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■ Synchronization Panel Wiring Diagram PDF — Complete Generator Paralleling System Connection Guide

Introduction

A generator synchronization panel, also known as a paralleling switchgear, is a sophisticated electrical control system that enables two or more generator sets to operate in parallel, sharing the total load proportionally according to their ratings. Synchronization panels are essential in applications where a single generator set cannot meet the required load capacity, where redundancy and N+1 configuration are mandated, or where load sharing optimization is required for fuel efficiency. The wiring of a synchronization panel is significantly more complex than a single-generator control panel because it must integrate multiple generators, each with its own controller, into a unified power distribution system.

This comprehensive guide covers the complete wiring architecture of a multi-generator synchronization panel. We explain the principles of generator paralleling, the function of the synchronizing controller, the interconnection between generator controllers (via CAN bus, RS485, or hard-wired analog load sharing lines), and the wiring of the common bus, tie breakers, and protection systems. Detailed pin assignments are provided for commonly used synchronizing controllers including the ComAp IntelliSys NT, DeepSea DSE7420/DSE8610, SmartGen S6700H, and Woodward EGCP-3.

A correctly wired synchronization panel ensures that all generators in the system operate at the same frequency and voltage phase angle before their output breakers are closed to the common bus. The panel continuously monitors each generator's real and reactive power output and adjusts engine speed (governor) and excitation (AVR) settings to maintain equal load sharing. This guide provides the wiring foundations required for systems ranging from a simple dual-generator master-slave configuration to complex multi-unit N+1 or peak-shaving installations with mains paralleling.

Synchronization Panel Wiring Connection Details

Common Bus Architecture

The synchronization panel's power circuit connects all generator outputs to a common distribution bus. Each generator connects through its dedicated molded case circuit breaker (MCCB) or air circuit breaker (ACB).

Generator Input Sections (repeated for each generator):

- Gen N (L1) — Generator N output phase A → Generator breaker → Common bus
- Gen N (L2) — Generator N output phase B → Generator breaker → Common bus
- Gen N (L3) — Generator N output phase C → Generator breaker → Common bus
- Gen N Neutral — Generator N neutral → Neutral busbar
- Gen N Ground — Generator N frame ground → Ground busbar

Common Load Bus:

- Bus L1, L2, L3 — Common copper busbar rated for total paralleled capacity
- Main breaker — Output to load (optional, may feed directly to facility distribution)
- Bus tie breaker — Connects sections of a split bus system

Mains/Utility Section (for peak-shaving or import/export):

- Mains L1, L2, L3 — Utility supply through main transformer breaker
- Mains Neutral — Utility neutral connection

- Mains synchronizing breaker — Paralleling breaker with synchronizing capability

Synchronizing Controller Wiring

The synchronizing controller (master) coordinates the operation of all generator controllers (slaves). The master controller monitors bus voltage and frequency, compares with each generator, and sends raise/lower commands to the engine governors and AVRs.

| Master Controller Terminal | Function | Connection | Notes |

|---|---|---|---|

| Bus Voltage L1, L2, L3, N | Common bus voltage sensing | Via VT/secondary fuses | 0–600 VAC |

| Gen 1 L1, L2, L3, N | Generator 1 voltage | Via sensing fuses | Before gen breaker |

| Gen 2 L1, L2, L3, N | Generator 2 voltage | Via sensing fuses | Before gen breaker |

| Gen N L1, L2, L3, N | Generator N voltage | Via sensing fuses | Before gen breaker |

| Master CAN H/L | CAN bus to slave controllers | Daisy-chain all controllers | 120 Ω termination |

| Load Share Lines | Analog load share (± 10 VDC) | Twisted pair between controllers | For non-CAN systems |

| Gen 1 Raise/Lower (Governor) | Speed control | PWM or analog to actuator | Isolated signal |

| Gen 1 Raise/Lower (AVR) | Voltage control | ± 10 VDC or 4–20 mA | Isolated signal |

| Gen 1 Breaker Close | ACB/MCCB close command | Relay output | Interlocked permissive |

| Gen 1 Breaker Trip | ACB/MCCB trip command | Relay output | Emergency trip |

| Gen 1 Breaker Status | Breaker auxiliary contact | Digital input | Position feedback |

