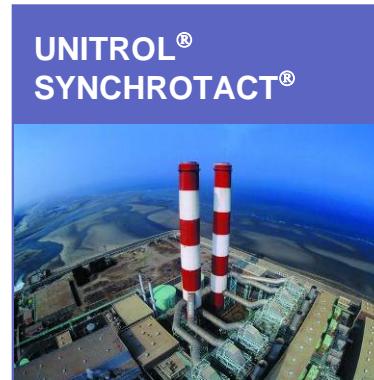
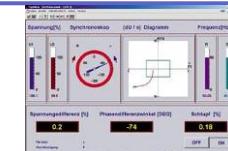


ABB Schweiz AG
Dr. Rudolf Wieser



Redundante Regelungssysteme für grosse Synchronmaschinen



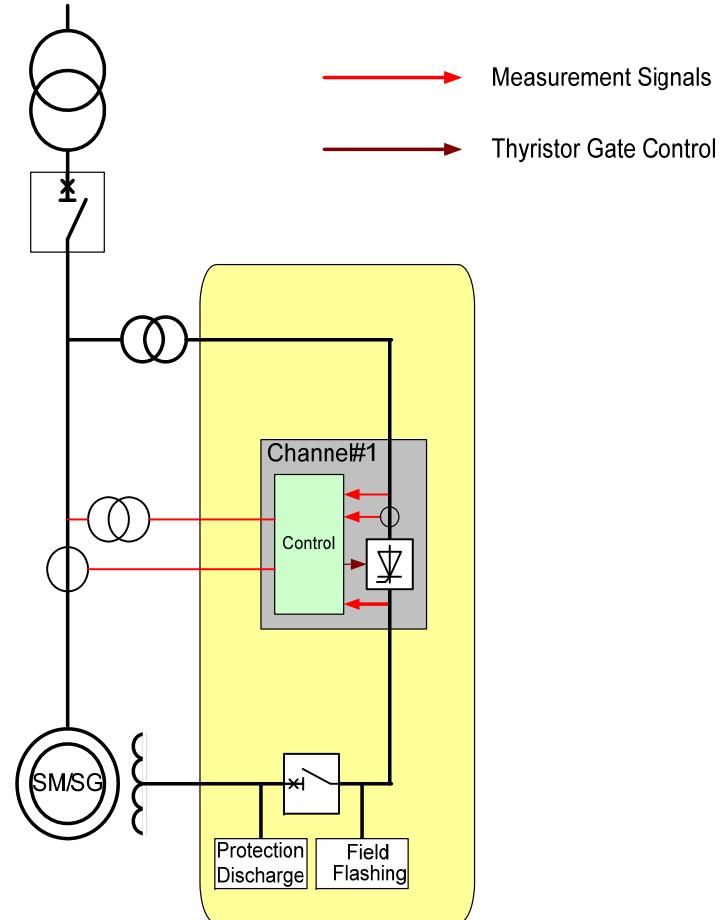
Inhalt Redundante Regelungssysteme

- Anforderungen und Funktionen
- Redundanzlösungen
- Funktionseinheiten
 - Regelungselektronik
 - Stromrichter
 - Schutz
- Ausblick

