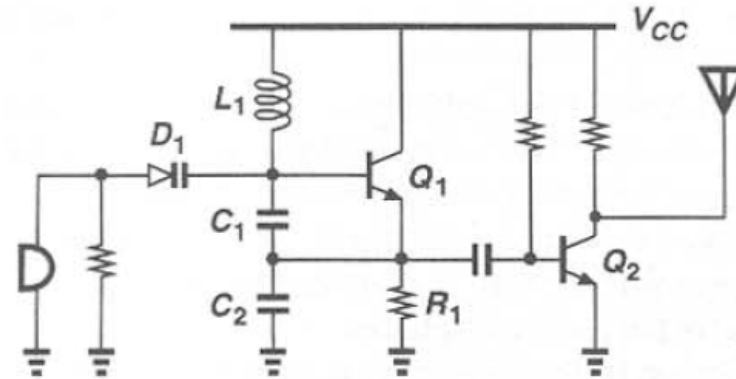


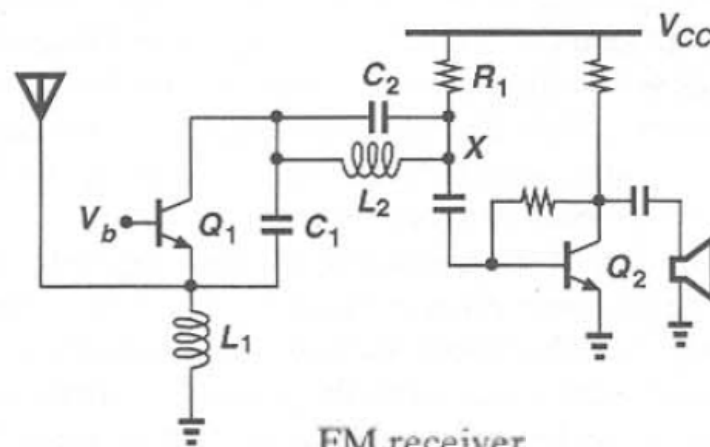
Introduction to RF and Wireless Technology

