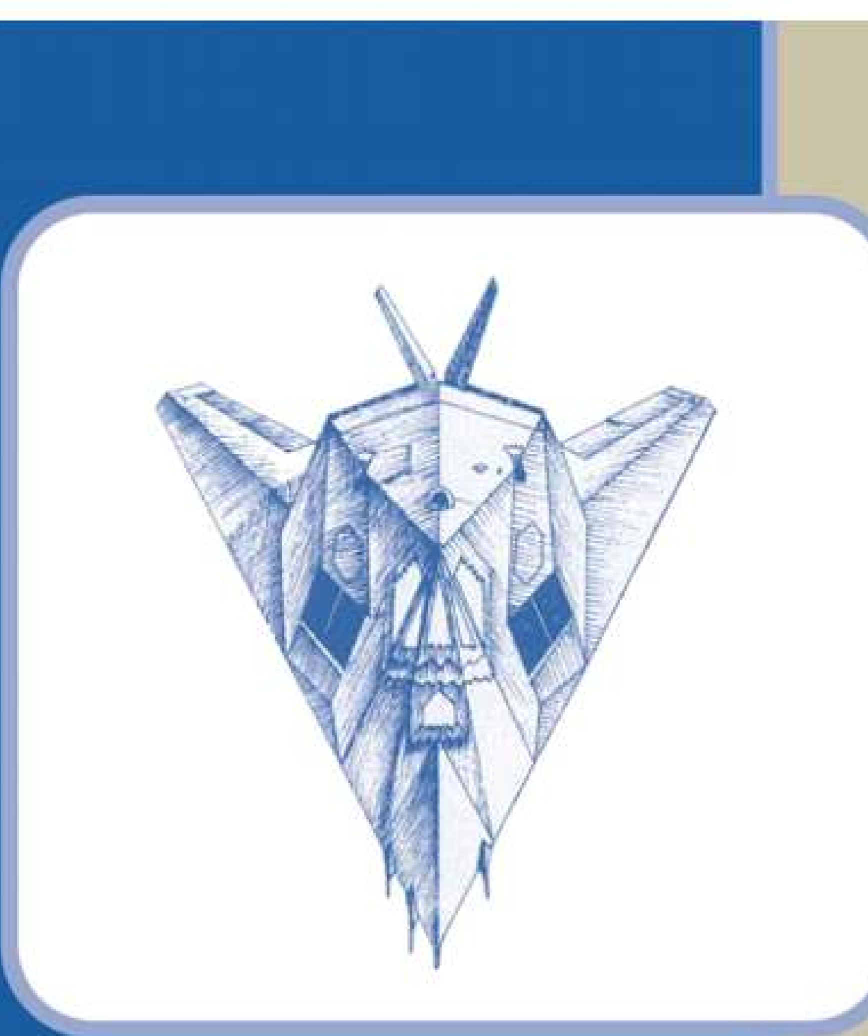
AIAA Education Series



ROBERT E. BALL

THE FUNDAMENTALS OF AIRCRAFT COMBAT SURVIVABILITY ANALYSIS AND DESIGN, SECOND EDITION

AIAA
Education Series
JOSEPH A. SCHETZ
EDITOR-IN-CHIEF

Book Navigation

ISBN: 978-1-56347-582-5
Book DOI: 10.2514/9781563475825
Chapter DOI: 10.2514/5.9781563475825.0202.0232

Home > Book Info

The Fundamentals of Aircraft Combat Survivability: Analysis and Design
Robert E. Ball

Tools
Zoom: 87 (%) Go Page: 356 Go rain Go

3.6.2.5 Propagation of radar signals through the atmosphere.

Learning Objective 3.6.14 Determine the attenuation of a radar signal as it propagates through the atmosphere.

Radar signals are attenuated by the oxygen and water vapor in the Earth's atmosphere. The attenuation becomes significant at frequencies above 10 GHz. The attenuation over a distance R can be expressed in the form $\exp(-R\alpha)$, where α is the rate of attenuation per unit distance. Converting the attenuation to a dB/km format, the approximate values of attenuation in terms of dB/km for a particular atmospheric condition are approximately −0.006 dB/km at 3 GHz, −0.01 dB/km at 10 GHz, and −0.07 dB/km at 30 GHz.[42] The corresponding attenuation over a distance of 100 km is −0.6, −1.0, and −7 dB.

