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Introduction

The increasing demand in radio communications for channel space as well as the use of sophisticated navigation systems and data transmission has resulted in increased frequency stability requirements in many items of equipment. As a result, the demands on crystal oscillators have become more stringent. In many cases, it is no longer sufficient merely to use a crystal oscillator; now it is necessary to take measures to ensure that the crystal oscillator will possess a high degree of frequency stability. Designs of this type are often quite difficult for the engineer who has had little or no prior experience with crystal oscillators; consequently, much of the material in this book is directed to the individual who has a good background in circuit theory but who is not necessarily experienced with crystal oscillator design.

The book deals primarily with transistor oscillators, since nearly all precision oscillators at the present time use discrete transistors. The use of gate oscillators and clock oscillator integrated circuits is widespread in lower stability applications, and these are discussed in Chapter 7.

A practical treatment of quartz crystal resonators is presented in Chapter 5 which gives the designer a good working knowledge of the devices. In Chapter 6, the nonlinear properties of transistors are explored to enable prediction of the amplitude of oscillation and the harmonic content for various oscillators. Chapter 7 then brings together all the information already presented and presents the actual design equations for oscillators covering the entire frequency spectrum from several kHz to 150 MHz. It also includes over 20 tested circuits with component values.

Crystal oscillators, in general, are more critical than most electronic circuits. As such, it behooves the design engineer to take special precautions to ensure that his oscillator circuit will perform properly when produced in quantity. Chapter 8 consists of a discussion of several tests which should be conducted to determine with reasonable assurance whether the circuit will perform properly when produced in quantity.

Crystal ovens, discussed briefly in Chapter 9, are used almost exclusively to achieve stabilities better than 5×10^8. The treatment of ovens is limited primarily to a description of the basic techniques and what can be achieved, no attempt is made to give detailed design information.

The spectral purity of crystal oscillators may be an important consideration in some applications and, although not treated in this book, should not be overlooked. The reader is directed to numerous articles in the literature for designs of this type.

A unique system is presented in Chapter 10, whereby a microprocessor can be used to temperature-compensate a crystal oscillator. This system is compared with three other methods for temperature compensation. Chapter 10 also contains a thorough treatment of temperature compensation in general, which enables the average design engineer to accomplish successful compensation of semiprecision oscillators, improving the stability by as much as two orders of magnitude.

Many of the derivations required to develop the design equations are carried out in the appendices, but the conclusions are presented in the main text. This results in an easily readable volume with the details still available for those interested in probing deeper into the mechanics of the derivations and the assumptions made.