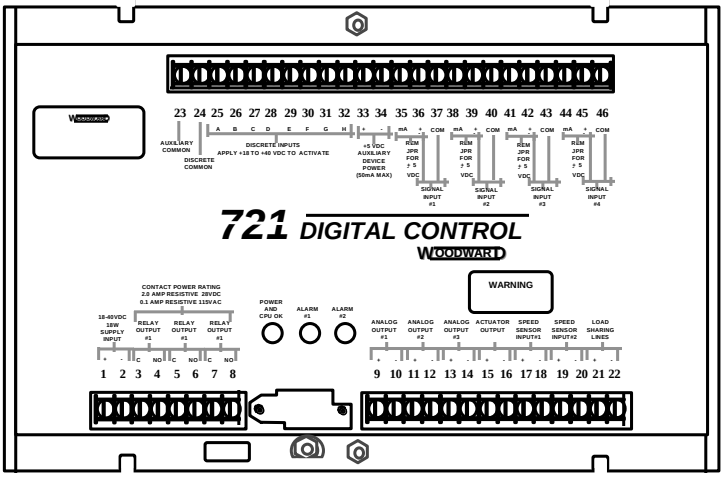
WOODWARD

Operation and Calibration Manual



721 Digital Speed Control

For Marine Propulsion Application

D/N 9907-717

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UKAS QUALITY MANAGEMENT 008

Manual 26004

WARNING—DANGER OF DEATH OR PERSONAL INJURY

WARNING—FOLLOW INSTRUCTIONS

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.

WARNING—OUT-OF-DATE PUBLICATION

This publication may have been revised or updated since this copy was produced. To verify that you have the latest revision, be sure to check the Woodward website:

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The revision level is shown at the bottom of the front cover after the publication number. The latest version of most publications is available at:

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If your publication is not there, please contact your customer service representative to get the latest copy.

WARNING—OVERSPEED PROTECTION

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

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

WARNING—PROPER USE

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

CAUTION—POSSIBLE DAMAGE TO EQUIPMENT OR PROPERTY

CAUTION—BATTERY CHARGING

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.

CAUTION—ELECTROSTATIC DISCHARGE

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

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

IMPORTANT DEFINITIONS

- **A WARNING indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.**
- **A CAUTION indicates a potentially hazardous situation which, if not avoided, could result in damage to equipment or property.**
- **A NOTE provides other helpful information that does not fall under the warning or caution categories.**

Revisions—Text changes are indicated by a black line alongside the text.

WARNING—THIS PUBLICATION MAY BE OUT OF DATE
The Japanese original of this publication may have been updated since this translation was made. For the most current information, be sure to check whether there is a Japanese version with a later revision.

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ILLUSTRATIONS AND TABLES

Chapter 1.
General Information

Introduction

This manual describes the Woodward 721 Digital Speed Control , 9907-717. For details on 721 control hardware , refer to Woodward manual 02770 (721 Digital Speed Control Hardware manual).

Application

This 721 Digital Speed Control was designed as a marine propulsion engine control to use with a changeable pitch propeller control. This control has two sets of control dynamics which the operator can switch to get most suitable engine operation: either when only the propeller shaft is driven, or when both the propeller shaft and the generator are driven. Normally, generators are operated in isolation. However this control has a load transfer mode to enable parallel operation in order to transfer the load to another generator.

721 Control Accessories

A hand-held programmer, part number 9907-205, is used to adjust and monitor the 721 DSC. The programmer plugs into serial port J1 (9-pin D connector).

Chapter 2
Electrostatic Discharge Awareness

Summary

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.

General Information

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.

Chapter 3
Installation

Scope

This chapter contains general installation instructions for the 721 control. Power requirements, environmental precautions, and location considerations are included to help you determine the best location for the control. Additional information includes unpacking instructions and electrical connections.

Unpacking

Before handling the control, read Chapter 2, 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.

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 in excess of levels defined in EN50082-2
- avoidance of vibration
- selection of a location that will provide an operating temperature range of –40 to +70 °C (–40 to +158 °F). A location providing an operating temperature range of 0 to +30 °C is preferred.

CAUTION

The control must NOT be mounted on the prime mover.

Electrical connections

Refer to the control wiring diagram in this manual for wiring details.

All shielded cable must be twisted conductor pairs. Do not attempt to tin the braided shield. All analog signal lines should be shielded to prevent picking up stray signals from adjacent equipment. Connect the shields to the point specified on the control wiring diagram. 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. If both ends of a shield are connected, the result may be worse than if the shield is not used.

DO NOT run shielded signal wires along with other wires carrying high voltage or high current. See Woodward application note 50532, *Interference Control in Electronic Governing Systems*, for more information.

Power Requirement

The 721 control requires the following power supply input voltages, with 18 watts as the nominal power consumption at rated voltage:

- 18-40 Vdc (24 Vdc or 32 Vdc nominal)

Discrete input voltages provide on/off command signals (like RUN/STOP or IDLE/START) to the electronic control. Each discrete input requires 10 mA at its 24 Vdc nominal voltage rating (for 24 volt switching logic).

CAUTION

To prevent damage to the control, do not power this control from any sources with an output voltage exceeding 41 Vdc.

Run the power leads directly from the power source to the control.
DO NOT POWER OTHER DEVICES WITH LEADS COMMON TO THE CONTROL.

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. Use the “Close to Run, Open to Shutdown” contact in the control wiring diagram to shut down the engine normally.

CAUTION

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.

CAUTION

To prevent damage to the engine, apply power to the 721 control at least 15 seconds prior to starting the engine. The control must have time to complete its power up diagnostics and become operational. Do not start the engine unless the green POWER AND CPU OK indicator on the 721 control cover comes on, because test failure turns off the output of the control.

Chapter 4
Description of Operation

General

This section provides an overview of the features and operation of the 721 Digital Speed Control. In the last part of this manual, the control block diagram and the plant wiring diagram are shown for reference in the following descriptions.

The 721 Digital Speed Control uses a 16-bit microprocessor for all control functions. All control adjustments are made with a hand-held terminal/display (i.e. the hand-held programmer) that communicates with the control via a serial port. The terminal/display is disconnected from the control when not in service, to provide security against tampering.

The speed sensors contain a special tracking filter designed for reciprocating engines, which minimizes the effects of flexible coupling torsionals. This provides exceptionally smooth steady-state control and allows the control dynamics to be matched to the engine rather than detuned to compensate for coupling torsionals. The speed signal itself is usually provided by a magnetic pickup supplying from 1 to 30 Vrms to the control.

The control also provides 4 to 20 mA terminals for tachometer output, speed reference output, and rack position output. Relay outputs provide a major alarm, a minor alarm, and the load transferring indication.

Control Dynamics

The control algorithms used in the 721 control are designed specifically for reciprocating engine applications.

To provide better transient performance, the control can be operated automatically with two gain settings depending on engine speed error (speed error is the difference between the speed setting and the actual engine speed). During steady-state operation with a constant load, the control uses the base gain setting. The control automatically increases gain by an adjustable ratio when a speed error exceeding an adjustable window occurs so that speed error is minimized. Operation with base gain is restored once the control senses the return to steady-state speed.

The control can also compensate for non-linear fuel systems and changes in engine dynamics with load. The control dynamics are mapped as a function of actuator current (actuator current is proportional to engine load). This provides optimal dynamics and smooth steady-state operation for all conditions from no load to full engine load.

The control also provides two complete sets of dynamic adjustments which are selected depending on the status of the Main Shaft Clutch On input. The two sets of dynamics are provided for use where engine operating conditions change (e.g., when the engine drives both the propeller shaft and the generator or when the engine drives only the generator).

Speed Reference

The 721DSC provides local control of the speed reference with Raise Speed command (contact input C), Lower Speed command (contact input D), Start Pos./Idle Speed selection (contact input B), and Shaft Generator Operation command (contact input G). For remote speed setting, the control provides a 4 to 20 mA Remote Speed Setting input. The Speed Reference of 721DSC ramps to another set point with Raise/Lower rate when Raise/Lower Speed command or Shaft Generator Operation command was input or Start Pos./Idle Speed selection was changed. However, when the generator is synchronizing or when the load transfer is being performed, the Load Transfer Rate is used to change the Speed Reference.

When the contact for Start Pos./Idle Speed selection input is opened, the Speed Reference is fixed at Start Speed.

When the contact for Start Pos./Idle Speed selection input is closed, the Speed Reference ramps to Idle Speed. When the Speed Reference reaches Idle Speed, it will be able to ramp to another set point as directed by Raise/Lower Speed command or Shaft Generator Operation command. The external Remote Speed Setting signal is enabled by closing both the Raise Speed contact and the Lower Speed contact.

When the contact for Shaft Generator Operation is closed, the Speed Reference will ramp to the speed specified with RATED SPEED set point and stay there. But the Raise Speed contact and Lower Speed contact are enable while the engine is synchronizing for parallel operation or performing Load Transfer. The Speed Reference returns to RATED SPEED automatically after Load Transfer finished.

Load Transfer

This engine control system does not provide parallel operation in isochronous mode, but it can make two engine-generator sets distribute the load which has been loaded by one engine-generator set.

To transfer the generator load, the operator needs to open the generator circuit breaker (GCBx) of the engine generator set to which the load will be transferred. (that is, if the load will be transferred from the starboard engine to the port engine in drawing 9951-626, GCB 2 must be opened, and vice versa.) Connect the tie circuit breaker (TCB in drawing 9951-626). When one of the 721 controls detects that the GCB x AUX contact (contact E) is open and the TCB contact (contact F) is closed, this control will switch the operation mode from isochronous mode to KW droop mode to perform load transfer. The 721 control whose GCB has been closed, will not switch operation mode , and continues to run in the isochronous mode.

Synchronize both engines and close the GCB which was opened first in this load transfer procedure. Next, transfer the engine-generator load to another engine by raising the speed set point of the 721 control working in the load transfer mode.. When the load levels of both engines are appropriate, open the TCB to switch the engine operation mode to the isochronous mode.

Now, the load transfer has completed.

Fuel Limit

The 721DSC has two fuel limits, Start Fuel Limit and Maximum Fuel Limits.

Start Fuel Limit (%) is the maximum percent actuator output during engine start-up. This should be set to a value which gives optimum start characteristics, while minimizing smoke emissions due to overfueling.

Maximum Fuel Limit (%) is the maximum percent actuator output during normal engine operation. This limit should normally be set just above the output at full load.

Monitoring Control

721DSC's analog input signals, analog output signals, and present discrete inputs status can be monitored using the hand-held programmer.

Three 4-20mA outputs are provided for monitoring Engine rpm, Speed Reference, and Rack Position (Actuator output), which are configurable at 4 mA and 20 mA.

Three relay outputs are provided for Major Alarm indication, Minor Alarm indication, and Load Transferring indication.

Chapter 5
Entering Control Set Points

Introduction

Because of the variety of installations, plus system and component tolerances, set points input to two 721 controls could not be identical even if these 721 controls are installed in same engine control systems. Therefore, the 721 control must be tuned to each system for optimum performance.

This chapter contains information on how to enter control set points through the control's menu system using the Hand Held Programmer. See the next chapter for prestart-up and start-up settings and adjustments.

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.

Hand Held Programmer and Menus

The Hand Held Programmer is a hand-held computer terminal that gets its power from the 721 control. The terminal connects to the RS-422 communication serial port on the control (terminal J1). 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.

