BI-DIRECTIONAL RECONFIGURABLE GAIN CIRCUIT FOR POWER CONVERTER APPLICATION

IITM Technology Available for Licensing

Problem Statement

- Convention **bi-directional dc-dc converters** are designed to meet the required gains during charging & discharging operations with higher secondary turns of the transformer or by using high gain resonant tank circuits or by specific control techniques.
- However, high secondary turns **result** in **higher transformer parasitic inductances & capacitances**, particularly for high voltage applications.
- Present patent addresses the technical problem stating as ***how to provide an efficient bi-directional power converter to overcome the shortcomings of existing bidirectional converters*** & subject matter of claimed invention provides efficient solution.

Technology Category/ Market

Technology: Bi-Directional Reconfigurable gain circuit; **Industry:** Energy, Electrical Industries; **Applications:** Power Converter application; Battery charging & etc..
Market: The global bidirectional amplifier market is projected to grow at a **CAGR** of **13.2%** during forecast period **(2024-2031).**

Technology

- Present invention explains about a power converter circuit comprises
→ a **primary circuit** including full bridge;
→ a **resonant tank stage** connected to primary circuit;
→ a **secondary circuit** connected to the resonant tank via a transformer connected to the resonant tank stage.
- Said **secondary circuit** comprises at least a secondary full bridge, a voltage doubler, and a **Bi-directional Reconfigurable Gain (BRG) circuit.**
- The BRG circuit is configured to be selectively connect to the **secondary full bridge** during **a charging mode** & to the **voltage doubler** during a **discharging mode.**
- Said resonant tank is a **LCLC resonant tank.**
- Said **BRG circuit** comprises at least **two pairs of anti-series** connected **MOSFETs** switches.
- A **BRG** circuit includes a first switch (S_R), a second switch (S_F).
- The **First switch** is configured to connect with the secondary full bridge during the charging mode of the power converter circuit.
- The **Secondary switch** is configured to connect with the voltage doubler during the discharging mode of the power converter circuit.

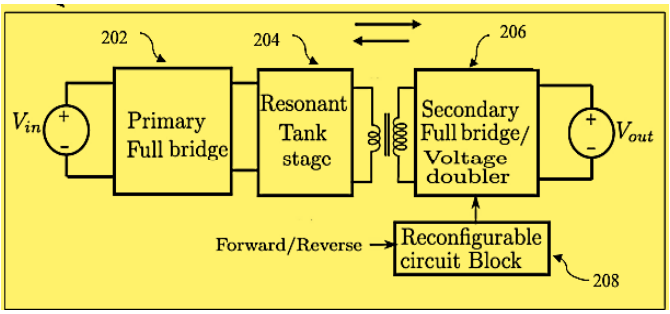

Fig.1 illustrates a block diagram of a bi-directional converter with a reconfigurable circuit block;

Intellectual Property

IITM IDF Ref. 2332;
IN Patent No. 482660 (Granted)

TRL (Technology Readiness Level)

TRL-4, Proof of Concept ready, tested and validated in Laboratory

Research Lab

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Key Features / Value Proposition

❖ *Technical Perspective:*

Efficient Techniques:

- The claimed invention provides a technique for providing a power converter capable of operating in a **wide input voltage range** with **high power conversion efficiency**.

Reconfigurable Gain Circuit:

- Facilitates a power converter with a reconfigurable gain circuit adept of configuring a secondary circuit of the converter as **voltage doubler** in **discharging mode** & as a **full bridge circuit** in **charging mode &** a **hybrid control scheme** along with the **BRG circuit** to operate the converter for a **wide input voltage variation**.

Improved Performance:

- Improved performance of the converter by **minimizing** the transformer secondary turns and **reducing** the parasitic inductances and capacitances.

❖ *Industrial Perspective:*

Utility:

- Applicable in the industry such as **dual active bridge, resonant tank based like LC or CLLC bi-directional converters, & etc..**

Simulation Result

In an exemplary implementation, the BRG circuit is tested for 800 W in charging & discharging mode. The developing **54 V DC bus** at the input side and **ensures battery charging**. The simulation results are shown in FIGs. 3(a) & 3(b).

