Improvements in Generator Breaker Failure Protection During Low-Current Conditions

Matchyaraju Alla, **Sumit Sawai**, and **Normann Fischer**,
Schweitzer Engineering Laboratories, Inc.

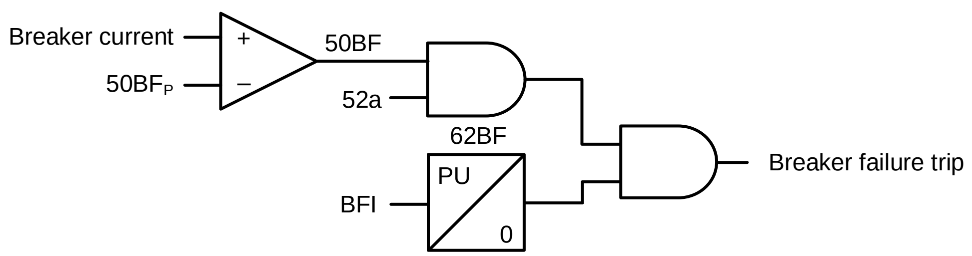
Breaker failure schemes

50BF AND 52a

If circuit breaker is stuck, 52a still indicates circuit breaker is open

Scheme is less dependable but more secure

NERC report identified issues with 52a contact



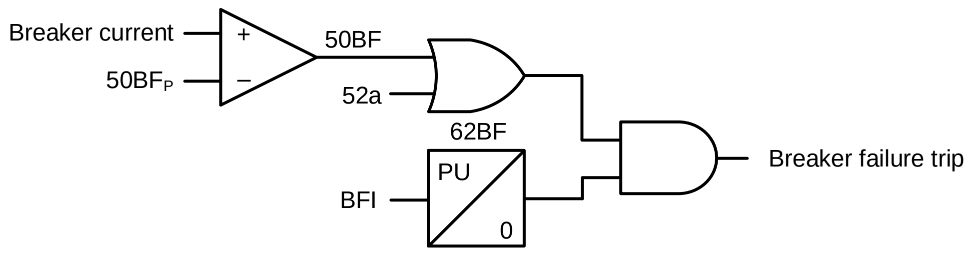