Complexity Comparison

- FM Transceiver as an old RF Design



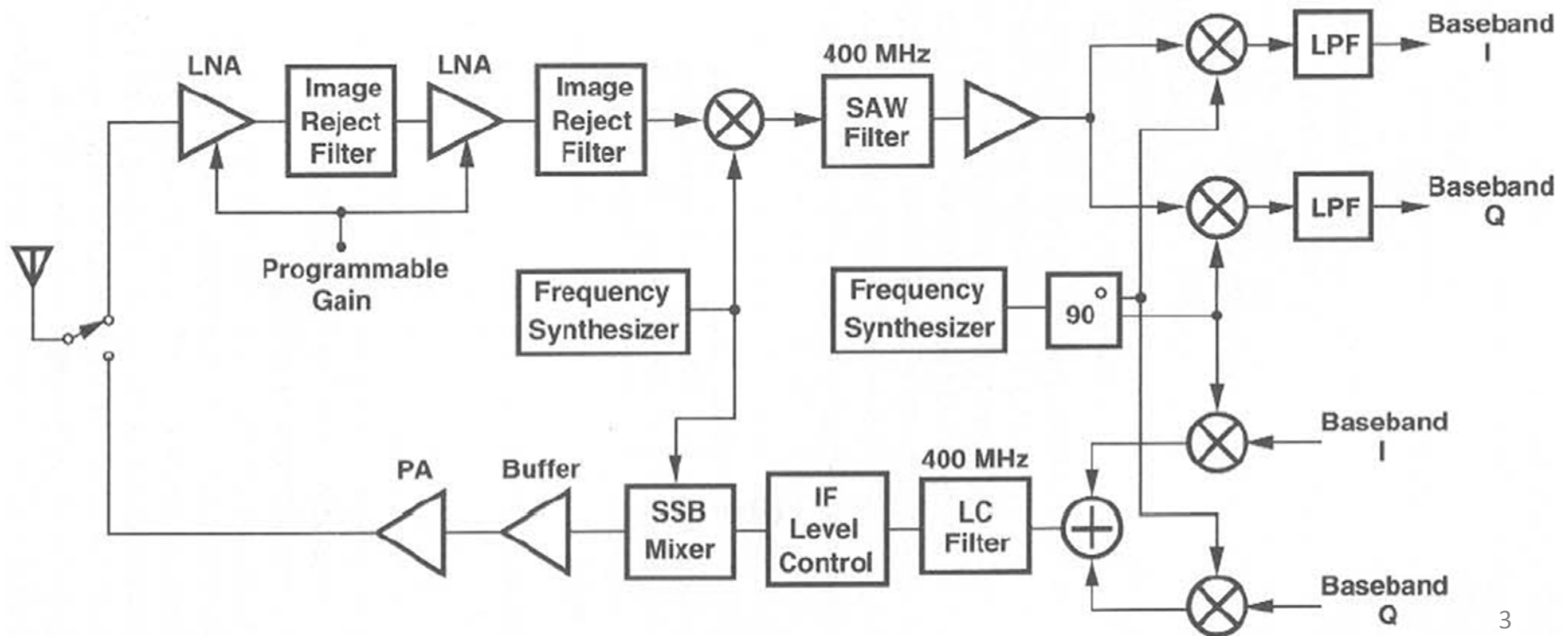
FM transmitter



FM receiver

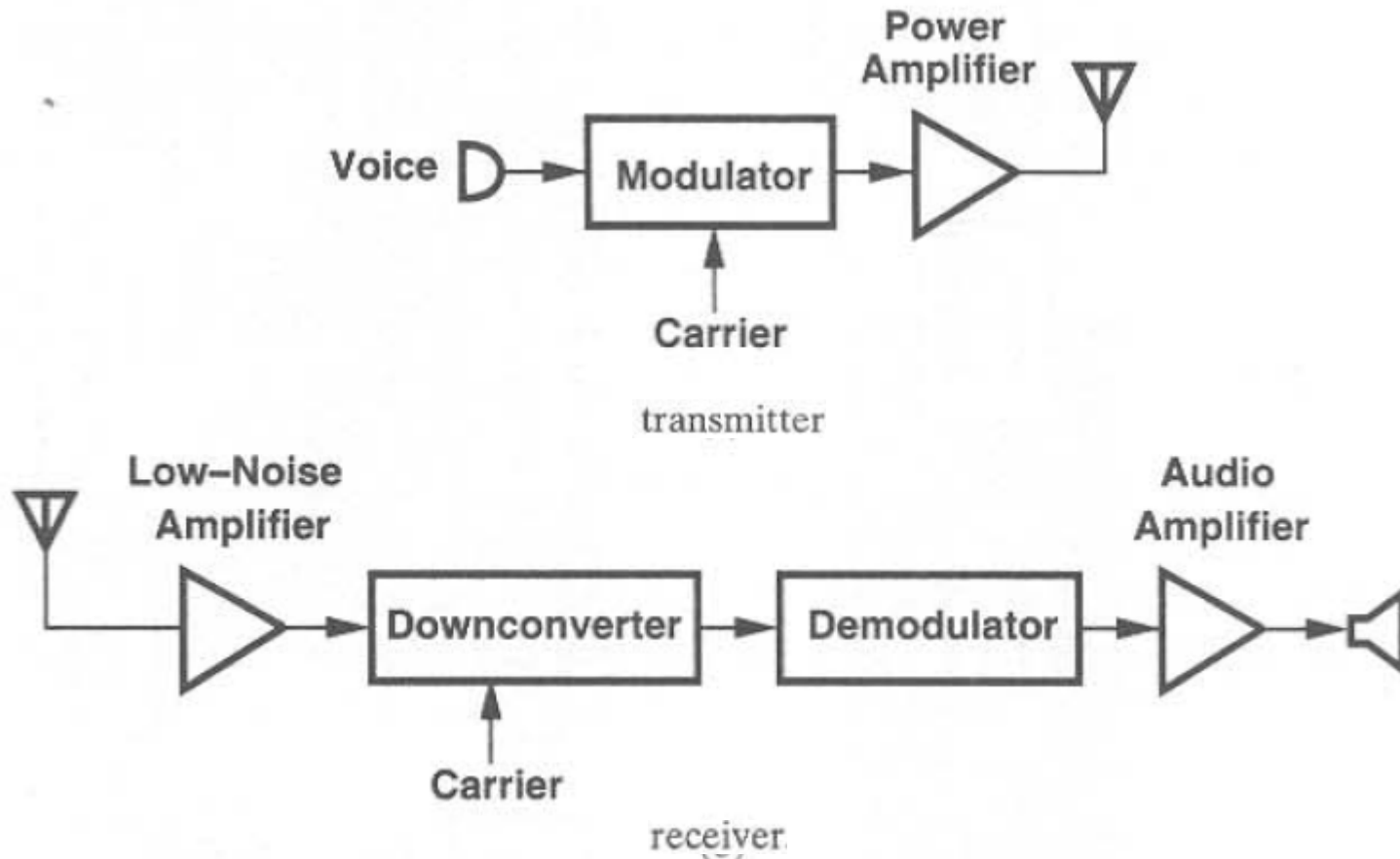
