Technical Manual

DYNA II

Silverline Microprocessor Auto-Synchronizer

DYN2 90200 — 115 VAC or 230 VAC UNIT

DYN2 90300 — 115 VAC or 230 VAC UNIT

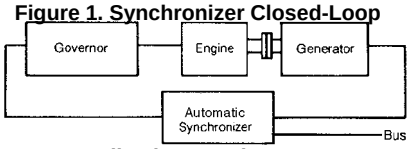
1. INTRODUCTION

The DYN2-90200/DYN2-90300 Automatic Synchronizer is used to match the frequency and phase of an incoming generator to the frequency and phase of either the bus, the utility or another generator. The synchronizer compares the incoming generator to the frequency and phase to be matched and controls its speed and phase to assure synchronization within a minimum of time.

1.1 Application

The Automatic Synchronizer is used in prime power installations, standby power installations and other situations where it is desirable to parallel an engine-generator to a stable power bus.

Figure 1. Synchronizer Closed-Loop



Feedback Control System

Since the synchronizer is part of a closed-loop feedback control system (see Figure 1), it has to be adjusted to match the various responses of the other components of that loop. For that reason, Barber-Colman recommends that one synchronizer be used per generator. Using only one synchronizer per system and switching all the various connections to each incoming generator, as needed, can possibly lead to complications and malfunctions of the total engine-generator system. Such malfunctions can take the form of erratic operation of the electronic governor or even, in extreme cases, internal damage to the synchronizer, even though Barber-Colman takes every economically-feasible precaution to protect the synchronizer.

1.2 Specifications

- **Input Voltages**
  Generator Terminals:
  115 ±20%, 230 ±20%; 50, 60 and 400 Hz nominal.
  Bus Terminals:
  115 ±20%, 230 ±20%; 50, 60 and 400 Hz nominal.

- **Power Consumption**
  Generator Terminals: Maximum of 7 VA.
  The synchronizer draws its operation power from the generator voltage terminals.
  Bus Terminals: Maximum of 2 VA.
  The input voltage on the bus terminals is for sensing only.

- **Ambient Temperature** -40° to +85°C (-40° to +180°F).

- **Output** Electronic signal.

- **Circuit Breaker Contact Rating**
  Isolated Form "C" Contacts: Rated at 10 AMP at 240 VAC.
  Voltage Matching Relays: Rated .5 AMP at 120 VAC.

- **Environment**
  PC board tropicalized with conformal coating.

2. OPERATION

The synchronizer has three different modes of operation:

- **Automatic**
  The synchronizer performs as a speed and voltage matching automatic synchronizer. The speed and phase of the incoming generator are controlled through the governor, up/down relays indicate voltage mismatch and an isolated contact is closed when the voltage, frequency and phase are within limits.

- **Permissive**
  The synchronizer performs as a synchronizing check relay only, with circuit breaker contact output but no connection on the incoming generator, governor or voltage regulator.

- **Reset**
  The synchronizer is still sensing but provides no contact outputs and no control signal.

In the AUTOMATIC mode the synchronizer operates as follows: As soon as the incoming generator voltage reaches approximately 50% of output voltage, the synchronizer compares its frequency to the bus. If there is a difference, the synchronizer sends a signal to the governor to bring the generator to the bus frequency. When the frequency difference is approximately ±0.2 Hz, the phase of the generator is also compared to the bus. The synchronizer then produces a governor control signal to bring the signal within the phase differential limit. The synchronizer energizes the output contacts (terminals 9, 10 and 11) only after the following conditions are met:

1. Frequency difference is within ±0.1 Hz.
2. Phase difference is within the adjusted range (±5° to ±20° for 50/60 Hz; ±10° to 40° for 400 Hz).
3. Voltage difference is within the adjusted range (±1% to ±15%)

The synchronizer also has voltage matching capability. The incoming generator voltage is compared to the bus voltage. Whenever the voltage difference is out of the set range, the circuit breaker contact will not close and one of the voltage matching contacts will be closed. If the generator voltage is out of the window and is lower than the bus voltage, then the up relay will be closed; if higher, the down relay will be closed. These relays can be connected to a motorized potentiometer or other device which will adjust the generator voltage up or down.