Breaker failure schemes

50BF OR 52a

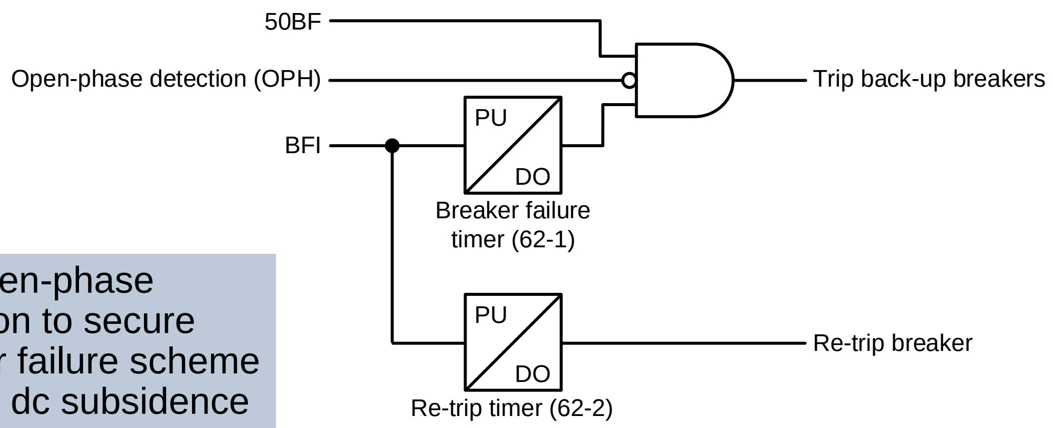
IEEE C37.119 recommends scheme

Scheme is more dependable but less secure

Incorrect 52a can issue breaker failure trip



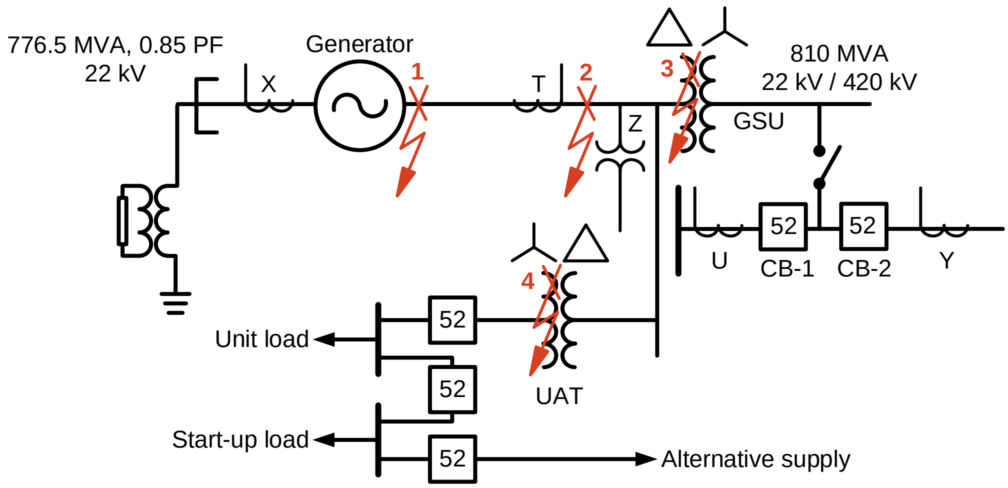
Breaker failure scheme in digital relays



Use open-phase detection to secure breaker failure scheme against dc subsidence

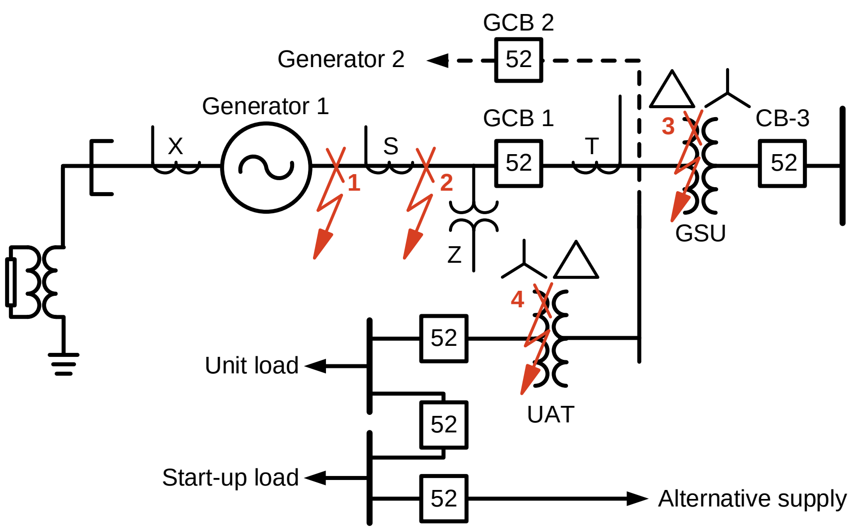
Schemes with GCB located on HV side of GSU

