BELTRAME
CENTRO SERVIZI ENERGIA

Speed Digital Governor S2007 User's Manual

Nr. Documento	Revisione	Autore	Data stampa	Nr. pagine
M_S2007	*04.3*			*21*

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Contents

Important Notice

Our experience has shown that, if the information and recommendations contained in this Operating Instructions are observed, the best possible reliability of our products is assured.

The data contained herein purports solely to describe the product and is not a warranty of performance or characteristics. It is with the best interests of our customers in mind that we constantly strive to improve our products and keep them abreast of advances in technology. This may, however, lead to discrepancies between a product and its "Technical Description" or " Operating Instructions".

This document has been carefully prepared and reviewed, however should in spite of this the reader find an error, he is requested to inform us at his earliest convenience.

It is scarcely possible for the operating instructions for technical equipment to cover every eventuality, which can occur in practice. We would therefore request you to notify us or our agent in the case of all unusual behaviour that does not appear to be covered by these operating instructions.

It is pointed out that all local regulations must be observed when connecting and commissioning this equipment in addition to these operating instructions.

We cannot accept any responsibility for damage incurred as a result of mishandling the equipment regardless of whether particular reference is made in these operating instructions or not.

We lay particular stress on the fact that only genuine spare parts should be used for replacements.

Manufacturer’s address

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SAFETY INSTRUCTIONS

General

The safety instructions shall be followed during installation, commissioning, operation and maintenance. Read all instructions carefully before operating the device and keep this manual for future reference.

Required Qualification

Personnel involved in installation work and commissioning of the S2007 must be familiar, specially instructed and informed about the residual danger areas according to the regulations currently in force.

Operating personnel is not permitted to work at the control system.

Specially instructed personnel must only carry out maintenance and repair work.
The maintenance personnel must be informed about the emergency shutdown measures and must be capable of turning off the system in case of emergency.
The maintenance personnel must be familiar with the accident prevention measures at their workplace and must be instructed in first aid and fire fighting.

It is the owner's responsibility to ensure that each person involved in the installation and commissioning of the S2007 has received the appropriate training or instructions and has thoroughly read and clearly understood the safety instructions in this chapter.

○ Safety Instructions

The safety instructions always appear at the beginning of each chapter and/or precede any instruction in the context where a potentially dangerous situation may appear. The safety instructions are divided into five categories and emphasized by the use of the following layout and safety signs:

	**DANGER!** This symbol indicates an imminent danger resulting from mechanical forces or high voltage. A non-observance leads to life-threatening physical injury or death.
	**CAUTION!** This symbol indicates a dangerous situation. A non-observance may lead to physical injury or cause damage to the device.
	**IMPORTANT!** This symbol indicates useful information. Not to be used to indicate dangerous situations.
	**NOTICE!** This symbol emphasizes important information. A non-observance may cause damage to the device or to objects close to it.

DEVICE DESCRIPTION

Introduction

The S2007 is an electronic device designed to control engine speed with fast and precise response to transient load changes.

This closed loop control, when connected to a proportional electric actuator and supplied with a magnetic speed sensor signal, will control a wide variety of engines.

This voltage regulator manages the following functions:

1) Isocron control of the rotation;
2) Safety controls (Overspeed e Overload);
3) Droop control for use in parallel mode.

It is designed for high reliability and built ruggedly to withstand the engine environment.

A practical and simple-to-operate panel on the unit is used for all control operations. In addition, user-friendly software facilitates commissioning and allows optimization of operation.

The mechanical construction is compact and robust.

Hardware

Structure:

The device is placed inside a plastic box then it is submerged in resin to allow the maximum resistance against engine vibrations and a long time reliability.

