Figure 8: Donor Antenna

The Donor antenna with 16 dB gain transfers the intercepted signals to the repeater and transmits uplink signals amplified by the repeater.

b. Diplexer

The signals received in the DL, through the antenna are split for individual band processing. The dual band outputs are fed to two different duplexers. One Diplexer is also provided before the server antenna in order to distribute combined signals to mobile users.

In the UL, signals received from server antenna are split and fed to two duplexers for processing. The amplified signals from both the duplexers are combined for further transmission through Donor antenna to BTS.

c. Duplexer

The main function of **duplexer** is to isolate the uplink frequency from the downlink frequency, i.e. isolate transmit path from receive path. Four duplexer units are provided in the repeater, two in the Donor antenna side and two in the server antenna side. Each duplexer transfers/receives signals from respective diplexer for further connectivity to low noise amplifier. The bandwidth of the duplex filter **depends on the operator's frequency band** (25MHz, 15MHz, 10MHz, 9MHz, or full Band etc.).

d. Low Noise Amplifier (LNA)

This module is provided after duplexer before the converter. The **LNA** provides compensation for the losses suffered by the stream of weak signals as it passes through splitter/combiner & duplexer (passive devices). Four LNAs are provided, two each for individual bands in the UL & DL directions.

e. Converter Module

The basic block of **converter** module comprises of L.O., frequency mixer, filter and intermediate amplifier. The low noise amplified signals are converted to IF in frequency mixer with frequency fed from LO. The signals are passed through sharply tuned filters. Number of converters equipped shall depend on the number of sub bands configured in the system. Two converters (one for DL & one for UL) for each sub band are provided.

f. Power Amplifier

It is the core module of repeater. It includes driver stage and final stage. It is installed directly on the heat sink of the repeater. Driver stage and final stage of power amplifier are in the same unit. Four power amplifiers with specific frequency bandwidths & gain are provided, two each for individual bands in the UL & DL directions.

g. Supervisory

The man-machine communication between the cellular operator and the repeater is established through this module. One of the two options as given below can be used for achieving this objective:

- USB interface
- Wireless modem (Optional)

Remote controlling function of repeater can be achieved by equipping Wireless modem. This arrangement also enables status of repeaters at different locations to be monitored.

h. POWER SUPPLY

The power supply unit incorporated in the repeater is of high efficiency and reliability. Different DC voltages required for the operation of electronic circuitries are derived in this unit. The standard input voltage is 100 to 240 V AC, 47 Hz to 63 Hz. When the power supply varies in this range and the frequency in 47 to 60Hz, its output DC derived voltages remain constant within 1% of nominal value.

i. SERVER Antenna

Server antenna transmits signals from the repeater station to mobile users and transport received uplink signals from the mobile users to the base station. Based on the coverage area, a set of select panel antennas with suitable gains & N type connecters is installed at pre-planned spots.

Figure 9: Server Antenna

7. DB5R Repeater Specifications

7.1. Electrical Specifications-RF

S.NO.	Parameter	Specified limits/Remarks
1.	Number of Bands	Two,
2.	Frequency band in DL path.	The bands are customized as per requirement.
3.	Frequency band in UL path.	The bands are customized as per requirement.
4.	Number of RF Sub bands	5 maximum in 3+2 configuration. Set as per requirement of the customer.
5.	RF composite power options DL	+33 dBm
6.	Spurious Emission	≤ 36dBm from 9 KHz to 1 GHz ≤ -30dBm from 1 GHz to 12.75 GHz
7.	Automatic Power Control	25 dB
8.	Repeater Gain	85 dB (+-5dB)
9.	Attenuation range for gain adjustment in DL & UL	31 dB in 1 dB step (Software control)
10.	Gain flatness over band	±2 dB
11.	Gain variation with temperature	± 1.5 dB
12.	Total delay in the signal path/direction	5.5 microseconds.
13.	Noise figure	5 dB Max.
14.	Impedance	50 Ohms
15.	Return loss	16 dB
16.	Power supply	100 to 240 V AC, 47/63 Hz
17.	RMS interface	Wireless modem (optional), USB port for local connection.

