DUAL-ACTIVE-BRIDGE CONVERTER FOR BI-DIRECTIONAL PV MICRO INVERTER APPLICATIONS WITH INTEGRATED STORAGE

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Abstract: - *This project targets photovoltaic micro inverters (MIVs) with integrated battery storage. The dual-active-bridge (DAB) topology provides bidirectional power flow; however, it generally suffers from poor efficiency and limited regulation accuracy at low power. It is shown that by modifying one switch, the DAB converter can operate as a two-transistor fly back to resolve these two issues. In addition, the dc-link voltage in the two-stage MIV can be dynamically adjusted for optimal performance in DAB mode. The proposed dual-mode control scheme is demonstrated experimentally on a 100-W prototype, with up to 8% increase in converter efficiency at low power.*

INTRODUCTION

The population without access to electricity globally exceeds1.4 billion, whereas the rural electrification rate is below 65%.The intermittent nature of PV and other renewable energy sources, and thus the need for energy storage and or load shedding, is a major challenge in small-scale PV-based power grids.[1,2,3]. This is despite power quality requirements. Low-power dc–dc micro converters and ac– dc (MIV) provide high-granularity maximum power point tracking (MPPT) at the module or substring level. This leads to increased robustness to clouds, dirt, and aging effects, as well as irradiance and temperature gradients. A conventional MIV-based ac power system with the energy storage system (ESS), which is definitely required for islanded operation on the scale of one or more houses, for example, is usually based on a high power centralized bidirectional ac–dc converter, which is interfaced to a battery bank or a flywheel is shown in fig 1[5] Existing MIV architectures satisfy the need for low capital cost and expandable ac generation, whereas there is a compelling argument to extend this technology to include small scale distributed storage. A novel topology with distributed storage is proposed for grid stabilization while potentially improving the generator lifetime and saving fuel. MIV integrated storage helps to buffer the frequent irradiance fluctuations while also providing loc al backup power and reactive power support
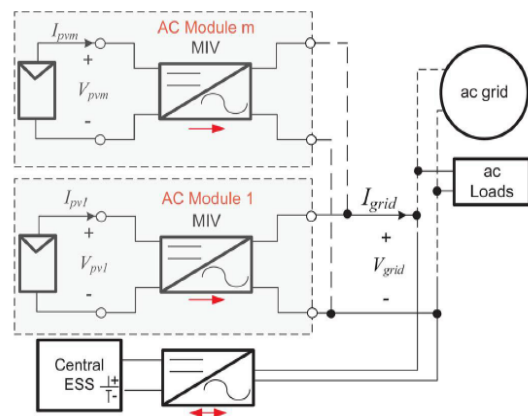

Fig.a. Two-stage MIV architecture with integrated storage

The worldwide populace without access to power surpasses 1.4 billion, while the country charge rate is underneath 65%. An expected 171 TWh of off-matrix power should be produced by 2030, which is equal to 100GWp of photovoltaic (PVs). The discontinuous idea of PV and other sustainable power sources, and subsequently the requirement for vitality storage and additionally stack shedding, is a noteworthy test in little scale PV-based power networks. This is notwithstanding power quality prerequisites. Low-control dc–dc micro converters and ac–dc micro inverters (MIV) give high-granularity most extreme power point following (MPPT) at the module or substring level. This prompts expanded strength to mists, earth, and maturing impacts, and also irradiance and temperature slopes. A customary MIV-based air conditioning power framework is appeared in Fig. 1. The vitality storage framework (ESS), which is certainly required for islanded operation on the size of at least one houses, for instance, is generally in view of a high-control brought together bidirectional ac–dc converter, which is interfaced to a battery bank or a flywheel.

