## Product Description

The LumenRadio W-DALI Node module is an innovative solution at the forefront of modern lighting control. It enables IEC 62386 without the constraints of physical cabling, providing wireless control of DALI-2 compatible luminaires and devices.
Harnessing the robust capabilities of LumenRadio's MiraMesh technology, the W-DALI Node module ensures reliable radio communication through its self-forming and self-healing wireless mesh architecture. MiraMesh is already trusted by numerous installations worldwide, spanning from lighting control to industrial sensor networks and building automation.
Operating within the internationally approved ISM band at 2.4GHz, the W-DALI Node module offers an operational range of up to 500 meters in line-of-sight conditions. This extensive reach, coupled with its scalable network architecture, allows for flexible deployment scenarios, catering to diverse installation needs.
At its essence, the W-DALI Node module prioritizes seamless integration and compatibility. A W-DALI network consist of a root gateway such as LumenRadio W-DALI DIN rail and a number of W-DALI Node modules. The gateway communicates over traditional DALI-2 with a controller, and the Node modules in turn do the same with the luminaire or other device in which it is integrated. This "wireless cable" approach allows it to seamlessly integrate into existing wired systems. Additionally, each node supports up to 10 wired devices on its local bus, meaning that a luminaire with an integrated W-DALI Node can act as a bridge to the gateway for a local traditional DALI-2 bus.
The W-DALI Node module requires very limited external circuitry for integration, meaning that it can easily be integrated into a DALI-2 compatible device.



## Features

- IEC 62386 compliant
- Plug and play integration into a DALI 2 compatible device
- Instant wireless setup and fully compatible with LumenRadio W-DALI DIN rail and W-DALI Node
- Built upon LumenRadios patented MiraMesh technology
- Self-optimizing network – the mesh network will always find the best way to send messages through the network between devices.
- Compliant against ETSI EN 300 328 (v2.2.2)
- Compact size with few external components required.
- Over-the-air firmware upgrades
- Minimal external circuitry needed

## Specifications

- Range: up to 500m free line of sight between two meshing units.
- Output (ERP): Max 20 dBm
- Sensitivity: -93dBm
- Frequency band: 2.45 GHz, ISM band (2402-2480 MHz)
- Up to 10 wired devices on each local Node bus
- Number of hops: 8 hops in the meshing network
- Dimensions: 33.5 x 18.5 x 3.77mm
- Supply voltage 3.0 - 3.6V
- Peak average current consumption 150mA in high power mode

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# Contents

# Specifications

- RF Output: Max 20 dBm
- Sensitivity: -96dBm
- 115.5dB link budget
- u.FL/IPEX external antenna connector
- Frequency band: 2.45 GHz, ISM band (2402-2480 MHz)
- Dimensions: 33.5 x 18.5 x 3.77mm

## Absolute maximum ratings

Maximum ratings are the extreme limits to which the W-DALI Node module can be exposed for a limited amount of time without permanently damaging it. Exposure to absolute maximum ratings for prolonged periods of time may affect the reliability of the device.

| Symbol | Parameter | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|
| VDD | Supply voltage | -0.3 | | 3.9 | V |
| TA | Operating temperature | -30 | | 75 | ℃ |
| VIO | IO Input voltage VDD < 3.6V | | | VDD + 0.3 | V |
| VIO | IO Input voltage VDD > 3.6V | | | 3.9 | V |
| VSS | Ground pad voltage | | | 0.0 | V |
| TS | Storage temperature | -40 | | +125 | ℃ |
| RFin | RF input power | | | +10 | dBm |
| ESD | ESD all pins, Human Body Model | | | 1 | kV |

## Recommended operating conditions

| Symbol | Parameter | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|
| VDD | Supply voltage | 3.0 | 3.3 | 3.6 | V |
| Vrise | Supply rise time (0 V to 3.7V) | | | 60 | ms |
| IDD | Supply peak current capability | | 150 | 250 | mA |

Please see Power supply recommendations for a more specific guideline.

## Digital I/O pins

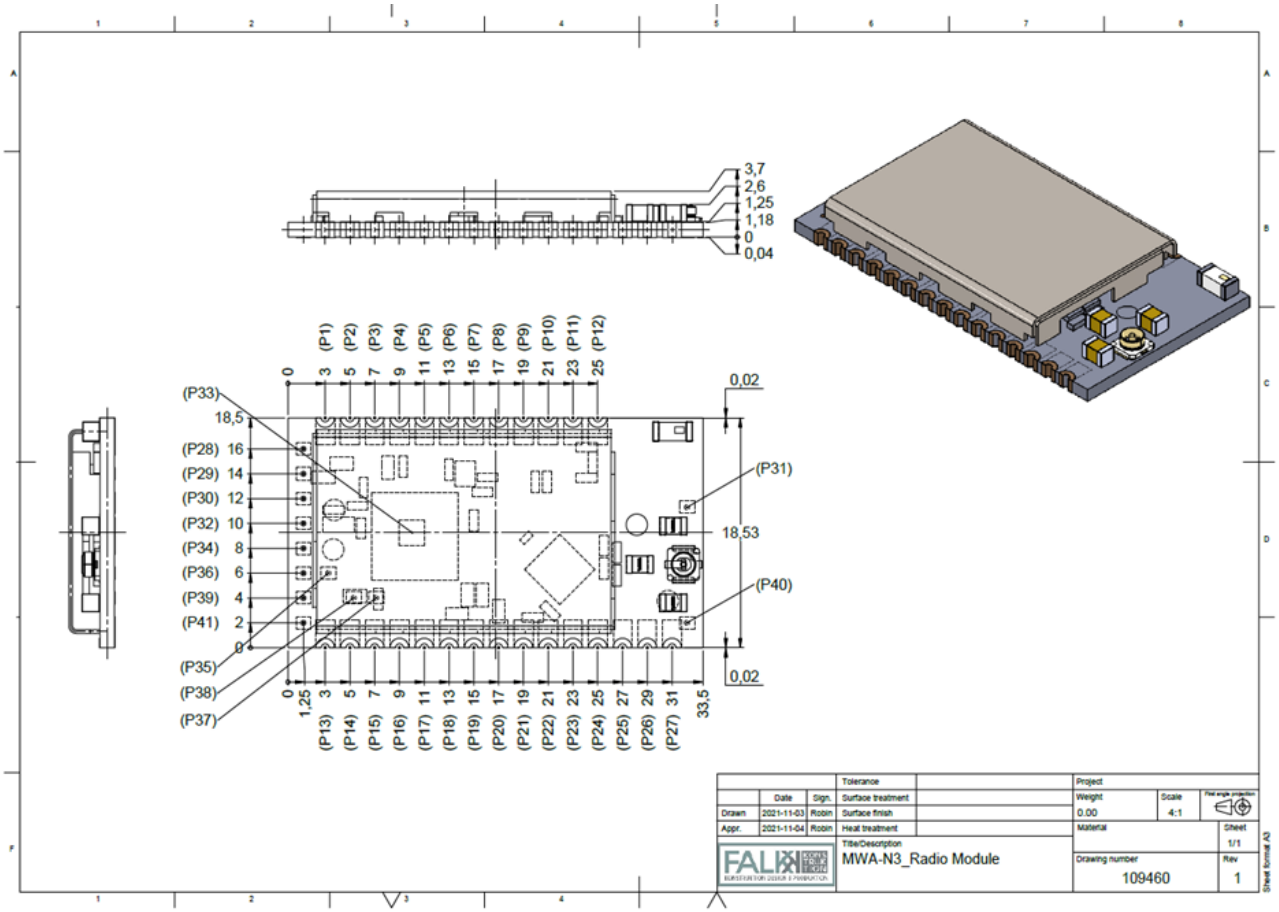
| Symbol | Parameter | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|
| VIL | Input voltage logic low | 0 | | 0.3*VDD | V |
| VIH | Input voltage logic high | 0.7*VDD | | VDD | V |
| VOL | Output voltage logic low | 0 | | 0.4 | V |
| VOH | Output voltage logic high | VDD-0.4 | | VDD | V |

