Technical Guide

DALI+ Systems

Version 1.0

September 2021

For any further explanation of the contents of this document, or in case of any perceived inconsistency or ambiguity of interpretation, please contact the DiiA:

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Document History

Publication Date	Status	Comments
20 Sep 2021	1.0	Initial publication of document “DiiA(SW)262c DiiA Guide to DALI plus over wireless and IP carriers”

Table of Contents

DALI+ Systems

1 Scope

This document is a technical guide to products that implement IEC 62386-104, together with the changes and additions published by DiiA. Products implementing these specifications and verified as meeting the requirements of the DALI+ certification process, may use the DALI+ Trademark.

NOTE This version of the document covers the use of Thread as the carrier, and will be revised if other carriers are added for certification.

2 References

The following documents are referred to or give additional guidance. The latest edition of the publication applies (including amendments) unless stated otherwise.

- DALI Quick Start Guide
- IEC 62386 series of standards. For part 207, edition 1 applies.
- DiiA specifications part 150 AUX, parts 250-253 and part 351
- DiiA Specification – Part 104 Changes and Additions
- DiiA Guidelines – Clarifications & Recommendations for IEC 62386
- DiiA Guide – Product Submission Guide
- Trademark Guidelines for Members - for DiiA Regular and Associate Members

3 Terms and definitions

3.1 DiiA

Digital Illumination Interface Alliance

NOTE Also known as the DALI Alliance.

3.2 101-unit

bus unit as defined in IEC 62386-101

3.3 101-system

system of 101-units and bus power supplies

3.4 104-node

logical entity on a telecommunication network using IEC 62386-104 defined communication methods

3.5 104-unit

logical unit or combination of logical units, acting as one or multiple 104-nodes, containing one telecommunication interface

NOTE As an example, a 104-unit could contain two 104-nodes, with each of these nodes having its own IP-address, and having its own range of system addresses, whilst sharing a single wireless transceiver.

3.6 104-system

system of 104-units and bus power supplies

3.7 transaction

collection of one or more forward or backward frames

4 General

4.1 Types of 104-units

104-units can be either a **control device** or a **control gear**, or a combination. Such control gear and control devices implement the same IEC 62386 parts and DiiA specifications as the 101-unit equivalents, and additionally implement IEC 62386-104 and the DiiA specification – *Part 104 Changes and Additions*. Bus power supplies are not required in 104-systems.

A new type of control device is defined for 104-units: a **bridge**. Currently one type of bridge is defined, but there may be more in the future. A bridge transports IEC 62386 frames between a 104-system and a 101-system. Further details are given in 5.4.

The initial work from DiiA has been on using IP as a carrier, and specifically Thread. Future work may add further carriers such as Bluetooth Mesh.

4.2 What 104-units do

104-units provide the same operation as their 101-unit equivalents. The difference being in the carrier used to transport commands. A complete system can be made entirely from 104-units. There is no need for any 101-units in such a system. However, there are several system architectures that allow 101-units and 104-units to be used together – see 5.2.

4.3 What 104-units don't do

Functionality that is not required or not necessary includes:

- A bus connection for a 101-system. There are some exceptions:
  - Bridge devices between 101-system (DALI bus) and a 104-system.
  - Application controllers that provide connections for 1-1-systems, and 104-systems. These application controllers are effectively providing multiple subnets, in the same way that some application controllers provide multiple wired connections, each connecting one subnet.
  - Bus units that have dual interfaces – 101-system wired bus connection, and an 104-system connection, such as Thread. Use may be restricted to only one of these interfaces at a time, selected at installation or commissioning time. See Figure 1.

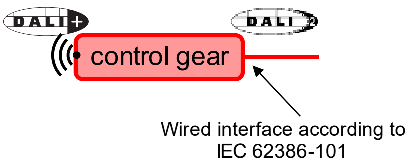

Figure 1 - Control gear with dual interfaces

- 104-units are not gateways between 104-systems and other ecosystems such as Bluetooth Mesh or Zigbee.

5 Method of operation

5.1 Overview of operation

The IEC 62386-104 standard, with DiiA Specification – Part 104 Changes and Additions, specifies a method to transport IEC 62386 frames across wireless and/or IP-based carriers. These frames contain the commands and addressing methods from the existing IEC 62386 and DiiA specifications, as well as some extensions that are specific to part 104.

