celduc® relais

DC SWITCHING

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1931 Congrescentrum 's-Hertogenbosch

POWER ELECTRONICS 2019

SUMMARY

Celduc Relais introduction

DC switching technologies:

- Bipolar
- Mosfet
- IGBT (SCI)
- IGBT (SDI)

U & I ranges by Celduc Relais

New technologies

- Mosfet SIC
- Mosfet GAN

SUMMARY

Necessary protections of DC relays

- Energy
- Passive Over Voltage components
- Active Over Voltage protection

Energy

Passive components

- TVS
- VDR

Active Over Voltage protection

Short circuit protection

SUMMARY

Applications

- Heating (tramways) Active clamp
- Reversing motors

COMPANY OVERVIEW

- Close to St-Etienne
- 60 km from Lyon
- 500 km from Paris

- Turnover 2018 : **26,6M€**
- Employees : **150**

PRODUCTS

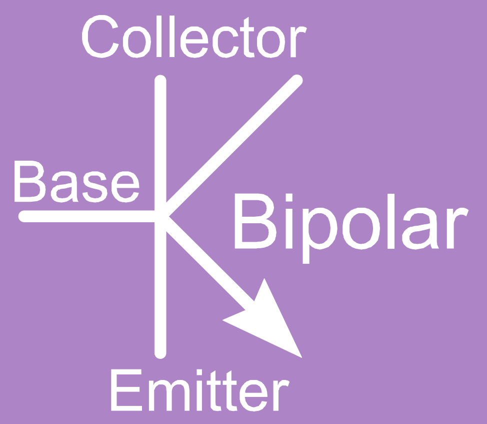
- Solid-State Relays (SSR)
- Power Controllers
- 73% of the Turnover

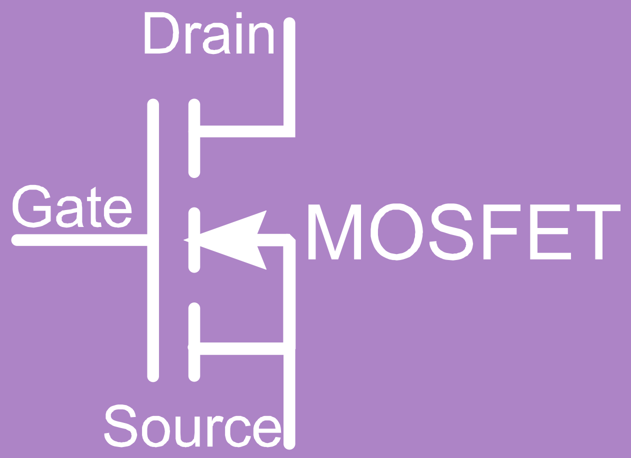
- Magnetic sensors for level, position, speed, safety
- 24% of the Turnover

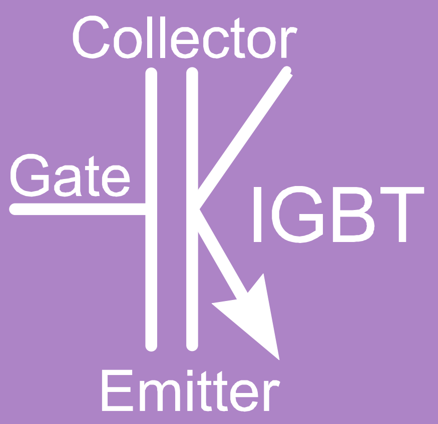
- Reed switches and relays
- 3% of the Turnover

DC SWITCHING TECHNOLOGY

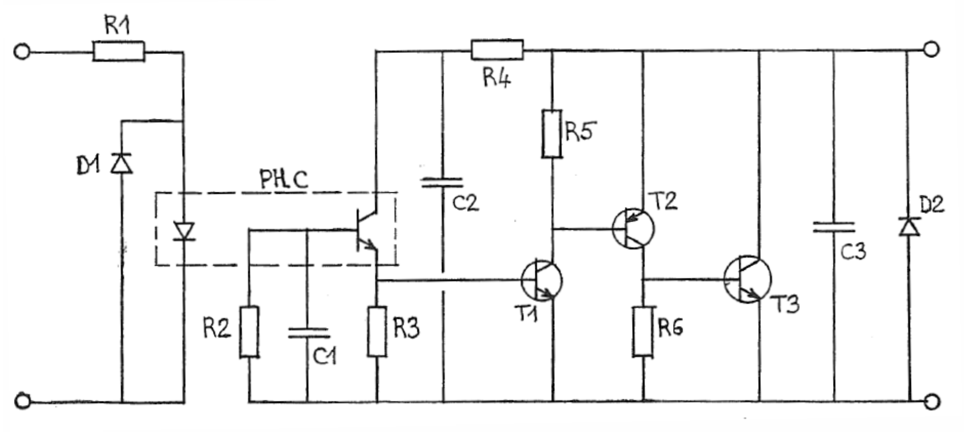
Bipolar Transistor	**MOSFET** ***(Metal Oxide Semiconductor Field Effect Transistor)***	**IGBT** ***(Insulated Gate Bipolar Transistor)***







DC SWITCHING TECHNOLOGIES
⇨ BIPOLAR TRANSISTOR



It is a current amplifier.
In bipolar DC SSR (e.g. SCC, SKD…), the control current is amplified through PHC, T1, T2 to T3.

Advantage **:** The SSR can be controlled by a very small input current

Disadvantages **:** The voltage drop is quite high at low load voltage even at low load current.