## RF performance

RF performance below is valid at an ambient temperature of 25℃ and a supply voltage of 3.3 V.

| Symbol | Parameter | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|
| f-range | Operating frequency range | 2402 | | 2480 | MHz |
| RXsens | Receiver sensitivity (0.1%BER) | | -96 | | dBm |
| TXpout | TC output power | | 19.5 | | dBm |

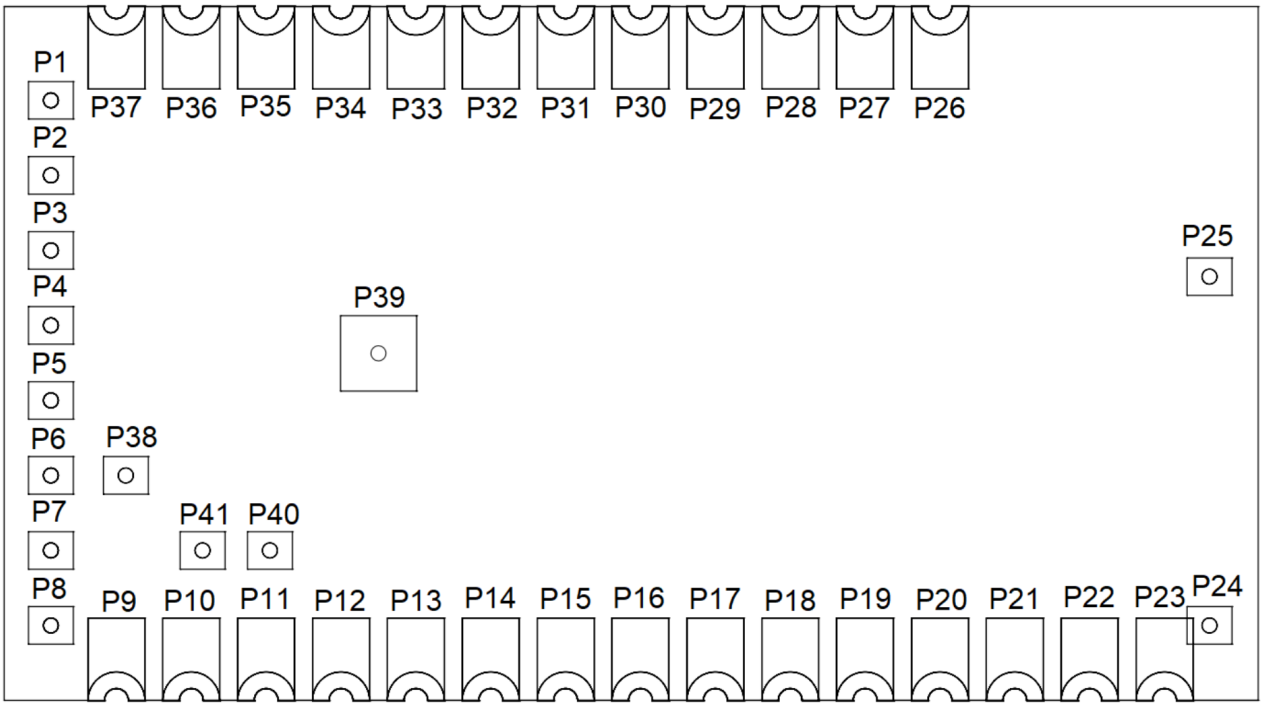
## Mechanical specification




All dimensions in mm. The W-DALI OEM module is implemented on the LumenRadio MWA-N3 radio module. Mechanical design files in .stp and .dxf format is available for download at the LumenRadio online support page.

# Pin assignments

## Pin functions




Module seen from top.

| No | Name | Type | Description |
|---|---|---|---|
| P1 | VSS | Power | Ground (0V) |
| P2-P3 | N.C. | No connection | Do not connect |
| P4 | TxD | UART transmit | Reserved for future use |
| P5 | RxD | UART recieve | Reserved for future use |
| P6 | N.C. | No connection | Do not connect |
| P7 | VSS | Power | Ground (0V) |
| P8 | N.C. | No connection | Do not connect |
| P9 | VSS | Power | Ground (0V) |
| P10 | SUBNET | Digital input | High: subnet 2, Low: subnet 1. Internal Pull up |
| P11 | CTRL | Digital input | High: idle, Low: active. Internal Pull up |
| P12-P22 | N.C. | No connection | Do not connect |
| P23-P27 | VSS | Power | Ground (0V) |
| P28-P30 | N.C. | No connection | Do not connect |
| P31 | DALI RX 2 | DALI recieve pin 2 | Active high |
| P32 | DALI RX 1 | DALI recieve pin 1 | Active high |
| P33 | DALI TX 2 | DALI transmit pin 2 | Active low |
| P34 | DALI TX 1 | DALI transmit pin 1 | Active low |
| P35 | N.C. | No connection | Do not connect |
| P36 | VDD | Power | Supply (3.3V) |

| No | Name | Type | Description |
|---|---|---|---|
| P37 | VSS | Power | Ground (0V) |
| P38-41 | N.C. | No connection | Do not connect |

The W-DALI Node module also has an RF antenna connector on the top of the module. This is reserved for future use of external antenna.

