EBU4202 Digital Circuit Design 2018-19
Week 4 Tutorial Sample Solution

1. a) Explain the difference and similarity between ROM and RAM.

ROM and RAM are both random access. Every location in both types of
memory can be accessed in the same length of time.
ROM is non-volatile, ie, contents of memory are retained when power is removed. On the other
hand, RAM is volatile, ie, contents of memory are lost when power is removed.

b) Explain what is meant by the terms Static RAM (SRAM) and Dynamic RAM (DRAM) and compare
them.

Static RAM uses transistors to store a single bit of information (0 or 1). Dynamic
RAM uses a capacitor to store its state. DRAMs need to be refreshed
periodically to retain their charge but SRAM does not need to be refreshed periodically. DRAMs are
less expensive and slower than SRAMs. DRAMs are used for main memory and SRAMs for cache
memory.

c) Using a suitable diagram, briefly explain the function of a DECODER.

A DECODER selects one output from many depending on an input address. Here is a 2-to-4 decoder, where each of the 4 input states selects one of the 4 outputs.

I1	I0	Y3	Y2	Y1	Y0
0	0	0	0	0	1
0	1	0	0	1	0
1	0	0	1	0	0
1	1	1	0	0	0
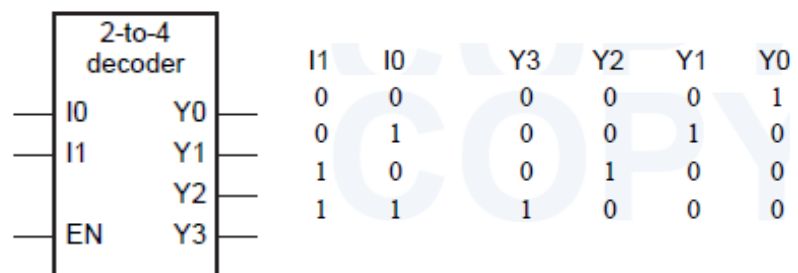
d) Suppose we have a computer with 256 MBytes of memory, with each memory chip having a
capacity of 4 MBytes.
i) How many memory chips are required?
ii) How many address bits are required?
iii) How many bits are required to select the memory chips?
iv) Draw a block diagram of a circuit using a decoder so that all 256 Mbytes of memory
can be addressed.

i) 256/4 =64 chips
ii) 256 M = 2^{28} . Therefore 28 address bits are required.
iii) 64 memory chip, so $\log_2(64)$ = 6. Therefore 6 bits are required to select 1 from 64 chips.
iv) A 6-to-64 decoder can be used. 6 address bits can be used to select the chip with the other 22
bits being used to select the memory location within the selected chip
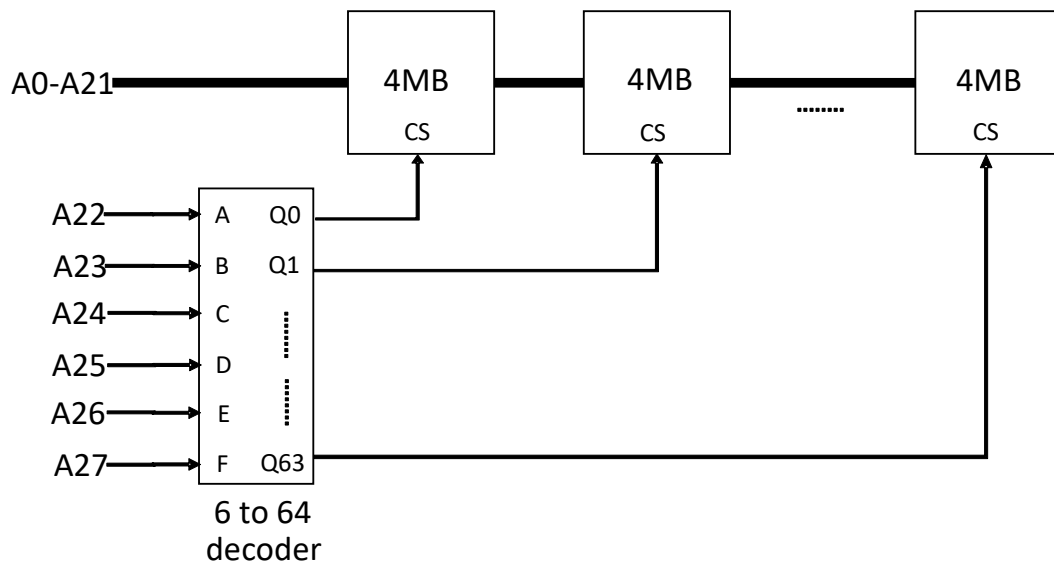
2. a) Explain what is meant by each of the following terms:
   i) Non-volatile
   ii) Random Access
   iii) DRAM
   iv) EPROM

