SENSORS AND INSTRUMENTATION

Guess Today’s Topic????

DISPLACEMENT MEASUREMENT

- LVDT is linear variable differential transformer and as like other transformers this also works on the principle of mutual inductions, mutual inductors means there is a flux change in primary coil there is going to be the induced EMF in secondary coil and which depends upon the mutual inductance between the 2 coils, but in LVDT there is 1 primary coil and there are 2 secondary coils.
- There is 1 primary coil and there are 2 secondary coils, the reason I will explain to you later. Now in this between these 2 coils we simply put an iron bar or an iron rod, so the flux interaction between these 2 coils can be increased. So, the moment this core it is called core right, so when the core moves in either direction right, there is a flux interaction between this coil 1 2 and 2 and 1 and 3 and due to this induced EMF produced right.

DISPLACEMENT MEASUREMENT

- measure this induced EMF and if we can relate this with the displacement in this core, then it this transformer can very well work for as a displacement measuring device, the property of LVDT is it can measure wide displacement with 0.5 percent linearity that is why it is very popular. Now regarding the working principle if we start with suppose there is an excitation voltage, so it has to have ac excitation voltage with an RMS value ranging between 3 to 15 volts, this order of excitation is given to the primary coil and which produces induces this secondary coil secondary coil ES1.

DISPLACEMENT MEASUREMENT

- this is es1 and this is ES2 right, so it is something like this excitation voltage excitation voltage and this is time. So, excitation voltage is like this it is an ac alternating current, there is a core if core is in the middle then it is balanced right and in the both the coils will get the wave form as like this in both the both the coils, but this is phase length right.
- Now if I reverse the polarity I mean if I connect this 1 2 to 4 if I connect this 2 to 4 and take out this and measure voltage here right; that is why we take 2 coils now it will be clear to you when the core is in the middle in the neutral position there is going to be no output because, the output in the second coil has reversed right.

DISPLACEMENT MEASUREMENT

- So, it will be something like this reverse of this, so the output will be cancelling out in es1 and ES2 and we are getting no deflection in the LVDT, but the moment we move in the either direction the deflection will start and the variation of this output ES is linear with the displacement in the core and finally we are going to get if we super impose these 2 wave forms and this is the linear part this is the linear part where we will be operating LVDT will be operating right because, here the variation of voltage with distance is linear.

DISPLACEMENT MEASUREMENT

- So, it will be something like this reverse of this, so the output will be cancelling out in es1 and ES2 and we are getting no deflection in the LVDT, but the moment we move in the either direction the deflection will start and the variation of this output ES is linear with the displacement in the core and finally we are going to get if we super impose these 2 wave forms and this is the linear part this is the linear part where we will be operating LVDT will be operating right because, here the variation of voltage with distance is linear.

DISPLACEMENT MEASUREMENT

- Now here excitation voltage we can take to the right hand side, now in the secondary side the secondary side es1 = M1 dip / dt, es2 =M2 d ip / dt. So, difference of these 2 this is differential that is why it is called differential, now difference of es1 and es2 is coming here. So, it is going to be ES is equal to es1 minus es2 is going to be M1 - M2 dip/ dt.
- Now, let us go back to this equation now ip Rp can always be written 1 / D Dip Rp + Lp Dip = ex and from here we can get Dip as 1 /[(1 / D 1 x 1/Rp) + Lp] ex; this Dip Dip from here Dip from here can be taken out and once we take the Dip and Dip out this is Lp right. So, we are going to get this expression, if you want to further simply this then we will get now this Dip is we can put here, if you are putting Dip here then output we are getting as, so output is M1 -M2 = [(D /Rp)/ DLp/Rp +1] ex

DISPLACEMENT MEASUREMENT

- Now from here if we divide this by Rp, so we will be getting this by Rp this is also Rp and here it will be 1. Now L / Rp can be taken as λ time constant and we can all comfortably used first order equation solution for the first order equation and that is going to be equal to eo by this is the excitation voltage ex, D = M1 – M D sorry by λ D + 1.

DISPLACEMENT MEASUREMENT

- Where already λ I have explained lambda is equal to Lp /Rp. Now LVDT can also be used suppose the frequency of input is 20 hertz Lp LVDT can go for a high frequency input also because, in potentiometer there is a limitation it cannot go of a more than 50 hertz; but LVDT we can go for higher input and in that case eo by excitation j ω or I ω this is D / Rp ok, then it is equal to ω (M1 - M2 / Rp) / [(ω λ) 2 +1]0.5 right and rest of the analysis we can use we can do as we did in the case of first order systems.
- Now LVDTs have variety of applications right and the best part of the LVDT is it can accommodate very high order of displacement, if you compare with the potentiometer and linearity is another benefit of using LVDTs and linearity is another benefit of using LVDT. So, after LVDTs we will go for the capacitive transducers, now in capacitive transducers it works on the principle that if the 2 plates which are charged with positive and negative charge right.

DISPLACEMENT MEASUREMENT

- Then capacitance is equal to ε A / d. ε is permittivity and if permittivity is equal to relative permittivity multiplied by absolute permittivity, d is the distance between 2 these 2 capacitance A is the cross section area.
- So, the moment this plate is moved either in either direction this direction or this direction there is going to be change in C right and if you are able to measure the change in C or we can relate the C with this movement we can find the displacement. Now instead of using 1 if we have to use bank of capacitance or let us say 2 capacitance.

DISPLACEMENT MEASUREMENT

- If 2 capacitance are used and they are put in series, so plus minus plus minus right and they are put certain voltage let the voltage E is applied between these 2 right and this capacitor has capacity C1 and this C2 right. So, total capacity of the capacitors is going to be because they are in series, 1 / C1 + 1 /C2 or C is equal to C1 C2 / C1 (C1+ C2) and charge on the plate is going to be q = CV = C1 C2 E/ (C1+ C2).

DISPLACEMENT MEASUREMENT

- Now here there is a displacement initially there is a displacement in the middle plate and displacement in the middle plate is let us say it is t sorry X displacement sorry this is plus minus. Now displacement of middle plate is X this the middle plate displacement is X, now there is a displacement in the this plate of x and voltage is q = CV right. If you want to have voltage V then we can take q / c right and then this q is nothing but C1 C2 / (C1+ C2) into E and this voltage q / C2 it is divided by C1.
- So, voltage is going to be C2 /[C1+ C2] x E right and similarly we can find the voltage for the second capacitor this is V1, similarly we can find the V2 as C1 /[C1+ C2] x E right when we are talking if you are using this formula C is equal to ε o d by sorry ε o A, A is constant epsilon sorry epsilon is same for every capacitor A is same only it is going to be C1 is d sorry t + x and C2 = ε A/ t -x. Now putting these values here, here we will get the final expression as and will take the difference of V1 and V2.

DISPLACEMENT MEASUREMENT

- Then final expression for V1 –V is going to be x / t. So, simply we can take V is a function of x because t is constant. So, that is how we can use these capacitive 541 transducers for distance measurement and the property is the main property of these transducers is, they can sense very small displacement, they can sense the displacement of the order of let us say 2.5 microns 2.5 micrometer because you know 0.0025 millimeter.


Thank you