Use breaker currents for 50BF schemes



Schemes with GCB located on LV side of GSU

Use breaker currents for 50BF schemes

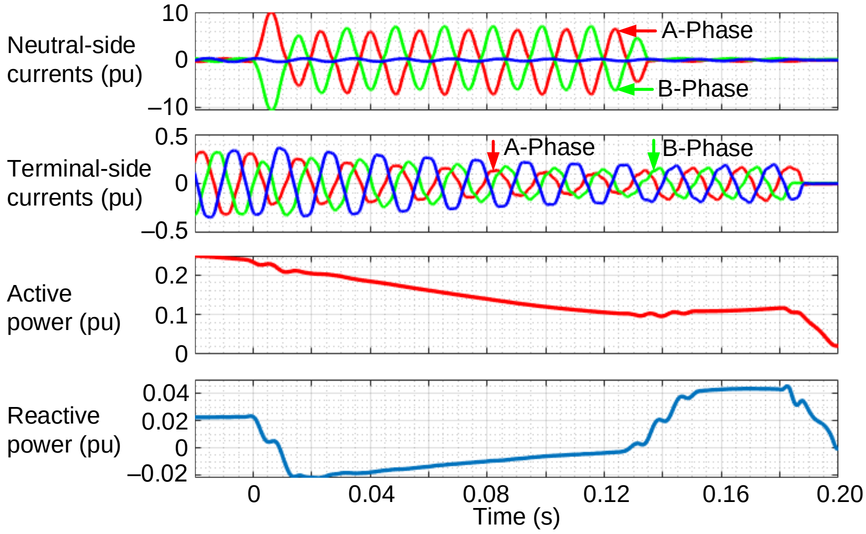


87 trips do not always engage 50BF scheme

A-B-phase fault close to generator neutral side

50BF schemes fail because of low breaker currents

Generator absorbs Q

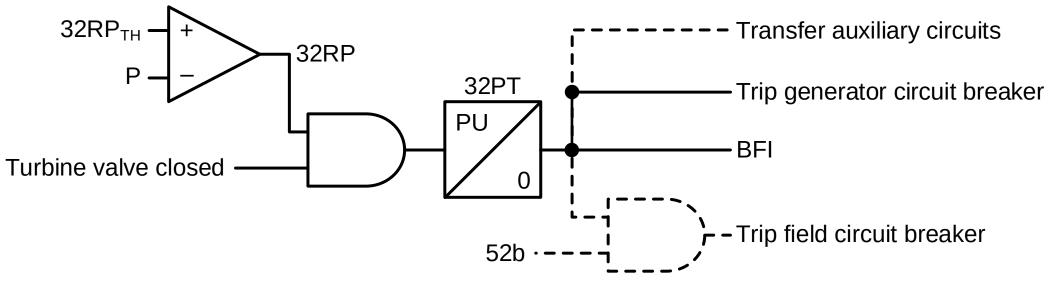


Sequential shutdown increases turbine life

Works on reverse power

Can also use low forward power

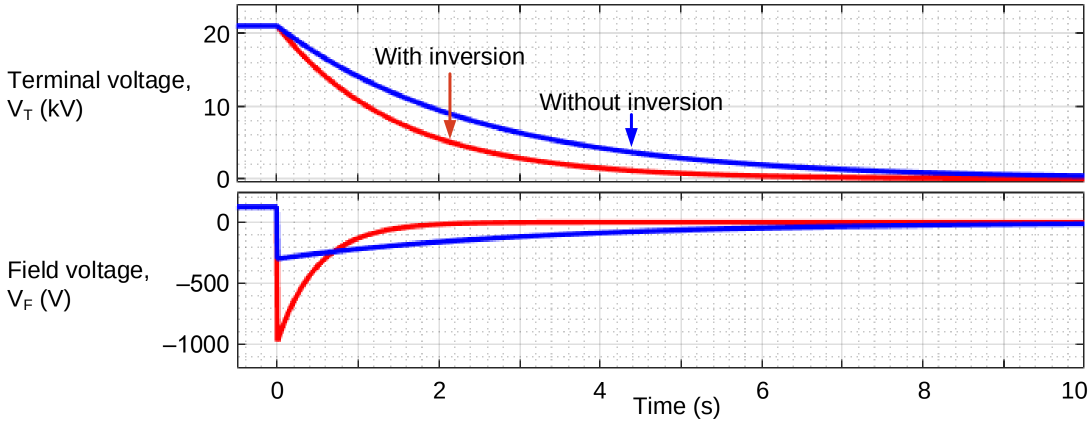
Uses 52b to supervise excitation trip (optional path)



