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# TREATMENT OF SLIDING PHENOMENON AT THE ROUMANIAN ELECTRIC LOCOMOTIVES LE 5100 Kw

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**Abstract:** Algorithm of sliding control in two steps on the ground of the exceeding of the threshold currents of the traction motors, threshold adapted upon the voltage on the motors.
1$^{st}$ step: switch off the tap-changer increasing, breaking, tap-changer decreasing
2$^{nd}$ step: decreasing of the tap-changer, breaking
Sequential Algorithm

**Keyword:** Sampling, threshold, derivate, tape-changer, breaking

## 1.Introduction

The equipment detects both the axles sliding during acceleration or their blocking during electro-pneumatic breaking, indicates the occurrence of these slip-slide phenomena to the locomotive driver, and control the anti-sliding relay, mainly stopping the increase of the tap-changer or controlling it's descending, until the phenomenon disappears [1],[5].

An old system provided with differential transformers and maximal current relays had been used to prevent sliding, overload and maximum currents on the traction motors of the electric locomotives LE 5100 kW.

The old system has some deficiencies:

- it does not work with an insulated traction motor at least,
- it does not indicate which motor (traction axle) is sliding,
- the value of the average traction current is not correctly indicated when there is a difference of current among the traction motors,
- the adjustable value of the maximal tripping current relays does not remain unchanged, varying with the temperature.

The equipment to prevent the sliding uses a number of 7 transducers with galvanic separation and receives the primary information about the current and the voltage that is processed through an electronic unit provided with microcontroller. Depending on the difference among the currents, on their value and on the speed of the locomotive, the followings are performed:

- control of the sliding sequences in two steps,

- disconnection of the automate current breaker if the maximum value of the current of the traction motors is exceeded,
- blocking of the tap-changer increase if the maximum value of the current in the traction motors is exceeded,
- blocking of the tap-changer increase if the maximum value of the voltage on the traction motors is exceeded,
- control of the tap-changer up and down depending on how severe is the sliding counting on the voltage level of the traction motors, too,
- sending the information to the displaying screen in order to show the level of the currents and of the voltage on the traction motors which are sliding or coming into overload.

The equipment allows the operation with not only one but two insulated motors, a single one from each bogie.

For the purpose of detecting the sliding phenomenon, two sliding thresholds are set, whose level change depending on the voltage of the motors due to the correlation with the average speed according to the relation :

$$V\,[Km/h] = K * \frac{U - R * I_R}{\phi(I_{EX})}$$

where:
***v*** = locomotive speed
***K*** = a constant calculated on the basis of the mean diameter of the locomotive wheels and the transmission ratio between the traction motor and the axle
**R** = is the resistive value of the traction motor windings
**U** = value of the voltage on the traction motors
$\mathbf{I_R}$ = the average current on the traction motors

### 2. Determination of sliding information

From constructive point of view it is considered that a characteristic of flux among motors has not a dispersion greater than 1% and the electromagnetic characteristic does not differ more than 4% among those motors mounted on the same locomotive (before mounting them on the locomotives the motors are checked and marched on the testing stand) .

The control of the sliding phenomenon takes place by mean of the calculation of the difference between the currents of the traction motors and also on the speed of variation of these ones. From the comparison of the current information with the updated thresholds, the algorithm sequence that shall be applied is determined.

For the symmetrically loaded bogies (having the same number of motors in operation on each bogie) the mean current is calculated as arithmetical average value of all the 6 currents of the motors [4].

For the asymmetrically loaded bogies (the number of motors in operation on each bogie is different) the mean current is determined as arithmetical average value of the current motors from the bogie II because the voltage on the drive motors is measured on the 4$^{th}$ motor placed on the bogie II. The insulated or non-insulated state of the traction motors is determined by mean of the auxiliary contacts of the separators of the traction motors and the breaking regime by mean of the auxiliary contact of the breaking contactor.

- All motors in operation:
  $\mathbf{I_R = (I1+I2+I3+I4+I5+I6)/6}$
- One of the motors of the bogie I is insulated (unused):
  $\mathbf{I_R = (I4+I5+I6)/3}$
- One of the motors of the bogie II is insulated:
  $\mathbf{I_R = (I4+I5)/2}$ **or**
  $\mathbf{I_R = (I4+I6)/2}$ **or**
  $\mathbf{I_R = (I5+I6)/2}$ depending on which one is the insulated motor ($6^{th}$, $5^{th}$ or $4^{th}$)

Depending on the insulation condition of the motors a reference current is determined, too.

- All traction motors in operation:
  $\mathbf{I_{REF} = max\ (I1,I2,I3,I4,I5,I6)}$
- One of the traction motors is insulated:
  $\mathbf{I_{REF\ 1} = max\ (I1,I2,I3)}$
  $\mathbf{I_{REF\ 2} = max\ (I4,I5,I6)}$

In order to find out the rate of the current decrease, the speed of variation of these currents is calculated:

$$\mathbf{dI1/dt,\ dI2/dt,\ dI3/dt,\ dI4/dt,\ dI5/dt,\ dI6/dt}$$

There is a limit level of the rate of current decrease for sliding control

$$\mathbf{(dIi/dt)_{LIM}}$$

After every real time processing the sliding thresholds are dynamically adjusted on the ground of the voltage level on the traction motors.

The characteristics of the magnitude correlations involved in the sliding phenomenon are given in fig. 1, 2, 3.

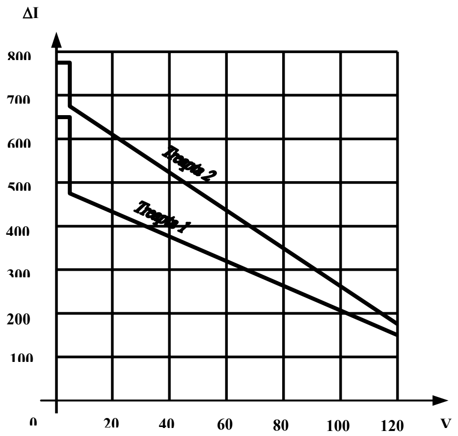



Fig. 1. Threshold characteristic i ΔI = f(V)

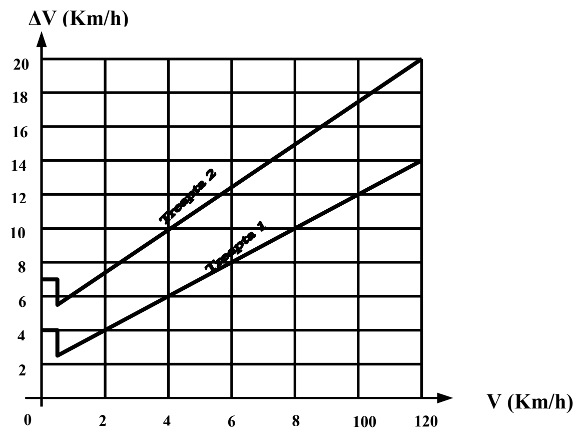



Fig. 2. Threshold characteristic Δ V = f (V)

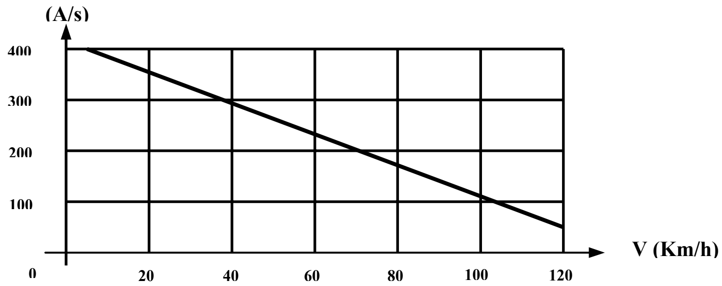



*Fig 3.* Threshold characteristic for *dI/dt = f (V)*

The procedure which offers the information about the sliding condition, uses the results of the previous sampling and numerical processing. Every deviation of the currents is compared with the threshold values and it is decided for every motor if it is sliding or not, as well as how severe is the actual sliding. The result of this procedure is received by the control al-go-rhythm and depending on how severe is the detected slide, the sequences of sliding removal (either the actuation of the tap-changer upon a programmed logic, intermittent breaking or sanding) is controlled. In the same time the information about the level of the slide is sent to the computer from the driving post in order to display it on the screen. The procedure decides how to differentiate the treatment according to the exceeding condition of the thresholds considering the present time and the previous. Three situations are distinguished: there is no sliding, the slide threshold 1 was exceeded and the slide threshold 2 was exceeded. For both sliding cases there is an algorithm that operates during the sliding phenomenon, framed in each respective category.

The temporary diagrams of the relays as operational elements in the sliding control are shown in figures 4 and 5.

The following remarks have to be considered:

K4 : relay for switching on the pneumatic break in sliding

K7 : relay for decreasing the tap-changer step (decreasing of the motor traction voltage)

K8 : relay allowing the increase of the tap-changer step.

The status of "1 " logic was considered as active status for each relay.

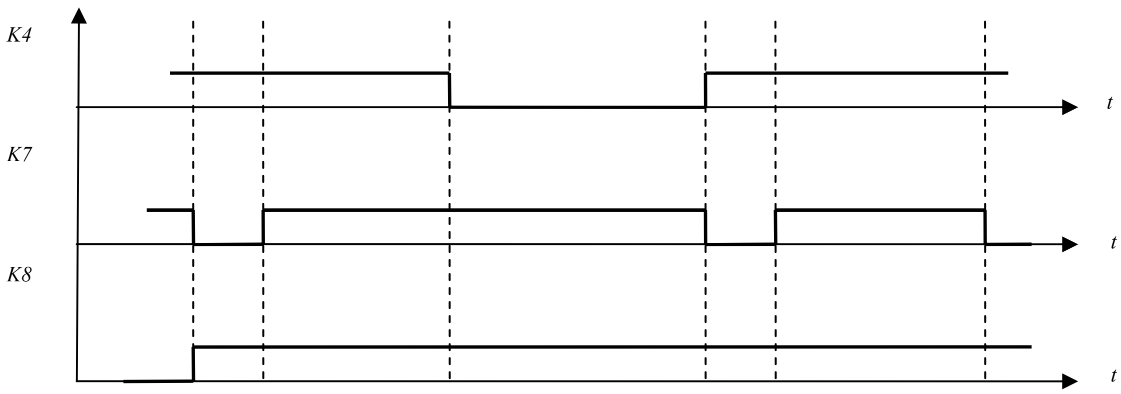



Fig.5 Exceed of slide threshold 2 control

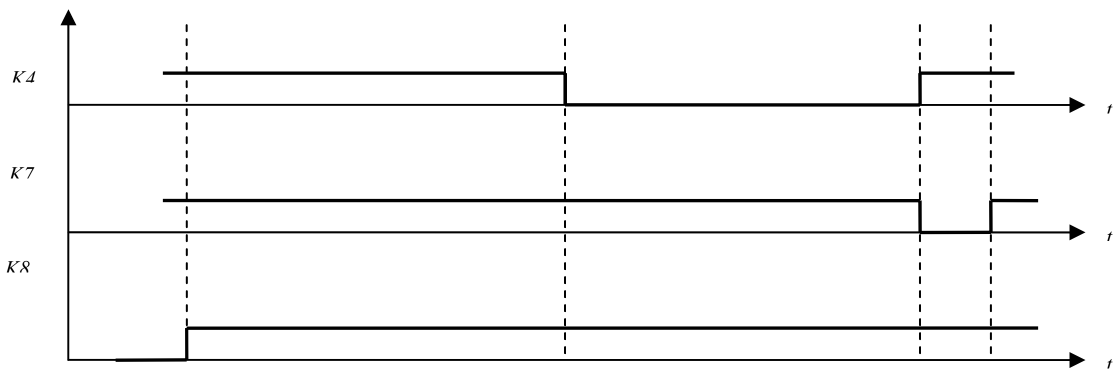



Fig.4 Exceed of slide threshold 1 control

**1. Control step I:**

Conditions : $\Delta I > \Delta I$ (TR1)

- the tap-changer stops
- an easy breaking of 0,8 – 1,2 bars in the break cylinders
- control of the sanding in travel direction

**2. Control step II:**

Conditions $(dI/dt) > (dI/dt)_{LIM}$ or $\Delta I > \Delta I$ (TR2)

- sanding is stopped
- easy breaking is stopped
- the tape-changer is returned with 10% steps from the number of the step it was found when the locomotive entered in the second step of sliding
- the sliding motor is displayed on the screen

When the slide is over the tap-changer returns on the step it was before sliding. On the EPS board computer screen from the driving post the information about sliding is given, also, as can be seen in fig. 6 [2].


Fig 6. Sliding display

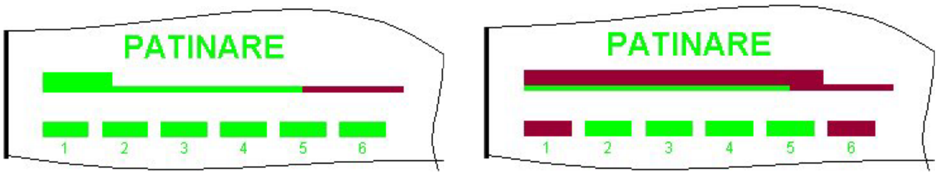



Fig 7.Sliding bargraf

In the field of the screen preserved for the traction motors status there are provided 6 rectangles, each of them associated to the corresponding traction motors and coloured in green. If a motor is insulated its corresponding rectangle disappears. If a certain axle (motor) is sliding its corresponding rectangle appears coloured in red.

Quantitative information about the sliding phenomenon is given on a bar-graph as the relative deviation together with the specification of exceeding the actuated threshold, which changes the green colour into red (see fig. 7).

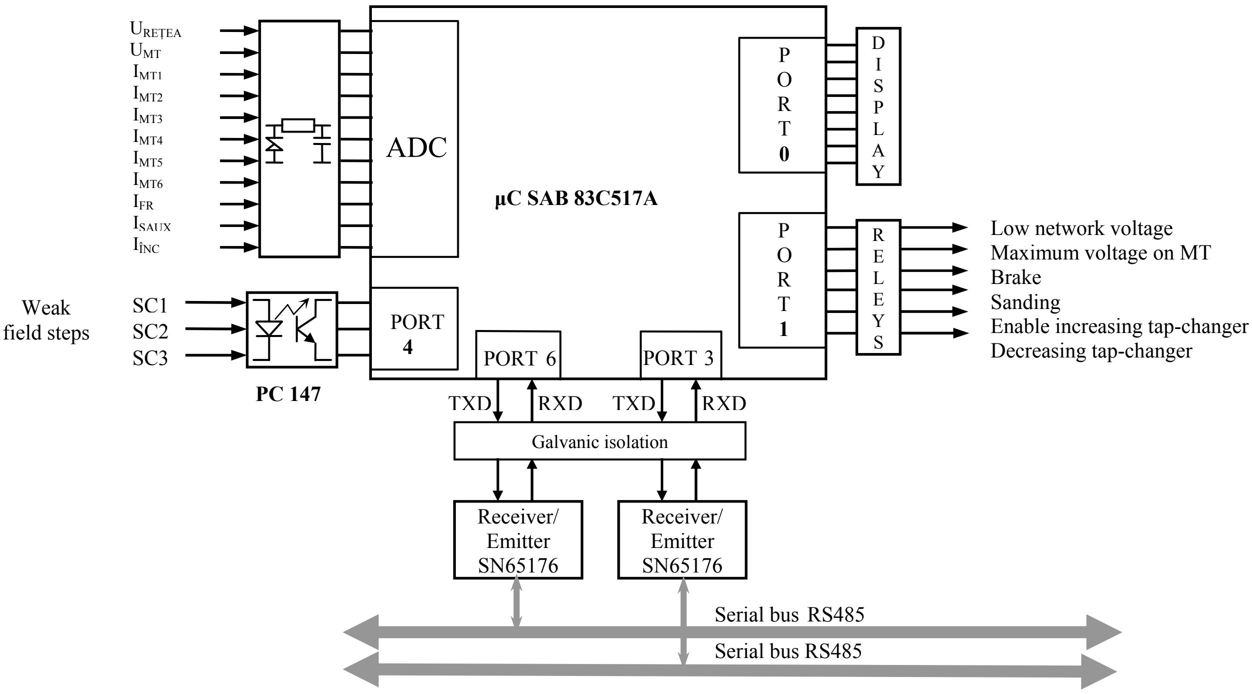
**3. Conclusions**

The equipment for the sliding control is developed around the SIEMENS SAB 83C517A microcontroller. The block schematic of this one is shown in fig. 9. The input signals which are presenting information about the steps of the field weakening are voltage type (0V or 110Vdc), being galvanic insulated from the rest of the electronic circuits through some appropriate optic-couplers (SHARP PC 847), connected on the port 4 of the microcontroller [3].

The control signals of the relays are generated on the port P1 of the microcontroller, then are amplified with some appropriate currents drivers (SN 74HC240) being then applied to the control transistors of the equipment output relays.

The microcontroller SAB 83C517 is provided with two serial ports that are used for communication with the other control equipment of the locomotive on two serial buses RS 485.

The traction computer EPS-LE 110/24 that includes the control of sliding is successfully in operation on a series of electrical locomotives of 5100 kW that belong to both Romanian Railways for Freight and Romanian Railways for Passengers.

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