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Role of Symmetry in present day Analog System Design – Passive Networks

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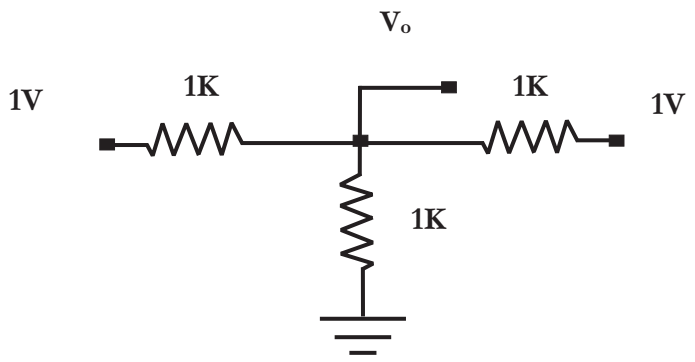
It is necessary to teach present day Electrical Engineering differently in order to make the undergraduate students take interest in basic core courses from the beginning itself. Common core courses in Engineering could emphasize on Signals, Systems and Specifications (Three S) rather than on devices and their characteristics. This top down approach adapted in the curriculum with the help of the industry can go a long way in kindling and fostering curiosity and interest of a student in the beginning itself. The same top down approach could be adopted in laboratory exercises making them more meaningful to the students in relating the concepts to the real world of analog systems.

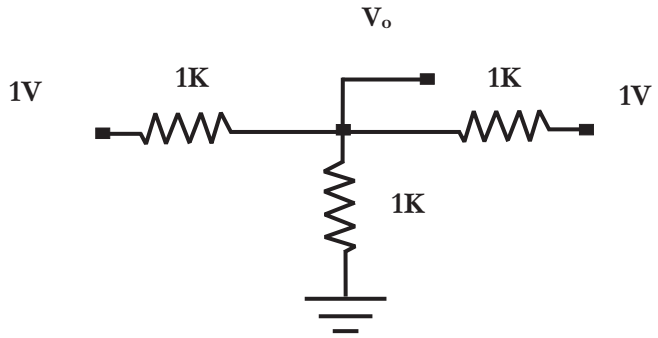
The following examples serve to illustrate how better understanding of networks helps with analog signal processing. These examples relate to familiar laws like the Kirchoff's law and the principle of superposition.

Improving the signal to noise ratio and amplifying signals to optimum levels for data conversion into digital domain for further processing using Digital Signal Processors [DSPs] is an area that is pertinent to the front end electronics of many systems. The best technique for improving signal to noise ratio is to treat signal as differential and noise as common mode. The use of this technique is preferred in the real world of circuit design since matched networks are far more easily realizable in practice than networks requiring control of the absolute values of components. Matched networks also have their properties rendered insensitive to absolute value changes in the components due to changes in the processing and temperature.

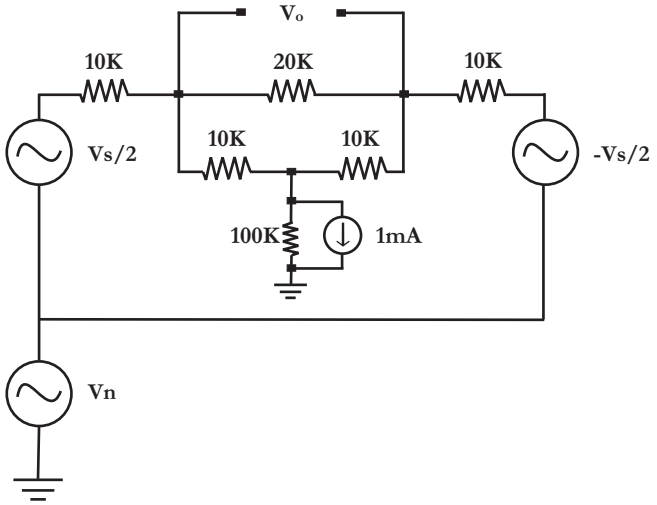
This concept can be understood by students with the following examples of passive-R network.
(a) For the symmetric network shown determine V_o



(b) For the same network determine Vo when the signal is differential.



The concept of superposition theorem and splitting any signal pair into common mode and differential mode part is illustrated in the next example. The concept of common mode input resistance and differential mode input resistance can be explained and evaluation of common mode rejection ratio can be carried out.



1. Using the concepts of superposition and symmetry compute Vo as a function of Vs and Vn.
2. Determine the common-mode rejection ratio for the network for the case where identical components have a tolerance of 10%.

a. The common-mode transfer ratio is given by Ac = Vo/Vn.
b. The differential-mode transfer ratio is given by Ad = Vo/Vs.
c. CMRR is defined as Ad/Ac.

The use of common-mode rejection of differential matched networks as a means to suppress noise and improving signal to noise ratio can be emphasized through such examples.

Imagine the power of using these ideas when you design your instrumentation or data acquisition systems and digital audio or video systems!!