RPA Redundant Parallel Architecture

GE Digital Energy
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imagination at work

Critical Applications

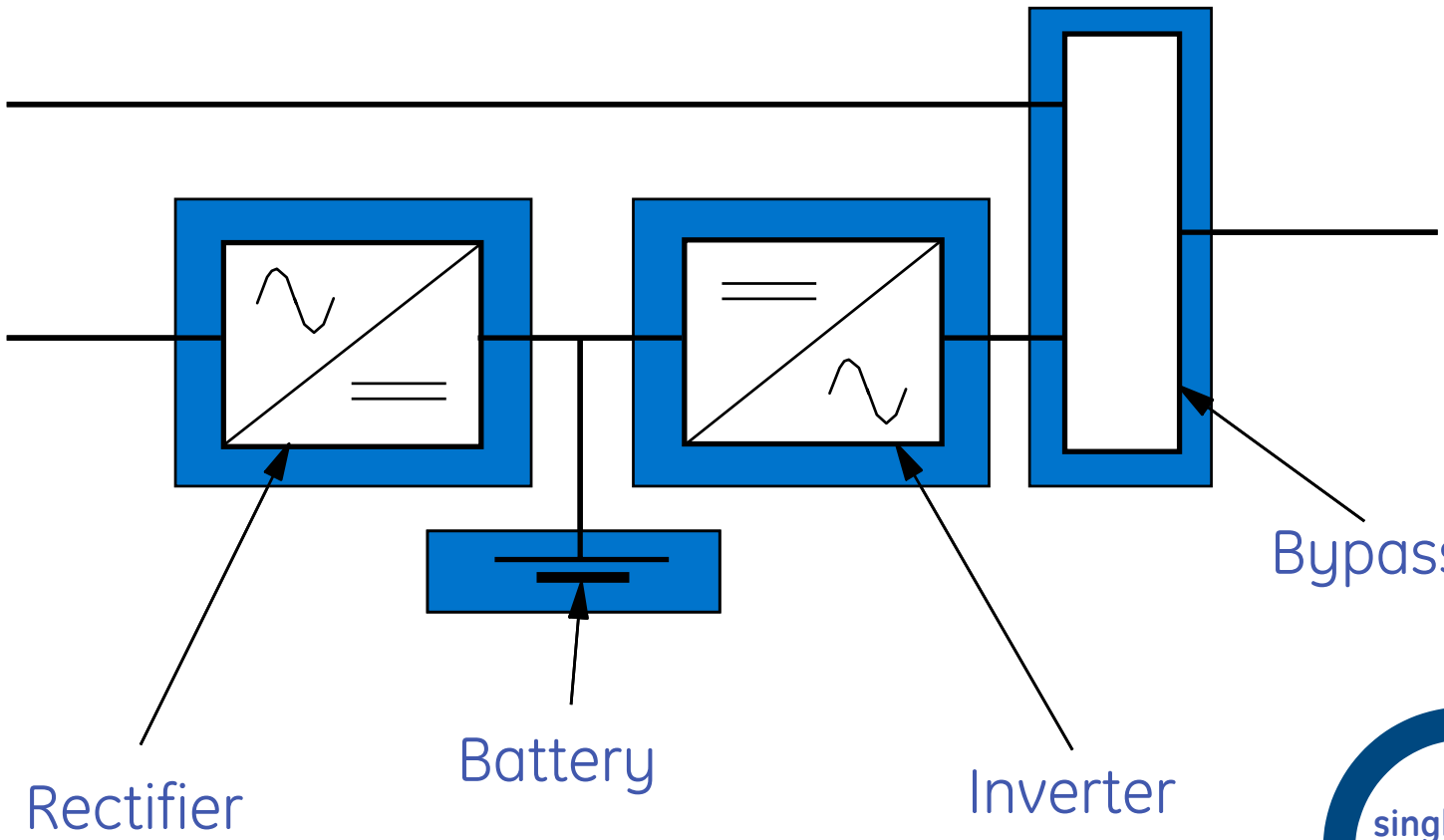
- High speed data
- E-commerce
- Communication hubs
- Large computer networks
- Real time process control