Difficult to reach high voltage because of the number of amplifying stages required (complexity)

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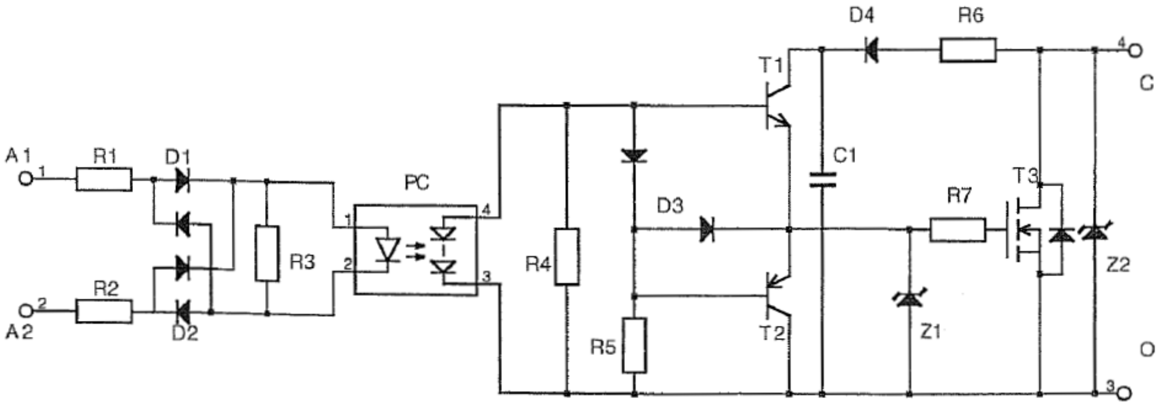
DC SWITCHING TECHNOLOGIES
⇨ MOSFET

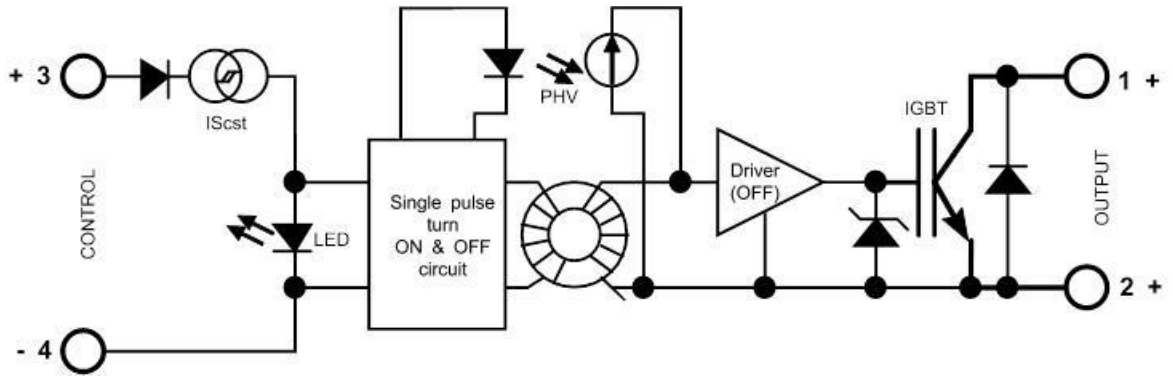


In Mosfet DC relays (e.g. SCM,SOM,SPD,SKLD…) the input control current generates Gate voltage through Photovoltaic PC

Advantage : The relay has a very low voltage drop for low load voltage

Disadvantages : The control current is quite high due to the low efficiency of the photovoltaic generator.
The relay has a high voltage drop for high load voltage

DC SWITCHING TECHNOLOGIES
⇨ IGBT (SCI)



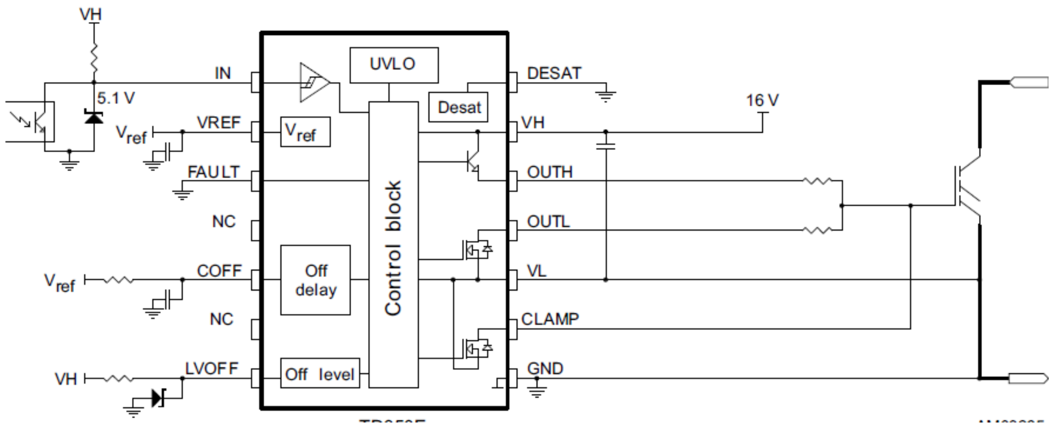
In SCI DC relays the input control current generates Gate voltage through the pulse transformer for a good switch ON and the photovoltaic PHV maintains the supply of gate voltage.

Advantage **:** Low voltage drop for high load voltage

Disadvantage **:** The control current is quite high due to the low efficiency of the photovoltaic generator.

DC SWITCHING TECHNOLOGIES

⇨ IGBT (SDI)

