

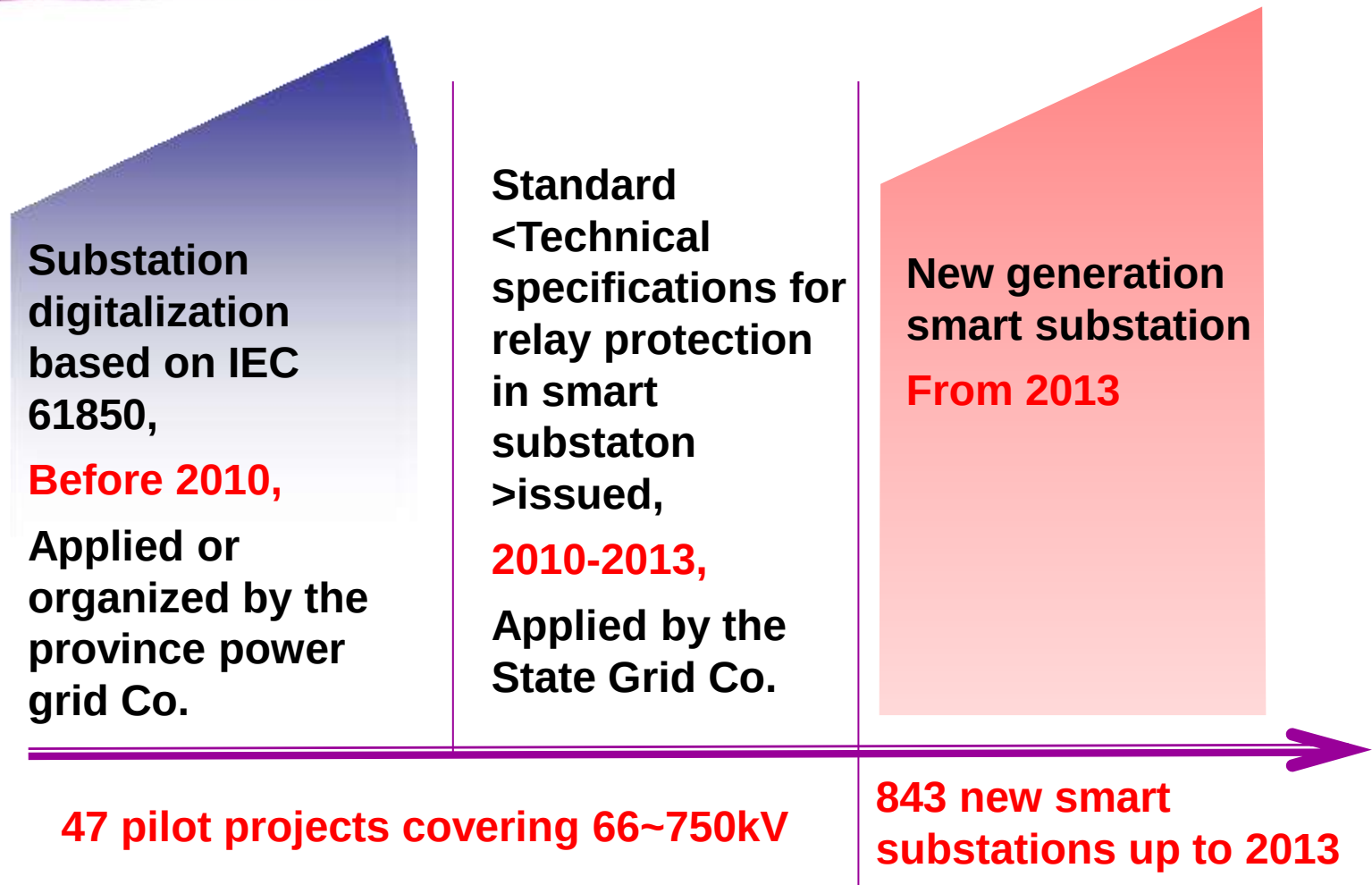


Smart Power Substation Development in China

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Three Stages of Smart Substations 'Development

