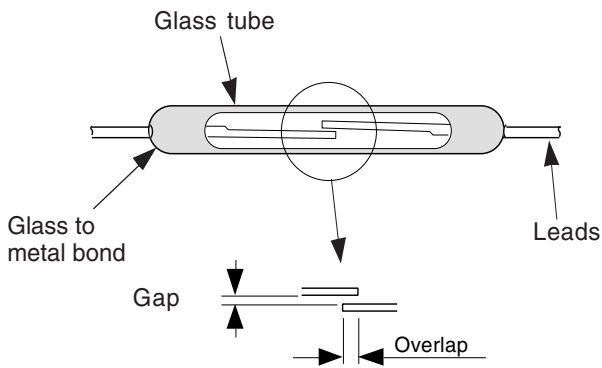


TECHNICAL NOTE : REED SWITCHES

General

REED Switches



A REED switch consists of two flattened ferromagnetic reeds which are sealed inside a glass tube containing a neutral atmosphere. The blades are laid out with a slight overlap at their free ends, so as to be able to close, and they are spaced a few hundredth of a millimetre apart in the overlap area (gap).

When the switch is brought into the influence of an appropriate magnetic field, the reeds, or blades, will assume opposite magnetic polarity, and will attract each other and make contact. When the magnetic field cancels out, the reeds will separate.

REED switches are manufactured in white room, on automatic sealing machines. In the course of the sealing process, the inner volume of the switch is filled with a neutral or slightly reducing atmosphere (Nitrogen + Hydrogen). The switch is thus explosion proof in its very concept, and is also protected from every form of atmospheric pollution (liquids or gases).

After the manufacture, every switch is inspected unitarily for its electrical characteristics (contact resistance, breakdown voltage, etc.) and its mechanical characteristics (sensitivity). Each switch is then graded in relation with the quality of its contact and its sensitivity.

REED Relays



A REED relay consists of one or more switches positioned in the centre of a coil winding (solenoid). The assembly can be protected by a surrounding magnetic shield, or it can be moulded.

A REED relay is manufactured with the same meticulous care as taken for the protection of the switches : it is continuously inspected in the course of assembly, impregnation, and moulding.

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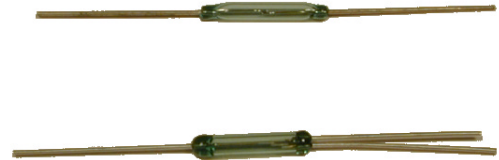
REED relays can be fitted with a magnetic shield (screen) which protects them from their magnetic environment, and in a reciprocal manner avoids interference between the field arising from the coil winding in the relay and neighbouring components.

The applications are large : Interface, telecommunication, modem, automatism, testing machines for Printed Circuit Boards, testing machines for high voltage relays, low switching, ...

REED Switches : Technical specifications

REED switches are characterised by :

- The nature of the contact
- Its sensitivity
- The shape of the contact
- Its dimensions
- Switching power
- Its reliability



1. Nature of the contact

There are two types of REED switches :

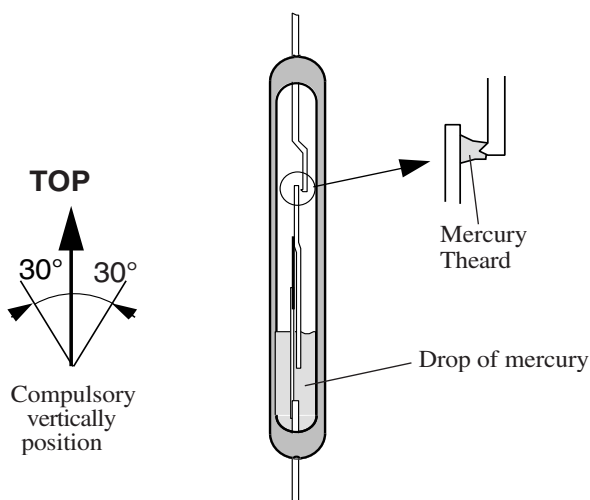
- Dry contact switches
- Mercury wetted switches

1.1 Dry REED switches

Dry REED switches are assembled using ferromagnetic materials for the reeds (FERRO-NICKEL) which are tipped with heat-resisting metal (RHODIUM), to improve their arc-resisting qualities. These switches can be used in any position.

Like most mechanical contacts, they are subject to bouncing when they close. Depending on the type of switch the contact resistance is in the order of 50 to 150 milliohms, the switching capacity varies from 0,4 to 3 Amps., along with a switching voltage

1.2 Mercury wetted REED switches (less and less used)



Mercury wetted REED switches contain a drop of mercury which irrigates the contact area by a capillarity effect.

The presence of liquid mercury makes the vertical positioning of the switch compulsory (+/- 30°).

The advantage of a mercury wetted contact is that bouncing is avoided when the contacts close, that contact resistance remains very low throughout the useful life of the switch, and that a lifespan of over ONE HUNDRED MILLION cycles is available at nominal current levels.



