WOODWARD

Product Manual 36044
(Revision C)
Original Instructions

Air/Fuel Ratio Control

Installation and Operation Manual

General Precautions

Read this entire manual and all other publications pertaining to the work to be performed before installing, operating, or servicing this equipment.

Practice all plant and safety instructions and precautions.

Failure to follow instructions can cause personal injury and/or property damage.

Revisions

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Proper Use

Any unauthorized modifications to or use of this equipment outside its specified mechanical, electrical, or other operating limits may cause personal injury and/or property damage, including damage to the equipment. Any such unauthorized modifications: (i) constitute "misuse" and/or "negligence" within the meaning of the product warranty thereby excluding warranty coverage for any resulting damage, and (ii) invalidate product certifications or listings.

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Warnings and Notices

Important Definitions

This is the safety alert symbol. It is used to alert you to potential personal injury hazards. Obey all safety messages that follow this symbol to avoid possible injury or death.

- **DANGER**—Indicates a hazardous situation which, if not avoided, will result in death or serious injury.
- **WARNING**—Indicates a hazardous situation which, if not avoided, could result in death or serious injury.
- **CAUTION**—Indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.
- **NOTICE**—Indicates a hazard that could result in property damage only (including damage to the control).
- **IMPORTANT**—Designates an operating tip or maintenance suggestion.

⚠WARNING

Overspeed / Overtemperature / Overpressure

The engine, turbine, or other type of prime mover should be equipped with an overspeed shutdown device to protect against runaway or damage to the prime mover with possible personal injury, loss of life, or property damage.

The overspeed shutdown device must be totally independent of the prime mover control system. An overtemperature or overpressure shutdown device may also be needed for safety, as appropriate.

⚠WARNING

Personal Protective Equipment

The products described in this publication may present risks that could lead to personal injury, loss of life, or property damage. Always wear the appropriate personal protective equipment (PPE) for the job at hand. Equipment that should be considered includes but is not limited to:

- **Eye Protection**
- **Hearing Protection**
- **Hard Hat**
- **Gloves**
- **Safety Boots**
- **Respirator**

Always read the proper Material Safety Data Sheet (MSDS) for any working fluid(s) and comply with recommended safety equipment.

⚠WARNING

Start-up

Be prepared to make an emergency shutdown when starting the engine, turbine, or other type of prime mover, to protect against runaway or overspeed with possible personal injury, loss of life, or property damage.

⚠WARNING

Automotive Applications

On- and off-highway Mobile Applications: Unless Woodward's control functions as the supervisory control, customer should install a system totally independent of the prime mover control system that monitors for supervisory control of engine (and takes appropriate action if supervisory control is lost) to protect against loss of engine control with possible personal injury, loss of life, or property damage.

NOTICE

Battery Charging Device

To prevent damage to a control system that uses an alternator or battery-charging device, make sure the charging device is turned off before disconnecting the battery from the system.

Electrostatic Discharge Awareness

NOTICE

Electrostatic Precautions

Electronic controls contain static-sensitive parts. Observe the following precautions to prevent damage to these parts:

- **Discharge body static before handling the control (with power to the control turned off, contact a grounded surface and maintain contact while handling the control).**
- **Avoid all plastic, vinyl, and Styrofoam (except antistatic versions) around printed circuit boards.**
- **Do not touch the components or conductors on a printed circuit board with your hands or with conductive devices.**

To prevent damage to electronic components caused by improper handling, read and observe the precautions in Woodward manual *82715*, *Guide for Handling and Protection of Electronic Controls, Printed Circuit Boards, and Modules*.

Follow these precautions when working with or near the control.

