KUNBUS
industrial communication

Data Sheet

IO-Link Wireless Device Module
KE2640MODA1

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1 Disclaimer

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Trademark Protection

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2 Overview

KE2640MODA1 is an IO-Link Wireless system on module (SOM) that supports physical layer, data link layer and all upper layer services of the IO-Link Wireless Device as specified in the IO-Link Wireless System Extensions v1.1. The module can either be used as SOM providing the entire IO-Link Wireless Device solution on module or as communication controller for a host processor.

- Integrates TI Low Energy Wireless MCU CC2640R2F to support all physical and upper layer services of an IO-Link Wireless Device
- With power amplifier (PA)/low noise amplifier (LNA) to support TX Power range and RX sensitivity required for IO-Link Wireless system
- Single-ended RF interface for external antenna
- Small form factor (10 mm x 19 mm)

2.1 Features

- Supply voltage: 2.0 - 3.6 V
- Frequency band: 2401 – 2480 MHz
- Maximum transmission power: 10 dBm
- Pre-certified for compliance with the following radio frequency regulations
  - FCC (USA)
  - IC (Canada)
  - ETSI EN (Europe)

2.2 Application

- 2.4 GHz low-power IO-Link Wireless systems
- IO-Link Wireless Device with or without host controller
- Device products (e.g. sensors or actuators)

3 Certification

The KE2640MODA1 module is certified to the standards listed in the following table (with IDs where applicable).

Certification Body	Specification	ID
FCC (USA)	Title 47 CFR Part 15 + MPE	2AYYK-2640M1
IC (Canada)	RSS - 247 Issue 2 + RSS-102 Issue 5 (MPE)	26994-2640M1
EN (Europe)	ETSI EN 300 328 V2.2.2	n/a

3.1 North America Statements (FCC and IC)

Compliance with Federal Communications Commission (FCC) Rules

NOTICE:

This device complies with Part 15 of the FCC Rules and with Industry Canada licence-exempt RSS standard(s).

Operation is subject to the following two conditions:

(1) this device may not cause harmful interference, and

(2) this device must accept any interference received, including interference that may cause undesired operation.

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence.

L'exploitation est autorisée aux deux conditions suivantes:

(1) l'appareil ne doit pas produire de brouillage, et

(2) l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

NOTICE:

Changes or modifications made to this equipment not expressly approved by KUNBUS GmbH may void the FCC authorization to operate this equipment.

Radiofrequency Radiation Exposure Information:

This equipment complies with FCC and IC radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance of 20 cm between the radiator and your body.

Digital Device Classification

NOTE: This module has been found to comply with the limits for both, a Class A digital device as well as for a Class B digital device, pursuant to Part 15 of the FCC Rules. It is the responsibility of the integrator of this module to define the environmental device classification for the final product.

3.2 FCC and IC Modular Transmitter Instructions

Specific Operational Use Conditions

This module has been granted Limited Modular Approval for mobile applications. It has been certified for integration into products - by OEM integrators - without additional FCC certifications under the following conditions only:

- The module integrator should not provide information to the user of the host product regarding how to install or remove this RF module. The user manual for the host product must clearly indicate the operating conditions for the product to ensure compliance with the FCC RF exposure guidelines.
- If this module is integrated in host products with several transmitters, the host product must be evaluated to comply with FCC and Industry Canada multi-transmitter product procedures.
- The module integrator must follow the antenna and RF exposure considerations mentioned in the chapters below. The module integrator must also ensure that RF related parameters are not configurable in a way that violates the RF exposure considerations by the customers.
- The host product must have a label which clearly indicates that this module is contained in the product. The FCC-ID and IC must be referenced. The following or similar labels must be used:
  “Contains FCC ID: 2AYYK-2640M1 ”
  “Contains IC:26994-2640M1 ”.

To be authorized as an FCC Part 15 device, the host product may also need to be evaluated against the FCC Part 15B criteria’s for unintentional radiators.

Limited Module Procedures

As the module is not equipped with an antenna, the module integrator is responsible to meet the necessary requirements. This document gives the design guidelines for host integration of the reference antennas, which were used for certification.

Trace Antenna Designs

Not applicable.

RF Exposure Considerations

The host product manufacturer must ensure that a separation distance of 20 cm or more is maintained between the host product’s antenna and persons during operation. This should be clearly indicated in the user manual of the host product.

If more than one module of this type, or other wireless modules, are integrated in the host product, additional FCC and Industry Canada multi-transmitter product procedures apply and the product must be evaluated according to these requirements.

Antennas

The module is not equipped with an antenna. The host product’s maximum RF output power and exposure limits must comply with the FCC regulations. The module complies to the regulations when used with one of the following antennas:

- U.FL connector dipole antenna (gain 2.8 dBi): https://linxtechnologies.com/wp/product/lpw-series/
- OnBoard SMD 2400 Antenna (gain 4.9 dBi): https://proantantennas.com/onboard-smd-2400-antenna/

Host integrators may use these antennas for their product designs. Other antennas of the same type are also acceptable if the maximum gain including cable loss is not exceeding these limits. This document gives the necessary guidelines for host PCB designs using the referenced antennas.

To support different antennas, the module must be configured with the correct antenna gain setting via the host controller software library, that is required for module operation. The antenna gain setting is described in this document. The module integrator must choose the adequate antenna gain setting for his antenna to meet the requirements. It is also the responsibility of the module integrator to ensure that the gain setting is not configurable by the user of the host product.

Label and Compliance Information

The host product using this module must be labeled clearly indicating the contained FCC-ID and IC. These or similar labels must be used:

“Contains FCC ID: 2AYYK-2640M1 ”

“Contains IC: 26994-2640M1”.

