PCTEL

SeeGull® HB*flex*™

Hardware Reference Manual

Document Number: 100130-00
Revision F

April 2020

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1. Preface

1.1. Purpose

This document is a reference manual for the main features and options available SeeGull HB*flex*. This manual provides instructions related to setup, operation, and maintenance. Other documentation may supplement this document for SeeGull HB*flex* scanner or related PCTEL products and applications.

1.2. Applicability

The SeeGull HB*flex* scanning receiver conducts in-build walk tests, drive test, and site-specific measurements of mobile networks around the world to optimize wireless network performance, survey tower sites, monitor base stations, demodulate RF signals, and analyze wireless market data and is specially designed to collect data across the mmWave band for 5G NR in addition to existing 2G,3G and 4G sub 6-GHz bands.

The SeeGull HB*flex* scanning receiver is a software-defined receiver, capable of supporting multiple protocols and any supported cellular band. It supports frequencies from 10MHz to 6 GHz and selected bands between 24Ghz to 40Ghz. It can be configured for 5G NR, FD-LTE, TD-LTE, LTE-LAA, NB-IoT, WCDMA, GSM, CDMA, EV-DO, , P25, TETRA, DMR and Wi-Fi technologies which can all be measured simultaneously.

The following 3GPP bands are supported for 5G New Radio (NR)

- N1 (UL: 1920 MHz – 1980 MHz, DL: 2110 MHz – 2170 MHz)
- N2 (UL: 1850 MHz - 1910 MHz; DL: 1930 MHz - 1990 MHz)
- N3 (UL: 1710 MHz – 1785 MHz; DL: 1805 MHz – 1880 MHz)
- N5 (UL: 824 MHz – 849 MHz; DL: 869 MHz – 984 MHz)
- N7 (UL: 2500 MHz – 2570 MHz; DL: 2620 MHz – 2690 MHz)
- N8 (UL: 880 MHz – 915 MHz; DL: 925 MHz – 960 MHz)
- N12 (UL: 699 MHz - 716 MHz; DL: 729 MHz - 746 MHz)
- N14 UL: 788 MHz – 798MHz, DL: 758MHz – 768MHz)
- N18 (UL: 815MHz – 830 MHz, DL: 860MHz – 875MHz)
- N20 (UL: 832 MHz - 862 MHz; DL: 791 MHz - 821 MHz)
- N25 (UL: 1850 MHz - 1915 MHz; DL: 1930 MHz - 1995 MHz)
- N28 (UL: 703 MHz – 748 MHz; DL: 758MHz – 803MHz)
- N29 (DL: 717MHz – 728MHz)
- N30 (UL: 2305MHz – 2315MHz, DL: 2350MHz – 2360MHz)
- N34 (UL/DL: 2010 MHz - 2025 MHz)
- N38 (UL/DL: 2570 MHz - 2620 MHz)
- N39 (UL/DL: 1880 MHz - 1920 MHz)
- N40 (UL/DL: 2300 MHz - 2400 MHz)
- N41/N90 (UL/DL: 2496 MHz – 2690MHz)
- N48 (UL/DL: 3550 MHz – 3700MHz)
- N50 (UL/DL: 1432 MHz - 1517 MHz)
- N51 (UL/DL: 1427 MHz - 1432 MHz)
- N65 Band (UL: 1920 MHz - 2010 MHz; DL: 2110 MHz - 2200 MHz)
- N66 Band (UL: 1710 MHz - 1780 MHz; DL: 2110 MHz - 2200 MHz)
- N70 (UL: 1695 MHz – 1710 MHz, DL: 1995 MHz – 2020 MHz)
- N71 (UL: 653 MHz – 698MHz, DL: 617 MHz – 652MHz)
- N74 (UL: 1427 MHz – 1470 MHz, DL: 1475 MHz – 1518 MHz)
- N75 (1432 MHz – 1517 MHz)
- N76 (1427 MHz – 1432 MHz)
- N77 (3300 MHz – 4200 MHz)

- N78 (3300 MHz – 3800 MHz)
- N79 (4400 MHz – 5000MHz**)**
- N80 (1710 MHz – 1785 MHz**)**
- N81 (880 MHz – 915 MHz**)**
- N82 (832 MHz – 862 MHz**)**
- N83 (703 MHz – 748 MHz**)**
- N84 (1920 MHz – 1980 MHz**)**
- N86 (1710 MHz – 1780 MHz**)**
- N91 (UL: 832 MHz – 862 MHz, DL: 1427MHz – 1432 MHz)
- N92 (UL: 832 MHz – 862 MHz, DL: 1432 MHz – 1517 MHz)
- N93 (UL 880 MHz – 915 MHz, DL: 1427 MHz – 1432 MHz)
- N94 (UL 880 MHz – 915 MHz, DL : 1432 MHz – 1517 MHz)
- N95 (UL 2010 – 2025 MHz)
- N257 (26.5 GHz to 29.5 GHz)
- N258 (24.25 GHz to 27.5 GHz)
- N260 (37 GHz to 40 GHz)
- N261 (27.5 GHz to 28.35 GHz)

The following bands are supported for FD-LTE with a subset of these bands supported for WCDMA, CDMA, EV-DO and GSM:

- ER-GSM-900
- E-UTRA 1 (2100 MHz UMTS)
- E-UTRA 2 (1900 MHz)
- E-UTRA 2/25 (1900/Ext 1900 MHz)
- E-UTRA 3 (1800 MHz)
- E-UTRA 4 (2100 MHz AWS)
- E-UTRA 4/66 (AWS/AWS-3)
- E-UTRA 5 (850 MHz)
- E-UTRA 6 (850 MHz Japan)
- E-UTRA 7 (2600 MHz IMT)
- E-UTRA 8 (900 MHz UMTS)
- E-UTRA 9 (1700 MHz Japan)
- E-UTRA 10 (Ext. 2100 MHz AWS)
- E-UTRA 11 (1500 MHz Japan)
- E-UTRA 12 (Lower 700 MHz A/B/C)
- E-UTRA 12/17 Lower 700 MHz A/B/C and Lower 700 MHz B/C)
- E-UTRA 13 (Upper 700 MHz C)
- E-UTRA 13/14L (Upper 700 MHz C and lower half Upper 700 MHz D)
- E-UTRA 14 (Upper 700 MHz D)
- E-UTRA 17 (Lower 700 MHz B/C)
- E-UTRA 18 (Lower 800 MHz Japan)
- E-UTRA 19 (Upper 800 MHz Japan)
- E-UTRA 20 (800 MHz EU)
- E-UTRA 21 (1510 MHz Japan)
- E-UTRA 22 (3500 MHz)
- E-UTRA 23 (2000 MHz)
- E-UTRA 24 (1600 MHz)
- E-UTRA 25 (1990 MHz [Ext. 1900])
- E-UTRA 26 (Upper Ext 850 MHz)
- E-UTRA 27 (Lower Ext 850 MHz)
- E-UTRA 28 (700 MHz APAC)
- E-UTRA 29 (US 700 MHz)
- E-UTRA 30 (2300 MHz WCS)
- E-UTRA 31 (450 MHz)
- E-UTRA 32 (1500 MHz L-Band, DL only)
- E-UTRA 65 (2100+)
- E-UTRA 66 (AWS-3)
- E-UTRA 67 (700 EU, DL only)
- E-UTRA 68 (700 ME)
- E-UTRA 69 IMT-E (2570 - 2620 MHz)(DL only)
- E-UTRA 70 (AWS-4)
- E-UTRA 71 (US 600)
- E-UTRA 72 PPDR, EU PMR/PAMR 450
- E-UTRA 73 APAC 450
- E-UTRA 74 L-Band
- E-UTRA 75 1500 SDL (1432 - 1517 MHz) (DL only)
- E-UTRA 76 1400 (1427 - 1432 MHz) (DL only)
- E-UTRA 85 (Lower 700 A+)
- E-UTRA 252 (5150 - 5250 MHz U-NII-1)
- E-UTRA 255 (5725 - 5850 MHz U-NII-3)

The following bands are supported for TD-LTE:

- E-UTRA 33 (1900 MHz)
- E-UTRA 34 (2000 MHz)
- E-UTRA 35 (1900 MHz Lower)
- E-UTRA 36 (1900 Upper)
- E-UTRA 37 (1900 MHz Center Gap)
- E-UTRA 38 (2.6 GHz)
- E-UTRA 39 (1.9 GHz)
- E-UTRA 40 (2.3 GHz)
- E-UTRA 41 (2.5 GHz)
- E-UTRA 42 (3.4 GHz)
- E-UTRA 43 (3.6 GHz)
- E-UTRA 44 (700 MHz)
- E-UTRA 45 (TD 1500)
- E-UTRA 46 (5150 - 5925 MHz)
- E-UTRA 47 (5855 - 5925 MHz)
- E-UTRA 48 (3550 - 3700 MHz)
- E-UTRA 49 (3550 - 3700 MHz)
- E-UTRA 50 (1432 - 1517 MHz)
- E-UTRA 51 (1427 - 1432 MHz)
- E-UTRA 52 (3300 – 3400 MHz)
- TDD Proprietary (179 - 199 MHz)
- TDD Proprietary (1785 - 1805 MHz)

The following bands are supported for RSSI channel measurements:

- P25 Public Safety 700 Band (769 - 774 MHz BS and 799 - 805 MHz MS)
- Wi-Fi Bands (2400 - 2484 MHz, 4900 - 6000 MHz)
- TETRA Public Safety 380, 390 Band (380 - 390 MHz MS, 390 - 400 MHz BS)
- TETRA Public Safety 410, 420 Band (410 - 420 MHz MS, 420 - 430 MHz BS)
- TETRA Public Safety 450, 460 Band (450 - 460 MHz MS, 460 - 470 MHz BS)
- TETRA Public Safety 870, 915 Band (870 - 876 MHz MS, 915 - 921 MHz BS)

The following “super” bands are supported for “LTE By Frequency” and EPS measurements:

- LTE Unchannelized Superband (10 MHz - 6 GHz)
- LTE Unchannelized Superband (300 MHz - 3.8 GHz)
- LTE Unchannelized Superband (570 MHz - 3.8 GHz)
- LTE Unchannelized Lower Superband (10 MHz - 1700 MHz)
- LTE Unchannelized Lower Superband (300 MHz - 1700 MHz)
- LTE Unchannelized Lower Superband (570 MHz - 1700 MHz)
- LTE Unchannelized Upper Superband (1700 MHz - 3.8 GHz)
- LTE Unchannelized Upper Superband (1700 MHz - 6 GHz)

For more information about the SeeGull HB*flex*, please contact your sales or marketing representative (contact information provided in *Section 8*).

