DAB DC/DC Convertor V2G/L Application

文曄科技

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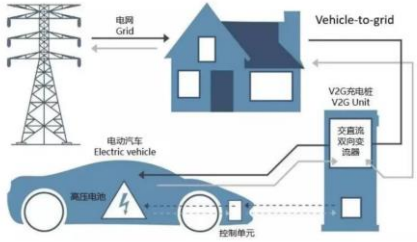
Application scenarios of optical storage and charging

Renewable energy systems

energy storage systems

electric car



V2G

V2L

DAB

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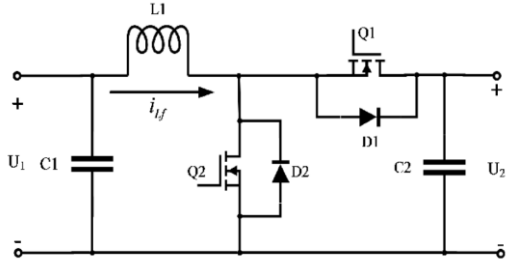
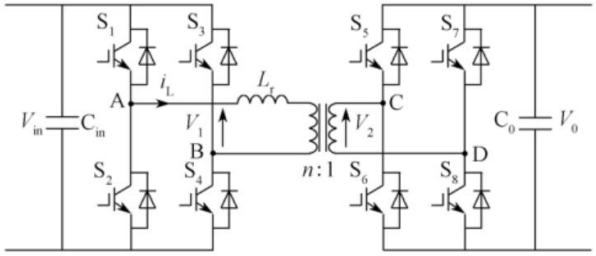
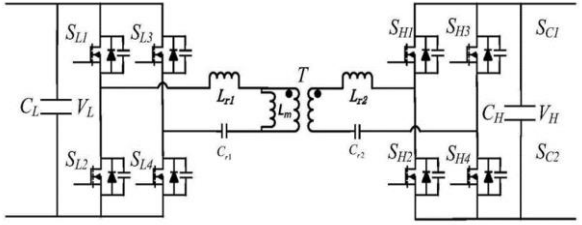
Agenda

1. Advantages of DAB in bidirectional DC
2. Operating principle of DAB
3. Transformer design of DAB
4. ST 25kw DAB solution
5. How to support customers
6. Summary

