

Chapter 1

ACTIVE-State Editor User's Guide

ACTIVE-CAD System Components

ACTIVE State Editor is a part of the ACTIVE-CAD design environment which supports device and system-level designs. ACTIVE-CAD includes the following closely associated software products:

ACTIVE-CAD Project Manager
ACTIVE-CAD Schematic Editor
ACTIVE-CAD Logic Simulator
ACTIVE-CAD Library Manager
ACTIVE-CAD Symbol Editor
ACTIVE-CAD Static Timing Analyzer
ACTIVE-CAD HDL Editor

Additional information on these tools can be found in the following documents:

ACTIVE-CAD Project Manager User's Guide
ACTIVE-CAD Schematic Editor User's Guide
ACTIVE-CAD Logic Simulator User's Guide
ACTIVE-XILINX Xilinx™ Applications

Preface

ACTIVE State Editor allows entering designs in the form of functional diagrams instead of the traditional cell and device-based schematic diagrams. The editor supports finite state machine (FSM) design entry, verification, and automatically converts design into a selected HDL code. Using some additional ACTIVE-CAD software products you can simulate the FSM diagrams and convert them into netlists for ASIC and FPGA devices.

From this manual you will learn how to effectively use ACTIVE State Editor to enter and check design, and how to compile them into HDL files.

Following topics will be covered:

- system requirements
- installation
- FSM Diagram entry and editing
- compilation of the State Machine into VHDL or ABEL Code

The manual shows some sample VHDL and ABEL designs (Applications Chapter). It also includes Glossary, Basic Vocabulary and Commonly Used Abbreviations.

Introduction

ACTIVE-CAD - State Editor Features Overview

The state machine editors allow you to enter your designs in the form of functional diagrams. Used quite widely in the 50's, the state machine editors came back in the 90's to simplify the complex designs through graphical design representation. The state machine designs are best suited to describe control applications, in which a sequence of events is taking place without extensive data manipulations.

The basic premise of the new generation of the state machine editors is to minimise the manual design entry. Only some basic design information is needed. Everything else is automatically provided by the software, including:

- checking whether there are any inconsistencies in the design
- automatic VHDL and ABEL code generation from the FSM graphs
- animation of the graphs for better understanding of information flow

Since today's technology involves complex relationships between data and control signals, ACTIVE-State Editor allows you to enter these signal conditions and relationships in an easy and efficient manner.

This User's Guide allows you to get a quick grasp of the ACTIVE-State Editor features. The enclosed Application Guide provides several examples with increasing complexity which will teach you the basics of using the state machine editor.

Installation

The ACTIVE-State Editor is automatically installed with the ACTIVE-CAD 2.0 or higher. However, special option in your keylock (dongle) must be programmed to activate this software.

Requirements

The ACTIVE-State Editor is an add-on to ACTIVE-CAD and does not put any additional requirements which are:

- IBM 486/Pentium compatible computer
- Windows 3.1, 95 or NT
- Minimum of 16 Mbytes of RAM

- 50 Mbytes of free hard disk space
- SVGA graphics board
- 2- or 3-button mouse device

Additional Requirements

- HDL Editor (provided with ACTIVE-CAD 2.0 and higher).
- VHDL Compiler (provided with ACTIVE-CAD 2.0 and higher)

WINDOWS Environment

The WINDOWS operating system communicates with the user by means of graphical objects such as windows, icons and buttons. Operations on these objects are performed with the help of mouse buttons and keyboard keys. In this manual all screenshots were taken from the ACTIVE State Editor working on Windows '95 platform. If you are not familiar with Windows '95, please read The Elements of Windows '95 User Interface chapter at the end of this manual.

System Start-Up

ACTIVE-State Editor is usually invoked from the Project Manager or Schematic.



Figure 1-1. ACTIVE State Editor Welcome Screen.

When the State Editor is started from the Project Manager icon, the welcome screen (Figure 1-1) allows selecting one of the existing diagram files or creating the new one.

ACTIVE-State Editor Window

ACTIVE-State Editor window is shown in the Figure 1-2 below.

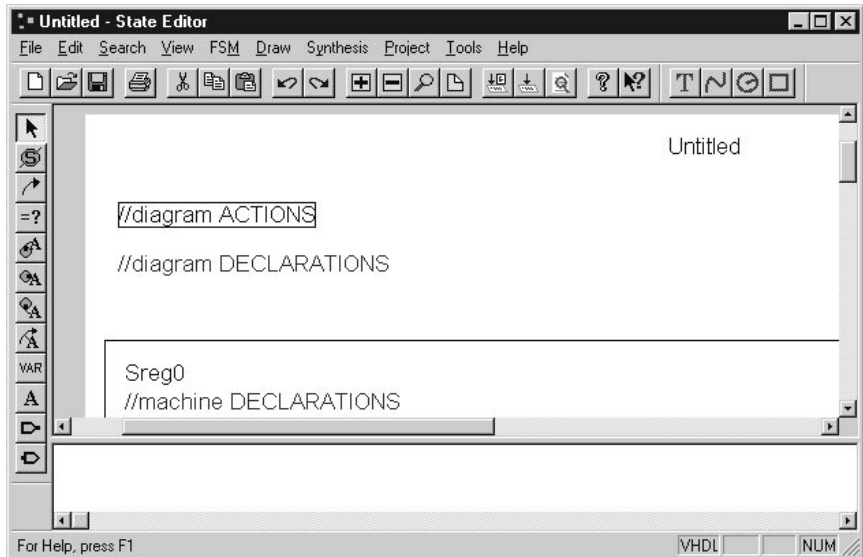


Figure 1-2. ACTIVE State Editor Main Window.

ACTIVE State Editor main window is comprised of the following items:

Window title bar - located at the top of the window. It lists the program name and the current document name, e.g. State Editor [AUTO-COOLING]. If no document has been selected, the title bar will display the [Untitled] message. If several windows are opened simultaneously, the color of the currently selected window's title bar will differ from the others. You can change the window's position on the screen by dragging the active window title bar with the mouse.

Menu bar - located under the title bar. It contains the following main menu options:

File, Edit, Search, View, FSM, Draw, Synthesis, Project, Tools and Help.

Main Menu Options

Note: If you click on a main menu option or program option, a pull-down menu will be displayed, listing the associated 'hot keys' in square brackets. Clicking on the underscored letter (keyboard key) will also invoke the selected operation.

File

- New [CTRL+N]** - Creates a new document.
- Open [CTRL+O]** - Saves the active document and opens an existing document.
- Save [CTRL+S]** - Saves the active document.
- Save As** - Saves the active document with a new name. This option is not present when the State Editor is invoked by ACTIVE-CAD.
- Print [CTRL+P]** - Prints the active document.
- Print Preview** - Displays full pages as they will be printed.
- Print Setup** - Changes the printer and printing options.
- Page Setup** - Changes paper size.
- <Recent File List>** - Opens one of four recently edited diagrams.
- Exit** - Quits the application; prompts to save documents.

Edit

- Undo [CTRL+Z]** - Undoes the last action
- Redo [CTRL+A]** - Redoes (cancels) the previously undone action
- Cut [CTRL+X]** - Cuts the selected items and puts them on the Clipboard.
- Copy [CTRL+C]** - Copies the selected items and puts them on the Clipboard
- Paste [CTRL+V]** - Inserts the Clipboard's contents (pastes copied or cut items).
- Delete [DEL]** - Erases the selected items.
- Select All** - Selects all items in a field of the entire diagram.
- Symbol** - Allows editing the symbol representing the state diagram in the Schematic Editor.
- Settings** - Chooses Text, Line and Fill bundles settings.

Search

- Find String [Alt+F3]** - Finds the specified text
- Find Next [F3]** - Repeats the last Find String or Find Next
- Replace** - Replaces the selected text with the desired text.
- Previous error [Shift+F4]** - Shows the previous error found during generation.

- Next error [F4]** - Shows the next error found during generation.

View

- Zoom in [CTRL +]** - Zooms the diagram to 200%
- Zoom out [CTRL -]** - Zooms the diagram to 50%
- Zoom Select** - Selects zoom rectangle for continuous Zoom.
- Page [PgDn]** - Shows the whole page
- Previous [PgUp]** - Shows the previously visible part of the diagram.
- Toolbars** - Displays sub-menu for selecting visible toolbars.
- Status bar** - Shows or hides the status bar.
- Machine Frames** - Shows or hides frames of machines.
- Grid** - Sets grid options.
- Redraw [F10]** - Redraws the entire window.

FSM

- Machines** - Displays a sub-menu for selecting the current machine in a diagram comprised of multiple machines.
- Select** - Selects and edits; allows such editing operations as drag, delete, etc.
- State** - Adds states to machines; it is used for entering the machine states or 'bubbles'
- Transition** - Adds transition to machines; it is used for drawing state transition lines.
- Condition** - Adds/Edits condition of a transition; allows to specify the conditions that cause a transition to a new state.
- Action** - Displays sub-menu for selecting actions taken by the machine
- Declarations** - Adds/Edits declarations to machine or diagram.
- Input Port** - Adds/Edits input port to the diagram; used for drawing input ports.
- Output Port** - Adds/Edits output port to the diagram; used for drawing output ports.

Draw

- Text** - Allows drawing text on the diagram.
- Bezier Curve** - Allows drawing Bezier curves on the diagram.
- Circle** - Allows drawing circles on the diagram.
- Rectangle** - Allows drawing rectangles on the diagram.

Synthesis

- Configuration** - Customizes synthesis options.
- HDL Code Generation [CTRL+H]** - Generates HDL Code
- Options ...** - Customizes synthesis tools options.
- Synthesize** - Starts synthesis tool.

- View Report** - Displays a report listing the compilation flow and errors.

Tools

- Preferences** - Customizes configuration
- Project Manager** - Activates Project Manager
- HDL Editor** - Runs HDL Editor
- Simulation** - Starts simulation

Help

- Help Topics** - Lists Help topics.
- Using Help** - Displays instructions on how to use Help.
- About State Editor** - Displays the program information, its version number and the copyright notice.

Detailed Menu Description

File	Edit	Search	View	FSM	Draw	Syntt
New						Ctrl+N
Open...						Ctrl+O
Save						Ctrl+S
Save As...						
Print...						Ctrl+P
Print Preview						
Print Setup...						
Page Setup...						
1 C:\ACI...\IQQQ\STATSYM0.ASF						
2 C:\NEWPROJ\BJACK7K\BJACK_C.ASF						
3 C:\ACX...\BJACK7K\BJACK.ASF						
4 C:\ACTIVE7...\IFSMTST\AUTO.ASF						
Exit						

Figure 1-3. File Pull-Down Menu.

The File Menu Options

File | New [CTRL+N]

Allows to create a new document. Selecting this option displays the *Design Wizard Welcome Window* (Figure 1-4).

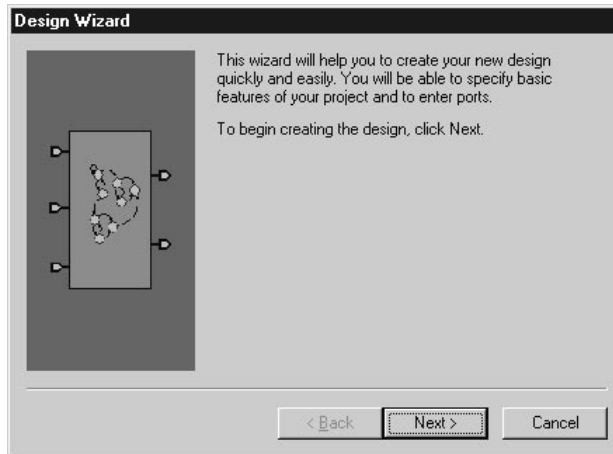


Figure 1-4. FSM Design Wizard Welcome Window.

Clicking on the **Next** button in the wizard's welcome window displays **HDL Language Selection** window (Figure 1-5).

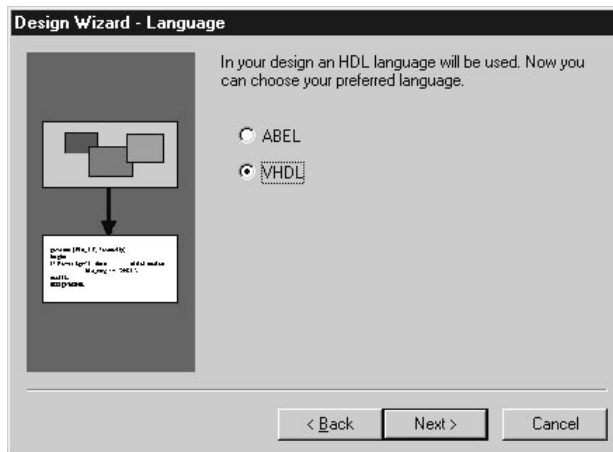


Figure 1-5. Design Wizard - Language Selection Window.

You need to select in that window the language into which the FSM diagram will be converted. Currently only ABEL and VHDL languages are supported. Please remember that the FSM diagram does not have any electrical meaning without an HDL representation.

1. Clicking on the **Back** button displays the preceding window.

2. Clicking on the **Next** button, activates the next window, which in this case it is the **Design Wizard - Name** window (Figure 1-6).
3. The **Cancel** button cancels the design entry and stops Design Wizard.

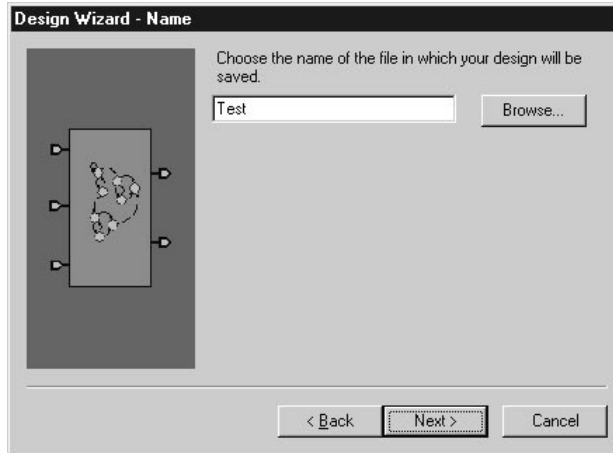


Figure 1-6. Design Wizard - Name Window.

The name of the diagram can be entered in the **Design Wizard - Name** window.

1. Clicking on the **Back** button displays the preceding window.
2. Clicking on the **Next** button, activates the next window, which in this case it is the **Design Wizard - Ports** window (Figure 1-7).
3. The **Cancel** button cancels the design entry and stops FSM Wizard.

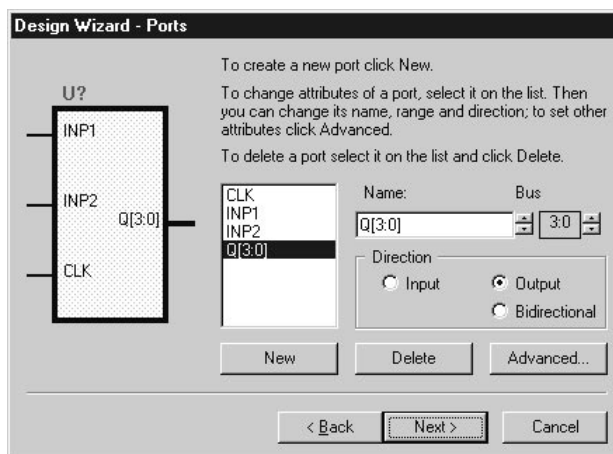


Figure 1-7. Design Wizard - Ports Window

In the **Design Wizard - Ports** window you should enter the port's name, range (for bus ports only) and type. After entering this information, you should press the **Add** button. If a mistake has been made, select the port from the list and press either the **Delete** button or make changes to the port and press the **Change** button to reenter port information. The **Back**, **Next** and **Cancel** buttons have the same meaning as in the previous window.

Clicking **Next** displays the **Design Wizard - Machines** window (Figure 1-8).

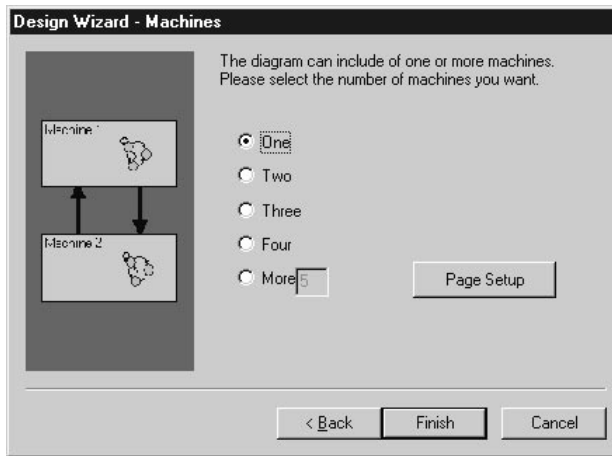


Figure 1-8. Design Wizard - Machines Window

The Machines window allows you to select how many state machines the FSM diagram will have. Clicking on the **Page Setup** button displays the window where diagram sheet size and orientation can be changed. Clicking on the **Finish** button, completes the design and State Editor exits the Wizard. **Back** and **Cancel** buttons have their usual meanings.




Using the FSM Design Wizard you can quickly define a new state machine, including its I/O ports.

File | Open [CTRL+O].

This option allows you to open an existing (saved) project and prompts you to save changes made to the current project. It displays the **Open** window (Figure 1-9) which is a typical Windows screen display.



Figure 1-9. Open Window.

1. **Look in** field allows you to select the project directory,
2. **Upper level folder** button () allows moving one step up in the folder hierarchy,
3. **New folder** button () allows creating a new folder,
4. **List/details** buttons () allow toggling between an abbreviated and detailed display of the documents,
5. **File name** field is used for entering project's name,
6. **Files of type** field allows viewing only files of the selected type.

All options of this window display are described in the Help menu, activated after clicking the Help button located in the Title bar.

Note: Since the OPEN window is a standard Windows screen, all its options are described in Windows user's documentation and in Windows Help.

File | Save.

This option saves the currently active document with the full file name and date/time stamp. If the document is new (Untitled), the **Save As** window will be displayed instead and will allow entering the name of the project. (See the next option)

File | Save As.

This option saves the active project with a new name. The **Save As** option is usually used to save the active document file under a new file name. It produces a typical Windows' **Save As** window (Figure 1-10).

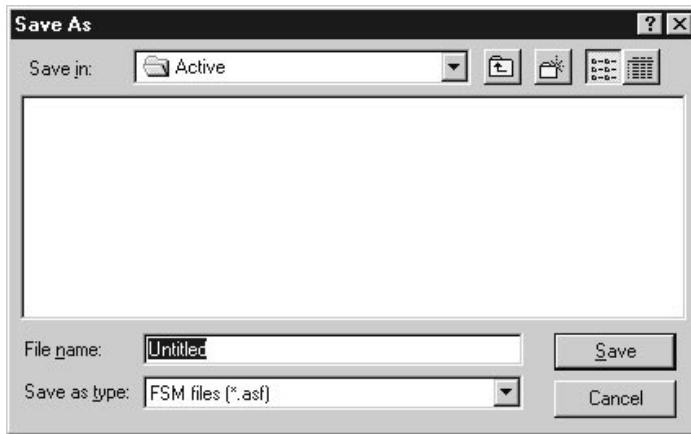


Figure 1-10. Save As Window.

1. **Save in** field allows you to specify the project's directory,
2. **File name** field is used for entering project's name
3. **Save as type** field allows selecting the type of the saved file (the file name extension).

Note: All saved documents have their file name extensions automatically set to .ASF (ALDEC Schematic File).

File | Print [CTRL+P].

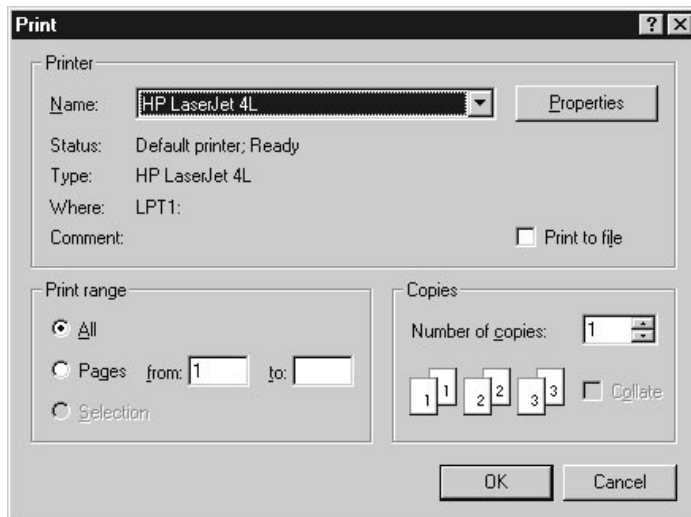


Figure 1-11. Print Window.

