Quartus ROM Creation Instructions

Problem: You have an ASM or CPU that you would like to control/test from an EEPROM. How can you simulate the EEPROM under Quartus?

Solution:
Use the ROM model found in the "megafunctions | storage" library called "lpm_rom."

Design Procedure:

1. Create a new project and BDF file (File->New…). In your schematic (BDF file), add an "lpm_rom" component found in the "megafunctions" library under "storage."
2. The MegaWizard Plug-In Manager should now help you with the rest of your design. (It will give a default name. I suggest you use it.)
3. Select "Next" to use AHDL for the output file.
4. For the device family, pick something that has RAM. The FLEX10K family has internal RAM, but only about 2kB. The FLEX10KE family has a device (the EPF10K200SR240-3) that has more then 64kB. For our example we will use the FLEX10KE family (and you will eventually pick the EPF10K200SR240-3 device).
5. We will make a 1k x 8 bit device (1kB), so we'll need 8 data bits and 10 address bits (2^{10}=1024 words). Answer "8" for "How wide should the 'q' output bus be?" Answer "1024" for "How many 8-bit words of memory?" Select "Next".
6. Remove the checks so that neither the address or data port are registered. Select "Next".
7. Enter a new file name for your memory initialization file (MIF) or use a previously made file like "rom_creation.mif" provided on our web site. Select "Next". Select "Next" again. Then select "Finish".
8. Place your ROM device somewhere in your ".bdf" window. You should see something like Figure 1 when you try to place the component onto your schematic:
9. Add a bus to the address inputs, address[9..0], and a bus to the data outputs, q[9..0]. Label the address or data bus by drawing it then typing the name. In Figure 2, we have used A[9..0] and D[7..0] as the example names. They must be in the form of "Name[msb..0]" where msb is the most significant bit's position, starting from zero on the right. You can now use these signals anywhere else in your circuit or as inputs & outputs (as shown in Figure 2).

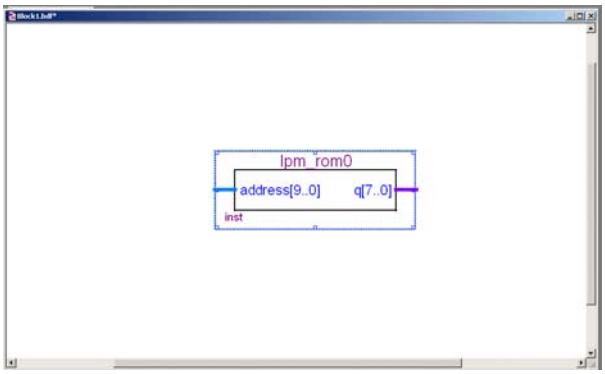


Figure 1: An lpm_rom component.

