1
Cn_Section 1.0 SectionB
[End_Cn_Model] MyModel
```

Example 5: (2 stub sections, one stub matrix is re-used)

```

      A      B      C
Pin >-----< >-----< >-----< Pin
      |stub1      |stub1
      |stub2
      |stub3

[Begin Cn Model] MyModel MyModelPinMap_in MyModelPinMap_out MLM
Cn_Section 1.0 A
Cn_Stub 1.0 stub1 1.0 stub2 1.0 stub3
Cn_Section 1.0 B
Cn_Stub 1.0 stub1
Cn_Section 1.0 C
[End_Cn_Model] MyModel
```

Example 6: (3 stubs)

```

      A      B      C      D
Pin >-----< >-----< >-----< >-----< Pin
      |Stub1      |Stub2      |Stub1
      |Stub3
      |Stub3

[Begin Cn Model] MyModel MyModelPinMap_A MyModelPinMap_B MLM
Cn_Section 1.0 A
Cn_Stub 1.0 Stub1
Cn_Section 1.0 B
Cn_Stub 1.0 Stub2 1.0 Stub3 1.0 Stub4
Cn_Section 1.0 C
Cn_Stub 1.0 Stub1
Cn_Section 1.0 D
[End Cn Model] MyModel
```


Example 7: (NOT ALLOWED, parallel stubs)

**** BAD EXAMPLE, DO NOT USE PARALLEL STUBS ****

```
      A      Stub1 Bee      C
Pin >-----< >-----< >-----< Pin
      |
      |Stub2
      |Stub3
```

```
[Begin Cn Model] MyModel MyModelPinMap_A MyModelPinMap_B MLM
Cn_Section 1.0 A
Cn_Stub 1.0 Stub1
Cn_Stub 1.0 Stub2 1.0 Stub3
Cn_Section 1.0 Bee
Cn_Section 1.0 C
[End Cn Model]
```

Example 8: (line continuation)

```
      C
Pin >-----< >-----< >-----< Pin
      A      B      |Stub1
      |          |Stub2
      |          |Stub3
      |          |Stub4
      |          |Stub5
      |          |Stub6
      |          |Stub7
      |          |Stub8
      |          |Stub9
      |          |Stub10
      |          |Stub11
```

**** BAD EXAMPLE ****

```
[Begin Cn Model] MyModel MyModelPinMap_A MyModelPinMap_B MLM
Cn_Section 1.0 A /
1.0 B
Cn_Stub 1.0 Stub1 1.0 Stub2 1.0 Stub3 1.0 Stub4 1.0 Stub5 /
1.0 Stub6 1.0 Stub7 1.0 Stub8 1.0 Stub9 1.0 Stub10 1.0 Stub11
Cn_Section 1.0 C
[End Cn Model] MyModel
```

=====

Keywords: [Begin Cn Model Description] [End Cn Model Description]
Required: No
Argument: Text Block
Description: Provides a concise yet easily human-readable description of this connector model

Usage Rules:

- 1) It is recommended that a maximum of 4 lines be used.
- 2) The end of this section is determined by finding the keyword [End_Cn_Model_Description]
- 3) This keyword may appear multiple times in the file however it may appear only once between each pair of [Begin_Cn_Model]/[End_Cn_Model] keywords.
- 4) Do not put spaces or indent at the beginning of the line as this text will be formatted in text display controls by CAE tools.

Usage Context:

- 1) This keyword pair MUST BE USED BETWEEN KEYWORDS [Begin_Cn_Model] and [End_Cn_Model].
- 2) The keyword [End_Cn_Model_Description] must be the first keyword following the keyword [Begin_Cn_Model_Description].

[Begin Cn Model Description]
High Density 0.1 center square pin connector designed
for use on EIA RS99999Example bus.
[End Cn Model Description]

=====
Keyword: [Cn Number of Conductors]
Required: Yes, when [Begin Cn Auto Map] is NOT used
Argument: Numeric Value
Description: Number of current carrying conductors used in the model.
It is assumed that all matrices in for the associated connector
model will have the SAME number of indices.
This also defines the size of the expected Matrix(s) unless the
optional [Begin Cn Swath] keyword is used.

Usage Rules: 1) If the [Begin Cn Pin Map] keyword is in use in this model
then a single numeric value from 1 to 100000 is recommended.
Larger values shall create warnings by the parser. Smaller
values shall create errors by the parser.
2) If the [Begin Cn Auto Map] keyword is in use in this model
then a range MUST be specified from 1 to 100000 is
recommended. Larger values shall create warnings by the
parser. Smaller values shall create errors by the parser.
3) If the [Begin Cn Auto Map] keyword is also used for this
connector model than a range MUST be specified as a
minimum values to a maximum value (see example below). If
the [Begin Cn Auto Map] is not used than a single fixed
number of conductors must be specified.

Usage Context:

- 1) This keyword MUST BE USED BETWEEN KEYWORDS [Begin Cn Model] and [End Cn Model].
- 2) It is required that this keyword be the 2nd keyword following the keyword [Begin Cn Model] (excluding the the keywords [Begin Cn Model Description] and [End Cn Model Description]).

Fixed sized connector example:

[Cn Number of Conductors] 8

=====
Keyword: [Cn Columns of Pins]
Required: Yes, when [Begin Cn Auto Map] is NOT used
Argument: Numeric Value
Description: The number of columns of pins for a non-rectangular connectors
the maximum number of pins "across" the connector should be
specified.

Usage Rules: - If the keyword [Begin Cn Auto Map] is present in this
connector model than the keyword VARIABLE MUST be used to
indicate a variable width connector.

- Else a numeric value from 1 to 100000 is recommended. Larger values shall create warnings by the parser. Smaller values shall create errors by the parser.
- If the keyword VARIABLE is used it must be all upper case.

Usage Context:

- 1) This keyword pair MUST BE USED BETWEEN KEYWORDS [Begin Cn Model] and [End Cn Model].
- 2) It is required that this keyword be the 3rd or 4th keyword following the keyword [Begin Cn Model] (excluding the the keywords [Begin Cn Model Description] and [End Cn Model Description]).

That is it MUST BE specified after the keyword [Cn Number of Conductors] for this model.

 | For fixed sized connector models use a single numeric value as shown below
 [Cn Columns of Pins] 4

| For variable size connector models using the [Begin Cn Auto Map] keyword
 | the special keyword VARIABLE may be used to indicate this axis is variable
 | width.
 [Cn Columns of Pins] VARIABLE

=====

Keyword: [Cn Rows of Pins]
 Required: Yes, when [Begin Cn Auto Map] is NOT used
 Argument: Numeric Value
 Description: The number of rows of pins.
 For a non-rectangular connectors the maximum number of pins "down" the connector should be specified.
 Usage Rules: 1) A numeric value is required following the keyword to specify the number of rows this connector model requires.
 A numeric value from 1 to 100000 is recommended. Larger values shall create warnings by the parser. Smaller values shall create errors by the parser.

Usage Context:

- 1) This keyword pair MUST BE USED BETWEEN KEYWORDS [Begin Cn Model] and [End Cn Model].
- 2) It is required that this keyword be the 3rd or 4th keyword following the keyword [Begin Cn Model] (excluding the the keywords [Begin Cn Model Description] and [End Cn Model Description]).

That is it MUST BE specified after the keyword [Cn Number of Conductors] for this model.

 [Cn Rows of Pins] 2

=====

***** For Variable size connectors ONLY *****

Keywords: [Begin Cn Auto Map] [End Cn Auto Map]
 Required: If the [Begin Cn Pin Map] keyword is NOT present than this keyword is required else it shall not be used.
 Argument: None
 Description: Using the [Begin Cn Auto Map] keyword indicates that this connector is variable size and will be automatically created by a CAE tool such as a simulator using the algorithm defined

below.

This keyword allows a tool like a simulator to create the pin map and connector map automatically for a connector by first determining the total number of pins need for the particular schematic/PCB layout or requested from the user interface and then executing the algorithm until the desired number of pins is created.

The Auto Map section contains a simple program function that provides the algorithm for generating the signal and pin names. The function must be written in a simplified form of the 'C' programming language.

The function may include:

- The built in variables ROW and COLUMN the result variables SIGNAL_NAME and PIN_NAME
- Integer variables, simply created on usage.
- Integer constants e.g 55
- String constants enclosed by double quotes e.g. "example"
- Character constants enclosed in forward single quotes e.g. 'a'
- The mathematical operators + - * / %
- Boolean operators > < >= <= == AND OR
- Statements terminated by a semicolon
- The formatting function `stringf(<template string>, <list of variables>)` the conditional statements `if (<expression>) { <statement> } else { <statement> }`

The formatting template string may include the following substitution sequences:

