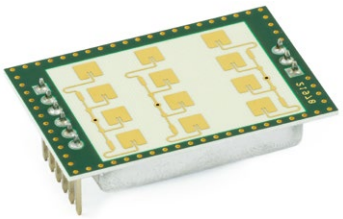
RFbeam Microwave GmbH

data sheet

K-LC7

radar transciever



Features

- Small and low cost 24 GHz transceiver
- Two Rx Antennas for angle measurement
- I/Q IF outputs
- Fully integrated low phase noise VCO
- Built in temperature compensation circuit for VCO stabilization
- Wide power supply range from 3.2 to 5.5V
- 3×4 patch antenna with 80°/34° beam aperture
- SMT type available on request

Applications

- Direction sensitive movement detection
- Security systems
- Home automation
- Indoor and outdoor lighting control applications
- Object speed measurement systems
- Ranging detection of moving objects using FSK
- Industrial sensors

Description

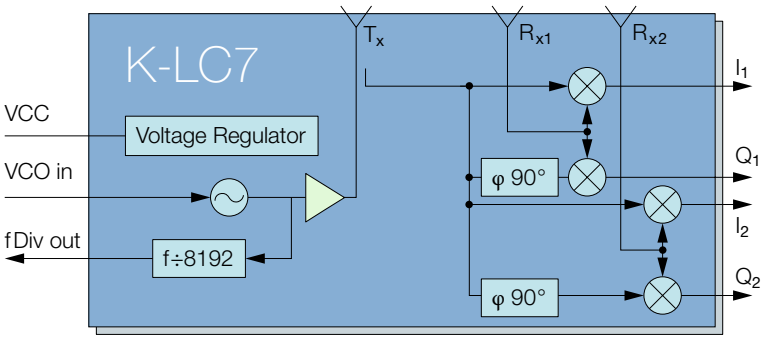
The K-LC7 is a small and low cost radar module which allows angle measurements. The module is operating in the 24.0 GHz to 24.25 GHz ISM band and it has a built in low phase noise VCO, which makes the module suitable for FSK or FMCW applications. The internal temperature compensating circuit keeps the output frequency stable over a wide temperature range.

IF outputs I and Q allow movement direction detection and high performance signal processing.

The sensor has a 3×4 patch radar frontend with an asymmetrical beam. The built-in voltage regulator covers a wide power supply range from 3.2 to 5.5V. The module provides a frequency divided output which can be used to measure the output frequency of the VCO.

Block Diagram

Figure 1: K-LC7 block diagram



CHARACTERISTICS

Parameter	Conditions/Notes	Symbol	Min	Typ	Max	Unit
Operating Conditions						
Supply voltage		Vcc	3.2		5.5	V
Supply current		Icc		90		mA
VCO input voltage		U_{VCO}	0		5	V
VCO pin resistance	Driving voltage source Note 1	R_{VCO}		120		kΩ
Operating temperature		T_{St}	-20		85	°C
Storage temperature		T_{op}	-20		105	°C
Transmitter						
Transmitter frequency	V_{CO} pin left open, Tamb = -20 °C .. +85 °C	f_{TX}	24	24.125	24.25	GHz
Frequency drift vs. temperature	V_{cc} = 5V, -20°C .. +85°C Note 2	Δf_{TX}		0.1		MHz/°C
Frequency tuning range		Δf_{VCO}	200	250	350	MHz
VCO sensitivity		S_{VCO}		80		MHz/V
VCO Modulation Bandwidth	Δf = 20 MHz	B_{VCO}		100		kHz
Output power	EIRP	P_{TX}		12		dBm
Output power deviation	Full V_{CO} tuning range	ΔP_{TX}			+/-1	dBm
Spurious emissions	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} = 1 kHz, IF load = 1 kΩ	D_{mixer1}		-6		dB
Antenna gain	f_{IF} = 20 MHz, IF load = 50 Ω	D_{mixer2}		-11		dB
	f_{TX} = 24.125 GHz	G_{Ant}		8.6		dBi
Receiver sensitivity	f_{IF} = 500 Hz, B = 1 kHz, R_{IF} = 1 kΩ, S/N = 6 dB	P_{RX}		-96		dBm
Overall sensitivity	f_{IF} = 500 Hz, B = 1 kHz, R_{IF} = 1 kΩ, S/N = 6 dB	D_{system}		-108		dBc
Antenna						
Horizontal –3 dB beamwidth	E-Plane	W_{φ}		80		°
Vertical –3 dB beamwidth	H-Plane	W_{θ}		34		°
Horiz. sidelobe suppression		D_{φ}	-12	-20		dB
Vertical sidelobe suppression		D_{θ}	-12	-20		dB
Rx1/Rx2 spacing		l		8.763		mm
IF output						
IF output resistance		R_{IF}		50		Ω
IF frequency range	-3 dB 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} = 1 MHz, IF load = 50 Ω	$P_{IFnoise2}$		-164		dBm/Hz
IF noise voltage	f_{IF} = 500 Hz, IF load = 1 kΩ	$U_{IFnoise1}$		-147		dBm/Hz
	f_{IF} = 500 Hz, IF load = 1 kΩ	$U_{IFnoise1}$		45		nV/√Hz
IF output offset voltage	Full VCO range, 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}		25		dB
Frequency divider output						
Prescaler division factor		X_{div}		8192		
Divider output frequency		F_{div}		2.94		MHz
Divider output voltage	Load = 1 kΩ	U_{div}		1.5		Vpp
Body						
Weight				5		g

Note 1 The VCO input has an internal voltage source with approximately 1.2 VDC and can be left open.

Note 2 Transmit frequency stays within 24.000 to 24.250GHz over the specified temperature range when the VCO pin is left open.

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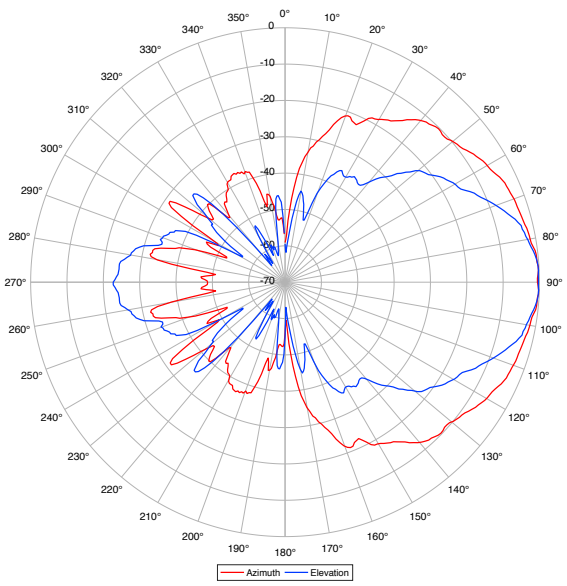
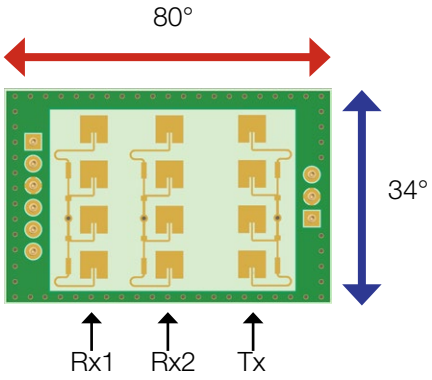
ANTENNA SYSTEM DIAGRAM