Mission Critical Applications require highest power reliability and availability

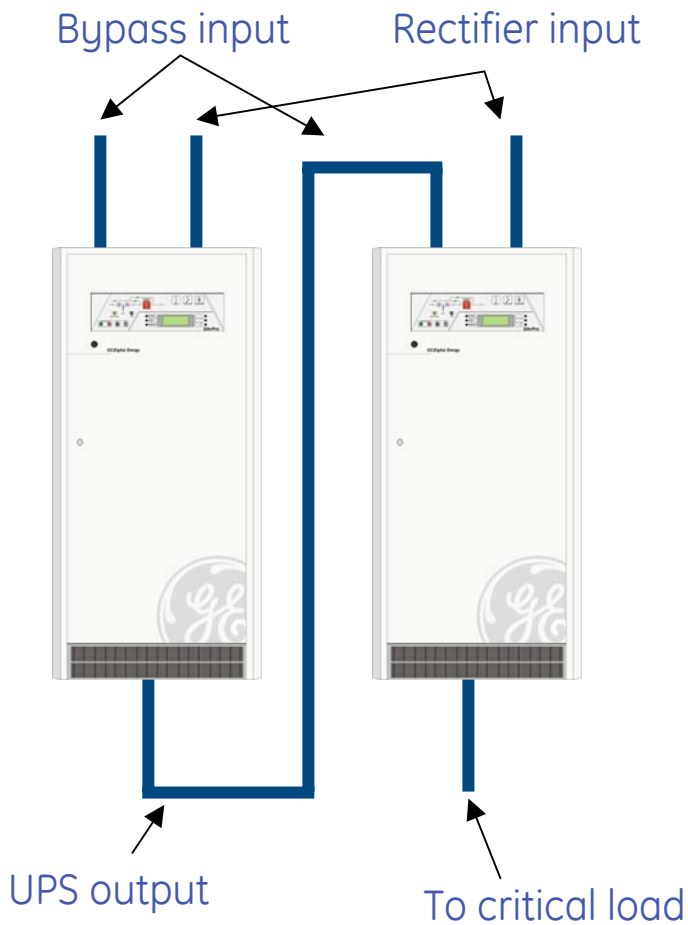
Evolution of UPS reliability

1. Basic reliability
   Single VFI UPS with static bypass
2. Fictitious reliability
   Two UPS systems in hot-standby (cascade)
3. Industry standard
   Parallel UPS
4. GE's leading concept
   RPA Redundant Parallel Architecture

Basic reliability



Fictitious Reliability



Hot Standby configuration

Cascade system

- Each UPS can support total load
- Limited to 2 units
- Bypass operation required
- Unit 2 is running idle (no load)
- No load sharing

single point of failure

Overload

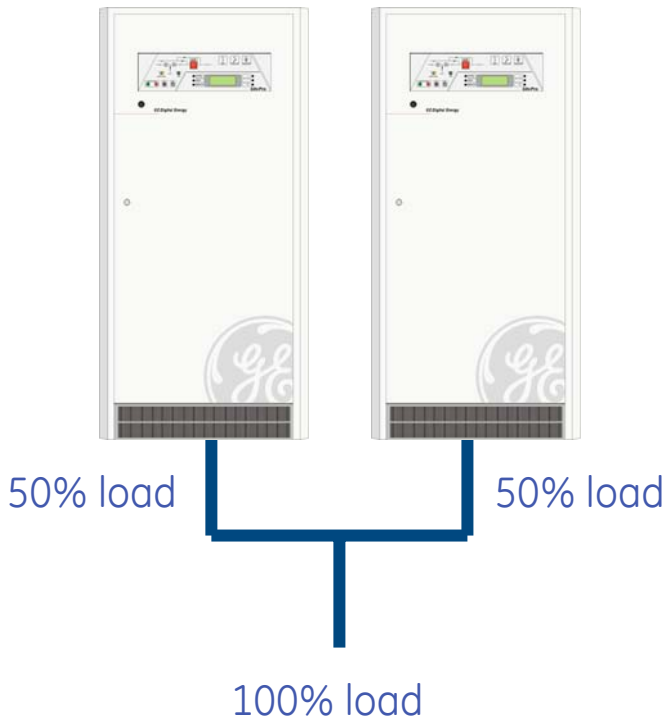
Most critical event with

Hot Stand-by: overload

- Overload capability limited to single system: typically 150%
- Two bypass operations in case of overload