Control elements*:*

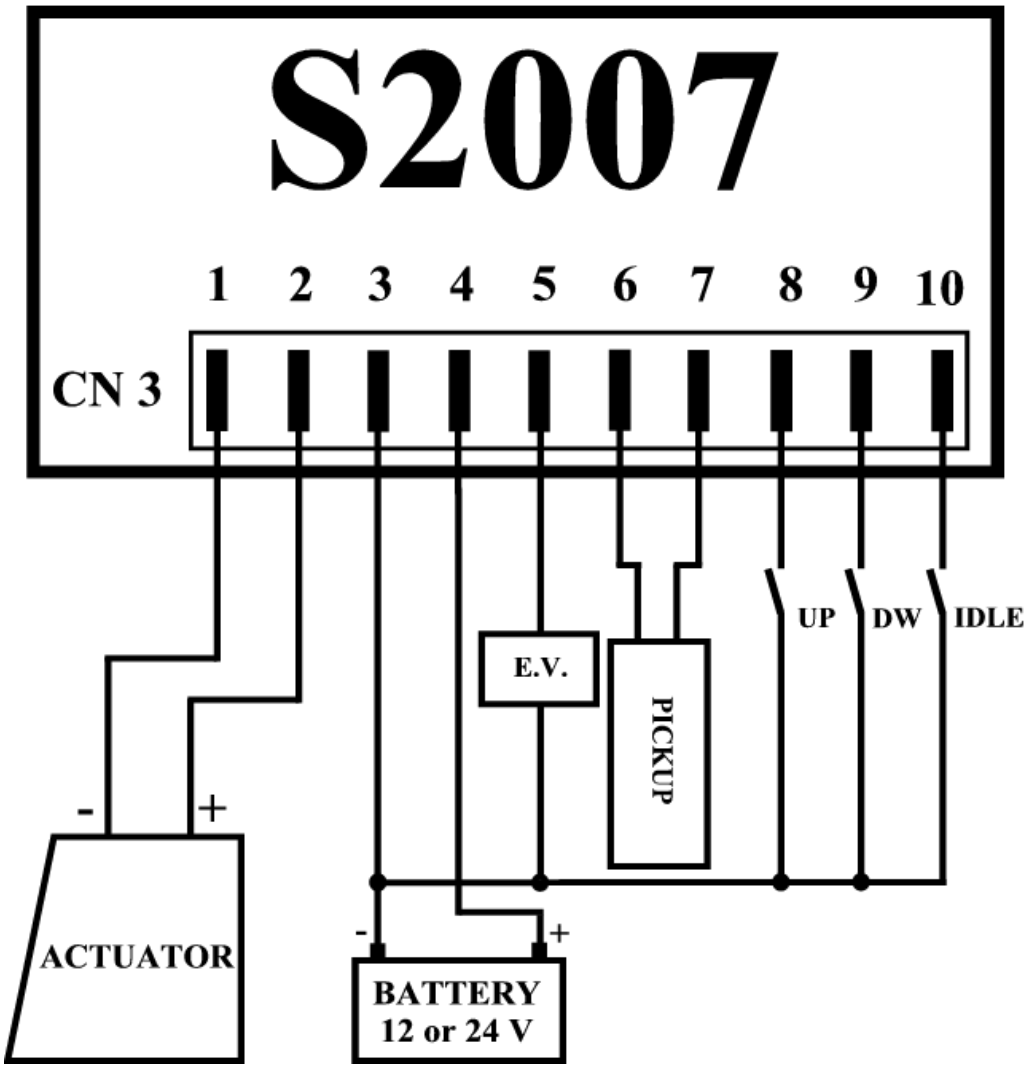
A four digit 7-segment display is located on it in order to allow an easy visualization of parameters. The use of push buttons placed at the side and below the display allows to scroll the menu of all parameters and to set those of interest.

Mounting:

The S2007 is designed for wall mounting on a metal panel.
Mounting on a non-dissipative surface such as a plastic panel may lead to device overheating and is to be avoided.
For optimal cooling is to keep free a minimum distance of 100 mm all around the unit.

Connection diagram:

Basic electrical connections are shown in the figure below.



- **Control elements and interfaces**

Carrying out settings on the unit

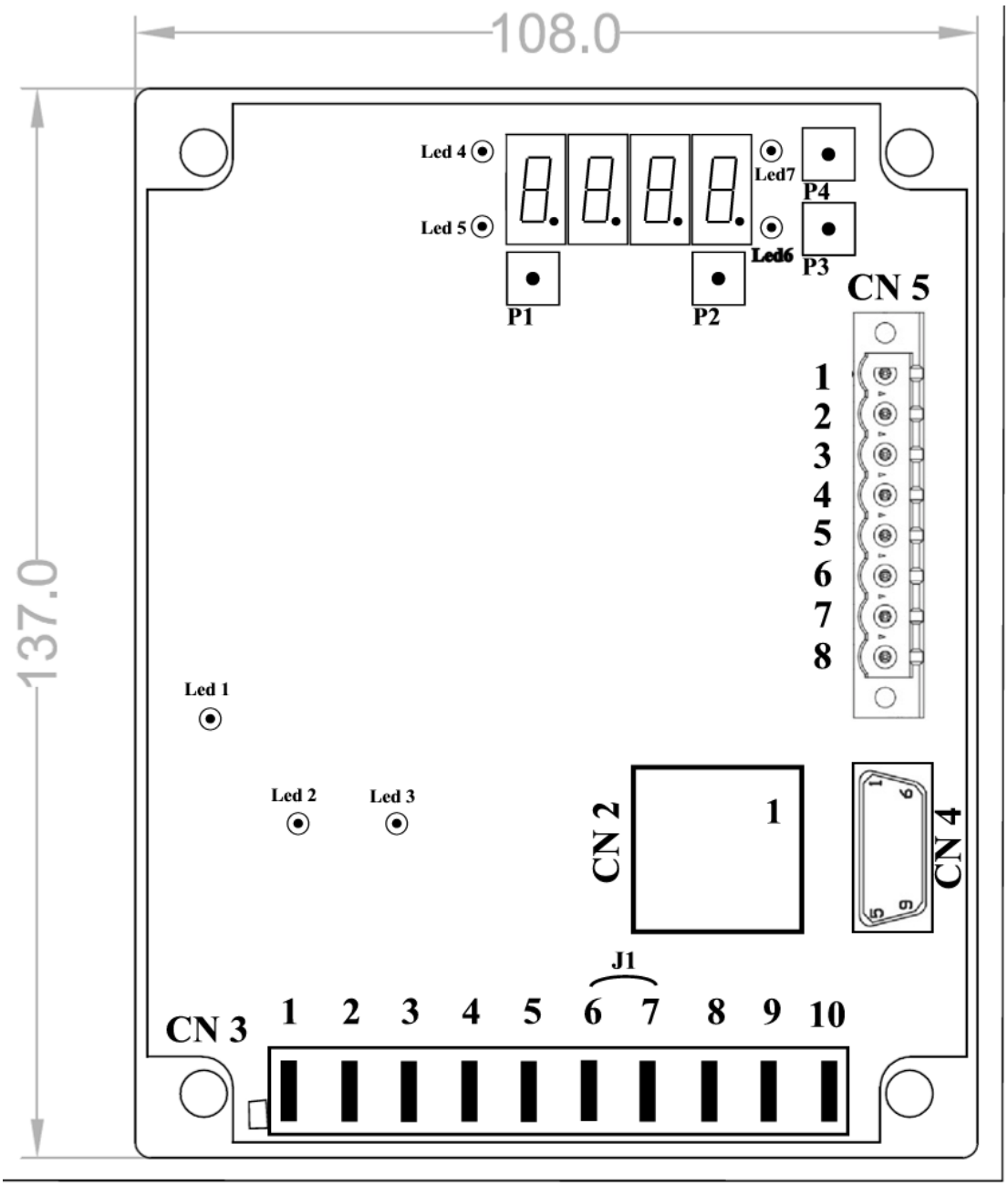
The display and the four keys are sufficient to allow complete operation.

