Design and Simulation of a Low-Frequency Filtered PIR Motion Sensor Interface Using Op-Amps

Introduction:

Passive Infrared (PIR) sensors detect motion by sensing changes in infrared radiation. However, raw PIR outputs are often noisy, especially in electrically noisy environments or fluctuating temperatures. To process and clean this signal before passing it to a microcontroller or actuator, we use an analog front-end circuit made from:

- Op-Amps for amplification and filtering
- RC low-pass filters to remove noise
- Comparator to digitize the motion detection event

Circuit Description

1. **Input Stage :**
   - **Input1** is a low-amplitude, slow-changing pulse (~100 mV,0.25Hz).
   - **Input2** is a high frequency noise is generated using Zener diode (0.05v,1k).
2. **Summing stage:**
   - Using inverting Summing amplifier ,the noise is added to the input signal(**output1**) ,which generates the required PIR sensor output (**output2**)for further processing.
3. **Amplification Stage:**
   - An op-amp in inverting amplifier mode amplifies the signal. (**output3**)
   - Gain = 10 is accomplished using the resistors.
4. **Low-Pass Filtering Stage :**
   - An RC low-pass filter (cutoff ~1Hz) removes electrical noise(**output4**).
5. **Comparator Stage :**
   - An op-amp in comparator configuration compares the filtered signal to a reference(**output5**).
   - When motion signal exceeds reference, output = HIGH.
   - Reference set using voltage source.

Schematic diagram:

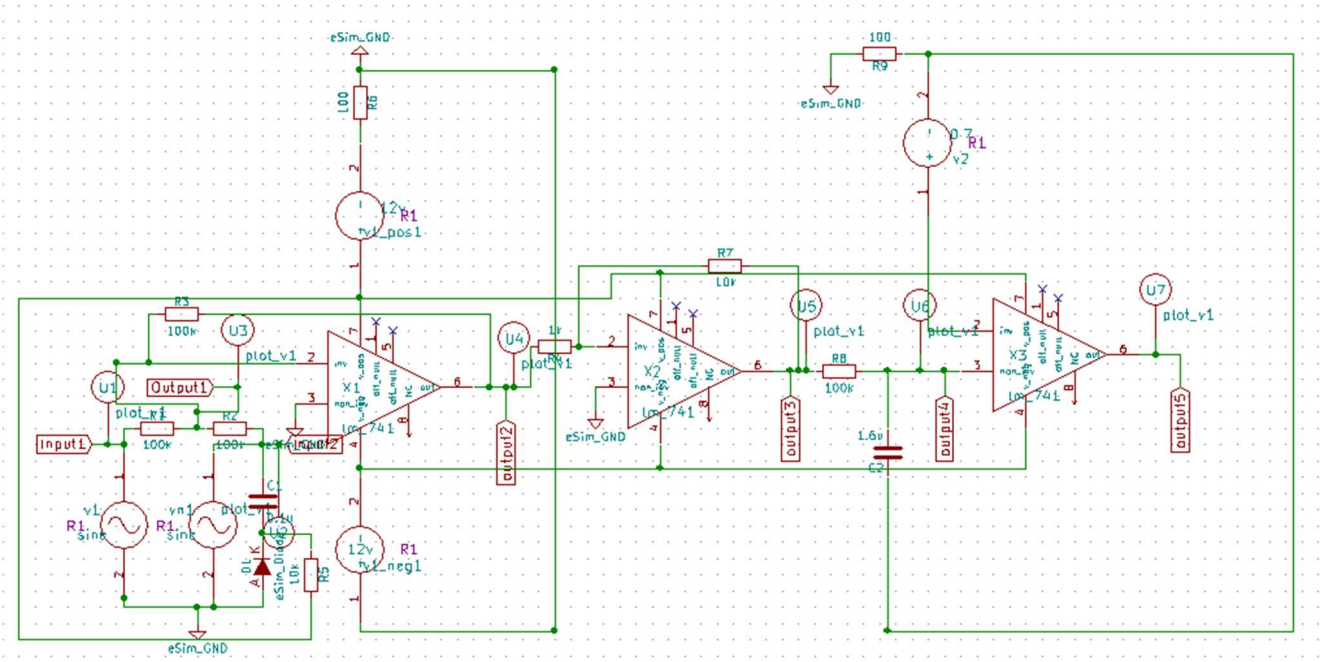

Fig.1. Schematic diagram

NGSPICE Output waveforms:

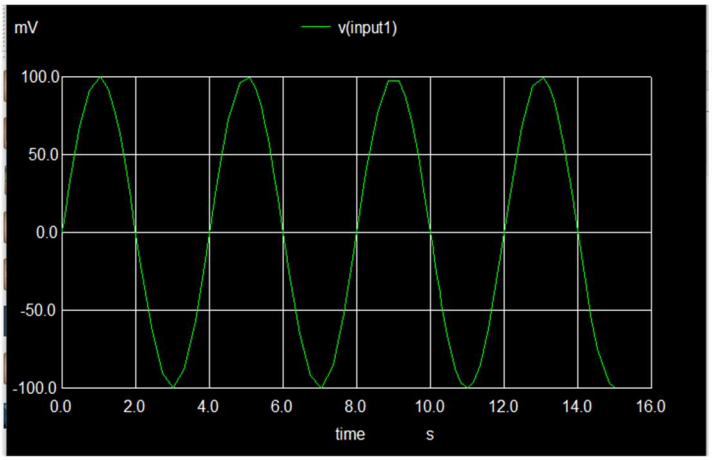

Fig.2.Low freq Signal(Input1)

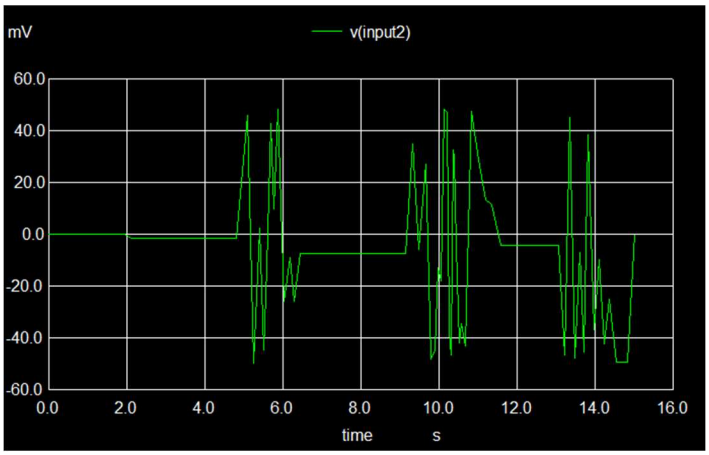

Fig.3.High freq noise (Input2)

