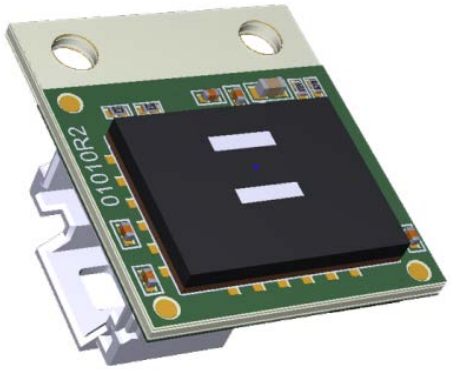
# Aura P Datasheet




Document Revision: 1.1

**Novanta Inc.**
125 Middlesex Turnpike,
Bedford, MA 01730, USA

www.celeramotion.com

# Table of Contents

| | |
|---|---|
| **Function** | Sales & Applications |
| **Owner** | @Jake Lantner |
| **SG0** | |
| **SG1** | |
| **SG2** | |
| **SG3** | CREATE |
| **SG4** | UPDATE |
| **SG5** | UPDATE |

# 1 General Information

## 1.1 Revision History

| Revision | Release Date | Changes |
|---|---|---|
| 1.0 | 24 Jul 2024 | Release |
| 1.1 | 03 Sep 2024 | • Removed "-WP" from ordering nomenclature |

## 1.2 Disclaimers and limitations of liability

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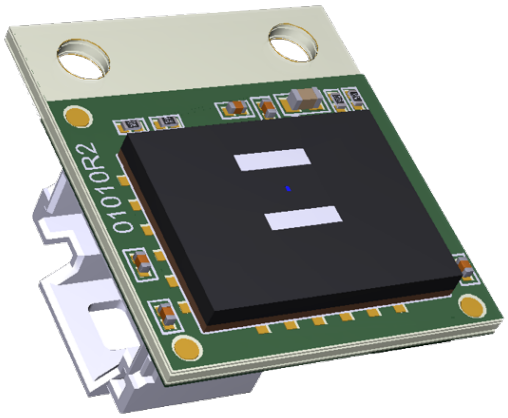
# 2 Overview

Aura-P is a board level, super-compact optical absolute encoder packed with class leading resolution, accuracy, and repeatability. It's equipped with the latest ASIC technology for low power, high bandwidth, and low-latency bi-directional BiSS-C commutation. Aura-P's small footprint and high performance offers customers flexibility with design and handling requirements, and satisfies the most demanding linear and rotary applications.




## 2.1 Board Features

Aura-P is built with our well-received, robust, error proof Aura series encoder. It's equipped with a voltage booster to compensate for voltage drop over long cables, an RS-485 differential driver to maintain the integrity of long distance communication, and a locking connector to ensure the cable stays connected in extreme vibration and shock conditions.

## 2.2 Benefits

- True absolute position → no wake-and-wiggle
- Small PCB footprint → (WxLxH) 14 x 12 x7.4 mm
- Low power SMT mounted on PCB → 90 mA total supply current (5V)
- Integrated voltage booster → PCB works with voltage as low as 2.97 V
- High resolution (1 LSB jittering) → 200 nm (linear), 18 bits (rotary Ø18mm scale)
- High accuracy → ±2µm (linear) or ±0.005 ° (rotary)
- Zero hysteresis → Repeatability is limited only by jittering noise
- High run-speed → Up to 83,721 RPM
- Low BiSS-C communication latency → < 5 us at 10 MHz clock rate
- Wide alignment tolerances
- One-click eccentricity compensation

## 2.3 Installation

The PCB is effortless to install given its wide alignment tolerances and high precision benching edges. To greater simplify installation, Aura-P is outfitted with a Tri-color LED for confirming proper installation and self diagnosis feedback. Aura-P coupled with SmartPrecision lll, our intuitive

installation-assisting software, is used for calibration, alignment, and status monitoring. Through SmartPrecision III, the encoder data can be sampled and recorded in a CSV file. To support faster and easier installations, Celera Motion also provides hubs with pre-mounted encoder scales. Please contact our sales representative for customizing scale, hub or board design options.

