Circular Polarization for Antenna Polarization Diversity To Overcome Deep Fading in Terrestrial Wireless Telecommunications

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The performance of terrestrial wireless communications link is mainly limited by deep fading and interference. To overcome the problem, diversity techniques have been employed, among which polarization diversity is noted to be about as effective as conventional spatial diversity yet provides space and cost savings (Dietrich et al, *IEEE AP Trans*., **49**-9, 1271-1281, 2001). However, polarization diversity has largely been employed at the receive side, and focused on dual orthogonal linear-polarizations (LP) in the form of either V/H (vertical/horizontal) or slanted $\pm 45^{o}$.

In this paper, polarization diversity on the transmit side is emphasized. Furthermore, the potential advantage of circular polarization (CP) on the transmit side in overcoming deep fades will be discussed.

A CP wave is in effect an LP vector rotating about the direction of propagation every 360^{o} for each period of the carrier wave, thus completely spanning the polarization subspace over any time period equal to or longer than the period of the carrier wave. A dual-LP antenna is equivalent to a single LP antenna unless the two orthogonal LP components of identical amplitude are 90^{o} apart in phase (time). This may explain why the diversity gain of slanted $\pm 45^{o}$ was observed to be slightly higher than that of V/H (Lempiainen, *IEEE Veh. Tech. Trans*., **47**-3, 1087-1092, 1998) while being equal in other analysis (Nilsson, *1998 Int. Symp. Adv. Radio Tech*., Boulder, 1998).

In radar and other line-of-sight paths, performance merits of CP over LP have been well established. In terrestrial telecommunications, a channel can be segmented into two categories: pseudo-line-of-sight sub-channels and polarization-sensitive scatterers. Scatterers on earth, whether man-made or natural, cause deeper fading to LP than to CP; more generally, the higher the axial ratio of an elliptically polarized wave, the deeper the fading.

On the receive side, dual-CP and dual-LP are equally effective as a polarization diversity scheme. In case no polarization diversity is implemented in the receive antenna, a CP receive antenna (of the same sense CP as the transmit antenna if applicable) is less vulnerable to deep fades than an LP receive antenna. This is because the channel is extremely unlikely to fully convert a signal to the opposite-sense CP to cause deep polarization-mismatch of 30-40 dB.