This manual only covers starting from CAN FW Ver 1.4 and up to Ver 2.3(5).

Manual: CAN Servo Control Protocol

CAN 2.0 A/B, DroneCAN

Rev 2.5_EN

HITEC RCD, INC.

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1 CAN Servo Control Protocol

1-1 Servo Control

The CAN servo is controlled by internal register values. You can control the servo by changing the register values or check the servo's status by reading the register values.

1-2 Communication System: CAN

CAN communication is a multi-master network, and all CAN controllers sharing a communication bus can act as a Master. CAN communication is resistant to noise by the Differential communication method using a two-wire twisted pair. It supports standard CAN (2.0 A) and extended CAN (2.0 B) and can communicate at speeds up to 1Mbps (ISO11898).

1-3 Test Configuration

You can change and check the settings of the CAN Servo by connecting DPC-CAN or DPC-20 to a PC. (COM port: Baud rate - 115,200bps, stop bit - 1, parity – none)

1-4 CAN ID, DATA combination

For CAN ID, use the value of Servo ID2 or 0 (Broadcast). Initially, ID2 is not set, so 0 should be used. Configure CAN DATA according to the message format for writing or reading the register.

CAN ID = Target ID2 = 0(Broadcast) or ID2 of Servo

CAN DATA = Write / Read Register Message or ETC

1-5 CAN DATA: Write/Read Register Message (Recommended)

The Data Length and Checksum fields were removed from the old Write/Read Register Message, and the functionality was extended with Message ID.

It is recommended to use this message format in TURN MODE.

Write 2 x Registers (Position New, Turn New)

Read 2 x Registers (Position, Turn Count)

Read 32 bit data (32bit position)

This format is divided into 4 areas, Message ID, Servo ID, Address A / B, DATA A / B as follows.

Write Register Message:

- Write 1 register value to Servo

Message ID 'w' (LowerCase)	Target Servo ID 0xHL	Address 0xHL	Data Low 0xHL	Data High 0xHL

- Write 2 registers to Servo

Message ID 'W' (UpperCase)	Target Servo ID 0xHL	Address A 0xHL	Data Low A 0xHL	Data High A 0xHL	Address B 0xHL	Data Low B 0xHL	Data High B 0xHL

NOTE: If you use 'x' or 'X' instead of 'w' or 'W', CAN Servo processes the read after writing. In other words, it sends a Return after writing.

Read Register Message:

- Request a register to Servo

Message ID 'r' (LowerCase)	Target Servo ID 0xHL	Address 0xHL

- Response from Servo

Message ID 'v' (LowerCase)	Return Servo ID 0xHL	Address 0xHL	Data Low 0xHL	Data High 0xHL

- Request 2 registers to Servo

Message ID 'R' (UpperCase)	Target Servo ID 0xHL	Address A 0xHL	Address B 0xHL

- Response from Servo

Message ID 'V' (UpperCase)	Return Servo ID 0xHL	Address A 0xHL	Data A Low 0xHL	Data A High 0xHL	Address B 0xHL	Data B Low 0xHL	Data B High 0xHL

1-5.1 **Message ID**

The start byte of the message. Message ID values are identified by the characters 'w', 'W', 'x', 'X', 'r', 'R', 'v' and 'V'.

1-5.2 **Target Servo ID**

The servo will execute the command if this value is 0 or matches its own ID1.

1-5.3 **Return Servo ID**

This is the ID1 value of the servo.

1-5.4 **Address**

Register Address Byte.

The registers of the servo are configured in 2-byte units.

1-5.5 **Data**

The data you want to write to the Register.

Data is 2 bytes or 2x2 bytes and follows Little Endian rules.

Data = Data High x 256 + Data Low.

1-6 CAN DATA: OLD Write/Read Register Message (Not Recommended)

The format used initially contains the length of the data and the checksum of the message.

Checksum is calculated as follows:

- Check Sum = (ID + Address + REG Length + Data Low + Data High) & 0xFF
- Data format: Little Endian

OLD Write Register Message:

- Data write to Servo

Write Header 0x96	Target Servo ID 0xHL	Address 0xHL	Data Length 0x02	Data Low 0xHL	Data High 0xHL	Check Sum 0xHL

OLD Read Register Message:

- Request a response to Servo

Write Header 0x96	Target Servo ID 0xHL	Address 0xHL	Data Length 0x00	Check Sum 0xHL

- Response from Servo

Return Header 0x69	Return Servo ID 0xHL	Address 0xHL	Data Length 0x02	Data Low 0xHL	Data High 0xHL	Check Sum 0xHL

1-6.1 Header

All messages begin with a header byte. Packets sent from the controller to the servo begin with 150 (0x96), and packets returned from the servo to the controller begin with 105 (0x69).

1-6.2 Target Servo ID

The servo will execute the command if this value is 0 or matches its own ID1.

1-6.3 Return Servo ID

This is the ID1 value of the servo.

1-6.4 Address

The CAN Servo is controlled through several registers, each of which has an address.

1-6.5 Data Length

A byte that indicates the length of data in the message

1-6.6 **Data**

Data follows the Little-Endian convention: data low is the low-order byte, and data high is the high-order byte. Data = Data High x 256 + Data Low

Header	Servo ID	Address	Data Length	**Data Low**	**Data High**	Check Sum

1-6.7 **Checksum**

This byte is used to check for message errors. If the checksum does not match, the message is recognized as an error and ignored. The checksum is the smallest 1-byte value among the sum of bytes in all areas of the message, excluding the header.

- Read Message
  - Checksum = (ID + Address + Length) BITAND 0xFF
- Write or Return Message
  - Checksum = (ID + Address + Length + Data Low + Data High) BITAND 0xFF
- NOTE: Does not check this checksum in FW < 1.11.

1-7 T-Message

1-7.1 What is T-Message?

"T-Message" defines how to transmit messages that cannot be sent in a single packet.
When the servo receives, CAN ID = 0x7FE (2.0A). When the servo transmits, CAN ID = 0x7FF (2.0A).
Check the length of the message to be transmitted. If multiple packets are required, add CRC16 value to the end of the message. Split the prepared message into chunks of up to 7 bytes and transmit packets with a TAIL BYTE attached to each packet. The DLC (Data Length Code) of a CAN-FD packet is not clear when it exceeds 8 bytes, so the actual length is put in the first byte. Excluding TAILBYTE, a CAN packet can contain up to 7 bytes (8 – tail byte), and a CAN-FD packet can contain up to 62 bytes (64 – tail byte – first length byte).

Step 1: MSG: ZSid(4), ID2(4), ID1(1), ADDR(1), bit + bits (1), Value(2)
Ex) 'Z', 'S', 'i', 'd', 0x33, 0x22, 0x11, 0x00, 0x77, 0x32, LH, 0x04, 0x03, 0x02, 0x01

Step 2 with CAN 2.0 packet: Since it needs to be sent in two or more packets, CRC16 is added.
Ex) 'Z', 'S', 'i', 'd', 0x33, 0x22, 0x11, 0x00, 0x77, 0x32, LH, 0x04, 0x03, 0x02, 0x01, CL, CH
NOTE: CRC16 Start Value is 0xFFFF.

Step 3 with CAN 2.0 packet: send 3 can packets
CAN ID = 0x7FE, CAN DATA = 'Z', 'S', 'i', 'd', 0x33, 0x22, 0x11, <TAILBYTE>
CAN ID = 0x7FE, CAN DATA = 0x00, 0x77, 0x32, LH, 0x04, 0x03, 0x02, <TAILBYTE>
CAN ID = 0x7FE, CAN DATA = 0x01, CL, CH, <TAILBYTE>

Step 2 with CAN-FD packet: Since it can be sent in one packet, CRC16 is not attached.
Step 3 with CAN-FD packet: send 1 packet, Since it exceeds 8 bytes, enter the length including TAILBYTE in the first byte.
CAN ID = 0x7FE, CAN DATA = 16, 'Z', 'S', 'i', 'd', 0x33, 0x22, 0x11, 0x00, 0x77, 0x32, LH, 0x04, 0x03, 0x02, 0x01, <TAILBYTE>
NOTE: 16 = bytes of 'Z' to TAILBYTE

1-7.2 TAIL BYTE

The TAIL BYTE configuration is as follows:

- Bit 7 = 1 if First Packet
- Bit 6 = 1 if Last Packet
- Bit 5 = 1 if first packet, Toggle bit on each packet
- Bit 4:0 = Stream Seq, 0 – 31, inc 1 on each message (not packet)

1-7.3 **Write / Read Bit(s) of Register Message: FW Ver >= 2.3(4)**

To Servo: CAN ID = 0x7FE (2.0A)

Write bit(s) of Register by ID: ZSid(4), Target ID2(4), Target ID1(1), Address(1), bit(0.5) + bits(0.5), Value(2)
Read bit(s) of Register by ID: ZGid(4), Target ID2(4), Target ID1(1), Address(1), bit(0.5) + bits(0.5)
Write bit(s) of Register by UID: ZSuu(4), UID(16), Address(1), bit(0.5) + bits(0.5), Value(2)
Read bit(s) of Register by UID: ZGuu(4), UID(16), Address(1), bit(0.5) + bits(0.5)

If Target ID2 is 0, the servo ignores the ID2 match condition.
If Target ID1 is 0, the servo ignores the ID1 match condition.
Write and Read: Using ZX instead of ZS handles writes and reads simultaneously.

