Implementation of FPGA Based Single Phase Grid Power Quality Improvement Using EV Charging and Discharging

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Abstract:

In this paper, Grid matched with EV battery system is constrained by hysteresis current control method. FPGA algorithm can be programmed to perform the control activity of BUCK/BOOST converter by charging and discharging of battery mode. Improving power quality by maintaining a current THD level of less than 4%. This scheme manages usage of battery in valuable manner. At its hour is improved to charge brace power quality. Battery is one of the stockpile components; utilize that the EV very still days or not utilized days. THD of current is decreased and compared this results is nearly great than existing one and this will realize in simulation and also hardware.

Keywords: Voltage Source Converter (VSC), Total harmonics distortion (THD), Electric vehicle (EV), Field Programmable Gate Array controller(FPGA), Grid to Vehicle (G2V),Vehicle to Grid (V2G).

Introduction:

The grid-based charger topologies for charging the EV battery demonstrated below. Due to the charger's unidirectional power flow, active electricity cannot travel from the vehicle to the grid. However, an EV battery might be used as a form of energy storage in the event of a power outage.

The bi-directional flow of power is supported by this charging station. A bi-directional converter is used to connect the EV to the charging station's DC-link. A bidirectional converter has the benefit of preventing second harmonic current and DC-link ripples from entering the EV battery, which deteriorates the battery and reduces its lifetime. Furthermore, the selection of the EV battery rating is no longer influenced by the DC-link voltage. The bidirectional converter's duty cycle is set to charge and drain the batteries. The VSC is used to provide the grid with the reactive power correction it requires[1,2].

The charging station's control is based on the reference DC link voltage and reference current command. The EV owner decides whether to charge or discharge the EV battery depending on the reference DC link voltage and reference current command. The charging station is programmed such that the EV owner controls the charging and discharging of the EV battery. The system functioning is known as G2V when grid electricity is required to charge the EV battery (Grid to Vehicle). The system operation is known as V2G when an EV battery discharges to give electricity to the grid (Vehicle to Grid)[3]. Furthermore, the charging station is capable of providing reactive power correction (lagging/leading) as needed.

PROPOSED SYSTEM:

The output voltage instruction is subtracted from the actual output voltage after the proportional integral (PI) link, and the pulse command signal is obtained after comparing with the current value of the PI link. However, if the access voltage fluctuates too much or there is wave distortion, the system's power factor and DC side output voltage stability would suffer. It can be separated into a single-phase rectifier in charging rectification, depending on the topologies of the main circuit. This drawback is overcome by control schemes.

For this proposed system instantaneous current generation method used for generating the PWM pulses for the inverter and battery current closed loop control used for generating the pulse for bidirectional converter. In a PV-based EV charging station, the power quality has improved.

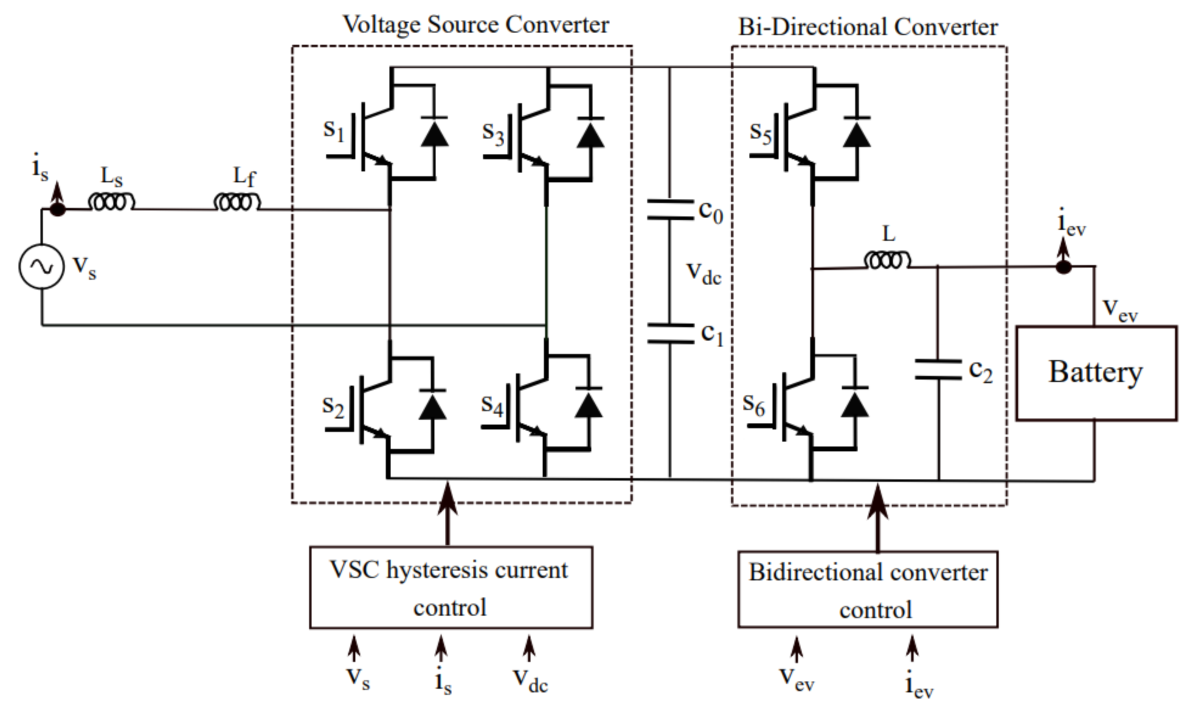

Figure.1: Proposed System Circuit

I.SINGLE PHASE ACTIVE VSI:

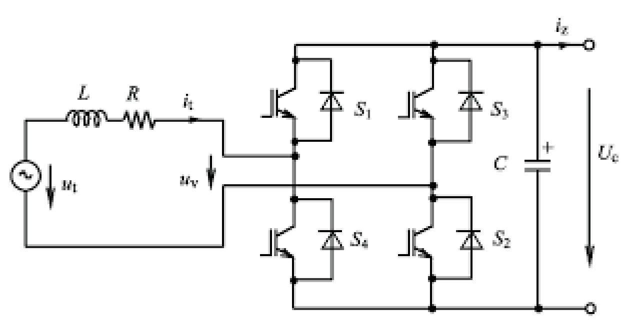

Figure.2: Single Phase Voltage Source Inverter

This active VSI has a dual purpose. Act as an active Rectifier when charging the batteries and as a grid-tied inverter when discharging the batteries. The bi-directional converter has two functions: first one is Buck mode- the bi-directional charger is being used to charge a battery in this mode. Second one is Boost mode- the battery is discharged using the bi-directional charger in this mode.

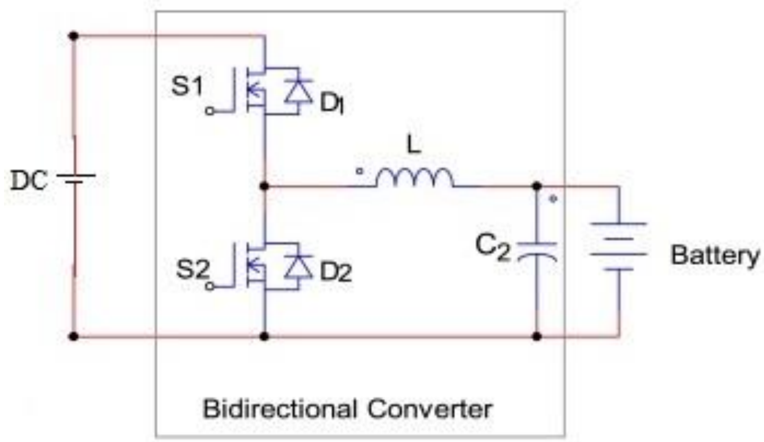

Figure .3: Bidirectional Converter

II.BATTERY CURRENT CLOSED CONTROL:

Based on the current reference for the bidirectional converter, this study uses battery current as a feedback and forms a current closed loop. Using a comparator, the reference current is compared to the actual current, and the difference is sent to the pi-controller. PI-controller output is sent to a DC-DC PWM generator with a duty cycle range of 0 to 95%. That is a buck bidirectional converter pulse, while an inverted pulse is a boost bidirectional converter pulse. The charging and draining of the battery can be controlled utilizing this closed loop system.

III.DESIGNING PROCESS:

MATLAB simulation uses 48V, 64AH lithium-ion battery specifications. Lithium ions flow from the negative electrode to the positive electrode during discharge and back to the negative electrode during charging in a lithium-ion battery. Lithium-ion battery types differ in terms of chemistry, performance, cost, and safety[6,8]. Lithium-ion batteries, unlike lithium primary batteries (which are disposable), use an intercalated lithium compound as the electrode material rather than metallic lithium. In consumer electronics, lithium-ion batteries are widely used. They have one of the best energy-to-weight ratios, a high open circuit, a low self-discharge rate, no memory impact, and a slow loss of energy when not in use, making them one of the most common types of rechargeable batteries for portable gadgets. Because of their great energy density, lithium-ion batteries are becoming increasingly used in military, electric vehicle, and aerospace applications.

To remove the AC component from the rectified output, an inductor is utilized as a filter. Inductors let DC pass through while blocking AC.

IV.SOFTWARE DESIGN OF CONTROL SCHEMES:

Control scheme of instantaneous current generation method is used for generating the PWM pulses for the inverter and battery current closed loop control method is used for generating the pulse for bidirectional converter. MATLAB Simulation model of control scheme is shown in figure 4 and 5.