Load Sharing Signal Wiring

Accurate load sharing is the critical function of a synchronization panel. There are two common wiring approaches:

CAN Bus Load Sharing (J1939 or CANopen):

- Master controller CAN H → Slave 1 CAN H → Slave 2 CAN H → termination
- Master controller CAN L → Slave 1 CAN L → Slave 2 CAN L → termination
- 120 Ω resistor at each end of the CAN segment
- Maximum segment length: 40 meters at 250 kbps
- Use Belden 9841 or equivalent shielded twisted pair

Analog Load Sharing (Droop or isochronous):

- Master kW Load Share + → Slave 1 kW LS + → Slave 2 kW LS + (daisy-chain)
- Master kW Load Share – → Slave 1 kW LS – → Slave 2 kW LS – (daisy-chain)
- Master kVAR Load Share + (for reactive power)
- Master kVAR Load Share – (for reactive power)
- Maximum cable length: 200 meters with 1.0 mm² shielded twisted pair
- Voltage swing: ± 10 VDC proportional to load percentage

Synchronization Panel Pin Assignments

ComAp IntelliSys NT Paralleling Controller Pinout (82-Pin Connector)

The IntelliSys NT is a dedicated synchronizing controller with comprehensive paralleling features.

Connector	Pin	Function	Signal Type	Description
P1	1	DC+ (8–36 V)	Power	Controller supply
P1	2	DC– (0 V)	Power	Supply ground
P1	3	PE (Ground)	Ground	Panel ground
P2	1–3	Bus L1, L2, L3	AC Sensing	Common bus voltage
P2	4	Bus Neutral	AC Sensing	Bus neutral reference
P2	5–7	Gen L1, L2, L3	AC Sensing	Generator voltage
P2	8	Gen Neutral	AC Sensing	Generator neutral
P4	1–8	Binary Inputs	Digital	Configurable per gen.
P4	9–14	Binary Outputs	Relay	250 VAC/8 A
P4	21–26	Analogue Inputs	4–20 mA / 0–10 V	Sensors
P4	27–30	Resistance Inputs	PT100/NTC	Temperature sensors
P5	1–2	MPU Speed	Input	Magnetic pickup
P6	1–2	RS485 A/B	Comms	Modbus RTU
P6	4–5	CAN H/L	Comms	J1939 bus
P6	7–8	USB D+/D–	Comms	Config port
Expansion	11–20	IOLB-01 bus	I/O	Expansion modules

Load Sharing Analog Wiring: Raise/Lower Signals

Governor and AVR raise/lower signals are critical for synchronizing and load sharing.

Signal	Generator 1	Generator 2	Generator N	Threshold
Speed Raise	PWM or +10 V	PWM or +10 V	PWM or +10 V	0–100% duty/voltage
Speed Lower	PWM or –10 V	PWM or –10 V	PWM or –10 V	0–100% duty/voltage
Voltage Raise	+10 VDC (max)	+10 VDC (max)	+10 VDC (max)	Proportional
Voltage Lower	–10 VDC (max)	–10 VDC (max)	–10 VDC (max)	Proportional
kW Share +	Common bus	Common bus	Common bus	±10 V
kVAR Share +	Common bus	Common bus	Common bus	±10 V

