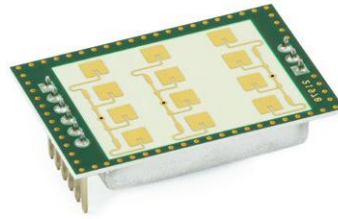


K-LC7

radar transceiver



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 x 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

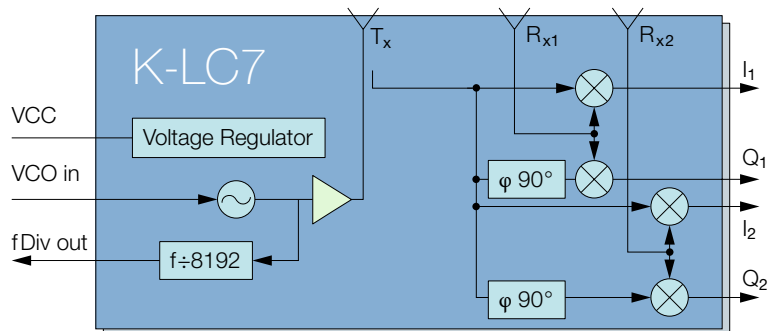
The K-LC7 is a small and low cost radar module which allows angle measurements. The module is operating in the 24.0 GHz to 24.25 GHz ISM band and it has a built in low phase noise VCO, which makes the module suitable for FSK or FMCW applications. The internal temperature compensating circuit keeps the 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 3x4 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		V _{CC}	3.2		5.5	V
Supply current		I _{CC}		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, T _{amb} = -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}	Δ f _{TX}		0.1		MHz/°C
Frequency tuning range		Δ f _{VCO}	200	250	350	MHz
VCO sensitivity		S _{VCO}		80		MHz/V
VCO Modulation Bandwidth	Δf = 20MHz	B _{VCO}		100		kHz
Output power	EIRP	P _{TX}		12		dBm
Output power deviation	Full V _{CO} tuning range	Δ P _{TX}			+/-1	dBm
Spurious emissions	According to ETSI 300 440	P _{Spur}		-30		dBm
Turn-on time	Until oscillator stable, Δ f _{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} = 20MHz, IF load = 50 Ω	D _{mixer2}		-11		dB
	f _{TX} = 24.125GHz	G _{Ant}		8.6		dBi
Receiver sensitivity	f _{IF} = 500Hz, B = 1 kHz, R _{IF} = 1 kΩ, S/N = 6 dB	P _{RX}		-96		dBm
Overall sensitivity	f _{IF} = 500Hz, B = 1 kHz, R _{IF} = 1 kΩ, S/N = 6 dB	D _{system}		-108		dBc

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
Rx1/Rx2 spacing		l		8.763		mm

IF output

IF output resistance		R _{IF}		50		Ω
IF frequency range	-3dB Bandwidth, IF load = 50 Ω	f _{IF}	0		50	MHz
IF noise power	f _{IF} = 500Hz, 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} = 500Hz, IF load = 1kΩ	U _{IFnoise1}		-147		dBm/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}	-200		200	mV
I/Q amplitude balance	f _{IF} = 500Hz, U _{IF} = 1 mVpp	Δ U _{IF}		3		dB
I/Q phase shift	f _{IF} = 1 Hz ... 20kHz	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
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Note 1 The VCO input has an internal voltage source with approximately 1.2VDC 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.

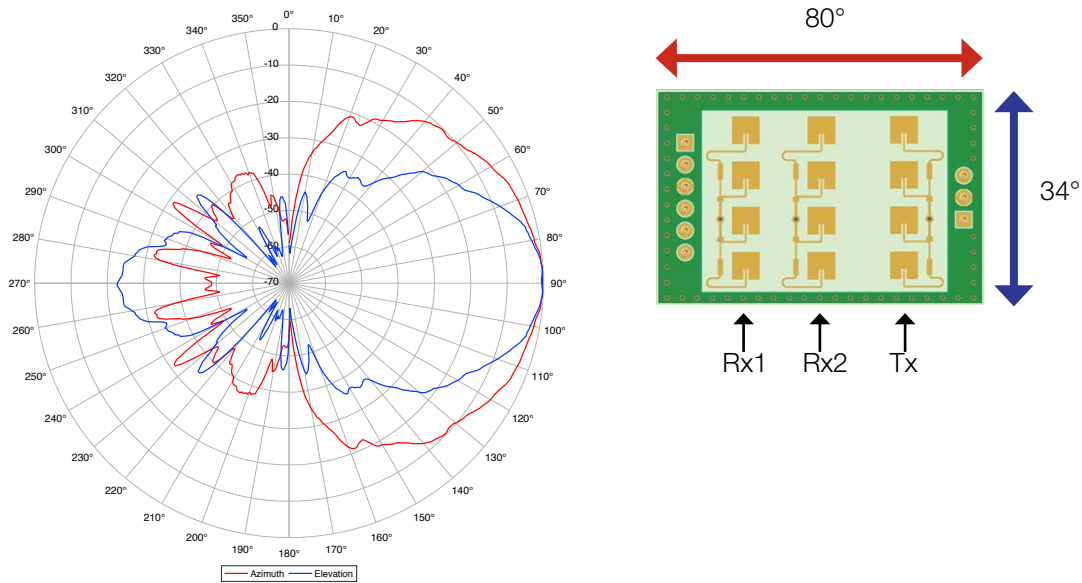
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ANTENNA SYSTEM DIAGRAM

