

NEW SOLUTIONS FOR CIRCUIT BREAKERS

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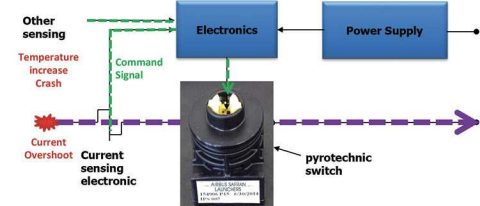
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Electrical power increase is a long term issue in aircraft installation. Higher voltage is already a challenge that has been faced through latest aircraft development (B787, A350). The protection of High Voltage DC network (HVDC) is one of the main issues of this challenge. Conventional pyro breakers have maximum operating voltages compatible with first generation aircrafts (115 V) but inconsistent with current or future generations of aircraft which can reach or exceed 540V. Airbus Safran Launchers and Mersen have developed a new circuit breaker concept to cut circuits operating at high voltages that can reach 1000 V (ie Pyrofuse).

Unlike fuses, Mosfet or electromechanical relays, the Pyrofuse has no impact on reliability (equivalent to connecting a busbar). It has an excellent selectivity which makes it compatible with a wide range of fault current. If necessary it can be provided with an additional function included self-triggered on high current to ensure operation even in case of failure of the monitoring system. Its very low resistance compared to other protection systems allows it to be positioned on a line without warm-Joule or Watt-losses. With this current limiter, you don't have to oversize networks to take into account possible fault currents. It prevents the propagation of defects that will ruin healthy line. They can also protect the outputs of the main control unit (Actuator Power Management Unit, Ice Protection System, Electrical cabinet...).

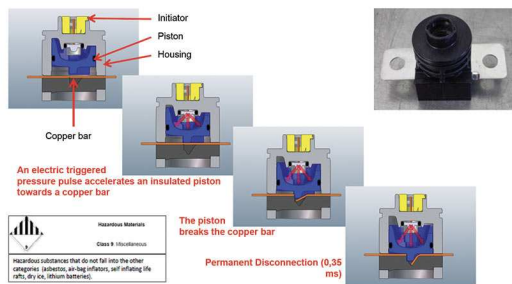
PYROBREAKER (IPS)

Airbus Safran Launchers manufactures and markets a range of Pyrobreaker named IPS. These devices are initiated by an ECU analysing various signals (deceleration, current, temperature...). They cut irreversibly a power line. The pyro breaker is an electrical interrupter and, in contrast to a fuse, the time to achieve a complete disconnection of a circuit will not be dependent on the magnitude of the over current. Pyrobreaker are currently used on various Internal Combustion Vehicles.



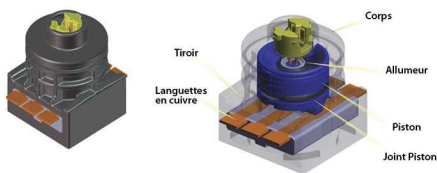
OPERATION

In general, a pyro breaker utilizes a miniature guillotine that is propelled by a pyrotechnic charge to achieve the force required to cut through a metal conductor (busbar). This gives a very simple and thus extremely reliable behaviour. The pyro breaker has no impact on the electric system before operating since it is positioned above the busbar. After operation, it cuts the busbar and separates/isolates the two conductors. The cut-off time is lower than one millisecond.



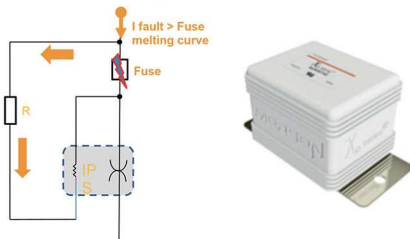
TRIPHASE PYROBREAKER

A three-phase circuit breaker uses 3 smaller bars. Each bar is insulated from its neighbour by insulating elements. Once pyro breaker ignited, the guillotine cuts the 3 bars in the same operation. Unlike a fuse that cuts only the faulty phase with the risk of keeping one or two phases with a residual current, the pyro breaker cut the 3 phases and completely isolates the faulty element.

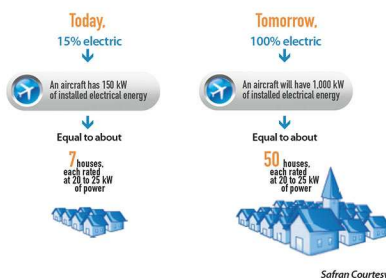


SELF TRIGGERED PYROBREAKER

A self triggered pyrobreaker associates a pyro breaker and a fuse in series to obtain a pyro breaker with self-triggering in rescue. During normal operation the current I goes through pyrobreaker (IPS). Fuse current rating is calculated to carry the RMS current I. If the current overpass a limitation, the pyro breaker operates even without external signal (in case of failure of the ECU for example). During clearing operation, fault leads fuse to melting. Electric arc generated by Fuse will be used to trigger the pyro breaker. Once IPS opens that opens the circuit. The pyro breaker clears the fault. No external energy is needed to trigger pyro breaker, it is a self-triggered system! Of course, the pyro breaker can be triggered as usual by the ECU.