1. Avoid the build-up of static electricity on your body by not wearing clothing made of synthetic materials. Wear cotton or cotton-blend materials as much as possible because these do not store static electric charges as much as synthetics.
2. Do not remove the printed circuit board (PCB) from the control cabinet unless absolutely necessary. If you must remove the PCB from the control cabinet, follow these precautions:
   - Do not touch any part of the PCB except the edges.
   - Do not touch the electrical conductors, the connectors, or the components with conductive devices or with your hands.
   - When replacing a PCB, keep the new PCB in the plastic antistatic protective bag it comes in until you are ready to install it. Immediately after removing the old PCB from the control cabinet, place it in the antistatic protective bag.

Air/Fuel Ratio Control

Description

The air/fuel ratio control system provides a signal which is a function of generator load. The signal is then used to adjust a device (not furnished by Woodward) to control the engine air/fuel ratio and improve engine performance and efficiency.

The air/fuel ratio control system consists of a resistor box, an AFR control, and a commercial transducer. The transducer is supplied by others to fit their particular application.

The generator voltage, either 120 or 208–240 volts 3 phase, is connected directly to the resistor box and AFR control or is through current and potential transformers. Usually, the current and potential transformers supplied by the switchboard manufacturer to power the switchboard instruments can also power the load sensing portion of this system. These are terminals 1 through 12 of the AFR control. The voltage proportional to load current is obtained from the resistor box having 0.3 ohm resistors connected in series with the current transformer in each phase. Each resistor is set so that at rated full load, unity power factor, the voltage across the resistor is less than 1.5 volts.

The AFR control measures kilowatts through circuitry which detects the in-phase component of the load current for each phase of the generator. The signals obtained from each phase are added, and their sum is fed into a constant current amplifier. The amplifier output is the output of the AFR control, and provides a 1–5 mA signal to the transducer (internal resistance, 2500 ohms).

AFR Control Installation

Refer to Figure 2 for mounting information. Ambient temperature must be between –40 and +160 °F (–40 and +71 °C). Provide adequate ventilation for cooling and space for installation and servicing.

This control can be tested and calibrated before it is installed (see Bench Calibration).

Electrical Connections

Figure 3 provides typical wiring instructions; however, a plant wiring diagram for your specific control part number must be used for actual installation.

There are no high currents in the circuits to the AFR control. Regular switchboard wire can be used for connections from the current transformer secondaries to the resistor box and to the AFR control gear. Use 18 or 20 AWG (0.5 or 0.8 mm²) stranded wire with oil resistant insulation to all connections on the AFR control. Avoid solid wire because vibration or other disturbances may cause failure.

⚠WARNING **HIGH VOLTAGE—Never disconnect current transformers from the resistor box or AFR control when the CTs are energized. The current transformers can develop dangerously high voltages when open circuited while energized.**