In the PERMISSIVE mode the synchronizer performs as in Automatic except that it does not control the speed, phase or voltage. The speed connection to the governor is left open, thus disconnecting its control of the generator frequency and phase. The voltage matching relay connections can be left open also, making the synchronizer permissive for voltage, frequency and phase. If desired, either the speed connections or voltage connections can be made permissive separate of the other functions. For example, voltage matching could be connected but not speed, therefore controlling voltage but permissive on frequency and phase.

In the RESET mode the synchronizer senses the frequency, voltage and phase but generates no governor control signal and does not energize the breaker output contacts or the voltage matching relays. It is standing by, ready to operate in the Automatic or Permissive mode.

2.1 LED Indicating Lights

The synchronizer has three LED Lights in the front of the unit to help the technician when first starting a control panel or when troubleshooting the control panel after it has been started. The LED lights serve to indicate whether the synchronizing limits have been met by the incoming generator.

Normally during tests a technician removes the leads from terminals 9,10 and 11 so that the incoming generator circuit breaker is not allowed to close onto the live bus. Then the technician can start the incoming generator and look at the LED lights to verify the operation of the synchronizer.

The red LED indicates a voltage differential, the green LED a frequency differential, and the yellow LED a phase angle differential. If the incoming generator voltage is different from the live bus by a margin of more or less than the adjusted amount, then the red LED comes on. Similarly, if the frequency of the incoming generator is different than the live bus by a margin of more or less than 0.1 Hz, then the green LED comes on. Finally, if the phase angle between the incoming generator frequency and the live bus frequency is more or less than the adjusted amount, then the yellow LED comes on. When all the synchronizing limits have been met, then all three LEDs are off.

There can be conditions when all three LEDs are off but the circuit breaker output (10 and 11) does not close. When the breaker closing angle becomes smaller than the adjusted amount, the yellow LED goes out, indicating acceptable phase match. At this time the microprocessor calculates when the generator phase will leave the adjusted window. If it will leave the window in less than 1 second, the breaker will not close. This prevents faulty closures when the phase simply passes through the window, allowing for fast synchronization but eliminating delays.

2.2 Dead Bus

If the bus is dead, the synchronizer waits until a voltage and frequency appear on the bus. Then it will attempt to match the incoming generator to the bus.

3. INSTALLATION

- **Mechanical**
  The synchronizer is not dependent on any orientation for its operation; therefore, it can be mounted in any position.

- **Electrical**
  For proper operation, connections to the synchronizer should be made in accordance with the wiring diagram in this manual and the following instructions.

The connections from the incoming generator and from the bus must be matched with respect to phase and rotation. Be sure that the voltages to terminals 1, 2 & 3 and 4, 5 & 6 are 115 VAC ±15% or 230 VAC ±15%.

A shielded cable is required for the control signal from terminals 7 and 8 to the electronic governor. This prevents stray pick-up and hum in the control circuitry. The shielded cable should be connected as shown in Figure 3.

Terminals 9, 10 and 11 provide an isolated single-pole, double-throw contact for the circuit breaker control. The normally-open side (terminals 10 and 11) is generally used to close an electrically-operated circuit breaker when the voltage, frequency and phase are within limits.

Terminals 12 and 13 determine under which operating mode the synchronizer functions. Closing a contact between terminals 12 and 13 initiates the Automatic mode. If 12 and 13 are left open, then the synchronizer is in the Reset mode and is standing by to operate. **For proper operation, the signal to go into the Automatic mode (e.g., closing a contact between terminals 12 and 13) should be given at the same time as the signal to start the incoming generator. As soon as the incoming generator is paralleled to the bus, the signal to the synchronizer (the contact between terminals 12 and 13) should be opened to prevent interaction between the synchronizer governor control signal.**

Terminals 14,15 and 16 are the up/common/down voltage matching relay outputs. Both are off whenever the generator voltage is in the adjusted voltage matching window. If the generator voltage is out of the window on the low side, the up contact is closed; if out on the high side, the down contact is closed.

