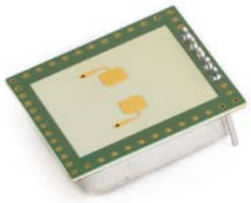
RFbeam Microwave GmbH

data sheet

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 mm² 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.

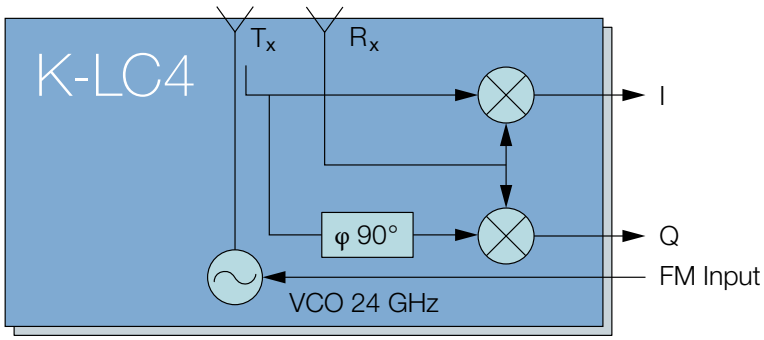
The module is extremely small and lightweight. With an IF bandwidth from DC to 50 MHz it opens many new applications.

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.

Block Diagram

Figure 1: K-LC4 block diagram



Characteristics

Parameter	Conditions/Notes	Symbol	Min	Typ	Max	Unit
Operating Conditions						
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 Note 1	R_{VCO}		570		Ω
Operating temperature		T_{op}	-20		+85	°C
Storage temperature		T_{st}	-20		+105	°C
Transmitter						
Transmitter frequency	T_{amb} = -20 °C .. +60 °C	f_{TX}	24.05	24.125	24.25	GHz
Frequency drift vs temperature	V_{CC} = 5.0 V, -20 °C .. +85 °C Note 2	Δf_{TX}		-0.9		MHz/°C
Frequency tuning range		Δf_{VCO}		140		MHz
VCO sensitivity		S_{VCO}		-55		MHz/V
VCO Modulation Bandwidth	Δf = 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, Δf_{TX} < 5 MHz	t_{on}		1		µs
Receiver						
Mixer Conversion loss	f_{IF} = 1 kHz, IF load = 1 kΩ	D_{mixer1}		-6		dB
	f_{IF} = 20 MHz, IF load = 50 Ω	D_{mixer2}		-11		dB
Antenna Gain	F_{TX} = 24.125 GHz Note 3	G_{Ant}		4.8		dB
Receiver sensitivity	f_{IF} = 500 Hz, B = 1 kHz, R_{IF} = 1 kΩ, S/N = 6 dB	P_{RX1}		-93		dBm
	f_{IF} = 1 MHz, B = 20 MHz, R_{IF} = 50 Ω, S/N = 6 dB	P_{RX1}		-81		dBm
Overall sensitivity	f_{IF} = 500 Hz, B = 1 kHz, R_{IF} = 1 kΩ, S/N=6 dB	D_{system}		-103		dBc
IF output						
IF resistance		R_{IF}		50		Ω
IF frequency range	-3dB Bandwidth, IF load = 50 Ω	f_{IF}	0		50	MHz
IF noise power	f_{IF} = 500 Hz, IF load = 50 Ω	$P_{IFnoise1}$		-134		dBm/Hz
	f_{IF} = 1M Hz, IF load = 50 Ω	$P_{IFnoise2}$		-164		dBm/Hz
IF noise voltage	f_{IF} = 500 Hz, IF load = 1 kΩ	$U_{IFnoise1}$		-147		dBV/Hz
	f_{IF} = 500 Hz, IF load = 1 kΩ	$U_{IFnoise1}$		45		nV/√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	ΔU_{IF}		3		dB
I/Q phase shift	f_{IF} = 1 Hz–20 kHz	φ	80	90	100	°
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_{φ}		138		°
Vertical -3 dB beamwidth	H-Plane	W_{φ}		132		°
Horiz. sidelobe suppression		D_{φ}		-12		dB
Vertical sidelobe suppression		D_{φ}		-12		dB
Body						
Outline Dimensions				25 × 25 × 6		mm³
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

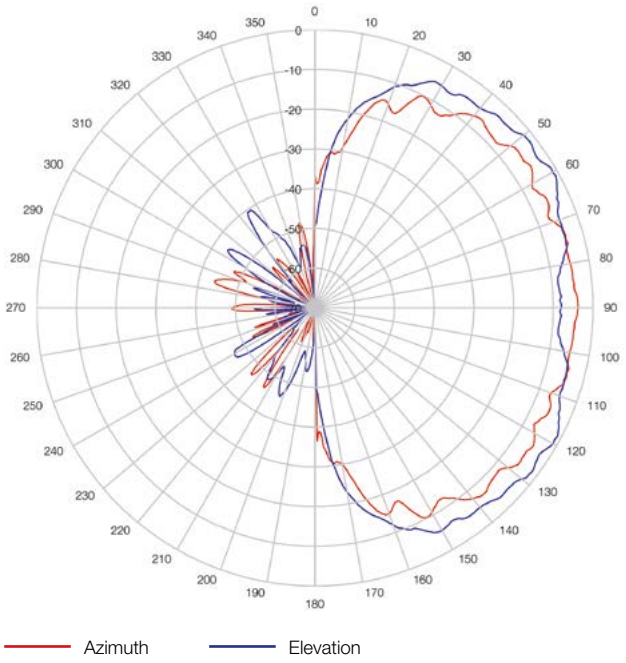
Note 2 Transmit frequency stays within 24.050 to 24.250GHz over the specified temperature range

Note 3 Theoretical value, given by Design

Antenna System Diagram

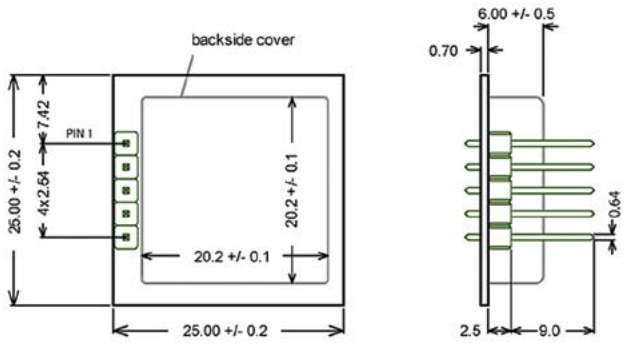
This diagram shows module sensitivity in both azimuth and elevation directions. It incorporates both transmitter and receiver antenna characteristics.

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.

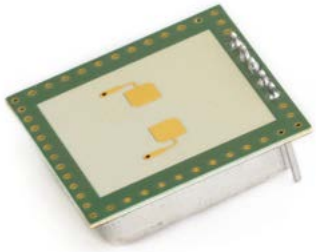
Mixer offset voltages are also dependent on production tolerances.

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_0: 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:
– 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