Complexity Comparison

- A cell-phone as a modern RF Design



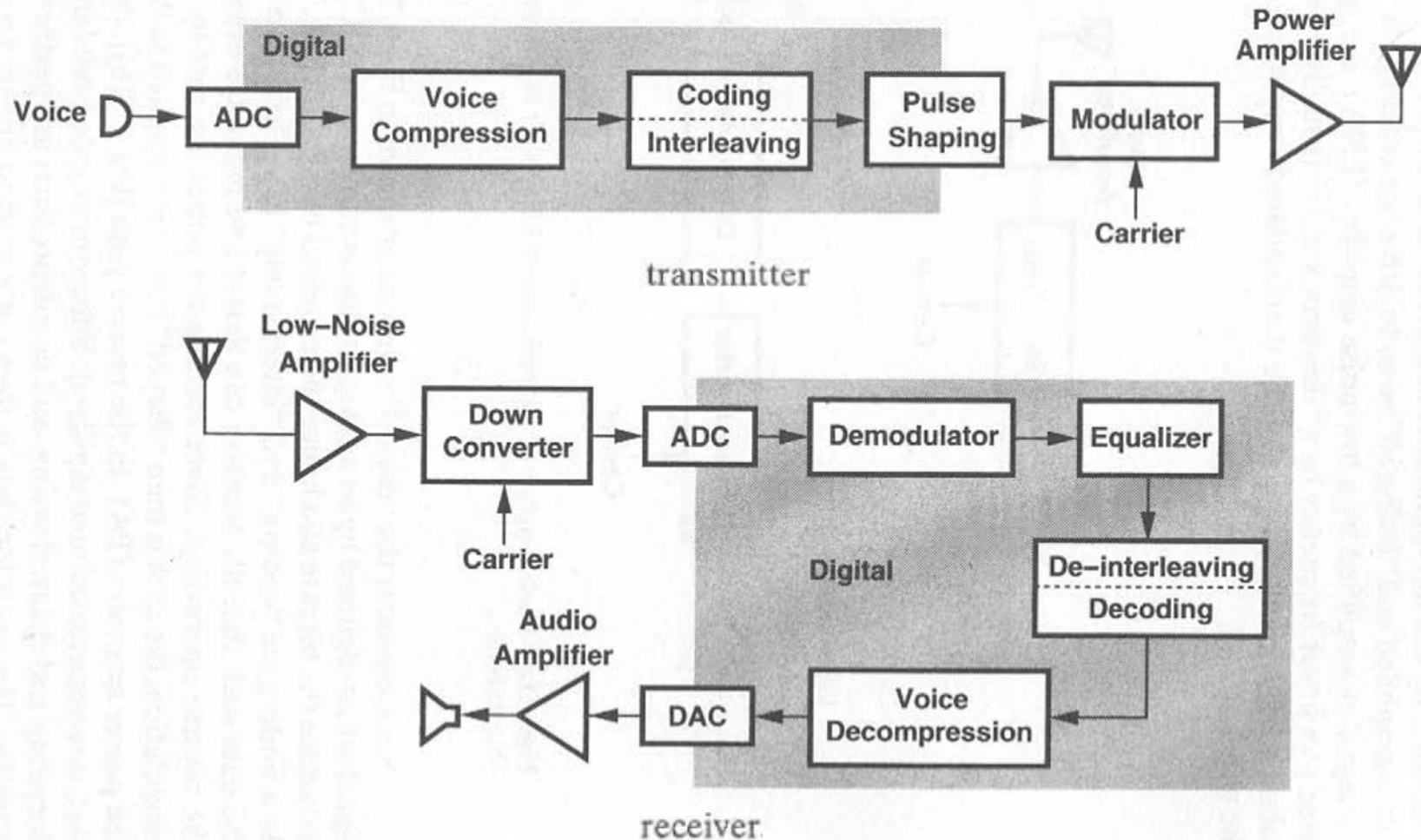
Analog and Digital Systems

- Block diagram of a generic **analog RF system**.