All settings can be carried out directly on the unit without additional equipment

- Input/Output configuration
- Parameters setting
- Display of main measures.

Terminal boards

Overview of the device connectors



Connectors

CN2 – CAN BUS interface

1. CAN H
2. CAN L
3. GND CAN
4. n.c.
5. n.c.
6. n.c.
7. GND CAN
8. n.c.

CN3 – Inputs/Outputs

1. Actuator -
2. Actuator +
3. Battery – (GND/COM)
4. Battery + (12÷24Vdc)
5. Out aux (Solenoid valve)
6. Pickup +
7. Pickup –
8. UP (COM=GND)
9. DOWN (COM=GND)
10. IDLE (COM=GND)

CN4 – RS232 interface

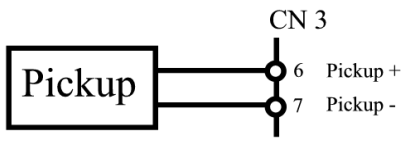
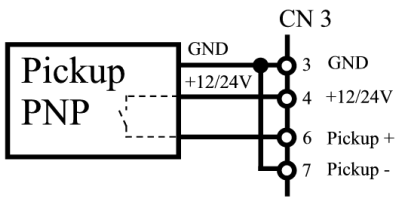
1. Reserved (do NOT use or connect!)
2. Tx (from regulator to pc)
3. Rx (from pc to regulator)
4. Reserved (do NOT use or connect!)
5. GND
6. Reserved (do NOT use or connect!)
7. Reserved (do NOT use or connect!)
8. Reserved (do NOT use or connect!)
9. Reserved (do NOT use or connect!)

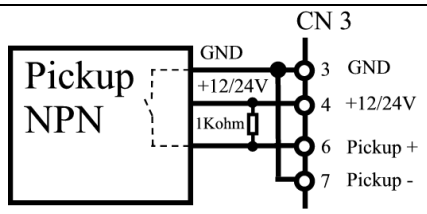
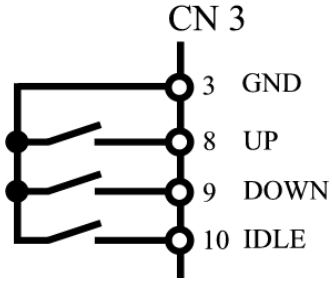
CN5 – Inputs/Outputs

1. Digital input (COM=GND)
2. Digital input (COM=GND, enabled droop)
3. GND/COM
4. Analog input 0÷10V
5. Supply output +10V (max 20mA)
6. Analog input 4÷20mA
7. Analog input -5÷5V
8. GND/COM

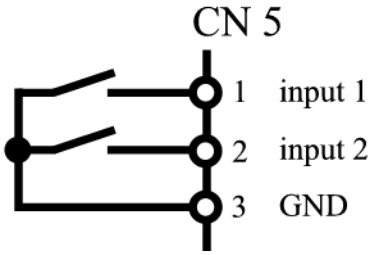
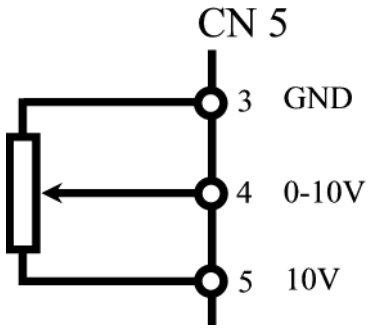
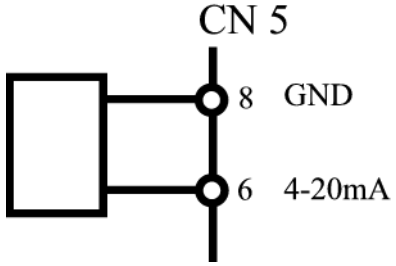
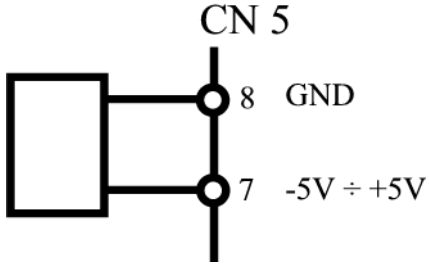
n.c. = not connected