Precipitation in the atmosphere in the form of rain, snow, and fog can significantly attenuate radar signals as well as contribute to background clutter. Generally, the higher the radar frequency, the more attenuation. The rate of attenuation for both a moderate rain and a heavy fog is approximately 0.1 dB/km for a 10 GHz radar signal. Consequently, the signal will be attenuated by 10 dB after traveling 100 km in a moderate rain or heavy fog.[43]

Go to Problems 3.6.43 to 3.6.44.

3.6.2.6 Surveillance and weapon control radar descriptions. Some of the attributes of effective air defense radars are all-weather capability, early and reliable detection (few false alarms) particularly for low-altitude targets, discrimination (the ability to detect and track a target in the presence of a high clutter environment), accurate target tracking, rapid automatic target acquisition, and countermeasures immunity. Table 3.13 lists estimated values for some of the major parameters of surveillance and weapon control radars, Example 3.8 contains the computations for several of the important radar parameters, and Refs. 44 and 45 contain descriptions of some current radar systems. Data on radar and radar systems is available online at http://www.aeronautics.ru/radru.htm, http://www.fas.org/man/dod-101/sys/ship/weaps/an-sps-49.htm, http://www.acronet.net/~target/products/misc/AN_SPS-55.html, http://www.periscopeone.com/demo/weapons/sensors/grdradar/index.html, http://webhome.idirect.com/~jproc/sari/sarintro.

Table 3.13 Estimated values for surveillance and weapon control radar parameters

Parameter	Surveillance	Weapon control
Power P_r	≥250–1000s kW	5–250 kW
Frequency f	VHF, UHF, L and S	S, C, X, K_u, K
Pulse width τ	5–10,000 μs	0.1–5 μs
Pulse repetition frequency	200–1,000 PPS	1,000–10,000 PPS
Beamwidth	1–10 deg	less than 1 to 2 deg

152,4 x 228,6 mm
Zoom: 87 (%) Go Page: 356 Go

Book Navigation
ISBN: 978-1-56347-582-5
Book DOI: 10.2514/9781563475825
Chapter DOI: 10.2514/5.9781563475825.0202.0232
Book Info
Front Cover
Title
Copyright
Foreword
Foreword to the Previous Edition
Table of Contents
Preface
Preface to the Previous Edition
Acknowledgment
Acknowledgment to the Previous Edition
Prologue—A Sense of Perspective
Acronyms
First Page
Chapter Links >>
Add Book to Cart
Add Chapters to Cart
Add to Wish List
Add to Your Website
Back to Search Results
Related Content
BOOKMARK

Home > Missions Threats and Threat Effects

The Fundamentals of Aircraft Combat Survivability: Analysis and Design
Robert E. Ball

Tools
Zoom: 87 (%) Go Page: 357 Go rain Go

html, http://www.army-technology.com/contractors/fire/daimler_benz/, http://www.naval-technology.com/contractors/weapon_control/thates5/index.html, http://www.naval-technology.com/contractors/data_management/israel_aircraft/index.html, http://www.milparade.com/1999/35/042.htm, http://ewhdbks.mugu.navy.mil/, and http://www.jedonline.com/.

Example 3.8 Determination of Several Radar Parameters

An MTI weapon control radar system has a parabolic dish antenna with a 1-m diameter, a uniform feed horn, and an efficiency of 90%. The signal is vertically polarized. Given the following parameters, determine the radar wavelength, the antenna gain, the beamwidth, the maximum unambiguous range, and the target resolution distance:

$$P_r = 200\,\text{kW} \quad f = 9\,\text{GHz (X band)}$$
$$\tau = 0.5\,\mu\text{s} \quad \text{PRF} = 2000\,\text{PPS}$$

The wavelength is given by Eq. (3.17):

$$\lambda = c/f = (300\,\text{m}/\mu\text{s})(10^6\,\mu\text{s/s})/(9\cdot 10^9\,\text{Hz}) = 0.0333\,\text{m} = 3.33\,\text{cm}$$

According to Eq. (3.23), the gain of the antenna is

$$G_r = 4\pi\rho A/\lambda^2 = 4\pi\cdot 0.9[\pi\cdot(1\,\text{m})^2/4]/(0.0333\,\text{m})^2 = 8{,}010 \text{ or } 39.0\,\text{dB}$$

The beamwidth for the parabolic dish antenna is

$$\text{Beamwidth (in degrees)} = b\lambda/D = 50(0.0333\,\text{m})/(1\,\text{m}) = 1.67\,\text{deg}$$

according to Eq. (3.24).