The common topology in bidirectional DC-DC

Miniwatt	Medium high power	
双向Buck-Boost	DAB	CLLC
		

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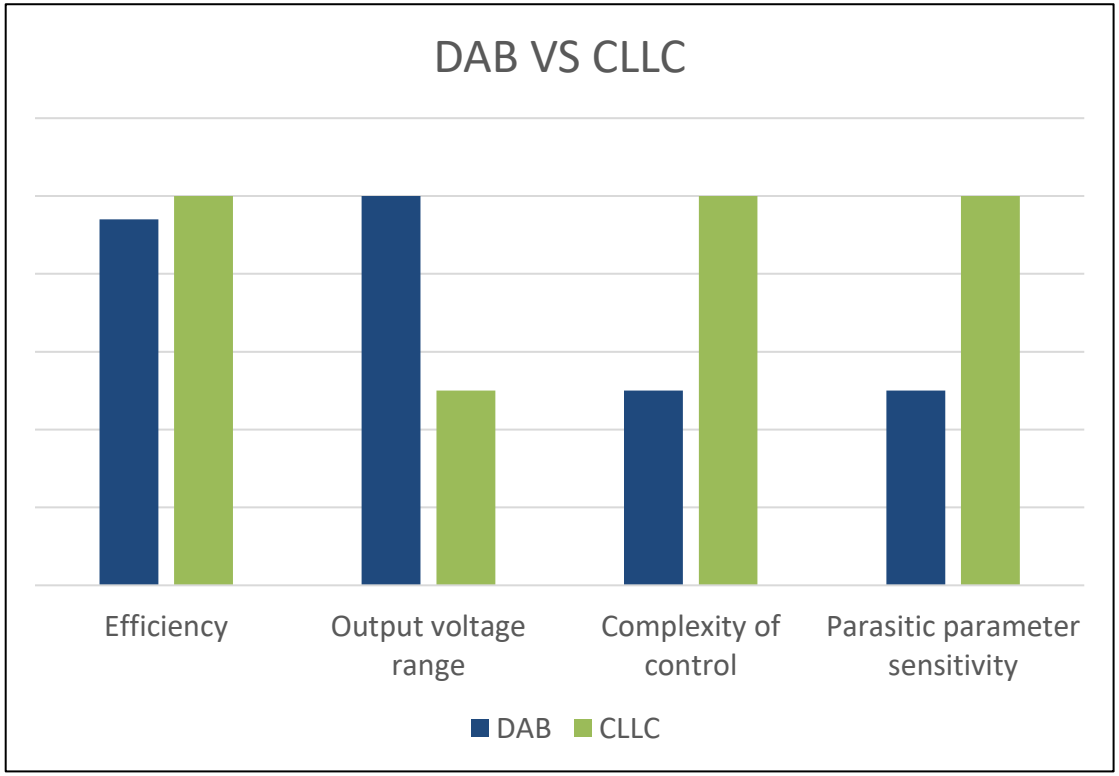
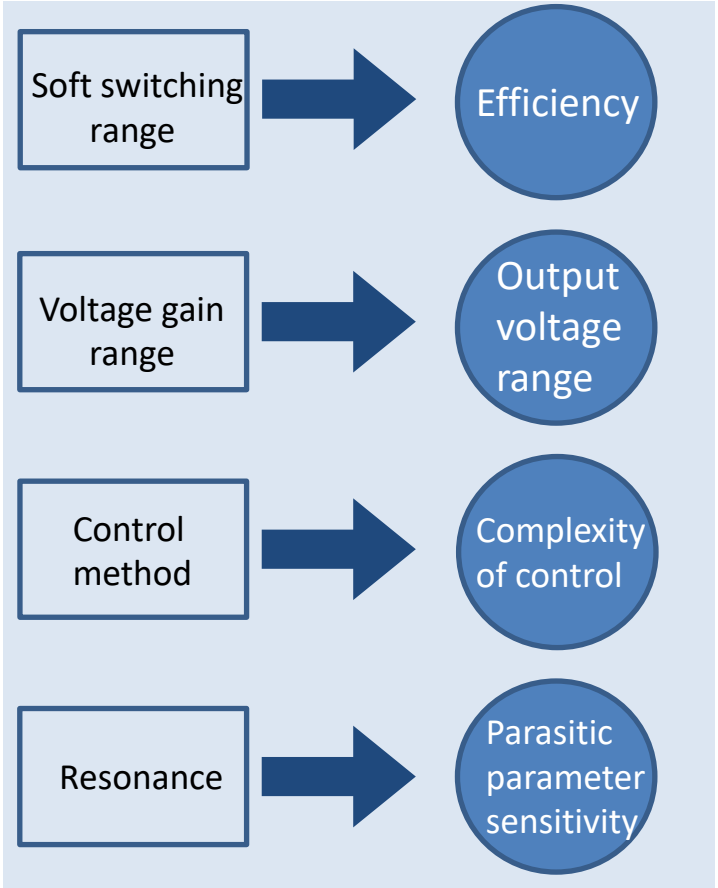
Advantages of DAB in bidirectional DC converter





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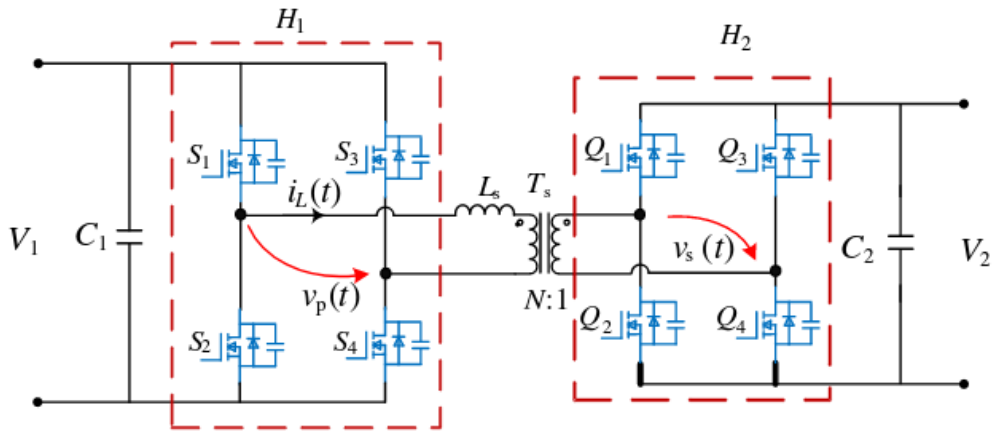
Operating principle of DAB

