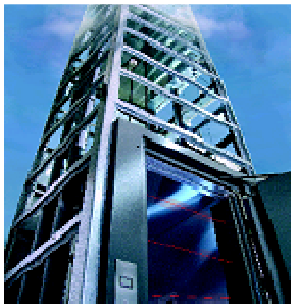
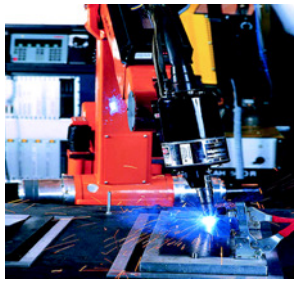


ELESTA relays GmbH

Contact protection

Workshop

Bad Ragaz, 16.04. – 18.04.2009



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Agenda

1. Types of loads
2. Switching characteristics
3. Contact protection circuits

Types of loads

There are 3 fundamental types of loads

1. **Resistive loads**
   - resistor networks
   - light bulbs, heating
2. **Capacitive loads**
   - frequency converters (high capacitors in the inverter)
   - switching converter, rectifier circuits
   - low batteries
3. **Inductive loads**
   - motors, generators
   - coils, contactors

Types of loads

Classification of standard loads (AC)

In the EN 60947-4 and EN 60947-5-1 are many kinds of AC – and DC loads defined, but for us is the AC1,AC15 and DC1,DC13 loads important.

Table 8.2—Utilization category according to VDE0660

Category	Typical applications
AC-1	noninductive or slightly inductive loads, resistance furnaces
AC-2	slip-ring motors: starting, plugging
AC-3	squirrel-cage motors: starting, switching, off during running
AC-4	squirrel-cage motors: starting, plugging, inching
AC-5	different incandescent lamp loads
AC-11	AC electromagnets
AC-14	Low electromagnetic loads
AC-15	AC electromagnetic loads
AC-20	switching without load
AC-21	resistive load with overload
AC-22	resistive-inductive load with overload
AC-23	motor loads and other heavy inductive loads

Types of loads

Classification of standard loads (DC)

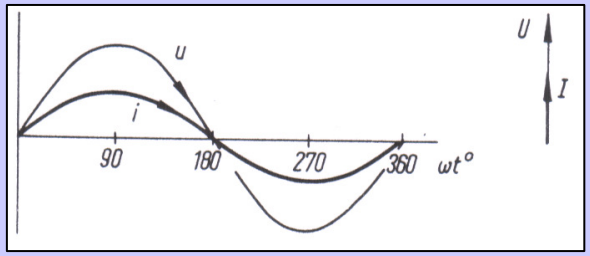
Table 8.3—Utilization category according to VDE0660

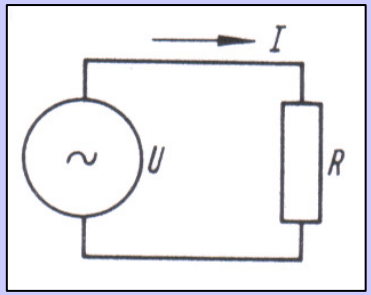
Category	Typical applications
DC-1	non-inductive or slightly inductive loads, resistance furnaces
DC-2	shunt motors: starting, switching off during running
DC-3	shunt motors: starting, plugging, inching
DC-4	series motors: starting, switching off during running
DC-5	series motors: starting, plugging, inching
DC-13	DC electromagnets
DC-14	electromagnetic loads with shunts
DC-20	switching without load
DC-21	resistive load with overload
DC-22	resistive-inductive load with overload
DC-23	motor loads and other heavy inductive loads

Types of loads
Resistive load (AC)

- **No (low) inrush arc**
- **No (low) switch off arc**
- **In real applications you didn't find a pure resistive load !**