This option prints the active document. Selecting the Print option displays a typical Windows' **Print** window (Figure 1-11).

1. **Printer field** options allow selecting the network printer . Its status, type and port are automatically displayed below the printer name field.
2. **Print range** field is for selecting pages to be printed
3. **Copies** field enables entering the number of printed copies.

File | Print Preview.

It displays the way pages will be printed. Selecting the Print Preview option displays a typical **Print Preview** window, similar to other Windows programs (Figure 1-12).

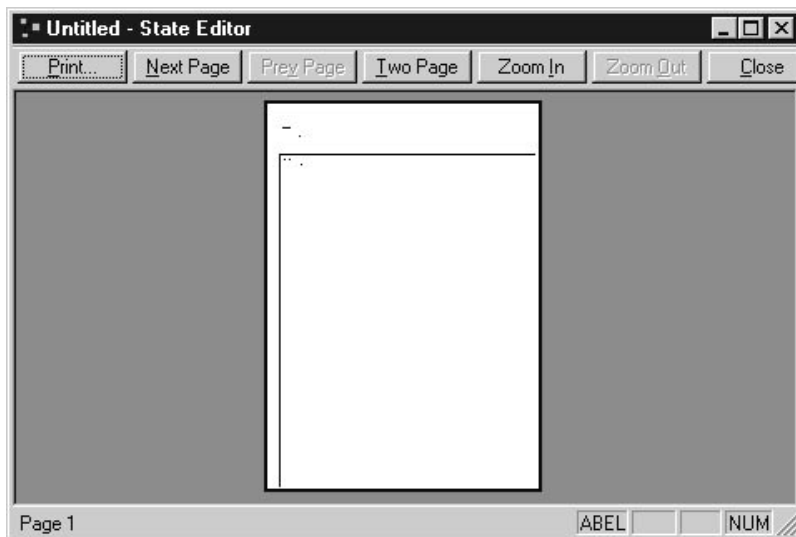


Figure 1-12. Print Preview Window

The Print Preview screen allows previewing how the FSM project will be printed.

File | Print Setup.

This option is used to select the printer and its options, such as the sheet size and its orientation. The **Print Setup** window is shown in Figure 1-13.

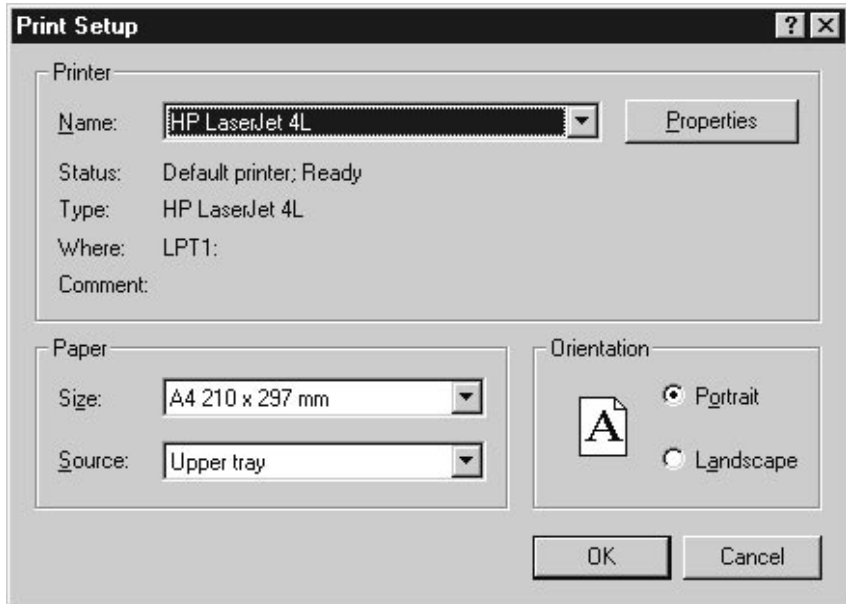


Figure 1-13. Print Setup Window.

1. **Printer** field options allow selecting the printer; its status, type and port are automatically displayed below the **Printer name** field.
2. **Paper** field allows selecting the **Size** of the sheet and its **Source**.
3. **Orientation** field allows selecting the orientation of printed page (portrait or landscape).

Note: The Printer Setup options are described in the Windows' Help menu.

File | Page Setup.

This option allows you to change the sheet size, its orientation and margins. The **Page Setup** window is typical for Windows applications (Figure 1-14).

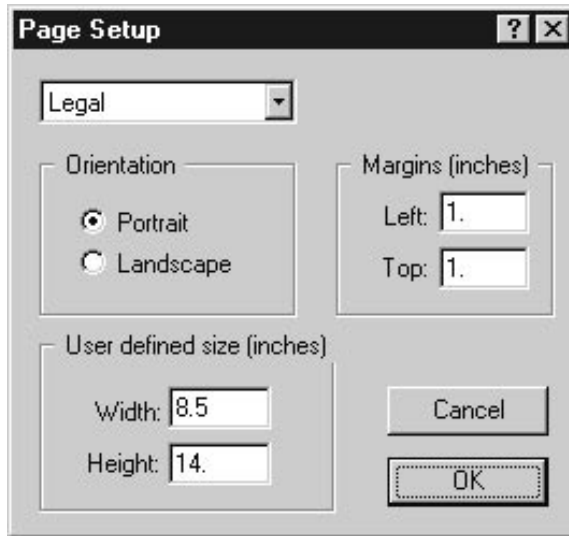


Figure 1-14. Page Setup Window.

File |Files List.

A list of up to four most recently edited documents is displayed in the File menu. Double-clicking on the selected name opens the document.

File | Exit.

This option prompts you to save the design and quits the State Editor.

The Exit option ends the session. The FSM window (Figure 1-15) will prompt you to save changes to an untitled document or exit the project without saving the latest design changes.

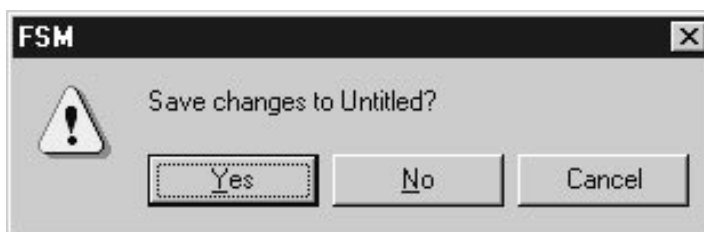


Figure 1-15. FSM SavePrompt Window.

Note: If ACTIVE-State Editor is invoked from the ACTIVE-CAD software, then the program on Exit may display more message boxes prompting you to save several of the project files. For details, see one of the next chapters, where the integration with ACTIVE-CAD software is described.

The EDIT Menu Options

Edit | Undo [CTRL+Z].

Undoes the last action. You can go back up to 512 steps.

Edit | Redo [CTRL+A].

Redoes (cancels) the previously undone action(s).

Edit | Cut [CTRL+X].

Cuts the selected items and puts them on the Clipboard.

Edit | Copy [CTRL+C].

Copies the selected items and puts them on the Clipboard

Edit | Paste [CTRL+V].

Inserts the Clipboard's contents at the current cursor location (pastes Copied or Cut items).

Edit | Delete [DEL].

Erases the selected items.

Note: The Cut, Copy, Paste and Delete options operate like any other Windows programs.

If no selection is made - the **Cut**, **Copy** and **Delete** options will not be active and will remain gray. Similarly, if nothing has been selected to Clipboard - the **Paste** option will not be active and will remain gray.

There are three methods of objects selection:

1. To select an object, position the mouse pointer within its body and click with the left mouse button.
2. To select several objects, click on each of them while holding the SHIFT key depressed.
3. To select a group of objects, click at some point on the screen, and drag the cursor to the opposite corner of the rectangle. When you release the left mouse button, all objects within the rectangle will be selected for subsequent cutting, copying or deleting.

Edit | Select All.

This option selects all items in the entire diagram.

Note: The Cut, Copy, Paste and Delete options allow you to export your FSM Project in the metafile format to all popular text editors via Clipboard. However, since a purely graphical file will be created, all design parameters will be lost in the process.

Edit | Symbol.

This option allows making changes to the port descriptions. The shape of the symbol associated with the diagram and all ports can be seen in the **View Symbol** window shown in figure 1-16.

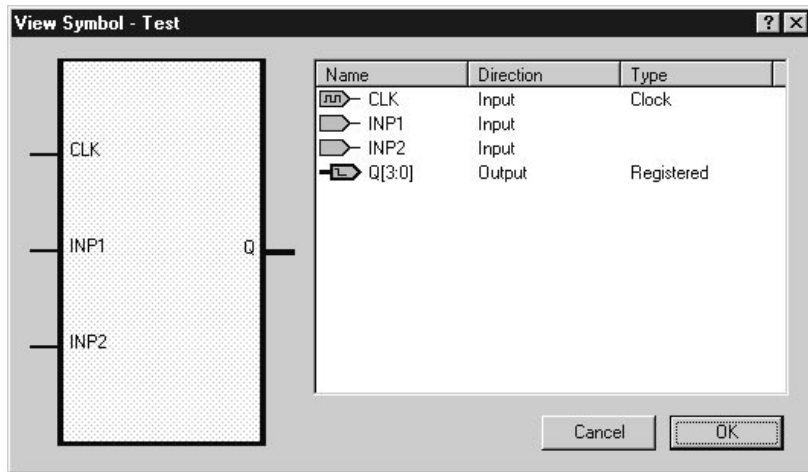


Figure 1-16. View Symbol Window.

Edit | Settings.

This option allows changes to **Text**, **Line** and **Fill** settings, which control color, font type and size, and other attributes of diagram objects.

All diagram objects can be set to any value or parameter. For example, the State object can be represented by a black circle filled with green background and having a black State label:

Frame color = black (see **Fill Bundles**)

Fill color = green (see **Fill Bundles**)

Text color = black (see **Text Bundles**)

Objects, called **Transitions** (means Transition lines) are drawn between states as **Bezier Curves** connected to **States**. They have their own graphical and logical attributes.

Graphical attributes can be defined using the **Text**, **Line** and **Fill** options described below:

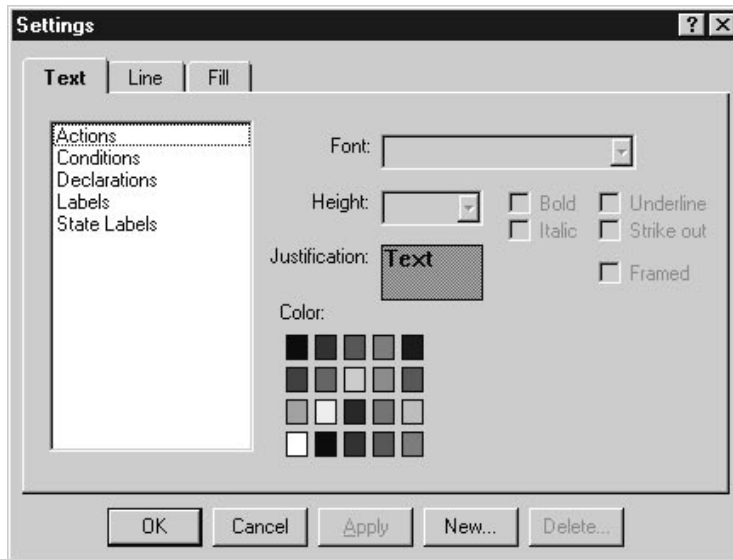


Figure 1-17. Settings Window - Text Card.

Note: The Text Settings screen is shown in the Figure 1-17. The Line Settings and Fill Settings look similar to the display in Figure 1-17.

Edit | Settings | Text.

Changes text color, font size and other settings for:

1. Actions.
2. Conditions.
3. Declarations.
4. Labels.
5. State Labels.

Edit | Settings | Line.

Changes the line color for:

1. Errors.
2. Transitions.

Edit | Settings | Fill.

Changes the fill and frame colors for:

1. Current State.
2. Ports.
3. States.

Note: Graphical attributes will be automatically saved with each document file.

The SEARCH Menu Options

Search | Find String [Alt+F3].

This option finds the specified text within the entire project. Selecting it displays the Find window (Figure 1-18).

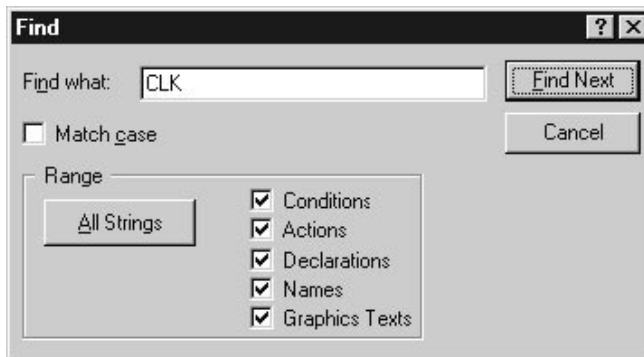


Figure 1-18. Find Window.

If you enter a text in **Find what** field, ACTIVE-State Editor will search the entire FSM project for that text. If the **Match case** option has been selected, then the text will also be checked for the compliance with upper-lower case letters. The operation of the **Find** window and its options is similar to other Windows programs. Consult the Help menu for details.

Search | Find Next [F3].

This option repeats the last Find String (or Find Next) operation.

Search | Find and Replace.

Replaces the selected text with the desired text. Selecting this option displays the **Replace** window (Figure 1-19) which is similar in operation to other Windows programs.

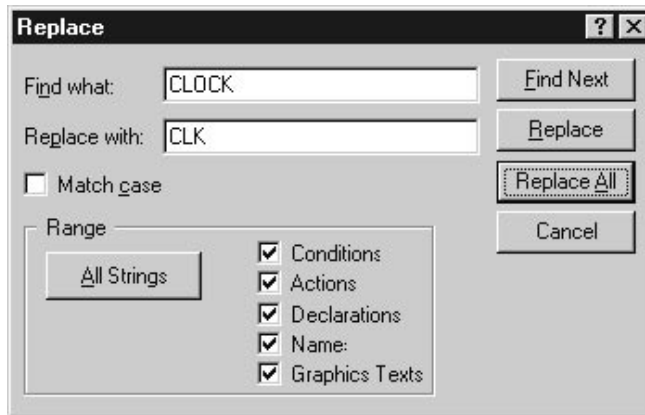


Figure 1-19. Replace Window.

Search | Previous error [Shift+F4].

This option displays sequentially all design errors which were detected during the HDL Code Generation process in the last- to-first order.

Search | Next error [F4].

This option displays sequentially all design errors which were detected during the HDL Code Generation process in the first- to-last order.

The View Menu Options

View | Zoom in [CTRL +].

Zooms the diagram to 200%.

View | Zoom out [CTRL -].

Zooms the diagram to 50%.

View | Zoom Select.

Selects zoom rectangle for continuous Zoom.

View | Page [PgDn].

Displays the entire design sheet.

View | Previous [PgUp].

Shows the previously visible part of the diagram.

View | Toolbars.

Shows a pull-down menu for toolbar display. See *The Toolbars* section in this chapter for detailed explanations.

View | Status bar.

It shows or hides the **status bar**, which is located at the bottom of the document's window. When enabled, the status bar will display help messages, e.g. *For Help press F1*. The Help information or message is context-sensitive.

There are four small windows located at the bottom right-hand corner of the screen. They are **VHDL/ABEL**, **OVR**, **CAP**, and **NUM** windows, and they are placed side by side horizontally. The windows will remain blank if the listed options are not selected.

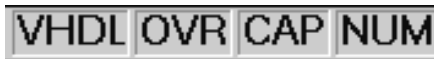


Figure 1-20. Status Bar.

1. The VHDL/ABEL window displays which HDL option has been selected for the HDL Code generation. Two options are available: **ABEL** and **VHDL**. These options are selected from FSM Wizard, and the **Synthesis | Configuration** options.
2. The **OVR** window displays the entry mode. It can be set to either **INSERT** or **OVERWRITE** by pressing the Insert key.
3. The **CAP** window indicates the state of Caps Lock.
4. The **NUM** window shows the state of Num Lock.

View | Machine Frames.

Shows or hides frames of machines. This option displays a graphical separation between the local Machines and the FSM Diagram, which includes all state machines.

Note: A Machine is distinguished from an FSM Diagram (or so called FSM Design or FSM project) by a thin rectangle frame.

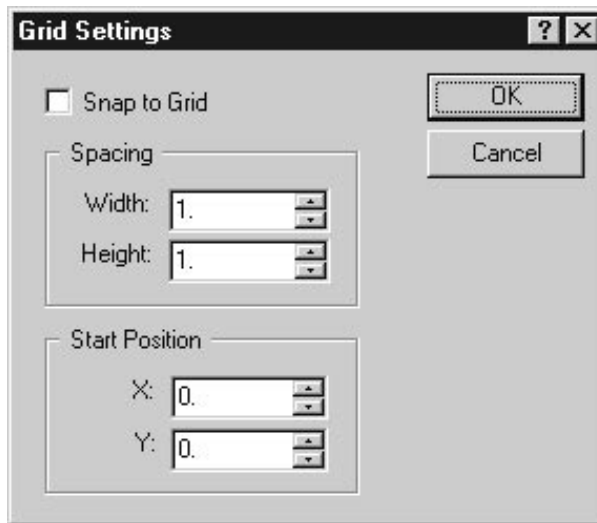


Figure 1-21. Grid Settings Window.

View | Grid.

Allows to set such grid options as **Snap to Grid**, **Grid Spacing** and the **Start Position** coordinates (Figure 1-21).

View | Redraw [F10].

Redraws the entire window and refreshes the FSM project design, displayed on the monitor screen.

The Toolbars

ACTIVE State editor displays by default three toolbars docked as horizontal or vertical bars at the main FSM document field edge. These three toolbars are: **Main**, **FSM** and **Draw** and they are activated and deactivated from the **View / Toolbars** option.

The Toolbars menu contains the following options:

1. Main.
2. FSM.
3. Draw.
4. Default Position.

By default, the Main toolbar is placed at the top of ACTIVE-State Editor window, just below the menu bar. The FSM and Draw toolbars are

placed on the left-hand side of the screen, just at the left FSM document field edge.

Note: The toolbars can also be docked as horizontal or vertical bars or sets of boxes anchored anywhere within the state machine window. To move a toolbar, click in the close proximity of the toolbar button (outside the button) and drag the toolbar to the desired new screen location. Depending upon its new position, the toolbar automatically changes its horizontal/vertical orientation.

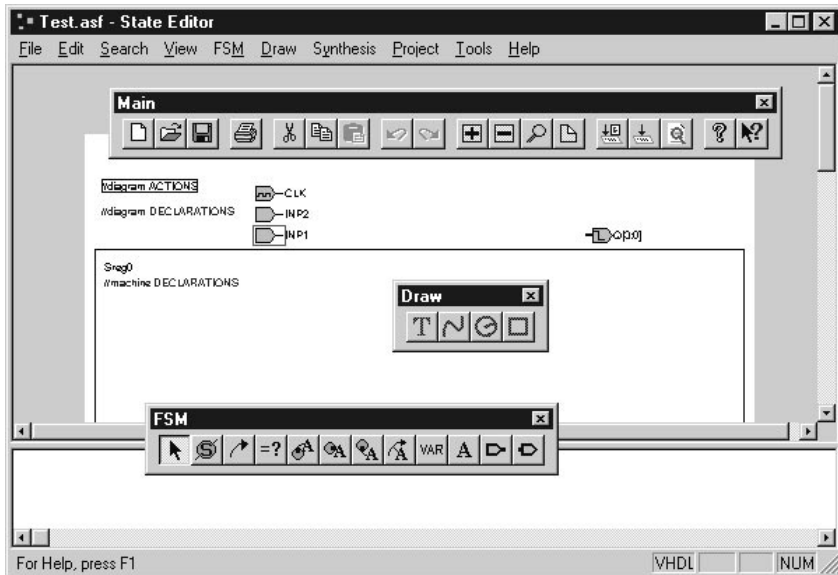


Figure 1-22. Toolbars' "Anywhere" Positions.

The Main Menu has considerable number of options. To simplify the use of the FSM editor, the most frequently used operations can be activated by clicking on buttons located within the three toolbars in Figure 1-22.

The Main Toolbar.

It is docked by default as a horizontal bar or a set of boxes at the top of the ACTIVE-State Editor window, just above the FSM document field edge. It contains the following tool-buttons:



Figure 1-23. Main Toolbar.

