Low-Cost and Prototype ECG Signal Recorder Design Based on Arduino Nano Platform

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***Abstract*—This paper presents an acquisition system design integrated with the Arduino Nano platform and commercial ICs for the prototype development of a portable ECG signal monitor. An pure ECG signal can be easily acquired by the proposed design. It would be a good choice for the application of ECG signal acquisition in the future.**

I. Proposed Archiecture Design of ECG Signal Acquisition System

The proposed front-end readout circuits are shown in **Fig. 1.** It includes an instrumentation amplifier (IA), isolation amplifier, gain stage, clamp circuit, and a band-pass filter. The common mode rejection ratio (CMRR) of IA has 96dB at least. The output of the IA follows the band-pass filter as shown in **Fig. 2**, which adopts 2-order Sallen-Key topology. The cut-off frequency is set at 40Hz to reduce high-frequency noise. The characteristics of LT1789-1 consist of low power consumption, high CMRR, high power supply rejection ratio (PSRR), high accuracy, rail-to-rail input and output range and wide supply voltage (2.2V~3.6V). On the other hand, the output of front-end readout circuit is connected to an ADC of ATmega328 for ECG data acquisition and TFT LCD screen for real-time display. A 8-bit RISC microcontroller (ATmega328) with a 10-bit ADC on Arduino Nano platform is employed as shown in **Fig. 3**.

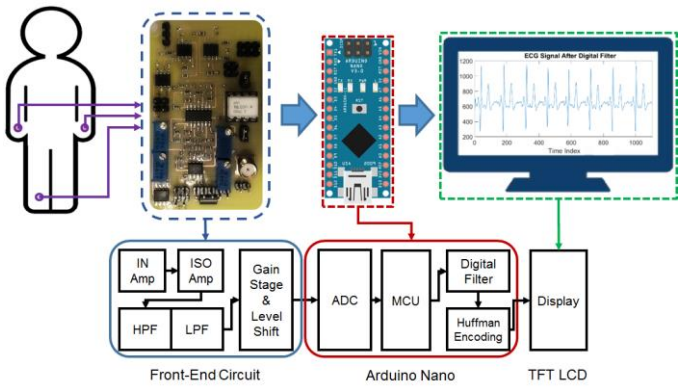

Fig. 1 Proposed ECG Acquisition System

II. Simply Lossless ECG Compression Algorithm

The proposed ECG lossless compression algorithm follows the procedures of Backward Difference (BD) and Huffman Encoding (HC). The BD calculation adopts (1) to generate the differential signal with a smaller dynamic range. Then, the output signal is processed into HC procedure which is composed of one differential table and one Huffman table. After we simulated all of the ECG patterns in the MIT-BIH database [13], we were able to specify the Huffman tree according to different occurrence probabilities. Therefore, a better compression ratio can be easily achieved.

$$diff(t) = \begin{cases} in(t), & t = 0; \\ in(t) - in(t-1), & t > 1; \end{cases} \quad (1)$$

III. Realization Results

Table I lists all components used for the proposed ECG acquisition system. Total cost of the proposed device is USD 69.21, where the most expensive cost is 1.77" TFT LCD module. It shows that the proposed ECG recorder is a quite low cost design.

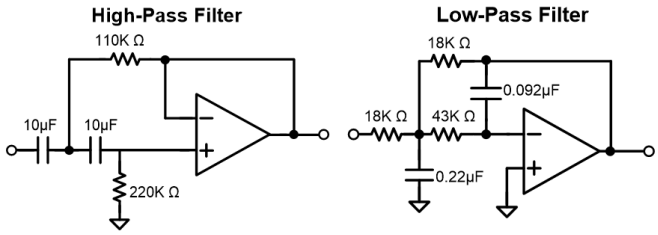

Fig. 2 Proposed Band-pass Filter Design

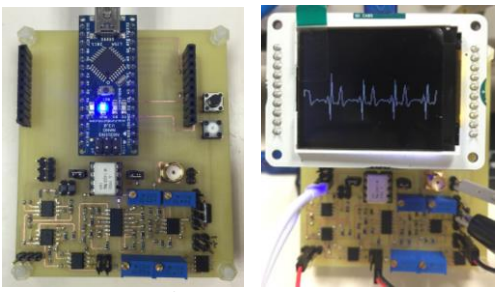

Fig. 3 Arduino Nano Platform Integrated to the Proposed Front-end Circuit Design

Table I. Equipment Cost of the Proposed Device

Component Name	Quantity	Unit Price (USD)	Total Cost (USD)
1.77" TFT LCD with Micro SD	1	23.99	23.99
Arduino Nano V3.0	1	6.94	6.94
OPA2335AID	4	4.36	17.5
MCP6074-E/SL	1	1.72	1.72
INA118UB	1	13.27	13.27
ACPL-7900-000E	1	5.33	5.33
Resistor / Capacitor	26/10	0.01/0.02	0.26/0.2
Total Cost of the proposed system (USD)			69.21