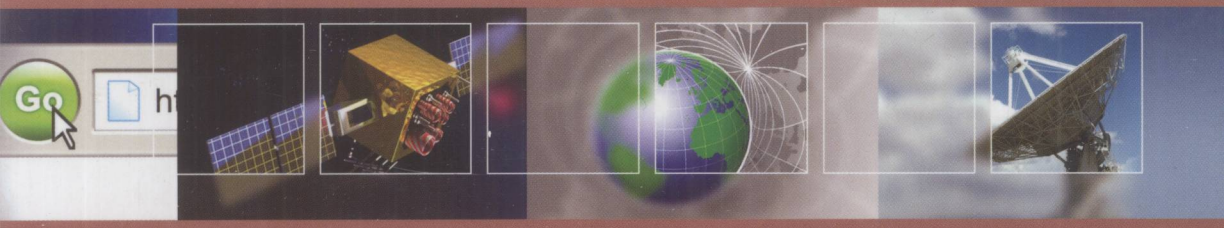
Louis J. Ippolito Jr.

Satellite Communications Systems Engineering

Atmospheric Effects, Satellite Link Design and System Performance



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Atmospheric Effects, Satellite Link Design and System Performance

Louis J. Ippolito, Jr.

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Satellite Communications Systems Engineering

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List of Acronyms

8ΦPSK	8-phase phase shift keying,

A

ACM	adaptive coded modulation
ACTS	Advanced Communications Technology Satellite
A/D	analog to digital converter
ADM	adaptive delta modulation
ADPCM	adaptive differential pulse code modulation
AGARD	Advisory Group for Aeronautical Research and Development (NATO)
AIAA	American Institute of Aeronautics and Astronautics
AM	amplitude modulation
AMI	alternate mark inversion
AMSS	aeronautical mobile satellite service
AOCS	Attitude and Orbit Control System
ATS-	Applications Technology Satellite-
AWGN	additive white Gaussian noise
Az	azimuth (angle)

B

BB	baseband
BER	bit error rate
BFSK	binary frequency shift keying
BO	backoff
BOL	beginning of life
BPF	band pass filter
BPSK	binary phase shift keying
BSS	broadcast satellite service

C

CBR	carrier and bit-timing recovery
CDC	coordination and delay channel
CDF	cumulative distribution function

CDMA	code division multiple access
CEPIT	Coordinamento Esperimento Propagazione Italsat
CEPT	European Conference of Postal and Telecommunications Administrations
C/I	carrier to interference ratio
CLW	cloud liquid water
cm	centimeters
C/N	carrier-to-noise ratio
C/No	carrier-to-noise density
COMSAT	Communications Satellite Corporation
CONUS	continental United States
CPA	copolar attenuation
CRC	cyclic redundancy check
CSC	common signaling channel
CTS	Communications Technology Satellite
CVSD	continuously variable slope delta modulation

D

D.C.	down converter
DA	demand assignment
DAH	Dissanayake, Allnutt, and Haidara (rain attenuation model)
DAMA	demand assigned multiple access
dB	decibel
dBHz	decibel-Hz
dbi	decibels above isotropic
dBK	decibel-Kelvin
dBm	decibel-milliwatts
dBW	decibel-watt
DEM	demodulator
DOS	United States Department of State
DS	digital signaling (also known as T-carrier TDM signaling)
DSB/SC	double sideband suppressed carrier
DSI	digital speech interpolation
DS-SS	direct sequence spread spectrum

E

Eb/No	energy per bit to noise density
EHF	extremely high frequency
EIRP	effective isotropic radiated power
El	elevation angle
EOL	end of life
erf	error function
erfc	complimentary error function
ERS	empirical roadside shadowing
ES	earth station
ESA	European Space Agency
E-W	east-west station keeping

F

FA	fixed access
FCC	Federal Communications Commission
FDM	frequency division multiplex
FDMA	frequency division multiple access
FEC	forward error correction
FET	field effect transistor
FH-SS	frequency hopping spread spectrum
FM	frequency modulation
FSK	frequency shift keying
FSS	fixed satellite service
FT	frequency translation transponder

G

GEO	geostationary satellite orbits
GHz	gigahertz
GSO	geosynchronous satellite
G/T,	receiver figure of merit

H

HEO	high elliptical earth orbit, high earth orbit
HEW	Health Education Experiment
HF	high frequency
HP	horizontal polarization
hPa	hectopascal (unit for air pressure, equal to 1 cm H_2O)
HPA	high power amplifier
Hz	hertz

I

IEE	Institute of Electrical Engineers
IEEE	Institute of Electrical and Electronics Engineers
IF	intermediate frequency
INTELSAT	International Satellite Organization
ISI	intersymbol interference
ITU	International Telecommunications Union
ITU-D	International Telecommunications Union, Development Sector
ITU-R	International Telecommunications Union, Radiocommunications Sector
ITU-T	International Telecommunications Union, Telecommunications Standards Sector

J

K

K	degrees Kelvin
Kbps	kilobits per second
kg	kilogram

KHz	kilohertz
km	kilometers

L

LEO	low earth orbit
LF	low-frequency
LHCP	left hand circular polarization
LMSS	land mobile satellite service
LNA	low noise amplifier
LNB	low noise block
LO	local oscillator
LPF	low pass filter

