ISSCC’09 Highlights
Medical Circuits

Analog Integrated System Design

A Wireless and Batteryless 130mg 300μW 10b Implantable Blood-Pressure-Sensing Microsystem for Genetically Engineered Mice Monitoring

Paper 25.1
Implantable Device Microassembly

Integrated Circuit

CDS C/V Converter with Automatic Offset Cancellation

Implantable Device Microassembly

Stainless Steel Wire as Clamp
Stainless Steel Sheet to Suppress Environmental Variation
Monitoring Cuff Made by Silicone Material
Opening/Closing Point for Vessel Insertion
Silicone Oil
Bond Wires
Silicone Coating
Coil for RF Powering
Flexible PCB
Discrete Components

Bond Wires
MEMS Pressure Sensor (0.4x0.3x0.4 mm³)
Bonded on 2.2x2.2 mm² IC

Total Weight: 130 mg
In Vivo Testing

- Laboratory Mouse with Implanted B.P. Monitoring Microsystem
  - Natural Habitat in Its Own Cage due to Untethering
  - Reliable & Accurate Measurement

- Cuff for B.P. Monitoring
- Internal Coil for RF Powering
- Class-E PA with Adaptive Supply Voltage Control
- Data Receiving Antenna

- External Coil on PCB (15x25cm²)
- Animal Cage (10x10x20cm³) with Dimension Designed for Minimizing Magnetic Coupling Variation due to Animal’s Dynamic Movement [5]

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Measurement Results

- For a typical laboratory mouse with B.P. from 80 to 120mmHg, a scaling factor of 0.13 is determined.
- The pressure amplitude drops after implant due to bleeding and recovery process.
- A 3dB noise increase after implant due to body vapor penetration through silicone coating.

- Quantized power-level signal
- Class-E amplifier supply voltage

- Class-E Amplifier $V_{oa}$ with testing animal freely moving
A 500μW Neural Tag with 2μVrms AFE and Frequency-Multiplying MICS/ISM FSK Transmitter

Neural spike streaming system block diagram

Analog Front-End Schematic

Neural spike streaming system block diagram
Transmitter Edge Combiner Schematic Details and Measured Output

Measured gain and noise response of LNA and VGA
**Measured System Summary**

![Graph of Measured System Summary](image)

**A Wireless IC for Time-Share Chemical and Electrical Neural Recording**

**Paper 25.2**

![Graph of FSCV](image)

Fast-scan cyclic voltammetry (FSCV) at a carbon-fiber microelectrode (CFM) for dopamine.
System Architecture and Timing

Time-share measurement of electrically evoked neuro-chemical (NC) activity using fast scan cyclic voltametry (FSCV) and neuro-electrical (NE) activity using EPHYS at the same recording site.

Circuit Schematic of One Channel
In Vivo Chemical and Electrical Neural Activity

A 5.2mW Self-Configured Wearable Body Sensor Network Controller and a 12μW 54.9% Efficiency Wirelessly Powered Sensor for Continuous Health Monitoring System
Wearable Body Sensor Network System

Sensor architecture and the P-FCB adhesive bandage type ECG AFE
A Pulsed UWB Receiver SoC for Insect Motion Control

System Block Diagram

Packet Structure

Receiver State

Digital Logic

Noncoherent Synchronizer & Demodulator

Cal. Logic

2.5V Moth Stimulator

0-to-5 Stage RF Gain & Tunable BPF

BB Gain

ADC

ADC

32 MHz Osc.

32 repetitions of OOK modulated sync. code

PPM modulated payload

32b code 32b code 32b code

32b code

SFD code

8b Header

Payload

Detection & Synchronization

Detect

Demodulate
Any of the 5 stages following the LNA can be disabled to reduce power consumption.

Any of the 5 stages following the LNA can be disabled to reduce power consumption.
In Vivo Testing of Tethered Moth

Before pulse stimulation

During pulse stimulation
(50, 1ms 2.5V pulses at 100 Hz)

Abdominal Deflection (°)

Pulse Frequency (Hz)

Voltage (V)

Time (ms)

System Specifications

<table>
<thead>
<tr>
<th>Process</th>
<th>90nm CMOS</th>
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<tbody>
<tr>
<td>Die Area</td>
<td>2.6mm × 2.1mm</td>
</tr>
<tr>
<td>Supply voltage</td>
<td>1V (Core), 2.5V (I/O &amp; Stimulus)</td>
</tr>
<tr>
<td>Modulation</td>
<td>On-off keying (Preamble), Pulse-position modulation (Payload)</td>
</tr>
<tr>
<td>f_s sub-bands</td>
<td>3.5GHz, 4GHz, 4.5GHz</td>
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Receiver PHY Measured Results  \( f_c=4.0\text{GHz}, T_{int}=31.25\text{ns} \)

| Maximum Sensitivity      | -76dBm at 10^{-3} BER, 16Mb/s |
| Front-end NF             | 9 dB                            |
| Energy-per-bit (for complete SoC) | 0.5 nJ/b to 1.4 nJ/b |

System Results

| PCB Area                 | 1.5cm × 2.6cm |
| Total System Weight      | 1000mg         |
| Power Consumption        | 2.5mW at 1.3V  |
| Moth Abdominal Deflection| Up to 7°       |