Foreword

Crystal oscillators have been in use now for well over 50 years–one of the first was built by W. G. Cady in 1921. Today, millions of them are made every year, covering a range of frequencies from a few Kilohertz to several hundred Megahertz and a range of stabilities from a fraction of one percent to a few parts in ten to the thirteenth, with most of them, by far, still in the range of several tens of parts per million.Their major application has long been the stabilization of frequencies in transmitters and receivers, and indeed, the utilization of the frequency spectrum would be in utter chaos, and the communication systems as we know them today unthinkable, without crystal oscillators.

With the need to accommodate ever increasing numbers of users in a limited spectrum space, this traditional application will continue to grow for the foreseeable future, and ever tighter tolerances will have to be met by an ever larger percentage of these devices.

Narrowing the channel spacing–with its concomitant requirements for increasingly more stable carrier frequencies–is but one of the alternatives to increase the number of potential users of the frequency spectrum. Subdividing the time during which a group of users has access to a given channel is another; and many modern radio transmission systems make use of this principle. Here again, the crystal oscillator plays a dominant role; not to control the carrier frequency, but to keep the time slots for the various users coordinated, that is, to serve as the clock rate generator of the systems clocks in transmitters and receivers. The demands on oscillator performance are often even more stringent in this application than for carrier stabilization alone.

The use of crystal oscillators as clock rate generators has seen a rate of growth in the recent past that is nothing short of explosive, with no end in sight yet, in applications that are quite unrelated to the communications field, such as in the quartz wrist watch and in the microprocessor. Other uses include reference standards in frequency counters and time interval meters, gauges for temperature and pressure, and instruments for the measurement of mass changes for scientific and environmental sensing purposes, to name just a few.

In short, the crystal oscillator is now more in demand than ever, and the need for improved performance in mass producible devices becomes more urgent with nearly every new application. An increasing number of engineers, therefore, find themselves confronted with the challenge of designing crystal oscillators with near optimum performance, as tailored to a specific application. Those new in the field are bound to discover very soon that there is no substitute for a considerable amount of hands-on experience. Rarely can a circuit reported on in the literature be used without modifications, and details, not discussed fully in the descriptions provided, are often found to be significant.

The possible combinations of circuit elements that make a viable oscillator are nearly limitless, and while most experienced designers have gravitated toward a few basic configurations, no one circuit, or even small group of circuits, has as yet evolved that is, in all details, universally suitable. Nor does it appear likely that this will happen in the foreseeable future, if for no other reason than because new active devices are continually being brought to market, with often significant advantages for use in oscillator circuits, but requiring different conditions for proper operation. The general principles of crystal oscillator design, however, remain.

The basic building blocks of a crystal oscillator are the feedback circuit containing the crystal unit; the amplifier containing one or more active devices; and circuitry or devices such as needed for modulation, temperature compensation or control, etc.

What is needed most by the circuit designer is a clear approach to understanding the interrelationship of the various circuit elements within each of these building blocks and of the blocks with one another. And this holds true whether the goal is an oscillator, hand-tailored in small quantities to achieve the highest performance possible, or mass produced and capable of meeting the specified requirements under worst case conditions. While such approaches do exist, their exposition in the literature is scarce. It is to fill this void that Mr. Frerking has written this book.

M. E. Frerking is surely one of the most accomplished and innovative practitioners of the art of crystal oscillator design, with extensive experience in the development of high performance oscillators for high volume use. In his book he shares with the reader the design techniques that he has found most useful and conveys a wealth of practical information that will be of immediate use to engineers who are faced with the challenge of designing a crystal oscillator for today's more demanding applications.

Mr. Frerking's book is a timely, and most welcome, major addition to the literature on crystal oscillators.

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