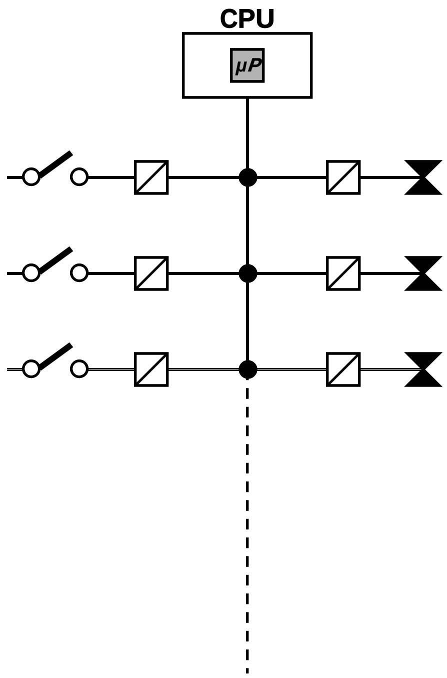
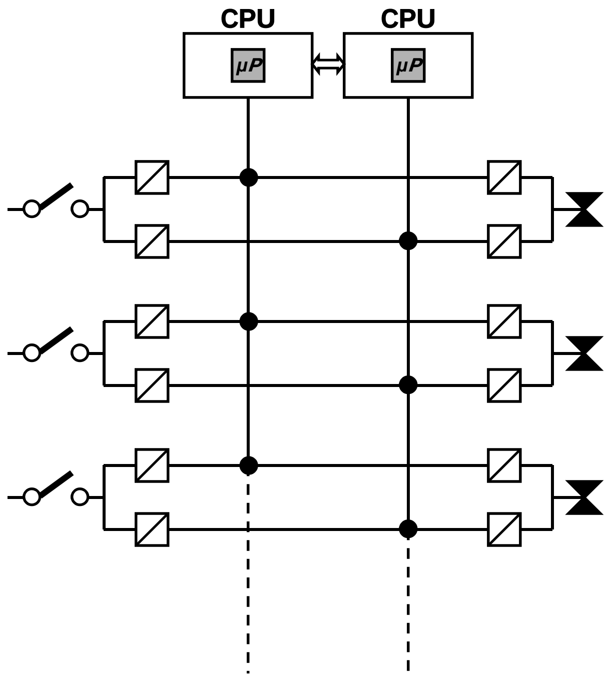
TMR vs. QMR

SYSTEM STRUCTURE

SIMPLEX
(1-out-of-1)

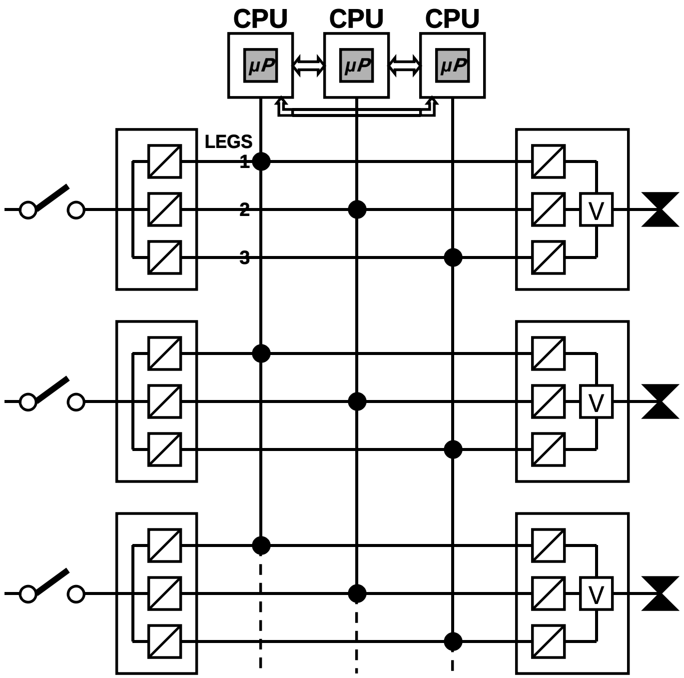


DUPLEX
(2-out-of-2 or 1-out-of-2D)

