Lpf transfer function

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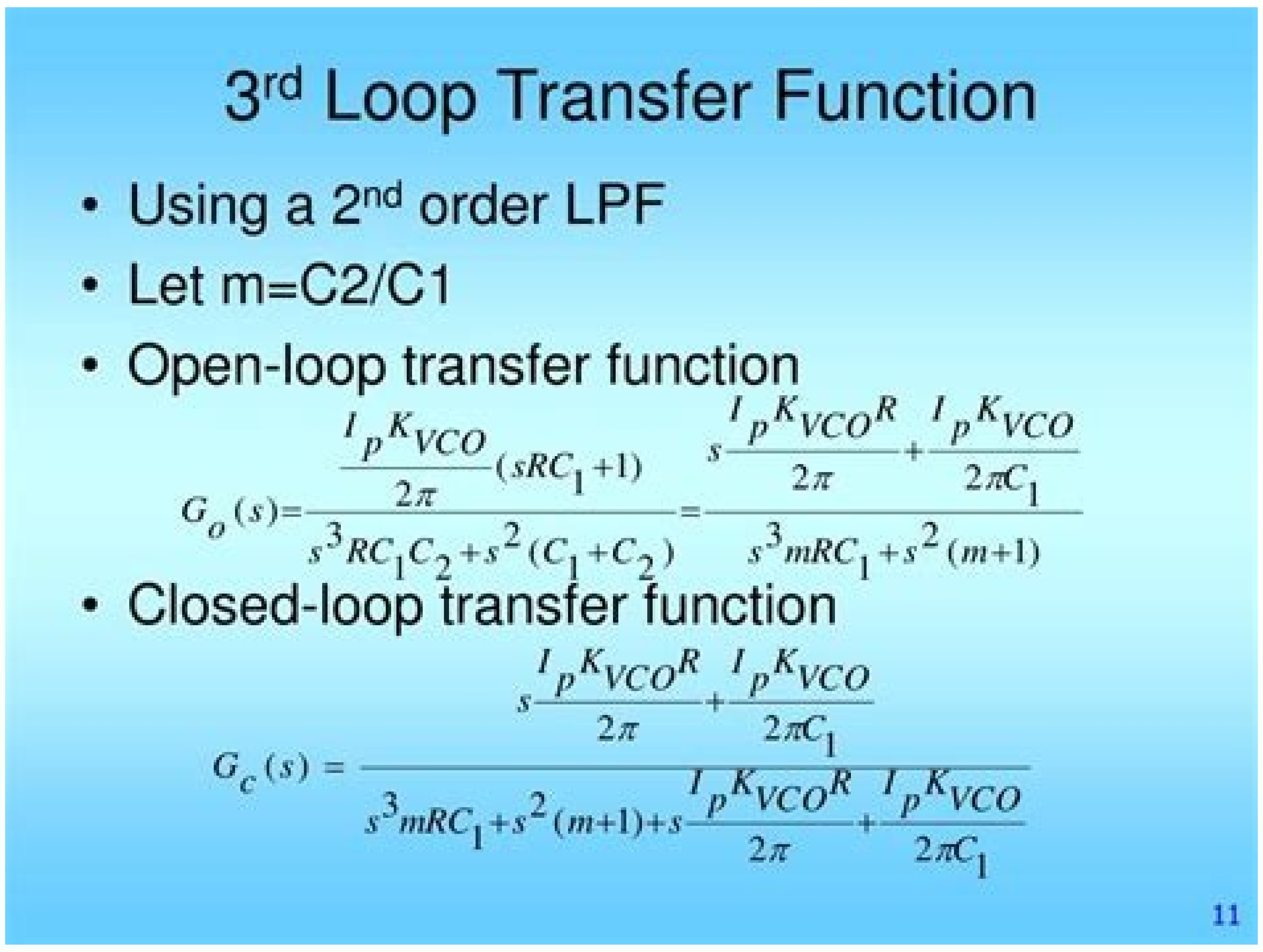

