Nano-Watt High-Resolution Continuous-Time Delta-Sigma Modulator With On-Chip PMIC for Sensor Applications

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Introduction

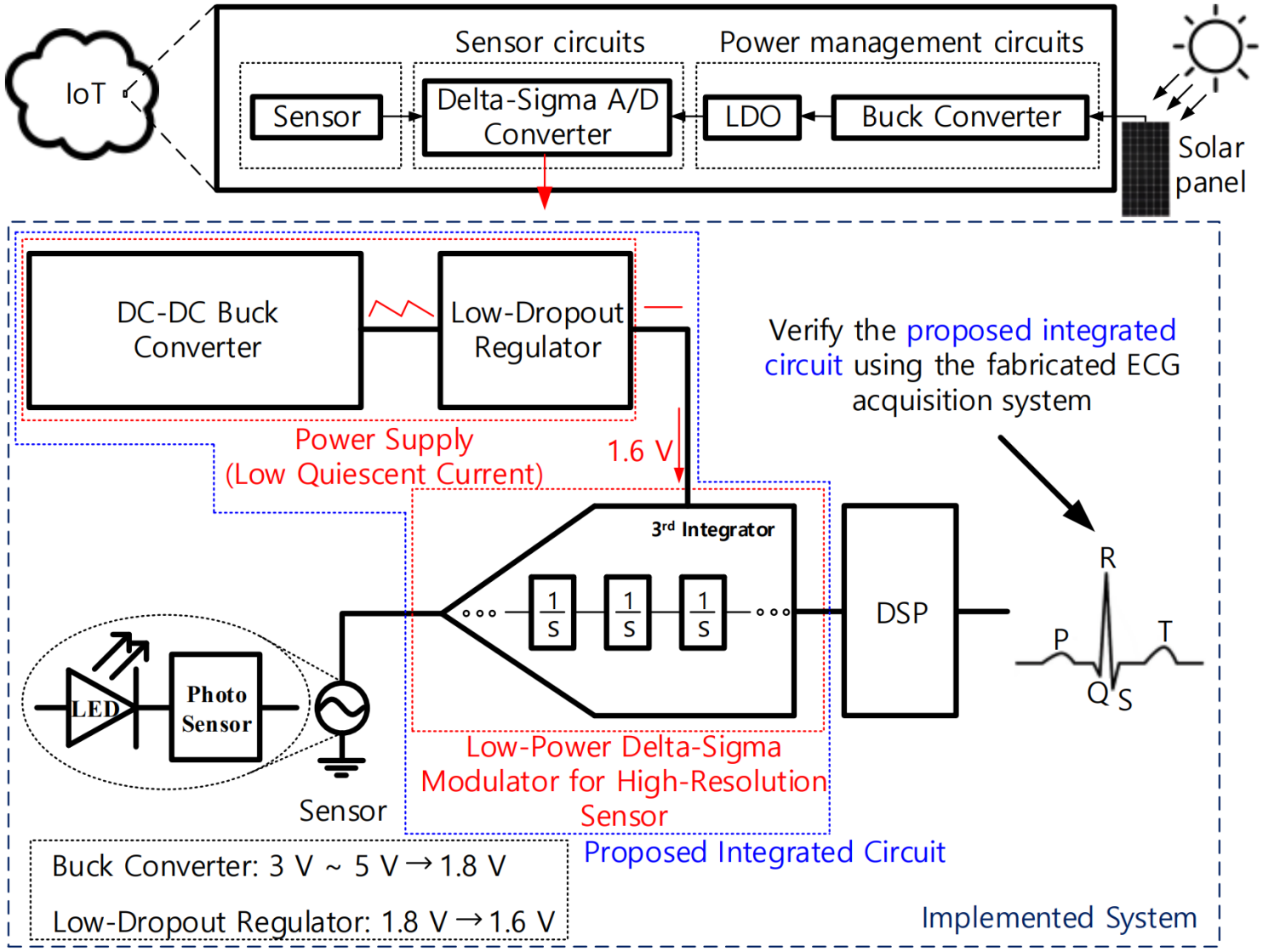
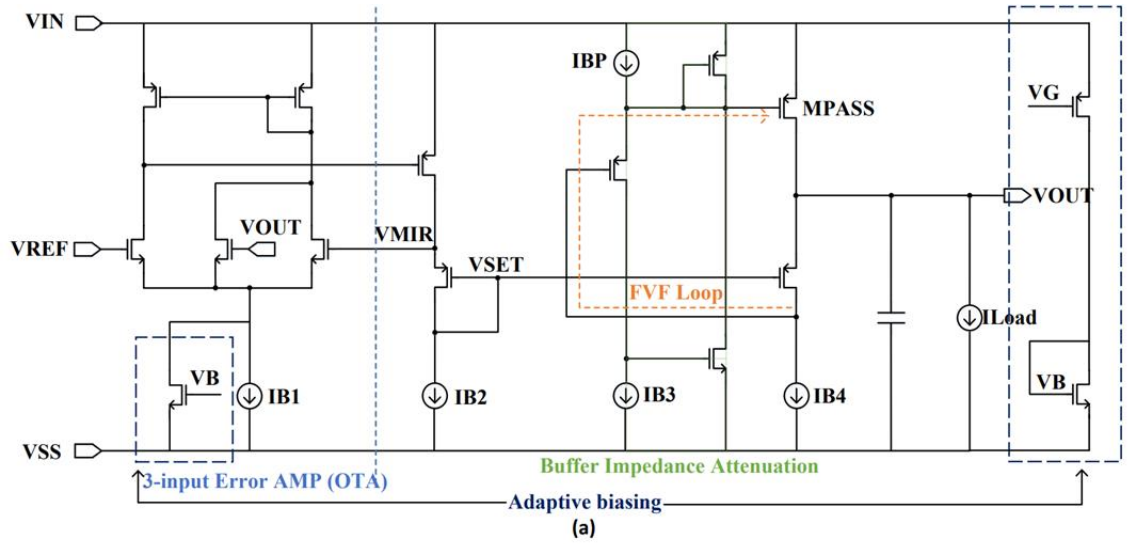
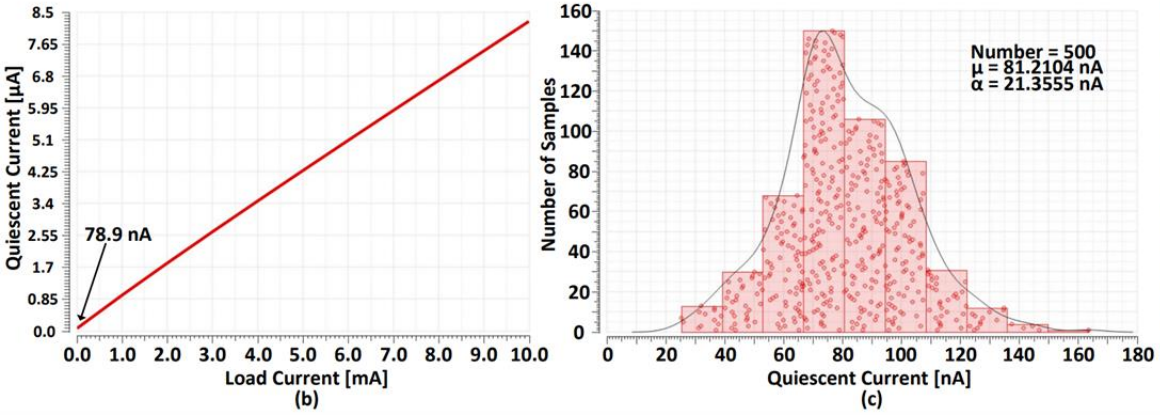