Features

- Fast scanning speeds
- High dynamic range
- Low false detection rate
- Built-in GPS
- LTE MIMO capability (**sub 6GHz Only**)
- Blind Scan for all technologies including 5G NR
- Layer 3 decoding of FD-LTE, TD-LTE, WCDMA and GSM
- USB Interface and Bluetooth® connectivity
- Ethernet connectivity
- On-board storage with SD card
- Plug-and-play capabilities
- Compatibility with industry-leading drive test, data analysis, and RF planning tools
- Modular architecture for easy upgrades
- Small form factor, light weight
- Low power consumption and hot swap battery system
- Power save mode

Supported Measurements

5G New Radio (NR)

- Maximum # of Channels: 12 (FR1) and 8 (FR2)
- NRTop N Reference Signal Scan
- PCI/Beam Index
- PSS_RP, PSS_RQ, PSS_CINR
- SSS_RP, SSS_RQ, SSS_CINR, SSS_delay spread
- RSPBCH_RP, RSPBCH_RQ, RSPBCH_CINR, SSB_RSSI, SSB_RP, SSB_RQ, SSB_CINR, SSB_Idx
- MIB
- Time Offset

LTE (FDD and TDD)

- Maximum # of Channels: 24
- eTop N Reference Signal Scan
- Automatic Bandwidth detection or manual selection
- P-SCH/S-SCH
- RSRP, RSRQ
- CINR
- Cyclic Prefix
- Time Offset
- Multi-Path Delay Spread
- MIMO ECQI for different transmission modes
- MIMO ETPUT for different transmission modes
- MIMO Condition number

TD-LTE Specific

- Uplink/Downlink Configuration #
- DwPTS Symbol
- UpPTS
- GP

LTE-LAA

- LTE-LAA measurement for RS and RS-RF Path:
  - RS_RP
  - RS_RQ
  - RS_CINR
  - TimeOffset
- LTE-LAA measurement for SS:
  - PSCH_RP
  - PSCH_RQ
  - PSCH_CINR
  - SSCH_RP
  - SSCH_RQ
  - SSCH_CINR

NB-IoT

- In-Band, Guard band or Stand Alone
- Top N NRS (Narrowband Reference Signal), NPSS (Narrowband Primary Synchronization Signal) and NSSS

(Narrowband Secondary Synchronization Signal)

- NSSS - RP, RQ, RSSI, CINR, Timeoffset

GSM

- BSIC Decoding Scan
- RSSI Channel Scan
- C/I (Co-Channel Interference)

WCDMA

- Maximum # of Channels: 24
- Top N Scan
- P-SCH/S-SCH Scan
- Io
- Ec/Io and Aggregate Ec/Io
- Signal to Interference Ratio (SIR)
- Rake Finger Count
- Time Offset
- Delay Spread

CDMA

- Maximum # of Channels: 24
- Top N Scan
- Ec
- Ec/Io and Aggregate Ec/Io
- Pilot Delay and Delay

EV-DO

- Maximum # of Channels: 24
- Top N Scan
- Ec
- Ec/Io and Aggregate Ec/Io
- Pilot Delay and Delay

W-Fi

- Channelized RSSI measurements for 2.4GHz, 4.9GHz and 5GHz
- Top N measurement in all channels in the 2.4 GHz and 5 GHz bands
- Signal Strength
- Noise Level
- CINR
- NRS - RP, RQ, RSSI, CINR, Timeoffset.
- NPSS - RP, RQ, RSSI, CINR.
- Channel Number and Bandwidth
- BSSID/Device Name/SSID
- Security Protocol
- 802.11 Media
- Beacon Interval
- Channel Utilization
- UDP Throughput and Lost Packets
- TCP Throughput and OOO Packets

P25

- Phase1 and Phase2 RSSI, SINR, NID, FBER and Out of Service BER measurements

TETRA

- Channelized RSSI measurements for supported TETRA bands
- Tetra Decode – RSSI, SNR, FBER, Color Code, MCC, MNC

DMR

- RSSI, SINR, FBER and Color Code

MULTI-TECHNOLOGY

- Aggregate Power measurement (RSSI, EPS, or Spectrum Analysis)
- Delay and Signal Strength of neighboring cells
- RSSI Channel Scans
- Spectrum Analyzer measurements
- High Performance GPS Receiver

Blind Scan

The Blind Scan feature for 5G NR, FD-LTE, TD-LTE, WCDMA, GSM, CDMA, EV-DO, NB-IoT and Wi-Fi technologies scans the selected band and provides the active channel numbers. Blind Scan is useful for conducting a full band network search where prior knowledge about active channels is incomplete or unknown. It is also beneficial for network benchmarking to obtain a first-glance view of the RF infrastructure density and configuration.

For LTE, Layer 3 option is supported.

Bluetooth Communication

The Bluetooth Communications enables the user to communicate wirelessly to an Android™ device. Bluetooth requires an antenna to operate and comes with the scanner.

For more information please visit www.pctel.com.

1.3. Notices

WARNING: These devices have no protection against lightning. Please turn off the scanning receiver during a thunderstorm and, if applicable, take the antenna inside the car before a thunderstorm approaches.

The scanning receiver itself is not intended for “in weather” outdoor use.

NOTICE: There are no user serviceable parts inside the SeeGull HB*flex* Scanning Receiver.

1.4. Compliance

RoHS Compliance

The PCTEL SeeGull HB*flex* scanning receiver being delivered to participating European nations is compliant to EU Directive 2011/65/EU (RoHS).

The PCTEL SeeGull HB*flex* scanning receiver is compliant to "Administrative Measure on the Control of Pollution Caused by Electronic Information Products" ("China RoHS").

ISO Compliance

PCTEL’s Quality Management System has been certified to be compliant with ISO 9001:2015.

2. Overview and System Requirements

This section describes the SeeGull HBflex scanning receiver, including the applicable system configuration and software requirements.

2.1. General Description

The SeeGull HB*flex* is a tool for signal strength and modulation measurement, engineered for the rigors of mobile network testing during planning, installation, and maintenance of wireless networks.

2.2. Initial Inspection

Upon receipt of the scanning receiver, inspect the shipping container and verify that the contents are complete and match the packing list. The HB*flex* scanning receiver should look similar to the picture in *Figure 1*. If the contents are incomplete or the SeeGull HB*flex* scanning receiver appears damaged, please call the Technical Support line at (240) 460-8833.

Figure 1 - SeeGull HBflex Scanning Receiver

2.3. Options

Optional multi-technology measurements available for the SeeGull HBflex are described below. These options can be installed at the time of purchase or later on as a field-upgradeable option. Please contact your PCTEL sales or marketing representative for pricing and delivery information.

Technologies

The following Technology options are standard on the 08910 base configuration: GSM, WCDMA, CDMA, EVDO, TD-LTE, FD-LTE, Wi-Fi, NR. Other available technology options include

OP527-FD-LTE-NB-IOT	LTE (FDD) Narrow Band IoT Technology Option
OP527-LTE-LAA	LTE-LAA (License Assisted Access) Technology Option

Enhanced Power Scan (EPS™) Option (OP608)

EPS Mode provides customizable power measurements, improving flexibility and precision over RSSI and Spectrum Analyzer measurements for highly-tuned analysis of individual parts of the RF signal. EPS features include:

- Absolute Time Stamp
- Auto and Immediate Measurement Modes
- Ability to set both Time and Frequency parameters
- Measure Frequency Spans from 7.5 kHz to 20 MHz user selectable in multiples of 2.5 kHz
- Measures Time Periods from 1 chip (50 µs) to 20,000 chips (1sec)

Spectrum Analyzer Option (OP607)

The built-in Spectrum Analyzer feature provides an effective means to detect and troubleshoot frequency-related problems. Spectrum Analysis is also available as a

package with the scanner that enables spectrum analysis of the wide band capability of the scanner. The Spectrum Analyzer shows a wealth of information about the signal spectrum that is not obtainable from the standard channel power measurement. The Spectrum Analyzer measures and reports power spectral density using frequency domain techniques (a segmented FFT approach that ensures various resolution bandwidths and fast update rates), whereas RSSI measurements use analog and digital filters to select the right frequency band and subsequently measure total power.

One advantage of this approach is that the Spectrum Analyzer can analyze the fast-changing spectrum of an unstable transmitter. The RSSI measurement in this case will most often show a normal smooth picture, as it averages a limited set of data over time. The Spectrum Analyzer, however, if used with an appropriate resolution bandwidth, will reveal erratic signal behavior due to its fast update rate and non-averaged data.

The user may set the resolution bandwidth to 5, 10, 20, 40, 80 or 160 kHz or 2, 4, or 8 MHz. Output data may be set to an average of 1, 2, 4, 8, or 16 sweeps.

LTE Power Analysis (OP616)

LTE Power Analysis is available for TD-LTE and provides power of the resource block and slot of the TD-LTE frame. This enables users to identify interference that is time (slots) or frequency (RBs)-selective, to obtain a snapshot of overall traffic levels, and to determine whether the base station is properly using the available resources.

Layer 3

OP615 - All Technologies (GSM, WCDMA, CDMA, EVDO, TD-LTE, FD-LTE)

Layer 3 decoding is available for FD-LTE, TD-LTE, FD-LTE-NB-IOT, GSM, WCDMA and CDMA technologies. This option provides decoding for:

- GSM BCCH (Broadcast Control Channel) messages
- WCDMA BCH (Broadcast Control Channel) Type 3 messages

In the GSM BCCH, types 1, 2, 3, 4, 9, and type 13 messages are supported. For WCDMA, and LTE, transport block from the scanner enable support of the Master Information Block (MIB) and System Information Blocks (SIBs).

