



RCOM User Manual

Ocado Operating Ltd.
Titan Court
3 Bishops Square
Hatfield Business Park
Hatfield
Hertfordshire
AL10 9NE

Cambridge Consultants Ltd
Science Park
Milton Road
Cambridge
England CB4 0DW

Tel +44 (0)1223 420024
Fax +44 (0)1223 423373
Registered No: 1036298 England
info@CambridgeConsultants.com
www.CambridgeConsultants.com

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Subject: RCOM User Manual

Distribution

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Cambridge Consultants Ltd – Project Team

Project Reviewer	Tim Ensor
Project Manager	Tony Price
Technical Contributors	Fraser Edwards, Nick Marley, Mike Rudin, Dave Bowkis
Project Secretary	Tracy Smith

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Preventing Electrostatic Discharge Damage

Electrostatic discharge (ESD) damage can occur when electronic components are improperly handled and can result in complete or intermittent equipment failures. To protect against ESD damage use a preventive antistatic strap during handling of the BS and the BCM.

The following are guidelines for preventing ESD damage:

- Always use an ESD wrist or ankle strap and ensure that it makes good skin contact.
- Specifically avoid direct hand contact with the centre conductor(s) of any of the connectors.
- Avoid contact between external connectors and clothing. The wrist or ankle strap only protects components from ESD voltages on the body; ESD voltages on clothing can still cause damage.
- Never attempt to remove the printed circuit board from the chassis.

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1 Introduction to RCOM

1.1 What is RCOM?

The Rainbow Communications System (RCOM) is a point to multipoint short range, radio communications system which operates in the frequency band 5470MHz to 5725MHz.

The overall system comprises both wired and wireless communications.

The wireless part comprised two units, the Base Station (BS) and the Bot Control Module (BCM) which form the two radio parts of the point to multipoint system. One BS can be connected to many BCMs at any one time.

The wired parts comprise of 1) An Ethernet LAN that connects the controlling system to the Base Station; when multiple Base Stations are used this is done via a Base Station Controller (BSC) and 2) the connection from the BCM to a PC on the device being controlled, again over Ethernet. See Figure 1.

1.2 Purpose

The purpose of the radio system is to provide a low data rate, bi-directional, wireless connection to a large number of low speed factory machineries which transport goods, in a controlled manner, around the facility. These machineries are unmanned and the purpose of the wireless connection is to issue commands to the machineries and relay status information back, from each of the machineries, to a central point in the factory

1.3 General Description of Operation

The radio system is arranged as a number of fixed BSs each of which is operating in a star formation connecting to a large number of BCMs. The BCMs can be moving slowly and can have a maximum range of up to 150m.

Multiple BSs may be used in the same vicinity and these use a Base Station Controller (BSC) to coordinate operation. The BSC is responsible for routing system configuration and reporting data between the factory network and the BSs. Command and reporting data is routed directly from 'the DASH' via the factory network to the BCMs via the serving BS. The DASH originates control commands to the BCMs and accepts position information from the BCMs.

This is shown in the diagram below.

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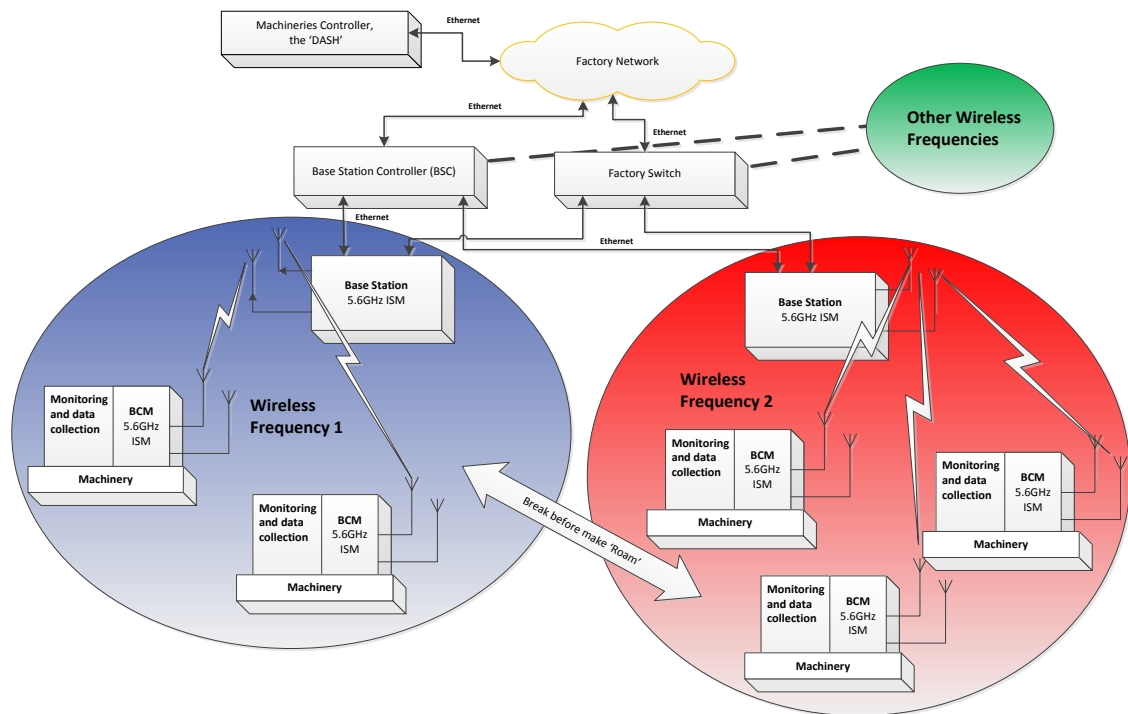


Figure 1 – System Structure

There is no BCM dynamic handover from a BS in the blue cell to the BS in the red cell however ‘break-before-make’ roaming is possible.

1.4 Approved Usage

The RCOM system is designed for operation in UK, France, Germany, USA and Canada. The system must only be used indoors. The system is only intended to provide bi-directional wireless connections to machineries in the factory.

The BCM must not be carried by a human operator and the transmitter must be more than 20cm distant from factory staff.

The BS must be stationary, and must be more than 20cm distant from factory staff.