The programmer does a power-up self-test whenever it is plugged into the control. When the self-test is complete, the screen will display two lines of information. This is information relating to the application. If it does not appear, press the ESC key. Pressing the 'ID' key will change the display to show the software part number and the revision level of the control.

Please record this software part number and revision level because Woodward will need these if you ever need factory service for any control problem.

The programmer screen is a four-line, backlighted LCD display. The display permits you to look at two separate functions or menu items at the same time. Use the ⇳“Up/Down Arrow” key to toggle between the two displayed items. An “@” mark will be displayed at the left side of the active line. The operator can change the set point only in the active line. The BKSP and SPACE keys will scroll through the display to show the remainder of a prompt if it is longer than the display screen's 18 characters.

The 721 has two sets of menus; the Service menus and the Configure menus. The Service menus allow easy access and tuning while the engine is running. The Configure menus may only be entered if the I/O is shut down, and hence the engine stopped.

Configure Menus

To access the Configure menus, the engine must be shut down. Press the . key at the control's master screen.("WOODWARD GOVERNOR, 721 DIGITAL CONTROL") The display will show "To Enable CONFIGURE, press *ENTER*". Press the ENTER key and the display will show, "To shutdown I/O, press *ENTER*". Press the ENTER key and this will allow you into the Configure menus.

NOTE

If the engine is running during this process, it will be shut down due to shutting down the I/O of the control.

To move between the menus use the ◄ and ► keys. To move through the set points within a menu, use the ▲ and ▼ keys. Once within a menu, to return to the menu header, press the ESC key.

To exit the Configure menus press the ESC key. The set points will be automatically saved when leaving Configure, and the control will automatically reboot itself.

CAUTION

Any values that are adjusted or tuned must be saved by pressing the ESC key to reboot the control prior to removing power to the 721 control, otherwise they will revert back to their original settings. Saving is done by pressing the SAVE key on the hand held programmer.

Service Menus

To access the Service menus, press the ▼ key at the master screen ("WOODWARD GOVERNOR, 721 DIGITAL CONTROL"). To move between menus, and to move through set points within menus, follow the instructions as for the Configure menus. Also to return to the menu header, or to leave Service, follow the Configure instructions.

Adjusting Set Points

To adjust a set point, use the "Turtle Up" or the "Rabbit Up" keys to increase the value, and the "Turtle Down" or "Rabbit Down" keys to decrease the value. The "Rabbit Up" and "Rabbit Down" keys will make the rate of change faster than the "Turtle Up" and "Turtle Down" keys. This is useful during initial set-up where a value may need to be changed significantly. Where necessary, to select TRUE, use either the "Turtle Up" or the "Rabbit Up" keys, and to select FALSE, use the "Turtle Down" or "Rabbit Down" keys.

To obtain an exact value, press the = key. Key in the required figure and press ENTER.

NOTE

This may be done only if the figure is within 10% of the existing value.

To save set points at any time, use the SAVE key. This will transfer all new set point values into the EEPROM memory. The EEPROM retains all set points when power is removed from the control.

CAUTION

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.

Hand Held Programmer Keys

The programmer keys do the following functions (see Figure 5-1):

(left arrow)	Moves backward through Configure or Service, one menu at a time.
(right arrow)	Advances through Configure or Service, one menu at a time.
(up/down arrow)	Toggles between the two displayed items.
(up arrow)	Moves backward through each menu, one step at a time.
(down arrow)	Advances through each menu, one step at a time. Selects Service from Master Screen.
(turtle up)	Increases the displayed set point value slowly.
(turtle down)	Decreases the displayed set point value slowly.
(rabbit up)	Increases the displayed set point value quickly (about 10 times faster than the turtle keys).
(rabbit down)	Decreases the displayed set point value quickly (about 10 times faster than the turtle keys).
– (minus)	Increases set point values by one step at a time.
+ (plus)	Decreases set point values by one step at a time.
■ (solid square)	Not used.
ID	Displays the 721 control part number and software revision level.
ESC	To return to menu header or to main screen.
SAVE	Saves entered values (set points).
BKSP	Scrolls left through line of display.
SPACE	Scrolls right through line of display.
ENTER	Used when entering exact values and accessing Configure.
= (equals)	For entering exact values (within 10%).
• (decimal)	To select Configure.

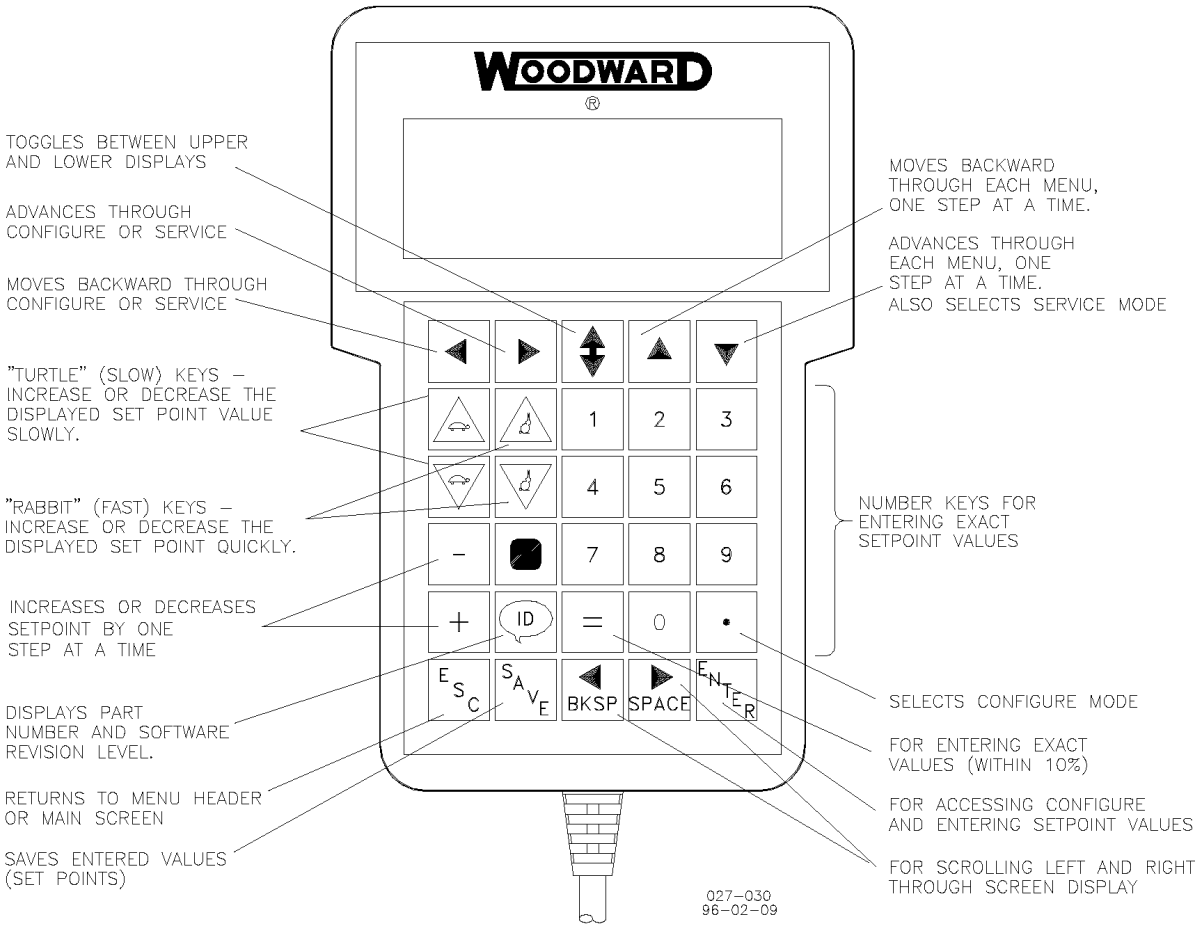

Figure-1. Hand Held Programmer Functions

Set Point List

Name	Min Value	Max Value	Initial Value	Dimension
CONFIGURE MENU				
1. Reverse Acting Act	FALSE	TRUE	FALSE	---
2. No.1 Gear Teeth	50	120	62	---
3. No.1 Max Hz	400	6000	700	Hz
4. Use No2 MPU	FALSE	TRUE	TRUE	---
5. No.2 Gear Teeth	50	120	62	---
6. No.2 Max Hz	400	6000	700	Hz
7.Normal Opn Minr Alm Ry	FALSE	TRUE	FALSE	---
8.Normal Opn Mjor Alm Ry	FALSE	TRUE	FALSE	---
SERVICE MENUS				
Display 1				
1. Engine Speed				rpm
2. Speed Reference				rpm
3. Generator Load				KW
4. Actuator Output				%
5. Fuel Limit Output				%
Dynamics 1				
1. Idle Prop. Gain1	0.001	50.0	1.0	---
2. Rated Prop. Gain1	0.001	50.0	1.0	---
3. Integrator Rate1	0.1	50.0	2.0	sec
4. Derivative Ratio1	1.0	100.0	5.0	---
5. Window Width1	1.0	50.0	10.0	rpm
6. Gain Ratio1	0.1	10.0	1.0	---
7. Gain Break Point	10.0	100.0	30.0	%
8. Gain Slope	0.1	10.0	1.0	---
9. Speed Filter	20.0	0.1	15.0	Hz
Dynamics 2				
1. Idle Prop. Gain2	0.001	50.0	1.0	---
2. Rated Prop. Gain2	0.001	50.0	1.0	---
3. Integrator Rate 2	0.1	50.0	2.0	sec
4. Derivative Ratio2	1.0	100.0	5.0	---
5. Window Width2	1.0	50.0	10.0	rpm
6. Gain Ratio2	0.1	10.0	1.0	---

Name	Min Value	Max Value	Initial Value	Dimension
Speed Setting				
1. Start Speed	200	1000	300	rpm
2. Idle Speed	200	1000	350	rpm
3. Rated Speed	300	1000	520	rpm
4. Raise Limit	300	1000	572	rpm
5. Raise/Lower Rate	0.1	100	1.0	rpm/sec
6. Load Transfer Rate	0.1	1000	1.0	rpm/sec
7. Spd Set at 4mA	200	1000	350	rpm
8. Spd Set at BP,mA	200	1000	8.0	mA
9. Spd Set at BP,RPM	200	1000	350	rpm
10. Spd Set at 20mA	200	1000	540	rpm
11. Tach at 4mA Output	0.0	1000	0.0	rpm
12 Tach at 20mA Output	0.0	1000	600	rpm
13. Speed Set at 4mA Output	0.0	1000	0.0	rpm
14. Speed Set at 20mA Output	0.0	1000	600	rpm
KW Setting				
1. Rated KW	100	10000	1280	KW
2. 20mA KW Load Input	100	10000	1500	KW
3. KW Droop Set(%)	0.0	10.0	5.0	%
Fuel Limit				
1. Start Fuel Limit	10.0	100.0	10.0	%
2. Torque Lmt P1,rpm	200	800	300	rpm
3. Torque Lmt P1,%	10.0	100.0	57.0	%
4. Torque Lmt P2,rpm	200	800	400	rpm
5. Torque Lmt P2,%	10.0	100.0	57.0	%
6. Torque Lmt P3,rpm	200	800	468	rpm
7. Torque Lmt P3,%	10.0	100.0	83.0	%
8. Torque Lmt P4,rpm	200	800	520	rpm
9. Torque Lmt P4,%	10.0	100.0	87.0	%
10. Maximum Fuel Limit	50.0	100.0	87.0	%

Name	Min Value	Max Value	Initial Value	Dimension
Display 2				
1. Speed Signal #1				rpm
2. Speed Signal #2				rpm
3. Kw Signal Input,%				%
4. Spd set Input,mA				mA
5. Contact A Status				
6. Contact B Status				
7. Contact C Status				
8. Contact D Status				
9. Contact E Status				
10. Contact F Status				
11. Contact G Status				
12. Contact H Status				
13. Major Alarm Ry Status				
14. Minor Alarm Ry Status				
15. Transfer Mode Ry Status				
16. #1 LED Status				
17. #2 LED Status				
Alarms				
1. Minor Alarm				
2. Major Alarm				
3. No1 MPU Failure				
4. No2 MPU Failure				
5. KW Signal Fail				
6. Spd Set Signal Fail				
7. Fault Reset	FALSE	TRUE	FALSE	---

CAUTION

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.