## DALI TX pin description

Pins P33, P34 are both used for transmitting DALI serial data and may be connected to each other externally. The polarity is active low, similar to the DALI protocol polarity, and thus an external pull up is recommended to avoid undefined behaviour during power off.

An external transistor circuit is needed to sink the required DALI Bus PSU current, see the reference design section for an example.

## DALI RX pin description

Pins P31 and P32 are both used for recieving DALI serial data and may be connected to each other externally. An external pull up is recommended. The polarity is active high, meaning that an active DALI bus (low voltage) shall correspond to high voltage on the input pins. Thus, external polarity flip and voltage shift circuitry is necessary, which can be achieved with only a few components. See the reference design section for an example.

## CTRL pin description

The CTRL pin is used for two functions. The first being to trigger a reset to factory default upon release of the pin after being held low for >3s during operation. This will disconnect the module from any mesh network that has been set up. The second function is to put the module in bootloader mode if the pin is held low during power on. This is a reserved mode that shall be avoided but is included here for transparency.

The CTRL pin is active low and has an internal pull up.

| CTRL pin action | Effect |
|---|---|
| 0V for >3s | Factory reset of W-DALI Node module |
| 0V during power on | W-DALI Node module enters bootloader mode (reserved) |

## Subnet pin description

The subnet pin can be used to select between subnet 1 or 2 for W-DALI network setup with a LumenRadio W-DALI RIN rail gateway without the W-DALI app.

The SUBNET pin has an internal pull up.

| SUBNET pin level | Effect |
|---|---|
| Low | Node module will join gateway set to subnet 1 |
| High or floating | Node module will join gateway set to subnet 2 |

### UART pin description

Pins P4 and P5 expose a UART interface to the W-DALI Node module. It is reserved for future use.

### RF antenna connector

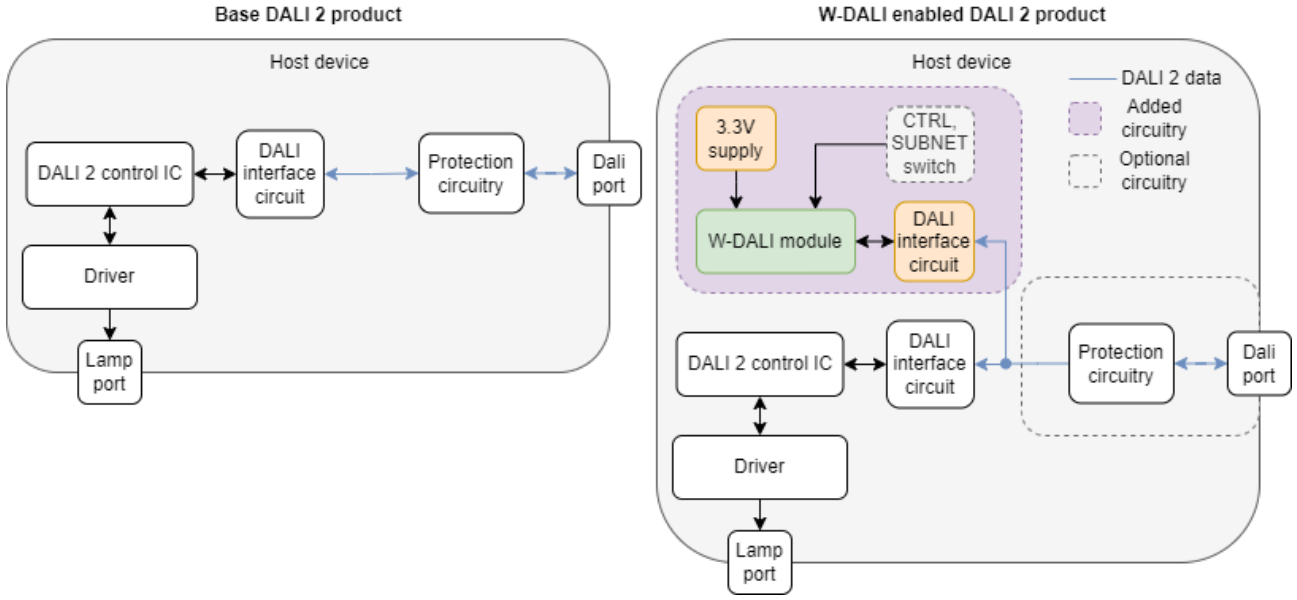
The top of the W-DALI Node module features an RF antenna connector of u.FL type. This is reserved for future use of an external antenna option for improved range.

## Integration overview

This section provides a top level view of the complete process of integrating the W-DALI Node module into a product.

### Block diagram

A typical OEM integration may look like the block diagram below. The base OEM product has a IEC 62386-interface to which the LumenRadio W-DALI OEM module is connected together with some limited external circuitry for DALI interface and power supply. By introducing the W-DALI module, the external DALI-2 port and related protection circuitry may be removed to obtain a pure W-DALI device. Note that an internal DALI PSU is needed in this case. Optionally, the external DALI-2 port may be kept which will allow for connection of up to 9 additional DALI-2 units on a local bus, all kept individually adressable from the DALI-2 controller connected to the W-DALI Root.