The RCOM kit is provisioned for a specific country due to different regulations in different geographical areas.

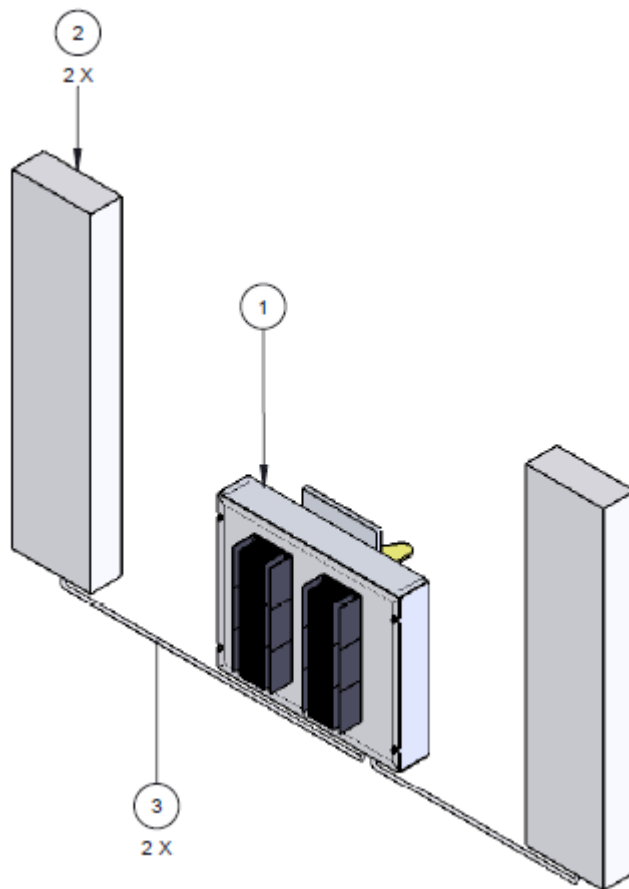
Please also refer to *Appendix B – FCC Warning Statement* and *Appendix C – Industry Canada Warning Statement*.

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2 Installation of Base Station/s

2.1 Packing List

Item No.	Description	Number Off
1	Base Station Assembly	1
2	Base Station Antenna <i>Ubiquiti AirMax Dual Polarisation, 16 dBi, 120° sector</i> <i>(Supplier ref: AM-5G16-120)</i>	2
3	Base Station to Antenna cables	2
4 (not shown)	M6 x 12 Cap Head Screw	4



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Figure 2 – Base Station and Antennas

You will be required to provide a number of installation dependent items:

- Mounting bracket for the Base Station
- Mounting brackets for the 2x Antenna if the ones provided are unsuitable for your installation
- Power cables (2 off if redundancy is required)
- Ethernet cables (optical or electrical or both if desired, 2 off if redundancy is required)
- 1PPS timing signal cable (optional; sync can be done over Ethernet instead)
- SD Card with software (this should be provided separately by your supplier)

Additional details of the cables required are in listed in the appropriate sections below.

2.2 Mechanical Fixing

1) First find a suitable location:

- The Base Station is 305mm x 254mm x 98mm including its fins to dissipate heat.
- The Base Station weighs 3.1kg
- The Base Station and its antennas take up no more than 1m by 780mm and should be mounted at least 0.2m above the level of the BCMs.

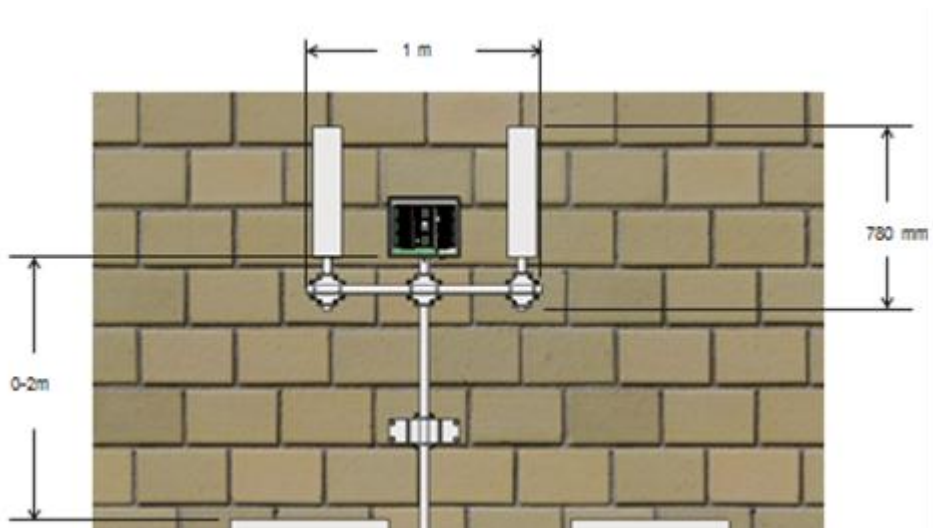


Figure 3 – Base Station Mounting

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- The antennas must be mounted 0.5m to 1m apart, nominally at the same height and clear of the Base Station. An example arrangement is shown above. The antennas should not be directly obstructed by building infrastructure if at all possible.
- The Base Station should be mounted to a wall or support where that will be at least 20cm from any factory operatives. Scaffolding poles are appropriate.
- The Base Station externally accessible switches and connectors are placed along one edge of the PCB, it should be installed so that these point downwards.

