International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-9 Issue-5, March 2020

IC 741 and IC AMP02FP Based Signal Conditioning Circuit for Electrostatic Sensor using Multisim

B. Rajesh, P. Srinivas, K. Premsagar, P. Prashanthi Reddy, M. Akhila

***Abstract*: The Electrostatic sensors are extensively used in military, radar and electronic applications which can sense the electric charge from the moving charged motes. The signal conditioning circuit for an electrostatic sensor is a voltage amplifier that can intensify a small input signal. This paper proposal is to design a low noise signal conditioning circuit using Multisim and to study the performance of its gain, bandwidth and noise properties.**

Keywords: Electrostatic sensors, Signal conditioning circuit, Multisim and Instrumentation amplifier.

I. INTRODUCTION

In measuring system, sensor plays a key role for detecting the physical parameters. The electrostatic sensor is simple, low power and fast response device which work on the principle of electrostatic induction. In practical, the design of electrostatic sensor is still inexplicable [1]. Electrostatic device applications are measuring dry particle mass flow rate, velocity and absorption in a conveyor. The electrostatic sensor has two components sensor electrode and signal conditioning circuit. The sensor electrode detects the electric charge and the signal conditioning circuit exaggerates the signal detected by the electrode. The design of signal conditioning circuit is to collect and amplify the electrostatic noise from the sensor electrode. The simulation process of signal conditioning circuit is done by using multisim. The sensor electrodes will available in different shapes including ring, pin and plate electrodes [2]. In this article, a ring electrode is employed to determine the bandwidth and electric charge in a pipe line. The ring electrode was analyzed by Gajewski [3]. The circuit for signal conditioning
the electro static amplifier receives the small signal and amplifies to the desired level and also detects the static noise. The output signal is highly inclined to be disfigured by intrinsic or extrinsic noise.

Revised Manuscript Received on March 30, 2020.
* Correspondence Author
B. Rajesh, Assistant Professor, Department of Electronics and Instrumentation Engineering , Vignan Institute of Technology and Science, Hyderabad.
P. Srinivas, Assistant Professor, Department of Electronics and Instrumentation Engineering , Vignan Institute of Technology and Science, Hyderabad.
K. Premsagar Assistant Professor, Department of Electronics and Instrumentation Engineering , Vignan Institute of Technology and Science, Hyderabad.
P. Prashanthi Reddy, Assistant Professor, Department of Electronics and Instrumentation Engineering , Vignan Institute of Technology and Science, Hyderabad.
M. Akhila, Assistant Professor, Department of Electronics and Instrumentation Engineering , Vignan Institute of Technology and Science, Hyderabad.

II. BASIC NOISE DETECTOR

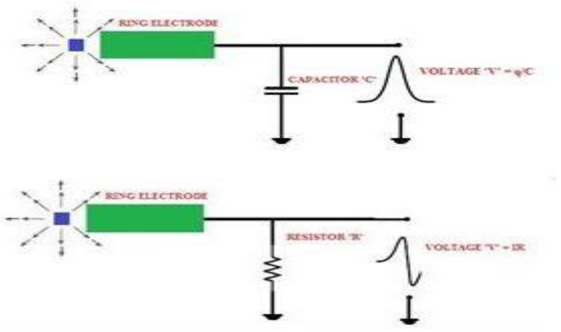

Figure 1 Basic Noise Detector circuit

Figure 1 shows a capacitive and a resistive load noise detector circuit. The basic principle behind the noise detector is when charged particles reach near to a ring electrode it inducts some amount of charge into the electrode. The accumulated charge (electrostatic noise) is collected using a capacitor or a resistor [4].

For capacitor

$$Voltage\ V = \frac{q}{C}$$

$$current\ i = \frac{dq}{dt}$$

For resistor

$$Voltage\ V = IR$$

III. GAJEWSKI MODEL OF ELECTROSTATIC SENSOR

For gas-solid flow measurement a ring shaped electrostatic sensors are used and it was designed by Gajewski in 1999. The circuit replica was designed as the electrodes for the sensor to be used in propose and circuit examination. To protect the electrode from environment a metal earthed screen is used [5].