```
%d decimal number
%c character
%s string
%% a percent character
```

Notes:

- 1) Variable map creation should only be used for connectors that are non-industry standard pin outs. For example an ISA, SCSI, or PCI bus connector should not use the [Begin Cn Auto Map] keyword as the signal names would not match generally defined signal names. It may be desired to create multiple models for some connectors for example: The model for a square pin connector might have two industry standard pin outs like 34 pin floppy and 50 pin SCSI and also a generic 8 to 100 pin model. The Generic version could use the variable size model and the 34 and 50 pin connectors would use fixed size models.
- 2) Signal names are automatically generated and may not be useful for identifying nets. The CAE tools should give priority to identifying connectivity with pin names if this keyword is used.

- Usage Rules:
- 1) The keyword [Begin Cn Auto Map] replaces the {Begin Cn Pin Map} keywords. These other keywords are not valid in the same model as the [Begin Cn Auto Map] keyword.
 - 2) If the keyword [Begin Cn Auto Map] is used than the connector model must be defined using the [Begin Cn Swath] keyword.

Usage Context: MUST BE USED after keywords [Begin Cn Model] and [End Cn Model].

Example one:

```
-----  
row_letter = 'a' + ROW - 1;  
SIGNAL_NAME = sprintf("Signal_%c%d", row_letter, COLUMN);  
PIN_NAME = sprintf ("%c%d", row_letter, COLUMN);
```

| This function results in pin and signal names as follows:

```
| Pin Name      Signal Name  
|   a1          Signal_a1  
|   a2          Signal_a2  
|   ....  
|   b1          Signal_b1  
|   ....
```

Example one can be condensed to:

```
SIGNAL_NAME = sprintf("Signal_%c%d", ROW + 'a' - 1, COLUMN);  
PIN_NAME = sprintf ("%c%d", ROW + 'a' - 1, COLUMN);
```

Example Two (with conditional)

```
if ((ROW < 5) OR (ROW > 7))  
{  
    SIGNAL_NAME = sprintf("Signal_%c%d", ROW + 'a' - 1, COLUMN);  
    PIN_NAME = sprintf ("%c%d", ROW + 'a' - 1, COLUMN);  
}  
else  
{  
    SIGNAL_NAME = "NA";  
    PIN_NAME = "NA";  
}
```

-signal names may also be defined by either algorithm or using one of the fixed reserved names:

- PWRGND- reserved model name, used with power or ground pins,
- POWER - reserved model name, used with power supply pins,
- RET - reserved word indicating either power or ground used
- GND - reserved model name, used with ground pins,
- NC - reserved model name, used with no-connect pins,
- NA - used where data not available.

=====
Keywords: [Cn Col Range]

Required: If the [Begin Cn Auto Map] keyword is present than this keyword is required else it shall not be used.

Argument: Numeric Values

Description: Used to define the minimum and maximum number of columns of pins for the connector represented by this model. The simulator will not expand or reduce the matrix beyond the limits defined by this parameter.

Usage Rules: [Cn Col Range] Must be followed by two numbers. The first number relates to the minimum number of conductor columns. The second number is the maximum number of conductor columns

Usage Context:

MUST BE USED after keywords [Begin Cn Auto Map] and [End Cn Auto Map].

Example: This example is of a connector that may have 9 to 25 columns

[Cn Col Range] 9 25

=====
Keywords: [Cn Row Range]

Required: If the [Begin Cn Auto Map] keyword is present than this keyword is required else it shall not be used.

Argument: Numeric Values

Description: Used to define the minimum and maximum number of rows of pins for the connector represented by this model. The simulator will not expand or reduce the matrix beyond the limits defined by this parameter.

Usage Rules: [Cn Row Range] Must be followed by two numbers. The first number relates to the minimum number of conductor columns. The second number is the maximum number of conductor columns

Usage Context: MUST BE USED after keywords [Begin Cn Auto Map] and [End Cn Auto Map].

Example: This example is of a connector that may have 2 to 5 rows
[Cn Col Range] 2 5

=====
Keywords: [Cn Column Swath]; [Cn Row Swath]

Required: No except if [Define Cn Auto Map] is used or if the number of matrix entries does not match the number defined by [Cn Number of Conductors] for [Define Cn Pin Map].

Argument: Numeric Values

Description: Describes a "swath" which is a smaller matrix used to represent connectors of equal or larger size and the matrix order convention. To visualize this, consider the swath matrix being a smaller version of the connector. The edges of the matrix represent the same edge effects that exists in the full size connector. The center area of the matrix represents the same effects as the center of the full size connector.

It is the responsibility of the EDA tool to use the matrix and the required keyword information as a "mini" connector that is centered about the electrical paths of interest and/or to expand this information into a larger sized swath up to the full sized connector itself.

For example a 2x8 matrix might be expanded to represent a connector that is 2x100. The "swath" can also be combined with the [Begin Cn Auto Map] keyword to create multiple connector models from a single description. For example a 2x10 matrix might be used to represent connectors ranging from 2x10 to 2x200 with a single descriptive model.

Usage Rules: 1. Full sized swath: If the [Cn Number of Conductors] value is the same as the number of matrix pin entries for [Begin Cn Section] then neither [Cn Column Swath] nor [Cn Row Swath] are used. The matrices must be ordered exactly as the pins listed under [Begin Cn Pin Map].

2. Smaller sized swath: The swath matrix must contain a set of pins documenting a complete rectangular section organized by rows and columns. [Cn Row Swath] describe the pins ordered by rows (starting with the top row), and [Cn Column Swath] describe the same information ordered by columns (starting with the left column from a "side A" perspective).

For example, consider a swath that documents rows A and B and columns 1, 2, and 3 of a six pin rectangular [Cn Column Swath] describe pins ordered by columns (for example, A1, B1, A2, B2, A3, B3), and [Cn Row Swath] defines pins ordered by rows (for example, A1, A2, A3, B1, B2, and B3).

When a smaller sized swath is defined for a fixed pin map as defined by [Begin Cn Pin Map], the pin order must be grouped in the same order (by rows or by columns) as the given by EITHER [Cn Row Swath] or [Cn Column Swath]

3. The edge effects describe the edge rows or columns that do not contain all of the coupling effects (from both sides) that the centermost rows or columns. This information is useful for "swath expansion" when determining what larger size to use.

When the swath represents a SLM or else documents all of the pins in a physical connector, the off diagonal entries are 0 by convention. If the swath describes a section with few columns, but the same number of rows as the physical connector, then the row edge effects are 0 by convention. Similarly, if the swath describes a section with fewer rows, but the same number of columns as the physical connector, then the column edge effects are 0 by convention.

In a fully coupled swath where all pins couple to all others, all of the rows or columns except for the one designated as the centermost row or column can have edge effect simplification. So the number of rows or columns can extend to all but the center row or column. On the other hand, a coupling pattern that extends over a few columns may result in a smaller number of edges designated. Below is an example of a 3 row by 5 column swath, where the lines in a rectangular connector represent the electrical coupling:

```

*--*--*--*--*
|\|/\|/\|/\|
|/\|/\|/\|/\|
*--*--*--*   [Cn Column Swath] 3 5 1 1 0 0
|\|/\|/\|/\|
|/\|/\|/\|/\|
*--*--*--*

```

Notice that columns 2, 3, and 4 have the maximum amount of coupling from each side. In this case the edge effect columns 1 and 5 do not have coupling from both sides.

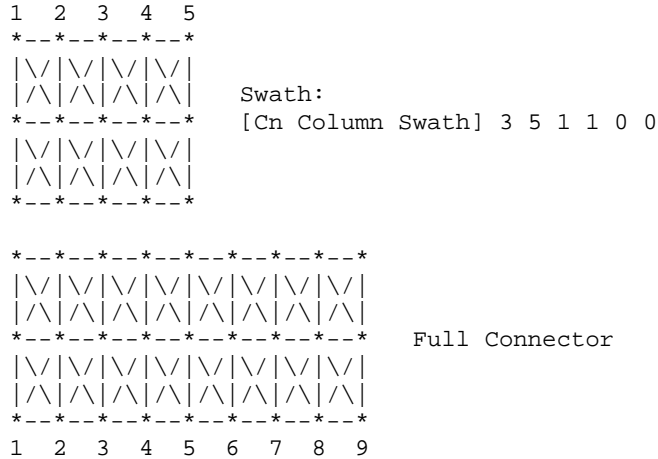
Application of Swath Matrices:

For the purposes of this discussion a 3 row by 5 column swath is used and the full sized connector is 3 rows by 9

columns. The swath matrix data can be organized by [Cn Column Swath] or [Cn Row Swath] pin ordering convention. However, the column expansion algorithms discussed later can be implemented using the [Cn Column Swath] format.

Three methods can be used to apply the Swath matrix information:

(1) Centering the Swath around the pins of interest



The Swath above is centered about column 4. The paths of interest including those of columns 3 and 5 are also described by swath matrix data that has coupling from both sides. However, because of edge effects, columns 2 and 6 are less accurately approximated.

The centering algorithm is a way to map the swath matrix pins directly into the corresponding pins of the actual connector.

When the signals of interest are at the left or right edges, the swath would normally be positioned just to the edges. For example, column 1 of the swath matrix would line up with column 1 of the connector.

(2) Expansion and Centering: Expanding the Swath matrix into a larger sized Swath matrix and centering it about the paths of interest.

This approach is the same as centering. However, the signal pins of interest might have more columns than the non-edge section of the swath. One solution is to expand the swath to a larger swath and then use the larger swath for centering. This is a subset of expanding the swath into the full sized connector.

Some EDA tools work with the a larger swath, and other tools work with full sized connectors. A larger swath might be constructed to span the number of columns of interest plus the edge effect columns to assure that the most accurate coupling information from both sides is used for the columns of interest.

- (3) Expansion to Full Sized Connector: Expanding the swath matrix to the full sized connector matrix. the Full-sized matrix

There are three steps to this procedure (a, b, and c below). This is illustrated using the 3 row, 5 column swath and showing how it is expanded into a 3 row, 9 column full sized connector

- (a) Copy the left column pattern

```

1  2  3  4  5
*--*--*--*--*
|\|/|\|/|\|/|\|/
|/|\|/|\|/|\|/
*--*--*--*--*
|\|/|\|/|\|/|\|/
|/|\|/|\|/|\|/
*--*--*--*--*

*--*--*--*--*--*--*--*--*
|\|/|\|/|\|/|\|/|\|/|\|/|\|/|\|/|\|/|\|/|\|/|\|/|\|/
|/|\|/|\|/|\|/|\|/|\|/|\|/|\|/|\|/|\|/|\|/|\|/|\|/|\|/
*--*--*--*--*--*--*--*--*
Full Connector

|\|/|\|/|\|/|\|/|\|/|\|/|\|/|\|/|\|/|\|/|\|/|\|/|\|/
|/|\|/|\|/|\|/|\|/|\|/|\|/|\|/|\|/|\|/|\|/|\|/|\|/|\|/
*--*--*--*--*--*--*--*--*
1  2  3  4  5  6  7  8  9

```

The matrix data for swath columns 1 and 2 (including forward references) copied into the new full connector matrix.

- (b) repeat the center pattern,

```

1  2  3  4  5
*--*--*--*--*
|\|/|\|/|\|/|\|/
|/|\|/|\|/|\|/
*--*--*--*--*
|\|/|\|/|\|/|\|/
|/|\|/|\|/|\|/
*--*--*--*--*

*--*--*--*--*--*--*--*--*
|\|/|\|/|\|/|\|/|\|/|\|/|\|/|\|/|\|/|\|/|\|/|\|/|\|/
|/|\|/|\|/|\|/|\|/|\|/|\|/|\|/|\|/|\|/|\|/|\|/|\|/|\|/
*--*--*--*--*--*--*--*--*
Full Connector

|\|/|\|/|\|/|\|/|\|/|\|/|\|/|\|/|\|/|\|/|\|/|\|/|\|/
|/|\|/|\|/|\|/|\|/|\|/|\|/|\|/|\|/|\|/|\|/|\|/|\|/|\|/
*--*--*--*--*--*--*--*--*
1  2  3  4  5  6  7  8  9

```

Starting at the center of the swath, the coupling pattern of just the center column (column 3 in this example) is copied for the connector matrix. In this case, the coupling pattern extends forward to the next column. The pattern is copied by mapping the swath pin numbers into the connector pin numbers and copying the center column forward referenced data. In this example, the operation starts at the full

connector column 3 and ends upon completion at the full connector column 7.

(c) Copy the right column patterns