Resistive load





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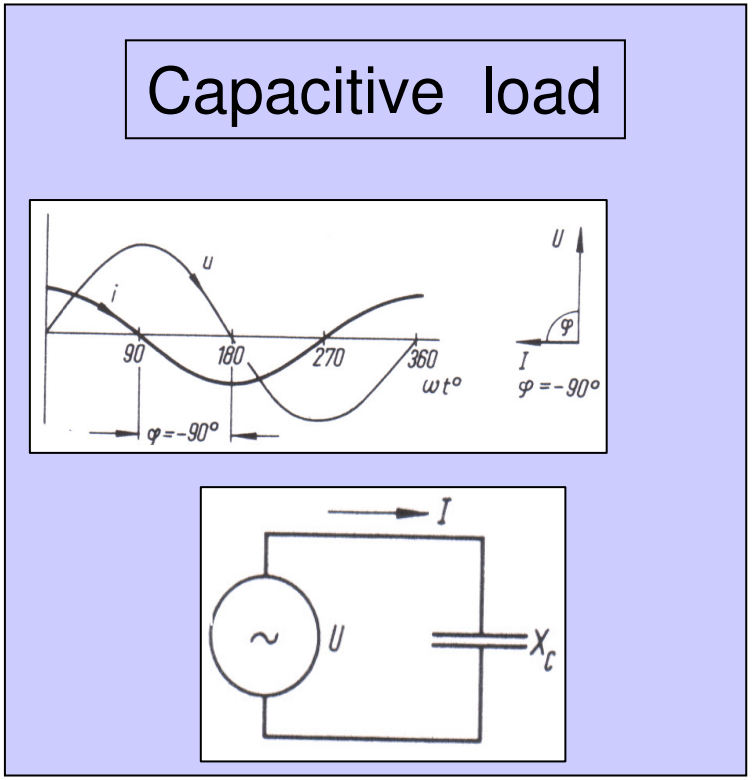
Types of loads
Capacitive load (AC)

- Current leads the voltage
- High inrush arcs
- No switch off arcs
- The relays get problems if the protection of the circuit is critical and the capacitive is high



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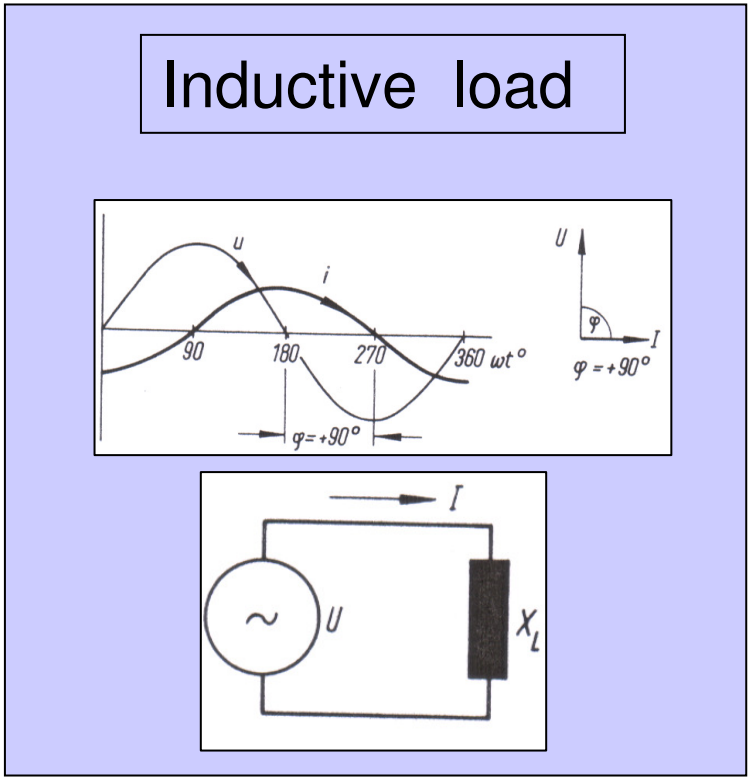
Types of loads
Inductive load (AC)