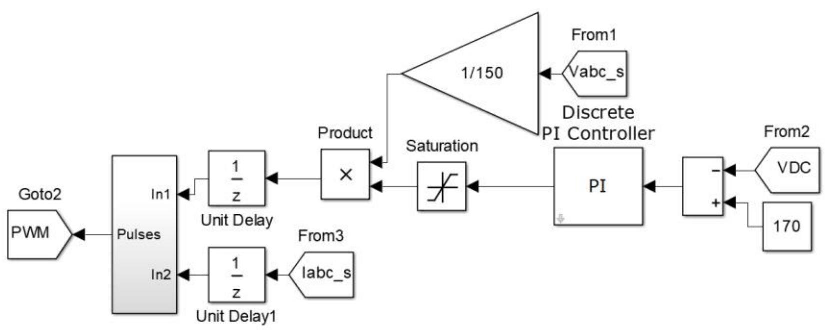

Figure.4:Instantaneous Current Generation Method

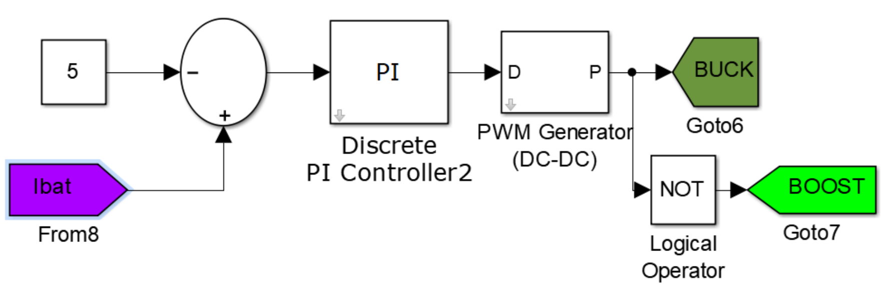

Figure.5: Battery Current Closed Loop Control

V.HARDWARE RESULTS

5.1 .BATTERY CHARGING IN UNCONTROLED BRIDGE RECTIFIER

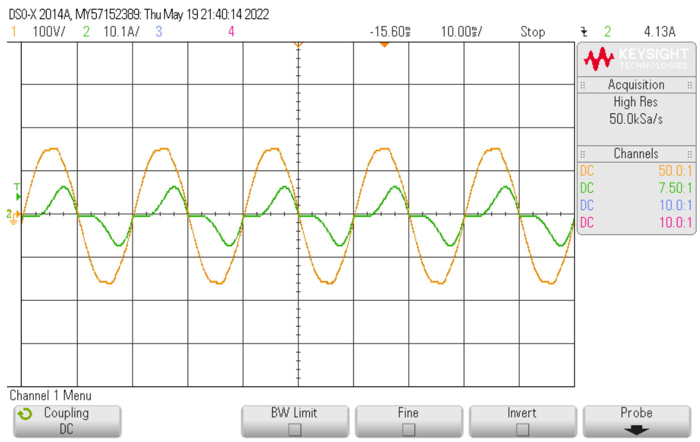

Figure.5.1.1 Grid voltage and Grid non-linear current

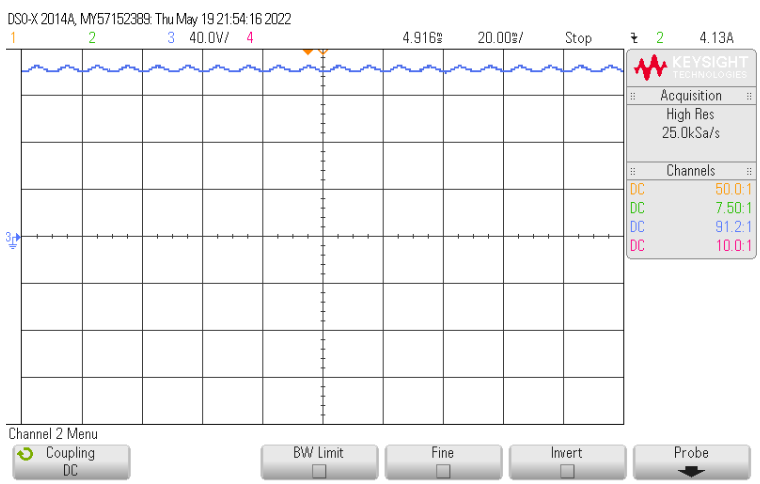

Figure .5.1.2 : DC link voltage

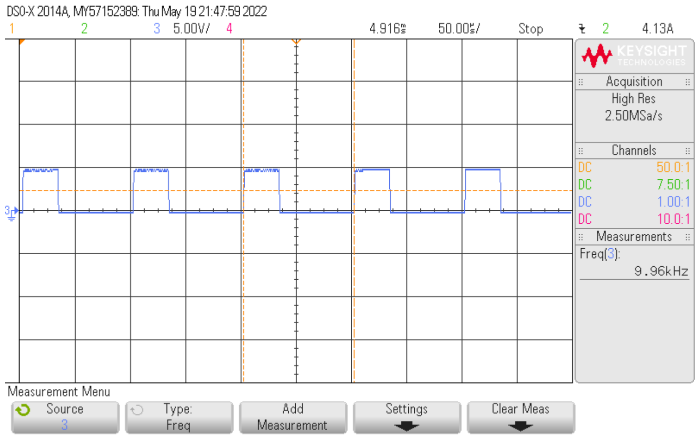

Figure 5.1.3: Buck PWM Pulse

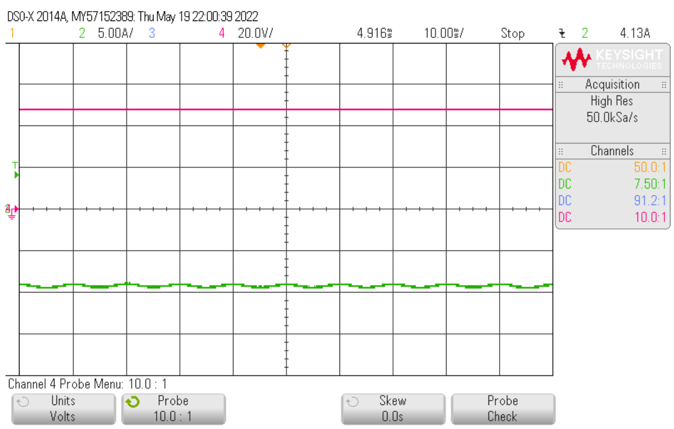

Figure 5.1.4 Battery Voltage and Current

5.2. BATTERY CHARGING IN INSTANTANEOUS CURRENT GENERATION METHOD

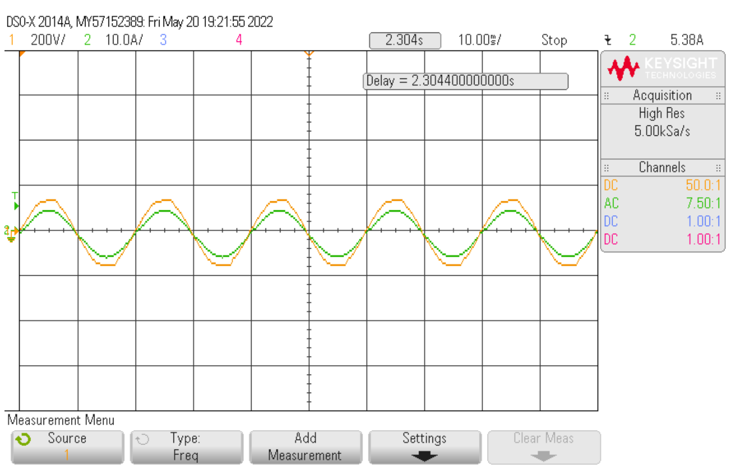

Figure 5.2.1 Grid voltage and Grid current

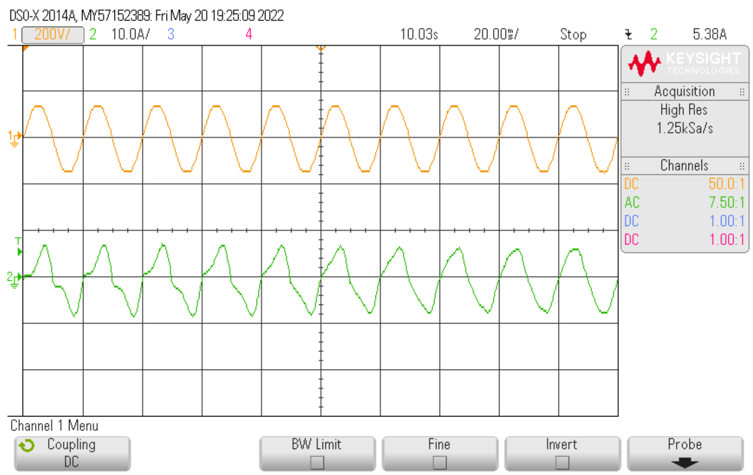

Figure 5.2.2. Grid voltage and Grid compensating current

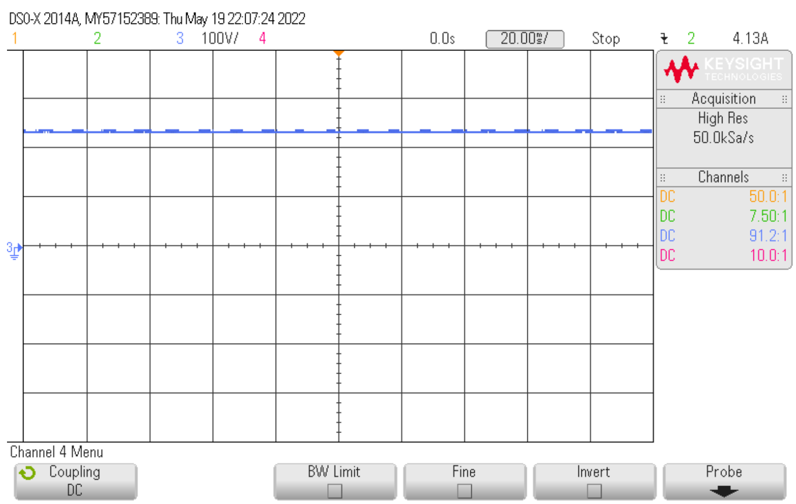

Figure 5.2.3 DC Link Voltage

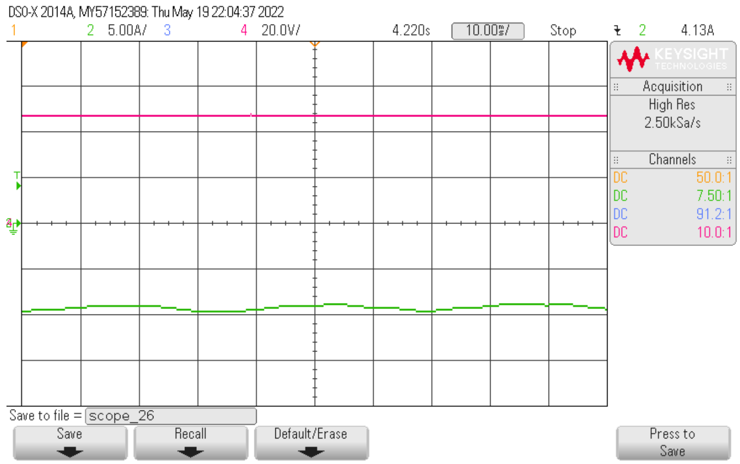

Figure 5.2.4 Battery Voltgae and Current

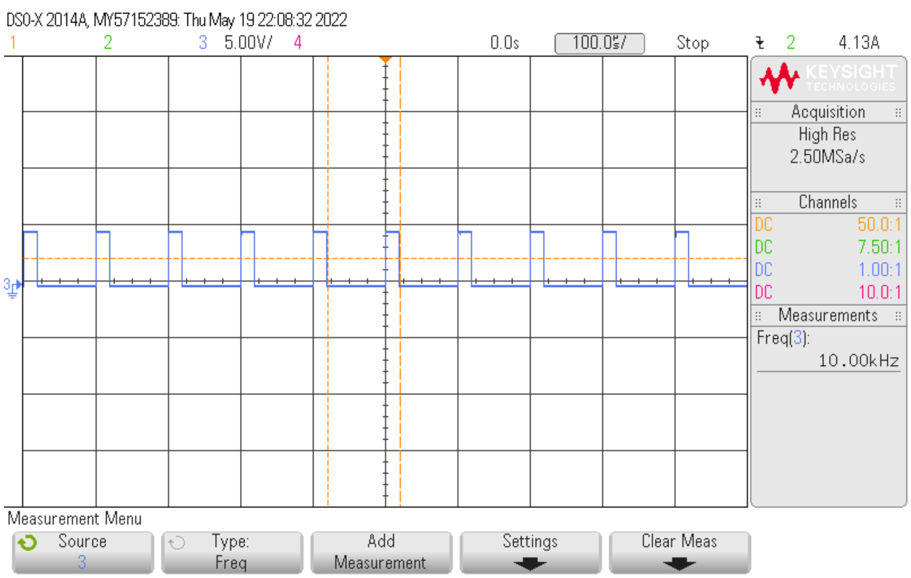

Figure 5.2.5 Buck PWM Pulse

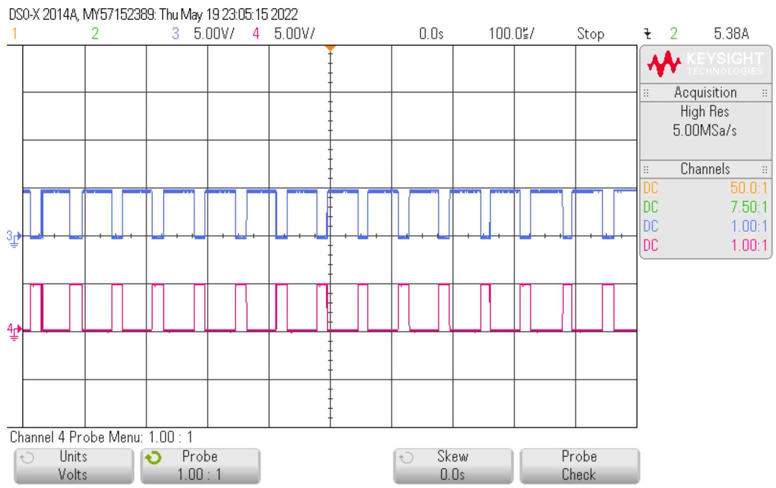

Figure 5.2.6 Inverter PWM1 and PWM2

5.3 BATTERY DISCHARGING

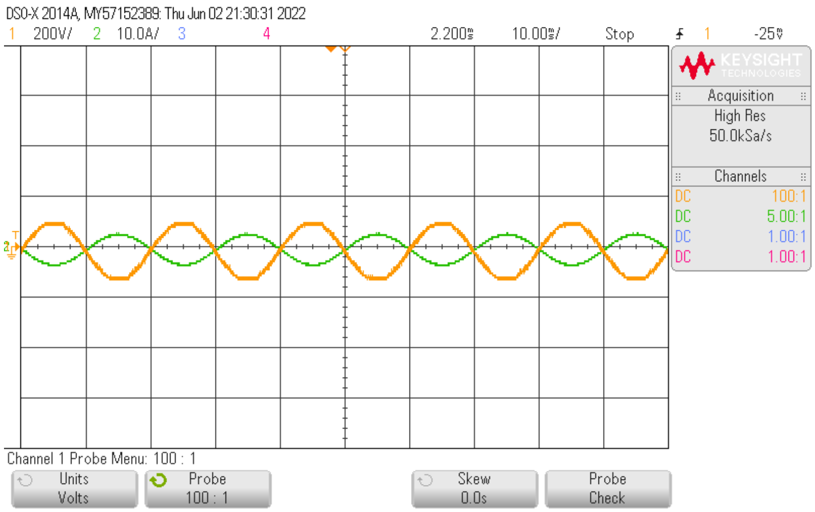

Figure 5.3.1 Grid Voltgae and current

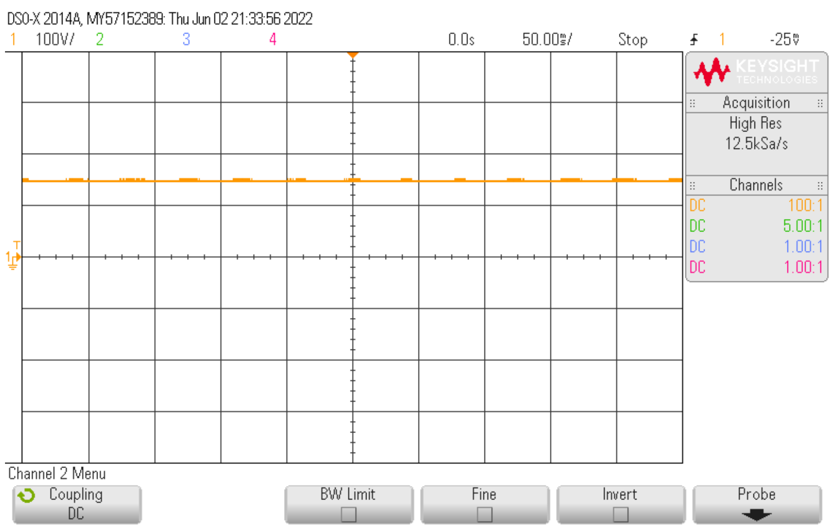

Figure 5.3.2 DC Link Voltage

