



HVDC驗證測試實務與國際標準趨勢

Prepared by 林益良 Joe Lin

HVDC Testing Concept

Solution Partner

Reliability and Package Test

ISO17025 Accredited
Verification
Validation

Certification (Safety)

CBTL under TUV and Dekra



Recognized Lab

EMC Test

under preparation but subcontracted
to ISO17025 Accredited lab

GMA Global Market Access

Subsidiaries in



South Korea



Thailand



Singapore



India



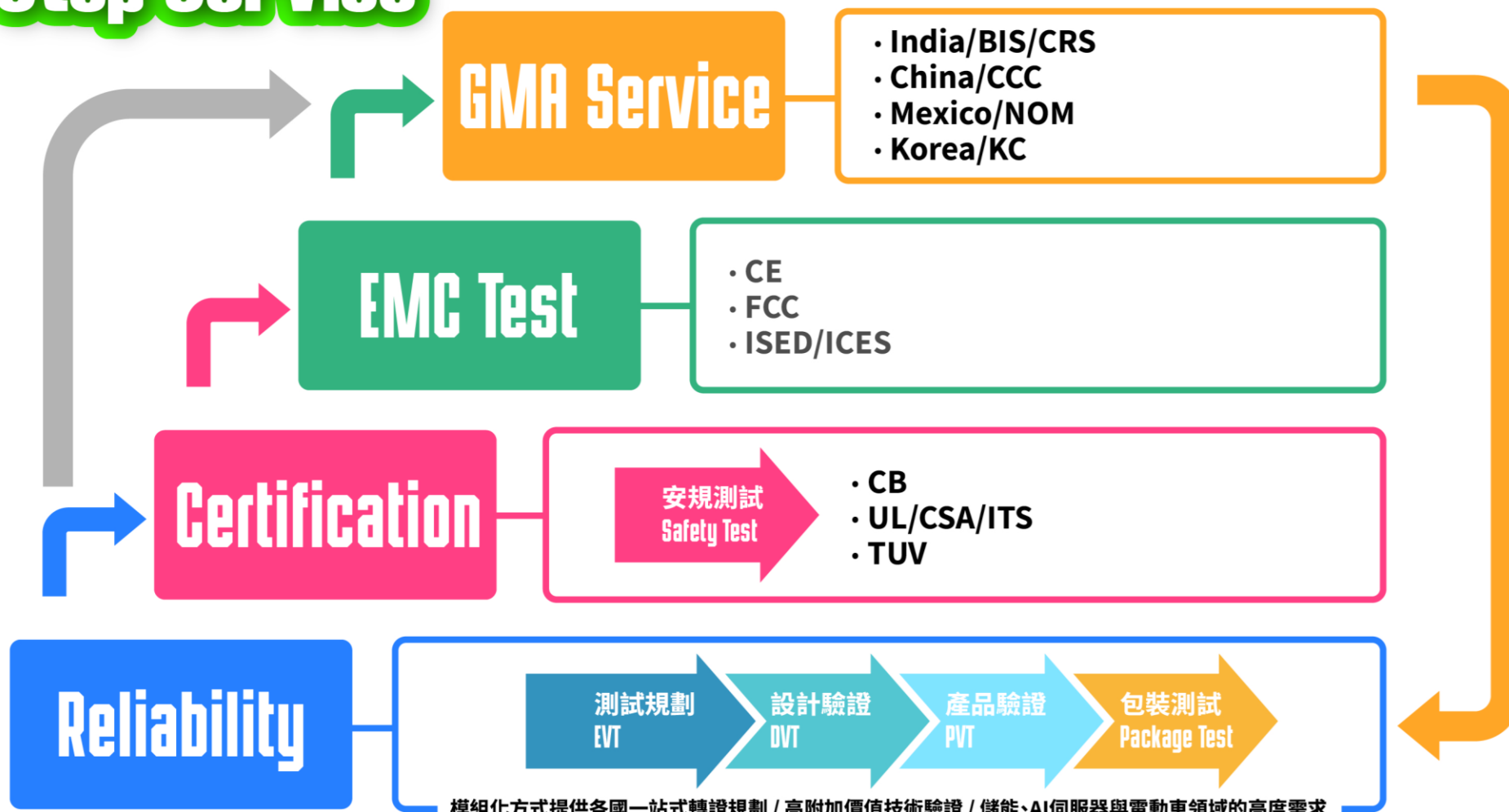
South Africa



Mexico



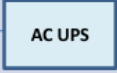
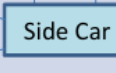
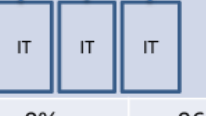
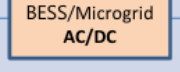
One Stop Service



