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**MX-28T/R/AT/AR**

1. Specifications
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[Edit on GitHub](#)**MX-28AR, MX-28AT****NOTE** : Compliance has been replaced with PID Gains.**NOTE** : Although the MX-28AT (TTL) and MX-28AR (RS-485) differ in communications protocols both have the same features and perform equally. (TTL uses 3-pin connectors while RS-485 uses 4)**NOTE**: MX(2.0) is a special firmware for the DYNAMIXEL MX series supporting the DYNAMIXEL Protocol 2.0. The MX(2.0) firmware can be upgraded from the Protocol 1.0 by using the [Firmware Recovery](#) in DYNAMIXEL Wizard 2.0 or [R+ Manager](#).**Dynamixel MX Series (Protocol v2.0) F/W Recovery****WARNING** : For MX-28(2.0) Protocol, please refer to the [MX-28\(2.0\) Control Table](#) as they are different.**1. Specifications**

Item	Specifications
MCU	ARM CORTEX-M3 (72 [MHz], 32Bit)
Position Sensor	Contactless absolute encoder (12Bit, 360 [°]) Maker : ams(www.ams.com), Part No : AS5045
Motor	Coreless(Maxon)
Baud Rate	7,834 [bps] ~ 3 [Mbps]



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Item	Specifications
Control Algorithm	PID control
Resolution	4096 [pulse/rev]
Backlash	20 [arcmin] (0.33 [°])
Operating Modes	Wheel Mode (Endless Turn) Joint Mode (0 ~ 360 [°]) Multi-turn Mode
Weight	MX-28AR/AT : 77 [g] MX-28R/T : 72 [g]
Dimensions (W x H x D)	35.6 x 50.6 x 35.5 [mm]
Gear Ratio	193 : 1
Stall Torque	2.3 [N.m] (at 11.1 [V], 1.3 [A]) 2.5 [N.m] (at 12 [V], 1.4 [A]) 3.1 [N.m] (at 14.8 [V], 1.7 [A])
No Load Speed	50 [rev/min] (at 11.1 [V]) 55 [rev/min] (at 12 [V]) 67 [rev/min] (at 14.8 [V])
Radial Load	¹ 30 [N] (10 [mm] away from the horn)
Axial Load	¹ 15 [N]
Operating Temperature	-5 ~ +80 [°C]
Input Voltage	10.0 ~ 14.8 [V] (Recommended : 12.0 [V])
Command Signal	Digital Packet
Physical Connection	RS485 / TTL Multidrop Bus TTL Half Duplex Asynchronous Serial Communication with 8bit, 1stop, No Parity RS485 Asynchronous Serial Communication with 8bit, 1stop, No Parity
ID	254 ID (0 ~ 253)
Feedback	Position, Temperature, Load, Input Voltage, etc
Case Material	Engineering Plastic(Front, Middle, Back) ¹ Metal(Front)
Gear Material	Full Metal Gear
Standby Current	100 [mA]

¹ Applies to aluminum housing products(MX-28AR/AT, MX-64AR/AT, MX-106R/T).

**DANGER**

(May cause serious injury or death)

- Never place items containing water, flammables, or solvents near the product.
- Never place fingers, arms, toes, and other body parts near product during operation.
- Cut the power off if the product begins to emit strange odors or smoke.
- Keep product out of reach of children.
- Check input polarity before installing wiring or cables.

**CAUTION**

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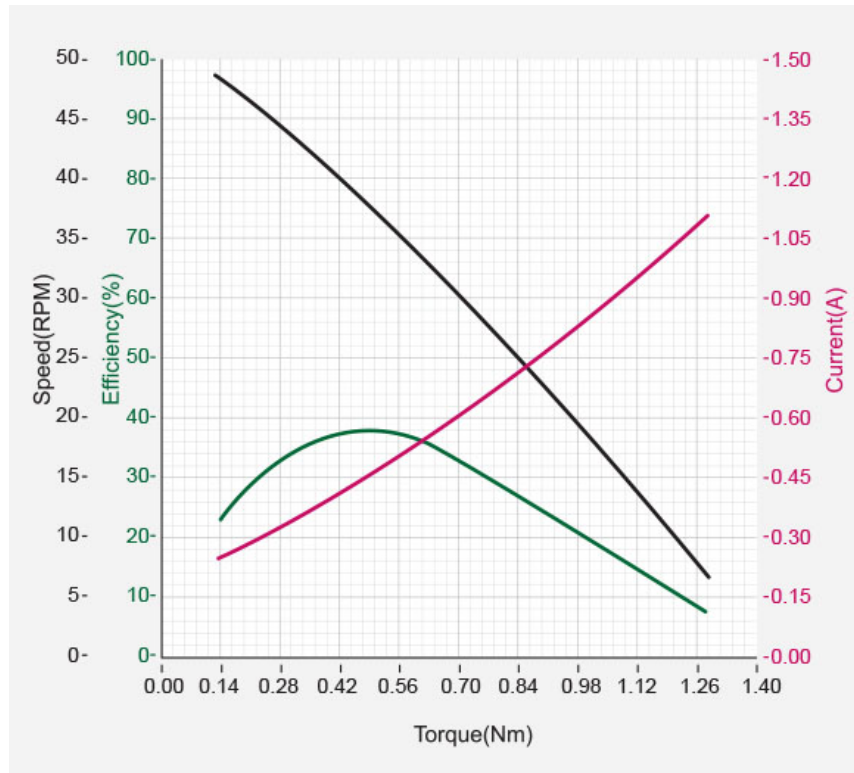
(May cause injury or damage to product)

- Always comply with operating environment specifications including voltage, current, and temperature.
- Do not insert blades or other sharp objects during product operation.

