SYSTEM ARCHITECTURE

SYSTEM ARCHITECTURE DESCRIPTION

STPL/SYSTEM ARCHITECTURE/AD/80 Ver 1.0

6 May 2023

APPROVAL HISTORY

	Prepared By	Reviewed By	Approved By
Name	C S Abhiram	Dr. Dinesh	Sudheer
Signature			
Date			

REVISION HISTORY

Version (x.y)	Date of Revision	Description of Change	Reason for Change
1.0	05/04/2023	Base Line Document	

Table of Contents

Preface

SYSTEM ARCHITECTURE module is primarily intended for automatic operation of sliding screened doors. SYSTEM ARCHITECTURE is used for speed and position control for the open and close positions of the door. In addition, SYSTEM ARCHITECTURE detects any obstruction and manages door movement during motion and prevents accidents.

The Metro has multiple compartments, each compartment will have the doors for passenger entry and exit. The platform will also have screened doors corresponding to the compartments. The compartment doors and platform doors are synchronized for opening and closing. The SYSTEM ARCHITECTURE controls and monitors the screened door on the platform. There is one SYSTEM ARCHITECTURE to control one set of left and right doors. The SYSTEM ARCHITECTURE ensures safety by detecting any obstructions in closing or opening movement. SYSTEM ARCHITECTURE is not responsible for synchronizing with compartment doorsof the Metro which is handled by the central controller of the metro station. The central controller communicates with the multiple SYSTEM ARCHITECTUREs for control and monitoring of all the PSDs(Platform Screen Door) on the platform.

Bharat Electronics Limited, Panchkula, Haryana is the nodal agency for SYSTEM ARCHITECTURE. Technical Requirement Document [Ref 6], Problem Definition Statement [Ref 5], and Requirement Breakdown Structure [Ref 7] have all been provided as requirement documents. system's functionality is to control the platform screen doors of Metro platforms based on the inputs from master and field devices(name the master and field devices). SYSTEM ARCHITECTURE shall comply with CENELEC EN 50126-1:2017[Ref 1] and part-2 [Ref 2], EN 50128: 2011[Ref 3], EN 50129:2018 [Ref 4] to achieve functional safety level of SIL 3.

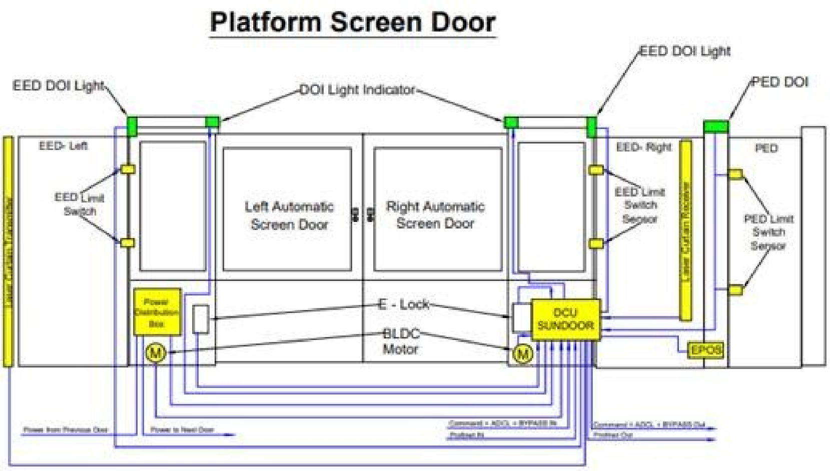

Figure 1: System Context Diagram

INTRODUCTION

PURPOSE

The purpose of this document is to provide a detailed description about the system architecture of SYSTEM ARCHITECTURE.

SCOPE

The Scope of architecture design document is for demonstrating how SYSTEM ARCHITECTURE architecture meets Safety Integrity Level 3 as per CENELEC standards. Customer specification for Technical Requirement Document [Ref 6], Problem Definition statement [Ref 5], and Requirement Breakdown Structure [Ref 7] have been referred as requirement documents.