single point of failure

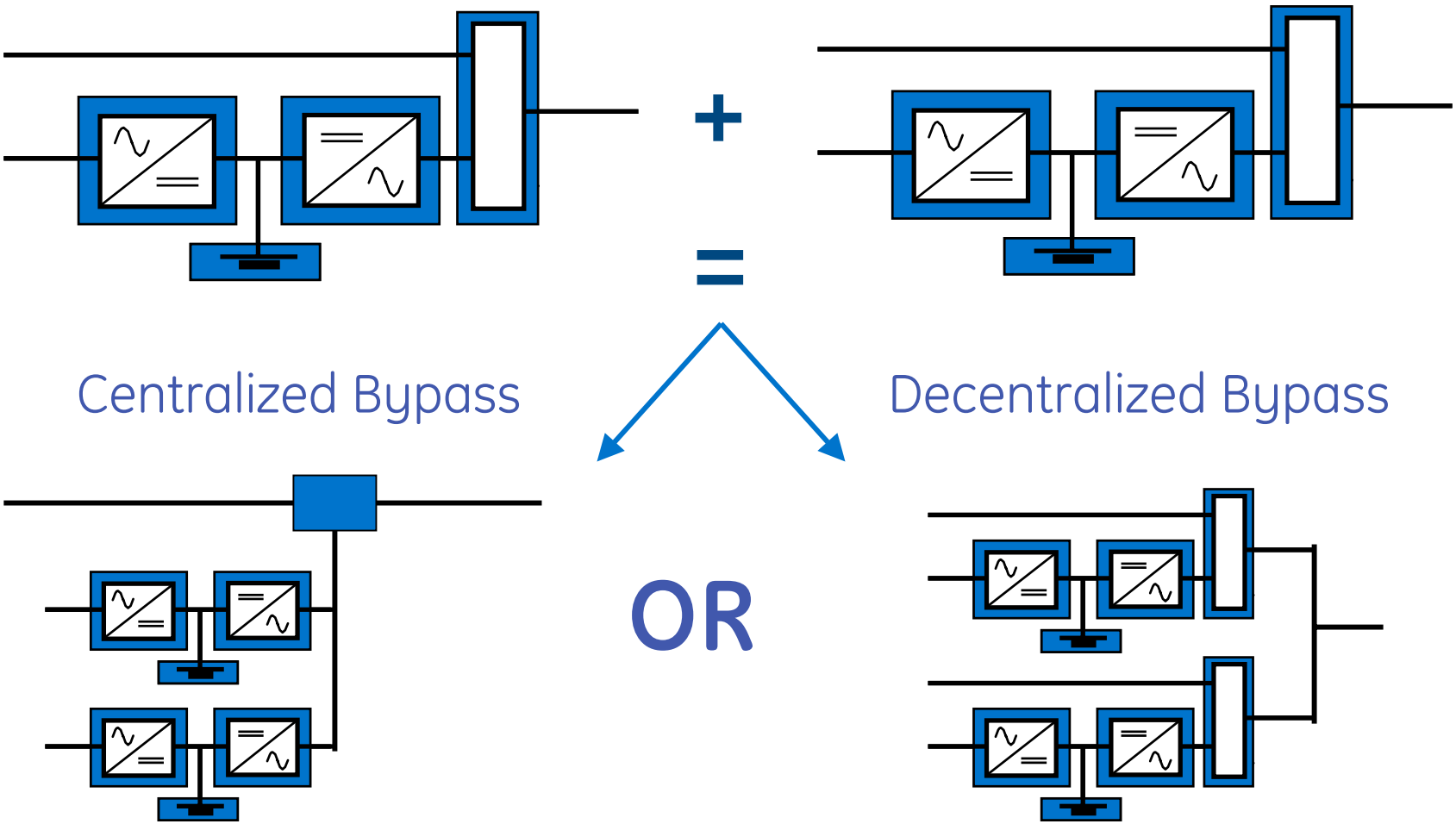
Increased Availability



Parallel UPS

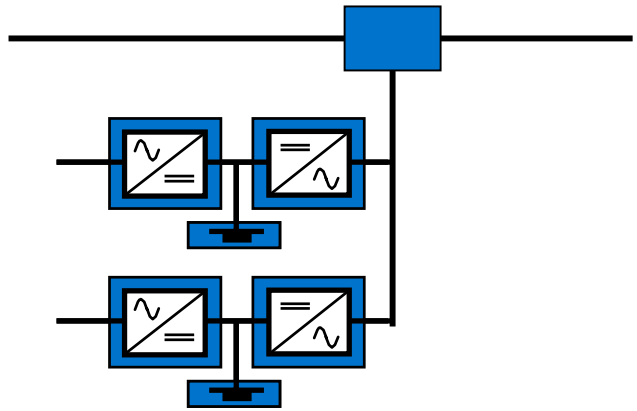
- Load sharing with 2 or more units
- System can support the load in case of 1 failure
- Overload capability of 2 units : typically: 300%

