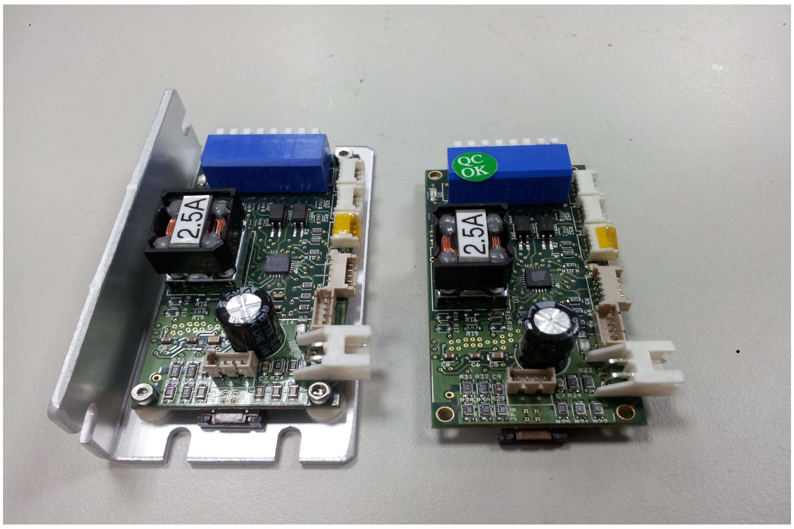
Miniature Smart Stepping Motor Driver with serial communication

User's Manual

Version: 1.0 2012-11-15



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1. Features

- Small size : 3cm x 6 cm x 1.5 cm (CB, CF)
- Built-in 115200 baud rate serial interface (RS485) to communicate up to 32 axes. The drive implements motion profile generator so that the PC-based motion controller is eventually eliminated.
- One-wire serial interface for status monitoring： Two optical isolated digital outputs of all axes can be monitored by using one wire scheme without tedious polling.
- Smart homing： reset position counter and correct lost steps by one negative limit sensor.
- Multiple function digital inputs: Position indexer digital IO, jog (+/-) motion buttons, or CW/CCW pulse inputs.
- **Positive/Negative limit sensor inputs**: This drive also contains two digital inputs for positive and negative limit sensors together with 5V voltage supply.
- Two versions of extension boards: Two types of extension boards with 3.5 mm pitch DIN connector can be selected for easy wiring.

2. Model Ordering Information

2.1 Order information

MTI – STD – 02 – XX – YY– ZZ

XX:
- 16: maximal current 1.6A
- 25: maximal current 2.5A

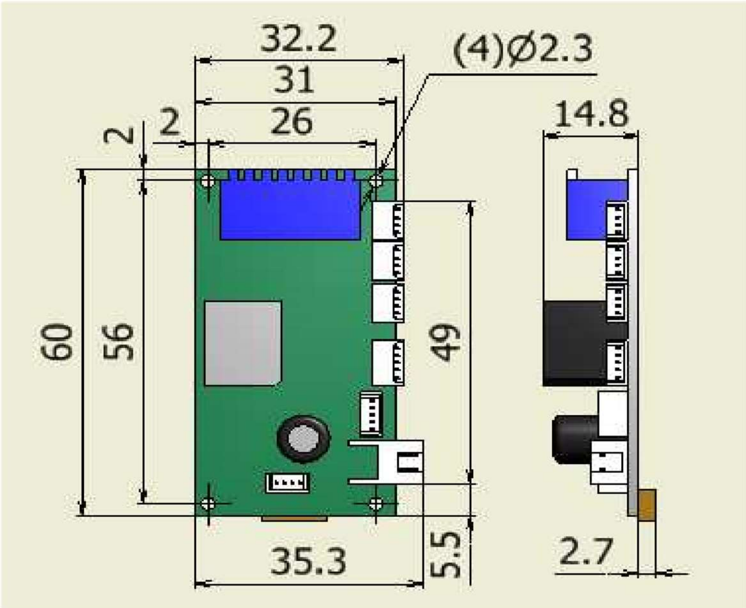
ZZ:
- 00: without aluminum back board
- 01: with aluminum back board

YY:

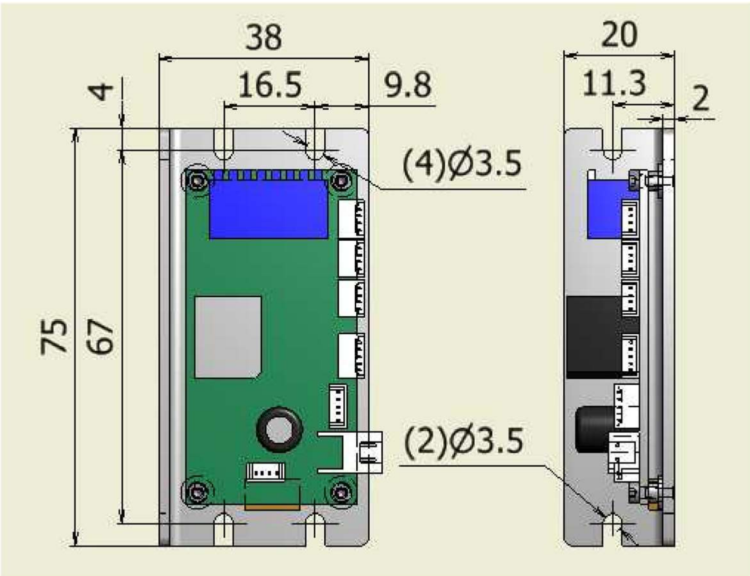
Type	I/O connector	Power connector	Motor connector
CB	1.25 mm pitch	2.5 mm pitch	1.25 mm pitch &1mm pitch FPC
ID	3.5 mm DIN	3.5 mm DIN	3.5 mm DIN

2.2 Dimensions

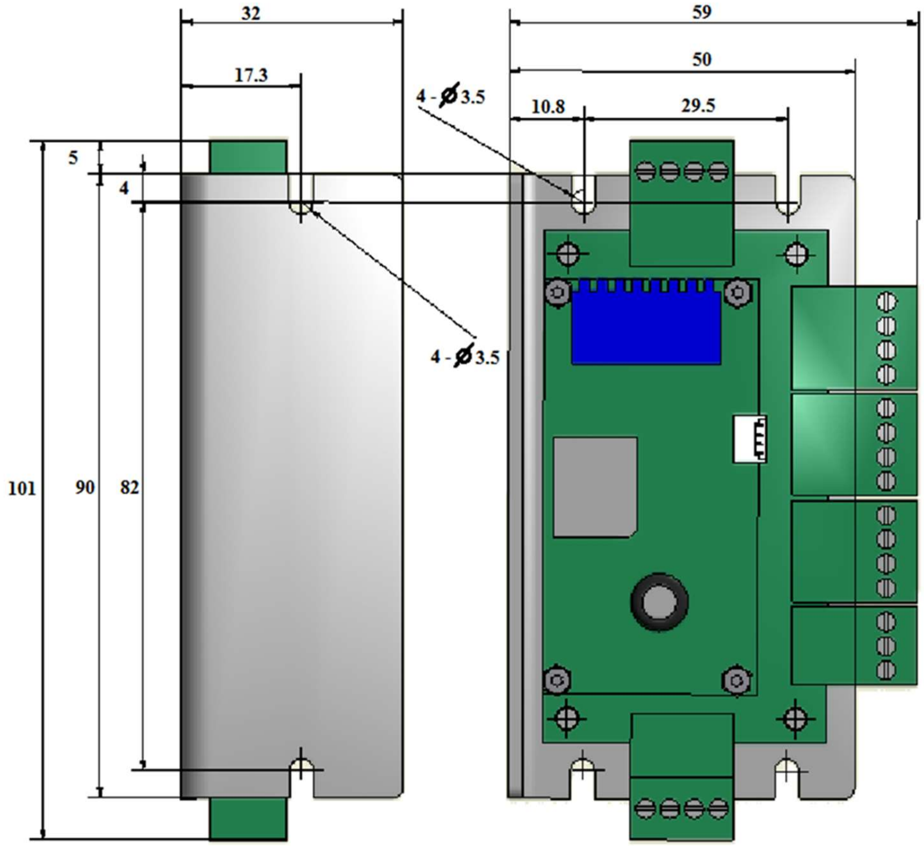
2.2.1 MTI – STD – 02 – XX– CB – 00



2.2.2 MTI – STD – 02 – XX – CB – 01



2.2.3 MTI – STD – 02 – XX – ID – 01

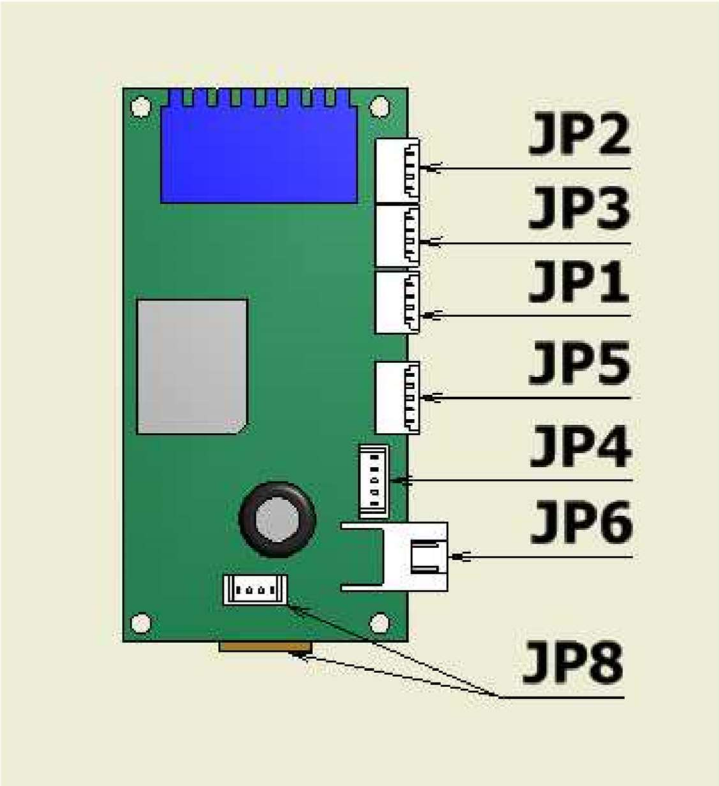


3. Electrical Specification

Items	Specification		Unit
Main supply voltage	9~24		V
Motor type	2 phase bipolar		
Maximal output current (Imax)	MTI–STD–02–16–XX–XX	1.6	A/ phase
	MTI–STD–02–25–XX–XX	2.5	
Continuous output current (Irated)	MTI–STD–02–16–XX–XX	1.1	A/ phase
	MTI–STD–02–25–XX–XX	1.8	
Operating temperature	0 ~ 50		℃
Humidity range	20 ~ 90		%
Max.VCE of digital output	24		V
Max. sink current of digital output	20		mA
Pull-high voltage of non-isolated digital input	5		V
Pull high resistor of non-isolated digital input	3.3k for DI 10k for limit sensor		ohm
Maximal Pulse rate Internal motion profile generator External CW/CCW pulse input	 64 100		kHz

4. Pin definision

4.1 CB model



4.2 CB pin definition ※

JP2：Serial IN (1.25 mm connector)

Pin	Symbol	Description
1	T+	RS485 transmit positive
2	T-	RS485 transmit negative
3	MF_C	Motion finish output (connected to previous module)
4	DO_C	Configurable output (connected to previous module)

JP3 ：Serial Out (1.25 mm connector)

Pin	Symbol	Description
1	T+	RS485 transmit positive
2	T-	RS485 transmit negative
3	MF_E	Motion finish output (connected to next module)
4	DO_E	Configurable output (connected to next module)

JP5：Digital Input (1.25 mm connector)

Pin	Symbol	Description
1	+5V	Voltage supply 5 V
2	DI1	Digital input for servo ON/OFF
3	DI2	Configurable input (bit0, jog+, CW)
4	DI3	Configurable input (bit1, jog-, CCW)
5	0V	Voltage supply 0 V

JP4：Limit Sensor Input (1.25 mm connector)

Pin	Symbol	Description
1	+5V	Voltage supply 5 V
2	S1	Current supply to diode of limit sensor
3	PL	Collector of positive direction limit sensor **(Must short to 0V if not used)**
4	NL	Collector of negative direction limit sensor **(Must short to 0V if not used)**
5	0V	Voltage supply 0 V

JP6：**Power** (1.25 mm connector)

Pin	Symbol	Description
1	V+	Motor supply positive
2	V-	Motor supply 0 V

JP8 ：Motor (1.25 mm 端子及 1 mm FPC socket)

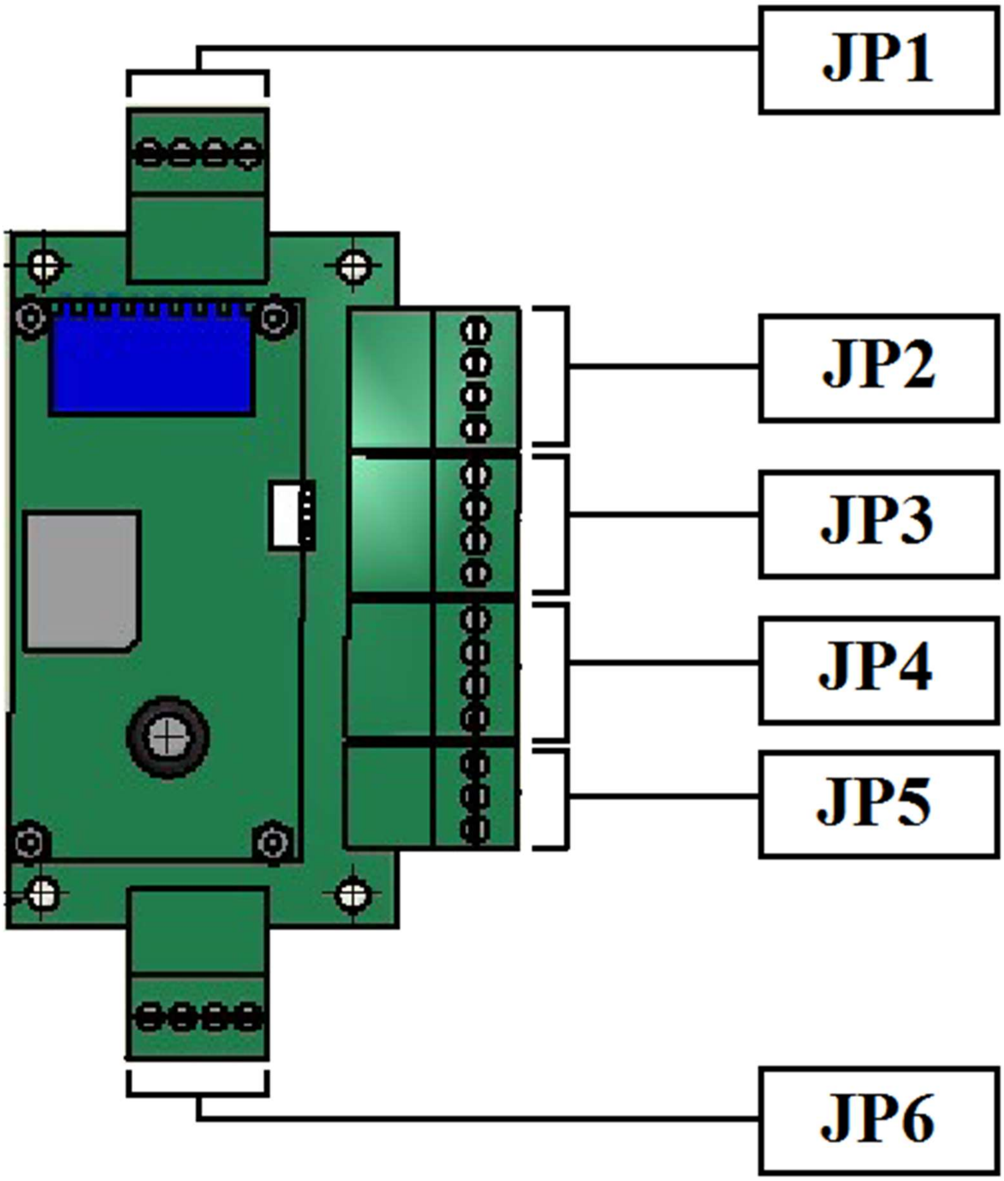
Pin	Symbol	Description
1	A+	Positive input of motor phase A
2	A-	Negative input of motor phase A
3	B-	Negative input of motor phase B
4	B+	Positive input of motor phase B

※： Pin 1 is at the top pin when viewing the above drawing

※※：JP8 pin 1 is at the left pin when viewing the above drawing

※：JP1 is no connection

4.3 ID model



JP1 ：Digital Output (3.5 mm connector) ※

Pin	Symbol	Description
1	DO_E	Configurable output (Emitter)
2	DO_C	Configurable output (Collector)
3	MF_E	Motion finish output (Emitter)
4	MF_C	Motion finish output (Collector)

JP2 ：Serial and DI1 (3.5 mm connector) ※※

Pin	Symbol	Description
1	T+	RS485 transmit positive
2	T-	RS485 transmit negative
3	I1+	ID: Positive of differential input
4	I1-	ID: Negative of differential input

JP3 ：DI2 and DI3 (3.5 mm connector)

Pin	Symbol	Description
1	I2-	ID: Negative of differential input
2	I2+	ID: Positive of differential input Bit 0, JOG+, CW
3	I3+	ID: Positive of differential input Bit 1, JOG-, CCW
4	I3-	ID: Negative of differential input

JP4：Limit Sensor Input (3.5 mm connector)

Pin	Symbol	Description
1	+5V	Voltage supply 5 V
3	PL	Collector of positive direction limit sensor
4	NL	Collector of negative direction limit sensor
5	0V	Voltage supply 0 V

JP5：Power (3.5 mm connector)

Pin	Symbol	Description
1	FG	Frame ground
2	V+	Motor supply positive
3	V-	Motor supply 0 V

JP6：Motor (3.5 mm connector)

Pin	Symbol	Description
1	A+	Positive input of motor phase A
2	A-	Negative input of motor phase A
3	B-	Negative input of motor phase B
4	B+	Positive input of motor phase B

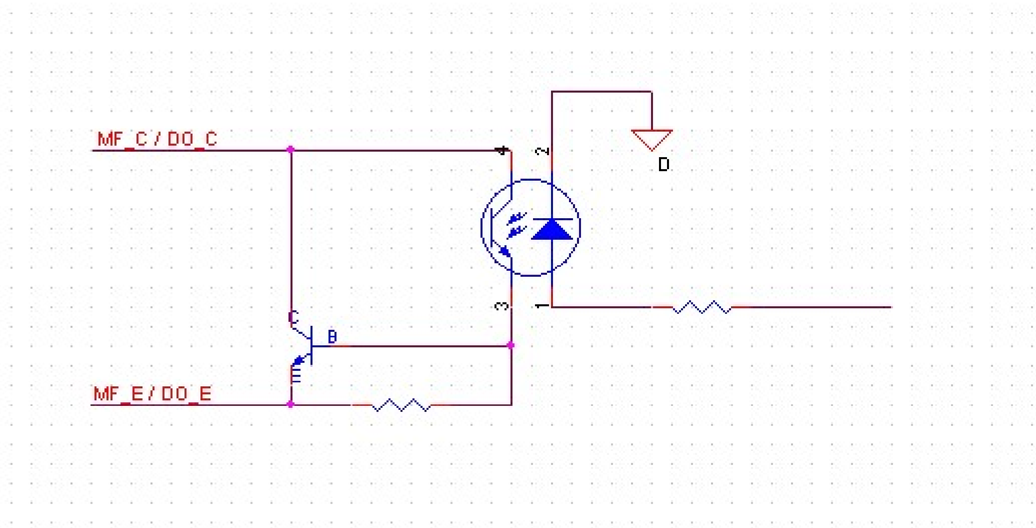
※：JP1、JP6 pin 1 is at the left pin when viewing the above drawing

※※：JP2、JP3、JP4、JP5 Pin 1 is at the top pin when viewing the above drawing

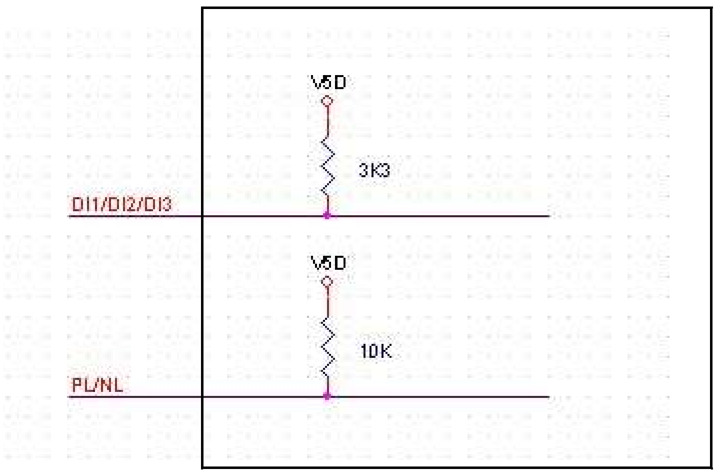
)

5. Digital Input/Output circuit inside drive

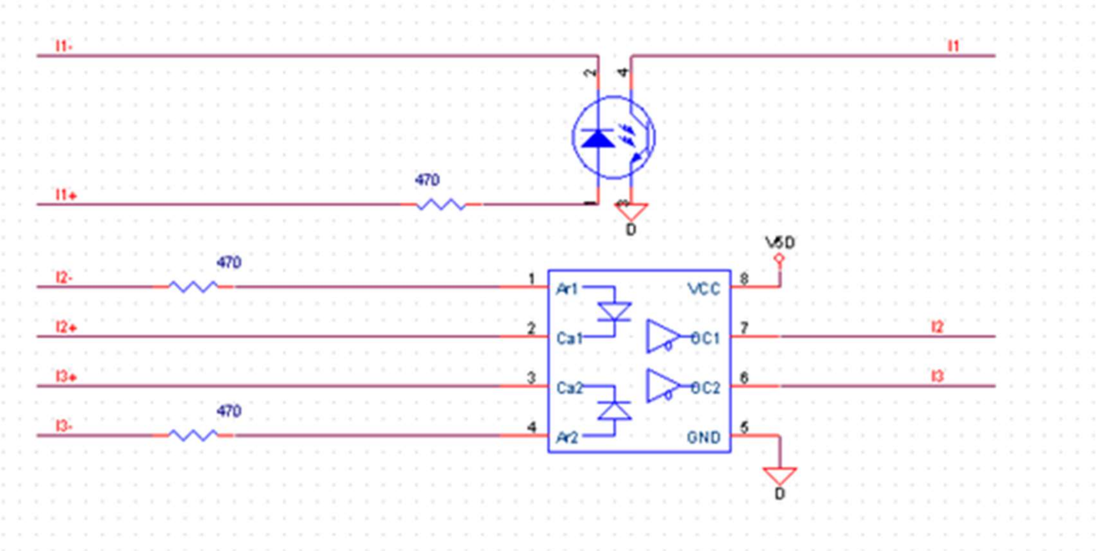
5.1 Digital Output (Isolated) (All types)



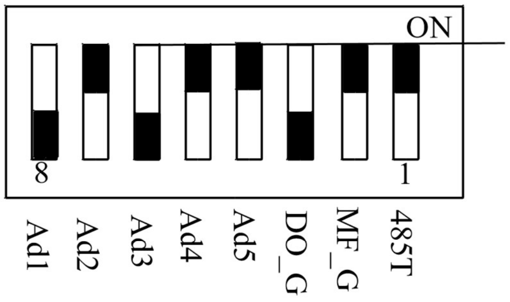
5.2 Digital input (CB type, Non-isolated)



5.3 Digital input (ID type, isolated)



6. Description of DIP switch



Note: The last module should turn ON 485T, MF_G, DO_G for proper operation.

Station=Ad5*16+Ad4*8+Ad3*4+Ad2*2+Ad1
=1*16+1*8+0*4+1*2+0*1=26

Pin	Symbol	Description
1	485T	RS485 termination resistor switch
2	MF_G	Motion finish output ground switch
3	DO_G	Configurable output ground switch
4	Ad5	RS485 address bit 5
5	Ad4	RS485 address bit 4
6	Ad3	RS485 address bit 3
7	Ad2	RS485 address bit 2
8	Ad1	RS485 address bit 1

7. RS485 Commands

7.1 Specification

Item	Value
Baud rate	115200
Data bits	8
Parity check	no
Stop bit	1
Handshake	None
RS485 station	0~3 (32 is for broadcast transmission)

7.2 Command list

TYPE	Symbol	Format	Description
Single listener	WT	[0~1] [0~n] [Value]	Write parameters of P、V groups. Ex: WT 1 3 100 Write the 3rd register of V group (IAC) to be 100
	RD	[0~1] [0~n]	Read parameters of P、V groups. Ex: RD 0 14 Read the 14th resister of P group (P14)
	RV	[Index]	Read state variable. Ex: RV 0 Read the value of 0th status register (Position)

Broadcasting	RN	[32 ASCII]	Move all connected axes according to the preset position. Ex: RN 135A427C Move 0th axis to P1 Move 1st axis to P3 Move 2nd axis to P5 Move 3rd axis to P10 Move 4th axis to P4 Move 5th axis to P2 Move 6th axis to P7 Move 7th axis to P12 Note: the ASCII follows RN command is Hex number (0~F) which represents the preset index of position. The maximal number of the characters following RN is 32, which represents position index of 32 axes.
	ST	[0~32]	Set station as listener (32 is for broadcasting) Ex: ST 3 Set station 3 as listener.
Normal	EN	[1/0]	Servo on/off drive Ex: EN 1 Servo ON the listener axis
	MN	[0~15]	Move to indexed position Ex: MN 12 The listener moves to position(P12)
	VA	[1~255]	Set motion speed Ex: VA 1 Set the speed of listener to 1. (MSP=1) (255 is exception=> MSP=1.5)
	AA	[0~7]	Set motion acceleration Ex: AA 1 Set the acceleration of listener to 1. (ACC=1)
	MA	[-2^31 ~2^31]	Move to absolute position Ex: MA 10000 The listener moves to absolute position 10000

	MI	[-2^31 ~2^31]	Move increment position Ex: MI -10000 Move to a relative position =(current position - 10000)
	HM		JOG to negative limit sensor and reset position
	SV		Save all parameters to EEPROM
	JP		JOG along positive direction
	JN		JOG along negative direction
	JS		JOG Stop
	JC	[1~255]	JOG change speed, valid when jog move
	ZP		Set current position to 0
	SP		Emergency stop and servo off, this action will be cleared by servo on again.

7.3 Command format

7.3.1

All command strings must be end with CHR（13） to notify the drive that the command is complete.

7.3.2

In RS485 communication, the sent command will NOT be Echo. If the station assigned by ST command exists, “CR LF [station] >” will be added to the response string. From now on, the active listener will respond to the master according to the command. If you want to change the listener, you should send “ST [station]” again.

7.3.3

Broadcasting command is used for broadcasting mode(Station number 32), single command is used for single listener mode(Station number 0 to 31), normal command is used for broadcasting or single mode.

7.3.4

If single listener mode is active, any wrong command will get an echo of “ER”.

Example: Read position form driver station number 8,and Driver response 1000.

Command	S	T			8	13 H								
Response							13 H	10 H	8	>				
Command	R	V			0	13 H								
Response							1	0	0	0	13 H	10 H	8	>

Example： Sent a wrong command to station 8 and got error response “ER”.

Command	R	T		0	13H						
Response						13H	10H	8	>	E	R

※If send command by **<u>Windows Hyper-terminal</u>** “Enter” means send a “CR” ASCII(13H).

8. Description of the control parameters

There are 2 groups of control parameters. P group is used for pre-programmed position. V group is used for control parameters. These parameters can be read or written through RS485 [WT/RD].

8.1 Parameters of P, V groups

		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
P	0	P0	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15
V	1	MSP	HSP	IDN	IAC	ISL	CFG	ACC									

8.2 P Group

Pre-programmed absolute positions. Value range: -2^{31}~2^{31}. These 16 positions can be indexed by MN, RN, or configurable inputs. Note: only P0~P3 can be indexed by DI2, D13.

8.3 V Group

Parameter	Description	Value Range	Real value	Units
MSP	Motion speed	1~255	Pulse Rate = 64000/*MSP*	PPS
HSP	Home speed / JOG speed	1~255	Pulse Rate = 64000/*HSP*	PPS
IDN	Motor Current when stop	0~255	Motor Current = *IDN*(Imax/255)*	A
IAC	Motor Current during acceleration or deceleration	0~255	Motor Current =*IAC*(Imax/255)*	A
ISL	Motor Current upon slewing at constant speed	0~255	Motor Current = *ISL*(Imax/255)*	A
CFG	Configuration register. **Take effect upon next power on. Definition of CFG bits, see 8.3.1.**			
ACC	Acceleration / deceleration steps※	0~7	Acceleration Step = $256*2^{ACC}$	Step

※**ACC**: Acceleration/deceleration steps, Value Range: (0~7)

The algorithm of acceleration or deceleration of this drive employs fixed steps operation. The steps used to accelerate to MSP or HSP is derived as follows.

Acceleration step=256 $*2^{ACC}$

Ex: ACC=1 => Acceleration step=256 $*2^{1}$ = 512

8.3.1 Definition of CFG bits

OM1	OM0	DO_I	MF_I	DIR_I	16I	IM1	IM0
Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0

Bit1-0: IM1-0： digital input mode bit
(0,0): No function
(0,1): JOG +/-
(1,0): 4 position index
(1,1): CW/CCW

Bit2： 16I:
0: 32 step interpolation
1: 16 step interpolation

Bit3： DIR_I (Motor direction inverse):
0: CW is positive (default)
1: CCW is positive

Bit4： MF_I (Motion Finish output logic inverse):
0: output transistor will be short upon motion finished
1: output transistor will be open upon motion finished

Bit5： DO_I (DO output logic inverse):
0: output transistor will be short upon active
1: output transistor will be open upon active

Bit6-7： OM1-0: digital output mode bit
(0,0): No function
(0,1): Enable Z break relay when servo on
(1,0): Output real time Negative Limit sensor status, enable smart home, and disable Positive Limit sensor.
(1,1): Reserved

8.4 Example of using commands

8.4.1 Change value of IAC

Command	W	T		1		3		1	0	0	13H

Description :

1.Use write command "WT" and add a "Space" with it.

2.Select group code first(IAC is in V-group, group code = 1), and add a "Space" with it.

3.Select Parameter code (IAC is NO.4 Parameter code = 3) and add a "Space" with it.

4.Enter value (In this example we set IAC = 100)

5.Add "CR"(ASCII : 13)

8.4.2 Read value of IAC

Command	R	D		1		3	13H

Description :

1.Use read command "RD" and add a "Space" with it.

2.Select group code first(IAC is in V-group, group code = 1) and add a "Space" with it.

3.Select Parameter code (IAC is NO.4 Parameter code = 3) and add a "Space" with it.

4.Add "CR"(ASCII : 13)

8.5 Calculation of speed and acceleration

8.5.1 Assumption

Motor step angle: 1.8 degree

MSP=1

ACC=0

16I=0 (32 step interpolation)

move distance 3200 steps

8.5.2 Calculation※

Motor Steps per round = 360*32/1.8
= 6400

Moving Speed = 64000/MSP
= 64000/1
= 64000 step/sec
= 10 round/sec
= 600 rpm

Acceleration Steps = $256*2^0$
= 256 steps

$$\text{Acceleration} = \frac{MovingSpee^{\;2}}{2} * \frac{1}{accelerationSteps}$$

$$= \frac{64000^2}{2} * \frac{1}{256}$$

= 8000000 step/sec^2

= 1250 round/sec^2

※Note: the above calculation is actually the drive limit. If you want to increase maximal speed, you can set 16I=1 such that the maximal speed will be 1200 rpm.

9. State variable description

There are 10 variables for monitoring the servo-loop state of this drive. These parameters can only be read through RS232/RS485.

For example, (RV 4) will return the firmware version.

index	0	1	2	3	4	5
RV	Position	Velocity	Status	CFG	Version	DI status

Item	Range of value	Description
Position	-2^{31}~2^{31}	Current Position
Velocity	1~255	Current operation speed
Status	0x00~0xFF	Status (hex)
CFG	0x00~0xFF	Current configuration register (hex)
Version	A.B	Version of firmware
DI_status	0x00~0x1F	3 Digital input status (hex)

10. Status register description

This drive uses one 8-bit register to store the internal status. These values can be read thru serial communication interface by sending command RV 2. The drive will respond with 2 ASCII characters to represent the 8-bit HEX value. The meaning of each bit in this byte is explained as follows.

10.1 Status: (Command "RV 2")

DO_bit	HOME	PL_trig	NL_trig	DIR	SVON	FAULT	MF_bit
Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0

Bit0: MF_bit：This bit is set when motion finish.
0: motion finish.
1: motion still not finish.

Bit1: FAULT：This bit is set when drive alarm.
0: Drive has no alarm.
1: Drive has an alarm.

Bit2: SVON：This bit is set when servo on.
0: Server off.
1: Servo on.

Bit3: DIR：This bit is set when motor move in positive direction.
0: move in negative direction.
1: move in positive direction.

Bit4: NL_bit：This bit is set when negative limit is triggered from on to off.
0: Not trigger.
1: Triggered (Switch from On to Off)

Bit5: PL_bit：This bit is set when positive limit is triggered from on to off.
0: Not trigger.
1: Triggered (Switch from On to Off)

Bit6: HOME：This bit is set when home procedure is successful.
0: Fault
1: Success

Bit7: DO_bit：This bit is set according to the function of DO mode.
0: DO=0
1: DO=1

10.2 DI_Status: (Command "RV 5")

X	X	X	PL_rt	NL_rt	DI3	DI2	DI1
Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0

Bit0: DI1：
0: OFF(open to GND)
1: ON(short to GND)

Bit1: DI2：
0: OFF(open to GND)
1: ON(short to GND)

Bit2: DI3：
0: OFF(open to GND)
1: ON(short to GND)

Bit3: NL_rt real-time status of negative limit
1: OFF(open to GND)
0: ON(short to GND)

Bit4: PL_rt real-time status of positive limit
1: OFF(open to GND)
0: ON(short to GND)

Bit5-7: No use.

11. Detailed description of Smart Homing

The special feature of this stepping motor drive is to use one negative limit sensor to correct lost steps. Set the output mode bits (OM1, OM0) = (1,0) will enable this function.

11.1 Homing mechanism

When HM command is received, the drive will check the input of negative limit sensor. If it is high (blocked) which means the motor is at negative limit sensor or home sensor is out of order, the motor will not move. At the meantime, the status bits of HOME, PL_trig, NL_trig, MF_bit will be cleared. The user must send a MI xxxx command to force the motor moving away from the negative limit sensor toward the positive direction. If the input of negative limit sensor becomes low (not blocked), the NL_rt will be set to 1. The user can detect this condition at real time without polling by using its corresponding digital output pin DO_bit. Then, issue HM command again to complete the home process.

If the input of negative limit sensor is low, the motor will jog in the negative direction until the input of negative limit sensor goes high. When the input of negative limit sensor is triggered from low to high, the drive will set MF_bit, HOME, and NL_trig which means the home operation is successful and the position counter is cleared to zero.

The meanings of NL_trig and NL_rt are different although they represent the negative limit sensor signal. NL_trig is latched only when the input of negative limit sensor rises from low to high, while NL_rt represents the real-time state of the input of negative limit sensor The latched NL_trig will be cleared only when the next move command is issued.

11.2 Lost step correction using smart homing

Due to the lost-step nature of stepping motor, moving to zero position is confirmed if and only if the negative limit sensor is triggered. Since ball screw or belt driven by stepping motor has backlash, the MA 0 command may not trigger negative limit sensor even when the motion is complete, and the position is supposed at zero. This circumstance may lead to an ambiguous condition that you are not sure whether the lost step or backlash results in the inactiveness of the negative limit switch.

To solve this problem, the following steps can correct lost steps.

1. Smart home must be enabled by setting (OM1, OM0) = (1,0).
2. Set the return position to be smaller than 0. (ex. P0= - 30). Usually, the amount is the backlash of the ball screw.

If the lost step happens during return movement such that the negative limit sensor is not detected, the MF_bit will not be asserted and the DO_bit will not be set. The user can issue HM again until the sensor is detected.

If the lost step happens during the forward motion, the return to the return position will exceed the original home position. The drive will stop the motor and set the position to zero upon negative limit sensor is detected. Hence, the next move of forward motion will be correct.

11.3 Height measurements using smart homing

The stepping motor does not include any feedback encoder. To perform the height measurement of the pick-&-place target, a vacuum sensor or contact sensor is employed which can be connected to the positive limit input. When (OM1, OM0) = (1,0) is set, the output DO reflecting DO_bit is defined as

DO_bit= (NL_rt) or (DIR and PL_rt).

When smart homing is complete, issuing JP command to jog in the positive direction can be used to detect contact height. The motor will be stopped immediately when the positive limit input is asserted. You can use RV0 to read current position.

Note that the JP command will stop motor if positive limit is asserted. The commands of MA, MN, and RN will stop the motor and set DO_bit only. This is the special feature of mode (OM1, OM0) = (1,0).

11.4 High-speed pick and place

The smart homing feature makes the multi-axis pick and place possible. The mechanism is described as follows.

1. Set P0 a negative number and work as the home position.
    1. Set P1~P15 as the target height of each axis.
    2. By issuing RN command, multiple axes can be moved toward target position simultaneously.
    3. Then check the status MF_bit and DO_bit which can be popped out to MF and DO outputs and serially connected among all axes. The host only monitors these 2 outputs and knows the status of all axes. See next chapter for detailed connection.
    4. If DO_bit is not asserted, lost steps or missing target may happen. The host then polling all axes to find which axis has problem.
    5. When RN XXXX… command is finished, a new RN 0000… can be issued to move all axes to zero position P0. The lost step during contact or some other reason will be corrected and the following movement will be normal again.

12. One-Wire Serial Monitoring

The following diagram shows how to use one wire scheme to serially connect the isolated digital outputs. This approach not only considerably reduces number of wires, but also be able to know the specific status of all axes without tedious polling. For example, when controller broadcasts a RS485 motion command to all axes, it is not necessary to polling around all axes to find out whether the motion of every axis is finished. By using use one wire scheme, if and only if all axes finish motion and short the transistors, the photo diode of the first stage would be pulled low to signal the controller that the all axes complete motion. As a consequence, the controller can hand shake all axes at high speed by monitoring only one output.