```

1  2  3  4  5
*--*--*--*--*
| \ | \ | \ | \ |
| / | / | / | / |
*--*--*--*--*
| \ | \ | \ | \ |
| / | / | / | / |
*--*--*--*--*

*--*--*--*--*--*--*
| \ | \ | \ | \ | \ | \ | \ |
| / | / | / | / | / | / | / |
*--*--*--*--*--*--*
| \ | \ | \ | \ | \ | \ | \ |
| / | / | / | / | / | / | / |
*--*--*--*--*--*--*
1  2  3  4  5  6  7  8  9

```

Swath:
[Cn Column Swath] 3 5 1 1 0 0

Full Connector

The final step is similar to Step (a), but concluded using the right side of the swath. When the swath is positioned against the right edge as shown, then the coupling patterns for the swath columns are duplicated for the final columns of the full sized connector. So the patterns of swath columns 4 and then 5 are duplicated for the full sized connector columns 8 and 9.

A similar process could be created for expanding the number of rows. Some details are left to the EDA tool to implement. For example, if the swath contains an even number of columns, then either the left of center or the right of center column may be used for center section expansion.

Usage Context:

- 1) Only one [Cn Column Swath] or [Cn Row Swath] shall be used per connector model.
- 2) MUST BE USED between keywords [Begin Cn Model] and [End Cn Model].
- 3) MUST BE specified after [Cn Number of Conductors], [Cn Rows of Pins], and [Cn Columns of Pins] have been specified for this connector model.
- 4) MUST be followed by 6 numbers in order as follows:
 - Rows in the swath matrix
 - Columns in the swath matrix
 - LEFT EDGE: Columns in the swath matrix used to represent left edge
 - RIGHT EDGE: Columns in the swath matrix used to represent right edge
 - TOP EDGE: Rows in the swath matrix used to represent top edge
 - BOTTOM EDGE: Rows in the swath matrix used to represent bottom

edge

Please see the example below to see how these are used with the keyword

Note, the orientation is with respect to 'side A' of the connector.

```

-----
                SwathRows SwathCols LeftEdge RightEdge TopEdge BottomEdge
[Cn Column Swath]      2         8         1         1         0         0

```

=====

- Keywords: [Begin Cn Pin Map], [End Cn Pin Map]
- Required: If the [Begin Cn Auto Map] keyword is NOT present than this keyword is required else it shall not be used.
- Argument: None
- Description: Describes the index into the matrix for which a given pin applies.
- Usage Rules:
 - 1) The keyword [Begin Cn Pin Map] must be followed by two required parameters which are ModelPinMapName_A and ModelPinMapName_B.
e.g. [Begin Cn Pin Map] ModelPinMapName_A ModelPinMapName_B
 - 2) The ModelPinMapName fields are required and must be less than 20 characters. The ModelPinMapName fields MUST appear after the [Begin Cn Pin Map] and may optionally appear as parameters following the [End Cn Pin Map] keyword. This name is used by the [Begin Cn Model] keyword to reference a pin map.
 - 3) More than one [Begin Cn Model] record may reference the same pin map.
 - 4) The keyword NA indicates that there is not a pin in the location (e.g. PGA socket with corner pin missing)
An end of line character indicates the end of the information for the row
 - 5) The lines between [Begin Cn Pin Map] and [Begin Cn Pin Map] shall contain one line for each pin in this connector model. The pin map line shall contain the following parameters.

```

Pin      (required)
If a pin name specified by the manufacture
This allows CAE tools to align pin names in the model
with pin names in the net list.

Signal (Optional, based on application but recommended if
        applicable)
Is the signal name used; required if this is an industry-
standard connector like RS232, PCI, EISA etc.

```

NOTE: NA should be used to indicate this field is not available.
 This can be used by CAE tools or by users interactively to easily identify the pins of the connector.
 This is an alternate method for CAE tools to align signal names in the model with net names from the design's net list if the pin names cannot be aligned.
 Maximum of 20 characters allowed for Pin Name
 Maximum of 20 characters allowed for Signal Name
 Pin or Signal names longer than 20 should be truncated to 20 to fit this specification.

- 6) It is acceptable to have more than one pin map in a file. Therefore the keywords [Begin Cn Pin Map] and [End Cn Pin Map] may appear as a pair more than once in a file.

Simulators should consider pin names with case sensitive compares. To make human comparison easy it is recommended that all uses of the pin name in the file utilize the same case.

Usage Context:

- 1) This keyword pair MUST be placed outside the keyword pair [Begin Cn Model] / [End Cn Model] keywords to allow it to be reused.
- 2) This keyword pair MUST appear between the keyword pair [Begin Cn Family Description] [End Cn Family Description]

NOTICE: The special Signal names POWER, RET, GND, and PWRGND shall be used to indicate that this pin should be connected to either a Power pin like +5V, a ground pin, or (either a power or ground pin). This information may be used by the simulator or PCB layout tool to provided a warning that the connector is not following an established industry standard layout. The keyword RET is available to indicate it is a return pin and could be either power or ground.

```
-----  
[Begin Cn Pin Map] 20PinHdiPin  
Pin    Signal  
A1     GND  
A2     D0  
A3     CLK  
A4     D1  
B1     STROBE1  
B2     A0  
B3     POWER  
B4     PWRGND  
[End Cn Pin Map]
```

```
-----  
Keyword: [Begin Cn Section], [End Cn Section]  
Required: No  
Argument: None  
Description: Indicates the beginning of a set of R,L,C matrix data.  
Usage Rules: -Each matrix used for given connector model MUST have exactly  
              the same number conductors.  
              -If the swath method is used the matrix may have fewer  
              conductors then the connector model.  
              -If the swath method is not used the matrix MUST have exactly  
              the same number of conductors as the connector has pins.  
              -The matrices used for the R,L,C description can be defined  
              using any of the matrix description methods allowed in the  
              specification. The matrix description methods can also be mixed  
              within a given section. For example the resistance matrix might  
              use the Diagonal_matrix and the inductance matrix might use a  
              Full matrix.
```

Usage Context:

- MUST be placed outside the context of keywords [Begin Cn Model] and [End Cn Model] as sections may be reused by more than one connector model.
- MUST be placed inside the context of the family
- The following keywords are optional: [Resistance Matrix], [Bandwidth], [Row]
- Must include [Derivation Method]

Sub parameters:

- One or more pairs of parameters must be specified after [Begin Cn Section].
- The first parameter of a pair is always the matrix multiplier.
- The 2nd parameter of a pair is always the matrix name to be used for that section.
- The matrix multiplier is a number which must be greater than zero.

For an example of [Begin Cn Section] see matrix examples that follow.