Basic structure of DAB



Original side full bridge

High-frequency transformer

Transmission inductance

Secondary side full bridge

Filter capacitance

Operating principle of DAB

Modal analysis of DAB

Example: single phase shift control(D_0>0, Forward transmission)

$[0\ ,\ t_0]$: Inductive discharge

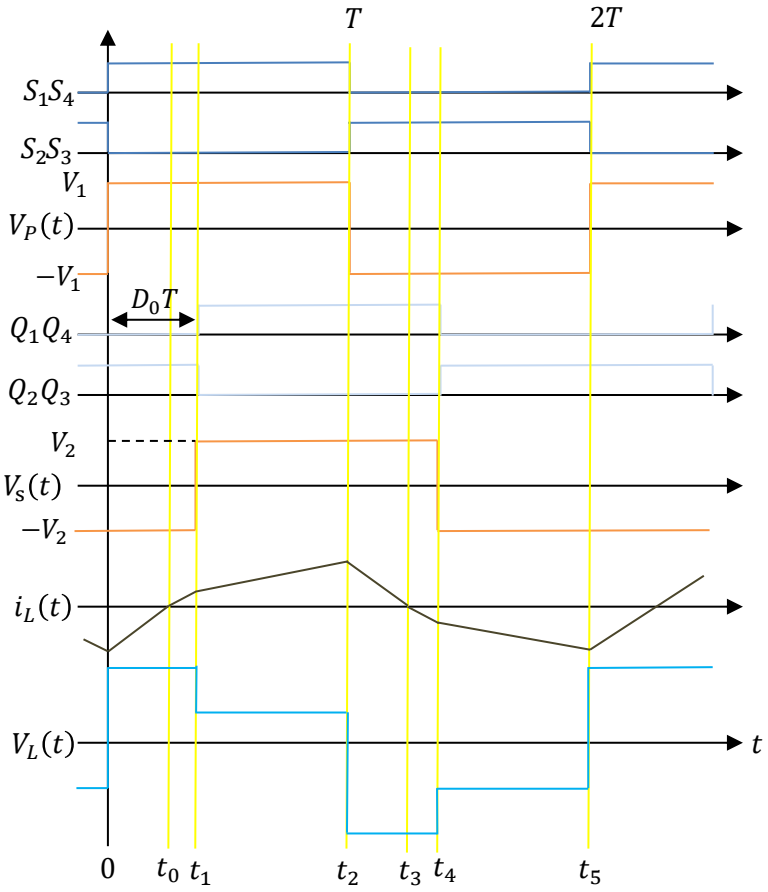
$[t_0,\ t_1]$: Inductive forward charging to achieve ZVS

$[t_1,\ t_2]$: The rise speed of inductor forward current decreases

$[t_2,\ t_3]$: Inductive reverse charge

$[t_3,\ t_4]$: Implement ZVS

$[t_4,\ t_5]$: The rise speed of inductor reverse current decreases

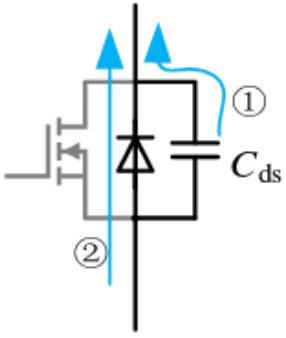


Operating principle of DAB

ZVS analysis of DAB

ZVS： Zero voltage on

例：S_1



Inductive current

The junction capacitor $C_{ds} is\ discharged$

Current flow diode

Channel voltage 0V to achieve ZVS

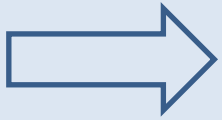
Each switching device realizes the current condition of ZVS

Switching device	Current direction
$S_1S_4Q_2Q_3$	$i_L < 0$
$S_2S_3Q_1Q_4$	$i_L > 0$

Transformer design of DAB

Characteristics of DAB transformer

- High power density
- High frequency
- Integration



DAB transformer selection

- Winding transformer
- Ferrite material
- Leakage induction of transformer

Transformer design of DAB

Transformer turns ratio

$$N = \frac{\sqrt{V_{1,max} \times V_{1,min}}}{\sqrt{V_{2,max} \times V_{2,min}}}$$

N: $Turns\ ratio$

$V_{1,max}$: $Maximum\ primary\ side\ voltage$

$V_{1,min}$: $Minimum\ primary\ side\ voltage$

$V_{2,max}$: $Maximum\ secondary\ side\ voltage$

$V_{2,min}$: $Minimum\ secondary\ side\ voltage$

Power inductance transmission

$$L = \frac{nV_1V_2}{2Pf_s} D_0(1 - D_0)$$

L:Inductance value

n:Turns ratio

V_1:Primary side voltage

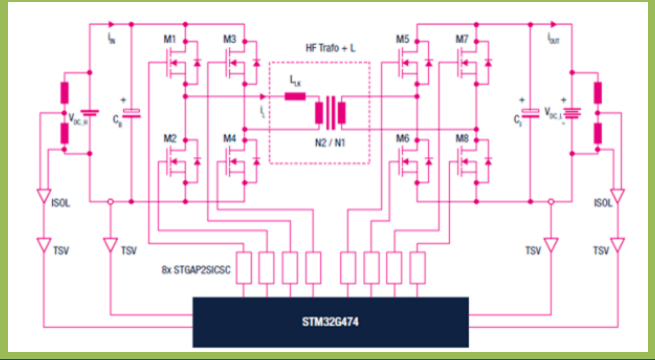
V_2:Secondary side voltage

D_0:Duty cycle

P: Power

f_s:Switching frequency

ST 25kw DAB



Features：

DC input： 800V(720V-880V)
DC output： 250V-500V
Output power： 25kW
Peak efficiency： >98%
Switching frequency： 100kHz

Key products：

A2F12M12W2-F1
A2H6M12W3-F
STGAP2SICS
STM32G474

Key benefits：

Bidirectional DC/DC converter based on SiC MOSFETs (power module) and a digital control (STM32G4). Topology is the «Dual Active Bridge –DAB»

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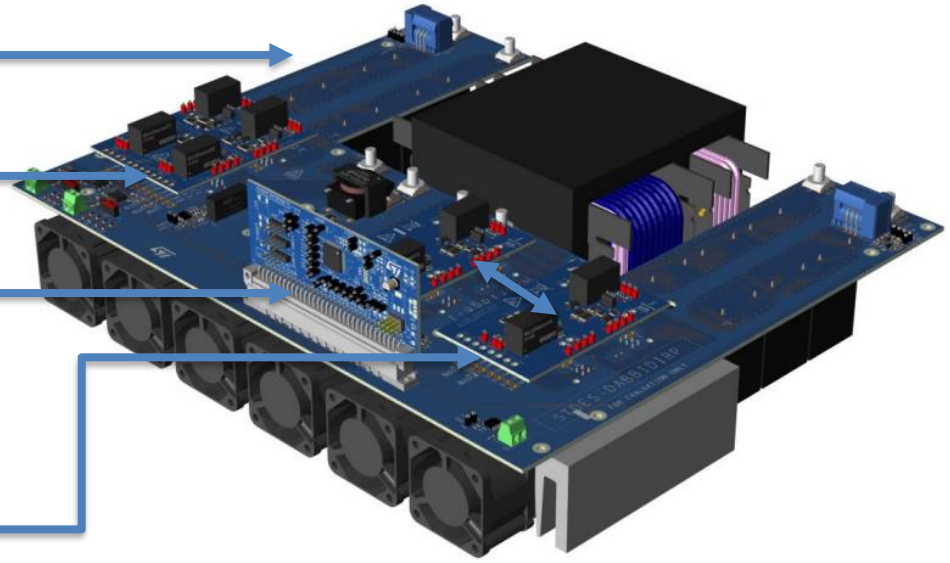
ST 25kw DAB