7.2. Electrical Specification Power Requirement

Parameters	Specified/Limits
Input AC Voltage Range	100-240 V, 47/63 Hz
Power Consumption approx.	175 watts (Varies as per number of sub bands equipped)

7.3. External Electrical Interface

Parameters	Specification
RF port UL	N-type (F)
RF port DL	N-type (F)

7.4. Mechanical Specification

Dimensions (w x h x d)	560x445x200 mm (22x17x8 inches)
Weight	30 Kg. (72 lbs.)
Housing	Metal for Outdoor application
Grounding Connection	Bolt

Housing Color	Grey
Cooling	Convection

7.5. Environmental Specification

Conditions	**Specification**
Operating Temperature	-35^{o}C to +55^{0}C (-31^{0}F to +131^{0}F)
Storage Temperature	-30^{0}C to +75^{0}C (-22^{0}F to +167^{0}F)
Enclosure	IP-65 (NEMA 5)

7.6 Contents of Delivery

ITEMS	**QUANTITY**
Repeater DB5R unit	1
PC interface cable for USB port	1
Power cable 3 pin	1
Operation & Installation manual	1
CD containing the application software	1
Wireless Modem (Optional)	1
Repeater Door Key	1 set
Screws, Nuts & Bolts for mounting	1 set

8. Installation

8.1. Preparation Sheet- Pre Installation

Before the installation commences, a preparation sheet to examine the various requirements is to be compiled as per detail given below:

1. General

Application: Outdoor
Service Band 1: Frequency Band DL- Frequency Band UL-
Service Band 2: Frequency Band DL- Frequency Band UL-

Number Of Sub Bands: six
Sub Band 1: Frequency Band DL- UL-
Sub Band 2: Frequency Band DL- UL-
Sub Band 3: Frequency Band DL- UL-
Sub Band 4: Frequency Band DL- UL-
Sub Band 5: Frequency Band DL- UL-

2. Technical requirements

S.NO.	Requirement	Remarks
1.	Estimated received signal strength available at site where donor antenna is to be installed	
2.	Estimated cable loss from donor antenna to the repeater unit	
3.	Estimated DL RF power to the input to the repeater	
4.	Desired RF Power in DL	
5.	Proposed gain settings in DL path	
6.	Attenuator to be inserted in DL path	
7.	Estimated cable loss from repeater unit to server antenna port	
8.	ERP at server antenna	
9.	Desired RF Power in UL	
10.	Proposed gain settings in UL path	
11.	Attenuator to be inserted in UL path	

3. Proposed site Address:----------

4. User's Address & other particulars:----------

Date: **Prepared by:----------**

8.2. Engineering Consideration

a. Site Selection

Site selection is one of the most critical decisions affecting the overall performance of the system. A repeater must be located where it can receive the maximum signal from the donor site in order to maximize the repeater's output and performance, a signal strength greater than or equal to -75dBm is desired.

Examples of repeater (and accompanying antenna) locations include (but are not limited to): the roof of a building adjacent to the affected area, with the antennas mounted at the highest point in the building; the top of the hill that is obstructing the donor site's coverage, with the antennas mounted on poles at ground level or as the situation permits.

Distance from both the donor site as well as from the new area to be covered must be taken into consideration. The repeater unit should be located close to the donor site to receive maximum signal strength and at the same time is located in the vicinity of area where coverage is desired. In addition, the donor antenna associated should have line of sight with BTS site to reduce the effects of fading.

Another important issue when choosing a repeater location is the availability of commercial power. Sites where repeater unit is installed should be easily accessible for the maintenance team.

b. Antenna Selection and Placement

Proper selection of the repeater's donor and server antennas is crucial in designing the repeater system. Good antenna characteristics help to provide proper isolation between the server (coverage) and donor antennas, which helps to prevent feedback. An isolation of at least 15dB more than the gain setting of the repeater is required. If the isolation is less than the repeater gain, oscillation will occur.

Specific ways to achieve proper isolation include: using high gain, directional antennas with good Front to Back ratios (25dB or better); physical separation of the repeater's donor and server antennas; and external shielding between antennas. A high gain antenna will help minimize overall path loss to achieve the desired output power. Donor antenna gains are typically 16 dB, while server antennas with proper gains are installed.

- The antennas should have proper frequency band of operation.
- Adequate separation is to be ensured from the power lines to avoid damage to the equipment and humans.
- Antenna with proper characteristics to maintain adequate isolation to avoid oscillations. Normally, isolation should be 15 dB more than the gain set for the repeater. It should have good front to back ratio.

- The beam width for the DONOR antenna should be as small as possible.

- The beam width for SERVER antenna is 60 degree to 120 degree.

- There should be adequate vertical & horizontal separation between the DONOR & SERVER antennas to avoid interference and noise. Separation can be determined by the mathematical formulas:

  Vertical Separation:

  Isolation (dB) = 28 + 40 log (D/ʎ in m)

  Horizontal Separation:

  Isolation (dB) = 22 + 20 log (D/ʎ in m) – (Gain of donor antenna + gain of server antenna)

  D-Distance between donor & server antennas in m

  ʎ- wavelength in m

  The following table is an approximate guide to antenna separation.

  The use of highly directional antennas with good front to back ratios can help to reduce isolation requirements.

