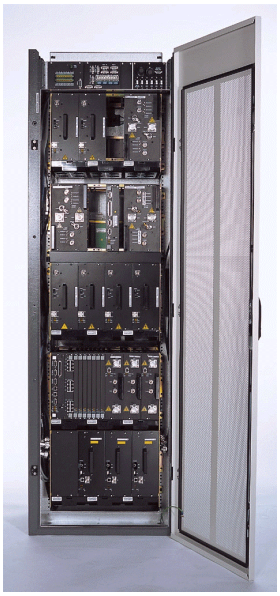
EVOLIUM™ A9100 Base Station

Product description



Scope

This document gives a description of the evolutions of the EVOLIUM™ A9100 Base Station product range.

Its major purpose is:

- to provide general information about the enhancements of the EVOLIUM™ A9100 Base Station product range,
- to give technical data for the different BTS configurations.

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CONTENTS

GENERAL

The EVOLIUM™ A9100 Base Station range is designed to ensure an outstanding quality of service through very high radio performances and minimum service interruption, and to facilitate all kinds of evolutions: Site extension or sectorization, implementation of future features. In addition, special attention was focused on ease of deployment and maintenance. The use of highly integrated modules and state-of-the-art components results in very high compactness and reliability.

The highlights of EVOLIUM™ A9100 Base Stations are:

- Outstanding quality of service due to

  - Very high radio performances, in particular
    - Reception sensitivity, -111 dBm, is far beyond the GSM requirement,
    - Coverage solutions (TRX GSM1800 High power, Range Extension Kit, low-loss configurations) for improved output power,
    - Radio (synthesizer) frequency hopping and antenna diversity offered as standards in EVOLIUM™ A9100 Base Stations.

  - Minimum service interruption
    - Very high BTS availability due to both high module reliability and system architecture,
    - Optimized software release migration thanks to the EVOLIUM™ A9100 Base Station capability to be pre-loaded and to store simultaneously two software-versions.

- High flexibility

  - Wide possibilities of extensions and sectorization can be performed within the same cabinet, e.g., the MBO2 cabinet can accommodate up to six sectors with a twelve-TRX total capacity,
  - Outdoor cabinets modularity provides flexibility for option equipment (transmission, batteries etc.),
  - Same cabinet and system architecture for GSM 850, GSM 900, GSM 1800 and GSM 1900; EVOLIUM™ A9100 Base Station product range includes mixed configurations (e.g. GSM 900 and GSM 1800 within the same cabinet),
  - High modularity, with a highly reduced set of modules and a common interface,
  - Large panel of configurations matching every customer needs.

- Ease of deployment and site interventions

  - High compactness (reaching 43 liters per TRX for the indoor configurations with twelve TRXs, or 162 liters per TRX for outdoor MBO2 cabinet in a foot print less than 1m²),
  - Outdoor cabinets extension principle allows an easy site installation,
  - Comprehensive set of self-tests,
  - Minimum maintenance space necessary due to front access only.

- Future proof

  - GPRS ready
  - EDGE ready by a simple “add TRE” operation
  - UMTS ready: the MBI5 and MBO2 outdoor cabinet allow mixed configurations with 3x2 TRX GSM and 3x4 carriers UMTS (description in a dedicated document.)

1. MAIN PRINCIPLES

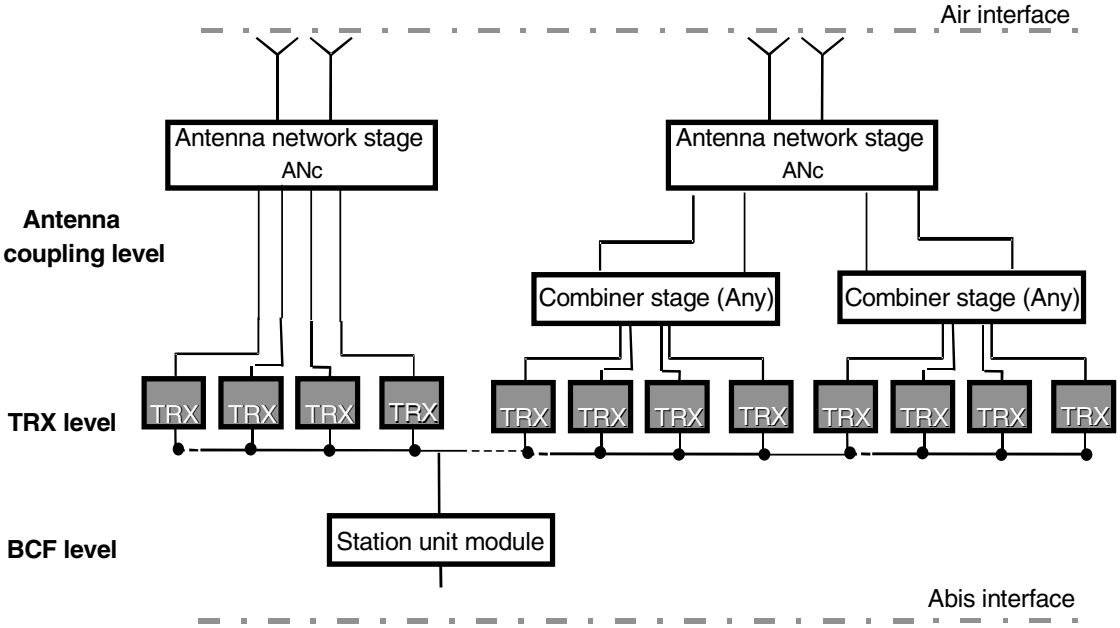
1.1 Overall architecture

The EVOLIUM™ A9100 Base Station is based on a three-level modular architecture, consisting of:

- Antenna coupling level,
- Transceiver (TRX) level,
- Base station Control Function (BCF) level,

for which a reduced set of very highly integrated modules was developed.

The information flow between the Air interface and the A-bis interface is presented Figure 1 below.



Abbreviations
BCF Base station Control Function
TRX Transceiver

Figure 1: Overall EVOLIUM™ A9100 Base Station architecture

1.1.1 Antenna coupling level

The antenna coupling level is the stage between the antennas and the TRX level; it handles the combining functions as well as the interface with the antennas. A single module called Antenna Network Combiner (ANc) performs these functions for up to 4 TRXs. For configurations of higher capacity, a Combiner stage can be added. Thanks to the ANc flexibility and this modular building, the antenna coupling level can be adapted to a wide range of requirements (reduction of attenuation losses, minimization of the number of antennas…).

The general functions performed at this level are:

- Duplexing transmit and receive paths onto common antennas;
- Feeding the received signals from the antenna to the receiver front end, where the signals are amplified and distributed to the different receivers (Low Noise Amplifier (LNA) and power splitter functions);
- Providing filtering for the transmit and the receive paths;
- Combining, if necessary, output signals of different transmitters and connecting them to the antenna(s);
- Supervising antennas VSWR (Voltage Standing Wave Ratio).

1.1.1.1 The Antenna Network Combiner (ANc) module

The Antenna Network combiner module (ANc) connects up to four transmit signals to two antennas, and distributes the received signals from each antenna to up to four receivers (for the normal and the diversity reception). This module includes twice the same structure, each structure containing:

- one duplexer allowing a single antenna to be used for the transmission and reception of both downlink and uplink channels- hence minimizing the number of antenna
- a frequency selective VSWR meter to monitor antenna feeder and antenna
- one LNA amplifying the receive RF signal, and giving good VSWR values, noise compression and good reliability
- two splitter levels distributing the received signal to two or four separate outputs so that each output receive the signal from its dedicated antenna and from the second one (diversity)
- one Wide Band Combiner (WBC), concentrating two transmitter outputs into one, only for configurations with more than two TRX.

Each sector is equipped with at least one such stage, which features very high sensitivity reception, low attenuation, and minimum inter-modulation products.

The ANc can be manually configured (on site) in two modes depending on the number of TRX in the sector:

- The **No-combining mode** for configuration up to 2 TRX, for which the Wide Band Combiner is not needed therefore bypassed as shown in the figure 2:

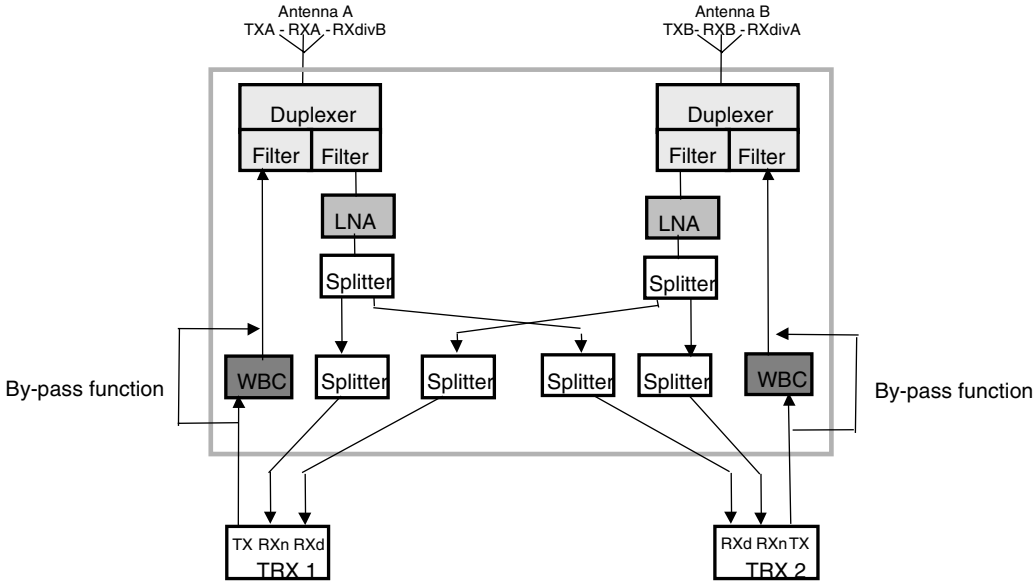


Figure 2 : The Antenna network Combiner (ANc)- No-combining mode

- The **Combining mode** for configuration from 3 up to 4 TRX, for which the Wide Band combiner is not bypassed as shown in the figure 3:

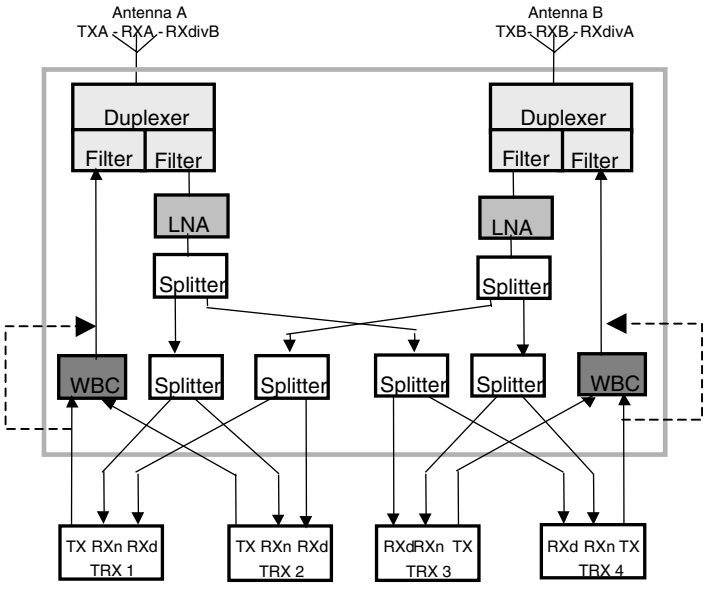


Figure 3: The Antenna network Combiner (ANc)- Combining mode

1.1.1.2 The Twin Wide Band Combiner (ANy) module

The Twin Wide Band Combiner stage (ANy) combines up to four transmitters into two outputs, and distributes the two received signals up to four receivers. This module includes twice the same structure, each structure containing:

- one wide band combiner (WBC), concentrating two transmitter outputs into one
- two splitters, each one distributing the received signal to two separate outputs providing diversity and non-diversity path

The hybrid Wide-band combining technique is used, since it avoids tuning problems and is more reliable compared to remotely tunable cavities. Moreover it is compatible with the Synthesized Frequency Hopping (SFH) feature.

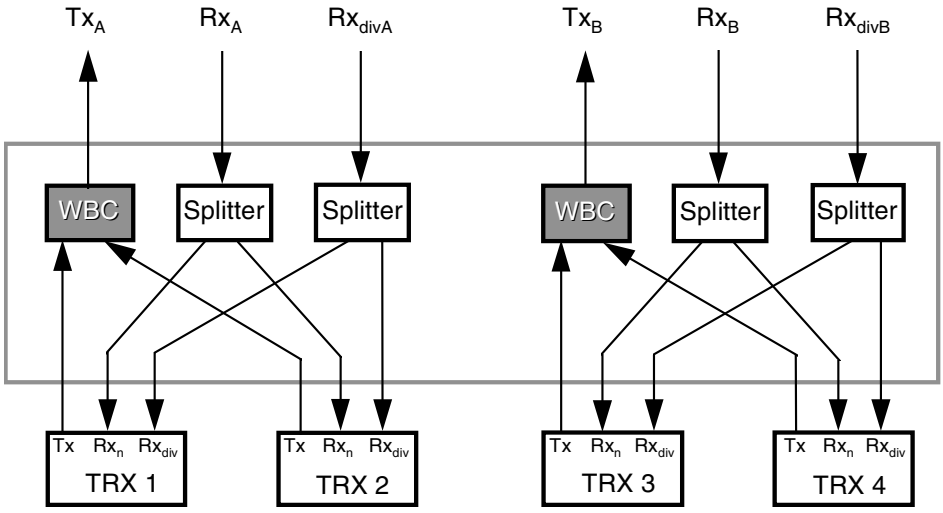


Figure 4: The twin Wide Band Combiner module (ANy)

For standard configurations (for details please refer to dedicated chapter), for which each sector is connected to two antennas (or one cross-polarized antenna), the *Twin Wide Band Combiner* module (ANy) is only necessary for sectors with five or more TRXs as shown in Figure 5 below.

