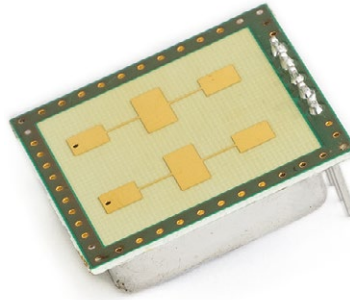


K-LC5

radar transceiver



Features

- 24 GHz short range transceiver
- Beam aperture 80°/34°
- Pin-compatible with K-LC2
- 3.3 V and 5 V 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

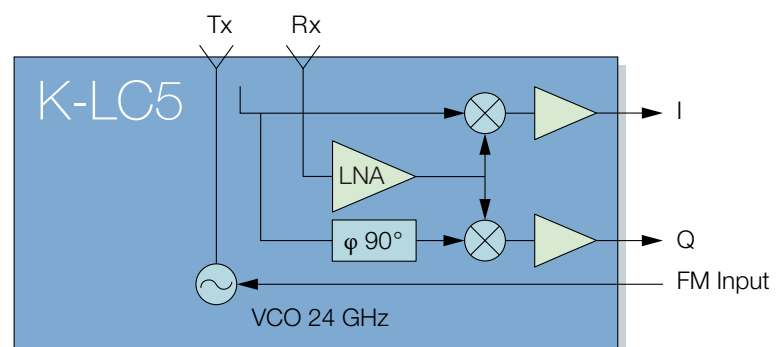
Description

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
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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	°C
Storage temperature		T_{st}	-20		+85	°C

Transmitter

Transmitter frequency	$T_{amb} = -20^{\circ}\text{C} \dots +85^{\circ}\text{C}$	f_{TX}	24.050	24.150	24.250	GHz
Frequency drift vs temp.	$V_{CC} = 5.0V, -20^{\circ}\text{C} \dots +85^{\circ}\text{C}$ ^{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	$F_{TX} = 24.125\text{ GHz}$ ^{Note 4}	G_{Ant}		8.6		dBi
Receiver Gain	$F_{RX} = 24.125\text{ GHz}$	G_{RX}		18		dB
Receiver sensitivity	$f_{IF} = 500\text{ Hz}, B = 1\text{ kHz}, S/N = 6\text{ dB}, R_{IF} = 1\text{ k}\Omega$	P_{RX}		-105		dBm
Overall sensitivity	$f_{IF} = 500\text{ Hz}, B = 1\text{ kHz}, S/N = 6\text{ dB}, R_{IF} = 1\text{ k}\Omega$	D_{system}		-118		dBc

IF output

IF output impedance		R_{IF}		100		Ω
I/Q amplitude balance	$f_{IF} = 500\text{ Hz}$	ΔU_{IF}		2		dB
I/Q phase shift	$f_{IF} = 500\text{ Hz}$	φ	80	90	100	°
IF frequency range	-3 dB Bandwidth	f_{IF}	0		10	MHz
IF noise voltage	$f_{IF} = 500\text{ Hz}$	$U_{IFnoise}$		45		nV/ $\sqrt{\text{Hz}}$
	$f_{IF} = 500\text{ Hz}$	$U_{IFnoise}$		-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		°
Vertical -3dB beamwidth	H-Plane	W_{θ}		34		°
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.

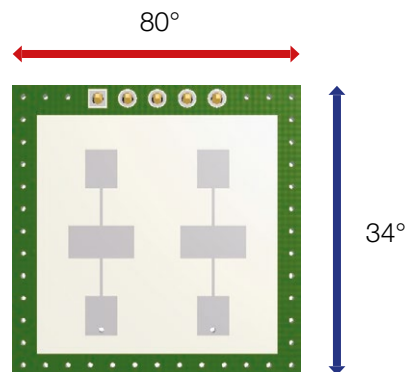
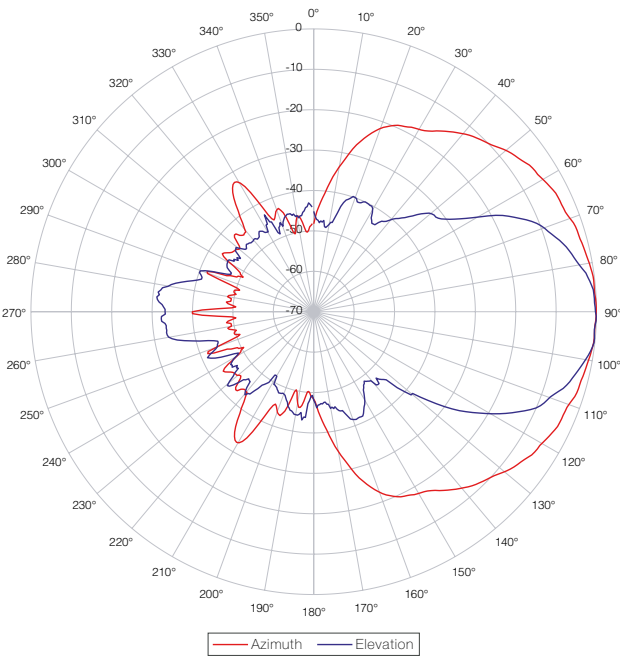
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ANTENNA SYSTEM DIAGRAM

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)



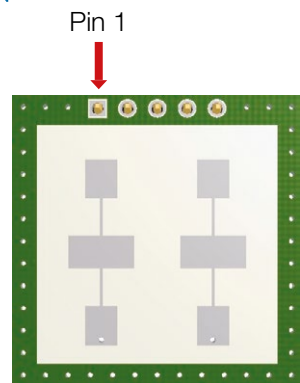
Azimuth 34°, Elevation 80°
At IF output voltage -6 dB
(corresponds to -3 dB Tx power)

PIN CONFIGURATION

Table 1: Pin function description

K-LC5-RFB-00x		
Pin No.	Name	Description
1	IF output Q	1k load
2	VCC	DC Supply V+
3	IF output I	1k load
4	GND	Supply GND
5	VCO in	0...+3.3V or left open

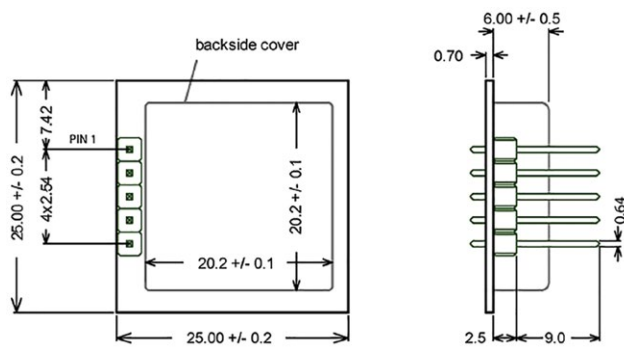
K-LC5-RFB-01x		
Pin No.	Name	Description
1	IF output Q	1k load
2	VCC	DC Supply V+
3	IF output I	1k load
4	GND	Supply GND
5	IF output Q	tied to pin 1



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.
- 60 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.

EC-DECLARATION OF CONFORMITY

This product complies with the essential requirements of the RED Directive 2014/53/EU, and can be used in all countries within Europe.

ORDER INFORMATION

Figure 4: Ordering number structure

Product	Customer	HW variant	Supply
= K-LC5	= RFB for standard products	= 00 With VCO = 01 Without VCO	= C for 3.3 V version = D for 5 V version

DATASHEET 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
6/2019 – Revision F:	New Datasheet design New Product name Changes in specification because of redesigned module