Figure 1. Configuration of overall proposed integrated chip.

Design of the proposed low-power CTDSM





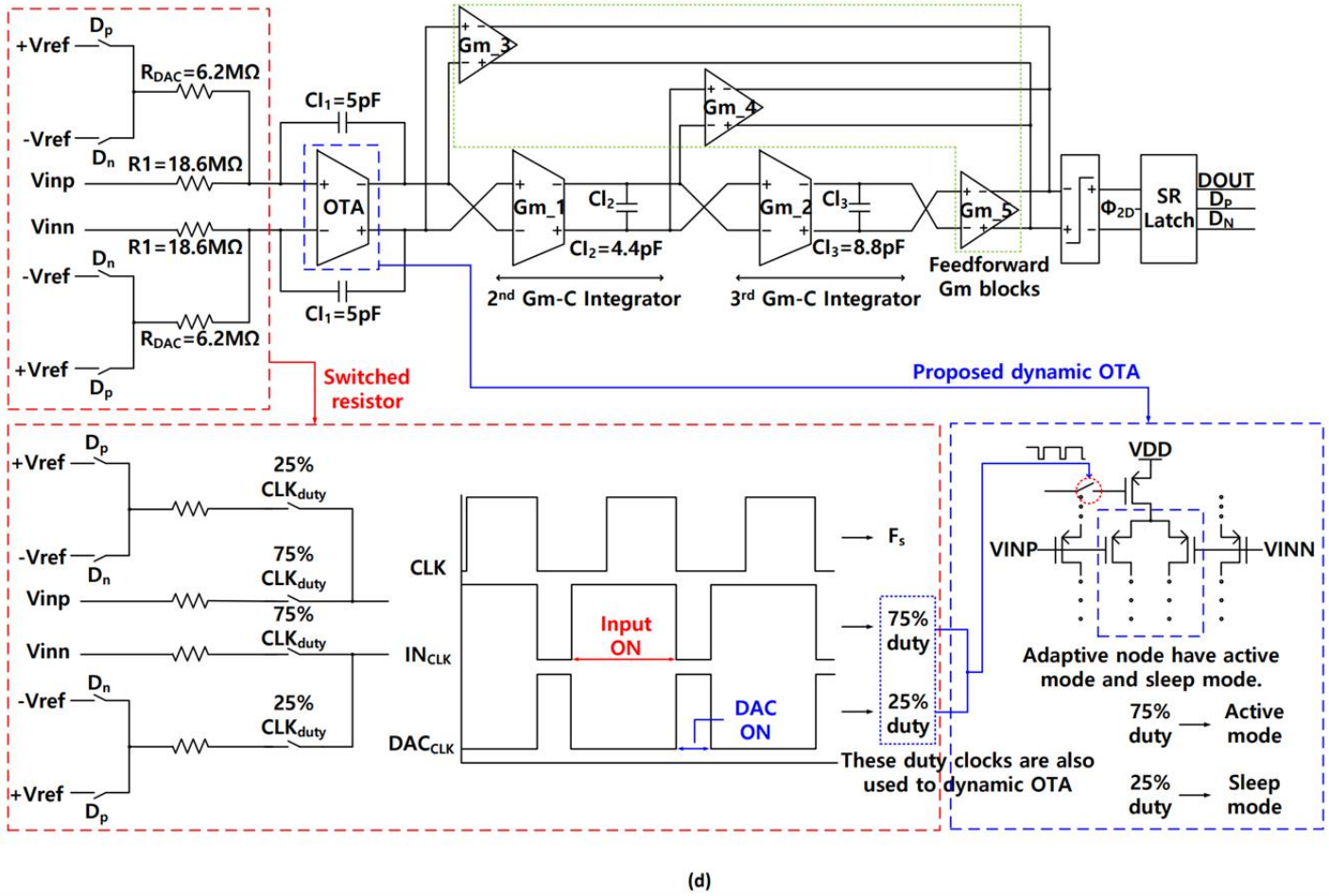


Figure 2. Proposed FVF LDO and low-power CTDSM schematics.

