CHAPTER 10: ABSOLUTE SYSTEM

TABLE OF CONTENTS

Introduction

This chapter introduces the absolute servo system, including the wiring and installation of the absolute encoder, the steps to set up the system, and the procedures for initializing and operating the system for the first time.

Note:

A complete absolute servo system includes a SureServo2 servo drive, a motor, and a backup battery box. All SureServo2 motors have a serial communication encoder system installed though they can be used in an incremental or absolute coordinate setup. The backup battery supplies power to the encoder system on the motor so that the encoder continues to operate even when the power is off. The encoders on the SureServo2 motors have a small amount of local memory which allows the motor to record positional changes when the drive is not powered and a battery box is installed. In addition, the absolute encoder can continuously record the motor's actual position at any time, even when the motor shaft is rotated after the power is off.

Install the battery properly with the encoder cable. One battery box (SV2-BBOX-1) for one drive/motor system only. Do not try to connect multiple drives or motors to one battery backup box. Please use AutomationDirect's motor feedback encoder cable to connect to the battery box. See the following section for the specifications of the battery box and its accessories.

The standard voltage level of the battery is 3.6 V. If the battery level reaches a 3.1 V threshold then P0.050 Bit 1 will turn ON along with AL061 (P0.050 Bit 1=1 means the battery is under-voltage; 0=normal). When the voltage is under 2.7 V, the motor's position might be lost when operated under battery power alone. The shelf life of the battery is 10 years. When the drive is powered off and the motor encoder is continuously powered by the SV2-BBOX-1 battery the battery can sustain encoder position for 5 cumulative years. The SV2 motor encoders only have a current draw of 30µA.

10.1 - Battery Box (Absolute Type) and Wiring

10.1.1 - Specifications

Precautions

Please carefully read through the following safety precautions. Use batteries only in accordance with the specifications so as to avoid damage or dangerous conditions.

The installation location must be free of all water, corrosive and inflammable gas.

Correctly place the battery into the battery box to avoid short circuiting.

Do not short circuit the positive and negative electrodes of the battery, and do not install the battery in reverse direction.

Only use new batteries to avoid losing power or shortening the life of the batteries.

Please follow the instructions when wiring the battery box to avoid dangerous conditions.

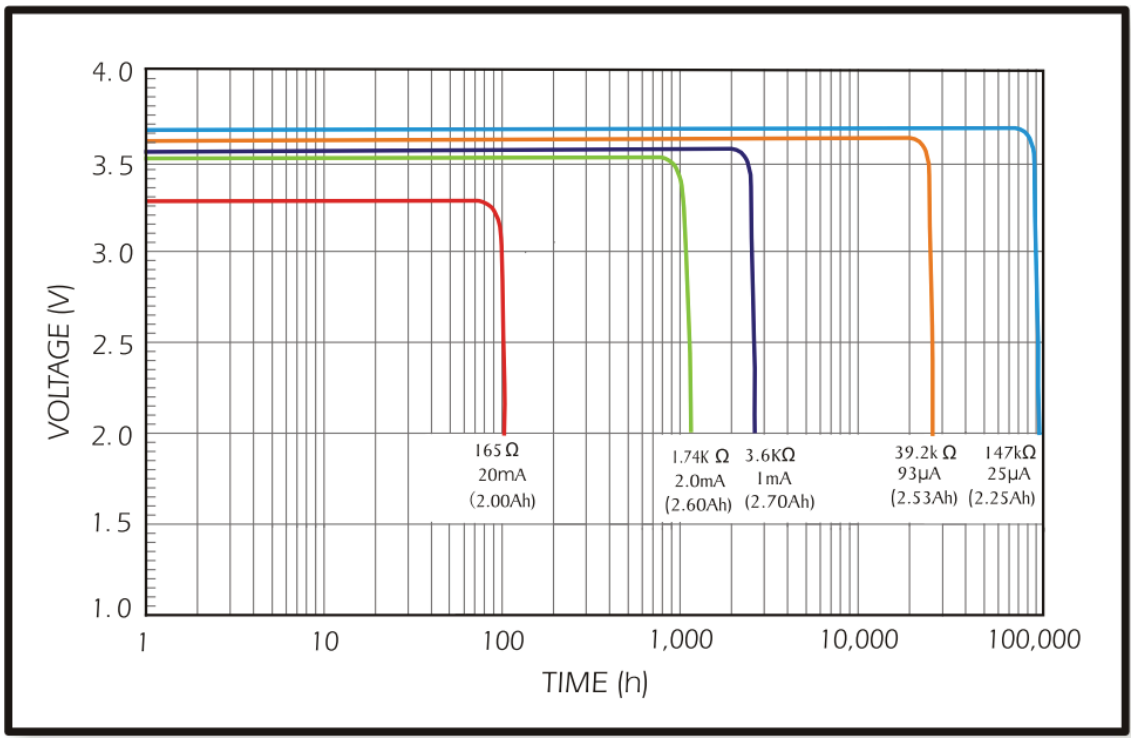
Do not place the battery in a high-temperature environment over 100°C, as this may cause a fire or an explosion.

The batteries are non-rechargeable. Do not charge the batteries as this might result in an explosion.

Do not directly weld on the surface of the battery.

Battery specifications

Item	Li/SOCl2 Cylindrical Battery
Type	ER14505
International Standard Size	AA
Standard Voltage	3.6 V
Standard Capacity	2700mAh
Maximum Continuous Discharge Current	100mA
Maximum Pulse Current	200mA
Dimensions (D X H)	14.5 x 50.5 mm
Weight	Approx. 19g
Operating Temperature	-40°C to +85°C



The figure above illustrates the discharge current curves measured in the constant current test. According to the five curves shown above, if the voltage of the battery keeps at 3V or higher, the expected battery life is as shown in the following table. Therefore, the lowest battery voltage level for an absolute encoder is set to 3.1 V.

For SureServo2 motors the battery mode current comsumption[2] is 45μA. Battery life expectancy is 58.33 months.

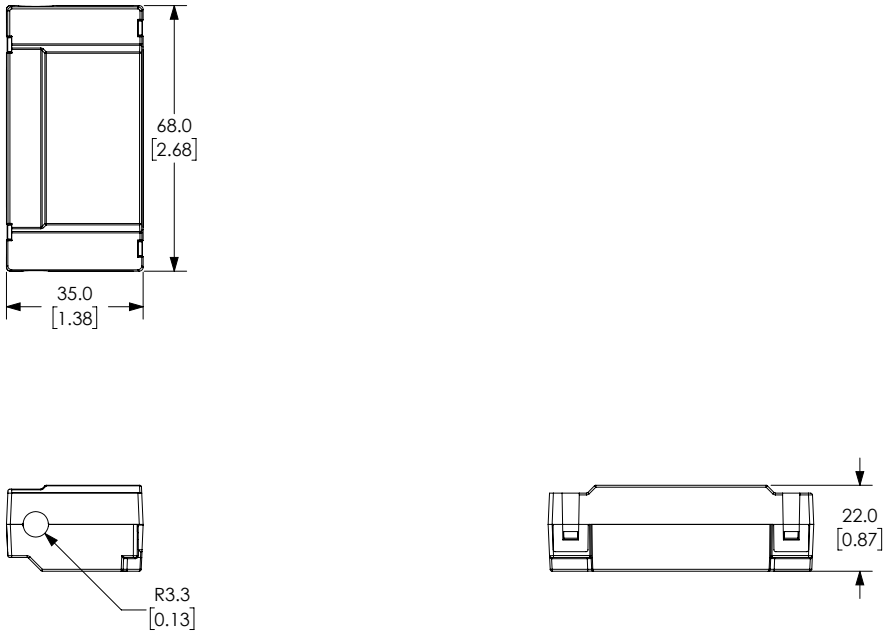
Notes:

1) The battery life expectancy is measured with a test using a servo drive, a motor, and a single battery.
2) The current consumption is nearly zero when the absolute origin coordinate is not established. Once the absolute origin coordinate is established, battery power consumption starts. To avoid battery power consumption when the machine is in transport, disconnect the servo drive and battery or do not establish the absolute origin coordinate.

10.1.2 - Battery Box Dimensions

Single battery box

Part number: SV2-BBOX-1



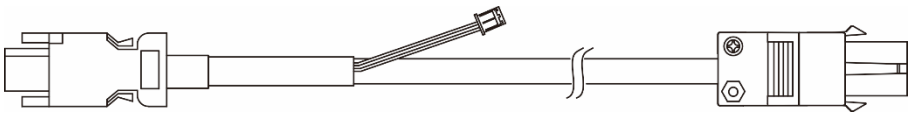
NOTE: SV2-BBOX-1 requires the use of SV2-BBOX-CBL (connectorized on both ends) if using SureServo2 factory encoder cables. Ensure the battery is plugged into the connector that is labeled J1 on the SV2-BBOX-1 circuit board and the encoder cable is plugged into the connector labeled J2 on the circuit board.

If you are constructing your own encoder cable, the SV2-BBOX-1 does come with a pigtail cable that can attach to custom encoder cables.

10.1.3 - Connection Cable for the Absolute Encoder

Quick connector

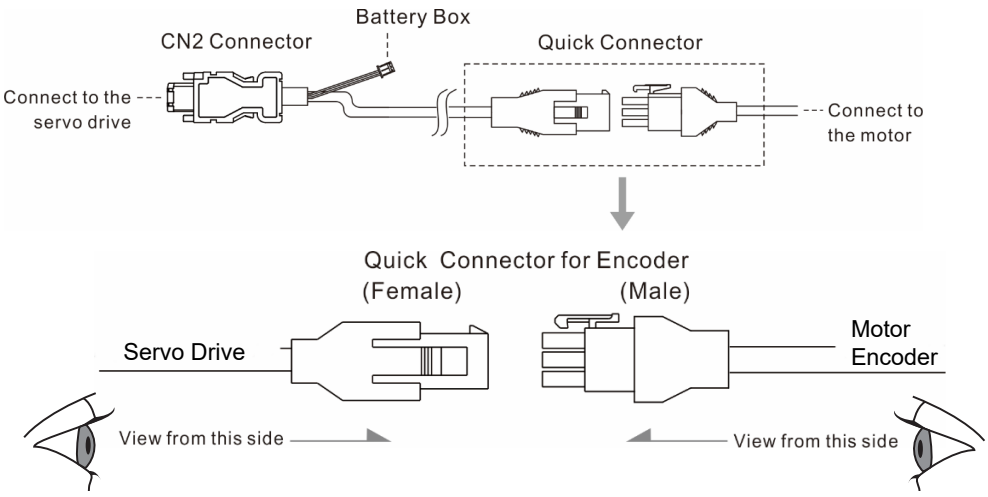
Part number: SV2C-E122-xxxN



Model Name	L	
	mm	inch
SV2C-E122-03FN	3000 ± 100	118 ± 4
SV2C-E122-03NN		
SV2C-E122-05FN	5000 ± 100	197 ± 4
SV2C-E122-05NN		
SV2C-E122-10FN	10000 ± 100	394 ± 4
SV2C-E122-10NN		
SV2C-E122-20FN	20000 ± 100	787 ± 4
SV2C-E122-20NN		

Connection method:

NOTE: Please follow the instructions below when connecting the cable. Incorrect wiring may result in a battery explosion.

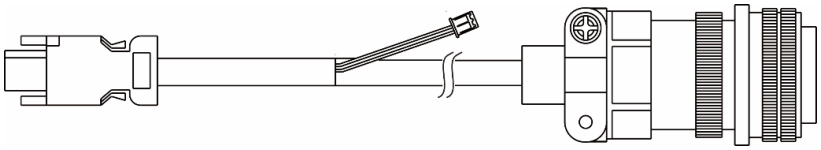


1 White T+	2 Red BAT+	3 N/C
4 White / Red T-	5 Black BAT-	6 N/C
7 Brown +5 VDC	8 Blue GND	9 Shield

3 N/C	2 Black BAT+	1 White T+
6 N/C	5 Red BAT-	4 White / Red T-
9 Shield	8 Blue GND	7 Brown +5 VDC

Military connector

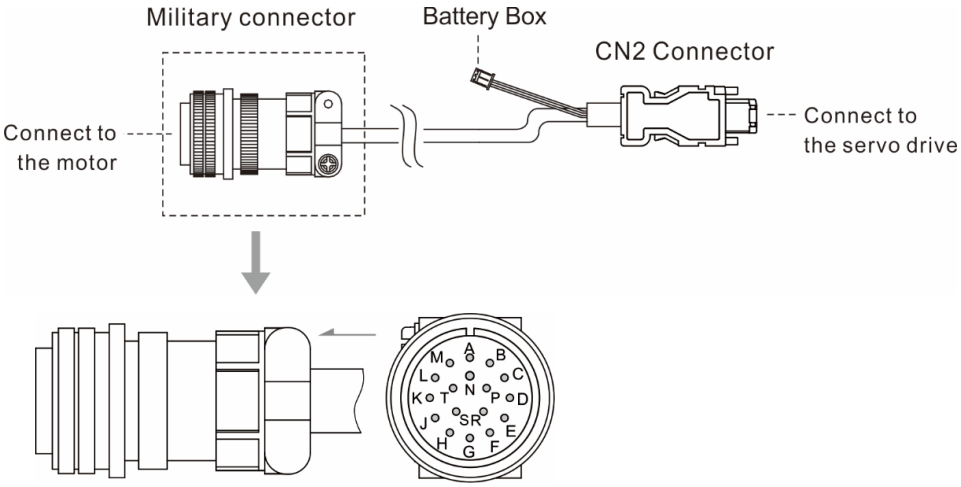
Part number: SV2C-E222-xxxN



Model name	L	
	mm	inch
SV2C-E222-03FN	3000 ± 100	118 ± 4
SV2C-E222-03NN		
SV2C-E222-05FN	5000 ± 100	197 ± 4
SV2C-E222-05NN		
SV2C-E222-10FN	10000 ± 100	394 ± 4
SV2C-E222-10NN		
SV2C-E222-20FN	20000 ± 100	787 ± 4
SV2C-E222-20NN		

Connection method:

NOTE: Please follow the instructions below when connecting the cable. Incorrect wiring may result in a battery explosion.

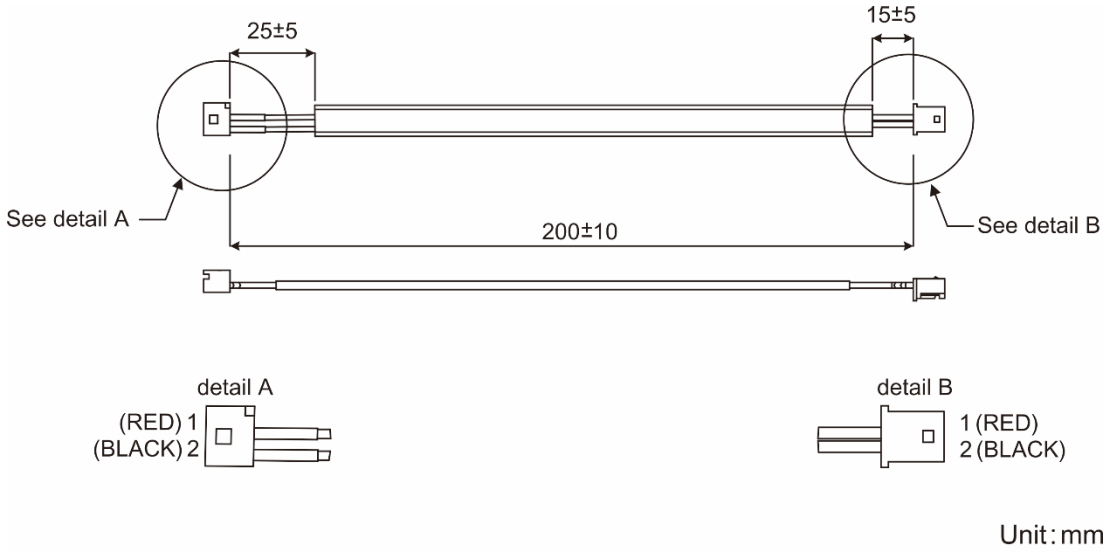


Pin No.	Terminal	Color
A	T+	White
B	T -	White / Red
C	BAT+	Red
D	BAT-	Black
S	+5 VDC	Brown
R	GND	Blue
L	BRAID SHIELD	–

10.1.4 - Battery Box Cable

Battery box cable.

