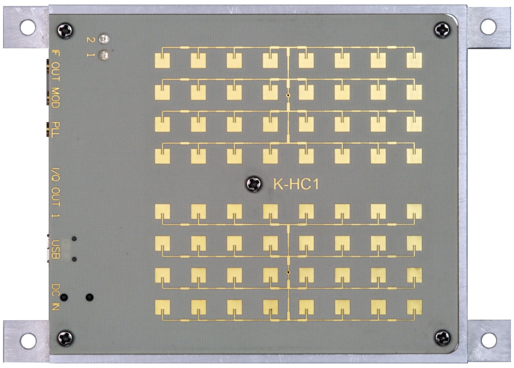
K-HC1 RADAR TRANSCEIVER

Datasheet

Features



- K-Band Superhet Transceiver System
- Highest Sensitivity Receiver with Integrated IF Amp
- Dual 32 Patch Antenna with 25°/12° Aperture
- PLL Controlled Precision Transmitter
- I/Q IF Doppler Output
- IF Amplitude Output
- USB Configurable Transmitter Modes
- Rugged and Compact Construction

Applications

- Long Range Traffic Measurement and Supervision
- Long Range Alarm Systems
- Object Speed Measurement Systems
- Measurement and Research Applications
- Industrial Sensors

Description

K-HC1 is a high-end Radar transceiver with an asymmetrical narrow beam for long distance detectors.
It includes a low phase noise, PLL controlled transmitter and a superhet receiver with 10MHz IF. This architecture results in a superb noise figure of 4dB and an overall sensitivity of -164dBc @BW=1kHz.

The Module can be used as sensitive Doppler sensor with I/Q output for speed and directional detection of moving objects.
External MMCX input allows using external oscillator for multi module operation or low noise carrier. Modulation input may be used for FM or AM.

