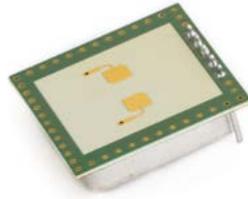


# K-LC4

radar transceiver



## Features

- 24 GHz K-band miniature transceiver
- Dual 1 patch circular polarized antenna
- Dual balanced mixer with 50 MHz bandwidth
- Excellent noise cancelling ability through I/Q technology
- Wide beam aperture 138°/132°
- 10 dBm EIRP output power
- 25 × 25 mm<sup>2</sup> surface, < 6 mm thickness
- Low cost design

## Applications

- Direction sensitive movement detectors
- Security systems
- Simple ranging detection using FSK
- Ceiling and wall mount surveillance system
- Industrial sensors

## Description

K-LC4 is a 2 patch Doppler module with a nearly symmetrical wide beam for low cost short distance applications.

Typical applications are movement sensors for security, lighting and building automation applications. This module may be an alternative or a complementary sensor for infrared PIR or AIR systems thanks to its outstanding performance/cost ratio.

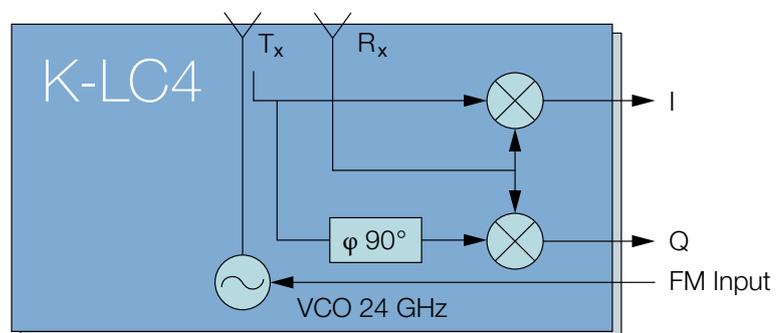
The module is extremely small and lightweight. With an IF bandwidth from DC to 50 MHz it opens many new applications.

The unique RFbeam circular polarized antenna form allows much wider acquisition fields than the traditional linear polarized patch antenna.

A powerful starterkit with signal conditioning and visualization is available from RFbeam. Find more informations on [www.rfbeam.ch](http://www.rfbeam.ch).

## Block Diagram

**Figure 1: K-LC4 block diagram**



# Characteristics

Parameter	Conditions/Notes	Symbol	Min	Typ	Max	Unit
<b>Operating Conditions</b>						
Supply voltage		$V_{CC}$	4.75	5	5.25	V
Supply current		$I_{CC}$		35	45	mA
VCO input voltage		$U_{VCO}$	-0.5		2.0	V
VCO pin resistance	Driving voltage source <b>Note 1</b>	$R_{VCO}$		570		$\Omega$
Operating temperature		$T_{op}$	-20		+85	$^{\circ}C$
Storage temperature		$T_{st}$	-20		+105	$^{\circ}C$

## Transmitter

Transmitter frequency	$T_{amb} = -20^{\circ}C \dots +60^{\circ}C$	$f_{TX}$	24.05	24.125	24.25	GHz
Frequency drift vs temperature	$V_{CC} = 5.0V, -20^{\circ}C \dots +85^{\circ}C$ <b>Note 2</b>	$\Delta f_{TX}$		-0.9		MHz/ $^{\circ}C$
Frequency tuning range		$\Delta f_{VCO}$		140		MHz
VCO sensitivity		$S_{VCO}$		-55		MHz/V
VCO Modulation Bandwidth	$\Delta f = 20$ MHz	$B_{VCO}$		3		MHz
Output power	EIRP	$P_{TX}$	+7	+10	+13	dBm
Spurious emission	According to ETSI 300 440	$P_{spur}$			-30	dBm
Turn-on time	Until oscillator stable, $\Delta f_{TX} < 5$ MHz	$t_{on}$		1		$\mu s$

## Receiver

Mixer Conversion loss	$f_{IF} = 1$ kHz, IF load = 1 k $\Omega$	$D_{mixer1}$		-6		dB
	$f_{IF} = 20$ MHz, IF load = 50 $\Omega$	$D_{mixer2}$		-11		dB
Antenna Gain	$F_{TX} = 24.125$ GHz <b>Note 3</b>	$G_{Ant}$		4.8		dB
Receiver sensitivity	$f_{IF} = 500$ Hz, B = 1 kHz, $R_{IF} = 1$ k $\Omega$ , S/N = 6 dB	$P_{RX1}$		-93		dBm
	$f_{IF} = 1$ MHz, B = 20 MHz, $R_{IF} = 50$ $\Omega$ , S/N = 6 dB	$P_{RX1}$		-81		dBm
Overall sensitivity	$f_{IF} = 500$ Hz, B = 1 kHz, $R_{IF} = 1$ k $\Omega$ , S/N=6 dB	$D_{system}$		-103		dBc

## IF output

IF resistance		$R_{IF}$		50		$\Omega$
IF frequency range	-3dB Bandwidth, IF load = 50 $\Omega$	$f_{IF}$	0		50	MHz
IF noise power	$f_{IF} = 500$ Hz, IF load = 50 $\Omega$	$P_{IFnoise1}$		-134		dBm/Hz
	$f_{IF} = 1$ MHz, IF load = 50 $\Omega$	$P_{IFnoise2}$		-164		dBm/Hz
IF noise voltage	$f_{IF} = 500$ Hz, IF load = 1 k $\Omega$	$U_{IFnoise1}$		-147		dBV/Hz
	$f_{IF} = 500$ Hz, IF load = 1 k $\Omega$	$U_{IFnoise1}$		45		nV/ $\sqrt{Hz}$
IF output offset voltage	no object in range	$U_{IF}$	-200		200	mV
I/Q amplitude balance	$f_{IF} = 500$ Hz, $U_{IF} = 1$ mVpp	$\Delta U_{IF}$		3		dB
I/Q phase shift	$f_{IF} = 1$ Hz–20 kHz	$\varphi$	80	90	100	$^{\circ}$
Supply rejection	Rejection supply pins to IF output	$D_{supply}$		26		dB

## Antenna

Antenna type	Right hand circular polarized	RHCP				
Horizontal -3 dB beamwidth	E-Plane	$W_{\varphi}$		138		$^{\circ}$
Vertical -3 dB beamwidth	H-Plane	$W_{\varphi}$		132		$^{\circ}$
Horiz. sidelobe suppression		$D_{\varphi}$		-12		dB
Vertical sidelobe suppression		$D_{\varphi}$		-12		dB

## Body

Outline Dimensions				25 × 25 × 6		mm <sup>3</sup>
Weight				4.5		g
Connector	5 pin single row jumper					

Note 1 The VCO input has an internal voltage source with approx. 0.9VDC. For driving this pin it is necessary to source and sink current

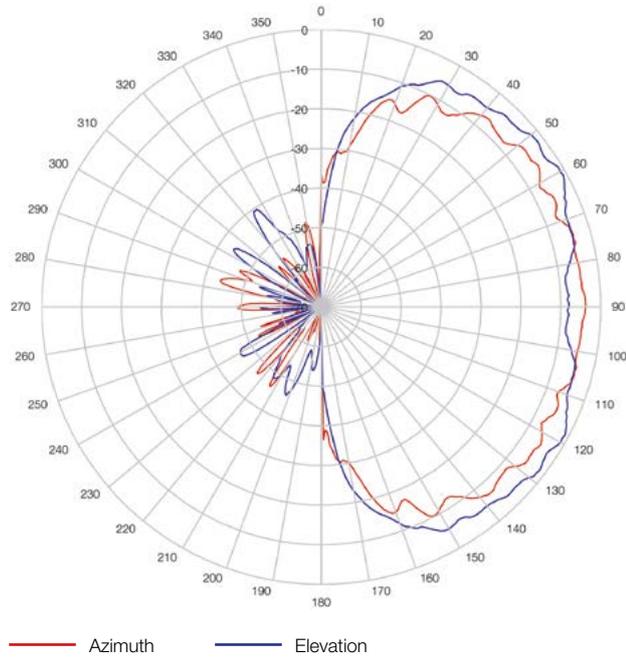
Note 2 Transmit frequency stays within 24.050 to 24.250GHz over the specified temperature range

Note 3 Theoretical value, given by Design

# Antenna System Diagram

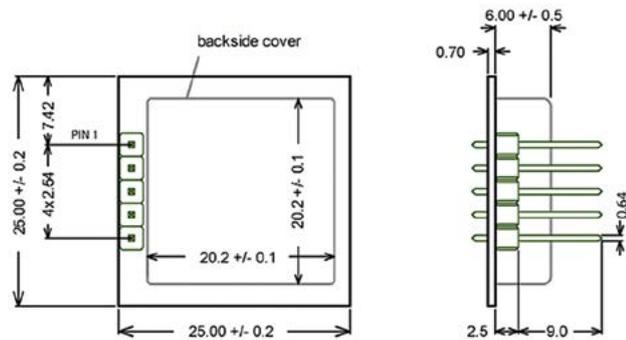
This diagram shows module sensitivity in both azimuth and elevation directions. It incorporates both transmitter and receiver antenna characteristics.

**Figure 2: System diagram**



# Outline Dimensions

**Figure 3: Mechanical data**



All dimensions in mm; values are typical unless otherwise specified

# FM Characteristics

VCO Voltage generates an output signal even without an object in range because of the finite isolation between transmitter and receiver path. This effect is called self-mixing and leads to a DC signal that depends on the carrier frequency.

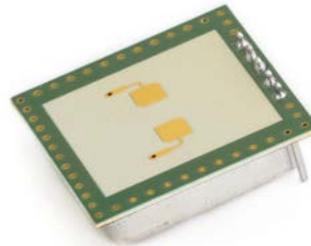
Mixer offset voltages are also dependent on production tolerances.

# Pin Configuration and Functions

**Table 1: Pin function description**

Pin No.	Name	Description
1	IF Q output	load 1 kOhm
2	VCC	5 VDC supply
3	IF I output	load 1 kOhm
4	GND	ground
5	VCO in	Open = $f_0$

**Figure 3: Pin configuration**



# 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: -103 dBc (@0.5 kHz IF Bandwidth)
- **Carrier frequency**  
f<sub>0</sub>: 24.125 GHz
- **Radar cross section RCS "reflectivity" of the object**  
σ<sup>1)</sup>: 1 m<sup>2</sup> approx. for a moving person  
> 50 m<sup>2</sup> for a moving car

note <sup>1)</sup> 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:

- 6 meters for a moving person.
- > 15 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.

For simple detection purposes (security applications e.g.) without the need of speed measurements, range may be enhanced by further reducing the IF bandwidth. With 250 Hz bandwidth and a simple comparator, we get already a 15 m frontal detection range.

## Datasheet Revision History

Version	Date	Changes
1.0	13. November 2017	initial release

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