To Host: CAN ID = 0x7FF (2.0A)

Return bit(s) of Register by ID: ZRid(4), Servo ID2(4), Servo ID1(1), Address(1), bit(0.5) + bits(0.5), Value(2)
Return bit(s) of Register by UID: ZRuu(4), UID(16), Address(1), bit(0.5) + bits(0.5), Value(2)

Bit = 0 - 15
Bits = 1 - 16 (0 is 16)
Bit in lower Nibble (Bit 3:0)
Bits in higher Nibble (Bit 7:4)

1-8 DroneCAN Protocol

The supported DroneCAN data types are:

Data Type	Note
Actuator.ArrayCommand	-
Actuator.Status	-
GetNodeInfo	-
NodeStatus	-
DNA	FW >= 1.6(2), >= 2.0
Param Service	FW >= 2.0
FW Update	FW >= 2.0

In FW versions below 1.6(2), RUN_MODE is ignored and operates in Servo Mode.
In FW 1.6(2) or later, RUN_MODE is not ignored and operates in the set mode.

For more detailed information, refer to the DroneCAN protocol documents below:

https://legacy.uavcan.org/Specification/7._List_of_standard_data_types/
https://legacy.uavcan.org/Specification/4._CAN_bus_transport_layer/
https://uavcan.org/specification/UAVCAN_Specification_v1.0-beta.pdf - Latest version document.

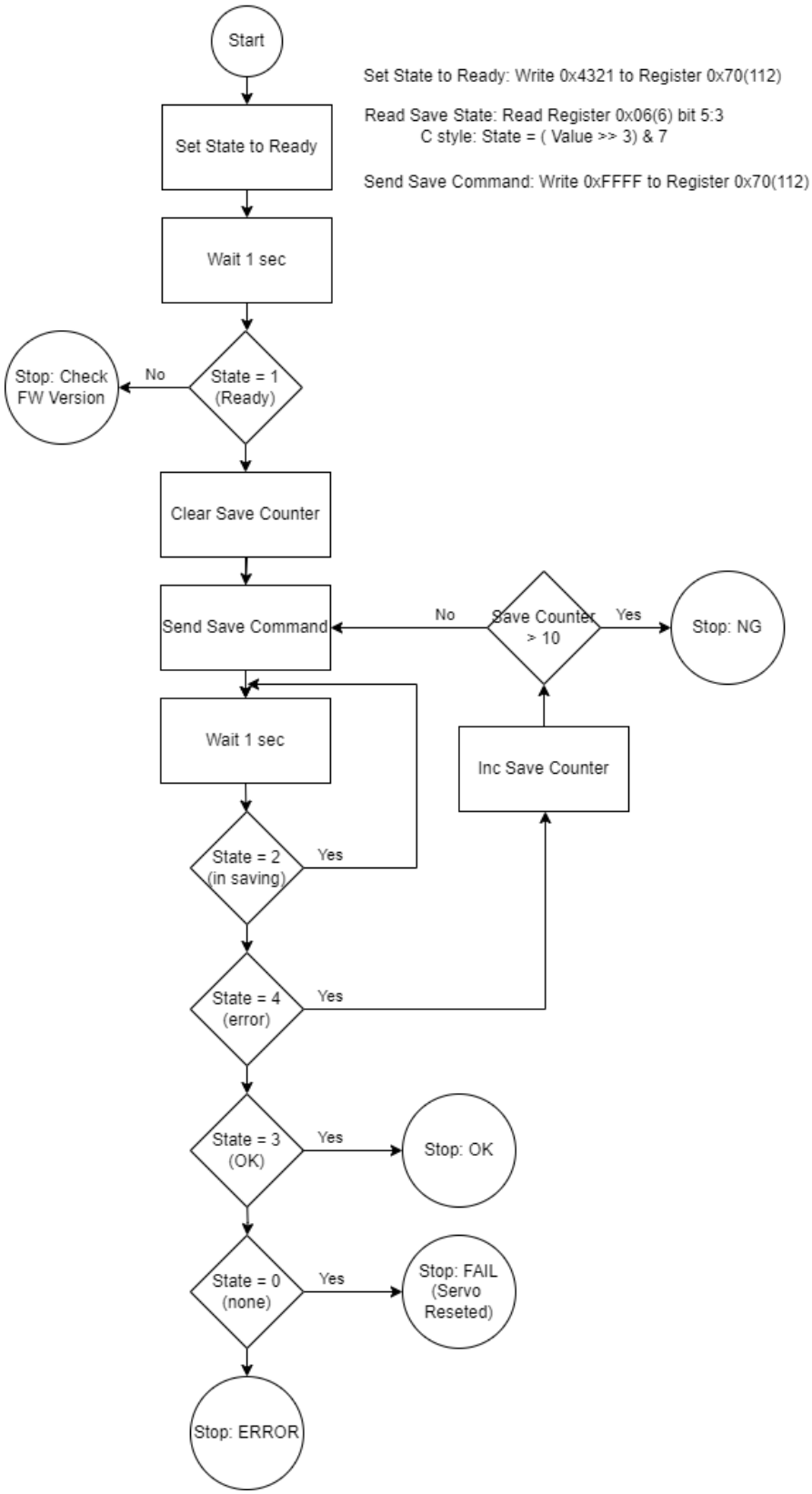
1-9 Save Process

The recommended SAVE procedure is as follows:

- Stop Servo
- Write 0xFFFF to Register 0x70(112) – Save Command
- Wait 1 sec
- Reset the servo
- Check Parameters and Working

1-10 Save Verify Process : FW Ver >= 2.1

In FW Ver 2.1, a confirmation procedure was added during the Save process.



1-11 Stream Style: Sync: FW Ver >= 2.3(3)

Currently, stream transmission is initiated by the servo. The transmission frequency can be set in intervals or Hz. In this case, the transmission settings of each device must be finely adjusted to accommodate increases or decreases in the number of devices or changes in the traffic volume. To improve this, let's consider a way for the host signals the servo that it can send a stream. This method allows the host to control the increase or decrease in the overall traffic volume, and each device only needs to set the level of response based on its importance.

Host side:

- Message To Servo:
  - CAN ID = Target ID2 or 0(Broadcast)
    - CAN DATA = 's', 'y', 'n', 'c' (DLC=4)
  - CAN ID = 0x7FE
    - CAN DATA = 's', 'y', 'n', 'c', TAIL BYTE (DLC=5)

Servo side:

- Register 0x2E (Stream Time)
  - Range: 11001 to 12000
  - C = (Value – 11000)
  - How it works: Transmit the stream every time a SYNC message is received C time(s).

2 CAN Servo Register Sheet

2-1 Address Table

This is the address list of the registers based on FW 1.4 or earlier.

Please note that content added or modified due to the firmware update is also indicated.

