POWERMAX® [ˈpou (ə)r ˈmaks] *noun:* a system designed to maintain stability

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Agenda

- POWERMAX – Power Management System Introduction
- POWERMAX – Functionalities (IDDS, LSP, GCS, A25A)
- POWERMAX – Simulators
- MOTORMAX – LV Motor Management System Introduction

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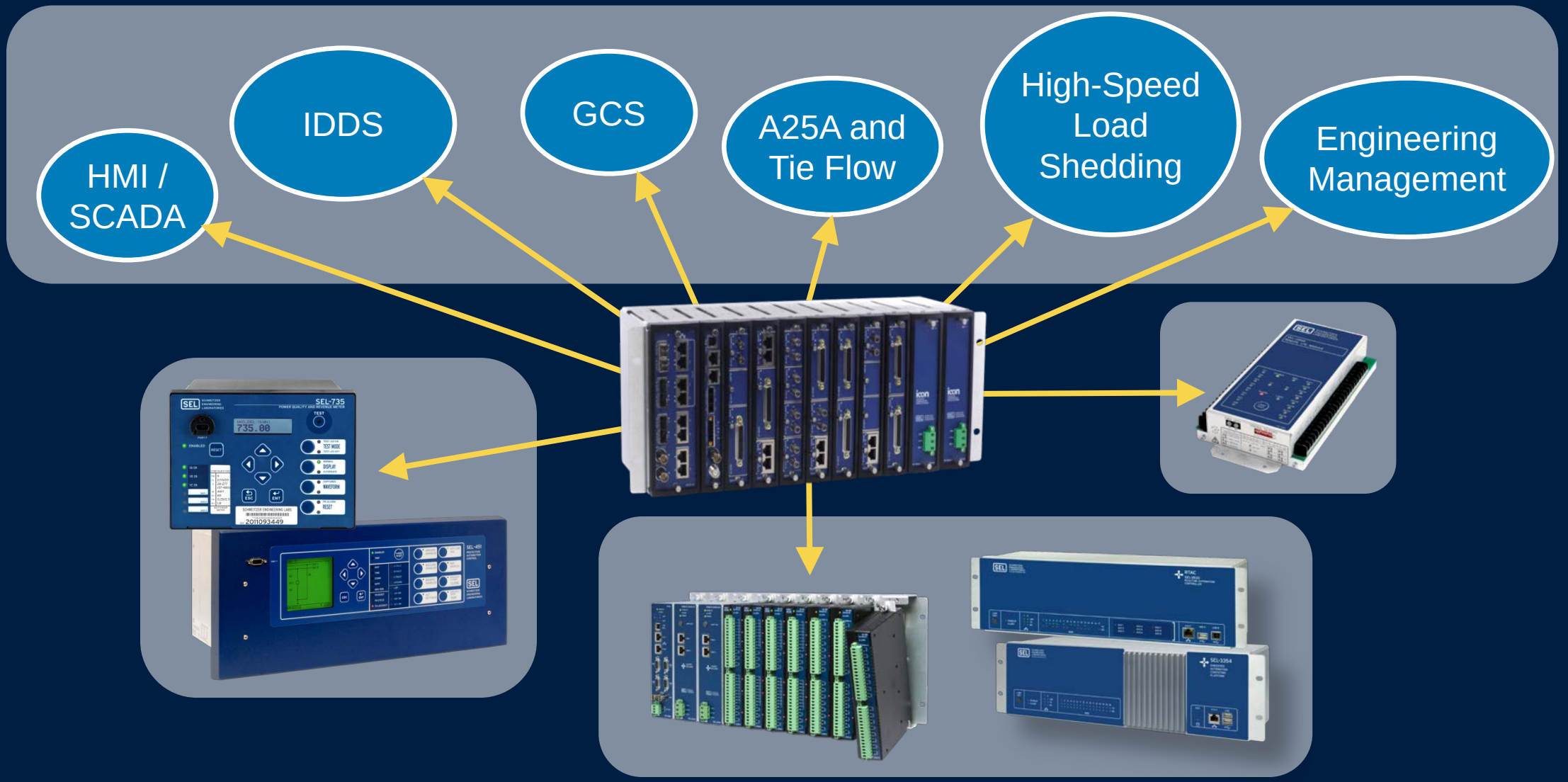
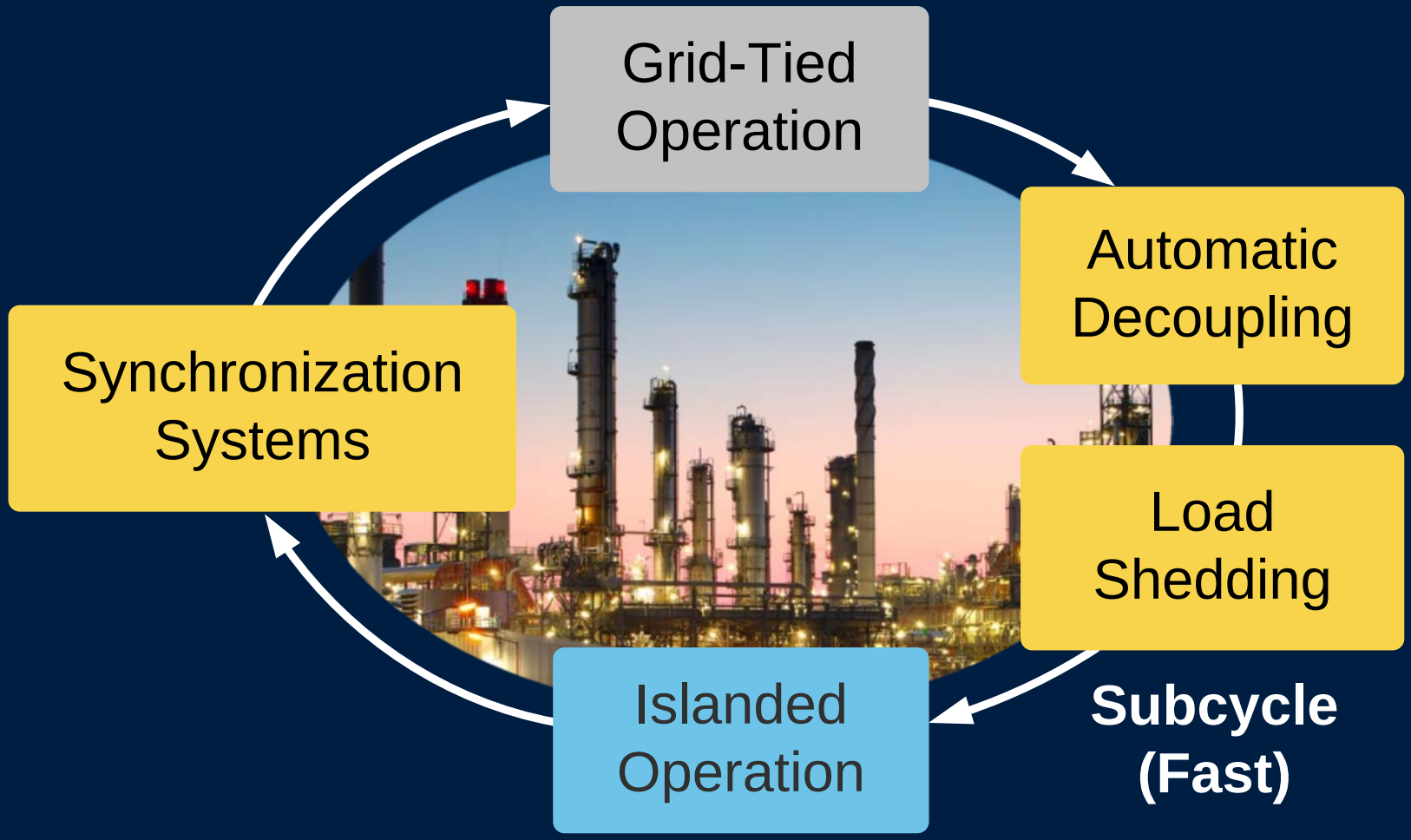
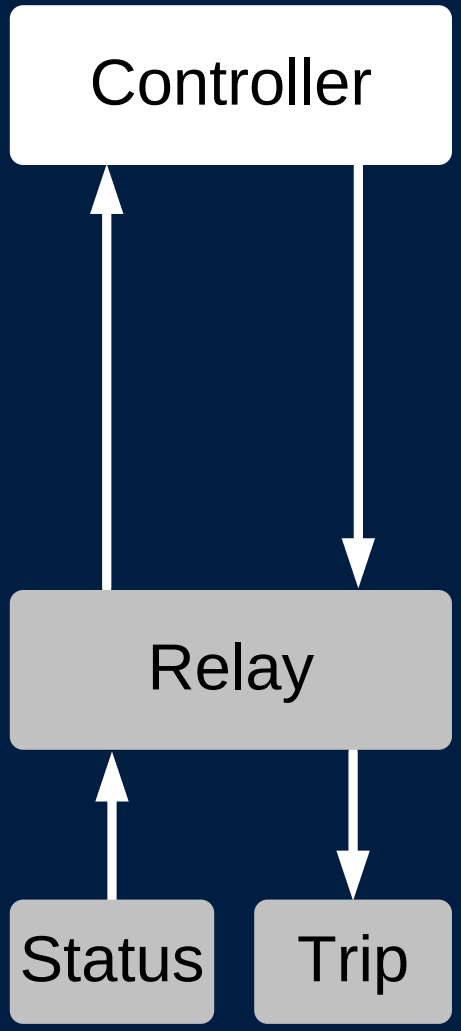
What Is POWERMAX?