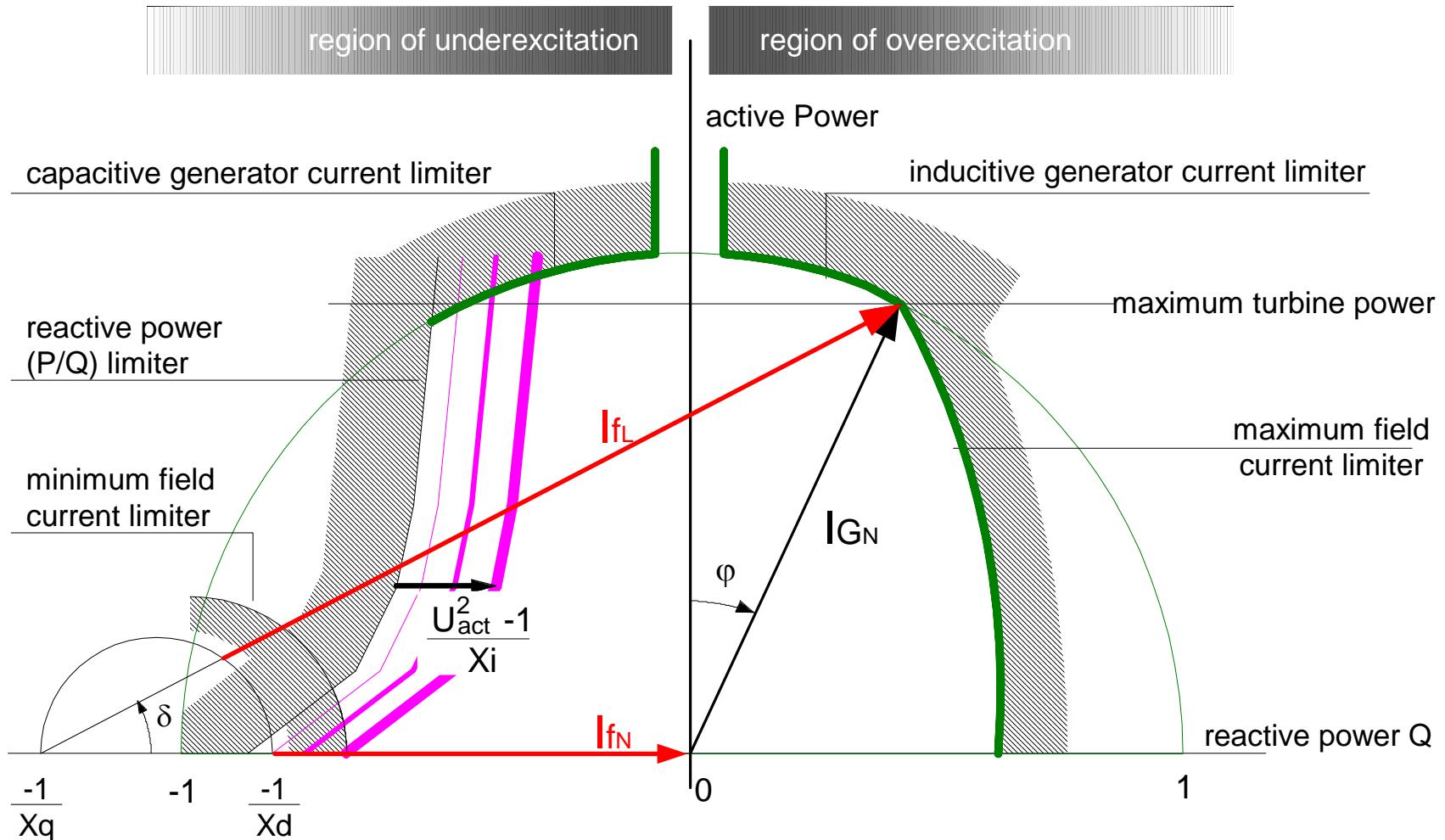


Excitation System Function

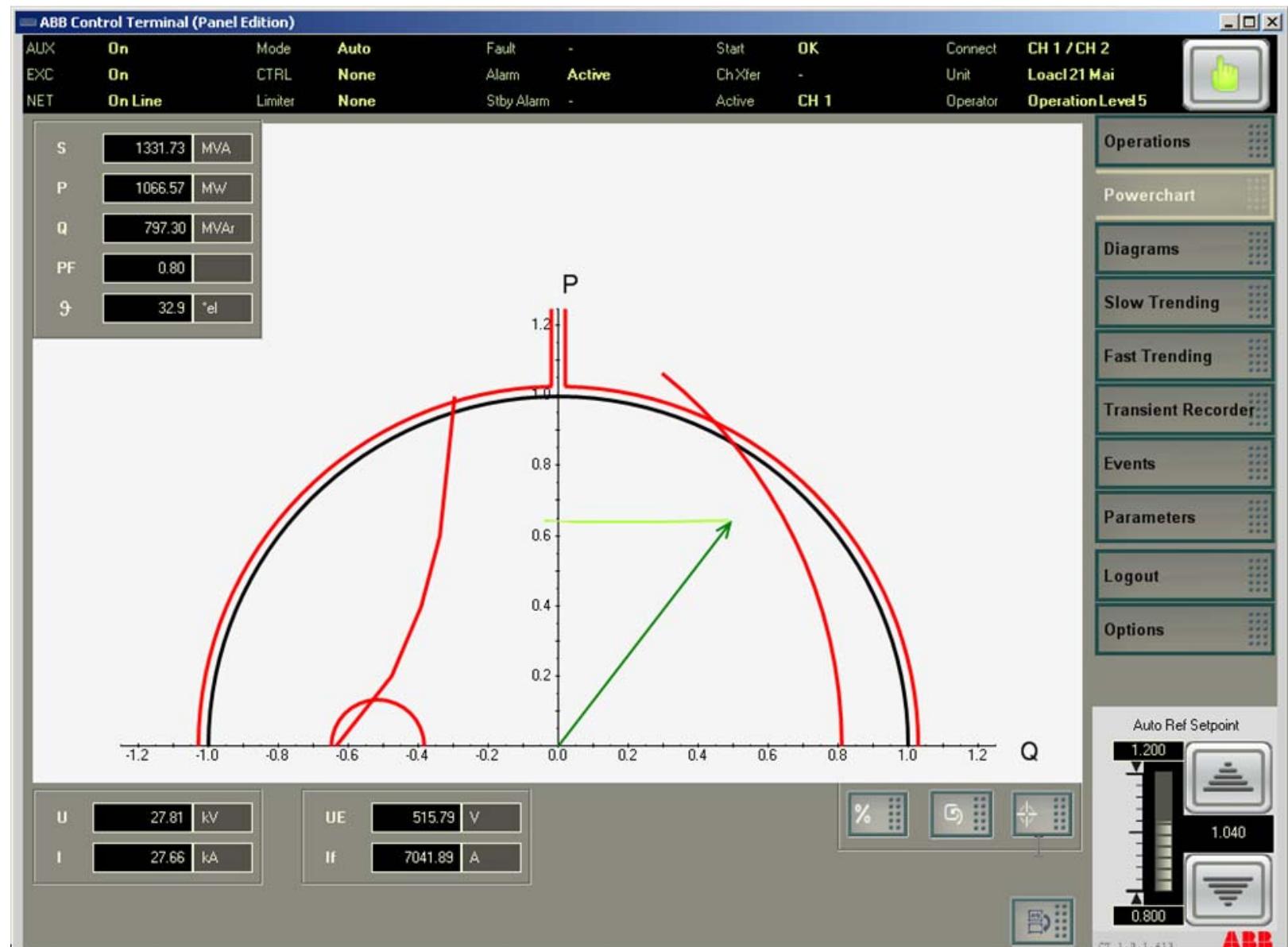
- Startup
- Control
- Protection



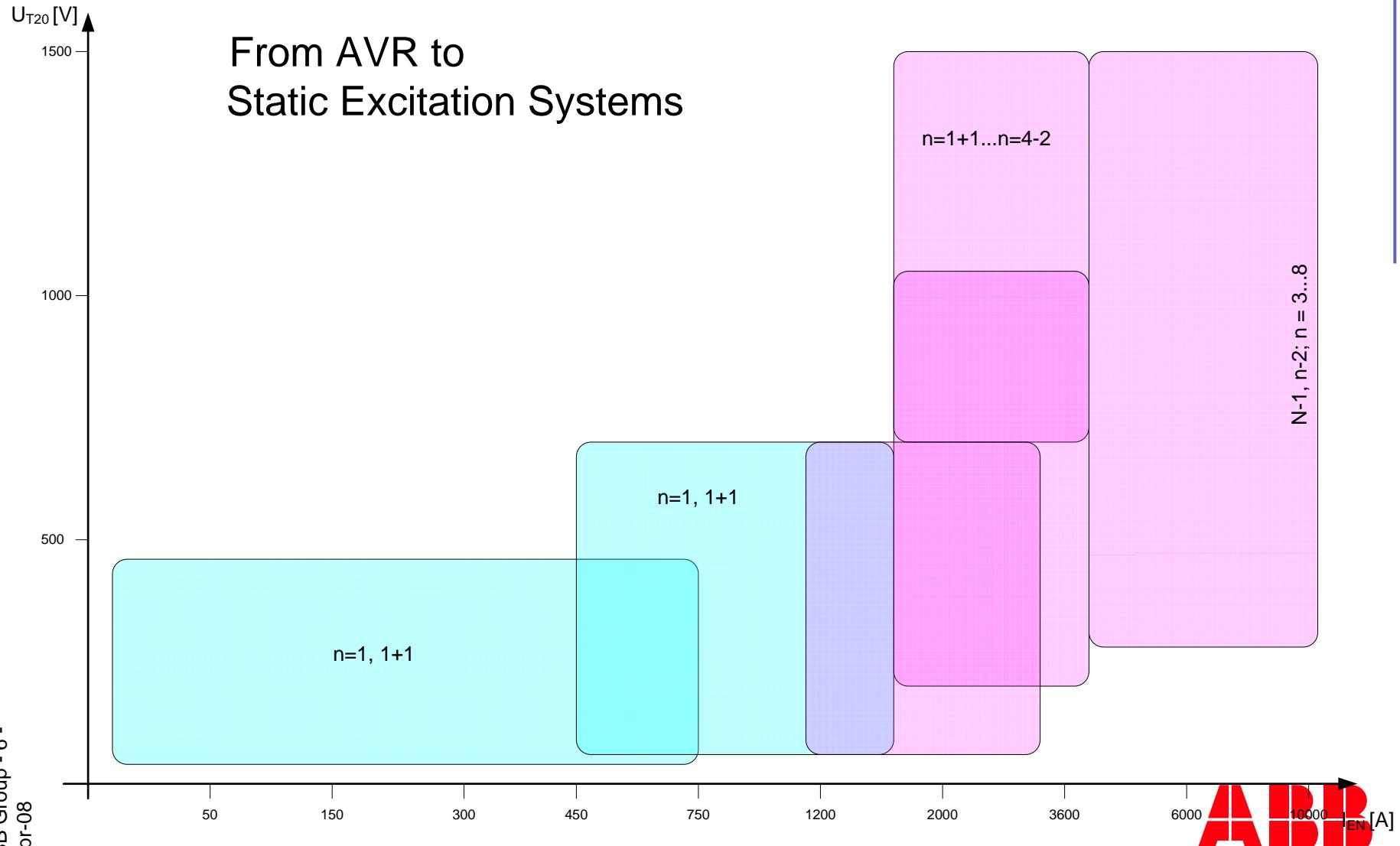
Operation within Capability Area



Operation within Capability Area

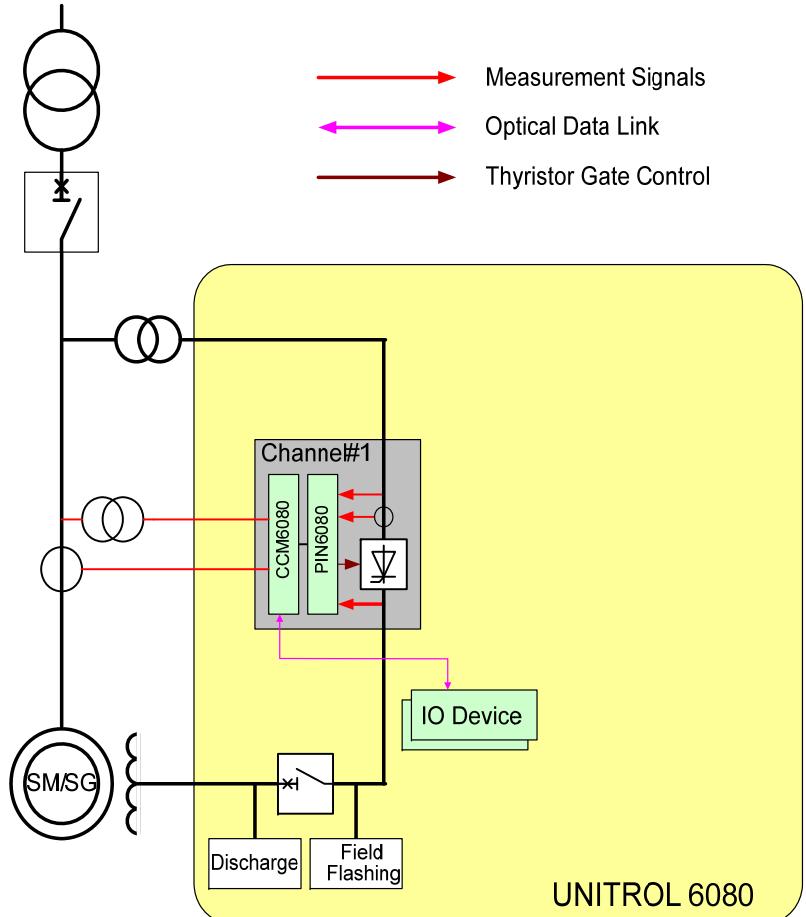
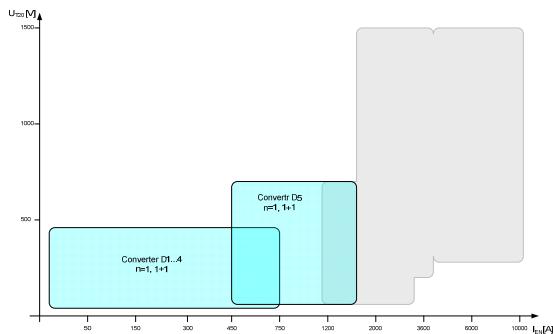


Application Requirements Excitation Systems



Control & Converter Units

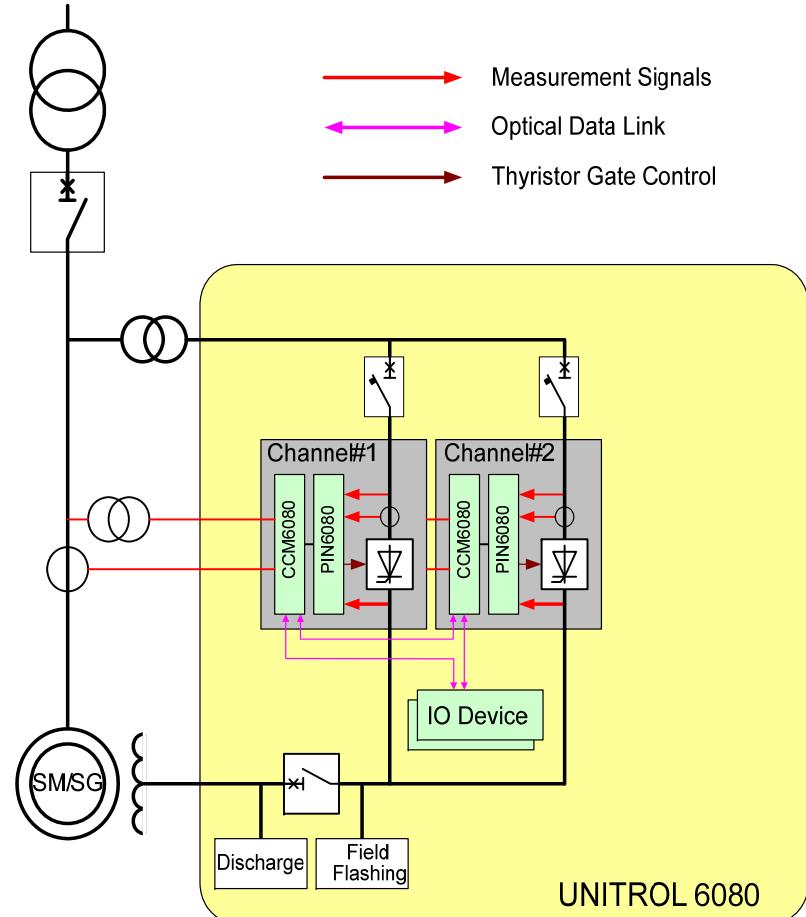
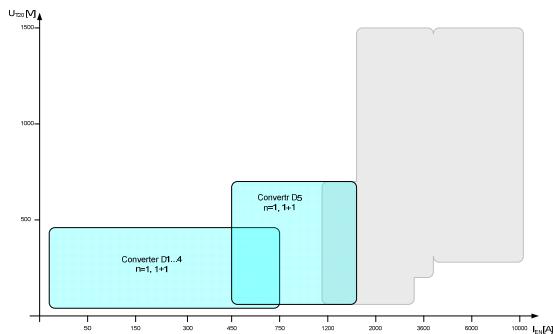
- Compact Converter and Control unit
- Single Configuration