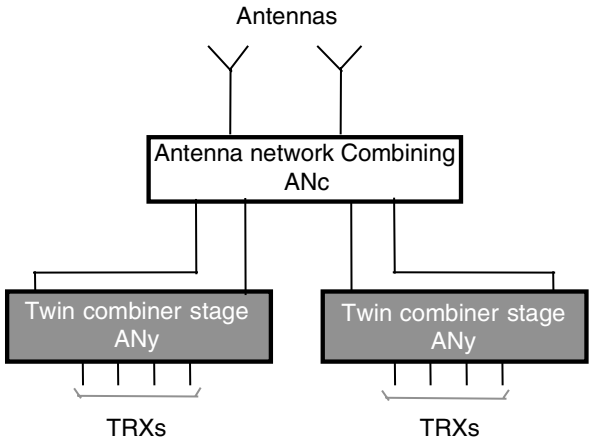


Figure 5: Configuration with 1x8 TRXs

1.1.2 Transceiver (TRX) level

The transceiver (TRX) level covers GSM850, GSM 900, GSM 1800 and GSM 1900 functionalities, including *full rate, half rate, enhanced full rate, antenna diversity, radio frequency hopping (synthesized hopping) and different ciphering algorithms*. For each band, these functions are integrated into one single module.

Inside each TRX module, an RF loop is implemented. The loop test is performed after downloading the frequencies to the BTS as a supplement to the autotest.

The TRX module also handles the Radio Signaling Link (RSL) protocol.

1.1.3 Base station Control Function (BCF) level

This level is ensured by the Station Unit Module (SUM), which is the central unit of the BTS. There is only one such module per BTS, whatever the number of sectors and TRXs is; this common control function of the SUM is also called Station Unit Sharing.

The main base station control functions performed are as follows:

- Generating the clocks for all other BTS modules; the clocks can be either synchronized to an external clock reference - e.g. A-bis link, GPS or another BTS - or generated in a pure free-run mode by an internal frequency generator.
- Ensuring central BTS Operation & Maintenance (O&M) application,
- Handling the A-bis transmission links (up to two A-bis interfaces),

- Handling Operation and Maintenance Link (OML) and Qmux (transmission equipment supervision) protocols,
- Controlling the AC/DC function when integrated inside the BTS (Outdoor or Indoor AC configurations),
- Controlling the battery (capacity, voltage, temperature),
- Setting the optimal voltage and current for battery charging.

1.2 Mechanical and interface principles

1.2.1 Main principles: Standardization and modularity

The back panels of all sub-racks are identical. A common interface for all modules has been defined. No dedicated locations on back panels for each module are preassigned; the module location within the BTS is driven by engineering rules, easy front cabling, optimization of thermal dissipation, easy assembly, dismounting and extensions on site.

All active modules have their own integrated power supply. Each basic module supports hot insertion and extraction. No service interruption is thus necessary during most maintenance interventions.

A connection area is provided on the top of the indoor cabinet so as to link all external connections to the BTS (A-bis, power supply, external alarms, etc.).

The BTSs have been designed in such a way, that an easy disassembling for recycling is possible. All modules are fixed in the sub-racks with Cam-Locks, which can be fastened and unfastened very quickly without need for specific tools.

To fulfil strong vibration requirements some heavy weight modules in outdoor BTS are additionally fastened with screws.

Snap-In technology is used as much as possible as e.g. for the fan cassettes, over voltages protection for data lines and signal inputs for external alarms.

1.2.2 Main advantages

The main advantages resulting from the architecture and the mechanical principles chosen are:

- The Antenna Network Combining (ANc) can be changed easily on site between Combining mode and No-combining mode,

- The addition of TRXs, or even sectors, is possible on operational sites. This can be made easier in terms of time intervention and outage if the necessary antenna coupling devices are already pre-equipped,

- The selection of a BTS cabinet type depends only on the maximum number of TRXs to be provided in future; it is not linked to the BTS organization, e.g. omni/sectored configuration, number of antennas or TRXs per sector.

- The Outdoor MBO1 BTS can be extended on site to an Outdoor MBO2 BTS, by adding an extension cabinet (MBOE).

- Easy commissioning and management of various configurations,

- Open for future evolutions.

2. MAIN FEATURES AND CHARACTERISTICS

2.1 Radio - Telecom - Transmission

Frequency bands

The hardware supports the *GSM 850, Extended GSM 900,* the *GSM 1800* and the *GSM 1900* bands:

	uplink	downlink
GSM 850	824 MHz to 849 MHz	869 MHz to 894 MHz
E-GSM 900	880 MHz to 915 MHz	925 MHz to 960 MHz
GSM 1800	1710 MHz to 1785 MHz	1805 MHz to 1880 MHz
GSM 1900	1850 MHz to 1910 MHz	1930 MHz to 1990 MHz

Speech Codecs

Full rate, half rate, enhanced full rate and Adaptive multi rate are supported. The half-rate, enhanced full-rate and adaptive multi-rate functioning requires that the BSS software release and the other network elements also support these codecs.

Ciphering algorithms

The BTS range supports A5/1 and A5/2 ciphering algorithms; A5/0 = ‘no ciphering’ is always supported. Provisions are taken for A5/3 to A5/7 when defined.

EDGE compatible TRX

A fully backward compatible TRX provides the EDGE (8-PSK and GMSK modulation schemes) capability (release dependant).

This TRX can be configured with or without the EDGE functionality on a time-slot basis. Depending on the EDGE/ no EDGE functionality choice, the RF performances for the time-slot are:

- **TX power of TRX :**

Frequency band	TX output power, **GMSK**	TX output power, **8-PSK (EDGE)**
GSM 850	45 W = 46.5 dBm –0.5/+1 dB	15 W = 41.8 dBm –0.5/+1 dB (4.7dB backoff included)
GSM 900	45 W = 46.5 dBm –0.5/+1 dB	15 W = 41.8 dBm –0.5/+1 dB (4.7dB backoff included)
GSM 1800 MP	35 W = 45.4 dBm –0.5/+1 dB	12 W = 40.8 dBm –0.5/+1 dB (4.7dB backoff included)
GSM 1800 HP	60 W = 47.8 dBm –0.5/+1 dB	25 W = 44.0 dBm –0.5/+1 dB (3.8dB backoff included)
GSM 1900	45 W = 46.5 dBm –0.5/+1 dB	25 W = 44.0 dBm –0.5/+1 dB (2.5dB backoff included)

- **RX sensitivity of TRX :**

The TRX has a RX sensitivity which allows to have at antenna connector the values given in the table below, independently from the number of combiner levels and from the frequency band.

Reference sensitivity, **GMSK**	Reference sensitivity, **8-PSK (EDGE)**
- 111 dBm (static and dynamic) - 116 dBm (dynamic with FH and diversity)	< -111 dBm, (static, MCS1) -108 dBm, (static, MCS5) -99 dBm, (static, MCS9)

Multiband capabilities

Thanks to the high flexibility of the EVOLIUM™ A9100 Base Station, GSM 850 and GSM 1800 TRXs or GSM 850 and GSM 1900 TRXs or GSM 900 and GSM 1800 TRXs can be located in the same cabinet with a single Station Unit Module (SUM).

Reception performance of the EVOLIUM™ A9100 Base Station family

The reception characteristics of any BTS is depending on two factors:

- The intrinsic sensitivity of its receiver,
- Its performance under specific mobile radio propagation conditions.

In dense urban environment, the radio propagation is mainly determined by the importance of multipath effects and the actual mobility of the mobile stations. The most severe conditions are met for quasi-stationary mobiles, for which the radio channel can be modeled as a TU3 channel, following ETSI GSM Recommendations.

The sensitivity of EVOLIUM™ A9100 BTSs (at the BTS antenna connector), which is fully guaranteed as per ETSI GSM Recommendation 11.21, is **-111 dBm** in GMSK modulation.

In dense urban environments, high capacity requirements generally lead to the choice of implementing frequency hopping for the purpose of tightening the frequency reuse scheme.

From our experience, Alcatel can assume a 2 dB gain by introducing frequency hopping. Depending on the environment conditions, up to 5 dB gain can be obtained thanks to the space diversity use.

With the EDGE compatible TRX, diversity algorithms are improved particularly for interference limited environments (directional noise):

- 0.5 dB SNR gain (Signal to Noise Ratio)
- Up to 5 dB SIR gain (compared to maximum ratio combining) (SIR: Signal to Interferer Ratio)

The reference sensitivity using the EDGE compatible TRX in 8-PSK modulation depends on the coding scheme and environment type. Values are given in the here above paragraph “EDGE compatible TRX”.

Antenna diversity

As a standard feature the A9100 configurations provide antenna diversity: two antennas per sector or one cross-polarized antenna.

Synthesizer frequency hopping

Synthesizer frequency hopping (or so-called radio frequency hopping) is supported by the whole BTS range, its use being optional. Two frequency hopping modes are available:

- Standard RF hopping mode: A cell with N TRXs can have N-1 TRXs hopping (except the TRX carrying the BCCH), on M frequencies (M usually > N).
- Pseudo baseband RF hopping mode: A cell with N TRXs can have all its N TRXs hopping on N frequencies.

Power control

According to GSM: Dynamic 30 dB - step size 2 dB.

Synchronization

The clocks can be

- generated in a pure free-run mode by an internal frequency generator,
- synchronized to an external clock reference:
  - A-bis link (PCM-synchronized),
  - Another BTS (slave mode), previous BTS generation may be used;
  - Integrated GPS receiver as an option,
  - Hardware provision for A-bis in-band signals synchronization, hence avoiding preventive maintenance for internal frequency generator calibration.

Transmission

Two physical A-bis interfaces, allowing a flexible connection of base stations to the BSC in star, chain or loop configuration, are realized according to ITU-T recommendations G.703/G.704. In case higher data throughputs (> 2 Mbit/s) are necessary on the A-bis interface e.g. due to introduction of EDGE, both A-bis interfaces can be configured as data inputs for the BTS.

In addition, Alcatel supports a signal attenuation on A-bis of up to 40 dB, which allows that base stations can be connected with increased transmission distances without any repeater. In case of BTS power shutdown, the A-bis link is not interrupted for the following BTSs (by-pass mechanism).

For A-bis termination impedance value, two standards exist : 75 Ω or 120 Ω. Depending on the country and /or the operator, the A-bis termination impedance can be one of these two values. The EVOLIUM™ A9100 Base Station accepts the two values. It is configured on site, during commissioning, to the value used by the operator.

The EVOLIUM™ A9100 Base Station supports A-bis static signaling multiplexing, where the Radio Signaling Links (RSLs) of four TRXs are submultiplexed on one 64-kbits/s PCM channel. It is thus possible to connect in particular a 3x4-TRXs configuration with only one PCM (28 time slots needed) if connected to other EVOLIUM™ BSS equipment.

The BTS also supports statistical signaling submultiplexing features (release dependant). The Statistical multiplexing on a 64-kbits/s channel enables the use of one to four RSLs and the OML on the same 64- kbits/s time slot. It will result in time-slot savings on the A-bis link.

For example, a BTS with four TRXs will take nine time slots and a BTS with two TRXs only five.

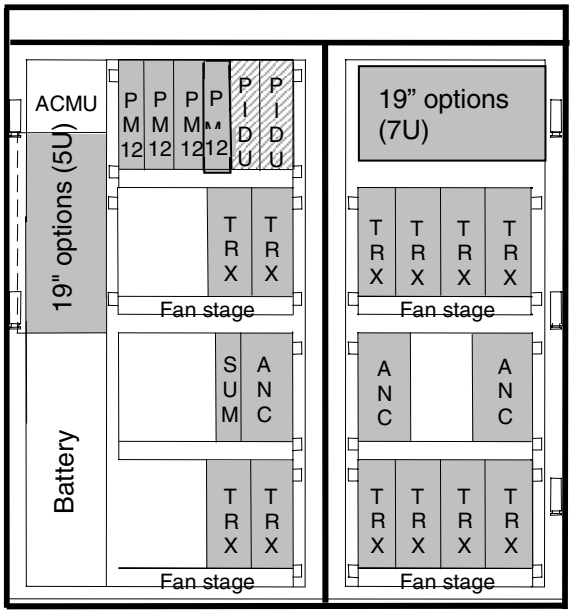
Microwave integration

A new mechanical version of the light IDU (limited to 1+0 configuration and capacity 4x2 Mbit/s) of the field-proven A9400 UX Micro-Wave, has been designed so as to be fully integrated in the indoor and outdoor cabinets as a BTS plug-in module.

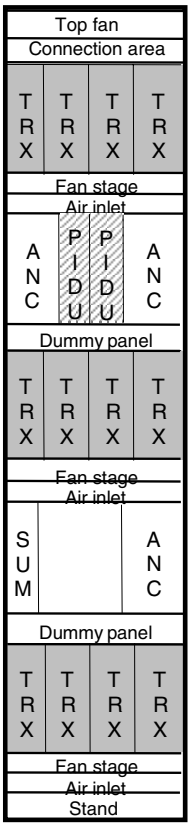
This module - called PIDU, for "Plug-in light IDU" - is located next to other BTS modules, in the same sub-racks (one PIDU is 1/6 sub-rack). One PIDU can be used per micro-wave link. 2 PIDUs can be integrated in the MBI5, MBO2 and MBO1 cabinets, hence providing the 2*(1+0) or 3*(1+0) configuration.

Notes :

- the IDU and PIDU can be used in any Abis configuration without redundancy (n*(1+ 0).
- Due to hardware architecture of PIDU, PIDU cannot be used in Abis with redundancy (n*(1+1)). Only IDU can be used in Abis redundancy. In this case, the total number of IDUs is twice the number of IDUs used in not redundant Abis configuration (e.g. 1IDU is needed for 1+ 0 configuration, and 2 IDUs are needed for 1+1 configuration)



Outdoor MBO2 3x4



Indoor MBI5 3x4

Figure 6: Integration of the Plug-in light IDU (PIDU) within Outdoor and Indoor cabinets.

This module includes the following features:

- Power supply via back panel as other BTS plug-in modules
- A-bis connector and connection to the Micro-wave Outdoor part accessible in front plate
- Monitoring of Micro-wave possible by external alarms
- Possible integration of the PIDU in the BTS remote inventory

In addition to this possibility, the outdoor cabinets include areas dedicated to 19" options: 5U in the MBO1 cabinet, 5U + 7U in the MBO2 cabinet, these areas can be used to integrate base-band part of other types of microwave equipment. The maximal number of modules that can be put in this option area is limited, by the number of available power supply connectors, to 7 modules.

GPRS

TRX hardware is prepared for broadband data applications as GPRS (release dependant).

No hardware retrofit is necessary inside the BTS for the GPRS functionality

2.2 Operation and maintenance

Station unit sharing

A single *station unit module* supports any BTS configuration, whatever the number of TRXs and sectors in one cabinet is.

Recovering - initiating

In case of interruptions on A-bis or of power supply, the BTS recovers automatically when the failure has disappeared.

The service interruption is minimized at initiation or restart: The EVOLIUM™ A9100 Base Station performs a fast restart after a breakdown (BTS software files are stored in a non-volatile memory). Only the minimum necessary files are required from the BSC.

