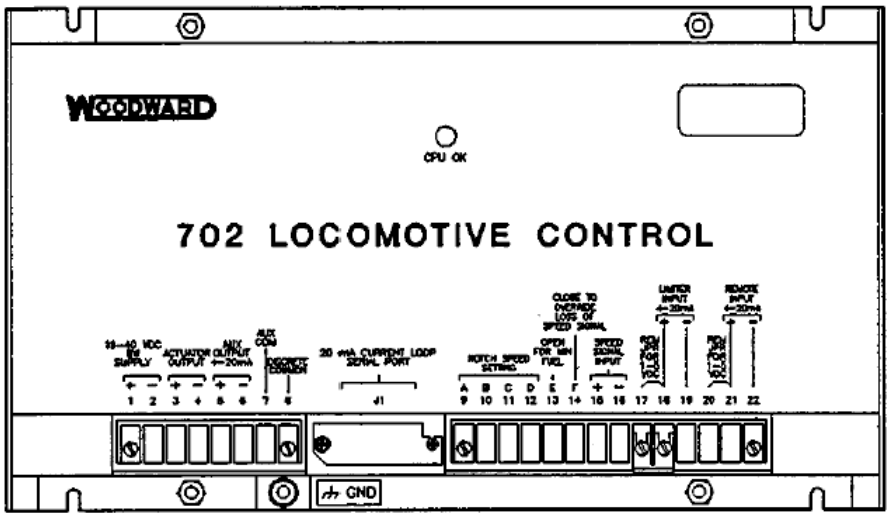
WOODWARD

Product Manual 02703
(Revision C)
Original Instructions



702 Locomotive Control

9905-210

Installation and Operation Manual

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

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.

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.

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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.

NOTICE

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.

NOTICE

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*.

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Illustrations and Tables

Electrostatic Discharge Awareness

All electronic equipment is static-sensitive, some components more than others. To protect these components from static damage, you must take special precautions to minimize or eliminate electrostatic discharges.

Follow these precautions when working with or near the control.

1. Before doing maintenance on the electronic control, discharge the static electricity on your body to ground by touching and holding a grounded metal object (pipes, cabinets, equipment, etc.).

2. 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.

3. Keep plastic, vinyl, and Styrofoam materials (such as plastic or Styrofoam cups, cup holders, cigarette packages, cellophane wrappers, vinyl books or folders, plastic bottles, and plastic ash trays) away from the control, the modules, and the work area as much as possible.

4. 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.

NOTICE

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*.

Chapter 1.
General Information

Introduction

This manual describes the Woodward 702 Locomotive Control, model 9905-210.

Application

The 702 Locomotive Control controls the speed of diesel locomotive engines. Control functions include:

- 4 discrete inputs for up to 16 notch speed settings
- user-optional input from a 4–20 mA speed-setting device
- adjustable start fuel limiting
- user-optional input from a 4–20 mA turbo boost pressure transmitter for fuel rack limiting
- user-optional torque limiting based on engine speed
- adjustable acceleration and deceleration times
- adjustable low-idle droop
- output for 4–20 mA tachometer
- self diagnostics on power up

The 702 control system includes:

- a 702 Locomotive Control
- an external 24 Vdc power source
- a speed-sensing device
- a proportional actuator to position the fuel rack
- a terminal for adjusting control parameters
- an optional 4–20 mA output turbo boost pressure-sensing device
- a notch speed-setting device
- an optional 4–20 mA remote speed-setting device
- a minimum fuel switch

The 702 control (Figure 1-1) consists of a single printed circuit board in a sheet-metal chassis. All inputs and outputs connect to two terminal strips and a 9-pin subminiature “D” connector.

702 Locomotive Control Accessories

Set Point Programmer (Figure 1-2), part number 8280-107, is used for adjusting the 702 control. It plugs into the serial port of the 702 control.

