RAPTOR Obtaining Maximum Power

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Raptor – Obtaining maximum power

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This document describes how to obtain the maximum power of your Raptor system.

Basically, the most powerful configuration in the Raptor System (not the optimum configuration) for a desired current is obtained:

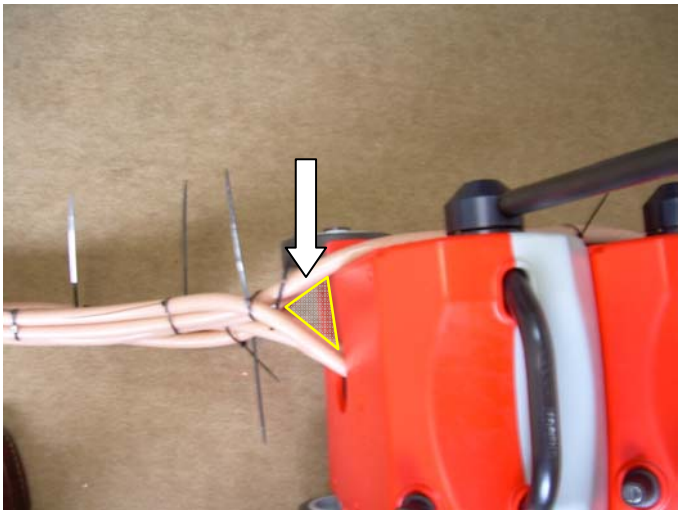
- By using the greatest possible number of Raptor-SL units.
- By increasing the number of turns to the maximum, as long as the maximum selectable current on the Raptor-HH continues to be greater than or equal to the desired current.
- By maximizing the cable cross-section, thereby attempting to occupy the largest possible space of the pass-through hole.
- By minimizing the cable length and the intermediate connections to the load.
- By braiding the cable both to and from the load.

But it is needed some **DO** and **DO NOT** recommendations for avoiding some common mistakes, and optimize getting the maximum from the system.

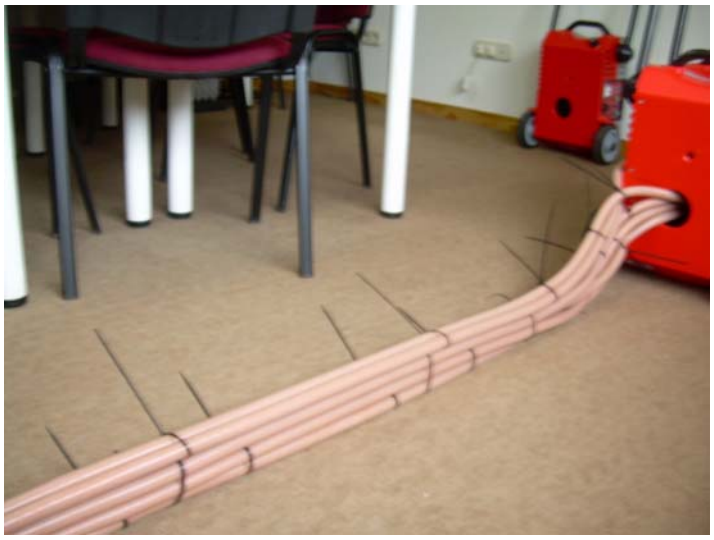
Proper layout of cables

Cables must be arranged as tight as possible to the Raptor's body; the picture shows 4 cables of 6 m each. Note that cables are cleanly placed parallel to each other to eliminate gaps as they traverse the induction tunnel.

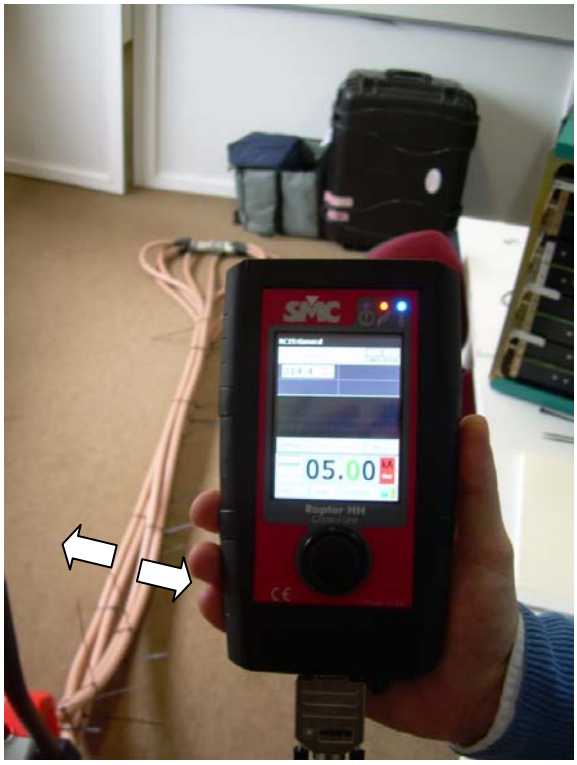
Properly paralleled cables:



Outgoing and incoming legs are immediately brought back together and tied with tape, straps or bridles as they exit the raptor's hole, so that the 'air' between both is reduced to the minimum possible. The smaller this 'air' is, the less inductive impedance will be added.
The inductive effect is even higher than the resistive effect in high currents. The objective of a proper setup of cables is to cancel as much as possible the parasitic inductance effect to reduce impedance.

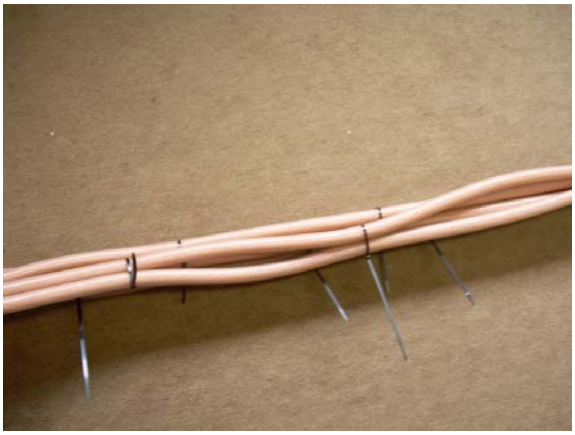


Cables joined together along the way to the load.
Each 'incoming' cable leg is joined to its 'outgoing' counterpart. With very high currents it is also recommended to keep the entire pack tied throughout its whole length, to prevent them from coming apart due to electromagnetic forces when the high current rushes in. The goal is to eliminate space between the cables.

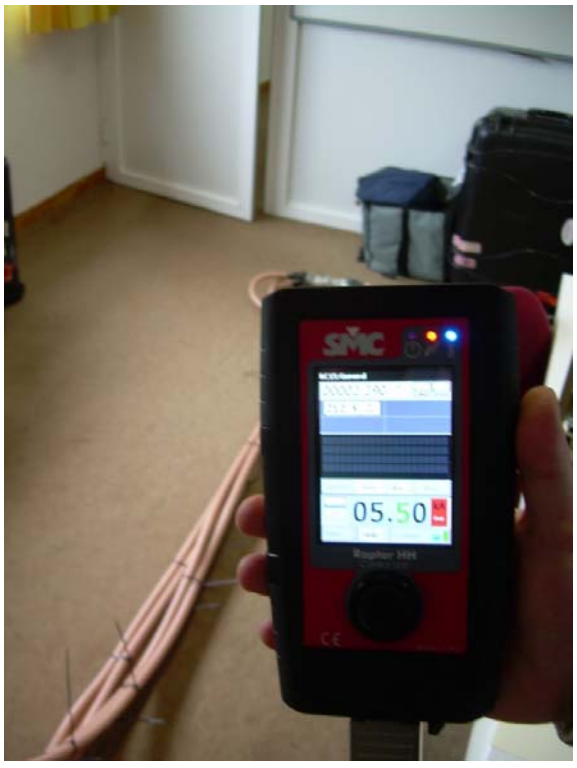


Injecting **5000 A** with this configuration.

Note the outgoing and incoming packs separating apart during the shot.

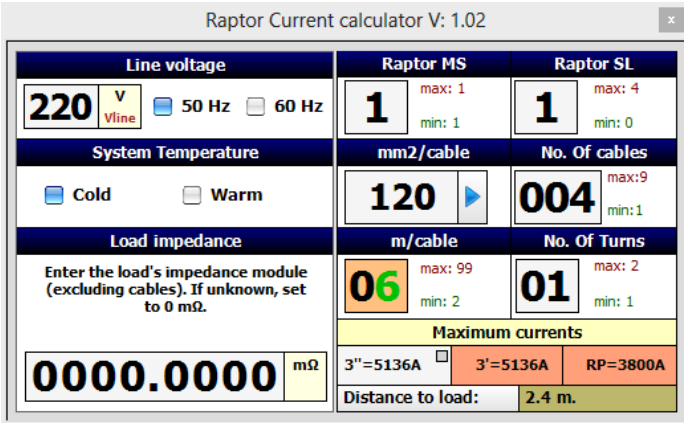


Even though tied, cables will try to separate from each other, and this must be avoided in next injections.



Injecting **5500 A** with this configuration

The Raptor Current Calculator was predicting the following, with 220 V and 50 Hz (and we have also some voltage drop in the power supply due to not using proper cable section in the mains, as indicated in the user manual):

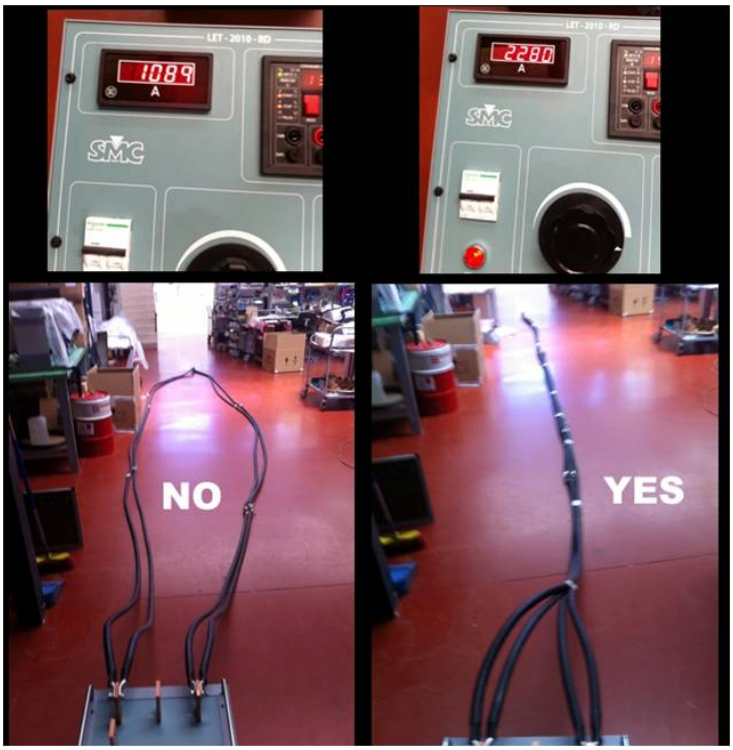


Therefore, with **a proper layout of cables** we are getting more current than the calculated, since the calculator is somewhat conservative. The calculator assumes that extra flexible cables are being used, so the turn wound around the Raptor's body is reasonably tight (as close as possible to the iron core of the output transformer) and the length of cables up to the load is either braided or set tied together. The calculator assumes a reasonably good connection to the load, too.

An example of what should **NOT** be done:

Here, the user nicely twisted the conductors to each other BEFORE threading them through the Raptor, which does not help eliminate the space inside the injection spire. As a result, the maximum current obtained was **1670 A only** (while with the proper cable layout up to 5500 A was possible)

The same effect is observed in the following pictures taken with our traditional variac-based units, the LETs, since this is common to all high current systems.

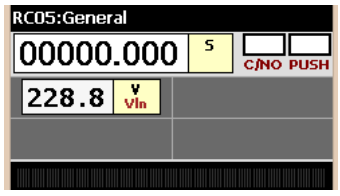


The quality of the main supply

An essential point to get the maximum from the system is to care about the proper supply voltage to the Raptor, which will drop dramatically as you raise the Raptor output, demanding more power from the main supply.

The worst case happens when used an extension cable; the standard extension cables cross section is ONLY from 1.5mm2 to 2.5mm2. It is critical that the extension cable be an industrial one, with a minimum cross section of 10 mm2, and if the length of the extension is over say 5 m, the cross section should increase as well. It also very important the proper insertion into the plug (or whatever method is being used to connect to the supply) to avoid contact failures; be aware that the RAPTOR draws significant power from the network.

As an example the following photos of a customer using to supply the system an extension which is evidently insufficient. It needs bigger cross-section of cables, otherwise the voltage loss in the extension will be very high reducing greatly the RAPTOR efficiency.
Raptor gives maximum power when fed at 240 Vac. When this voltage drops during the test, the maximum output current, or maximum output voltage, will also drop.



The new Vin Measurement instrument implemented in the RAPTOR shows the actual voltage input value to the test set, measuring the input voltage continuously, during the whole test, helping the user to know if the voltage supply is adequate.
The Raptor calculator allows you to introduce the supply value, but it needs to be the full load voltage, not the no-load voltage.

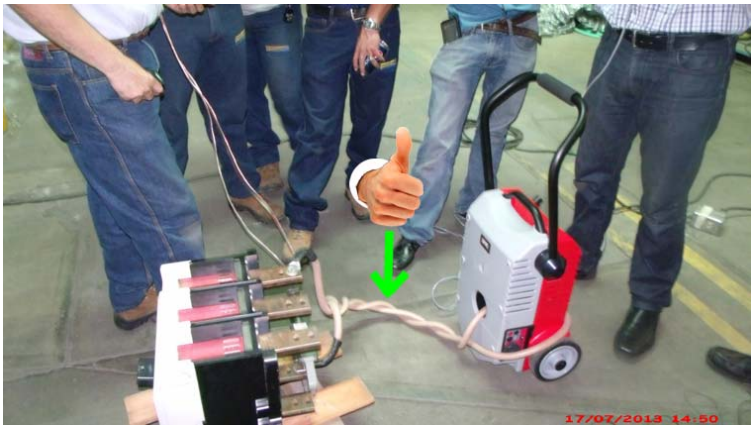
Use the right winding side.

A common mistake is to make the cable layout using the WRONG side of the Raptor, as in the following photo; the right side to turn cables around the Raptor body is marked in the equipment. As commented, the cable/s must be placed as tight as possible to the Raptor body, making small loop, and closer to the internal toroidal, but in the proper side, avoiding including the power supply cable into the loop. The system will work in the wrong side, but the efficiency and output got will be much lower, and of course you will not get the maximum predicted by the Calculator.

Twisting Cables

Twisting cables help to get the most of the system, but a common mistake is to twist the cables that form the same Test Lead, which not provides the desired benefit (which is to cancel as much as possible the inductive effect). The next photo shows this misconception.

When we insist in the necessity of twisting cables, or lay them parallel and as closer to each other as possible, we never refer to the cables themselves but to the **Test Leads** that can be (or not) composed by various cables. One test lead is the part of the conductor which, from the load, "enter" to the Raptor and the other test lead is the part of the conductor that, after exiting the Raptor turn around the equipment body and run to the load. These are the ones (the test leads) that need to be twisted (or run together) for as long as possible.

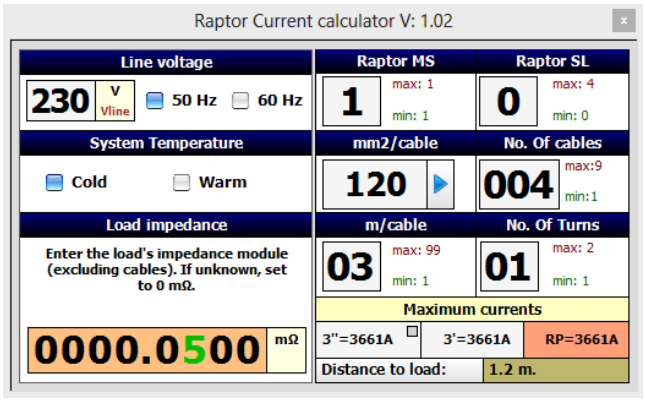


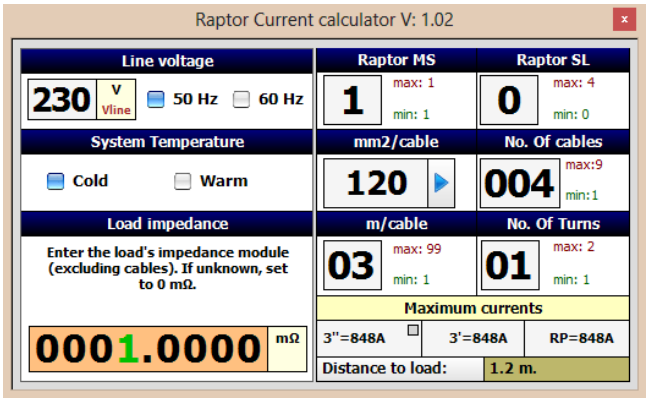
The Impedance of the DUT (Device Under Test) and the Current Calculator.

