GE Digital Energy
Multilin

GE Multilin technical note

Synchronizing multiple buses using common voltage measurements

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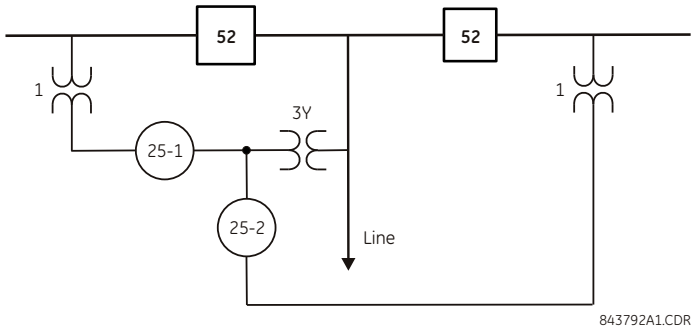
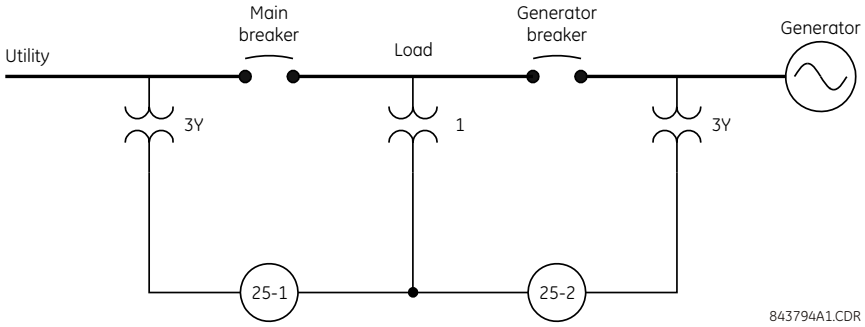
Introduction

There are several applications on the power system when it is necessary to synchronize one bus or line to two different buses or lines. One such application is reclosing a transmission line that uses dual breaker line terminals, such as breaker-and-a-half and ring bus. It is necessary to synchronize the line between each source separately, requiring two independent synchrocheck functions using a common voltage measurement from the transmission line.



A second application is a small generation system that can operate in parallel with the utility source, or serve and maintain load separate from the utility source. In this application, it is typical to synchronize voltages across the load bus. This method requires synchrocheck from the generator to the load bus, and from the utility source to the load bus. Both synchrocheck functions use a common voltage measurement from the load bus.



The traditional solution for either of these applications requires the use of two independent synchrocheck relays. The UR family of protection relays from GE Multilin provide two independent synchronism check functions in each relay. An individual UR-series device can have multiple voltage inputs to measure the synchronism voltages. Configurable analog signal sources allow any voltage measurement to be explicitly assigned to the two independent synchrocheck functions.

Voltage measurements in the UR family

The UR family is a modular platform, allowing great flexibility when configuring a relay for a specific application. A key module for the UR-series device is the "magnetics" or digital signal processing (DSP) CT/VT module that directly measures current and voltage from the power system. Each CT/VT module has two banks of input signals, and each bank accepts four current or four voltage measurements. A voltage bank measures three phase voltages (VA, VB, VC) and an auxiliary voltage. The auxiliary voltage can be assigned as any single-phase voltage measurement, including zero-sequence voltage. Therefore, applications for two independent synchrocheck functions require the use of two voltage banks. Practically, this requires the use of two CT/VT modules in a UR-series device.