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Control & Converter Units

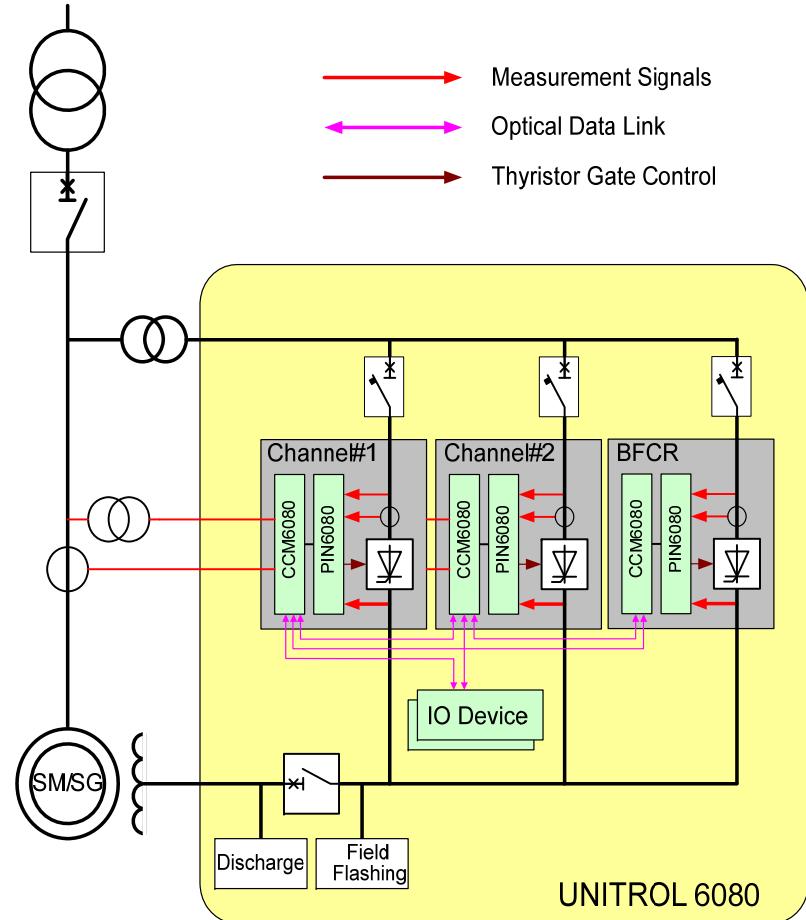
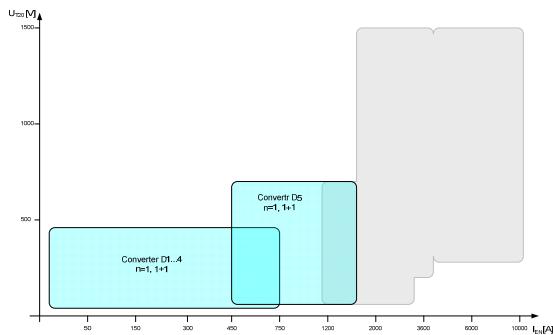
- Compact Converter and Control unit
- Redundant Configuration



