

Pulse Oximeter Based Heart-rate Monitor

Datasheet

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1. General Description

The Pulse Oximeter Based Heart-rate Monitor is an integrated signal conditioning block for measuring heart rate.

It is composed of a high-pass filter and two-stage amplifiers with low pass filters followed by a hysteresis comparator that can convert analog signal to digital signal. The high-pass filter can eliminate motion artifacts noise and respiratory noise, and it is placed off-chip. The low-pass filters are also implemented off-chip to allow users to change the cut off frequency of all filters to suit different situations.

2. Features

Typical input voltage swing: 20mV
Typical output voltage swing: 1.8V
Input current source: 25uA

3. Applications

Heart-rate monitor

5. Pin Configuration and Function Description

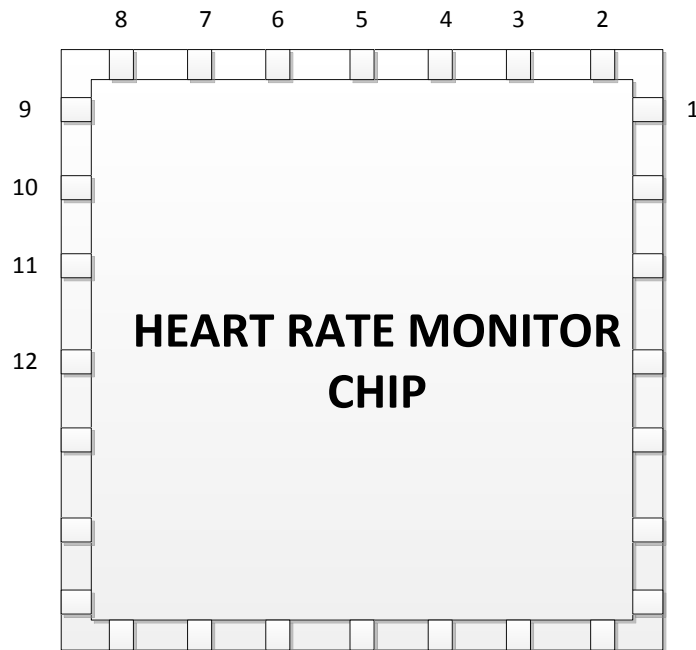


Figure 2. Pin configuration

Table 1. Pin Function Description

Pin number	Mnemonic	Type ¹	Description
1	out	O	Output to digital part for counting heart rate
2	vref	I	Reference voltage for comparator
3	out2	I/O	Output from the second stage amplifier, and input to comparator
4	vi2-	I/O	Negative input of the second stage amplifier
5	vi2+	I/O	Positive input of the second stage amplifier
6	out1	I/O	Output from the first stage amplifier
7	vi1-	I/O	Negative input of the first stage amplifier
8	vi1+	I/O	Positive input of the first stage amplifier
9	vdd	P	Power supply: positive power supply
10	i_source	I	Input current source
11	vcm	I	Common mode voltage
12	vss	P	Power supply: power ground

