CHAPTER 1

INTRODUCTION

1.1 History Background

Most engineering situations are inherently nonlinear, and can be successfully linearized only for particular operating conditions which should be carefully specified and understood. Nonlinear effects, which are presented in some degree in all system, arise from imperfections in circuit elements such as transducers, from stiction, backlash and saturation.[1,2,3,4,5] The methods of harmonic analysis may be adapted for application to certain nonlinear problems and the analysis of systems employing time domain may also be made by several methods.[1,2,3,4,5] Describing function analysis,[2,3] which is an extension of steady state frequency response analysis, is used to investigate the stability of certain types of nonlinear systems. The phaseplane method,[1,2,3] which is the graphical method, has an appreciate degree of generality in time domain analysis. However this method is limitt to the second order system only, the higher order derivative causes the plotting of the trajectories in the space much difficulty.[3] The various methods to study the characteristics of nonlinear systems in time domain have been described by many authors [1,2,3] and most of those methods have disadvantages due to the use of differential equations which can be easily derived only when the systems are the first or second order. When the systems are of higher orders than the second order, the very few solutions are known according to difficulty and time consuming in analysis. Consequently, a simple graphical method for obtaining the frequency response of nonlinear systems has been investigated in order to save time and difficulty in the construction comparing to those of describing function approaches.

1.2 Some Typical Behavior Nonlinearities

The behavior of nonlinear system is complex, and in some cases can appear to be quite arbitary. However, certain patterns of behavior are commonly experienced, and well be summarized here for an easy reference.

Typically, the behavior of a nonlinear system will depend on the form of an input, on the size of the input, and on the initial state of the system when the input is introduced.

Some nonlinear systems develop a steady-state oscillation, which persists after the transient response to an input, such as a step, decay to zero. The oscillation is usually periodic, but not necessarily sinusoidal. This self-excited or natural oscillation is call limit cycle oscillation. If of very small amplitude, such as oscillation is not always harmful, and is classified as "noise".

Other nonlinear systems subjected to a sinusoidal input develop a multifrequency steadystate response. The frequencies involved can be less than the input frequency (subharmonics) or greater than it (superharmonics). This condition is referred to as harmonic oscillation.

1.3 Nonlinear System Analysis

The analysis of nonlinear systems can be mainly divided into the time domain and frequency domain techniques. For the time domain analysis, the system is governed by the differential equation. The numerical method may be employed to obtain the approximate solution. This solution is relatively crude and errors tend to accumulate during the step by step integration process.[2,3] The analysis may involve multidimeansional transforms and their inverse transform pairs which are suitable for certain type of nonlinear systems. For the frequency domain analysis, the describing function method can be used to analyze the nonlinear systems in a similar manner to the transfer function on the assumption that the system is stable so that the amplitudes of the harmonics are less than the amplitudes of the fundamental, the linear portion consists of a low-pass filter, so the harmonics are well attenuated and the approximation works quite well in practice. The graphical method suggested by Levinson, in the year of 1953,[4] for determining the frequency response of nonlinear system. However this method has some disadvantages because it requires quite a long time and it is difficult to construct the curves which are not in the simple forms.

1.4 Outline of the Work

The objective of this research may be summarized as :-

(a) Mathematical representation of a nonlinear system under investigated and the normalization of various circle curves will be described in chapter 2.

(b) The applications of this new graphical method for determining the frequency response of various types of nonlinear systems are given in chapter 3.

(c) The conclusions and discussions are described in chapter 4. Some suggestions and recommendation for future study are also presented.