DiiA specification – *Part 104 Changes and Additions*, gives additional requirements, including those for a new type of device – bridges.

5.2 System structure and architecture

104-units support several system architectures. Several examples of these are shown in this clause.

Figure 2 shows a 104-system containing control gear, input devices and a single application controller. The complete system is comprised of 104-units.

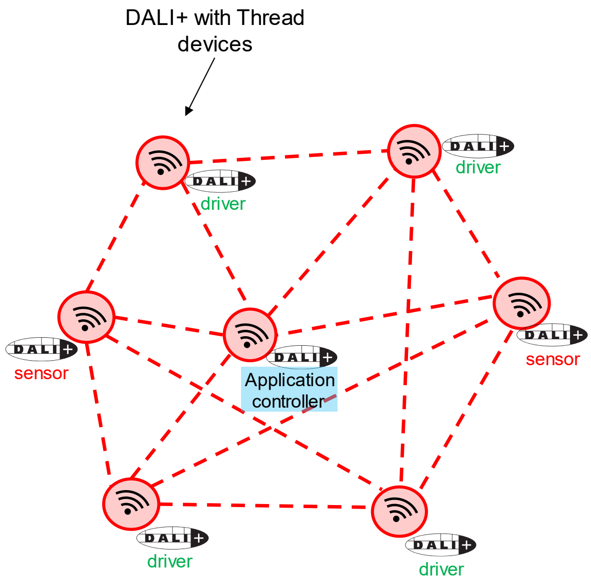

Figure 2 - 104-system with control gear and control devices

Figure 3 shows a 104-system with multiple control gear and a single application controller. The application controller also has two interfaces for 101-systems, shown as “DALI-2 subnets (wired)”. 104 is being used to allow wireless connectivity for control gear (drivers). Any interaction between the three systems (one DALI+ and two 101-systems) is determined by the design of the application controller.

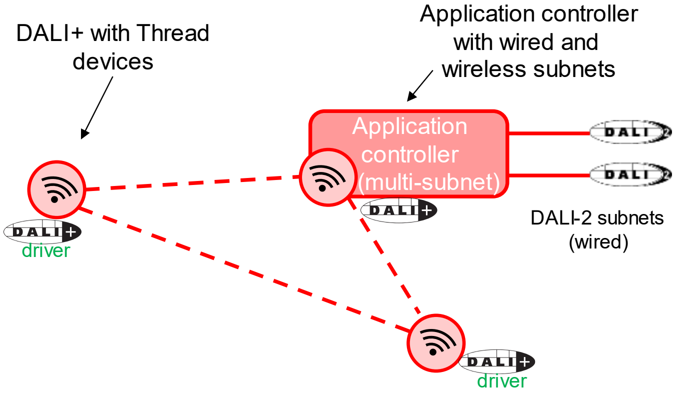

Figure 3 - Application controller with 104 and 101 interfaces

Figure 4 shows a 104-system with multiple input devices (sensor and push-button) and a single application controller. The application controller also has two interfaces for 101-systems. 104 is being used to allow wireless connectivity for buttons and sensors. The application controller receives event messages or polls the sensors and push-buttons in the 104-system and 101-system (if any), makes decisions, and sends commands to the bus units in the 101-systems, controlling the lighting.

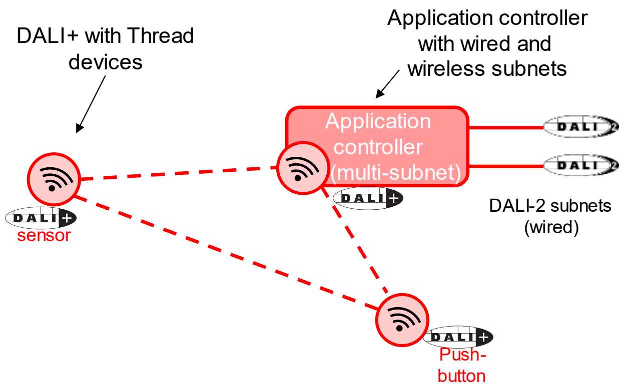

Figure 4 – Application controller with 104 and 101 interfaces

Figure 5 shows a 104-system, including a bridge to a 101-system. The 101-system is a single luminaire containing control gear and a sensor connected through an IEC 62386 wired bus. The bridge device automatically forwards frames between the 104-system and the 101-system, allowing application controllers in the 104-system to control, configure and query the 101-system, and make use of events and information from the sensor in the 101-system.