Address		Name	len	R/W	Range			Feature	Unit
					Default	min	max		
Status	0x48	REG_EMERGENCY_STOP	2	R	-	0	65535	Bit 6: Voltage Very Low	1 = Very Low
								Bit 7: Voltage Very High	1 = Very High
								Bit 8: Position Emg Min Over	0 = OK, 1 = Over
								Bit 9: Position Emg Max Over	0 = OK, 1 = Over
								Bit 10: MCU temper under error	0 = OK, 1 = Error
								Bit 11: MCU temper over error	0 = OK, 1 = Error
								Bit 13: Volt under error	0 = OK, 1 = Error
								Bit 14: Volt over error	0 = OK, 1 = Error
	0x0C	REG_POSITION	2	R	-	0	16383	Read the Position.	4096=90°
	0x0E	REG_VELOCITY	2	R	-	0	65535	Read the Velocity.	posdiff/100msec
	0x10	REG_TORQUE	2	R	-	0	4095	Read the Motor PWM Duty.	4095=100%
	0x12	REG_VOLTAGE	2	R	-	0	65535	Read the Input Voltage.	100 = 1.00V
	0x14	REG_MCU_TEMPER	2	R	-	-40	105	Read the MCU temperature.	℃
	0x18	REG_TURN_COUNT	2	R (R/W)	-	-32760	32760	Accumulated Turn Count. (R/W is only available : FW >= v1.4)	1 = 360°
	0x1A	REG_32BITS_POSITION_L	2	R	-	0	65535	Read the Accumulated Turn Position High 2 Bytes.	4096=90°
	0x1C	REG_32BITS_POSITION_H	2	R	-	0	65535	Read the Accumulated Turn Position Low 2 Bytes.	1=4 x 360°
	0xC8	REG_TIME_L	2	R	-	0	65535	Read the Servo operation time Low 2 Bytes.	sec
	0xCA	REG_TIME_H	2	R	-	0	65535	Read the Servo operation time High 2 Bytes.	1=65536 sec
	0x74	REG_PRODUCT_NO	2	R	-	0	65535	Read the Servo product number.	-
	0xFC	REG_VERSION	2	R	-	0	65535	Read the Servo version.	-
	0xFE	REG_VERSION	2	R	-	0	65535	Read the Servo version. (Bit Inverse)	-
Status 2	0x16	REG_CURRENT	2	R	-	0	65535	Read the generated Current.	mA
	0xD0	REG_MOTOR_TEMP	2	R	-	-32767	32767	Read the Motor temperature.	Computational reference
	0xD2	REG_TEMP	2	R	-	-32767	32767	Read the internal temperature of the Servo.	Computational reference
	0xD4	REG_HUM	2	R	-	0	32767	Read the internal relative humidity of the servo.	Computational reference
Action	0x1E	REG_POSITION_NEW	2	R/W	-	0	16383	Set New Position.	4096=90°
	0x24	REG_TURN_NEW	2	R/W	-	-32760	32760	Set New Turn (TURN mode only)	1=360°
Comm	0x32	REG_ID1 [In case of DroneCAN]	2	R/W	0	1	255 [127]	Set the SERVO ID. [Set the Actuator ID]	0 is not setted, need Broadcast.
	0x38	REG_CAN_BAUDRATE	2	R/W	0	0	8	Set the baud rate.	0 = 1000 kbps
									1 = 800 kbps
									2 = 750 kbps
									3 = 500 kbps
									4 = 400 kbps

									5 = 250 kbps
									6 = 200 kbps
									7 = 150 kbps
									8 = 125 kbps
	0x3C	REG_ID2_H (CAN_BUS_ID_H) [In case of DroneCAN]	2	R/W	0	0	65535 [0]	Set the CAN ID High 2 Bytes. (2.0A: 0-2047, 2.0B: 0-536870911) [Not used on DroneCAN.]	- [Keep 0]
	0x3E	REG_ID2_L (CAN_BUS_ID_L) [In case of DroneCAN]	2	R/W	0	0	65535 [127]	Set the CAN ID Low 2 Bytes. (2.0A: 0-2047, 2.0B: 0-536870911) [Set the Node ID.] [Add 0x100, if v1.4(2) <= FW < v1.5(1)]	0 is not setted
	0x40	REG_SAMPLE_POINT	2	R/W	1	0	1	Set the CAN Sample Point. 50% is work FW Ver < 1.7 or >= 2.3(2)	0 = 50%,
									1 = 87.5%
	0x6A	REG_CAN_MODE	2	R/W	-	0	2	Select Protocol Type.	0 = 2.0A If FW Type = A or C
									1 = 2.0B If FW Type = A or C
									2 = DroneCAN, if FW Type = A
Mode	0x44	REG_RUN_MODE [In case of DroneCAN]	2	R/W	0	0	3	Set run mode. [Servo MODE is fixed, FW Ver < 1.6(2)]	0: Multi-Turn mode
									1: Servo mode
									2: CR (FW >= 2.0)
									3: Speed (FW >= 2.0) (Experimental)
	0x9A	REG_POS_LOCK_TIME	2	R/W	3	0	5000	Set the time for OLP to operate. (Only Servo Mode)	Sec
	0x9C	REG_POS_LOCK_TORQUE_RATIO	2	R/W	-	0	100	Set torque ratio when OLP operates. (Only Servo Mode)	%
	0xB0	REG_POSITION_MAX_LIMIT	2	R/W	-	-16384	16384	Set the position max limits. (Only Servo Mode)	4096=90°
	0xC2	REG_POSITION_MID	2	R/W	8192	-16384	16384	Set Mid position.	4096=90°
	0xB2	REG_POSITION_MIN_LIMIT	2	R/W	-	-16384	16384	Set the position min limits. (Only Servo Mode)	4096=90°
Option	0x2E	REG_STREAM_TIME	2	R/W	1000	0	12000	Set the Stream Interval. Range: 1 to 10000 Set the Stream Freq. Range: 10001 to 11000 - FW Ver >= 1.4 Stream by Sync: Range: 11001 to 12000 - FW Ver >= 2.3(3)	Interval: value msec Freq: (value – 10000) Hz Sync: (value – 11000)
	0x30	REG_STREAM_MODE	2	R/W	0	0	1	Set the Stream Mode.	0 = Off, 1 = On
	0xE2	REG_STREAM ADDR_0	2	R/W	0	0	65535	Bit 7:0 = Stream Custom 1 Address	-
								Bit 15:8 = Stream Custom 2 Address	
	0xE4	REG_STREAM ADDR_1	2	R/W	0	0	65535	Bit 7:0 = Stream Custom 3 Address	-
								Bit 15:8 = Stream Custom 4 Address	
	0xE6	REG_STREAM ADDR_2	2	R/W	0	0	65535	Bit 7:0 = Stream Custom 5 Address	-
								Bit 15:8 = Stream Custom 6 Address	
	0xE8	REG_STREAM ADDR_3	2	R/W	0	0	65535	Bit 7:0 = Stream Custom 7 Address	-
								Bit 15:8 = Stream Custom 8 Address	
	0x46	REG_POWER_CONFIG	2	R/W	0	0	1536	Bit 10:9 = Forced Emergency Stop	0 = Off

									1= Motor_Free
									2= Speed_Down
									3=Motor_Hold
								Bit 0 = S/W Reset	0 = Off, 1 = Reset
	0x4E	REG_DEADBAND	2	R/W	-	0	4095	Set the Position Dead band.	4096=90°
	0x50	REG_POS_EMG_MAX	2	R/W	-	0	16383	Set the emg maximum position. (0 is inactive)	4096=90°
	0x52	REG_POS_EMG_MIN	2	R/W	-	0	16383	Set the emg minimum position. (0 is inactive)	4096=90°
	0xDA	REG_SPEED_VOLTAGE	2	R/W	-	0	65535	Set the reference voltage for the speed.	100mV (120 = 12.0V)
	0xDC	REG_SPEED_UP	2	R/W	-	0	65535	Set the acceleration time.	msec
	0xDE	REG_SPEED_DN	2	R/W	-	0	65535	Set the deceleration time.	msec
	0xE0	REG_SPEED_ES	2	R/W	-	0	65535	Set the deceleration time in case of an emergency stop.	msec
	0x64	REG_INERTIA_RANGE	2	R/W	1	0	4095	Set the Inertia gain range.	0 = smart sense disable
									1 = smart sense auto
									Gain Range 2 to 4095 (4095=100%)
	0x54	REG_VELOCITY_MAX (SPEED)	2	R/W	-	0	4095	Set the maximum velocity.	posdiff / 100msec 4096=90°
	0x56	REG_TORQUE_MAX	2	R/W	4095	0	4095	Set the maximum torque.	4095=100%
	0x58	REG_VOLTAGE_MAX	2	R/W	-	0	65535	Set the maximum Voltage	10mV (100 = 1.00V)
	0x5A	REG_VOLTAGE_MIN	2	R/W	-	0	65535	Set the minimum Voltage	10mV (100 = 1.00V)
	0x5C	REG_MCU_TEMPER_MAX	2	R/W	-	-30000	30000	Set the MCU maximum Temperature. 0 is inactive	℃
	0x6C	REG_MCU_TEMPER_MIN	2	R/W	-	-30000	30000	Set the MCU minimum Temperature. 0 is inactive	℃
	0xC6	REG_ECHO	2	R/W	0	0	65535	User define Volatile memory.	-
								(It becomes '0' when power is reset.)	
	0xCC	REG_USER_1	2	R/W	0	0	65535	User define Non-volatile memory.	-
	0xCE	REG_USER_2	2	R/W	0	0	65535	User define Non-volatile memory.	-
Current Circuit Model Only	0x26	REG_SPEC_TORQUE	2	R/W	-	0	65535	Set the torque output by measuring the current.	1 = 10mW (9000=90.00W)
	0xD8	REG_CURRENT_MAX	2	R/W	-	0	65535	Set the Max Current.	mA
Drone CAN Only	0x2C	REG_UNITLESS_RAD_MODE	2	R/W	0	0	1	Set the unit of angle for stream mode.	0=unitless
									1=radian
Config	0x6E	REG_FACTORY_DEFAULT	2	W	0	0	65535	Set data to previous or factory default.	3855 = factory default
									65535 = Load User Page
	0x70	REG_CONFIG_SAVE	2	W	0	0	65535	Save changed data in memory.	65535 = Save User Page
NOTE) Yellow Values need SAVE and RESET									