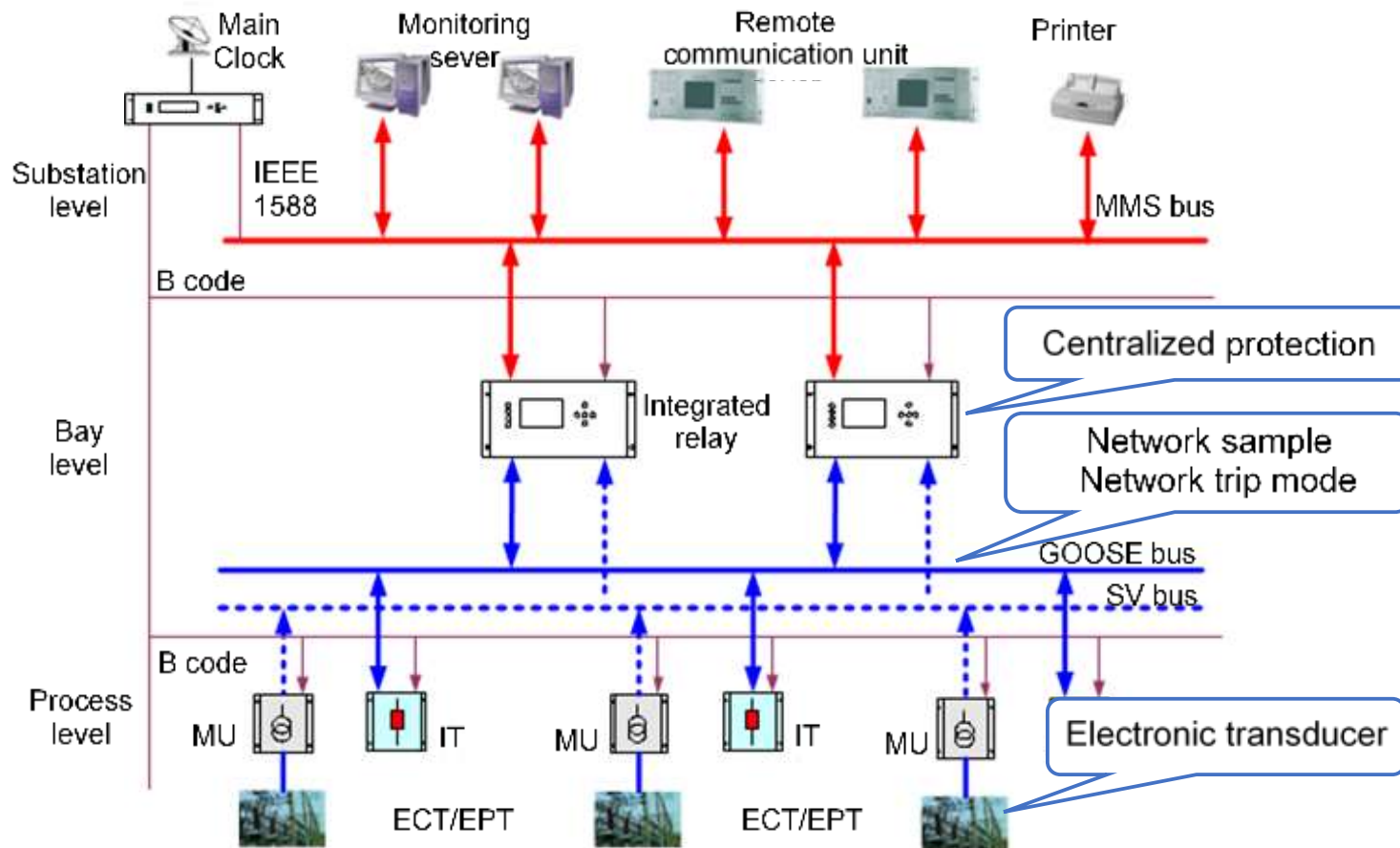


Three Stages of Smart Substations 'Development

Stage I: Digital substation

Failed !