POWERMAX Operation





POWERMAX Applications and Goals

Power Management System (PMS)

- Heavy Industries
- Blackout Prevention
- Process Survivability

Remedial Action Scheme (RAS)

- Utilities
- Blackout Prevention
- Wide-Area Schemes
- Efficiency
- Security

Microgrid

- Small Communities
- Resiliency
- Economics
- Renewables
- Speed of Operation
- Adaptive Protection

Controller Provides Many Features

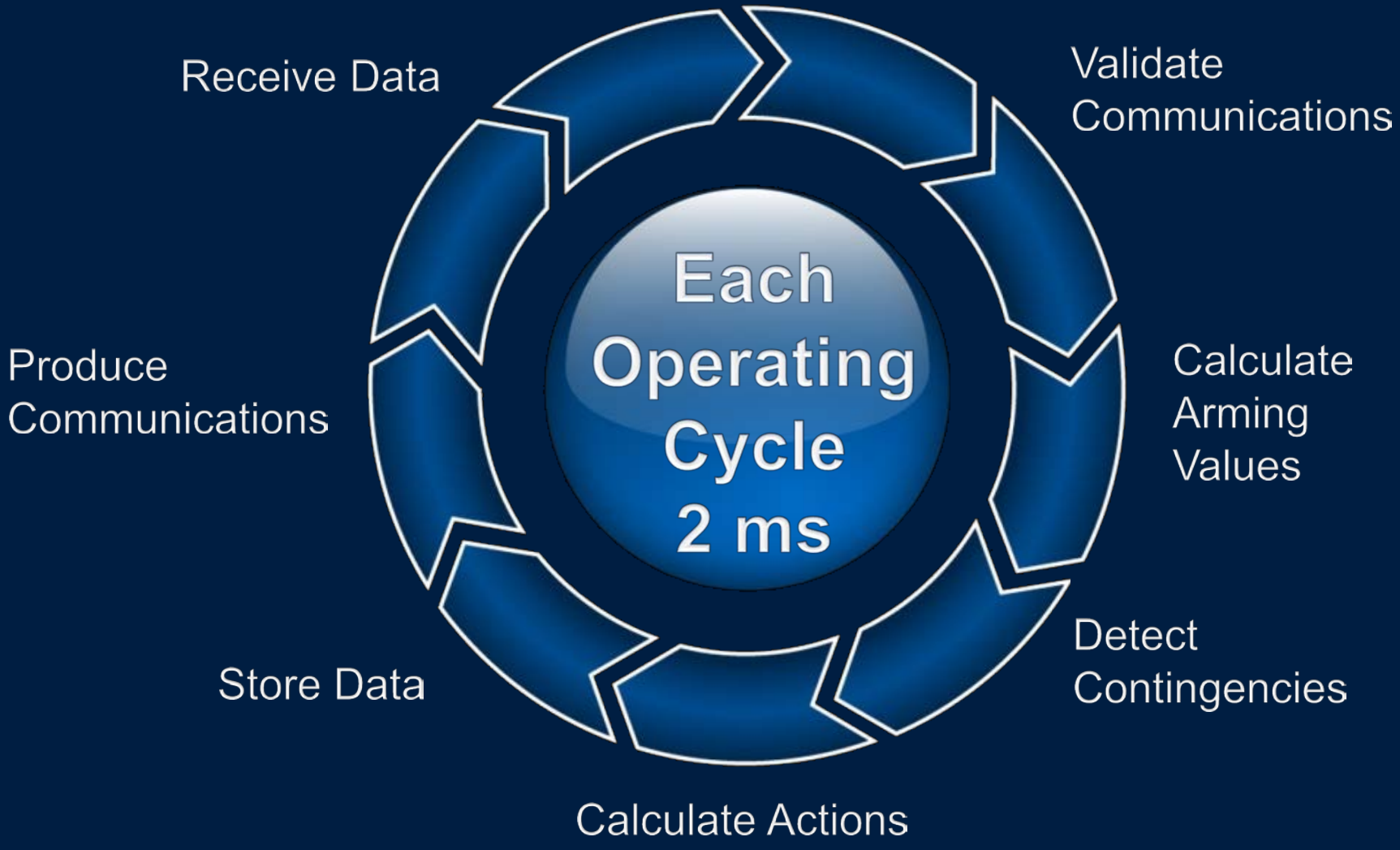
Hardware

- Linux OS
- Multithread Processing
- 2 ms Scan
- Self-Diagnostics
- Substation Graded
- No Moving Parts
- Dual Ethernet