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2. Sensitivity

The sensitivity of a REED switch is characterized by the value of the magnetic field which is required to change its state. For practical considerations of measurement, each switch manufacturer uses a reference coil (inner and outer dia., length, wire dia. And number of turns defined) which is adjusted in relation with the test coil.

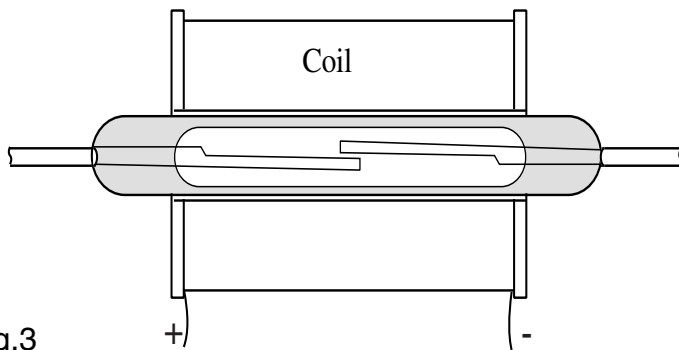


Fig.3

The magnetic field is then expressed in Ampere-turns (or ampere/meter).

In order to close a normally open switch, for instance, a certain number of Ampere-turns, called CAT, are required (closing Ampere-turns). To open the same switch the magnetic field must be reduced down to an opening value in Ampere-turns (OAT).

$OAT < CAT$ is always true

In point of fact when the reeds are in contact, the gap between the magnetic sections of the reeds, or blades, is very small, it in fact amounts to the two Rhodium coatings on the blades. A similarly reduced magnetic field will suffice to maintain contact. The difference between OAT and CAT is called the differential.(fig.4).

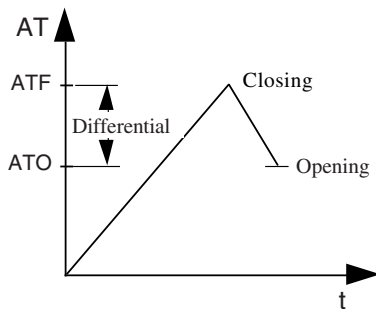


Fig.4

Order of magnitude OAT-CAT :

- For miniature switches : CAT is included between 12 and 50 Ampere-turns, OAT between 5 and 30.

-For standard or mercury wetted switches : CAT between 35 and 150 Ampere-turns, OAT between 10 and 80.

NOTE : if the leads on a switch are cut, the CAT and OAT values will increase (refer to : The effects of cutting and forming).

After electrical inspection each switch is graded with regard to its sensitivity, into "sensitivity grades". A grade is equal to $5AT \pm 5\%$.

When ordering REED switches the required sensitivity grade **MUST** be indicated.

For instance : the order made out for the requirements could be drawn up as follows : IA 21 19-36. The sensitivity grades encompassed in this manner are grades 19-26, 24-31, and 29-36. The order may thus be satisfied using availabilities in these three grades.



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3. Contact mode

Two contacts modes are constructed :

- Normally open contacts
- Normally closed contacts

3.1 Normally open contacts (NO)

A contact which is normally open in the absence of a magnetic field will close in the presence of a magnetic field, it will be known as a Class A switch (Fig. 5).

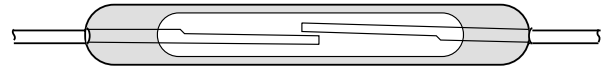
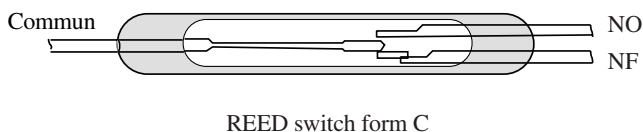


Fig.5

3.2 Change over contact

A reversing REED switch includes a common reed, or blade, on one side, and two sealed contacts on the opposite side.



REED switch form C

Fig.6

When at rest the common Ferro-Nickel reed is mechanically biased against one of the contact in non magnetic material. This contact is known as an NC (Normally closed contact).

Under the influence of a magnetic field, the common reed moves over onto the NO contact, which is in a magnetic material (NO = Normally Open). The NC circuit is then open.

This type of switch is known as a C type switch (Fig. 6).

3.3 Other types of contracts

It is possible to obtain, on the basis of the two above mentioned types of contacts, either normally closed contacts, or bi-stable contacts, or bi-stable inverters.

-Magnetic held normally closed contact

This contact is obtained using a permanent magnet positioned against a type A switch. (Fig. 7). The power of the magnet is adjusted so as to close the switch. The magnetic field created by the relay coil must be directed in the inverse direction to that of the magnet, with the ability to shift the saturation point of the polarizing magnet. (This precaution is an absolute necessity in the case of bi-stable relays).

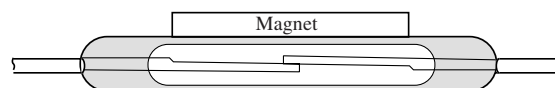


Fig.7

REED switch form B



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The breaking of the contact, which is obtained with a coil in the case above, can also be obtained with a magnet if the field is directed in the opposite direction to the polarizing magnet (Fig. 8 et 9).