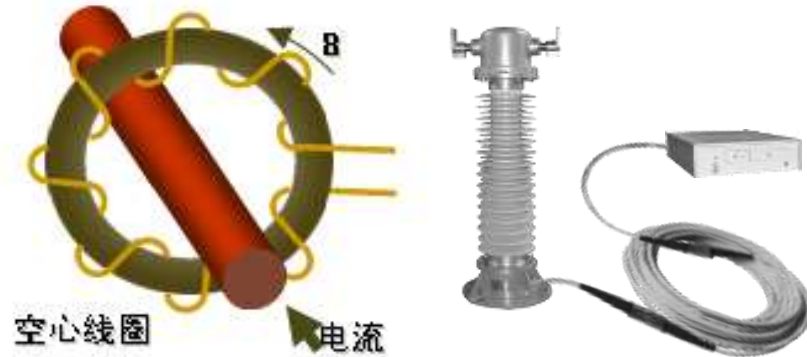
Unqualified new devices



Stage I: Digital substation

Three Stages of Smart Substations 'Development

Stage I: Digital substation

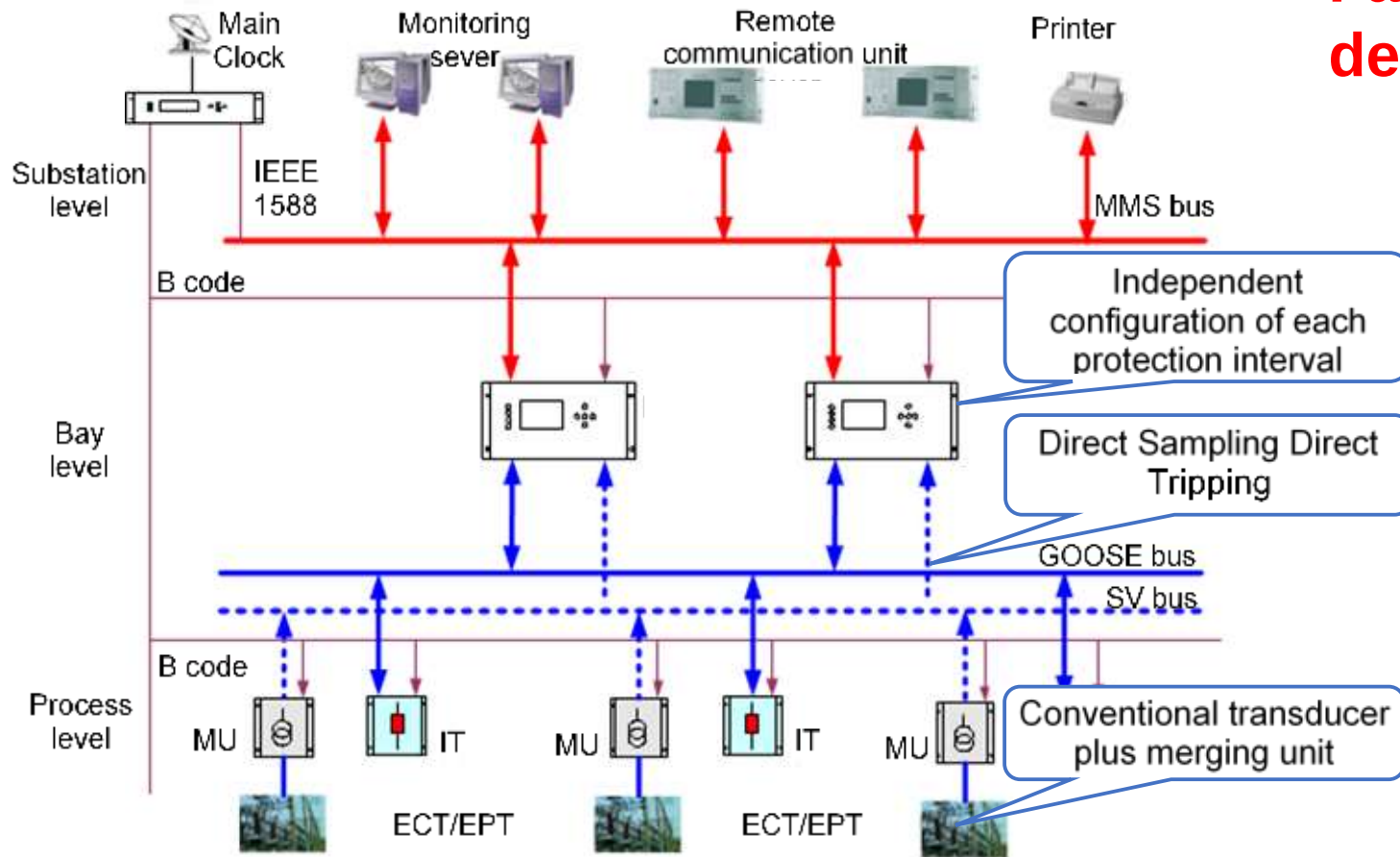


- Poor anti-EMI ability of electronic components in CT/PT
- Temperature and long-run stabilities of CT/PT are low
- The quality of switcher is not good
- Integrated relay based on CSMA/CD Ethernet communication produce the fault tripping delay due to the **mechanism of data queuing delay**.
- Rely on the synchronization from external clock

