# POWER SOLID STATE RELAYS
# WITH HIGHER LIFE EXPECTANCY

**celduc®** has been improving non-stop the Quality of its solid state relays over the past 20 years. We can boast being the first to market :

--> relays with a low synchronism level.

--> relays with a low leakage current.

--> touch-protected relays (physical contact): IP20.

--> high immunity relays (4KVolts standard A / IEC1000-4-4 & IEC1000-4-5 ).

--> relays with the best overload characteristics ( $I^2t$ up to $20000A^2s$ for 125A products) with circuit-breaker protection.

The reliability of our relays is renowned all over the world.

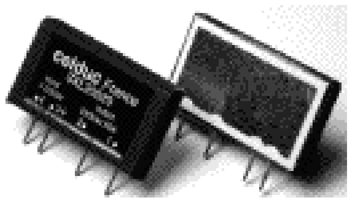
Innovation is our driving force.

Today, making use of up-to-the-minute technology in the manufacture of our power solid state relays, we present :

**A thermal stress life expectancy multiplied by 2.**

## celduc® Power Solid State Relays:

## Details that count :



### --> <u>Chip thyristors :</u>

* Voltage resistance up to 1600Volts

= high long term blocking stability.

* Sufficiently-sized chips.

= greater overload ($I^2t$) characteristics.

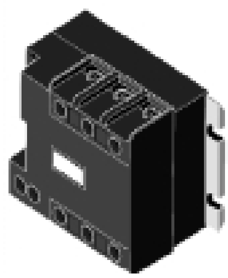
### --> <u>New materials and new process:</u>

* New ceramic substrate using DCB technology.

* Cathode connections of thyristors by bonding wires.

* SMD technology control components

(process reliability with over 10 years' experience).



*Proud to serve you*

celduc®
r e l a i s

## celduc® Power Solid State Relays:

# The difference is in the :

Mounting technology

1 --> The "Standard" technology used by the majority of solid state relay manufacturers, makes use of a conventional ceramic substrate and cathode connections known as "jumpers" :
see mounting technology below ( fig 1).

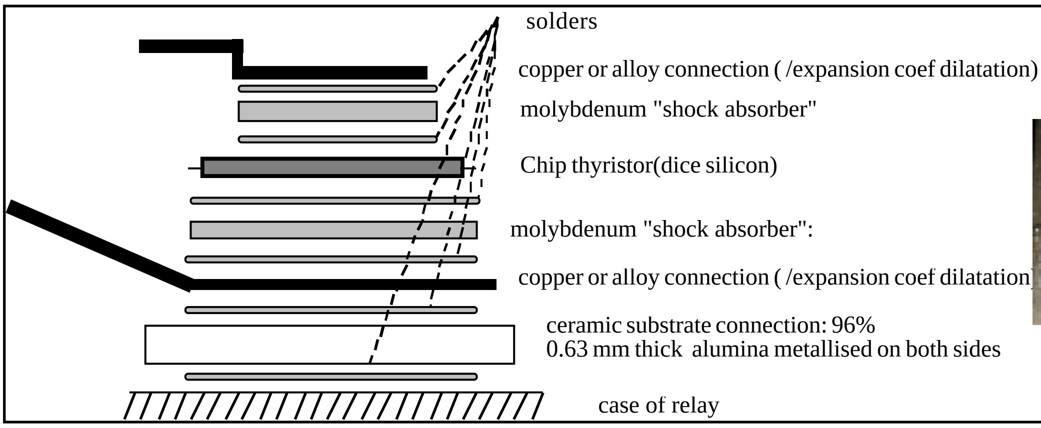
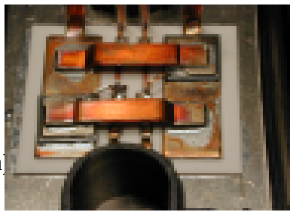



fig 1



This technology has the disadvantage of cumulating the number of layers with the increase of the junction/case (Rthj/c) thermal resistance, of being limited in thermal stress (number of cycles according to the variation in temperature) and being difficult to automate (process reliability).