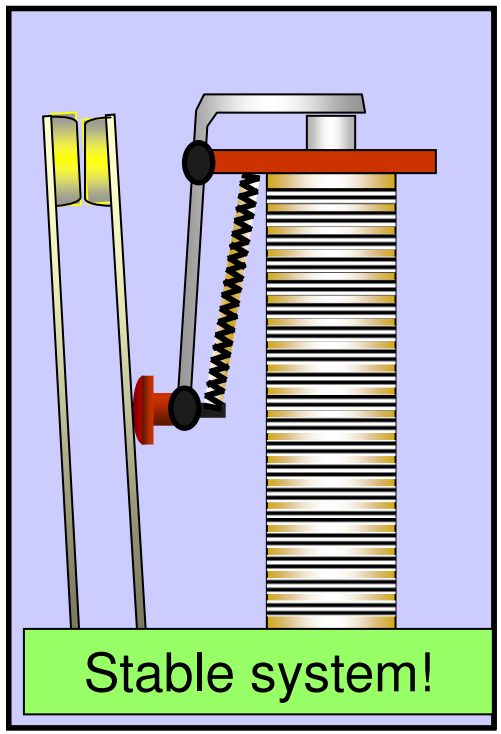
- Voltage leads the current
- High inrush arcs
- High switch off arcs because of high reverse induction voltage
- In some applications the switch off or disconnect time is very long



Switching characteristics

At a relay

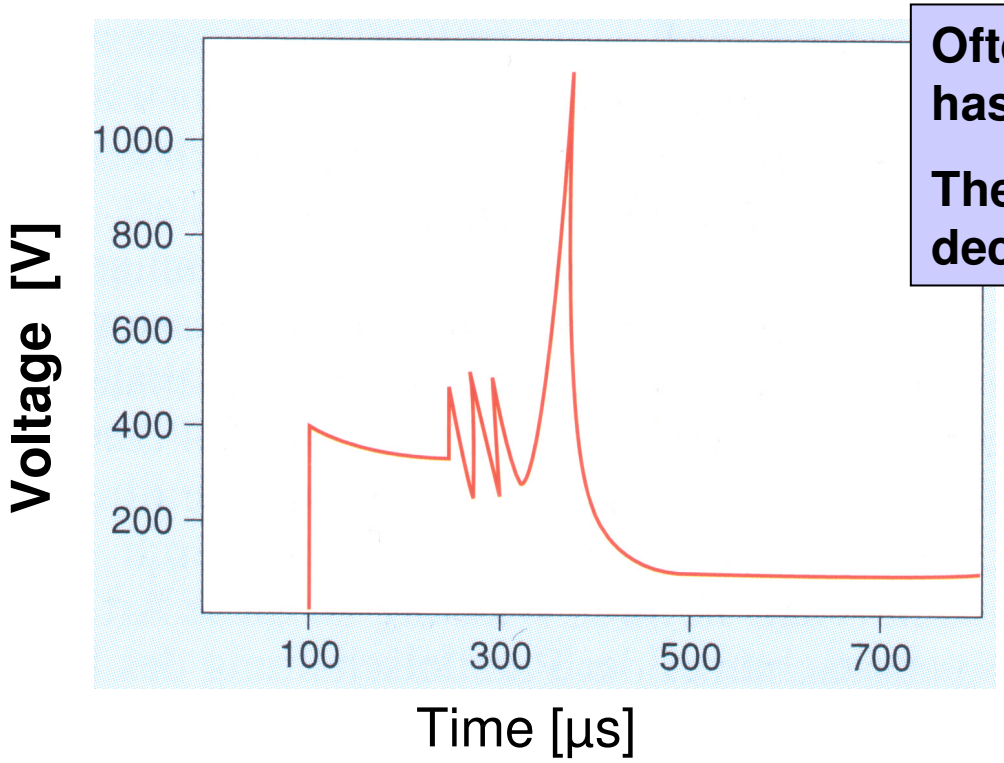
1. **Power on**
   - Electric energy get into the copper wire
2. **Transfer electric energy into magnetic power**
   - The iron core gets magnetic
3. **Transfer magnetic power into movement**
   - The magnetic energy pulls the armature to the iron core.
4. **Transfer armature movement to the contact side**
   - The actuator the forces working contact travels to the fixed contact. Its a accelerate movement.
   - **The contact is bouncing. This is the most critical moment for the contacts.**
   - After bounce time the power side is closed



Switching characteristics

The critical moment

The real load isn‘t a pure resistive load. There are a mix of resistive, inductive and capacitive load.



