Upgrading SVC’s Firing Circuitry Improves Performance

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ABSTRACT

A Static VAR Compensator (SVC) regulates voltage stability, improves power factor, and compensates for reactive power in electrical systems. SVC´s above the 100MW range predominantly employs Thyristor Controlled Reactor technology, which has been in use for over 30 years. While thyristor valves remain operational, controls and firing circuitry face lack of spare parts availability, service support and face integration challenges with new technologies. Advances in Hi-Performance Real-Time Controls allows the possibility to generate optimal control solution with tailored interfaces to existing Power devices. This article presents the design, installation, and benefits of the implementation, presenting advantages, efficiency, and versatility versus a complete valve replacement.

Index Terms: Static VAR Compensator, TCR, Power Factor, Reactive Power, Voltage Stability, Power Quality, Harmonics, SVC Upgrade, Control Systems.

INTRODUCTION

A SVC (Static Var Compensator) behaves as a variable capacitor whose capacity is regulated according to load variations to achieve unity power factor, balance asymmetrical loads, and minimize voltage disturbances (flicker). It also can reduce the harmonic content caused by non-linear loads. In addition, it can have functions such as the utilization of surplus power in the Thyristor Controlled Reactor (TCR) to minimize overvoltage events and allow smooth commissioning.

The most common arrangement in industry is shown in Figure 1, where different harmonic filters tuned to the different frequencies of interest can be observed. These filters serve a double function. First, they reduce the harmonic content to comply with standards such as IEEE 519, and secondarily, at the fundamental frequency, they behave like a large capacitor, capable of providing a reactive power higher than that consumed by the load. The surplus capacitive reactive power is consumed by the TCR because varying the firing angle of the thyristors is achieved by varying the inductance of the TCR controlled inductance reactor.

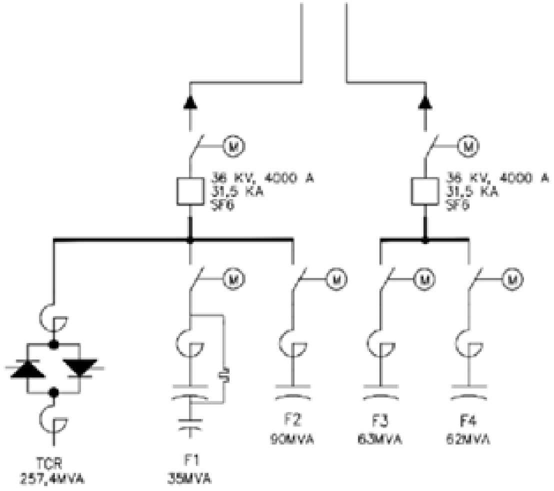

Figure 1. *250 MVAR SVC with TCR.*

DISCUSSION

A. SVC Upgrade Challenges

The efficient use of electrical energy is taking relevance in several industries, and the steel industry is not the exception, especially when controlling processes like an Electric Arc Furnace, where each installation demands power in the range of tens to hundreds of MVAs.

Additionally, energy regulators, in different regions around the world, have been imposing tighter regulations to load centers. In response, the power utility companies force consumers to meet the tighter regulations by imposing different tariffs or penalties, even service shutdown. The focus on power quality KPI’s (Key Performance Indicator) such as power factor, current unbalance, flicker, harmonics, and voltage variations become an essential task for an optimal process performance. This means that a fast-acting, high efficiency and highly reliable SVC system is indispensable to meet all these power quality standards.

Having an updated and efficient SVC system is not an easy task. In several cases, the control equipment is reaching a mature or obsolete status in their product lifetime cycle, making it difficult to get spares parts, support, and to maintain the equipment operational.

Moreover, a SVC requirement is to communicate and integrate multiple subsystems at different levels, which may include a water cooling system, HMIs (Human Machine Interface), Distributed Control Systems (DCS), Remote IO (Input/Output) systems, among others. All these subsystems are subject to change during multiple plant upgrades, and if any of those are no longer available to communicate with the SVC, the overall system starts to operate inefficiently.

B. Opportunities

There are different types of SVCs, but nowadays there are two types which dominate the market: TCR SVC and STATCOM (Static Synchronous Compensator) SVC.

