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Description of mine ventilation network simulator

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ABSTRACT. The elements used in a mine network simulator, which have parabolic features can be presented in 2 ways, passives, (formed of a function generator with a very small adjusting range) and actives (containing electronic elements that allow the change of the parabola parameters in a wide range). The study of ventilation cannot be done without taking into account the basic laws of flowing (for compressible fluids) in a pipe network.

ОПИСАНИЕ НА СИМУЛАТОР ЗА МИННА ВЕНТИЛАЦИОННА СИСТЕМА
РЕЗЮМЕ. Елементите използвани в минният мрежови симулатор, които имат параболични особености, могат да бъдат представени по 2 начина: пасивни (формирани от функционален генератор с много малък диапазон на настройка) и активни (съдържащи електронни елементи, които позволяват изменение на параметрите на параболата в широк диапазон). Изучаването на вентилацията не може да бъде направено без да се вземе под внимание основните закони на потоците (за свиването на течността) в тръбите на мрежата.

1. Introduction

The most used simulation is made through electric analogy.

To obtain the analogy we have to find an element that has a square relation between tension and the current:

$$U = KI|I| \tag{1}$$

Choosing the functions generator which serves the reference element depends on the required precision and price. Moreover, the mine network has, as a special feature, the fact that resistance of the branches covers a variation range from 0,0001 to 300 kmurgi (1 kmurg is the resistance of the mine tunnel where a volume of $1m^3/s$ triggers a pressure fall of $1kgf/m^2$) - fig.1.

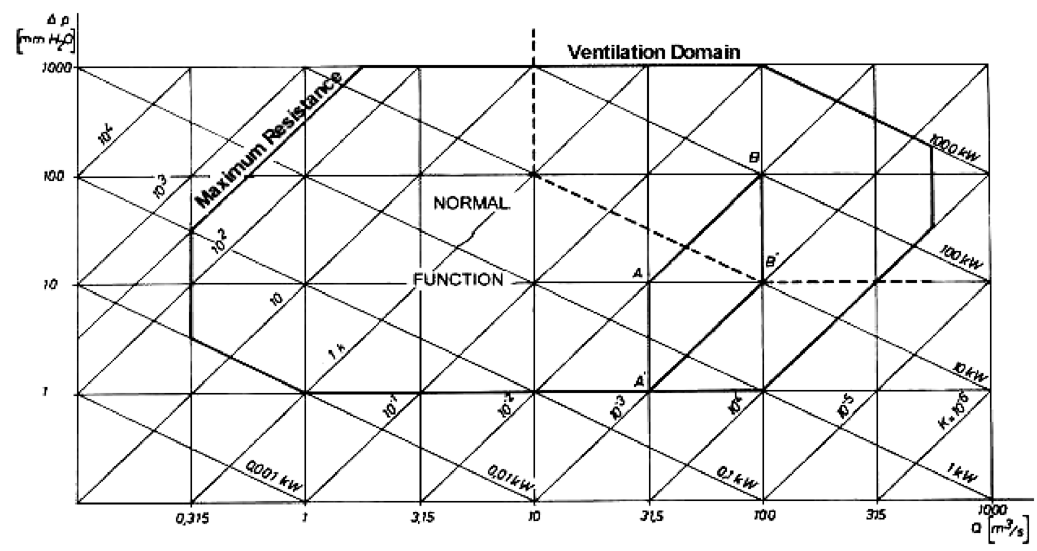

Fig. 1. The way of functioning for a fan

The domain of volumes and pressure will be covered in different ways of continuous adjustment (vertically or horizontally).

2. The active solution: module K, V, I

The main solution of the module, the K parameter, V tension and I power stream is represented in fig.2, which is obtained using a function generator realized with resistance's connected in parallel with diodes, and which equation is: $y = y_0 - k\sqrt{x - x_0}$.