Not all the DUT's have the same impedance and in some cases it may be noticeable. The calculator has a place where it is possible to introduce this value, and must be considered at the time of planning the required configuration to get the desired output.

For example, a CT typically has much lower impedance than an ACB (air circuit breaker) or a MCCB (molded case circuit breaker). In the CT case, introducing an estimated or measured impedance value in the Calculator will not affect that much the calculated output current, but in MCCB's it may affect the calculated current a great deal as it is relatively high compared with the connection circuit.

The next two screenshots of the Current Calculator shows the big effect in maximum output when considering quite different values of the load´s impedance.





In the same way, the total test circuit impedance limits the current (load + cables + connections) so, using the shortest cables as possible has a direct impact on maximum possible current. The small size and weight of the Raptor allows placing it **closer to the device under test**, even to place the Raptor in a table, platform, raised close to the load, etc.., reducing the distance to the load, allowing using **shorter cables** and getting therefore higher current in the load.
There is no reason to burn power in unnecessarily long cables.

With the same purpose, it is placed more **cables in parallel** to reduce the impedance of the circuit. Sometimes the only solution to get the maximum current required is both, to reduce cables length and to increase cross-section of the test leads by adding cables in parallel (or using cables with bigger section).

It is also very important a **good connection** to the load. Dirt, grease, corrosion, or a small contact surface in the connections, increase much the impedance and reduces the maximum current obtained. Try to connect cables to the device under test with the largest and most clean contact surface.

Number of turns

In our traditional primary injection equipment, the LETs, it is advised to use a lower tap if still cannot reach the desired current, having chances to get it from lower (higher compliance voltage) taps, mainly with big impedance loads that requires higher voltage. The same is used in the Raptor system, but with the number of turns. The difference is that in the Raptor system, there is higher number of output ranges, enabling you to adapt more to the voltage/current need, and in a simple way.
Thus, the best adaptation will always be achieved when you can wind the maximum number of turns, for the required current and time.

Using the Raptor Slaves units to make the testing easier and faster

Generally speaking we are always trying to find the configuration to be able to get the highest possible current with the minimum of units, which corresponds with the minimum purchase value, hence the minimum of Raptor-SL units.
This being true in most occasions, it is also important to point out that the Slaves units also allows to the operator to be less attentive to the cabling layout, to the distance to the load or with the connections quality. Setting up the cable layout as shown at the beginning takes time and attention from the operator.

Therefore, some of the described advices can be very well avoided by just adding one more Raptor Slave unit to the system, justifying the initial higher investment with the simplicity of the training that the operator will need and in the testing speed, which is much better as no special attention will be needed to the cabling layout for example. Also, adding Slaves is a very simple and quick process, and thanks to the infrared connection user does not need to connect any cable between units.

CONCLUSIONS

For obtaining the maximum power of the high current injection system, the following points must be observed:

- Cabling layout must be optimized, by tightening the turn to the Raptor body and twisting or firmly tying together the connection test leads. Generally speaking, make a proper layout for avoiding the high impedance due to inductance.

- Be sure to use a suitable power supply line with enough power for your configuration, avoid voltage drops in the supply, check the quality of the connection plug and pay attention to not suitable extensions and/or provide the suitable cross section.

- Use the right side of the Raptor to turn cables.

- Take in consideration the impedance of the device under test in the configuration selected. Test object impedance can be measured. Use the Test Template included in Raptor for this purpose, or any other instrument to measure it.

- Be sure that the connection to the device under test is properly made, using either screws or if a kind of C clamp used, make sure they are tight and allowing the maximum contact surface. The calculator assumes a reasonable good connection point to the load.