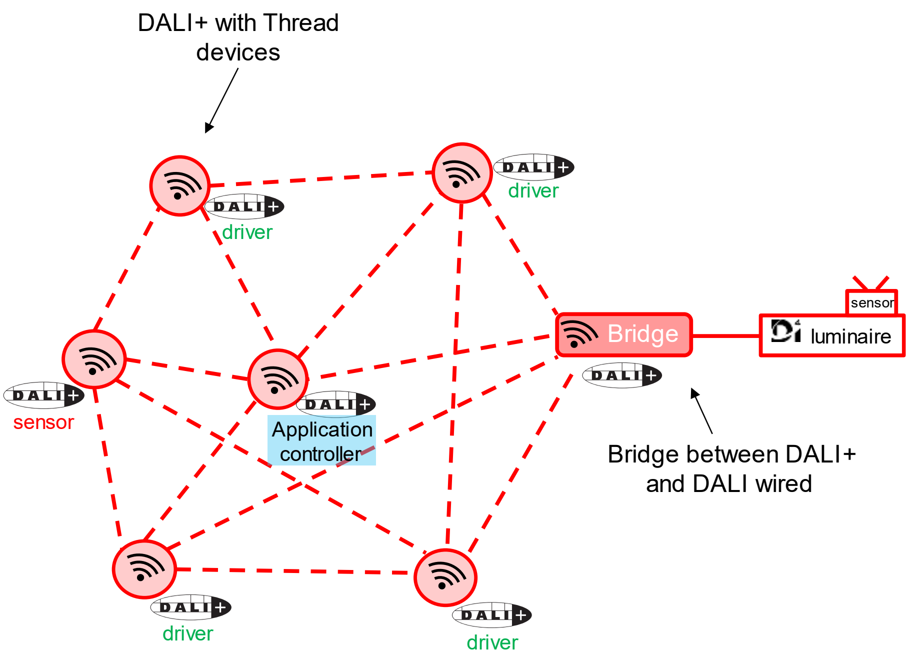

Figure 5 – 104-system with bridge to luminaire containing control gear and sensor

Figure 6 shows a 104-system across two Thread networks that are joined through an Ethernet cable using Thread border routers, with 104-units on each Thread network, and a Thread door locking device in one of the Thread networks. A bridge device including three bridge functions allows connection to three 101-systems which could contain D4i luminaires and other DALI-2 devices. An application controller is connected to one of the Thread networks, and contains the 104-interface for Thread and two 101-interfaces. Control gear, control devices and a bridge device are in the 104-system.

The non-DALI+ devices in this example (Thread enabled door lock) show that the Thread network is not limited to transporting only DALI+ communications, but can also support devices for other building systems. Such devices can support all communications in the Thread network, but are not controlled by DALI commands.

This example could be connected to a larger building-wide IP network, for example containing computers and other devices.