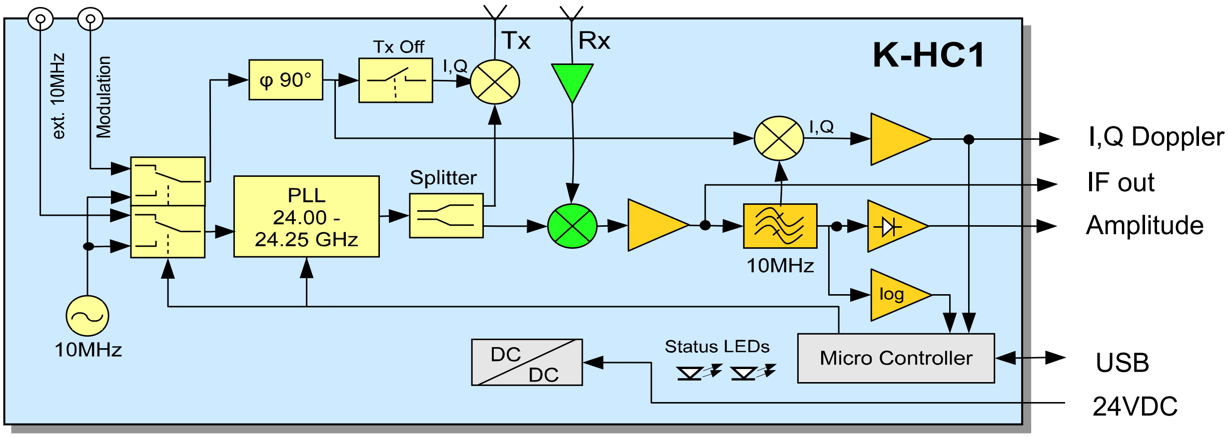


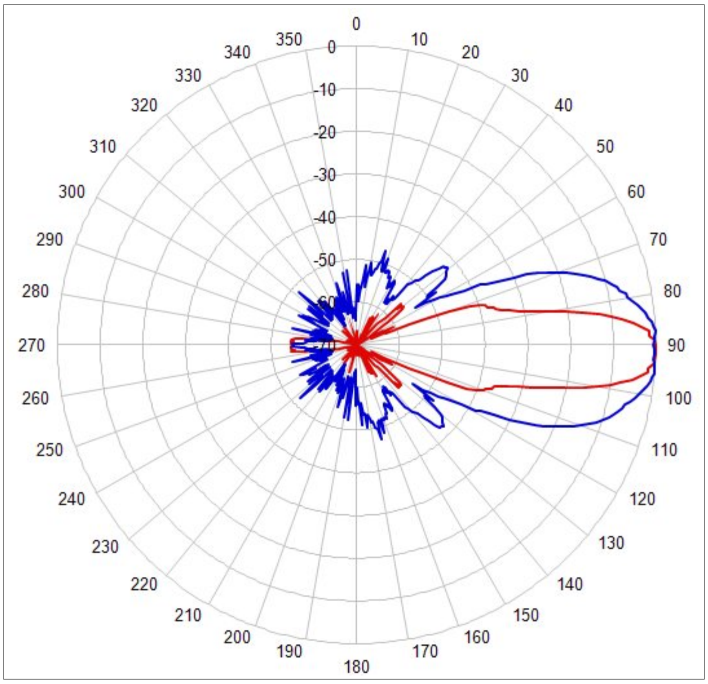
Fig. 1: K-HC1 Superhet Structure

Characteristics

Parameter	Conditions / Notes	Symbol	Min	Typ	Max	Unit
Operating conditions						
Supply Voltage		V_{cc}	15	24	30	V
Supply Current		I_{cc}		220		mA
Connector Type				RASM752		
Operating temperature		T_{St}	-20		+60	°C
Storage temperature		T_{op}	-20		+80	°C
Transmitter						
LO frequency (PLL)		f_{LO}	23.500		24.500	GHz
Transmitter frequency	LO frequency + SSB-Modulator Input	f_{TX}	23.510		24.510	GHz
Frequency step width	PLL Step-width	Δf		1		MHz
Output Power	EIRP @ 24.000 .. 24.250GHz	P_{TX}	+15		+20	dBm
Output Power deviation	f_{TX}=24.000 .. 24.250GHz	ΔP_{TX}		+/-1		dB
Frequency drift vs. temperature	V_{cc}=24V, -20°C .. +60°C	Δf_{TX}		1		ppm/°C
Maximum frequency error	V_{cc}=24V, -20°C .. +60°C	Δf_{Error}		50		ppm
Phase Noise	@ 100kHz	P_N		-95		dBc
Spurious	f_{TX}=24.000 .. 24.250GHz	P_{Spur1}		-30		dBc
Out of Band Spurious	f_{TX}=24.000 .. 24.250GHz	P_{Spur2}		-40		dBc
Carrier suppression	IRM Mixer Carrier suppression	$P_{Carrier}$		20		dB
Unwanted sideband suppression	IRM Mixer sideband supression	$P_{Sideband}$		20		dB
TX Antenna 'Off' Isolation	TX Antenna switched off	P_{TXoff}		30		dB
SSB-Modulator Input						
Frequency Range		f_{SSB}	9.0		11.0	MHz
Input Power	Transmitter fully modulated	P_{SSB}	+5		+15	dBm
Antenna						
Antenna Gain	f_{TX}=24.125GHz	G_{Ant}		17.5		dBi
Polarisation	Connectors on the right side			Vertical		
Horizontal –3dB beamwidth	E-Plane	W_{φ}		25		°
Vertical –3dB beamwidth	H-Plane	W_{θ}		12		°
Horiz. Sidelobe suppression		D_{φ}		-15		dB
Vert. Sidelobe suppression		D_{θ}		-15		dB
Isolation RX/TX Antenna	f_{TX}=24.125GHz	D_{RXTX}		60		dB
Receiver						
LNA Gain	f_{RX}=24.000 .. 24.250GHz	G_{LNA}		18		dB
LNA Noisefigure	f_{RX}=24.000 .. 24.250GHz	NF_{LNA}		4.0		dB
Mixer Conversion Loss	f_{IF}=10MHz	D_{Mixer}		-10		dB
IF Amplifier Gain	f_{IF}=10MHz	G_{IF}		32		dB
IF bandwidth	-3dB	B_{IF}	9.5		10.5	MHz
Receiver sensitivity	f_{IF}=500Hz,B=1kHz,S/N=6dB	P_{RX}		-144		dBm
Overall sensitivity	f_{IF}=500Hz,B=1kHz,S/N=6dB	D_{system}		-164		dBc
PLL Input						
Frequency Range		f_{PLL}	9.0		100	MHz
Input Power	Performance comparable to internal XTAL	P_{PLL}	0		+10	dBm
Phase Noise	@ 1kHz, identical Performance as internal	PN_{PLL}			-150	dBc

