Temperature sweep modeling of the electronic elements in medium and deep vacuum conditions

Dr. Eng. Ivan Evstatiev[1], Dr. Eng. Dimitar Dimitrov[2]

Abstract - **The description of heat exchange of the electronic elements in medium and deep vacuum conditions is a priority based on the radiant heat exchange.**
The approximating hypotheses for building the model are stated (grounded) in the publication. Special attention is put on the relations describing the radiant heat exchange. Considered are the basic connecting relations used in the publication.
Synthesized a logarithmic model by developing algorithm describing the relations of the basic physical dependencies. The modeling is based on the final differences' method. Given is a graphic interpretation of modeling process.

Key words: **mathematical model, electronic elements, vacuum.**

The work of the electronic devices in the medium and deep vacuum conditions is typical for rocket and military industry. The temperature regime of the electronic devices in these conditions is basic circumstance for their standard (normal) exploitation.
The task of this publication is modeling of the temperature regime of the electronic elements, set as a electronic module, situated in a closed area in medium and in deep vacuum.
Hypothesis and basic thermodynamic dependencies.
The work of the electronic module situated in a closed area in vacuum presumes that the basic heat exchange is radiant. Transfer of energy through heat emitting and heat conductance are ignored.
Starting conditions are: temperatures of the electronic module and the surface of the closed area are equal. Besides this the temperature of the closed area is constant.
The electronic product is considered as a printed circuit board average specific heat capacity and specific area.
The electric energy consumed by the module is being transferred into heat. It is well known that for a period of time $\Delta\tau$, S , the liberated energy over the model is:

(1) $$W_{EL} = U.I.\Delta\tau, \ J,$$

where U is the voltage of the source, V;
I – current, consumed by the module, A.
The change in the temperature of the electronic module for the period of time $\Delta\tau$, S , is calculated on the basis of the following calorimetric equation [1, 3]

(2) $$Q = m_{EL}.c_{EL}.(t_2 - t_1), \ J,$$

where m_{EL} is the mass of the electronic module, kg ;
c_{EL} – average specific heat capacity of the electronic module, $J.kg^{-1}.K^{-1}$;
t_1, t_2 – temperatures respectfully in the beginning and after the energy reception, ^0C.
The radiant energy exchange is calculated with the following subjection [1]:
(3)

$$Q = \Delta\tau.\varepsilon_P.c_0.F_{EL}.\left[\left(\frac{273,16 + t_{EL}}{100}\right)^4 - \left(\frac{273,16 + t_{PR}}{100}\right)^4\right], \ J,$$

where ε_P is the given rate of black. It is defined regarding [1].

(4) $$\varepsilon_P = \frac{1}{\frac{1}{\varepsilon_{EL}} + \frac{F_{EL}}{F_{PR}}\left(\frac{1}{\varepsilon_{PR}} - 1\right)},$$

where
ε_{EL} and ε_{PR} are respectively the rates of black of the electronic module and the wall of the closed area;
F_{EL} and F_{PR} - respectively the areas of the surfaces of the electronic module and closed area, m^2;
c_0 - coefficient of the radiation of the absolute black body, $c_0 = 5,67$, $W.m^{-2}.K^{-4}$;
t_{EL} and t_{PR} - respectively temperatures of the surfaces of the electronic module and closed area, ^0C.

PROCESS MODELING

An algorithm is established on the basis of the upraised hypothesis, the basic thermodynamic dependencies and the energy balance, describing the change in the temperature regime of the electronic module (Fig. 1).
In block 1 are given the basic conditions. Blocks 2 and 6 do organize the time change. The energy changes are calculated in block 3, 4 and 5.

[1] Ivan Evstatiev, University of Russe "Angel Kanchev", Faculty of Electro technique, Electronics and Automatics. e-mail: ievstatiev@ecs.ru.acad.bg address: Bulgaria, Russe 7017, ul. "Studentska" 8.
[2] Dimitar Dimitrov, Technical University – Sofia, Faculty of Coommunications and Communication Technologies, e-mail: ddim@tu-sofia.bg address: Bulgaria, Sofia 1000, bul. Kliment Ohridski 8.

RESULTS

Described are approximating hypothesis and basic thermodynamic dependencies, modeling energy processes in vacuum conditions.

Mathematic-algorithmic model is synthesized, simulating the change of the temperature in a time function of the electronic module working in vacuum conditions.

CONCLUSIONS

The given model is appropriate for examination of the temperature regime of the electronic devices working in rocket and military industry.

LITERATURE

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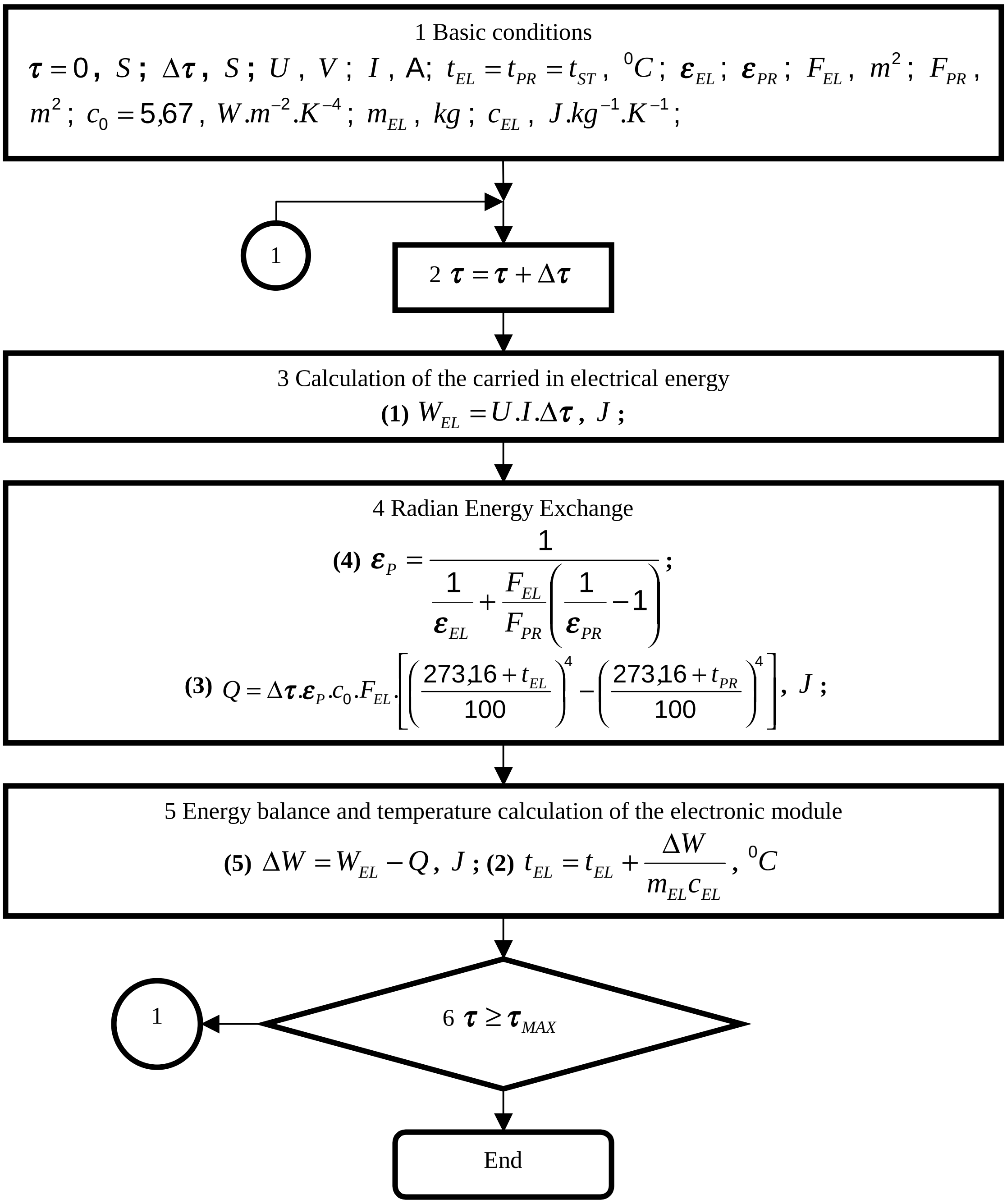

Fig. 1. Algorithm of the temperature regime of an electronic module working in vacuum conditions