NVA100X-C

THE LATEST SOLUTION FROM THYTRONIC FOR HARMONIC FILTER & CAPACITOR BANK PROTECTION

PRO N eXtended

— Harmonic filtering – why?

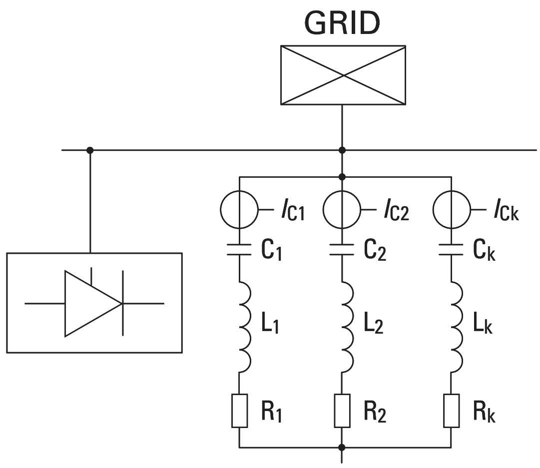
In recent years the harmonics producing part of total load has increased continuously because of the massive usage of power electronic in all the voltage levels. Thyristor convertors, frequency convertors, thyristor switches and static var compensator, such as thyristor controlled reactors (TCR) and thyristor switched capacitors (TSC), are commonly adopted in industrial applications and power utilities.
The large amount of nonlinear loads significantly affects the power quality in a power system and, consequently, the quality of the electric power.
The presence of significant harmonic currents causes problems in additional transformer capacity, make power factor correction more complicated, generates resonant conditions which magnify the distortion levels causing excessive overvoltages.
One of the most common methods to prevent adverse effects of harmonics is the use of passive filters. Different configurations should be considered, however all of them include capacitors and reactors that must be protected.

— Kind of harmonic filters

Designing filters' structures lead to mainly these three selections:

A group of single-tuned filters

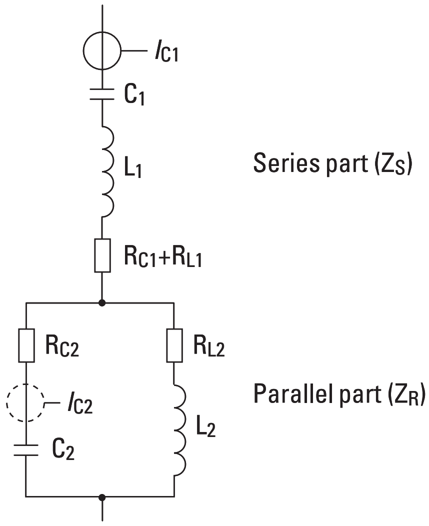
At first sight one NVA100X-C is adopted for every single-tuned filter branch



Single-tuned filters - Typical configuration

Double-tuned filter

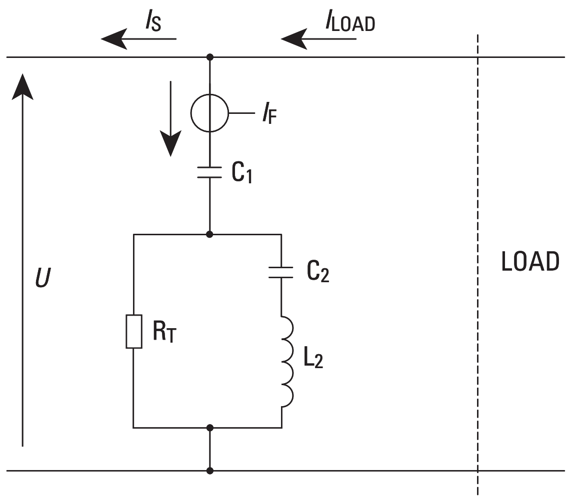
An additional ring type CT could be taken into consideration at the designing stage, therefore two NVA100X-C might be adopted for double-tuned filter for protecting C1 and C2.



Double-tuned filter – Typical configuration

C-type filter

Largely adopted in high frequencies filtering, these broadband filters have more advantages when co-operating with power electronic converters and eliminating interharmonic components.

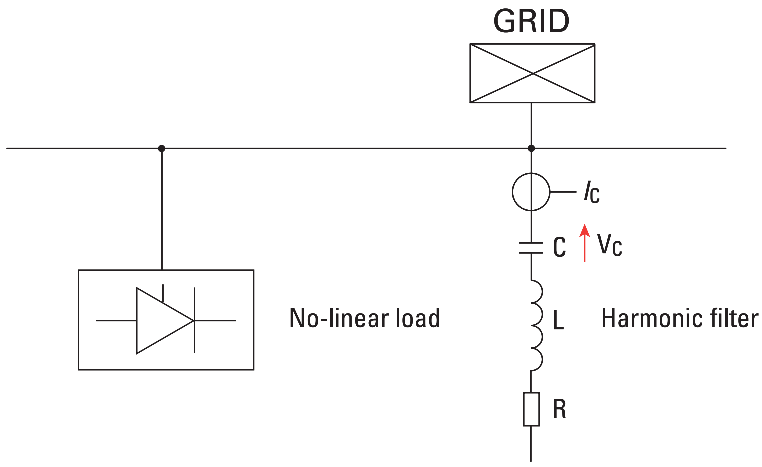


Double-tuned filter – Typical configuration

The wide flexibility of NVA100X-C's setup let users also to find a solution for more complex filter configuration such as double-tuned filter and C-type filter (engineers engaged in harmonic filter design can provide a computation about the contributes in terms of harmonic current in each part of the filter).