In Fig.1 is represented on logarithmic coordinates the domain covered by three ways of adjustment. For a given module adjustment, the variation of the tension in the terminals, allows the description of a straight (line) segment, for example AB; the continuous adjustment of K moves this segment from AB in A'B. The parallelogram formed like this can be moved in various regions of the diagram by commuting the tension and power flow ranges. Choosing the scales of tension and power stream if there is known the size of tensions and power streams.

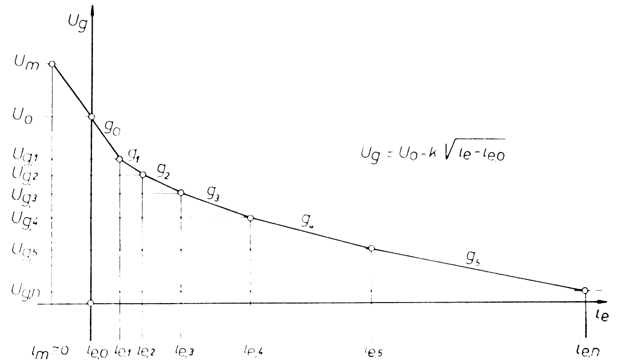

Fig. 2. The main parabola of the module K, V, I

A simulation on the ventilation network is possible using two optic alarms which signal at the extremities with a precision of 1%.

In fig.3. the adjustment of the module through the factor K (K_I, K_{II}, P), is represented the alternator with 6 steps K_{II} and the 2 diodes which allow the passage from a parabolic function to the function of the power stream regulator and into the wires at the alarm block [I].

In fig. 3, 4, 5 are described different steps of elaboration of the module K, V, I and in fig.6 is presented the description of the general diagram. In fig. 4. functioning with U<0, I<0 becomes possible. In fig. 5. the power of the divider K_1 doesn't pass through the resistance K_{II} which delivers the tension "e" to the comparator [2].

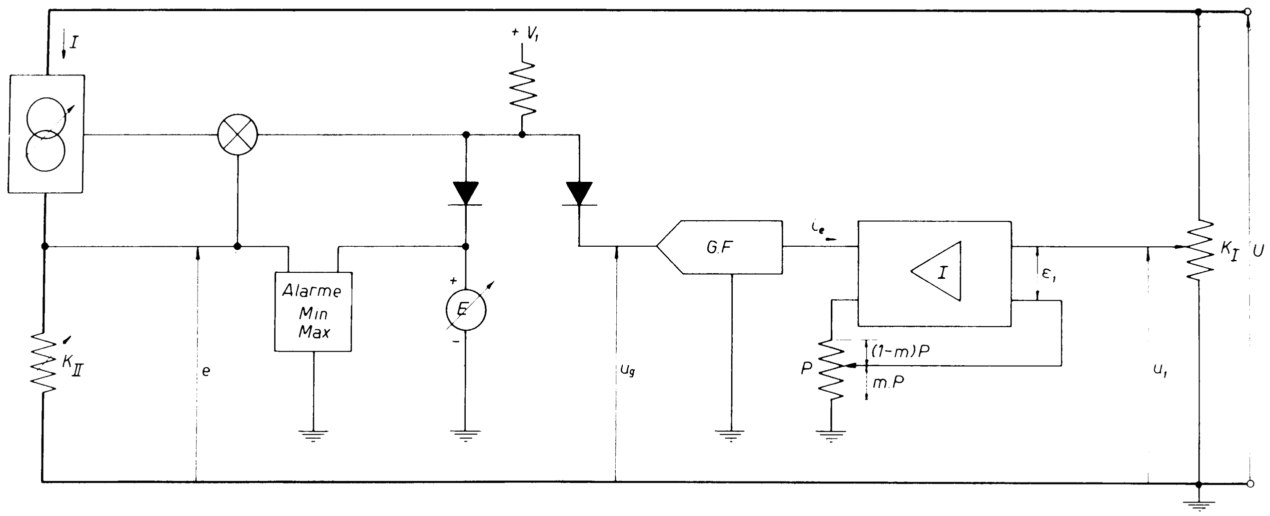

Fig. 3. The adjustment of the module through the factor K (K_I, K_{II}, P)

