Microwave

Assit.Prof. Nipapon Siripon

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- Objective of communication systems is
  - To transmit high quality voice video and data between users separated by a few meters or thousands of kilometers
- The distance between sites to be connected determines the type of transmission equipment, which can be Metalic wires, Optic fiber, Microwave radio link or Satelllite

2

History of Microwave Engineering

- The field of microwave engineering, as well as other areas of applied electromagnetics, is referred to as "nature discipline" because of fact that the fundamental concepts of electronmagnetics were laid by Jame Clark Maxwell in 1873, and probably because of radar, being the first major application of microwave , was intensively developed during World War II.

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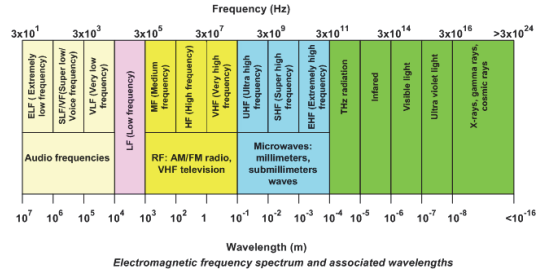
Frequency Spectrum



Electromagnetic frequency spectrum and associated wavelengths

4

Frequency

- Microwave refers to the alternating current signals with frequency between 300MHz ($3x10^8$ Hz) and 300GHz ($3x10^{11}$ Hz)

Frequency range	*Band Designations*
1-2GHz	L-Band
2-4GHz	S-Band
4-8GHz	C-Band
8-12GHz	X-Band
12-18GHz	Ku-Band
18-26GHz	K-Band
26-40GHz	Ka-Band
40-60GHz	U-Band

Wavelength $(\lambda) = \frac{C}{f} m$

Speed of lighth $(C) = 3x10^8 m/s$

5

Factors provide unique applications for microwave systems

- Antenna gain depends on the physical size at higher frquency
- More bandwidth can be realized at high frequency: 1% 0f 60GHz is 600MHz
- Microwave signals travel by line-of sight, and are not bent by ionoisphere as lower frequency signals, communication links with high capacities are thus possible
- The reflective area of radar target is usually proportion to the large 's electrical size
- Various molecular, atomic and nuclear resonatnces at microwave frequencies , creating a variety in the area of basic science, remote sensing, medical dianoistics and treatment, and cooking methods

Today major applications of microwaves are relates to radar and communication systems.

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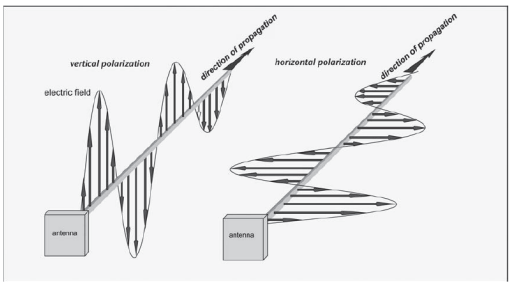

Figure 3.31: Linearly Polarized Radiation.

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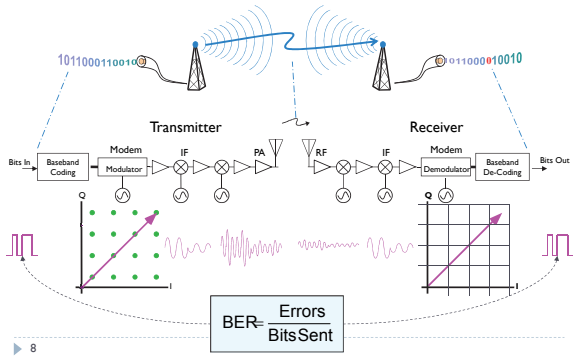
Example of Microwave System



