

Assignment - 3

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Digital Electronics (CER3C4)

Assignment - 3

1. Explain each of the converter with proper circuit diagram.

(i) R-2R Ladder

- The R-2R ladder type DAC is the most popular DAC.
- It uses a ladder network containing series - parallel combinations of two resistors of values R and $2R$.
- The operational amplifier configured as voltage follower is used to prevent loading.
- Figure shows the circuit diagram of a R-2R ladder type DAC having 4-bit digital input.
- When a digital signal $D_3 D_2 D_1 D_0$ is applied at the input terminals of the DAC, an equivalent analog signal is produced at the output terminal.

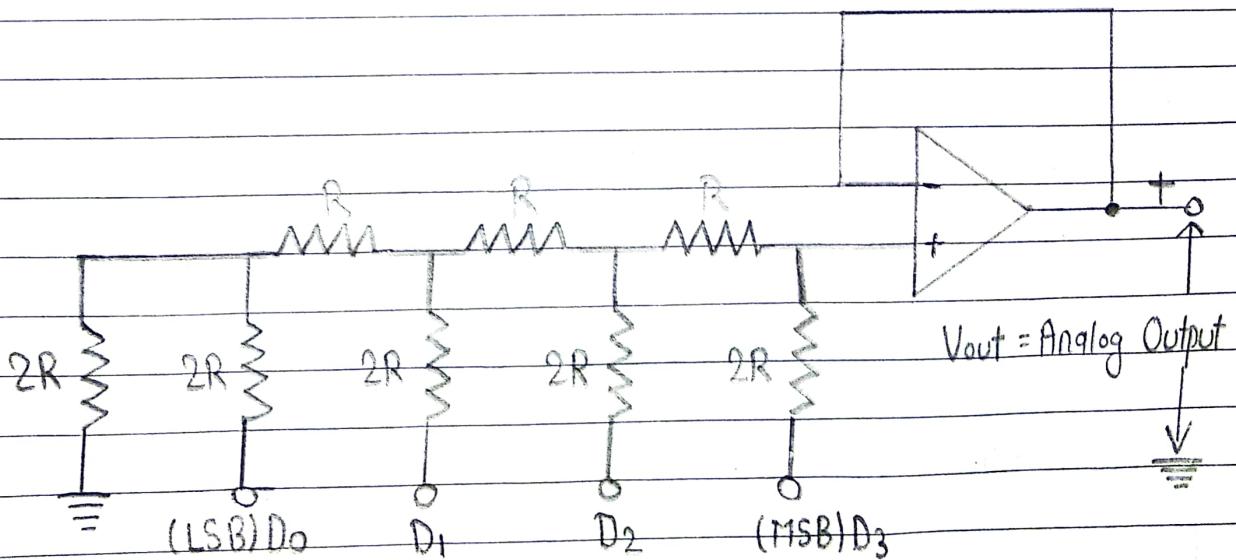
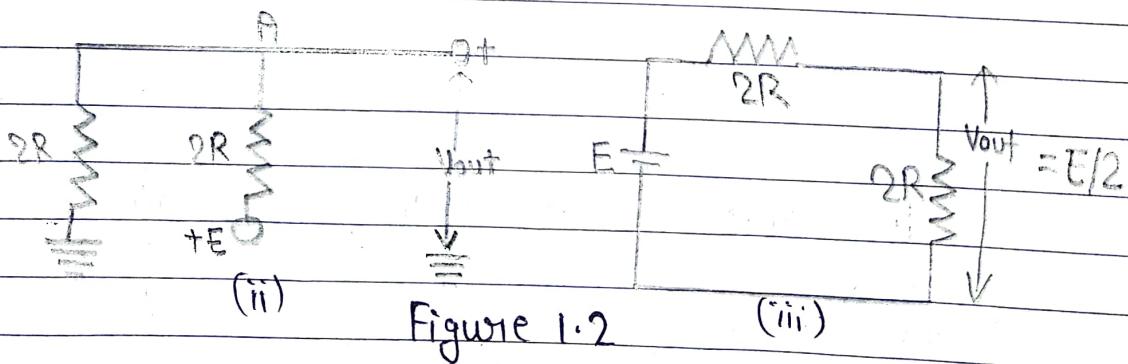
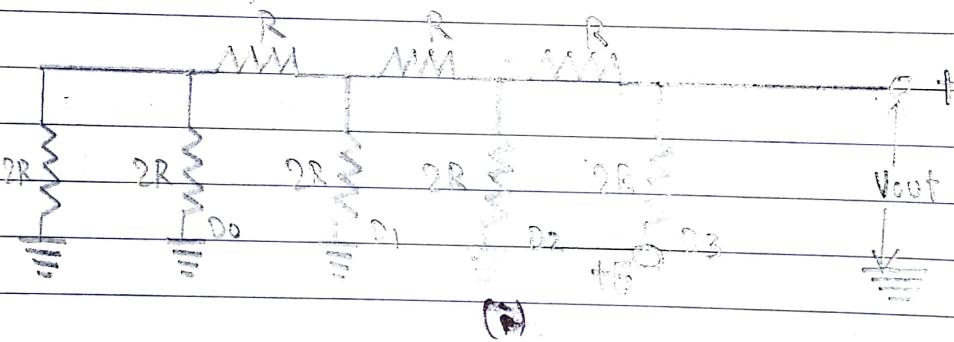