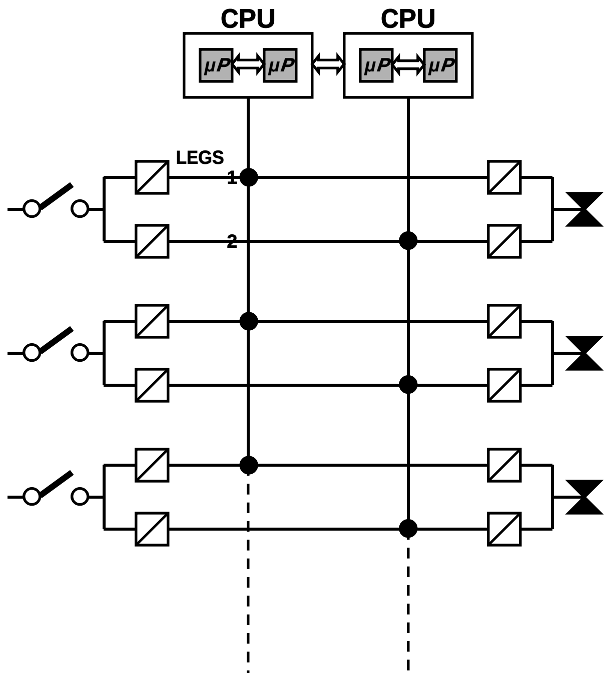


SYSTEM STRUCTURE

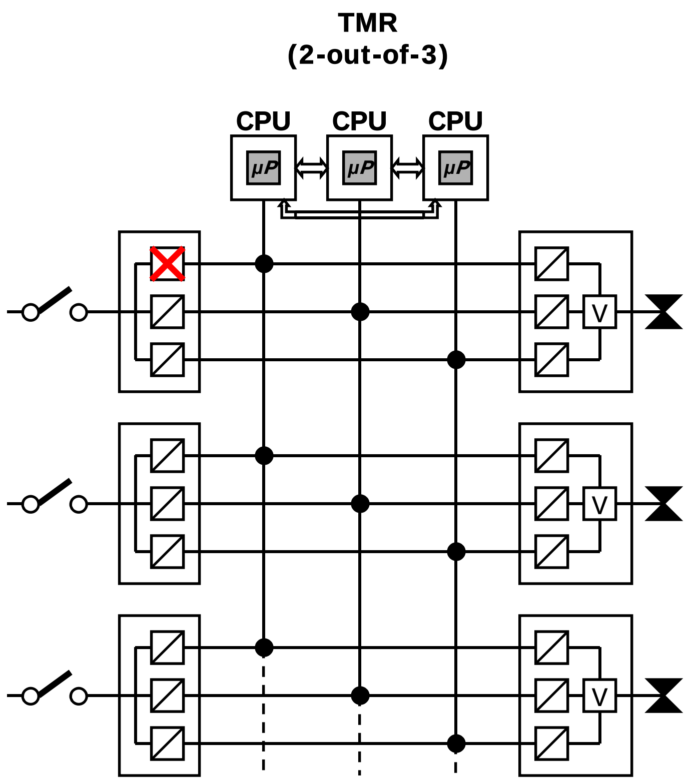
TMR
(2-out-of-3)

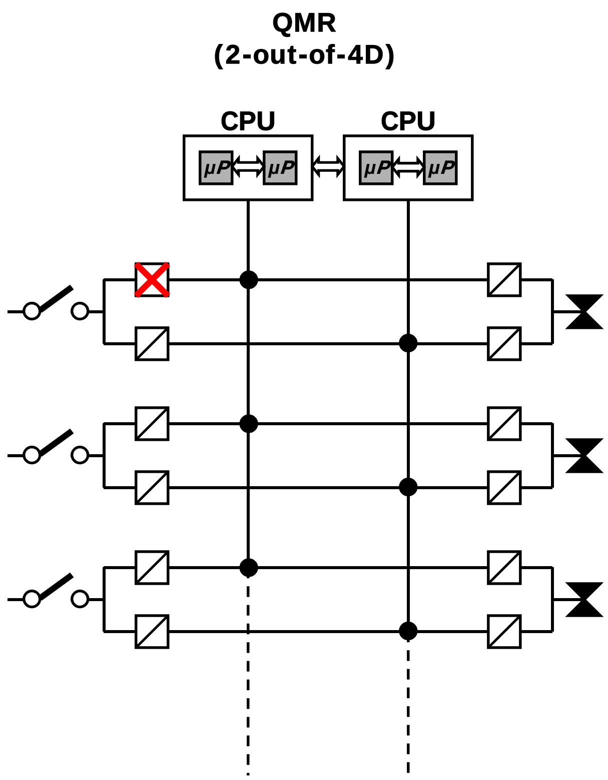


QMR
(2-out-of-4D)



