# SG33BL (TTL/ RS485) Protocol Manual

Revision 1.04_EN

HITEC RCD, INC.

# INDEX

# 1 SG33 Feature

## 1-1 Industrial Servo Actuator

## 1-2 Various Communication System

It supports TTL communication control method, RS-485 method and PWM pulse control method which is the industry standard. Supports both bus-based serial connection (Multi-Drop) and parallel connection method (Single-Drop), so it can be applied to various platforms that users want. It is 100% compatible with existing R / C Servo, so it can be used not only in robot field, but also as R / C airplane, helicopter, automobile servo motor.
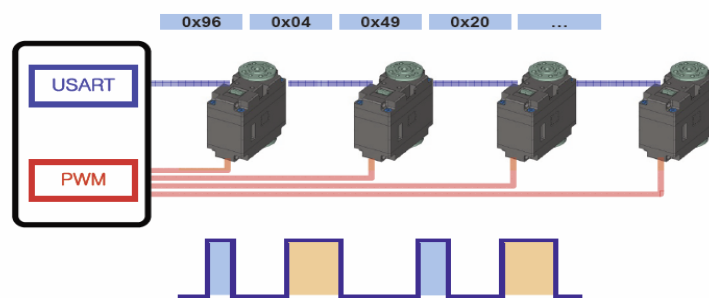


## 1-3 High Precision / Strong Power

With an angle resolution of 0.088˚, it is possible to control the most precise servo motors available in the market. With powerful coreless motor and special heat treatment and surface treatment metal gear, it can output the torque over 30(kgf/cm).

## 1-4 Output Torque / Speed Control Function

You can set the torque and speed of the output to suit your purpose. You can set the torque from no torque at all to the strongest state and from the state where there is no speed to the state where the speed is the fastest.

## 1-5 Acceleration Function

Control through acceleration/deceleration is possible. By using this, it is possible to realize smooth motion similar to human when used on joints of humanoid robot.

## 1-6 Feedback Function

It provides various feedback function to check status easily. Actuator status information such as position, speed, motor voltage, CPU voltage, temperature, and actuator setting information such as backlash, PID gain, and firmware can be fed back.

# 2  SG33BL Summary

## 2-1  General Specification

| | SG33BL-S-12V | SG33BL-T-12V |
|---|---|---|
| Operating Voltage Range | 9.0 V  ~  15.0 V | |
| Test Voltage | AT 12.0 V | AT 12.0V |
| No Load Speed | 0.15 sec / 60° (400°/sec) | 0.185 sec / 60° (320°/sec) |
| Rated Torque | 18.35 kgf·cm (1.8N·m) | 24.47 kgf·cm (2.4N·m) |
| Peak Torque | 110.12 kgf·cm (10.8N·m) | 146.84 kgf·cm (14.4N·m) |
| Control Signal | PWM // RS-485 // TTL (Half Duplex) | |
| Operating Travel | PWM : Standard : ±60˚±0.5 Optional : ±160˚±0.5 | |
| Multi Turn | Optional : Max ±8 Turn (±2880˚) | |
| Motor Type | Brushless | |
| Position Type | Contactless | |

## 2-2  Mechanical Features

| | |
|---|---|
| Dimensions | 64.0 x 33.0 x 95.0mm (±0.2mm) / (2.52 x 1.30 x 3.74in) |
| Weight | 400g (±10%) |
| Housing | Rugged Aluminum Alloy |
| Gear Reduction | Durable Hardened Steel with Gear Protection System |
| Ball Bearing | 2 Ball Bearing & 2 Needle Bearing |
| Gear Train Backlash | < 0.5˚ |
| Slip Cluth Release Momentum | >Peak torque +20% |

## 2-3  Environmental Specifications

| | | |
|---|---|---|
| Operation Temperature | -30˚C (-22˚F) +70˚C (+158˚F) | MIL-STD-810G Method 502.5 |
| Storage Temperature | -40˚C (-40˚F) +80˚C (+176˚F) | |
| Humidity | 95% @35˚C ~ 60˚C @300hours | |
| Water & Dust Protected | IP68 | IEC 60529 |
| Variation | Orthogonal Axes : ±X, ±Y, ±Z from 50 ~ 500Hz Duration : Sweep 5min Acceleration 30G Displament : 5mm | MIL-STD-810G 514.6C-VII EN 60068-2-6 |
| Mechanical Shock | Procedure 1 - Functional shock 20g, 11ms,Sawtooth Waveform | MIL-STD-810G 516.6 |
| EMC | - | CISPR 16-1,2 IEC 61000-4-2,4,6 |
| MTBF | >500h | Test Condition Load : 20% of Max Torque 0.5Hz sweep(±60) |