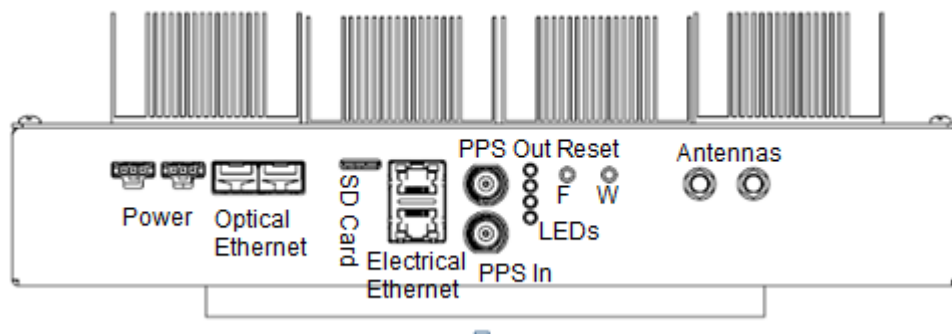


Figure 4 –Base Station Connectors

- Strain relief must be provided for any cables between the BS and the antennas or other parts of the system.
- 2) Mount the Base Station using a suitable brackets for this installation
 - 3) Mount the Antennas paying attention to the distances and constraints listed above
 - 4) Cable the Antennas to the Base Station using the cables supplied (see the diagram above for the location of the antenna connectors on the Base Station). Use strain relief on the cables so that their weight is not taken directly on the connectors. If condensation may be a problem ensure the cables loop down so any moisture will drip off an insulated part of the cable and not into the antenna or the Base Station.
 - 5) The antenna has two connectors which provide for both vertical and horizontal polarisation. The cables should be attached to the connector marked for vertical polarization.

2.3 Electrical Connection

The Base Station has two redundant, independent, electrically isolated power sources with the following characteristics:

- Voltage Rating: 48V dc nominal
- Current Rating: less than 1A

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The Base Station will operate if only one supply is connected but redundancy is recommended.

- 1) Make suitable power cables for the Base Station these are not supplied because the length of the cable required is installation dependent. The power cables must be less than 3m long.

The power connectors on the RCOM Base Station are Molex 43650-0300 3-Way Microfit Connectors. The pin out of the power connectors on the RCOM Base Station are:

- Pin 1 = Positive terminal
 - Pin 2 = Not Used, internally connected to Pin 1
 - Pin 3 = Negative terminal
- 2) Connect the power cables to the Base Station see Figure 4 for the location of these connectors.

2.4 Communications Connection

The Base Station is connected to a central control system via Ethernet. This 1 GB Ethernet connection can be electrical or optical. The optical interface takes precedence over the electrical interface if both are present. Both electrical and optical interfaces provide 2 ports for redundancy. The Base Station will operate if only one is connected but redundancy is recommended.

Decide on which you want to use and connect the appropriate length and type of cables to the appropriate Ethernet connector on the Base Station, see Figure 4 for the location of these connectors.

2.4.1 Electrical Ethernet

When using the electrical interfaces the use of shielded cables is recommended.

The electrical Ethernet interfaces are RJ45 jacks with LEDs, WURTH ELECTRONIK 7499151120

The electrical Ethernet interfaces have the following pin-out:

- Pin 1 = TR0+, Transmit/receive pair 0, positive wire
- Pin 2 = TR0-, Transmit/receive pair 0, negative wire
- Pin 3 = TR1+, Transmit/receive pair 1, positive wire
- Pin 4 = TR2+, Transmit/receive pair 2, positive wire
- Pin 5 = TR2-, Transmit/receive pair 2, negative wire
- Pin 6 = TR1-, Transmit/receive pair 1, negative wire
- Pin 7 = TR3+, Transmit/receive pair 3, positive wire

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- Pin 8 = TR3-, Transmit/receive pair 3, negative wire

2.4.2 Optical Ethernet

The optical Ethernet interfaces are TYCO ELECTRONICS 1888247-2 SFP (Small Form-factor Pluggable) cages to allow various laser modules to be inserted. The optical interfaces uses 1000Base-SX Gigabit Ethernet standard, over multi-mode fibre, with a wavelength of 850nm.

2.5 Timing Sources

When using multiple Base Stations it is important that the air-interface signals are aligned between all the various Base Stations operating in a system. The three requirements for synchronisation are:

- an accurate frequency reference,
- precise phase alignment to within about 1 microsecond, and
- time-of-day to within a few milliseconds.

To achieve the phase and frequency requirements, the following subsections describe PTP and 1PPS options, plus an option of adding Synchronous Ethernet to either.

For time-of-day, the network infrastructure must provide an NTP server, with its timing aligned to that of the PTP or 1PPS source and to the DASH controller

2.5.1 Synchronisation using PTP

The Base Station supports IEEE 1588v2 PTP (Precision Time Protocol) messages – the local clock generators can use PTP messages received over either of the Ethernet ports to allow multiple Base Stations to operate with locked air-interface timing. The network infrastructure must provide at least one PTP timing Master, and intermediate network switches must support PTP.

By editing `/opt/rainbow/rcom/etc/rcom-link.cfg` you can select PTP and must then identify the network host(s) of the PTP Master(s):

- `sync_mode = 1588ptp`
- `ptp_addrlist[1] = PTP-HOSTNAME-B`
- `ptp_addrlist[0] = PTP-HOSTNAME-A`

2.5.2 Synchronisation using 1PPS

For smaller systems, an independent 1PPS (one pulse per second) strobe connection can be used. The 1PPS generator used should pick up its signal from the GPS system. There are a number of commercially available systems.

The timing source should be connected to the PPS IN connector on the Base Station.

The physical 1PPS interface is a BOMAR 364A2595 dual stack BNC connector (one out, one in), that operate at 5V TTL logic levels.

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Normally, the 1PPS master source should be fanned out to multiple BSs via distribution amplifiers in a star or tree configuration. However, the PPS OUT connector allows a second Base Station to be synchronised to the first, e.g. in a situation where the first is free-running and acting as the timing master. A daisy chain of multiple BSs is not recommended, as each will take a few minutes from start-up to generate a stable output, and the chain would be sensitive to a point failure. See Figure 4 for the PPS OUT connector position.

By editing `/opt/rainbow/rcom/etc/rcom-link.cfg` you can select 1PPS mode, and optionally compensate at each BS for delays via different length cables from the 1PPS source (values in nanoseconds):

- `sync_mode = 1pps`
- `cable_delay_1pps = 0`
- `global_cable_delay_1pps = 0`

2.5.3 Additional timing performance via SyncE

It is possible to improve BS frequency and phase stability using Synchronous Ethernet as a frequency source, by configuring either:

- `sync_mode = 1588ptp+sync`
- `sync_mode = 1pps+sync`

In this case, the network infrastructure must distribute SyncE, frequency locked to the PTP or 1PPS timing master. However, the use of SyncE is not currently recommended because (a) sufficient performance is achieved without it, and (b) BS timing can currently slip permanently out of alignment during a redundancy failover if using SyncE.