The logic necessary to provide the timely and proper signals to the Automatic Synchronizer is the responsibility of the engine generator control system.

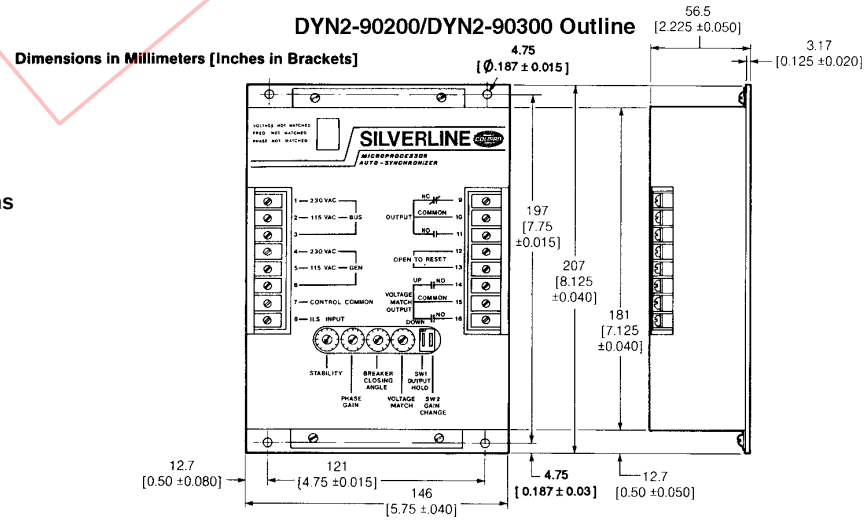


Figure 2. Dimensions

DYNA II Auto-Synchronizer

The DYNA II Auto-Synchronizer (P/N DYN2 90200/DYN2 90300) can be used with the DYNA 8000 governor and DYNA II Digital Isochronous Load Sharing Control to automatically synchronize one generator with another or with a bus. The Auto-Synchronizer eliminates the risk of operator error inherent with manual synchronizing.

Figure 3 illustrates the wiring of two engine generator sets having DYNA 8000 governors, DYNA II Digital Isochronous Load Sharing Controls and DYNA II Auto-Synchronizers. Additional engine generator sets can be paralleled by wiring them at the point designated, PARALLELING LINES TO OTHER SYSTEMS.