# 3  SG33 Drawing

## 3-1  Dimension
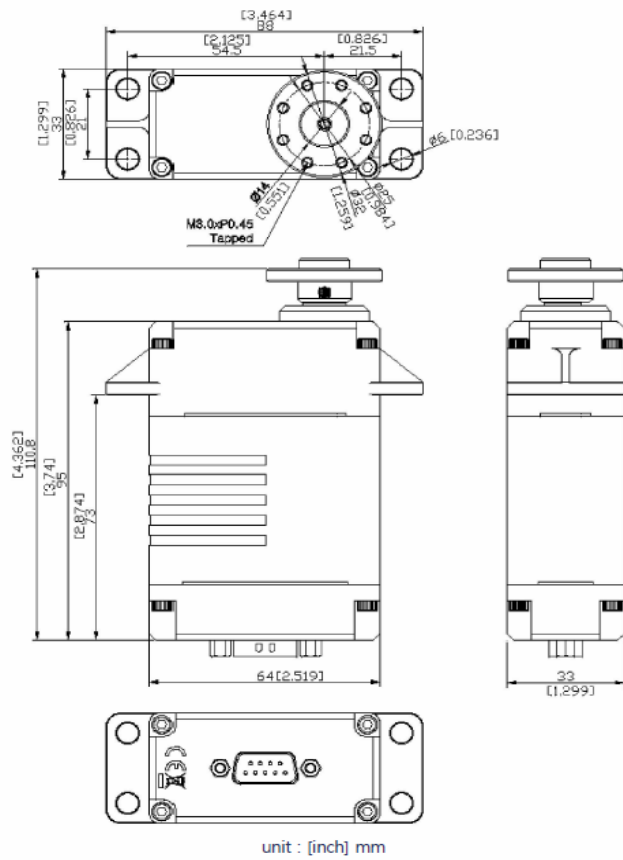


< Dimension >

## 3-2  Connector and Pin Assign
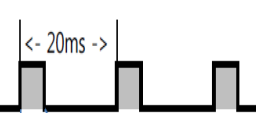


| Pin# | Signal |
|------|--------|
| 1 | RS485 A |
| 2 | RS485 B |
| 3 | Analog Feedback "+" |
| 4 | RPW/TTL |
| 5 | Case GND |
| 6 | V+ |
| 7 | V- |
| 8 | Not connected |
| 9 | Analog Feedback "-" |

<Pin Assign>

# 4 SG33 Analog Control

## 4-1 PWM Control

As a pulse for position control, basically 1500μs is used as a center position and it is controlled from -60° ~ +60° position by 900μs ~ 2100μs pulse value.

| Control Signal type | | - | PWM | |
|---|---|---|---|---|
| PWM Periode | | - | typ. 20ms/50Hz (5ms min) | <- 20ms -> |
| Pulse Width value vs. position(cw mode) | min(left end) | 900us | -60°(±10%) | 900us |
| | neutral(center) | 1500us | 0° | 1500us |
| | max(right end) | 2100us | +60°(±10%) | 2100us |
| | resolution | - | 3us max | |

- If you change the setting value, you can control up to ±90° based on the pulse value from 900μs to 2100μs.

## 4-2 Continuous Rotation Control

As a pulse for rotation, basically 1500μs as a stop reference and the rotation speed can be controlled by the pulse value.

| | | |
|---|---|---|
| 900μs | : | Left direction / Max Speed |
| 1500μs | : | Stop Position |
| 2100μs | : | Right direction / Max Speed |

- When CR bit is set in RED_ACTION_MODE item of Configuration using Protocol controller, Continuous Rotation Mode is operated after the next power reset.

# 5  SG33 Protocol Control

## 5-1  Protocol

When using SG33-Protocol, you can write or read the data on the register of SG33.

SG33 Protocol is using Variable Packet which can change the length depending on parameters. The Packet should be identical with SG3 Protocol Packet Format on this manual.

## 5-2  Communication

Only one line is used as the signal line and it communicates with the external device by Half Duplex method. It supports Simple Mode and Normal Mode Communication method to communicate with an external controller or PC. It can send and receive bi-directional communication and it supports both of "Multi-Drop" which can control several SG33 using only one line and "Single-Drop" which can control SG33 using a single connection method.

## 5-3  Test Configuration

Using DPC-485, you can connect SG33 to PC to control.

(Communication Parameter: Baud rate - 115,200bps, stop bit - 1, parity – none)



**RS-485 Signal Transceiver**

**PC(Controller)**
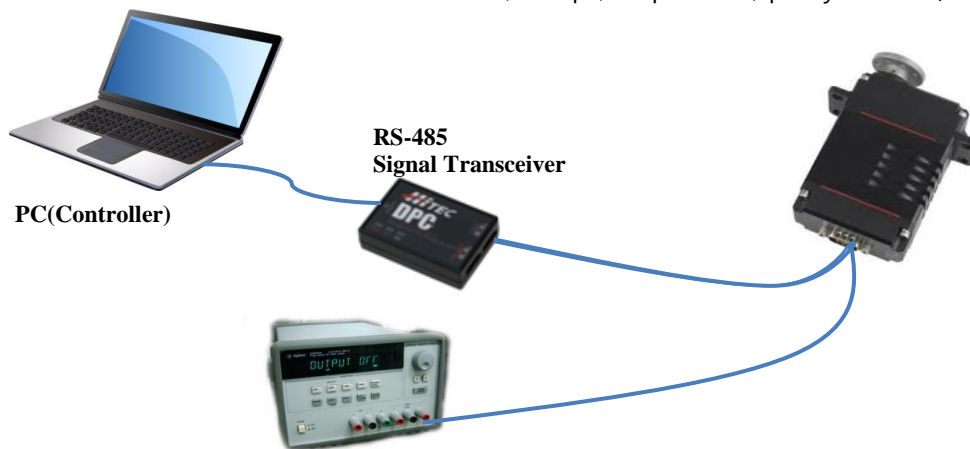
< Typical Test Circuit>

● DPC-485 is a PC interface device that can control SG33 through RS-485 or TTL communication method.

## 5-4  SG33-Protocol Packet Format

Packet Format is divided into 6 areas such as Header, ID, Address, Parameter Length, Parameter, Check Sum as follow.