Chapter 6
Entering Control Set Points

CONFIGURE MENUS

To access the Configure menus, the engine must be shut down. Press the . key. The display will show, "To select configure, press ENTER". Press the ENTER key and the display will show, "To shutdown I/O, press ENTER". Press the ENTER key and this will allow you into the Configure menus.

NOTE

The set points in the Configure menus must be set to the correct values before starting the engine, otherwise the engine may overspeed or will not start.

1. Reverse Acting Act
   This set point determines to which direction the actuator rotates when the actuator output current from the 721 control increases. Setting "FALSE" will select Forward acting output. In this case the actuator output current must be increased to increase fuel. Setting "TRUE" will select Reverse acting output. In this case the actuator output current must be decreased to increase fuel. A mechanical ballhead back-up governor (for example, Woodward EGB or PGA-EG) is required for reverse-acting applications.

2. No.1 Gear Teeth
   Set this to the number of teeth or holes on the speed sensing gear for speed sensor #1. If the speed sensing gear is not rotating at the same speed as the crankshaft, this is the number of gear teeth that will pass the speed sensor in one complete engine revolution.

3. No.1 Max Hz
   This is the maximum frequency for speed sensor #1. Set the input frequency which will be sensed when the engine is running at the Raise Limit or more.

4. Use No.2 MPU
   Set this to "TRUE" when both speed sensors are used. Set this to "FALSE" when only one speed sensor is used. When this set point is set to "TRUE", only speed sensor #1 is available.

5. No.2 Gear Teeth
   Set this to the number of teeth or holes on the speed sensing gear for speed sensor #2. If the speed sensing gear is not rotating at the same speed as the crankshaft, this is the number of gear teeth that will pass the speed sensor in one complete engine revolution.

6. No.2 Max Hz
   This is the maximum frequency for speed sensor #2. Set the input frequency which will be sensed when the engine is running at the Raise Limit or more.

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.

CAUTION

Never set Max Hz to a value over 125% of the frequency at Raise Limit. Otherwise the 721 control may not control the engine.

7. Normal Opn Minr Alm Ry
   This set point determines the operating mode of Minor Alarm relay. Set the set point to "TRUE" if this relay is used as normally open. Set the set point to "FALSE" if this relay is normally closed. If it was set to "TRUE", the relay will be closed when a minor alarm happens.

8. Normal Opn Mjr Alm Ry
   This set point determines the operating mode of Major Alarm relay. Set the set point to "TRUE" if this relay is used as normally open. Set the set point to "FALSE" if this relay is normally closed. If it was set to "TRUE", the relay will be closed when a major alarm happens.

SERVICE MENUS

It is not necessary to stop the engine to access the Service menus. The Service menus are used to adjust or monitor the set points.

Display 1

The operator can monitor engine parameters on the Hand Held programmer's screen.

1. Engine Speed
   The current engine speed is displayed in rpm.

2. Speed Reference
   The current Speed Reference is displayed in rpm. However, the value displayed here may not match the actual speed reference value if the engine is operating in droop mode, the actuator output is limited by fuel limiters, or the actual speed reference is changed for some other reason. So this value may not match the actual speed reference.

3. Generator Load
   The current generator load (KW output) is shown.

4. Actuator Output
   The actuator percent output is shown. When the 721 control actuator driver outputs 180 mA, the value shown here is 100%. This monitor value is referred when setting set points for fuel limits and the gain breakpoint.

5. Fuel Limit Output
   The max actuator percent output limited by the current fuel limit is shown.

Dynamics 1

Tune the control dynamics for stable engine operation and most suitable transient performance. This 721 control has two sets of dynamics. The dynamics used in the 721 control are selected with an external contact input. See figure 2 for tuning Prop.Gain (traditional Gain in Woodward controls) and Integrator Rate (traditional Reset in Woodward controls).

1. Idle Prop. Gain 1
   This set point is effective while Start Speed is selected as the speed reference. (Hence, contact B is open.) Idle Prop. Gain determines how fast the control responds to an error in engine speed from the speed reference setting while Start Speed is selected.

2. Rated Prop. Gain 1
   Adjust this set point to get stable engine operation above and below the rated speed with light load or no load. Rated Prop. Gain determines how fast the control responds to an error in engine speed from the speed reference setting while the Rated Speed is selected.

3. Integrator Rate 1
   Integrator Rate 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. Integrator Rate is adjusted to prevent slow hunting and to minimize speed overshoot after a load disturbance.

4. Derivative Ratio 1
   Derivative Ratio compensates for the actuator time constant. Set this set point to 5 for ordinary applications.

5. Window Width 1
   Window Width 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 Ratio 1
   Gain Ratio 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.

7. Gain Breakpoint 1
   Gain Breakpoint sets the percent output above which the Gain Slope becomes effective. It should usually be set just above the minimum load output. See figure 4. The Gain Breakpoint adjustment is common to both sets of dynamics.

8. Gain Slope 1
   Gain Slope 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 with high (or low) gain at low load levels. This allows the gain settings to be lower at light or no load for engine stability, yet provide good control performance under loaded conditions.

9. Speed Filter
   Set this value to the cutoff frequency found by using the formula below (see figure 5). This is the roll-off frequency for the firing torsional filter. The formula to get the proper roll-off frequency setting is:

   camshaft frequency = (engine rpm)/60 [for 2-cycle engines]
   = (engine rpm)/120 [for 4-cycle engines]

   firing frequency = *(camshaft frequency*) × (number of cylinders)

   Initially set the filter frequency to the firing frequency.

Dynamics 2

Dynamics 2 is enabled when external contact H (Main Shaft Clutch On) is closed.

1. Idle Prop. Gain 2
   This set point is effective while Start Speed is selected as the speed reference. (Hence, contact B is open.) Idle Prop. Gain determines how fast the control responds to an error in engine speed from the speed reference setting while the Start Speed is selected.

2. Rated Prop. Gain 2
   Adjust this set point to get the stable engine operation above and below the rated speed with light load or no load. Rated Prop. Gain determines how fast the control responds to an error in engine speed from the speed reference setting while the Rated Speed is selected.

3. Integrator Rate 2
   Integrator Rate 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. Integrator Rate is adjusted to prevent slow hunting and to minimize speed overshoot after a load disturbance.

4. Derivative Ratio 2
   Derivative Ratio compensates for the actuator time constant. Set this set point to 5 for ordinary applications.

5. Window Width 2
   Window Width 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 Ratio 2
   Gain Ratio 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.

Speed Settings

Set set points for speed references.

1. Start Speed
   Start Speed is the speed reference selected when the Start Pos/Idle contact (external contact B) is open.

2. Idle Speed
   Idle Speed is the lowest speed reference selected when the Start Pos/Idle contact (external contact B) is closed.

3. Rated Speed
   Rated Speed is the speed reference selected when the Shaft Generator Operation Mode contact (external contact G) is closed.

4. Raise Limit
   Raise Limit is the maximum speed reference setting. It is used to limit the Raise Speed command and the Remote Speed Reference to a maximum. It normally is set at the maximum rated engine speed.

5. Raise/Lower Rate
   Raise/Lower Rate is the rate at which the speed reference is ramped when using the Raise command or the Lower command as well as when the Remote Speed Setting input is changed in the increase or 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 Raise/Lower Rate.

6. Load Transfer Rate
   The Load Transfer Rate is the speed raise/lower rate which is used for generator load transfer or for generator synchronization. This speed change rate is selected automatically when the engine is operated in the KW droop mode. Normally, the speed change rate of Load Transfer Rate is less than that of Raise/Lower Rate.

7. Spd Set at 4mA
   Spd Set at 4mA is the speed reference when the remote speed setting input is 4 mA.

8. Spd Set at BP, mA
   Spd Set at BP, mA is the remote speed setting signal in mA at the break point at which the speed reference slope to the remote speed setting input changes.

9. Spd Set at BP, RPM
   Spd Set at BP, RPM is the engine speed in RPM at the same break point above. The Speed Reference moves between 'Speed Set Point at 4mA', 'Speed Set Point at Breakpoint' (above), and 'Speed Set Point at 20mA' (below).

10. Spd Set at 20mA
    Spd Set at 20mA is the speed reference when the remote speed setting input is 20 mA.

11. Tach at 4mA Output
    Set this set point to the engine speed in RPM when the tachometer output channel outputs 4 mA.

12. Tach at 20mA Output
    Set this set point to the engine speed in RPM when the tachometer output channel outputs 20 mA.

13. Speed Set at 4mA Output
    Set this set point to the speed reference value in RPM when the Speed Reference output channel outputs 4 mA.

14. Speed Set at 20mA Output
    Set this set point to the speed reference value in RPM when the Speed Reference output channel outputs 20 mA.

KW Settings

KW Setting Menus are set point menus for setting engine load set points.

1. Rated KW
   Rated KW is the generator's rated output.

2. 20mA KW Load Input
   20mA KW Load Input is the KW load level when the KW transducer input signal (connected to terminal 36 and 37) is 20 mA.

3. KW Droop Set (%)
   KW Droop is the rate at which the engine speed droops based on the KW transducer input signal which varies from no load to full load. The actual droop 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.

Fuel Limit

Fuel Limiters limit the actuator output current from the control.

1. Start Fuel Limit
   Start Fuel Limit sets the maximum actuator output current for starting the engine. Set this set point to the fuel supply level necessary to start the engine.

2. Torque Lmt P1, rpm
   Torque Lmt P1, rpm is the engine speed in RPM at the first torque limit.

3. Torque Lmt P1, %
   Torque Lmt P1, % is the maximum actuator output current in percent at the first torque limit.

4. Torque Lmt P2, rpm
   Torque Lmt P2, rpm is the engine speed in RPM at the second torque limit.

5. Torque Lmt P2, %
   Torque Lmt P2, % is the maximum actuator output current in percent at the second torque limit.

6. Torque Lmt P3, rpm
   Torque Lmt P3, rpm is the engine speed in RPM at the third torque limit.

7. Torque Lmt P3, %
   Torque Lmt P3, % is the maximum actuator output current in percent at the third torque limit.

8. Torque Lmt P4, rpm
   Torque Lmt P4, rpm is the engine speed in RPM at the fourth torque limit.

9. Torque Lmt P4, %
   Torque Lmt P4, % is the maximum actuator output current in percent at the fourth torque limit.

10. Maximum Fuel Limit
    Maximum Fuel Limit sets the maximum actuator output current. If 100% is set at this set point, the maximum actuator output current is 180 mA. Set this set point to a value a little above the actuator output value for full load.