Test Modes

The module supports different test modes on specified test channels. These test modes can be activated via the host controller software library, which is required for the module operation. The following test mode configurations are considered most suitable for compliance testing:

– Continuous transmit test mode with random payload (PN9 sequence), IO-Link Wireless power level 31 (max. 10 dBm), transmit frequency 2401 MHz (lowest IO-Link Wireless configuration channel)

– Continuous transmit test mode with random payload (PN9 sequence), IO-Link Wireless power level 31 (max. 10 dBm), transmit frequency 2480 MHz (highest IO-Link Wireless configuration channel)

Additional Testing, Part 15 Subpart B Disclaimer

The module itself is not required to be evaluated for FCC Part 15B unintentional radiator requirements. The host product must be evaluated for FCC Part 15B.

4 Key Specification

The absolute maximum ratings are as follows:

Parameter	Nominal Data Min	Nominal Data Max	Note
Supply voltage	0 V	4 V	
Input RF level	-	4 dBm	
Operating temperature range	-40 °C	+85 °C	
V_{ESD} - Human Body Model (HBM), per ANSI/ESDA/JEDEC/JS001[1]	-2500 V	2500 V	All pins
V_{ESD} - Charged Device Model (CDM), per JESd22-C101[2]	-750 V	750 V	RF pins
	-750 V	750 V	Non-RF pins

[1]JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process

[2]JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process

The following table gives an overview of the recommended operating conditions.

Parameter		Nominal Data Min	Nominal Data Typ	Nominal Data Max	Note
Supply voltage		2.0 V	3.3 V	3.6 V	Power ripple should not exceed 30 mV peak to peak
Operating temperature range		-40 °C	-	+85 °C	-
Storage temperature range		-40 °C	-	+85 °C	-
Frequency band		2401 MHz	-	2480 MHz	-
Operating Humidity		0 %	-	90 % (non-condensing)	-
Power consumption	Transmit	-	90 mA@10 dBm 46 mA@0 dBm 40 mA@-10 dBm 37 mA@-20 dBm	-	PA on, @3.3 V
	Receive	-	18 mA	-	LNA on, @3.3 V
	Idle	-	8 mA	-	PA/LNA Standby, @3.3 V
	Sleep	-	TBD	-	MCU standby, @3.3 V
Transmit power		-20 dBm	-	10 dBm	Programmable
Receive sensitivity		-91 dBm (@ 0.3 PEP typ.)			-
Communication protocol		IO-Link Wireless			-
Modulation type		GFSK			-
Communication distance (indoor) [1]		-	20 m	-	@10 dBm @3.3 V

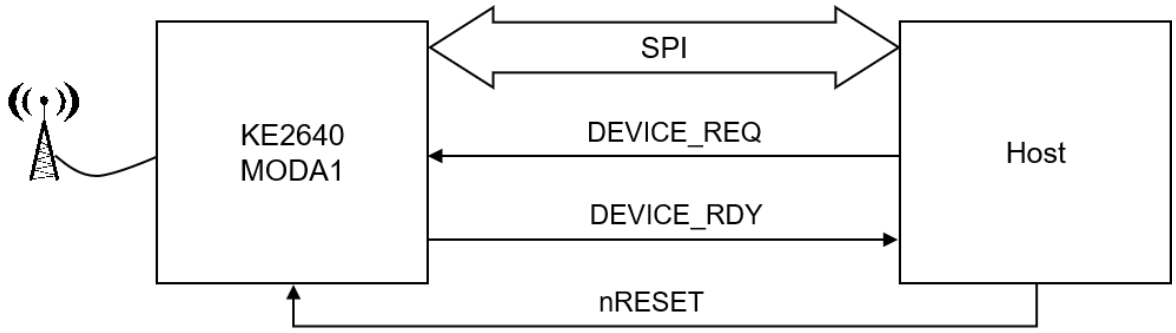
[1]"Communication distance" is generally influenced by factors such as surrounding environment. This value is just for reference.

Safety Note

This product may only be assembled, installed and put into operation by personnel qualified for working in electrostatic protected areas. It is subject to damage by ESD and may only be handled in ESD-protected environments.