The tool buttons are described in the left-to-right order:

- New [CTRL+N]** - Creates a new document.
- Open [CTRL+O]** - Saves the active document and opens an existing document.
- Save [CTRL+S]** - Saves the active document.
- Print [CTRL+P]** - Prints the active document.
- Cut [CTRL+X]** - Cuts the selected items and puts them on the Clipboard.
- Copy [CTRL+C]** - Copies the selected items and puts them on the Clipboard.
- Paste [CTRL+V]** - Inserts the Clipboard's contents (pastes copied or cut items).
- Undo [CTRL+Z]** - Undoes the last action.
- Redo [CTRL+A]** - Redoes (cancels) the previously undone action.
- Zoom in [CTRL +]** - Zooms the diagram to 200%.
- Zoom out [CTRL -]** - Zooms the diagram to 50%.
- Zoom Select** - Selects zoom rectangle for continuous Zoom.
- Page [PgDn]** - Shows the whole page.
- Generate HDL** - Translates current diagram into HDL code.
- Synthesize** - Starts the selected synthesis tool.
- View Report** - Displays logic synthesis report.
- About State Editor** - Displays the program information, its version number and the copyright notice.
- Help** - Invokes context-sensitive Help. Displays help for activated buttons, menus and windows.

The FSM Toolbar.

It is docked by default as a vertical bar or a set of boxes on the left-hand side of ACTIVE-State Editor window, just at the left edge of the FSM document window. It contains the following tool-buttons:



Figure 1-24. FSM Toolbar.

The tool buttons are described in the left-to-right order:

- Select** - Selects and edits. It allows such editing operations as drag, delete, etc.
- State** - Allows entering new machine states or “bubbles”.
- Transition** - Allows drawing state transition lines.
- Condition** - Allows to specify conditions that cause a transition to a new state.

- Entry Action** - Adds/Edits entry action of a state. It sets all output ports on the state entry.
- State Action** - Adds/Edits state action of a state. It sets I/O ports upon detecting a new state.
- Exit Action** - Adds/Edits exit action of a state. It sets I/O ports on exit from the selected state.
- Transition Action** - Adds/Edits action of a transition. It sets I/O ports upon detecting a state transition.
- Declarations** - Adds/Edits machine or diagram declarations.
- Machine/Diagram Action** - Adds/Edits machine or diagram actions.
- Input Port** - Adds/Edits input ports. It is used for drawing input ports.
- Output Port** - Adds/Edits output ports. It is used for drawing output ports.

The Draw Toolbar

It is docked by default as a vertical bar or a set of boxes on the left-hand side of the ACTIVE State Editor. It contains the following tool-buttons:

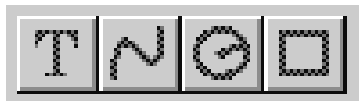


Figure 1-25. Draw Toolbar.

- Text** - Places text string.
- Bezier Curve** - Draws Bezier Curve.
- Circle** - Draws Circle.
- Rectangle** - Draws Rectangle.

Note: All elements drawn in the graphics mode do not have any electrical properties.

The FSM Menu Options

Note: There is a direct correlation between the FSM Options chosen from its Menu and the icon tools selected from the (vertical) FSM Toolbar.

FSM | Machines.

Selecting this menu will display a pull-down sub-menu, which will list following items:

```
[machine names]
Add New
```

The first item lists Machine names in the current diagram (e.g. Sreg0, Sreg1).

If you want to add a new Machine you should make some space for it by shrinking existing machine(s) outline. When you click on the **Add New** option, the new, empty machine outline will appear. However, if there is no place for a new Machine design then the window in Figure 1-26 will appear.



Figure 1-26. FSM Warning Window.

If a new Machine design is allowed, a window or frame will appear, and you will be able to enter **//Declaration** statements for the new machine design.

Note: You need to keep track of the number of machine designs in your FSM Diagram.

Let's review the example of an FSM Design (FSM Graph) shown in Fig. 1-27 (see the *Applications Guide*).

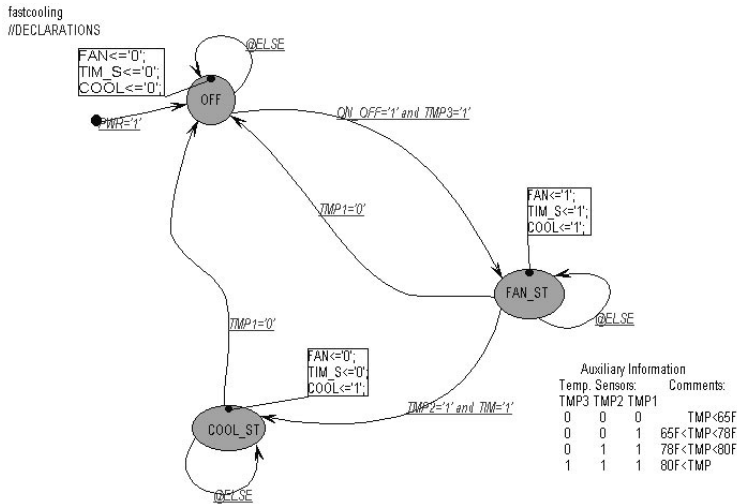



Figure 1-27. AIR_COND Design Diagram.

 **FSM | Select.**

Allows selecting objects and performing such editing operations as drag, delete, etc. Using the **Select** option, you can select an object for editing, dragging, etc. The equivalent toolbar button is shown above.

Note: The mouse cursor changes its shape depending upon the selected operation.


 **FSM | State.**

Allows to add new **State** objects to machines. Typically, the state symbol appears as a black circle filled with green and black symbol name. The symbol name is automatically placed inside the symbol field. Initially, the bubbles are named in sequence as S1, S2, etc. You can then edit these names to the desired ones.

Note: The FSM Machine (finite state machine) is always in one of its multiple states.

If a condition is satisfied i.e. when a logical Boolean equation becomes true then a transition from one state to another will occur.

Once the **State** option is selected, then each click of the left mouse button will produce a new state symbol on the screen. Pressing the right mouse button will return the FSM editor to the **Select** mode, which is the default mode.

 **FSM | Transition.**

This option is for drawing new state transition lines. It allows connecting any two states with a line or curve - which is called the Bezier's curve.

Note: You can edit the transition lines by dragging its middle-point locations or delete them by activating the **Select** toolbar button and then selecting **Edit | Delete** options. To disconnect a transition line end, double click at the selected transition line end. When a free-floating transition line end marked with ⊗ symbol (open connection) appears, drag it to the desired screen location.

 **FSM | Condition.**

Allows to specify the conditions that cause a transition from one state to another. Using this option you can write a set of conditions at each transition line.

Note: A condition is the attribute of the transition line. It is displayed by default in a dark violet frame around the condition text. The frame with its condition text, is connected to the associated transition line by a thin line displaying their logical association.

Attributes of the condition text can be set using the **Edit / Settings** and **Text bundles**. For example, you can select *Arial, 10, Italic, Underline* for a specific condition text.


The easiest way to learn this feature is by editing any of the design samples which are provided with *ACTIVE-State Editor Applications Guide*.


Note: Since the State Editor allows cutting, copying, and moving text via Clipboard, you can edit the text with such text editors as Word for Windows, etc.


To magnify a text selected for editing, drag the corner handles of its outline. The text font will automatically rescale to fit the new box outline.


FSM | Action.

Actions are the state and transition-associated operations. The I/O ports may change their logical state upon detecting an **Action**. There can be three (3) different actions associated with each state and one (1) associated with each transition.

 **Entry Action** - Adds/Edits entry action of a state. It sets all output ports on the entry to the selected state.

 **State Action** - Adds/Edits state action of a state. It sets I/O ports upon detecting a new state, which can be some time after the transition to that state occurred.

 **Exit Action** - Adds/Edits exit action of a state. It sets I/O ports upon exit from the selected state.

 **Transition Action** - Adds/Edits actions of a transition. It sets I/O ports upon detecting a change on the transition line.

Note: There can be only one action of each kind associated with a state or transition!

For example, in the diagram shown in Figure 1-27 there is an entry action associated with the FAN_ST state. You can add a state action or exit action to this state. However, you cannot add yet another entry action.

Actions can be selected, dragged and edited, similarly to operations on conditions.

Note: If an action is associated with a transition, it is called the ***transition action***.

There can be only one transition action for each transition!

A transition with its attributes (condition and a transition action) constitutes an independent object, which can be disconnected from a state. However, the condition and transition actions are unique for each transition, and without it have no meaning. The same is true for state actions.

Note: No action (entry, state, or exit) can be specified without a direct reference to the selected state or transition line. However, a transition line without actions and conditions and a state without action are allowed!

An FSM diagram must consist of at least one Machine. A state and its transitions can only be placed within a Machine schematic sheet. You cannot connect states located in different Machine designs.

Note: Each Machine is delineated by a thin rectangular line. Several machines can share the same I/O pins but they cannot directly interact with each other.

Note:
Object selecting - is performed by clicking within the object area.
Machine selecting - is performed by clicking within the machine rectangular outline.

Machine/Diagram Action.

Adds/Edits action of an individual machine or the entire diagram. Actions must be specified in reference to a Machine or to the entire FSM Diagram. Clicking on the empty area inside the machine frame or at the

top of the FSM diagram opens a frame for entering the Machine or FSM Diagram action, respectively.

FSM | Declarations.

Adds/Edits declarations to machine or diagram.

ACTIVE-State Editor ä places the word: **//DECLARATIONS** right below the Machine name. Everything you enter (states, transitions, actions, etc.) is considered FSM declarations. Each declaration is a single entity which can be entered by the user as a multiline declaration text. Declarations may pertain to a selected Machine or to the entire FSM Diagram. For example, to simplify conditions you can define auxiliary variable in the declarations section and use it in any actions and conditions.

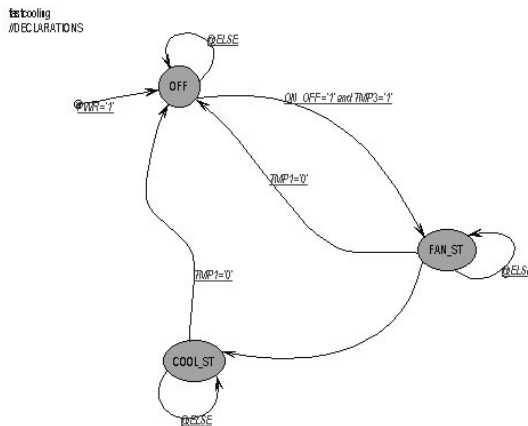


Figure 1-28. State MachineGraph.

FSM | Input Port.

Adds/Edits input ports to the diagram; used for adding new input ports.

FSM | Output Port.

Adds/Edits output ports to the diagram; used for adding new output ports.

Input and Output Port icons are automatically placed outside the particular Machine outline because ports are pertaining to the entire FSM Diagram and not to its local Machine designs. Global variables are declared in the same field as the Input/Output ports. Depending on the direction

of the information flow, ports can be defined as Input, Output or Bi-directional type.

An **Input Port** can be defined as **Normal** or **Clock** type.





Output and **Bi-directional** ports can be defined as **Registered** or **Combinatorial** type.

Note: The Normal port type is assumed if Clock checkbox remains empty! The Registered output port will store an input signal on the active clock transition.

When all ports of an FSM Diagram have been entered, start editing the objects by selecting the **Edit / Symbol** option. In response, a window containing the list of ports will be displayed. You will be able to change any name by clicking within its field and editing it.

Clicking on the header fields allows to sort ports by **Name**, **Direction** or **Type** of ports.

The Draw Menu Options

-  **Draw | Text** - Places text string.
-  **Draw | Bezier Curve** - Draws Bezier Curve.
-  **Draw | Circle** - Draws circles.
-  **Draw | Rectangle** - Draws rectangles.

All DRAW Menu Options correspond to the icons which are displayed in the vertical Draw Toolbox. These tools and options allow for typical design editing operations such as drawing and writing within the FSM design area.

The SYNTHESIS Menu Options

Synthesis | Configuration.

It allows to select such synthesis options as the HDL language and the logic synthesis tool vendor. Selecting this option displays the **HDL Configuration** window shown in Figure 1-29.

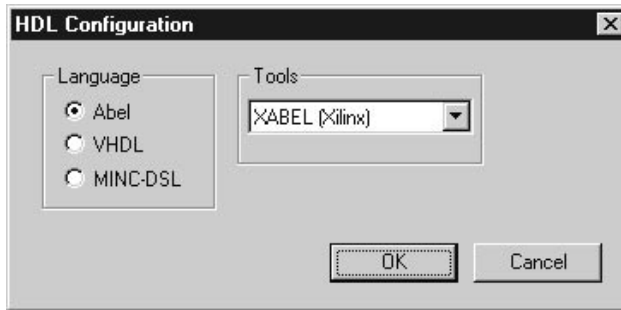


Figure 1-29. HDL Configuration - ABEL Window.

ACTIVE-State Editor offers three HDL choices: ABEL, VHDL, and MINC-DSL. They are listed in the **Language** field (Figure 1-29). ABEL is being set as the default language. Since XABEL (Xilinx) is the only ABEL tool supported by ACTIVE-State Editor, it will be automatically displayed in the **Tools** field.

If you chose the **VHDL** option, a list of VHDL-compatible logic synthesis tools will be displayed (Figure 1-30).

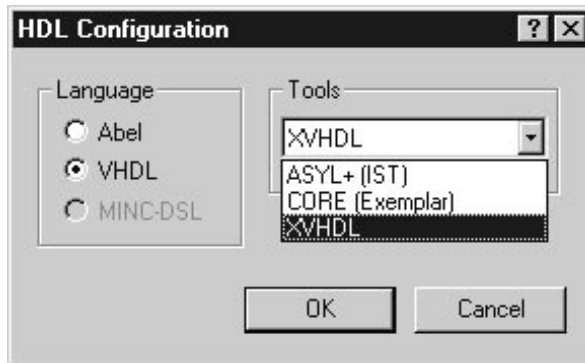


Figure 1-30. HDL Configuration - VHDL Window.

ACTIVE-State Editor currently supports the following logic synthesis tools:

1. ASYL + (IST).
2. CORE (Exemplar).
3. XVHDL (Metamor).

Synthesis | HDL Code Generation [CTRL+H].

Automatically generates HDL Code for the selected logic synthesis tool.

Note: You need to make sure that the selected logic synthesis tool is installed on your computer. Otherwise, you will not be able to further process the generated HDL code!

Synthesis | Options ...

Customizes synthesis tools options for area, speed and compilation effort. If you have selected VHDL as your HDL platform then the [Synthesis] Options window (Fig. 1-31) will appear.

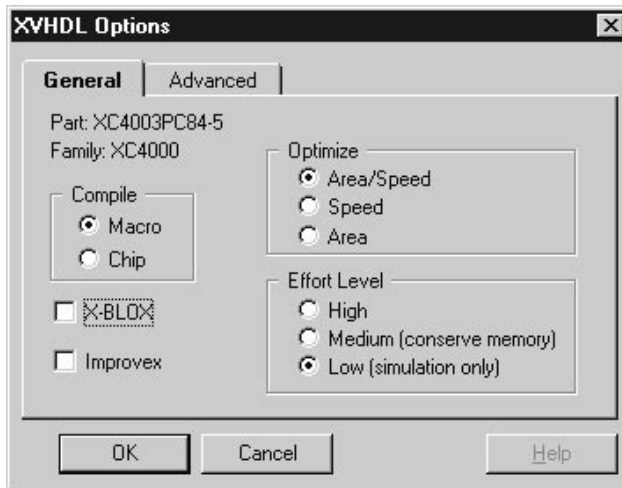


Figure 1-31. METAMOR Options.

The **Compile** field will allow converting the VHDL code into either a **Macro** or a **Chip**. In addition, you can compile the code as **XBLOX**.

The **Optimize** field allows you to optimize the compilation process for **Area**, **Speed** and **Area/Speed**.

The **Effort Level** field controls how much compilation effort will be put into the netlist generation process.

After you have made your decision regarding the HDL language and the logic synthesis tool, select the **Synthesis | HDL Code Generation**.

Synthesis | Synthesize.

Starts the logic synthesis process. It activates the logic synthesis tool and its options that have been selected in Figures 1-29, 1-30 and 1-31.

Synthesis | View Report.

Displays the errors and other messages generated by the logic synthesis process.

The PROJECT Menu Options

Project | Add to Project

Adds current diagram to the ACTIVE-CAD project resources.

Project | Create Macro

Creates ACTIVE-CAD macro from the current diagram.

Project | Update Macro

Updates macro after the changes made to the diagram.

The TOOLS Menu Options

Tools | Preferences.

Customizes configuration of the design graphics. Enables/disables text scaling and State Codes display on the FSM diagram. These preferences can be set directly in the window below (Figure 1-32).

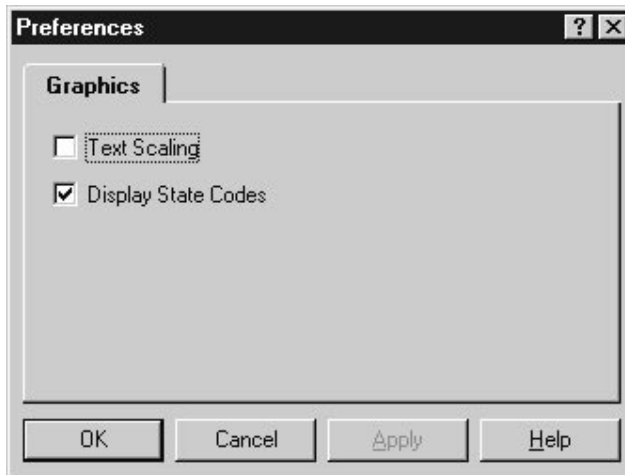


Figure 1-32. Preferences - Graphics Card.

Tools | Project Manager.

Activates **Project Manager** which controls other design tools and project files.

Tools | HDL Editor.

Runs **HDL Editor**. It invokes the HDL Editor which displays the generated HDL Code. The editor will allow you to edit and analyze in detail the HDL code.

Tools | Simulation.

Activates the logic simulator if a valid netlist has been loaded or generated (see *ACTIVE-CAD Logic Simulator User's Guide*).

The Help Menu Options

- Help | Help Index** - Lists Help topics.
- Help | Using Help** - Displays instructions on how to use Help.
- Help | About State Editor** - This option displays the information in Figure 1-33.

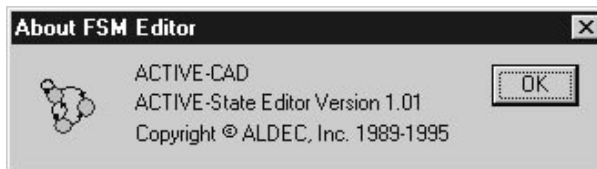


Figure 1-33. About State Editor Window.

Context Sensitive Menu

States, Transitions, Conditions, & Actions

Clicking the left mouse button creates actions such as placing or selecting objects.

Placing mouse pointer over an object and clicking the right mouse button activates context sensitive menus for the selected object.

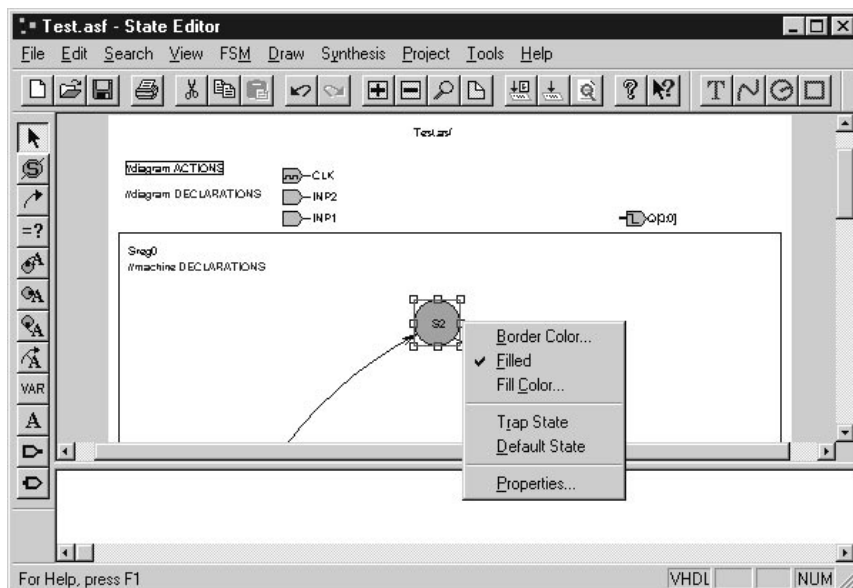


Figure 1-34. State Context Sensitive Menu.

