Wi-Fi For Beginners Module 2

RF Basics

Introduction

Hello, my name's Nigel Bowden. Welcome to module 2 of the WiFi for beginners podcast. This is a series of podcasts discussing the fundamentals of wireless LAN networking.

In each episode, we'll take a look at a different aspect of WiFi to build your understanding and knowledge of wireless LAN networks.

Each episode is be accompanied by a set of slides describing the topics covered in that episode. Although you don't need to review these slides whilst listening to the podcast, they will be useful for reviewing the material we discuss and may provide some visual aids to more fully understand some of the concepts and equipment described.

All recordings and supporting material can be found at WiFiForBeginners.com

Aims of Podcast Series

- Present the fundamentals of WiFi in a series of audio presentations
  - Hopefully in an easy-to-understand format
  - Useful to those on a daily commute, driving, running etc.
- Who is it aimed at?
  - Most likely IT professionals, students, people interested in career move
- Assumed knowledge:
  - Fundamentals of the 7 layer OSI model
  - Ethernet, switching and routing
  - IP addressing
  - Local Area Networks (LAN)
  - You have reviewed previous episodes! :)
- WiFi in commercial/professional environment - not home

Who Am I?

- Nigel Bowden
- UK Based
- IT Industry for 30+ years
- Specializing in Wireless LANs for 5+ years
- Industry certifications:
  - CWNP: Certified Wireless Network Expert (CWNE #135)
  - Cisco CCNP R&S
  - Cisco CCNP Wireless
  - Miscellaneous other vendor specific certs
- Roles: Design, Consultancy & Deployment of WLANs (mainly Cisco)
- Prolific social media participant:
  - @WiFiNigel (Twitter)
  - WiFiNigel.blogspot.com (Blog)

In This Module

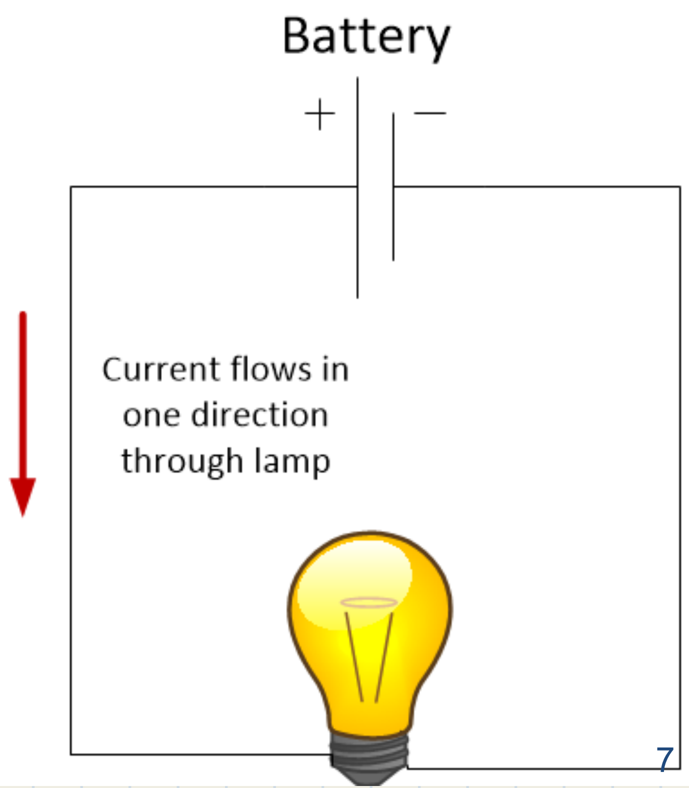
- What is RF?
- Electromagnetic Signals
- The RF Spectrum
- RF Concepts
  - Coverage area
  - Propagation
  - Modulation
- RF Behaviour
- WiFi Bands

What is “RF”?

- "RF" abbreviation for Radio Frequency
  - common term used when discussing wireless LANs
- Refers to electrical (electromagnetic) signals that are propagated through space
- Radio Frequency signals are used to enable a whole range of communications:
  - Commercial radio (“FM” stations, “AM” stations)
  - Satellite communications
  - Emergency services radio communications
  - Cell phones
  - TV
  - WiFi
  - Bluetooth headsets, mice, keyboards etc.

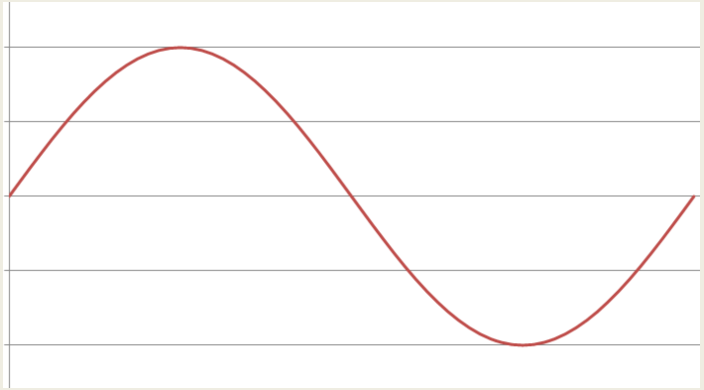
What is “RF”?

- An Radio Frequency signal is a “high frequency alternating current”
- Analysis:
  - Connect a lamp to a battery, light is created by “direct current” flowing between the terminals of the battery
  - Current flows in one direction from positive to negative terminals

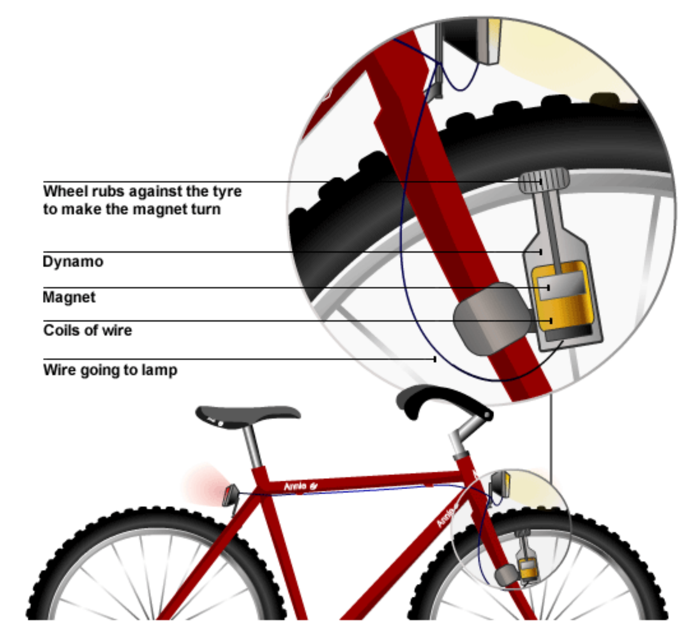


What is “RF”?

- Analysis:
  - Sending electric current over distance an issue, alternating current (AC) found to be more useful
  - AC created when using a generator or dynamo



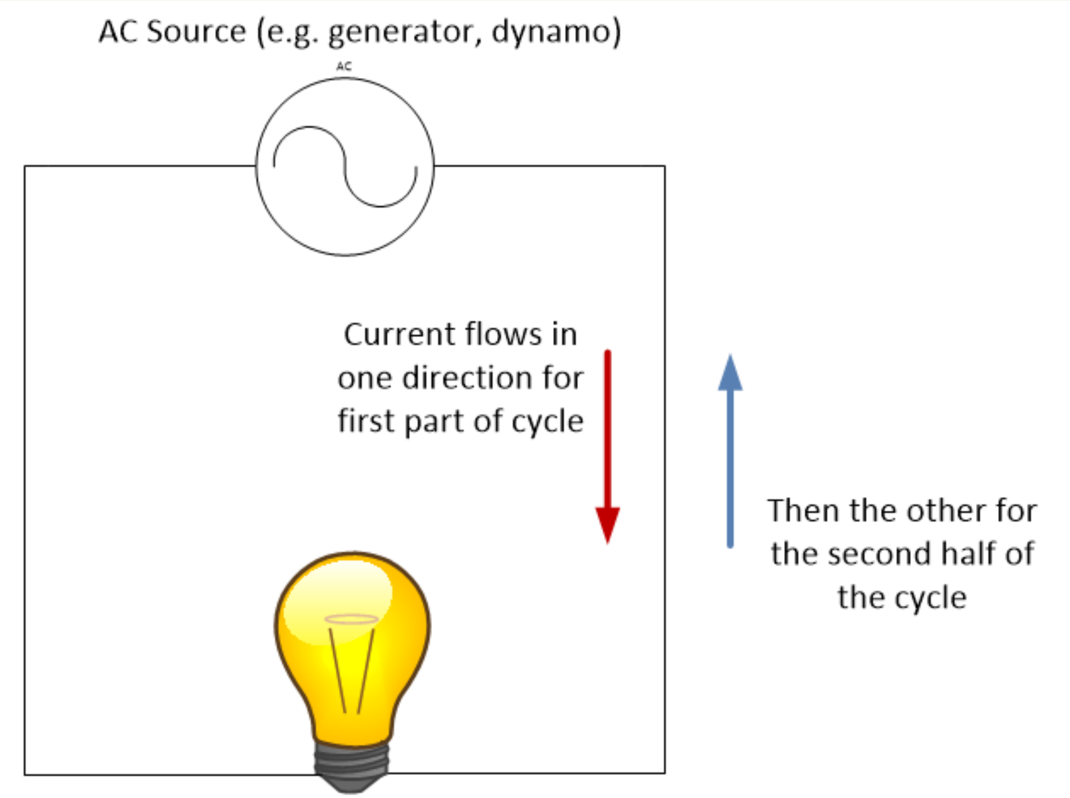
Alternating Current - Sine Wave



Alternating Current

- AC created when using a generator or dynamo
- Current direction regular reverses as the coils of a generator rotate in magnetic field
- Each time current alternates from one direction and then back again : one cycle
- By rotating generator faster, polarity shifts back and forth (cycles) increase - this is the “frequency” if the alternating current

Alternating Current

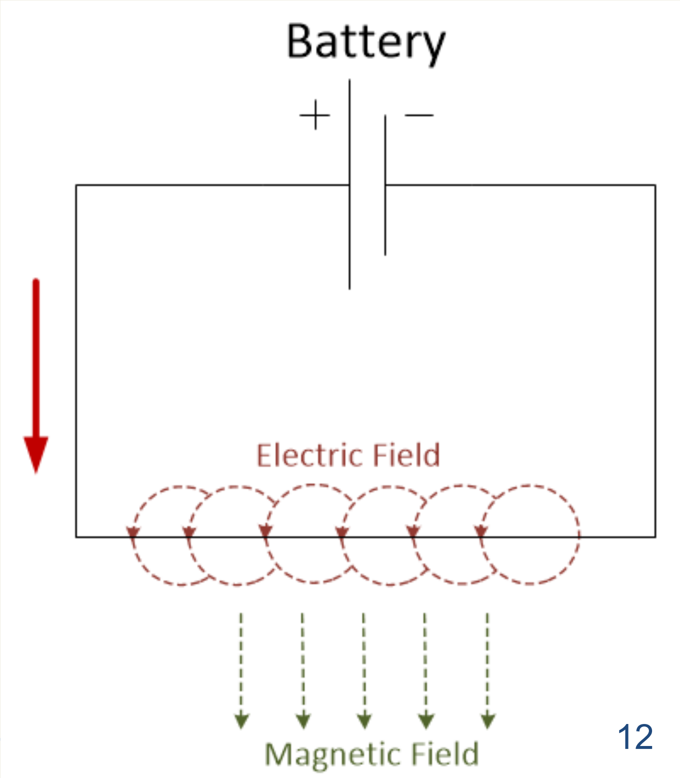


Alternating Current

- If we have a cycle of current change each second, this is known as a frequency of 1Hertz (Hz)
  - 10 cycles back and forth per second is 10 Hz
- If we raise this to 50 times per second, we get 50Hz - this is the frequency of our mains AC supply
- What has this got to do with radio, RF, or WiFi !!???

Electromagnetic Waves

- Good question: What has this got to do with RF?
- As DC current flows through a wire an electric and a magnetic field surrounds the wire
- As an AC electric current shifts back and forth
  - fields are constantly ebbing and flowing as the current changes direction - “electromagnetic” field



Electromagnetic Waves

- If we can keep increasing the frequency, at a certain frequency, the electromagnetic field will break free of the conductor and travel through space - electromagnetic waves
    - several thousand cycles per second
- We now have a radio frequency signal - the electric signal is no longer constrained by the electrical conductor - “wireless” signal
- We don't use mechanical generator to create electromagnetic signal - use electronic circuit (oscillator)

Electromagnetic Waves

- Frequency units
- Basic unit of measurement: 1 cycle per second = 1 Hertz (Hz)
- Multipliers:
  - 1,000 Hz = 1KiloHertz (KHz)
  - 1,000,000Hz = 1MegaHertz (MHz)
  - 1,000,000,000Hz = 1GigaHertz (GHz)
- WiFi networks operate in the Gigahertz range:
  - 2.4GHz
  - 5GHz

Radio Frequency Spectrum

- As we increase the frequency of the signal, its characteristics change e.g. distance
- We can vary the frequency of our signal from very low frequencies e.g. a few tens of KHz, up to many thousands of millions of Hertz where WiFi networks operate
- This range of frequencies that are available is known as the radio frequency spectrum - range of available radio frequencies available
- One key characteristic that changes as we increase frequencies is the distance that a signal can travel and be received by a receiving stations

Radio Frequency Spectrum

- Radio frequency divided up (for reference) into convenient chunks, which have varying characteristics and are suitable for differing services
- Low Frequency (Long Wave): 30 - 300KHz
  - travel very long distances around the surface of the earth
  - talk stations, submarine communications
- Medium Frequency (Medium wave): 300 - 3000 KHz
  - coverage country or state wide (depends on power level)
  - AM radio stations, low quality music

Radio Frequency Spectrum

- Short Wave/High Frequency 3 - 30MHz
    - Interact with ionosphere so that instead of RF signals travelling out into space, they are reflected back down to earth - provides hop (or multiple hops) over large distances
    - Military, some commercial, Ham radio
- Very High Frequency (VHF): 30 - 300MHz
    - Distance covered generally around neighbourhood, town/city
    - FM radio stations, emergency services

Radio Frequency Spectrum

- Ultra High Frequencies: 300 - 3000MHz
  - Distances of few hundred feet to tens of miles (power dependant)
  - Diffculty passing through obstructions (e.g. buildings)
  - TV broadcasts, cellular phones, wireless LANs, Bluetooth, (microwave ovens)
- Super High Frequencies - 3GHz - 30GHz
  - Distances become very limited and penetration of obstructions very problematic
  - Radar systems, satellite TV, wireless LANs

Concept: Coverage Area

- Coverage area:
  - Signal transmitted from a transmitting station may be received at various distances
  - Depends on frequency (AM station vs cell tower)
  - Depends on transmit power
- Area in which receiving stations can successfully receive and “understand” the signal is the coverage area
- May be many miles, may be a few feet

Concept: Propagation

- Propagation:
  - When an RF signal is transmitted, it travels in many directions and may be received by stations listening on the frequency used by the transmitter
  - the movement of the signal from the transmitter to the receiver is known as the “propagation” of the signal (electromagnetic wave)
- Analogy:
  - Wave travelling through the ocean
  - Energy that created the waves propagates through the ocean and manifests itself visibly as the rise and fall of waves

Concept: Modulation

- Modulation:
  - An RF signal on its own does not convey information
    - music, speech, data, video
  - To convey information, have to change some characteristic of the radio frequency signal
    - piggy-back or imprint the data we want to transfer on to the transmitted RF signal
      - RF signal acts as “carrier” for information
  - Process of altering the RF signal to enable it to carry data is called “modulation”
  - Simple example: shift frequency up by few Hz for ‘1’, down by a few Hz for ‘0’
    - Frequency shift keying (FSK)

RF Behaviour

- RF Behaviour: light bulb moment
  - When considering how a WiFi network might behave a very useful analogy is to think of a light bulb suspended from the ceiling
    - many APs often suspended from ceiling in commercial/professional deployments
  - The higher frequencies used by WiFi networks share some very similar characteristics to how visible light (our light bulb) operates:
    - to see it, “line of sight” best
    - shines in many directions and visible from many points
    - obstructions between us and the light may obscure our view
    - the light may be reflected by metal, shiny surfaces

RF Behaviour

- RF Behaviour: light bulb moment
  - Analogy breaks down slightly as RF signals can pass through walls and obstructions
    - they are degraded and reduced as pass through obstructions
    - obstructions perhaps through of as smoked or frosted glass from a WiFi signal point of view
    - as signal frequency gets higher, less likely to pass through obstructions (getting more like light)
    - 5GHz WiFi signals do not travel through obstructions as well as 2.4GHz signals

RF Behaviour

- Reflection
  - RF Signals may be reflected off metallic surfaces
- Attenuation
  - As signals pass through obstructions they lose some of their energy and are reduced
    - e.g. office walls, doors, trees etc.
  - Known as “attenuation”
- Free space loss
  - RF signals are naturally received at a lower level the further you move away from a transmitter
  - Signals reduce in a predictable manner as they move through space
  - Know as “free space loss”

WiFi Bands

- Although we talked about VHF, UHF, SHF bands, when talking about WiFi we talk about the 2 WiFi bands:
    - 2.4GHz
    - 5GHz
- The band is a range of frequencies that can be used (e.g. 2.412 - 2.462 GHz)
- Band broken down into smaller chunk of frequency called channels
    - typically 20MHz wide
- WiFi bands are “unlicensed” frequencies
    - anyone can use them within certain limitations
    - may be shared with other types of communications devices:
        - Bluetooth devices (2.4GHz), Baby Monitors (2.4GHz), Radar (5GHz)

WiFi Bands

- 2.4GHz band originally the most popular:
    - lower cost components
    - travels further through builds etc
        - good when coverage was main concern
- 2.4GHz now often considered a “junk band”
    - Number of non-WiFi devices on the band (as unlicensed)
    - Many neighbouring WiFi networks due to success of 2.4GHz WiFi
        - made worse by better penetration of 2.4GHz through walls etc.

WiFi Bands

- 5GHz growing very quickly in popularity
  - lower “noise” on the band as less up-take (so better signal quality & speed)
    - less neighbour interference as does not “travel” as far as 2.4GHz
  - more channels, therefore more capacity (better performance)
  - less non-WiFi devices using 5GHz
  - newest standard only supports 5GHz (802.11ac)
  - should be the “band of choice”
- Reality check:
  - do my WiFi clients support operate on the 5GHz bands:
    - lower cost devices: often “no”
  - do my APs support the 2.4GHz and 5GHz bands?
    - generally, “yes”, unless very low cost or low spec (home network)

Summary

- What is RF?
    - Direct current, Alternating current,
- Electromagnetic Signals
- The RF Spectrum
- RF Concepts
    - Coverage area
    - Propagation
    - Modulation
- RF Behaviour
- WiFi Bands