KUNBUS

■ industrial communication

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1 Disclaimer

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2 Overview

KE2640MODA2 is an IO-Link Wireless transceiver module that supports physical layer and data link layer services of the IO-Link Wireless Master as specified in the IO-Link Wireless System Extensions v1.1. The module is capable to serve up to 8 IO-Link Wireless-Devices as one track with a cycle time of 1.664ms.

– Integrates two TI Low Energy Wireless MCU CC2640R2F to support all physical layer services of IO-Link Wireless Master

– With power amplifier (PA)/low noise amplifier (LNA) to support TX Power range and RX sensitivity required for IO-Link Wireless system

– SPI interface for the communication with a superior CPU system, in which the higher layers of the IO-Link Wireless specification are implemented

– Single-ended RF interface for external antenna

– Small form factor (20 mm x 24 mm)

2.1 Features

– Supply voltage: 2.5 - 3.3 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

– Single or multi track IO-Link Wireless Master

3 Certification

The KE2640MODA2 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-2640M2
IC (Canada)	RSS - 247 Issue 2 + RSS-102 Issue 5 (MPE)	26994-2640M2
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-2640M2 "
"Contains IC:26994-2640M2 ".

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-2640M2 "

"Contains IC: 26994-2640M2".

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)

– Single frequency packet mode (normal IO-Link Wireless operational payload), IO-Link Wireless power level 31 (max. 10 dBm), transmit frequency 2403 MHz (lowest IO-Link Wireless data channel) or 2478 MHz (highest IO-Link Wireless data 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	3.7 V	
Input RF level	-	10 dBm	
Operating temperature range	-30 °C	+85 °C	
V_{ESD} - Human Body Model (HBM), per ANSI/ESDA/JEDEC/JS001[1]	-2000 V	2000 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 shows an overview of the recommended operating conditions.

Parameter		Nominal Data Min	Nominal Data Typ	Nominal Data Max	Note
Supply voltage		2.5 V	3.0 V	3.3 V	Power ripple should not exceed 20 mV peak to peak
Operating temperature range		-30 °C	-	+85 °C	-
Storage temperature range		-40 °C	-	+150 °C	-
Frequency band		2400 MHz	-	2480 MHz	-
Power consumption	Transmit	-	66 mA@10 dBm 60 mA@0 dBm 58 mA@-10 dBm	-	PA on, @3.3 V
	Receive	-	25 mA	-	LNA on, @3.3 V
	Idle	-	8 mA	-	PA/LNA Standby, @3.3 V
Transmit power		-18 dBm	-	10 dBm	Programmable
Receive sensitivity		-91 dBm (@ 0.3 PEP typ.)			-
Communication protocol		IO-Link Wireless			-
Modulation type		1-Mbps 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

The block diagram outlines the main functional blocks, their interconnections as well as the external connections.
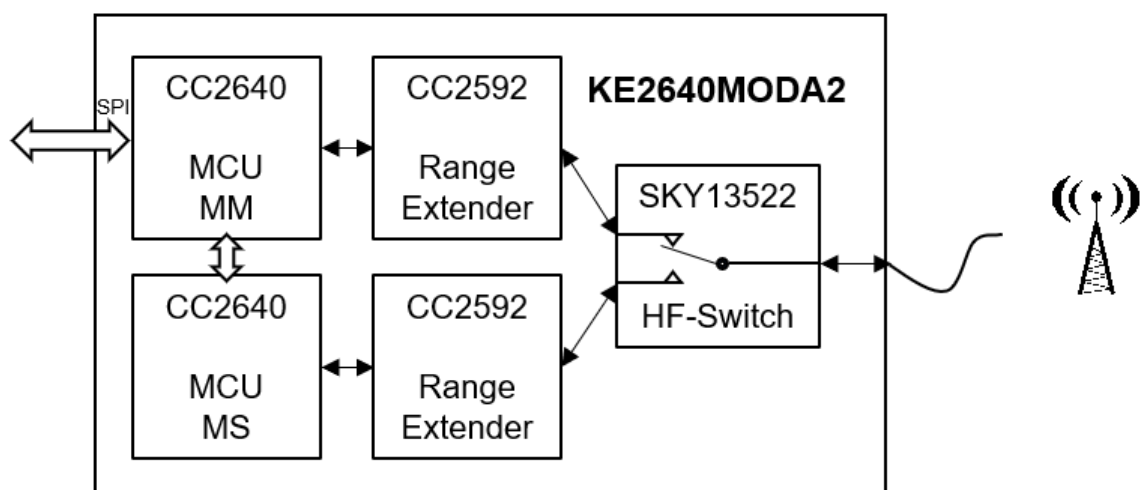
Two RF transceivers of the type CC2640 from Texas Instruments are integrated in this module. It is specified here that only one of the transceivers is used for transmit mode. The second transceiver is only used to support the receive mode of the module. The symmetric RF path design in combination with an RF switch ensures that both transceivers show the same behavior in receive mode. It also ensures that only one RF path can be active at a time.