IF Output						
Frequency Range		f_{IF}	0.01		100	MHz
Output Impedance		R_{IF}		50		Ω
Noise Floor	Bandwidth filtered to 100MHz	N_{IF}		-130		dBm/Hz
Doppler Output						
Frequency Range		$f_{Doppler}$	3		15k	Hz
IF Buffer Gain		$G_{Doppler}$		46		dB
Noise Floor	B=10kHz, RX-Antenna covered	$N_{Doppler}$		-96		dBV/Hz
				1.6		mV_{RMS}
DC Offset	RX-Antenna covered	$U_{Doppler}$	2.0	2.5	3.0	V
I/Q Amplitude balance	$f_{Doppler}$=1kHz	$\Delta U_{Doppler}$		3		dB
I/Q phase shift		$\varphi_{Doppler}$	80	90	100	°
AM Output						
Frequency Range		f_{AMout}	0		3k	Hz
AM Buffer Gain		G_{AM}		20		dB
Noise Floor	B=10kHz, RX-Antenna covered	N_{AM}		-109		dBV/Hz
DC Offset		V_{osAM}		350		mV
DC Offset Drift		ΔV_{os}		2		mV/°C
Host Interface						
USB				VCP (virtual COM Port)		
Body						
Outline Dimensions				110*77*19		mm
Weight				182		g

Antenna System Diagram



Azimuth 12° , Elevation 25°
At IF output voltage -6dB
(corresponds to -3dB Tx power)

Programming

Programming is necessary only for special applications of K-HC1. For normal operation as Doppler Sensor is no need to program anything.

Some important parameters of the K-HC1 transceiver are configurable by an USB interface. It is also possible read back the received RF power.
New settings can permanently be stored in the EEPROM of K-HC1.

Communication takes place via a serial protocol, that can be handled by any terminal software.

```
RFbeam K-HC1 Radarmodule #09250106
==================================
Program Version V1.00 Apr 22 2010

[f] RF Frequency      :  24.125    [23.500 .. 24.500 GHz]
[c] Carrier           :       1    [0=OFF 1=ON]
[p] PLL Reference     :       0    [0 = INTERN, 1=EXTERN]
[m] Modulation        :       0    [0 = INTERN, 1=EXTERN]
[r] ext. Reference    :      10    [10 MHz ...100 MHz]
[o] int. Oscillator   :       1    [0=OFF 1=ON]
[i] Read IF Power     :   -56.1    [dBm]
[e] Store to EEPROM
[b] Enter Bootloader

->_
```

Fig. 2: K-HC1 Terminal Dialog

Examples:
To enter Frequency `f24.012 <Enter>`
To store new parameters permanently: `e <Enter>`

Special Functions

Please refer to the application notes at the end of this document for more details.

Carrier OFF

Transmitter can be completely switched off, while the internal receiver oscillator is still active. This is interesting, if using K-HC1 as pure superhet receiver.

PLL Reference external

Instead of using the internal 10MHz oscillator, an external oscillator may applied to connector “PLL”. This allows generating FM for FMCW operation of the K-HC1.

Modulation external

Carrier my be modulated by an external signal applied to connector “Mod”. This allows e.g. generating small frequency steps for FSK operation.

Ext Reference

Optionally, a 100MHz instead of a 10MHz reference may be used. This is interesting when using K-HC1 as high performance receiver or as downconverter for a spectrum analyzer.

Store to EEPROM

Actual settings will be stored permanently in K-HC1.

Enter Bootloader

This function is for reloading th K-HC1 firmware. Do not use this function without prior contacting RFbeam.

Connectors and Pin Configuration

Please refer to Fig. 4 below for locating the connectors.
Refer to chapter Characteristics for description of signals and levels.

