

IEC 61850

智慧型電網變電站自動化 系統概念暨整合運用

Shenchyei Engineering Consultant Co. Ltd. 24th June 2013
神捷工程顧問股份有限公司

簡報大綱



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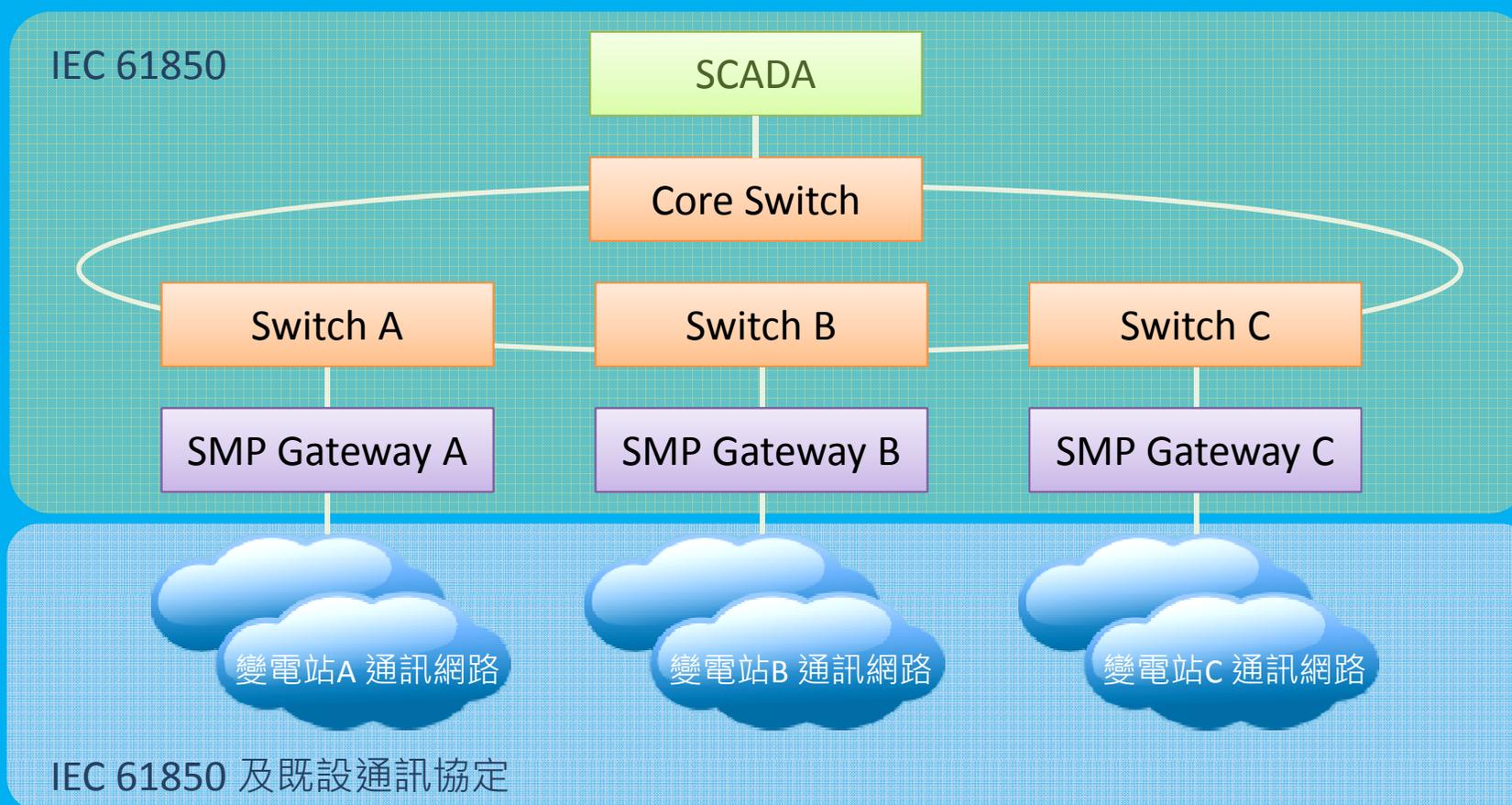
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變電站自動化整合策略

