

The Art Of Electronics - 2nd Edition

Paul Horowitz HARVARD UNIVERSITY

Winfield Hill ROWLAND INSTITUTE FOR SCIENCE, CAMBRIDGE, MASSACHUSETTS

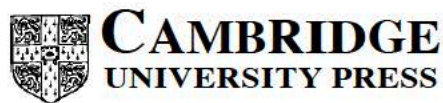


**Exhibit
2016**

Andrew Wolfe, Ph.D.

Published by the Press Syndicate of the University of Cambridge
The Pitt Building, Trumpington Street, Cambridge CB2 1RP
40 West 20th Street, New York, NY 10011-4211, USA
10 Stamford Road, Oakleigh, Melbourne 3166, Australia

© Cambridge University Press 1980, 1989

First published 1980

Second edition 1989

Reprinted 1990 (twice), 1991, 1993, 1994

Printed in the United States of America

Library of Congress Cataloguing-in-Publication Data is available.

A catalogue record for this book is available from the British Library.

ISBN 0-521-37095-7 hardback

relatively narrow slice of spectrum (perhaps 50–100Hz), whereas something like a television picture requires several megahertz. For completeness it should be pointed out that more information can be sent on a channel of given bandwidth if there is sufficiently high signal/noise ratio (SNR). Such "frequency compression" takes advantage of the fact that "channel capacity" equals bandwidth times $\log_2(1 + \text{SNR})$.

13.15 Amplitude modulation

Let's begin with the simplest form of modulation (AM), taking a look at its frequency spectrum and methods of detection. Imagine a simple carrier, $\cos \omega_c t$, varied in amplitude by a modulating signal of much lower frequency, $\cos \omega_m t$, in the following way:

$$\text{signal} = (1 + m \cos \omega_m t) \cos \omega_c t$$

with m , the "modulation index," less than or equal to 1. Expanding the product, you get

$$\begin{aligned} \text{signal} = & \cos \omega_c t + \frac{1}{2} m \cos(\omega_c + \omega_m) t \\ & + \frac{1}{2} m \cos(\omega_c - \omega_m) t \end{aligned}$$

i.e., the modulated carrier has power at frequency ω_c and at frequencies on either side ω_m away. Figure 13.37 shows the signal and its spectrum. In this case the modulation (m) is 50%, and the two "sidebands" each contain $\frac{1}{16}$ of the power contained in the carrier.

If the modulating signal is some complex waveform $[f(t)]$, like speech, the amplitude-modulated waveform is given by

$$\text{signal} = [A + f(t)] \cos \omega_c t$$

with the constant A large enough so that $A + f(t)$ is never negative. The resulting spectrum simply appears as symmetrical sidebands around the carrier (Fig. 13.38).

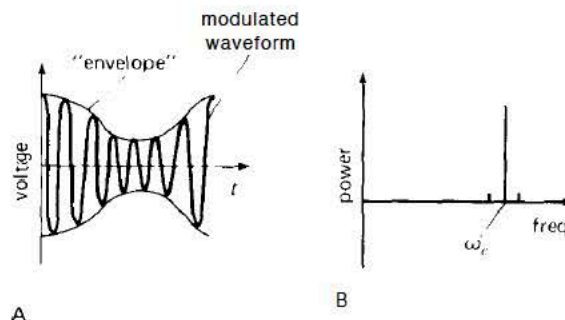


Figure 13.37. Amplitude modulation.

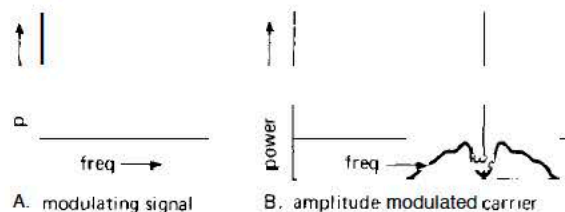


Figure 13.38. AM spectrum for a band of modulating frequencies (speech).

AM generation and detection

It is easy to generate amplitude-modulated RE Any technique that lets you control the signal amplitude with a voltage in a linear manner will do. Common methods involve varying the RF amplifier supply voltage (if the modulation is done at the output stage) or using a multiplier chip such as the 1496. When the modulation is done at a low-level stage, all following stages of amplification must be linear. Note that in AM the modulating waveform must be biased up so that it never assumes negative values. Look at the graphs in Figure 13.39.

The simplest receiver of AM consists of several stages of tuned RF amplification, followed by a diode detector (Fig. 13.40). The amplifier stages provide selectivity against signals nearby in frequency, and they amplify the input signals (which may be at the microvolt level) for the detector. The latter simply rectifies the RF waveform, then recovers the smooth "envelope" with low-pass filtering. The