Motion Control System Standard

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Authored by:	**Yazeed Momani**
Reviewed by:	**----------**
Approved by:	**----------**
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SESAME, P.O. Box 7, Allan, 19252, Jordan, Tel: (+962) 5 351 1348 ext. 203, Fax: (+962) 5 351 1423

REVISION HISTORY

Revision	Date	Description	Author
0.1	01-04-2017	First Draft	Yazeed Momani
1.0	23-04-2017	Version 1.0	Yazeed Momani
1.1	14-06-2017	Added Motion Direction	Yazeed Momani
1.2	19-12-2018	Added Auxiliary Encoder	Yazeed Momani
1.3	05-02-2019	Added BiSS Encoder	Yazeed Momani
1.4	17-06-2020	Added Wires and Cables	Yazeed Momani
1.5	24-01-2021	Removed Contact Details	Yazeed Momani
1.6	27-06-2021	Updated Main and AUX Encoder Pin Assignments	Yazeed Momani
1.7	07-10-2021	Updated Motor Pin Assignments	Yazeed Momani
1.8	12-10-2022	Updated Absolute Encoders and added Encoders Manufacturers	Yazeed Momani
1.9	14-11-2022	Minor changes (rewording)	Yazeed Momani

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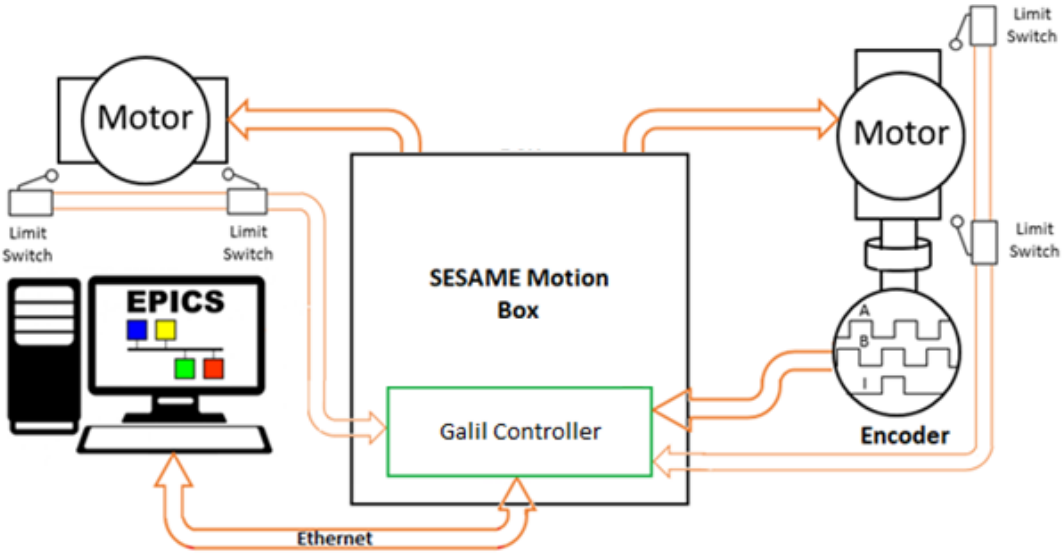
1. Intruduction

Complex machines such as light sources require precise and highly repeatable motion systems, A typical beamline makes use of over fifty motors that are used to position the optical elements as well as sample and detectors. This precise motion is implemented using motion control systems.

This document defines SESAME standards for motion control systems. Technologies, vendors, and products have been selected to meet most of SESAME's motion applications needs.



2. Motors

SESAME has selected stepper motors as the standard type of motors that should be used in all its motion applications.

Stepper motors were selected because of their reliability, ease of implementation, and excellent position stability.

For certain applications, DC-Servo motor may be used, but their use should be justified and must remain marginal (section 3.2).

For pin assignment go to section 9.1

2.1 Stepper Motors

SMB can drive any stepper motors with the following specifications:

Type	2-Phase Bipolar
Step Angle	1.8° and 0.9°
Configuration	Series and parallel windings
Current	0.1 to 10A (in increments of 0.01A)
Voltage	48VDC
Microstep Resolution	200 to 51200 steps/rev (in increments of 2 steps/rev)
Idle current reduction	Adjustable, up to 90% of set current.

2.2 DC Servo Motors

For certain applications, DC-Servo motor may be used, but their use should be justified and must remain marginal.