Power board

Low voltage drive board

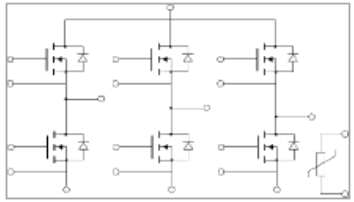
Control board

High voltage drive board

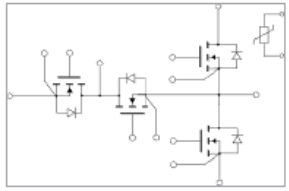


ST SiC Mosfet Moduel

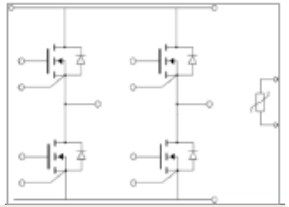
Species



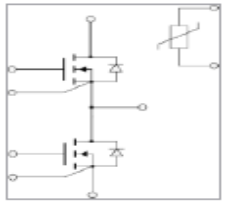
Six-Pack



Three Level



Four Pack



Half Bridge

ACEPACK 1
33.8 x 48 mm

ACEPACK 2
48 x 56.7 mm

Q4-2022

25mΩ
A1P25M12W2-1

25mΩ
A1F25M12W2-F1

12mΩ
A1H12M12W2-F

6mΩ
A2H6M12W3-F

Q3-2022

18mΩ
A1P18M65W2-1

12mΩ
A2U12M12W2-F1C

A2U12M12W2-F2

12mΩ
A2F12M12W2-F1

Released

BV=1200V

BV=650V

ACEPACK 2

ACEPACK 1

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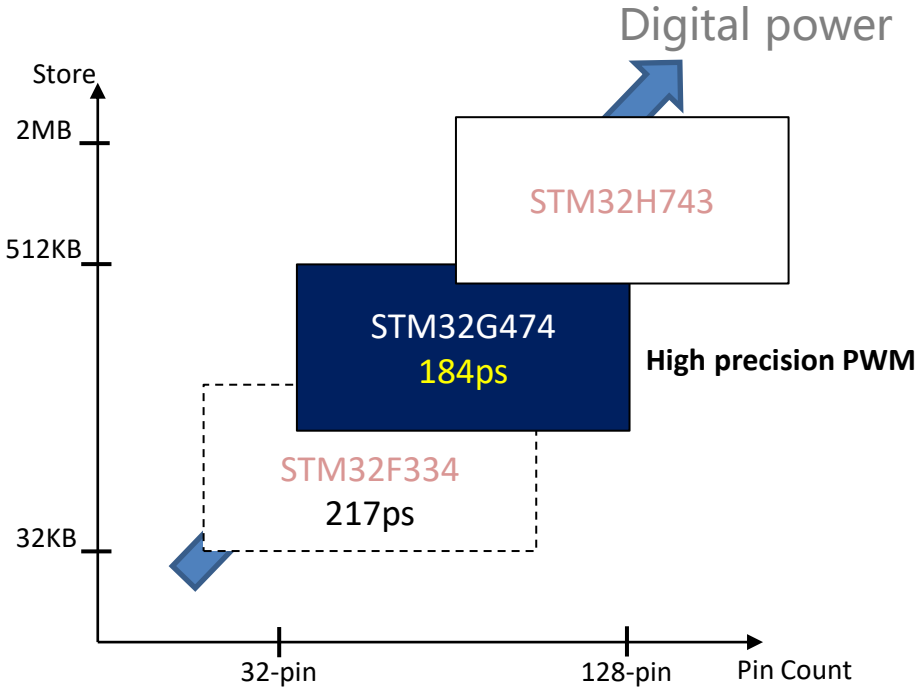
STM32 MCU