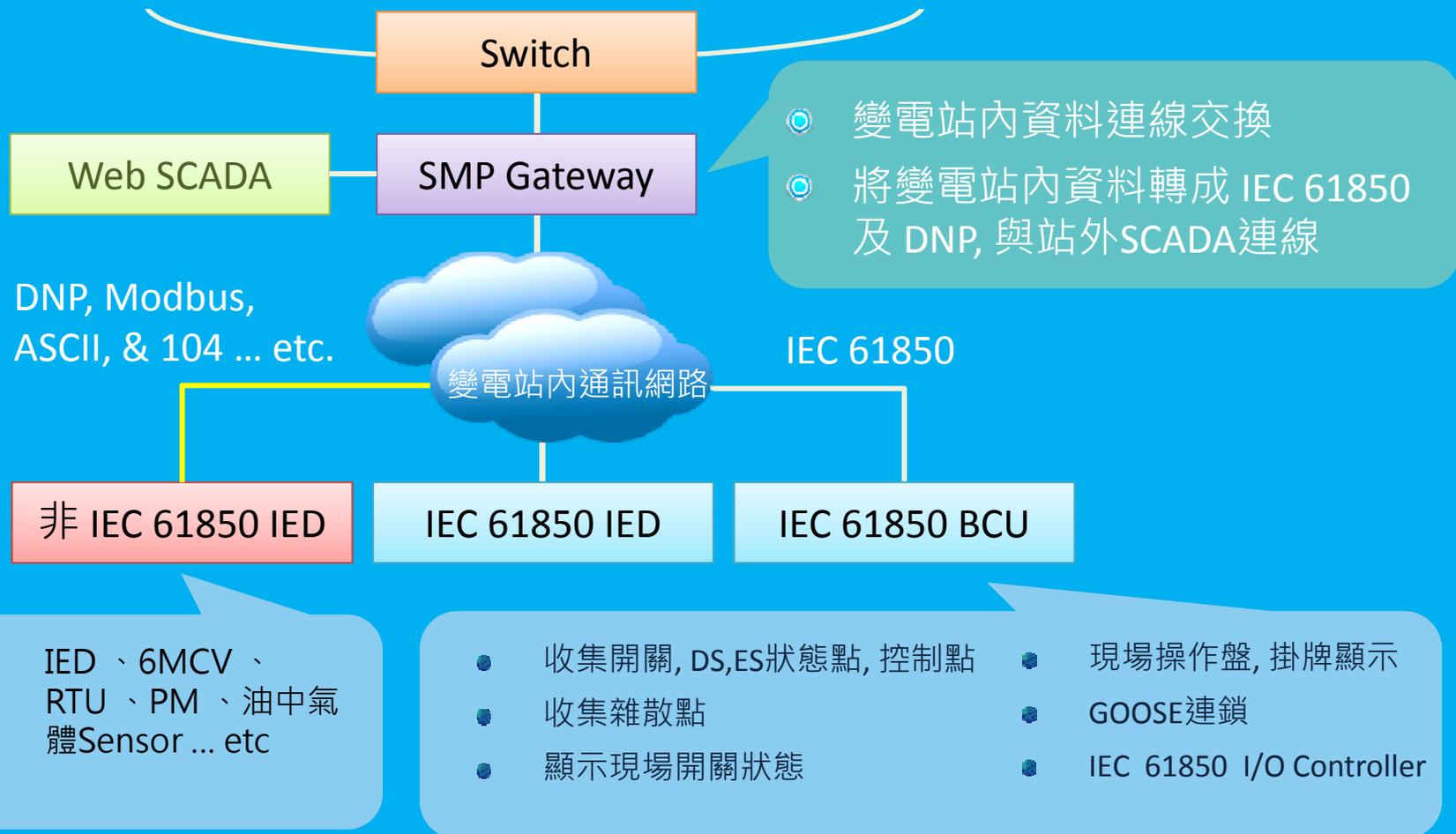


IEC 61850 多變電站系統架構

- ◎ 任一變電站通訊網路經 Gateway 與外部網路
- ◎ SCADA 經上層通訊環路與 Gateway 交換資料



IEC 61850 變電站內系統架構



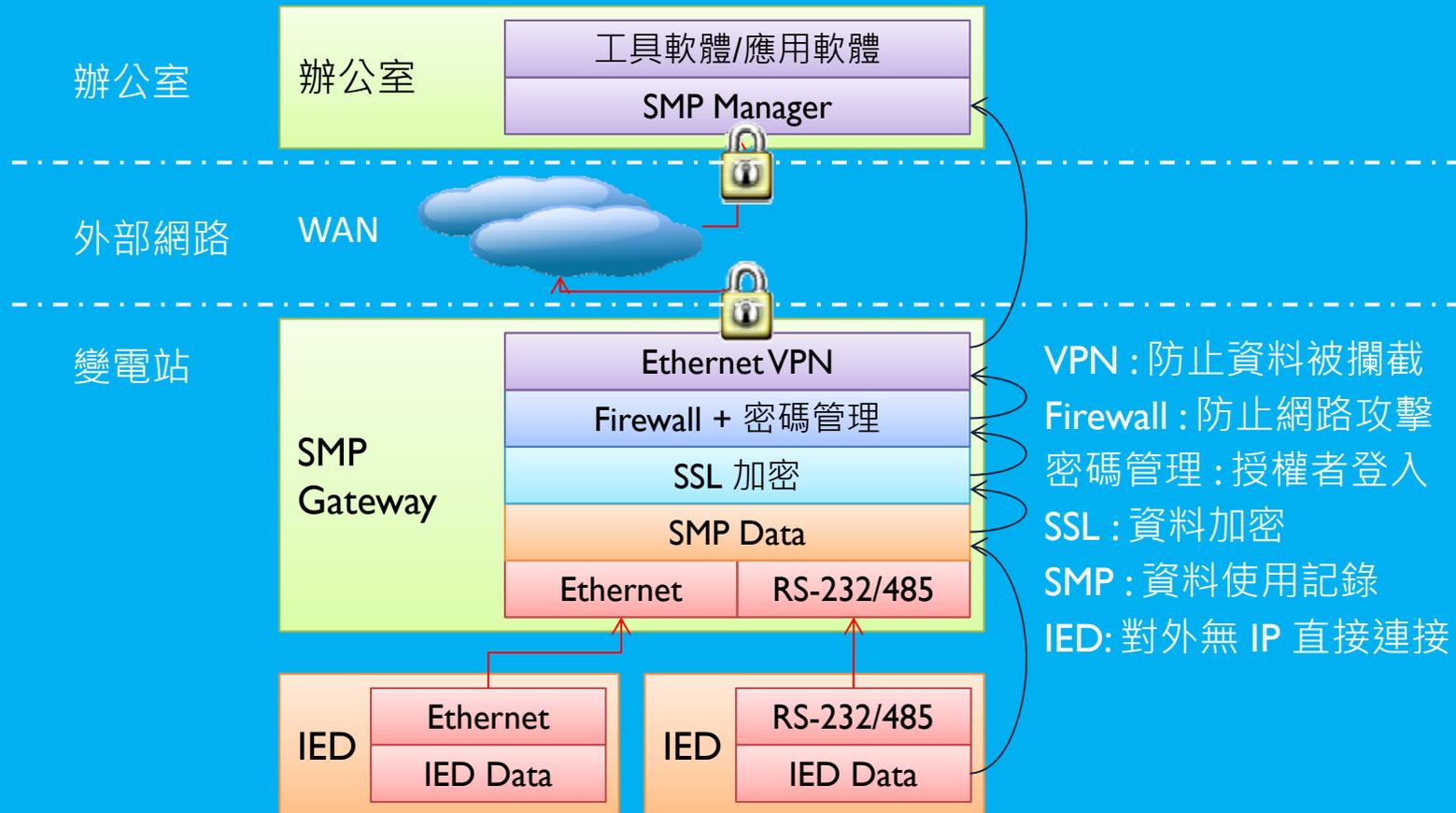
電驛工具遠端使用與網路安全架構



安全的網路通訊架構：NERC-CIP

North American Electric Reliability Corporation - Critical Infrastructure Protection