- **Device connections CN3**

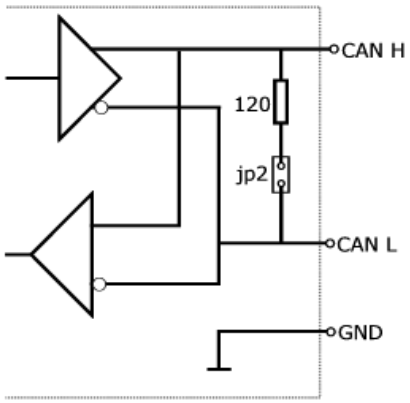
Terminal designation	**Signal**	**Specifications**
Actuator	DC output	12÷24Vdc 0÷12 A (15A for 10s)
Solenoid valve	Digital output	12÷24Vdc 2Amax
Pickup	Passive pickup	
	Active pickup **N.B.** Open jumper J1	 or

		
Up	Digital Input	
Down	Digital Input	
IDLE	Digital Input	

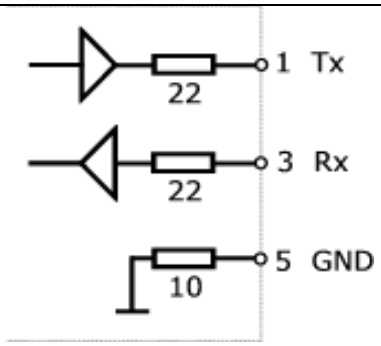
- **Device connections CN5**

Terminal designation	Signal	Specifications
Digital inputs	2 digital inputs	 • 10V, 5mA • programmable function
Analog inputs **N.B.:** Inputs 0÷10V and 4÷20mA are to be used one at a time. They can't operate simultaneously	analog input 0÷10Vdc (Potentiometer =2kΩ ÷ 5kΩ 0,25W)	
	analog input 4÷20mA	
	analog input -5V ÷ +5V	

- **Device connections CN2**

Terminal designation	Signal	Specifications
Communication (Optional)	CAN	 • Selectable termination • CANopen and proprietary protocols

- **Device connections CN4**

Terminal designation	Signal	Specifications
Communication	RS232	

NOTICE!

To connect a device such as a notebook or personal computer at the **Digital controller revolutions S2007**, an USB/RS232 or RS232/RS232 adapter is needed. Please request it directly to BELTRAME CSE.

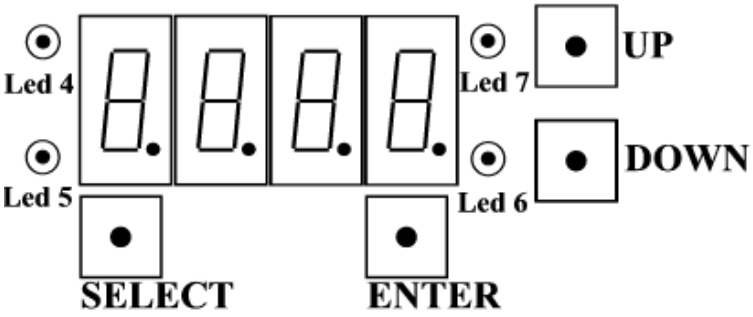
NEVER CONNECT TRADE CABLES (more than three conductors)!

- # OPERATOR INTERFACE

In this following charter are described the operations of management parameter using the integrated display.

- ### Set or change parameters

Many parameter can be accessed using the integrated display and keys.



SELECT Select viewing menu (d.xxx) or parameters menu (P.xxx)