2.6 Software

The Base Station software is loaded at power on from a microSD Card inserted into the Base Station (see Figure 4 for location). microSD Cards of up to 32GB are supported.

Your supplier should provide you with a suitable SD Card.

You can see the version of the software being run by looking at the `/temp/bsinfo.txt` file on the Base Station.

All Base Stations in a system **MUST** be running the same version of software.

2.7 User Interface – Buttons and Lights

The Base Station has a number of lights that indicate activity on the unit, the power and status indicator lights are mounted in a single 4-way LED and the lights that indicate Ethernet activity are part of the relevant connectors block (see Figure 4 for their location).

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The Ethernet LEDs operate in the same way, irrespective of whether an electrical or optical network connection is active.

Light Colour/Label	Purpose
Green - Power Input 1	Shows that power input 1 has power and that the internal fuse is intact
Green - Power Input 2	Shows that power input 2 has power and that the internal fuse is intact
Green - Status 1	Acts as a heartbeat, flashing to indicate that the unit is operational (flashing more quickly if the processor is heavily loaded).
Green - Status 2	Indicates processor activity.
Green - Ethernet Port 1	This LED indicates the presence of a 1Gbit/s link. If off (and the Yellow LED is lit), a lower link rate has been negotiated.
Yellow - Ethernet Port 1	This LED indicates activity on the Ethernet link. If off, no link is present.
Green - Ethernet Port 2	This LED indicates the presence of a 1Gbit/s link. If off (and the Yellow LED is lit), a lower link rate has been negotiated.
Yellow - Ethernet Port 2	This LED indicates activity on the Ethernet link. If off, no link is present.

The Base Station has two reset buttons under normal circumstances these should not be required.

The long button that is easily accessible resets the Base Station processor.

The Factory Reset button is recessed into the Base Station, this can be operated by using a straightened paper clip, pressing this button causes certain configuration settings to be returned to their 'factory' defaults. It may be necessary to automatically or manually power down and re power the unit for the changes to take effect. This button is effective only while the unit is powered and running normally.

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3 Installation of BCM

3.1 Packing List

Item No.	Description	Number Off
1	BCM Assembly	1
2	BCM Antenna Brackets (optional)	2
3	BCM Antenna <i>Flat Type 5.1-5.8GHz Dipole 5 dBi Antenna for SMA Plug RP</i> <i>(Supplier Ref: DA-5158-11-SMR)</i>	2
4	BCM to Antenna Cable (length 1)	1
5	BCM to Antenna cables (length 2)	1
6	BCM-PC (not shown)	1

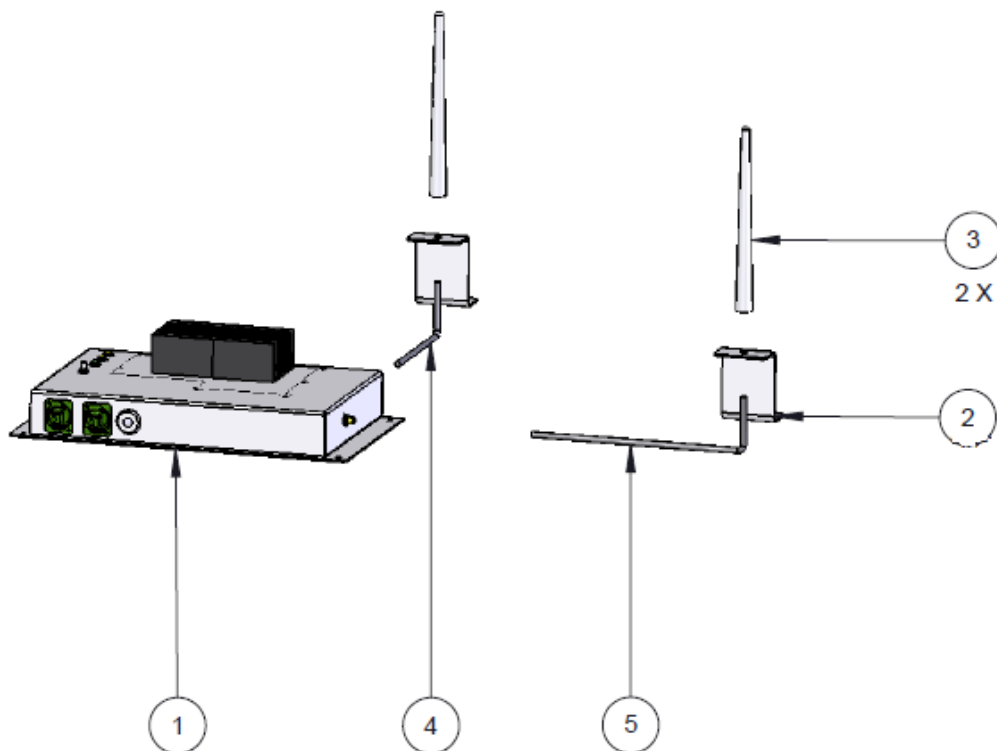


Figure 5 – BCM and Antennas

You will be required to provide a number of installation dependent items:

- Screws/bolts for attaching the BCM and BCM-PC to the mobile device. Locking nuts/washers should be used to avoid loosening due to vibration.
- Power cable, this can be two separate cables one for the BCM and one the BCM-PC or a single Y shaped cable.
- Ethernet cables for connecting the BCM to the BCM-PC and for connecting the BCM-PC to the Bot's PC and control unit (RTC).

3.2 Mechanical Fixing

The BCM is designed to be connected along with the BCM-PC to a mobile device (Bot) which contains a PC and a control unit (RTC) both with an Ethernet interface. The mobile device provides power to both the BCM and the BCM-PC hence the mounting location of the BCM and BCM-PC should take these interconnections into consideration.