**ATTENTION**

(May cause injury or damage to product)

- Do not disassemble or modify the product.
- Do not drop or apply strong impacts to the product.

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NOTE : The given Stall torque rating for a servo is different from it's continuous output rating, and may also differ from it's expected real world performance.

Stall torque is the maximum momentary torque output the servo is capable of, an is generally how RC servos are measured. The Performance graph, or N-T curve, from the above graph is measured under conditions simulating a gradually increasing load.

The actual real world performance of the servo will generally be closer to the performance graph measurements, not the rated stall torque. For this reason, the performance graph is broadly used in the industrial field.

Generally, the Maximum Torque shown through Performance Graph testing is less than the maximum Stall Torque.

CAUTION - When supplying power:

- It is recommended to use a ROBOTIS controller or SMPS2DYNAMIXEL power adapter.
- Do not connect or disconnect DYNAMIXEL actuator cables while power is being supplied.



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2. Control Table

The Control Table is a structure of data implemented in the device. Users can read a specific Data to get status of the device with Read Instruction Packets, and modify Data as well to control the device with WRITE Instruction Packets.

2. 1. Control Table, Data, Address

The Control Table is a structure that consists of multiple Data fields to store status or to control the device. Users can check current status of the device by reading a specific Data from the Control Table with Read Instruction Packets. WRITE Instruction Packets enable users to control the device by changing specific Data in the Control Table. The Address is a unique value when accessing a specific Data in the Control Table with Instruction Packets. In order to read or write data, users must designate a specific Address in the Instruction Packet. Please refer to [DYNAMIXEL Protocol 1.0](#) for more details about Instruction Packets.

2. 1. 1. Area (EEPROM, RAM)

The Control Table is divided into 2 Areas. Data in the RAM Area is reset to initial values when the power is reset(Volatile). On the other hand, data in the EEPROM Area is maintained even when the device is powered off(Non-Volatile).

2. 1. 2. Size

The Size of data varies from 1 ~ 2 bytes depend on their usage. Please check the size of data when updating the data with an Instruction Packet. For data larger than 2 bytes will be saved according to [Little Endian](#).

2. 1. 3. Access

The Control Table has two different access properties. 'RW' property stands for read and write access permission while 'R' stands for read only access permission. Data with the read only property cannot be changed by the WRITE Instruction. Read only property('R') is generally used for measuring and monitoring purpose, and read write property('RW') is used for controlling device.

2. 1. 4. Initial Value

Each data in the Control Table is restored to initial values when the device is turned on. Default values in the EEPROM area are initial values of the device (factory default settings). If any values in the EEPROM area are modified by a user, modified values will be restored as initial values when the device is turned on. Initial Values in the RAM area are restored when the device is turned on.

2. 2. Control Table of EEPROM Area

Address	Size(Byte)	Data Name	Description	Access	Initial Value
0	2	Model Number	Model Number	R	29
2	1	Firmware Version	Firmware Version	R	-
3	1	ID	DYNAMIXEL ID	RW	1
4	1	Baud Rate	Communication Speed	RW	34
5	1	Return Delay Time	Response Delay Time	RW	250
6	2	CW Angle Limit	Clockwise Angle Limit	RW	0
8	2	CCW Angle Limit	Counter-Clockwise Angle Limit	RW	4,095
11	1	Temperature Limit	Maximum Internal Temperature Limit	RW	80



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Address	Size(Byte)	Data Name	Description	Access	Initial Value
12	1	Min Voltage Limit	Minimum Input Voltage Limit	RW	60
13	1	Max Voltage Limit	Maximum Input Voltage Limit	RW	160
14	2	Max Torque	Maximun Torque	RW	1023
16	1	Status Return Level	Select Types of Status Return	RW	2
17	1	Alarm LED	LED for Alarm	RW	36
18	1	Shutdown	Shutdown Error Information	RW	36
20	2	Multi Turn Offset	Adjust Position with Offset	RW	0
22	1	Resolution Divider	Divider for Position Resolution	RW	1

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2. 3. Control Table of RAM Area

