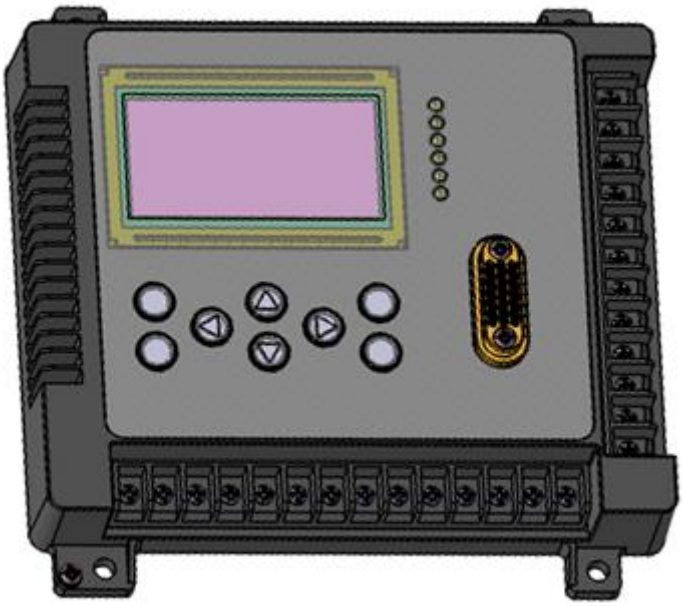
Diesel Engine for Generators

Digital Speed Controller

User Manual

(DSC-1000)

Ver_1.0



Doosan Infracore

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1. Product Overview and General Specification

1.1 Product Information

Digital Speed Controller (DSC-1000) is applicable to generator (vehicles and vessels) engines as a high performance embedded electronic control system designed based on PID control for fast and precise control of engine speed with an enhanced micro controller unit (MCU) that minimizes analog circuits vulnerable to user environments.

This product features PID auto setting functions along with battery voltage, pick-up sensors and actuator condition checking. It also has a black box function that manages engine operation records when faults are detected for users to have more convenience in operating this precise digital speed controller.

[Product Features]

- Rigid and stable case structure and easily recognizable front design
- Readily understandable GUI (graphic user interface) with graphic LCD displays
- Easy and simple setup with 8 button keys without manual controls by users
- Fast setting available by migrating initial settings depending on types of the engines
- Listing fault messages (over speed, pick-up error, etc.) and recording messages
- RS232 and CAN ports available for communication
- Digital inputs and PID auto setup functions for PID control parameters
- Application of digital clock for fault timing and engine operating hours

1.2 Product Appearance

Digital Speed Controller is made of a rigid aluminum case taking into account anti-shock, electromagnetic resistance and environmental protection. An embedded system containing graphic LCD and high performance MCU is inside the controller and a heat sink is located on the outside of the case for protection and precise control of actuator operating elements.

A terminal block is located on the bottom and right of the front side for easy connection to external devices. Over speed, run and crank signals are displayed on the front LED and contact points (a or b) are also available for outputs on external controllers or indicators.

RS232 and CAN communication is available and DSUB-9 connector enables universal use of RS232 communication.

Users can easily input and adjust values for parameter inputs using 8 button keys. In addition, graphic LCD shows graphic displays, bar graphs and design symbols so that users can readily identify the control information while external LED displays important conditions of the engine.

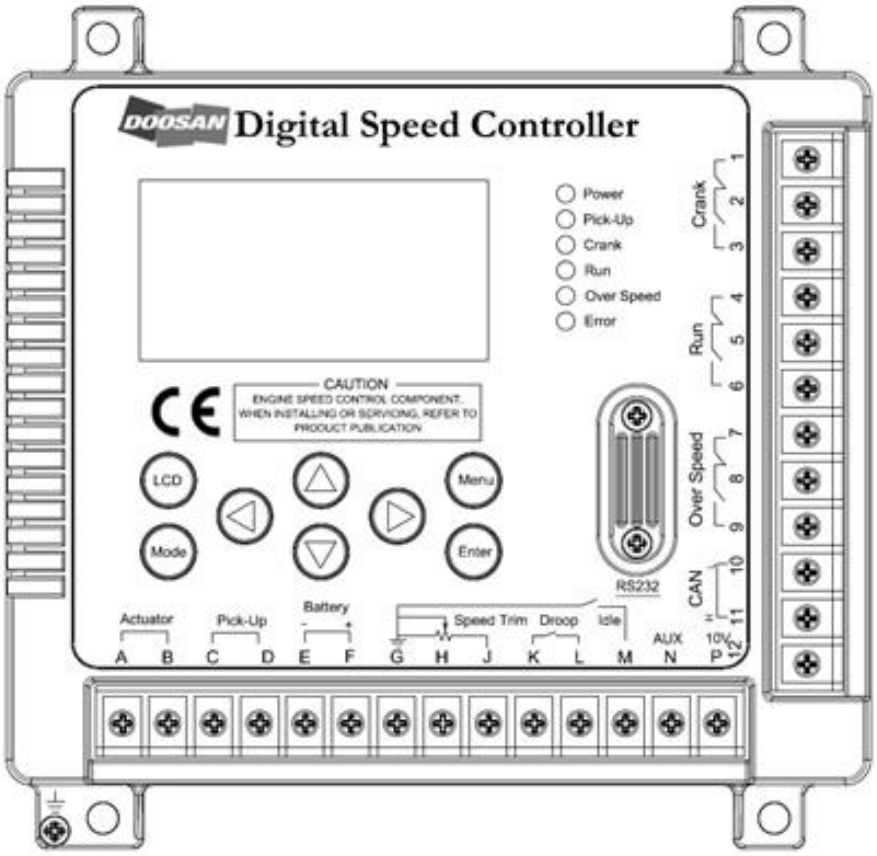


Figure 1: Product Front View

Product Specification

No.	Item	Description
1	MCU	16-bit DSC dsPIC33FJ256
2	Display	Graphic LCD 128*64
		LED: 6 EA
3	Keypad	8 Button Keys
4	Output	3 Contact Points (a and b)
5	Input	RMS 3V (Min)
6	Memory	128Mb
7	Communication	RS232 57600bps
		CAN (J1939) / 250kbps
8	Rated Power	DC 24V (12V to 30V)
9	Current Consumption	120mA
10	Operating Temperature	-20 to +70℃
11	Storing Temperature	-30 to +80℃
12	Operating Humidity	0 to 95%

