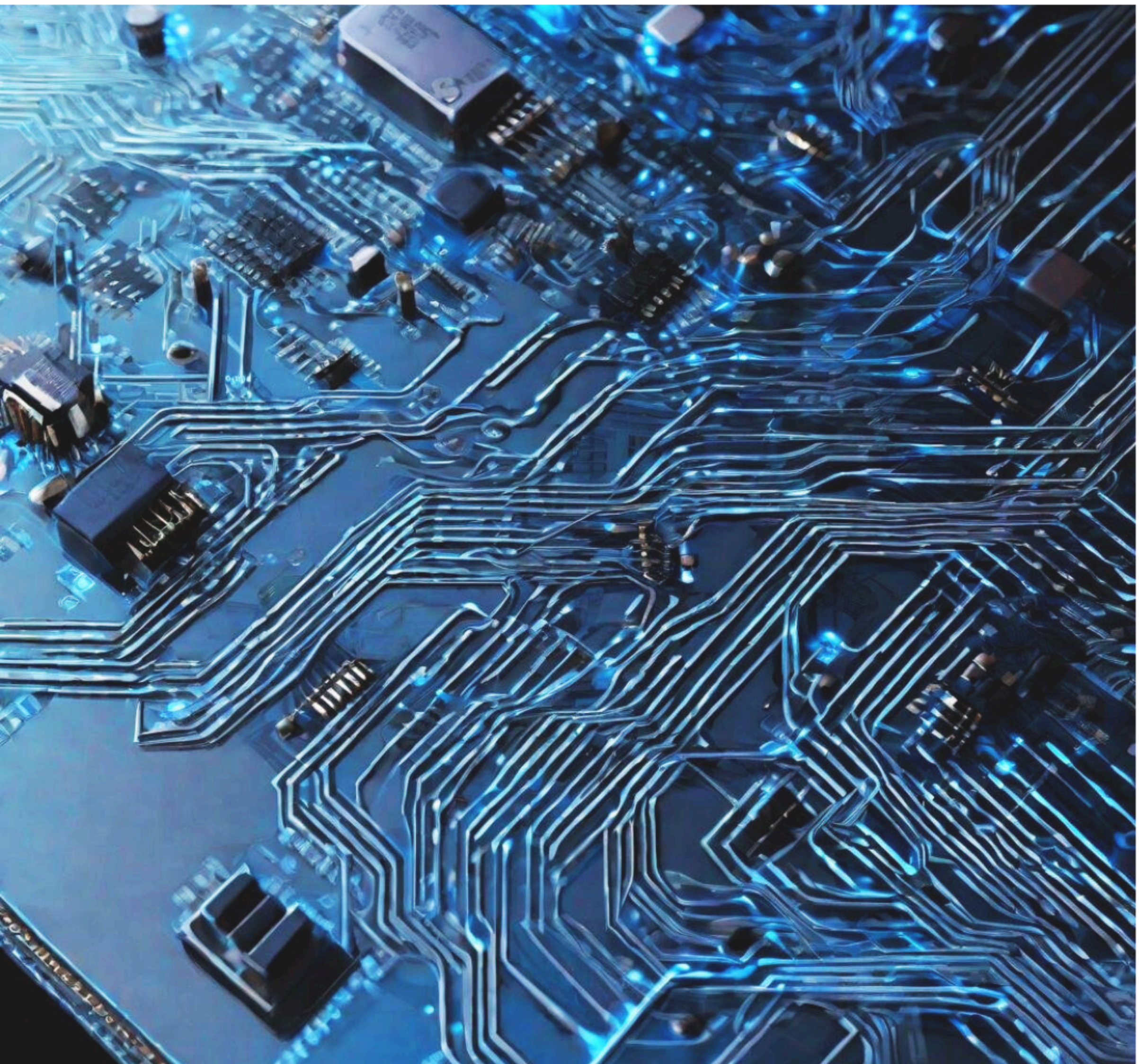
Silov Solutions
Incubated at Indian Institute of Technology, Delhi