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Control & Converter Units

- Compact Converter and Control unit
- Triple Redundant Configuration



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UNITROL 6080 System



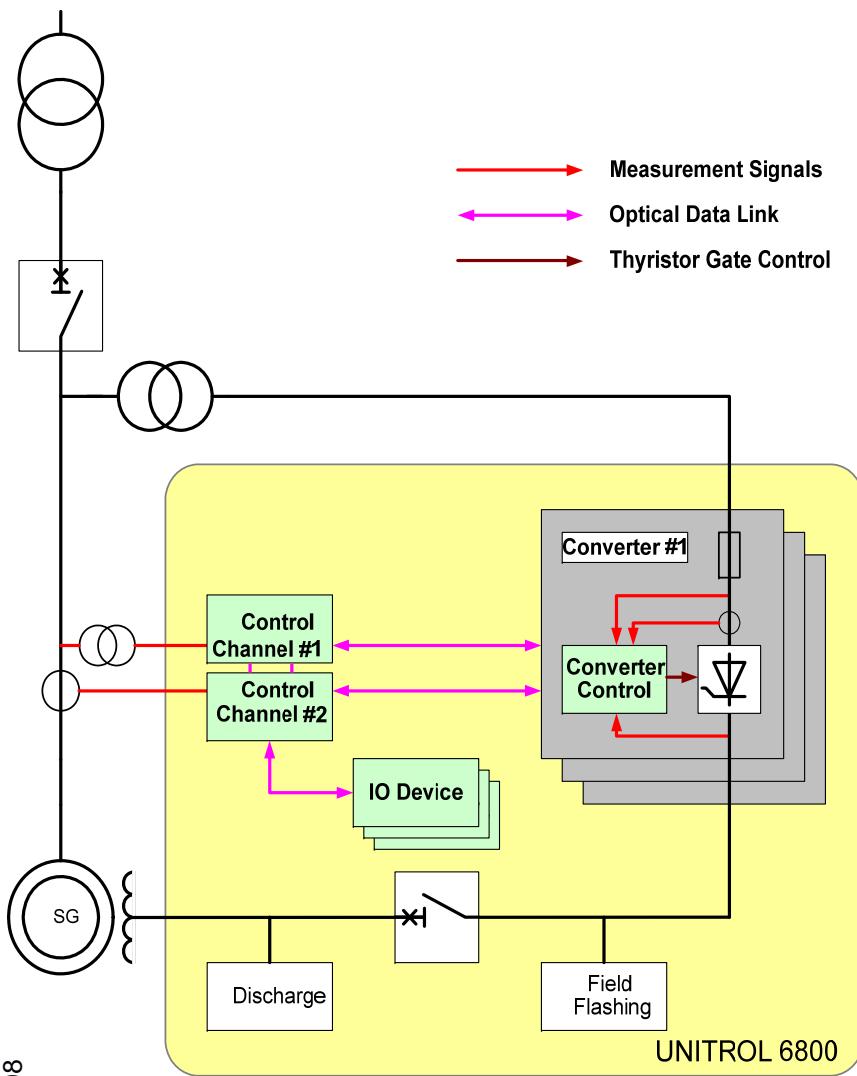
ABB

UNITROL 6080 System

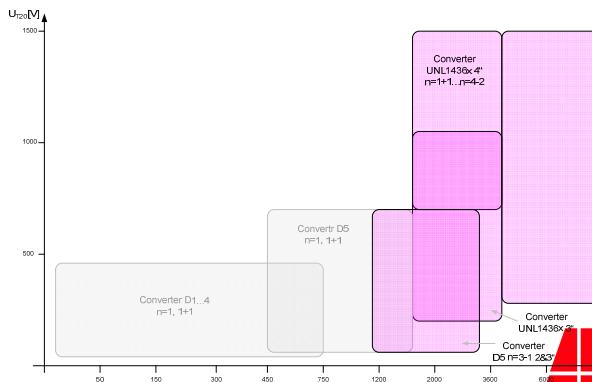


ABB

Multiple Converter Control

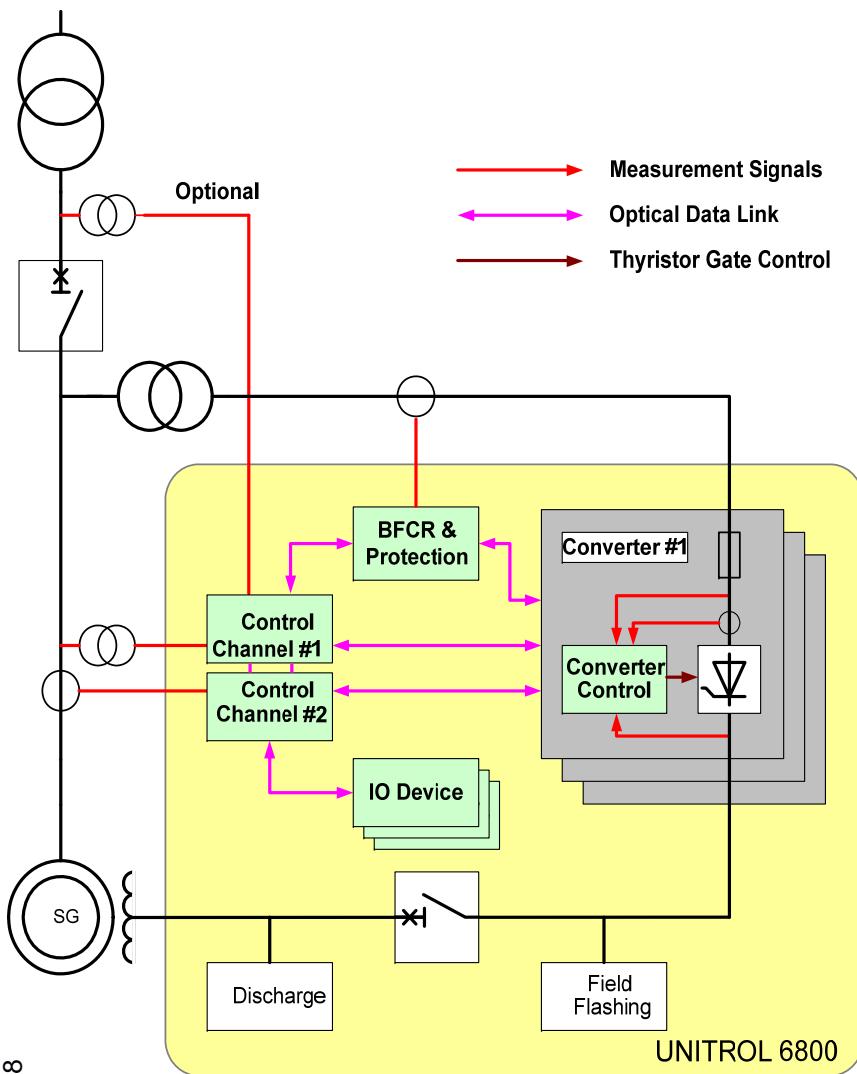


- TWIN Converter
- N-1 redundant Converter
- Single and Dual Redundant Control Configuration

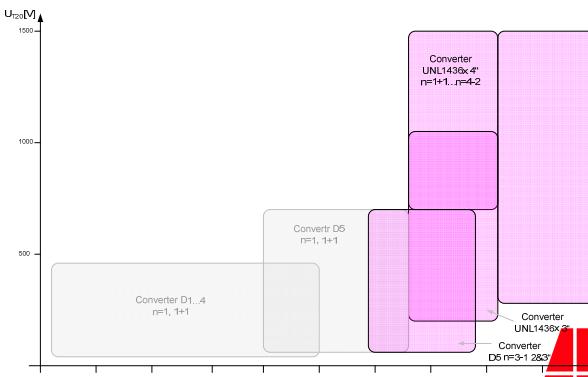


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Multiple Converter Control



- N-1 Redundant Converter
- Triple Redundant Control Configuration
- Backup Field Current Regulator (BFCR)
- Independent Protection Functions



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UNITROL 6000 Static Excitation System



ABB

UNITROL 6000 Static Excitation System



ABB

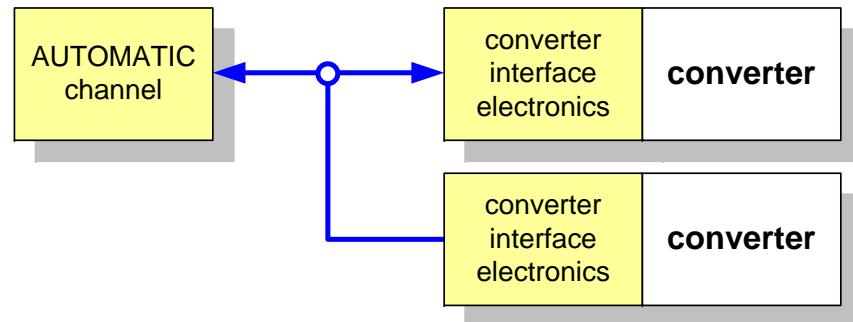
UNITROL 6000 Static Excitation System



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Converter Redundancy

- Controller
 - Control channel is connected to redundant converters
 - All control connections by 10Mbit fiber optical links

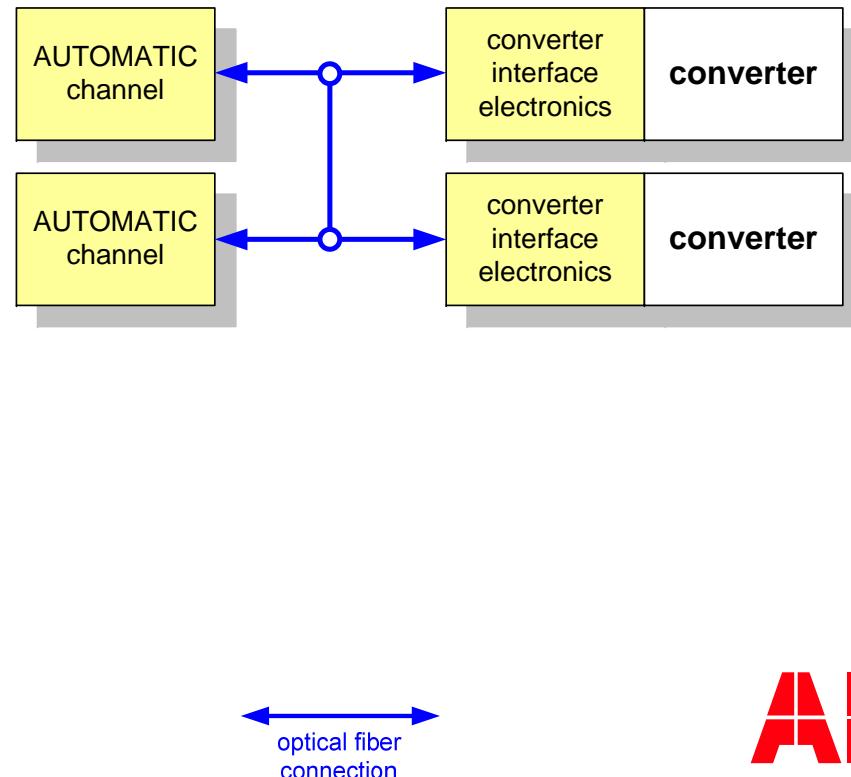


optical fiber
connection

ABB

Controller & Converter Redundancy

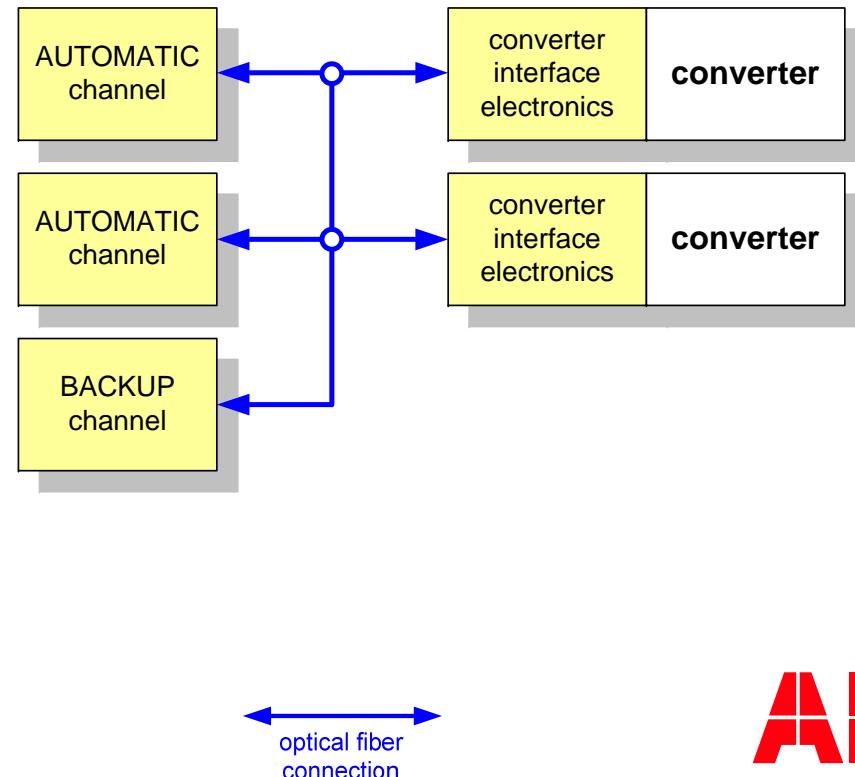
- Redundant Controller
 - Control channel is non-exclusively allocated to redundant converters
 - All control connections by 10Mbit fiber optical links



Controller & Converter Redundancy

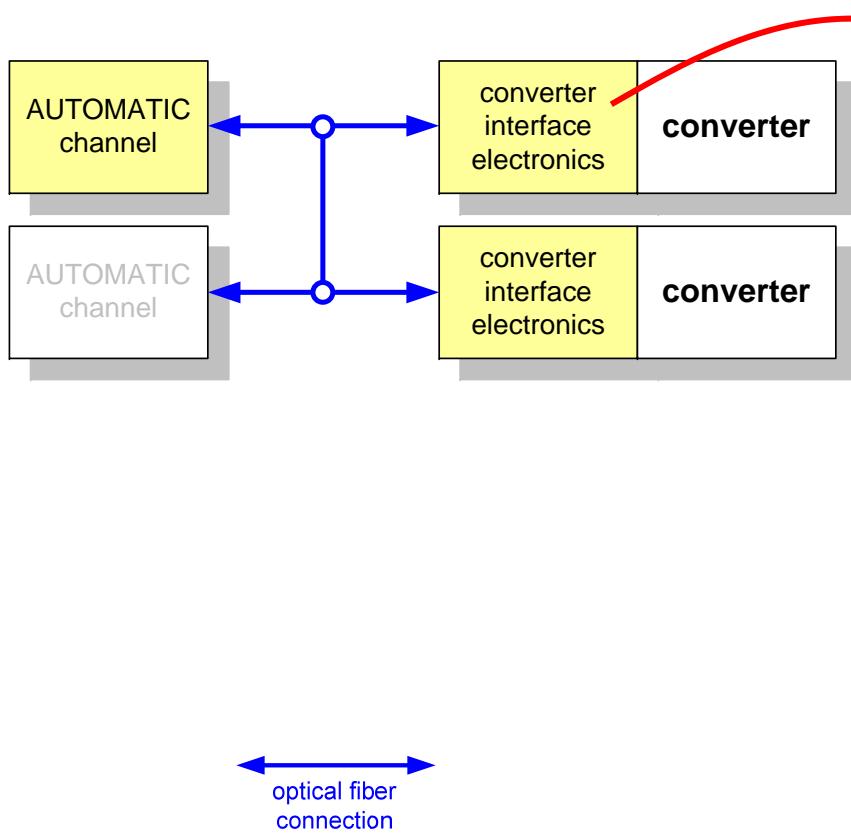
■ Redundant Controller

- Control channel is non-exclusively allocated to redundant converters
- All control connections by 10Mbit fiber optical links