Three Stages of Smart Substations 'Development

Stage II: Smart substation

**Fast
development!**



Stage II: Smart substation

Three Stages of Smart Substations 'Development

Stage II: Smart substation

- **Direct sampling +Direct tripping**

Improve the reliability of relay, no rely on synchronization and switcher' performance.

- **Independent configuration of each protection interval**

Improve the reliability of relay, easy maintenance.

- **Traditional transformer+ MU**

Transition phase to wait for the mature technology

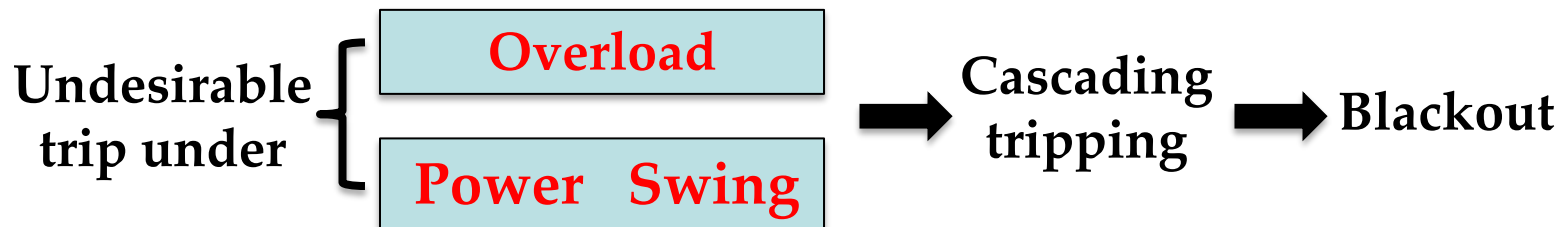
Three Stages of Smart Substations 'Development

Stage II: Smart substation

- **Main protection**

highly reliable, correct action rate is higher than 99.9%

- **Backup protection**



- **Related work**

Local

limited information, limited effect (hard to identify overload)