# 3 Specifications

## 3.1 Performance Specifications - Rotary

| System Data | AUR-P-R-B | | | AUR-P-R-C | |
|---|---|---|---|---|---|
| Scale Sizes (OD) outer diameter | 18.0 mm | 26.0 mm | 33.0 mm | 51.8 mm | 63.5 mm |
| Resolution[1] | 18-22 bits | 18-22 bits | 18-22 bits | 20-22 bits | 20-22 bits |
| Accuracy [2] | ± 0.01 ° | ± 0.01 ° | ± 0.01 ° | ± 0.005 ° | ± 0.005 ° |
| Standoff Height | 1.75 mm | 1.75 mm | 1.75 mm | 1.75 mm | 1.75 mm |
| Alignment Tolerances: Tan (X), Rad (Y), Z | ± 0.13, ± 0.13, ± 0.40 mm | ± 0.23, ± 0.13, ± 0.40 mm | ± 0.43, ± 0.13 ± 0.40 mm | ± 0.43, ± 0.18, ± 0.40 mm | ± 0.43, ± 0.18, ± 0.40 mm |
| Theta Tolerances: X, Y, Z | ± 2 °, ± 1 °, ± 1 ° | ± 2 °, ± 1 °, ± 1 ° | ± 2 °, ± 1 °, ± 1 ° | ± 2 °, ± 1 °, ± 1 ° | ± 2 °, ± 1 °, ± 1 ° |
| Concentricity Tolerance [3] | 50 µm | 100 µm | 100 µm | 100 µm | 100 µm |
| Max. Speed | 83,721 RPM | 56,250 RPM | 41,983 RPM | 18,922 RPM | 15,859 RPM |
| Repeatability | 1 LSB | 1 LSB | 1 LSB | 1 LSB | 1 LSB |
| Jitter (Position Noise) | ±1 LSB | ±1 LSB | ±1 LSB | ±1 LSB | ±1 LSB |
| Jitter Averaging Sample Size [4] | 18 bits: no averaging<br>19 bits: 4<br>20 bits: 12<br>21 bits: 45<br>22 bits: 287 | | | 20 bits: no averaging<br>21 bits: 4<br>22 bits: 65 | |

1. Higher resolution can be achieved by increasing averaging sample size. See Jitter Averaging Sample Size above for specific sample sizes.
2. Specification assumes eccentricity error after installation has been corrected.

3. The center of the scale pattern circumference should align with the axis of rotation within the concentricity tolerance.
4. Position sample averaging in the drive/controller can be used to eliminate jitter at higher resolutions. The recommended number of samples depends on the resolution. In noisy environments it may be necessary to increase the averaging sample size.

## 3.2 Performance Specifications - Linear

| System Data | AUR-P-L-C |
|---|---|
| Scale Lengths | custom lengths (glass scales) |
| Resolution[1] | ± 12.5 nm to ± 200 nm |
| Accuracy [2] | ± 2.0 µm (250 mm glass scale) |
| Standoff Height | 1.75 mm |
| Alignment Tolerances Y, Z | ± 0.18, ± 0.40 mm |
| Theta Tolerances X, Y, Z | ± 2 °, ± 1 °, ± 1 ° |
| Max. Speed | 50 m/s |
| Repeatability | 1 LSB |
| Jitter (Position Noise) | ±1 LSB |
| Jitter Averaging Sample Size [3] | ± 12.5 nm: 112<br>± 25 nm: 27<br>± 50 nm: 7<br>± 100 nm: 2<br>± 200 nm: no averaging |

1. Higher resolution can be achieved by increasing averaging sample size. See Jitter Averaging Sample Size in table above for specific sample sizes.
2. Accuracy is measured using a glass scale with 250 mm of measurable length.
3. Per factory default resolution of 25 bits (10 bits of interpolation and 15 bits of line pairs), each incremental line pair with 204.8 µm width is interpolated with 10 bits depth. Therefore, the resolution is 200 nm with jittering noise < 1 LSB (± 200 nm). User can interpolate deeper by changing the default resolution of 25 bits to a higher number via Smart precision III or register application note. However, the jittering noise will increase as interpolation depth increases. User

can reduce the jittering noise to < 1 LSB by the recommended averaging number of samples as shown in the spec sheet. Please note that actual averaging sample size may vary with the noise level.

## 3.3 Electrical Specifications

| Electrical Data | |
|---|---|
| Input Supply Voltage | 2.97V to 5.5 V |
| Supply Current | 90 mA (5V)<br>180 mA (2.97V) |
| Receiver Input Voltage (MA+/MA-) | -10 V to 15 V |
| Receiver Differential Input Threshold Voltage | ±0.2 V |
| Differential Driver Output Voltage (SLO+ vs SLO-) | 1.5 V to 5 V (RS-485)<br>2 V to 5 V (RS-422) |
| Driver Common Mode Output Voltage | < 3V |
| Output Voltage Thresholds | Low: 10% VDDIO, High: 90% VDDIO |
| BiSS-C Max. Clock Rate | 10 MHz |
| BiSS-C Latency | < 5 µsec |
| AB Min. Edge Separation | 37.5 nsec |
| Initialization Time (power reset to encoder ready) | 14 msec |

## 3.4 Mechanical Specifications

| Mechanical Data | PCB |
|---|---|
| Size | 12.0 x 14.0 x 7.4 mm |
| Fly Height | 1.75 mm |
| Weight | 0.9 g |
| Connector | Locking 6-pin connector: Molex 2023960607<br>Mate with: Molex 5013300600<br>Cable assembly: Molex 151330606 |
| Cable | No standard cable - PN 512-00344<br>• 12 inches long (no shielding or twisted pairs) - Cable is for evaluation purpose only<br>• Pico-clasp to DB9 connector with an external 5V barrel connector for connecting Aura P with MB5U BiSS master and Smart precision III<br><br>For custom cables, please **contact Celera Motion**. |

