Basic analysis and design procedures for optimizing transmission via meteor trails

by Richard Raymond Stone

A thesis submitted in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE in Electrical Engineering
Montana State University

Abstract:
Herein, analytical tools in the form of graphs and approximating formulae are developed for the Meteor Burst Communication System. Further, design (synthesis) procedures are developed which allow the MBCS designer to determine the parameter (e. g., bit rate, message duration, power levels) that give rise to a maximum average information rate within the constraints imposed on these parameters and/or the probability of error. Various modes of operation are defined and evaluated.

STATEMENT OF PERMISSION TO COPY

In presenting this thesis in partial fulfillment of the requirements for an advanced degree at Montana State University, I agree that the Library shall make it freely available for inspection. I further agree that permission for extensive copying of this thesis for scholarly purposes may be granted by my major professor, or in his absence, by the Director of Libraries. It is understood that any copying or publication of this thesis for financial gain shall not be allowed without my written permission.

Signature Richard R. Stone

Date Feb 18, 1977

BASIC ANALYSIS AND DESIGN PROCEDURES FOR OPTIMIZING TRANSMISSION VIA METEOR TRAILS

by

RICHARD RAYMOND STONE

A thesis submitted in partial fulfillment of the requirements for the degree

of

MASTER OF SCIENCE

in

Electrical Engineering

Approved:

Daniel N. March
Chairperson, Graduate Committee

Paul E. Uhlrich
Head, Major Department

Henry L. Parsons
Graduate Dean

MONTANA STATE UNIVERSITY
Bozeman, Montana

February, 1977

ACKKNOWLEDGMENTS

The author wishes to express his sincere gratitude to his adviser, Dr. D. N. March, who suggested that he pursue the area of Meteor Burst Communication System analysis and design, and for securing sponsorship from Boeing Company for the initial research leading to this thesis.

The author also would like to thank his wife for her typing and patience throughout the development of this thesis.

TABLE OF CONTENTS

LIST OF FIGURES

ABSTRACT

Herein, analytical tools in the form of graphs and approximating formulae are developed for the Meteor Burst Communication System. Further, design (synthesis) procedures are developed which allow the MBCS designer to determine the parameter (e. g., bit rate, message duration, power levels) that give rise to a maximum average information rate within the constraints imposed on these parameters and/or the probability of error. Various modes of operation are defined and evaluated.

CHAPTER I

INTRODUCTION

1.1 Historical Review

In the 1950's, it was experimentally determined that with only moderate power levels, VHF forward scatter off ionized meteor trails at high altitudes produced high signal-to-noise ratios at considerable distances.[5] And, it was determined that reciprocity existed between the communication terminals. Although the meteor trails occurred only intermittently and were short-lived, it was evident that they provided an ideal channel for low-rate remote data sampling. Such communication systems, assumed to be digital throughout, were called Meteor Burst Communication Systems (MBCS).

1.2 MBCS Operation

The MBCS is assumed to be a digital communication system that operates as follows in the forward scatter mode (see Figure 1.1). A base station transmits a continuous wave, VHF, interrogate signal that is received by a remote station when a properly oriented meteor trail forms between these stations. If the signal received at the remote station is above a given threshold, indicating a meteor trail that will provide a reasonably good forward scatter medium, messages are transmitted back to the base station via that meteor trail. The meteor trail disperses with time and gives rise to a signal of decaying strength at the base station. Hence, after some time, the remote station must stop transmitting. This constitutes a full cycle of MBCS operation.[4]

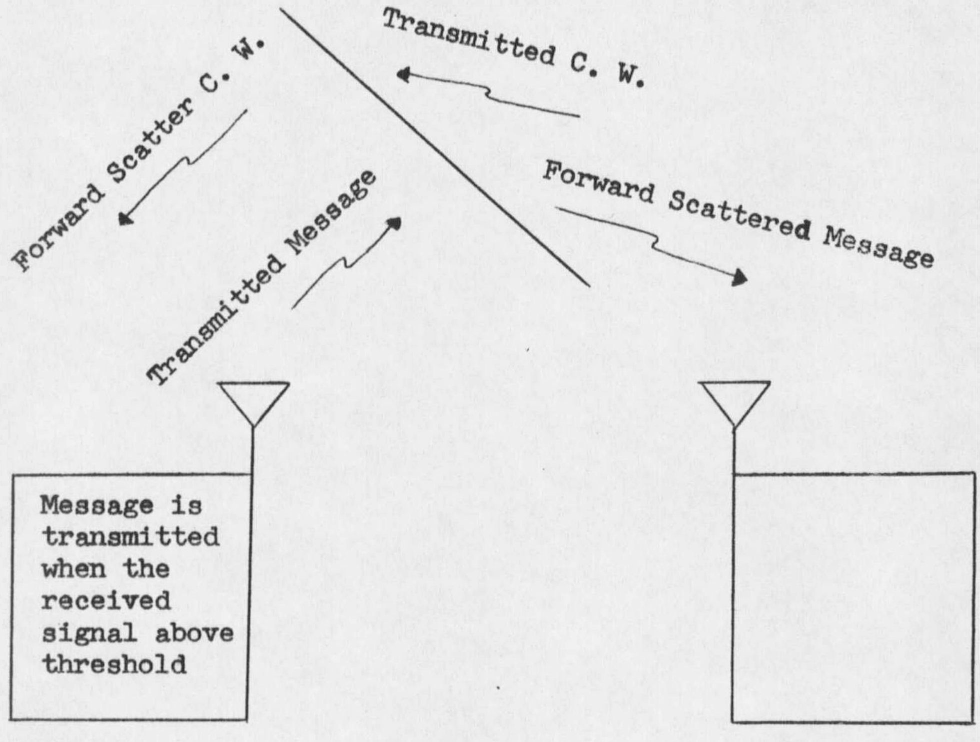

Figure 1.1
The Meteor Burst Communication System

1.3 Types of Meteor Trails

There are two types of meteor trails. They are the overdense and underdense meteor trails. Overdense meteor trails are infrequent compared to underdense meteor trails, and the signals reflected from such meteor trails are erratic in nature, and generally produce high error rates. As a result, simple error detection methods are adequate to reject the data received from transmissions during which the forward scatter medium is an overdense meteor trail. Hence, it is assumed that the forward scatter medium consists of only underdense meteor trails--simply called meteor trails in much of what follows.

1.4 Initializing MBCS Base Station Receiver

Underdense meteor trails are characterized by the fact that they cause reflected signals' strength to decay nearly exponentially, after a finite rise time, as shown in Figure 1.2. Prior to receiving the binary information sequence from the remote station via an underdense meteor trail, an initializing binary sequence is received at the base station. This initializing binary sequence serves several purposes. First, it acts as a delay that is of sufficient duration to allow most signals reflected from the underdense meteor trails to reach their peak values before the binary information sequence is received. Secondly, bit phase coherence of the receive clock is established at this time. And thirdly, any coding or other logic devices are zeroed at this time.