FAILURE OF ONE INPUT LEG





No voting on the card = basic principle killed

Diagnostic downgrade

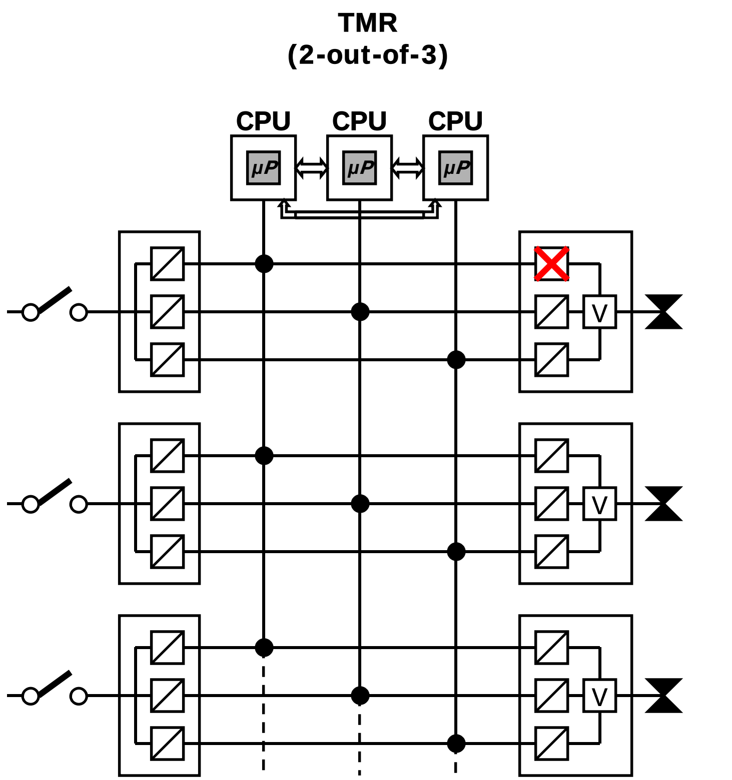
Time limit

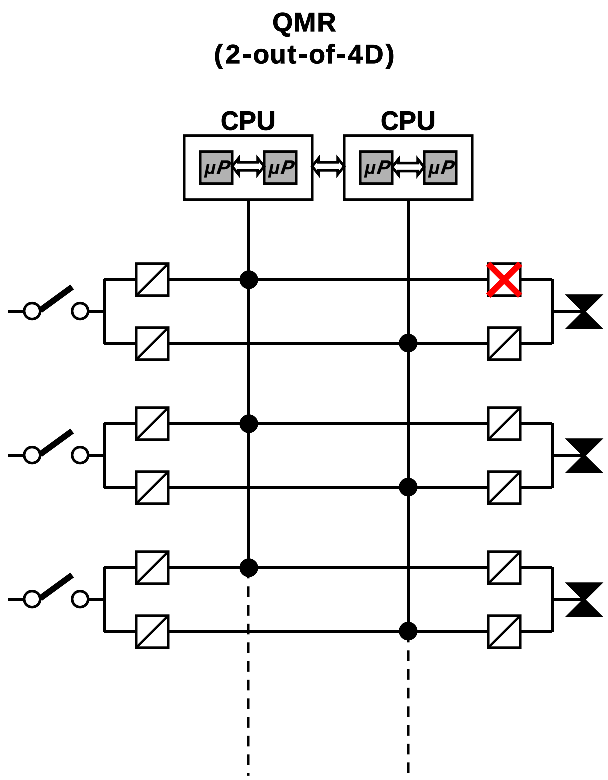
100 % diagnostic on healthy card

No downgrade

No time limit

FAILURE OF ONE OUTPUT LEG





No voting on the card = basic principle killed