Figure 1-34 shows a context sensitive menu for a state object.

Using the menu you can:

1. change the Border color of the State object,
2. fill the object with a color or disable filling,
3. choose the desired fill color,
4. set up the **Trap** state,
5. set up the **Default** state,
6. define or set up the **State Properties** (Figure 1-35).

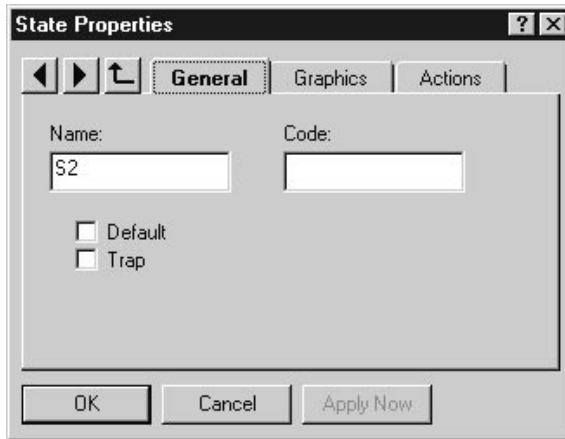


Figure 1-35. State Properties Window.

Clicking the right mouse button within the Machine outline (border), and selecting **Properties** option will display the **Machine Properties** window (Figure 1-36).

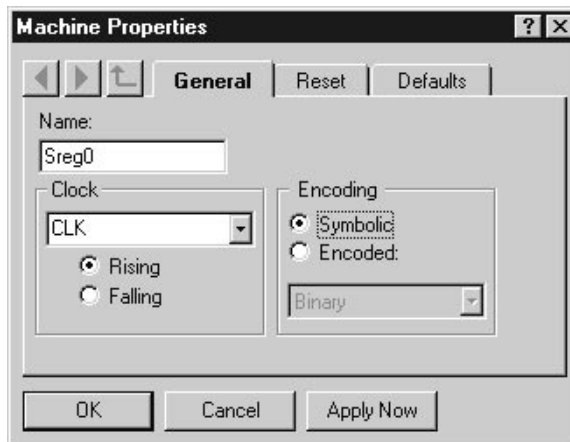


Figure 1-36. Machine Properties Window.

Transition Text & Transition Properties

Clicking the right mouse button on a transition object will display a context sensitive menu for the **Transition** (Figure 1-37). This menu will allow you to change **Color** of the transition line, set the global exit for all states and set a **Priority** level for the transition. Selecting the **Properties** option will display the **Transition Properties** window (Fig. 1-38).

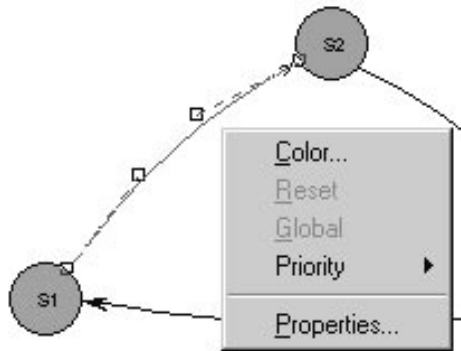


Figure 1-37. Transition Context Sensitive Menu.

Note: The priority level decides which of the transitions will take place, should several of them come up at the same time. The priority level of 0 (the lowest) is not displayed on the screen.

The Transition Properties window (Fig. 1-38) allows selecting transition properties:

1. select the starting point of the transition in the **From** field,
2. select the end point of the transition from the **To** field,
3. select the priority level for the transition in the **Priority** field,
4. click on **OK** button to complete the priority assignments.

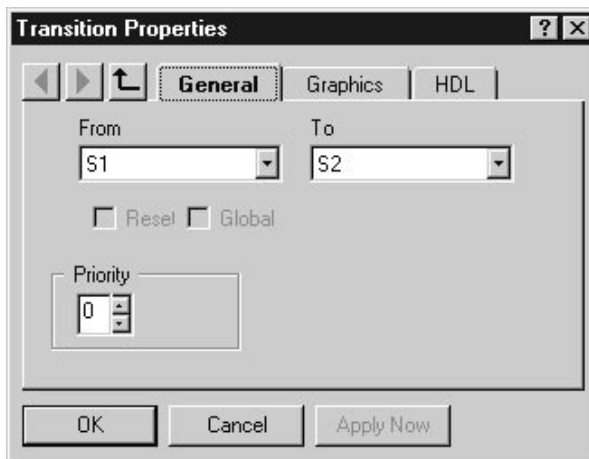


Figure 1-38. Transition Properties General Card.

Note: Three buttons at the top of the properties window allow moving through the object hierarchy:

- **left** and **right arrow** buttons display the properties of objects on the same hierarchy level,
 - **up arrow** button displays the properties of higher level objects.
-

Clicking on the tabs in the Transition Properties window (Fig. 1-38) will display other cards from that window.

- Graphics** tab displays a card for color selection for for transition and error lines.
- HDL** tab displays a card for direct editing of Transition conditions and Transition actions.

Placing the mouse pointer over text and clicking the right mouse button will display context sensitive menu which is the same for all text objects (Figure 1-39) .

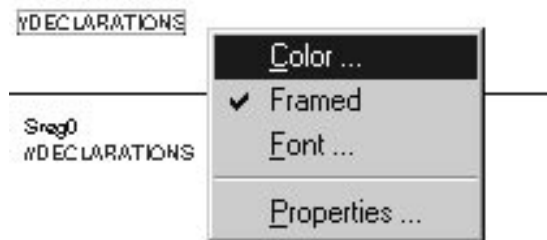


Figure 1-39. Texts Context Sensitive Menu.

You can select the text **Color** (Figure 1-40), **Frame** (framed or not framed), and text **Font** (Figure 1-41). These are typical Windows options.

The Properties option in Fig. 1-39 refers to the selected object. Text itself does not have any properties other than font and color.

Note: Text is used to define states, transitions, conditions and actions. The **Edit | Settings** allows global settings of text parameters. The context sensitive menu provides for local text settings.

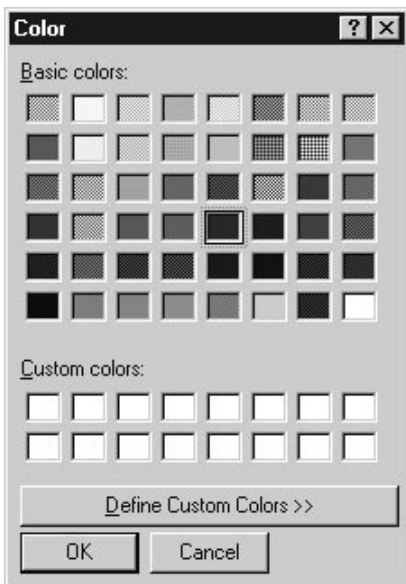


Figure 1-40. Color Window.

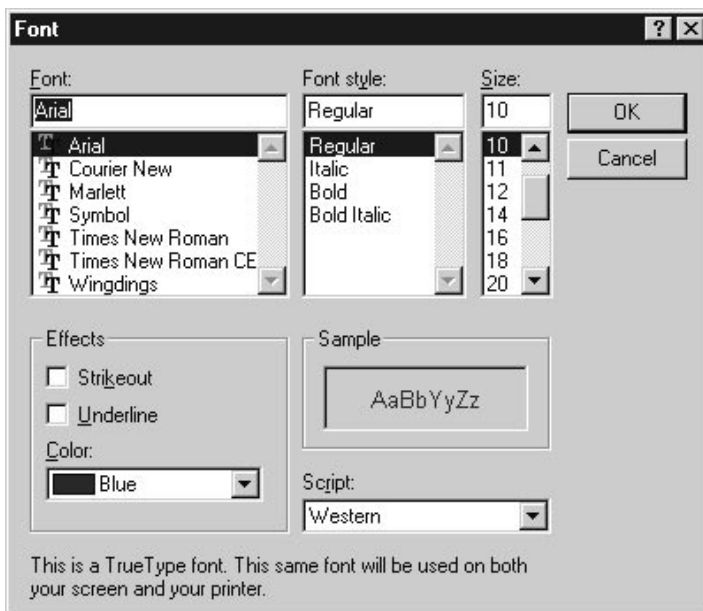


Figure 1-41. Font Window.

Condition Text & Condition Properties

Placing the mouse pointer over a **Condition** object and clicking the right mouse button will display the context sensitive menu for the condition. With the help of the menu in Figure 1-39 you can change **Color** of the condition text. In addition, you can have it **Framed** or not. Also, you can change the **Font** for the condition text, and select the **Condition Properties** window in Figure 1-42. Its **Graphics** card and **Editor** card are shown in the Figure 1-42 and 1-43.

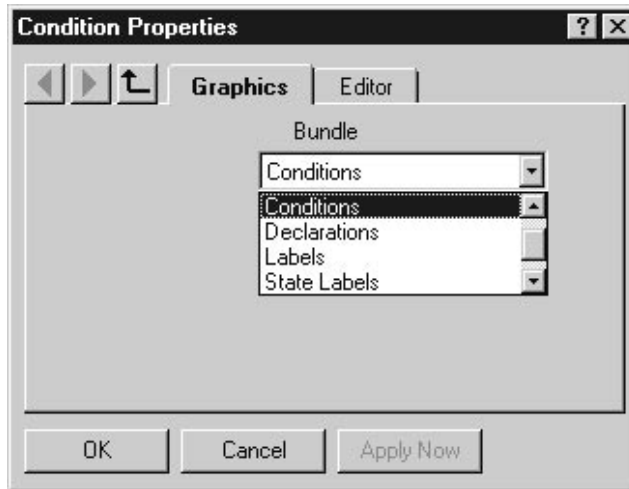


Figure 1-42. Condition Properties Graphics Card.

The Graphics card (Figure 1-42) allows assigning the text attributes defined for the following objects:

1. **Actions.**
2. **Conditions.**
3. **Declarations.**
4. **Labels.**
5. **State Labels.**

Select a bundle from the **Condition Properties** window and click on the **Apply Now** button to apply attributes.

The selected condition text can be edited in the **Editor** card window (Fig. 1-43). After editing the text, click on the **Apply Now** (or **OK**) button to transfer the edited text to the FSM diagram.

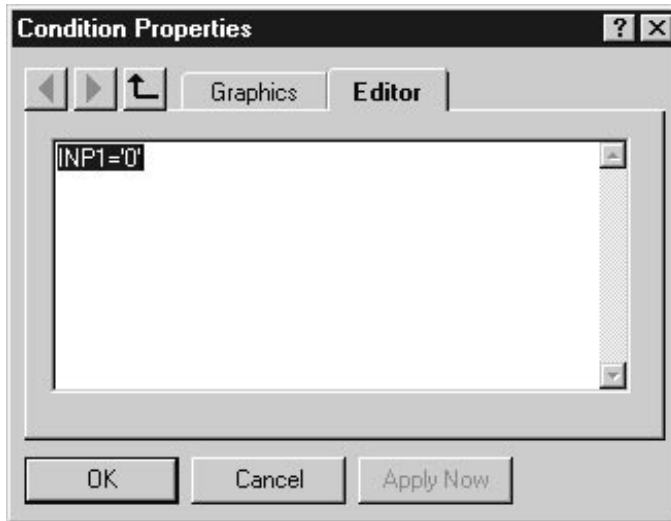


Figure 1-43. Condition Properties Editor Card.

By placing mouse cursor over any port symbol and clicking the right mouse button you can activate the context sensitive menu. This menu will allow you to change the **Port Color** and **Port Properties** (Figure 1-44).

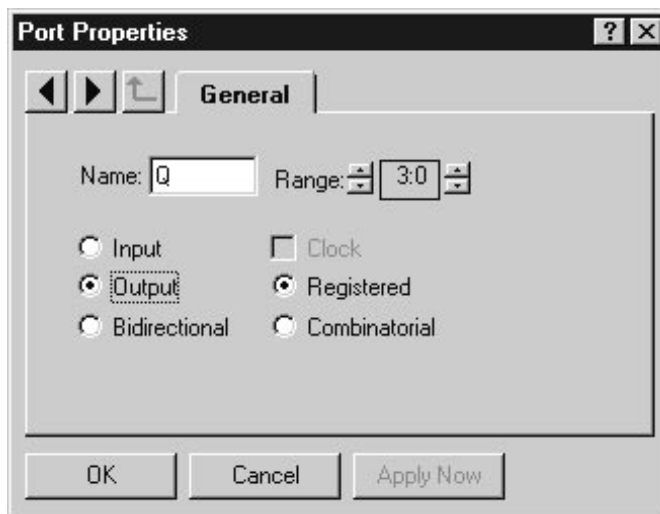


Figure 1-44. Port Properties Window.

The General card from the Port Properties window (Figure 1-44) allows defining or redefining of the I/O ports parameters, including:

1. the port *Name*,
2. type of the port: *Input*, *Output*, or *Bi-directional*,
3. type of Input port
 - a. *Normal* (the empty checkbox) or
 - b. *Clock* type,
4. type of *Output* or *Bi-directional* port:
 - a. *Registered* or
 - b. *Combinatorial* type.

The **Apply Now** (or **OK**) button saves your new setups. The **Left** and **Right Arrow** buttons facilitate browsing of ports. The **Up Arrow** button allows selecting higher hierarchical design levels.

The 'DRAW' Toolbar Context Sensitive Menu

Note: All operations performed with these options have no effect on the electrical properties of the FSM diagram. Use these operations for “cosmetic” improvement of the documentation only.

The **Text Properties** window is similar to the previously described **Condition Properties** window (Figure 1-42 and 1-43). **Graphics** card and **Editor** card are shown in the Figure 1-45 and 1-46, respectively.

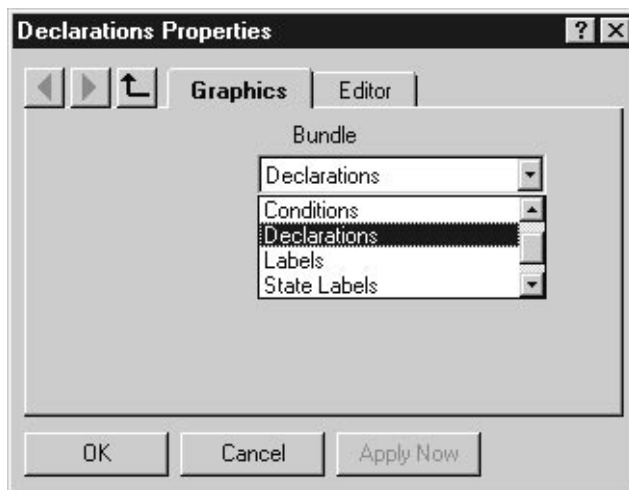


Figure 1-45. Text Properties Graphics Card.

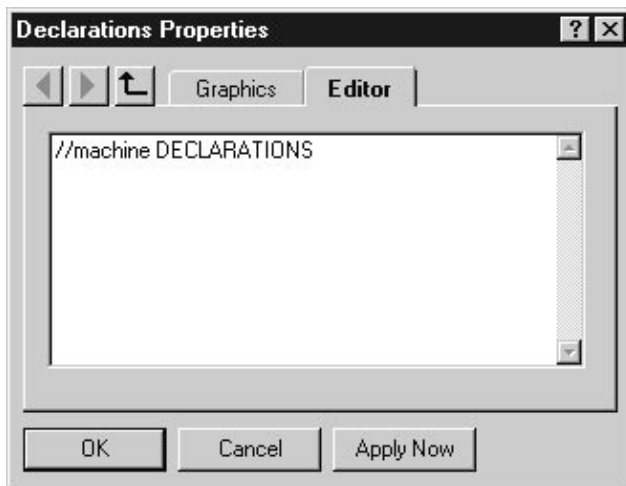


Figure 1-46. Text Properties Editor Card.

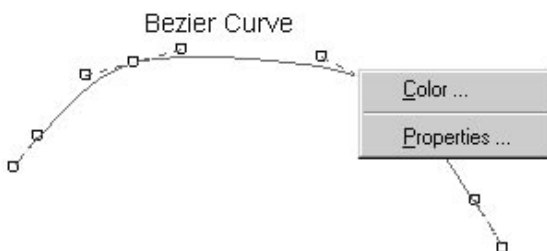


Figure 1-47. Bezier Curves Context Sensitive Menu.

Placing the mouse pointer within Bezier's object area (curved line) and clicking the right mouse button will display the menu in Figure 1-47. You can select the **Color** option to change the Bezier curve's color, or **Properties** option to open **Polyline Properties** window (Figure 1-48). The **Graphics** card allows selection of color for the transitions and errors.

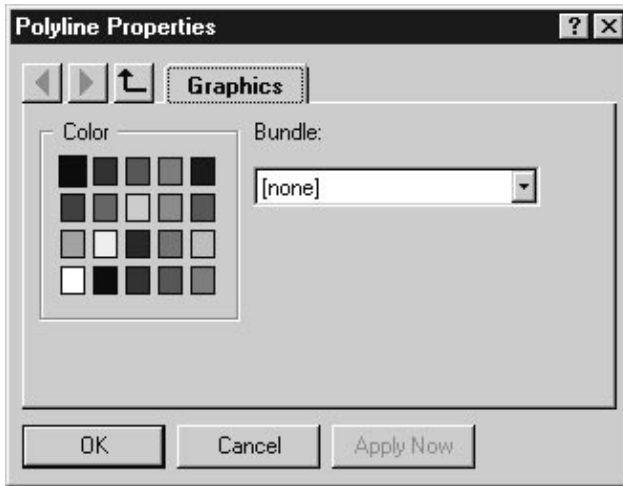


Figure 1-48. Polyline Properties Graphics Card.

The context sensitive menus for **Circle** (Ellipse) and **Rectangle** objects entered in the **Draw** mode are similar to Figures 1-47 and 1-48. The **Graphics** card (Figure 1-49 and 1-50) allows color settings, similarly to the **Edit / Settings** option.

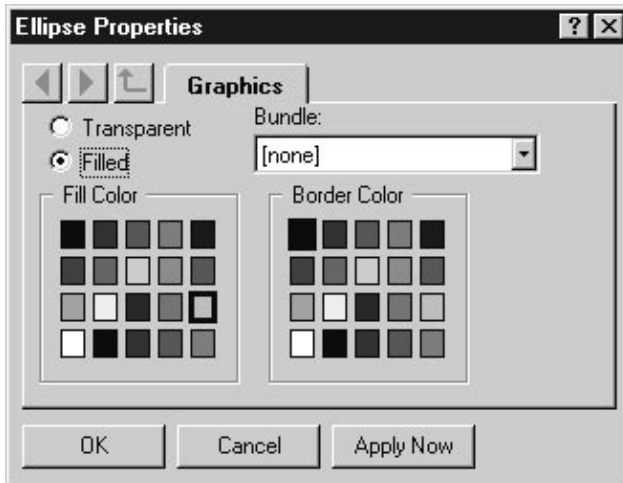


Figure 1-49. Ellipse Properties Window.

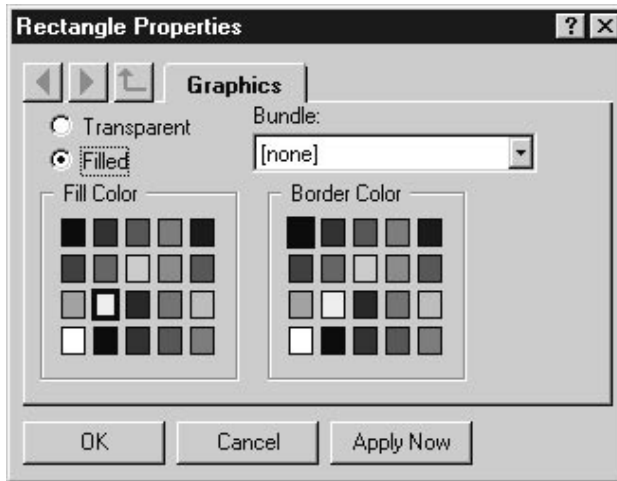


Figure 1-50. Rectangle Properties Window.

Note: Clicking on the Draw type object with the right mouse button always invokes a menu with Properties option. Selecting that option displays Polyline Properties, Ellipse Properties or Rectangle Properties window, depending on the object that has been clicked. These windows operate similarly to other FSM properties windows.

The FSM Diagram Context Sensitive Menu.