2-2 Additional Address Table

This is the Address list of the registered added due to FW version update.

Address		Name	len	R/W	Range			Feature	Unit
					Default	min	max		
>= 1.4	0x06	REG_STATUS FW Ver < 1.7 only	2	R	-	0	3	Bit 0 : Read the E_STATUS.	0 = Enabled 1 = Disabled
								Bit 1: Read the Over Current state.	0 = Over Current status 1 = Normal status
	0xA6	REG_REF_1	2	R/W	-	0	65535	Referenceable flags Bit 0 = Reg 0xA8 Control: Bit 1 = Start Motor Free Ver >= 2.3(4) or >= 1.6(5) Bit 2 = Fail Safe Motor Free Ver >= 2.3(4) or >= 1.6(5)	Bit 0=1 (Referenceable)
	0xA8	REG_PAD_VOLT	2	R	-	0	65535	PAD voltages	Byte0=PAD volt1 Byte1=PAD volt2
	0xA2	REG_SETUP	2	R/W	-	0	65535	Bit 0: PAD Control Bit 1: Start Position Bit 2: Brake instead of Free (BLDC) Bit 3: Over Volt Brake Bit 7: Stream CAN ID: FW >= v1.5(1) Bit 10: Fail Safe: FW >= v1.5(2) Bit 12: Realtime ID1, ID2: FW >= v2.0 Bit 15: Motor Direction: FW >= v2.1	Keep bits
	0x7A	REG_START_POSITION	2	R/W	0	0	16383	Start Position. Reg 0xA2: bit 1 = needed.	
	0x80	REG_OVERVOLT_BRAKE_VOLTAGE	2	R/W	0	0	65535	Brake Voltage Reg 0xA2: bit 3 = 1 needed.	1000 = 10.00V
>= 1.5	0x20	REG_TMP_CONFIG	2	R/W	0	0	65535	Bit 0 = Pause Stream Must FW >= v1.5	Bit 0 = 1(Paused)
	0x3A	REG_STREAM_CAN_ID_H	2	R/W	0	0	65535	Custom Stream CAN ID, Reg 0xA2: bit 7 = 1 needed. Must FW Ver >= v1.5(1)	Bit 31 = 1 (CAN 2.0B) Bit 31 = 0 (CAN 2.0A)
	0x42	REG_STREAM_CAN_ID_L	2	R/W	0	0	65535		
	0x94	REG_FAIL_SAFE_POSITION	2	R/W	0	0	16383	Fail Safe Position. Reg 0xA2: bit 10 = 1 needed. Must FW Ver >= v1.5(2)	4096=90°
	0xB4	REG_FAIL_SAFE_TIME	2	R/W	0	0	65535	Set the time period for the condition where Fail Safe activates. Reg 0xA2: bit 10 = 1 needed. Must FW Ver >= v1.5(2)	msec
>= 1.6(3)	0xAC	TURN_MULIPLIER FW Ver < 1.7	2	R/W	1	-32760	32760	DroneCAN, Multi-Turn: +/-1.0 x MULTIPLIER	
>= 1.10	0xD0	MOTOR_TEMP	2	R	-	0	4095	ADC Value	
	0xD1	MOTOR_TEMP_DEG	2	R	-	-32768	32767	-40 to +125	°C
	0x5D	MOTOR_TEMP_MAX	2	R/W	0	0	32767	0 is disabled °C Value, if Value <= 32767 ADC Value, if Value >= 32768 - Not recommanded.	°C
	0x6D	MOTOR_TEMP_HYS	2	R/W	0	0	4095	difference in °C	°C
>= 1.11	0x9F	VOLTAGE_VERY_LOW	7:0	R/W	-	0	255		255 = 25.5 V
>= 2.1	0xA0	REG_SETUP_2	2	R/W	-	0	65535	Bit 14:0 = Reserved Bit 15 = Enable SETUP_EX Regs - Must Keep bit if bit is 1 aleady	You must keep reserved bits
	0x41	REG_SETUP_EX_0x41 YOU MUST Reg 0xA0 bit 15 = 1	2	R/W	-	0	65535	Bit 0 = Reserved Bit 1 = Enable TURN_MULTIPLIER Bit 2 = Enable Velocity Target (FW Ver >= 2.3(3)) Bit 15:3 = Reserved	You must keep reserved bits

	0xAC	SETUP_EX/ TURN_MULIPLIER YOU MUST Reg 0x41 bit 1 = 1	2	R/W	1	-32760	32760	DroneCAN, Multi-Turn: +/-1.0 x MULTIPLIER	
>= 1.6(4) >= 2.3(3)	0x60	SETUP_EX/ Velocity Target YOU MUST Reg 0x41 bit 2 = 1	2	R/W	-	0	32767	Velocity Target	

2-3 Status

Registers used to check the status of the servo

2-3.1 REG_EMERGENCY_STOP

The current error states. Items that do not meet the set criteria can be checked with Flag.

15	14	13	12	11	10	9	8
Reserved	Volt Over	Volt Under	Reserved	MCU TEMP Over	MCU TEMP Under	Emg POS Max	Emg POS Min

7	6	5	4	3	2	1	0
OverVolt Brake	Volt Very Low	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved

Address	length	R/W	Default	Min	Max
0x48	2	R	0	0	65535

- Bit 14: Voltage over
- Bit 13: Voltage under
- Bit 11: MCU Temper over
- Bit 10: MCU Temper under
- Bit 9: Pos Emg Max over
- Bit 8: Pos Emg Min under
- Bit 7: Voltage Very High = Over Voltage Brake
- Bit 6: Voltage Very Low
  - 3.8V fixed, or If FW Ver >= 1.11, Reg 0x9F bit 7:0 (255=25.5V)

2-3.2 REG_POSITION

The current position value of CAN Servo and the range is 0 to 16383.

Based on the position '0', it can be operated 360° in clockwise direction.

Address	Length	R/W	Default	Min	Max
0x0C	2	R	-	0	16383

- The resolution is 4096 = 90˚

2-3.3 **REG_VELOCITY**

The current speed (VEL) of the Servo. The unit is posdiff / 100msec. 4096 posdiff = 90°

- Unit is posdiff / msec, if FW Ver < 1.3

It is shown through the following equation.

PT (PID SAMPLE TIME) = Register 0xA4

V = unit: sec / 60°

RPM = VEL x 10 x 90 / 4096 / 360 x 60 / PT x 10

VEL = (1 / (V / 60)) x PT / 10 x 4096 / 90 / 10

If PT = 10

VEL = (about)27.3 x RPM

V =(about)273.06 / VEL

Address	Length	R/W	Default	Min	Max
0x0E	2	R	-	-32767	+32767

Firmware	RPM Calculation	Unit
FW Ver < 1.3	RPM = VELx1000x90/4096/360x60/PTx10	posdiff / msec
FW Ver >= 1.3	RPM = VELx10x90/4096/360x60/PTx10	posdiff / 100msec

2-3.4 **REG_TORQUE**

The Duty of current Motor's PWM. It affects the torque.