Diagnostic downgrade

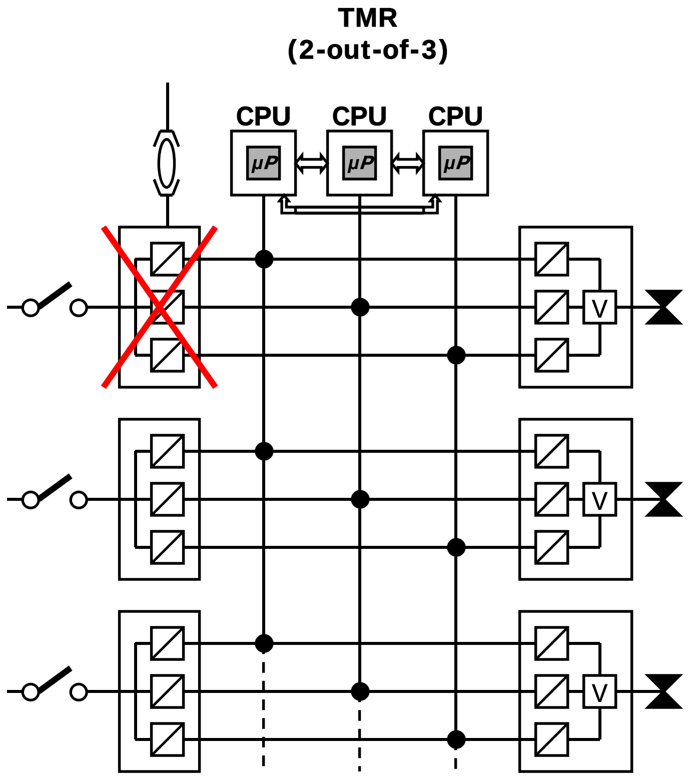
Time limit

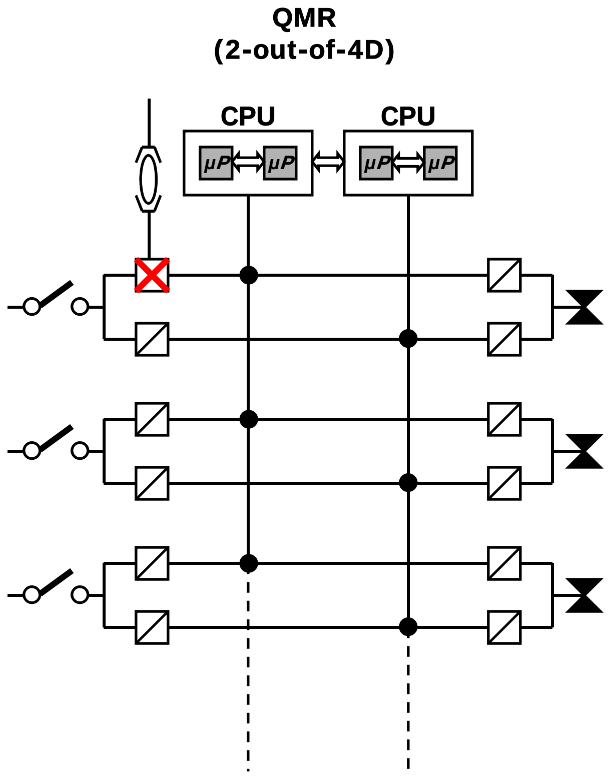
100 % diagnostic on healthy card

No downgrade

No time limit

FAILURE ON INDIVIDUAL POWER SUPPLY





No signal available for control

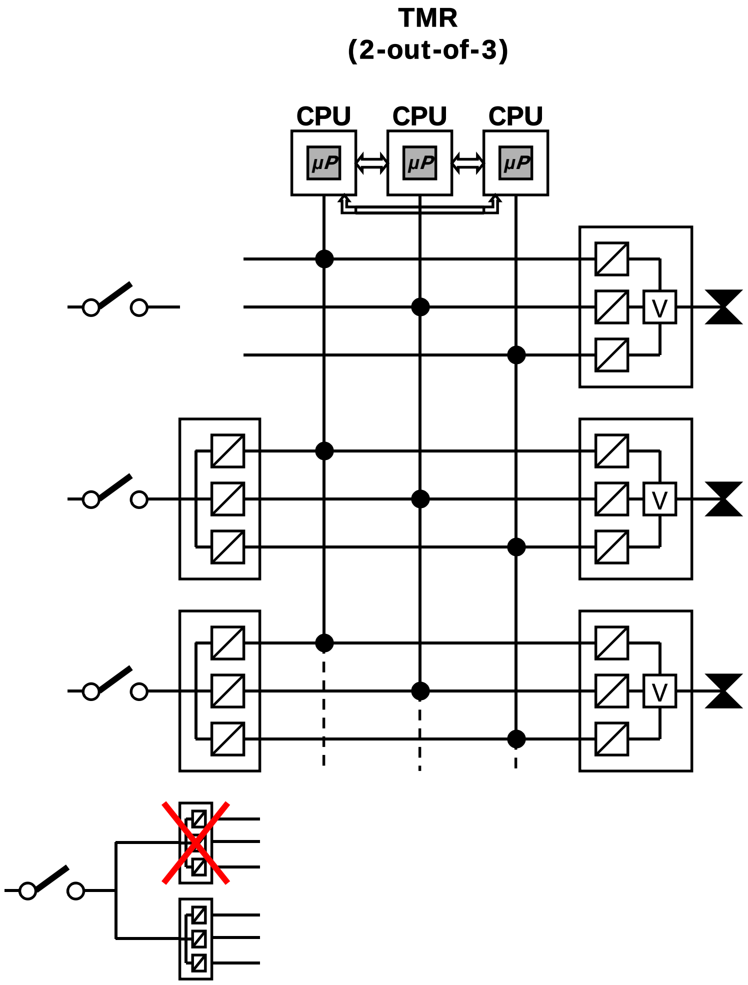
