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Fluence Gen 6 Safety Systems

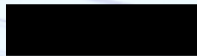
March 16, 2021

Document Control Number: 06-01-0001-INF-002

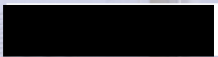
Revision Number: 00

Expiration Date: N/A

Author:



Approval:



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| HQ: Arlington, VA USA | Erlangen, Germany | Alpharetta, GA USA | Melbourne, Australia |
|--|---|--|--|
| 4601 N. Fairfax Drive, Suite 600 Arlington, VA 22203 1-833-FLUENCE (1-833- 358-3623) | Schallershofer Strasse 143 91056 Erlangen +49 9131 9289400 | 1725 Winward Concourse, Suite 420 Alpharetta, GA 30004 | 525 Collins St, Suite 212 Spaces Rialto Melbourne VIC 3000 |

<https://fluenceenergy.com/>

Fluence Support Services can be contacted 24/7 at **+1 (703) 635-7631**.



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Revision History

| Revision Number | Date | Authored By | Reviewed By | Approved By | Pages Affected |
|-----------------|----------------|-------------|-----------------|----------------|-----------------|
| 00 | March 16, 2021 | TJ Winter | Alfredo Iaconis | Daniel Shapiro | Initial Release |
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1. Preface

1.1 Support Services

Fluence is committed to fully supporting every Cube site. Our primary point of contact is our 24/7 Operations group, which logs each issue raised into our workflow-tracking tool and progressively escalates each issue within the Fluence Support Services team, as needed.

Fluence Support Services can be contacted 24/7 at **+1 (703) 635-7631**.

1.2 Scope of This Document

This document is a guide for the safety system design of the Fluence Gen 6 Energy Storage System (ESS), hereafter referred to as “the Cube.” This document covers the operation of the fire protection system and its interaction with the Fast-Stop system for the Cube and its application within Fluence’s Gridstack, Sunstack, and Edgestack platforms.

1.3 The Cube: Overview

The Cube is a discrete energy-storage unit that includes batteries, a battery management system, a data acquisition system, and other equipment and accessories necessary to maintain health and long-term operation in an outdoor environment.



Fig. 1. Fluence Cube. Height ~2.6 meters.



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An Energy Storage System (ESS) consists of one or more Cubes, a power conversion system, and associated auxiliary equipment, to include AC switchgear, meters, relays, and telecommunications equipment. Cubes can be, and usually are, interconnected to form larger systems. In particular, the Cube is the fundamental building block of the Gridstack, Edgestack, and Sunstack ESS configurations.

NOTE: The Cube comes in two configurations, Short Duration and Long Duration, and can be configured to house a variety of battery models from different suppliers. The current version of this document covers the liquid-cooled version of the Gen 6 Cube.

1.4 Further Information

Further details on Cube enclosure and Cube specifications are given in “Fluence Gen 6 Cube Battery Enclosure Specification,” Document Control Number CUBE-PM-INF-001.

1.5 Disclaimer

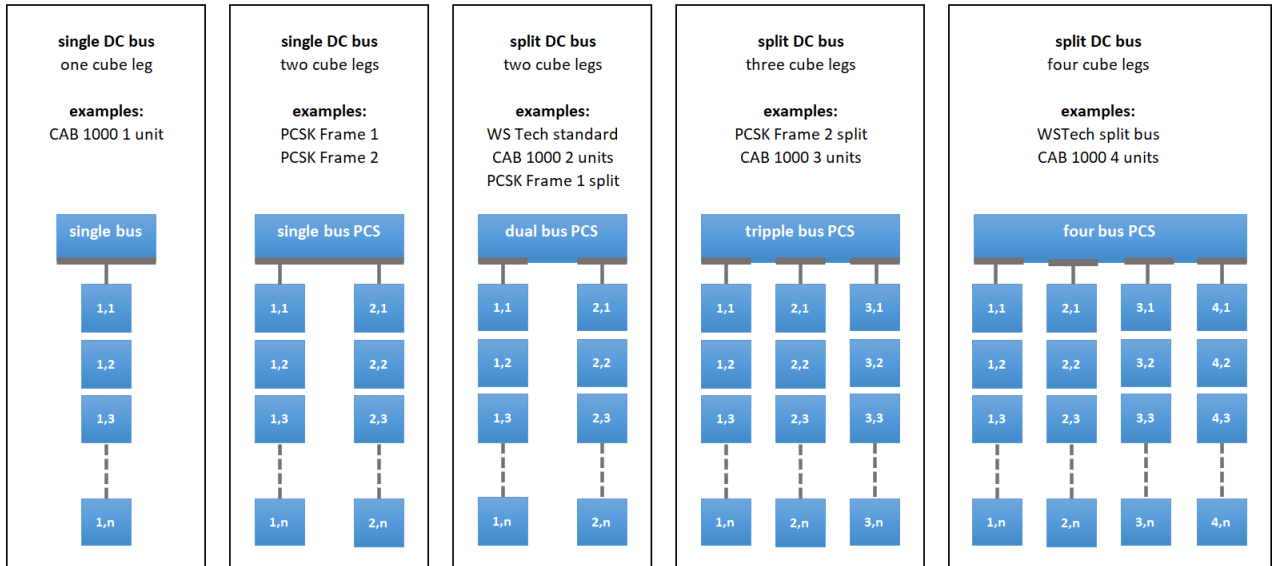
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2. System Topology Definitions