```

=====
Keyword: [End]
Required: Yes
Argument: None
Description: Specifies end of file
-----

```

[End]

```

=====
6.1 MATRIX KEYWORDS

```

```

=====
Keyword: [Derivation Method]
Required: Yes
Argument: Test Value
Description: - Must be between [Begin Cn Section] and [End Cn Section]
              - The [Derivation Method] keyword is required for each section.
                "Lumped" or "Distributed"
              - For LUMPED models any single, any pair, or all of the following
                keywords could be used: [Inductance Matrix], [Capacitance
                Matrix] , [Resistance Matrix]
              - For DISTRIBUTED models BOTH the [Inductance Matrix] and
                [Capacitance Matrix] keywords are required. The [Resistance
                Matrix] keyword is optional.
              - All three matrices within the same section share the same
                derivation method
-----

```

[Derivation Method] LUMPED

```

=====
Keywords: [Resistance Matrix], [Inductance Matrix], [Capacitance Matrix]
Required: Yes, If a simple single line model is defined then the
          following matrices are required:
            case 1: [Resistance Matrix] only
                   OR
            case 2: [Inductance Matrix] and [Capacitance Matrix] only
                   for which the [Resistance Matrix] is assumed to
-----

```

be zero ohms

OR

case 3: [Resistance Matrix] and [Inductance Matrix]
and [Capacitance Matrix]

NOTE: In case 1,2,3 the matrices must be Diagonal_matrix.

If a coupled model is defined then the following matrices are required:

case 4: [Inductance Matrix] and [Capacitance Matrix] only
for which the [Resistance Matrix] is assumed to be
zero ohms

OR

case 5: [Resistance Matrix] and [Inductance Matrix]
and [Capacitance Matrix]

NOTE: In case 4,5 the matrices shall be any combination of
matrix types (Diagonal, Banded, Sparse, Full).

Argument: Numeric None

Description: The sub-parameters mark the beginning of a matrix, and
specify how the matrix data is formatted.

Sub-Params: Diagonal_matrix, Banded_matrix, Sparse_matrix, or Full_matrix

Usage Rules: 1) For each matrix keyword, use only one of the sub-parameters.
2) After each of these sub-parameters, insert the matrix data in
the appropriate format. (These formats are described in
detail below.)

Usage Context: MUST BE USED between keywords [Begin Cn Section]
and [End Cn Section].

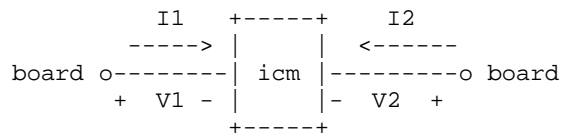
Notes:

Numeric Accuracy:

The numeric accuracy used in the file should not be
significantly greater than the known accuracy of the
model. Refer to usage rule 13 (top of document) for more
details.

Currents and Sign Conventions:

The resistance, inductance, and capacitance matrices may
also be referred to as "RLC matrices" within this
specification. When measuring the entries of the RLC
matrices, either with laboratory equipment or field-
solver software, currents are defined as ENTERING the
pins of the package from the board. The corresponding
voltage drops are to be measured with the current
pointing "in" to the "+" sign and "out" of the "-" sign.



It is important to observe this convention in order to
get the correct signs for the mutual inductance's and
resistances.

For each [Resistance Matrix], [Inductance Matrix], or [Capacitance Matrix] a different format can be used for the data. The choice of formats is provided to satisfy different simulation accuracy and speed requirements. Also, there are many packages in which the resistance matrix can have no coupling terms at all. In this case, the most concise format (Banded_matrix) can be used.

RESISTANCE MATRIX DESCRIPTION

```
=====
UNITS:  OHMS
DESCRIPTION:  The resistance matrix represents the total DC resistance
              between the two ends of this section of the connector.
NOTES:
1) The resistance matrix is optional. Simulation tools shall
   use 0.0 ohms for all diagonal entries and "infinite" for all
   off diagonal entries if this matrix is not present.
2) DO NOT USE ohms/meter as this is the total value and
   includes the length of this section.
3) Values should all appear in the diagonal terms of the
   matrix. For example: value 1,1 is the resistance for pin 1
   and value 2,2 is the resistance for pin 2.
4) A "Diagonal_matrix" matrix type is the best choice for
   describing the resistance matrix. Diagonal elements
   may be dominant. Comparably, the off diagonal elements may
   be negligible thus leading to off diagonal element values
   of zero leading to the [Diagonal_matrix] format
```

INDUCTANCE MATRIX DESCRIPTION

```
=====
UNITS:  HENRIES
DESCRIPTION:  Two inductance matrix methods are supported:
              SLM, Single-Line, Loop-Inductance Matrix (non-coupled)
              MLM, Multi-Line, Partial-Inductance Matrix (coupled)

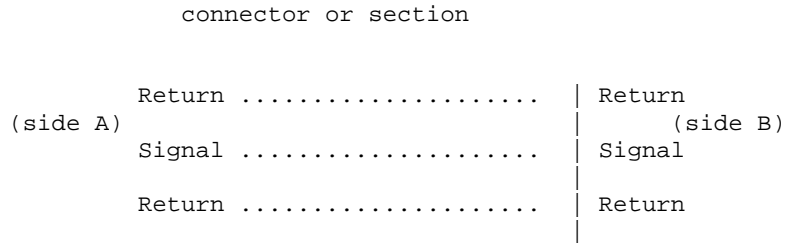
              If ModelType is SLM then all sections must use single-line loop-
              inductance and capacitance matrices.

              If ModelType is MLM then all sections must use partial-inductance
              and capacitance matrices.

              Both capacitance and inductance matrix of a given section must
              use the same method.
```

Single-Line Loop-Inductance Matrix:

```
=====
DESCRIPTION:  To define inductance requires a loop. The loop consists of a
              closed path including a signal and all possible return paths.
              The inductance is a coefficient between the emf induced in the
              loop and the change of magnetic flux through the loop.
```



The return path must include all pins that are power or ground.

In a loop inductance matrix, the diagonal terms represent the loop inductance of a specific pin with return currents assumed returned through all pins defined to be power or ground.

NOTES (Single-Line Loop-Inductance Matrix):

- 1) This method must be used if the ModelType is SLM.
- 2) Loop inductance can be experimentally measured.
- 3) Loop inductance matrices can be created using field solvers.
- 4) An SGR value is normally specified for an SLM model that indicates the ratio of signal pins to return path pins (i.e. power or ground) pins.
- 5) SLM models make have zero values for power or ground R,L,C values which prevents there use in analyzing connector ground bounce effects.
- 6) Typical uses for SLM model might include for example a 2x17 header connector where the bottom row is all grounded. The SGR would be specified in this case as 1:1. A model would be developed with these assumptions made. Then all pins would be filled with average values. To further expand this example see the figure below:

Pin out:

```
1 ..... 17
18 ..... 34
```

Measurement or Field solver connection:

```
Sig Sig Sig ... Sig Sig
Gnd Gnd Gnd ... Gnd Gnd
```

Measured or Computed values:

```
3nH 4nH 4nH ....4nH 3nH
```

Matrix data:

```
3nH 4nH 4nH ....4nH 3nH
3nH 4nH 4nH ....4nH 3nH
```

This allows the user to specify any of the following power/ground connections and still use this model:

Simulator Connection A:

```
Sig Sig Sig ... Sig Sig
Gnd Gnd Gnd ... Gnd Gnd
```

Simulator Connection B:

```
Gnd Gnd Gnd ... Gnd Gnd
Sig Sig Sig ... Sig Sig
```

Simulator Connection C:

```
Sig +5V Sig ... Gnd Sig
Gnd Sig Gnd ... Sig +5V
```

Given the following connection a simulation should generate a warning to the user indicate the ground-signal-ratio has been violated.

Simulator Connection D:

```
Sig Sig Sig ... Sig Sig
Gnd Sig Sig ... Sig Sig
```

- 7) All connector pins must be specified with non-zero L and C values in at least one of the sections. The

simulator will zero out portions of all sections corresponding to the ground or power pins.

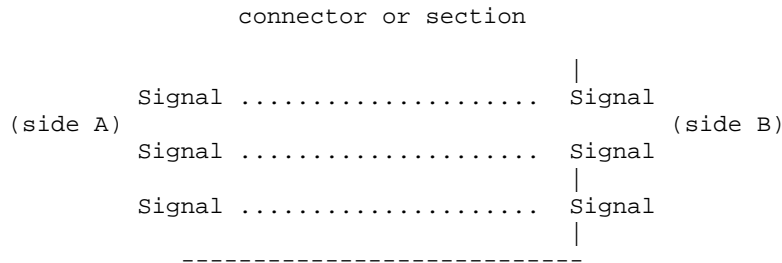
- 8) SLM models are most useful where coupling analysis is not critical and where the rise time of the signal is long compared to the electrical delay through the connector.

Multi-Line Partial-Inductance Matrix:

=====

DESCRIPTION: A partial inductance is an approximation of the loop inductance in situations where the current return path cannot be explicitly stated in the field extraction stages. Partial inductance can be numerically calculated by introducing a current in a circuit element that originates on one end and terminates on the other end. There is no physical loop per se, instead charges will build up on each side of the circuit element. In practice, this situation cannot exist more than instantaneously. For the purposes of simulation the condition does not affect the resultant loop inductance values. Then from the currents found the magnetic fields and inductance's can be calculated. In this way, the self and mutual inductances of any section of a closed circuit can be calculated.

This representation of inductance in terms of partial self and mutual inductance allows the analysis of any combination of current paths. The signal and return current paths can be defined in circuit after the model is established. Assuming that the self inductance is included in the return path, the circuit under simulation can account for the impact on signal-integrity, cross-talk and ground-bounce from currents passing through any combination of pins.



There are many ways to create this information using either 2D or 3D field solvers. It may also be possible to create this information using other methods which are left to the model developer.

For an MLM model it is required that at least one section include partial inductance and capacitance matrices.

CAPACITANCE MATRIX DESCRIPTION

=====

UNITS: FARAD
 DESCRIPTION: A capacitance is an approximation of the capacitance in situations where the return path cannot be explicitly stated in the field extraction stages.

See "Multi-Line Capacitance Matrix" section above for more

information on Multi-Line Matrices.

USAGE RULES: Two Maxwell capacitance matrix methods are supported:

SLM, Single-Line, Loop-capacitance Matrix (non-coupled)
MLM, Multi-Line, Partial-capacitance Matrix (coupled)

If ModelType is SLM then all sections must only contain a single capacitance value per line.

If ModelType is MLM then all sections must use a Maxwell Capacitance as stated below.

Both capacitance and inductance matrix of a given section must use the same method.

Single-Line Capacitance Matrix Description:

To define capacitance requires conductors separated by a dielectric. The conductors are the those found in a loop consisting of a closed path including a signal and all possible return paths. The Maxwell Capacitance matrix relates the total charges on the conductors to the voltages applied to them. $[Q]=[C_m][V]$ Where $[C_m]$ is the Maxwell matrix, $[Q]$ is the vector of total conductor charges, and $[V]$ is a vector of applied voltages. The negative values of the off-diagonal entries can be explained on physical grounds: if you put +1 Volt on a single conductor and 0 Volts on the others, then you induce negative charges on those other conductors to terminate the field lines emanating from the conductor at 1 Volt.

In the Maxwell Capacitance matrix, the diagonal term is the maximum capacitance that the conductor encounters, meaning the capacitance to ground plus the capacitances to all the other conductors.

In the Maxwell Capacitance matrix, the OFF-diagonal term is the capacitance that the conductor encounters relative to a second conductor. This capacitance value is effected by other nearby conductors during the field extraction phase. As such it should not normally be used by itself to determine the capacitance of a random pair of conductors in a given structure.

LOSS MATRIX DESCRIPTION

=====

This release does not support frequency dependent loss matrices. A future release is expected to add support for frequency dependent loss matrices.

UNCOUPLED MODELS:

=====

These are also called Single-Line-Models or SLM models. These models are useful for most simulations where coupled effects can be ignored safely. These models are most accurate if closely spaced ground pins or a ground plane is present.

A "Diagonal_matrix" matrix type is the best choice for describing all matrices R,L and C for SLM models.

(see matrix descriptions below).

Several methods can be used:

- 1) 2D field solver with return path pins defined. Only the diagonal matrix data is used. The coupling information is ignored. The R,L,C matrices should represent the electrical parameters for a specific section.
- 2) 2D field solver without specific return path pins. A return plane is specified as a reference only and is placed far field from the pin field. Only the diagonal matrix data is used and the off diagonal information must be appropriately reduced to a single diagonal matrix. No coupling data is present in the final matrix
- 3) Closed form round wire inductance equation.
- 4) Experimental lab data may be obtained from TDR, VNA or other means

COUPLED:

=====

These are also called Multi-Line-Models or MLM models.

A "Diagonal_matrix" matrix type is the best choice for describing all matrices R,L and C for SLM models. (see matrix descriptions below).

Several methods can be used:

- 1) 3D field solver can be used to create partial inductance and capacitance matrices that allow accurate simulations without the need to pre-define the ground pins.
- 2) 2D field solver without specific return path pins. A return plane is specified as a reference only and is placed far field.
- 3) 2D field solver with return path pins specifically defined.
- 4) Experimental lab data may be obtained from multichannel measurements that incorporate TDR, VNAs or other means as long as the resulting inductance matrix contains partial inductance values.

One common aspect of all the different formats is that they exploit the symmetry of the matrices they describe. This means that the entries below the main diagonal of the matrix are identical to the corresponding entries above the main diagonal. Therefore, only roughly one-half of the matrix needs to be described. By convention, the main diagonal and the UPPER half of the matrix are provided.

In the following text, we use the notation [I, J] to refer to the entry in row I and column J of the matrix. Note that I and J are allowed to be alphanumeric strings as well as integers.

The ordering of these strings is determined by the row/column ordering convention given by the [Cn Row Swath] or [Cn Column Swath] convention, or else matches exactly the [Cn Pin Map] order when the pin map contains the same number of pins as the Swath.

In the following text, "Row 1", means the row corresponding to the first pin.

Also note that the numeric entries of the RLC matrices are standard IBIS floating point numbers. As such, it is permissible to use metric "suffix" notation. Thus, an entry of the C matrix could be given as 1.23e-12 or as 1.23p or 1.23pF.

Full_matrix

When the Full_matrix format is used, the couplings between every pair of elements is specified explicitly. Assume that

the matrix has N rows and N columns. The Full_matrix is specified one row at a time, starting with Row 1 and continuing down to Row N.

Each new row is identified with the Row keyword.

See example "Matrix Example" lower in this document.

=====

Keyword: [Row]
Required: Yes if a matrix is being defined.
Argument: None
Description: Indicates the beginning of a new row of the matrix.
Usage Rules: The argument must be a sequential number beginning at 1 and continuing to the last row for the matrix

Following a [Row] keyword is a block of numbers that represent the entries for that row. Suppose that the current row is number M. Then the first number listed is the diagonal entry, [M,M]. Following this number are the entries of the upper half of the matrix that belong to row M: [M, M+1], [M, M+2], ... up to [M,N].

For even a modest-sized matrix, this data will not all fit on one line. You can break the data up with new-line characters so that this limit is observed.

Example: Suppose the matrix has 40 conductors and that we are currently working on Row 19. There is 1 diagonal entry, plus $40 - 19 = 21$ entries in the upper half of the matrix to be specified, for 22 entries total.

Row 1 always has the most entries, and that each successive row has one fewer entry than the last; the last row always has just a single entry.

Usage Context:

- 1) MUST be used between keywords [Begin Cn Section] and [End Cn Section].
- 2) MUST follow any usage of one of the following keywords: Banded_matrix, Sparse_matrix, Full_matrix

See example "Matrix Example" lower in this document.

=====

Keyword: [Bandwidth]
Required: Yes if a Banded_matrix matrix is being defined.
Argument: Numeric Value
Description: Indicates the bandwidth of the matrix. The bandwidth field must be a nonnegative integer. This is the number of off-diagonal matrix rows for which data is provided.
Usage Rules: 1) MUST be used between keywords [Begin Cn Section] and [End Cn Section].
2) MUST follow any usage of one of the following keyword: Banded_matrix

See example "Matrix Example" lower in this document.

=====

sub-parameter: Diagonal_matrix

Required: No
Argument: None
Description: The Diagonal_matrix is used to specify uncoupled models. This sub-parameter is exactly the same as using the Banded_matrix described below with a Bandwidth=0. It also has the added benefit of requiring half as many lines.
Usage Rules: A Diagonal_matrix is one whose entries are guaranteed to be zero if they are not on the main diagonal. Let the matrix size be N x N, An entry [I,J] of the matrix is zero if: $|I - J| \neq 0$ where $| \cdot |$ denotes the absolute value.

Specify the Diagonal_matrix one row at a time, starting with row 1 and working up to higher rows. Diagonal elements are entered one per line. MUST be used between keywords [Begin Cn Section] and [End Cn Section].

See example "Matrix Example" lower in this document.

=====

sub-parameter: Banded_matrix

Required: No
Argument: None
Description: The Banded_matrix is used to specify the coupling effects up to B pins on either side. Two variations are supported. One allows for the coupling to circle back on itself. This is technically a simple form of a bordered block diagonal matrix. However, its data can be completely specified in terms of a Banded_matrix for an N x M matrix consisting of N rows and M = N + B columns. The second variation is just in terms of an N x N matrix where no circle back coupling needs to be specified.
Usage Rules: A Banded_matrix is one whose entries are guaranteed to be zero if they are farther away from the main diagonal than a certain distance, known as the "bandwidth." Let the matrix size be N x M, and let the bandwidth be B. An entry [I,J] of the matrix is zero if: $|I - J| > B$ where $| \cdot |$ denotes the absolute value.

The bandwidth for a Banded_matrix must be specified using the [Bandwidth] keyword:

Specify the banded matrix one row at a time, starting with row 1 and working up to higher rows. Mark each row with the [Row] keyword, as above. As before, symmetry is exploited: do not provide entries below the main diagonal.

For case where coupling can circle back on itself, consider a matrix of N pins organized into N rows 1 ... N and M columns 1 ... N, 1 ... B. The first row only needs to specify the entries [1,1] through [1,1+B] since all other entries are guaranteed to be zero. The second row will need to specify the entries [2,2] through [2,2+B], and so on. For row K the entries [K,K] through [K,K+B] are given when K + B is less than or equal to the size of the matrix N. When K + B exceeds N, the entries in the last columns 1 ... B specify the coupling to the first rows. For row K, the entries [K,K] ... [K,N] [K,1] ... [K,R] are given where $R = \text{mod}(K + B - 1, N) + 1$. All rows will contain B + 1 entries. To avoid redundant entries, the bandwidth is limited to $B \leq \text{int}((N - 1) / 2)$.

For the case where coupling does not circle back on itself, the

process is modified. Only N columns need to be considered. When K + B finally exceeds the size of the matrix N, the number of entries in each row starts to decrease; the last row (row N) has only 1 entry. This construction constrains the bandwidth to $B < N$.

As in the Full_matrix, if all the entries for a particular row do not fit into a single 120-character line, the entries can be broken across several lines.

It is possible to use a bandwidth of 0 to specify a diagonal matrix (a matrix with no coupling terms.) This is sometimes useful for resistance matrices.

MUST be used between keywords [Begin Cn Section] and [End Cn Section].

See example "Matrix Example" lower in this document.

=====
sub-parameter: Sparse_matrix

Required: No

Argument: None

Description: A Sparse_matrix is expected to consist mostly of zero-valued entries, except for a few nonzero. Unlike the Banded_matrix, there is no restriction on where the nonzero entries can occur. This feature is useful in certain situations, such as for Pin Grid Arrays (PGAs)sockets.

As usual, symmetry can be exploited to reduce the amount of data by eliminating from the matrix any entries below the main diagonal.

Usage Rules: MUST be used between keywords [Begin Cn Section] and [End Cn Section].

An N x N Sparse_matrix is specified one row at a time, starting with row 1 and continuing down to row N. Each new row is marked with [Row] keyword, as in the other matrix formats.

Data for the entries of a row is given in a slightly different format, however. For the entry [I, J] of a row, it is necessary to explicitly list the name of pin J before the value of the entry is given. This specification serves to indicate to the parser where the entry is put into the matrix.

Note that each of the column indices listed for any row must be greater than or equal to the row index, because they always come from the upper half of the matrix. When alphanumeric pin names are used, special care must be taken to ensure that the ordering defined in the [Pin Numbers] section is observed.

With this convention, please note that the N'th row of an N x N matrix has just a single entry (the diagonal entry).

The proper location is not otherwise obvious because of the lack of restrictions on where nonzero entries can occur. Each (Index, Value) pair is listed upon a separate line. An example follows. Suppose that row 10 has nonzero entries [10,10], [10,11], [10,15], and [10,25]. The following row data would be provided:

See example "Matrix Example" lower in this document.