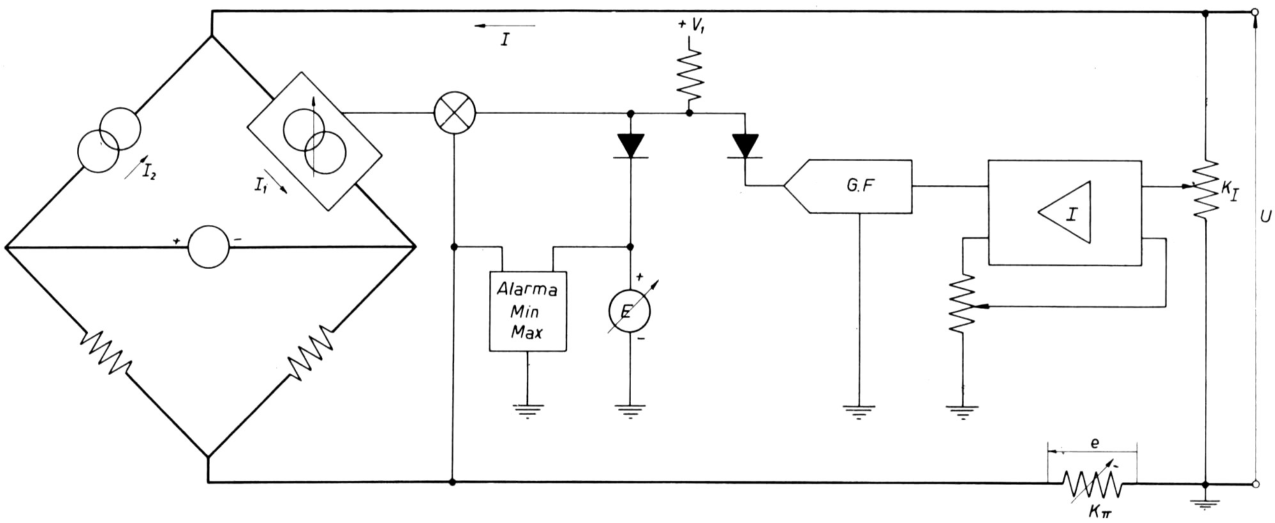

Fig. 4. The adjustment of the module through K_I

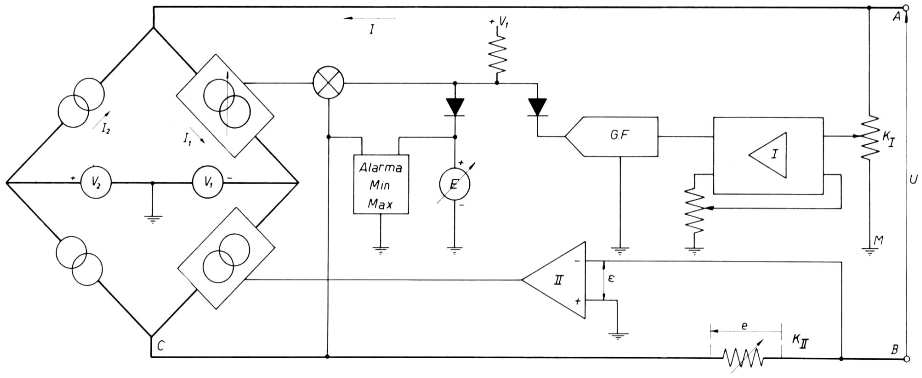

Fig. 5. Final elaboration of the module

For the extension of the parabolic feature in the frame U<0, I<0, the Wheatstone bridge assembly (fig.4). The adjustable dissipation element is conducted through the same circuits as the ones represented in fig. 3.

2.1. The calculation of some elements of the device

Considering the tension U, it has to be calculated the current I; and the input signal U is reduced through the variolosser K_1 at a value of

$$u_1 = K_I U \tag{2}$$

The operational amplifier I receives the tension u_1 and applies a voltage u_2 to the level Q_1 and it results:

$$u_1 + \varepsilon_1 \approx u_1 = m \cdot u_p \tag{3}$$

u_p being the voltage in the potentiometer terminals P; n is the unclosed section of this potentiometer in the anti-reaction loop, and ε_1 is the difference of potential between the two inputs:

From fig.6. results:

$$i_1 + i_e - i_p = \frac{u_p + E_p}{Z_S} \tag{4}$$

If the power gain at the Q_1, level is enough and if the potentiometer resistance is very high, the power streams i_1 and i_p are negligible in relation to i_e, from which

$$i_e = \frac{u_p + E_p}{Z_S} = \frac{(u_1/m) + E_p}{Z_S} = \frac{K_I U/m + E_p}{Z_S} \tag{5}$$

The values U_1, K_I, m, E_p and Z_1 are mainly random but the limits for the power i_e through level Q_1 and the function generator ($i_c<i_{max}$), must be respected.

The potential difference u_g is related to the i_e

$$u_g = u_0 - k\sqrt{i_e - i_{e,0}} = u_0 - k\sqrt{\frac{K_I U/m + E_p}{Z_S} - i_{e,0}} \tag{6}$$

K is being the parabola's parameter, while u_0 and i_{c0} represent the coordinates of the parabola's peak.

If the voltage at input $\varepsilon_2 \approx 0$:

$$e = K_{II} I \tag{7}$$

If it's considered the potential in D equal to 0 and the input power of the amplifier negligible, it could be:

$$\frac{e}{R_0} + u_g \cdot G_{01} - E_{02} \cdot G_{02} = 0 \tag{8}$$

$$U - U_0 = K(I - I_0)^2 \tag{9}$$

only if:

$$U_0 = -\frac{m}{K_I}(E_p - Z_S \cdot i_{e,0}) \tag{10}$$

$$K = \left(\frac{K_{II}}{R_0 \cdot k \cdot G_{01}}\right)^2 \frac{Z_S m}{K_I} \tag{11}$$

$$I_0 = \frac{R_0}{K_{II}}(E_{02} \cdot G_{02} - u_0 \cdot G_{01}) \tag{12}$$

The thinking that leads to relation (9) must have an established equilibrium status. If in a case of an external noise the relation (8), (9) is no longer valid, there will be a change in the division of power in the Wheatstone bridge. The power will vary in the branches Q_2 and Q_3 as well as crossing, until a new equilibrium status settles.

One can notice that due to the bridge device and the chosen values for given powers, the adjustment period obtained through Q_2 and Q_3 and allows the external power to reverse.

The relations (10), (11), (12) show the elements on which can be acted in order to notify the external parabola's parameters.

- an action on K_I modifies in the same time the y axe U_{01} of the parabola's peak.
- an action on K_{II} modifies in the same time the x axe I_0 of the parabola's peak.

These 2 possibilities were used to modify the K parameter through 10 powers. Accordingly to the relation (11), the resistance K_I must be in geometrical progression of 10 ratio, while the resistance K_{II} must be in geometrical progression of $\sqrt{10}$ ratio.

- the adjustment of R_0, $1/G_{01}$, Z_s parameters or the n ratio of the potentiometer P of anti-reaction of I amplifier.

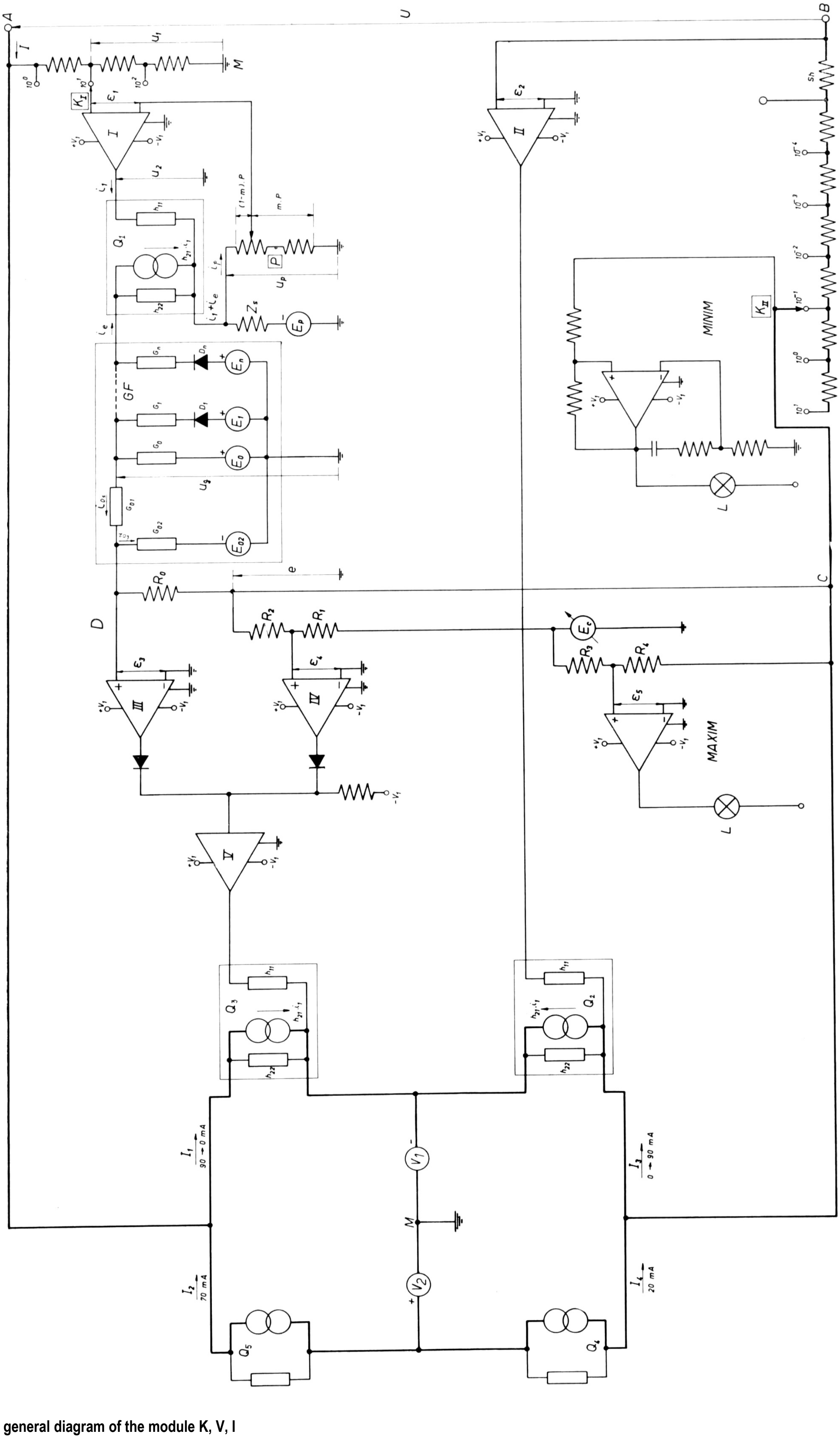

Fig. 6. The general diagram of the module K, V, I

To place parabola's peak exactly in the area is necessary to have both U_0=0 and I_0=0.

$$E_p = Z_S \cdot i_{e0} \text{ and} \tag{13}$$

$$E_{02} = u_0 \cdot \frac{G_{01}}{G_{02}} = \frac{G_{01}}{G_{02}} \cdot \frac{E_0 G_0 - i_{e,0}}{G_0 + G_{01}} \tag{14}$$

i_{20} being equal to the highest negative x axe taken for the function generator .

For the fan to function in the ventilation network we must have $E_p \neq E_{02}$. In practice, after choosing the scales for k_1 , n_0 and I_0 , it starts by adjusting the potentiometer P accordingly to the value of the k parameter and this parabola will be deviated in the plan U, I horizontally, acting on E_{02} or G_{02} , vertically acting on E_p.

In the function of the module as power limit, the amplifier IV intervenes.

The repartition of the power in the Wheatstone bridge makes the voltage E_4 to become negligible.

$$\varepsilon_4 = \frac{eR_1 - E_C R_2}{R_1 + R_2} \tag{15}$$

And it becomes 0 for:

$$e = K_{II} I = \frac{E_C R_2}{R_1} \tag{16}$$

The condition for power adaptation is:

$$I = \frac{E_C R_2}{K_{II} \cdot R_1} \tag{17}$$

Choosing K_{II} settles the scale of the current I and the progression has $\sqrt{10}$ ratio, and the fine adjustment is made acting on E_c. The passage from the functioning in K mode is obtained automatically due to the 2 diodes that precede 5^{th} level.

The alarm maximum is commanded in the same way as the IV amplifier. Its input signal is:

$$\varepsilon_5 = \frac{eR_3 - E_C R_4}{R_3 + R_4} \tag{18}$$

And it becomes 0 for:

$$e = K_{II} I = \frac{E_C R_3}{R_4} \tag{19}$$

2.2. Description for alarm of minimum voltage

The bulb L is connected between the alimentation voltage V_1 and the output of the amplifier. When the current I is low, the input signal is negative and the output of the amplifier is at the $-V_1$ potential, the bulb is off. When the current I grows wear the values given by (19) the output voltage of the amplifier varies from $-V_1$ to $+V_1$ and the voltage at the terminals of the bulb passes quickly from 0 to 2V the bulb is on (fig.7).

Through simple graphic constructions are obtained the voltages V_{CR} and V_R after every switching of the amplifier.

On the right side it is represented the U_R voltage as a function of time.

The system is stable when the controlled voltage E_i is maintained out of a certain period [$-E_{i,1}$,$+E_{i,1}$]. For E_i<-$E_{i,1}$ the lamp L is on. For E_i<$E_{i,1}$it is off.

If E_i has an intermediary value the bulb L blinks; the ratio of the going on and off of the bulb varies progressively with Ei. One can observe if the voltage is closer to its inferior or superior limit by following which of the moments of going on or off of the bulb are more often.

2.2.1 The case of stable functioning

The voltage Ei doesn't influence the voltage E_0 if the amplifier is full. The voltages at the terminals of the C capacity is constant, the power I_c and the voltage V_r are 0. The input voltage will be:

$$\varepsilon = -V_{CR} = -E_o m - E_i (1 - m) \tag{20}$$

And the output voltage (20)

$$E_o = \pm V_1 \tag{21}$$

The relation (20) gives the values for Ei

$$\pm E_{i,1} = V_1 \frac{m + \alpha}{1 - m} \text{ , whit } \alpha = 1/A . \tag{22}$$

2.2.2 The case of unstable functioning

Considering that coming from a stable state with Ei>Ei,1 , E_0=-V_1 , and V_c=-E_0=+V_1 the voltage E_1 like that (23)

$$-V_1 \frac{m + \alpha}{1 - m} < E_i < +V_1 \frac{m + \alpha}{1 - m} \tag{23}$$

In certain circumstances the system becomes unstable.

Fig.7. shows the behavior in unstable regime on the left side there are the voltages $+V_1$ and $-V_1$ as well as the voltage E_i.

When V_c is constant, the voltage $E_0 \rightarrow -\infty$ for value from $-V_1$ to $+V_1$.

The p1, m and A values are choice in order to:

$$(p - m)A > 1 \text{ or } p > m + \alpha \tag{24}$$

this being the only condition for unstable functioning

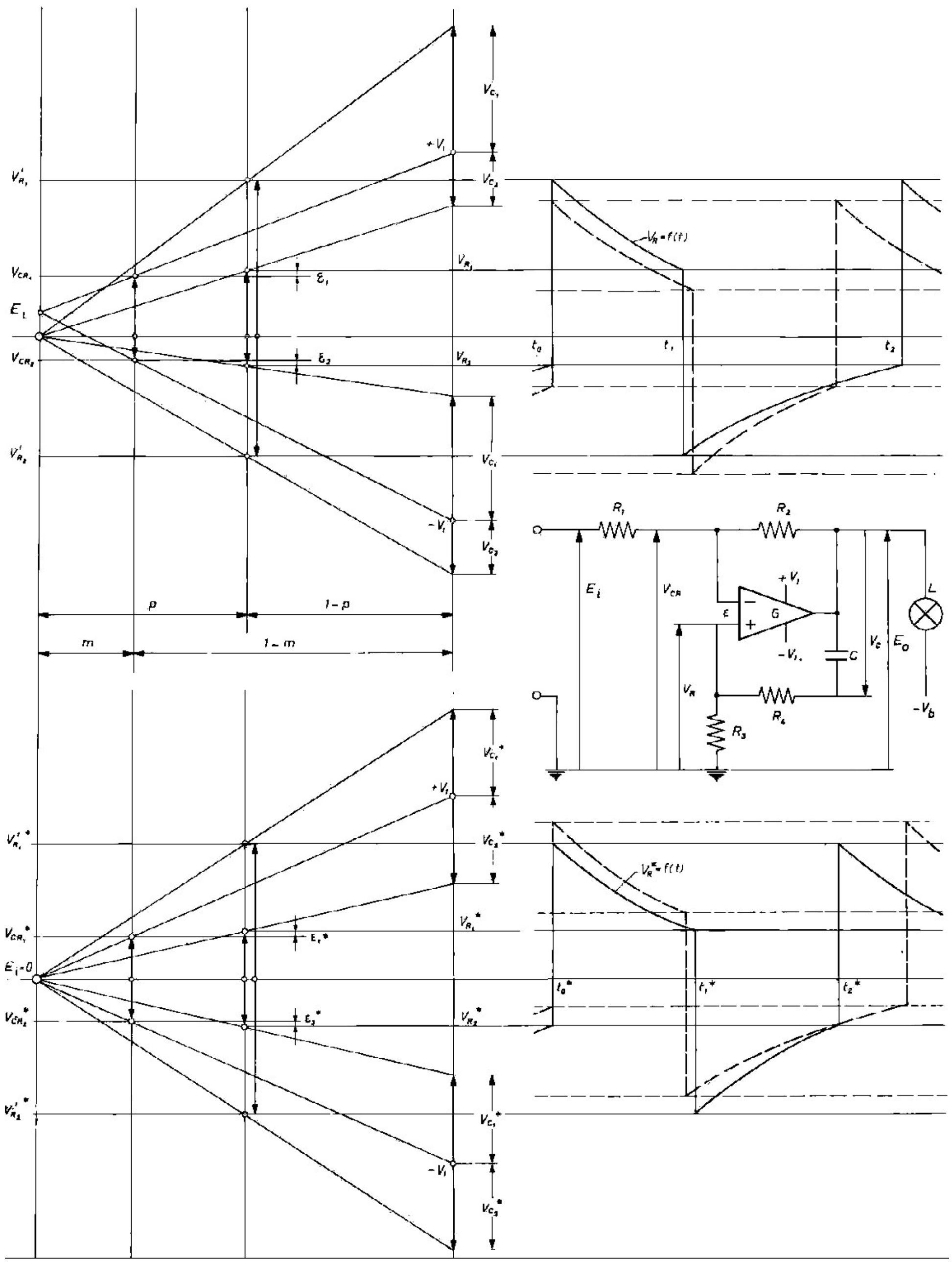

Fig. 7. Alarm for minimum voltage: the main diagram, the graphic representation of the voltage V_c, the evolution as function of time of the V_R voltage

3. Conclusions

The simulator can be used in stable functioning regime or unstable functioning regime when is knowing the parameter to be modified; It also establish the fun working type in the ventilation network.

4. References

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