2.1 Core Topology (Gridstack)



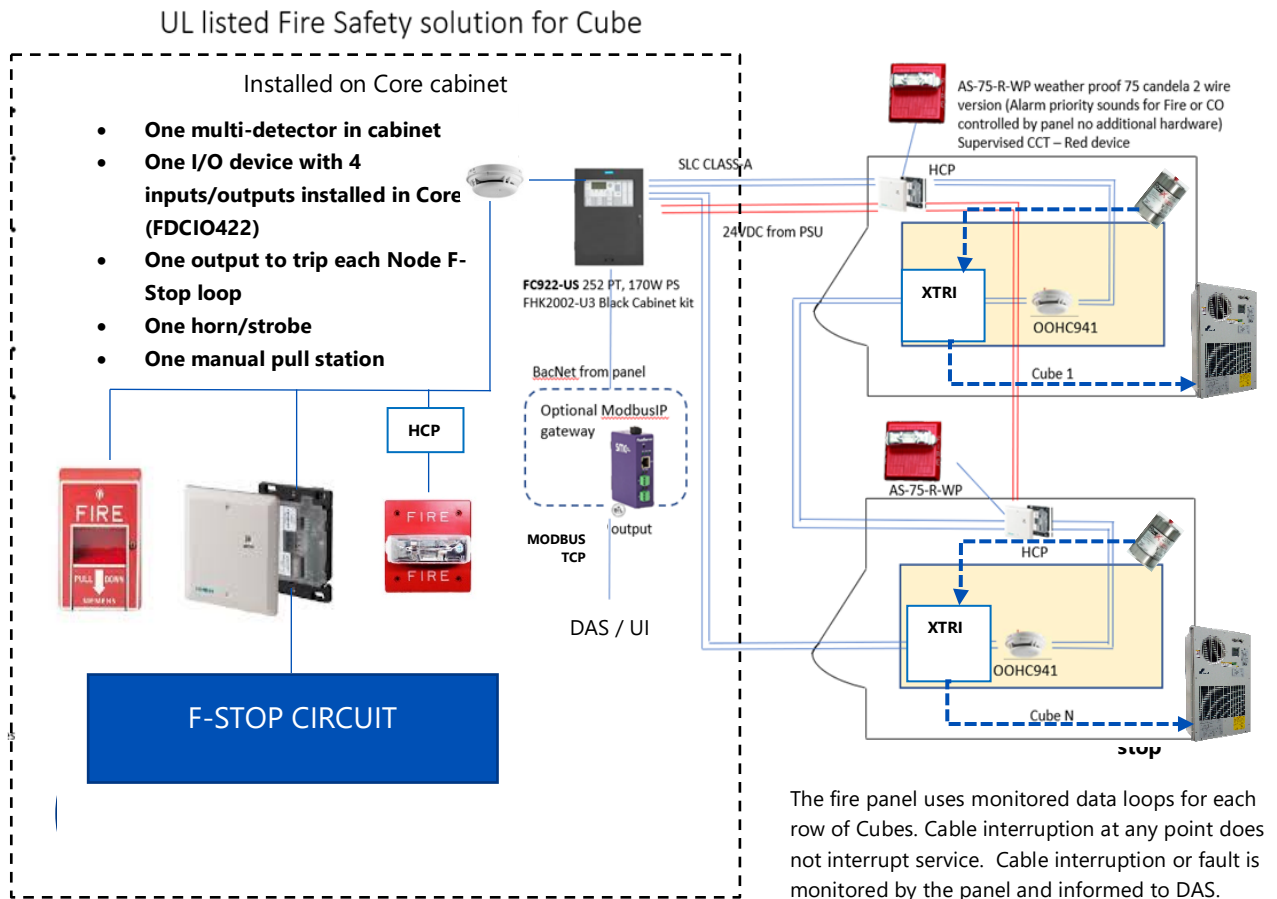
2.2 Topology Definitions

- A Cube is the smallest unit and will contain one or more strings of batteries and all associated cooling and climate control and monitoring equipment.
- Each battery string has a Battery Protection unit (BPU). The BPU may also be called the DC Protection Module (DCPM); the terms BPU and DCPM are used interchangeably. The BPU or DCPM will always contain a means to remotely disconnect the battery string.
- In some cases, the battery string will physically correspond to one rack. In other cases, a string may occupy more than one physical rack.
- A Node is the smallest dispatchable part of the system. It comprises one or two rows of Cubes connected to a single DC bus on the Power Conversion System (PCS).
- One Core includes:
 - Isolation transformer between low voltage and medium voltage;
 - Power conversion system;
 - One or more Nodes per PCS;
 - One Core telco enclosure, containing the main Core-level ethernet switch, the Core-level fire panel, and the F-Stop system at Node / Core level.



3. Fire Detection and Alarm

3.1 Overview Diagram



The diagram above shows devices for the UL version of the system. The EN/IEC version is similar with the following differences:

- The EN/IEC version does not use the HCP devices;
- The EN/IEC version uses the FDCIO 422 instead of the XTRI device.



3.2 Fire Detection and Alarm Devices at Cube Level

Each Cube contains a fire detection and alarm system; the fire suppression system is self-activated thermally. Each Cube also contains an I/O interface between the fire panel (located at Core level) and the fire suppression system and the HVAC and chiller cooling system. All devices are UL and EN/IEC listed per applicable codes and standards. Details are provided in the table below.