Existing MIV models fulfil the requirement for low capital cost and expandable air conditioning era, though there is a convincing contention to stretch out this innovation to incorporate little scale dispersed storage. A novel topology with disseminated storage is proposed in for network stabilization while conceivably enhancing the generator lifetime and sparing fuel. MIV incorporated storage cradles the incessant irradiance changes while likewise giving neighbourhood reinforcement control and responsive power bolster. A low-control single-organize multiport converter for PV and battery is proposed in, while a 3-kW interconnection of a battery pack and a PV module through a segregated dc–dc converter is examined in. The general engineering of a two-arrange MIV with a coordinated ESS is appeared in Fig. 2. While two-arrange MIVs have a somewhat bring down productivity than their single-organize partners, the high-voltage dc-connect capacitance Cubs can be utilized for air conditioning power decoupling in single-stage frameworks. Interfacing the low-voltage dc storage, either batteries or ultra capacitors, specifically to the PV transport is ideal for high proficiency. Lithium-particle ultra capacitors, which offer 2–4× higher particular vitality than traditional electric twofold layer capacitors and can withstand more than 200 000 charge/release cycles, are an alluring future possibility for here and now MIV coordinated storage. The concentrate of this venture is toward the front dc–dc organize.
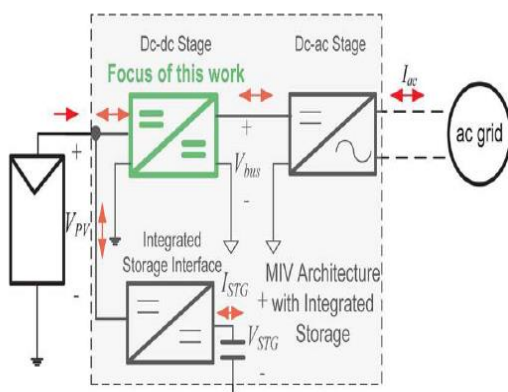

Fig.1. Conventional MIV-based PV system with a central ESS.

The goal of this venture is to show a novel low power working mode in the dual-active-bridge (DAB) converter, and also a dynamic dc-interface advancement plan to keep up high effectiveness over a wide power go. This is pivotal in any business MIV design; for instance, the European productivity file devotes 32% of the aggregate assessment weight to operation underneath 30% of the appraised

control. This venture is an expansion of and incorporates an examination of the quantization impacts, control exactness, and magnetic related issues in both working modes. This venture is composed as takes after. The dual-mode converter operation is portrayed and pertinent quantization issues are talked about. Magnetics plan and converter misfortune investigations are given. Though the recreation and estimations for the exploratory model are accounted for.

PROPOSED DAB ARCHITECTURE AND PRINCIPLE OF OPERATION

The proposed dc–dc architecture is shown in Fig. This converter is a modified DAB that interfaces VPV with the dc link Vbus.
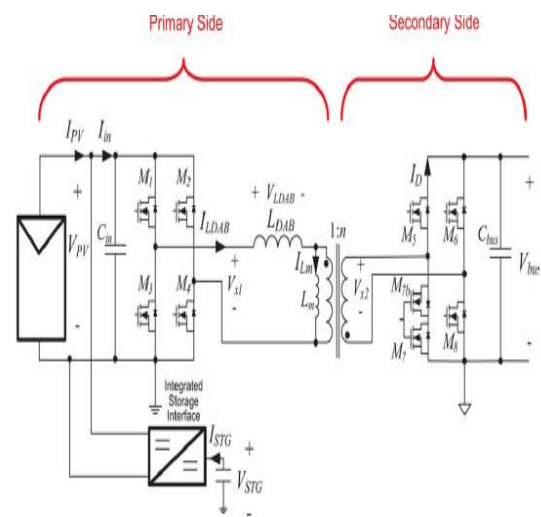

Fig 2 Two-stage MIV architecture with integrated storage

The DAB topology was selected based on

1) galvanic isolation,

2) soft-switching operation, and

3) Simple phase-shift power control.

In addition, the DAB topology is bidirectional; therefore, the storage can be used to transfer energy to/from other elements in the grid. The average power from VPV to Vbus, i.e., P, is

$$P = \frac{V_{\mathrm{PV}} V_{\mathrm{bus}}}{n\omega_s L_{\mathrm{DAB}}} \phi \left(1 - \frac{|\phi|}{\pi}\right) \qquad (1)$$