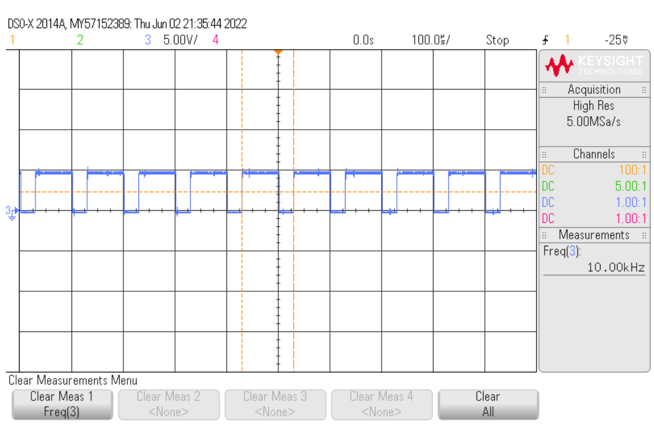

Figure 5.3.3 Boost PWM Pulse

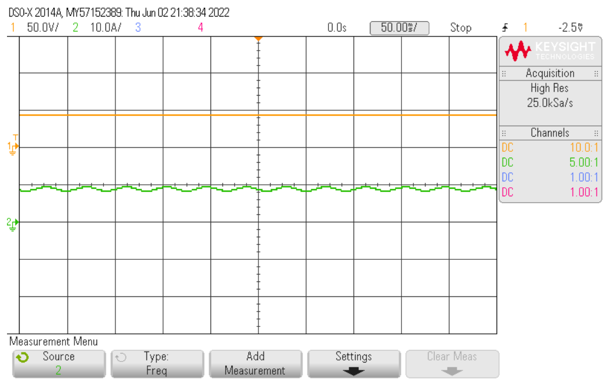

Figure 5.3.4 Battery Voltage and Current

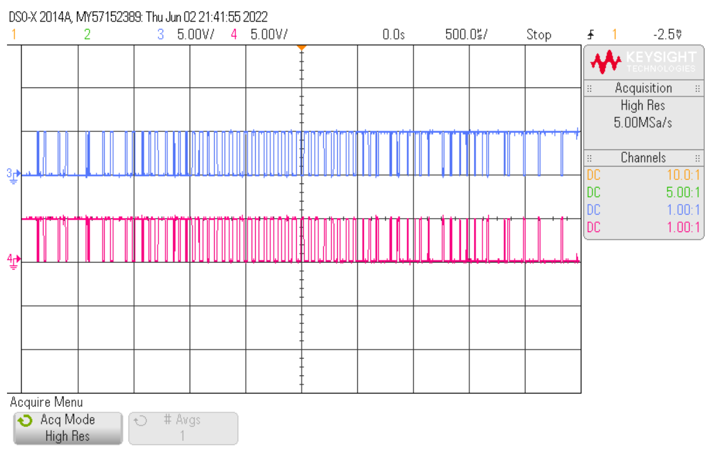

Figure 5.3.5 Inverter PWM1 and PWM2

Conclusion:

When electric vehicles are connected to an intermittent new energy field, the distortion and fluctuation caused by the charging process shortens the life of the chargers and batteries, while also affecting the accuracy of electric energy metering. When linked to the grid, the charging station adjusted for reactive power and improves the power quality. This is achieved and results are there in this paper. The EV charging station was designed to be capable of synchronizing with the grid and earning revenues by discharging EV batteries to the grid during peak hours.

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