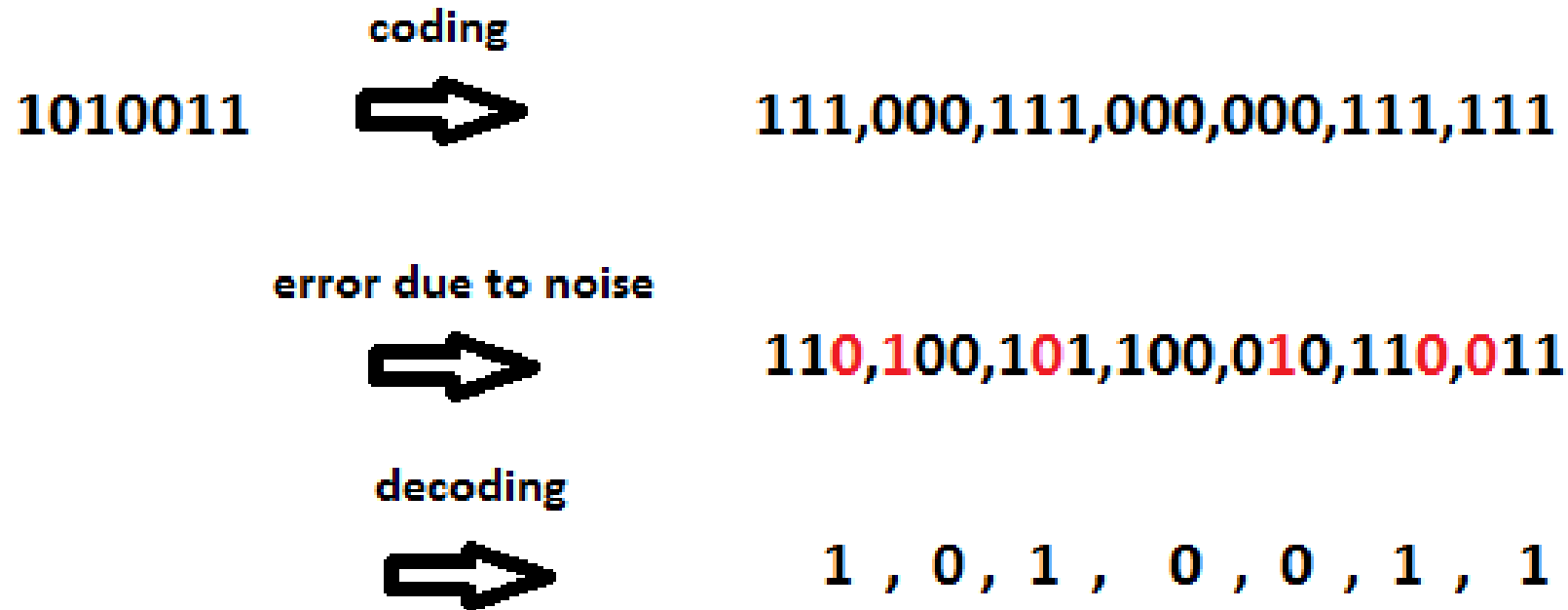


Analog and Digital Systems

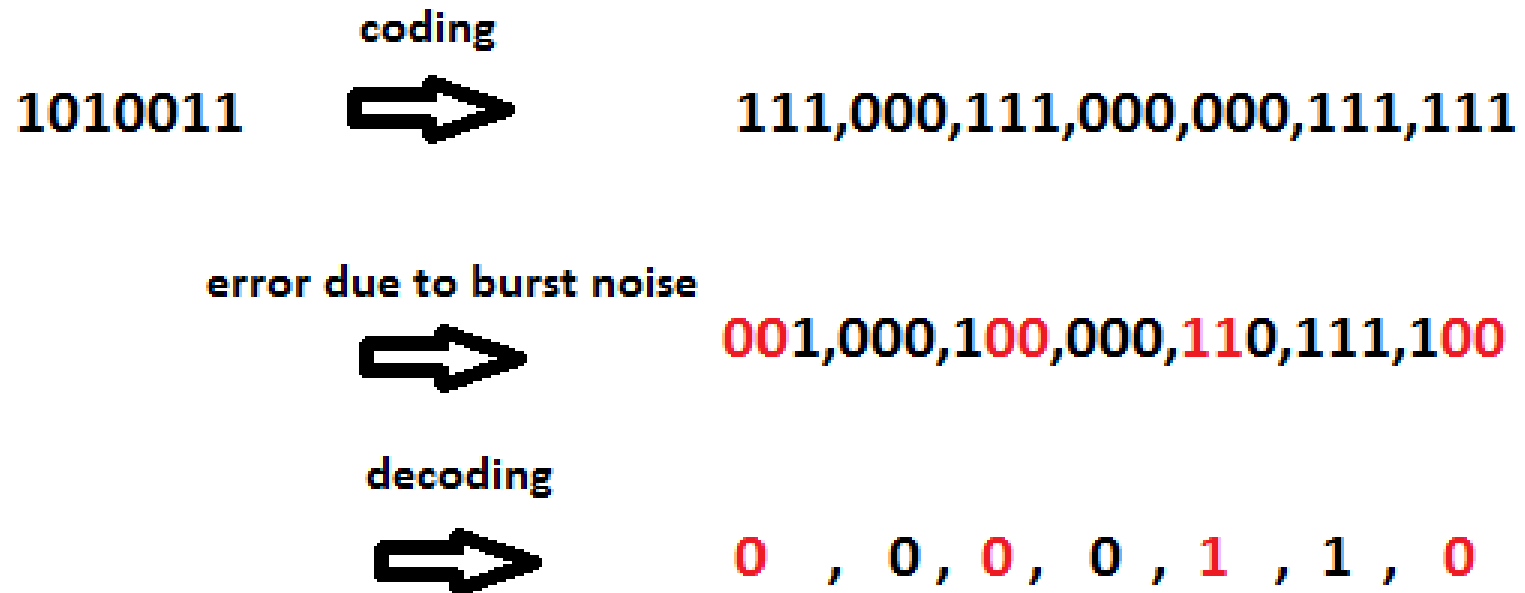
- Block diagram of a generic **digital RF system**.