Substation integrated

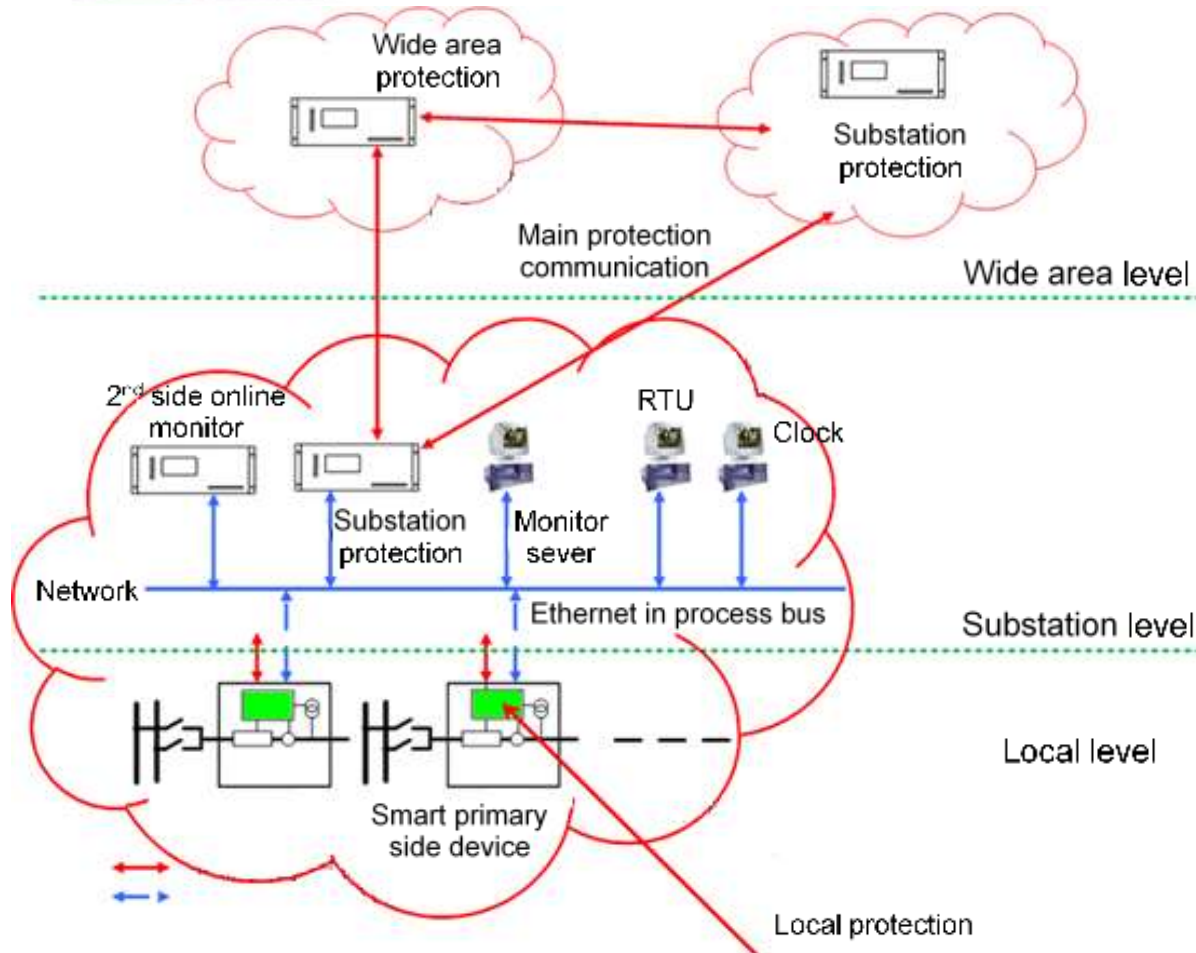
Promising candidate for these problems

Wide-area

large computation and communication; may not meet the requirement of real-time

Three Stages of Smart Substations 'Development

Stage III: New gene. of smart substation



Spatial dimension

Local, substation area, and wide area multi-level protection and control, realizing system-wide function coverage.

Time dimension

Link each other in time, collaborative realization of different needs.

Function dimension

Integration and optimization of protection and control functions, realizing protection from equipment to the power grid.

Stage III: New gene. of smart substation

Three Stages of Smart Substations 'Development

Stage III: New gene. of smart substation

Layered protection control system —Local Protection & Control

- **Synchronous sampling, Fast tripping**

Line, transformer, busbar protection.

- **Direct sampling & Direct tripping**

No rely on external clock and network communication.

Three Stages of Smart Substations 'Development

Stage III: New gene. of smart substation

Layered protection control system — Substation P&C based on Network

No.	Classification	Function module	Function description
1	Redundancy Protection function	110 kV line redundancy protection	As redundancy protection of a single set of protection
		Bus tie (segmentation) over-current protection	
2	Backup Protection optimization	Failure protection	Circuit breaker tripping failure protection function
		Backup protection acceleration	Substation internal fault location, shortening the fault clearing time of backup protection
		35 kV and 10 kV bus bar backup protection	Simplified bus bar protection function based on GOOSE
3	Safe and Automatic Control	Low frequency low voltage load shedding	Load shedding function under Low frequency low voltage
		Substation area spare power automatic switching	Spare power automatic switching function of multiple voltage level within substation
		Main transformer overload cut	Function of main transformer overload cut and load sharing
4	Wide-area Protection Control support	Wide area protection control substation	Collection , process and transmission of substation area information, sub-function of protection and control in area power system

Three Stages of Smart Substations 'Development

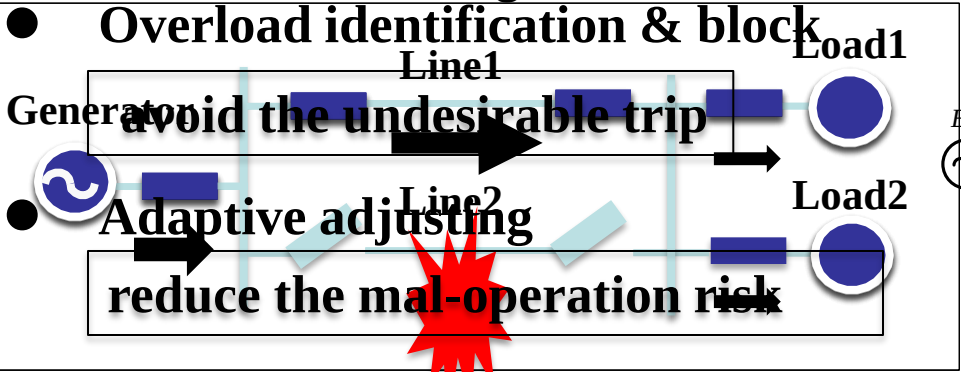
Stage III: New gene. of smart substation

