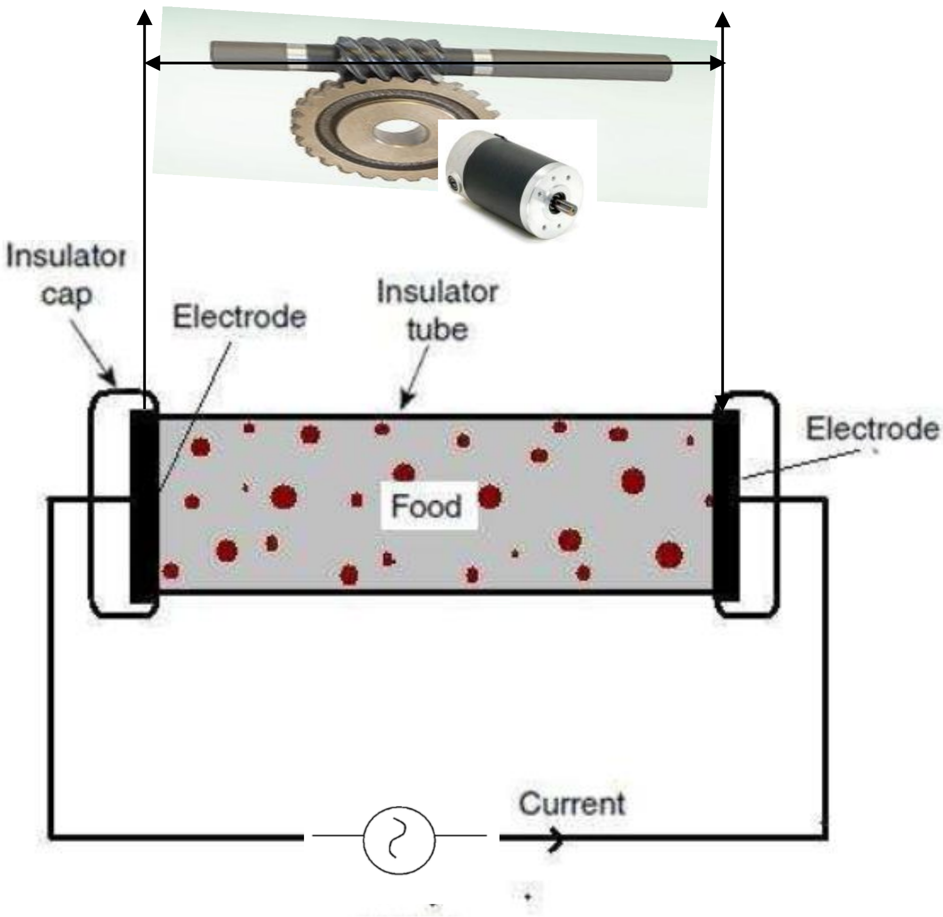
MECHATRONICS – EXAM JULY 16th 2015

Candidate Name and Surname …………………………………………………………………..

Registration N° …………………………………………………………………………………….



One of the most diffused system for the alimentary sterilization foresees that the food passes across two electrodes supplied with Alternate Current. This heats up the food compound (usually the richer of NaCl the better conductive) up to 90-95 °C therefore destroying or at least inactivating mold and bacteria.
The distance between electrodes is regulated through a DC motor together with a screw to determine a more or less fast heating.

1. Draw the block scheme of the acquisition/regulation chain identifying the input and output variables in every block and in particular the process variable.
2. Calculate the transfer function of the process highlighting what variables must be known.
3. Plot the Bode diagram of the loop function (process + actuator) discussing the eventual problems in terms of stability/instability.
4. Describe what kind of regulators can be introduced to eliminate the sources of instability and their numerical implementation.
5. Design the power supply system to regulate the current for the electrodes.
6. Answer to the following questions:

- What is the transfer function of a piezoelectric accelerometer and how to keep it stable?
- Why the input impedance of a circuit is high and the output one must be low?
- What is the sensibility of a typical strain gage and how to augment it?
- Decoupling diodes: describe the usage in a contact matrix

Solution

1) PV=T (the degree of sterilisation depends on the reached temperature)

V_M=ω, distance between the electrodes

Vc=V_{PS} (power supply)

2-3) The distance *d* between the electrodes is obtained through the rotation of the shaft f the motor on the screw, so trasforrming the rotation into a linear movement.

The generic angular displacement θ, is the integral function of the angular velocity ω.

The transfer function of the motor is: V_M / Vc = ω/ V_{PS} =k/(1+sτ)

Therefore the gain of the control chain is PV/V_C = (T/d)*(d/ω)*(ω/V_al) where d/ω=1/s

From the text of the exam we know that the temperature augments when the distance of the electrodes diminishes or in other words:

(L−d)k' ∝ dT/dt

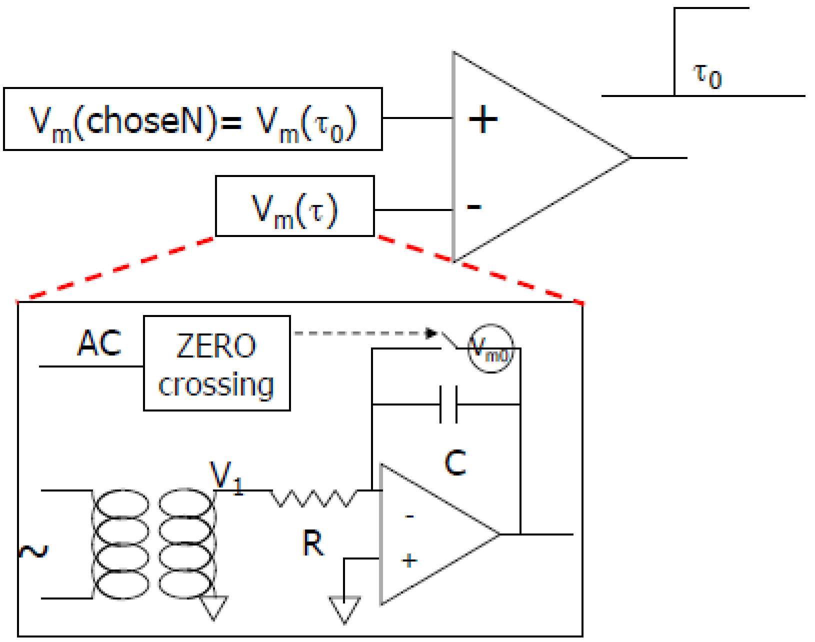
therefore: T=(L-d)/s

A Feed-Forward compensation block allows to eliminate the dependence on the constant term L therefore we have:

T=-d/s or T/d=-1/s

The general transfer function is then: G= PV/V_C = T/ V_{PS} = = − k/(s^2*(1+sτ))

4) Once more the system can be made stable with a double dynamic compensation with two functions zero/pole as we have seen many times. The numeric implementation is straightforward.



5) concerning the power supply of the electrodes one possible solution could be found in the *Actuators* section slide 14 since the process can be considered sensible to the average value of the input signal provided (it is a slow process) and, moreover, features a resistive nature

The questions:

- What is the transfer function of a piezoelectric accelerometer and how to keep it stable?

$$ma = -m\ddot{X} - k_P X$$

It is not possible to make it stable since at the resonance frequency the gain is infinite. Simply it is necessary to work at lower frequencies

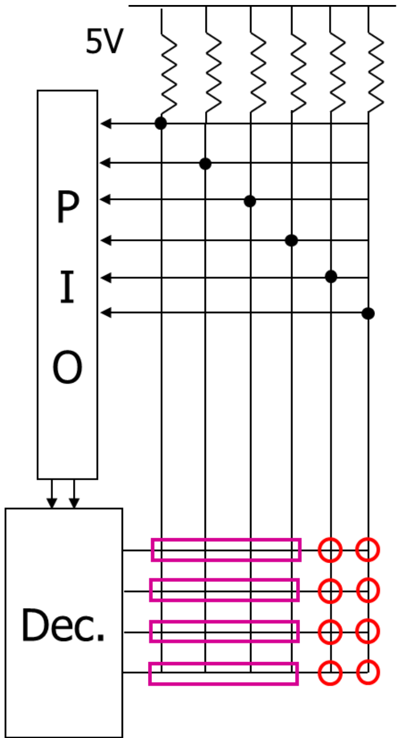
$$\frac{X}{a} = -\frac{m}{k}\frac{1}{1+\frac{m}{k_P}s^2} \qquad \omega_{RIS} = \sqrt{\frac{k_P}{m}}$$

- Why the input impedance of a circuit is high and the output one must be low?

When we consider the output voltage of a transducer is read onto its output impedance that is in parallel to the input impedance of what follows. If this last one is not much greater than Zout of the transducer and since in a parallel cicuit the minor impedance is prevalent the value of the voltage will be determined by what is connected after the transducer and this is not acceptable because it would make the measurement no more univocal. To avoid this problem we introduce a buffer operational amplifier that is characterize by a (ideal) infinite input impedance and an (ideal) null output impedance so as to decouple the acquisition of a physical magnitude from the following electronic circuits.

- What is the sensibility of a typical strain gage and how to augment it?

See *Transducers* section and in particular slides 61-63



- Decoupling diodes: describe the usage in a contact matrix

See *Conditioning Networks* section and in particular slide 29