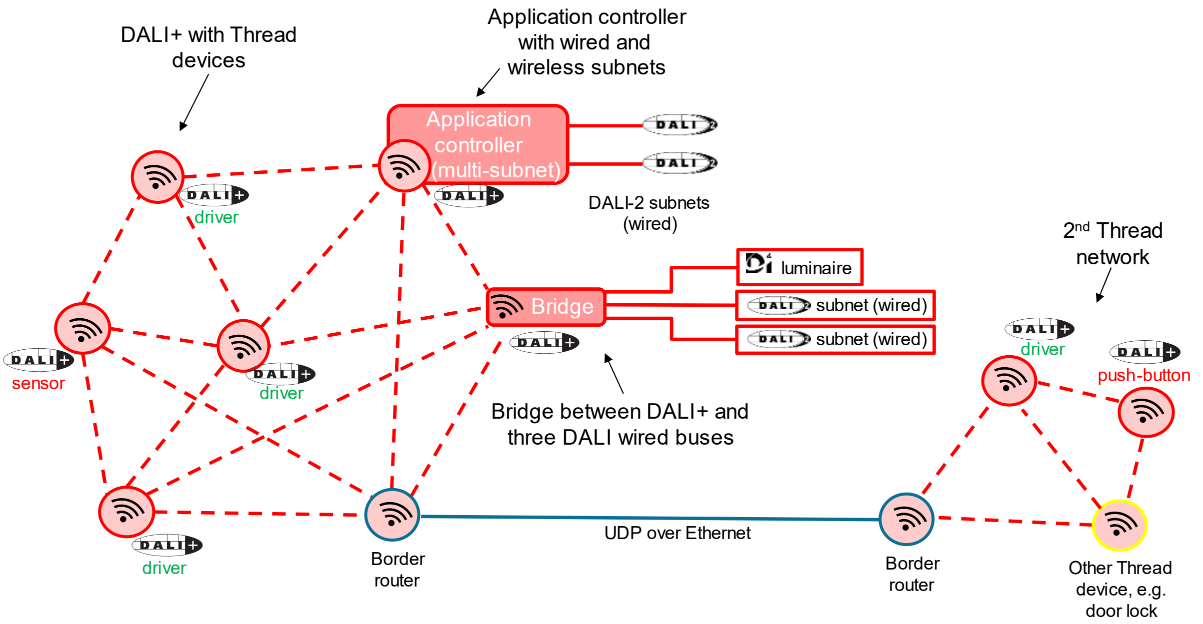

Figure 6 – 104-system example with multiple Thread networks, multiple 101-systems and other Thread devices

5.3 Carriers

THREAD

Initially, DALI+ will support Thread as the carrier. Thread uses the UDP protocol over 6LoWPAN, a low-power wireless protocol that implements IPv6. 6LoWPAN uses IEEE 802.15.4 wireless technology.

DALI+ with Thread devices are Full Thread Devices (FTD), and are capable to perform any of the Leader, Router or Router-Eligible End Device (REED) roles in Thread networks.

In the future, support for wired carriers, as well as other wireless carriers, is likely to be added, depending on support from DiiA members.

5.4 Bridges

Bridges are a new type of device. They include an interface for the wireless (or alternative wired) network connection, as well as an interface for one or more wired buses as described in IEC 62386-101. This allows a network of conventional IEC 62386 wired bus products to be accessible and controllable from the application controllers in a 104-system.

Figure 7 shows that a bridge device contains a **bridge function** and an **application controller**.

The bridge function receives transactions from the 104-system, and forwards these to the 101-system, taking care of frames that need to be sent twice. Additionally, the bridge function receives backward frames and event messages from the 101-system. Backward frames form part of a backward frame transaction and event frames form part of the forward frame transaction sent out to the 104-system. All other frames received from the 101-system are discarded by the bridge function.

The bridge device includes a multi-master application controller that can be accessed from the 101-system, and can optionally send forward frames on both the 104-system and 101-system.

NOTE The application controller in a simple bridge device would not create forward frames other than for test purposes. In this case, the application controller is simply present to allow configuration and querying of the bridge function.

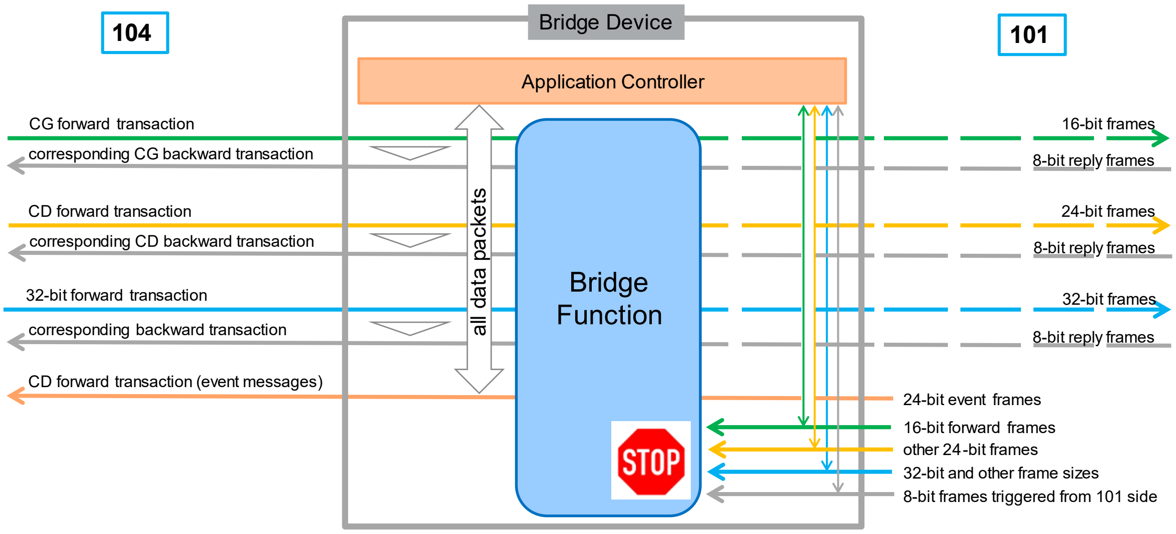

Figure 7 - Bridge device

The rules for filtering of frames forwarded between the 104-system and 101-system allow the following:

- Application controllers in the 104-system can control, configure and query all devices in the 101-system, using any of the addressing methods. This includes the use of 32-bit frames as defined in IEC 62386-105.
- Event messages from input devices in the 104-system can be used by application controllers in the 101-system.

The filtering rules prevent the following:

- Control, configuration or querying of devices in the 104-system from an application controller in the 101-system. The exception is the application controller that is inside the bridge device – it has full access to both systems.

From the above rules, it can be seen that the 104-system is in control of the 101-system, but the opposite is not possible using a bridge. However, input devices such as sensors or push-buttons in the 101-system are able to influence the operation of the 104-system through an application controller in the 104-system. It is also allowed for an application controller with interfaces to a 101-system and 104-system to forward frames from its 101-system to its 104-system. Such operation is not currently standardised, since it is in the reverse direction to that provided by a bridge.

5.5 Addressing

104-units include the addressing methods that are already included for 101-units. For control gear these are: short address, group, broadcast, broadcast unaddressed. For control devices these are short address, control device group, broadcast and broadcast unaddressed. For input devices, they additionally include instance number, type and group addressing methods.

104-units also include a *systemAddress* variable. This is a level above the short address, so each system address effectively allows 64 control gear short addresses and 64 control device short addresses. Transaction sent to system address 0 are accepted by all 104-units, regardless of their individual *systemAddress* settings.

104-units also implement the addressing system provided by the carrier. In the case that Thread is used as the carrier, IPv6 addressing is implemented, providing another level of addressing above the short address and system address. As well as an IPv6 unicast address which can be used to individually address devices, the 104-units can make use of IPv6 multicast, which can be used to reach one or a group of devices with a single IPv6 data packet using any of the above DALI addressing methods. The multicast address range is given in the DiiA specification – *Part 104 Changes and Additions*, as well as in the IANA list of permanently assigned multicast addresses. The IPv6 multicast scope and multicast group (subnet) can be configured. IPv6 unicast supports reliable/confirmable messaging techniques supported by the carrier. The UDP port number to be used as the destination port is also given in the specification, and published by IANA.

5.5.1 Addressing examples

The following examples show some of the possibilities allowed by these various addressing methods. Combinations are also possible:

- Example 1: DALI+ with Thread devices are not assigned a DALI short address. IP unicast addressing is used to communicate with individual devices. IP multicasting can be used to communicate with all devices or with DALI groups, allowing communication with a subset of the devices. Without DALI short addressing, the 64+64 limit for the number of devices in a system does not apply, however this requires that all devices contain no more than one logical unit.
- Example 2: DALI+ with Thread devices are assigned short addresses. IP unicast addressing can be used to communicate with individual devices. DALI addressing methods inside each frame are used in the usual way, selecting which logical units respond to the frame.
- Example 3: DALI+ with Thread devices are assigned short addresses, and are arranged into DALI groups. IP multicasting can be used to communicate with multiple devices. DALI addressing methods inside each frame are used in the usual way, selecting which devices, or logical units, respond to the frame. This example provides a simple method to enable the re-use of existing application controller software to work with a DALI+ network. However, this approach will not benefit from the efficient use of a Thread network's routing capability and is likely to result in unnecessary radio traffic.
- Example 4: Thread devices make use of the system address that is described in part 104. DALI+ with Thread devices are assigned short addresses, are arranged into DALI groups and are assigned a system address. Each system address supports the usual limits of 64 control gear and 64 control devices. For larger areas, multiple system addresses are used within the same Thread network. IP multicasting can be used to communicate with a system address, or even across all system addresses.
- Example 5: Bridge device with multiple wired interfaces: Similar to the previous example, except that the bridge device may contain multiple system addresses, each used for one of the wired interfaces. IP unicasting may be used to communicate with the bridge device, with the system address selecting the wired interface.

5.6 Security

The transport/link-layer security provided by the carrier is used. In addition, the application layer security can be activated.

For Thread, this means that only devices commissioned with the network key can exchange data. A device specific authentication secret is used to securely deliver the network key to the device joining the network. Network commissioning can be done through the Thread network, e.g. by an application controller with a Thread interface, or directly through an out-of-band method such as NFC or Bluetooth.

All Thread communication is encrypted and authenticated using the 802.15.4 security mechanisms specified by Thread, using AES with a 128-bit key.

Application layer security is included, using two methods:

- Unicast forward and backward frames can use CoAPs, which uses DTLS security. A derived, device-specific authentication secret is used to establish the DTLS connection with the authenticated device.
- Multicast and unicast forward frames, backward frames and simple acknowledgement frames can use AES with a 128-bit UDP encryption key that is distributed only to 104-units within the 104-system. This key is not shared with other devices in the Thread network and therefore forms a security domain of 104-units within the (potentially shared) IP network. CoAPs is used to securely distribute UDP encryption keys to 104-units.

5.7 Reliable delivery of transactions

Reliable delivery is achieved by using message acknowledgement to confirm delivery. CoAP/CoAPs confirmable messages can be used for this, or the application controller sending a transaction can set a flag to request confirmation even if no reply would normally result.

6 Testing, certification and Trademark use

6.1 Requirements from IEC 62386 and DiiA

Products need to implement IEC 62386-104, together with the DiiA specification – *Part 104 Changes and Additions*. Part 101 applies, except for the requirements for the physical interface. Other parts of the standard are also implemented as usual, according to the type of product. Two examples are given below:

- Colour controllable LED driver
  - IEC 62386, parts 101, 102, 104, 207, 209
  - DiiA specification – *Part 104 Changes and Additions*
  - DiiA Guidelines – *Clarifications & Recommendations for IEC 62386*
- Combined occupancy and light sensor
  - IEC 62386, parts 101, 103, 104, 303, 304
  - DiiA specification – *Part 104 Changes and Additions*
  - DiiA Guidelines – *Clarifications & Recommendations for IEC 62386*

6.2 Testing

DiiA is currently developing tests for DALI+ with Thread. This includes new tests for part 104, some modification of the existing tests for parts 1xx, 2xx and 3xx, and will require the use of the ProbitLab2 with the addition of a low-cost USB wireless interface connected to the PC running the tests. Figure 8 shows a typical test set-up.

