UNIVERSITI PUTRA MALAYSIA

LOW POWER MODULATOR FOR CAPSULE ENDOSCOPE

LIOE DE XING

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LOW POWER MODULATOR FOR CAPSULE ENDOSCOPE

By

LIOE DE XING

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LIOE DE XING

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Chair: Suhaidi Shafie, D. Eng

Faculty: Engineering

The evolution of wireless communication and circuit integration has brought medical science and devices to a new dimension. This leads to the invention of wireless capsule endoscope. Conventional endoscope for gastrointestinal diseases diagnoses which are uncomfortable for patients, have certain limitations in performing diagnosis or treatment. Thus it is not feasible for the conventional endoscope, in terms of travelling through a long and convoluted small intestine. Wireless capsule endoscopy addresses the disadvantages of the conventional wired endoscopes where it can reach the small intestine and achieve diagnosis without discomforting the patients as well as easily travel through the digestion tract.

Being a wireless device, the design of the capsule endoscope transmitter is paramount for the overall performance. Power consumption is the utmost important aspect in the consideration. The selection of the standard or carrier frequency is optimum to other

requirements which are image quality and frame rate. Considering the loss against frequency in a human body wireless communication, Industrial, Scientific, Medical (ISM) band of 434 MHz is employed in the design of the transmitter. This band has lower loss and relatively higher data rate compared to other standards. Inductorless architecture was adopted in the circuit design to reduce the circuit area, thus contribute to the reduction of capsule size.

Taking into account on the aspects in concern, the up-conversion mixer, ring oscillator and the integrated modulator is designed using CMOS 0.13 µm technology with voltage supply of 1.2 V. Low power consumption is achieved where the mixer consumes only 594 uA, which is equivalent to 712.8 uW of power consumption. Positive linearity is achieved with Third-Order Intercept Point (IIP3) of 2 dBm, while the dynamic range which is represented by P1dB is -5.43 dBm. Noise figure of the mixer is found to be 23 dB. The ring oscillator consumes 740 µA which translate to 888 µW of power consumption. Phase noise achieved is -81 dBc/Hz at 160 kHz of offset frequency. The integrated modulator achieves power consumption of 1.88 mW, which is superior compared to other reported work. Battery life utilizing the proposed architecture can reach 13.8 hours compared to the average of 8 hours operational time. Die area utilized is merely 0.44 mm^2 which allows better integration of other blocks in the capsule endoscope.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk ijazah Master Sains

PEMODULAT KUASA RENDAH UNTUK KAPSUL ENDOSKOP

Oleh

LIOE DE XING

Julai 2013

Pengerusi: Suhaidi Shafie, D. Eng

Fakulti: Kejuruteraan

Evolusi komunikasi tanpa wayar and litar bersepadu telah membawa sains perubatan dan peranti kepada satu dimensi baru. Ini membawa kepada ciptaan kapsul endoskop tanpa wayar. Endoskop konvensional untuk diagnosis penyakit gastrousus adalah tidak selesa untuk pesakit dan mempunyai batasan tertentu dalam melaksanakan diagnosis atau rawatan. Endoskop konvensional tidak dapat melalui seluruh usus kecil yang panjang dan berbelit-belit. Kapsul endoskop tanpa wayar boleh menangani kelemahan endoskop berwayar konvensional di mana ia boleh sampai ke usus kecil dan melakukan diagnosis tanpa menyebabkan ketidakselesaan pesakit, serta dapat melalui saluran penghadaman dengan mudah.

Sebagai peranti tanpa wayar, reka bentuk pemancar adalah sangat penting untuk menentukan prestasi keseluruhan kapsul endoskop. Jumlah penggunaan kuasa adalah elemen terpenting dalam pertimbangan. Pemilihan standard atau frekuensi pembawa hendaklah optimum untuk keperluan lain iaitu kualiti imej dan kadar bingkai.

Memandangkan pengurangan kuasa terhadap frekuensi bagi komunikasi tanpa wayar melalui badan manusia, kumpulan Perindustrian, Saintifik, Perubatan (ISM) 434 MHz digunakan dalam reka bentuk pemancar. Kumpulan ini mempunyai pengurangan kuasa yang lebih rendah dan kadar data yang lebih tinggi berbanding dengan standard lain. Reka bentuk tanpa induktor telah digunakan dalam reka bentuk litar untuk mengurangkan saiz litar, sekali gus menyumbang kepada pengurangan saiz kapsul.

Dengan mengambil kira aspek-aspek yang berkaitan, pengadun tinggi, pengayun cincin dan pemodulat direka dengan menggunakan teknologi CMOS 0.13 μm dengan bekalan voltan 1.2V. Penggunaan kuasa yang rendah telah dicapai di mana pengadun hanya menggunakan 594 uA, bersamaan dengan 712.8 μW penggunaan kuasa. Kelelurusan positif telah dicapai dengan Titik Pintasan Tertib Ketiga (IIP3) adalah 2 dBm, manakala julat dinamik yang digambarkan oleh P1dB adalah -5.43 dBm. Angka hingar pengadun adalah 23 dB. Pengayun cincin menggunakan 740 μA yang bersamaan dengan penggunaan kuasa sebanyak 888 μW. Hingar fasa yang dicapai adalah -81 dBC/Hz pada frekuensi cabang sebanyank 160 kHz. Pemodulat bersepadu mencapai penggunaan kuasa sebanyak 1.88 mW, yang mana adalah lebih tinggi berbanding dengan kerja-kerja lain yang dilaporkan. Hayat bateri menggunakan reka bentuk yang dicadangkan boleh mencapai 13.8 jam berbanding dengan purata masa operasi selama 8 jam. Kawasan dadu yang digunakan cuma 0.44 milimeter persegi yang membolehkan integrasi yang lebih baik dengan blok-blok lain di kapsul endoskop.

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Suhaidi Shafie, D. Eng
Senior Lecturer
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

Harikrishnan Ramiah, PhD
Senior Lecturer
Faculty of Engineering
University of Malaya
(Member)

Nasri Sulaiman, PhD
Senior Lecturer
Faculty of Engineering
Universiti Putra Malaysia
(Member)

_____

BUJANG BIN KIM HUAT, PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

DECLARATION

I declare that the thesis is my original work except for quotations and citations, which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institution.

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LIOE DE XING

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