1.3 Product System Diagram

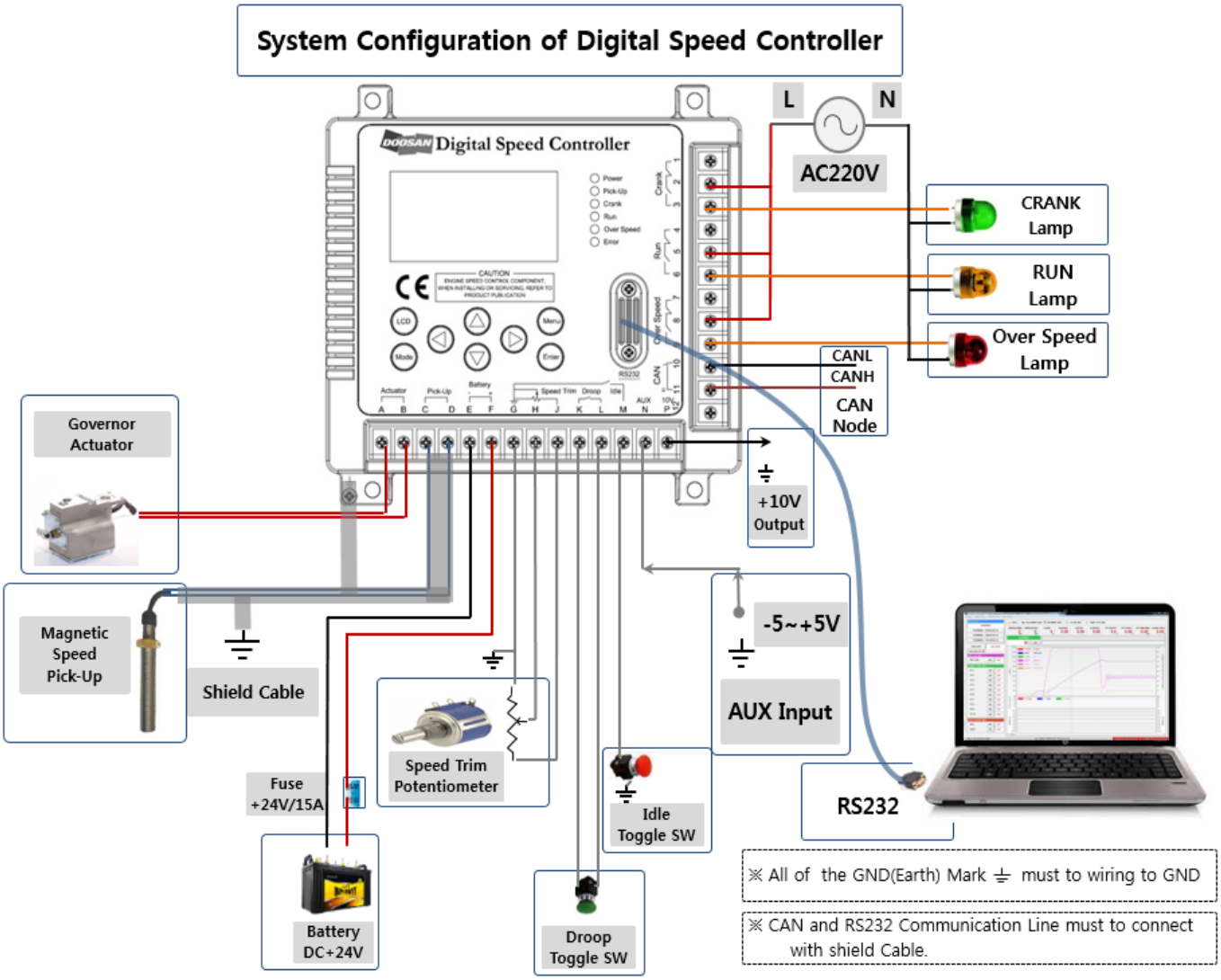


Figure 2: System Diagram for Digital Speed Controller

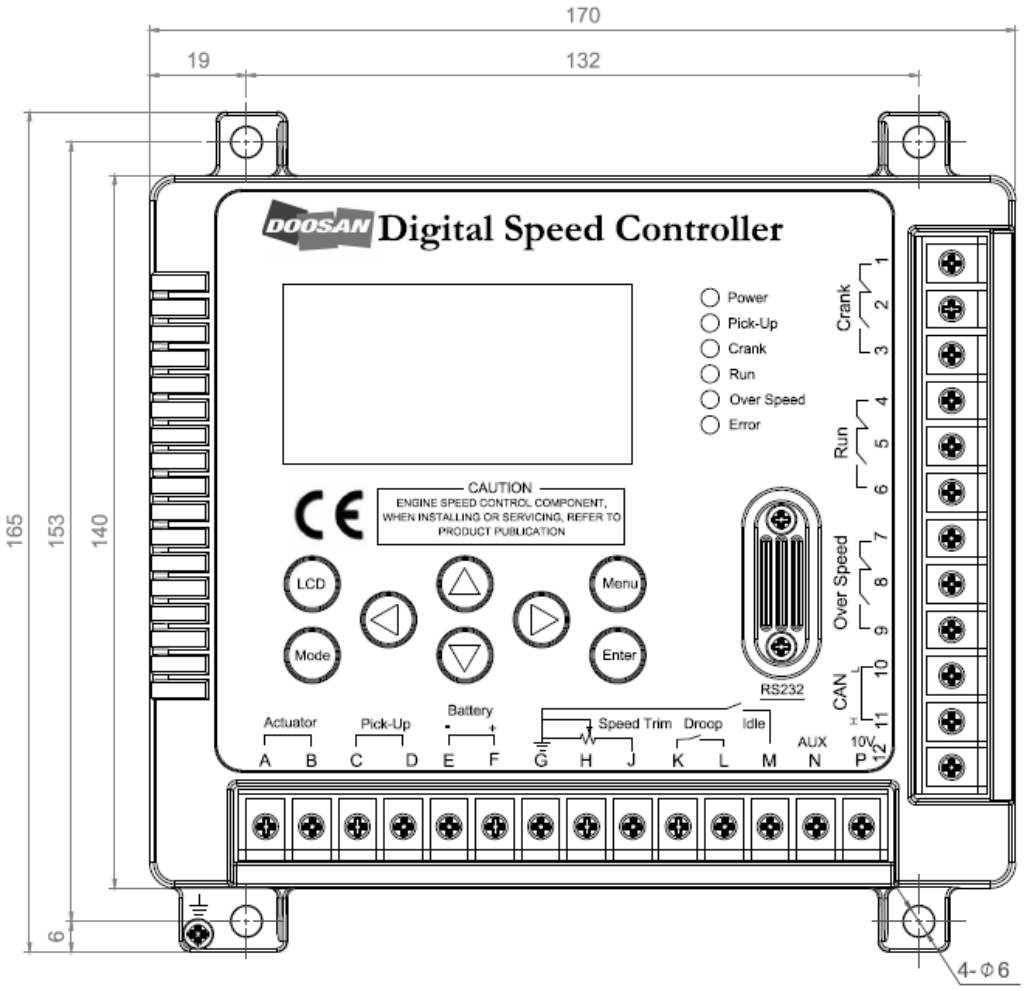
1.4 Product I/O Signals

No	Terminal	I/O type	Terminal Functions
1	Actuator (A, B)	Output	Outputs are actuator control signals. Wiring should be 18AWG (105℃) or better. (However, terminals A and B can be used regardless of their polarities)
2	Pick-Up (C, D)	Input	Inputs are RPM sensor signals. Terminal D should be connected to the ground in connection with the shield cable. Gap between the RPM sensor and the gear tooth should be adjusted between 0.9 and 1.1mm (sensor inputs should be at least 3V AC RMS).

3	Battery Voltage (-E, +F)	Input	It is a power input terminal for the controller and inputs are DC +24V/15A. The positive pole of the battery should be connected to the terminal F. (Back voltage protection circuit is built in.)
4	Speed Trim (G, H, J)	Input (G)	It has a ground signal and is connected to the ground of the potentiometer.
5		Input (H)	Inputs are RPM trim signal values and the voltage level is between 0 and 5V. It is connected to the output of the potentiometer.
6		Input (J)	Outputs are DC +5V and it is connected to VCC of the potentiometer.
7	Droop (K, L)	Input	Terminal K receives droop function selecting information. Terminal L has a ground signal and the switch is connected to terminals K and L. Once the terminal K is connected to the ground, droop starts to operate.
8	Idle (M)	Input	Terminal M receives idle function selection signals. Once it is connected to the ground, idle operation starts.
9	AUX (N)	Input	Terminal N receive load sharing and synchronization signal for parallel operation. The signal level is an input between DC -5 and +5V.
10	10V (P)	Output	Outputs are +10V/20mA ratings and it can be used for various purposes including power to external auxiliary devices.
11	Crank Contact Point (1, 2, 3)	Output	The second crank contact point is a shared terminal while terminals 1 and 2 are for the contract point b and terminals 2 and 3 for the contact point a. The contact point a starts to operate when the digital speed controller reaches at the RPM delivering control signals to the actuator after the engine is activated.
12	Run Contact Point (4, 5, 6)	Output	The fifth run contact point is a shared terminal while terminals 4 and 5 are for the contact point b and terminals 5 and 6 for the contact point a. The contact point a starts to operate when the engine reaches its designated normal speed RPM.
13	Over Speed Contact Point (7, 8, 9)	Output	The eighth over speed contact point is a shared terminal while terminals 7 and 8 are for the contact point b and terminals 8 and 9 for the contact point a. The contact point a starts to operate when the engine reaches its designated over speed RPM.
14	CAN (10, 11)	I/O	Terminal 10 is for CAN-L communication and 11 is for CAN-H communication. CAN-H and CAN-L are used for CAN communication.
15	Power LED	Output	When DC+24V power is supplied to the controller, the LED turns on in red on the power level.
16	Pick-Up LED	Output	When the controller receives normal input signals from the pick-up sensor, the LED turns on in red on the pick-up level.

17	Crank LED	Output	The 2- and 3-terminal contact point a starts to operate and the LED turns on in red on the crank level when the digital speed controller reaches at the RPM delivering control signals to the actuator after the engine is activated.
18	Run LED	Output	The LED turns on in red on the run level when the engine reaches its designated normal speed RPM with 5- and 6-terminal contact point a starting to operate.
19	Over Speed LED	Output	The LED turns on in red on the over speed level when the engine reaches its designated over speed RPM with 8- and 9-terminal contact point a starting to operate..
20	Error LED	Output	The LED turns on in red on the error level when abnormal events of the controller occur.
21	RS232	I/O	D-SUB 9PIN (male) is connected to the host through RS232 communication port.
22	Ground	Ground	The GND part and the ground should be earthed in shared connection.

1.5 Product Dimension



2. Installation

Digital Speed Controller should be connected to the pick-up sensor attached on the engine and the actuator. Speed trim, droop, idle and aux terminals can be used for additional functions in connection with surrounding circuits. Contact points a or b can also be used to operate external devices using crank, run and over speed functions. RS232 and CAN port allow communication with PCs or external host computers for data transfer and monitoring functions.

2.1 Connecting to the Engine

2.1.1 Battery, Pick-Up and Actuator Connection Diagram

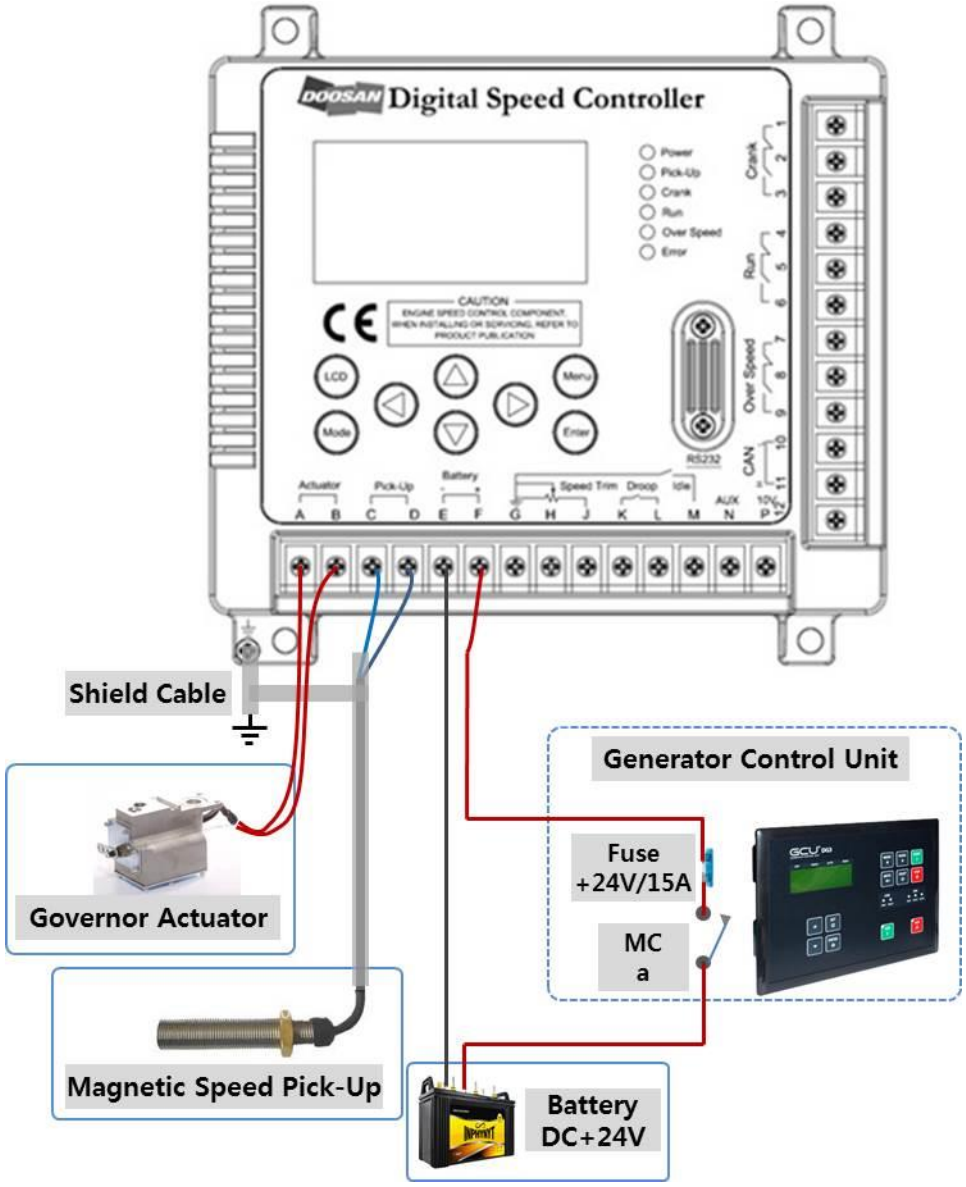


Figure 3: Battery, Pick-Up and Actuator Connection Diagram

2.1.2 Connecting to Batteries

Battery voltage is DC +24V and the battery is connected to the controller matching **E (-)** and **F (+)** with the respective polarities of the battery. **E (-)** is connected to **(-)** of the battery and **F (+)** to **(+)** of the battery. Depending on cases, wiring can be done in a serial connection to the contact point a of MC and the fuse (DC +24V/15A) when connecting to system panels or generator control devices.

2.1.3 Connecting to Actuators

The actuator is also called governor and controls the amount of the fuel spray to the engine cylinder. The controller is connected to the actuator attached on the engine by connecting two wires of the controller terminal to A and B of the actuator regardless of their polarities. Wiring should be 18AWG (105℃) or better and the outside should be wrapped by plastic tubes for insulation or insulated mesh lines.

2.1.4 Connecting to Pick-Up Sensors

The pick-up sensor lets users know the engine speed and is connected to terminals **C** and **D** that can receive signals of AC RMS 3V or higher. Wiring should be twisted or shielded cables connected to the ground together with the terminal **D**. Gap between the pick-up sensor and the gear tooth should be adjusted between 0.9 and 1.1mm.

2.1.5 Operating Sequence for Digital Speed Controller

● **Power On/Off:** It means that DC +24V power is either supplied or terminated through **E (-)** and **F (+)** of the battery matching with their respective polarities.

● **LCD On/Off:** It means to turn **on** or **off** the LCD display alone while DC +24V power is supplied through **E (-)** and **F (+)** of the battery matching with their respective polarities and the controller is in operation.

[Operating Sequence for the Controller]

Step1) When DC +24V power is supplied to the controller, the controller starts to operate. It indicates that power LED turns on and the power is being normally supplied.

Step2) Inputs for speed trim, droop and idle functions are received.

Step3) The controller checks the signals of the speed pick-up sensor.

Step4) Actuator control signals are output together with designated values of other information for crank, run and over speed functions according to the PID control values.

Step5) The controller checks the operation condition and displays LED outputs and fault messages according to the detected information.

