# Team 11

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# Designing a Mixed-Signal ASIC for Medical Applications: Focus on Power Efficiency and Functionality

A low power mixed-signal ASIC for triple-chamber cardiac pacemakers aimed at CRT applications is presented in the research paper. The ASIC is designed to be power-efficient by incorporating a programmable stimulator with a 5-bit low-voltage DAC and a triple-mode voltage multiplier to reduce the capacitive load of the charge pump, leading to a significant reduction in dynamic power.

To further enhance power efficiency, a low-power systematic control strategy is employed in the sensing channel, where the op-amp is turned off when the sensing function is not required, reducing average power consumption.

The ASIC includes a contact resistance measurement function based on bidirectional current

injection to reflect the connection status of the electrode leads and the pathological status of the patient's heart.

The ASIC is fabricated in a 0.35-μm BCD technology with a chip area of 3.8 mm×3.8 mm, ensuring compactness and efficiency in medical device applications. Measurement results show that the ASIC consumes an average current of 4 μA from a 2.8-V supply voltage, demonstrating its low power consumption capabilities.

The ASIC achieves excellent power efficiency with a maximum power consumption of only 81 μW at extreme conditions, making it safe for patients in terms of heat dissipation concerns.

The ASIC design allows for programming the stimulus pulse magnitude from 0.1 to 7.5 V with a 0.1-V step, providing flexibility in pacing algorithms for different patient needs.

The ASIC design also ensures almost linear heart resistance measuring in the range of 250-4000 Ω, contributing to accurate monitoring and diagnosis in medical applications.

# Key Features, Advancements, and Power Efficiency Key Features:

* The ASIC integrates a programmable stimulator with a 5-bit low-voltage DAC and a triple-mode voltage multiplier to reduce the capacitive load of the charge pump, enhancing power efficiency.
* It includes a contact resistance measurement function based on bidirectional current injection to reflect the connection status and pathological conditions of the patient's heart.
* The ASIC allows for programming the stimulus pulse magnitude from 0.1 to 7.5 V with a 0.1-V step, offering flexibility in pacing algorithms for different patient requirements
* Almost linear heart resistance measuring is achieved in the range of 250-4000 Ω, ensuring accurate monitoring and diagnosis in medical applications

# Advancements:

* The ASIC design incorporates a low-power control strategy in the sensing channel, automatically turning off the op-amp when not in use to reduce average power consumption, aligning with the refractory periods of the heart.
* It features a compact design fabricated in a 0.35-μm BCD process, ensuring efficiency and functionality in medical device applications
* The ASIC achieves excellent power efficiency with a maximum power consumption of only 81 μW under extreme conditions, ensuring patient safety by minimizing heat dissipation concerns

# Working Principle:

* The ASIC operates based on a mixed-signal approach, combining analog and digital circuitry to perform functions such as stimulation, sensing, and contact resistance measurement in cardiac pacemakers.
* The power efficiency is achieved through the integration of a low-voltage DAC, a triple-mode voltage multiplier, and a low-power control strategy, reducing dynamic power consumption and ensuring optimal performance while conserving energy.

# Functionality:

* The ASIC's functionality includes delivering programmable stimulus pulses, measuring heart
* resistance accurately, and monitoring contact resistance to provide crucial information about the patient's heart condition.
* By incorporating advanced features and efficient power management techniques, the ASIC enhances the performance and reliability of triple-chamber cardiac pacemakers, contributing to improved patient care and treatment outcomes.

# Summary

ASIC Design:

The research paper presents a mixed-signal ASIC designed for triple-chamber pacemakers, featuring a compact chip area of 3.8 mm×3.8 mm fabricated in a 0.35-μm BCD process.

# Power Efficiency:

To enhance power efficiency, the ASIC incorporates a programmable stimulator with a 5-bit low-

voltage DAC and a triple-mode voltage multiplier. This design reduces the charge pump driving clock frequency to 100 Hz, significantly lowering dynamic power consumption.

# Control Strategy:

A low-power control strategy is adopted in the sensing channel, aligning with the refractory periods of the heart. The op-amp is turned on by a sensing command and automatically turned off by a valid sensing event, effectively reducing average power consumption.

# Contact Resistance Measurement:

The ASIC integrates a contact resistance measurement function based on bidirectional current

injection. This feature reflects the connection status and pathological conditions of the patient's heart, providing valuable insights for medical diagnosis and treatment.

# Stimulus Pulse Programming:

The ASIC allows for programming the stimulus pulse magnitude from 0.1 to 7.5 V with a 0.1-V step.

This programmability offers flexibility in adjusting pacing algorithms to suit different patient requirements, enhancing the effectiveness of cardiac pacing therapies.

# Heart Resistance Measurement:

The ASIC achieves almost linear heart resistance measuring in the range of 250-4000 Ω. This capability ensures accurate monitoring of heart resistance, enabling healthcare providers to make informed decisions regarding patient care and treatment.

# Average Current Consumption:

Under typical pacing algorithms from a 2.8-V power supply, the ASIC demonstrates an average

current consumption of 4 μA. This low power consumption profile contributes to prolonged device battery life and improved patient safety during cardiac pacing procedures.

In conclusion, the research paper showcases a state-of-the-art ASIC tailored for triple-chamber

cardiac pacemakers, emphasizing power efficiency, advanced functionality, and precise measurement capabilities to enhance patient care in the field of cardiology.

# Some examples where this kind of IC can be used

## Neurostimulators:

* + ASICs could be employed in neurostimulation devices used for treating conditions like Parkinson's disease, chronic pain, or epilepsy, where precise stimulation pulses and low power consumption are critical for long-term implant use.

## Implantable Defibrillators (ICDs):

* + In implantable defibrillators, ASICs could manage the detection of arrhythmias, deliver high-energy shocks when necessary, and ensure continuous monitoring of heart activity, all while conserving battery power.

## Implantable Glucose Monitors:

* + ASICs could be integrated into implantable glucose monitors for continuous monitoring of blood glucose levels in diabetic patients, combining sensor interfaces with low-power processing and wireless communication.

## Neuromodulation Devices:

* + Devices for deep brain stimulation (DBS) or spinal cord stimulation (SCS) could benefit from ASICs that control stimulation parameters, process neural signals, and maintain low power consumption to extend battery life and improve patient comfort.

**Reference:**

https:/[/w](http://www.sciencedirect.com/science/article/abs/pii/S0026269216303561)w[w.sciencedirect.com/science/article/abs/pii/S0026269216303561](http://www.sciencedirect.com/science/article/abs/pii/S0026269216303561)