D12-085

作品摘要

作品名稱
具降低偵測錯誤率之77-GHz長距離汽車防撞雷達收發機
77-GHz long-range automotive radar transceiver with false-alarm reduction

隊伍名稱
三角 / Triangle

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安全以及舒適的駕駛環境，無疑的是汽車運輸的主要目標。雷達已應用在車輛上用來測量目標範圍與相對速度。因為可以在白天、夜晚以及大多數的天氣狀況下良好運作，毫米波雷達有優於其他如超聲波、紅外線和雷射雷達技術的特性。圖一是典型毫米波雷達的應用，諸如自適應巡航控制、自動起步、盲點偵測和碰撞警告等功能。操作在22到29GHz和77到81GHz的短距離雷達可在30公尺內，應用於自動起步、盲點偵測和碰撞警告等。短距離雷達需要數公分的偵測距離解析度。相對應的，長距離雷達操作在76到77GHz，提供150公尺的自適應巡航控制範圍。自適應巡航控制系統可感測與目標的距離和相對速度，以保持足夠制動距離。

隨著CMOS製程技術的發展，因為其低成本和積體化的特點，CMOS毫米波電路變得更具有優勢。這使得汽車雷達可能更加普及。因為越來越多的汽車雷達在同一個鄰近區域裡操作，干擾將成為一個問題。這提高了偵測錯誤率，導致虛假目標偵測。在本作品中，我們設計了一個具有降低互相干擾之全積體化77GHz長距離汽車雷達。收發機的方塊圖如圖二所示。和直接數位頻率合成器比較，使用分數型頻率合成器產生連續波頻率調變訊號，具有小面積以及低功耗的優點。採用多變的連續波頻率調變，可以降低因互相干擾所導致的偵測錯誤率。調變使用跳頻、改變頻寬以及掃描時間的方式，使得干擾訊號在降頻之後，頻率響應如同雜訊一般，主要訊號得以辨認。

電路使用TSMC 65奈米製程研製。晶片面積為，長1030μm寬940μm。在1/64輸出頻率下，使用訊號分析儀測試，多變的連續波頻率調變結果如圖三所示。電路總功率消耗為275毫瓦。

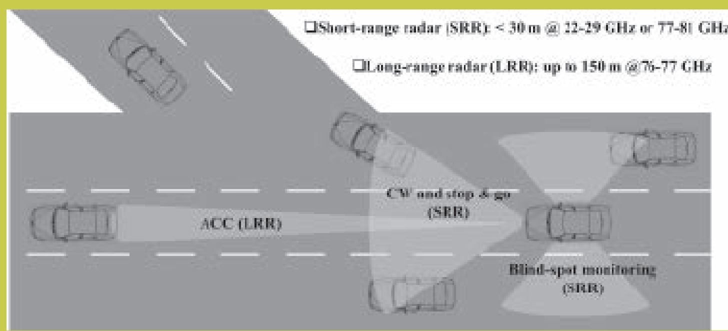

Fig.1 > Typical applications of MMW radars.

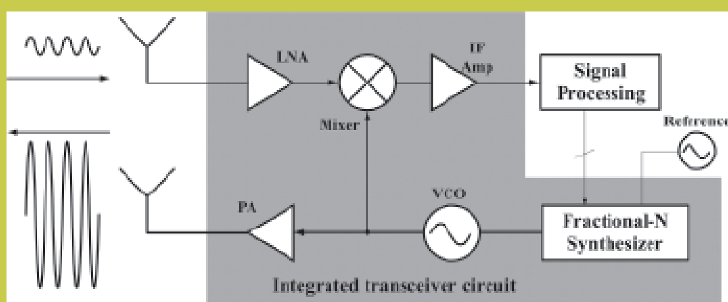

Fig.2 > The long-range FMCW radar system architecture.

Abstract

Safe and comfortable driving environment are undoubtedly the main goals of automotive transportation. Radar had been applied to vehicles to sense the range and relative speed of objects. Millimeter-wave radars are superior to other radar technologies like ultrasonic, infrared and laser radars since they can operate well at day, night and most weather conditions. Typical applications of MMW radars such as adaptive cruise control (ACC), stop & go functionality, blind-spot monitoring, and collision warnings (CW) are shown in Fig.1. The short-range radar (SRR), operated at 22–29 GHz or 77–81 GHz, provides the functions of stop & go, blind-spot monitoring and collision warnings within 30-m range. It requires fine range resolution in the order of centimeter. The long-range radar (LRR), comparatively, operated at 76–77 GHz for longer range detection up to 150 m is applied for ACC operation. The ACC system senses the objects' separation and relative speed in front of vehicle in order to keep the enough stopping distance.

With the advanced CMOS technology development, the CMOS MMW circuits become more attractive because of its low cost and high integration characteristics. It makes the automotive radar popularize possible. Interference will become an issue because of the increasing use of automotive radars. The more radars operate within adjacent area will raise the false alarm rate. This will cause the ghost target detection. In this work, we present an integrated 77-GHz long-range automotive radar with mutual interference reduction. The block diagram of radar transceiver is depicted in Fig. 2. In the system, it consists of transmitted and received antennas, integrated transceiver circuit, low-frequency reference source and signal processing block. In this work, we design the transceiver part of this frequency-modulated continuous-wave (FMCW) radar system with variable modulation scheme included. A fractional-N frequency synthesizer is chosen for FMCW generation since it has the advantages of small area occupation and low power consumption compared with direct digital frequency synthesizer (DDFS) when the fine frequency tuning is required. The variable-FMCW modulation scheme is adopted to lower the possibility of false alarm due to the mutual interference. The modulation scheme uses frequency hopping to shift the center frequency of the radar, change chirp bandwidth and slope of FMCW to achieve different chirp bandwidth and time. These result in noise-like frequency response of mutual interference after signal down-converting. The interference could be identified and the false alarm rate degrades significantly because of using this strategy.

The integrated transceiver circuit was implemented in TSMC 65-nm CMOS technology with 1P9M and the occupied silicon area is 1030μm by 940μm. After dividing-by-64, the variable-FMCW mode testing is done by using signal analyzer. Fig. 3 illustrates the measurement result of transmitted variable-FMCW signal. The total power consumption of integrated transceiver is 275 mW.

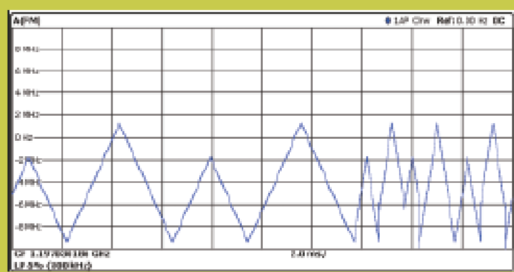

Fig.3 > The transmitted variable-FMCW signal.

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Professor Yi-Jan Emery Chen received the B.S. degree in electrical engineering from National Taiwan University, Taipei, Taiwan, R.O.C., in 1987, the M.S. degree in electrical and computer engineering from the University of California at Santa Barbara, CA, in 1991, and the Ph.D. degree in electrical engineering from the Georgia Institute of Technology, Atlanta, in 2001. Since 2003, he has been with National Taiwan University, Taipei, Taiwan, R.O.C., where he is currently an Associate Professor. He has authored or coauthored over 70 refereed journal and conference papers.

研究領域

the design of RFIC, RF power amplifier, LCD driver / LED driver IC, power management IC, LTPS IC, and System-in-Package integration.