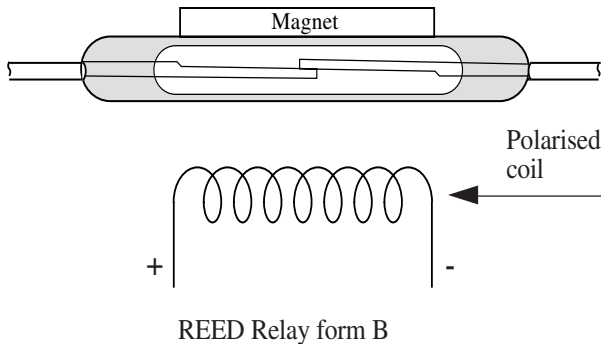


Fig.8

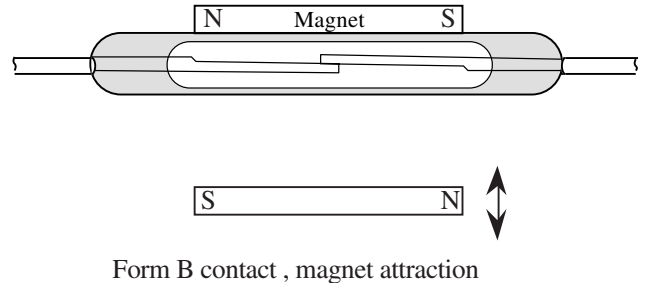


Fig.9

-Bi-stable contact

This type of contact is obtained by the adjunction of a permanent magnet with sufficient magnetizing force to hold the switch in make, but too weak to close a contact in the open state.

In more detail, with a switch with a given CAT and OAT, the magnet is equivalent to AT magnet in such a manner that : $CAT > AT \text{ magnet} > OAT$ (Fig. 10).

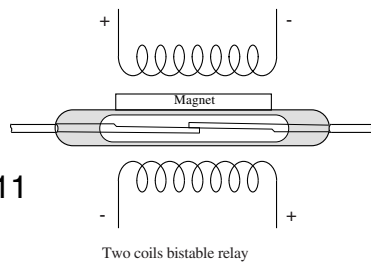


Fig.11

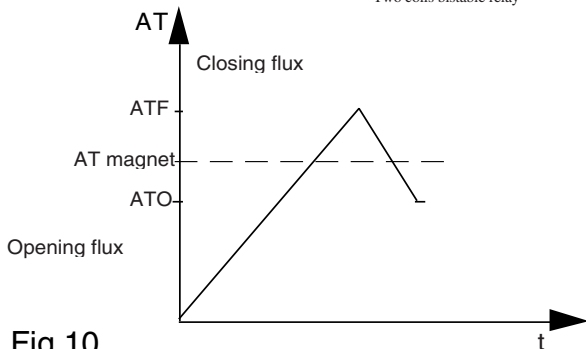


Fig.10

Under these conditions if the switch is open, it will stay open, if it is closed, it will remain closed as long as no current runs through the actuating coil.

To obtain the making of the contact, the coil must generate a magnetic field in the same direction as that of the polarizing magnet. The total field reaches CAT and the switch closes. The current can then be stopped in the coil, as the magnet upholds a field $AT \text{ magnet} > OAT$. The switch stays closed.

To open the switch, an inversely directed current must be sent through the coil in such a manner that an inversely directed magnetic field is created in relation with the magnet. When the resulting field is lower than OAT, the switch opens. As in the previous case, the current through the coil can be stopped, the switch remains open.



In order to avoid having to reverse the direction in which the current flows through the coil, bi-stable relays are generally designed with two parallel wound coils, which are connected for opposite polarities. It is important to note that an impulse lasting a few thousandth of a second suffices to create a trigger effect for the relay state.

Bi-stable relays are thus very sparing in their control power consumption. Their switching capacity is however reduced and they must be used in conjunction with impact and vibration protected equipment : these disturbing influences could in point of fact result in an accidental change of state, which would then be upheld in an uncertain manner.

It is possible to obtain bi-stable relays with A type switches (which are then known as L type), or with change-over relays (which are then known as R type), both in dry or mercury wetted contact form. The switches which are used must be selected with a high differential.

NOTE : In the same manner as for normally closed contacts, great care must be taken not to overload the control coil, and to use a parallel mounted diode alongside the coil.

SYNOPTICAL TABLE FOR THE VARIOUS TYPES OF CONTACTS

1 Make contact (or normally open at rest)	: Type A
1 Break contact (or normally closed at rest)	: Type B
1 Change-over contact (1 NO + 1 NC, 1 common)	: Type C
1 Bi-stable contact	: Type L
1 Bi-stable change-over	: Type R

4. Switching capacity

The switching capacity of a switch is related to its dimension and to its manufacturing technology. It is characterized by :

- The maximum switchable power rate (expressed in Volts-Amperes)
- The maximum switchable amperage
- The maximum switchable voltage

For instance : IA23 -Max. switchable power : 18 VA
 -Max. switchable amps. 400 mA
 -Max. switchable voltage : 250 Vcc

Taking into account the maximum switchable power rating of 10 VA, the 500 mA current rating will not be switched beyond 20 Volts. With 200 Volts the current will not exceed 50 mA.