- Use the Raptor Calculator; it is a simple to use, yet sophisticated and reliable tool, to define the suitable Raptor configuration and number/section/length/turns of cables required as minimum to successfully accomplish a specific high current job. The Raptor Current Calculator is included as standard in the Raptor HH console, but can also be installed on any PC. (http://www.eurosmc.com/downloads/winraptorcalculatorinstaller.msi)

- Update your Raptor System with the latest software available from EuroSMC, securing to use the latest improvements and algorithms for all the functions.

- Use Raptor Slaves for having higher power available in the system, minimizing the effect of any of the above circumstances, and not paying much attention to the same.

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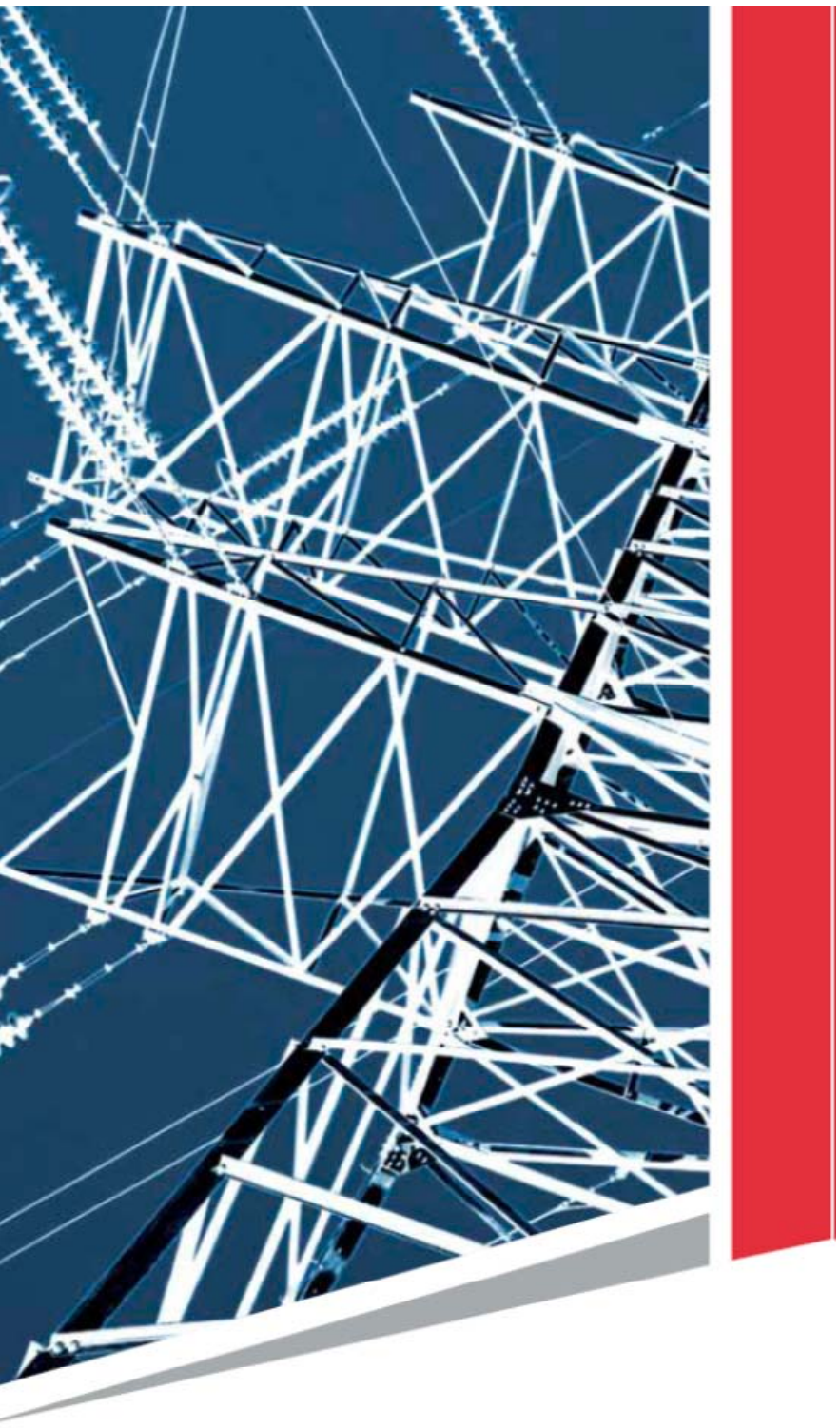

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