6 Typical Application Circuit
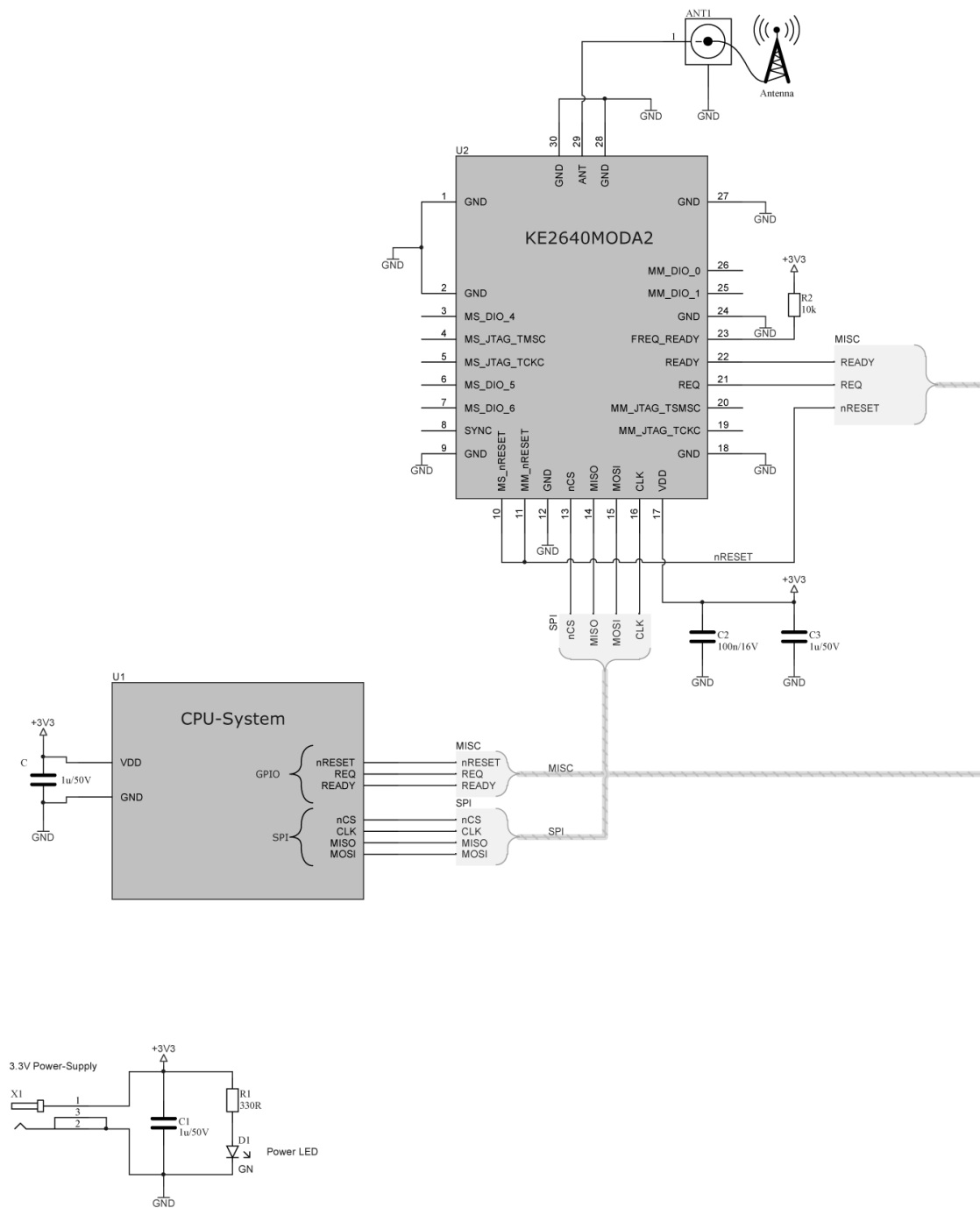
7 Pin Assignment

The following table gives an overview of all pin functions:

Pin	Name	Function	Note
1	GND	Ground	-
2	GND	Ground	-
3	MS_DIO_4	Digital I/O	Debug MS 0
4	MS_JTAG_TMSC	Digital I/O	cJTAG TMSC MS[1]
5	MS_JTAG_TCKC	Digital I/O	cJTAG TCKC MS[1]
6	MS_DIO_5	Digital I/O	Debug MS 1
7	MS_DIO_6	Digital I/O	Debug MS 2
8	SYNC	Digital I/O	Sync: SubCycle clk (T=1664 µs) Output if module configured as Sync Master Input with pull-down if module is slave Master
9	GND	Ground	-
10	MS_nRESET	Digital Input	Reset MS, active low, connected internally to VDD via pull-up resistor
11	MM_nRESET	Digital Input	Reset MM, active low, connected internally to VDD via pull-up resistor
12	GND	Ground	-
13	nCS	Digital I/O	SPI CS, active low
14	MISO	Digital I/O	SPI MISO
15	MOSI	Digital I/O	SPI MOSI
16	CLK	Digital I/O	SPI CLK
17	VDD	Power	2.5 V to 3.3 V supply
18	GND	Ground	-
19	MM_JTAG_TCKC	Digital I/O	cJTAG TCKC MM[1]
20	MM_JTAG_TMSC	Digital I/O	cJTAG TMSC MM[1]
21	REQ	Digital IN	MM shall start SPI com for new request
22	READY	Digital OUT	MM is ready to receive new request over SPI
23	FREQ_READY	Digital I/O	Sync signal for freq. hopping-table - as Input with pull-up during freq sync phase - as output with open-drain after freq sync
24	GND	Ground	-
25	MM_DIO_1	Digital I/O	Debug MM 1
26	MM_DIO_0	Digital I/O	Debug MM 0
27	GND	Ground	-
28	GND	Ground	-
29	ANT	RF I/O	External antenna Interface, 50Ω
30	GND	Ground	-

[1]Reduced pin count JTAG (IEEE 1149.7)

8 Firmware

The module is delivered with a pre-installed firmware containing parts of a low-layer IO-Link Wireless protocol stack for the IO-Link Wireless-Master. 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) and data link layer (DL). The other parts of the protocol stack like application layer (AL) and system management (SM) shall be located on the host controller. All services of DL and PL are accessible via SPI using the KUNBUS Wireless-Master-Stack-Library on the host controller.
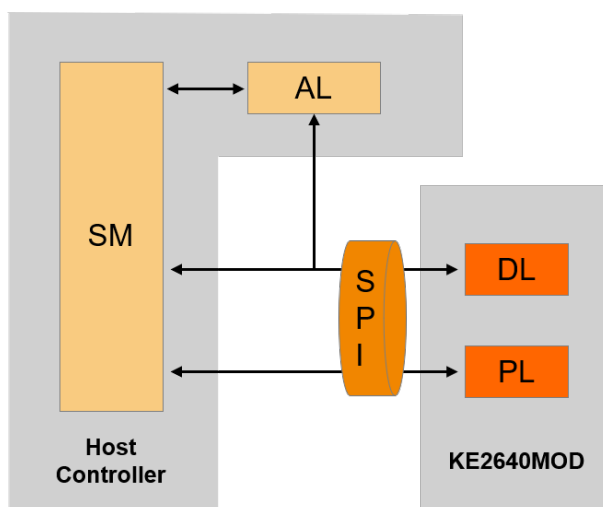
9 Host Interface

For the connection to the host controller the KE2640MODA2 uses a 4-wire serial peripheral interface (SPI) with two additional handshake signals (REQ and READY). The KE2640MODA2 operates as SPI master with a maximum data rate of 12 Mbps in this configuration.