2 --> DCB ( Direct Copper Bonding ) Technology :

The innovation is in the substrate. Thanks to a high temperature (approx. 1000°C) diffusion process, a thick layer of copper (usually 0.4 mm) is directly imbedded onto the alumina substrate. The jumpers are replaced by a multitude of bonding wires with several anchor points to withstand significant overload currents. This technology brings the following assets :

* Well improved thermal resistance.

* "Thermal" stress divided by 2 or 3.

* Simplified mounting, with automation giving rise to total control of the production process

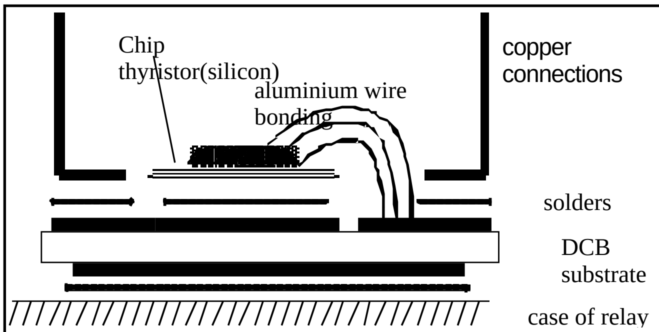
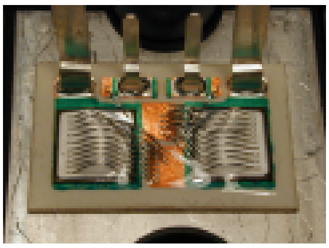



fig 2





Rue Ampère B.P. 4 42290 SORBIERS - FRANCE E-Mail : celduc-relais@celduc.com
Fax +33 (0) 4 77 53 85 51 Service Commercial France Tél. : +33 (0) 4 77 53 90 20
Sales Dept.For Europe Tel. : +33 (0) 4 77 53 90 21 Sales Dept. Asia : Tél. +33 (0) 4 77 53 90 19

# What is "thermal stress" ?

A solid state relay is a macrocomponent using power thyristors, optocouplers and other standard electronic components. If the current and voltage characteristics are adhered to, the life expectancy is greatly higher compared to an electromechanical relay (no wear on the contacts --> "virutally unlimited" ! ).
Over the past decades, electronics have progressed by leaps and bounds when it comes to reliability and components such as optocouplers now have a very high life expectancy.
(**celduc®** exclusively uses Quality optocouplers with MTBF > $2 \times 10^6$ hours ).

**--> The current life expectancy of power electronic components mainly depends on the thermal stress, due to variations in temperature during use.**

Indeed, every switching action subjects the thyristor chip to a variation in temperature due to local heating on the chip related to different factors:

a) This variation in temperature is above all linked to the switched current linked to the load.
Examples below :
--> fig 1 : variation in temperature on a resistive load with significant amplitudes in the preheating phase (ΔT1) , then less in the regulation phase (ΔT2).
--> fig 2 : variation in temperature on a motor with significant variations (ΔT2) on every start-up due to starting currents capable of reaching 8 x In for 1.6s.

Fig 1 : junction variation temperature on resistive load

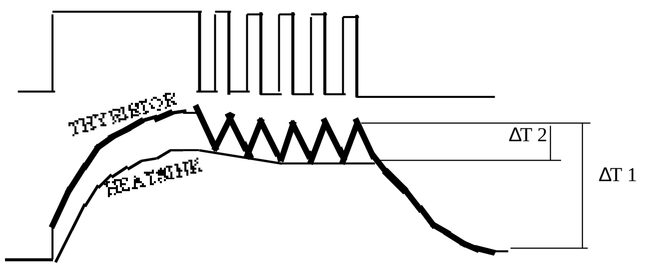
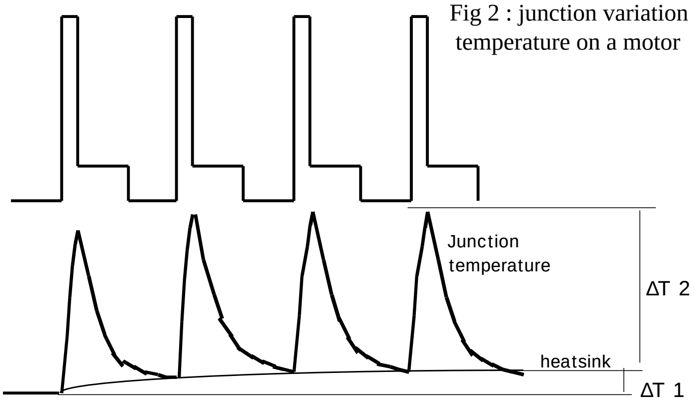