Placing the mouse cursor over the FSM Design border or any Machine thin frame, and clicking the right mouse button, will display a context sensitive menu window (Figure 1-51).



Figure 1-51. FSM Diagram Context Sensitive Menu.

The menu in Figure 1-51 allows selecting:

1. Border color.
2. Filled (or unfilled) design border.
3. Fill Color of the border.
4. Properties (of the Machine).

Selecting the Properties option in Figure 1-51, displays the Machine Properties window. The General card (Figure 1-52) allows to edit:

1. Machine name (Name field).
2. Active clock edges (Clock field).
3. Encoding process (Encoding field).

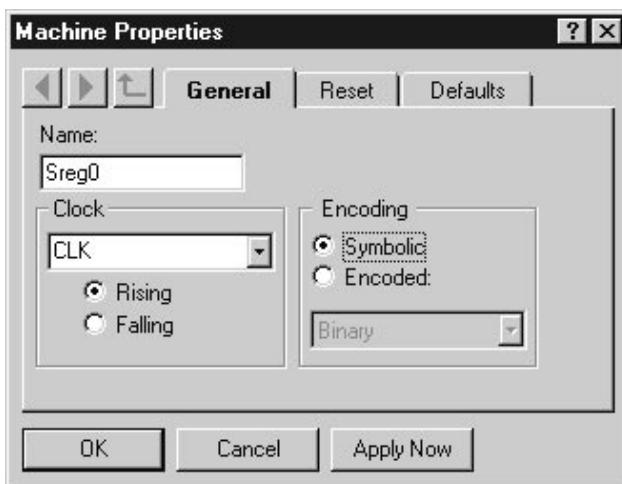


Figure 1-52. Machine Properties General Card.

The **Reset** card (Fig. 1-53) allows to select the reset signal and its effect on the FSM diagram behavior.

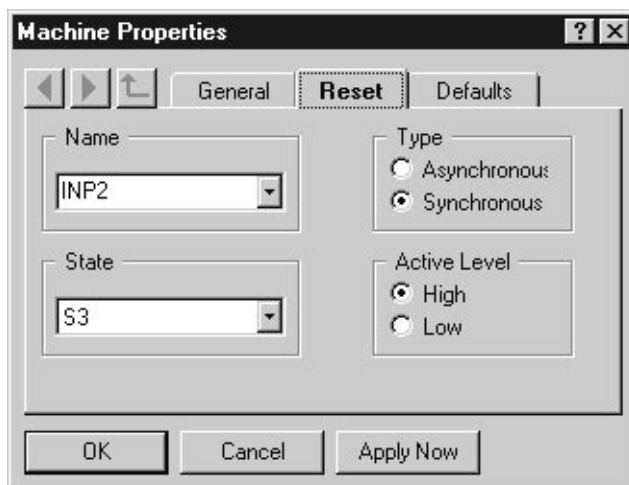


Figure 1-53. Machine Properties Reset Card.

The Defaults card (Fig. 1-54) allows to set the initial design conditions. For example, you can force a trap state or leave the design in the don't care state (unknown).

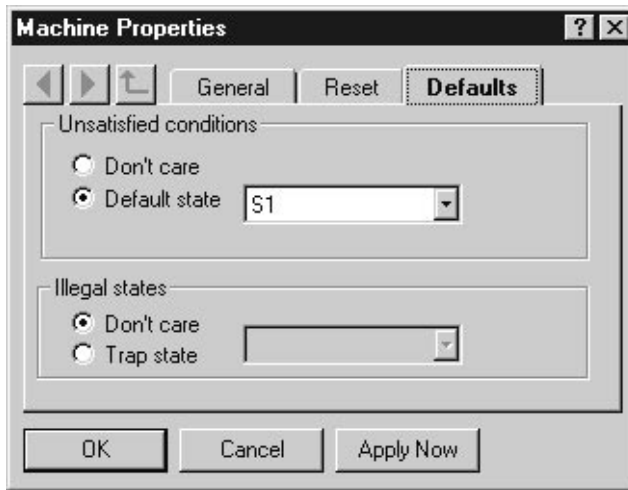


Figure 1-54. Machine Properties Default Card.

Basic Elements of the Windows '95 interface

The Windows '95 main screen displays the following items:

- small square pictures called Icons,
- horizontal bar at the bottom of the screen, called Taskbar,
- rectangular button on the taskbar with the Windows logo and 'Start' text, called Start Button,
- small arrow that changes its position when you move your mouse, called Mouse Pointer.

You can also see large rectangular areas with their own icons, text and buttons; they are called Application Windows.

All these items are described in the Windows '95 documentation and you should refer to the original Windows '95 manual for more details.

Most operations are performed with the mouse device. The mouse pointer follows the mouse movements and allows for pointing at screen objects.

- Placing mouse pointer over an object and clicking the left mouse button, selects the object.
- Double clicking on an object (i.e. clicking twice, quickly) with the left mouse button invokes an action associated with that object (invokes a program, displays a document).
- Clicking on an object with the right mouse button displays a menu of options or actions for the selected object.

All documents and programs in the Windows '95 operating system are usually displayed as small square pictures, called icons. For your convenience, related icons are usually grouped into folders, represented by an icon depicting paper folder. When the folder is closed, you cannot see its icons. Double-clicking on the icon opens the folder, which takes the shape of the window with Title bar at the top, Horizontal Menu Bar below, and area filled with icons representing folders, programs and documents. Windows usually have three buttons in the top right-hand corner:

- Minimize button (the first from the left) reduces the entire window to a button on the taskbar; clicking that button with the mouse restores the window to its original size.
- Maximize/normalize button (the middle one) toggles the window between partial and full-screen display.
- Close button (the right button) completely closes the window.

1. Some windows may have the Help button (H?). Pressing that button and then clicking on an object will display a short information on that object.
2. When a window is too small to show the entire document, scrollbars will appear on the right and bottom edge of the window. They contain arrow buttons that allow moving the window over the document and scroll box that shows current position of the window in the document.
3. Both horizontal menu bar and vertical pull-down menus work the same: selecting an option starts an immediate action.
4. Some options may have shortcut keys or hotkeys assigned to them (they are displayed with the option). Pressing shortcut key invokes the action associated with the option, even if the option is not visible on the screen.
5. When the option name is displayed in gray it means that the option is inactive at the moment and cannot be selected.
6. Some menu options and buttons may have one letter underscored - instead of clicking in that option you can press the underscored letter on the keyboard while holding the ALT key down.

GLOSSARY

<i>ACTIVE-State Editor</i>	a graphical state machine-editor developed and manufactured by ALDEC Co. Inc. It generates ABEL and VHDL design files from graphical designs representations.
<i>ACTIVE-CAD</i>	a device and system-level ESDA tools for entering schematics, FSM diagrams, and simulating the entries.
<i>FSM</i> (Finite State Machine)	a digital design with a finite number of logical states.
<i>FSM Design Wizard</i>	user guidance program for ACTIVE-State Editor.
<i>HDL Code Generator</i>	a program which creates an HDL text description of an FSM or flowchart based project.
<i>Netlist</i>	a file containing binary or text data regarding electronic design . The file lists all elements, their connections and properties.
<i>Schematic Capture</i>	a program for entering graphical design representation. Generally, each element represents a physically equivalent item.
<i>Symbol Editor</i>	a program which comes as a part of Schematic Capture and allows for creating graphical representations of physical objects.
<i>Toolbars</i>	groups of icons for speedy selection of programs and options.

Basic Vocabulary & Commonly Used Abbreviations

.ASF = ALDEC Schematic File standard name extension

ABEL - An HDL Language (Hardware Description Language) developed by Data I/O.

ACTIVE-CAD - ESDA product line developed by ALDEC.

ALDEC - Automated Logic Design Company, Inc.

BBS transfer - transferring data via bulletin-board service.

CAE - Computer Aided Engineering - designing with the aid of computer.

CAP = Caps mode = Capital Letters mode.

CLK - clock.

CYPRESS - An abbreviated name of the Cypress Semiconductor company.

DOWNLOAD - loading a file for processing by the computer.

E-MAIL - electronic mail.

EDA - Electronic Design Automation.

EPLD - Electrically Programmable Logical Devices.

FAX - facsimile equipment for electronic transition of documents.

FPGA - Field Programmable Gate Array.

FSM = Finite State Machine - this is a generic term for the state machine editor.

I/O = Input/Output.

Logic synthesis - A process which converts HDL design files into a netlists for selected devices.

NUM = Numerals - Num Lock's key depended mode.

OrCAD - Name of a CAE company.

OVR = Overwrite mode.

PWR - power.

R = Registered; a trade name registered in The Registration Office.

RPM - Revolutions per minute.

State Editor = State Machine Editor.

TIM - timer.

TM = Trade Mark.

TMP - temperature.

VHDL - 1076-IEEE hardware description language.

ViewLogic - A name of an EDA company.

XACT - An FPGA layout tool manufactured by Xilinx.

XCHECKER - An FPGA layout support tool manufactured by Xilinx.

XILINX - A name of an FPGA manufacturer.

XNF netlist, netfiles - Netlist format defined by XILINX.

Main Menu Command Index

A List Of Commands Available From Main Menu Options & Toolbars:

About State Editor - Displays the program information, its version number and the copyright notice.

Action - an FSM pull-down menu option, the basic name for the group of commands

Add to project - Adds a diagram to the current project.

Bezier Curve - Draws Bezier Curve.

Circle - Draws circle.

Condition - Adds/Edits condition of a transition; allows to specify the conditions that cause a transition to a new state.

Configuration - Customizes synthesis options.

Copy [CTRL+C] - Copies the selected items and puts them on the Clipboard.

Create macro - Creates macro from the current diagram.

Cut [CTRL+X] - Cuts the selected items and puts them on the Clipboard.

Declarations - Adds/Edits declarations to machine or diagram.

Delete [DEL] - Erases the selected items.

Draw (main menu options)

Edit (main menu options)

Entry Action - Adds/Edits entry action of a state. It sets all output ports on the state entry to a new state.

Exit - Quits the application; prompts to save documents.

Exit Action - Adds/Edits exit action of a state. It sets I/O ports upon exit from the selected state.

File (main menu options)

Fill bundles - Changes fill bundles settings.

Find Next [F3] - Repeats the last find\Find Next.

Find String - Finds the specified text.

FSM (main menu options)

Graphics - Bezier Curve - Draws Bezier Curve.

Graphics - Circle - Draws Circle.

- Graphics - Rectangle** - Draws Rectangle.
- Graphics - Text** - Places text string.
- Grid** - Sets grid options.
- HDL Code Generation [CTRL+H]** - Generates HDL Code.
- HDL Editor** - Runs HDL Editor.
- Help** (main menu options)
- Help** - It is a context-sensitive Help. Displays help objects pointed by the mouse cursor.
- Help Topics** - Lists Help topics.
- Input Port** - Adds/Edits input ports; used for drawing new input ports.
- Line bundles** - Changes line bundles settings.
- Machine Frames** - Shows or hides frames of machines.
- Machine/Diagram Action** - Adds/Edits actions of a machine or diagram.
- Machines** - (an FSM pull-down menu option)
- New [CTRL+N]** - Creates a new document.
- Next error [F4]** - Shows the next error found during HDL generation.
- Open [CTRL+O]** - Saves the active document and opens an existing document.
- Options** (main menu options)
- Output Port** - Adds/Edits output port to the diagram; used for drawing output ports.
- Page Setup** - Changes paper size.
- Page [PgDn]** - Shows the whole page.
- Paste [CTRL+V]** - Inserts the Clipboard's contents (pastes copied or cut items).
- Preferences** - Customizes configuration.
- Previous** - Shows the previously visible part of the diagram.
- Previous error [Shift+F4]** - Shows the previous error found during HDL generation.
- Print [CTRL+P]** - Prints the active document.
- Print Preview** - Displays (full) pages as they will be printed.
- Print Setup** - Changes the printer and printing options.

Project (main menu options)

Project Manager - Activates Project Contents Manager.

Recent File(s) - Opens one of four recently edited diagrams.

Rectangle - Draws rectangle.

Redo [CTRL+A] - Redoes (cancels) the previously undone action.

Redraw [F10] - Redraws the entire window.

Replace - replaces found text with thw other.

Save [CTRL+S] - Saves the active document.

Save As - Saves the active document with a new name.

Search (main menu options)

Select - Selects and edits; allows such editing operations as drag, delete, etc.

Select All - Selects all items in the current field.

Settings - Chooses Text, Line and Fill bundles settings.

Simulation - Starts simulation.

State - Adds states to machines; it is used for entering the machine states or “bubbles”.

State Action - Adds/Edits state action of a state. It sets I/O ports upon detecting a new state.

Status bar - Shows or hides the status bar.

Synthesis (main menu options)

Synthesis Tools Options ... - Allows selection of synthesis tool options.

Synthesize - starts synthesis tool

Text - Places text string.

Text bundles - Changes text bundles settings.

Toolbars - (a View pull-down menu option).

Transition - Adds transition to machines; it is used for drawing state transition lines.

Transition Action - Adds/Edits action of a transition. It sets I/O ports upon detecting a state transition.

Undo [CTRL+Z] - Undoes the last action.

Using Help - Displays instructions on how to use Help.

View (main menu options)

View Report - Displays a report listing the compilation flow and errors.

Zoom in [CTRL +] - Zooms the diagram to 200%.

Zoom out [CTRL -] - Zooms the diagram to 50%.

Zoom Select - Selects zoom rectangle for continuous Zoom.

Chapter 2

ACTIVE-State Editor Applications Guide

Introduction

The state machine editors allow you to enter your designs in graphical form. Used quite widely in the 50's, the state machine editors came back in the 90's to simplify the complex designs through graphical design representation.

The basic premise of the new generation of the state machine editors is that you need only to enter the key information. All details are automatically done for you, including:

- checking for conflicts in your statements and expectations
- automatic VHDL and ABEL code generation from the FSM graphs
- animation of the graphs for better understanding of information flow

Since today's technology involves complex relationships between data and control signals, ACTIVE-State Editor allows you to enter these signal conditions and relationships in an efficient and easy to understand manner.

This Tutorial allows you to get a quick grasp of the ACTIVE-State Editor features. Several examples with increasing complexity will teach you the basics on how to use the state machine editor.

Basic Vocabulary

- ABEL*; a hardware description language developed by Data I/O

- ACTIVE-State Machine Editor*; a graphical state machine editor manufactured by ALDEC. It generates ABEL and VHDL design files from graphical designs.
- FSM (Finite State Machine)*; a generic term for state machine editor
- Logic synthesis*; a software product that converts VHDL and ABEL design files into a netlist for a target ASIC or FPGA physical implementation
- State Machine Editor*; a graphical design entry tool which allows to describe the relationships between the input and output signals with the help of 'state' bubbles and conditional transitions between the states.
- VHDL*; 1076-IEEE hardware description language

What Do You Need To Know About VHDL?

Since the state machine editor automatically generates the VHDL code from the graph, you need to learn only minimum information about the VHDL syntax:

- Signal types** - how to define single bit signals and buses
- Operators** - what operators are allowed and what they do
- Expressions** - used for testing signal conditions and signal value assignment

ACTIVE-State Editor allows you to generate complex VHDL designs without extensive VHDL language knowledge. If you learn the basic VHDL statements listed below, you will be able to design fairly complex VHDL state machines. The enclosed state machine examples will clarify the use of the VHDL syntax statements. The examples listed below have been taken out of the FSM graphs presented in the following sections.

Signal Types

- Bit** - any signal and port name are automatically considered a single bit type signal, e.g. *FAN*, *FAST_CLK*, *Reset*, *preset*, *ctrl_on* are examples of single bit "entities." Only '0' and '1' logical values are allowed.
- Bit_vector**- is used to describe a bus signal. Signals such as *ADDR[0:7]* or *video[1:16]* are called "bit_vectors." Any time you enter such a symbol in the symbol editor or in Wizard, it will automatically be compiled by the state machine editor into the VHDL "bit_vector" entity.

NOTE: For bit type signal you must use '0' and '1' as its value. You cannot enter 1s and 0s without the apostrophe markers.

VHDL also recognizes *Boolean*, *Integer*, *Std_logic*, *Std_logic_vector* and other types but you do not need to be concerned with them in typical state machine designs. For all practical reasons, you may forget about these types.

Operators

The basic operator classes are listed below. Their operation and use are implied by their names.

- ❑ **Logical** - *and, or, nand, nor, xor, not*
- ❑ **Relational** - *=(equal), /=(not equal), < (less than), <=(less than or equal), >(grater than), >=(greater than or equal)*
- ❑ **Assignment** - *<=* ; this operator has a signal (entity port) on the left-hand side, and a logical expression such as '0', '1', *B, C, etc. on the right. The assignment operator(<=) is automatically differentiated from the relational operator <=(less than or equal) by the VHDL compiler.*

Expressions

There are only two kinds of VHDL expressions; (1) expressions that test for signal conditions and (2) expressions that assign logical states to entities (e.g. output ports).

- ❑ **Condition expression** - using logical or relational statements it tests for certain conditions in the design. For example, *ON_OFF='1' and TMP3='1'* will test when both signals have logical '1'. *TMP1='0'* will test for condition when input signal *TMP1* is at logical '0'. You can have spaces between "=" sign and other parameters in the statement. These expressions are written directly into the Transition lines between machine states.
- ❑ **Action assignment** - forces the desired value into the signal (entity port). For example *FAN<='1'* will force value '1' into the *FAN* output port. These statements are written directly into the associated machine state bubbles.

Since ACTIVE-State Editor allows you to write the above expressions directly on the state diagram, this cuts on editing and minimizes the number of errors.

Practicing with the enclosed examples will build your confidence in the VHDL design tools. For more information, read some basic books on

VHDL. *WARP VHDL Synthesis Reference* from Cypress Semiconductor (TEL. 408-943-2600) has an excellent chapter on VHDL language.

Drawing State Machines With The FSM Wizard

An FSM diagram can be started from either from the FSM Design Wizard icon or system level ACTIVE-CAD software. Since designers are typically using the system level tools, most of our effort will be devoted to FSM designs from the ACTIVE-CA design framework. Designing an FSM graph from Wizard will be covered in a cursory manner.

FSM Design Wizard

Clicking on the finite state machine (FSM) icon, representing ACTIVE-State Editor, activates the **State Editor** window which simplifies design entry (Figure 2-1). It allows you to open an existing diagram or start a new one. Clicking on the **Use FSM Design Wizard** button displays Design Wizard Welcome screen; pressing **Next>** on that screen opens a new window for selecting the HDL language (Figure 2-2).



Figure 2-1. Design Entry Options.

Selecting HDL Language

The **FSM Design Wizard** window (Figure 2-2) allows you to select either ABEL or VHDL for assignments and statements on the design graph. To confirm your HDL language selection, click on the **Next** button. ACTIVE State Editor will store your selection and automatically open the **FSM Design Wizard-Ports** window for entering state machine ports.

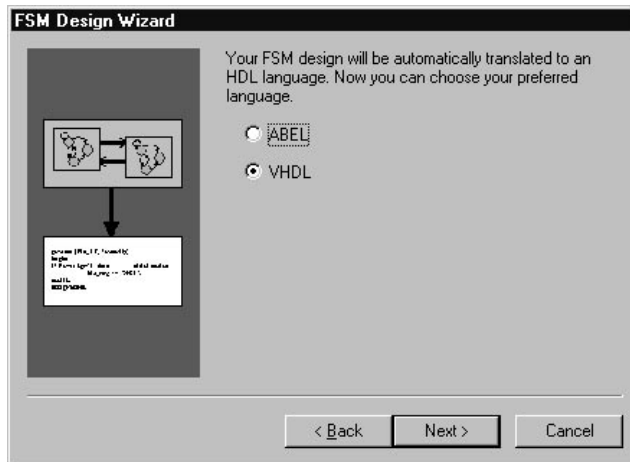


Figure 2-2. Selecting The HDL Language

Entering Input Signals

Clicking on the **Next** button in the **FSM Design Wizard** window activates the **FSM Design Wizard-Ports** window (Figure 2-3) which allows selecting port names, their I/O direction and function.

