Setting the Standard for Automation™

Radio System Co-existence

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Standards
Certification
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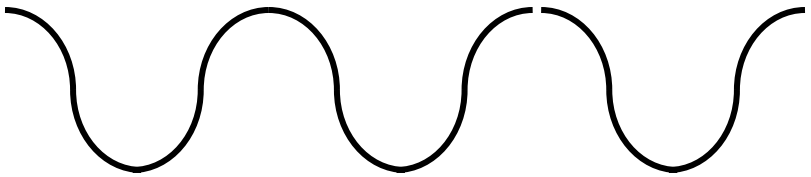
Agenda

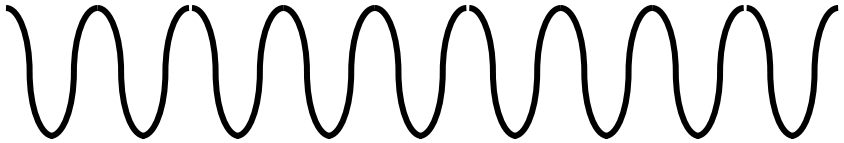
- Frequencies
  - Frequency choices
  - ISM bands
  - Filters
- Antenna Gain
  - Omni and Yagi antennas
- Antenna Aiming and Mounting
  - Suitable locations
  - Polarization
- Signal-to-Noise Ratios
  - Measurements and numbers
  - Bandwidth implications
- Antenna Guidelines Conclusion

Frequencies – as long as different, can co-exist

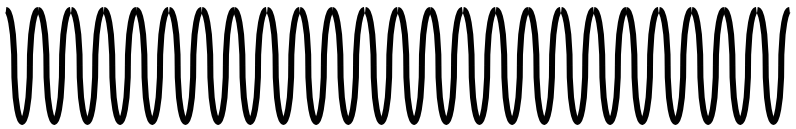
- Lower Frequencies:
  - propagate further
  - penetrate objects better
  - 900 band is 26MHz wide
- 2.4GHz:
  - used by microwave ovens (rain fade on longer links)
  - is license free around the world
  - 2.4 band is 81MHz wide
- 5.8GHz
  - brand new ISM band



900MHz



2.4GHz

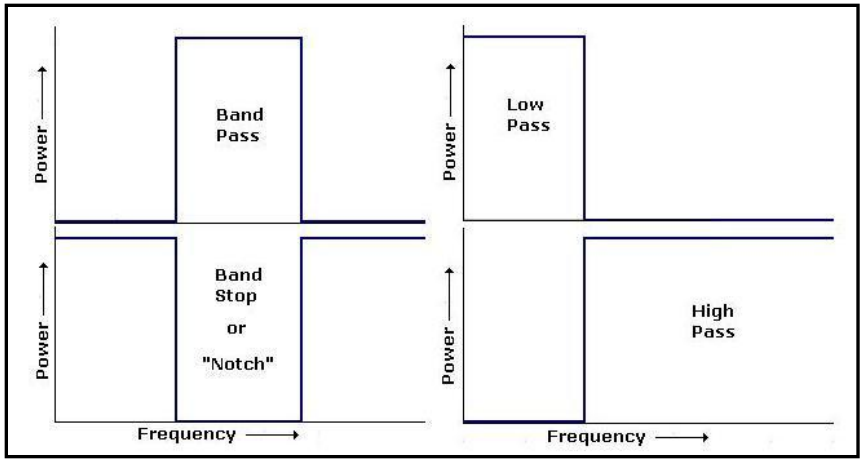


5.8GHz

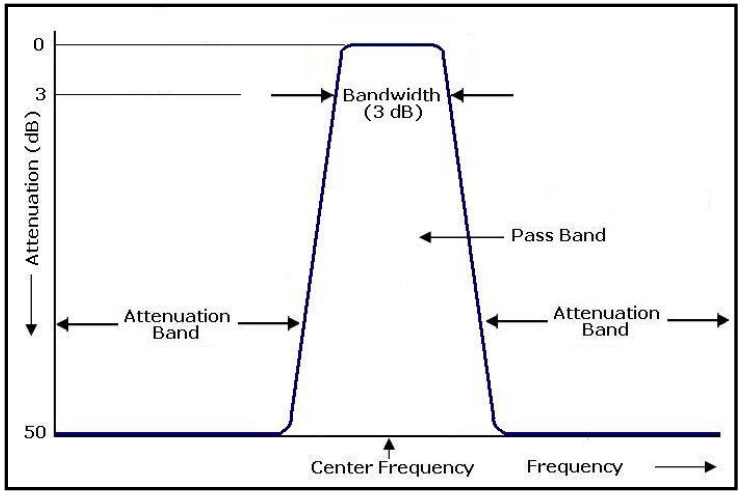
Spread Spectrum Introduction

- FCC allocated a portion of the 900MHz band, then later 2.4GHz and later 5GHz.
- Created Rules Manufacturers Must Adhere to:
  - 1W of Transmit Power
  - FH or DS or OFDM
  - FCC will not referee in case of interference from others
  - Many other technical requirements
- Manufacturers Must Submit Prototype for Testing
- FCC then Certifies, and Assigns ID to Appear on Label
- Radio can then be Used by Anyone, Anywhere (in the US)

Filters – A measure of quality



Ideal filter characteristics



Real world filter characteristics

- Filters work better the greater the frequency difference
- Radios with multiple levels of filtering offer better performance but at a higher cost

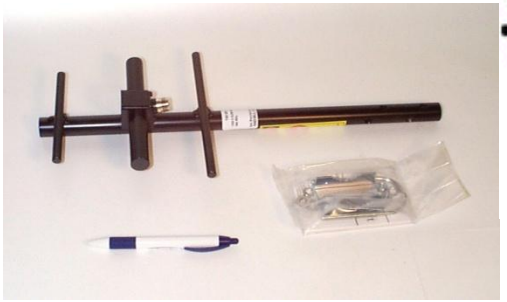
Antenna Gain - Defined

- The higher the Gain, the greater the Range and the greater the Directivity
- Gain is analogous to a Telescope's Lenses - a High Gain antenna does not add energy, it just focus's energy in a specific direction
- Gain is Expressed in dB (0dBd = 2.15dBi) (dBd abbreviated as dB)
- 1 Watt 900MHz Transmitters are Limited to 6dBi net gain
- Net Gain = (Antenna Gain - Cable Losses)
- Rule of thumb: for every 6dB "gained" the distance a signal will travel doubles

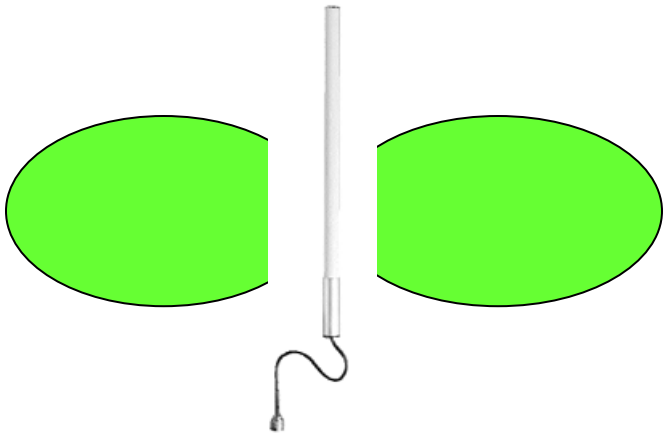
There are 2 Types of Antennas

- OMNI Directional
  - Antenna Points (mounts) Vertically
  - Radiates energy (mostly) in Horizontal Plane
  - Radiates energy 360 degrees

- Directional
  - Yagi Antenna is a Type of Directional Antenna
- Yagi Antenna
  - Radiates energy in a specific direction
  - Must be aimed towards transmitter/receiver
  - Named after one of 2 Japanese inventors (Yagi and Uda)



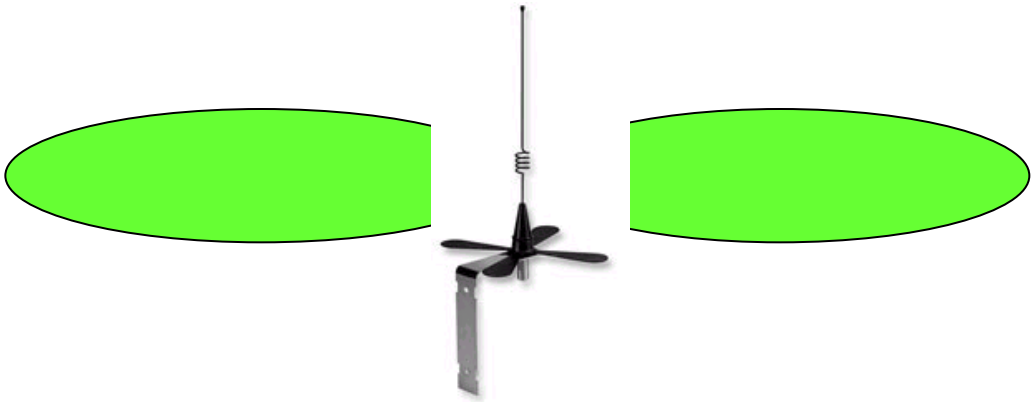
Omni Directional Antenna Radiation Patterns



3dB Omni

Vertical Beamwidth = 40º

(with MaxRad 3dB Antenna)



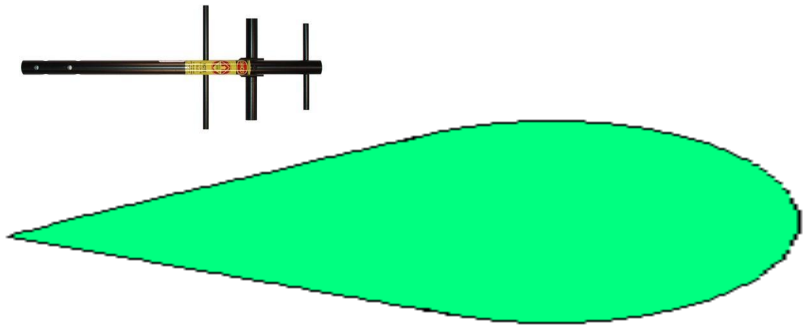
5dB Omni

Vertical Beamwidth = 17º

(with Radial Larsen 5dB Antenna)

Yagi Antenna Gain - Aiming and Radiation Patterns

6dB Yagi Antenna

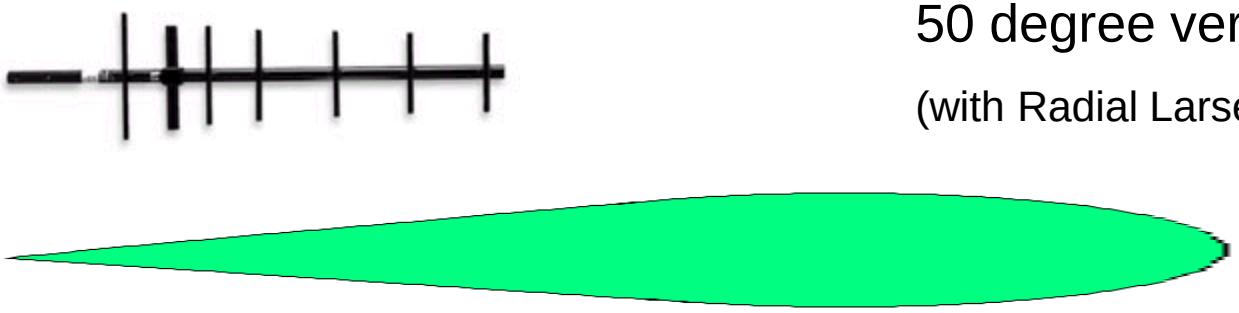


94 degree horizontal beamwidth

58 degree vertical beamwidth

(with Radial Larsen 6dB yagi)

10dB Yagi Antenna



50 degree horizontal beamwidth

50 degree vertical beamwidth

(with Radial Larsen 10dB yagi)

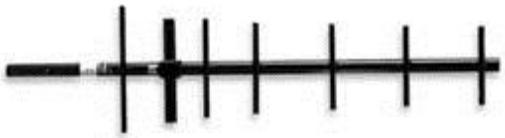
Omni vs. Yagi Antenna - Which to Use?

- Omni Recommended:
  - Multiple Transmitters/ Receivers in different directions
  - No Line-of-sight and lots of Metal Structures
  - Generally best for Industrial Plant Applications

- Yagi Recommended:
  - Long Range needed - Yagi's offer higher gain
  - No Line-of-sight and Trees, Brick or Concrete obstructions (non-metallic)
  - Generally best for Municipal Applications

900 MHz Antenna Examples

6dB Gain



10dB Gain

3dB Gain

3dB Gain

6dB Gain

0dB Gain

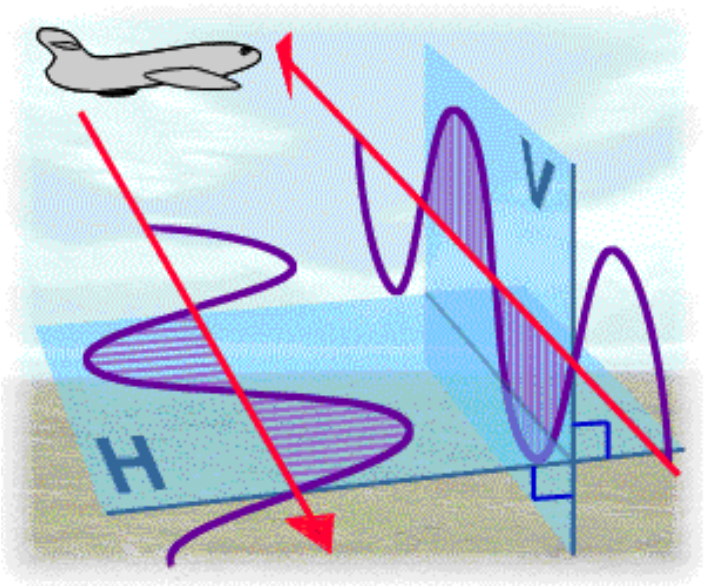
5dB Gain

Fiberglass Radome

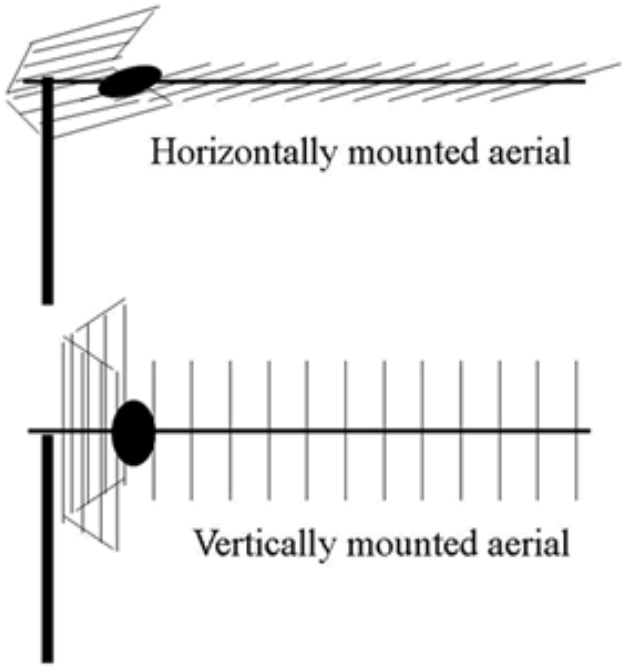
- Some antennas have a fiberglass radome enclosing the metal radiating elements
- Protects internal metal radiating element from corrosion, snow build-up, in some cases reduced wind loading
- Inside the radome, the antenna looks the same as one without

Antenna Polarization

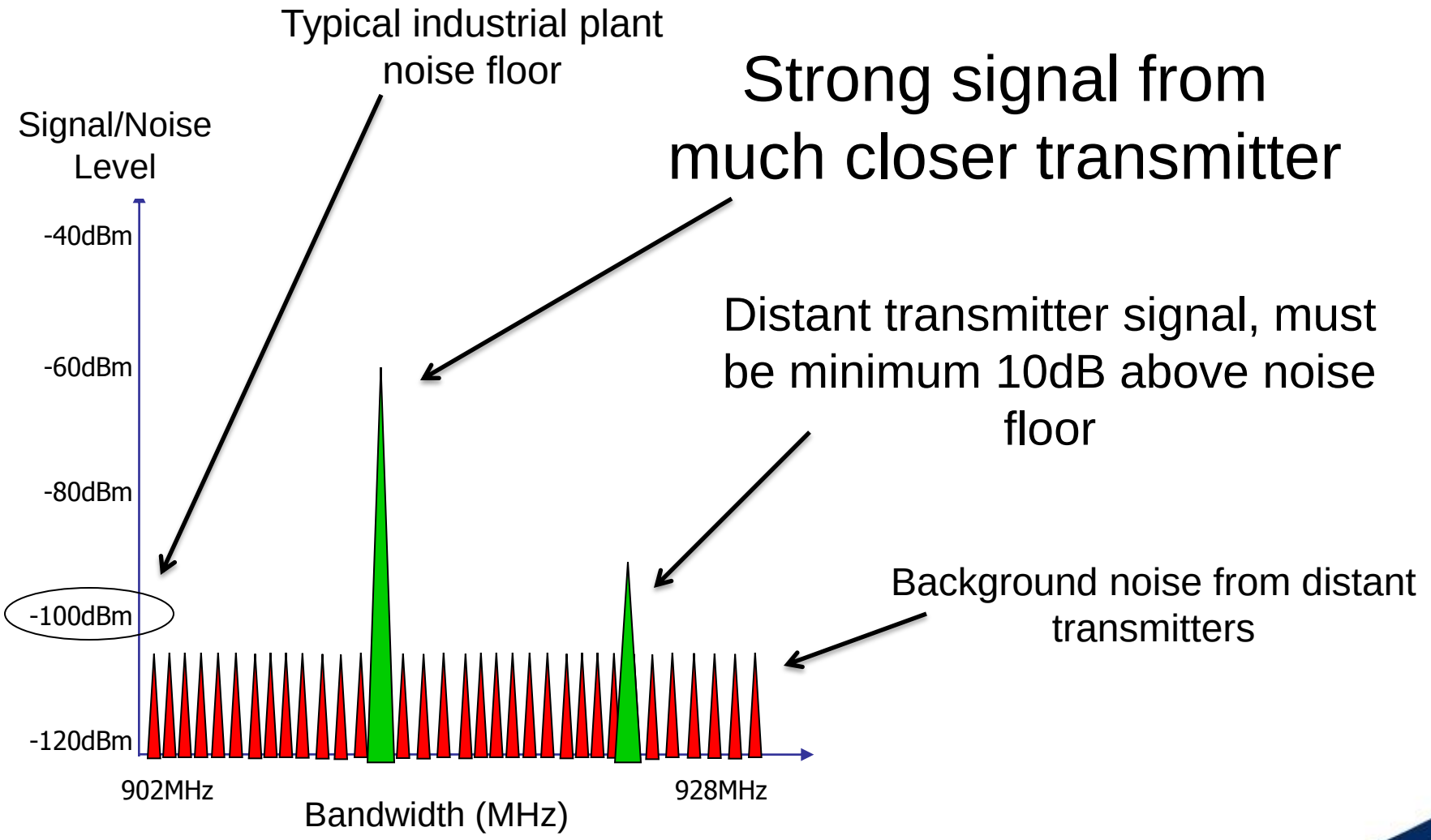
- Vertical Polarization
  - Must be used with omni antennas
  - Minimizes snow build up
  - By far, most common and popular installation method