Layered protection control system——Wide Area Protection & Control

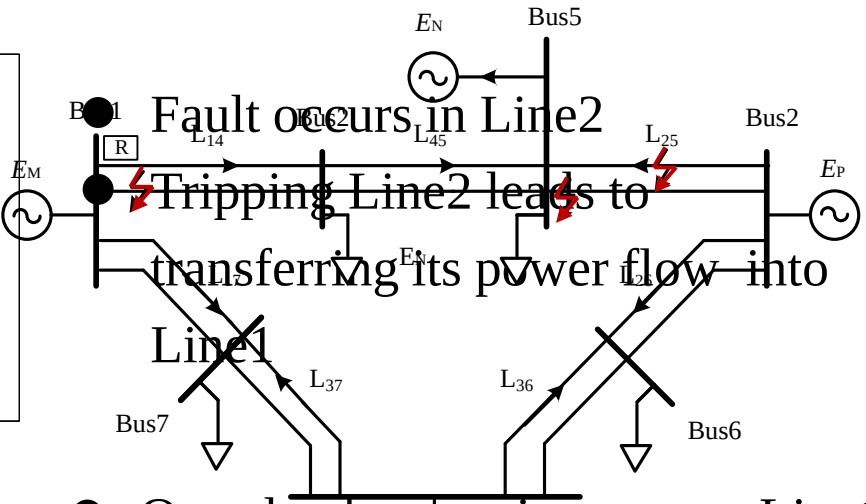
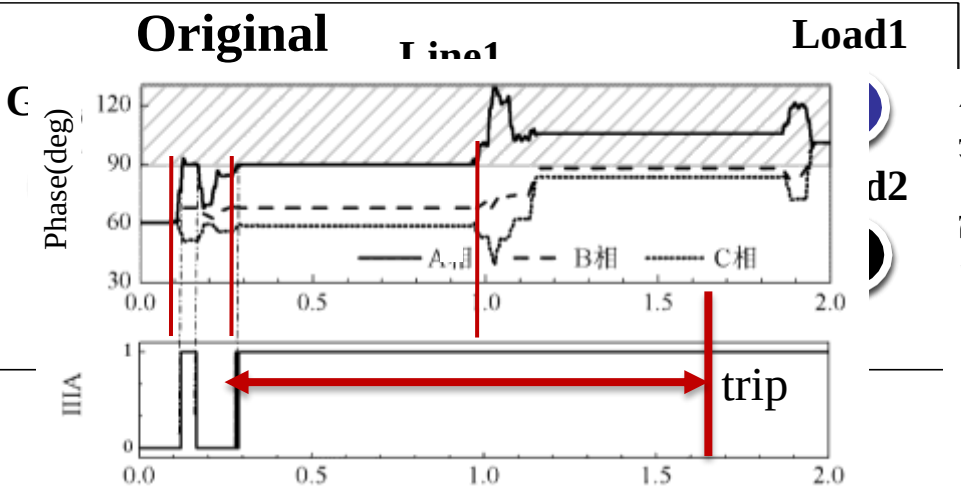
No.	Classification	Function module	Function description
1	Optimization of safe and stable control function	Regional safety and stability control	Realization of area power system safe and stable control function based on wide-area information
		Wide area low-frequency low-voltage load shedding	Allocation of load shedding amount and load shedding cycles
		Wide area out of synchronism disconnect	Optimized cross section selection to disconnect based on wide-area information
		Area power system self-healing function	Automatic recovery function of power system after clearance of fault
2	Optimization of protection function	Local power system redundancy protection	Emergency protection and failure protection function after loss of protection and control function of single substation
		Optimization of backup protection	Realization of area power system fault location, reduction of clearance time of backup protection