The reasons to use the peak repetitive overvoltage function – 59H

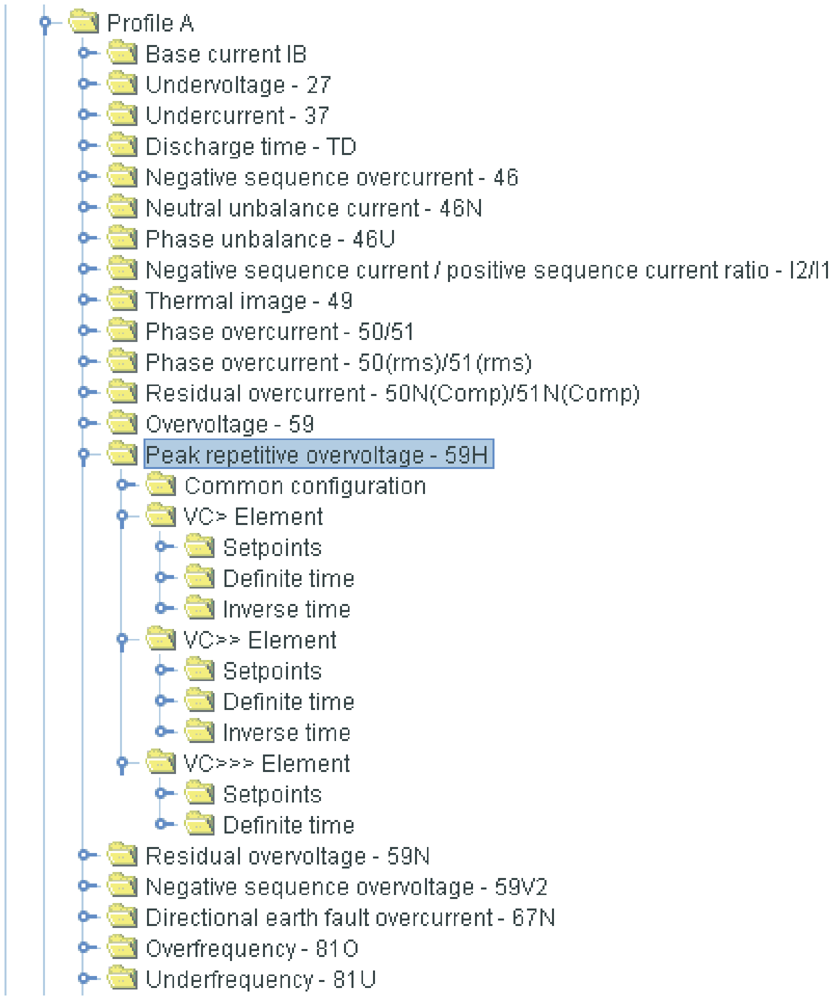
The weakest component in the filter is the capacitor. It is mainly necessary to protect it against peak overvoltages, due to fundamental and harmonics currents, which might lead to dielectric breakdown. The design of a capacitor bank take into consideration to make it able to withstand a sinusoidal voltage of 110% of its rated voltage at rated frequency, therefore withstanding a peak repetitive voltage equal to $1.1\sqrt{2}E_n$, for an extended period, therefore the true voltage waveform across the capacitor must be acquired.
Because the terminals of the capacitors are not accessible, in order to measure the V_C voltage across the capacitor (red arrow in the following schematic diagram), the only solution is to calculate the voltages from the three-phase line currents (fundamental frequency component and harmonics up to fiftieth order in NVA100X-C) for any phase by means of mathematical treatment of the fundamental and all the harmonics of the relative voltage components. The peak overvoltage protective function applied to the capacitor bank, using the phase current waveforms in an advanced signal processing algorithm, is called 59H in NVA100X-C.



Schematic representation of a filter branch where the voltage across the capacitor is investigated by the peak repetitive overvoltage function - 59H.

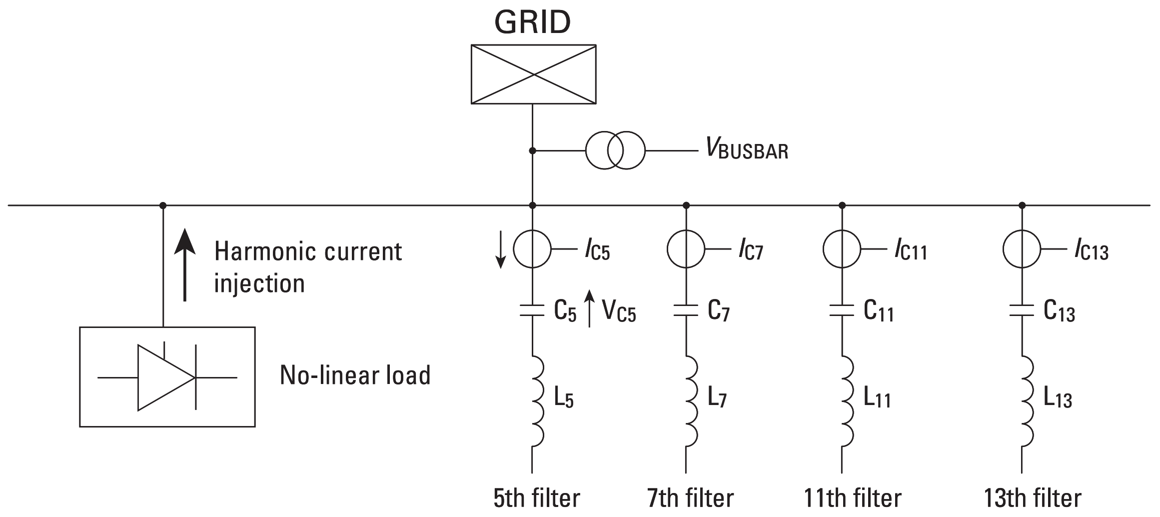
For peak repetitive voltages above $1.1\sqrt{2}E_n$, an inverse time curve defines the time the capacitor can withstand the peak repetitive voltage before a damage.