In the WCDMA BCH, the MIB and SIBs 1, 2, 3, 5, 7, 11 and 19 are available.

In the GSM BCCH, WCDMA, these messages contain the Cell Identity and Local Area Identification information broadcast by the network infrastructure. This information includes the:

- MCC (Mobile Country Code),
- MNC (Mobile Network Code),
- LAC (Location Area Code)
- RAC (Routing Area Code)

These messages also contain significant information on the configuration, activity and performance of the network. This includes information concerning:

- Neighbor list
- Mobility management (handovers, etc.)
- Group and broadcast call control
- GPRS mobility management, transparent transport and session management

- Radio resource management
- SMS messages
- Location services
- Uplink Interference parameters (WCDMA).

The LTE BCCH Layer 3 option conveys system information about the cell. These transport blocks contain the cell identity, channel bandwidth, mobility management (handovers), neighbor lists, barred cells, intra-frequency selection, public safety messages, etc. It supports decoding of the MIB and SIBs 1-16, 24, 25 and 32.

The FD-LTE NB-IOT Layer 3 option conveys system information about the cell. It supports the decoding of the MIB and SIB 1.

The CDMA Layer 3 option provides this information:

- Synch Message.
- System Parameter Message.
- Extended System Parameter Message.
- Neighbor List Message.
- Extended Neighbor List Message.
- CDMA Channel List Message.
- CDMA Extended Channel List Message

The SeeGull HB*flex* supports scanning of numerous GSM and LTE BCCH, and WCDMA BCH channels during the same test.

Mobile Blindscan Option (Mobile Measurement):

OP505 - All Technologies (GSM, WCDMA, CDMA, EVDO, TD-LTE, FD-LTE)

Mobile Blindscan (Mobile Measurement) combines the functionality to detect new channels in defined Bands, known as Blindscan, and performs additional measurement on the identified channels. When channels are no longer recognized, they are removed from the monitoring channels.

LTE (FDD and TDD) 2x2 and 4x2 MIMO Option (OP617)

MIMO testing is available for 2x2 and 4x2 FD-LTE and TD-LTE. This enables users to determine the maximum throughput capability of the RF environment and the degree of correlation between the 2 base station transmission antennas for the purpose of optimizing throughput.

Dynamic Spectrum Sharing (OP527- DSS)

This option is available on FD-LTE and TD-LTE for users to accurately measure the LTE frames for cases employing Dynamic Spectrum Sharing with 5G NR.

2.4. System Requirements

This section describes the system requirements for the SeeGull HBflex scanning receiver.

Typical System

Depending on a user's requirements, various hardware and software components may be used in the scanning system along with the SeeGull HB*flex* scanning receiver. However, in most cases, a typical configuration will include a host PC connected to the scanning receiver via a USB cable, or Android tablet or UE connected to the scanning receiver via a USB cable or Bluetooth, running the user's application software.

Antenna Requirements

The HBflex can support two types of antennas for different requirements.

For 10MHz to 6GHz measurements: Use a 50 Ohm impedance antenna with an SMA male connector at the end of the cable.

For mmWave antennas: Omni antennas designed for 24GHz to 40GHz support have to be connected with an SMA male connector at the end of the cable.

Note: Outdoor antennas, including those used by other devices, should be placed a minimum of 6 in. (15 cm) apart, with a recommended distance of 34 in. (86 cm).

Power Source Requirements

Maximum power the SeeGull HB*flex* scanning receiver draws:

- 25 watts (max)

Voltage range for the HB*flex* scanning receiver:

- 9 to 17 VDC

Use a car battery, a 12-volt battery, or an AC/DC adapter. It is imperative that the power source be capable of supplying the receiver with the voltage and current levels as described above. It is HIGHLY recommended that the power supply not exceed the working DC voltage range of the scanning receiver. Applying excessive voltage to the receiver will void the unit's warranty.

The scanning receiver should be powered through the power cord provided by PCTEL. If another power cord is used, the power cord must be one that incorporates a fuse for protection and safety purposes or this will void any warranties.

Software Requirements

For supported SeeGull HB*flex* supported data collection software and technical interfaces, please contact PCTEL support.

3. Installation

This section describes how to set up the SeeGull HBflex scanning receiver.

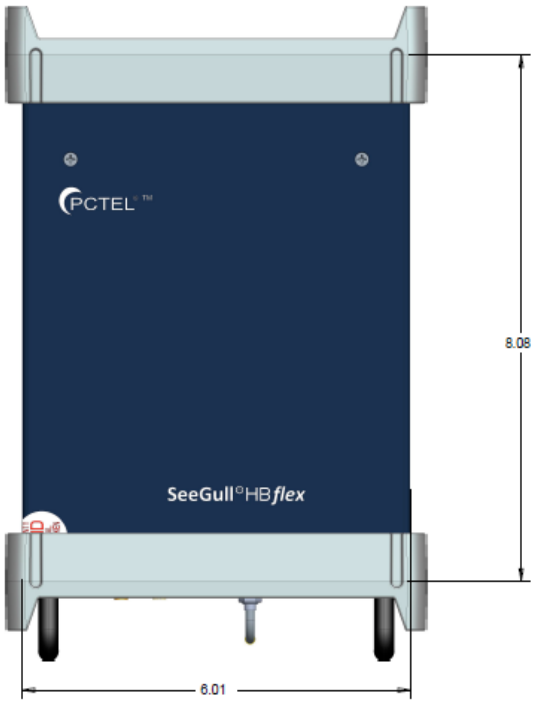

Figure 2 – SeeGull HBflex Scanning Receiver Top View

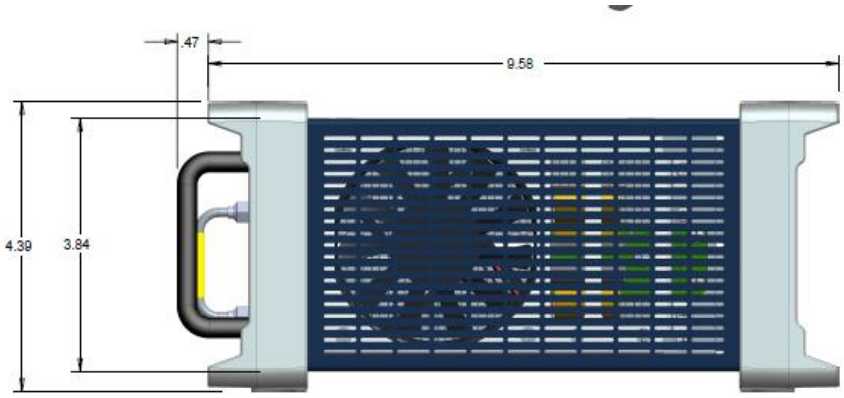

Figure 3 - SeeGull HBflex Scanning Receiver Side View

3.1. Setup

The following steps explain how to connect the unit to the host PC, tablet, or UE, and power source to begin collecting data.

1. Depending on the type of measurements to be carried out, please connect appropriate antennas:
    a. **10MHz-6GHz only**: If trying to carryout measurements between the frequency range of 10MHz to 6GHz then connect the antennas to the SMA connectors labeled RF1 and RF2 on the unit (*Figure 4*). Note that for 10MHz to 6GHz measurements RF2 is only used for these applications (otherwise, RF2 is inactive):
        i. LTE MIMO measurements enabled during eTopN scans (**sub 6GHz only**)
        ii. When setting up scans in different frequency bands while using antennas with different frequency ranges on the different ports (RF1 and RF2) (**sub 6GHz only for technologies except 5GNR**)
        iii. The Signal Analyzer feature in SeeHawk Touch.
    b. **Both 10MHz-6GHz and 24-40GHz range**: For this case, connect the antenna for sub 6GHz measurements to appropriate RF1/RF2 port and then other mmWave antenna to other the appropriate mmWave RF1/RF2 antenna port. Ensure that the RF cable connector (OP306) from the mmWave DC1/DC2 is connected into the RF1/RF2 port which is being used for mmWave measurements and not sub 6GHz measurements. See Figure 4.
2. **24-40GHz only**: When carrying out mmWave measurements only (24GHz to 40GHz) ensure that the DC1 and DC2 ports have RF cable connectors (OP306) connected to RF1 and RF2 ports and the mmWave antennas are connected to mmWave RF1 and mmWave RF2 ports.Connect the GPS antenna (or input) to the SMB connector.
3. If using a USB connection to a Windows laptop or tablet computer, connect the USB cable to both the SeeGull HB*flex* scanning receiver (COM port) and to a PC USB port.
4. If using an Ethernet connection, the HB*flex* must be connected to a network or the user's laptop. Connect an Ethernet cable to the LAN connector on the unit.
5. If using a Bluetooth connection to connect to an Android device connect the Bluetooth antenna to the SMA connector on the unit.
6. For Wi-Fi testing, insert the Wi-Fi Adapter (with extender) into the USB port.
7. Connect the power cable to the SeeGull HB*flex* scanning receiver (*Figure 5*) and to the car Power Socket or to the battery pack for in-building testing. After the power switch at the back of the unit is turned on, the SYS LED on the receiver blinks orange. After a short delay, the light turns green (*Figure 4*). If the light turns dark red (either solid or blinking), the unit has failed the power-up test. Please contact Customer Support.
8. If saving data to SD card, insert SD card into SD port. SD card use is limited to 32 Gigabytes.