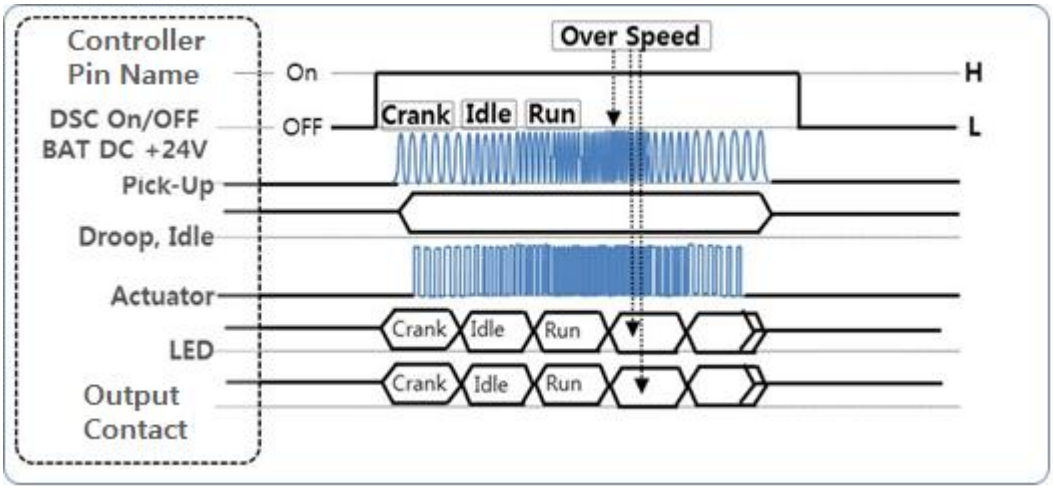


Figure 4: Time Chart for Operation of the Controller

2.2 Connecting to Speed Trim, Droop, Idle and Other Inputs

2.2.1 Speed Trim, Droop, Idle and Other Inputs Diagram

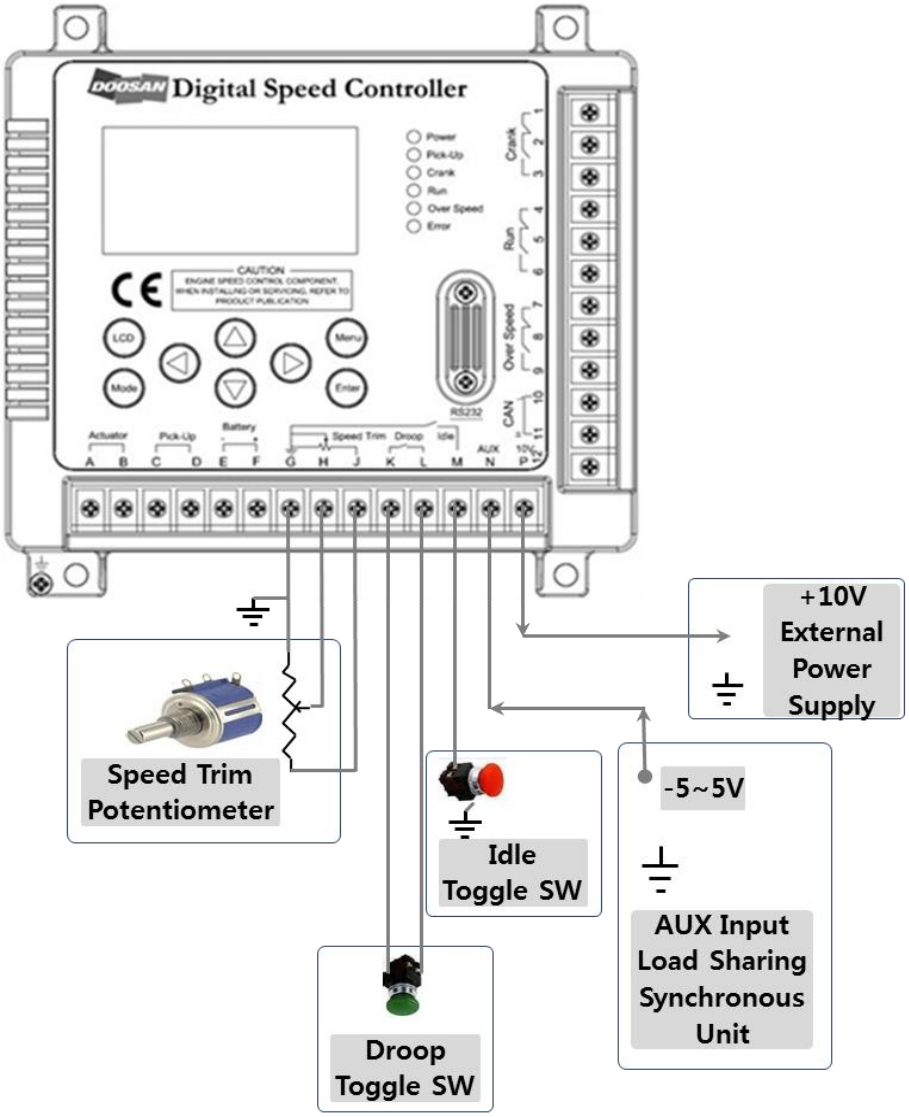


Figure 5: Speed Trim, Droop, Idle and Other Inputs Diagram

2.2.2 Connecting to Speed Trim

Speed trim is an analog voltage signal port for input to fine-tune the engine speed. A potentiometer is used for precise adjustment of the resistance values. The potentiometer needs to be connected to terminals **G**, **H** and **J**. Terminal **G** should be connected to the ground and it is recommended to use shielded cables. Terminal **H** is connected to **G** depending on the current consumption of the actuator (for actuators with 5A or higher). **J** is an input terminal for fine-tuned voltage values between 0 to 5V.

2.2.3 Connecting to Droop

The switch is connected to terminals **K** and **L**. Signals indicating whether **droop** function works or not serve as inputs to the controller by keeping K and L either **open** or **close**. Inputs can be done by toggle or converting switches.

2.2.4 Connecting to Idle

The port on one side of the switch is connected to terminal **M** and the port on the other side to the **ground**. Connection between terminal **M** and the **ground** becomes either **open** or **close** by keeping the switch **open** or **close**. When connection between the terminal and the **ground** becomes **close**, the controller will have **idle** function. Inputs can be done by toggle or converting switches.

2.2.5 Connecting to AUX

AUX is a terminal for control signal inputs from load sharing devices or synchronization devices through terminal **N**. It shares load from the generator in parallel operation and receives signal inputs from synchronization devices for the controller to control changes to load. Input signal level is between **DC -5** and **5V** and it is recommended to use shielded cables for signal wires.

2.2.6 Connecting Power to External Devices

It can supply power output of **10V/20mA** to external devices through terminal **P**. Users can easily use this terminal when external auxiliary devices need power supply.

However, power supply of **20mA** or higher should not be used and care should be given to prevent short circuits.

2.3 Connecting to Crank, Run, Over Speed and Communication

2.3.1 Crank, Run, Over Speed and Communication Connection Diagram

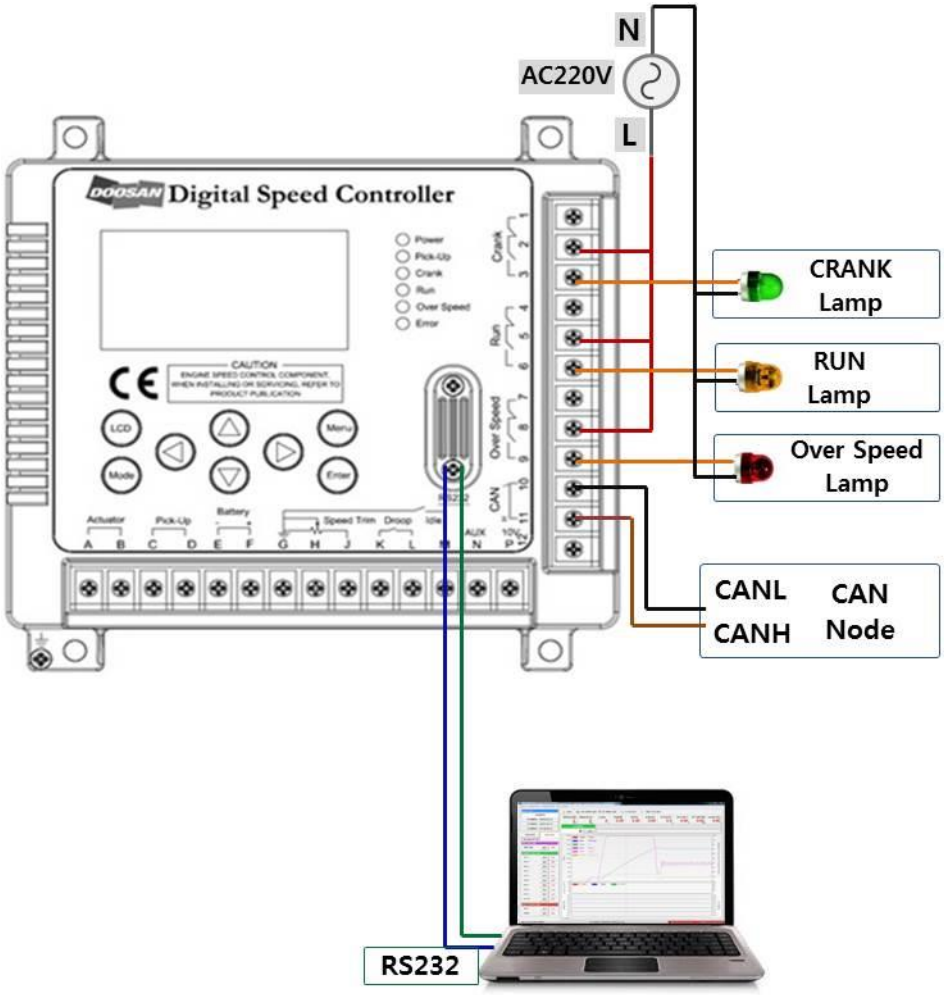


Figure 6: Crank, Run, Over Speed and Communication Connection Diagram

It is used to deliver operation information to external devices by activating contact point (a or b) when activating crank, run or over speed functions.

RS232 and CAN communication is connected to external PCs or hosts so that the controller can transmit system settings or operation information.

2.3.2 Connecting to Crank Terminals

Terminals **1**, **2** and **3** are the ones for **crank** output contact point and the contact point will be in operation when the controller activates the crank function. The second crank contact point is a shared terminal while terminals **1** and **2** are for the contact point **b** and terminals **2** and **3** for the contact point **a**.

Contact points **a** and **b** start to operate when the controller reaches at the RPM delivering control

signals to the actuator after the engine is activated. The diagram shows wiring to operate AC220V lamp. The shared terminal is for 220V inputs and the **crank** lamp turns **on** when the contact point a starts to operate.

2.3.3 Connecting to Run Terminals

Terminals **4**, **5** and **6** are the ones for **run** output contact point and the contact point will be in operation when the controller activates the **run** function. The fifth crank contact point is a shared terminal while terminals **4** and **5** are for the contact point **b** and terminals **5** and **6** for the contact point **a**.
Contact points **a** and **b** start to operate when the engine reaches its designated normal speed RPM. The diagram shows wiring to operate AC220V lamp. The shared terminal is for 220V inputs the **run** lamp turns **on** when the contact point a starts to operate.

2.3.4 Connecting to Over Speed

Terminals **7**, **8** and **9** are the ones for **over speed** output contact point and the contact point will be in operation when the controller activates the **over speed** function. The eighth **over speed** contact point is a shared terminal while terminals **7** and **8** are for the contact point **b** and terminals **8** and **9** for the contact point **a**.

