

Chopper Integration Controller (CHIC) & CHIC- EPICS integration

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On behalf of the ESS chopper group

www.europeanspallationsource.se

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Introduction

Situation

- ESS instruments will have complex chopper systems
- >140 chopper axis at facility
- Facility wide integrated control system (ICS)

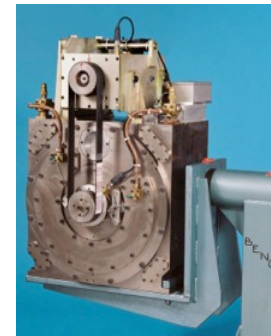
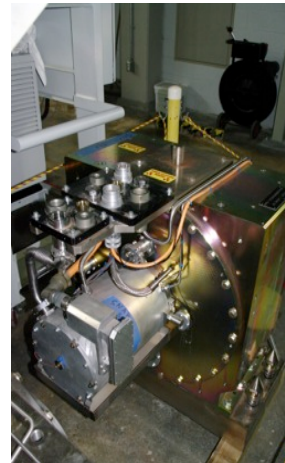


Challenge

- Integrate chopper drives from multiple suppliers with the facility

Goal is to ensure:

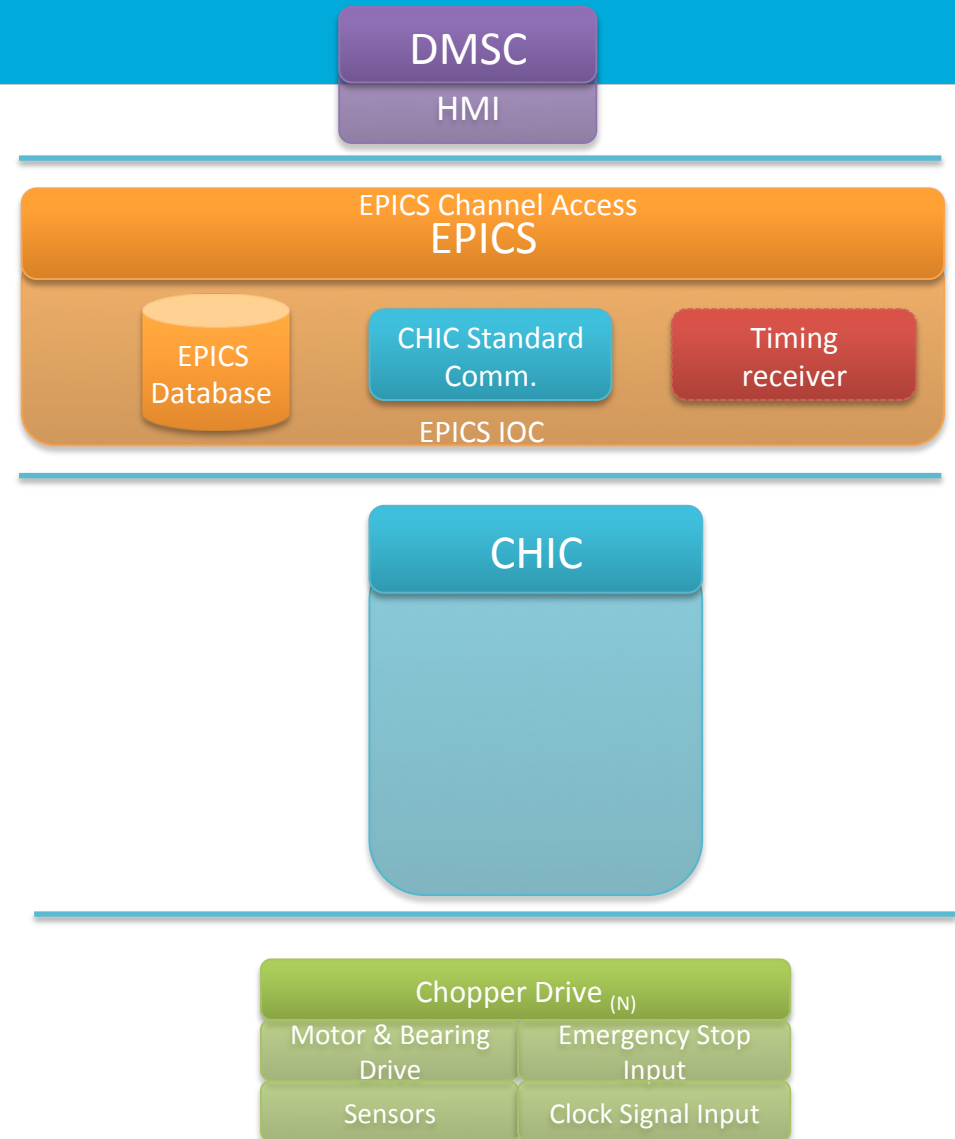
- Performance
- Reliability
- Maintainability
- Cost



Chopper Integration Controller (CHIC)

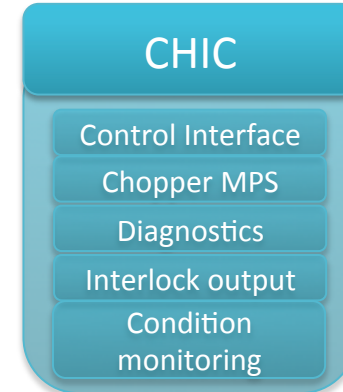
Chopper Control System

- Four layers
 - DMSC – HMI for users
 - EPICS
 - Facility wide control network
 - EPICS IOC
 - Timing receiver
 - CHIC – Chopper integration controller
 - Chopper drive and support equipment



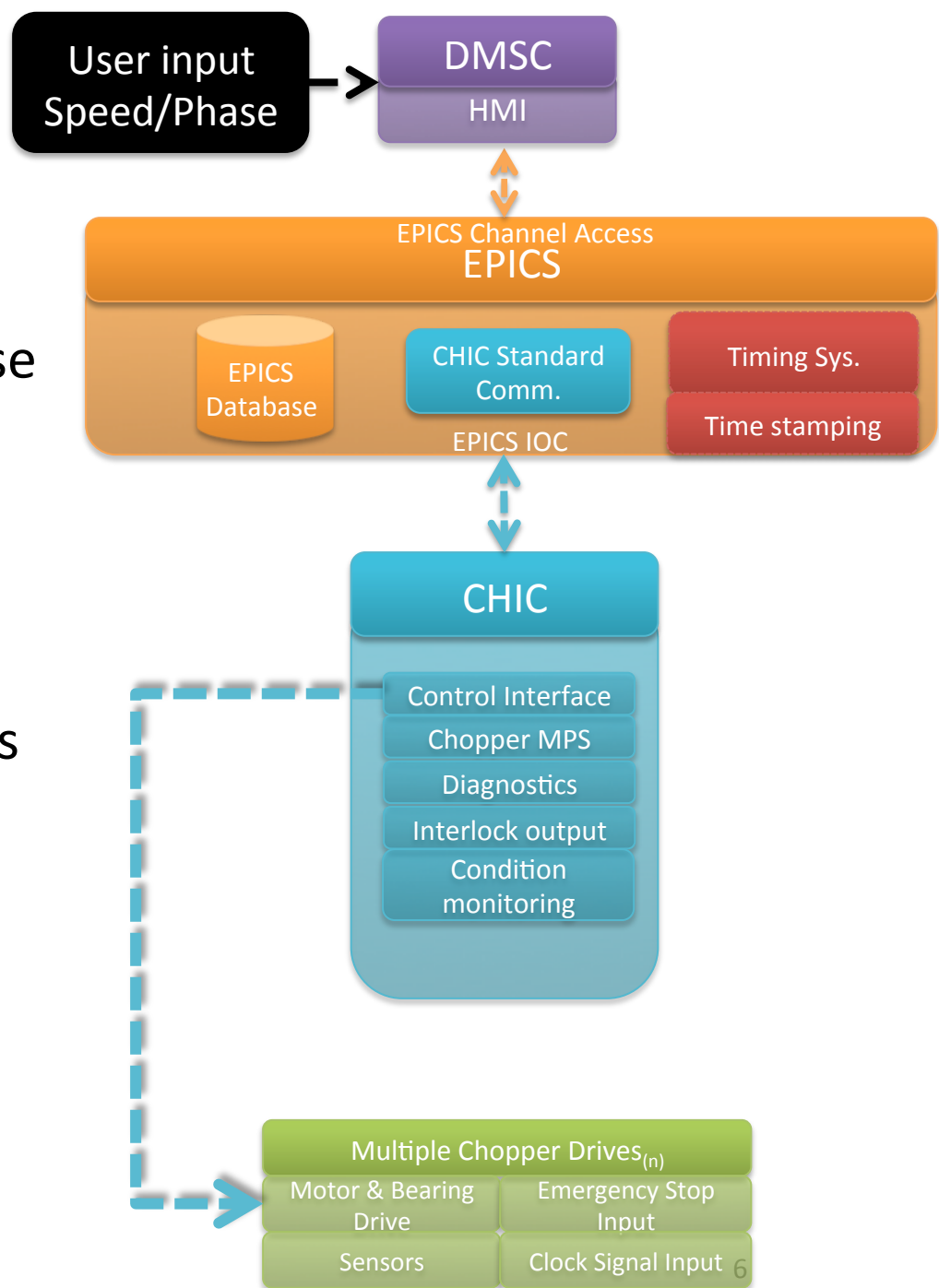
CHIC Functions

- Control Interface
 - Standard interface between EPICS and chopper drives
 - Same interface and GUI for all drives
- Chopper MPS
 - Vacuum, Cooling, UPS, Vibrations
- Diagnostics
 - Readout from drives
 - Motor temp, currents, alarms
- Interlock output
 - E.g loss of vacuum, cooling, power
- Condition monitoring
 - Predictive maintenance
 - Monitors changes and trends