The voltage, amperage, and power rating indicated for switching purposes are peak instantaneous values. None of these values should be exceeded under normal conditions. This can be represented graphically with a switching capacity hyperbola (fig. 12). This switching capacity hyperbola represents the limit between the working limits and the forbidden area of a particular switch.

The parameters which constitute the amount of power switched directly influence the life span and the reliability of the switches (Fig. 12).



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The amount of power switched directly influence the life span and the reliability of the switches

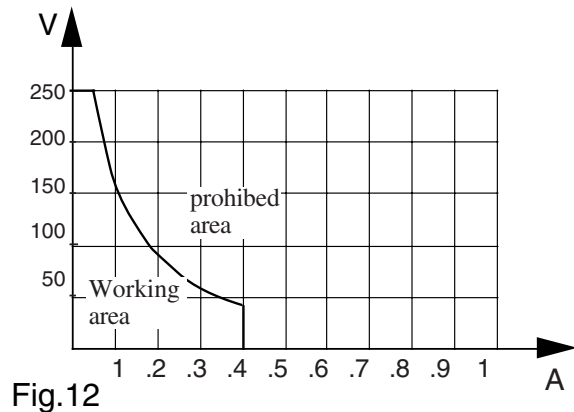


Fig.12

5. Withstand voltage, breakdown voltage

The withstand voltage is the highest level of voltage which the switch can withstand in a continuous manner. The arc voltage, which is also known as the breakdown voltage, is the voltage at which an electric arc (discharge) appears at the tip of the blades ; it is essentially dependent on the gap. Gas pressure and this parameter is related to the sensitivity of the switch, in point of fact the larger the gap the lower the sensitivity, but also the higher the arc voltage.

Example:

-standard IA23

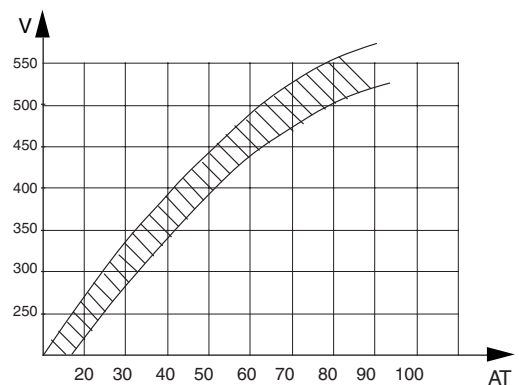


Fig.13

6. Problems related to the nature of the load

The problems related to closing and opening are different :

-Upon closing, a moderate and increasing amount of current is preferable. This is the case in the closing period on an inductive circuit. On the other hand, closing a circuit on the filament of an incandescent lamp is very rough on the contact. In this case the current appropriate for the cold filament must be taken into account when selecting the switch, this will be 10 to 15 times the rated current. The same precautions are to be taken when the contacts close on a capacitive load, which may amount to a transient short-circuit when the switch closes.

-Upon opening, it is the speed at which the voltage appears (dv/dt) which is to be considered. The duration of the electric arc which appears as soon as the contacts open is directly dependent on this parameter.

The circuits in the following page will enable the selection of the best suited protective network for the considered application, in relation with the load to be switched, the voltage, and the current. The curves on the following page will enable the calculation of the values of the elements selected for the protective circuit.

For particular information, please get in touch with our technical department.



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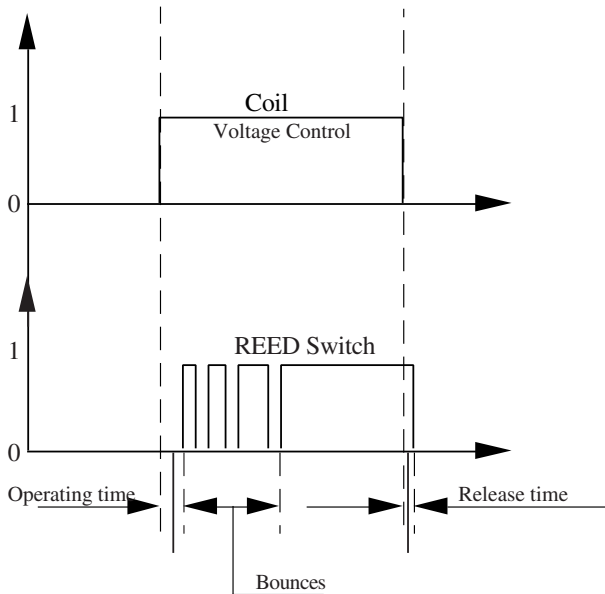
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7. Operating time

As in every type of mechanical contact, REED switches are subject to bouncing when they close. It is practically impossible to avoid bounce in dry REED type switches. The bounce duration is related to the force exerted on the blades when they close under impact, and with the mechanical frequency proper to the blades. The first opening generally occurs after the first time that the blade oscillation runs through point zero. When the REED switch is controlled with an impulse which corresponds with the response current, normally speaking things will go no further, that is to say that the switch will not open again, or possibly only once.