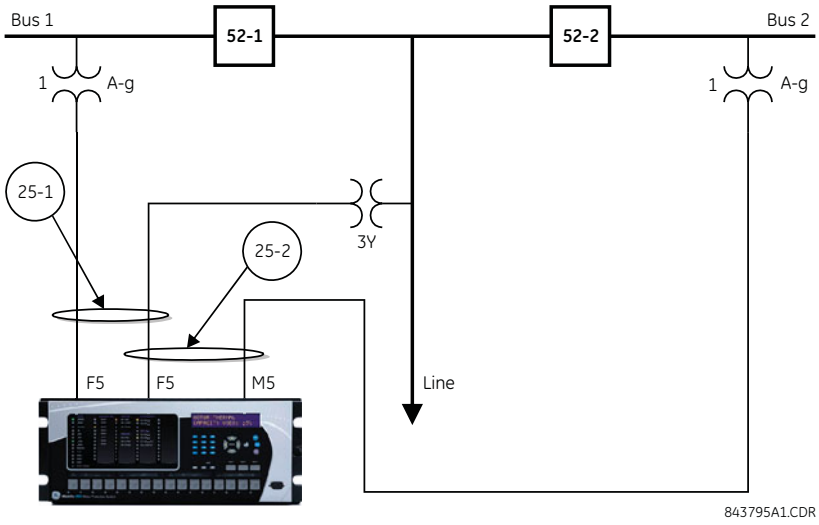
Analog signal sources

Analog signal sources (a "source") combine the physical current and voltage measurements from CT/VT modules together to create a single measurement point in the UR-series device. Protection functions are then configured to use a specific source or sources. This allows great flexibility in assigning different protection functions in the UR-series device to protect different equipment. A source can include any combination of phase current, ground current, phase voltage, and auxiliary voltage measurements. For a given protection function, these measurements can be drawn from any CT/VT module installed in the UR-series device. Any specific measurement can be used in more than one source.

The synchrocheck function in the UR-series device uses two different sources for the two voltage measurements. These two sources can be three-phase or single-phase voltage measurements. The application of two independent synchrocheck functions described here therefore requires the use of at least three sources.

Synchrocheck example 1: dual-breaker line terminals

This example uses the D60 Line Distance Protection System measuring the three-phase line voltage, and two different single-phase synchronism voltages (the configuration is the same for the L60, L90, and C60 devices). This example also assumes an 8L module (one current bank and one voltage bank) in the "F" slot of the relay, and an 8L module in the "M" slot. For synchronizing to either bus, the relay uses a phase A-to-ground voltage measurement.



The following steps are used configure a UR-series device to synchronize across multiple buses.

1. Configure the voltage inputs.
2. Configure the voltage signal sources.
3. Configure the synchrocheck functions.

Voltage inputs

Each voltage bank has three phase voltage inputs and an auxiliary voltage input. The inputs are labeled based on the first terminal of the bank. Therefore "F5" means the voltage bank that is associated with the 8L module in the "F" slot, and terminals F5 (VA), F6 (VB), F7 (VC), and F8 (VX). The three-phase voltages are configured for Wye or Delta connection, with the appropriate turns ratio. The auxiliary voltage is configured as appropriate: a specific phase-ground voltage (phase A-to-ground in this example), phase-to-phase voltage, or auxiliary voltage.

PARAMETER	VT F5	VT M5
Phase VT Connection	Wye	Wye
Phase VT Secondary	66.4 V	66.4 V
Phase VT Ratio	100.00 :1	100.00 :1
Auxiliary VT Connection	Vag	Vag
Auxiliary VT Secondary	66.4 V	66.4 V
Auxiliary VT Ratio	100.00 :1	100.00 :1

A-g auxiliary voltage for synchrocheck

Three-phase voltage for line

Voltage connections for synchrocheck applications can be either phase-to-ground voltages or phase-to-phase voltages. However, synchrocheck only works when the voltages in both sources are the same type: either both phase-to-ground or both phase-to-phase voltages.