Design of the proposed low-power CTDSM

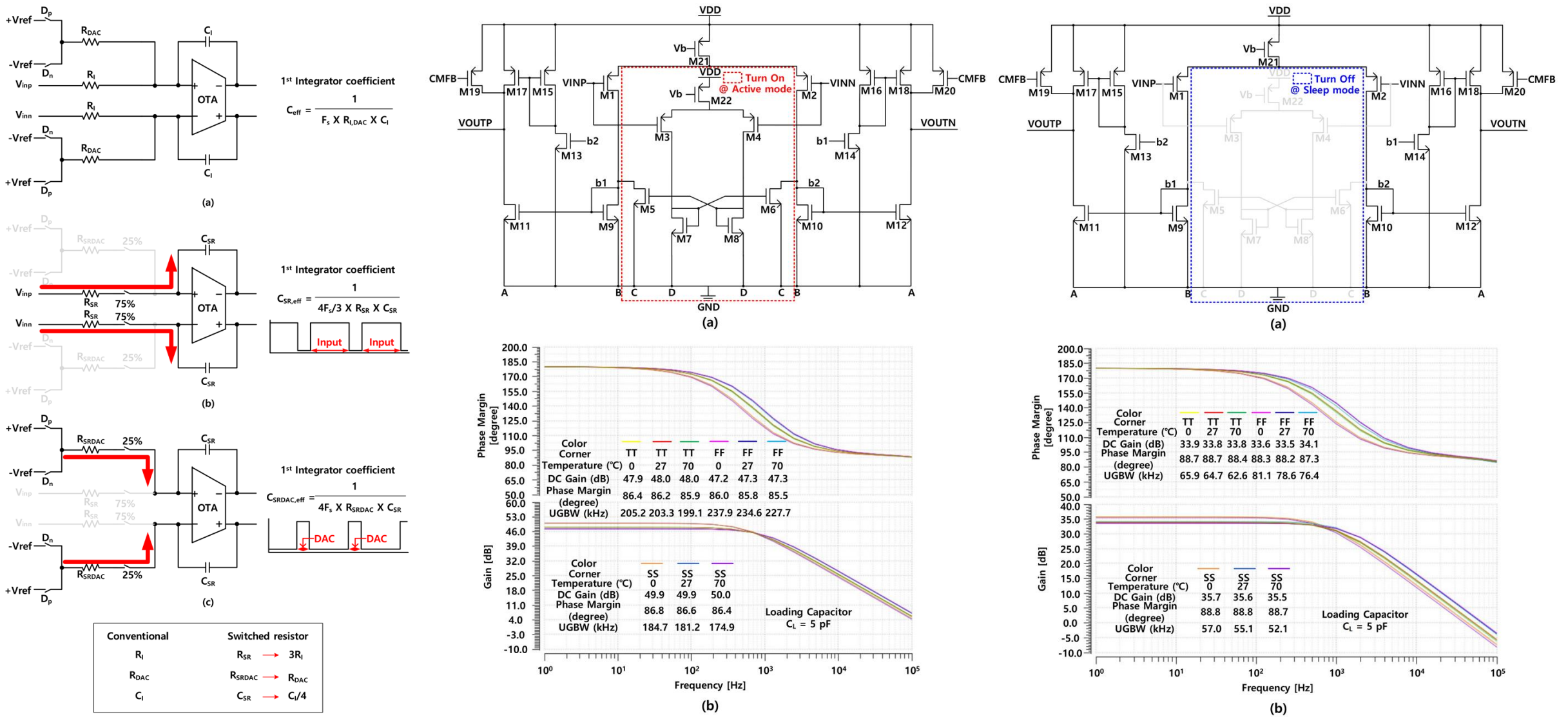