| Device | Purpose / Description |
|--|--|
| Multi-criteria detector (CO, smoke, and temperature) UL model: OOH941 EN/IEC model: OOH940 | <ul style="list-style-type: none"> • CO detector at 30 ppm: separate signal via data loop to fire panel. CO signal used to trigger F-stop at Core level. CO used as indicator of pre-thermal runaway conditions. • Smoke detector / temperature detector – Indicates a fire alarm and triggers an F-Stop at Core level. This is managed by programming activation of the I/O device located at Core level. See “Core System” description below. |
| HCP access point device (UL version only) | <ul style="list-style-type: none"> • Used as interface for the horn/strobe. This is present on the UL version of the Cube only. For the EN/IEC version, the horn/strobe contains itself the monitoring function, so the HCP is not applicable |
| Horn/Strobe device UL model: AS-75-R-WP EN/IEC model: FDS226-RR | <ul style="list-style-type: none"> • The horn/strobe is used to unequivocally identify the Cube affected by an event. The horn/strobe will be activated upon: <ul style="list-style-type: none"> ○ CO detection – specific sound and strobe ○ Fire detection – fire alarm sound and strobe |
| I/O device UL model: XTRI-R EN/IEC model: FDCIO222 | <ul style="list-style-type: none"> • Provides an addressable digital input and digital output to devices installed in the Cube to communicate with the fire panel: <ul style="list-style-type: none"> ○ Digital Input: - connected to the aerosol canister thermal switch to register the release of the fire suppression agent ○ Digital Output: - connected to the F-stop system inside the Cube to trigger the stopping of the HVAC and chiller units |
| Fire suppression system (FSS) | <ul style="list-style-type: none"> • Independent, thermally activated suppression system, containing an auxiliary contact to provide information to the fire panel upon release. • FSS: Thermally activated aerosol canister, with 95°C activation temperature |



3.3 Fire Detection and Alarm Devices at Core Level

The Core-level devices are located in the Core telco enclosure. A description is provided below.

| Device | Purpose / Description |
|--|---|
| Core fire panel UL model: OOH941 EN/IEC model: OOH740 | <p>The Core fire panel will provide up to 4 loops, where each loop covers one row of Cubes. The Core fire panel uses a 2-wire data loop which collects data from, and monitors, all devices connected to that loop. For I/O devices, the Core fire panel also sends signals to control outputs of the device. In the UL version a 4-wire cable is used, as 24V power signal is provided for some of the devices. In the EN/IEC version a 2-wire cable is used, as the data loop also powers the devices.</p> <p>Additionally, the Core fire panel includes 2 x 25Ah 12V (IEC) or 1 x 24V 18Ah (UL) batteries to cover for up to 24h monitoring of all devices, including enough power to provide at least 5 minutes power to all horn/strobe units operating at the same time, or 1h power for 4 horn/strobe units (one unit on the Core + 3 units on potentially affected Cubes), or 3h power to two horn/strobe units (one unit on the affected Cube and one unit on the Core).</p> |
| Horn/Strobe device UL model: AS-75-R-WP EN/IEC model: FDS226-RR | <ul style="list-style-type: none"> The horn/strobe is used to unequivocally identify the Core where a Cube is affected by an event. The horn/strobe will be activated upon: <ul style="list-style-type: none"> CO detection – specific sound and strobe Fire detection – fire alarm sound and strobe Manual pulling of the manual pull station |
| HCP access point device (UL version only) | <ul style="list-style-type: none"> Used as interface for the horn/strobe. This is present on the UL version of the Cube only. For the EN/IEC version, the horn/strobe contains itself the monitoring function, so the HCP is not applicable |
| I/O device UL model: FDCIO422 EN/IEC model: FDCIO222 | <ul style="list-style-type: none"> Provides 4 addressable digital inputs and digital outputs to devices installed in the Core cabinet to communicate with the fire panel: <ul style="list-style-type: none"> Digital Inputs: - not being used Digital Outputs: - connected to each F-stop system to trigger the F-stop of the Core. |
| Manual pull station UL model: MSM-KD-WP EN/IEC model: FDM223 | <ul style="list-style-type: none"> Provides a means to manually activate the fire alarm at Core level |



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3.4 Compliance

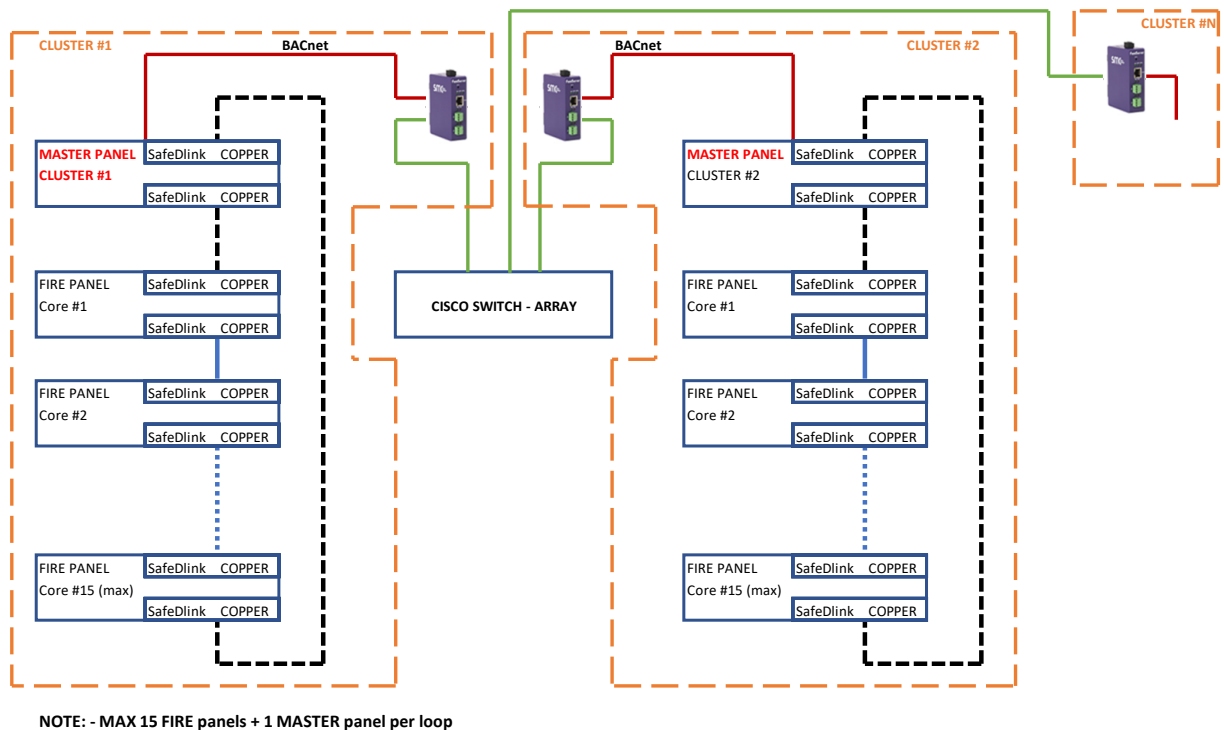
The fire alarm system is an object protection system. As such, there is no mandatory NFPA nor EN standards that are mandatory. However, the system has been designed to comply with NFPA 72 (applied for UL region) and with EN 54 (applied for IEC regions).