Parallel UPS



Centralized Bypass

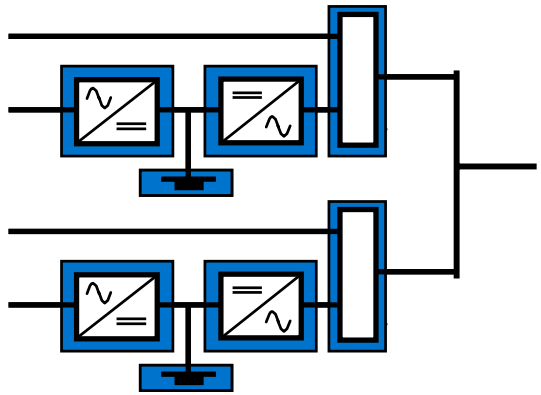
- Limited extension at high cost
- Lower Reliability
- Expansion only with interruption
- No system splitting
- Additional cabling and cabinet



The centralized bypass becomes single point of failure

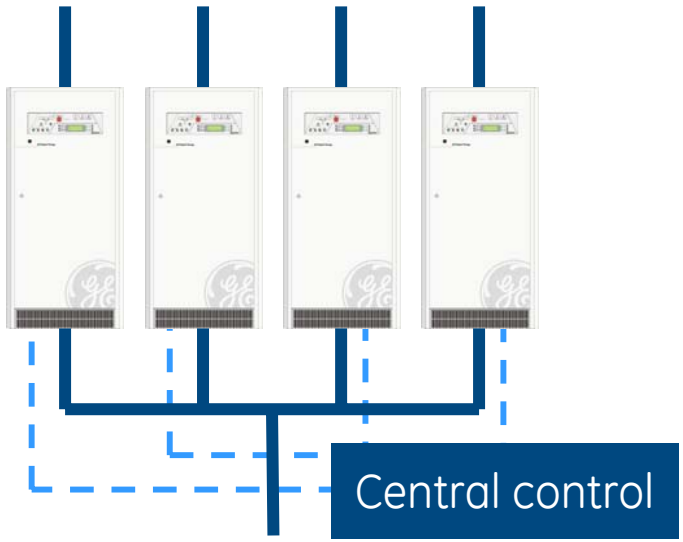
Decentralized Bypass

- Easy to expand
- Higher Reliability
- Expansion at low cost
- Possibility to split system and use units elsewhere



Decentralized bypass offers higher reliability and more flexibility

Centralized Control Logic



Centralized control boxes or static master/slave concepts create a single point of failure

Logic failure = system failure

single point of failure

Centralized Control Logic

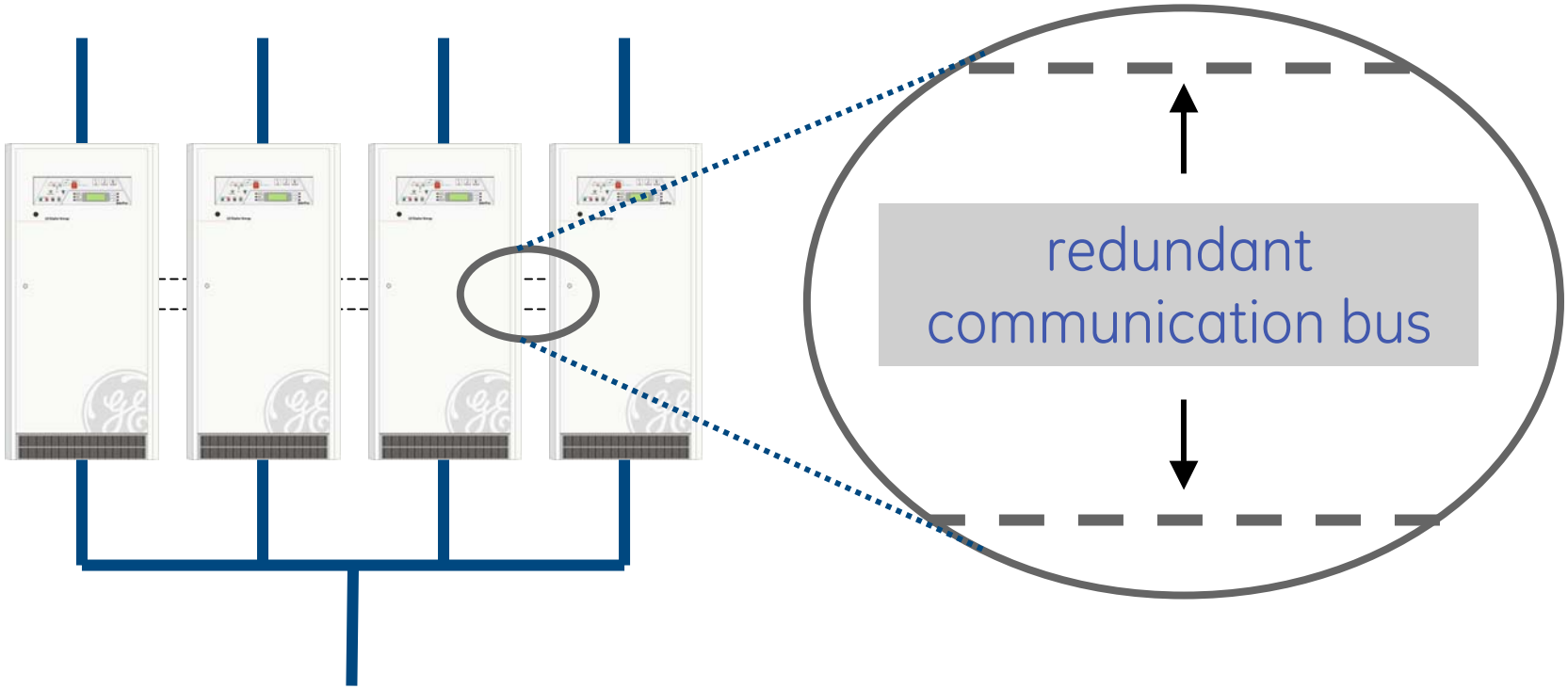
Consequences:

If the centralized control logic fails, the UPS system may:

- go to bypass with all units
- go to bypass with some units
- stop operation

These situations are uncontrolled!

RPA: dynamic control with redundant communication bus



Any UPS can be the logic leader
Failure of the leader will not cause a system failure
An other unit will take leadership in such case

From parallel to redundant

Parallel systems offer increased reliability

They still have single failure points

Note:

Having multiple components does not mean a system is redundant:

An airplane has two engines and two wings but only the engines are a redundant system

Not every parallel UPS is a redundant system !

Highest level of reliability: redundant parallel systems

Redundancy: The existence in the system of more than one possibility to fulfill the demanded function – or: the system can afford at least one single failure of each type

Redundancy degree is “n+x”:

n = number of units to fulfill the demanded function

x = number of units which can fail without system impact

n+1 = one unit can fail and the function is maintained

Redundancy means:

Fault Tolerance

A fault-tolerant system is a system which continues its operation even if one or more parts of the system fail

Instant Monitoring

A sensor / supervisory-element to detect single failures

Transparent Fail-over Procedure

Capability to mask failures in order to avoid any impact on the Required function

Transparent Cluster Re-organization:

Capability to isolate faulty parts without impacting the required function

Redundancy means:

Fault Analysis - part identification

Capability to analyze a failure and identify the faulty part

Error Removal

Replacement of faulty parts without impacting the required function

Transparent Redundancy Recovery:

Normal operation restored without interrupting the supply to the load

Redundancy means:

Fault Tolerance

Instant Monitoring

Transparent Fail-over Procedure

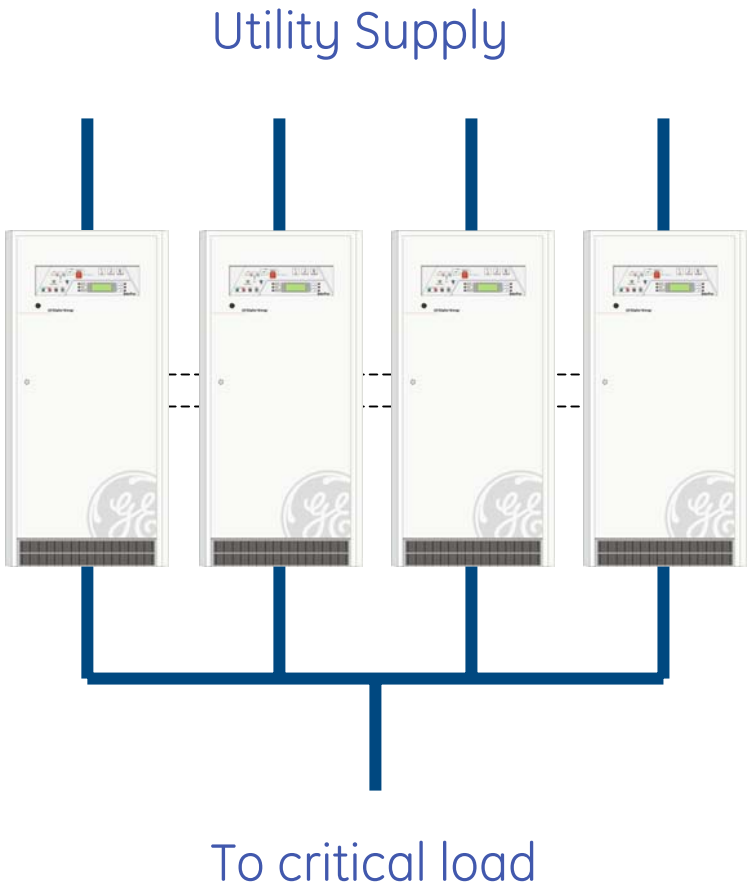
Transparent Cluster Re-organization

Error Isolation & Removal

Transparent Redundancy Recovery

No single point of failure

RPA Redundant Parallel Architecture



- Up to 8 units in parallel
- Any UPS able to be the logic leader
- Decentralized bypass
- Redundant Communication Bus
- Transparent failover and recovery process
- True redundancy with no single point of failure

Features of RPA

Sequential softstart

No instability in case of genset supply

Monitoring of all elements via 1 connection

Simplified monitoring, more connections possible

Up to 8 units parallel (8x500kVA = 4MVA)

But it starts already at 2x10kVA

Maximum phase difference between units: 0.03 ms

Power independent loadsharing

No currents circulating between units

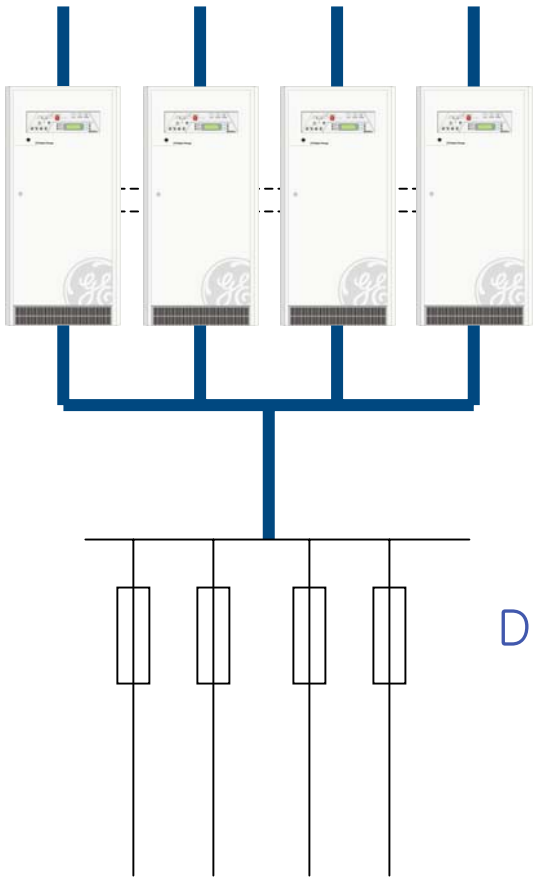
Maintaining excellent output performance

Outputvoltage THD, Dynamic response and Asymmetric load handling

Units field upgradeable from single to parallel

And from parallel to single, offering maximum flexibility

RPA best in class technology for paralleling UPS systems but what is the next bottle neck...