9. If you are using a Windows computer: Install and start the collection software. The system is now ready for use.

10. If using an Android device: Refer to the Application User Manual. The system is now ready for use.

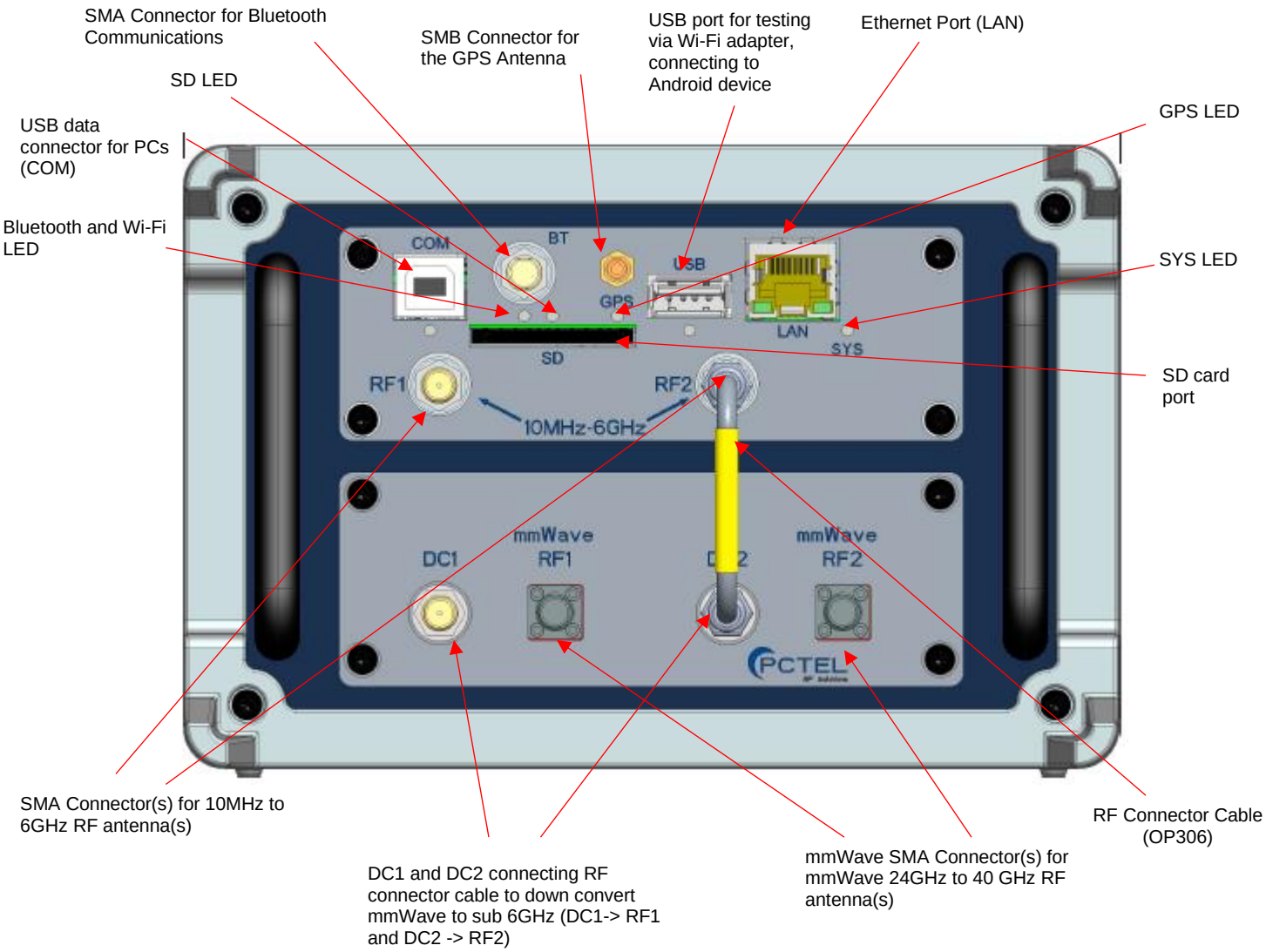

Figure 4 - SeeGull HBflex Scanning Receiver Front Display

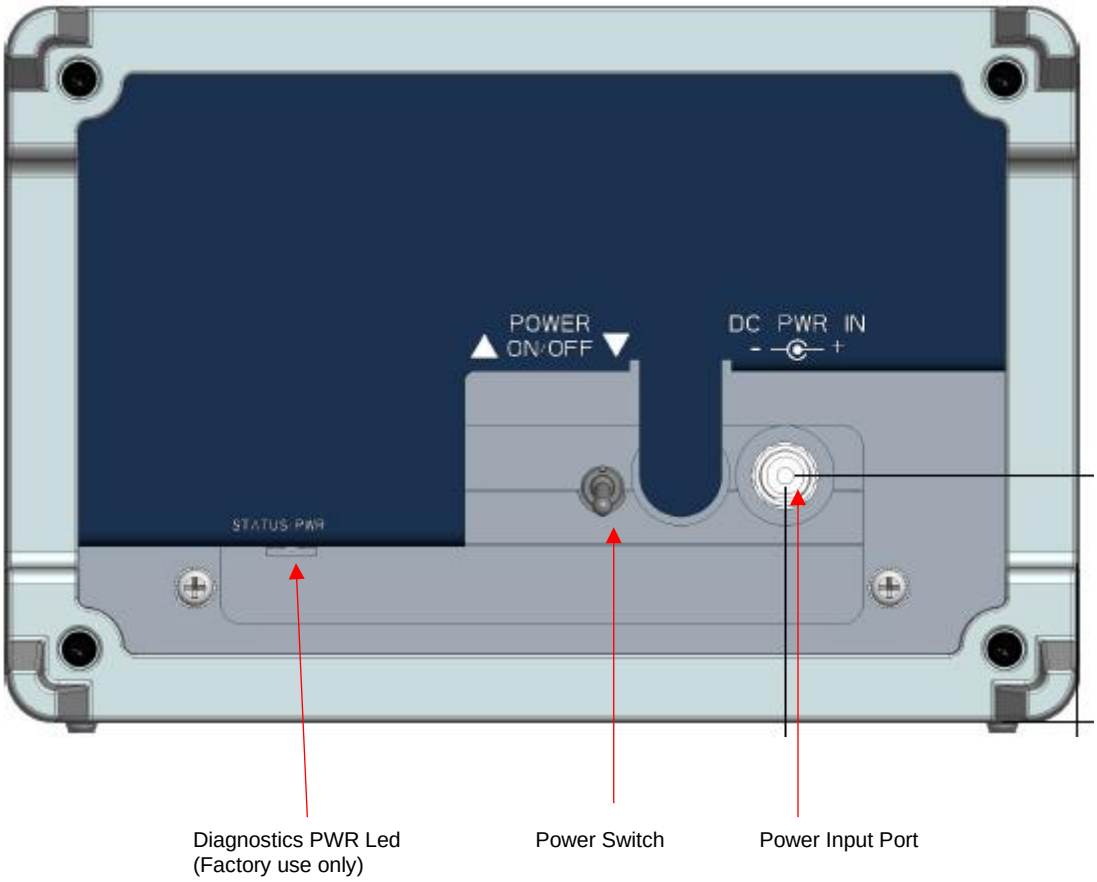

Figure 5 - SeeGull HBflex Scanning Receiver Rear Display

The table below illustrates the support for HBflex 5G NR measurements with single antenna (simultaneous mode) and dual antenna mode

Measurement type/Feature Support	64 Beams	40 ms SSB periodicity	Dynamic spectrum sharing	Multi-channel blind scan
Simultaneous 4G/FR1 and FR2 support	✓	**N/A**	✓	✓
Two port FR2 only measurements	✓	✓	**N/A**	✓

3.2. LEDs

The **GPS LED** colors indicate the following states:

- Green: GPS module locked to GPS signal
- Amber: GPS module unlocked Flashing Amber: Lost GPS lock within past 5 seconds
- Red: System Error
- Purple: GPS not trained (may take up to 30 minutes and will only occur after a software upgrade from early software versions)

The **System LED** turns solid green after the successful boot up of the system. It turns solid red or blinking green if the boot up is faulty. It turns blinking red if the firmware is terminated abnormally due to an internal error. It turns blinking amber if an internal communication error is detected.

The **SD card LED** is normally off. When the unit is writing to the SD card it turns solid green. If the SD card is full the LED color is red. If the card is ejected during a write operation and error is detected the LED color is orange.

If the HBflex has the Bluetooth option, then the **Bluetooth LED** is blue. The unit is in discovery mode during this period. Once another device connects to scanner application via Bluetooth, the LED turns off and the scanner is no longer discoverable. After this, the LED turns off and will blink during data transfer. When the other device disconnects, the LED turns solid blue again.

The **Com port LED** blinks green during data transfer.

4. Operation

This section discusses calibration, software upgrades, and integrating the SeeGull HBflex scanning receiver into the user's test system.

4.1. Calibration

SeeGull HB*flex* scanning receivers are calibrated at the factory. The calibration data is stored in the internal non-volatile memory for each 1 dB step for the whole input signal dynamic range. Recalibration is recommended every 2 years in order to maintain the specified accuracy levels. Please refer to the Calibration Notice in the Support section for more information. Re-calibration is available as an optional service from PCTEL Inc..

> **Note:** It is highly recommended to have the SeeGull HB*flex* scanning receiver recalibrated every 2 years.

4.2. Software Upgrades

SeeGull HB*flex* scanning receiver stores the application program in internal non-volatile memory, and accordingly, is capable of being upgraded via software. Upgrades may be needed to incorporate new features or bug fixes. Most software upgrades can be done remotely using PCTEL's SeeGull Assistant. Please note that some upgrades can only be performed at PCTEL's factory.

4.3. Controlling the Scanner and Acquiring Data

A unit is controlled, and the measurement data is received via the USB data cable for PC, or Bluetooth for Android tablet or UE. Control of the SeeGull HB*flex* scanning receiver is dependent upon the software in order to collect data coming from

measurements taken from the SeeGull HB*flex* scanning receiver.

4.4. Ethernet Instructions

The Ethernet feature enables TCP/IP communication between HB*flex* and a control PC (or laptop). PC DHCP connection is recommended for remote access to the scanner. The user also has the option of manually entering a Static IP Address.

Note: If the TCP socket connection is lost without a proper shutdown, the scanner must be power cycled before accepting a new connection.

Ethernet Using DHCP

Using this method, an IP address, Subnet mask, and Gateway are acquired on the PC automatically from a DHCP server. The scanner is then assigned a corresponding IP address with identical Subnet mask using SeeGull Assistant. Make sure the selected IP address for Scanner is not in use or duplicated.

