Star-C - A New Converter Topology

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Power electronics is today used almost everywhere. The development of power electronics hardware is fast, pushing the performance limits forward. Still the conventional two level converter is the most commonly used converter on the market. The pulsed output voltage from the two level converter generates high amount of electro magnetic emissions, which is one of the problems the new Star-C converter aims to solve.

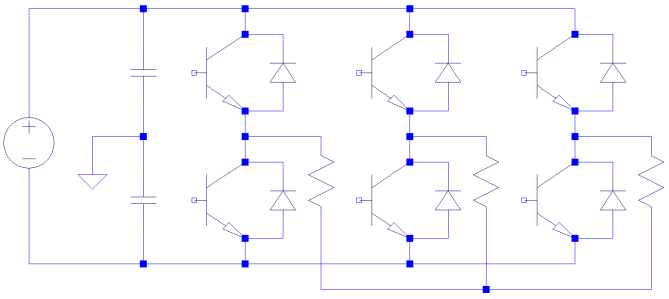

Figure 1: *The 2-level converter.*

The Two Level Converter

The output voltage of the conventional two level converter is generated as pulses. The pulses are generated with semiconductor switches with short switching times to keep the switching losses at an acceptable level. The big voltage steps combined with the short switching times cause very high voltage derivatives with a lot of harmonic content.

Such derivatives generates high amounts of electromagnetic emissions that may cause electromagnetic compatibility (EMC) problems. In these cases some kind of physical implementation has to be made in order to reduce the emissions. This can be done by integrating the converter and load in the same encapsulation, shielding of cables and connectors or adding filters to the converter. EMC handling implementations both increase the cost and limit the freedom of installation. Therefore, it results interesting to find alternative converter designs that allow the need for such implementations to be minimized or spared.

The Star-C Converter

The Star-C is a new converter topology invented by Hans Bängtsson. This converter can provide a continues output voltage waveform by the means of charging output capacitors. This results in a close to perfect sinusoidal output voltage with much lower harmonic content than the pulsed output voltage from the conventional converters, see figure 4.

With the low harmonic voltage output from the Star-C there is no need for EMC-handling implementation. This gives the Star-C a big advantage over the two level converter in applications where there is no space for encapsulation and filters or need for cables to long to shield.

Another big advantage with the Star-C converter is that it can utilize zero current switching, which reduces the switching losses, yielding high efficiency. The high efficiency combined with the close to perfect sinusoidal output makes the Star-C a very attractive converter.

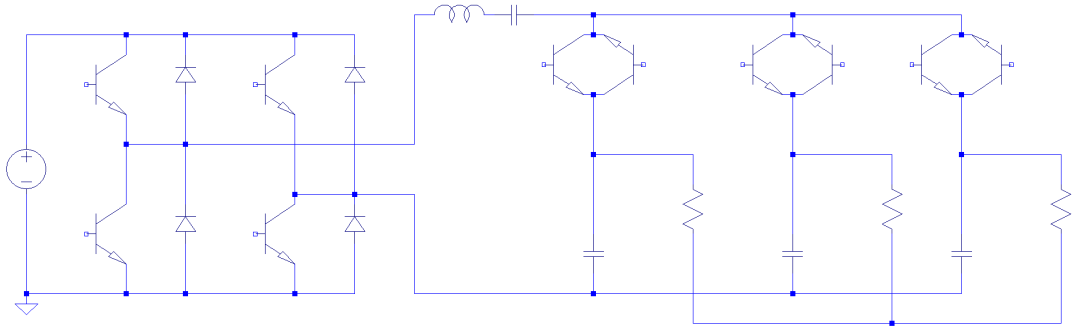

Figure 2: *The Star-C converter.*

Two Level VS Star-C

Simulations are used to compare the two converters with each other. The performance is quantified in terms of total harmonic distortion (THD) and efficiency. THD is a measurement of the power quality of the output voltage, and is defined as the ratio between the sum of the power at all harmonic components and the power at the fundamental frequency. Ideally all the power is at the fundamental frequency which yields a THD equal to 0%. The efficiency is the ratio between output- and input power and is ideally 100%, which would mean that there is no power losses in the converter.

Comparing the harmonic spectra in the figures below it is apparent that the Star-C got lower harmonic content than the two level converter. Both spectra got a high power at 178Hz, which is the wanted fundamental frequency in the figure example. However, the two level converter got much more of the unwanted high frequency content than the Star-C. The converter comparison is summarized in table 1 below. It is clear that in terms of performance the Star-C is uncontested.

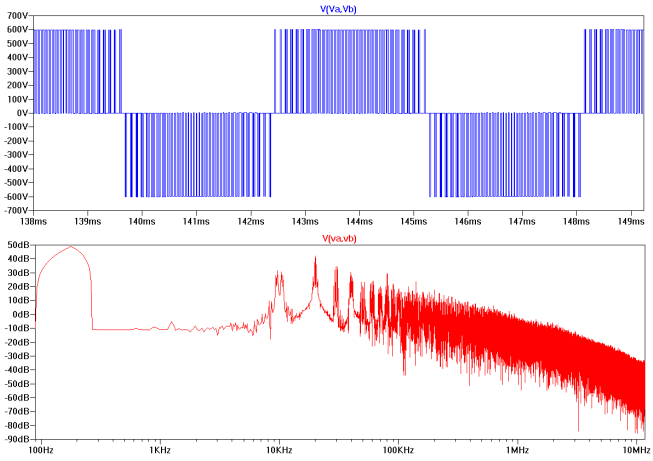

Figure 3: *Phase-to-phase voltage and harmonic spectrum of the output from the two level converter.*

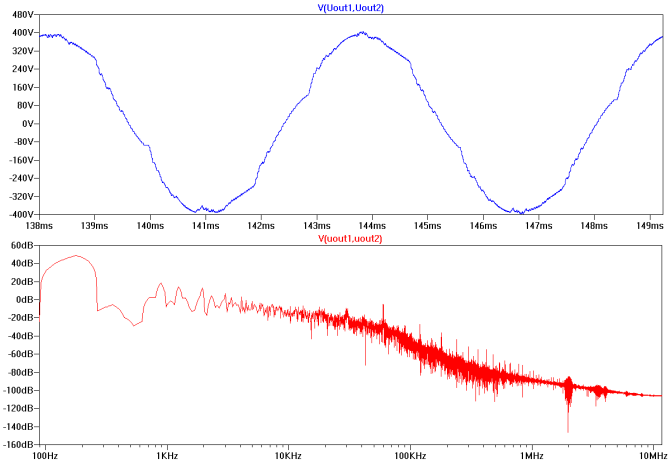

Figure 4: *Phase-to-phase voltage and harmonic spectrum of the output from the Star-C converter.*

The cost of the converters are also presented in table 1. The cost is approximated by Gabriel Domingues and Pontus Fyhr, and contains both hardware and production costs. It is here the big drawback of the Star-C converter lies. The cost of the Star-C converter is almost four times as high as for the two level converter. However, this cost approximation does not take EMC handling into consideration, which would increase the cost of the two level converter in the comparison.

	THD	Efficiency	Cost
2-level	96.5%	92.7%	5597kr
StarC	4.2%	94.7%	19000kr

Table 1: *Result summary*