   i)   Non-volatile memory keeps its contents even if there is no power to the device
   ii) All memory contents can be accessed in the same time as each other
   iii) Dynamic RAM. Compact type of RAM, but relatively slow. Uses a capacitor to store its
        state. DRAMs need to be refreshed periodically to retain their charge.
   iv) Erasable PROM. Programmed by the user using a programming device. Contents can be
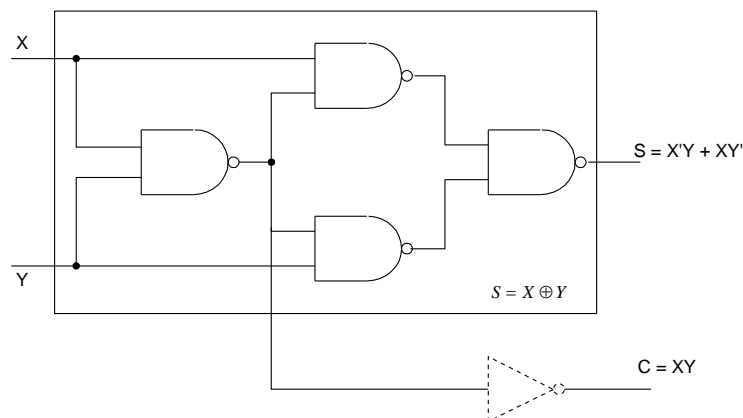   erased and the chip reprogrammed.

b) Mask programmed Read Only Memories (ROM) are programmed in manufacture. Using a
suitable diagram, show the typical structure of a 4x4-bit ROM.
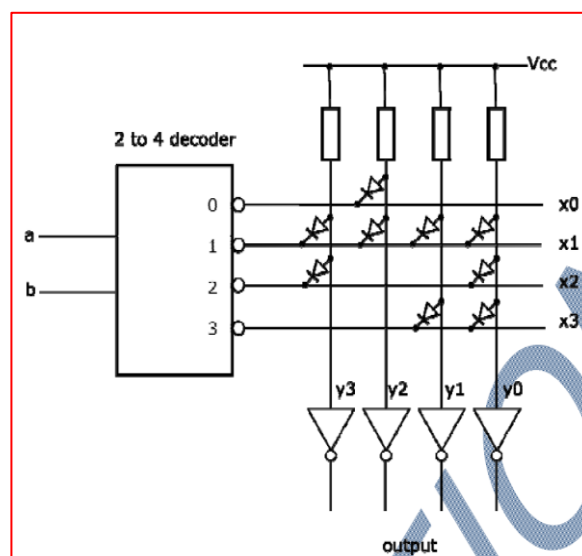
c) Design and draw the diagram of an Arithmetic Unit, which can add and subtract as well as can make it increment and decrement by 2.

Control		Arithmetic
1	0	Function
0	0	A + 2
0	1	A + B
1	0	A - 2
1	1	A - B
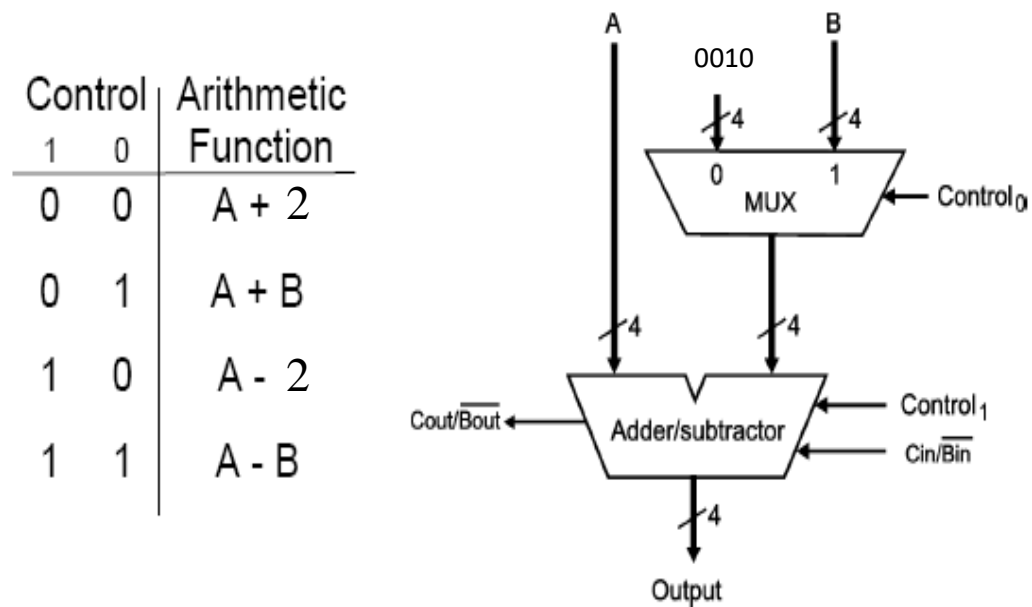
3. (a) Draw the gate logic diagram of an half adder using NAND gates.
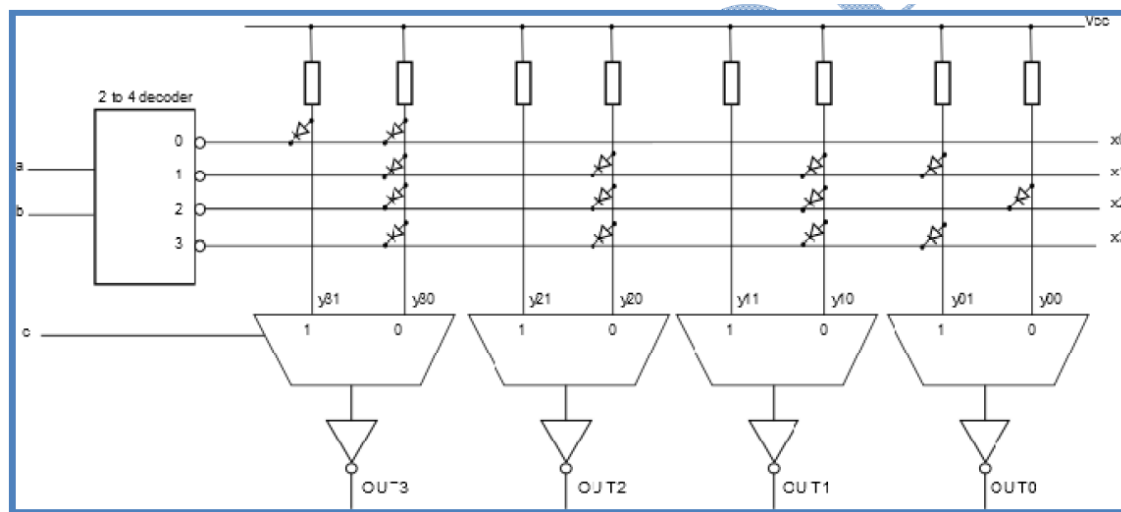

