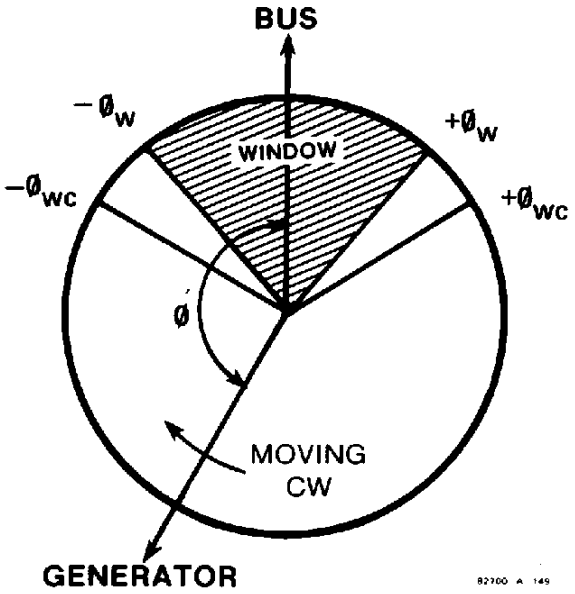
WOODWARD

Application Note 50511
(Revision A)

Original Instructions



Prediction of Phase Angle at Paralleling Breaker Closure

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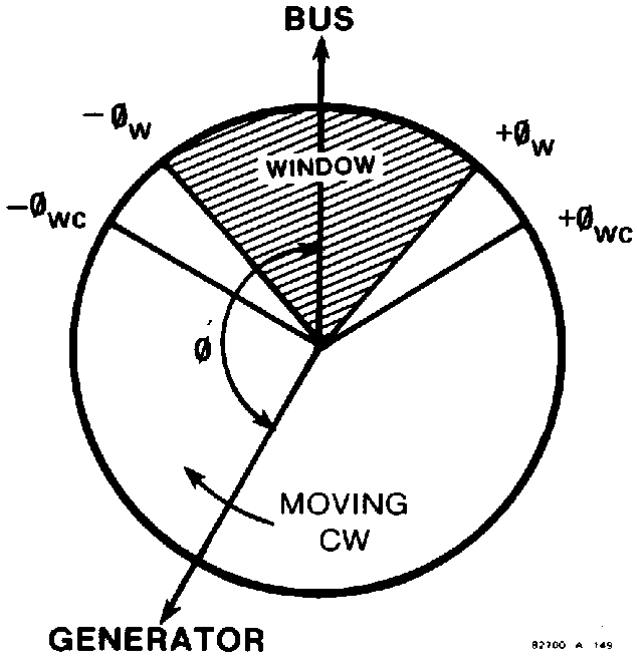
Reduction of the Worst Case Phase Angle Difference (Φ) at the Instant of Breaker Closure



Worst-case prediction of phase-angle difference assumes there is no generator-speed correction from the SPM-A synchronizer (in the permissive mode). In the run mode, the SPM-A continues to adjust generator speed toward exact phase match during the period the breaker is closing. This provides even better synchronization than the calculations indicate.

The following calculation can be performed to determine if the SPM-A synchronizer will provide adequate synchronization before the breaker contacts engage in the permissive mode.

Each generator system has a worst case of maximum allowable relative phase angle (Φ_{wc}) that can be tolerated at the time of breaker closure. If Φ_{wc} and the breaker time delay (T_b) are known, the synchronizer's phase window (Φ_w) and window dwell time may be chosen by resistor and switch options to ensure that Φ is less than Φ_{wc} when the generator breaker contacts engage. The SPM-A will not issue the breaker closure command unless Φ is within the window ($\Phi \leqq \Phi_w$) and has been there for at least the window dwell time. The drawing shows the relative values of Φ and assumes that the bus voltage is fixed and pointing straight up.

The relative phase angle, at the instant the main generator breaker contacts engage, depends on many things. The worst case value would exist when the SPM-A is in the permissive mode and therefore is not actively correcting the phase angle during the window dwell time and breaker closing time.

Assuming Φ continues to rotate at a constant rate, and that the circuit-breaker time delay (T_b), selected SPM-A window (Φ_w), and selected SPM-A window dwell time (T_{wd}), are known, the worst-case value which the SPM-A will allow (Φ_s) can be predicted. Φ_s is equal to Φ at the time the SPM-A issues the breaker closure command (Φ_w in the worst case) plus the change in Φ due to the rate of change in Φ times the breaker delay (T_b in the worst case). Therefore, $\Phi = \Phi_{wc}$ when Φ (at the instant the breaker-closure command Is issued) = Φ_w. The rate of change of Φ (Φ/sec) is the total degrees in the window divided by the window dwell time or

$$\frac{2\Phi_w}{T_{wd}}$$

Then

$$\Phi_{wc} = \Phi_s = \Phi_w + \frac{2\Phi_w}{T_{wd}}(T_b)$$

For Example:

Assume an SPM-A configured for a window of ±10 degrees and a window dwell time of 1/2 second. Assume the breaker is never slower than 13 cycles.

If:

$\Phi_{wc} = 10°$

$T_{wd} = 0.5$ s

$$T_b = \frac{13 \text{ cycles}}{60 \text{ cycles/s}} = 0.217 \text{ s}$$

Then:

$$\Phi_{wc} = \Phi_s = 10° + \frac{2(10°)}{0.5 \text{ s}}(0.217 \text{ s})$$

$\Phi_{wc} = 18.7°$

In comparison, a window of ±5° and a window dwell of 1 second, using the same breaker:

$$\Phi_{wc} = \Phi_s = 5° + \frac{2(5°)}{1 \text{ s}}(0.217 \text{ s})$$

$\Phi_{wc} = 7.2°$

IMPORTANT **These calculations are for worst case, which would be in the permissive mode. In the run mode, the SPM-A continually reduces the relative phase angle toward 0 until the circuit-breaker contacts close.**

We appreciate your comments about the content of our publications.

Send comments to: icinfo@woodward.com

Please reference publication 50511A.

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