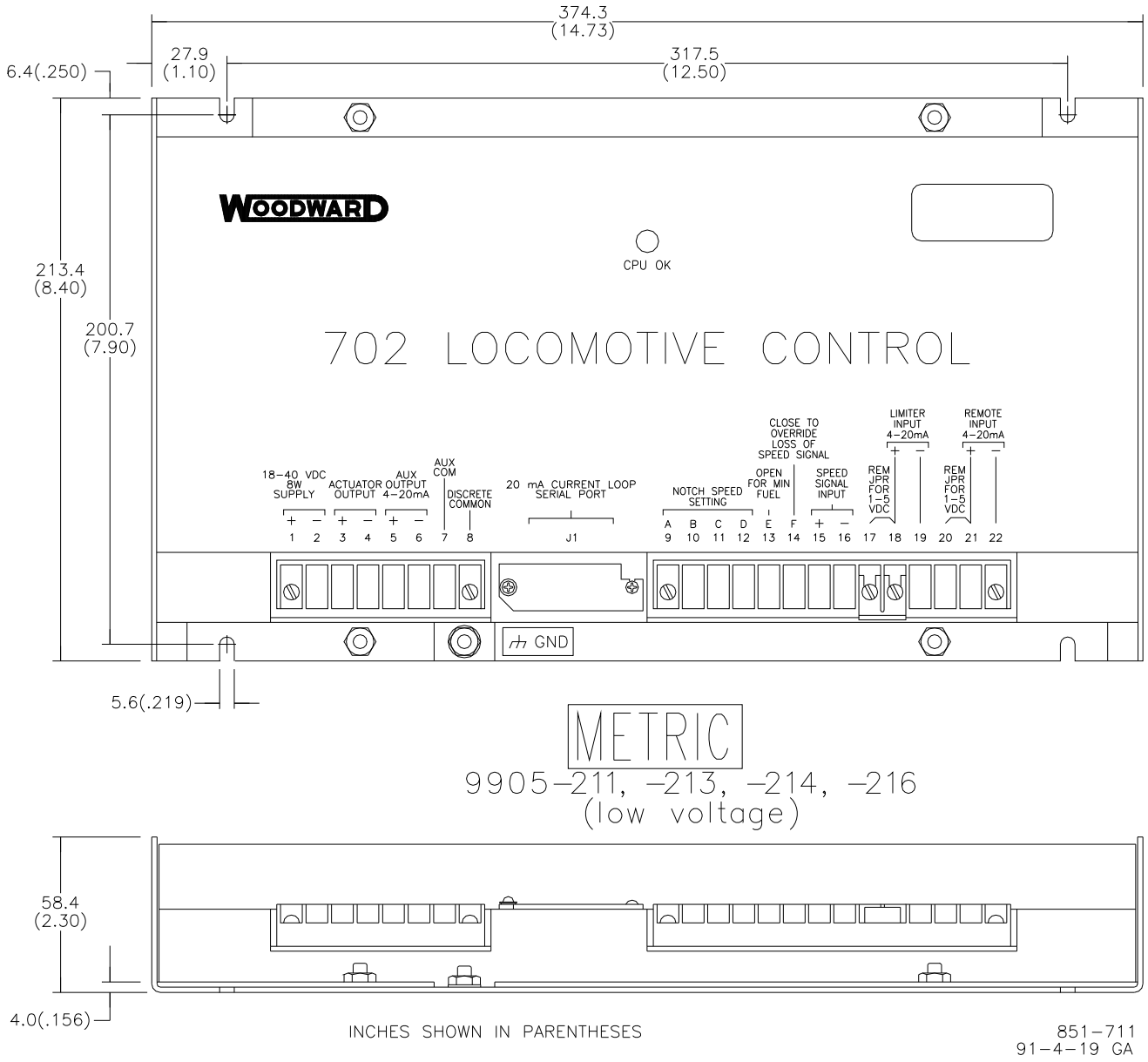


Figure 1-1. 702 Locomotive Control

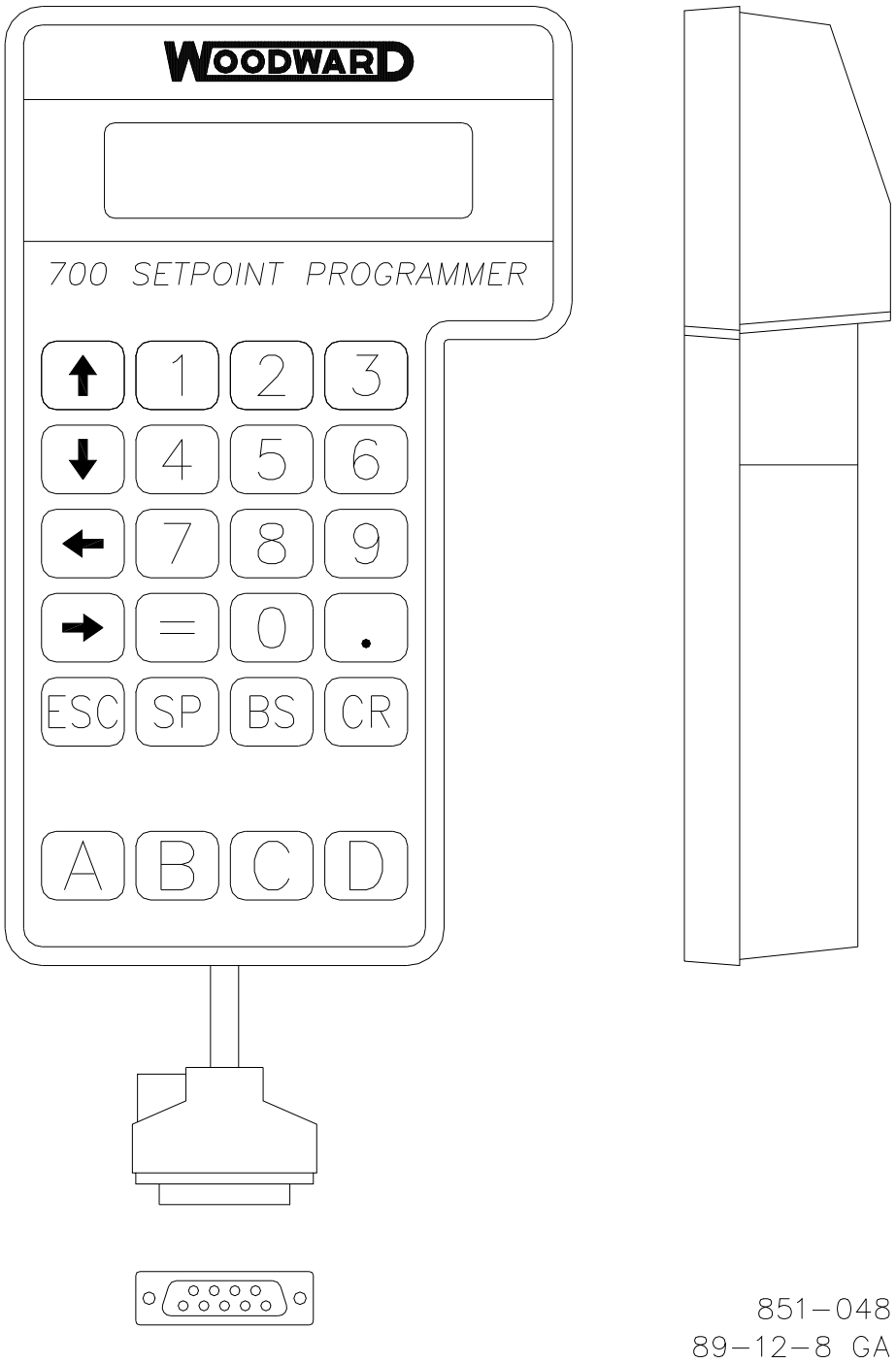


Figure 1-2. Set Point Programmer

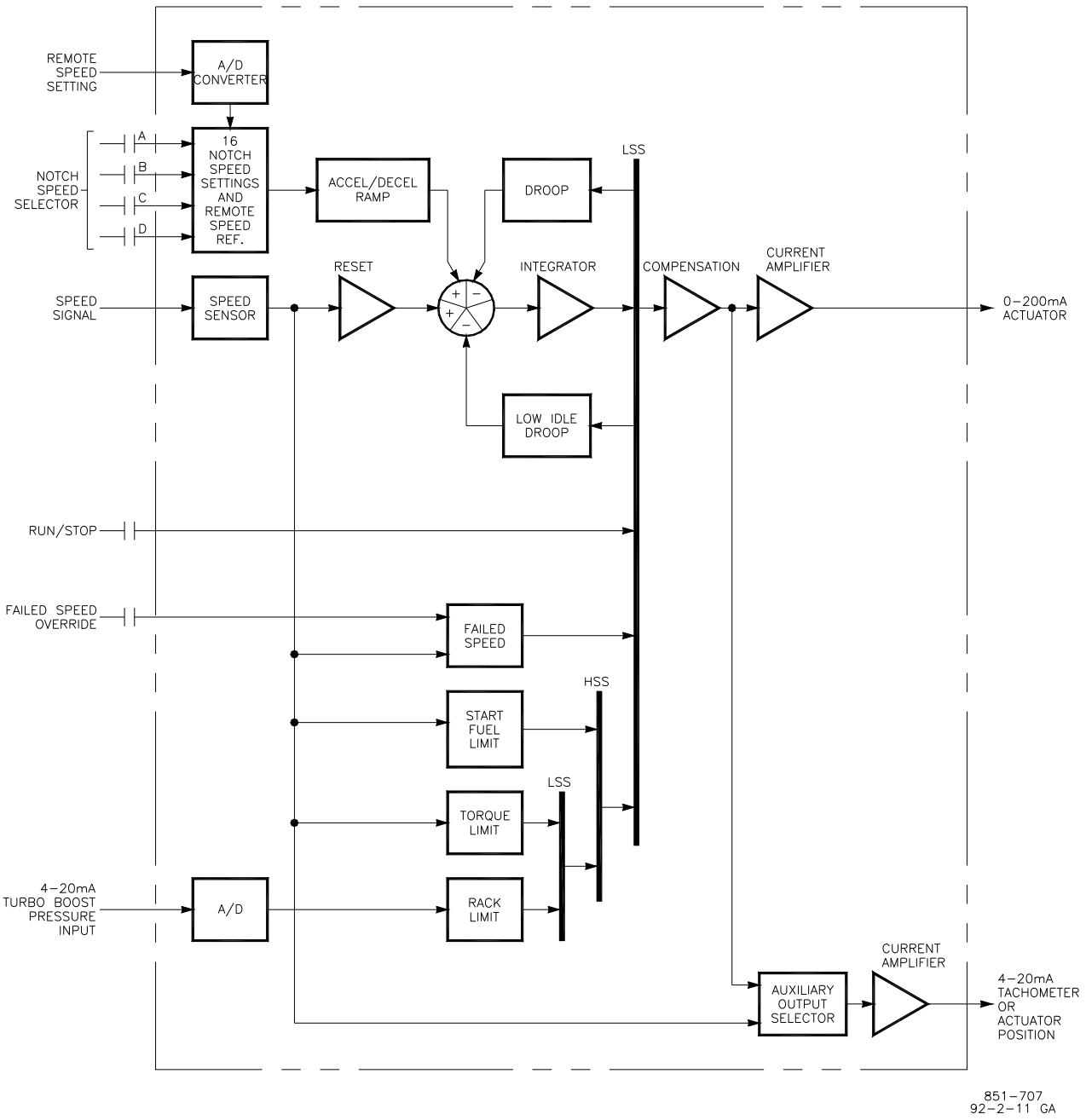
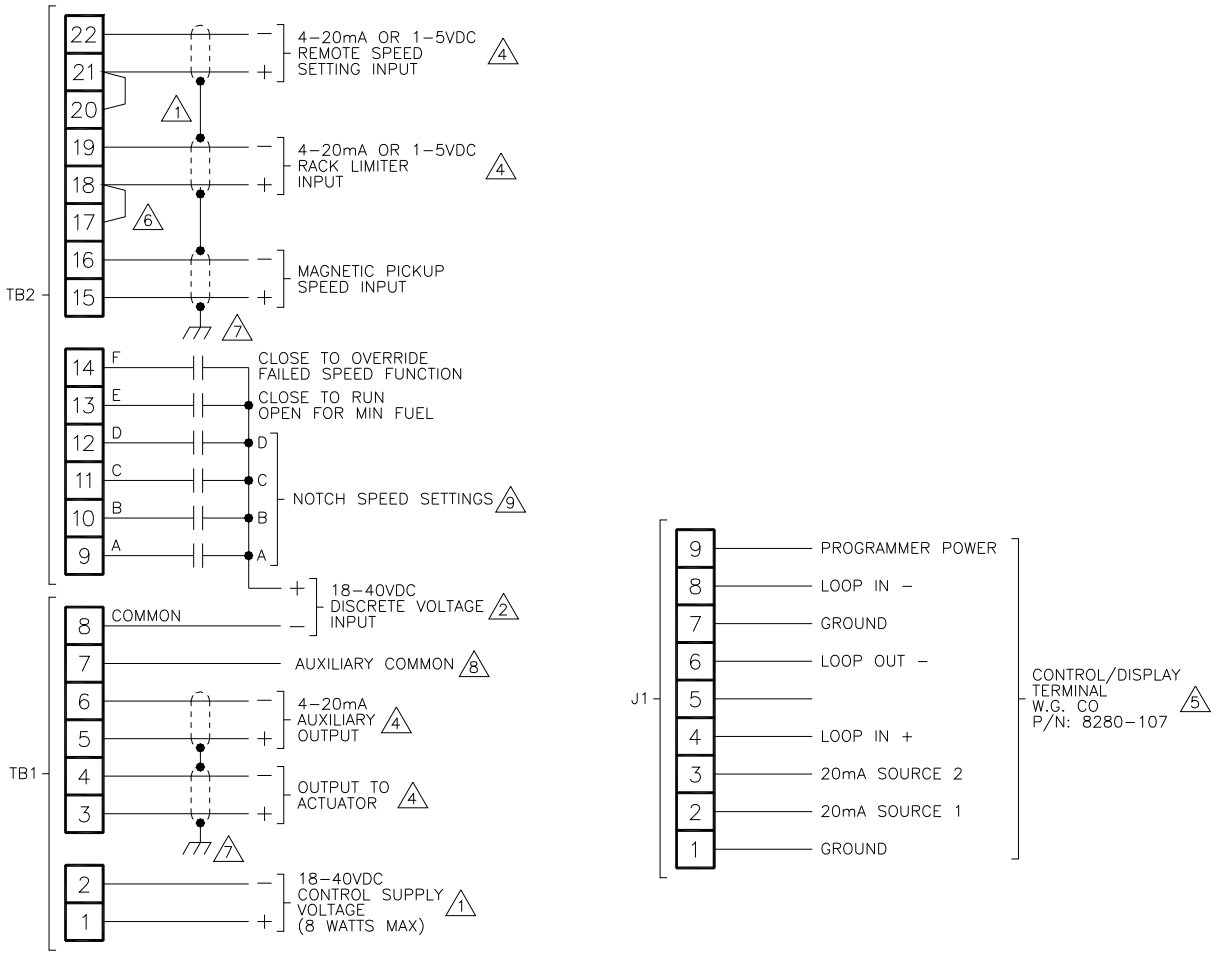


Figure 1-3. Block Diagram



NOTES:

1. INTERNAL POWER SUPPLY PROVIDES DC ISOLATION BETWEEN THE POWER SOURCE AND ALL OTHER INPUTS AND OUTPUTS.
2. DISCRETE INPUTS ARE OPTICALLY ISOLATED FROM OTHER CIRCUITS. INPUT CURRENT IS NOMINALLY 10 MILLIAMPS PER INPUT INTO 2100 OHMS.
3. DO NOT MAKE CONNECTIONS TO TERMINALS MARKED N.C.
4. WHILE THE CONTROL CIRCUITS ARE ISOLATED FROM THE POWER SOURCE, ANALOG INPUTS AND OUTPUTS ARE NOT ISOLATED FROM EACH OTHER. IF THE 4–20mA RACK LIMITER INPUT IS BEING USED, THE ACTUATOR OUTPUT AND TACHOMETER OUTPUT MUST NOT BE INPUT TO CIRCUITS WITH A COMMON GROUND TO THE 4–20mA RACK LIMITER SIGNAL. 20mA CURRENT LOOP ISOLATORS ARE AVAILABLE FROM A NUMBER OF MANUFACTURERS. CONTACT WOODWARD GOVERNOR COMPANY FOR FURTHER INFORMATION.
5. THE 20mA CURRENT LOOP SERIAL PORT IS SET UP TO INTERFACE WITH THE WOODWARD GOVERNOR CO. P/N 8280–107 CONTROL/DISPLAY TERMINAL. THIS PORT IS COMPATIBLE WITH OTHER TERMINALS SUPPORTING 20MA CURRENT LOOP. INFORMATION ON UTILIZING OTHER DEVICES ON THE SERIAL PORT IS CONTAINED IN THE USERS MANUAL.
6. REMOVE JUMPER FOR 1–5VDC INPUT.
7. SHIELDED WIRES TO BE TWISTED PAIRS WITH SHIELD GROUNDED AT ONE END ONLY. WHEN MOUNTING CONTROL TO BULKHEAD, USE EXTERNAL TOOTH LOCK WASHER UNDER ONE SCREWHEAD TO ENSURE PROPER GROUNDING. A GROUND STUD IS PROVIDED ON THE CHASSIS.
8. DO NOT MAKE ANY CONNECTIONS TO AUXILIARY COMMON.
9. NOTCH SPEED SETTING CODES:

CODE	D	C	B	A
0	OFF	OFF	OFF	OFF
1	OFF	OFF	OFF	ON
2	OFF	OFF	ON	OFF
3	OFF	OFF	ON	ON
4	OFF	ON	OFF	OFF
5	OFF	ON	OFF	ON
6	OFF	ON	ON	OFF
7	OFF	ON	ON	ON

CODE	D	C	B	A
8	ON	OFF	OFF	OFF
9	ON	OFF	OFF	ON
10	ON	OFF	ON	OFF
11	ON	OFF	ON	ON
12	ON	ON	OFF	OFF
13	ON	ON	OFF	ON
14	ON	ON	ON	OFF
15	ON	ON	ON	ON

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Figure 1-4. 702 Plant Wiring Diagram

Chapter 2. Installation

Unpacking

Before handling the control, read page ii, Electrostatic Discharge Awareness. Be careful when unpacking the electronic control. Check the control for signs of damage such as bent panels, scratches, and loose or broken parts. If any damage is found, immediately notify the shipper.

Power Requirements

The low-voltage 702 control requires a low-impedance voltage source of 20 to 40 Vdc at 8 W. Apply and remove power to the control only through a non-bouncing switch.

NOTICE **To prevent damage to the control, do not exceed the input voltage range.**

IMPORTANT **If a battery is used for operating power, an alternator or other battery-charging device is necessary to maintain a stable supply voltage.**

NOTICE **To prevent damage to the control, make sure that the alternator or other battery-charging device is turned off or disconnected before disconnecting the battery from the control.**

Location Considerations

Consider these requirements when selecting the mounting location:

- adequate ventilation for cooling
- space for servicing and repair
- protection from direct exposure to water or to a condensation-prone environment
- protection from high-voltage or high-current devices, or devices which produce electromagnetic interference
- avoidance of vibration
- selection of a location that provides an operating temperature range of –40 to +70 °C (–40 to +158 °F)

Do NOT mount the control on the engine.

Electrical Connections

The plant wiring diagram (Figure 1-4) shows external wiring connections and shielding requirements for a typical control installation. The rest of this chapter explains the plant wiring connections.

Shielded Wiring

All shielded cable must be twisted conductor pairs. Do not attempt to tin the braided shield. All signal lines must be shielded to prevent picking up stray signals from adjacent equipment. Connect the shields to the nearest chassis ground. Wire exposed beyond the shield should be as short as possible, not exceeding 50 mm (2 inches). The other end of the shields must be left open and insulated from any other conductor. DO NOT run shielded signal wires along with other wires carrying large currents. See Woodward application note 50532, *EMI Control for Electronic Governing Systems*, for more information.

Where shielded cable is required, cut the cable to the desired length and prepare the cable as instructed below.

1. Strip outer insulation from BOTH ENDS, exposing the braided or spiral wrapped shield. DO NOT CUT THE SHIELD.

2. Using a sharp, pointed tool, carefully spread the strands of the shield.

3. Pull inner conductor(s) out of the shield. If the shield is the braided type, twist it to prevent fraying.

4. Remove 6 mm (1/4 inch) of insulation from the inner conductors.

Installations with severe electromagnetic interference (EMI) may require additional shielding precautions. Contact Woodward for more information.

Power Supply

Power supply output must be low impedance (for example, directly from batteries). DO NOT power the control from high-voltage sources with resistors and zener diodes in series with the control power input. The 702 control contains a switching power supply which requires a current surge to start properly.

NOTICE **To prevent damage to the control, do not power the control from high-voltage sources.**

Run the power leads directly from the power source to the control. DO NOT POWER OTHER DEVICES WITH LEADS COMMON TO THE CONTROL. Avoid long wire lengths. Connect the positive (line) to terminal 1 and negative (common) to terminal 2. If the power source is a battery, be sure the system includes an alternator or other battery-charging device.

If possible, do NOT turn off control power as part of a normal shutdown procedure. Leave the control powered except for service of the system and extended periods of disuse.

NOTICE **Do NOT apply power to the control at this time. Applying power may damage the control.**

NOTICE

To prevent damage to the engine, apply power to the 702 control at least ten seconds prior to starting the engine. This allows the control time to perform its power up diagnostics and become operational. Do not start the engine if the diagnostic tests fail, because test failure turns off the output of the control.

Actuator Output

The actuator wires connect to terminals 3(+) and 4(–). Use shielded wires with the shield connected to chassis at the control.

Aux Output

The tachometer or actuator position readout wires connect to terminals 5(+) and 6(–). Use shielded twisted-pair wires. For an electrically isolated input device such as a 4 to 20 mA input analog meter, the shield must be grounded at the control end of the cable. For input to other devices, follow the recommendation of the device manufacturer.

NOTICE

To prevent possible damage to the control or poor control performance resulting from ground loop problems, follow these instructions. The control common is electrically isolated from the power supply input; however, the actuator and aux outputs are current sources and have a common mode voltage on them with respect to the control's internal common (terminal 7–Aux Common). The analog inputs to the control use this same common. Connecting the actuator or aux outputs to external circuits that are not isolated from the rack limit or the remote speed reference 4 to 20 mA current sources will create ground loop problems. We recommend using current-loop isolators if the 702 control's analog inputs and outputs must both be used with non-isolated devices. A number of manufacturers offer 20 mA loop isolators. Consult Woodward Governor Company for further information.

Discrete Inputs

Discrete inputs are the switch input commands to the 702 control.

Connect the discrete input voltage source negative (–) to terminal 8. Then run the voltage source positive (+) to the appropriate switch or relay contact and then to the corresponding discrete input.