SYSTEM OVERVIEW

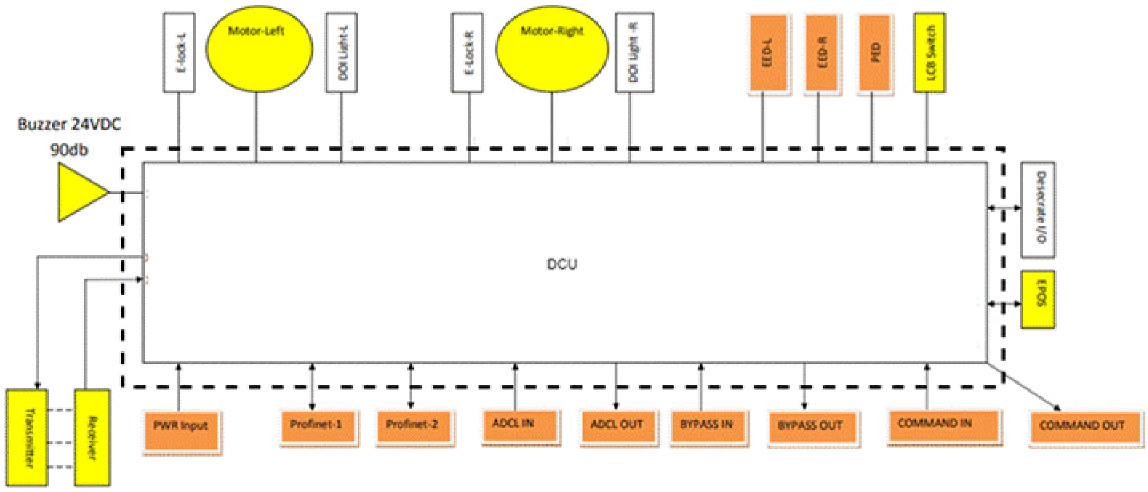

Figure 2: System Overview

SYSTEM ARCHITECTURE shall control the screened doors on the platform for metros. The half-height or full height PSD will consist of 2 sliding leaves.   These leaves are called left and right doors and are driven by independent motors. SYSTEM ARCHITECTURE will be mounted on the right FDP panel as shown in figure 2. Both the motors will be connected to the SYSTEM ARCHITECTURE. The doors are mechanically locked by an electromechanical latch called E-lock. The E-Lock has two Limit switches for door open/close monitoring. The safety inputs for door open and close are generated by these limit switches when the E-lock operates with electrical actuation from the SYSTEM ARCHITECTURE. The Motor drive command is given based on the ENABLE and NOT-ENABLE inputs from E-lock. The E-Lock can be operated manually under emergency conditions with lever connected to the E-Lock. The manual operation activates the limit switches which give   two Signals to SYSTEM ARCHITECTURE ERM and NOT-ERM as inputs.

The SYSTEM ARCHITECTURE provides the following statuses to the central controller,namely ADCL of right and Left PSDoors, PED, EED. For safety of the passengers there is laser switch to avoid any accidents when the PSD is closing. The EPOS (Digital Positioning system) sends a signal to SYSTEM ARCHITECTURE to stop the door from closing and provides a flashing light Indicator and Buzzer. SYSTEM ARCHITECTURE signals to the lamps and the buzzer for alerts. The SYSTEM ARCHITECTURE controls the opening and closing of the door in the set time(set time?) and also detects obstruction and takes corrective action during closing of the doors for safety. The Process to handle any obstruction while closing of PSDs is predefined in the SYSTEM ARCHITECTURE.

The opening and closing of the doors are defined with learn mode. The drive parameters for the motor speed, torque and distance for the profile(profile ??) are learnt and stored in non-volatile memory for use during normal operation. So, the Learn mode becomes safety operation. The learn mode is activated by a pushbutton switch mounted inside the SYSTEM ARCHITECTURE enclosure. It is manually activated by pressing it for 20 seconds to avoid any accidental activation. The learn mode parameters and the events will be logged in the non-volatile memory and these cannot be modified or erased without authorisation. There is an application SUNCOFIG which will run on laptops to program the door profile. This application will also have facility to down load the set parameters and events with authorisation.