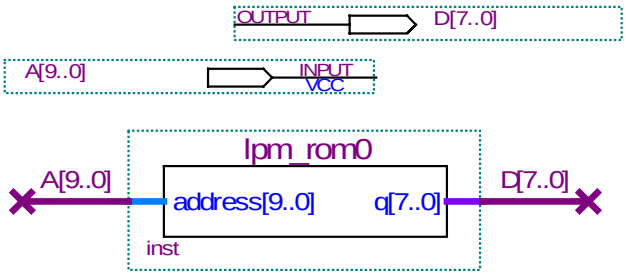


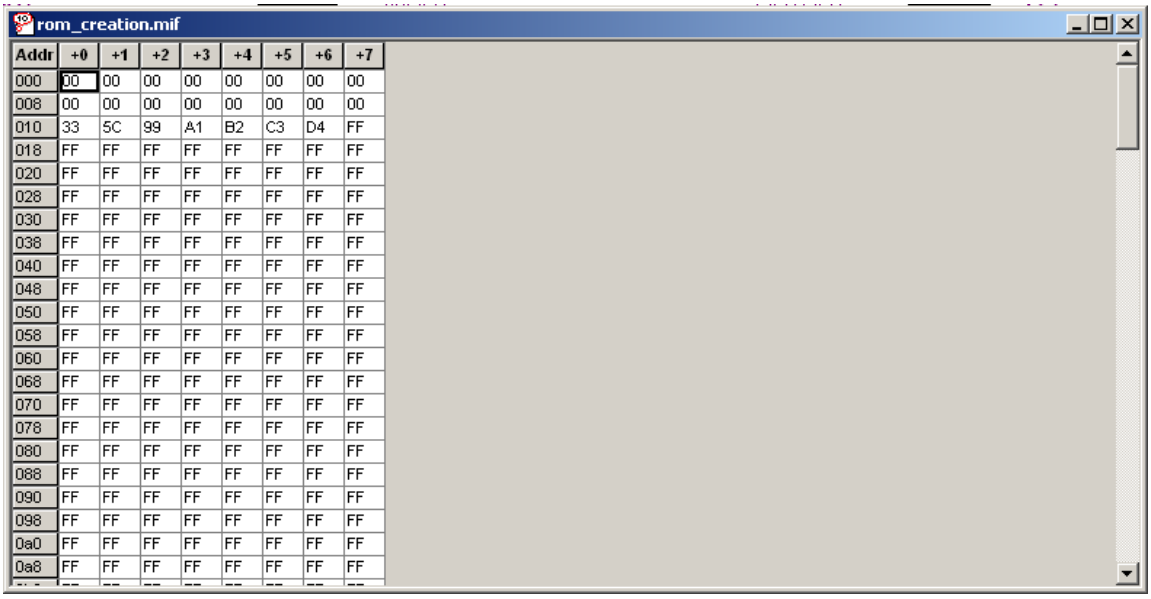
Figure 2: ROM with signals named and defined.

10. Create a MIF file that will contain the memory contents you want programmed in the ROM. This example is called "rom_creation.mif" and can be created with a text editor in Quartus or other text editiors (i.e., Notepad, emacs, etc.). This file is shown in Figure 3. Note that you can use any base you want (BIN, DEC, HEX or OCT) in the MIF file. The DEPTH is the number of addresses (memory words) in the ROM and the WIDTH is the size of the data bus (the number of data bits per word). This example has 16 locations with zeros, 7 different data values and then $FF for the remaining locations.

```
DEPTH = 1024;  % Memory depth and width are required %
WIDTH = 8;     %   Enter decimal numbers for each    %

ADDRESS_RADIX = HEX;   % Address and value radixes are optional     %
DATA_RADIX = HEX;      % Enter BIN, DEC, HEX, or OCT; unless        %
                       % otherwise specified, radixes = HEX         %

-- Specify values for addresses, which can be single address or range

CONTENT
BEGIN

[0..F]     :    0;    % First 16 values are zero %
10         :    33;   % Single address data %
11         :    5C;   % Addr[11] = 5C %
12         :    99;
13         :    A1;   % Addr[13] = A1 %
14         :    B2;
15         :    C3;
16         :    D4;   % Addr[16] = D4 %
[17..3FF]  :    FF;   % remaining locations are FF %
END ;                 % You must have END statement! %
```

Figure 3: Example MIF file, rom_creation.mif.

11. You can also create a MIF file by selecting "File | New | Other Files | Memory Initialization File.
    a. Then you must supply the "Number of Words" and the "Word Size". These are 1024 and 8, respectively, in our example.
    b. A table will now appear. Enter your data directly in this table. All data in this table must used base 10 (unsigned decimal).
    c. Figure 4 shows the results of using or creating the rom_creation.mif file with a text editor and then opening it in Quartus.



Addr	+0	+1	+2	+3	+4	+5	+6	+7
000	00	00	00	00	00	00	00	00
008	00	00	00	00	00	00	00	00
010	33	5C	99	A1	B2	C3	D4	FF
018	FF	FF	FF	FF	FF	FF	FF	FF
020	FF	FF	FF	FF	FF	FF	FF	FF
028	FF	FF	FF	FF	FF	FF	FF	FF
030	FF	FF	FF	FF	FF	FF	FF	FF
038	FF	FF	FF	FF	FF	FF	FF	FF
040	FF	FF	FF	FF	FF	FF	FF	FF
048	FF	FF	FF	FF	FF	FF	FF	FF
050	FF	FF	FF	FF	FF	FF	FF	FF
058	FF	FF	FF	FF	FF	FF	FF	FF
060	FF	FF	FF	FF	FF	FF	FF	FF
068	FF	FF	FF	FF	FF	FF	FF	FF
070	FF	FF	FF	FF	FF	FF	FF	FF
078	FF	FF	FF	FF	FF	FF	FF	FF
080	FF	FF	FF	FF	FF	FF	FF	FF
088	FF	FF	FF	FF	FF	FF	FF	FF
090	FF	FF	FF	FF	FF	FF	FF	FF
098	FF	FF	FF	FF	FF	FF	FF	FF
0a0	FF	FF	FF	FF	FF	FF	FF	FF
0a8	FF	FF	FF	FF	FF	FF	FF	FF

Figure 4: Example MIF file, rom_creation.mif, displayed in Quartus.