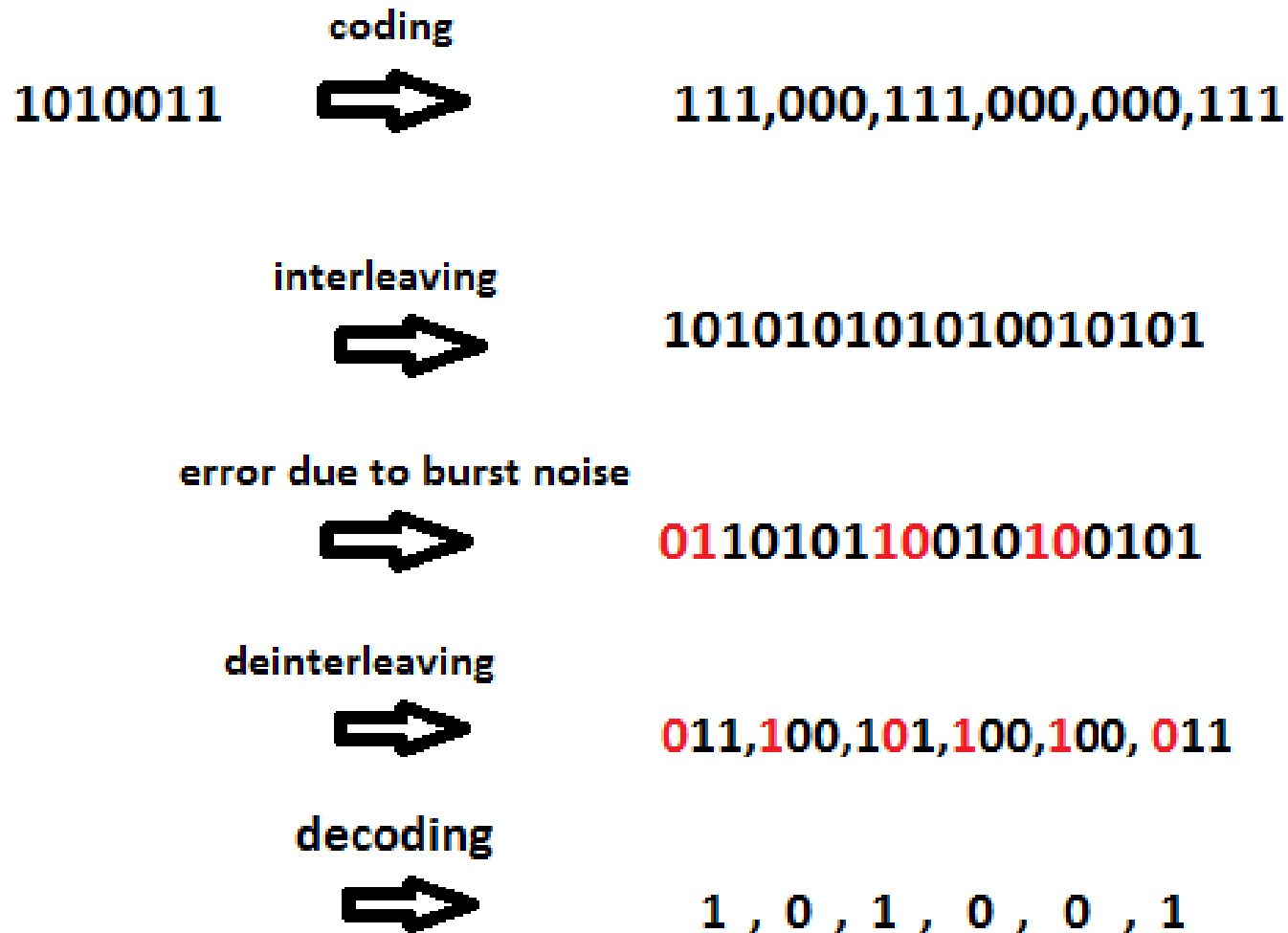
Coding/Decoding



Burst Noise

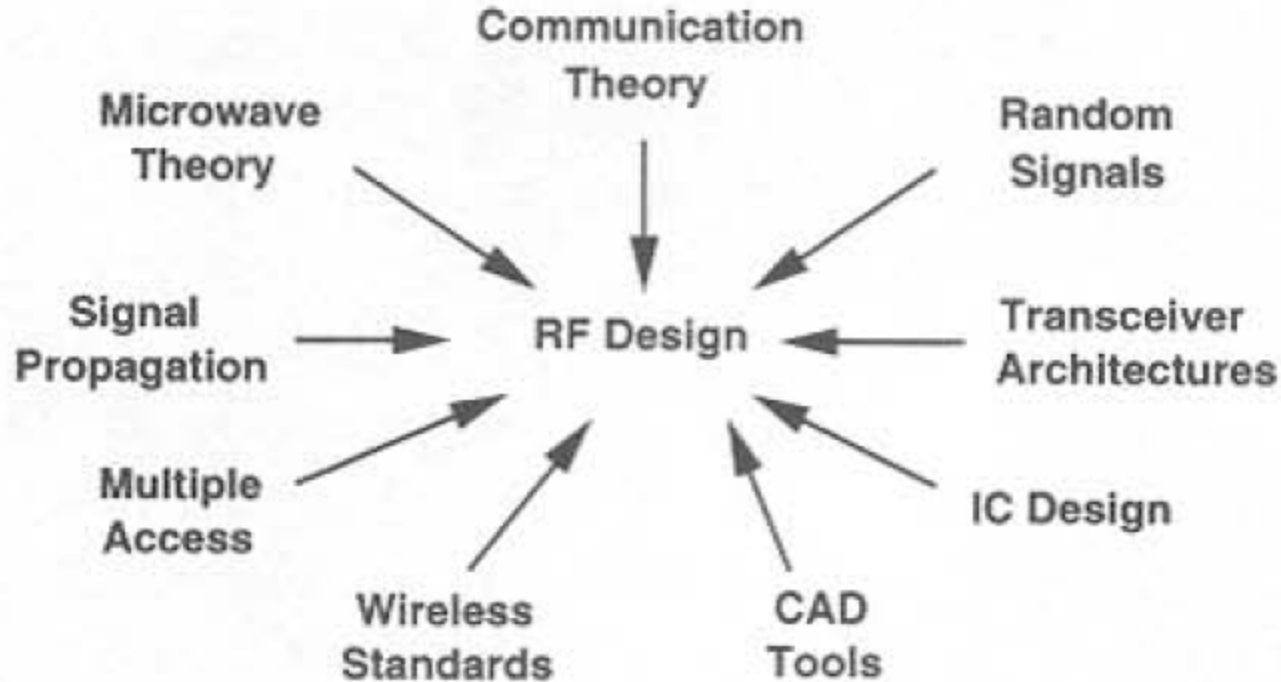


Interleaving/Deinterleaving



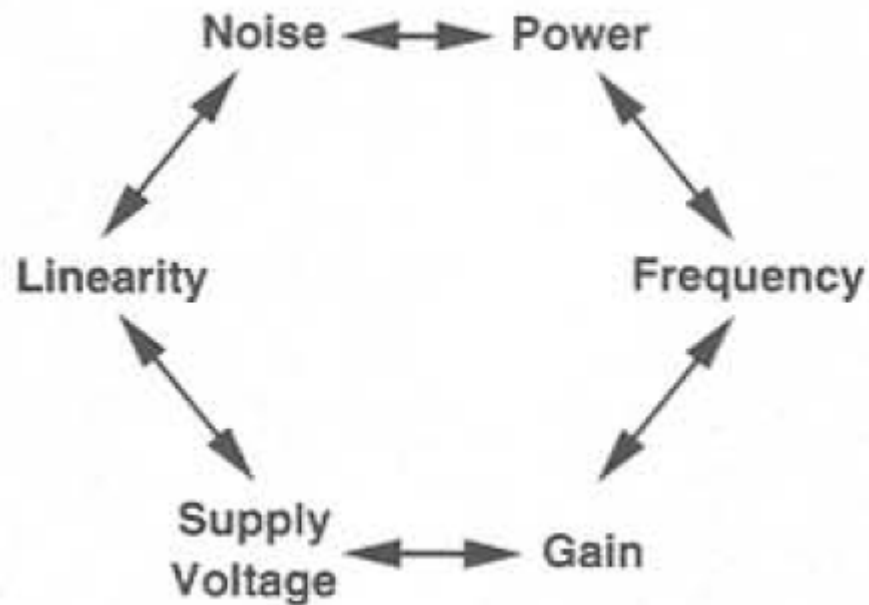
Design Bottleneck

- RF design is a **multidisciplinary field**.



Design Bottleneck

- **RF Hexagon** is another bottleneck.



