Historical Development of Wireless

Wireless

- 1901 Guglielmo Marconi transmits radio signals across the Atlantic Ocean
- 1948 Invention of the transistor (Bell Labs)
- 1948 Shannon's Information theory (Bell Labs)
- 1958 Invention of the IC (TI)
- 1976 Conception of the Cellular phone (Bell Labs)

Evolution of mobile communication generations

- 1G: Analog mobile voice calls (1979)
- 2G: Digital mobile voice calls and SMS (1991)
- 3G: Digital mobile data (internet) (1998)
- 4G: Digital mobile video consumption and higher data speed (2009)
- 5G: deployments started in 2019 in some countries

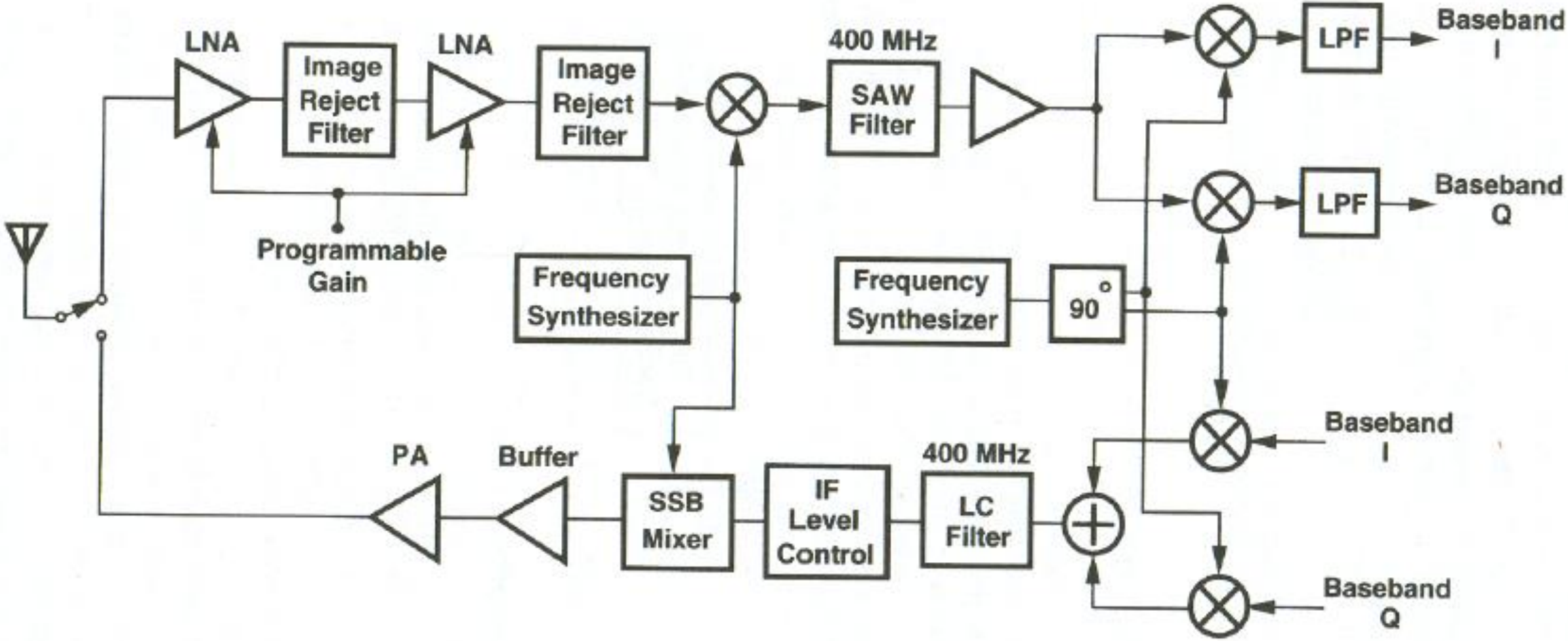

Figure 1.2 RF section of a cellphone [1]