### Step by step

Given a base product with an existing DALI-2-interface, the replacement of the external DALI terminal interface with the LumenRadio W-DALI module could include the following steps:

- Provide a suitable 3.3V power supply. See Power supply recommendations for details.
- Provide interface circuitry between W-DALI module and IEC 62386 bus of host product. See reference designs section for details.
- Decide between internal and external PSU

- Decide if to keep external DALI terminal
- Integrate the W-DALI module on a host PCB. See Layout considerations for details.
- Perform compliance testing for market access

### Common mistakes

The integration of the W-DALI Node module is straightforward, but for optimal RF performance it is important to follow the power supply and layout considerations. Failure to do so may result in inferior RF performance. Some important highlights to avoid the most common mistakes are shown below:

- The carrier PCB shall be of the recommended type and have a proper ground plane
- Product enclosure and carrier PCB shall adhere to the clearance recommendations
- Product enclosure shall not block radio-signals
- Power supply pins shall have sufficient decoupling

## Functional description

### Supported DALI commands

The list below specifies the currently supported list of substandards of IEC 62386. Any future additions are made available to already deployed modules via LumanRadios Firmware Over The Air feature in the W-DALI app.

| IEC 62386 subpart: | Description | Status |
|---|---|---|
| 101 | General requirements – System components | 16 and 24bit fame formats supported<br>Backward frames supported<br>Proprietary forward frames or other frame formats not supported |
| 102 | General requirements – Control Gear | 7 device types are supported per device<br>Memory banks 0 and 1 are supported |
| 103 | General requirements – Control devices | Memory banks 0 and 1 are supported |
| 205 | Incandescent lamp dimmer | Supported |
| 207 | LED (DT6) | Supported |
| 208 | Switching | Supported |
| 209 | Colour control (DT8) | Supported |
| 250 | Integrated Bus Power Supply | Supported |
| 251 | Luminaire Data | Supported |
| 252 | Energy Data | Supported |
| 253 | Diagnostics & Maintenance Data | Supported |
| 301 | Push buttons | Supported |
| 302 | Absolute input devices | Supported |
| 303 | Occupancy sensors | Supported |
| 304 | Light sensors | Supported |

W-DALI reads the following parts of the memory banks as defined in the standards:

| IEC 62386 subpart: | Read memory banks |
|---|---|
| 201 | 6 memory cells |
| 202-204 | 15 memory cells |
| 205 | 28 memory cells |
| 206 | 32 memory cells |
| 207 | 7 memory cells |
| 208 | 51 memory cells |

Furthermore, the following limitations apply:

- Max 64 part 102 devices (including devices having the same short addresses).
- Max 64 part 103 devices (including devices having the same short addresses).
- Memory writing (WRITE MEMORY . . . ) commands are not supported.
- RESET is only supported for short address addressing and only when there are no duplicates.

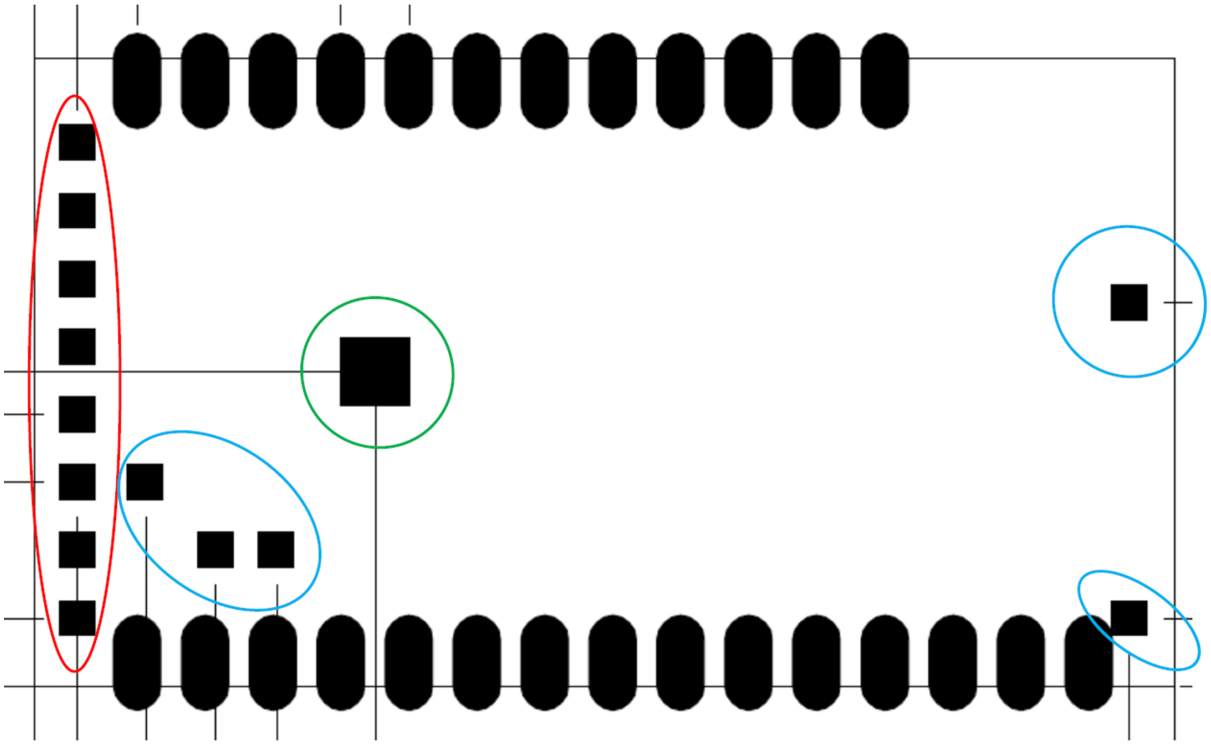
### W-DALI App

Any product with an integrated W-DALI module is compatible with the W-DALI App from LumenRadio. It will simplify commissioning of the system and can be used to perform upgrade of device FW.

## Layout considerations

Electrical and mechanical design files are available for download at the LumenRadio online support page.