VERTICAL ANTENNA SEPARATION		HORIZONTAL ANTENNA SEPARATION	
Separation (m.)	**Isolation (dB)**	**Separation (m.)**	**Isolation (dB)**
5	75.0	5	45.5
10	87.1	10	51.7
20	99.1	50	65.5
30	106.2	100	71.5
40	111.2	150	75.1
50	115.0	250	77.6

Vertical and Horizontal Antenna Separation @ 900 MHz

The antenna separation table demonstrates that vertical separation yields better results than horizontal separation. However, when desired isolation cannot be met due to insufficient separation, external shielding can help; for example, mounting the antennas on either side of a rooftop penthouse or using some type of grounded metal screen or wire mesh (so called chicken wire) between antennas.

The following example illustrates the various signal levels and antenna gains needed to form a properly functioning repeater system.

Received Signal Level	-72	dBm
Donor Antenna gain	16	dBi
Cable loss (100 ft. of 7/8 inch)	2	dB
Input to Repeater	-62	dBm
Gain of Repeater set	85	dB
Output of Repeater	+33	dBm

Cable loss (100 ft. of 7/8 inch)	2	dB
Server Antenna Gain	9	dBi
Repeater ERP	+41	dBm

c) Overlapping Coverage

Ideally, the repeater system will be engineered with minimal overlapping coverage between the donor base station and the repeater. However, the mobile users will occasionally receive signals from both the donor and the repeater at similar levels. This situation is comparable to a mobile receiving multiple signals at varying times due to multi-path propagation.

This repeater contributes a maximum signal delay of 5.5 microseconds in one direction.

d) Call Processing

The mobile communication system perceives calls handled by the repeater as actually being handled by the donor site (BTS); the repeater is just an extension of the base station's coverage. Therefore, the donor handles call initiation, power control messages, hand-over requests, etc., for mobiles in the repeater area. When the base station assigns a channel to the mobile, that channel is sent through the repeater and then reradiated under the same frequency. Since the repeater is technically part of the base station, no hand-over takes place when a mobile moves from the repeater's coverage area to that of the base station. When the mobile moves from the repeater's area to a neighboring site, the base station handles the hand-off in the same way as for a mobile in the base station area.

8.3. Installation Tools

You will need the following basic tools for installation:

a. Standard wrenches/screwdrivers/cable stripper/cable cutter/pliers set for installing the **DB5R** Unit and antennas. (Refer to the manufacturer's recommendations for installing the antennas).
b. RF coaxial cable connection tools for installing connectors.
c. Multi-meter.
d. Mobile handset loaded (e.g. Nokia) with Net engineering software to be used for signal level measurement.
e. Magnetic compass for measuring the azimuth of the BTS and repeater site.

8.4. Installation Procedure

The **DB5R** repeater has been designed for outdoor applications. The repeater unit shall be mounted vertically to a mast, which means the RF connectors will be at the bottom side.

In case of wall mounting, minimum physical separation between the repeater housing & the wall should be 50 mm.

Furthermore, the repeater shall be mounted in a way so that there is free access to the individual units, while the door of the repeater is open.

The repeater is mounted at the pre-selected site firmly placed with clamps and other mechanical accessories. Connections as detailed are carried out:

- RF cable routed from DONOR antenna is connected at the BTS port as indicated.
- RF cable routed to SERVER antenna is connected at TX/RX port for signal distribution.
- For energizing the system, the cable from AC mains is connected at AC mains port, range 100-240 V.
- USB port is provided for carrying out configuration and monitoring.

Important: Grounding of the unit has to be ensured before extending the power to the repeater system.

Following points need considerations for laying of RF cable:

1. RF coaxial cable installation must comply with local or National Electrical Codes. The cable shall have nominal 50-Ohm impedance. Routing of the RF coaxial cables is to be as per the site installation plan.
2. Fix the supplied connectors to the RF coaxial cable and verify the following:
   - The center conductor to outer shield of RF coaxial cable indicates an “Open Circuit” condition.
   - Check for any short circuit between center conductor and outer shield.
   - Place short between the center conductor and outer shield using a piece of wire temporarily and check the other end of conductor for any break in the RF cable.

8.5. Repeater Gain Settings

The **repeater gain setting** is one of the vital parameters since it also decides the area to be provided with RF coverage. The noise contribution has to be minimum while setting the gain hence it should be set with utmost care. The variation in gain up to 31 dB in steps 1 dB is possible to be achieved with the help of software control attenuator, provided in the system. The gain setting for Uplink and Downlink path is independent of each other.

For example, if repeater has a maximum gain of 85 dB and the required repeater gain is 60 dB, the attenuation of 30 dB is required to be incorporated by inserting attenuator of this value.

Note: Repeater gain should be at least 15 dB less than the antenna isolation.

Signals intercepted by DONOR antenna from BTS and transmitted to the repeater are termed as **Downlink/Forward** signals and the signals originated by mobile users and intercepted by SERVER antenna for application to repeater are termed as **Uplink/Reverse** signals.

a. Forward Gain Setting

The process of setting the forward gain is very simple. Forward signal level strength can be measured using NET engineering software in any NOKIA handset e.g. NOKIA 6210 or any other engineering mobile handset.