12. To change the MIF file associated with the ROM, double-click on the ROM and go through the MegaWizard Plug-In Manager until you find the screen that associates the ROM with a MIF file.
13. Assign a device that allows for ROM creation. I chose the FLEX10KE family and the EPF10K200SR240-3 device so that it would easily fit. (The EPF10K200SR240-3 is the last part on the device list.)
14. Save the file, then compile it, and you are now ready to simulate the design.

Simulation:

The simulation is very similar to any other simulation you have performed. Simply set the address input lines (or drive them from a counter or register) and observe the data that comes out of the ROM. An example is given in Figure 5.

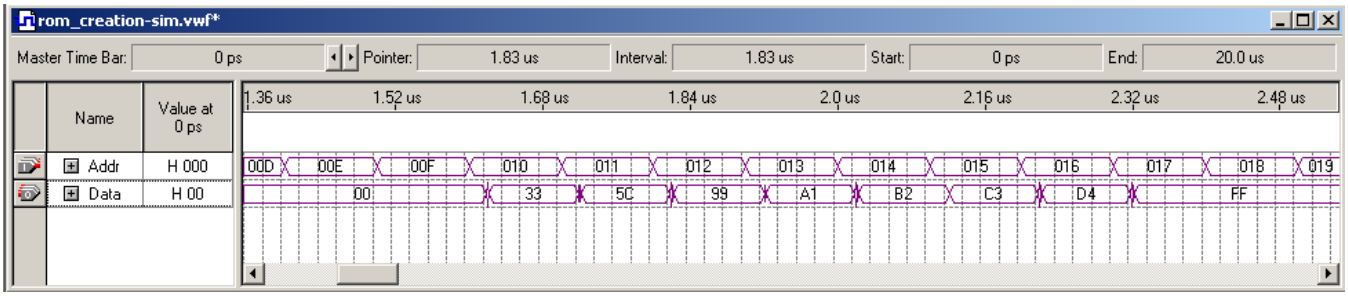


Figure 5: Simulation output.

The nodes used in simulation were A9, A8, A7, … A0 and D7, D6, D5, … D0. These were then highlighted (selected using the mouse) and upon right clicking the mouse, were set as buses using the "Group" option. The address lines were then set to use a "Count Value" for easy simulation.

Very Important Note: The ROMs are very slow. Therefore when you simulate you should change the smallest increment of time to about 100ns and the end time to at least 20µs (where micro seconds in Quartus is selected with "us"). You can increase the simulation end time by selected "Edit | End Time ..." and entering the desired end time. To set the count time, select the address to use "Count Value" go to the "Timing" menu and change the "Count every" entry to 100ns. This window is shown in Figure 6.

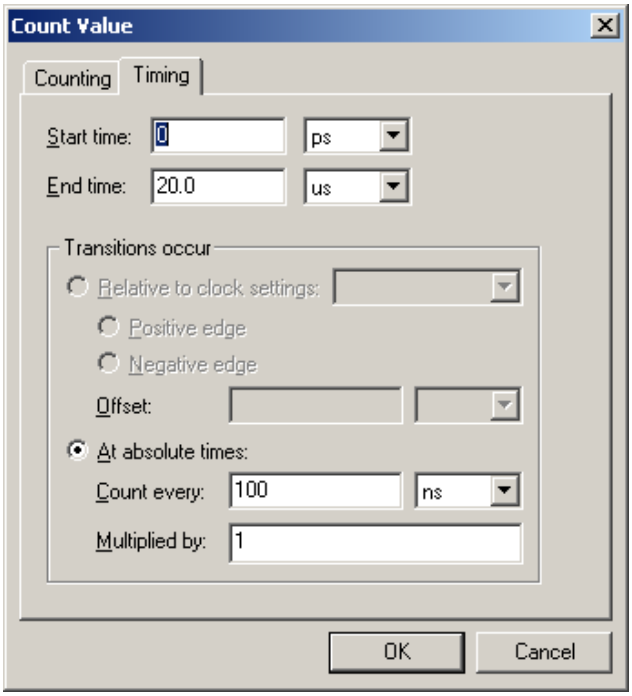


Figure 6: Count value timing increment.