Notch Speed Setting Contact Inputs

The notch speed setting contact inputs are discrete inputs A, B, C, and D (terminals 9, 10, 11, and 12). Binary codes 0000 to 1111, corresponding to 0 to 15 decimal, select the speed reference corresponding to the code. Unused codes not selected can be ignored. Each discrete input registers binary 0 (OFF) when no voltage is applied, and binary 1 (ON) when voltage is applied. See the plant wiring diagram for a complete listing of the binary codes.

Minimum Fuel Contact

The minimum-fuel contact is discrete input E (terminal 13). We recommend using the minimum-fuel contact for a normal engine shutdown (NOT for an emergency shutdown). The control will not operate without voltage applied to terminal 13. When the contact is closed, the voltage applied to terminal 13 allows the control to move the actuator to any position required for operating conditions. Removal of the voltage to terminal 13 causes the control to move the actuator to the minimum fuel position.

⚠WARNING

The minimum-fuel contact is not intended for use in any emergency stop sequence. To prevent possible serious injury from an overspeeding engine, do NOT use the minimum-fuel contact as part of any emergency stop sequence.

Failed Speed Signal Override

The failed speed signal override is discrete input F (terminal 14). When the contact is open, the control operates normally, turning the control output to minimum fuel in the event of a loss of speed signal. Closing the contact overrides the failed speed signal function, which may be required for start-up since there is no speed signal before the engine starts. On engines requiring fuel during cranking, the failed speed signal override allows the actuator to open and provide fuel for starting. The contact must be open (override disabled) during normal engine operation.

⚠WARNING

When the failed speed signal override contact is closed, the control will NOT shut down the engine on loss of speed input signal, possibly resulting in engine overspeed. To prevent possible serious injury from an overspeeding engine, make sure the contact is open during normal engine operation.

Remote Speed Setting Input

Connect the 4 to 20 mA current transmitter or 1 to 5 Vdc transmitter to terminals 21(+) and 22(–). Use a shielded, twisted-pair cable. When using 4 to 20 mA, you must install a jumper between terminals 20 and 21 to connect a 243 ohm internal burden resistor in the loop. This input is not isolated from the other control inputs and outputs (except the power supply input and the discrete inputs). If any other analog input or output is used in a common ground system, an isolator must be installed. A number of manufacturers offer 20 mA loop isolators. Consult Woodward Governor Company for further information.

The remote speed setting is automatically selected when an input of 2 mA or greater is detected on the remote speed setting input.

When the remote speed setting input is between 2 and 4 mA, the speed reference will ramp at the Raise Rate (Menu B) or Lower Rate (Menu B) to the 4 mA Remote Reference set point (Menu B).

When the remote speed setting input is between 4 mA and 20 mA, the speed reference will track the remote speed setting input linearly between the 4 mA Remote Reference set point (Menu B) and the 20 mA Remote Reference set point (Menu B) at the ramp rate determined by the Raise Rate (Menu B) or the Lower Rate (Menu B).

When the remote speed setting input is less than 2 mA, the speed reference will ramp at the Accel Time (Menu B) or Decel Time (Menu B) to the speed reference value determined by the notch speed settings inputs, terminals 8(–) and terminals 9 through 12(+).

IMPORTANT

When the remote speed setting input falls below 2 mA or fails, the control's speed reference will automatically default to the speed reference value determined by the notch speed setting inputs. When remote speed setting input is used, we recommend that a default speed setting code be selected on the notch speed setting inputs.

Speed Signal Input

Connect a speed-sensing device, such as a magnetic pickup, to terminals 15 and 16 using shielded wire. Connect the shield to the chassis. Make sure the shield has continuity the entire distance to the speed sensor, and make sure the shield is insulated from all other conducting surfaces. For more information on the magnetic pickup, see Manual 82510.

⚠WARNING

The number of gear teeth is used by the control to convert pulses from the speed sensing device to engine rpm. To prevent possible serious injury from an overspeeding engine, make sure the control is properly programmed to convert the gear-tooth count into engine rpm. Improper conversion could cause engine overspeed.

Rack Limiter Input

Connect the 4 to 20 mA current or 1 to 5 Vdc transmitter of the turbo boost pressure sensor to terminals 18(+) and 19(–). Use a shielded, twisted-pair cable. When using 4 to 20 mA, you must install a jumper between terminals 17 and 18 to connect the 243 ohm internal burden resistor in the loop. This input is not isolated from the other control inputs and outputs (except the power supply input and the discrete inputs). If any other analog input or output is used in a common-ground system, a loop isolator must be installed. A number of manufacturers offer 20 mA loop isolators. Contact Woodward Governor Company for further information.

Installation Checkout Procedure

With the installation complete as described in this chapter, perform the following checkout procedure before beginning the start-up adjustments in Chapter 3.

1. Visual inspection
   A. Check the linkage between the actuator and fuel metering device for looseness or binding. Refer to the appropriate actuator manual, and Manual 25070, *Electronic Governor Installation Guide*, for additional information on linkage.

⚠WARNING

To prevent possible serious injury from an overspeeding engine, the actuator lever or stroke must be near but not at the minimum position when the fuel valve or fuel rack is at the minimum fuel delivery position.

   B. Check for correct wiring in accordance with the plant wiring diagram (Figure 1-4).

   C. Check for broken terminals and loose terminal screws.

   D. Check the speed sensor for visible damage. If the sensor is a magnetic pickup, check the clearance between the gear and the sensor, and adjust if necessary. Clearance should be between 0.25 and 1.25 mm (0.010 and 0.050 inch) at the closest point. Make sure the gear runout does not exceed the pickup gap.

2. Check for grounds

   Check for grounds by measuring the resistance from all control terminals to chassis. All terminals except terminals 2 and 8 should measure infinite resistance (the resistance of terminals 2 and 8 depends on whether a floating or grounded power source is used). If you find a resistance less than infinite, remove the connections from each terminal one at a time until the resistance is infinite. Check the line that was removed last to locate the fault.

Chapter 3.
Operation and Adjustment

Introduction

Because of the variety of installations, plus system and component tolerances, the control must be tuned to each system for optimum performance.

WARNING

An improperly calibrated control could cause an engine overspeed or other damage to the engine. To prevent possible serious injury from an overspeeding engine, read this entire procedure before starting the engine.

Using the Set Point Programmer

The Set Point Programmer is a hand-held computer terminal that gets its power from the 702 control. The terminal connects to the 20 mA Loop Serial Port on the control. To connect the terminal, slightly loosen the right hand screw in the cover over J1 and rotate the cover clockwise to expose the 9-pin connector. Then firmly seat the connector on the terminal into J1.

When power is applied to the terminal by plugging it into the control, it performs a power-up self-test. At completion of the self-test, the screen remains blank. Press the SP (Space) key to display the part number and revision level of the software in the control. (The SP key also turns on the display backlighting.) Please refer to this number and revision level in any correspondence with Woodward Governor Company. The set points or adjustments of the control are arranged in five menus. You access these menus with the A, B, C, D, and 1 keys. Pressing the appropriate key selects the first item on each menu.

A—Dynamics Menu
1. Gain
2. Reset
3. Compensation
4. Gain Ratio
5. Window Width
6. Gain Slope
7. Gain Breakpoint

[menu items 4-7 not present on all versions]

B—Speed Setting Menu
1. Code 0 Speed
2. Code 1 Speed
3. Code 2 Speed
4. Code 3 Speed
5. Code 4 Speed
6. Code 5 Speed
7. Code 6 Speed
8. Code 7 Speed
9. Code 8 Speed
10. Code 9 Speed
11. Code 10 Speed
12. Code 11 Speed
13. Code 12 Speed

14. Code 13 Speed
15. Code 14 Speed
16. Code 15 Speed
17. Accel Time
18. Decel Time
19. Raise Rate
20. Lower Rate
21. 20 mA Remote Reference
22. 4 mA Remote Reference
23. 20 mA Tachometer RPM
24. 4 mA Tachometer RPM
25. Droop
26. Idle Droop
27. Idle Breakpoint

C—Rack Limiters and Control Output Menu

1. Rack Limit Breakpoint
2. 4 mA Rack Limit
3. Breakpoint Rack Limit
4. 20 mA Rack Limit
5. Torque Limit Breakpoint
6. Minimum Torque Limit
7. Breakpoint Torque Limit
8. Maximum Torque Limit
9. Start Fuel Limit
10. 20 mA Actuator Percent
11. 4 mA Actuator Percent

D—Display Menu

1. Engine Speed
2. Speed Reference
3. Actuator Output
4. Aux Output
5. Rack Limit Input
6. Remote Input
7. Notch Code Selected
8. Run/Stop Switch Status
9. Failsafe On/Off Switch Status
10. Watchdog Status
11. Self Test Result
12. ROM Check Sum

1—Calibration/Configuration Menu

1. Calibration Key
2. Number of Gear Teeth
3. Rack Limit Calibration
4. Remote Input Calibration
5. Aux Output Configuration
6. Aux Output Calibration
7. Forward/Reverse Acting Actuator
8. Dynamics Map

Pressing the appropriate key (A, B, C, D, 1) selects the desired menu. To step through the menu, use the left and right arrow keys. The right arrow advances through the menu and the left arrow moves backward through the menu. The menus are continuous; that is, pressing the right arrow at the last menu item takes the menu to the first item, or pressing the left arrow at the beginning of the menu takes the menu to the last item.

To adjust a set point, use the up arrow to increase the value, or the down arrow to decrease the value. Holding the up or down arrow longer than a few moments causes the rate of change to increase. This is useful during initial setup where a value may need to be changed significantly.

Finally, use the "=" key to save entered values. After you are satisfied with all entries and adjustments, press the "=" key to transfer all new set point values into EEPROM memory. The EEPROM retains all set points when power is removed from the control and restores them when power is reapplied.

NOTICE

To prevent possible damage to the engine resulting from improper control settings, make sure you save the set points before removing power from the control. Failure to save the set points before removing power from the control causes them to revert to the previously saved settings.

The control ignores all other keys on the Set Point Programmer.

Description of the 702 Locomotive Control Set Points

Menu A—Dynamics Menu

Dynamic adjustments are settings that affect the stability and transient performance of the engine. Read through all of the set point descriptions before beginning setup of the control. Several of the set points are dependent on others. Also see Figures 3-1 and 3-2.

1. Gain determines how fast the control responds to an error in engine speed from the speed-reference setting. The gain is set to provide stable control of the engine under all operating conditions.

2. Reset compensates for the lag time of the engine. It adjusts the time required for the control to return the speed to zero error after a disturbance. Reset is adjusted to prevent slow hunting and to minimize speed overshoot after a load disturbance.

3. Compensation is used to compensate for actuator and fuel system lag time.

4. Gain Ratio (not present on all versions) is the ratio of the Gain setting at steady state to the Gain setting during transient conditions. The Gain Ratio operates in conjunction with the Window Width and Gain adjustments by multiplying the Gain set point by the Gain Ratio when the speed error is greater than the Window Width. This makes the control dynamics fast enough to minimize engine-speed overshoot on start-up and to reduce the magnitude of speed error when loads are changing. This allows a lower gain at steady state for better stability and reduced steady-state actuator linkage movement.

5. Window Width (not present on all versions) is the magnitude (in rpm) of a speed error at which the control automatically switches to fast response. The control does not use the absolute value of speed error, but "anticipated" speed error to make this switch. This method provides for quick switching to the high gain value when an offspeed occurs and early switching to the low gain value when recovering from the speed transient. This provides smoother switching than if the absolute speed error was used for the window.

6. Gain Slope (not present on all versions) changes Gain as a function of actuator output. Since actuator output is proportional to engine load, this makes gain a function of engine load. Gain Slope operates in conjunction with the Gain Breakpoint adjustment to increase (or decrease) gain when percent actuator output is greater than the breakpoint. This compensates for systems having high (or low) gain at low load levels. This allows the Gain setting to be lower at light or no load for engine stability, yet provide good control performance under loaded conditions.

7. Gain Breakpoint (not present on all versions) sets the percent output above which the Gain Slope becomes effective. It should usually be set just above the minimum load output. The Gain Breakpoint adjustment is common to both sets of dynamics.

Menu B—Speed Setting Menu

Speed adjustments are the settings that affect the speed reference and other functions related to speed.

1. Code 0-15 Speed. Set for the speed desired when the corresponding code is applied to the discrete inputs A, B, C, and D by the notch speed setting device. The speed settings are independent and may be in any order. Unused codes must be set to a speed between the minimum and maximum speed settings, as the minimum and maximum values are used by the control for dynamics mapping, ramp times, and torque limiting functions.

2. Accel Time is the time required for the control to ramp the engine speed from minimum speed to maximum speed. Minimum and maximum speeds are determined by the lowest and highest speeds set in step 1 above. The ramp starts automatically whenever the notch setting switches are changed to a code with a speed setting greater than the current setting. The actual ramp time obtained between notches will be proportional to the difference in speed between the notches and the difference between the minimum and maximum speed settings.

IMPORTANT

Actual engine acceleration time may be slower than that set by the Accel Time set point if the Rack Limiter or Torque Limiter come into effect during acceleration.

3. Decel Time is the time required for the control to ramp the engine speed from maximum speed to minimum speed. Minimum and maximum speeds are determined by the lowest and highest speeds set in step 1 above. The ramp starts automatically whenever the notch setting switches are changed to a code with a speed setting lower than the current setting. The actual ramp time obtained between notches will be proportional to the difference in speed between the notches and the difference between the minimum and maximum speed settings.

IMPORTANT

Actual engine deceleration may be slower than that set by the Decel Time set point. This occurs when the Decel Time set point is faster than system inertias will allow the engine to come down in speed. This condition is indicated by the control actuator output going to the minimum fuel position. See Low Idle Droop below.