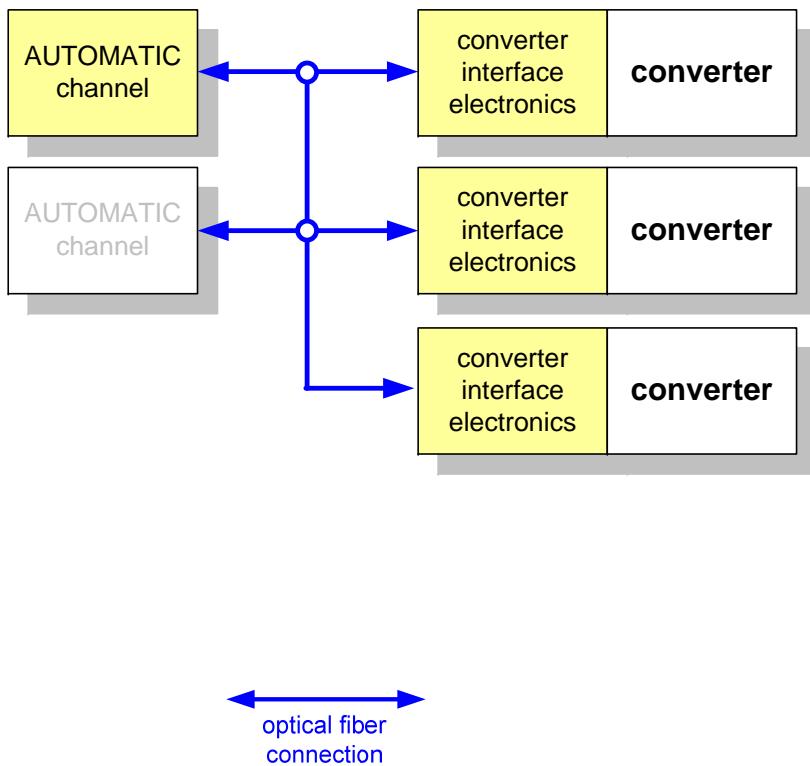
Controller & Converter Redundancy

- Redundant Converter
 - Converter interface electronics

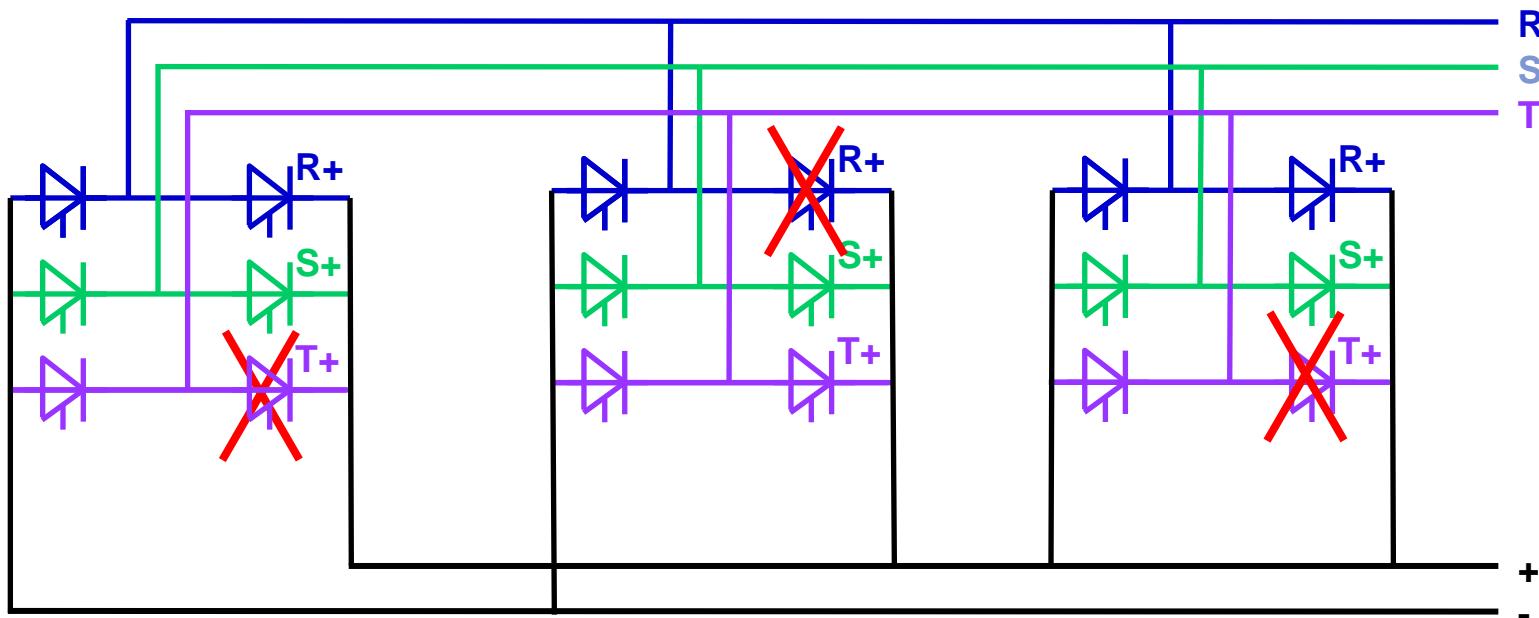


Converter Redundancy

- Redundant Converter
 - Current distribution control
 - Individual Thyristor redundancy
 - Redundant cooling fan

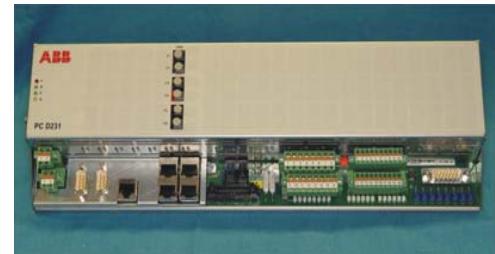
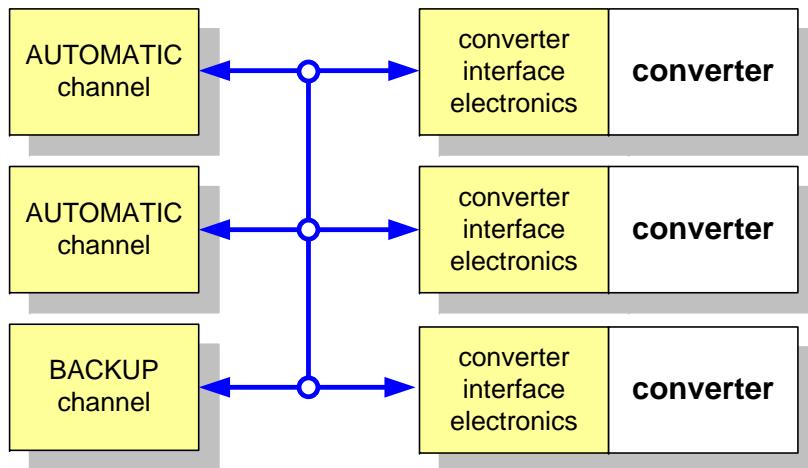