Compatible Synchronization Controllers

Controller	Manufacturer	Max Generators	Paralleling Method	Display	Communication
InteliSys NT	ComAp	32	CAN bus + analog	4.3" LCD	RS485, CAN, Ethernet, GSM
InteliGen NT	ComAp	16	CAN bus	4.3" LCD	RS485, CAN, Ethernet
DSE8610 MKII	DeepSea	16	CAN bus + analog	Color TFT	RS485, CAN, Ethernet
DSE7420	DeepSea	8	CAN bus	Color LCD	RS485, CAN
DSE7410	DeepSea	8 (master)	CAN bus	Color LCD	RS485, CAN
S6700H	SmartGen	32	CAN bus	7" Touch	RS485, Ethernet, GSM
S5600S	SmartGen	8	CAN bus	4.3" LCD	RS485, USB
EGCP-3	Woodward	16	Analog	LCD	Modbus, Ethernet
easYgen-3200	Woodward	16	CAN + analog	4.3" LCD	RS485, CAN, Ethernet
GCP-31	Cat	16	CAN bus	4.3" LCD	Ethernet, Modbus
MGC-100	Woodward	8	Analog	LCD	Modbus, RS485
DGC-2020	Beckwith	8	Analog	LCD	RS485, DNP3

Synchronization Panel Connection Specifications

Parameter	Specification	Notes
System Voltage	400/230 VAC, 3-phase	50/60 Hz
Maximum Paralleled Power	Up to 20 MW	System dependent
Generators per System	2–32 units	Master-slave architecture
Bus Voltage Sensing	100–690 VAC (direct)	Higher via VT
Sync Accuracy	$\pm 5^\circ$ phase angle	Before breaker close
Load Share Accuracy	$\pm 5\%$ of rated kW	With calibrated CTs
Reactive Share Accuracy	$\pm 5\%$ of rated kVAR	With voltage matching
Sync Breaker Close Time	50–200 ms	Relay response dependent
CAN Bus Speed	250 kbps (J1939)	40 m max segment
Analog Load Share	± 10 VDC, 0–100% load	Droop or isochronous
Governor Interface	PWM / ± 10 V / 4–20 mA	Programmable
AVR Interface	± 10 V / Potentiometer / 4–20 mA	Depends on AVR type
Protection	Sync check, reverse power, overcurrent	Per IEC 60255
Operating Temperature	-10°C to +55°C	Panel enclosure rated
Panel Type	Floor-standing cubicle	IP42 minimum
Standards	IEC 61439-2, ISO 8528-5	UL 1558 optional
CT Accuracy Class	Class 0.5S or better	For accurate power metering

Synchronization Panel Sequence of Operations

1. Start and Synchronize Sequence

1. First generator (master) selected by controller
2. Generator starts and reaches nominal voltage (via AVR) and frequency (via governor)
3. Master controller compares generator voltage, frequency, and phase angle with bus (or other running generators)
4. Controller sends raise/lower commands to match generator to bus
5. When all parameters are within sync window (typically ± 0.2 Hz frequency, $\pm 10^\circ$ phase, $\pm 5\%$ voltage), the controller sends breaker close command
6. Breaker closes and generator begins sharing load

2. Load Sharing Sequence

1. After all generators are synchronized to bus, master controller engages isochronous load sharing
2. Each generator's kW output is balanced per its rated capacity (proportional sharing)
3. Reactive power (kVAR) is shared proportionally by adjusting AVR setpoints
4. Load sharing is continuously monitored and adjusted at 50 ms intervals

3. Load Shedding and Stop Sequence

1. When load decreases, controller can shed generators (configurable priority)
2. Load is transferred from the generator being shed to remaining generators
3. Surplus generator's breaker opens after load transfer
4. Generator runs unloaded for cool-down period (typically 5 minutes)
5. Generator stops

Download PDF — Synchronization Panel Wiring Diagram

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Click the button above to download the complete Synchronization Panel Wiring Diagram PDF. This comprehensive reference includes:

- Full single-line diagram for a 4-generator paralleling system
- Synchronizing controller wiring for ComAp IntelliSys NT (primary reference)
- CAN bus network wiring with J1939 termination resistor placement
- Analog load share line wiring diagram for non-CAN systems
- Governor and AVR raise/lower signal wiring for each generator
- Breaker control and interlock wiring (tie breaker, gen breakers, main breaker)
- Voltage transformer (VT) wiring for bus and generator voltage sensing
- Protective relay wiring (sync check relay 25G, reverse power relay 32G, overcurrent 51G)
- Current transformer wiring for summation metering
- Generator controller slave configuration and wiring (for DSE/ComAp/SmartGen)
- Panel power supply and control power distribution

- Grounding and bonding requirements for paralleled systems

The PDF is 4.1 MB, A3 format with full vector graphics, suitable for printing and digital viewing. Includes wiring tables for all interconnection cables with recommended conductor sizes.

15 Frequently Asked Questions About Synchronization Panel Wiring

1. What is a sync check relay and why do I need one?

A sync check relay (ANSI device 25G) prevents the generator breaker from closing unless the generator and bus voltages are within acceptable limits of matching in magnitude, frequency, and phase angle. It acts as a safety interlock to prevent closing the breaker under out-of-sync conditions that could cause severe mechanical stress on the generator and prime mover. The sync check relay provides both voltage matching ($\pm 5\text{--}10\%$) and slip frequency detection (typically <0.2 Hz).

2. What is the difference between droop load sharing and isochronous load sharing?

In droop mode, each generator reduces its frequency slightly as load increases (typically 3–4% droop from no-load to full-load). Generators running in parallel naturally share load based on their droop characteristics. In isochronous mode, the master controller maintains exact frequency regardless of load and sends raise/lower commands to slave generators to achieve proportional load sharing. Isochronous mode provides better frequency regulation and is standard in modern digital control systems.

3. How many generators can be paralleled with a single synchronizing panel?

Modern synchronizing controllers can manage up to 32 generators in a single system. The practical limit depends on the controller model, communication bus capacity, and the physical layout of the switchgear. The ComAp IntelliSys NT and SmartGen S6700H support up to 32 units, while the DeepSea DSE8610 supports up to 16 units.

4. What cable type is required for the CAN bus between controllers?

Use CAN bus-specific cable with $120\ \Omega$ characteristic impedance: Belden 3084A, Unitronic FD CP CAN, or equivalent. The cable must be twisted pair with an overall braid shield. Conductor size: minimum $0.5\ \text{mm}^2$. Maximum stub length from bus to each controller: 300 mm. Termination resistors ($120\ \Omega$, $1/4\ \text{W}$) at both physical ends of the bus.

5. How do I wire current transformers for parallel operation?

Each generator must have its own set of three CTs (one per phase) for individual generator power measurement. For total system power measurement, the CT secondaries can be summed by paralleling the S2 terminals of all CTs. Use Class 0.5S or better CTs for accurate kW/kVAR measurement required for load sharing. The CT burden must not exceed the controller's specified maximum.

6. What is reverse power protection and how is it wired?

Reverse power protection prevents the generator from motoring (acting as a motor when the prime mover fails). The reverse power relay (ANSI 32G) monitors real power flow direction. If power flows into the generator (reverse power), indicating the engine is not driving the generator, the relay trips the generator breaker. Typical reverse power threshold: 2–10% of rated power with a 2–10 second time delay.

7. Can I parallel generators with different power ratings?

Yes, generators of different ratings can be paralleled as long as their controllers support proportional load sharing. Each generator contributes load in proportion to its rated capacity. For example, a 500 kVA and a 250 kVA

generator would share a 600 kVA load as 400 kVA and 200 kVA respectively. The total load must not exceed the sum of individual ratings.

8. What is the purpose of voltage transformers (VTs) in a synchronizing panel?

VTs step down high bus voltage (e.g., 11 kV) to a safe measurement level (typically 110 VAC or 100 VAC) for the synchronizing controller and protection relays. VTs provide galvanic isolation between the high-voltage bus and the control equipment. For low-voltage systems (400–690 V), VTs are not required — direct voltage sensing is used through fused circuits.

