Flexible Inclinometer and Fixed-Type Communication Protocol

The rod devices communicate based on the RS485 bus, and the protocol is a proprietary protocol.

- **Rod device long address (fixed address):** 4 x uint8_t; the fixed address is provided at the time of factory shipment.
- **Rod device short address (AutoID):** 2 x uint8_t; it changes according to the installation length.

1. Command Table

Command	Meaning	Data	Length (uint8_t len, excl. start/end, excl. total bytes)	Total Bytes
`00 A0`	Command rod to write fixed address based on AutoID	AutoID, Long address	1 + 1 + 2 + 2 + 4 + 1 + 1	12
`00 A1`	Command rod to re-acquire AutoID		1 + 1 + 2 + 1 + 1	6
`00 A2`	Command rod with specified AutoID to return fixed address	AutoID	1 + 1 + 2 + 2 + 1 + 1	8
`00 A3`	Command rod with fixed address to return data, with sleep mode	00 A3, Long address	1 + 1 + 2 + 4 + 1 + 1	10
`00 A4`	Return all data (only for one-to-one communication)	00 A4	1 + 1 + 2 + 1 + 1	6
`00 5A`	Command rod with fixed address to return data without sleep mode	00 5A, Long address	1 + 1 + 2 + 4 + 1 + 1	10
`00 A6`	Command rod to update fixed address (one-to-one)	00 A6, Long address	1 + 1 + 2 + 4 + 1 + 1	10
`00 A7`	Command rod with fixed address to modify fixed address	00 A7, Long address, Long address	1 + 1 + 2 + 4 + 4 + 1 + 1	14
`00 A8`	Command rod with fixed address to return temperature	00 A8, Long address	1 + 1 + 2 + 4 + 1 + 1	10
`00 C7`	Command rod to update measurement range	00 C7, Long addr, Range data	1 + 1 + 2 + 4 + 1 + 1 + 1	11
`00 C8`	Read rod's measurement range value	00 C8, Long address	1 + 1 + 2 + 4 + 1 + 1	10
`00 AB`	Command rod with fixed address to update MODBUS ID	00 AB, Long addr, MODBUS ID	1 + 1 + 2 + 4 + 1 + 1 + 1	11

Controller sending command format:
`CC | Total bytes (incl. CC, EE, and checksum) | Command | Data | Checksum | EE`

2. Received Commands / Return Commands

Received	Return	Meaning	Data	Length	Total Bytes
00 A0	**00 B0**	Return written status	AutoID, Long address	1 + 1 + 2 + 2 + 4 + 1 + 1	12
00 A1	No return	No return			0
00 A2	**00 B2**	Return AutoID	Short address, Long address		12
00 A3	**00 3B**	Reading	Long addr, 3 data pieces, Voltage, Ver, Status		27
00 A4	**00 4B**	Reading	Short addr, Long addr, 3 data pieces, Volt, Ver, Status		29
00 5A	**00 5B**	Reading	Long addr, 3 data pieces, Voltage, Ver, Status		27
00 A6	No response				
00 A7	**00 7B**	Fixed address	Long address	1 + 1 + 2 + 4 + 1 + 1	10
00 A8	**00 8B**	Fixed address	Temperature	1 + 1 + 2 + 4 + 1 + 1 + 1	11
00 C7	No response				
00 C8	**00 8D**	Range status	Long address, Range Data	1 + 1 + 2 + 4 + 1 + 1 + 1	11
00 AB	**00 BA**	Fixed address	Long address, MODBUS ID	1 + 1 + 2 + 4 + 1 + 1 + 1	11

- **Temperature:** 4-bit floating-point number.
- **Flexible inclinometer rod reply command format:**
  `DD | Total bytes (incl. CC, EE, and checksum) | Command | Data | Checksum | EE`
- The returned reading values are all IEEE 754 four-byte floating-point numbers.

3. Examples

3.1 Command all online rods to acquire

> `Command: CC 06 00 A1 6B EE`

After transmission is completed, wait for 1 second; if the rod has no return, it will automatically recalculate and acquire the AutoID.

3.2 Command specified address to return data

```
Sent: CC 08 00 A2 02 32 56 EE
Return: DD 0C 00 B2 02 32 8B 1E 03 80 45 EE
```

The rod with automatic address 562 returns the device's fixed address. The automatic address range is 999~1, generally polled sequentially from high to low.
PS: Using functions 1 and 2 requires configuring a special wiring connected at the tail end of the last rod, and providing a 3V power supply at the address line of the first rod.

3.3 Command device with specified fixed address to return data (Sleep mode)

Data return takes 3 seconds, enters sleep mode after 8 seconds if not queried again.

```
Sent: CC 0A 00 A3 01 42 92 21 95 EE
Return: DD 1B 00 3B 01 42 92 21 3F AE 14 7B 44 79 23 D7 C0 1E 14 7B 44 96 A0 A4 03 5E EE
```

- Rod fixed address: 21140001
- Axis A direction: 1.36 (horizontal displacement 1.36mm / tilt rate 1.36 per thousand)
- Axis Z direction: 996.56
- Axis B direction: -2.47
- Voltage & Version: 4496A0A4 (~1205.02, i.e., 12V power supply, software version 5.02)
- Status data: 03 (Normal)

To reduce power consumption, the rod enters sleep mode after this command. Next read requires powering the rod on again. Use the **5A** command if the controller lacks an external power output switch to prevent sleep mode.

3.4 Forced one-to-one command for rod to return data

```
Sent: CC 06 00 A4 6E EE
Return: DD 1D 00 4B 02 23 01 42 92 21 3F AE 14 7B 44 79 23 D7 C0 1E 14 7B 44 96 A0 A4 03
09 EE
```

3.5 Command device with specified fixed address to return data (Non-sleep command)

```
Sent: CC 0A 00 5A 01 42 92 21 6C EE
Return: DD 1B 00 5B 01 42 92 21 3F AE 14 7B 44 79 23 D7 C0 1E 14 7B 44 96 A0 A4 03 3E EE
```

[Special Note for Fixed-Type] The read value is the raw sensor value. The sensor is installed in reverse inside the rod (due to structural design/waterproofing and communication requirements), meaning the positive direction points toward the lower wheel direction. If using custom data loggers, please multiply by **-1** after reading the value. (e.g., Reading 1.36 means actual is -1.36mm).

4. Checksum Algorithm

The checksum part includes all data from CC/DD up to before the checksum byte:

```
uint8_t Verify_XOR_C(uint8_t *buffer, uint16_t len)
{
  uint16_t i;
  uint8_t verify = 0;
  for (i = 0; i < len; i++)
  {
    verify ^= buffer[i];
  }
  return verify;
}
```

IEEE 754 4-byte to float conversion:

```
uint32_t a = 0x12345678;
float b = *(float*)&a;
```

5. Return Status Meaning

Meaning	Rod Status Data
Normal	`0x03`
Sensor Type	`0xFE`
Range exceeded, over 10 degrees (173mm)	`0xFD`