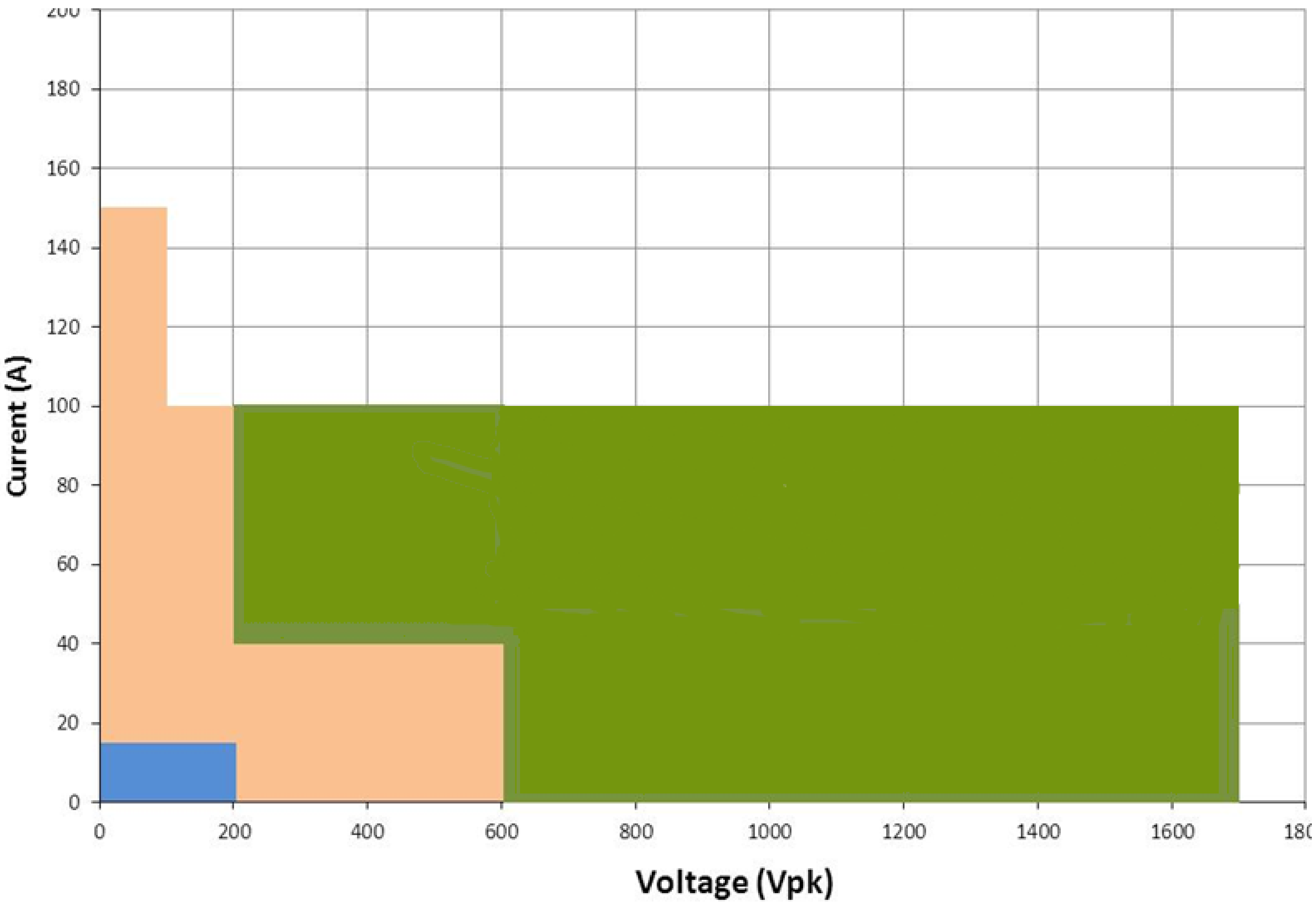


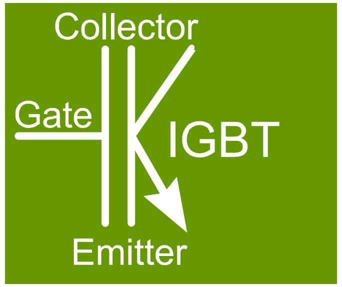
In DC relays (e.g. SDI) the input control current generates Gate voltage through a negative (turn OFF) and positive (turn ON) supply

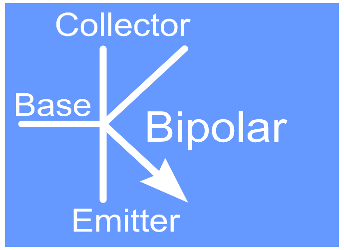
Advantages : Low voltage drop for high load voltage
Low control current
Integrated Protection (UVLO, Desaturation detection…)
Better turn OFF with negative gate voltage

Disadvantage : Requires an auxiliary supply

Present celduc solutions







BENCHMARKING

New technologies like SIC-MOSFETS and GAN-MOSFETS

- Lower RdsON
- High switching performance, higher voltage
- Higher junction T°C

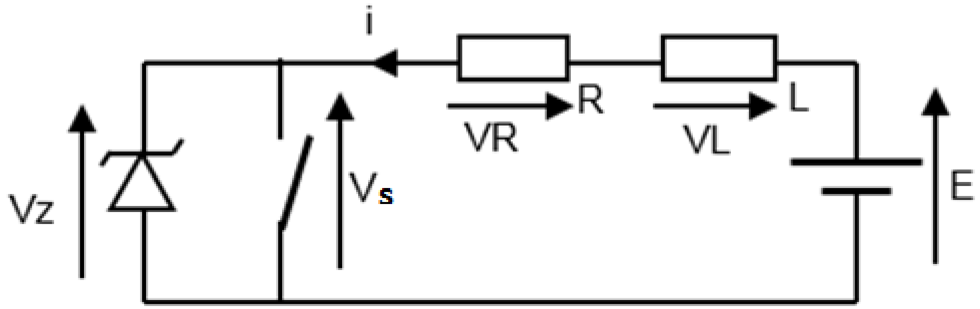
BUT STILL TOO EXPENSIVE TODAY FOR USE IN SSR

