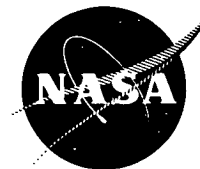


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NASA TECH BRIEF

Lewis Research Center



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Solid State Remote Power Controllers for 120 VDC Power Systems

The Problem:

Conventional power distribution systems require a series of mechanical circuit breakers, relays, and fuses to perform the needed functions of load switching and of total system protection of equipment and wires. As distribution and transmission systems grow in size, sophistication, and complexity, however, so do the requirements for the power control and protection equipment. Studies by NASA and the Navy reveal significant system benefits in efficiency, weight, cost, reliability, and design flexibility, if aircraft and spacecraft power distribution and transmission is done at dc voltages above 100 Vdc rather than at conventional 28 Vdc and 115 Vdc levels.

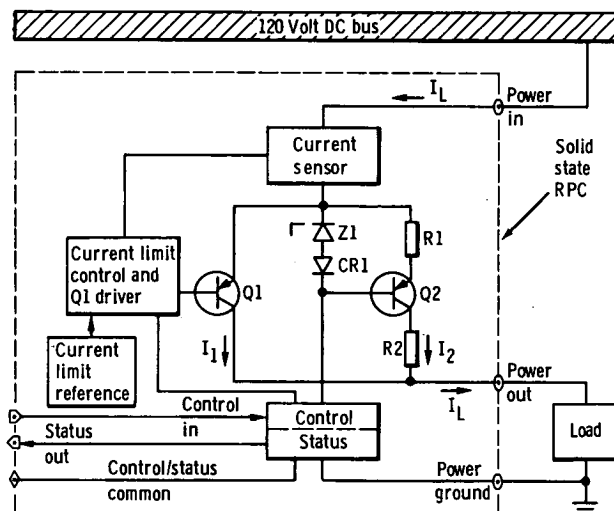
The Solution:

Solid state remote power controllers (RPCs) that can be applied to any dc power system up to 120 Vdc and distribute power up to 3.6 kW per hour. These RPCs have demonstrated total electrical efficiencies of 98.5 percent to 99.0 percent at rated load currents.

RPC devices combine in one unit the capability to perform all the needed functions of load switching and provide total system protection of equipment and wires. In addition, solid state RPCs possess several added advantages that contribute directly to power system benefits. These advantages include: "contactless" switching (no contact wear or arcing); controlled rates of current rise and fall; current limiting; and fast, well-defined, repeatable response to overloads and faults, especially over temperature extremes from 218 to 373 K (-67 to 212°F).

How It's Done:

Transistors are used as the basic switching and control elements of the solid state RPCs. The transistor was selected for its ability to change quickly from a full saturation state to a voltage-blocking, current-limiting state upon application of a short circuit fault. In this application, the transistor offers the lowest forward voltage drop and is the easiest to control under all conditions, when compared to SCRs or gate turn-off thyristors.



Basic RPC switch circuit shown in a typical application.

The figure illustrates the basic switching circuit with current limiting as used in a typical RPC application. Dielectric isolation up to 1500 Vac is provided between the low power controls and the high power side of the RPC. The main power switch Q1 is an NPN transistor in a Darlington configuration or an NPN with a transformer-oscillator efficiency boost. Q1 is represented here by a single PNP transistor for clarity. Transistor Q2 and resistors R1 and R2 assist the main transistor Q1 during current limiting. As the voltage increases across Q1, more current (and dissipation) is diverted to R1 and R2. Since I_L is constant, then I_1 will decrease and reduce substantially the dissipation in Q1 that would be encountered without the assist. In the non-current limiting types, however, Q1 does the switching with short term di/dt limiting provided by a resistor-capacitor combination. The Q2 helper circuit is not required.

Of significance for 120 Vdc applications is the development of three types of RPCs with two types having a 5 ampere current rating and one type a 30 ampere rating. All three types have a coordination of trip characteristics

(continued overleaf)

to permit the series/parallel operation of the RPCs in a distribution system. Also of significance is the inherent capability of the RPC designs to control the ultimate current resulting from an applied zero impedance fault with no passive di/dt limiting, i.e., no inductors. Response time to any applied fault is typically less than 3 μ sec with peak currents during this time limited to three times the maximum current capacity of the RPC.

Two fundamental types of protection were developed for the RPC. The first type is current limiting at 3X (three times rated current) for 0.1 second followed by an I^2T trip time. The second type is non-current limiting with instant trips at 3X or 5X preceded by an I^2T trip time. The desired I^2T trip time functions were closely approximated with a linear circuit, which is simpler and easier to build than a conventional squaring circuit.

Second generation RPCs have dramatically simplified circuits that reduce parts count by one-half at one-third the cost. The simplified circuits using the Darlington power switch have superior partial load efficiency. The most important benefit of the Darlington power switch, however, is that it permits a universal circuit design with a steady state operating voltage range from 25 to 132 Vdc. This universal design leads to standardization of the control and drive circuits. From this point, reasonable extensions of the design can be made to accommodate any higher voltages for which transistors are available.

Additional features of the RPCs are remote, optically isolated, control and status indication, trip free and fail-safe operation, and optional multiple reset capability. The RPCs are self-powered from the load line, and are immune to voltage transients up to 200 Vdc.

Notes:

1. The solid state RPCs have been demonstrated to be compatible with any source-type batteries, fuel cells, generators and solar arrays. They are compatible with any load-type resistive, capacitive, inductive motor, or incandescent lamp.
2. The RPCs have potential application in spacecraft and aircraft electrical systems, in transportation systems, in industrial systems, and in hazardous areas with volatile gases present.
3. Further information is available in the following report:

NASA CR-134772 (N75-21522), Aerospace Technology Development of Three Types of Solid State Remote Power Controllers for 120 VDC with Current Ratings of Five and Thirty Amperes, One Type Having Current Limiting

Copies may be obtained at cost from:

Aerospace Research Applications Center
Indiana University
400 East Seventh Street
Bloomington, Indiana 47401
Telephone: 812-337-7833
Reference: B75-10150

4. Specific technical questions may be directed to:
Technology Utilization Officer
Lewis Research Center
21000 Brookpark Road
Cleveland, Ohio 44135
Reference: B75-10150

Patent Status:

NASA has decided not to apply for a patent.

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Lewis Research Center, and
D.E. Baker
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