

Preface

Stepped-frequency radar sensors are attractive for various surface and subsurface sensing applications. Stepped-frequency systems transmit consecutive trains of continuous-wave signals at different frequencies that are separated by a fixed amount. The unique characteristic of stepped-frequency systems is, although they work as frequency-based systems, their final response is described in a time-domain quantity, namely “synthetic pulse,” which contains the information about targets. This unique “synthetic pulse” product enables stepped-frequency radar sensors to have some of the advantages of impulse-based ultra-wideband (UWB) systems, which operate completely in the time domain, such as ease in identification and characterization of adjacent targets. Specifically, stepped-frequency radar sensors have several major advantages. First, they have a very narrow instantaneous bandwidth at each frequency, resulting in less receiver’s noise figure and hence increased sensitivity and dynamic range. Second, their absolute RF operating bandwidth, on the other hand, can be very wide, leading to fine range resolution. Third, they can transmit high average power enabling long range or deep penetration. Fourth, it is possible to properly shape the transmitted spectrum by transmitting constituent signals with certain amplitudes and phases, helping improve the system’s performance and possibly compensate for inevitable effects due to system’s imperfection and operating environment. Stepped-frequency radar sensors find numerous applications for military, security, civilian, commerce, medicine, and healthcare.

This book presents the theory, analysis, and design of stepped-frequency radar sensors and their components. Specifically, it addresses the following main topics of stepped-frequency radar sensors: system analysis, transmitter design, receiver design, antenna design, and system integration and test. It also presents the development of two practical stepped-frequency radar sensors and their transmitters, receivers, antennas, signal processing, integrations, electrical tests, and sensing measurements, which serve as an effective way to demonstrate not only the analysis, design, test, and sensing applications of stepped-frequency radar sensors, but also the design of constituent components. Although the book is succinct,

the material is very much self-contained and contains practical, valuable, and sufficient information presented in such a way that allows readers with an undergraduate background in electrical engineering or physics, with some experiences or graduate courses in microwave circuits, to understand and design easily stepped-frequency radar sensors and their transmitters, receivers, and antennas for various sensing applications.

The book is useful for engineers, physicists, and graduate students who work in radar, sensor, and communication systems as well as those involved in the design of RF circuits and systems. It is our hope that the book can serve not only as a reference for the development of stepped-frequency systems and components, but also for possible generation of ideas that can benefit many existing sensing applications or be implemented for other new applications.

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Theory, Analysis and Design

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