NECESSARY PROTECTIONS OF DC RELAYS

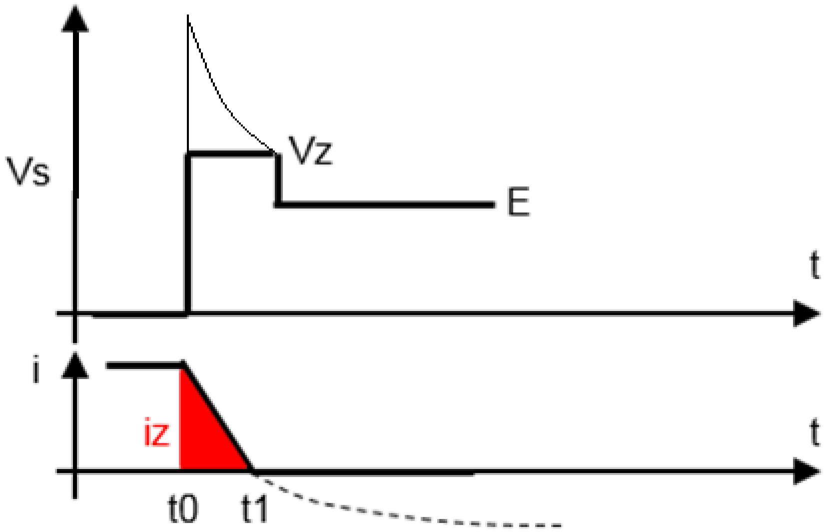
- OVER-VOLTAGES FROM MAINS, WIRES, LOADS…
- SHORT CIRCUIT

NECESSARY PROTECTIONS OF DC RELAYS

- ENERGY AT SWITCH OFF



Opening the switch



Over-voltage and energy

NECESSARY PROTECTIONS OF DC RELAYS

Formulas

Ip Initial current = E/R

E_L Initial energy in L = ½ L Ip^2

Pz instant power = Vz Ip

Ez energy in Zener = (Vz.Tau/R).[E+(Vz-E).ln(1-E/Vz)]

With Tau = L/R

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NECESSARY PROTECTIONS OF DC RELAYS

Difficult to stop the current!

$$E=0.5 \times L \times I^2$$

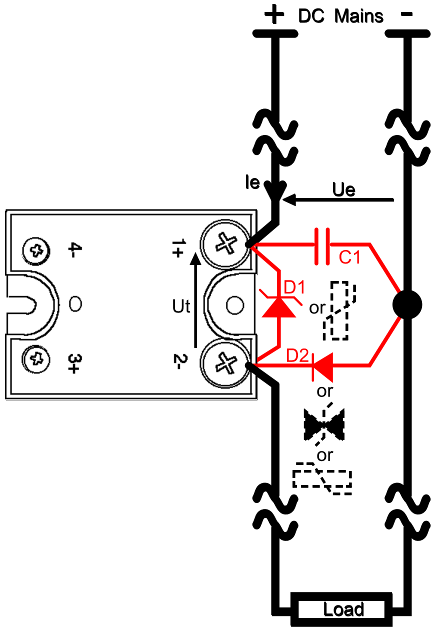
« E » is the energy stored in the wires or in inductive loads.

This energy must be dissipated when switching OFF.

L is the circuit inductance and « I » is the load current.

Current at turn OFF is the LOAD current!!!

A voltage protection is mandatory!

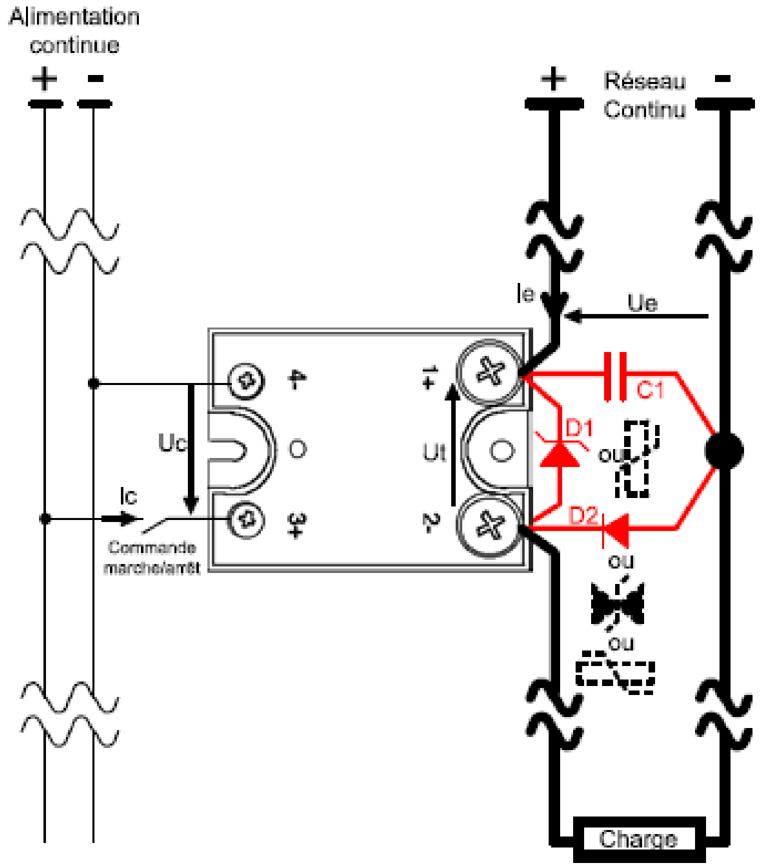


NECESSARY PROTECTIONS OF DC RELAYS

- PROTECTION WITH PASSIVE COMPONENTS

- PROTECTION BY ACTIVE CLAMP

Passive components



Why C1, D1 and D2 ?

C1 to compensate the line inductance from the mains (dv/dt)

D1 protects the relay against over-voltages, mains and load

D2 is the free-wheel diode. It will allow magnetic energy stored in load and lines to flow, finally dissipated in heat (Joule's law)

Passive components

TVS: Transient Voltage Suppressor

Can be unidirectional or bidirectional

Fast response but limited energy

VDR: Voltage Dependent Resistor

Bidirectional

More energy but ageing

Passive components

Differences between varistor and Transil

	Varistor	Transil
Topology	Bidirectional	Uni or Bidirectional
Leakagecurrent	< 5 µA	< 1 µA
8/20µs Clamping factors (= Vcl / Vbr)	2.00	1.5
ESD ruggedness	> 30 kV	> 30 kV
ESD clamping voltage	See *Figure 6*	See *Figure 6*
Ageing	Yes, see *Figure 7*	Yes, see *Figure 7*