4. Raise Rate is the rate at which the speed reference is ramped when the Remote Speed Setting input is changed in the increase direction. A step change on the remote input does not cause an immediate change in the reference, which is ramped to the new setting at the Raise Rate.

5. Lower Rate is the rate at which the speed reference is ramped when the Remote Speed Setting input is changed in the decrease direction. A step change on the remote input does not cause an immediate change in the reference, which is ramped to the new setting at the Lower Rate.

6. 20 mA Remote Reference is the engine speed desired when 20 mA is applied to the Remote Speed Reference input.

7. 4 mA Remote Reference is the engine speed desired when 4 mA is applied to the Remote Speed Reference input.

8. 20 mA Tachometer RPM is the engine speed when the auxiliary output is 20 mA and "Tachometer" is selected in Menu 1.

9. 4 mA Tachometer RPM is the engine speed when the auxiliary output is 4 mA and "Tachometer" is selected in Menu 1.

10. Droop is based on the control output, which is proportional to engine load. The droop obtained is dependent on linkage adjustment and stroke. For example, 5% droop gives a real droop of 2.5% if the control output changes 50% from no load to full load.

11. Idle Droop is based on the control output current when it drops below the Idle Breakpoint setting. Linkage affects the Idle Droop percentage, so large Idle Droop settings may be required to achieve the desired results.

12. Idle Breakpoint is normally set equal to the control output obtained when the engine is unloaded and at low idle. When the output of the control drops below this setting or goes to minimum fuel during rapid engine deceleration, Idle Droop, described below, will raise the speed reference. This brings the engine back under control sooner and reduces speed undershoot. Speed undershoot may occur because the time required for the control to return to the new fuel setting takes time dependent on control dynamics and linkage adjustment.

Menu C—Rack Limiters and Control Output Menu

The 702 Control provides Start, Rack, and Torque Limiters to limit the actuator output current from the control. The actuator current determines the position of the actuator and thus the rack position.

1. Rack Limit Breakpoint is the input milliamps from the turbo boost pressure sensor at which the slope of the two-slope rack limiter changes.

2. 4 mA Rack Limit determines the maximum percent actuator output current when the boost pressure input is 4 mA. The control responds to inputs from 2 to 20 mA. Inputs between 2 and 4 mA are treated as 4 mA. The rack limit does not go below the 4 mA setting. The control interpolates the rack limit between the 4 mA Rack Limit and the Breakpoint Rack Limit set points. An input below 2 mA is considered failed and the control defaults to the maximum setting at 20 mA for continued operation.

3. Breakpoint (BP) Rack Limit is the percent actuator output current at the Rack Limit Breakpoint set above.

4. 20 mA Rack Limit determines the maximum percent actuator output current when the turbo boost pressure input is 20 mA. Straight line interpolation is made between the Breakpoint and 20 mA settings.

   Figure 3-3 illustrates the breakpoint and these adjustments.

5. Torque Limit Breakpoint (BP) is the engine speed at which the slope of the torque limiter output changes.

6. Minimum Torque Limit is the maximum percent actuator output current when the engine speed is at the minimum, or lowest, speed setting determined from the notch speed settings above. The output current limit does not go below this setting even when speed may drop lower. The limiter interpolates between Minimum Torque Limit and Breakpoint Torque Limit for intermediate engine speeds.

7. Breakpoint (BP) Torque Limit is the percent actuator output current at the engine speed set by the Torque Limit Breakpoint described above.

8. Maximum Torque Limit is the maximum percent actuator output current when the engine speed is at the maximum, or highest, speed setting determined from the notch speed settings above. The limiter interpolates between the Breakpoint Torque Limit and Maximum Torque Limit for intermediate speeds.

   Figure 3-4 illustrates the breakpoint and these adjustments.

9. Start Fuel Limit sets the maximum percent actuator output during engine start-up. The limit is usually set to obtain the fuel required to start the engine reliably under all conditions. The Start Fuel Limit is disabled after engine speed reaches the speed set by the current notch setting input. The Start Fuel Limit is independent of the Rack and Torque Limiters, so it may be set higher or lower than those limits.

10. 20 mA Actuator Percent is the actuator percentage when the auxiliary output is 20 mA and "Actuator Percent" is selected in Menu 1.

11. 4 mA Actuator Percent is the actuator percentage when the auxiliary output is 4 mA and "Actuator Percent" is selected in Menu 1.

Menu D—Display Menu

Input and output values are displayed once when each item is selected. To get a continuous update, hold down either the up or down arrow.

1. Engine Speed displays the current engine speed in rpm.

2. Speed Reference displays the current speed reference in rpm.

3. Actuator Output displays the current percent of output. Maximum (100%) indicates the control actuator current is approximately 210 mA for forward-acting actuators or 0 mA for reverse-acting actuators. This set point is useful for setup of the start fuel, turbo boost rack, or torque limiters and the Idle Droop Breakpoint.

4. Aux Output displays the milliamps on the auxiliary output. This is useful for testing and system calibration.

5. Rack Limit Input displays the milliamps currently on the turbo boost pressure rack limit input.

6. Remote Input displays the milliamps on the Remote Speed Setting Input. This is useful for testing and system calibration.

7. Notch Code Selected is the decimal value of the notch speed setting inputs. Note that this number does not display the actual “notch,” but rather the code output by the notch speed setting device.

8. Run/Stop Switch Status displays the status of discrete input E, terminal 13. Closed indicates 24 Vdc is applied to the input selecting the run position. Open selects minimum fuel or the stop position.

9. Failsafe On/Off Switch Status displays the status of discrete input F, terminal 14. Closed overrides the failed speed function (control will not go to minimum fuel when no speed signal is detected). Open enables the failed speed function (control will go to minimum fuel when no speed signal is detected).

10. Watchdog Status displays the status of the control CPU. The normal status displayed is CPU OK. If a CPU fault occurs, the CPU OK indicator on the front of the control will turn off, the Actuator Output and Aux Output will decrease to minimum output, and the Watchdog Status will display TIME OUT. To reset the watchdog, turn off power to the control for a minimum of 10 seconds.

11. Self Test Result displays the result of power up diagnostics performed on the microprocessor, data, and program memory. A successful test gives a result of 49. Report any other result to Woodward Governor Company when returning the control for repair.

12. ROM Check Sum is used by Woodward Governor Company during factory tests. This number is verified each time the control is powered up. An incorrect result displays a Self Test Result value other than 49 and causes a control shutdown.

Menu 1—Calibration/Configuration Menu

1. Calibration Key is a code which you must enter before you can change any of the set points on the calibration menu. This helps prevent accidental modification of the set points. The code is factory set to “49”. Use the up and down arrow keys to select the code. Whenever the Run/Stop input is changed, the code will be reset to “0”.

2. Number of Gear Teeth is the number of teeth or holes in the gear or flywheel the speed sensing device is on. If the gear is running at camshaft speed (one-half engine speed) then you must enter one-half the number of teeth on the gear. The control requires the number of teeth per engine revolution.

IMPORTANT

Best control performance will be obtained when sensing speed from a gear rotating at full engine speed. Slower-speed gears (such as the camshaft) provide a lower sampling rate which impairs control response time.

⚠WARNING

The number of gear teeth is used by the control to convert pulses from the speed-sensing device to engine rpm. To prevent possible serious injury from an overspeeding engine, make sure the control is properly programmed to convert the gear-tooth count into engine rpm. Improper conversion could cause engine overspeed.

3. Rack Limit Calibration calibrates the 4–20 mA Rack Limit input by adjusting the value of the input voltage as seen by the control software. This calibration is performed by Woodward Governor Company prior to shipment and should not normally require field adjustment. See the Control Test and Calibration section in Chapter 5 for proper adjustment procedure.

4. Remote Input Calibration calibrates the 4–20 mA Remote Speed Setting input by adjusting the value of the input current as seen by the control software. This calibration is performed by Woodward Governor Company prior to shipment and should not normally require field adjustment. See the Control Test and Calibration section in Chapter 5 for proper adjustment procedure.

5. Aux Output Configuration selects either actuator position readout (Menu C) or tachometer readout (Menu B) for the 4 to 20 mA auxiliary output. Use the up and down arrow keys to select the desired display.

6. Aux Output Calibration calibrates the 4–20 mA auxiliary output by adjusting the value of the aux output current as seen by the control software. This calibration is performed by Woodward Governor Company prior to shipment and should not normally require field adjustment. See the Control Test and Calibration section in Chapter 5 for proper adjustment procedure.

7. Forward/Reverse Acting Actuator sets the direction of the control actuator output to increase fuel. Forward-acting actuators require increased current to increase fuel. Reverse-acting actuators require decreased current to increase fuel. The Minimum Fuel contact must be open, engine speed must be 0, and the Calibration Key must be set to “49” to change the Forward/Reverse setting. Failure to meet any of these conditions will result in an error message being displayed on the Set Point Programmer.

8. Dynamics Map selects the mapping algorithm used to map dynamics as a function of engine speed. Figure 3-1 illustrates how dynamics vary as a function of engine speed for each map.

   With Map 0, gain is proportional to engine speed and Reset and Compensation are held constant. The Gain set point may be adjusted at any engine speed, but the value is normalized to the maximum speed reference. For example, if gain is set to 0.1 and current engine speed is 50 percent of the maximum, then the actual gain used in the control algorithm will be 0.05, or 50 percent of the set point value. If engine speed is at maximum, actual gain will be 100 percent of the set point value.

   Map 1 provides additional Reset and Compensation inversely proportional to engine speed. Gain for Map 1 is proportional to the square of engine speed. For example, at 50 percent of maximum speed, the actual gain will be 25 percent of the set point value and Reset and Compensation values will be two times greater than at maximum speed.

The final decision on the use of Map 0 or Map 1 depends on engine performance obtained throughout the operating speed and load range. After tuning the control for desired performance under rated speed and load conditions, performance at low speed and light loads should be evaluated. If low frequency speed oscillation occurs at low speeds using Map 0, Map 1 will provide additional stability. If performance is poor at low speed on Map 1, Map 0 will provide higher performance. Select the Map that provides the best overall performance for all operating conditions.

Initial Prestart Settings

Menu A

1. Gain—0.1
2. Reset—1.00
3. Compensation—0.2
4. Gain Ratio—1.0
5. Window Width—60
6. Gain Slope—0.0
7. Gain Breakpoint—25

[menu items 4-7 not present on all versions]

Menu B

1. Code 0–Code 15—Set to the speed desired for the code selected by the notch speed selecting device. Note that these codes are not the notch numbers, but the code supplied by the notch setting device. All unused codes, or codes not selected by the notch setting device must be set between the minimum and maximum speed settings.
   At this time, select each notch and verify the correct Speed Reference (Menu D, item 2) is obtained.
2. Accel Time—Set to the time desired to ramp from the minimum to maximum speeds set on menu item 1 above. The ramp time between notches will then be proportional to this time.
3. Decel Time—Set to the time desired to ramp from the maximum to minimum speeds set on menu items 1 and 2 above. The ramp time between notches will then be proportional to this time.
4. Raise Rate—Set to the rpm-per-minute rate desired to raise speed with the Raise command or with the 4 to 20 mA Remote Speed Reference.
5. Lower Rate—Set to the rpm-per-minute rate desired to lower speed with the Lower command or with the 4 to 20 mA Remote Speed Reference.
6. 20 mA Remote Reference—Set to operating speed with 20 mA input. Skip if remote input is not used.
7. 4 mA Remote Reference—Set to operating speed with 4 mA input. Skip if remote input is not used.
8. 20 mA Tachometer RPM—Set to full scale rpm of your meter.
9. 4 mA Tachometer RPM—Set to minimum scale rpm of your meter.
10. Droop—Set to 0 for isochronous operation or to desired droop. Note that droop is dependent on the actuator stroke actually used. If actuator stroke is 50% from no load to full load, set droop at twice the desired droop value.
11. Idle Droop—25%
12. Idle Breakpoint—0

Menu C

1. Rack Limit Breakpoint—between 4 and 20 mA
2. 4 mA Rack Limit—100%
3. Breakpoint Rack Limit—100%
4. 20 mA Rack Limit—100%
5. Torque Limit Breakpoint—between min and max set speed
6. Minimum Torque Limit—100%
7. Breakpoint Torque Limit—100%
8. Maximum Torque Limit—100%
9. Start Fuel Limit—100%
10. 20 mA Actuator Percent—(will be set after start-up)
11. 4 mA Actuator Percent—(will be set after start-up)

Menu 1

1. Calibration Key—49.
2. Number of Gear Teeth—Set to number of teeth or holes in the gear where the speed sensor is mounted. If this gear is not turning at the same speed as the engine, enter the number of teeth seen by the sensor in one engine revolution.
3. Rack Limit Calibration—Do not adjust (see Control Test and Calibration procedure in Chapter 5).
4. Remote Input Calibration—Do not adjust (see Control Test and Calibration procedure in Chapter 5).
5. Aux Output Configuration.
   Tachometer for 4–20mA tachometer output
   Actuator Percent for 4–20mA actuator position output
6. Aux Output Calibration—Do not adjust (see Control Test and Calibration procedure in Chapter 5).
7. Forward/Reverse Acting Actuator
   Forward for forward-acting actuators
   Reverse for reverse-acting actuators
   To enable the control for changing the Forward/Reverse mode, the following conditions must be met: Calibration Key must be set to “49”, the Minimum Fuel contact must be open, and engine speed must be 0.
8. Dynamics Map—Map 1 is the preferred dynamics mapping for all engines. Use Map 0 if the specific application is determined to require higher Gain and lower Reset tuning parameters when using Map 1 to achieve best performance at the lowest operating speed.