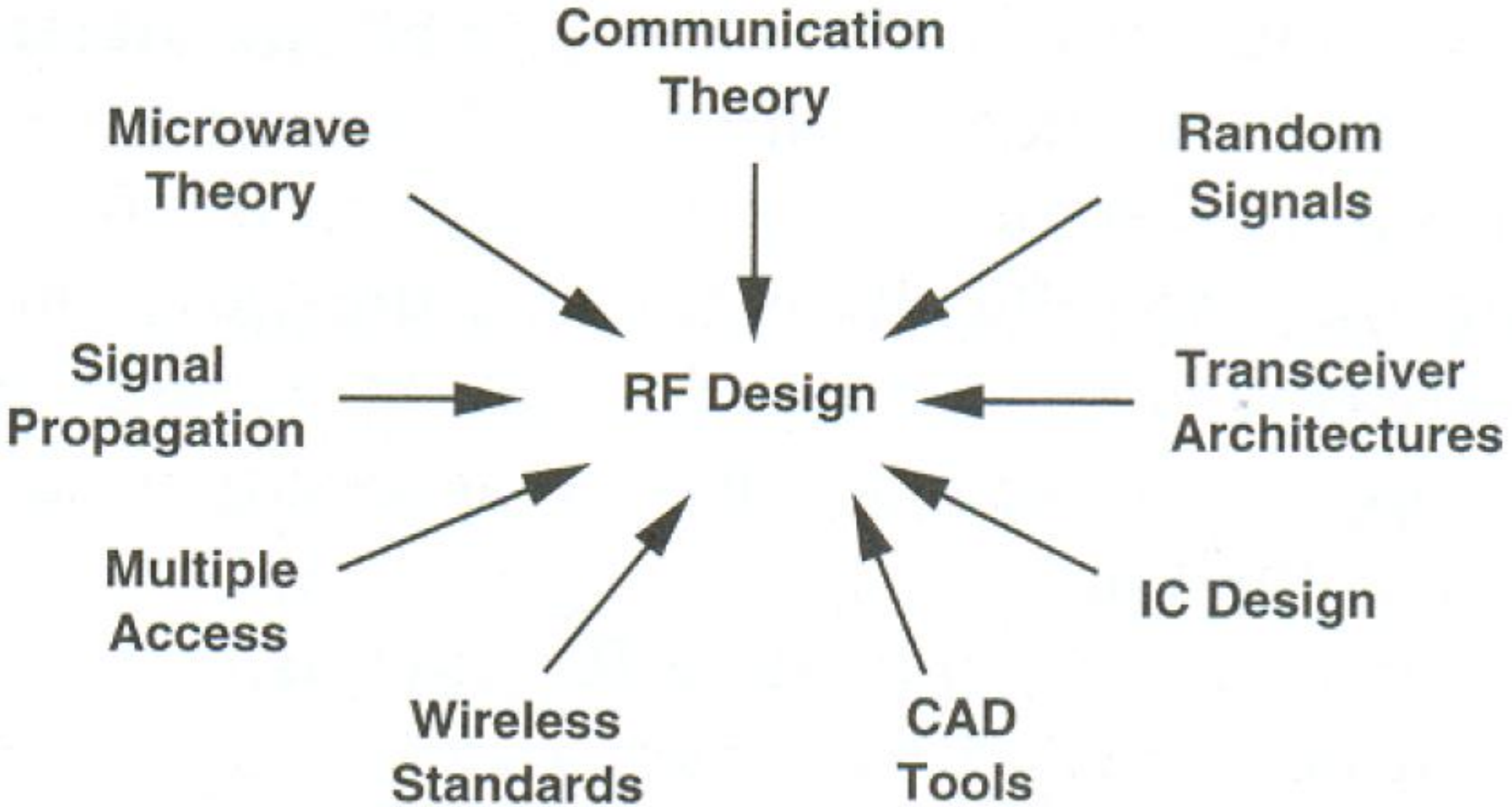

Figure 1.4 Disciplines required in RF design.

