

ENSC327

Communications Systems

14: Multiplexing



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Outline

- ❑ Required background (Recall various modulation schemes)
- ❑ Different Multiplexing strategies:
 - Frequency-division multiplexing (FDM) (3.9)
 - Example: Stereophonic FM Broadcasting (4.9)
 - Other:
 - ❑ Time-division multiplexing (TDM)
 - ❑ Code-division multiplexing (CDM)
 - ❑ Space-division multiplexing (SDM)

Frequency-division multiplexing (FDM) (3.9)

- ❑ With *Multiplexing* a number of independent signals can be combined into a composite signal suitable for transmission over a common channel.
- ❑ Baseband signal: Several messages are translated by modulation to different spectral locations (sub-carriers) to form a composite signal.
- ❑ Different modulation schemes can be used to form the baseband: AM, DSB, SSB, FM...
- ❑ The composite baseband signal is then transmitted over a single channel, using a single modulation scheme.
- ❑ The sub-carriers used for modulation of individual signals have a much lower frequency than the final carrier.

Frequency-division multiplexing

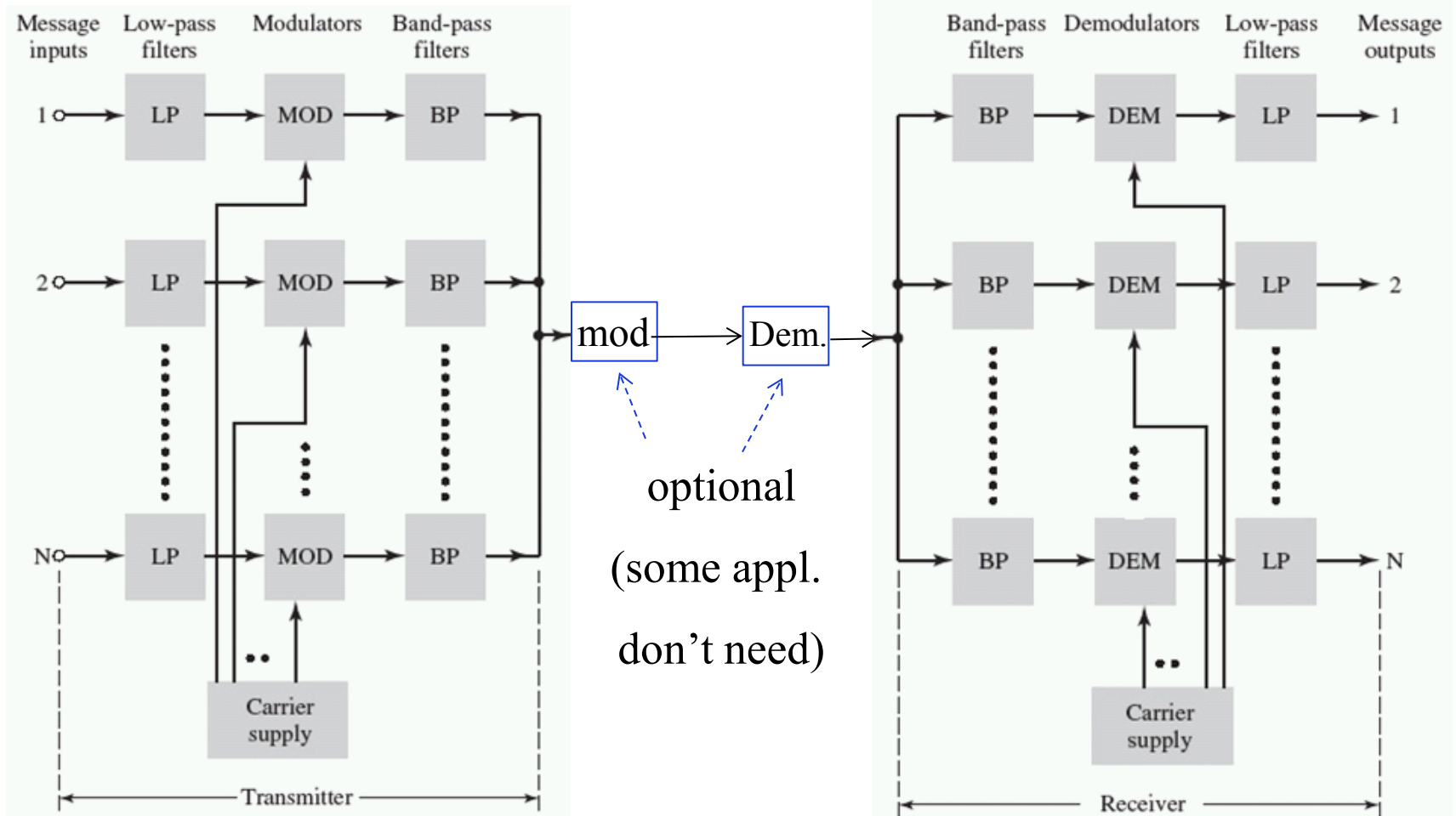
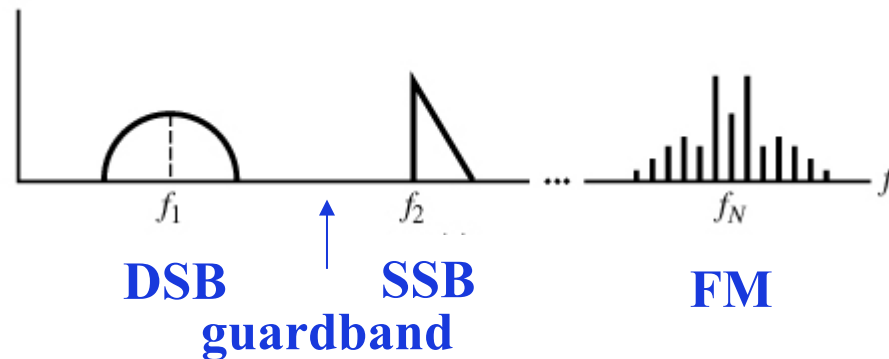


