STATIC CAPACITOR BANKS

Advantages in front of conventional (contactor) banks

When compensation of reactive power is required, depending on the type of loads in the installation, it may be necessary to do a selection between a traditional capacitor bank and a capacitor bank with static contactors. This technical note gives information to make easier this selection as it shows the advantages and disadvantages on the use of a capacitor bank with static contactors in front of a traditional capacitor bank.

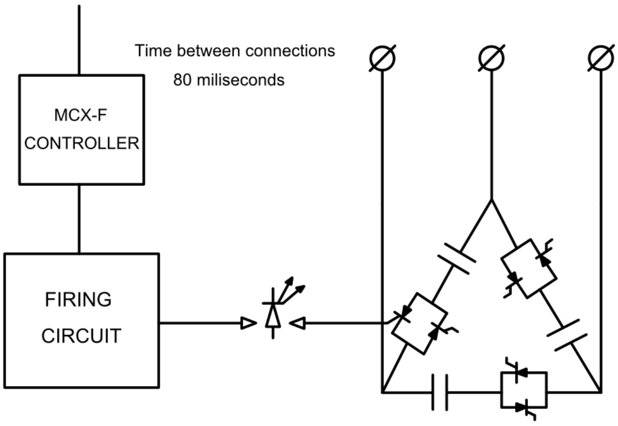

Figure 1: Automatic capacitor bank with static control

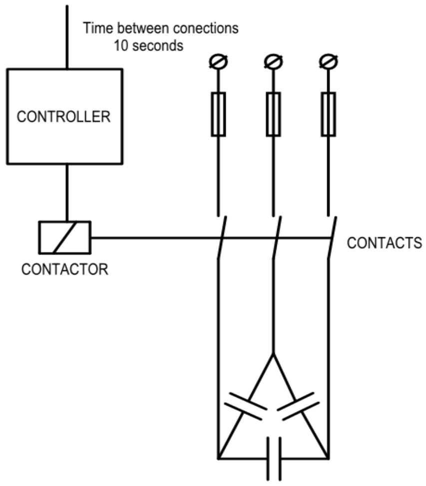

Figure 2: Automatic capacitor bank with contactors

Automatic capacitor banks with static contactors are a new generation of compensation equipment that uses the latest semiconductor technologies that have been rise in the last years. These banks use static contactors (thyristors or SCR) instead of conventional contactors. They are formed by a fast response reactive power controller, an electronic control circuit that gives the firing pulses to the thyristors, three pairs of anti-parallel connected thyristors and a group of MiniFILMETAL or FILMETAL power capacitors.

1. Advantages of SCR system over contactor system

Traditional reactive power compensation equipment with electromechanical contactors has a well proven performance in installations where loads have slow variations and are not very sensitive to voltage fluctuations. Today, however, more and more industrial installations include electronic equipment very sensitive to voltage variations (like PLC's, computers, etc.) and also very fast changing working cycles (automatic welding machines, robots, etc.) The thyristors switch on capacitors on zero crossing voltage, and switch them off on zero current situation. This firing strategy grants a totally transient free switching of power capacitors, avoiding any problem with transient voltages (Fig. 3). This added to the no existence of mechanical contacts give some advantages to SCR systems over contactor systems:

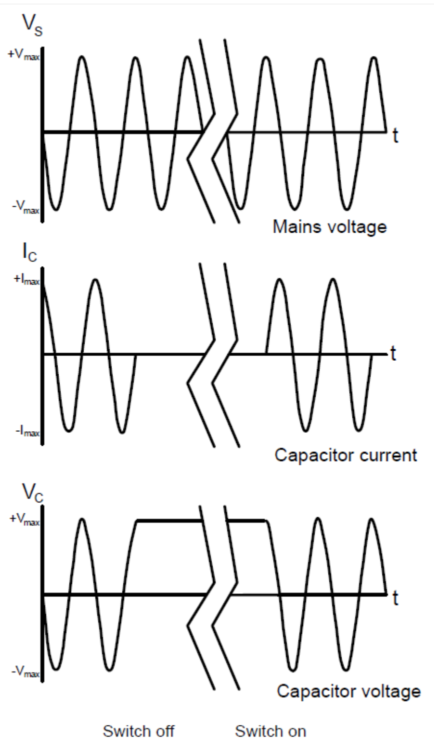

Figure 3: Switching on/off in a capacitor bank with static control

Speed

The transient free switching gives a very fast reaction time of the power factor equipment in front of sudden reactive power demand variations. This reaction time (the time to switch on or off a capacitor step) is usually not higher than 80 milliseconds. That means that up to 12 operations per second are possible.
With the traditional contactor system a much higher delay in the connection of each new step is required in order to assure the discharge the capacitors. A typical delay is 10 seconds. That means that, with a 12 steps bank, two minutes are required for its total connection, while with a thyristor system this time is only about one second.

Overvoltage

According IEC 831, when a step is connected in a capacitor bank with contactors, an overcurrent up to 100 I_N goes through the capacitor causing an overvoltage up to $2\sqrt{2}\ U_N$. If the busbar also have connected loads sensitive to voltage fluctuations like PLC's or computers, these may have a bad function during the switching transients. With an automatic bank with static control this overcurrent does not exist allowing the connection of any kind of load to the busbar.

Maintenance

The contacts of the contactors used in the capacitor banks have an expected service life of 100.000 switchings, which means in normal operation they must be changed in about two years. The change of these contacts is an important expense in materials and in labour. With a capacitor bank with static control no maintenance works are required and only is necessary a simple revision from time to time.

2. Disadvantages of SCR system over contactor system

Special capacitors

In the capacitor banks with static control each phase of capacitor step is controlled by the firing circuit, which means we must have access to each phase of the three phase capacitor. We must use in this capacitors banks the FMS capacitors series with six terminals or use three single phase capacitors in each step. These capacitors are a little more expensive than standard series.
In capacitor banks with traditional contactors, standard capacitors are used.

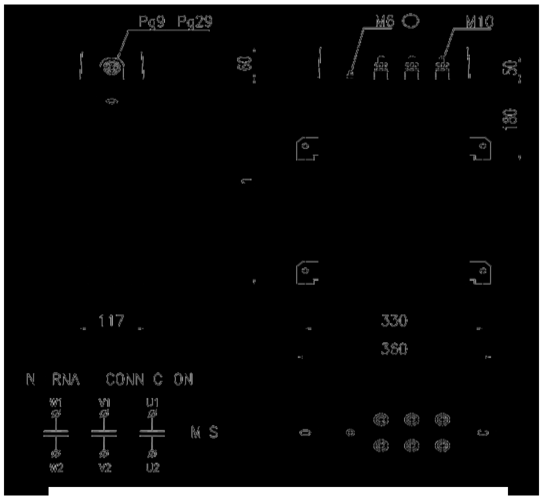

Figure 4: Special capacitor with six terminals, FMS series

Isolator

Capacitor banks with static control require an isolator, in order to do maintenance works due to the fact that thyristors do not guarantee the galvanic isolation of the capacitors.
This is not an important disadvantage because in some countries this isolator is required by local standards and in many others this isolator is placed in any case to assure the safety of the works.

Fuses only protect the capacitors

To protect the thyristors in front of external overcurrents, ultra-fast fuses are needed. These fuses are usually almost as expensive as the thyristors themselves. In order to be cheaper, in the capacitors banks with static control this protection is not installed and only limiting inductances (to avoid high di/dtin internal delta connection of the capacitors) and standard protection fuses (to protect the capacitor, the cables, etc.) are installed.

Heat

In capacitor banks with static control it must be taken into account the heat generated by the thyristor losses. This heat is evacuated by means of heat sinks properly calculated.
It is very important to install the capacitor bank in well ventilated places and to leave enough room close to heat sinks in order to assure a proper cooling. Minimum distance between heat sinks and walls should be 200 mm. That is shown in the next example:

Capacitor bank with 7 steps of 80 kvar 400 V

$$I_{NC} = \frac{Q_N}{\sqrt{3} * U_N} = \frac{80000\ var}{\sqrt{3} * 400V} = 115.5\ A$$

The line drop in thyristors is typically 0.9 V (maximum 1.8 V), that means that the active power loses in thyristors is:

$$P = \sqrt{3} * U_N * I_{NC} = \sqrt{3} * 0.9V * 115.5A = 180W$$

The typical power losses in a 160 A contactor are 19 W.

That means that the additional power losses of use thyristors instead of contactors are:

$$P_{add} = P - P_{cont} = 180W - 19W = 161W$$

If we suppose a function of the capacitor bank during 16 hours a day, 365 days per year, the total increment of energy is:

$$E_{add} = 7\ steps * 161W * \frac{16\ hour}{day} * \frac{365\ days}{year} = 6581\ kWh/year$$

Price

The capacitor banks with static control include the latest technologies in the world of semiconductors. These technologies are expensive and cause that this system of capacitor banks be a little more expensive than the contactor system. This additional cost is however compensated by the fact of the no necessity of maintenance works.
Another overprice to be taken into account in the capacitor banks with static control is the consumption of active power due to the active losses of the thyristors, as it is shown in paragraph Heat.

3. Conclusions

It is not possible to give a simple rule to choose between traditional and static contactor capacitor banks.

The selection of capacitor banks with static contactors is usually recommended in cases where a fast response of the compensation equipment is required (automatic welding machines, robots, etc). In these cases the additional cost of the static capacitor is compensated by the fact that with traditional equipment a correct compensation is not possible. This equipment is also recommended in case of installation sensible to voltage variations.

Note: Usually, the installations with a fast variation of the load have also a high distortion level of harmonic currents, for that reason sometimes it is necessary to install capacitor banks with static contactors and protection filters.