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A Low-power High-data-rate Wireless Transceiver for Short Range Communications

應用於短距離通訊的低功率高資料量無線收發機

隊名 部落的最後戰役
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作品摘要

隨著高齡化社會的來臨，研究更方便且更安全的醫療電子器材是社會的趨勢。配合半導體技術的發展，使得可攜式醫療器材問世，並開啟了遠距醫療照護的時代：病人只要待在家裡，電子產品能夠隨時監控病人的身體狀況，需以無線傳輸即時回傳給遠端的醫院，使病人有任何生理上的異常醫院能緊急處理，而通常都需要使用多通道的感測器，造成傳收的資料量大量增加，而在可攜裝置上，低功率的要求又是需要的，因此我們提出低功率高資料量之無線收發機來因應此需求。

本次提出的發射機使用相位選擇器（Phase MUX）以及邊緣結合器（Edge Combiner）來實現高頻譜效率的 D-BPSK 調變，並提出一注入擾動技巧來抑制注入式鎖定技巧在輸出頻譜造成的參考突波；以相位選擇器作載波調變比起以往傳統電路架構來的簡單且不易受環境變異以及元件匹配因素所影響，加上邊緣合成器可降低頻率產生電路的操作頻率，有利於實現低功率消耗以及高傳輸效率。另外，使用注入擾動技巧也能有效抑制注入訊號造成的參考突波，增加發射機的發送信號品質。

所提出的無線接收機，使用 D-BPSK 傳輸的特性，在轉態上的相位改變產生的高頻訊號會被輸入匹配網路和 LNA 所濾掉，所以在 LNA 輸入後的振幅會變小，所以這個振幅變化會被包絡偵測器所偵測到，然後產生出一個脈波，這時我們就知道 D-BPSK 傳過來一個「1」信號，都沒有變化就是「0」，所以在經過 RZ-to-NRZ 轉換就可以還原信號，因此，不需要使用降頻混波器、產生精準相位之 PLL、和複雜高功率的類比數位轉換器，達成生醫應用所要求的低功率目標。

本低功率無線收發機系統晶片的創新及完整度部分整理如下：

1. 提出創新的低功率無線收發機，以 D-BPSK 的調變模式在短距離傳輸（1~2m）達到 10Mbps 的高資料傳輸量，消耗功率小於 1.5mW。
2. 本設計之無線射頻發射機，使用邊緣合併以及相位切換之技術達到低功耗以及高傳輸速率。在開啟注入擾動技巧時，參考突波能有下降 9.5 dBm 的改善。
3. 在無線射頻接收機部分，使用相位暫態對振幅變化的轉換技巧，用來偵測訊號的 0 或是 1，達到 1.09mW，10Mbps 以上和 -62dbm 的靈敏度。

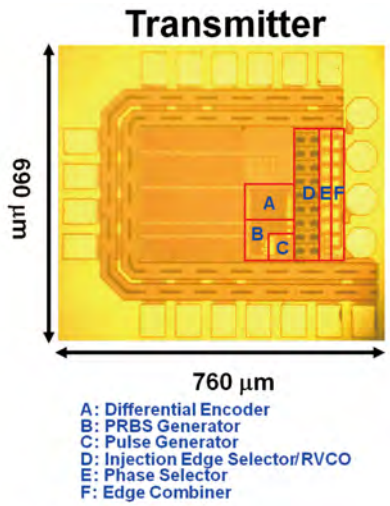

圖 1 / 發射機的晶片圖

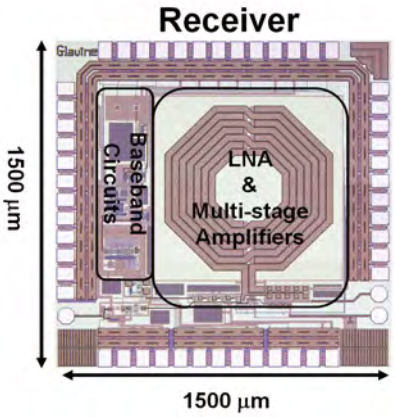

圖 2 / 接收機的晶片圖

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於 2001 取得美國加州大學洛杉磯校區（UCLA）博士學位，曾任職於博通（Broadcom Corporation）參與類比 / 射頻 / 混合訊號電路設計，並開發無線傳輸系統。2004 年加入臺灣大學電子工程學研究所擔任助理教授，並於 2009 年獲得臺大教學傑出獎，2011 年升任教授。

研究領域

無線通訊積體電路、頻率合成器、三角積分調變器、介面感測電路、電源管理電路。

Abstract

As the population is ageing in our society, there is a tendency for developing convenient and safe medical electric equipment. With the development of semiconductor technology, biomedical electronic systems execute signal amplification and processing with integrating several chips instead of bulky apparatus composed of transistor modules and discrete circuit elements. The evolution of very-large-scale integration technology not only results in portable medical equipment widespread gradually but reveals medical telehealth caring era. Patients just stay home with their physical conditions monitored by the bioelectronic equipment. The real-time monitored data is further transfer to the hospital through wireless transmission system immediately. This enables the doctors to take emergency treatment in time while abnormal physical situation occurs. Since multi-channel signals are wildly adopted recently, high-data-rate transmission is required for dealing with the large amount of data. In addition, low-power-consumption design is inevitable in wireless sensors. Therefore, we proposed a low-power high-data-rate wireless transceiver to satisfy the above mentioned demand.

For low power requirement in bio-medical applications, phase MUX and edge combiner technique are utilized in the transmitter to implement high bandwidth efficiency modulation scheme, D-BPSK. In addition, the proposed injection-dithering technique can effectively suppress the reference spur resulting from injection-locked technique in Ring-VCO. In the proposed transmitter, carrier frequency is generated by edge-combiner based PA and multi-phase low frequency oscillator, which significantly reduces the system power consumption. Besides, phase-MUX-based transmitter is much immune to noise from environment and PVT (process, supply voltage, and temperature) in CMOS process. Furthermore, the proposed injection-dithering technique can suppress the reference spur caused by injection-locking technique, and maintain the quality of transmit data.

The proposed wireless receiver adopts the characteristics of D-BPSK transmission. The phase change composed of high-frequency signals through input matching network and LNA is filtered out, which results in the LNA output variation. Therefore, this amplitude variation is detected by an envelope detector. The envelope detector generates a pulse, and then we know that the transmitter pass over a "1" signal. After RZ-to-NRZ conversion, we can restore the signal. Therefore, the down-conversion mixer, a PLL for precise phase information, and a power-hungry analog-to-digital converter are not required, which achieves low power target for biomedical applications.

In this transceiver design, we highlight innovations and full integration:

1. An innovative wireless D-BPSK transceiver can support 10Mbps data rate within 2-meter transmission distance.
2. The proposed wireless transmitter achieves low-power and high-efficiency operation with the help of edge combiner and phase-MUX technique, and the output reference spur has 9.5dB improvement with the proposed injection-dithering technique.
3. 3. The proposed wireless receiver adopts phase to amplitude conversion by matching network and LNA and achieves 15Mbps and -62 dBm. It draw only 1.09mW, achieving an FoM of 73pJ/bit.

Fig. 3 / Measurement setup