Figure 1.1 : Circuit Diagram of R-2R ladder

Case 1 : When the input is 1000

- Below figure illustrates the procedure to calculate V_{out} when the input is 1000.
- At the left end of the ladder, $2R$ is in parallel with $2R$, so that the combination is equivalent to R .
- This R is in series with another R giving $2R$. This $2R$ in parallel with another $2R$ is equivalent to R .
- Continuing in this manner, we ultimately find that $R_{eq} = 2R$.
- The output voltage $V_{out} = E/2$



Case 2 : When the input is 0100

- Figure 1.3 illustrates the procedure to calculate V_{out} when the input is 0100.
- Here, we find that to left terminal B, $R_{eq} = 2R$.
- The output voltage, $V_{out} = E/4$

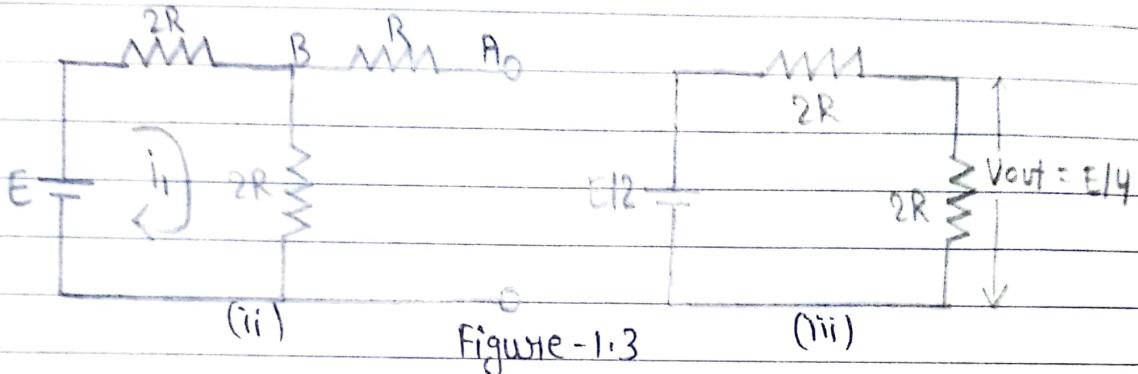
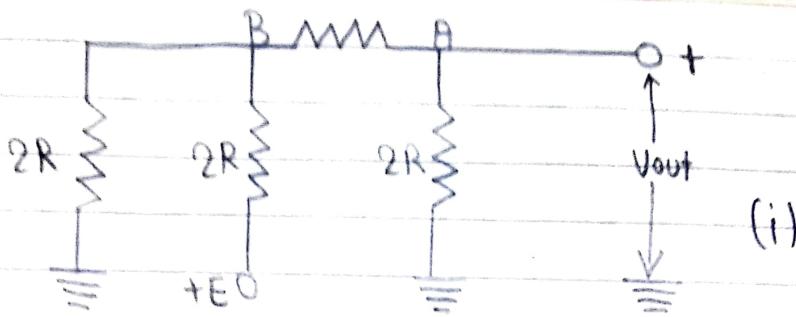
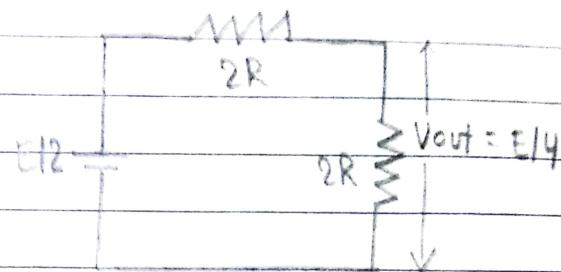


Figure-1.3



(iii)

Case 3: When the input is 0010

- Figure 1.4 illustrates the procedure to calculate V_{out} when the input is 0010.
- Here, we find that to left of terminal C, $R_{eq} = 2R$.
- The output voltage, $V_{out} = E/8$.

