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DEVELOPMENT OF THE PROGRAM AND ESTIMATION PROCEDURE FOR ELECTRICAL POWER CONVERT EQUIPMENT TECHNICAL RATE OF SPACECRAFT ELECTRICAL POWER SUBSYSTEM TO COMPARE THE DIFFERENT ELECTRICAL POWER CONVERT EQUIPMENT FOR MAXIMUM EFFICIENCY OF SPACECRAFT ELECTRIC POWER SUBSYSTEM

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Electrical power convert equipment (EPCE) is a complex set of devices which work is energetically connected to each other. Used as parts of the electric power subsystem (EPS) solar array wings (SAW), chemical energy storage batteries, and the spacecraft load have different laws of changing of electrical characteristics which depend on the voltage. This requires mutual agreement, implemented in EPS EPCE with the help of appropriate scheme of power spacecraft organization.

In modern spacecraft power supply with shared buses between chemical batteries, SAW and load is used. Load voltage regulation in the circuit with separated power buses is implemented in two ways: parallel and sequential.

In the parallel SAW control method SAW is directly connected to the load preventing loss of voltage stabilizing. There are three types of parallel regulators of SAW energy: with the sequential switching shunt regulator (S3R), with the transistor switch and throttle, with ballast load.

In sequential way a serial regulator is installed between the SAW bus and the load bus.

The method of control influences the energy losses in EPCE. These EPCE losses are classified into two types:

−management schemes losses;

−power circuit elements losses.

Losses of the first group don’t depend on EPS load power, but losses of the second group depend on it. Thus, according to the power load the EPCE efficiency can vary widely. In this sense, from the point of view of a spacecraft design both the efficiency and EPCE heat generation in all modes are important. In this situation it is necessary to conduct a valid comparison between EPCEs in energy efficiency and to choose the best solution.

According to information written above, the purpose of the research is to develop and to define efficiency of electrical power convert equipment with different structures and power conversion principles, which describes the sequence of measurements of input and output EPCE parameters in different modes for its objective evaluation.

For comparative analysis of different types and EPS schemes we use equations that link the SAW and the load power and the equations that link the EPS mass with the load power, which are the specific efficient of EPS power in normal operation of a spacecraft.

Typically, the EPCE efficiency is not constant. The coefficient of efficiency is affected by the relation between the EPS parameters, such as the current payload power, the battery voltage, the battery charge and discharge currents, SAW currents change with the glance of SAW degradation. Therefore, the EPCE efficiency measurement program should include the efficiency measurement of its separate components – the SAW energy converter (the shunt regulator, the load voltage regulator, the battery charge regulator), the battery energy converter (the battery discharge regulator). For the SAW energy converter it is necessary to value the efficiency in the volt-ampere characteristic change range due to SAW degradation processes, when its current and voltage are being changed. For the battery energy converter it

is necessary to value the efficiency in acceptable range of battery voltage. The more difficult task is measuring the battery charge regulator efficiency, because not only input parameters are changed (SAW current and voltage), but output are too (battery voltage). In the efficiency calculation of the above parts it is also necessary to consider the payload powers change from zero to nominal value. Methodology should also include methods for assessing the EPCE integral efficiency in various combinations of parts described above.

In determining the efficiency of multi-channel parallel SAW regulators it is necessary to consider mode of each regulator: short circuit, pulse-width modulation (PWM) mode, open state. However, the efficiency calculation is different from the calculation of EPCE heat generation that the efficiency calculation takes into account the energy of those generators that power the load only.

During the experimental tests of EPS to determine the EPCE efficiency there are both stationary and dynamic EPS modes. Since the dynamic processes take a little time in the life cycle of EPS, it is obvious that the efficiency should be measured in stationary modes of EPS. Therefore it is necessary to formulate requirements to determine steady state. This is mainly due to changes in temperature of EPCE units in EPS mode changing (charge - discharge, the solar section of the orbit - the shadow section of the orbit, switching on - off the load).

The experimental efficiency determination involves holding precise measurements that can be performed by measuring electrical values or calorimetric measurements. However calorimetric measurements do not provide high accuracy. Mainly they are used for objects associated with the accumulation of internal energy, such as a chemical battery. Usage of calorimetric methods for static converters is impractical, since the measurement of the input and output energy can be made by taking electrical parameters - current and voltage.

At the same time, the analog static converters in EPS of the spacecraft are hardly used. To obtain a high specific energy transformation, achieve high efficiency, pulsed (key) converters are mainly used, the work of which is accompanied by periodic processes in a wide range of frequencies. This imposes some constraints for high accuracy measurements. Therefore, in time of methodology developing it is necessary to schedule the preliminary work using a reasonable combination of oscilloscope measurement methods and measurement of precision direct current instruments.

Thus, the development of estimation procedure for electrical power convert equipment technical rate of spacecraft electrical power subsystem, taking into account all of the above limitations and characteristics is topical. Its solution has rather complicated scientific and technical problems, requires a deep knowledge of the spacecraft EPS and its components. This methodology will increase the objective comparison of different EPCE.