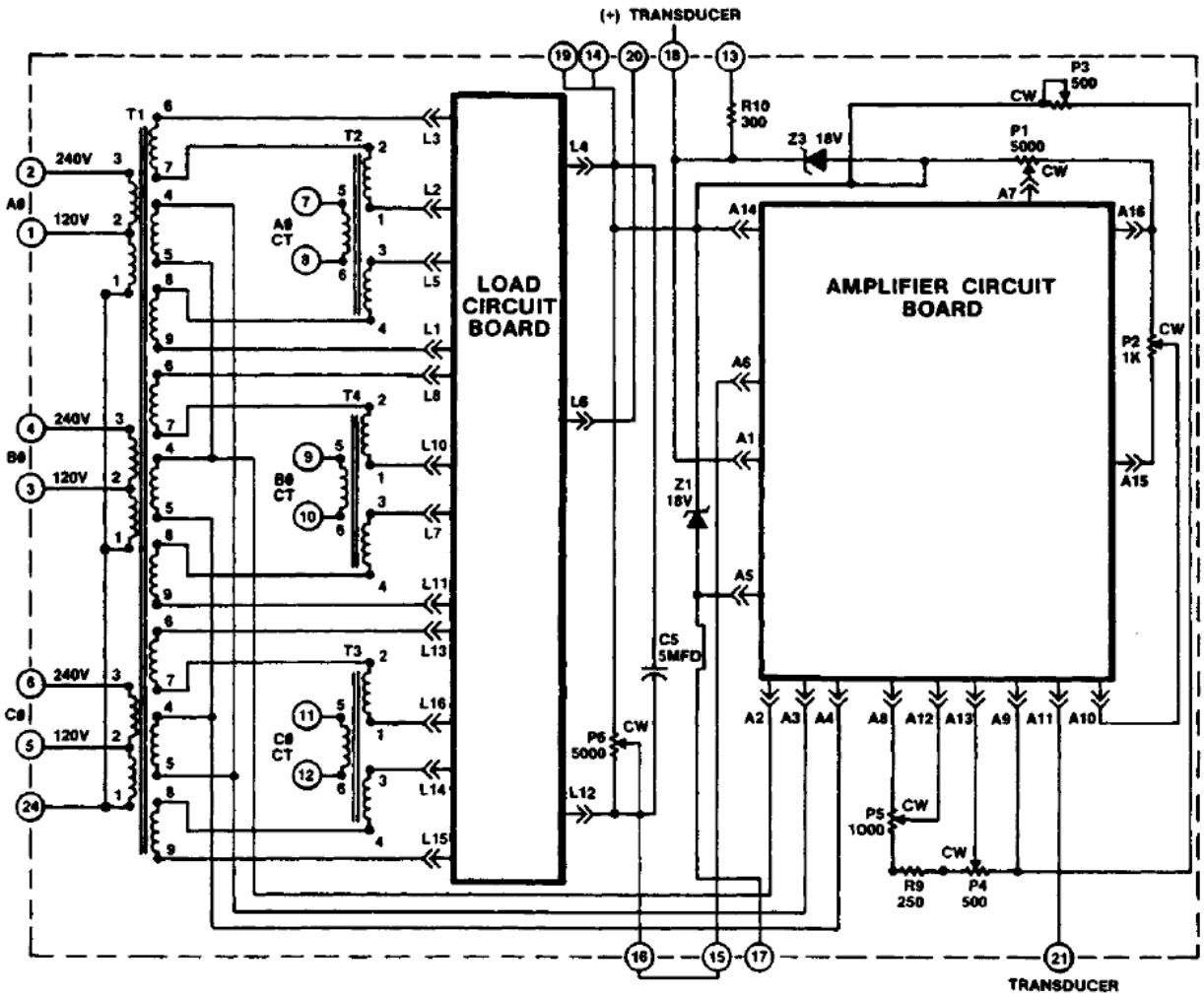

Figure 1. AFR Block Schematic Diagram

The generator voltage supply to the AFR control must be 120 or 208 to 240 volts, three phase. A potential transformer selected to provide a voltage within either range can be used. The burden on the potential transformers is about 50 VA three phase. Wye-Wye, delta-delta, or open delta potential transformer connections are satisfactory.

- For 120 volt operation, make connections at the following terminals: ΦA to 1, ΦB to 3, and ΦC to 5.
- For 208 to 240 volt operation make the following connections: ΦA to 2, ΦB to 4, and ΦC to 6.

Make the connections as shown in your plant wiring diagram between the resistor box and AFR control. The wires between the resistor box and the AFR control must connect directly to the resistor box terminals as shown. These resistors have values of a fraction of an ohm and are adjusted at the factory. Connection at any other point in the current transformer secondary circuit will, by adding an unknown wire resistance, nullify this calibration and result in an improper load signal in the AFR control.

