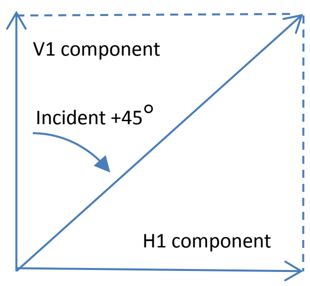
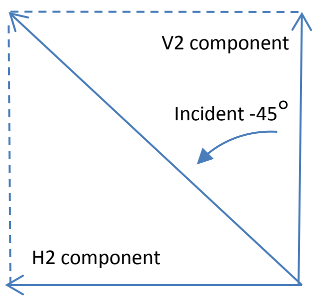
ePMP 2.4 GHz Antenna Configuration

Cambium supply a 2.4 GHz dual slant sector antenna for use in the ePMP system. The ePMP SM is designed with a V/H antenna and so the two antennas would appear to be mismatched. This note explains why the ePMP system works without change in performance compared to using a V/H antenna at both ends of the link.

With a dual slant antenna at the AP, the two TX signals output from the ePMP AP radio are radiated with polarisations of +45° and -45°, both with the same power. Assuming a benign radio path that does not alter the polarisations, the same +45° and -45° polarised waves are incident on the V/H SM antenna.

The V/H antenna at the SM decomposes the composite wave front into a V component (0°) and an H component (90°) and outputs these components as signals to the V and H ports respectively. In the following diagram V1 and H1 are the signals output by the incident +45° polarised wave and V2 and H2 the signals output by the -45° polarised wave.





The magnitudes of the V1, H1 and V2 and H2 signals are all equal. Since V1 and V2 are the same, and H1 and H2 are the same, it appears as measured at the individual ports that the two incident polarisations have completely interfered with each other. For example, the overall cross polarisation isolation is 0 dB. This is in contrast to the case when the antennas of the same polarisation are used at both ends of the link where typically cross polarisation isolations of > 12 dB are achieved.

While there is no difference between the magnitude of the V and H port outputs based on the incident polarisations, there is a big difference between the phase relationships at the outputs depending on whether the incident wave is +45° or -45° in polarisation. Notice in the diagrams above that for both incident waves, the V1 and V2 signals point in the same direction (up) but the H1 and H2 signals point in opposite directions (right and left). The difference in direction for the H1 and H2 components is the equivalent of a 180° phase shift applied to one port depending on whether the incident wave is +45° or -45°.

The useful consequence of the 180° shift of the H component for the -45° polarisation wave, is that subtracting the received V and H signals null the 45° polarisation but maximises the -45° polarisation. Adding the V and H signals, nulls the -45° incident polarisation but maximises the 45° incident polarisation.

The MIMO equaliser in the SM receiver, attempts to regenerate the two transmitted signals by forming suitable combination of the signals at the V and H ports. For the received signals described above, the equaliser regenerates the +45° TX signal by adding the V and H signals, which cancels the -45° interference and maximise the +45° wanted signal. In parallel it regenerates the -45° TX signal by subtracting the H from the V signal, which cancels the 45° interference and maximises the -45° wanted signal.

There is no net SNR benefit or loss in using the dual slant to V/H system compared to the V/H to V/H scheme. The 6 dB gain obtained by summing two in-phase signals to generate the wanted TX signal is compensated for the 3 dB loss at the antenna and a 3 dB increase in noise by adding the noise from two RX chains.

Note it is possible to arrange antennas so that H1 and H2 point in the same direction and V1 and V2 point in the same direction. This alternate arrangement is not considered useful since the equaliser cannot resolve the two TX signals.

The air interface in most MIMO systems such as ePMP include training sequences which enable the MIMO equaliser to determine the complete MIMO channel response. This composite response includes the responses of the paths from each TX antenna to each RX antenna. The MIMO demodulator uses this information to calculate the best combination of receiver input signals to regenerate all the transmit signals which in the example above would be result in adding and subtracting the V and H receive signals.

Traditional XPIC system do not include the training sequences and XPIC demodulators assume the strongest signal at a receive port is the desired polarisation and the weaker interference signal is the undesired polarisation. In contrast to MIMO system with training sequences, these systems cannot work in the +/- 45 degree region where the desired polarisation is similar in level to the undesired polarisation.

Mathematically the act of rotating the SM antenna by an angle θ is to multiply the MIMO channel response between the AP and SM by the following unitary matrix.

$$\begin{bmatrix} \cos\theta & \sin\theta \\ -\sin\theta & \cos\theta \end{bmatrix}$$

Modifying a MIMO channel by multiplying by any unitary matrix does not change the theoretical MIMO channel capacity. Furthermore, good MIMO equaliser implementations such as that used in the ePMP product show minimal variation in link performance by modifying the MIMO channel by the equivalent of a unitary matrix such as rotating the dual polar RX antenna.

In summary, we have described how the ePMP SM with a V/H antenna is able to equalise the signals received from a dual slant antenna. Even though the effective cross polar isolation in 0 dB, a good MIMO equaliser of the type used in ePMP demodulates the received signals as if the RX antenna was physically rotated to match the TX antenna polarisation.