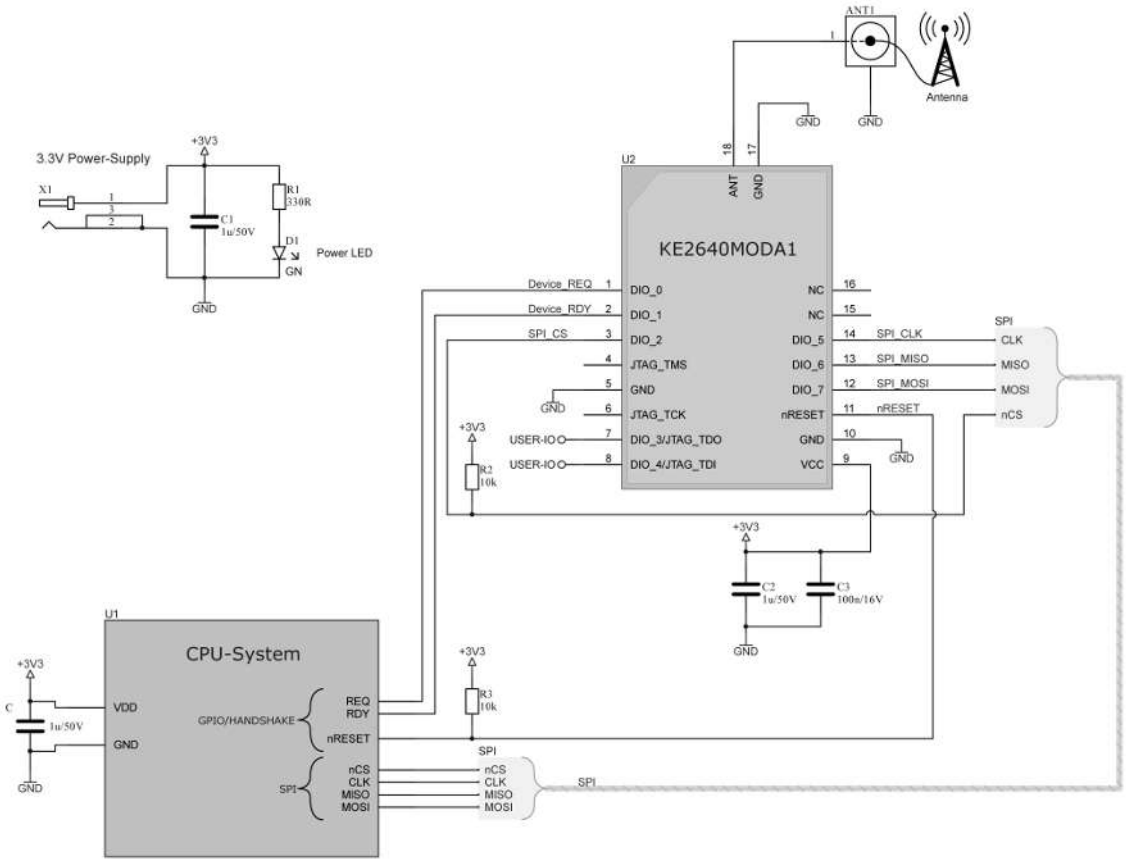
5 Block Diagram

If the KE2640MODA1 module is used with the pre-installed firmware, the following block diagram applies. It outlines the rules for the connection of the KE2640MODA1 module to the host controller.

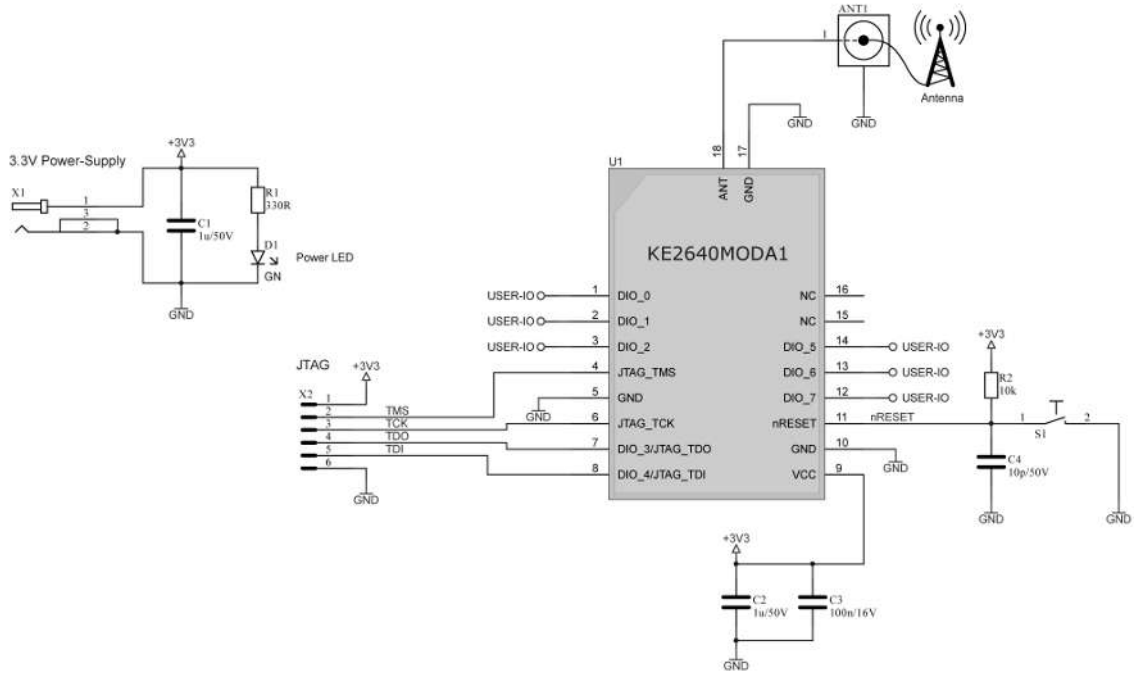


6 Typical Application Circuit

Set-up including Host CPU



Stand-alone Set-up



7 Pin Assignment

The following table gives an overview of all pin functions:

Pin	Name	Function using pre-installed firmware	Function if used as SOM
1	DIO_0	DEVICE_REQ (Input)	Digital I/O[2], high drive capability (8mA)
2	DIO_1	DEVICE_RDY (Output)	Digital I/O[2], high drive capability (8mA)
3	DIO_2	SPI_CS (Input)	Digital I/O[2], high drive capability (8mA)
4	JTAG_TMS	Debugging port	Debugging port
5	GND	Ground	Ground
6	JTAG_TCK	Debugging port	Debugging port
7	DIO_3/JTAG_TDO[1]	Debugging port	Digital I/O[2], high drive capability / Debugging port
8	DIO_4/JTAG_TDI[1]	Debugging port	Digital I/O[2], high drive capability / Debugging port
9	VCC	Voltage supply	Voltage supply
10	GND	Ground	Ground
11	RESET	nRESET (Input active LOW)	nRESET (Input active LOW)
12	DIO_7	SPI_MOSI (Input)	Digital I/O[2] / Analog I/O
13	DIO_6	SPI_MISO (Output)	Digital I/O[2], high drive capability (8mA)
14	DIO_5	SPI_CLK (Input)	Digital I/O[2], high drive capability (8mA)
15	NC	Not connected	Not connected
16	NC	Not connected	Not connected
17	GND	Ground	Ground
18	ANT	External antenna interface	External antenna interface

[1]During Debug-Mode this pin is reserved for the programming and is not applicable.

[2]The I/O controller controls the digital I/O pins and contains multiplexer circuitry to allow a set of peripherals (e.g. serial interfaces, timers) to be assigned to I/O pins in a flexible manner. All digital I/Os are interrupt and wake-up capable and have a programmable pullup and pulldown function. If configured as an output, pins can function as either push-pull or open-drain.

