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Study on Innovative Integrated Power Amplifier/Low Noise Amplifier/Switch for Wireless Application

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by

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Abstract

The front-end transmit/receive switch circuit is one of the essential elements in modern wireless handsets. The main function of the transmit/receive switch is switch the antenna either to the transmitter or the receiver. It must have high isolation in order to avoid the RF-power of the transmitter (PA) turning on the receiver (LNA), resulting in high loss or in the worst case damage. Low insertion loss is also necessary to maintain efficiency for the transmit power amplifier and low noise for the receive low noise amplifier. The RF switch circuits either uses PIN-Diodes or FET based mmics. Normally, silicon PIN-Diode based switches are suited for low cost or narrow band applications, while FET based mmic switches are suited more for higher performance/cost wide band application. For many handsets PIN-diodes and λ/4 transmission line topology is used to form a low cost, single supply switch. However, the main disadvantages of this low cost PIN-diode switch are its large size and narrow bandwidth. So, the research work performed here is to study a new RF switch circuit topology that is low in cost, small in size, and while maintaining a single positive control voltage. The method proposed here eliminates the RF switch in the RF-front end entirely by directly connecting the Power Amplifier with the Low Noise Amplifier. When connected to the antenna it forms a single pole double throw RF-Switch, herein
called the Power Amplifier/ Low Noise Amplifier/Switch or PA/LNA/SW for short. This switch can reduce the board size and cost, and if properly designed can even enhance the performance when compared with traditional switches. In addition, the PA/LNA/SW can provide a wider bandwidth, because it does not have the $\lambda/4$ transmission line which is frequency dependence component. The bandwidth limitation of the PA/LNA/SW is entirely limited by the matching network in the amplifier design. Although the PA/LNA/SW can provide a dual band application, such as 3G and Bluetooth, it still can not fulfill the requirement for future software defined radios (SDRs). Future SDRs requires the use of broadband front-ends and the use of such switches will require low cost and high performance. In such circumstances, the FET-Distributed MMIC switches would be used, but the cost can be high. For low cost broadband applications we propose a distributed form of the same idea as in the PA/LNA/SW to form a Distributed Integrated Power Amplifier/ Low Noise Amplifier/ Switch or DI-PA/LNA/SW for short. The DI-PA/LNA/SW proposed achieved the wideband objective and at a reduced cost. The bandwidth performance of the DI-PA/LNA/SW is limited by the gain cell within the distributed amplifier. The novel Darlington gain cell have was also studied to extend the bandwidth of the distributed amplifier. This novel Darlington gain cell solved the current variation problem of the traditional Darlington gain cell, and still maintained the high gain and wide bandwidth.
The novel Darlington gain cell was also applied to the distributed amplifier, called DI-NDA. Finally, the DI-NDA was applied to the DI-PA/LNA/SW to form a Novel Distributed Integrated Darlington Cell-Power Amplifier/Low Noise Amplifier/Switch or NDI-DC-PA/LNA/SW for short.
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