Address	Size(Byte)	Data Name	Description	Access	Initial Value
24	1	Torque Enable	Motor Torque On/Off	RW	0
25	1	LED	Status LED On/Off	RW	0
26	1	D Gain	Derivative Gain	RW	0
27	1	I Gain	Integral Gain	RW	0
28	1	P Gain	Proportional Gain	RW	32
30	2	Goal Position	Desired Position	RW	-
32	2	Moving Speed	Moving Speed(Moving Velocity)	RW	-
34	2	Torque Limit	Torque Limit	RW	Max Torque
36	2	Present Position	Present Position	R	-
38	2	Present Speed	Present Speed	R	-
40	2	Present Load	Present Load	R	-
42	1	Present Voltage	Present Voltage	R	-
43	1	Present Temperature	Present Temperature	R	-
44	1	Registered	If Instruction is registered	R	0
46	1	Moving	Movement Status	R	0
47	1	Lock	Locking EEPROM	RW	0
48	2	Punch	Minimum Current Threshold	RW	0
50	2	Realtime Tick	Count Time in millisecond	R	0
73	1	Goal Acceleration	Goal Acceleration	RW	0

2. 4. Control Table Description

2. 4. 1. Model Number (0)

This address stores model number of DYNAMIXEL.

2. 4. 2. Firmware Version (2)

This address stores firmware version of DYNAMIXEL.

2. 4. 3. ID (3)



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The ID is a unique value in the network to identify each DYNAMIXEL with an Instruction Packet. 0~253 (0xFD) values can be used as an ID, and 254(0xFE) is occupied as a broadcast ID. The Broadcast ID(254, 0xFE) can send an Instruction Packet to all connected DYNAMIXEL simultaneously.

NOTE : Please avoid using an identical ID for multiple DYNAMIXEL. You may face communication failure or may not be able to detect DYNAMIXEL with an identical ID.

NOTE : If the Instruction Packet ID is set to the Broadcast ID(0xFE), Status Packets will not be returned for READ or WRITE Instructions regardless of the set value of Status Return Level (16). For more details, please refer to the [Status Packet](#) section for [DYNAMIXEL Protocol 1.0](#)



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2. 4. 4. Baud Rate (4)

Baud Rate determines serial communication speed between a controller and DYNAMIXEL. Available value range is 0 ~ 254(0xFE), and below is the equation for BPS calculation.

$$\text{Baudrate(BPS)} = 2,000,000 / (\text{Value} + 1)$$

Value	Baud Rate(bps)	Margin of Error
0	2M	0.000 [%]
1	1M	0.000 [%]
3	500,000	0.000 [%]
4	400,000	0.000 [%]
7	250,000	0.000 [%]
9	200,000	0.000 [%]
16	115200	-2.124 [%]
34(Default)	57600	0.794 [%]
103	19200	-0.160 [%]
207	9600	-0.160 [%]

NOTE : Less than 3% of the baud rate error margin will not affect to UART communication.

NOTE : For the stable communication with higher Baudrate, configure USB Latency value to the lower.

[USB Latency Setting](#)

For BPS over 250 values :

Value	Baud Rate	Margin of Error
250	2,250,000	0.000%
251	2,500,000	0.000%
252	3,000,000	0.000%

2. 4. 5. Return Delay Time (5)

If the DYNAMIXEL receives an Instruction Packet, it will return the Status Packet after the time of the set Return Delay Time(5).

Note that the range of values is 0 to 254 (0xFE) and its unit is 2 [μsec]. For instance,

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if the Return Delay Time(5) is set to '10', the Status Packet will be returned after 20[μsec] when the Instruction Packet is received.

Unit	Value Range	Description
2[μsec]	0 ~ 254	Default value '250'(500[μsec]) Maximum value: '508'[μsec]

2. 4. 6. CW/CCW Angle Limit(6, 8)

The angle limit allows the motion to be restrained. The range and the unit of the value is the same as [Goal Position\(30\)](#).

- CW Angle Limit: the minimum value of [Goal Position\(30\)](#)
- CCW Angle Limit: the maximum value of [Goal Position\(30\)](#)

The following three modes can be set pursuant to the value of CW and CCW.

Operation Type	CW / CCW
Wheel Mode	Condition that both CW and CCW are 0
Joint Mode	Neither CW or CCW are 0 (Conditions excluding Wheel Mode and Multi-turn Mode)
Multi-turn Mode	Condition that Both CW and CCW are 4095

The wheel mode can be used to wheel-type operation robots since motors of the robots spin infinitely. The joint mode can be used to multi-joints robot since the robots can be controlled with specific angles. Multi-turn mode allows joint mode control over multiple rotations (Position range : -28,672 ~ 28,672)

2. 4. 7. Temperature Limit (11)

The operating temperature's upper bound of the DYNAMIXEL.

For instance, if the value of the Temperature Limit(11) is set as '80', it means 80 °C. If the operating DYNAMIXEL's internal temperature is over the Temperature Limit(11), the Status Packet transmits Overheating Error Bit (Bit2) via the ERROR field.

Providing that Overheating flag is set in the [Alarm LED\(17\)/Shutdown\(18\)](#), the Alarm LED will start blinking and the motor's output will be 0 [%].

Unit	Value Range
About 1°C	0 ~ 100

CAUTION : Do not set the temperature higher than the default value. When the temperature alarm shutdown occurs, wait 20 minutes to cool the temperature before re-use. Keep using the product when the temperature is high can cause severe damage.

2. 4. 8. Min/Max Voltage Limit (12, 13)

The operating voltage's upper and lower bound of the DYNAMIXEL.

Unit	Value Range	Description
About 0.1V	50 ~ 160	5.0 ~ 16.0V

The range of value is from 50 to 160 and the per unit value is 0.1 [V]. For instance, if the value of the Max Voltage Limit(13) is set as '80', it means 8 V. If the [Present Voltage\(42\)](#) which is representing the input voltage to the device (the DYNAMIXEL) is lower than the Min Voltage Limit(12) or over the Max Voltage Limit(13), the Status Packet transmits Input Voltage Error Bit(0x01) via the ERROR field. Providing that Input Voltage Error Bit(0x01) flag is set in the [Alarm LED\(17\)/Shutdown\(18\)](#), the Alarm LED will start blinking and the motor's output will be 0 [%].



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**2. 4. 9. Max Torque (14)**

It is the torque value of maximum output. 0 to 1,023 (0x3FF) can be used, and the unit is about 0.1%.

For example, Data 1,023 (0x3FF) means that DYNAMIXEL will use 100% of the maximum torque it can produce while Data 512 (0x200) means that DYNAMIXEL will use 50% of the maximum torque.

When the power is turned on, [Torque Limit\(34\)](#) is reset to the value of Max Torque(14).

2. 4. 10. Status Return Level (16)

The Status Return Level (16) decides how to return Status Packet when DYNAMIXEL receives an Instruction Packet.

Value	Responding Instructions	Description
0	PING Instruction	Returns the Status Packet for PING Instruction only
1	PING Instruction READ Instruction	Returns the Status Packet for PING and READ Instruction
2	All Instructions	Returns the Status Packet for all Instructions

NOTE : If the Instruction Packet ID is set to the Broadcast ID(0xFE), Status Packet will not be returned for READ or WRITE Instructions regardless of Status Return Level (16). For more details, please refer to the [Status Packet](#) section for [DYNAMIXEL Protocol 1.0](#).

2. 4. 11. Alarm LED(17), Shutdown(18)

The DYNAMIXEL can protect itself by detecting dangerous situations that could occur during the operation. Each Bit is inclusively processed with the 'OR' logic, therefore, multiple options can be generated. For instance, when '0x05' (binary : 00000101) is defined in Shutdown(18), DYNAMIXEL can detect both Input Voltage Error(binary : 00000001) and Overheating Error(binary : 00000100). If those errors are detected, the Alarm LED will start blinking and the motor's output will be 0 [%].

The followings are detectable situations.

Bit	Item	Description
Bit 7	0	-
Bit 6	Instruction Error	Detects that undefined Instruction is transmitted or the ACTION command is delivered without the REG_WRITE command
Bit 5	Overload Error	Detects that persistent load exceeds maximum output
Bit 4	Checksum Error	Detects that the Checksum of the transmitted Instruction Packet is invalid
Bit 3	Range Error	Detects that the command is given beyond the range of usage
Bit 2	Overheating Error	Detects that the internal temperature exceeds the set temperature
Bit 1	Angle Limit Error	Detects that Goal Position is written with the value that is not between CW Angle Limit and CCW Angle Limit
Bit 0	Input Voltage Error	Detects that input voltage exceeds the configured operating voltage

NOTE : If Shutdown occurs, **LED will flicker every second.**



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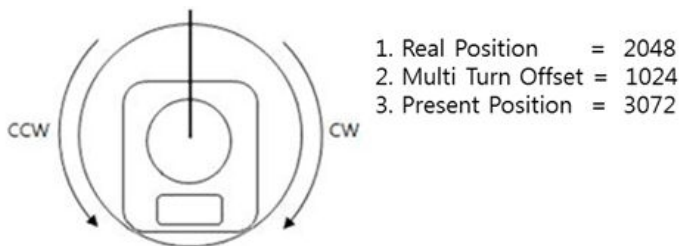


2. 4. 12. Multi Turn Offset (20)

Adjusts offset position. This offset value is added to the [Present Position\(36\)](#).

Initial value is 0 and the range is from -24,576 to 24,576.

DYNAMIXEL with a Present position of 2,048 with an offset of 1,024 will return an adjusted Present position of 3,072.



NOTE : The [Multiturn Offset\(20\)](#) and [Resolution Divider\(22\)](#) can be applied in Munti-turn Mode only (The condition that both CW and CCW are 0, see [CW/CCW Angle Limit\(6, 8\)](#) for more operation types.), otherwise, the set value in Multiturn Offset(20) and Resolution Divider(22) is ignored in different operation types.

2. 4. 13. Resolution Divider (22)

It allows the user to change DYNAMIXEL's resolution.

The default Resolution Divider Value is set as 1. (1 ~ 4 available)

When resolution is lowered, revolutions (in both directions) can be increased (up to 28 turns in each direction).

$$\text{Present Position} = \text{Real Position} / \text{Resolution Divider}$$

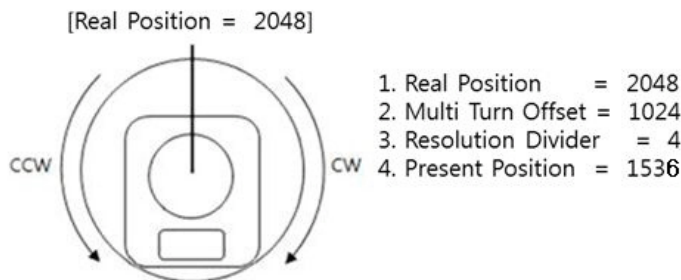
For example, a Real Position of 2048 with a Resolution Divider set as 2 will yield a Present Position value of 1024 ($2048/2 = 1024$).

A DYNAMIXEL with Resolution Divider set as 2 will have a resolution 2048 for a single revolution.

The Present Position can be obtained while Multi-turn Offset and Resolution Divider are taken into account.

$$\text{Present position} = (\text{Real Position} / \text{Resolution Divider}) + \text{Multi-turn Offset}$$

For example, a DYNAMIXEL with a Real Position of 2048 with a Resolution Divider set as 4 and Multi-turn Offset as 1024 will yield a Present Position of 1536 ($(2048/4) + 1024 = 1536$).



NOTE : The [Multiturn Offset\(20\)](#) and [Resolution Divider\(22\)](#) can be applied in Munti-turn Mode only (The condition that both CW and CCW are 0, see [CW/CCW Angle Limit\(6, 8\)](#) for more operation types.), otherwise, the set value in Multiturn Offset(20) and Resolution Divider(22) is ignored in different operation types.

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**2. 4. 14. Torque Enable (24)**

Value	Description
0(Default)	Torque Off
1	Torque On

2. 4. 15. LED (25)

The LED(65) determines LED On or Off.

Bit	Description
0(Default)	Turn OFF the LED
1	Turn ON the LED

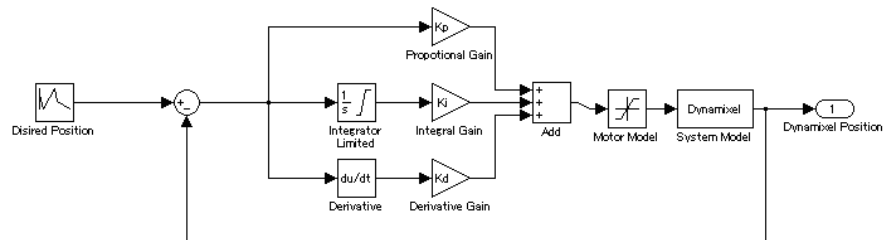
NOTE : Check the status of DYNAMIXEL by the counts of flickering LED.

Status	LED Representation
Booting	LED flickers once
Factory Reset	LED flickers 4 times
Alarm	LED flickers
Boot Mode	LED On

2. 4. 16. PID Gains (26, 27, 28)

The following is the block-diagram for the PID controller.

- **P gain** : value of proportional band.
- **I gain** : value of integral action.
- **D Gain** : value of derivative action. Gains values are in between 0 ~ 254.



- K_p : P Gain / 8
- K_i : I Gain * 1,000 / 2,048
- K_d : D Gain * 4 / 1,000

The relationship between Compliance Slop and PID

Slope	P Gain
8	128
16	64
32	32
64	16
128	8

The less the P gain, The larger the back lash, and the weaker the amount of output near goal position.

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At some extent, it is like a combined concept of margin and slope.

It does not exactly match the previous concept of compliance. So it is obvious if you see the difference in terms of motion.

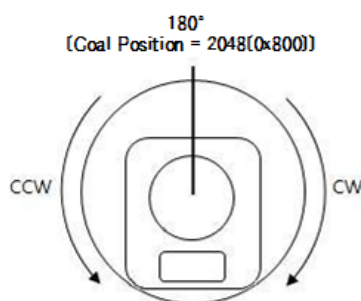
NOTE: PID control theory is not only limited to the control of motor(actuator) but is a generic theory that can be applied to all kinds of control. For more details about the PID controller, see [PID Controller](#).

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2. 4. 17. Goal Position (30)

Set the DYNAMIXEL's goal position through the Goal Position(30).

0 to 4,095 (0xFFFF) is available. The unit is 0.088 [°]. If the Goal Position(30) is set over the [CW/CCW Angle Limit\(6, 8\)](#), the Status Packet transmits Angle Limit Error Bit (0x01) via its ERROR field. In the case, providing that Angle Limit Error Bit(0x01) in [Alarm LED/Shutdown](#) is set, the Alarm LED will start blinking and the motor's output will be 0 [%].



The picture above is the front view of DYNAMIXEL.

In multi-turn mode DYNAMIXEL has a range from -28,672 to 28,672 (can turn up to 7 revolutions in either CW or CCW direction). When resolution divider is set to a different value revolutions can increase.

NOTE : If it is set to Wheel Mode, Goal Position value is not used.