北美電力可靠度組織 – 關鍵基礎設施保護



校時系統

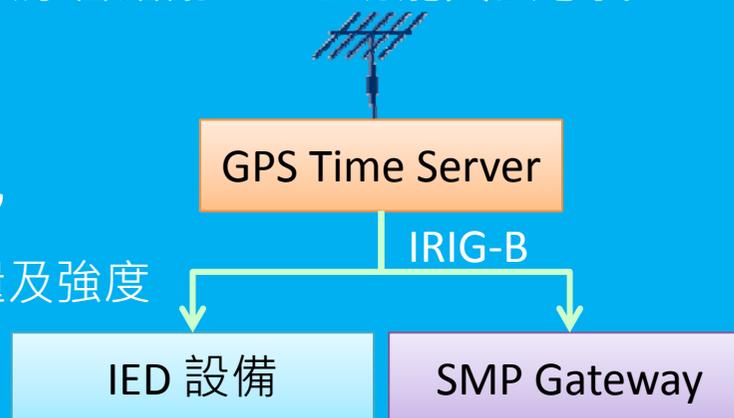


◎ 系統校時精確度非常重要

- ◎ IEC 61850 SCADA 讀取 IED 設備內部 SOE (Sequence of Event) · 正確報告事件 (事故 · 警報 · 位置改變) 發生時間點 · 解析度至毫秒 (ms) · 清楚分辨並記錄事件發生的順序 · 供事件分析及故障診斷；
- ◎ 保護電驛可於數毫秒之內對反應故障 · 系統校時精準度大於 $\pm 10\text{ms}$ 時 · 電力事件記錄先後順序會錯亂 · SOE 功能失去意義 · 故障診斷可能導致錯誤結論。

◎ 系統校時需要被監視

- ◎ 即時監視 GPS 接收衛星訊號數量及強度
- ◎ GPS 顯示已接受衛星的校時
- ◎ IED 設備由通訊點回覆已收到 IRIG-B 校時狀態



IEC 61850 KEMA 認證範例





IEC 61850 Test Register

Test Register for

IEC 61850 Ed1 Client Systems
IEC 61850 Ed1 Server Devices
IEC 61850 Ed1 Sampled Value Publishers (Merging Units)
IEC 61850 Ethernet Switches

Updated: February 6, 2013

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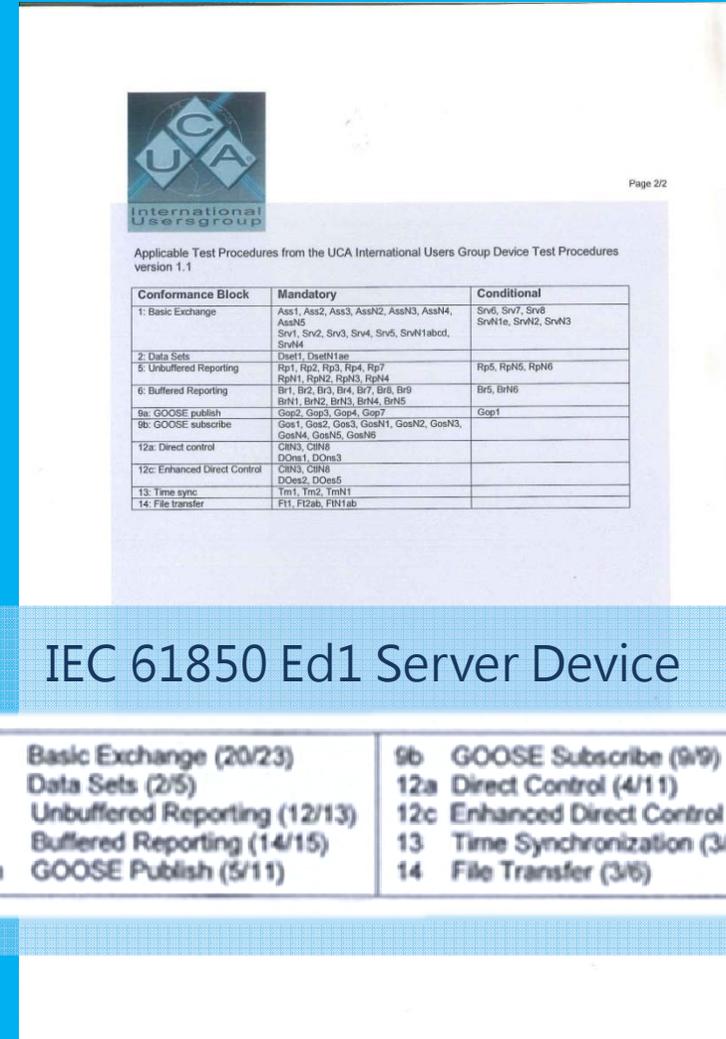
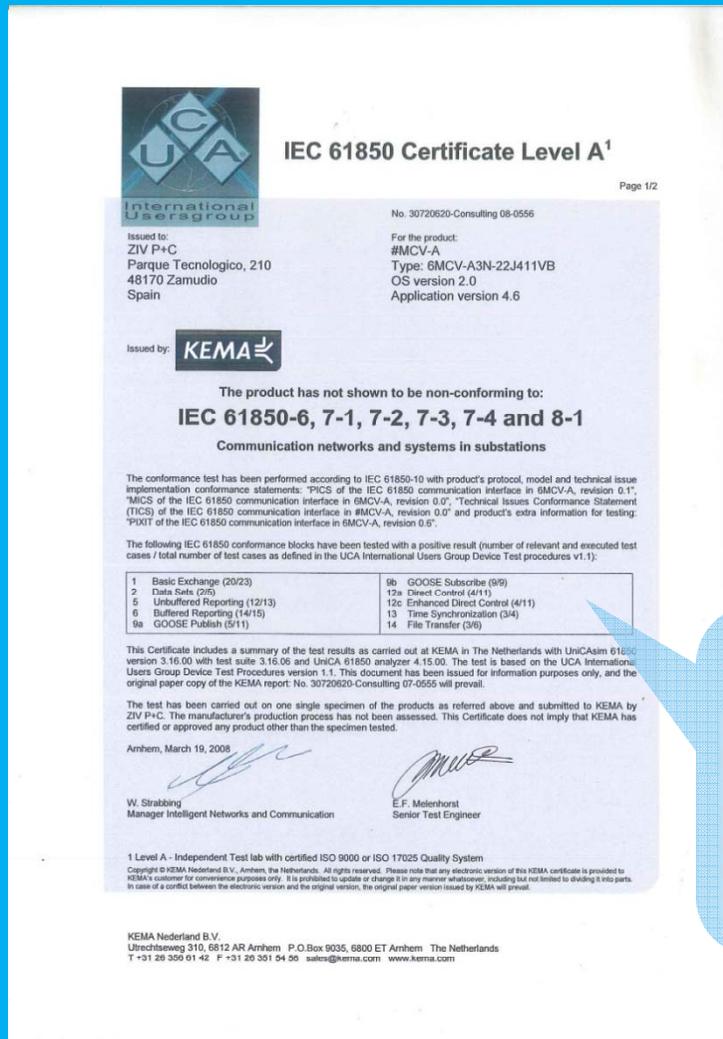