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

Figure 2: Antenna characteristics





PIN CONFIGURATION AND FUNCTIONS

Figure 3: Pin configuration

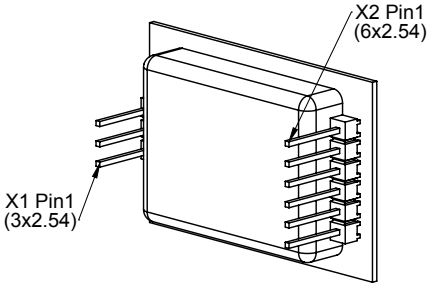


Table 1: Pin function description

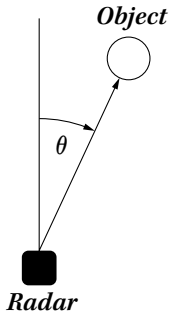
Pin No.	Type	Name	Description	Typical Value
X1,1	Supply	Vcc	Power supply	+3.2 to +5.5V
X1,2	Ground	GND	Ground	–
X1,3	Digital out	fDiv_out	Frequency divider output (f_{TX} / 8192)	–
X2,1	Analog out	Out_I1	IF I (In-Phase) of Antenna Rx1	Load 1 kOhm
X2,2	Analog out	Out_Q1	IF Q (Quadrature) of Antenna Rx1	Load 1 kOhm
X2,3	Ground	GND	Ground	–
X2,4	Analog out	Out_Q2	IF Q (Quadrature) of Antenna Rx2	Load 1 kOhm
X2,5	Analog out	Out_I2	IF I (In-Phase) of Antenna Rx2	Load 1 kOhm
X2,6	Analog in	VCO_In	Voltage controlled oscillator input	0 to +5V

APPLICATION INFORMATION

Angle measurement

The angle of arrival θ of an object in front of the sensor can be determined by the phase difference ΔΦ of the output signals I1_Out/I2_Out or Q1_Out/Q2_Out. Use the following equation for calculation:

Figure 4: Angle of arrival

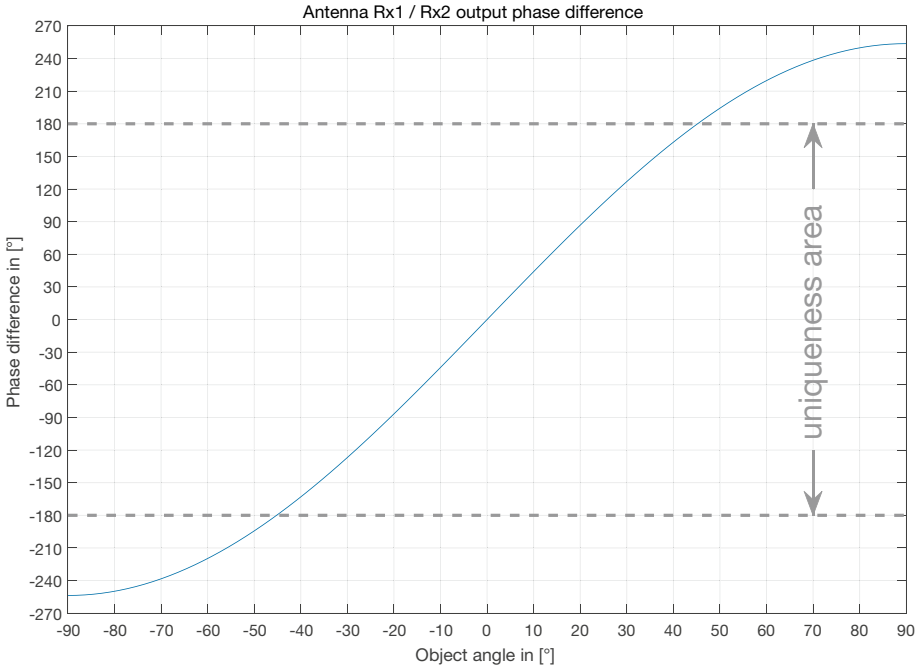


Wavelength: $\lambda = \frac{c}{f} = \frac{300 \cdot 10^6\, m/s}{24.125\, GHz} = 12.43\, mm$

Antenna Spacing: $l = 345\, mil = 8.763\, mm$

Angle of Arrival in radian: $\theta = arcsin\left(\frac{\lambda \Delta\phi}{2\pi l}\right) = arcsin\left(\frac{12.43\, mm \cdot \Delta\phi}{2\pi \cdot 8.763\, mm}\right) = arcsin(0.2257 \cdot \Delta\phi)$

Figure 5: Phase difference vs. object angle



OUTLINE DIMENSIONS

Figure 6: Outline dimensions K-LC7 (SMD-Type)