AI算力HVDC高功率發展趨勢

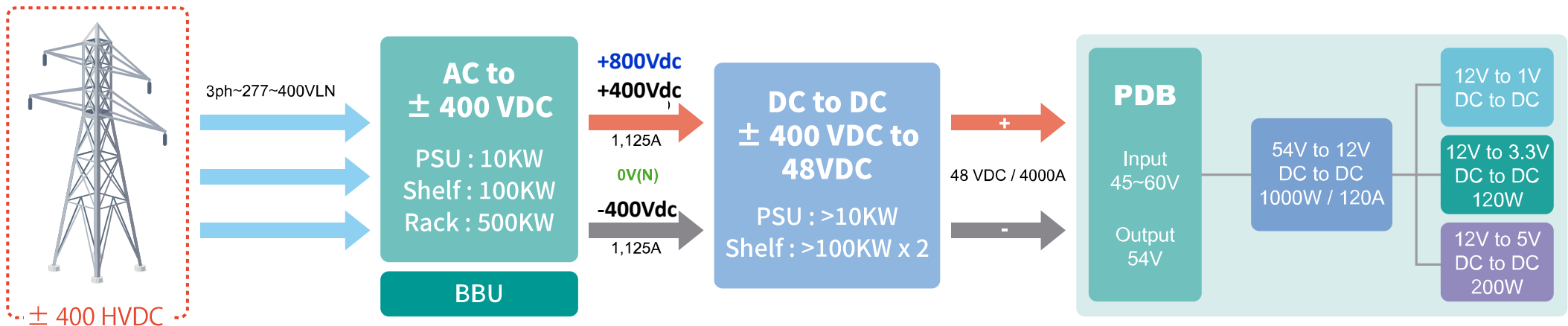
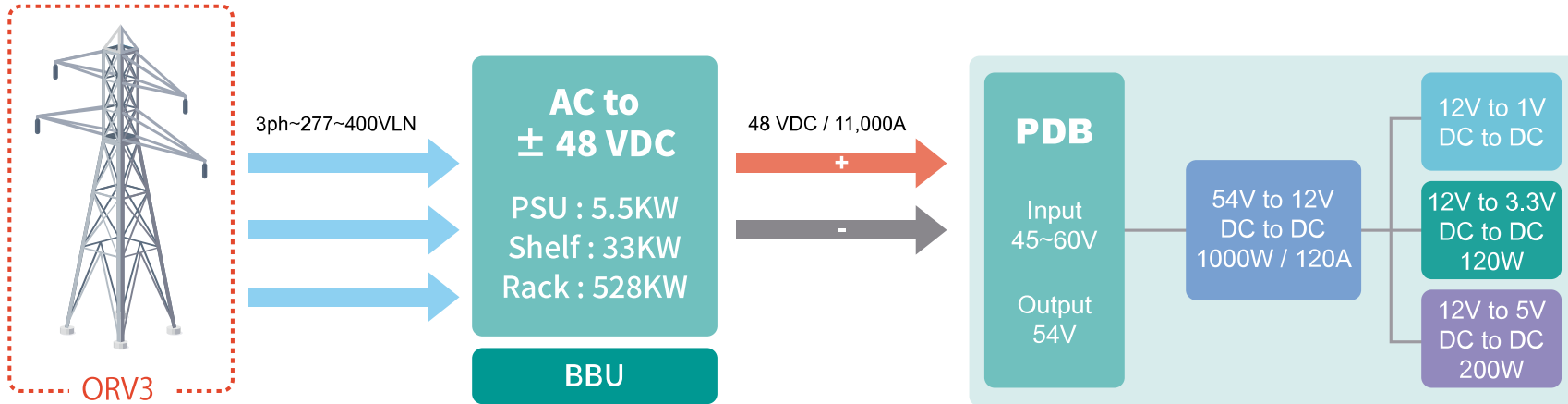
HVDC 發展架構圖

Four architectures of server power and backup power

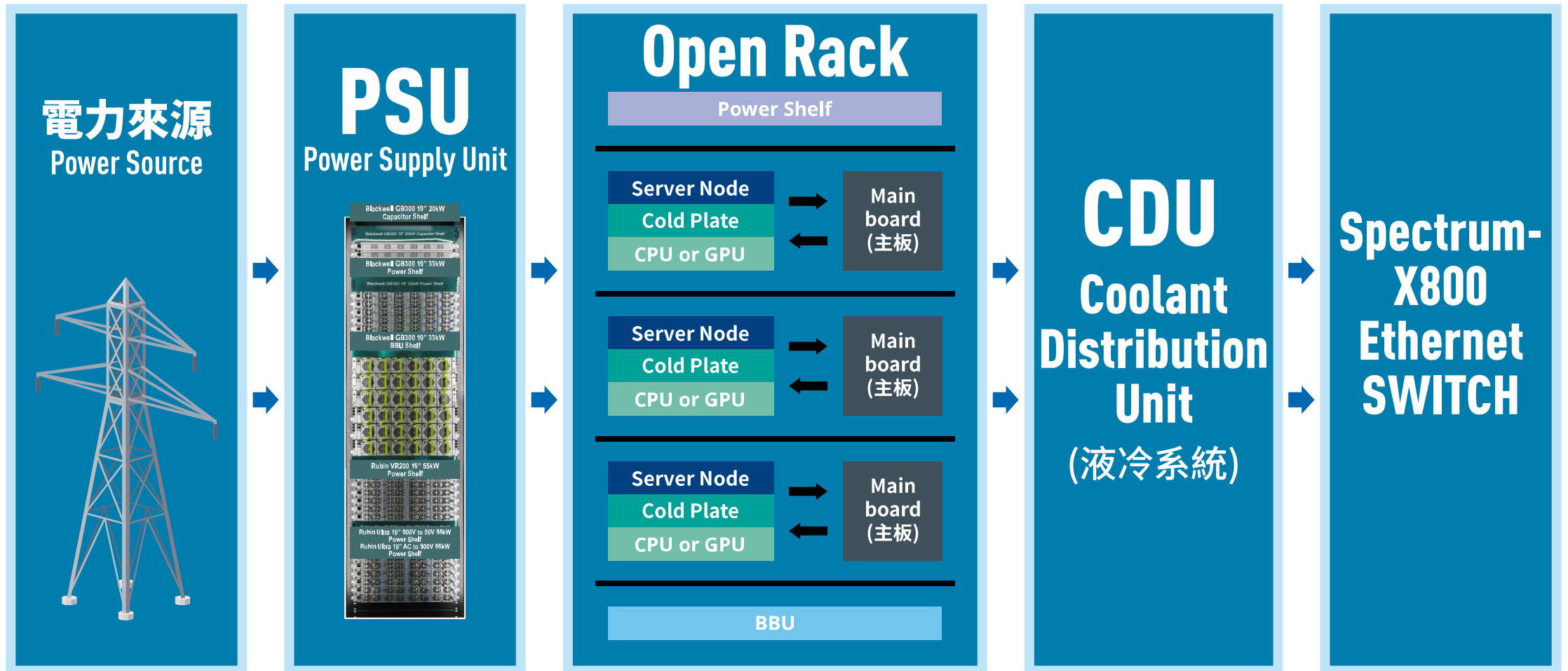
Architecture	AC/DC	BBU	MVAC-54Vdc eff.	Rack Power Distribution	Rack Power Distribution Loss (200kW rack)	End to End eff. Including power dis. Loss	IT rack space consumption	Data center Floor space	Ecosystem Maturity
(1) AC UPS + In Rack PSU									
	in rack	AC ups - online	93.63%	54Vdc	0.2-0.5%	93.13-93.4%	low	high	high
(2) In Rack + PSU + BBU									
	in rack	in rack	96.52%	54Vdc	0.2-0.5%	96.02-96.32%	high	high	high
(3) Off-rack (Sidecar) inc. PSU + BBU ±400Vdc									
	Sidecar	Sidecar	96.05%	±400Vdc	0%	96.05%	no	high	med
(4) architecture w/ BESS/microgrid									
	Intra level	Intra level	96.53%	±400Vdc	0%	96.53%	no	no	low