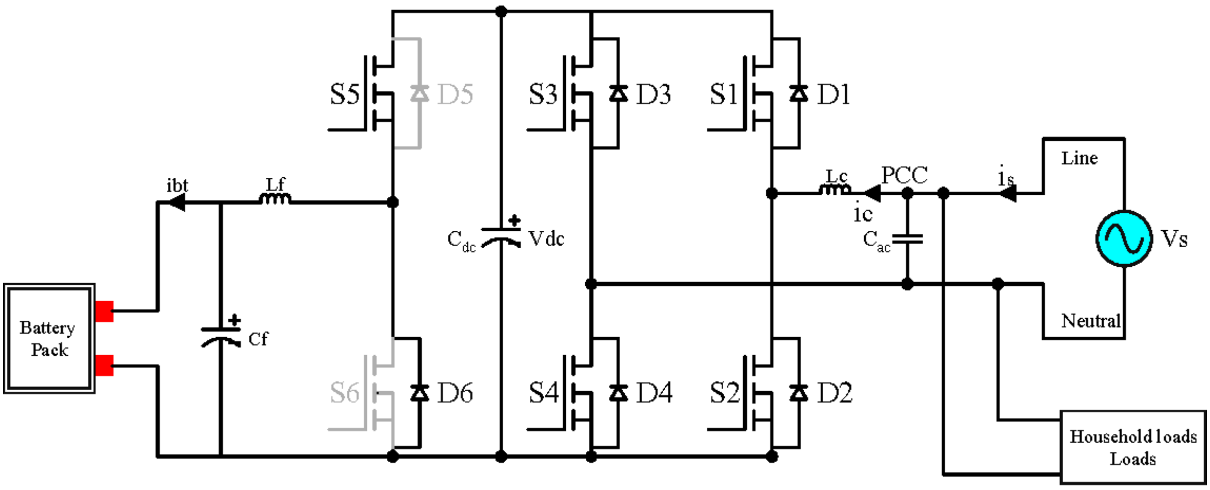
# PRODUCT
# BROCHURE



## Product Details



## Technical Specifications of Grid Interface Converter




**Grid:** 220 V +/- 10%AC, 50 Hz (+/- 0.5 Hz)

**Power rating**: 1 kVA

**Controller:** Onboard microcontroller

**Control:** LabVIEW-based GUI for V2V and V2G

**Current Control:** Yes

**DC Voltage:** 48 V

**Protection:** Over Voltage, Under Voltage, Over Current, Under Current, Over Frequency and Under frequency

**Sensors:** Non-isolated with isolated ADC via communication to microcontroller

**Inductors**: On-board fixed

**Auxiliary Power supply**: Included

**Sensors**: DC Voltage, AC Current, AC voltage Included and Onboard

**Grid Current THD:** < 3%

## Key Experiments as EV Charger

### Experiment 1A: Vehicle-to-Grid (V2G) Current Regulation and Error Analysis

**Objective:**
To regulate and measure the current fed from the vehicle's battery to the grid through the converter, and analyze any error between the set-point and the actual current.

#### Version 1: Using POT for Regulation

**Procedure:**

1. **Setup:**
   - Connect the Grid Interface Converter between the vehicle's battery and the grid.
   - Ensure all connections are secure and that the system is powered on.
2. **Regulating Current:**
   - Use the potentiometer (POT) on the back of the converter box to adjust the current flow from the vehicle's battery to the grid.
3. **Measurement:**
   - Measure the current fed into the grid using a digital multimeter.
   - Record the set-point value manually set by the POT.
4. **Error Analysis:**
   - Calculate the error by comparing the actual measured current with the manually set value.
   - Record and analyze the error, if any.
5. **Battery Voltage Drop:**
   - Measure the current flowing from the vehicle's battery.
   - Observe and record the voltage at the battery terminals under no-load and loaded conditions.
   - Analyze the voltage drop and its implications on system performance.

**Expected Outcome:**
Students will understand how to manually regulate current in a V2G scenario using a potentiometer and will develop skills in measuring and analyzing the difference between

set-point and actual current. They will also observe the impact of current flow on battery voltage stability.

### Version 2: Using Software Interface for Regulation

**Procedure:**

1. **Setup:**
   - Connect the Grid Interface Converter between the vehicle's battery and the grid.
   - Power on the system and launch the proprietary LabView-based software interface.
2. **Regulating Current:**
   - Set the desired current flow from the vehicle's battery to the grid using the software interface.
   - Monitor the real-time current data displayed in the software.
3. **Measurement:**
   - Measure the actual current fed into the grid using the software's measurement tools.
   - Record the set-point value as specified in the software.
4. **Error Analysis:**
   - Calculate the error by comparing the actual measured current with the software set-point value.
   - Record and analyze the error, if any.
5. **Battery Voltage Drop:**
   - Measure the current drawn from the vehicle's battery.
   - Record the voltage at the battery terminals in both no-load and loaded conditions.
   - Analyze the voltage drop and its impact on battery health and converter efficiency.

**Expected Outcome:**

Students will gain experience in using software interfaces for current regulation in a V2G setup, learning how to measure and analyze deviations from set-point values. Additionally, they will understand the effects of varying current flow on battery voltage and overall system performance.

## Experiment 1B: Grid-to-Vehicle (G2V) Current Regulation and Error Analysis

**Objective:**

To regulate and measure the current fed from the grid to the vehicle's battery through the converter, and analyze any error between the set-point and the actual current.

### Version 1: Using POT for Regulation

**Procedure:**

1. **Setup:**

- Connect the Grid Interface Converter between the grid and the vehicle's battery.
- Ensure all connections are secure and that the system is powered on.

2. **Regulating Current:**
- Adjust the current flowing from the grid to the vehicle's battery using the potentiometer (POT) located on the converter box.

3. **Measurement:**
- Measure the current supplied to the battery using a digital multimeter.
- Record the set-point current value manually set by the POT.

4. **Error Analysis:**
- Calculate the error by comparing the actual measured current with the manually set value.
- Record and analyze the error, if any.

5. **Battery Voltage Change:**
- Measure the current received by the vehicle's battery.
- Record the battery terminal voltage under both no-load and loaded conditions.
- Analyze any voltage changes and their effect on battery charging efficiency.

**Expected Outcome:**
Students will learn how to manually regulate the current from the grid to the vehicle's battery, measure the resulting current, and analyze any deviations from the set-point. They will also gain insight into how current regulation impacts battery voltage during charging.



**Version 2: Using Software Interface for Regulation**
**Procedure:**

1. **Setup:**
- Connect the Grid Interface Converter between the grid and the vehicle's battery.
- Power on the system and launch the proprietary LabView-based software interface.

2. **Regulating Current:**
- Use the software interface to set the desired current flow from the grid to the vehicle's battery.
- Monitor the real-time data on current flow as displayed in the software.

3. **Measurement:**
- Measure the actual current supplied to the battery using the software's measurement tools.
- Record the set-point current value as specified in the software.

4. **Error Analysis:**
- Calculate the error by comparing the actual measured current with the software set-point value.
- Record and analyze the error, if any.

5. **Battery Voltage Change:**
- Measure the current received by the vehicle's battery.
- Record the voltage at the battery terminals under no-load and loaded conditions.
- Analyze the voltage changes and their effect on battery health and charging performance.

**Expected Outcome:**
Students will develop proficiency in using software for current regulation in a G2V scenario, learning to measure and analyze deviations from set-point values. They will also observe the impact of current flow on battery voltage during the charging process, gaining insights into battery charging dynamics.

## Experiment 2: Efficiency Measurement of the Grid Interface Converter

**Objective:**
To measure the efficiency of the Grid Interface Converter during both Vehicle-to-Grid (V2G) and Grid-to-Vehicle (G2V) operations.

**Procedure:**

1. **Setup:**
   - Connect the converter between the battery and the grid.
   - Ensure all connections are correct and system parameters are set according to the experiment requirements.
2. **Data Collection:**
   - Measure the input power from the battery and the output power fed to the grid during V2G operation.
   - Measure the input power from the grid and the output power supplied to the battery during G2V operation.
3. **Efficiency Calculation:**
   - Calculate the efficiency of the converter for both V2G and G2V modes using the formula:

$$Efficiency\ (\%) = (Output\ Power)/(Input\ Power) * 100$$

4. **Analysis:**
   - Compare the efficiency values obtained for V2G and G2V operations.
   - Discuss factors affecting the efficiency, such as internal losses, temperature variations, and loading conditions.



## Experiment 3: Harmonic Analysis in Grid-Connected Mode

**Objective:**
To analyze the harmonic distortion introduced by the Grid Interface Converter during grid-connected operations.

**Procedure:**

1. **Setup:**
   - Connect the converter to the grid and battery as per the standard configuration.
   - Ensure the system is operating under normal conditions.
2. **Harmonic Measurement:**
   - Use a power quality analyzer to measure the harmonic content in the current fed to the grid.
   - Record the Total Harmonic Distortion (THD) and individual harmonic levels (e.g., 3rd, 5th, 7th harmonics).
3. **Data Analysis:**
   - Compare the harmonic levels with the acceptable standards (e.g., IEEE 519).
   - Analyze the effect of loading conditions on harmonic distortion.
4. **Mitigation Techniques:**
   - Implement and test various harmonic mitigation techniques, such as filtering or modifying the control algorithm.
   - Measure the effectiveness of these techniques by comparing the THD before and after implementation.

**Expected Outcome:**
Students will learn how to measure and analyze harmonics in grid-connected systems and explore methods for reducing harmonic distortion to maintain power quality. They will gain practical experience in applying mitigation techniques and evaluating their effectiveness.

# Sample Outputs and trend analysis

| Power 2 - Power Quality | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Measurement** | **Test** | **Sources** | **Mean'** | **Min'** | **Max'** | **PK-PK'** | **Std Dev'** | **Pop'** | **Accum Mean** | **Accum Min** | **Accum Max** | **Accum Pk-Pk** | **Accum Std Dev** | **Accum Pop** |
| Power Quality | Frequency | Ch 1, Ch 2 | 49.906 Hz | 49.906 Hz | 49.906 Hz | 0.0000 Hz | 0.0000 Hz | 1 | 49.938 Hz | 49.905 Hz | 49.964 Hz | 58.480 mHz | 19.323 mHz | 528 |
| | VRMS | | 245.14 V | 245.14 V | 245.14 V | 0.0000 V | 0.0000 V | 1 | 244.89 V | 244.63 V | 245.38 V | 750.60 mV | 144.86 mV | 528 |
| | IRMS | | 3.8797 A | 3.8797 A | 3.8797 A | 0.0000 A | 0.0000 A | 1 | 3.8723 A | 3.8670 A | 3.8797 A | 12.710 mA | 2.1314 mA | 528 |
| | Voltage Crest Factor | | 1.3936 | 1.3936 | 1.3936 | 0.0000 | 0.0000 | 1 | 1.3933 | 1.3913 | 1.3958 | 4.4258 m | 753.10 u | 528 |
| | Current Crest Factor | | 1.4797 | 1.4797 | 1.4797 | 0.0000 | 0.0000 | 1 | 1.4757 | 1.4601 | 1.5786 | 118.44 m | 17.756 m | 528 |
| | True Power | | 948.51 W | 948.51 W | 948.51 W | 0.0000 W | 0.0000 W | 1 | 945.69 W | 943.67 W | 949.25 W | 5.5781 W | 929.06 mW | 528 |
| | Reactive Power | | 69.984 VAR | 69.984 VAR | 69.984 VAR | 0.0000 VAR | 0.0000 VAR | 1 | 70.145 VAR | 68.233 VAR | 77.741 VAR | 9.5086 VAR | 1.4172 VAR | 528 |
| | Apparent Power | | 951.09 VA | 951.09 VA | 951.09 VA | 0.0000 VA | 0.0000 VA | 1 | 948.29 VA | 946.24 VA | 951.85 VA | 5.6130 VA | 951.63 mVA | 528 |
| | Power Factor | | 997.29 m | 997.29 m | 997.29 m | 0.0000 | 0.0000 | 1 | 997.26 m | 996.64 m | 997.40 m | 767.94 u | 112.82 u | 528 |
| | Phase Angle | | 4.2198 Degrees | 4.2198 Degrees | 4.2198 Degrees | 0.0000 Degrees | 0.0000 Degrees | 1 | 4.2421 Degrees | 4.1291 Degrees | 4.7007 Degrees | 571.58 mDegrees | 84.711 mDegrees | 528 |

| Power 1 - Harmonics' | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Measurement** | **Sources** | **Standard** | **Harmonics** | **F1 Mag** | **F3 Mag** | **THD-F** | **THD-R** | **IRMS** | **VRMS** | **Frequency** | **TruePower** | **Status** |
| Harmonics | Ch 1, Ch 2 | IEC | 40 | 3.8765 A | 4.1054 mA | 1.4316 % | 1.4314 % | 3.8786 A | 245.08 V | 49.906 Hz | 948.51 W | Pass |

| Power 2 - Power Quality' | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Measurement** | **Sources** | **Frequency** | **VRMS** | **IRMS** | **Voltage Crest Factor** | **Current Crest Factor** | **True Power** | **Reactive Power** | **Apparent Power** | **Power Factor** | **Phase Angle** |
| Power Quality | Ch 1, Ch 2 | 49.906 Hz | 245.14 V | 3.8797 A | 1.3936 | 1.4797 | 948.51 W | 69.984 VAR | 951.09 VA | 997.29 m | 4.2198 Degrees |