IEC 61850 Test Register

Annex A: Overview of ACSI services per conformance block for IEC 61850 Ed1 Server Devices

Conformance Block	Mandatory	Optional
1: Basic Exchange	Associate, Abort, Release GetServerDirectory, GetLogicalDeviceDirectory GetLogicalNodeDirectory (DATA) GetDataValues, GetDataDirectory, GetDataDefinition	GetAllDataValues SetDataValues
2: Data Set	GetLogicalNodeDirectory (DATA-SET) GetDataSetValues GetDataSetDirectory	DataSetValues
2+: Data Set Definition	CreateDataSet, DeleteDataSet	
3: Substitution	SetDataValues, GetDataValues	
4: Setting Group	SelectActiveSG, GetSGValues	GetSGValues
4+: Setting Group Definition	SelectEditSG, GetSGValues, SetSGValues ConfirmEditSGValues	
5: Unbuffered Reporting	Report, GetURCBValues, SetURCBValues	
6: Buffered Reporting	Report, GetBRCBValues, SetBRCBValues	
7: Logging	GetLCBValues, GetLogicalNodeDirectory(LOG) QueryLogByTime or QueryLogAfter, GetLogStatusValues	SetLCBValues
8a: GSSE publish	SendGSSEMessage (publish)	GetGsCBValues SetGsCBValues
8b: GSSE subscribe	SendGSSEMessage (subscribe)	
8c: GSSE mngt	GetGsReference, GetGSSEDataOffset	
9a: GOOSE publish	SendGOOSEMessage (publish)	GetGoCBValues SetGoCBValues
9b: GOOSE subscribe	SendGOOSEMessage (subscribe)	
9c: GOOSE mngt	GetGoReference, GetGOOSEElementNumber	
10: Sampled values part 9-1 pub/sub	<no ACSI service associated>	
11: Sampled values part 9-2 pub/sub	SendUSVMessage or SendMSVMessage	GetxSVCBValues SetxSVCBValues
12a: Direct control	Operate	TimeActivatedOperate
12b: SBO control	Select, Cancel, Operate	TimeActivatedOperate
12c: Enhanced Direct Control	Operate CommandTermination	TimeActivatedOperate
12d: Enhanced SBO control	SelectWithValue, Cancel, Operate CommandTermination	TimeActivatedOperate
13: Time sync	SNTP Time Synchronization	
14: File transfer	GetFile GetFileAttributeValues	SetFile DeleteFile

IEC 61850 KEMA 認證範例



IEC 61850 KEMA 認證範例



IEC 61850 Certificate Level A¹

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No. 74104095-MOC/INC 13-1214

Issued to:
Cooper Power Systems
730 Commerciale Street, Suite 200
Saint-Jean-Christostome
Quebec, Canada

For the client system:
SMP 16 / CP-PM
Version 6.2C374104095

Issued by: **KEMA**

The client system has not shown to be non-conforming to:
IEC 61850 First Edition Parts 6, 7-1, 7-2, 7-3, 7-4 and 8-1
Communication networks and systems in substations

The conformance test has been performed according to IEC 61850-10 and UCA IUG Conformance Test Procedures for Client System with IEC 61850-8-1 interface, revision 1.1 with TPCL² version 1.2 with client system's protocol, model and technical issue implementation conformance statements: "Conformity Specification IEC 61850 Master Protocol, S1120-19-6, version 1". This document also includes the product's extra information for testing.

The following IEC 61850 conformance blocks have been tested with a positive result (number of relevant and executed test cases / total number of test cases):

1 Basic Exchange (18/22)	12a Direct Control (5/7)
2 Data Sets (7/9)	12b SBO Control (7/9)
5 Unbuffered Reporting (16/18)	12c Enhanced Direct Control (5/7)
6 Buffered Reporting (20/22)	12d Enhanced SBO Control (7/9)
	13 Time Synchronization (3/4)
	14 File Transfer (6/8)

This certificate includes a summary of the test results as carried out at KEMA in the Netherlands with UniCA Multi IEC Simulator version 3.26.1 and UniCA 61850 Analyzer version 4.25.0. This document has been issued for information purposes only, and the original paper copy of the KEMA report: No. 74104095-MOC/INC 13-1215 will prevail.

The test has been carried out on one single specimen of the client system as referred above and submitted to KEMA by Cooper Power Systems. The manufacturer's production process has not been assessed. This attestation does not imply that KEMA has approved any product other than the specimen tested.

Arnhem, February 25, 2013

M. Adriaens
Director Intelligent Networks & Communication

R. Schimmel
Certification Manager

¹ Level A - Independent test lab with certified ISO 9001 quality system
² TPCL - Test Procedure Change List

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Applicable Test Procedures from the UCA IUG Conformance Test Procedures for Client System with IEC 61850-8-1 interface, revision 1.1 with TPCL version 1.2

Conformance Block	Mandatory	Conditional
1: Basic Exchange	cAss1, cAss2, cAss3, cAss4, cAssN1, cAssN4, cAssN5, cAssN6	cAssN7, cSrv1, cSrv2, cSrv3, cSrv4, cSrv5, cSrvN1, cSrvN3, cSrvN5, cSrvN6
2: Data set		cDs1, cDs2, cDs3, cDs5, cDsN1a, cDsN1b, cDsN2
5: Unbuffered Reporting	cRp3, cRp4, cRp5, cRp8, cRp9, cRp10, cRpN2, cRpN3, cRpN7, cRpN8	cRp1, cRp2, cRp6, cRp7, cRpN1, cRpN4
6: Buffered Reporting	cBr3, cBr4, cBr5, cBr8, cBr9, cBr10, cBr11, cBr12, cBrN2, cBrN3, cBrN7, cBrN8, cBrN9	cBr1, cBr2, cBr6, cBr7, cBr13, cBrN1, cBrN4
12a: Direct control	cCt4, cCtN1 cDOms1, cDOms2	cCt2
12b: SBO control	cCt4, cCtN1 cSBOms1, cSBOms2, cSBOms3	cCt2, cSBOms4
12c: Enhanced Direct Control	cCt4, cCtN1 cDOms1, cDOms2	cCt2
12d: Enhanced SBO control	cCt4, cCtN1, cSBOms1, cSBOms2, cSBOms3	cCt2, cSBOms4
13: Time sync	cTm1	cTm2, cTmN1
14: Get File Transfer	cFt1, cFt2, cFt3, cFtN1, cFtN2	cFt5