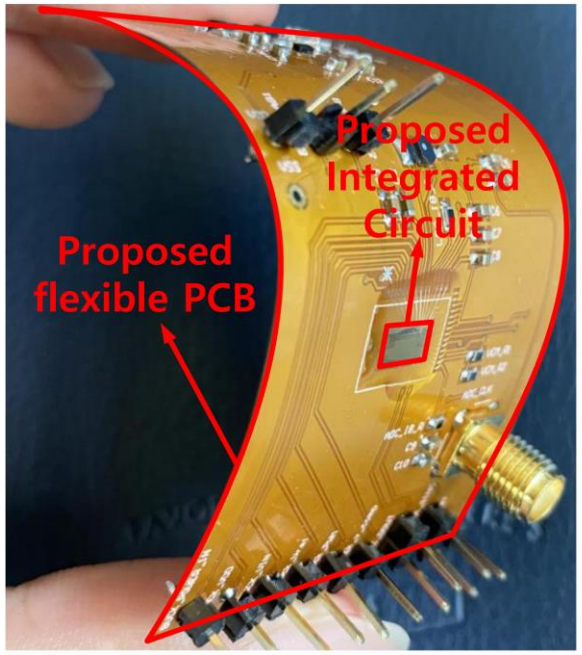
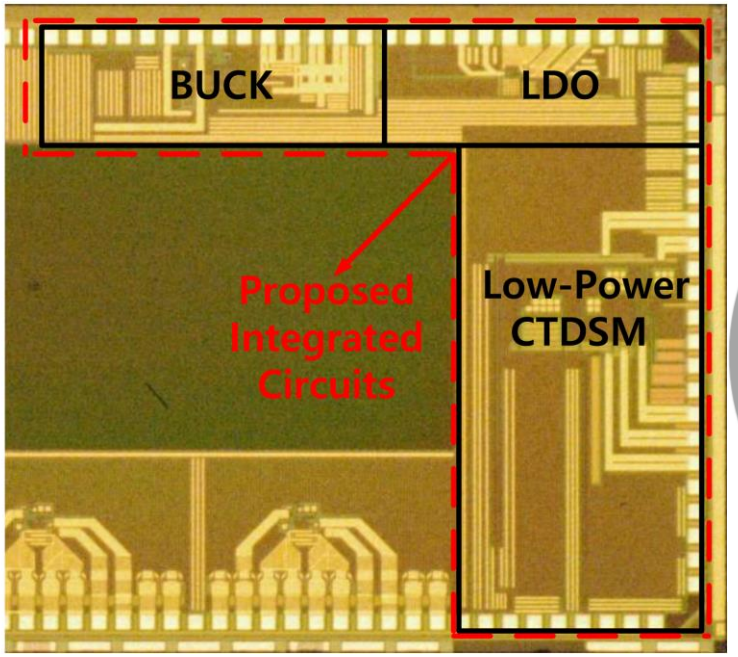