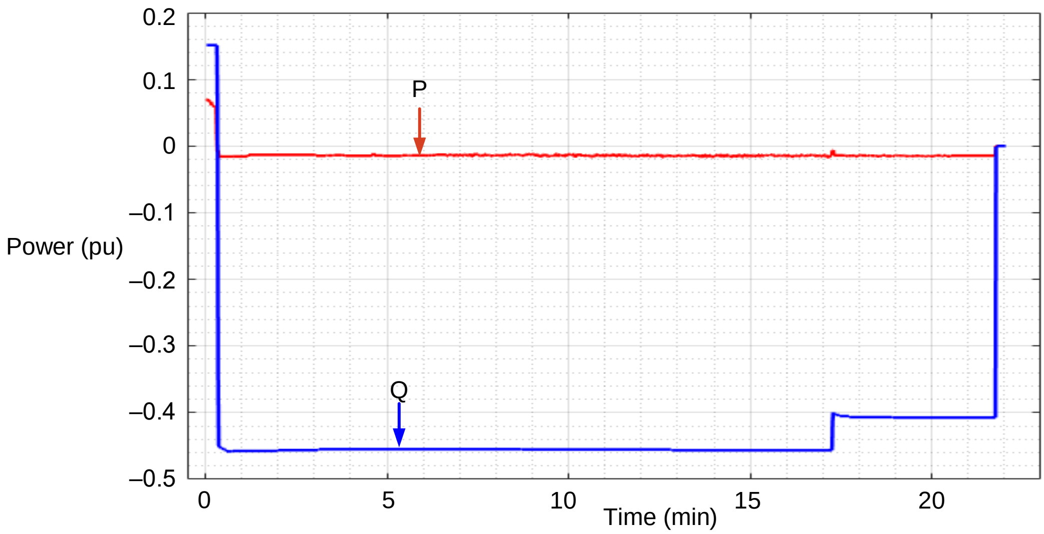
Examining generator de-excitation

$V_F = 1.35 \cdot V_{ac} \cdot \cos \alpha$

where V_{ac} is the excitation transformer-rated secondary voltage



GCB failure to open caused motoring of steam-driven turbo generator



Breaker failure schemes in generator protective relays have benefits

Avoid issues caused by BFI spurious initiations or dc circuit issues

Set 50BFP to sensitive limit

Breaker-status logic

Uses 52a, 52b, and OPH for better breaker-status logic

Synchronization-check-based scheme

Uses voltage measurements of both sides of breaker

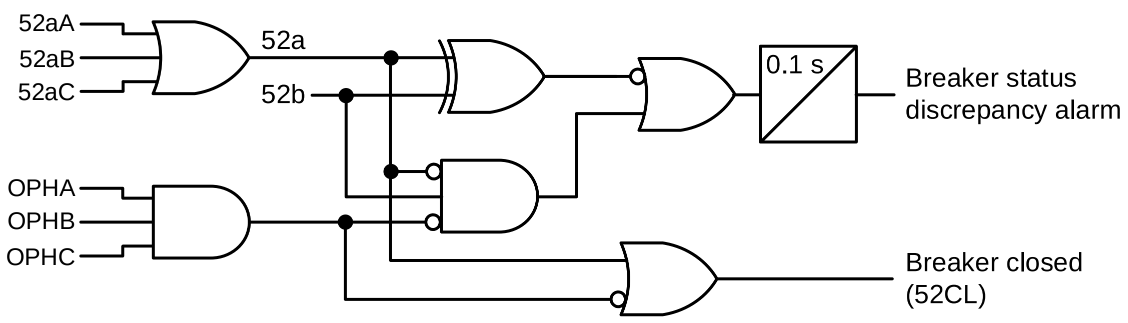
Power-based scheme

Uses both active and reactive power measured at generator terminals

Open-phase detection improves breaker status

52CL is more dependable and less secure than 52a

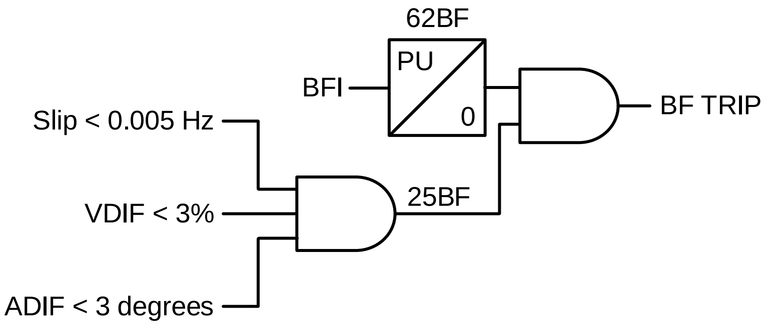
OPH deasserts when ac current peak is more than 0.05 pu