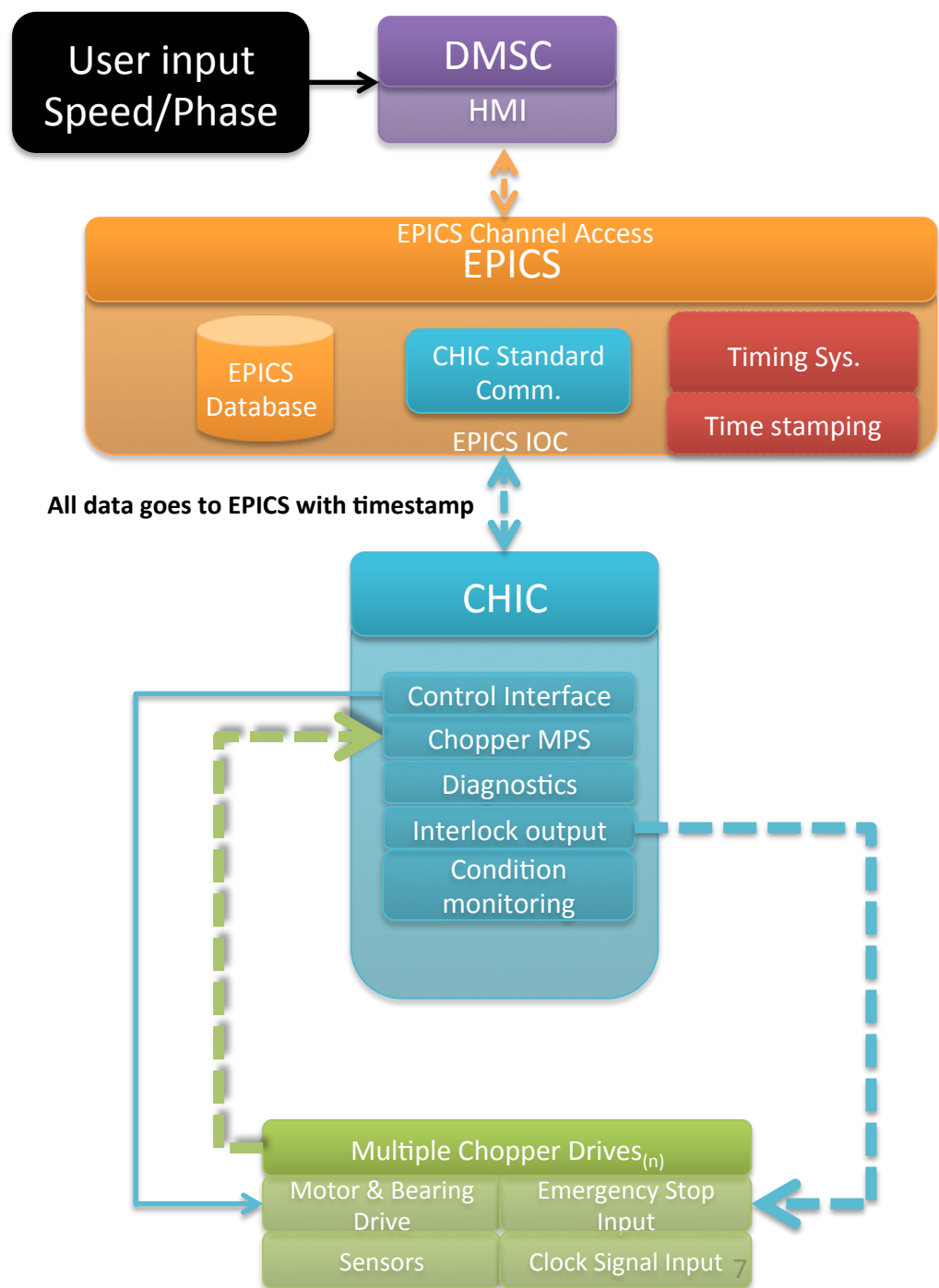
Communication Structure

- User inputs speed/phase
- EPICS sends the command to CHIC.
- CHIC is sending a supplier specific commands to the drives



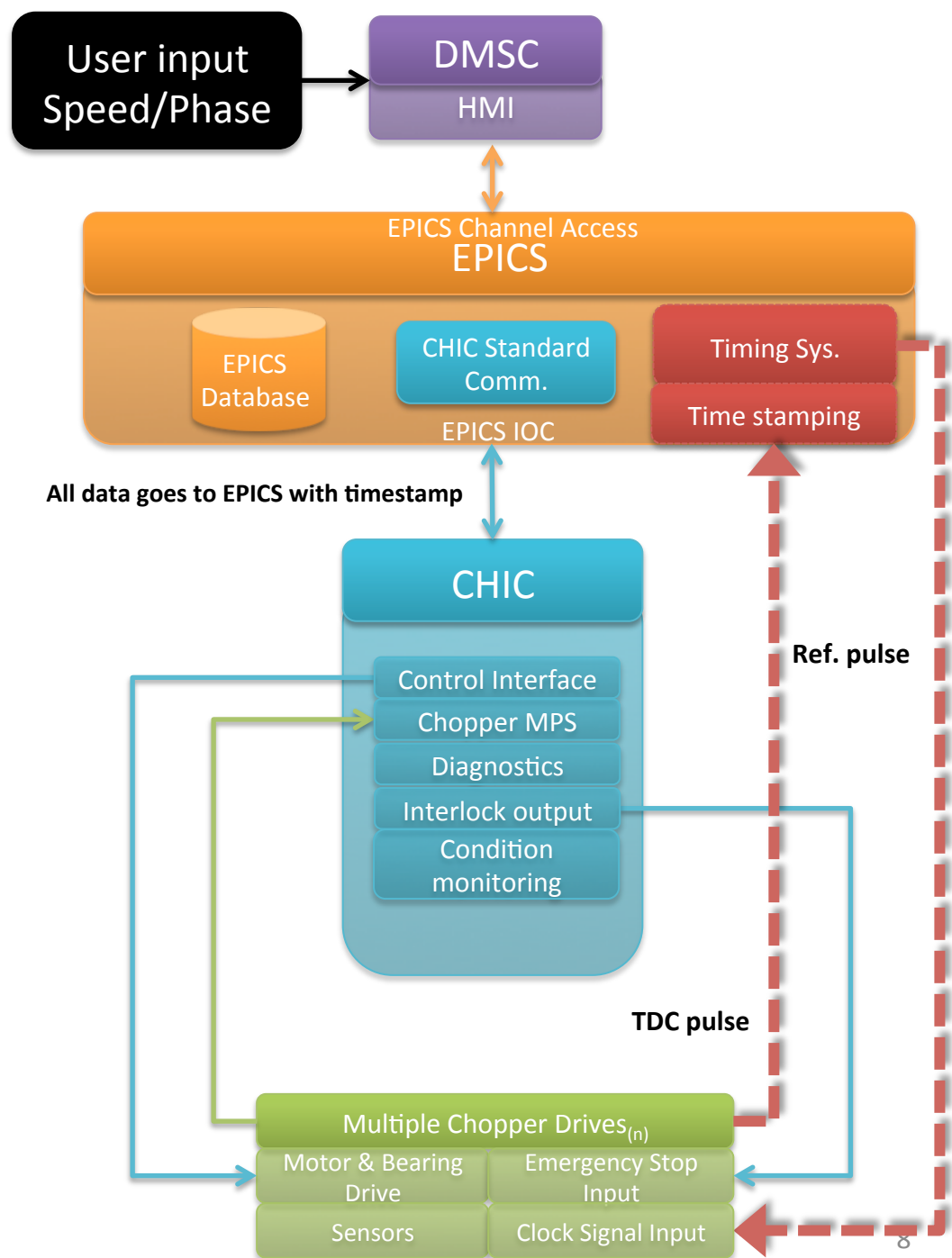
Communication Structure

- Readout from chopper drives
 - Motor temp, motor currents, error messages etc.
 - Monitoring
- Chopper MPS
 - External system, vacuum, UPS, cooling, vibrations.
- Interlock signal
 - Stopping the Chopper



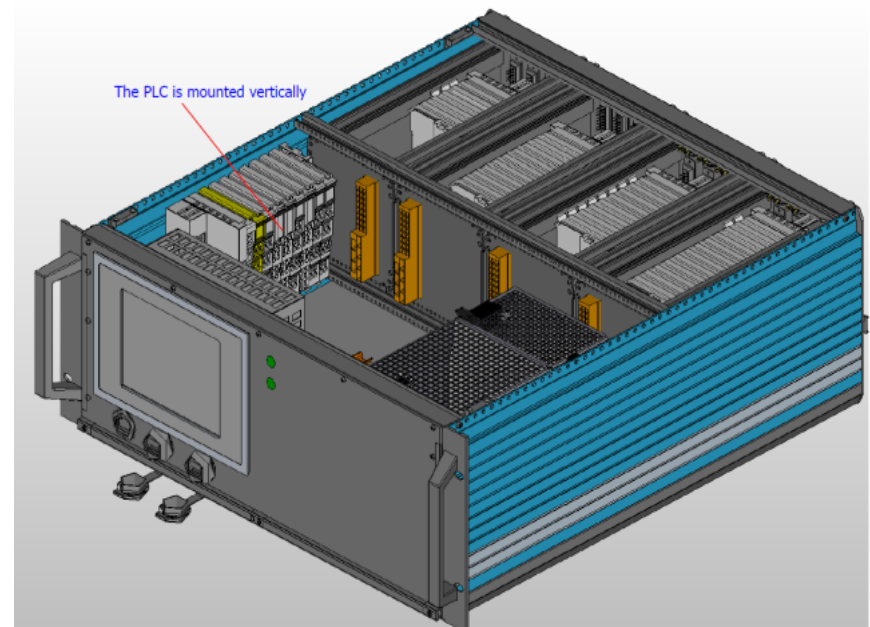
Communication Structure

- Veto at DMSC level
- Phase error is determined with Ref pulse and TDC pulse
- All chopper drives will receive the pulse simultaneously



CHIC Hardware

- CHIC Crate
 - Designed for 19" rack
 - Beckhoff PLC
 - 24V Power supply
 - Customized I/O modules
 - LCD screen