¹ I=Input O=Output P=Power

6. Typical Performance Characteristic

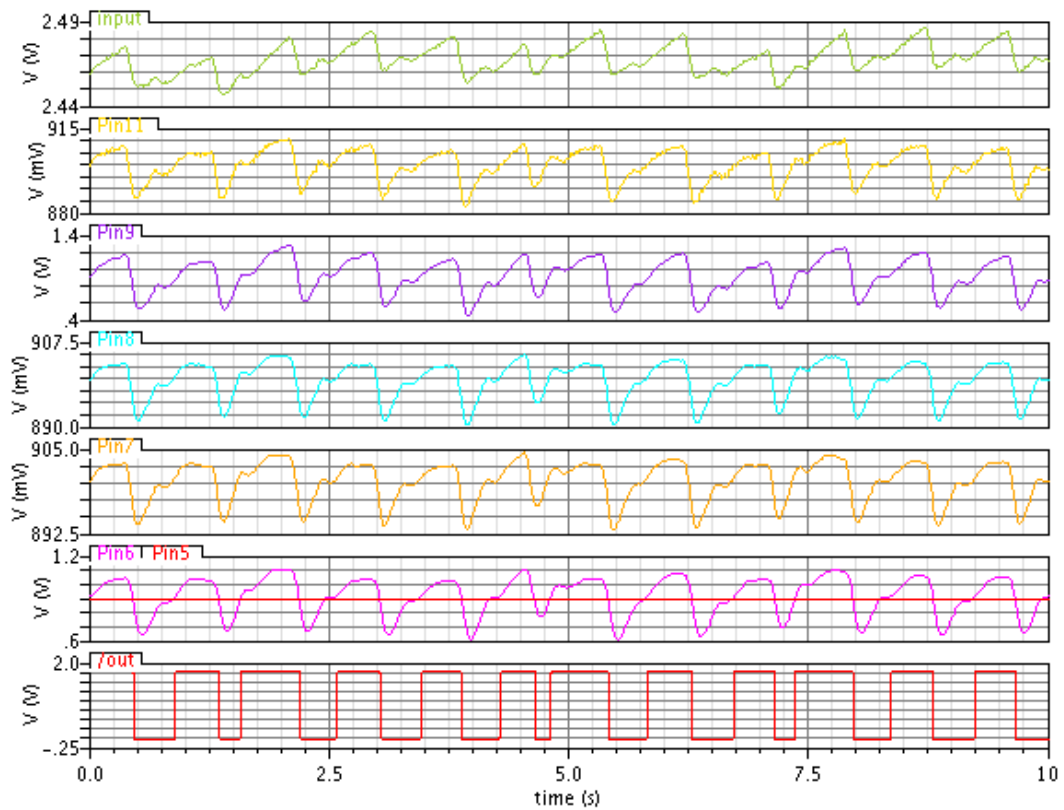


Figure 3. Typical Performance Characteristic

7. Theory of Operation

7.1 Overview

The system consists of a high-pass filter, two stages of amplifiers with low-pass filters, a potentiometer and a hysteresis comparator feeding into the digital part. The input signal will first go through the high-pass filter to eliminate the motion artifacts noise and respiratory noise, and amplifiers with low-pass filters and potentiometer will amplify the signal and further eliminate noises. The hysteresis comparator will convert the analog signal to digital signal and feed into the digital part for the heart rate count.

7.2 High-pass Filter

The frequency spectrum of motion artifact (MA) corrupted PPG signal includes different frequency components: the cardiac portion (0.5-4 Hz) and its harmonics, respiratory activity (0.2-0.35 Hz), and motion artifacts noise component (0.1 Hz or more) information.

So the system requires a high-pass filter to eliminate the low frequency noises. The cut off frequency of the high-pass filter is set to be 0.5 Hz.

7.3 Amplifier

The chip has two stages of OTAs followed by low-pass filters. The OTA is implemented as a single stage folded cascade to achieve a high gain amplifier.

For a non-inverting amplifier, if we consider an ideal case, the gain of the amplifier is assumed to be infinite, the characteristic of the operational amplifier is

$V_{out} = V_{in}(1 + \frac{R_2}{R_1})$. But in a real case, the gain of the amplifier is not infinite, so

we have the characteristic $V_{out} = V_{in}(\frac{1}{\beta + 1/A})$, and $\beta = \frac{R_1}{R_1 + R_2}$. In our case, we

want $A \gg R_2/R_1$. The open loop gain is set to be approximately 50 dB, and the closed loop gain with feedback is set to be 30 dB.