Passive components

Figure 7. Aging effect on both varistor and Transil characteristics

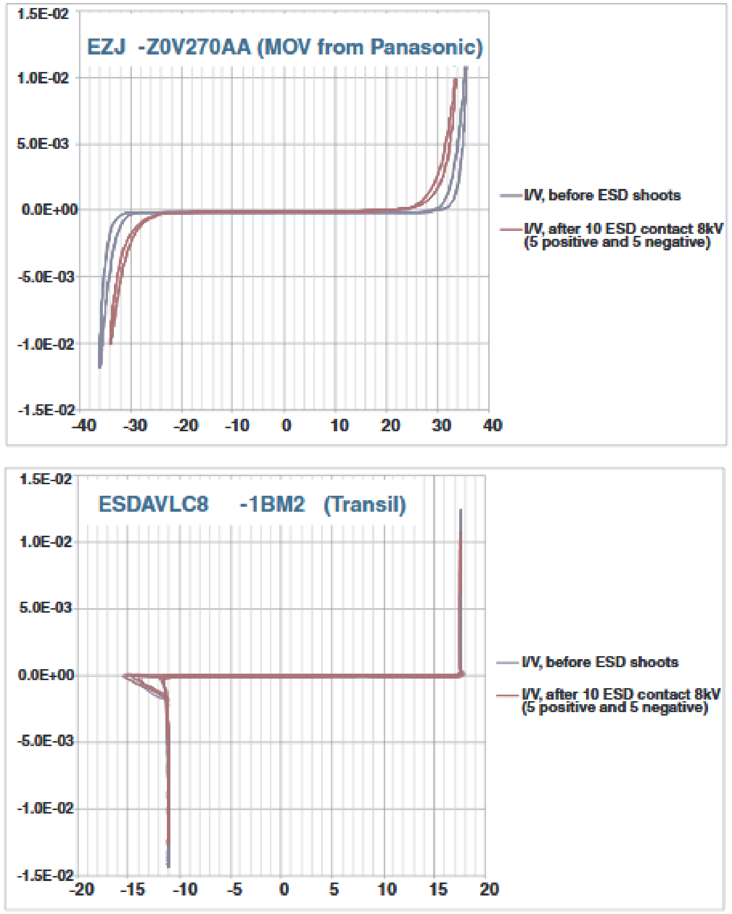
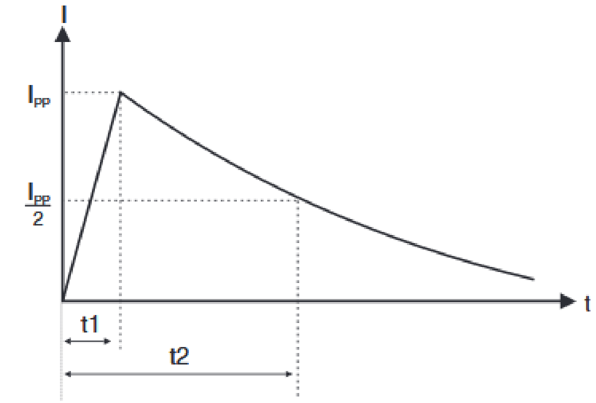


Figure 7 shows the impact of repetitive ESD IEC 61000-4-2 level 4 contact discharge surges. After 10 surges, the I/V characteristics of the varistor changed while the Transil one presents no change.