## 3.5 Environmental Specifications

| Environmental Data | |
|---|---|
| Operating Temperature | -40°C to 85°C |
| Storage Temperature | -40°C to 100°C |
| Operating Humidity | IEC 60068-2-78. 93% RH Non-Condensing at 40°C |
| Storage Humidity | 10-93 % RH Non-Condensing |
| Contamination Immunity* | Recommended that optics are kept clean at all times. |

| Environmental Data | |
|---|---|
| Operating Vibration | IEC 60068-2-6<br>*Device is operational under the following test condition:*<br>• 10 to 58.1 Hz at 0.75 mm displacement, 10 g from 58.1 to 2000 Hz<br>• 10 sweep cycles from 10 to 2000 to 10 Hz at one octave per minute is ~150 minutes per axis |
| Operating Shock | IEC 60068-2-27<br>*Device is operational under the following test condition:*<br>• 50 g, 11 ms, half sine<br>• 18 total shock pulses: 6 per axis, 3 per direction for 2 directions (±) |
| Radiated Emission | EN55011 Emissions - Industrial, scientific, and medical (ISM) products and applications Class A, Group 1 |
| Radiated Immunity | EN61326-1 (2021) - Industrial Electrical equipment for measurement, control and laboratory use – EMC requirements – Includes testing to the following: EN61000-4-3 - Radiated Immunity to 6 GHz |

* See Handling and Installation for guidelines on minimizing contamination

## 3.6 Reliability Specifications

| Reliability Data | |
|---|---|
| MTBF | > 77,000 hours (@ 55°C operating temperature) |

# 4 Storage and Handling

Aura P is a precision electronic instrument. It has been designed to function in a wide range of applications and environments. To take full advantage of the encoder design, allow easy access to the sensor for service and/or replacement. For optimal performance and reliability:

- DO follow standard ESD precautions while handling the sensor.
- DO allow proper clearance for sensor head alignment.
- DO follow setup and alignment instructions for the encoder system.
- DO, where possible, install the scales in an inverted or vertical position to minimize accumulation of dust.
- DO NOT place screw holes, reflective edges, epoxy bubbles or big reflective features directly under the scale pattern. A smooth (125 µin is recommended) metal surface is acceptable. For more information, please see our **hub design guideline**.
- DO NOT store sensors in an uncontrolled environment.
- DO NOT electrically overstress the sensor (power supply ripple/noise).
- DO NOT intentionally “hot swap” the sensor if the device is energized.

## 4.1 Safety Considerations

Depending on the mode of operation, Aura P can emit a highly concentrated visible blue light which can be hazardous to the human eye. Products that incorporate this device must follow the safety precautions given in IEC 60825-1 and IEC 62471.

## 4.2 PCB Handling Considerations

Follow Electrostatic Discharge (ESD) precautions at all times. Finger prints can trigger position read error. Avoid contact wherever possible. Please see our technical paper for more information on **cleaning encoder optics**.

## 4.3 Scale Handling Considerations

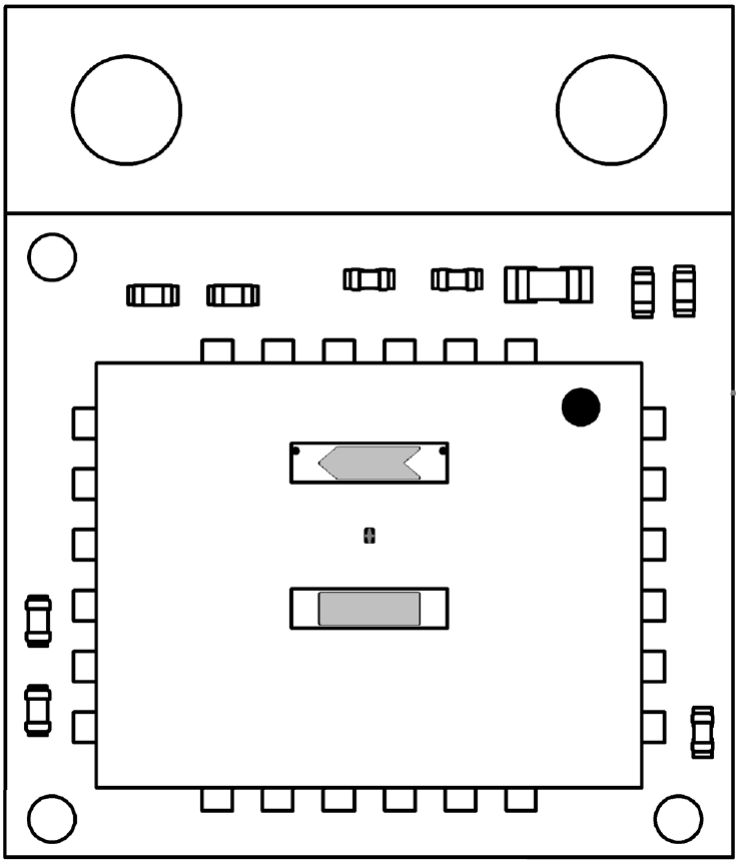
Gloved handling is strongly recommended. If gloves are not used, hands should be clean and contact with scale tracks avoided.