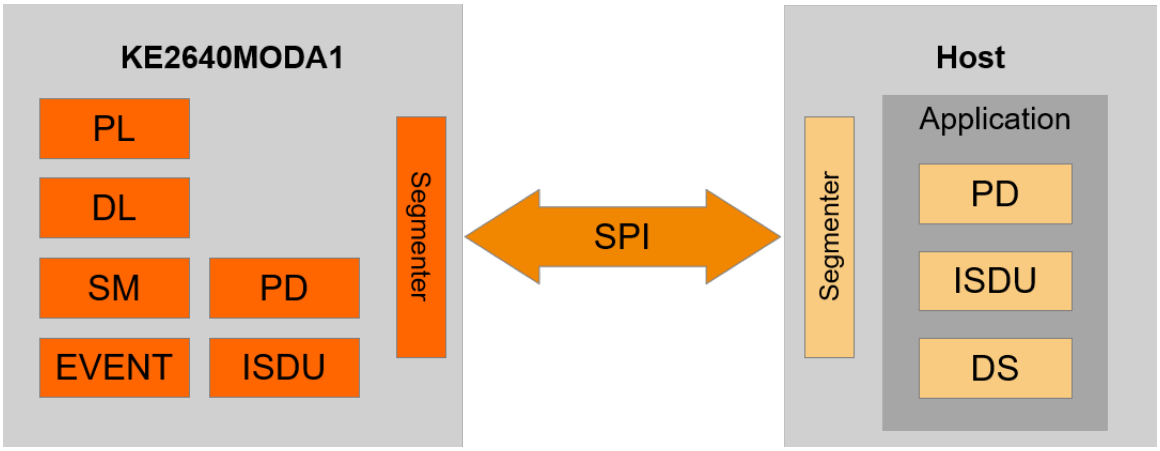
8 Firmware

The pre-installed firmware is designed for using the KE2640MODA1 module in combination with an external host controller for the user's application. Although the KE2640MODA1 module can also be used as system on module (SOM) where the user implements the application directly on the KE2640MODA1 module, the following subchapters describe only the function of the pre-installed firmware.

8.1 Pre-installed Firmware

The module is delivered with a pre-installed firmware containing the IO Link Wireless protocol stack for the IO-Link Wireless-Device. A detailed description of the protocol stack can be found in the IO-Link Wireless System Extensions v1.1 which can be downloaded from the IO-Link Homepage: https://io-link.com.

The firmware includes the implementation of the physical layer (PL), data link layer (DL), System Management (SM), indexed service data unit transfer layer (ISDU), event generation and transfer layer (EVENT) and process data transfer layer (PD). The other parts of the protocol stack like application layer containing the Data Storage (DS), Process Data (PD) and ISDU Handling shall be located on the host controller. All services are accessible via serial peripheral interface (SPI) or internally using the provided KUNBUS Wireless-Device-SPI-Library on the host controller.



8.2 Host Interface

For the connection to the host controller the KE2640MODA1 module uses a 4-wire SPI with two additional handshake signals (DEVICE REQ and DEVICE_RDY). The KE2640MODA1 module operates as SPI Slave with a maximum data rate of 4 Mbps in this configuration.

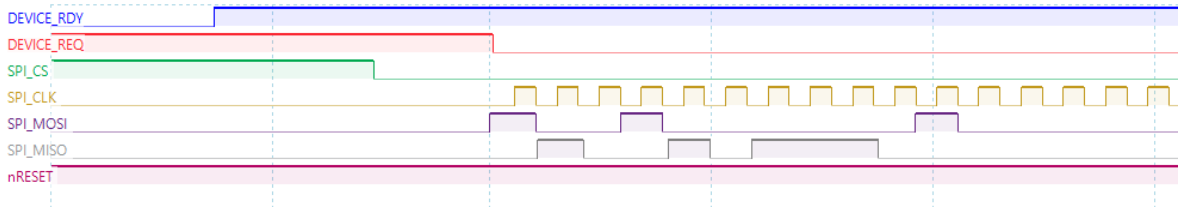
Before running a communication protocol, all pins at the host should be initialized according to the configuration listed in the following table.

Pin Name	Configuration
nRESET	Output
DEVICE_RDY	Input
DEVICE_REQ	Output (handled as interrupt on rising edge at KE2640MODA1 module side)
SPI_CS	Output

After the pins are configured, the IO-Link Wireless Module nRESET pin should be set to LOW to perform a reset of the KE2640MODA1 module. This is an important step as it is required for the synchronization of the state machines of both controllers. After the KE2640MODA1 module is set to the reset state, the SPI periphery should be initialized with the following parameters at the host controller.

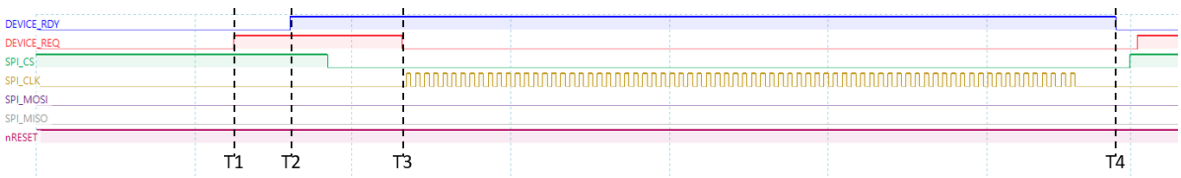
SPI Parameter	Value
SPI Mode	SPI Master
SPI Duplex	Full
Data Size	8 Bit
Clock Polarity	Low
Clock Phase	First Edge
Bit Order	MSB First
Chip Select	Manual

The SPI signals MOSI and MISO shall update on falling edges of the CLK signal and remain stable on rising edges. They are captured on rising edges of the CLK signal.