$$BER = \frac{Errors}{Bits\,Sent}$$

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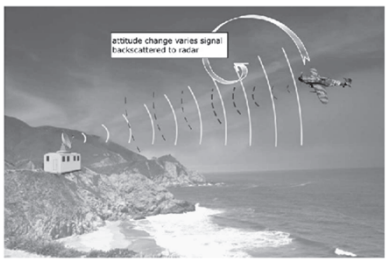
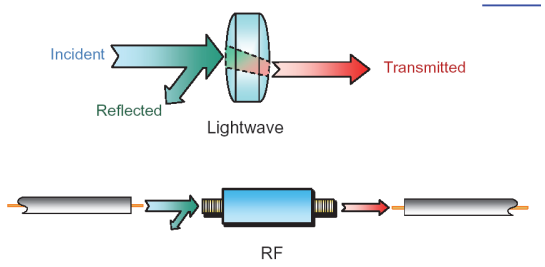


The Use of Backscattered Radiation to Communicate With a Radar Operator

9

Lightwave Analogy to RF Energy



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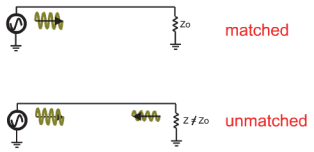

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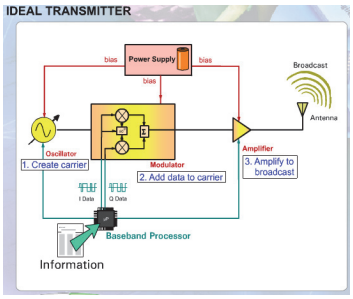

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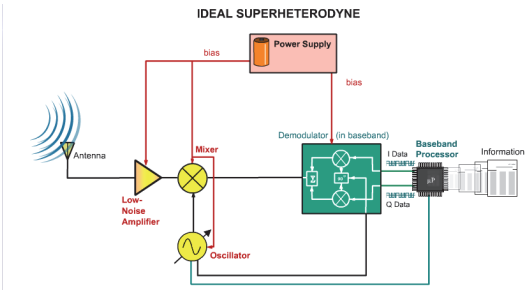

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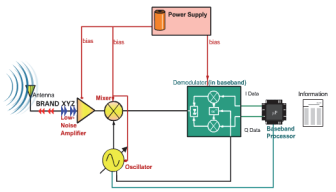
This aspect of high-frequency performance also explains why there are so few "drop-in" replacements in the RF world. It is very rare that devices with equivalent functionality from two different manufacturers will have impedances that are similar enough to allow the same impedance-matching circuitry to work effectively with both.



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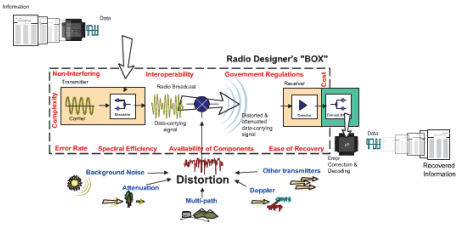
The real world is a little more complex than the situation we have presented so far. For a rea radio design, we have to account for distortion and the designer's box. The designer's box is made up of the technical, regulator and other considerations (like scalability and cost) that restrict a designer's product development options.



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Solar radiation produces background noise.

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Items in the transmission path, such as trees or walls, attenuate signals.

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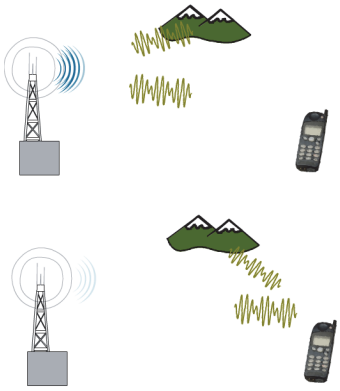
A non-directional signal may reach a receiver by more than one path, meaning out-of-phase copies of the information interact to cancel (create fades).



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If the transmitter and receiver are moving quickly relative to each other, you cannot use the trick of sending known information to characterize the transmission channel; the channel will change too quickly.

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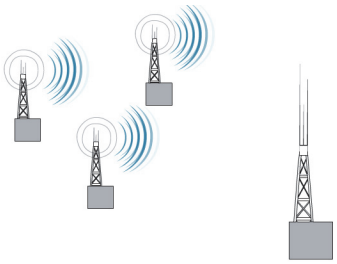
Other transmitters may be present, and create interfering signals.



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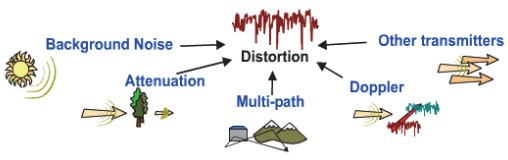
All these effects interact with our broadcast information-carrying signal, and have to be corrected at the receiver.



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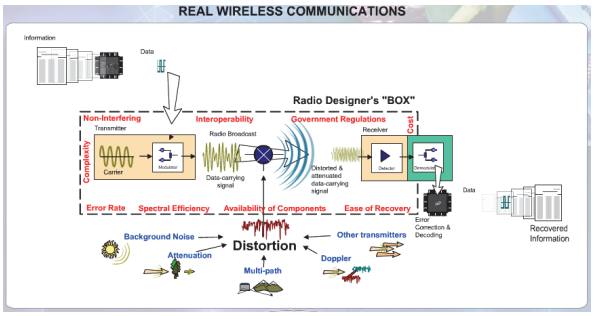
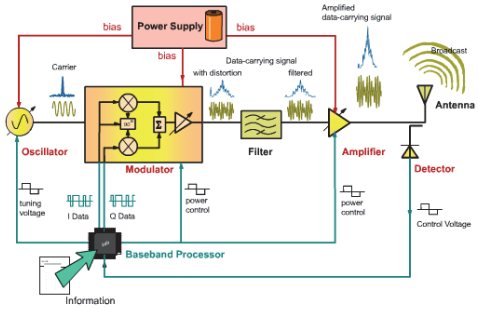
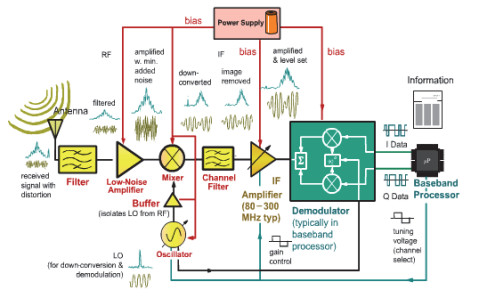

REAL WIRELESS COMMUNICATIONS
Information
Data
Radio Designer's "BOX"
Non-Interfering
Interoperability
Government Regulations
Cost
Complexity
Transmitter
Receiver
Radio Broadcast
Carrier
Modulator
Data-carrying signal
Distorted & attenuated data-carrying signal
Detector
Demodulator
Error Correction & Decoding
Error Rate
Spectral Efficiency
Availability of Components
Ease of Recovery
Background Noise
Attenuation
Distortion
Multi-path
Other transmitters
Doppler
Recovered Information

22


bias
Power Supply
bias
bias
Amplified data-carrying signal
Carrier
Data-carrying signal with distortion
Data-carrying signal filtered
Broadcast
Antenna
Oscillator
Modulator
Filter
Amplifier
Detector
tuning voltage
I Data
Q Data
power control
power control
Control Voltage
Baseband Processor
Information

23


bias
Power Supply
RF
amplified w. min. added noise
IF
bias
amplified & level set
bias
Information
Antenna
filtered
down-converted
image removed
I Data
Filter
Low-Noise Amplifier
Mixer
Channel Filter
IF Amplifier (80 – 300 MHz typ)
Demodulator (typically in baseband processor)
Baseband Processor
Q Data
received signal with distortion
Buffer
(isolates LO from RF)
tuning voltage (channel select)
Oscillator
LO
(for down-conversion & demodulation)
gain control

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References:

Agilent Technologies

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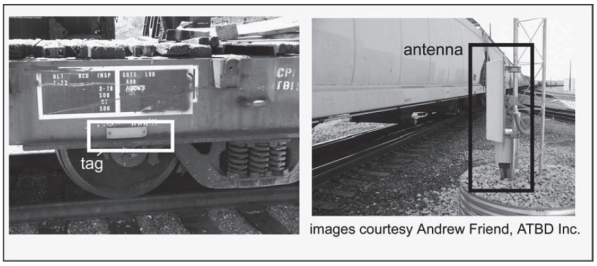

Figure 2.7: Example of Typical Passive Tag and Reader Antenna for Identification of Railcars.

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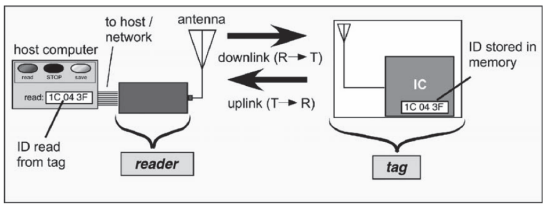

Figure 2.8: Overview of RFID System.

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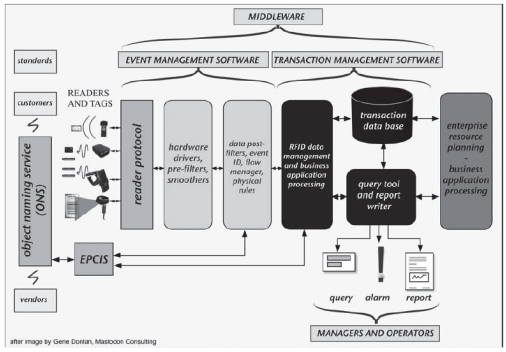

Figure 2.9: RFID as a Sensor Within an Overall Software Infrastructure.

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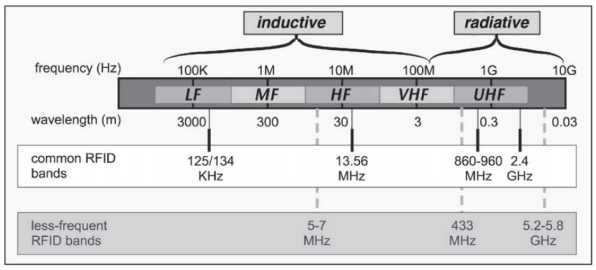

Figure 2.10: RFID Frequency Bands.

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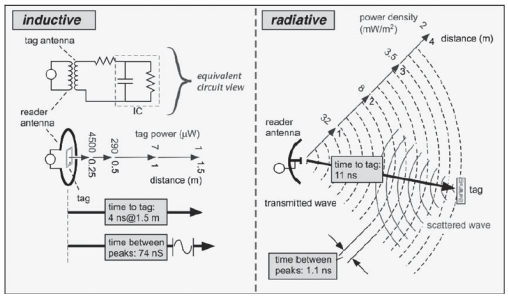

Figure 2.11: Inductive Coupling (13.56 MHz, 50 cm diameter antenna) vs. Radiative Coupling (900 MHz), With Associated Power and Time Delays.

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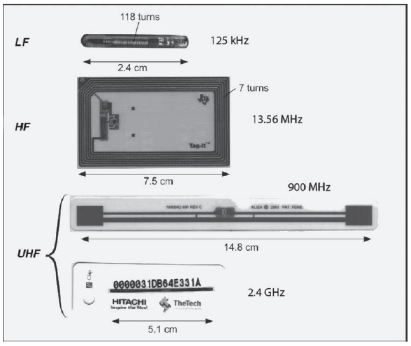

Figure 2.14: Examples of Tag Antenna Configuration Designed for Different Operating Frequencies.

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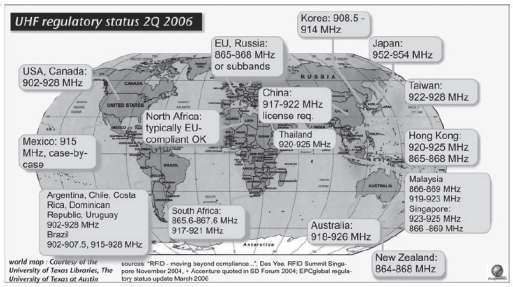

Figure 2.15: Capsule Summary of Worldwide UHF RFID Band Allocations.