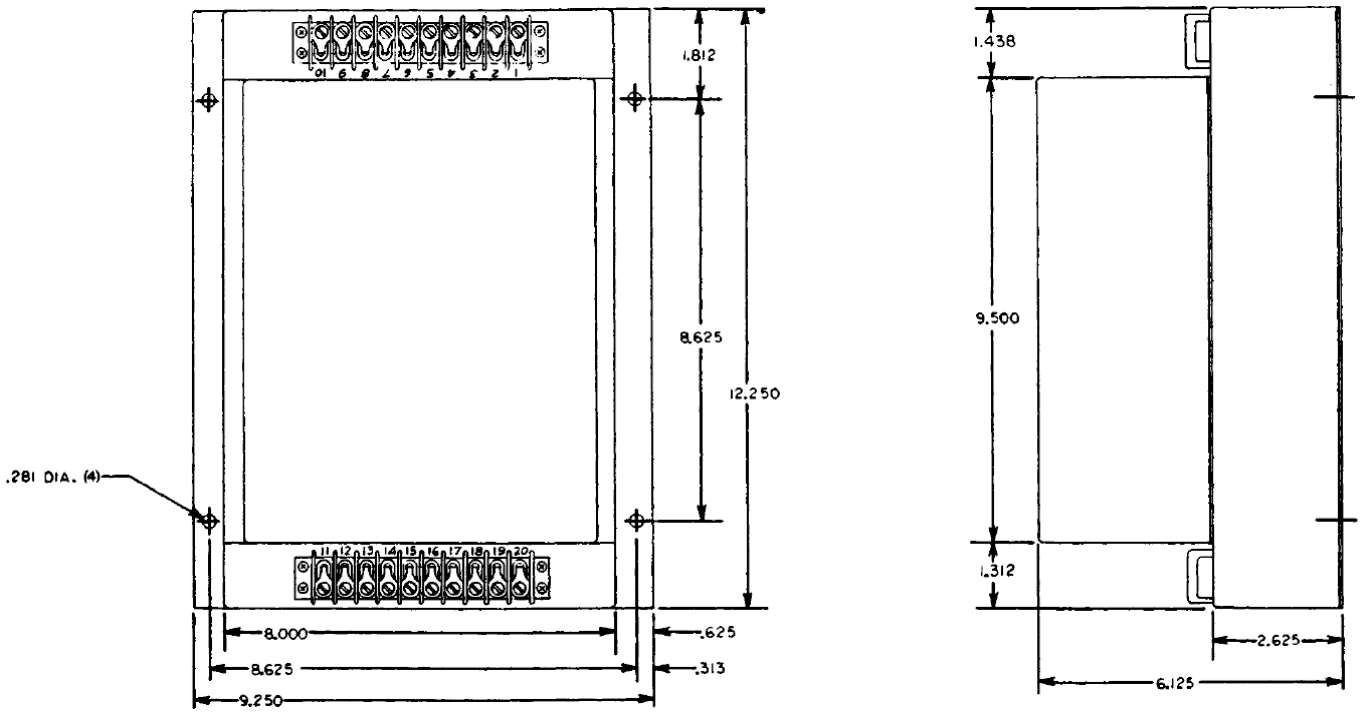

Figure 2. AFR Outline Drawing

The current transformers must be sized so the voltage across terminal pairs 7 and 8, 9 and 10, 11 and 12, is 0 Vac at no load and up to 1.5 Vac at rated full load with unity power factor. When this is correct, connect the current transformers to the resistor box as shown in the plant wiring diagram.

Make the connections for the transducer to terminals 18 (+) and 21. Jumper terminals 15 to 16.

Installation Check

With the AFR Control input wires (1 through 12) connected, measure the load voltage across terminals 14 (+) and 16. It must read 10 Vdc at rated full load. The reading will be proportionately less at smaller loads (5 V at half load and 2.5 V at one-quarter load). This is adjusted with the load gain potentiometer in the AFR control.

If the reading is only one-third of what it should be when the generator is loaded, one of the connections from the resistor box to the AFR is reversed. Leave the meter connected to AFR terminals 14 and 16. Using 18 AWG (0.8 mm²) or heavier wire, no longer than 4 inches (10 cm), short circuit terminals A and D (9 and 10) at the resistor box. If the meter reading drops further, the connections from these terminals to the input plug are correct. Repeat the procedure for the other two phases.

⚠WARNING

HIGH VOLTAGE—Never disconnect current transformers from the resistor box or AFR control when the CTs are energized. The current transformers can develop dangerously high voltages when open circuited while energized.

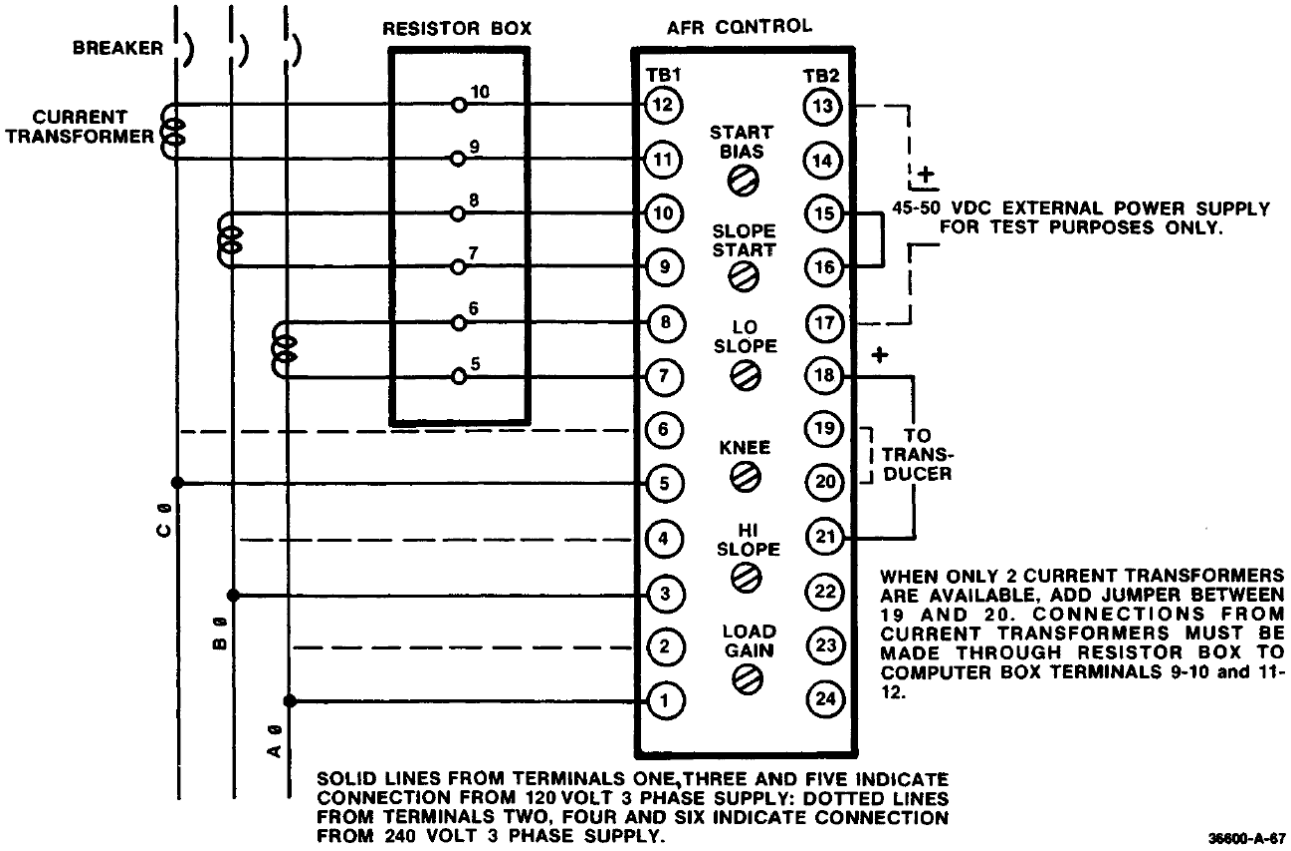

Figure 3. Typical Wiring Diagram AFR
(Do not use for construction.)

If shorting any of these pairs of terminals increases the meter reading, it indicates reversed connections from here to the AFR control.