Contact points **a** and **b** start to operate when the engine reaches its designated over speed RPM. The diagram shows wiring to operate AC220V lamp. The shared terminal is for 220V inputs the **over speed** lamp turns **on** when the contact point a starts to operate.

2.3.5 Connecting to CAN Communication

Terminal **10** is for **CAN-L** communication and terminal **11** for **CAN-H** communication. **CAN-H** and **CAN-L** are used for CAN communication with remote control and monitoring of the controller operation. The communication code is based on **J1939**.

2.3.6 Connecting to RS232 Communication

D-SUB 9pin (female) is for RS232 communication for connection to external PCs or hosts. It can configure system parameters of the controller or communicate with analytic applications.

3. Configuration and Operation

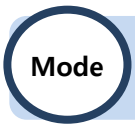
The controller can be configured and operated by input keys according to the menus on the LCD display by selecting proper ones and assigning values in the selected menu to input control information to the system. Input information should immediately apply to the controller system once updated.

3.1 Input Keys

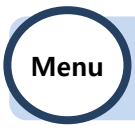
The controller has 8 input keys including LCD, Mode, Menu, Enter, Up, Down, Left and Right.

Each key as respective functions as follows:

LCD key turns on and off the display.



Mode key switches the display to either operation mode or wave form display.



Menu key lets users change the menu display and go back to the previous menu.

Enter key applies designated values on the LCD display to the system.

Up key lets users go up or increase values in the selected menu on the LCD display.

Down key lets users go down or decrease values in the selected menu on the display.

Left key lets users move to the left in the selected menu.

Right key lets users move to the right in the selected menu.

3.2 LCD Display Menu

The overall menu tree of the controller is as follows:

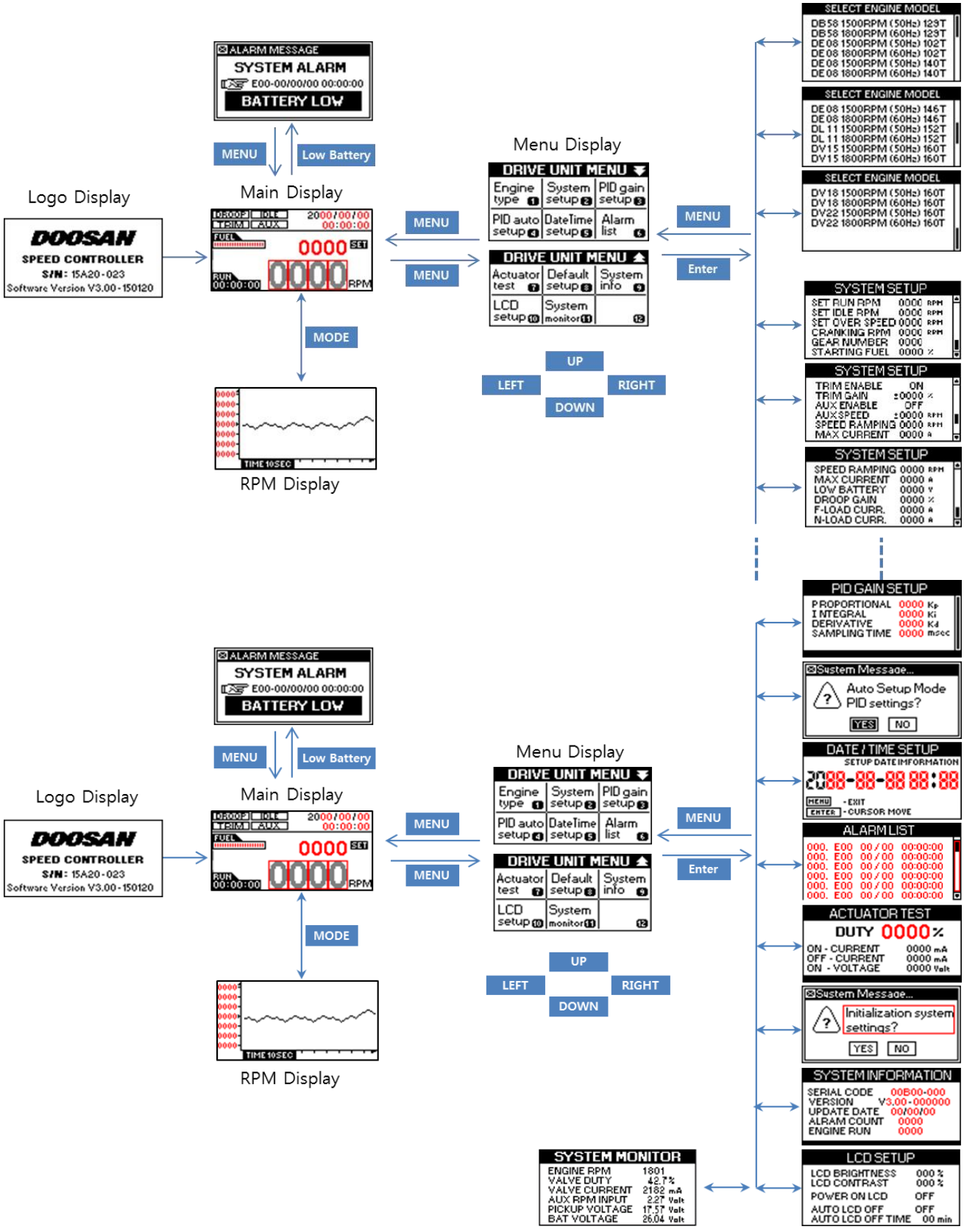


Figure 7: Overall LCD Menu Tree Diagram

3.2.1 LCD Displays After Powered On

When DC +24V power is supplied to the battery terminal (E (-), F (+)) of the controller, the **power** LED in the front side of the controller turns on in **red** and the **error** LED turns on in **red** where there are fault conditions. At this moment, the LCD display is not activated and Doosan logo will appear for 1 second followed by the operation display after pressing the **LCD** button.

The controller will start control based on information from pick-up sensor and other input devices and designated parameter values. At this moment, where breakdowns of the surrounding devices or system errors occur, the LCD display will show such errors and processing messages.

Step 1) DC +24V power supply to the terminals E (-) and F (+)

When DC +24V power is supplied to the terminals E (-) and F (+), the controller will start to operate with the LCD display off. After pressing the **LCD** button, Doosan logo will appear for 1 second as shown below followed by the controller operation display. Then, the LCD display will switch between on and off by pressing the **LCD** button.

Figure 8: Doosan Logo

Step 2) The operation display will show 1 second after the logo appears.

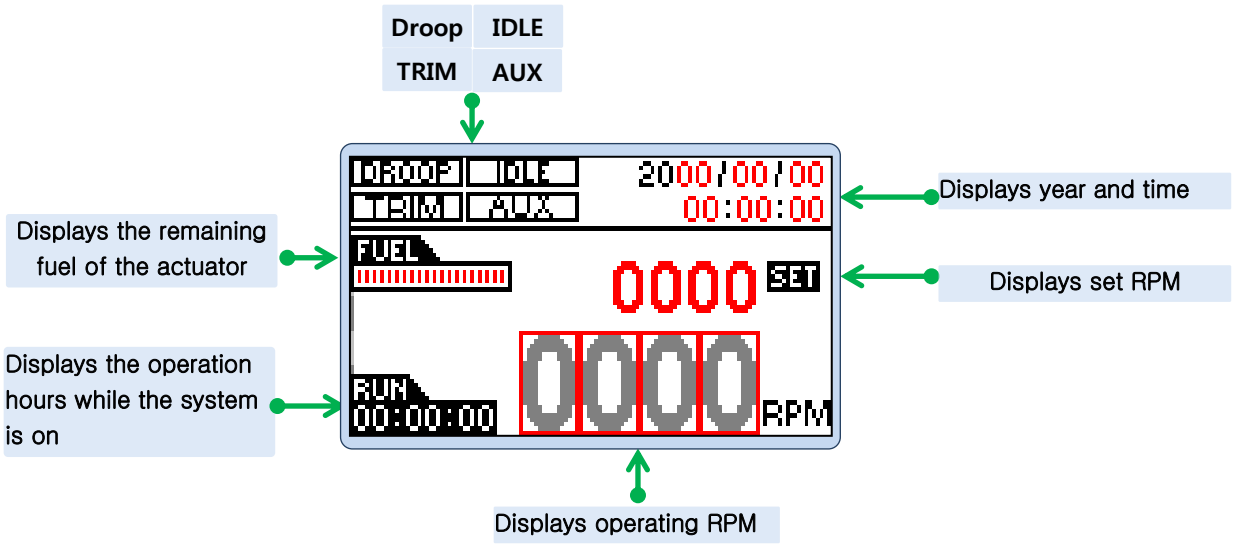
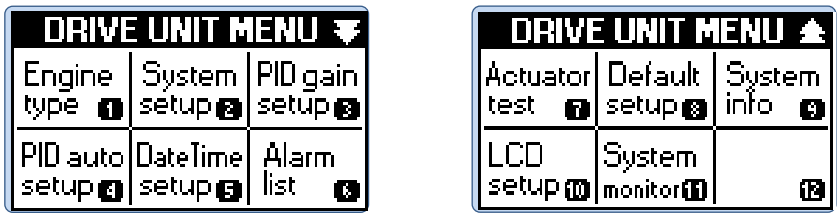


Figure 9: Operation Display

3.2.2 LCD Main Menu Display

Displays main menu screen of the controller

The main menu of the controller has 10 sub-menus.



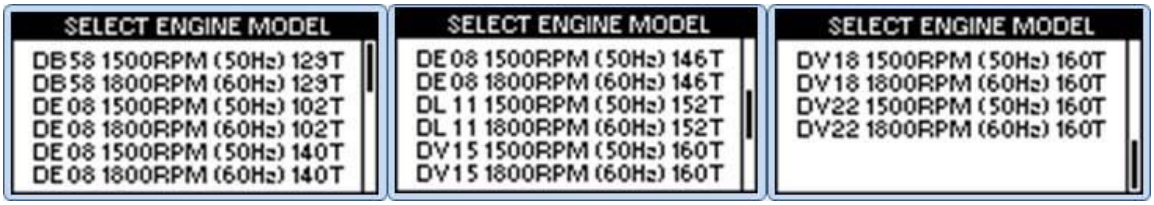
Menu 1: Main Menu of the Controller - 1 to 2

1) **Engine type**
   The controller can start operation once the initial system values are configured.
   Users can load preset values depending on types of the engines by selecting the type.
2) **System setup**
   It consists of sub-menus related to system settings including
   RUN/IDLE/OVERSPEED/CRANK/GEARNUMBER.
3) **PID gain setup**
   It consists of sub-menus to designate Kp, Ki and Kd parameter values related to the engine PID control.
4) **PID auto setup**
   It offers function for automatic designation of Kp, Ki and Kd parameter values related to the engine PID control.
5) **DateTime setup**
   It offers function for users to move to the screen for designating year, month, day and hour.
6) **Alarm list**
   It offers function for users to move to the alarm display for the alarm list.
7) **Actuator Test**
   It offers menu to test the impedance (X_L) of the actuator and any problems in operating load current. It displays current and voltage according to the duty values.
8) **Default setup**
   It offers menu to apply designated default values to the selected engine.
9) **System info**
   It offers menu that shows information of the controller. Such information includes the serial number, software version, last update date, alarm count and engine runs.
10) **LCD setup**
    It offers menu to configure LCD operating conditions including brightness, auto on/off and off hours.
11) **System monitor**

It offers menu to monitor the controller operation. It shows values for Engine RPM, Valve Duty, Valve Current, Aux RPM Input, Pickup Voltage and Bat Voltage.