Address	Length	R/W	Default	Min	Max
0x10	2	R	0	0	4095

- It outputs 100% Duty at 4095

2-3.5 **REG_VOLTAGE**

The value of current supply voltage.

1200 = 12.00 V

Address	Length	R/W	Default	Min	Max
0x12	2	R	-	0	65535

2-3.6 **REG_MCU_TEMPER**

The internal temperature of MCU. Unit is ℃.

Address	Length	R/W	Default	Min	Max
0x14	2	R	0	-57	196

2-3.7 REG_TURN_COUNT

The current number of rotations.

In case of + 360˚ position, it is +1. In case of -360˚ position, Register value is -1.

Address	Length	R/W	Default	Min	Max
0x18	2	R or R/W	0	-32760	+32760

- Work as R/W, if FW Ver >= 1.4

2-3.8 REG_32BITS_POSITION_L(0x1A), REG_32BIT_POSITION_H(0x1C)

The current position with turn count.

Address	length	R/W	Default	Min	Max
0x1A	2	R	-	0	65535
0x1C	2	R	-	0	65535

- 32 BIT POSITION = 32 BIT POSITION_L + 32 BIT POSITION_H x 65536
- 32 BIT POSITION = REG_POSITION + REG_TURN_COUNT x 16384
- Since atomic processing is required during position changes, "R" and "V" messages are recommended.

2-3.9 REG_TIME_L(0xC8), REG_TIME_H(0xCA)

Operating time after Servo power is turned on or reset

Time = TIME_L + TIME_H x 65536

Unit: second

Address	Length	R/W	Default	Min	Max
0xC8	2	R	-	0	65535
0xCA	2	R	-	0	65535

- Since atomic processing is required, "R" and "V" messages are recommended.

2-3.10 **REG_PRODUCT_NO**

Read the production number of Servo

Address	Length	R/W	Default	Min	Max
0x74	2	R	-	0	65535

2-3.11 **REG_VERSION**

Read the version of Servo, The bitwise inverse of this value must be equal to Reg 0xFE.

Address	Length	R/W	Default	Min	Max
0xFC	2	R	-	0	65535

Bit 15 = 0(New Bootloader >= B2), 1(Old Bootloader = B1)

Bit 14:0 = FW Version = 0 to 32767 = aabbc = x.y(z) = FW Ver a x 1000 + b x 10 + c

Example:

31052 = 1.5(2) /U, if 30000 of more, /U, x = aa - 30

11052 = 1.5(2) /C, if 10000 or more, /C, x = aa - 10

3052 = 1.5(2) /A, if 3000 or more, /A, x = aa - 2

Exception: 2012 = 2.1(2) = 1.1(2) /U

2-3.12 **REG_VERSION(BITWISE_INVERSE)**

Read the version of Servo (bitwise inverse)

Address	Length	R/W	Default	Min	Max
0xFE	2	R	-	0	65535

2-4 Status 2

The registers to check the status of the motor current or temperature.

2-4.1 REG_CURRENT

The current value used by motor. Unit is mA.

Address	Length	R/W	Default	Min	Max
0x16	2	R	0	0	65535

- This function works only for current sensor equipped model only (ex: SG series, MDB950SW)

2-4.2 REG_MOTOR_TEMP

The temperature of the Motor.

The temperature value of the motor can be calculated by the following equation.

T0 = 298.15, VT = 3.3 / 4096 * data

Rt = (10 * VT) / (3.3 - VT)

Temperature(℃) = 1007747 / (log(Rt) * T0 - log(10) * T0 + 3380) - 273.15

Address	Length	R/W	Default	Min	Max
0xD0	2	R	0	-32768	32767

- This function works only for motor temper sensor equipped model only (ex: SG series, MDB950SW)

2-4.3 REG_TEMP

The internal temperature of the Servo.

The temperature value of the Servo can be calculated by the following equation.

Temperature(℃) = 175.72 * data / 65536 - 46.85

Address	Length	R/W	Default	Min	Max
0xD2	2	R	0	-32768	32767

- This function works only for humidity sensor model only

2-4.4 REG_HUM

The relative humidity inside the Servo.

The humidity value of the Servo can be calculated by the following equation.

Humidity(%RH) = 125 * data / 65536 - 6

Address	Length	R/W	Default	Min	Max
0x4D	2	R	0	0	65535

- This function works only for humidity sensor model only

2-5 Action

It is the Register to operate CAN Servo.

2-5.1 REG_POSITION_NEW

Specify a new position for Servo with a resolution of 4096 = 90°

Address	length	R/W	Default	Min	Max
0x1E	2	R/W	-	0	16383

- In Servo Mode, it only can move from the range of POSITION_MIN_LIMIT to POSITION_MAX_LIMIT.

2-5.2 REG_TURN_NEW

Set the number of rotations. The initial value is 0.

If set +1, the servo rotates 360° in the + direction relative to 0.

Address	length	R/W	Default	Min	Max
0x24	2	R/W	0	-32760	32760

- It only operates in TURN Mode.
- It is recommended to send POSITION_NEW and TURN_NEW together using the "W" message.

2-6 Communication Setup

Registers that set the communication environment of the servo.

These settings require save and reset(or power off and on) actions.

2-6.1 REG_ID1

Set the Servo ID or Actuator ID (DroneCAN).

Set to distinguish when using multiple devices.

Mode	Address	length	R/W	Default	Min	Max
CAN 2.0A, B	0x32	2	R/W	0	1	255
DroneCAN				0	1	127

- 0 is the unset value. Broadcasting is required. (Target Servo ID = 0)

2-6.2 REG_BAUDRATE

Set the Baud Rate.

It can support communication speed from at least 125 Kbps up to 1000 Kbps.

Address	length	R/W	Default	Min	Max
0x38	2	R/W	0	0	8

REG_BAUDRATE	Baud Rate
0	1000 Kbps
1	800 Kbps
2	750 Kbps
3	500 Kbps
4	400 Kbps
5	250 Kbps
6	200 Kbps
7	150 Kbps
8	125 Kbps

2-6.3 REG_ID2_H (CAN_BUS_ID_H)

Set higher 16 bits of the CAN ID. In CAN 2.0A / DroneCAN, set this value to 0.

Mode	Address	Length	R/W	Default	Min	Max
CAN 2.0A	0x3C	2	R/W	0	0	0
CAN 2.0B				0	0	8191
DroneCAN				0	0	0

2-6.4 REG_ID2_L (CAN_BUS_ID_L)

Set lower 16 bits of the CAN ID.

Mode	Address	Length	R/W	Default	Min	Max
CAN 2.0A	0x3E	2	R/W	0	0	2047
CAN 2.0B				0	0	65535
DroneCAN				0	0	127

- In CAN 2.0A, it can be specified from 0 to 2047.
- In CAN 2.0B, it is available to designate 0 to 536870911 as ID2 (L+Hx65536)
- ID2 = 0 is the unset value. Broadcasting is required (Target CAN ID = 0)

2-6.5 REG_SAMPLE_POINT

Selects the sampling point ratio of the CAN communication signal.

Address	length	R/W	Default	Min	Max
0x40	2	R/W	0	0	1

- 0 = 50% and 1 = 87.5%
- 0 act as 1, 87.5% only, if FW Ver >= 1.7 and < 2.3(1)

2-6.6 REG_CAN_MODE

Set Protocol Type.

Address	length	R/W	Default	Min	Max
0x6A	2	R/W	-	0	2

- 0 = CAN 2.0, 1 = CAN 2.0B, 2 = DroneCAN
- If the FW type is C, 2 act as 0 (No DroneCAN)
- If the FW type is U, this register will be ignored.

2-7 MODE

This Register is used to set RUN MODE of Servo. Each item can be applied at reset or immediately. To apply it after a reset, you must save.

2-7.1 REG_RUN_MODE

Select SERVO MODE or Multi-Turn MODE of CAN Servo.

In DroneCAN, RUN MODE setting is ignored in FW < 1.6(2) and operates in Servo Mode.

This setting requires saving and resetting.