If more than one KE2640MODA2 is connected to one host controller, two additional signals are required for synchronization of the KE2640MODA2 (SYNC and FREQ_READY). These signals interconnect the KE2640MODA2 modules but are not required to be connected to the host controller.
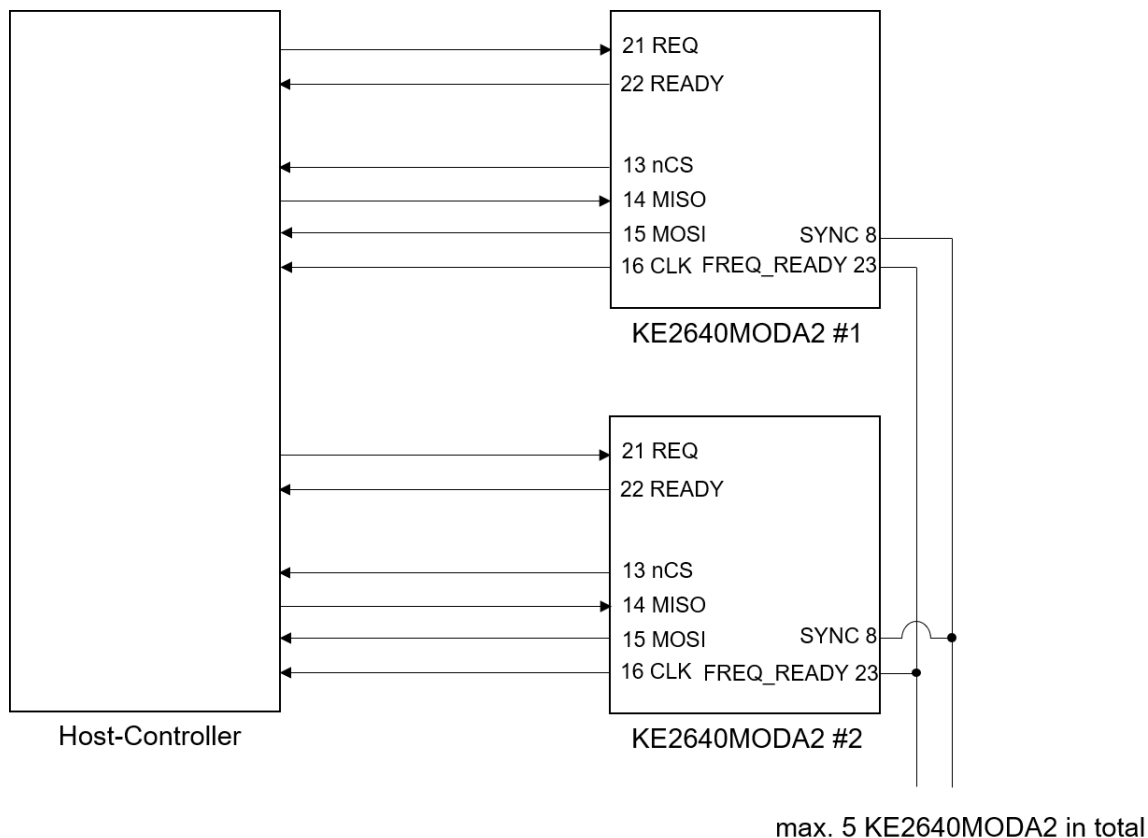
|	
READY	Indication from the KE2640MODA2 to the host controller that it may initiate a transfer request (REQ).
REQ	Indication from the host controller to the KE2640MODA2 that it shall start a SPI communication to receive a new request.
nCS, CLK, MISO, MOSI	Standard 4-wire SPI interface with KE2640MODA2 as master and a maximum data rate of 12 Mbps.
SYNC	This pin is used for synchronization of multiple KE2640MODA2. One module generates a rectangular output signal with a period of 1.664 ms according to the IO-Link Wireless W-subcycle duration. This signal is used as input by the other KE2640MODA2.
FREQ_READY	This pin is used for synchronization of multiple KE2640MODA2. One module generates a short output pulse each time the frequency hopping algorithm is restarted. This signal is used as input by the other KE2640-MODA2

The typical behavior of the SPI interface and the additional handshake signals are shown in the following figure.
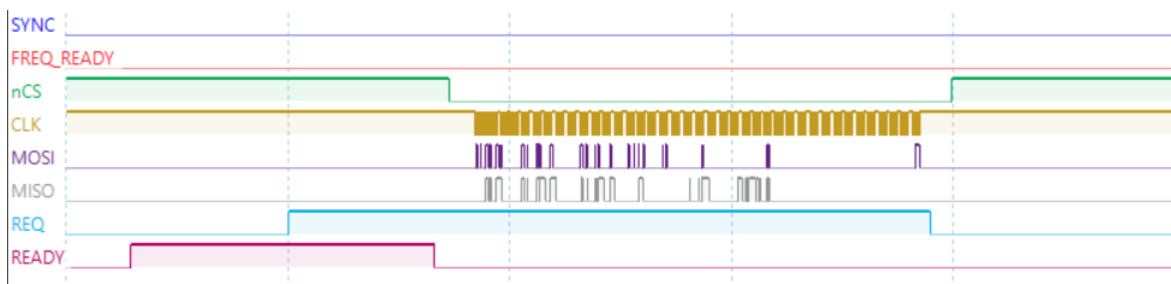
In this configuration, the following occurs during idle periods:

– CLK is forced high

– nCS is forced high

– The transmit data line MOSI is arbitrarily forced low

– As the KE2640MODA2 is configured as a SPI master, the KE2640MODA2 enables the CLK pad

If valid data has to be transmitted, the start of transmission is triggered by the nCS master signal going low. The master MOSI output pad is enabled. After the next half CLK period, both master and slave data are enabled onto their respective transmission lines. At the same time, CLK is enabled with a falling-edge transition. Data is then captured on the rising edges and propagated on the falling edges of the CLK signal. See example in the next figure.
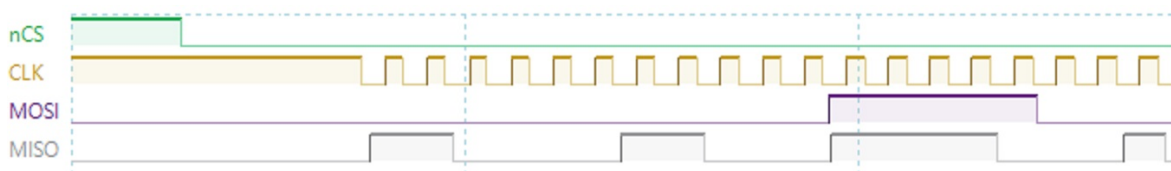
The nCS pin remains in its active low state until the final bit of the last word is captured and then returns to its IDLE state. This means nCS remains low between words of a continuous transmission until this transmission ends.