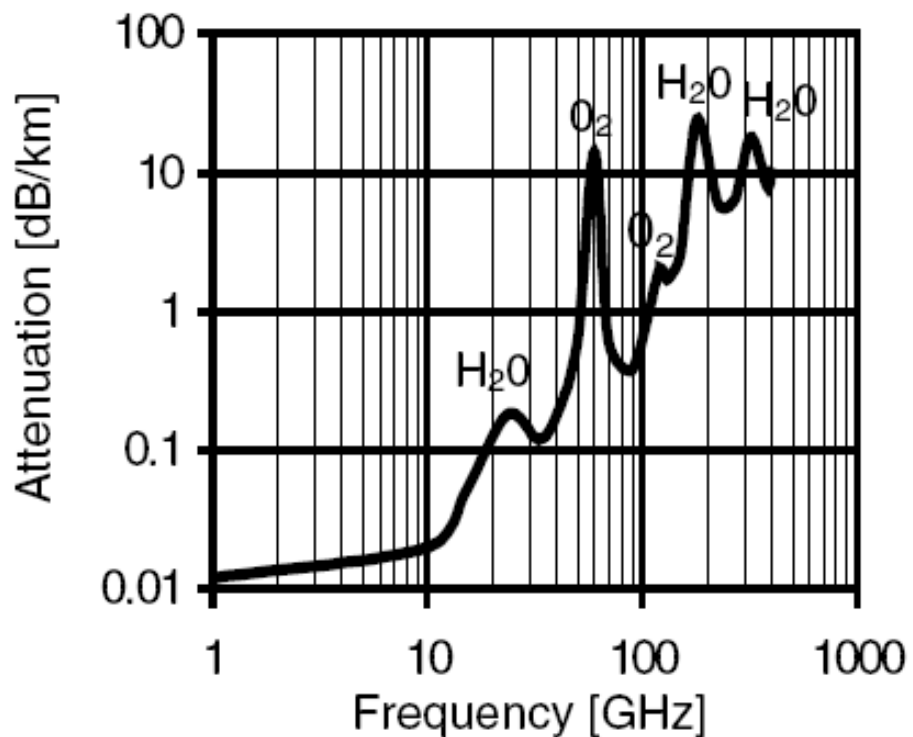
- **RF CAD Tools** are still infancy, forcing the designer to rely on experience.

RF Frequency Band

Microwave frequency allocations according to IEEE

Band	L	S	C	X	Ku	K	Ka	V	W
Frequency range	0.8–2 GHz	2–4 GHz	4–8 GHz	8–12 GHz	12–18 GHz	18–27 GHz	27–40 GHz	40–75 GHz	75–110 GHz

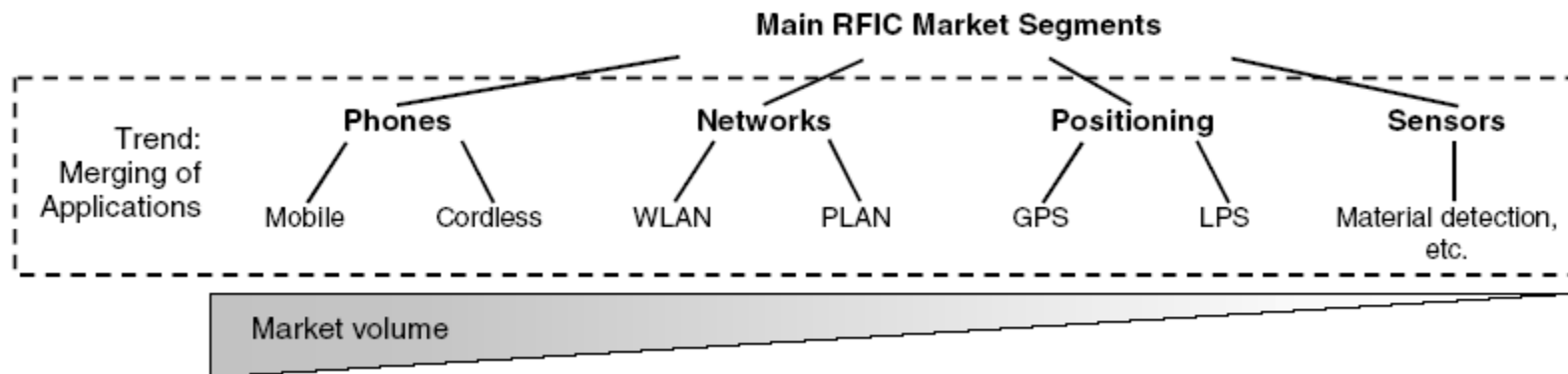
Air Propagation



Approximated free-air attenuation at sea level, $T=20\text{ }^{\circ}\text{C}$, $\text{H}_2\text{O}: 7.5\text{ g/m}^3$ [Fcc97]

RF Technology Applications and Markets

- Cellular Phones (Mobile Phones)
- WLAN
- GPS
- RFID
- Home Satellite Network



Overview of the most important wireless systems

Mobile Phones

Gen.	2G			2.5G		3G	
Name	GSM	PDC	IS95	GPRS	EDGE	CDMA 2000	UMTS
Mod.	GMSK	QPSK	QPSK	GMSK	8PSK	QPSK	QPSK
Max. DR	14.4 kbit/s	6.7 kbit/s	1.2–9.4 kbit/s	115 kbit/s	384 kbit/s	2 Mbit/s	2 Mbit/s
Freq.	0.9/1.8 GHz	0.9 GHz	1.9 GHz	0.9/1.8 GHz	0.9/1.8 GHz	2.4 GHz	2.4 GHz
Realistic data rate	9.6–14.4 kbit/s	6.7 kbit/s	1.2–9.4 kbit/s	20–50 kbit/s	60–150 kbit/s	144 kbit/s	144 kbit/s
Access mode	TDMA/ FDMA	TDMA/ FDMA	CDMA	TDMA/ FDMA	TDMA/ FDMA	CDMA	WCDMA
Main regions	Europe, worldwide	USA	USA, Canada, Asia	Europe, worldwide		USA, Asia	Europe, worldwide
Launch	1989	1990	1992	2001	2002	2002	2003
Market share 2005	~60% together with GPRS	~8%	~15%	60% to- gether with GSM	n.a.	1%	2%
Life-cycle	Decrease	Saturation	Growth/ saturation	Saturation	Development	Onset/growth	Onset
Strengths	1. Market size 2. Cash cow	-	1. Good chan- nel separation 2. Good posi- tion in USA and Asia	1. GSM com- patibility 2. Data rate	1. High data rate 2. GSM com- patibility	1. Very high data rate 2. Good starting posi- tion in USA and China	1. Top standard in Europe, very high data rate 2. Good starting position world- wide
Weak- nesses	1. Relative low data rate 2. Competition with 2.5G and 3G, decreasing market share	1. Low data rate 2. End of life-cycle	1. Relative low data rate 2. End of life- cycle	Life-cycle in- fluenced by launch of 3G	Life-cycle in- fluenced by launch of 3G	1. Competition with UMTS, no chances in Europe 2. High infrastructure costs	1. Extremely high license costs in Europe 2. Competition with CDMA2000 in USA and China 3. High infrastructure costs