```

=====
sub-parameter: Full_matrix
  Required:      No
  Argument:     None
  Description:
    When the Full_matrix format is used, the couplings between every pair
    of elements is specified explicitly. Assume that the matrix
    has N rows and N columns.

```

```

Usage Context:
  1) MUST be used between keywords [Begin Cn Section] and [End Cn Section].

```

```

Usage:
  The Full_matrix is specified one row at a time, starting with Row 1
  and continuing down to Row N. Each new row is identified with the
  [Row] keyword.
  To conserve the file size it is recommended that the Full_matrix
  sub-parameter not be used if one of the other matrix sub-parameters
  provides sufficient accuracy. The definition of sufficiency being
  at the discretion of the model creator.

```

```

-----
See example "Matrix Example" lower in this document.

```

```

=====
Section 8

```

```

MATRIX EXAMPLES
=====

```

The resistance matrix for this package has no coupling

```

[Begin Cn Section]      ExampleMatrix00
[Derivation Method]    Distributed
[Resistance Matrix]     Diagonal_matrix
10.0
15.0
15.0
10.0
10.0
15.0
15.0
10.0
[End Cn Section] ExampleMatrix00

```

```

[Begin Cn Section]      ExampleMatrix01

```

The resistance matrix for this package has no coupling and is exactly the same as the Diagonal_matrix shown above it is described using a trivial version of the Banded_matrix as an example only. The Diagonal_matrix should be used for this example to conserve file size.