- Horizontal Polarization
  - Only used with yagi-to-yagi
  - Only used to minimize interference from nearby radio system using vertical polarization
  - Problem with snow build-up (except when antenna has fiberglass radome)



Background Noise vs Signal

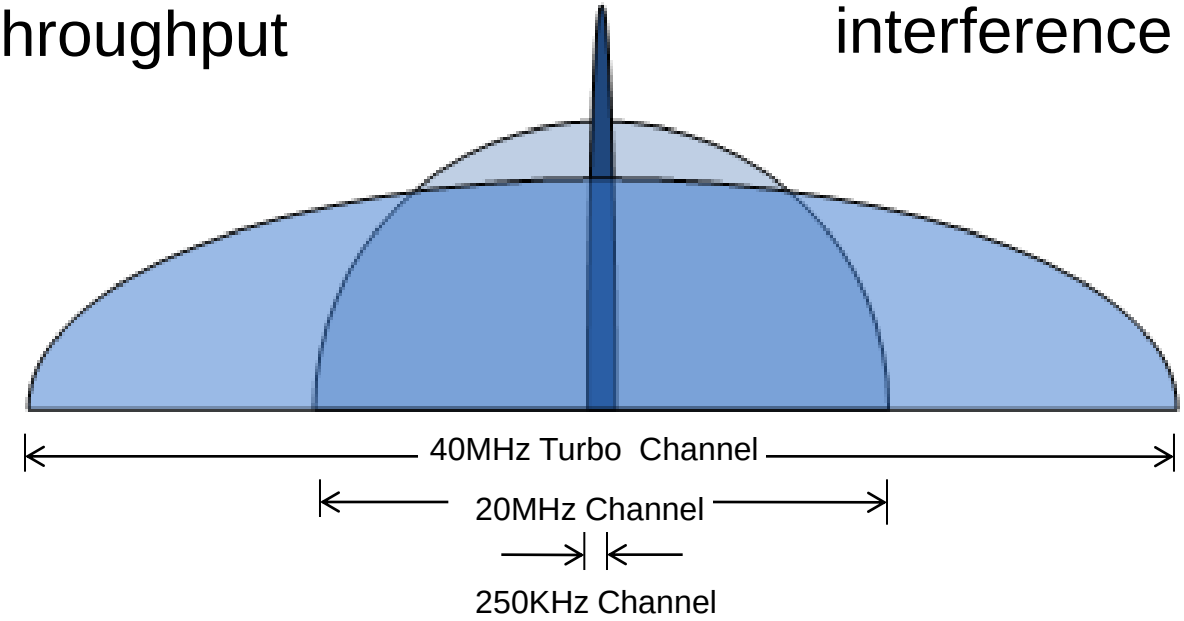


Occupied Band Width of your Radio

Wider Channels allow greater throughput

BUT…

Wider Channels mean the filters must be set wider, allowing more interference through



40MHz = 108Mbps
20MHz = 54Mbps
250KHz = 200Kbps

Practical Recommendations

- Use a high gain antenna
  - Narrow beam width excludes interference
  - Will boost signal (to noise) level
  - Make sure you do not violate FCC's rules
- Locate your antenna far from others
  - Vertical separation is most effective
  - Rule of thumb – 10' (3m) vertical
- Mount the antennas outside, up high
  - Metal electrical enclosures and steel corrugated buildings will contain radio waves
  - Height increases propagation distance

Conclusion – Questions?

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