Often switch peak has a high load.

The first peak is decisive!

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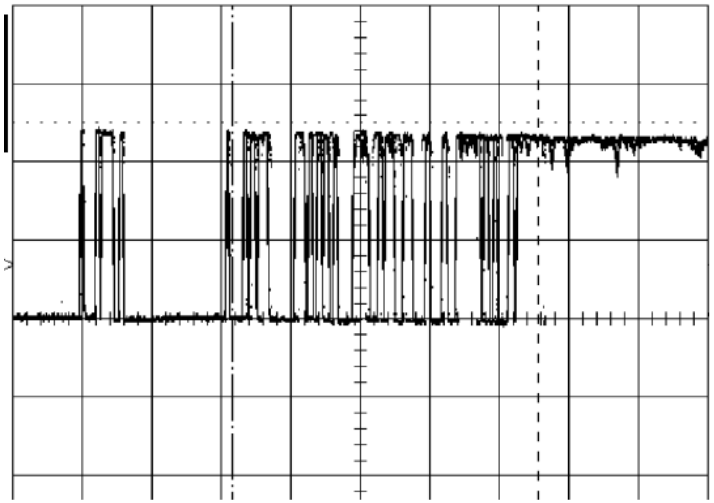
Switching characteristics

Bouncing at switch on and switch off

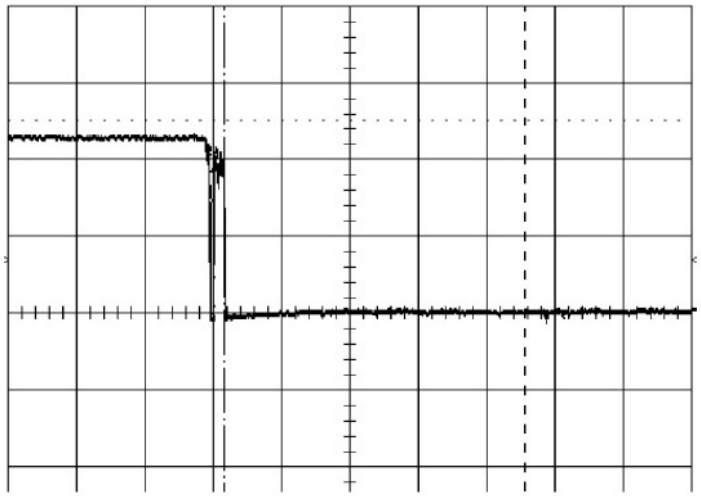
Contact bouncing is the most critical moment

Multiple switching in a short time (0,7…5ms)

Picture shows the voltage characteristic for a resistive load.



Switch-on



Switch-off

Switching characteristics
Conclusion

- The first peak is decisive
- The bouncing has a high influence of contact lifetime
- High electromagnetic radiation during the bouncing
- An arc can cause a contact welding

Contact protection circuits

Arcs can be dangerous!

Contact protection increase relays lifetime and / or enabled a relay to switch higher loads!

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Contact protection circuits

Variations of loads and protective circuits

Resistive load

There are no problems in both cases (switch on / off), if there no develops an arc. For example glue lamps or heater have an high inrush current for a relatively long time. The relays contact must are able to carry the high current for this time.

Contact protection circuits

Variations of loads and protective circuits

Capacitive loads

The main problem is the high inrush current by switch on,

because a low capacitor is like a short circuit.