Early version of the CHIC crate

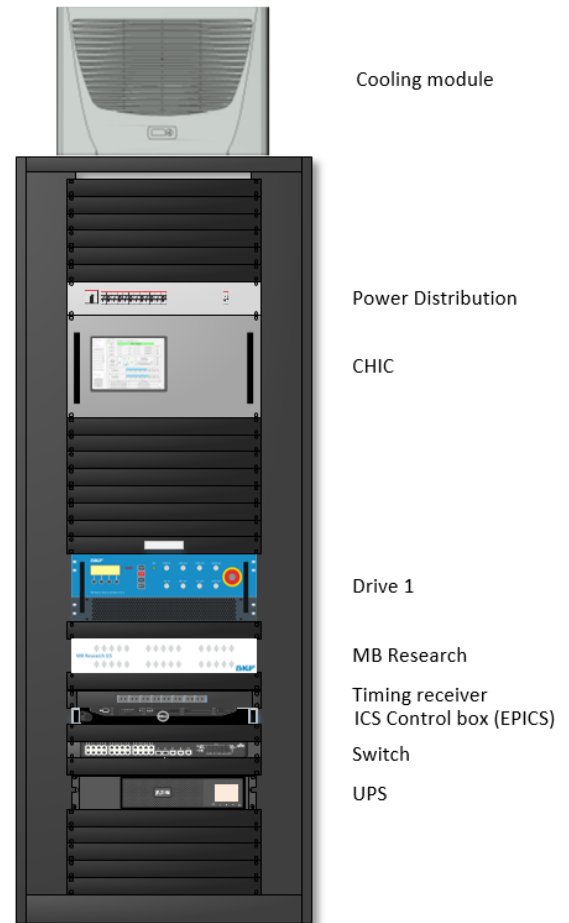
CHIC Benefits

- Standardized interface to EPICS for all chopper suppliers
- One GUI for all suppliers
- Unified error handling
- Monitoring system can be embedded in the CHIC

Chopper control rack

Chopper control rack

- Variant of the ESS standard instrument rack
 - Designed according to ESS standards and SE legislation.
- Modular design
 - Cooling unit (water- air)
 - Power distribution panel
 - CHIC
 - Chopper drives (≤ 4 / rack)
 - Timing receiver card
 - ICS Control box EPICS
 - UPS
- Adoptable to fit all the established chopper suppliers
- Prototype in the poster session



Prototype chopper control rack

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Prototype chopper control rack

CHIC-EPICS integration (ESSIIP)

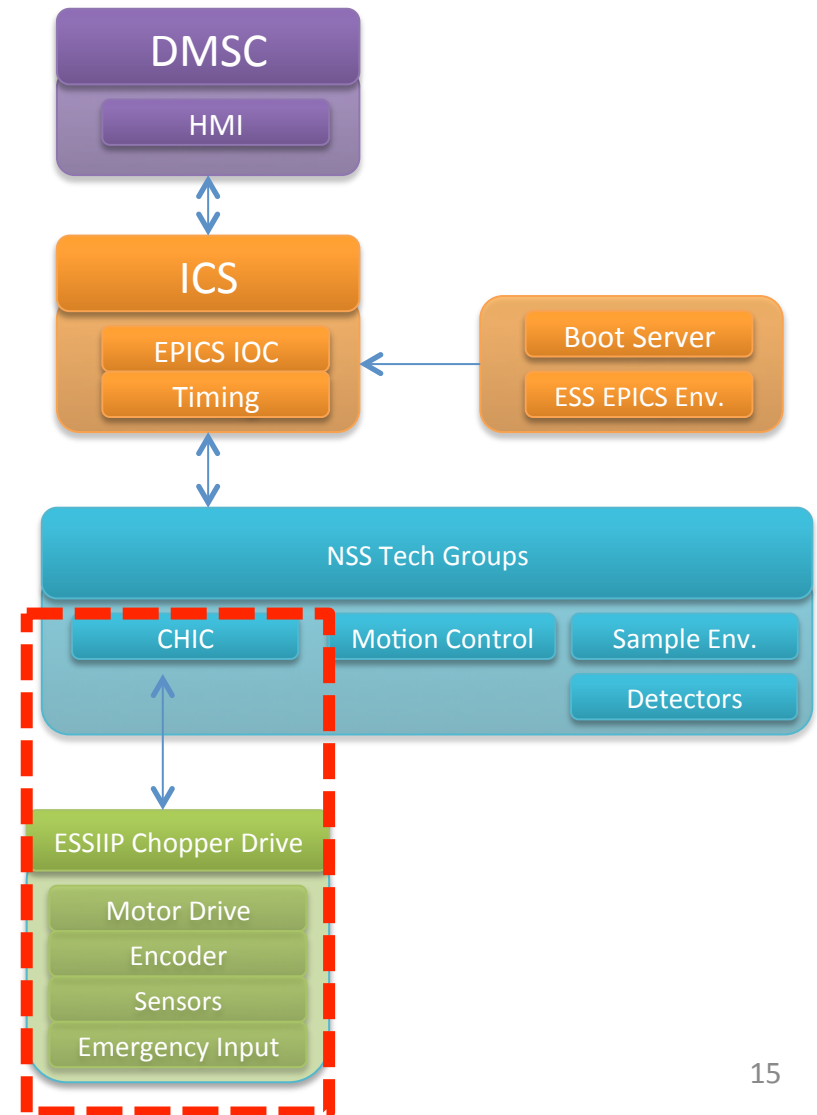
Andres Quintanilla
Mechatronics Engineer

ESS Instrument Integration Project

- Technology development
- Evaluate integration strategies for ESS instrument control software & Hardware
- Testbed for different version of the CHIC

Main ESS stakeholders

- DMSC
- ICS
- NSS technology groups



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ESSIIP Chopper Mechanics

Quarter scale model of the ESS chopper tested at EMBLA

- Servo motor with resolver
- 200 mm Aluminum Disc
- Aluminum Housing
- Temperature sensor
- Optical sensor



ESSIIP Chopper Drive

- The Drive simulates the behaviour of a ball bearing chopper.
- Main Functionalities:
 - Set speed
 - Phasing of disc
 - Change direction of rotation
 - Parking functionality
 - Emergency Stop functionality
 - Diagnostics



Controls the commands being sent to the drive

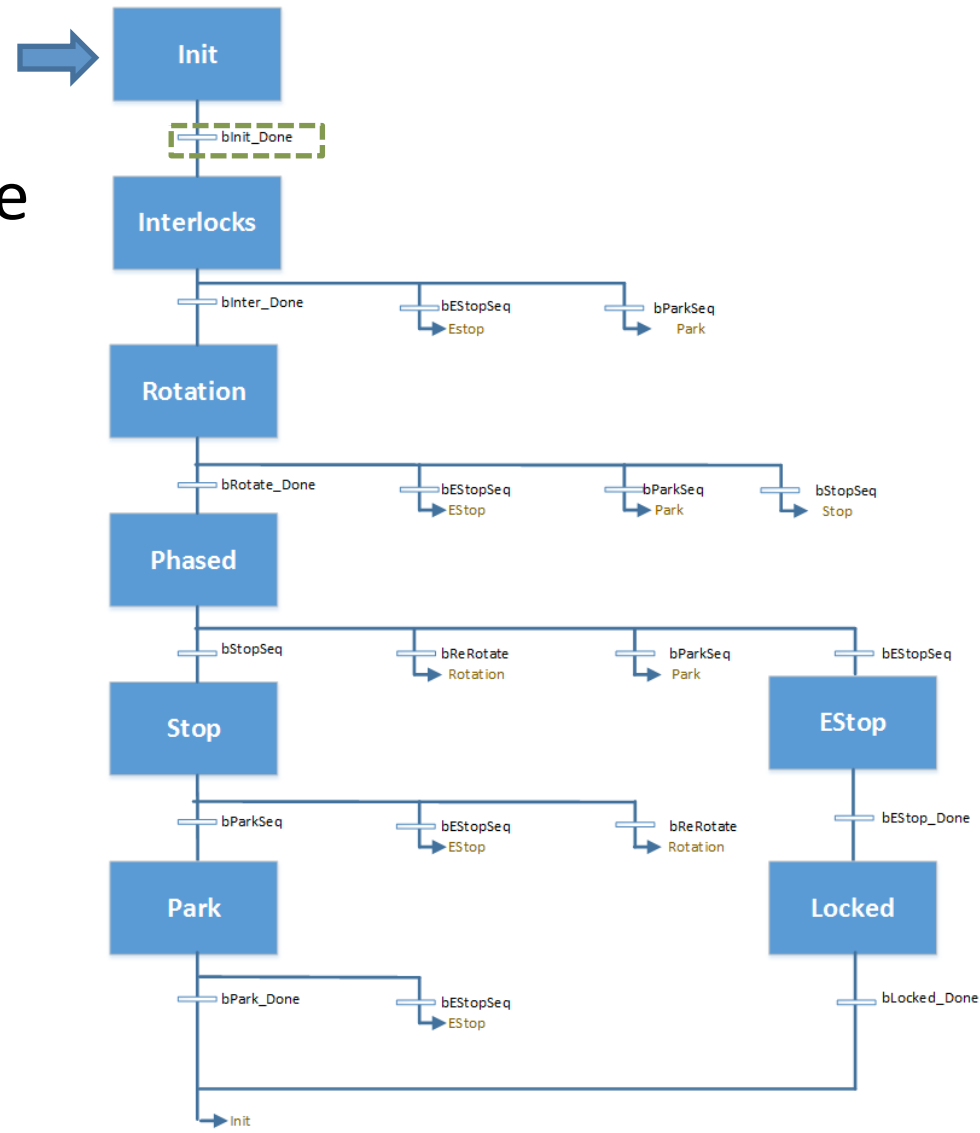
- Controlled transitions with Finite-state Machine logic
- Exposes all data with a standardized structure (error handling, commands, limits, etc).
- Feedback if a command was executed or not
- Communication diagnostics
- Calibration
Parameters(Thresholds)



CHIC - State Machine

Initialization:

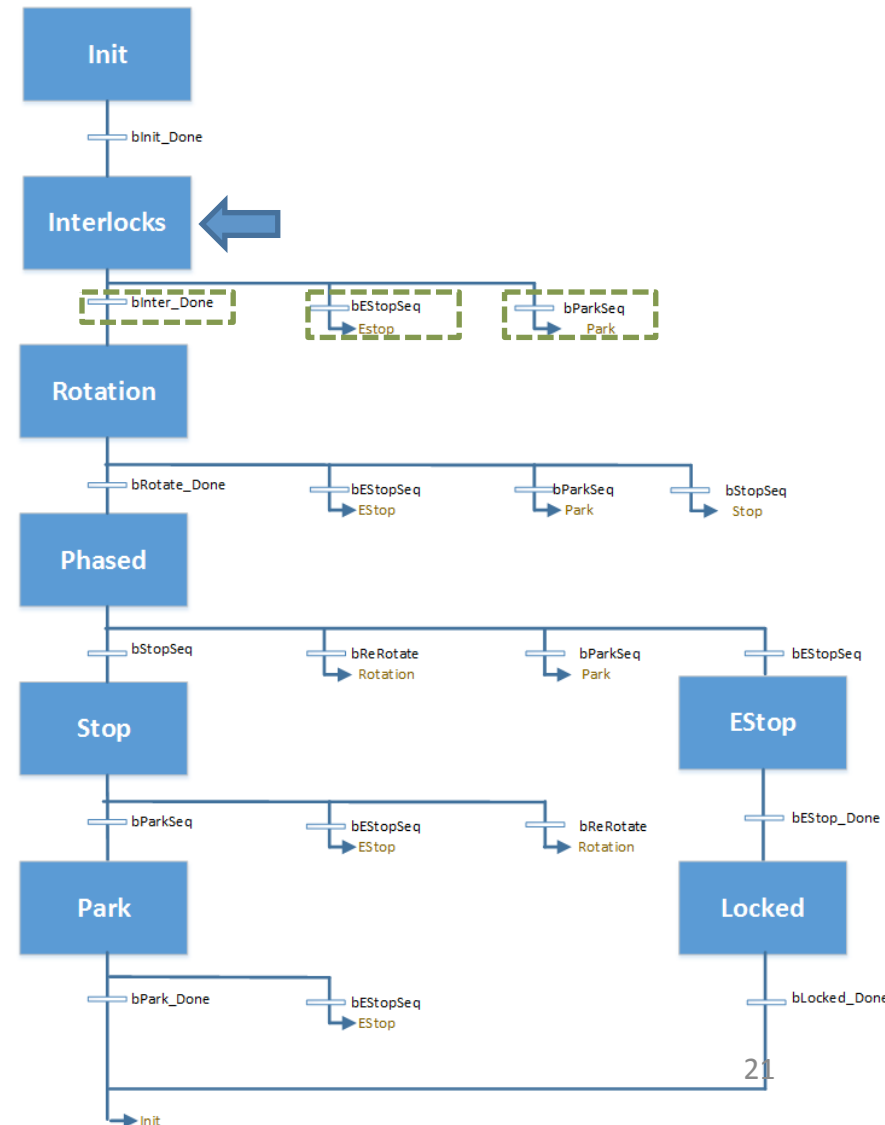
- Enables/powers the Drive
- Transition occurs when Drive and motor are powered.



CHIC - State Machine

Interlocks:

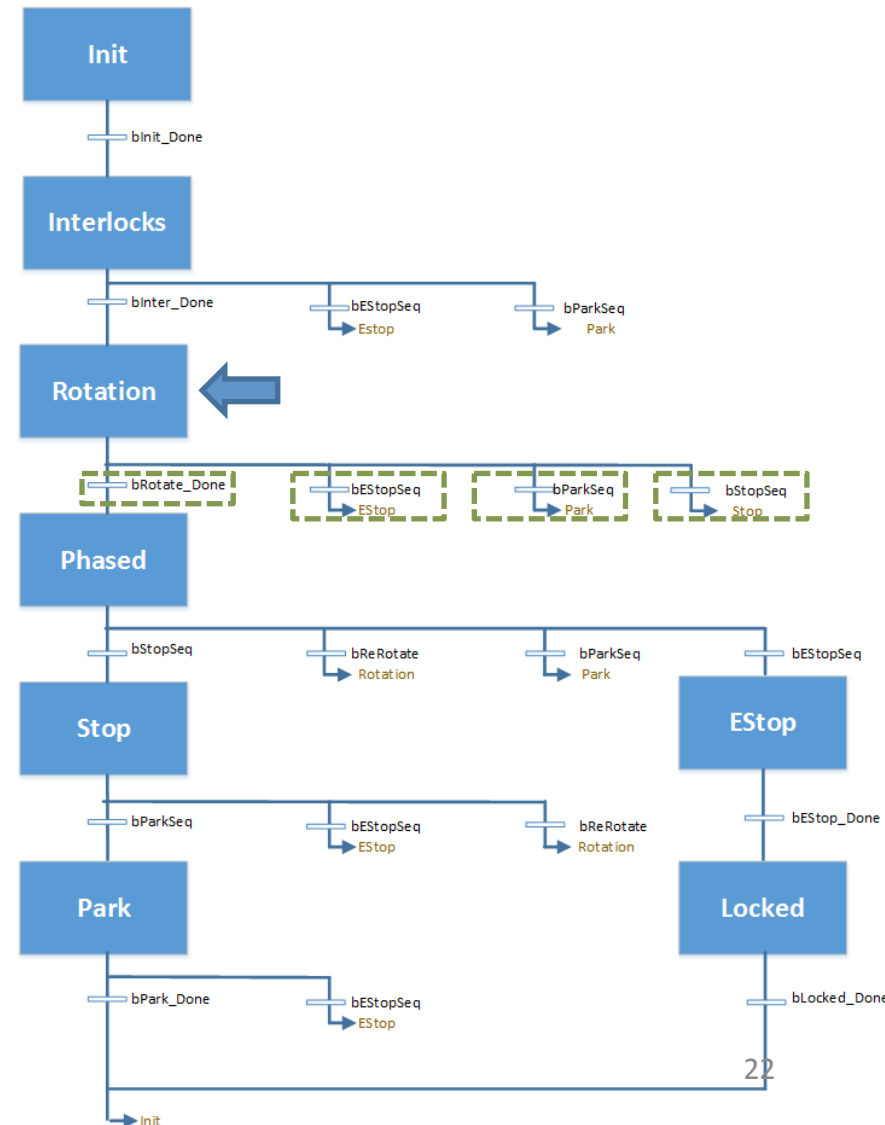
- Checks all critical variables (Interlocks-thresholds) in order to allow rotation
- Transition can go to:
 - Rotate
 - Emergency Stop
 - Park



CHIC - State Machine

Rotation:

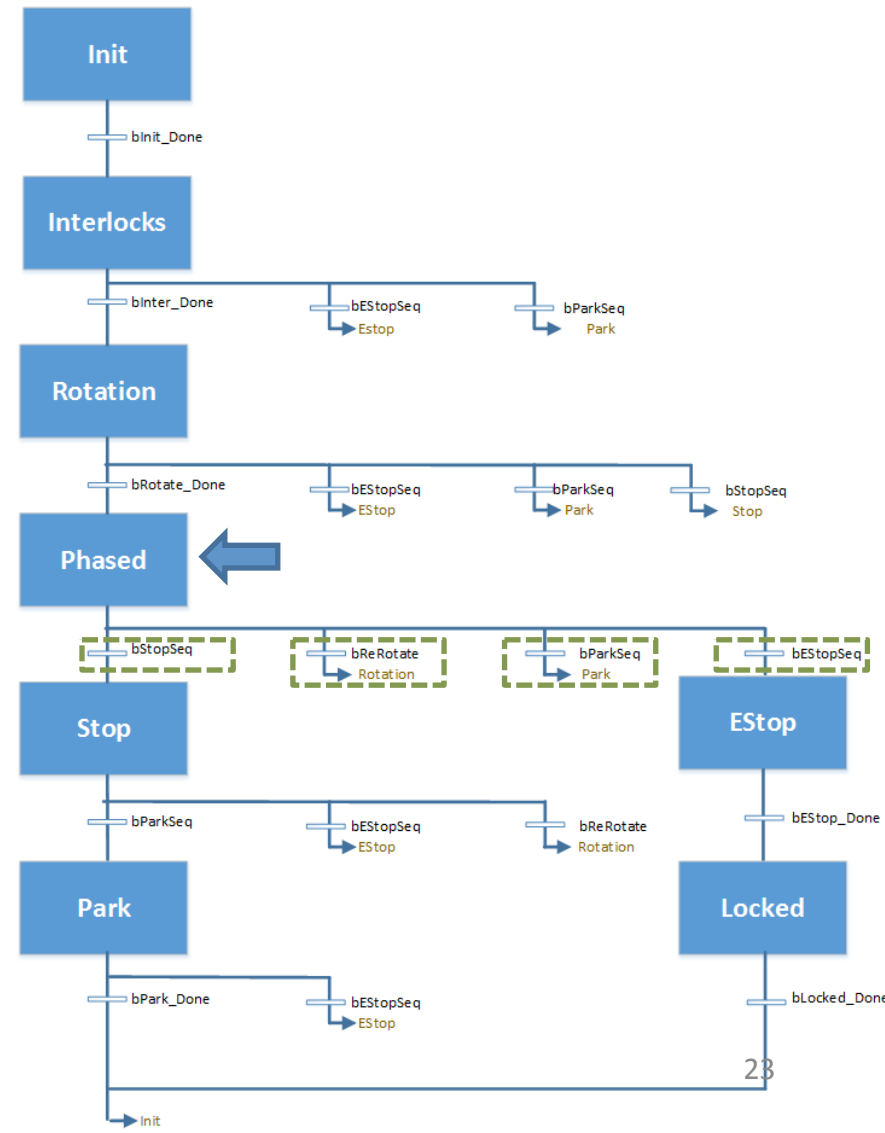
- Controls the commands to be sent in order to rotate in a safe way
- Transition can go to:
 - Phased
 - Emergency Stop
 - Park
 - Stop



CHIC - State Machine

Phased:

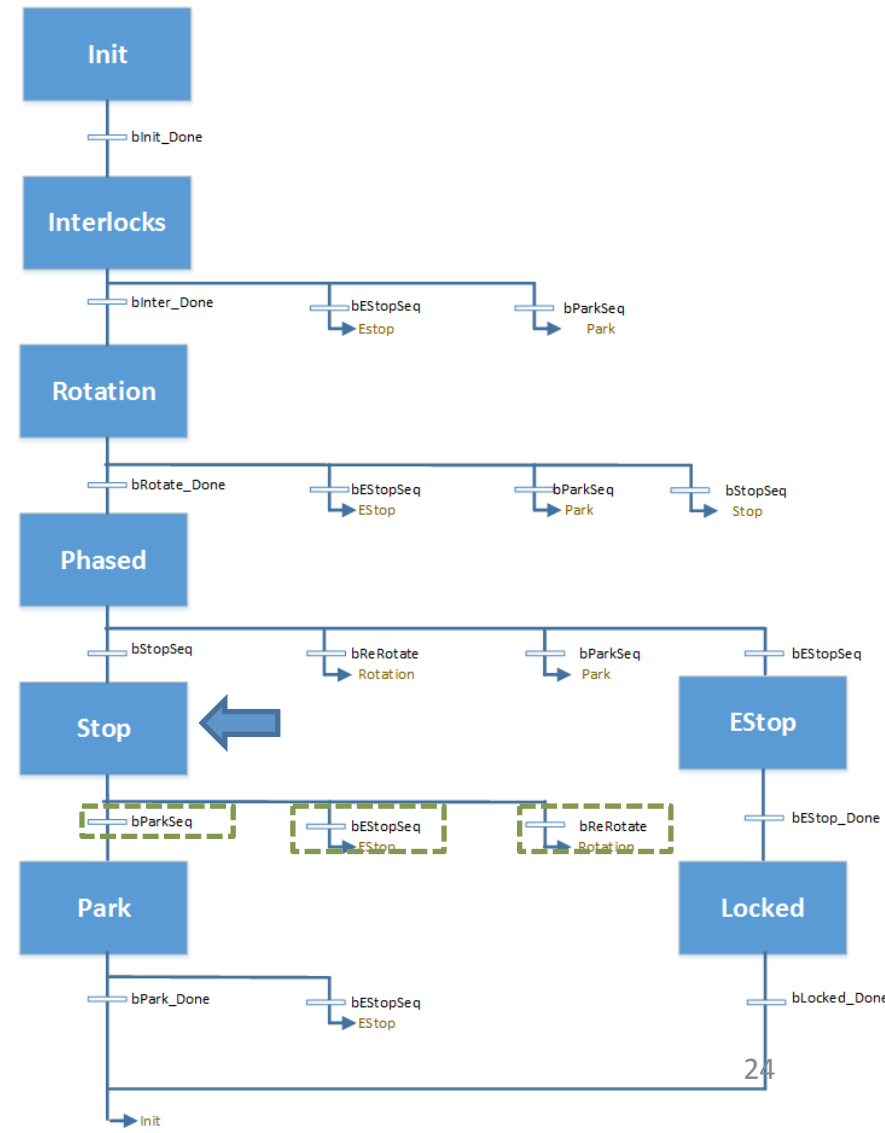
- Keeps track of the time that has been in phase lock.
- Transition can go to:
 - Stop
 - Re rotate (new parameters)
 - Park
 - Emergency Stop



CHIC - State Machine

Stop:

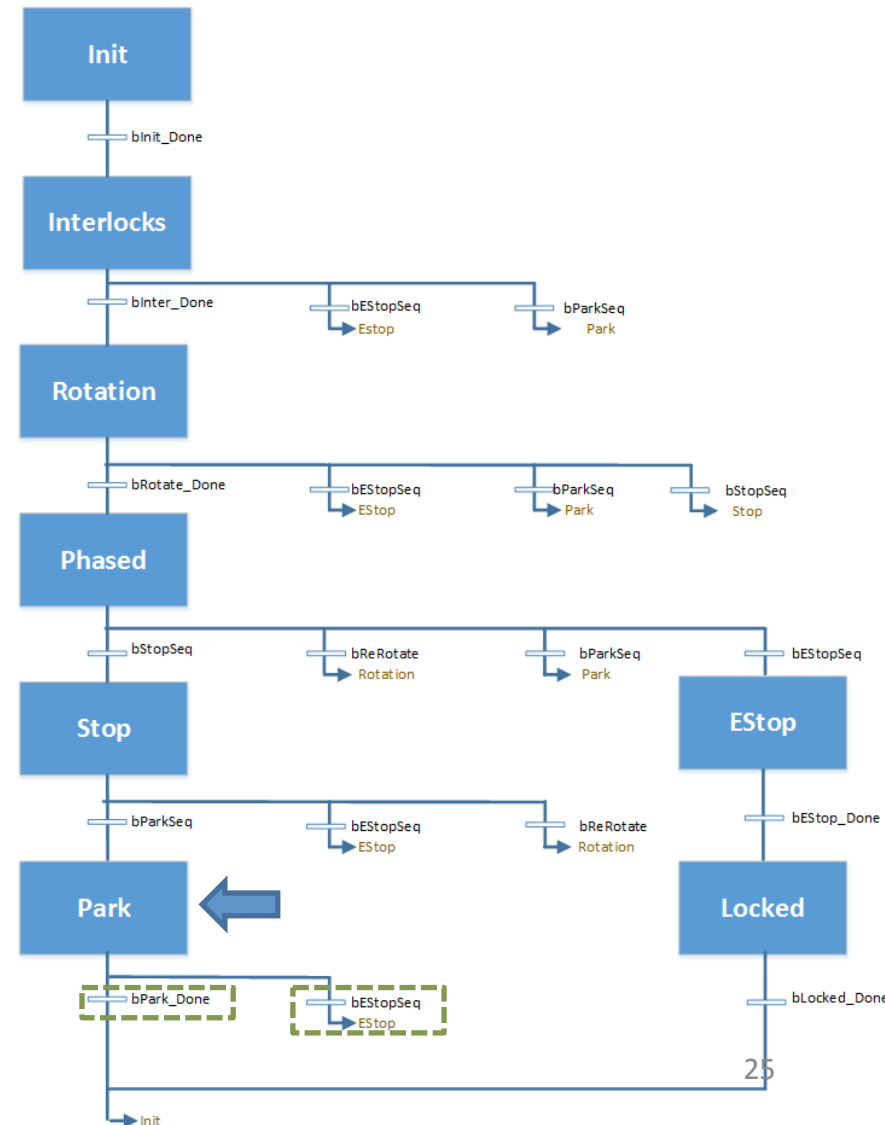
- Stops the rotation with a low deceleration rate to reduce electrical and mechanical stress
- Transition can go to:
 - Park
 - Re Rotate
 - Emergency Stop



CHIC - State Machine

Park:

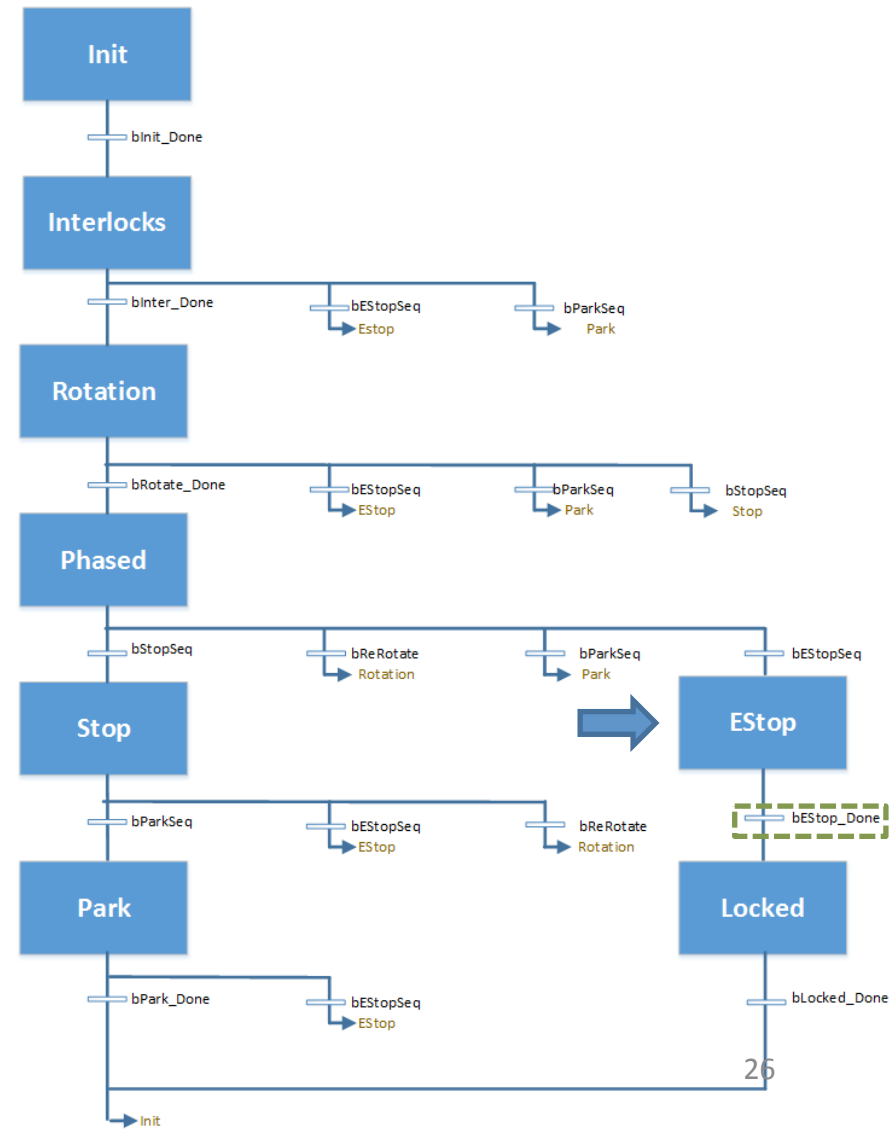
- It will move the disc to the Park setpoint, normally is the open position.
- Transition can go to:
 - Init
 - Emergency Stop



CHIC - State Machine

EStop:

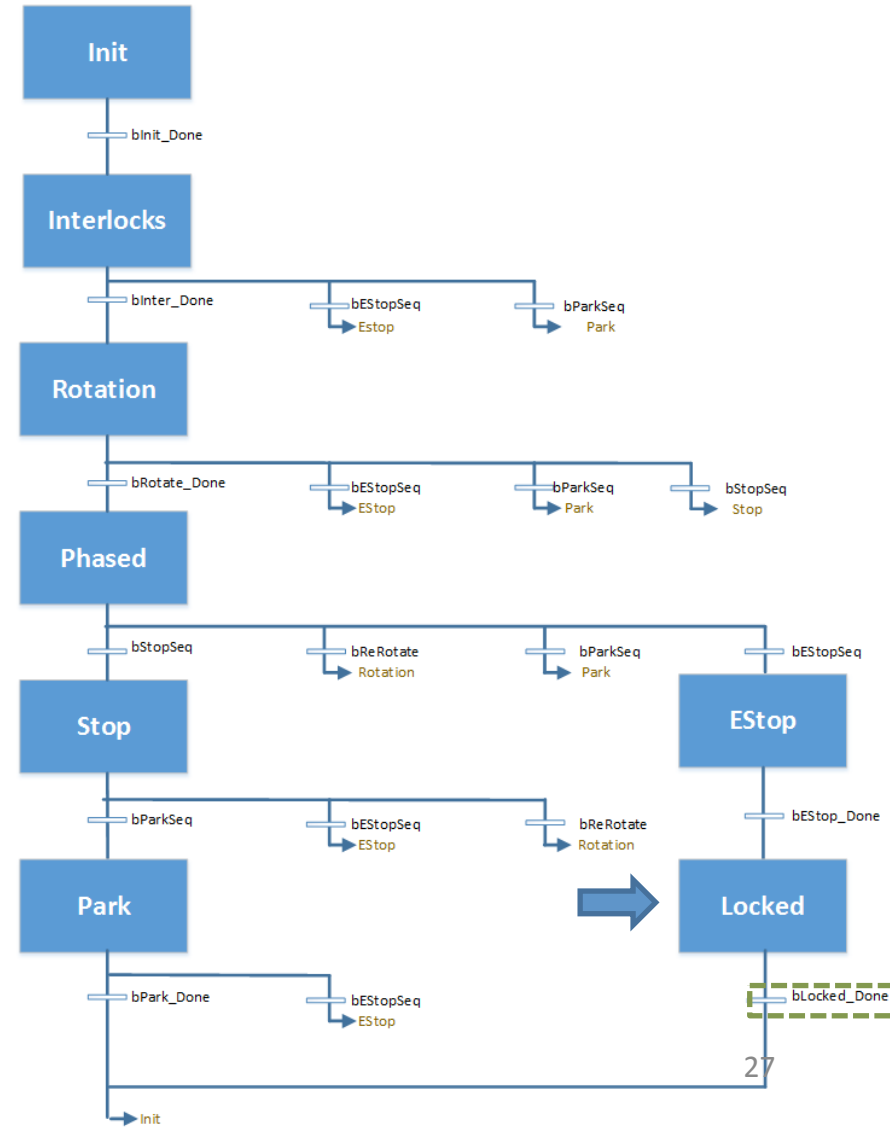
- “Emergency stop” can be accessed from any state
- It will stop the rotation with the maximum deceleration rate allowed by the chopper.
- Transition can go to:
 - Locked



CHIC - State Machine

Locked:

- Blocks all commands and rotation in the chopper
- It makes possible to identify that last stop was by an Emergency and Mechanical/Electrical parts should be inspected.
- Transition to init only happens after the state is acknowledge by user/operator



CHIC Graphical User Interface

CHIC Interface V1: General alarm log in fixed left panel

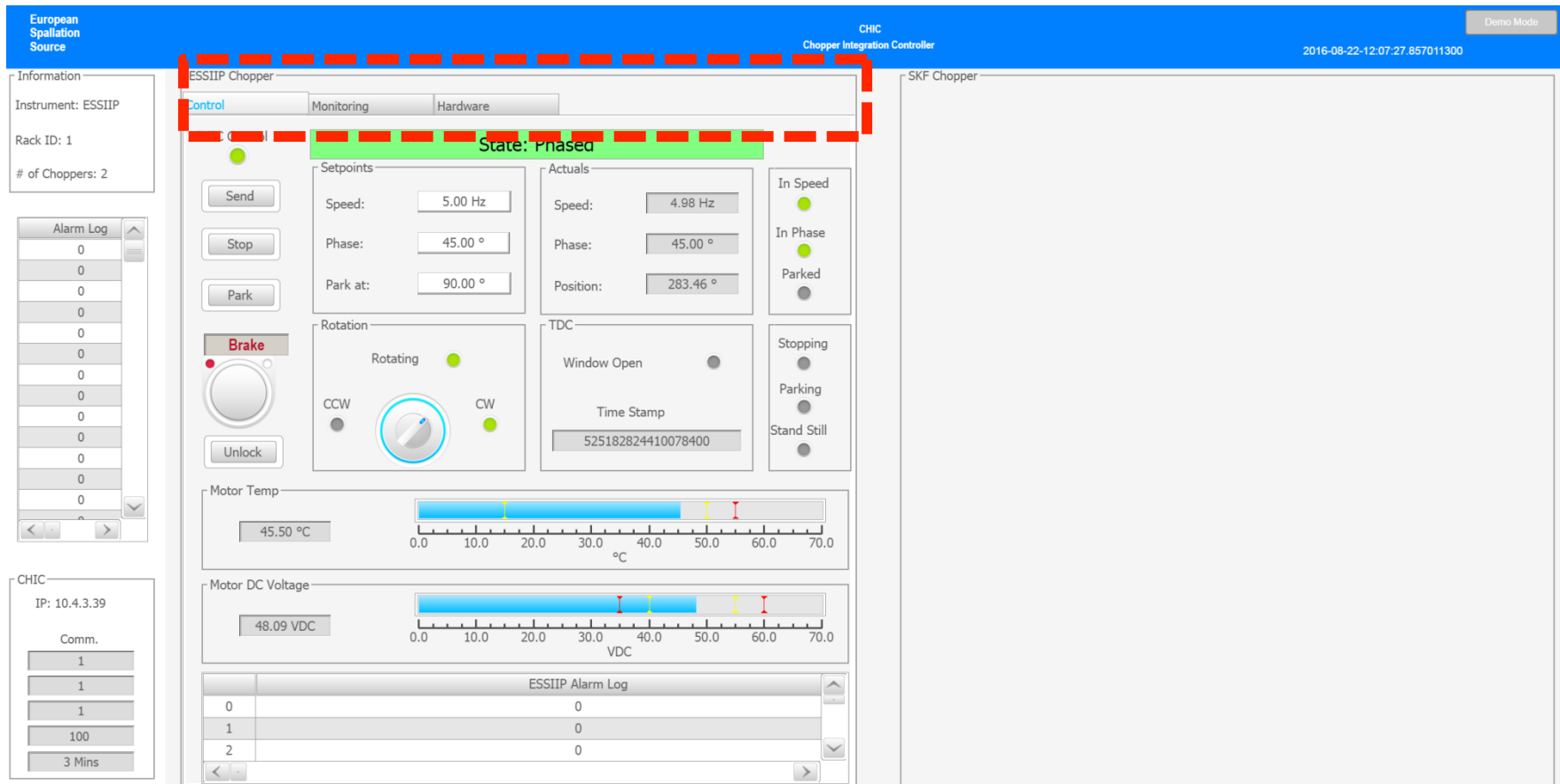


The screenshot displays the CHIC (Chopper Integration Controller) graphical user interface. The interface is divided into several sections:

- Header:** European Spallation Source logo, CHIC Chopper Integration Controller, Demo Mode, and timestamp 2016-08-22-12:07:27.857011300.
- Left Panel (Fixed):** Information section (Instrument: ESSIIP, Rack ID: 1, # of Choppers: 2), Alarm Log (table with 10 rows of 0s), and CHIC settings (IP: 10.4.3.39, Comm. 1, 1, 1, 100, 3 Mins).
- Main Panel (ESSIIP Chopper):**
 - Control:** State: Phased (green bar), Send, Stop, Park buttons.
 - Setpoints:** Speed: 5.00 Hz, Phase: 45.00 °, Park at: 90.00 °.
 - Actuals:** Speed: 4.98 Hz, Phase: 45.00 °, Position: 283.46 °.
 - Rotation:** Rotating (green dot), CCW, CW buttons.
 - TDC:** Window Open (grey dot), Time Stamp: 525182824410078400.
 - Motor Temp:** 45.50 °C, scale 0.0 to 70.0 °C.
 - Motor DC Voltage:** 48.09 VDC, scale 0.0 to 70.0 VDC.
 - ESSIIP Alarm Log:** Table with 3 rows (0, 1, 2) and 2 columns (0, 0).
- Right Panel (SKF Chopper):** In Speed, In Phase, Parked, Stopping, Parking, Stand Still indicators.