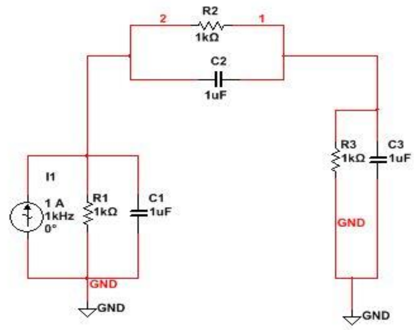

Figure 2 Gajewski model of electrostatic sensor

The value of resistance between node 1 and ground potential should be very large to make the resistance as open circuit. The current generator is connected between node 2 and ground potential. The resultant circuit with current generator is shown in figure 3.

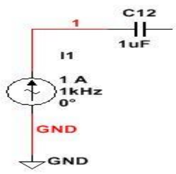

Figure 3 Equivalent model of electrode

The capacitance C_{12} is the series combination of C_1 and C_2 and the resistances are neglected due to high resistance i.e., open circuit.

IV. SIGNAL CONDITIONING CIRCUIT

Signal conditioning circuit is a voltage amplifier circuit which will enhance the quality of the sensor signal.

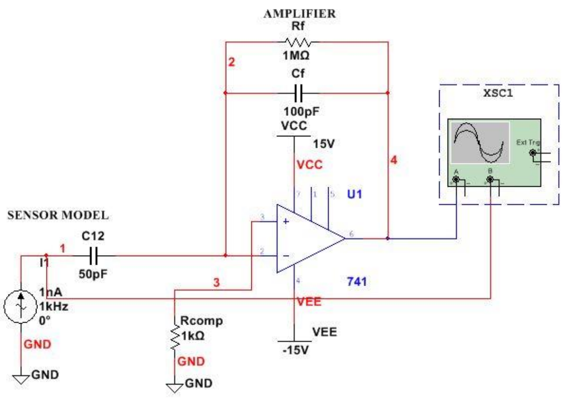

Figure 4 Basic signal conditioning circuit for electrostatic sensor

In this R_f and C_f are used in parallel combination to control the gain and bandwidth. The cutoff frequency of the circuit is

$$fc = 1/2\pi RfCf$$

The Rf is used for biasing the amplifier and the capacitor C_f will be open under low frequencies. At high frequency Cf reacts and reduces the output gain. The values of R_f and C_f will affect the gain and bandwidth of the amplifier.

V. TWO STAGE SIGNAL CONDITIONING CIRCUIT

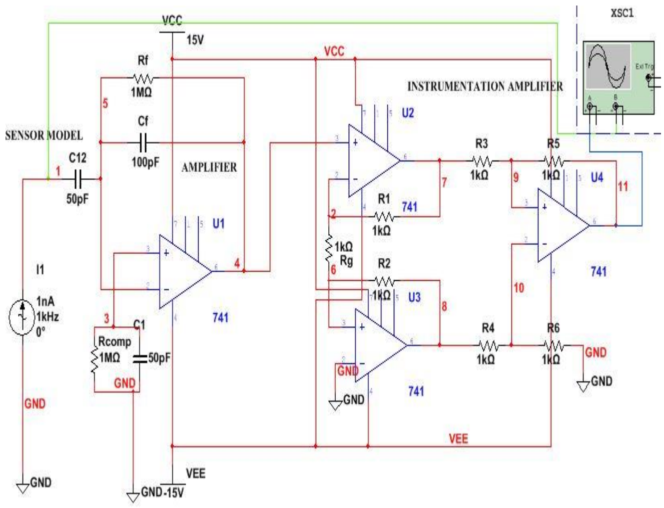

Figure 5 Two stage Signal conditioning circuit

The two-stage Signal conditioning circuit comprises of sensor electrode, amplifier and an instrumentation amplifier. The instrumentation amplifier furnishes low noise, high input impedance and high CMRR. For wider range of noise detection applications instrumentation amplifiers are used [6].

The gain of the two-stage signal conditioning circuit is given by

$$Gain = \left(1 + \frac{2R1}{Rg}\right) Rf$$

VI. AMP02FP INSTRUMENTATION AMPLIFIER

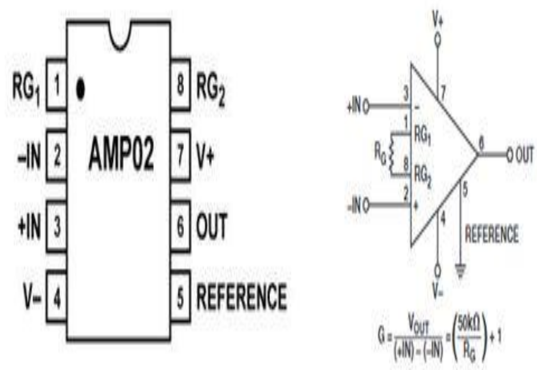

Figure 6 AMP02FP Instrumentation Amplifiers

The AMP02PF is an instrumentation amplifier available in 8 lead and 16 lead packages. The gain of AMP02PF is set by an external resistor Rg and that can vary from 1 to 10,000. The bandwidth is very high and the slew rate is above 4V/µS [7]. It has a A reference pin which allows the output to an external dc level and we can use this pin for offset correction or shifting the level as per our requirement. In this 8-lead package, the term sense is within associated to the output.

VII. SIGNAL CONDITIONING CIRCUIT SIMULATION

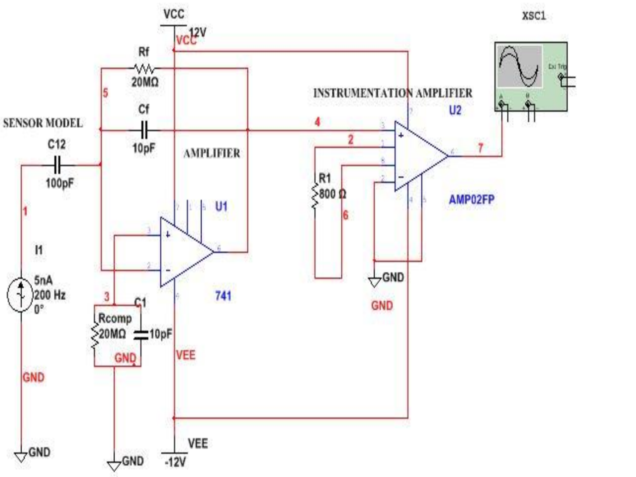

Figure 7 signal conditioning circuit in Multisim simulator

The AMP02FP is a high gain instrumentation amplifier with low offset voltage. The gain equation of the amplifier is $\text{Gain} = \frac{V_{out}}{(+IN)-(-IN)} = \left(\frac{50K\Omega}{R_g}\right) + 1$. An 800Ω resistor is used to avoid the output voltage from saturation. Here $R_g = R_1 = 800\ \Omega$ and the total gain is 63.5. The frequency bandwidth is determined from $f_c = 1/2\pi R_f C_f$ equals to 1.59 KHz for electrostatic sensor.

VIII. AC ANALYSIS AND NOISE SPECTRAL DENSITY

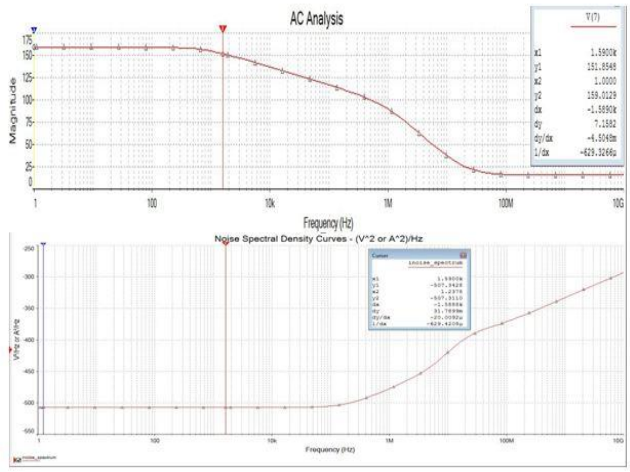

Figure 8 AC analysis and Noise spectral Curve

Using Multisim the frequency response is analysed using AC analysis. The output voltage swings between ± 10 V. By adjusting the gain we can control the electrostatic noise when output voltage leads to saturation level. At frequency 1.59 KHz the gain is 151 dB and noise is -507 V2/Hz or A2/Hz.

IX. CONCLUSION

In this review, according to the prerequisites of a ring type electrostatic sensor a signal conditioning circuit was designed using IC 741 and IC AMP02PF and studied its gain, bandwidth and noise characteristics.

REFERENCES

1. Mao, Huijie & Zuo, Hongfu & Wang, Han. (2018). Electrostatic Sensor Application for On-Line Monitoring of Wind Turbine Gearboxes. Sensors. 18. 3574. Doi: 10.3390/s18103574.
2. Tajdari, Teimour & Rahmat, Mohd & Wahab, Assoc. Prof. Ir. Dr. Norhaliza & Thuku, Iliya. (2013). Low Noise Signal Conditioning Design for Electrostatic Sensors. Sensors and Transducers. 153. 200-208.
3. J. B. Gajewski, Continuous non-contact measurement of electric charges of solid particles in pipes of pneumatic transport. I. Physical and mathematical models of a method, in Proceedings of the Industry Applications Society Annual Meeting, Conference Record of the 1989 IEEE, Vol. 2, 1989, pp. 1958-1963.
4. J. B. Gajewski, Electrostatic, inductive ring probe bandwidth, Measurement Science and Technology, Vol. 7, 1996, p. 1766.
5. Jianyong Zhang 1,2,*, Ruixue Cheng 1, Bing Yan 2 and Mohamed Abdalla 1 " Reweighting Signal Spectra to Improve Spatial Sensitivity for an Electrostatic Sensor " Sensors 2019, 19, 4963; doi:10.3390/s19224963 www.mdpi.com/journal/sensors
6. B. P. Sharma and R. Mehra, "Design of CMOS instrumentation amplifier with improved gain & CMRR for low power sensor applications," 2016 2nd International Conference on Next Generation Computing Technologies (NGCT), Dehradun, 2016, pp. 72-77. doi: 10.1109/NGCT.2016.7877392
7. https://www.analog.com/media/en/technical-documentation/data-sheets/AMP02.pdf

AUTHORS PROFILE

Bodduna Rajesh received his M.Tech (VLSI Design) from JNTU Hyderabad. He is working as Assistant Professor in the Department of Electronics and Instrumentation Engineering at Vignan Institute of Technology and Science, Hyderabad. He had 3 Scopus indexed publications and his areas of interest are VLSI.

Papani Srinivas received M.Tech degree Electronics and Communication Engineering with specialization of Instrumentation and Control Systems from JNTUK, Kakinada in 2010. Presently he is working as Assistant Professor at Vignan Institute of Technology and Science, Deshmukhi, Hyderabad. His current Research interests include Biomedical Instrumentation, Sensors and Process Control Instrumentation for Industrial Applications.

Premsagar Konapally had 10 years of experience in teaching field and presently working in Vignan Institute of Technology and Science, Hyderabad as an Assistant Professor in the Department of Electronics and Instrumentation Engineering. He completed his M.Tech (Electronics Instrumentation Engineering) from Andhra University Vishakapatanam.

Pinninti Prashanthi received her M.Tech degree Electronics and Communication Engineering with specialization of VLSI DESIGN from JNTU, Hyderabad in 2014. Presently she is working as Assistant Professor at Vignan Institute of Technology and Science, Deshmukhi,, Hyderabad. Her current Research interests include VLSI chip Design, testing and Process Control Instrumentation for Industrial Applications.

Mudireddy Akhila M.Tech degree Electronics and Communication Engineering with specialization of VLSI and Embeded Systems from JNTU, Hyderabad in 2014.Her area of interests are biomedical instrumentation and process control instrumentation.