Manual for Logic Simulator (version 1.01)

Aims

The program was designed to simulate a logic patch board. These
boards, as their name suggests, contain electronic devices which
can be connected together (or patched) by push-in leads. The
result is a digital logic circuit to perform a required function.
The design and construction of the circuit can be tested to
ensure that the function is performed correctly. The wires can
then be unplugged and a different circuit constructed.

Patch boards are generally used as a teaching aid in courses that
involve digital electronics, but can also be employed by
electronics hobbyists to test-bed their ideas before producing a
printed circuit board (PCB) design.

An Overview of Features

The simulated logic board has the following types of device
available in the quantities shown:

Quantities   Device type
----------   -----------

   20   J-K flip flops
   20   2-input AND gates
   20   4-input AND gates
   20   2-input NAND gates
   20   4-input NAND gates
   20   2-input OR gates
   20   4-input OR gates
   20   2-input NOR gates
   20   4-input NOR gates
   20   Binary to decimal decoders (with decimal display)
   20   NOT gates
   20   Lamps
   20   Toggle switches to give either 1 or 0 output.
    1   Clock pulse output
    1   Logic high output (is permanently at a logic 1)
    1   Logic low output (is permanently at a logic 0)

The output from any device can be connected to the input of any
device. The logic states of the lamps and switches are displayed
on the screen and continually updated.

A much greater quantity of devices have been incorporated in the
simulation than are currently available on commercial logic
boards and therefore the simulation allows the connection of more
complex circuits.

The options available to the user are:

    Editing connections (making or changing them).
    Remove connections to all devices, or to just one device.
    Displaying a list of connections on the screen or printer.
    Testing the board for missing connections.
    Showing the current logic state of devices on the screen.
    Saving connections to a file.
    Loading connections from a file.
    Operation of the toggle switches and clock pulse generation.

The ESC key can be pressed to exit during any options. The F1 key
can be pressed to get pop-up on-line help during all options.

Starting the Logic Simulator

The logic simulator is invoked by typing

   LOGIC

and pressing the RETURN key.

When the program begins, an initial screen is first presented
containing a copyright notice together with a version number. The
initial screen may be interrupted by pressing any key, or the
user can wait a short time while the central 'LOGIC SIMULATOR'
message becomes complete.

The main screen then appears showing some numbered lamps,
switches and boxes. At the top of the screen is a message
describing how to get help (the F1 key), and how to leave the
program (the Q for Quit key).

A number of actions are available by pressing appropriate keys,
and these are described below.

Making Connections Between Devices - the E for Edit key

To wire up a circuit, the editing facilities must be used.
Pressing the E key will invoke the editing screen where a choice
of input to output connection will be requested.

The information that is required to make the connection is the
input device type, device number and input number to connect
from, and the device type, device number and output number to
connect to.

Unlike a physical logic board, the connection of an input to
another input, or an output to another output (which is not
desirable) is not allowed.

The choices of device type are made by using the upward and downward arrow (or cursor) keys to highlight an entry in a list of possible device types, and pressing the return key to record the selection.

An example might be to connect the second input of 2-input AND gate number 3, to the output from 4-input AND gate number 2. We would have to make the following key strokes:

```
 'E' to enter the editor screen
 'Downward arrow key' to move to the 2-input AND gate device type
 'RETURN' to make the selection
 'Downward arrow key' to move to the 2nd device number
 'Downward arrow key' to move to the 3rd device number
 'RETURN' to make the selection
 'Downward arrow key' to move to the 2nd input pin
 'RETURN' to make the selection
 'Downward arrow key' to move to the 2-input AND gate device type
 'Downward arrow key' to move to the 4-input AND gate device type
 'RETURN' to make the selection
 'Downward arrow key' to move to the 2nd device number
 'RETURN' to make the selection
```

The program accepts the connection and requests another by showing the input device type list again. As many connections as are required can be consecutively entered by this method.

To either abort the current connection (in the advent of a connection being entered incorrectly but not completed), or to finish entering connections, the ESC key must be pressed. Pressing the ESC key does not affect any connections already completed, only the current incomplete one.

Connections can be made in any order. Connecting an input to different output later, overwrites the original connection.

Listing the Connections Made - the D for Display key

Pressing the D key will allow a list of the connections currently wired to be displayed. Before the list is given, a decision has to be made as to whether the connections should be shown sorted in order of the device whose input is connected, or sorted in order of the device to whose output it is connected.

Pressing the I key shows the list sorted by input, while pressing the O key sorts by output.

The connections are then are listed, one per line, with each line giving:

    - an '=' sign followed by the current logic state of the input
    - the type of device whose input is used in the connection
    - the number of that type of device in square brackets '[ ]'

- a description of the input (where this is relevant)
        - the word '..to..' meaning 'is connected to'
        - the type of device whose output is used in the connection
        - the number of that type of device in square brackets '[ ]'
        - a description of the output (where there is more than one)

If more than 20 connections have been made, the display will pause to allow the user to view the screen, before continuing when the user presses any key.

Listing the Connections Made to a Printer- the P for Printer key
----

Pressing the P key will send a list of connections similar to that produced by the Display option above to the printer. To see the format of the printed output, see the description of the Display option.

It should be noted that although the Display option description largely applies, there are some differences:

   - The printer connection is tested and any faults found are
     reported (printer off-line, not switched on etc.)

   - The user is not requested to 'press any key' following each
     20 or so connections.

Switching Switches and Clock Pulses

Upon completion of a circuit, testing will be required. A sequence of input conditions may be provided and the performance of the circuit monitored. The input conditions can be specified by using either the toggle switches (numbered 1 to 20) or the clock pulse.