3.2.3 Engine Type Setup Menu

This menu offers function to configure setting values of the controller depending on types of the engines in advance and apply such preset values to the selected engine.

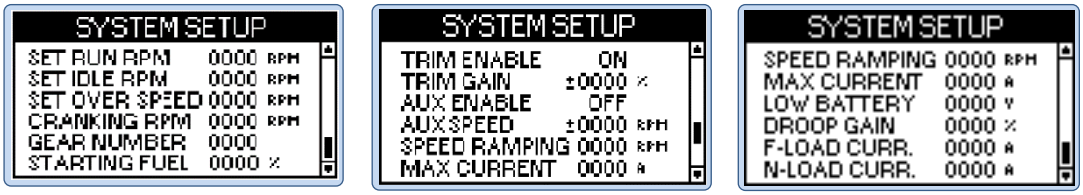


Menu 2: Engine Type Selection Menu

3.2.4 System Setup Menu

System Setup Menu Display of the Controller

It consists of sub-menus for the system configuration items of the controller including the one for configuring RUN/IDLE/OVERSPEED/CRANK/GEAR NUMBER related to RPM setting. Depending on additional functions, users can designate values for STARTING FUEL/SPEED RAMPING/ACTUATOR MAX/LOW BATTERY.



Menu 3: System Setup Menu - 1 to 3

1) **SET RUN RPM**

Users can designate normal speed (target RPM) of the engine.

Users need to input different normal speed values depending on the specification of the selected engine.

2) **SET IDLE RPM**

Users can designate the idle speed values of the engine as RPM.

Users need to input values to control the idle operating speed of the engine.

3) **SET OVER SPEED**

Users can designate RPM values to activate engine protection function when the speed exceeds the normal level (target RPM) and reaches the overspeed range that may cause problems to the engine.

When the engine RPM reaches the over speed RPM range, the engine immediately stops with error messages and alarms.

4) **CRANKING RPM**

Users can designate RPM values to activate the actuator when the engine starts to operate.

5) **GEAR NUMBER**

Users can input the number of flywheel teeth in the engine to the controller so that the controller can calculate the accurate RPM depending on the values of the pick-up sensor from the engine.

6) **STARTING FUEL**

Users can designate the amount of fuels used when the engine starts to operate and the operating current for the controller to activate the actuator changes based on these values.

7) **AUX SPEED**

Users can adjust values to ensure safe operation of the engine based on the AUX signal values when AUX is enabled.

8) **SPEED RAMPING**

Users can input ratio values of speed changes when the speed increases or decreases in the idle condition of the engine.

9) **MAX CURRENT**

Users can designate the maximum operating current for the **actuator** of the engine.

10) **LOW BATTERY**

It measures the battery voltage supplied to the controller. When the measured values are lower than the present voltage values, it will be alarmed. Usually, the acceptable battery voltage is between 20 and 22V (without load).

11) **DROOP GAIN**

Users can designate the droop values applicable to maximum load based on the current consumption of the **actuator**.

12) **F-LOAD CURR**

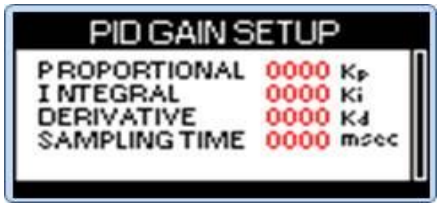
Users can designate the maximum current values when the generator is in full load.

13) **N-LOAD CURR**

Users can designate the operating current values of the actuator when the generator has no load.

3.2.5 PID Gain Setup Menu

Users can input Kp, Ki and Kd values as inputs to the PID control of the engine. Kp means proportional values while Ki means integral of the proportional values and Kd means differential of the proportional values.



Menu 4: PID Gain Setup Menu

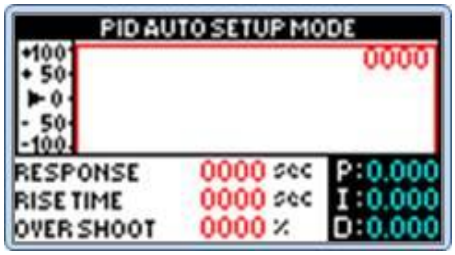
3.2.6 PID Auto Setup Menu

The menu offers function for automatic designation of the P, I and D parameter values related to the engine PID control.

After starting the engine, select **DRIVE UNIT MENU** in the main menu while the engine has no load and then **PID auto setup** menu, press Enter. Then, the system message shows "Auto Setup Mode PID setting?" with YES or NO option. If you select YES, the controller will repeatedly change the RPM to automatically calculate the optimized P, I and D values.

If the controller identifies the optimized P, I and D values within 30 cycles, it will display "PID Auto Setup Complete, OK". When you press Enter, it will apply tuned P, I and D values and close the menu.

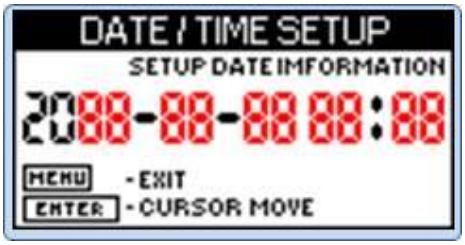
If the controller fails to identify the optimized P, I and D values within 30 cycles, it will display "PID No Successful, OK". When you press Enter, it will apply the final P, I and D values and close the menu.



Menu 5: PID auto setup menu

3.2.7 Date/Time Setup Menu

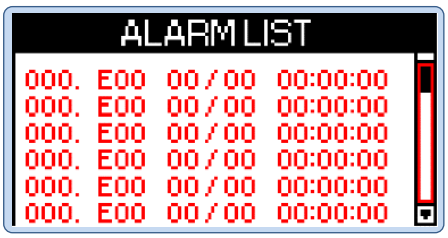
Users can designate year, month, day, hour and minute for the controller and the designated time will be used to monitor the system and manage fault messages.



Menu 6: DATE/TIME SETUP Menu

3.2.8 Alarm List Menu

This menu displays year, month, day, hour and minute for the errors in the controller and types of the faults in codes which are used in troubleshooting.



Menu 7: ALARM LIST Menu

3.2.9 Default Setup Menu

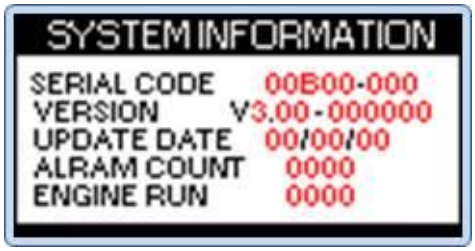
When you cannot identify the type of the control engine by the controller, this menu offers the most common parameter setting values. For default setup, select YES and then press Enter button. If you don't want to implement this function, press No button.

If you press YES, all the configuration values will be changed to the default ones of the engine.

Menu 8: Default Setup Menu

3.2.10 System Info Menu

The controller displays its information including the serial number, software version, last update date, alarm count and engine runs.



Menu 9: System Info Menu

3.3 Engine Configuration

3.3.1 Engine Type Configuration

Users can store control setting information depending on types of the engines in the internal memory of the controller. If you select your engine type, applicable parameters will be automatically configured accordingly. This feature is available for 16 different types of engines.

Designated Parameters by Engine Type

No	Menu Name	Run RPM	Over Speed	Gear Teeth	Starting Fuel	PID Value
1	DB58 1500RPM (50Hz) 129T	1500RPM	1725RPM	129	65%	Optimal Value
2	DB58 1800RPM (60Hz) 129T	1800RPM	2070RPM	129	65%	Optimal Value
3	DE08 1500RPM (50Hz) 102T	1500RPM	1725RPM	102	65%	Optimal Value
4	DE08 1800RPM (60Hz) 102T	1800RPM	2070RPM	102	65%	Optimal Value
5	DE08 1500RPM (50Hz) 140T	1500RPM	1725RPM	140	65%	Optimal Value
6	DE08 1800RPM (60Hz) 140T	1800RPM	2070RPM	140	65%	Optimal Value
7	DE08 1500RPM (50Hz) 146T	1500RPM	1725RPM	146	65%	Optimal Value
8	DE08 1800RPM (60Hz) 146T	1800RPM	2070RPM	146	65%	Optimal Value

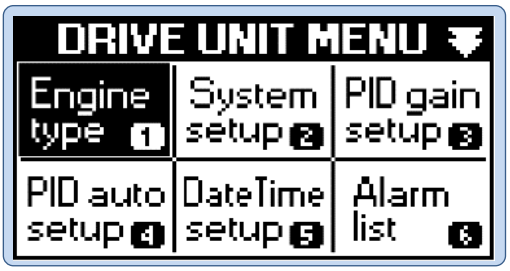
9	DL11 1500RPM (50Hz) 152T	1500RPM	1725RPM	152	65%	Optimal Value
10	DL11 1800RPM (60Hz) 152T	1800RPM	2070RPM	152	65%	Optimal Value
11	DV15 1500RPM (50Hz) 160T	1500RPM	1725RPM	160	65%	Optimal Value
12	DV15 1800RPM (60Hz) 160T	1800RPM	2070RPM	160	65%	Optimal Value
13	DV18 1500RPM (50Hz) 160T	1500RPM	1725RPM	160	65%	Optimal Value
14	DV18 1800RPM (60Hz) 160T	1800RPM	2070RPM	160	65%	Optimal Value
15	DV22 1500RPM (50Hz) 160T	1500RPM	1725RPM	160	65%	Optimal Value
16	DV22 1800RPM (60Hz) 160T	1800RPM	2070RPM	160	65%	Optimal Value

Table 1: Configuration Values by Engine Type

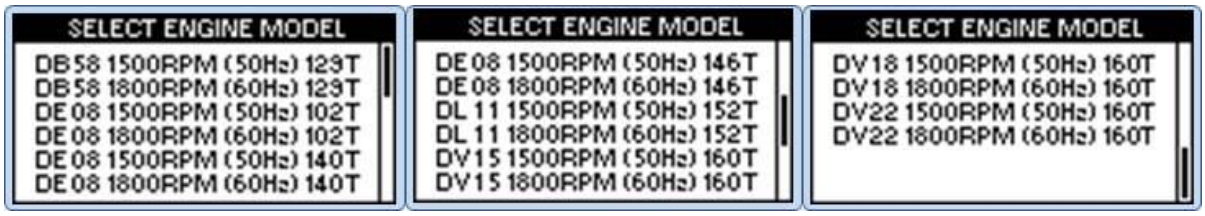
- **Engine Configuration Procedure**

Step1) Press **Menu** button of the controller and then you can see **DRIVE UNIT MENU**.

Step2) Select **Engine Type** by using **Up** and **Down** buttons in **DRIVE UNIT MENU** and then press **Enter** button.



Step3) Go to **Engine Type** menu and select your engine type using **Up** and **Down** buttons. Then, press **Enter** button. At this moment, setting values according to the selected type of the engine are designated and will be used as information for the controller to control the actuator.



Menu 10: Selection List by Engine Type

3.3.2 System Setup Configuration

Main setting items of the controller includes **GEAR NUMBER, CRANKING RPM** and **SET RUN RPM**. You need to designate setting values to these items. Other system setup items are optional and therefore you can designate values for those items as necessary.

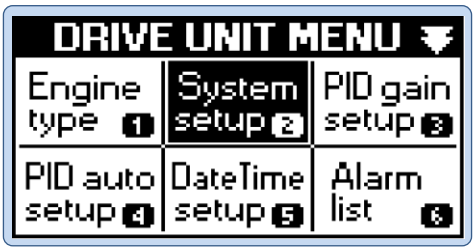
- Configuring **SET RUN RPM**

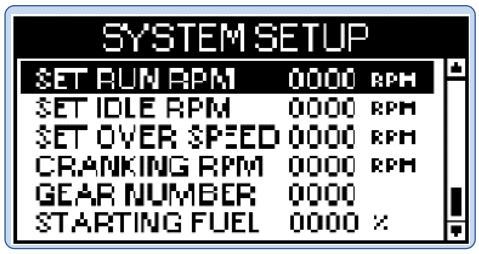
Step1) Press **Menu** button of the controller and then you can see **DRIVE UNIT MENU**.

Step2) Select **System setup** menu in **DRIVE UNIT MENU** using **Up, Down, Left** and **Right** buttons and then press **Enter** button.

Step3) Select **SET RUN RPM** in **SYSTEM SETUP** menu and then press **Enter** button. Use **Up** and

Down buttons to increase or decrease the normal operating speed of the engine and then press **Enter** button.



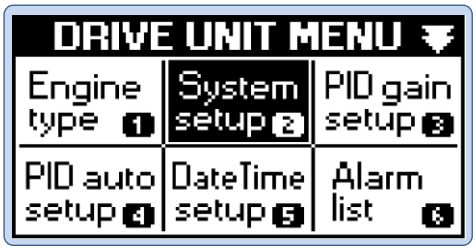


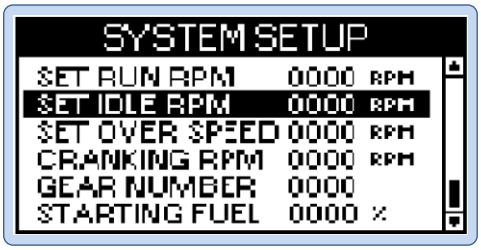
- Configuring **SET IDLE RPM**

Step1) Press **Menu** button of the controller and then you can see **DRIVE UNIT MENU**.

Step2) Select **System setup** menu in **DRIVE UNIT MENU** using **Up, Down, Left** and **Right** buttons and then press **Enter** button.

Step3) Select **SET IDLE RPM** in **SYSTEM SETUP** menu and then press **Enter** button. Use **Up** and **Down** buttons to increase or decrease the **idle** operating speed of the engine and then press **Enter** button.



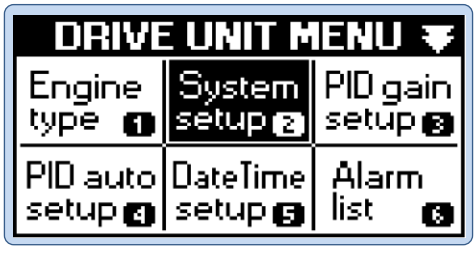


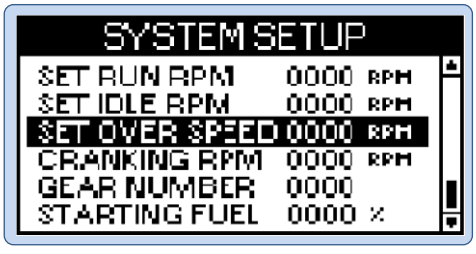
- Configuring **SET OVER SPEED**

Step1) Press **Menu** button of the controller and then you can see **DRIVE UNIT MENU**.

Step2) Select **System setup** menu in **DRIVE UNIT MENU** using **Up, Down, Left** and **Right** buttons and then press **Enter** button.

Step3) Select **SET OVER SPEED** in **SYSTEM SETUP** menu and then press **Enter** button. Use **Up** and **Down** buttons to increase or decrease the **over speed** values of the engine and then press **Enter** button.



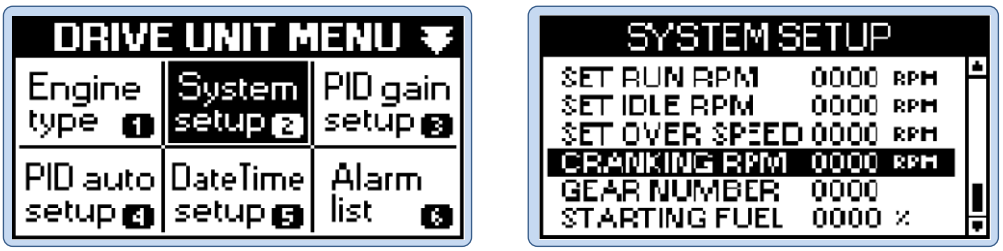


- Configuring **CRANKING RPM**

Step1) Press **Menu** button of the controller and then you can see **DRIVE UNIT MENU**.

Step2) Select **System setup** menu in **DRIVE UNIT MENU** using **Up, Down, Left** and **Right** buttons and then press **Enter** button.

Step3) Select **CRANKING RPM** in **SYSTEM SETUP** menu and then press **Enter** button. Use **Up** and **Down** buttons to increase or decrease the **RPM** values at which the controller starts to control the **actuator** when the engine starts to operate and then press **Enter** button.

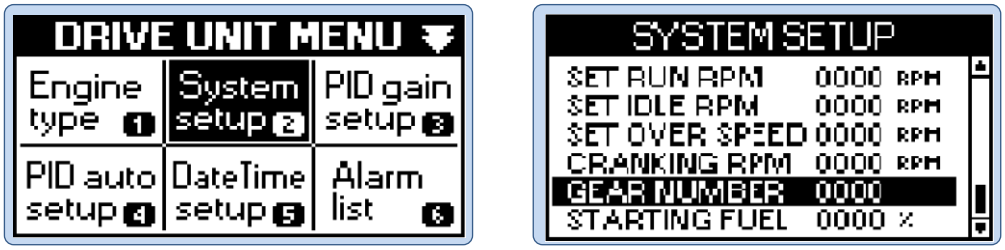


- Configuring **GEAR NUMBER**

Step1) Press **Menu** button of the controller and then you can see **DRIVE UNIT MENU**.

Step2) Select **System setup** menu in **DRIVE UNIT MENU** using **Up, Down, Left** and **Right** buttons and then press **Enter** button.

Step3) Select **GEAR NUMBER** in **SYSTEM SETUP** menu and then press **Enter** button. Use **Up** and **Down** buttons to increase or decrease the number of gear teeth in the engine and then press **Enter** button.

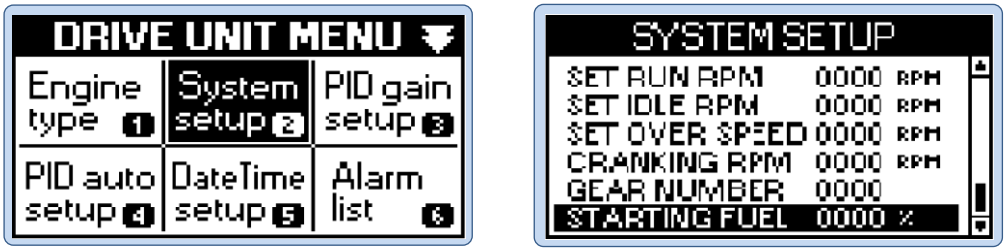


- Configuring **STARTING FUEL**

Step1) Press **Menu** button of the controller and then you can see **DRIVE UNIT MENU**.

Step2) Select **System setup** menu in **DRIVE UNIT MENU** using **Up, Down, Left** and **Right** buttons and then press **Enter** button.

Step3) Select **STARTING FUEL** in **SYSTEM SETUP** menu and then press **Enter** button. Use **Up** and **Down** buttons to increase or decrease the percentage for the amount of fuel sprayed when the engine starts and then press **Enter** button.

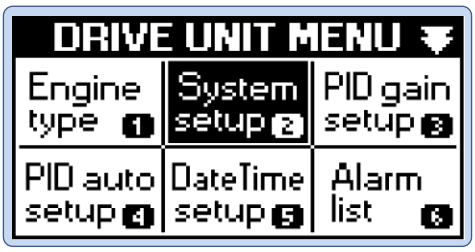


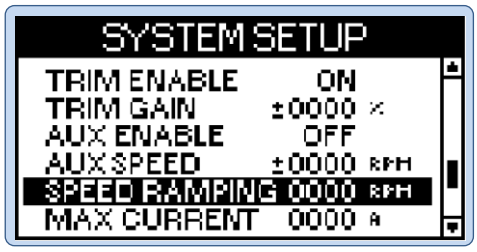
- Configuring **SPEED RAMPING**

Step1) Press **Menu** button of the controller and then you can see **DRIVE UNIT MENU**.

Step2) Select **System setup** menu in **DRIVE UNIT MENU** using **Up, Down, Left** and **Right** buttons and then press **Enter** button.

Step3) Select **SPEED RAMPING** in **SYSTEM SETUP** menu and then press **Enter** button. Use **Up** and **Down** buttons to increase or decrease the ratio of changes to the speed when increasing from the idle speed or decreasing from the increased speed and then press **Enter** button.



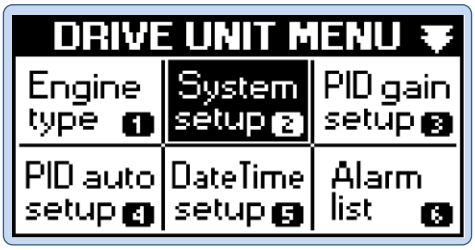


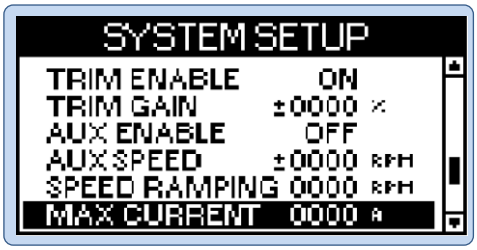
- Configuring **MAX CURRENT**

Step1) Press **Menu** button of the controller and then you can see **DRIVE UNIT MENU**.

Step2) Select **System setup** menu in **DRIVE UNIT MENU** using **Up, Down, Left** and **Right** buttons and then press **Enter** button.

Step3) Select **MAX CURRENT** in **SYSTEM SETUP** menu and then press **Enter** button. Use **Up** and **Down** buttons to increase or decrease the limit of the maximum current consumption of the **actuator** and then press **Enter** button (Max. 10A).



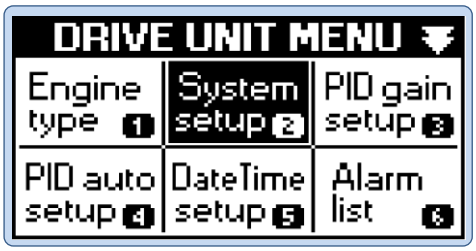


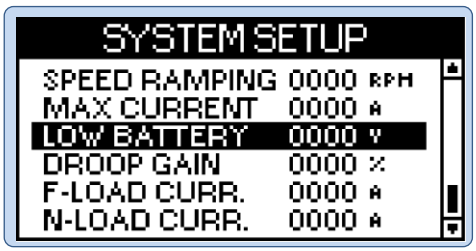
- Configuring **LOW BATTERY**

Step1) Press **Menu** button of the controller and then you can see **DRIVE UNIT MENU**.

Step2) Select **System setup** menu in **DRIVE UNIT MENU** using **Up, Down, Left** and **Right** buttons and then press **Enter** button.

Step3) Select **LOW BATTERY** in **SYSTEM SETUP** menu and then press **Enter** button. Use **Up** and **Down** buttons to input voltage values at which low battery alarms are activated and then press **Enter** button.