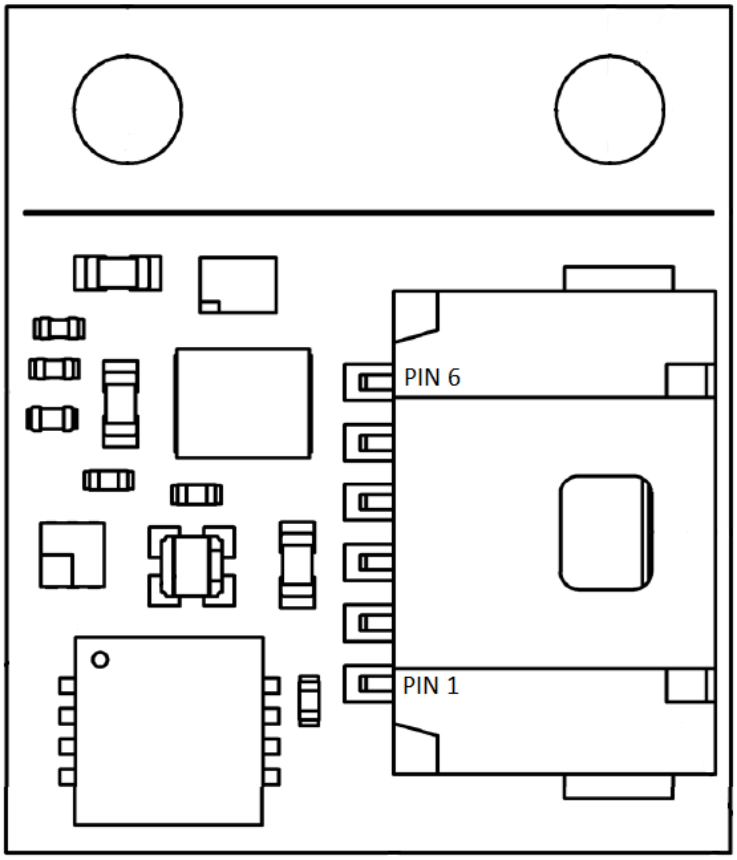
## 4.4 Surface Sensitivity

When handling Aura P, do not to touch anywhere in the Keep Out Zone - LED surface and glass windows. Scratches or 'digs' in the Keep Out Zone can affect the encoder performance.

# 5 Electrical Interface

## 5.1 Pinout






| Cable Connector J2 Pinouts | |
|---|---|
| Pin | Function |
| 1 | MA+ |
| 2 | MA- |
| 3 | VIN (2.97 - 5.5 V) |
| 4 | SLO- |
| 5 | SLO+ |
| 6 | GND |

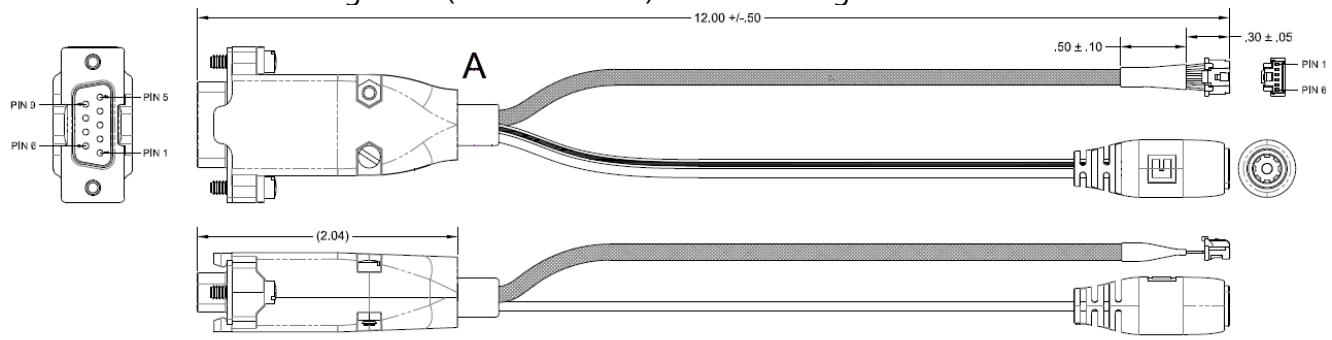
### 5.1.1 Status LED logic

| GPIO (0) (Error) | GPIO (1) Warning | LED Color |
|---|---|---|
| 1 | 1 | Green |
| 1 | 0 | Yellow |
| 0 | 1 | Red |
| 0 | 0 | Red |

Please refer to **Aura Series datasheet** for chip electrical interface.

### 5.1.2 SmartPrecision lll Connectivity

SmartPrecision lll requires access to Aura's BiSS-C interface via the MB5U BiSS/USB converter. Celera Motion offers an interfacing cable (PN: 512-00344) for connecting the Aura P and MB5U.