To change the state (low to high, or high to low) of switches 1 to 9, simply press press the keys '1' to '9' on the top of the keyboard. The keys on the numeric keypad at the right of the keyboard will not work for this purpose.

To alter the state to switch 10, press the '0' key. To change switches 11 to 20, the process is the same as for switches 1 to 10 except that the ALT key is held down during the pressing of the number keys.

To initiate a clock pulse (low to high and then back to low), press the 'C' (for Clock) key.

Viewing the Current States of Devices - the V for View key

The current logic state of all connected devices can be seen as
part of the D (for Display) option above. This however only gives
a snapshot of the states. In order to see to logic levels
of the inputs and output of a device continually displayed, the
diagram of the device must be shown in one of the View boxes.

These View boxes are shown on the lower part of the screen and
are labelled 1 to 8. The positions are:

     1   2   3   4

     5   6   7   8

On pressing the V key, two options are presented, C (for change)
and B (for Blank). Pressing the C key allows the changing of the
diagram contents of any View box, whether the box was already
occupied or not. Pressing the B key clears or empties any
specified box or boxes.

Pressing the C to Change key will initiate a request for a choice
of which box to change. The choice of box number is made by using
the upward and downward arrow (or cursor) keys to highlight an
entry in a list of possible boxes, and pressing the return key to
record the selection.

A choice of the type of device to be shown, and the device number
of that type, are performed in a similar manner.

For example, filling box number 3 with 2-input AND gate number 3
would require the following key strokes:

 'V' to enter the View altering screen
 'C' to enter the View Changing screen
 'Downward arrow key' to move to the box number 2
 'Downward arrow key' to move to the box number 3
 'RETURN' to make the selection
 'Downward arrow key' to move to the 2-input AND gate device type
 'RETURN' to make the selection
 'Downward arrow key' to move to the 2nd device number
 'Downward arrow key' to move to the 3rd device number
 'RETURN' to make the selection

At this stage either more views in boxes may be selected, or by
pressing the ESC key the view editing sequence can be terminated.

Blanking (or clearing) a View box follows a similar process
except only the 'box number to clear' is requested. Again,
pressing the ESC key finishes the blanking of boxes.

Storing Connections - the S for Save key

Pressing the S for Save option allows the storing of details of
which connections have been made, together with which diagrams
occupy which View boxes.

Pressing the S key generates a list (if any) of Logic Simulator
files already in store is shown on the screen, and a request for
a filename under which to save the current connections.
If connections have been saved to a file, or loaded from a file
earlier in the current session with the program, the filename
last used will appear at the place where the filename is to be
typed. If such a filename appears, pressing the RETURN key will
make this previous filename be used to store the current
connections.

If no filename has been used before, or if a different filename
is required, the name of the file in which to save the
connections can be typed. Note that the filename used must be of
the form:

    XXXXXXXX.LOG

where the XXXXXXXX can be any characters (up to 8 of them), and
that the '.LOG' part must follow these characters without any
intervening spaces.

Typical examples might be   divide.log
                                   DIV6.LOG
                                   COUNTERS.LOG
                                   JKflip.log

Note that upper and lower case letters are equally valid.

If the filename already exists a message to that effect is shown
and the user is offered the choice of whether to overwrite the
file or to abort the saving process.

Note that the filename used becomes the new default filename for
future save options.

Retrieving Connections - the L for Load key

Pressing the L key initiates the process of loading connection
and view details from a file, which is a similar process to that
of storing connections. The only difference arises when a
filename that does not exist is entered. Then a message is
displayed and the loading option aborted.

It should be noted that all view boxes, switch settings and
connections are cleared before the new connections and views are
read from the file.

Removing Connections to Devices - the B for Blank key

Pressing the B key allows the removal of connections to one or
all devices. After pressing the B key, two options become
available. These are the O (for One) or the A (for ALL) keys.

Pressing the A key will remove all connections to every device,
but only after requesting confirmation by an 'Are you sure'
message.
Pressing the O key will allow the choice of which device to
disconnect. For the device selection process, see the View box
blanking option given under 'Viewing the Current States of
Devices - the V for View key'

Searching for Incomplete Connections - the T for Test key

Pressing the T (for Test) key from the main screen starts a
testing of the completeness of the connections that have been
made. The list of incompletely connected devices (see below) can
be shown on the screen by pressing the S key, or on the printer
by pressing the P key.

An examination of each device to which a connection has been made
is performed. Each connected device is checked to ensure that all
its other inputs have been connected to something, and that its
output is used by another device. A list of unused connections is
then shown.

It should be noted, however, that testing in this manner will not
pick up every forgotten connection as:

  - it only checks that AT LEAST ONE connection is made to an
    output, there perhaps should have been five.

  - the connection of an input to the wrong output will appear to
    be correct, as a connection has nevertheless been completed.

  - J-K flip flops are only checked to see that at least one of
    the outputs have been connected.

  - binary to decimal decoders are not checked as they have no
    connectable output, and it is assumed that the user may not
    want to connect all of the inputs (the rest being left as
    'pulled low').

If more than 20 missing connections are located, a pause is
implemented to allow the user to view the screen, before
continuing after the user presses any key.

Things to Note

If a circuit remains unstable 20 time cycles after the last key
press is made, a message to that effect appears on the upper left
side of the screen. The connections should be reviewed and
altered until the condition returns to stability.

The simulated devices all have the same propagation delay (time
between setting the input conditions and being certain of the
output conditions). Real logic devices (even of the same type)
have slightly different propagation delays. A few circuits
require these slightly different delays for the circuit to work.
These circuits which require the 'race hazards' will not work on
the logic simulator, and will generally cause the instability
described above.

→→→→→→→→→→→→→→→→→