M

m	meters
MA	multiple access
MAC	medium access control
Mbps	megabits per second
MCPC	multiple channel per carrier
MEO	medium earth orbit
MF	medium frequency
MF-TDMA	multi-frequency time division multiple access
MHz	megahertz
MKF	street masking function
MMSS	maritime mobile satellite service
MOD	modulator
MODEM	modulator/demodulator
MSK	minimum shift keying
MSS	mobile satellite, service
MUX	multiplexer

N

NASA	National Aeronautics and Space Administration
NF	noise figure (or noise factor)
NGSO	non geosynchronous (or geostationary) satellite orbits
NIC	nearly instantaneous companding
NRZ	non return to zero
N-S	north-south station keeping
NTIA	National Telecommunications and Information Agency
NTSC	National Television System Committee

O

OBP	on-board processing transponder
OFDM	orthogonal frequency division multiplexing
OOK	on/off keying

P

PA	pre-assigned access
PAL	phase alternation line
PAM	pulse amplitude modulation
PCM	pulse code modulation
PFD	power flux density
PLACE	Position Location and Aircraft Communication Experiment
PN	pseudorandom sequence
PSK	phase shift keying
PSTN	public switched telephone network

Q

QAM	quadrature amplitude modulation
QPSK	quadrature phase shift keying

R

REC	receiver
RF	radio frequency
RFI	radio frequency interference
RHCP	right hand circular polarization
RZ	return to zero

S

SC	service channel
SCORE	Signal Communications Orbiting Relay Experiment
SCPC	single channel per carrier
SDMA	space division multiple access
SECAM	SEquential Couleur Avec Memoire
SGN	satellite news gathering
SHF	super high frequency
SITE	satellite instructional television experiment
S/N	signal-to-noise ratio
SS	subsatellite point
SS/TDMA	time division multiple access, satellite switched
SSB/SC	single sideband suppressed carrier
SSPA	solid state amplifier
SYNC	synchronization

T

TDM	time division multiplex(ing)
TDMA	time division multiple access
TDRS	Tracking and Data Relay Satellite
TEC	total electron content
T-R	transmitter-receiver
TRANS	transmitter
TRUST	Television Relay Using Small Terminals

TT&C	tracking, telemetry and command
TTC&M	tracking, telemetry, command and monitoring
TTY	teletype
TWT	traveling wave tube
TWTA	traveling wave tube amplifier

U

UHF	ultra high frequency
USSR	Union of Soviet Socialist Republics
UW	unique word

V

VA	voice activation (factor)
VF	voice frequency (channel)
VHF	very high frequency
VLF	very low frequency
VOW	voice order wire
VP	vertical polarization
VPI&SU	Virginia Polytechnic Institute and State University
VSAT	very small antenna (aperture) terminal

W

WVD	water vapor density

X

XPD	cross-polarization discrimination

Y

Z

Preface

The book is written for those concerned with the design and performance of satellite communications systems employed in fixed point-to-point, broadcasting, mobile, radio-navigation, data-relay, computer communications, and related satellite-based applications. The recent rapid growth in satellite communications has created a need for accurate information on both satellite communications systems engineering and the impact of atmospheric effects on satellite link design and system performance. This book addresses that need for the first time in a single comprehensive source.

Significant progress has been made in the last decade in the understanding and modeling of propagation effects on radiowave propagation in the bands used for satellite communications, including extensive direct measurements and evaluation utilizing orbiting satellites. This book provides a single source for a comprehensive description and analysis of all the atmospheric effects of concern for today's satellite systems and the tools necessary to design the links and evaluate system performance. Many of the tools and calculations are provided in a 'handbook' form, with step-by-step procedures and all necessary algorithms are in one place to allow direct calculations without the need to consult other material.

The book provides the latest information on communications satellite link design and performance from the practicing engineer perspective – concise descriptions, specific procedures, and comprehensive solutions. I focus on the satellite free-space link as the primary element in the design and performance for satellite communications. This focus recognizes and includes the importance of free-space considerations such as atmospheric effects, frequency of operation, and adaptive mitigation techniques.

The reader can enter the book from at least three perspectives:

- for basic information on satellite systems and related technologies, with minimum theoretical developments and practical, useable, up-to-date information;
- as a satellite link design handbook, with extensive examples, step-by-step procedures, and the latest applications oriented solutions;
- as a textbook for a graduate level course on satellite communications systems – the book includes problems at the end of each chapter and a solutions manual for the instructor.

Unlike many other books on satellite communications, this book does not bog down the reader in specialized, regional technologies and hardware dependent developments that have limited general interest and a short lifetime. The intent of the author is to keep the book relevant for the entire global wireless community by focusing on the important basic principles that are unique and timeless to satellite-based communications delivery systems.

I would like to acknowledge the contributions of the many individuals and organizations whose work and efforts are reflected and referenced in this book. I have had the privilege of knowing and working with many of these researchers, some pioneers in the field of satellite communications, through my long affiliations with NASA, the ITU, and other organizations. The ideas and concepts that led to the development of this book were honed and enhanced through extensive discussions and interchange of ideas with many of the original developers of the technologies and processes covered in the book.

Finally, I gratefully acknowledge the support and encouragement of my wife Sandi who kept me focused on the project and whose patience I could always count on. This book is dedicated to Sandi, and to our children Karen, Rusty, Ted, and Cathie.

Louis J. Ippolito

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