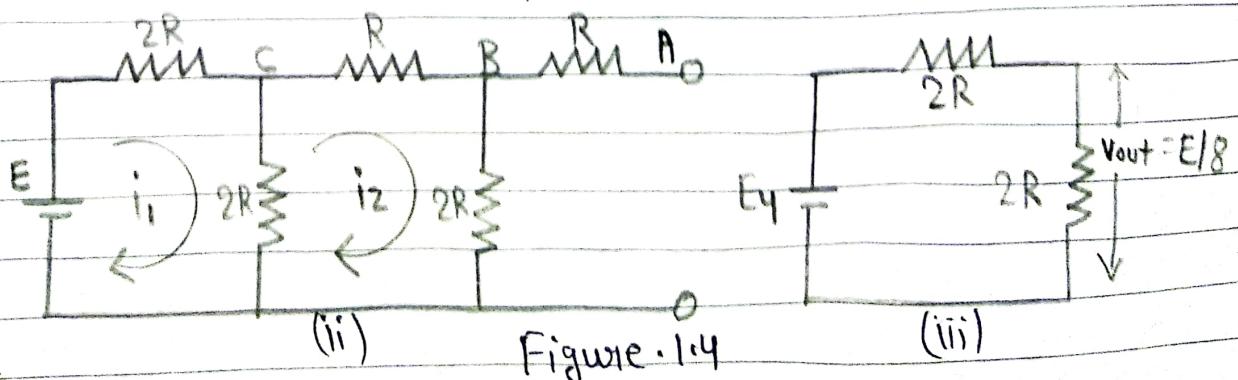
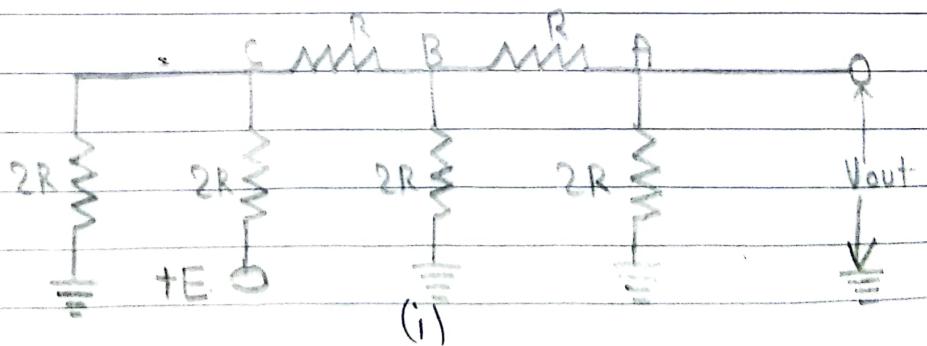
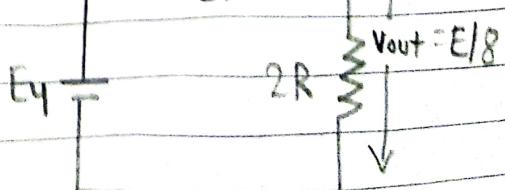


Figure-1.4



(iii)

Case 4: When the input is 0001

- Figure 1.5 illustrates the procedure to calculate V_{out} when the input is 0001.
- The total output voltage, $V_{out} = E/16$.