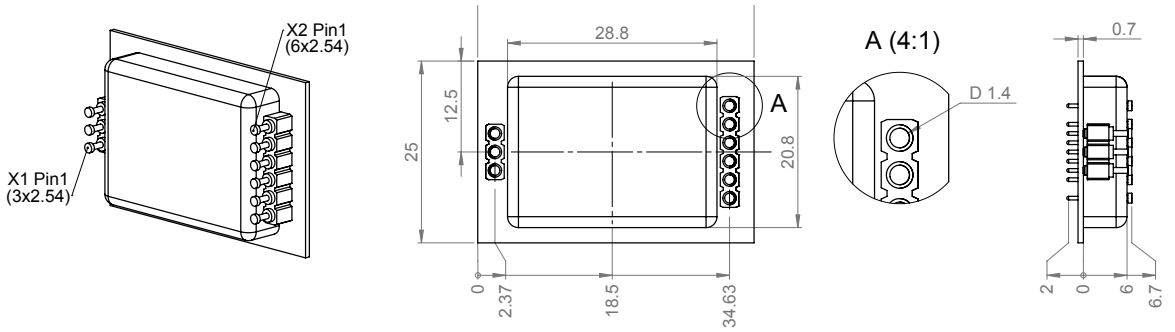


Figure 7: Outline dimensions K-LC7 (THT-Type)

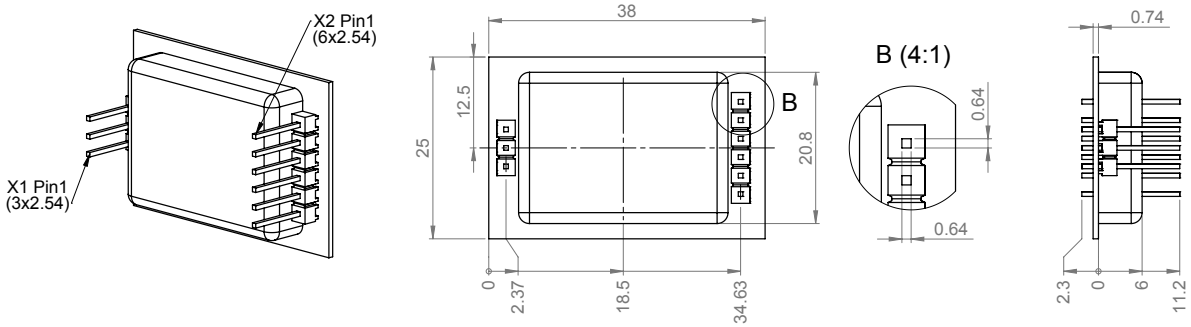
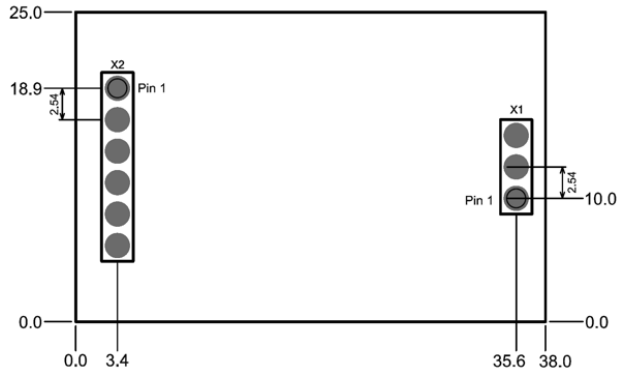


Figure 8: Footprint recommendation for SMD-Type



Top view

Pads: Round d = 2 mm

All dimensions in (mm)

ORDERING INFORMATION

The ordering number consists of different parts with the structure below.

Figure 9: Ordering number structure

Product	–	Customer	–	HW variant	Supply
= K-LC7		**= RFB** for standard products		**= 00** for THT-type **= 01** for SMD-type	**= H** for 3.2V…5V version

Table 2: Available ordering numbers

Ordering number	Description
K-LC7-RFB-00H	Standard K-LC7 THT-type
K-LC7-RFB-01H	Standard K-LC7 SMD-type

REVISION HISTORY

02/2018 – Revision A: Initial Version

10/2018 – Revision B: Change to supply current on page 2
Added Rx1/Rx2 spacing on page 2
Change to Note 1 on page 2
Added table of contents
Added application information