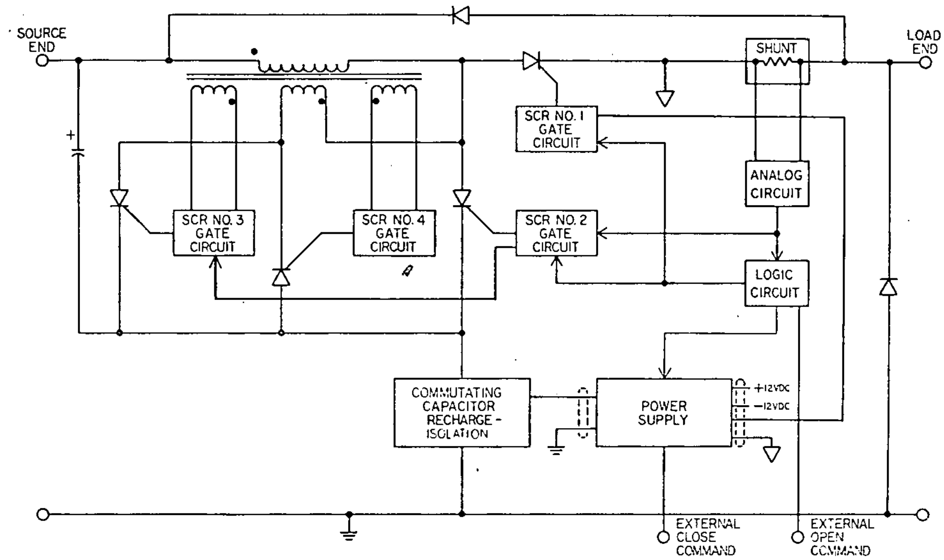
NASA TECH BRIEF

Lewis Research Center

Logic Controlled Solid State Switchgear



The Problem:

High voltage dc electric power systems (above 100 V dc) are being considered for future generations of aircraft and spacecraft. Recent NASA-sponsored studies have shown that high voltage dc transmission and distribution can provide significant weight reduction, greater design flexibility, higher reliability, and lower cost than conventional 28 V dc or 115 V ac systems. However, one of the principal factors delaying the use of high voltage dc in aircraft and space vehicle power systems is the lack of available, flight rated, control and protection equipment; e.g., remote power controllers, circuit breakers, and power transfer switches.

The Solution:

Logic controlled solid state switchgear. Logic controlled solid state circuit breakers and power transfer switches have been designed and built to demonstrate their use for 270 V dc power systems. This switchgear provides remote operation, automatic current level and i^2t trip out, and operates several orders of magnitude faster with much greater accuracy of response than conventional switchgear.

How It's Done:

The main functional circuits of the solid state circuit breaker are shown in Figure 1. The basic operation of the circuit breaker is achieved by SCR-1 which can be turned on, on command, and can be commutated off either by a command or a sensed overload. Commutation is achieved by a circuit that is essentially isolated from the power source and the load. This results in relatively little transient generation back on the power line and none on the load when the current is interrupted. When a trip signal is received, the auxiliary SCR's (2, 3, and 4) are gated sequentially in such a manner that the precharged capacitor is discharged in the L-C circuit formed. This action back biases SCR-1 to allow recovery of its blocking capability, and, ultimately, returns the capacitor to its original charge state. Compensation for circuit losses is provided by the capacitor recharge circuit.

The entire commutation cycle requires 500 microseconds. However, circuit current begins to divert from the load to the commutation bus within a few microseconds after receiving a trip signal. The load current drops from the 45 ampere trip level to zero in about 50 microseconds with a resistive load.

(continued overleaf)

A continuous gate drive is provided for the main SCR. This drive insures that SCR-1 will remain ready to conduct at all times while the circuit breaker is on, even though the load current may go to zero.

Open and close commands are achieved electrically by millijoule signals, which are isolated from both the power and load circuits. Overload sensing is accomplished by a high frequency current sampling resistor connected within the analog circuit to electronic amplifiers and comparators that provide the ultimate current trip level and the i^2t functions required. In operation, the analog squarer-integrator generates a trip signal to open the breaker if the difference between circuit heat gain, i^2t, and design heat loss, $(15)^2t$, exceeds a reference energy. This difference between heat gain and heat loss is represented by the integral of $(i^2 - 15^2)\,dt$, which is compared to the value of 5 A^2-sec. If the current i is less than 15A, the value of the integral is prevented electrically from going negative.

The overall operation of the circuit breaker is controlled by logic circuitry that relates the time and order of each operational function required. There are some 14 separate steps or sequences provided. The logic circuitry uses COS/MOS flat pack integrated circuits because of its relatively high noise immunity.

Circuit breakers incorporating SCR switching elements have been built, tested, and have performed the majority of the requirements imposed upon them. The circuit breakers with their automatic trip and recycle capability as well as remote control can be interconnected to provide remote control transfer switches with overload protection.

Notes:

1. Further information is available in the following report:

   NASA CR-121140 (N73-18223), Study of Feasibility of Solid-State Electric Switch Gear for Aircraft and Spacecraft

   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: B73-10408

2. Specific technical questions may be directed to:

   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
   Cleveland, Ohio 44135
   Reference: B73-10408

Patent Status:

NASA has decided not to apply for a patent.

Source: E. Buchanan and D. Waddington
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