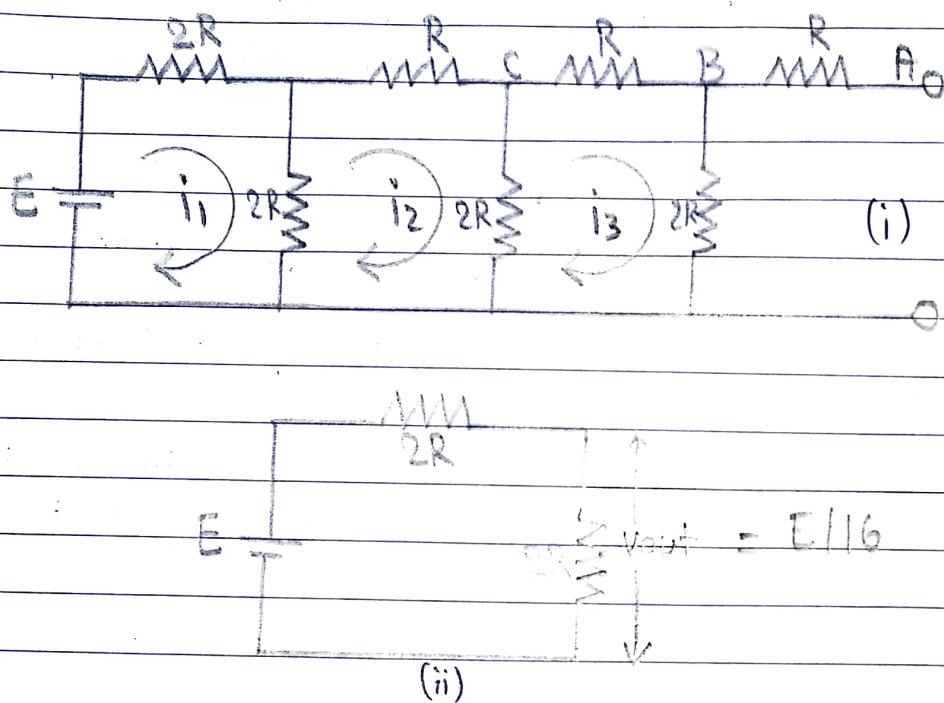


Figure 1.5

- It is difficult to get the generalized output voltage equation of a R-2R Ladder DAC. But, we can find the analog output voltage values of R-2R Ladder DAC for individual binary input combinations easily.

Advantages of R-2R Ladder

- R-2R Ladder DAC contains only two values of resistors: R and $2R$. So, it is easy to select and design more accurate resistors.

- If more number of bits are present in the digital input, then we have to include required number of R-2R sections additionally.
- Due to these advantages, R-2R Ladder DAC is preferred over binary weighted resistor DAC.

(ii) Successive Approximation type A/D converter

- A successive approximation A/D converter consists of a comparator, a successive approximation register (SAR), output latches, and a D/A converter.
- The circuit diagram is shown below.