Fig 2 : junction variation temperature on a motor




b) The amplitude of this variation is also due to the Quality of the thermal resistance between the junction and the heatsink (or case) : Rthj/c (or Zthj/c : Thermal impedance / non-stabilised temperatures).
**DCB technology ensures a very significant reduction in this Rthj/c .**
The difference in temperature between the junction and the heatsink (case) is directly related to the thermal impedance and the power dissipated : ΔTj/c= Zthj/c x Pd.
(The heatsink stays at a fairly constant temperature during normal operation).

c) The size of the chip (silicon chip) used determining the surface area of the silicon is of prime importance. --> The bigger the chip, the weaker the power dissipated with :

$Pd = 0.9Vt \times I + rt \times I^2t$ : the dynamic resistance "rt" drops with a bigger chip.

➔ The junction/case ( Rthj/c) thermal resistance is also inversely proportional to the surface area of silicon. (ΔTj/c= Rthj/c x Pd) .

**This is why celduc® uses sufficiently-sized chips.**

Example for a relay of 50A : chip size of a thyristor : 7.2 x 7.2 mm when compared to competitors' chips of 6.3x6.3 or 5.8 x5.8mm , not as expensive but not as efficient either.

d) The size of the heatsink is also important. **celduc®** complies to the European standards with maxi. ΔT of the heatsink at 50°C for a room temperature of 40°C.


Rue Ampère B.P. 4 42290 SORBIERS - FRANCE E-Mail : celduc-relais@celduc.com
Fax +33 (0) 4 77 53 85 51 Service Commercial France Tél. : +33 (0) 4 77 53 90 20
Sales Dept.For Europe Tel. : +33 (0) 4 77 53 90 21 Sales Dept. Asia : Tél. +33 (0) 4 77 53 90 19

# Consequence

These variations in temperature give rise to thermal expansion constraints which are all the more severe when the materials used differ. Hence, "molybdenum" type shock absorbers are required between the silicon and the connections which may be either made of copper or special (bimetallic) alloys and well-suited solders.

**--> The technology used in the celduc® relays already made use of the best connection materials with harmonised expansion characteristics. The number of thermal stress cycles, already greatly superior to the majority of products on the market have been doubled with the "DCB + bonding" technology used in the latest generation of celduc® relays. This technology, combined with optimum-sized components, gives second-to-none results.**

**celduc ® power solid state relays:**

# The results :

It is not easy to verify the life expectancy of a power components (mainly due to low variations in temperature) as very long tests are involved.

With over 20 years' experience in the matter and the backing of major Silicon manufacturers, **celduc®** provides its customers with elements regarding the number of cycles according to the temperature thanks to the tests it has finalized to accelerate the ageing.