ENTER Select or save current displayed parameter

UP Increase parameter number or value

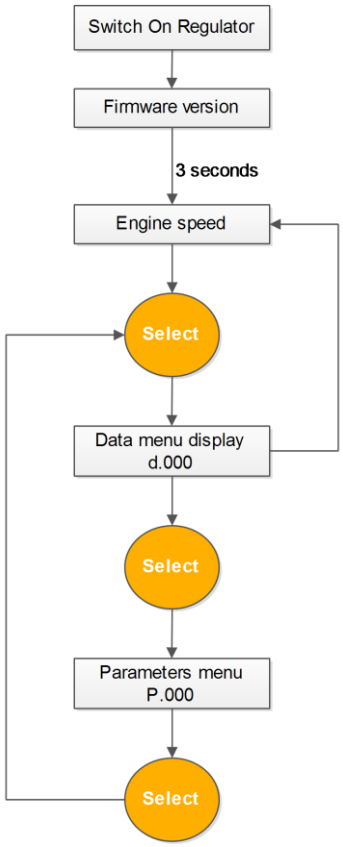
DOWN Decrease parameter number or value

d.XXX Data menu, viewing only

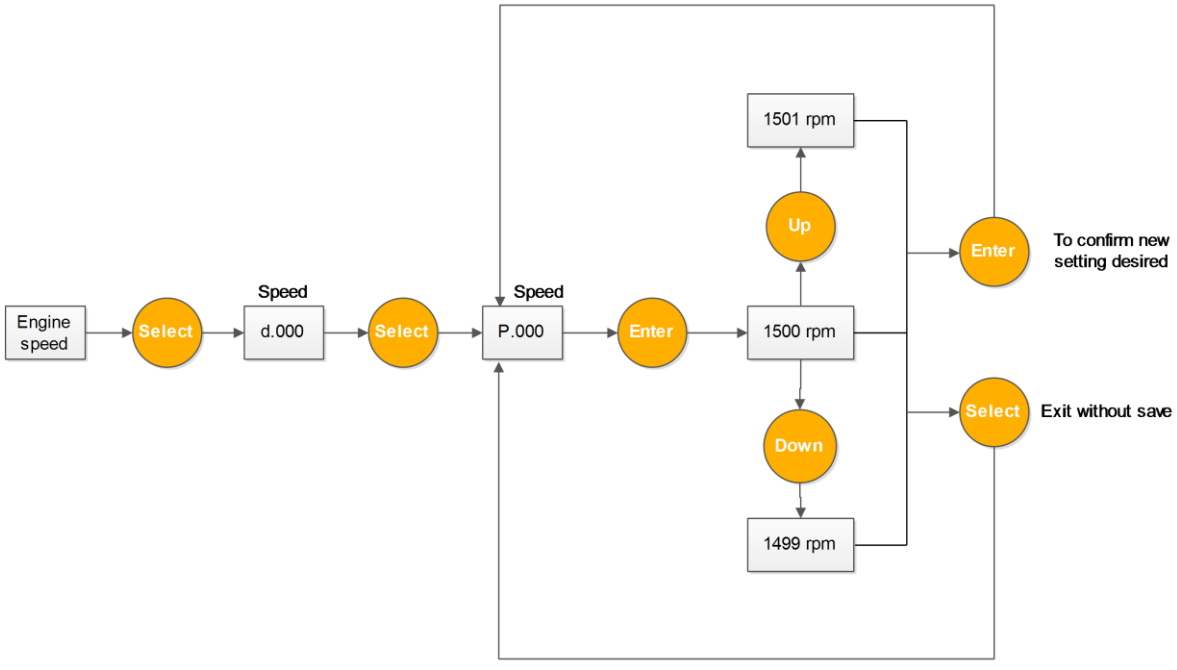
P.XXX Parameters menu

○ Navigating the menus

When the S2007 is power on, the display automatically shows parameter d.000 (Engine speed) in the Display menu.



Example: how to change a SPEED reference



○ Menu

▪Menu d - Display

Display	Name	Description	[Units]	
D.000	Engine speed	Actual engine speed	rpm	
D.001	Speed set	Speed set point	rpm	
D.002	Actuator current	Current supplied to actuator	A	
D.003	Actuator voltage	Voltage supplied to actuator	V	
D.004	Input 0÷10V	0÷10V analog input voltage	V	
D.005	Input 4÷20mA	4÷20mA analog input current	mA	
D.006	V Batt	Battery voltage	V	
D.007		Firmware version		

▪Menu P - Parameters

Parameter	Name	Description	[Units]	Default	Range
P.000	Rated Speed	Engine speed Set Point	Rpm	1500	600 - 4000
P.001	Kp (GAIN)	Proportional gain for PID control loop		150	20 - 5000
P.002	Ki (STABILITY)	Integral gain for PID control loop		140	0 - 5000
P.003	Kd (DEADTIME)	Derivative gain for PID control loop		80	0 - 5000
P.004	IDLE speed	Sets engine speed when the IDLE input is connected to GND/COM	Rpm	1300	600 - 4000
P.005	Crank speed	Crank termination threshold: RPM when the governor changes from crank mode to control mode	Rpm	1200	600 - 4000
P.006	Over speed	Over speed: RPM when actuator is shut off for safety reason and active an overspeed alarm	Rpm	1700	1350 - 4750
P.007	Max cranking fuel	Max output to actuator while cranking	%	100%	5% - 100%
P.008	Speed ramp	Time to change speed from crank speed to rated speed (or IDLE speed in IDLE mode)	s	8	0,5 – 60
P.009	Droop	Droop at maximun actuator current	%	1,5 %	0,1% - 8%
P.010	Max current	Max actuator current *	A	10	1 - 15
P.011	Overload time	Time before actuator current is clamped to Max current (P.010)	s	10	5 – 60
P.012	Variable speed control	Maximum speed change from analog inputs	%	3%	0% - 100%
P.013	Teeth	Number of teeth on flywheel		60	10 – 250
P.014	PID Rate	Time of the PID action		20	1 - 200

P.015	Reset	Reserved for the manufacturer			

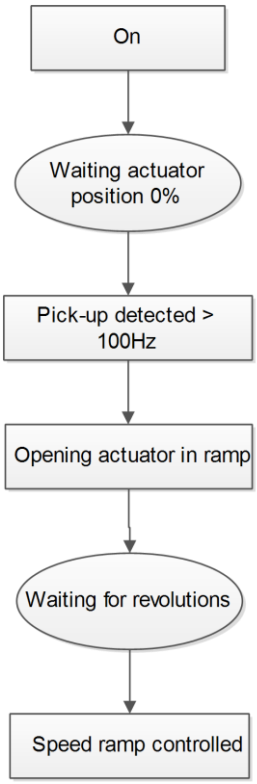
* **NOTICE!**

In case of a short circuit at the actuator output, the S2007 goes in Alarm Mode to prevent any device failure.