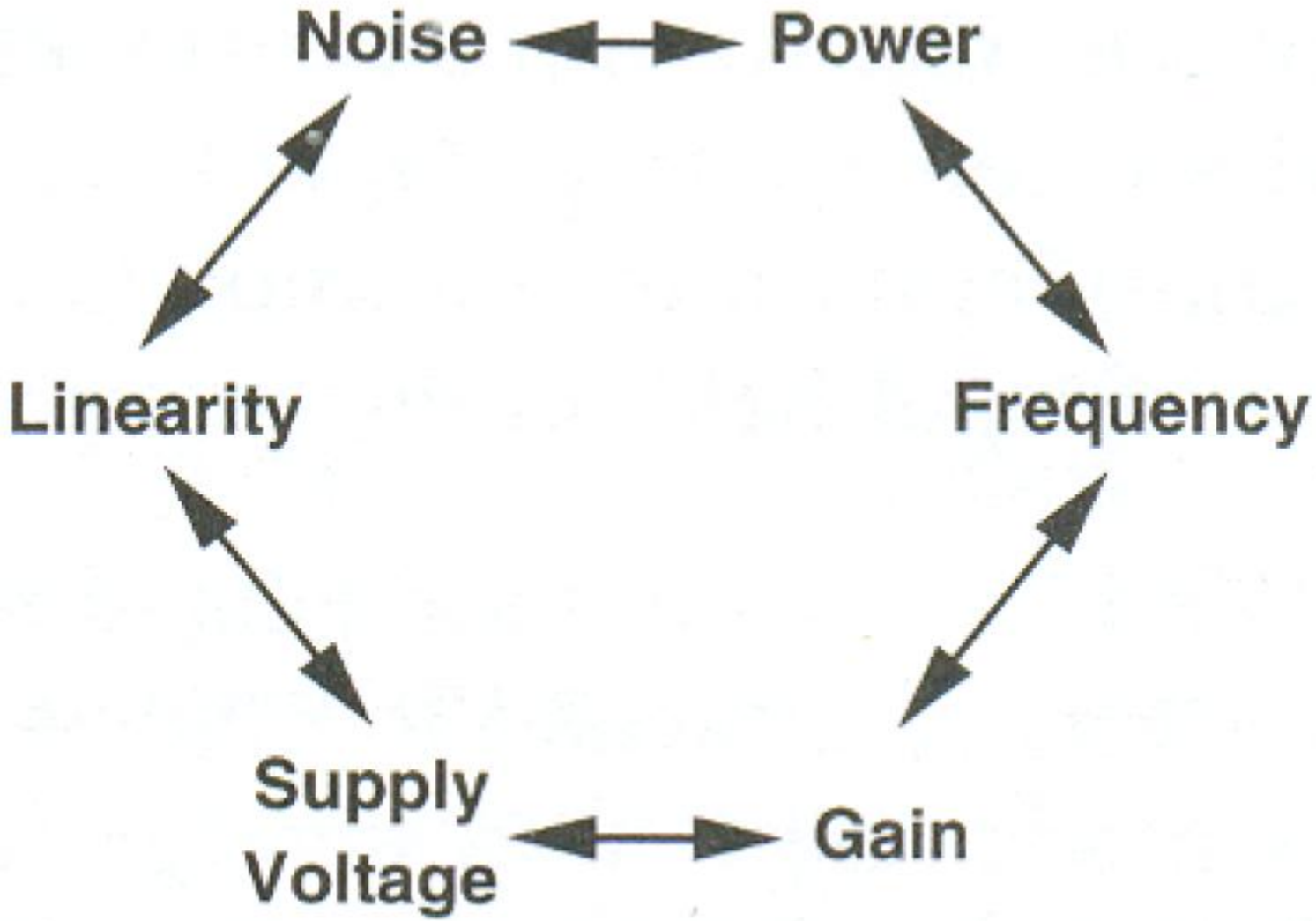

Figure 1.5 RF design hexagon.