After initialization, the nRESET shall be set to HIGH by the host controller. This step leads to the initialization of the communication between the host and the KE2640MODA1 module. After the host is ready, the DEVICE_REQ pin is set HIGH by the host to trigger the KE2640MODA1 module. The DEVICE_RDY pin is set to HIGH by the KE2640MODA1 module after the initialization is finished. The purpose of this procedure is to prepare the SPI Slave for the transaction. The KE2640MODA1 module performs the initialization steps in parallel to the host. It should be considered that the initialization time of the KE2640MODA1 module and the host are not equal.

In a normal case, a single SPI transaction proceeds as shown in the following figure. After each SPI transfer, incoming messages should be processed by the host and the KE2640MODA1 module.

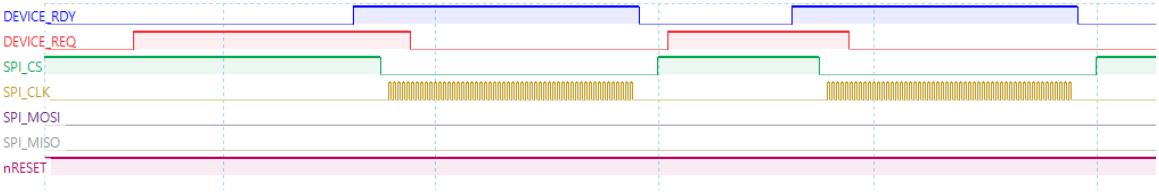


If the host has to send data to the KE2640MODA1 module it shall set the DEVICE_REQ pin to HIGH (T1) and wait until the DEVICE_RDY pin is set to HIGH (T2) by the KE2640MODA1 module. Afterwards the host can start to transmit the data. After the transmission has started the DEVICE_REQ pin shall be set to LOW (T3).

The DEVICE_RDY pin will be set to LOW by the KE2640MODA1 when it starts to process the message (T4). Then the host may set the next DEVICE_REQ and wait again for the DEVICE_RDY signal.

In the case data has to be transmitted by the KE2640MODA1 module and no DEVICE_REQ is coming from the host, the KE2640MODA1 module will set the DEVICE_RDY pin to HIGH. Then the host shall initiate SPI communication as soon as possible even if no DEVICE_REQ is pending.

If multiple transactions are caused by the host a signaling as shown in the following figure occurs. If the same is caused by the KE2640MODA1 module the only difference is an absence of the activation of the DEVICE_REQ pin.



9 Antenna Gain Setting

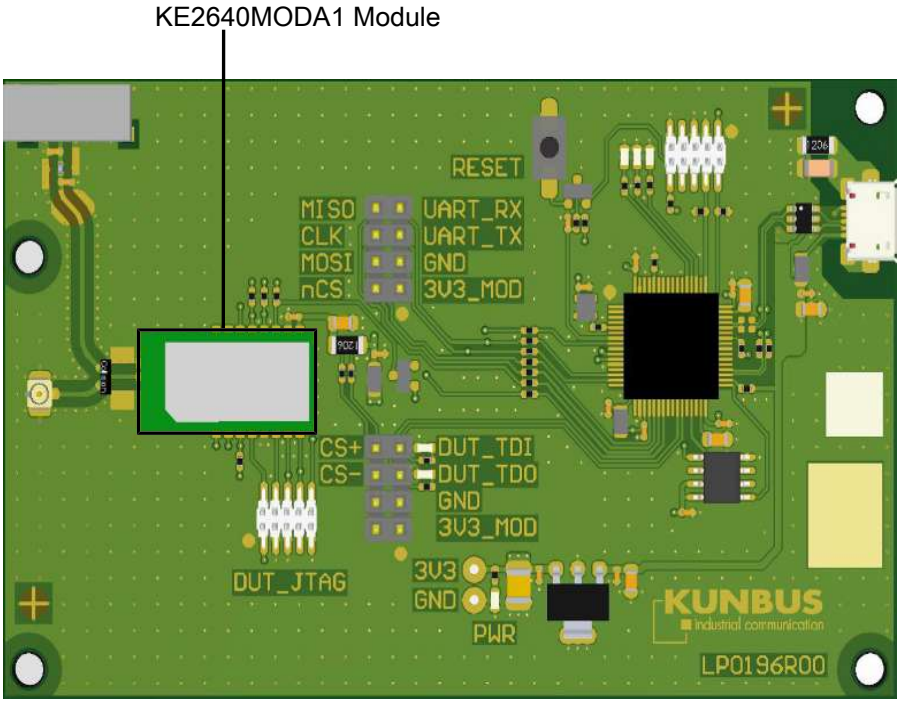
This module supports the setting of the gain of the connected antenna. The setting mechanism is accessible via the host controller software library, that is required for module operation. The gain setting mechanism reduces the maximum module output power of 10 dBm by the amount of the selected antenna gain in 1 dB steps.

For the certification of the module with its reference antennas, the following antenna gain settings were used:

Antenna	Maximum Antenna Gain	Module Gain Setting Parameter
U.FL connector dipole antenna https://linxtechnologies.com/wp/product/lpw-series/	2.8 dBi	3 dBi
OnBoard SMD 2400 Antenna https://proantantennas.com/onboard-smd-2400-antenna/	4.9 dBi	5 dBi

Note: The host integrator must use the correct gain setting for the applied antenna design to ensure compliance with the prescribed emission limits. The host integrator must also ensure that this antenna gain cannot be configured by the user of the host product.

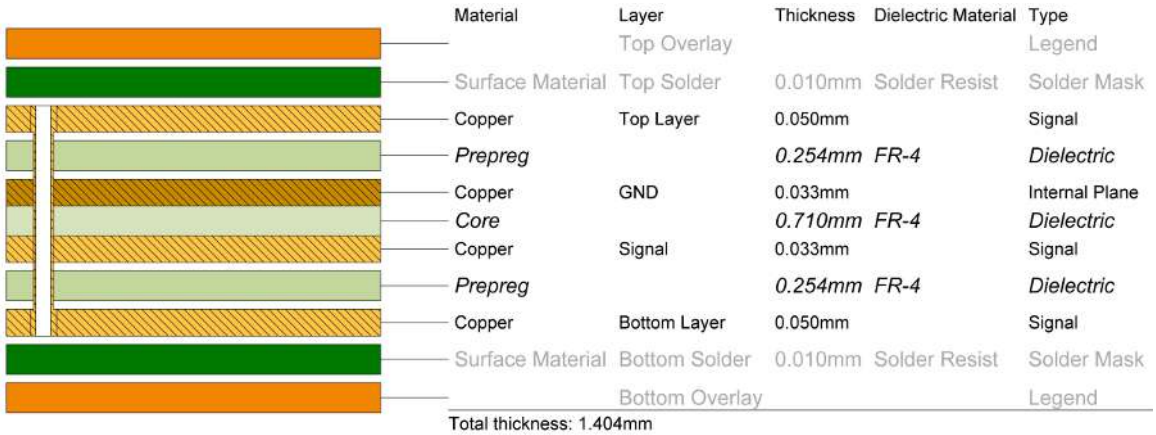
10 Layout Guidelines



10.1 PCB Specification

PCB Stack-Up

The following figure shows an example stack-up for a KE2640MODA1 design.



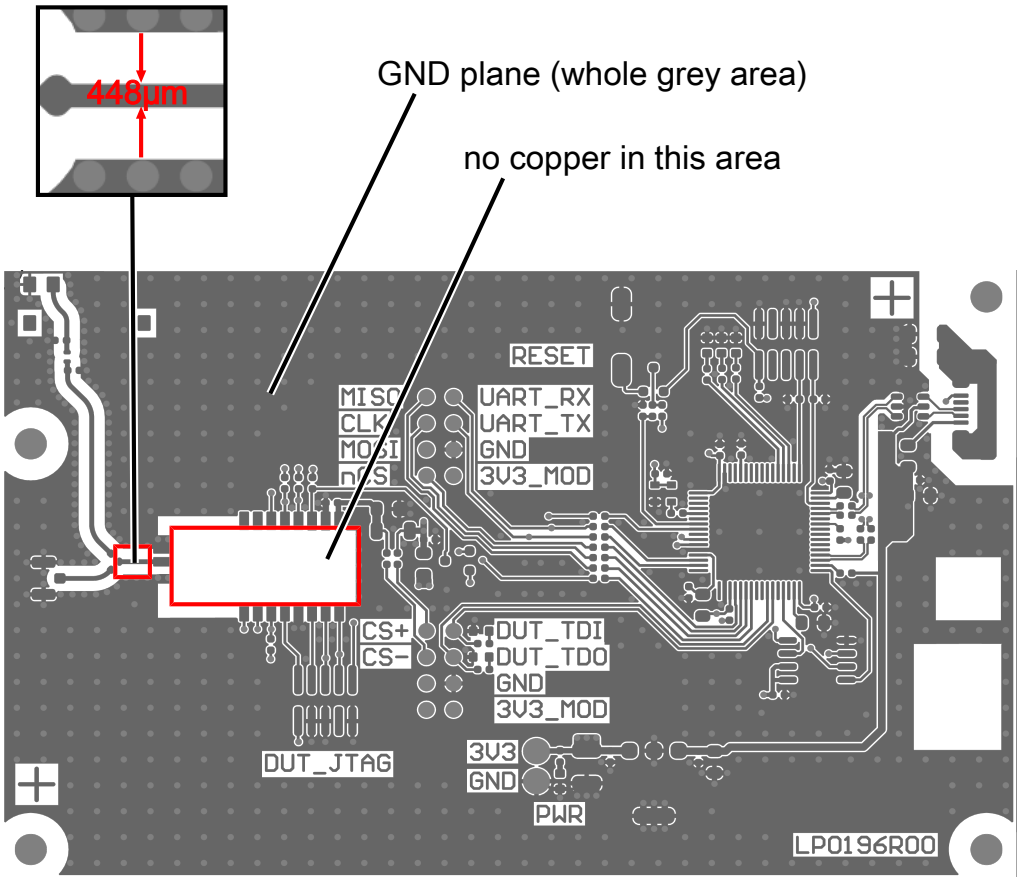
The user can adapt the layer stack-up according to his own requirements. In this case the correct impedance of 50 Ω has to be ensured. Ideally this is done in cooperation with the selected PCB manufacturer.

With this example stack-up, the width of a 50 Ω track is about 448 µm. For 100 Ω differential-pair lines the width is 200 µm with 150 µm spacing.

10.2 Layout

An example layout is shown in the following by means of a KUNBUS breakout board.

Layer 1 - Top Layer



On this layer the module is connected to its periphery. The unused areas are filled with copper that is connected to GND potential. The GND pins of the module are connected directly to this GND plane to receive best possible GND connection with low impedance. There is a copper-free area below the module to avoid short-circuits with non-isolated parts on the bottom side of the module.