- Data format - Little Endian
- Check Sum = (ID + Address + REG Length + Data_L + Data_H)%256

- **Normal Write**
- Data write to Servo

| Write Header | ID | Address | REG Length | Data Low | Data High | Check Sum |
|---|---|---|---|---|---|---|
| 0x96 | 0xXX | 0xXX | 0x02 | 0xXX | 0xXX | 0xXX |

- **Normal Read**
- Request a response to SERVO

| Write Header | ID | Address | REG Length | Check Sum |
|---|---|---|---|---|
| 0x96 | 0xXX | 0xXX | 0x00 | 0xXX |

- Response from SERVO

| Return Header | ID | Address | REG Length | Data Low | Data High | Check Sum |
|---|---|---|---|---|---|---|
| 0x69 | 0xXX | 0xXX | 0x02 | 0xXX | 0xXX | 0xXX |

- **Configuration change**
- Data write to SERVO

| Write Header | ID | Address | REG Length | Data Low | Data High | Check Sum |
|---|---|---|---|---|---|---|
| 0x96 | 0xXX | 0xXX | 0x02 | 0xXX | 0xXX | 0xXX |

- Send the save command to the SERVO

| Write Header | ID | Address | REG Length | Data Low | Data High | Check Sum |
|---|---|---|---|---|---|---|
| 0x96 | 0xXX | 0x70 | 0x02 | 0xFF | 0xFF | 0xXX |

### 5-4.1  Header

Packet starts with Byte.

Every Protocol Packet should start with Header Byte.

When writing the data to the register of SG33 by controller, 150(0x96) which is the header byte of write packet is used.

When reading the data from the register of SG33 by controller, the controller uses 150(0x96) which is the header byte of read packet to transmit the Packet, SG33 uses 105(0x69) which is the header byte of return packet to transmit the Packet.

| Header | ID | Address | REG Length | Data Low | Data High | Check Sum |
|--------|----|---------|-----------|----------|-----------|-----------|
|        |    |         |           |          |           |           |

### 5-4.2  ID

It shows Byte which represents the unique ID of SG33 to receive the packet.

The corresponding packet is recognized only in the servo that matches the ID of the packet. Unmatched servos will not respond. ID can be specified from 0 to 255.

| Header | ID | Address | REG Length | Data Low | Data High | Check Sum |
|--------|----|---------|-----------|----------|-----------|-----------|
|        |    |         |           |          |           |           |

● Packets whose ID is set to 0 (0x00) are recognized as the same parameters in all servos regardless of the SG33's unique ID.

### 5-4.3  Address

Register Address Byte.

Registers of SG33 are configured in 2-byte units, and Register Address has Even value.

| Header | ID | Address | REG Length | Data Low | Data High | Check Sum |
|--------|----|---------|-----------|----------|-----------|-----------|
|        |    |         |           |          |           |           |

### 5-4.4  Register Length

A Byte that indicates the length of the parameter contained in the packet.
A Byte that indicates the length of the parameter contained in the packet.
It refers to the number of bytes of data contained in the parameter area where the length can be variably changed among the six areas including the Header, ID, Address, REG Length, Parameter, and CheckSum that make up the Protocol Packet.

| Header | ID | Address | REG Length | Data Low | Data High | Check Sum |
|--------|----|---------|-----------|----------|-----------|-----------|
|        |    |         |           |          |           |           |

● Write Mode

Parameter Length indicates the number of bytes of the following Parameter's Byte.

● Read Mode

If parameter length is '0', it indicates that there is no parameter to be transmitted subsequently. It is used to read the parameter in the register corresponding to the address of the packet.

5-4.5  **Data**

The data you want to write to the Register.

When the parameter is [Write Mode], it can have a length from 1 byte to a maximum of 255 bytes.

When the parameter is [Read Mode], it has a length of 0 Byte. In other words, parameter is omitted after Parameter Length in Packet.

When writing or reading 2 Byte Data value to register specified by Address of Packet, follow Little Endian rule as follows. Parameter [0] has 2 bytes of Low Byte and Parameter [1] has High Byte.

| Header | ID | Address | REG Length | **Data Low** | **Data High** | Check Sum |
|---|---|---|---|---|---|---|

5-4.6  **CheckSum**

This is a byte to verify the error of the packet.

If CheckSum does not match, it recognizes as an error packet and does not respond to the corresponding packet.

CheckSum is the lower 1 byte value of the sum of the bytes of all areas excluding the header in the packet.

| Header | ID | Address | REG Length | Data Low | Data High | **Check Sum** |
|---|---|---|---|---|---|---|