Possibilities of protection :

- Take a NTC (ec. inrush Current Limiter). We can reduce the inrush current. But if the NTC is always hot, there is no more protection. The NTC must cool down, before switch on again.
- Put on a serial resistor to the load. The Resistor must have a low resistance and a high power consumption.
- Take a preloading circuit parallel to the relays contact. It‘s also a relays with a serial resistor.

Contact protection circuits

Variations of loads and protective circuits

ELESTA relays

Inductive loads

This load is the most considered problem with a wide variation of protective circuits. The main problem is the bouncing and the switch off process.

We have to consider two cases:

AC – loads :

There are higher loads possible because the zero cross of the voltage. But there are also have an arc for 10ms.

DC – loads :

There are only low loads possible, because the arc can be stable if the distance between the contacts is to small.

In both cases it needs an overvoltage protection circuit as closed as possible to the load !

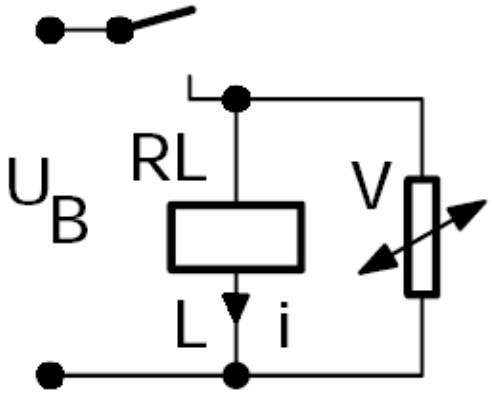
Contact protection circuits

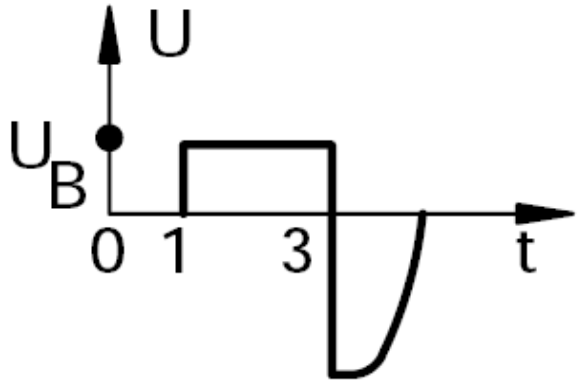
Types of contact protection for inductive loads

- Contact protection with Varistor
- Contact protection with Diode
- Contact protection with Diode und Z – Diode
- Contact protection with TVS – Diode
- Contact protection with RC - Components

Contact protection circuits

Voltage characteristic with Varistor





Advantages:

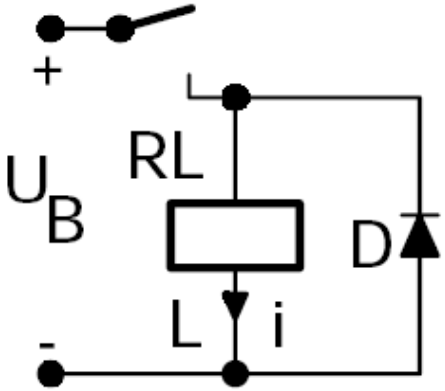
- Short fall delay time
- High energy consumption
- For all kinds of load (AC, DC)

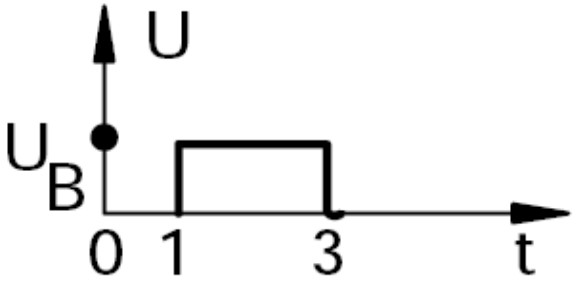
Disadvantages:

- High value of Voltage limitation (3 x Ub)
- Not able to use for all kinds of applications

Contact protection circuits

Voltage characteristic with Diode





Advantages:

- Low value of voltage limitation

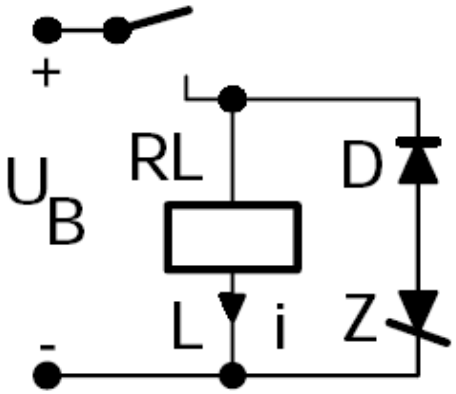
  (Its the forward voltage)

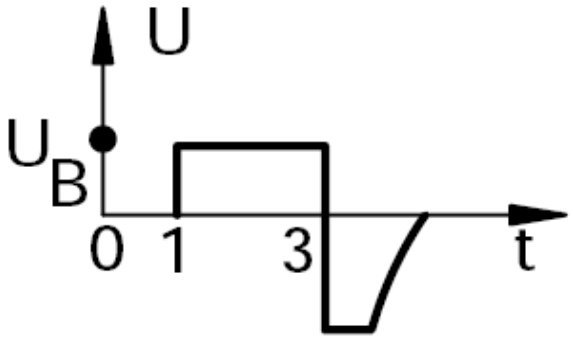
Disadvantages:

- Long fall delay time
- Not used for AC

Contact protection circuits

Voltage characteristic with Diode and Z-diode





Advantages:

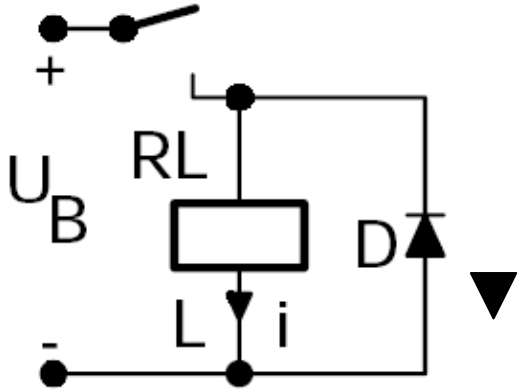
- Voltage limitation is setting by
- Z-Diode
- Short fall delay time

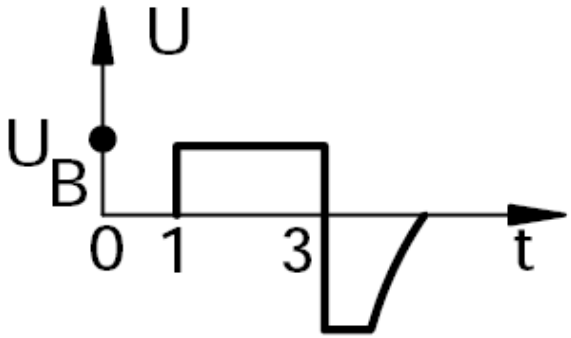
Disadvantages:

- It is necessary to look for the diode value
- Not used for AC

Contact protection circuits

Voltage characteristic with TVS-Diode





Advantages:

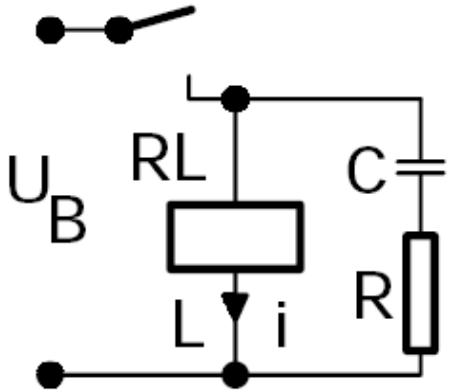
- Voltage limitation ist setting by TVS-diode
- Short fall delay time
- It can be used for all applications (AC, DC)