## W-DALI OEM module pad dimensions

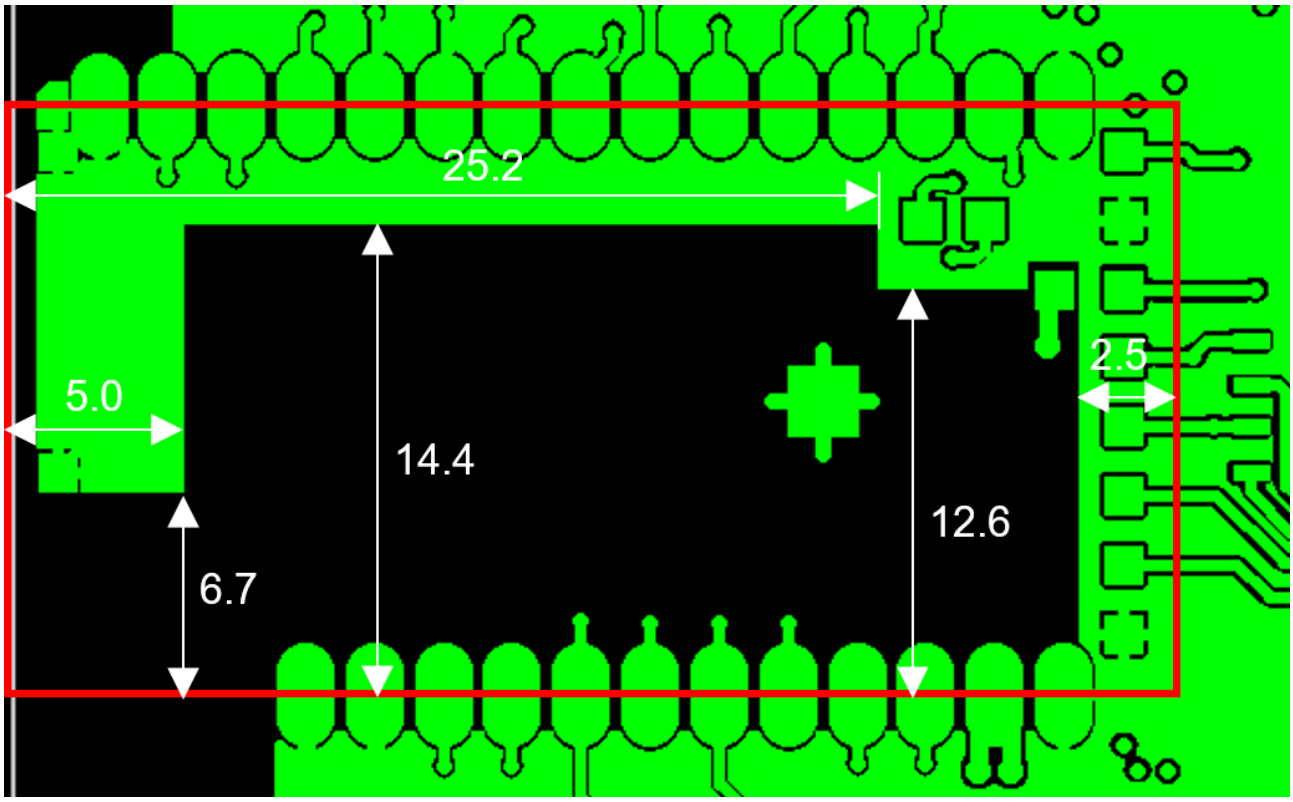


Refer to the picture above. All units in mm. - Oblong 1.4 x 2.79 (oblong edge a half circle with diameter 1.4) - Small rectangles left edge 1.0 x 0.8 (red) - Small squares right edge 1.02 x 1.02 (blue) - Large square 2.0 x 2.0 (green)

## Layout considerations for the main board

The W-DALI module has been specifically designed to achieve optimal RF performance. To maintain this, there are some important guidelines that is recommended to follow:

- The use of ground planes also on the carrier board for the W-DALI module cannot be emphasized enough. Good decoupling of any high-speed digital circuitry utilized on the carrier board is a must. Many embedded type microprocessors today have clock frequencies with clocks or overtones that reach well into the GHz range. It is possible for an embedded design to pass any EMC certification and still cause disturbances that will block the RF reception of the W-DALI module. The sensitivity of the W-DALI receiver is -96dBm therefore it is recommended to keep disturbances below -100dBm in the frequency range of operation. A near field probe connected to a spectrum analyzer will show if there are any disturbances present on the 2.45 GHz band generated by the microprocessor or any other device that is placed on the main board. Pay special attention to readymade LAN-products “Server in a RJ connector”. They pass EMC certifications, but some of them radiate badly on 2.45 GHz. If disturbances can be seen on a spectrum analyzer - then the W-DALI module will have impaired reception.
- W-DALI OEM module has a supply voltage decoupling on the circuit board. The supply voltage still needs to be adequately filtered. If any disturbance or intermittent communication failures occur, as one of the troubleshooting steps; check the supply voltage for drop-outs, switch supply ripple etc.
- The top layer inside the W-DALI module footprint must be free from copper as indicated in drawing below. There is a ground plane on the W-DALI module bottom layer, but there are also supply lines. It is an unnecessary risk to rely on solder mask lacquer for isolation.