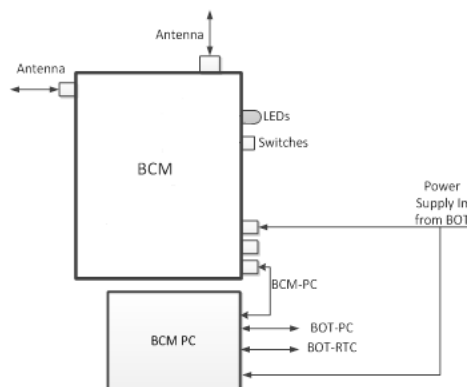
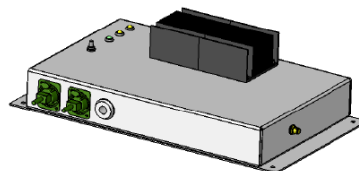


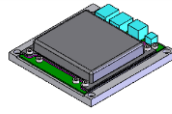
Figure 6 – BCM and BCM-PC Cabling

The BCM complete with mounting bracket and heat fins is 319.4mm x 177.8mm x 87mm and weighs 1.4kg.



The BCM-PC is 28.5mm x 132mm x 128.5mm and weighs less than 0.5kg

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Both the BCM and BCM-PC should be mounted such that their connectors are protected from condensation e.g. face connectors downwards with cables looping down.

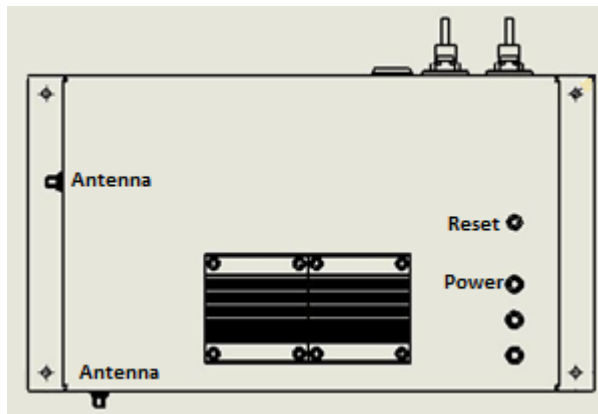
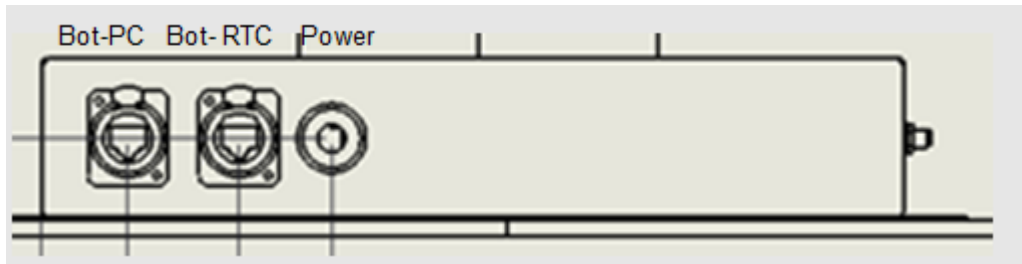


Figure 7 – BCM Connectors and LEDs

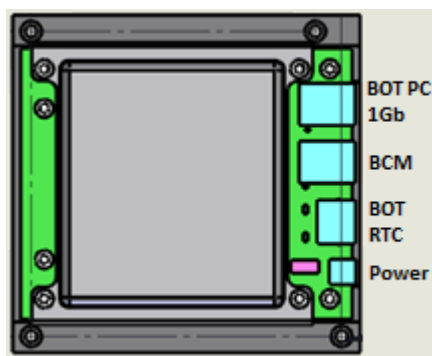


Figure 8 – BCM-PC Connectors and LEDs

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The BCM mounting plate has 4 x 4.5mm diameter holes located as indicated below. The fixing mechanism should allow for any vibration, e.g. using locking washers or nuts.

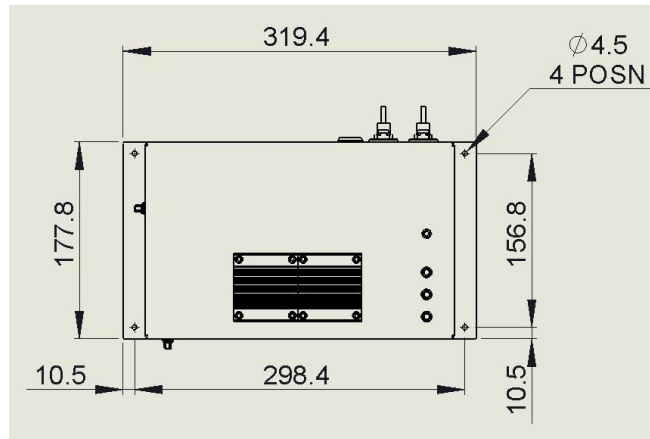


Figure 9 – BCM Mounting Holes

The BCM-PC has 4 x 4.5mm diameter holes for mounting it as indicated below. The mounting holes are counter bored so the bolt surface is 5.6mm away from the mounting surface. The fixing mechanism should allow for any vibration.

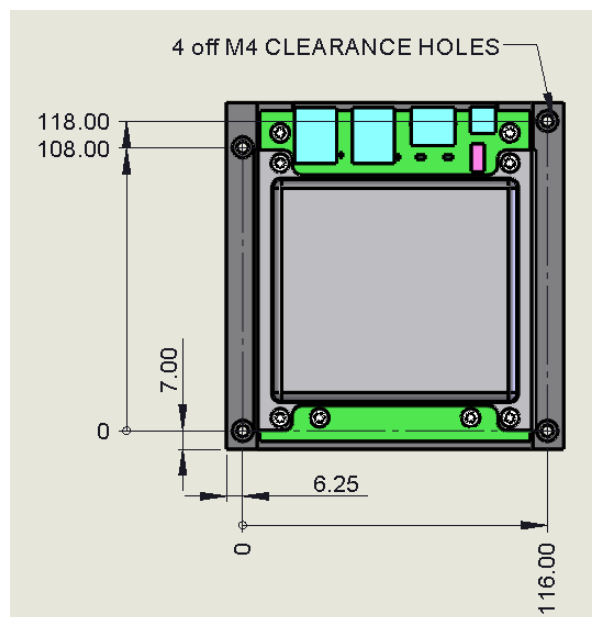


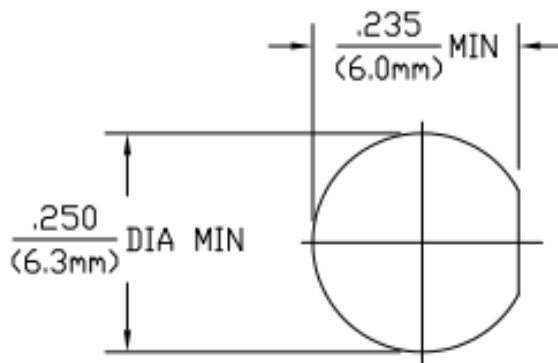
Figure 10 – BCM-PC Mounting Holes

The antennas should be mounted vertically onto bulkhead connectors through a plate on the mobile device, at least 0.5m apart from each other so that they are above the Vehicle

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body and pointing towards the ceiling. The antennas must be mounted to avoid metallic obstructions close to the antenna.

