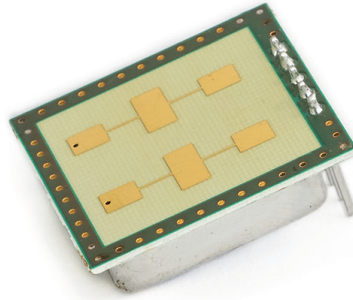


K-LC5

radar transceiver



Features

- 24 GHz short range transceiver
- Beam aperture 80°/34°
- Pin-compatible with K-LC2
- 3.3V and 5V Version available
- Highly linear VCO with 260 MHz tuning range
- High sensitive LNA receiver
- I/Q IF outputs
- Compact size: 25 mm × 25 mm × 6 mm
- Low frequency drift over temperature

Applications

- Security systems
- Directional object speed measurement systems
- Directional movement detectors
- Ranging of objects using FSK or FMCW
- Industrial sensors
- Home automation

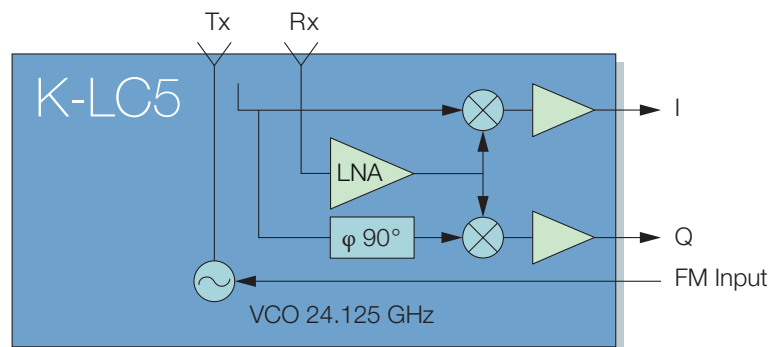
Description

K-LC5 is an extended range dual channel Doppler Radar module with an asymmetrical beam for short range sensors. Dual IF I and Q allow movement direction detection and high performance signal processing. The FM input allows FSK or FMCW ranging applications.

An extremely slim construction with only 6 mm depth gives you maximum flexibility in your equipment design. Powerful starterkits with signal conditioning and visualization are also available. (ST100/ST200)

Block Diagram

Figure 1: K-LC5 Blockdiagram (FM input not present on K-LC5-RFB-01x)



CHARACTERISTICS

Parameter Conditions/Notes Symbol Min Typ Max Unit

Operating Conditions

Supply voltage (5V Version) ^{Note 1}		$V_{cc, 5V}$	4.8	5.0	5.2	V
Supply voltage (3.3V Version) ^{Note 1}		$V_{cc, 3.3V}$	3.13	3.3	3.47	V
Supply current		I_{cc}		75		mA
VCO input voltage	Internal Voltage divider ^{Note 2}	U_{vco}	0		3.3	V
VCO pin resistance		R_{vco}		20		k Ω
Operating temperature		T_{op}	-20		+85	$^{\circ}C$
Storage temperature		T_{st}	-20		+85	$^{\circ}C$

Transmitter

Transmitter frequency	$T_{amb} = -20^{\circ}C \dots +85^{\circ}C$, VCO pin open	f_{TX}	24.050	24.150	24.250	GHz
Frequency drift vs temp.	$V_{cc} = 5.0V, -20^{\circ}C \dots +85^{\circ}C$ ^{Note 3}	Δf_{TX}		-0.13		MHz/K
Frequency tuning range		Δf_{vco}		260		MHz
VCO sensitivity		S_{vco}		80		MHz/V
VCO Modulation Bandwidth		B_{vco}		3		MHz
Output power	EIRP	P_{TX}		+12		dBm
Turn-on Time	Until IF signal valid	T_{ON}		6		μs
Spurious emission	According to ETSI 300 440	P_{spur}			-30	dBm

Receiver

Antenna gain	$F_{TX} = 24.125 GHz$ ^{Note 4}	G_{Ant}		8.6		dBi
Receiver Gain	$F_{RX} = 24.125 GHz$	G_{RX}		18		dB
Receiver sensitivity	$f_{IF} = 500 Hz, B = 1 kHz, S/N = 6 dB, R_{IF} = 1 k\Omega$	P_{RX}		-105		dBm
Overall sensitivity	$f_{IF} = 500 Hz, B = 1 kHz, S/N = 6 dB, R_{IF} = 1 k\Omega$	D_{system}		-118		dBc

IF output

IF output impedance		R_{IF}		100		Ω
I/Q amplitude balance	$f_{IF} = 500 Hz$	ΔU_{IF}	-2	0	+2	dB
I/Q phase shift	$f_{IF} = 500 Hz$	φ	80	90	100	$^{\circ}$
IF frequency range	-3 dB Bandwidth	f_{IF}	0		10	MHz
IF noise voltage	$f_{IF} = 500 Hz$	$U_{IFnoise}$		45		nV/ \sqrt{Hz}
	$f_{IF} = 500 Hz$	$U_{IFnoise}$		-147		dBV/Hz
IF output offset voltage		U_{os}		0.2		V
Supply rejection	Rejection supply pins to outputs, 500Hz	D_{supply}		-50		dB

Antenna

Horizontal -3dB beamwidth	E-Plane	W_{φ}		80		$^{\circ}$
Vertical -3dB beamwidth	H-Plane	W_{θ}		34		$^{\circ}$
Horiz. sidelobe suppression		D_{φ}	-12	-20		dB
Vert. sidelobe suppression		D_{θ}	-12	-20		dB

Body

Outline Dimensions	connector left unconnected			25 × 25 × 6		mm ³
Weight				4		g
Connector				5		pins

ESD Ratings

Electrostatic Discharge	Human Body Model Class 1A	VESD		500		V
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Note 1 Use a low noise voltage source.

Note 2 The VCO Input has an internal voltage divider. If the VCO Pin is left open the voltage is typically 1.65V.

Note 3 Transmit frequency stays within 24.050 to 24.250 GHz over the specified temperature.

Note 4 Theoretical value, given by design.

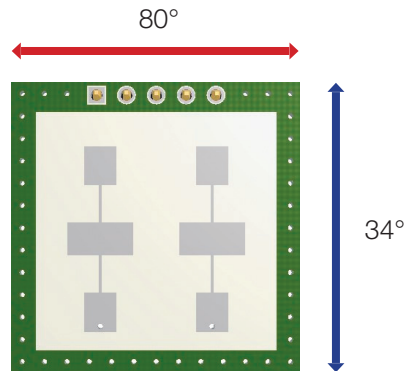
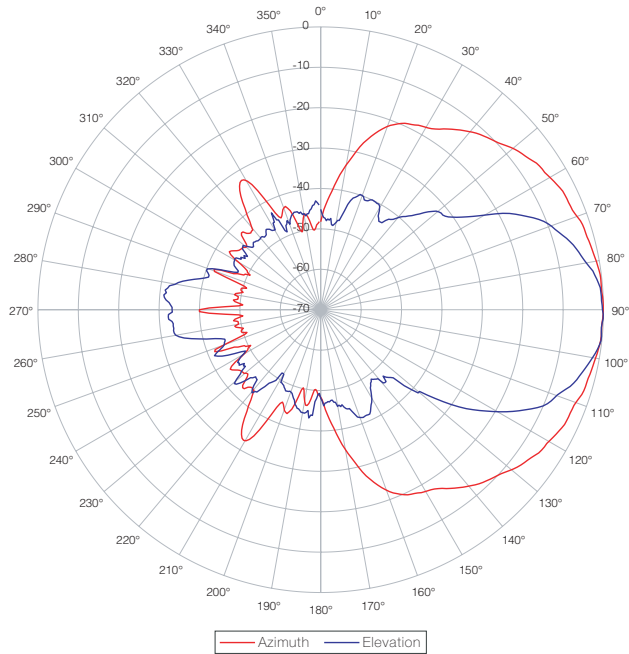
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ANTENNA SYSTEM DIAGRAM

This diagram shows module sensitivity (output voltage) in both azimuth and elevation directions. It incorporates the transmitter and receiver antenna characteristics.