10 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.
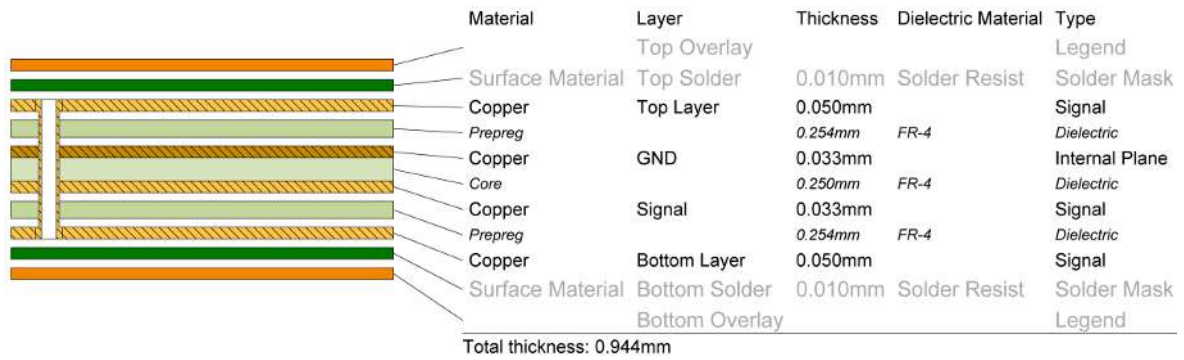
11 Layout Guidelines

KE2640MODA2 Module
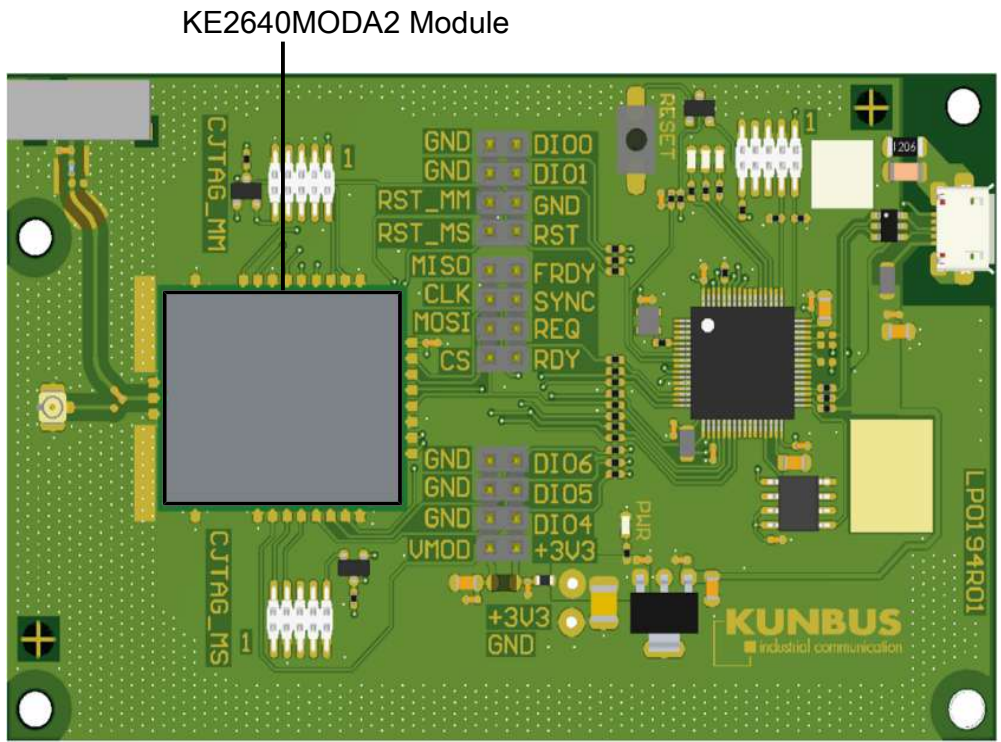
11.1 PCB Specification

