An Isolated Topology for Reactive Power Compensation with a Modularized Dynamic-Current Building-Block

Introduction:

Proliferation of non-resistive loads imposes power quality concerns over the existing grid network. The reactive power loads, which possess a low power factor, draw high amount of volt-ampere reactive power from the grid and thus restrict the active power transfer capability. The excessive reactive power flow over the network heavily burdens the transformer, distribution and transmission lines, increases the line losses, and impacts the voltage stability. Reactive power compensators used for grid support with slow dynamic response include the mechanically-switched capacitor with damping network (MSCDN), the thyristor switched capacitor (TSC), and the thyristor-controlled reactor (TCR). A static synchronous compensator (STATCOM), built using voltage source converter (VSC), can provide reactive power support with a less noisy sinusoidal current injection due to operation at higher effective frequency and generally take up less real estate compared to TSCs and TCRs for the same level of harmonics and power rating.

Existing system:

The Multi-level STATCOM architectures such as the diode or neutral-clamped, flying capacitor, and cascaded H-bridges, can be scaled to medium voltage with fractionally-rated components. VSC-based VAr compensators require bulk energy storage, typically
implemented using electrolytic capacitors, to support the DC link voltages. While the technology advances in electrolytic capacitors have come a long way, compared to film-based capacitors, they still have reliability and safety issues that contribute to a shorter life. In addition, fault management in a VSC-based architecture is made complex due to the presence of DC source(s) that can contribute to high fault currents, requiring fast detection and isolation. As reliability and long life is of utmost concern with utility-grade equipment, a technology that can provide STATCOM functionality but with higher reliability and longer life is needed. As an alternative to the VSC based VAr compensator, this paper proposes a novel modular current source inverter (CSI) based topology to provide STATCOM functionality. The topology is derived from Dynamic-Current or Dyna-C, a patented power converter capable of transferring energy for two- or multi-terminal DC, single- and/or multi-phase AC systems.

**Disadvantages:**

- Excessive reactive power flow over the network heavily burdens the transformer,
- Distribution and transmission lines,
- Increases the line losses,
- Impact the voltage stability.

**Proposed system:**

The proposed topology of the Dyna-C DVC, which is also a modular building block, consists of three single-phase CSI modules coupled together with a three-winding medium- to high-frequency transformer. Appropriate LC filters are used around the three low frequency AC terminals for suppressing switching harmonics in the
current. Unlike a CSI, the magnetizing inductance of the transformer itself is used to store energy. The modules are the proposed topology of the Dyna-C DVC. The topology, which is also a modular building block, consists of three single-phase CSI modules coupled together with a three-winding medium- to high-frequency transformer. Appropriate LC filters are used around the three low frequency AC terminals for suppressing switching harmonics in the current. Unlike a CSI, the magnetizing inductance of the transformer itself is used to store energy. The modules are to isolate a fault on one phase from propagating to the other two phases, especially in medium-voltage application where the fault could quickly bridge the phases and propagate through all the modules, compromising safety and speed of fault isolation. However, in low-voltage applications in which alternate safety mechanisms are provides, the three-winding transformer can be replaced by an inductor with a single winding and a core. The switching devices of the CSI bridges conduct current in one direction but block voltages in both directions. This is typically implemented with either a MOSFET or IGBT in series with a diode, or a revere blocking IGBT (RB-IGBT).
Advantages:

- Dynamically leading or lagging of reactive power.
- High-frequency transformer is used for inter-phase fault isolation among the three-phase.
- Current ripple can be significantly reduced,
- Smaller filter design.

Applications:

- Medium voltage applications
- Power transmission applications
Block diagram:

AC → Impedance circuit → Unbalanced Load

DC supply → Inductive circuit → CSI 1

DC supply → Inductive circuit → CSI 3

Gate driver circuit

12 V DC

Buffer circuit

5V DC

Micro-controller circuit

CSI 2 → Multi winding Transformer

L filter