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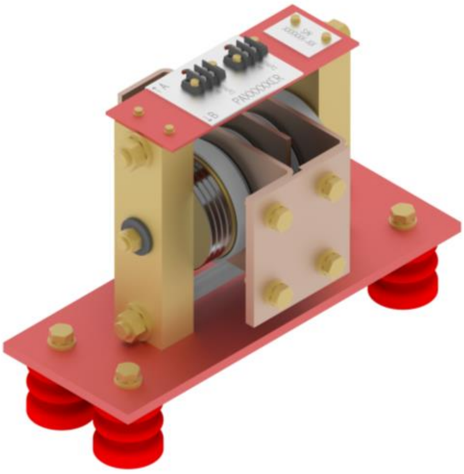
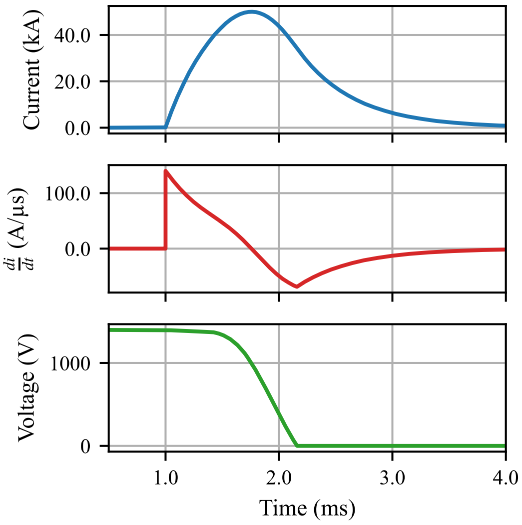
AN6673
Overvoltage Protection for Power Electronic Systems Incorporating Dynex Power Semiconductor Devices
Application Note

AN6673-1 July 2026 (LN44995)





Abstract— Overvoltage events in power electronic systems can arise from external disturbances (e.g., lightning and grid resonance), internal switching and fault conditions. Overvoltages can lead to semiconductor damage, insulation stress, and reduced equipment life. This application note reviews common overvoltage mechanisms and compares practical protection approaches, including clamping devices (MOVs and TVS diodes) and crowbar devices (gas discharge tubes and thyristor crowbars). Particular attention is given to thyristor crowbars, which are often well-suited to high-energy or sustained overvoltage scenarios, where rapid reduction of bus voltage and therefore upstream fault clearing are required. A crowbar design procedure and device selection considerations are provided in this application note. These help ensure that a crowbar designed to use Dynex devices will operate reliable, and that upstream protection devices, such as fuses, are correctly sized.

1 Introduction

This application note aims to review common overvoltage threats and protection approaches, and to introduce specific devices suitable for use in power electronic systems.

Multiple protective devices are often used in combination within a power electronic system; however, this application note places specific emphasis on thyristor crowbars.

Crowbars are widely applied in medium- and high-power equipment, as they can provide a controlled low-impedance path to rapidly collapse the bus voltage. This allows the fault current to be redirected, enabling upstream protection devices to clear faults.

Dynex manufactures a broad range of high-power thyristors suitable for crowbar applications; hence, this application note provides detailed crowbar selection and implementation guidance to support power electronic system designers.

2 Overvoltage Threats

Overvoltages in a power electronic system can arise from numerous causes, including both internal and external sources, and may lead to a range of effects, from minor damage to complete equipment destruction in the worst-case scenario.

2.1 Causes

This section aims to provide a list of possible causes of overvoltages in a power electronic system.

It is the responsibility of the system designer to assess these causes of overvoltages in their specific application and apply appropriate mitigation measures.

2.1.1 External Events

2.1.1.1 Lightning strikes

Lightning strikes can cause an overvoltage to occur due to the sudden change in current. A lightning strike causes a high current to flow for a short period of time, inducing a change in voltage which can reach several hundreds of kilovolts in magnitude [1].

The most exposed areas of a power transmission/distribution system contain protective components such as surge arresters, which help to reduce the magnitude of any strikes affecting downstream equipment [1]. However, strikes can still influence downstream equipment by inducing a temporary overvoltage.

2.1.1.2 Temporary overvoltages

Temporary overvoltages (TOVs) are slow-changing overvoltages caused by resonance conditions on the power grid.

Different grid companies have differing definitions of what constitutes a TOV - for example, the United Kingdom National Grid defines TOVs with durations between 10 ms and 5 s, with RMS magnitudes up to 1.4 per unit (p.u.) [2].

2.1.2 Internal Events

2.1.2.1 Switching surges

Switching surges are caused when switching operations within the system induce a sudden change in voltage or current.

Overvoltages due to switching surges can occur due to the presence of energy storage components in the system, such as capacitances or inductances.

For example, switching of inductive loads, such as motors, reactors or contactor coils, can cause an overvoltage if there is a sudden change in current, as the voltage drop of an inductive element is proportional to the rate of change of current.

Switching capacitors in and out of a system can also cause oscillatory transients; for example, an inrush current caused by a capacitor bank charging could result in an overvoltage if inductive components are in the current path.

2.1.2.2 Ground faults

Ground faults can cause an overvoltage to occur when the ground reference is lost, depending on the system grounding scheme. This is because the voltage of non-fault phases may rise above an allowable voltage limit when this reference is lost, causing an overvoltage.

Ground faults are becoming a greater concern with the move towards distributed renewable energy sources [3], which have lower inertia compared to large generators such as gas turbines. This lower inertia can cause more grid-level instability, increasing the likelihood of a ground fault.

2.1.3 System-Specific Events

These events are specific to a particular type of system.

2.1.3.1 Load rejection

Load rejection can cause an overvoltage, especially in generator systems with high inertia. This is because there is an excess of electrical energy caused by the rejection of the generated energy, which can result in an overvoltage.

2.1.3.2 Transformer energisation

Transformer energisation can cause an overvoltage due to high inrush currents caused by core saturation and reflected transients – these occur especially when switching at certain points in the AC cycle.

2.2 Effects

Overvoltages can have numerous undesirable effects within a power electronic system:

- **Semiconductor device damage** can occur – power semiconductors such as insulated gate bipolar transistors (IGBTs) and diodes are sensitive to overvoltage, and this can cause breakdown of internal insulation, overheating or destruction of the device's silicon.

- **Insulation breakdown** can occur, as overvoltage can stress the insulation within a system, leading to partial discharge, material tracking or full dielectric failure in the worst case.
- **Accelerated aging of components** can occur when components in a system, such as capacitors or transformers, are operated close to or above their rated voltage.
- **Overheating** can also occur – for example a transformer may experience elevated core losses when operating at a higher voltage than it was designed for.
- **Damage to the load** can occur if the voltage rating of the load is exceeded.
- **The electric shock risk** is elevated as accessible conductive parts could rise above a safe voltage.
- **Control system issues** may arise, for example sensor failures or false triggering of power devices, causing safety issues.

3 Protection Behaviours

Numerous protective devices exist to protect against overvoltages in a power electronic system.

These are usually in one of two categories, depending on their behaviour during an overvoltage event:

- **Clamping** – this limits the voltage between defined levels by absorbing excess energy, preventing it from exceeding specified thresholds.
- **Crowbar** – this introduces a controlled low-impedance path to rapidly reduce the voltage to near zero, allowing upstream protection devices such as circuit breakers to operate.
  The 'crowbar' name for this type of protection originates from an analogy of placing a metal crowbar across busbars to intentionally force a short circuit.

While each device type has different characteristics, these are often complementary, so different device types are often used in combination with each other to protect circuits.

Figure 1 shows the difference between the clamping and crowbar behaviours for an exemplar voltage waveform.

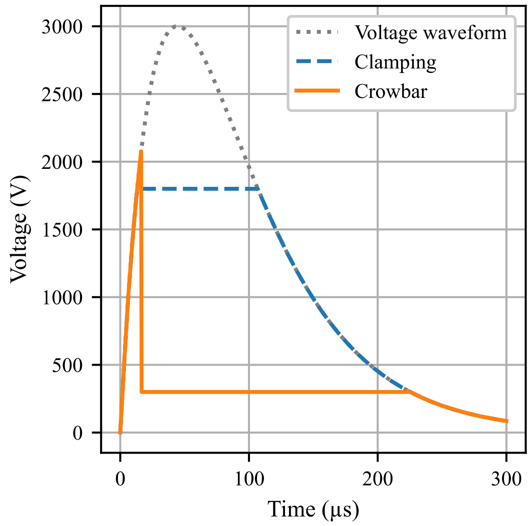


Figure 1. Comparison of clamping and crowbar characteristics for an example waveform.

3.1 Thyristor Crowbars

Thyristor crowbars place one or more thyristors in parallel with the protected supply (for example across a DC link). Under normal operation, the thyristor remains in its blocking state; hence, only a small leakage current flows.

Figure 2 shows a typical thyristor crowbar circuit. The trigger circuit detects the overvoltage and provides a gate current pulse. This current pulse causes current to flow between the anode and cathode, creating a low-impedance path to rapidly collapse the protected voltage.

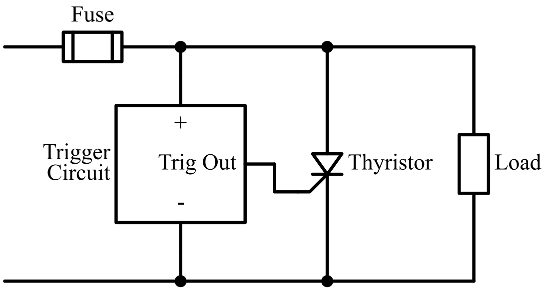


Figure 2. Simplified DC thyristor crowbar circuit.

Once triggered, a thyristor ‘latches’ on and remains conducting without further gate drive, provided the anode current remains above the device’s holding current.

In AC systems, the current naturally passes through zero every half-cycle, which can commutate the thyristor off. However, in DC systems, the current will not self-commutate, so current needs to be interrupted using another mechanism, such as using a fuse, a forced-commutation method or using a thyristor with turn-off capability (e.g. a gate turn-off thyristor).

This latching behaviour is advantageous in a crowbar application as only a single gate pulse is required during the event.

In AC systems, two thyristors may be connected in an antiparallel configuration to ensure that the AC line can be collapsed in both directions, as shown in **Figure 3.**

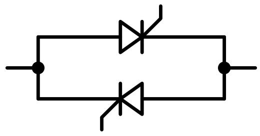


Figure 3. Example of an antiparallel thyristor configuration.

3.2 Gas Discharge Tubes

3.2.1 Performance

Gas discharge tubes consist of two electrodes enclosed within a sealed gas-filled tube. They are typically connected in a circuit in a shunt configuration between different voltage levels, for example between the positive and negative terminals in a DC system, or between phases in an AC system.

A large voltage between two electrodes causes a strong electric field between them, which leads to an avalanche of impact ionisation and therefore allows current to flow between the electrodes [4, p. 697] – this large voltage is known as the breakdown voltage.

This phenomenon is exploited by a gas discharge tube – the manufacturing parameters such as the gas, electrodes and electrode distance are carefully controlled to set the breakdown voltage accordingly.

Once the discharge is triggered, the gas discharge tube will continue to conduct until the current reduces to a certain level – this reduction could, for example, be achieved with external protection devices in the system such as circuit breakers set to trip at a specific current.

3.2.2 Practical Considerations

Gas discharge tubes cannot be controlled externally; therefore, the breakdown voltage needs to be set appropriately to ensure that the tube does not trigger spuriously.

Gas discharge tubes may have a limited lifespan for certain applications – most gas discharge tubes are only rated for a finite number of shots depending on the type of event. Replacement could entail taking the system out of service to replace the gas discharge tube, impacting system availability.

3.3 Metal-Oxide Varistors

3.3.1 Performance

Metal-oxide varistors (MOVs) are a type of variable resistor whose resistance changes in proportion to the voltage across it. These are placed in a shunt configuration in a circuit.

Figure 4 shows the typical voltage-current characteristics of the MOV.

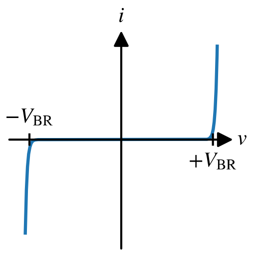


Figure 4. Typical current-voltage characteristics for a metal-oxide varistor.

MOVs are bidirectional devices, i.e. they protect both in Quadrant 1 and Quadrant 3.

Their resistance is very high while the magnitude of the voltage is less than the breakdown voltage, V_{BR}. As soon as V_{BR} is reached, the MOV's resistance decreases significantly, allowing current to flow. This therefore clamps the voltage to be around the breakdown voltage of the MOV.

3.3.2 Practical Considerations

MOVs are typically formed of a semiconducting material placed between two electrodes – due to this construction, which is very similar to a capacitor, they can exhibit relatively high leakage currents at higher frequencies.

MOVs can absorb relatively high amounts of energy, such as the energy released by a lightning impulse. These lightning impulses are usually modelled as a 1.2/50 µs waveform (as shown in **Figure 5**), as per IEC 61000-4-5 [5]. This has a rise time of 1.2 µs from 10% to 90% of the expected overvoltage and then takes 50 µs to decrease to 50% of the expected overvoltage.

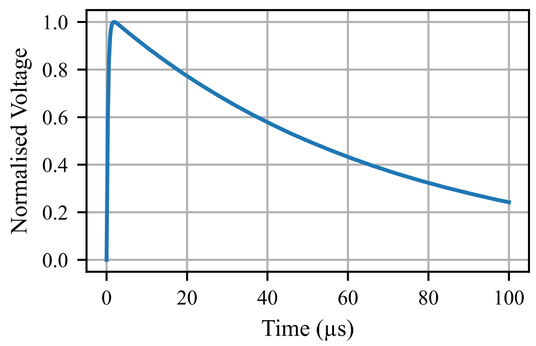


Figure 5. Normalised waveform of a 1.2/50µs overvoltage, generated using the method described in [6].

MOVs are often able to act faster than other means of protection, which makes them an excellent choice for events such as lightning impulses, but they are not designed to conduct a continuous amount of current for a significant amount of time – doing so can cause damage to the MOV itself and the wider system.

Methods to mitigate this include careful selection of the MOV to ensure the clamping voltage is not too low. It is also important to ensure that upstream protection, such as fuses and/or circuit breakers, is dimensioned correctly.

Alternatively, a thyristor crowbar or gas discharge tube can be used as an additional protection device to reduce the voltage using a crowbar action, essentially forcing the MOV's resistance to increase and helping to stop the MOV from conducting.

3.4 Transient Voltage Suppression Diodes

Transient voltage suppression (TVS) diodes are clamping devices – they are placed across the device they are protecting and clamp the voltage between two lines. These have similar behaviours in general to MOVs but are semiconductor devices rather than acting as voltage-dependent resistors.

TVS diodes are available in both unidirectional and bidirectional versions – the unidirectional versions are often used to protect DC lines, whereas the bidirectional versions are more commonly used to protect AC lines.

In power electronics applications, TVS diodes are not commonly used directly at the power electronics level, as they are only available in lower voltage and current ranges.

However, they still play an important role in power electronic systems. For example, they can be found on the power lines of a semiconductor gate driver, or on the signal lines of analogue inputs on a microcontroller board used to control a power electronics system.

3.5 Summary of Protection Methods

A comparison of the four main types of overvoltage protection devices discussed in this application note is provided in Error! Reference source not found..

In practice, effective overvoltage protection in a power electronics system is achieved using multiple devices in combination with each other.

Table 1. Comparison of the four main types of overvoltage protection devices discussed in this application note, based on [4].

Device	Thyristor Crowbar	Gas Discharge Tube	Transient Voltage Suppression Diodes	Metal Oxide Varistors
Behaviour	Crowbar	Crowbar	Clamping	Clamping
Response time (trigger time)	µs range	ms range	ns range	µs range
Voltage rating	Tens of kV depending on number of series devices	Can reach MV range depending on design	Maximum 1 kV	Around 5 kV
Current rating	Tens of kA depending on device	Hundreds of kA	Hundreds of A	Thousands of A
Accuracy	Very good – drive circuit can determine when to fire	Fair – dependent on the gas discharge tube design	Poor – may trigger spuriously	Fair – dependent on the MOV design
Most suitable for	High energy events or sustained overvoltages	Extremely high surge currents, where acceptable and replaceable	Fast low-energy spikes, e.g. to protect signal rails on a microcontroller	Lower-energy sustained events where ride-through is desirable and MOV can handle the pulse

4 Dynex's Thyristors in a Crowbar Application

Dynex manufactures a very comprehensive range of high-power thyristors which lend themselves very well to crowbar applications, with the following characteristics:

- **High surge current** – the high surge current capability of Dynex thyristors allows a thyristor to conduct a current significantly more than its rated value for a short duration of time without damage.
- **High energy absorption capability (I^2t)** – Dynex thyristors have a high energy absorption capability and high I^2t rating, meaning that the thyristor will not fail before any upstream protection, such as fuses or circuit breakers, if the thyristor is chosen carefully. This also ensures that any assemblies remain mechanically robust as the thyristor's case should not rupture if the I^2t rating is not exceeded.
- **Low thermal resistance** – the low thermal resistance of Dynex press-pack thyristors allows them to be cooled effectively, especially when the surge currents cause localised heating.
- **Low on-state voltage** – the low on-state voltage of Dynex thyristors provides a hard clamping effect.
- **High mechanical robustness** – Dynex press-pack thyristors, especially when paired with an appropriate clamp, such as the Dynex DC range, are mechanically very robust – when clamped correctly, there is consistent conduction across the entire silicon surface, and resistance to vibration and thermal cycling.
- **High electrical ruggedness** – Dynex thyristors are designed to withstand high rates of change of currents ($\frac{di}{dt}$), so remain reliable even when the current changes quickly – this is important in a crowbar application where the device is expected to switch in quickly.

5 Design Considerations for Thyristor Crowbars

There are certain parameters that should be considered when selecting thyristors for a crowbar application. This section aims to address these parameters.

5.1 Device Type

Dynex manufacture multiple types of thyristors that are suitable for a crowbar application.

- **Press-pack thyristors** are very commonly used for a crowbar application, especially at standard speeds. Dynex press-pack thyristors are available at voltage ratings up to 8.5kV.
- **Pressure contact bipolar modules** offer a lower-cost solution, especially for lower voltages – they can be easily integrated into a system by being mounted onto a heatsink or coldplate.
- **Bidirectional thyristors** are press-pack thyristors with two anti-parallel thyristor basic units in one package.
  This may reduce the size of the crowbar assembly, but the main drawback is that they are harder to cool, possibly resulting in a higher peak junction temperature or longer reset time.
- **Gate turn-off thyristors** have the key advantage of a controllable turn-off mechanism when compared to regular thyristors. Therefore, they may be a good choice for applications where this is required, such as a repetitive pulse application.
  However, gate turn-off thyristors often have lower current ratings than an equivalently sized press-pack thyristor. Additionally, the turn-off mechanism requires a significant amount of current, so the gate driver needs to be carefully designed.

- **Pulse power thyristors** are thyristors specifically designed for high $\frac{di}{dt}$ applications – they have $\frac{di}{dt}$ ratings 10 to 20 times higher than a standard thyristor.
  Depending on the pulse power thyristor chosen and the application, series diodes may need to be added to the crowbar assembly to enhance the reverse voltage blocking capability.

5.2 Selecting the Appropriate Device

This section details the steps that should be taken to select the appropriate device(s) for a crowbar application.

5.2.1 Blocking Voltage

The selected thyristor must have an appropriate blocking voltage, such that it is able to block the voltage across it while the crowbar is off.

A good rule-of-thumb is to select a blocking voltage that is at least 2 times the voltage expected across the thyristor in the application.

5.2.2 Determine the Current Waveform

The current waveform through the crowbar should be determined, as if the crowbar was an ideal switch.

While, in theory, an ideal switch being closed would result in an infinite current, in practice, this is limited by numerous circuit elements, such as parasitic inductances and any system capacitances.

From the current waveform, the following parameters can be determined:

- $\frac{di}{dt}$ (rate of change of current through the thyristor).
- Peak current.

5.2.3 Fuse/Protection Coordination

If the crowbar application relies on a fuse to provide the upstream protection in the power system, the rated I^2t of the thyristors used should be greater than or equal to the I^2t of the fuse. If this is not observed, there is a risk that the thyristor's case may rupture before the fuse or other upstream protection mechanism activates.

It is also common to add a safety margin to the required thyristor I^2t above that of the fuse.

5.2.4 $\frac{di}{dt}$ Limitations

The $\frac{di}{dt}$ (rate of change of current flowing through the thyristor) should be kept below the non-repetitive limit given in the thyristor datasheet.
In a circuit, stray or loop inductance may help to control the $\frac{di}{dt}$, but the layout is critical and should therefore be assessed using simulations or measurements of the system.

5.2.5 $\frac{dv}{dt}$ Limitations

The $\frac{dv}{dt}$ (rate of change of voltage across the thyristor) should be kept below the datasheet limit – if this is exceeded, there is a risk of unwanted thyristor triggering, meaning that the crowbar activates spuriously.

A snubber may be placed across the thyristor to limit the $\frac{dv}{dt}$ across the thyristor – Dynex application note AN6481 covers the practical design of an RC snubber, but the system designer should determine the appropriate snubber type for their application.

5.2.6 Gate Drive

For a crowbar application, the gate drive should be able to provide a high peak gate trigger current $I_{\mathrm{GT(pk)}}$ as well as a fast gate current rise time ($\frac{dI_{\mathrm{G}}}{dt}$). This allows the thyristor(s) to turn on as quickly as possible and ensures the active conduction area is as large as possible.

However, the peak gate trigger current should not exceed the datasheet rated value, as this could cause damage to the device.

Dynex application note AN6148 covers the design of gate drivers for thyristors. However, numerous off-the-shelf and custom gate driver solutions are also available on the market.

5.2.7 Thermal Analysis

A transient thermal analysis should be performed to assess the maximum junction temperature. This is usually performed by inputting the expected current waveform into a conduction loss model of the thyristor(s), and then using the transient conduction loss to determine the maximum junction temperature.

Many circuit simulation packages, such as PLECS, include the ability to run these simulations.

Most thyristor datasheets provide thermal models as a Foster model, which is comprised of a sum of multiple exponentials. However, the Cauer model represents the thermal models as a chain of thermal resistances and capacitances representing the different layers within the device, which means that it more accurately represents the realistic device behaviour.

Foster models can be converted to Cauer models using numerous tools, such as within MATLAB/Simulink [7] or PLECS [8, p. 183].

If the crowbar is expected to be fired repetitively, a larger device with a lower thermal resistance may be required – this will allow the junction to be cooled faster.

Therefore, a steady-state thermal analysis, such as that offered by PLECS [8, p. 222], can be used to assess this by trialling different devices and determining whether the maximum junction temperature of the device is exceeded.

5.3 Triggering Strategies

For a crowbar application, ideally the triggering system should be self-contained, i.e. not requiring any external input from a controller or other means.

Traditionally, break-over diodes [9] are employed – these provide a break-over action when the voltage exceeds the device's set voltage to create a trigger pulse to drive the thyristor gate.

Other approaches to achieve triggering are possible, such as using a Zener diode trigger or an external comparator circuit.

5.4 Assemblies

Typically, thyristors used in a crowbar application must be assembled into a clamp or other form of assembly as shown in **Figure 6**.

The design of this assembly is critical to ensure proper crowbar function and system protection. For example, the loop and parasitic inductance must be controlled, and the clamp must be properly designed to account for potential expansion and contraction during high-energy events.

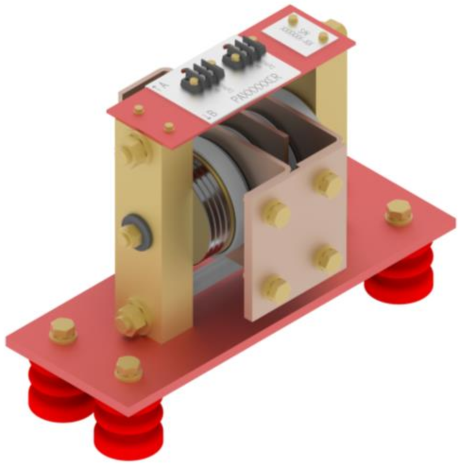


Figure 6. Illustrative example of a typical Dynex crowbar assembly.

Dynex has extensive experience supplying thyristor crowbar assemblies through the Power Assemblies department, as well as discrete devices for this application.

The Power Assemblies team can provide multidisciplinary design support covering electrical, mechanical, thermal and testing aspects.

Engaging early with the expected fault waveform (voltage, current, $\frac{di}{dt}$, pulse width, repetition) and upstream protection approach can help ensure the implemented solution meets electrical and thermal and mechanical margins.

As with discrete implementations, final designs should be validated by calculation and/or simulation and confirmed by appropriate test, ensuring electrical coordination and thermal margins remain acceptable across tolerances and credible operating extremes.

6 Design Example

A simplified design example is presented in this section to show the process of designing a crowbar.

6.1 Design Requirements

In this instance, a crowbar is used to rapidly discharge a capacitor bank. The simplified circuit diagram is shown in **Figure 7**, and the key system parameters are detailed in the following list:

- Capacitance C_{bank} = 15 mF
- DC voltage V = 1400 V
- Approximate equivalent series resistance of the capacitor bank $R_{\text{ESR(bank)}}$ = 600 µΩ
- Approximate loop inductance L_{loop} = 10 µH
- Approximate loop resistance R_{loop} = 20 mΩ
- Ambient temperature = 50 °C
- Fuse current = 500 A
- Fuse pre-arcing I^2t = 221.5 kA²s

The capacitor bank will store an energy equivalent to $\frac{1}{2}CV^2$ when it is charged:

$$E = \frac{1}{2}CV^2 = \frac{1}{2} \times 15 \times 10^{-3} \times 1400^2 = 14.7\ \text{kJ}$$

This example assumes that the capacitor bank is discharged due to an overvoltage event, but to simplify the modelling, the overvoltage is not modelled here.

While this application note mainly covers overvoltages, such a circuit could also be used include to safely discharge a capacitor bank when an emergency stop is pressed, or in scientific applications where a high current pulse is required.

A freewheeling diode is placed across the capacitor in this example. This is to ensure the capacitor current flows through the loop inductance and capacitance to allow the capacitor to discharge.

The snubber design is not covered as part of this example.

6.2 Design Steps

6.2.1 Blocking Voltage

As the DC voltage of the capacitor bank is 1400 V, the device blocking voltage has been selected as 2800 V to satisfy the rule of thumb given in section 5.2.1.

6.2.2 Determining the Current Waveform

The current through the thyristor has been simulated to assess the size of the device required.

As shown in **Figure 9**, the current reaches a peak of 50 kA, and the $\frac{di}{dt}$ reaches a peak of 140 A/µs.

For part of the fault waveform, the DC voltage source will increase the fault current, as before the fuse trips, some current will flow from the grid through the crowbar assembly.

From this simulation, a device was selected based on the selection process shown in Error! Reference source not found., by comparing the I_{TSM} (the peak current that the thyristor can withstand) and $\frac{di}{dt}$ with the datasheet values.

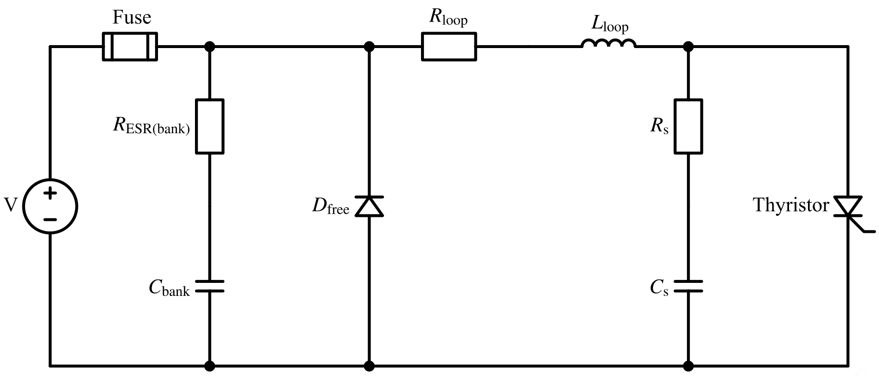


Figure 7 - Simplified schematic of the crowbar circuit evaluated in the design example.

This is done rather than using the continuous current rating as using the continuous current rating would result in a larger device or more devices than necessary.

The headline I_{TSM} value on the datasheet is determined based on a 10 ms wide half-sine. Many Dynex datasheets provide a single-cycle surge current plot for differing pulse widths, such as that shown in **Figure 8**Error! Reference source not found.Error! Reference source not found., so for shorter or longer periods this can be used to scale I_{TSM} accordingly.

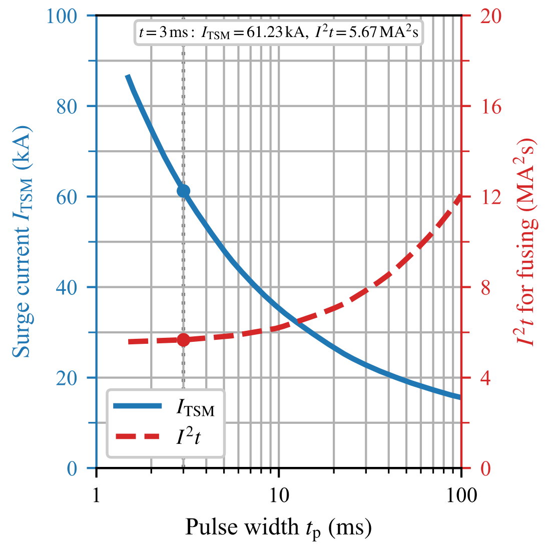


Figure 8. Single-cycle surge plot for the Dynex DCR2480L28 thyristor.

One caveat of the single-cycle surge plot is that the thyristor is only rated to survive a minimum of 100 pulses of this surge. For many crowbar applications where the crowbar is only expected to fire very occasionally, this is not an issue, but the peak current through the device should be derated if the crowbar is expected to survive a higher number of pulses.

The device selected is a Dynex DCR2480L28, which is rated for a peak current I_{TSM} of 61.23 kA with a 3 ms pulse width, providing a 25% current margin. It also has a rated non-continuous $\frac{di}{dt}$ rating of 300 A/µs, which is twice that required in this application.

To confirm the suitability of this device in this application, a thermal simulation has been conducted in PLECS, using a thermal model of the thyristor placed on a heatsink.

The results of this simulation are shown in **Figure 9**, which show that the peak junction temperature for an ambient temperature of 50 °C reaches 102.7 °C, less than the 125 °C maximum junction temperature for the DCR2480L28 device.