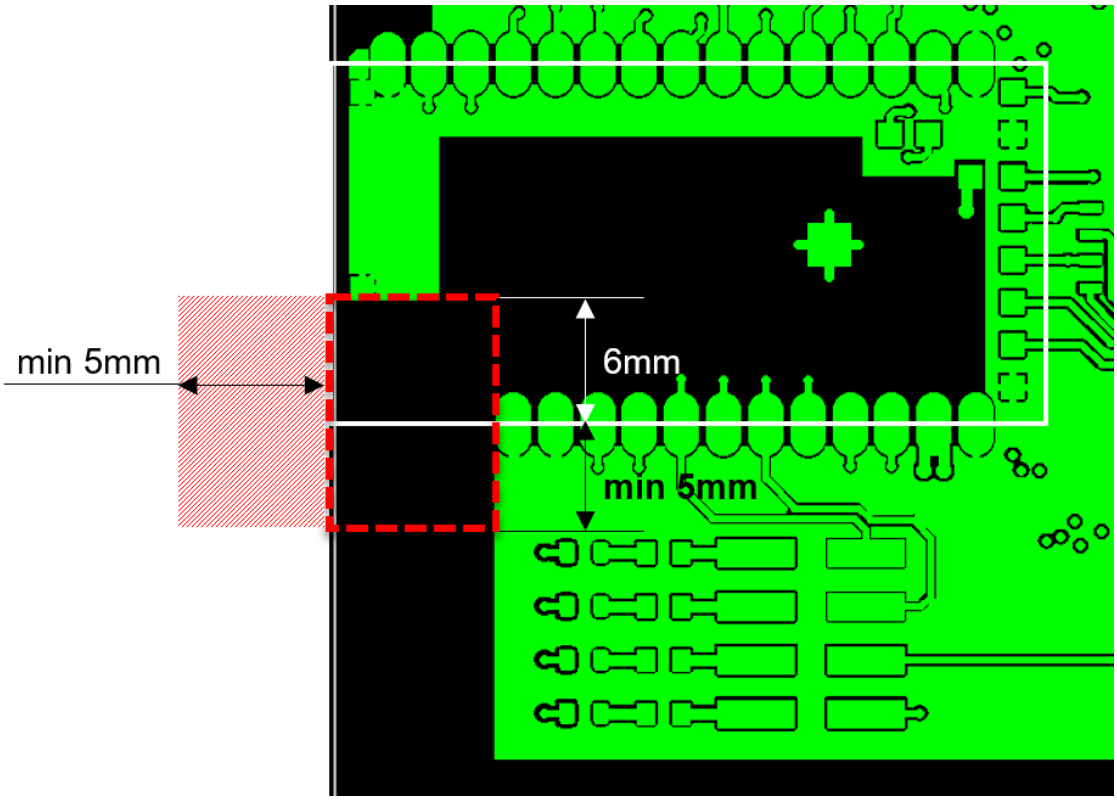



## Guidelines for optimal performance for the internal antenna

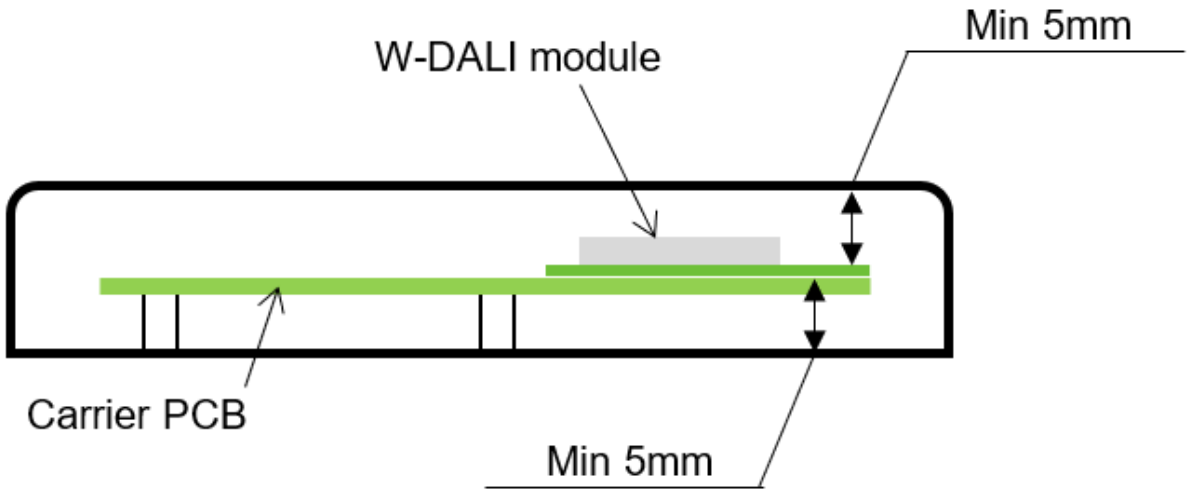
It is important to consider the guidelines for the internal antenna. Failure to do so may result in inferior performance.

The W-DALI module has been tested on 1.6mm carrier boards of the brands ITEQ IT180 and Isola 370HR. For optimal performance it is recommended to use those for the carrier board design or a PCB with similar specification.

Minimum dimensions for ground plane clearance for optimum antenna performance are shown below. The W-DALI module board edge shall align with the carrier PCB edge, and the area within the red dashed rectangle shall be free from any traces, copper, or components an all carrier PCB layers. The white solid line represents the W-DALI module board outer edge. The area marked with the striped -pattern is a keep-out area for any solid material including carrier board PCB material.



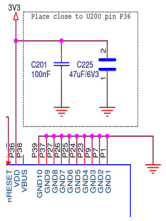

The keep-out area extends from the module PCB surface in the vertical directions as well. Note that the carrier board thickness can be included i the total distance below the module, so that given a 1.6mm carrier board, its standoff shall be minimum 3.4mm.



## Power supplyrecommendations

The W-DALI Module is designed for 3.3V operation. All pins should not have any power applied to them before the +3.3V rail is applied.

To ensure reliable operation, the supply pin should be decoupled with a 100nF ceramic capacitor close to the supply pin. It is also recommended to add a high value ceramic bulk capacitor, such as 47uF, which will reduce the current ripple of the 3.3V net.

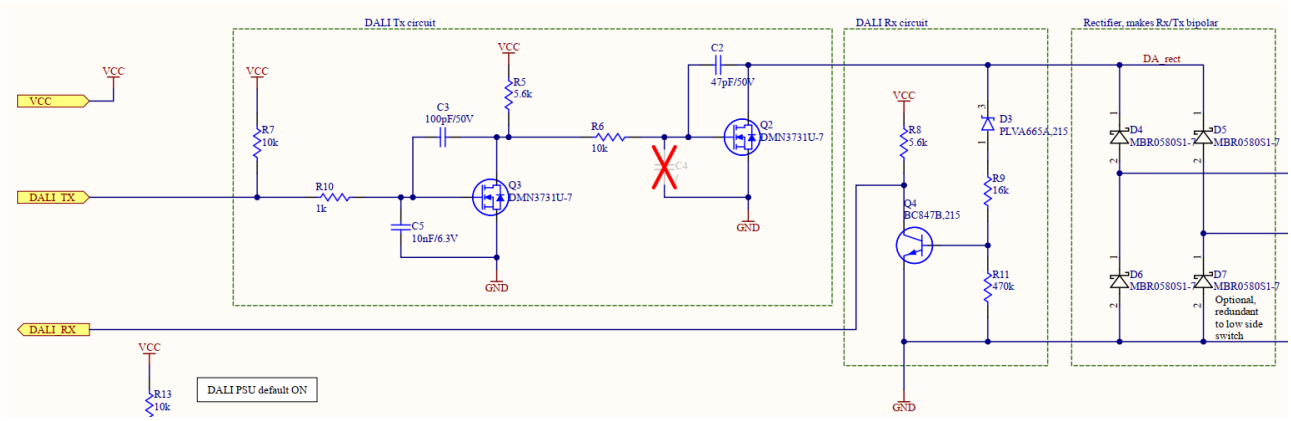



During radio transmission, current consumption will rise sharply to 150mA typical, 250mA max. A typical slew rate value is 300A/s during radio transmission.

| Symbol | Parameter | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|
| VDD | Supply voltage | 3.0 | 3.3 | 3.6 | V |
| Vrise | Supply rise time (0 V to 3.7V) | | | 60 | ms |
| IDD | Supply peak current capability | | 150 | 250 | mA |
| IDD_rate | Supply current slew rate | | 300 | | A/s |

## Reference designs

### Example: DALI interface circuitry




Show BOM list

A DALI interface circuit to connect the W-DALI module to a DALI bus can be constructed as in the design above.