NVA100X-C proposes three independent stages for this function, the first and second can be either inverse time or definite time, letting the engineers to define the best setup.

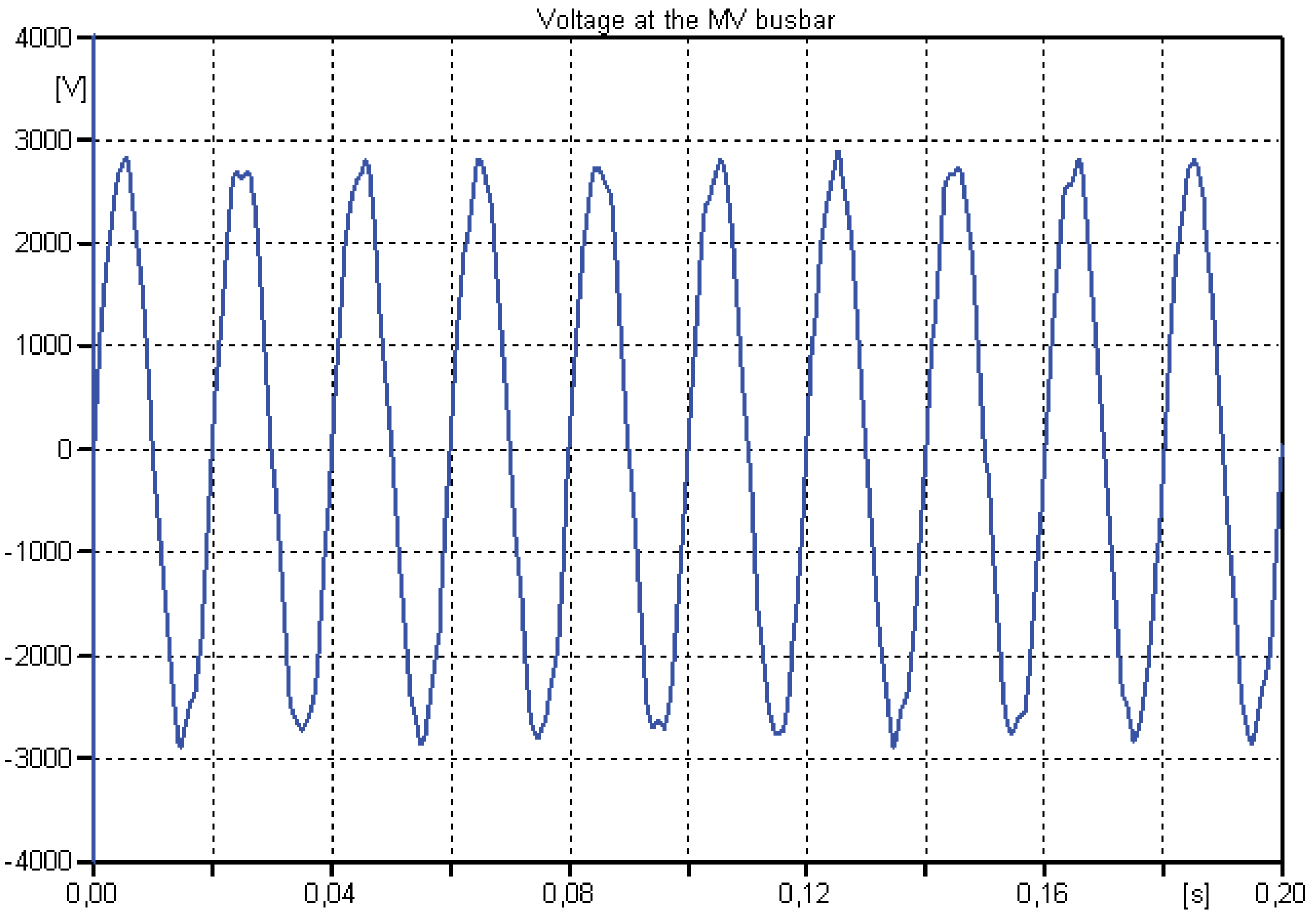


— A case study

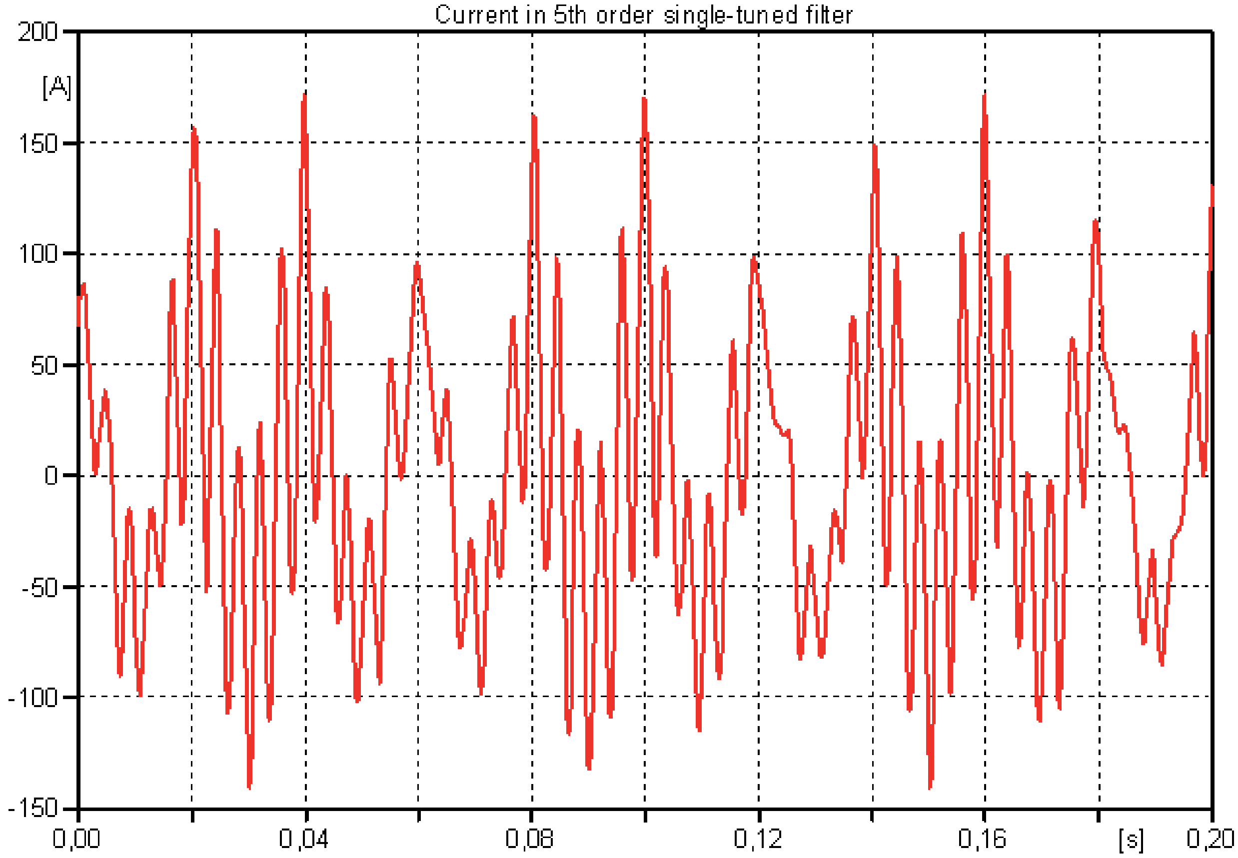
An industrial plant has been analyzed where the effects of the