Automatic shutdown

For AC powered EVOLIUM™ base stations, automatic progressive shutdown is performed in case of mains power failure so as to save the battery capacity, thus increasing the backup time. In such a situation, a timer is set and when it expires, TRXs are switched off with the exception of the BCCH TRX. If the BCCH TRX is configured without SDCCH and/or TCH, the TRX which carries the missing SDCCH and/or TCH is also kept powered so that calls are still possible in the cell.

When the mains comes back during battery usage, for a given time (BTS timer), the TRX previously switched off for automatic shutdown, are autonomously switched on and initialized, in order to be used by the system.

The value of the timers can be modified via the BTS terminal equipment.

The automatic shutdown feature can be activated or de-activated by the operator from BTS terminal.

Battery backup

For Indoor AC cabinet, following choices are offered depending on the backup time required:

- Small battery integrated in the Indoor AC cabinet, with backup time up to 5 minutes (depending on configuration).
- one 90 Ah battery integrated in the cabinet itself,
- up to three 90 Ah batteries in an external dedicated indoor cabinet, with no impact on the maximum number of TRX available in the Indoor AC cabinet.

For outdoor cabinet, following choices are offered depending on the backup time required (with no impact on the maximum number of TRX available in the cabinet):

- one 90 Ah battery integrated in the cabinet itself,
- up to three 90 Ah batteries in an external dedicated outdoor cabinet.

The external battery cabinet can be shared between up to 3 BTS; e.g. battery cabinet shared between 2 BTS : one BTS uses one battery and another BTS uses 2 batteries (Batteries themselves cannot not shared: each one has to be dedicated to a given BTS).

In order to avoid battery damage, a hardware mechanism powers off the BTS when the battery is at 10 % of its capacity.

Hot replacement / insertion of modules

All basic modules support hot insertion and extraction.

External alarms

For all BTSs, 16 inputs can be used for external alarms.

For the outdoor BTSs:

- 11 of the inputs are available for external equipment;
    - 3 inputs are available from outside the cabinet, with galvanic protection,
    - 8 inputs are available for optional modules inside the cabinet
- the other 5 inputs are pre-cabled inside the cabinet (heat exchanger, door, fire detector, key switch and water detector),

Power supply

Indoor EVOLIUM™ A9100 Base Stations are available in two types of configurations (see chapter "PRODUCT RANGE"):

- Indoor DC, supplied by -48 V / -60 V DC ± 20 %
- Indoor AC, supplied by 230 V AC ± 15 %.

Outdoor EVOLIUM™ A9100 Base Stations are supplied by 230 V or 400 V AC ± 15 %.

Temperature

In order to ensure appropriate cooling within the cabinets, indoor and outdoor EVOLIUM™ A9100 BTS are equipped with cooling fans. The on/off and speed of the cooling fans are controlled autonomously by the BTS, thanks to some sensors. The cooling fans are redundant modules. If a cooling fan fails, the BTS autonomously increases the speed of the other cooling fans, if necessary.

Moreover, the outdoor EVOLIUM™ A9100 BTS are equipped with heat exchangers in order to reduce the internal BTS temperature, by exchanging the heat between outside and inside the BTS.

Note : The outdoor EVOLIUM™ A9100 BTS can also be equipped with heating unit. But the function of the heating unit is the opposite of the one of the heat exchangers. In fact, the heating units are used in order to increase the BTS internal temperature when required (which in fact occurs, if ever, during very limited periods of times: see below).

Heating units

For outdoor configurations, heating units may have to be added according to the climate where the BTS is installed. They are in fact used in order to maintain the internal BTS temperature above 0°C. Note that in general, in the climate where heating units are needed, the case where the internal BTS can be below 0°C is during BTS startup. In fact, when the BTS is operational, the internal temperature increases due to heat dissipation of internal modules (e.g. TRX).

The following table gives the climate types definition and the number of heating units needed for each climate type :

Climate type	MBO1	MBO2
Temperate and cold climate	1	2
Tropical climate	0	0

Tropical climate: Temperature range according to ETS 300-019-1-3 class 3.1 (T> +5°C)
Temperate climate: Temperature range according to ETS 300-019-1-4 class 4.1 (T> -33°C)
Cold climate: Temperature range according to ETS 300-019-1-4 class 4.1E (T> -45°C)

Heat exchangers

Outdoor configurations include heat exchangers; they ensure proper heat exchanges between the inside and the outside of the cabinet, in order to reduce the BTS internal temperature, while isolating the airflow within the cabinet from the outside environment; they include their own fans (not to be confused with the cooling fans mentioned above).

Unbalanced losses/powers detection and regulation

Thanks to the Antenna network Combining (ANc) module, the BTS is able to detect unbalanced losses/powers within a sector and automatically compensate it. This enables the use of TRXs of different power within the same sector, or the use of different combining path for TRX belonging to the same sector.

Auto-detection (release dependent)

Through internal permanent hardware polling, the BTS is able to detect any new plugged-in hardware components (TRE, coupling elements…) and informs the BSC.

This facility allows to simplify and speed up the BTS extension (typically add TRE), with no need for the operator to describe explicitly neither the BTS configuration, nor its hardware capabilities.

Auto-identification

The following parameters are stored and are accessible from the BTS terminal equipment and in a second step from the OMC-R:

- Type and location for each managed module (i.e. replaceable units),
- The sector to which each Antenna Network Combining (ANc) module belongs to,
- The mapping TRX / ANc and the connectivity status,
- The hardware capabilities,
- All the installed BTS hardware and software modules.

Commissioning tests

In order to reduce the commissioning time, a set of dedicated autotests has been developed. These tests are used to check that the BTS will operate correctly according to the expected configuration. Two kinds of test can be run:

- Checking that the BTS has not suffered a fatal damage during transport and installation,
- Checking the complete BTS configuration (hardware, software, and parameter configuration).

Software migration

Thanks to the EVOLIUM™ A9100 Base Station capability to be pre-loaded and to store simultaneously two software-versions (with the possibility of activating one or the other on request from the BSC), the software migration is performed with very minimum service interruption.

Firmware downloading

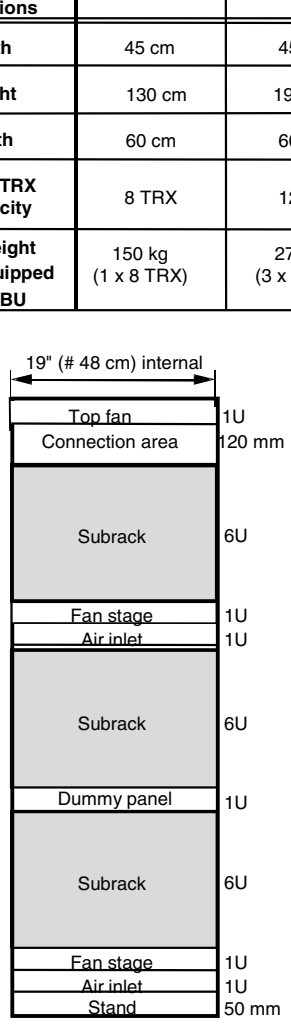
All firmware are downloadable, except boot firmware.

3. CABINET DESCRIPTION

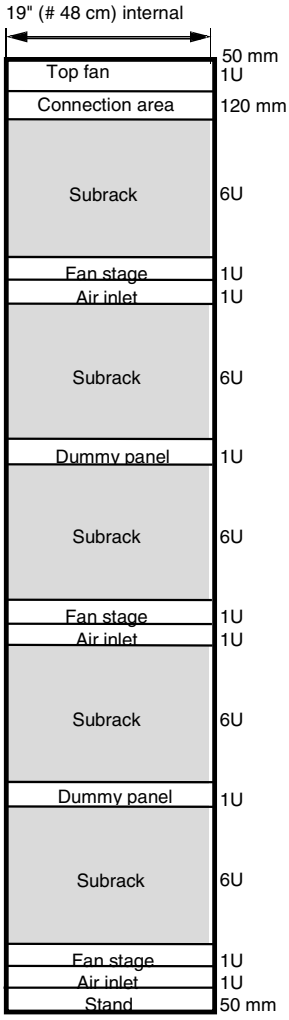
3.1 Indoor cabinet description

Two types of indoor cabinets (also called racks) are available: the MBI3 cabinet, with three sub-racks, and the MBI5 cabinet, with five sub-racks.

External dimensions	MBI3 BTS	MBI5 BTS
Depth	45 cm	45 cm
Height	130 cm	194 cm
Width	60 cm	60 cm
Max. TRX capacity	8 TRX	12 TRX
Max. weight fully equipped w/o BBU	150 kg (1 x 8 TRX)	270 kg (3 x 4 TRX)



MBI3 BTS
(3 subracks)



MBI5 BTS
(5 subracks)

Figure 7: EVOLIUM™ indoor A9100 Base Stations

The cabinet is designed for installation back to back or to the wall; installation in rows can be done.

The cabinet has no side doors; the interior can be accessed from the front (all cabling is also accessible from the front side).

The only distance constraints are:

- Front clearance 1 m (doors opening and external connections)
- Top side clearance 0.3 m (external connections)

The EVOLIUM™ MBI3 and MBI5 A9100 Base Station cabinets are generally not fixed on the floor, but positioned on leveling plates; they can be fixed on the floor as an option.

MBI3 and MBI5 are two independent cabinets. MBI3 cabinet can not then be extended to MBI5 cabinet.

The DC version of the MBI3 and MBI5 Indoor cabinets is designed to operate from external Direct Current (DC) power supply voltages (0/-48V or 0/-60V). Therefore, external power supply equipment containing AC/DC rectifiers as well as optional batteries must be added on the site.

The AC version of these cabinets is designed to operate directly from external Alternative Current (AC) main supplies (230V AC or 400 V AC). This solution avoids the use of an external power supply equipment, which is a gain in term of cost and floor space.

In case of backup need, the choice between three types of batteries is offered, depending on the required backup time: see section "Battery backup" of chapter "MAIN FEATURES AND CHARACTERISTICS" above).

When equipped for AC power, MBI3 and MBI5 include the necessary rectifiers: then, several possibilities may exist (with different maximum TRX capacity, as shown in chapter "PRODUCT RANGE"):

- inclusion of a 90 Ah (BU90) inside a MBI5 cabinet, in which case an appropriate version of this MBI5 cabinet is used, with the bottom subrack dedicated to this battery,
- using a "small battery" or using an external cabinet including up to three 90Ah batteries (BU90), in which cases there is no subrack dedicated to batteries inside the cabinet.

Tables in chapter "PRODUCT RANGE" give the exact types of configurations and maximum capacity that are available in Indoor AC.

The AC version of MBI3 and MBI5 allows to supply external modules with in 48 V DC, with up to 500 W.

3.2 Outdoor cabinet description

The EVOLIUM™ A9100 Base Station outdoor cabinets (also called racks) offer operators important flexibility with:

- An easy extension on-site from the Outdoor MBO1 BTS (up to eight TRXs capacity) to the Outdoor MBO2 BTS (up to twelve TRXs capacity),
- Dedicated empty sub-racks to answer operator needs in transmission equipment, power equipment ...,
- An easy site installation (or dismantling) due to the cabinets modularity; the most heavy module weights only 90 kg.
- a height limited to less than 150cm (with an integrated mounting plinth avoiding the need of additional frame): the constraints of site implementation are thus minimized.

External dimensions	MBO1 BTS	MBO2 BTS
Depth	74 cm	74 cm
Height	149 cm	149 cm
Width	90 cm	152 cm
Max TRX capacity	8 TRX	12 TRX
Max. weight fully equipped w/o BBU (note1)	255 kg (1 x 8 TRX)	425 kg (3 x 4 TRX)

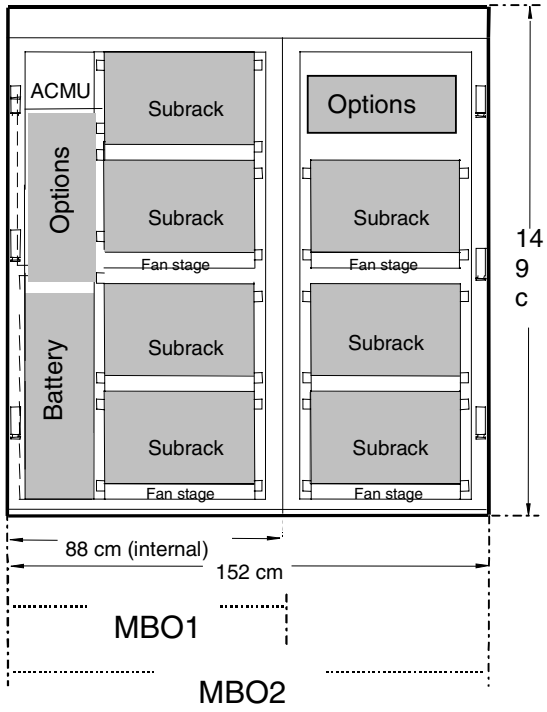


Figure 8: EVOLIUM™ outdoor A9100 Base Station

The MBO1 cabinet includes two areas:

- The area dedicated to sub-racks for TRXs, antenna coupling modules and SUM; these sub-racks are the same as those used in the indoor cabinets;

- An area dedicated to the modules that are more specific to the outdoor context (compared to the indoor case, it is more appropriate that additional equipment can be included in the cabinet itself, avoiding the need of side cabinets):

    - a dedicated mounting frame with 5U of height available for 19" options; such options might be:
        - PDUs for REK or TMA,
        - NTL (for PCM signal amplification)
        - IDUs for microwave; these IDUs typically have a height of 1U; if a DDF is to be used, its own height must be taken into consideration to determine the maximum number of IDU that can be used.
    - a "Battery support unit" sub-rack to insert a 90 Ah. battery for backup. Note that the battery contains always 4 batteries units, with 12 V each (the battery backup voltage is 48 V).

The MBO2 cabinet is obtained by adding to the MBO1 cabinet an extension cabinet (MBOE) with three standard sub-racks and a sub-rack 19" (7U) dedicated to 19" options (PDUs (for REK or TMA) or NTL (for PCM signal amplification) or IDUs (for microwave), (see note below)).

The MBO1 and MBO2 BTS allow to supply external modules with in 48 V DC, with up to 200 W.

Notes :

- The PDUs used for REK are different from the ones used for TMA
- If DDF is used for PCM interconnection, the maximal number of IDU which can be put in the option part of MBO1, is reduced to 2, since DDF needs 3U space.
- The maximal number of modules that can be put in the options area (5U in MBO1 and 12 U in MBO2), is limited by the number of available power supply connectors, to 7 modules.