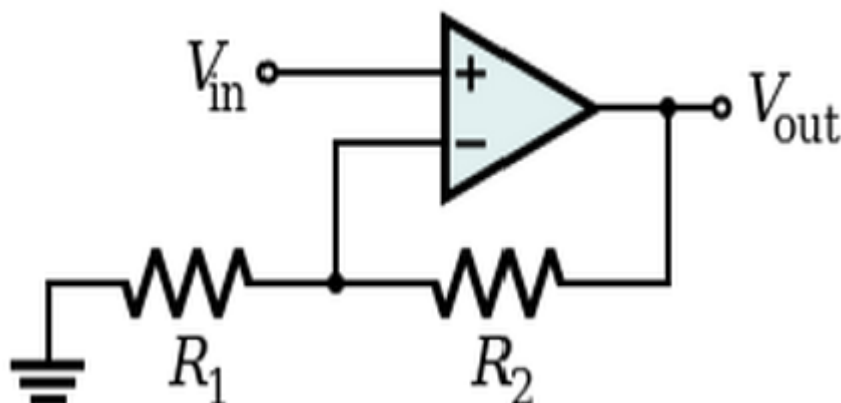


Figure 4. Amplifier with feedback

Expressions

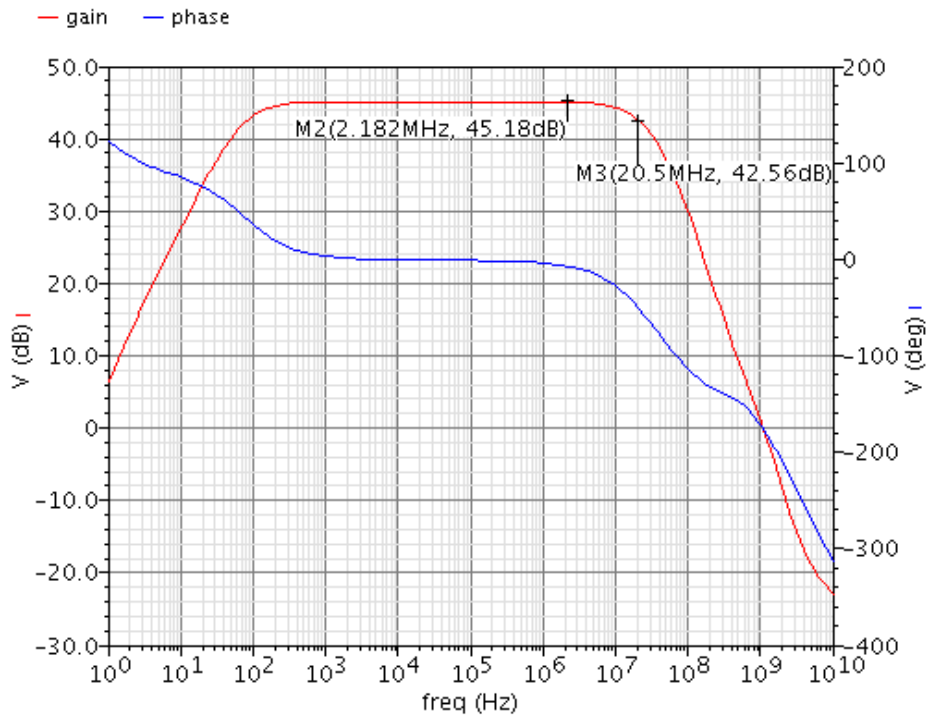


Figure 5. Open loop gain and phase margin

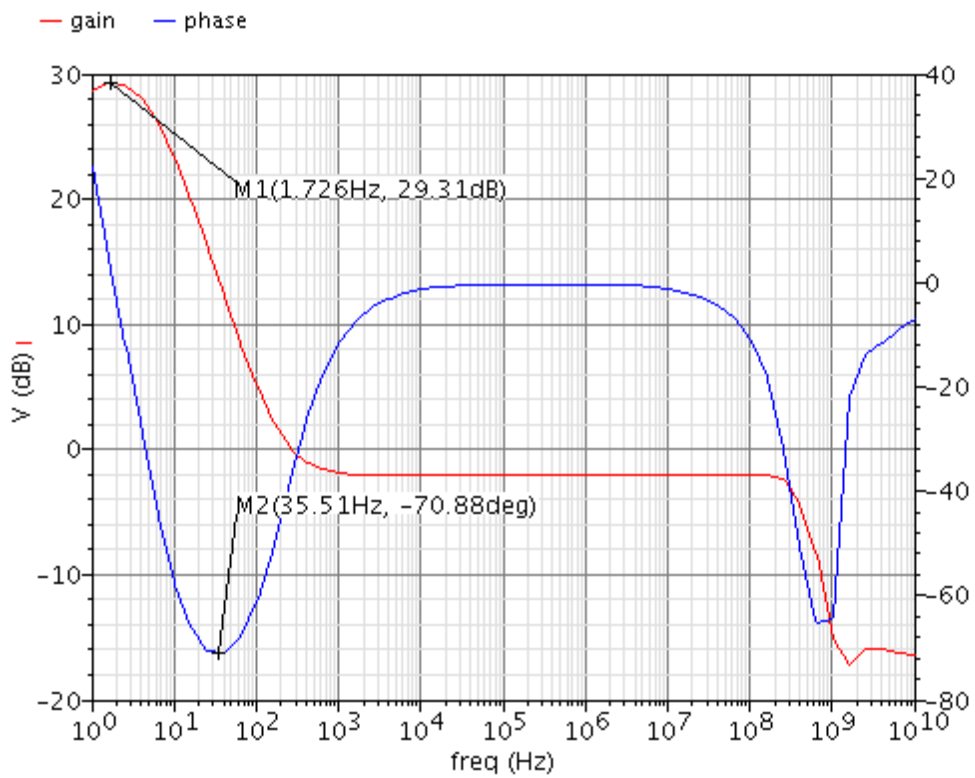


Figure 6. Closed loop gain and phase margin

7.4 Hysteresis Comparator

There are noises in the applications, so a hysteresis comparator is required to get an accurate result. The hysteresis of the comparator is 50mV.