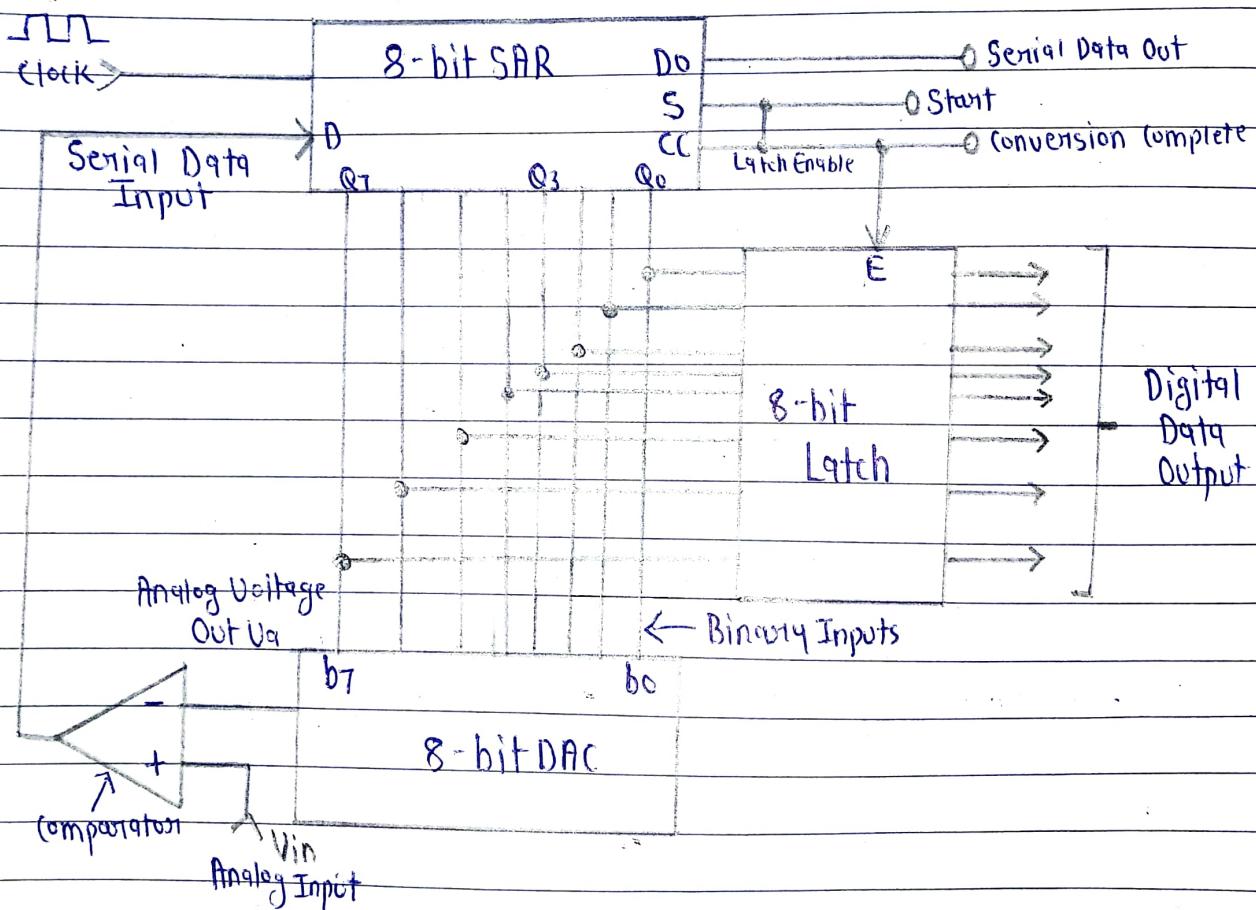


Figure: 1.(ii). 1 : Successive Approximation type A/D converter

- The main part of the circuit is the 8-bit SAR, whose output is given to an 8-bit D/A converter.
- The analog output V_q of the D/A converter is then compared to an analog signal V_{in} by the comparator.

- The output of the comparators is a serial data input to the SAR.
- Till the digital outputs (8-bits) of the SAR is equivalent to the analog input V_{in} , the SAR adjusts itself.
- The 8-bit latch at the end of conversion holds onto the resultant digital data output.

Working

- At the start of a conversion cycle, the SAR is reset by making the start signal (S) high.
- The MSB of the SAR (Q_7) is set as soon as the first transition from LOW to HIGH is introduced.
- The output is given to the D/A converter which produces an analog equivalent of the MSB and is compared with the analog input V_{in} .
- If comparator output is LOW, D/A output will be greater than V_{in} and the MSB will be cleared by the SAR.
- If comparator output is HIGH, D/A output will be less than V_{in} and the MSB will be set to the next position (Q_7 to Q_6) by the SAR.
- According to the comparator output, the SAR will either keep or reset the Q_6 bit.
- This process goes on until all the bits are tried. After Q_0 is tried, the SAR makes the conversion complete (CC) signal HIGH to show that the parallel output lines contain valid data.
- The CC signal in turn enables the latch, and digital data appear at the output of the latch.

- As the SAR determines each bit, digital data is also available serially.
- The CC signal is connected to the start conversion input in order to convert the cycle continuously.
- The biggest advantage of such a circuit is its high speed. It may be more complex than an A/D converter, but it offers better resolution.

Advantages :

- Conversion time is very small.
- Conversion time is constant and independent of the amplitude of the analog input signal V_A .

Disadvantages :

- Circuit is complex.
- The conversion time is more compared to flash type ADC.

(iii) Binary Weighted DAC

- A weighted resistor DAC produces an analog output, which is almost equal to the digital (binary) input by using binary weighted resistors in the inverting adder circuit.
- In short, a binary weighted resistor DAC is called as weighted resistor DAC.
- The circuit diagram of a 4-bit binary weighted resistor DAC is shown in the following figure.

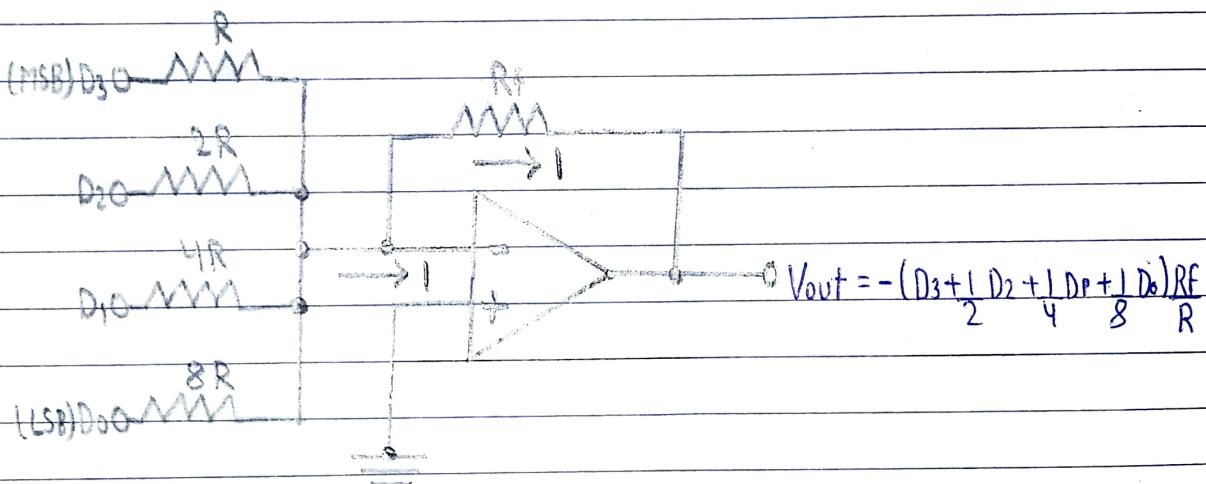


Figure 1.(iii). 1 :- Binary Weighted DAC

- The operational amplifier is used to produce a weighted sum of digital inputs, where the weights are proportional to the weights of the bit positions of inputs.
- Since the op-amp is connected as an inverting amplifier, each input is amplified by a factor equal to the ratio of the feedback resistance divided by the input resistance to which it is connected.

- The MSB D_3 is amplified by RF/R , D_2 is amplified by $RF/2R$, D_1 is amplified by $RF/4R$ and D_0 is, the LSB is amplified by $RF/8R$.
- The inverting terminal of the op-amp acts as a virtual ground.
- Since the op-amp adds and inverts,

$$V_{out} = - \left(D_3 + \frac{D_2}{2} + \frac{D_1}{4} + \frac{D_0}{8} \right) \times \left(\frac{RF}{R} \right)$$

- The main disadvantage of this type of DAC is, that 9 different valued precision resistors must be used for each bit position of the digital input.

Example :- For the weighted-resistor DAC, determine (a) the weight of each input bit if the inputs are 0V and 5V, (b) the full-scale output, if $RF = R = 1\text{ k}\Omega$.

Solution :-

(a) If MSB passes with a gain of 1, so, its weight = 5V; the next bit passes with a gain of 1/2, so, its weight = 2.5V; the following bit passes with a gain of 1/4, so, its weight = 1.25V; the LSB passes with a gain of 1/8, so, its weight = 0.625V.

(b) Therefore, the full scale output when $RF = R = 1\text{ k}\Omega$

$$V_{out} = - \left(5 + \frac{5}{2} + \frac{5}{4} + \frac{5}{8} \right) = - 9.375\text{ V}$$

2. Difference between RAM and ROM.

S.No	Difference	RAM	ROM
1.	Definition	RAM stands for Random Access Memory.	ROM stands for Read Only Memory.
2.	Data Retention	RAM is a volatile memory which could store the data as long as the power is supplied.	ROM is a non-volatile memory which could retain the data even when power is turned off.
3.	Working Type	Data stored in RAM can be retrieved and altered.	Data stored in ROM can only be read
4.	Use	Used to store the data that has to be currently processed by CPU temporarily.	It stores the instruction required during bootstrap of the computer.
5.	Speed	It is a high-speed memory.	It is much slower than the RAM.
6.	(CPU Interaction	The CPU can access the data stored on it.	The CPU can not access the data stored on it unless the data is stored in RAM.
7.	Size (Capacity)	Larger size with higher capacity.	Small size with less capacity.
8.	Used as in	CPU cache, Primary memory	Firmware, Micro-controllers
9.	Cost	RAM is costly	ROM is cheap
10.	Accessibility	The data stored is easily accessible.	The data stored is not as easily accessible as in RAM.