NEWNES

Radio and RF Engineering

POCKET BOOK

STEVE WINDER & JOE CARR

THIRD EDITION

Newnes Radio and RF Engineering
Pocket Book

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Newnes Radio and RF Engineering Pocket Book

3rd edition

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Joe Carr

Newnes

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Preface to second edition

This edition of the *Newnes Radio and RF Engineer's Pocket Book* is something special. It is a compendium of information of use to engineers and technologists who are engaged in radio and RF engineering. It has been updated to reflect the changing interests of those communities, and reflects a view of the technology like no other. It is packed with information!

This whole series of books is rather amazing with regard to the range and quality of the information they provide, and this book is no different. It covers topics as diverse as circuit symbols and the abbreviations used for transistors, as well as more complex things as satellite communications and television channels for multiple countries in the English speaking world. It is a truly amazing work.

We hope that you will refer to this book frequently, and will enjoy it as much as we did in preparing it.

John Davies
Joseph J. Carr

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Preface to third edition

This, the third edition of the *Newnes Radio and RF Engineering Pocket Book* has been prepared with a tinge of sadness. Joe Carr, who edited the second edition, has died since the last edition was published. Although I did not know Joe personally, his prolific writing over recent years has impressed me. His was a hard act to follow.

I have updated this book to be more international. Thus the long tables giving details of British television transmitters have been removed (they are available on the Web). Details of the European E1 multiplexing system have been supplemented by a description of the US and Japanese T1 system. There are many more general updates included throughout.

Steve Winder

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1 Propagation of radio waves

1.1 Frequency and wavelength

There is a fixed relationship between the frequency and the wavelength, which is the distance between identical points on two adjacent waves (*Figure 1.1*), of any type of wave: sound (pressure), electromagnetic (radio) and light. The type of wave and the speed at which the wavefront travels through the medium determines the relationship. The speed of propagation is slower in higher density media.

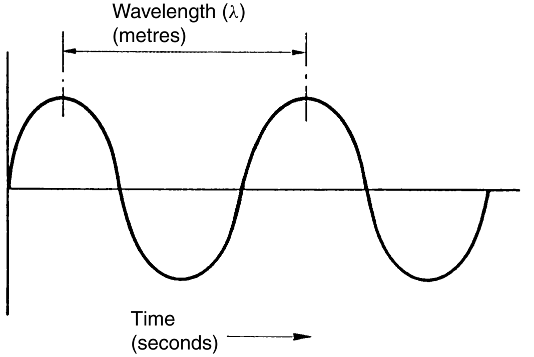

Figure 1.1 Frequency and wavelength

Sound waves travel more slowly than radio and light waves which, in free space, travel at the same speed, approximately 3×10^8 metres per second, and the relationship between the frequency and wavelength of a radio wave is given by:

$$\lambda = \frac{3 \times 10^8}{f} \text{ metres}$$

where λ is the wavelength and f is the frequency in hertz (Hz).

1.2 The radio frequency spectrum

The electromagnetic wave spectrum is shown in *Figure 1.2*: the part usable for radio communication ranges from below 10 kHz to over 100 GHz.

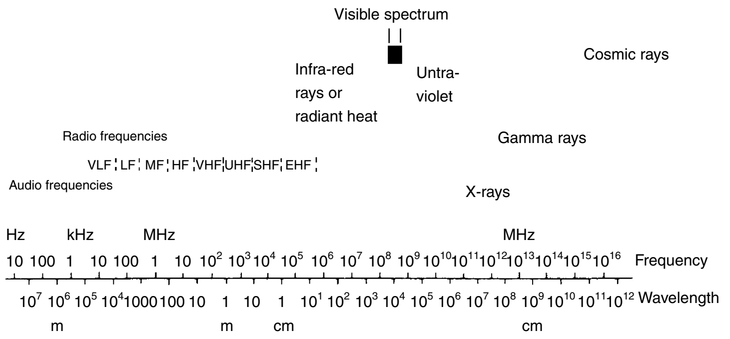

Figure 1.2 The electromagnetic wave spectrum

The radio spectrum is divided into bands and the designation of the bands, their principal use and method of propagation is shown in *Table 1.1*. Waves of different frequencies behave differently and this, along with the amount of spectrum available in terms of radio communication channels in each band, governs their use.

Table 1.1 Use of radio frequencies

Frequency band	*Designation, use and propagation*
3–30 kHz	Very low frequency (VLF). Worldwide and long distance communications. Navigation. Submarine communications. Surface wave.
30–300 kHz	Low frequency (LF). Long distance communications, time and frequency standard stations, long-wave broadcasting. Ground wave.
300–3000 kHz	Medium frequency (MF) or medium wave (MW). Medium-wave local and regional broadcasting. Marine communications. Ground wave.
3–30 MHz	High frequency (HF). 'Short-wave' bands. Long distance communications and short-wave broadcasting. Ionospheric sky wave.
30–300 MHz	Very high frequency (VHF). Short range and mobile communications, television and FM broadcasting. Sound broadcasting. Space wave.
300–3000 MHz	Ultra high frequency (UHF). Short range and mobile communications. Television broadcasting. Point-to-point links. Space wave. Note: The usual practice in the USA is to designate 300–1000 MHz as 'UHF' and above 1000 MHz as 'microwaves'.
3–30 GHz	Microwave or super high frequency (SHF). Point-to-point links, radar, satellite communications. Space wave.
Above 30 GHz	Extra high frequency (EHF). Inter-satellite and micro-cellular radio-telephone. Space wave.

1.3 The isotropic radiator

A starting point for considering the propagation of radio- or lightwaves is the isotropic radiator, an imaginary point source radiating equally in all directions in free space. Such a radiator placed at the centre of a sphere illuminates equally the complete surface of the sphere. As the surface area of a sphere is given by $4\pi r^2$ where r is the radius of the sphere, the brilliance of illumination at any point on the surface varies inversely with the distance from the radiator. In radio terms, the power density at distance from the source is given by:

$$P_{\rm d} = \frac{P_{\rm t}}{4\pi r^2}$$

where $P_{\rm t}$ = transmitted power.

1.4 Formation of radio waves

Radio waves are electromagnetic. They contain both electric and magnetic fields at right angles to each other and also at right angles to the direction of propagation. An alternating current flowing in a conductor produces an alternating magnetic field surrounding it and an alternating voltage gradient – an electric field – along the length of the conductor. The fields combine to radiate from the conductor as in *Figure 1.3*.

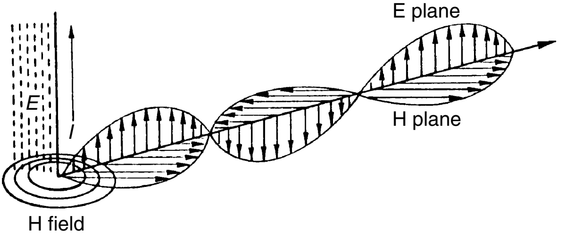

Figure 1.3 Formation of electromagnetic wave

The plane of the electric field is referred to as the E plane and that of the magnetic field as the H plane. The two fields are equivalent to the voltage and current in a wired circuit. They are measured in similar terms, volts per metre and amperes per metre, and the medium through