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4. Safety System Topology and Logic

4.1 Array-Level Safety System Topology

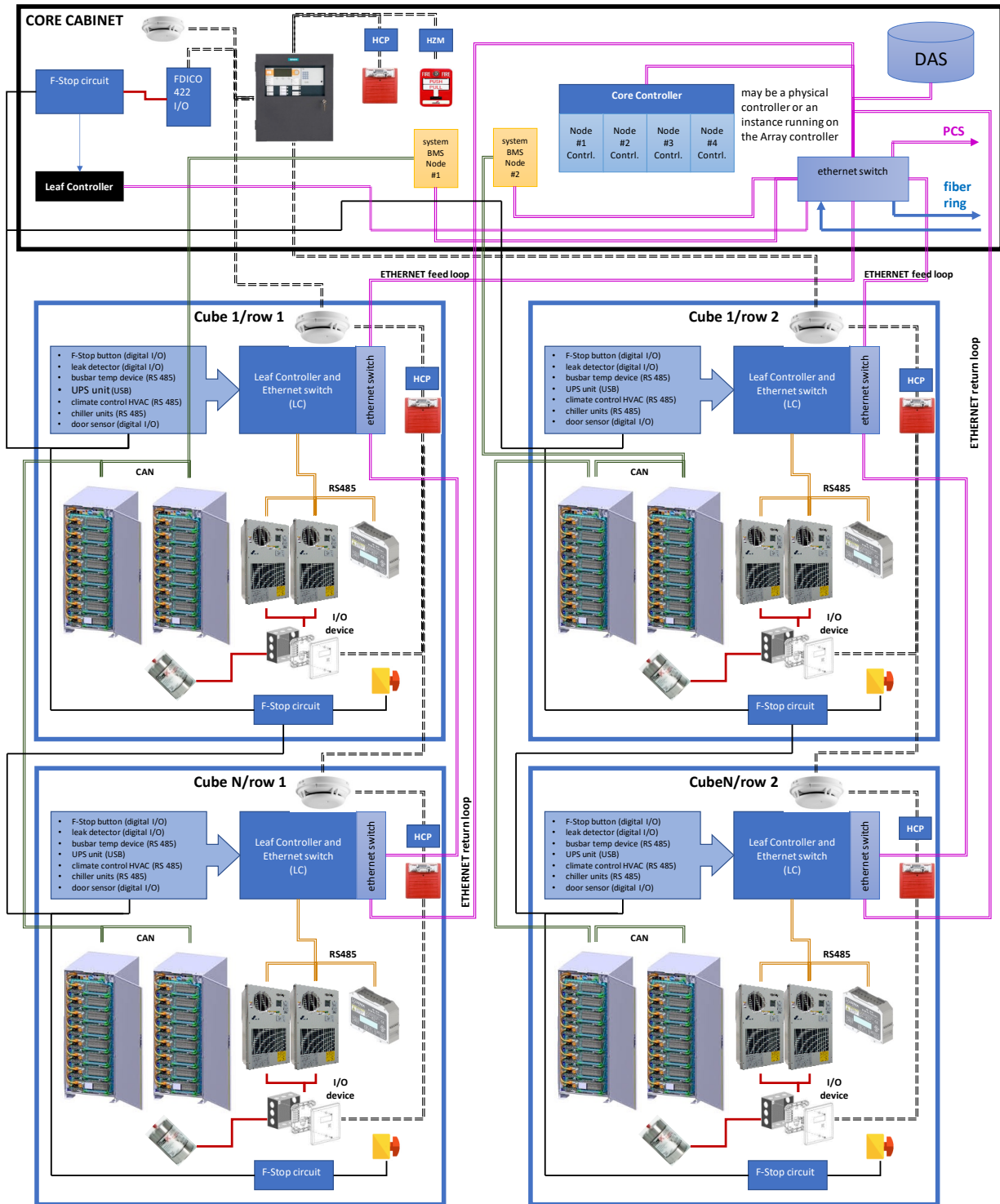


Groups of up to 15 fire panels will form CLUSTERS. Data from these Clusters is aggregated in a MASTER PANEL and transmitted via BACnet to a protocol converter to MODBUS TCP/IP and sent to the Array Controller's CISCO switch.