To recover from Alarm Mode shut off the S2007, remove short circuit then switch on again the S2007.

- # RUNNING THE ENGINE
  - ## Running the engine
    - ### Starting the engine

Power the regulator before starting engine. The actuator remains in rest position until the detection of the minimum starting threshold (100Hz). Once the threshold is exceeded, the speed controller command the opening of the actuator in ramp, and after have completed the engine cranking, ramps up to the set point engine.



NOTICE!

if engine speed is unstable after start up, adjust **GAIN** (P.001), **STABILITY** (P.002), and **DEADTIME COMPENSATION** (P.003) until engine speed is stabilized.
Once rated speed is achieved, PID parameters may required further fine adjustment.

1.1.2 Governor Performance

Once the engine is at rated speed and at no load, the following governor performance adjustment can be made:

A. Increase **GAIN** parameter until motor speed reaches instability. Gradually decrease the Gain until stability is recovered. Decrease one count further to insure stable performance.

B. Increase **STABILITY** parameter until motor speed reaches instability. Gradually decrease Stability until stability is recovered. Decrease one count further to insure stable performance. If no instability appears, leave default value.

C. Increase **DEADTIME** parameter until motor speed reaches instability. Gradually decrease Deadtime until stability is recovered. Decrease one count further to insure stable performance. If no instability appears, leave default value.

D. **GAIN**, **STABILITY** and **DEADTIME** small adjustments may be required after load is applied to engine. Normally, adjustments made in no load conditions achieve satisfactory performance.

○ Description capabilities

▪ Real-Time Display

While engine runs, S2007 Digital Speed Controller can display real time measures and other useful information (see table below). Cycle through the table with UP / DOWN keys.

Display	Parametet	Description	Units
D.000	Engine speed	Actual engine speed	rpm
D.001	Speed set	Speed set point	rpm
D.002	Actuator current	Actual actuator current	A
D.003	Actuator voltage	Actual actuator voltage	V
D.004	Input 0-10V	0-10V input voltage	V
D.005	Input 4-20mA	4-20mA input current	mA
D.006	V Batt	Battery voltage	V
D.007		Firmware version	

▪ Pickup detection

The speed regulator supplies energy to the actuator only if the pickup signal is higher than 100Hz and remains so stable for at least 100ms time.

▪ Actuator ramp / Actuator slope

Once obtained the signal of the pickups, the speed regulator supplies a raising current in ramp allowing the flow of fuel.

A controlled ramp is programmed from 0 (zero) to the percentage value previously set through the parameter P.007 (maximum actuator value) in a time fixed in 1 (one) second.

Example: the parameter P.007 is set at 75% and the ramp time value is 1 second per default, the pwm increases in a linear way from 0 to 75% in one second.

In this phase the speed regulator controls continuously the frequency input at the regulator's pickup input and when the frequency exceeds stably the value of the Minimum Rpm Set (P.005), the speed regulator switches to the PID control.

▪ Start Up Ramp

The Speed Ramp (P.008) setting is used to reduce excess fuel and thus black smoke during startup. After cranking, Speed Ramp represents how fast the motor reaches the rated speed (P.000).

▪ Speed set control

This is the main running status of the speed regulator. The regulator follows the Nominal Rpm Set (P.000).

In this status:

1. The closing of the UP/Down external inputs causes a variation of the speed set, changing the preset value in parameter P.000. This variation is not saved and stored. The variation has a fixed slope of 10Hz per second (the rpm slope depends from the number of the wheel's teeth).

   The revolutions' set varies within the limits set through the parameter Max. Variation Set (P.012).

   Example: The Nominal Rpm Set (P.000) is set up at 1500rpm. The Max. Variation Set (P.012) is set up at 3%. In this situation a closing of the Down Input for an undefined time will decrease the rpm number until the minimum value of 1455 rpm; while a closing of the Up input for an undefined time will increase the rpm number until 1545rpm.
2. The closing of IDLE input switches the speed regulator in IDLE mode (see below).
3. In case of a voltage exceeding 0,3Vdc on the 0-10V input (or on the 4-20mA input) switches the regulator in the Analogic Variation mode of the Set.
4. The closing of the DROOP enabling input (input 2) enable the DROOP mode (vedi below).

A variation of the P.000 parameter (Nominal Rpm set) through the keyboard, involves a real time variation of the Rotation System Set.

Even a variation of the control parameters PID (P.001=Kp, P.002=Ki, P003=Kd, P.014=intervention time) is done in real time to allow a fast tuning of the parameters themselves.

- **Variable Speed Inputs**

If a voltage exceeding 0,3V is detected on the 0-10V input (or 4-20mA) during the Rpm Control Set phase, the regulator enable the Analogic Variation of the Set.

In this phase the followed Rpm Set is set up through the analog input with continuous variation of the set as a function of the value on the analog input.