STM32 digital power platform



STM32G474
ADC +MCU(170MHz) +PWM

STM32H743
ADC +MCU(480MHz) +PWM

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Configurations of MCU key functions

Arm® Cortex® -M4 Up to 170MHz

Floating Point Unit (FPU)

- Control loop computation (reserved for future use)

32-Kbyte CCM-SRAM

- Zero wait-state for critical code execution

CORDIC for trigonometric functions acceleration

- Software phase-locked loop (reserved for future use)

Hi-Resolution PWM Timer (184ps)

- For MOSFET control at 100-350kHz switching frequency

Multiple ADCs (4Msps) Up to 5

- AC voltage/current , DC voltage/current, and hotspot temperature sensing

Comparators and DACs

- Reducing the number of components

FMAC filter mathematical accelerator

- Hardware digital filter (CPU off-load) for loop computation (reserved for future use)

UART, SPI, CAN and USB

- UART for communication

Configurations of MCU key functions

Arm® Cortex® -M7 Up to 480MHz

Floating Point Unit (FPU)

- Control loop computation (reserved for future use)

64-Kbyte ITCM RAM
128-Kbyte DTCM RAM

- Zero wait-state for critical code execution

CORDIC for trigonometric functions acceleration

- Software phase-locked loop (reserved for future use)

FMAC filter mathematical accelerator

- Hardware digital filter (CPU off-load) for loop computation (reserved for future use)

Hi-Resolution PWM Timer

- For MOSFET control at 100-350kHz switching frequency

Multiple **ADCs**

- AC voltage/current , DC voltage/current, and hotspot temperature sensing

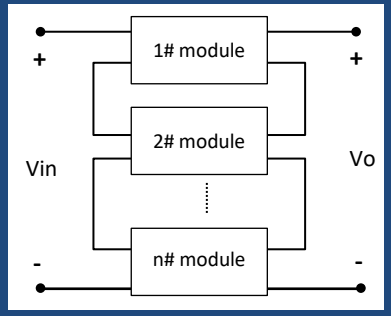
Comparators and **DACs**

- Reducing the number of components

UART, **SPI**, **CAN**

- UART for communication

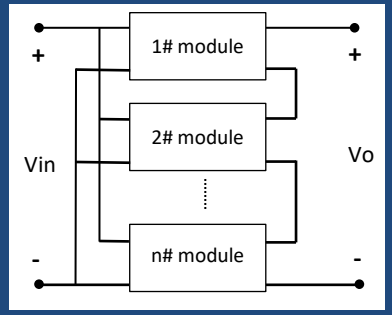
How to achieve 50kw DAB



ISOS

Serial input and serial output

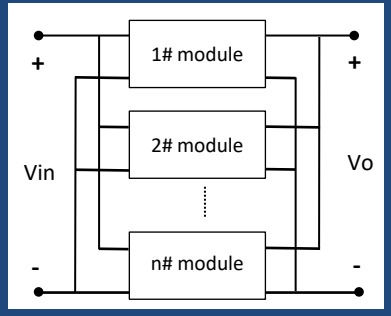
Application scenario：
High voltage power supply, new energy power generation, high-speed rail and other high voltage occasions



IPOS

Parallel input and serial output

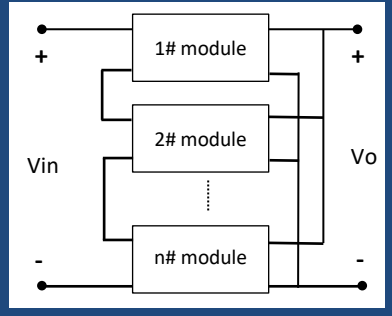
Application scenario：
Solar photovoltaic power generation, fuel cell and other occasions



