Design of Low cost Load cell Amplification Card

Ravi Kumar, Chanchal, Sunil K S Kushwaha

Master of Technology in Electronics and Communication form Maharshi Dayanand University, Rohtak

Abstract - Whether being used for closed loop feedback, automation and assembly lines, stamping or other industrial applications, load cells provide accurate measurement of a load and convert tension or force into a proportional electrical signal. A load cell amplifier is then used for signal conditioning so the signal can be amplified and converted into an output value. Without a load cell amplifier, the signal from the load cell may be too weak to read. The amplifier simply “amplifies” the signal so it can be read and used wherever and however needed.

As load cell can gives the output in the range of 0-20 mV. It is very low voltage so it should be amplified to -10V to +10V range so that Programmable controller or DAQ device can process the signal accurately.

In market many brand of load cell amplifier are available. But we are going to make a simple low cost amplifier which will be more accurate and also have gain adjustable feature.

1. INTRODUCTION

In this amplification card we are using three OP-Amp IC named as OP07C. The op07c is Low Noise amplifier IC. It replace Chopper Amplifiers at a Lower Cost (about ₹15 per piece). OP07 Op-amp IC have wide Input-Voltage Range: 0 to ±14 V and Wide Supply-Voltage Range: ±3 V to ±18 V.

For reducing environmental interferences and noise we are using Polyester Capacitors. The polyester dielectric used in these capacitors also referred to as PET offers a high dielectric strength. This means that high voltage capacitors can be made relatively small. The construction and dielectric of polyester, PET capacitors means that they are able to be used in applications where sharp, fast rise time spikes are present as they are able to accommodate high dV/dt.

For making power supply for the Amplifier we are using 5 Volt regulator (LM7805), 12 Volt regulator (LM7812), -5volt regulator (LM7905) and -12 volt regulator (LM7912). A 12-0-12 step down, center tap transformer is also required in power supply circuit.

2. STUDY

2.1 Amplification Card

Now next we are going to understand circuit diagram for amplification card. The circuit diagram of the amplification is shown in figure 1.

<table>
<thead>
<tr>
<th>Sr.no</th>
<th>Component name</th>
<th>Specification</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>VR1, VR2, VR3</td>
<td>10k (103 W)</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>R1, R7, R8</td>
<td>180k</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>R2</td>
<td>100k (104 W)</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>R3, R4</td>
<td>470E</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>R5, R6</td>
<td>33K</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>R9</td>
<td>1K</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>R10</td>
<td>1M</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>R11</td>
<td>10k</td>
<td>1</td>
</tr>
</tbody>
</table>
> Circuit diagram have three stages for amplification. In which middle op-amp connected such that it gives unity gain.
> In the circuit VR1 and VR2 are variable potentiometer which can be used for adjusting the offset if it will occurs.
> The VR3 is used to adjust gain of the amplifier circuit.
> The input terminal +I and -I accepts millivolt signal and after amplification we can get output between OUT and 0V leads.
> For the derivation of gain we will disconnect R1, R2, VR1 and VR2.
> Let voltage at +I is V1 and at -I it is V2.
> V01 is the output of first op-amp. V02 is the output of second op-amp.
> Vout is the output of last op-amp.

\[
\frac{V1 - V2}{470k} + \frac{V1 - V01}{33k} = 0
\]
\[
33V1 - 33V2 + 0.47V1 - 0.47V01 = 0
\]
\[
V01 = 71.21V1 - 70.21V2
\]

Eq. (1)

Similarly,
\[
\frac{V01 - V1}{33} + \frac{V01 - V02}{180 + 160} = 0
\]

Now put the value of V01 from Equation (1). We get
\[
373(71.21V1 - 70.21V2) - 340V1 - 33V01 = 0
\]
\[
V02 = 794.58V1 - 793.58V2
\]

Eq. (2)

Now let Va is the voltage non-inverting terminal of last Op-amp

\[
\frac{V02 - V02}{1k} + \frac{Va}{100k} = 0
\]

Put the vale of V02 from Eq. (2) we get,
\[
V02 = 786.71V1 - 758.72V2
\]

Eq. (3)

Also for last op-Amp,
\[
\frac{V0}{10k} + \frac{Va - Vout}{R} = 0
\]

Now put the value of Va from Eq. (3) we get,
\[
(10 + R)(786.71V1 - 785.72V2) = 10Vout
\]

Eq. (4)

The equation (4) is the input output equation which gives the gain of the amplifier.

2.2 POWER SUPPLY

Now we after this we have to need a proper power supply for the amplification card.

We know that the loadcell have four lead wires. Out of those 2 are excitation input to the Strain Gauge Bridge and other two are output of the load cell.

For the excitation to the load cell we have to apply +5V and -5V. So load cell get a differensial input of 10V.

The resistance of the load cell generly found in the range of 250E to 350E ranges.

According to load the variation of resistance is not much more.

At this resistance we get output in mv from the bri-ge.

So we are going to make a power supply which have +5V, -5V, +12V, -12V and 0V terminals.

For making the power supply we are using a step-down centered tab transformer.

<table>
<thead>
<tr>
<th>Sr.no</th>
<th>Component Name</th>
<th>Specification</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>LM7805</td>
<td>5 volt regulator</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>LM7812</td>
<td>12 volt</td>
<td>1</td>
</tr>
</tbody>
</table>
### Table: Components of the Power Supply

<table>
<thead>
<tr>
<th></th>
<th>Component</th>
<th>Voltage/Value</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>LM7905</td>
<td>-5 volt regulator</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>LM7912</td>
<td>-12 volt regulator</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>C1, C5</td>
<td>Electrolyte Capacitor</td>
<td>2200uf 25V</td>
</tr>
<tr>
<td>6</td>
<td>C3, C4, C8, C6</td>
<td>Electrolyte Capacitor</td>
<td>1000uf 50V</td>
</tr>
<tr>
<td>7</td>
<td>C2, C7</td>
<td>Electrolyte Capacitor</td>
<td>.01uf (104 PF)</td>
</tr>
</tbody>
</table>

The circuit diagram of the power supply is shown in fig. 2.

**Fig. 2: Power supply circuit.**

### 3. EXPLANATION OF THE CIRCUIT:

In the first step, 220V AC is stepdown to 12V AC by using a transformer.

Next, a bridge rectifier is used for converting AC to DC.

The centered tab wire from the transformer is used for the 0V reference.

Now at point 1, we are getting only positive waveform of the AC waveform.

And at point 3, only negative waveform will be found.

Now, this pulsed DC has ripples. For removing that, we are using electrolyte capacitors.

Now, the positive terminal 1 is connected to the input of LM7812. It regulates the voltage to 12 volts.

Similarly, for negative, we are using LM7912, which regulates the voltage to -12 volts.

In the circuit, we can see that there is a difference in the connection of LM7812 and LM7912. In LM7912, at the input, we have to provide 0V and at the COM terminal, we have to apply -voltage. Then, at the output, we get the regulated supply -12 volt.

The same connection will be done for making +5V and -5V.

For removing the ripples, connect the capacitor of 1000uf at every output of the regulator IC.

Make sure that while connecting the electrolyte capacitor, the positive terminal should be at a higher potential than the negative terminal potential.

PCB Layout for both the Load cell amplifier and Power Supply.
RESULT

If we see the gain equation of the amplification card then we can get the idea of resistance value of R.

Suppose we are applying 10mv and at output we have to get 10 volt. then by using the gain expression we can find the value of R.

If we calculate R then it will be about 2.8 and as in calculation we are using all values in kilo-ohm, so it will be in kilo-ohm.

Now for adjustable gain we have provide a 100k resistance potentiometer at the place of R.

This R is VR3 in the circuit diagram.

So as a result we can amplify the load cell low level voltage to high voltage for data acquisition by PLC, Arduino or other DAQ devices.

REFERENCES


BIOGRAPHIES

Er Ravi Kumar
(Automation Engineer at Autotest Mechnism)
MTech From EC-MDU 2017
BTech From EI-UPTU 2015

Chanchal
(Electronics Engineer at Dixon Technologies)
MTech From EC-MDU 2017
BTech From EC-UPTU

Er. Sunil Kumar Singh Kushwaha
(Automation Engineer at Comapl Electronic)
MTech From EC-MDU 2017
BTech From EI-UPTU 2015