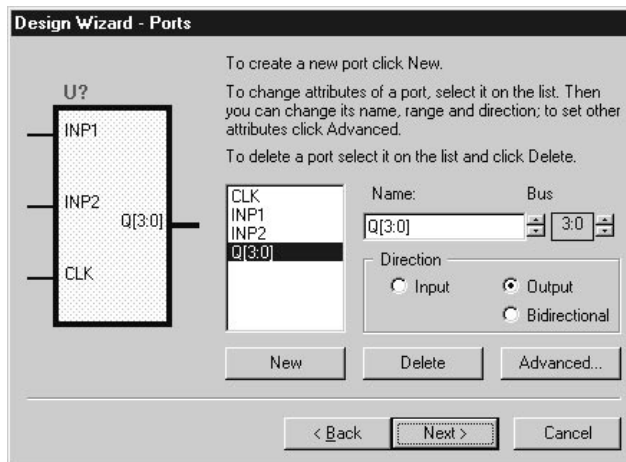


Figure 2-3. FSM Design Wizard - Entering Ports

1. To enter an input port, click on the **New** button and enter the port name in the **Name** field.
2. Next, select the I/O port's direction (**Input**). If the input port is a clock, then you need to click on **Advanced** button and check the **Clock** box.

Entering Output and Bi-directional Ports

The **FSM Design Wizard-Ports** window (Figure 2-3) provides for entering the ports' name, its I/O direction and function.

1. To enter an output or bi-directional port, click on the **New** button and enter the port name in the **Name** field.
2. Next, select the I/O port's direction (**Output** or **Bi-directional**). You may also check off either the **Registered** or **Combinatorial** box in the window that appears after clicking on the **Advanced** button. In response, FSM will automatically store these outputs in its internal latches or produce them directly from combinatorial logic outputs.

Editing I/O Ports

1. To delete a port, select it in the **Port Listing** field with the mouse cursor and click on the **Delete** button.
2. To modify an I/O port, select it in the **Port Listing**, field and when it appears in the **Port Name** field, select the new parameters.

Entering Bus names

To enter a bus, first enter its name, and then click on the **Range** buttons to set the upper and lower limit (range) bus signals. You may also add the range in the square brackets after the bus name. ACTIVE State Editor will automatically create the specified bus port.

Example 1:

Using the described above methods, enter the following port names and their characteristics:

- Data_end; output, registered
- Data_out; output, registered
- Data_start; output, combinatorial
- Enable; input
- Hi_clock; input, clock
- Reset; input
- Video_In; input

A sample screen with the above listed ports is shown in Figure 2-4.

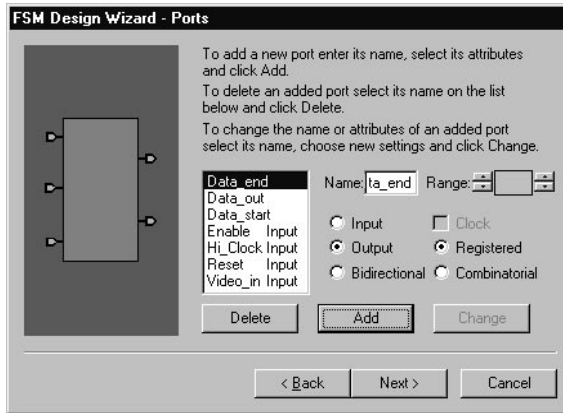


Figure 2-4. An Example Of Port Entries.

Multiple State Machines

ACTIVE-State Editor allows you to enter multiple FSM designs for a single device (for the set of device pins that you have entered above). Clicking on the **NEXT** button in the **FSM Design Wizard-Ports** window (Figure 2-4), activates the **FSM Design Wizard-Machines** window (Figure 2-5). Select in that window the number of concurrent state machines by clicking on the appropriate fields (**One**, **Two**, **Three** or **Four**).

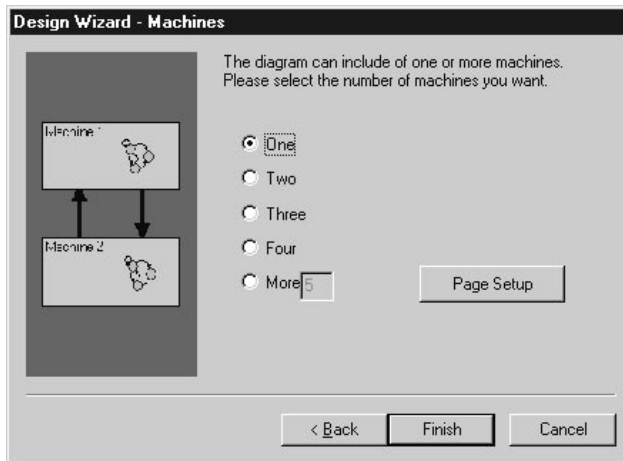


Figure 2-5. Selecting The Number Of FSM Designs

To select more than four state machines, click on the **More** option and enter the number of concurrent state machines in the field to the right.

When finished selecting the number of state machines, click on the **Finish** button. In response, ACTIVE State Editor will produce a display that will allow for entering the selected number of independent state machines.

To name each individual state machine, place the mouse cursor on the automatically assigned name (Sreg1, Sreg2, Sreg3, etc.) and click the left mouse button.. The first click will put a red frame around the state machine name and the second click will display an editing cursor. Enter the desired name. To complete the editing, place the mouse cursor outside the editing area and click the mouse button.

Enter as many independent FSM design names as you may need. Unused or empty FSM designs will not foil the HDL compilations.

Entering An FSM Diagram Under The Wizard

If you click on the **Finish** button in the **FSM Design Wizard-Machines** window (Figure 2-4) , a new screen will appear, and it will lists all the signals and clocks that you have entered in the previous steps. Figure 2-6 shows the port assignment for *Example1*.

By selecting the buttons on the left-hand side of the screen you will be able to draw the state bubbles, transitions lines between bubbles. You will also be able to assign the desired values to state signals and logical or HDL expressions to transitions. Since this process is described in detail in reference to Figures 17 - 24, please refer to these figures for more details.

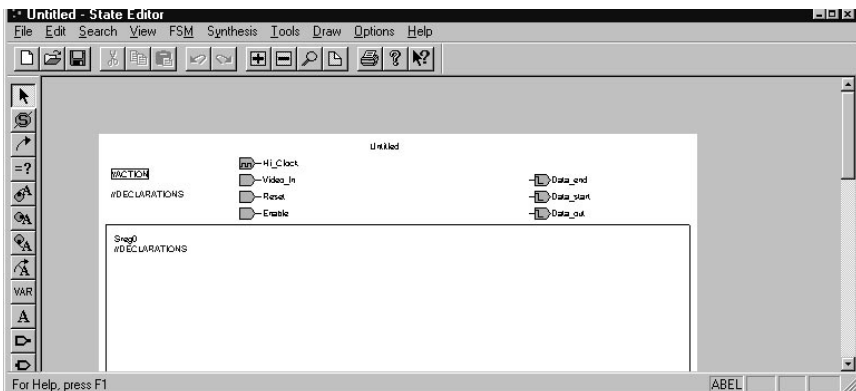


Figure 2-6. State Machine Entry Screen.

System-Level FSM Design Process

ACTIVE-State Editor is a part of the ACTIVE-CAD set of EDA tools which allow for direct schematic, HDL, VHDL and other forms of design entry. Working with a software that provides for a total design solution has its benefits:

- consistent top-down system design
- design block interfaces are clearly defined
- inter-block signal integrity is enforced
- all design tools have similar user interface

To effectively design complex systems follow this procedure with ACTIVE-CAD:

1. Start a top-level schematic sheet.
2. Place all major design blocks as empty symbols.
3. Interconnect the empty symbols
4. Perform detailed block designs in VHDL, state machine, etc.
5. Simulate the functional operation of each individual block
6. Simulate the top-level functional design
7. Layout the device(s) and verify their timing
8. Verify the top-level design timing

We will follow the above procedure with one example comprised of two state machine designs:

AIR_COND System-Level Design

This is a system-level design (top-level schematic) that is comprised of two devices:

1. CONTROL1 ; state machine design with VHDL syntax
2. CL_CTRL2 ; state machine design with ABEL syntax

The design dependencies are as follows:

AIR_COND ; top level design

CONTROL1 ; a device to be used at the system level, it may contain several state machines, such as *fastcooling*, etc.

fastcooling ; the name of the state machine design within the CONTROL1 device

CL_CTRL2 ; an independent operating device

CONTROL1

This design is an air-conditioning system operating as follows:

1. After the *ON-OFF* push button switch is activated, a fan is turned on if the temperature is over 80 degrees F.
2. If the fan is not able to bring the temperature down to below 78 F within 10 minutes, the fan is turned off and a cooling system is turned on.
3. If at any time the temperature falls below 65 F, the cooling system and/or fan are turned off.

CL_CTRL2

This control system is optimized for energy efficiency. It is described in more detail in the *Sample FSM ABEL Design* chapter.

Create Top-Level Schematic Sheet

Using the procedures described in the *Schematic Editor User's Guide*, start a new project (e.g. AIR_COND) and open its first schematic sheet (e.g. AIR_CON1.SCH), as shown below. To enter an empty symbol at the top-level schematic, select the **Symbol Editor** option from the **Options** menu (Figure 2-7).

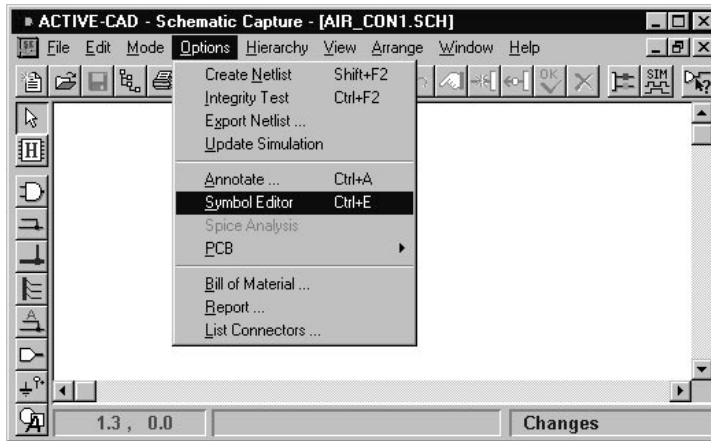


Figure 2-7. Schematic Editor Options Menu.

Edit Block Symbol In Symbol Editor

Selecting the **Symbol Editor** option from the **Options** menu displays the **ACTIVE-CAD- Symbol Editor** window. Select the **New** option from its **File** menu. When ACTIVE-CAD responds with the **New Symbol** window (Figure 2-8), enter CONTROL1 in the **Symbol** field and select (click on) AIR_COND from the **Library** menu. Click on the **OK** button to close the **New Symbol** window. In response, the **ACTIVE-CAD - Symbol Editor** window fills with graphics and options (Figure 2-9).

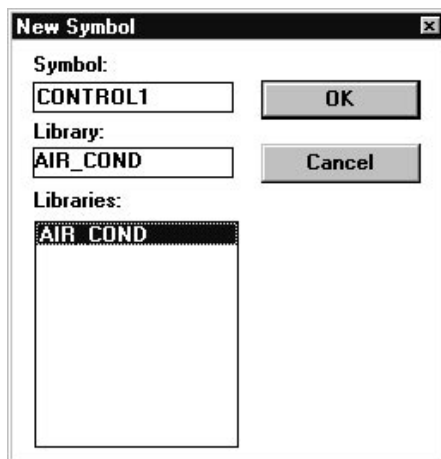


Figure 2-8. Entering A New Symbol.

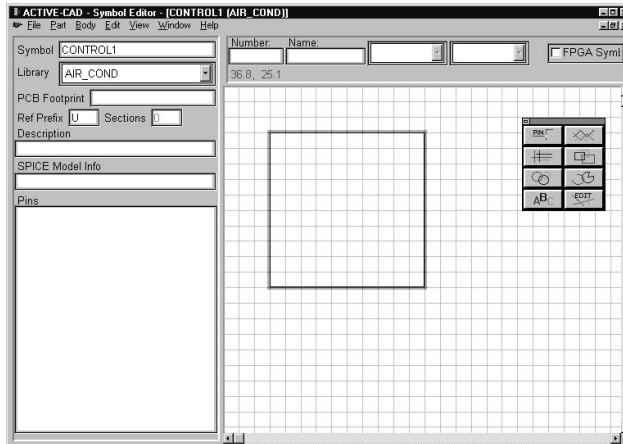


Figure 2-9. Symbol Editor Setup.

If you wish to move the symbol box, click within the blue symbol outline and drag it to a new location. To accommodate large number of pins and their long nomenclature, you need to expand the box by placing the cursor on its blue outline and (when the double-pointed arrow appears), dragging it to the desired location.

To enter pin names and numbers, click on the **PIN** button within the symbol editor's toolbox (Figure 2-10). In response, ACTIVE-CAD displays the **Add Pin** window (Figure 2-9) for entering the pin name and number and its graphical shape. To accommodate long pin names, you may need to drag the symbol outline to enlarge it.

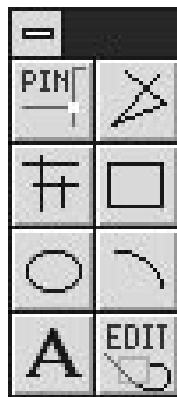


Figure 2-10. Symbol Editor's Toolbox.

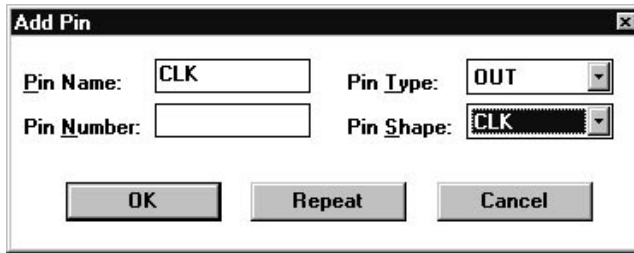


Figure 2-11. Entering Symbol Pins.

When adding pins in the **Add Pin** window, you must select as a minimum:

- pin name
- I/O direction (input, output, etc.)
- graphical look (CLK, Line, dot, etc.)

For full compliance with the follow-on examples, enter the pin names listed in the figure below (Figure 2-12). For more information on Symbol Editor, read the *Schematic Editor User's Guide*.

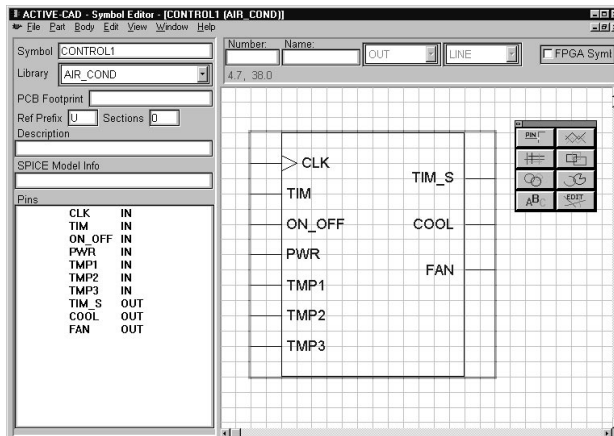


Figure 2-12. CONTROL1 Symbol Pins Listing.

QUICK REVIEW OF SYMBOL EDITOR OPERATIONS

- Define PWR pins as INPUT if you want them visible. Assigning to them the PWR status (in **Pin_Type** field in Figure 2-11) will make them invisible.

- ❑ Use the **Repeat** option for signal names with incremental names (TMP1, TMP2, TMP3...). You do not have to enter the full name (TMP1). Entering TMP and then pressing the **Repeat** button will automatically generate the TMP1 pin name. You need to enter the number only if you start the count from zero, e.g. TEMP0 will automatically increment the pin count from 0.
- ❑ The pin shape has no meaning in the logical model behavior. It is only a graphical reminder of the pin's function, which is defined by its VHDL model.
- ❑ All operations are performed by clicking on the desired pin. When it turns red, you can edit it in the appropriate field like **Name** or **Number** and drag it to a new location on the symbol outline.

Place The New Symbol On The Schematic Sheet

After you have saved the CONTROL1 symbol in the symbol editor, it will be added to the project library and will be listed together with all other symbols in the **SC Symbols** list of the schematic editor. To display the **SC Symbols** table, select the **Symbols** icon from the toolbar. Using the editing options, place the newly created symbol on the top-level schematic sheet.

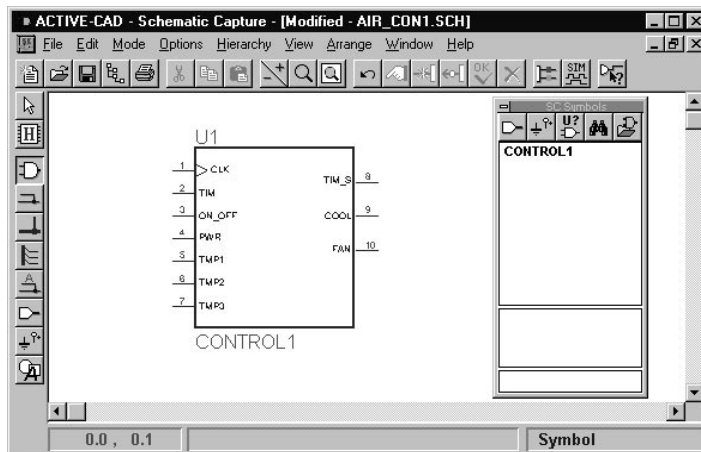


Figure 2-13. An Empty Block Symbol Placement.

Invoke the hierarchical 'H' cursor {Ctrl H} or select the **Hierarchical Push/Pop** option from the **Hierarchy** menu. Next, click with the 'H' cursor over the CONTROL1 symbol.

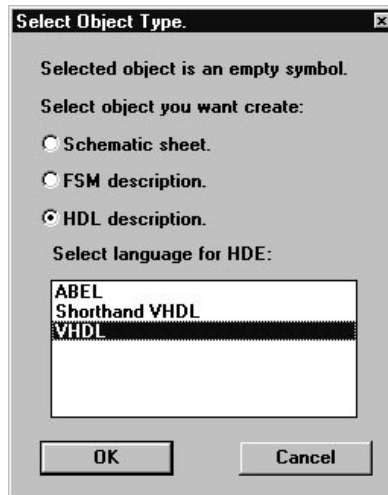


Figure 2-14. Empty Block Symbol Design Type.

Since the selected symbol is empty, ACTIVE-CAD will display **Select Object Type** window and will prompt you for entering the design type that will be stored in the symbol (Figure 2-14). You need to select one of the following types:

- Schematic Sheet*; for entering gates, cells and macros, etc.
- FSM Description*; for entering design bubble diagram
- HDL Description*; for entering designs in HDL format.

Should you select the *HDL description* option, you must in addition select the HDL language type. All HDL languages are listed in the field below (**ABEL**, **VHDL** and **VHDL Shorthand**). The VHDL Shorthand is a subset of the 1076 IEEE VHDL, which has been used by ALDEC and ACTIVE-CAD users to write their IC models.

To enter a state machine design, select the *FSM Description* option and click on the **OK** button. In response, ACTIVE-CAD will display the **FSM Design Wizard** title page (Figure 2-15).

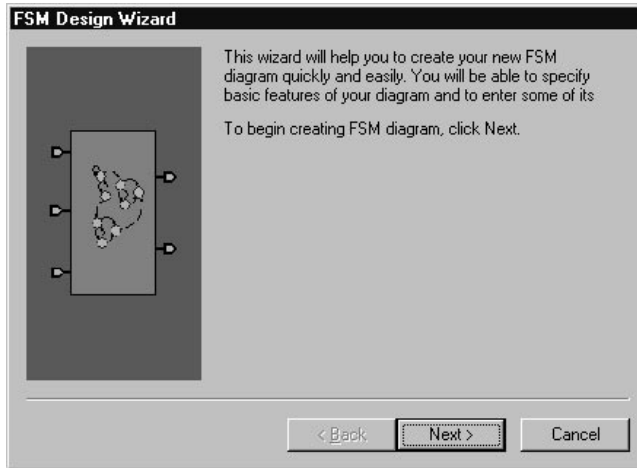


Figure 2-15. FSM Design Wizard Title Page.

Clicking on the **Next** button will display a screen for selecting the HDL language to be used for entering state machine diagram (Figure 2-16). Currently, you can choose either ABEL or VHDL. Please choose VHDL to comply with the following examples.

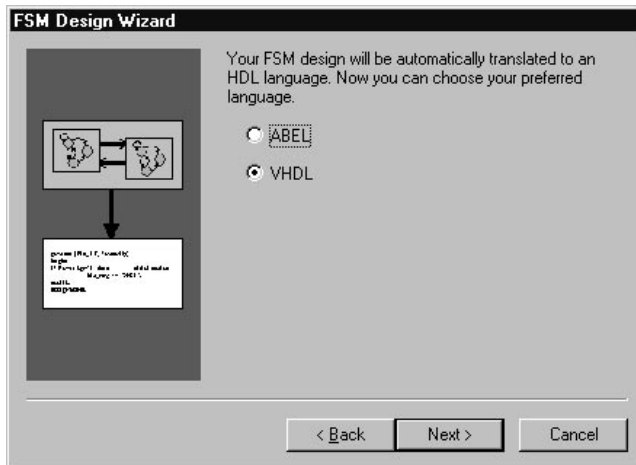


Figure 2-16. FSM Design Wizard: HDL Selection

The **Next** button activates the **FSM Design Wizard-Ports** window (Figure 17). This window allows you to enter I/O signals and define their characteristics.