3.3 Sub-rack and modules organization

The following figure gives an example of indoor and outdoor 3*4 configuration:

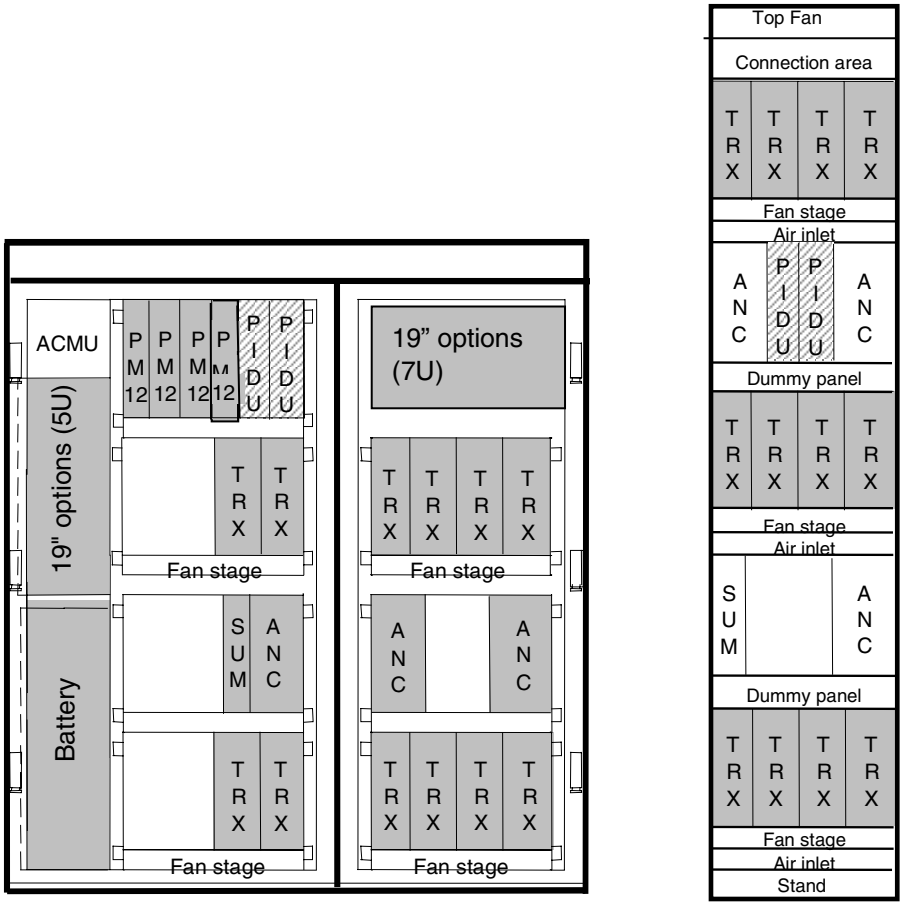


Figure 9: Sub-rack organization - configurations examples

The following rules apply for the different modules location (see Figure 10):

- In order to optimize thermal dissipation as well as RF cabling, a sub-rack is generally equipped either with TRXs only, or with a Station Unit Module (SUM) and/or antenna coupling modules.

- The sub-racks are filled alternatively as follows: The bottom sub-rack is filled with TRXs, the next one with SUM / antenna coupling modules, and so on.

- One sub-rack can accommodate up to four TRXs; The different TRXs of a given sector are filled from bottom to top and from right to left.

- At the bottom of each TRX sub-rack there is a fan stage which includes six fans. Fans speed is controlled by SUM according to the internal BTS temperature; this results in reduced average noise level and higher reliability.

Different sub-rack organizations are given in the Figure 10. The following widths hold true for the different modules (taken L for one sub-rack):

		Legend
SUM	L / 8	SUM
Antenna Network Combining	L / 3	ANC
Twin WBC stage	L / 8	ANY
TRX	L / 4	TRX
Integrated part of Microwave: Plug-in light IDU	L / 6	PIDU

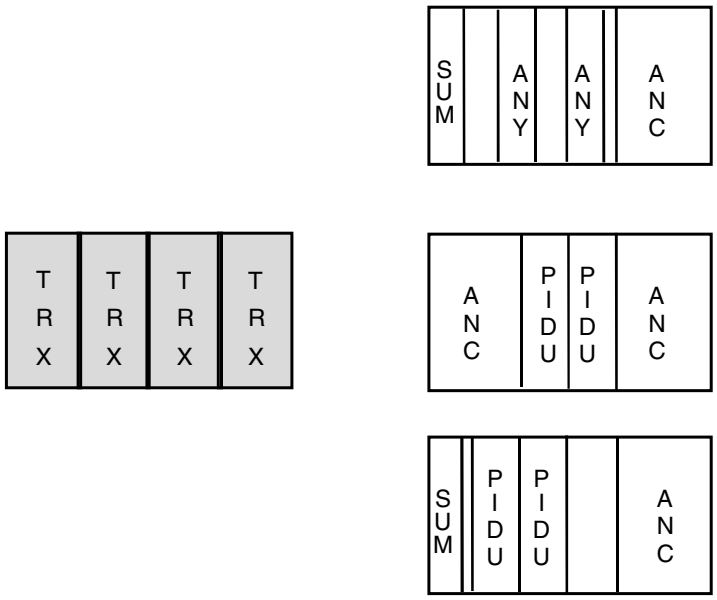


Figure 10: Sub-rack layouts

3.4 External battery cabinet for outdoor BTSs

An external battery cabinet for outdoor BTSs can contain up to three 90 Ah batteries and is adapted to those situation where long backup times are wanted for outdoor BTSs.

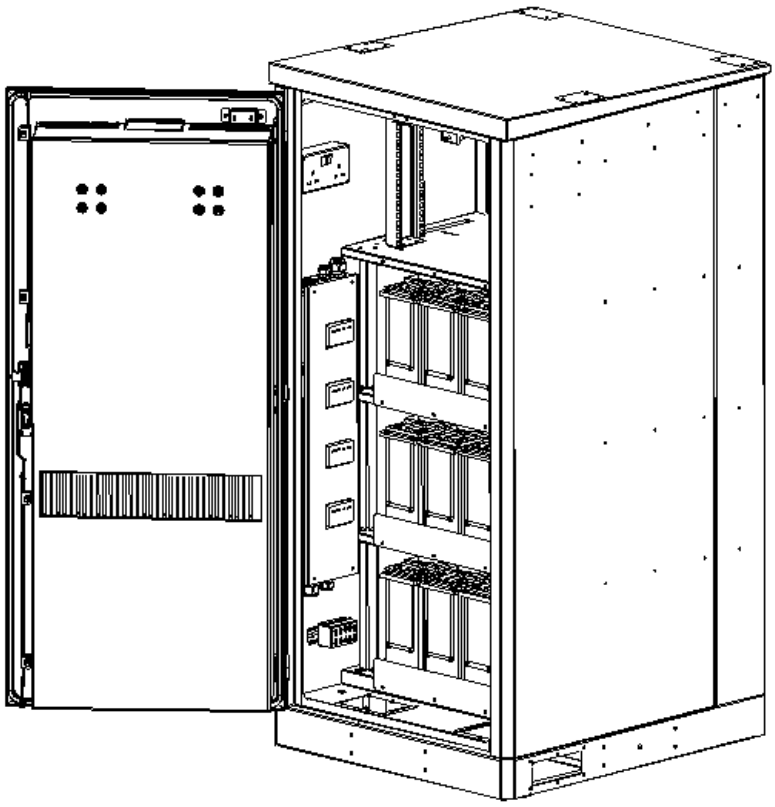
This cabinet can be equipped with an air conditioning system allowing to avoid excessive temperature (resulting from exposure to sun) and thus preserving battery lifetime.

Height	1500 mm
Width	700 mm
Depth	800 mm
Weight without batteries	180 kg
Weight with batteries	600 kg

Max. cabinet temperature at top of rack	25 ºC
Minimum cabinet temp.	0 ºC

Maximum external ambient temp.	45 ºC
Minimum external ambient temp	-33 ºC

Max. external Relative Humidity	100 %RH
Min. external Relative Humidity	5 %RH



- DC distribution module (3U) fitted at top of rack
- 3 Battery shelves
- 19 inch equipment rack
- 12V DC Smoke Alarm
- Door alarm

Environmental and Testing requirements applicable to the outdoor external battery cabinet are the following:

ETS 300 019-2-4: Class 4.1E	Operational Vibration/Shock to IEC 60721-3-4 Class 4M3
Bellcore GR-063-CORE:1995 Sec4.4.1	Earth Quake Resistance ZONE 3
EN 60529	IP 55
EN 60950:2000	Safety of information technology equipment

4. PRODUCT RANGE

The flexibility of the EVOLIUM™ A9100 Base Station architecture allows to build a wide variety of configurations answering various needs. The purpose of present chapter is to describe them in more detail.

The different possible BTS configurations are sorted in families inside which common principles are shared.

- Monoband configurations:
  - standard
  - low-loss
  - high power
  - Extended Cell
- Multiband configurations:
  - without multiband cell
  - with multiband cell

These families are defined as follows:

- ”standard” configurations:

  - a single frequency band (as opposed to multiband configurations)
  - an interface with the antenna system realized through one single ANc module in each sector (and then through two feeders and two antennas or one dual-polarized antenna); depending on the configuration, no ANy level or one ANy level (i.e. two modules) has to be used.

- ”low-loss” configurations:

  - for these configurations, the interface with the antenna system is through at least two ANc modules in each sector;
  - this allows to decrease the losses compared to a “standard” configuration with the same number of TRXs,
  - such configurations exist only above 2 TRXs per sector.

- ”high-power” configurations:

    - these configurations use the High Power (60W) TRX in 1800 MHz
    - compared to the other 1800 MHz configurations (that use a Medium Power (45W) TRX) only a subset of all the configurations is available, all with the “standard” type of coupling to the antenna system, i.e. with one ANc per sector (as opposed to the "low-loss" type; see above)

- “multiband” configurations

    - “multiband” configurations are of two possible types:
        - multiband BTS without multiband cell
        - multiband BTS with multiband cell
    - the allowed frequencies bands combinations are GSM 850 / GSM 1800, GSM 850 / GSM 1900 and GSM 900 / GSM 1800 for multiband BTS without multiband cell and GSM 900 / GSM 1800 for multiband BTS with multiband cell.
    - multiband BTS configurations without multiband cell have some sectors with TRXs of one frequency band, other sectors with TRXs of the other frequency band;
    - multiband BTS with multiband cell configurations have sectors including TRXs with both frequency bands;
    - within each band, “multiband” configurations are of “standard” type (as opposed to "low-loss"); as far as 1800 MHz is concerned, they use the Medium Power (45 W) TRX (i.e. not the “High Power” one).

- “Extended cell” configurations

    - these configurations are using two sectors organized in an inner and an outer cell:
    - inner cell is always Standard configuration 1x1..4
    - outer cell is either:
        - a low-loss configuration 1x1..4 with REK
        - a standard configuration 1x1..4 with TMA

Depending on the frequency band, all or part of those configurations families are available as described in the following tables respectively dedicated to:

- Non multiband configurations
- Multiband configurations,
  - without multiband cell
  - with multiband cell,
- Extended Cell configurations

	Sectors	Min TRX per sect.	Max TRX per sect									Notes	Frequency band (all: 850, 900, 1800, 1900)
			MBI3			MBI5				MBO1	MBO2		
			AC BU5	AC other	DC	AC BU90	AC BU5	AC other	DC				
Standard	1	1	4	4	8*	8	8	8	8	8*	8	* GSM 1900: 6	all
Standard	2	1	2	2	4*	4	6***	6***	6***	4*	6**	* GSM 1900: 3 ** 8,4 allowed *** idem ** plus GSM 1900: 5	all
Standard	3	1	1	1	2*	2	4***	4***	4***	2**	4	* 3,2,2 allowed ** 3,3,2 allowed *** GSM 1900: 3	all
Low-loss	1	3	4	4	4	8	12*	12*	12*	8**	12	* GSM 1900 : 10 ** GSM 1900 : 6	all
Low-loss	2	3							6*		6	* GSM 1900 : 5	all
Low-loss	3	3									4		all
High power	1	1					4	4	4	4			1800
High power	2	1	1	1	1		4	4	4	2	4		1800
High power	3	1					3	3	3	2	4		1800

Note: "AC other" is referring to the Indoor AC configurations without integrated battery, i.e. either with no battery, or with batteries in an external cabinet.

Summary of non multiband configurations

Sectors in 1st band	Sectors in 2nd band	Max. number of TRX in 1st band	Max. number of TRX in 2nd band	Type of cabinet
1	1	4	4	MBO1; MBO2
1	1	6	6	MBI5 (except -AC-BU90); MBO2
1	1	8	4	MBI5 (except -AC-BU90; -AC-BU5); MBO2
1	2	4	4,4	MBI5 (except -AC-BU90); MBO2
1	3	4	4,2,2	MBI5 (except -AC-BU90; -AC-BU5); MBO2
2	2	2,2	4,4	MBI5 (except -AC-BU90; -AC-BU5); MBO2
3	3	2,2,2	2,2,2	MBO2

Summary of multiband without multiband cell configurations

Sectors		Max. number of TRX in 1st band	Max. number of TRX in 2nd band	Type of cabinet
1		4	4	MBO1; MBO2
1		6	6	MBI5 (except -AC-BU90); MBO2
1		8	4	MBI5 (except -AC-BU90); MBO2
2		2,2	4,4	MBI5 (except -AC-BU90; -AC-BU5); MBO2
2		4,2	4,2	MBI5 (except -AC-BU90; -AC-BU5); MBO2
2		3,3	3,3	MBI5 (except -AC-BU90; -AC-BU5); MBO2
3		2,2,2	2,2,2	MBO2

Summary of multiband with multiband cell configurations

Min. Number of TRX		Max. number of TRX		Type of cabinet	Frequency band
Inner	Outer	Inner	Outer		
1	1	4	4	MBI5; MBO2	900

Extended Cell configurations

Following chapters detail the characteristics specific to each of these families, especially regarding the arrangement of Antenna Network Combiners (ANc), Wide Band Combiners (ANy) and TRXs.

A table in chapter "Overview of EVOLIUM™ Base Station main characteristics" lists the "output power at antenna connector" available in the different sector arrangements, an output power at antenna connector that depends on:

- the output power of the TRX itself, for each frequency band and each type of modulation (GMSK / 8PSK)
- the number of combiner levels, that depends itself on the number of TRXs per sector, and whether the combiner pre-equipment option is selected or not.