```

[Resistance Matrix]     Banded_matrix
[Bandwidth]             0
[Row] 1
10.0
[Row] 2
15.0
[Row] 3

```

```

15.0
[Row] 4
10.0
[Row] 5
10.0
[Row] 6
15.0
[Row] 7
15.0
[Row] 8
10.0

```

The inductance matrix has coupling between pins

```

[Inductance Matrix]      Full_matrix
[Row] 1
3.04859e-07      4.73185e-08      1.3428e-08      6.12191e-09
1.74022e-07      7.35469e-08      2.73201e-08      1.33807e-08
[Row] 2
3.04859e-07      4.73185e-08      1.3428e-08      7.35469e-08
1.74022e-07      7.35469e-08      2.73201e-08
[Row] 3
3.04859e-07      4.73185e-08      2.73201e-08      7.35469e-08
1.74022e-07      7.35469e-08
[Row] 4
3.04859e-07      1.33807e-08      2.73201e-08      7.35469e-08
1.74022e-07
[Row] 5
4.70049e-07      1.43791e-07      5.75805e-08      2.95088e-08
[Row] 6
4.70049e-07      1.43791e-07      5.75805e-08
[Row] 7
4.70049e-07      1.43791e-07
[Row] 8
4.70049e-07

```

The capacitance matrix has sparse coupling

```

[Capacitance Matrix]      Sparse_matrix
[Row] 1
1      2.48227e-10
2      -1.56651e-11
5      -9.54158e-11
6      -7.15684e-12
[Row] 2
2      2.51798e-10
3      -1.56552e-11
5      -6.85199e-12
6      -9.0486e-11
7      -6.82003e-12
[Row] 3
3      2.51798e-10
4      -1.56651e-11
6      -6.82003e-12
7      -9.0486e-11
8      -6.85199e-12
[Row] 4
4      2.48227e-10
7      -7.15684e-12
8      -9.54158e-11
[Row] 5
5      1.73542e-10
6      -3.38247e-11

```



```

[Row] 6
6      1.86833e-10
7      -3.27226e-11
[Row] 7
7      1.86833e-10
8      -3.38247e-11
[Row] 8
8      1.73542e-10

```

[End Cn Section] ExampleMatrix01

=====
Section 7

7.0 IBIS CONNECTOR FILE EXAMPLES
=====

```

[IBIS Cn Model Ver] 0.953
[File Rev]          1.0           1.0 -> design data, no verification
[Date]              July 1, 2000  The latest file revision date

```

```

[Begin Cn Model Family]
[Begin Cn Model List]
DB9      Mated          10ns          db9mated.jpg
Header2x5 Mated          500ps         Header100.jpg
Header2x5s Mated          500ps         Header100.jpg
[End Cn Model List]

```

EXAMPLE: single SLM DB9 connector
(NOTE: DATA IS "MAKE BELIEVE")

```

[Begin Cn Model] DB9 PinMapDB9a PinMapDB9b SLM 1:9
[Cn Number of Conductors] 9
[Cn Columns of Pins]      5
[Cn Rows of Pins]         2
Cn_Section                SectionDB9
[End Cn Model] DB9

```

EXAMPLE: single SLM DB9 connector with swath
(NOTE: DATA IS "MAKE BELIEVE")

```

[Begin Cn Model] DB25swath PinMapDB25_in PinMapDB25_out SLM 1:25
[Cn Number of Conductors] 25
[Cn Columns of Pins]      13
[Cn Rows of Pins]         2
Cn_Section                SectionDBSwath
                          SwathRows SwathCols RightEdge LeftEdge TopEdge BottomEdge
[Begin Cn Swath]         2           3           1           1           0           0
[End Cn Swath]
[End Cn Model] DB25swath

```

Pin maps for DB9

```

[Begin Cn Pin Map] PinMapDB9
|Index Pin  Signal
1         1    CD
2         2    RXD
3         3    TXD
4         4    DTR

```

```

5          5          GND
6          6          DSR
7          7          RTS
8          8          CTS
9          9          RI

```

[End Cn Pin Map]

[Begin Cn Pin Map] PinMapDB25

```
|Index Pin      Signal
```

```

1          1          CD
2          2          RXD
3          3          TXD
4          4          DTR
5          5          GND
6          6          DSR
7          7          RTS
8          8          CTS
9          9          RI
10         10         CD
11         11         CD
12         12         RXD
13         13         TXD
14         14         DTR
15         15         GND
16         16         DSR
17         17         RTS
18         18         CTS
19         19         RI
20         20         RI
21         21         CD
22         22         RXD
23         23         TXD
24         24         DTR
25         25         GND

```

[End Cn Pin Map]

SECTION EXAMPLES WITH MATRICES

[Begin Cn Section] SectionDB9

[Derivation Method] Distributed

[Resistance Matrix] Diagonal_matrix

```

.05
.05
.05
.05
.05
.05
.05
.05
.05
.05

```

[Inductance Matrix] Diagonal_matrix

```

1.5nH
1.5nH
1.5nH
1.5nH
1.5nH
1.5nH
1.5nH
1.5nH
1.5nH

```

[Capacitance Matrix] Diagonal_matrix

```

0.3pF          |Edge pin has less capacitance

```

```

0.5pF
0.5pF
0.5pF
0.3pF      |Edge pin has less capacitance
0.3pF      |Edge pin has less capacitance
0.5pF
0.5pF
0.3pF      |Edge pin has less capacitance
[End Cn Section] SectionDB9

[Begin Cn Section] SectionDBswath
[Resistance Matrix] Diagonal_matrix
.05
.05
.05
.05
.05
.05
[Inductance Matrix] Diagonal_matrix
1.5nH
1.5nH
1.5nH
1.5nH
1.5nH
1.5nH
[Capacitance Matrix] Diagonal_matrix
0.3pF      |Edge pin has less capacitance
0.3pF      |Edge pin has less capacitance
0.5pF
0.5pF
0.3pF      |Edge pin has less capacitance
0.3pF      |Edge pin has less capacitance
[End Cn Section] SectionDBswath

[Endn Cn Model Family]

[End]

```