Address	length	R/W	Default	Min	Max
0x44	2	R/W	1	0	3

- 0= Multi-Turn MODE, 1= SERVO MODE, 2= CR MODE, 3 = Speed MODE

- **SERVO MODE**

  SERVO MODE controls the servo within a range of 0 to 360 degrees

  By using REG_POSITION_MIN_LIMIT and REG_POSITION_MAX_LIMIT, you can adjust the angle of Servo.

- **Multi-Turn MODE**

  Multi-Turn MODE is the mode to control until ±32760 turns.

  By using REG_TURN_NEW, you can adjust the number of turns. And also, by using REG_POSITION_NEW, you can adjust the position. After reset, the position becomes 0. (not 8192)

- **CR MODE – FW Ver >= v2.0**

  This is continuous rotation mode. It specifies only the motor direction and output. Actual rotation speed may vary depending on external load.

  POSITION_MIN_LIMIT, POSITION_MAX_LIMIT values become duty -100%, +100%.

- **Speed MODE (Experimental) – FW Ver >= v2.0**

  This is continuous rotation mode. Adjusts the output to the specified speed. The motor output varies according to the load to keep the rotational speed constant.

  The speed set in Reg 0x54 VELOCITY MAX. Set the speed at which the motor can actually operate. 32767 should be considered as infinity (Not recommanded).

2-7.2 **REG_POS_LOCK_TIME**

Set the operation time, when CAN Servo is in OLP condition. 1 = 1 second. If you set 3, OLP will be activate when CAN Servo is being in OLP condition over 3 seconds.

Address	length	R/W	Default	Min	Max
0x9A	2	R/W	3	0	5000

- At 0, OLP is activate all the time.
- In multi-rotation mode it operates at FW >= 2.3(3).

2-7.3 **REG_POS_LOCK_TORQUE_RATIO**

Set the Torque when OLP is activate.

The torque is output as much as the percentage of the currently set torque.

0 = 0% and 100 = 100%.

Address	length	R/W	Default	Min	Max
0x9C	2	R/W	100	0	100

- In multi-rotation mode it operates at FW >= 2.3(3).

2-7.4 **REG_POSITION_MAX_LIMIT**

Set the maximum position that can be operated.

The resolution: 4096 = 90°.

Address	length	R/W	Default	Min	Max
0xB0	2	R/W	10922	-16384	16384

- If the value of REG_POSITION_NEW is set higher than REG_POSITION_MAX_LIMIT, it does not move.
- REG_POSITION_MAX_LIMIT should be set higher than REG_POSITION_MIN_LIMIT value.

2-7.5 **REG_POSITION_MID**

Set the center value of the position that can be operated.

It acts as a zero point in states such as CR or Speed mode. Also referenced in DroneCAN.

Resolution of data: 4096 = 90°

Address	length	R/W	Default	Min	Max
0xC2	2	R/W	8192	-16384	16384

- It should be set to the center value between REG_POSITION_MAX_LIMIT and REG_POSITION_MIN_LIMIT.

2-7.6 **REG_POSITION_MIN_LIMIT**

Set the minimum position that can be operated.

The resolution = 4096 = 90°.

Address	length	R/W	Default	Min	Max
0xB2	2	R/W	5462	-16384	16384

- If the value of REG_POSITION_NEW is set lower than REG_POSITION_MIN_LIMIT, it does not move.
- REG_POSITION_MIN_LIMIT should be set lower than REG_POSITION_MAX_LIMIT value.

2-8 Option

Register to set Servo function. Most of these values take effect immediately. If not saved, they will revert to their previous values upon reset.

2-8.1 REG_STREAM_TIME

Set the time of the stream.

Address	length	R/W	Default	Min	Max
0x2E	2	R/W	1000	0	12000

- Period Mode : 0 to 10000 ms
- Frequency Mode : 10001 to 11000 = (Value-10000) Hz, FW Ver >= v1.4(2)
- Sync Mode : 11001 to 12000 = (Value – 11000) Count, FW Ver >= 2.3(3)

2-8.2 REG_STREAM_MODE

Set STREAM ON / OFF.

Address	length	R/W	Default	Min	Max
0x30	2	R/W	0	0	1

- 0 = off, 1 = on

2-8.3 REG_STREAM_ADDR_0

Set the desired addresses when outputting in Stream Mode.

Address	length	R/W	Default	Min	Max
0xE2	2	R/W	0	0	65535

- Bit 7:0 = Address of Stream Custom 1
- Bit 15:8 = Address of Stream Custom 2
- Applicable only when the servo is CAN2.0A or CAN2.0B

2-8.4 REG_STREAM_ADDR_1

Set the desired addresses when outputting in Stream Mode.

Address	length	R/W	Default	Min	Max
0xE4	2	R/W	0	0	65535

- Bit 7:0 = Address of Stream Custom 3
- Bit 15:8 = Address of Stream Custom 4
- Applicable only when the servo is CAN2.0A or CAN2.0B

2-8.5 REG_STREAM_ADDR_2

Set the desired addresses when outputting in Stream Mode.

Address	length	R/W	Default	Min	Max
0xE6	2	R/W	0	0	65535

- Bit 7:0 = Address of Stream Custom 5
- Bit 15:8 = Address of Stream Custom 6
- Applicable only when the servo is CAN2.0A or CAN2.0B

2-8.6 REG_STREAM_ADDR_3

Set the desired addresses when outputting in Stream Mode.

Address	length	R/W	Default	Min	Max
0xE8	2	R/W	0	0	65535

- Bit 7:0 = Address of Stream Custom 7
- Bit 15:8 = Address of Stream Custom 8
- Applicable only when the servo is CAN2.0A or CAN2.0B

2-8.7 REG_POWER_CONFIG

Set the power management method.

15	14	13	12	11	10	9	8
Reserved					Forced Emergency Stop		Reserved

7	6	5	4	3	2	1	0
Reserved							S/W RESET

Address	length	R/W	Default	Min	Max
0x46	2	W	-	0	65535

- Bit 15:11, 7:1 = Reserved – Do not use.
- Bit 10:9 = Forced Emergency Stop – Use Forced Emergency Stop function
  0: Off
  1: Motor_Free
  (Forced Emergency Stop is turned ON when the motor power is off.)
  2: Speed_Down
  (After Motor Speed decreases (REG_SPEED_ES setting) and stops, the motor goes into the HOLD state and Forced Emergency Stop is turned ON.)
  3: Motor_Hold
  (The motor goes into the Hold state and Forced Emergency Stop is turned ON.)
- Bit 0 = Reset – Software Reset of Servo

2-8.8 **REG_DEADBAND**

Set Dead Band area of Servo.

Address	length	R/W	Default	Min	Max
0x4E	2	R/W	0	0	4095

- If the value is high, Jitter may occur during operation. (20 or less recommended)
- The resolution is 4096 = 90˚

2-8.9 **REG_POS_EMG_MAX**

Set the maximum position value that operates in the normal state.

Data = 0 to 16383 and the resolution of data: 4096 = 90°.

Address	length	R/W	Default	Min	Max
0x50	2	R/W	16383	0	16383

- 0 = disabled
- If the servo movement angle goes out of range, the motor will stop after a while.

2-8.10 **REG_POS_EMG_MIN**

Set the minimum position value that operates in the normal state.

Data = 0 to 16383 and the resolution of data: 4096 = 90°.

Address	length	R/W	Default	Min	Max
0x52	2	R/W	0	0	16383

- 0 = disabled
- If the servo movement angle goes out of range, the motor will stop after a while.

2-8.11 **REG_SPEED_VOLTAGE**

It automatically lowers the maximum speed when the actual voltage falls below this voltage. ex: 120 = 12.0 V

EX) REG_VELOCITY_MAX(SPEED) = 2000, REG_SPEED_VOLTAGE = 120

If REG_VOLTAGE value is 60, the actual maximum speed is applied as 60/120*2000=1000 in voltage proportion and operates.

Address	length	R/W	Default	Min	Max
0xDA	2	R/W	0	0	65535

- 0 = disabled

2-8.12 **REG_SPEED_UP**

Set the Acceleration time in a trapezoidal velocity profile. Unit is msec.

Address	length	R/W	Default	Min	Max
0xDC	2	R/W	0	0	65535

- When set to 0, it changes to the specified speed immediately.

2-8.13 **REG_SPEED_DN**

Set the Deceleration time in a trapezoidal velocity profile. Unit is msec.

Address	Length	R/W	Default	Min	Max
0xDE	2	R/W	0	0	65535

- When set to 0, it changes to the specified speed immediately.

