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Current-Voltage Nonampere Transformer with Automatic Switching of the Measurement Range

M. N. Gousheva

The need to measure current variations within a large dynamic range in space probe experiments should be matched by reliability (maximum simplicity of the equipment) and by information restriction (minimum number of telemetric channels used). The switching of the sensitivity scales of the DC measuring tract of the spaceborn service equipment when the rocket attains a definite altitude involves a certain hazard. Such switching at an inappropriate moment results in loss of useful information due to insufficient dynamic range of the electron block.

That is why it is necessary to switch the range in accordance with the concrete situation (charge carriers density in space plasma) [1]. The availability of only one channel providing information as well as two sensitivity scales covering a dynamic range of 10^3 (in case of measurements with meteorological rockets) imposes certain restrictions on the transformer design.

The block circuit of the DC measuring tract (current-voltage transformer, Fig. 1) satisfies the above requirements. The circuit consists of a DC amplifier (DCA), a comparator (C), a repeater (R), and a switching device (S). When collector current from a spherical ion trap is applied to the DCA input, it is transformed into U_2 voltage and enters the telemetric channel (TMS). The entire DCA divider is switched on at the initial moment, because the range has to be selected regardless of the magnitude of the input current. $U_{z1}=-10$ V is applied to the non-inverting input of *C*. The electron keys are in the following positions: K_1 — open, K_2 — closed, and K_3 — open. The three possible cases under these conditions are: (1) The V-A characteristics is entirely described within the sensitive scale (Fig. 2 — sector a_1). This sector corresponds to a region of very low densities. The DCA range is not switched. (2) The V-A characteristics is described both within the sensitive and the coarse scales due to the sensitive scale saturation at a given moment (Fig. 2 — sector b_1). This is the case of high-density measurements. At $U_1=-10$ V (saturation of the sensitive scale), C is actuated and S sets the keys as follows: key 1 — closed (the DCA coefficient of amplification decreases ten times), key 2 — open, key 3 — closed ($U_{z2}=-0.5$ V). (3) The V-A characteristics is fully described

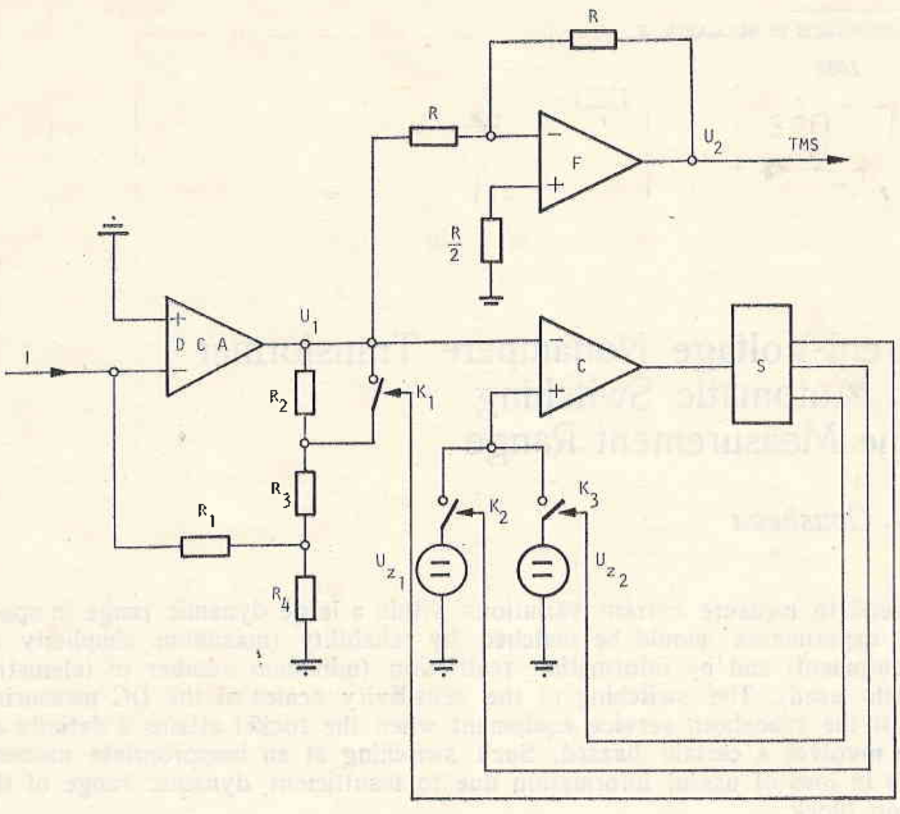

R
R
U2
TMS
F
R/2
D C A
U1
C
S
I
R2
K1
R3
K3
K2
R1
Uz1
Uz2
R4

Fig. 1

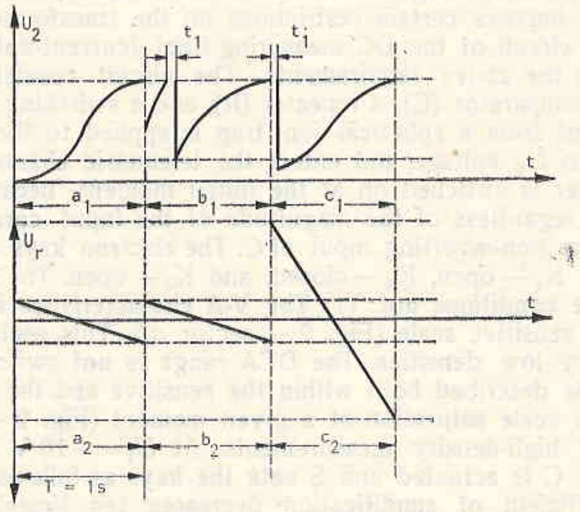
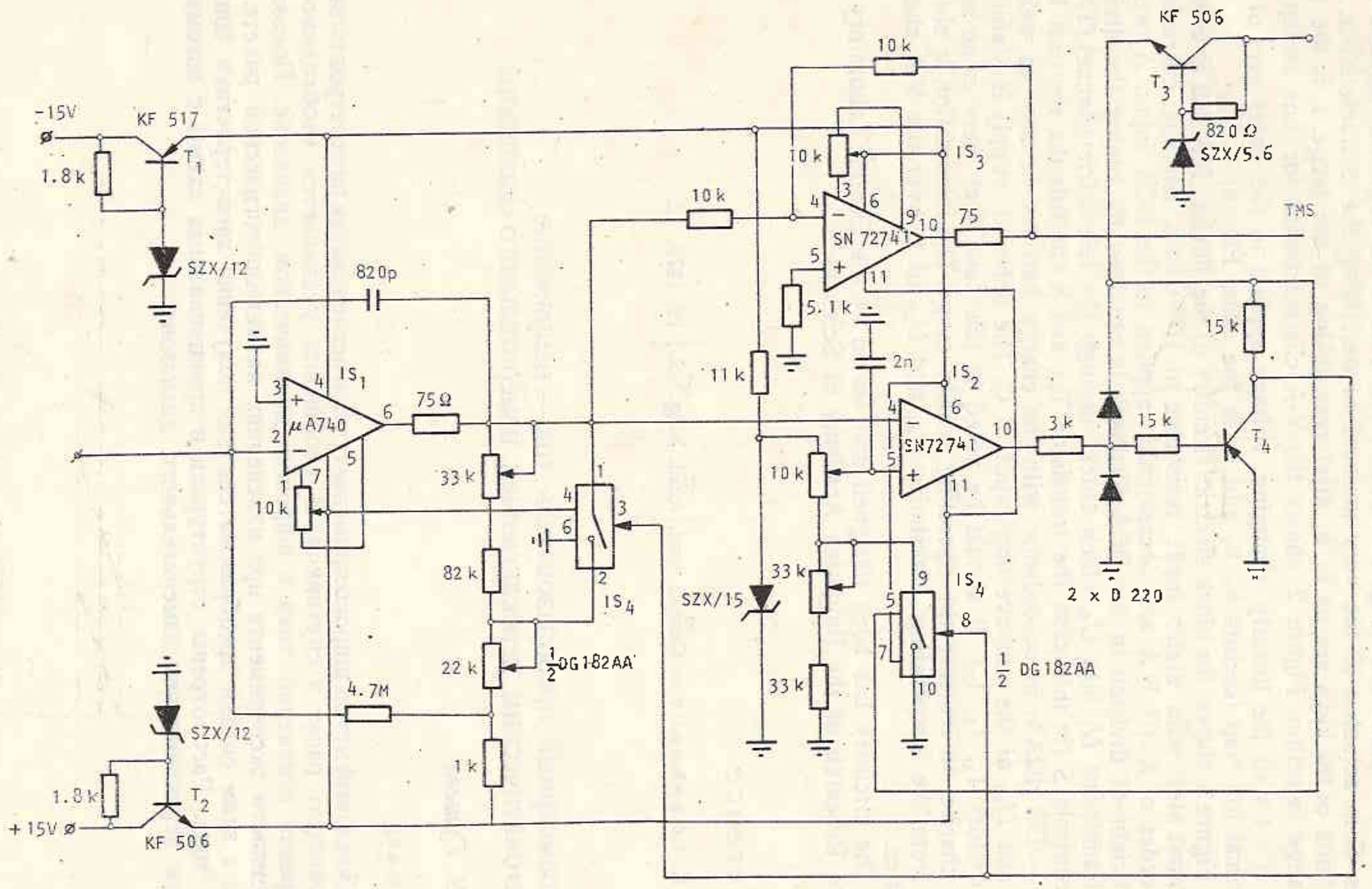

U2
t1
t1
t
a1
b1
c1
U1
t
a2
b2
c2
T = 1s

Fig. 2



-15V
KF 517
T_1
1.8 k
SZX/12
820p
IS_1
μA740
75 Ω
33 k
10 k
82 k
22 k
$\frac{1}{2}$ DG 182AA
4.7M
1 k
SZX/12
1.8 k
T_2
+15V
KF 506
IS_4
10 k
10 k
SN 72741
IS_3
75
5.1 k
2n
11 k
IS_2
SN72741
SZX/15
33 k
33 k
3 k
15 k
15 k
2 x D 220
T_4
$\frac{1}{2}$ DG 182AA
KF 506
T_3
820 Ω
SZX/5.6
TMS

Fig. 3

within the coarse scale (Fig. 2 — sector c_1). This is the region of highest densities. C is actuated at the very moment of describing the characteristics. The positions of the keys are as in b_1 after reswitching of the range. t_1 is the time of range selection. Figure 2 shows the V-A characteristics for one sweep period $T = 1$ s of the linearly changing voltage applied to the outer grid of the spherical ion trap (sectors a_1, b_2 and c_2 in the same Figure) — U_r.

Figure 3 shows the block electric circuitry of the device. MA 740 is used as an input step with static input resistance of 10^{12} Ohms, because currents of the order of $X.10^{-10}$ A are occasionally applied to the DCA input. A precise coefficient of division in the DCA feedback is obtained by tuning the divider. IS_3 transforms U_1 into U_2, which enters through the telemetric channel (TMS), IS_2 controls S (in this case the transistor T_4), and S controls the electron keys (IS_4) — DG 182AA, in accordance with the charge carriers density, as well as U_{z1} and U_{z2} of the noninverting input of C. The onboard supply is stabilized (transistors T_1, T_2, T_3). It should be noted in this case that there is no separate channel to indicate the operating sensity range. This information is obtained from the cooperating thresholds U_{z1} and U_{z2} of C over the V-A characteristics.

The circuitry has been designed and tested at the Central Laboratory for Space Research of the Bulgarian Academy of Sciences.

Reference

1. S. K. Chapkunov. — Compt. rend. Acad. bulg. sci., 19, 1976, 12.

Наноамперный преобразователь ток — напряжение с автоматическим переключением измерительного диапазона

М. Н. Гушева

(Резюме)

Зондовый метод широко применяется при исследовании параметров плазмы с помощью ракет и спутников. В сообщении указывается необходимость измерения изменений тока в широком динамическом диапазоне. Показаны особенности эксперимента при изменениях на метеорологической ракете. В связи с этим создан преобразователь для получения характеристики зондового тока. Рассмотрены структурная и принципиальная схемы с автоматическим переключением измерительного диапазона.