#### **RFbeam Microwave GmbH**

data sheet

K-LC4

radar transceiver

Features

**Applications** 

Description

Block Diagram



- 24 GHz K-band miniature transceiver
- Dual 1 patch circular polarized antenna
- Dual balanced mixer with 50 MHz bandwidth
- Excellent noise cancelling ability through I/Q technology
- Wide beam aperture 138°/132°
- 10 dBm EIRP output power
- 25×25 mm<sup>2</sup> surface, < 6 mm thickness
- Low cost design
- Direction sensitive movement detectors
- Security systems
- Simple ranging detection using FSK
- Ceiling and wall mount surveillance system
- Industrial sensors

K-LC4 is a 2 patch Doppler module with a nearly symmetrical wide beam for low cost short distance applications.

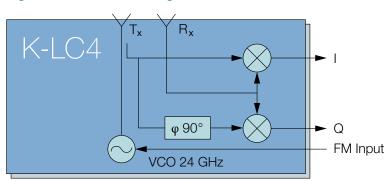
Typical applications are movement sensors for security, lighting and building automation applications. This module may be an alternative or a complementary sensor for infrared PIR or AIR systems thanks to its outstanding performance/cost ratio.

The module is extremely small and lightweight. With an IF bandwidth from DC to 50 MHz it opens many new applications.

The unique RFbeam circular polarized antenna form 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.

