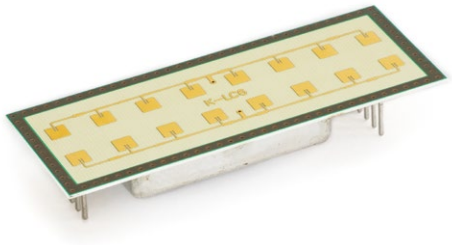
RFbeam Microwave GmbH

data sheet

K-LC6

radar transceiver



Features

- 24 GHz short range transceiver
- Narrow–wide asymmetrical field pattern
- Beam aperture 80°/12°
- High sensitive LNA receiver
- 300 MHz wide sweep FM input
- I/Q IF outputs
- Optional IF amplifier (K-LC6-RFB-01x)
- Compact size: 66 mm × 25 mm × 6 mm
- Available as 3.3V or 5V version

Applications

- Indoor and outdoor lighting control applications
- Traffic supervision and counting
- Object speed measurement systems
- Ranging and distance detection using FSK or FMCW
- Industrial sensors
- Home automation

Description

K-LC6 is a dual channel Doppler Radar module with an asymmetrical narrow beam for short to medium distance sensors. It is ideally suited for person and vehicle movement and presence sensors.

This module includes an RF low noise amplifier (LNA) for best signal to noise performance. Dual IF I and Q allow movement direction detection and high performance signal processing.

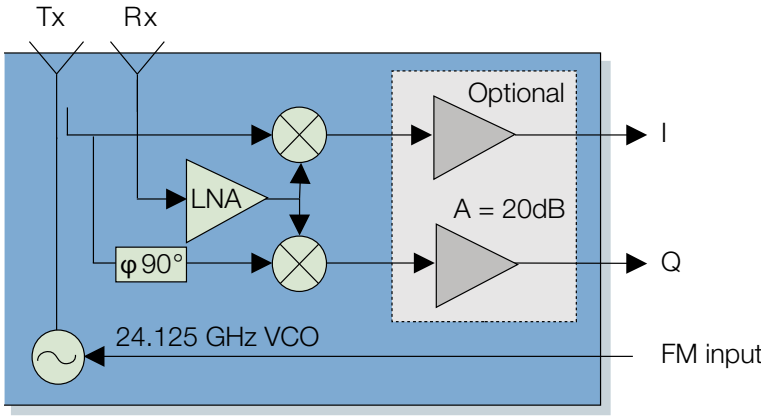
The optional internal IF amplifier is available in version K-LC6-RFB-01x.

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: Blockdiagram



Optional amplifier is present in the K-LC6-RFB-01x version.

CHARACTERISTICS

Parameter	Conditions/Notes	Symbol	Min	Typ	Max	Unit
Operating conditions K-LC6-RFB-xxC (3.3V version)						
Supply voltage Note 1		V_{cc}	3.13	3.3	3.47	V
Supply current		I_{cc}		85		mA
VCO input voltage		U_{vco}	0		3.3	V
VCO pin resistance	Internal voltage divider Note 3	R_{vco}		20k		Ω
Operating temperature		T_{op}	-20		+85	°C
Storage temperature		T_{st}	-20		+85	°C
Operating conditions K-LC6-RFB-xxD (5V version)						
Supply voltage Note 1		V_{cc}	4.8	5	5.2	V
Supply current		I_{cc}		85		mA
VCO input voltage		U_{vco}	0		10	V
VCO pin resistance	Internal pullup to 5V	R_{vco}		4.7k		Ω
Operating temperature		T_{op}	-20		+85	°C
Storage temperature		T_{st}	-20		+85	°C
Transmitter						
Transmitter frequency	VCO pin open, Ta = -20°C .. +85°C Note 4	f_{TX}	24.05	125	24.25	GHz
Frequency drift vs temp.	-20°C .. +85°C Note 3	Δf_{TX}		-0.13		MHz/K
Frequency tuning range		Δf_{vco}		300		MHz
VCO Modulation Bandwidth	Δf=20MHz	B_{vco}		3		MHz
Output power	EIRP	P_{TX}		16		dBm
Spurious emission	According to ETSI 300 440	P_{spur}			-30	dBm
Turn-on time	Until IF signal is valid	T_{ON}		6		µs
Receiver						
Antenna gain	f_{TX}=24.125GHz Note 2	G_{Ant}		12.5		dBi
Receiver gain	f_{RX}=24.125GHz	G_{LNA}		10		dB
Receiver sensitivity	f_{IF}=500Hz, B=1kHz, S/N=6dB, R_{Load} = 1kΩ	P_{RX}		-108		dBm
Overall sensitivity	f_{IF}=500Hz, B=1kHz, S/N=6dB, R_{Load} = 1kΩ	D_{system}		-126		dBc
IF output K-LC6-RFB-00x						
IF output impedance		R_{IF}		100		Ω
I/Q amplitude balance	f_{IF}=500Hz	ΔU_{IF}		3		dB
I/Q phase shift	f_{IF}=500Hz	φ	80	90	100	°
IF frequency range	-3dB Bandwidth	f_{IF}	0		10	MHz
IF noise voltage	f_{IF}=500Hz	$U_{IFnoise}$		45		nV/√Hz
	f_{IF}=500Hz	$U_{IFnoise}$		-147		dBV/Hz
IF output offset voltage		U_{os}		0.2		V
Supply rejection	Rejection supply pins to outputs, 500Hz	D_{supply}		-50		dB
IF output K-LC6-RFB-01x						
IF output impedance		R_{IF}		100		Ω
IF Amplifier gain		G_{IF}		20		dB
I/Q amplitude balance	f_{IF}=500Hz	ΔU_{IF}		3		dB
I/Q phase shift	f_{IF}=500Hz	φ	80	90	100	°
IF frequency range	-3dB Bandwidth	f_{IF}	10		15k	Hz
IF noise voltage	f_{IF}=500Hz	$U_{IFnoise}$		450		nV/√Hz
	f_{IF}=500Hz	$U_{IFnoise}$		-127		dBV/Hz
IF output offset voltage		U_{os}	2.25	2.5	2.75	V
Supply rejection	Rejection supply pins to outputs, 500Hz	D_{supply}		-50		dB
Antenna						