Converter Redundancy



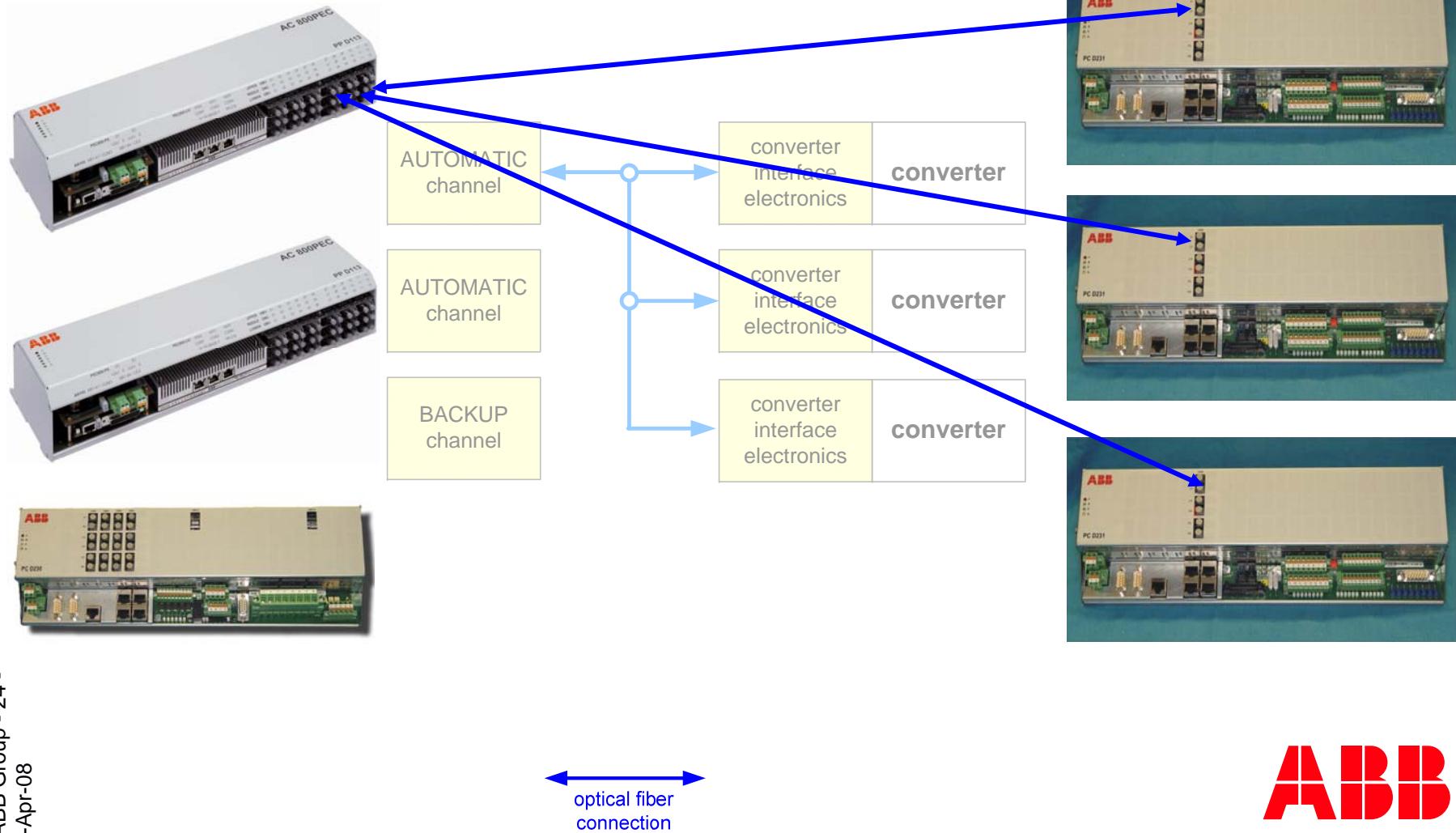
- **ONE Thyristor fail**
⇒ Still fulfil full load and field forcing
- **TWO Thyristors fail (but not in the same branch)**
⇒ still fulfil full load and field forcing
- **TWO Thyristors fail (in same branch)**
⇒ TRIP!!!! (or n-2 redundancy)

Controller & Converter Redundancy



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Communication Redundancy



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Communication Redundancy



AUTOMATIC
channel



AUTOMATIC
channel

BACKUP
channel



converter
interface
electronics

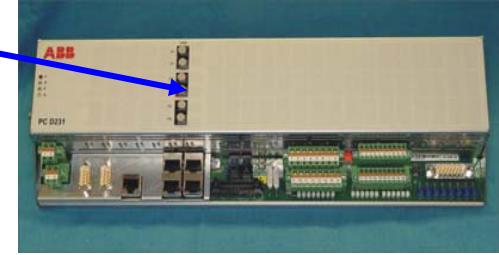
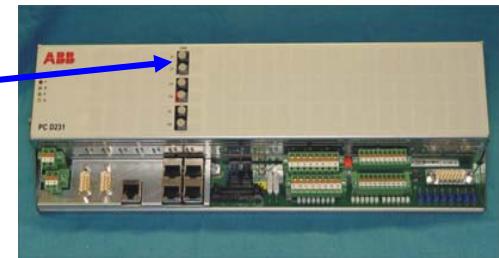
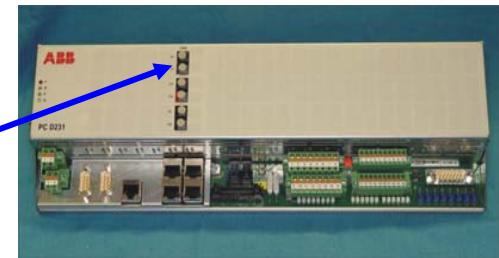
converter

converter
interface
electronics

converter

converter
interface
electronics

converter



optical fiber
connection

ABB

Communication Redundancy



AUTOMATIC
channel



AUTOMATIC
channel



BACKUP
channel

optical fiber
connection

converter
interface
electronics

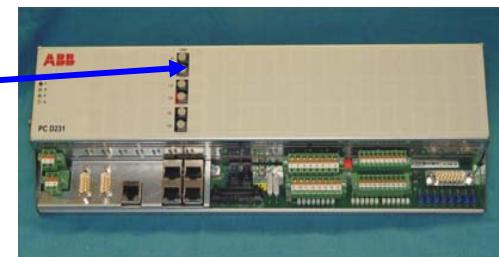
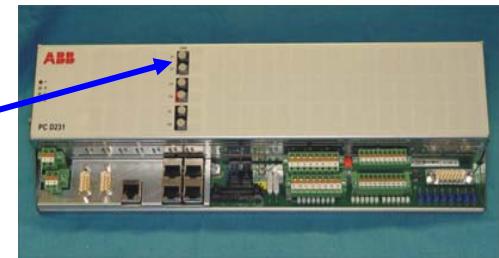
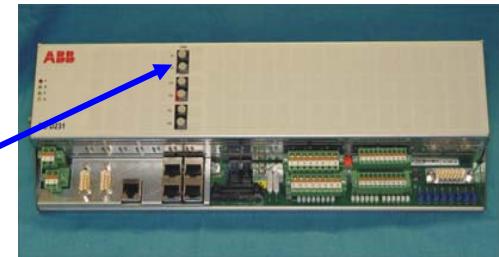
converter

converter
interface
electronics

converter

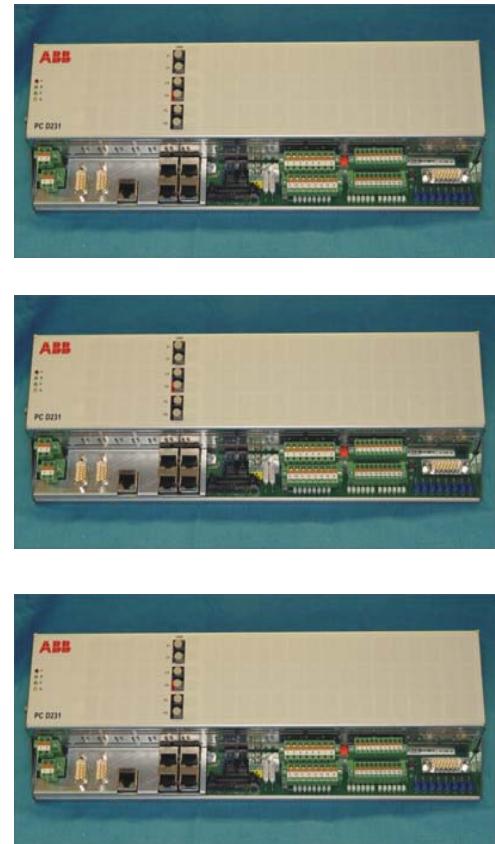
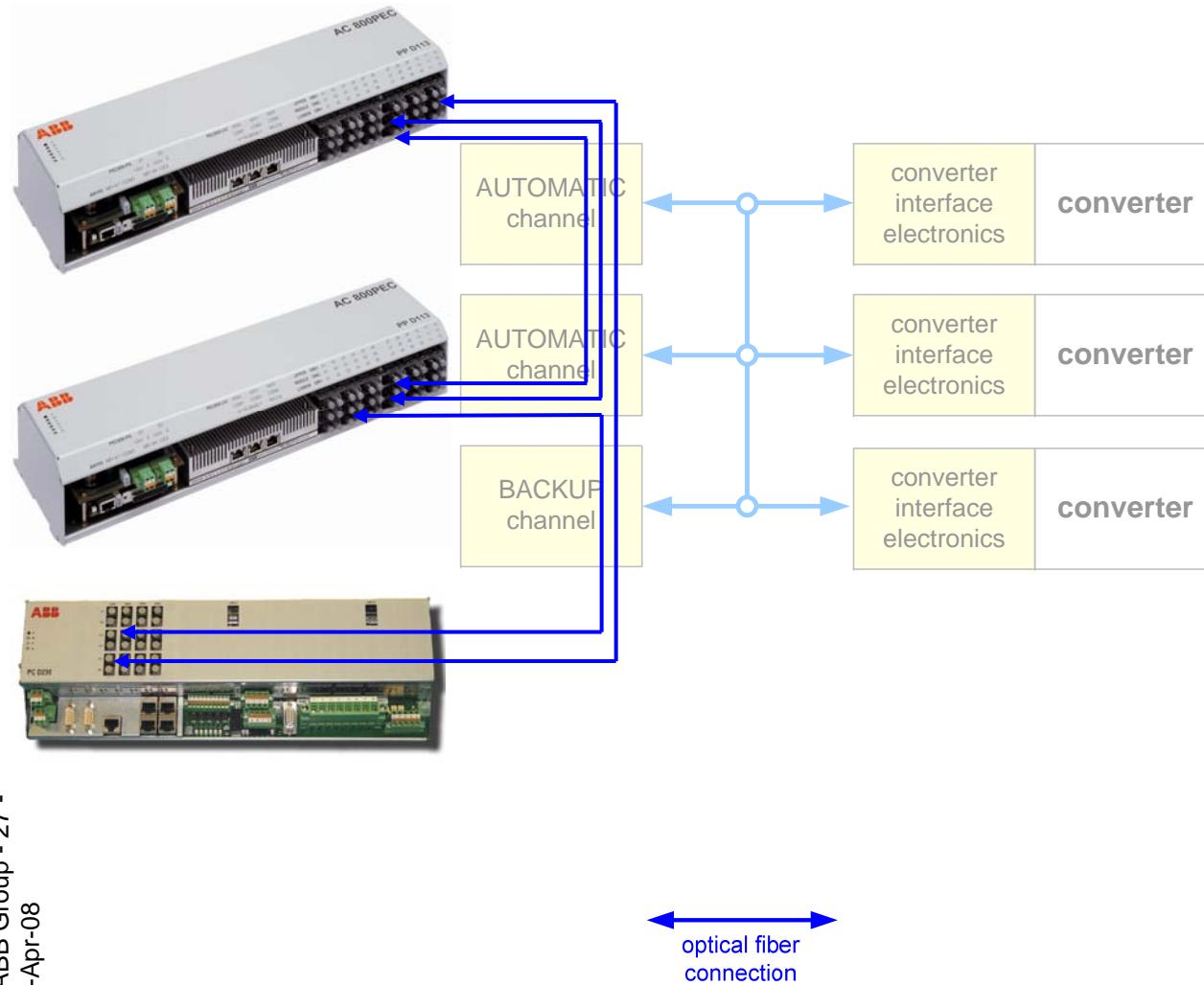
converter
interface
electronics