The bulkhead connector is part of the cable assembly which is used to connect the antenna to the BCM antenna connector.



Cable the antennas to the BCM, use strain relief so that the weight of the cable or vibrations in the cable will not stress the connectors. If condensation may be a problem ensure the cables loop down so any moisture will drop off an insulated part of the cable and not into the antenna or the BCM.

The cables provided for connecting the antennas to the BCM are 300mm and 650mm length for historical reasons.

3.3 Electrical Connection

The BCM power input needs to be provided with:

- Voltage rating : 18V to 28V
- Current rating : The BCM will draw less than 2A at 18V

The BCM-PC power input needs to be provided with:

- Voltage rating : 18V to 28V
- Current rating : The BCM-PC will draw less than 1A at 15V

The power cable must be less than 3m in length for the BCM and BCM PC, this can be two separate cables on one Y shaped cable, whichever is more convenient. See Figure 7 and Figure 8 for the position of these connectors.

The power connector on the BCM is a REDEL - PKG.M0.2GL.LG - SOCKET, PANEL MOUNT, GREY, 2WAY with the following pin out.

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Pin Number	Name	Function
1	+VBat	Battery voltage positive terminal
2	-VBat	Battery voltage negative terminal (power ground and BOT Chassis)

The mating half on the cable from the mobile device should be a REDEL - PAG.M0.2GL.AC39G - PLUG, 3MM, GREY, 2WAY

The power connector on the BCM-PC is a MOLEX 43045-0402 with the following pin out.

Pin Number	Name	Function
1 & 2	+VBat	Battery voltage positive terminal
3 & 4	-VBat	Battery voltage negative terminal (power ground and BOT Chassis)

The mating half on the cable from the mobile device should be a Molex 43025-0402.

3.4 Communications Connection

3.4.1 BCM to BCM-PC

The BCM-PC port on the BCM must be connected to the BCM-PC port using shielded CAT5 Ethernet cable. See Figure 7 and Figure 8 for the position of these connectors.

3.4.2 BCM-PC to Mobile Unit PC

The BCM-PC Bot-PC port should be connected to the PC on the mobile unit using shielded CAT5 Ethernet cable. See Figure 8 for the position of this connector on the BCM-PC.

3.4.3 BCM-PC to Mobile Controller

The BCM-PC BOT-RTC port should be connected to the Mobile Controller (RTC) using shielded CAT6 Ethernet cable. See Figure 8 for the position of this connector on the BCM-PC.

3.5 Software

The software for the BCM is loaded from the mobile device PC via the BCM PC at power up. You can see the version of the software being run by looking at the /temp/bcminfo.txt file on the BCM-PC.

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3.6 User Interface – Buttons and Lights

The BCM has three lights that indicate power and activity on the unit. The BCM-PC has two lights, again one to indicate power (nearest the power connector) and the other to indicate status. See Figure 7 and Figure 8 for the position of these lights. Only the power LEDs are of interest to the user.

In addition the BCM has a reset button to reset the BCM, under normal circumstances this should not be required. See Figure 7 for its location.

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4 Commissioning of RCOM

Both the BS and BCM have configuration files, these can be found at /opt/rainbow/rcom/etc/rcom-link.cfg on the BS and in the same directory on the BCM-PC.

The BS file allows you to allocate the frequency that the BS should use, and the BCM file allows you to associate your mobile devices via their BCMs to each BS.

Sections 4.1 and 4.2 describe configuration file contents for standalone operation. However in both cases, in a system that includes a BSC most of the configuration details will be supplied from the BSC over the wired network, and the only local configuration needed is the identity of that BSC.

To edit the configuration file you must log into the BS/BCM-PC using SSH. You require the IP address or host name of the BS/BCM-PC, the root password (obtainable from your supplier), and a Linux or Windows PC connected to the factory network.

If using a Linux PC, log into the BS/BCM-PC using:

```
ssh root@<ip address>
```

If using a Windows PC you require a terminal program such as putty to SSH into the BS/BCM using:

```
root@<ip address>
```

From this shell session, the configuration file can be edited with a text editor, nano, on the BS/BCM-PC:

```
/nano /opt/rainbow/rcom/etc/rcom-link.cfg
```

4.1 Base Station Configuration

Example Base Station configuration file, found in /opt/rainbow/rcom/etc/rcom-link.cfg.

```
[bs]
cable_delay_1pps = 0
crystal_trim = 0
state = Active
ptp_addrlist[1] = PTP-HOSTNAME-B
ptp_addrlist[0] = PTP-HOSTNAME-A
global_cable_delay_1pps = 0
sync_mode = Freerun
bsid = 12345
traffic_hostname = 172.18.24.38
next_channel = 2,Whitelisted
channel = 22,Whitelisted
thin_pipe_mode = Single
max_num_fat_pipes = 4
bot[0x00000d80] = 00:02:00,172.18.24.44
```