Where n is the transformer's turns ratio; and LDAB is the DAB inductance, which is the sum of transformer's leakage inductance Lleak and an optional external inductance Lext. φ

is the phase shift between the two bridges, and $\omega s = 2\pi fs$, where fs is the switching frequency. The switching waveforms of the DAB converter are shown in Fig. 4(a). The slopes of the DAB inductance current ILDAB in switching states I and II are, respectively, calculated as

$$S1 = \frac{VPV + \frac{vbus}{n}}{L\,DAB} \qquad (2)$$

$$S2 = \frac{Vpv - \frac{Vbus}{n}}{L\,DAB} \qquad (3)$$

In two-organize MIV structures, Vbus is by and large directed to a settled voltage by theinverter stage.The reference voltage $V * $ transport is normally improved effectiveness at the ostensible working point. It can be demonstrated that the DAB converter accomplishes turn-on zero-voltage exchanging (ZVS) and most extreme productivity when Vbus = nVPV, as the reactive circling current is limited. Meeting this condition prompts s2 = 0, along these lines bringing about full freewheeling in ILDAB amid state II. Keeping in mind the end goal to limit the misfortunes in the DAB, the reference for the dc-connect voltage V * transport is powerfully balanced in the inverter stage with the end goal that V * transport = nVMPP, where VMPP is the PV MPP voltage. It is notable that VMPP experiences a moderately low vacillation of around 30% over the span of an average day. This is rather than the PV current at MPP, i.e., IMPP, which is relative to irradiance and in this way has vast scale vacillations, especially on shady days.
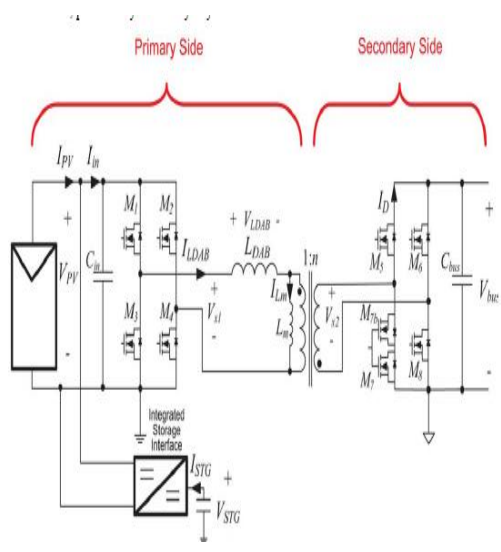

Fig.3.Proposed modified DAB dc–dc architecture for improved low-power efficiency

Flyback Mode

An average PV generator spends more than 66% of the time working underneath half of its evaluated control [7]. The ordinary DAB converter experiences generally poor effectiveness at low power because of high exchanging and drive misfortunes [20], henceforth the requirement for a committed low-influence mode. A general outline technique for DAB mode operation in view of frequency improvement

The nearness of LDAB, which is not required in the 2T-flyback topology, brings about extra misfortunes, since it courses current in an exchanging period. The vitality caught in LDAB is exchanged back to the information capacitance Cin in the 2T-flyback topology, instead of a traditional flyback plot, which does not give an arrival way to the vitality consumed by the spillage inductance. Furthermore, LDAB brings about the delicate turn-on of the yield diode. The flyback mode displays unidirectional power exchange. The converter can work with turn around control stream by including another switch the essential side. This extra switch is excluded in the exploratory model, as the effectiveness in DAB mode is delicate to conduction misfortunes at the low-voltage high-current essential side. While conceivable, invert control capacity is not entirely required in low-control flyback mode; the DAB can be kept from working in this condition by receiving burst-mode control rather, though at somewhat bring down proficiency than flyback mode.

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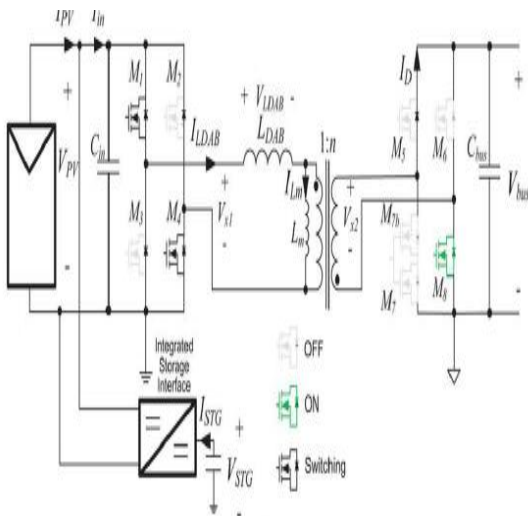
Fig: 4 Switch configuration in flyback mode

Dual-Mode Control

The calculated control graph of the converter is appeared in Fig. 5. c1–8 mean the gating voltages for switches M1–8. The DAB mode is received if P is higher than an edge esteem Pthresh or if P is negative, in which case the storage is charged specifically from the transport. In DAB mode, φ is controlled to manage the power stream to/from the dc–ac arrange, though the storage component's condition of-charge and MPPT operation can be controlled by the devoted interface converter