CAUTION

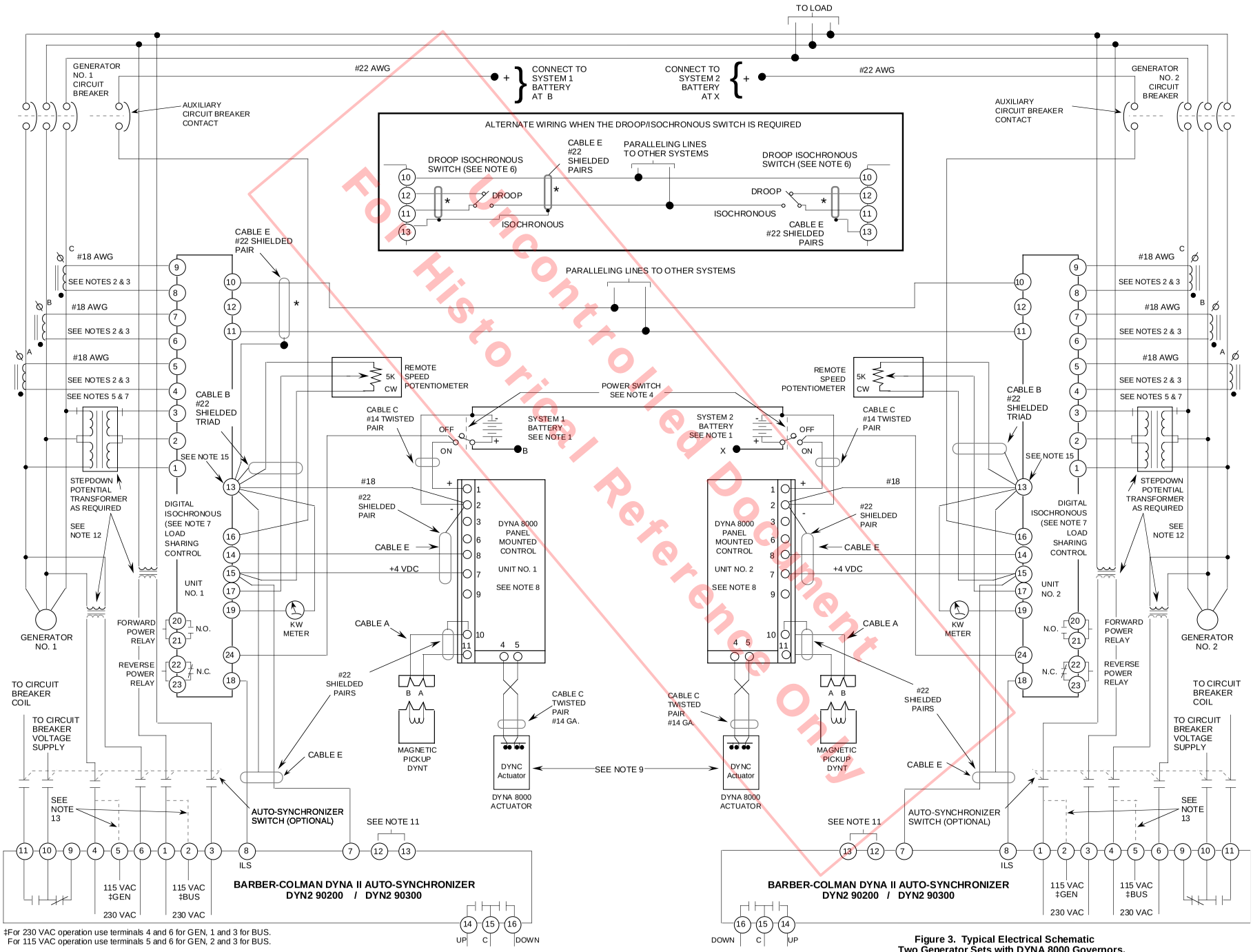
It is recommended that an independent overspeed device be incorporated in every engine control system.

NOTES

1. If more than one engine is started using the same battery supply use separate battery supply for each governor system. Twist power leads and use shielded leads as shown.
2. Select current transformers to provide 2.5 to 5 0 amps at full rated load. Current transformers require nominal 0.32 VA/ PHASE at 2.5 amps; 1.25 VA/PHASE at 5 0 amps.
3. Observe current transformer polarity markings when connecting.
4. Power switch current rating: 10 amps.
5. Phasing of potential Terminals 1, 2 and 3 is necessary to keep each signal in its correct phase relationship. If the generator voltage is not the same as the voltage rating on Terminals 1, 2 and 3 of the Isochronous Load Sharing Control, a step-down transformer is required. Correct phasing of the transformer leads is necessary. Step-down transformers require nominal 1 VA/PHASE.
6. Droop/Isochronous switch is not required if units are always operated in the Isochronous mode.
7. Digital ILS (Also see F-22396)
   DYN2 80108 — 115/230 VAC input 50/60 Hz
   DYN2 80109 — 230/480 VAC input 50/60 Hz
   DYN2 80110 — 230/480 VAC input 400 Hz
8. DYNA 8000 Controllers: DYN1-10653, DYN1-10654 or DYN1-10656: and DYN1-10683 , DYN1-10684 or DYN1-10686.
9. a. DYNA 8000 Actuators: DYNC-11020 and DYNC-11024 Series.
   b. DYNA 8400 Actuators: DYNC-14800 and DYNC-14801 Series.
10. If Load Pulse funchon is not being used, the Load Pulse Potentiometer must be set fully counterclockwise.