2-8.14 **REG_SPEED_ES**

This is the deceleration time when an emergency stop occurs. Unit is msec.

Address	length	R/W	Default	Min	Max
0xE0	2	R/W	0	0	65535

- When set to 0, it changes to the specified speed immediately.
- It is recommended to set it to less than the normal deceleration time.

2-8.15 **REG_INERTIA_RANGE**

Set the rate when INERTIA occurs in Servo. In the range of 2 to 4095, the ratio of the Gain Range value can be set to 0 to 100% (4095 = 100%), and the Smart Sense that automatically adjusts the ratio can be turned On/Off.

Address	length	R/W	Default	Min	Max
0x64	2	R/W	0	0	4095

- 0 = the Smart Sense is turned OFF, and the Gain value is 100%.
- 1 = the Smart Sense is turned ON to automatically adjust the Gain value.
- **Smart Sense**

  When Servo generates continuous INERTIA due to the load, it reads the average value of the INERTIA and adjust the Gain Range value to prevent INERTIA.

2-8.16 **REG_VELOCITY_MAX(SPEED)**

Set the maximum speed value and its unit is posdiff/100msec. 4096 posdiff = 90°

It is shown through the following equation.

PT (PID SAMPLE TIME) = Register 0xA4

V = unit: sec / 60°

RPM = VEL x 10 x 90 / 4096 / 360 x 60 / PT x 10

VEL = (1 / (V / 60)) x PT / 10 x 4096 / 90 / 10

If PT = 10

VEL = (about)27.3 x RPM

V =(about)273.06 / VEL

Address	Length	R/W	Default	Min	Max
0x0E	2	R/W	-	-32768	+32767

Firmware	RPM Calculation	Unit
FW Ver < 1.3	RPM = VELx1000x90/4096/360x60/PTx10	posdiff / msec
FW Ver >= 1.3	RPM = VELx10x90/4096/360x60/PTx10	posdiff / 100msec

2-8.17 **REG_TORQUE_MAX**

Set the maximum width of the motor PWM duty. 4095 = 100%

Address	length	R/W	Default	Min	Max
0x56	2	R/W	4095	0	4095

2-8.18 **REG_VOLTAGE_MAX**

Set the highest voltage that operates in the normal state. Unit: 1 = 0.01V. 1200 = 12V.

Address	length	R/W	Default	Min	Max
0x58	2	R/W	0	0	65535

- 0 = Off, If the range is exceeded, the motor will stop.

2-8.19 **REG_VOLTAGE_MIN**

Set the lowest voltage that operates in the normal state. Unit: 1 = 0.01V. 1200 = 12V.

Address	length	R/W	Default	Min	Max
0x5A	2	R/W	-	0	65535

- 0 = Off, If the range is exceeded, the motor will stop.

2-8.20 **REG_TEMPER_MAX**

Set the maximum temperature value at which MCU TEMPER operates in a normal state.
Unit: 1 = 1˚C, 20 = 20˚C.

Address	length	R/W	Default	Min	Max
0x5C	2	R/W	0	-32767	32767

- 0 = Off, If the range is exceeded, the motor will stop.

2-8.21 **REG_TEMPER_MIN**

Set the maximum temperature value at which MCU TEMPER operates in a normal state.
Unit: 1 = 1˚C, 20 = 20˚C.

Address	length	R/W	Default	Min	Max
0x6C	2	R/W	0	-32767	32767

- 0 = Off, If the range is exceeded, the motor will stop.

2-8.22 **REG_ECHO**

Any value can be stored. This value is not saved. It will be 0 when the Servo is reset.

Address	length	R/W	Default	Min	Max
0xC6	2	R/W	0	0	65535

2-8.23 **REG_USER_1**

Any value can be stored.

Address	length	R/W	Default	Min	Max
0xCC	2	R/W	0	0	65535

2-8.24 **REG_USER_2**

Any value can be stored.

Address	length	R/W	Default	Min	Max
0xCE	2	R/W	0	0	65535

2-9 Option (Only models with current measurement circuit)

Most of these values take effect immediately. If not saved, they will revert to their previous values upon reset.

2-9.1 REG_SPEC_TORQUE

Set the maximum power of the torque output.

1 = 10mW. 9000 = 90.00 W.

Address	length	R/W	Default	Min	Max
0x26	2	R/W	0	0	65535

2-9.2 REG_CURRENT_MAX

Set the maximum current to limit for products with a current measurement circuit.

1 = 1mA, 10000 = 10A.

Address	length	R/W	Default	Min	Max
0xD8	2	R/W	65535	0	65535

- 0 = Off.

2-10 Option (DroneCAN Only)

Most of these values take effect immediately. If not saved, they will revert to their previous values upon reset.

2-10.1 REG_UNITLESS_RAD_MODE

Sets the unit of angle for stream mode.

Address	length	R/W	Default	Min	Max
0x2C	2	R/W	0	0	1

- 0 = Unitless, 1 = Radian

2-11 Configuration: Save and Restore

This is about saving and restoring settings.

2-11.1 REG_DEFAULT

Restore all register values to factory default or recently saved.

Writing 3855 to this register will return all register values to their factory defaults. If you write 0xFFFF, it will return to the last saved state.

If you want to maintain this state after power reset, you should save all the register values using REG_CONFIG_SAVE register.

Address	length	R/W	Default	Min	Max
0x6E	2	W	-	-	-

- When returning to the factory defaults, all register values you have changed will be erased. Please be careful to use.

2-11.2 REG_CONFIG_SAVE

Save all register change values.

Even if the register value is changed, it will return to the last saved setting after the power is reset. If you write 0xFFFF to REG_CONFIG_SAVE, all current register values are saved and you can maintain the current state even after power reset.

Address	length	R/W	Default	Min	Max
0x70	2	R/W	0	0	65535

- After saved, previous Configuration Register values cannot be recalled. Please be careful to use.

2-12 Added: FW Ver >= 1.4

This is what was added in FW Ver 1.4. Any content added after that is marked separately.

2-12.1 REG_STATUS : FW Ver < 1.7

Check the status of E_STATUS.

Address	length	R/W	Default	Min	Max
0x06	2	R	-	0	3

- Bit 0: Flag that becomes 1 if possible to refer to REG_STATUS
  - 0 = disabled, 1= referenceable
- Bit 1: Over Current status.
  - 0 = Normal status, 1 = Over Current status
- Bit 2: Over Loaded status
  - 0 = Normal status, 1 = Over Loaded status

2-12.2 REG_REF_1

Address	length	R/W	Default	Min	Max
0xA6	2	R/W	-	0	1

- If Bit 0 = 1, e_PAD_VOLT [0xA8] can be referenced. Please keep this bit.
- Bit 1 = Start Motor Free: FW Ver >= 2.3(4) or >= 1.6(5)
- Bit 2 = Fail Safe Motor Free: FW Ver >= 2.3(4) or >= 1.6(5)

NOTE: This register was originally read-only. However, writable bits have been added, so read and then write to preserve the values of the bits that are not subject to write. OR use ZSid command.

NOTE: When the motor free function is activated, it enters the motor free state without moving to the specified position. The motor free function will not work if the move to a specified location function is enabled, as it has priority.

2-12.3 REG_PAD_VOLT

The operating voltage of the installed PAD

Address	length	R/W	Default	Min	Max
0xA8	2	R	-	0	65535

- Low Byte = Voltage 1 [V]
- High Byte = Voltage 2 [V]

2-12.4 **REG_SETUP**

Set various functions.

Address	length	R/W	Default	Min	Max
0xA2	2	R/W	-	0	65535

- Bit 0 = PAD Set the operating voltage (PAD installed Product only)
  - 0 = Voltage 1, 1 = Voltage 2
- Bit 1 = Use Start Position
  - To use the "Start Motor Free" function, setting it to 0 is required.
- Bit 2 = Use Brake Instead Free (BLDC Servo Only)
- Bit 3 = Use Over Volt Brake
- Bit 7 = Use Stream Custom CAN ID (FW Ver >= 1.5(1))
- Bit 10 = Use Fail Safe (FW Ver >= 1.5(2))
  - To use the "Fail Safe Motor Free" function, setting it to 0 is required.
- Bit 12 = Use Realtime ID1, ID2 (FW Ver >= 1.11)
  - If enabled, ID1(Servo ID) and ID2(Node ID) are applied immediately without Servo Reset.
- Bit 13 = Use Return CAN ID = ID2 BitOR 1 (FW Ver >= 1.11)
- Bit 15 = Motor Direction = 0(normal), 1(reverse) (FW Ver >= 2.1)
- Please keep other bits.