FIGURE 3.29 Block diagram of frequency-division multiplexing (FDM) system.

Frequency-division multiplexing

- In general the Baseband composite signal can use different modulation schemes for each independent message:



- Example: In Analog telephone systems, each voice channel is assigned a BW of 4 kHz and is SSB modulated, before being modulated with one single carrier and transmitted over the channel.

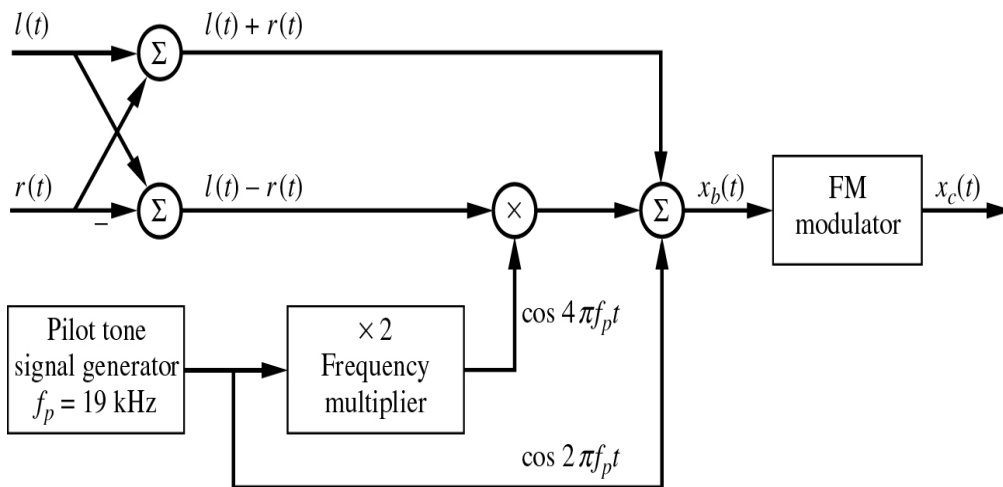
Example: Stereo FM (4.9)

- FM radio was originally monophonic
 - Message bandwidth: 15kHz
 - Each station has 200 kHz
 - Use a superhetrodyne receiver
 - Intermediate frequency (IF) 10.7 MHz

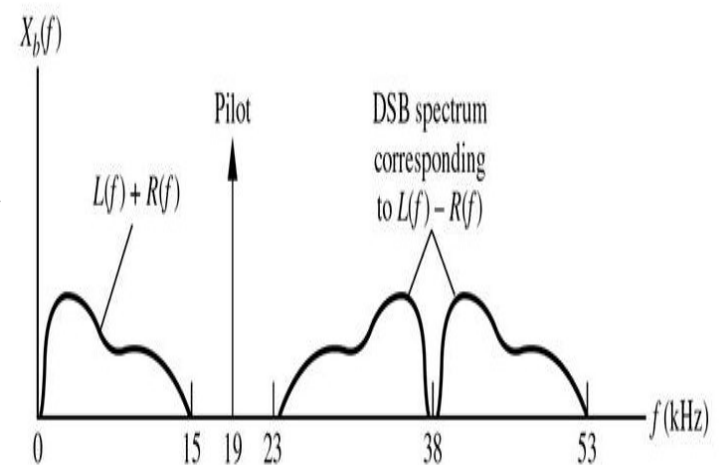
- Later converted to stereo in a **compatible** way
 - Developed by GE and Zenith in 1960s
 - Compatibility is usually needed in upgrades
 - E.g., black and white TV → colour TV
 - Analog TV to Digital TV

Stereophonic FM Broadcasting

□ Stereo FM transmitter



FM baseband spectrum:

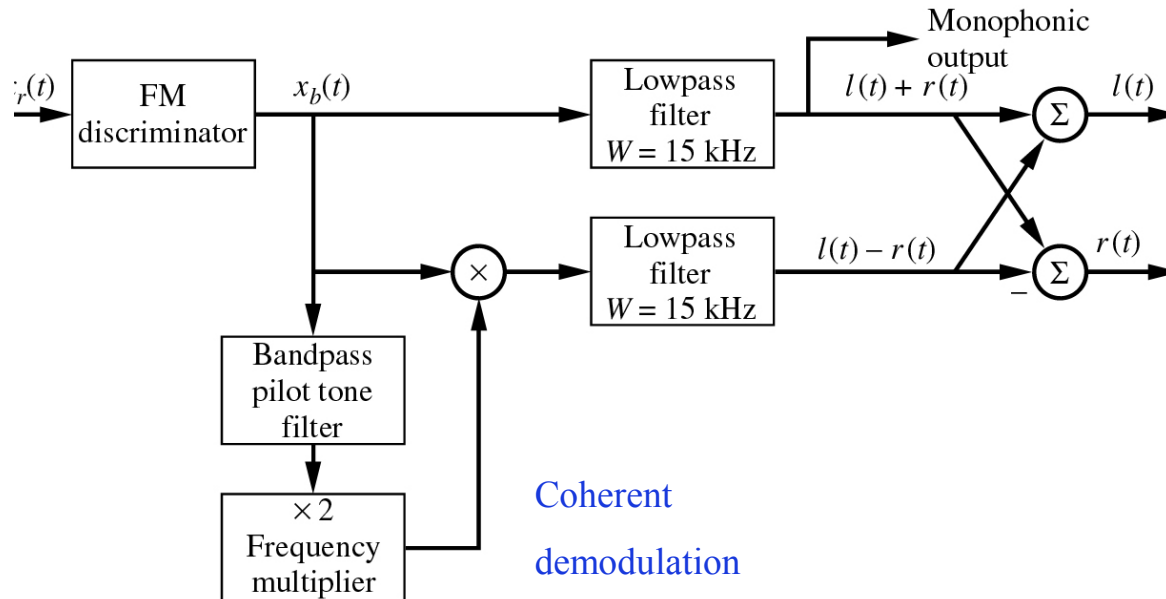


□ Use FDM to multiplex 3 signals:

- 0-15kHz: Left + Right (compatible to mono FM)
- 23-53kHz: DSB-SC modulation of Left-Right signal
- 19kHz: **Pilot** for coherent DSB demodulation
 - Also used to differentiate and switch between mono and stereo receiver circuits.

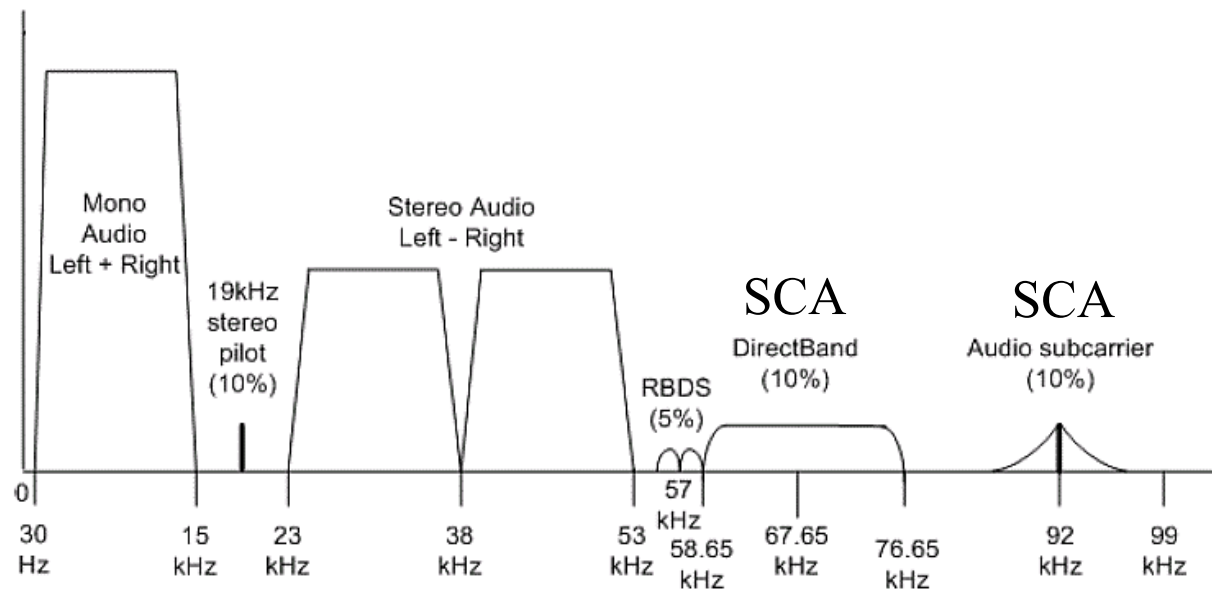
Stereo FM Receiver

- ❑ First use FM demodulation to get back to baseband
- ❑ Then demodulate L+R and L-R, respectively.
- ❑ Extract 19kHz pilot, use freq. multiplier to recover 38kHz carrier for DSB demodulation.



Other subcarriers services

- The FM subcarrier system has been extended to other services.
 - RDS (Radio Data System) or RBDS (Radio Broadcast Data System) at 57k Hz
 - SCA (subsidiary communications authority) Services: at 67 kHz or 92 kHz.

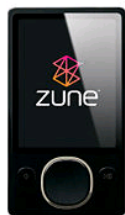


RDS and RBDS

- ❑ RDS and RBDS are digital services
 - ❑ Use digital modulation, e.g., QPSK (studied later)
 - ❑ Error correction can be used.
- ❑ In Europe, a 57 kHz subcarrier is used to carry a low-bandwidth digital **Radio Data System (RDS)** signal. This signal runs at only 1187.5 bits per second, thus is only suitable for text.
- ❑ Applications: RDS can be used to transmit song title, artist name or radio station info that can be displayed by receiver.
- ❑ A variant of RDS is the North American **Radio Broadcast Data System (RBDS)**.

RDS and RBDS

- ❑ There are a growing number of RDS implementations in portable and navigation devices:
 - ❑ Apple Radio Remote for iPod
 - ❑ Microsoft Zune
 - ❑ Garmin GPS
 - ❑ Many cell phones



SCA Services

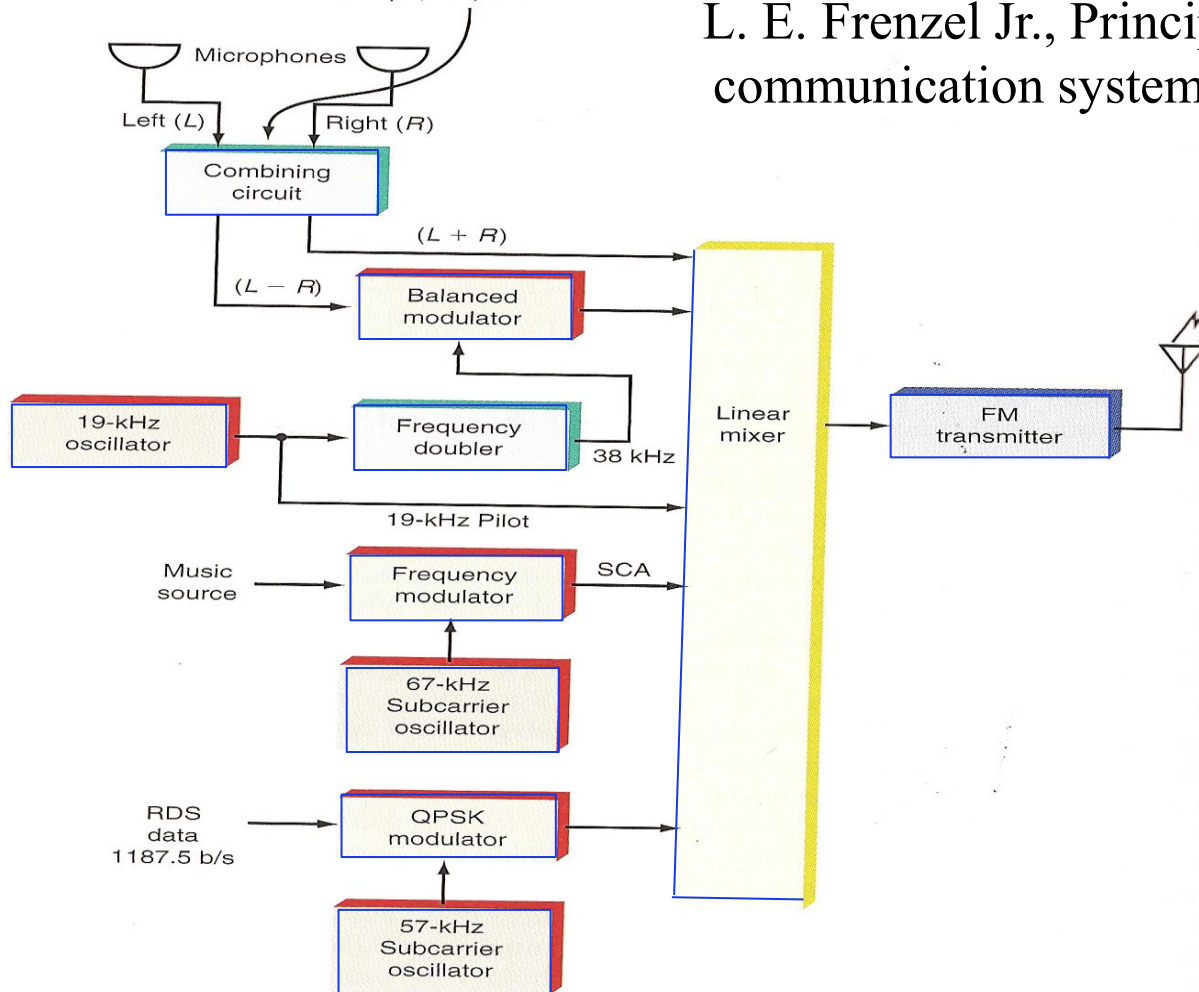
- ❑ SCA: subsidiary communications authority services.
- ❑ Examples:
 - ❑ Book/newspaper reading services for blind people
 - ❑ Private data transmission services (e.g. stock info)
 - ❑ Commercial-free background music services for shops, elevators, and restaurants.
 - ❑ Paging services

SCA Services

- ❑ SCA subcarriers are typically 67 kHz and 92 kHz,
- ❑ The SCA signal is also freq modulated, but with a simple VCO-based **NBFM** method.
- ❑ The modulated SCA signal has a freq deviation of 7.5kHz.
- ❑ **PLL** is usually used to demodulate the SCA signal.

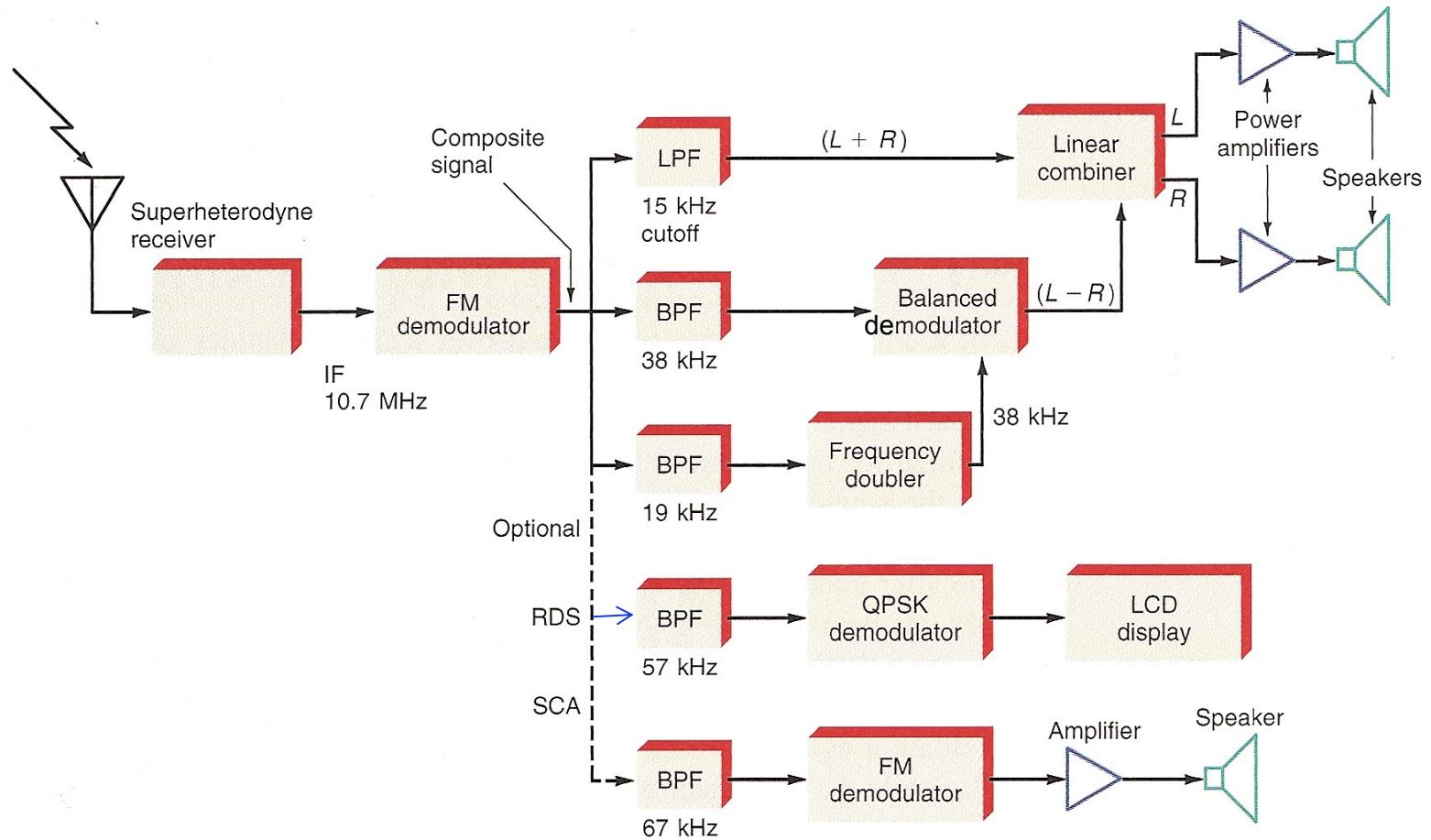
Complete FM Transmitter

Or stereo input from cassette tape, CD, etc.



L. E. Frenzel Jr., Principles of electronic communication systems, pp. 366-367.

Complete FM Receiver



Reference

- http://en.wikipedia.org/wiki/FM_broadcasting
- http://en.wikipedia.org/wiki/Radio_Data_System
- http://en.wikipedia.org/wiki/Subsidiary_Communications_Authority