When the impulse is upgraded, the number of bounces however rises and the length of time involving the bounces increases. Beyond that point, no further increase in the bounce time occurs, because the material reaches its magnetic saturation point in the mean time.

The figure on the LH side represents the time lag on making and breaking, as well as the time during which bounces occurs.

The making time is calculated from the moment where the control coil is excited to the first making of the contact. Typical values here are 500S for miniature switches and 1mS for standard switches. Breaking time is the amount of time between the moment where the power supply voltage is cut and the opening of the contact.

This duration only in general represents 10% of the making time, but in a relay the coil impedance must also be taken into account. In the same manner, connecting a diode up in parallel onto the control coil carries this value to a few hundred micro-seconds.

8. Contact resistance

The resistance of the flow of current in REED switches is with due regard to the type generally in the order of 50 to 150 milliohms. It breaks down into two main components :

- The ohmic resistance of the blades
- The resistance of the contact itself known as the constriction resistance

The constriction resistance depends on numerous components : nature of the contact material and its resistivity, hardness and roughness of the contacting surfaces, the presence of impurities, as the case may be, the amount of pressure on the contact, etc.

The constriction resistance can vary, although within narrow limits, upon each successive making and breaking. The difference between the largest and the smallest value of constriction resistance within a sequence of switching operations is an indicator of the quality of the contact. Contact resistance values can vary within slightly wider limits in the course of a life span, this will be in relation with the current-voltage couple, and with the load, and the switching frequency.



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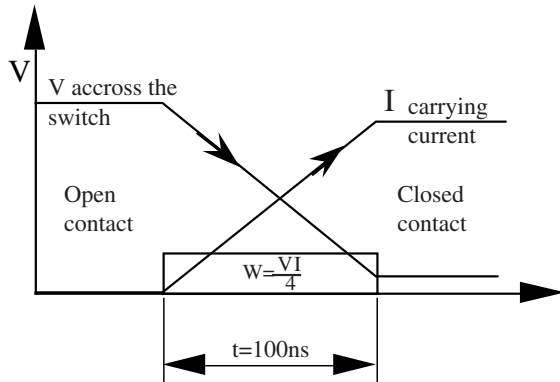
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9. Life expectancy

The life expectancy of a REED switch depends on the amount of energy spent on the occasion of each operation throughout the successive changes of state.



This life expectancy is thus directly related to the current-voltage components and nature of the switched load, said load defines the corresponding transient state relating to the moment at which the blade strikes ($t > 100\text{ns}$).

The behaviour of the contact is itself a function of the physical particularities of the contacting surfaces (contact pressure, material resistivity, etc.).

Small technological discrepancies result in considerable variations in the rate of failure. The results obtained in life expectancy tests, from which reliability forecasts will result, can only therefore apply to the types of switches concerned.

celduc has invested in very up-to-date reliability evaluation equipment, thus enabling the systematic inspection of each batch of switches, by random sampling, to CNET STC 45-54111 spec. sheet.

The statistical use of the results obtained with hundreds of billions of operations / components supports the publication of the reliability rates which are germane to the main types of switches mentioned in this catalogue, and at trustworthiness ratios of 95%. The reliability forecast rates concern a very wide range of current-voltage couples, they will be sent on request.

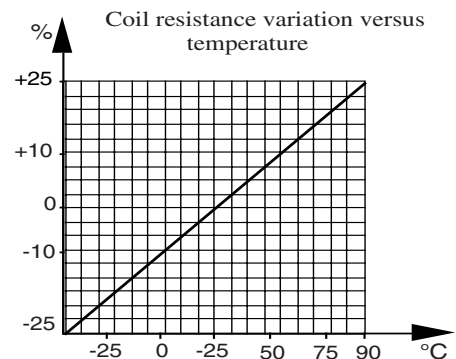
It is however to be noted that the life expectancy can only be significant if the following elements at least have been defines :

- transient current and voltage levels
- the nature of the load (possibly complex, with or without protective network)
- the end of life span criteria (welding up, contact resistance) and their limits
- the operating temperature

10. REED Relays : Precautions for use

On all reed-relays we secure the normal using up to 65 or 85°C following types. For higher temperatures we advise to order the coil with a current.

See the curve on the right about coil resistance variations versus temperature.