資料來源: Chroma ATE

ORV3 與 $\pm 400/800$ HVDC 電源架構



AI GPU Computing Eco System



AI Server Power Consumption



General server



About 7 kW = 3.5KW x 2

一個普通服務器機架的平均功耗約7kW

Architecture	A100	H100	H200	GH200	B100	B200	Full B200	GB200
	Ampere	Hopper			Blackwell			
VRAM Size	80GB	80GB	141GB	96GB/144GB	180/192GB	180/192GB	192GB	384GB
VRAM Bandwidth	2TB/s	3.35TB/s	4.8TB/s	4TB/s / 4.9TB/s	8TB/s	8TB/s	8TB/s	16TB/s
NVLink Bandwidth	600GB/s	900GB/s	900GB/s	900GB/s	1.8TB/s	1.8TB/s	1.8TB/s	3.6TB/s
Power Consumption	400w	700w	700w	1000w	700w	1000w	1200w	2700w
	2021	2023	2024					2024

AI服務器的廣義定義是指搭載AI芯片(如GPU / FPGA / ASIC 芯片)的服務器，相對狹義的定義則是**至少搭載一顆GPU的服務器被視作是AI服務器**。

由于AI算力的需求攀升，使得芯片耗電功率也不斷升級，一台AI服務器需要2顆CPU與**4至8顆的GPU**，GPU又是CPU功率的2至4倍。

NVIDIA的AI處理器H100的峰值功耗高達700瓦，加上儲存裝置、網路設備等，運作AI應用程序的機櫃功耗可能超過**30kW**。



AI Server system由外部
Power Shelf / BBU 供電48Vdc

資料來源: Chroma ATE

NVIDIA GB200 NVL 72

GB200 NVL72 ¹ 規格		
	GB200 NVL72	GB200 Grace Blackwell Superchip
組成	36 個 Grace CPU + 72 個 Blackwell GPU	1 個 Grace CPU + 2 個 Blackwell GPU
FP4 Tensor 核心 ²	1,440 PFLOPS	40 PFLOPS
FP8/FP6 Tensor 核心 ²	720 PFLOPS	20 PFLOPS

Architecture	A100	H100	H200	GH200	B100	B200	Full B200	GB200
	Ampere	Hopper		Blackwell				
VRAM Size	80GB	80GB	141GB	96GB/144GB	180/192GB	180/192GB	192GB	384GB
VRAM Bandwidth	2TB/s	3.35TB/s	4.8TB/s	4TB/s / 4.9TB/s	8TB/s	8TB/s	8TB/s	16TB/s
NVLink Bandwidth	800GB/s	900GB/s	900GB/s	900GB/s	1.8TB/s	1.8TB/s	1.8TB/s	3.6TB/s
Power Consumption	400w	700w	700w	1000w	700w	1000w	1200w	2700w

NVL72 需求功率：2700W x 72 = 194.4KW

194.4KW / 33KW 需 6 个 Power Shelves



Power Shelf X 6

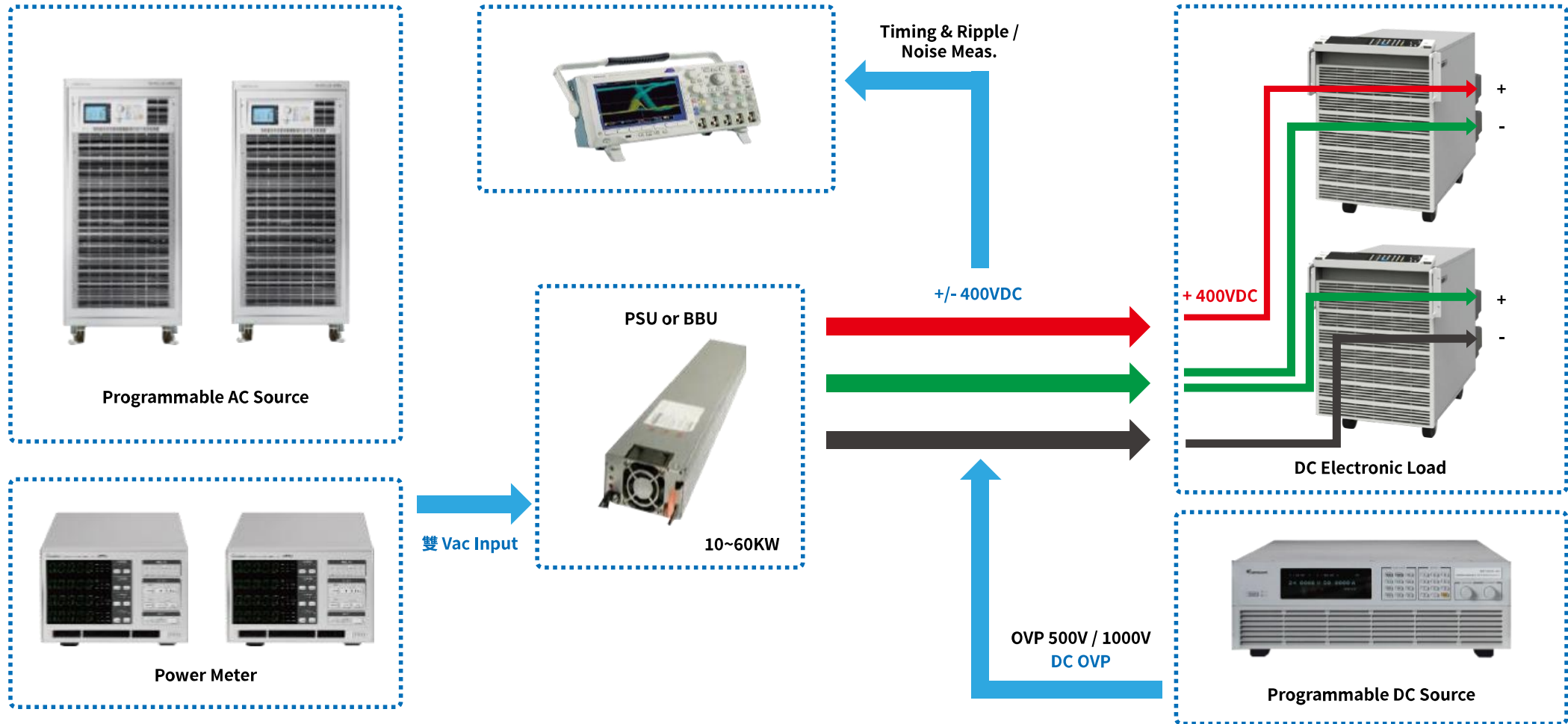
已沒有多余空間放置BBU和Redundant應用

對策：1.提高PSU功率密度8kW，10kW

2.獨立Rack Power

資料來源: Chroma ATE

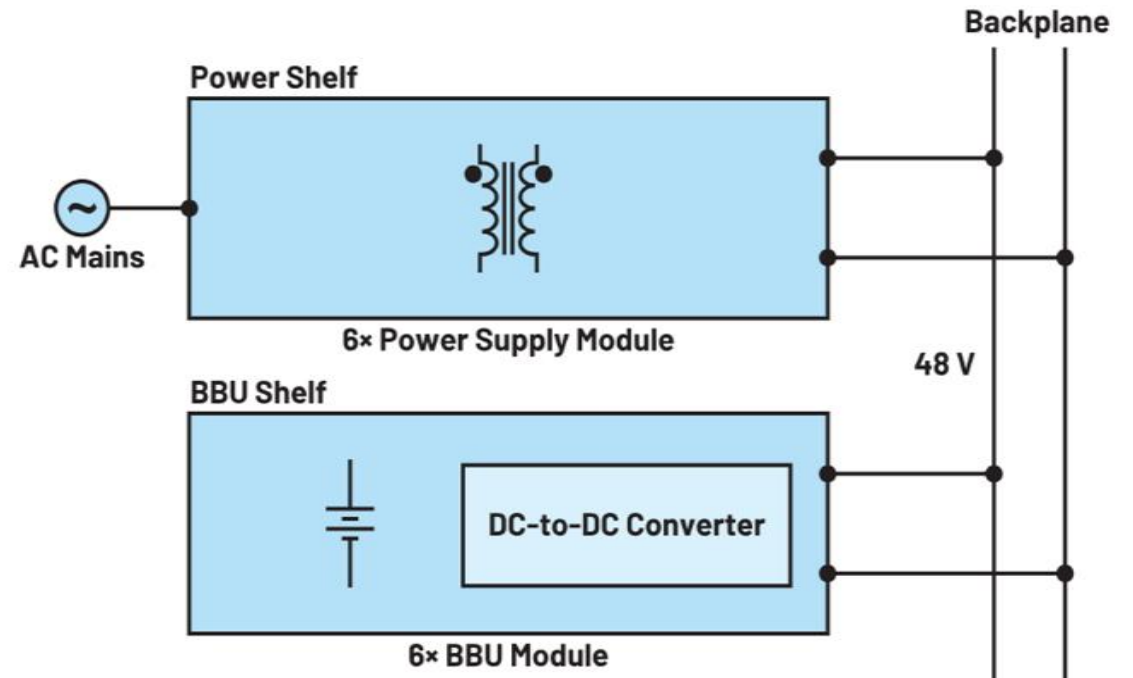
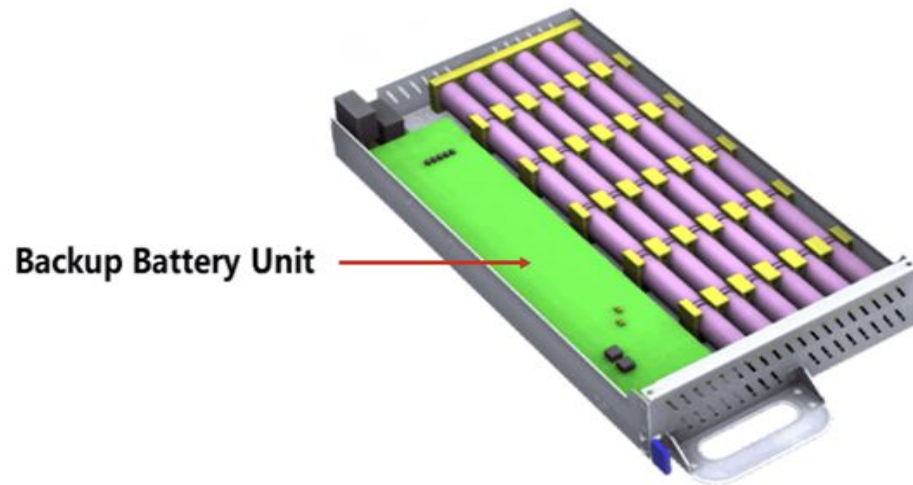
800/±400 Vdc 輸出PSU測試架構



BBU

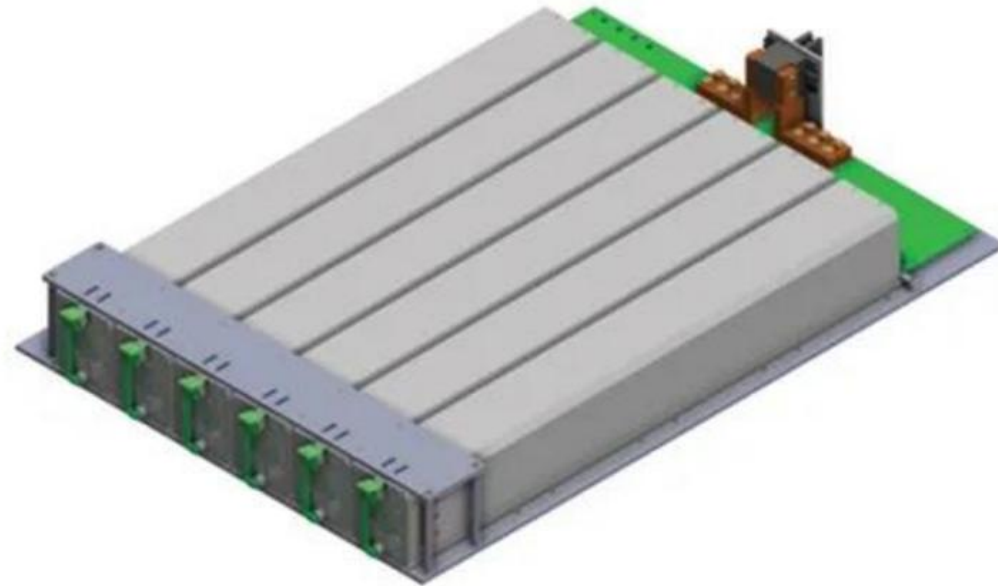
什麼是BBU:(Backup Battery Unit)電池備援電力模組，可直接安裝在伺服器裡，除了降低伺服器斷電的風險外，還可以保護資料的正確性

電池備援電力模組(BBU)示意圖



BBU

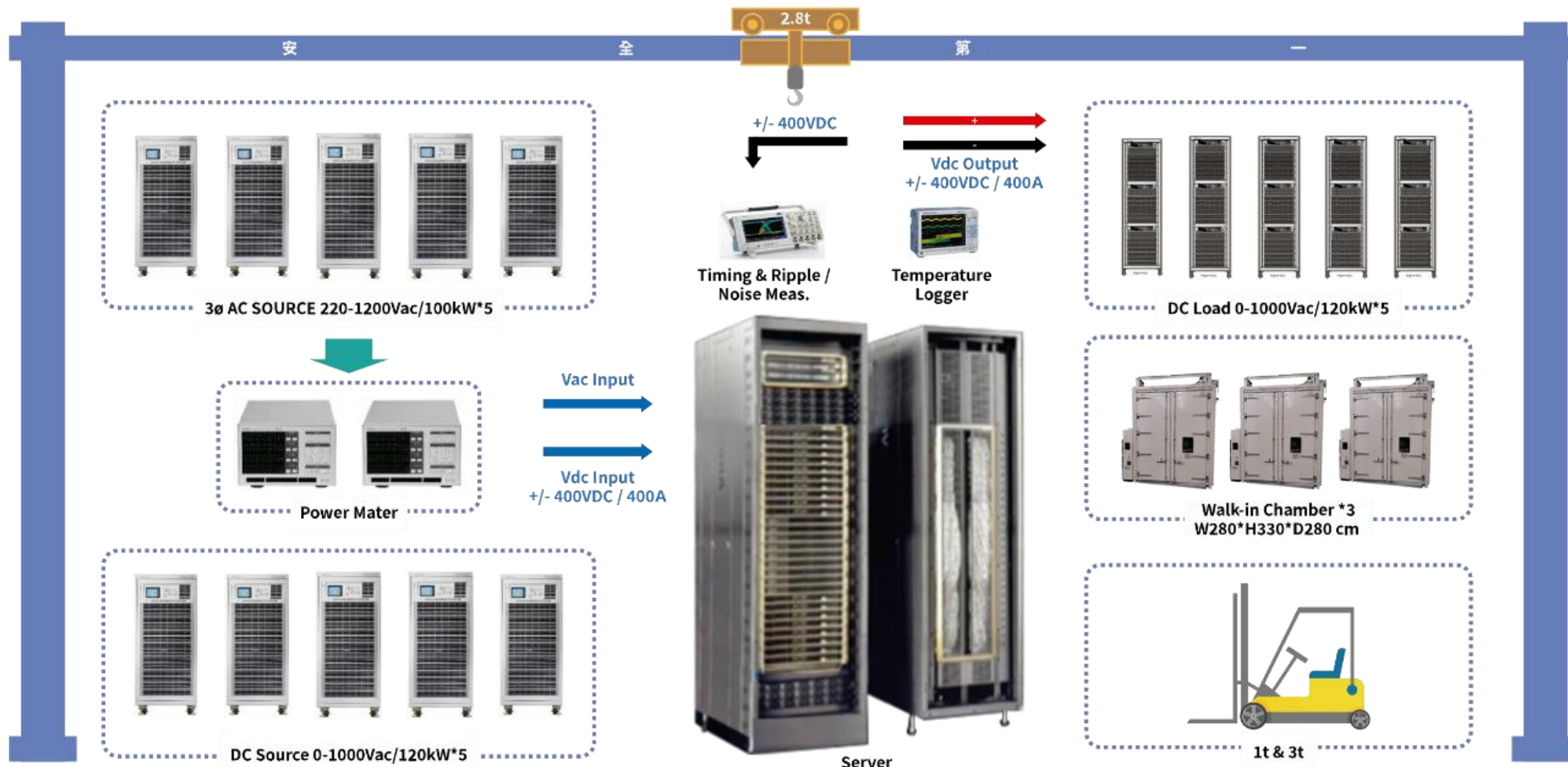
BBU在資料中心應用有看到很完整藍圖，當前BBU主流規格為3KW到5.5KW(48V)，GB200/GB300 AI伺服器BBU為48V、5.5KW一顆，6顆一組，我們也看來未來會朝8KW、10多KW、20多KW，甚至達到400V的100KW。



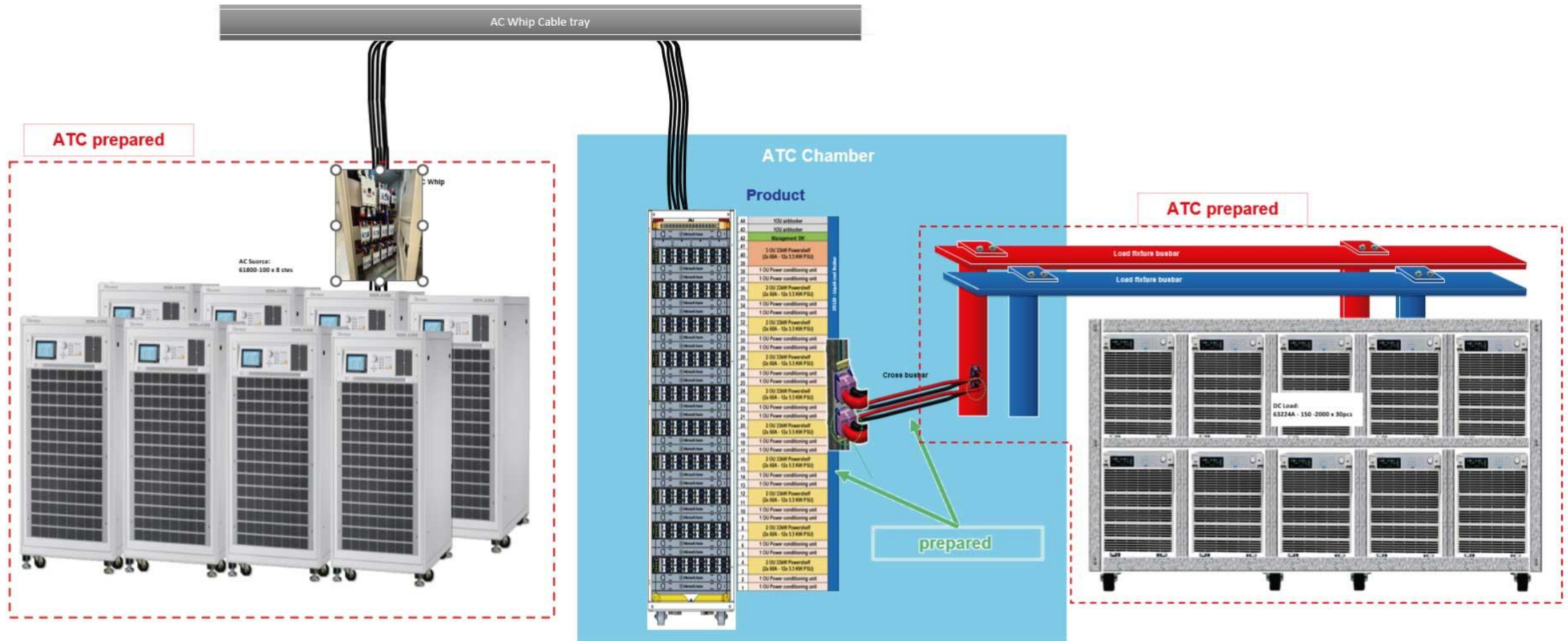
BBU模組實圖

HVDC高功率測試解決方案

ATC測試架構情境



實際BBU Power Rack 測試示意圖

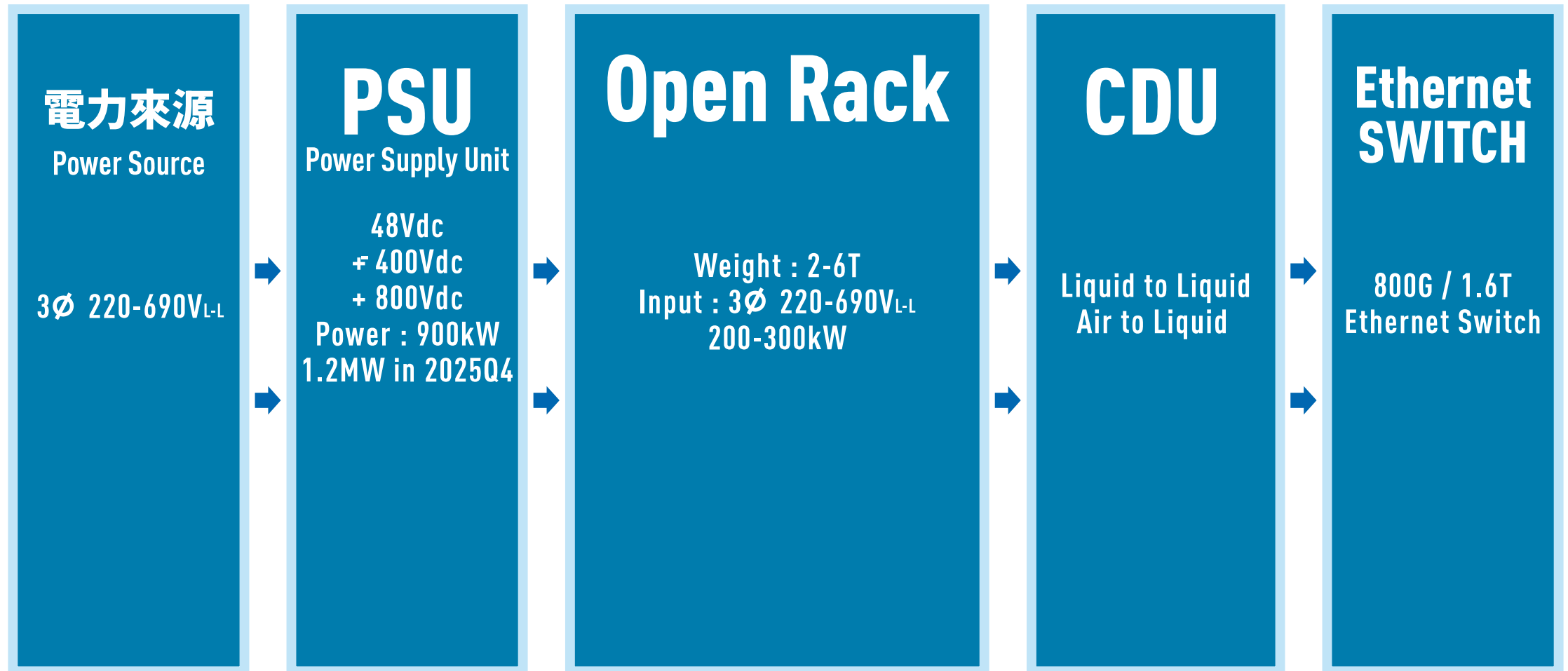


實際BBU Power Rack 測試示意圖

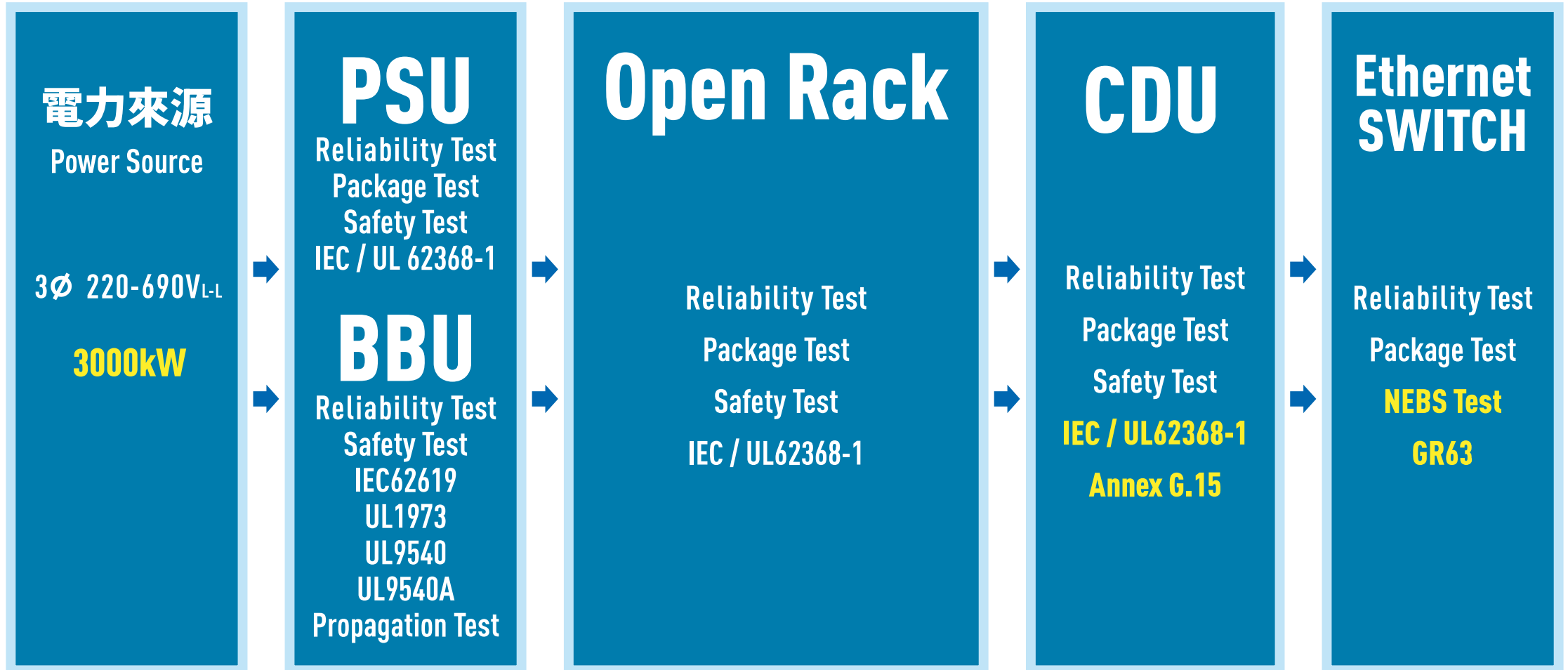
100V/10800A 輸出系統負載櫃建置



ATC CAN provide those technical support



ATC's Capability



HVDC Safety Standards

AI Server

- 北美市場 NRTL/UL62368-1
- 歐洲市場 IEC/EN62368-1

POWER SUPPLY UNIT

- 北美市場 NRTL/UL62368-1
- 歐洲市場 IEC/EN62368-1

BBU

- 運輸法規 UN 38.3
- 北美市場 NRTL/UL62368-1 、 UL1973 、 UL9540 、 UL9540A
- 歐洲市場 IEC/EN62368-1 、 IEC/EN62619

source from: Open Compute Project
Open Rack V3 48V BBU Rev: 1.

HVDC 測試要點

IEC62368-1 :2023 Ed4

IEC 62368-1 對 HVDC($\pm 400\text{Vdc}$ / 800Vdc)之應用

1. HVDC 系統設計與 IEC 62368-1 之關聯

- HVDC 的輸入電壓、過電壓行為、暫態特性與 AC 系統完全不同，不可直接採用 AC 絕緣規格。
- 正式納入 DC Mains OVC 要求。
- HVDC系統需於設計初期即評估穩態與暫態電壓，以確保整體安全架構。

2. 絕緣距離要求(Creepage & Clearance)

- 爬電距離與間隙應以「暫態電壓 (Transient Voltage)」計算，而非僅依穩態電壓。
- 暫態電壓常影響間隙(Clearance)需求，而穩態電壓與污染等級決定爬電距離(Creepage)。
- 若系統屬 OVC II 或 OVC III，會影響絕緣等級與所需耐壓距離。

IEC 62368-1 對 HVDC($\pm 400\text{Vdc}$ / 800Vdc)之應用

3. 過電壓(OVC)類別影響

- OVC II：常用於資料中心、通信用電環境，保護中度。
- OVC III：屬工業環境或近配電端，耐壓要求更高。
- 不同類別會直接影響基本/加強絕緣之距離與測試電壓。

4. 測試電壓與 DC Mains 容差

- IEC 62368-1 對 DC Mains 規定 $+20\%$ / -15% 電壓容差，用以模擬真實電壓波動。
 - 測試電壓需於設計與認證階段即納入。
- 例如 400Vdc 系統測試電壓最高可達 480Vdc ； 800Vdc 系統可能需要測至 960Vdc 。

IEC 62368-1 對 HVDC($\pm 400\text{Vdc}$ / 800Vdc)之應用

5. 關鍵零件的直流認證

- 電容器、端子、連接器、電弧元件、接觸器、熔絲等皆需具備直流電壓評等。
- AC 認證不等同於 DC 認證；直流弧光消弭更困難、長期偏壓會加速老化。
- 元件選型需以 DC 資料與耐壓能力為準。

關鍵零件-直流高壓輸入端及電容器要求

1. 輸入端子(Primary Connector / Terminal Block)要求

- Power Supply Input Voltage: 800 Vdc
- 主要風險：端子或 PCB 因高電壓導致軟化或過熱
- 依 IEC/UL/EN 62368-1 之 5.4.1.10.3 進行 Ball Pressure Test 檢查零件額定 Vac 是否可支援 HVDC之實際條件

2. 電容器(X / Y / Bridge Capacitor)要求

- 依 IEC 60384-14:2013 + AMD1:2016 Annex H： $V_{ac} \times 1.414 = V_{dc}$ 等效電壓
- 依據換算後之耐壓確認電容器可否適用於 HVDC 系統

IEC 62368-1 針對 HVDC 系統之評估觀點

1. HBSE 危害導向評估模式

- 採 Hazard-Based Safety Engineering(HBSE)方式：從危害來源而非事件結果進行評估
- 評估重點包括能量來源、能量傳遞途徑與對應防護措施(Safeguards)

2. 輸出 ≤ 60 Vdc 仍可能需要測試

- ≤ 60 Vdc 並不代表自動豁免測試
- 須依 Energy Source(ES1/ES2/ES3)判定安全要求

3. 多級架構需系統層級(System-Level)評估

- 多階段降壓： $800/\pm 400$ Vdc $\rightarrow$ 48 Vdc $\rightarrow$ 1 Vdc
- 不可僅檢查單一零件，需從整體能量流與故障傳遞機制評估
- 可避免未預期能量路徑與連鎖故障(Cascading Failure)

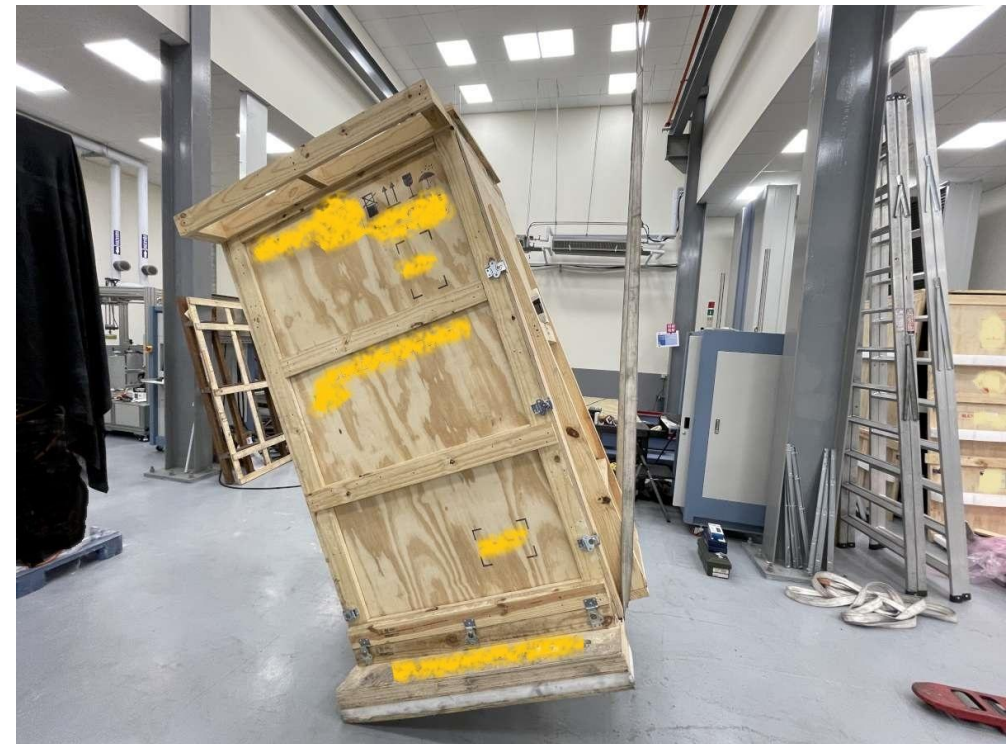
HVDC 系統針對Mechanical Design評估觀點

Example for Tilt Test



HVDC 系統針對Mechanical Design評估觀點

Example for Tilt Test

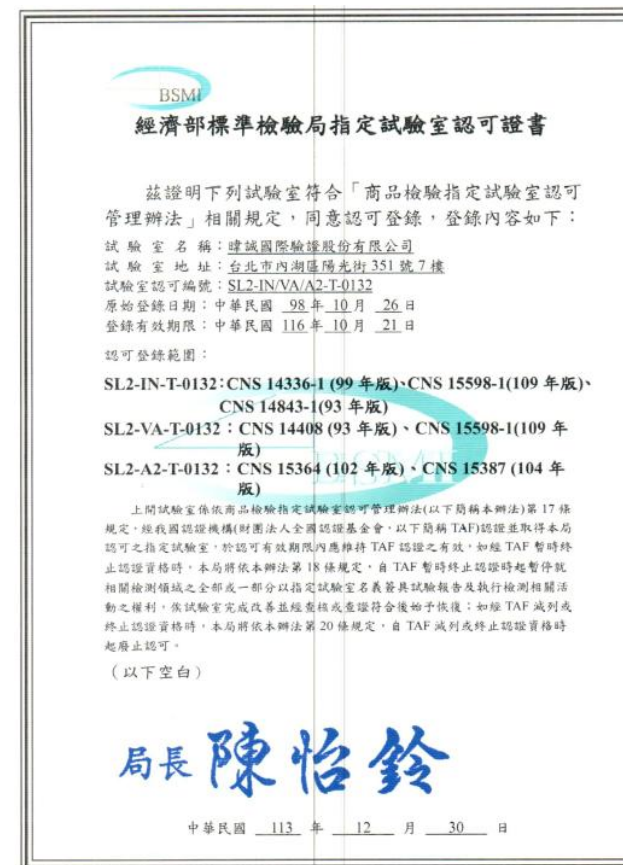


ATC Accreditation

Accreditation



TAF Accreditation



BSMI Accreditation



NCB Dekra Accreditation



NCB Intertek SG Accreditation



UL WTDP

Testing Site Acceptance

RTL
Level 2

The following organization has been assessed and found to comply with the relevant requirements of ISO/IEC 17025 and the Intertek Global Recognized Test Laboratory Policy Manual and accepted by Intertek as a Level 2

Recognized Test Laboratory

under the Test Data Acceptance for the ETL mark and is authorized to perform test work for the product types identified on the endorsement to this Testing Site Acceptance.

Intertek RTL Program
Our data acceptance testing program allows a qualified laboratory to perform product testing at their site, with the same validity as if it were conducted in an Intertek laboratory.

Organization:

AnTek Certification Inc.

No. 21 Gongjian Road, Qidu District, Keelung City 206007, Taiwan

Acceptance Number	2021-RTL-L2-355
Issue Number	00002
Issue Date	11 May 2023
Expiry Date	10 May 2024

This Testing Site Acceptance is valid until the expiry date shown above, subject to continuing compliance with the conditions specified in the endorsement of this site acceptance.

The Testing Site Acceptance is comprised of this front sheet and 2 endorsements.

Signature:

Name: Wellington Huang
Title: RTL Program Technical Manager
Date: 2023-05-11

Intertek RTL



DELL S&V



JET Recognized Lab. (Only One) for ESS

Q & A

atc@antek.com.tw





Thank you !