At this time, we recommend saving this setup by pressing the “=” key on the Set Point Programmer. The programmer will display the message “Set Points Saved.” Be sure to select a menu prior to continuing.

NOTICE

To prevent possible damage to the engine resulting from improper control settings, make sure you save the set points before removing power from the control. Failure to save the set points before removing power from the control causes them to revert to the previously saved settings.

Start-Up Adjustments

1. Complete the installation checkout procedure in Chapter 2 and the initial prestart settings above.

2. Apply power to the control and close the Run/Stop contact. Select the desired starting speed with the notch setting device.

3. Check the speed sensor.

   Minimum voltage required from the speed sensor to operate the control is 1.0 Vrms, measured at cranking speed or the lowest controlling speed. For this test, measure the voltage while cranking, with the speed sensor connected to the control. Before cranking, be sure to prevent the engine from starting. At 5% of maximum speed, the failed speed sensing circuit function is cleared and the engine speed should be displayed on Menu D, item 1.

⚠WARNING **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.**

4. Start the engine.

   If there is insufficient fuel to start the engine, increase the Start Fuel Limit (Menu C). (The control reduces fuel as required when the speed setting is reached. It requires extra fuel to accelerate the engine to idle speed.) It may take a few starts to determine the final setting of the Start Fuel Limit. If the start time is excessive, increase the Start Fuel Limit. If the start time is too fast or flooding is occurring, decrease the Start Fuel Limit. We recommend trying both hot and cold starts to determine a final setting.

5. Adjust dynamics for stable operation.

   If the engine is hunting at a rapid rate, slowly decrease the Gain (Menu A) until performance is stable. If the engine is hunting at a slow rate, increase the Reset time. If increasing the Reset time does not stabilize the engine, it also may be necessary to slowly decrease the Gain OR to slowly decrease the Gain and increase the Compensation.

This completes the Start-up adjustments. We recommend saving the settings at this time by pressing the “=” key on the Set Point Programmer.

Dynamic Adjustments

The objective of the dynamic adjustments is to obtain the optimum, stable engine speed response from minimum load to full load and speed operating conditions. See Figures 3-1 and 3-2.

1. No-Load Adjustments

   Perform this adjustment without load applied.

   Slowly increase the Gain set point until the engine becomes slightly unstable, then reduce the Gain as necessary to stabilize the engine.

   After obtaining acceptable performance at no load, record the Actuator Output as read on Menu D. Set the Gain Breakpoint (Menu A) to this reading.

2. Minimum Load Adjustment

   Perform this adjustment at the minimum speed and load conditions at which the engine is operated.

   Observe the movement of the actuator. If the activity of the actuator is excessive, reduce the Gain set point slightly to get the actuator movement to an acceptable level.

   If there is a slow periodic cycling of the engine speed above and below the speed setting, there are two possible causes:

   - Gain is too high and Reset is too low. Reduce the gain by 50% (if the gain was 0.02, reduce it to 0.01) and increase Reset slightly. Observe the movement of the actuator. Continue to increase Reset until the movement is acceptable but not excessive. A final value of Reset should be between 1.0 and 2.0 for most large engines. If the Reset value exceeds 2.0, but this procedure continues to improve performance, increase the Compensation set point 50% and repeat the procedure.

   - Gain is too low. If the preceding procedure does not improve the slow periodic cycling of the engine speed, the control may be limiting cycling through the low gain control region set by the Window Width set point. Increase the Gain set point to minimize the cycling. If actuator movement becomes excessive, reduce the Compensation set point until movement is acceptable. In some cases, Compensation may be reduced to zero and only the Gain and Reset adjustments used. This should be done only if necessary to eliminate excessive actuator response to misfiring or other periodic disturbances. Reduce the Window Width set point until the limit cycle amplitude is acceptable without excessive rapid actuator movement.

3. Full Load Adjustment

   Perform these adjustments at the speed and load ratings at which the engine is most often operated.

   If operation in this range is satisfactory, no further dynamic adjustments are necessary. If during changes in speed or load, excessive speed errors occur, increase the Gain Slope adjustment until engine performance is satisfactory. If excessive actuator movement again occurs, do procedure 4, then repeat procedure 3. If the settling time after a speed or load change is too long, reduce the Reset set point slightly and increase the Gain slightly. If slow-speed hunting occurs after a load or speed change but decreases or stops in time, increase the Reset set point slightly and reduce the Gain set point. See Figure 3-3.

⚠WARNING

The use of negative gain slope should be considered carefully. Low gain at high fuel levels will result in poor load rejection response or possible overspeed. To prevent possible serious injury from an overspeeding engine, the Max Fuel Limit, Menu C, must be set near the full load output current demand to prevent excessive integrator windup and a subsequent low gain condition.

4. When speed and load changes occur, the control should switch automatically to high gain to reduce the amplitude of the offspeeds. Reduce (or increase) the Window Width set point to just greater than the magnitude of acceptable speed error. A value of Gain ratio too high will cause the control to hunt through the low-gain region. This normally will occur only if the Window Width is too low. If necessary to decrease the Window Width to control limit cycling (identified by the engine speed slowly cycling from below to above the speed setting by the amount of Window Width), the Gain Ratio may be reduced for more stable operation.

5. Verify that performance at all speed and load conditions is satisfactory and repeat the above procedures if necessary.

6. While operating at minimum speed and load, record the Actuator Output on Menu D. Select the Idle Breakpoint on Menu B. Set at the recorded value.

7. While operating at full load, record the Actuator Output on Menu D. Select the Maximum Torque Limit set point on Menu C. Set at approximately 10% over the full load output if desired, otherwise leave at 100%.

8. If your installation uses the turbo boost pressure rack limiter, record the Actuator Output (Menu D) and output of the turbo boost sensor at various operating points between low idle and full rated speed and load. These values are needed to determine the values for the initial Rack Limit set points below.

9. If your installation uses the Torque Limiter, record the control Output (Menu D) and the engine speed at operating points between minimum and maximum load. These values are used to determine the initial Torque Limit set points below.

We recommend you check the operation from both hot and cold starts to obtain the optimum stability under all conditions.

Speed Menu Adjustments

1. 4 to 20 mA Tachometer Output

   Set engine speed to the speed desired for 4 mA output. If this is not possible, skip this step or use a signal generator into the speed input with the frequency corresponding to the desired rpm. Trim the 4 mA Tach rpm set point for 4 mA output. Note that the set point and actual engine speed may not be the same. This adjustment provides calibration of the output.

   Set engine speed to the speed desired for 20 mA output. Trim the 20 mA Tach rpm set point for 20 mA output.

   Repeat the steps above until the speeds at 4 mA and 20 mA are within your required range.

IMPORTANT **If 4mA Aux Output and 20mA Aux Output are the same value, the Aux Output will be 0 mA.**

2. Droop adjustment

   If the control is operated isochronously, set Droop to 0%. If droop operation is required, increase load to rated, set Droop to obtain the desired amount of speed droop. Readjustment of speed set points may be required to obtain the desired speed.

IMPORTANT

The percent Droop is only a guide. Since droop is a function of actuator current, droop is affected by linkage adjustment, fuel system, etc.

3. Idle Droop adjustment

   Set the Idle Breakpoint to the output percent obtained previously at no load. Move the notch speed selector to operate the engine at least 25% above the low speed notch. Move the notch speed selector to the low speed notch. Observe undershoot of engine speed below the low speed set point. If excessive undershoot is observed, increase the Idle Droop set point by 10% and repeat the procedure above. Proper adjustment is obtained when undershoot is within desired specification.

IMPORTANT

The Low Idle Droop causes an increase in the speed reference when actuator current is below the Idle Breakpoint. The amount the reference is increased depends on linkage adjustment, reflected in the Idle Breakpoint setting and Low Idle Droop set point. Large values of droop may be required to achieve the desired performance when small Idle Breakpoint settings are obtained. For best performance in controlling speed undershoot, the output percent at idle should be less than 25 percent. If a value greater than this is obtained, the linkage adjustment should be modified to reduce the control output to below 25 percent at idle. After adjusting the linkage, verify that complete fuel cutoff occurs before the actuator reaches the minimum stop.

Fuel Rack Limit Adjustment

If a turbo boost pressure rack limiter is not being used, leave the set points at the 100% values set during prestart adjustment. Continue with the Torque Limiter adjustments below.

The values of the Actuator Output (Menu D) and turbo boost pressure sensor outputs obtained for each notch speed setting provide the guide to adjustment of the rack limit set points. As a starting point, plot actuator output percent versus turbo boost pressure milliamps as show in Figure 3-3. If necessary, extrapolate the curve to include 4 and 20 mA. Plot a best-fit two-slope line 10% of the output range (maximum–minimum output values) above the curve obtained. Set the BP Rack Limit to the turbo boost pressure input current corresponding to the breakpoint in the two lines. Set the 4 mA Rack Limit, Breakpoint Rack Limit, and the 20 mA Rack Limit at the output values obtained at their respective points. Test engine performance through the speed and load range for satisfactory performance. Set point values may require readjustment from the starting values to obtain the desired result.

Torque Limiter Adjustment

If the torque limiter is not being used, leave the set points at the 100% values set during prestart adjustment.

The values of the Actuator Output and Engine RPM (Menu D) obtained for each notch speed setting provide the guide to adjustment of the torque limiter set points. As a starting point, plot actuator output percent versus engine rpm as show in Figure 3-4. Plot a best-fit two-slope line 10% of the output range (maximum–minimum output values) above the curve obtained. Set the Breakpoint Torque Limit to the engine speed corresponding to the breakpoint in the two lines. Set the Minimum Torque Limit, Breakpoint Torque Limit, and the Maximum Torque Limit at the output values obtained at their respective speeds. Test engine performance through the speed and load range for satisfactory performance. Set point values may require readjustment from the starting values to obtain the desired result.

Aux Actuator Output Adjustment

Set engine speed to the speed desired for actuator terminal shaft position at 4 mA output. If this is not possible, skip this step or use a signal generator into the speed input with the frequency corresponding to the desired rpm. Trim the 4 mA Actuator Percent set point for 4 mA output. Note that the set point and actual actuator terminal shaft position may not be the same. This adjustment provides calibration of the output.

Set engine speed to the speed desired for actuator terminal shaft position at 20 mA output. Trim the 20 mA Actuator Percent set point for 20 mA output.

Repeat the steps above until the actuator terminal shaft position at 4 mA and 20 mA are within your required range.

IMPORTANT

If 4mA Actuator Percent and 20mA Actuator Percent are the same value, the Aux Output will be 0 mA.

Conclusion of Setup Procedures

This completes the adjustment chapter. Save the set points by pressing the “=” key on the Set Point Programmer. Run through all the set points and record them for future reference. This can be useful if a replacement control is necessary or for start-up of another similar unit. Power down the control for about 10 seconds. Restore power and verify that all set points are as recorded.

NOTICE

To prevent possible damage to the engine resulting from improper control settings, make sure you save the set points before removing power from the control. Failure to save the set points before removing power from the control causes them to revert to the previously saved settings.

Disconnect the Set Point Programmer from the control. Close the cover over J1 and retighten the retaining screw.