NOTES FOR AUTO-SYNCHRONIZER

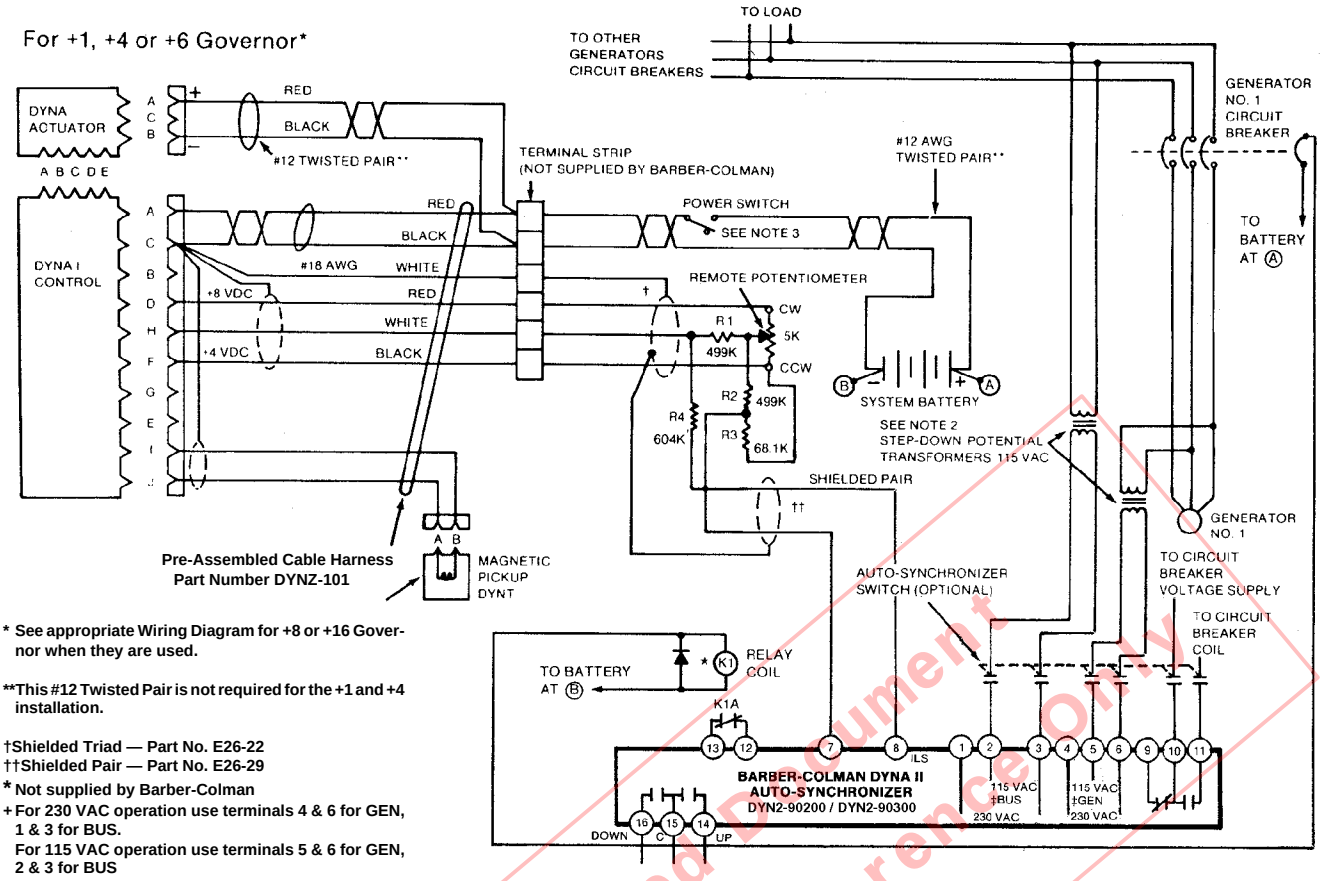
11. a. Closing a contact between 12 to 13 allows the Auto-Synchronizer to perform as a speed matching unit. The speed and phase of the incoming generator are controlled and a contact is closed to drive a circuit breaker. Once the circuit breaker is closed the contact between 12 and 13 should be opened. Another method would be to use the "Output Hold" dip switch, SW1, on the front of the unit.
    b. Open contacts or no jumper between 12 and 13 allows the Auto-Synchronizer to still sense any error, but it does not provide any control or contact closure.
12. Phasing of voltage potential to the Auto-Synchronizer is necessary to keep each signal in its correct phase relationship. If the generator voltage is not the same as the voltage rating of the Auto-Synchronizer, step-down transformers are required. The step-down transformers require a nominal 7 VA/PHASE for the Generator input and 2 VA/ PHASE for the Bus input.
13. Connections to terminals 1-3 or 2-3 and 4-6 or 5-6 of the Auto-Synchronizer must be the same voltage potential. Applying generator voltage without applying bus voltage may cause the engine to run faster or slower than the desired speed. However, when bus voltage is applied, the Auto-Synchronizer will change engine speed to quickly match the generator to the bus frequency.
14. Step-down transformers require nominal 10 VA/PHASE.
15. When using DYN2-90300 Auto-Synchronizer, the shield terminations are to be connected to chassis ground, as this unit is CE rated.