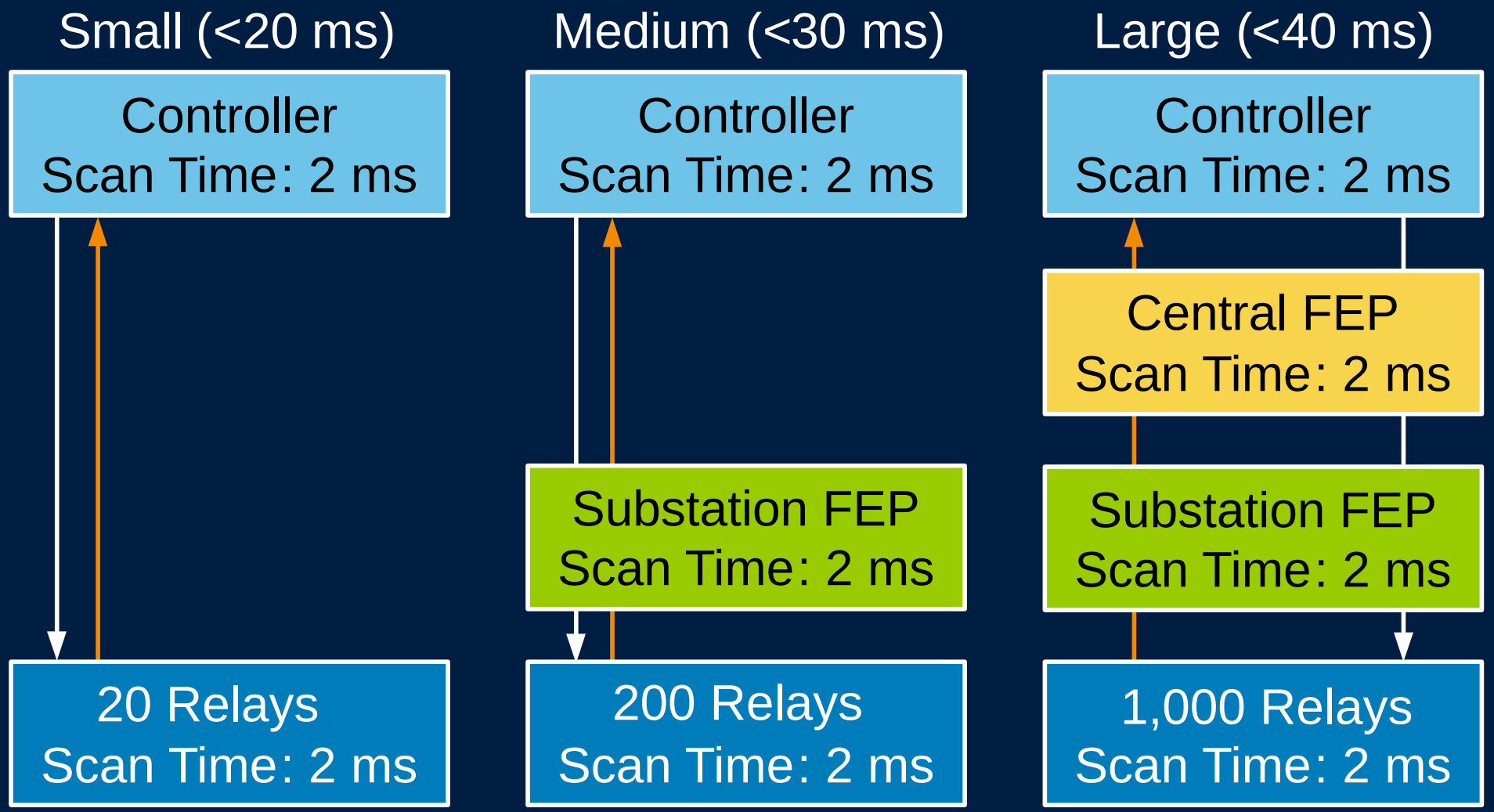
Software

- IEC 61850
- SEL Protocols
- DNP3 / IP
- Modbus RTU / IP
- Web HMI
- MIRRORED BITS®
- IEC 61131 Interface

All High-Priority Controller Tasks Must Execute Each Operating Cycle



Fast and Scalable Architectures Are Required



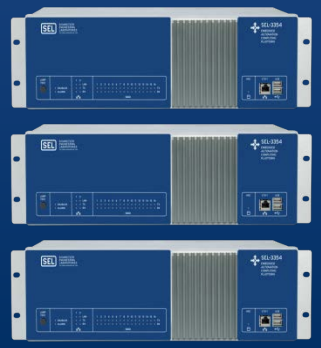
Redundancy

Single

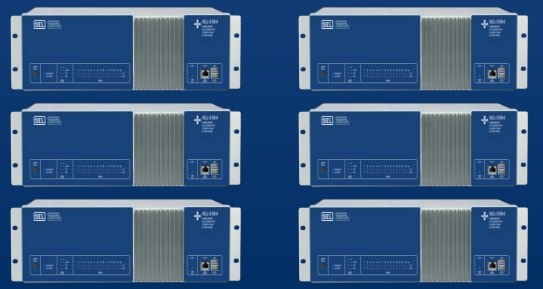
Dual

Dependability
Security
Complexity and Cost

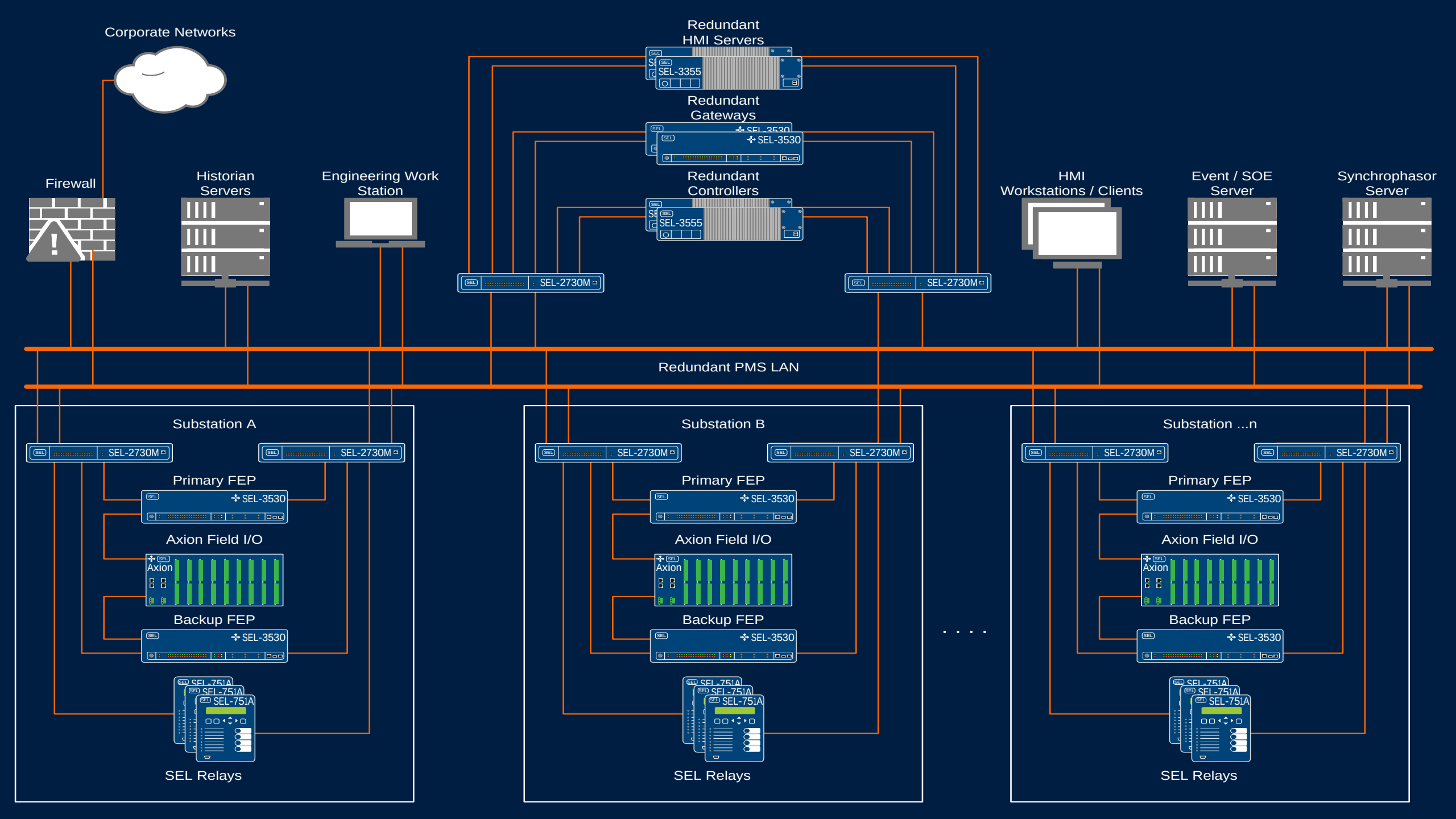
TMR



Dual TMR



All dual systems can be hot, standby, or dual primary


Corporate Networks
Redundant HMI Servers
SEL-3355
Redundant Gateways
SEL-3530
Redundant Controllers
SEL-3555
Firewall
Historian Servers
Engineering Work Station
SEL-2730M
SEL-2730M
HMI Workstations / Clients
Event / SOE Server
Synchrophasor Server
Redundant PMS LAN
Substation A
SEL-2730M
SEL-2730M
Primary FEP
SEL-3530
Axion Field I/O
Axion
Backup FEP
SEL-3530
SEL-751A
SEL-751A
SEL-751A
SEL Relays
Substation B
SEL-2730M
SEL-2730M
Primary FEP
SEL-3530
Axion Field I/O
Axion
Backup FEP
SEL-3530
SEL-751A
SEL-751A
SEL-751A
SEL Relays
Substation ...n
SEL-2730M
SEL-2730M
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Axion
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SEL-3530
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SEL-751A
SEL-751A
SEL Relays