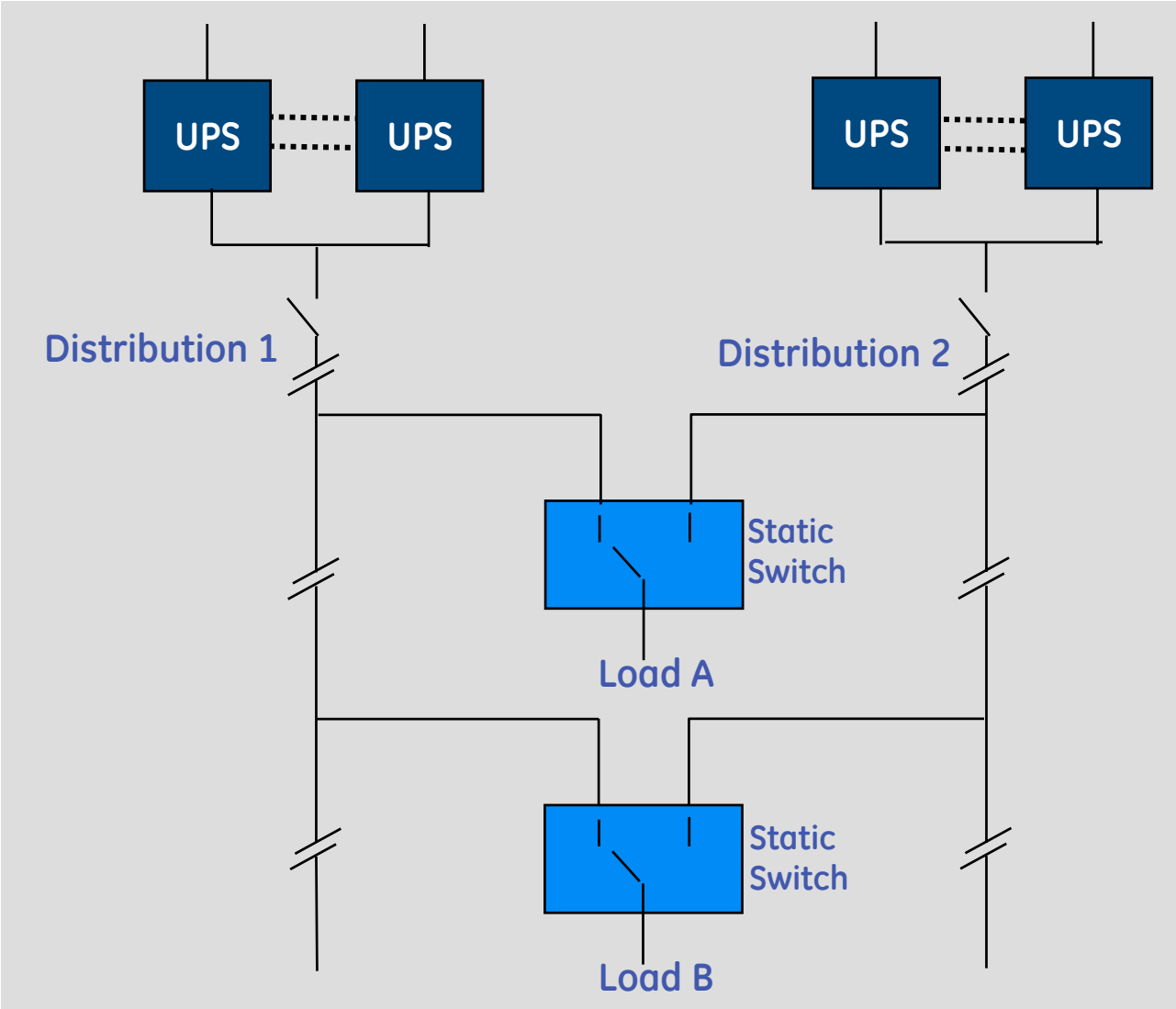
Distribution

RPA offers most reliable and flexible power supply systems with high degree of serviceability and availability

The distribution and cabling is the next single point of failure in the complete system

This is where most errors occur (fuse tripping, short circuits etc.)