Set Up PC:

1. Click Start menu, then click on Control Panel.

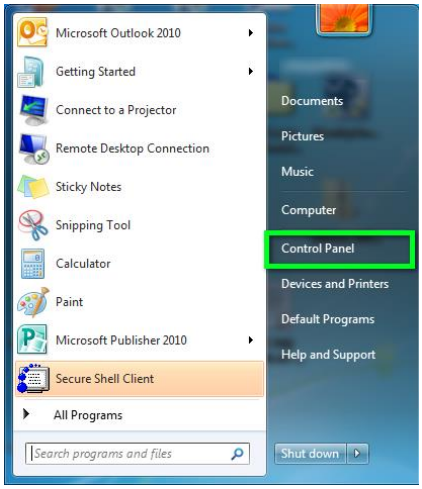

Figure 6 - Control Panel

2. Click Network and Internet.

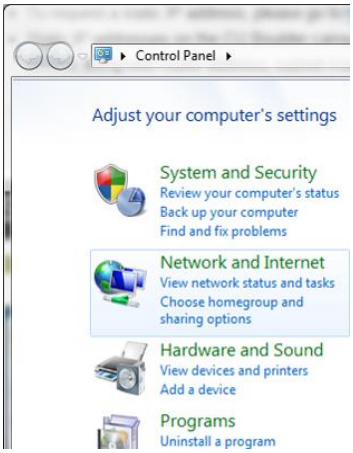

Figure 7 - Network and Internet

3. Click Network and Sharing Center.

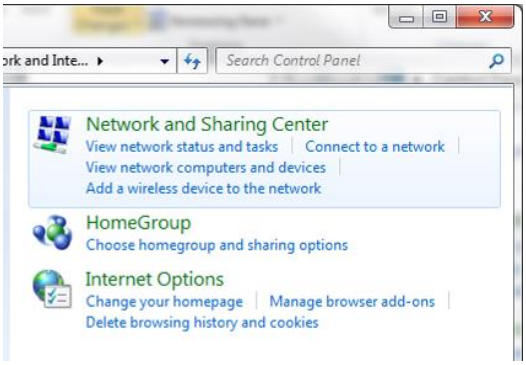

Figure 8 - Network and Sharing Center

4. Click Change adapter settings.

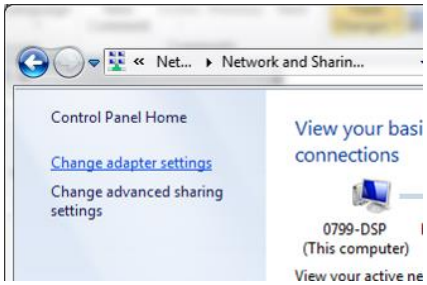

Figure 9 - Change Adapter Settings

5. Right-click Local Area Connection icon, then click Properties.

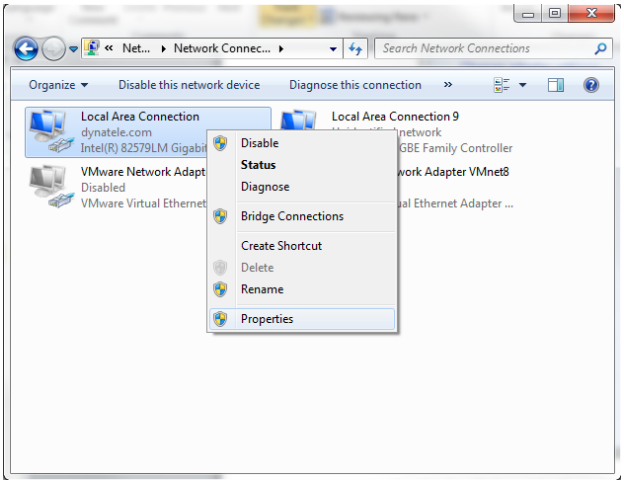

Figure 10 - Local Area Connection Properties

6. Double-click Internet Protocol Version 4 (TCP/IPv4).

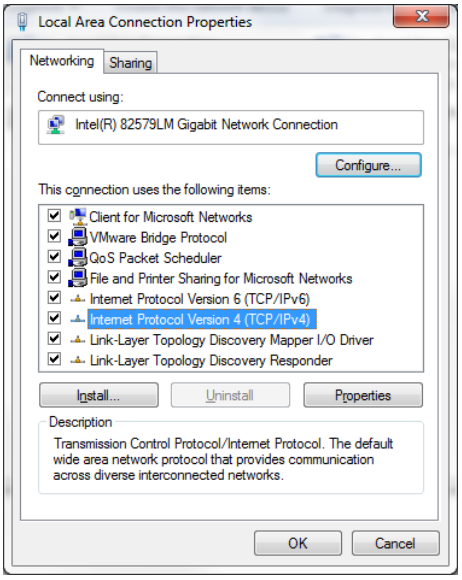

Figure 11 - Internet Protocol Version

7. Select Obtain an IP address automatically and click OK.

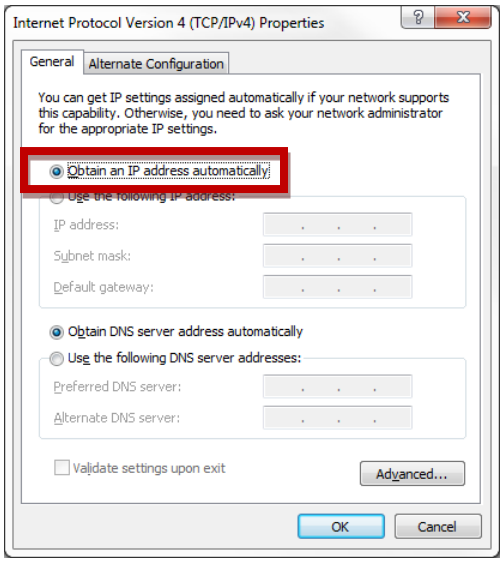

Figure 12 - Obtain IP Address Automatically

Set Up Scanner

After the IP address and Subnet mask are confirmed for the PC, the scanner must be assigned a corresponding IP address and identical Subnet mask using SeeGull Assistant. Please refer to the SeeGull Assistant User Guide for more information.

NOTE: The SeeGull Assistant application is available at PCTEL's website under the support page.

Note: Consult your IT department to confirm IP Address and Subnet mask for the PC and then to Assign corresponding address and identical Subnet mask to the scanner.

The IP address network identification must be identical to the connected PC's IP address. The IP address host cannot be identical to the connected PC.

The subnet mask number must be identical for both the scanner and connected PC.

Example:

PC:
IP Address: XXX.YYY.ZZZ.**2**
Subnet Mask: 255.255.255.0

Scanner:
IP Address: XXX.YYY.ZZZ.**100**
Subnet Mask: 255.255.255.0

IP Address Note:

XXX.YYY.ZZZ is the network identification and is identical for the PC and scanner.

The bold numbers are the host identification and cannot be identical.

Default Network Configuration:

The HB*flex* comes with the following default network configuration:

DHCP: Disabled
IP Address: 192.168.2.100
Subnet mask: 255.255.255.0
Default Gateway: None

Ethernet Using Static IP Address:
Using this method, an IP address and Subnet mask are entered in to the PC manually using numbers assigned by your IT Department. A corresponding IP address and identical Subnet mask are then assigned to the scanner using SeeGull Assistant.

Set Up PC

Repeat steps 1-6.

8. Select Use the following IP address.

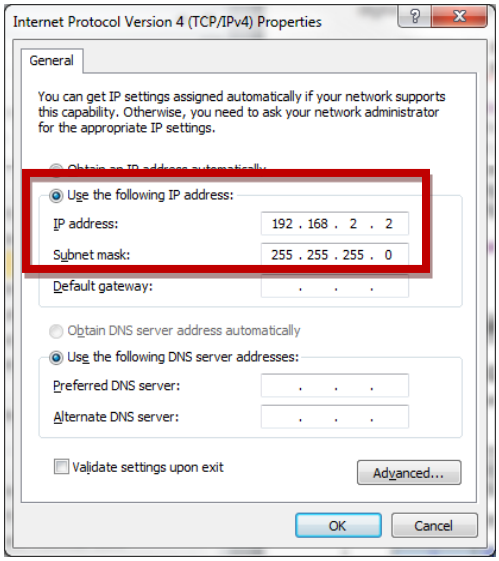

Figure 13 - IP Address and Subnet Mask

9. The default network configuration of HB*flex* may be used for the PC's IP address and Subnet mask. It is recommended to confirm with your IT department. Enter numbers and press OK.

Set Up Scanner:

After the IP address and Subnet mask are confirmed for the PC, the scanner must be assigned a corresponding IP address and identical Subnet mask using SeeGull Assistant. Please refer to the SeeGull Assistant User Guide for more information.

Note: Consult Your IT Department to Assign IP Address and Subnet mask for the Scanner.

The IP address network identification must be identical to the connected PC's IP address. The IP address host cannot be identical to the connected PC.

The subnet mask number must be identical for both the scanner and connected PC.

Example:

PC:
IP Address: 192.168.2.**2**
Subnet Mask: 255.255.255.0

Scanner:
IP Address: 192.168.2.**100**
Subnet Mask: 255.255.255.0

IP Address Note:

192.168.2 is the network identification and are identical for the PC and scanner.

The bold numbers are the host identification and cannot be identical.

4.5. CDMA/EV-DO Holdover Operation

When a GPS signal is present, CDMA and EV-DO technologies use the GPS data for timing information to decode the signals. With the Holdover option, the SeeGull HB*flex* will continue to accurately decode the pilots and cell IDs for a period of 4 hours in the absence of any GPS signal. To get the best performance of the Holdover option during indoor measurements, we recommend that the GPS be locked for at least 30 minutes before using the SeeGull HB*flex* scanning receiver in an unlocked / holdover mode (with power maintained).

5. RF Antenna Information

This section discusses antennas that are used with the SeeGull HBflex scanning receiver system.