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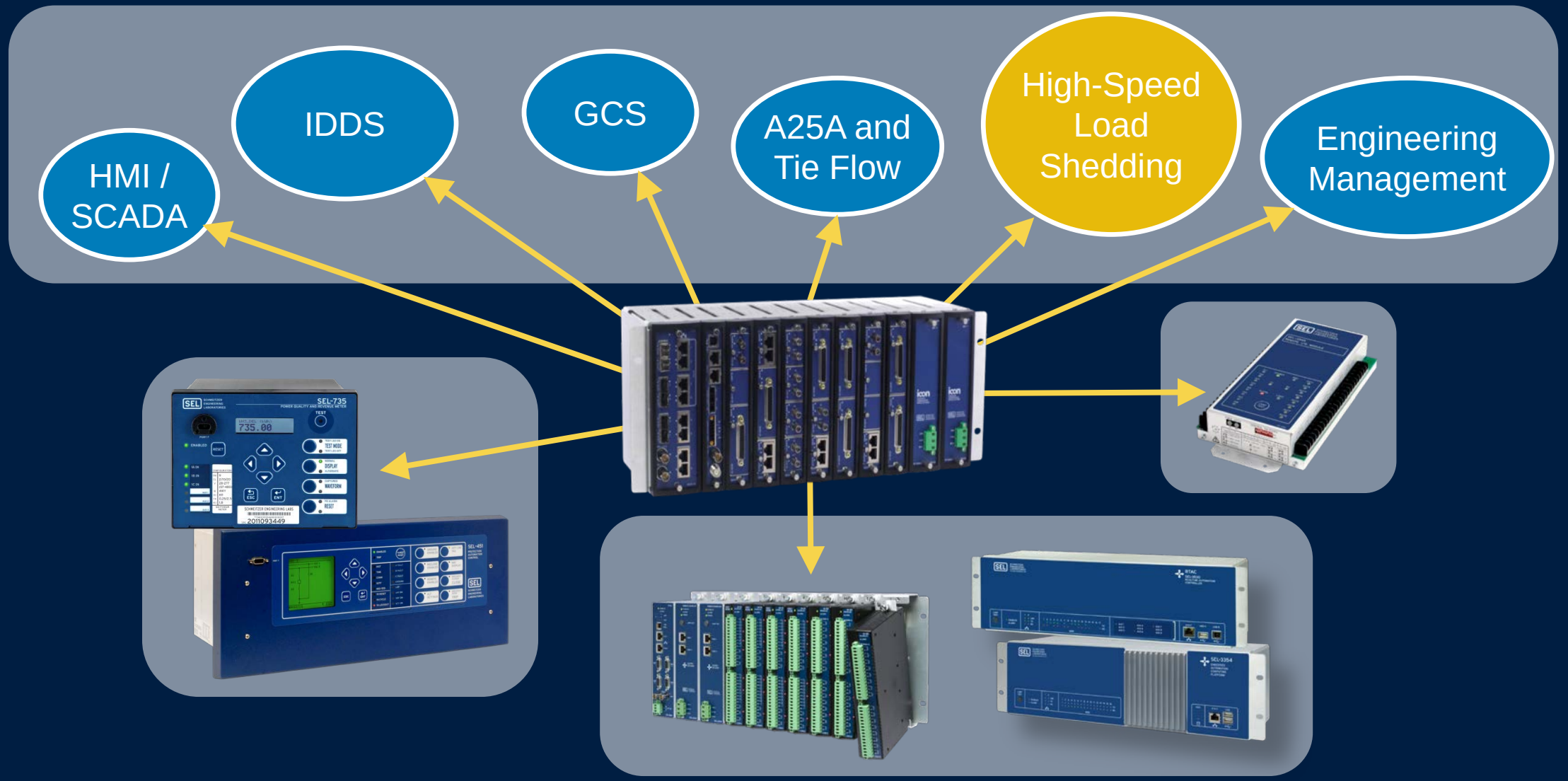
POWERMAX Functions



High-Speed Load Shedding
Objectives

- Power system frequency stability
  - Shed the correct amount of load
  - Quickly shed load
- Process survivability
  - Intelligently select loads that minimize the effect on the production process

SEL Load Shedding

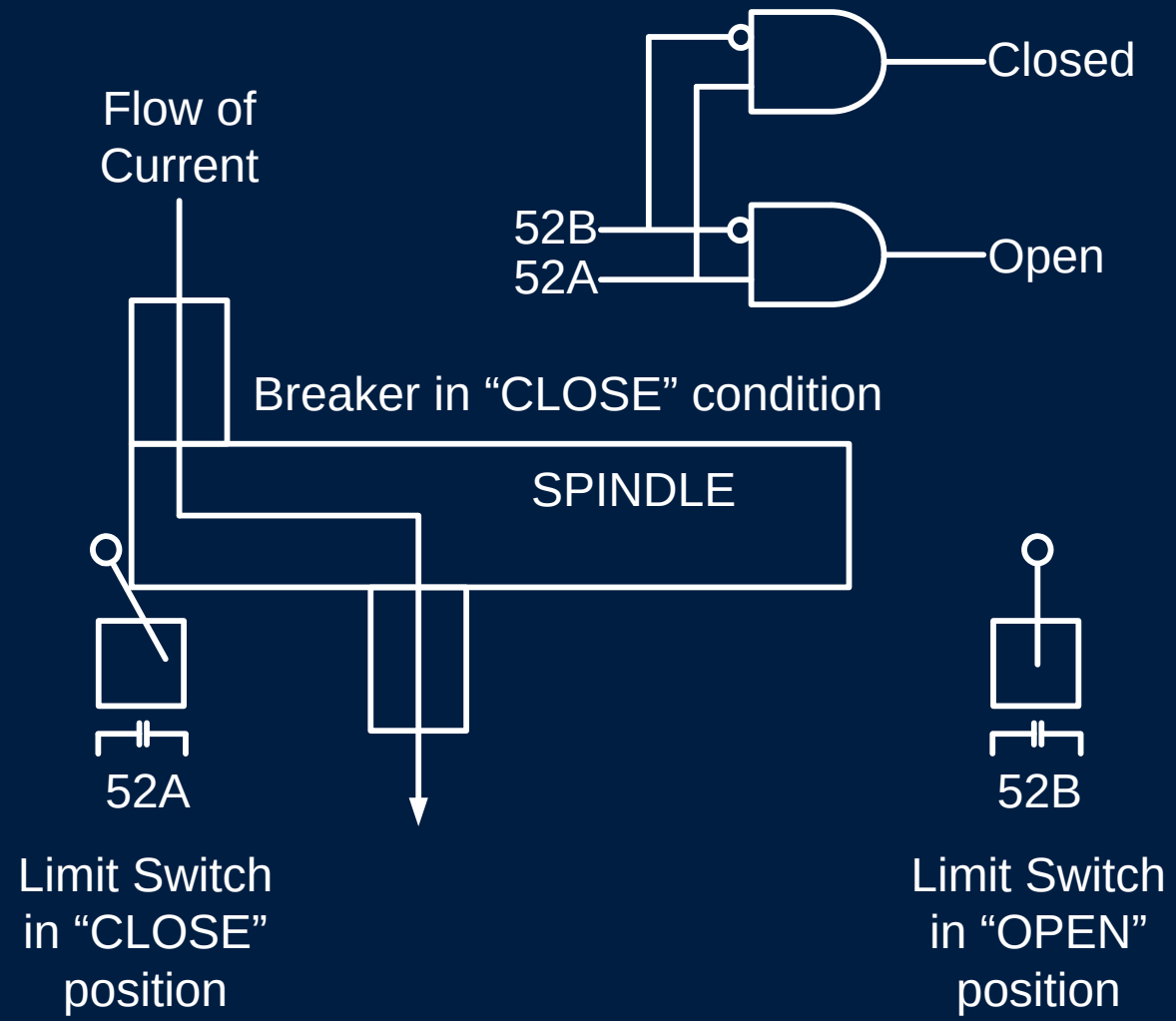
Features

- Subcycle speed
- Dual primary mechanism
- Primary CLSP
- Backup UFLSP / ICLT
- Asset overload shedding
- Multiple simultaneous contingencies
- SOEs and event records
- Backup Web HMI