4.2 Core-Level Safety System Topology

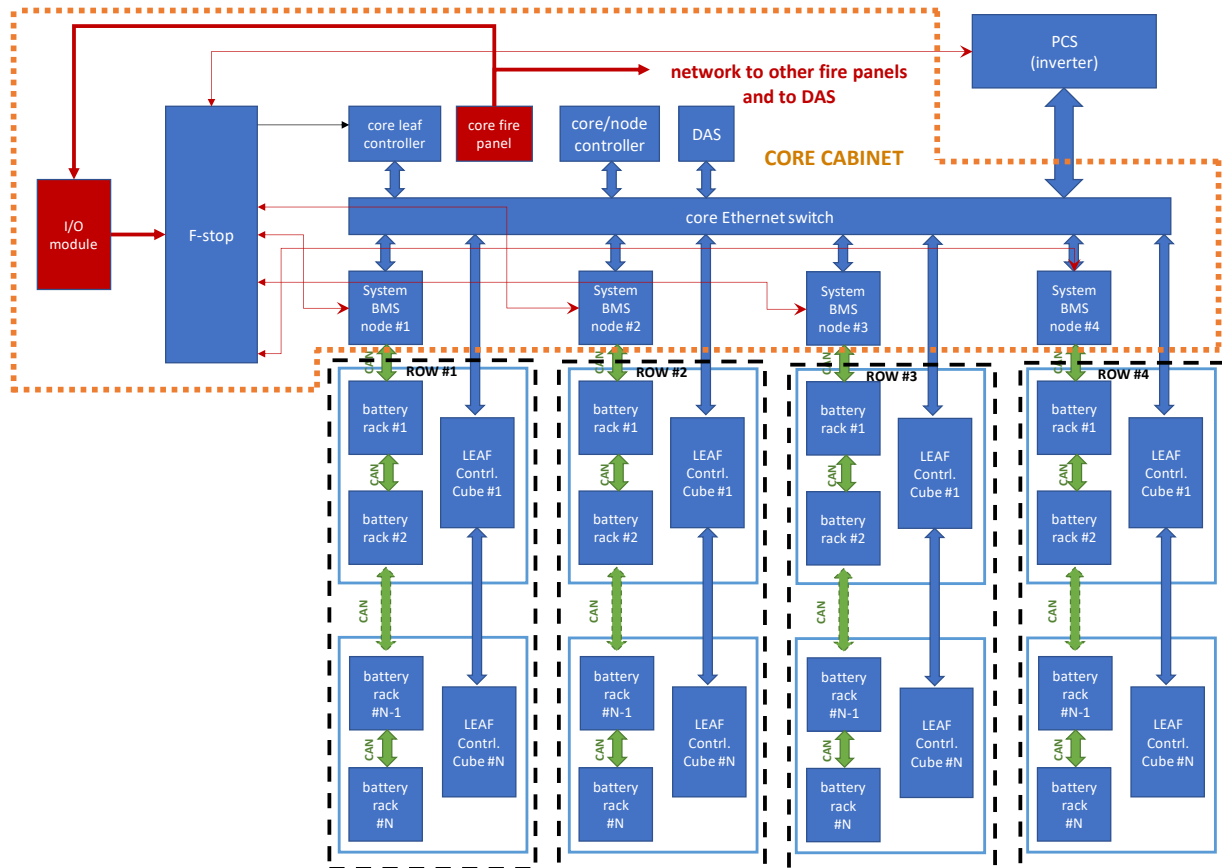
The diagram below is an example of the control topology for the Gen 6 safety systems; the example configuration contains two Cube rows.





4.3 Core-Level Information Flow

The safety system information flow at the Core level is summarized in the diagram below.



4.4 Fire Panel Logic

| outputs | inputs | | | | |
|---------|---|---|--|--|---|
| | | CO detector in Cube 30ppm [data loop] | Smoke or temp. in Cube [data loop] | FSS release [Signal via I/O device in Cube] | Pull station and detector located at Core cabinet |
| | Cube: I/O device to chiller/HVAC | HVAC timed OFF / Chiller no action (*) | I/O device Output: Stop HVAC/chiller affected Cube only | I/O device Output: Stop HVAC/chiller affected Cube only | I/O device Output: Stop HVAC/chiller all Cubes |
| | Cube: Output signal Horn/strobe | Strobe & horn (sound signal #1) affected Cube only | Strobe & horn (sound signal #2) affected Cube only | Strobe & horn (sound signal #2) affected Cube only | No action |
| | Core: I/O device outputs (1 to 4) | Trigger fast-stop of entire Core | Trigger fast-stop of entire Core | Trigger fast-stop of entire Core | Trigger fast-stop of entire Core |
| | Core: Horn/strobe in Core cabinet | Strobe & horn (sound signal #1) | Strobe & horn (sound signal #2) | Strobe & horn (sound signal #2) | Strobe & horn (sound signal #2) |
| | Core: MODBUS gateway | State of relevant device / data- point updates | State of relevant device / data- point updates | State of relevant device / data- point updates | State of relevant device / data- point updates |

The fire panel functionality will be pre-programmed in each Core's fire panel.

- 4 loop panels are used.
- Each loop is a row of Cubes. Max 4 rows per Core, max 9 Cubes/row.
- Devices to receive standard sequential numbering IDs, related to row and order number
- Relevant device ID and state of each device accessible via the MODBUS gateway
- Every Cube has:
 - Multi-criteria detector with CO, smoke and temperature with segregated signal for CO
 - I/O device, with on input connected to FSS, and output relay to stop HVAC and chiller
 - Horn/strobe and monitoring driver device (monitoring device on UL version only)

(*) under a potential pre-thermal-runway scenario, the chiller units should continue cooling the battery as much as possible. Under a smoke or fire scenario the HVAC and chiller units are



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stopped because the chiller and HVAC units are the heaviest electrical loads in the Cube and may potentially be the cause of the smoke and/or fire.