Display 2

These are menus to monitor input/output status.

1. Speed Signal #1
   Speed Signal #1 displays the speed signal input to speed signal input channel #1.

2. Speed Signal #2
   Speed Signal #2 displays the speed signal input to speed signal input channel #2.

3. KW Signal Input,%
   KW Signal Input,% displays the input signal from the KW transducer in percent.

4. Spd Set Input,mA
   Spd Set Input,mA displays the external remote speed setting input signal in mA.

5. Contact A Status
   Contact A Status displays the status of the RUN/STOP contact (open or closed).

6. Contact B Status
   Contact B Status displays the status of the IDLE SPEED/START SPEED contact (open or closed).

7. Contact C Status
   Contact C Status displays the status of the RAISE SPEED contact (open or closed).

8. Contact D Status
   Contact D Status displays the status of the LOWER SPEED contact (open or closed).

9. Contact E Status
   Contact E Status displays the status of the Generator Circuit Breaker Aux. (GCB AUX) contact (open or closed).

10. Contact F Status
    Contact F Status displays the status of the Tie Circuit Breaker Aux. (TCB AUX) contact (open or closed).

11. Contact G Status
    Contact G Status displays the status of the SHAFT GENERATOR OPERATION MODE selection contact (open or closed).

12. Contact H Status
    Contact H Status displays the status of the MAIN SHAFT CLUTCH ON contact (open or closed).

13. Major Alarm Ry Status
    Major Alarm Ry Status indicates if a major alarm has been issued or not (open or closed).

14. Minor Alarm Ry Status
    Minor Alarm Ry Status indicates if a minor alarm has been issued or not (open or closed).

15. Transfer Mode Ry Status
    Transfer Mode Ry Status indicates if the engine is transferring load or not (open or closed).

16. #1 LED Status
    #1 LED Status displays the status of #1 LED (on or off).

17. #2 LED Status
    #2 LED Status displays the status of #2 LED (on or off).

Alarms

These are menus to monitor fault status.

1. Minor Alarm
   Minor Alarm displays “TRUE” if the control has detected any minor alarm.

2. Major Alarm
   Major Alarm displays “TRUE” if the control has detected the major alarm.

3. No.1 MPU Failure
   No.1 MPU Failure displays “TRUE” if MPU #1 has failed.

4. No.2 MPU Failure
   No.2 MPU Failure displays “TRUE” if MPU #2 has failed.

5. KW Signal Fail
   KW Signal Fail displays “TRUE” if the 4-20 mA KW transducer signal has failed.

6. Spd Set Signal Fail
   Spd Set Signal Fail displays “TRUE” if the 4-20 mA remote speed setting signal has failed.

7. Fault Reset SW
   Fault Reset SW is a software reset function to reset alarms. Change the set point value to “TRUE” to reset alarms. Be sure to change the set point value back to “FALSE” after resetting alarms.

If you have completed the adjustments, save the set points by pressing the SAVE key. Disconnect the Hand Held Programmer from the control. Close the cover over J1 and retighten the retaining screw.

CAUTION

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.