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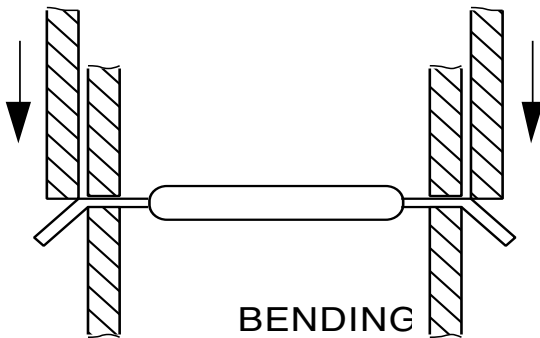
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11. The effects of cutting and forming

Whenever the application so requires, it is possible to cut or bend the leads on a REED switch.

-Forming

Bending the leads on a REED switch requires certain vitally important precautions :



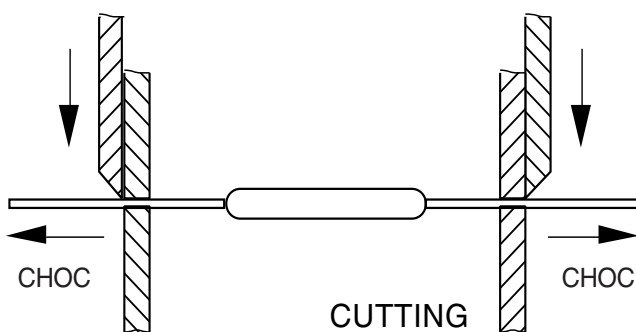
-The lead to be formed must be held firmly, between the centreline of the bent section and the glass / metal bonding interface, in such a manner as to avoid overstressing the seal

-Bending modifies the CAT and OAT values of a switch

All our switches can be supplied ready formed on request, the rate of sensitivity is usually defined before forming.

- Cutting

As is the case for bending, it is important to avoid overstressing the metal to glass seal, and to hold the switch firmly between the glass tube and the cutting point.

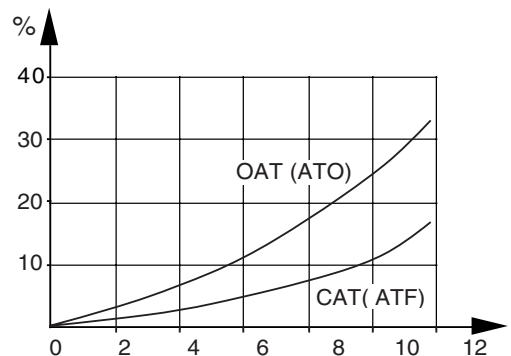


-It is advisable to use a well sharpened set of end nippers, so as to exert the ejecting force on the part of the lead which is to be discarded. Shock up to 70 G can thus be avoided.

-Cutting the leads on a REED switch has the effect of increasing the CAT and OAT ratings in a significant manner. The figure below illustrates this variation.

On request all our switches can be supplied pre-cut. They then benefit from a quality guarantee which is not available to users whose knowledge and equipment may be short of perfect. The sensitivity is usually defined before cutting.

CAT and OAT variation as a function of the length cut off the leads.



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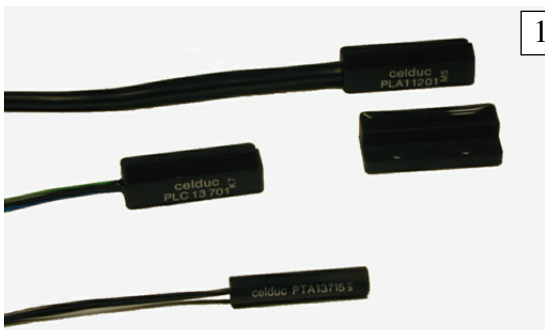
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12. Permanent magnet control for REED switches

Simple, reliable, and practical for very high frequency operation, controlling REED switches with permanent magnets opens the way for innumerable applications.

A REED switch controlled by a permanent magnet offers an economical solution to all types of level detection, displacement, proximity rotational or angular displacement problems, as well as limit switch layouts.



celduc[®] offers a whole range of switches and moulded permanent magnets in different sizes and power rating, at the end of this catalogue. But we are at your entire disposal to help you to design and manufacture the type of sensor which will suit your application.



The picture on the left illustrates a few of these custom sensors, manufactured to our customers specifications :

-Sensors for air cylinders, flow controlling devices, level detectors, D.O.R. sensors, waterproof switches, etc.

Our references in this area include the following applications :

- Avionics
- Medical
- Automotive
- Telecommunication
- Space industry
- Household electrical appliances

Precautions

It is important to take great care of the magnetic environment for a given assembly, when developing a sensing system involving a REED switch and a permanent magnet. In point of fact a ferromagnetic body located too near to the sensor would capture a large share of the magnetic field from the magnet, and could interfere with the proper operation of the system.