‡For 230 VAC operation use terminals 4 and 6 for GEN, 1 and 3 for BUS.
For 115 VAC operation use terminals 5 and 6 for GEN, 2 and 3 for BUS.

CABLE A — DYNZ 62-XX (specify length)
CABLE B — E26-22 (specify length)
CABLE C — DYNK-123-XX (specify length)
CABLE D — DYNZ 70-5 (specify length)
CABLE E — E26-29 (specify length)

Figure 3. Typical Electrical Schematic Two Generator Sets with DYNA 8000 Governors, DYNA II ILS, DYN2-80108 Series and DYNA II DYN2-90200 / DYN2-90300 Auto- Synchronizer



* See appropriate Wiring Diagram for +8 or +16 Governor when they are used.

**This #12 Twisted Pair is not required for the +1 and +4 installation.

†Shielded Triad — Part No. E26-22
††Shielded Pair — Part No. E26-29
* Not supplied by Barber-Colman
\+ For 230 VAC operation use terminals 4 & 6 for GEN, 1 & 3 for BUS.
For 115 VAC operation use terminals 5 & 6 for GEN, 2 & 3 for BUS

Figure 4. Typical Wiring Schematic for DYNA I Governor Operating without an ILS Module

DYNA II Auto-Synchronizer with a Single DYN1 Governor

The DYNA II Auto-Synchronizer (P/N DYN2-90200 / DYN2-90300*) can be used with any DYNA governor to automatically synchronize one generator with another or with an infinite bus. The Auto-Synchronizer eliminates the risk of operator error inherent with manual synchronizing.

Notes

1. If more than one engine is started using the same battery supply, use separate battery supply for each governor system. Twist power leads and use shielded leads as shown.

2. Observe transformer polarity markings when connecting. 230 VAC secondaries are acceptable.

3. Power switch current rating:
   For +1 or +4 actuators — 10 amps.
   For +6 actuators — 25 amps.
   For +8 actuators — 30 amps.

4. If the generator voltage is not the same as the voltage rating of the Auto-Synchronizer, step-down transformers are required. Correct phasing of the transformer leads is necessary. Step-down transformers require a nominal 7 VA/PHASE for the GEN. input to the Auto-Synchronizer; 2 VA/PHASE for the BUS input to the Auto-Synchronizer.

* DYN2-90300 is CE rated, therefore it should be used with a CE rated governor.

5. Resistor Part Numbers:
   R1: 499K — CYZR-932-015
   R2: 499K — CYZR-932-015
   R3: 68.1K — CYZR-932-029
   R4: 604K — CYZR-932-120

   R1 and R2 values must be the same. If R1 is changed to 220K, then R2 must be changed to 220K.

6. See paragraph 4.1 and 4.11.

7. a. Leaving terminals 7 and 8 disconnected allows the Auto-Synchronizer to perform as a sync check relay only, with a relay contact output but no control of the engine/generator speed.

   b. Closing a contact between 12 to 13 allows the Auto-Synchronizer to perform as a speed matching unit. The speed and phase of the incoming generator are controlled and contact is closed to drive circuit breaker. Once the circuit is closed, the contact between 12 and 13 should be opened. (See Figure 4 for an example of how one would most likely wire terminals 12 and 13.) Another method uses the “Output Hold” function; see Section 4.6 for more information.

   c. Open contacts between 12 and 13 allows the Auto-Synchronizer to still sense any error but it does not provide any control or contact closures between 9, 10 and 11 or 14, 15 and 16.