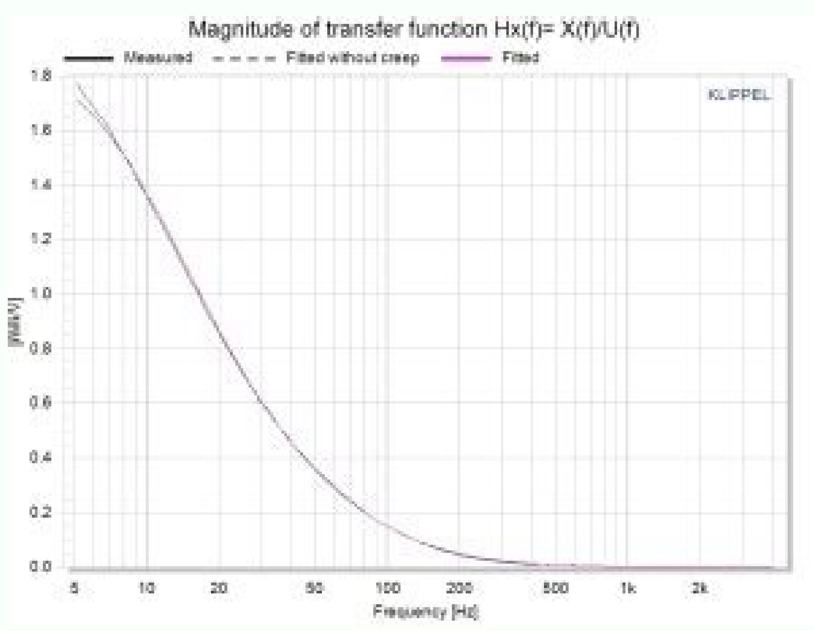

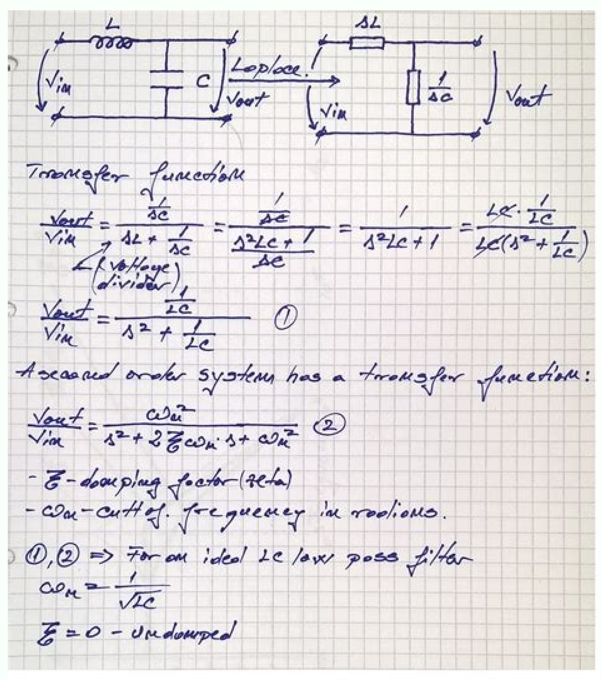

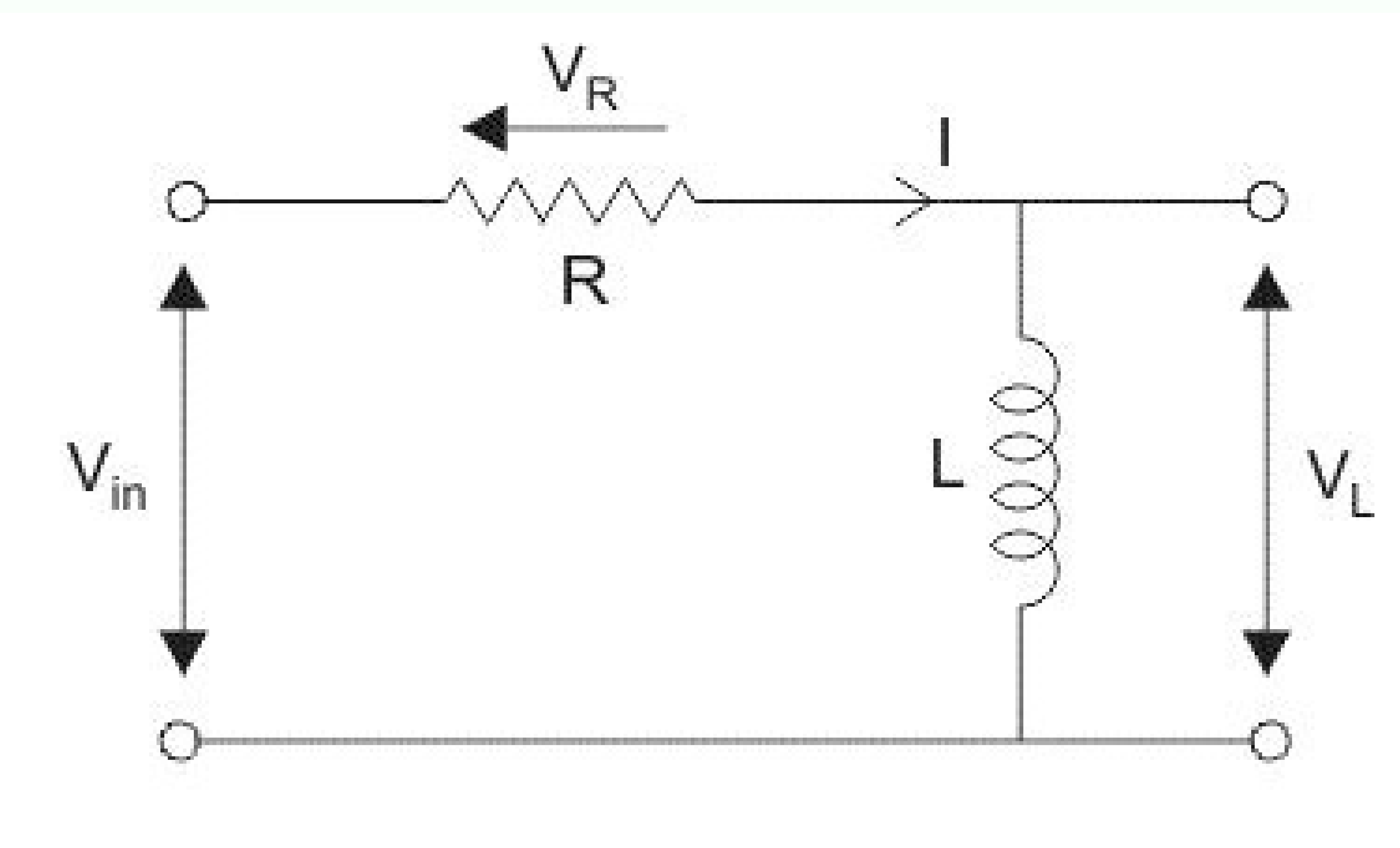

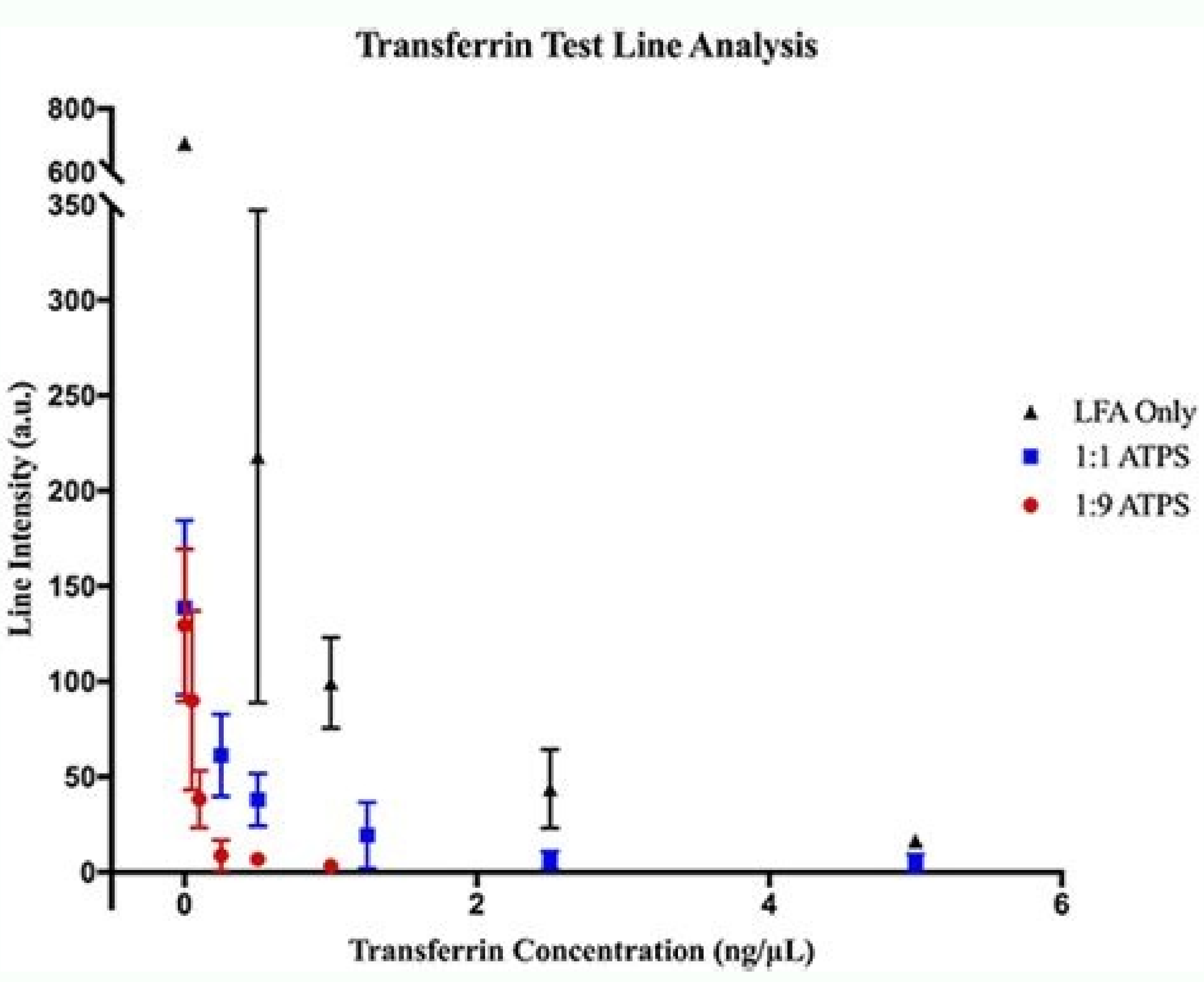

Passive high pass filter transfer function. Second order lpf transfer function. High-pass filter transfer function. First order lpf transfer function. Active high pass filter transfer function.

Go to EE494 Index Experiment | 1 | 2 | 3 | ECE Lab Home EE 494 Electrical Engineering Laboratory IV (Part B) Version 1.3 TUTORIAL: Introduction to Filter Design 1.1 Objectives 1.2 Equipment Needed 1.3 References 1.4 Background 1.5 Specifying Butterworth Filters 1.6 Specifying Chebyshev Filters 1.7 Conversion of Specifications 1.8 Examples of Filter Realizations 1.9 Student’s Filter Specification 1.1 Objectives In this experiment the student will become familiar with methods used to go from a filter specification to specifying the polynomial transfer function of the filter. Then the student will learn to translate the polynomial transfer function into a working filter design. 1.2 Equipment Needed A decent scientific calculator. A few μA741 integrated circuit operational amplifiers, resistors and capacitors and a prototyping board. 1.3 References Figure 1.1: A filter specification diagram with a sketch of a Butterworth response that exactly satisfies the specs. 1.4 Background The assignment of designing and building analog filters can be broken up into various tasks. We will assume that the given filter specification is presented in the form shown in figure 1.1. The interpretation of the diagram is the following: It