Power Combining by Means of Injection Locking

M.Kühn, E.Biebl
Technische Universität München

Power combining can be used to enhance the detecting distance with low expense. An increasing number of applications for the 24 GHz ISM-band like short range communication links and automotive radar systems demand for oscillators providing moderate power of a few mW and a moderate frequency stability of about 0.5%.

The maximum oscillation frequency of low-cost off-the-shelf transistors is not sufficient for stable operation of a fundamental 24 GHz oscillator. So, we designed a 24 GHz first harmonic oscillator. The power generated at the fundamental frequency (12 GHz) is reflected. This generates a high output power at the first harmonic in an effective way. We measured a power radiated by an integrated planar antenna of more than 1 mW. Though this oscillator provides better frequency stability compared to fundamental oscillator, for some application additional stabilization is required.

For a low-cost method, injection locking can be used to phase lock oscillators that provide sufficient stability in free running mode. Based on our harmonic oscillator concept injection locking has to be achieved at the first harmonic, because only the antenna is accessible for signal injection. We designed, built up and characterized an harmonic oscillator using the antenna as a port for injection locking. The locking range was measured versus various parameters. In addition, phase-noise improvement was investigated. A theoretical approach for the mechanism of first harmonic injection locking is presented.

For power combining, it is necessary that all oscillator are synchronised in frequency and phase. In this work the 3x1 array is optimised for power combining. The method of injection locking is used for synchronising in frequency and phase of each oscillator to the others. Besides increased radiated power in the far field the geometry of the beam lobe can be controlled by the distance of the antenna elements. So the maximum distance and the area of the detecting region can be selected. Furthermore the array can be locked to an external device by one of the two antennas at the periphery of the array. This extends the application possibilities because the array is synchronised to the stable external source.