4.1 Standard configurations

The interface with the antenna system is through one single *Antenna network combining* (ANc) module in each sector (and then through 2 feeders and two antennas or one dual-polarized antenna).

The building of configurations regarding the number and type of used modules, depends on the number of TRX per sector and is done in the following way:

- One ANc in No-combining mode per sector for configurations from 1 up to 2 TRX in the sector
- One ANc in combining mode per sector for configurations from 3 up to 4 TRX in the sector
- Two ANys (one level) per sector for configurations from 5 up to 8 TRX in the sector

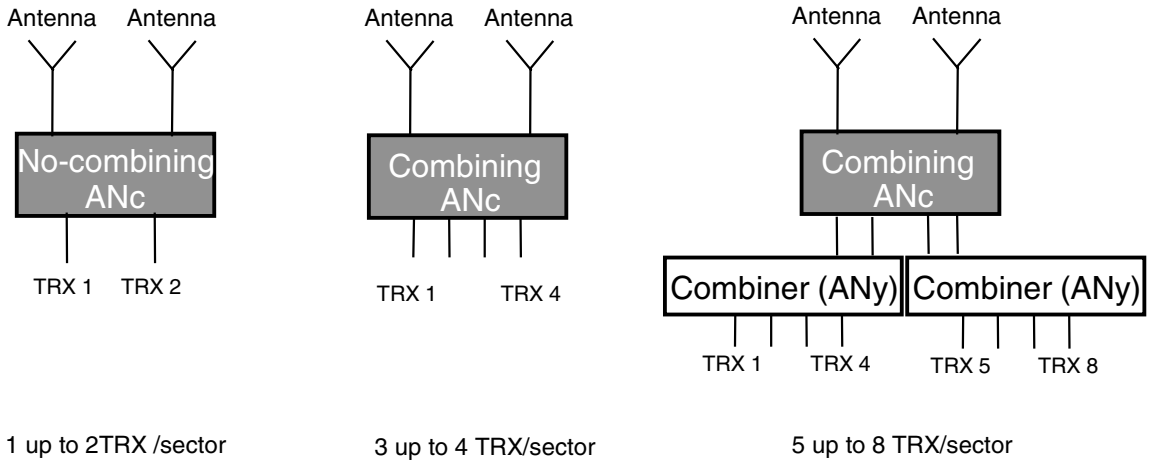


Figure 11: Standard configurations

The number of sectors and TRXs depends on the cabinet type, with a maximum of 3 sectors and 12 TRXs in a Indoor MBI5 or an Outdoor MBO2 cabinet (see table above for details).

The different sectors of a given BTS can include different numbers of TRXs. Sectored sites requiring more TRXs than indicated in the table above can be achieved by means of two or three BTSs; EVOLIUM™ A9100 Base Stations can be combined with BTSs of other generations at the same site.

As an option, configurations can be pre-equipped so that the TRX extension involves a minimum outage or time intervention. For initial configuration with 1 or 2 TRXs per sector, the pre-equipment is realized simply by configuring the ANc module in the combining mode. For initial configuration of higher capacity, the combiner stage is added. This pre-equipment facility is especially suitable for urban sites where capacity extensions are foreseen, as it enables to maintain the same cell-coverage radius.

4.2 Low-loss configurations

The principle of low-loss configurations, is to decrease the losses in one sector compared to standard configurations with the same number of TRX, by decreasing the number of combiner (ANy) level, therefore increasing the number of antennas in the sector.

The low-loss configurations use the *Antenna Network Combining* module (ANc) and if necessary *Twin Wide Band Combiner* module(s) (ANy), in the following way:

- Two ANc per sector (therefore four antennas or two with cross-polarized antenna per sector)
- Two ANc per sector in No-combining mode for configurations from 3 up to 4 TRX in the sector
- Two ANc per sector in combining mode for configurations from 5 up to 8 TRX in the sector

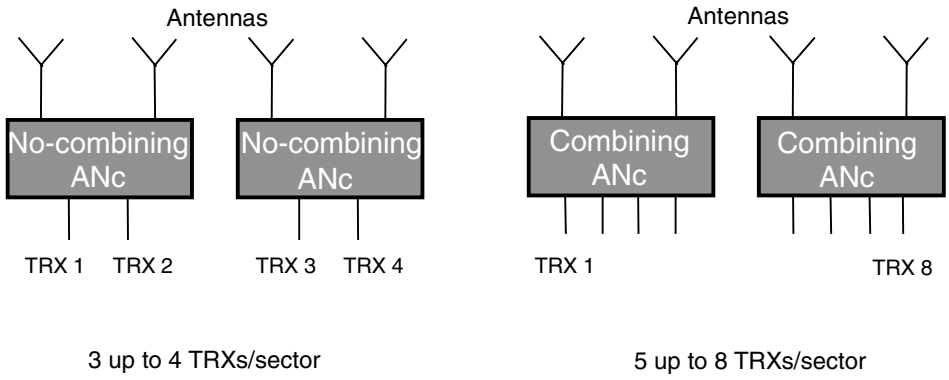


Figure 12: Low-loss configurations for more than two TRXs per sector

Furthermore Alcatel proposes a 1x12-TRX configuration based on this principle: Antenna Network Combining module (ANc) are affected to the same sector, requiring four antennas (or two cross-polarized antennas) (Figure 13). The unbalanced losses are autonomously compensated by the BTS.

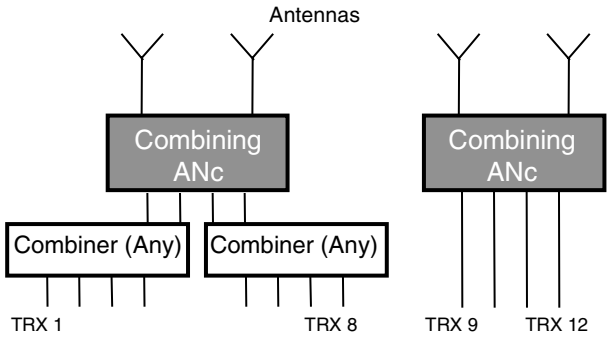


Figure 13: 1x12-TRX low-loss configuration

4.3 Multiband configurations

All EVOLIUM™ A9100 Base Stations have been designed so as to allow multiband operation, following the 'One-cabinet concept': The same cabinets, the same sub-racks are used for all possible configurations with GSM 850, GSM 900, GSM 1800 or GSM 1900 elements.

Multiband configurations include GSM 850 and GSM 1800 modules or GSM 850 and GSM 1900 modules or GSM 900 and GSM 1800 modules, in the same cabinet with a single Station Unit Module (SUM), which handles the control functions of the BTS (operation and maintenance, transmission, clock generation ...).

Alcatel proposes two types of multiband configurations depending on way BCCH is handled: one BCH in each band ("without multiband cell"), or a common BCCH ("with multiband cell").

On the hardware point of view, there is no difference between a configuration "without multiband cell" and its equivalent "with multiband cell"; only the SUM software (part of the BSS software package) is different.

All configurations installed in a single-band infrastructure can be upgraded for multiband operation, in either multiband BTS without multiband cell or multiband BTS with multiband cell mode, by inserting transceivers and antenna-coupling modules operating in the second band and by downloading the relevant software version and data base.

As already mentioned, the 1-sector configurations - single BCCH - are similar on a hardware point of view to the 2-sector configurations of the multiband BTS - dual BCCH; the 2-sector configurations - single BCCH - are similar on a hardware point of view to the 4-sector configurations of the multiband BTS - dual BCCH - and the 3-sector configurations - single BCCH - are similar on a hardware point of view to the 6-sector configurations of the multiband BTS - dual BCCH.

4.3.1 Multiband BTS configurations without multiband cell

GSM 850 and GSM 1800 bands or GSM 850 and GSM 1900 bands or GSM 900 and GSM 1800 bands, are affected to different sectors of the base station. It means that each band has its own BCCH. The following figure gives an example of a 4 sectors multiband BTS without multiband cell configuration:

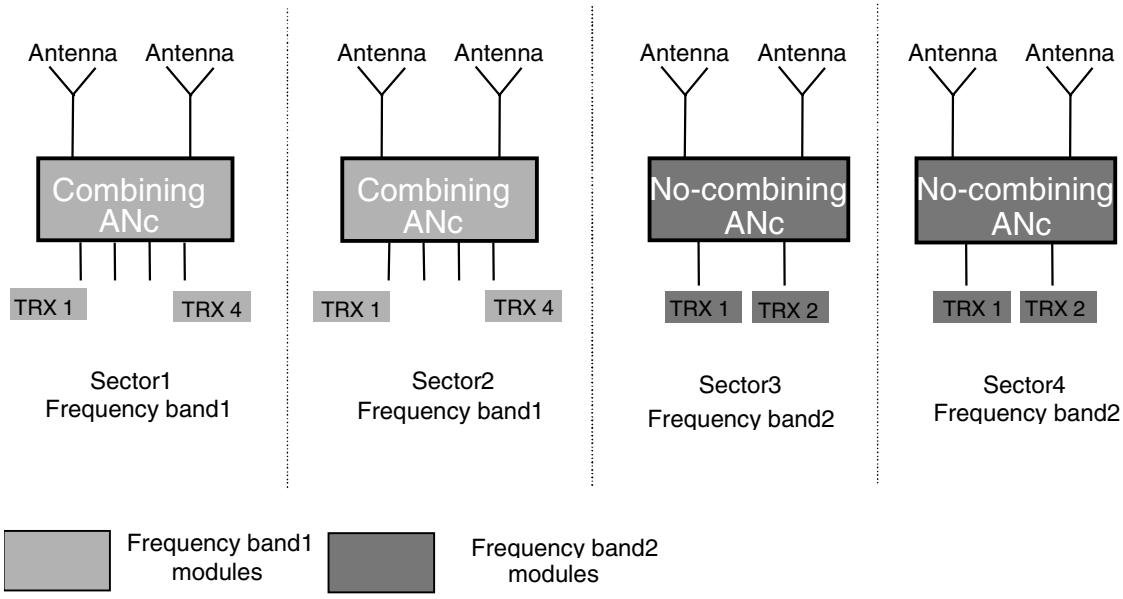


Figure 14: Multiband BTS without multiband cell configuration (four sectors)

4.3.2 Multiband BTS configurations with multiband cell

GSM 900 and GSM 1800 bands are assigned to the same sector. There is only one BCCH for both bands. These configurations are supported by the software release B6. The following figure gives an example of a 2 sectors multiband BTS configuration with multiband cells:

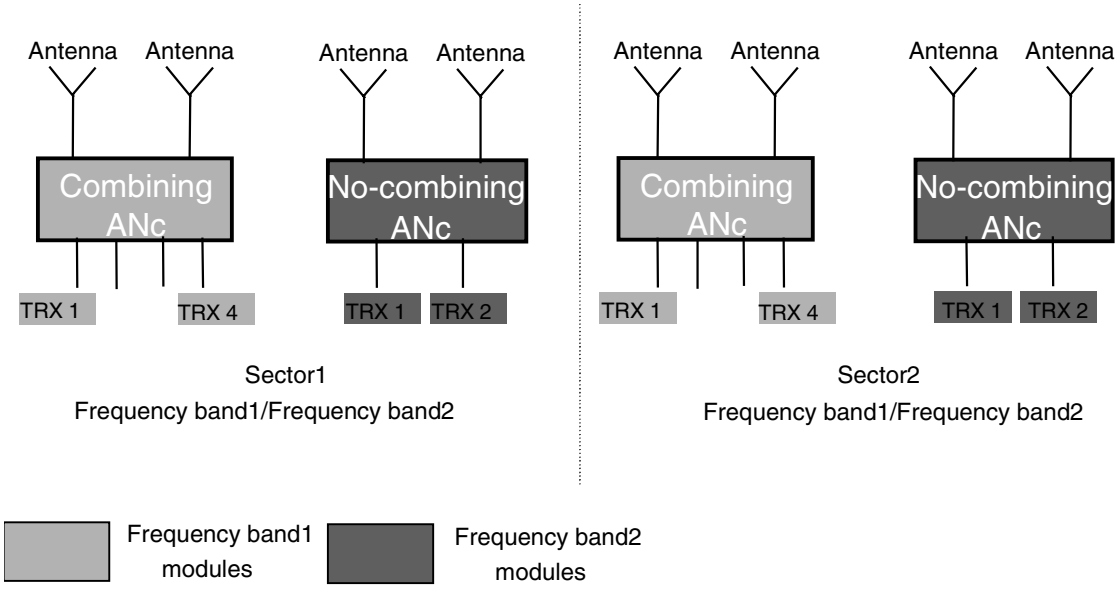


Figure 15: Multiband BTS configurations with multiband cell (two sectors)

4.4 High-power GSM 1800 configurations

To reach a sufficient coverage area and a high quality of service with the smallest number of sites is the goal of all operators of new networks. Especially critical is the coverage optimization for networks using a higher frequency band like GSM 1800.

An important coverage improvement with EVOLIUM™ A9100 Base Stations is achievable by use of High-Power TRX (TRX HP). Alcatel offers a High-Power TRX for GSM 1800 configurations with 47.78 dBm (**60 W**) +/-0.5 dB as output power (before combining). These A9100 configurations, with a guaranteed sensitivity of -111 dBm, will ensure a 2.3-dB gain in the path loss.

4.5 Configurations built with several cabinets

4.5.1 Configuration built with several cabinets and no split of sectors over two cabinets

If the needed site configurations (indoor or outdoor, single band or multiband) can not be achieved with a single cabinet, it can be done using several collocated and synchronized cabinets. In that case, all the TRXs of one sector must belong to the same cabinet. Different configurations are possible, if the following conditions are fulfilled :

- Maximal number of collocated cabinets is 3.
- Maximal number of TRX per cell is 12.

Hereafter, are given some examples. The list is not exhaustive.

Examples:

- The 3x6 TRXs Standard Indoor configuration is made of:
  - one MBI5 Indoor Standard 1x6 TRXs cabinet
  - one MBI5 Indoor Standard 2x6 TRXs cabinet
- The 3x8 TRXs Standard Indoor configuration is made of:
  - three MBI5 Indoor Standard 1x8 TRXs cabinet
- The 3x4 MBI5 Outdoor High power configuration is made of:
  - one MBO1 Outdoor High power 1x4 TRXs cabinet
  - one MBO2 Outdoor High power 2x4 TRXs cabinet
- The 3x4 / 3x4 outdoor (MBO2) standard multiband configuration is made of:
  - one MBO2 standard 3x4 frequency band1 cabinet
  - one MBO2 standard 3x4 frequency band2 cabinet

4.5.2 Configuration built with several cabinets and the “cell split over two BTSs” feature

It is possible to optimize the number of cabinets needed for a site configuration (indoor or outdoor, single band or multiband) built with more than one cabinet, thanks to a feature called “cell split over two BTSs” (release B7).

In that case, the TRXs of one sector, can be split over two cabinets. Different configurations are possible, if the following conditions are fulfilled :

- Maximal number of collocated cabinets is 3.
- Maximal number of TRX per cell is 12.
- Maximal number of cabinets where a cell is shared is 2.

Hereafter, are given some examples. The list is not exhaustive.

- Standard 3x8 in two cabinets

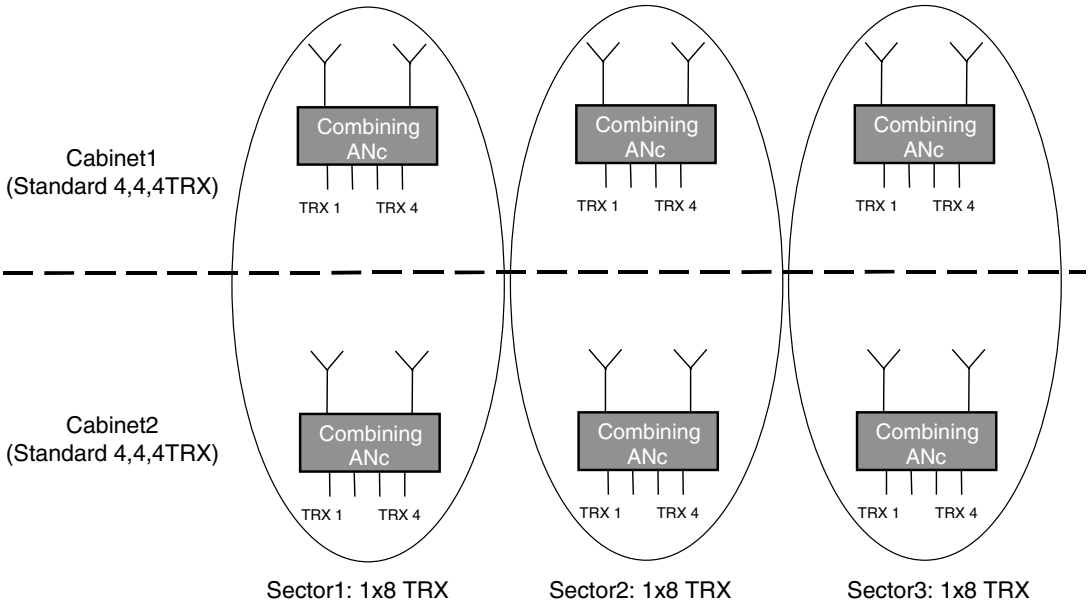


Figure 16: Standard 3x8 TRXs in two cabinets

- 3x6 TRXs High power in two cabinets

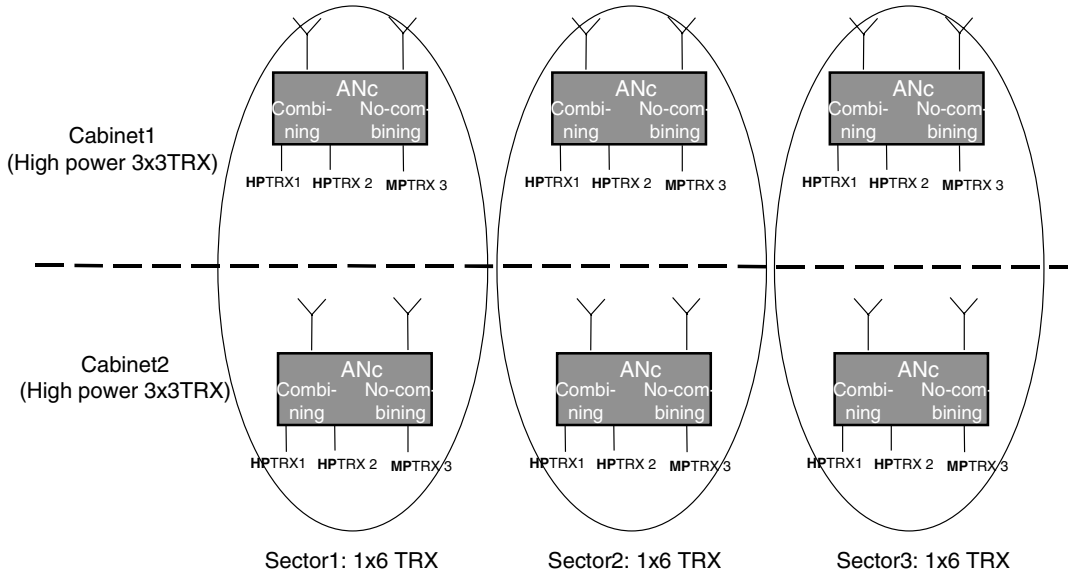


Figure 17: 3x6 TRXs High power in two cabinets

- Very low-loss 3x6 TRXs (3 antenna systems per sector, outdoor BTS only) in two cabinets

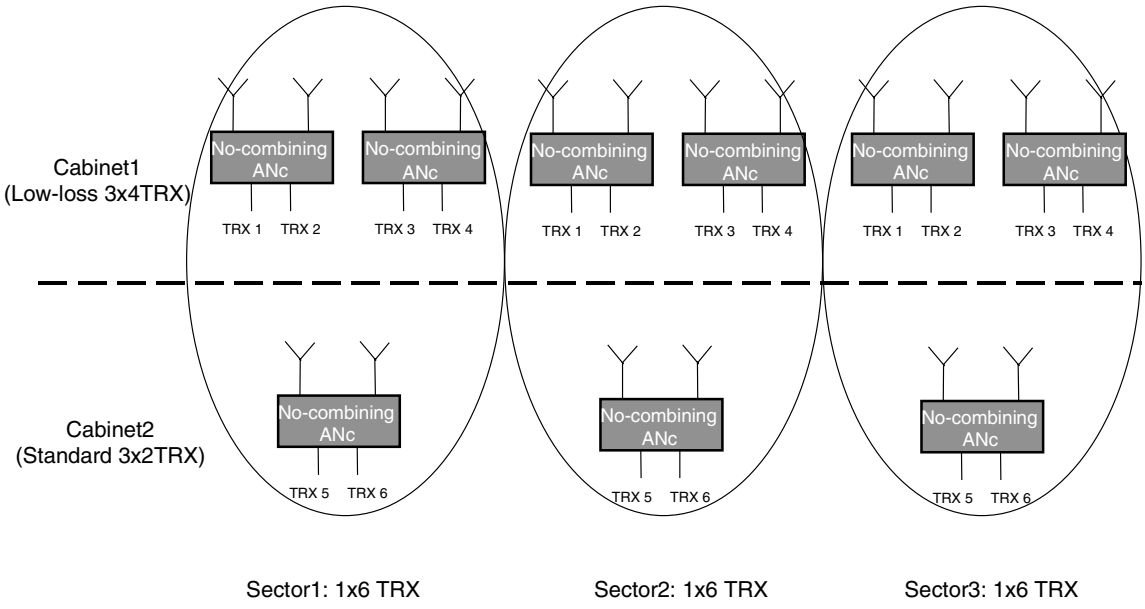


Figure 18: Very low-loss 3x6 TRXs (outdoor BTS only) in two cabinets

- **Very low-loss 3x8 TRXs (3 antenna systems per sector, outdoor BTS only) used in "concentric cell" in two cabinets**

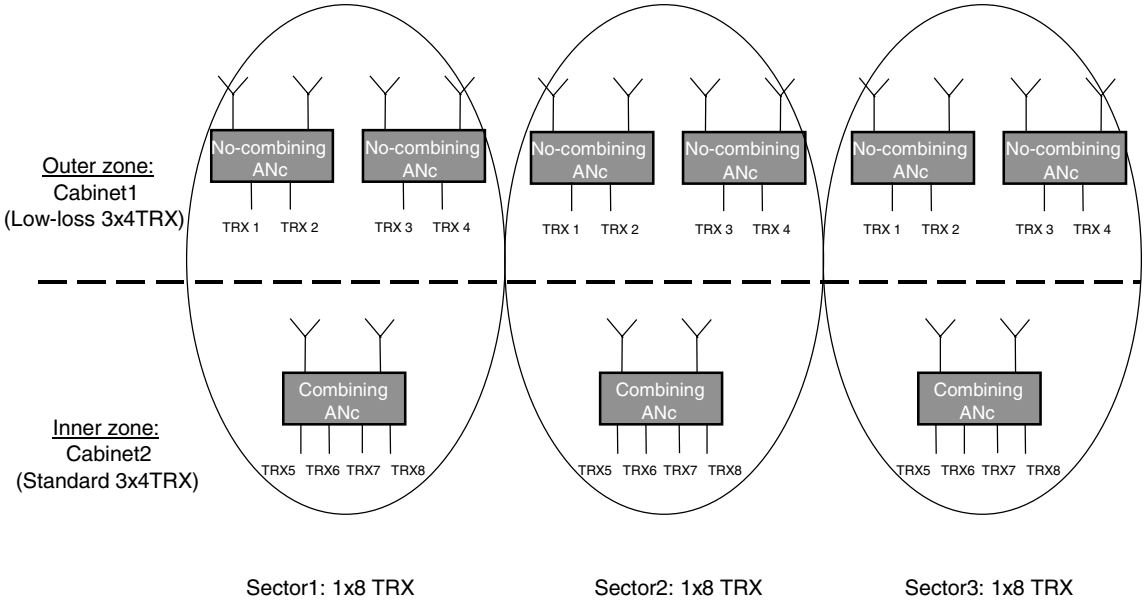


Figure 19: Very low-loss 3x8 TRXs (outdoor BTS only) in two cabinets

- **Standard multiband 3x4 / 3x4 in two cabinets**

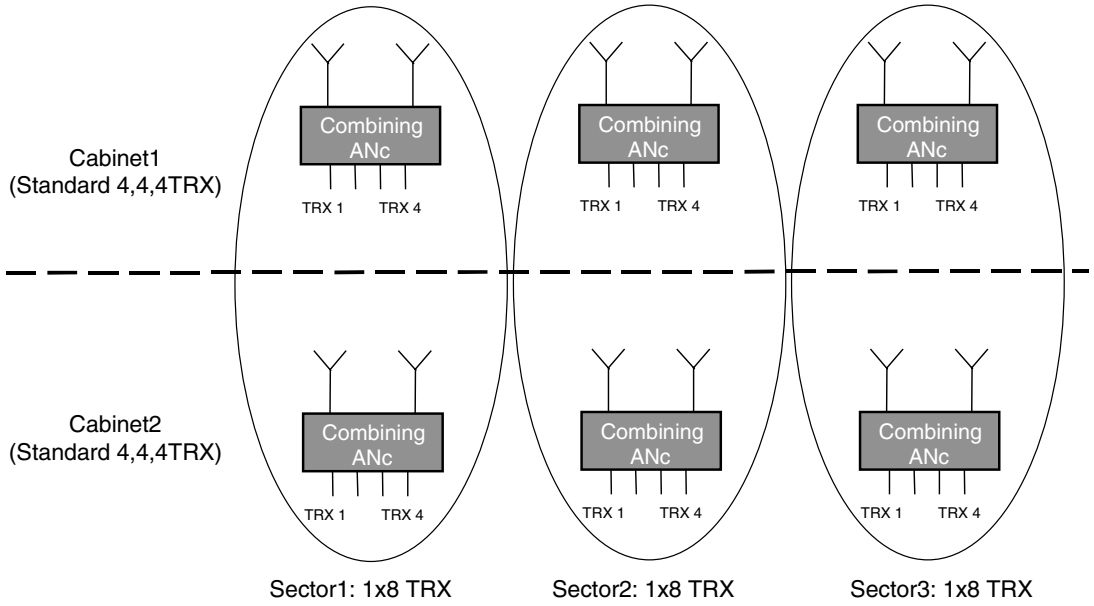


Figure 20: Standard multiband 3x4 / 3x4 TRXs in two cabinets

4.6 Extended cell configurations

To provide a continuous coverage minimizing the number of sites is the goal of all operators. Particularly difficult is to reach this goal in sparsely populated areas, because of the 35 kilometers limitation in cell size stipulated by GSM recommendations.

The Extended-cell technology, which allows reaching a coverage range of up to 70 km, is a solution in low traffic density areas as rural areas, highways, off shore, desert areas, isles in coastal vicinity...

Due to the propagation limitation constraint of GSM 1800 and GSM 1900 frequencies, the extended cell solution is used only for GSM 900.

An extended cell is composed of one EVOLIUM™ BTS including two sectors. The first sector handles inner-cell traffic up to 35 km; the second sector handles outer-cell traffic, from 33 km to a maximum of 70 km. Depending on the needed traffic, each sector can include from 1 up to 4 TRX.

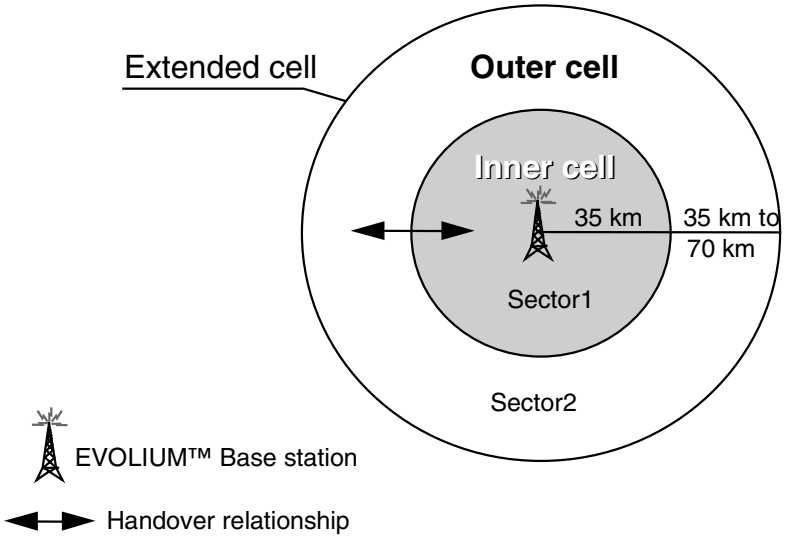


Figure 21: Extended cell principle

To compensate for the propagation delay of bursts from mobiles located in the outer cell, the receiver of the outer cell BTS is delayed. The inner cell is barred and the receiver of the Inner cell BCCH TRE is tuned to the outer cell BCCH frequency. Wherever the mobile is located (Inner, Outer or overlap zone) it always camps on the outer cell (for initial access). If the mobile is located within the Inner cell, the channel for the Inner cell will be allocated by the Outer cell. Because the Inner cell is barred, the Inner cell must be completely covered by the Outer cell area.

Active call mobiles moving from the inner cell to the outer cell, or vice versa, will be handed over to the complementary cell respectively. Mobiles leaving the extended cell coverage will be handed over to an appropriate neighbor cell which can be either a normal or an extended cell. This clever use of hand-over procedures is in full accordance with standard GSM parameters.

To achieve the coverage range up to 70 km for the Outer cell, the use of high gains and high height antennas or the use of either a range extension kit (REK) or a TMA is advised.

Extended cell EVOLIUM™ BTS using Range Extension Kit (REK):

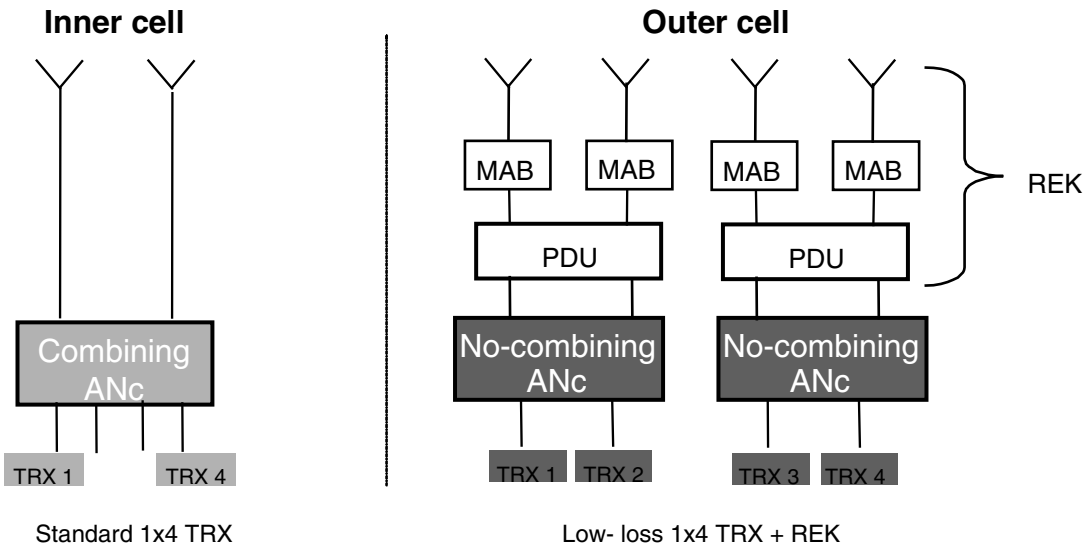


Figure 22: Extended cell EVOLIUM™ BTS using Range Extension Kit (REK)

Extended cell EVOLIUM™ BTS using Tower Mounted Amplifier (TMA):

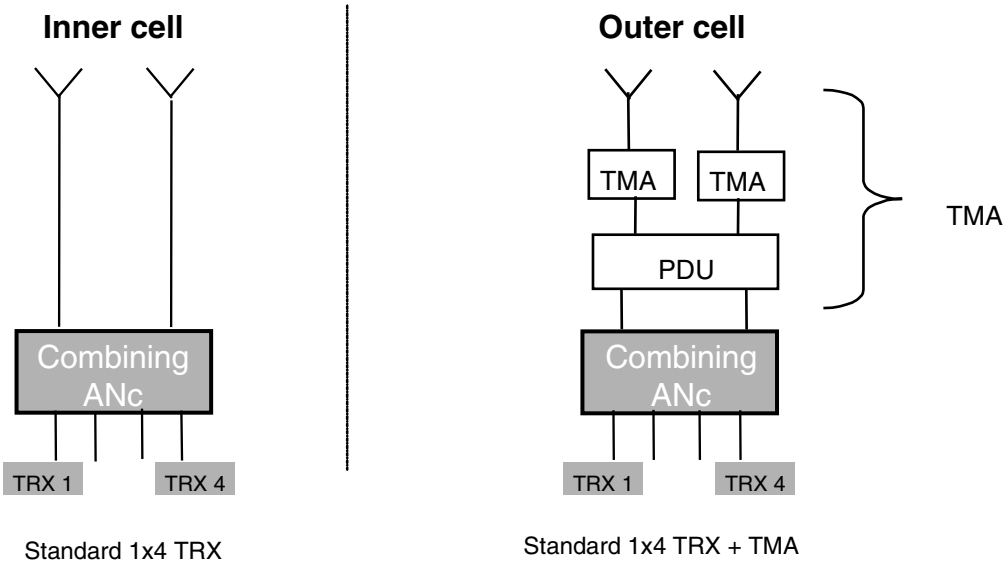


Figure 23: Extended cell EVOLIUM™ BTS using Tower Mounted Amplifier (TMA)

Therefore the possible configurations with associated Outer cell coverage (as examples) are:

MBI5 Indoor	Low-tree / Outdoor* Outer cell range	Open area/ Outdoor* Outer cell range	Agriculture/ Outdoor* Outer cell range
Inner cell: Standard 1x..4 Outer cell Low-loss 1x..4 with REK	52 km	70 km	70 km
Inner cell: Standard 1x..4 Outer cell Standard 1x..4 with TMA	38 km	70 km	65 km

*: 19 dBi antenna gain

4.7 Options

4.7.1 Range extension kit

4.7.1.1 Functional description

The Range Extension Kit (REK) is intended to provide operators with enhanced coverage solutions (in uplink and in downlink) applicable to a variety of practical situations (in terms of mobile environment). The range extension kit has been designed as an add-on to the complete family of EVOLIUM™ A9100 Base Stations; it shall be applicable whenever a maximum coverage range is sought, provided that there is no coupling of TRX in the cell (in fact, the REK is not broadband).

The REK has been designed so as to compensate the feeder losses encountered in most of the practical situations (up to 10 dB, allowing to use 1/2" thin cables) and to provide 62 dBm maximum EIRP with a balanced link budget. It is available in the GSM 900 band, and can be used with indoor or outdoor BTS.

The overall design of the range extension kit is consistent with the architectural options selected for EVOLIUM™ A9100 Base Stations: Use of duplexed outputs and of the air-combining scheme. Further-more, it is intended for use with antenna systems featuring one separate transmit antenna per radio channel.

The range extension kit is composed of two functional blocks:

- A two-way amplification module (called the *Mast-head Amplification Box* or *MAB*) to be installed close to the antenna, featuring Power Amplification (PA) downlink and Low-Noise Amplification (LNA) uplink, along with proper supervision means.

- A Power Distribution Unit (PDU) provides power supply and alarm interface for two MABs. It is located at the BTS site, either wall-mounted close to the BTS in the case of an indoor site or integrated inside the BTS cabinet in the case of an outdoor BTS.

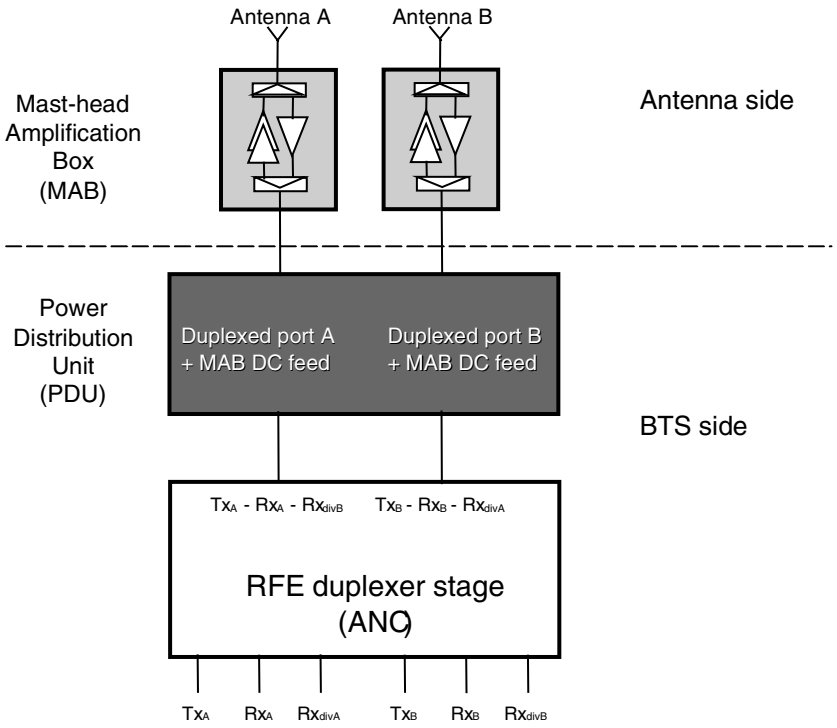


Figure 24: REK - Functional block diagram

4.7.1.2 RF performance

- Downlink, the output power of the mast-head equipment (including output filter) is 44.5 dBm (28 W) +/- 1.5 dB. To adapt the amplifier to the different BTS types and antenna cable losses, the REK is equipped with a fixed attenuator (8 dB) and a variable attenuator (from 0 to 15.5 dB) in front of the amplifier. The power amplifier of the MAB is 24.4 dB and the max nominal MAB gain, for variable attenuator set to 0 dB, is 14.1 dB (this corresponds to MAB gain minus the different losses (fixed attenuator (8 dB), loss ar MAB input (0.85 dB) and loss after amplification (1.45 dB)).
- Uplink, the receiver amplifier is made of a single balanced stage of high-performance LNAs. The maximum overall gain measured from the antenna input to the output of the MAB is 16 dB for GSM 900. The receive amplifier includes a manually settable attenuator at its output, allowing to decrease the gain by 10 dB in 1-dB steps in order to adapt for the different cable lengths.

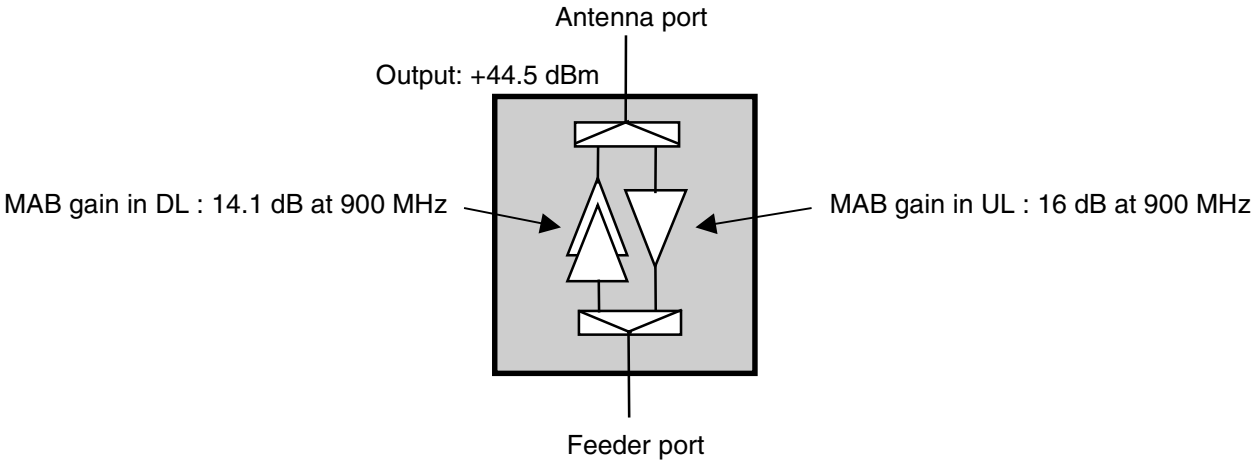


Figure 25: REK - RF characteristics of mast-head amplification box

4.7.1.3 Configurations

The REK is applicable to a wide variety of A9100 indoor and outdoor configurations in GSM 900. The main constraint is that there must be no TX coupling in the BTS, i.e. only one TRX can transmit on each antenna (one MAB per TRX); therefore there must be (at least) as many antennas as TRXs.

One PDU is required per two TRXs and these two TRXs do not need to belong to the same sector, e.g. the 3x1-TRX configuration requires only two PDUs (and three MABs).

The PDU can be housed in an outdoor cabinet in the optional sub-rack with up to three PDUs capacity.

The possibilities are summarized in the following table:

Configuration	Number of PDU per sector	Number of MAB per sector
Standard 1TRX/sector	1	1 if diversity not required
Standard 1TRX/sector	1	2 if diversity required
Standard 2TRX/sector	1	2
Low-loss 3TRX/sector	2	3 if diversity not required
Low-loss 3TRX/sector	2	4 if diversity required
Low-loss 4TRX/sector	2	4

4.7.2 Tower-mounted amplifier

4.7.2.1 Functional description

A significant part of the benefits brought by the outstanding sensitivity of the EVOLIUM™ A9100 Base Station can be lost if the losses incurred by signals along the feeder cable between the receiving antenna and the antenna coupling module (ANc) are too high. As a matter of fact the noise factor of the system is degraded by an amount depending on the feeder loss.

The basic idea of tower-mounted amplification is to implement a low-noise amplifier as close as possible to the antenna (figure below), so as to compensate for all losses incurred by received signals. The TMA solution can be used in GSM 900 or 1800, indoor or outdoor configurations.

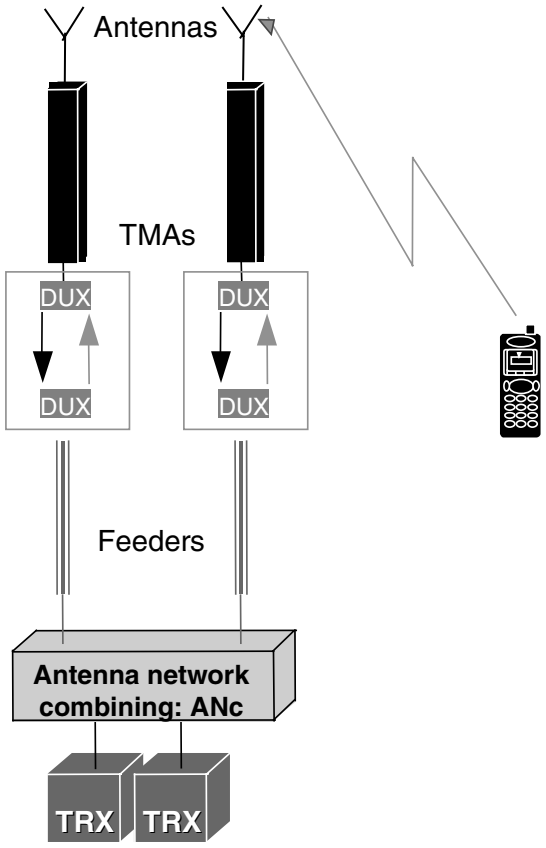


Figure 26: Principles of tower-mounted amplification

Tower-mounted amplification appears as an efficient sensitivity enhancement technique; however, both uplink and downlink power budgets must be considered for the calculation of the coverage range: The smallest available path loss determines the range. In that respect, tower-mounted amplification can be beneficial in those cases where system performance is limited by a weaker uplink budget (for example when using GSM 1800 High-Power TRX without the combiner module - *twin wide band combiner stage*-ANy).