Benefit: overload identification & elimination

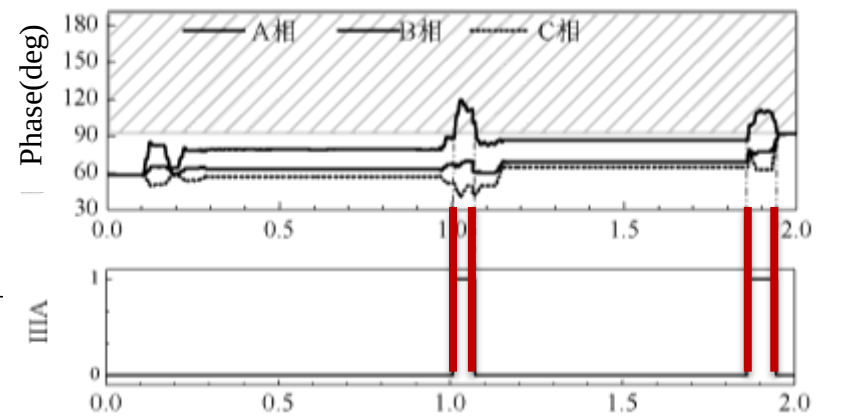
Neutral Fault Transferring



Active load shedding

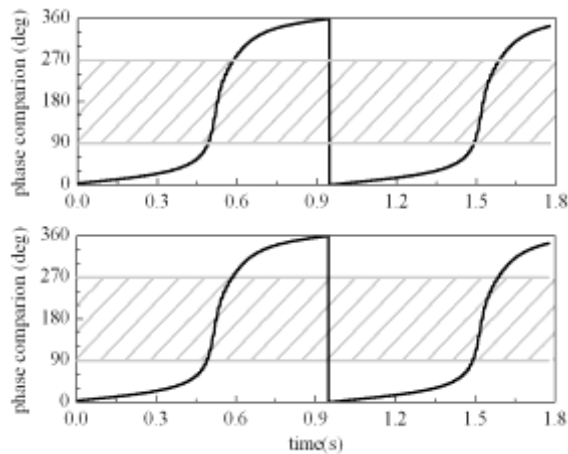


- Over-load protection acts on Line1
 - This kind of protection
- Add blocking and adjusting

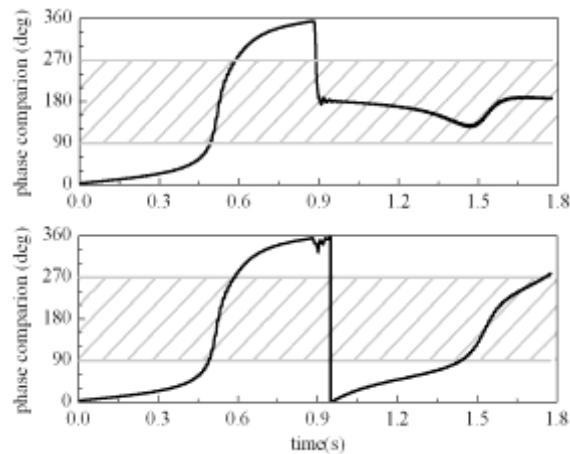


Benefit: overload identification & elimination

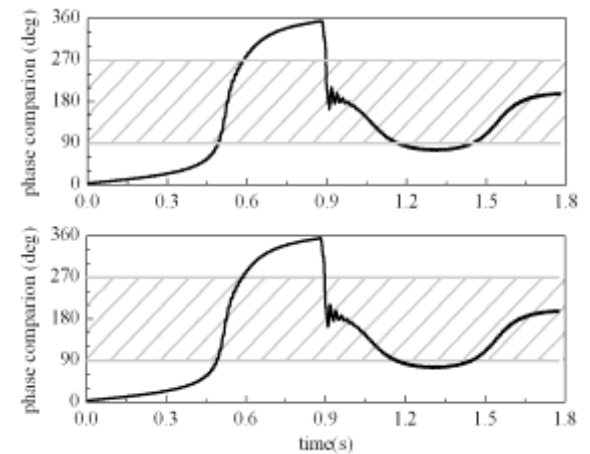
- Using the action angle of Zone 3 relay and their change rate of double lines to distinguish the fault and swings



(a) System oscillation without fault



(b) System oscillation with one line fault



(c) System oscillation with next line fault