Selecting HDL Language

Clicking on the **Advanced** button in the **FSM Design Wizard** window activates the **Advanced Options** window (Figure 2). You can select from that window either ABEL or VHDL as the design description language. Click on the selected HDL prompt (ABEL or VHDL) and then click on the **OK** button to complete the HDL language selection.

Entering Input Signals

To enter an I/O port, click on the **Next** button in the **FSM Design Wizard** window. In response, ACTIVE-State Editor displays the **FSM Design Wizard-Ports** window (Figure 3) for selecting the ports' name, their I/O direction and function.

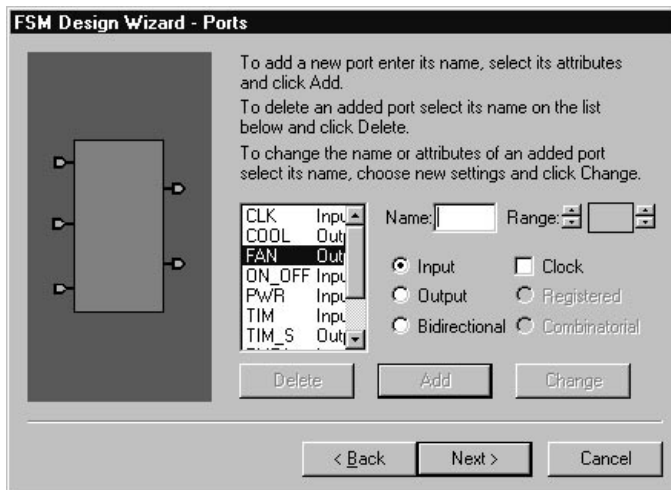


Figure 2-17. FSM Design Wizard: Entering Ports

Since the port names have been entered during the symbol editing (Figure 12), they are automatically be listed in Figure 2-17. You need to review these signals and assign to them the proper I/O port properties:

- ❑ click on the top-most signal name listed in Figure 2-17. If the port's parameters (input, output, bi-directional, latched, non-latched and clock) are correct, skip to the next signal name. If the port's parameters are incorrect, select the appropriate parameters and click on the **Change** button.

- ❑ all output signals need to be checked for “*latched*” and “*non-latched*” parameter. Any time you change this parameter, you need to click on the **Change** button.
- ❑ If you enter a new port in Figure 2-17, it will automatically be added to the symbol. If you need to reposition the automatically added pin on the symbol outline, select the symbol editor and manually edit the symbol pins.

If you plan ahead, you should know all pin names beforehand and be able to enter them in Symbol Editor. If you want to add some new pins in the FSM editor, you need to follow this procedure:

1. To enter an input port, click the mouse cursor in the **Port Name** field and type the port’s name.
2. Next, select the I/O port’s direction (**Input**). If the input port is a clock, then you need to check off the **Clock** box.
3. After the port’s name and its I/O characteristics have been defined, click on the **Add** button. The port’s name will automatically be transferred into the **Port Listing** field that lists all I/O ports.

Entering Clock Signals

If the input signal is a clock, you must select the **Clock** option in the **FSM Design Wizard-Ports** window and click on the **Change** button. This will convert the signal into a clock. It will be treated by the FSM editor as a special state machine signal.

Entering Output and Bi-directional Ports

1. To enter an output or bi-directional port, click the mouse cursor in the **Port Name** field and type the port’s name.
2. Next, select the I/O port’s direction (**Output** or **Bi-directional**). You also to check off either the **Latched** or **Non-latched** box. In response, FSM will automatically store these outputs in its internal latches or produce them directly from combinatorial logic outputs.
3. After the port’s name and its I/O characteristics have been defined, click on the **Add** button. The port’s name will automatically be transferred into the **Port Listing** field that lists all I/O ports.

Entering Bus names

To enter a bus, first enter its lowest order bus name, and then click repeatedly on the **Add** button. ACTIVE State Editor will automatically create new I/O ports with names incremented by '1'.

Editing I/O Ports

1. To delete a port, select it in the **Port Listing** field with the mouse cursor and click on the **Delete** button.
2. To modify an I/O port, select it in the **Port Listing**, field and when it appears in the **Port Name** field, select the new parameters. To confirm the changes, click on the **Change** button.

The I/O ports are selected for the entire FSM design which may include several independent state machine designs. To select the number of independent state machines, click on the **Next** button. In response, ACTIVE-CAD displays a window for selecting the number independent state machine designs (Figure 2-18). Select the number of concurrent state machines by clicking on the appropriate fields (**One**, **Two**, **Three** or **Four**).

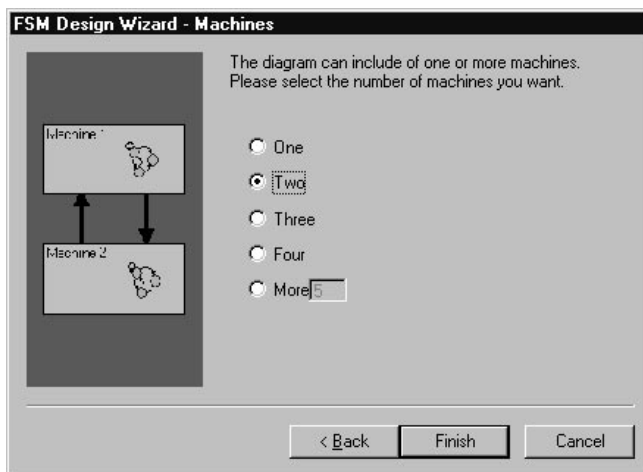


Figure 2-18. Selecting The Number Of FSM Designs.

To select more than four state machines, click on the **More** option and enter the number of concurrent state machines in the field to the right. After selecting the number of state machines, click on the **Finish** button. In response, a screen with the selected number of state machines will appear (Figure 2-20). You will be able to edit each section individually.

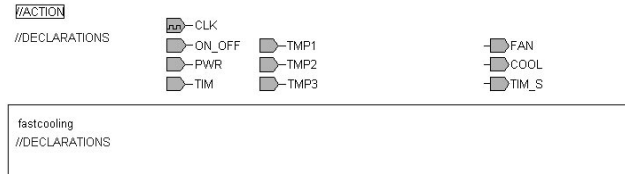


Figure 2-20. The State Machine Entry Window.

To name each individual state machine, place the mouse cursor on the automatically assigned name (Sreg1, Sreg2, Sreg3, etc.) and click the left mouse button.. The first click will put a red frame around the state machine name and the second click will display an editing cursor. Enter the desired name. To complete the editing, place the mouse cursor outside the editing area and click the mouse button.

Enter as many independent FSM design names as you may need. Unused or empty FSM designs will not foil the HDL compilations.

Entering The State Machine Designs

To simplify the arrangements of toolboxes, click on the **View/Toolbars** menu. A menu similar to the one below (Figure 20) appears.

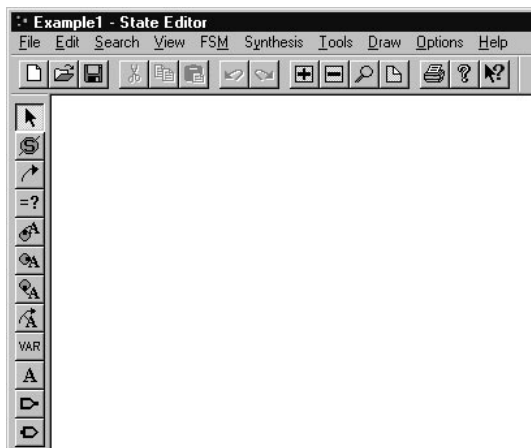


Figure 2-19. Arrangement Of Toolbars.











	<i>Select</i>	allows editing operations such as drag, delete, etc.
	<i>State</i>	used for entry the machine states or “bubbles
	<i>Transition</i>	used for drawing state transition lines
	<i>Condition</i>	allows to specify the conditions at each state
	<i>Entry Action</i>	sets all output ports on state entry
	<i>State Actions</i>	sets I/O ports on detecting new state
	<i>Exit Actions</i>	sets I/O ports on exit from the state
	<i>Transition Action</i>	sets I/O ports on detecting a state transition
	<i>Input Port</i>	used for drawing input ports
	<i>Output Port</i>	used for drawing output ports

Table 1. Editing Control Bars.






	<i>Zoom In</i>
	<i>Zoom Out</i>
	<i>Continuous Zoom</i>
	<i>View (full) Page</i>

Table 2. Display Control Bars.

Entering Machine States

Activate  the **State** toolbar and click left mouse button in three (3) different places on the state machine diagram, as shown in figure below (Figure2-22). Note that the machine states are numbered automatically from S1 through S3.

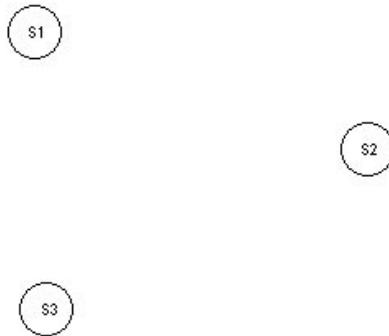


Figure 2-22. Entering Machine State Symbols.

Editing Machine States

To change a name of a machine states (e.g. S3 in Figure 2-22), click on it. A set of editing markers will appear around the selected state symbol. Clicking inside the symbol S3 will create a white editing area. Delete the S3 name with the help of the **BkSp** or **DELETE** keyboard keys and enter `COOL_ST` as the new machine state name.

If the state machine bubble is too small for you to see, activate on the Zoom toolbar at the top of the screen and pressing the left mouse button drag a dotted-line square around the state machine name. When you release the mouse button, the S3 bubble expands, as shown below (Figure 2-21).



Figure 2-21. State Name Before The Bubble Expansion.

Since the new text (`COOL_ST`) does not fit within the original shape of the S3 bubble, click on the bubble, outside its text area. The bubble will be surrounded with editing lines and little squares. As you drag these little editing squares away from the center of the bubble, the bubble becomes oval-shaped. Release the mouse button when the oval becomes sufficiently large for the `COOL_ST` text. To fit the text in the center of the

new oval-shaped bubble, click on it and drag it to the desired position inside the bubble, as shown below (Figure 2-24).



Figure 2-24. Alignment Of Text Inside State Bubble

After completing editing of the machine state ‘bubbles’, you should end-up with the figure below (Figure 2-23).

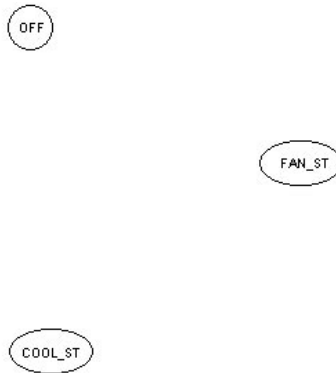


Figure 2-23. Machine States After Editing.

Entering Machine State Transitions

Select the **Transition** toolbar and click in the center of the *OFF* bubble. Note that a line follows each cursor movement. position the cursor over the *FAN_ST* bubble and click the mouse button. In response, a line is drawn between both state machine ‘bubbles’. To allow for more complex line shapes, you can click the mouse button several times as you draw a segmented line between two bubbles. The figure below shows such segmented line between the *OFF* and *COOL_ST* bubbles.

Draw two additional lines, as shown in the figure below (Figure 2-26). To edit them, switch to the edit mode by activating the **Select** toolbar.

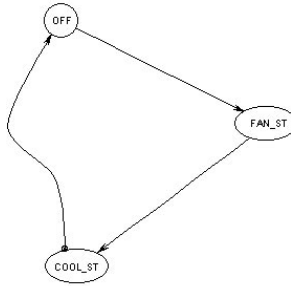


Figure 2-26. Adding Transitions To A Diagram.

With the **Select** toolbar active, click on the transition line between the *OFF* and *FAN_ST* bubbles. The line will change to a dotted line and will have some little squares. To edit the diagram, follow these rules:

- Pull on the little squares to force the transition line into the desired shape.
- For more flexibility place segmented transition lines
- Click at the tip of the transition line to move it along the bubble outline.
- Click at the bubble to move it to a new position on the schematic screen.
- You can re-edit the diagram at any time.

An example of edited transition lines is shown below (Figure 2-25).

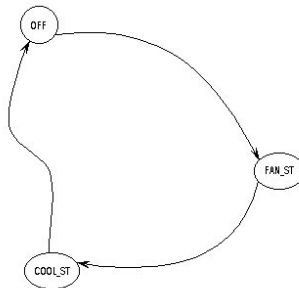


Figure 2-25. Edited Transition Lines.

Entering Conditions

To add conditions to transition lines, select the **Conditions** toolbar. Next, click on the line and enter the desired text. During editing the text is displayed within a box. When you click outside the editing area, the box disappears.

To complete the design, draw the transition lines shown in the figure below (Figure 2-27).

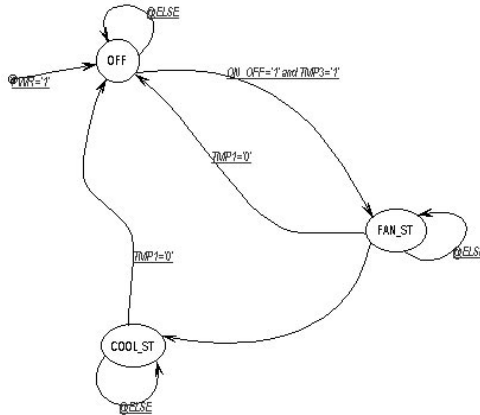


Figure 2-27. Graph With Transitions And Conditions.

Entering Actions (Output Pins State)

You can explicitly specify the logical state of output pins for each machine state. The process of setting the output pins is called ‘actions’. ACTIVE-State Editor allows the following state machine ‘actions’:

- Entry Action - output pins are changing upon the entry into a machine state
- State Action - output pins are changing while a machine state is executed
- Exit Action - output pins are changing upon the exit from a machine state
- Transition Action - output pins are changing upon detection of machine state transition

The ‘action’ type is selected by clicking on the appropriate icons in the toolbar. The most popular ‘action’ is the Entry Action in which the output pins are changing concurrently with the entry into the selected machine state. Let’s assume that in our design the output pins are changing their logical states upon entering a new machine state.

Click on the **Entry Action** button. A small rectangle will appear and follow the mouse cursor. Click the mouse cursor within the **OFF** bubble and start entering the text listed below:

FAN <='0'; - assigning '0' logical state to the FAN output pin

TIM_S <='0'; - assigning '0' logical state to the TIM_S output pin

COOL <='0'; - assigns '0' logical state to the COOL output pin

NOTE: VHDL syntax requires you to place the ';' (semi-colon) marker after the logical state assignment. If you miss this marker, VHDL editor will give you an error message!

Complete the *AIR_COND* design as shown in figure below (Figure 2-28).

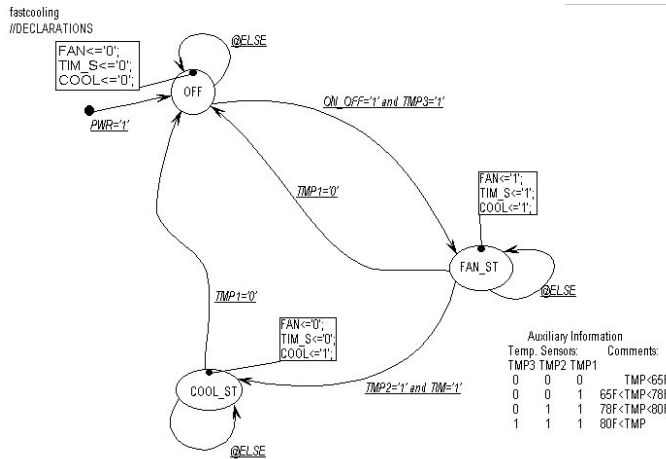


Figure 2-28. *AIR_COND* Design State Machine.

Compilation Of State Machine Into VHDL Code.

System Signal Setup

State machine designs are driven by common clocks, reset and other signals, which can be set by selecting the **FSM/Machine** option (Figure 2-29). You must set these signals before generating HDL code from the state machine.

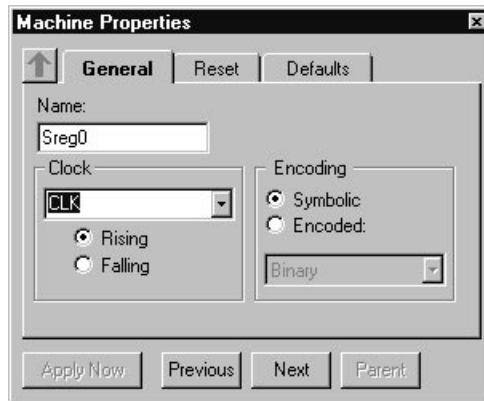


Figure 2-29. A Window For Setting Common Signals.

- Encoding* allows the designer to select the coding scheme (e.g. binary, one-hot, etc.)

State machine design may have a general reset signal. You need to enter the input reset signal in the **Signal** field. You must specify its:

1. Type (*Asynchronous* or *Synchronous*)
2. Active Level (*High* or *Low* logical level)

In addition, you must specify in the **State** field the default state after the reset signal has been applied.

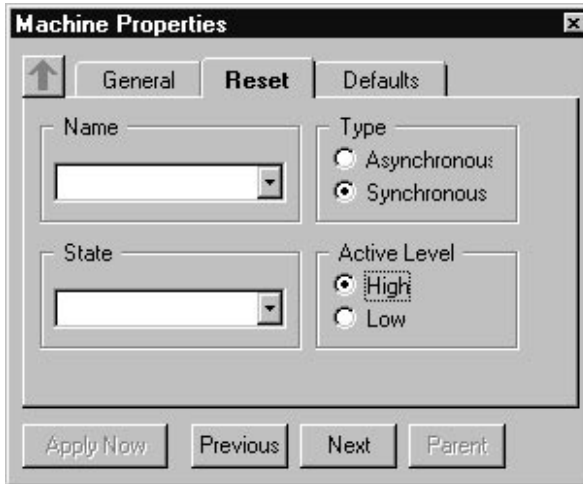


Figure 2-31. A Window For Setting Reset Conditions.

To select default and the trap conditions, click on the **Defaults** option in the **Machine Properties** window, selected by the **FSM/Machines** option.

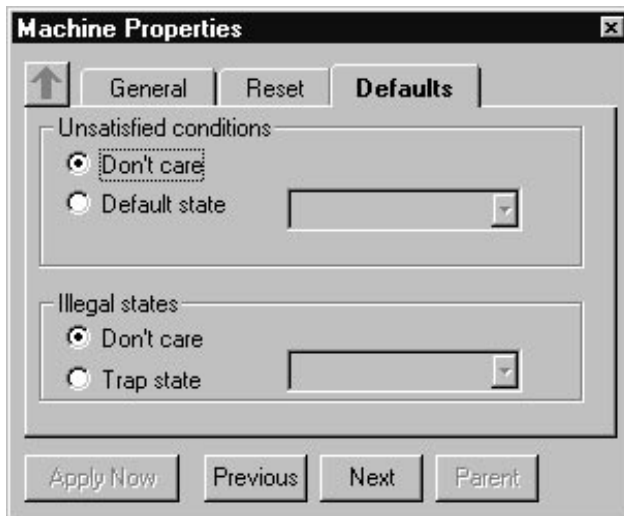


Figure 2-30. Default And Trap State Setup Window.

Compilation Setups

After the state machine design has been completed, you need to compile it into a VHDL. Select the **Synthesis/Configuration** option. In response, the **HDL Configuration** window will be displayed (Figure 2-32). You need to select from that window:

- Language (ABEL, VHDL or MINC-DSL)
- Logic Synthesis tool for which the VHDL code has to be fine-tuned (e.g. Exemplar, Synopsys, ASYL+, Metamor, etc.)

Since the output signal assignments for the *fastcooling* state machine has been made using the VHDL syntax, you will need to compile it with the VHDL option.

A fine tuning of the code for the specific logic synthesis tool is required because these tools may work with different subsets of the VHDL and ABEL design languages.