5.1. Antenna Verification

Verify that all the necessary antennas are included in the shipment and that each is marked. Each antenna comes in a bag labeled with the antenna's model number and its corresponding frequency range, while the antenna itself is labeled by the frequency range.

5.2. Cellular Antennas

PCTEL offers several antennas that are industry superior antennas supporting low dB loss cable, extended temperature ranges and a frequency range wide enough to cover PCTEL's SeeGull HB*flex* scanning receiver.

Figure 14 - OP278H

The OP278H supports a wide frequency range from 698 MHz to 3.8 GHz. The antenna gain is shown in *Figure 15*. The antenna comes standard with a magnetic mounting base and a male SMA[2] connector for the RF, as shown in *Figure 14*.

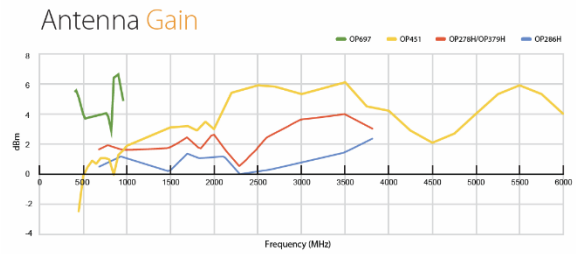

Figure 15 - OP379H, OP697, OP451 and OP286H Gain

The OP379H, as shown in *Figure 16*, has a built-in High Performance GPS base and a high performance multi-mode antenna. It supports a wide frequency range from 698 MHz to 3.0 GHz. It provides a gain[3] of 3 dBi across the entire spectrum. The antenna comes standard with a male SMA[2] connector for the RF and an SMB (push-on/pull-off) adapter for the GPS.

Figure 16 - OP379H

PCTEL's OP697 wide spectrum multi-band antenna (Figure 17) supports multi-band radio technology to provide interoperability among emergency management and response personnel, regardless of the frequency band used. It provides outstanding coverage of VHF and UHF bands, including 700 MHz public safety, 800 MHz and 900 MHz frequencies in a ready-to-install, no tune design. Its multi-band elements are housed in a rugged, impact-resistant housing for maximum durability and its base is designed to interface with standard NMO mobile mounts to facilitate existing installation upgrades on public safety vehicles.

Figure 17 - OP697 wide spectrum multi-band antenna

For wide range measurements PCTEL provides OP451 omni directional antenna (Figure 18). This antenna has a range from 450MHz – 6GHz and it's a multi band mag mount high performance antenna.

Figure 18 – OP451 Wide spectrum multi-band antenna

For mmWave measurements the SAGE omnidirectional antenna is recommended with the mounting bracket with 1 m pigtail cable connected to it. The part number for the kit is OP307. The kit consists of 1 mmWave antenna, bracket, wave-guide connector and 1 meter pigtail cable

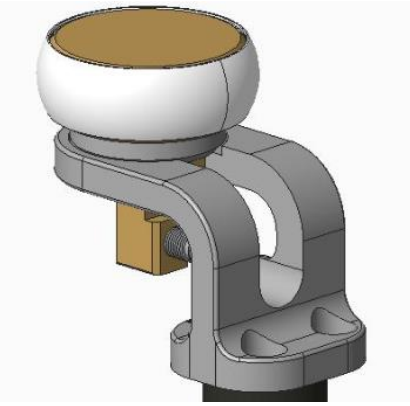

Figure 19 - OP307 mmWave Antenna kit

Indoor RF Antenna Information

PCTEL offers wideband rubber duck style antennas for indoor use. There are two models depending on the frequency required.

- OP691: Indoor Antenna, 600 MHz - 6 GHz

Figure 20 - OP034H

- OP452: Indoor Antenna, Public Safety VHF/UHF/ 700 MHz/ 800 MHz

5.3. GPS Antenna Information

PCTEL offers a single standalone GPS antenna, the OP034H. The OP034H is a High Gain GPS standalone antenna which comes standard with a magnetic mounting base and a SMB connector. See *Figure 20*.

5.4. Wi-Fi Wireless Adapter

For Wi-Fi testing, PCTEL offers wireless adapters for purchase; there are others we have tested and support (see the table below). The wireless adapter (with an extension adapter) is connected to the USB port on the front panel of the HB*flex*.

Wi-Fi Device	**802.11 Version**	**Security Mode**	**PCTEL OP #**
Proxim ORiNOCO USB-9100 (US, WD)	a/b/g/n/ac	WEP, WPA Personal, WPA2 Personal and Open Network	OP614-US OP614-WD
Ubiquiti Networks SR71-USB	a/b/g/n	WEP and Open Network	N/A
D-Link DWA-182 Rev C1	a/b/g/n/ac	WEP, WPA Personal, WPA2 Personal and Open Network	N/A
Planex GW-900D	a/b/g/n/ac	WEP, WPA Personal, WPA2 Personal and Open Network	N/A
ASUS USB-AC56	a/b/g/n/ac	64-bit WEP, 128-bit WEP, WPA2-PSK, WPA-PSK, WPA-Enterprise , WPA2-Enterprise , WPS support	N/A

Figure 21 – Supported Wi-Fi Adapters

6. **Walk Test Kit** Information (to be updated)

This section discusses walk test options that can be used with the SeeGull scanning receivers.

Deployment of wireless data services is resulting in further increases of in-building traffic and coverage requirements. The design, testing, and optimization of indoor coverage are now an increasingly important aspect of wireless engineering.

The PCTEL SeeHawk Walk Test Kit comprises a complete set of accessories that enable the indoor use of the PCTEL SeeGull HB*flex* scanning receiver. The Walk Test Kit provides a cost-effective solution for evaluating existing in-building coverage and for planning, deploying, and testing indoor coverage systems.

The PCTEL's Walk Test Kit provides the right solution for "Walk Testing" that enables wireless engineers to address the three key steps of in-building coverage assessment and planning:

- Evaluating In-building Coverage from Outside Networks
- Planning New In-Building Networks
- Coverage Validation for New or Existing In-Building Networks

6.1. Walk Test Kits

PCTEL offers a Walk Test Kit for the SeeGull HB*flex* scanning receiver, the IND-CBL-ANT-HB Walk Test Kit as shown in *Figure 22*. It delivers a convenient way to carry and power the SeeGull HB*flex* scanning receiver for in-building measurements. The IND-CBL-ANT-HB Walk Test Kit consists of:

- OP204 - USB data Cable
- OP304-BP - HBflex Backpack package includes backpack and telescopic antenna mounts
- OP417- MXflex Battery pack
- OP691 Indoor Antennas (x2)
- OP307 - Omni Antenna for mmWave (x2): includes Antenna with bracket and 1m pigtail cable

Figure 22 - IND-CBL-ANT-HB kit

6.2. Bluetooth Communications RF Antenna Information

The use of Bluetooth Communications requires an antenna for operation which comes standard with the HB*flex*.

7. Troubleshooting

This section describes a few suggestions for several common problems that might occur. These suggestions are user serviceable.

7.1. No Power: Receiver LEDs not illuminated

If the SYS LED located on the face of the scanning receiver is not illuminated, please check the power connection first, then the fuse, which is in the Power Plug end of the power cord.

> **Note:** Check the fuse in the Power Plug first.

The fuse can be "blown" by a surge in the portable or mobile battery system. A temporarily shorted wire can also cause other problems.

If the fuse is not operating normally, it will open up, thereby disconnecting the input power from the SeeGull HB*flex* scanning receiver. The fuse is the first line of defense should any short circuit, large spike, or other problems occur within the power wiring circuitry. When the fuse "blows", there will be no power to the receiver.

7.2. Changing the Fuse in the Power Plug

If it is necessary to change the fuse in the power plug, remove the Power Plug end from the power source. See *Figure 23* for an illustration of the power plug.

Loosen the fuse-holding finger nut by turning it counter-clockwise until the plug comes apart. The fuse is inside the power plug housing and can be removed.

Figure 23 - SeeGull HBflex Scanning Receiver Power Plug

Replace the fuse with an identical 4-amp fuse.

> **Note:** Only use a 4-amp fuse (HB*flex*); any other fuse value may cause severe problems with the unit and void the warranty. In order not to violate the safety approval of the receiver, the fuse must be safety approved.

Insert the new fuse in the housing and re-assemble the plug by turning the knurled finger nut in a clockwise direction. Tighten this nut as tight as you can with your fingers.

> **Note:** Do not use tools to tighten.

7.3. Received Signal Strength Appears Low

If the received signal strength appears to be lower than expected, it is likely that (1) an incorrect antenna is being used, (2) an antenna is not properly connected, (3) the antenna is connected to the wrong RF port, the application software is not mapping the scan to the correct port/antenna, or (3) the antenna or antenna cable is damaged.

Check that the antenna is properly connected to the scanning receiver, and that the antenna is of the correct frequency.

8. Support

This section provides support information, including PCTEL contacts, warranty information, calibration notice, and technical specifications.

8.1. Contact Information

Phone Numbers	
Departments	**Contact Information**
CUSTOMER SUPPORT / RMA REQUESTS	+1-240-460-8833
QUALITY MANAGER	+1-301-444-2045

Table 1: Phone Numbers

Email Addresses	
Departments	**Contact Information**
PRODUCT FEEDBACK	PRODUCTFEEDBACK@PCTEL.COM
CUSTOMER SUPPORT / RMA REQUESTS	SUPPORT.RFSG@PCTEL.COM
QUALITY MANAGER	QUALITY.RFSG@PCTEL.COM

Table 2: Email Addresses

8.2. Warranty Information

WARRANTY

PCTEL warrants that the Product will be free from defects in material and workmanship for a period of two (2) years from the date of shipment under normal use and operation. PCTEL's sole and exclusive obligation under the foregoing warranty shall be, at its option, to repair or replace any defective Product, which fails during the warranty period, provided that PCTEL receives written notice of the defect during the warranty period. The expense of removal and reinstallation of any item(s) of equipment is not included in this warranty. This warranty shall only apply to the Product purchased or licensed and shall not apply to any other equipment and its removal and reinstallation. THE FOREGOING WARRANTY IS EXCLUSIVE AND IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING THE IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. Repair or replacement in the manner provided above shall be the sole and exclusive remedy of Buyer for breach of warranty and shall constitute fulfillment of all liabilities of PCTEL with respect to the quality and performance of the Products. PCTEL shall have no obligation to make repairs or replacement necessitated by catastrophe, fault, negligence, misuse, abuse or accident of Buyer or other users. IN NO EVENT SHALL PCTEL BE LIABLE FOR ANY SPECIAL, INCIDENTAL OR CONSEQUENTIAL DAMAGES TO BUYER OR ANY THIRD PARTY ARISING OUT OF THESE TERMS AND CONDITIONS OR ANY DEFECTIVE PRODUCT WHETHER THE DEFECT IS WARRANTED AGAINST OR NOT, WHETHER THE CLAIM IS BASED UPON CONTRACT, TORT, STRICT LIABILITY OR OTHERWISE, NOR SHALL PCTEL BE LIABLE TO BUYER FOR ANY AMOUNT EXCEEDING THE PURCHASE PRICE OF THE PRODUCT.