SYSTEM ARCHITECTURE Communicates with Central controller on PROFINET Protocol on ethernet physical media. There are other interfaces like USB, CAN bus and RS485 interfaces on the SYSTEM ARCHITECTURE for external connection(External Connection is required in what situations?). There is data logger with on board flash memory for storage –(On SYSTEM ARCHITECTURE? Data is stored for how long and then backed up?). How does this data of door opening and closing timestamps help with the safety measures? The events with time stamps will be logged in the Data Logger and also the same information is transferred to central controller on PROFINET for monitoring,

SYSTEM ARCHITECTURE OPERATION

Learn mode (One Time after Installation of Door): A learn run serves to determine and store the characteristics of the door. The learned door parameters are stored in the SYSTEM ARCHITECTURE retentively. The parameters must be adapted in accordance with the friction of the door system, so that the learn run can be completed error free and these parameters for the door are stored in non-volatile memory for operation.

Learn mode is used while testing the SYSTEM ARCHITECTURE system. Based on the door weight and size the door movement in normal operation the parameters to be learnt are

- Movement of the door distance
- Time for opening and closing
- Force value for normal operation
- Speed of the movement as per the profile to be finalized. – profile has to be explained
- Control value parameters as per algorithm.--- State the control parameters
- Operation sequence timings
- Obstruction detection parameters.
- Motor Voltage
- Motor Currents.
- The learn mode is safety mode as it generates parameters for the safe running of the gate. Gate ??

- Learn mode is initiated by the Pushbutton by pressing it for 20 seconds continuously. Manual, so it is done while testing?

The SUNConfig Application running on the laptop (remotely? Or at each station? Because there are many SYSTEM ARCHITECTURE units on each platform) is connected to the SYSTEM ARCHITECTURE. The Media configuration is RS-485 (Media Config? Or serial communication between each SYSTEM ARCHITECTURE and the app?). The communication happens with one MCU but the parameters are collected by both the controllers(drivers and controllers?) and vetted for safety. The configuration interface and the software follow the same guide lines as per EN 50128: 2011[Ref 3].

SUNConfig has programmable parameters for the doors including door width and door movement profile. This will be detailed in design documents. SYSTEM ARCHITECTURE has a data logger which saves the data for up to 2 hours, this data is accessible by using SUNConfig application.

With learn mode parameters as reference the SYSTEM ARCHITECTURE operated in following modes for Door opening and closing with obstruction detection features.--- statement not clear.

Normal mode: In normal mode, SYSTEM ARCHITECTURE controls the doors on learned parameters.

LCB mode: Based on command from central controller and LCB mode selection switch, the SYSTEM ARCHITECTURE performs door opening and closing operation.

LCB mode selection is divided into the following three parts: --LCB full form

Auto Mode: In auto mode, SYSTEM ARCHITECTURE will receive hardwire switch commands from signalling through central controller and perform the door opening and closing action.

During door opening, the SYSTEM ARCHITECTURE controls the electromagnetic lock to unlock and drives the motor to open the sliding door.

After closing the doors as operation, the door is locked with electromagnetic lock

Isolation mode: Disconnect the central controller hardwire command and release the motor to the drive the door.--- When will this mode be used?

Bypass Mode: Include local closing and local opening, cuts off the central controller hardwire Command, provides power to the local switch control, bypass the safety circuit, and provide the local bypass signal to the central controller. --- when will this mode be used?

Restart after power failure: At recovery from power failure SYSTEM ARCHITECTURE shall first determine the status of the door (closed end position) and close the door. After achieving a safe state of door closure SYSTEM ARCHITECTURE should initialize in normal run mode and shall be able to execute normal commands. ---- Door positions should be explained, what is door end position and close door position?

Maximum response time for the motor drive 80 m Sec.--- This should be in the problem statement.

Key Safety Functions for SYSTEM ARCHITECTURE

There are SIL 3 functions identified for the screened door operation which are as listed below. These are taken care by the SYSTEM ARCHITECTURE.