IF Out, MOD, PLL

Type: MMCX plug Distributor example: Farnell/Newark #1056316
Cable: MMCX/MMCX Distributor example: Farnell/Newark #1756021

I/Q Out

Housing: JST PHR-6 Farnell/Newark #3616228
Contacts: JST BPH-002T-P0.5S Farnell/Newark #3617210
(Module Side: JST S6B-PH-SM4-TB(LF)(SN), 6-pin, 2mm)

Pin	Description	Typical Value
1	AM Output	.3VDC + IF DC level
2	Doppler Output I	2.5V + Doppler AC
3	--	Not connected
4	Doppler Output Q	2.5V + Doppler AC
5	--	Not connected
6	GND	Signal Ground

Fig. 3: Pinning of I/Q Out Connector

USB

Type: Mini B

DC In

Type: DC power plug KobiConn 1771-3218-EX, Distributor example Mouser #1771-3218-EX,

Outline Dimensions

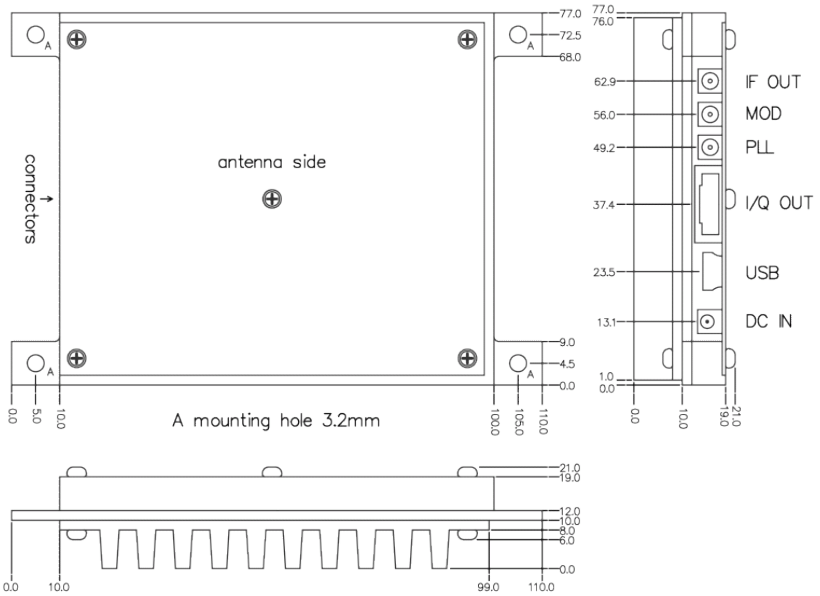


Fig. 4: Outline and Connector Configuration

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 (for S/N ration > 6dB)	S:	-164dBc (@1kHz IF bandwidth)
- Carrier frequency	f_0:	24.125GHz
- Radar cross section RCS ("reflectivity") of the object	$\sigma^{1)}$:	1m² approx. for a moving person >50m² 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 and a comparator as ADC, you get an indicative detection range of
- > 210 meters for a moving person
- > 560 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.
Maximal distance is also limited by the phase noise of the oscillator. With K-HC1, you get an absolute maximum range of > 1km.

High Sensitivity Sensor

The superhet architecture leads to a significantly better signal to noise (S/N) ratio than the direct conversion principle used in traditional Doppler transceivers.
K-HC1 features an enhancement of 20-25dB compared to a K-MC1 sensor. This means a 4 times distance enhancement. (Each 12dB means doubling the distance range).
Typical applications are

- Long range movement detection of persons up to 400m
- Speed measurements in sports applications (persons, balls, …)
- Long range traffic detector (cars up to 1'000m)

Best results regarding maximum distance may be achieved by using FFT processing.

Datasheet Revision History

Version 0.1	Sept 15 2010	Initial preliminary release
Version 0.2	Sept 30 2010	Preliminary release. Minor correction. Antenna diagram updated
Version 1.0	Dec 01 2012	Release. Minor correction.
Version 1.1	Oct 23 2011	Minor cosmetic corrections
Version 1.2	Nov 02 2018	Changed footer to new address