Applications

- Cellular Phone (5G)
- Satellite Internet (Starlink)
- Wireless local area network (WLAN)
  - 802.11b (DSCC, 11 Mbps, 2.5 GHz)
  - 802.11g (OFDM, 54 Mbps, 2.5 GHz)
  - 802.11a (OFDM, 54 Mbps, 5 GHz)
- RFID
- Home Satellite
- Global Positioning System (GPS)

Standard Frequencies and Standards

Wireless System	Operating Frequency
Advanced Mobile Phone Service (AMPS)	T: 824–849 MHz R: 869–894 MHz
Global System Mobile (European GSM)	T: 880–915 MHz R: 925–960 MHz
Personal Communications Services (PCS)	T: 1710–1785 MHz R: 1805–1880 MHz
US Paging	931–932 MHz
Global Positioning Satellite (GPS)	L1: 1575.42 MHz L2: 1227.60 MHz
Direct Broadcast Satellite (DBS)	11.7–12.5 GHz
Wireless Local Area Networks (WLANs)	902–928 MHz 2.400–2.484 GHz 5.725–5.850 GHz
Local Multipoint Distribution Service (LMDS)	28 GHz
US Industrial, Medical, and Scientific bands (ISM)	902–928 MHz 2.400–2.484 GHz 5.725–5.850 GHz

T/R = mobile unit transmit/receive frequency.

TABLE 1.2 Major Worldwide Cellular and PCS Telephone Systems

Standard	Country	Year of Introduction	Type	Frequency Band (MHz)	Modulation	Channel Bandwidth
NTT	Japan	1979	Cellular	860–940	FM	25 kHz
NMT-450	Europe	1981	Cellular	453–468	FM	25 kHz
AMPS	United States	1983	Cellular	824–894	FM	30 kHz
E-TACS	Europe	1985	Cellular	872–950	FM	25 kHz
C-450	Germany	1985	Cellular	450–466	FM	20 kHz
NMT-900	Europe	1986	Cellular	890–960	FM	12.5 kHz
JTACS	Japan	1988	Cellular	860–925	FM	25 kHz
GSM	Europe	1990	PCS	890–960	GMSK	200 kHz
IS-54	United States	1991	PCS	824–894	DQPSK	30 kHz
NAMPS	United States	1992	Cellular	824–894	FM	10 kHz
IS-95	United States	1993	PCS	824–894	QPSK	1.25 MHz
PDC	Japan	1993	Cellular	810–1513	DQPSK	25 kHz
NTACS	Japan	1993	Cellular	843–922	FM	12.5 kHz

3G Universal Mobile Telecommunication System (UMTS)

WCDMA (UTRA FDD) (universal terrestrial radio access):

Parameters	Specifications
Up-link frequency band (mobile transmit)	1920-1980 MHz
Down-line frequency band (mobile receive)	2110-2117 MHz
Modulation	QPSK (downlink), HPSK (uplink)
Multiple access schemes	FDD/WCDMA
User bit rate	384 kbps to 2 Mbps
BER	10^{-3}
Chip rate	3.84 Mcps
Maximum transmitted power	Up to 2W (class 1)

Analog and Digital Systems

- Typical problems in a realistic environment:

- Noise
- Interferers (other users)
- Multiple pathes of RF signals (fading)

Signal processing of the baseband and IF signals (compression, coding, interleaving, pulse shaping) permits digital systems to achieve a higher performance than that of analog signals.

RFIC design includes not only the design of the various system blocks but also the study of the trade-offs at the system level.

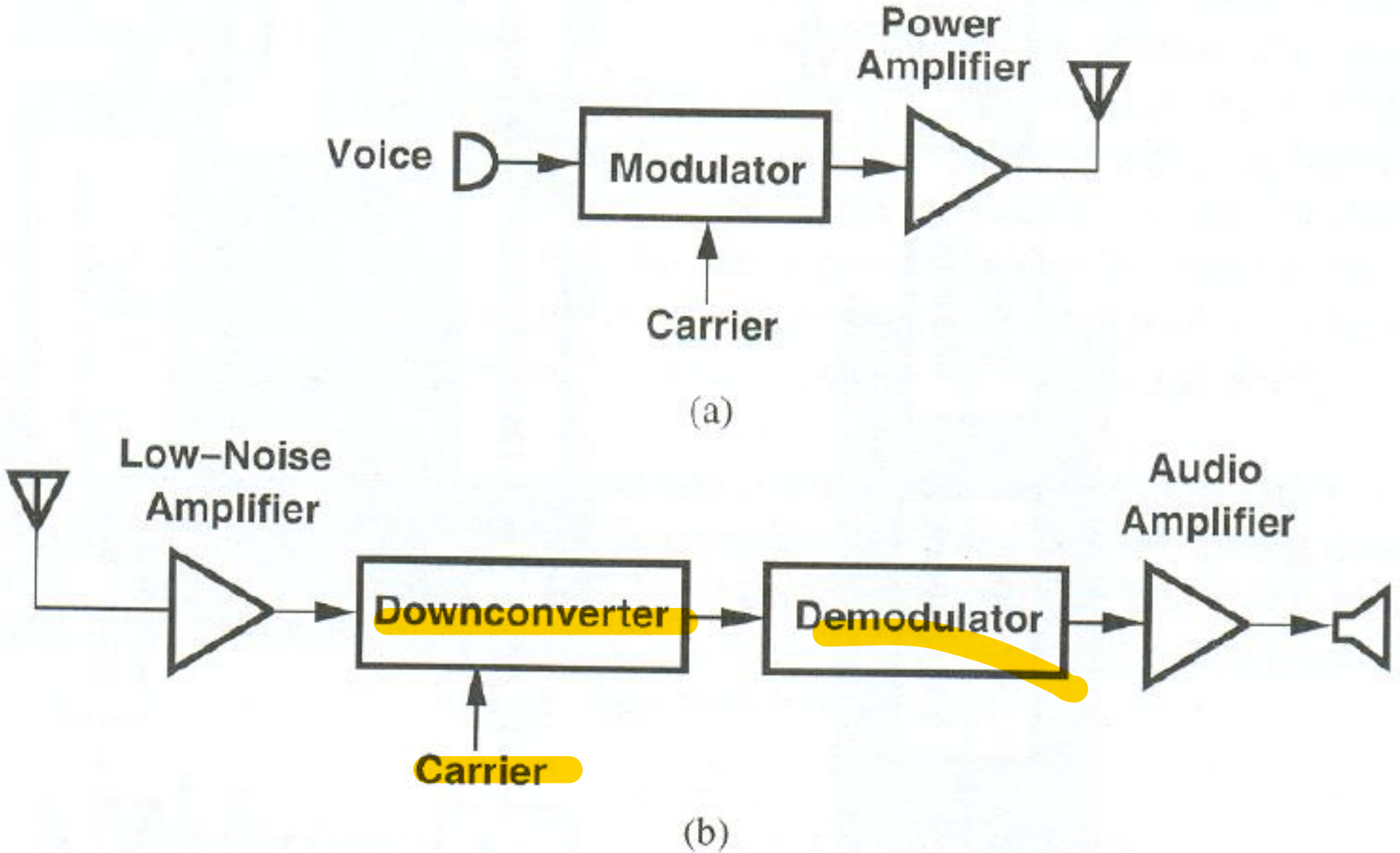

Figure 1.6 Block diagram of a generic analog RF system: (a) transmitter, (b) receiver.