Redundancy on input / output killed

Common Cause Failure

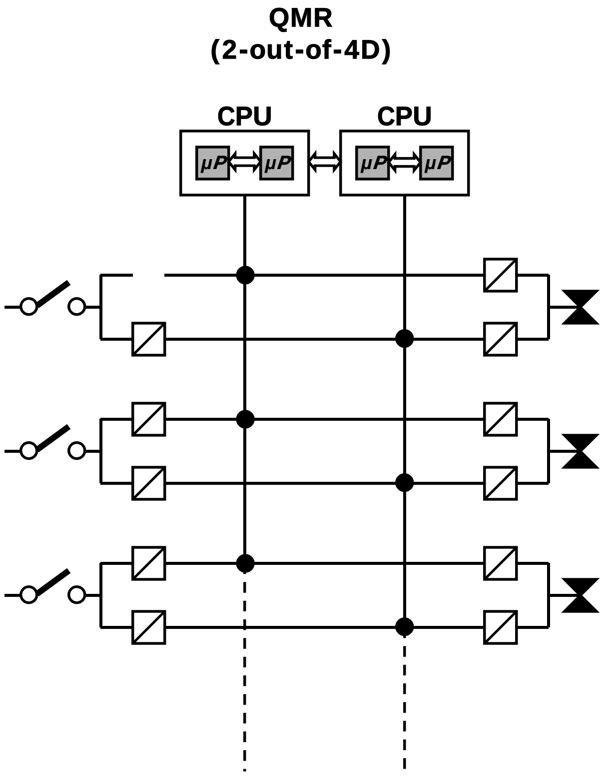
No effect

No Common Cause Failure

REPLACEMENT OF FAILURED MODULE

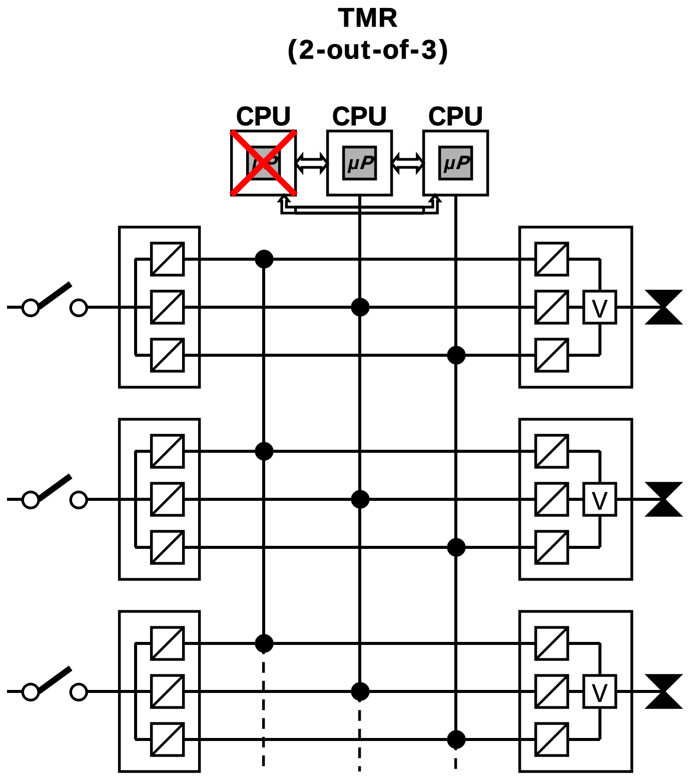


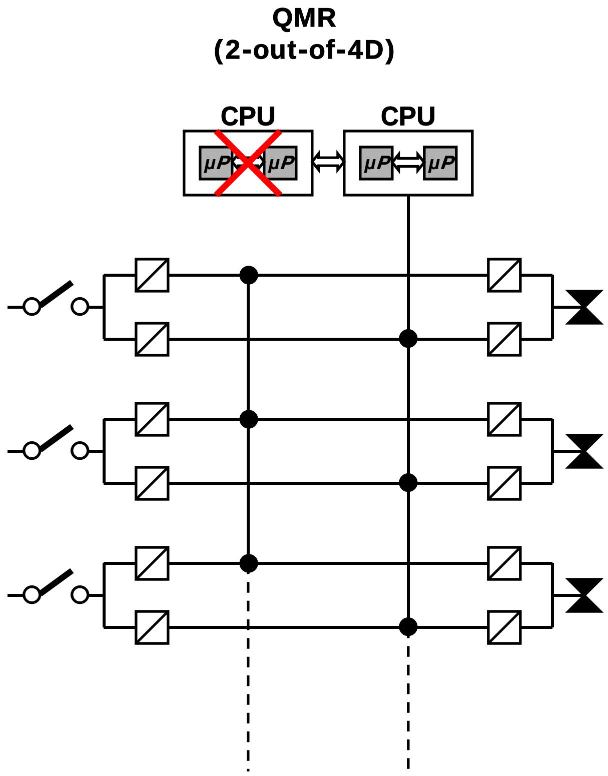
When replacing, a stand-by card must be inserted, unless installed redundant cards



