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ROBOTIS e-Manual v1.25.00

Instruction/Status Packet

1. Instruction Packet is command data sent from the main controller to Dynamixel.

Instruction Packet structure is illustrated below.

0xFF	0xFF	0xFD	0x00	ID	LEN_L	LEN_H	INST	Param1	...	ParamN	CRC_L	CRC_H
Header			Reserved	ID	Packet Length		Instruction	Parameter			16bit CRC	

- A. Header : Field indicating start of packet
- B. Reserved : 0x00 (cannot use 0xFD)
- C. ID : Dynamixel ID designated for Instruction Packet processing
 - ① Value range: 0 ~ 252 (0x00 ~ 0xFC) 253 unique values
 - ② 253(0xFD), 255(0xFF) in Header prohibited use.
 - ③ 254 (0xFE): Broadcast ID, ALL connected Dynamixels controlled by Instruction Packet.
- D. Packet Length : Packet length after Packet Length field
 - ① [Instruction] [Parameter] [CRC_L] [CRC_H] , Parameter length + 3.
- E. Instruction: individual packet's command field

value	designation	description
0x01	Ping	corresponding device ID command to check if packet reaches
0x02	Read	Data read command
0x03	Write	Data write command
0x04	Reg Write	When receiving a write command packet data is not immediately written instead it goes into standby momentarily until action command arrives
0x05	Action	Go command for Reg Write
0x06	Factory Reset	All data to factory default settings
0x08	Reboot	Reboot device
0x55	Status(Return)	Instruction Packet response
0x82	Sync Read	Read data from the same location and same size for multiple devices simultaneously
0x83	Sync Write	Write data from the same location and same size for multiple devices simultaneously
0x92	Bulk Read	Read data from the different locations and different sizes for multiple devices simultaneously
0x93	Bulk Write	Write data from the different locations and different sizes for multiple devices simultaneously

- F. Parameter: when auxiliary data is required. Depends on the instruction.
 - G. 16bit CRC : CRC-16 values to verify reliability of data.
- CRC-16 values can be used against packet communications to check for damages on data.

1. Refer to the link below for implementations of CRC functions

2. Calculating transmitted/received packets

```
unsigned short update_crc(unsigned short crc_accum, unsigned char *data_blk_ptr, unsigned short data_blk_size);
```

Output : calculated CRC values

Input :

1) crc_accum : always set at

2) data_blk_ptr : pointer for packet array transmission or reception

3) data_blk_size : Packet's size not subject to CRC See the the following for data_blk_size

$$\text{data_blk_size} = \text{Header}(3) + \text{Reserved}(1) + \text{ID}(1) + \text{Length}(2) + \text{Packet Length}(?) - \text{CRC}(2) = 3+1+1+2+\text{Pakcet Length}-2 = 5 + \text{Packet Length};$$

$$\text{Packet Length} = (\text{LEN_H} \ll 8) + \text{LEN_L}; \text{ // refer to packet's \#6 and \#7}$$

example :

```
unsigned char TxPacket[] = { 0xFF 0xFF 0xFD 0x00 0x01 0x07 0x00 0x02 0x00 0x00 0x00 0x02  CRC_L
CRC_H }
```

An instruction packet is made for transmission. The following are the packet's components

0xFF 0xFF 0xFD : header

0x00 : Reserved

0x01 : ID 1

0x00 0x07 : size of packet of 7

0x02 : Read Instruction

0x00 0x00 : begin from address 0

0x00 0x02 : Read 2 bytes

CRC_L CRC_H : CRC values

Then calculate CRC values with the functions shown below

```
CRC = update_crc ( 0, TxPacket , 12 ) ; // 12 = 5 + Packet Length(0x00 0x07) = 5+7
```

```
CRC_L = (CRC & 0x00FF);
```

```
CRC_H = (CRC>>8) & 0x00FF;
```

2. Status Packet (Return Packet) basic structure

0xFF	0xFF	0xFD	0x00	ID	LEN_L	LEN_H	0x55	Error	Param1	...	ParamN	CRC_L	CRC_H
Header			Reserved	ID	Packet Length		Instruction	Error	Parameter			16bit CRC	