SMB can drive DC-servo motors with the following specifications:

Type	BDC and 3-phase BLDC
Current	Up to 10A
Voltage	48VDC

2.3 Motors Manufacturers

As motors are manufactured by several companies and to limit the types of motors used and to ensure the quality and availability, the products of the following companies will be preferred :

- McLennan
- Oriental Motor
- Applied Motion
- Phytron
- Portescap
- Slo-Syn

In case of doubt selecting a motor for your application don't hesitate to contact SESAME Electronics and Instrumentation Group.

3. Encoders

SMB accepts two encoders (main and auxiliary) for each servo motor and only one for each stepper motor (main).

The main encoder can be an incremental, absolute SSI or absolute BiSS encoder while the auxiliary encoder can only be an incremental encoder.

SMB can supply the encoder with 5VDC or 12VDC (for pin assignment go to encoder connector).

3.1 Incremental Encoders

SMB accept quadrature differential TTL encoders.

The input frequency to the controller must not exceed 3,000,000 full encoder cycles/second (12,000,000 quadrature counts/sec).

Encoders can be with or without an index pulse. The minimum index pulse width is 80 ns.

3.2 Absolute Encoders

SMB accepts absolute encoders with SSI and BiSS Interfaces. The SSI/BiSS absolute position encoders must meet the following specifications:

- For SSI, the maximum number of Data bits is 31 bit .
- For BiSS, the maximum number of Data bits 32 bit.
- The power supply in 5VDC or 12VDC.
- Clock frequency 370 kHz up to 2 MHz
- The SSI position value can be encoded in either Binary or Gray code and Status bits can be prepended or appended to the Data bits.
- The BiSS error bit and warning bit, these two bits can be either active high or low.

3.3 Encoders Manufacturers

As encoders are manufactured by several companies and to limit the types of encoders used and to ensure the quality and availability, the products of the following companies will be preferred :

- Heidenhain
- TR-Electronic
- FAGOR
- Renishaw
- Kübler
- US Digital

In case of doubt selecting a encoders for your application don't hesitate to contact SESAME Electronics and Instrumentation Group.

4. Limit Switches

All motorized stages should be equipped with at least two limit switches; one at the start of the travel range and one at the end of it.

SESAME Standard limit switches must be a dry contact, normally-closed switches.

Forward Limit (Pin F) and Reverse Limit (Pin G) are normally-closed to GND (Pin M) in the motor connector.

The use of non-standard limit switches such as inductive, capacitive, photoelectric, and magnetic proximity sensors should be first discussed and justified with the E&I group and it should be stated clearly in the documentation.

When it's not possible to equip a motorized stage with limit switches, or when extra switches are needed, this should also be discussed and justified with the E&I group and it should be stated clearly in the documentation.

Limit switches should be selected based on the application requirements, therefore, it is expected that the limit switches characteristics, such as temperature rating, repeatability and accuracy/ precision will meet the minimum requirements of that application.

5. Home Switch

Whenever it is possible, It's highly recommended to equip all motorized stages with at least one Home switches at a known reference/datum point within the travel range.

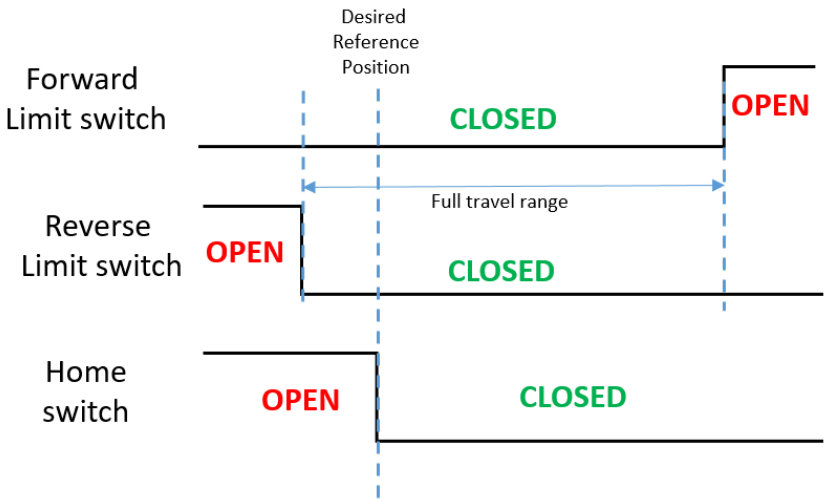
SESAME Standard Home switches must be a dry contact, normally-closed switches.