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```
[private]
startup_mode = Managed
bsc = bsc-physical
heartbeat_not = netaddr_dsp_controller
```

The parameters that you may wish to configure are described below:

"state"

Indicates if this (physical) BS is to run as the active node in a group of nodes making up a (logical) BS. A logical group of BSs are used when you want to have one or more spare BSs in standby ready to take over from the active BS in case of a fault, this is known as failover.

Defaults to 'standby' to ensure the radio is not started until the BSC (or user) brings the BS online by setting state = Active.

"sync_mode"

Indicates how the BS is to try and obtain time-synchronisation with the upstream networking equipment. This is a bitmask of modes which the BS's hardware should attempt to use. Order is not significant. In principle the BS tries to use the 'most advanced' system out of the ones specified and falls back eventually onto 'freerun'. The options are Freerun, 1pps+synce, 1pps, 1588ptp, 1588ptp+synce (see section 11 for more details).

"bsid"

This specifies the Base Station ID, which is the logical-BS to which this device belongs.

"channel"

The channel this BS is supposed to be using. NB: Booting multiple base-stations without configuring this independently will not stablest

work. The channels equate to the frequency channel to use, a maximum of 24 channels are available with RCOM. Set this to a unique number in your system between 0 and 23. It should be noted that in a stand-alone system the channel number should be carefully selected to comply with the country of operations regulatory requirements.

[private]

"startup_mode"

Indicates if the BS starts standalone or managed. Default is "managed" which causes the BS to wait for the BSC to configure it before examining further configuration keys. You may also set this key to 'standalone' if a BSC is not being used in which case the BS will not look for a BSC and must be entirely hand-configured using this configuration file.

"fpserver"

This specifies the address of the device running the fat-pipe server to which this BS should connect. If not set (as in the default distribution), this defaults to the BSC. If set

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to 'none' then the functionality is disabled. If set to anything else then the value is assumed to be a resolvable hostname. Uncomment this and specify a device name.

"ptpaddrs[0] ... ptpaddrs[3]"

Specify the PTP server addresses if used, that is when the "sync_mode" value is set to "1588ptp". The Base Station PTP client receives streams from these and chooses the one that is the most stable. Up to 4 may be specified e.g. ptpaddrs[0] = 172.18.24.163, ptpaddrs[1] = 172.18.24.164.

"bsc"

Hostname/IP-Address of the server responsible for managing this device. If the configuration server is running in 'managed' mode (which it will be by default) then it periodically attempts to register with the management server for inclusion into the RCOM system, e.g. bsc = 172.18.36.162

Additional parameters are contained within the configuration file but should not be edited.

4.2 BCM Station Configuration

Example BCM configuration file, found on the BCM-PC /opt/rainbow/rcom/etc/rcom-link.cfg.