- Safe force output

- Safe speed observance
- Safe monitoring of the rotor position
- Safe reading in of digital control signals
- SYSTEM ARCHITECTURE validation - self-tests
- Safe stopping process
- Obstruction detection during opening or closing.
    - If there is any obstruction during opening conditions the SYSTEM ARCHITECTURE will check for this and wait for 1 second and retry for three times and if the obstruction persists it will alert and open the doors fully.
    - If there is obstruction during closing the SYSTEM ARCHITECTURE will stop and open the doors for 25 cm and try to close again and will try this for three attempts and if the obstruction persists it will alert and open the gate.

DEFINITIONS

Terms	**Definitions**
PROFINET	An open industrial ethernet solution built on global standards. It is a protocol for communicating between controllers and devices in an automation environment.
Modules	Each hardware block is considered as module.

Table 1: Definitions

ACRONYMS AND ABBREVIATIONS

Abbreviations	**Description**
ADCL	All Door Closed Locked signal
ADC	Analog to Digital Converter
ASD	Automatic Screen Door
PED	Platform End Door
PG	Platform Gate
EED	Emergency Exit Door
CAN	Controller Area Network
CPU	Central Processing Unit

CRC	Cyclic Redundancy Check
DCU	Door Control Unit
E-LOCK	Electromagnetic Lock
EOF	End of Frame
ERM	Emergency Release Manual
GUI	Graphical User Interface
ID	Identification Data
IC	Integrated Circuit
LED	Light Emitting Diode
RS-485	RS485 is a common communications standard for serial communication with multidrop facility with 2 or 4 wire media.
RTC	Real Time Clock
SIL	Safety Integrity Level
SYSTEM ARCHITECTURE	Sunlux Name for Door Control Unit.
PFC	Potential Free Contact.
MCU	Microcontroller unit
RTC	Real Time Clock
UART	Universal Asynchronous Receiver and Transmitter.
USB	Universal Serial Bus
TVS	Transient Voltage Suppressor
CRC	Cyclic Redundancy Check

EPOS full form not provided, GPIO full form not provided, SPI full form not providedTable 2: Abbreviations

REFERENCES

The following are the reference documents referred during the preparation of System Requirement Specifications for SYSTEM ARCHITECTURE:

Ref. No.	Document Title	Version	Document Description
1.	EN 50126-1:2017	-	The Specification and Demonstration of Reliability, Availability, Maintainability and Safety (RAMS).
2.	EN 50126-2:2017	-	The Specification and Demonstration of Reliability, Availability, Maintainability and Safety (RAMS).
3.	EN 50128: 2011	-	Railway applications - Communication, signalling and processing systems – Software for railway control and protection systems
4.	EN 50129: 2018	-	Railway applications – Communication, signalling and processing systems – Safety related electronic systems for signaling.
5.	PDS-DCU	1.1	Problem definition statement provided by BEL; Panchkula dated: 27/02/23 Ver 1.1
6.	Technical Requirement Document	-	Technical Requirement provided by BEL, Panchkula
7.	Requirement Breakdown Structure	-	Requirement Breakdown Structure provided by BEL Panchkula.
8.	EN 50159:2010	-	Railway applications - Communication, signalling and processing systems - Safety-related communication in transmission systems

Table 3: References

Architecture Description

SYSTEM ARCHITECTURE is designed as 2oo2 architecture with two micro controllers. The basic philosophy of SYSTEM ARCHITECTURE architecture is validation of the safety inputs by both the controllers. The digital outputs and motor drive are also activated once the two controllers agree with voting. The two controllers communicate with each other on UART for validating the inputs and outputs. The communication protocol will adhere to EN 50159 :2010 [Ref 8] recommendations.