No problems for continuation

FAILURE OF ONE CENTRAL MODULE





The basic diagnostic principle “voting” is killed on all input and output cards

Diagnostic downgrade

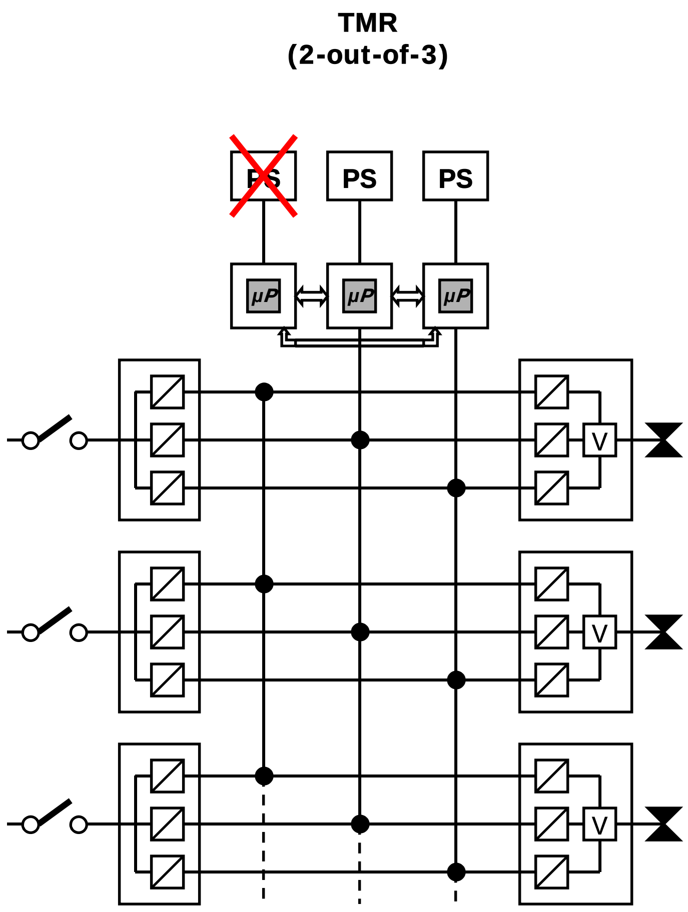
Time limit

