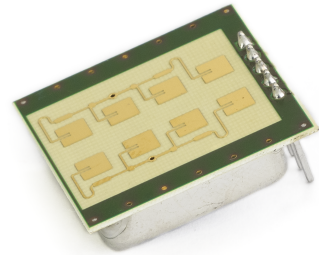


## Features

- 24 GHz K-band miniature transceiver
- Dual 4 patch antenna
- Beam aperture 80°/34°
- 15dBm EIRP output power
- 25x25mm<sup>2</sup> surface, 6mm thickness
- Lowcost design
- With or without FM input depending on variant
- 3.3V or 5V variant



## Applications

- General purpose movement detectors
- Security systems
- Object speed measurement systems
- Simple shorrange ranging detection
- Highspeed shorrange data transmission
- Industrial sensors

## Description

K-LC1a is a 8 patch Doppler module with an asymmetrical beam for lowcost short distance applications. Its typical applications are movement sensors in the security and automatic door domain. In building automation this module may be an alternative for infrared PIR or AIR systems thanks to its outstanding performance/cost ratio.

The module is extremely small and lightweight.

With its wide IF bandwidth it opens many new applications.

FSK is possible thanks to the unique RFbeam oscillator design. This allows to use this lowcost module even in ranging applications.

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

## Blockdiagram

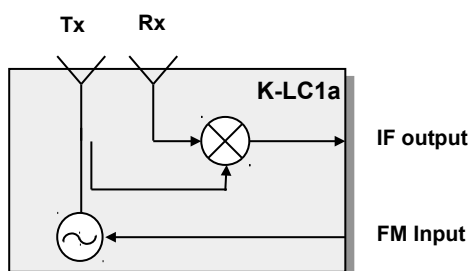


Fig. 1: Block diagram (FM input not present on K-LC1a\_V2 & K-LC1a\_V5)

## Characteristics

Parameter	Conditions / Notes	Symbol	Min	Typ	Max	Unit
<b>Operating conditions</b>						
Supply voltage	For K-LC1a & K-LC1a_V2 variant	$V_{cc}$	4.75	5.0	5.25	V
	For K-LC1a_V4 & K-LV1a_V5 variant	$V_{cc}$	3.0	3.3	3.6	V
Supply current	VCO Pin open	$I_{cc}$		35	65	mA
VCO input voltage	For K-LC1a variant	$U_{vco}$	-0.5		2.0	V
	For K-LC1a_V4 variant	$U_{vco}$	-0.5		1.0	V
VCO pin resistance	Driving voltage source <sup>Note 1</sup>	$R_{vco}$		570		$\Omega$
Operating temperature		$T_{op}$	-20		+85	$^{\circ}\text{C}$
Storage temperature		$T_{st}$	-20		+105	$^{\circ}\text{C}$
<b>Transmitter</b>						
Transmitter frequency	VCO pin left open, $T_{amb} = -20^{\circ}\text{C} \dots +85^{\circ}\text{C}$	$f_{TX}$	24.050	24.125	24.250	GHz
Frequency drift vs temperature	$V_{cc}=5.0\text{V}$ , $-20^{\circ}\text{C} \dots +85^{\circ}\text{C}$ <sup>Note 2</sup>	$\Delta f_{TX}$		-1		MHz/ $^{\circ}\text{C}$
Frequency tuning range		$\Delta f_{vco}$		180		MHz
VCO sensitivity		$S_{vco}$		-80		MHz/V
VCO Modulation Bandwidth	$\Delta f=20\text{MHz}$	$B_{vco}$		3		MHz
Output power	EIRP	$P_{TX}$		+15		dBm
Output power deviation	Full VCO tuning range	$\Delta P_{TX}$			+/- 1	dBm
Spurious emission		$P_{spur}$		-30		dBm
Turn-on time	Until oscillator stable, $\Delta f_{TX} < 5\text{MHz}$	$t_{on}$		1	6	$\mu\text{s}$
<b>Receiver</b>						
Mixer Conversion loss	$f_{IF} = 1\text{kHz}$ , IF load = $1\text{k}\Omega$	$D_{mixer1}$		-6		dB
	$f_{IF} = 20\text{MHz}$ , IF load = $50\Omega$	$D_{mixer2}$		-11		dB
Antenna Gain	$F_{TX}=24.125\text{GHz}$ <sup>Note 3</sup>	$G_{Ant}$		8.6		dB
Receiver sensitivity	$f_{IF} = 500\text{Hz}$ , $B=1\text{kHz}$ , $R_{IF} = 1\text{k}\Omega$ , $S/N=6\text{dB}$	$P_{RX1}$		-96		dBm
	$f_{IF} = 1\text{MHz}$ , $B=20\text{MHz}$ , $R_{IF} = 50\Omega$ , $S/N=6\text{dB}$	$P_{RX1}$		-84		dBm
Overall sensitivity	$f_{IF} = 500\text{Hz}$ , $B=1\text{kHz}$ , $R_{IF} = 1\text{k}\Omega$ , $S/N=6\text{dB}$	$D_{system}$		-111		dBc
<b>IF output</b>						
IF resistance		$R_{IF}$		50		$\Omega$
IF frequency range	-3dB Bandwidth, IF load = $50\Omega$	$f_{IF}$	0	10	50	MHz
IF noise power	$f_{IF} = 500\text{Hz}$ , IF load = $50\Omega$	$P_{IFnoise1}$		-134		dBm/Hz
	$f_{IF} = 1\text{MHz}$ , IF load = $50\Omega$	$P_{IFnoise2}$		-164		dBm/Hz
IF noise voltage	$f_{IF} = 500\text{Hz}$ , IF load = $1\text{k}\Omega$	$U_{IFnoise1}$		-147		dBV/Hz
	$f_{IF} = 500\text{Hz}$ , IF load = $1\text{k}\Omega$	$U_{IFnoise1}$		45		nV/ $\sqrt{\text{Hz}}$
IF output offset voltage	Full VCO range, no object in range	$U_{IF}$	10		200	mV
Supply rejection	Rejection supply pins to IF output	$D_{supply}$		26		dB

## K-LC1a RADAR TRANSCEIVER

Datasheet

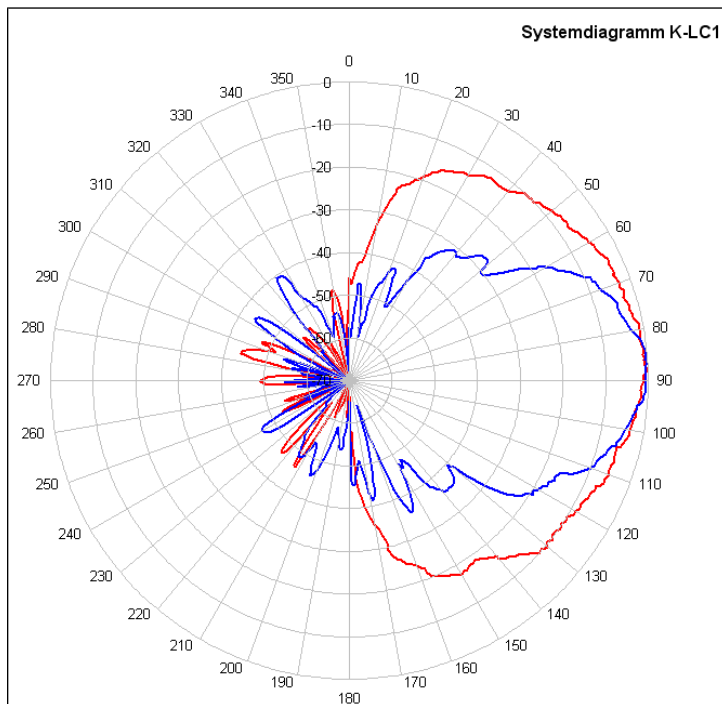
Parameter	Conditions / Notes	Symbol	Min	Typ	Max	Unit
<b>Antenna</b>						
Horizontal -3dB beamwidth	E-Plane	$W_e$		80		°
Vertical -3dB beamwidth	H-Plane	$W_h$		34		°
Horiz. sidelobe suppression		$D_e$		-12		dB
Vertical sidelobe suppression		$D_h$		-12		dB
<b>Body</b>						
Outline Dimensions				25*25*6		mm <sup>3</sup>
Weight				4.5		g
Connector	Depending on variant, 2.54mm spacing			3 or 5		pins
<b>ESD Rating</b>						
Electrostatic Discharge	Human body model class 0	$V_{ESD}$			250	V

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 when the VCO pin is left open

Note 3 Theoretical value, given by Design

## Antenna System Diagram



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

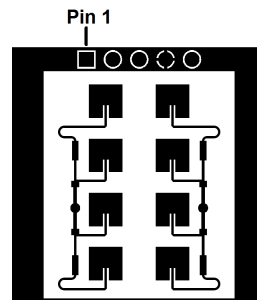
Fig. 2: System diagram

## 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 / the VCO voltage.

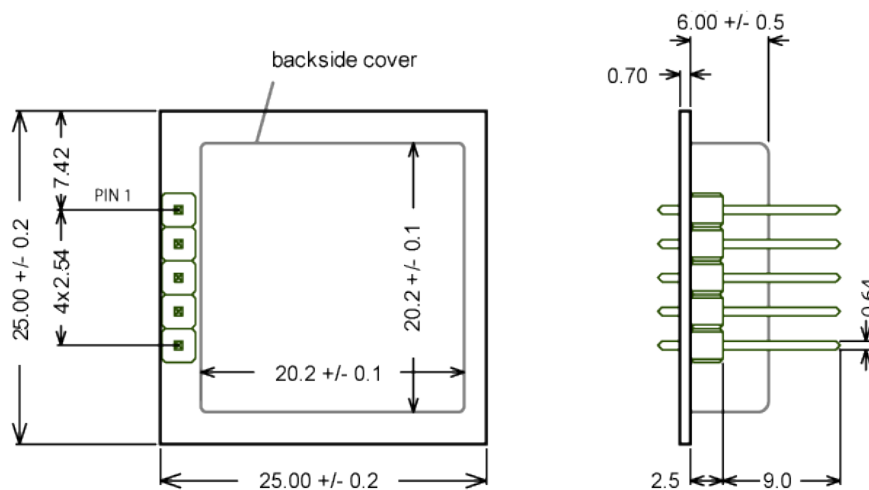
## Pin Configuration

Pin	Description	Typical Value
1 *)	nc	---
2	VCC	DC supply
3	IF output	load 1kOhm
4	GND	ground
5 *)	VCO in	Open = $f_{TX}$



\*) not present in the variants  
K-LC1a\_V2 & K-LC1a\_V5

## Outline Dimensions



All Dimensions in mm; values are typical unless otherwise specified

**Fig. 3: Mechanical data**

## 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:	-114dBc (@0.5kHz IF Bandwidth)
- Carrier frequency	f <sub>TX</sub> :	24.125GHz
- Radar cross section RCS ("reflectivity") of the object	σ <sup>1)</sup> :	1m <sup>2</sup> approx. for a moving person >50m <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

- 12 meters for a moving person.
- > 31 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 250Hz bandwidth and a simple comparator, we get already a 25m detection range.

## Ordering Information

Ordering number	# of Pins	FM input	Supply voltage
K-LC1a	5	yes	5V
K-LC1a_V2	3	no	5V
K-LC1a_V4	5	yes	3.3V
K-LC1a_V5	3	no	3.3V

## Datasheet Revision History

Version	Date	Changes
1.0	Aug-2007	initial release
1.1	Oct-2008	Some typing errors corrected
1.2	Apr-2009	Outline Dimensions changed for K-LC1a: thickness and pin length
1.3	June-2009	Dimensions corrected in table Characteristics, Position Body
1.4	Feb-2010	Typing corrected K-LC1 to K-LC1a. VCO sensitivity typ. 80MHz/V instead of 45MHz/V
1.5	Sep-2010	Typing error corrected: frequency temp. drift from 1MHz/°C to -1MHz/°C
1.6	Jan-2012	Chapter FM Characteristics minor text changes. Diagram dropped.
1.7	Sept-2013	Added part# for K-LC1a_V4 (3.3V version)
1.8	Oct-2014	Notes added regarding K-LC1a_V2 (no FM input)
1.9	Jun-2017	Directive 2014/53/EU and full address added
2.0	Apr-2018	Outer Outline Dimensions corrected
2.1	Mar-2020	Added ESD information, changed operating temperature and spurious, merged K-LC1a datasheets

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