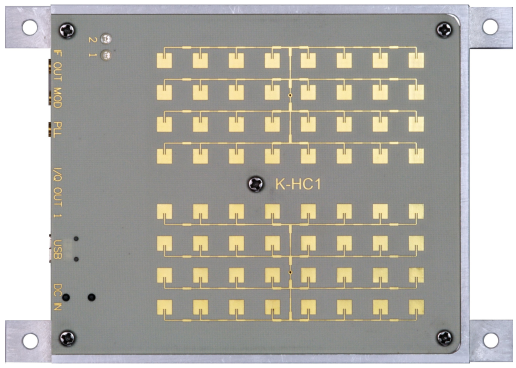
# K-HC1 RADAR TRANSCEIVER

*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.

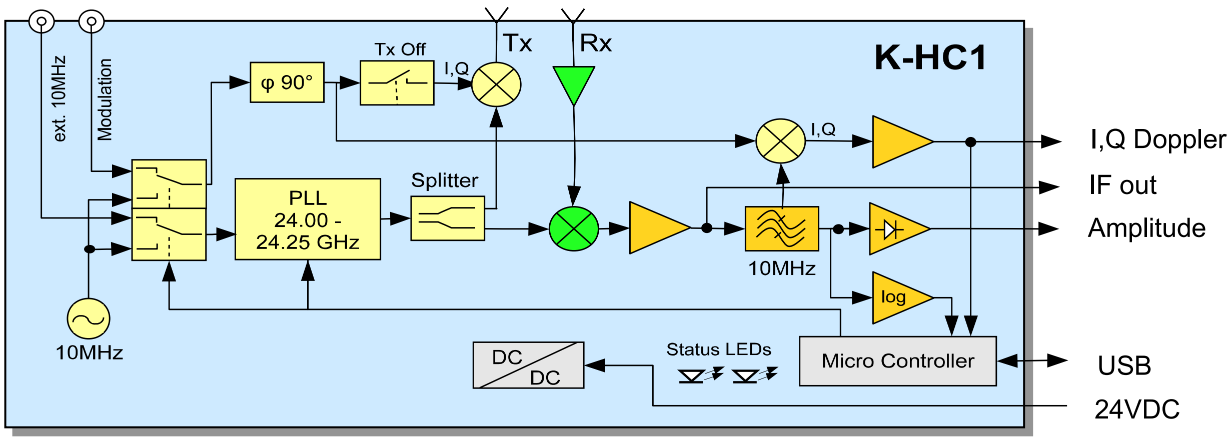


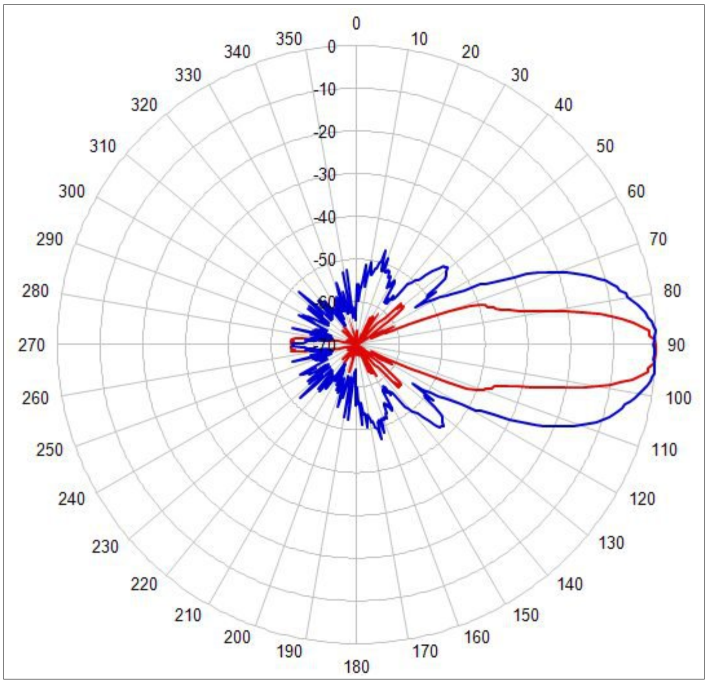

**Fig. 1: K-HC1 Superhet Structure**

# 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 | $\Delta f$ | | 1 | | MHz |
| Output Power | EIRP @ 24.000 .. 24.250GHz | $P_{TX}$ | +15 | | +20 | dBm |
| Output Power deviation | $f_{TX}$=24.000 .. 24.250GHz | $\Delta P_{TX}$ | | +/-1 | | dB |
| Frequency drift vs. temperature | $V_{cc}$=24V, -20°C .. +60°C | $\Delta f_{TX}$ | | 1 | | ppm/°C |
| Maximum frequency error | $V_{cc}$=24V, -20°C .. +60°C | $\Delta f_{Error}$ | | 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 | $W_{\varphi}$ | | 25 | | ° |
| Vertical –3dB beamwidth | H-Plane | $W_{\theta}$ | | 12 | | ° |
| Horiz. Sidelobe suppression | | $D_{\varphi}$ | | -15 | | dB |
| Vert. Sidelobe suppression | | $D_{\theta}$ | | -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 | | $\Delta V_{os}$ | | 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

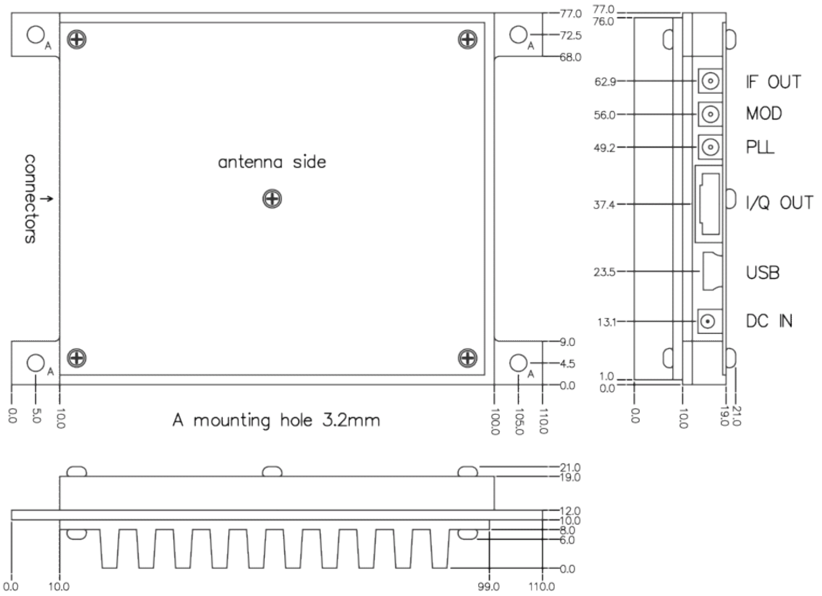



**Fig. 4: Outline and Connector Configuration**

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# 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<br>>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 |