ECE233
Laboratory Experiment 5
Ladder Network

Ladder Network: A ladder network is used in order to obtain gradually increasing voltage levels. These voltage levels demonstrate a regular structure like a ladder. The operation of the ladder network is supported and provided by the input terminal nodes. Either a constant DC voltage (**V_S**) is applied to these nodes or they are grounded. Hence, these nodes are either activated (by applying constant voltage) or deactivated (by grounding). The number of input terminal nodes determines the number of voltage levels that will occur. If there are N input terminal nodes, the number of voltage levels that can be obtained is equal to 2^N. The smallest of these voltage levels is equal to zero where as the highest of them will be equal to $\frac{2^N - 1}{2^N} V_S$. Thus, the incremental change from a lower level to one higher level will be equal to $\frac{V_S}{2^N}$.

1-) Construct the ladder network shown in Figure 1 (R_1=10 kΩ, R_2=5 kΩ). This ladder network has 4 input terminal nodes (A, B, C, D) and an output node (shown by node E). A **voltmeter** is also connected to the circuit for measuring the **voltage at node E**. Fill up the voltage measurements part (Voltage at node E) in Table 1 according to the different input terminal node voltage configurations. If an input terminal node is **active** (**ON**) than apply **V_S=16 Volt** to the node. If an input terminal node is **inactive** (**OFF**) apply **0 Volt** to the node (**simply connect the node to the ground point**).

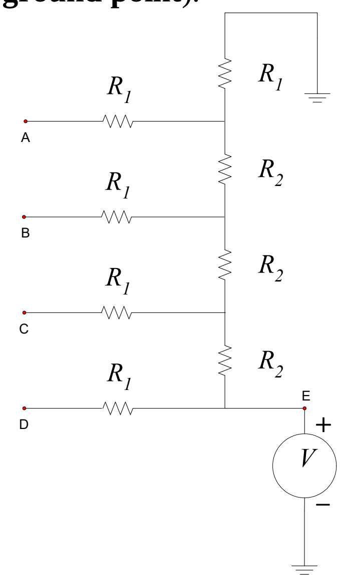

Figure 1: Ladder network for voltage measurements**.**

Questions:

- For the ladder circuit in Figure 2 (R_1=10 kΩ, R_2=5 kΩ), show that the output voltage (voltage at node E or V_E) is equal to $V_E = \frac{V_A}{2} + \frac{V_B}{4} + \frac{V_C}{8} + \frac{V_D}{16}$, where V_A, V_B, V_C and V_D are the applied voltage values to corresponding nodes A, B, C and D respectively.

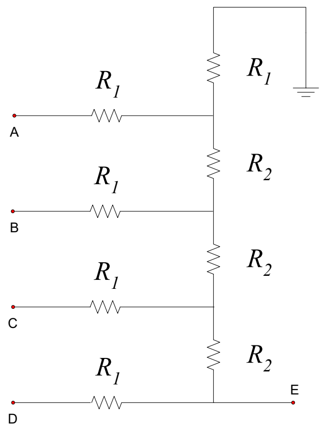

Figure 2: Ladder network for deriving the output voltage at node E.

Table 1: Voltage and resistance measurements over the ladder network

	Node D	Node C	Node B	Node A	Voltage at node E	Resistance seen from node E
1	OFF	OFF	OFF	OFF		
2	OFF	OFF	OFF	ON		
3	OFF	OFF	ON	OFF		
4	OFF	OFF	ON	ON		
5	OFF	ON	OFF	OFF		
6	OFF	ON	OFF	ON		
7	OFF	ON	ON	OFF		
8	OFF	ON	ON	ON		
9	ON	OFF	OFF	OFF		
10	ON	OFF	OFF	ON		
11	ON	OFF	ON	OFF		
12	ON	OFF	ON	ON		
13	ON	ON	OFF	OFF		
14	ON	ON	OFF	ON		
15	ON	ON	ON	OFF		
16	ON	ON	ON	ON		

2-) Construct the ladder network shown in Figure 3 (R_1=10 kΩ, R_2=5 kΩ). This ladder network has 4 input terminal nodes (A, B, C, D) and an output node (shown by node E) where the **ohmmeter** is connected for measuring the **resistance seen from node E**. Fill up the resistance measurements part (Resistance seen from node E) in Table 1 according to the different input terminal **connection configurations**. If an input terminal node is **active** (**ON**) than leave that node **open** (**do not connect the node to anywhere**). If an input terminal node is **inactive** (**OFF**) **simply connect the node to the ground point**.

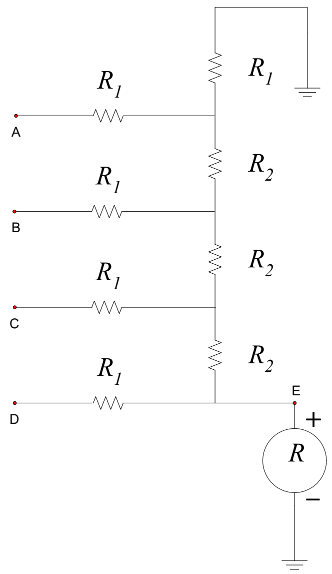

Figure 3: Ladder network for resistance measurements

Questions:

- For the ladder circuit in Figure 4 (R_1=10 kΩ, R_2=5 kΩ), show that the resistance seen from node E (R_E) is equal to 5 kΩ, when A, B, C and D are **OFF** (**connected to ground**).
- For the ladder circuit in Figure 5 (R_1=10 kΩ, R_2=5 kΩ), show that the resistance seen from node E (R_E) is equal to 25 kΩ, when A, B, C and D are **ON** (**connected to nowhere**).
- For the ladder circuit in Figure 6 (R_1=10 kΩ, R_2=5 kΩ), show that the resistance seen from node E (R_E) is equal to 20 kΩ, when A is **OFF** (**connected to ground**) and B, C and D are **ON** (**connected to nowhere**).

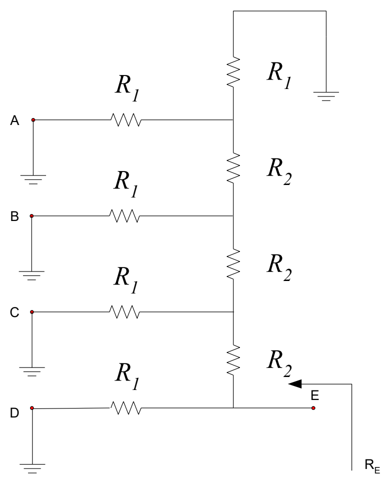

Figure 4:

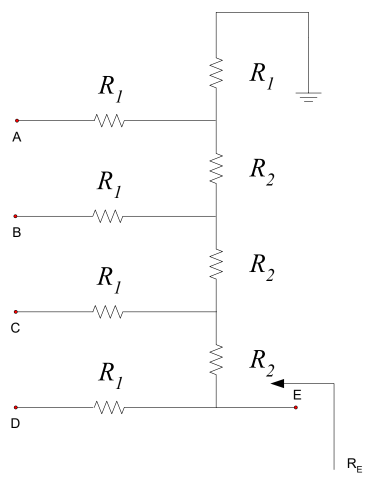

Figure 5:

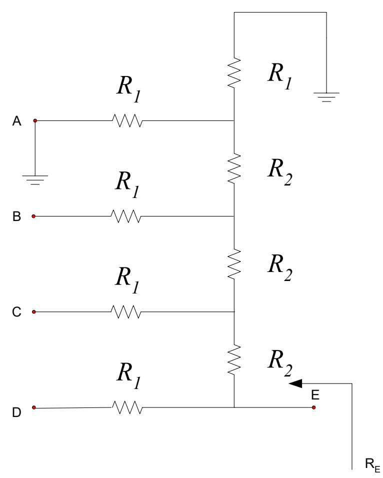

Figure 6: