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LOW-TEMPERATURE POWER ELECTRONICS PROGRAM

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INTRODUCTION

Many space and some terrestrial applications would benefit from the availability of low-temperature electronics. Exploration missions to the outer planets, Earth-orbiting and deep-space probes, and communications satellites are examples of space applications which operate in low-temperature environments. Space probes deployed near Pluto must operate in temperatures as low as -229 °C.[1] Figure 1 depicts the average temperature of a space probe warmed by the sun for various locations throughout the solar system[2]. Terrestrial applications where components and systems must operate in low-temperature environments include cryogenic instrumentation, superconducting magnetic energy storage, magnetic levitation transportation system, and arctic exploration. The development of electrical power systems capable of extremely low-temperature operation represents a key element of some advanced space power systems.

The Low-Temperature Power Electronics Program at NASA Lewis Research Center focuses on the design, fabrication, and characterization of low-temperature power systems and the development of supporting technologies for low-temperature operations such as dielectric and insulating materials, power components, optoelectronic components, and packaging and integration of devices, components, and systems.

PROGRAM

The goal of the low-temperature program is to develop and demonstrate reliable, efficient, power systems capable of surviving and exploiting the advantages of low-temperature environments. The targeted systems are mission-driven and include converters, inverters, controls, digital circuits, and special-purpose circuits. Initial development efforts have produced the successful demonstration of low-temperature operation and cold-restart of several DC/DC converters (with outputs from 5 to 1000 Watts) utilizing different design topologies.[3-5] Some of these circuits employed superconducting inductors.

In support of system development, device and component research and development efforts are underway in critical areas of passive and active components, optoelectronic devices, and energy generation and storage. Initially, commercial devices and components are being characterized at low-temperatures. Where there does not exist a viable commercial device or component, a development effort is undertaken.

In addition to the development efforts to fill the key holes in low-temperature power electronics, thermal issues relating to packaging, integration, and cycling are being explored.

LOW-TEMPERATURE DEVELOPMENTAL FACILITIES

At NASA Lewis Research Center, facilities exist for the testing of power and control circuits operating from DC to several Megahertz over a wide temperature range. These facilities consist of a liquid nitrogen cooled environmental chamber in which a circuit can be operated with controlled temperature in the range of 300 °C to -185 °C. Measurement and test equipment include a digital signal analyzer, precision digital multimeters, precision temperature controller and recorder, 3kW electronic load, and resistive loads from mW's to kW's in power.

A complete computer-controlled semiconductor device characterization system is used in conjunction with a cryopumped vacuum chamber containing a cryocooled sample holder to characterize commercial and developmental devices and components. This facility is capable of *in-situ* I-V and C-V characterization of semiconductor devices from 23 °C to -248 °C.

Lewis has built computer-controlled facilities for low-temperature thermal cycling and characterization of electrical and physical properties of dielectrics and capacitors. In addition, facilities have been built at Lewis for reliability studies and life testing of capacitors and other components in space-like environments under multi-stress conditions.

In the area of optoelectronics, Lewis has facilities to characterize and test fiber-optic sources, receivers, cables, connectors, and other components and assemblies at temperatures from 300 °C to -185 °C. Although most low temperature testing on fiber-optic components has concentrated on 1300 nm to date, tests can be conducted at other wavelengths.

CONCLUSION

The Low-Temperature Power Electronics Program at NASA Lewis Research Center is developing selected, mission-driven, power systems and supporting technologies for low-temperature operation. Coordination of these and other related research and development efforts are always encouraged and are implemented with other U.S. Government agencies, academia, and the aerospace industry.

REFERENCES

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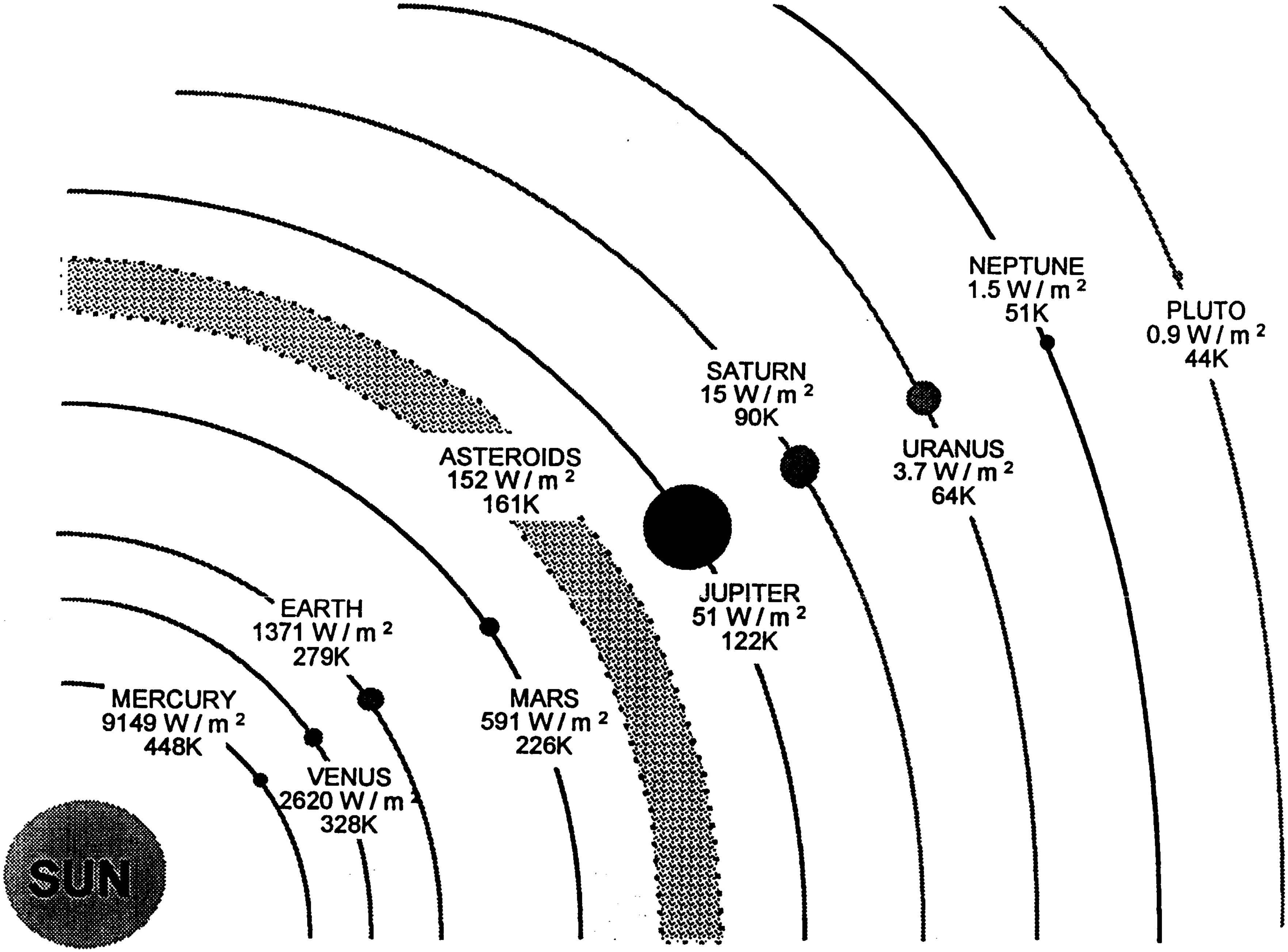
SOLAR INTENSITY & SPACE PROBE TEMPERATURE



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