Figure 2: Antenna system diagram (logarithmic scale)



Azimuth 34°, Elevation 80°
At IF output voltage -6 dB
(corresponds to -3 dB Tx power)

PIN CONFIGURATION

Table 1: Pin function description

K-LC5-RFB-00x

Pin No.	Name	Description
1	IF output Q	Intermediate frequency output Q, typical load: 1 kΩ
2	VCC	DC Supply V_{CC}
3	IF output I	Intermediate frequency output I, typical load: 1 kΩ
4	GND	Supply GND
5	VCO in	Frequency modulation input, U_{VCO} or left open

K-LC5-RFB-01x

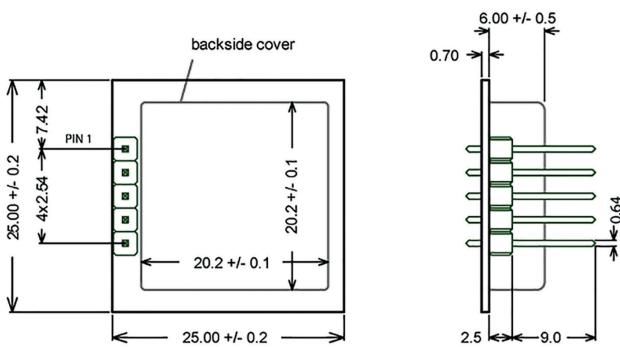
Pin No.	Name	Description
1	IF output Q	Intermediate frequency output Q, typical load: 1 kΩ
2	VCC	DC Supply V_{CC}
3	IF output I	Intermediate frequency output I, typical load: 1 kΩ
4	GND	Supply GND
5	IF output Q	Tied to pin 1



Do not touch open connector pins. RFbeam K-LC5 radar module is susceptible to electrical discharge as long as it is not placed in the circuit.

OUTLINE DIMENSIONS

Figure 3: Outline dimensions



All Dimensions in mm; values are typical unless otherwise specified

APPLICATION NOTES

Sensitivity and Maximum Range

The values indicated here are intended to give you a 'feeling' of the attainable detection range with this module. It is not possible to define an exact RCS (radar cross section) value of real objects because reflectivity depends on many parameters. The RCS variations however influence the maximum range only by $\sqrt[4]{\sigma}$.

Maximum range for Doppler movement depends mainly on:

- **Module sensitivity**
S: -118 dBc (@ 1kHz IF Bandwidth)
- **Carrier frequency**
 f_{TX} : 24.150 GHz
- **Radar cross section RCS "reflectivity" of the object**
 σ 1): 1 m² approx. for a moving person
> 50 m² for a moving car

note ¹⁾ RCS indications are very inaccurate and may vary by factors of 10 and more.

The famous "Radar Equation" may be reduced for our K-band module to the following relation:

$$r = 0.0167 \cdot 10^{\frac{S}{40}} \cdot \sqrt[4]{\sigma}$$

Using this formula, you get an indicative detection range of:

- 15 meters for a moving person.
- 40 meters for a moving car

Please note, that range values also highly depend on the performance of signal processing, environment conditions (i.e. rain, fog), housing of the module and other factors.

By reducing IF amplifier bandwidth, detection range can be enhanced. With BW = 250 Hz instead of 1 kHz, sensitivity will raise by 6 dB to -124 dBc. Maximum range will then become 21 m.

INTEGRATORS INFORMATION

Installation Instruction

Mechanical enclosure

It is possible to hide the sensor behind a so called radome (short for radar dome) to protect it from environmental influences or to simply integrate it in the case of the end product. A radar sensor can see through different types of plastic and glass of any colour as long as it is not metallized. This allows for a very flexible design of the housing as long as the rules below are observed.

- Cover must not be metallic.
- No plastic coating with colors containing metallic or carbon particles.
- Distance between cover and front of Radar sensor should be $\geq 6.2\text{mm}$
- Cover thickness is very important and depends on the used material. Examples can be found in the application note „AN-03-Radome“.
- Vibrations of the Radar antenna relatively to the cover should be avoided, because this generates signals that can trigger the output
- The cover material can act as a lens and focus or disperse the transmitted waves. Use a constant material thickness within the area used for transmission to minimize the effect of the radome to the radiated antenna pattern.



Detailed information about the calculation and thickness for different cover materials can be found in the application note “AN-03-Radome”.

United States (FCC) and Canada (ISED)

This module has been granted modular approval for fixed and/or mobile applications by FCC and ISED.

Testing for the modular approval has been performed in CW mode with an open VCO input. This setup can easily be used by the customer for certification purposes.

This module meets the title 47 of the Code of Federal Regulations, part 15 section 15.249 for intentional radiators operating in the 24.00 to 24.25 GHz band.



Modification to this product will void the users' authority to operate this equipment.



The OEM integrator is responsible for the final compliance to any other FCC rules that apply to the host not covered by the modular transmitter grant of certification.