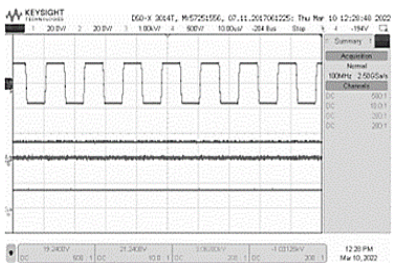

FIG. 3(a)

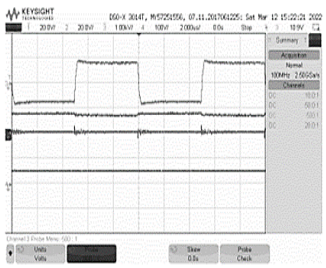

FIG. 3(b)

Images

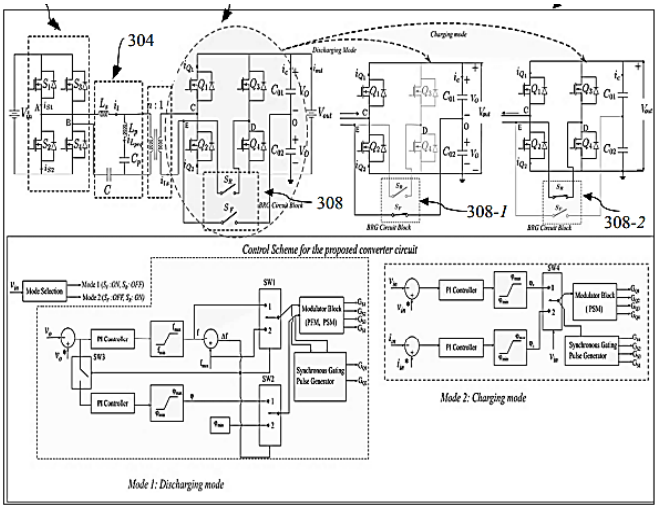

FIG.2a: Illustrates circuit diagram of a LCLC resonant converter with a BRG circuit and hybrid control scheme;

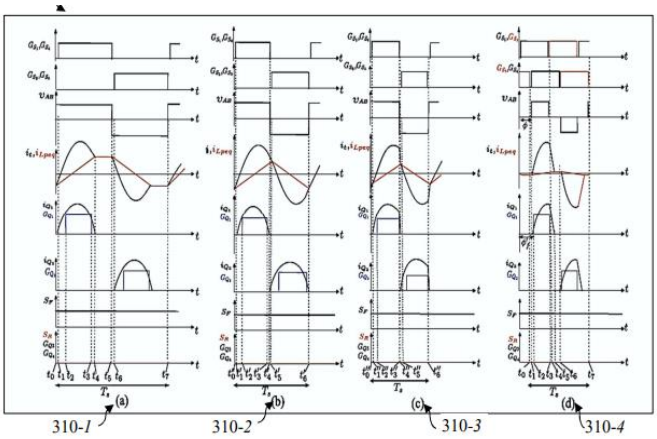

FIG.2b: Illustrates a steady state waveform in forward power transfer mode and frequency modulation;

Exemplary Result

Operating Mode	Converter Gain	Remarks
Discharging Mode (Secondary Voltage Doubler)	$G_1G_2G_3*2$	$G_4 = 2$; voltage doubler (Prefered)
Discharging Mode (Secondary Full bridge Circuit)	$G_1G_2G_3*1$	$G_4 = 1$; Secondary full bridge Circuit (not prefered)
Charging Mode (Secondary Voltage Doubler)	$G_1G_2G_3*0.5$	$G_4 = 0.5$; Voltage doubler behaves as a half bridge circuit (not prefered)
Charging Mode (Secondary Full bridge Circuit)	$G_1G_2G_3*1$	$G_4 = 1$; Secondary full bridge Circuit (Prefered)

Table 1: Steady state converter gain

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