The Home (Pin H) is normally-closed to GND (Pin M) in the motor connector.

The use of non-standard home switches such as inductive, capacitive, photoelectric, and magnetic proximity sensors should be first discussed and justified with the E&I group and it should be stated clearly in the documentation.

When it's not possible to equip a motorized stage with Home switches, or when extra position-switches are needed, this should also be discussed and justified with the E&I group and it should be stated clearly in the documentation.

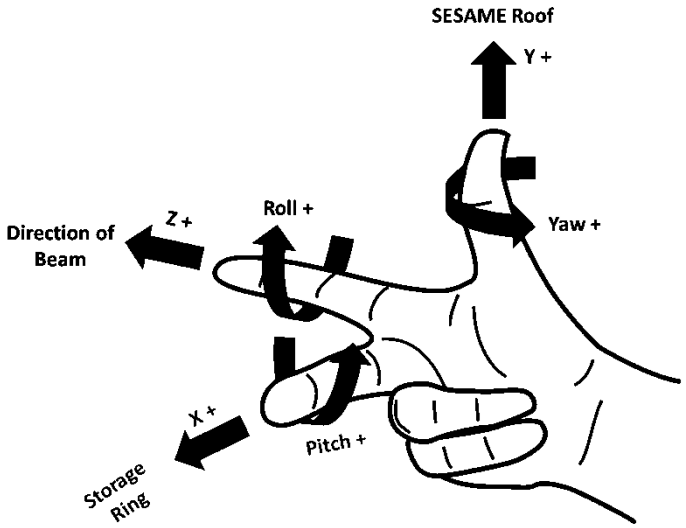
Home switches should be selected based on the application requirements, therefore, it is expected that the limit switches characteristics, such as temperature rating, repeatability and accuracy/ precision will meet the minimum requirements of that application.



6. Brakes

For certain applications, a motor brake could be used, both electromagnetic and friction brakes are accepted, brake will be connected to and powered by PLC, brake voltage should not exceed 24VDC with maximum current of 500mA.

7. Motion Directions



7.1 Linear Motion

Regardless of the motor rotation itself being clockwise or counterclockwise, any linear motorized stage is moving in the positive (forward) direction based on the Right-Hand rule where;

- The Thumb points toward SESAME Roof
- The Index finger with the direction of the beam
- and Middle finger towards the Storage-ring

7.2 Rotational Motion

For rotational motion, the stage is moving in the positive (forward) direction also based on the Right-Hand rule where the Thumb points in the positive direction of the axis of rotation, and the fingers curl along the positive direction of the rotation.

Encoders should be configured/wired accordingly.

8. Homing

Homing should be performed in one of the following three scenarios:

A) When the motorized stage is equipped with an Encoder, the Encoder Index should be used as Home, the Encoder Index will be approached in the forward direction starting from the reverse limit switch.

B) When there is a Home switch but no Encoder, the home switch should be used as Home, the home switch will be approached in the forward direction starting from the reverse limit switch.

C) When there is neither an Encoder Index nor a home switch, the reverse limit switch will be used as home.

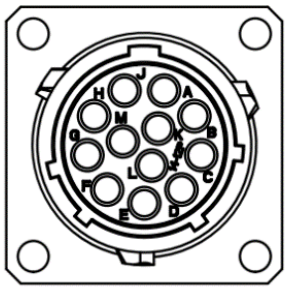
9. Connectors

9.1 Motor

Connector Type	Industrial Circular Connector
Mounting Type	Flange Receptacle
Shell-size	14
Pin-count	12
Reference	Amphenol RT001412PNH SOURIAU UT001412PH
Contacts Type	Machined Crimp Male
Reference	Amphenol MP16M23F SOURIAU RM16M23K
Pin Assignments	see table below
Mating Part	Amphenol RT061412SNH SOURIAU UT061412SH

The motor connector should be mounted on the equipment body or on a junction box attached to the equipment and as close as possible to the motor.