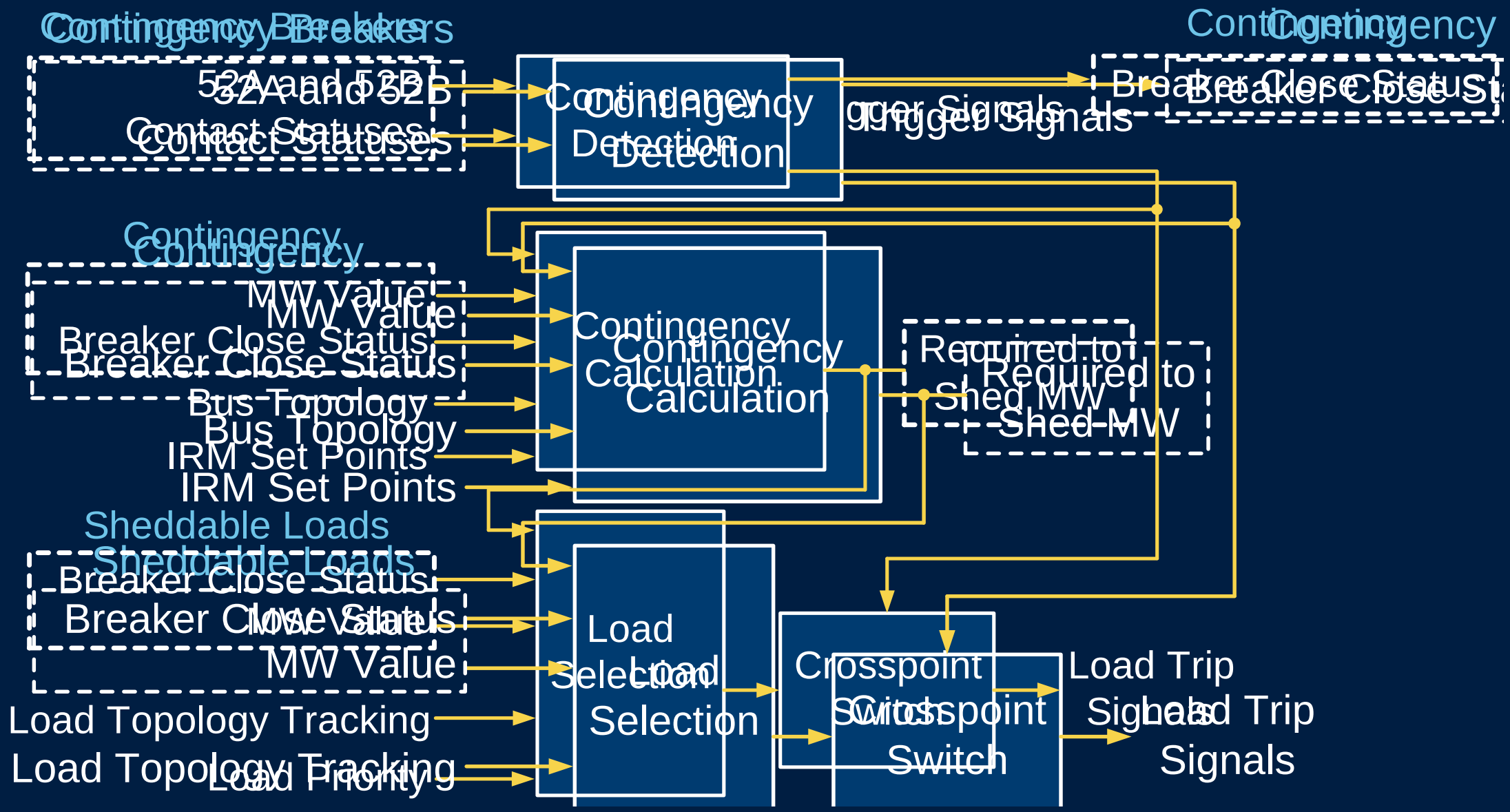
Contingency Load Shedding

- System contingencies
  - Tie line
  - Bus tie
  - Generator breaker
  - Turbine trip
  - Asset overload
- Primary load shedding
- Blackout prevention
- Fastest – independent
- Decision based on topology, contingency and load calculations

Contingency Breaker Opening Is Determined by 52A and 52B Limit Switches



Contingency-Based Load-Shedding System



Required to Shed (kW)

$$L_n = P_n - \sum_{g=1}^{m} IRM_{ng}$$

n = contingency (event) number

m = number of sources (generators) in system

g = generator number, 1 through *m*

L_n = amount of load selected for *n* event (kW)

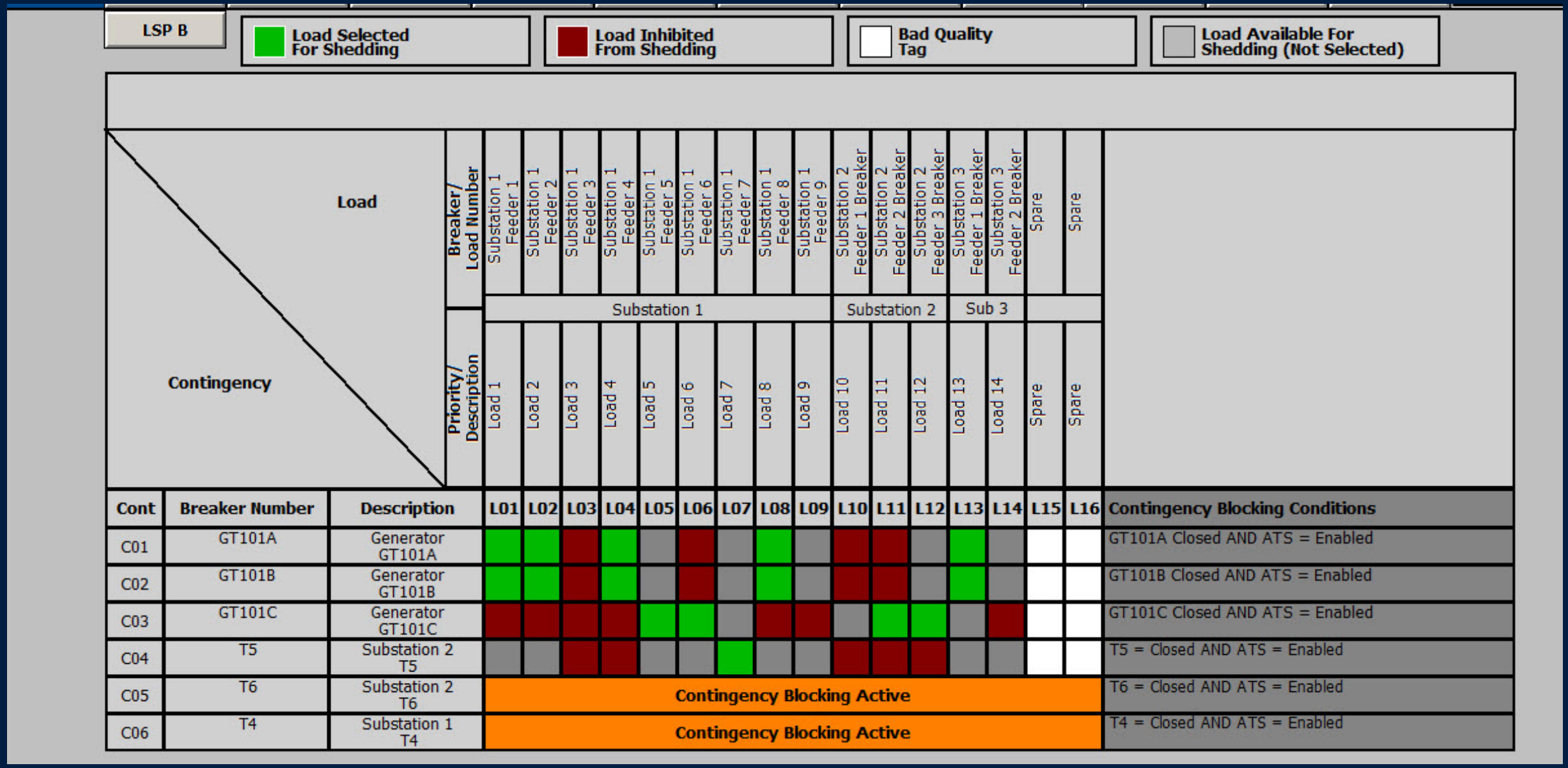
P_n = power disparity caused by *n* event (kW)

IRM_{ng} = incremental reserve margin of all generators (sources) remaining after *n* event (kW)

Typical CLSP Contingency Screen

Description		Source Status					Details							
Contingency Number	Contingency Description	Breaker Status Open Close	Bus Connection	Present Power (MW)	IRM Set Point (MW)	IRM Maximum (MW)	IRM Actual (MW)	Current Maximum (MW)	Contingency Status	Available Capacity (MW)	Measured Load (MW)	Required To Shed (MW)	Selected to Shed (MW)	Contingency Satisfied
C1	Generator GT-101A Turbine Trip	Close	Bus 0	21.96	2.00	4.00	2.00	23.96	Enabled	71.45	41.58	0.00	0.00	Yes
C2	Generator GT-101B Turbine Trip	Open	Bus 0	0.00	2.00	4.00	0.00	0.00	Disabled	0.00	0.00	0.00	0.00	Yes
C3	Generator GT-101C Turbine Trip	Close	Bus 1	20.45	1.00	4.00	1.00	21.45	Enabled	73.96	41.58	0.00	0.00	Yes
C4	T5 Breaker Trip	Racked Out	Bus 5	0.00	50.00	50.00	0.00	0.00	Disabled	0.00	0.00	0.00	0.00	Yes
C5	T6 Breaker Trip	Close	Bus 0	-0.83	50.00	50.00	50.00	0.00	Enabled	45.41	41.58	0.00	0.00	No
C6	T4 Breaker Trip	Bad Breaker	Bus 1	0.00	N/A	N/A	0.00	0.00	Disabled	0.00	0.00	0.00	0.00	Yes

SEL CLSP Crosspoint Switch Screen



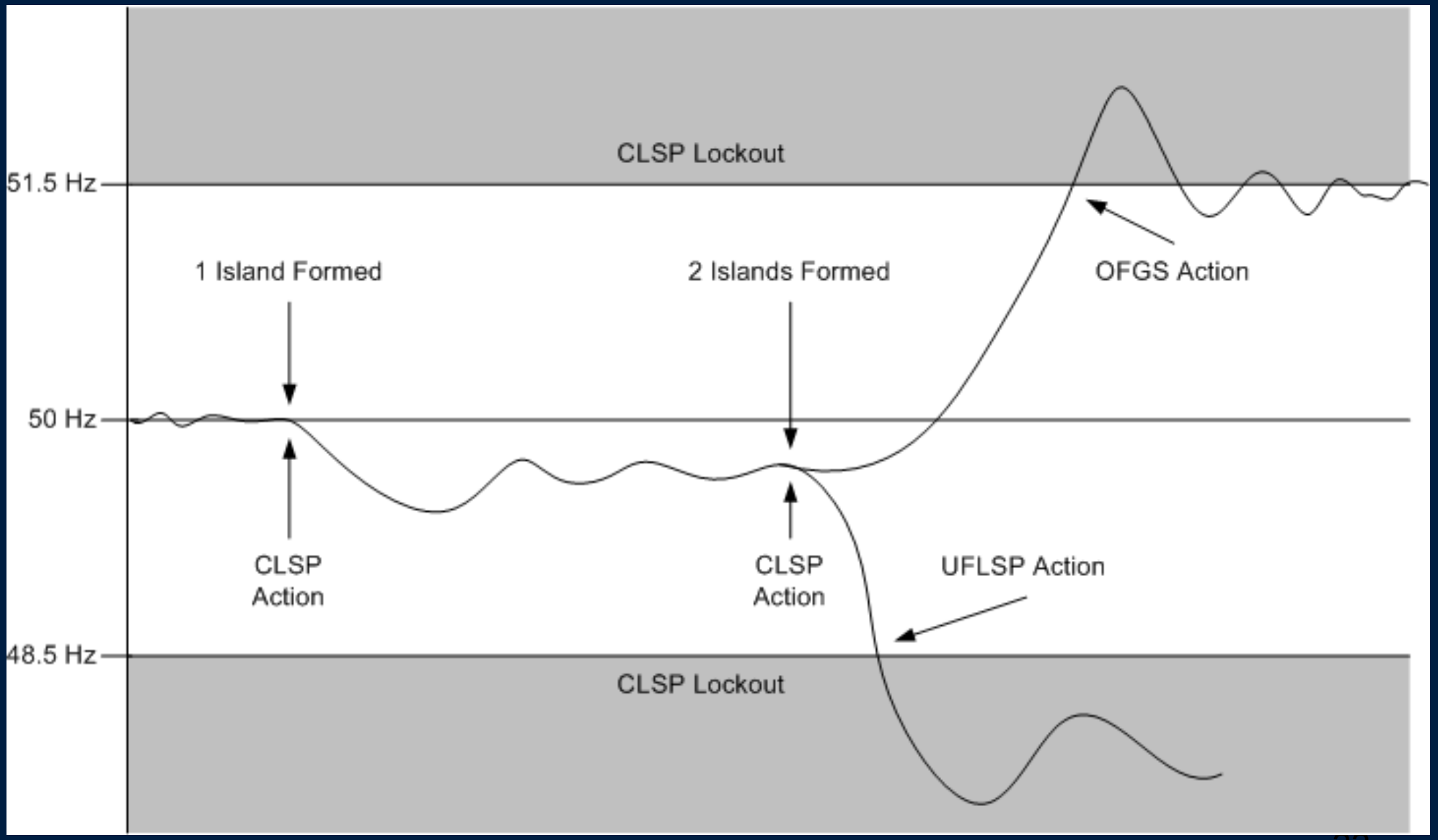
Cont	Breaker Number	Description	L01	L02	L03	L04	L05	L06	L07	L08	L09	L10	L11	L12	L13	L14	L15	L16	Contingency Blocking Conditions
C01	GT101A	Generator GT101A																	GT101A Closed AND ATS = Enabled
C02	GT101B	Generator GT101B																	GT101B Closed AND ATS = Enabled
C03	GT101C	Generator GT101C																	GT101C Closed AND ATS = Enabled
C04	T5	Substation 2 T5																	T5 = Closed AND ATS = Enabled
C05	T6	Substation 2 T6	Contingency Blocking Active																T6 = Closed AND ATS = Enabled
C06	T4	Substation 1 T4	Contingency Blocking Active																T4 = Closed AND ATS = Enabled

SEL CLSP Load Screen

Test Mode Enabled

Load List			Load Status					
Load Number	Breaker Number	Description	Breaker Status Open Close	Test Shed Select	Load Priority	Live Power (MW)	Force Value Of Power (MW)	Toggle Live Force
L01	Load 1	Substation 1 Feeder 1	Close	Normal	1	1.89	0.00	Normal
L02	Load 2	Substation 1 Feeder 2	Close	Normal	2	4.43	0.00	Normal
L03	Load 3	Substation 1 Feeder 3	Close	Normal	3	6.21	0.00	Normal
L04	Load 4	Substation 1 Feeder 4	Close	Normal	4	3.59	0.00	Normal
L05	Load 5	Substation 1 Feeder 5	Open	Normal	5	0.00	0.00	Normal
L06	Load 6	Substation 1 Feeder 6	Racked Out	Normal	6	0.00	0.00	Normal
L07	Load 7	Substation 1 Feeder 7	Close	Normal	8	0.00 MA	0.00	Normal
L08	Load 8	Substation 1 Feeder 8	Close	Normal	12	0.97	0.00	Normal
L09	Load 9	Substation 1 Feeder 9	Close	Normal	7	2.96	0.00	Normal
L10	Load 10	Substation 2 Feeder 1 Breaker	Open	Test Shed	0	1.26	0.00	Normal
L11	Load 11	Substation 2 Feeder 2 Breaker	Close	Normal	10	3.68	0.00	Normal
L12	Load 12	Substation 2 Feeder 3 breaker	Close	Normal	11	2.13	2.13	Forced
L13	Load 13	Substation 3 Feeder 1 Breaker	Bad Breaker	Normal	0	0.00	0.00	Normal
L14	Load 14	Substation 3 Feeder 2 Breaker	Close	Normal	9	6.16	0.00	Normal