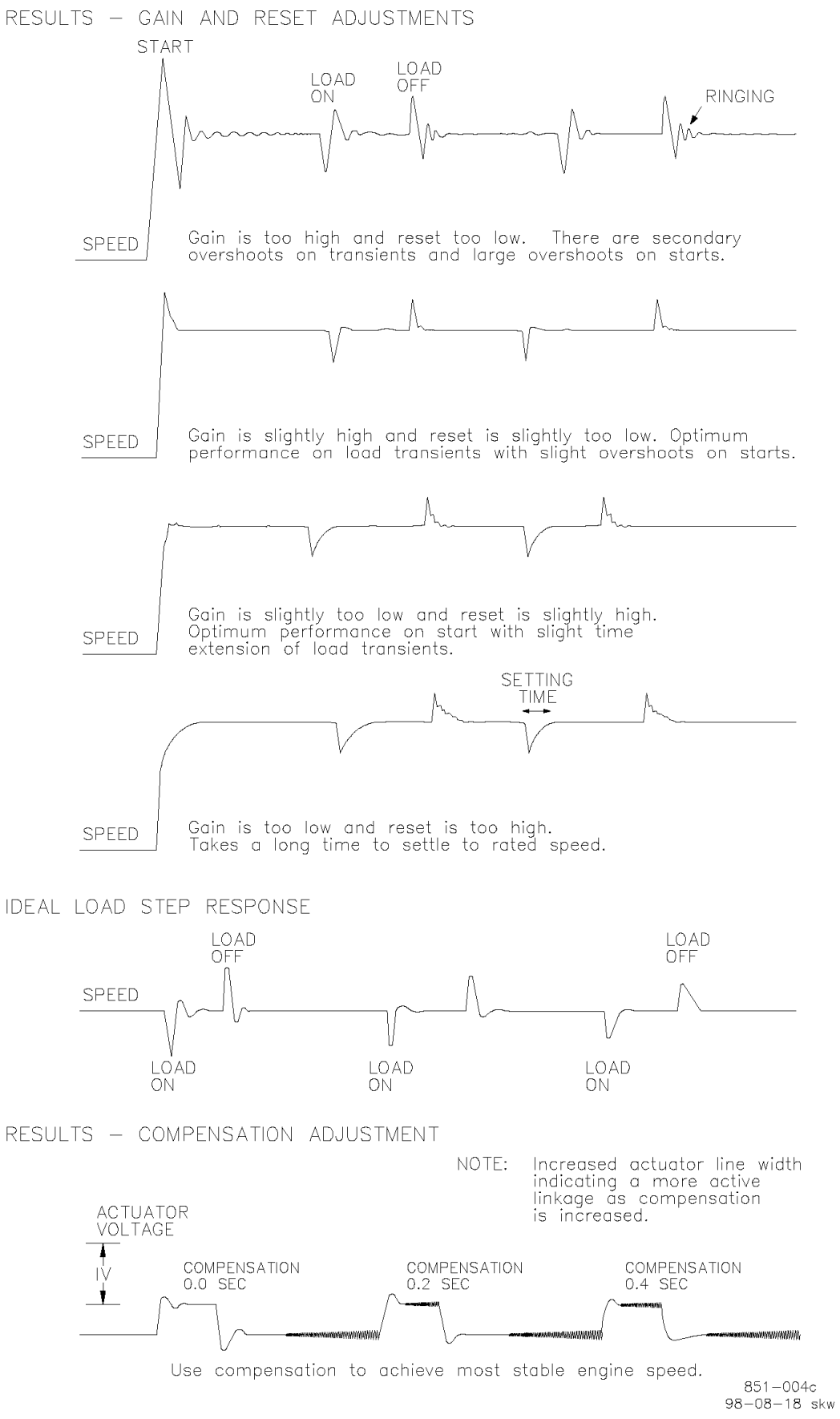

Figure 2. Typical Transient Response Curve

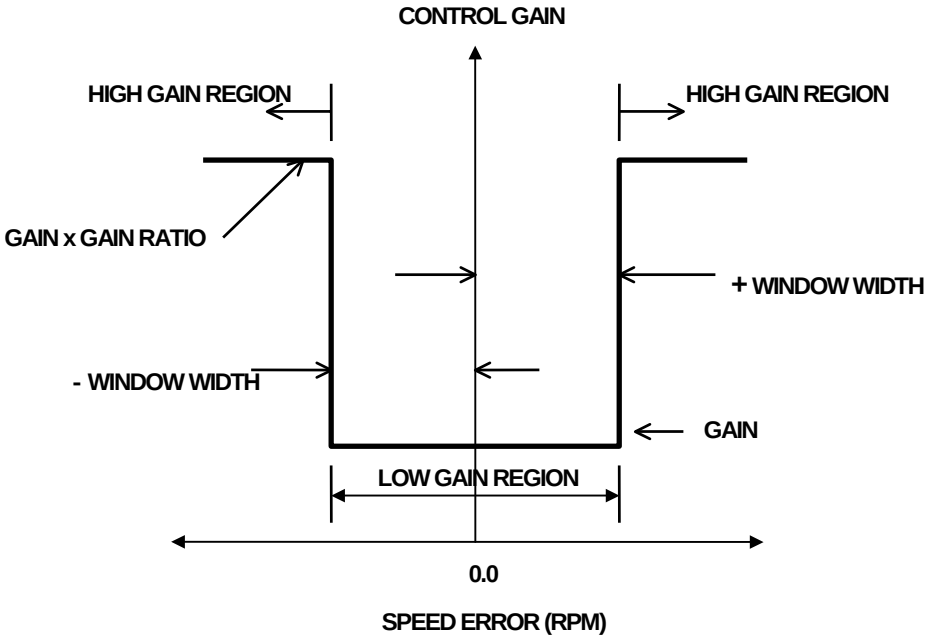

Figure 3. Control Gain as a Function of Speed Error

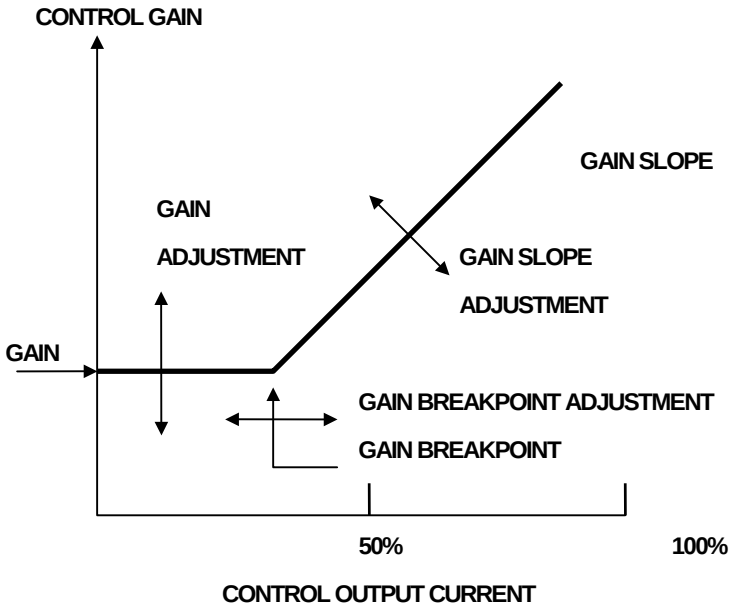

Figure 4. Control Gain as a Function of Control Output

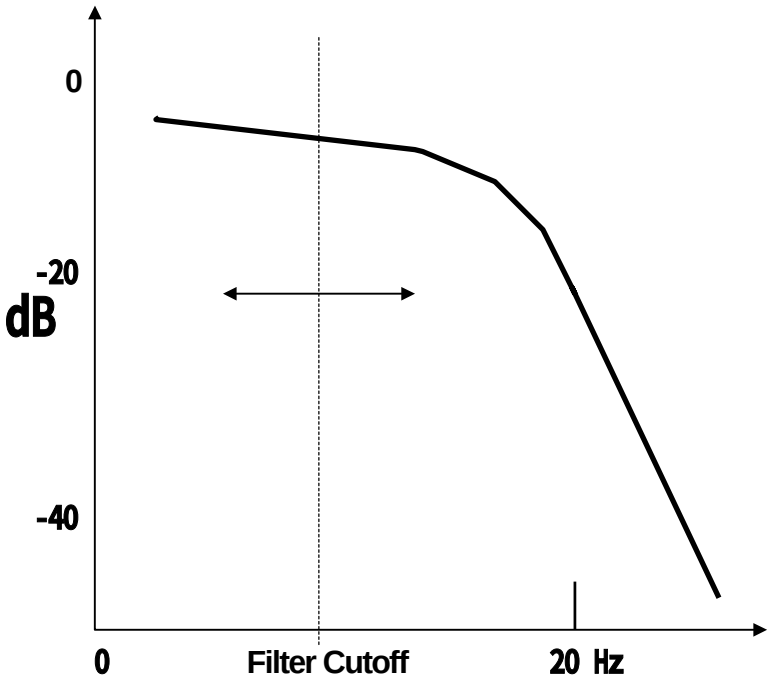

Figure 5. Speed Filter

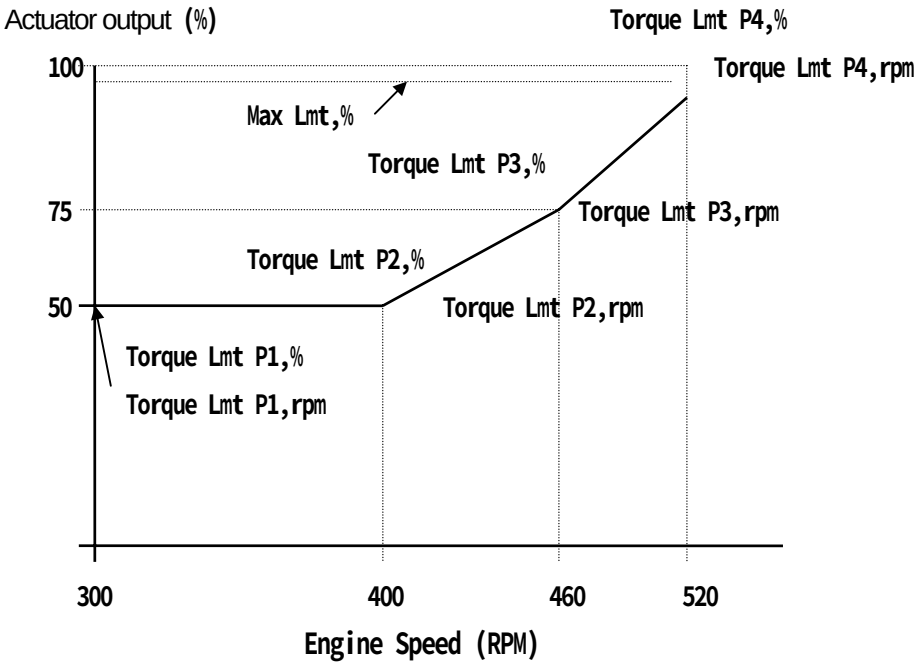

Figure 6. Torque Fuel Limit Curve

Chapter 7
Major Alarm and Minor Alarm

Major Alarm

If the 721 control detects a major alarm, it will activate the major alarm relay and drive the actuator output to 0 mA to shut down the engine. If a mechanical reverse-acting actuator is used with the electronic control, the mechanical governor will take over the engine control.

The condition to cause a major alarm is:

* Both speed sensors failed.

CAUTION

The 721 control will not activate a major alarm even on an actuator internal open-circuit. However, an actuator internal open-circuit will cause engine shutdown, consequently both speed sensors will fail for engine stalls. This will then cause the 721 control to activate a major alarm.

Minor Alarm

If the 721 control detects a minor alarm, it will activate the minor alarm relay, but it does not shut down the engine.

The conditions to cause a minor alarm are:

* One speed sensor failed.
* KW transducer input signal failed.
* Remote Speed Setting input signal failed.

WOODWARD GOVERNOR COMPANY
ENGINE CONTROLS DIVISION
721 DIGITAL ENGINE CONTROL
FOR KAWASAKI HEAVY INDUSTRIES, LTD.
SYSTEM 9907-717

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C.C1

∗ CONFIGURE MENU ∗

1	Reverse Acting Act	#FALSE (TRUE, FALSE)	_____
2	No.1 Gear Teeth	#62 (50, 120)	_____
3	No.1 Max Hz	#700 (400, 6000)	_____
4	Use No2 MPU	#TRUE (TRUE, FALSE)	_____
5	No.2 Gear Teeth	#62 (50, 120)	_____
6	No.2 Max Hz	#700 (400, 6000)	_____
7	Normal Opn Minr Alm Ry	#FALSE (TRUE, FALSE)	_____
8	Normal Opn Mjr Alm Ry	#FALSE (TRUE, FALSE)	_____

==========

S.S1

∗ Display 1 ∗

1	Engine Speed	_____
2	Speed Reference	_____
3	Generator Load	_____
4	Actuator Output	_____
5	Fuel Limit Output	_____

==========

S.S2

∗ Dynamics 1 ∗

1	Idle Prop. Gain1	∗1.0 (0.001, 50.0)	_____
2	Rated Prop. Gain1	∗1.0 (0.001, 50.0)	_____
3	Integrator Rate1	∗2.0 (0.1, 50.0)	_____
4	Derivative Ratio1	∗5.0 (1.0, 100.0)	_____
5	Window Width1	∗10.0 (1.0, 50.0)	_____
6	Gain Ratio1	∗1.0 (0.1, 10.0)	_____
7	Gain Break Point	∗30.0 (10.0, 100.0)	_____
8	Gain Slope	∗1.0 (0.1, 10.0)	_____
9	Speed Filter	∗15.0 (0.1, 20.0)	_____

==========

S.S3

∗ Dynamics 2 ∗

1	Idle Prop. Gain2	∗1.0 (0.001, 50.0)	_____
2	Rated Prop. Gain2	∗1.0 (0.001, 50.0)	_____
3	Integrator Rate2	∗2.0 (0.1, 50.0)	_____
4	Derivative Ratio2	∗5.0 (1.0, 100.0)	_____
5	Window Width2	∗10.0 (1.0, 50.0)	_____
6	Gain Ratio2	∗1.0 (0.1, 10.0)	_____

==========

S.S4

∗ Speed Setting ∗

1	Start Speed	∗300.0 (200.0, 1000.0)	_____
2	Idle Speed	∗350.0 (200.0, 1000.0)	_____
3	Rated Speed	∗520.0 (300.0, 1000.0)	_____
4	Raise Limit	∗572.0 (300.0, 1000.0)	_____
5	Raise/Lower Rate	∗1.0 (0.1, 100.0)	_____
6	Load Transfer Rate	∗1.0 (0.1, 100.0)	_____
7	Spd Set at 4mA	∗350.0 (200.0, 1000.0)	_____
8	Spd Set at BP,mA	∗8.0 (4.0, 20.0)	_____
9	Spd Set at BP,RPM	∗350.0 (200.0, 1000.0)	_____
10	Spd Set at 20mA	∗540.0 (200.0, 1000.0)	_____
11	Tach at 4mA Output	∗0.0 (0.0, 1000.0)	_____
12	Tach at 20mA Output	∗600.0 (0.0, 1000.0)	_____
13	Spd Set at 4mA Output	∗0.0 (0.0, 1000.0)	_____
14	Spd Set at 20mA Output	∗600.0 (0.0, 1000.0)	_____

==========

S.S5

∗ Kw Setting ∗

1	Rated KW	∗1280.0 (100.0, 10000.0)	_____
2	20mA KW Load Input	∗1500.0 (100.0, 10000.0)	_____
3	Kw Droop Set(%)	∗ 5.0 (0.0, 10.0)	_____

==========

S.S6

∗ Fuel Limit ∗

1	Start Fuel Limit	∗10.0 (10.0, 100.0)	_____
2	Torque Lmt P1,rpm	∗300.0 (200.0, 800.0)	_____
3	Torque Lmt P1,%	∗57.0 (10.0, 100.0)	_____
4	Torque Lmt P2,rpm	∗400.0 (200.0, 800.0)	_____
5	Torque Lmt P2,%	∗57.0 (10.0, 100.0)	_____
6	Torque Lmt P3,rpm	∗468.0 (200.0, 800.0)	_____
7	Torque Lmt P3,%	∗83.0 (10.0, 100.0)	_____
8	Torque Lmt P4,rpm	∗520.0 (200.0, 800.0)	_____
9	Torque Lmt P4,%	∗87.0 (10.0, 100.0)	_____
10	Maximum Fuel Limit	∗87.0 (10.0, 100.0)	_____

==========

S.S7

∗ Display 2 ∗

1	Speed Signal #1	_____
2	Speed Signal #2	_____
3	Kw Signal Input,%	_____
4	Spd Set Input, mA	_____
5	Contact A Status	_____
6	Contact B Status	_____
7	Contact C Status	_____
8	Contact D Status	_____
9	Contact E Status	_____
10	Contact F Status	_____
11	Contact G Status	_____
12	Contact H Status	_____
13	Major Alarm Ry Status	_____
14	Minor Alarm Ry Status	_____
15	Transfer Mode Ry Status	_____
16	#1 LED Status	_____
17	#2 LED Status	_____

==========

S.S8

	* Alarms *		
1	Minor Alarm		_____
2	Major Alarm		_____
3	No1 MPU Failure		_____
4	No2 MPU Failure		_____
5	KW Signal Fail		_____
6	Spd Set Signal Fail		_____
7	Fault Reset	* FALSE (TRUE, FALSE)	_____

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED
NEW	EC 1012666	98/12	

REV STATUS OF SHEETS	
SHEET	REV
1	NEW
2	NEW
3	NEW
4	
5	
6	
7	
8	
9	
10	
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12	
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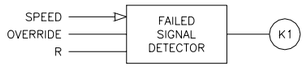
FUNCTIONAL BLOCK DIAGRAM NOTES

SIGNAL FLOW

SIGNAL FLOW IS FROM LEFT TO RIGHT. ALL INPUTS FROM THE LEFT. ALL OUTPUTS EXIT TO THE RIGHT. EXCEPTIONS ARE NOTED. SIGNAL VALUES ARE SHOWN WITH AN ARROW. LOGIC SIGNALS ARE SHOW WITHOUT AN ARROW.

EXAMPLE



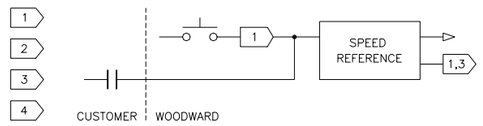
CUSTOMER INPUT/OUTPUT (I/O)

INPUTS ORIGINATE ON THE LEFT SIDE OF THE DRAWING. OUTPUTS TERMINATE ON THE RIGHT SIDE OF THE DRAWING. WITH THE EXCEPTION OF RELAYS. WHICH ARE SHOWN NEAR THEIR ASSOCIATED FUNCTION BLOCK. VERTICAL DASHED LINES SEPARATE SIGNAL FLOW BETWEEN WOODWARD GOVERNOR AND CUSTOMER EQUIPMENT.