Figure 1: K-LC4 block diagram



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## Characteristics

Supply current VCO input voltage VCO pin resistance Driving voltage source Note 1    Operating temperature Storage temperature    Transmitter Transmitter frequency   Frequency drift vs temperature    VCO = 5.0 V, -20 °C +85 °C Note 2    Frequency tuning range   VCO sensitivity   VCO Modulation Bandwidth   Output power   EIRP   Spurious emission   According to ETSI 300 440   Until oscillator stable, $\Delta f_{TX} < 5  \text{MHz}$ Receiver    Mixer Conversion loss $f_{IF} = 1  \text{kHz}$ , $IF  \text{load} = 1  \text{k}\Omega$ $f_{IF} = 20  \text{MHz}$ , $IF  \text{load} = 50  \Omega$ Antenna Gain $F_{TX} = 24.125  \text{GHz}$ Note 3   Receiver sensitivity $f_{IF} = 500  \text{Hz}$ , $B_{IF} = 1  \text{k}\Omega$ , $S/N = 6  \text{dB}$ $f_{IF} = 1  \text{mHz}$ , $B_{IF} = 1  \text{k}\Omega$ , $S/N = 6  \text{dB}$ IF output    IF requency range   -3dB Bandwidth, $IF  \text{load} = 50  \Omega$ $f_{IF} = 100  \text{Hz}$ , $IF  \text{load} = 50  \Omega$ IF noise power $f_{IF} = 500  \text{Hz}$ , $IF  \text{load} = 50  \Omega$ IF noise voltage $f_{IF} = 500  \text{Hz}$ , $IF  \text{load} = 50  \Omega$ IF noise voltage $f_{IF} = 500  \text{Hz}$ , $IF  \text{load} = 50  \Omega$ IF noise voltage $f_{IF} = 500  \text{Hz}$ , $IF  \text{load} = 1  \text{k}\Omega$ IF output offset voltage $f_{IF} = 500  \text{Hz}$ , $IF  \text{load} = 1  \text{k}\Omega$ IF output offset voltage $f_{IF} = 500  \text{Hz}$ , $IF  \text{load} = 1  \text{k}\Omega$ IF output offset voltage $f_{IF} = 500  \text{Hz}$ , $IF  \text{load} = 1  \text{k}\Omega$ IF output offset voltage $f_{IF} = 500  \text{Hz}$ , $IF  \text{load} = 1  \text{k}\Omega$ IF output offset voltage $f_{IF} = 500  \text{Hz}$ , $IF  \text{load} = 1  \text{k}\Omega$ IF output offset voltage $f_{IF} = 500  \text{Hz}$ , $IF  \text{load} = 1  \text{k}\Omega$ IF output offset voltage $f_{IF} = 500  \text{Hz}$ , $IF  \text{load} = 1  \text{k}\Omega$ IF output offset voltage $f_{IF} = 500  \text{Hz}$ , $IF  \text{load} = 1  \text{k}\Omega$ IF output offset voltage $f_{IF} = 500  \text{Hz}$ , $IF  \text{load} = 1  \text{k}\Omega$ IF output offset voltage $f_{IF} = 500  \text{Hz}$ , $IF  \text{load} = 1  \text{k}\Omega$ IF output offset voltage $f_{IF} = 500  \text{Hz}$ , $IF  l$	V <sub>CC</sub> I <sub>CC</sub> U <sub>VCO</sub> R <sub>VCO</sub> T <sub>op</sub> T <sub>st</sub>	4.75	5		
Supply current VCO input voltage VCO pin resistance Driving voltage source Note 1    Driving voltage source Note 2    Driving volta	I <sub>cc</sub> U <sub>vco</sub> R <sub>vco</sub> T <sub>op</sub>				
VCO input voltage  VCO pin resistance  Operating temperature  Storage temperature  Fransmitter  Transmitter  Transmitter frequency  Frequency drift vs temperature  VCC = 5.0 V, -20 °C +85 °C Note 2  Frequency tuning range  VCO sensitivity  VCO Modulation Bandwidth $\Delta f = 20 \text{ MHz}$ Cutput power  EIRP  Spurious emission  According to ETSI 300 440  Until oscillator stable, $\Delta f_{TX} < 5 \text{ MHz}$ Receiver  Mixer Conversion loss $f_{IF} = 1 \text{ kHz}, \text{ IF load} = 1 \text{ k}\Omega$ $f_{IF} = 20 \text{ MHz}, \text{ IF load} = 50 \Omega$ Antenna Gain $F_{TX} = 24.125 \text{ GHz}, \text{ Note 3}$ $f_{IF} = 1 \text{ MHz}, \text{ B} = 20 \text{ MHz}, \text{ R}_{IF} = 1 \text{ k}\Omega, \text{ S/N} = 6 \text{ dB}$ Goverall sensitivity $f_{IF} = 500 \text{ Hz}, \text{ B} = 1 \text{ kHz}, \text{ R}_{IF} = 1 \text{ k}\Omega, \text{ S/N} = 6 \text{ dB}$ Foutput  IF resistance  IF frequency range $f_{IF} = 500 \text{ Hz}, \text{ IF load} = 50 \Omega$ $f_{IF} = 1 \text{ MHz}, \text{ IF load} = 50 \Omega$ $f_{IF} = 500 \text{ Hz}, \text{ IF load} = 50 \Omega$ IF noise power $f_{IF} = 500 \text{ Hz}, \text{ IF load} = 50 \Omega$ IF resistance  IF frequency range $f_{IF} = 500 \text{ Hz}, \text{ IF load} = 50 \Omega$ IF noise voltage $f_{IF} = 500 \text{ Hz}, \text{ IF load} = 1 \text{ k}\Omega$ $f_{IF} = 500 \text{ Hz}, \text{ IF load} = 1 \text{ k}\Omega$ IF output offset voltage $f_{IF} = 500 \text{ Hz}, \text{ IF load} = 1 \text{ k}\Omega$ $f_{IF} = 500 \text{ Hz}, \text{ IF load} = 1 \text{ k}\Omega$ $f_{IF} = 500 \text{ Hz}, \text{ IF load} = 1 \text{ k}\Omega$ $f_{IF} = 500 \text{ Hz}, \text{ IF load} = 1 \text{ k}\Omega$ IF output offset voltage $f_{IF} = 500 \text{ Hz}, \text{ IF load} = 1 \text{ k}\Omega$ $f_{IF} = 500 \text{ Hz}, \text{ IF load} = 1 \text{ k}\Omega$ $f_{IF} = 500 \text{ Hz}, \text{ IF load} = 1 \text{ k}\Omega$ Foutput offset voltage $f_{IF} = 500 \text{ Hz}, \text{ IF load} = 1 \text{ k}\Omega$ Receiver so shift $f_{IF} = 500 \text{ Hz}, \text{ IF load} = 1 \text{ k}\Omega$ Foutput offset voltage $f_{IF} = 500 \text{ Hz}, \text{ IF load} = 1 \text{ k}\Omega$ Receiver so shift $f_{IF} = 500 \text{ Hz}, \text{ IF load} = 1 \text{ k}\Omega$ Receiver so shift $f_{IF} = 500 \text{ Hz}, \text{ IF load} = 1 \text{ k}\Omega$ Receiver so shift $f_{IF} = 1 \text{ Hz}, \text{ IF load} = 1 \text{ k}\Omega$ Receiver so shift $f_{IF} = 1 \text{ Hz}, \text{ IF load} = 1 \text{ k}\Omega$ Rec	U <sub>vco</sub> R <sub>vco</sub> T <sub>op</sub>	-0.5		5.25	V