no-linear loads have been balanced by 4 different single-tuned filters for 5th, 7th, 11th and 13th order of harmonics.
In the scheme below the harmonics current injection is caused by the no-linear load.



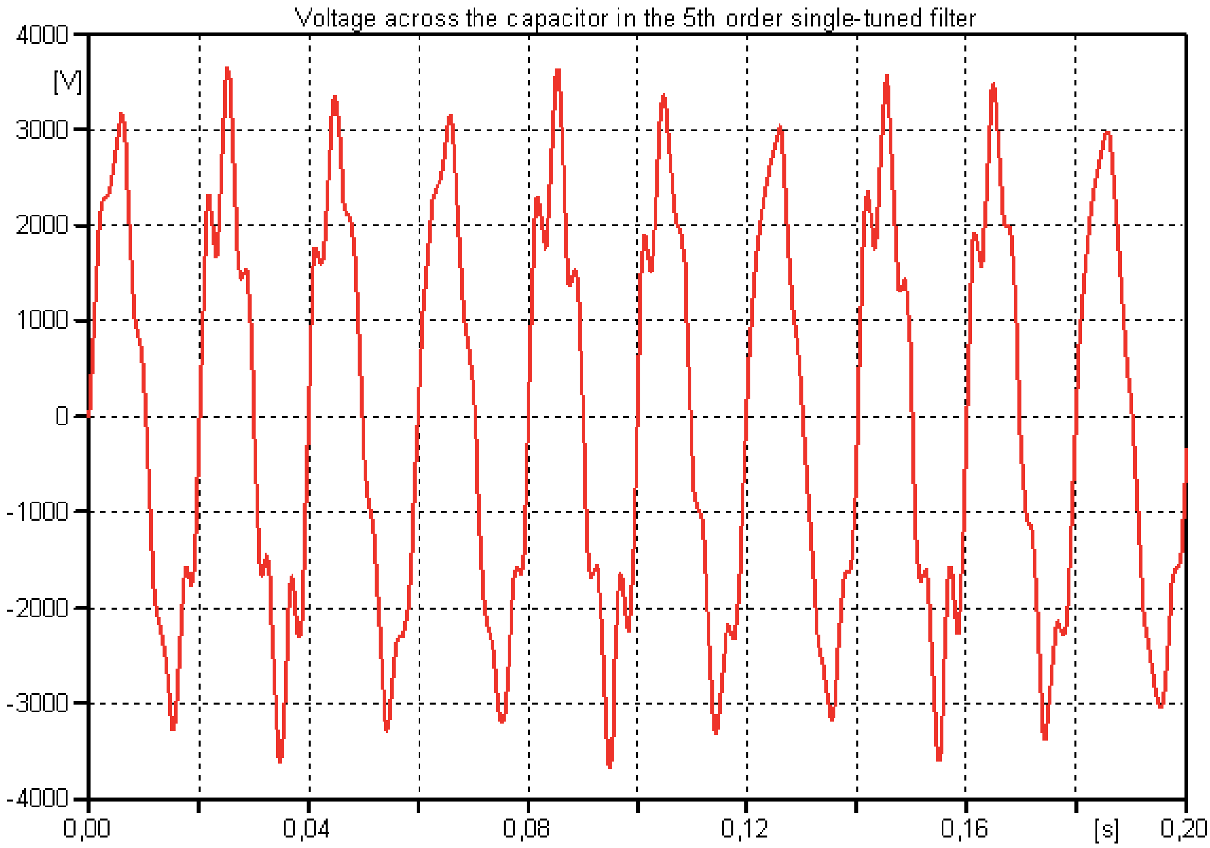
The voltage measured at the MV busbar (V_{BUSBAR}) shows an acceptable level of voltage distortion.



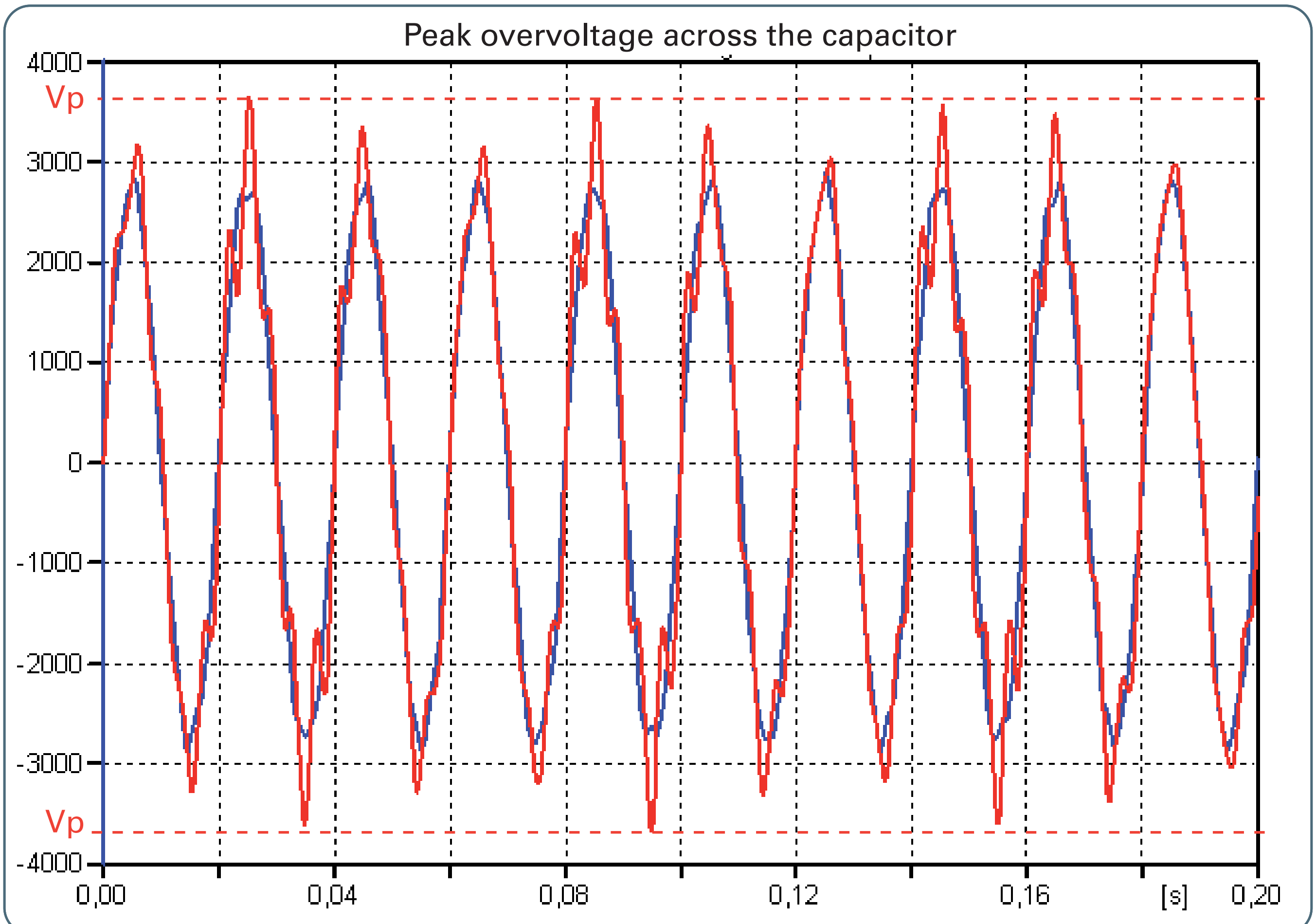
The current through the 5th filter is shown (I_{C5}).



Looking at the electrical quantities into the filter itself they show in detail the real voltage stress at the capacitors; the I_{C5} current generates the V_{C5} voltage waveform across the capacitor in the 5th order single-tuned filter



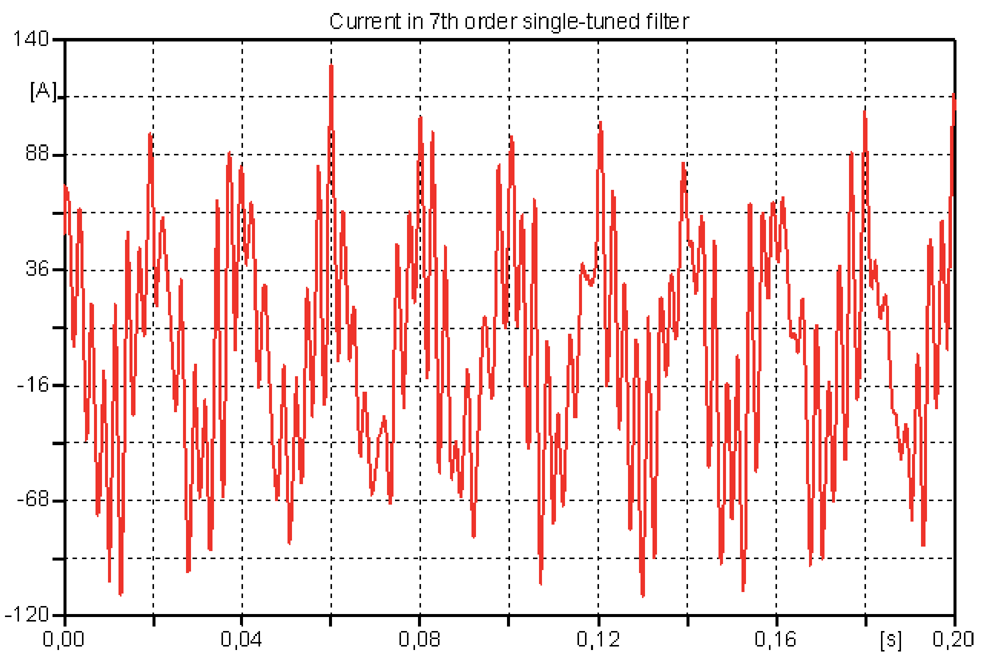
Overlapping the V_{C5} waveform (red trace) with the MV V_{BUSBAR} voltage (blue trace) it is evident how higher can be the voltage stress at the capacitor, thus to bring capacitor to failure.

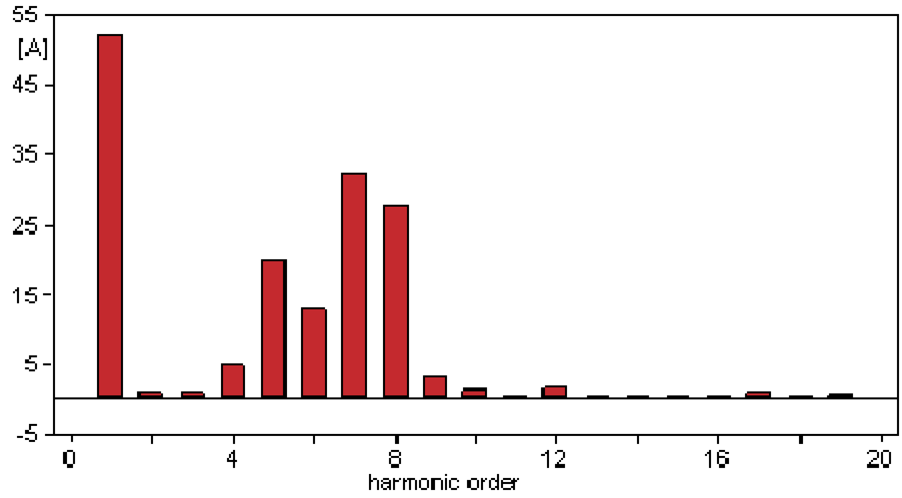


The solution is to calculate the peak repetitive overvoltage (dashed red line), monitored by the 59H function available in NVA100X-C.

Further protective functions for capacitors

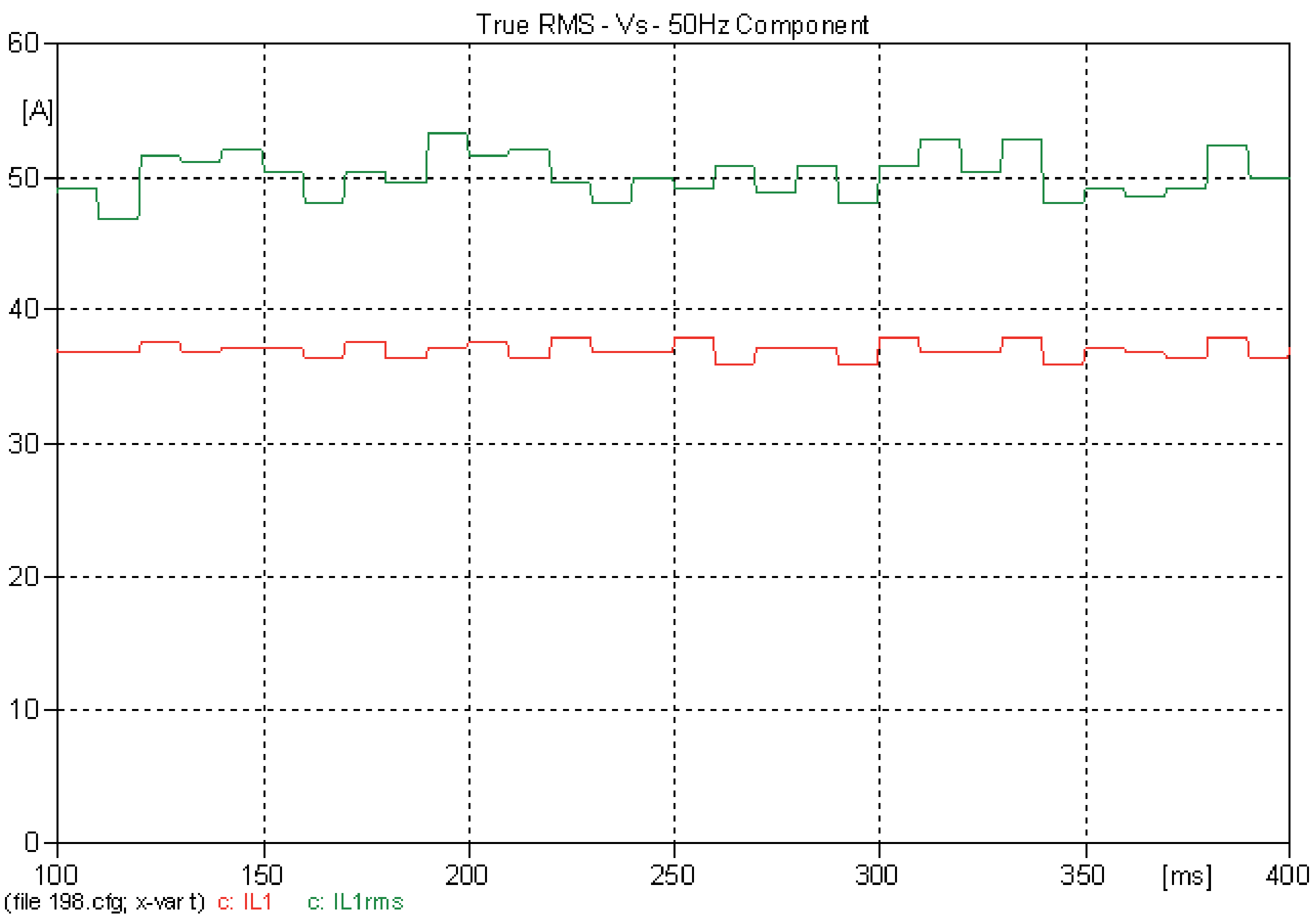
True rms phase overcurrent
50/51rms



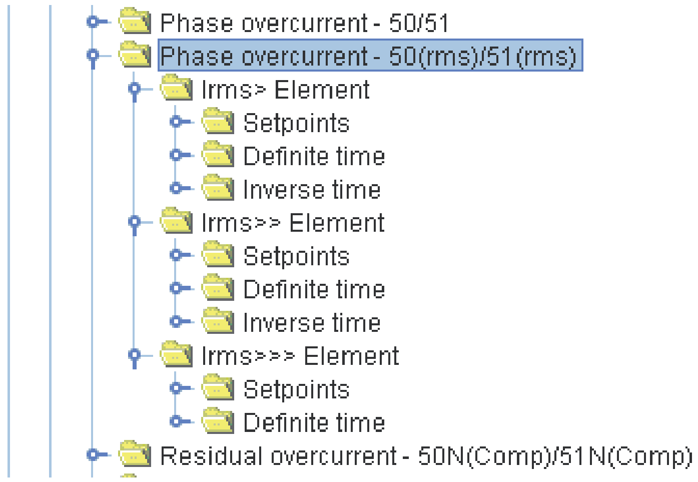


In event of a high harmonic content the 50/51RMS function is requested in a capacitor bank protection.
The filter is mainly loaded with the fundamental harmonic and the harmonic to which it is tuned.
The analysis of its spectrum shows clearly even the influence of all the other components.
The peak of the current of the fundamental component is 52 A while the peak of the true RMS current is around 130 A.

The large difference between the fundamental component of the current (red line) and the TRUE RMS of the current (green line) is shown in the next plot where the contribute of all the harmonic components is considered.

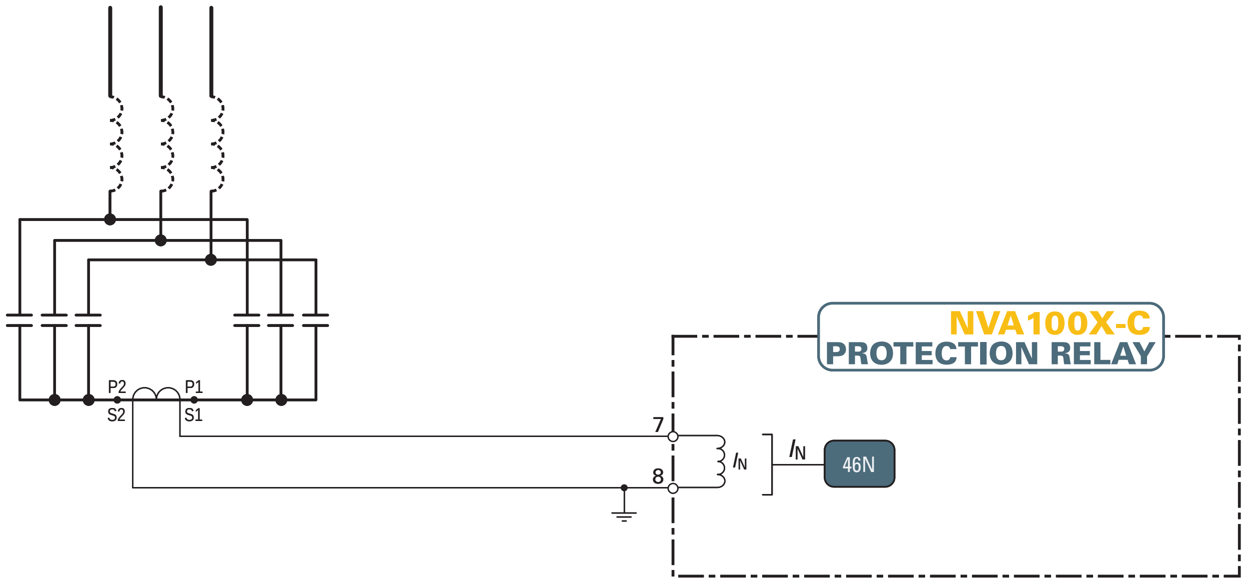


In a protection relay for capacitor bank the availability of the function 50/51RMS phase overcurrent (True RMS type) is requested. The function available in NVA100X-C provide high protection because it realize harmonic analysis up to the 50th order, with three independent thresholds (where the first and second can be set as inverse time curve or definite time).



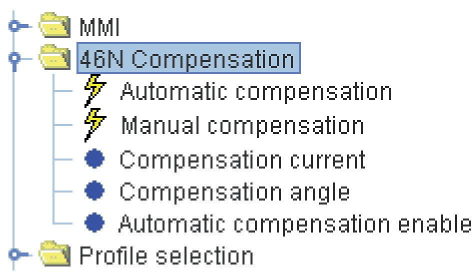
Unbalance current – 46N

The analysis of the unbalance current leads to one of the most used function for capacitor banks protection in double star connection.
A suitable CT measures the current flowing between the two neutral points, in NVA100X-C it is available a 46N function with three stages, typically one stage for Alarm and two for tripping.



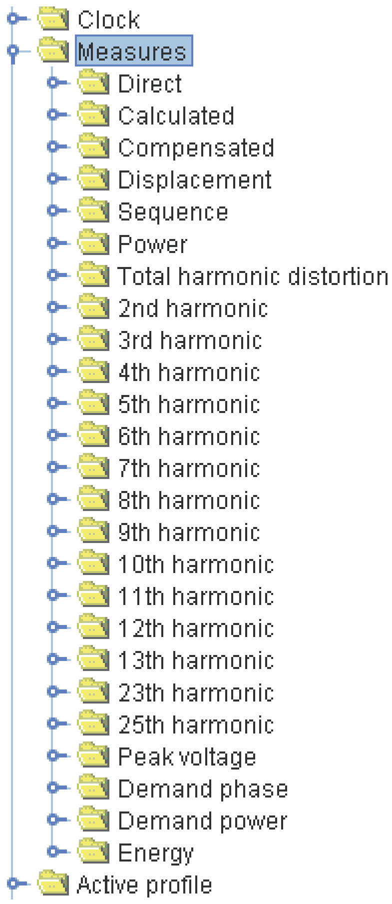
Double Star unearthed capacitor bank

Due to the natural unbalance of the capacitor banks this current might be different from zero during the steady state. In order to take over this condition a proper compensation may be performed. In NVA100X-C it is possible to use a Manual compensation (defining both magnitude and angle of the unbalance current) or an Automatic compensation.



Additional plus in NVA100X-C

The measures available inside the **Rad \ Measures** menu, together with the oscillographic waveform recording, the list of faults and events, represent an effective tool supporting the engineers in tuning the setup of the NVA100X-C during on-field operation.
Nearly 200 quantities are monitored, grouped in several sub-menu like i.e. *Direct* (directly from the 8 analogue inputs), *Sequence* (for checking the right insertion) and *Harmonic Component* of the phase currents (both magnitude and angle).
These quantities can be even used in a proper environment for modelling an electric power systems, i.e. leading to the calculation of the threshold of the peak repetitive overvoltage function 59H.



Sede: 20139 Milano - Piazza Mistral, 7 - Tel. +39 02 574 957 01 ra - Fax +39 02 574 037 63
Stabilimento: 35127 Padova - Z.I. Sud - Via dell'Artigianato, 48 - Tel. +39 049 894 770 1 ra - Fax +39 049 870 139 0

www.thytronic.it www.thytronic.com thytronic@thytronic.it