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Power Quality Enhancement in a Motor Manufacturing Industry using SVC

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Abstract: Power quality is a significant concern in motor manufacturing industry because of the widespread use of inductive loads. These include induction motors, welding machines, variable frequency drives and testing equipment. These loads can cause poor power factor, voltage fluctuations, excessive reactive power demand and harmonic distortion. As a result this leads to increased energy losses and reduced equipment lifespan. This study presents a detailed examination of how to improve power quality in a motor manufacturing industry using a Static Var Compensator (SVC).The proposed system uses a SVC which includes Thyristor Switched Capacitors (TSC) and Thyristor Controlled Reactors (TCR) to provide reactive power compensation.By continuously monitoring system parameters such as voltage, current, and reactive power the SVC responds in real time to load variations thereby maintaining the power factor close to unity and stabilizing the bus voltage. The performance of the SVC-based compensation plan is assessed through simulation studies conducted under different operating conditions. The results demonstrate significant improvement in power factor and enhanced voltage regulation at the point of common coupling (PCC). Additionally overall system efficiency is improved and compliance with IEEE power quality standards is achieved. According to the study's findings SVC is a practical and affordable way to enhance power quality in motor manufacturing sectors with highly variable and inductive loads.

Keywords: Static Var Compensation, Total Harmonic Distortion, IEEE 519 Standards, Reactive Power Compensation, Power Factor Improvement.

I. INTRODUCTION

Power quality plays a vital role in modern industrial systems, especially in motor manufacturing industries where large electrical machines, testing setups, welding equipment and VFDs are extensively used. These loads are predominantly inductive and non-linear in nature which leads to various power quality problems such as voltage fluctuations, voltage sag and swell, poor power factor, harmonic distortion and reactive power imbalance. In a motor manufacturing industry heavy motor testing under different load conditions causes sudden variations in reactive power demand. This results in voltage instability at the PCC, increased system losses, overheating of equipment, malfunction of sensitive electronic devices and reduced efficiency of motors. Poor power factor also leads to higher electricity bills and penalties from the utility.

To overcome these issues a SVC is implemented as a dynamic reactive power compensation device. An SVC is a shunt-connected Flexible AC Transmission System (FACTS) device that regulates voltage and improves power factor by controlling reactive power injection or absorption. It mainly consists of TCR and TSC which provide fast and continuous reactive power control.

II. LITERATURE REVIEW

Yoon et al. (2009) examined the coordinated operation of SVC and STATCOM devices for voltage stability enhancement in interconnected systems. Their study presented in IEEE conferences demonstrated that SVC effectively regulates bus voltage under varying load conditions and improves system stability margins through dynamic reactive power support [1]. Similarly, Gelen & Yalcin Oz (2008) compared TSR and TCR based SVC configurations. Their findings indicated that TCR-based SVC provides smoother control characteristics and better harmonic performance in industrial applications making it suitable for systems with fluctuating inductive loads [2].

Research by Xavier et al. (2008) focused on intelligent control strategies for FACTS devices. The study emphasized the use of advanced controllers to enhance dynamic response and reduce steady-state errors in reactive power compensation systems. The results showed significant improvement in voltage regulation and transient performance when adaptive control techniques were applied [3]. Harmonic distortion in industrial networks has also been widely studied under the guidelines of IEEE Standard 519 which specifies permissible limits for voltage and current Total Harmonic Distortion (THD).

Several researchers utilized simulation platforms such as DIgSILENT PowerFactory to perform load flow and harmonic analysis for industrial case studies. These studies confirmed that while SVC is primarily designed for reactive power compensation, it indirectly contributes to THD reduction by stabilizing voltage magnitude and improving system impedance characteristics [4].This study applied dynamic reactive power control using SVC to improve voltage stability and reduce system losses in an industrial power network. By adjusting reactive power according to load variations, the SVC minimized voltage fluctuations and enhanced power factor. Harmonic analysis was also performed to ensure compliance with IEEE 519 standards.

III. ANALYSIS AND DISCUSSION

The performance of the industrial power system was analyzed under two operating conditions: without SVC and with SVC using load flow and harmonic analysis in DIgSILENT PowerFactory.

A. Load Flow Analysis: The heavy presence of induction motors and variable frequency drives caused significant lagging reactive power consumption. As a result, voltage drop was observed at the load buses, leading to reduced voltage stability. After integrating the SVC, the system performance improved considerably. The SVC supplied the required reactive power dynamically. By adjusting the effective reactance, the SVC maintained voltage within permissible limits and stabilized the system under varying load conditions.

B. Harmonic Analysis: Harmonic distortion was evaluated in terms of Total Harmonic Distortion (THD). In the absence of SVC, voltage distortion at the busbar was higher due to non-linear loads such as VFDs and welding equipment. Although SVC is primarily a reactive power compensator, voltage stabilization indirectly contributed to harmonic performance improvement.

C. Overall Discussion: The comparative analysis clearly indicates that the integration of SVC enhances overall power quality in a motor manufacturing industry. The system becomes more stable, efficient, and reliable. Improved voltage regulation and power factor correction reduce stress on equipment, minimize overheating, and extend equipment lifespan. Thus, the simulation results validate that SVC is an effective and economical solution for industrial power quality enhancement.

IV. CONTROL STRATEGY OF STATIC VAR COMPENSATOR (SVC)

The effectiveness of a Static Var Compensator (SVC) in improving power quality mainly depends on its control strategy. In a motor manufacturing industry, where load variations are frequent due to motor starting, testing operations, and welding processes, the control system must respond rapidly and accurately to maintain voltage stability and power factor. The SVC control strategy ensures dynamic reactive power compensation by continuously monitoring system parameters and adjusting the firing angle of thyristors accordingly.

A. Objective of SVC Control: The primary objectives of the SVC control system in an industrial environment are Maintain bus voltage at the Point of Common Coupling (PCC) within permissible limits (±5%),Improve and maintain power factor close to unity,Compensate reactive power variations dynamically,Reduce voltage fluctuations during motor starting,Enhance system stability under fluctuating loads.In motor manufacturing industries, reactive power demand changes continuously due to the operation of induction motors and nonlinear loads. Therefore, a fast closed-loop control mechanism is essential.

B. Basic Control Principle: The SVC operates as a shunt-connected FACTS device that either injects or absorbs reactive power depending on system requirements. The control system measures the bus voltage at PCC and compares it with a predefined reference voltage.
The basic control equation is:

$$V_{error} = V_{ref} - V_{measured}$$

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Where:
V_{ref} = Desired reference voltage
$V_{measured}$ = Actual PCC voltage
$V_{measured} < V_{ref}$ = System requires reactive power injects
$V_{measured} > V_{ref}$ = System requires reactive power absorb

Thus, the SVC automatically balances reactive power to regulate voltage.

C. Closed-Loop Voltage Control System: The SVC uses a closed-loop feedback control system consisting of Voltage measurement unit, Signal conditioning block, Error detector, PI controller, Firing angle control circuit, Thyristor gating system.

Step 1: Voltage Measurement: The three-phase PCC voltage is continuously measured using voltage transformers. The RMS value of the voltage is calculated and fed into the controller.

Step 2: Error Calculation: The measured voltage is compared with the reference voltage to generate the error signal.

Step 3: PI Controller Action: The error signal is processed using a Proportional-Integral (PI) controller Formula $U(t) = K_p\, e(t) + K_i \int e(t)\, dt$

Where:

K_p = Proportional gain, K_i = Integral gain, $e(t)$= Voltage error

The proportional term provides fast response, while the integral term eliminates steady-state error.

Step 4: Firing Angle Control: The controller output determines the firing angle (α) of the thyristors in the TCR. Firing angle range $90° < \alpha < 180°$. By adjusting α Smaller α → Higher reactor current → More inductive reactive power absorbed, Larger α → Lower reactor current → Less inductive compensation. Thus, smooth reactive power control is achieved.

D. Reactive Power Control of SVC: In addition to voltage regulation, the SVC also performs reactive power control to maintain system stability under varying industrial load conditions. In motor manufacturing industries, large induction motors and welding equipment create sudden variations in reactive power demand. The SVC dynamically compensates these variations by adjusting the reactive power exchanged with the power system.

The susceptance of the SVC is controlled by varying the firing angle of the thyristor-controlled reactor (TCR). When the system requires capacitive reactive power, the SVC increases capacitive susceptance using thyristor switched capacitors (TSC). When the system requires inductive reactive power absorption, the TCR current is increased by reducing the firing angle. This dynamic adjustment allows the SVC to maintain the desired voltage profile and improve overall power quality in the industrial network.

E. Overall Control Flow of SVC: The overall operation of the SVC control system follows a sequential process to maintain voltage stability and reactive power balance in the system. The control process can be summarized as follows: The bus voltage at the Point of Common Coupling (PCC) is continuously measured using voltage transformers. The measured voltage is compared with the reference voltage to determine the voltage deviation. The error signal is processed by a PI controller to generate a control signal. The control signal determines the appropriate firing angle of the thyristors in the TCR. Based on the firing angle, the SVC adjusts its reactive power output by either injecting or absorbing reactive power. This process continuously repeats in a closed-loop manner to maintain voltage stability and improve power factor. Through this control mechanism, the SVC provides fast and reliable reactive power compensation, which is essential for maintaining power quality in motor manufacturing industries with fluctuating loads.

V. LOAD FLOW RESULTS AND ANALYSIS

The load flow analysis was carried out to evaluate the performance of the power system under two different operating conditions**:** without the SVC and with the SVC**.** The objective of this analysis is to examine the impact of SVC on voltage regulation, reactive power compensation, power factor improvement, and overall system losses in the motor manufacturing industry power network.

A. System Performance without SVC: Initially, the load flow simulation was performed without integrating the Static Var Compensator in the system. Under this condition, the results indicate that the bus voltage at the PCC drops below the rated value due to the high reactive power demand of inductive loads such as induction motors, testing equipment, and welding machines. The absence of reactive power compensation leads to a significant increase in reactive power flow through the transmission network. Consequently, the system experiences a poor power factor, which increases the current drawn from the supply and results in higher transmission losses. Additionally, the voltage profile across the buses becomes weak and unstable during heavy motor starting and load variation conditions. This situation negatively affects the overall power quality and system efficiency.

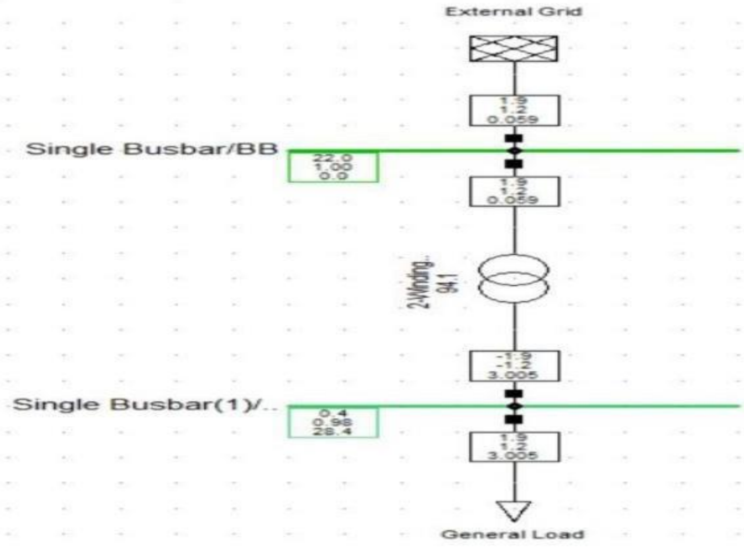
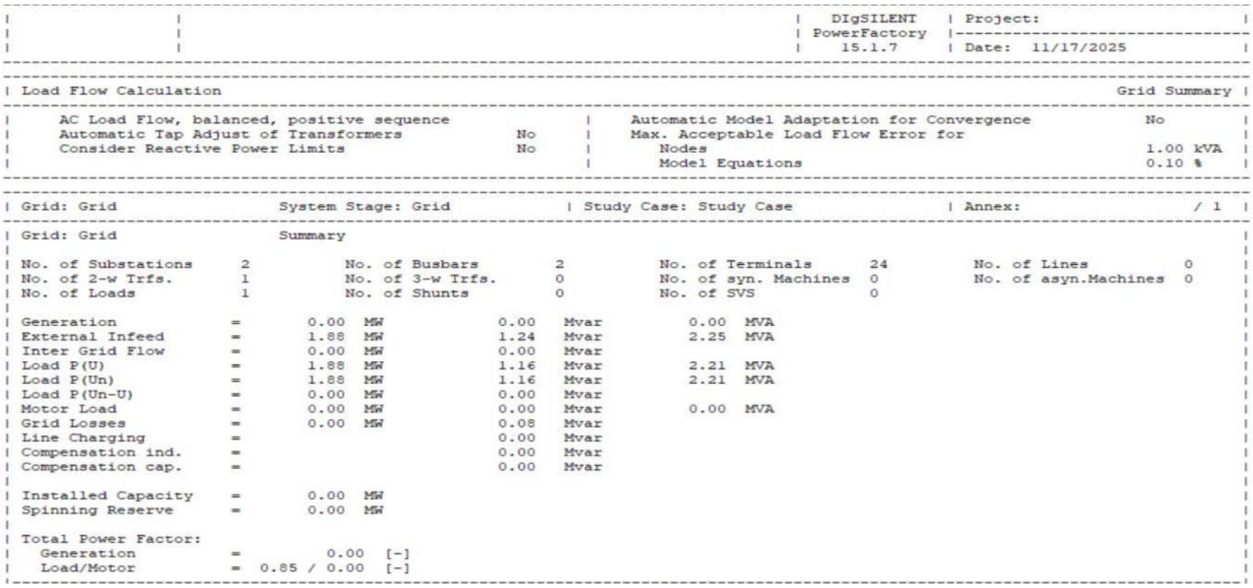


Fig:5.1 Load Flow Analysis Without SVC

The load flow analysis of the proposed power system was performed using DIgSILENT PowerFactory to evaluate the steady-state operating conditions of the network without the integration of a Static Var Compensator (SVC). The modeled system consists of an external grid, two substations, two busbars, a two-winding transformer, and a general load. The external grid acts as the primary source supplying electrical power to the system through the main busbar operating at approximately 22 kV, where the voltage magnitude remains close to the rated value of about 1.00 p.u. The power is then transferred through a two-winding transformer to the load bus. Due to the reactive power demand of the load, the voltage at the load bus decreases slightly to around 0.98 p.u. indicating a minor voltage drop in the distribution side of the network.



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|                    |                                                        | PowerFactory |-----------------------
|                    |                                                        |   15.1.7     | Date:  11/17/2025     |
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| Load Flow Calculation                                                                               Grid Summary |
--------------------------------------------------------------------------------------------------------------------
|    AC Load Flow, balanced, positive sequence              |   Automatic Model Adaptation for Convergence      No   |
|    Automatic Tap Adjust of Transformers          No       |   Max. Acceptable Load Flow Error for                  |
|    Consider Reactive Power Limits                No       |     Nodes                                     1.00 kVA |
|                                                           |     Model Equations                           0.10 %   |
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| Grid: Grid                 System Stage: Grid          | Study Case: Study Case            | Annex:          / 1  |
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| Grid: Grid                 Summary                                                                               |
|                                                                                                                  |
| No. of Substations     2        No. of Busbars       2         No. of Terminals      24        No. of Lines           0  |
| No. of 2-w Trfs.       1        No. of 3-w Trfs.     0         No. of syn. Machines  0         No. of asyn.Machines   0  |
| No. of Loads           1        No. of Shunts        0         No. of SVS            0                                 |
|                                                                                                                  |
| Generation            =      0.00  MW           0.00   Mvar       0.00  MVA                                      |
| External Infeed       =      1.88  MW           1.24   Mvar       2.25  MVA                                      |
| Inter Grid Flow       =      0.00  MW           0.00   Mvar                                                      |
| Load P(U)             =      1.88  MW           1.16   Mvar       2.21  MVA                                      |
| Load P(Un)            =      1.88  MW           1.16   Mvar       2.21  MVA                                      |
| Load P(Un-U)          =      0.00  MW           0.00   Mvar                                                      |
| Motor Load            =      0.00  MW           0.00   Mvar       0.00  MVA                                      |
| Grid Losses           =      0.00  MW           0.08   Mvar                                                      |
| Line Charging         =                         0.00   Mvar                                                      |
| Compensation ind.     =                         0.00   Mvar                                                      |
| Compensation cap.     =                         0.00   Mvar                                                      |
|                                                                                                                  |
| Installed Capacity    =      0.00  MW                                                                            |
| Spinning Reserve      =      0.00  MW                                                                            |
|                                                                                                                  |
| Total Power Factor:                                                                                              |
|   Generation          =        0.00  [-]                                                                         |
|   Load/Motor          =  0.85 / 0.00  [-]                                                                        |
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Fig 5.2 Power Flow Results and System Performance

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The load flow results indicate that the external grid supplies approximately 1.88 MW of active power and 1.24 MVAr of reactive power to meet the system demand, resulting in an apparent power of about 2.25 MVA. The connected load consumes nearly 1.88 MW of active power and 1.16 MVAr of reactive power, while the remaining difference corresponds to minor network losses. The load operates at a power factor of approximately 0.85, showing that a significant portion of the power demand is reactive. Since no reactive power compensation device is installed in the system, the external grid must supply the entire reactive power requirement, leading to increased reactive power flow and a slight reduction in voltage at the load bus. Therefore, this load flow analysis without compensation serves as the baseline case for the study and highlights the necessity of integrating reactive power compensation devices such as SVC or STATCOM to improve voltage stability and overall system performance.

B. System Performance with SVC: In the next stage, a SVC was incorporated into the system at the Point of Common Coupling. The load flow simulation results demonstrate a significant improvement in system performance after the installation of the SVC. The SVC dynamically supplies or absorbs reactive power depending on the system requirement, thereby maintaining the bus voltage close to its rated value. The voltage profile across the network shows considerable improvement compared to the uncompensated system. Furthermore, the reactive power demand from the source is significantly reduced as the SVC provides local reactive power support. This results in a substantial improvement in power factor, bringing it closer to unity. With the reduction in reactive power flow through transmission lines, the overall system current decreases, which leads to reduced transmission losses and improved system efficiency. The comparative analysis clearly indicates that the integration of SVC enhances voltage stability, improves power factor, and reduces system losses, thereby improving the overall power quality of the motor manufacturing industry power system.

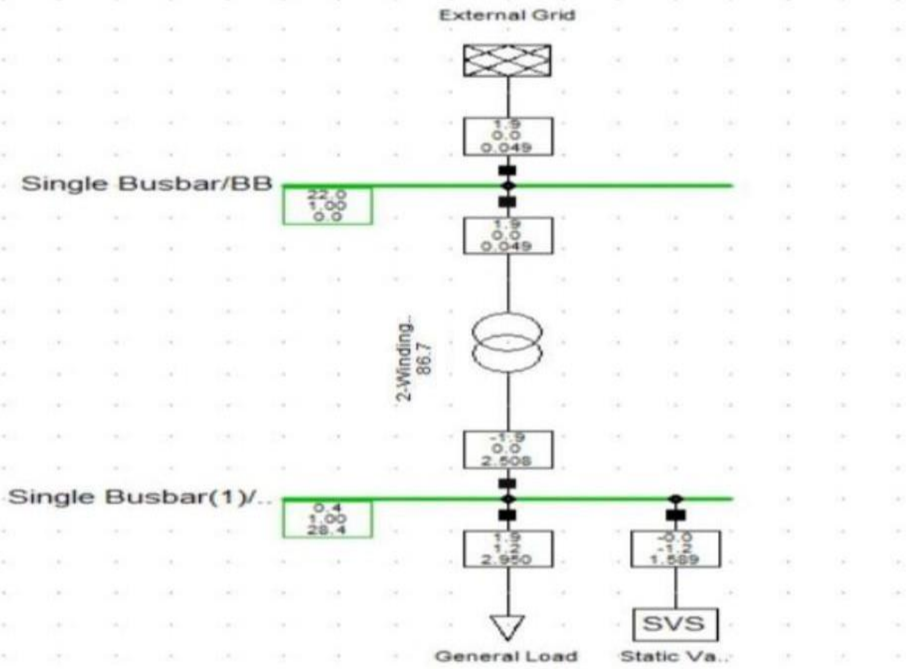

Fig:5.3 Load Flow Analysis With SVC

The load flow analysis of the proposed system with reactive power compensation was performed using DIgSILENT PowerFactory to evaluate the steady-state performance of the network. The simulated system consists of an external grid, two substations, two busbars, a two-winding transformer, a general load, and a Static Var Compensator (SVC) connected in shunt at the load bus. The external grid acts as the primary power source supplying electrical energy to the network through the primary busbar operating at approximately 22 kV with a voltage magnitude close to 1.0 p.u. The power is transferred through a two-winding transformer to the load bus, where the general load is connected. In this configuration, the presence of the SVC helps maintain the load bus voltage close to the nominal value of around 1.00 p.u., thereby improving the overall voltage profile of the system.

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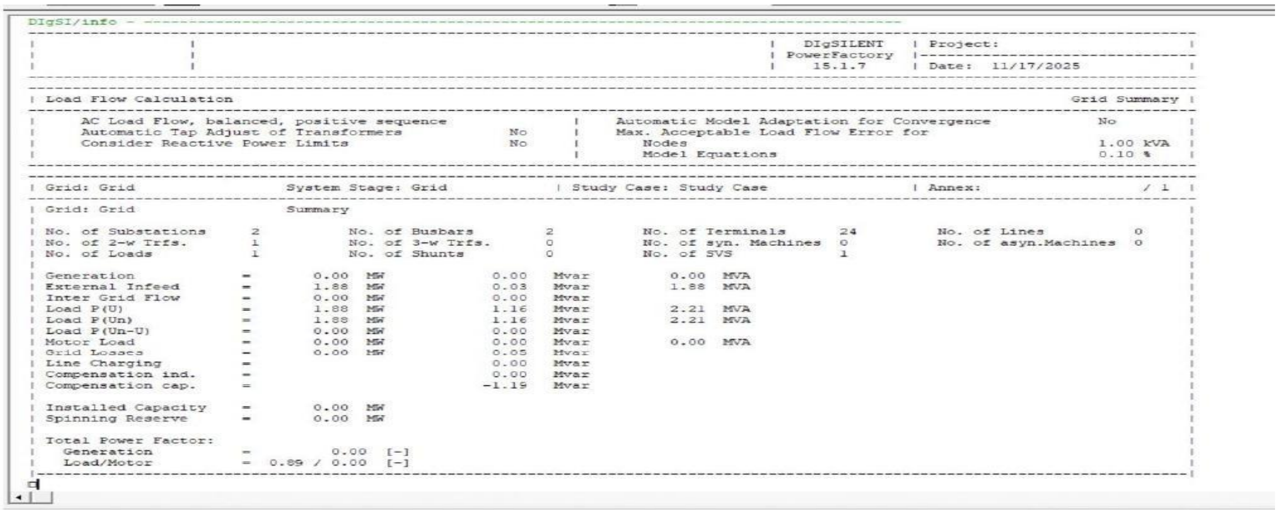

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|                     |                                                |   DIgSILENT   | Project:                   |
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| Load Flow Calculation                                                                 Grid Summary |
----------------------------------------------------------------------------------------------------
|      AC Load Flow, balanced, positive sequence         |  Automatic Model Adaptation for Convergence      No     |
|      Automatic Tap Adjust of Transformers          No  |  Max. Acceptable Load Flow Error for                    |
|      Consider Reactive Power Limits                No  |      Nodes                                   1.00 kVA   |
|                                                        |      Model Equations                         0.10 %     |
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| Grid: Grid                 System Stage: Grid              | Study Case: Study Case               | Annex:       / 1 |
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| Grid: Grid                 Summary                                                                  |
|                                                                                                     |
| No. of Substations      2        No. of Busbars        2      No. of Terminals      24     No. of Lines           0 |
| No. of 2-w Trfs.        1        No. of 3-w Trfs.      0      No. of syn. Machines  0      No. of asyn.Machines   0 |
| No. of Loads            1        No. of Shunts         0      No. of SVS            1                               |
|                                                                                                     |
| Generation              =      0.00  MW          0.00  Mvar      0.00  MVA                          |
| External Infeed         =      1.88  MW          0.03  Mvar      1.88  MVA                          |
| Inter Grid Flow         =      0.00  MW          0.00  Mvar                                         |
| Load P(U)               =      1.88  MW          1.16  Mvar      2.21  MVA                          |
| Load P(Un)              =      1.88  MW          1.16  Mvar      2.21  MVA                          |
| Load P(Un-U)            =      0.00  MW          0.00  Mvar                                         |
| Motor Load              =      0.00  MW          0.00  Mvar      0.00  MVA                          |
| Grid Losses             =      0.00  MW          0.05  Mvar                                         |
| Line Charging           =                        0.00  Mvar                                         |
| Compensation ind.       =                        0.00  Mvar                                         |
| Compensation cap.       =                       -1.19  Mvar                                         |
|                                                                                                     |
| Installed Capacity      =      0.00  MW                                                             |
| Spinning Reserve        =      0.00  MW                                                             |
|                                                                                                     |
| Total Power Factor:                                                                                 |
|   Generation            =        0.00  [-]                                                          |
|   Load/Motor            =  0.89 / 0.00  [-]                                                         |
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Fig :5.4 Power Flow Results and System Performance With SVC

The load flow results indicate that the external grid supplies approximately 1.88 MW of active power and only about 0.03 MVAr of reactive power, while the connected load requires both active and reactive power for its operation. The SVC provides reactive power compensation of about −1.19 MVAr, where the negative sign indicates that reactive power is injected into the network to support the load bus voltage. By supplying reactive power locally, the SVC significantly reduces the reactive power demand from the external grid and minimizes voltage drop across the system.

VI. HARMONIC ANALYSIS

Harmonic distortion is one of the major power quality issues in industrial power systems, especially in motor manufacturing industries where power electronic converters, welding equipment, and variable frequency drives are widely used. These non-linear loads inject harmonic currents into the power system, which leads to voltage distortion at different buses of the network. Therefore, harmonic analysis was carried out to evaluate the impact of the SVC on the harmonic performance of the system. The level of harmonic distortion in the system is commonly measured using THD.

A. Harmonic Performance without SVC: Initially, the harmonic analysis was performed without the integration of the Static Var Compensator in the system. The results indicate that the presence of non-linear loads produces significant harmonic currents, which propagate through the network and cause voltage distortion at the busbar. Due to the lack of reactive power compensation and voltage regulation, the harmonic distortion level becomes relatively higher. The increased THD affects the voltage waveform quality and may lead to several operational issues such as overheating of electrical equipment, additional losses in transformers and motors, and reduced system efficiency.

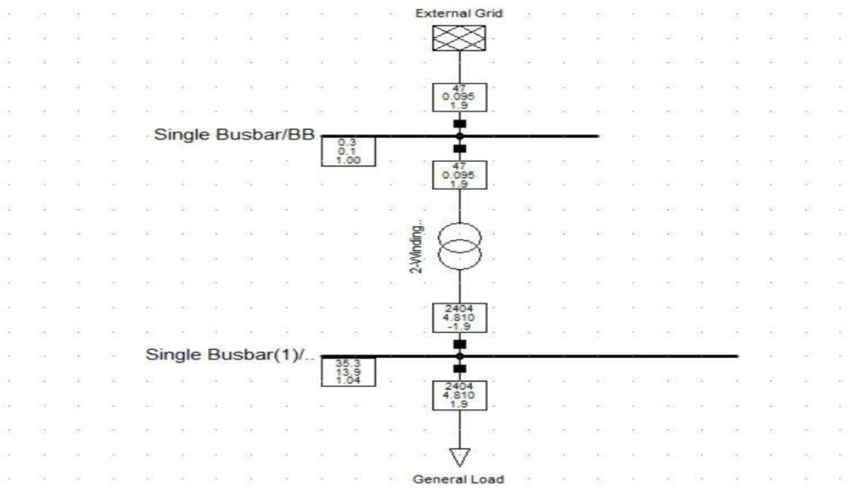
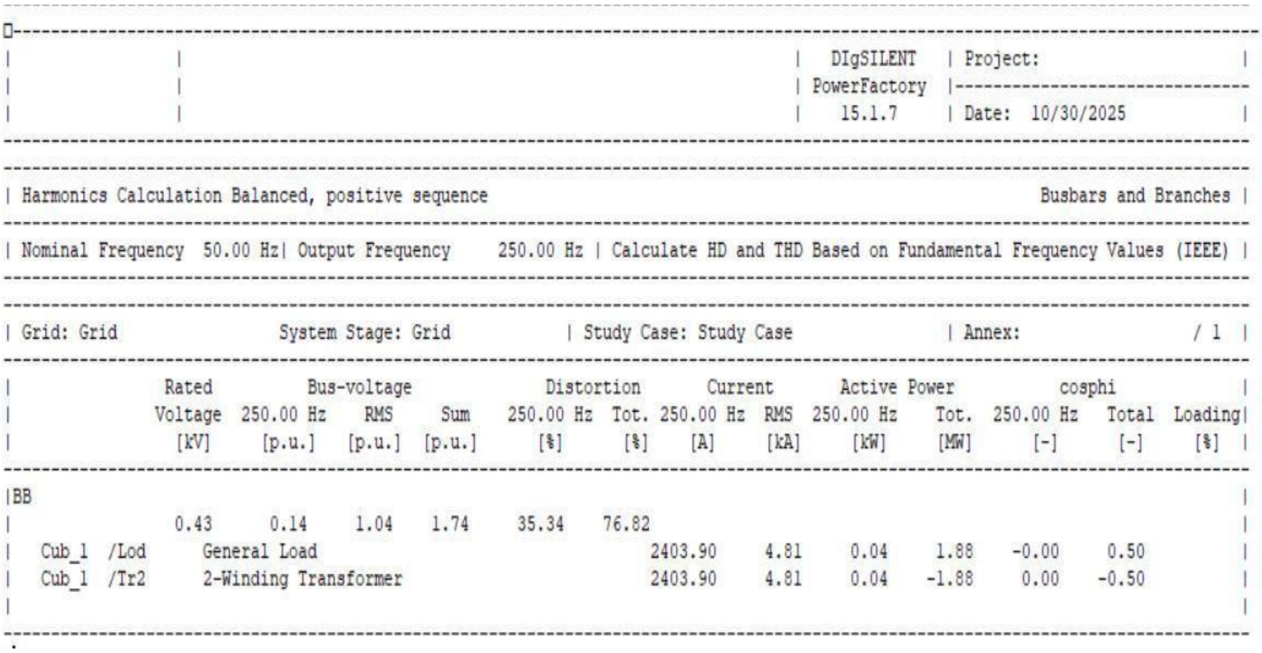


Fig:6.1 Harmonic Load Flow Without SVC

The harmonic load flow analysis of the proposed power system was carried out using DIgSILENT PowerFactory to evaluate the propagation of harmonic currents and voltages in the absence of reactive power compensation. The simulated system consists of an external grid, busbars, a two-winding transformer, and a general load. The analysis was performed with a nominal frequency of 50 Hz and an output frequency of 250 Hz, which corresponds to the 5th harmonic component of the fundamental frequency. The balanced positive-sequence harmonic analysis method was used to calculate harmonic distortion (HD) and total harmonic distortion (THD) based on standard fundamental frequency values. The busbar voltage at the load side shows a combined voltage magnitude of approximately 1.04 p.u., indicating that the voltage level is slightly above the nominal value when harmonic components are included.



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|                 |                                                          | PowerFactory |------------------------------
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| Harmonics Calculation Balanced, positive sequence                                     Busbars and Branches |
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| Nominal Frequency  50.00 Hz| Output Frequency    250.00 Hz | Calculate HD and THD Based on Fundamental Frequency Values (IEEE) |
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| Grid: Grid                 System Stage: Grid          | Study Case: Study Case              | Annex:              / 1  |
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|                  Rated       Bus-voltage            Distortion       Current      Active Power        cosphi          |
|                 Voltage 250.00 Hz   RMS     Sum   250.00 Hz Tot. 250.00 Hz RMS  250.00 Hz   Tot. 250.00 Hz  Total Loading|
|                   [kV]     [p.u.]  [p.u.] [p.u.]    [%]     [%]     [A]   [kA]    [kW]     [MW]    [-]      [-]    [%]  |
-----------------------------------------------------------------------------------------------------------
|BB                                                                                                                      |
|                  0.43      0.14    1.04    1.74    35.34    76.82                                                      |
|  Cub_1  /Lod      General Load                                 2403.90   4.81    0.04     1.88    -0.00     0.50         |
|  Cub_1  /Tr2      2-Winding Transformer                        2403.90   4.81    0.04    -1.88     0.00    -0.50         |
|                                                                                                                        |
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Fig: 6.2 Harmonic Distortion and System Performance

The harmonic calculation results indicate a high voltage distortion level at the load bus, with harmonic distortion reaching approximately 35.34% and total distortion about 76.82%, which significantly exceeds the recommended limits for acceptable power quality. The harmonic current flowing through the network is approximately 2403.90 A with an RMS value of about 4.81 kA, demonstrating that nonlinear loads inject considerable harmonic currents into the system. The load operates with a low power factor of around 0.50, indicating high reactive power consumption and inefficient power utilization. Since no Static Var Compensator or harmonic filtering device is connected, the harmonic currents generated by the load propagate through the transformer and back toward the external grid. Consequently, the system experiences increased voltage distortion, reduced power quality, and greater electrical stress on network components. These results highlight the need for reactive power compensation and harmonic mitigation devices such as SVC to improve overall system performance.

B. Harmonic Performance with SVC: In the next stage, the Static Var Compensator was integrated into the system to provide dynamic reactive power compensation. The harmonic analysis results show a noticeable improvement in waveform quality after the installation of the SVC. The SVC helps stabilize the bus voltage and reduces the propagation of harmonic distortion in the system. As a result, the THD at the busbar is significantly reduced compared to the uncompensated case. The improved voltage profile and reduced distortion contribute to better power quality and reliable operation of electrical equipment. Furthermore, the harmonic distortion levels obtained after compensation satisfy the limits specified in the IEEE 519 standard, which ensures acceptable power quality for industrial power systems. The comparative analysis clearly demonstrates that the implementation of SVC not only improves voltage stability and reactive power compensation but also contributes to the reduction of harmonic distortion in the power network.

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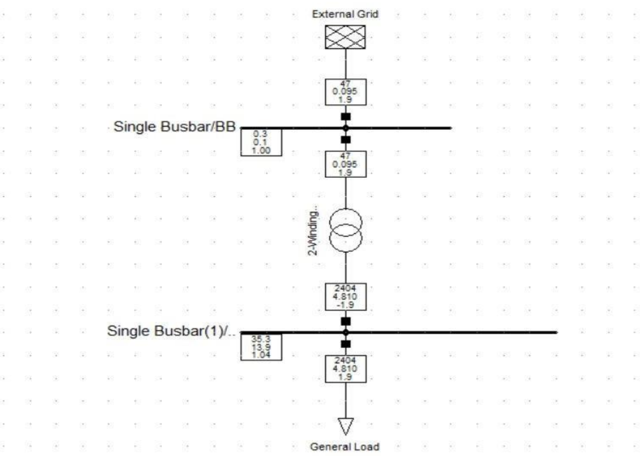
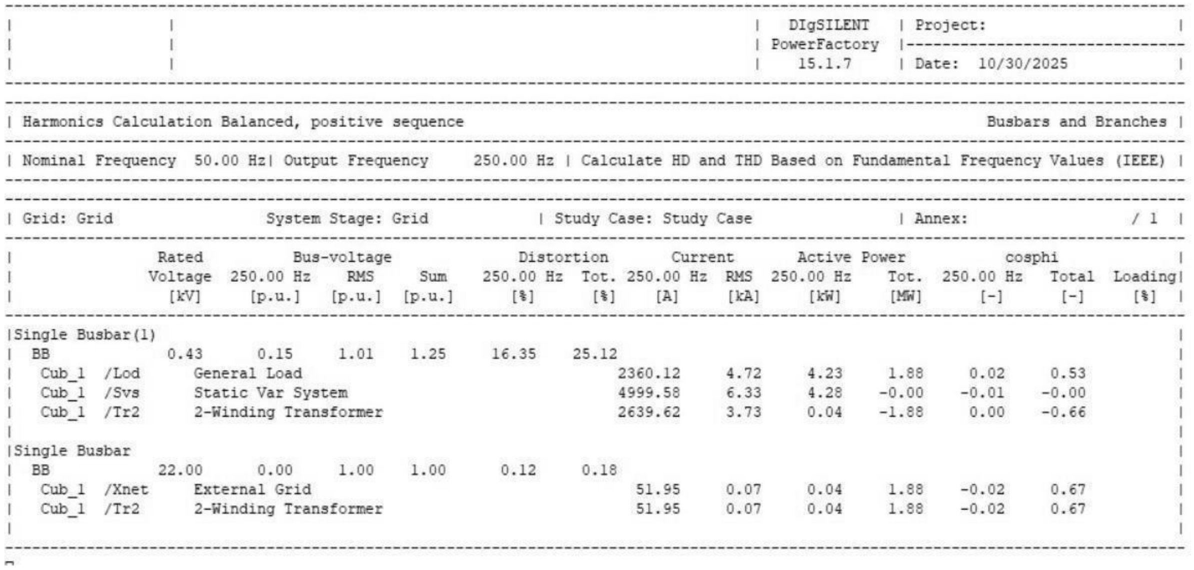


Fig:6.3 Harmonic Load Flow Analysis With SVC

The harmonic load flow analysis of the proposed system with reactive power compensation was carried out using DIgSILENT PowerFactory to evaluate the effect of harmonic currents and voltages in the presence of a Static Var Compensator (SVC). The modeled system consists of an external grid, two busbars, a two-winding transformer, a general load, and an SVC connected at the load bus. The external grid acts as the primary power source, maintaining the system reference voltage and frequency while supplying power to the network. The voltage magnitude at the sending bus remains close to the rated value of about 1.00 p.u., while the transformer transfers power to the load bus. At the receiving bus, the voltage magnitude is maintained around 1.01 p.u., indicating that the voltage profile remains stable even in the presence of harmonic components generated by nonlinear loads.



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|                 |                                                                | PowerFactory  |-------------------------------
|                 |                                                                |    15.1.7     | Date:  10/30/2025            |
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| Harmonics Calculation Balanced, positive sequence                                                          Busbars and Branches |
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| Nominal Frequency  50.00 Hz| Output Frequency     250.00 Hz | Calculate HD and THD Based on Fundamental Frequency Values (IEEE) |
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| Grid: Grid                 System Stage: Grid            | Study Case: Study Case                | Annex:                  / 1  |
-----------------------------------------------------------------------------------------------------------------------------------
|                Rated          Bus-voltage              Distortion       Current       Active Power           cosphi             |
|              Voltage  250.00 Hz  RMS       Sum    250.00 Hz  Tot. 250.00 Hz  RMS  250.00 Hz    Tot.  250.00 Hz   Total  Loading|
|                 [kV]     [p.u.]   [p.u.]  [p.u.]      [%]      [%]    [A]     [kA]     [kW]     [MW]      [-]      [-]     [%]  |
-----------------------------------------------------------------------------------------------------------------------------------
|Single Busbar(1)                                                                                                                 |
|  BB              0.43      0.15     1.01    1.25     16.35    25.12                                                              |
|   Cub_1  /Lod      General Load                                   2360.12     4.72     4.23     1.88     0.02     0.53          |
|   Cub_1  /Svs      Static Var System                              4999.58     6.33     4.28    -0.00    -0.01    -0.00          |
|   Cub_1  /Tr2      2-Winding Transformer                          2639.62     3.73     0.04    -1.88     0.00    -0.66          |
|                                                                                                                                 |
|Single Busbar                                                                                                                    |
|  BB             22.00      0.00     1.00    1.00      0.12     0.18                                                              |
|   Cub_1  /Xnet     External Grid                                    51.95     0.07     0.04     1.88    -0.02     0.67          |
|   Cub_1  /Tr2      2-Winding Transformer                            51.95     0.07     0.04     1.88    -0.02     0.67          |
|                                                                                                                                 |
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Fig:6.4 Harmonic Distortion and System Performance With SVC

The harmonic analysis results indicate that the nonlinear load introduces harmonic distortion at the load bus, with total harmonic distortion (THD) of approximately 16.3% and harmonic distortion (HD) around 15.0%. The load consumes active power of about 2360 kW and reactive power of approximately 4.723 kVAr, while the SVC provides reactive power compensation of nearly 5000 kVAr to support the system voltage. By injecting reactive power locally, the SVC helps maintain the bus voltage close to 1.0 p.u., improves the power factor, and reduces the reactive power burden on the external grid. Although harmonic components generated by the nonlinear load propagate through the transformer and network, the presence of the SVC significantly improves voltage regulation and overall power quality compared to the uncompensated system.

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VII. CONCLUSION AND FUTURE SCOPE

This study presented the improvement of power quality in a motor manufacturing industry using a SVC. Industrial power systems with large inductive loads such as induction motors, welding equipment, and variable frequency drives often suffer from problems including poor power factor, voltage fluctuations, excessive reactive power demand, and harmonic distortion. To address these issues, an SVC consisting of TCR and TSC was implemented to provide dynamic reactive power compensation. The performance of the proposed system was analysed using load flow and harmonic analysis in DIgSILENT Power Factory under two operating conditions: without SVC and with SVC. The simulation results showed that without compensation the system experienced voltage drop at the load bus, poor power factor, and higher reactive power demand from the external grid. After integrating the SVC at the PCC, the bus voltage was maintained close to its rated value, reactive power demand from the grid was significantly reduced, and the power factor improved close to unity. Additionally, harmonic analysis indicated that the voltage distortion level was reduced after compensation, resulting in improved waveform quality and better system performance. Therefore, the implementation of SVC proves to be an effective and economical solution for enhancing power quality, improving voltage stability, and reducing system losses in motor manufacturing industries. In future work, comparative studies with other FACTS devices such as STATCOM or UPFC, integration of harmonic filtering techniques, and real-time hardware implementation can be investigated to further enhance power quality and system reliability in modern industrial power networks.

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