$ \begin{array}{llllllllllllllllllllllllllllllllllll$	R <sub>vco</sub> T <sub>op</sub>	-0.5	35	45	mA
$ \begin{array}{llllllllllllllllllllllllllllllllllll$	T <sub>op</sub>			2.0	V
Storage temperature  Fransmitter  Transmitter frequency Frequency drift vs temperature  Frequency drift vs temperature  Frequency tuning range  VCO sensitivity  VCO Modulation Bandwidth $\Delta f = 20  \text{MHz}$ Cutput power  EIRP  Spurious emission  According to ETSI 300 440  Turn-on time  Until oscillator stable, $\Delta f_{TX} < 5  \text{MHz}$ Receiver  Mixer Conversion loss $f_{IF} = 1  \text{kHz}, IF  \text{load} = 1  \text{k}\Omega$ $f_{IF} = 20  \text{MHz}, IF  \text{load} = 50  \Omega$ Antenna Gain $F_{TX} = 24.125  \text{GHz}  \text{Note 3}$ Receiver sensitivity $f_{IF} = 500  \text{Hz}, B = 1  \text{kHz}, R_{IF} = 1  \text{k}\Omega, S/N = 6  \text{dB}$ $f_{IF} = 1  \text{MHz}, B = 20  \text{MHz}, R_{IF} = 1  \text{k}\Omega, S/N = 6  \text{dB}$ $f_{IF} = 500  \text{Hz}, B = 1  \text{kHz}, R_{IF} = 1  \text{k}\Omega, S/N = 6  \text{dB}$ Foutput  IF resistance  IF frequency range $f_{IF} = 500  \text{Hz}, IF  \text{load} = 50  \Omega$ $f_{IF} = 500  \text{Hz}, IF  \text{load} = 50  \Omega$ $f_{IF} = 500  \text{Hz}, IF  \text{load} = 1  \text{k}\Omega$ IF noise power $f_{IF} = 500  \text{Hz}, IF  \text{load} = 1  \text{k}\Omega$ IF noise voltage $f_{IF} = 500  \text{Hz}, IF  \text{load} = 1  \text{k}\Omega$ IF output offset voltage $f_{IF} = 500  \text{Hz}, IF  \text{load} = 1  \text{k}\Omega$ IF output offset voltage $f_{IF} = 500  \text{Hz}, IF  \text{load} = 1  \text{k}\Omega$ IF output offset voltage $f_{IF} = 500  \text{Hz}, IF  \text{load} = 1  \text{k}\Omega$ $f_{IF} = 500  \text{Hz}, IF  \text{load} = 1  \text{k}\Omega$ $f_{IF} = 500  \text{Hz}, IF  \text{load} = 1  \text{k}\Omega$ $f_{IF} = 500  \text{Hz}, IF  \text{load} = 1  \text{k}\Omega$ From the power of the powe			570		Ω
Transmitter         Transmitter frequency $T_{amb} = -20 ^{\circ}\text{C} +60 ^{\circ}\text{C}$ Frequency drift vs temperature $V_{CC} = 5.0 \text{V}, -20 ^{\circ}\text{C} +85 ^{\circ}\text{C}$ Note 2         Frequency tuning range       VCO sensitivity         VCO Modulation Bandwidth $\Delta f = 20 \text{MHz}$ Output power       EIRP         Spurious emission       According to ETSI 300 440         Turn-on time       Until oscillator stable, $\Delta f_{TX} < 5 \text{MHz}$ Receiver       Mixer Conversion loss $f_{IF} = 1 \text{kHz}$ , IF load = 1 kΩ $f_{IF} = 20 \text{MHz}$ , IF load = 50 Ω         Antenna Gain $F_{TX} = 24.125 \text{GHz}$ Note 3         Receiver sensitivity $f_{IF} = 500 \text{Hz}$ , B = 1 kHz, $R_{IF} = 1 \text{k}\Omega$ , S/N = 6 dB $f_{IF} = 1 \text{MHz}$ , B = 20 MHz, $R_{IF} = 150 \Omega$ , S/N = 6 dB         Foutput         IF output         IF registance         IF registance         IF registance         IF registance         IF registance         IF noise power $f_{IF} = 500 \text{Hz}$ , IF load = $50 \Omega$ IF registance $f_{IF} = 500 \text{Hz}$ , IF load = $50 \Omega$ IF noise voltage $f_{IF} = 500 \text{Hz}$ , IF load = $1 \text{k}\Omega$ IF noise voltage $f_{IF} = 500 \text{Hz}$ , IF load	T <sub>st</sub>	-20		+85	°C
$ Transmitter frequency & T_{amb} = -20^{\circ}\text{C} + 60^{\circ}\text{C} \\ V_{CC} = 5.0\text{V}, -20^{\circ}\text{C} + 85^{\circ}\text{C} \text{Note 2} \\ \hline Frequency tuning range & VCO sensitivity \\ VCO Modulation Bandwidth & \Delta f = 20\text{MHz} \\ \text{Output power} & \text{EIRP} \\ \text{Spurious emission} & \text{According to ETSI 300 440} \\ \text{Turn-on time} & \text{Until oscillator stable, } \Delta f_{TX} < 5\text{MHz} \\ \hline \textbf{Receiver} \\ \hline \textbf{Mixer Conversion loss} & f_{IF} = 1\text{kHz, IF load} = 1\text{k}\Omega \\ f_{IF} = 20\text{MHz, IF load} = 50\Omega \\ \hline \textbf{Antenna Gain} & F_{TX} = 24.125\text{GHz} \text{Note 3} \\ \hline \textbf{Receiver sensitivity} & f_{IF} = 500\text{Hz, B} = 1\text{kHz, R}_{IF} = 1\text{k}\Omega, \text{S/N} = 6\text{dB} \\ \hline \textbf{Overall sensitivity} & f_{IF} = 500\text{Hz, B} = 1\text{kHz, R}_{IF} = 1\text{k}\Omega, \text{S/N} = 6\text{dB} \\ \hline \textbf{Overall sensitivity} & f_{IF} = 500\text{Hz, B} = 1\text{kHz, R}_{IF} = 1\text{k}\Omega, \text{S/N} = 6\text{dB} \\ \hline \textbf{Foutput} \\ \hline \textbf{IF resistance} & IF frequency range & -3dB\text{Bandwidth, IF load} = 50\Omega \\ \hline \textbf{IF noise power} & f_{IF} = 500\text{Hz, IF load} = 50\Omega \\ \hline \textbf{IF noise voltage} & f_{IF} = 500\text{Hz, IF load} = 1\text{k}\Omega \\ \hline \textbf{IF noise voltage} & \text{no object in range} \\ \hline \textbf{I/Q amplitude balance} & f_{IF} = 500\text{Hz, U}_{IF} = 1\text{mVpp} \\ \hline \textbf{I/Q phase shift} & f_{IF} = 112-20\text{kHz} \\ \hline \textbf{Supply rejection} & \text{Rejection supply pins to IF output} \\ \hline \textbf{Antenna} \\ \hline \textbf{Antenna} & \text{Antenna type} & \text{Right hand circular polarized} \\ \hline \textbf{E-Plane} \\ \hline \end{tabular}$		-20		+105	°C
Frequency drift vs temperature $V_{CC} = 5.0\text{V}, -20^{\circ}\text{C} +85^{\circ}\text{C}$ Note 2 Frequency tuning range $V_{CC} = 5.0\text{V}, -20^{\circ}\text{C} +85^{\circ}\text{C}$ Note 2 $V_{CC} = 5.0\text{V}$ Note 3 $V_{CC} = 5.0\text{V}$ N					
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$VCO \   \text{Modulation Bandwidth} \qquad                   $	∆ f <sub>TX</sub>		-0.9		MHz/°C
$ \begin{array}{llllllllllllllllllllllllllllllllllll$	∆ f <sub>vco</sub>		140		MHz
Output power EIRP  Spurious emission  According to ETSI 300 440  Turn-on time  Until oscillator stable, $\Delta f_{TX} < 5\text{MHz}$ Receiver  Mixer Conversion loss $f_{IF} = 1\text{kHz},   F   \text{load} = 1\text{k}\Omega$ $f_{IF} = 20\text{MHz},   F   \text{load} = 50\Omega$ Antenna Gain $F_{TX} = 24.125\text{GHz}  \text{Note 3}$ Receiver sensitivity $f_{IF} = 500\text{Hz},  B = 1\text{kHz},  R_{IF} = 1\text{k}\Omega,  \text{S/N} = 6\text{dB}$ $f_{IF} = 1\text{MHz},  B = 20\text{MHz},  R_{IF} = 50\Omega,  \text{S/N} = 6\text{dB}$ Overall sensitivity $f_{IF} = 500\text{Hz},  B = 1\text{kHz},  R_{IF} = 1\text{k}\Omega,  \text{S/N} = 6\text{dB}$ Foutput  IF resistance $ F  \text{ frequency range} \qquad -3\text{dB Bandwidth},   F  \text{ load} = 50\Omega$ $ F  \text{ noise power} \qquad f_{IF} = 500\text{Hz},   F  \text{ load} = 50\Omega$ $ F  \text{ noise voltage} \qquad f_{IF} = 500\text{Hz},   F  \text{ load} = 1\text{k}\Omega$ $ F  \text{ output offset voltage} \qquad  f _{IF} = 500\text{Hz},   F  \text{ load} = 1\text{k}\Omega$ IF output offset voltage $ A  \text{ no object in range} \qquad  A  \text{ loaded} = 1\text{k}\Omega$ $ A  \text{ log applitude balance} \qquad  f _{IF} = 500\text{Hz},   F  = 1\text{mVpp}$ $ A  \text{ log applitude balance} \qquad  f _{IF} = 1\text{Hz} - 20\text{kHz}$ Supply rejection  Rejection supply pins to  F  \text{ output}  Antenna  Antenna type  Right hand circular polarized  Horizontal -3 dB beamwidth  E-Plane	S <sub>vco</sub>		-55		MHz/V
Output power EIRP  Spurious emission  According to ETSI 300 440  Turn-on time  Until oscillator stable, $\Delta f_{TX} < 5\text{MHz}$ Receiver  Mixer Conversion loss $f_{IF} = 1\text{kHz},   F   \text{load} = 1\text{k}\Omega$ $f_{IF} = 20\text{MHz},   F   \text{load} = 50\Omega$ Antenna Gain $F_{TX} = 24.125\text{GHz}  \text{Note 3}$ Receiver sensitivity $f_{IF} = 500\text{Hz},  B = 1\text{kHz},  R_{IF} = 1\text{k}\Omega,  \text{S/N} = 6\text{dB}$ $f_{IF} = 1\text{MHz},  B = 20\text{MHz},  R_{IF} = 50\Omega,  \text{S/N} = 6\text{dB}$ Overall sensitivity $f_{IF} = 500\text{Hz},  B = 1\text{kHz},  R_{IF} = 1\text{k}\Omega,  \text{S/N} = 6\text{dB}$ Foutput  IF resistance $ F  \text{ frequency range} \qquad -3\text{dB Bandwidth},   F  \text{ load} = 50\Omega$ $ F  \text{ noise power} \qquad f_{IF} = 500\text{Hz},   F  \text{ load} = 50\Omega$ IF noise voltage $ F  \text{ final model} = 1\text{k}\Omega$ $ F  \text{ soon Hz},   F  \text{ load} = 1\text{k}\Omega$ $ F  \text{ soon Hz},   F  \text{ load} = 1\text{k}\Omega$ $ F  \text{ output offset voltage} \qquad  f _{IF} = 500\text{Hz},   F  \text{ load} = 1\text{k}\Omega$ $ F  \text{ output offset voltage} \qquad  f _{IF} = 500\text{Hz},   F  \text{ load} = 1\text{k}\Omega$ $ F  \text{ output offset voltage} \qquad  f _{IF} = 500\text{Hz},   F  \text{ load} = 1\text{k}\Omega$ $ F  \text{ output offset voltage} \qquad  f _{IF} = 500\text{Hz},   F  \text{ load} = 1\text{k}\Omega$ $ F  \text{ output offset voltage} \qquad  f _{IF} = 500\text{Hz},   F  \text{ load} = 1\text{k}\Omega$ $ F  \text{ output offset voltage} \qquad  f _{IF} = 500\text{Hz},   F  \text{ load} = 1\text{k}\Omega$ $ F  \text{ output offset voltage} \qquad  f _{IF} = 500\text{Hz},   F  \text{ load} = 1\text{k}\Omega$ $ F  \text{ output offset voltage} \qquad  f _{IF} = 500\text{Hz},   F  \text{ load} = 1\text{k}\Omega$ $ F  \text{ output offset voltage} \qquad  f _{IF} = 1\text{Hz} - 20\text{kHz}$ Supply rejection  Rejection supply pins to  F  \text{ output}  Antenna  Antenna type  Right hand circular polarized  Horizontal -3 dB beamwidth  E-Plane	B <sub>vco</sub>		3		MHz