Operation Example – Multiple Contingencies



Proactive Overload Load-Shedding Integrator

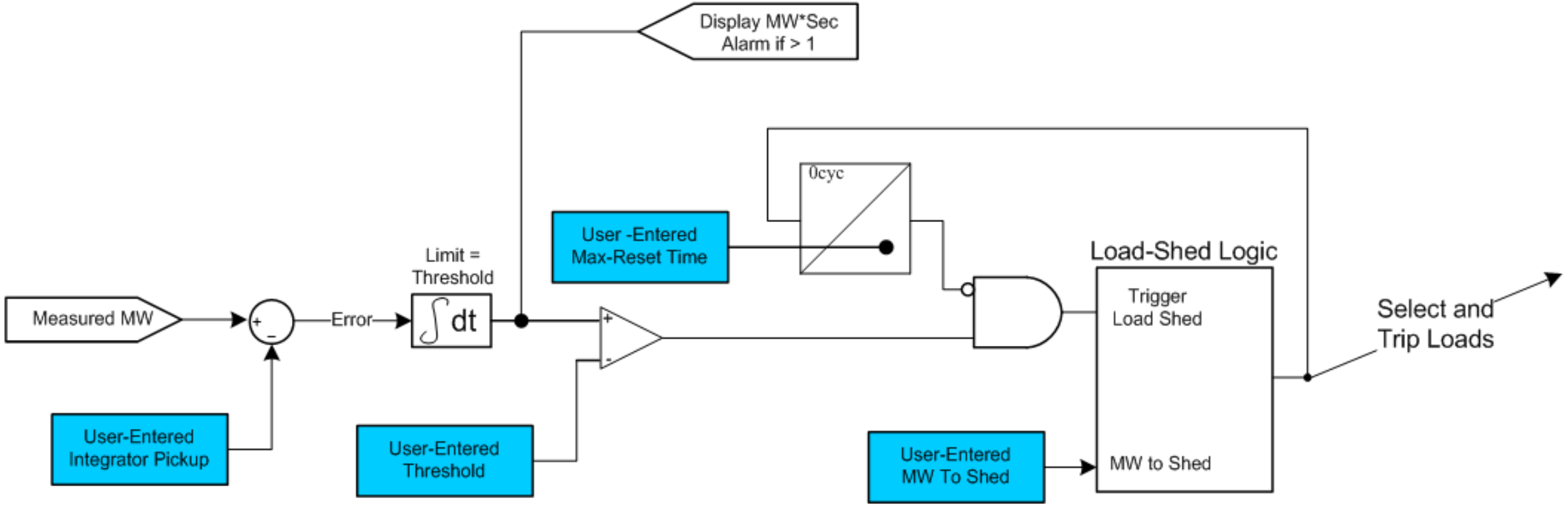


Figure 3-1: Integrator Load-Shedding Logic

Proactive Overload Load-Shedding Screen

Test Mode Enabled

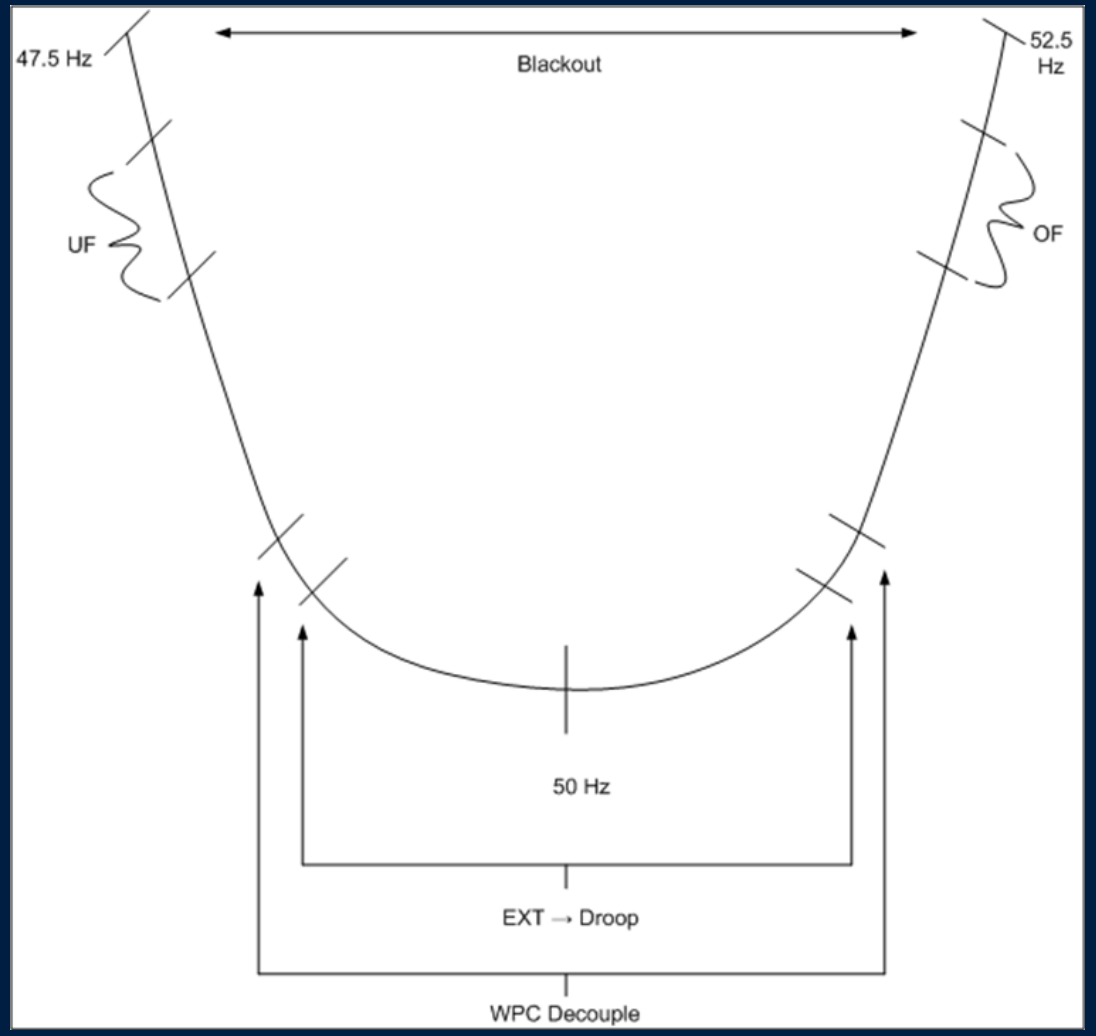
Description	Setpoints				Status							
Generation Number	Integration Pickup % of MW	Integrator Threshold (PU x Second)	Minimum to Shed (MW)	Maximum Reset Time (Seconds)	Breaker Status Open Close	Available Capacity (MW)	Present Power (MW)	Frequency (Hz)	Contingency Status	Seconds to Shed	Required to Shed (MW)	Selected to Shed (MW)
Generator GT-101A	98.00	100.00	2.00	10.00	Close	21.75	21.97	59.97	Disabled	0	0.00	0.00
Generator GT-101B	98.00	100.00	2.00	10.00	Open	18.22	0.00	60.00	Disabled	0	0.00	0.00
Generator GT-101C	98.00	100.00	2.00	10.00	Close	21.17	20.63	60.00	Disabled	0	0.00	0.00
Substation T6	98.00	100.00	2.00	10.00	Open	50.00	0.00	59.97	Disabled	0	0.00	0.00
Substation T5	98.00	100.00	2.00	10.00	Close	50.00	-1.43	59.96	Enabled	0	0.00	0.00

Backup – Underfrequency Load Shedding

Why ?