Voltage sources

The synchrocheck function in the UR-series device must use two different signal sources as inputs. Therefore, this application requires three signal sources: one for each bus voltage and one for the protected line. Each source can be either a single-phase source or a three-phase source. When using a three-phase source and a single-phase source, the UR-series device automatically selects the correct voltage from the three-phase source to compare to the single-phase source. If using two single-phase sources, then both signal sources must use the same relative voltage (VAG to VAG, VAB to VAB, etc.) The three sources, when configured, look like:

PARAMETER	SOURCE 1	SOURCE 2	SOURCE 3
Name	52-1	52-2	Line
Phase CT	F1	M1	F1+M1
Ground CT	None	None	None
Phase VT	None	None	F5
Aux VT	F5	M5	None

A-g voltage from bus 1

A-g voltage from bus 2

Three-phase voltage from line

Source 1 is the A-phase-to-ground voltage from bus 1. This source also included the current flowing through breaker 52-1.

Source 2 is the A-phase-to-ground voltage from bus 2. This source also included the current flowing through breaker 52-2.

Source 3 is the three-phase voltage on the protected line. This source also includes the total line current, which is the summation of the currents from each breaker supplying the line.

Synchrocheck function

Configuring the synchrocheck function is a matter of selecting the appropriate sources for each function, then entering settings as appropriate. In this example:

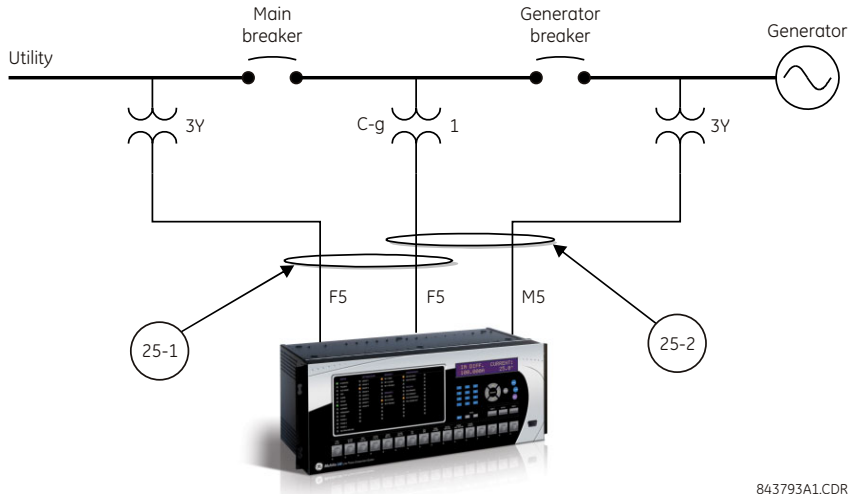
PARAMETER	SYNCHROCHECK1	SYNCHROCHECK2
Function	Enabled	Enabled
Block	OFF	OFF
V1 Source	LINE (SRC 3)	LINE (SRC 3)
V2 Source	BKR 1 (SRC 1)	BKR 2 (SRC 2)
Max Volt Diff	37000 V	37000 V
Max Angle Diff	40 deg	40 deg
Max Freq Diff	0.04 Hz	0.04 Hz
Freq Hysteresis	0.06 Hz	0.06 Hz
Dead Source Select	None	None
Dead V1 Max Volt	0.20 pu	0.20 pu
Dead V2 Max Volt	0.20 pu	0.20 pu
Live V1 Min Volt	0.80 pu	0.80 pu
Live V2 Min Volt	0.80 pu	0.80 pu
Target	Self-reset	Self-reset
Events	Disabled	Disabled

Synchronize line to bus 1

Synchronize line to bus 2

Synchrocheck example 2: small generator paralleling

This example uses a G30 Generator Protection System to provide generator protection, and utility interface protection. The G30 also provides synchrocheck capability between the generator and the load bus, and the utility interface and the load bus (configuration is the same for a G60 device). The G30 measures a three-phase voltage from the utility source using the type "8L" CT/VT module installed in the "F" slot, a three-phase voltage from the generator using an "8L" module installed in the "M" slot. The load bus voltage is the phase C-to-ground voltage, measured by the auxiliary voltage input of the module in the "F" slot.



The steps to configuring the G30 for dual synchrocheck functions are the same as for example 1, with only some differences in the actual settings.

Voltage inputs

The three-phase utility voltage and three-phase generator voltage are configured as wye-connected voltage measurements. The single-phase load bus voltage is configured for a phase C-to-ground voltage. The voltage ratings and turns ratio of the instrument transformers is set as appropriate to the specific application.

PARAMETER	VT F5	VT M5
Phase VT Connection	Wye	Wye
Phase VT Secondary	120.0 V	120.0 V
Phase VT Ratio	1.00 :1	1.00 :1
Auxiliary VT Connection	Vcg	Vcg
Auxiliary VT Secondary	120.0 V	120.0 V
Auxiliary VT Ratio	1.00 :1	1.00 :1

Three-phase voltage from utility source

C-g auxiliary voltage from load bus for synchrocheck

Three-phase voltage from generator source

Voltage sources

This example uses three voltage sources for synchrocheck: the "Util" source to measure the three-phase voltage from the utility, the "Gen" source to measure the three-phase voltage from the generator, and the "Sync" source to measure the phase C-to-ground voltage from the load bus.

PARAMETER	SOURCE 1	SOURCE 2	SOURCE 4
Name	Util	Gen	Sync
Phase CT	F1	M1	None
Ground CT	None	None	None
Phase VT	F5	M5	None
Aux VT	None	None	F5

Three-phase voltage from utility source

Three-phase voltage from generator

Single-phase voltage from load bus

Synchrocheck function

As before, configuring the synchrocheck function is a matter of selecting the appropriate sources for each function, and then entering settings. In this example:

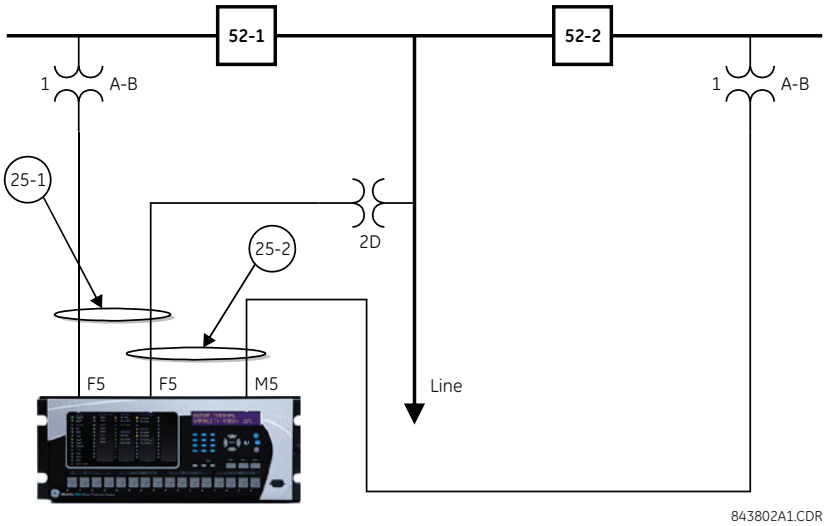
PARAMETER	SYNCHROCHECK1	SYNCHROCHECK2
Function	Enabled	Enabled
Block	OFF	OFF
V1 Source	Util (SRC 1)	Gen (SRC 2)
V2 Source	Sync (SRC 4)	Sync (SRC 4)
Max Volt Diff	10 V	10 V
Max Angle Diff	10 deg	10 deg
Max Freq Diff	1.00 Hz	1.00 Hz
Freq Hysteresis	0.06 Hz	0.06 Hz
Dead Source Select	LV1 and DV2	LV1 and DV2
Dead V1 Max Volt	0.30 pu	0.30 pu
Dead V2 Max Volt	0.30 pu	0.30 pu
Live V1 Min Volt	0.70 pu	0.70 pu
Live V2 Min Volt	0.70 pu	0.70 pu
Target	Disabled	Disabled
Events	Disabled	Disabled

Synchronize utility to load bus

Synchronize generator to load bus

Synchrocheck example 3: using phase-to-phase voltages

In many applications, particularly at distribution voltages, only phase-to-phase voltages are available. It is still possible to use multiple synchrocheck elements in the UR family in this case. However, both voltage sources in a one synchrocheck element must use phase-to-phase voltages.