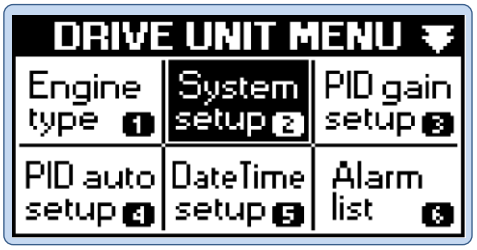
- Configuring **DROOP GAIN**

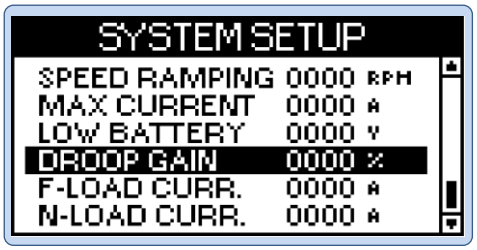
Step1) Press **Menu** button of the controller and then you can see **DRIVE UNIT MENU**.

Step2) Select **System setup** menu in **DRIVE UNIT MENU** using **Up, Down, Left** and **Right** buttons

and then press **Enter** button.

Step3) Select **DROOP GAIN** in **SYSTEM SETUP** menu and then press **Enter** button. Use **Up** and **Down** buttons to increase or decrease the RPM values with adjusted ratio to decrease at the maximum load when the generator is in parallel operation and then press **Enter** button.





DROOP Function

Droop function is indicated in percentages as follows: RPM with no load is subtracted by RPM with maximum load and then divided by RPM with no load.

$$\textbf{Droop}\% = \frac{\text{RPM with no load} - \text{RPM with maximum load}}{\text{RPM with no load}}$$

(Example for 3% Droop)

Assuming that RPM with no load is 1,800 and RPM with maximum load is 1,854 then the percentage will be 3%. It means that the generator output will be changed by 33.3% as the frequency changes by 1% due to the actuator control.

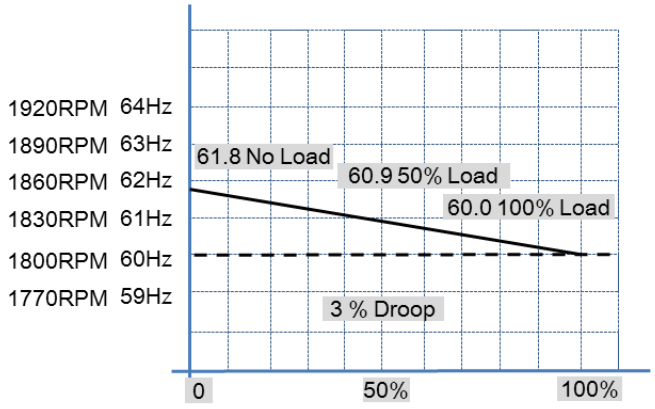


Figure 1: 3% Droop

(Example for 7% Droop)

Assuming that RPM with no load is 1,800 and RPM with maximum load is 1,926 then the percentage will be 5%. It means that the generator output will be changed by 14.3% as the frequency changes by 1% due to the actuator control.

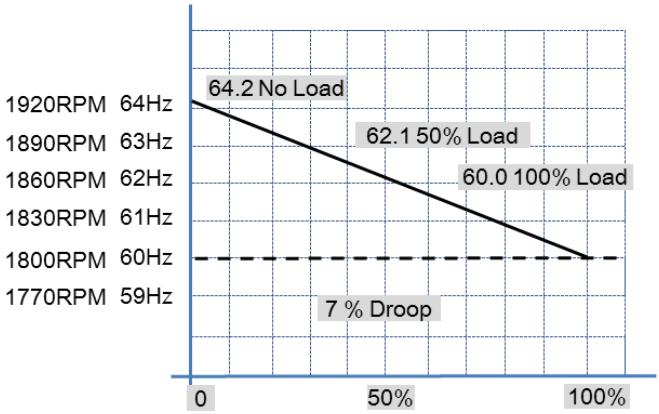


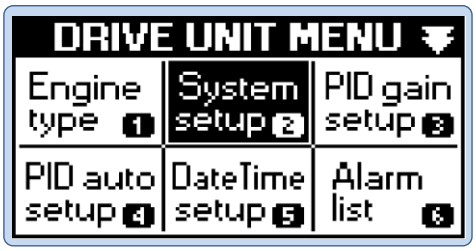
Figure 2: 7% Droop

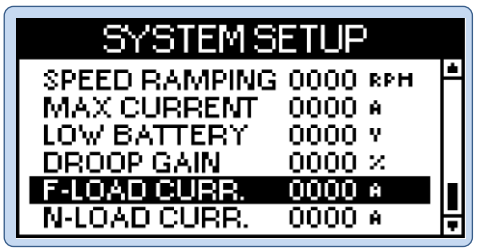
- **F-LOAD CURR.**

  Step1) Press **Menu** button of the controller and then you can see **DRIVE UNIT MENU**.

  Step2) Select **System setup** menu in **DRIVE UNIT MENU** using **Up, Down, Left** and **Right** buttons and then press **Enter** button.

  Step3) Select **F-LOAD CURR.** in SYSTEM SETUP menu and then press **Enter** button. Use **Up** and **Down** buttons to input the maximum current values of the **actuator** for the generator with full load and then press **Enter** button.



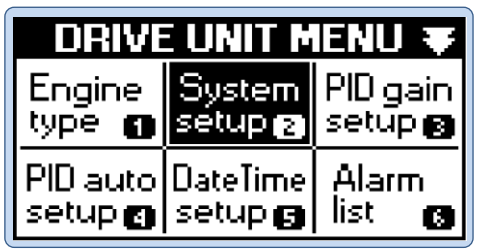


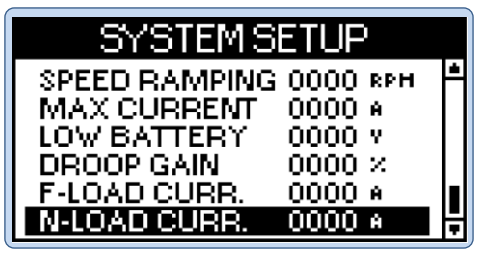
- **N-LOAD CURR.**

  Step1) Press **Menu** button of the controller and then you can see **DRIVE UNIT MENU**.

  Step2) Select **System setup** menu in **DRIVE UNIT MENU** using **Up, Down, Left** and **Right** buttons and then press **Enter** button.

  Step3) Select **N-LOAD CURR.** in SYSTEM SETUP menu and then press **Enter** button. Use **Up** and **Down** buttons to input the operating current values of the **actuator** for the generator with no load and then press **Enter** button.





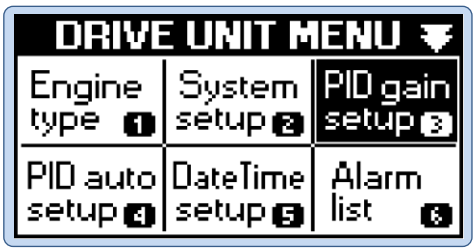
3.3.3 PID Gain Setup Configuration

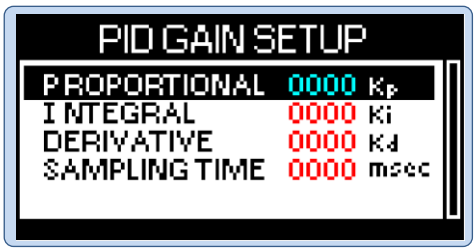
- Configuring **PID Gain Kp, Ki and Kd Values**

Step1) Press **Menu** button of the controller and then you can see **DRIVE UNIT MENU**. Use **Up,**

Down, Left and **Right** buttons to select **PID gain setup** menu and then press **Enter** button.

Step2) Use **Up** and **Down** buttons in **PID GAIN SETUP** to select **PROPORTIONAL, INTEGRAL** or **DERIVATIVE** and then press **Enter** button**.**

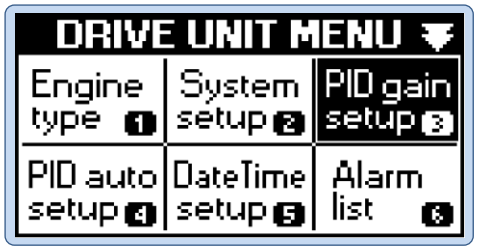


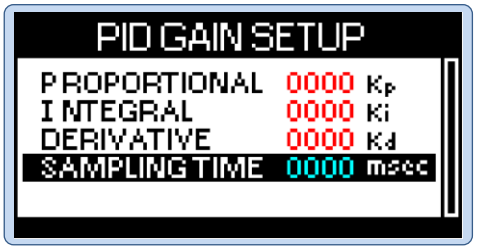


- Configuring **PID SAMPLING TIME**

Step1) Press **Menu** button of the controller and then you can see **DRIVE UNIT MENU**. Use **Up, Down, Left** and **Right** buttons to select **PID gain setup** menu and then press **Enter** button.

Step2) Use **Up** and **Down** buttons in **PID GAIN SETUP** to select **SAMPLING TIME** and then press **Enter** button**.** Use **Up** and **Down** buttons to input **SAMPLING TIME** values and then press **Enter** button.



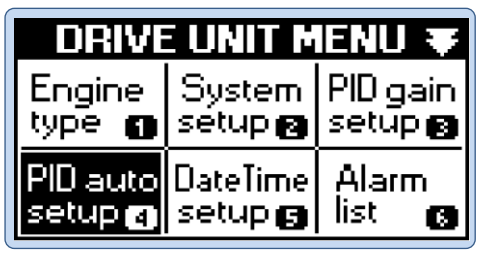


3.3.4 PID Auto Setup Value Configuration

Step1) Select your type in Engine Type menu and then start the engine with the preset configuration values maintaining it with no load.

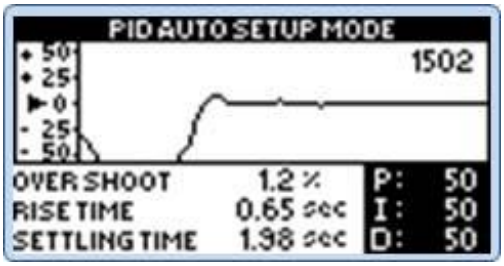
Step2) During the normal operation, press **Menu** button of the controller and then you can see **DRIVE UNIT MENU**. Use **Up**, **Down**, **Left** and **Right** buttons to select **PID auto setup** menu and then press **Enter** button.

Step3) The menu offers function for automatic designation of the P, I and D parameter values related to the engine PID control. Select PID auto setup menu in **DRIVE UNIT MENU** and then press Enter button to see the system message "Auto Setup Mode PID setting?" with YES or NO options.



Step4) Press YES and then the system message "PID AUTO SETUP MODE" will appear. As PID auto

setup was initiated during the operation, PID auto tuning is already in progress.



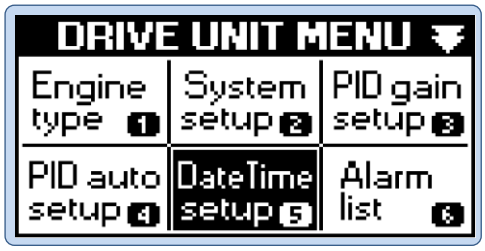
Step5) PID tuning repeats a process to obtain PID values and a window to indicate whether the process succeeded or failed will appear in several minutes (approx. 4 to 6 minutes). If the process succeeded, the system message window will appear together with OK button. If you press Enter button, you will go back to normal operation window and the auto-tuned values will apply to the normal operation that will be continued.

Step6) If auto-tuning failed to identify optimized P, I and D values within 4 to 6 minutes, the system message window will display failure. If you press Enter button, you will go back to normal operation window. If you want to repeat the process, you need to start with Step1 again.

3.3.5 DATE/TIME Value Configuration

Step1) press **Menu** button of the controller and then you can see **DRIVE UNIT MENU**. Use direction buttons to select **DateTime setup** menu.

