In any wireless communication system, signals play a crucial role in facilitating the seamless transmission and reception of information. From the initial stages of generating microwave signals to transforming them into communication-ready formats, existing communication systems are built upon established techniques that incorporate various innovations. This thesis is an attempt to introduce some novel concepts in signal generation, modulation, and detection within the context of wireless microwave communication systems. Each chapter of this thesis delves into specific aspects, ranging from microwave signal generation using oscillators and mixers to the integration of self-oscillating mixers with antennas to create compact receiver designs. Additionally, the potential of polarization modulation and mixer-less detection is extensively explored, with the aim of utilizing them to develop efficient and innovative solutions tailored to present-day communication challenges. The overall contribution is detailed below.

A voltage-controlled oscillator (VCO) serves as a fundamental component in any communication system, operating as the local oscillator for both up and down-conversion mixers. Traditionally, in C-MOS based designs, variable MOS capacitance is utilized for tuning the oscillation frequency, yet the tuning range of an individual MOS remains limited due to small capacitance variation. A varactor diode based oscillator has similar issues. The impedance transformation part is redesigned to address this problem. A stepped-impedance transformer is connected between a varactor diode and the gate terminal of a transistor to achieve an extended tuning range without compromising the output power. The implementation can be achieved using an LC circuit, thereby enabling RFIC implementation.

The overlapping of RF and image frequencies in a wideband image-rejecting sub-harmonic mixer (SHM) necessitates the incorporation of a wide tunable band-stop filter in the RF path. To overcome this challenge, a single varactor diode is employed for the realization of the tunable band-stop filter, effectively suppressing the image frequencies, and thereby resolving the limitations associated with using a fixed band-stop filter for image suppression.

In a self-oscillating mixer, a single transistor serves the dual purpose of down-conversion and oscillation. Consequently, the antenna port might offer two distinct terminating impedances at the frequencies for oscillation and down-conversion. Typically, this is achieved through the integration of an antenna with a bandpass filter. Here, through the utilization of a co-design approach, a varactor-based series impedance transformer is implemented to tune the local oscillator (LO) signal, representing a significant advancement in this domain. This approach ensures the consistent maintenance of the intermediate frequency (IF) in Cognitive Radio applications, thereby preserving the required impedance conditions at LO and all inter-modulation products, as well as the IF frequency for a wide range of RF frequencies.

In communication systems, various forms of modulation, such as phase, frequency, or amplitude modulation, are employed to convey messages. In this thesis, the concept of altering the polarization of the transmitted signal is introduced for line-of-sight communications. This novel approach significantly enhances the effective bandwidth efficiency in wireless RF channels. A comprehensive transmit-receive system is devised to implement this polarization modulation scheme, effectively enhancing the capacity of the RF channel.

For all the design examples, the initial analysis utilizes a lossless transmission line model to obtain the primary design parameters. Subsequently, a comprehensive analysis is conducted using full-wave electromagnetic simulations and the co-design concept. Finally, the anticipated results are validated through fabrication and measurements.