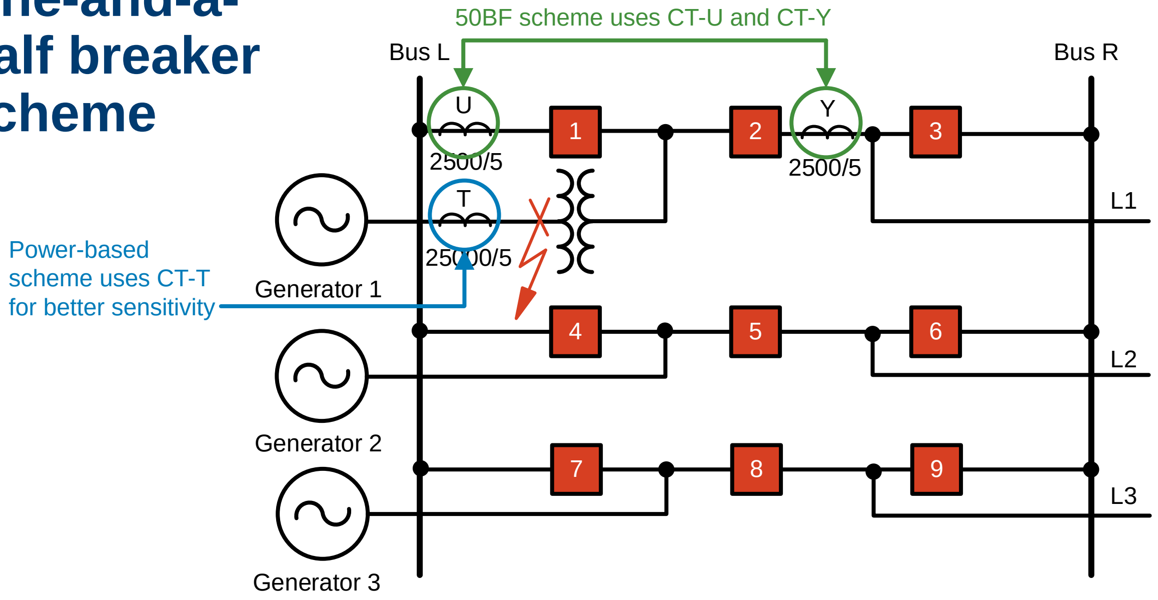
Voltage-based scheme checks for synchronism

Requires synchronism-check function in relay

Setting of 15 to 60 cycles is recommended



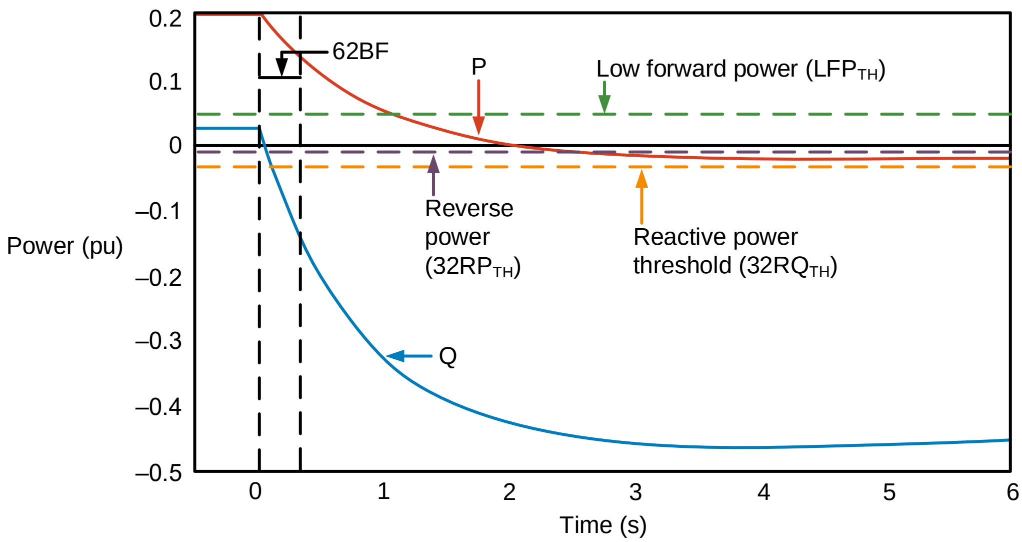
One-and-a-half breaker scheme



New power-based logic improves dependability

- $50BF_P$ for CT-U = 0.05 pu on I_{NOM}
- $50BF_P$ for CT-Y = 0.05 pu
- Total 50BFP = 0.1 pu
- CT-T current = 0.19 pu
- Generator MVA corresponds to 50BFP = 181 MVA
- 50BF scheme cannot determine if GCB is open or closed if load <181 MVA