9. How do I wire a dead bus closure for the first generator?

The first generator to start sees a dead (de-energized) bus and must close its breaker without synchronizing. The controller's "dead bus" or "first start" logic bypasses the sync check relay when bus voltage is below a configurable threshold (typically <20% of nominal). The wiring must include a bus voltage sensing circuit that signals "bus dead" to the controller.

10. What is the correct terminating resistor arrangement for analog load share lines?

Analog load share lines require a 120 Ω terminating resistor at each end of the daisy-chain. The load share wiring must be a continuous loop through all controllers — no spurs or tee connections. Use a shielded twisted pair (Belden 8761 or equivalent) with the shield grounded at the master controller only.

11. Can I mix controller brands in a single synchronization system?

Mixing controller brands (e.g., ComAp and DeepSea) in a single synchronization system is generally not recommended. Each brand uses proprietary load sharing and communication protocols. However, it is possible if using a common standardized interface such as analog ± 10 V load share lines or open protocols like Modbus RTU for monitoring. For reliable operation, use controllers from the same manufacturer in a single synchronization system.

12. How should I wire the breaker control circuit for fail-safe operation?

The breaker close circuit should use a "permissive" interlock scheme: the close signal passes through the sync check relay contact, the controller's close output, and the local/remote selector switch in series. The trip circuit should be separate and direct — any trip condition (reverse power, overcurrent, emergency stop) directly de-energizes the breaker's shunt trip coil. Use a DC control voltage (24 or 48 VDC) for breaker control to ensure trip operation even during AC power failure.

13. What protection settings are recommended for paralleled generators?

Recommended protection settings: sync check (25G) — $\pm 10^\circ$ phase, ± 0.2 Hz slip frequency, $\pm 5\%$ voltage; reverse power (32G) — 5% of rated for 5 seconds; overcurrent (51G) — 110% rated, inverse time curve; over-voltage (59G) — 110% of nominal; under-voltage (27G) — 85% of nominal; under-frequency (81U) — 47 Hz (50 Hz system); over-frequency (81O) — 52 Hz (50 Hz system).

14. How do I commission a new synchronization panel?

Commissioning steps: (1) Visual inspection of all power and control wiring against the approved schematic, (2) Insulation resistance test on all power circuits (>10 M Ω), (3) CT polarity verification (primary injection test), (4) Voltage sensing phase rotation and magnitude check, (5) CAN bus or analog load share wiring continuity check, (6) Individual generator start and manual synchronization test with a single unit, (7) Breaker close and load application test (25%, 50%, 75%, 100%), (8) Automatic synchronization test with second generator, (9) Load sharing verification at various load levels, (10) Load rejection and generator shedding test, (11) Reverse power protection test, (12) Emergency stop test from full load.

15. What maintenance is required for synchronization panel wiring?

Annual maintenance: (a) Inspect and re-torque all power connections in generators, breakers, and busbars, (b) Verify CT secondary connections are tight and not open-circuited, (c) Check CAN bus/load share cable connections for corrosion, (d) Test all protection relays with secondary injection, (e) Verify sync check relay calibration, (f) Perform a full synchronizing cycle test, (g) Clean panel interiors and check for dust accumulation, (h) Update controller firmware if recommended by manufacturer, (i) Review alarm logs for recurring issues.

Synchronization Panel Wiring Installation Best Practices

Physical Layout Requirements

The synchronization panel must be designed with specific physical layout considerations to accommodate multiple generator incoming cables and the common bus system:

1. **Cable Gland Plate Sizing:** Provide sufficient gland plate area for all incoming generator cables, utility cables, and load cables. Allow 20% spare capacity for future expansion. Typical arrangement: generator cables enter from the left side, utility cables from the right, and load cables exit from the top or bottom.
2. **Busbar System Design:** The common busbar must be sized for the total paralleled capacity plus 20% margin. For a 4-generator system rated 500 kVA each, the busbar must handle 2000 kVA (≈ 2887 A at 400 V). Use multiple paralleled busbars per phase or heavy-section copper bars (120 x 10 mm or larger). Consider using a busbar trunking system for larger installations.
3. **Arc Flash Mitigation:** Install arc flash protection within each generator breaker compartment. Use arc flash relays with light sensors and pressure sensors connected to a shunt trip output for the main breaker. Comply with IEEE 1584 arc flash hazard calculations when designing the panel layout.
4. **Component Access:** Maintain minimum 800 mm clear working space in front of all breaker compartments. Provide separate compartments for: generator 1 breakers, generator 2 breakers (and subsequent), the common busbar, the synchronizing controller, and the load shedding/relay compartment. Each compartment must have independent door access with interlocks.

Synchronization Panel Testing and Commissioning

Pre-Power Tests:

1. Megger test all generator cables to busbars: >100 M Ω at 1000 VDC
2. Megger test all control circuits: >10 M Ω at 500 VDC
3. Verify CT polarity with primary injection testing
4. Check CAN bus termination: measure resistance between CAN H and CAN L at each controller — should read 60 Ω (two 120 Ω resistors in parallel) on a properly terminated bus
5. Verify all emergency stop circuits function: press each unit's E-stop — all generators in that group should initiate shutdown

Individual Generator Synchronization Test:

1. Start generator 1 in manual mode
2. Use the synchronizing controller to close the generator 1 breaker to a dead bus
3. Verify voltage and frequency on the common bus are correct

4. Apply 25% load to generator 1 — verify proper regulation
5. Test generator 1 protection relays (overcurrent, reverse power via secondary injection)
6. Shut down and proceed to test generator 2 identically

Multi-Unit Synchronization Test:

1. With generator 1 running and loaded (25% load), start generator 2
2. Allow generator 2 to synchronize and close its breaker to the live bus
3. Verify that load sharing activates: generator 2 takes approximately 50% of the total load, generator 1 reduces to equal share
4. Repeat for all remaining generators
5. Test load sharing at 25%, 50%, 75%, and 100% of total paralleled capacity
6. Test load shedding: manually reduce load — verify one generator sheds and stops
7. Test emergency shutdown: press E-stop on one generator — verify its breaker opens with minimal load disturbance

Maintenance of Synchronization Panel Wiring

| Interval | Task | Details |

|-----|-----|-----|

| Monthly | Visual inspection | Check for loose connections, moisture, dust, insect activity |

| Quarterly | Protection relay test | Secondary injection test of all relays (25G, 32G, 51G, 59G, 27G) |

| Quarterly | Sync check test | Verify sync relay closes within configured phase angle window |

| Semi-annual | CAN bus check | Verify communication health, check for CRC errors in controller logs |

| Semi-annual | Thermal scan | Full-load thermographic scan of all busbar and breaker connections |

| Annual | Full commissioning test | Repeat all commissioning tests; document results |

| Annual | CT secondary check | Verify CT secondary connections are tight (visual + torque check) |

| Annual | Busbar torque check | Re-torque all busbar connections to manufacturer specification |

| Biennial | Controller firmware | Update all controller firmware to latest stable version |

Related Downloads

- [\[Generator Control Panel Wiring Diagram\]\(\)](#) — Complete gen-set electrical connection guide
- [\[AMF Panel Wiring Diagram PDF\]\(\)](#) — Automatic mains failure panel wiring reference
- [\[Automatic Voltage Regulator Wiring PDF\]\(\)](#) — AVR connection and adjustment guide
- [\[DeepSea Controller Wiring Diagram PDF\]\(\)](#) — DSE7320/DSE8610 synchronization wiring
- [\[ComAp Controller Wiring Diagram PDF\]\(\)](#) — InteliSys NT paralleling controller reference

This Synchronization Panel Wiring Diagram guide is provided by HuaQuan Power — professional generator set manufacturer specializing in multi-unit paralleling systems. For customized synchronization panel designs and technical support, contact our power systems engineering team.

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