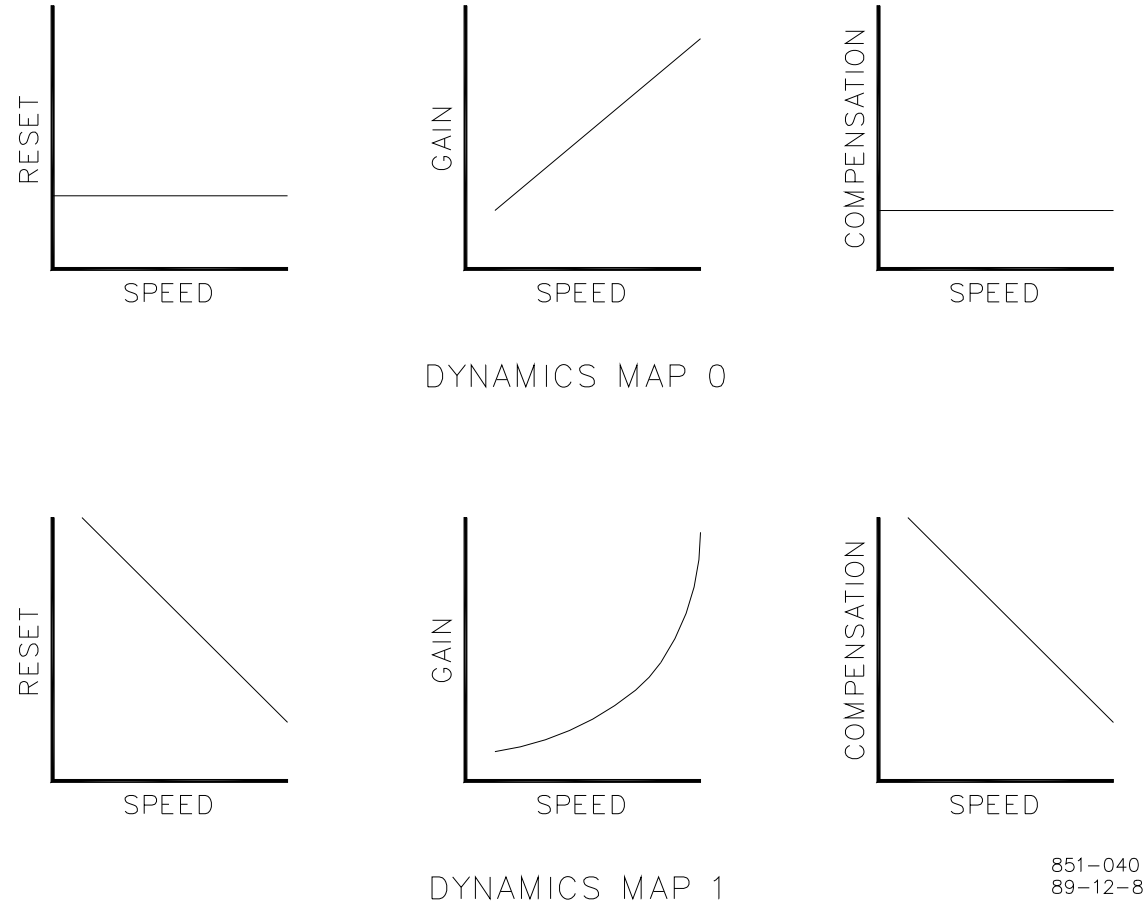

Figure 3-1. Dynamics Map Curves

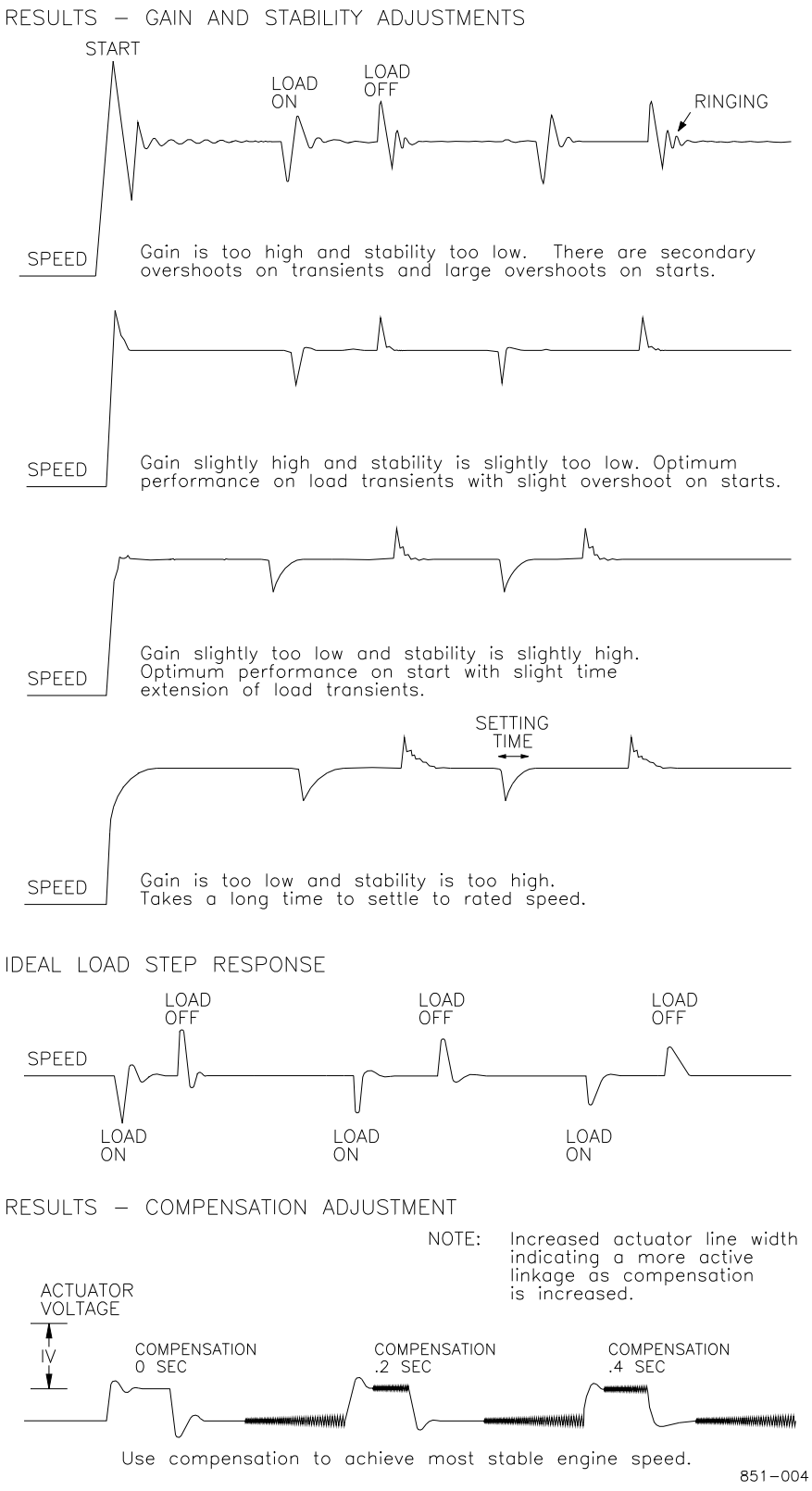

Figure 3-2. Typical Transient Response Curves

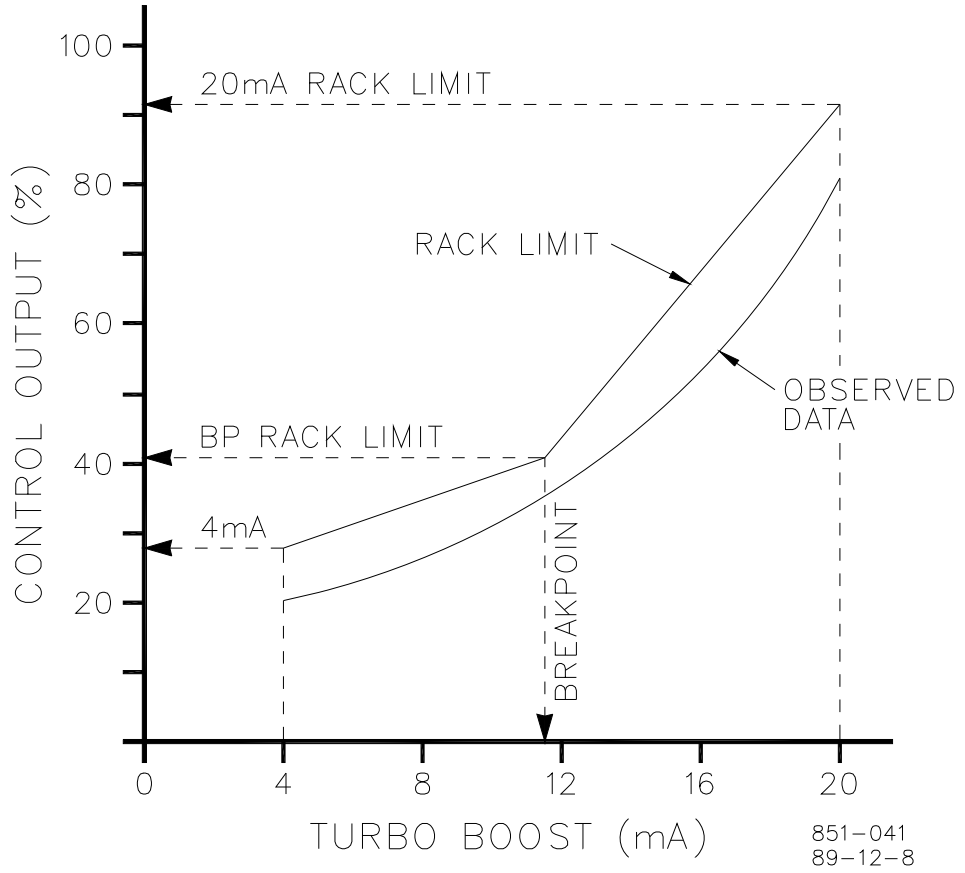

Figure 3-3. Rack Limiter Setup Example

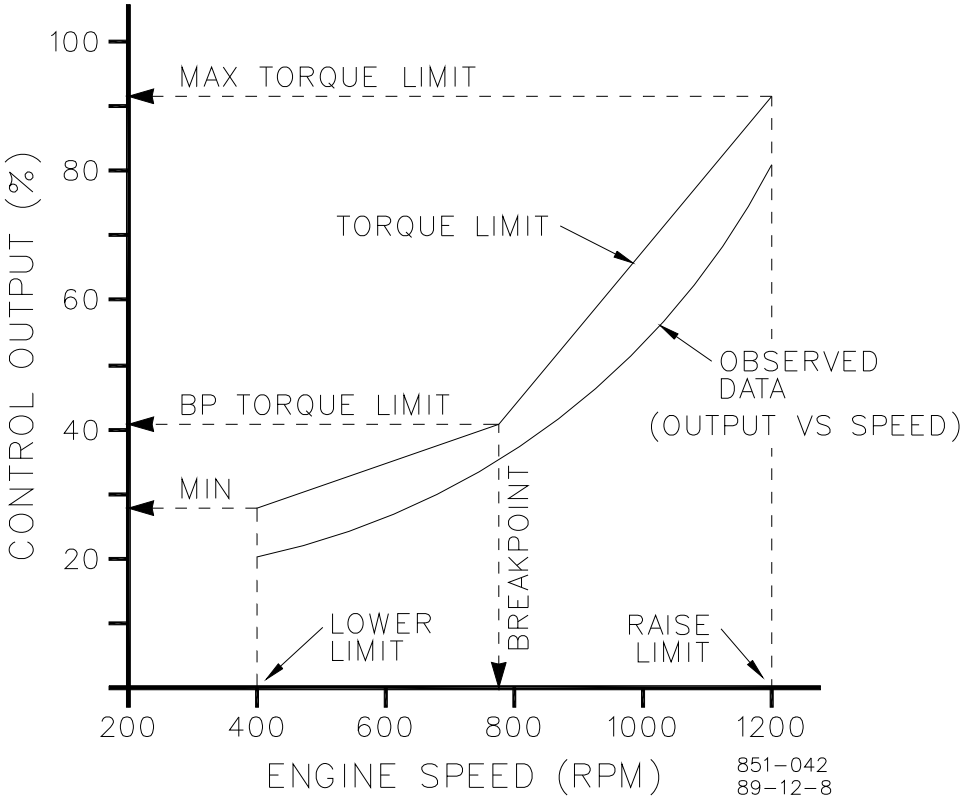

Figure 3-4. Torque Limit Setup Example

Chapter 4.
Description of Operation

General

The 702 Locomotive Control uses a 16-bit microprocessor for all control functions, such as computing engine speed, performing the control algorithm calculations, speed ramps, etc. All control adjustments are made with a hand-held terminal/display that connects to the 702 control's serial port. Disconnect the terminal/display from the control to provide security against tampering.

The 702 control's switching power supply has increased spike, ripple, and EMI (electromagnetic interference) rejection. The control optically isolates all discrete inputs and is capable of rejecting EMI and variable resistance in switch or relay contacts. Analog inputs are differential type with extra filtering for common mode noise rejection. This protects the control from spurious interference and noise which can cause speed and load shifts.

Control Operation

Figure 1-3 shows the control block diagram, which is described in this section.

The control decodes four discrete inputs from a notch speed-setting device to select up to 16 independently adjustable engine speeds. When the operator changes the notch setting input, the control accelerates or decelerates the engine to the new selected speed based on a time ramp. Accel and decel times are independently adjustable.

The speed sensor contains a special tracking filter designed for reciprocating engines, which minimizes the effects of engine torsionals or irregularities in the gear used for sensing speed. This provides exceptionally smooth steady-state control and allows the control dynamics to be matched to the engine rather than detuned to compensate for speed torsionals. A magnetic pickup (1 to 60 Vrms output) usually provides the speed signal.

Failed speed detection automatically reduces the control output to minimum if the speed signal is lost. This function may be overridden for engine start-up.

The control provides speed droop as a function of control actuator output for additional stability, if desired. Speed droop reduces the speed reference proportional to the load on the engine.

The control provides low-idle droop to reduce or prevent engine speed undershoot when quickly reducing speed to low idle. Low-idle droop increases the speed reference when the rack moves below the low-idle position.

The 702 Locomotive Control provides an independently adjustable rack limiter to prevent overfueling or flooding during engine start-up. When the speed set point is reached, the control reduces fuel as required to control engine speed. The control automatically switches off the start limit when the speed set point is reached. The limit set by the rack or torque limiter then takes effect.

The control provides a 4–20 mA/1–5 Vdc input for fuel rack limiting based on turbo boost pressure. When used, the two-slope limiter helps prevent overfueling and subsequent smoke emission. The 20 mA (5 Vdc) setting provides a maximum load limit if the fuel rack limiter is not used.

The control provides optional two-slope torque limiting as a function of engine speed if the turbo boost pressure signal is not available.

The control provides a 4–20 mA output that may be used as a tachometer output or a load indication for an analog meter or as input to a computer. The offset and span are adjustable for range.

The control provides a 4–20 mA/1–5 Vdc input for remote speed setting. The remote speed setting input is automatically selected when an input of 2 mA (0.5 Vdc) or greater is detected on the remote speed setting input. The speed reference will ramp up or down at the specified raise rate or lower rate to the speed reference value determined by the remote speed input.

These functions are described in more detail in the descriptions of the control adjustments in later sections.

Power Up Diagnostics

The Power Up Diagnostics feature is provided to verify the proper operation of the microprocessor and memory components. The diagnostics take about four seconds after the control is powered on. A failure of the test will turn off the output of the control. If diagnostic testing is successful, the CPU OK indicator on the control cover will light.