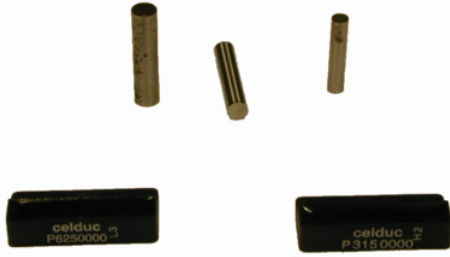


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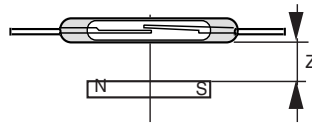
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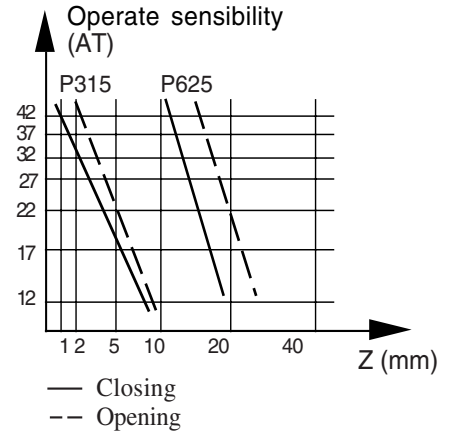
Typical operating distances in relation with the sensitivity rating of the switch and the type of magnet.

References	Dimensions
UH 310000	1,6x1,6x12,7mm
U 3150000	Ø 3x15mm
U 4200000	Ø 4x20mm
U 6250000	Ø 6x25mm

These same magnets can be supplied moulded inside a casing type PL for a better mounting.



IA 23 SWITCH



Working principles of a REED switch with a magnet

It is important to note that the way of presenting the magnet in front of the switch is a key point.

For example if the magnet is presented parallel to the switch, it wont have the opening and closing zones as if the same magnet is presented perpendicular to the same switch.

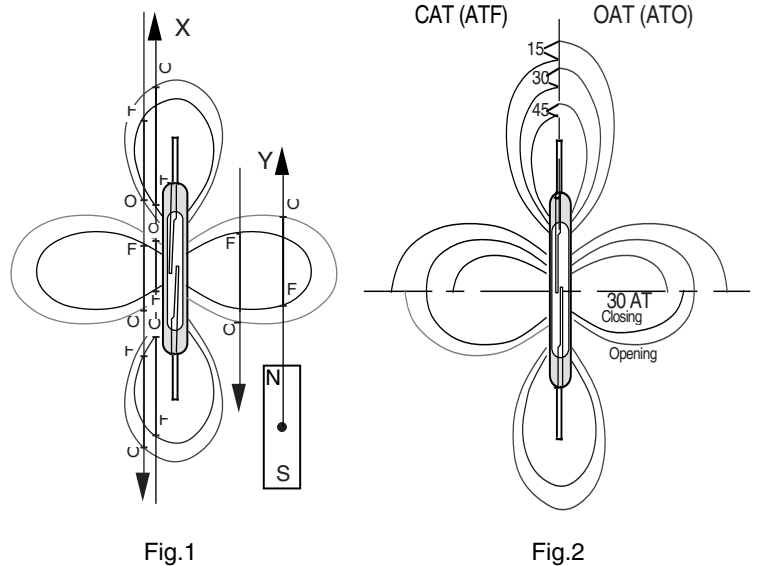
-Magnet parallel to the switch

When the magnet is laid out parallel to the switch, three closing zones can be observed (Fig. 1).

The full line corresponds with the switch closing when the centre of the magnet is on the line. The dotted line corresponds with the opening of the switch.

When the magnet is moved towards the switch (path X, L.H. side of Fig. 1) there are three successive closing / opening zones. If the path of the magnet is somewhat remote from the switch, there will only be one zone (the central one) of closing (path Y, R.H. side of Fig. 1).

The size of these zones is directly proportional with the sensitivity of the switch or the size of the magnet. Fig 2 gives an indication of the variation of the opening / closing zones in relation with the sensitivity of the switch for a given magnet.



-Magnet perpendicular to the switch

In this case one observes two symmetrical closing zones (Fig. 3). The full line corresponds with the closing of the switch when the centre of the magnet is over the line. The dotted line corresponds with the opening of the relay.

When the magnet is moved along a path which is parallel to the switch (path X, on L.H. side of Fig. 3) there are two closing / opening zones. If one moves it along a path which is perpendicular to the switch (path Y, on lower side of Fig. 3) there is one single closing / opening zone.

The size of these zones is directly proportional with the sensitivity of the switch or the size of the magnet. Fig 4 gives an indication of the variation of the opening / closing zones in relation with the sensitivity of the switch for a given magnet.

