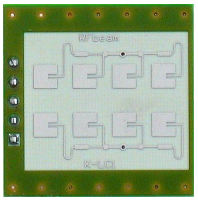
LC1 RADAR TRANSCEIVER

Features

- 24 GHz K-band miniature transceiver
- 100MHz sweep FM input
- Dual 4 patch antenna
- Single balanced mixer with 50MHz bandwidth
- Beam aperture 80°/34°
- 15dBm EIRP output power
- 25x25mm^2 surface, <5mm thickness
- Lowcost design



LC1 Actual Size

Applications

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

Description

LC1 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 IF bandwidth from DC to 50MHz it opens many new applications.

FM and FSK are possible thanks to the unique RFbeam oscillator design. This allows to use this lowcost module even in ranging applications.
RFbeam offers also a separate and directly mountable IF "LC1 Preamp" featuring a buffered DC mixer output and a high gain, low noise AC amplifier with 66dB total gain.
A powerful starterkit with signal conditioning and visualization using the PC's soundcard is also available.

Blockdiagram

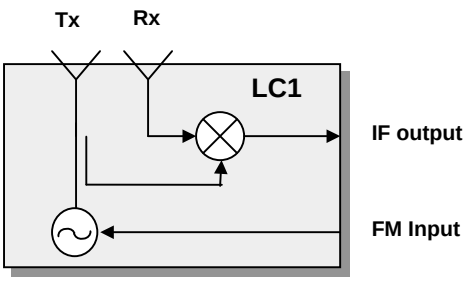


Fig. 1: Block diagram

LC1 RADAR TRANSCEIVER

Characteristics

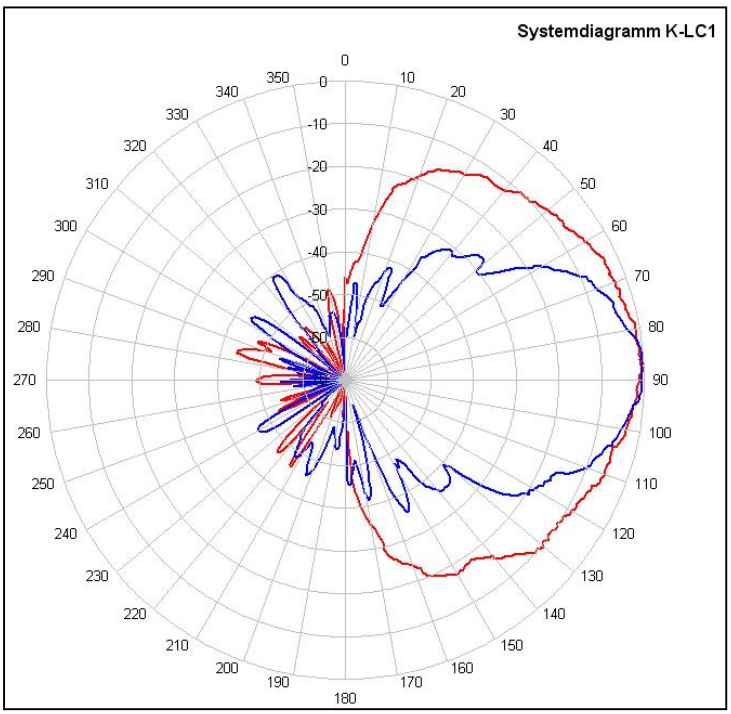
Parameter	Conditions / Notes	Symbol	Min	Typ	Max	Unit
Operating conditions						
Supply voltage		V_{cc}	4.75	5.0	5.25	V
Supply current	VCO Pin open	I_{cc}		35	45	mA
VCO input voltage		U_{vco}	-0.5		2.0	V
VCO pin resistance	Driving voltage source Note 1	R_{vco}		570		Ω
Operating temperature		T_{op}	-20		+60	°C
Storage temperature		T_{st}	-20		+80	°C
Transmitter						
Transmitter frequency	VCO pin left open, T_{amb}=-20°C .. +60°C	f_{TX}	24.050	24.125	24.250	GHz
Frequency drift vs temperature	V_{cc}=5.0V, -20°C .. +60°C Note 2	Δf_{TX}		1.0		MHz/°C
Frequency tuning range		Δf_{vco}		100		MHz
VCO sensitivity		S_{vco}		-45		MHz/V
VCO Modulation Bandwidth	Δf=20MHz	B_{VCO}		3		MHz
Output power	EIRP	P_{TX}	+12	+15	+17	dBm
Output power deviation	Full VCO tuning range	ΔP_{TX}			+/- 1	dBm
Spurious emission	According to ETSI 300 440	P_{spur}			-30	dBm
Turn-on time	Until oscillator stable, Δf_{TX} < 5MHz	t_{on}		1		µs
Receiver						
Mixer Conversion loss	f_{IF} = 1kHz, IF load = 1kΩ	D_{mixer1}		-6		dB
	f_{IF} = 20MHz, IF load = 50Ω	D_{mixer2}		-11		dB
Antenna Gain	F_{TX}=24.125GHz Note 3	G_{Ant}		8.6		dB
Receiver sensitivity	f_{IF} =500Hz,B=1kHz,R_{IF} =1kΩ,S/N=6dB	P_{RX1}		-96		dBm
	f_{IF} =1MHz,B=20MHz,R_{IF} =50Ω,S/N=6dB	P_{RX1}		-84		dBm
Overall sensitivity	f_{IF} =500Hz,B=1kHz,R_{IF} =1kΩ,S/N=6dB	D_{system}		-111		dBc
IF output						
IF resistance		R_{IF}		50		Ω
IF frequency range	-3dB Bandwidth, IF load = 50Ω	f_{IF}	0		50	MHz
IF noise power	f_{IF} =500Hz, IF load = 50Ω	$P_{IFnoise1}$		-134		dBm/Hz
	f_{IF} =1MHz, IF load = 50Ω	$P_{IFnoise2}$		-164		dBm/Hz
IF noise voltage	f_{IF} =500Hz, IF load = 1kΩ	$U_{IFnoise1}$		-147		dBV/Hz
	f_{IF} =500Hz, IF load = 1kΩ	$U_{IFnoise1}$		45		nV/√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

LC1 RADAR TRANSCEIVER

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		dB
Vertical sidelobe suppression		D_θ		-12		dB
Body						
Outline Dimensions				25*25*4		mm^3
Weight				4.5		g
Connector	5pin 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 when the VCO pin is left open
Note 3 Theoretical value, given by Design

Antenna System Diagram

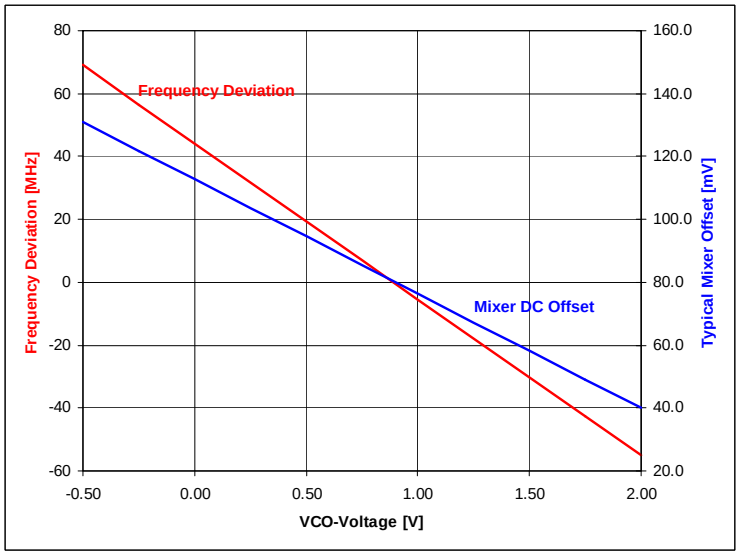


This diagram shows module sensitivity in both azimuth and elevation directions. It incorporates therefore the transmitter and receiver antenna characteristics.

Fig. 2: System diagram

LC1 RADAR TRANSCEIVER

FM Characteristics

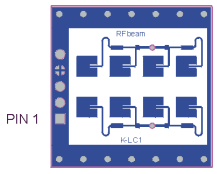


VCO Voltagte generates an output signal even without an object in range because of the finite isolation between transmitter and receiver path. This effect is called self-mixing and leads to a DC signal that depends on the carrier frequency.

Fig. 3: Typical VCO characteristics

Pin Configuration

Pin	Description	Typical Value
1	nc	---
2	VCC	5VDC supply
3	IF output	load 1kOhm
4	GND	ground
5	VCO in	Open = f_0



Outline Dimensions

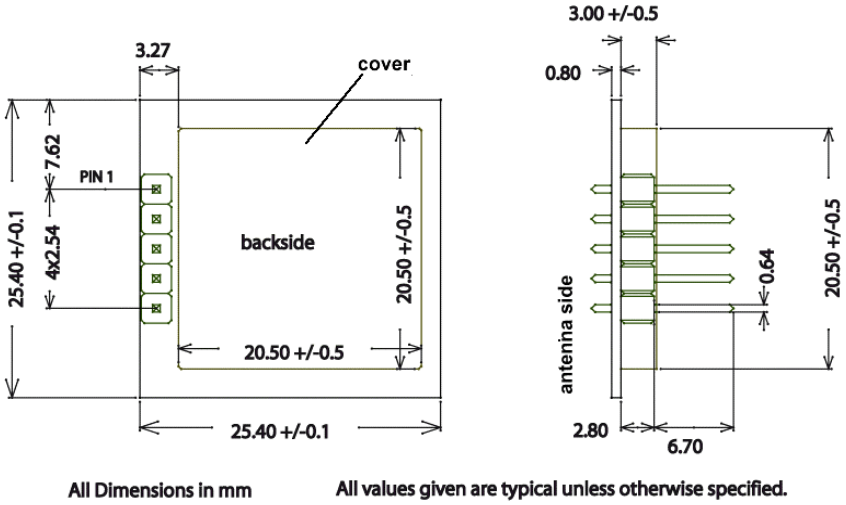


Fig. 4; Mechanical data

LC1 RADAR TRANSCEIVER

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_0:	24.125GHz
- Radar cross section RCS ("reflectivity") of the object	$\sigma^{1)}$:	$1m^2$ 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
- 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.

Datasheet Revision History

Version	Date	Changes
1.0	08-aug-2007	initial release