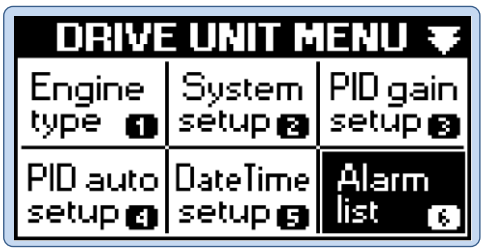
Step2) Use **Up**, **Down**, **Left** and **Right** buttons to input year, month, day and hour and then press **Enter** button.

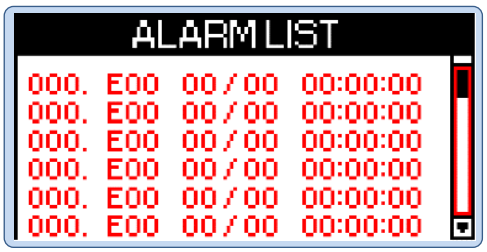


3.3.6 ALARM LIST

Step1) press **Menu** button of the controller and then you can see **DRIVE UNIT MENU**. Use direction buttons to select **Alarm List** menu and then press **Enter** button.

Step2) Use **Up**, **Down**, **Left** and **Right** buttons in **ALARM LIST** menu to confirm the fault messages.





[Alarm Code Table]

Alarm Code	Alarm Item	Description	Identified Alarm Output
E01	Battery Low	When the battery voltage continues to be lower than Low Battery voltage values for more than 5 seconds	LCD alarm message, Error LED lamp
E02	Battery High	When the battery maintains its voltage exceeding 30VDC for more than 5 seconds	LCD alarm message, Error LED lamp
E03	Pick-up Error	Problems in sensor signals when the engine starts. (Engine RPM lower than 600)	LCD alarm message, Error LED lamp
E04	Pick-up Error	Problems in sensor signals during the engine operation (Engine RPM 600 or higher)	LCD alarm message, Error LED lamp
E05	Actuator Current Short	Disconnection in the actuator or the connecting circuits	LCD alarm message, Error LED lamp
E06	Actuator Current Broken	Short-circuits in the actuator or the connecting circuits	LCD alarm message, Error LED lamp
E07	Over Speed	Engine RPM exceeding the configured over speed values	LCD alarm message, Error LED lamp
E08	FET Drive Error	Damages to components in the actuator output section inside the controller	LCD alarm message, Error LED lamp

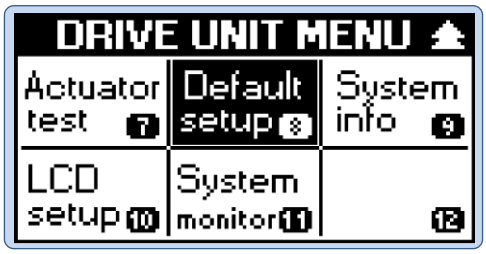
3.3.7 Actuator test

The menu offers function to test whether there is any problem in operating load current of the actuator attached to the engine. It indicates voltage and current for on/off.

3.3.8Default setup Functions

Step1) Press **Menu** button of the controller and then you can see **DRIVE UNIT MENU**. Use **Up**, **Down**, **Left** and **Right** buttons to select **Default setup** menu and then press **Enter** button. At this moment, the system message **"Initialization system setting?"** will appear**.**

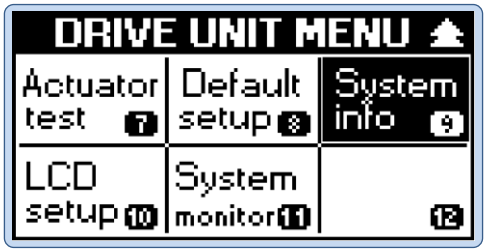
Step2) Use **Left** and **Right** buttons to select either **YES** or **NO** in **System Message** and then press **Enter** button.

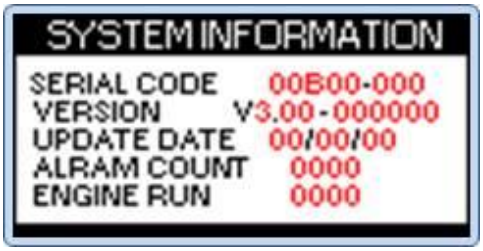


Default setup will change the configuration values of the engine to the default values. In order to initiate default setup, you need to select **YES** and then press **Enter** button. Press **No** button if you don't want to.

3.3.9 System info Functions

Step1) Press **Menu** button of the controller and then you can see **DRIVE UNIT MENU**. Use **Up**, **Down**, **Left** and **Right** buttons to select **System info** menu and then press **Enter** button.



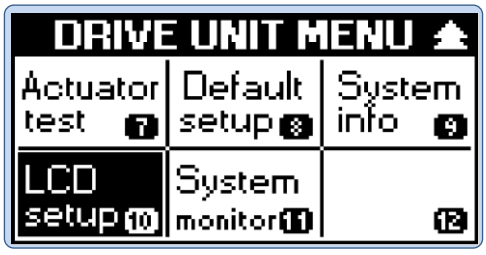


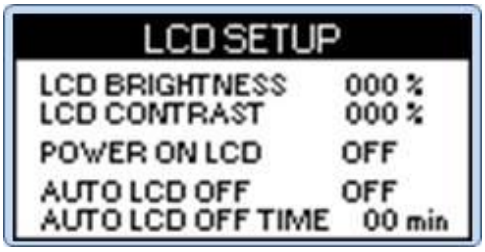
The menu displays information of the controller and the information includes the serial number, software version, last update date, alarm count and engine runs.

3.3.10 LCD setup Functions

Step1) Press **Menu** button of the controller and then you can see **DRIVE UNIT MENU**. Use **Up**, **Down**, **Left** and **Right** buttons to select **LCD setup** menu and then press **Enter** button.

Step2) Use **Up** and **Down** buttons to select menus including **LCD BRIGHTNESS** and **LCD CONTRAST** for adjustment and then press **Enter** button. Use **Up** and **Down** buttons to input setting values and then press **Enter** button.





3.3.11 System monitor Functions

Step1) Press **Menu** button of the controller and then you can see **DRIVE UNIT MENU**. Use **Up**, **Down**, **Left** and **Right** buttons to select **System monitor** menu and then press **Enter** button. It offers menu to monitor the controller operation. It shows values for Engine RPM, Valve Duty, Valve Current, Aux RPM Input, Pickup Voltage and Bat Voltage.

4. How to Operate

4.1 Operating Sequence for Digital Speed Controller

STEP1) Supply DC +24V power to the battery terminals (E (-), F (+)) of the controller.

STEP2) Configure parameter values required for selection of the engine type and control of the engine.

STEP3) Install the controller on the generator system and complete circuit wiring.

STEP4) The controller will activate the actuator with power supply and pick-up sensor input.

4.2 Detailed Operating Sequence

STEP1) Supply DC +24V power to the battery terminals (E (-), F (+)) of the controller.

Power supply to the controller can be done by direct connection to the battery or power supply controlled by external control devices. Fuses (15A/24V) are required for power supply to the controller through the terminal.

When the controller displays **Low Battery** Fault message, you need to charge the battery or replace it with the one having normal voltage before starting the controller.

STEP2) Configure parameter values required for selection of the engine type and control of the engine.

There are 3 ways to configure parameters required for the controller:

1. Using default setup
2. Designating the engine type in Engine Type menu
3. Configuring each parameter in System setup menu

For more information, see **Chapter 3**. Configuration and Operation.

STEP3) Install the controller on the generator system and complete circuit wiring.

Once the configuration is completed, the controller will be in **Stand By** condition preparing to receive input information from **pick-up** sensor and surrounding terminals and operate.

STEP4) The controller will activate the actuator with power supply and pick-up sensor input.

When the power is supplied and the **pick-up** terminal delivers normal sensor inputs as the **engine** starts, the **controller** activate the **actuator**.

5. Troubleshooting

5.1 Alarm List Check

Where there are problems in the system operation, you need to review the alarm list menu of the controller and then check the engine and the system in reference to the alarm codes.

Alarm Code	Alarm Item	Alarm Condition	Output Control	Measures
E01	Battery Low	When the battery voltage continues to be lower than Low Battery voltage values for more than 5 seconds	1. Alarm message pop-up on LCD 2. Error LED on	1. Check the battery line 2. Replace the battery
E02	Battery High	When the battery maintains its voltage exceeding 30VDC for more than 5 seconds	1. Alarm message pop-up on LCD 2. Error LED on	1. Check the battery line 2. Replace the battery
E03	Pick-up Error	Problems in sensor signals when the engine starts (Engine RPM lower than 600)	1. Alarm message pop-up on LCD 2. Error LED on 3. Actuator control signal off	1. Check the RPM sensor and connecting circuits 2. Replace the RPM sensor
E04	Pick-up Error	Problems in sensor signals during the engine operation (Engine RPM 600 or higher)	1. Alarm message pop-up on LCD 2. Error LED on 3. Actuator control signal off	1. Check the RPM sensor and connecting circuits 2. Replace the RPM sensor
E05	Actuator Current Open	Disconnection in the actuator or the connecting circuits	1. Alarm message pop-up on LCD 2. Error LED on	1. Check the disconnection in the actuator and connecting circuits 2. Replace the actuator
E06	Actuator Current short	Short-circuits in the actuator or the connecting circuits	1. Alarm message pop-up on LCD 2. Error LED on	1. Check the disconnection in the actuator and connecting circuits 2. Replace the actuator
E07	Over Speed	Engine RPM exceeding the configured over speed values	1. Alarm message pop-up on LCD 2. Error LED on 3. Actuator control off	1. Check the speed setting 2. Adjust PID setting values
E08	FET Drive Error	Damages to components in the actuator output section inside the controller	1. Alarm message pop-up on LCD 2. Error LED on 3. Actuator output power cutoff	1. Check the actuator and connecting circuits 2. Replace the controller

1) When problems described in alarm codes E03, E04, E07 or E08 occur, the engine is not available for safe operation and therefore the engine will stop as the controller will turn off the actuator for safety.
2) When problems described in alarm codes E03, E04, E07 or E08 occur, the engine will not be able to restart as long as the alarm is not released.
3) When alarms occur, you can release them by turning off the power of the controller.

5.2 System Checks and Measures

For initial installation, it is recommended for you to check any disconnection in circuits before taking

measures described here (see Chapter 2. Installation for how to install the controller).

You can check the controller for failure diagnosis in accordance with the following procedure.

Step1) Check the battery voltage whether it is higher than the Low Voltage setting value. If normal, supply power to the controller and then operate it. If the voltage is lower than the setting value, you need to charge the battery or replace it before operating the system.

Step2) Check the input resistance in the DC +24V input terminals (-E, +F) of the battery whether the resistance is higher than approx. 10K Ohm. If the resistance does not meet this condition, do not supply power to the controller and contact our A/S center for service request.

Step3) Check whether the power LED turns on or not after supplying power to DC +24V input terminals (-E, +F) of the battery. If the LED does not turn on, cut the power off and contact our A/S center for service request.

Step4) Check whether the power LED turns on and Doosan logo appears on the LCD display after supplying power to DC +24V input terminals (-E, +F) of the battery. If you cannot see the logo, press LCD key button to check the LCD display once again. If you cannot still see the logo, cut the power off and contact our A/S center for service request.

Step5) Check the controller terminals (C & D) with AC meter or oscilloscope to check whether signal inputs of AC RMS 3V or higher are detected. If no signal detected, check whether the pick-up sensor maintains the gap between 0.9 and 1.1mm and then check whether the pick-up sensor has resistance of 110 Ohms (±10%). If you cannot still detect no signal, replace the pick-up sensor and then operate the controller.

Enquiry for A/S Services **Engine Technical Service Team:** **+82 32 211 1114**	**Enquiry for Purchasing** **Ansan Component Center:** **+82 31 400 2114**