Strategy: Keep Frequency at Nominal

Ball in a Bowl Analogy



Advantages of powerMAX UFLSP

- Dynamically selects loads (only active loads to shed)
- Incorporates load consumption (MW) into selection
- Tracks power system topology
- Selects correct amount of load to shed for every underfrequency threshold
- Sheds less load with better impact
- Easily changes priority of sheddable load

UFLSP Algorithm

- Detection logic monitors frequency and asserts underfrequency trigger
- Signal conditioning logic in UFLSP protects against chatter
- Event calculation logic calculates load shed for each event
- Crosspoint logic determines load trip signals

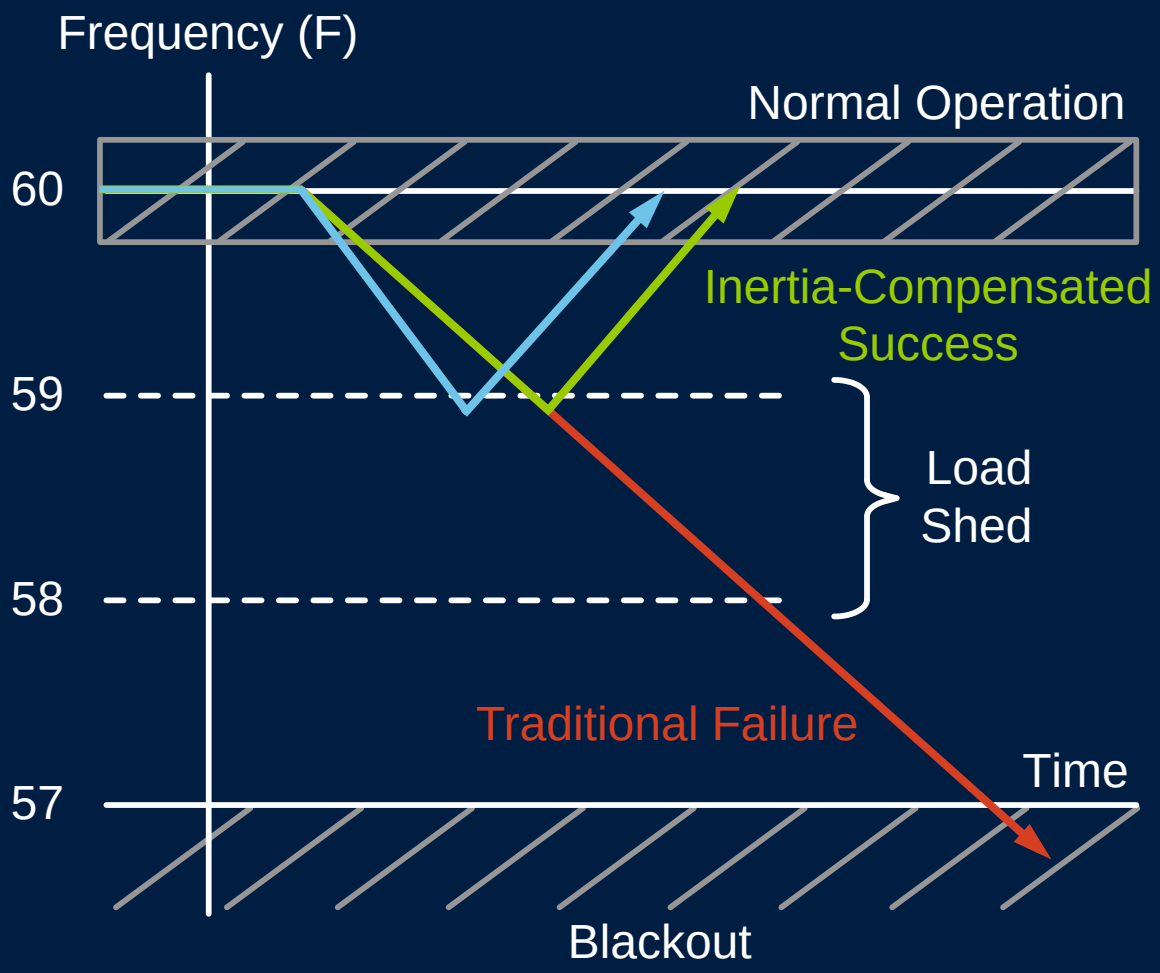
UFLSP Screen

Contingency \ Load	Breaker/ Load Number	Substation 1 Feeder 1	Substation 1 Feeder 2	Substation 1 Feeder 3	Substation 1 Feeder 4	Substation 1 Feeder 5	Substation 1 Feeder 6	Substation 1 Feeder 7	Substation 1 Feeder 8	Substation 1 Feeder 9	Substation 2 Feeder 1 Breaker	Substation 2 Feeder 2 Breaker	Substation 2 Feeder 3 Breaker	Substation 3 Feeder 1 Breaker	Substation 3 Feeder 2 Breaker	Spare	Spare
		Substation 1									Substation 2			Sub 3			
	Priority/ Description	Load 1	Load 2	Load 3	Load 4	Load 5	Load 6	Load 7	Load 8	Load 9	Load 10	Load 11	Load 12	Load 13	Load 14	Spare	Spare

Contingency	Description	Contingency Status	UF Pickup (Hz)	Frequency (Hz)	Required to Shed (MW)	Selected to Shed (MW)	Contingency Satisfied	L01	L02	L03	L04	L05	L06	L07	L08	L09	L10	L11	L12	L13	L14	L15	L16
UFC1	Generator GT-101A Under Frequency Level 1	Disabled	59.00	59.96	5.00	0.00	Yes																
UFC2	Generator GT-101A Under Frequency Level 2	Disabled	58.50		5.00	0.00	Yes																
UFC3	Generator GT-101B Under Frequency Level 1	Disabled	59.00	60.00	5.00	0.00	Yes																
UFC4	Generator GT-101B Under Frequency Level 2	Disabled	58.50			0.00	Yes																
UFC5	Generator GT-101C Under Frequency Level 1	Disabled	59.00	59.97	5.00	0.00	Yes																
UFC6	Generator GT-101C Under Frequency Level 2	Disabled	58.50			0.00	Yes																

Inertia-Compensated Load Shedding

Do It Right!

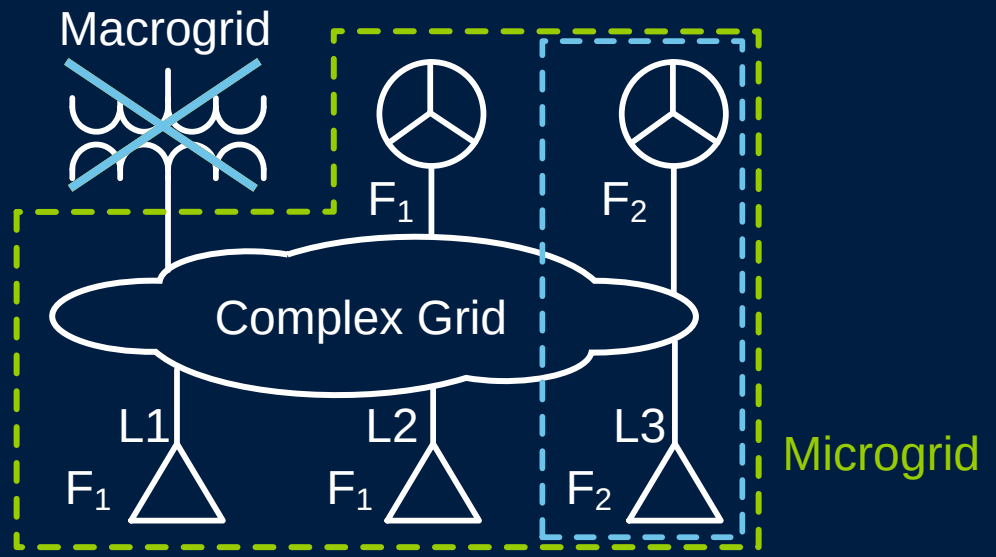


Load Shed ~ H • DFDT = 8 • 1 = 8 MW

Load Shed ~ H • DFDT = 4 • 2 = 8 MW

MW Load to Shed

DFDT \ F	59	58
< 0.5	2	4
0.5–1.0	4	8
> 1.0	8	16



Questions?