IPOP

Parallel input and parallel output

Application scenario：
Multiphase Buck and other simple circuits



ISOP

Serial input and parallel output

Application scenario：
HV DC microgrid, electric vehicle charging

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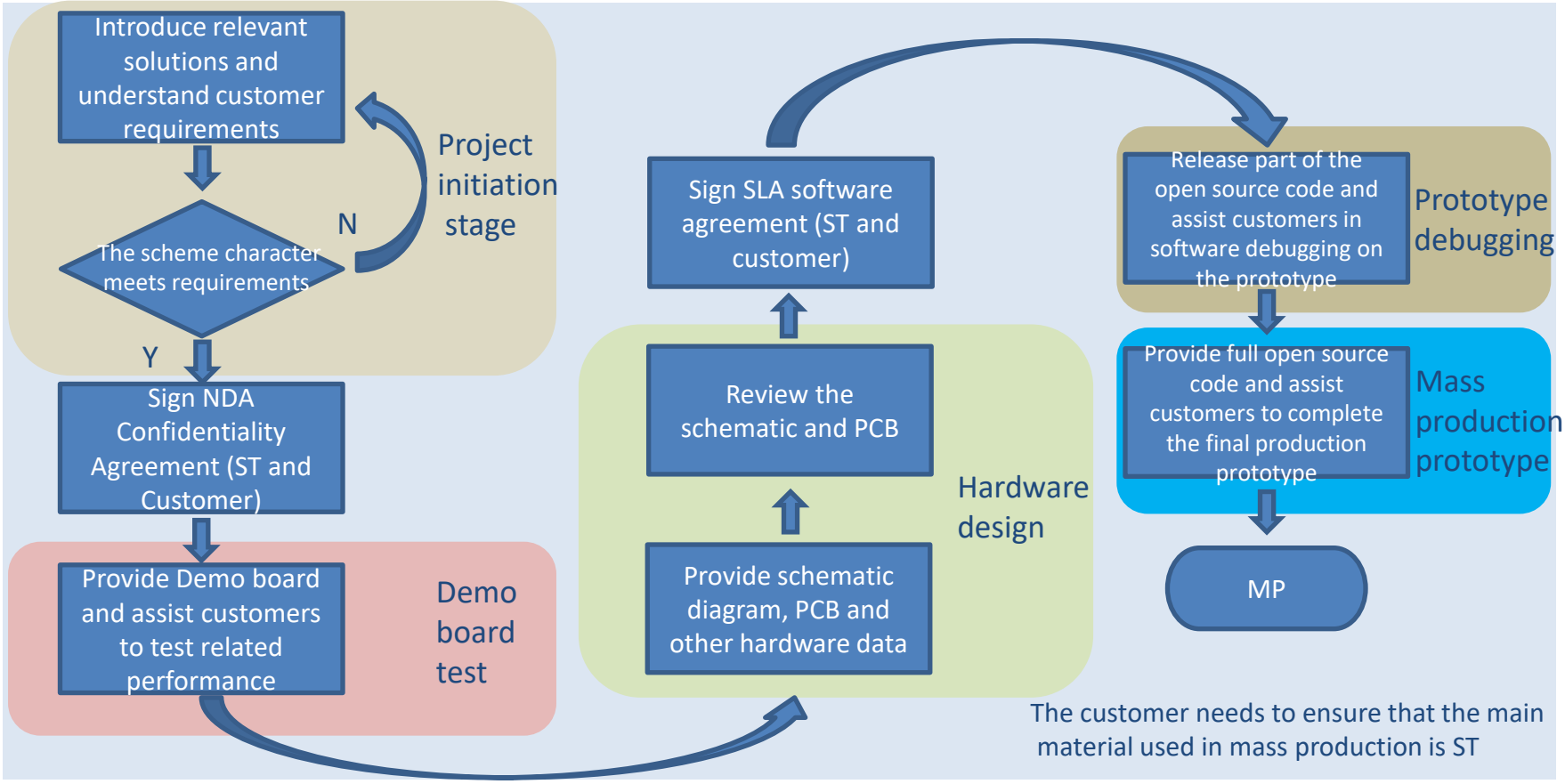
How to support the customer in the solution



Summary

Advantages of DAB in bidirectional DC converter

About ST 25kw DAB solution

ST advantage products in this application

How to support the customer in the solution

2024

WT

Work together!