ELECTRICAL POWER ON AIRCRAFT



THE TESTIMONY OF A USER

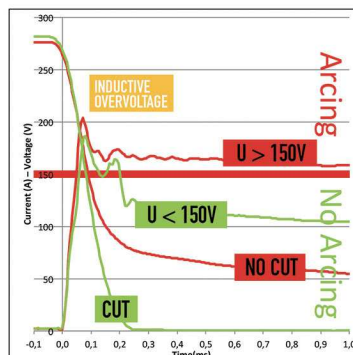
The pyro breaker/pyrofuse cut quickly and definitively the three-phase arrival of equipment which not only fails but may pose a safety problem to the Aircraft. Indeed, because of insufficiently sized insulation, an arc can be established between two PCB tracks then extend to the outer housing of the equipment. In this case, the arc may bore the case at several points, and finally pierce it. In the fuel zone such an incident can ignite a fire.

The pyrobreaker has the following advantages : It has no loss. Indeed, the current of the circuit breaker passes through copper conductors which the pyrotechnic charge will break if necessary.

- It does not use the Joule effect as a trigger for failure and therefore does not have the losses, even if minimal if dimensioned, of a fuse.
- The current does not pass through power semiconductors and therefore does not have the ohmic or saturation voltage loss of a MOSFET or an IGBT, and will be on this point always better than the MESFETs or HEMTs GaN or other.
- It is triggerable by any event that crosses the threshold of the sensor of a physical magnitude: current of course, but also, voltage, temperature, other anomaly.
- It is very fast (<1ms) with a breaking time independent of the fault current unlike a fuse.
- It is safe (pyrotechnics is considered very reliable in multi environments including spatial or nuclear and over time).

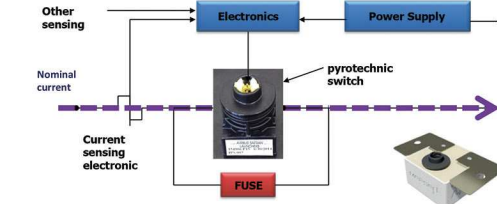
ARCING

Pyrobreaker are currently limited to low Voltage (<300V) due to arcing. A drawn arc can be initiated by two electrodes initially in contact and drawn apart. example is separation of electrical contacts in switches, relays and circuit breakers. In high-energy circuits arc suppression may be required to prevent damage to contacts. (source:Wikipedia)



PYROFUSE (XP)

Airbus Safran Launchers and Mersen have developed a new circuit breaker concept to cut pyrotechnic circuits operating at high voltages that can reach 1500 V. This new hybrid protection solution combines a pyro breaker element and a fuse element configured electrically in parallel. The pyrobreaker cut the current, the fuse extinguishes the arc.



STEP 1: Overall topology & nominal operation conditions

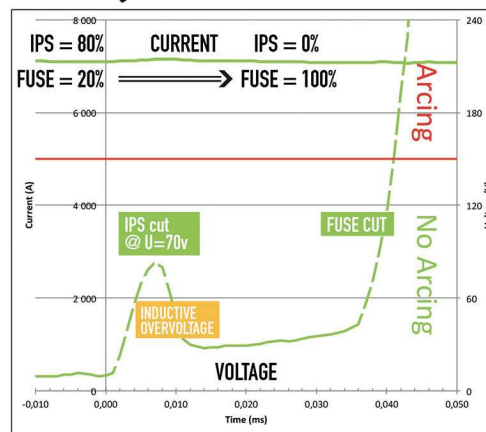
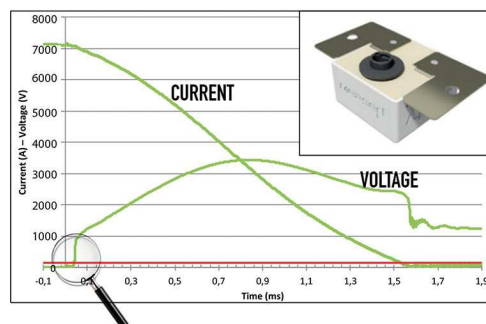
The system is based on a pyroswitch in parallel with an undersized rated current fuse. Under normal operation, most of the current flows through the pyroswitch due to the fuse high resistance compared to the pyroswitch resistance → very few losses

STEP 2: A current overshoot is detected by the current sensor

A signal is sent to the pyrofuse to operate
The pyroswitch breaks under no voltage (being in parallel with the fuse) → No arc
The default current is transferred to the fuse path

STEP 3: The circuit safely opens

Due to the large fault current and the undersized fuse, the fuse melts very quickly.
The current is quickly cleared and the circuit is open and safe



OPERATION

During its lifetime, the entire device is closed and the nominal current is flowing. The pyro breaker resistance (copper bar) is lower than the fuse resistance. Thus most of the nominal current (80% - 90%) flows through pyro breaker. Cycling performance and lifetime are improved in comparison to a simple fuse. Moreover, with the very low resistance of the entire system (~200µΩ), the on-state losses drastically decrease. Fuse could be sized with a low nominal current calibre (10 – 20 % of IN) and thus a low cost. When the current abnormally increases because of a failure in the DC application, a sensor detects the fault current and sends the triggered signal to pyro breaker thanks to a control board. A fuse is situated in parallel and is still closed. Thus pyro breaker cuts the copper bar without any voltage and the fault current flows through the fuse. As this fuse is underrated, it opens the circuit with a very short cut-off time. To summarize, the fuse is sized for the nominal voltage and underrated for the current. This new protection makes it possible to cut off high voltage (until 1000V) and high fault current (7000A).