ABSTRACT

Since smart computing has become more ubiquitous and distributed, there is a growing need for human machine interface (HMI) that supports a new interaction paradigm. As the media of human-machine interaction, HMI is the platform for cognition and communication between human and machine, and the approach for HMI is information transmittal. For machine to recognize and understand the information in the process of human-machine interaction, data is collected and translated by various systems, which mainly contain vision, audition and tactility. A good HMI design can improve the performance, the usability, and the security for Electric Vehicles (EV).

Electroencephalogram (EEG) provides a new interacting methodology for HMI in EV without body movement, which reduces the risks of distraction for drivers while driving. By placing multiple noninvasive sensing electrodes on a human scalp to record real-time EEG signals, individual brain activities can be transmitted and classified into specific commands for EV application. Moreover, some neurological disorder, such as epileptic seizure, can be recorded and observed by the EEG-based HMI, to trigger the emergency braking system in EV to prevent any potential traffic accidents. Considering the ease of use, dry electrodes instead of gel-based wet electrodes are selected for monitoring the real-time brain activities in wearable HMI. A typical EEG-based HMI contains three segments: 1) analog front-end interface; 2) analog-to-digital convertor (ADC) and 3) digital processing unit. As the first step of EEG recording, a wearable multi-channel EEG front-end interface is proposed in this design.

In order to create a large database for signal analysis and machine learning, multi-channel recording is necessary. With the increasing number of recording channels, hardware cost is considered as one of key parameters for EEG recording. The time division multiplexing (TDM) technique is engaged for hardware saving, and hence maintaining low power consumption based on the proposed two stage cascaded structure during long term monitoring.

In consideration of the fact that EEG signals (α, β, θ and δ waves) are mainly located around the baseband (from 0.5 Hz to 100 Hz), which suffer from the detriment of flicker noise, a low noise analog front-end interface is necessary for ensuring good signal quality. The chopping stabilization which is one of the most effective methods for noise reduction, separates the $1/f$ noise in baseband

from the original EEG signal, and dramatically decreases the noise within the frequency range from 0.5 Hz to 100 Hz.

EEG signal, due to its small amplitude (1 μV~100 μV), can be easily ruined by large common-mode interference. Hence, Common Mode Rejection Ratio (CMRR) is a critical parameter for the EEG front-end interface. In order to improve the CMRR, some circuit-level techniques such as driven right leg (DRL), digital-assisted DRL, common-mode feedback (CMFB) and common-mode feed-forward (CMFF) are explored for the cancellation of the common-mode voltage. Comparing with current techniques for CMRR boosting, a system-level innovation of the Chop/Mux structure is proposed to achieve a system-level CMRR of more than 80 dB at 50 Hz, which is among the highest reported to-date.