

THE MINIMUM REQUIRED ANGLE BETWEEN CO-LOCATED SAF LINKS FOR FREQUENCY REUSE



Often it is desirable to reuse the same frequency channel for co-located point-to-point microwave radio systems. This paper assesses basic practical aspects and SAF recommendations of interference avoidance commonly queried by engineers, i.e., what minimum angle is required between microwave links sharing the same site in order to reuse the same frequency.

There is no universal value for every installation; however SAF engineers have determined that approximately **60 degrees** between links provides good discrimination from co-located systems with a safe margin to be discussed later in this paper.

Careful interference analysis should be done in order to estimate precise interference affect on microwave link performance. Interference analysis is complex case-by-case process involving large number of parameters, objectives and deep knowledge of microwave link planning. Through various case studies SAF engineers determined that under favorable conditions the angle may be decreased to **30 degrees** (or even less) and retain acceptable link reliability. The example is given below.

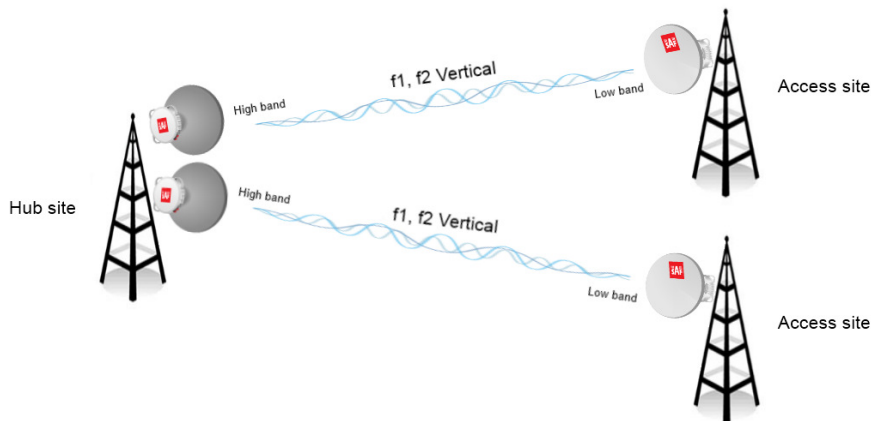


Fig.1 Two SAF CFIP Lumina links with 3ft antennas - azimuth difference is 30 degrees

Properties:

Azimuth difference is 30 degrees, same frequency channel, same distance, same Tx/Rx polarization, Rx level on both links is -36dBm

Objective:

99.999% at 366Mbps (256QAM modulation) predicted annual multipath + rain availability

Radiation pattern of particular antenna determines 45dB discrimination at 30 degrees offset from main lobe, hence the expected interference signal at the victim receiver is -81dBm. Clear line of sight between victim receiver and interfering transmitter has been assumed.

Interference rejection of radio system is described with Threshold to Interference (T/I) parameter. T/I is defined as the ratio of desired to the undesired signal power that degrades the digital receiver 10-6 BER threshold by 1 dB. This parameter is modulation dependant. Lower modulation schemes tolerate higher interference level, hence provide better T/I values. T/I co-channel value for SAF CFIP Lumina 366Mbps/256QAM mode is 32dB. In this case study difference between carrier and interferer is roughly 45dB, meaning there are no instantaneous signs of interference or channel degradation and both links are likely to operate error free with 366Mbps.

However, microwave links are prone to fading independently from each other from such atmospheric phenomena as rain, multipath, ducting etc. At some period intended signal can fade to a level close to

receiver threshold of -63.5dBm. It does not necessarily mean the interferer signal will be affected by same amount of fading during this period.

For instance, assume the interferer signal is still at -81dBm and our victim signal has faded to -63dBm. Since only 17dB of discrimination exists now, the T/I value is being exceeded causing receiver threshold and link fade margin degradation. Consequently, link annual availability decreases below the previously set objective due to fade margin degradation. This incident is referred to as Threshold Degradation.

Threshold degradation can be minimized by:

- Using lower modulation (32QAM for instance) would improve T/I considerably and make „30 degrees” link scenario feasible even during unequal fading of victim and interferer signals.
- Installation of links with opposite polarizations almost certainly would make „30 degrees” scenario long-term feasible with 256QAM modulation due to additional ~30dB antenna cross-polarization discrimination.

Network engineers are often faced with challenges of designing a network with frequency reuse without an access to detailed interference analysis. There are recommended practical implementations though, that one needs to consider for minimizing interference between links:

1. Actual interference between links is very sensitive to layout geometry. Wider angle separation would result in higher interferer discrimination. The most favourable same channel link topology is chain with roughly 180 degrees angle between links
2. Distance separation between two antennas may also provide a certain degree of discrimination. Try employing the benefits on the site – if it is a tower structure, separate the antennas vertically to gain additional spatial discrimination. If it is a rooftop, separate the antennas apart horizontally
3. Install only same band radios at the same site (Low „L” with Low band or High „H” with High band) to avoid overshoot interference and interference from the back/side of the antennas
4. Use opposite polarizations for possible interfering links to gain additional cross-polarization discrimination
5. Antennas have characteristics that can be used for reducing interference. Larger, high or super high performance antennas incorporate better radiation patterns in terms of side lobe suppression. Comparatively, the interference level at a certain offset from main lobe is being better suppressed. Note that light rotation or tilt of the antenna can make a significant difference in power level of the interfering signal. Use it to reduce interference without significant loss in power of the desired signal
6. For parallel links consider different channels use. Adjacent channels (one channel bandwidth apart) can be used in case links use cross-polarization. In case of same polarization additional guard band is recommended. A reliable guard band between channels is $\frac{1}{4}$ part of used channel width. For example, center frequency offset between two parallel 56MHz channels should be 70MHz.
7. Enable Automatic Transmit Power Control (ATPC) in order to decrease possible overshoot interference during non-faded periods
8. During link design stage take into account near-by obstructions: vegetation, buildings, terrain etc. Ensuring there is no direct line of sight between victim receiver and interferer transmitter in some cases can minimize interference level that would never compromise link performance

It is probable that many existing microwave networks operate paths with angles closer than the recommendation above unaware that the annual availability has been sacrificed. Understandably - annual availability is a parameter difficult to measure for radio systems that utilize ACM (Adaptive Coding and Modulation). Network engineers should not underestimate a long-term affect on performance caused by interference that may not occur immediately. Safety margin should always be considered.