$ \begin{array}{llllllllllllllllllllllllllllllllllll$	P <sub>TX</sub>	+7	+10	+13	dBm
Turn-on time Until oscillator stable, $\Delta f_{TX} < 5\text{MHz}$ Receiver  Mixer Conversion loss $f_{IF} = 1\text{kHz},  \text{IF load} = 1\text{k}\Omega$ $f_{IF} = 20\text{MHz},  \text{IF load} = 50\Omega$ Antenna Gain $F_{TX} = 24.125\text{GHz}  \text{Note 3}$ Receiver sensitivity $f_{IF} = 500\text{Hz},  B = 1\text{kHz},  R_{IF} = 1\text{k}\Omega,  \text{S/N} = 6\text{dB}$ $f_{IF} = 1\text{MHz},  B = 20\text{MHz},  R_{IF} = 50\Omega,  \text{S/N} = 6\text{dB}$ Overall sensitivity $f_{IF} = 500\text{Hz},  B = 1\text{kHz},  R_{IF} = 1\text{k}\Omega,  \text{S/N} = 6\text{dB}$ Foutput  IF resistance  IF frequency range $-3\text{dB Bandwidth},  \text{IF load} = 50\Omega$ $f_{IF} = 500\text{Hz},  \text{IF load} = 50\Omega$ $f_{IF} = 1\text{M Hz},  \text{IF load} = 50\Omega$ IF noise power $f_{IF} = 500\text{Hz},  \text{IF load} = 1\text{k}\Omega$ $f_{IF} = 500\text{Hz},  \text{IF load} = 1\text{k}\Omega$ IF output offset voltage $f_{IF} = 500\text{Hz},  \text{IF load} = 1\text{k}\Omega$ IF output offset voltage $f_{IF} = 500\text{Hz},  \text{IF load} = 1\text{k}\Omega$ IF output offset voltage $f_{IF} = 500\text{Hz},  \text{U}_{IF} = 1\text{mVpp}$ $I/Q  \text{amplitude balance} \qquad f_{IF} = 500\text{Hz},  \text{U}_{IF} = 1\text{mVpp}$ $I/Q  \text{phase shift} \qquad f_{IF} = 1\text{Hz} - 20\text{kHz}$ Supply rejection $Receiver a  \text{Receiver} a  \text{Note of the supply pins to IF output}$ Antenna  Antenna type $Right  \text{hand circular polarized}$ Horizontal -3 dB beamwidth $E-\text{Plane}$	P <sub>spur</sub>			-30	dBm
$f_{IF} = 1  \text{kHz},  \text{IF load} = 1  \text{k}\Omega$ $f_{IF} = 20  \text{MHz},  \text{IF load} = 50  \Omega$ Antenna Gain $F_{TX} = 24.125  \text{GHz}  \text{Note 3}$ Receiver sensitivity $f_{IF} = 500  \text{Hz},  B = 1  \text{kHz},  R_{IF} = 1  \text{k}\Omega,  \text{S/N} = 6  \text{dB}$ $f_{IF} = 1  \text{MHz},  B = 20  \text{MHz},  R_{IF} = 500  \text{Q},  \text{S/N} = 6  \text{dB}$ Overall sensitivity $f_{IF} = 500  \text{Hz},  B = 1  \text{kHz},  R_{IF} = 1  \text{k}\Omega,  \text{S/N} = 6  \text{dB}$ $F  \text{output}$ IF resistance $IF  \text{frequency range} \qquad -3  \text{dB}  \text{Bandwidth},  IF  \text{load} = 50  \Omega$ $IF  \text{noise power} \qquad f_{IF} = 500  \text{Hz},  IF  \text{load} = 50  \Omega$ $IF  \text{noise voltage} \qquad f_{IF} = 500  \text{Hz},  IF  \text{load} = 1  \text{k}\Omega$ $f_{IF} = 500  \text{Hz},  IF  \text{load} = 1  \text{k}\Omega$ $IF  \text{output offset voltage} \qquad \text{no object in range}$ $I/Q  \text{amplitude balance} \qquad f_{IF} = 500  \text{Hz},  U_{IF} = 1  \text{mVpp}$ $I/Q  \text{phase shift} \qquad f_{IF} = 1  \text{Hz} - 20  \text{kHz}$ Supply rejection $Receiver  \text{and}  \text{ejection supply pins to IF output}$ Antenna $Antenna  \text{Antenna}  \text{Antenna type} \qquad Right  \text{hand circular polarized}$ $E-\text{Plane}$	t <sub>on</sub>		1		μs
$f_{IF} = 20\text{MHz},  \text{IF load} = 50\Omega$ Antenna Gain $F_{TX} = 24.125\text{GHz}\text{Note 3}$ Receiver sensitivity $f_{IF} = 500\text{Hz},  B = 1\text{kHz},  R_{IF} = 1\text{k}\Omega,  \text{S/N} = 6\text{dB}$ $f_{IF} = 1\text{MHz},  B = 20\text{MHz},  R_{IF} = 50\Omega,  \text{S/N} = 6\text{dB}$ Overall sensitivity $f_{IF} = 500\text{Hz},  B = 1\text{kHz},  R_{IF} = 1\text{k}\Omega,  \text{S/N=6dB}$ Foutput $F_{IF} = 500\text{Hz},  B = 1\text{kHz},  R_{IF} = 1\text{k}\Omega,  \text{S/N=6dB}$ Foutput $F_{IF} = 500\text{Hz},  B = 1\text{kHz},  R_{IF} = 1\text{k}\Omega,  \text{S/N=6dB}$ Foutput $F_{IF} = 500\text{Hz},  B = 1\text{kHz},  R_{IF} = 1\text{k}\Omega,  \text{S/N=6dB}$ Foutput $F_{IF} = 500\text{Hz},  B = 1\text{kHz},  R_{IF} = 1\text{k}\Omega,  \text{S/N=6dB}$ Foutput $F_{IF} = 500\text{Hz},  B = 1\text{kHz},  R_{IF} = 1\text{k}\Omega,  \text{S/N=6dB}$ Foutput $F_{IF} = 500\text{Hz},  B = 1\text{kHz},  B = 1\text{k}\Omega,  B = 1\text{k}\Omega, $					
$f_{IF} = 20\text{MHz},  \text{IF load} = 50\Omega$ Antenna Gain $F_{TX} = 24.125\text{GHz}\text{Note 3}$ Receiver sensitivity $f_{IF} = 500\text{Hz},  B = 1\text{kHz},  R_{IF} = 1\text{k}\Omega,  \text{S/N} = 6\text{dB}$ $f_{IF} = 1\text{MHz},  B = 20\text{MHz},  R_{IF} = 50\Omega,  \text{S/N} = 6\text{dB}$ Overall sensitivity $f_{IF} = 500\text{Hz},  B = 1\text{kHz},  R_{IF} = 1\text{k}\Omega,  \text{S/N=6}\text{dB}$ Foutput $F_{IF} = 500\text{Hz},  B = 1\text{kHz},  R_{IF} = 1\text{k}\Omega,  \text{S/N=6}\text{dB}$ Foutput $F_{IF} = 500\text{Hz},  B = 1\text{kHz},  R_{IF} = 1\text{k}\Omega,  \text{S/N=6}\text{dB}$ Foutput $F_{IF} = 500\text{Hz},  B = 1\text{kHz},  R_{IF} = 1\text{k}\Omega,  \text{S/N=6}\text{dB}$ Foutput $F_{IF} = 500\text{Hz},  B = 1\text{k}\Omega,  B = 1\text{k}\Omega, $	D <sub>mixer1</sub>		-6		dB
Antenna Gain $F_{TX} = 24.125\text{GHz}\text{Note}3$ Receiver sensitivity $f_{IF} = 500\text{Hz},B = 1\text{kHz},R_{IF} = 1\text{k}\Omega,\text{S/N} = 6\text{dB}$ $f_{IF} = 1\text{MHz},B = 20\text{MHz},R_{IF} = 50\Omega,\text{S/N} = 6\text{dB}$ Overall sensitivity $f_{IF} = 500\text{Hz},B = 1\text{kHz},R_{IF} = 1\text{k}\Omega,\text{S/N} = 6\text{dB}$ Foutput $F \text{ output}$ IF resistance $F \text{ output}$ IF resistance $F \text{ output}$ IF requency range $F \text{ output}$ IF noise power $F \text{ output}$ IF noise power $F \text{ output}$ IF noise voltage $F \text{ output}$ IF noise voltage $F \text{ output}$ IF noise voltage $F \text{ output}$ IF load = $50\Omega$ IF noise voltage $F \text{ output}$ IF output offset voltage $F \text{ output}$ no object in range $F \text{ output}$ IP output offset voltage $F \text{ output}$ No object in range $F \text{ output}$ IP = $500\text{Hz}$ , U <sub>IF</sub> = $1\text{mVpp}$ I/Q amplitude balance $F \text{ output}$ If $F \text{ output}$ IF = $100\text{Hz}$ Rejection supply pins to IF output $F \text{ output}$ Antenna $F \text{ output}$ Antenna type $F \text{ Right hand circular polarized}$ E-Plane	D <sub>mixer2</sub>		-11		dB
Receiver sensitivity $f_{IF} = 500  \text{Hz},  B = 1  \text{kHz},  R_{IF} = 1  \text{k}\Omega,  \text{S/N} = 6  \text{dB}$ $f_{IF} = 1  \text{MHz},  B = 20  \text{MHz},  R_{IF} = 50  \Omega,  \text{S/N} = 6  \text{dB}$ Overall sensitivity $f_{IF} = 500  \text{Hz},  B = 1  \text{kHz},  R_{IF} = 1  \text{k}\Omega,  \text{S/N} = 6  \text{dB}$ F output $IF \text{ resistance}$ $IF \text{ resistance}$ $IF \text{ frequency range}$ $-3 \text{dB Bandwidth, IF load} = 50  \Omega$ $IF \text{ noise power}$ $f_{IF} = 500  \text{Hz},  \text{IF load} = 50  \Omega$ $f_{IF} = 1  \text{M Hz},  \text{IF load} = 50  \Omega$ $f_{IF} = 100  \text{Hz},  \text{IF load} = 1  \text{k}\Omega$ $f_{IF} = 500  \text{Hz},  \text{IF load} = 1  \text{k}\Omega$ $f_{IF} = 500  \text{Hz},  \text{IF load} = 1  \text{k}\Omega$ IF output offset voltage $I/Q \text{ amplitude balance}$ $I/Q \text{ amplitude balance}$ $I/Q \text{ phase shift}$ $f_{IF} = 1  \text{Hz} - 20  \text{kHz}$ Supply rejection $I/Q \text{ phase shift}$ $I/Q  phase $	G <sub>Ant</sub>		4.8		dB
$f_{IF} = 1  \text{MHz},  \text{B} = 20  \text{MHz},  R_{IF} = 50  \Omega,  \text{S/N} = 6  \text{dB}$ Overall sensitivity $f_{IF} = 500  \text{Hz},  \text{B} = 1  \text{kHz},  R_{IF} = 1  \text{k} \Omega,  \text{S/N=6}  \text{dB}$ Foutput $IF \text{ resistance}$ $IF \text{ frequency range} \qquad -3  \text{dB}  \text{Bandwidth},  IF \text{ load} = 50  \Omega$ $IF \text{ noise power} \qquad f_{IF} = 500  \text{Hz},  IF \text{ load} = 50  \Omega$ $f_{IF} = 1  \text{M Hz},  IF \text{ load} = 50  \Omega$ $f_{IF} = 500  \text{Hz},  IF \text{ load} = 1  \text{k} \Omega$ $f_{IF} = 500  \text{Hz},  IF \text{ load} = 1  \text{k} \Omega$ IF output offset voltage $I/Q \text{ amplitude balance} \qquad f_{IF} = 500  \text{Hz},  U_{IF} = 1  \text{mVpp}$ $I/Q \text{ phase shift} \qquad f_{IF} = 1  \text{Hz} - 20  \text{kHz}$ Supply rejection $I/Q \text{ Rejection supply pins to IF output}$ Antenna $I/Q \text{ Antenna} = I/Q \text{ Right hand circular polarized}$ Horizontal -3 dB beamwidth $I/Q \text{ load} = I/Q \text{ load} = I/Q$	P <sub>RX1</sub>		-93		dBm
Overall sensitivity $f_{IF} = 500\text{Hz},  \text{B} = 1\text{kHz},  \text{R}_{IF} = 1\text{k}\Omega,  \text{S/N=6}\text{dB}$ $\textbf{F output}$ $IF resistance$ $IF frequency range                                    $	P <sub>RX1</sub>		-81		dBm
Foutput  IF resistance  IF frequency range  -3dB Bandwidth, IF load = $50 \Omega$ IF noise power $f_{IF} = 500 \text{ Hz}, \text{ IF load} = 50 \Omega$ IF noise voltage $f_{IF} = 1M \text{ Hz}, \text{ IF load} = 50 \Omega$ IF noise voltage $f_{IF} = 500 \text{ Hz}, \text{ IF load} = 1 \text{ k}\Omega$ IF output offset voltage  no object in range  I/Q amplitude balance $f_{IF} = 500 \text{ Hz}, \text{ U}_{IF} = 1 \text{ mVpp}$ I/Q phase shift $f_{IF} = 1 \text{ Hz} - 20 \text{ kHz}$ Supply rejection  Rejection supply pins to IF output  Antenna  Antenna type  Right hand circular polarized  Horizontal -3 dB beamwidth  E-Plane	D <sub>system</sub>		-103		dBc
$ \begin{tabular}{l l l l l l l l l l l l l l l l l l l $					
$\begin{array}{c} \text{IF noise power} & f_{\text{IF}} = 500 \text{ Hz, IF load} = 50  \Omega \\ & f_{\text{IF}} = 1 \text{M Hz, IF load} = 50  \Omega \\ \\ \text{IF noise voltage} & f_{\text{IF}} = 500 \text{ Hz, IF load} = 1  \text{k} \Omega \\ & f_{\text{IF}} = 500 \text{ Hz, IF load} = 1  \text{k} \Omega \\ \\ \text{IF output offset voltage} & \text{no object in range} \\ \\ \text{I/Q amplitude balance} & f_{\text{IF}} = 500 \text{ Hz, U}_{\text{IF}} = 1  \text{mVpp} \\ \\ \text{I/Q phase shift} & f_{\text{IF}} = 1  \text{Hz} - 20  \text{kHz} \\ \\ \text{Supply rejection} & \text{Rejection supply pins to IF output} \\ \\ \textbf{Antenna} \\ \\ \text{Antenna type} & \text{Right hand circular polarized} \\ \\ \text{Horizontal -3 dB beamwidth} & \text{E-Plane} \\ \\ \end{array}$	R <sub>IF</sub>		50		Ω
$\begin{array}{c} \text{IF noise power} & f_{\text{IF}} = 500 \text{ Hz, IF load} = 50  \Omega \\ & f_{\text{IF}} = 1 \text{M Hz, IF load} = 50  \Omega \\ \text{IF noise voltage} & f_{\text{IF}} = 500 \text{ Hz, IF load} = 1  \text{k} \Omega \\ & f_{\text{IF}} = 500 \text{ Hz, IF load} = 1  \text{k} \Omega \\ \text{IF output offset voltage} & \text{no object in range} \\ \text{I/Q amplitude balance} & f_{\text{IF}} = 500 \text{ Hz, U}_{\text{IF}} = 1  \text{mVpp} \\ \text{I/Q phase shift} & f_{\text{IF}} = 1  \text{Hz} - 20  \text{kHz} \\ \text{Supply rejection} & \text{Rejection supply pins to IF output} \\ \\ \textbf{Antenna} \\ \text{Antenna type} & \text{Right hand circular polarized} \\ \text{Horizontal -3 dB beamwidth} & \text{E-Plane} \\ \end{array}$	f <sub>IF</sub>	0		50	MHz
$f_{IF} = 1 \text{M Hz, IF load} = 50  \Omega$ IF noise voltage $f_{IF} = 500  \text{Hz, IF load} = 1  \text{k} \Omega$ $f_{IF} = 500  \text{Hz, IF load} = 1  \text{k} \Omega$ IF output offset voltage $f_{IF} = 500  \text{Hz, IF load} = 1  \text{k} \Omega$ IF output offset voltage $f_{IF} = 500  \text{Hz, U}_{IF} = 1  \text{mVpp}$ $I/Q  \text{amplitude balance} \qquad f_{IF} = 500  \text{Hz, U}_{IF} = 1  \text{mVpp}$ $I/Q  \text{phase shift} \qquad f_{IF} = 1  \text{Hz} - 20  \text{kHz}$ Supply rejection $ \text{Rejection supply pins to IF output} $ Antenna $ \text{Antenna} $ Antenna type $ \text{Right hand circular polarized} $ Horizontal -3 dB beamwidth $ \text{E-Plane} $	P <sub>IFnoise1</sub>		-134		dBm/Hz
$f_{IF} = 500 \text{ Hz}, \text{ IF load} = 1 \text{ k}\Omega$ $f_{IF} = 500 \text{ Hz}, \text{ IF load} = 1 \text{ k}\Omega$ $IF \text{ output offset voltage} \qquad \text{no object in range}$ $I/Q \text{ amplitude balance} \qquad f_{IF} = 500 \text{ Hz},  U_{IF} = 1 \text{ mVpp}$ $I/Q \text{ phase shift} \qquad f_{IF} = 1 \text{ Hz} - 20 \text{ kHz}$ $Supply \text{ rejection} \qquad \text{Rejection supply pins to IF output}$ $Antenna$ $Antenna \text{ type} \qquad \text{Right hand circular polarized}$ $Horizontal - 3 \text{ dB beamwidth} \qquad \text{E-Plane}$	P <sub>IFnoise2</sub> -164			dBm/Hz	
$f_{IF} = 500 \text{ Hz}, \text{ IF load} = 1 \text{ k}\Omega$ IF output offset voltage	U <sub>IFnoise1</sub>		-147		dBV/Hz
IF output offset voltage  I/Q amplitude balance  I/Q phase shift  I/Q phase shift  Supply rejection  Antenna  Antenna type  Rejection supply plant of supply p	U <sub>IFnoise1</sub>		45		nV/√Hz
$I/Q$ amplitude balance $f_{IF} = 500$ Hz, $U_{IF} = 1$ mVpp $I/Q$ phase shift $f_{IF} = 1$ Hz $-20$ kHz Supply rejection Rejection supply pins to IF output Antenna  Antenna Horizontal -3 dB beamwidth E-Plane	U <sub>IF</sub>	-200		200	mV
I/Q phase shift  Supply rejection  Rejection supply pins to IF output  Antenna  Antenna type  Right hand circular polarized  Horizontal -3 dB beamwidth  Fig. = 1 Hz-20 kHz  Rejection supply pins to IF output  E-Plane	ΔU <sub>IF</sub>		3		dB
Supply rejection Rejection supply pins to IF output  Antenna  Antenna type Right hand circular polarized  Horizontal -3 dB beamwidth E-Plane	φ	80	90	100	0
Antenna type Right hand circular polarized  Horizontal -3 dB beamwidth E-Plane	D <sub>supply</sub>		26		dB
Horizontal -3 dB beamwidth E-Plane					
	RHCP				
Vertical -3 dB heamwidth H-Plane	$W_{\phi}$		138		0
Vertical -5 db beartividati	W <sub>φ</sub>		132		0
	$D_{\phi}$		-12		dB
	$D_{\varphi}$		-12		dB
Body					
Outline Dimensions			25 × 25 × 6	6	mm³
Weight			4.5		g