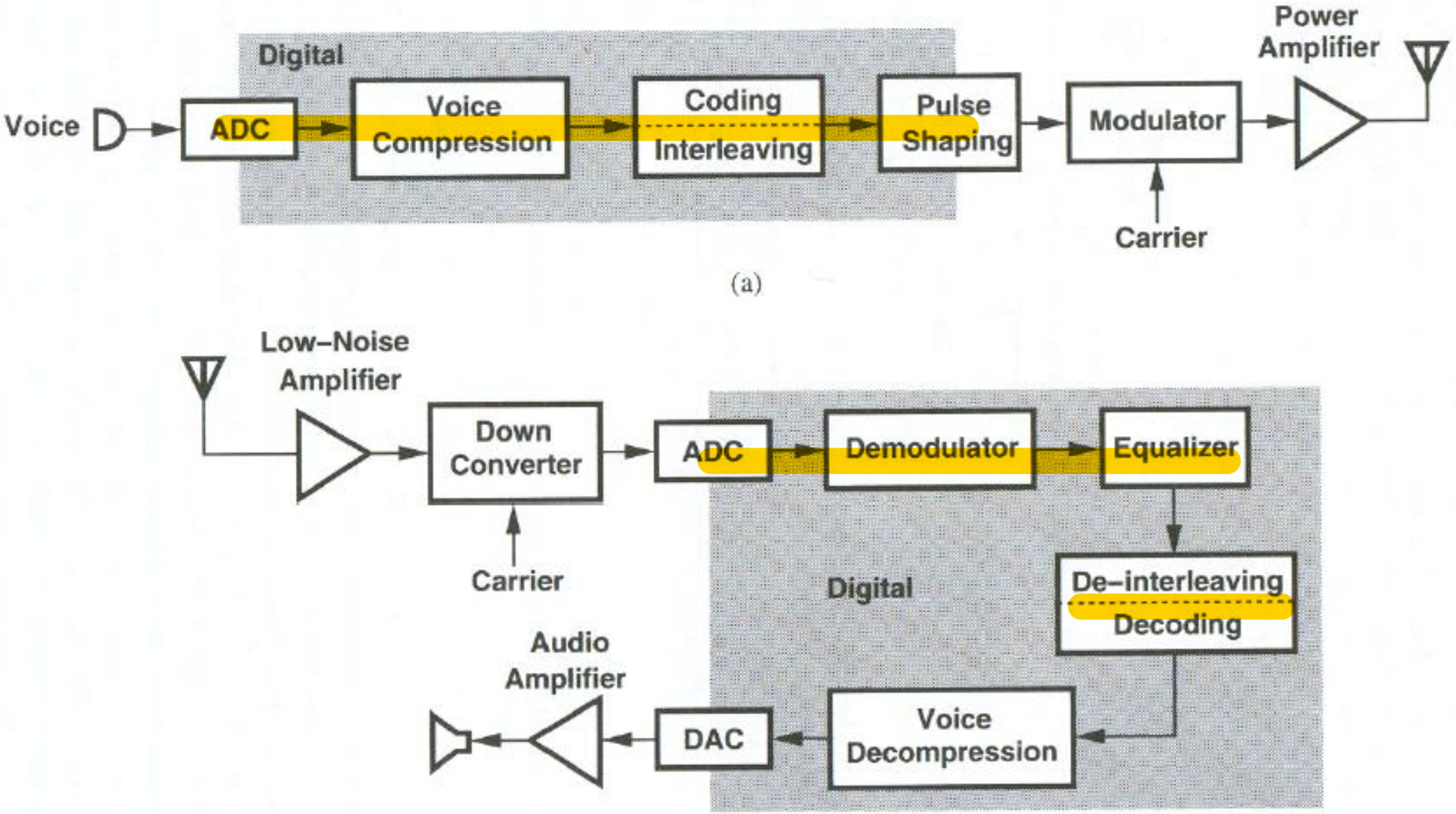

Figure 1.7 Block diagram of a generic digital RF system: (a) transmitter, (b) receiver.

Choice of IC Technologies

Various technologies are competing offering different performance, cost and time to market trade-offs and all continuously improving

- Si bipolar
  - BiCMOS
  - SiGe (heterojunction devices)
- Si FET
  - CMOS
  - SoI-CMOS
- High Power
  - GaAs MESFET (power amp & switches)
  - InGaAs/InAlAs HEMT and HBTs (50 GHz)
  - GaN/AlGaN (very high power amp)