converter



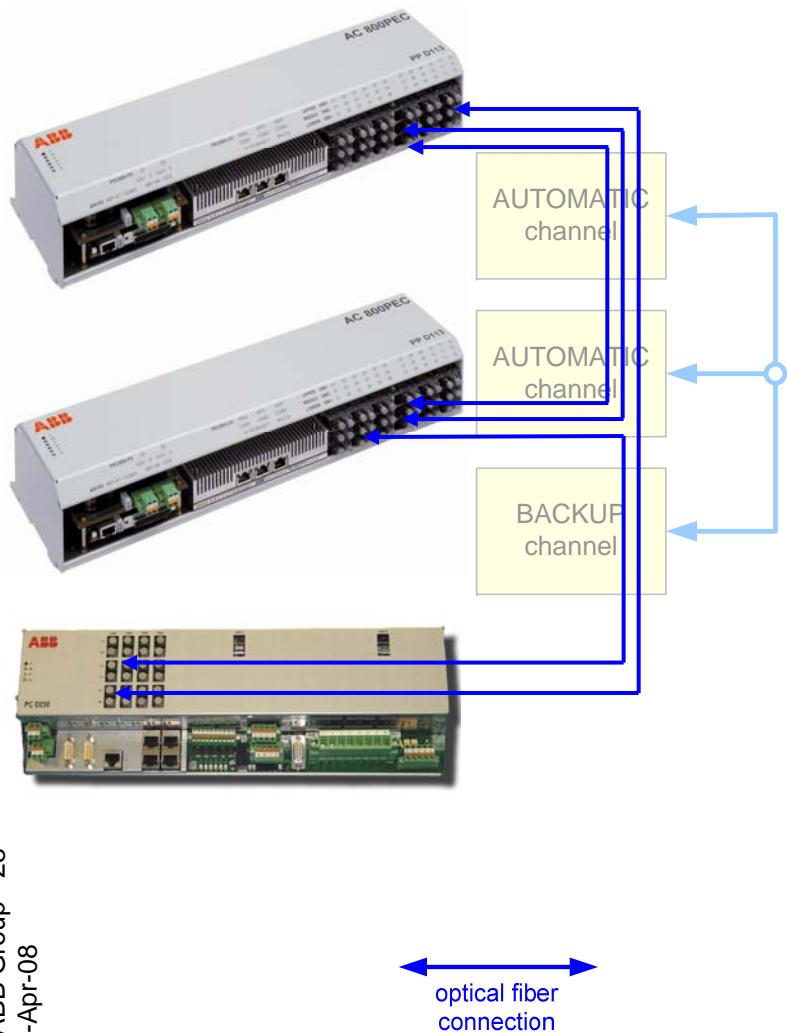
ABB

Communication Redundancy



ABB

Control Function Redundancy

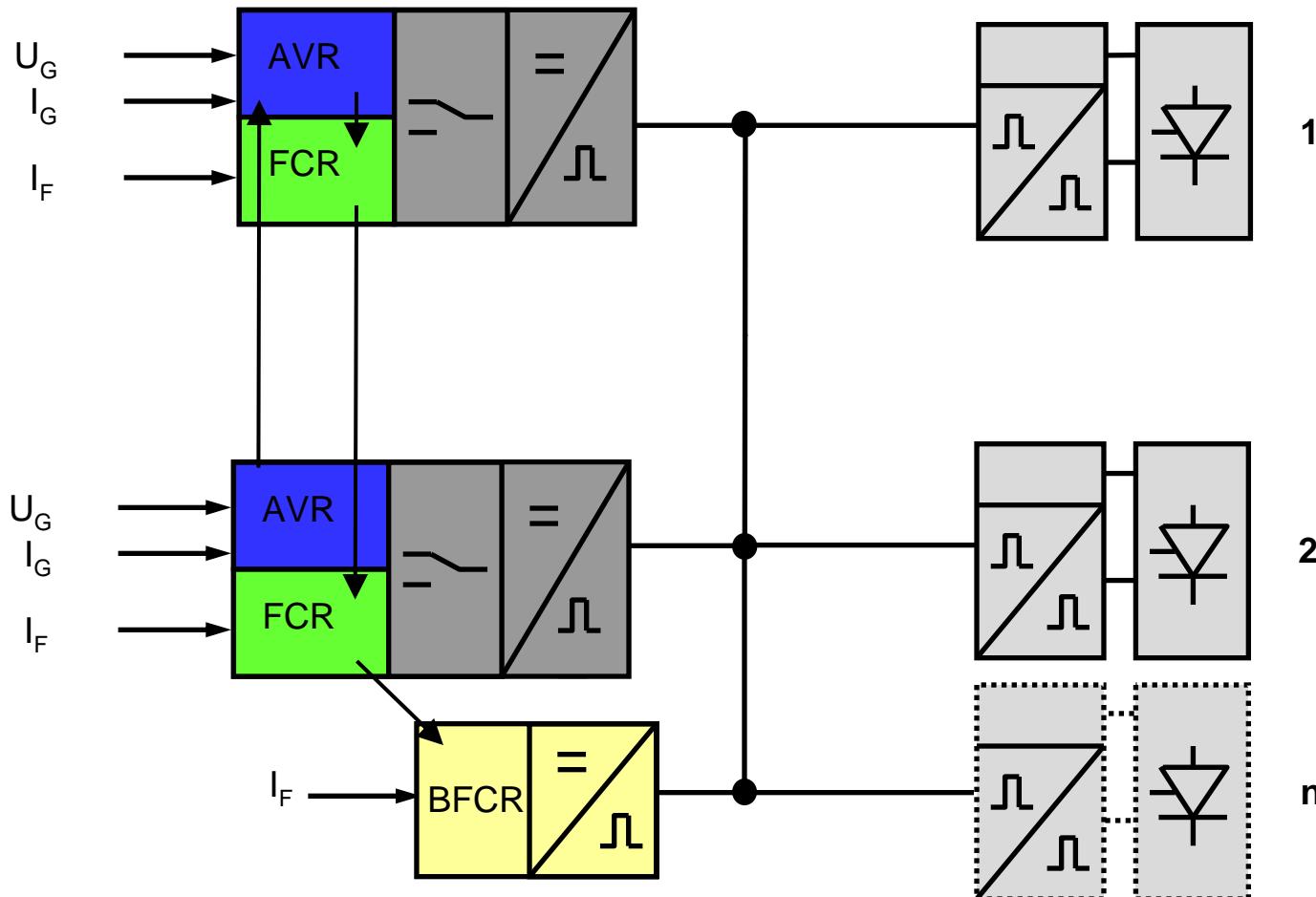


- Controller supervision
 - Two control devices
 - Supervised communication
 - Supervised analog circuits
 - Supervised auxiliary supply
- Redundancy state machine
 - Automatic Control (voltage control)
 - Manual Control (field current control)
- Required Interfaces
 - Control
 - Protection



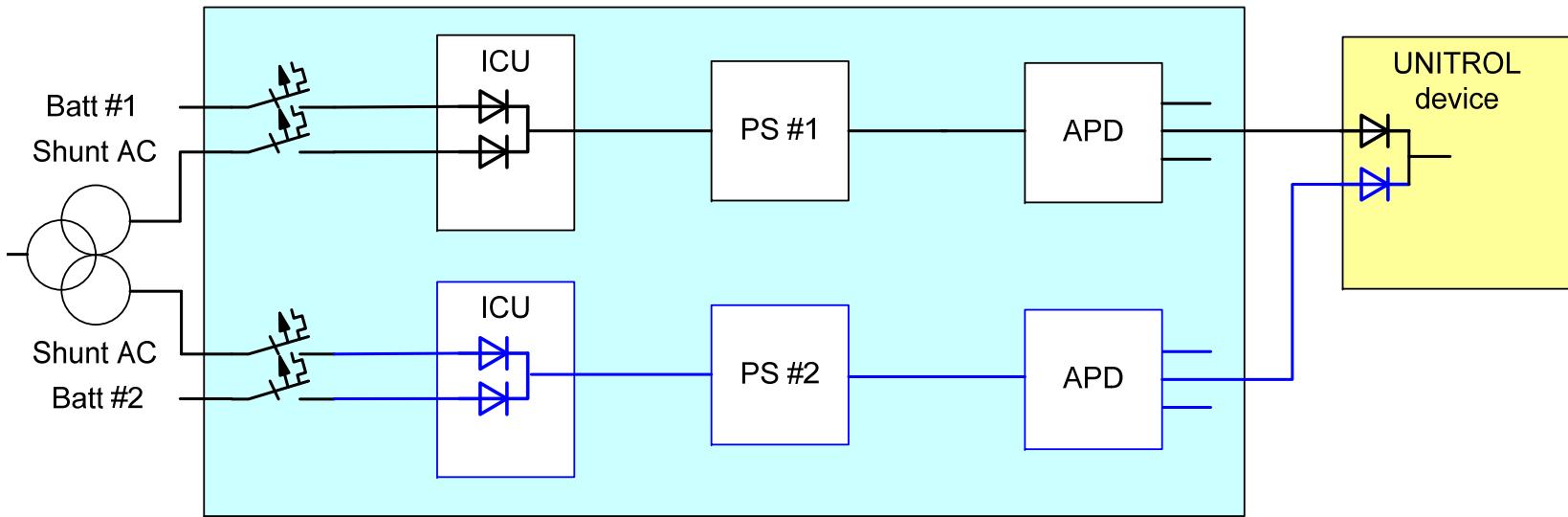
Triple Channel Failure Sequence

Type T6S



Supply Redundancy

- Double Redundant power supply (principle) for a control device



ICU = Input Coupling Unit

PS = 24V Power Supply

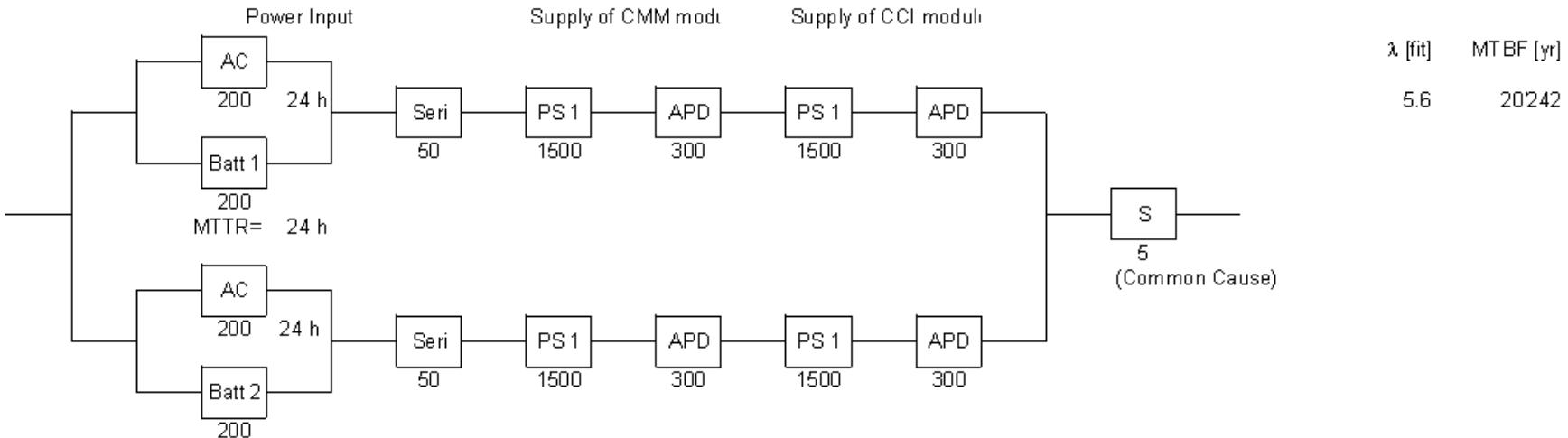
APD = Auxiliary Power Distribution unit (electronic current limiting)

Reliability Figures

■ Reliability chart 24V Power supply

Power Supply

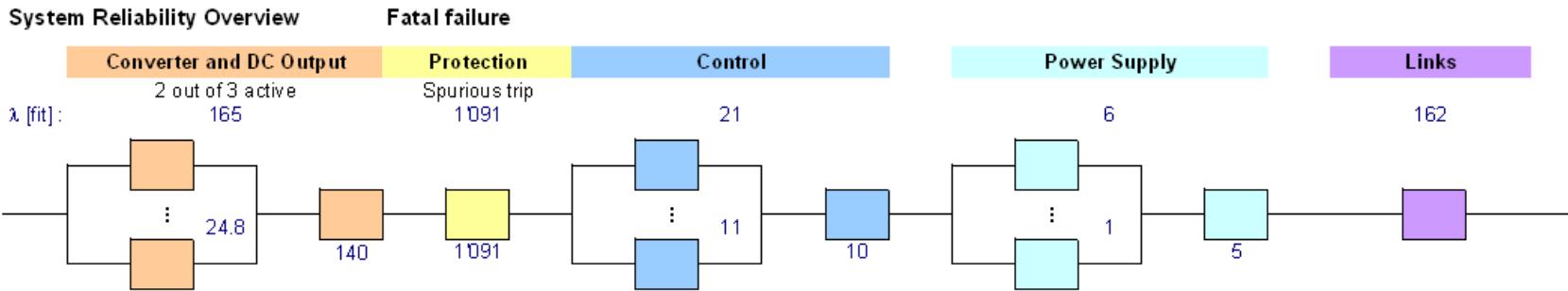
24V Power Supply (PS) and Auxiliay Power Distribution (APD) redundant



Reliability Figures

■ Overall reliability chart

- Converter
- Protection
- Control
- Power Supply
- Device Communication (Links)

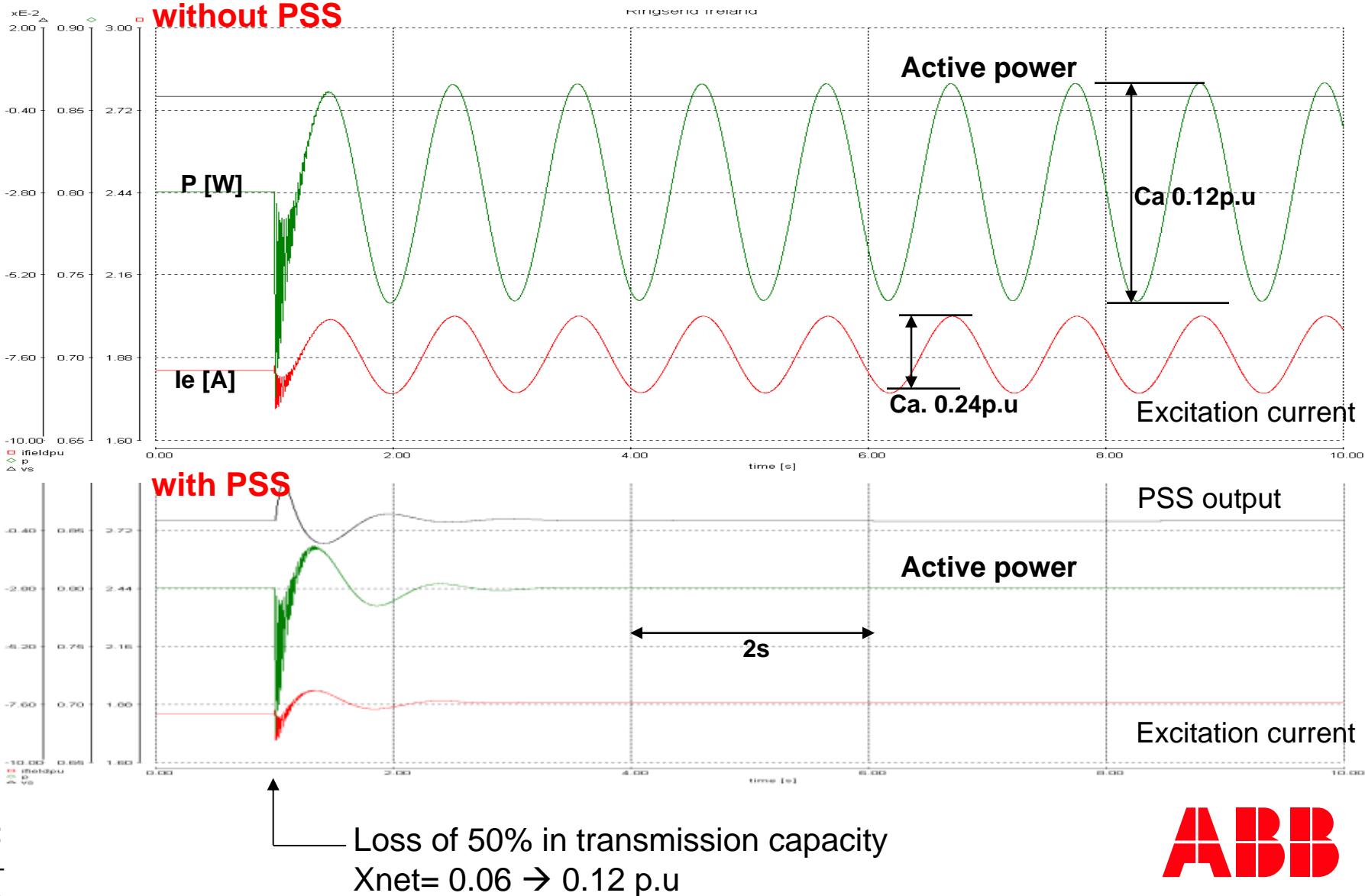


Outlook

- Plant Control Integration
 - IEC61850 for Hydro- and Windpower
- Wide Area Control Systems
 - Local stabilization with PSS
 - Wide area monitoring (PMU)
 - Wide area stabilization

Example II: 500 MVA Generator

Damping of active power oscillations



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for a better world™