PCB Stack-Up

The following figure shows an example stack-up for a KE2640MODA2 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.
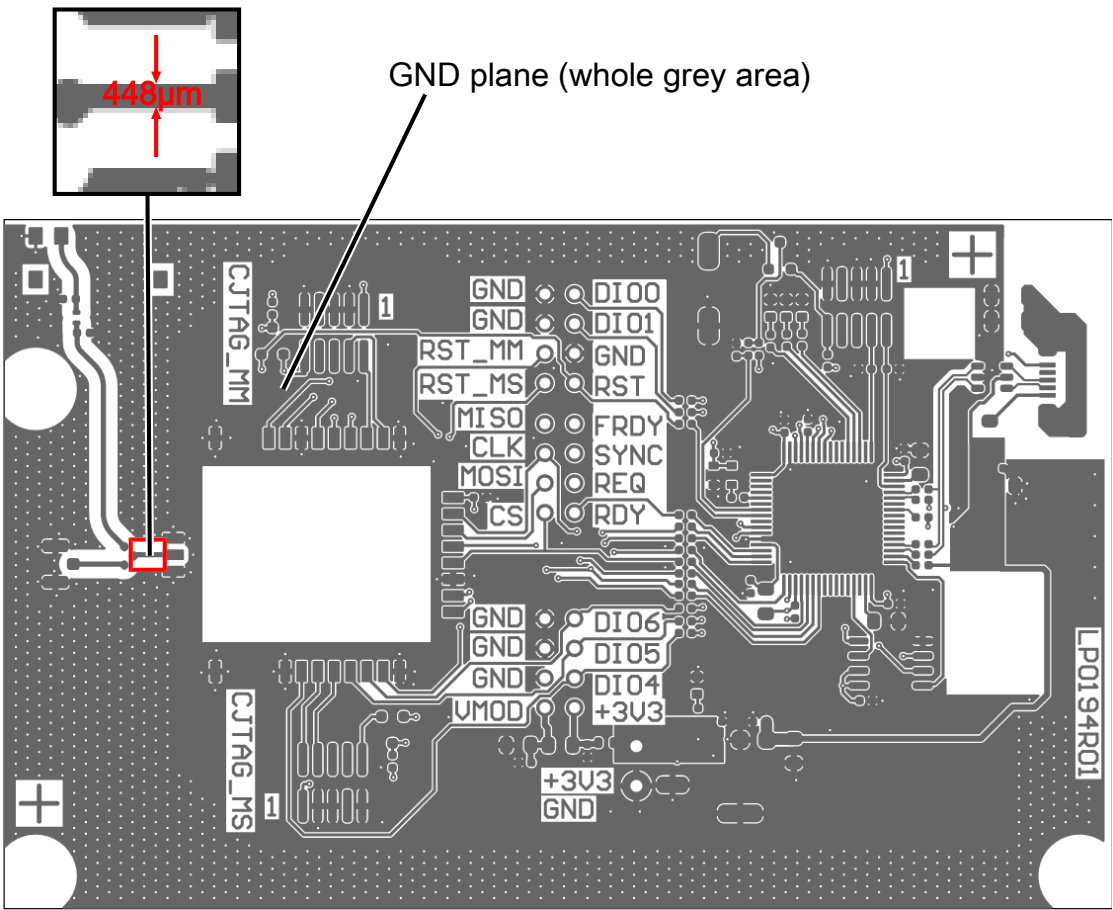
With this example stack-up, the width of a 50 Ω track is about 448 µm. For 100 Ω differential-pair lines the width is 200 µm with 150 µm spacing.

11.2 Layout

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

Layer 1 - Top Layer

GND plane (whole grey area)

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.
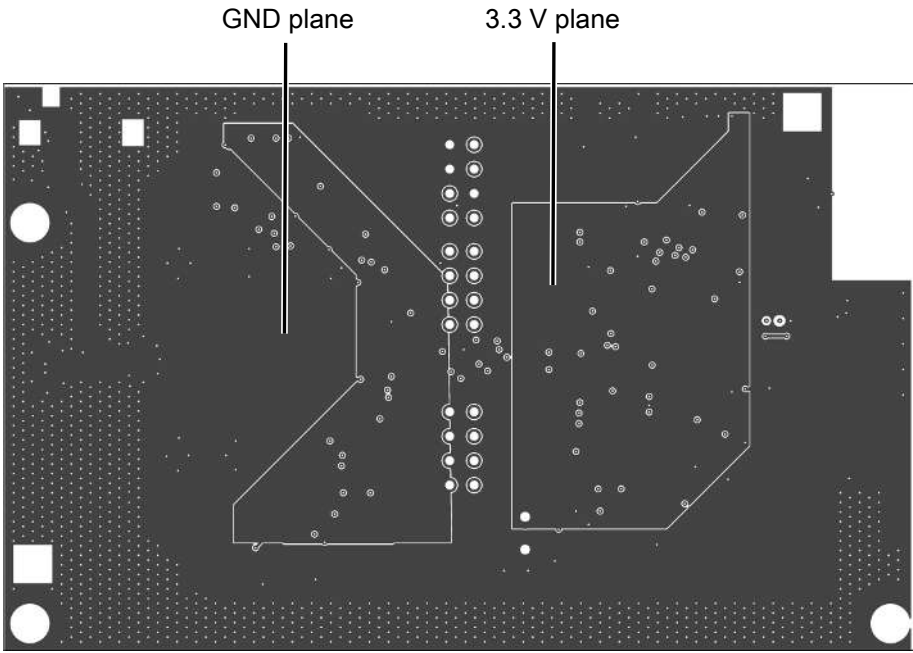
A keep-out area is not required due to an isolation layer on the bottom side of the module.