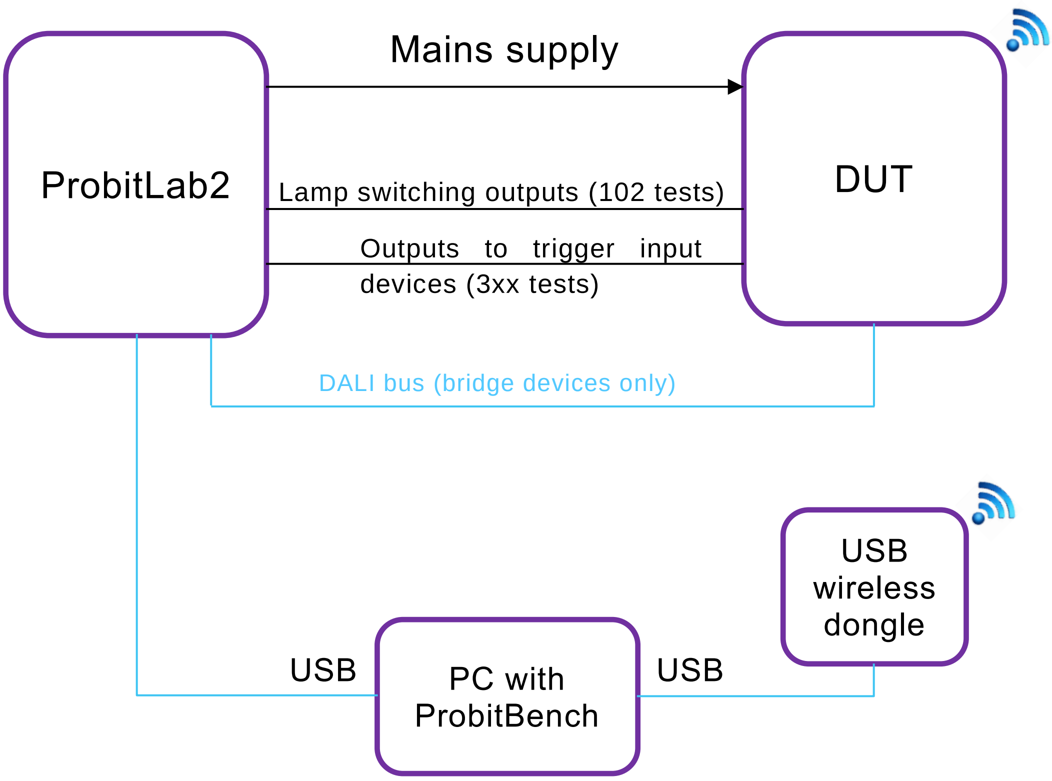

Figure 8 – Test set-up

6.3 Certification

The certification process and tools for DALI+ devices is expected to be no different from those already in place for DALI-2 and D4i. The existing web-interface will simply be extended to allow the additional part (104) and properties (wireless carrier selection, and bridge device option). The use of certification credits will also be unchanged.

Depending on the carrier, certification of the carrier technology may be required. In the case of Thread, a 104-unit may be based on a Thread certified component (e.g. an RF module), simplifying certification.

6.4 Trademark use

Use of the DALI+ word Trademark and logo Trademark are strictly controlled to ensure the same high level of interoperability already achieved with DALI-2 and D4i. Trademark use will be permitted once certification starts, and rules will be added to the DiiA document, *Trademark Guidelines for Members*. Before certification starts, DALI+ word and logo Trademarks are not permitted to be used on products or in association with products. The limited use that is allowed, is published in the members area of the DiiA website.

7 Commissioning

Commissioning can generally be divided into the following steps:

- Joining to the network
    - In some protocols, this may be called “provisioning”.
    - Devices need to be given the correct security credentials before they are able to communicate with other devices in the same network.

    - This could be achieved by using a tool that provides the credentials for a device, for example after scanning a QR code on the device or after pressing a button on the device.
    - Credentials may also include the application layer security keys (UDP encryption keys) for all 104-units, if this security method is used.
- Assigning addresses and groups
    - The network protocol has its own address types, for example IPv6 unicast addresses and multicast addresses. In addition, the short addresses and group addresses defined in IEC 62386 can be assigned. For Thread, IPv6 unicast addresses are automatically assigned by the network stack.
- Configuring the devices
    - Settings such as scene levels and colours, fade times, button and sensor configuration and many other IEC 62386 settings that are specific to the type of device can be configured.

In the simplest of cases, there may be no need to assign addresses or any other configuration settings. Some settings, such as addresses, may also be assigned automatically by the tool or application controller in a system.

8 Future additions

DiiA is considering adding DALI+ support for the following:

- Bluetooth mesh as the wireless carrier.
- Ethernet (including PoE) as the carrier.
- WiFi as the carrier.

9 FAQ

Timing

- Q: How does 104 guarantee the timing requirements of IEC 62386. For example, the short time required to obtain a reply to a query command?
- A: Part 104 avoids the timing problem by embedding both the query command and answer together in the reply frame.

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For more information, please contact us:

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