## K-LC3 RADAR TRANSCEIVER
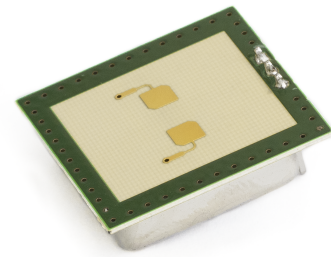
## Features

- 24 GHz K-band miniature transceiver
- Dual 1 patch circular polarized antenna
- Wide beam aperture 138°/132°
- 10dBm EIRP output power
- 25x25mm$^2$ surface, <6mm thickness
- Low cost design
- 3.3V or 5V variant

## Applications

- Lowcost general purpose movement detectors
- Security systems
- Ceiling and wall mount surveillance system
- Industrial sensors

## Description

K-LC3 is a 2 patch Doppler module with a nearly symmetrical wide beam for low cost short distance applications.

Its typical applications are movement sensors for security, lighting and building automation applications This module may be an alternative or a complementary sensor 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.

The unique RFbeam circular polarized antenna forms allows much wider acquisition fields than the traditional linear polarized patch antenna.

A powerful starterkit with signal conditioning and visualization is available from RFbeam. Find more informations on www.rfbeam.ch.
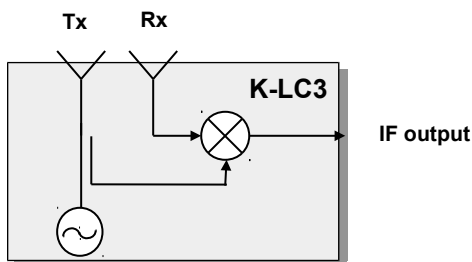
## Blockdiagram

**Fig. 1: Block diagram**

## Characteristics

| Parameter | Conditions / Notes | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| **Operating conditions** | | | | | | |
| Supply voltage | For K-LC3 variant | $V_{cc}$ | 4.75 | 5.0 | 5.25 | V |
| | For K-LC3_V2 variant | $V_{cc}$ | 3.0 | 3.3 | 3.6 | V |
| Supply current | | $I_{cc}$ | | 35 | 65 | mA |
| Operating temperature | | $T_{op}$ | -20 | | +85 | °C |
| Storage temperature | | $T_{st}$ | -20 | | +105 | °C |
| **Transmitter** | | | | | | |
| Transmitter frequency | $T_{amb}$=-20°C .. +85°C | $f_{TX}$ | 24.150 | 24.200 | 24.250 | GHz |
| Frequency drift vs temperature | $V_{cc}$=5.0V, -20°C .. +85°C [Note 1] | $\Delta f_{TX}$ | | -0.9 | | MHz/°C |
| Output power | EIRP | $P_{TX}$ | | +10 | | dBm |
| Spurious emission | | $P_{spur}$ | | -30 | | dBm |
| Turn-on time | Until oscillator stable, $\Delta f_{TX}$ < 5MHz | $t_{on}$ | | 1 | 6 | 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 2] | $G_{Ant}$ | | 4.8 | | dB |
| Receiver sensitivity | $f_{IF}$=500Hz,B=1kHz,$R_{IF}$=1kΩ,S/N=6dB | $P_{RX1}$ | | -95 | | dBm |
| | $f_{IF}$=1MHz,B=20MHz,$R_{IF}$=50Ω,S/N=6dB | $P_{RX1}$ | | -83 | | dBm |
| Overall sensitivity | $f_{IF}$=500Hz,B=1kHz,$R_{IF}$=1kΩ,S/N=6dB | $D_{system}$ | | -105 | | dBc |
| **IF output** | | | | | | |
| IF 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 | $P_{IFnoise2}$ | | -164 | | 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 | no object in range | $U_{IF}$ | 10 | | 200 | mV |
| Supply rejection | Rejection supply pins to IF output | $D_{supply}$ | | 26 | | dB |
| **Antenna** | | | | | | |
| Antenna type | Right hand circular polarized | RHCP | | | | |
| Horizontal -3dB beamwidth | E-Plane | $W_{\varphi}$ | | 138 | | ° |
| Vertical -3dB beamwidth | H-Plane | $W_{\theta}$ | | 132 | | ° |
| Horiz. sidelobe suppression | | $D_{\varphi}$ | | -12 | | dB |
| Vertical sidelobe suppression | | $D_{\theta}$ | | -12 | | dB |
| **Body** | | | | | | |
| Outline Dimensions | | | | 25*25*6 | | mm³ |
| Weight | | | | 4.5 | | g |
| Connector | 3pin single row jumper | | | | | |
| **ESD Rating** | | | | | | |
| Electrostatic Discharge | Human body model class 0 | $V_{ESD}$ | | | 250 | V |