4.5 Cube Fast Stop Logic

| outputs | | Cube's own fast stop button | Signal from Core fast-stop (K2) – relevant for non-affected Cubes | From fire panel: Output signal from XTRI I/O device in affected Cube | FSS release: input signal into XTR I/O device in affected Cube |
|---------|--|--|--|---|---|
| | Cube: I/O device to chiller/HVAC | Trip chiller units and HVAC units (by hardware) | No action | Trip chiller units and HVAC units | Trip chiller units and HVAC units (signal goes to fire panel, is processed, and returns via I/O to trip HVAC/chiller units) |
| | Cube: DCPM of individual racks with F-Stop input (applies for certain battery models) | Trip DCPM of rack(s) via Hardwire (applicable for specific batt models) | Trip DCPM of rack(s) via Hardwire (applicable for specific batt models) | N/A | Trip DCPM of rack(s) – triggered centrally by the fire panel at Core level triggered at Cube level by K2. (applicable for specific batt models) |
| | Trigger fast-stop for entire Core via hardware | Trigger fast-stop of entire Core | Trigger fast-stop of entire Core | N/A | Core tripped via fire panel connection to I/O device and to F- stop circuit |

Background as to why only the local fast-stop of the Cube will stop the chiller/HVAC:

The objective of the fast-stop triggered from the Core is to disconnect the batteries in all Cubes, while continuing data collection and cooling. If however a fast-stop is manually triggered at a



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specific Cube by pressing the fast-stop button, the chiller and HVAC are stopped at that Cube because the button push may be related to the chiller or HVAC.

Tripping battery racks:

Depending on the model, battery racks are tripped individually (rack-level trip), or collectively for the entire DC busbar (system-level trip). The fast-stop system design accommodates either option.

4.6 Node/Core Fast Stop Logic

| outputs | | F-Stop button at Core cabinet has been pressed [Core stop] | F-Stop signal from one of the Cubes (via Cube's K1) [Core stop] | FDCIO422 output from fire panel in Core cabinet [Core stop] | F-Stop from battery system BMS at Core level [Core stop] |
|---------|----------------------|--|---|---|--|
| | PCS (Core) Fast Stop | Immediate F-Stop of PCS Core (all Nodes) | Immediate F-Stop of PCS Core (all Nodes) | Immediate F-Stop of PCS Core (all Nodes) | Immediate F-Stop of PCS Core (all Nodes) |
| | Battery System BMS | Stop of all battery racks in Core with 1s delay | Stop of all battery racks in Core with 1s delay | Stop of all battery racks in Core with 1s delay | Stop of all battery racks in Core with 1s delay |
| | Trigger K2 (F-Stop) | Trigger K2 (open) in F-Stop circuit | Trigger K2 (open) in F-Stop circuit | Trigger K2 (open) in F-Stop circuit | Trigger K2 (open) in F-Stop circuit |

F-Stop button design approach:

- F-Stop button at Core level stops the Core;
- F-Stop button at Cube stops the Cube itself and its own row but not the entire Core;
- F-Stop button at the Cube stops **all devices in the affected Cube**, including HVAC and chillers except data collection; other Cubes in the same row will not stop the HVAC nor the chiller.



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4.7 Fluence OS Software Safety Logic

| <div>inputs</div> | | | | |
|--|--|--|---|--|
| | Battery strings in Cube | Chillers and HVAC units in Cube | Node and Core (PCS section) | DAS / Warning / Alarm / HMI |
| Cube's F-Stop button pressed | <p>All racks in the Core are stopped</p> <p>How: via hardwired connection</p> | <p>Both chillers and both HVAC units stop in affected Cube only (hardwired)</p> <p>For other Cubes in Node: HVAC and Chiller continue normal operation (no change)</p> | <p>Cube Controller informs Node & Core Controller to stop the Core (redundant to hardwired signal).</p> <p>Note: Cube controller reads digital input after the F-stop button</p> | <p>"Manual F-Stop button forced on Cube ####/##/##"</p> <p>Core down alarm (Core ##)</p> <p>Alert: interference required</p> |
| Core F-stop main relay voltage drop | <p>All racks in the Core are stopped</p> <p>How: via hardwired connection</p> | NO ACTION | <p>Core Telco Rack Controller at Core informs Node & Core Controller to stop Node (redundant to hardwired signal).</p> <p>PLC at Core uses digital input connected to R1 relay</p> | <p>"F-Stop on Core ##"</p> <p>Core down alarm (Core ##)</p> <p>Alert: interference required</p> |
| Leak detector in Cube activated | <p>Node (all racks where affected Cube is located) stopped as result of Node shut-down sequence being initiated.</p> | <p>NO ACTION</p> <p>(in case the chiller has not stopped due to low pressure alarm, this indicates the leak may have a different source)</p> | <p>Cube Controller in Cube informs Node Controller to start Node shut-down sequence (no delay).</p> <p>Partial load operation applies for the Core (N-1 Nodes), to the extent that the PCS has more than one Node. If only one Node, stop entire Core.</p> <p>(*)</p> | <p>"Leak Alarm in Cube ####/##/##"</p> <p>Node down alarm (Node ##/##)</p> <p>Alert: interference required</p> |



