

Angular Displacement Sensor (ADS) Two-Axis I2C Protocol Specification

1. General Specifications

- Default I2C Address: 0x13
- Bootloader Address: 0x12
- I2C Speed: 400 kHz
- Packet Size: 5 bytes

2. I2C Transaction Format

The Two-Axis ADS uses a standard 5-byte packet format for all I2C transactions.

2.1 Write Format

- Byte 0: Command code
- Bytes 1-4: Command parameters

2.2 Read Format

- Byte 0: Packet type
- Bytes 1-4: Data (typically containing data for two axes)

3. Command Codes

Command Code (Hex)	Command Name	Description
0x00	RUN	Set sensor in free-run or standby mode
0x01	SPS	Set sample rate for free-run mode
0x02	RESET	Software reset
0x03	DFU	Enter bootloader mode for firmware update
0x04	SET_ADDRESS	Update the I2C address

Command Code (Hex)	Command Name	Description
0x05	INTERRUPT_ENABLE	Enable/disable data ready interrupt
0x06	GET_FW_VER	Get firmware version
0x07	CALIBRATE	Perform sensor calibration
0x08	AXES_ENABLED	Enable/disable individual axes
0x09	SHUTDOWN	Enter ultra-low power mode (~50nA)
0x0A	GET_DEV_ID	Get device ID

4. Packet Types (Response Codes)

Packet Type (Hex)	Name	Description
0x00	SAMPLE	Packet contains angles for both axes
0x01	FW_VER	Packet contains firmware version
0x02	DEV_ID	Packet contains device ID

5. Command Details

5.1 RUN (0x00)

Sets the sensor in free-run interrupt mode or standby.

Write Format:

- Byte 0: 0x00
- Byte 1: 0x01 = activate, 0x00 = standby
- Bytes 2-4: 0x00 (unused)

Example:

To activate: 0x00 0x01 0x00 0x00 0x00

To standby: 0x00 0x00 0x00 0x00 0x00

5.2 SPS (0x01)

Sets the sample rate in free-run mode.

Write Format:

- Byte 0: 0x01
- Bytes 1-2: Sample rate value (16-bit, little-endian)
- Bytes 3-4: 0x00 (unused)

Sample Rate Values:

Value (Hex)	Value (Dec)	Rate	Notes
0x4000	16384	1 Hz	
0x0666	1638	10 Hz	
0x0333	819	20 Hz	
0x0147	327	50 Hz	
0x00A3	163	100 Hz	
0x0051	81	200 Hz	
0x0031	49	333 Hz	
0x0020	32	500 Hz	Max rate

Example:

For 100 Hz: 0x01 0xA3 0x00 0x00 0x00

5.3 RESET (0x02)

Performs a software reset.

Write Format:

- Byte 0: 0x02
- Bytes 1-4: 0x00 0x00 0x00 0x00 (unused)

Example:

0x02 0x00 0x00 0x00 0x00

5.4 DFU (0x03)

Resets the sensor into bootloader mode for firmware update.

Write Format:

- Byte 0: 0x03
- Bytes 1-4: 0x00 0x00 0x00 0x00 (unused)

Example:

0x03 0x00 0x00 0x00 0x00

5.5 SET_ADDRESS (0x04)

Updates the I2C address of the sensor.

Write Format:

- Byte 0: 0x04
- Byte 1: New 7-bit I2C address
- Bytes 2-4: 0x00 0x00 0x00 (unused)

Example:

To set address 0x14: 0x04 0x14 0x00 0x00 0x00

5.6 INTERRUPT_ENABLE (0x05)

Enables or disables the data ready interrupt line.

Write Format:

- Byte 0: 0x05
- Byte 1: 0x01 = enable, 0x00 = disable
- Bytes 2-4: 0x00 0x00 0x00 (unused)

Example:

To enable: 0x05 0x01 0x00 0x00 0x00

To disable: 0x05 0x00 0x00 0x00 0x00

5.7 GET_FW_VER (0x06)

Gets the firmware version.

Write Format:

- Byte 0: 0x06
- Bytes 1-4: 0x00 0x00 0x00 0x00 (unused)

Read Response:

- Byte 0: 0x01 (FW_VER)
- Bytes 1-2: Firmware version (16-bit, little-endian)

- Bytes 3-4: 0x00 0x00 (unused)

Example:

Write: 0x06 0x00 0x00 0x00 0x00

Read response: 0x01 0x2A 0x01 0x00 0x00 (firmware version 0x012A = 298)

5.8 CALIBRATE (0x07)

Performs sensor calibration.