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

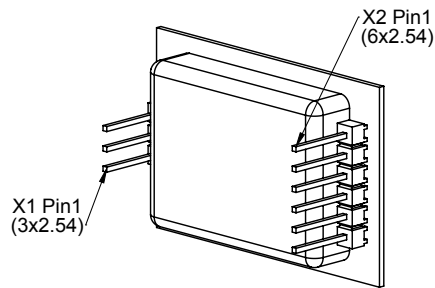


Table 1: Pin function description

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 $\Delta\Phi$ of the output signals I1_Out/I2_Out or Q1_Out/Q2_Out. Use the following equation for calculation:

Figure 4: Angle of arrival

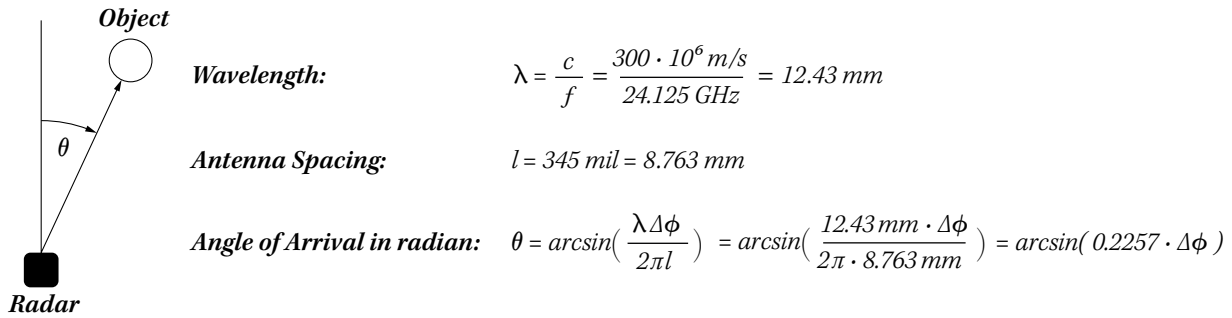
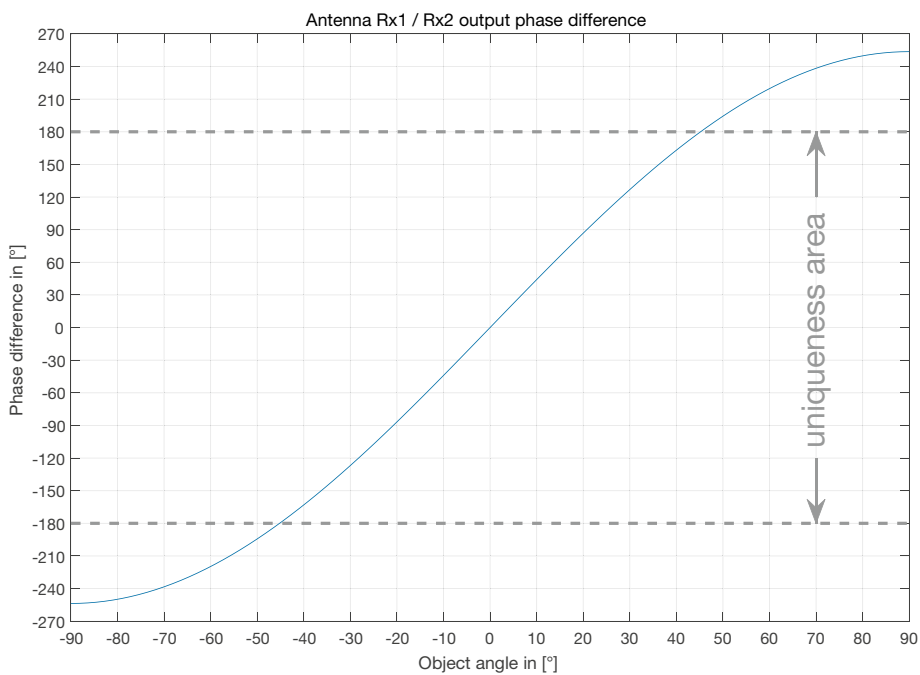