| | Battery strings in Cube | Chillers and HVAC units in Cube | Node and Core (PCS section) | DAS / Warning / Alarm / HMI |
|---|---|--|--|--|
| Pressure drop chiller #1 or #2 (MODBUS RTU) | Node (all racks where affected Cube is located) stopped as result of Node shut-down sequence being initiated. | Both chillers in affected Cube will stop automatically when pressure is low (no SW implementation needed) HVAC units continue working | Cube Controller in Cube informs Node Controller to start Node shut-down sequence. Partial load operation applies for the Core (N-1 Nodes), to the extent that the PCS has more than one Node. If only one Node, stop entire Core. (*) | "Low pressure alarm Chiller #X in Cube ####/#" Node down alarm (Node ###) Alert: interference required |
| Chiller #1 or Chiller #2 fault alarm on MODBUS RTU which lead to a chiller STOP | Node (all racks where affected Cube is located) stopped as result of Node shut-down sequence being initiated. | Both chillers stopped by software from Node controller after stopping the batteries. HVAC units continue working | Cube Controller in Cube informs Node Controller to start Node shut-down sequence (no delay). Partial load operation applies for the Core (N-1 Nodes), to the extent that the PCS has more than one Node. If only one Node, stop entire Core. (*) | Chiller #X fault alarm in Cube ####/# Node down alarm (Node ###) Alert: interference required |
| Chiller #1 or Chiller #2 fault alarm on MODBUS RTU which do NOT lead to chiller stop | NO ACTION | NO ACTION | NO ACTION | Chiller #X fault alarm in Cube ####/# |
| Manual disconnection of one Cube from Node (partial operation using a lower number of Cubes in a Node) | First need to stop entire Node, then disconnect affected Cube by manually switching off each rack in that Cube, and finally restart the affected Node with one Cube less in Node. | CHILLERS: Will stop on disconnected Cube (by software) – the Node controller will know that the BMS has 2 racks less in the Node HVAC: No change – continue working | First need to stop entire Node, then disconnect affected Cube, and finally restart the affected Node with one Cube less in Node. | Note on HMI/DAS – Cube ####/# disconnected |



| | Battery strings in Cube | Chillers and HVAC units in Cube | Node and Core (PCS section) | DAS / Warning / Alarm / HMI |
|--|---|--|--|--|
| One or two HVAC units fail | NO ACTION. Will stop alone if high temperature in Cube results. | CHILLERS: NO ACTION (continue working) | NO ACTION. Will stop alone if high temperature in Cube results. | Alarm: HVAC# down in Cube ##/##/##/ Alert: interference required |
| Busbar high temperature warning (92.5°C) (OSENSA sensor via MODBUS RTU) Note: - this is an optional feature | NO ACTION | HVAC units: NO ACTION Chiller units: NO ACTION | NO ACTION | Busbar high temperature warning (92.5°C) on Cube ##/##/##/## |
| Busbar high temperature alarm (>95°C) (OSENSA sensor via MODBUS RTU) Note: - this is an optional feature | NO ACTION | HVAC units: NO ACTION Chiller units: NO ACTION | Cube Controller in Cube informs Node Controller to stop Node (no delay). Partial load operation applies for the Core (N-1 Nodes), to the extent that the PCS has more than one Node. (*) | Busbar high temperature alarm (>95°C) on Cube ##/##/##/## Node down alarm (Node ##/##/##) Alert: interference required |
| HUMIDITY CONTROL | NO ACTION | HVAC units: Cube controller commands chiller operations to remove humidity. CHILLER units: NO ACTION | NO ACTION | DAS / HMI to indicate when humidity control is ON or OFF with |



| | Battery strings in Cube | Chillers and HVAC units in Cube | Node and Core (PCS section) | DAS / Warning / Alarm / HMI |
|---|--|--|--|--|
| Excessive humidity (>95%) in Cube persisting for more than 2h Humidity sensor in Cube | NO ACTION | HVAC units: NO ACTION Chiller units: NO ACTION | NO ACTION | High Humidity Alarm on Cube #/#/#/#/# Alert: interference required |
| Excessive Cube internal temperature Tair > 40°C persisting for more than 2h | NO ACTION | NO ACTION | Cube Controller in Cube informs Node Controller to start Node shut-down sequence (no delay). Partial load operation applies for the Core (N-1 Nodes), to the extent that the PCS has more than one Node. If only one Node, stop entire Core. (*) | High Temperature Alarm on Cube ###/# Alert: interference required |
| Maintenance work in one or more Cubes, requiring disconnection of a full Node or a full Core disconnect via UI | All racks in a Node or Core must be disconnected prior to initiating maintenance work. | Aux power to the Cube need to be manually disconnected on the Core's aux distribution panel. | PCS (entirely or Node thereof) disconnected prior to initiating maintenance work. | Core #/# disconnected message |
| Door sensor | NO ACTION | NO ACTION | NO ACTION | Door open on Cube #/#/#/#/# intervention required |



| | Battery strings in Cube | Chillers and HVAC units in Cube | Node and Core (PCS section) | DAS / Warning / Alarm / HMI |
|--|--|--|---|--|
| Power outage in one Cube (detected by the Cube Controller's communication to the UPS unit) | Node controller to Initiate shut-down sequence for the Node | NO ACTION | Node controller to Initiate shut-down sequence for the Node <i>Partial load operation applies for the Core (N-1 Nodes).</i> (*) | Alarms: 1) Power outage in Cube #/#/#/#/# 2) Node #/#/# disconnected |
| Power outage at Core | Core controller to Initiate shut-down sequence for the Core of the identified power loss | NO ACTION | Core controller to Initiate shut-down sequence for the Core of the identified power loss | Alarm: Power outage in Core #/# |
| Remote power cycling feature for the Cube | DCPM will be reset | No action, only communication to Leaf Controller will fall and be re-established | Signal for the power-cycling of a Cube comes via Core/Node controller. The Core should be in standby when resetting a Cube | Will register power-cycling command for Cube #/#/# |
| Remote power cycling for Core | Battery Bank will be reset, all Controllers will be reset. Power cycling can only be activated if the Core is not operational. | NO ACTION | Signal for the power-cycling of a Cube comes via Core/Node controller. The Core should be in standby when resetting a Cube | Power cycle command CORE ### |