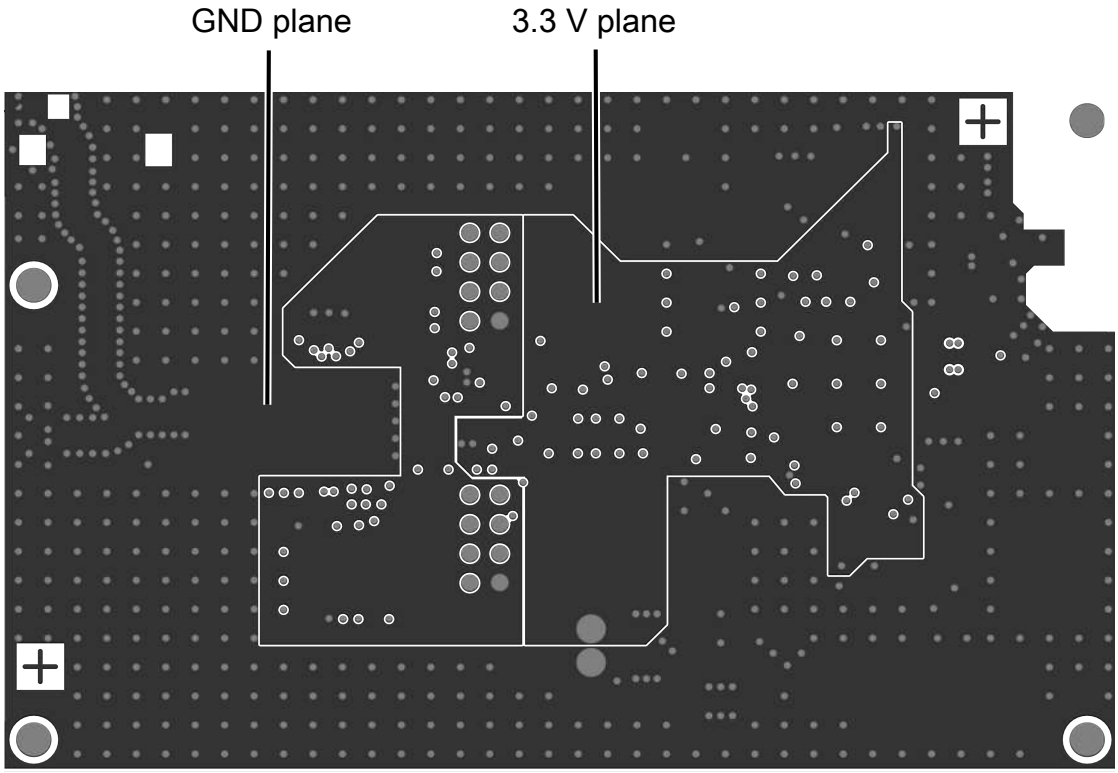
Note: The non-isolated parts on the bottom side must not be connected in order to avoid short circuits. We recommend to protect the main board by solder resist over the whole surface except at the here defined contacts.

The trace to the antenna connector has a width of 448 µm to achieve the required impedance of 50 Ω.

Layer 2 - GND

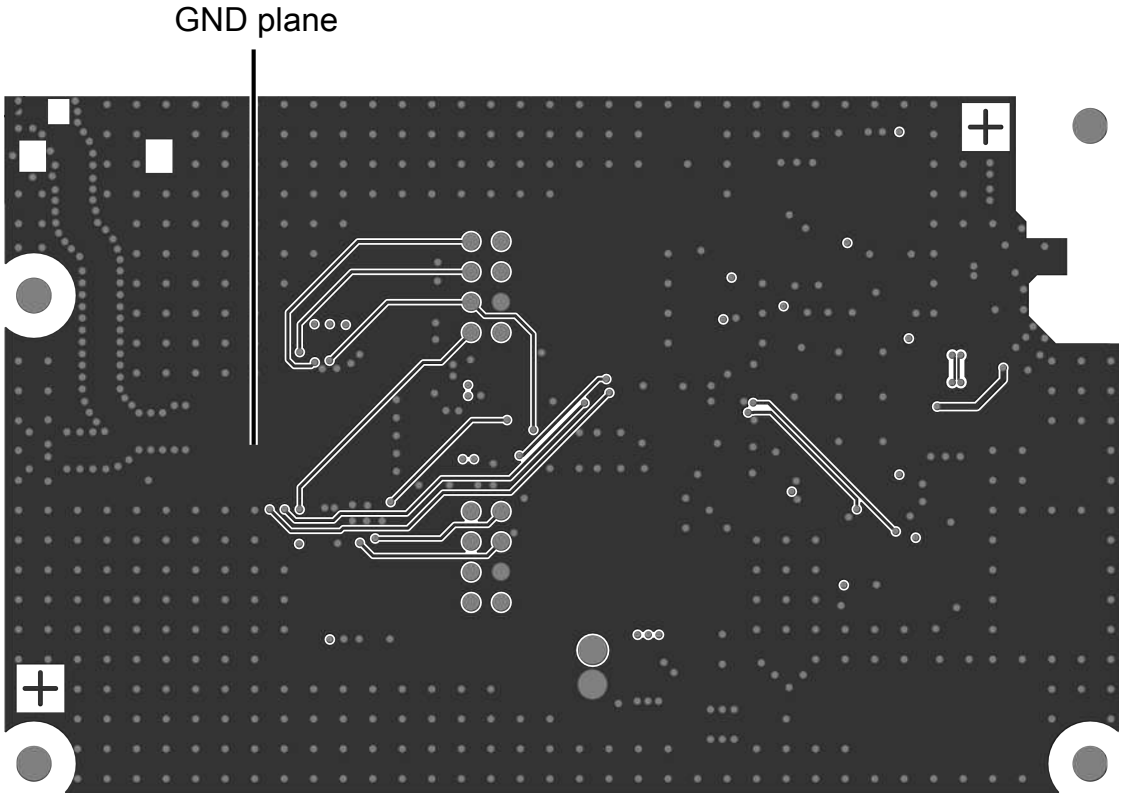
This layer is completely used as GND signal plane for all high frequency signals.

Layer 3 – Signal



This layer is used for supply planes (3.3V and GND).