Pin	Stepper Motor	Brushed DC Motor	3-Phase BLDC Motor
PIN A	Phase A+	Phase +	Phase U
PIN B	Phase A-	Phase -	Phase V
PIN C	Phase B+	*Not Used*	Phase W
PIN D	Phase B-	*Not Used*	*Not Used*
PIN E	*12VDC*		
PIN F	Forward Limit Switch		
PIN G	Reverse Limit Switch		
PIN H	Home Switch		
PIN J	*Not Used*		
PIN K	*Not Used*		
PIN L	*5VDC*		
PIN M	GND		
Body/Shell	Shield/PE		

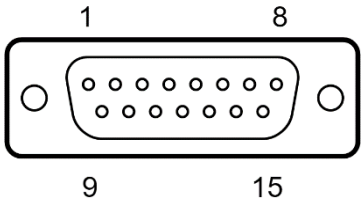


9.2 Main Encoder

Connector Type	D-Sub Connector
Mounting Type	Flange Receptacle
Size	DA-15
Pin-count	15
Reference	Amphenol L777-RRA-15P PHOENIX CONTACT 1688939
Contacts Type	Machined Crimp Male
Reference	PHOENIX CONTACT 1597862
Pin Assignments	see table below

Figure 1 D-Sub 15 Connector Male

The Encoder connector should be mounted on the equipment body or on a junction box attached to the equipment and as close as possible to the Encoder.

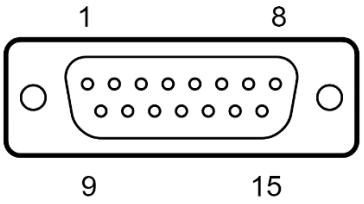


Pin	Incremental Differential Quadrature	Absolute SSI	Absolute BiSS
PIN 01	12VDC		
PIN 02	CHA+	*Not Used*	
PIN 03	CHB+	*Not Used*	
PIN 04	Index+	*Not Used*	
PIN 05	GND		
PIN 06	*Not Used*	Clock+	MA+
PIN 07	*Not Used*	Data+	SLO+
PIN 08	*Not Used*		
PIN 09	5VDC		
PIN 10	CHA-	*Not Used*	
PIN 11	CHB-	*Not Used*	
PIN 12	Index-	*Not Used*	
PIN 13	Inner shield (if avaialbe)		
PIN 14	*Not Used*	Clock-	MA-
PIN 15	*Not Used*	Data-	SLO-
Case/Shell	Shield/Earth		

9.3 Auxiliary Encoder

Connector Type	D-Sub Connector
Mounting Type	Flange Receptacle
Size	DA-15
Pin-count	15
Reference	Amphenol L777-RRA-15P PHOENIX CONTACT 1688939
Contacts Type	Machined Crimp Male
Reference	PHOENIX CONTACT 1597862
Pin Assignments	see table below

The Encoder connector should be mounted on the equipment body or on a junction box attached to the equipment and as close as possible to the Encoder.



Pin	Incremental Differential Quadrature
PIN 01	12VDC
PIN 02	CHA+
PIN 03	CHB+
PIN 04	*Not Used*
PIN 05	GND
PIN 06	*Not Used*
PIN 07	*Not Used*
PIN 08	*Not Used*
PIN 09	5VDC
PIN 10	CHA-
PIN 11	CHB-
PIN 12	*Not Used*
PIN 13	Inner shield (if avaialbe)
PIN 14	*Not Used*
PIN 15	*Not Used*
Case/Shell	Shield/Earth

10. Wires and Cables

- Only shielded cables may be used, with the shields connected to the chassis ground at both ends with a distance between shield and mechanics less than 25 mm (the use of EMC clips will be strongly appreciated).

- No wires may be unshielded for a distance longer than 50 mm.

11. Documentation and Manuals

The manufacturer shall provide full documentation, manuals and datasheets for all the motors, encoders, limit and home switches that will be used/installed.

In addition, the manufacturer shall provide for each motorized stage a table with at least the following information:

- Type, make and model number for all the Motors, Encoders, Gearboxes, Brake Couplers, Clutches, Limit, and Home switches.
- FULL-STEP resolution (FULL-STEP/rev) and (EGU/FULL-STEP).
- Encoder counts per revolution (count/rev), and (count per motor rev) for linear Encoders.
- Encoder count resolution (EGU/count).
- Motor and gearboxes backlash in (EGU) and the recommended producers to overcome/eliminate the backlash.
- Full travel range between the upper and lower limit switches in (EGU) and (FULL-STEP) and/or (count).
- Homing method, direction, and Home value in (EGU).
- Distance between both Limit Switches and Home switch in (EGU) and (FULL-STEP) and/or (count).
- Recommended upper and lower soft limits in (EGU).
- Operational velocity and maximum velocity (EGU/s).
- Operational acceleration and deceleration (EGU/s^2).
- Limit and Home switches repeatability/hysteresis in (EGU) and (FULL-STEP) and/or (count).