INTERCONNECT CODE

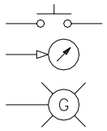
THE ⬠ SYMBOL INDICATES INTERCONNECTING SIGNAL FLOW BY CABLES WITH CONNECTORS ON BOTH ENDS. NO CUSTOMER WIRING REQUIRED. EACH CABLE IS DISTINGUISHED WITHIN THE BLOCK DIAGRAM NUMERICALLY AND GENERALLY EACH RACK WILL BE SHOWN ON SEPARATE SHEETS.

EXAMPLE



OPERATOR CONTROL PANELS

THE FOLLOWING SYMBOLS ARE USED TO DISPLAY OPERATOR CONTROL PANEL FUNCTIONS.



PUSHBUTTON SWITCH

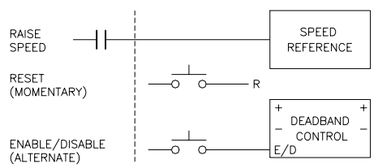
METER

INDICATOR: LED,LAMP OR BACKLIGHTED PUSHBUTTON SWITCH. COLOR SHOWN IN CIRCLE: G = GREEN, R = RED, W = WHITE, Y = YELLOW.

OPERATOR CONTROL PANELS

UNLESS OTHERWISE NOTED. ALL SWITCH CONTACTS CLOSE TO MAKE THE INPUT DESCRIPTION TRUE AND OPEN TO MAKE IT FALSE. SOME INPUTS ONLY REQUIRE A MOMENTARY CONTACT CLOSURE TO MAKE THE INPUT DESCRIPTION TRUE. THEY ARE LABELED AS MOMENTARY. SOME INPUTS REQUIRE AN ALTERNATE ACTION SWITCH CONTACT TO MAKE THE FIRST DESCRIPTION TRUE WHEN THE CONTACT IS CLOSED AND THE SECOND TRUE WHEN CONTACT IS OPENED. THEY ARE LABELED AS ALTERNATE.

EXAMPLE



FUNCTION CONNECTORS

TO REDUCE THE NUMBER OF LINES ON THE DRAWING. SOME FUNCTIONS ARE CONNECTED TOGETHER BY USING LIKE CHARACTERS, WORDS, OR TIEPOINT SYMBOLS.

R – RESET
A SINGLE INPUT, RESET IS DISTRIBUTED TO ALL OF THE LATCHING FUNCTIONS. AFTER THE INPUT SIGNAL RETURNS TO NORMAL. A RESET IS REQUIRED TO RESTORE THE OUTPUT TO A NORMAL STATE.

S – SHUTDOWN
MULTIPLE INPUTS CAN INITIATE A SHUTDOWN. THE SHUTDOWN FUNCTION BLOCK IS USUALLY LOCATED PHYSICALLY ON THE DRAWING NEAR THE FINAL DRIVER.

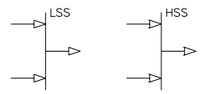
A – ALARM
MULTIPLE INPUTS CAN INITIATE AN ALARM. THE ALARM FUNCTION BLOCK IS USUALLY LOCATED ON THE DRAWING NEAR THE FINAL DRIVER.

⬡ – TIEPOINT SYMBOLS

BUSES

SIGNAL BUSES ARE SHOWN AS HEAVY LINES.

EXAMPLE



FUNCTION SYMBOLS

COMMON GOVERNOR FUNCTIONS ARE REPRESENTED BY RECTANGULAR BLOCKS. A DESCRIPTION OF THE FUNCTION IS SHOWN INSIDE THE BLOCK.

EXAMPLE

COMMONLY USED ABBREVIATED FUNCTIONS ARE:

F/D — FREQUENCY TO DIGITAL CONVERTER

I/D — CURRENT TO DIGITAL CONVERTER

V/D — VOLTAGE TO DIGITAL CONVERTER

D/I — DIGITAL TO CURRENT CONVERTER

D/V — DIGITAL TO VOLTAGE CONVERTER

LSS
LOW SIGNAL SELECTOR WHERE LOWEST INPUT SIGNAL IS PASSED TO THE OUTPUT.

HSS
HIGH SIGNAL SELECTOR WHERE HIGHEST INPUT SIGNAL IS PASSED TO THE OUTPUT.

LOGIC * — CONSOLIDATED LOGIC FUNCTIONS WHICH ARE EXPANDED ON THE LAST SHEET WHEN A * IS PRESENT.

ONE SHOT — FOR INPUT LOGIC LEVEL HIGH. THE OUTPUT LOGIC LEVEL IS HIGH FOR A SHORT TIME. THEN IT SWITCHES TO LOGIC LEVEL LOW.

COMMONLY USED ABBREVIATED FUNCTIONS ARE: (CONT)

AND — AND LOGIC GATE

OR — OR LOGIC GATE

NAND — NAND LOGIC GATE

NOR — NOR LOGIC GATE

XOR — EXCLUSIVE OR LOGIC GATE

NOT — INVERTER

SUMMING POINT. INPUT SIGNAL POLARITY SIGNS SHOW RELATIVE EFFECT ON OUTPUT SIGANAL.

E, D — LATCH — SPECIAL LOGIC FUNCTION. MOMENTARY HIGH LOGIC LEVEL AT ENABLE (E) INPUT SIGNAL CAUSES OUTPUT TO BE A MAINTAINED HIGH LOGIC LEVEL. MOMENTARY HIGH LOGIC LEVEL AT DISABLE (D) INPUT SIGNAL CAUSES OUTPUT TO BE A MAINTAINED LOW LOGIC LEVEL.

C — ANALOG SWITCH. FOR THE CONTROL LOGIC LEVEL INPUT SIGNAL (C) HIGH. THE ANALOG SIGNAL PATH IS COMPLETED OR CHANGED. ALL SWITCHES SHOWN IN STATE WHERE CONTROL INPUT SIGNAL (C) LOGIC LEVEL IS LOW.

OR

C

P, PI, PID — CONTROL — CONTROLLERS WHICH HAVE PROPORTIONAL, INTEGRAL AND DERIVATIVE DYNAMICS ARE REPRESENTED BY TRIANGLES WITH LETTERS P, I, OR D SHOWING WHICH TERMS ARE PRESENT.

+, – DEADBAND CONTROL E/D — SIMPLE DEADBAND CONTROLLERS OUTPUT DIGITAL LOGIC LEVELS BY COMPARING TWO INPUT ANALOG SIGNALS. THE (+) LOGIC OUTPUT IS HIGH WHILE THE SUM OF THE ANALOG INPUT SIGNALS EXCEEDS THE DEADBAND IN THE POSITIVE DIRECTION AND THE (–) LOGIC OUTPUT IS HIGH WHILE THE SUM EXCEEDS THE DEADBAND IN THE NEGATIVE DIRECTION. OUTPUT LOGIC IS BLOCKED WHEN E/D (ENABLE/DISABLE) INPUT IS LOW.

+, –, E, D — PWM DEADBAND CONTROL — +, –, R — PWM (PULSE WIDTH MODULATION) DEADBAND CONTROLLERS ARE SIMPLE DEADBAND CONTROLS EXPANDED TO INCLUDE SEPARATE ENABLE (E) AND DISABLE (D) INPUTS AND A THIRD DIGITAL OUTPUT (R) FOR RAMP RATE SELECTION. WHEN THE DEADBAND IS EXCEEDED THE (R) LOGIC OUTPUT REMAINS HIGH. LOGIC OUTPUTS (+) AND (–) ARE CONTROLLED BY THE POLARITY OF THE SUMMED (ERROR) ANALOG SIGNALS AS IT EXCEEDS THE DEADBAND LIMITS LIKE IN THE SIMPLE CONTROLLER EXCEPT THAT THE OUTPUTS ARE A SERIES OF PULSES. THE LENGTH OF TIME THE PULSE IS HIGH INCREASES PROPORTIONALLY AS THE ERROR SIGNAL INCREASES.

UNLESS OTHERWISE SPECIFIED:
ALL DIMENSIONS ARE IN MILLIMETERS INCHES.
DRAWING DEFINITIONS AND TOLERANCES SHALL BE FOUND IN SS-112

MATERIALS:

9907-717

NEXT LEVEL | FINAL LEVEL

APPLICATION

THIRD ANGLE PROJECTION

C/C		
APPROV		
CHECKED		
DRAWN	TS	98/10
CAD OPR.	TS	98/10

APPROVAL

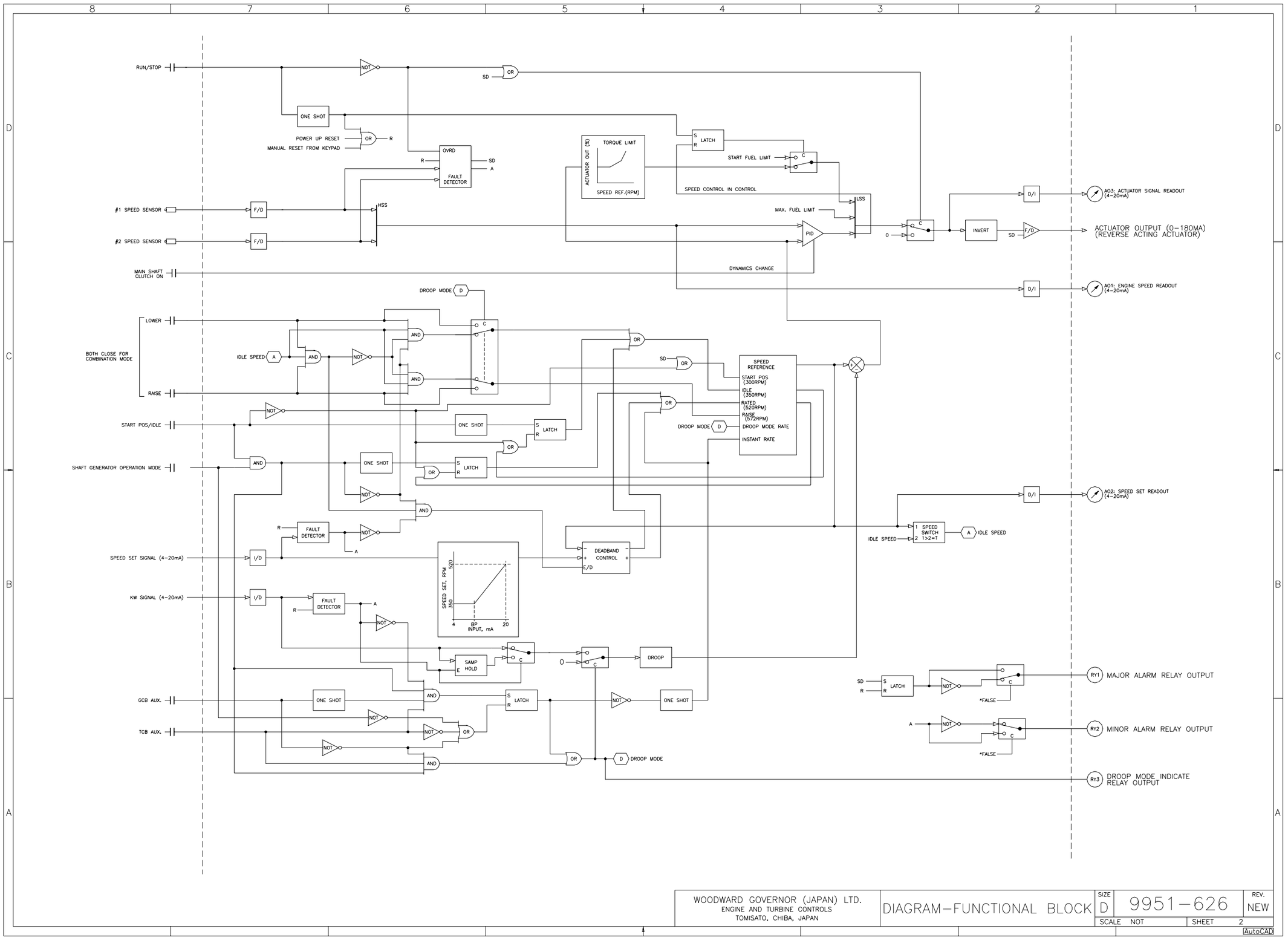
WOODWARD GOVERNOR (JAPAN) LTD.
ENGINE AND TURBINE CONTROLS
TOMISATO, CHIBA, JAPAN