Warranty Procedures

See Return Material Authorization (RMA) Process further below.

8.3. Calibration Notice

Note: It is highly recommended to have the SeeGull HB*flex* scanning receiver recalibrated every 2 years.

SeeGull HB*flex* scanning receiver is calibrated at the factory. The calibration data is stored in the internal non-volatile memory in 1 dB steps for the whole input signal dynamic range. Recalibration is recommended every 2 years in order to maintain the specified accuracy levels. Re-calibration is available as an optional service from PCTEL.

The SeeGull HB*flex* scanning receiver is calibrated for several sources of variations including amplitude levels, ambient temperature, input frequency, and internal noise levels for narrow and wide channel bandwidths. The calibration parameters are stored as single values or arrays in the scanning receivers' non-volatile memory. Automated test and calibration stations use proprietary software which performs the process with no or minimum human intervention. The calibration process is followed by a fully automated production test. The test results are stored in a central quality database and they are extracted and used for periodic quality audits.

Every unit that passes the calibration and test process successfully receives a Certificate of Calibration. This Certificate is shipped back with the unit.

The complexity of the calibration process precludes field calibration. It is highly recommended that PCTEL's scanning receivers be returned to the factory annually to maintain the units' exceptional measurement capability.

8.4. Return Material Authorization Procedure for the SeeGull HB*flex* scanning receiver

NOTICE: There are no user serviceable parts inside the SeeGull HB*flex* receiver. *Any tampering with the components within the unit will void any applicable warranties*.

All repairs must be performed by PCTEL in accordance to the procedure outlined below:

1. Complete the RMA form on the website at:

   http://pctel.com/rma

2. A response including an RMA number and in-warranty or out-of-warranty information will be provided within 24 hours, or the next working day.

3. Please ship the unit to:

   PCTEL, Inc.
   Attn: RMA Coordinator
   22600 Gateway Center Dr Suite 100
   Clarksburg, MD 20871
   +1 (240) 460-8833

4. Reference PCTEL's RMA number on all shipping documentation.

Note: Units shipped without an RMA number may be returned to the customer without the unit being repaired.

9. Appendix A: SeeGull HB*flex* Specification

5G New Radio	Measurement Modes		NR TopN Signal : Synchronization channels (P-SS/S-SS) & PBCH, SSB
	Data Modes		PCI, PSS_RP [dBm] ,SSS_RP [dBm], PSS_RQ [dB] ,SSS_RQ [dB], PSS_CINR, SSS_CINR, SS_CINR [dB], RSPBCH_RP [dBm], RSPBCH_RQ [dB].RSPBCH_CINR [dB], SSB_RSSI, SSB_RP [dBm], SSB_RQ [dB], SSB_CINR [dB], SSB_idx, MIB , Time Offset
	Channel Bandwidths		15/30/120/240 KHz
	Max. Number of Channels		12 FR1 and 8 FR2
	Max. number of beams/channel		8 (sub-6 GHz), 64 (mmWave)
	Measurement Rates:		30/sec (sub-6 GHz), 10/sec (mmWave, 2 RF ports), 5/sec (mmWave, 1 RF port)
	Dynamic Range (CINR)	PSS/SSS	-10 to +33 dB(sub 6GHz); -10 to +23dB (mmWave)
		PBCH DMRS CINR	-8 to +40 dB
	Min. Detection Level:	RP	-132 dBm (SCS @ 15 KHz)
	Relative Accuracy (CINR):	PSS/SSS CINR	±2 dB

FD-LTE and TD-LTE	Measurement Modes		Top N Synchronization Channel Reference Signal, (P-SCH/S-SCH), and Resource Block (Wideband, Subband); Layer 3 Reporting; Top N eMBMS Multicast Reference Signal; Unicast Synchronization Channel Reference Signal and (P-SCH/S-SCH)
	Data Modes		RP, RQ, CINR, Cyclic Prefix, Time Offsets, Delay Spread; MIMO: Condition Number, ECQI, EPUT eMBMS: Area TD, Cluster ID, Frame Configuration
	Channel Bandwidths		1.4 / 3 / 5 / 10 / 15 / 20 MHz
	Max. Number of Channels		24 (16 for eMBMS)
	Receive Modes		SISO; MIMO (2x2)
	Transmit Antenna Configurations		1, 2, 4 (with path measurement)
	Measurement Rates:	Sync Channel RS	LTE FDD: 50/sec; TD-LTE: 25/sec
		Multicast RS	eMBMS: 2/sec
	Dynamic Range (CINR) @10 /15/20 MHz	RS	-26 to +40 dB
		P-SCH/S -SCH	-10 to +18 dB
		Multicast RS	-9 to +30 dB
	Min. Detection Level:	RSRP	-140 dBm (RSRP @ 15 MHz)
	Relative Accuracy (CINR):	P-SCH/S-SCH & RS	±1 dB

LTE-LAA	Measurement Modes		Quick Top N Reference Signal and Sync Signal (P-SCH/S-SCH)
	Data Modes		RS_RP, RS_RQ, RS_CINR, RS_TimeOffset, PSCH_RP, PSCH_RQ, PSCH_CINR, SSCH_RP, SSCH_RQ, SSCH_CINR
	Channel Bandwidths		20 MHz
	Max. Number of Channels		16
	Receive Modes		MISO
	Transmit Antenna Configurations		1, 2 (with path measurement)
	Measurement Rates:	Sync Channel RS	1 Sig 160ms, 4 Sig 182ms, 8 Sig 205ms, 16 Sig 249ms
	Dynamic Range (CINR) @20 MHz	RS P-SCH/S -SCH	-11 to +25 dB -10 to +18 dB
	Min. Detection Level:	RSRP	-130 dBm (RSRP @ 20 MHz)
	Relative Accuracy (CINR):	RS	RS ±2 dB (-10dB ~ +20dB)

NB-IoT	Measurement Modes		Top N NRS (Narrowband Reference Signal), NPSS (Narrowband Primary Synchronization Signal), NSSS (Narrowband Secondary Synchronization Signal) and Layer 3 Reporting
	Data Modes		NRS - RP, RQ, RSSI, CINR, Timeoffset. NPSS - RP, RQ, RSSI, CINR. NSSS - RP, RQ, RSSI, CINR, Timeoffset
	Operation Mode		In-Band, Guard-band, Standalone
	Channel Bandwidths		180 kHz
	Measurement Rates		190 ms
	Dynamic Range	NRS_CINR	-10 to + 40 dB
	Min. Detection Level	NRS_RP	-138 dBm
	Relative Accuracy	NRS_CINR	±2
	Maximum Number of PCIs		16

WCDMA	Measurement Modes		Top N Pilot, Layer 3 Reporting
	Data Modes		Io, Ec/Io, Aggregate Ec/Io, SIR, Rake Finger Count, Time Offset, Delay Spread
	Channel Bandwidths		200 kHz / 3.84 MHz
	Max. Number of Channels		24
	Measurement Rate		100/sec (High Speed Mode); 50/sec (High Dynamic Range Mode)
	Top N CPICH Dynamic Range	EcIo	-26 dB
	Min. Detection Level		-120 dBm (High Dynamic Range Mode)
	Relative Accuracy		±1 dB

GSM	Measurement Modes	Color Code, Layer 3 Reporting
	Data Modes	BSIC, C/I, RSSI
	Channel Bandwidths	30 kHz / 200 kHz
	Measurement Rate	Up to 200 BSIC Decodes/sec
	Dynamic Range	+2 dB C/I
	Min. BSIC Detection Level	-110 dBm
	Relative Accuracy	±1 dB

CDMA/EV-DO	Measurement Modes	Top N PN
	Data Modes	Ec, Io, Ec/Io, Aggregate Ec/Io, Pilot Delay, Delay Spread
	Channel Bandwidths	30 kHz / 1.25 MHz
	Max. Number of Channels	24
	Measurement Rate	CDMA: 25/sec; EV-DO: 18/sec
	Top N PN Dynamic Range Ec/Io	CDMA: - 28 dB***; EV-DO: -18.5 dBm
	Min. PN Det ec tion Level	CDMA: -130 dBm; EV-DO: -120 dBm
	Relative Accuracy	±1 dB

Wi-Fi	Measurement Modes	ORiNOCO® USB-9100 (adapter is country specific)
	Radio Configuration	802.11a/b/g/n, 802.11a/b/g/n/ac
	Data Modes	Signal Strength, Noise Level, SNR, Channel Number, Channel Bandwidth, BSSID, Device Name, SSID, Security Protocol, 802.11 Media, Beacon Interval, Channel Utilization, Throughput
	Frequency Range	2.4 – 2.483 GHz; 5.15 – 5.85 GHz (subject to country regulations)
	Measurement Rates	9/sec (Typical); 5/sec (Typical) for 802.11ac