Reliability – the next level (1)

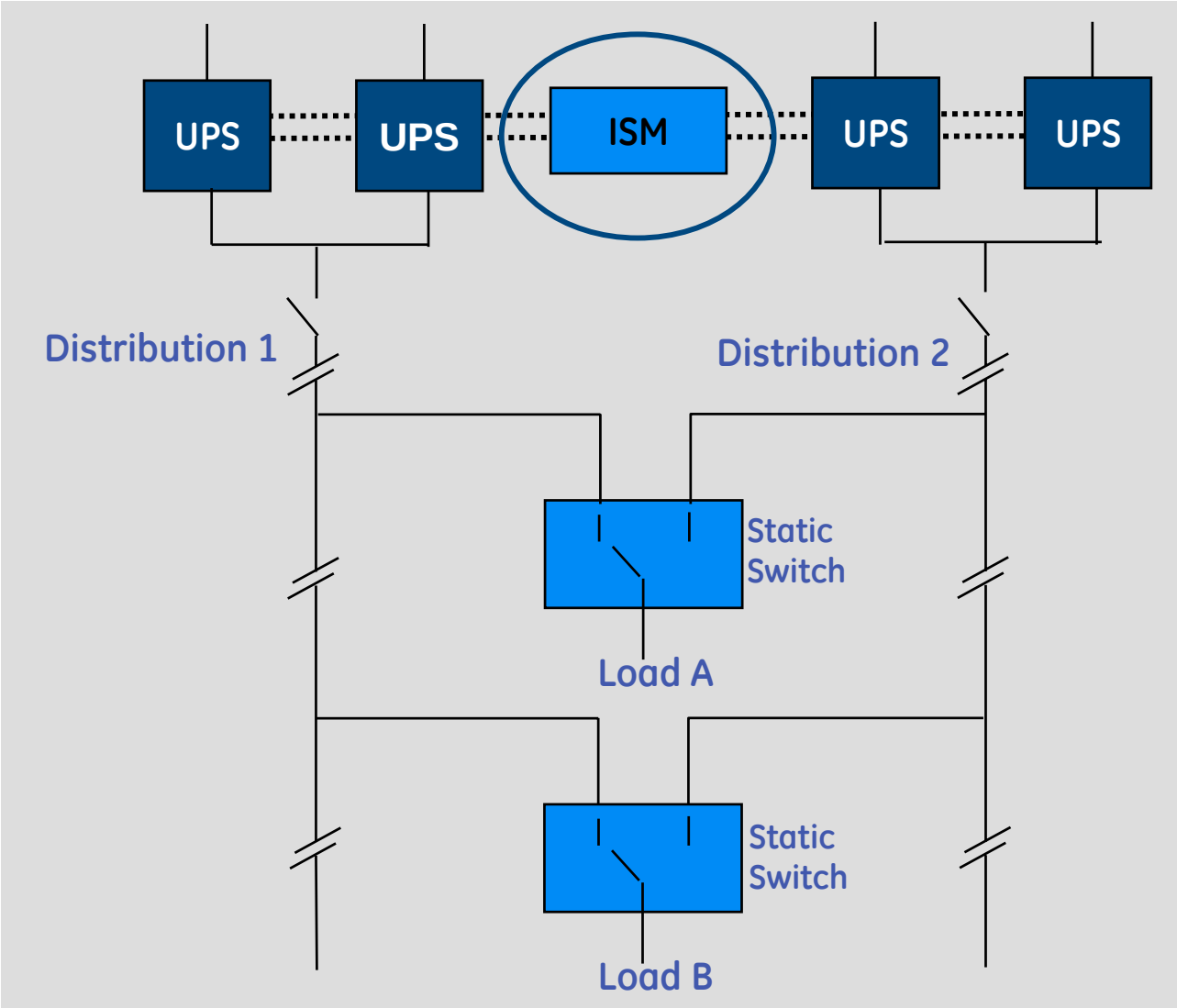


By implementing
2 UPS systems
and
2 separate
distributions
A redundant supply to the load is created

Static Transfer Switches are applied to select between 2 sources

The STS protects a load from interruptions caused by external factors

Reliability – the next level (2)



Synchronization is critical in case of application of Static Transfer Switches

Path to market leadership for redundant parallel UPS

1965 Invertomatic introduces the first static bypass on true online UPS

1985 Introducing the first decentralized bypass on parallel UPS

1989 Introduction of RPA Version 1

1995 Introduction of redundant 16-bit multiprocessor technology

1996 Introduction of ARGUS control network

2000 Full digital FLEX electronics with DSP and JUMP Management platform

2003 Introduction of ISM and Static Transfer Switch