$S = X'Y + XY'$

$S = X \oplus Y$

$C = XY$

(b) Use a suitable diagram to explain how a 4-bit parallel ripple adder can be used as a subtractor, where you want to perform (N1-N2) operation.
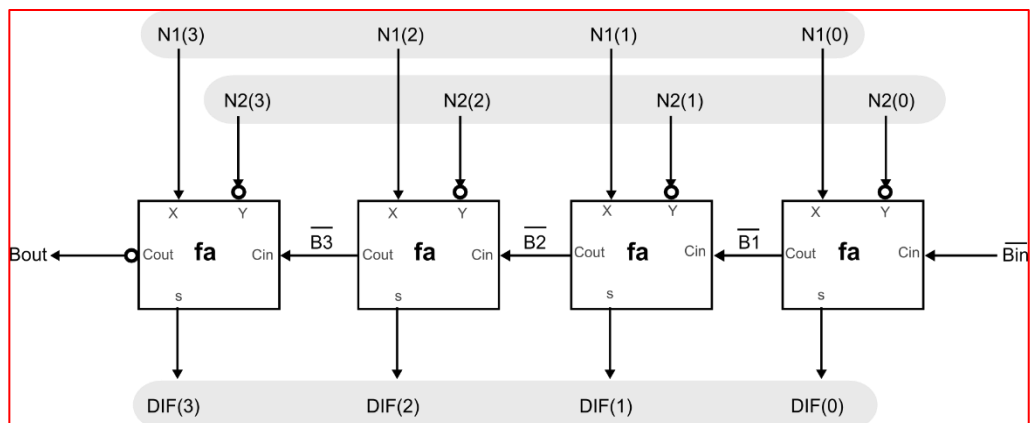
4. Design an 8 x 4-bit read-only memory (ROM) circuit pre-programmed with the data shown in the Table below. (Hint: diodes, decoder, multiplexer etc. are required in the ROM circuit).
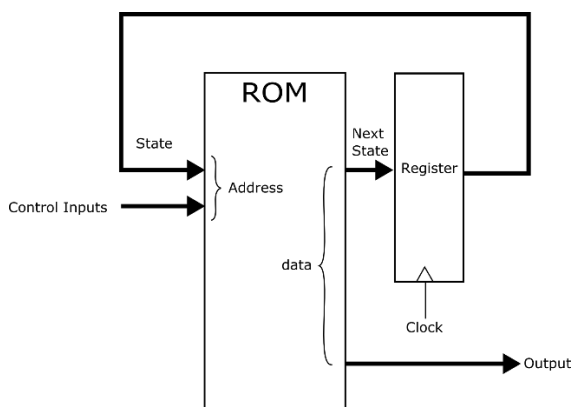
Address	Data (4 bit)
0	8
1	8
2	14
3	1
4	15
5	0
6	14
7	1

5. Using appropriate diagrams, briefly describe the use of ROM as a Look-up table, referring to an example.

Look-up Tables can be used as a fast alternative to implement a software programme that performs repetitive calculations, or logic that performs code conversions. The ROM is pre-programmed with the appropriate data. The input value is applied to the ROMs address bus and the corresponding value is output on the data bus. A simple example would be conversion between Fahrenheit and Celcius temperature values. The Fahrenheit value would be applied to the address bus and the corresponding pre-programmed Celcius value will output on the data bus. Because the device is random access, all values will be accessed in the same time.
NOTE: Any correct relevant example would gain the marks. Any of the following diagrams will be acceptable.