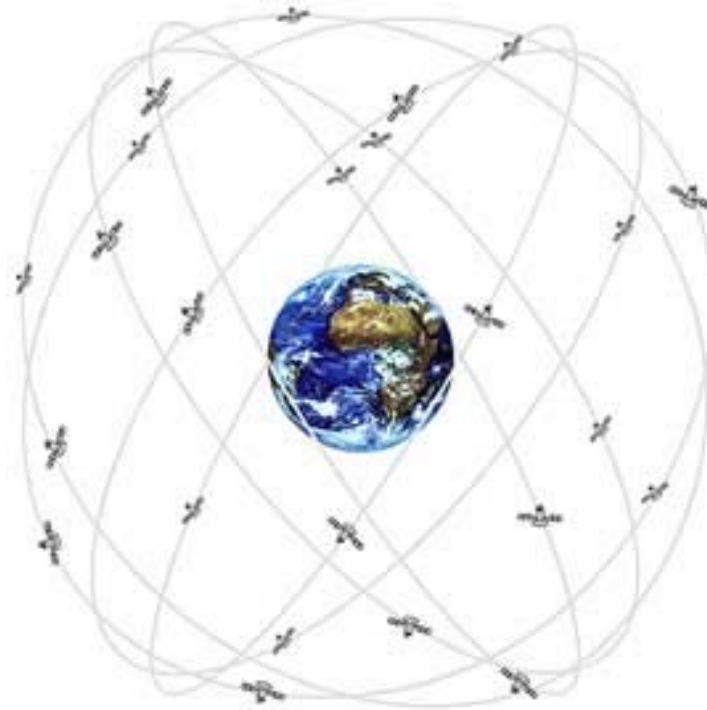
Mod.: modulation, DR: data rate, GMSK: Gaussian Minimum Shift Keying, QPSK: Quadrature Phase Shift Keying, 8PSK: Eight Times Phase Shift Keying

Wireless Networks

Type	WLAN			WPAN		
Group	802.11 (WiFi)			Bluetooth	UWB	
Sub-group	a	b	g		Multicarrier	Im-pulse
Modulation/spreading	BPSK/OFDM	QPSK/CCK	OFDM/CCK	GFSK/DSFH	PSK/OFDM	PPM/n.a.
Frequency band	5.15–5.35/5.725–5.825 GHz	2.4–2.483 GHz	2.4–2.483 GHz	2.4–2.483 GHz	3.1–10.6 GHz	
					Multiband	-
Maximum emitted power	1 W	1 W	100 mW/1 W	1 mW/100 mW	0.5 mW	
Max. data speed	54 Mb/s	11 Mb/s	54 Mb/s	0.7 Mb/s	110–200 Mb/s	
Max. coverage range	50–100 m	100 m	100 m	10 m/100 m	10 m	
Market launch	2001	1999	2005	2003	2002 (USA) 2005 (Europe)	
Recent life cycle status	Growth	Growth/saturation	Growth	Growth	Development	
Complexity and costs	High	Moderate	High	Low	High	Very low
Power consumption	High	Moderate	High	Low	Low	Very low
Standardisation	IEEE	IEEE	IEEE	1.2	Draft IEEE 802.15.3a	

PSK: Phase Shift Keying, BPSK: Binary PSK, QPSK: Quadrature PSK, GFSK: Gaussian Frequency Shift Keying, CCK: Complementary Code Keying, OFDM: Orthogonal Frequency Division Multiplexing, DSFH: Direct Sequence Frequency-Hopping

GPS (Global Positioning System)



