# Summary Report Week 3

Manpa Barman

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## 1. Simulation Details

- **Environment**: LTspiceXVII
- **Important component(s)**: LM741 op-amp IC

## 2. Instrumentation Amplifier - Why do we need it?

In this week I will discuss about Instrumentation Amplifiers[1].
In a practical environment around us, we don't often see electrical signals however, in the devices we have seen so far the input given is always an electrical signal i.e. a voltage or current signal.The signals we naturally obtain in and around us are physical signals like temperature, force, pressure etc which are converted into electrical signals to study them. The device used to convert these signals is called the transducer.
This transducer takes a physical signal as input and outputs an electrical signal.For practical purposes,these transducers are used in sites when human presence is hazardous so that site information can be retrieved easily and safely. This data obtained from the transducer is then used as an input to the instrumentation amplifier. The data from the output of the transducer may be passed to the Instrumentation Amplifier(IA) via transmission lines if the IA is placed far away from the site. Then the output of the IA is fed to any indicator device like meters, oscilloscope, charts etc for interpreting the physical quantity.The major function of an IA is to amplify the low-level output signal of the transducer so that it can drive the indicator or display.
This combination of the transducer stage, instrumentation amplifier stage and the output stage comprises of the **instrumentation system**[1].

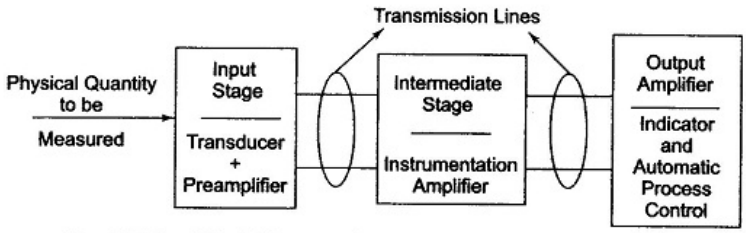


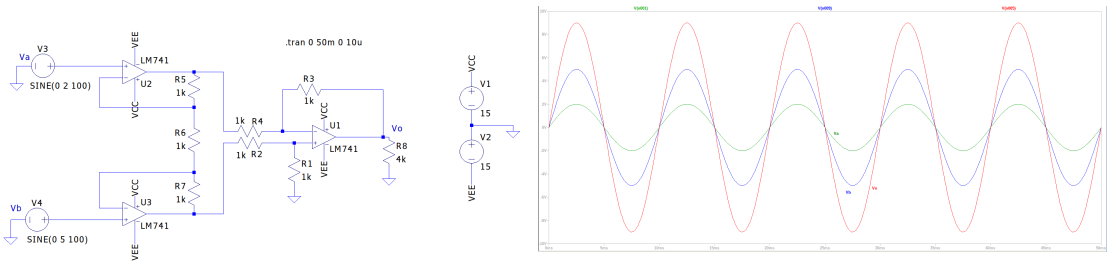

**Fig. 14.24** Block Diagram of an Instrumentation System

Figure 1: Block Diagram of an Instrumentation System

## 3. Instrumentation Amplifier Design

IA's are found in the market in the form of chips.They are often specialized and specifically designed to make the circuit stable and accurate according to the purpose of the system. Examples are $\mu A725$, ICL7605 etc.
In this special purpose circuits electrical parameters like offsets, drifts, and power consumption are minimized. whereas input resistance, CMRR and supply range needs to be optimized. Designing such precise circuits is beyond the scope of this report.

However there are certain applications which are more general purpose and have a loose requirement. In this case we can simply used op-amps in differential mode with slight modification




((i)) Circuit Diagram

((ii)) Waveform

Figure 2: Instrumentation Amplifier and its I/O waveforms

done to remove the noise from site measurement. Instrumentation Amplifier's using Transducer Bridges are most common in this domain.

As already mentioned we can take the physical measurements in the site and then pass the signals via the transmission lines for amplification and indication. This transmission process can induce noise to the original signals which in turn will also get amplified by the amplifier setup. To remove this noise we use a differential amplifier setup with two voltage followers in the input terminals of the original circuit to remove the noise signal completely.To understand the circuit with derived formulas you can refer to this video.[2]

The figure 2(i) refers to the circuit diagram of an Instrumentation Amplifier and 2(ii) refers to the i/p and o/p waveforms.

## 4. Transducer Bridge Circuits

In the previous sections we discussed about the input and output specifications of the IA.The input to the IA comes from a transducer which can be a strain gauge, thermocouple, thermistor, photocells etc. This transducer is placed, replacing one of the bridge resistances in the circuits.

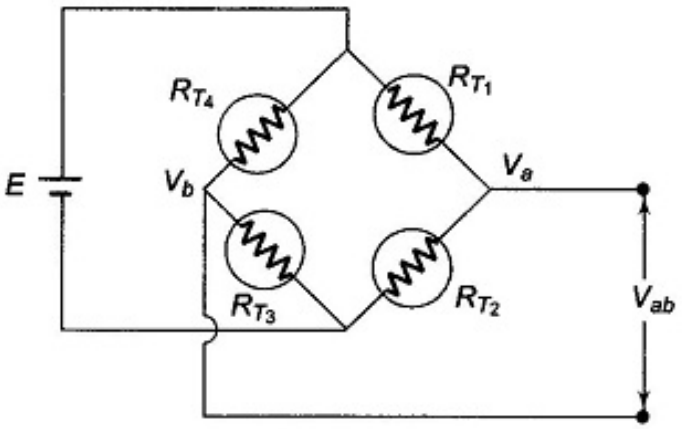



Figure 3: Transducer Bridge Circuit

In fig 3 we have the bridge circuit[3] where $R_T$ represents any transducer output resistance like photocell, strain gauge etc. The bridge circuit is calibrated to change to resistance $R_T$ of the transducer as soon as there is any chance in physical quantity like temperature, light energy etc. The change is $R_T$ causes an unbalances bridge and thus a voltage appears across $V_a$ and $V_b$. This $V_a$ and $V_b$ are fed into the instrumentation amplifier input terminals. The IA output is then fed to the indicator input which gives a human readable interpretation. This in turn measures the physical quantity easily and accurately.

## References

[1] Ramakant A. Gayakwad. *Op-Amps and Linear Integrated Circuits*. PHI Learning Pvt. Ltd., New Delhi-110001, fourth edition, 2010.

[2] All About Electronics. Instrumentation Amplifier Explained (with Derivation). https://www.youtube.com/watch?v=pSctPegtZfc.

[3] EEE Guide. Differential Instrumentation Amplifier Transducer Bridge:). https://www.eeeguide.com/differential-instrumentation-amplifier-transducer-bridge/.