| | Battery strings in Cube | Chillers and HVAC units in Cube | Node and Core (PCS section) | DAS / Warning / Alarm / HMI |
|---|---|---------------------------------|--|---|
| Insulation monitoring device | <p>The IMD is installed at the PCS DC cabinet. Signal from the IMD will trigger the shut-down sequence for the Core (hardwired).</p> <p>Cube Controller will notice voltage drop on the F-Stop relay at Core level and send signal to Core controller to drop the Core (redundant to hardwired F-stop)</p> | NO ACTION | <p>The IMD is installed at the PCS DC cabinet. Signal from the IMD will trigger the shut-down sequence for the Core (hardwired).</p> <p>Cube Controller will notice voltage drop on the F-Stop relay at Core level and send signal to Core controller to drop the Core (redundant to hardwired F-stop)</p> | <p>Alarm: Ground Fault on Core #/#/#</p> <p>Alert: interference required</p> |
| Manual pull station pulled at Core level or fire alarm in the Core cabinet | <ul style="list-style-type: none"> Signal from the fire panel's MODBUS gateway will be sent to both DAS and to the Array Controller. Signal from the Array controller is sent to the relevant Core Controller Core Controller initiates CORE Shutdown Sequence This is redundant to the hardwired signal to shut-down the Core. | NO ACTION | <ul style="list-style-type: none"> Signal from the fire panel's MODBUS gateway will be sent to both DAS and to the Array Controller. Signal from the Array controller is sent to the relevant Core Controller. Core Controller initiates CORE Shutdown Sequence This is redundant to the hardwired signal to shut-down the Core. | <p>Alarm: Fire Alarm: Manual pull station on Core # activated</p> <p>Alert: Intervention required</p> |



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| | Battery strings in Cube | Chillers and HVAC units in Cube | Node and Core (PCS section) | DAS / Warning / Alarm / HMI |
|---|---|--|---|--|
| Fire alarm (smoke or temperature or FSS release) in Cube #/#/#/#/# | <ul style="list-style-type: none"> • Status from the fire panel's MODBUS gateway will be read/passed on to both DAS and to the Array Controller. • Signal from the Array controller is sent to the relevant Core Controller • Core Controller initiates CORE Shutdown Sequence • This is redundant to the hardwired signal to shut-down the Core. | Only the chillers in the affected Cube are stopped by hardware (signal sent by the fire panel located at the Core cabinet) | <ul style="list-style-type: none"> • Status from the fire panel's MODBUS gateway will be read/passed on to both DAS and to the Array Controller. • Signal from the Array controller is sent to the relevant Core Controller • Core Controller initiates CORE Shutdown Sequence • This is redundant to the hardwired signal to shut-down the Core. | <p>FIRE ALARM on Cube #/#/#/#/#</p> <p>Alert: Intervention required</p> |
| Fire Panel Trouble | <ul style="list-style-type: none"> • Status from the fire panel's MODBUS gateway will be read/passed on to both DAS and to the Array Controller. • Signal from the Array controller is sent to the relevant Core Controller. • Core Controller initiates Core Shutdown Sequence | NO ACTION | <ul style="list-style-type: none"> • Status from the fire panel's MODBUS gateway will be read/passed on to both DAS and to the Array Controller. • Signal from the Array controller is sent to the relevant Core Controller. • Core Controller initiates Core Shutdown Sequence | <p>FIRE PANEL FAILURE – CORE #/#/# shutdown.</p> <p>Alert: Intervention required</p> |



| | Battery strings in Cube | Chillers and HVAC units in Cube | Node and Core (PCS section) | DAS / Warning / Alarm / HMI |
|---|---|---------------------------------|---|---|
| CO detected in Cube #/#/#/#/# | <ul style="list-style-type: none"> Signal from the fire panel's MODBUS gateway will be sent to both DAS and to the Array Controller. Signal from the Array controller is sent to the relevant Core Controller Core Controller initiates Core Shutdown Sequence This is redundant to the hardwired signal to shut-down the Core. | HVAC stopped | <ul style="list-style-type: none"> Signal from the fire panel's MODBUS gateway will be sent to both DAS and to the Array Controller. Signal from the Array controller is sent to the relevant Core Controller Core Controller initiates CORE Shutdown Sequence This is redundant to the hardwired signal to shut-down the Core. | <p>Carbon Monoxide ALARM on Cube #/#/#/#/#</p> <p>Intervention required</p> |
| Transformer Alarm in Core Telco Rack #/#/#/#/# | <p>Signal from the Transformer will trigger the shut-down sequence for the Core.</p> <p>Core Controller initiates Core Shutdown Sequence</p> | NO ACTION | <p>Signal from the Transformer will trigger the shut-down sequence for the Core.</p> <p>Core Controller initiates Core Shutdown Sequence</p> | <p>Transformer Failure – CORE #/#/# shut down</p> <p>Alert: Intervention required</p> |



5. Deflagration Panels

5.1 Description

Each Cube includes two deflagration panels, which are passive devices engineered to direct the force of an explosion should one occur in the Cube. The deflagration panels are located on the roof of the Cube, to direct any such forces upwards above the Cube. The panels are tethered; if activated, the panel tethers prevent the panels from flying free from the Cube. The panels are engineered according to NFPA 68 and serve as explosion control per Section 4.12.1(2) of NFPA 855.

5.2 Test Results

Deflagration panels are designed based on potential gas concentrations based on data from UL 9540A, "Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems". In Cube testing, explosions could not be created until gas concentrations were >5 times greater than likely gas concentrations based on UL9540A testing. Upon ignition, the deflagration panels successfully directed the force of the explosion upwards. The Cube structure remained intact.

5.3 Snow Load

In order to simulate potential snow loads on the deflagration panels, sandbag testing was conducted. The deflagration panels were shown to successfully operate at loads of 30 lbs / sqft, equivalent to approximately 30 inches (75 cm) of "average snow".



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