Alternatively, RF output power of repeater can be measured using the visual indication shown on the display panel of the repeater.
Once the RF output power has been determined, the attenuation will have to be modified to reach the desired output signal level.
The gain of repeater can be set using any of the following methods:

a. Local manual mode (using built in key pad and display)
b. Local USB serial interface mode (GUI based)
c. Through (optional) wireless modem.

b. Reverse Gain Setting

For reverse gain setting, a 31 dB variable attenuator is provided; the required value can be inserted for the desired gain. The gain is set to such a value so as to cause minimum interference at the base station but high enough to ensure a strong signal.
Generally, reverse gain is set 5db less than the forward signal.

8.6. Commissioning

Note:-Repeater should not be connected to Power without termination of the antenna connection. The termination can be performed either by the antenna connection as well as a dummy load or the 50 Ω terminated connection of a measuring instrument (Power Meter, Spectrum analyzer with appropriate PAD)

After setting the gain, verify the parameters:

1. DL RF power radiated in the set frequency band.
2. Received RF power in the DL.
3. UL RF power radiated in the set frequency band.
4. Received RF power in the UL.
5. Record the value of attenuation introduced for setting the gain.

8.7. Dos & Don't Dos

The site should be accessible for the maintenance team.

1. Arrangement is to be made to avoid unauthorized access to the repeater.
2. Proper grounding of the repeater is required to be done to avoid damage to the system.
3. For outdoor applications, the housing must be waterproof.
4. Stable power supply for repeater unit should be ensured.
5. The route of Cables to/from antennas should be short to limit the cable losses and should be free from sharp bends & kinks.
6. Local standard of cabling should be followed.
7. The donor antenna should have proper line of sight with the BTS from where the signals are to be intercepted for maximum signal strength and to reduce the effect of fading.
8. There should be adequate separation between the cables (antenna system) and the power lines to avoid damage to the equipment & injury to humans.
10. The selection of BTS should be made taking other BTSs in the same vicinity in to consideration to avoid interference.

11. Gain of the repeater should be set after taking antenna isolation in to consideration.
12. The estimation of coverage area should be confirmed.
13. The system should be made over for normal traffic after actual measurement of:
    a) RF power in the DL
    b) RF power in the UL
    c) Antenna Isolation
    d) Gain settings in DL & UL
14. Feedback regarding performance of the system must be obtained from the user.

8.7.Checklist – Post Installation

After the installation of the system is accomplished, points as indicated in the checklist are verified.

Service Bands Particulars:

Frequency Band for Band 1 DL	
Frequency Band for Band 1 UL	
Frequency Band for Band 2 DL	
Frequency Band for Band 2 UL	

A. Repeater Installation

S.NO.	Point(s) To be Verified	Remarks
1.	Ensure isolation between server and donor antennas, it has to be 15 dB + Gain set of the repeater.	
2.	Actual isolation measured	
3.	Ensure proper grounding of the unit	
4.	Cable from donor antenna connected to donor antenna port	
5.	Cable from server antenna connected to the relevant port in the unit	
6.	Mains cable connected to the repeater unit	
7.	Cable protection ensured and outdoor connections are waterproof	

B. Repeater Set Up

S.NO.	Point(s) To be Verified	Remarks
1.	Number of sub bands equipped	
2.	Number of Sub band(s) in Band 1 with frequency bandwidth of each.	
3.	Number of Sub band(s) in Band 2 with frequency bandwidth of each.	
4.	Repeater switched ON	
5.	Any error (alarms) observed	
6.	Gain set	
7.	Power level in DL	
8.	Attenuation in DL	
9.	Power level in UL	
10.	Attenuation in UL	
11.	Observation on CMC software & GUI	
12.	Repeater secured & locked	

Any Other Remark/Comment:

Date Of Installation:---------- Repeater ID & Site Address:----------

Name of the Installer:----------

9. System Maintenance

9.1. General

The system normally operates without any operator intervention or maintenance. If, in the unlikely event of a unit failure, the field replaceable units (antenna unit, cables) should be checked for faults and the system restored. The faulty unit can be removed and replaced with a spare while the rest of the system is still operating. Soldering or local repair of the modules should be avoided for better maintenance point of view. Faulty module/unit should be replaced with genuine spares from Shyam Telecom Limited only.

However, the power supply of the failed repeater should be isolated from AC mains and DC power before any module is replaced. In the event of a system malfunction, the status of the antenna systems should be checked as well as the continuity of the cabling before replacing any modules within the repeater.

9.2. Preventative Maintenance

The **DB5R** repeater does not require any preventative maintenance.

For Technical Support, please contact at any of the following addresses:

For Americas

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6, KILMER ROAD, SUIT D,
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