Chapter 5. Troubleshooting

General

The following troubleshooting guide is an aid in isolating trouble to the control box, actuator, plant wiring, or elsewhere. Troubleshooting beyond this level is recommended ONLY when a complete facility for control testing is available.

NOTICE

The control can be damaged by the wrong voltage. When replacing a control, check the power supply, battery, or other external power input for the correct voltage before applying power.

Troubleshooting Procedure

Table 5-1 is a general guide for isolating system problems. This guide assumes that the system wiring, soldering connections, switch and relay contacts, and input and output connections are correct and in good working order. Make the checks in the order indicated. Each system check assumes that the previous checks have been done properly.

Control Test and Calibration

General

Perform the following checks on the 702 Control. Then verify the functioning of set points and adjustments.

1. Connect the Set Point Programmer to the control in accordance with the instructions in Chapter 3. Verify that correct voltage and polarity are applied to the control. Verify that the programmer performs its power-up tests. Failure to perform the power up test indicates either the control or Set Point Programmer has failed. Replace the control or Set Point Programmer.

2. Press the SP key. The message “702 Speed Control P/N 5410-867” should appear. Failure indicates either the control or Set Point Programmer has failed. Replace the control or Set Point Programmer.

3. Select Menu D. Step through the menu to the Self Test Result step. Verify that the displayed value is 49. If any other value is displayed, replace the control.

4. Select Menu A. Verify that all set points are as recorded during installation. Repeat for Menus B and C. If any differences are found, change the set point(s) to the correct value. Press the “=” key. The message “Set Points Saved” should be displayed. Remove power from the control for at least 10 seconds. Verify correct values were retained during power down. Failure indicates the control has failed and should be replaced.

Discrete Inputs

Perform the following test to verify the function of the discrete inputs. Do not perform these tests with the engine running. When reading the Set Point Programmer, be sure to update the display by pressing the up or down arrow.

1. Open all contacts used with the notch speed setting inputs. Select the “Code Selected” item on Menu D. The value should be 0. If the value is not 0, verify that the voltage is 0 between terminal 8(–) and terminals 9 through 12. If any non-zero voltage is found, correct and recheck the “Code Selected” menu item. (Be sure to press the up or down arrow to update the display.) If the value is not 0, the control has failed and should be replaced.

   Select each speed setting notch and verify the correct code for the selected notch is displayed on the Set Point Programmer. If any discrepancies are found, verify the voltage between terminal 8(–) and the corresponding terminals 9 through 12 for 0 or 24 volts. If the code value does not change when the voltage is switched at the control terminals, the control has failed and should be replaced.

2. Close the Run/Stop contact or apply 24 Vdc between terminals 8(–) and 13(+) to select Run. Select Run/Stop Switch Status on Menu D. The value should be “Switch Closed.” If the value does not change from Open to Closed when the Run/Stop switch is closed, verify the voltage at the control terminals. Be sure to press the up or down arrow to display the change. If correct voltage is verified, the control has failed and should be replaced.

3. Open the Failed Speed Function Override Switch. The value of the “Failsafe On/Off” should be “Switch Open.” Close the Failed Speed Function Override Switch. The value of “Failsafe On/Off” should be “Switch Closed.” If correct values are not obtained, the control has failed and should be replaced.

Actuator Output

The following tests verify the actuator output of the control.

1. Select Run and Failed Speed Function Off. (Terminals 13 and 14 have the correct voltage applied.) Connect a milliamp meter across terminals 3(+) and 4(–) if no actuator is connected. Connect the milliamp meter in series with the actuator if one is connected to the control. (Alternately, a dc voltmeter may be connected across the output, terminals 3(+) and 4(–), when an actuator is connected. The correct output currents must be computed using the voltage measured and the input resistance of the actuator.)

2. Select the Start Fuel Limit set point on Menu C. Set Start Fuel Limit to 20%. The output current should be 42 ± 2 mA (168 ± 8 mA for reverse-acting actuators).

3. Set the Start Fuel Limit to 100%. The output current should be 210 ± 10 mA (0 ± 10 mA for reverse-acting actuators). If the output of the control fails to perform as above, replace the control.

Speed Input

The following tests verify the operation of the Speed Input.

1. Connect an audio frequency signal generator to the speed signal input. Set the output level above 1.0 Vrms. Set the Number of Gear Teeth set point on Menu 1 to 60 (this causes the rpm values and Hertz values to be the same for ease of performing the tests).

2. Set the signal generator to 120 Hz. Read engine rpm value of 120 rpm on Menu D. Increase the signal generator frequency to 1000 Hz. The value read should follow the signal generator frequency.

NOTICE

To prevent possible damage to the engine, return the Number of Gear Teeth to the correct value.

Remote Input

The following tests calibrate and verify the function of the Remote Input.

IMPORTANT

Use voltage or current for calibration as determined by the application.

IMPORTANT

The input must be greater than 18 mA or 4.5 Vdc for adjustment to occur.

1. Connect a 4 to 20 mA or 1 to 5 Vdc source to terminals 21(+) and 22(–). If a mA source is used, a jumper must be installed across terminals 20 and 21. Connect a dc voltmeter across terminals 21(+) and 22(–) for a 1 to 5 Vdc input. Install a milliamp meter in series with the 4 to 20 mA source for a 4 to 20 mA input.

2. Set the source for 5.0 volts (20.0 mA) on the meter. Select Menu 1 on the Set Point Programmer.

3. Set the Calibration Key to 49. Select Remote Input Calibration on Menu 1.

4. Set the value on the display by pressing the up or down arrow until the display reads 20.0 ± 0.01 mA.

5. Set the source for 1.0 volts, (4.0 mA). Update the display by pressing the up or down arrow. The Remote Input value should be 4.0 ± 0.2 mA. If the meter indicates proper voltage or current is present on the Remote Input, but readings on the Set Point Programmer are incorrect, the 702 control is defective and should be replaced.

Rack Limit Input

IMPORTANT **Use voltage or current for calibration as determined by the application.**

IMPORTANT **The input must be greater than 18 mA or 4.5 Vdc for adjustment to occur.**

The following checks calibrate and verify the function of the Rack Limit Input. When reading the Set Point Programmer, be sure to update the display by pressing the up or down arrow.

1. Connect a 4 to 20 mA or 1 to 5 Vdc source to terminals 18(+) and 19(–). A jumper must be installed across terminals 17 and 18 for a 4 to 20 mA input. Install a milliamp meter in series with the 4 to 20 mA source or connect a dc voltmeter across terminals 18(+) and 19(–) for a 1 to 5 Vdc input.

2. Set the source for 5.0 volts (20.0 mA) on the meter. Select Menu 1 on the Set Point Programmer.

3. Set the Calibration Key to 49. Select Rack Limit Calibration on Menu 1.

4. Set the value on the display by pressing the up or down arrow until the display reads 20.0 ± 0.01 mA.

5. Set the source for 1.0 volts, (4.0 mA). Update the display by pressing the up or down arrow. The Rack Limit value should be 4.0 ± 0.2 mA. If the meter indicates proper voltage or current is present on the Rack Limiter Input, but readings on the Set Point Programmer are incorrect, the 702 control is defective and should be replaced.

Aux Output

The following checks calibrate and verify the operation of the Aux Output, using the Actuator Percent. (Calibration of the Aux Output automatically calibrates the Tachometer Output.)

1. Connect a mA meter across the Aux 4–20 mA Output, terminal 5(+) and terminal 6(–). Select Menu 1 on the Set Point Programmer.

2. Set the Calibration Key to 49. Select Aux Output Configuration on Menu 1, and select Actuator Percent.

3. Select Actuator Output on Menu D and record the value shown.

4. Select 20 mA Actuator Percent on Menu C and record the value. Then set to the same value recorded in step 3.

5. Select Aux Output Calibration on Menu 1 and update the value on the meter by pressing the up or down arrow until the meter reads 20.00 ± 0.01 mA.

IMPORTANT **If 4mA Actuator Percent and 20mA Actuator Percent are the same value, the Aux Output will be 0 mA.**

6. Select 20 mA Actuator Percent on Menu C and reset to the original value recorded in step 4.

7. Select 4mA Actuator Percent on Menu C and record the value. Then set to the same value recorded in step 3. The mA meter should read 4.0 ± 0.1 mA. Failure of this test indicates a faulty control, which should be replaced.

8. Select 4mA Actuator Percent on Menu C and reset to the original value recorded in step 7.

Conclusion of Test and Calibration Procedures

This completes the test and calibration section. Save the set points by pressing the "=" key on the Set Point Programmer. Power down the control for about 10 seconds. Restore power and verify that all set points are as recorded.

NOTICE

To prevent possible damage to the engine resulting from improper control settings, make sure you save the set points before removing power from the control. Failure to save the set points before removing power from the control will cause them to revert to the previously saved settings.

Disconnect the Set Point Programmer from the control. Close the cover over J1 and retighten the retaining screw.

⚠WARNING

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.

Table 5-1. System Troubleshooting

Problem	Cause	Remedy
Engine will not start. Actuator not moving to start fuel position. **IMPORTANT** **If the actuator moves to start position, a problem with the engine fuel supply is indicated.**	Supply voltage polarity reversed, or no supply voltage.	Check for supply voltage from terminals 1(+) to 2(–). Reverse leads if polarity is incorrect.
	Actuator not responding to input signal from control. **IMPORTANT** **The pneumatic actuator must have air pressure to operate (respond).**	If there is a voltage output at control terminals 3(+) and 4(–), but the actuator does not move, check the wiring to the actuator for opens or shorts. With the EG-P actuators, remember that terminals C and D of the mating plug should be jumpered. Make resistance checks at the actuator. Coil resistance is approximately 35 ohms. (Read with leads at T3 and T4 disconnected.)
	Start fuel limit set too low.	Increase start fuel limit until engine starts. Check actuator and linkage for proper installation and operation. Problems may be oil supply, air supply, direction of rotation, insufficient drainage, linkage, worn actuator components, or improper adjustment.
	No actuator voltage at terminals 3 and 4.	Check for shorted or grounded actuator leads by removing wires to terminals 3 and 4. Check for at least 1 Vrms at terminals 15 and 16, and at least 5% of the maximum speed frequency range.
	Speed setting too low on initial start.	Speed setting may be lower than cranking speed. Increase Speed setting.
	Minimum Fuel contact open.	Check T13. Minimum Fuel contact must be closed for normal operation. Check for 18 to 40 Vdc from terminal 13(+) to 8(–).
	Speed sensor signal not clearing failed speed signal circuit (cranking speed must be over 5% of max set speed).	Check wiring for proper connection. Check shields for proper installation. Speed sensor not spaced properly. Check for at least 1.0 Vac and 5% rated speed at terminals 15 and 16 during cranking. If less than 1.0 Vac or 5% rated speed, magnetic pickup may be spaced too far from gear. Make sure there are no metal chips on end of pickup. If no voltage is present, magnetic pickup may be open-circuited or shorted. Make resistance check with the leads disconnected from control. Should be about 100 to 300 ohms. Failed speed-signal circuit may be disabled by connecting 18 to 40 Vdc to terminal 14. **WARNING** **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.**
	Faulty 702 control.	Replace control.

Problem	Cause	Remedy
Engine overspeeds only on starts.	Speed setting too high.	Set Speed as described in Chapter 3.
	Control adjustment.	Control may be adjusted for sluggish operation causing overspeed on start. Slowly adjust GAIN for fastest stable response. RESET may be adjusted too low. Increase RESET setting.
	Determine if engine is malfunctioning.	Verify that fuel rack is not binding and linkage is properly adjusted. It may be necessary to determine if the fuel rack is quickly following the actuator input voltage. Verify proper operation of overspeed protection devices to determine if a shutdown is occurring without an overspeed condition.
	702 control.	If the control does not cut back the actuator voltage (T3 and T4), the 702 control may be faulty. If the voltage is cut back, look for a problem in the linkage or actuator.
Engine overspeeds after operating at rated speed for some time.	Engine.	Check for proper operation of engine fuel system. If actuator moves toward minimum fuel during overspeed, problem is in fuel system.
	Magnetic pickup and 702 control.	Check the magnetic pickup output voltage at speeds above idle—at least 1.0 Vrms. If magnetic pickup should fail and the speed-signal-override-failed circuit is disabled, the 702 control will call for maximum fuel.
Low speed is not regulated.	Actuator and linkage.	The Speed setting may be below the minimum-fuel position of the actuator or engine fuel stop. The engine will be maintained at the minimum-fuel position by the actuator or the engine minimum-fuel stop. These conditions indicate that the engine minimum-fuel position should be decreased by linkage adjustment or the Speed setting should be raised. If this action does not correct the problem, the 702 control may be faulty.
Engine does not accelerate or decelerate.	Faulty Notch Speed Setting contacts.	Check contacts. Measure voltage signals on terminals 9-12. Verify that the notch code selected (Menu D) has correct code determined by signals on terminals 9-12.
	702 control circuitry.	A faulty contact may remain in position with the contact open.
	Control in Remote Speed input mode.	Check Remote Input (Menu D). If 4 mA or greater (then control is in the Remote Speed input mode), remove wires from terminals 15 and 16. If the Remote Input (Menu D) still reads 4 mA or greater, the control is faulty and should be replaced.
	Accel Time or Decel Time has small setting.	Check and increase Accel Time (Menu B) or Decel Time (Menu B).

