# SPACE SHUTTLE ELECTRIC POWER DISTRIBUTION CONSIDERATIONS

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## ABSTRACT

The development of the Space Shuttle electric power distribution system is examined considering the state-of-technology. A brief review of conventional air and spacecraft electrical power systems is discussed, and the advantages of a new approach are described. The objectives of MSFC's advanced development studies devoted to this technology area are described. A recommended philosophy of approach for the Space Shuttle electric power distribution system is expressed.

## INTRODUCTION

The requirements the Space Shuttle imposes on the electric power distribution system are considerably greater than previously encountered on manned spacecraft or high performance military and commercial aircraft. Advances in the electrical/electronic state-of-technology made during the past decade should be applied to meet these requirements. MSFC and other NASA Centers have been very active in this technology area. This discussion deals primarily with the work done by the Electrical Division at MSFC, presents a philosophy of approach to meet the Space Shuttle requirements, and identifies some of the problems and what can be done to solve them.

## GENERAL

In performance, the functions of the electric power distribution subsystem are to transmit, distribute, switch, condition, control, protect, and monitor the flow of power from source to utilization equipment. In meeting these requirements, the subsystem must evolve in terms of performance and economy of weight, volume, and ownership cost.

The traditional system concept requires the distribution wiring, often of heavy conductors, to be routed from the source through various switches, circuit breakers, and relays located throughout the vehicle and ultimately to the load. The result is complex cabling with inherent weight and bulk.

## REALITY OF THE PROBLEM

The main problem is that the state-of-technology application related to electric power distribution, processing, and control has not kept pace with the rapidly expanding electrical/electronic technology in general.

Contributing to the problem is the accepted industry standard, MIL-STD-704A, which defines aircraft electrical system power quality. This document specifies the voltage levels of 28 VDC and 115/200 VAC, 400 Hz, 1 Ø and 3 Ø, and provides a rather liberal tolerance for voltage variations.

If significant advantages are to be achieved, the parameters of MIL-STD-704A will have to be changed to values more suitable for today's technology.

## CONVENTIONAL AIR AND SPACE VEHICLE POWER SYSTEMS

In general, aircraft electric power is derived from the propulsion engine driven alternators producing 115/200 VAC, 400 Hz, 3 Ø power. This power and 28 VDC produced by rectification are the only power normally distributed. Power of other forms and quality required is usually produced within or in proximity of the utilization equipment.

To date, manned space vehicle electric power has primarily been derived from batteries and fuel cells and distributed at 28 VDC. Other forms of power required have been produced by inversion or conversion as appropriate to supply the demands of specific utilization equipment.

Currently in both aircraft and space vehicles, the conventional concept is to route power from bus to load through separate electro-mechanical devices required to switch, protect, and control the logic, all performed at the load power level. It should be emphasized that the many series contacts and the interconnecting cabling result in voltage drop and power loss which can only be minimized by increasing wire size, resulting in increased weight and volume.

## THE NEW APPROACH

In the development of aircraft and space vehicle electric power systems, the incorporation of solid-state and hybrid techniques to power distribution and management is unquestionably the remedy.

The technical feasibility of solid-state switching, circuit protection, and software control concepts has been demonstrated by such development programs as the Navy ''SOSTEL'' (Solid State Electric Logic), the Westinghouse ''ACES'' (Automatically Controlled Electrical System), and the Bendix-developed Airborne Display and Electric Management System.

Advanced systems as such provide the following improvements over today's conventional systems:

- Increased Reliability
- Reduced Weight and Volume
- Increased Flexibility
- Easier Maintenance
- Software Control

New components and concepts for the advanced system are being developed as follows:

- Solid-State Power Controllers
- Multiplexed Control Data Transmission
- Programmable Control Logic
- Built-In Test (BIT) Capability
- High-Voltage DC Systems
- Automated Onboard Checkout

There are still continuing R&D requirements in the following technological areas:

- Solid-State Physics
- Data Transmission and Processing
- Heat Transfer and Dissipation
- High-Density Microelectronics
- Transducers
- Memory Systems
- Power Management Software

## MSFC ADVANCED STUDIES

At the MSFC Electrical Division, work is being performed in-house and under contract covering the following electrical power system technology areas:

- Solid-State Switches
- Hybrid Switches
- Circuit Protection
- Power Controllers
- Power Sources
- Standard Power Supplies
- Wire, Cable, Connectors, and Termination Devices
- Power Switching and Control Concepts
- Controls and Displays

In the contract area, one major effort is the "Space Vehicle Power Processing, Distribution, and Control Study" being performed by TRW Systems Group under NASA Contract NAS8-26270. The primary objective of this study is the definition of a practical generalized concept for electric power processing, distribution, and control applicable to manned space vehicles and future aircraft with special emphasis on the needs of the Space Station/ Base and Space Shuttle. The additional objectives are the identification of deficiencies in existing power processing, distribution, and control technology and the establishment of specific goals for the development of advanced components, circuits, or related technology. This program started in March 1971 and will be completed in April 1972.

## CONCLUSIONS

The Space Shuttle can be the beginning for a new philosophy of approach for advanced electric power systems. Knowledge will be obtained and shared; application will become more widespread. Problems will develop and be solved. Time does not permit a deep technical discussion of the application of existing technology to the development of advanced power system concepts.

It is believed that a Solid-State/Hybrid multiplexed software managed power distribution and control system will be incorporated in the next generation of aircraft and in the Space Shuttle.