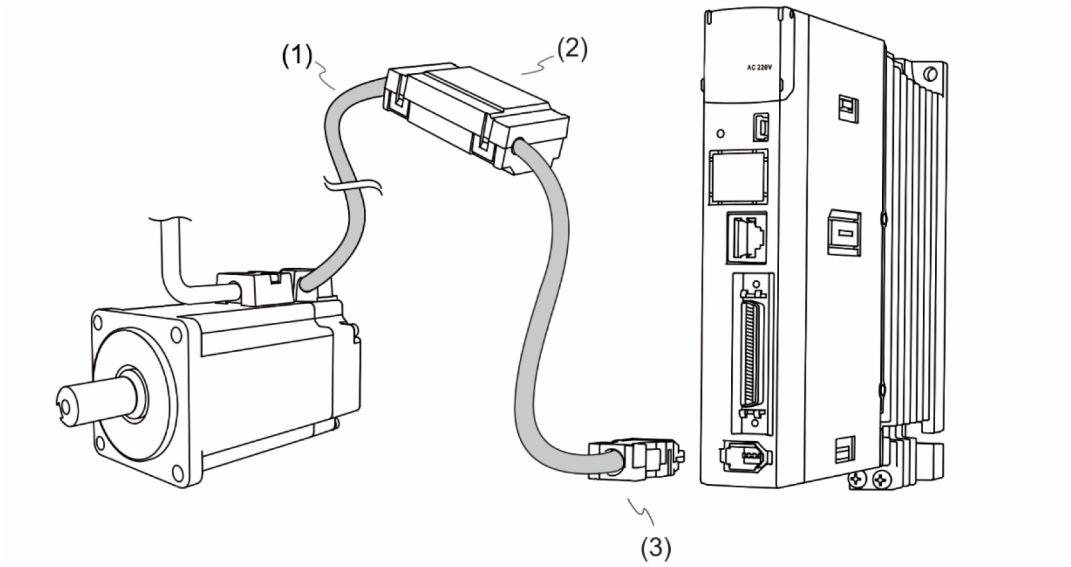
Part number: SV2-BBOX-CBL

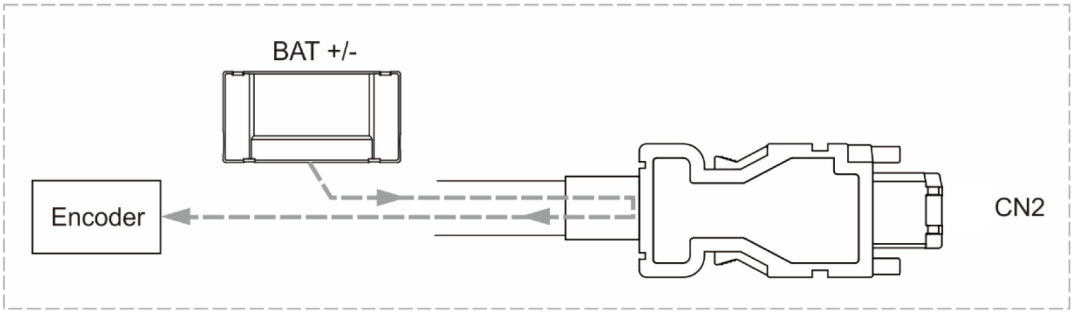


10.2 - Installation

10.2.1 - Installing the battery box in the servo system

Standard Wiring





(4)

(1) Encoder cable; (2) Battery Box; (3) CN2 connector; (4) Battery box wiring

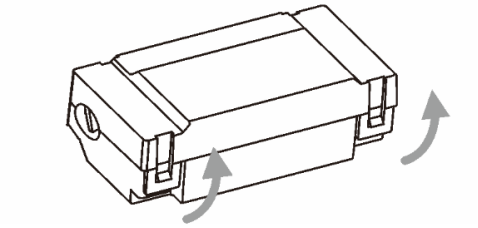
Pin assignment of CN2:

Encoder End			Servo Drive End		
Military Connector	**Quick Connector**	**Color**	**Pin No.**	**Symbol**	**Description**
A	1	White	5	T+	Serial communication signal (+)
B	4	White / Red	6	T-	Serial communication signal (-)
S	7	Brown	1	+5V	Power +5V
R	8	Blue	2	GND	Power ground
L	9	-	Case	Shielding	Shielding
C	2	Red	–	–	Battery +3.6 V
D	5	Black	–	–	Battery ground

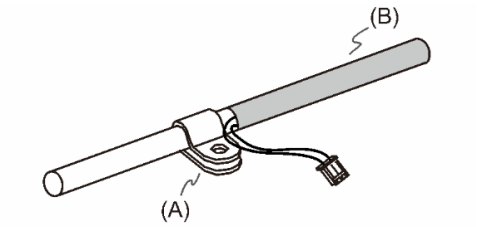
NOTE: When using the battery box, the battery supplies power directly to the encoder. Thus, connecting the encoder cable to the drive's CN2 port is not required to maintain position. This is useful if you want to maintain encoder position and need to disconnect it from the drive. Please refer to the wiring description in Section 3.6 Specifications of encoder connector for details.

10.2.2 - Installing and replacing a battery

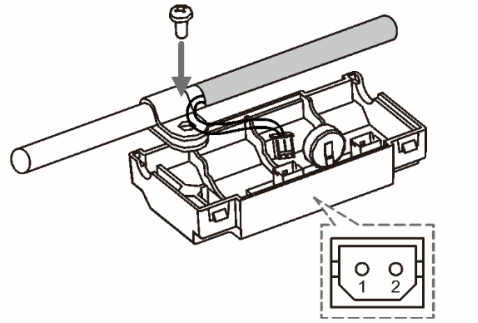
If you need to replace the battery and maintain absolute position you will need to purchase another SV2-BBOX-1 and use the new battery that comes with it.



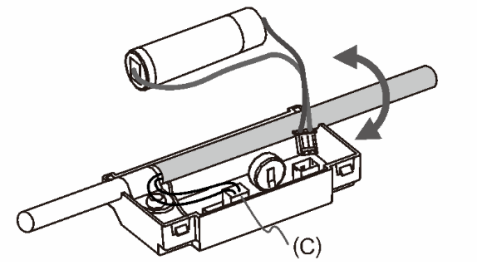
Step 1:
Loosen the hooks on both sides to open the lid of the battery box.



Step 2:
Attach the metal clip to the connection cable. Please note that the metal clip should be placed close to the heat shrink.
Metal clip; (B) Heat shrink

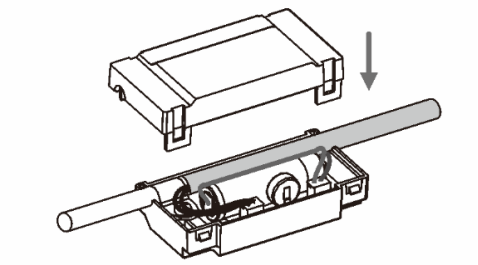


Step 3:
Plug in the connection cable and tighten the screw.



Step 4:
Install a new battery and connect it to the cable.
(C) Please replace the battery only when the main power to the servo drive is still on.

CAUTION: Do not remove the power cable, as the system might lose data.



Step 5:
Place the cable into the box and close the lid.

To avoid data loss, please replace the battery when any of the following circumstances occurs:

1) The servo drive shows alarm AL061, which means the voltage is too low. Please refer to Chapter 11 for more information.
2) When the voltage is under 2.9 V, the motor's position record might be lost if the motor is moved while solely under battery power, so you should perform the homing procedure after installing a new battery. You should replace the battery while the main power is connected to the servo drive.

10.3 - System Initialization and Operating Procedures

10.3.1 - System Initialization

When the absolute coordinates are lost, the servo drive provides three ways to establish the absolute origin coordinates: DI/DO, parameter setting, or the PR homing function. The following provides more details for each operation mode.

After the servo system resumes operation, the host controller can acquire the motor's current absolute position either with communication or SureServo2 Pro. AutomationDirect's absolute system provides two types of position value for the host controller: pulse and PUU.

AL060 occurs when you initialize the absolute system for the first time because the coordinate system has not been created. Clear the alarm by setting up the coordinate system. Insufficient encoder battery power or the failure of the main power supply when no battery is connected also causes loss of the coordinate system and the re-occurrence of AL060. In the absolute system, when the number of motor rotations exceeds the range -32768 to 32767, AL062 occurs. The number of motor rotations is being recorded in the drive's memory but there is no parameter to view this value. When the PUU position value goes outside the range -2147483648 to 2147483647, AL289 occurs.

Except for the alarms mentioned above, you can use P2.069 and P2.070 to set up AutomationDirect's absolute servo system. You can choose not to show AL062 and AL289 if the absolute coordinate system overflows when the number of rotations exceeds the range -32768 to 32767 or when the PUU exceeds the range -2147483648 to 2147483647 (32 bit register). For example, you might do this on a system that uses incremental commands to operate in a single direction.

P2.069.X Setting

- *X: Set up operation mode*
- *0: Incremental type system*
- *1: Absolute type system*

P2.071 setting:

1) Initialize the absolute coordinates. When the coordinate setting is complete, AL06A (or AL060) is automatically cleared. There are two ways for you to initialize the host controller coordinates: DI (please refer to Section 10.3.4) or setting parameters (please refer to Section 10.3.5).
2) When the system is powered on again, you can access the drive's absolute position with Modbus RTU, MODTCP, or EtherNet/IP communication (please refer to Section 9.3). Based on the setting of P2.070, the host controller can select the requested value, either the PUU (please refer to Section 10.3.3) or the pulse value of 16777216, within a single turn (please refer to Section 10.3.2).

10.3.2 - Pulse Number (P2.070 bit1 = 1)

When the motor is running in the clockwise direction, the shaft rotation number is expressed as a negative value. When the motor runs in the counterclockwise direction, the shaft rotation number is expressed as a positive value. The range of the number of rotations is between -32768 and +32767, and AL062 occurs once the number exceeds the range. To clear the alarm, you must re-initialize the coordinate system. If P2.070 has been set to ignore the AL062 alarm, then the system shows no error. If the system is operating in the counterclockwise direction and it reaches 32,767 turns, the value jumps to -32768 once it reaches the target position in the next shaft rotation, and the value keeps increasing to -32768, -32767, -32766, and so on. When the system is operating in the clockwise direction, the value jumps to 32767 in the next shaft rotation after reaching -32768.

In addition to the shaft rotation counter, there are 16,777,216 pulses (0 – 16777215) in one (shaft or encoder) rotation. Please pay attention to the motor's running direction. You can read the shaft rotation number and the pulse number with communication. Total pulse number = m (shaft rotation number(P0.051)) x 16777216 + pulse number(P0.052) (0 – 16777215). The conversions between pulse number and PUU are as follows:

When the rotation direction is defined as CCW in P1.001,

then the PUU number = pulse number × $\frac{P1.045}{P1.044}$ + P6.001.

When the rotation direction is defined as CW in P1.001,

then the PUU number = (-1) × pulse number × $\frac{P1.045}{P1.044}$ + P6.001.

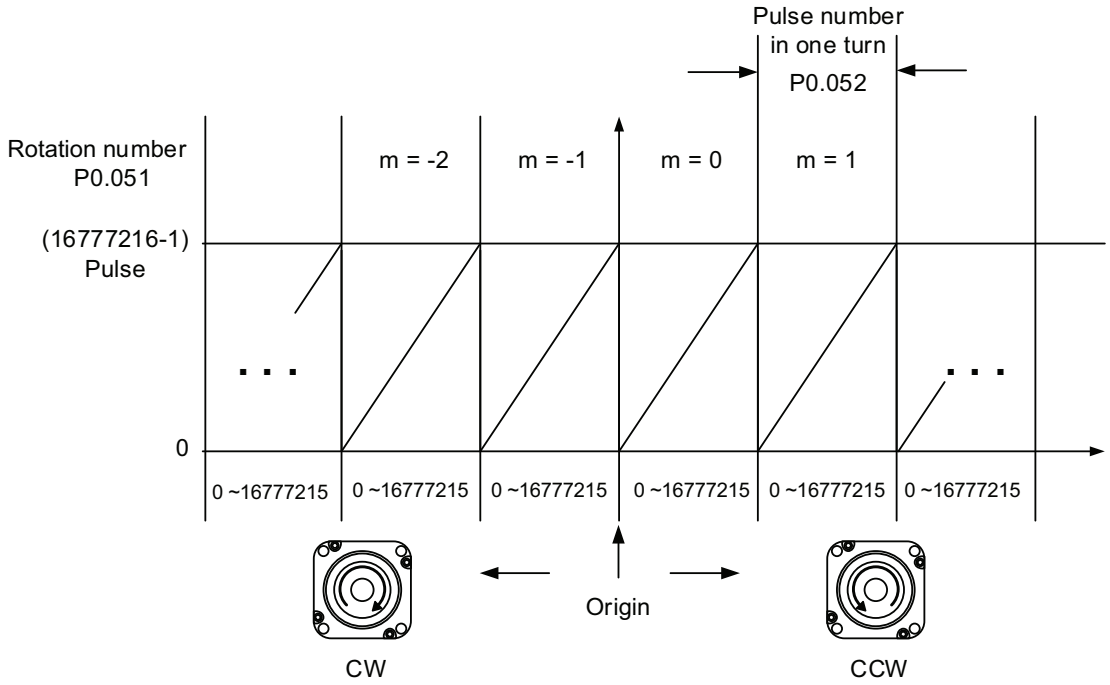


Figure 10-1 Absolute position for PUU number

10.3.3 - PUU Number (P2.070 bit1=0)

The PUU number is a 32-bit absolute value with positive and negative signs. When the motor is running in the forward direction, the PUU number increases; when it is running in the reverse direction, the PUU number decreases. The forward direction does not mean the motor is running clockwise; the direction is defined by P1.001.Z. The maximum range of the shaft rotation number is -32768 to +32767, the drive keeps track of this cycle count internally but it is not reported in any parameter. AL062 occurs when the number of rotations overflows the range. If the PUU number exceeds the range -2147483648 to 2147483647, the position counter overflows and AL289 occurs. Re-initialize the system to clear these alarms (AL062 or AL289). You can determine whether or not to show AL062 and AL289 when the position overflows through P2.070. When reaching the maximum PUU number in the forward direction, the value changes from 2147483647 to -2147483648, -2147483647, 2147483647, and so on. The value changes the other way when the motor operates in the reverse direction. See the following examples:

Example 1:

When P1.044 = 16777216 and P1.045 = 100000, the motor needs 100,000 PUU to run one shaft rotation. 2,147,483,647 ÷ 100,000 = 21,474.8, so once the motor runs over 21,474.8 (< 32,767) rotations in the forward direction, AL289 occurs.

Example 2:

When P1.044 = 16777216 and P1.045 = 10000, the motor needs 10,000 PUU to run one shaft rotation. 2,147,483,647 ÷ 10,000 = 214,748.3, so once the motor runs over 32,767 (< 214,748.3) rotations in the forward direction, AL062 occurs.

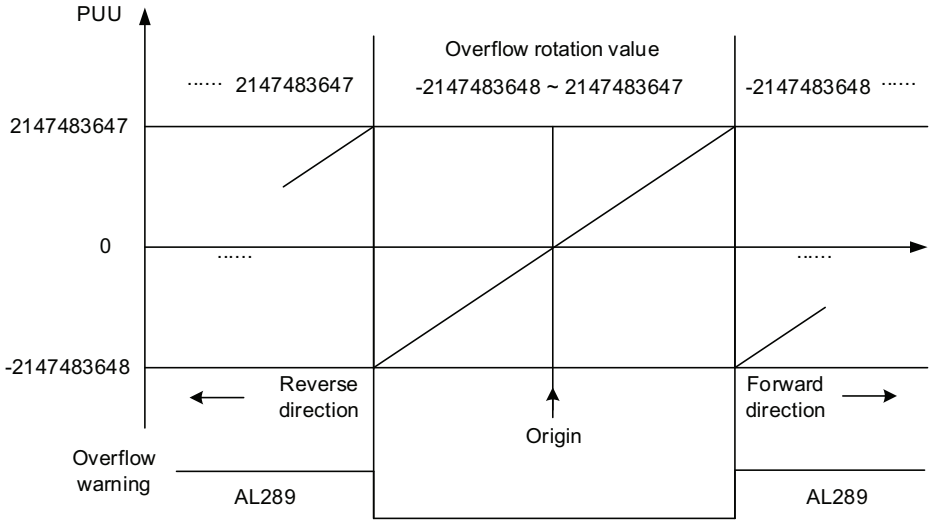


Figure 10-2 Absolute position for PUU number

NOTE: After initializing the absolute coordinate system, any change to P1.001.Z or E-Gear ratio (P1.044 and P1.045) changes the original setting of the absolute coordinate system. If the above parameters are changed, please re-initialize the coordinate system.

10.3.4 - Establishing the Absolute Origin Coordinates with DI/DO

When the servo system is controlled by the host controller, you can reset the absolute coordinate system with DI/DO. To initialize the coordinate system first set P2.069.X=1, then power cycle the drive for the setting to take affect, set DI.ABSE (***0x1D***) to on and switch DI.ABSC (***0x1F***) to ON. At that point, the pulse number is set to 0 and the PUU number is the value of P6.001. Please refer to the following diagram for detailed descriptions.

NOTE: (1), (2), and (3) represent the required delay time between triggering DI.ABSE and DI.ABSC to enable the function.

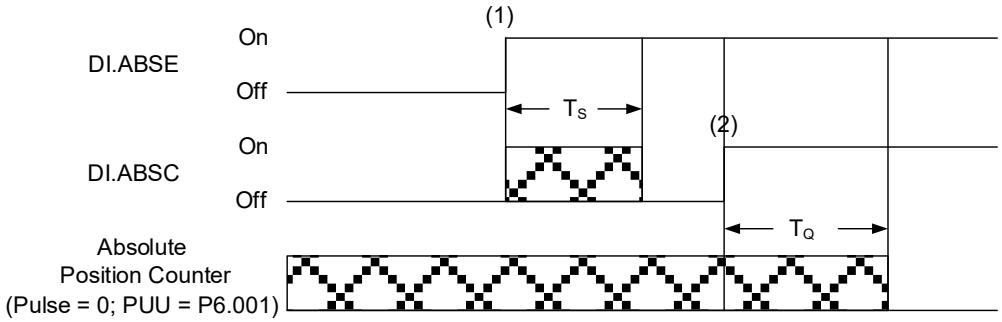


Figure 10-3 Timing diagram for initializing the absolute coordinate system with DI/DO

The following table describes the TS and TQ delay time after triggering DI.ABSE and DI. ABSC.

	$T_{S(ms)}$	$T_{Q(ms)}$
Min (T_S, T_Q)	Value of P2.009 + 2	
Max	P2.009 + 250	

Description:

1) When DI.ABSE turns on, it has to wait for TS ms before setting DI.ABSC on.
2) When DI.ABSC turns on and remains on for TQ ms, the pulse number is set to zero and the PUU number is set to the value of P6.001.

10.3.5 - Establishing the Absolute Origin Coordinates with Parameters

Set P2.069.X to 1 then power cycle. This must be done before P2.071 can be set to 1. This is to initialize the absolute coordinates and can be done through the panel or with communication. As soon as P2.071 is set to 1, the absolute coordinate system resets. Since the write-protect function of P2.071 is protected by P2.008, you must set P2.008 to 271 first. In other words, the sequence is: set P2.008 to 271, then set P2.071 to 1. At this point, the pulse number is set to 0 and the PUU number is the value of P6.001.

10.3.6 - Establishing the Absolute Origin Coordinates with the PR Homing Function

You can use the 11 homing modes in the PR mode to establish the absolute origin coordinates. For more details, refer to Section 7.1.3.1 Homing methods.

10.3.7 - Reading the Absolute Position with Communication

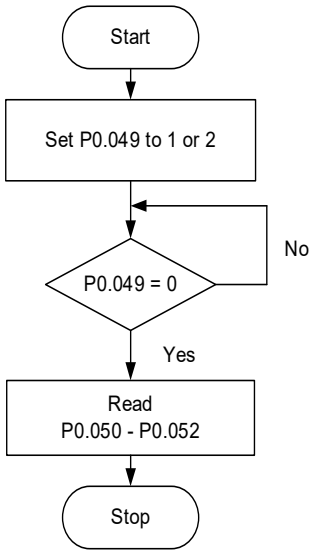
You can access the data of the absolute encoder through two communication methods: instant access or parameter access.

Instant access refers to reading the motor's feedback position as soon as power is sent to the servo. When you set the status monitoring register 1 to the motor's feedback pulse number (P0.017 = 0), you can access the motor's current position by reading P0.009.

Parameter access means the motor's position is temporarily stored in parameters. Once you set P0.049 with communication, the encoder's status, absolute position (shaft rotation number), and pulse number (or PUU) are stored in P0.050, P0.051, and P0.052 respectively. You can choose to read the pulse number or PUU by setting P2.070 Bit 1. Even when the motor is stopped, it still moves slightly forward and backward.

- *When you set P0.049 to 1, the encoder will perform a one-time read of the exact position where the motor stops without changing anything else.*
- *On the other hand, when you set P0.049 to 2, the encoder updates the motor's current position on the servo drive, which clears any position error.*
- *After all positions are updated in P0.050 – P0.052, P0.049 is automatically reset to 0. At that point, the controller can access the values of P0.050 – P0.052.*
- *P0.050 shows the status of the absolute encoder. When it shows absolute position lost or overflow, that indicates that the absolute position is invalid. You must re-do the homing procedure and re-initialize the absolute coordinates.*

For example, the motor's current position is 20000, but it varies between 19999 and 20001. If you send the command to read the motor's position when it stops at 20001, the motor's position is updated to 20001.



10.3.8 - Reading the absolute position with DI/DO

NOTE: Using DI/DO to read the absolute position is not recommended. It is an old method for communicating to devices that don't have more reliable communications such as RS485 or Ethernet. It is highly suggested to use RS485 or Ethernet for reading absolute position when in absolute mode.

Reading the absolute position via DI/DO is not recommended unless there is a specific need to do so. The DI/DO method mimics serial protocol. Using communications to read the position is recommended (Section 10.3.7).

- *Set P2.070 [Bit 0] to 0 so that you can read the value in PUU with DI/DO. See the following descriptions.*

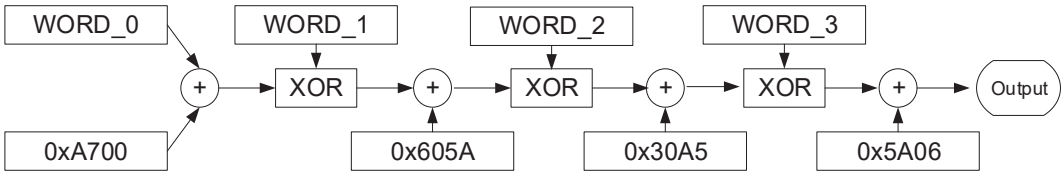
Bit	Description
Bit 79 – Bit 64	Checksum
Bit 63 – Bit 32	Encoder PUU -2,147,483,648 to 2,147,483,647
Bit 31 – Bit 16	0
Bit 15 – Bit 0	Encoder status (P0.050)

- *Set P2.070 [Bit 0] to 1 so that you can read the value in pulse with DI/DO. See the following descriptions.*

Bit	Description
Bit 79 – Bit 64	Checksum
Bit 63 – Bit 32	Pulse number of one encoder revolution 0 to 16,777,215 (=16,777,216-1)
Bit 31 – Bit 16	Number of encoder revolution -32,768 to 32,767
Bit 15 – Bit 0	Encoder status (P0.050)

Description:

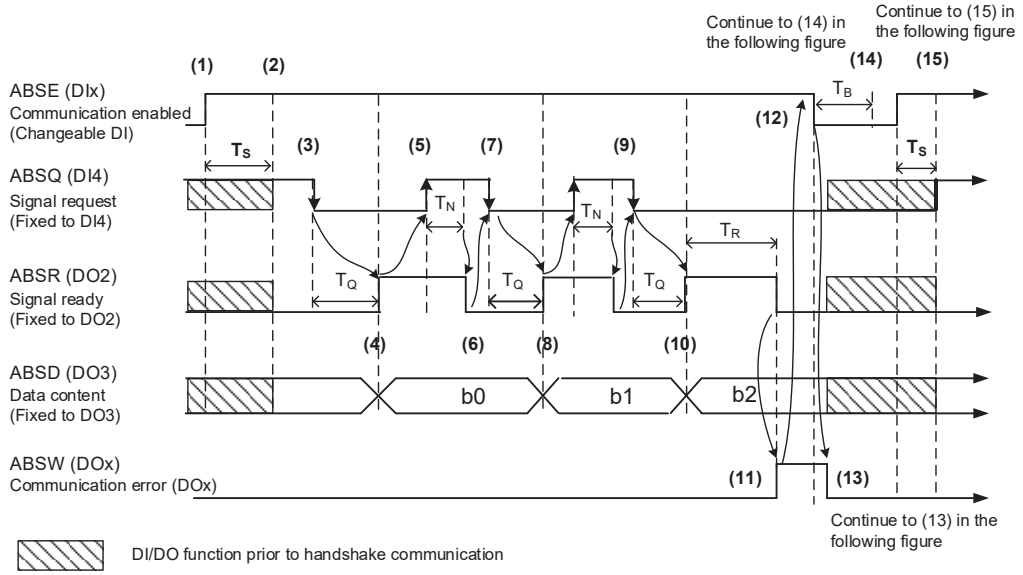
Checksum = (((((((WORD_0+0xA700) XOR WORD_1) + 0x605A) XOR WORD_2) + 0x30A5) XOR WORD_3) + 0x5A06)

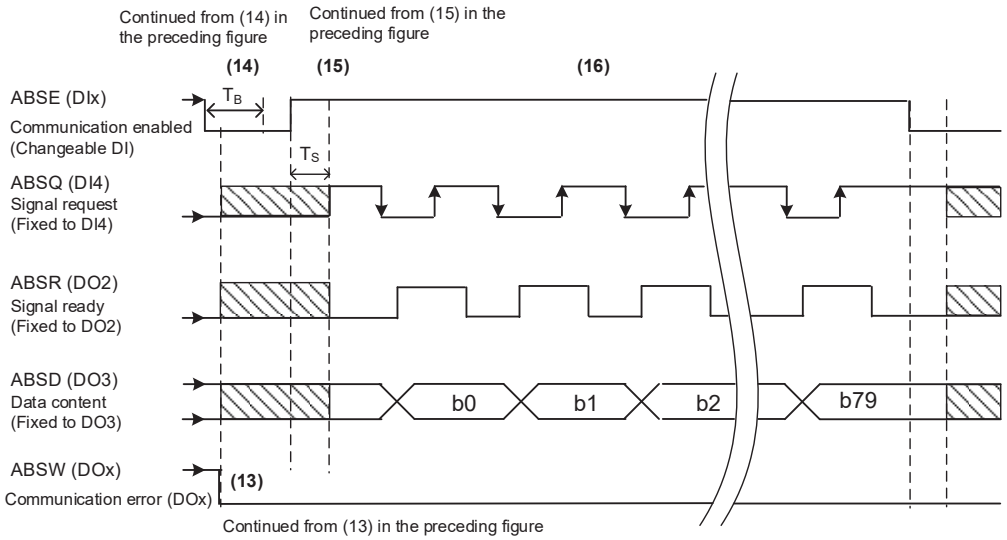


Notes:

1) This algorithm has no positive or negative sign.
2) 0xA700, 0x605A, 0x30A5, and 0x5A06 are constants in hexadecimal format.
3) WORD_0: encoder status (Bit 15–0)
   WORD_1: number of encoder revolution (Bit 31–16)
   WORD_2: encoder pulse number (Bit 47–32)
   WORD_3: encoder pulse number (Bit 63–48)

You can set P2.070 to read the position value in the unit of pulse or PUU with DI/DO. See the timing diagram below:





The following table describes the delay time when reading the absolute position with DI/DO.

	$T_{R(ms)}$	$T_{S(ms)}$	$T_{Q(ms)}$	$T_{N(ms)}$	$T_{B(ms)}$
Min.	–	P2.009 + 2			
Max.	200	P2.009 + 10			

Steps:

1) When the handshake communication starts, the ABSE signal is triggered.
2) After the T_S delay time (make sure the signal is on), the functions for DI4, DO2, and DO3 are switched to ABSQ, ABSR, and ABSD, respectively. If DI4 was in the high-level state before, it remains in the high-level state when switched to ABSQ (logic high-level signal). DI4, DO2, and DO3 are dual-function DI/DO, which means DI4, DO2, and DO3 share the same DI with ABSQ, ABSR, and ABSD. Pay special attention when switching functions or set the DI/DO to 0 to disable the dual-function of DI/DO.
3) If DI4 was in the high-level state and switched to ABSQ after the T_S delay time, when the controller

resets this signal to low level, the new signal is interpreted as the data access command.

4) After the T_Q time, the handshake data is ready and the absolute position is sent to ABSD. Now the servo drive turns on the ABSR signal and the controller can access the data.
If the controller still cannot detect the ABSR status while it is changing to high level after the maximum T_Q time, there may be a communication error.
5) Once the ABSR signal is set to high level, the controller accesses the data, and the ABSQ signal is set to high level to notify the servo drive that data was read.
6) When ABSQ is at high level, ABSR is set to low level after the T_N time in order to send the data for the next bit communication.
7) When ABSR is at low level, ABSQ is also set to low level and the servo drive needs to send the data for the next bit communication.
8) Repeat steps 3 and 4. Send the absolute position to ABSD for the next bit communication.
9) (Repeat steps 5 to 7. The controller has read and received the data.
10) The third bit data is ready.
11) After the T_R waiting time, if the controller has not read the data and turned on the ABSQ signal, the servo drive sends the ABSW signal (communication error) and stops the handshake communication.
12) When the controller receives the communication error signal, it sets ABSE to low level and prepares to restart the handshake communication.
13) ABSW resumes to low level after the servo drive receives the ABSE signal.
14) The controller resumes communication after the T_B time.
15) Repeat step 1.
16) If no error occurs, the controller completes 80 bits (0 - 79) of the handshake communication with the servo drive. DI4, DO2, and DO3 then resume their original functions.

10.4 - List of Absolute Parameters, DI/DO, and Alarms

Relevant parameters (please refer to Chapter 8 for detailed information):

Parameter	*Function*
P0.002	Drive status
P0.049	Update encoder absolute position
P0.050	Absolute coordinate system status
P0.051	Encoder absolute position - Multiple turns
P0.052	Encoder absolute position - Pulse number or PUU within single turn
P2.069	Absolute encoder
P2.070	Read data selection
P2.071	Absolute position homing

Relevant DI/DO (please refer to Chapter 8 for detailed information):

Setting Value	*DI Name*	*Setting Value*	*DO Name*
0x1D	ABSE	WHEN DI.ABSE is on, DI.ABSR triggered by DO2 replaced the DO2 assigned by P2.019	ABSR always output by DO2
When DI.ABSE is on, the DI.ABSQ from DI4 replaced the DI4 function from P2.013.	ABSQ always input by DI4	When DI.ABSE is on, DI.ABSD triggered by DO3 replaced the DO3 assigned by P2.012.	ABSD always output by DO3
0x1F	ABSC	0x0D	ABSW

Relevant alarms (please refer to Chapter 11 for detailed information):

Display	*Alarm name*
AL060	Absolute position is lost
AL061	Encoder undervoltage
AL062	Number of turns for the absolute encoder overflows
AL066	Number of turns for the absolute encoder overflows (servo drive)
AL072	Encoder overspeed
AL073	Encoder memory error
AL074	Absolute encoder single turn position error
AL075	Absolute encoder position error
AL077	Encoder computing error
AL079	Encoder parameter error
AL07B	Encoder memory busy
AL07C	Command to clear the absolute position is issued when the motor speed is over 200 rpm
AL07D	Servo drive power is cycled before AL07C is cleared
AL07E	Encoder clearing procedure error
AL289	Feedback position counter overflows

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