- Read Mode CheckSum Calculation

  CheckSum =(ID + Address + Length)% 256

- Write Mode CheckSum Calculation

  CheckSum =(ID + Address + Length +Parameter [0] + Parameter [1])% 256

# 6 SG33 Register

## 6-1Address Table

| Address | | Name | length | R/W | Range | | | Feature |
|---|---|---|---|---|---|---|---|---|
| | | | | | Reset | | max | |
| Product Information | 0x00 | REG_PRODUCT_NO | 2 | r | - | 0 | 65535 | Read the Version Product Number. |
| | 0X02 | REG_PRODUCT_VERSION | 2 | r | - | 0 | 65535 | Read the Version. |
| | 0X04 | REG_FIRMWARE_VERSION | 2 | r | - | 0 | 65535 | Read the Firmware Version. |
| | 0X06 | REG_SERIAL_NO_SUB | 2 | r | - | 0 | 65535 | Read the Sub-Sirial number. |
| | 0X08 | REG_SERIAL_NO_MAIN | 2 | r | - | 0 | 65535 | Read the Main-Serial number. |
| Status | 0x0A | REG_STATUS_FLAG | 2 | r | 0 | 0 | 65535 | Read the System status Flag. |
| | 0x0C | REG_POSITION | 2 | r | - | -33767 | 33767 | Read the Current Position. |
| | 0x0E | REG_VELOCITY | 2 | r | 0 | -4095 | 4095 | Read the Velocity. |
| | 0x10 | REG_TORQUE | 2 | r | 0 | -4095 | 4095 | Read the Torque. |
| | 0x12 | REG_VOLTAGE | 2 | r | 0 | 0 | 4095 | Read the Input Voltage(V). |
| | 0x14 | REG_MCU_TEMP | 2 | r | - | 0 | 4095 | Read the MCU temperature (℃). |
| | 0x16 | REG_MOTOR_TEMP | 2 | r | - | 0 | 4095 | Read the Motor temperature(℃). |
| | 0x1A | REG_WORKING_TIME | 4 | r | - | 0 | $2^{32}$ | Read the Accumulated Operating time(minute). |
| | 0x3C | REG_HUMIDITY | 2 | r | - | 0 | 100 | Read the Current Humidity(%). |
| | 0x40 | REG_HUMIDITY_MAX | 2 | r | - | 0 | 100 | Read the Current Max Humidity(%). |
| | 0x42 | REG_HUMIDITY_MIN | 2 | r | - | 0 | 100 | Read the Current Min Humidity(%). |
| Action | 0x1E | REG_POSITION_NEW | 2 | r/w | - | -32767 | 32767 | Set the new Position. |
| | 0x20 | REG_VELOCITY/TIME_NEW | 2 | r/w | 0 | 0 | 4095 | Set the new Velocity. |
| | 0x22 | REG_TORQUE_NEW | 2 | r/w | 0 | 0 | 4095 | Set the new torque. |
| | 0X24 | REG_360DEG_TURN_NEW | 2 | r/w | 0 | 0 | 2 | Set the 360 °rotation. |
| Config | 0x32 | REG_ID | 2 | r/w | 0 | 0 | 255 | Set the ID. |
| | 0x34 | REG_BAUD_RATE | 2 | r/w | 5 | 0 | 8 | Set the baud rate.(bps). |
| | 0x3A | REG_NORMAL_RETURN_DELAY | 2 | r/w | 20000 | 0 | 65535 | Set the delay time until Return-Packet is transmitted. |
| | 0x46 | REG_POWER_CONFIG | 2 | r/w | 0 | 0 | 65535 | Set the power management control |
| | 0x48 | REG_EMERGENCY_STOP | 2 | r/w | 0 | 0 | 65535 | Set the emergency stop control bit |
| | 0x4A | REG_ACTION_MODE | 2 | r/w | 96 | 0 | 4095 | Set the Action control bit |
| | 0x4C | REG_POSITION_SLOPE | 2 | r/w | 3275 | 0 | 4095 | Set the Position Slope. |
| | 0x4E | REG_DEAD_BAND | 2 | r/w | 0 | 0 | 4095 | Set the Dead-band. |
| | 0x54 | REG_VELOCITY_MAX | 2 | r/w | 4095 | 0 | 4095 | Set the maximum velocity. |
| | 0x56 | REG_TORQUE_MAX | 2 | r/w | 4095 | 0 | 4095 | Set the maximum torque. |
| | 0x58 | REG_VOLTAGE_MAX | 2 | r/w | 1500 | 0 | 4095 | Set the maximum operating Voltage. |
| | 0x5A | REG_VOLTAGE_MIN | 2 | r/w | 400 | 0 | 4095 | Set the minimum operating Voltage. |
| | 0x5C | REG_TEMP_MAX | 2 | r/w | 800 | 0 | 4095 | Set the maximum operating temperature. |
| | 0x5E | REG_TEMP_MIN | 2 | r/w | 0 | 0 | 4095 | Set the minimum operating temperature. |
| | 0x96 | REG_POS_START | 2 | r/w | 0 | -32767 | 32767 | Set the start position. |
| | 0x94 | REG_POS_END | 2 | r/w | 4095 | -32767 | 32767 | Set the end position. |
| | 0XC2 | REG_POS_NEUTRAL | 2 | r/w | 2048 | -32767 | 32767 | Set the neutral Position. |
| | 0X6E | REG_FACTORY_DEFAULT | 2 | r/w | 0 | 0 | 65535 | Restore data to factory default |
| | 0X70 | REG_CONFIG_SAVE | 2 | r/w | 0 | 0 | 65535 | Save changed data in memory. |

### 6-2  Product Information

A Register that store product information.

### 6-2.1  REG_PRODUCT_NO

Product Number

The factory production number is 0x00XX.

| Address | length | R/W | Reset | Min | Max |
|---------|--------|-----|-------|-----|-------|
| 0x00 | 2 | R/O | - | 0 | 65535 |

### 6-2.2  REG_PRODUCT_VERSION

Product Version

The factory default Product Version is 0x0001 (Factory default values may change depending on the product version at the time of shipment).

| Address | length | R/W | Reset | Min | Max |
|---------|--------|-----|-------|-----|-------|
| 0x02 | 2 | R/O | - | 0 | 65535 |

### 6-2.3  REG_FIRMWARE_VERSION

Firmware version stored in MCU

Factory default firmware version is 0x0001 (Factory default value can be changed depending on the firmware version at the time of shipment).

| Address | length | R/W | Reset | Min | Max |
|---------|--------|-----|-------|-----|-------|
| 0x04 | 2 | R/O | - | 0 | 65535 |

### 6-2.4  REG_SERIAL_NO_SUB

Unique Serial Number is a sub-Byte.

| Address | length | R/W | Reset | Min | Max |
|---------|--------|-----|-------|-----|-------|
| 0x06 | 2 | R/O | - | 0 | 65535 |

### 6-2.5  REG_SERIAL_NO_MAIN

**Unique Serial Number is a upper-Byte.**

| Address | length | R/W | Reset | Min | Max |
|---------|--------|-----|-------|-----|-------|
| 0x08 | 2 | R/O | - | 0 | 65535 |

## 6-3 Status

A Register that store status information.