IEC 61850 Ed1 Client System

1 Basic Exchange (18/22)	12a Direct Control (5/7)
2 Data Sets (7/9)	12b SBO Control (7/9)
5 Unbuffered Reporting (16/18)	12c Enhanced Direct Control (5/7)
6 Buffered Reporting (20/22)	12d Enhanced SBO Control (7/9)
	13 Time Synchronization (3/4)
	14 File Transfer (6/8)

IEC 61850 整合應用實例



◎ 實際工程案 IEC 61850 系統發展整合流程

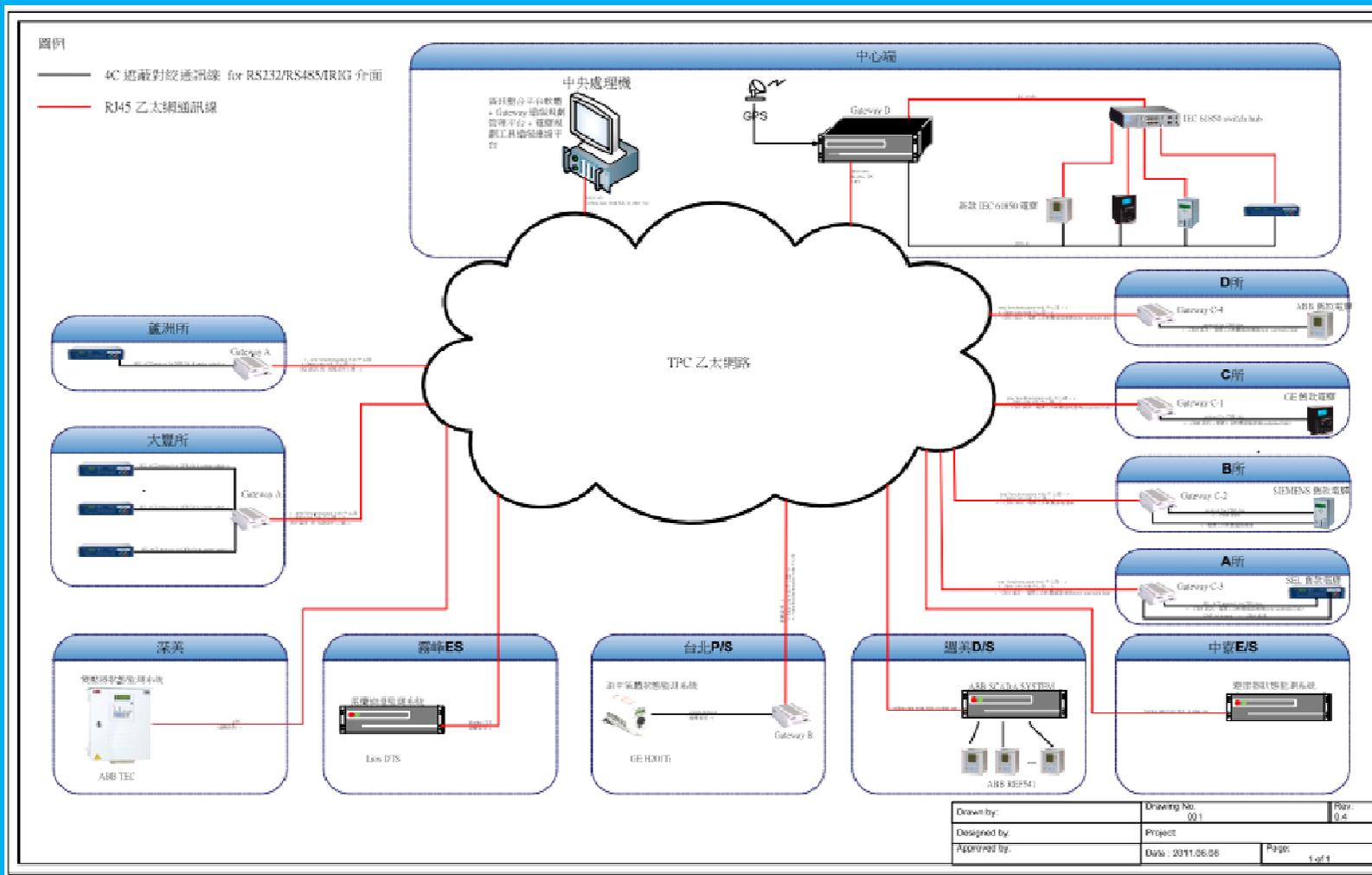


IEC 61850 通訊整合



- ◎ 工程案採用 ABB, SIEMENS, GE, 及 SEL IEC 61850 IED 保護電驛各一顆，與業主既設非 IEC 61850 設備進行通訊整合。
- ◎ IED 保護電驛為『智慧型變電站自動化系統』的『基礎設備』。
- ◎ 台電 IED 保護電驛使用為多廠牌型號及版本並用，與一般工業界單一品牌及版本狀況不同。
- ◎ 實際成果：
 - ◎ 完成 IED configuration for IEC 61850。
 - ◎ 完成 IED Logic Node/Attribute point 建立。
 - ◎ 完成 IED circuit breaker Condition-Based Maintenance 應用。
 - ◎ 完成 IED Time Synchronization。
 - ◎ 完成 IED native tool pass through 功能。