RTDS simulation of a simultaneous trip

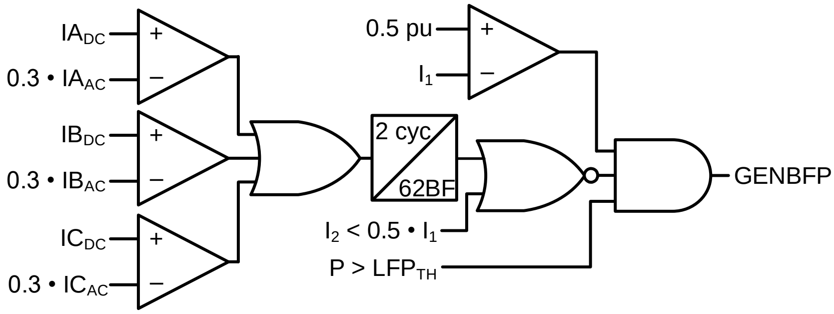


New logic uses generator power to supervise breaker opening during simultaneous trip

Low forward power checks for breaker failure condition

I_2 checks for phase-to-phase faults

DC check identifies three-phase faults

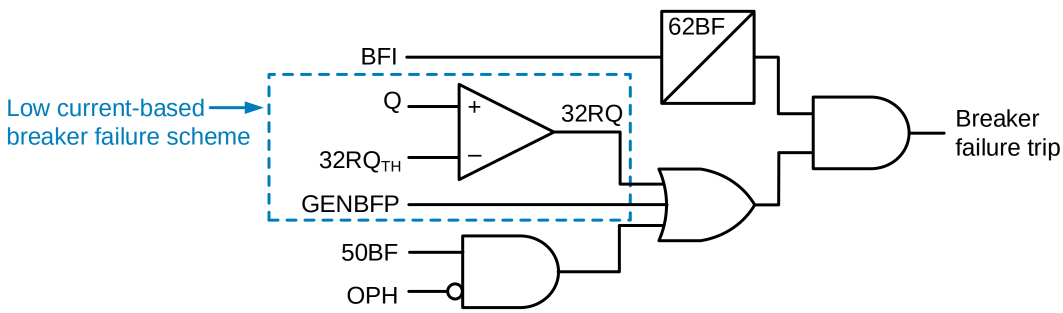


New logic uses generator power to supervise breaker opening during simultaneous trip

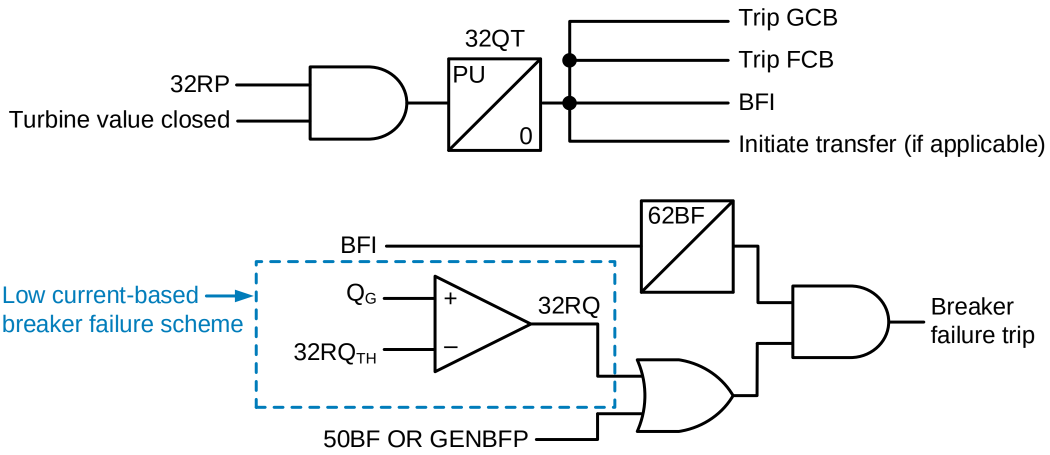
50BF uses breaker currents (CT-U and CT-Y)

GENBFP is for simultaneous trip

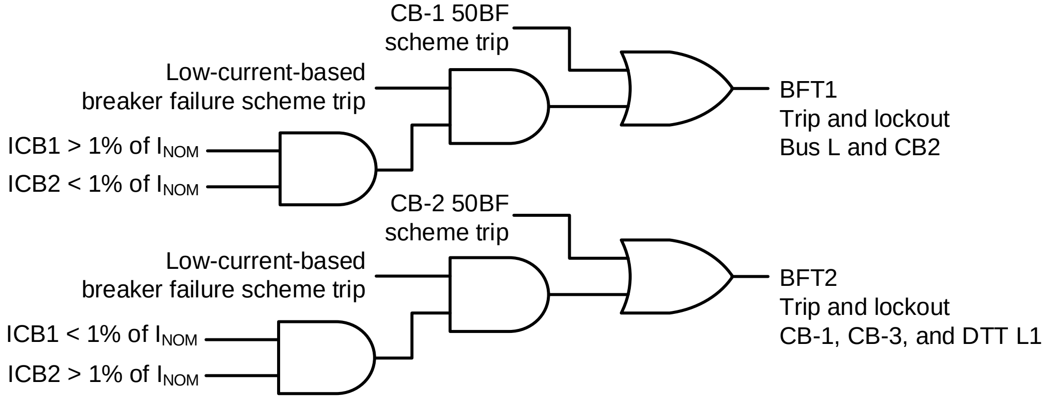
32RQ can see based on Q loading prior to trip



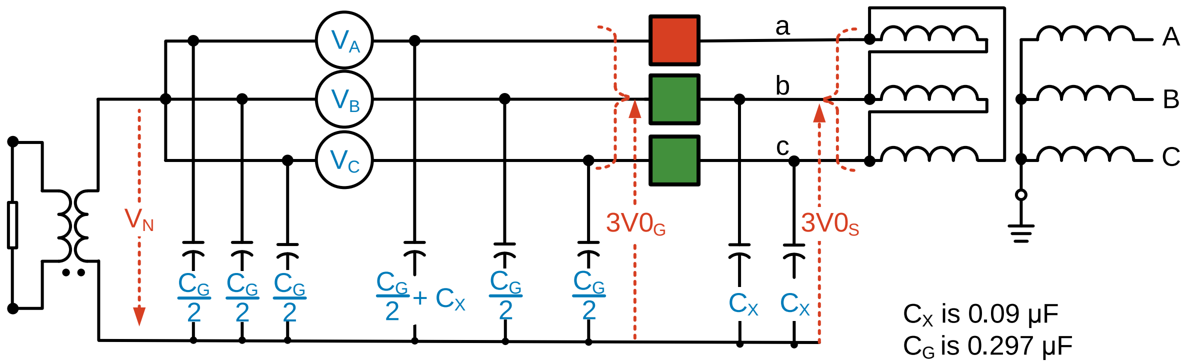
New breaker failure scheme uses reactive power to supervise breaker opening under sequential shutdown