### 6-3.1 REG_STATUS_FLAG

This is the current status. When the value of Voltage, Temperature, Torque, Position and etc. is out of maximum and minimum value, Flag is generated for each Bit.

| Address | length | R/W | Reset | Min | Max |
|---------|--------|-----|-------|-----|-------|
| 0x0A | 2 | R/O | 0 | 0 | 65535 |

- Bit 14: Voltage Max Over
- Bit 13: Voltage Min Over
- Bit 11: Temp. Max Over
- Bit 10: Temp. Min Over

### 6-3.2 REG_POSITION

The current position (angle)

Based on the position '0', it can be operated in the range of 8 cycles in clockwise direction and 8 cycles in counterclockwise. The corresponding data value is from -32767 ~ +32767, and as the data value increases by 1, it moves about 0.088°.

| Address | length | R/W | Reset | Min | Max |
|---------|--------|-----|-------|--------|--------|
| 0x0C | 2 | R/O | - | -32767 | +32767 |

- It indicates the current position value which is not related with POS start, End value.

### 6-3.3 REG_VELOCITY

Current Speed

When viewed from the front side, it has a (+) value when it rotates clockwise, and a (-) value when it rotates counterclockwise.

The speed data value represents the position data value moved for 510ms and has a value from -4095 ~ +4095. When the data value is 0, it is in a state of being stopped.

| Address | length | R/W | Reset | Min | Max |
|---------|--------|-----|-------|-------|-------|
| 0x0E | 2 | R/O | 0 | -4095 | +4095 |

- The higher the supply voltage, the higher the maximum speed that SG33 can reach.

### 6-3.4 REG_TORQUE

The Torque applied from the outside.

When viewed from the front, it has positive (+) torque value in the clockwise direction,

and negative (-) torque value in the counterclockwise direction which has a value of - 4095 ~ +4095.

When the data value is 0, no external load is applied to SG33.

| Address | length | R/W | Reset | Min | Max |
|---------|--------|-----|-------|------|------|
| 0x10 | 2 | R/O | 0 | -4095 | +4095 |

### 6-3.5 **REG_VOLTAGE**

This is the voltage value supplied to SG33.

It represents 0.1 V per value 1. If the Register value is 120, the actual supplied voltage is 12V.

| Address | length | R/W | Reset | Min | Max |
|---------|--------|-----|-------|------|------|
| 0x12 | 2 | R/O | - | 0 | +4095 |

### 6-3.6 **REG_MCU_TEMPERATURE**

MCU internal temperature

It represents 0.1˚C per value 1. If the Register value is 200, the actual temperature is 20˚C.

| Address | length | R/W | Reset | Min | Max |
|---------|--------|-----|-------|------|------|
| 0x14 | 2 | R/O | - | 0 | +4095 |

### 6-3.7 **REG_MOTOR_TEMPERATURE**

The temperature of the motor

It represents 0.1˚C per value 1. If the Register value is 200, the actual temperature is 20˚C.

| Address | length | R/W | Reset | Min | Max |
|---------|--------|-----|-------|------|------|
| 0x16 | 2 | R/O | - | 0 | +4095 |

### 6-3.8 **REG_WORKING_TIME**

Cumulative usage time. The value is expressed in minutes.

| Address | length | R/W | Reset | Min | Max |
|---------|--------|-----|-------|------|------|
| 0x1A | 4 | R/O | 0 | 0 | 2^32 |

- **REG_FACTORY_DEFAULT**

    It is not initialized even if it is initialized with a register.

### 6-3.9 **REG_HUMIDITY**

Current humidity which measures in Percent (%)

| Address | length | R/W | Reset | Min | Max |
|---------|--------|-----|-------|------|------|
| 0x3C | 2 | R/O | - | 0 | 100 |

### 6-3.10 REG_HUMIDITY_MAX

Current maximum humidity which measured in Percent (%)

| Address | length | R/W | Reset | Min | Max |
|---------|--------|-----|-------|-----|-----|
| 0x40 | 2 | R/O | - | 0 | 100 |

### 6-3.11 REG_HUMIDITY_MIN

Current minimum humidity which measured in Percent (%)

| Address | length | R/W | Reset | Min | Max |
|---------|--------|-----|-------|-----|-----|
| 0x42 | 2 | R/O | - | 0 | 100 |

## 6-4  Action

Register to operate SG33

### 6-4.1  REG_POSITION_NEW

Move to the new position (angle).

Based on the position '0', it can be operated in the range of 8 cycle in clockwise direction and 8 cycle in counterclockwise. The corresponding data value is from -32767 ~ +32767, and as the data value increases by 1, it moves about 0.088°.

| Address | length | R/W | Reset | Min | Max |
|---------|--------|-----|-------|-----|-----|
| 0x1E | 2 | R/W | - | -32767 | +32767 |

- **REG_POS_START** & **REG_POS END**

    Only move between register values.

- **REG_ACTION_MODE**

    Depending on the Acceleration mode setting of the register, acceleration / deceleration movement or constant speed movement can be selected.

- Acceleration Enable (Acceleration / Deceleration Movement)

    **REG_POSITION_NEW** If you move to the register, you will be able to move smoothly by acceleration at start and at deceleration at stop. Especially, in Acceleration Enable state, acceleration / deceleration through speed can be performed without changing the torque. So, even if there is a large load torque, it can be moved more accurately to the desired position.

- Acceleration Disable (Constant Movement)

    When moving through REG_PORISION_NEW, it moves at the same speed when starting and stopping.

6-4.2 **REG_VELOCITY/TIME_NEW**

Set the travel speed or travel time.

During the position move, it moves to set the mode which selected between Velocity Mode and Time M

| Address | length | R/W | Reset | Min | Max |
|---------|--------|-----|-------|-----|------|
| 0x20 | 2 | R/W | 0 | 0 | +4095 |

● **REG_ACTION_MODE** Depending on the Velocity/Time mode setting of register, you can select time mode movement and velocity mode movement.

● The initial value when the power is reset is 0.


● Velocity Mode:

> If you change the position, as REG_VELOCITY/TIME_NEW by moving at the speed set in the register, you can achieve smooth movement without any rapid change in speed. The speed data value indicates the position data value moved for 510ms and has a value from 0 to 4095. If the data value is 0, it does not work. If the speed value is higher than the maximum speed of the motor performance, it moves at the maximum speed.


● Time Mode:

> If you change the position, it will move for the time set in REG_VELOCITY / TIME_NEW register, so you can drive multiple servos synchronously. If several servos are driven like a robot, you can start moving the position at the same time and end the position movement at the same time to realize synchronized movement.
> After setting all connected SG33 to Time Mode and setting the same time data value in REG_VELOCITY / TIME_NEW register, all servos will end movement at the same time, and movements of robot can be realized more smoothly. The data value can be set in units of 1ms and has a value from 0 to 4095. When the value is 0, it operates at the maximum speed and 4095 does not work.


6-4.3 **REG_TORQUE_NEW**

Set a new torque.

It can be set to the data value of 0 ~ 4095.

If the data value is 0, it does not work. If the data value is 4095, this is the maximum torque that can be operated at the current supply voltage.

| Address | length | R/W | Reset | Min | Max |
|---------|--------|-----|-------|-----|------|
| 0x22 | 2 | R/W | 0 | 0 | 4095 |

● The initial value is 0 when the power is reset.

### 6-4.4 **REG_360DRG _TURN_NEW**

Set to rotate 360°.

Speed control is not performed at 360°. Torque can be used to adjust the speed. POSITION_NEW Register takes precedence over TURN Register. In other words, if a new value is written to the REG_POSITION_NEW Register while 360° is being rotated, 360° rotation stops and stops at the position written in OSITION_NEW Register. At this time, the value of TURN Register changes to 0.

| Address | length | R/W | Reset | Min | Max |
|---------|--------|-----|-------|-----|-----|
| 0x24 | 2 | R/W | 0 | 0 | 2 |

- Bit 0: It is not rotating.
- Bit 1: Rotating clockwise.
- Bit 2: Rotating counterclockwise.

## 6-5 Configuration

Register that set the operating environment of the servo. Configuration Data can be saved and initialized.

### 6-5.1 **REG_ID**

Set the ID.

Set the ID.If multiple SG33s are connected by the same signal line, the ID must be assigned a unique value. Only the SG33 that matches the ID of the packet will recognize the corresponding packet. Unmatched SG33 will not respond.ID can be specified from 0 to 255.

| Address | length | R/W | Reset | Min | Max |
|---------|--------|-----|-------|-----|-----|
| 0x32 | 2 | R/W | 0 | 0 | 255 |

- If REG_ID is changed, it operates with changed ID from the next power reset.
- Packets specified as 0 (0x00) and 255 (0xFF) are recognized by all SG33s regardless of their unique ID.

### 6-5.2 **REG_BAUDRATE**

Set baud rate.

Support communication speed up to 229k bps from the minimum of 9.6K bps.

| Address | length | R/W | Reset | Min | Max |
|---------|--------|-----|-------|-----|-----|
| 0x32 | 2 | R/W | 5 | 0 | 8 |

| REG_BAUDRATE | Baud Rate |
|:---:|:---:|
| 0 | 9600 |
| 1 | 14400 |
| 2 | 19200 |
| 3 | 38400 |
| 4 | 54600 |
| 5 | 115200 |
| 6 | 229800 |

● If REG_BAUDRATE is changed, it operates at the communication speed changed from the next power reset.

### 6-5.3 REG_NORMAL_RETURN_DELAY

Set the delay time from when Read Packet is received until when Return Packet is transmitted. After receiving Read Packet, it sends Return Packet after the delay time set in REG_NORMAL_RETURN_DELAY Register. The REG_NORMAL_RETURN_DELAY value can be set in units of 1 ms.

| Address | length | R/W | Reset | Min | Max |
|:---:|:---:|:---:|:---:|:---:|:---:|
| 0x3A | 2 | R/W | 20000 | 0 | 65535 |

● After the Read Packet is transmitted, the normal return packet can be received only after changing the controller's signal line from Output (MCU TX Enable / MCU RX Disable) to Input (MCU TX Disable / MCU RX Enable) within REG_NORMAL_RETURN_DELAY time.

### 6-5.4 REG_POWER_CONFIG

Set the power management method.

| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 |
|:---:|:---:|:---:|:---:|:---:|:---:|:---:|:---:|
| Reserved | | | | | | Emg Stop On | Reserved |

| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|:---:|:---:|:---:|:---:|:---:|:---:|:---:|:---:|
| Reserved | | | | | | Torque On/off | Reset |

● 15~10 Bit:      Reserved – Not in use.
Always 0.

| Address | length | R/W | Reset | Min | Max |
|:---:|:---:|:---:|:---:|:---:|:---:|
| 0x46 | 2 | R/W | 0 | 0 | 65535 |

● 9 Bit: Emg      Stop On – Use Emergency
stop

0: Emergency stop OFF

1: Emergency stop ON

● 1 Bit: Torque On/off – Enable/Disable Torque

0: Torque Disable

1: Torque Enable (Automatically On when Torque New value

is 1 or more)
- 0 Bit: Reset          – Power Config Reset

    0: Reset Off

    1: Reset On (Power Config value is initialized to 0 when setting)

### 6-5.5  REG_EMERGENCY_STOP

Set Emergency Stop occurrence condition according to internal status.