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

5 pin single row jumper

Note 3 Theoretical value, given by Design

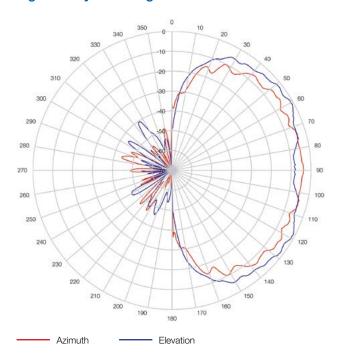
Connector

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## Antenna System Diagram

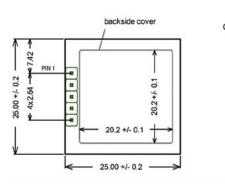
This diagram shows module sensitivity in both azimuth and elevation directions. It incorporates both transmitter and receiver antenna characteristics.

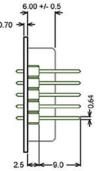
Figure 2: System diagram



### **Outline Dimensions**

Figure 3: Mechanical data





All dimensions in mm; values are typical unless otherwise specified

### 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 and Functions

**Table 1: Pin function description** 

Pin No.	Name	Description
1	IF Q output	load 1 kOhm
2	VCC	5 VDC supply
3	IF I output	load 1 kOhm
4	GND	ground
5	VCO in	Open = $f_0$

Figure 3: Pin configuration



# 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: -103 dBc (@0.5 kHz IF Bandwidth)

Carrier frequency

f<sub>0</sub>: 24.125 GHz

 Radar cross section RCS "reflectivity" of the object

 $\sigma^{1}$ : 1 m<sup>2</sup> approx. for a moving person > 50 m<sup>2</sup> 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:

- 6 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 250 Hz bandwidth and a simple comparator, we get already a 15 m frontal detection range.

## Datasheet Revision History

1.0 10 November 2017 initial release	V	ersion	Date	Changes
1.0 13. November 2017 Initial release		1.0	13. November 2017	initial release

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