8. DYNA governor must be operated in the Droop mode when paralleled without the ILS module.

4. CALIBRATION AND ADJUSTMENTS

A voltage matching synchronizer performs three functions: measure and compare generator voltage and bus voltage then provide a signal to increase or decrease the generator voltage; measure and compare bus and generator frequency and alter the governor set speed appropriately; and finally measure and compare the bus and generator phase relationship and alter the governor set speed to provide phase synchronization. These functions are all provided simultaneously and all will or can affect synchronization times.

The governor control signal will provide approximately ±3.0 Hz of gain. This means that should the unloaded frequency of the engine-generator happen to be preset (by means of the speed potentiometer) at 57.0 or 63.0 Hz, the synchronizer is still able to control the frequency of the engine-generator such as to synchronize it to a 60 Hz bus. However, had the frequency been preset outside of that range (±3.0 Hz), the Auto-Synchronizer would be restricted in its capacity to control the speed of the engine and would not achieve synchronization.

The Auto-Synchronizer is pre-adjusted to provide stable operation. However, there will be times when, for example, potentiometers of the electronic governor are misadjusted or the engine response is different than normal. These items can cause unstable operation of the Auto-Synchronizer. If this occurs, it can be detected as an oscillation or hunting of frequency and phase (this is best observed on a synchroscope) when the Auto-Synchronizer is controlling the governor of the incoming engine-generator.

The synchronizer has four potentiometer adjustments and two dip switches. Each is discussed below.

It is recommended that for new installations, synchronization should be first tried in a low gain/slower synchronizing mode. Once stable operation is achieved then try optimizing the performance with the STABILITY and PHASE GAIN pots or the GAIN CHANGE dip switch. Please read and understand the effects of each adjustment. Generally, the higher the pot settings, the faster synchronization is done if the system does not become unstable. However, an over-stabilized system can be very slow to synchronize.

- **Initial Settings**
  STABILITY: 50 SW1: OFF
  PHASE GAIN: 30 SW2: OFF

4.1 Stability

The stability pot affects the rate and amount that the synchronizer reacts to frequency error. The ratio of STABILITY to PHASE GAIN determines the stability of the system. Observe operation of the system on a synchroscope while the Auto-Synchronizer is controlling the incoming generator. If the needle on the synchroscope has wide overshoots around the “noon" position while being synchronized, increasing the stability will generally reduce the overshoots. On the other hand, if the needle hesitates on the way to the “noon” position, there is too much stability and the potentiometer should be turned counterclockwise to reduce stability and decrease the time required to synchronize. Should a synchroscope not be available, the operator can listen closely to the incoming engine to determine whether it is over-stabilized or understabilized. On slow engines the phase may still have wide overshoots (understabilized) with the stability full CW. In this case the PHASE GAIN may have to be reduced.

4.2 Phase Gain

The PHASE GAIN adjustment affects the amount and rate that the synchronizer reacts to phase error. Generally, increasing the PHASE GAIN increases the rate at which phase error is reduced. Too much PHASE GAIN can cause overshoots (understabilized) or, if high enough, erratic or inconsistent synchronization. If you have a very slow responding engine or are synchronizing through a Load Commander (DYN2-94001), the PHASE GAIN may have to be reduced significantly. Sometimes, especially on fast responding engines, synchronizing times can be improved by changing the ratios between STABILITY and PHASE GAIN even further. This is done by the GAIN CHANGE dip switch SW2.

4.3 Gain Change

A gain ratio change is achieved by engaging switch SW2 to the ON position. Although both the STABILITY and PHASE GAIN effects are increased, the PHASE GAIN is increased substantially more than the STABILITY. In addition to increasing the PHASE GAIN, the microprocessor allows the easy introduction of some nonlinear terms which significantly improve performance on some engines. Although generally the switch is better suited for faster engines, some slower engines have been improved by using this switch and then setting the PHASE GAIN very low (0-10 range).

