

Introduction

With the advent of deregulated low power data radio the economics of using traditional wire links for telemetry need to be examined. Licence exempt data radio has low infrastructure costs, low installation cost and provides good system flexibility.

The UHF band between 400MHz to 500MHz has become internationally adopted for low power licence exempt use for digital data, telemetry and telecommand systems. It has the advantage of propagating in direct line of sight and will penetrate conventional build materials.

The RF signal fades quickly at the edge of its range. This factor allows multiple use of the same adjacent frequencies in close proximity.

International Perspective

Although a common UHF band is used national authorities have defined different specifications for licence exempt radio data transmissions.

They differ in the number of allocated RF channels, their bandwidth, spurious emissions and maximum RF power that can be transmitted. In the UK, the ETSI 300-220 specification for operating on the 433.92MHz channel, allows one channel at 10mW RF power.

The radio range is limited to a few hundreds of metres. But the power consumption is low as is the unit cost of the transmitters and receivers. Radios conforming to this specification are widely used in portable battery equipment or communicating with moving machinery.

The UK MPT1329 specification covers operation at frequencies of 458.500MHz to 458.950MHz. Either 15 channels at 25kHz or 31 channels at 12.5kHz or 31 channels at 12.5kHz spacing are allowed with a maximum transmitter power of 500mW.

Radios using this band have data rates of up to 10kbits with good in building penetration and can achieve ranges of 10 to 20km depending on the antenna configuration.

Most continental European countries adopt the ETSI 300-220 standard covering the 433.10MHz to 434.75MHz band with a transmitter power of 10mW. Data radios operating on this band have a range of up to 2km in free space and are used for short range data transfer.

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Estimating radio range

Range is the most important parameter when assessing the practical implication of using a low power, licence exempt, radio system. It is sometimes difficult to correlate the transmitter RF power to the receiver sensitivity and estimate an effective range.

The main factors effecting the performance of a radio system are:

- Transmitter power
- Receiver sensitivity
- Terrain
- Antenna height
- Antenna feeder cable loss

UHF signals on the 400MHz to 500MHz band propagate directly between the transmitter and receiver and act in a similar way to light. There is therefore a maximum distance that a uhf signal can travel due to the curvature of the earth.

With both the transmitter and receiving antenna at a height of three metres and assuming there are no geographical obstacles, the radio horizon will be around 16 kilometres. If both antennas are raised to 100 metres the radio horizon would extend to around 90 kilometres.

With all licence-exempt radios, the RF power is strictly limited. The achievable range can therefore be much less than the radio horizon.

The radio range can be calculated by subtracting the factors causing the attenuation of the signal from the transmitter power. These include losses due to the antenna configuration, losses due to the terrain over which the signal will pass and the loss caused by the antenna feeder cable.

The propagation of the signal will depend on the height at which the receiver and transmitter antenna is above the ground. The higher the antenna the better the propagation.

Figure 1 correlates the height of both antennas to the expected propagation loss. The left and right scales give the height of the transmitter and receiver antenna. By placing a ruler between the two, a propagation loss can be estimated for any combination of heights.

Losses caused by the terrain can be estimated at around 50dB in open country or over water. This would be considerably more if the transmission path was to pass through buildings.

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By subtracting all the propagation losses from the power irradiated from the transmitter, the required sensitivity at a near distance can be determined. The diagonal lines in Fig 2 can then be used to determine the required receiver sensitivity at any given distance from the transmitter.

For example, if licence exempt MPT1329 radio, radiating 500mW (27dBm) was transmitting at full power and both the transmitting and receiving antenna were at 12 metres high, then from Fig. 1 the antenna propagation loss would be 55dB. If five metres of low-loss coaxial cable was used to connect the antenna to the transmitter and to the receiver there would be a further loss of 2dB.

To give a good bit error rate over an average terrain the Terrain Loss would be approximately 50dB.

$$\begin{aligned}\text{Receiver Sensitivity Factor} &= \text{The Transmitter power} - \text{Propagation Loss} - \text{Terrain Loss} \\ &\quad - \text{Antenna Feeder Losses.} \\ &= 27\text{dB} - 55\text{dB} - 50\text{dB} - 2\text{dB} \\ &= -80\text{dB}\end{aligned}$$

Using the diagonal lines in Fig. 2 the required sensitivity of the receiver starting at - 80dB can then be obtained at any distance from the transmitter. The maximum range using this configuration would be around 16 kilometres, given that the sensitivity of the receiver was as good as - 120dBm.

Installation criteria

Where ever possible, it is important to beam the RF signal by using a directional Yagi antenna. This reduces interference from other users that might be on the same channel. It also prevents the transmitter radiating its signal over more area than it needs to.

Yagi antennas have a specified power gain. Therefore the transmitting power must be adjusted to conform with both the licence exempt regulations and the power to which the transmitter has been type approved.

If care is not taken to make this adjustment then both the RF power and the spurious emissions will be amplified. This will cause RF pollution over the band, rendering nearby channels inoperable.

Before installing a licence exempt radio system it is also important to check that the intended channel is free. Most receivers have a relative signal strength indication (RSSI). This gives a voltage output if the RF channel is in use. Hence a voltmeter can be used to

check that no other signal is being transmitted on the frequency. When a free channel has been found the receiver RSSI signal can then be used to check the signal strength of the distant transmitter signal. This also provides a good method of finding the best position for the antenna and checking its alignment.

In summary

Low power, licence-exempt data radio is a powerful alternative to wire over short and medium ranges. The cost compares well with dedicated telephone lines, data cabling in buildings and communicating with moving machinery. Added to this are the low cost of installation and physical flexibility afforded by radio communications.

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