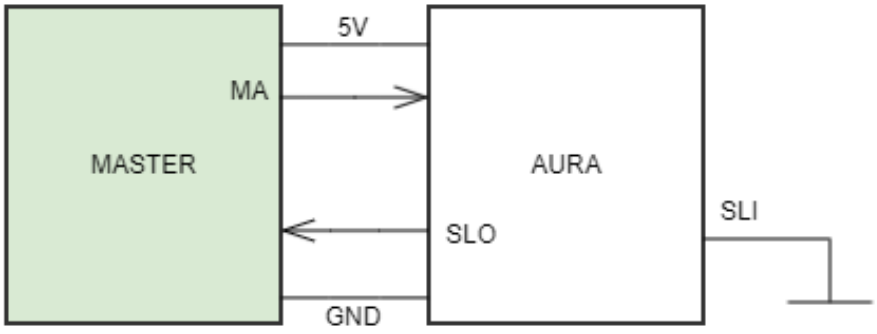

*Wiring diamgram for AURA-P Interface Cable (BiSS)*

| P1 (Molex) | P2 (DB9) | P3 (Barrel) | Function | Wire color |
|---|---|---|---|---|
| 1 | 2 | | SCLK/MA+ | Black |
| 2 | 3 | | SCLK/MA- | Black |
| 3 | | 5V | VDDIO | Black/White Stripe |
| 4 | 8 | | MISO/SLO- | Black |
| 5 | 7 | | MISO/SLO+ | Black |
| 6 | 6 | | GNDIO | Black |
| | 6 | GND | GND DC PWR | Black |

# 6 Communications

## 6.1 BiSS-C

### 6.1.1 Single Encoder Operation

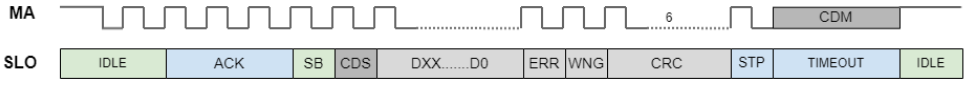



Aura P employs a bidirectional implementation of BiSS-C. BiSS-C can incorporate a channel embedded in the operational frame for control, configuration and status. This method is initiated by the state of the master clock (CDM - Control Data Master) at the end of a data frame. The response (CDS - Control Data Slave) is embedded in subsequent frames one bit per frame. This technique is used for accessing Aura registers while the encoder is reporting position.

The BiSS profile identification (ID), which can be used for establishing the communication automatically with the controller, is stored in the read-only direct access register 0x42 and 0x43 based on the factory configurations per **BP3 Standard Encoder Profile guidelines**.

Please note that any BiSS profile changes (e.g. CRC polynomial; enabling working counter) will make the BP3 profile ID invalid (register 0x42 and 0x43 will be shown as 0x00).

The BiSS-C BP3 protocol sequence is outlined below. Note that CDS and CDM are included for completeness.




Note: green=1, blue=0, grey=0/1

1. Master initiates communication, clock active
2. ACK Acknowledge [0] - encoder responds on second rising clock edge, begins to compile data. This typically takes 3 clock cycles.
3. SB Start [1] - encoder is ready to transmit data after three clocks
4. CDS Control Data Slave - one bit of data packet transferred over multiple cycles in response to CDM

5. Default data size: 18 bits for AUR-P-R-B, 20 bits for AUR-P-R-C, 25 bits for AUR-P-L-C. Data size can be configured in SmartPrecision III. AUR-P-B and AUR-P-C data size depends on the rotary scale size.
6. ERR Error [0 if error]
7. WNG Warning [0 if warning]
8. CRC Cyclic Redundancy Check - 6 bits (bits inverted transmission)
    a. CRC start value is 0x0 or 000000
    b. The polynomials are 0x43 or $x^6 + x^1 + 1$ (1000011)
    c. Max data length < 57 bits
9. STP Stop [0] + Timeout [0]
10. During Stop and Timeout, Master can transmit CDM (Control Data Master) by bringing MA high or low - note the encoder interprets the clock state as a single control/data bit
11. MA & SLO [1] - idle, encoder ready

The duration of the BiSS timeout is determined by the master clock interval. The minimum timeout is equal to 1.5 x the master clock interval and the maximum timeout is equal to 1.5 x the master clock interval plus 200ns. For example, if your master clock interval is 100ns (10MHZ), then the BiSS timeout will be between 150-350ns.

Control data commands (CMD) do not need to be sent on the user end. The following commands are implemented:

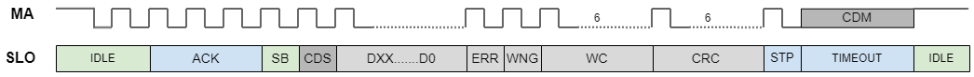
- Addressed CMD '00': activate single-cycle data channels
- Broadcast CMD '00': deactivate single-cycle data channels

When interfacing with an Ingenia servo drive, set the following parameters in MotionLab 3. Note that the frame size does not include ACK, Start, CDS, Stop.

| MotionLab 3 Feedback Settings | AUR-P-B | AUR-P-C |
|---|---|---|
| Protocol | BiSS-C | BiSS-C |
| Frame Type | BP3 | BP3 |
| Frame Size | 26 | 28 |
| Position Bits | 18 (default) | 20 (default) |
| Single-turn Bits | 18 | 20 |
| Position Start Bit | 8 | 8 |

If working counter (also known as sign-of-life counter) bits are needed, use SmartPrecision III to reconfigure your Aura encoder. If registers are preferred, please contact a Celera Motion representative for access to the Aura Registers document. If enabled, the working counter is initialized at 0, then

counts each frame from 1 to 63 skipping the 0 when wrapping. The modified BiSS protocol sequence below shows the BiSS frame with the working counter (WC) bits included.




Aura P is limited to BiSS-C. For more communication protocol options, please see the **Aura datasheet**.
For applications requiring daisy-chained operation, please **contact Celera Motion**.

# 7 Installation

## 7.1 General Installation Guidelines

- Please refer to Interface Drawings (see table below for ID numbers) during installation
- Alignment tolerances are listed in **Specifications** and interface drawings
- Z alignment in the interface drawings is defined by the distance from the scale to the chip mounting surface of the PCB. Chip height variance is factored into the drawing.
- Radial and tangential alignments are defined by the locations of the Aura P benching surfaces relative to the scale centerlines.

## 7.2 Rotary Installation

1. Ensure optics (scale and optics window on chip) are clean before installation.
2. Alignment
    a. Scale to center of rotation:
        i. Use alignment tolerances in **Specifications** to properly align the scale relative to the center of rotation with run out less than the concentricity tolerance. Refer to **Alignment Guidelines** for more information.
        ii. Where possible, install the scales in an inverted or vertical position to minimize accumulation of dust. Please reference our **recommended design guidelines**. If the patterned side of the scale must be oriented upwards, consider designing a labyrinth seal into your assembly design to further protect against debris build-up. If contamination is present, follow the clean guideline in **Cleaning Optics**.
    b. Aura P to center of the scale
        i. Create flat benching surfaces for benching datum B and C of Aura P. Please be aware that the benching surface should not extend beyond the Aura P Datum B and C range (see Interface Drawings).
        ii. Employ Aura P benching edges to accurately position the board relative to the center of scale.
3. Coarse alignment verification: check if the scale zero position, indicated by the reflective bar on the inner diameter of the tracks, is read as zero in SmartPrecision III before proceeding to the calibration. Checking that the reading matches the zero scale position ensures the PCB is approximately within tolerance.
4. Once the scale and encoder are aligned, perform the mandatory misalignment and GOP calibration using Smart Precision III as described in **Calibration**. If you would prefer to use registers, please contact your Celera Motion representative for access to our registers document. If the mandatory calibration is not performed, the encoder will likely report a position read error.
5. Perform optional eccentricity calibration if higher accuracy is needed.
6. Follow steps in **Confirming Alignment** to verify the alignment is within tolerance.

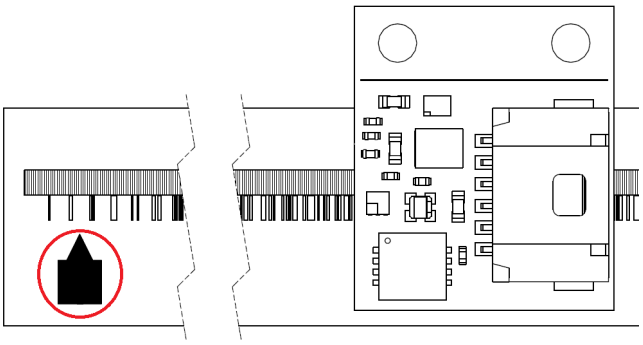
## 7.3 Linear Installation

1. Ensure optics (scale and optics window on chip) are clean before installation.
2. Alignment
    a. Scale to benching edge:

i. Use alignment tolerances in **Specifications** to properly align the scale relative to the application benching surfaces.
ii. Where possible, install the scales in an inverted or vertical position to minimize accumulation of dust. If the patterned side of the scale must be oriented upwards, consider designing a labyrinth seal into your assembly design to further protect against debris build-up. If contamination is present, follow the clean guideline in **Cleaning Optics**.

b. Aura P to the edge of the scale
i. Create flat benching surfaces for benching datum B and C of Aura P. Please be aware that the benching surface should not extend beyond the Aura P Datum B and C range (see Interface Drawings).
ii. Employ Aura P benching edges to accurately position the board relative to the edge of the scale.

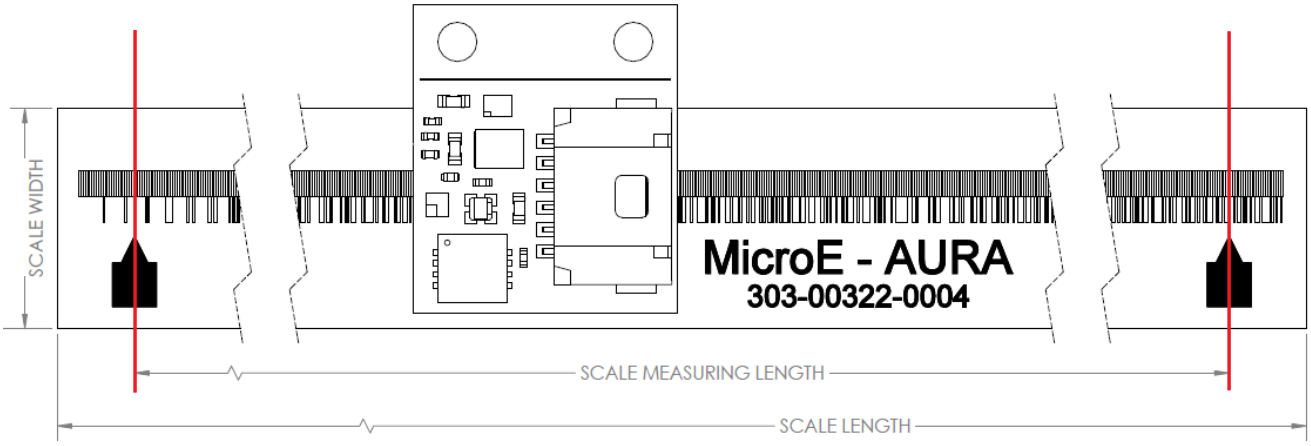
3. Coarse alignment verification: check if the scale left limit position, indicated by the left side reflective pointer box (shown below), is approximately 2.4576 mm in SmartPrecision III before proceeding to the calibration.



4. Once the scale and encoder are aligned, perform the mandatory misalignment and GOP calibration using Smart Precision III as described in **Calibration**. If you would prefer to use registers, please contact your Celera Motion representative for access to our registers document. If the mandatory calibration is not performed, the encoder will likely report a position read error.
5. Follow steps in **Confirming Alignment** to verify the alignment is within tolerance.

### 7.3.1 Linear Scale Measuring Length

The measuring length of the scale is 7.0 mm less than the overall length of the scale. There are 3.5mm buffer zones on either end of the scale indicated by the pointer boxes shown in the picture below. The center line of the PCB should never go beyond the solid red lines. The absolute reading may be erroneous if the center line of the PCB is in the buffer zone.




**1 Aura P Linear Scale with Measuring Length**

### 7.3.2 Interface Drawing Numbers

| Scale Part Number | Scale Size | Interface Drawing Number |
|---|---|---|
| AURP-R-G-0002 | 18 mm | ID-00440 |
| AURP-R-G-0001 | 26 mm | ID-00443 |
| AURP-R-G-0003 | 33 mm | ID-00441 |
| AURP-R-G-0006 | 51.8 mm | ID-00442 |
| AURP-R-G-0004 | 63.5 mm | ID-00444 |
| AURP-L-G-XXXX | Linear (All) | ID-00433 |

**Contact Celera Motion** for drawings.

# 8 SmartPrecision III

SmartPrecision III connects and functions the same with all Aura series encoders. Please consult the **Aura datasheet** for device pairing instructions.

# 9 Calibration

SmartPrecision III calibrates Aura P the same as with all Aura series encoders. Please consult the **Aura datasheet** for calibration instructions.