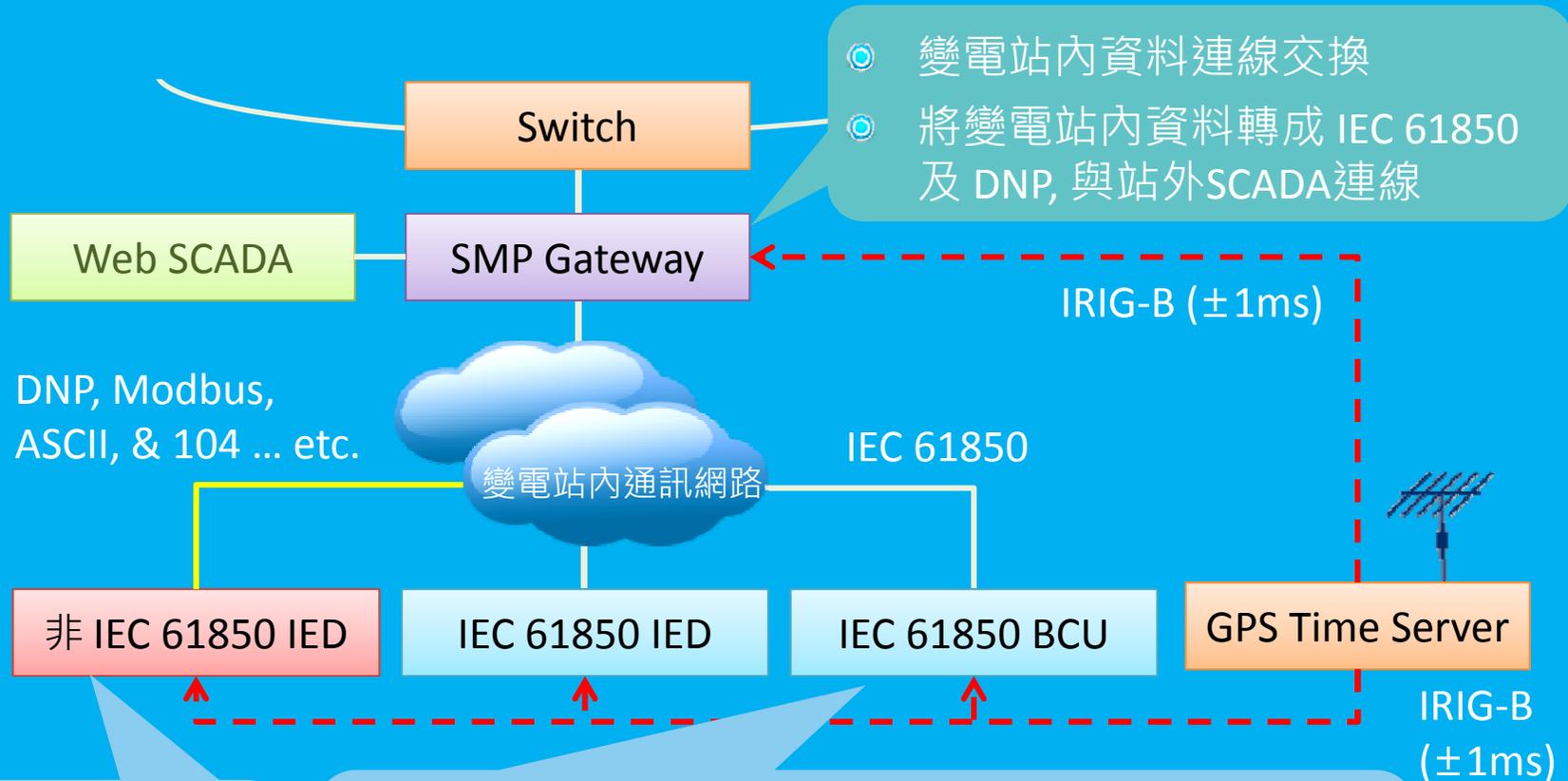
IEC 61850 通訊整合



IEC 61850 變電站實際架構



IEC 61850 變電站實際架構



- 變電站內資料連線交換
- 將變電站內資料轉成 IEC 61850 及 DNP, 與站外SCADA連線

- IED、6MVC、RTU、PM、油中氣體Sensor ... etc

- 收集開關, DS, ES狀態點, 控制點
- 收集雜散點
- 顯示現場開關狀態
- 現場操作盤, 掛牌顯示
- GOOSE連鎖
- IEC 61850 I/O Controller

IEC 61850 變電站實際架構



- ◎ 使用 Protection IED Goose Out (IEC 61850 Ed1 9a) ;
- ◎ 使用 Distribution Protection IED command (IEC 61850 Ed1 12) ;
- ◎ 不使用 Transmission Protection IED command (IEC 61850 Ed1 12) ;
- ◎ 不使用 IEC 61850B Ed1 13 『SNTP Time Synchronization』，採用 IRIG-B 替代；
- ◎ 變電所設置 IEC 61850 BCU (Bay Control Unit) ，符合 IEC 61850 Ed1 1, 2, 5, 6, 9ab, 12ac, 13, 14 ，以 command 與 Goose in/out 應用為主 ；
- ◎ 資訊安全遵循 NERC-CIP 規定，Pass-through IED native tool remote access 等應用均符合 NERC-CIP 要求，**變電站資安管理非常重要**。

IEC 61850 變電站實際架構



- ◎ 輸電網路操作影響範圍廣泛，台電禁止設備經 Protection IED 遙控操作，Protection IED 單純做系統保護之用，故不使用 IEC 61850 Ed1 12 - Transmission Protection IED command ；
- ◎ IEEE 1588 尚未成熟普及於 Protection IED，SNTP 不能滿足 SOE 時間精確度需求，故台電採用廣泛被 Protection IED 支援的IRIG-B 校時策略。

Protocol Time sync	SNTP Time sync	Modulated IRIG-B Time sync	Demodulated IRIG-B Time sync
~±500ms	~±100ms	~±10ms	~±1ms