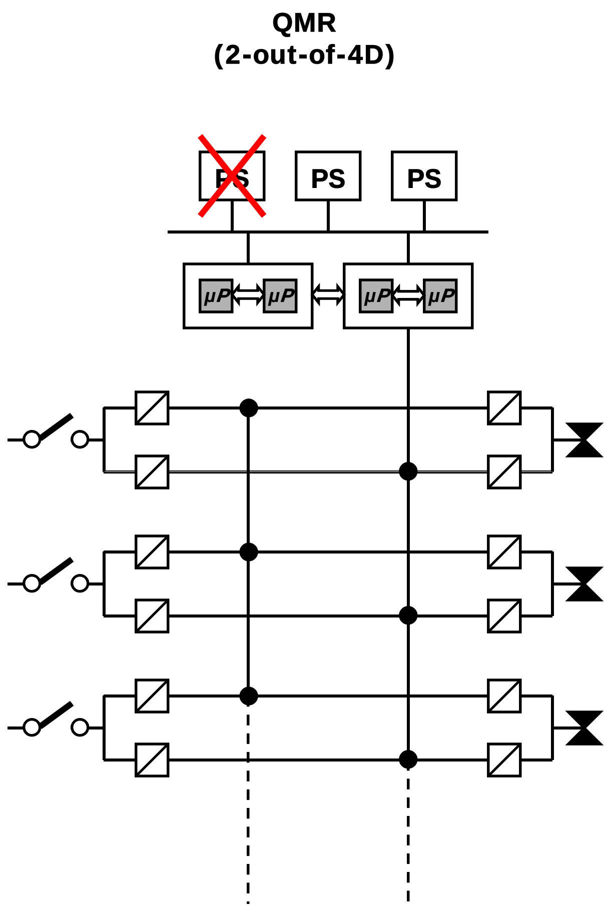
No impairment

No downgrade

No time limit

THE LOSS OF POEER UNIT

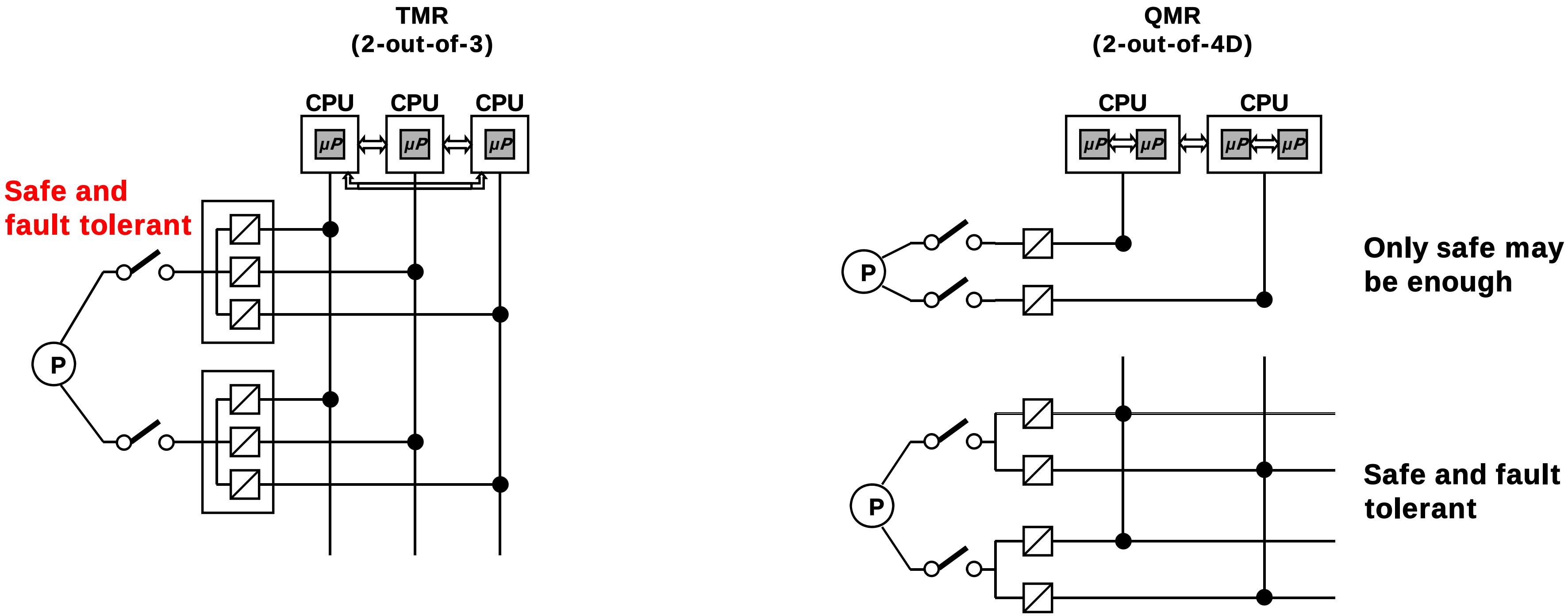




(In some TMR systems), it causes failure of the relavent central unit, bus, legs, and etc.