is desired to build a low pass filter whose passband lies in the region 0 ≤ f ≤ f p. The transfer function | G(f) | is almost invariably given in units of dB. Within the passband, the magnitude of the transfer function may vary between zero and Gp. When it enters the stop band, the magnitude of the transfer function should decrease to Gs or less as the frequency fs is reached. A possible transfer function, in the form of the smooth curve, is shown in figure 1.1. We plan on realizing the filter using a linear analog-circuit. Such circuits have transfer functions whose magnitude squared is an even polynomial in the frequency variable f. Therefore the first step in the design process is to find a polynomial transfer-function that will satisfy the specifications. Many different well-known polynomial transfer-functions are used for approximating filter specifications. Because of time constraints, however, our attention will be confined entirely to Butterworth and Chebyshev polynomial realizations. They have the advantage of having over the years acquired extensive tabulations. But it must be understood at the outset that additional polynomial realizations exist, and that with each is associated a set of advantages and disadvantages which are discussed in the literature. We will now address the question of how to fulfill the specification of the filter by using Butterworth and Chebyshev transfer functions. Back to top EE494 Index 1.5 Specifying Butterworth Filters At the outset we observe that Butterworth filters have the magnitude characteristic given by (1.1) where n is the order of the filter and fc is the frequency at which the transfer function magnitude is reduced by 3 dB. This class of filters has a monotonically decreasing amplitude characteristic. It has no ripples in the passband, in contrast to Chebyshev and some other filters, and is consequently described as maximally flat. In order to fully specify the filter we need an expression for determining n as well as a method for computing the fc needed in (1.1). To reach this goal we substitute the filter specifications at fp and fs into (1.1) to obtain 1 + (fp / fc)2n = 10 -(Gp / 10) (1.2) 1 + (fs / fc)2n = 10 -(Gs / 10) (1.3) From the last two equations we readily get the two expressions (1.4) (1.5) Taking the ratio of the last two expressions we readily find that (1.6) The example which follows will illustrate the use of the above equations. Example 1: We wish to design a Butterworth filter satisfying Gp = -1 dB at fp = 3 kHz and Gs = - 25 dB at fs = 8 kHz. Substituting the specifications given into (1.6), we obtain the solution (1.7) We need an integer exceeding that given in (1.7), so we fix the value of n at 4. We now simply need to find the value of fc needed to finish specifying (1.1). Since n = 4 exceeds the value of n found in (1.7) we will have some extra latitude in choosing fc. To find fc we substitute n = 4 into (1.4) and (1.5) to obtain the two equations (1.8) (1.9) The last two equations produce the two results for fc, fc1 = 3.55 kHz (1.10) fc2 = 3.90 kHz (1.11) If we choose a value of fc somewhere in the range fc1

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