CHIC Graphical User Interface

CHIC Interface V1: Tab control

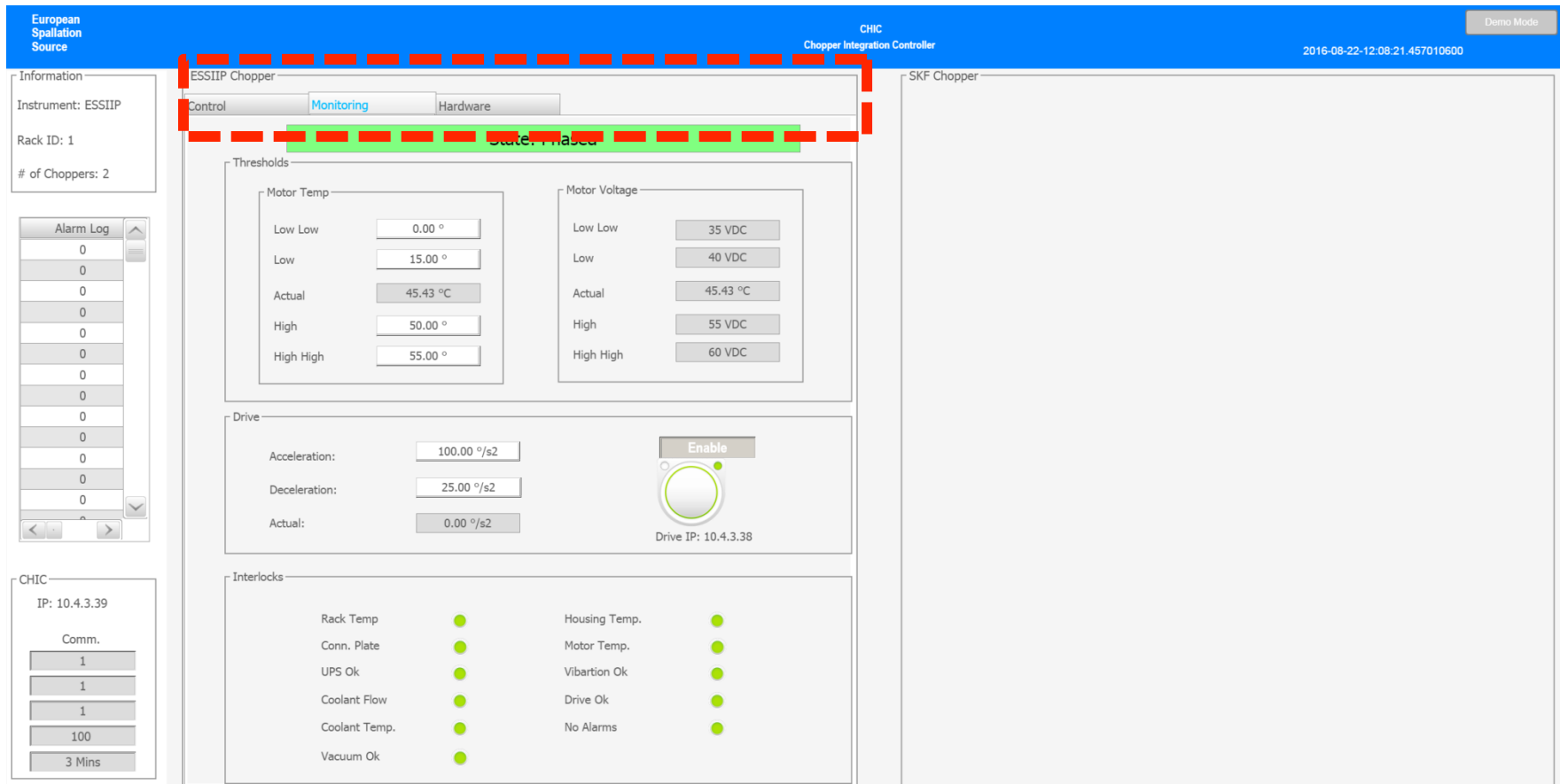


The screenshot displays the CHIC (Chopper Integration Controller) graphical user interface. The interface is divided into several sections:

- Header:** European Spallation Source logo on the left, "CHIC Chopper Integration Controller" in the center, and "Demo Mode" and a timestamp "2016-08-22-12:07:27.857011300" on the right.
- Information Panel (Left):** Shows "Instrument: ESSIIIP", "Rack ID: 1", and "# of Choppers: 2". Below this is an "Alarm Log" table with 10 rows, each containing a "0".
- Control Panel (Center):** Features a "Control" tab (highlighted with a red dashed box), "Monitoring", and "Hardware" tabs. A green box highlights the "State: Phased" indicator. The panel includes:
 - Setpoints:** Speed (5.00 Hz), Phase (45.00 °), and Park at (90.00 °).
 - Actuals:** Speed (4.98 Hz), Phase (45.00 °), and Position (283.46 °).
 - Rotation:** A dial with "Rotating" (green), "CCW" (grey), and "CW" (green) indicators.
 - TDC:** "Window Open" (grey) and "Time Stamp" (525182824410078400).
 - Buttons:** "Send", "Stop", "Park", "Brake" (with a red indicator), and "Unlock".
 - Indicators:** "In Speed", "In Phase", "Parked", "Stopping", "Parking", and "Stand Still" (all grey).
 - Meters:** "Motor Temp" (45.50 °C) and "Motor DC Voltage" (48.09 VDC), each with a corresponding scale from 0.0 to 70.0.
- SKF Chopper (Right):** A large empty panel for the SKF Chopper.
- CHIC Settings (Bottom Left):** Shows "IP: 10.4.3.39" and a "Comm." table with values 1, 1, 1, 100, and 3 Mins.
- ESSIIIP Alarm Log (Bottom Center):** A table with 3 rows, each containing "0".

CHIC Graphical User Interface

CHIC Interface V1: Tab control



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- Header:** European Spallation Source logo on the left, "CHIC Chopper Integration Controller" in the center, and "Demo Mode" and a timestamp "2016-08-22-12:08:21.457010600" on the right.
- Information Panel (Left):** Instrument: ESSIIIP, Rack ID: 1, # of Choppers: 2. Below this is an "Alarm Log" table with 10 rows, all showing "0".
- ESSIIIP Chopper Panel (Center):** Features three tabs: "Control", "Monitoring" (selected), and "Hardware". A red dashed box highlights the "Monitoring" tab and the "Status" label below it. The "Status" label is highlighted in green. Below the tabs are two sections:
 - Thresholds:** Two columns of settings for "Motor Temp" and "Motor Voltage".

Level	Value
Low Low	0.00 °
Low	15.00 °
Actual	45.43 °C
High	50.00 °
High High	55.00 °
 - Drive:** Includes "Acceleration: 100.00 °/s2", "Deceleration: 25.00 °/s2", and "Actual: 0.00 °/s2". A large "Enable" button is present, along with a circular indicator and "Drive IP: 10.4.3.38".
- Interlocks (Bottom):** A grid of status indicators (green dots) for:
 - Rack Temp, Conn. Plate, UPS Ok, Coolant Flow, Coolant Temp, Vacuum Ok
 - Housing Temp., Motor Temp., Vibration Ok, Drive Ok, No Alarms

CHIC Graphical User Interface

CHIC Interface V1: Emergency stop



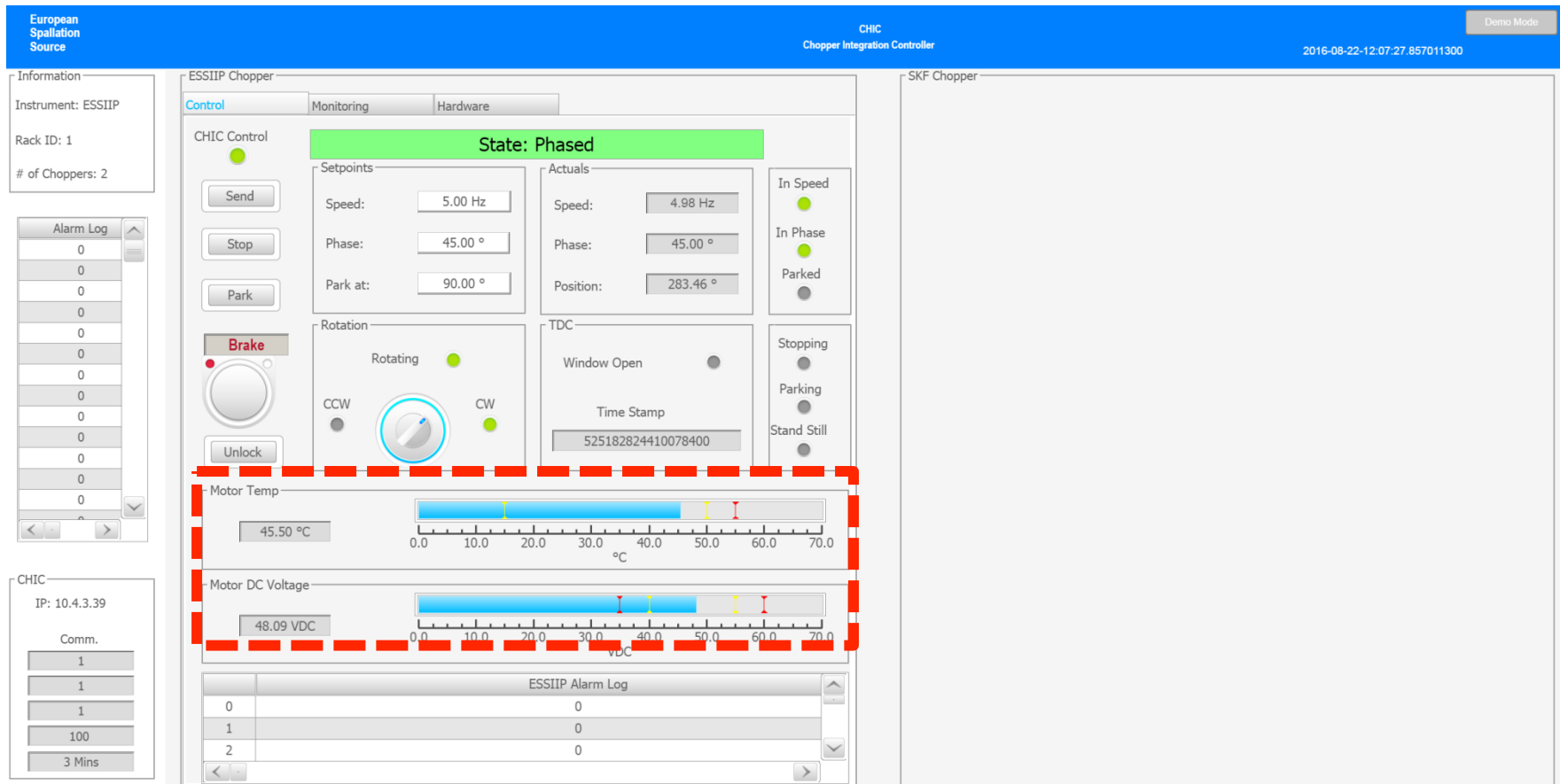
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- Header:** European Spallation Source logo, CHIC Chopper Integration Controller, Demo Mode, and timestamp 2016-08-22-12:07:27.857011300.
- Information Panel (Left):** Instrument: ESSIIP, Rack ID: 1, # of Choppers: 2.
- Control Panel (Center):**
 - State:** Phased (highlighted in green).
 - Setpoints:** Speed: 5.00 Hz, Phase: 45.00°, Park at: 90.00°.
 - Actuals:** Speed: 4.98 Hz, Phase: 45.00°, Position: 283.46°.
 - Buttons:** Send, Stop, Park, Brake (highlighted with a red dashed box), Unlock.
 - Rotation:** Rotating (green indicator), CCW, CW (green indicator).
 - TDC:** Window Open (grey indicator), Time Stamp: 525182824410078400.
 - Stopping:** Stopping, Parking, Stand Still (all grey indicators).
- Motor Temp:** 45.50 °C, with a scale from 0.0 to 70.0 °C.
- Motor DC Voltage:** 48.09 VDC, with a scale from 0.0 to 70.0 VDC.
- Alarm Log (Bottom):** ESSIIP Alarm Log table.

ESSIIP Alarm Log	
0	0
1	0
2	0

CHIC Graphical User Interface

CHIC Interface V1: Thresholds



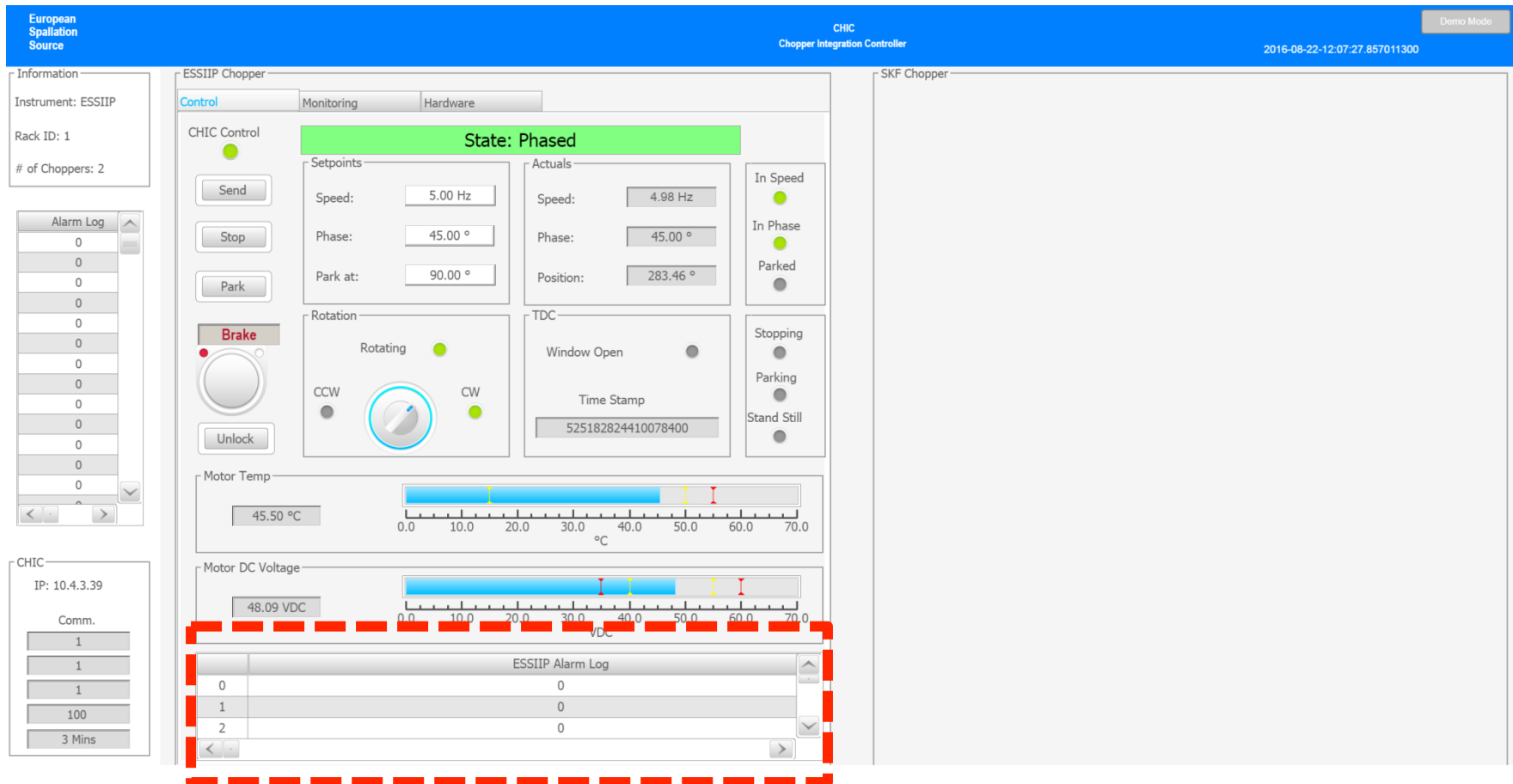
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- Information Panel (Left):** Instrument: ESSIIP, Rack ID: 1, # of Choppers: 2.
- Control Panel (Center):**
 - CHIC Control:** State: Phased (highlighted in green). Includes buttons for Send, Stop, Park, Brake, and Unlock.
 - Setpoints:** Speed: 5.00 Hz, Phase: 45.00°, Park at: 90.00°.
 - Actuals:** Speed: 4.98 Hz, Phase: 45.00°, Position: 283.46°.
 - Rotation:** Rotating (green indicator), CCW (grey), CW (green).
 - TDC:** Window Open (grey), Time Stamp: 525182824410078400.
 - Stopping:** In Speed (green), In Phase (green), Parked (grey), Stopping (grey), Parking (grey), Stand Still (grey).
- Motor Temp:** 45.50 °C. Scale from 0.0 to 70.0 °C.
- Motor DC Voltage:** 48.09 VDC. Scale from 0.0 to 70.0 VDC.
- ESSIIP Alarm Log (Bottom):**

Alarm ID	Alarm Name	Status
0		0
1		0
2		0

CHIC Graphical User Interface

CHIC Interface V1: Detailed chopper Alarm log



The screenshot displays the CHIC (Chopper Integration Controller) graphical user interface. The interface is divided into several sections:

- Information Panel (Left):** Shows instrument details: Instrument: ESSIIP, Rack ID: 1, and # of Choppers: 2.
- Alarm Log (Left):** A vertical list of alarm counts, all currently at 0.
- CHIC Control Panel (Center):**
 - State:** Phased (indicated by a green bar).
 - Setpoints:** Speed: 5.00 Hz, Phase: 45.00°, Park at: 90.00°.
 - Actuals:** Speed: 4.98 Hz, Phase: 45.00°, Position: 283.46°.
 - Rotation:** Rotating (green dot), CCW (grey dot), CW (green dot).
 - TDC:** Window Open (grey dot), Time Stamp: 525182824410078400.
 - Motor Temp:** 45.50 °C (with a scale from 0.0 to 70.0 °C).
 - Motor DC Voltage:** 48.09 VDC (with a scale from 0.0 to 70.0 VDC).
- ESSIIP Alarm Log (Bottom Center, highlighted with a red dashed box):**

ESSIIP Alarm Log	
0	0
1	0
2	0
- SKF Chopper (Right):** A large empty panel for SKF Chopper status.

CHIC Graphical User Interface

CHIC Interface V1: Several choppers

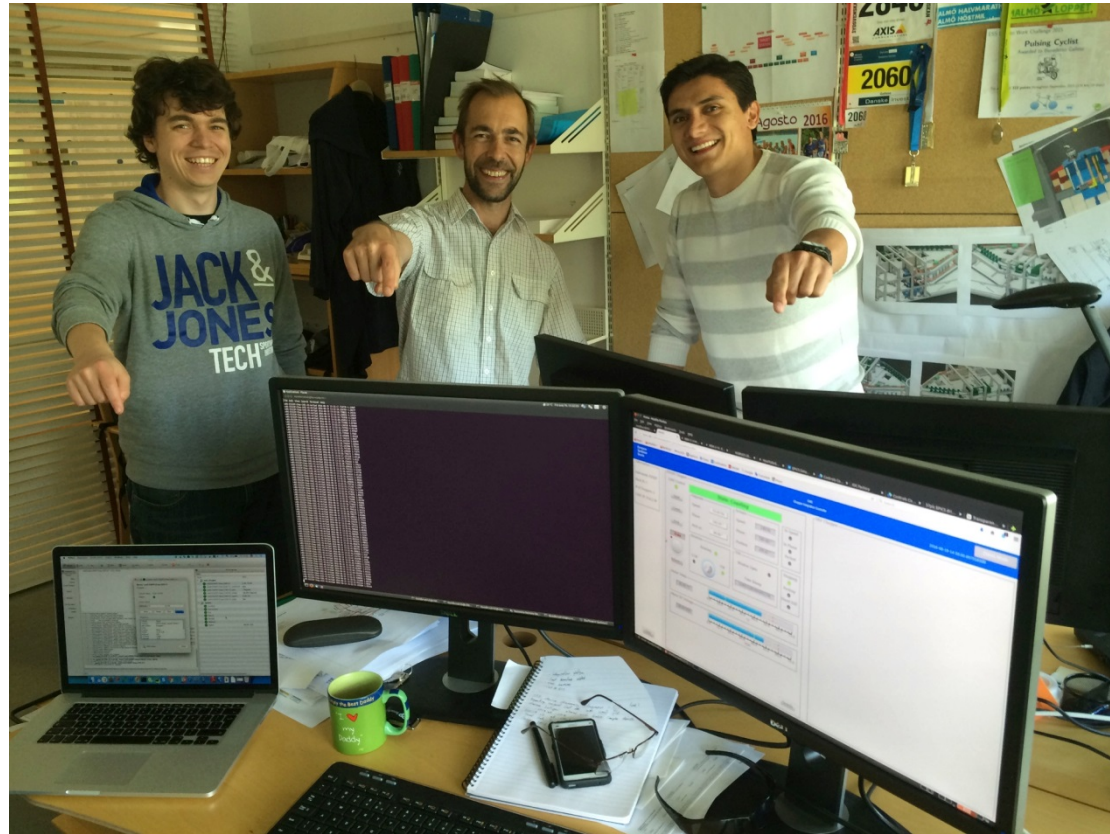


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- Header:** European Spallation Source logo, CHIC Chopper Integration Controller, and a Demo Mode button.
- Information Panel (Left):** Instrument: ESSIIP, Rack ID: 1, # of Choppers: 2.
- Alarm Log (Left):** A table with 10 rows, each containing a '0'.
- ESSIP Chopper Control Panel (Center-Left):**
 - Control Tab:** State: Phased (highlighted in green).
 - Setpoints:** Speed: 5.00 Hz, Phase: 45.00 °, Park at: 90.00 °.
 - Actuals:** Speed: 4.98 Hz, Phase: 45.00 °, Position: 283.46 °.
 - Rotation:** Rotating (green indicator), CCW (grey indicator), CW (green indicator).
 - TDC:** Window Open (grey indicator), Time Stamp: 525182824410078400.
 - Motor Temp:** 45.50 °C, with a scale from 0.0 to 70.0 °C.
 - Motor DC Voltage:** 48.09 VDC, with a scale from 0.0 to 70.0 VDC.
 - Buttons:** Send, Stop, Park, Brake (with a red indicator), Unlock.
 - Indicators:** In Speed (green), In Phase (green), Parked (grey), Stopping (grey), Parking (grey), Stand Still (grey).
- SKF Chopper Control Panel (Center-Right):** Currently blank.
- ESSIIP Alarm Log (Bottom):** A table with 3 rows, each containing a '0'.

Latest achievement

- Friday 19th of August, first command was sent from Nicos, passing through EPICS IOC, then to the CHIC and eventually the chopper was rotating.



Questions?