2-12.5 **REG_START_POSITION**

When the servo starts, it moves to the specified position.

Address	length	R/W	Default	Min	Max
0x7A	2	R/W	0	0	16383

- This feature is enabled when Reg 0xA2 bit 1 = 1.
- To use the "Start Motor Free" feature, Register 0xA2 bit 1 must be 0.

2-12.6 **REG_OVERVOLT_BRAKE_VOLTAGE**

If the current voltage is higher than the set voltage, an electromagnetic brake is applied to the motor. Unit is 0.01 V, ex: 1000 = 10.00 V

Address	length	R/W	Default	Min	Max
0x80	2	R/W	0	0	65535

- This feature is enabled when Reg 0xA2 bit 3 = 1.

2-13 Added: FW Ver >= 1.5

This is what was added in FW Ver 1.5. Any content added after that is marked separately.

2-13.1 REG_TMP_CONFIG

The initial value is 0.

Address	length	R/W	Default	Min	Max
0x20	2	R/W	0	0	65535

- Bit 0 = Pause Stream = 0(Stream), 1(Pause Stream)

2-13.2 REG_STREAM_CUSTOM_CAN_ID_H

Sets the upper 13 bits of STREAM CAN ID and CAN 2.0A/B selection. FW Ver >= v1.5(1)

15	14	13	12	11	10	9	8
2.0B	Custom CAN ID bits						

Address	Length	R/W	Default	Min	Max
0x3A	2	R/W	-	0	65535

- Bit 15 = 0(CAN 2.0A), 1(CAN 2.0B)
- Bit 14:0 = High 13 bits of CAN ID
- You must set e_SETUP(0xA2) bit 7 = 1

2-13.3 REG_STREAM_CUSTOM_CAN_ID_L

Sets the lower 16 bits of STREAM CAN ID. FW Ver >= v1.5(1)

Address	Length	R/W	Default	Min	Max
0x42	2	R/W	-	0	65535

- bit 15:0 = Low Word of CAN ID
- You must set e_SETUP(0xA2) bit 7 = 1

2-13.4 REG_FAIL_SAFE_POSITION

Specifies where to move to in Fail Safe state.

Address	length	R/W	Default	Min	Max
0x94	2	R/W	0	0	16383

- You must set e_SETUP (0xA2) bit 10 = 1

2-13.5 REG_FAIL_SAFE_TIME

Set the time period for the condition where Fail Safe activates. Unit is ms.

FW Ver >= v1.5(1)

Address	length	R/W	Default	Min	Max
0xB4	2	R/W	0	0	65535

- You must set e_SETUP (0xA2) bit 10 = 1
- To use the "Fail Safe Motor Free" feature, Register 0xA2 bit 10 must be 0.

2-14 Added: FW Ver >= 1.6(3) and Ver < 1.7

This is what was added in FW Ver 1.6(3). Any content added after that is marked separately.

2-14.1 REG_TURN_MULTIPLIER

Address	Length	R/W	Default	Min	Max
0xAC	2	R/W	0	-32760	+32760

- In DroneCAN, Multi-TURN state, magnify the target +/-1.0 by the specified magnification.

2-15 Added: FW Ver >= 1.10

This is what was added in FW Ver 1.10. Any content added after that is marked separately.

2-15.1 REG_MOTOR_TEMP_ADC

Address	Length	R/W	Default	Min	Max
0xD0	2	R	-	0	4095

- This is ADC Value
- B = 3380, R0 = 10, T0 = 298.15, K=273.15, Bt0 = B x T0
- VT = 3.3 / 4096 x ADC Value
- Rt = (R0 x VT) / (3.3 – VT)
- Temperature(°C) = Bt0 / (Log(Rt) x T0 – Log(R0) x T0 + B) - K

2-15.2 REG_MOTOR_TEMP_DEG

Address	length	R/W	Default	Min	Max
0xA0	2	R	-	-32768	32767

- This is °C value converted from Reg 0xD0

2-15.3 REG_MOTOR_TEMP_MAX

Address	Length	R/W	Default	Min	Max
0x5D	2	R/W	-	0	32767

- When the motor temperature rises above the set temperature, the motor output is

turned off. Unit is °C

2-15.4 **REG_MOTOR_TEMP_HYS**

Address	length	R/W	Default	Min	Max
0x6D	2	R/W	-	0	65535

- After the motor stops, the temperature difference of must drop by the amount set here before the motor will restart. Unit is °C.

2-16 Added: FW Ver >= 1.11

2-16.1 **REG_VOLTAGE_VERY_LOW**

Address	Length	R/W	Default	Min	Max
0x9F	bit 7:0	R/W	-	0	255

- Below this voltage, the motor output will be turned off. 255 = 25.5 V
- Please, Keep other bit values.

2-17 Added: FW Ver >= 2.1

This is what was added in FW Ver 2.1. Any content added after that is marked separately.

2-17.1 **REG_SETUP_2 – Enable SETUP_EX registers**

Address	length	R/W	Default	Min	Max
0xA0	2	R/W	-	0	65535

- Bit 14:0 = System Configuration Bits - You must keep these bits.
- Bit 15 = Enable SETUP_EX Registers (ex: SETUP_EX_3) – Keep bit value if already 1
  - There are many hidden system settings in SETUP_EX registers,
  - so if it is already ON, you should never change it to OFF.

2-17.2 **REG_SETUP_EX_0x41**

Address	Length	R/W	Default	Min	Max
0x41	2	R/W	-	0	65535

- Bit 0 = Reversed bit - You must keep this bit.
- Bit 1 = Enable TURN_MULTIPLIER function
- Bit 15:2 = Reversed bits - You must keep these bits.
- You must set REG_SETUP_2(0xA0) bit 15 = 1 (Enable SETUP_EX registers)

2-17.3 **REG_TURN_MULTIPLIER**

In DroneCAN, Multi-TURN state, magnify the target +/-1.0 by the specified magnification.

Address	Length	R/W	Default	Min	Max
0xAC	2	R/W	0	-32760	+32760

- You must set REG_SETUP_EX_3(0x41) bit 1 = 1 and REG_SETUP_2(0xA0) bit 15 = 1

2-18 Added: FW Ver >= 2.3(2)

This is what was added in FW Ver 2.3(2). Any content added after that is marked separately.

2-18.1 CAN Sample Point 50%

Starting with FW Ver. 1.7, the 50% Sample Point setting was removed, and it operated at 87.5%. The 50% setting was restored on FW Ver 2.3(2).

2-19 Added: FW Ver >= 2.3(3) or FW Ver >= 1.6(4)

This is what was added in FW Ver 2.3(3) and 1.6(4). Any content added after that is marked separately.

2-19.1 Velocity Target

Address	Length	R/W	Default	Min	Max
0x60	2	R/W	-	0	32767

Changing Velocity Max may disrupt the trapezoidal velocity profile implemented with Time Speed Up/Down. Therefore, use Velocity Max to set the maximum velocity of the trapezoidal velocity profile, and Velocity Target to set the desired maximum velocity.

2-19.2 Velocity Target Enable (FW Ver >= 2.3(3))

The Velocity Target feature is enabled when register 0x41 is activated and bit 2 is set to 1.
Activating Register 0x41 requires SETUP_EX activation (Register 0xA0 bit 15 = 1).

2-19.3 Stream by SYNC message (FW Ver >= 2.3(3))

Transmit a stream for each received SYNC message.
Simply enter the desired counter + 11000 in register 0x2E (Stream Time).

2-20 Added: FW Ver >= 2.3(4) and FW Ver >= 1.6(5)

This is what was added in FW Ver 2.3(4) and 1.6(5). Any content added after that is marked separately.

2-20.1 **Start Motor Free, Fail Safe Motor Free**

Ability to turn off motor output without moving to a specified position in each situation.

Address	Bit	R/W	Default	Description
0xA6	1	R/W	0	Start Motor Free
0xA6	2	R/W	0	Fail Safe Motor Free

Be careful not to change the values of other bits. (Reg 0xA6 = REG_REF_1)
Since the Start Position and Fail Safe settings each have priority, the Motor Free function will not work if either function is turned on.

END OF FILE