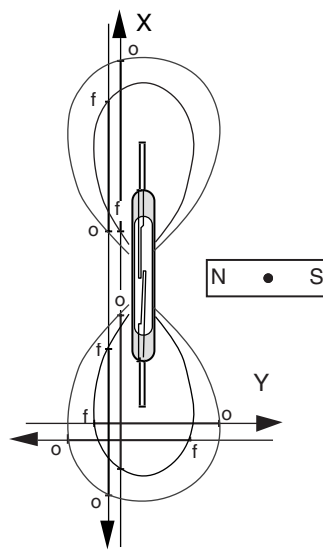


Fig.3

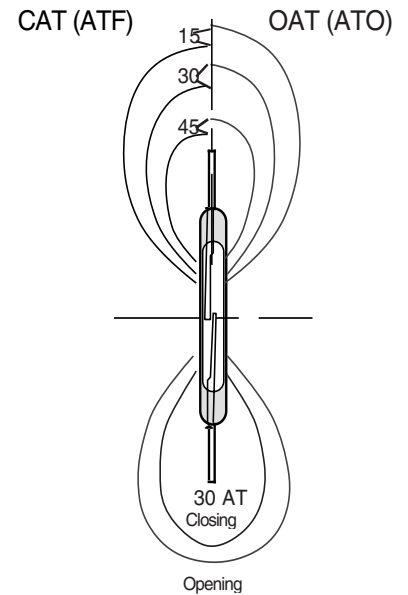


Fig.4

-Other working principles

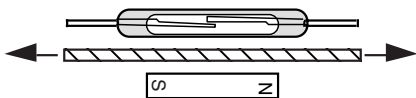


Fig.5

Magnetic shunt (Fig. 5)

The magnet is attached perpendicular to the switch in such a manner as to close it. A ferromagnetic plate is inserted between the magnet and the switch : the field closes through the plate, the switch opens. When the plate is moved away, the switch closes again

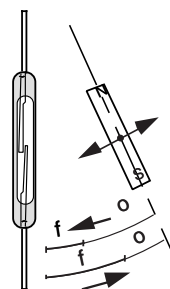


Fig.6

o Open
f Close

Angular displacement (Fig. 6)

The magnet is moved away along pivoting path. For a given distance the switch opens. Fig. 6 gives an indication of the opening / closing zones in relation with the movement. It is to be noted that the closing zone is larger when the magnet is swinging away than when it is closing in.

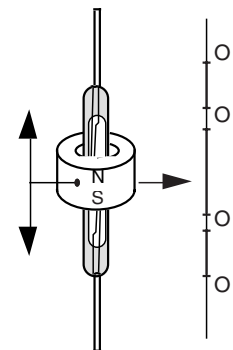


Fig.7

Annular magnet (Fig. 7)

This case is similar to that where a magnet is situated in parallel with the switch. There will in general be three opening / closing zones. For a less powerful magnet or a less sensitive switch only the central zone will remain effective. (Refer to Fig. 1, path Y).



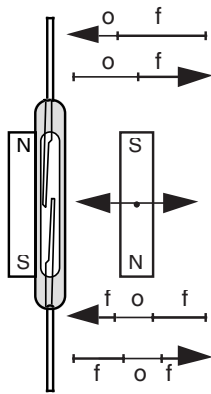


Fig.8

Normally closed contact (Fig. 8)

A magnet is bonded against the switch and holds it closed. A second mobile magnet, parallel to the switch but with its poles in the opposite direction, is moved towards the switch along a parallel path. The field of this second magnet is opposed to the field of the first one. For a given distance, the total field at switch level will be much smaller and the switch will open. When the mobile magnet is moved away, the switch closes.

It is to be noted that if the mobile magnet is much more powerful than the fixed magnet, and if it is moved close enough to the switch, another closing of the switch will be obtained (curves in lower part of the Fig.).

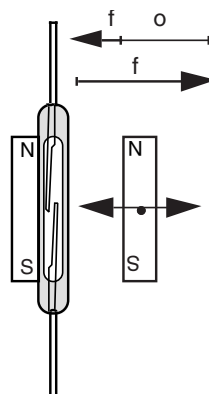


Fig.9

Memory type contact (Fig. 9)

A magnet is bonded to the switch. Its magnetic field is strong enough to hold the switch closed, but not strong enough to close it if it is open ($OAT < AT$ magnet $< CAT$, refer to page 5, bi-stable contacts).

If the switch is open and a second parallel magnet is moved close, which is polarized in the same direction as the magnet bonded to the switch, the magnetic fields will add to each other and the switch will close.

The mobile magnet can then be moved away, the switch will remain closed.

To open the switch it will suffice to create a magnetic field in opposition with that of the bonded magnet, either by bringing a magnet with reverse polarization close to it, or by using a concentric solenoid (coil) which is powered in the appropriate manner.

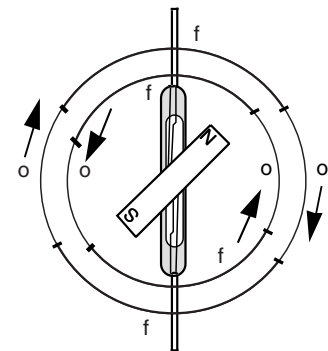


Fig.10

Rotation (Fig. 10)

The rotation of a permanent magnet in front of a REED switch will successively reproduce the characteristics of parallel and perpendicular magnets. The diagram in Fig. 10 indicates the outline of the opening and closing zones with regard to the direction of rotation. These zones always have the same general layout, with the switch opening when the magnet is perpendicular. The size of these zones will be in direct proportion with the sensitivity of the switch or the size of the magnet, or with the proximity of the magnet in relation with the switch.

To conclude:

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