## Description of this test :

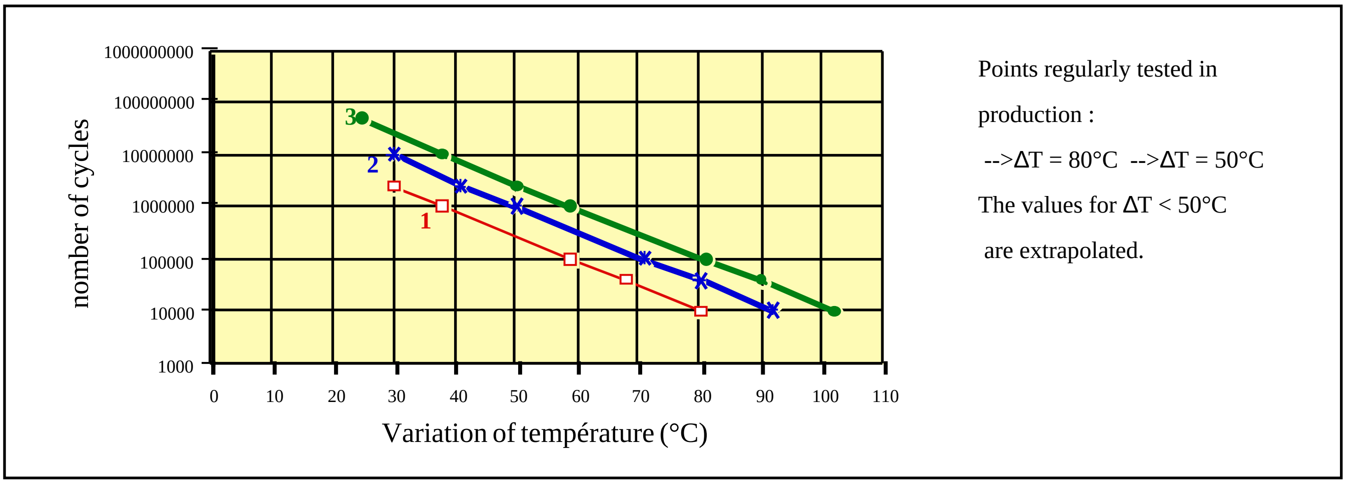
The majority of our tests are performed for ΔT = 80°C with permanent monitoring of our production.

The relay is mounted on a heatsink of a very low Rth: <0.2K/W ==> the temperature of the heatsink is practically constant.

Current pulses are sent to the relay in order for : Zthj/c x Pd = ΔTj/c desired .

Example for a relay of 50A : test performed with 100A/1s "ON"  then 7s "OFF".

The results are given in the curve below :




curve N°1 : technology found in the majority of solid state relays on the market.

curve N°2 : **celduc®** technology since 1995

curve N°3 : **celduc®** technology in 2000 with DCB + bonding.



Rue Ampère B.P. 4 42290 SORBIERS - FRANCE E-Mail : celduc-relais@celduc.com
Fax +33 (0) 4 77 53 85 51 Service Commercial France Tél. : +33 (0) 4 77 53 90 20
Sales Dept.For Europe Tel. : +33 (0) 4 77 53 90 21 Sales Dept. Asia : Tél. +33 (0) 4 77 53 90 19

# celduc® Power Solid State Relays:

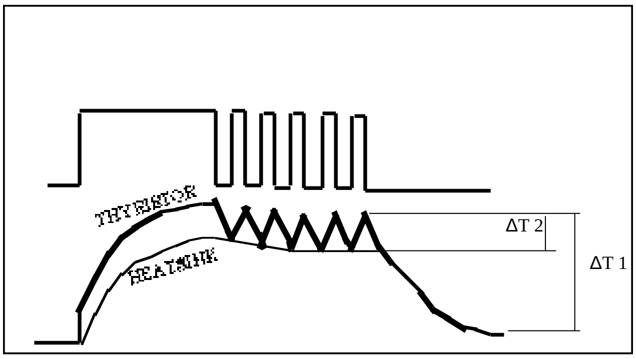
# Applications

a) Heating application : I AC-51 = 32A under 400 VAC

--> **celduc®** offers a 50A relay, reference SC965xxx mounted on heatsink of 1.5K/W in order to comply with the IEC947-4-3 standards which give a rise in temperature of the components that can be touched of a maximum of 50°C at a room temperature of 40°C.