Satellites orbiting around the earth for global positioning

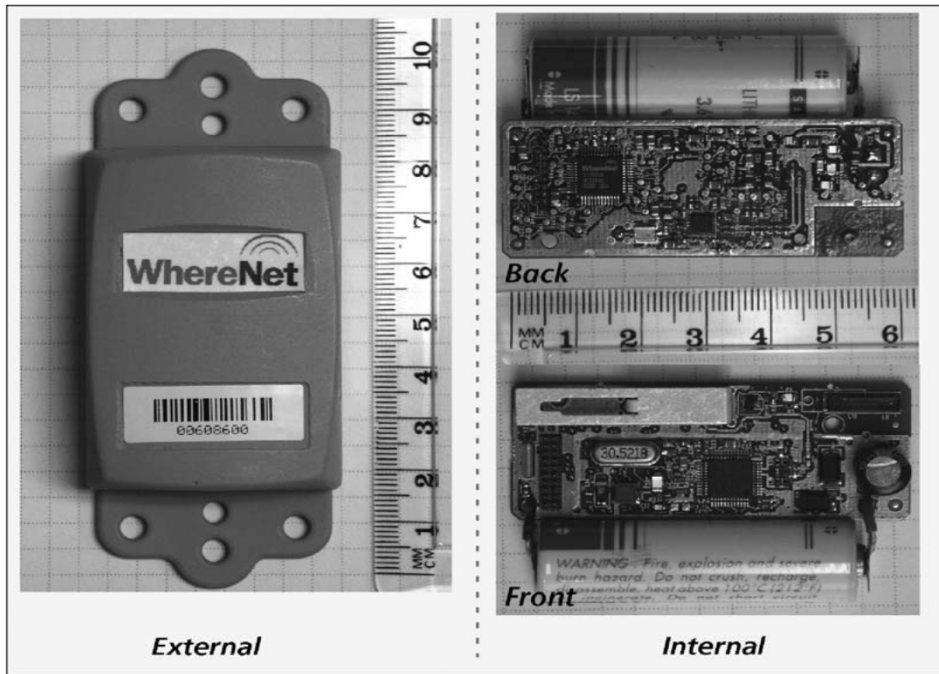
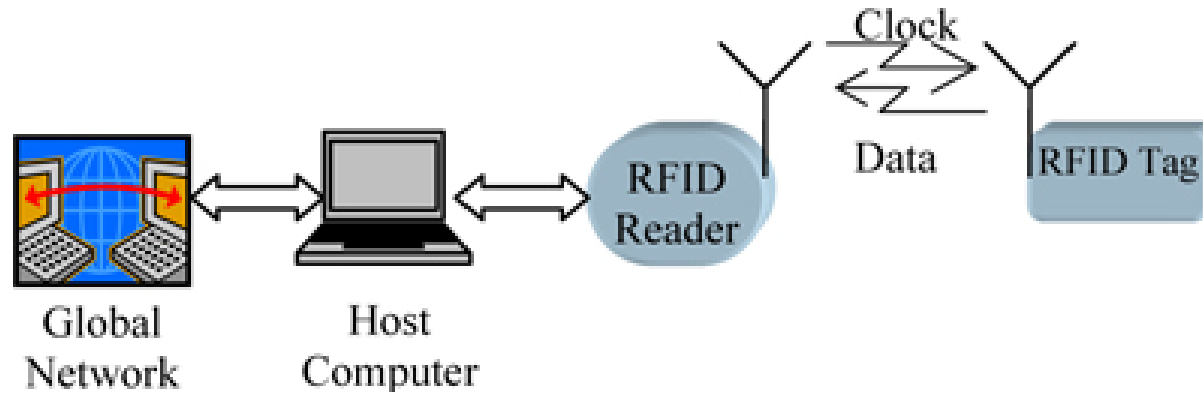


GPS Module

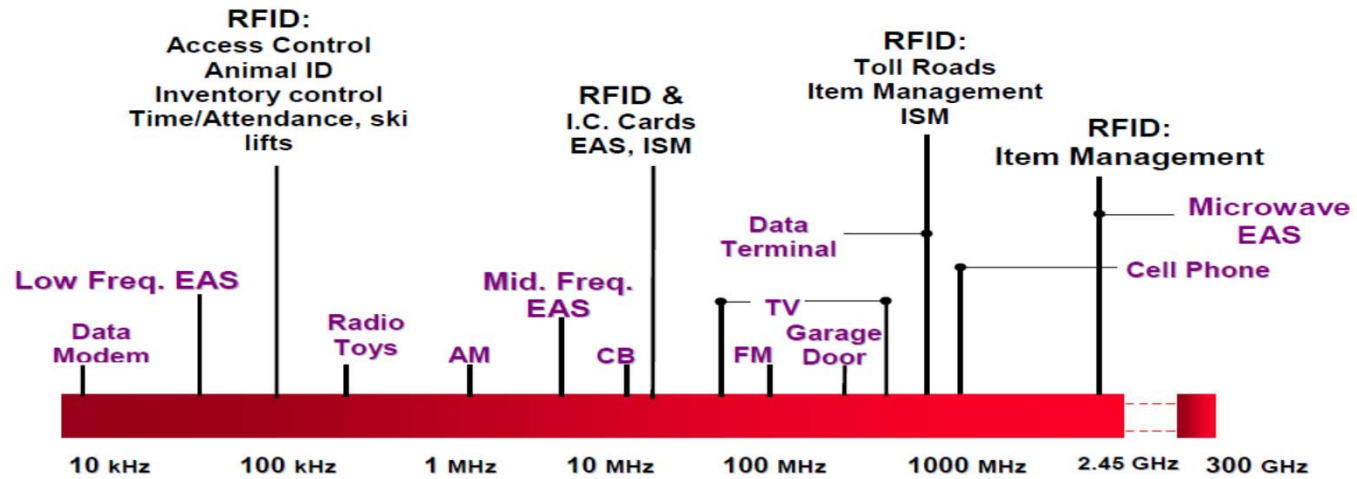


GPS Antenna

RFID (Radio Frequency Identification)



RFID



Commercial CAD Software

Simulations	Circuit design				EM Simulation	Device Modelling
Tool	ADS	Virtuoso Spectre	MW office	Genesys	HFSS	IC CAP
Supplier	Agilent	Cadence	AWR	Eagleware	Ansoft	Agilent
DC	Yes	Yes	Yes	Yes	No	Extraction of linear models
Small signal	Yes	Yes	Yes	Yes	Yes	
Linear noise	Yes	Yes	Yes	Yes	No	
Transient	Yes	Yes	Yes	Yes	No	Extraction of nonlinear models based on linear data arrays
Harmonic balance	Yes	Possible via ADS	Yes	Yes	No	
Nonlinear noise	Yes	Yes	Yes	Yes	No	
Envelope	Yes	Yes, by using harmonic balance				-
Mixed mode	Yes	Yes	No	Yes	No	-
EM	Yes, 2.5D	No	No	Yes, 3D	Yes, 3D	-
DRC	Yes	Yes	Yes	Yes	-	-
LVS	Yes	Yes	Yes	e.g. via MW office	-	-
Unix	Yes	Yes	No	No	Yes	Yes
PC	Yes	No	Yes	Yes	Yes	Yes
Parameter extraction	No					Yes
Layout editor	Yes					
Major application	Analogue, RFIC	Mixed signal, digital	Analogue, RFIC	Analogue, RFIC	EM simulation of passive devices	Device modelling

MW: Microwave, EM: Electromagnetic