DIAGRAM–FUNCTIONAL BLOCK
721 DIGITAL ENGINE CONTROL

SIZE D | CODE IDENT NO. 31361 | 9951–626

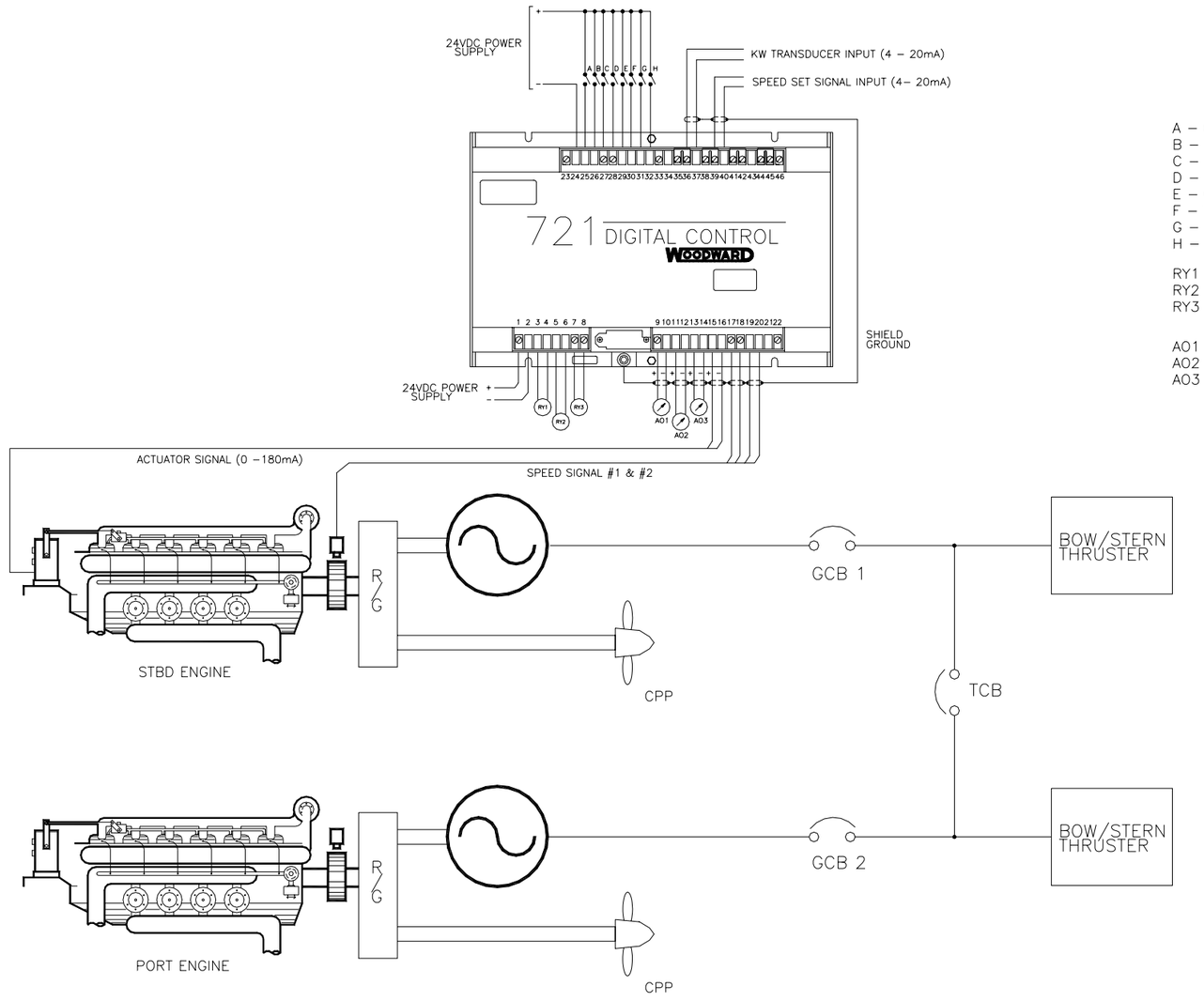
SCALE NOT | WEIGHT | SHEET 1 OF 3

AutoCAD



WOODWARD GOVERNOR (JAPAN) LTD. ENGINE AND TURBINE CONTROLS TOMISATO, CHIBA, JAPAN	DIAGRAM-FUNCTIONAL BLOCK	SIZE D	9951-626 REV. NEW
		SCALE NOT	SHEET 2

AutoCAD



A – CLOSE TO RUN, OPEN TO SHUTDOWN
B – CLOSE FOR IDLE SPEED, OPEN FOR START SPEED
C – RAISE SPEED (MOMENTARY)]
D – LOWER SPEED (MOMENTARY)] BOTH CLOSE FOR COMBINATION MODE
E – GCB1 AUX. CONTACT
F – TCB AUX. CONTACT
G – SHAFT GEN. OPERATION MODE
H – CLOSE FOR MAIN SHAFT CLUTCH ON

RY1 – MAJOR ALARM RELAY
RY2 – MINOR ALARM RELAY
RY3 – LOAD TRANSFER MODE INDICATOR

AO1 – ENGINE SPEED READOUT (4 – 20Ma)
AO2 – SPEED REFERENCE READOUT (4 – 20Ma)
AO3 – ACTUATOR SIGNAL READOUT (4 – 20Ma)

WOODWARD GOVERNOR (JAPAN) LTD. ENGINE AND TURBINE CONTROLS TOMISATO, CHIBA, JAPAN	DIAGRAM–FUNCTIONAL BLOCK	SIZE D	9951–626	REV. NEW
		SCALE NOT	SHEET 3	

AutoCAD

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED
NEW	EC 1012666	98/12	

NOTES:

1. SHIELDED WIRES TO BE TWISTED PAIR OR THREE CONDUCTORS AS NEEDED. WITH SHIELD GROUND AT ONE END ONLY. SHIELDS MUST BE GROUNDED AT ANY EXTERNAL POINT UNLESS OTHERWISE NOTED. ALL SHIELDS MUSE BE CARRIED CONTINOUSLY THROUGH ALL TERMINAL BLOCKS AND MUST NOT BE TIED TO OTHER SHIELDS EXCEPT AT THE COMMON GROUND POINT. THE SHIELDS ARE TIED TOGETHER AT GROUND STUD.
2. REMOVE JUMPER FOR 1−5V DC VOLTAGE INPUT.
3. ANALOG INPUT SIGNALS FROM OTHER SYSTEMS MUST BE ISOLATED FROM GROUND EITHER BY DESIGN OR EMPLOYMENT OF ISOLATION AMPLIFIERS.
4. ANALOG OUTPUTS TO OTHER SYSTEMS MUST BE ISOLATED FROM GROUND EITHER BY DESIGN OR EMPLOYMENT OF ISOLATION AMPLIFIERS.
5. AXILIALY POWER OUTPUT TO BE GIVEN AT DISCRETE INPUT AND PROXIMITY SWITCH POWER.
6. DISCRETE INPUTS ARE ISOLATED FROM OTHER CIRCUITS AND INTENDED TO BE POWERED BY THE SAME SOURCE AS CONTROL SUPPLY VOLTAGE. INPUTS IS NORMALLY 10mA PER INPUT INTO 2100OHMS.
7. POWER SOURCE FOR PROXMITY SWITCH TO BE SUPPLY FROM THE SAME SOURCE AS CONTROL SUPPLY VOLTAGE. AUXILIALY POWER OUTPUT OF CONTROL OR EXTERNAL ISOLATED POWER SOURCE. WHEN USEING THE WOODWARD P/N PROXMITY SWITCH. SUPPLY VOLTAGE MUSE BE 10V−30V DC.
8. RELAY CONTACT RATINGS: RESISTIVE − 2.0A AT 28V DC
   0.1A AT 115V AC 50 TO 400Hz
   INDUCTIVE − 0.75A AT 28V DC 200mH
   0.1A AT 28V DC LAMP
9. RECOMENDED PROXIMITY SWITCH IS WOODWARD P/N 1680−635 OR P/N 1680−655.
10. FACTORY SET FOR PROXIMITY SWITCH INPUT. SEE DETAIL FOR MPU INPUT.
11. WHEN MOUNTING CONTROL TO BULKHEAD, USE THE GROUNDING STUT AND HARDWARE SUPPLY WITH THE CHASSIS TO ENSURE PROPER GROUNDING.
12. THE TERMINALS MARKED "NO CONNECTION" MUST REMAIN OPEN.
13. INTERNAL POWER SUPPLY PROVIDES DC ISOLATION BETWEEN POWER SOURCE AND ALL OTHER INPUTS AND OUTPUTS.
14. SEE OPTION CHART SHEET3

REV STATUS OF SHEETS					
SHT	REV	SHT	REV	SHT	REV
1	NEW	6		11	
2	NEW	7		12	
3	NEW	8		13	
4		9		14	
5		10		15	

UNLESS OTHERWISE SPECIFIED:
ALL DIMENSIONS ARE IN MILLIMETERS INCHES.
DRAWING DEFINITIONS AND TOLERANCES SHALL BE FOUND IN SS−112

THIRD ANGLE PROJECTION

	721DEC
	9907−717
NEXT LEVEL	FINAL LEVEL
APPLICATION	

MATERIALS:

C/C		
APPROV		
CHECKED		
DRAWN	TS	98/10
CAD OPR.	TS	98/10
APPROVAL		

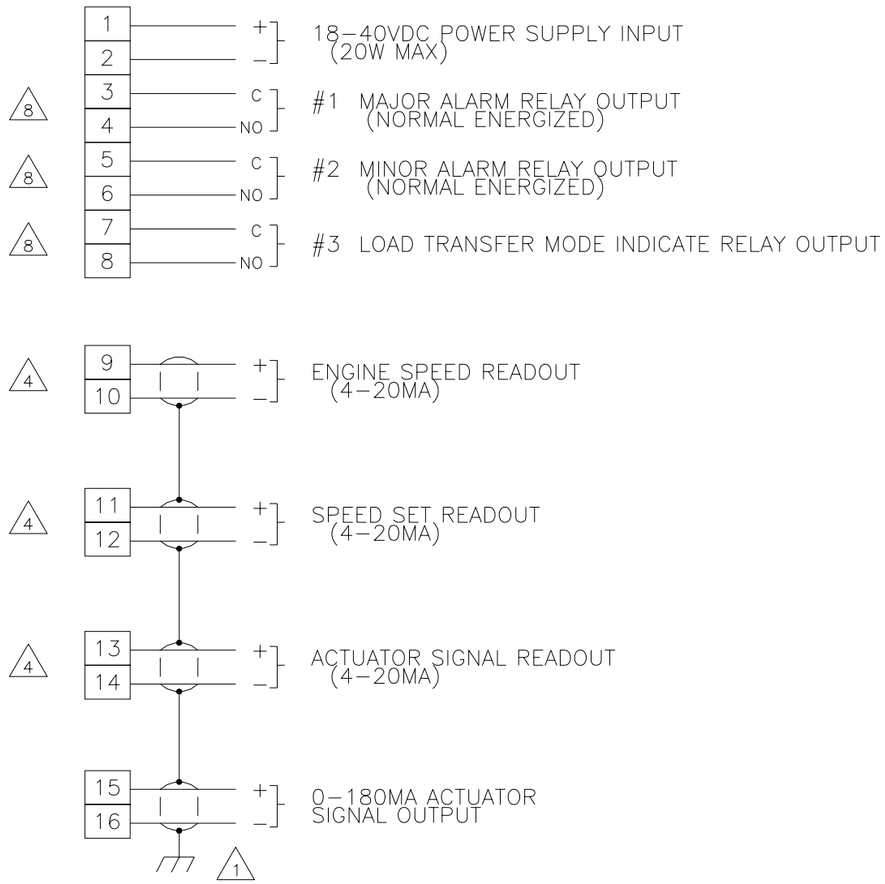
WOODWARD GOVERNOR (JAPAN) LTD.
ENGINE AND TURBINE CONTROLS
TOMISATO, CHIBA, JAPAN

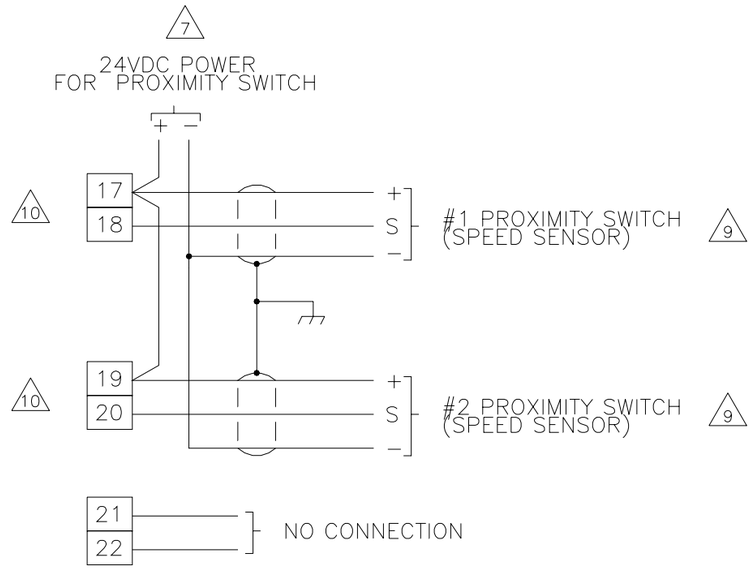
DIAGRAM−PLANT WIRING
721 DIGITAL ENGINE CONTROL

SIZE	CODE IDENT NO.	
C	31361	9952−195

SCALE NOT	WEIGHT	SHEET 1 OF 3

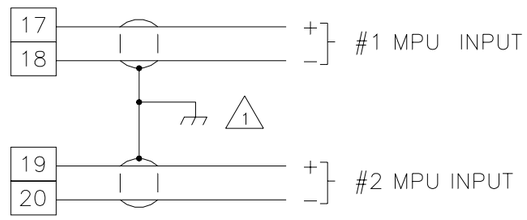
AutoCAD





(WIRING FOR PROXIMITY SW)

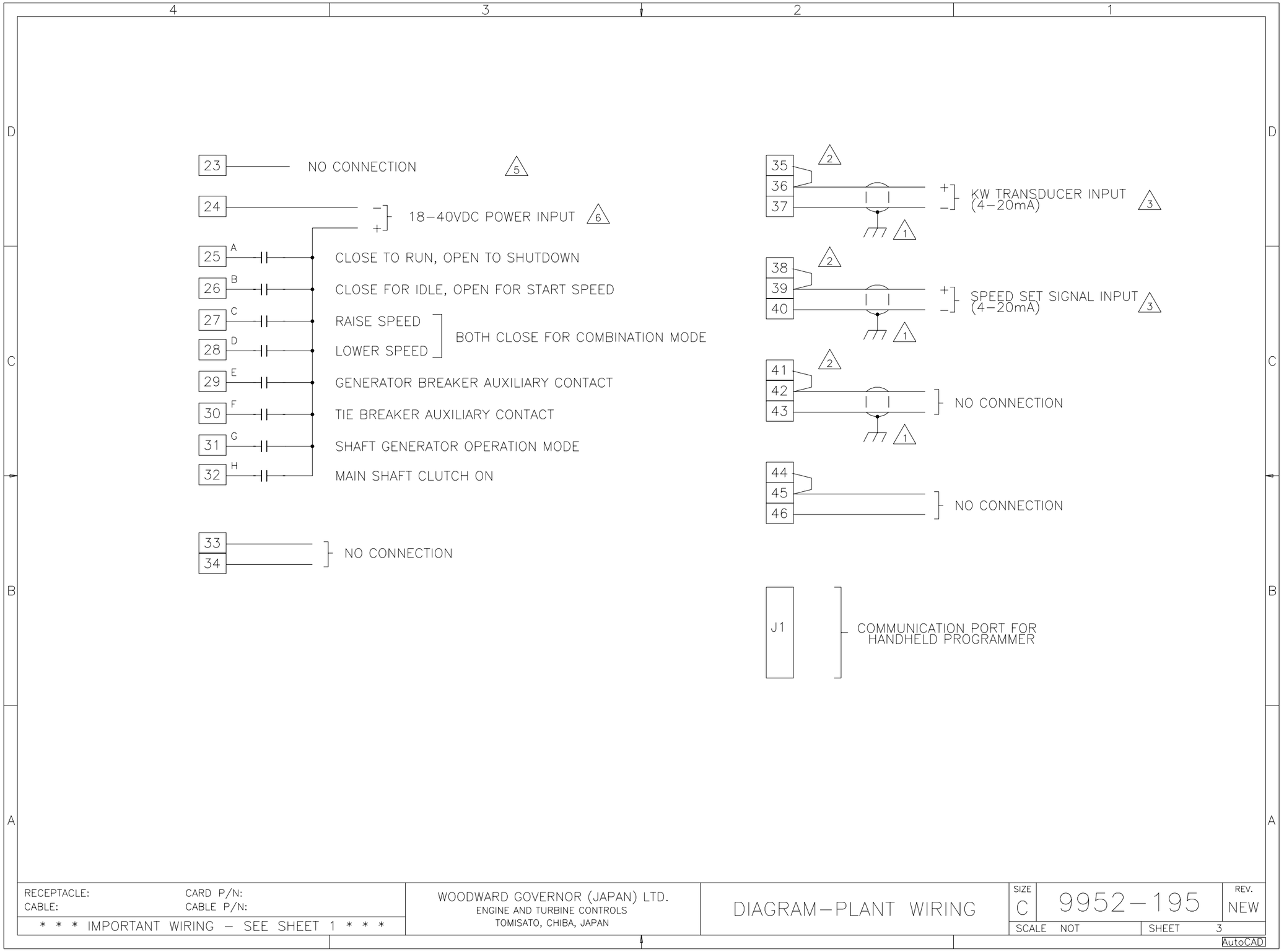
REMOVE JPR11,13,16 AND JPR18.
INSTALL JPR10, JPR12, JPR15, AND JPR17.



(DETAIL 1: WIRING FOR MPU)

REMOVE JPR10,12,15 AND JPR17.
INSTALL JPR11, JPR13, JPR16, AND JPR18.

RECEPTACLE: CARD P/N: CABLE: CABLE P/N: * * * IMPORTANT WIRING – SEE SHEET 1 * * *	WOODWARD GOVERNOR (JAPAN) LTD. ENGINE AND TURBINE CONTROLS TOMISATO, CHIBA, JAPAN	DIAGRAM–PLANT WIRING	SIZE C	9952–195 / REV. NEW SCALE NOT / SHEET 2 AutoCAD


4
3
2
1
D
C
B
A
23
NO CONNECTION
5
24
18–40VDC POWER INPUT
6
25 A
CLOSE TO RUN, OPEN TO SHUTDOWN
26 B
CLOSE FOR IDLE, OPEN FOR START SPEED
27 C
RAISE SPEED
28 D
LOWER SPEED
BOTH CLOSE FOR COMBINATION MODE
29 E
GENERATOR BREAKER AUXILIARY CONTACT
30 F
TIE BREAKER AUXILIARY CONTACT
31 G
SHAFT GENERATOR OPERATION MODE
32 H
MAIN SHAFT CLUTCH ON
33
34
NO CONNECTION
35
36
37
KW TRANSDUCER INPUT
(4–20mA)
38
39
40
SPEED SET SIGNAL INPUT
(4–20mA)
41
42
43
NO CONNECTION
44
45
46
NO CONNECTION
J1
COMMUNICATION PORT FOR
HANDHELD PROGRAMMER
RECEPTACLE:
CABLE:
CARD P/N:
CABLE P/N:
* * * IMPORTANT WIRING – SEE SHEET 1 * * *
WOODWARD GOVERNOR (JAPAN) LTD.
ENGINE AND TURBINE CONTROLS
TOMISATO, CHIBA, JAPAN
DIAGRAM–PLANT WIRING
SIZE
C
9952–195
REV.
NEW
SCALE NOT
SHEET 3
AutoCAD

721 Control Specifications

Woodward Part Numbers:	8237-735
Power Supply Rating	18–32 Vdc (24 Vdc or 32Vdc nominal)
Power Consumption	18 watts nominal
Steady State Speed Band	magnetic pickup: 400–15 000 Hz (8–2100 rpm) proximity switch: 7.5–1000 Hz (8–2100 rpm)
Discrete Inputs (8)	10 mA at 24 Vdc
KW Transducer Input	4–20 mA or 1–5 Vdc
Remote Speed Setting Input	4–20 mA or 1–5 Vdc
Actuator Output	0–180 mA
Tachometer Output	4–20 mA
Speed Reference Output	4–20 mA
Rack position Output	4–20 mA
Relay Outputs	Load Transferring, Major Alarm, Minor Alarm
Programmer Serial Port	RS-422, 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)
Humidity	95% at 38 °C
EMI/RFI Susceptibility	US MIL-STD 461C (Parts 5 & 9)
Humidity	US MIL-STD 810D, Method 507.2, Procedure III
Mechanical Vibration	24–2000 Hz swept sine, 2.5 Gs constant acceleration, resonant dwells , 1 million cycles, total time , 6 hours/axis
Mechanical Shock	US MIL-STD 810C, Method 516.2, Procedure I (basic design test), Procedure II (transit drop test, packaged), Procedure V (bench handling)
Salt Spray	ASTM B 117-73

We appreciate your comments about the content of our publications.
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Please include the manual number from the front cover of this publication.

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

06/10/J