The trace to the antenna connector has a width of 448 µm to achieve the required impedance of 50 Ω.
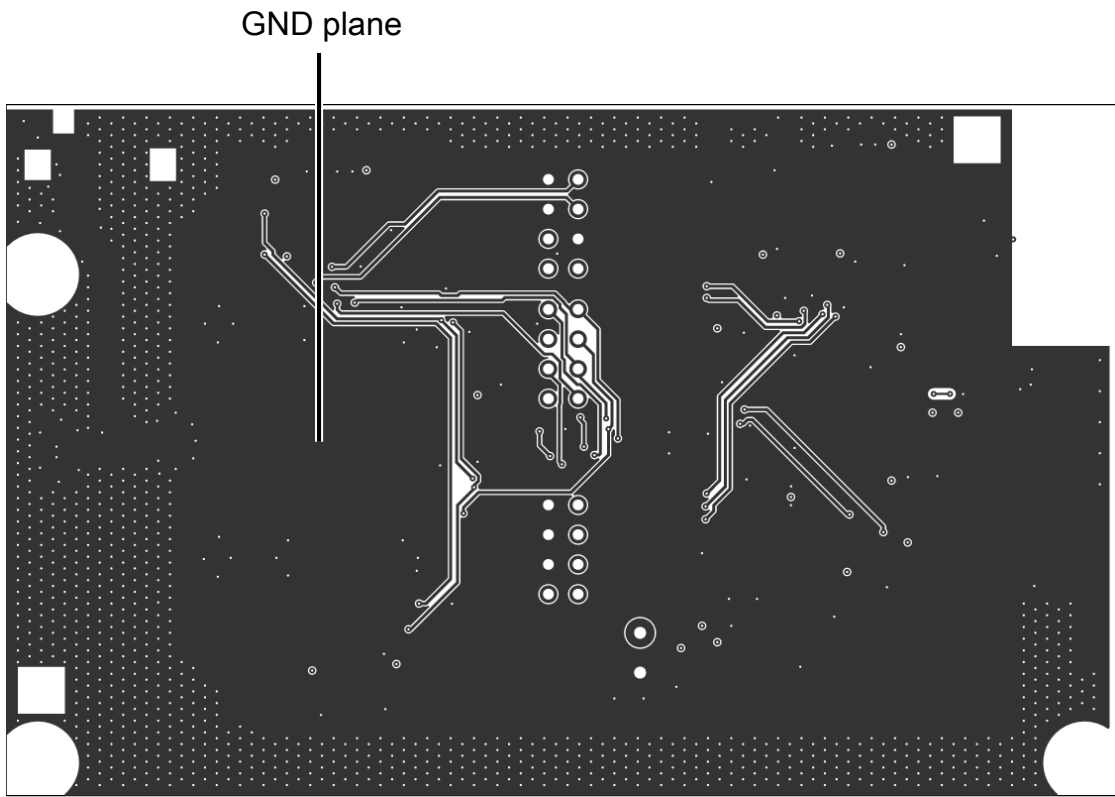
Layer 2 - GND