No problems for continuation

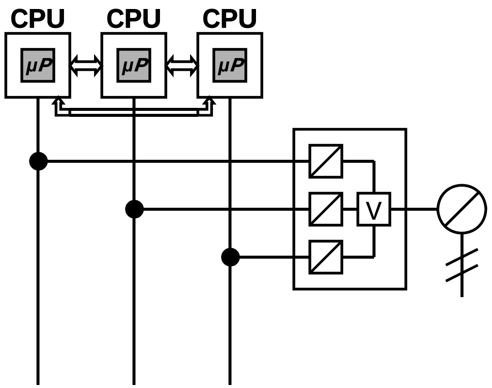
SIL 3: NON SAFETY RELATED SENSORS MUST BE DUPLICATED



HENCE, TWO POINTS OF CONNECTION NEEDED

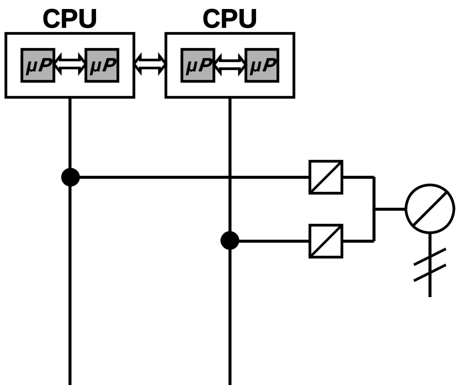
ANALOG OUTPUT FAULT TOLERANT

TMR
(2-out-of-3)



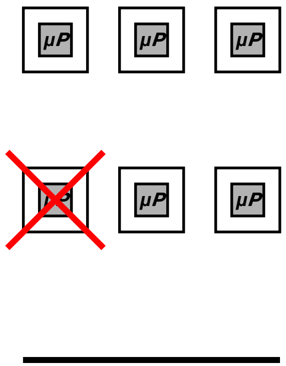
Not available

QMR
(2-out-of-4D)

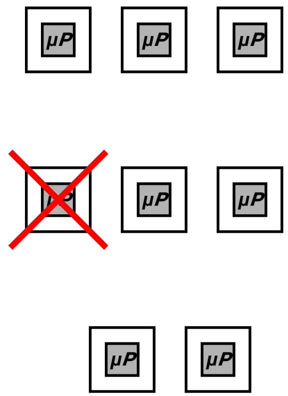


Available

TMR CENTRAL SYSTEM DOWNGRADING STEPS



STOP



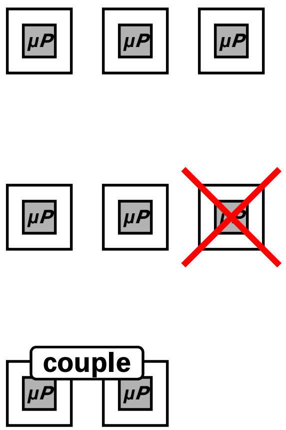
TIME LIMIT

REASON BEING: The diagnostic coverage factor provided by the healthy COUPLE of CU's is...

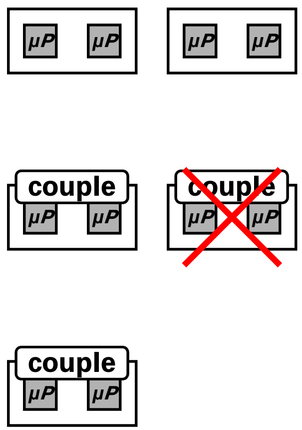
NOT SUFFICIENT	SUFFICIENT BUT... NOT ENOUGH
Pilz	Triconex

HIMA IS MORE FAULT TOLERANT THAN TMR

TMR
(2-out-of-3)



QMR
(2-out-of-4D)



Limited diagnostic coverage

Time limit

IMPERFECT COUPLE

Full diagnostic coverage

No time limit

PERFECT COUPLE

CONCLUSION

TMR: What customer believe...

One triplicated system combines the benefits of three safety systems

Downgrade is 3 → 2 → 1 → 0

Fault tolerant is maximum

The superiority of triplicated system is confirmed by Markov modeling

It is more expensive because it is worth more

MTBF is higher

CONCLUSION

Indeed…

As far as safety is concerned TMR needs three systems to do what HIMA can do with one!

Downgrading steps are as many as HIMA (3 → 2 → 0 vs. 4 → 2 → 0)!

HIMA is more fault tolerant than TMR!

HIMA's MTBF is about 10 times higher than TMR!

TMR has more Common Mode Failures (voting itself, power, disturbance to external influences, and etc.)!

TMR requires a lot of cycles to perform the complete memory test (for an average application, a time from 20 to 30 seconds can be expected – what about the safety time then?)!

What is the meaning of faster cycle time?!

Ask customers about false trips by TMR, high maintenance costs, alarming due to flickering of contacts!