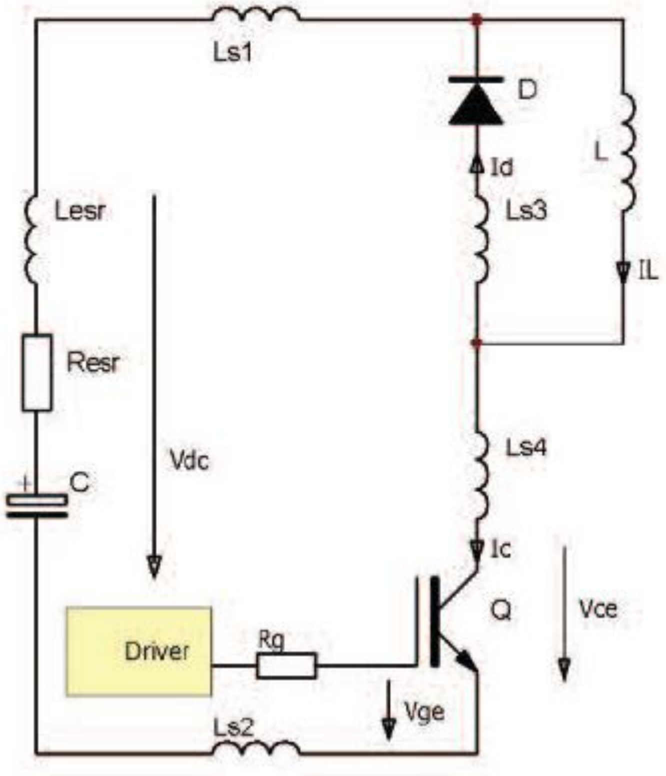
Figure 2. Standard exponential pulse

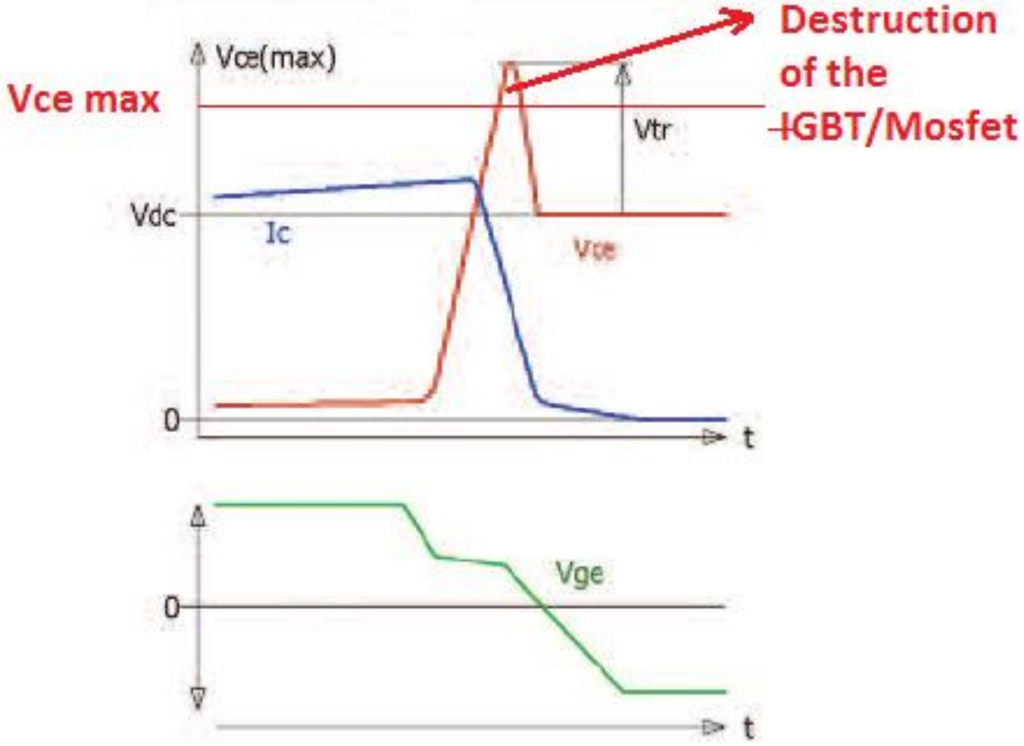


	t1	t2
Wave "8/20µs"	8	20
Wave "10/1000µs"	10	1000

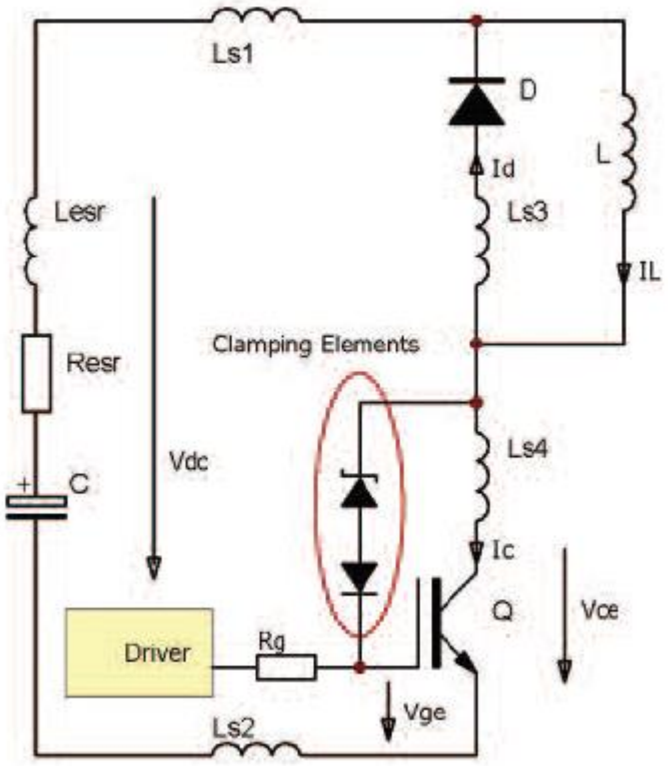
This type of pulse corresponds to most of the standards used for the protection device.

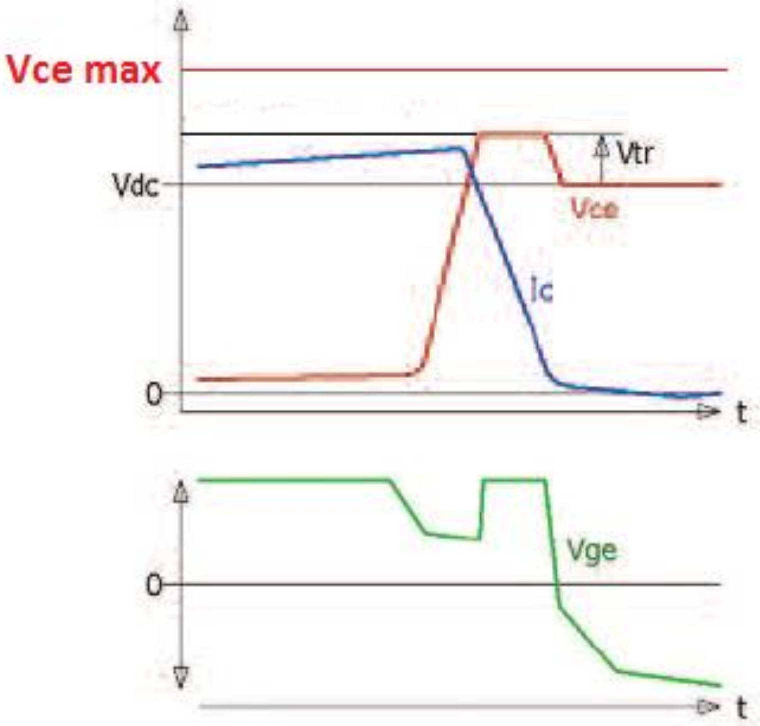
ACTIVE CLAMP





ACTIVE CLAMP

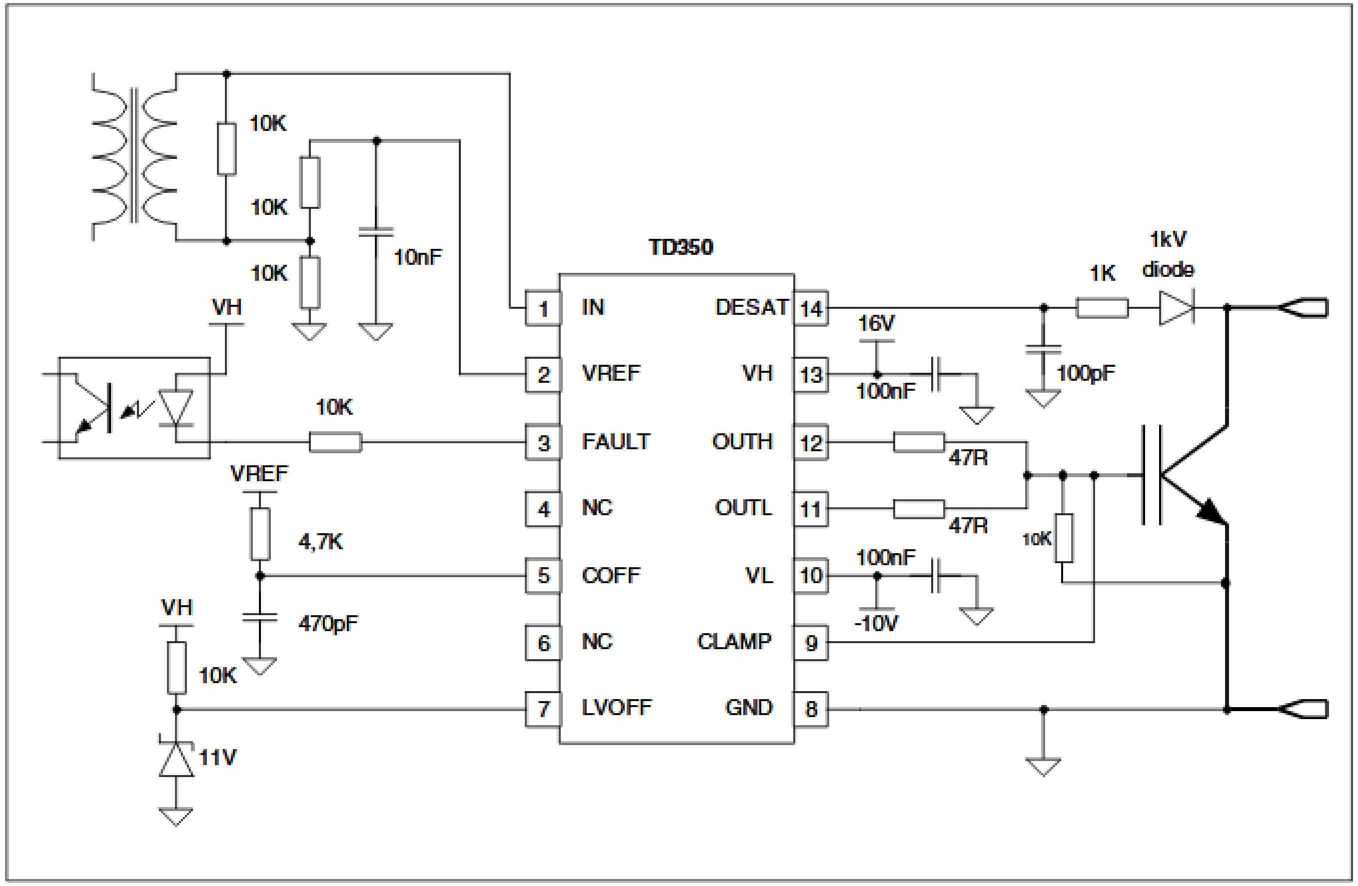




SHORT CIRCUIT

Driver chips for IGBT control

Figure 1. TD350 application example showing all the features



SHORT CIRCUIT

Figure 14. Application schematic for DESAT feature

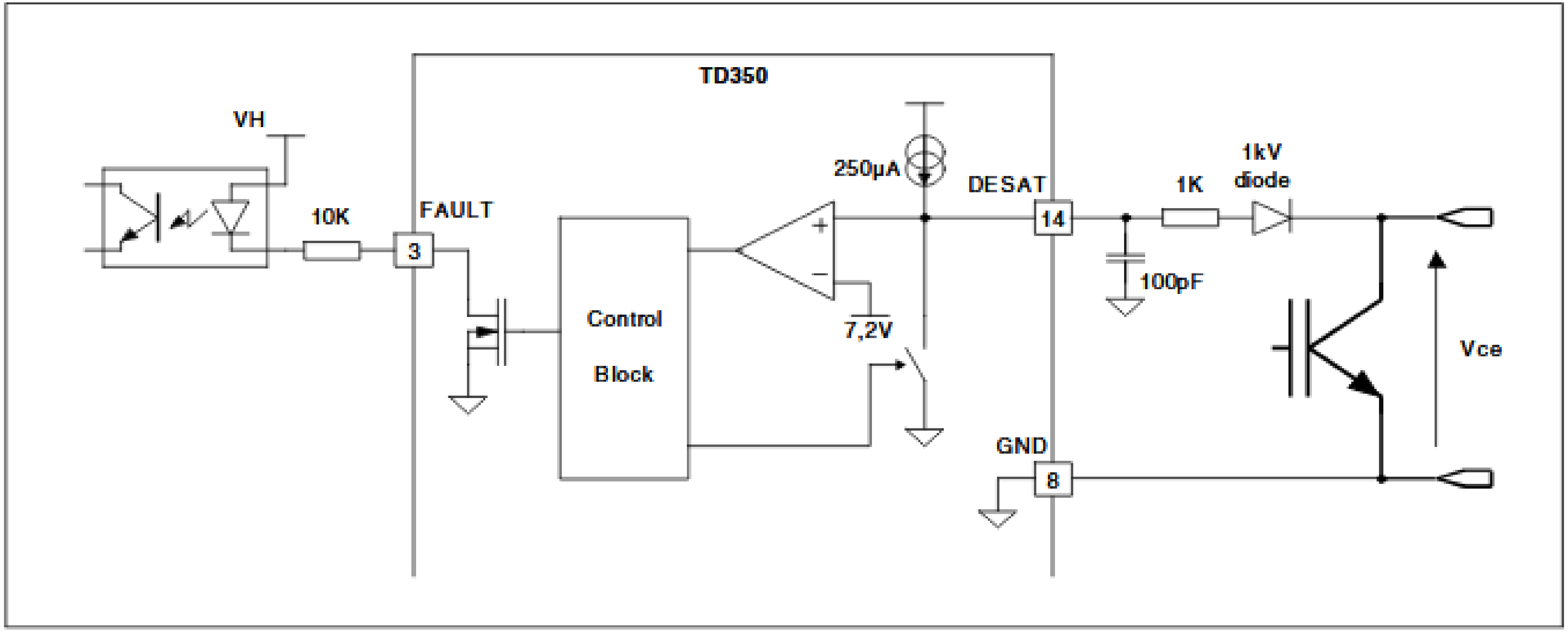
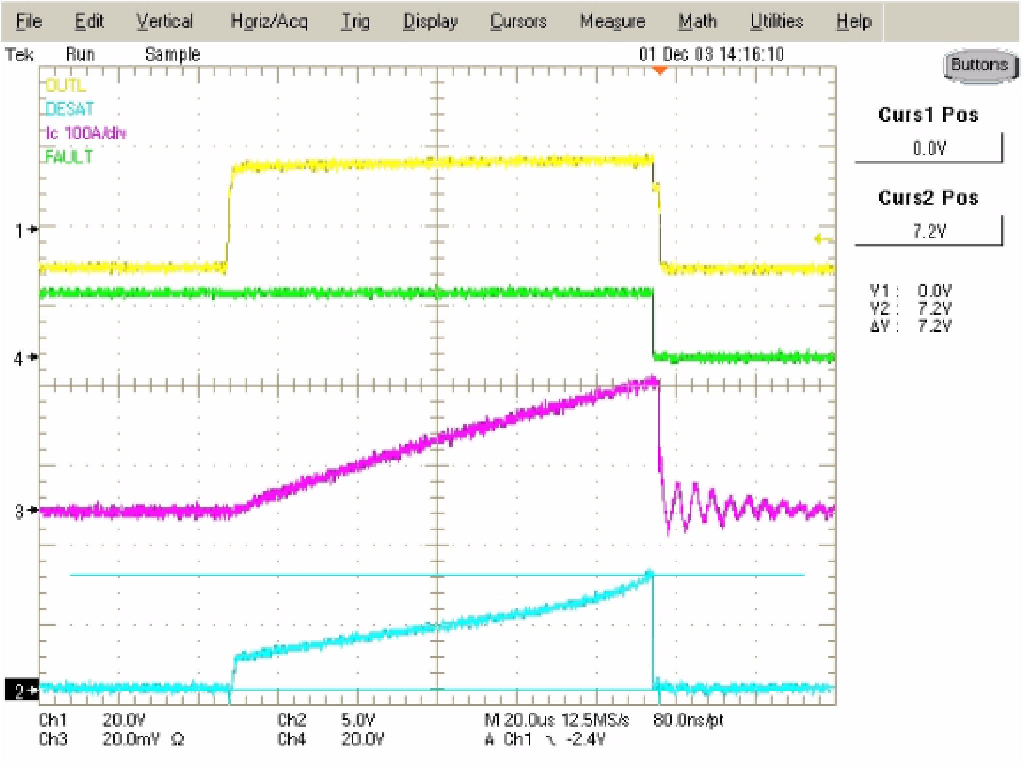