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

Layer 3 - Signal

GND plane   3.3 V plane

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

Layer 4 - Bottom Layer

GND plane

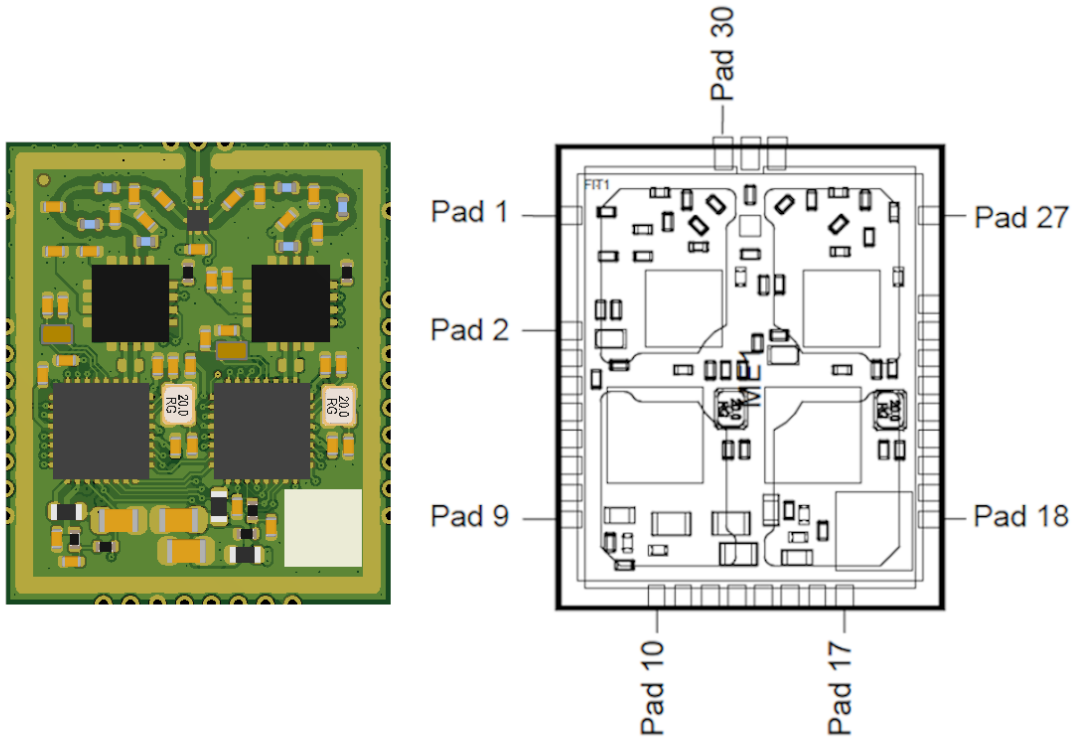

This layer is used for routing signals. Unused areas are filled with GND plane.
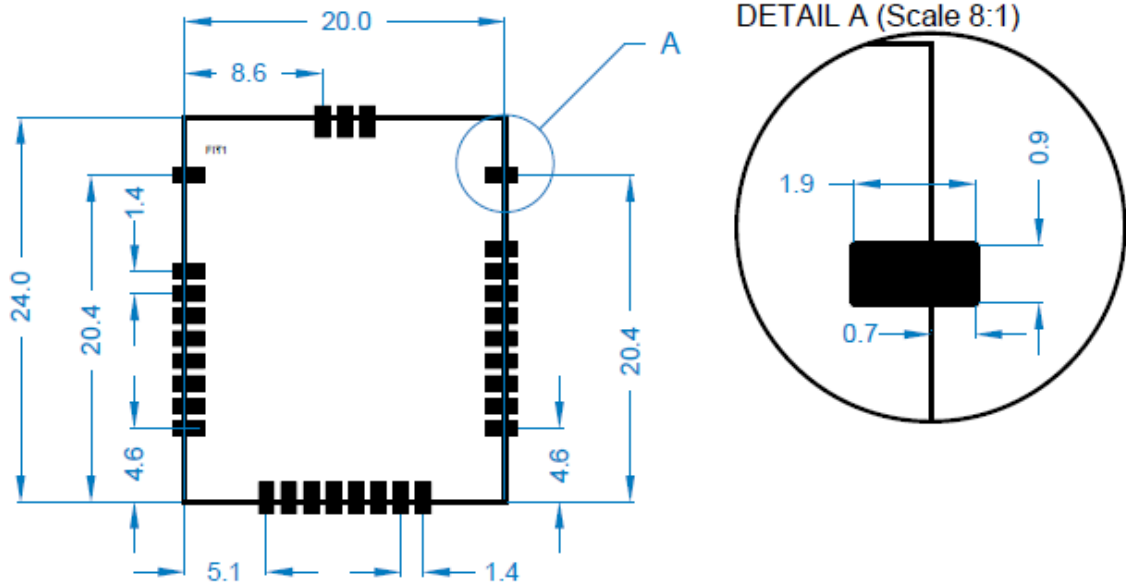
12 Footprint Indications

12.1 Top View

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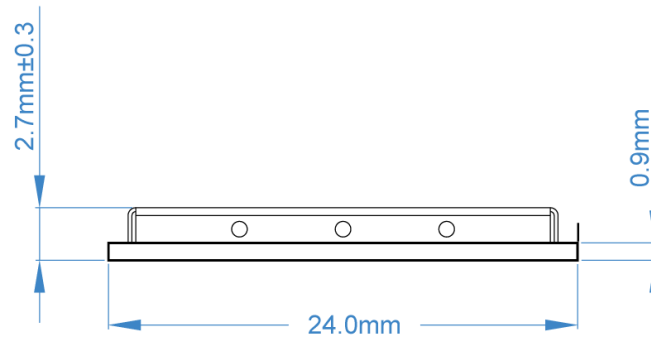
12.2 Dimensions

The outline dimensions of the module are as shown below.

Top View

DETAIL A (Scale 8:1)

Side View

Suggested Land Pattern, all dimensions in mm.

13 Contact Details

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

Address	KUNBUS GmbH
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	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 Master Module

Order No.: 100332