Selecting breakers for one-and-a-half breaker scheme

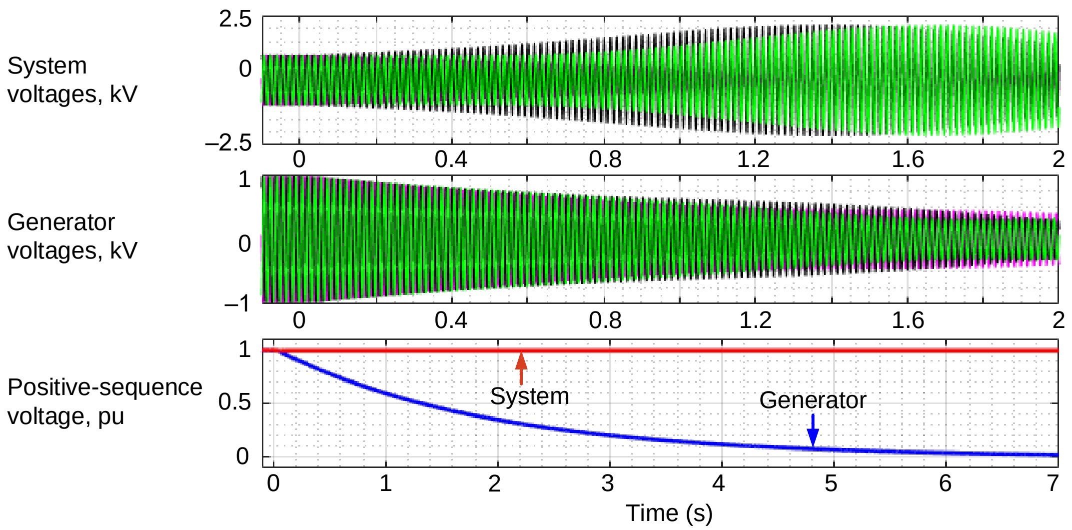


Examining generator equivalent circuit with capacitances

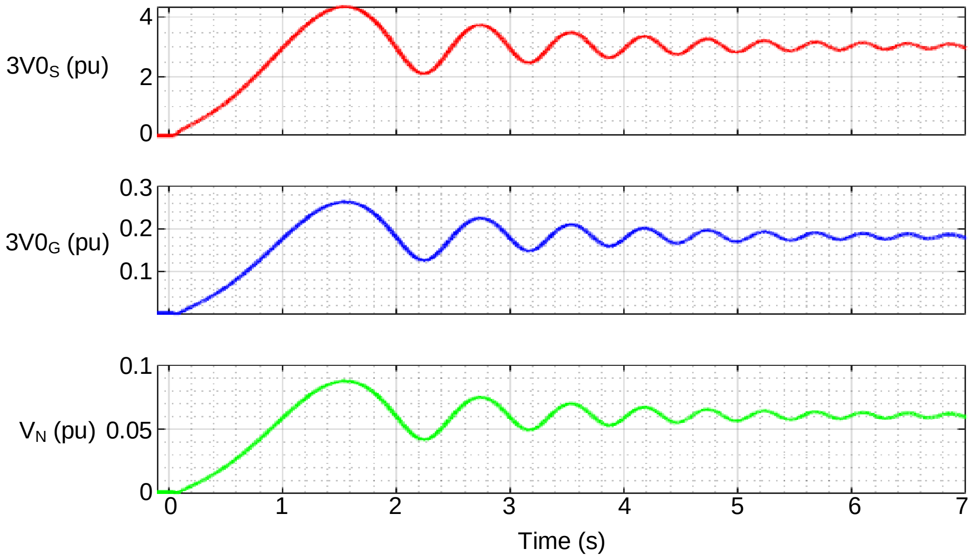


C_X is 0.09 μF
C_G is 0.297 μF

Analyzing an RTDS simulation of single-pole stuck condition on GSU LV breaker

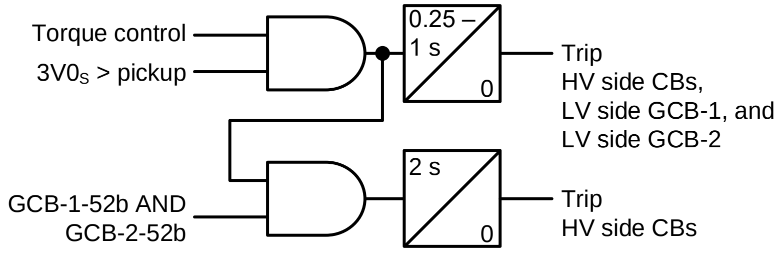


3V0 at LV bus can detect single-pole stuck



Ground fault isolation logic for two generators sharing common GSU has benefits

Torque control can supervise scheme operation for system faults and LOP conditions



Conclusions

50BF scheme cannot cover most faults if $50BF_P$ is not sensitive

Breaker failure schemes should be more biased toward security

Schemes implemented inside generator protective relay are immune to unwanted BFI assertions

Conclusions

Use one of the following schemes to improve breaker failure protection

- Improved auxiliary contact scheme
- Synchronism-check-based scheme – uses PT on both sides of GCB
- New power-based breaker failure scheme that uses generator terminal measurements to make scheme more secure and dependable

GSU LV-side pole stuck can be identified as traditional iso-phase bus ground fault protection

Questions?