The maximum unambiguous range is given by Eq. (3.18b). Using the fact PRI = 1/PRF results in

$$R_u = c(\text{PRI})/2 = c/(2\text{PRF}) = (3\cdot 10^8\,\text{m/s})/(2\cdot 2000\,\text{PPS}) = 75\,\text{km}$$

The range resolution of this radar is given by Eq. (3.19),

$$\Delta R = c\tau/2 = (300\,\text{m}/\mu\text{s})(0.5\,\mu\text{s})/2 = 75\,\text{m}$$

Suppose an aircraft approaches this radar at 200 m/s. What is the Doppler shift f_d?

Rearranging Eq. (3.21c) to solve for f_d leads to

$$f_d = 2V_r/\lambda = 2(200\,\text{m/s})/(0.0333\,\text{m}) = 12.0\,\text{KHz}$$

Will the velocity be ambiguous, and what are the blind speeds?

152,4 x 228,6 mm
Zoom: 87 (%) Go Page: 357 Go

Book Navigation
ISBN: 978-1-56347-582-5
Book DOI: 10.2514/9781563475825
Chapter DOI: 10.2514/5.9781563475825.0202.0232
Book Info
Front Cover
Title
Copyright
Foreword
Foreword to the Previous Edition
Table of Contents
Preface
Preface to the Previous Edition
Acknowledgment
Acknowledgment to the Previous Edition
Prologue—A Sense of Perspective
Acronyms
First Page
Chapter Links >>
Add Book to Cart
Add Chapters to Cart
Add to Wish List
Add to Your Website
Back to Search Results
Related Content
BOOKMARK
Home > Missions Threats and Threat Effects
The Fundamentals of Aircraft Combat Survivability: Analysis and Design
Robert E. Ball

Tools
Zoom: 87 (%) Go Page: 358 Go rain Go

AIAA Purchased from American Institute of Aeronautics and Astronautics

According to Eq. (3.22),

$$(f_d)_{\max} \le 1/\text{PRI} = \text{PRF} = 2\,\text{KHz}$$

Hence, $f_d \ge (f_d)_{\max}$, so the velocity is ambiguous. According to Eq. (3.21c), with $f_d = n\text{PRF}$ the blind speeds are

$$\text{Blind speeds} = V_r = \lambda(n\text{PRF})/2 = (0.0333\,\text{m})(2{,}000n\,\text{PPS})/2$$
$$= 33.3,\ 66.6, \ldots 200,\ \text{etc. m/s}$$

Because the design target velocity is equal to one of the blind speeds, the use of staggered PRFs is recommended.

3.6.3 Infrared

Learning Objective 3.6.15 Describe the IR portion of the EM spectrum.

Infrared radiation, like radar, is a band of the electromagnetic spectrum. The IR band lies within the optical band and encompasses wavelengths from 0.7 to 1000 μm. Radiation in this band is referred to as heat or thermal radiation. The IR band has been subdivided into many different subbands by various authors and organizations, and there is no standard. Here, the IR band is subdivided into the shortwave (SWIR) or near (1 to 3 μm) band, the midwave (MWIR) or middle (3 to 5 μm) band, the longwave (LWIR) (8 to 16 μm) band, and the far or extreme (16 to 1000 μm) band.[46] The locations of these IR subbands within the optical band are shown in Fig. 3.62 (Note 73).

Infrared radiation is used by air defense thermal imaging (TI) systems, by infrared search and track (IRST) systems, and by missile guidance systems. The thermal or infrared imaging systems, such as the IR camera, produce a two-dimensional picture or image of the radiation from a scene viewed by an optical device. The radiation sensed is usually in either the MWIR band or the LWIR band. (http://www.x20.org/thermal/.) The IRST is used by the air defense forces to search, detect, and track aircraft or missiles based upon their IR signature, typically in the LWIR band. The IRST can be surface-based or carried by enemy aircraft. (http://www.optronics.co.uk/irst.htm.)

Infrared systems can be used in the guidance of missiles that employ command guidance, beam rider guidance, or passive homing. Missiles with command guidance can carry an IR beacon in the tail. The beacon is passively tracked by an IR sensor in the target tracking device while an operator attempts to track the aircraft, usually with the aid of either direct-view optics or electro-optics. The tracking system notes the difference in the target and missile positions and generates the

152,4 x 228,6 mm
Zoom: 87 (%) Go Page: 358 Go