By and by, the transformer in a DAB converter is intended to restrain the center misfortunes at the appraised influence and most extreme frequency, which brings about the immersion flux thickness of the material being admirably above Bpeak from. For this situation, it is conceivable to expand Ton considerably higher than anticipated by for the flyback operation at low power and low frequency, without turning to a gapped center. In this venture, a Ton estimation of 8 μs was utilized to accomplish Pthresh = 40 W in flyback

mode without bringing an air crevice into the center. The greatest ontime proposed by is 1.28 μs, henceforth, the center works with an altogether higher Bpeak in flyback mode.
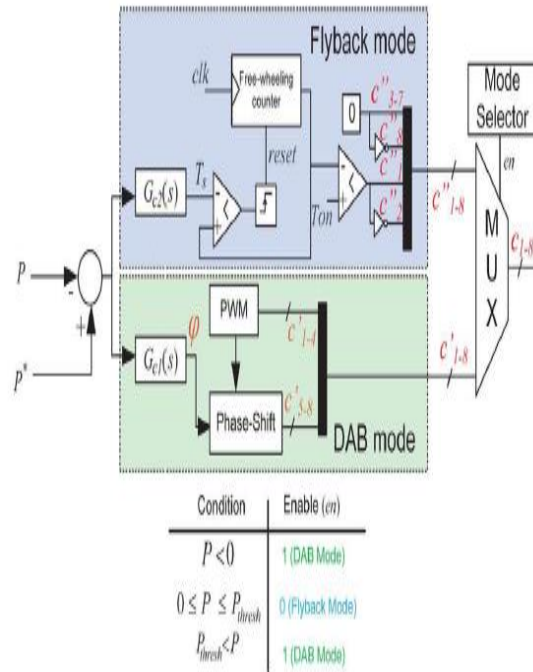

Fig.5 Simplified conceptual control diagram.

The ascertained misfortune breakdown for P = 10W and P = 40W is appeared in Fig.. The conduction misfortunes in all active and uninvolved components are lumped together. The exchanging misfortunes likewise incorporate the drive misfortunes. In flyback mode, the exchanging misfortunes are decreased by no less than 10×, for the most part by dispensing with the side road misfortunes on the high-voltage side, at a cost of peripheral increment in conduction misfortunes. The transformer and inductor center misfortune is marginally higher in flyback mode, because of higher Bpeak. The center misfortunes in flyback mode quickly increment with the influence because of higher Bpeak and fs. This is not the situation for the DAB converter, in which the center misfortunes remain practically consistent over the full stage move go because of steady Lm excitation

RESULTS AND ANALYSIS

The Simulation of the proposed system using MATLAB is shown in figures. It is observed that proposed system is more efficient for both high efficiency and low efficiency applications as DAB and Flyback modes.
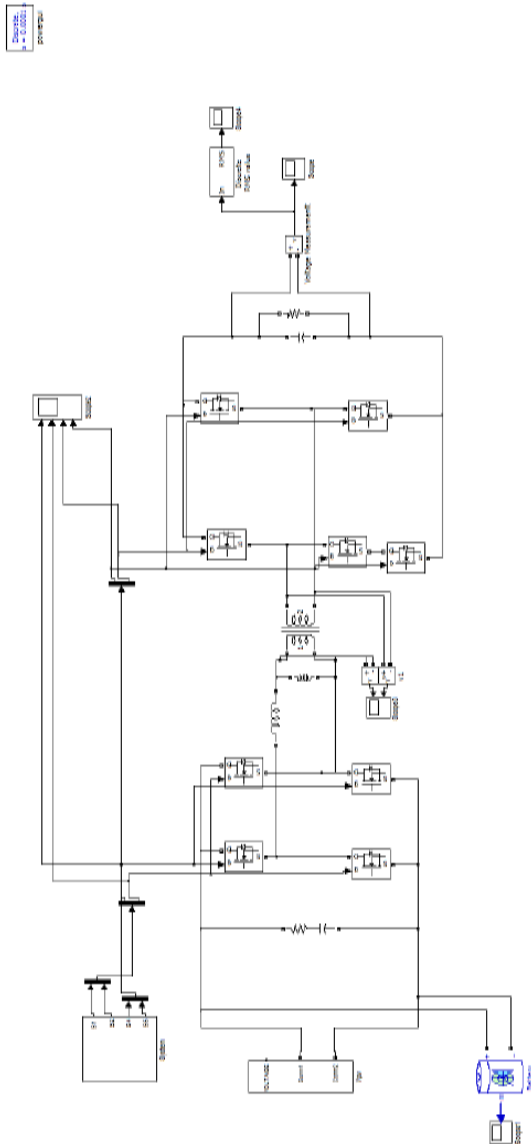
Fig 8. Voltage Measurement

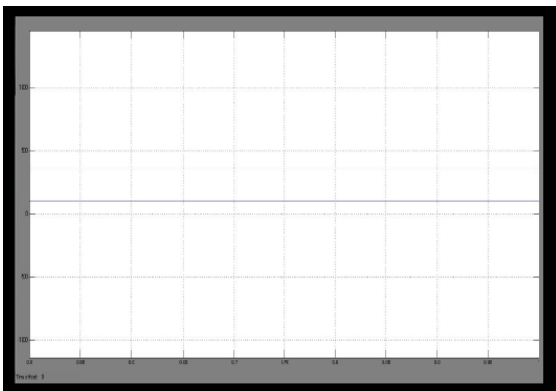Fig:6. Matlab/simulink results with dab mode
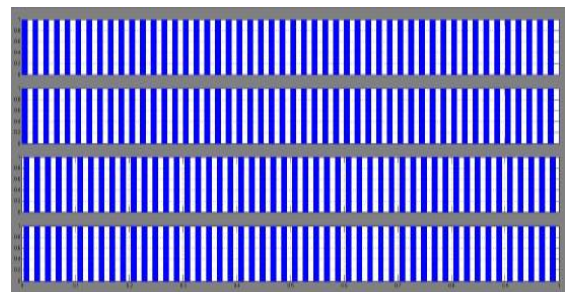

Fig 9 DAB mode output pulses
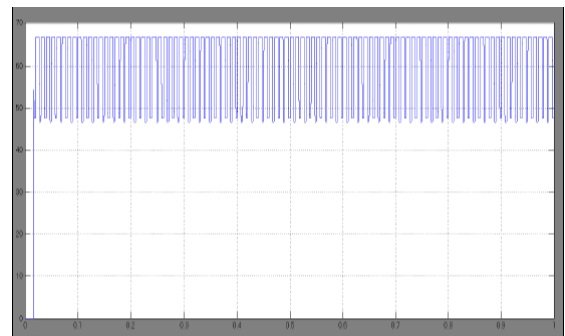
Fig 10. Discrete RMS value

Fig 7. DAB mode input voltage and current
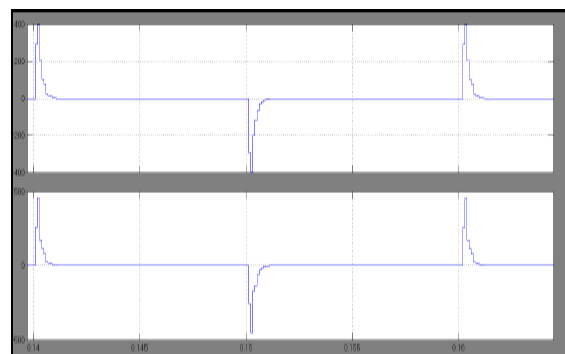
Fig 11. Output voltage