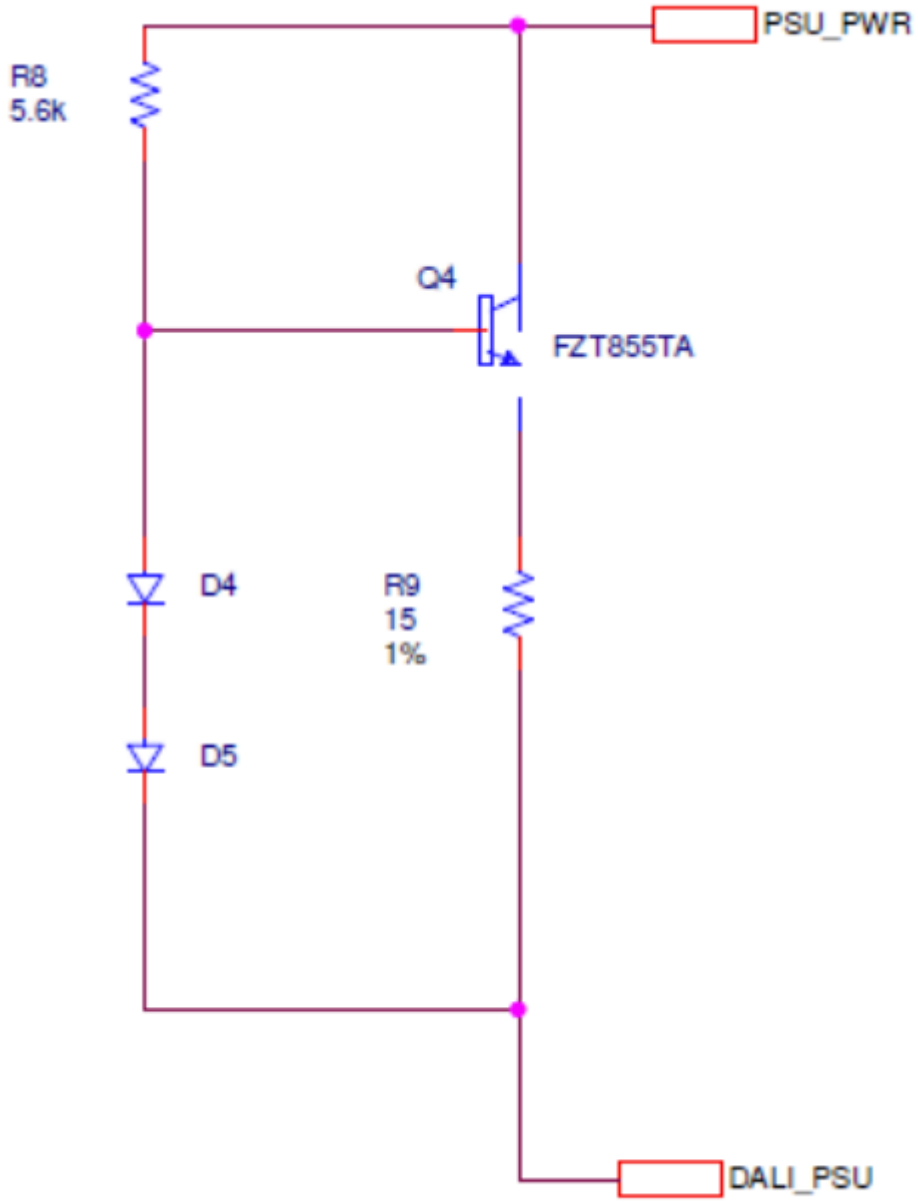
**DALI Tx circuit:** Purpose: allow device to sink the required current during DALI transmission. DALI TX offpage is connected directly to the corresponding pins of W-DALI module. R7 is used as an external pull up to keep the bus at defined inactive state if the DALI module is restarted or similar. R10, C3, and C5 are all used to trim the on and off slope of Q3 FET which acts as a signal polarity inverter. It in turn controls the gate of Q2, which is the main current sinking FET and must be able to continously sink 260mA if it is used to connect to a DALI bus according to IEC 62386. C2, R6, and R5 can all be trimmed fo adapt signal slope.

**DALI Rx circuit:** The purpose of this circuit is to separate W-DALI module from the high voltages of the DALI bus. It also polarity flips the signal voltage so that 3.3V at DALI_RX pin corresponds to an active bus. Q4 is operated in saturation mode and its base voltage is controlled by the R9 and R11 divider together with the D3 zener. If the DA_rect voltage is below the D3 breakdown voltage, no current will flow through the Q4 base and DALI_RX net will be pulled high. If the bus is inactive with a coltage higher than the D3 breakdown voltage, reverse current will flow through D3 and correspondingly, through R9, D11 and Q4 base. This will result in a low voltage on DALI_RX due to the current through R8 and Q4 to GND.

**DA Rect:** This diode bridge rectifies the DALI bus voltage. Diodes need to be dimensioned to handle the necessary current on the bus.

Show image of rise and fall times

### Example: DALI PSU (simple)

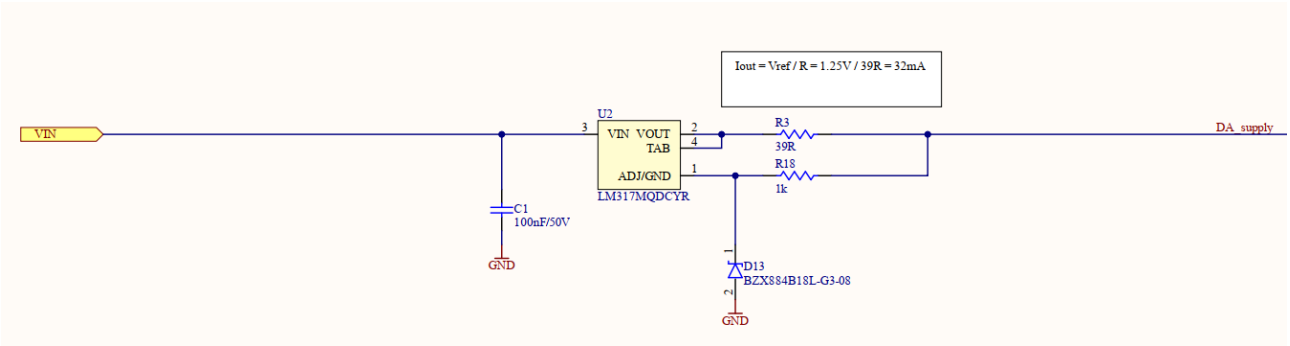



This is a simplistic but adequate low power DALI PSU circuit design. The minimum supply current for the DALI bus utilizing the above circuit is 30mA with a short circuit current of approx. 50mA. If higher supply current capabilities are required for power of a sensor from the DALI bus a more advanced DALI PSU design is required. In the circuit above the voltage drop of the base-emitter is matched by the voltage drop of diode D4. The voltage drop over D5 is therefore equal to the voltage drop of R9 which resistance will dimension the short circuit current. When the short circuit current is reached the voltage dop over R9 becomes larger than the voltage drop over D5. When this happens

the two diodes will start to conduct and the current will flow through the diodes and not to the base of Q4 which then turns off.

Show BOM list

### Example: DALI PSU (precise)




A more advanced PSU design can be achieved using the above circuit, which allow for more precise control over guaranteed PSU current while keeping the max current fairly close to the guaranteed.

The VIN pin of U2 is supplied with a constant voltage source of 17-21V. U2 tries to regulate the output voltage such that the voltage on pin 1 is 1.25V below VOUT, i.e the voltage drop over output resistance R3 shall not exceed 1.25V. If there is little current through R3 such that the drop over R3 is lower than 1.25V, the VOUT pin voltage will increase until i reaches the input rail minus dropout voltage and act as a constant voltage supply. If output current is too high, such that the voltage on pin 1 will become lower than 1.25V below VOUT, U2 will respond by lowering the output voltage and in such a way act as a current limiting circuit. Pin 1 has a high impedence input and thus the value of R18 is not critical.

Show BOM list <!— |Refdes |Item name |Manufacturer | Part number | |——-|————————-|————— |————| |C1 |Cap 100nF | | | |U2 |LM317 linear regulator |TI | LKM317MQDCYR | |R3 |Res 39R | | | |R18 |Res 1k | | |

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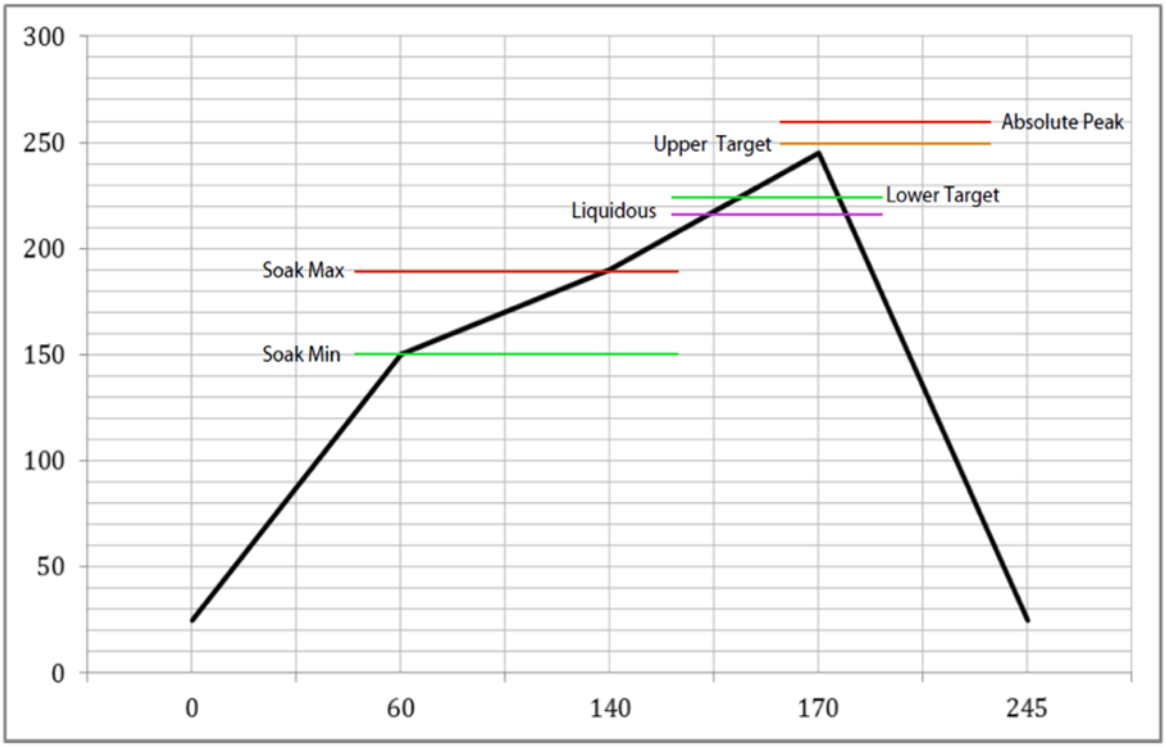
## Reflow soldering specification

The W-DALI module is a surface mounted device (SMD) designed to be easily integrated into high-volume production lines including reflow soldering to a PCB. It is ultimately the responsibility of the customer to choose the appropriate solder paste and to ensure oven temperatures during reflow meet the requirements of the solder paste. The W-DALI module conforms to JSTD-020D1 standards for reflow temperatures.




Temperatures should not exceed the minimums or maximums presented in the table below

| Specification | Value | Unit |
|---|---|---|
| Temperature Inc./Dec. rate (max) | 3 | ℃/s |
| Temperature Decrease rate (target) | 2-3 | ℃/s |
| Soak Temp increase rate (goal) | 0.5-1.0 | ℃/s |
| Flux soak period (min) | 70 | s |
| Flux soak period (max) | 120 | s |
| Flux soak temp (min) | 150 | ℃ |
| Flux soak temp (max) | 190 | ℃ |
| Time above Liquidous (min) | 50 | s |
| Time above Liquidous (max) | 70 | s |
| Time in target reflow range (goal) | 30 | s |
| Time at absolute peak (max) | 5 | s |
| Liquidous temnperature (SAC305) | 218 | ℃ |
| Lower target reflow temperature | 225 | ℃ |
| Upper target reflow temperature | 250 | ℃ |
| Absolute peak temperature | 260 | ℃ |

## Product verification guideline

TBA

<!— No content yet >

## Contact and ordering information

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The LumenRadio support team can be reached through our support portal.

| Product | Order code |
|---|---|
| W-DALI Module 400pc reel | TBA |
| W-DALI Node DEV kit | TBA |