Layer 4 - Bottom Layer

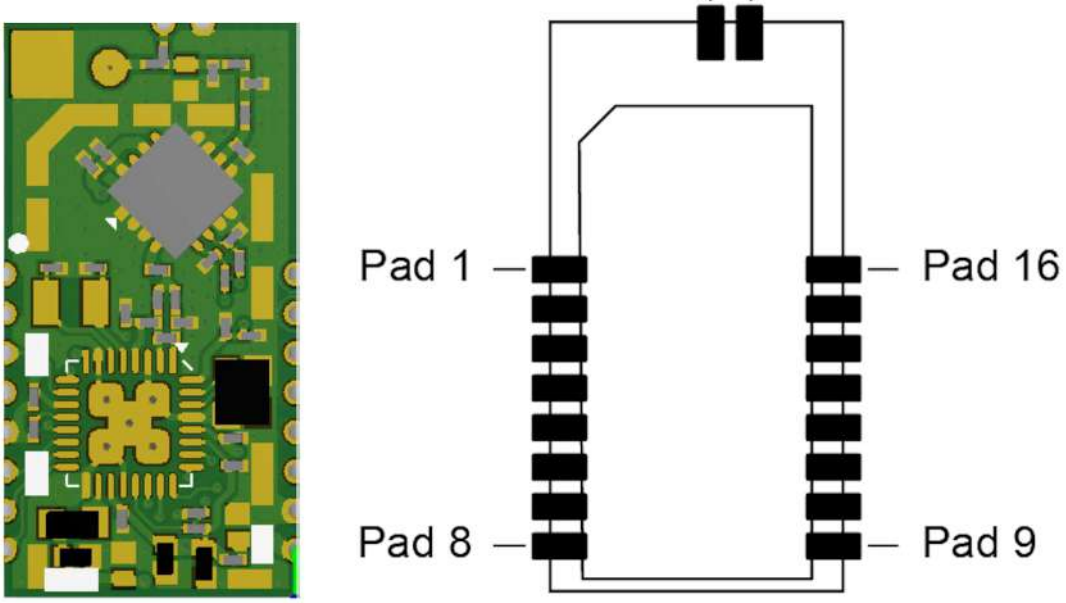


This layer is used for routing signals. Unused areas are filled with GND plane.

11 Footprint Indications

11.1 Top View

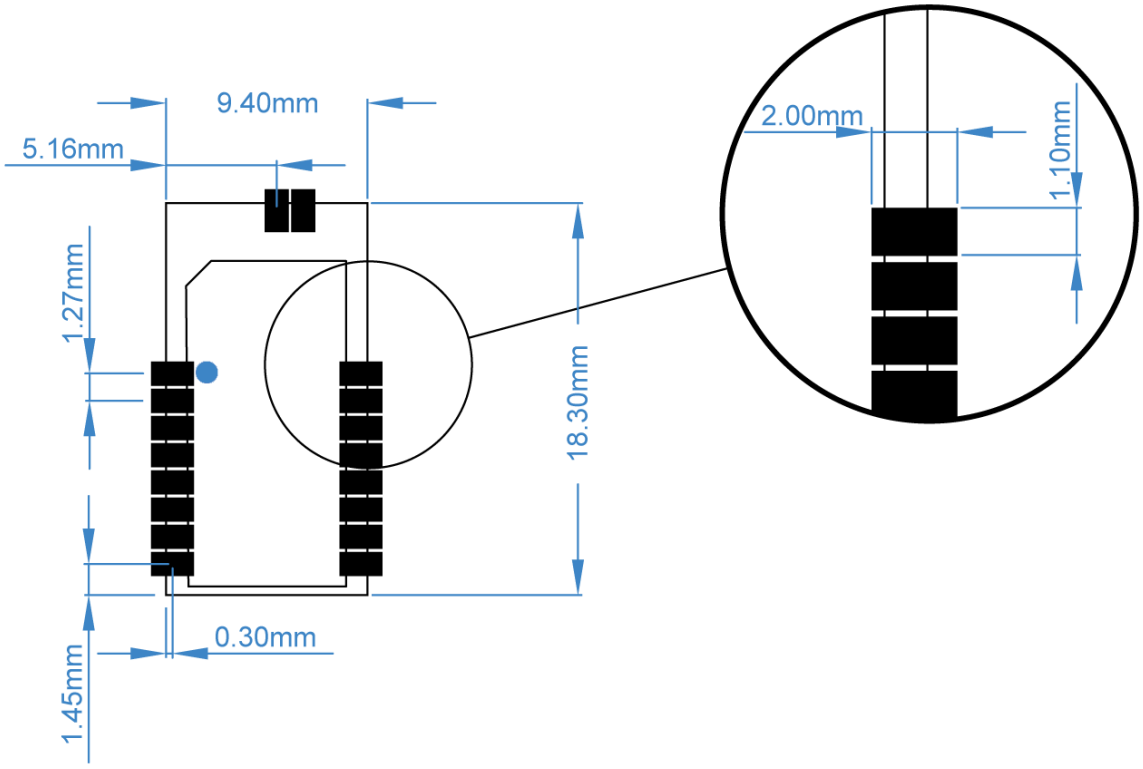
The following figures show the view on the top side of the module:



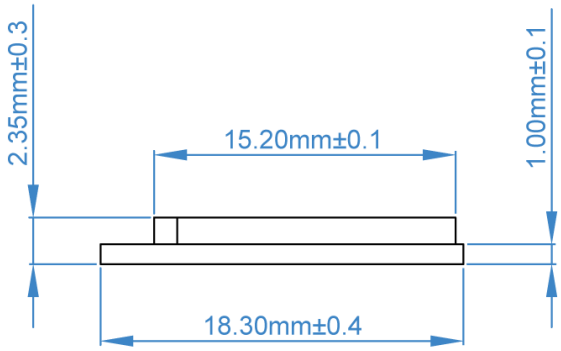
11.2 Dimensions

The outline dimensions of the module are as shown below.

Top View



Side View



Suggested Land Pattern, all dimensions in mm.

12 Contact Details

Your points of contact for all questions related to development, delivery, support and quotations are:

Address	KUNBUS GmbH Heerweg 15C 73770 Denkendorf Germany
Technical Support	E-Mail: support@kunbus.com
Sales	Tel.: +49 (0)711 300 20 678 E-Mail: info@kunbus.com

For any request, please use the following reference:

Article Name: IOLW Device Module

Order No.: 100335

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industrial communication