Labelling and user information requirements

If the label of the module is not visible from the outside of the end product, it must include the following texts on the label of the host product:

FCC Contains FCC ID: 2ASYV-K-LC5
ISED Contains IC: 24358-KLC5

In addition to marking the product with the appropriate ID's, the end product shall bear the following statement in a conspicuous location on the label or alternatively in the user manual:

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.

RF Exposure

The radiated output power of the device is far below the FCC radio frequency exposure limits. Nevertheless, the device should be used in such a manner that the potential for human contact during normal operation is minimized.

Europe (CE-RED)

This module is a Radio Equipment Directive assessed radio module that is CE complaint and have been manufactured and tested with the intention of being integrated into a final product.

According to the RED every final product that includes a radio module is also a radio product which falls under the scope of the RED. This means that OEM and host manufacturers are ultimately responsible for the compliance of the host and the module. The final product must be reassessed against all of the essential requirements of the RED before it can be placed on the EU market. This includes reassessing the module for compliance against the following RED articles:

- Article 3.1(a): Health and safety
- Article 3.1(b): Electromagnetic compatibility (EMC)
- Article 3.2: Efficient use of radio spectrum (RF)

The RED knows different conformity assessment procedures to show compliance against the essential requirements (See RED Guide, chapter 2.6b). As long as the radio module can show compliance to Article 3.2 by the use of a harmonized standard, which is listed in the official journal of the EU (OJEU), it is not necessary to do an EU type examination for the final radio product by a notified body. In this case it is possible to demonstrate conformity according to the essential requirements of the RED by using Module A (Annex II of the RED), which allows to show conformity by internal production control.



As long as a harmonized standard listed in the OJEU can be used to demonstrate conformity in accordance with Article 3.2 of the RED, it is possible to carry out the CE certification in self-declaration without the involvement of a notified body.

The K-LC5 shows compliance against the Article 3.2 by the use of the standard EN 300 440 which is a harmonized standard listed in the OJEU, what gives the possibility to show conformity by internal production control.

An OEM integrator can show compliance to article 3.1(a) and 3.1(b) for the final product by doing internal or external tests and following the Module A (Annex II of the RED) assessment procedure. To show compliance against article 3.2 it is possible to reuse the assessment of the K-LC5 as long as it is the only radio module in the final product or if the integrator can guarantee that only one radio module is operating at the same time. Test reports of the K-LC5 are available on request.



The ETSI guide EG 203 367 provides detailed guidance on the application of harmonized standards to multi-radio and combined equipment to demonstrate conformity.

RF Exposure Information (MPE)

This device has been tested and meets applicable limits for Radio Frequency (RF) exposure. A detailed calculation to show compliance to the RED Article 3.1(a) is available on request.

Simplified DoC Statement

Hereby, RFbeam Microwave GmbH declares that the radio equipment type K-LC5 is in compliance with Directive 2014/53/EU. The declaration of conformity may be consulted at www.rfbeam.ch.

ORDER INFORMATION

Figure 4: Ordering number structure

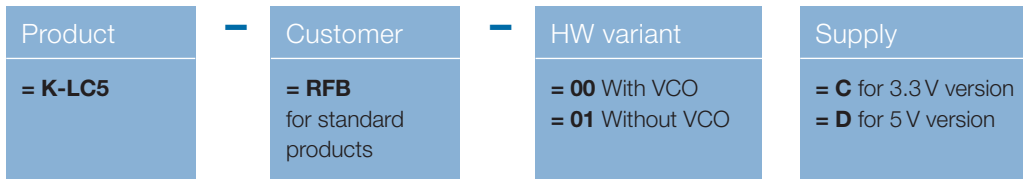


Table 2: Available ordering numbers

Ordering number	Description
K-LC5-RFB-00C	Standard K-LC5, 3.3V version
K-LC5-RFB-00D	Standard K-LC5, 5V version
K-LC5-RFB-01D	K-LC5 without VCO input, 5V version

REVISION HISTORY

04/2012 – Revision A:	initial release
09/2012 – Revision B:	K-LC5 standard contains a VCO. K-LC5-v2 does not contain a VCO
08/2017 – Revision C:	New module picture page 1, Directive 2014/53/EUR and full address added
10/2017 – Revision D:	New module picture page 1, typing error in address corrected
11/2018 – Revision E:	Outer Outline Dimensions corrected and corrected the part number of the K-LC5_V2
06/2019 – Revision F:	New Datasheet design New Product name Changes in specification because of redesigned module
03/2021 – Revision G:	Added integrators information Added available ordering numbers