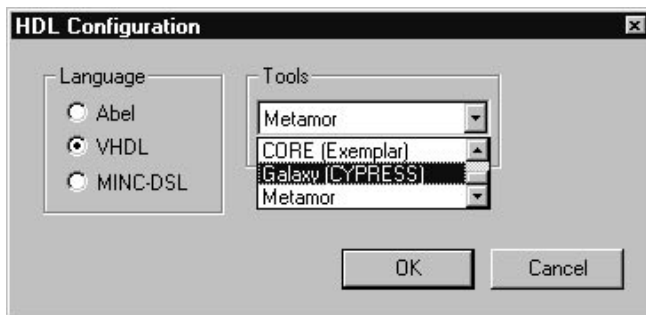


Figure 2-32. Selecting Language/Logic Synthesis Tool

Design Compilation

After the common state machine signals have been defined and the target logic synthesis environment has been set, you need to compile the design. Select the **Synthesis/HDL Code Generator** option. ACTIVE-State Editor will automatically process the state machine design and generate the selected HDL code.

Should any errors be found during the VHDL code generation, you will be warned, and a location of the error will be provided.

Typical VHDL Entry Errors

1. Missing the semi-colon character (;) after the assignment statement, e.g. *FAN<='1'* is wrong. The correct statement is *FAN<='1';*
2. Missing or misspelled signal names
3. Two or more machine states are forced active concurrently
4. Missing *Clock* or *Reset* signals (undefined)
5. Different clocks for different state machines (within the same device) are used
6. Improper reset signal operation

Sample FSM ABEL Design

ABEL Language Basics

ABEL is one of the oldest HDL languages. Because of its simplicity, its use is wide-spread. If you plan on converting FSM designs into ABEL, you need to learn the following specification:

Object Types

- Signals* (ports); single-bit items, e.g. *CLK, reset, Enable*
- Constants*; typically *0* and *1*, but can also be *78* (temperature), etc.
- Sets*; a collection of *Signals* $Q=[q1,q2,q3]$ or *Constants* $[0,1,1]$

Operators

- Logical;
 - ! NOT
 - & AND
 - # OR
 - \$ XOR
 - !\$ XNOR
- Arithmetic;
 - MINUS
 - + PLUS
- Relational;
 - = equal
 - != not equal
 - < less than

- <= less than or equal
- > greater than
- >= greater than or equal

Assignment

- ❑ Combinatorial = ; assigns logical states to combinatorial outputs
- ❑ Registered := ; the logical state on the right-hand side is forced into the signal on the left of the equation statement, e.g. $Q3 := 1$ will force 1 logical state into D input of flip-flop Q3

Expressions

- ❑ *Logical Expression* for conditions, e.g. $ON_OFF \& TMP3$ (ON_OFF switch is ON AND $TMP3$ switch is ON AND $TMP3$ switch is also ON or TRUE), $TMP2 \& TIM=4$ (switch $TMP2$ is ON and timer TIM equals or exceeded 4 minutes). These conditions can be assigned to transitions on the FSM graph and be tested for.
- ❑ *Assignment Statement* for actions, such as assignment of logical states to output pins, e.g. $TIM_S = 0; FAN = [0,0,1,1];$

CL_CTRL2

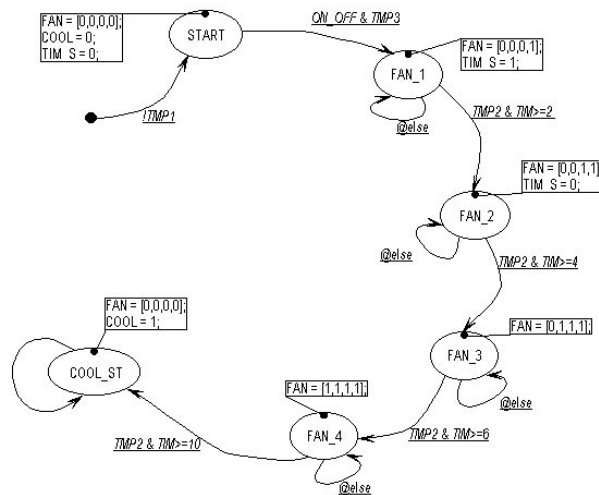


Figure 2-33. A State Machine Design With ABEL Syntax.

This control system is optimized for energy efficiency:

1. After the *ON-OFF* push button switch is activated, and temperature is over 80 degrees F, the first fan is turned on.
2. If the temperature does not fall below 78 F within 2 minutes, a second fan is turned on.
3. If after additional 2 minutes the temperature does not fall below 78 F, a third fan is turned on
4. The 4th fan is turned on after additional 2 minutes, if the temperature remains over 78 F.
5. If after additional 10 minutes the temperature does not fall below 78 F, a cooling system is turned on.
6. The cooling system and fans are automatically turned off if at any time the temperature drops below 65 F.

An FSM diagram of this controller is shown above (Figure 2-33).

System Signal Setup

After the bubble diagram has been drawn, you need to define common signals such as clock, reset and other global signals, which can be set by selecting the **FSM/Machine** option (Figure 2-34). You must set these signals before generating HDL code from the state machine.

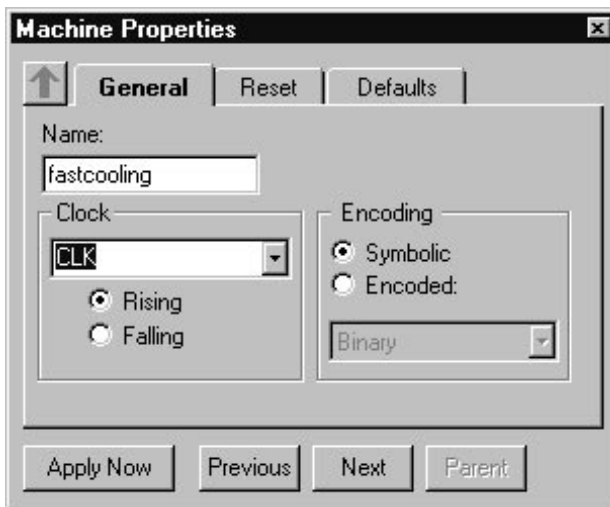


Figure 2-34. A Window For Setting Common Signals.

You need to set in the above figure as a minimum:

1. Clock (*Rising* or *Falling* edge)
2. State encoding scheme:
 - Symbolic* causes the logic synthesis tool to perform the state coding
 - Encoding* allows the designer to select the coding scheme (e.g. binary, one-hot, etc.)

State machine design may have a general reset signal. You need to enter the input reset signal in the **Signal** field. You must specify its:

1. Type (*Asynchronous* or *Synchronous*)
2. Active Level (*High* or *Low* logical level)

In addition, you must specify in the **State** field the default state of the state machine, after the reset signal has been applied.

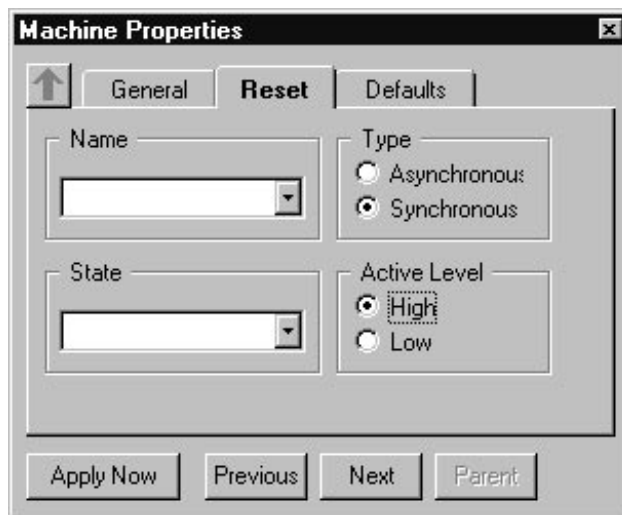


Figure 2-35. A Window For Setting Reset Conditions.

Compilation Setups

After the state machine design has been completed, you need to compile it into ABEL code. Select the **Synthesis/Configuration** option. In response, the **HDL Configuration** window will be displayed (Figure 2-36). You need to select from that window:

- Language (ABEL)
- Logic Synthesis tool (e.g. XABEL, ASYL+, Metamor, etc.)

Since the output signal assignments for the CL_CTRL2 FSM design has been made using the ABEL syntax, you will need to compile it with the ABEL option.

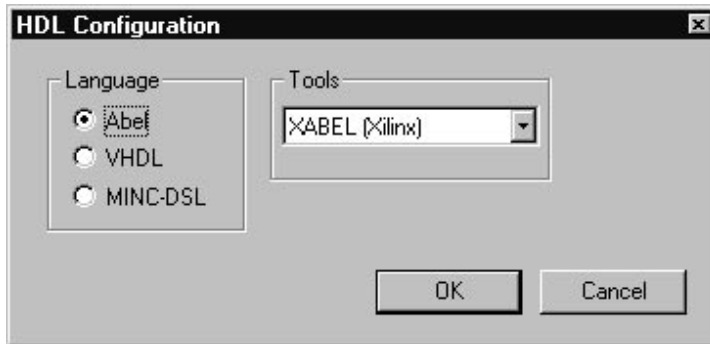


Figure 2-36. A Setup Window For ABEL Code Generation.

Design Compilation

After the common state machine signals have been defined and the target logic synthesis environment has been set, you need to compile the design. Select the **Synthesis/HDL Code Generator** option. ACTIVE-State Editor will automatically process the state machine design and generate ABEL code.

Design Examples

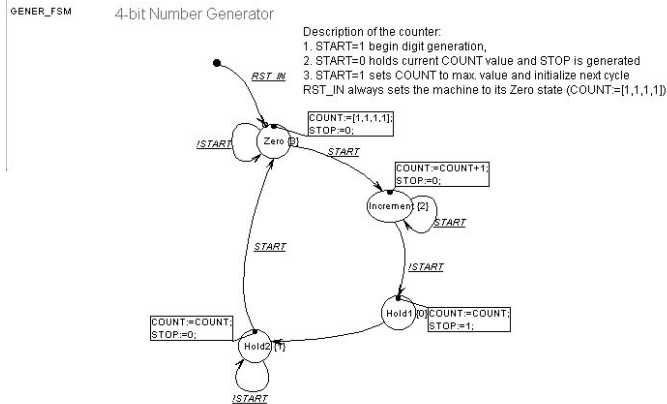


Figure 2-37. ABEL FSM Diagram: Number Generator

1. Try to analyze the operation of the above design.
2. Convert the design to a 3-bit counter.
3. Convert the design to a 6-bit counter.
4. Force the design to start after RST_IN in the INCREMENT state.
5. Change the design clock from rising to falling edge.
6. Convert the design from ABEL to VHDL format

Tests And Responses:

1. Try to analyze the operation of the above design:

This is a design of a counter which counts continuously from 0 to F/h (hexadecimal). Upon reaching F/h, it overflows and starts counting from 0 again.

The START =1 starts the COUNTER which counts up continuously till the START=0. At that instant the COUNT permanently holds the last numerical value and the STOP(=1) signal is being generated. The machine goes to the HOLD1 state for one clock cycle, and then is forced into the HOLD2 state in which it awaits a new START signal.

Upon receiving a new START signal, the machine goes into the ZERO state and sets the COUNTER to [1,1,1,1]. In the next clock, if START stays at logical 1, the machine goes into the INCREMENT state and starts incrementing the COUNTER.

2. Convert the design to a 3-bit counter:

Change the name of the COUNT[0:3] port to COUNT[0:2] port in the above figure. To change the port name, click on the COUNT[0:3] port name, located at the top of the screen in the I/O PORT section, and edit it directly on the screen to COUNT[0:2]. You can also position the mouse cursor over the COUNT[0:3] port's graphical outline and click the right mouse button. In response, ACTIVE State Editor will display the figure below (Figure 2-38).



Figure 2-38. Selecting The Port Properties Option.

Select the **Properties** option, and when the **Port Properties** window appears, edit the COUNT [0:3] to COUNT[0:2] directly in this window. Use the **Range** field to set the bus range, e.g. 0:3.

NOTE: If you click the right mouse button over the port's name instead of the port's outline, a different set of windows will be displayed. They will allow you to edit the signal name properties instead of the port properties.

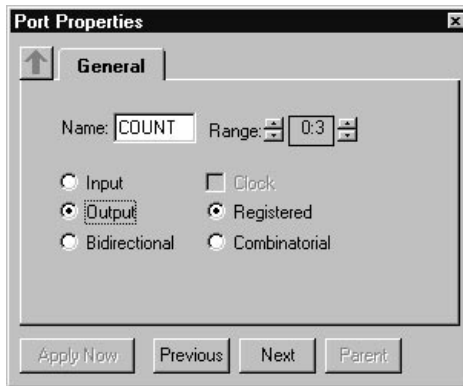


Figure 2-39. Port Properties Window.

Change the 'action' in the ZERO state from COUNT=[1,1,1,1] to COUNT=[1,1,1]. You can edit it directly on the FSM diagram. As an alternative, you can place the mouse cursor over the COUNT editing area and press the right mouse button. A displays in figure below will appear (Figure 2-40).

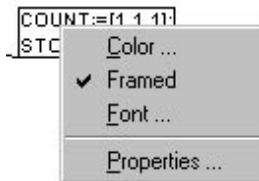


Figure 2-40. Menu for Editing Flowchart Parameters.

Select the **Properties** option from the above figure and when the **Action Properties** window appears (Figure 2-41), select the **Edit** option (Figure 2-42).

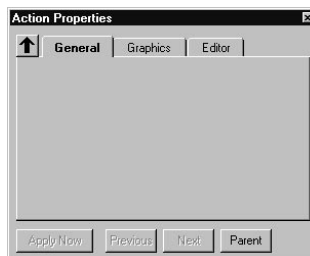


Figure 2-41. Action Properties Window.

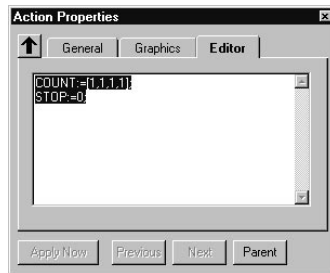


Figure 2-42. Editing Of State Properties.

You can edit the COUNT from [1,1,1,1] to [1,1,1] directly in the above window.

3. Convert the design to a 6-bit counter:

- Starting with the state machine diagram, change the COUNT[0:3] port to COUNT[0:5] port directly on the diagram. If you are modifying design in the *Example 2*, above, change from COUNT[0:2] port to COUNT[0:5] port.
- Change the 'action' in the ZERO state from COUNT=[1,1,1,1] to COUNT=[1,1,1,1,1,1]. If you are starting from *Example 2*, above, change the 'action' from COUNT[1,1,1] to COUNT[1,1,1,1,1,1]

4. Force the design to start after RST_IN in the INCREMENT state:

A. Manually;

Drag the tip of the RST_IN signal line from the ZERO state to the INCREMENT state. Click on the associated small squares to change the shape of the RST_IN signal line .

B. Automatically;

Position the mouse cursor over the RST_IN signal line and click the right mouse button. A new menu appears. Select from that menu, which is shown below, the **Properties** option.



Figure 2-43. Selecting The Properties Of Signals.

ACTIVE State Editor responds with **Transition Properties** window. Select the **Increment** option from the **To** field. This automatically redraws the RST_IN signal line and places it in direct contact with the INCREMENT state bubble. If you want to change the shape of the RST_IN signal line, click on it and drag it to the desired shape.

NOTE: If you click the right mouse button over the line's name instead of the line itself, a different set of windows will be displayed. They will allow you to edit the signal name properties instead of the line properties.

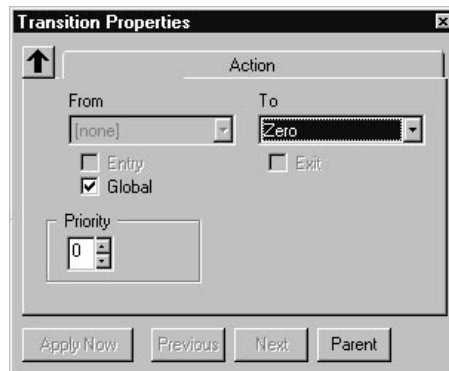


Figure 2-44. The Transition Properties Options.

If the RST_IN signal line feeds directly into the INCREMENT state, it will start counting up from an unknown state because no reset through the ZERO state will be made. You must return the RST_IN signal line back to the ZERO state to have a predictable operation by always starting from the COUNT:= $[1,1,1,1,1,1]$ state.

NOTE: If there are more than one (1) transition line coming out of any state bubble, it is best to assign to it a priority in the **Priority** field (Figure 44). This will automatically resolve a conflict that may arise when two transition conditions are concurrently fulfilled.

5. Change the design clock from rising to falling edge:

Select the state machine name (e.g. *fastcooling*) from the **FSM/Machines** option

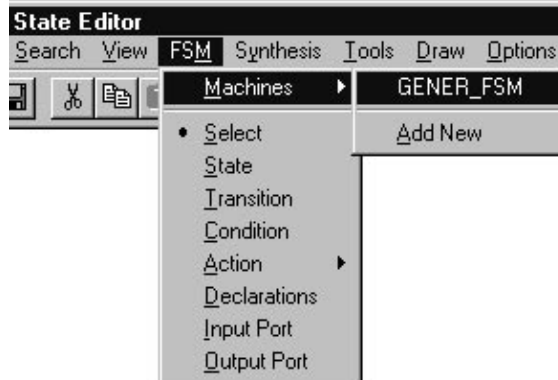


Figure 2-45. Selecting FSM Design For Editing.

ACTIVE-State Editor displays the menu below for setting up the active clock edge.

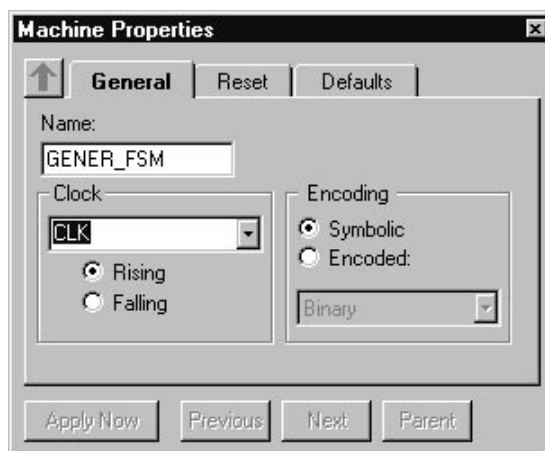


Figure 2-46. Changing the Clock Setup.

6. Convert the design from ABEL to VHDL format

- Select the **Configuration** option from the **Synthesis** menu. In response, ACTIVE Synthesis Editor displays the figure below. Select from the **VHDL** option in the **Language** field and the desired logic synthesis tool (e.g. ASYL+) from the **Tools** field.

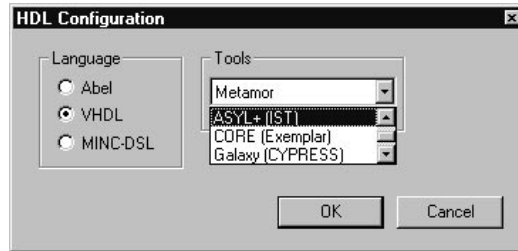


Figure 2-47. VHDL Selection Options.

- Change the ABEL operators to VHDL operators (from := to <=). You can do it through manual editing right on the graph. Another option is to select the **Search** option from the main menu. When the **Search** menu appears, select the **Find and Replace** option.



Figure 2-48. The Search Menu Options.

When ACTIVE State Editor displays the **Replace** window, enter the item to be replaced, as shown below.



Figure 2-49. ABEL->VHDL Global Expression Replacement.

The **Replace** window allows global replacement of all ABEL expressions to VHDL expressions. You need to visually verify if all ABEL expressions have been changed to the VHDL format.

- Change all listed below ABEL expressions to VHDL:

Conditions:

!START to START='0'

RST_IN to RST_IN='1'

START to START='1'

Actions:

all 0's into '0'

all 1's into '1'

States:

Change the *Increment* state from 1 to "0001" (in VHDL you cannot mix integers and bit_vectors)

Change the *ZERO* state from [1,1,1,1] to "1111"

Select the *Port Properties* window (Figure 39), and redefine the COUNT port as bi-directional (all bus ports must be bi-directional).

You need to set in the above figure as a minimum:

1. Clock (*Rising* or *Falling* edge)
2. State encoding scheme:
 - Symbolic* causes the logic synthesis tool to perform the state coding

NOTE: You must add a semicolon (;) at the end of each VHDL expression. The omission of the ';' character is the most popular source of compilation errors.
