Fundamentals of Electrical Engineering

Modulated Communication

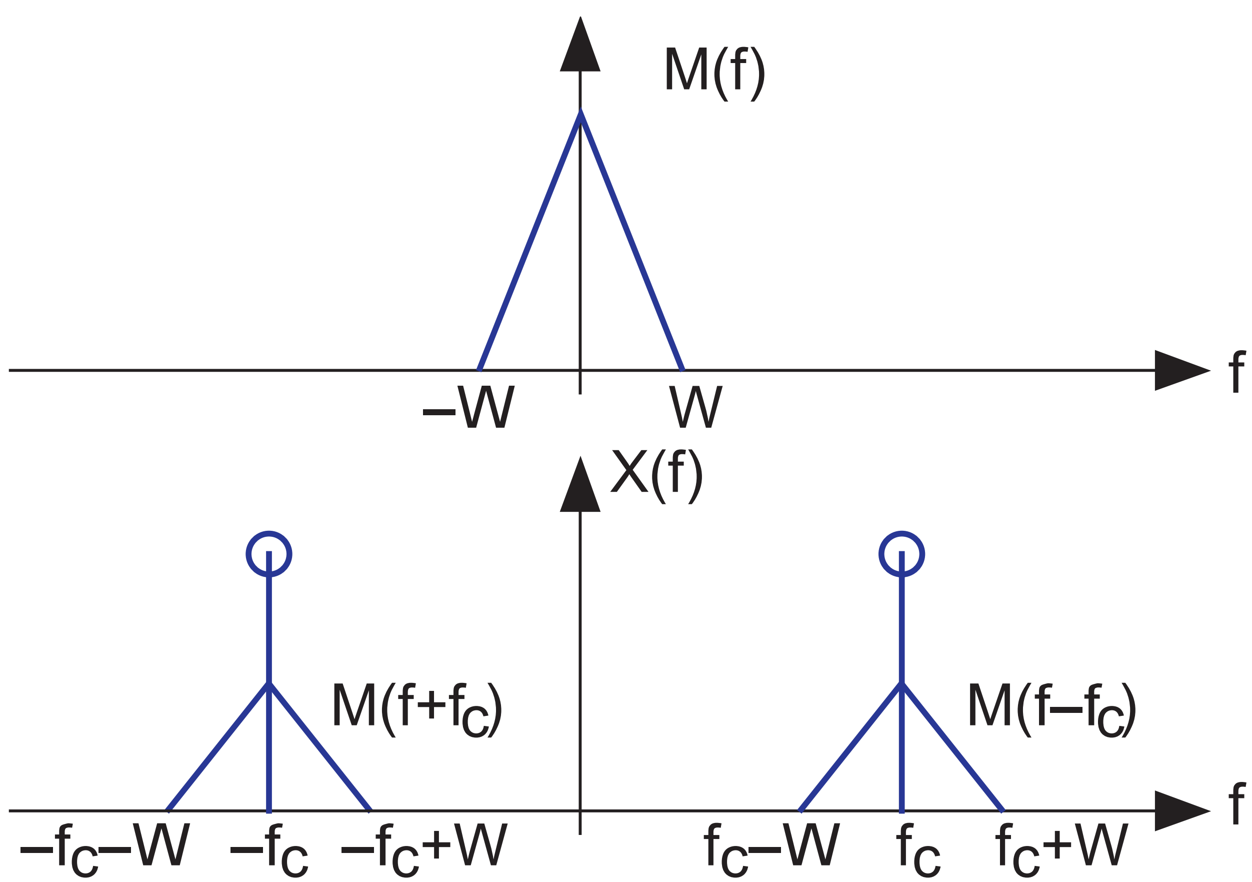
- Sending signals in a higher-frequency band
- Transmitter/receiver
- SNR

RICE

Transmitter for Modulated Communication

$$x(t) = A \cdot (1 + m(t)) \cos 2\pi f_c t \qquad |m(t)| \leq 1$$

transmitter amplitude — carrier frequency

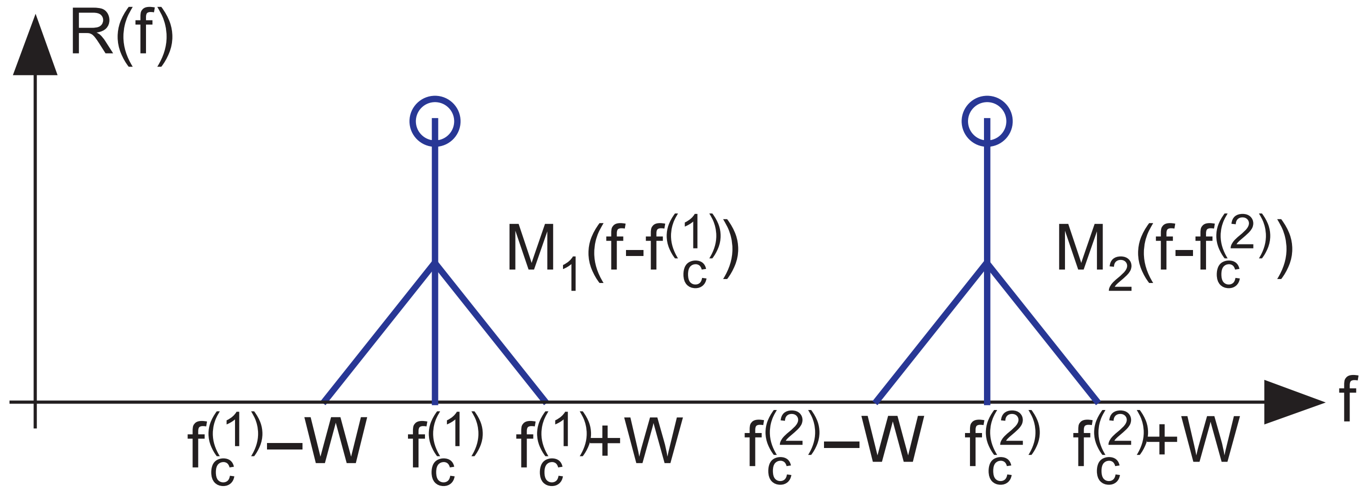


message bandwidth: W

transmission bandwidth: 2W

Modulated Communication

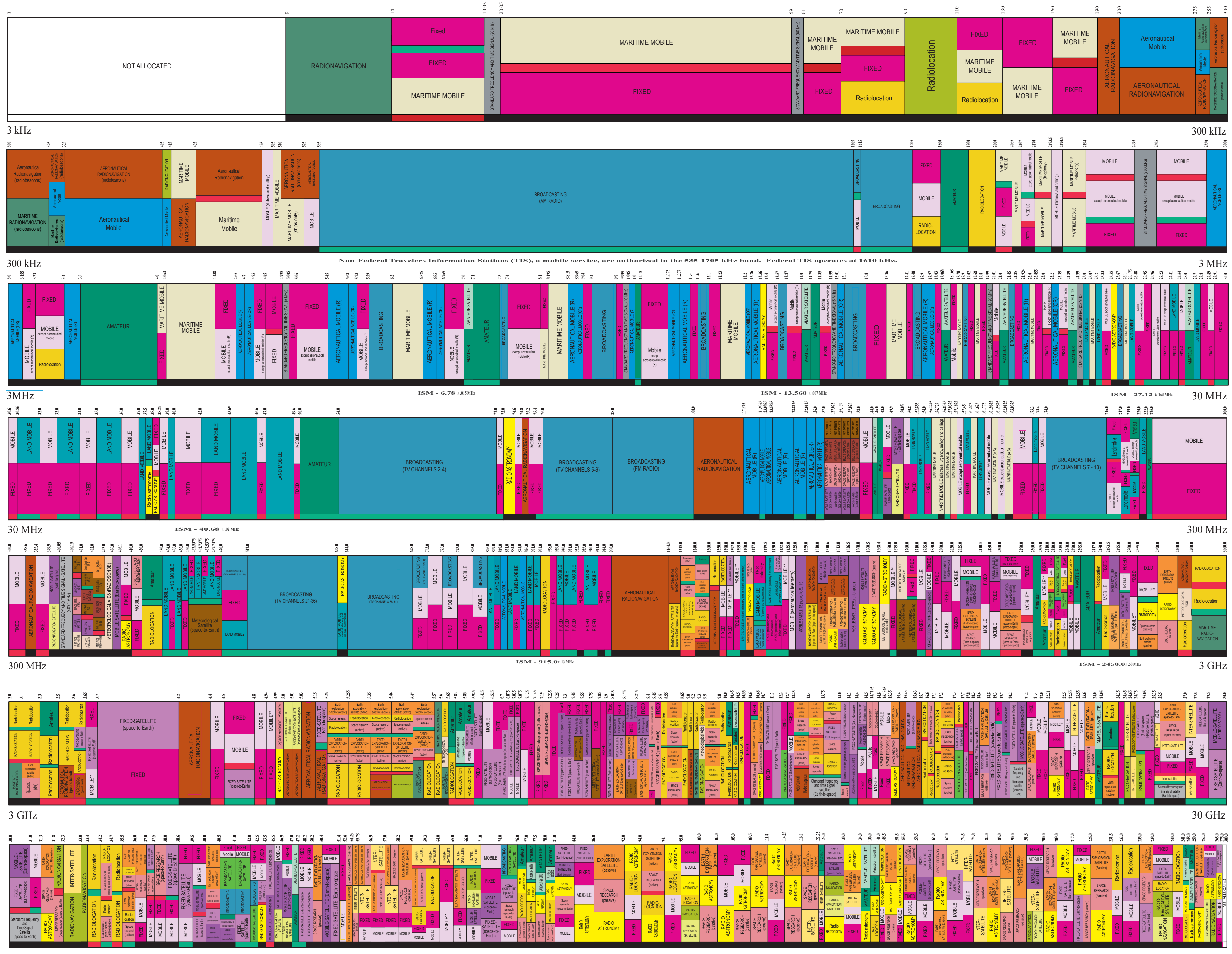
frequency-division multiplexing



Modulated Communication

UNITED STATES FREQUENCY ALLOCATIONS

THE RADIO SPECTRUM



* EXCEPT AERONAUTICAL MOBILE (R)

** EXCEPT AERONAUTICAL MOBILE

PLEASE NOTE: THE SPACING ALLOTTED THE SERVICES IN THE SPECTRUM SEGMENTS SHOWN IS NOT PROPORTIONAL TO THE ACTUAL AMOUNT OF SPECTRUM OCCUPIED.

RADIO SERVICES COLOR LEGEND

- AERONAUTICAL MOBILE
- INTER-SATELLITE
- RADIO ASTRONOMY
- AERONAUTICAL MOBILE SATELLITE
- LAND MOBILE
- RADIODETERMINATION SATELLITE
- AERONAUTICAL RADIONAVIGATION
- LAND MOBILE SATELLITE
- RADIOLOCATION
- AMATEUR
- MARITIME MOBILE
- RADIOLOCATION SATELLITE
- AMATEUR SATELLITE
- MARITIME MOBILE SATELLITE
- RADIONAVIGATION
- BROADCASTING
- MARITIME RADIONAVIGATION
- RADIONAVIGATION SATELLITE
- BROADCASTING SATELLITE
- METEOROLOGICAL
- SPACE OPERATION
- EARTH EXPLORATION SATELLITE
- METEOROLOGICAL SATELLITE
- SPACE RESEARCH
- FIXED
- MOBILE
- STANDARD FREQUENCY AND TIME SIGNAL
- FIXED SATELLITE
- MOBILE SATELLITE
- STANDARD FREQUENCY AND TIME SIGNAL SATELLITE

ACTIVITY CODE

- GOVERNMENT EXCLUSIVE
- GOVERNMENT/NON-GOVERNMENT SHARED
- NON-GOVERNMENT EXCLUSIVE

ALLOCATION USAGE DESIGNATION

SERVICE	EXAMPLE	DESCRIPTION
Primary	FIXED	Capital Letters
Secondary	Mobile	1st Capital with lower case letters

This chart is a graphic single-point-in-time portrayal of the Table of Frequency Allocations used by the FCC and NTIA. As such, it does not completely reflect all aspects, i.e. footnotes and recent changes made to the Table of Frequency Allocations. Therefore, for complete information, users should consult the Table to determine the current status of U.S. allocations.

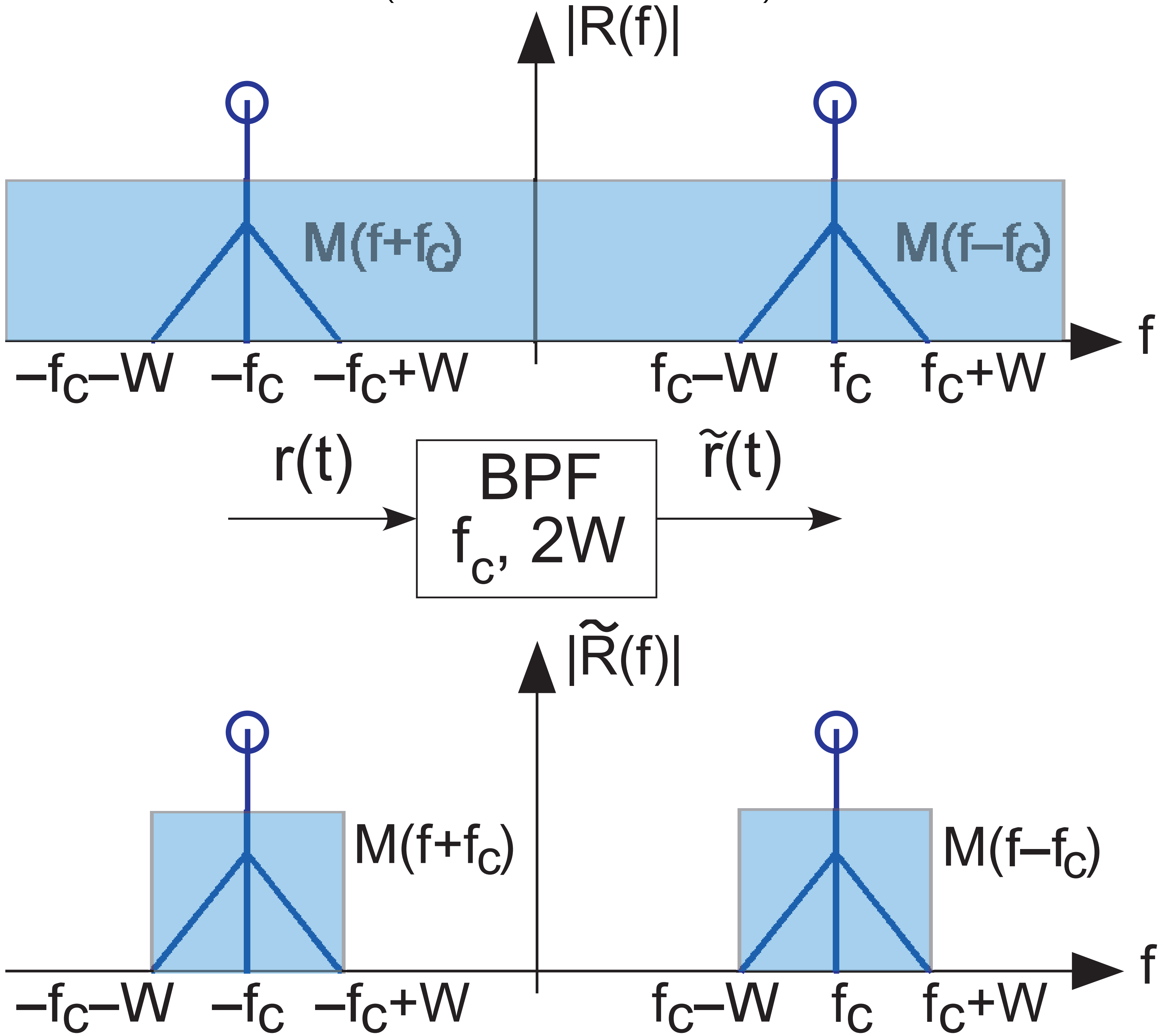
U.S. DEPARTMENT OF COMMERCE
National Telecommunications and Information Administration
Office of Spectrum Management

August 2011

For sale by the Superintendent of Documents, U.S. Government Printing Office
Internet: bookstore.gpo.gov Phone toll free (866) 512-1800; Washington, DC area (202) 512-1800
Facsimile: (202) 512-2250 Mail: Stop SSOP, Washington, DC 20402-0001

Receiver Front-End

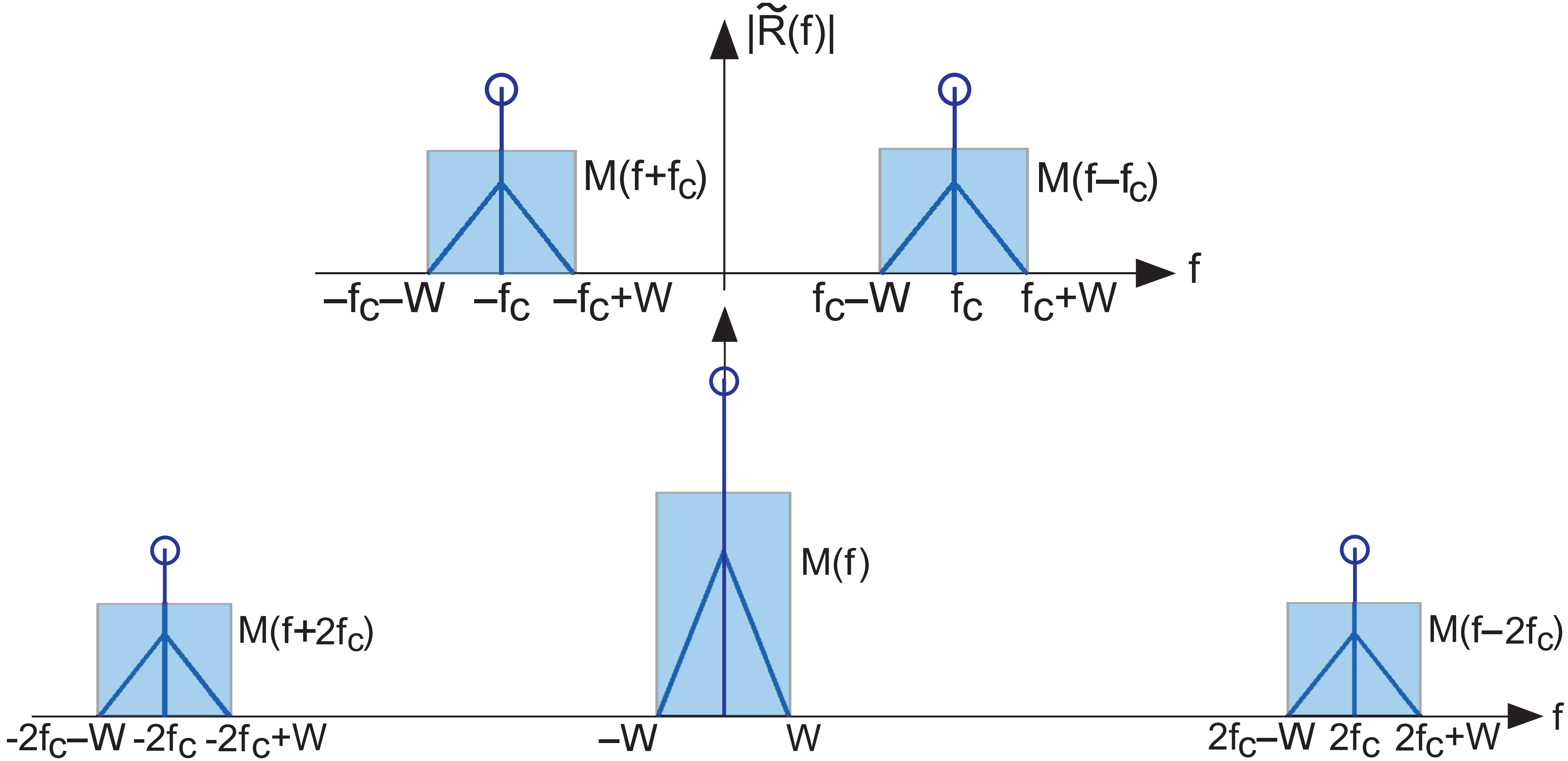
Need to remove "out-of-band" noise and other transmissions (interference)



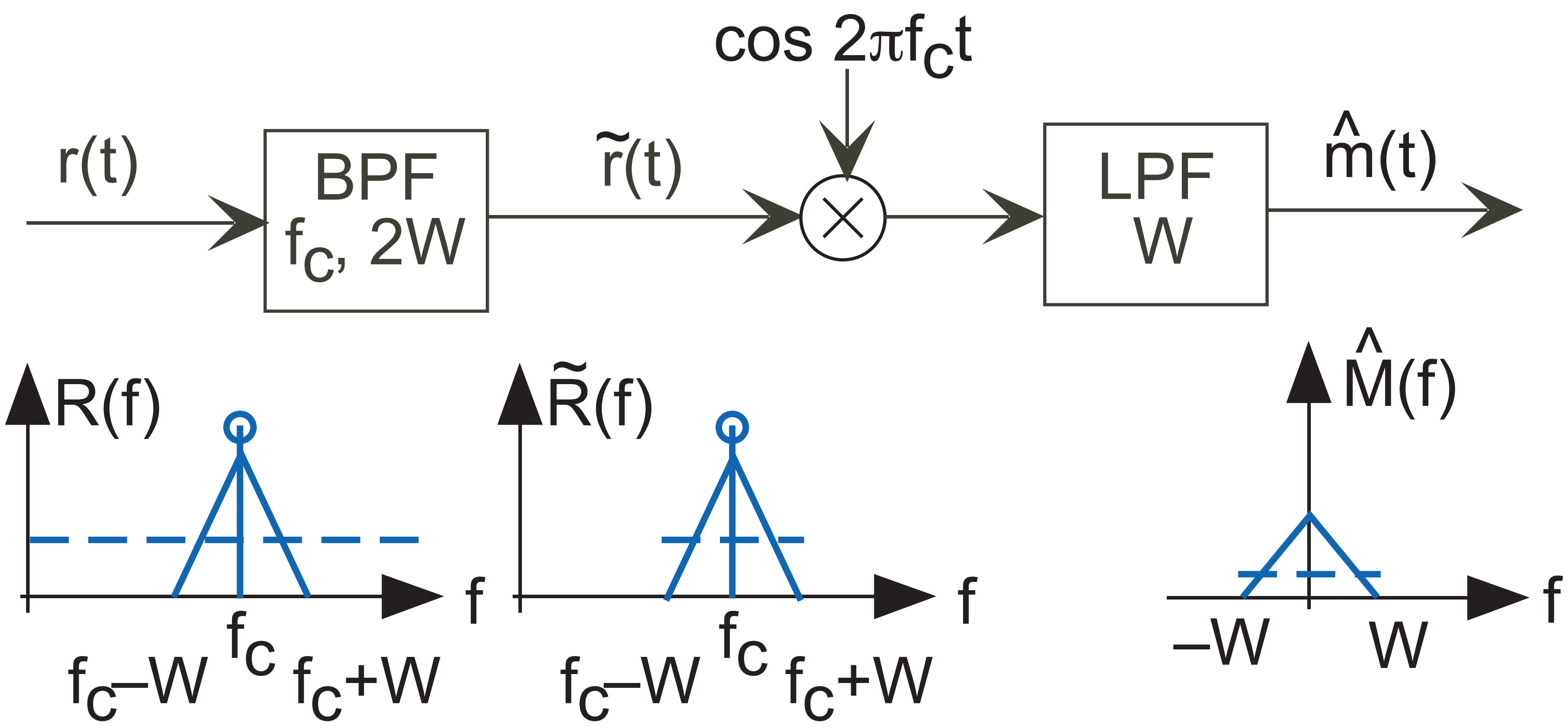
Demodulator

An interesting property

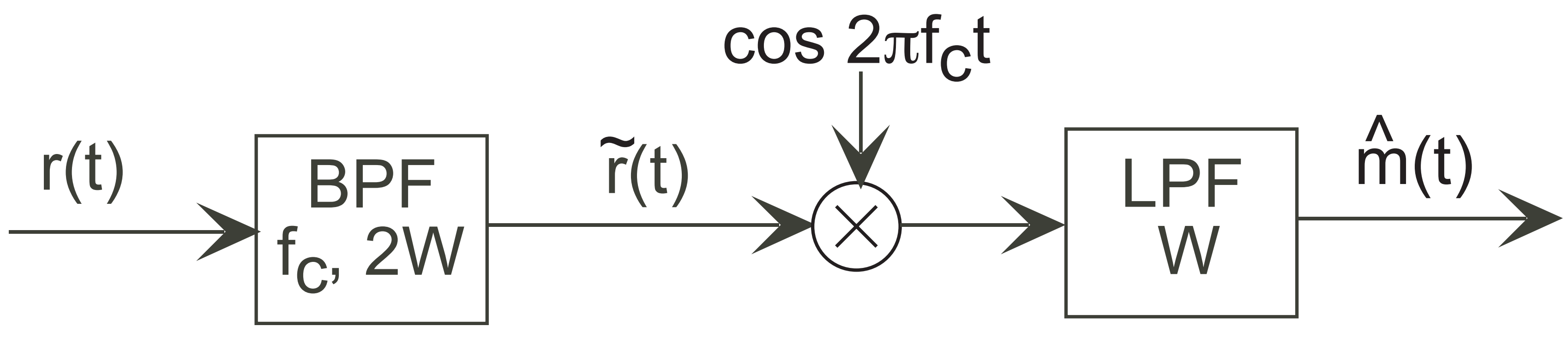
$$x(t)\cos 2\pi f_c t = A\big(1 + m(t)\big)\cos^2 2\pi f_c t$$
$$= A\big(1 + m(t)\big)\cdot \frac{1}{2}\big(1 + \cos 2\pi\, 2 f_c t\big)$$



Demodulator



SNR



Find SNR for front-end output and demodulated message

front-end message:

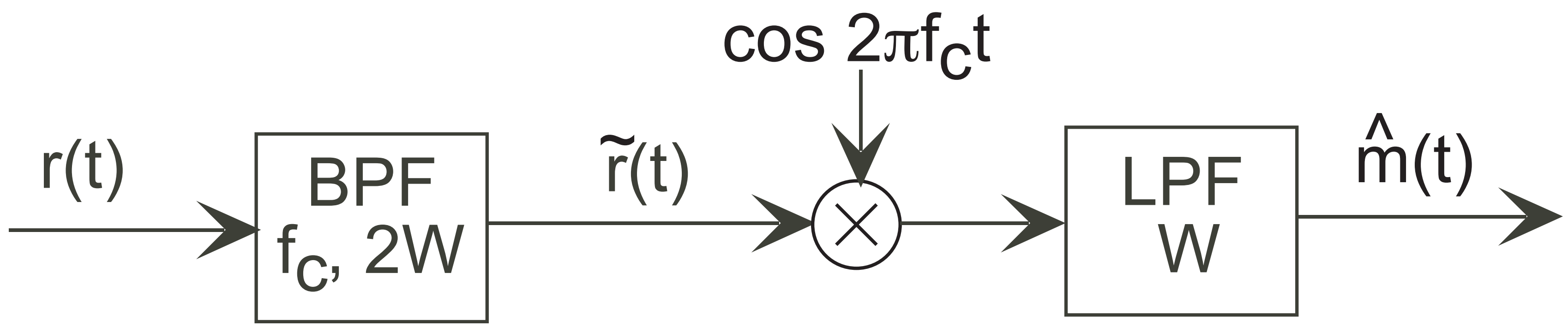
$$\text{power}[\alpha A m(t) \cos 2\pi f_c t] = \frac{1}{2}\alpha^2 A^2 \text{power}[m]$$

front-end noise:

$$\text{power}[n] \text{ in } [f_c - W, f_c + W] = N_0 \cdot 2W$$

$$\text{SNR}_{\tilde{r}} = \frac{\alpha^2 A^2 \text{power}[m]}{4 N_0 W}$$

SNR



SNR for demodulated message

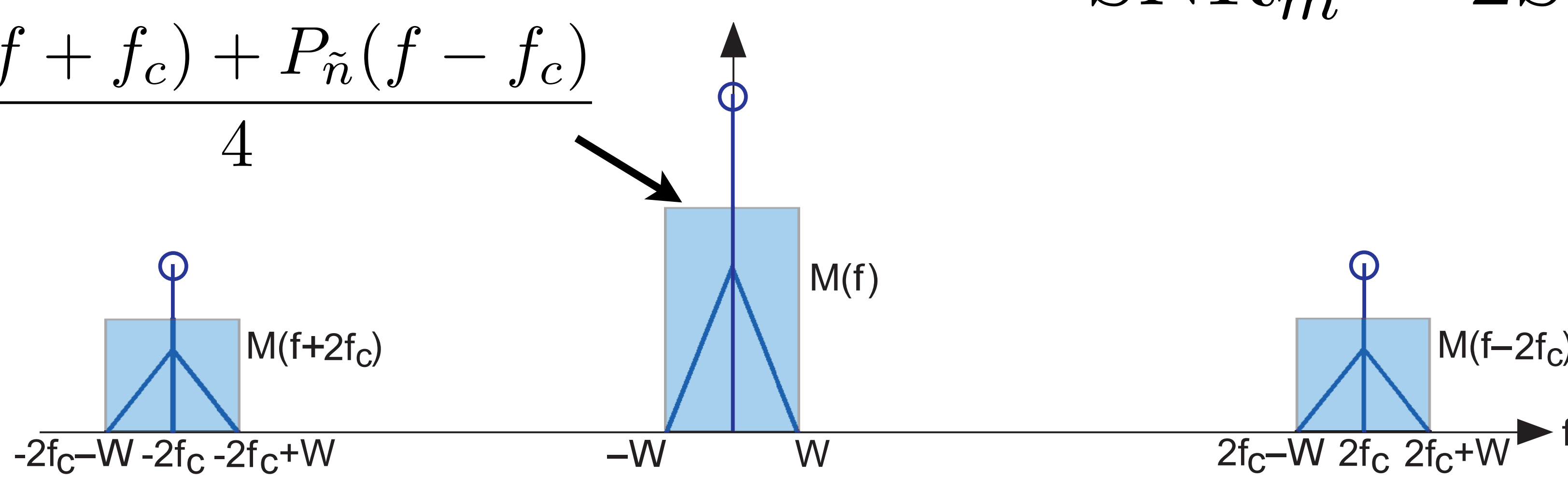
message: $\text{power}\left[\frac{1}{2}\alpha A m(t)\right] = \frac{1}{4}\alpha^2 A^2 \text{power}[m]$

noise: $2 \cdot \frac{N_0}{2} \cdot W \cdot \frac{2}{4} = \frac{N_0 W}{2}$

$$\text{SNR}_{\widehat{m}} = \frac{\alpha^2 A^2 \text{power}[m]}{2 N_0 W}$$

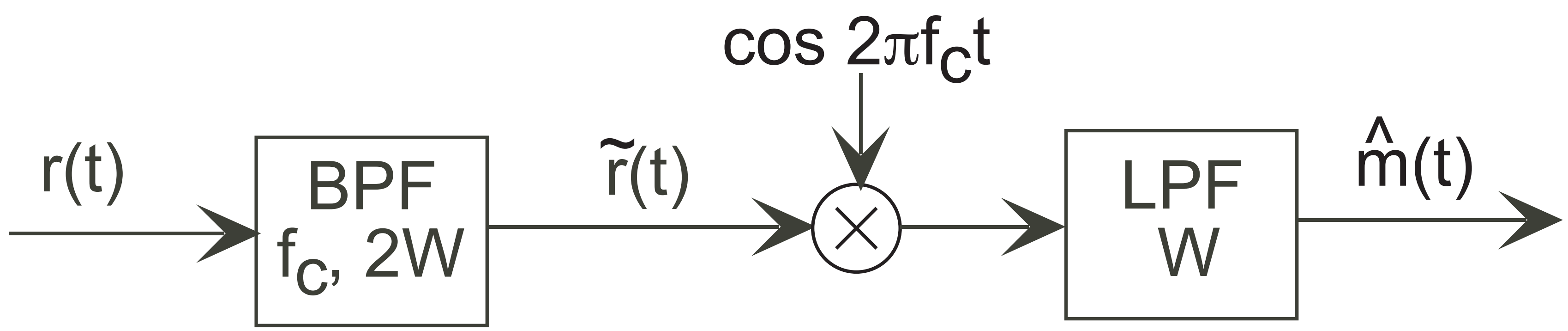
$$\text{SNR}_{\widehat{m}} = 2\text{SNR}_{\tilde{r}}$$

$$P(f) = \frac{P_{\tilde{n}}(f + f_c) + P_{\tilde{n}}(f - f_c)}{4}$$



Modulated Communication

$$x(t) = A \cdot \bigl(1 + m(t)\bigr) \cos 2\pi f_c t$$



- Using amplitude modulation, transmitted signals pass through wireless channels more easily
- Frequency multiplexing now possible
- $\text{SNR}_{\widehat{m}} = \dfrac{\alpha^2 A^2 \text{power}[m]}{2N_0 W}$