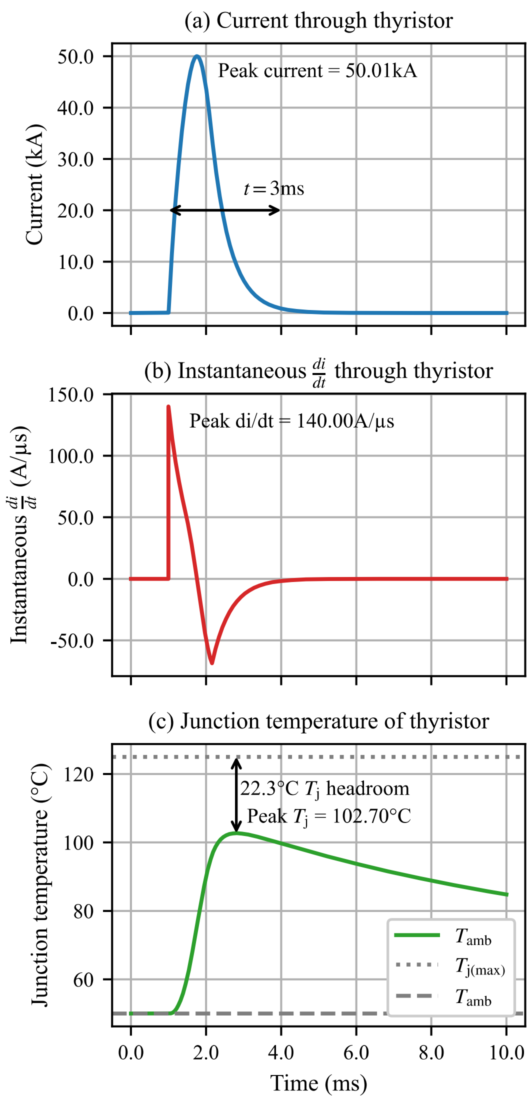


Figure 9. Current, di/dt and junction temperature for the Dynex DCR2480L28 thyristor.

The I^2t rating of the Dynex DCR2480L28 thyristor is 5.67 MA²s for a 3ms pulse. This is approximately 25x the pre-arcing I^2t of the fuse, meaning that the fuse should always interrupt the circuit before there is any damage to the device.

Table 2 - Table of evaluated 2.8kV thyristors in the design example.

Part number	Rated I_{TSM} for 10ms pulse (kA)	Rated I_{TSM} for 3ms pulse (kA)	Rated non-continuous $\frac{di}{dt}$ (A/µs)	Suitable?
DCR960G28	13	22	500	No
DCR1610F28	21.5	37	1000	No
DCR2480L28	35.25	62	300	Yes
DCR2630C28	35.3	58	300	Yes
DCR3650Y28	50.2	88	300	Yes
DCR3780V28	50.2	85	300	Yes
DCR4590B28	63	110	500	Yes
DCR4910W28	63	110	500	Yes

7 Final Remarks

Overvoltage events in power electronic systems can arise from a wide range of external and internal mechanisms, and their effects can range from accelerated aging to catastrophic semiconductor or insulation failure.

In practice, robust protection is achieved by selecting a protection strategy that matches the event energy and event duration, and by coordinating the protection device with the surrounding system (source impedance, wiring inductance, and upstream protective devices).

This application note has grouped protection devices into two broad behaviours: clamping, where a device limits voltage by absorbing energy (e.g., MOVs and TVS diodes), and crowbar, where a device rapidly introduces a low-impedance path to collapse the protected voltage (e.g., gas discharge tubes and thyristor crowbars). Clamping solutions are often effective for fast transients and lower energy events, but they may be unsuitable for sustained conduction because absorbed energy and thermal stress can rise quickly. Crowbar solutions are frequently well-suited to high-energy or sustained overvoltage scenarios where the primary objective is to force a fast reduction of bus voltage and prompt action from upstream protection.

Thyristor crowbars in particular offer a practical route to handling severe events because a triggered thyristor provides a controlled, low-impedance path and latches on, enabling rapid bus collapse with only a short gate command.

When specifying a thyristor crowbar, engineers should focus on a small number of core checks: adequate blocking voltage margin, an understanding of the expected crowbar current waveform (peak current and $\frac{di}{dt}$), coordination of device capability versus upstream protection (in particular I^2t where fuses are used), and verification of junction temperature using an appropriate transient thermal model.

Dynex manufactures a broad range of high-power thyristors that lend themselves to crowbar duty, and the selection guidance and example in this note are intended to help designers converge quickly on a robust, coordinated solution.

Where customers prefer an implementation-ready approach, Dynex can also supply power assembly solutions, including crowbars. The team has over 30 years of experience designing crowbars in demanding applications, where thermal and mechanical robustness are key.

For best results, Dynex recommends validating the final design using calculation and/or simulation and confirming that protective device coordination and thermal margins remain acceptable across tolerances and credible operating extremes.

8 References

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