Note 1　Transmit frequency stays within 24.150 to 24.250GHz over the specified temperature range
Note 2　Theoretical value, given by Design
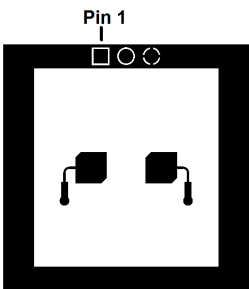
## Antenna System Diagram
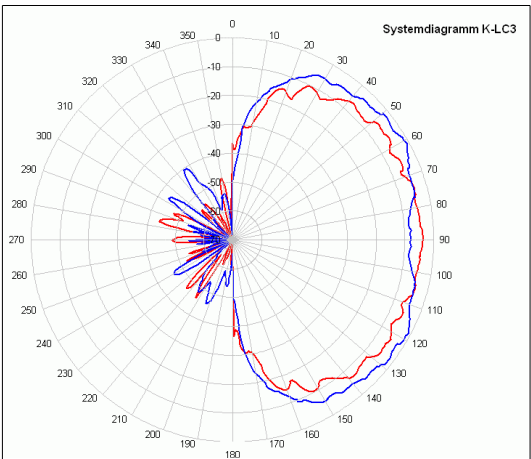


This diagram shows module sensitivity in both azimuth and elevation directions. It incorporates both transmitter and receiver antenna characteristics.
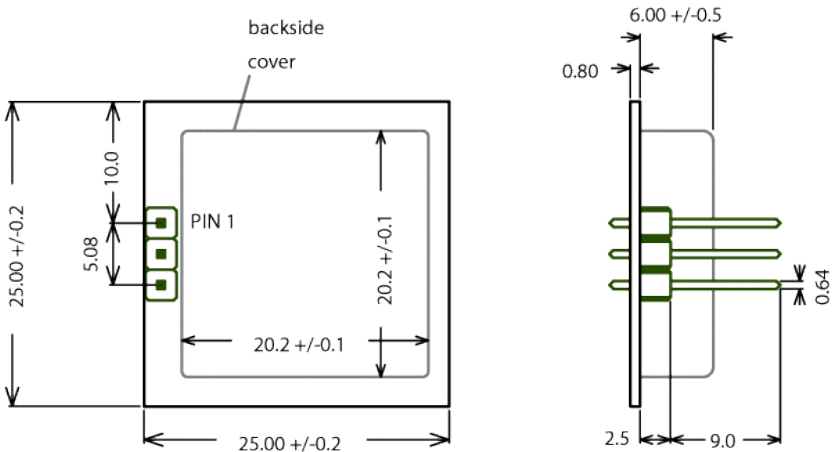
**Fig. 2: System diagram**

## Pin Configuration

| Pin | Description | Typical Value |
|-----|-------------|---------------|
| 1 | VCC | DC supply |
| 2 | IF output | load 1kOhm |
| 3 | GND | ground |



## Outline Dimensions



All Dimensions in mm        All values given 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:       -105dBc (@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
- 7 meters for a moving person.
- > 15 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 12m frontal detection range.

## Ordering Information

| Ordering number | Supply voltage |
|---|---|
| K-LC3 | 5V |
| K-LC3_V2 | 3.3V |

## Datasheet Revision History

| Version | Date | Changes |
| --- | --- | --- |
| 0.1 | Apr-2009 | initial release |
| 1.0 | Mar-2011 | Typical transmit frequency = 24.200; range 24.150 .. 24.250 over temp. |
| 1.1 | Nov-2018 | Changed footer to new address |
| 1.2 | Mar-2020 | Added ESD information, changed operating temperature and spurious, added ordering informations |

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