If just one phase current signal is reversed, the meter will read approximately 3.3 volts at AFR terminals 16 (negative) to 14 (positive) with full load on the generator. If two are reversed, 14 will be negative and 16 will be approximately 3.3 volts positive. If all three are reversed, 14 will be negative and 16 will be approximately 10 volts positive. In other words, the correct full load reading of the 10 volts from 16 (negative) to 14 (positive) will be decreased by 6.6 volts for each reversed load signal. Shorting out the incorrect current signal resistor reduces this decrease to 3.3 volts.

If there is a reduction in voltage for each pair of resistor terminals that is shorted, but the meter reading is appreciably lower than it should be, it is possible that two or all three of the phase wiring are exchanged. Shut the unit down and correct the wiring.

Bench Calibration

The AFR control can be calibrated to match a specified curve before it is installed. See the Typical Wiring Diagram (Figure 3) for test connections.

Power is supplied to terminals 1, 3, and 5, or 2, 4, and 6 depending on the generator supply voltage, or a 48 Vdc power source connected to AFR terminals 13 (+) and 17 (–). Connect to the transducer terminals the transducer itself or a 2500 ohm resistor. If the transducer is used, the adjustments can be made reading transducer output direct. If a resistor is used, adjustments are made by reading the current flowing in the output circuit to the resistor. The signal input to the AFR control is at terminals 14 (positive) and 15 (negative) with the jumper between 15 and 16 removed. The input signal must be a battery voltage adjustable from 0 to 10 volts to simulate the load from zero to rated full load.

Adjustments

There are six adjustments on the AFR control to permit adjustment of the computer output to match the desired computer output vs. load curve. These adjustments are set to customer's specifications using factory test equipment. Changing these settings in the field without the test equipment is not recommended and should not be attempted unless absolutely necessary. A typical curve is shown below.

- The "A" adjustment holds the output constant on the desired level at low loads until point "B" has been reached.
- The "B" or "Slope-Start" adjustment permits a change in the point at which the system takes over. It must be readjusted every time a change Is made to the "C" adjustment.
- The "C" or "Low-Slope" adjustment establishes the slope or the rate at the lower end of KW range.
- The "D" or "Knee" adjustment changes the point at which the slope changes.
- The "E" or "High Slope" adjustment is the fifth adjustment.

The load gain sets the output of the load section to 10 volts dc at full load unity power factor.

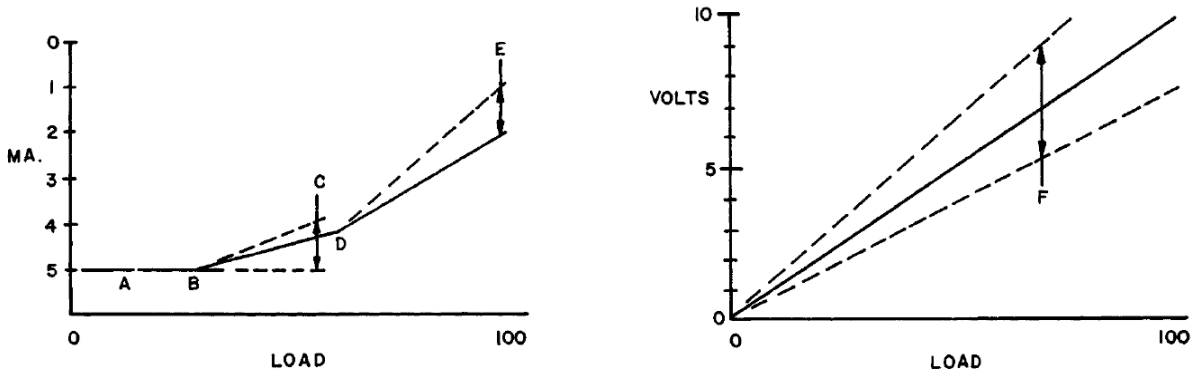

Figure 4. Adjustment Diagrams

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Send comments to: icinfo@woodward.com

Please reference publication 36044C.

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