When the bit is set to '1', if a flag corresponding to each item occurs in the Status Flag Register, the TORQUE_NEW register value is changed to 0 and stopped.

- If Emergency Stop occurs, correct the status and then write the normal torque value to the TORQUE_NEW Register to operate again.
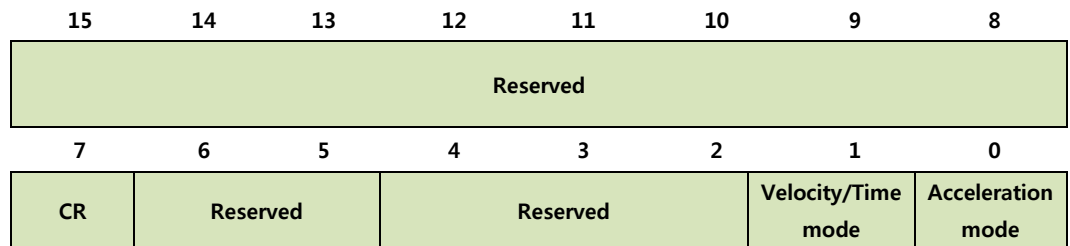
| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 |
|---|---|---|---|---|---|---|---|
| Reserved | Voltage Max over | Voltage Min over | Reserved | Temp. Max over | Temp. Min over | Reserved | |

| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|
| Reserved | | | | | | | |

| Address | length | R/W | Reset | Min | Max |
|---|---|---|---|---|---|
| 0x48 | 2 | R/W | 0 | 0 | 65535 |

- 15 Bit: Reserved          – Not in Use. Always 0.
- 14 Bit: Voltage Max over – Set to 1, if the supply voltage is higher than the set maximum voltage.
- 13 Bit: Voltage Min over – Set to 1, if the supply voltage is lower than the set minimum voltage.
- 11 Bit: Temp. Max over – Set to 1, if the internal temperature is higher than the set maximum temperature.
- 10 Bit: Temp. Min over – Set to 1, if the internal temperature is higher than the set minimum temperature.

6-5.6  **REG_ACTION_MODE**

Set the operation mode.

| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 |
|----|----|----|----|----|----|----|----|
| Reserved | | | | | | | |
| **7** | **6** | **5** | **4** | **3** | **2** | **1** | **0** |
| CR | Reserved | | Reserved | | | Velocity/Time mode | Acceleration mode |

| Address | length | R/W | Reset | Min | Max |
|---------|--------|-----|-------|-----|-----|
| 0x4A | 2 | R/W | 0 | 0 | 65535 |

- 15~8Bit: Reserved – Not in use. Always 0
- 7 Bit: CR            – Set Continuous Rotation Mode

    0: Continuous Rotation Mode Disable

    1: Continuous Rotation Mode Enable

- 6~5 Bit: Reserved – Not in use. But, always 1
- 1 Bit: Velocity/Time mode – Set Velocity/Time Mode.

    0: Velocity mode

    1: Time mode

- 1 Bit: Acceleration mode – Enable/Disable Acceleration.

    0: Acceleration Disable (Constant Velocity Movement)

    1: Acceleration Enable

6-5.7  **REG_POSITION_SLOPE**

It sets the torque state when it reaches the target point. If the position slope is large, it maintains a large torque near the target point. If the position slope is small, a small torque is maintained near the target point. By properly using the position slope, you can obtain a shock absorbing effect smoothly without stopping when reaching the target point.



<REG_POSITION_SLOPE is small >     <REG_POSITION_SLOPE is large>
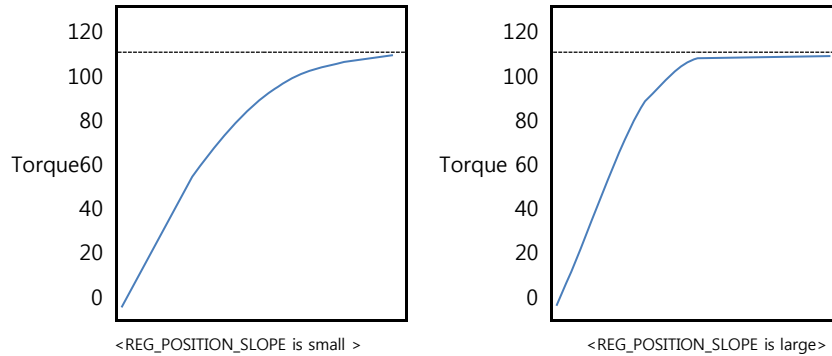
| Address | length | R/W | Reset | Min | Max |
|---------|--------|-----|-------|-----|-----|
| 0x4C | 2 | R/W | 4095 | 0 | 4095 |

- If there is a load torque, setting REG_POSITION_SLOPE to a large value may cause vibration.

6-5.8  **REG_POSITION_DEADBAND**

Set the section that does not control the position near the target point. If the dead band is greater than 0, keep the torque at zero for the ± deadband interval at the target point. When the dead band value changes by 1, the actual angle changes by about 0.088 degrees.

| Address | length | R/W | Reset | Min | Max |
|---------|--------|-----|-------|-----|-----|
| 0x4E | 2 | R/W | 2 | 0 | 4095 |

- **REG_POSITION_DEADBAND** If the value is set to 2 or less, vibration may occur. Set to a value greater than 2.

6-5.9  **REG_VELOCITY_MAX**

Set the maximum speed. The data value represents the position data value moved for 510ms and has a value from 0 to 4095.The higher the supply voltage, the higher the maximum speed that can be drawn.

| Address | length | R/W | Reset | Min | Max |
|---------|--------|-----|-------|-----|-----|
| 0x54 | 2 | R/W | 4095 | 0 | 4095 |

- It does not work, if the maximum speed data value is 0.
- The set value may differ depending on SG33's characteristic difference (gear ratio, input power, etc.).

### 6-5.10 **REG_TORQUE_MAX**

Set the maximum torque that can be output.

The value can be set from 0 to 4095.

| Address | length | R/W | Reset | Min | Max |
|---------|--------|-----|-------|-----|-----|
| 0x56 | 2 | R/W | 4095 | 0 | 4095 |

- It does not work, if the maximum torque data value is 0.
- Even if Torque New value is higher than Torque max value, it has torque value of Max value.

### 6-5.11 **REG_VOLTAGE_MAX**

Set the maximum voltage that can operate.

It represents 0.1 V per 1 register value. If the value is 120, the actual supply voltage is 12V.

| Address | length | R/W | Reset | Min | Max |
|---------|--------|-----|-------|-----|-----|
| 0x58 | 2 | R/W | 1500 | 0 | 4095 |

- The operating voltage is 9.0V to 15.0V (recommended 12.0V). The higher the voltage, the more the internal motor may be damaged. Use within the recommended voltage range.

### 6-5.12 **REG_VOLTAGE_MIN**

Set the minimum voltage that can operate.

It represents 0.1 V per 1 register value. If the value is 120, the actual supply voltage is 12V.

| Address | length | R/W | Reset | Min | Max |
|---------|--------|-----|-------|-----|-----|
| 0x5A | 2 | R/W | 400 | 0 | 4095 |

- The operating voltage is 9.0V to 15.0V (recommended 12.0V). The higher the voltage, the more the internal motor may be damaged. Use within the recommended voltage range.

### 6-5.13 **REG_TEMP._MAX**

Set the maximum internal temperature that can operate. It can be set to 0.1 ℃ per data value. o set the temperature to 70 ° C, the data value is 700.

| Address | length | R/W | Reset | Min | Max |
|---------|--------|-----|-------|-----|-----|
| 0x5C | 2 | R/W | 0x0320 | 0 | 4095 |

- The factory default maximum internal temperature is 70 ℃. If the internal temperature rises, internal circuits and motors may be damaged. It is recommended to set the maximum internal temperature below 70 °.

### 6-5.14 REG_TEMP._MIN

Set the minimum internal temperature that can operate. It can be set to 0.1 ℃ per data value.

| Address | length | R/W | Reset | Min | Max |
|---------|--------|-----|--------|-----|------|
| 0x5E | 2 | R/W | 0x0320 | 0 | 4095 |

### 6-5.15 REG_POS_START

Set the position value at which the position begins.

Based on the position '0', it can be operated in the range of 8 cycle in clockwise direction and 8 cycle in counterclockwise. The corresponding data value is from -32767 ~ +32767, and as the data value increases by 1, it moves about 0.088°.

| Address | length | R/W | Reset | Min | Max |
|---------|--------|-----|-------|--------|--------|
| 0x96 | 2 | R/W | 0 | -32767 | +32767 |

- **REG_POSITION_NEW** A value lower than the REG_POS_START value does not work when controlling the position with register.

### 6-5.16 REG_POS_END

Sets the position value at which the position ends.

Based on the position '0', it can be operated in the range of 8 cycles in clockwise direction and 8 cycles in counterclockwise. The corresponding data value is from -32767 ~ +32767, and as the data value increases by 1, it moves about 0.088°.

| Address | length | R/W | Reset | Min | Max |
|---------|--------|-----|-------|--------|--------|
| 0x94 | 2 | R/W | 4095 | -32767 | +32767 |

- **REG_POSITION_NEW** A value higher than REG_POS_END value does not work when controlling the position with register.

### 6-5.17 REG_POS_NEUTRAL

Set the middle value between start position and end position.

The corresponding data value is from -32767 ~ +32767, and as the data value increases by 1, it moves about 0.088°.

| Address | length | R/W | Reset | Min | Max |
|---------|--------|-----|-------|--------|--------|
| 0xC2 | 2 | R/W | 2048 | -32767 | +32767 |

- Although it is possible to set the value arbitrarily, it is recommended to set it to the middle value between the start and end positions, since it may affect the control in PWM and CR mode.

### 6-5.18 REG_FACTORY_DEFAULT

Return the Register value to the factory default. If you write 5397 (0x1515) to the Register, all Configuration Register values will be returned to the factory defaults. If you want to keep the initial factory state even after power reset, you have to save all values of Configuration Register to Flash ROM by using REG_CONFIG_SAVE register.

| Address | length | R/W | Reset | Min | Max |
|---------|--------|-----|-------|-----|-------|
| 0x63    | 2      | R/W | 0     | 0   | 65535 |

- Data Value 5397(0x1515) : Factory Default
- When returning to the initial factory state, all configuration register values changed by the user will be cleared. Please be careful to use.

### 6-5.19 REG_CONFIG_SAVE

Save the configuration register change value to the Flash ROM. Even if configuration register value is changed, it returns to the previous state after power is reset. If you want to keep the changed state even after power reset, you must save the Configuration Register to Flash ROM. If 0xFFFF is written to the register, all the currently set Configuration Register values are stored in the Flash ROM and the current status can be maintained even after power reset.

| Address | length | R/W | Reset | Min | Max |
|---------|--------|-----|-------|-----|-------|
| 0x70    | 2      | R/W | 0     | 0   | 65535 |

- Data Value 65535(0xFFFF): Save Configuration register value
- All previously saved Flash ROM Configuration Register values will be erased and cannot be recalled. Please be careful to use.