



***Australia's Microwave Solutions Company***

***(An EMSolutions Subsidiary Company)***

## ***What are Microwaves?***

Microwaves represent a small segment of the electromagnetic spectrum generally considered to cover the frequency range of 1 GHz to 30 GHz. The equivalent wavelength range is 300 mm to 10 mm. The derivation of the term microwave is lost in the mists of time but probably had its origin in the early days of radio when wavelengths of some tens of millimetres were considered 'micro' with respect to the wavelengths of meters to hundreds of meters then used. In more recent years, microwave technology has been extended to higher frequencies, up to 300 GHz (1 mm) where it is designated as millimetre wave.

When considering other frequencies in the electromagnetic spectrum, microwaves approximately occupy the middle region of the spectrum. Typically the electromagnetic spectrum below the microwave region is occupied by TV and FM broadcasters and various UHF (ultra high frequency) satellite and communication systems. The electromagnetic spectrum above the microwave region is used for infrared systems and then gradually merges into the visible light region.

## ***Why use Microwave for WAN Networking?***

Choosing the right networking technology to improve productivity and reduce operational expenses has become more important for many medium to large organisations. The benefits microwave technology offers organisations requiring broadband WAN networks are: reliability, flexibility, cost effective bandwidth, and rapid deployment. While initial capital outlay or switching costs may not seem competitive at first glance, when comparing with other WAN networking technologies, the long term return on investment of microwave technology in many cases is positive. Investing in microwave technology offers users the opportunity to control their networks, a luxury not extended to users of its wired counterpart.

As microwave frequencies are quite high, a large amount of information can be attached (modulated) on to the microwave carrier. Modulation techniques vary but in general there is a trade off between how much information can be packed into a given bandwidth and the susceptibility of the information to noise and interference. A data rate of 100 Mb/s can be compressed into a bandwidth of 28 MHz. A 20 GHz spectrum allocation could easily accommodate 50 channels whereas at 500 MHz one or two such channels would occupy far too much relative bandwidth to be acceptable. Consequently microwaves are ideal for communication systems requiring moderate to large data rates, 2-1000 Mb/s. For data rates lower, < 1Mb/s, lower frequency systems generally prove more cost effective whereas for higher data rates, >1000Mb/s, optical networks are clearly preferred.

The limited spectrum available below the microwave segment makes lower frequencies more suitable for low data rate communications and the antenna size constraints strongly favour non directive or point to multi point communications. The microwave sector on the other hand, offers the flexibility of point to point, point to multi point and mobile communications with cost effective data rates from around 100 kb/s to 1000 Mb/s depending on the application. With the exception of some very short range applications, optical systems invariably utilise guided (i.e. optical fibre) wave technology and so are particularly suitable for high capacity point to point communications.

## ***What is the range of a microwave system?***

Apart from atmospheric absorption peaks around 50 - 60 GHz, microwaves travel through the atmosphere almost as well as through free space. Smog, cloud and mist have very little effect, unlike infrared signals that can be completely absorbed under these conditions. This is a key advantage of 'free space' microwave systems compared to higher frequency infrared and optical ones. Rain and atmospheric effects associated with 'path deflection' or 'ray bending' may be significant factors over long paths ( $\sim > 10$  km) and/or at higher frequencies ( $> 10$  GHz) but these effects can be properly accounted for in the design of a microwave system.

EMClarity's microwave links have been designed for distances of 500m, 2km, 5km, 15km, 25km, 35km and 50km using a range of antennas that include planar array, and 300mm, 600mm, 1200mm and 1800mm parabolic antennas.

### **Safety and Security**

It is well known that microwave energy interacts with the human body with the physiological effects ranging from sensible heating through to increased cancer risks. Based on world wide convention, Australian health authorities recommend a maximum exposure level of  $10 \text{ mW/cm}^2$ . Since the equipment provided by EM Solutions relies more on receiver sensitivity than on transmitter power to meet performance objectives, this recommended safety level may only be exceeded when very close to and directly in front of a typical antenna. Since these are mounted on towers and/or on top of buildings, the microwave energy presents no danger to the public.

Microwave systems are inherently secure by virtue of the directive nature of the beam (in point to point systems), the typically high level modulation and the low power levels used. If high security is essential then encryption can be added with only a minimal impact on the overall data rate.

## ***Is Microwave Performance Affected by the environment?***

As a wireless communication method microwave may be subjected to some interference from its surrounding environment. This however, can be minimized through the design of hardware and network design and implementation. Often when microwave performance is impeded it is due to the terrain or atmospheric effects. The operation of a Microwave communication system is fundamentally dependant on a direct 'line of site' from the source to destination. A direct 'line of site' can be interpreted as a transmission path with no obstructions, buildings, trees or other obstacles, that could potentially interfere with the microwave transmission. If no direct line of site is possible from the source to destination then the microwave link cannot be reliably established between the two endpoints. However the propagation path can be broken into smaller more direct paths to produce a virtual line of site from the source to destination. This process uses repeaters that are microwave relays for receiving and transmitting signals along a propagation path. The use of repeaters makes it possible to transmit data from A-B where no direct line of site is possible by introducing steps A-C-D-...-B, where each smaller step has a direct line of site to the next step.

Microwave wavelengths are approximately the same size as everyday objects. This has implications both for how microwave circuits are constructed and how microwave energy interacts with matter. For example, it is possible to make highly directive antennas of a reasonable size enabling microwave beams to be pointed precisely and to operate over very long distances. The beam shaping characteristics of microwave antennas offer one of the key advantages of microwave communications systems compared to lower frequency systems.

Finally, the background 'noise' from natural sources has a distinct minimum around microwave frequencies. This microwave background radiation is at a very low level and the peak in the energy occurs at around 280 GHz, thus the low background noise means that microwave receivers can be made very sensitive and will work well with very long signal levels. Consequently this reduces the need to use high power transmitters, and highly reliable microwave systems can operate over distances of 20 km say with transmit power levels less than 1 W.

With proper design, microwave systems offer bit error rates (BER) and overall reliability approaching that of optical networks but in a much more flexible format. Whether a particular communication application is best served with VHF/UHF, microwave or optical, the decision depends on an interactive mix of factors such as data rates required, system configuration (e.g. point to point, point to multi point), regulatory constraints, existing infrastructure, availability and cost of sites, geography and so on. In most modern networks, some combination of all three technologies is typically used and EM Solutions have configured their microwave systems to offer value for money options for integration into existing WAN networks.