A Low Noise EEG/ECG Signal Readout Front-End and An ECG Motion Artifact Analog Detector

EEG/ECG低雜訊前端電路及類比心電訊號動作雜訊干擾偵測器

組別：B377　　指導教授：鄭桂忠　組員：曾邁、陳柏諺、廖子瑜

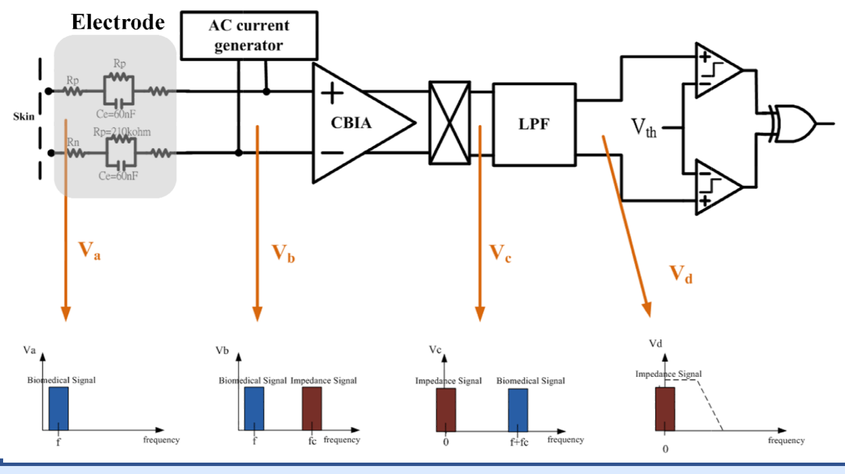
Abstract

With the continuous advancement of microelectronic technology, medical instruments have been miniaturized to devices that can be carried conveniently without interrupting daily life. Among these, the crucial aspect of the low-noise biological signal readout front-end lies in amplifying weak biological signals while mitigating interference from noise. This study reproduces the architecture proposed in "A Low Noise EEG/ECG Signal Readout Front-End and An ECG Motion Artifact Analog Detector for Telemedicine Mobile Biomedical Signal Acquisition Systems" (Wei-Chih Huang, 2013), utilizing the TSMC 90nm CMOS standard process. It incorporates a low-noise readout front-end consisting of a chopper current-balancing instrumentation amplifier (CCBIA) that reduces flicker noise and has a high common-mode rejection ratio, and an analog ECG motion artifact detector that senses variations in ECG signal and the skin-electrode impedance, which can then be served as a control signal for adaptive filters for the backend DSP, saving power consumption in the presence of motion artifacts.

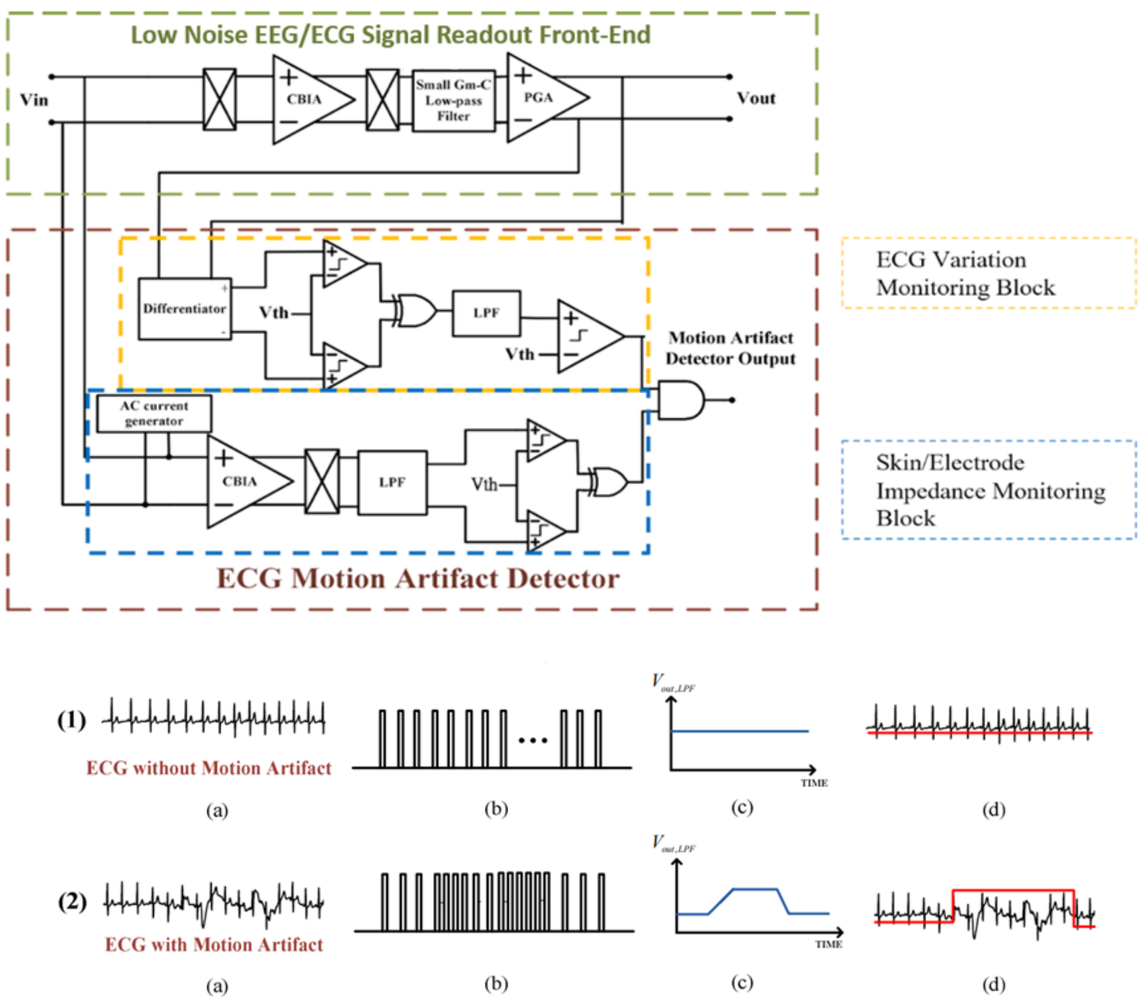
Principle

Our project employs external methods to detect and amplify EEG (electroencephalogram) / ECG (electrocardiogram) signals. Given the inherent weakness of these signals and their susceptibility to noise interference, careful consideration must be given to low-noise design. Moreover, to improve the portability of the read-out device, an emphasis on low power consumption is imperative in the design process.

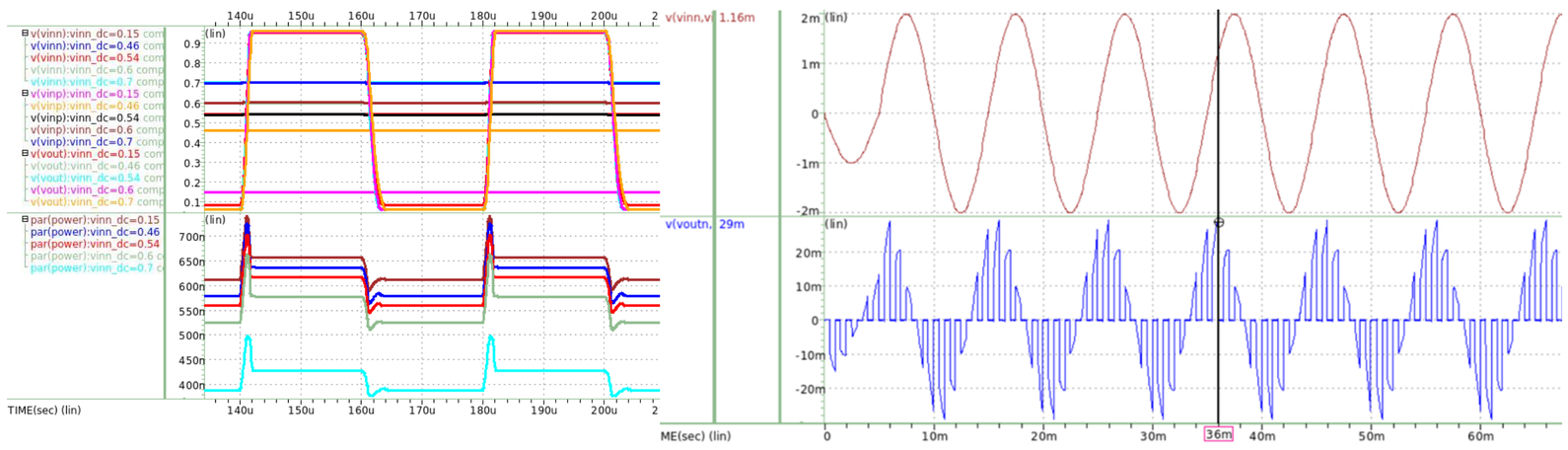
When the skin experiences pressure, compression, or traction, electrical potentials undergo alteration, consequently affecting the retrieval of target signals; giving rise to interference called motion artifact. To detect and mitigate the impact of motion artifact, the detector senses the skin-electrode impedance variation signals, which can then be passed to the backend and be processed through algorithms to eliminate motion artifacts. Additionally, skin impedance variation signals can also serve the purpose of detecting motion artifacts.

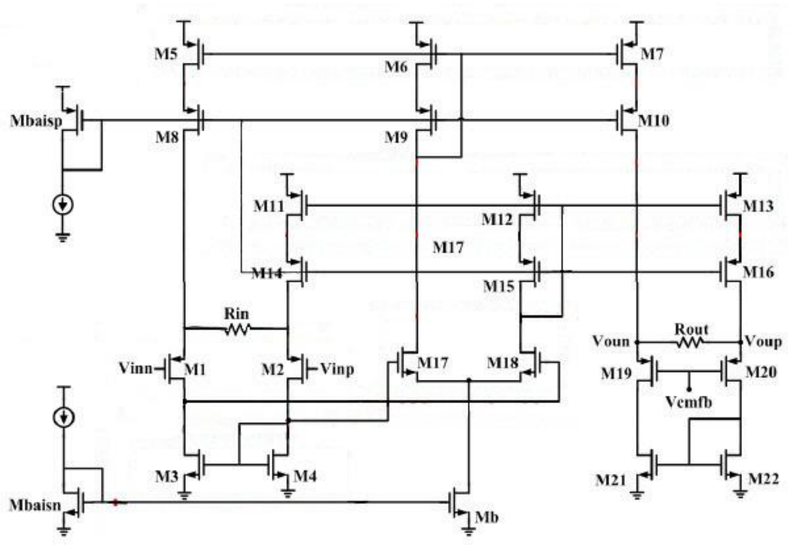


Design



Result





Main Circuit: the Architecture of CBIA

Conclusion

This project employs the TSMC 90nm CMOS standard process with supply voltage at 1 volt, replicating the low-noise front-end circuits for emplifying both EEG and ECG signals, along with an analog motion artifact detector for the latter. On the primary pathway, we are currently enhanceming of the voltage gain of the current balancing instrumentation amplifier's (CBIA) and its common-mode feedback circuit (CMFB), as well as adjusting the CMFB of the fully differential low-pass filter. The pathway for detecting variations in ECG signals currently incorporates a functional differentiator and low-pass filter with a cut-off frequency at 10 Hz. Current efforts are directed towards enhancing the differentiator's gain and lowering the capacitance connected to the low-pass filter. The pathway for detecting skin-electrode impedance signals utilizes the same CBIA and CMFB circuits as the primary pathway. Following integration with the primary pathway, a comprehensive signal simulation of the complete pathway can be performed.

Reference

[1] Wei-Chih Huang, “A Low Noise EEG /ECG Signal Readout Frond-End and An ECG Motion Artifact Analog Detector for Telemedicine Mobile Biomedical Signal Acquisition Systems , ” National Tsinghua University, Jun 2013.