SYSTEM ARCHITECTURE Motor Interface

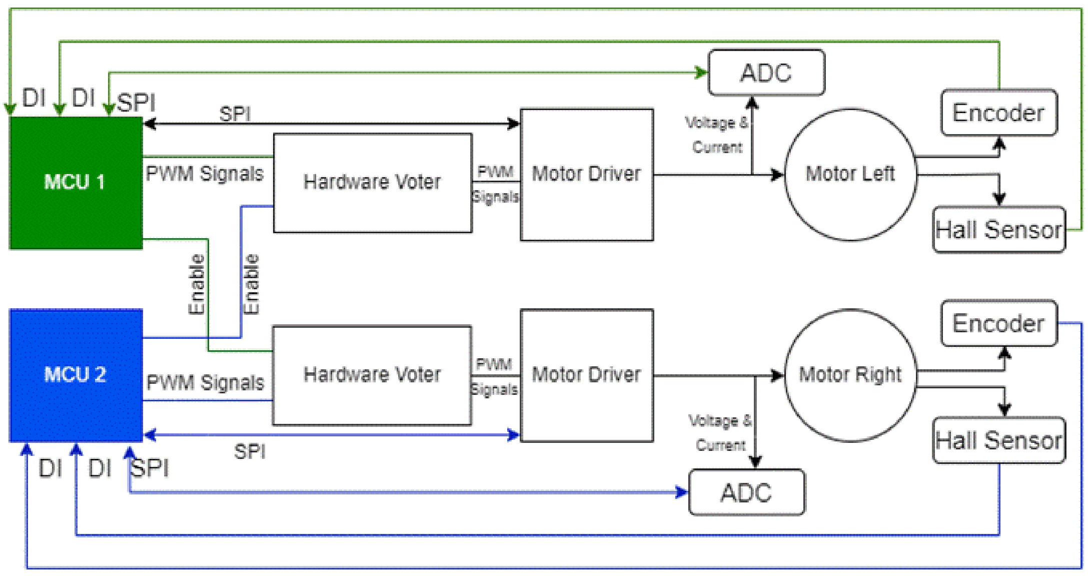

Figure 9: Motor Interface

SYSTEM ARCHITECTURE controllers shall have Motor interfaces connecting to Motor 1 and Motor 2. MCU 1 will control motor 1 and MCU 2 will control motor 2. The motor drive will be initiated with Enable and Not-Enable inputs being validated by both the controllers.

SYSTEM ARCHITECTURE motor driver consist of BLDC(full form) motor driver IC and H bridge Inverter. Motor drive IC will have PWM (full form)signals as input from MCU. Required parameters are configured with the SPI interface to MCU. Configured parameters and health status of motor driver IC will be monitored with help of health diagnostics. If any fault occurs, it will stop driving the motor and put the system in to safe state as mentioned in section 4.8.

The doors movement is achieved by the belt drive driven by the motor. The motor drive for the door movement and torque control is done in closed loop operation. This interface is illustrated in figure 9. The PWM signals will be generated based on the feedback from the encoder for door position control. Hall sensor feedback is using for rotor position and current feedback is using to get the torque/force.

The motor speed, door position and door speed are controlled based on the parameters acquired during the learn mode. These parameters are stored in non-volatile memory. The normal operation reference for motor current will be generated in learn mode.

The vital parameters such as each phase voltage and phase current will be monitored from the motor in real time to ensure the correct operation. The phase current is also monitored for the required torque levels. High precision ADCs are used for the measurement of voltage and current. The ADC has a SPI interface to the MCU. The current feedback of each motor is connected to the respective MCU. The obstruction is detected by measuring the motor current. During obstruction detection, the current profile will not match with normal operation reference profile, this mismatch in profiles is used for detecting the obstruction.

SYSTEM ARCHITECTURE will take encoder feedback. Encoder will be interfaced with MCU as Digital Inputs. Encoder feedback from motor 1 will be given to MCU 1 and encoder feedback from motor 2 will be given to MCU 2. SYSTEM ARCHITECTURE identifies the door position based on the encoder feedback. The encoder feedback is used in closed loop for position control. The belt drive is also monitored with the help of encoder feedback to detect any break in the belt, looseness of the belt and taughtness of the belt. The control algorithm will be detailed in design document.

The motor has hall effect sensors. Hall effect sensor will be interfaced with MCU as Digital Inputs. Hall effect sensor feedback from motor 1 will be given to MCU 1 and hall effect sensor feedback from motor 2. The hall effect sensor feedback will be used for rotor potion which will also be used for position control.

The motor drive IC has protection features like temperature sense which will be used to detect the raise in temperature.