--> The competition offers a 50A relay mounted on a heatsink of 1.9K/W (smaller) in order to limit the junction temperature to its maximum , i.e. 125°C, without worrying about the temperature of the heatsink.

| CHARACTERISTICS | celduc 50A relay | competitors' 50A relay |
|---|---|---|
| Size of chip used | 7,2 x7,2 mm | 6,3x6,3 mm |
| Techno | "DCB + Bonding" | "standard" |
| Vto (typ measured) | 0,9V | 0,9V |
| rt (typ measured) | 7mΩ | 8 mΩ |
| Pd @ 32A = 0,9VtxI +rt x I2 | 33W | 34W |
| Rthj/c (typ) | 0,3 | 0,4 |
| Rthd (Rthheatsink | 1,5 | 1,9 |
| ΔT1(*)=(Rthj/c+ Rthd) xPd + 2 | 80°C | 98°C |
| ΔT2 = Rthj/c x Pd | 10°C | 13,5°C |
| * calculation made at initial room T = 20°C , then rise of room temperature up to 40°C | | |




By referring to the thermal stress curves ( page 4/5), the latest generation **celduc®** product could withstand a very high quantity of thermal cycles in regulation mode ( ΔT2 =10°C) and over 100,000 preheating cycles with ΔT1 = 80°C .

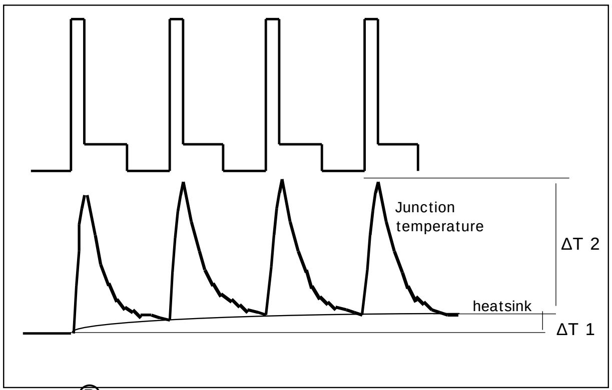
For the competitors' product with ΔT2 = 13,5°C and especially ΔT1 = 98°C , the number of cycles is much more limited : less than 2,000 preheating cycles.

--> **Hence the advantage of using adapted cooling and advanced technology.**

a) Motor application : I AC-53 = 8,5A under 400 VAC three phase.

--> Adhering to the IEC947-4-2 standards which give a starting current of 8 xIn for 1.6 seconds. --> For a IAC-53 current of 8.5A, **celduc®** offers a 50A relay.

| CHARACTERISTICS | celduc 50A relay | competitors' 50A relay |
|---|---|---|
| Size of chip used | 7,2 x7,2 mm | 6,3x6,3 mm |
| Techno | "DCB + Bonding" | "standard" |
| Vto (typ measured) | 0,9V | 0,9V |
| rt (typ measured) | 7mΩ | 8 mΩ |
| Pd @ 8x8.5A = 0,9VtxI +rt x I2 on starting per channel | 87W | 92W |
| Pd @ 8.5A = 0.9VtxI +rt x I2 in operation per channel | 7W | 7,5W |
| Rthj/c (typ) (= Zthj/c pour t=1,6s) | 0,3 | 0,4 |
| ΔT1(*)= Pd@8Ax( Rthd+Rthj/c) | faible | faible |
| ΔT2 = Rthj/c x Pd @ 8x8,5A | 26°C | 37°C |




Referring to the thermal stress curves, the latest generation **celduc®** product could withstand a very high quantity of starts: ΔT2 =26°C --> over $40x10^6$ switching actions.

For the competitors' product with ΔT2 = 37°C, the number of starts would be much more limited : less than $1x10^6$ switching actions ==> not suitable for high output motor applications.

**Hence the advantage of using a well-sized semiconductor and advanced technology.**



Rue Ampère B.P. 4 42290 SORBIERS - FRANCE E-Mail : celduc-relais@celduc.com
Fax +33 (0) 4 77 53 85 51 Service Commercial France Tél. : +33 (0) 4 77 53 90 20
Sales Dept.For Europe Tel. : +33 (0) 4 77 53 90 21 Sales Dept. Asia : Tél. +33 (0) 4 77 53 90 19