The steps to configuring the G30 for dual synchrocheck functions are the same as for example 1, with only some differences in the voltage input settings.

Voltage inputs

The three-phase line voltage is configured as delta-connected phase-to-phase voltage measurements. The auxiliary synchrocheck voltages therefore must be a phase-to-phase voltage, the A-B voltage in this example. The voltage ratings and turns ratio of the instrument transformers is set as appropriate to the specific application.

PARAMETER	VT F5	VT M5
Phase VT Connection	Delta	Wye
Phase VT Secondary	115.0 V	66.4 V
Phase VT Ratio	1400.00 :1	1.00 :1
Auxiliary VT Connection	Vab	Vab
Auxiliary VT Secondary	115.0 V	115.0 V
Auxiliary VT Ratio	1400.00 :1	1400.00 :1

Three-phase line voltage measured by two delta-connected VTs

A-B auxiliary voltage for synchrocheck

A-B auxiliary voltage for synchrocheck

Voltage sources

This example uses three voltage sources for synchrocheck: the "BKR 1" source to measure the phase-to-phase synchrocheck voltage from one bus, the "BKR 2" source to measure the phase-to-phase synchrocheck voltage from the second bus, and the "LINE" source to phase-to-phase voltages on the protected line.

PARAMETER	SOURCE 1	SOURCE 2	SOURCE 3
Name	BKR 1	BKR 2	LINE
Phase CT	F1	M1	F1+M1
Ground CT	None	None	F1
Phase VT	None	None	F5
Aux VT	F5	M5	None

Phase-to-phase auxiliary voltage from bus 1

Phase-to-phase auxiliary voltage from bus 2

Three-phase voltage using two delta-connected VTs

Synchrocheck function

As before, configuring the synchrocheck function is a matter of selecting the appropriate sources for each function, and then entering settings. In this example:

PARAMETER	SYNCHROCHECK1	SYNCHROCHECK2
Function	Enabled	Enabled
Block	OFF	OFF
V1 Source	LINE (SRC 3)	LINE (SRC 3)
V2 Source	BKR 1 (SRC 1)	BKR 2 (SRC 2)
Max Volt Diff	37000 V	37000 V
Max Angle Diff	40 deg	40 deg
Max Freq Diff	0.04 Hz	0.04 Hz
Freq Hysteresis	0.06 Hz	0.06 Hz
Dead Source Select	None	None
Dead V1 Max Volt	0.20 pu	0.20 pu
Dead V2 Max Volt	0.20 pu	0.20 pu
Live V1 Min Volt	0.80 pu	0.80 pu
Live V2 Min Volt	0.80 pu	0.80 pu
Target	Self-reset	Self-reset
Events	Disabled	Disabled

Synchronize line to bus 1

Synchronize line to bus 2

Summary

Providing multiple synchrocheck functions is a practical challenge for most microprocessor-based relays. Specific models of the UR family from GE Multilin include two synchrocheck functions. The modular platform of the UR family allows the measurement of multiple sets of three-phase and single-phase voltages. The use of analog signal sources provides easy configuration of the UR-series device to distinguish between individual voltage measurements to provide synchrocheck between a transmission line and two different buses, or between a generator, utility source, and load bus.

References

1. B. Kasztenny, K. Kuras, "The Source Concept Considerations in a Protective Relay", GE Multilin publication GER-3985, Markham, Ontario, Canada, 2001.
2. *D60 Line Distance Relay Instruction Manual*, GE Multilin publication GEK-113317A, Markham, Ontario, Canada, 2007.

Symbols

The following symbols are used in this document.