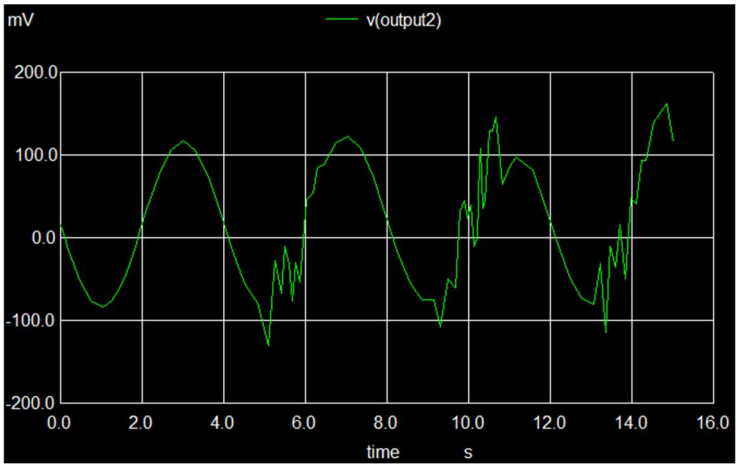

Fig.4.Inverting Summing amplifier stage output

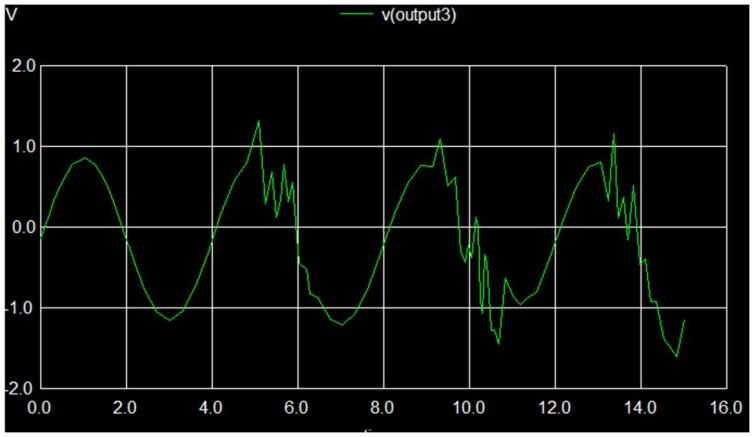

Fig.5.Inverting amplifier stage output

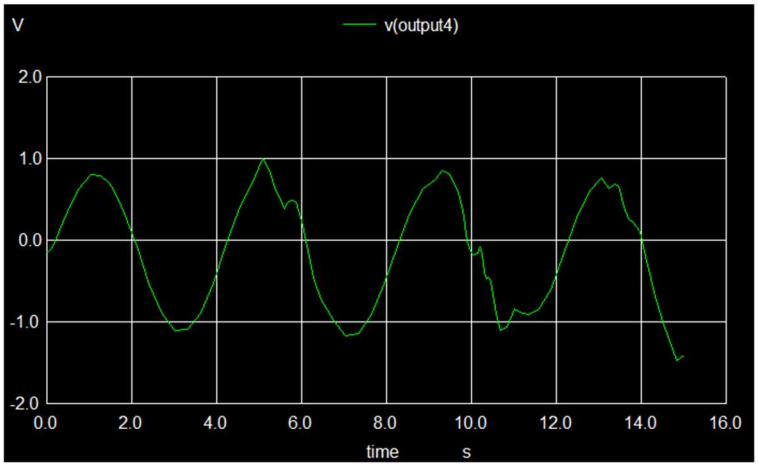

Fig.6.Low pass filter stage output

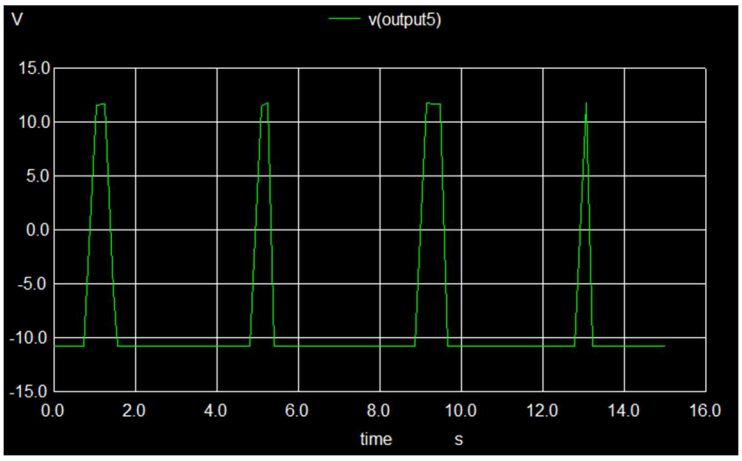

Fig.7.Comparator stage output

Python plots

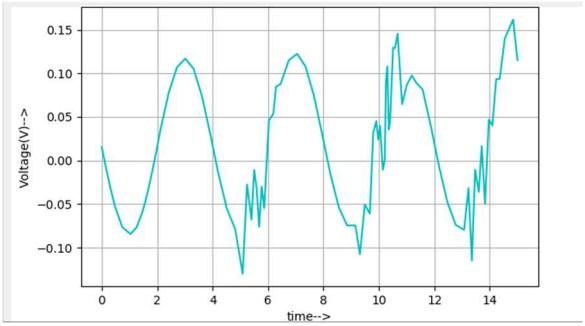

Fig 8.Python plot of noisy PIR sensor output

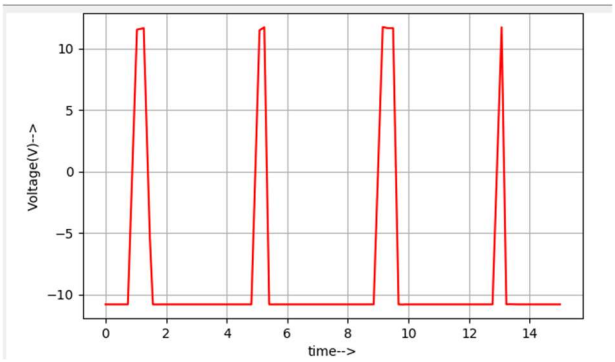

Fig 9.Python plot of comparator output

References:

- Spoken tutorial in esim website, You tube videos to learn about esim software
- Wikipedia to learn about PIR sensors

Conclusion:

Thus Low-Frequency Filtered PIR Motion Sensor Interface Using Op-Amps was designed and output waveform is obtained successfully using eSim software.

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