Fig 11. FLYBACK MODE

Fig 12 Discrete RMS value

Fig 12. Voltage Measurement
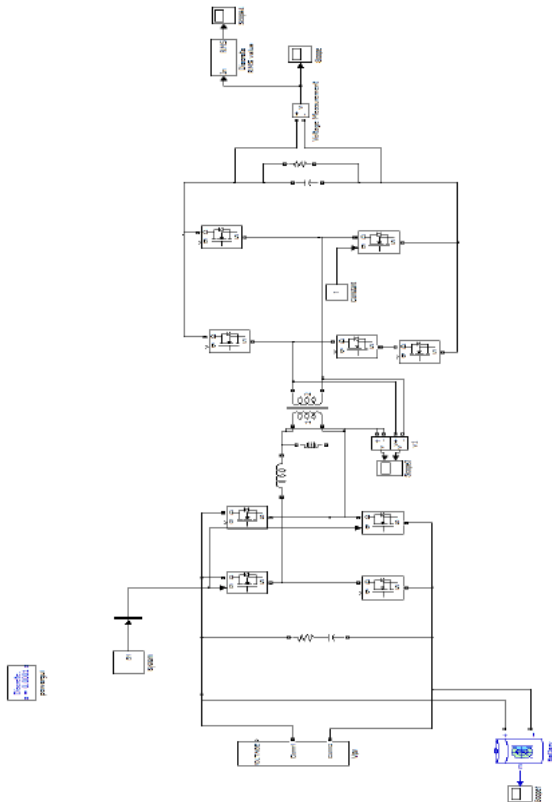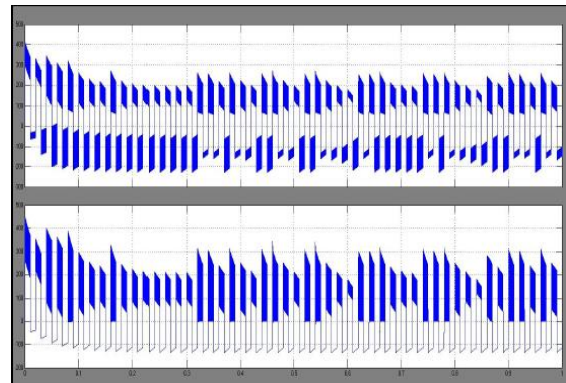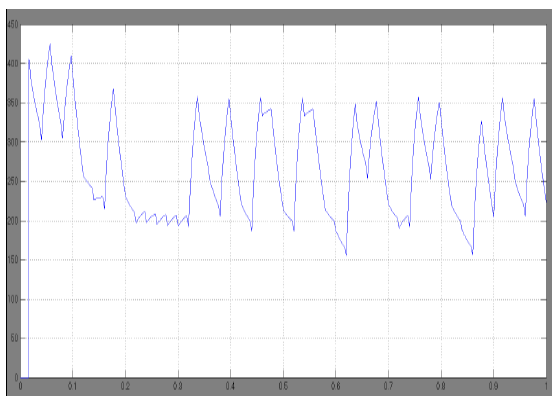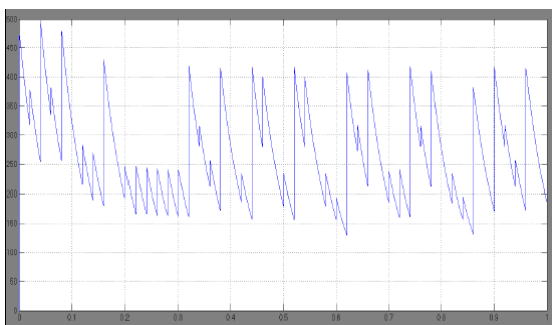

Fig 13 Output voltage for flyback mode
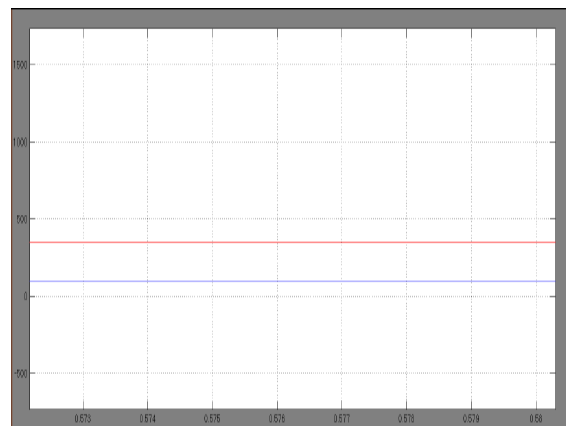
Fig14 Current &voltage measurement

CONCLUSION

A novel DAB exchanging plan was presented for the dc–dc phase of module incorporated power converters for PV applications. The changed flyback exchanging plan shows 8% higher effectiveness than DAB mode at 10 W, which comes at the cost of an extra switch. While flyback mode shows more center misfortunes and marginally more conduction misfortunes contrasted with DAB mode, the exchanging misfortunes are altogether lessened by disposing of the greater part of the exchanging activities and decreasing the frequency. Likewise, it was demonstrated that the flyback mode accomplishes higher exactness in control direction for low-control levels contrasted with the DAB mode, bringing about a more steady operation and maintaining a strategic distance from potential breaking point cycle motions.

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