4.4 Breaker Closing Angle

The potentiometer adjusts the phase angle acceptance window and its range from ±5° to ±20° for 50/60 Hz and ±10° to ±40° for 400 Hz. (Turning the potentiometer clockwise increases the differential.) This adjustment determines the permissible phase angle differential between the incoming generator and the bus. For example, if the pot is adjusted for ±10° differential, the Auto-Synchronizer will not close its contact until the generator frequency is within 10° of being in phase with the bus (provided, of course, that the frequency and voltage are within the synchronizing limits; refer to Section 2.1 for more on contact breaker closing).

4.5 Voltage Match

The VOLTAGE MATCH adjustment selects the acceptable percent of voltage difference that will be allowed for circuit breaker closure. Its range is ±1% to ±15% of bus voltage with full CW being ±15%. If the generator voltage is out of the adjusted range, the appropriate voltage matching relay contact will be closed. Closure of the up contact (14 to 15) indicates that the generator voltage is too low; closure of the down contact (15 to 16) indicates the voltage is too high. When the generator voltage is out of the match window, the red LED will be lit and the circuit breaker output terminals (10 to 11) will be inhibited from closing.

4.6 Output Hold

Placing dip switch SW1 in the ON position provides an output hold function. Whenever the circuit breaker output terminals (10 and 11) are closed and the voltage, frequency and phase remain in the acceptable synchronization windows, the synchronizer will hold its current value of output. This is useful for some applications where the speed of the incoming generator has to be trimmed greatly for synchronization. By holding the output, speed and load transients are minimized when the circuit breaker closes. RESET (opening 12 to 13) overrides all relay closures and the HOLD mode, thus resetting the synchronizer to the zero speed trim output.

5. MAINTENANCE AND TROUBLESHOOTING

The DYN2-90200/DYN2-90300 requires no maintenance or upkeep to provide years of trouble-free operation.

The Automatic Synchronizer is a solid-state device, and it is recommended that the PC board not be tested or repaired in the field. Instead, it should be returned to our factory for inspection and repair. There is, however, a bench test that can be made to determine if circuits in the synchronizer are functioning properly. When performing this test, the AC source can be either 50, 60 or 400 Hz.

5.1 Visual Inspection

Before starting the test, visually inspect the printed circuit board for burned, loose or broken components.

5.2 Simple Synchronizing Test

1. Connect proper AC voltage to bus terminals. Connect jumpers from bus to GEN. terminals.
2. Connect a jumper from 12 to 13.
3. The contact between terminals 10 and 11 should close. Contacts between 9 and 10 should be open. All LED lights should be OFF.
4. Remove jumper between 12 and 13. Contact between terminals 10 and 11 should open; 9 and 10 should close.

The above test indicated that the synchronization comparison level circuits are functioning properly.

5.3 Troubleshooting Procedure Table

Problem	Probable Cause	Corrective Action
Synchronizer does not correct frequency.	Generator or bus voltage not present.	Check voltage on synchronizer at bus and generator terminals.
	Wrong bus and/or generator voltage level	Check wiring.
	Generator free running frequency too far from bus frequency (±3 Hz).	Adjust governor to correct generator's frequency.
Frequency correction unstable.	Summing point connected to wrong terminal on synchronizer.	Check wiring.
	Shield of twisted pair shielded wire is ungrounded or not used.	Check wiring.
	Gain range jumper not correct.	Adjust gain range per instruction manual.
	Governor unstable.	Consult governor manual.
Synchronizer gives sync command, but no breaker closure occurs.	Improperly wired sync contacts.	Check wiring.
Synchronizer won't give sync command.	Generator and bus voltages are not the same	Check voltages and correct.
Synchronizer phase locks generator 180° out of phase.	Either bus voltage or generator voltage polarity is reversed.	Correct wiring.
Generator frequency runs away high or low.	Summing point connections are backwards.	Check wiring.
	Connections of bus and oncoming generator inputs to synchronizer are reversed.	Check wiring.
Synchronizer gives breaker closure too far away from 0° phase angle.	Phase angle adjustment out of calibration.	Check phase angle adjustment.

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CAUTION
As a safety measure, the engine should be equipped with an independent overspeed shutdown device in the event of failure which may render the governor inoperative.