Generator Synchronising: Slip, Advance Angle and Breaker Voltage

Slip frequency, beat period and synchroscope speed when paralleling a generator, the breaker closing advance angle and the voltage across the open breaker.

Method: Synchronising of synchronous machines

Input parameters

Unit system: SI

Parameter	Value	Unit
Incoming generator frequency	50.120	Hz
Bus frequency	50.000	Hz
Incoming generator voltage	11,100	V
Bus voltage	11,000	V
Present phase angle between them	10.000	°
Breaker closing time	80.000	ms

Calculated results

Parameter	Value	Unit
Slip frequency	0.12000	Hz
Beat (slip) period	8.3333	s
Advance angle to cover the breaker closing time	3.4560	°
Voltage across the open breaker at δ	1,928.7	V
Maximum voltage across the breaker (out of phase)	22,100	V
Voltage mismatch	0.90909	%

Notes for this case

• The phase angle between the incoming machine and the bus advances by 360° every 1/Δf seconds (the synchroscope turns at Δf revolutions per second, clockwise when the generator is fast). Because the breaker takes t_cb to close, the close command must be given an angle 360°·Δf·t_cb before coincidence. The voltage across the open breaker is |V_g − V_b∠δ|, reaching V_g + V_b at 180°. Typical limits for automatic synchronisers are about 0.1–0.2 Hz slip, ±10° and ±5 % voltage, with the generator slightly fast so it picks up load on closing.

Formula and method

$$\Delta f = f_g - f_b, \quad \delta_{adv} = 360^\circ \, \Delta f \, t_{cb}, \quad V_{CB} = \sqrt{V_g^2 + V_b^2 - 2 V_g V_b \cos\delta}$$

Variables

f_g	Incoming generator frequency	1/s
f_b	Bus frequency	1/s
V_g	Incoming generator voltage	V
V_b	Bus voltage	V
δ	Present phase angle between them	rad
t_{cb}	Breaker closing time	s
Δf	Slip frequency	1/s
T_s	Beat (slip) period	s
δ_{adv}	Advance angle to cover the breaker closing time	rad

V_{CB}	Voltage across the open breaker at δ	V
$V_{CB,max}$	Maximum voltage across the breaker (out of phase)	V
ΔV	Voltage mismatch	-

Method and standards

Synchronising.

Assumptions and limits

- Steady slip during the closing time; balanced three-phase voltages.

References

Synchronising of synchronous machines

Report details

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Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

https://calc.firecad.com/electrical/power/synchronising-slip-frequency

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.