Figure 5: Phase difference vs. object angle



OUTLINE DIMENSIONS

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

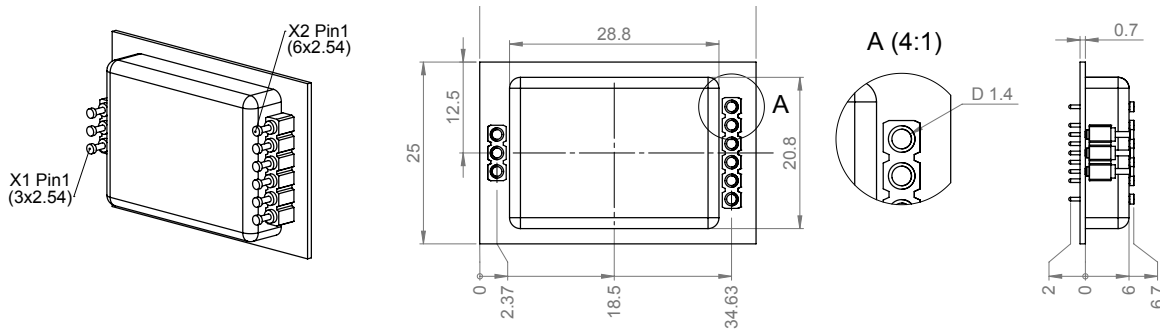


Figure 7: Outline dimensions K-LC7 (THT-Type)

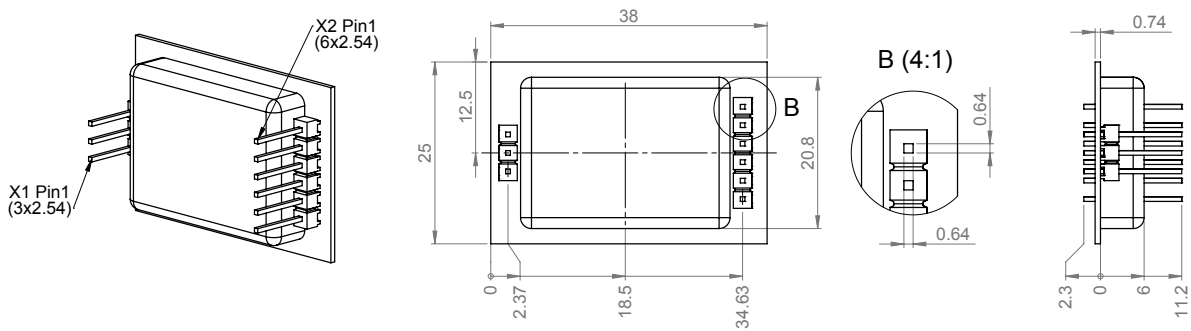
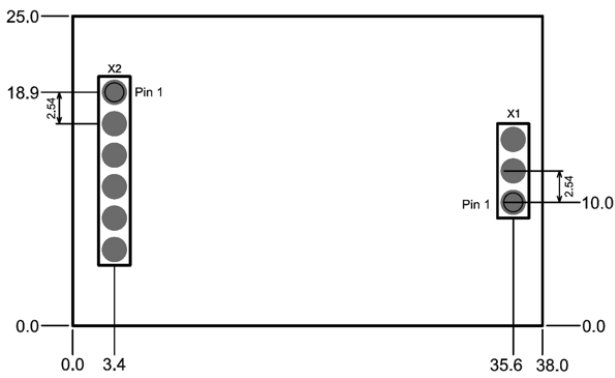


Figure 8: Footprint recommendation for SMD-Type



Top view

Pads: Round $d = 2\text{ mm}$

All dimensions in (mm)

ORDERING INFORMATION

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

Figure 9: Ordering number structure

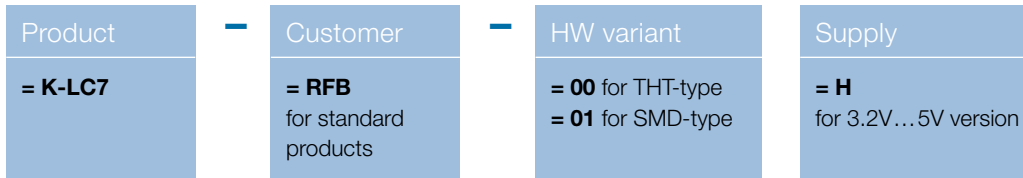


Table 2: Available ordering numbers

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