Write Format:

- Byte 0: 0x07
- Byte 1: Calibration step (see table below)
- Byte 2: Angle in degrees (for step 0x01 and 0x02) or 0x00 for other steps
- Bytes 3-4: 0x00 0x00 (unused)

Calibration Steps:

Value (Hex)	Description
0x00	First calibration point (0° on both axes)
0x01	Flat axis calibration (45°-255°, recommended 90°)
0x02	Perpendicular axis calibration (45°-255°)
0x03	Clear user calibration, restore factory

Example:

For 0° calibration on both axes: 0x07 0x00 0x00 0x00 0x00

For 90° on flat axis: 0x07 0x01 0x5A 0x00 0x00 (0x5A = 90 in decimal)

5.9 AXES_ENABLED (0x08)

Enables or disables individual axes.

Write Format:

- Byte 0: 0x08
- Byte 1: Bit mask of axes to enable (see table below)
- Bytes 2-4: 0x00 0x00 0x00 (unused)

Axes Bit Mask:

Value (Hex)	Description
0x01	Enable axis 0 (flat), disable axis 1
0x02	Enable axis 1 (perpendicular), disable axis 0
0x03	Enable both axes

Example:

To enable both axes: 0x08 0x03 0x00 0x00 0x00

To enable only flat axis: 0x08 0x01 0x00 0x00 0x00

5.10 SHUTDOWN (0x09)

Puts the sensor in ultra-low power mode (~50nA). Requires reset to wake up.

Write Format:

- Byte 0: 0x09
- Bytes 1-4: 0x00 0x00 0x00 0x00 (unused)

Example:

0x09 0x00 0x00 0x00 0x00

5.11 GET_DEV_ID (0x0A)

Gets the device ID.

Write Format:

- Byte 0: 0x0A
- Bytes 1-4: 0x00 0x00 0x00 0x00 (unused)

Read Response:

- Byte 0: 0x02 (DEV_ID)
- Byte 1: Device ID (see table below)
- Bytes 2-4: 0x00 0x00 0x00 (unused)

Device ID Values:

Value (Hex)	Description
0x01	One-axis sensor v1
0x02	Two-axis sensor v1

Value (Hex)	Description
0x0C	One-axis sensor v2
0x16	Two-axis sensor v2

Example:

Write: 0x0A 0x00 0x00 0x00 0x00

Read response: 0x02 0x02 0x00 0x00 0x00 (Two-axis sensor v1)

6. Data Interpretation

6.1 Angle Data

When reading from the sensor in any mode, a packet with type 0x00 (SAMPLE) contains angle data for both axes.

Read Format:

- Byte 0: 0x00 (SAMPLE)
- Bytes 1-2: Flat axis angle data (16-bit signed int, little-endian)
- Bytes 3-4: Perpendicular axis angle data (16-bit signed int, little-endian)

Conversion:

Angle in degrees = (16-bit value) / 32.0

Example:

Read: 0x00 0x80 0x01 0x00 0x02

Flat axis: 0x0180 = 384 → 384/32.0 = 12.0 degrees

Perpendicular axis: 0x0200 = 512 → 512/32.0 = 16.0 degrees

7. Typical I2C Operation Examples

7.1 Initialize in Free-Run Mode (100 Hz)

Set sample rate to 100 Hz

Write: 0x01 0xA3 0x00 0x00 0x00

Enable interrupt

Write: 0x05 0x01 0x00 0x00 0x00

```
# Start sampling in free-run mode
```

```
Write: 0x00 0x01 0x00 0x00 0x00
```

```
# Sensor will now generate samples at 100 Hz on the interrupt pin
```

7.2 Calibration Sequence

```
# First calibration point at 0 degrees on both axes
```

```
Write: 0x07 0x00 0x00 0x00 0x00
```

```
# Calibrate flat axis at 90 degrees (perpendicular axis at 0)
```

```
Write: 0x07 0x01 0x5A 0x00 0x00
```

```
# Calibrate perpendicular axis at 90 degrees (flat axis at 0)
```

```
Write: 0x07 0x02 0x5A 0x00 0x00
```

7.3 Enable Only One Axis

```
# Enable only the flat axis (axis 0)
```

```
Write: 0x08 0x01 0x00 0x00 0x00
```

```
# Enable only the perpendicular axis (axis 1)
```

```
Write: 0x08 0x02 0x00 0x00 0x00
```

```
# Enable both axes
```

```
Write: 0x08 0x03 0x00 0x00 0x00
```

8. Bootloader Operation

8.1 Update Process

1. Reset the device into bootloader mode:

```
Write: 0x03 0x00 0x00 0x00 0x00
```

2. Subsequent communications should be addressed to the bootloader address(0x12) and follow the bootloader protocol.

3. The bootloader protocol involves:

- Sending a 4-byte firmware length
- Sending firmware data in 64-byte pages

- Receiving acknowledgments between operations

Note: Detailed bootloader protocol is available in the firmware update documentation.