P25	Measurement Modes	Decode, RSSI
	Data Modes	SINR, RSSI, BER, Frame BER, Network ID, Auto Classification of Phase and Modulation Type
	Channel Bandwidths	12.5 Khz
	Measurement Rate	14 Decodes/sec (maximum) 7 Decodes/sec (typical) 100 RSSI/sec
	Dynamic Range	-1 dB minimum detection
	Relative accuracy SINR Phase 1 C4FM and Phase 2 RSSI HDQPSK	±1 dB over 8 to 25 dB; ±2 dB over 3 to 8 dB, 25 to 30 dB ±1 dB over -118 to -10 dBm
	Adjacent channel rejection	49 dB

DMR	Measurement Modes		Decode, RSSI
	Data Modes		SINR, RSSI, BER, Frame BER,
	Channel Bandwidths		12.5 Khz
	Measurement Rate		14 Decodes/sec (maximum) 7 Decodes/sec (typical) 100 RSSI/sec
	Dynamic Range		-1 dB minimum detection
	Accuracy	SINR RSSI	±1 dB over 6 to 40 dB; ±2 dB over 3 to 6 dB ±1 dB over -118 to -10 dBm
	Adjacent channel rejection		49 dB

TETRA	Measurement Modes		Decode, RSSI
	Data Modes		SINR, RSSI, Frame BER, Color Code, MCC, MNC
	Channel Bandwidths		25 Khz
	Measurement Rate		6.5 Decodes/sec (maximum) 3.5 Decodes/sec (typical) 100 RSSI/sec
	Dynamic Range		-2 dB minimum detection
	Accuracy	SINR RSSI	±2 dB over +8 to +20 dB; ±3 dB over +4 to +8 dB ±1 dB over -118 to -10 dBm
	Adjacent channel rejection		20 dB

Power Measurements	**Measurement Modes**		
	RSSI RSSI RSSI	LTE, 5G NR WCDMA, GSM, NB-IoT CDMA, EV-DO	11,050 ch/sec 4,250 ch/sec 8,500 ch/sec
	Dynamic Range		-120 to -20 dBm @ 30 kHz
	Absolut e Accuracy		±1 dB (across Basic RF Input Power Range)
	ENHANCED POWER SCAN (EPS™) MEASUREMENTS		
	Channel Bandwidths		5 kHz to 20 MHz in 2.5 kHz Increments
	Measurement Rate		1,000 MHz/sec @ 5 MHz (Typical)
	Absolute Accuracy		±1 dB (across Basic RF Input Power Range)
	SPECTRUM ANALYSIS MEASUREMENTS		
	Measurement Range		> 90 dB
	Measurement Rate (Single Sweep)		>270 MHz/sec
	Accuracy		±1 dB (across Basic RF Input Power Range)
	LTE POWER ANALYSIS MEASUREMENTS (Available for TD-LTE Only)		
	Channel Bandwidths		1.4 / 3 / 5 / 10 / 15 / 20 MHz
	Measurement Rate		20 msec @ 5 MHz
	Accuracy		±1 dB (across Basic RF Input Power Range)

RF Characteristics	Measurement Modes		Sub GHz10 MHz – 6 GHz mmWave : N257 (26.5-29.5GHz), N258 (24.25-27.5GHz), N260 (37-40GHz)
	Internally Generated Spurious Response		-105 dBm (Typical)
	Conducted Local Oscillator		-55 dBm (Typical).
	RF Operating Range	In-Band	-20 dBm Max.
	Desensitization	Adjacent Channel	>50 dB (20 MHz RBW)
	Safe RF Input Range		≤ +0 dBm
	Frequency Accuracy		±0.05 ppm (GPS Locked); ± 0.1 ppm (GPS Unlocked)
	Intermodulation-free Dynamic Range		2 tone @ -30 dBm, 40GHz, -50 dBc (Typical),

GPS	Measurement Modes	56 Channel Internal Receiver
	Vertical Position Accuracy	±2.5 meters
	Horizontal Accuracy (Altitude)	2x Vertical Position Accuracy
	Acquisition Time	Cold Start: <30 sec; Hot Start: <2 sec
	Sensitivity (Tracking)	> -150 dBm

Physical	Maximum Power (+9 to +17 VDC)	25W MAX
	Size	10.10” D x 6.50” W x 4.40” H (255.3 mm D x 165.1mm W x111.5mmH)
	Weight	7.26 lbs (3.3kg)
	Temperature Range	Operating: 0 °C to +50 °C; Storage: - 30 °C to +80°C
	Host Data Communications Interface	USB 2.0, High Speed; Bluetooth
	Data Storage	SD (32 GB)
	Antenna Ports	RF(sub 6GHz, Bluetooth) : SMA Female (50 Ω); GPS: Male (50 Ω) SMB, RF (mmWave): 2.92mm Female
	Safety (CE)	IEC 62368-1
	EMC	EN 301 489 -1
	Shock and Vibration	MIL-STD-810G, SAE J1455
	RoHS	Compliant (6/6)

10. Appendix B: NB-IoT Measurements

10.1. NB-IoT: Introduction

PCTEL is introducing a new measurement to quantify the KPI metrics of the NB-IoT network. This application note will discuss the new features of this measurement.

10.2. NB-IoT Physical Layer

The NB-IoT physical channels can be located as a stand-alone network or they could be part of a standard LTE network in Guard-band and In-Band spectrum. Below is a representation of these signals.

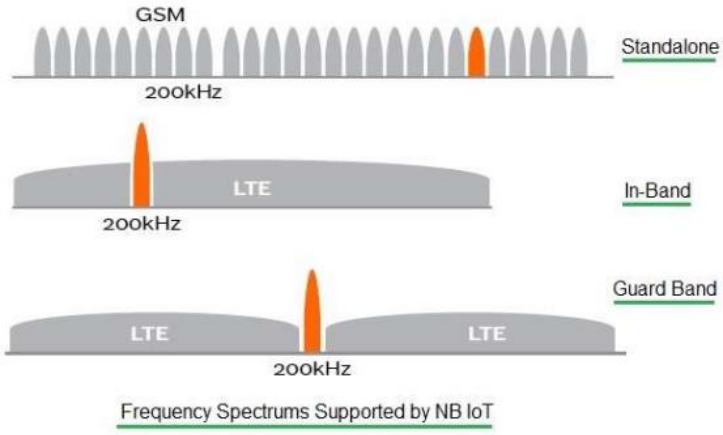

Figure 24 - NB-IoT

10.3. Top N NB-IoT Signal Measurement

Below is a list of key features of the new measurement.

- The NB-IoT carrier follows the 3GPP FD-LTE channel raster. It has a channel index value of 100 kHz. To align the NB-IoT signal with standard LTE the 3GPP standard introduces a *frequency offset* value from the channel raster. The values of the *offset* could be 0, +/-2.5 kHz and +/- 7.5 kHz. The scanner will calculate this value as explained below.
- The user must select the 'operation mode' to determine whether the network is stand-alone, Guard-band or In-Band.
- When the user selects the 'stand-alone' they must provide the *channel* or *frequency* of the NB-IoT network. In this mode the scanner calculates the *frequency offset* as zero.
- When the user selects the 'In-Band' operation mode the scanner calculates the frequency offset from the channel raster as shown in the second column of Table 1.

- When the user selects the 'Guard-band' mode the scanner needs additional information to calculate the frequency offset since there is a +/-7.5 kHz ambiguity as shown in column 3 of Table 2. In this mode the user has three choices for 'frequency offset':
  - '0': The scanner automatically calculates the offset based on the table. In case of +/- 7.5 kHz ambiguity the scanner defaults to -7.5 kHz. In that case other modes should be used. See below.
  - '1': The scanner inserts +7.5 kHz offset for the channel raster.
  - '2': The scanner inserts -7.5 kHz offset for the channel raster.

- The scanner provides RP, RQ, CINR, Time offset values for primary and secondary synchronization channels as well as reference signal.
- In order to monitor the standard LTE network, the user can initiate a separate eTOPN LTE measurement.

LTE BW	Frequency Offset to 100kHz Raster	In-Band RB	In-Band EARFCN difference to Regular LTE
1.4MHz	-2.5kHz	N/A	N/A
	+2.5kHz	N/A	N/A
3MHz	+7.5kHz	12	9
	-7.5kHz	2	-9
5MHz	+7.5kHz	17, 22	9, 18
	-7.5kHz	2, 7	-18, -9
10MHz	-2.5kHz	30, 35, 40, 45	10, 19, 28, 37
	+2.5kHz	4, 9, 14, 19	-37, -28, -19, -10
15MHz	+7.5kHz	42, 47, 52, 57, 62, 67, 72	9, 18, 27, 36, 45, 54, 63
	-7.5kHz	2, 7, 12, 17, 22, 27, 32	-63, -54, -45, -36, -27, -18, -9
20MHz	-2.5kHz	55, 60, 65, 70, 75, 80, 85, 90, 95	10, 19, 28, 37, 46, 55, 64, 73, 82
	+2.5kHz	4, 9, 14, 19, 24, 29, 34, 39, 44,	-82, -73, -64, -55, -46, -37, -28, -19, -10

Table 3: NB-IoT In Band

LTE BW	Guard-Band EARFCN difference to Regular LTE	Frequency Offset to 100kHz Raster (kHz)
1.4MHz	N/A	N/A
	N/A	N/A
3MHz	N/A	N/A
	N/A	N/A
5MHz	24	+/- 7.5
	-24	-/+ 7.5
10MHz	46, 47, 48, 49	-2.5, 2.5, +/- 7.5, -2.5
	-46, -47, -48, -49	2.5, -2.5, -/+ 7.5, 2.5
15MHz	69, 70, 71, 72, 73, 74	+/- 7.5, -2.5, 2.5, +/- 7.5, -2.5, 2.5
	-69, -70, -71, -72, -73, -74	-/+ 7.5, 2.5, -2.5, -/+ 7.5, 2.5, -2.5
20MHz	91, 92, 93, 94, 95, 96, 97, 98, 99	-2.5, 2.5, +/- 7.5, -2.5, 2.5, +/- 7.5, -2.5, 2.5, +/- 7.5
	-91, -92, -93, -94, -95, -96, -97, -98, -99	2.5, -2.5, -/+ 7.5, 2.5, -2.5, -/+ 7.5, 2.5, -2.5, -/+ 7.5

Table 4: NB-IoT Guard Band

Trademarks

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