Problem	Cause	Remedy
Engine will not stabilize at rated no-load speed. The instability may occur at no load or it may vary with load. Control may be erratic.	702 control.	Adjust GAIN, RESET, and COMPENSATION as described in Chapter 3.
	Improper linkage adjustment.	Make sure that the actuator moves approximately 2/3 of its travel from no load to full load. Refer to actuator manual for proper installation.
	Necessary external wires not properly shielded. (Electrical noise, caused by wiring carrying an ac voltage, stray magnetic fields from transformers, etc., can be picked up by improperly shielded wire. Noise will cause instability if picked up by magnetic pickup lines and actuator lines.)	The following tests will isolate noise and interference. Verify that the switchgear frame, governor chassis, and engine have a common ground connection. Temporarily remove the battery-charger cables from the control battery system. Remove all wires except the battery, speed sensor, and actuator wires. Close the necessary discrete inputs. If the prime-mover operation is significantly improved by these modifications, replace the wires one at a time to locate the source of the trouble. External wiring may require additional shielding or rerouting from high-current lines or components. If the problem cannot be solved by these checks, it will be necessary to remove the 702 control from the switchgear. Temporarily mount the control next to the engine and connect only a battery, magnetic pickup, and actuator to the control (use a separate battery placed next to the engine). After starting the engine, if necessary, apply load to check stability. If stability occurs when the control is mounted next to the engine, return the control to the switchgear. Run new magnetic pickup, actuator, and battery power lines. Shield all wires to the control. Route all wires through conduit or an outer shield. Tie the outer shield to system ground at the end opposite to the control.
	Engine may not be receiving fuel as called for by the actuator voltage.	Check actuator linkage to fuel-controlling mechanism for any lost motion, binding, or excessive loading. Verify a steady fuel pressure of proper value. Check actuator per appropriate actuator manual.
	Engine not operating properly.	Engine may be causing speed variations. Control engine manually to determine if instability is in engine or governor control. Verify proper adjustment of fuel control linkage.
	Input voltage low.	Check supply voltage. It should be at least 18 Vdc.
Engine does not maintain constant speed (isochronous).	Actuator.	If actuator has a ballhead backup, verify that its hydraulic governor section, speed setting, and speed droop adjustments are properly set (see the applicable governor manual).
	Engine.	If droop occurs near the full-load point only, it is possible the engine is not producing the power called for by the fuel control, or is being overloaded. Either is indicated if the fuel control is at maximum position.
	702 Control.	Check Max Fuel Limit setting. Increase if required. Check droop setting. Set to 0 if required.

Chapter 6.
Product Support and Service Options

Product Support Options

If you are experiencing problems with the installation, or unsatisfactory performance of a Woodward product, the following options are available:

1. Consult the troubleshooting guide in the manual.
2. Contact the **OE Manufacturer or Packager** of your system.
3. Contact the **Woodward Business Partner** serving your area.
4. Contact Woodward technical assistance via email (**EngineHelpDesk@Woodward.com**) with detailed information on the product, application, and symptoms. Your email will be forwarded to an appropriate expert on the product and application to respond by telephone or return email.
5. If the issue cannot be resolved, you can select a further course of action to pursue based on the available services listed in this chapter.

OEM or Packager Support: Many Woodward controls and control devices are installed into the equipment system and programmed by an Original Equipment Manufacturer (OEM) or Equipment Packager at their factory. In some cases, the programming is password-protected by the OEM or packager, and they are the best source for product service and support. Warranty service for Woodward products shipped with an equipment system should also be handled through the OEM or Packager. Please review your equipment system documentation for details.

Woodward Business Partner Support: Woodward works with and supports a global network of independent business partners whose mission is to serve the users of Woodward controls, as described here:

- A **Full-Service Distributor** has the primary responsibility for sales, service, system integration solutions, technical desk support, and aftermarket marketing of standard Woodward products within a specific geographic area and market segment.
- An **Authorized Independent Service Facility (AISF)** provides authorized service that includes repairs, repair parts, and warranty service on Woodward's behalf. Service (not new unit sales) is an AISF's primary mission.
- A **Recognized Engine Retrofitter (RER)** is an independent company that does retrofits and upgrades on reciprocating gas engines and dual-fuel conversions, and can provide the full line of Woodward systems and components for the retrofits and overhauls, emission compliance upgrades, long term service contracts, emergency repairs, etc.

A current list of Woodward Business Partners is available at **www.woodward.com/directory**.

Product Service Options

Depending on the type of product, the following options for servicing Woodward products may be available through your local Full-Service Distributor or the OEM or Packager of the equipment system.

- Replacement/Exchange (24-hour service)
- Flat Rate Repair
- Flat Rate Remanufacture

Replacement/Exchange: Replacement/Exchange is a premium program designed for the user who is in need of immediate service. It allows you to request and receive a like-new replacement unit in minimum time (usually within 24 hours of the request), providing a suitable unit is available at the time of the request, thereby minimizing costly downtime.

This option allows you to call your Full-Service Distributor in the event of an unexpected outage, or in advance of a scheduled outage, to request a replacement control unit. If the unit is available at the time of the call, it can usually be shipped out within 24 hours. You replace your field control unit with the like-new replacement and return the field unit to the Full-Service Distributor.

Flat Rate Repair: Flat Rate Repair is available for many of the standard mechanical products and some of the electronic products in the field. This program offers you repair service for your products with the advantage of knowing in advance what the cost will be.

Flat Rate Remanufacture: Flat Rate Remanufacture is very similar to the Flat Rate Repair option, with the exception that the unit will be returned to you in "like-new" condition. This option is applicable to mechanical products only.

Returning Equipment for Repair

If a control (or any part of an electronic control) is to be returned for repair, please contact your Full-Service Distributor in advance to obtain Return Authorization and shipping instructions.

When shipping the item(s), attach a tag with the following information:
- return number;
- name and location where the control is installed;
- name and phone number of contact person;
- complete Woodward part number(s) and serial number(s);
- description of the problem;
- instructions describing the desired type of repair.

Packing a Control

Use the following materials when returning a complete control:
- protective caps on any connectors;
- antistatic protective bags on all electronic modules;
- packing materials that will not damage the surface of the unit;
- at least 100 mm (4 inches) of tightly packed, industry-approved packing material;
- a packing carton with double walls;
- a strong tape around the outside of the carton for increased strength.

NOTICE

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*.

Replacement Parts

When ordering replacement parts for controls, include the following information:
- the part number(s) (XXXX-XXXX) that is on the enclosure nameplate;
- the unit serial number, which is also on the nameplate.

Engineering Services

Woodward's Full-Service Distributors offer various Engineering Services for our products. For these services, you can contact the Distributor by telephone or by email.

- Technical Support
- Product Training
- Field Service

Technical Support is available from your equipment system supplier, your local Full-Service Distributor, or from many of Woodward's worldwide locations, depending upon the product and application. This service can assist you with technical questions or problem solving during the normal business hours of the Woodward location you contact.

Product Training is available as standard classes at many Distributor locations. Customized classes are also available, which can be tailored to your needs and held at one of our Distributor locations or at your site. This training, conducted by experienced personnel, will assure that you will be able to maintain system reliability and availability.

Field Service engineering on-site support is available, depending on the product and location, from one of our Full-Service Distributors. The field engineers are experienced both on Woodward products as well as on much of the non-Woodward equipment with which our products interface.

For information on these services, please contact one of the Full-Service Distributors listed at **www.woodward.com/directory**.

Contacting Woodward's Support Organization

For the name of your nearest Woodward Full-Service Distributor or service facility, please consult our worldwide directory published at **www.woodward.com/directory**.

You can also contact the Woodward Customer Service Department at one of the following Woodward facilities to obtain the address and phone number of the nearest facility at which you can obtain information and service.

Products Used In Electrical Power Systems

Facility	Phone Number
Brazil	+55 (19) 3708 4800
China	+86 (512) 6762 6727
Germany:	
Kempen	+49 (0) 21 52 14 51
Stuttgart	+49 (711) 78954-510
India	+91 (129) 4097100
Japan	+81 (43) 213-2191
Korea	+82 (51) 636-7080
Poland	+48 12 295 13 00
United States	+1 (970) 482-5811

Products Used In Engine Systems

Facility	Phone Number
Brazil	+55 (19) 3708 4800
China	+86 (512) 6762 6727
Germany	+49 (711) 78954-510
India	+91 (129) 4097100
Japan	+81 (43) 213-2191
Korea	+82 (51) 636-7080
The Netherlands	+31 (23) 5661111
United States	+1 (970) 482-5811

Products Used In Industrial Turbomachinery Systems

Facility	Phone Number
Brazil	+55 (19) 3708 4800
China	+86 (512) 6762 6727
India	+91 (129) 4097100
Japan	+81 (43) 213-2191
Korea	+82 (51) 636-7080
The Netherlands	+31 (23) 5661111
Poland	+48 12 295 13 00
United States	+1 (970) 482-5811

For the most current product support and contact information, please visit our website directory at **www.woodward.com/directory**.

Technical Assistance

If you need to contact technical assistance, you will need to provide the following information. Please write it down here before contacting the Engine OEM, the Packager, a Woodward Business Partner, or the Woodward factory:

General

Your Name _____

Site Location _____

Phone Number _____

Fax Number _____

Prime Mover Information

Manufacturer _____

Engine Model Number _____

Number of Cylinders _____

Type of Fuel (gas, gaseous, diesel, dual-fuel, etc.) _____

Power Output Rating _____

Application (power generation, marine, etc.) _____

Control/Governor Information

Control/Governor #1

Woodward Part Number & Rev. Letter _____

Control Description or Governor Type _____

Serial Number _____

Control/Governor #2

Woodward Part Number & Rev. Letter _____

Control Description or Governor Type _____

Serial Number _____

Control/Governor #3

Woodward Part Number & Rev. Letter _____

Control Description or Governor Type _____

Serial Number _____

Symptoms

Description _____

_____

If you have an electronic or programmable control, please have the adjustment setting positions or the menu settings written down and with you at the time of the call.

Appendix.
Programming Checklist

We recommend you write down the final value of each menu item here so you will have a record if you later need to reprogram or replace the control.

_____ Software Part Number and Revision Letter

A—Dynamics Menu

_____ 1. Gain
_____ 2. Reset
_____ 3. Compensation
_____ 4. Gain Ratio
_____ 5. Window Width
_____ 6. Gain Slope
_____ 7. Gain Breakpoint

[menu items 4-7 not present on all versions]

B—Speed Setting Menu

_____ 1. Code 0 Speed
_____ 2. Code 1 Speed
_____ 3. Code 2 Speed
_____ 4. Code 3 Speed
_____ 5. Code 4 Speed
_____ 6. Code 5 Speed
_____ 7. Code 6 Speed
_____ 8. Code 7 Speed
_____ 9. Code 8 Speed
_____ 10. Code 9 Speed
_____ 11. Code 10 Speed
_____ 12. Code 11 Speed
_____ 13. Code 12 Speed
_____ 14. Code 13 Speed
_____ 15. Code 14 Speed
_____ 16. Code 15 Speed
_____ 17. Accel Time
_____ 18. Decel Time
_____ 19. Raise Rate
_____ 20. Lower Rate
_____ 21. 20 mA Remote Reference
_____ 22. 4 mA Remote Reference
_____ 23. 20 mA Tachometer RPM
_____ 24. 4 mA Tachometer RPM
_____ 25. Droop
_____ 26. Idle Droop
_____ 27. Idle Breakpoint

C—Rack Limiters and Control Output Menu

_____ 1. Rack Limit Breakpoint
_____ 2. 4 mA Rack Limit
_____ 3. Breakpoint Rack Limit
_____ 4. 20 mA Rack limit
_____ 5. Torque Limit Breakpoint
_____ 6. Minimum Torque Limit
_____ 7. Breakpoint Torque Limit
_____ 8. Maximum Torque Limit
_____ 9. Start Fuel Limit
_____ 10. 20mA Actuator Percent
_____ 11. 4mA Actuator Percent

D—Display Menu

_____ 1. Engine Speed
_____ 2. Speed Reference
_____ 3. Actuator Output
_____ 4. Aux Output
_____ 5. Rack Limit Input
_____ 6. Remote Input
_____ 7. Notch Code Selected
_____ 8. Run/Stop Switch Status
_____ 9. Failsafe On/Off Switch Status
_____ 10. Watchdog Status
_____ 11. Self Test Result
_____ 12. ROM Check Sum

1—Calibration/Configuration Menu

_____ 1. Calibration Key
_____ 2. Number of Gear Teeth
_____ 3. Rack Limit Calibration
_____ 4. Remote Input Calibration
_____ 5. Aux Output Configuration
_____ 6. Aux Output Calibration
_____ 7. Forward/Reverse Acting Actuator
_____ 8. Dynamics Map

702 Locomotive Control Specifications

Woodward Part Numbers:	
9905-210	702 Locomotive Control
8280-107	Set Point Programmer
Power Supply Rating	18–40 Vdc
Power Consumption	8 W nominal
Steady State Speed Band	60–15 000 Hz (8–2100 rpm)
Discrete Inputs (6)	18–40 Vdc
Rack Limit Input	4–20 mA/1–5 Vdc
Remote Speed Setting Input	4–20 mA/1–5 Vdc
Tachometer Output	4–20 mA
Programmer Serial Port	20 mA current loop, 9-pin D connector, 1200 baud, full duplex
Ambient Operating Temperature	–40 to +70 °C (–40 to +158 °F)
Storage Temperature	–55 to +105 °C (–67 to +221 °F)
EMI/RFI Specification	US MIL-STD 461C (Parts 5 & 9)

We appreciate your comments about the content of our publications.

Send comments to: icinfo@woodward.com

Please reference publication 02703C.

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as well as authorized distributors and other authorized service and sales facilities throughout the world.**

Complete address / phone / fax / email information for all locations is available on our website.

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