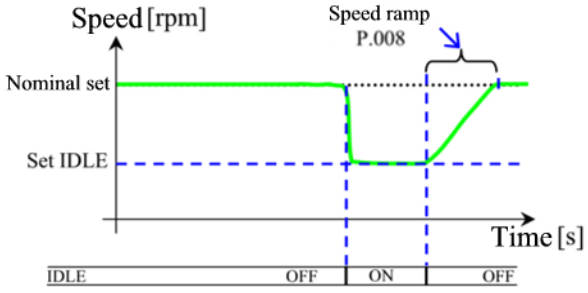
During this phase the inputs UP/DOWN and DROOP are disabled.

The variation limit is always given by the parameter Max. Variation Set (P.012)

Example: The Nominal Rpm Set (P.000) is set up at 1500rpm. The Max. Rpm Variation Set (P.012) is set up at 3%. In this situation a voltage equal to 0,4Vdc on the analog input will bring the rotation set to 1455rpm, while a voltage equal to 10Vdc will bring the rotation to 1545rpm.

The input 4-20mA for the regulator looks like the 0-10V input and acts exactly in the same way.

If the value of the analog input decreases below 0,3V following again the RPM Nominal Set, the regulator comes back to the Nominal Rpm Set Control (P.000).



- **Idle**

Idle is a feature that allows to run the motor at reduced speed.

Upon closing the input Idle, the speed governor changes in a step the motor speed from the Nominal Rpm Set (P.000) ti the Set RPM Idle (P.004).

The rotation speed remains set to this value for all the time that the IDLE input remains closed.

Opening the IDLE input, the regulator performs a controlled ramp from the Set RPM IDLE (P.004) to the Nominal Rpm Set (P.000) in a time equal to the one set for the Speed Ramp (P.008)

- **Droop**

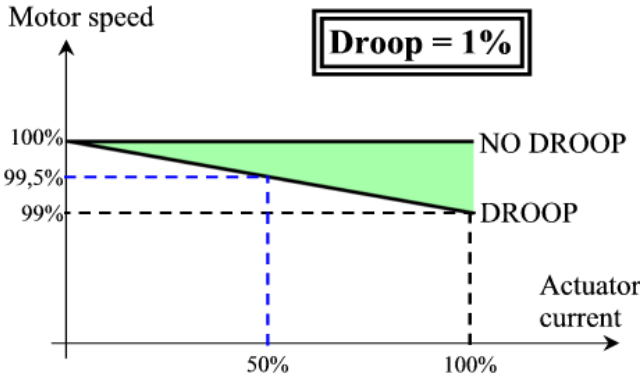
The Droop function is tipically used for parallel between generators.

This function makes reduction of the engine speed as a function of the actuator control current.

Until the input 2 is closed, the speed governor makes a downward correction of the Set Rpm Nominal (P.000) as a function of current supplied to the actuator.

Increasing the current, the number of revolutions is decreased in an inversely proportional manner.

The maximum percentage change the number of revolutions is given by Droop parameter (P.009) and happens at the set of maximum current (P.010).



Example: The Nominal Rpm Set (P.000) is set to 1500rpm and the Maximum Current

(P.010) at 6Adc, the Droop (P.009) to 1%. At the increase of the actuator current, the rotation set decreases in a linear way until the rotation set is equal to 1485rpm. If instead the current on the actuator is 3Adc, the rotation set is equal to 1492rpm.

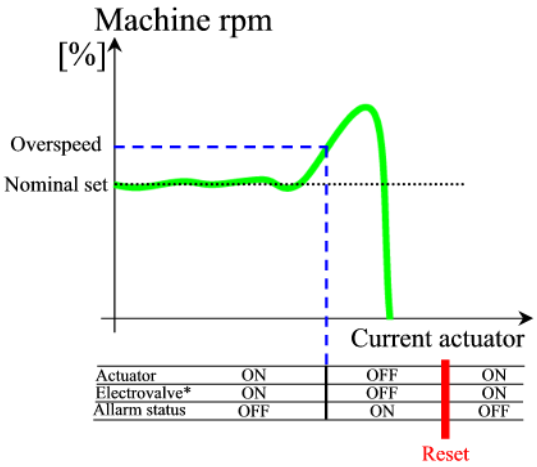
○ Description of the protections

▪ Overspeed

If, during the operation, the Rpm value is higher than the value Overspeed Set (P.006) for a time exceeding 1200ms, the rpm regulator blocks the generating se.

The actuator goes immediately (<1ms) in pause position and the aux. output (electrovalve) is disabled.

The rpm regulator remains in this status until the switching off.



If the number of teeth or the value of the overspeed parameter is not correctly set you may having unwanted interventions or lack of operations.

It's recommended not to rely on this protection if the entered parameters are not correct.

▪ Overload

The regulator controls the actuator's voltage during the operation. When the requested current is higher than the Max. Current (P.010) the regulator allows an overload for a time to be set up through the parameter Overload Time (P.011). Once the set time finishes, the regulator limits the current at the set up value of Max. Current (P.010) even if the engine speed decrease.

When the load condition decreases the regulator follows again the RPM Nominal Set

▪ Loss of pick-up signal

If the regulator looses the pick-up signal during the running, the actuator goes automatically (<1ms) in pause mode and disables the command/control of the auxiliary output electrovalve (block).