```
[bot]
radio = 0x000000cc,00:02:00,0

[private]
startup_mode = Managed
bsc = 192.168.91.100
heartbeat_not = netaddr_dsp_controller
minloglevel = info
rrm_transport = spi
rrm_spidev_name = /dev/spidev1.1
spi_debug = 0
```

The parameters that you may wish to configure are described below:

4.2.1 ***Distribution-time configuration for RCOM applications***

Radio configuration information, sets Base Station ID, TPN (Thin Pipe Number) and channel that the BCM should use: <BSID>,<TPN>,<Channel Number>

E.g. radio = 0xFFFFFFFF,_,255

The TPN (thin pipe number) is set by the BSC when the mobile device is connected (docked) to the system network

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"startup_mode"

Indicates to the BCMs configuration daemon that it should always expect to receive its configuration. A BCM is always a 'managed' device (managed by a BS/BSC). Setting this to anything except 'Managed' is not supported. startup_mode = Managed

"bsc"

Hostname/IP-Address of server responsible for managing this device. The BCM periodically attempts to register with the management server for inclusion into the RCOM system and to receive radio configuration. E.g. bsc = bsc

"fpserver"

This specifies the address of the device running the fat-pipe server to which this BCM should connect. If set to the value 'none' the functionality is disabled. If empty this defaults to the loopback address.

fp_server = none

Additional parameters are contained within the configuration file but should not be edited.

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5 Technical Operating Parameters

In this description the word ‘downlink’ means in the direction of the BS to the BCM and the word ‘uplink’ means in the direction of the BCM to the BS.

The radio system has the following key parameters:

- Operating temperature of BS and BCM is 0°C to +45°C
- Operating distance BS to BCM is 150m. It runs with a sectored antenna, the 150cm is the maximum distance from the mid-point of the antenna
- A single BS will communicate with several hundred low data rate BCMs which will be either static or moving around at a maximum speed of a few meters per second inside the building. Maximum number of BCMs per BS is 1000
- More than one BS may be operating simultaneously depending on the size of the factory. Maximum number of active BSs per factory is 24
- Safe distance for staff from BS and BCM antennas is 20cm
- The system works in the frequency band 5470MHz to 5725MHz.
- The nominal channel bandwidth is 10MHz. The channel centre frequencies are defined by:

$$F_c = 5482.5\text{MHz} + N \cdot 10\text{MHz}, \quad N = 0 \dots 23$$

- The system will carry data only.
- The system uses a Time Division Duplex (TDD) frame to split uplink and downlink connectivity, the uplink sub frame is 10ms and the downlink sub frame is also 10ms making a complete frame 20ms.
- The system uses Frequency Division Multiple Access (FDMA) to divide the RF channel into smaller blocks and Time Division Multiple Access (TDMA) method to further split the time into timeslots. Each BCM is then allocated two frequency blocks and a timeslot as the physical resource used to support the wireless communication.
- The BS transmits a broadcast channel at the start of every frame. This broadcast channel is received by every BCM and is used for system control messages.
- The BS can send downlink data to up to 20 BCMs simultaneously across an occupied bandwidth of 9MHz.
- The BCM/BS will support bidirectional data in one of two possible modes:
 - A narrow band mode using an instantaneous 450kHz of bandwidth but frequency hopping over the entire 9MHz occupied bandwidth with one hop every 100ms and with a transmit duty cycle of 0.5%. The narrow band mode carries command and control data for an individual BCM.

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- A wide band mode that uses the entire occupied bandwidth of 9MHz with a transmit duty cycle of 10%. This is used to allow a faster data transfer from a BCM for uploading long term performance data stored on the BCM. Only a few BCMs (maximum of 4) can be allocated the wide band mode at any one time.
- In narrow band mode up to 20 devices may be simultaneously in communication in a total occupied bandwidth of $20 \times 450 \text{ kHz} = 9 \text{ MHz}$.
- The downlink modulation method is OFDM and the uplink modulation method is OFDMA.
- The system will monitor for other users in the band and if radar or any other interfering signal is detected the system will change frequency.

5.1 Dynamic Frequency Selection (DFS) & Interference Avoidance (Adaptivity)

The system is designed to comply with the requirements of EN 301 893 which includes the requirement to detect and avoid radar (DFS) and to cease transmission in the presence of other users of the band (Adaptivity).

This functionality in the BS (DFS and Adaptivity) and the BCM (Adaptivity) executes autonomously and there is no facility for the user to change the operating parameters.

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6 Glossary

Term	Description
BCM	Bot Control Module, the mobile part of the RCOM communications system.
BS	Basestation, the fixed part of the RCOM communications system.
BSC	Basestation Controller, used to coordinate when multiple Basestations are used
DASH	Command and control system
FDMA	Frequency Division Multiple Access
ID	Identifier
LAN	Local Area Network
LED	Light Emitting Diode
NTP	Network Time Protocol
OFDM/A	Orthogonal Frequency Division Multiplexing
OFDMA	Orthogonal Frequency Division Multiple Access
PC	Personal Computer
PPS	Pulse Per Second
PTP	Precision Time Protocol
RCOM	Rainbow Communications System
SyncE	Synchronous Ethernet
TDD	Time Division Duplex

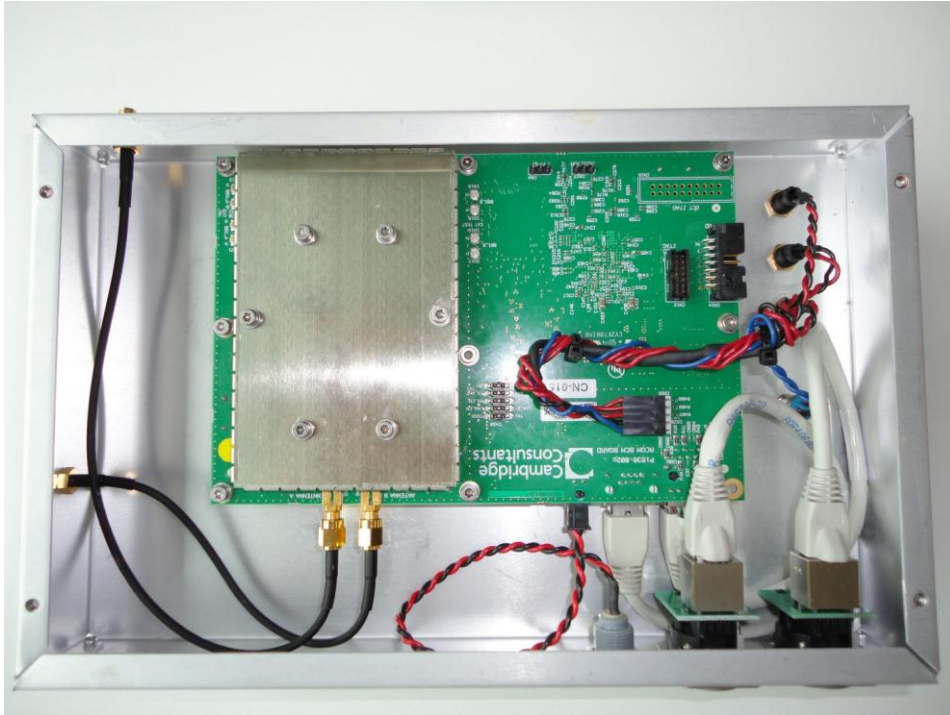
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Term	Description
TDMA	Time Division Multiple Access
TPN	Thin Pipe Number

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7 Appendix A – Photographs

7.1 BCM



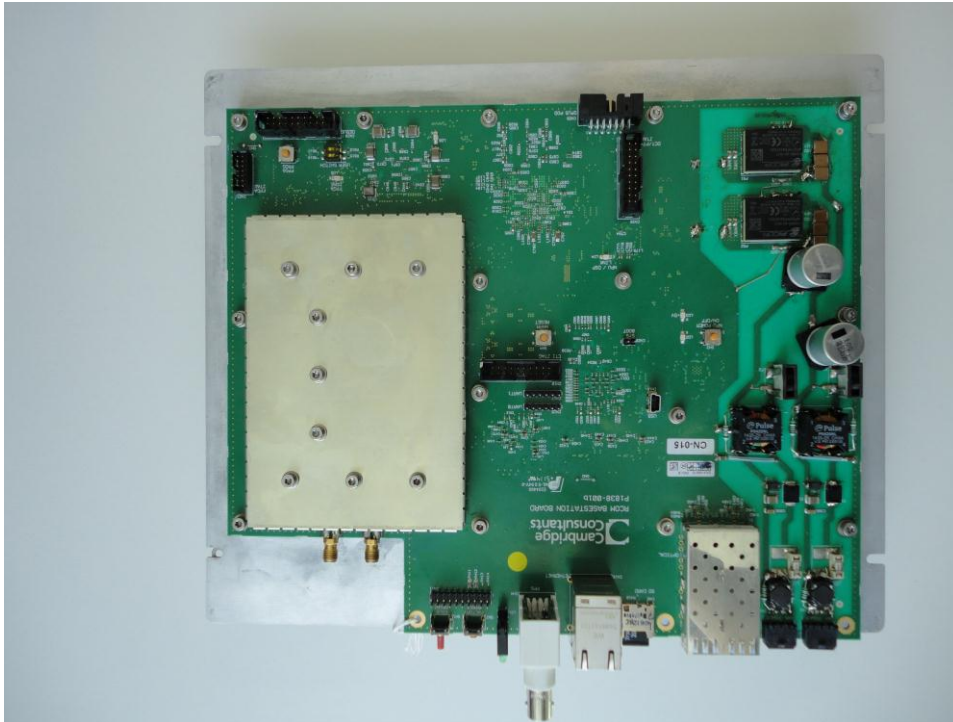
Internal view with bottom cover removed



External view

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7.2 Base Station



Internal view



External view

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8 Appendix B – FCC Warning Statement

This device complies with Part 15 of the FCC Rules.

Operation is subject to the following two conditions:

- (1) This device may not cause harmful interference, and
- (2) This device must accept any interference received, including interference that may cause undesired operation.

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. End users must follow the specific operating instructions for satisfying RF exposure compliance. This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment

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9 Appendix C – Industry Canada Warning Statement

"Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada.

To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication."

"This device complies with Industry Canada licence-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device."

"Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada.

Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante."

"Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes : (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement."