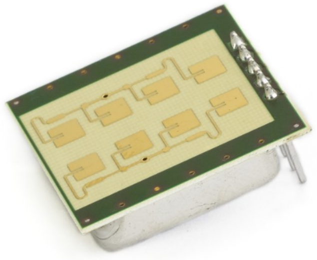
K-LC2 RADAR TRANSCEIVER Datasheet

Features



- 24 GHz K-band miniature I/Q transceiver
- 140MHz sweep FM input
- 2 x 4 patch antenna
- Excellent noise cancelling ability though I/Q technology
- Beam aperture 80°/34°
- 15dBm EIRP output power
- 25x25mm^2 surface, <6.5mm thickness
- Lowcost design

Applications

- Direction sensitive movement detectors
- Security systems
- Object speed measurement systems
- Simple ranging detection using FSK
- Industrial sensors

Description

K-LC2 is a 2 x 4 patch Doppler module with an asymmetrical beam for lowcost short distance applications. Its typical applications are movement sensors in the security and presence detection 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.
Powerful starterkits (ST100 and ST200) with signal conditioning and visualization on the PC's are available.

Blockdiagram

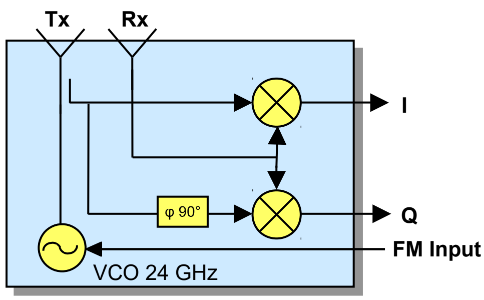


Fig. 1: Block diagram

Characteristics

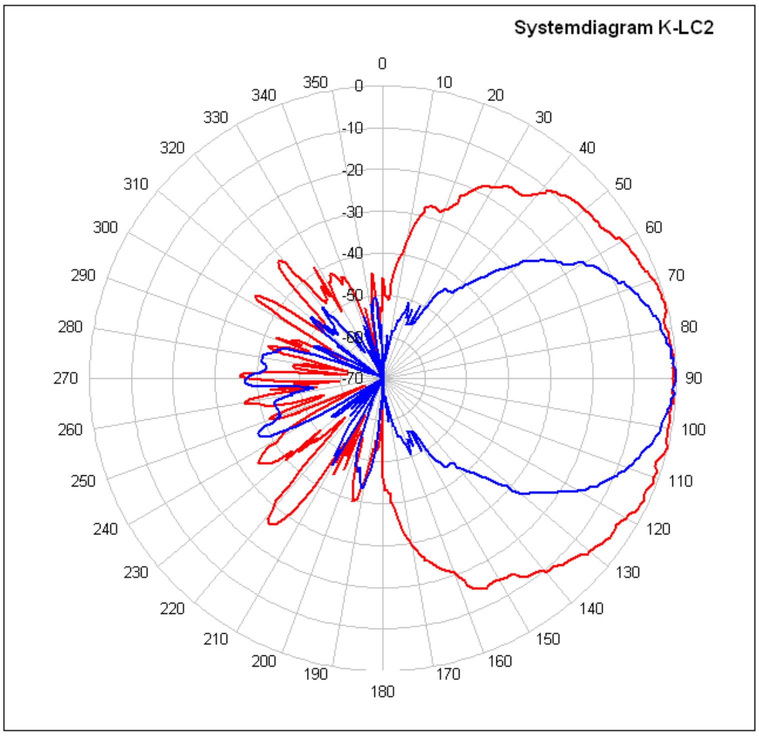
Parameter	Conditions / Notes	Symbol	Min	Typ	Max	Unit
Operating conditions						
Supply voltage		V_{cc}	4.75	5.0	5.25	V
Supply current	VCO Pin open	I_{cc}		35	65	mA
VCO input voltage		U_{vco}	-0.5		2.0	V
VCO pin resistance	Driving voltage source Note 1	R_{vco}		570		Ω
Operating temperature		T_{op}	-20		+85	°C
Storage temperature		T_{st}	-20		+105	°C
Transmitter						
Transmitter frequency	VCO pin left open, T_{amb}=-20°C .. +85°C	f_{TX}	24.050	24.125	24.250	GHz
Frequency drift vs temperature	V_{cc}=5.0V, -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=20MHz	B_{VCO}		3		MHz
Output power	EIRP	P_{TX}		+15		dBm
Output power deviation	Full VCO tuning range	ΔP_{TX}			+/- 1	dBm
Spurious emission		P_{spur}		-30		dBm
Turn-on time	Until oscillator stable, Δf_{TX} < 5MHz	t_{on}		1	6	µs
Receiver						
Mixer Conversion loss	f_{IF} = 1kHz, IF load = 1kΩ	D_{mixer1}		-8		dB
	f_{IF} = 20MHz, IF load = 50Ω	D_{mixer2}		-13		dB
Antenna Gain	F_{TX}=24.125GHz Note 3	G_{Ant}		8.6		dBi
Receiver sensitivity	f_{IF} =500Hz,B=1kHz,R_{IF} =1kΩ,S/N=6dB	P_{RX1}		-94		dBm
	f_{IF} =1MHz,B=20MHz,R_{IF} =50Ω,S/N=6dB	P_{RX1}		-82		dBm
Overall sensitivity	f_{IF} =500Hz,B=1kHz,R_{IF} =1kΩ,S/N=6dB	D_{system}		-109		dBc
IF output						
IF output resistance		R_{IF}		50		Ω
IF frequency range	-3dB Bandwidth, IF load = 50Ω	f_{IF}	0	10	50	MHz
IF noise power	f_{IF} =500Hz, IF load = 50Ω	$P_{IFnoise1}$		-137		dBm/Hz
	f_{IF} =1MHz, IF load = 50Ω	$P_{IFnoise2}$		-165		dBm/Hz
IF noise voltage	f_{IF} =500Hz, IF load = 1kΩ	$U_{IFnoise1}$		-150		dBV/Hz
	f_{IF} =500Hz, IF load = 1kΩ	$U_{IFnoise1}$		31		nV/√Hz
IF output offset voltage	Full VCO range, no object in range	U_{IF}	-200		200	mV
I/Q amplitude balance	f_{IF} =500Hz, U_{IF} = 1mVpp	ΔU_{IF}		0		dB
I/Q phase shift	f_{IF} = 1Hz - 20kHz	φ	80	90	100	°
Supply rejection	Rejection supply pins to IF output	D_{supply}		25		dB

Parameter	Conditions / Notes	Symbol	Min	Typ	Max	Unit
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
Vertical sidelobe suppression		D_{θ}	-12	-20		dB
Body						
Outline Dimensions				25*25*6		mm^3
Weight				4.5		g
Connector	2.54mm spacing			5		pins
ESD Rating						
Electrostatic Discharge	Human body model class 0	V_{ESD}			250	V

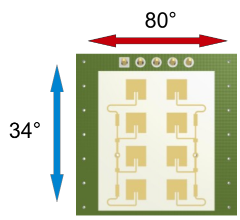
Note 1 The VCO input has an internal voltage source with approx. 0.9VDC. For driving this pin it is necessary to source and sink current
Note 2 Transmit frequency stays within 24.050 to 24.250GHz over the specified temperature range when the VCO pin is left open
Note 3 Theoretical value, given by Design

Antenna System Diagram

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



Horizontal 80°, vertical 34°
at IF output voltage -6dB
(corresponds to -3dB TX power)



Remarks:
The broader the antenna, the narrower the beam.

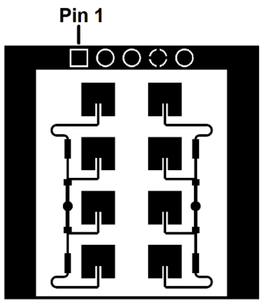
Fig. 2: System diagram

FM Characteristics

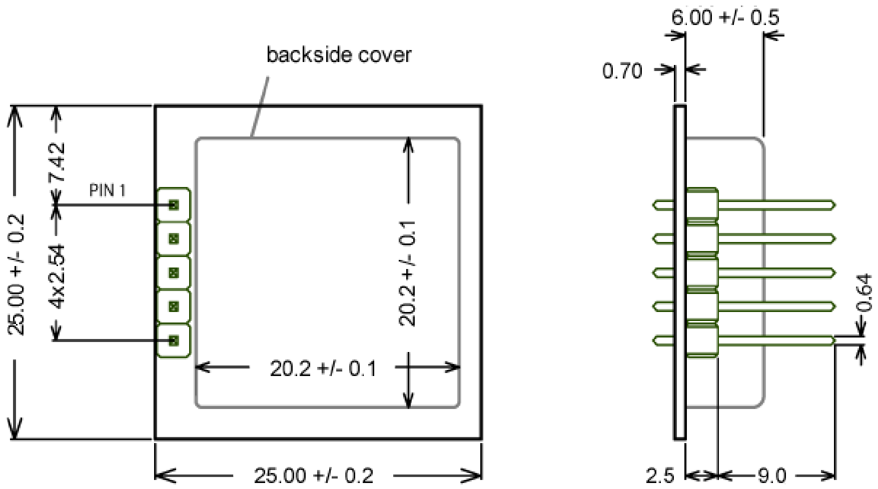
VCO Voltage generates an output signal even without an object in range because of the finite isolation between transmitter and receiver path. This effect is called self-mixing and leads to a DC signal that depends on the carrier frequency. Mixer offset voltages are also dependent on production tolerances.

Pin Configuration

Pin	Description	Typical Value
1	IF Q output	load 1kOhm
2	VCC	DC supply
3	IF I output	load 1kOhm
4	GND	ground
5	VCO in	Open = f_{TX}



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:	-109dBc (@0.5kHz IF Bandwidth)
- Carrier frequency	f_{TX}:	24.125GHz
- Radar cross section RCS ("reflectivity") of the object	σ[1]:	$1m^2$ approx. for a moving person $>50m^2$ 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
- >8.9 meters for a moving person.
- >23.6 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 20m detection range.

Ordering Information

Ordering number	# of Pins	FM input	Supply voltage
K-LC2-RFB-00D	5	yes	5V

Datasheet Revision History

Version	Date	Changes
1.0	Aug-2008	Preliminary release
1.1	Oct-2008	Replaced diagram FM characteristics
1.2	Apr-2009	Replaced Fig. 4. Changes dual 4 patch to single 4 patch antenna
1.3	May-2009	Fig. 1 changed blockdiagram
1.4	June-2009	Updated System diagram
1.5	May-2011	Cosmetic text correction
1.6	April-2014	Fig. 2 System diagram comments added
2.0	July-2014	New antenna design starting from production lot 1421. Better sensitivity.
2.1	Aug-2018	Changed footer to new address
2.2	Mar-2020	Added ESD information, changed operating temperature and spurious, added ordering informations
2.3	Sept-2021	Changed sensitivity and noise parameters and ordering information