PGESCo
Engineering Magazine

Issue 37
June, 2021

Sample Transport and Tubing Guidelines for Steam and Water Analysis (SWAS)...................................... P4

STATCOM (Static Synchronous Compensator)........ P8

Editor's Note..

The editors are very pleased to introduce this 37th issue of this magazine that include two excellent articles that I would hope that they will be appreciated by the interested readers.

The first article is by **Eng. Hani Salah, Eng. Hazem El Sayed** is titled "*Sample Transport and Tubing Guide lines for Steam and Water Analysis"* provides some guidelines and considerations to be taken while designing and sizing the sample transport tubing and introduces PGESCo development efforts to provide optimum tube sizing.

The second article is by **Eng. Amr Hegazy** is titled "*STATCOM*" the article is an introduction to STATCOM Technology and illustrate the design concept, operation, and Equipment that is connected in parallel (shunt) with a power system that is able to generate (compensate) and/or absorb (consume) reactive power, the output of the STATCOM reactive power can be controlled independently of the AC system voltage.

I hope that you enjoy reading these articles, until our next issue after three months.

I'll be glad to hear your opinion, and expect your contributions in our next issues.

Dr. Wael Youssef

In This Issue

P4 ········· *Sample Transport and Tubing Guidelines for Steam and Water Analysis (SWAS)*

P8 ········· *STATCOM (Static Synchronous Compensator)*

The Magazine Cover about

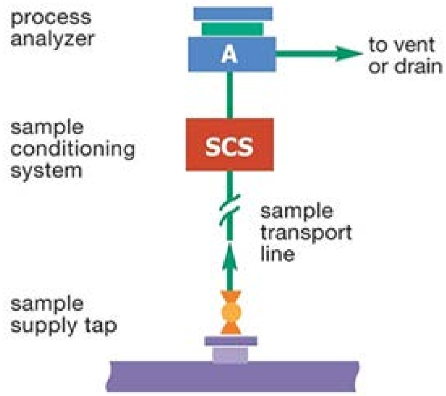
>>>> STATCOM (STATIC SYNCHRONOUS COMPENSATOR)

Sample Transport and Tubing Guidelines for Steam and Water Analysis (SWAS)

Article By : Eng. Hani Salah, Eng. Hazem El Sayed

Background

In a centralized Steam and Water Analysis System (SWAS), most samples like steam, feedwater or condensates are transported to a common analyzer room where sample conditioning and analysis is done. Transportation of samples over long distances may cause some physical and chemical changes in sample properties such as deposition of impurities in lines, throttling or heat loss, and crystallization or chemical reaction.



In addition, long transportation lines introduce time lag in the sampling and the total loop response time is increased.
A steam sample of a large specific volume is extracted from the source. As the sample travels through the sample tubing, a pressure drop occurs which is a function of the specific volume. As the specific volume of steam is large, large pressure drop is expected. This large pressure drop if not properly calculated and accounted for may prevent the sample to be transported any further.

However, as steam enters the sample tubing, heat transfer occurs between the steam sample and the surrounding. This heat transfer tends to cool the sample. As the sample is cooled, its specific volume decreases leading to decreasing the pressure drop in the tubing and allowing it to be transferred further with lower travelling velocity and as such, the transport time increases.

This article provides some guidelines and considerations to be taken while designing and sizing the sample transport tubing and introduces PGESCo development efforts to provide optimum tube sizing.
General Sample Tubing Design and Sizing Guidelines
Sample tubing material shall be designed in accordance with codes and standards as described in ASME B31.1 and ASME BPV Code.
Sample line tube material shall be selected based on temperature and pressure rating. For most applications material like 316 austenitic stainless steel should be used. Seamless construction is recommended. It gets tricky when operating in corrosive environment, as materials tend to be more exotic and more costly. Optimizing material selection that withstand corrosively, ASME B31.1 listing, cost friendly is challenging task. Sizing of the sample tubing is very critical in order to get the representative sample. Sample velocity and pressure drop should be considered for sizing criteria.
As this exercise uses several iterations for heat loss and pressure drop calculation at several process flows, a computer program or calculation sheet should be used for sample tube sizing.

The following are the minimum design considerations to be followed while selecting the sample tube size.

- Ensuring adequate sample velocity.
- Sample shall be kept turbulent, without losing ionic or particulate components.
- Minimizing the tendency for particulate matter (crud) fouling
- Minimizing sample transport lag time
- Minimizing excessive consumption of process fluid by drawing at high-speed volumetric flow rate.
- Ensuring that the sampling pressure drop will be acceptable.

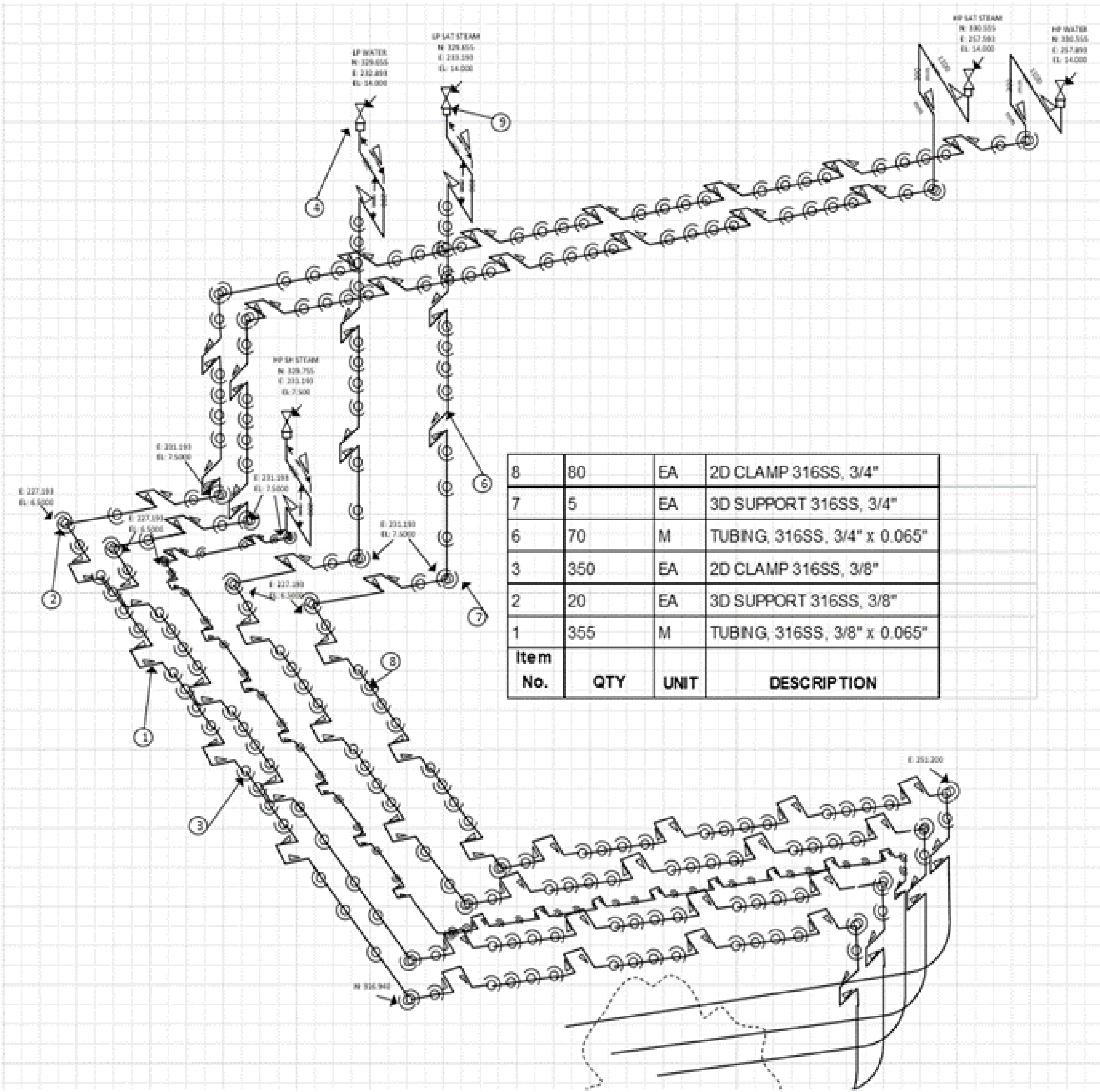
Maintaining a proper velocity always becomes a challenging task to take care of all thermodynamic changes into the sample transportation. A compromise must be made between the desired velocity and acceptable velocity.
If the sampling tube diameter is too large, the velocity will be low and the condensed steam with vapor may not be transported. In this case, the depositions of impurities on tube wall tend to increase, resulting in erroneous analysis. On the other hand, too small diameter of sampling tube may increase the pressure drop resulting in inadequate quantity of sample availability at the sampling panel.

PGESCo Development

In an effort to overcome the issues that may result from improper sample tube sizing, PGESCo Instrumentation and Controls Engineering Department has developed a calculation sheet with a goal to provide the optimum tube sizing that would allow the sample to be transported as far as required within reasonable transport time, without sacrificing large pressure drops. With this calculation, a methodology is provided to select the sample tube sizing for each sample, taking into consideration various parameters including heat transfer, pressure loss, and transport time.
The Calculation requires user input of basic data easily obtained within project and delivers a user-friendly conclusion for each sample as shown in Figure (1).
The program conclusion make it possible to have a solid installation drawing for the sample tubing such as that shown in Figure (2).

Sample Stream	Sample 1		Sample 2		Sample 3	
Case	Max	Min	Max	Min	Max	Min
Pressure (Bara)	Results Reported					
Temperature (Deg C)						
Specific Volume (m³/Kg)						
Sample Flow (Kg/Hr)						
Tube Size (mm)						
Tube Wall (mm)						
Tube Length (m)						
Final Velocity (m/sec)						
Transport Time (sec)						

Figure (1) – Program Conclusion



Item No.	QTY	UNIT	DESCRIPTION
8	80	EA	2D CLAMP 316SS, 3/4"
7	5	EA	3D SUPPORT 316SS, 3/4"
6	70	M	TUBING, 316SS, 3/4" x 0.065"
3	350	EA	2D CLAMP 316SS, 3/8"
2	20	EA	3D SUPPORT 316SS, 3/8"
1	355	M	TUBING, 316SS, 3/8" x 0.065"

Figure (2) – SWAS Tubing Arrangment

References:

ASME PTC 19.11 Steam and Water Sampling, Conditioning, and Analysis in the Power Cycle

Author Biography:

Eng. Hani Salah, PMP

Senior I&C Supervisor

Nineteen years of experience in Power Generation Projects. Received B.Sc degree in electrical computer systems engineering from Ain Shams University in 2002. Project Management Professional (PMP®) since 2012 and Certified Functional Safety Engineer (TÜV Rheinland) since 2016.

Eng. Hazem El Sayed

Deputy I&C Supervisor

Thirteen years of experience in Power Generation Projects. Received BSc degree in Electrical Power and Machines from Ain Shams University in 2007. Certified Automation Professional® (CAP®) (ISA) since 2017 and Certified Functional Safety Engineer (TÜV Rheinland) since 2016.

STATCOM (Static Synchronous Compensator)

Article By : Eng. Amr Hegazy

1. Introduction

STATCOM stands for static synchronous compensator or condenser, it is an equipment that is connected in parallel (shunt) with a power system that is able to generate (compensate) and/or absorb (consume) reactive power, the output of the STATCOM reactive power can be controlled independently of the AC system voltage.
A Typical STATCOM system is installed on a power network to enhance power factor and voltage regulation, and is an important flexible AC transmission System component (FACTS).

2. Why STATCOM

The idea of a continuous compensation for power system was always considered the ideal solution for a perfect distribution system / power network system, however the pervious older compensation equipment provided partial imperfect solutions.

During the last decades power electronic science and equipment had a breakthrough, especially in power semiconductor technology which provided the right components for the cause.

A typical STATCOM is able to provide and compensate reactive power to/from the grid continuously while mitigating harmonics, fluctuations due to transmission and switching and sudden load application/rejection.

Aspect	Traditional Capacitors	STATCOM
Cost $$	Less Expensive	More Expensive
Cons for Network	Harmonics and other components by switching	No Negative Impacts
Response Time	Limited By SWGR (>70ms)	<10ms
Response Type	Fixed Steps	Continuous
Inductive Control	Not Available	Available

Table.1 Comparison between Traditional Capacitors and STATCOM

While thinking power factor improvement a static VAR compensator might be the first concept to come in mind, which was normally used for this requirement, however after STATCOM system have been in service, it is noticeable how superior they are to the older solutions such as VAR compensator or STATCON

3. STATCOM Applications

Wind farms: STATCOM system are connected to wind turbines to enhance the generated power quality of wind turbines.

Industrial application: Power factor correction, flicker control, harmonic filtering, compensation of unbalanced loads and starting current of large motors.

Utilities: Enhancement of very long transmission line parameters.

4. Basic Single Line Diagram

STATCOM can have varying configurations however the main components can be illustrated in the following single line diagram.

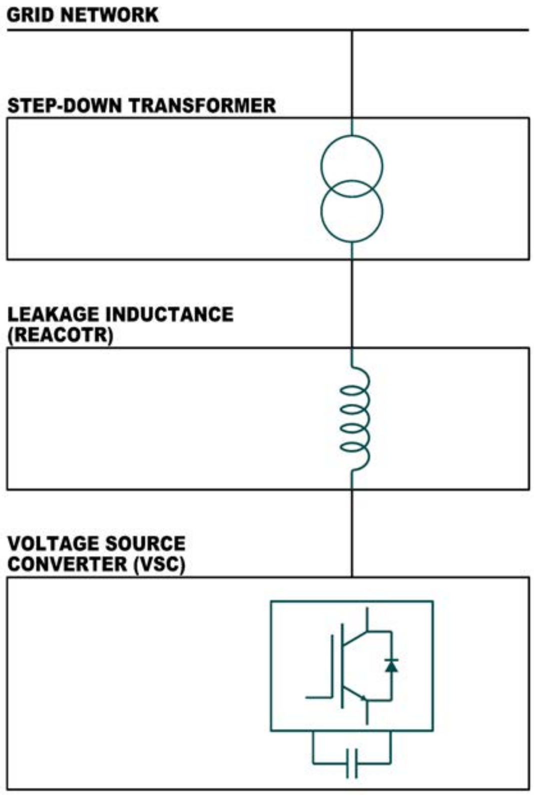


Fig.1 STATCOM Basic Single Line Diagram

5. Definitions

VSC: Voltage source converter
IGBT: insulated gate bipolar transistor
FWD: Free-wheeling diode
PWM: Pulse width modulation

6. Components

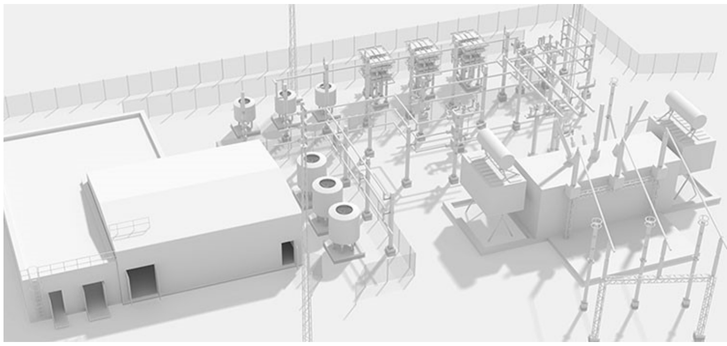


Fig.2 STATCOM Components

6.1 Step Down Transformer:

can be also named as coupling transformer which is a power transformer used to step down the network voltage level to STATCOM operating voltage level. It also forms a connection reactance between the network and STATCOM SVC together with reactor.

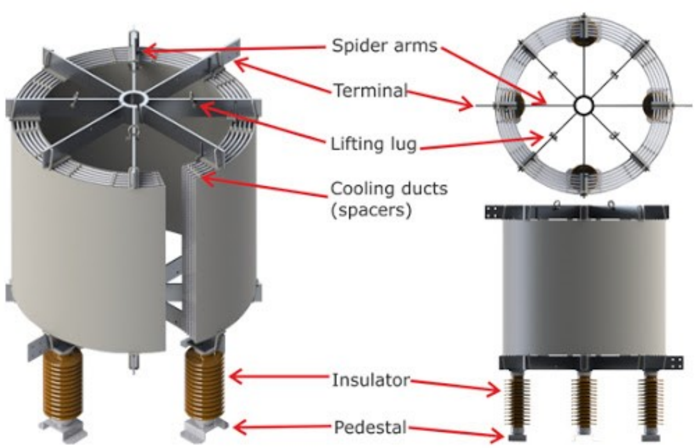


Fig.3 Air Reactor

6.2 Reactor (Leakage Inductance)

STATCOM reactor provides the coupling reactance between the converter and the network. In addition the STATCOM reactors provide protection for the converter valves (IGBTs for ex.) against short circuit currents from failures between transformer and reactor.

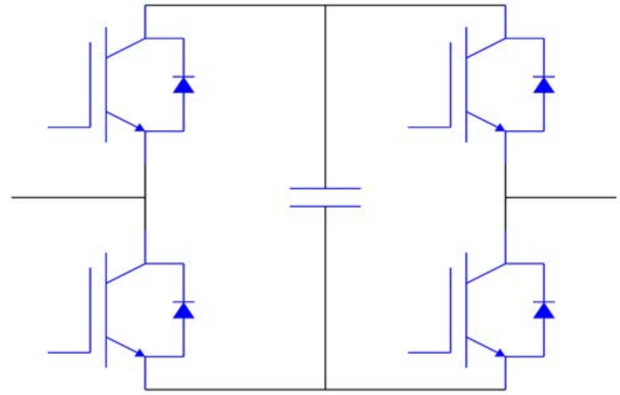


Fig. 4 Capacitors and IGBTs in H-Bridge circuit

6.3 DC Capacitors & Power Electronics

DC capacitors are the main energy storing components of a STATCOM, coupled with controlled power electronics (IGBTs or GTOs) to produce a controlled wave form to operate STATCOM in different modes. Figure 4 presents a single stage of modular multilevel converter (MMC), depending on the configuration, multi stage converters can be cascaded to produce higher quality/power wave forms.

Fig.5 ABB IGBT 5SNA 200045K0301

The capacitor technology normally utilized for STATCOM purpose is metallized polypropylene film, for low losses and high stability.

GTO/IGBT valve is the power electronic component that is switched to control the flow to the DC capacitor and to control, figure 5 shows an example for 4500V, 2000A IGBT by ABB.

6.4 AC Harmonic filters

While it is not a part of all STATCOM system configurations, it depends on the harmonic spectrum of the type of voltage source converter to decide the need and the type of ac harmonic filter. When it is required the design is similar to HVDC station filters and is mainly covered in IEC 62001.

6.5 Control System:

STATCOM control is a hierarchy of control systems as shown in figure 6 below.

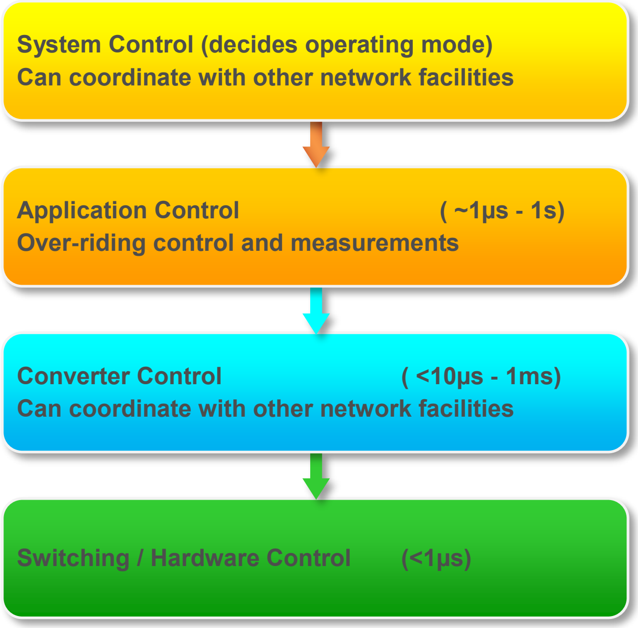


Fig. 6 STATCOM Control system hierarchy

6.6 Cooling system

Cooling of major equipment such as transformers is achieved by ordinary fans for ONAF transformers, however the main equipment the requires special cooling are IGBT valves 'stacks.

To achieve cooling requirements of such equipment, ordinary cooling fans aren't sufficient, and a liquid cooling HVAC system must be utilized.

Sufficient cooling is achieved by a closed cooling water system, however to avoid water freezing inside cooling loop pipes, ethylene (old) or propylene glycol is mixed with water which decreases the freezing point of water to ~ -50°C, and keeps cooling system highly chilled at lower temperatures. The closed loop is then cooled via heat exchangers.

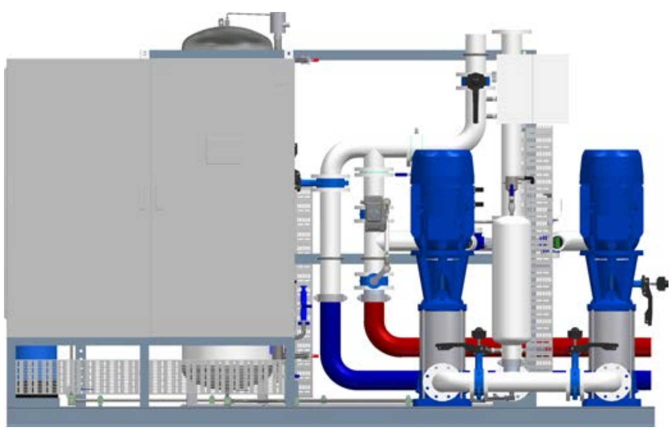


Fig.7 Typical pumping unit for IGBT cooling

7. How STATCOM works

The main purpose of a typical STATCOM is to compensate/consume the reactive power of a network, a simple explanation of how STATCOM works can be:

1-If STATCOM output voltage is higher than the network voltage, then the STATCOM will provide capacitive power to the network, aka provides reactive current to the network and compensate the network with capacitive reactive power.

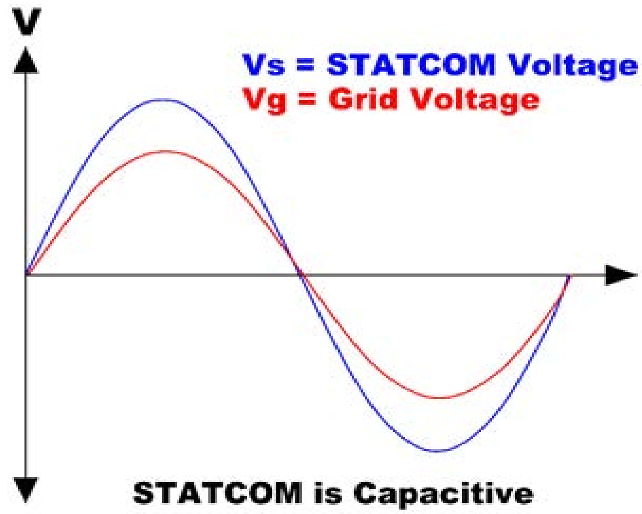


Fig. 8 STATCOM operating in capacitive mode

2-If STATCOM output voltage is lower than the network voltage, then the STATCOM will provide inductive power to the network, aka consumes reactive current from the network and compensate the network with inductive reactive power.

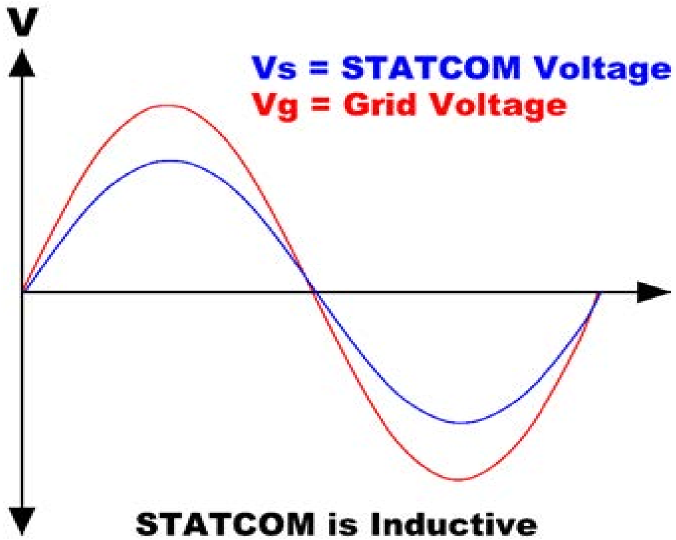


Fig. 9 STATCOM operating in inductive mode

3-If STATCOM output voltage is the same as the network voltage, then the STATCOM will not provide inductive nor capacitive power to the network.

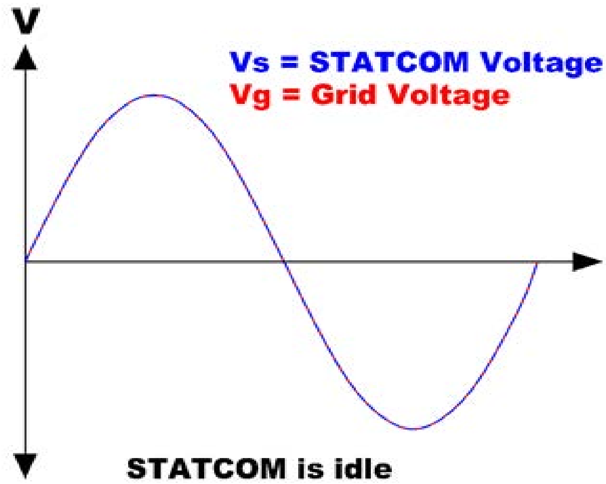


Fig. 10 STATCOM operating in idle mode

The amount of reactive current depends on the transformer (reactor) short circuit reactance.

The amount of system voltage depends on the IGBT limits. For example, a group of 8 IGBTs of rated voltage of 4500V installed in series will be able to provide a full voltage of 36kV system with a much more wave form quality.

8. References

[1] CIGRÉ Technical Brochure 144 Technical Description of Static Synchronous Compensator (STATCOM).

[2] IEEE 1052-2018 IEEE Guide for Specification of Transmission Static Synchronous Compensator (STATCOM) Systems.

[3] IEC 62927:2017 Voltage sourced converter (VSC) valves for static synchronous compensator (STATCOM) - Electrical testing.

[4] HITACHI ABB Power grid solutions: https://www.hitachiabb-powergrids.com/offering/product-and-system/facts/statcom

[5] GE Power Grid Solutions: https://www.gegridsolutions.com/powerd/catalog/statcom.htm

Author Biography:

Amr El Morsy Hegazy

Is an Electrical Engineer in PGESCo with strong programming skills. He has more than 12 years of experience with power system engineering. Amr holds BSc in Electrical Power and Machines from Alexandria university at 2009.

www.pgesco.com