Figure 15. The collector current ramp-up to 150A triggers the DESAT feature (test on 25A module)

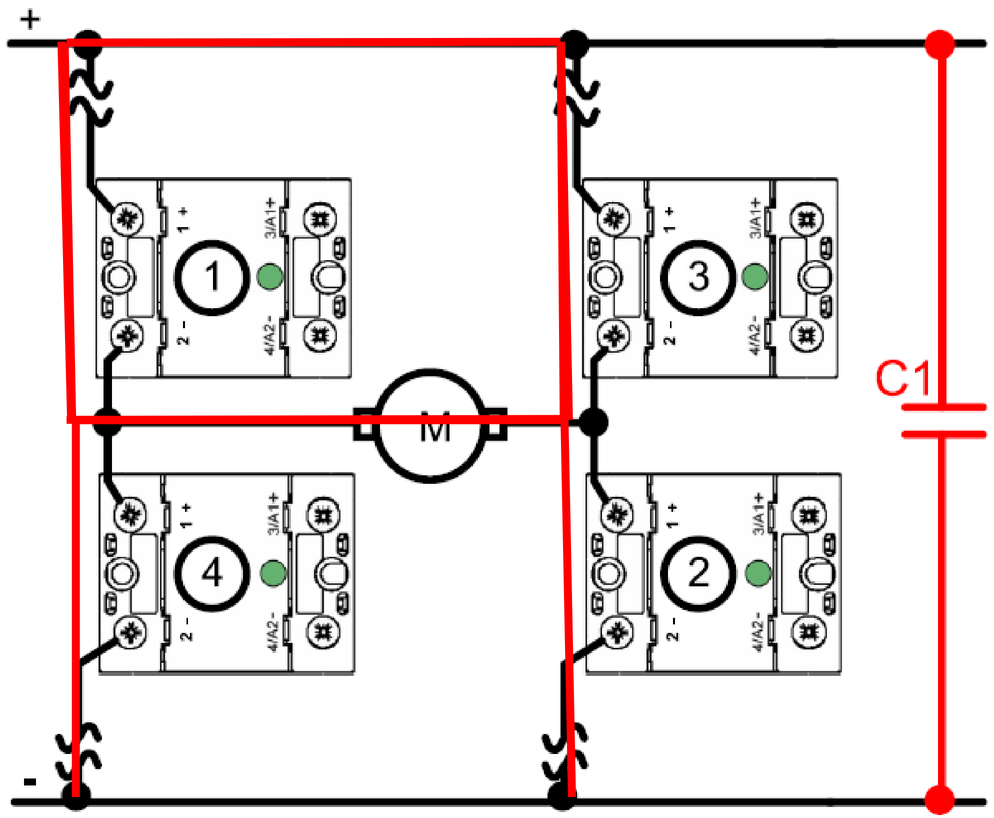


APPLICATIONS

HEATING (TRAMWAY) WITH ACTIVE CLAMP

APPLICATIONS

REVERSING MOTORS WITH PASSIVE CLAMP



Motor direction 1:	**Motor direction 2:**
Control of « 1 » Control of « 2 »	Control of « 3 » Control of « 4 »
PWM : « 1 » permanently controlled « 2 » controlled with PWM signal or vice-versa	**PWM :** « 3 » permanently controlled « 4 » controlled with PWM signal or vice-versa
Change of direction: Control OFF of « 2 » Wait 1 second mini (Flywheel) Control OFF of « 1 » Proceed with Motor direction 2	**Change of direction:** Control OFF of « 4 » Wait 1 second mini (Flywheel) Control OFF of « 3 » Proceed with Motor direction 1

THANKS FOR YOUR ATTENTION

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