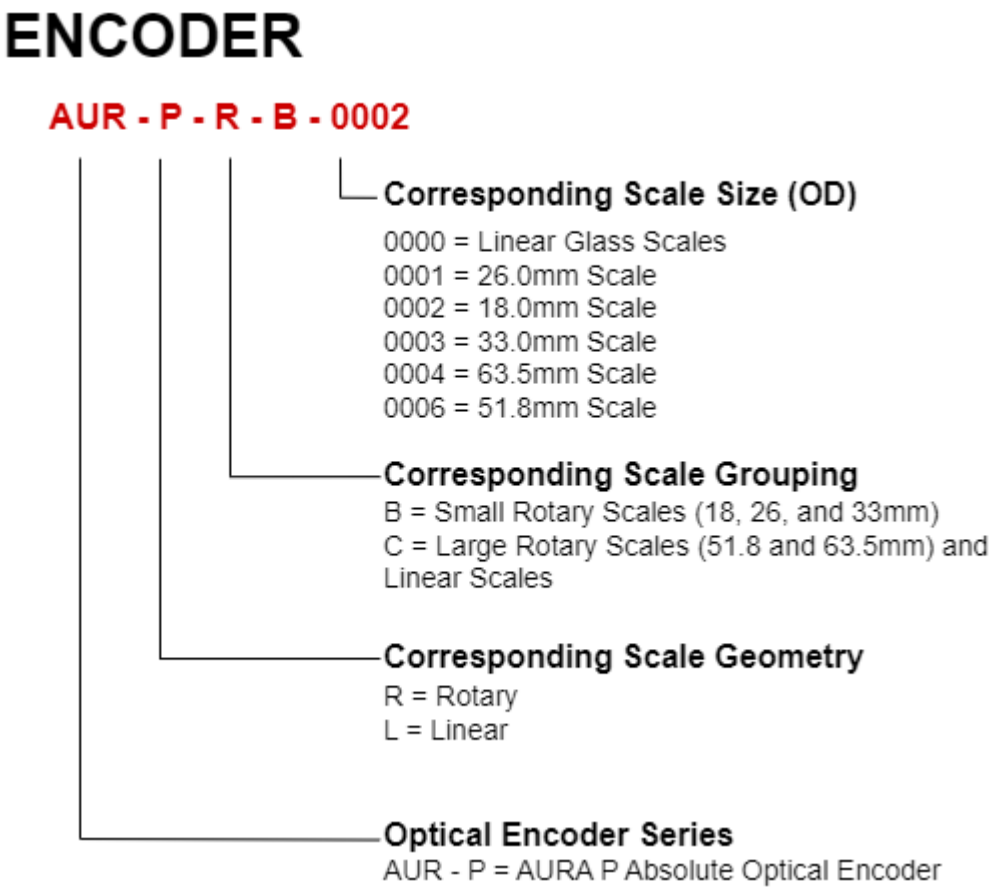
# 10 Confirming Alignment

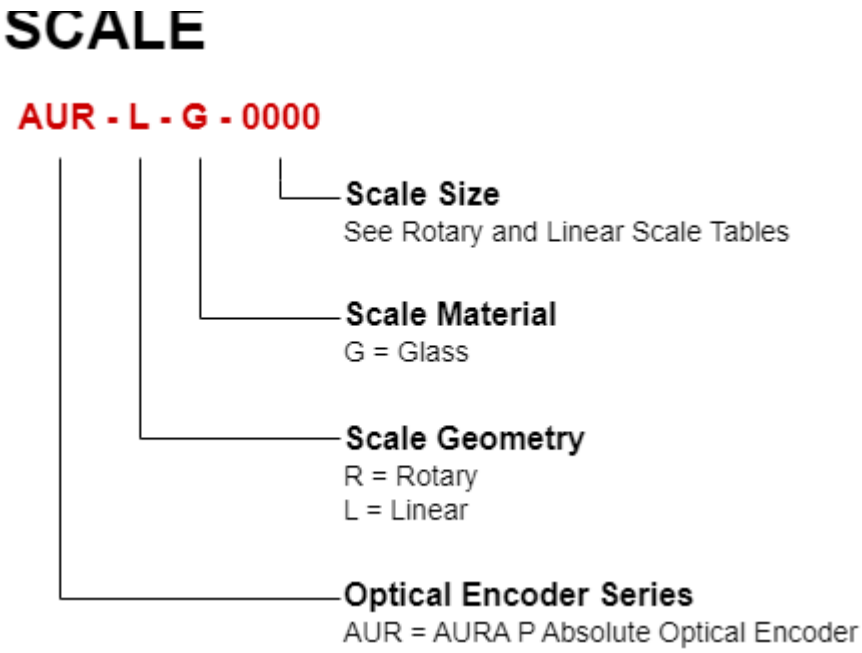
SmartPrecision III connects and functions the same with all Aura series encoders. Please consult the **Aura datasheet** for confirming alignment procedure instructions.

# 11 Ordering Information

The Aura encoder is configured for a specific scale. Be sure to specify the correct encoder/scale pair.

## 11.1 Part Number Nomenclature






## 11.2 Rotary Scales

| Part Number | Inner Diameter | Outer Diameter (OD) | Counts Per Rev (CPR) | Corresponding Encoder |
|---|---|---|---|---|
| AUR-R-G-0001 | 12.0 mm | 26.0 mm | 256 | AUR-P-R-B-0001 |
| AUR-R-G-0002 | 7.0 mm | 18.0 mm | 172 | AUR-P-R-B-0002 |
| AUR-R-G-0003 | 21.0 mm | 33.0 mm | 343 | AUR-P-R-B-0003 |
| AUR-R-G-0004 | 49.0 mm | 63.5 mm | 908 | AUR-P-R-C-0004 |
| AUR-R-G-0006 | 38.0 mm | 51.8 mm | 761 | AUR-P-R-C-0006 |

## 11.3 Rotary Hub/Scale Assemblies

| Part Number | Description |
|---|---|
| AUR-R-GSH-0001 | 26 mm OD Rotary Scale Mounted to a Hub |
| AUR-R-GSH-0004 | 63.5 mm OD Rotary Scale Mounted to a Hub |

For a custom scale hub/scale assembly, please contact Celera Motion.

## 11.4 Linear Scales

| Part Number | Measuring Length | Overall Length | Thickness | Corresponding Encoder |
|---|---|---|---|---|
| AUR-L-G-0001 | 9.0 mm | 16.0 mm | 2.29 mm | AUR-P-L-C-0000 |
| AUR-L-G-0002 | 50.0 mm | 57.0 mm | | |
| AUR-L-G-0004 | 195.0 mm | 202.0 mm | | |

### 11.4.1 Ordering Examples

- Aura P with 18mm rotary glass scale: AUR-P-R-B-0002 and AUR-R-G-0002
- Aura P with 26mm rotary glass scale: AUR-P-R-B-0001 and AURP-R-G-0001
- Aura P with 33mm rotary glass scale: AUR-P-R-B-0003 and AUR-R-G-0003
- Aura P with 9mm linear glass scale: AUR-P-L-C-0000 and AUR-L-G-0001

For custom scale sizes, please contact Celera Motion.

## 11.5 Evaluation Kits

| Part Number | Scale Size |
|---|---|
| AUR-P-R-B-EK | 26 mm Rotary |
| AUR-P-R-C-EK | 63.5 mm Rotary |
| AUR-P-L-C-EK | 57 mm Linear |

**Evaluation Kits include:**

- Aura P encoder
- Aura P Interfacing Cable
- Scale (linear) or Hub/Scale Assembly (rotary)

**Evaluation Kits do not include:**

- BiSS-C to PC Adapter
- Evaluation fixture to interface Aura P with scale

## 11.6 Accessories

| Part Number | Description |
|---|---|
| 193-00182 | BiSS-C to PC Adapter |
| 512-00344 | Interfacing Cable |