The Speed regulator remains indefinitely in this status until the switching off.

▪ Led signals

The following advice are implemented on the four leds positioned/located at the sides of the display:

1) Led 5 (on the left side of the display – bottom position)
   Normally off, it flash when overspeed alarm Ton=Toff=250ms (fast flash). switch on during the whole time of overload condition.
2) Led 4 (on the left side of the display – top position)
   Normally off, it flash when IDLE input is enable Ton=Toff=500ms (slow flash), switch on if input 0-10Vdc (o 4-20mA) is enable (Voltage above 0.3Vdc)
3) Led 6 and 7 (at the right side of the display)
   Normally off; led 7 (the highest) switch on when a speed increase variation is requested by input UP, led 6 (the lowest) switch on when a speed increase variation is requested by input DW. Both led are switch on when input Droop function is enable.
4) Led 1: Mains
5) Led 2: Actuator
6) Led 3: Electrovalve

- **SPECIFICATIONS**

  - **Performance**

Speed Range / Governor	10Hz – 5 KHz *
Idle Adjust	600÷4000rpm

  - **Enviromental**

Ambient Temperature	-40° to 85°C (-40 to +180°F)
Relative Humidity	Up to 95%

  - **Inputs/Outputs**

Supply	12-24 VDC Battery Systems (8.5 to 30 VDC allowed)
Polarity	Negative Ground (Case Isolated)
Power Consumption	70mA max. plus actuator and solenoid current
Speed Sensor Signal	1-70 VRMS
Actuator Current (25°C)	15 A
Input for loading or synchronoscope variation	0÷10Vdc, 4÷20mA, -5÷+5V
Reverse Power Protection	Yes
Transient Voltage Protection	Yes
Fuse	FF 12,5A 250V Ultra Fast action, 5x20mm glass type

  - **Physical**

Dimension	110x140mm
Weight	560g
Mounting	Mount on a plane metal surface to allow for heatsinking. Any position allowed, vertical preferred. When mounted on non dissipative surface (e.g. plastic), actuator output current must be derated (-30%).

* Although the speed is defined in rpm, the operating range is defined at the frequency detected by the sensor on the flywheel.

• NOTES ON THE OPERATION OF THE REGULATOR

○ MANAGEMENT AND FINDING OF THE FLYWHEEL TEETH (P013)

All calculations inside the speed regulator are in Hz tenth, the pick-up reading is done with accuracy of Hz tenth in the lapse from 60Hz to 5000Hz.

The display shows values in RPM for the rotation set. The conversion from rpm to Hz*10 is carried out by the regulator.

The max accuracy of the speed controller is a tenth of Hz. This allows a conversion from Hz to RPM and vice versa.

Before to start the speed regulator it is necessary to set up the number of the flywheel teeth (P013).

In case the number of flywheel teeth is unknown we suggest to set up the value of P013 parameter at 60 teeth. Start the engine and read the number of speed (in this case it coincides with the frequency), then modify manually the parameter Nominal Rpm Set (P000) until the alternator's frequency reaches 50 Hz.

At this point, the Rotation Set correspondent to the value shown on the display and the Rotation desired in RPM (i.e. 1500rpm), the teeth number can be determined from the following formula:

Teeth Number = Rotation Set / Desired rotation set * 60

Remember that relation between Hz and rpm is always:

Speed in Hz = (Speed RPM / 60) * Teeth Number

If during starting the engine rotates too fast that measn that the number of the flywheel teeth is lower than 60 so switch off the engine and set up the parameters Nominal Rpm Set (P000) and Minimum Rpm Set (P005) with lower values (i.e. 1000 for the minimum speed and 1200 for the nominal set), then start again the engine. An different way to operate can be done maintaining unchanged the sets and set up the number of the flywheel teeth at 30 instead of 60. If you choose this mode, keep note that in the calculations the revolutions number read on the display does't reflect the frequency but its half.

Exemple:

The number of flywheel teeth is unknown.

To have 50Hz at the alternator's exit, the engine must rotate at 1500rpm. Set up the parameter (P013) at 60, and the nominal rotations number at 1500rpm.

- At the engine starting you listen to a **low** rotation.

  Enter the parameter Nominal Rpm Set (P000) and slowly increase the value until you read 50Hz at the alternator's exit – i.e. bring P000=2400.
  Stop the engine.
  At this point Teeth Number = 2400 / 1500 *60 = 96
  The flywheel has 96 teeth and this value has to be write in the parameter P013 while P000 Speed Nominal Set must be modify wit 1500.
  Start the engine.
- At the engine starting you listen to a **high** rotation. Stop the engine and set up parameter P013 at 30. Now start the engine again. The engine rotates now at a low speed (the RPM value of 1500 brings the controller to check on 750Hz frequency). Increase the Speed Nominal Rpm Set (P000) until 50 Hz will be reached at the alternator's exit. The numebr read on the display is i.e. 2250. Now, the teeth number is set at 30 and the real frequency on the pick-up is 1125Hz (2250/2), so we can determine that: teeth number = 1125/1500*60=45 or 2250/1500*30=45.

  At this point set up the parameter P013 at 45 and the Speed Nominal Set P000 at 1500.