Parameter	Conditions/Notes	Symbol	Min	Typ	Max	Unit
Horizontal -3dB beamwidth	E-Plane	W_φ		12		°
Vertical -3dB beamwidth	H-Plane	W_θ		80		°
Horiz. sidelobe suppression		D_φ		-20		dB
Vert. sidelobe suppression		D_θ		-18		dB

Body

Outline Dimensions	connector left unconnected			66×5×6		mm³
Weight				6		g
Connector				5 (+ 3)		Pins

ESD Ratings

Electrostatic Discharge	Human Body Model Class 1A	VESD			500	V

Note 1 Use a low noise voltage source.

Note 2 Theoretical value, given by design.

Note 3 The VCO Input has an internal voltage divider. If the VCO Pin is left open the voltage is typically 1.65V.

Note 4 Transmit frequency stays within 24.050 to 24.250 GHz over the specified temperature.

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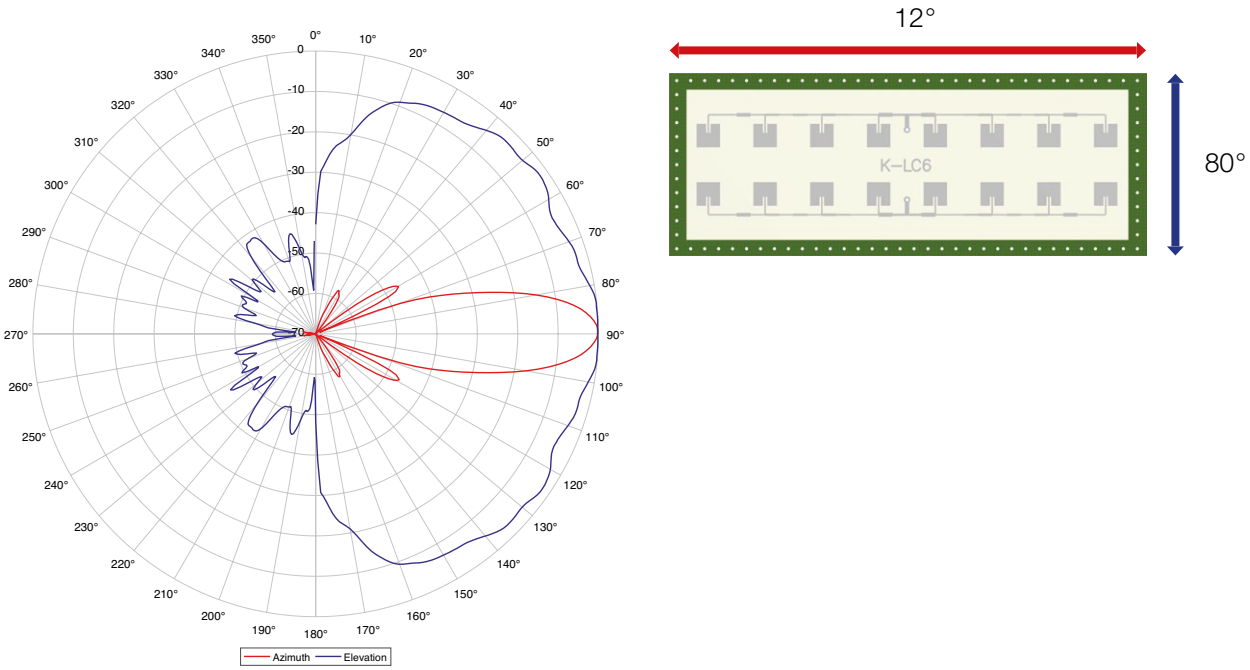
ANTENNA SYSTEM DIAGRAM

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



PIN CONFIGURATION

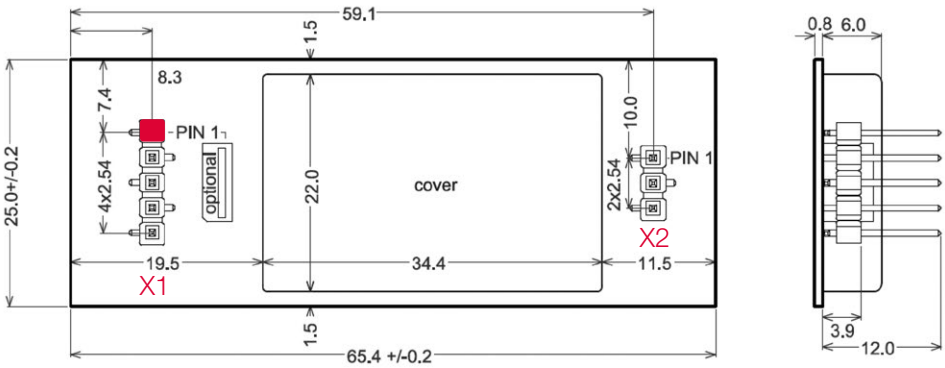
Table 1: Pin function description

Connector	Pin No.	Name	Description
X1	1	IF out Q	Intermediate frequency output Q, typical load: 1 kΩ
	2	Vcc	DC Supply V+
	3	IF out I	Intermediate frequency output I, typical load: 1 kΩ
	4	GND	Supply GND
	5	VCO in	U_{VCO} or left open
X2	1-3	Mounting	Leave this pins floating or connect it to GND

Do not touch open connector pins. RFbeam K-LC6 radar module is susceptible to electrical discharge as long as it is not placed in the circuit.

OUTLINE DIMENSIONS

Figure 3: Outline dimensions



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: -126 dBc (@ 1kHz IF Bandwidth)
- **Carrier frequency**
  f_{TX}: 24.125 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:
– 24 meters for a moving person.
– 62 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.

With K-LC6, you can achieve a maximum range of more than 100 m when using high resolution AD-converters and selective FFT algorithms.

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 trough 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 ≥ 6.2 mm
- Best cover material is Polycarbonat or ABS
- Best cover thickness is 3–4 mm
- 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. The modular approval allows the end user to integrate the module into a finished product without obtaining subsequent and separate FCC/ISED approvals for intentional radiation, provided no changes or modifications are made to the module circuitry. Changes or modifications could void the user's authority to operate the equipment. The end user must comply with all of the instructions provided by the Grantee, which indicate installation and/or operating conditions necessary for compliance. The finished product is required to comply with all applicable FCC/ISED equipment authorizations regulations, requirements and equipment functions not associated with the transmitter module portion.

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

The OEM integrator is responsible for the final compliance of the end product with this integrated modular approved transmitter module. This includes measurements with the RF module integrated and activated as defined in KDB 996369 and if applicable appropriate equipment authorizations as defined in §15.101.

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-LC6
ISED Contains IC: 24358-KLC6

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

This module is approved for installation into fixed and/or mobile host platforms and must not be co-located or operating in conjunction with any other antenna or transmitter except in accordance with FCC/ISED multi-transmitter guidelines. End users must be provided with transmitter operating conditions for satisfying RF Exposure compliance.

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-LC6 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-LC6 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-LC6 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-LC6 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

Product	–	Customer	–	HW variant	Supply
= K-LC6		**= RFB** for standard products		**= 00** no IF Amplifier **= 01** with IF Amplifier	**= C** for 3.3 V version **= D** for 5 V version

Table 2: Available ordering numbers

Ordering number	Description
K-LC6-RFB-00C	Standard K-LC6, 3.3V version
K-LC6-RFB-00D	Standard K-LC6, 5V version
K-LC6-RFB-01C	K-LC6 with internal IF Amplifier, 3.3V version
K-LC6-RFB-01D	K-LC6 with internal IF Amplifier, 5V version

DATASHEET REVISION HISTORY

04/2012 – Revision A: initial release
04/2012 – Revision B: Corrected values in chapter Using VCO and IF Amplifier
11/2018 – Revision C: Changed footer to new address
10/2019 – Revision D: Changes in specification because of redesigned module
02/2020 – Revision E: Added new chapter integrators information

Mouser Electronics

Authorized Distributor

Click to View Pricing, Inventory, Delivery & Lifecycle Information:

RFbeam:

K-LC6-RFB-00D