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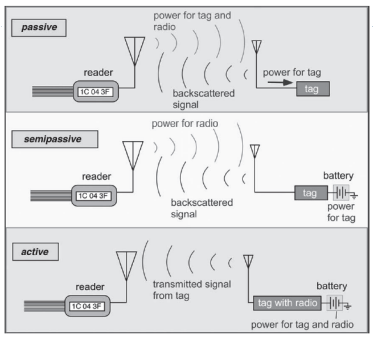

Figure 2.16: Options for Tag Power/Transmit Configuration.

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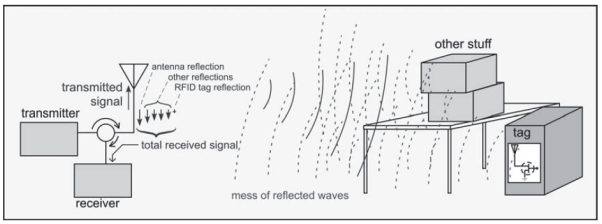

Figure 3.16: Realistic Environments Create Many Reflected Waves in Addition to that from the Wanted Tag.

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Specific Absorption Rate (SAR) for Cellular Telephones

Working closely with federal health and safety agencies, such as the Food and Drug Administration (FDA), the FCC has adopted limits for safe exposure to radiofrequency (RF) energy. These limits are given in terms of a unit referred to as the Specific Absorption Rate (SAR), which is a measure of the amount of radio frequency energy absorbed by the body when using a mobile phone. The FCC requires cell phone manufacturers to ensure that their phones comply with these objective limits for safe exposure. Any cell phone at or below these SAR levels (that is, any phone legally sold in the U.S.) is a "safe" phone, as measured by these standards. The FCC limit for public exposure from cellular telephones is an SAR level of 1.6 watts per kilogram (1.6 W/kg).

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Specific Absorption Rate (SAR) For Cell Phones: What It Means For You

SAR is a measure of the rate of RF (radiofrequency) energy absorption by the body from the source being measured – in this case, a cell phone. SAR provides a straightforward means for measuring the RF exposure characteristics of cell phones to ensure that they are within the safety guidelines set by the FCC.

SAR values are an important tool in judging the maximum possible exposure to RF energy from a particular model of cell phone, a single SAR value does not provide sufficient information about the amount of RF exposure under typical usage conditions to reliably compare individual cell phone models the SAR values collected by the FCC are intended only to ensure that the cell phone does not exceed the FCC's maximum permissible exposure levels even when operating in conditions which result in the device's highest possible – but not its typical - RF energy absorption for a user.

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Wireless Devices and Health Concerns

All wireless devices sold in the US go through a formal FCC approval process to ensure that they do not exceed the maximum allowable SAR level when operating at the device's highest possible power level. If the FCC learns that a device does not confirm with the test report upon which FCC approval is based – in essence, if the device in stores is not the device the FCC approved – the FCC can withdraw its approval and pursue enforcement action against the appropriate party.

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What You Can Do

Even though no scientific evidence currently establishes a definite link between wireless device use and cancer or other illnesses, and even though all cell phones must meet established federal standards for exposure to RF energy, some consumers are skeptical of the science and/or the analysis that underlies the FCC's RF exposure guidelines.

Some measures to reduce your RF exposure include:

•Use a speakerphone, earpiece or headset to reduce proximity to the head (and thus exposure). While wired earpieces may conduct some energy to the head and wireless earpieces also emit a small amount of RF energy, both wired and wireless earpieces remove the greatest source of RF energy (the cell phone) from proximity to the head and thus can greatly reduce total exposure to the head.

•Increase the distance between wireless devices and your body.

•Consider texting rather than talking - **but don't text while you are driving**.

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