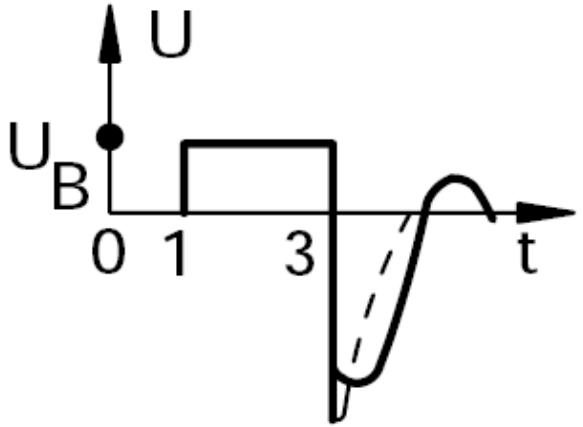
Disadvantages:

- It is necessary to look for the diode value

Contact protection circuits

Voltage characteristic with RC-Circuit





Advantages:

- Low value of voltage limitation
- Short fall time delay
- Can used for AC and DC - loads

Disadvantages:

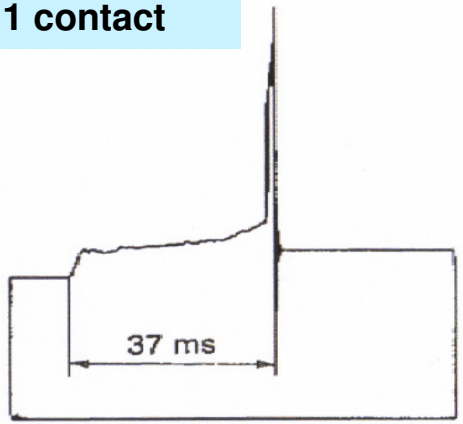
- It‘s difficult to select right components
- Big components
- It‘s the best method of protection but expensive

Contact protection circuits

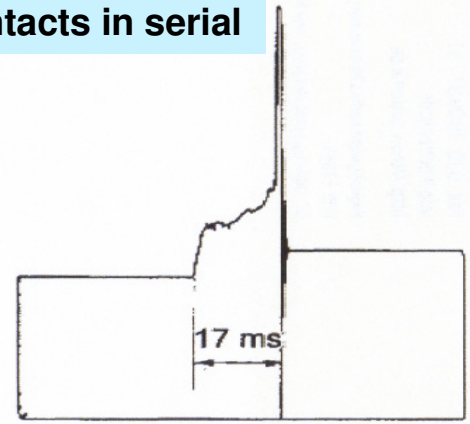
Other possibilities

Contacts can also save by switching two relay contacts in serial

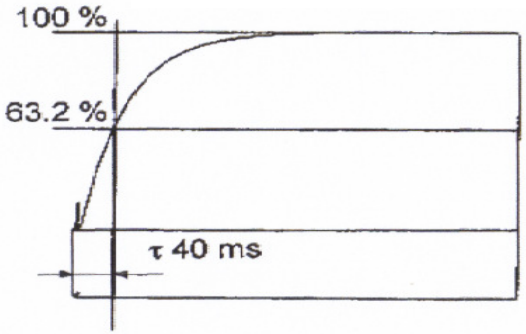
1 contact



2 contacts in serial



Arc-walking-time of arc with 2 serial contacts (SIR – Relay)



SIR Kontakte 10 A
Kontaktmaterial: AgSnO2 + 0.2 µm AU

Beispiel: Last: 50 V, 0.7 A induktiv L/R 40 ms

Contact protection circuits
Advantages

- Contacts in series increase the air-gab
- Reduction of arc-walking-time
- Used for AC and DC – applications
- Fast cut-off of arc

Contacts in series increase the lifetime!

Contact protection circuits

Conclusions

- Always consider the characteristics of load
- To protect contacts against welding and to increase the contact lifetime it is necessary to insert a contact protection circuit
- In safety applications its not allowed to put a protection circuit parallel to the contacts of the safety relay.