Figure 3. Proposed switched resistor and dynamic OTA schematics.

Measurement results





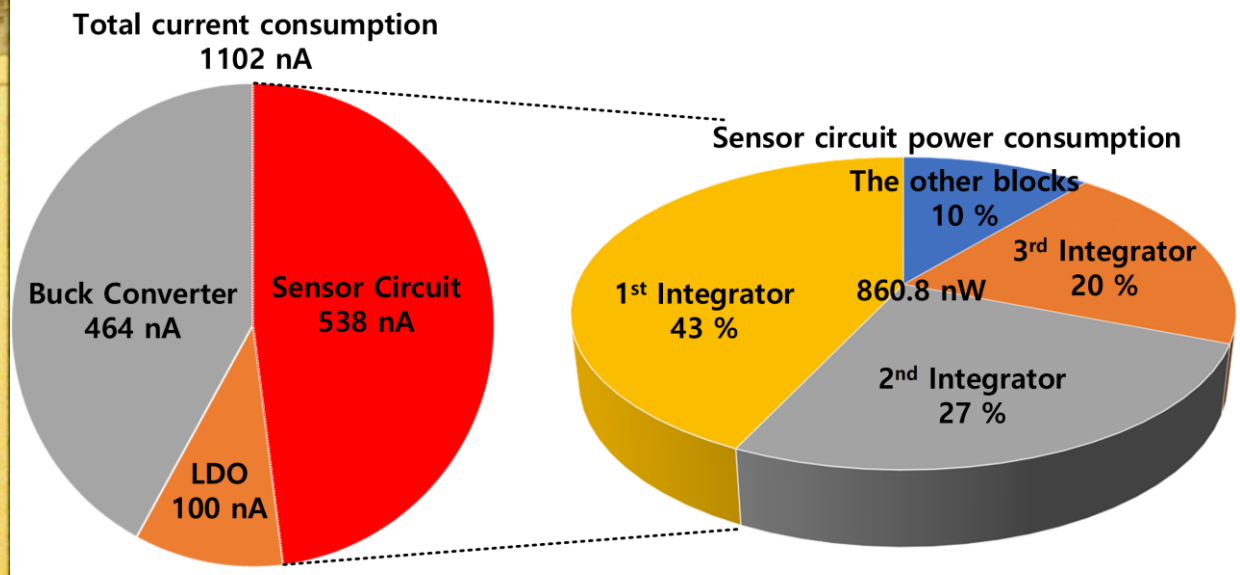


Figure 4. Chip microphotograph and flexible test board and the total current of the proposed integrated chip and the power consumption of the sensor circuit.

Measurement results

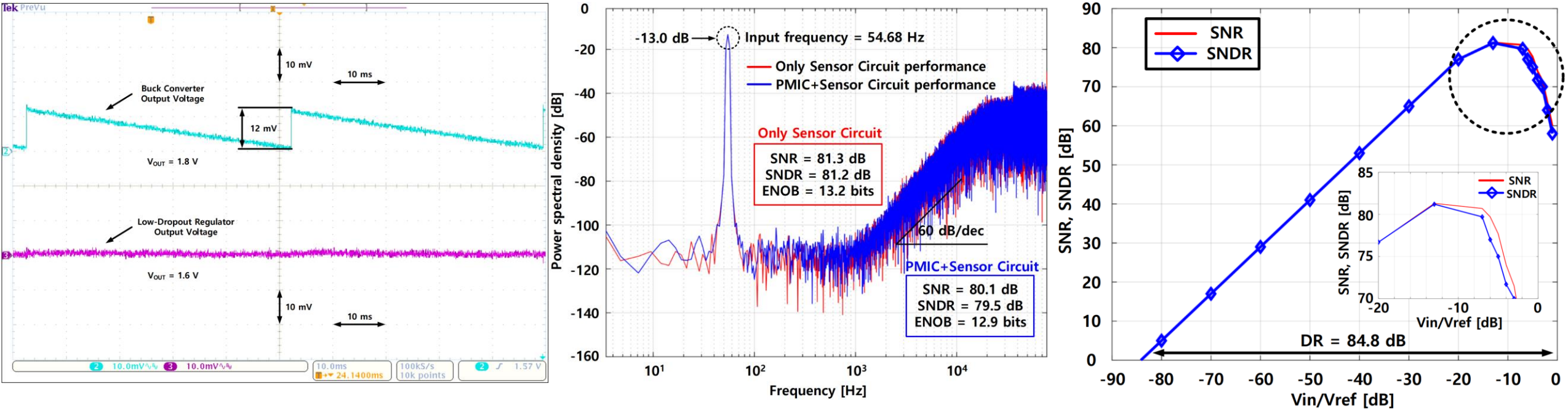
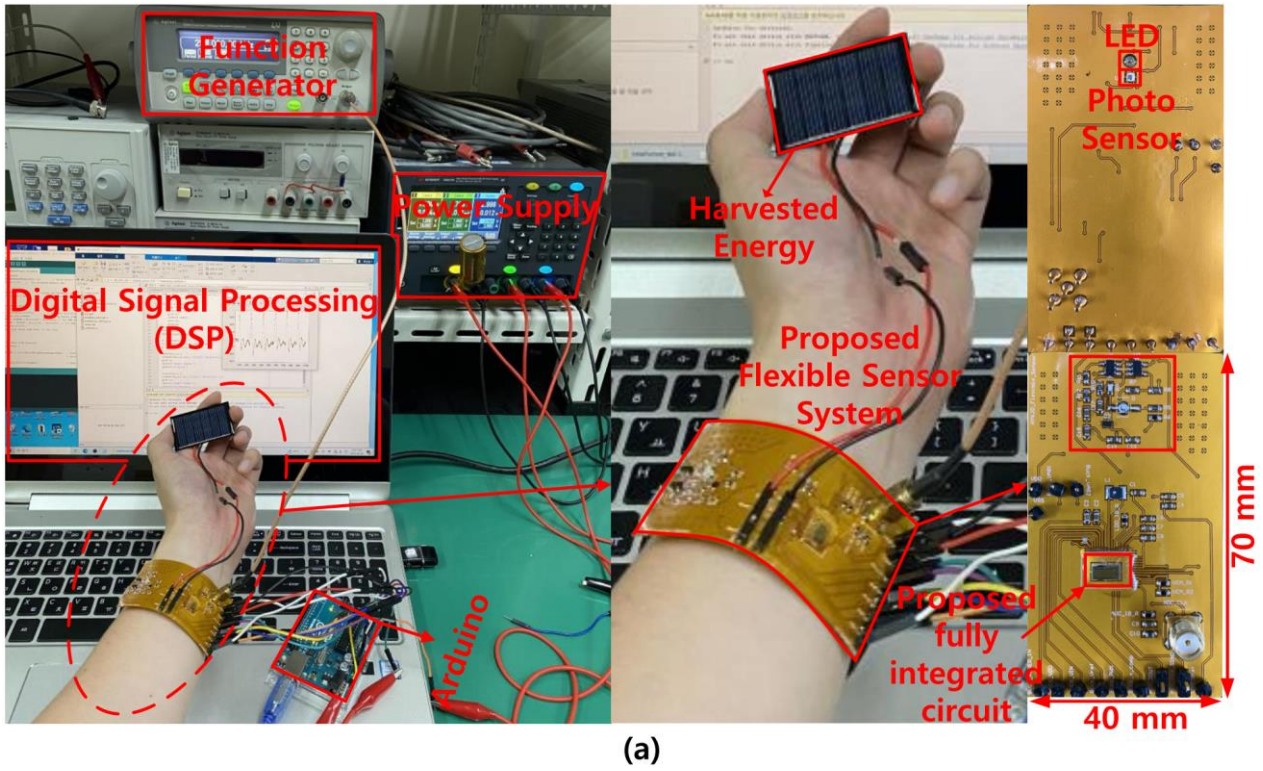


Figure 5. Measured PMIC output waveform and output FFT spectrum of the proposed low-power CTDSM.

Measurement results



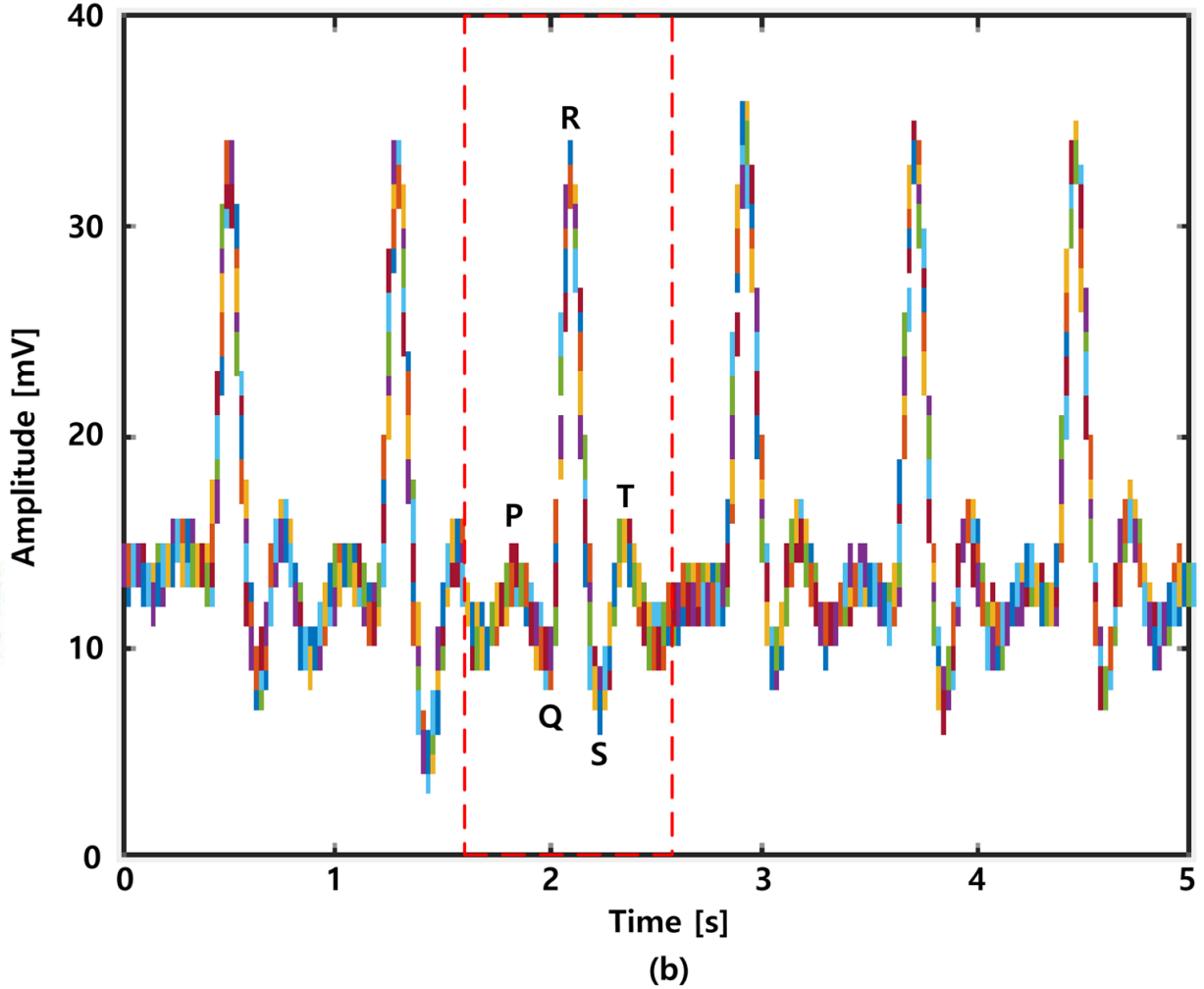


Figure 6. Test bench of the ECG acquisition system with the proposed integrated chip, and (b) measured real-time ECG waveform of the ECG acquisition system.

Conclusion

Table 1. Comparison of state-of-art low-power sensor chips

Parameter	TCAS-II'22 [4]	TCAS-II'22 [5]	TBCAS'23 [26]	JSSC'19 [27]	TBCAS'22 [6]	JSSC'20 [28]	JSSC'21 [9]	TCAS-I'21 [29]	This work	
ADC Type	DSM	Level Crossing	Zoom-DSM	DSM	DSM	DSM	SAR	NS-SAR	DSM	
Architecture	CT	–	DT	CT	DT	DT	–	–	CT	
Structure	A-RC+Gm-C	–	–	Gm-C	–	–	–	–	A-RC+Gm-C	
Order	3rd	–	2nd	–	2nd	1st	–	–	3rd	
Process (nm)	180	180	180	180	180	130	180	130	180	
Supply (V)	1.8	0.8	1.8/1.2	1.2	1	1.2	1	1.6	1.6	
Bandwidth (kHz)	0.25	4	1	0.2	0.2	0.5	9	2	0.25	
Sampling Frequency (kHz)	64	–	512	81.2	25.6	–	–	128	64	
Power Consumption (nW)	2160	180	130000	3900	800	1700	3000	40800	860.8	
SNR (dB)	80.1	–	104.9	–	–	–	–	–	81.3	80.1
SNDR (dB)	78.4	43	99.3	81.3	74	69.79	53.5	82.6	81.2	79.5
DR (dB)	81.4	–	107.6	–	78.2	92	–	85.1	84.8	
FoM_W (pJ/Conv.)	0.63	0.34	0.86	1.02	0.48	0.67	0.42	0.92	0.18	0.22
Power Delivery Network	Off-Chip LDO	Off-Chip LDO	Off-Chip LDO	Off-Chip LDO	Off-Chip LDO	Off-Chip LDO	On-Chip LDO	Off-Chip LDO	Off-Chip LDO	On-Chip Buck+LDO
Sensor Applications	ECG Sensor	ECG Sensor	ECG sensor	Neural Interface	ECG Sensor	–	Neural Interface	–	ECG Sensor	
Energy Source	–	–	–	–	–	–	–	–	Solar Panel	

Reference

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Thank you.

Q&A