A. Header, Reserved, ID, Packet Length, 16bit CRC (same sequence as Instruction Packet)

B. Instruction has 0x55 (Status) fixed

C. Error : Instruction Packet error result (shown below)

--	--	--	--	--	--	--	--	--	--	--	--	--	--

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Alert	Error Number						

- ① Alert : When the device detects a problem it returns a 1. Check the Control Table's Device Status Check values to determine the cause.
- ② Error Number : Instruction Packet 's error

value	designation	description
0x01	Result Fail	Failed process of Instruction Packet
0x02	Instruction Error	– undefined Instruction – action without Reg Write
0x03	CRC Error	Failed Packet's CRC value match
0x04	Data Range Error	Over the range value of data of corresponding address
0x05	Data Length Error	Data length shorter than required length to corresponding address (ex: 4-byte value if only 2 bytes long)
0x06	Data Limit Error	Data length longer than required length to corresponding address
0x07	Accrss Error	– Read-only does not allow writting of Address – Write-only does not allow reading of Address – Torque Enable (ROM lock): does not allow writing of ROM domain addresses

D. Parameter is Instruction Packet's instruction field value.

3. Packet pre-transmission / post-processing (Header emerging pattern byte stuffing update)

A. Transmission sequence

- ① Generated according to Instruction Packet
- ② byte stuffing in 0xFF and 0xFD patterns; from length (excluding instruction) to CRC16. (if 0xFF 0xFF 0xFD show 0xFF 0xFF 0xFD 0xFD; additional 0xFD added at the end)
- ③ Length modified with byte stuffing
- ④ Byte stuffing adds the last 2 bytes to the CRC16 calculation
- ⑤ transmission

B. Reception sequence

- ① Find Header (0xFF 0xFF 0xFD). 0xFF 0xFF 0xFD 0xFD ignored.
- ② When Header shows, ID is verified, after getting ID or 0xFE move on to next field for data of length Length.
- ③ While receiving all data in 1 byte chunks to be matched with CRC16 (byte stuffing included).
- ④ After CRC calculation if 0xFF 0xFF 0xFD 0xFD pattern appears discard the last 0xFD; use only 0xFF 0xFF

0xFD (byte stuffing eliminated)

- ⑤ Last 2 bytes matched and verified with CRC.

Dynamixel Protocol 2.0 Instruction Parameter

1. Ping

- A. Instruction Packet Parameter : none
- B. Status Packet Parameter

Parameter Byte	Description
Parameter 0	Error Byte (please refer to the basic structure)
Parameter 1	Model number LSB
Parameter 2	Model number MSB
Parameter 3	Firmware version

C. Instruction

- ① Command for device presence and basic information
- ② Response level value. Ping returns a value regardless
- ③ ID field 0xFE (Broadcast ID) prevents all devices from conflicting with each other and send a Status Packet

2. Read

A. Instruction Packet Parameter

Parameter Byte	Description
Parameter 0	Read data start address LSB
Parameter 1	Read data start address MSB
Parameter 2	Read data length LSB
Parameter 3	Read data length MSB

B. Status Packet Parameter (read data length: N)

Parameter Byte	Description
Parameter 0	Error Byte (please refer to the basic structure)
Parameter 1	Read data start address 1st byte
Parameter 2	Read data start address 2nd byte
...	...
Parameter N	Read data start address Nth byte

B. Instruction

- ① Description for control table values

3. Write

A. Instruction Packet Parameter (Write data length: N)

Parameter Byte	Description
Parameter 0	Write data start address LSB
Parameter 1	Write data start address MSB
Parameter 2	Write data 1 st byte
Parameter 3	Write data 2nd byte
...	...
Parameter N+1	Write data Nth byte

B. Status Packet Parameter : basic form

Parameter Byte	Description
Parameter 0	Error Byte (please refer to the basic structure)

C. Instruction

- ① Description for control table write values

4. Reg Write

A. Instruction Packet Parameter : same as Write Instruction

B. Status Packet Parameter : basic form

C. Instruction

- ① Write command, but different when writing in Control Table
- ② When Write command is sent to Instruction Packet Reg Write's received Instruction Packet gets saved to a buffer and said value is not written in control table. The control table is registered with a 1.
- ③ When Action Instruction Packet is received the saved buffer is then written to the control table. The control table is registered with a 0.

5. Action

A. Instruction Packet Parameter : none

B. Status Packet not sent

C. Instruction

- ① Command for Reg Write to perform write task
- ② With many devices there might be a difference between command for the first device and command for the last device.
- ③ When this takes place Action command via Reg Write with broadcast ID.

6. Factory Reset

A. Instruction Packet Parameter

Parameter Byte	Description
Parameter 0	OPTION :

- | | |
|--|---|
| | <ul style="list-style-type: none"> – 0xFF : reset all values – 0x01 : reset all values except ID – 0x02 : reset all values except ID and baud rate |
|--|---|

B. Status Packet Parameter : basic form

C. Instruction : command to reset all values in control table to factory default.

7. Reboot

A. Instruction Packet Parameter : none

B. Status Packet Parameter : basic form

C. Instruction: command to restart device

8. Sync Read

A. Instruction Packet Parameter

Parameter Byte	Description
Parameter 0	Common read data start address LSB
Parameter 1	Common read data start address MSB
Parameter 2	Common read data length LSB
Parameter 3	Common read data length MSB
Parameter 4	Read value of 1 st device ID
Parameter 5	Read value of 2 nd device ID
...	...
Parameter N+3	Read value of Nth device ID

B. Status Packet Parameter : N number of Read Status packets

C. Instruction

- ① One transmitted Instruction Packet command for many connected devices with the same start address and same data length
- ② Packet ID field 0xFE (Broadcast ID) transmission.

9. Sync Write

A. Instruction Packet Parameter

Parameter Byte	Description
Parameter 0	Common write data start address LSB
Parameter 1	Common write data start address MSB
Parameter 2	Common write data length (L) LSB
Parameter 3	Common write data length (L) MSB
Parameter 4	Write data for ID of 1 st device (ID 1)
Parameter 5	ID 1 write data 1 st byte
Parameter 6	ID 1 write data 2 nd byte
...	...
Parameter (L+1)+3	ID 1 write data Lth byte

Parameter (L+1)+4	Write data for ID of 2 nd device (ID 2)
Parameter (L+1)+5	ID 2 write data 1 st byte
Parameter (L+1)+6	ID 2 write data 2 nd byte
...	...
Parameter 2(L+1)+3	ID 2 write data Lth byte
...	...

B. Status Packet not sent

C. Instruction

- ① Command for one transmittable instruction packet to control multiple devices. However, start address and length data must concur.
- ② Packet's ID field 0xFE (Broadcast ID) is for broadcast transmission.

10. Bulk Read

A. Instruction Packet Parameter

Parameter Byte	Description
Parameter 0	ID of 1 st device (ID 1)
Parameter 1	ID 1 start address LSB
Parameter 2	ID 1 start address MSB
Parameter 3	ID 1 data length LSB
Parameter 4	ID 1 data length MSB
Parameter 5	ID of 2 nd device (ID 2)
Parameter 6	ID 2 start address LSB
Parameter 7	ID 2 start address MSB
...	...
Parameter 5(N-1)+0	ID of Nth device (ID N)
Parameter 5(N-1)+1	ID N start address LSB
Parameter 5(N-1)+2	ID N start address MSB
Parameter 5(N-1)+3	ID N data length LSB
Parameter 5(N-1)+4	ID N data length MSB

B. Status Packet Parameter : Read status packet (N packets, from N devices)

C. Instruction

- ① Command for synch read for transmitted of instruction packet of multiple devices. However, each device's Bulk Read data may be of different lengths.
- ② Operation not possible with devices having the same ID. In other words, each ID is read once. Use indirect addressing for sparsely read.
- ③ Packet's ID field 0xFE (Broadcast ID) is for broadcast transmission.
- ④ The IDs packet get monitored in the data bus then when status packet gets transmitted back the interval is minimal between is minimal.

11. Bulk Write

A. Instruction Packet Parameter

Parameter Byte	Description
Parameter 0	ID of 1 st device (ID 1)
Parameter 1	Write data start address of ID 1 LSB
Parameter 2	Write data start address of ID 1 MSB
Parameter 3	Write data length of ID 1 LSB
Parameter 4	Write data length of ID 1 MSB
Parameter 5	ID 1 write data 1 st byte
Parameter 6	ID 1 write data 2 nd byte
...	...
Parameter L+4	ID 1 write data Lth byte
Parameter L+5	ID of 2 nd device (ID 2)
Parameter L+6	Write data start address of ID 2 LSB
...	...

B. Status Packet not sent

C. Instruction

- ① Sync write's command for one transmittable instruction packet to control multiple devices. However, with Bulk write each device may have different addresses and data lengths.
- ② Operation not possible with devices having the same ID. In other words, each ID is written once. Use indirect addressing for sparsely write.
- ③ Packet's ID field 0xFE (Broadcast ID) is for broadcast transmission..

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