The TCR SVC is used more in higher power applications, because it is a very robust and reliable design, even though TCR and filters continue to have a high cost, it represents a lower investment than the STATCOM SVC.

TCR SVCs are widely used in many applications, and even though the control equipment obsoletes rapidly, the power equipment such as filters, thyristors, and mechanical valve(a set of thyristors used to control electrical power) and heatsink designs remain very reliable because their components are repairable and fully compatible with the current technology.

Normally the cost of the control system represents a small part of the invested value, around 20%, compared with the value of the power section. This leads to the opportunity of upgrading only the control section, increasing the system reliability, extending diagnostics, simplifying troubleshooting, digitizing control algorithms and electrical measurements.

C. Upgrade Strategy

SVC control system upgrade needs to be analyzed carefully. The strategy for a successful upgrade needs to consider the following engineering design stages:

- Full Simulations
- Thyristor Firing Circuit
- Valve Cooling Unit
- Circuit Breaker control
- Power Quality measurements
- Regulation modes
- Trends
- HMIs

Simulations are a key stage during the evaluation of the SVC upgrade, because they can estimate the results of the control algorithms while keeping the same power equipment, and they can simulate the response of the SVC under different conditions or sporadic events. Some of the critical conditions may include but not limited to:

- Full-range operating voltage
- Electrical network supplier
- High voltage short-circuit
- Step-down transformer's inrush
- Voltage unbalance
- Frequency variations
- External electrical disturbances
- Electric Arc furnace actual operation data
- Blackout

The results from the simulations may conclude that a modification of the filters or other critical devices are required.

A second very important stage includes the Firing Circuit Replacement (FCR) that needs to be meticulously analyzed to define the interface boards required to control the SVC's valve thyristors, and subsequently the whole TCR. A simplified oneline diagram is shown in Figure 2.

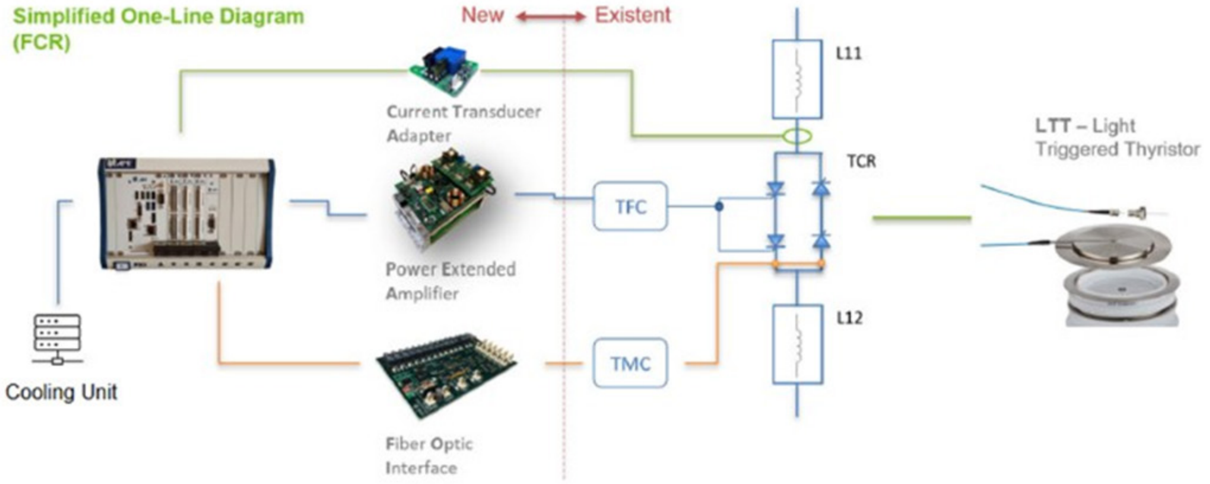

Figure 2. *FCR Simplified One-Line Diagram.*

The additional stages will include site-specific information from existing equipment to complement the design phases and deliver a highly customized product to the customer.

D. Objectives and Scope of the Upgrade

To address the obsolescence of an existing SVC control system, producer and supplier collaborated on a targeted modernization strategy that would enhance reliability, improve diagnostic capabilities, and ensure long-term maintainability, without requiring a full replacement. The upgrade focused on modernizing the controls, monitoring, and LTT (Loop Tuning Test) firing circuitry, while preserving existing power infrastructure and cooling unit to minimize downtime and optimize costs. The scope of the upgrade included:

- Design a new SVC control system architecture to handle the dynamic nature of EAF (Electric Arc Furnace) operations more effectively.
- Replace legacy components with modern, supportable equivalents to ensure long-term system sustainability.
- Enhance operator interface and monitoring capabilities with advanced diagnostic tools and real-time data visualization.
- Retain key power components such as LTT thyristor valve assemblies, TCR reactors, harmonic filters, disconnects, circuit breakers, and cooling unit, ensuring compatibility with the plant's existing infrastructure.
- Update protection relays to enhance fault detection, protection response, and overall system stability.

Through these improvements, the new SVC system integrated cutting-edge control strategies, ensuring optimized power factor and voltage regulation, enhanced reactive power compensation, and increased operational flexibility.

RESULTS

A. Enhanced Monitoring and Diagnostic Tools

The new state-of-the-art high-performance controller provides enhanced diagnostics tools and ultra-high-speed trends with a sampling rate up to 4µs, as shown in Figure 3. These tools are available through a web browser and allows the end user to troubleshoot in a more effective and accurate way. The capability to identify failure root causes faster increased system availability and furnace up-time.

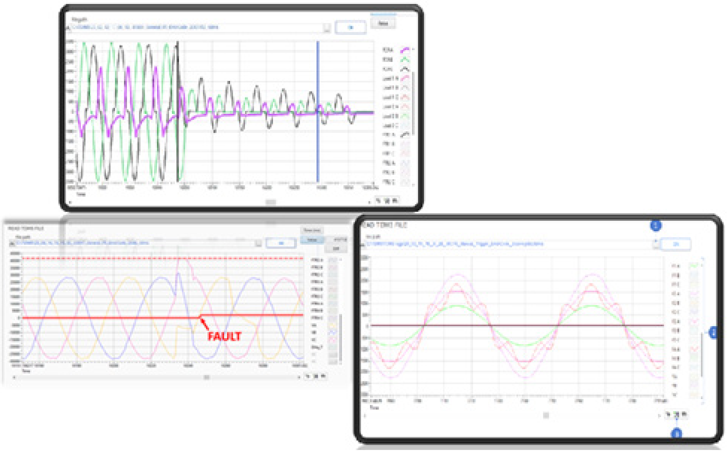

Figure 2. *High speed trends with a sampling rate of 4µs. Power Quality and Electrical Stress*

Following the SVC control upgrade, fundamental power quality parameters, such as bus voltage stability, harmonic distortion levels, and flicker indices, generally remain consistent with previous performance, as shown in Table 1. In practice, the modernized control algorithms offer improved diagnostic insight and faster fault isolation, resulting in fewer unplanned stoppages despite similar key power quality indicators.

TABLE 1				
Electrical Parameter (Unit)	Before	After	Limit	Change Observed
Frequency (Hz)	60.02	60.02	-	No change
Rapid Voltage Changes (events/day)	2	2	5	No change
Flicker PST	0.61	0.64	0.8	Slight increase, still within limit
Flicker PLT	0.5	0.5	0.6	No change
Voltage Total Harmonic Distortion (THD) (%)	1.25	1.37	1.5	Slight increase, still within limit
Power Factor (-)	0.999	0.999	-	No change

Table I. *Power Quality Parameters Comparison before and after the upgrade*

CONCLUSIONS

The SVC control upgrade successfully addressed system obsolescence while maintaining power quality, improving operational stability, and extending equipment lifespan. By modernizing the control platform while preserving existing power infrastructure, the upgrade provided a cost-effective alternative to a full system replacement.

The success of this upgrade was accomplished by state of the art control platform, which integrates advanced regulation, real-time monitoring, and optimized firing control. Additionally, the use of pre-commissioning simulations, scaled model FAT (Factory Acceptance Test) testing, and strategic implementation planning allowed for a seamless transition without disrupting production.

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