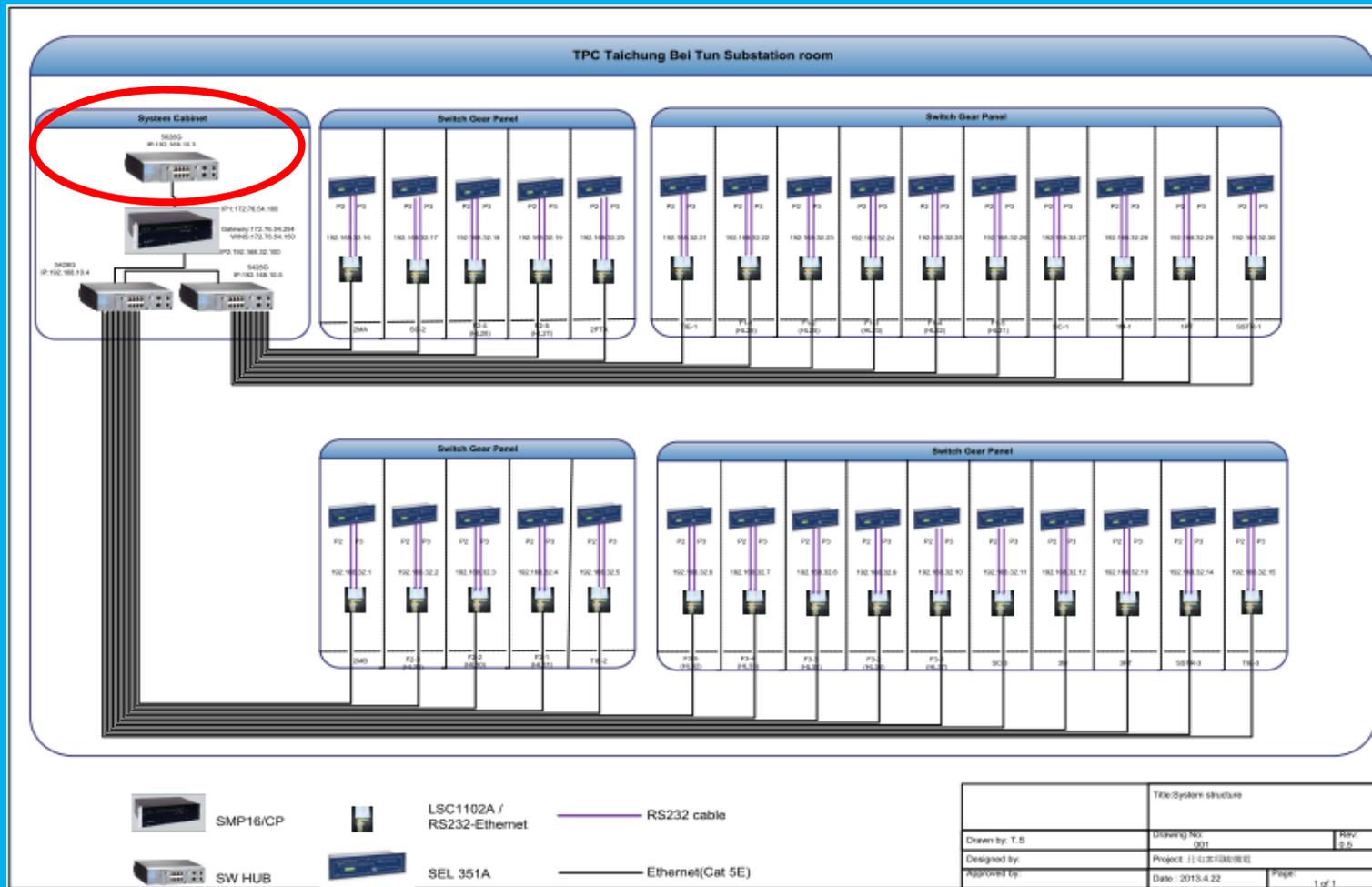
IEC 61850 Server



IEC 61850 Server



◎ SEL Legacy IED Relay IEC 61850 整合應用實例：





IEC 61850 Server

- ◎ Protection IED : SEL Legacy IED Relay ;
- ◎ 以台電六輸統包 IED 4 點表為基礎，發展 IEC 61850 Server Logic Node 與 Attribute point ;
- ◎ SCADA 圖控資料庫及 SMP Gateway 資料庫資料以 ICD file 直接載入映設，避免人為輸入錯誤；
- ◎ 完成 Fault-Recorder file auto-retrieve 功能；
- ◎ 完成 IED native tool remote access pass through 功能；
- ◎ 完成 IRIG-B Time Synchronization ；
- ◎ 完成 Circuit Breaker Condition-Based Maintenance 功能，包括 CB spring charge, CB trip coil, CB contact wear, CB operate travel time 監視記錄等。

IEC 61850 GOOSE 功能應用



IEC 61850 GOOSE 功能應用



- ◎ 變電站間 (Sub2Sub) ES operate security Goose interlocking (project:2014/4)
- ◎ 81L load shedding application (project:2014/4)
- ◎ CIGRE will release GOOSE application scheme as below in months :
 - ◎ Transmission Bus Protection: Directional Comparison Scheme
 - ◎ Transmission Line Protection: Inter-trip scheme
 - ◎ Transmission Line Protection: Breaker Failure Protection (RBRF)
 - ◎ Transmission Line Protection: Automatic reclosing (AR) for One Breaker (internal or external AR device)
 - ◎ Transmission Line Protection: Check Sync for One or Two Breakers
 - ◎ Breaker Control IED
 - ◎ Distribution Feeder: Breaker Failure Protection Scheme for One or Two Bus Sections (Shenchyei Lab : 2013)
 - ◎ Sympathetic Tripping or Blocking Scheme
 - ◎ Feeder Interlocking and Substation Interlocking (project:2014/4)
 - ◎ Distribution bus protection (Shenchyei Lab : 2013)
 - ◎ Substation Control Lockout or Control Uniqueness (project:2014/4)
 - ◎ Under Frequency Load Shedding – UFLS (project:2013)

IEC 61850 Server 標準點表規則



IEC 61850 設備規格基準

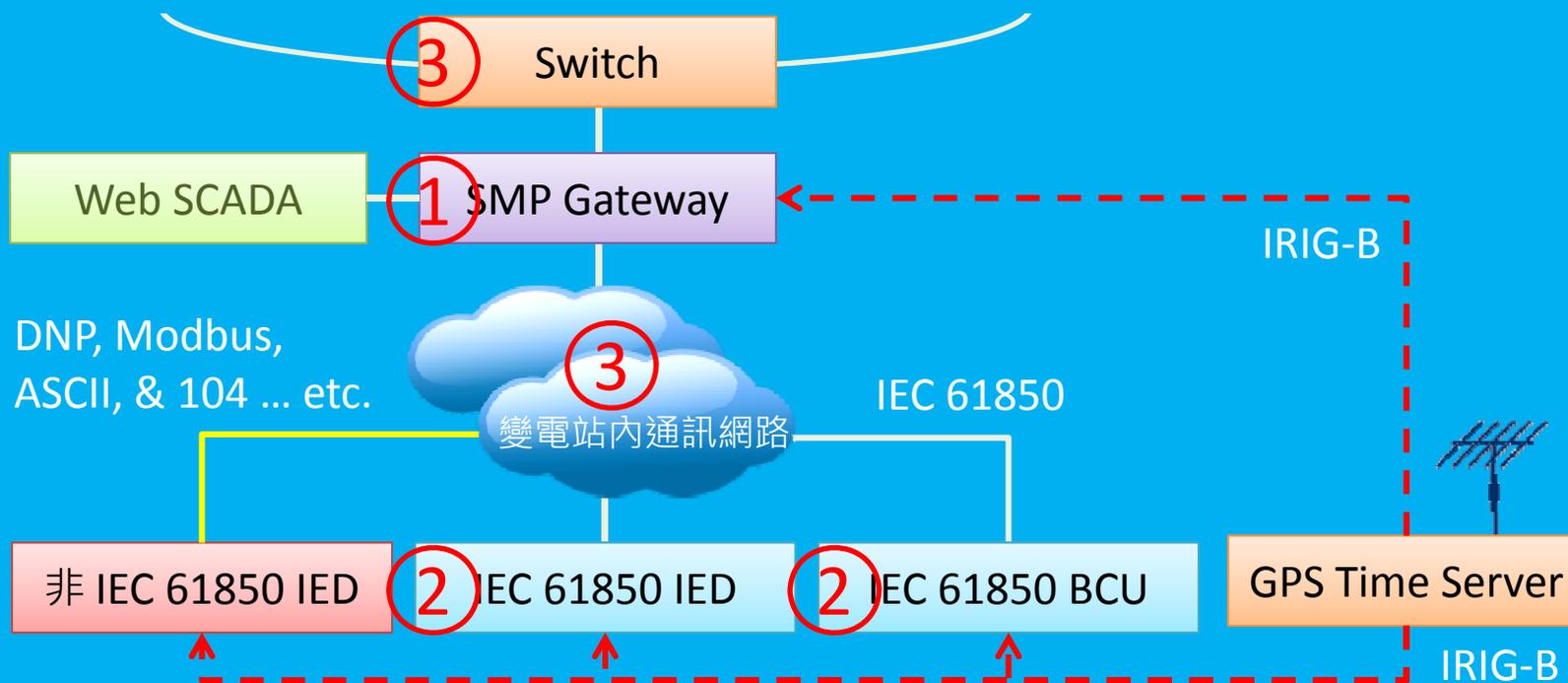


IEC 61850 設備規格基準



◎ 以 KEMA 認證 Register Table 為依據：

1. IEC 61850 Ed1 Client Systems
2. IEC 61850 Ed1 Server Devices
3. IEC 61850 Ethernet Switches



IEC 61850 設備規格基準



- ◎ 以 KEMA 認證 Register Table 為依據：
 1. IEC 61850 Ed1 Client Systems
Apply to IEC 61850-8-1 Block 1, 2, 5, 6, 12abcd, 13, 14
 2. IEC 61850 Ed1 Server Devices
Apply to IEC 61850-8-1 Block 1, 2, 5, 6, 9ab, 12xxxx, 13, 14
 3. IEC 61850 Ethernet Switches
Apply to functional test IEC 61850-3 application depending on operation environment requirement
 4. IEC 61850 Ed1 Sampled Value Publishers (Merging Units)
Apply to IEC 61850-9 Block 10, 11

IEC 61850 設備規格基準



◎ KEMA IEC 61850 Test Register Table

ACSI services per conformance block for IEC 61850 Ed1 Server Devices

Conformance Block	Mandatory	Optional
1: Basic Exchange	Associate, Abort, Release GetServerDirectory, GetLogicalDeviceDirectory GetLogicalNodeDirectory (DATA) GetDataValues, GetDataDirectory, GetDataDefinition	GetAllDataValues SetDataValues
2: Data Set	GetLogicalNodeDirectory (DATA-SET) GetDataSetValues GetDataSetDirectory	DataSetValues
2+: Data Set Definition	CreateDataSet, DeleteDataSet	
3: Substitution	SetDataValues, GetDataValues	
4: Setting Group	SelectActiveSG, GetSGCBValues	GetSGValues
4+: Setting Group Definition	SelectEditSG, GetSGValues, SetSGValues ConfirmEditSGValues	
5: Unbuffered Reporting	Report, GetURCBValues, SetURCBValues	
6: Buffered Reporting	Report, GetBRCBValues, SetBRCBValues	
7: Logging	GetLCBValues, GetLogicalNodeDirectory(LOG) QueryLogByTime or QueryLogAfter, GetLogStatusValues	SetLCBValues

IEC 61850 設備規格基準



◎ KEMA IEC 61850 Test Register Table

ACSI services per conformance block for IEC 61850 Ed1 Server Devices
(Continue)

Conformance Block	Mandatory	Optional
8a: GSSE publish	SendGSSEMessage (publish)	GetGsCBValues SetGsCBValues
8b: GSSE subscribe	SendGSSEMessage (subscribe)	
8c: GSSE mngt	GetGsReference, GetGSSEDataOffset	
9a: GOOSE publish	SendGOOSEMessage (publish)	GetGoCBValues SetGoCBValues
9b: GOOSE subscribe	SendGOOSEMessage (subscribe)	
9c: GOOSE mngt	GetGoReference, GetGOOSEElementNumber	
10: Sampled values part 9-1 pub/sub	<no ACSI service associated>	
11: Sampled values part 9-2 pub/sub	SendUSVMessage or SendMSVMessage	GetxSVCBValues SetxSVCBValues

IEC 61850 設備規格基準



◎ KEMA IEC 61850 Test Register Table

ACSI services per conformance block for IEC 61850 Ed1 Server Devices
(Continue)

Conformance Block	Mandatory	Optional
12a: Direct control	Operate	TimeActivatedOperate
12b: SBO control	Select, Cancel, Operate	TimeActivatedOperate
12c: Enhanced Direct Control	Operate CommandTermination	TimeActivatedOperate
12d: Enhanced SBO control	SelectWithValue, Cancel, Operate CommandTermination	TimeActivatedOperate
13: Time sync	SNTP Time Synchronization	
14: File transfer	GetFile GetFileAttributeValues	SetFile DeleteFile

結論



- ◎ 基礎於變電站現代化整合平台 (SMP) 發展的 IEC 61850 系統架構，能支援過去、現在、及未來變電站自動化需求；
- ◎ 工程實例證明既設系統可成功整合於 IEC 61850 新建變電站自動化系統；
- ◎ 實際採行之 IEC 61850 系統發展整合流程，可順利使既設變電站自動化系統逐步汰換至 IEC 61850 系統，系統轉換期間不影響正常供電，系統升級衝擊減到最低。

討論



- ◎ 感謝聆聽；
- ◎ 敬請賜教。