2. 4. 18. Moving Speed (32)

- **Join Mode, Multi-Turn mode** It is a moving speed to Goal Position. 0~1023 (0X3FF) can be used, and the unit is about 0.114rpm. If it is set to 0, it means the maximum rpm of the motor is used without controlling the speed. If it is 1023, it is about 116.62rpm. For example, if it is set to 300, it is about 34.2 rpm. However, the rpm will not exceed the No Load Speed.
- **Wheel Mode** It is a moving speed to Goal direction. 0~2047 (0X7FF) can be used, and the unit is about 0.114rpm. If a value in the range of 0~1023 is used, it is stopped by setting to 0 while rotating to CCW direction. If a value in the range of 1024~2047 is used, it is stopped by setting to 1024 while rotating to CW direction. That is, the 10th bit becomes the direction bit to control the direction.

NOTE : Wheel mode allows to check max rpm. Any values higher than max rpm will not take effect.

2. 4. 19. Torque Limit (34)

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It is the value of the maximum torque limit.

0 ~ 1,023(0x3FF) is available, and the unit is about 0.1%.

For example, if the value is 512, it is about 50%; that means only 50% of the maximum torque will be used.

When the power is turned on, Torque Limit(34) is reset to the value of [Max Torque\(14\)](#).

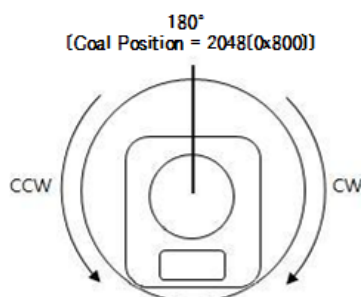
NOTE : If the function of [Alarm LED\(17\)/Shutdown\(18\)](#) is triggered, the motor loses its torque because Torque Limit(34) becomes 0. Once error conditions are resolved and Torque Limit(34) is changed to the value other than 0, the motor can be operated again.



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2. 4. 20. Present Position (36)

It is the present position value of DYNAMIXEL. The range of the value is 0~4095 (0xFFFF), and the unit is 0.088 [°].



- The picture above is the front view of DYNAMIXEL.

In multi-turn mode, the range is from -28,672 to 28,672 with unit values dependent on Resolution Divider (0.088 * Resolution Divider)

NOTE : In multi-turn mode, Present position depends on resolution divider and multi-turn offset. For more information, turn to the section on Multi Turn offset and Resolution Divider.

NOTE : In multi-turn mode, Two's complement is applied for the negative value. For more information, please refer to [Two's complement](#) from Wikipedia.

2. 4. 21. Present Speed (38)

Is the current moving speed.

0 ~ 2,047 (0x000 ~ 0x7FF) can be used.

If a value is in the range of 0 ~ 1,023 then the motor rotates to the CCW direction.

If a value is in the range of 1,024 ~ 2,047 then the motor rotates to the CW direction.

The 10th bit becomes the direction bit to control the direction; 0 and 1,024 are equal.

The value unit is about 0.11rpm.

For example, if it is set to 300 then the motor is moving to the CCW direction at a rate of about 34.33rpm.

2. 4. 22. Present Load (40)

It means currently applied load. The range of the value is 0~2047, and the unit is about 0.1%. If the value is 0~1,023, it means the load works to the CCW direction. If the value is 1,024~2,047, it means the load works to the CW direction. That is, the 10th bit becomes the direction bit to control the direction, and 1,024 is equal to 0. For example, the value is 512, it means the load is detected in the direction of CCW about 50% of the maximum torque.

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Bit	15 ~ 11	10	9 ~ 0
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Value	0	Load Direction	Data (Load Ratio)
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NOTE : CCW Load : Load Direction = 0, CW Load : Load Direction = 1

NOTE : Present load is an inferred value based on the internal output value; not a measured value using torque sensor, etc. Therefore, it may be inaccurate for measuring weight or torque. It is recommended to use it for predicting the direction and size of the force being applied to the joint.

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2. 4. 23. Present Voltage (42)

It is the size of the present voltage supplied. This value is 10 times larger than the actual voltage. For example, when 10V is supplied, the data value is 100 (0x64)

For more details, see [Min/Max Voltage Limit \(12, 13\)](#).

2. 4. 24. Present Temperature (43)

It is the internal temperature of DYNAMIXEL in Celsius. Data value is identical to the actual temperature in Celsius. For example, if the data value is 85 (0x55), the current internal temperature is 85°C.

For more details, see [Temperature Limit \(11\)](#).

2. 4. 25. Registered Instruction (44)

Indicates whether the Write Instruction is registered by [Reg Write Instruction](#)

Value	Description
0	No instruction registered by REG_WRITE.
1	Instruction registered by REG_WRITE exists.

NOTE : If ACTION instruction is executed, the Registered Instruction (44) will be changed to 0.

2. 4. 26. Moving (46)

Value	Description
0	Goal position command execution is completed
1	Goal position command execution is in progress

2. 4. 27. Lock (47)

Value	Description
0	EEPROM area can be modified
1	EEPROM area cannot be modified

CAUTION : If Lock is set to 1, the power must be turned off and then turned on again to change into 0.

2. 4. 28. Punch (48)

Minimum current to drive motor. This value ranges from 0x20 to 0x3FF.