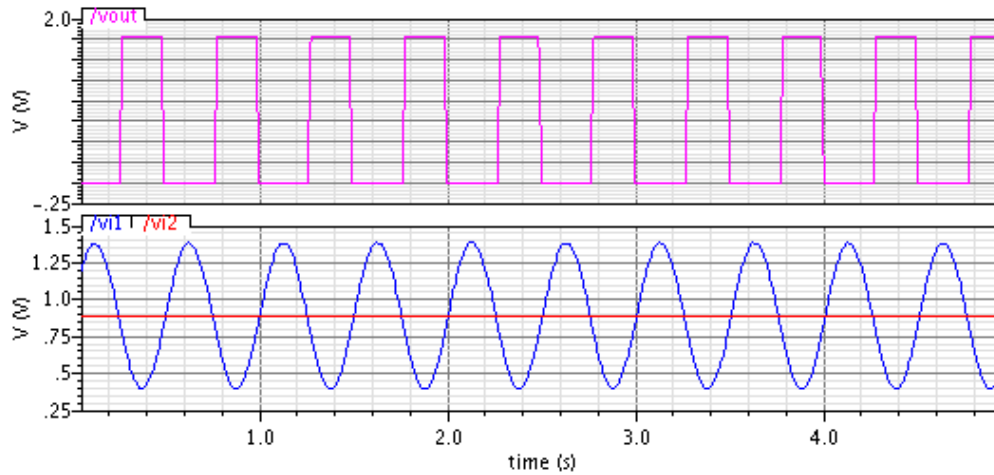


Figure 7. Simulation result of hysteresis comparator

8. Application Information

The whole system of the heart-rate monitor can be implemented as follows.

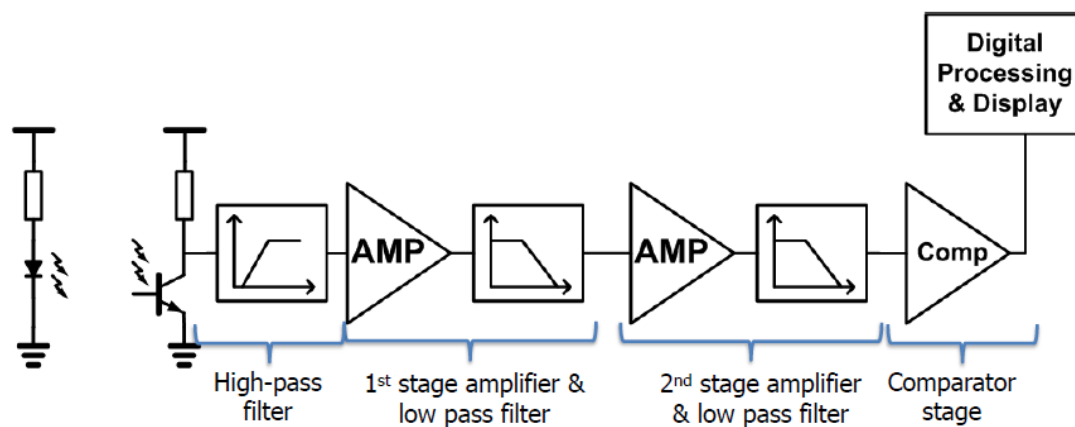


Figure 8. System overview

The detailed application circuit of the chip is shown below.