2. 4. 29. Realtime-Tick (50)

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The Realtime Tick(120) indicates DYNAMIXEL's time.

Unit	Value Range	Description
1 ms	0 ~ 32,767	The value resets to '0' when it exceeds 32,767

NOTE : This feature is available from Firmware v40.

2. 4. 30. Goal Acceleration (73)

This is Goal Acceleration value.

It can be used from 0~254(0xFE) and the unit is approximately $8.583 [^{\circ} / \text{sec}^2]$.

When it is set to 0, there is no control over acceleration and moves with the maximum acceleration of the motor.

When it is set to 254, it becomes $2,180 [^{\circ} / \text{sec}^2]$.

For example, the present speed of DYNAMIXEL is 0, and Goal Acceleration is 10.

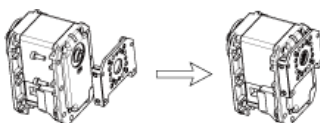
The speed of DYNAMIXEL after 1 second will be 14.3 [RPM].



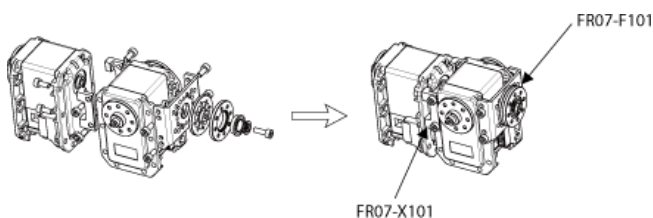
TOP

3. How to Assemble**3. 1. Frames**

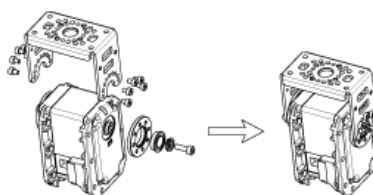
- FR07-B101 Option Frame



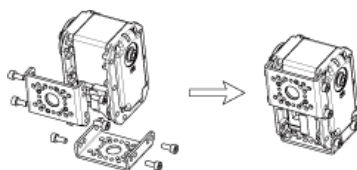
- FR07-F101_FR07-X101 Option Frame



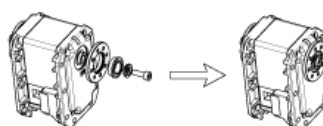
- FR07-H101 Option Frame



- FR07-S101 Option Frame

**3. 2. Horns**

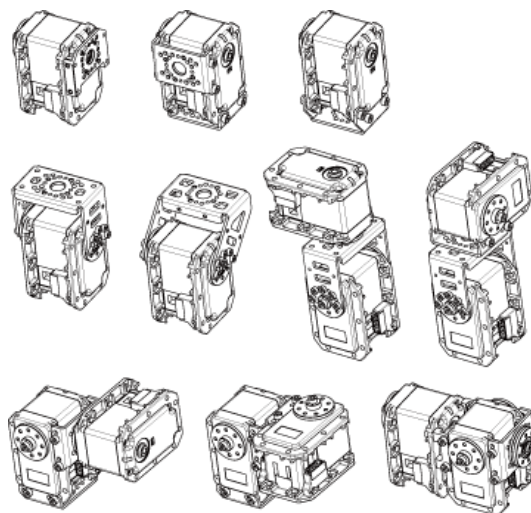
- HN07-I101



- HN07-N101

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**3. 3. Combination Structures**

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4. Maintenance**4. 1. Horn and Bearing Replacement**

The horn is installed on the front wheel gear serration of the DYNAMIXEL whereas the bearing set is installed on the back.

**4. 1. 1. Installing the Horn**

Place the thrust horn washer into the actuator before inserting the horn. You must carefully align the horn to the wheel gear serration by aligning dots.



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Once alignment is properly done, gently push the center of the horn toward the actuator. Make sure that the horn washer is in place as you tighten the bolt.

4. 1. 2. Installing the Bearing Set

You may need to remove the bearing set from the previous actuator and reinstall it into the new actuator. The bearing set can also be purchased separately. As bearing set is rotating freely, therefore alignment is not required when assembling to DYNAMIXEL.

**4. 2. Gear Replacement**

When gears inside DYNAMIXEL are damaged or worn out, replace the gears in DYNAMIXEL to maintain the good condition.

See the following video on how to replace the gears properly.

ROBOTIS FAQ-DXL Gear Replacement (MX-28) ENG**4. 3. DYNAMIXEL Calibration**

Calibrate the DYNAMIXEL after the gear replacement to arrange the gears in the right position.

See the following video on how to calibrate the DYNAMIXEL properly using software.



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ROBOTIS FAQ-DXL Gear Calibration (MX-28) ENG (RoboPlus 1.0)



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- NOTE:**
- As the USB2Dynamixel has been discontinued, a [U2D2](#) is required to communicate with DYNAMIXEL via PC using the software in the video.
 - Alternatively, you can calibrate the DYNAMIXEL (X / MX only) using the [DYNAMIXEL Wizard 2.0](#) instead of using the R+ Manager 2.0 used in the video.

5. Reference

- NOTE**
- [Compatibility Guide](#)
 - [Harness Compatibility](#)

5. 1. Certifications

Please inquire us for information regarding unlisted certifications.

5. 1. 1. FCC

Note: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

WARNING

Any changes or modifications not expressly approved by the manufacturer could void the user's authority to operate the equipment.

5. 2. Connector Information

Item	TTL	RS-485
Pinout	<div>1</div> GND	<div>1</div> GND
	<div>2</div> VDD	<div>2</div> VDD
	<div>3</div> DATA	<div>3</div> DATA+
		<div>4</div> DATA-

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Item	TTL	RS-485
Diagram		
Housing	 MOLEX 50-37-5033	 MOLEX 50-37-5043
PCB Header	 MOLEX 22-03-5035	 MOLEX 22-03-5045
Crimp Terminal	MOLEX 08-70-1039	MOLEX 08-70-1039
Wire Gauge for DYNAMIXEL	21 AWG	21 AWG

WARNING: To enhance user safety and to prevent proprietary risk or damage, **be sure to check the pinout installed on DYNAMIXEL and the board.** The Pinout of DYNAMIXEL may differ depending on a manufacturer of connector.

5. 3. Drawings

- [Download](#) [MX-28AT_AR DWG](#)
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5. 4. Communication Circuit

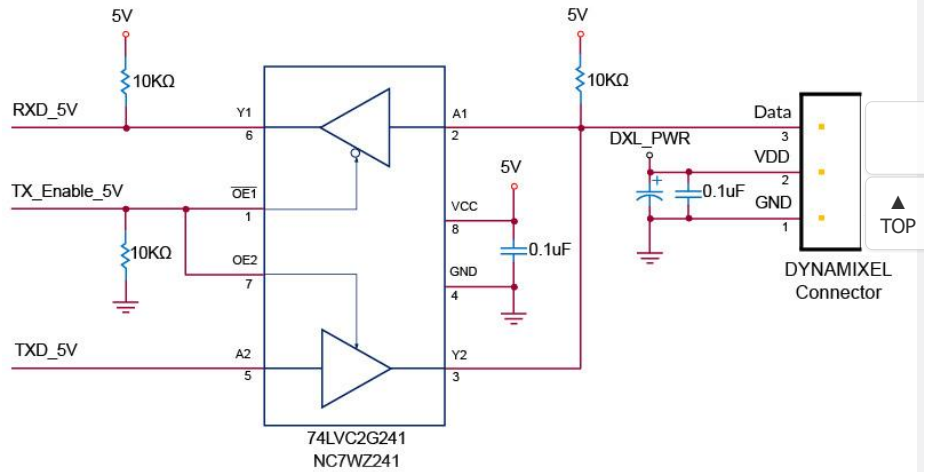
To control the DYNAMIXEL actuators, the main controller needs to convert its UART signals to the half duplex type. The recommended circuit diagram for this is shown below.

5. 4. 1. TTL Communication

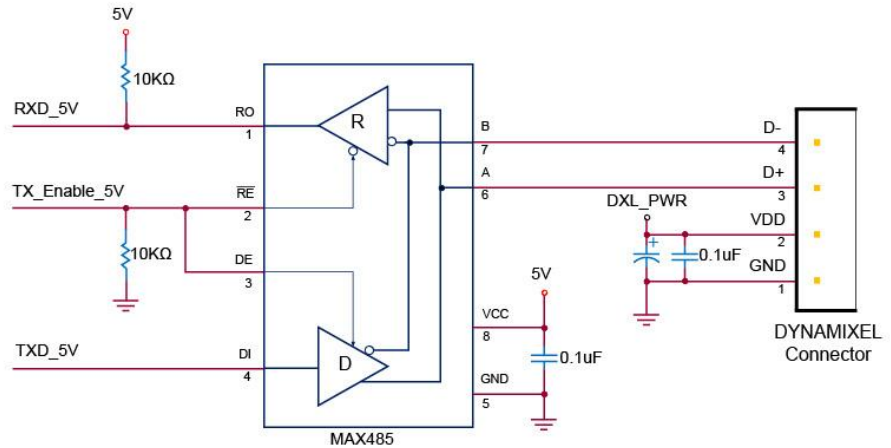
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TTL Communication Circuit

NOTE: Above circuit is designed for 5V or 5V tolerant MCU. Otherwise, use a Level Shifter to match the voltage of MCU.

5. 4. 2. RS-485 Communication**RS485 Communication Circuit**

NOTE: Above circuit is designed for 5V or 5V tolerant MCU. Otherwise, use a Level Shifter to match the voltage of MCU.

The power of DYNAMIXEL is supplied via Pin1(-), Pin2(+).

(The above circuit is built into DYNAMIXEL's controller only)

In the above circuit diagram, the direction of data signal of TxD and RxD in the TTL Level is determined according to the level of TX_Enable_5V as follows:

In case of TX_Enable_5V = High: The signal of TxD is output to D+ and D-

In case of TX_Enable_5V = Low: The signal of D+ and D- is output to RxD