On the other hand, in the case of a balanced uplink/downlink situation, the introduction of tower-mounted amplification can be an efficient mean to reduce the output power level of all mobile stations. The uplink power control mechanism provided at each base station will force all mobiles to reduce their emission level. Two benefits can be obtained in that case:

- A lower output power favorably impacts the standby time of every mobile station,
- A lower output power can contribute to minimize the 'electromagnetic pollution' within the service area.

In summary, the decision to exploit tower-mounted amplification may be influenced by system design considerations but also result from the application of the operator's internal policy.

The counterpart of getting a better sensitivity by means of a tower-mounted amplifier is the risk to degrade the blocking and intermodulation characteristics of the base station if the value of the amplification gain greatly exceeds the value of the feeder losses. The attention of operators is drawn to the fact that, in such a case, the site equipment might not fully comply with ETSI requirements settled in the GSM recommendation 05.05.

All EVOLIUM™ A9100 Base Stations are compatible with tower-mounted amplifiers, provided the following requirements are fulfilled:

- The TMA shall allow for one single feeder to be used for transmit and receive signals,

- The TMA shall be equipped with duplexers, allowing for the splitting of uplink and downlink signals with at least 30 dB isolation. The transmit signal shall be bypassed to the antenna and the receive signal shall be amplified by a low-noise amplifier.

- Multiband configurations are possible only if the signals used in each antenna are monoband (in fact, TMA module which is used per antenna, is monoband).

4.7.2.2 Equipment description

The TMA system is basically made of three part parts (Figure below):

- The mast-head TMA. Note that the LNA of the TMA has a gain depending on the frequency band (e.g. 14 dB for GSM 900), but the TMA solution gain, which takes into account all the UL reception chain (e.g. feeders loss) is 4 dB in GSM 900 and GSM 1800. Note that this TMA can provoke intermodulation and/or blocking in the mobile, if the antenna is installed in a height less than 20 meter.
- The bias tee, used for insertion of the DC voltage in the RF antenna cable to feed the TMA. The proposed bias tee is suited for GSM 900 and GSM 1800.

- The Power Distribution Unit (PDU) is used for the power supply for the TMA units itself and for alarm monitoring (via BTS external alarms).
  The PDU is designed to supply and to monitor up to six TMAs (typical BTS configuration 3x2 TRXs), independently from their frequency band (i.e. same PDU equipment can be used with TMA of GSM 900 or 1800. In fact PDU has no frequency notion).

  For indoor-BTS installations the PDU can be installed in a separate transmission cabinet and be powered by the BTS UPS. For outdoor-BTS configurations the DC supply should be provided by the BTS power supply and the installation is possible in the BTS cabinet. However, an AC PDU with outdoor characteristics could also be used.

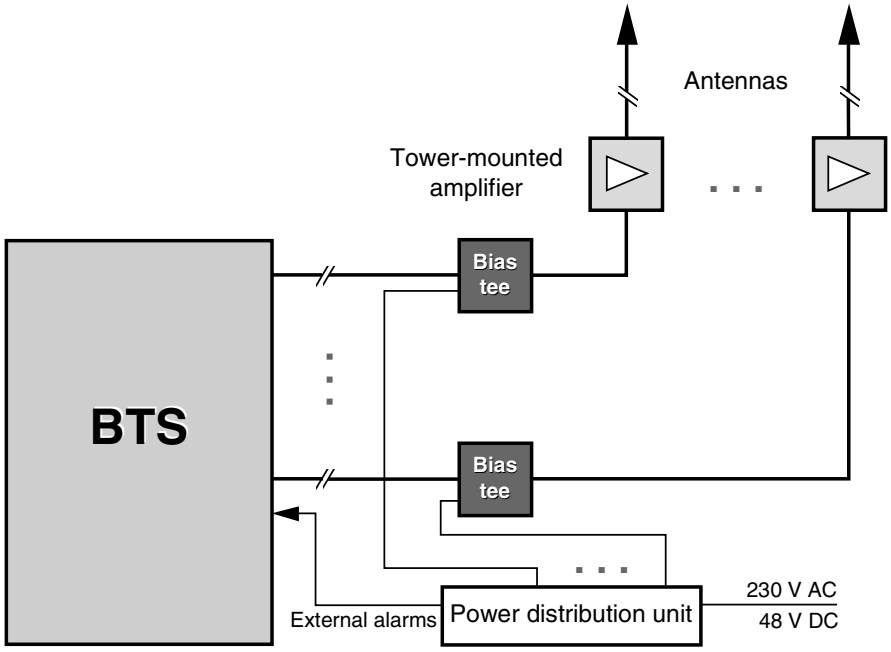


Figure 27: TMA principle of installation

4.7.3 Transmission equipment

For the outdoor BTS, transmission equipment can be integrated in the options space of the cabinet : 19” (5U) in MBO1 and 19” (5U + 7U) in MBO2. Two types of transmission equipment are possible:

- Line termination equipment for 75-ohm or 120-ohm wires (NTL). The NTL equipment is used to amplify the PCM signal received from A-bis interface.
- Baseband unit for microwave (IDU).

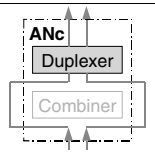
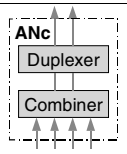
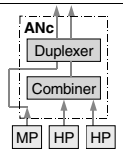
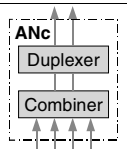
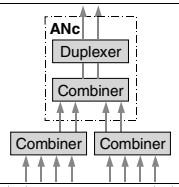
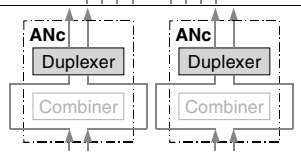
These equipment depend on the country and customer requirements and are defined on a case by case.

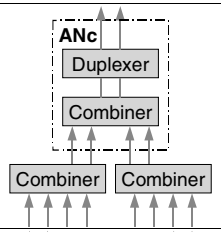
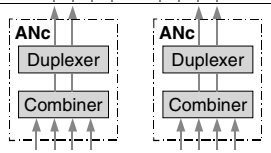
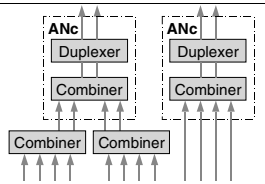
In MBI and in MBO, we can also integrate up to 3 PIDUs.

4.8 Output power at antenna connector

The following table gives the "output power at antenna connector" available in the different combinations of

- frequency band
- type of modulation (GMSK / 8PSK)
- number of TRX per sector
- ANc mode (Combining / No combining) when relevant
- Any preequipment, when relevant

	Type	Combiner pre-equipment	ANc mode	Configuration	Total combiner stages	Output power in dBm at antenna connector for GSM 850 GMSK 45 W	GSM 850 8PSK 15 W	GSM 900 GMSK 45 W	GSM 900 8PSK 15 W	GSM 1800 GMSK 35 W	GSM 1800 8PSK 12 W	GSM 1800 GMSK 60 W	GSM 1800 8PSK 25 W	GSM 1900 GMSK 45 W	GSM 1900 8PSK 25 W
1	Standard	no	No Combining		0	46.0	41.2	46.0	41.2	44.4	39.8	46.5	42.6	46.0	42.6
2	Prepared	(yes)	Combining		1	42.6	37.8	42.6	37.8	41.0	36.4	42.7	39.5	42.6	39.5
3*)	Standard	no	Combining		0 & 1							42.7	39.5		
3	Standard	no	Combining		1	42.6	37.8	42.6	37.8	41.0	36.4	42.7	39.5	42.6	39.5
	Pre-equipped	yes	Combining		2	39.1	34.3	39.1	34.3	37.5	32.9			39.1	36.6
4	Low-loss	no	No Combining		0	46.0	41.2	46.0	41.2	44.4	39.8			46.0	42.6

	Type	Combiner pre-equipment	ANc mode	Configuration	Total combiner stages	Output power in dBm at antenna connector for GSM 850 GMSK 45 W	GSM 850 8PSK 15 W	GSM 900 GMSK 45 W	GSM 900 8PSK 15 W	GSM 1800 GMSK 35 W	GSM 1800 8PSK 12 W	GSM 1800 GMSK 60 W	GSM 1800 8PSK 25 W	GSM 1900 GMSK 45 W	GSM 1900 8PSK 25 W
5 6	Standard	no	Combining		2	39.1	34.3	39.1	34.3	37.5	32.9			39.1	36.6
7 8	Low-loss	no	Combining		1	42.6	37.8	42.6	37.8	41.0	36.4			42.6	39.5
9 10 11 12	Low-loss	no	Combining		1 & 2	42.6	37.8	42.6	37.8	41.0	36.4			42.6	39.5

Output TX power at antenna connector

*) This arrangement is used for the 3 x 3 TRX BTS in one MBI5-cabinet for thermal reasons.

5. ENVIRONMENTAL AND EMC ASPECTS

5.1 Environmental conditions

The environmental conditions define the limits (temperature, humidity, etc.) for BTS cabinets in operation, storage, and transportation conditions as specified in the following classes:

EVOLIUM™ Base Station	Indoor	Outdoor
Operation	ETS 300 019-1-3 class 3.1E (see note 1)	ETS 300 019-1-4 class 4.1E (see note 4)
Transportation	ETS 300 019-1-2 class 2.2 (see note 2)	ETS 300 019-1-2 class 2.2 (see note 2)
Storage	ETS 300 019-1-1 class 1.2 (see note 3)	ETS 300 019-1-1 class 1.2 (see note 3)

Note 1: The ETS 300 019-1-3 class 3.1E (temperature controlled locations) is a combination of classes 3K3 (but with low air temperature of -5 °C, high air temperature of +45 °C, and high relative humidity of 90 %), 3Z2, 3Z4, 3B1, 3C2, 3S2 and 3M1 according to IEC721-3-3.

Note 2: The ETS 300 019-1-2 class 2.2 (careful transportation) is a combination of classes 2K3, 2B2, 2C2, 2S2 and 2M1 according to IEC721-3-2.

Note 3: The ETS 300 019-1-1 class 1.2 (weather protected, not temperature controlled) is a combination of classes 1K4, 1Z2, 1Z3, 1Z5, 1B2, 1C2, 1S3 and 1M2 according to IEC721-3-1.

Note 4: The ETS 300 019-1-4 class 4.1E (non-weather protected locations, extended) is a combination of classes 4Z5, 4Z7, 4B1, 4C2, 4S2 and 4M3 according to IEC721-3-4.

In the following tables, the conditions for the different environmental classes are listed.

Climatic conditions for indoor operation, outdoor operation and storage:

Environmental parameter	Unit	indoor operation ETS 300 019-1-3 Class 3.1E	outdoor operation ETS 300 019-1-4 Class 4.1E	storage ETS 300 019-1-1 Class 1.2
Low air temperature	°C	-5	-45	-25
High air temperature	°C	+45 (Note 1)	+45 (Note 2)	+55
Low relative humidity	%	5	8	10
High relative humidity	%	90	100	100
Low absolute humidity	g/m³	1	0.03	0.5
High absolute humidity	g/m³	25	30	29
Rain intensity	mm/min	-	15	no
Rate of change of temperature	°C/min	0.5	0.5	0,5
Low air pressure	kPa	70	70	70
High air pressure	kPa	106	106	106
Solar radiation	W/m^2	700	1120	1120
Heat radiation	W/m^2	600	Negligible	Note 3
Movement of the surrounding air	m/s	5	50	30
Conditions of condensation	none	no	yes	yes
Conditions of precipitation (rain, snow, hail ...)	none	no	yes	yes
Low rain temperature	°C	-	5	no
Conditions of water from sources other than rain	none	no	Splashing water	Dripping water
Conditions of icing and frosting	none	no	yes	yes

Note 1: Apart from this maximum temperature, the EVOLIUM™ Base Station supports direct exposure to solar radiation, with power up to 700 W/m^2.

Note 2: Apart from this maximum temperature, the EVOLIUM™ Base Station supports direct exposure to solar radiation, with power up to 1120 W/m^2.

For Outdoor cabinet, Maximum temperature extended to:

GSM900:

- up to +50 °C: for long term operation with all TRX transmitting with maximum power on all timeslots
- up to +55 °C: for long term operation of a full configuration (12TRX : 3*4) under realistic conditions (3 BCCH TRX with 100 % output power on all timeslots, the other TRXs with 60 % of TS used, at power: Pmax - 2 dB)

GSM1800

- up to +45 °C: for long term operation with all TRX transmitting with maximum power on all timeslots

- up to +50 °C: for long term operation of a full configuration (12TRX : 3*4) under realistic conditions (3 BCCH TRX with 100 % output power on all timeslots, the other TRXs with 60 % of TS used, at power: Pmax - 2 dB)

Note 3: Conditions of heat radiation (e.g. in the vicinity of a room-heating system)

Mechanically active substances for indoor operation, outdoor operation and storage:

Environmental parameter	Unit	indoor operation ETS 300 019-1-3 Class 3.1E	outdoor operation ETS 300 019-1-4 Class 4.1E	storage ETS 300 019-1-1 Class 1.2
Sand	mg/m³	30	300	300
Dust (suspension)	mg/m³	0.2	5	5
Dust (sedimentation)	mg/(m²h)	1.5	20	20

Mechanical conditions for indoor operation, outdoor operation and storage:

Environmental parameter	Unit	indoor operation ETS 300 019-1-3 Class 3.1E		outdoor operation ETS 300 019-1-4 Class 4.1E		storage ETS 300 019-1-1 Class 1.2	
Stationary vibration, sinusoidal							
- Peak displacement amplitude	mm	0.3		1.5		1.5	
- Peak acceleration amplitude	m/s^2		1		5		5
- Frequency range	Hz	2 to 9	9 to 200	2 to 9	9 to 200	2 to 9	9 to 200
Non-stationary vibration including shock							
- Shock-response spectrum type L, peak acceleration	m/s²	40		70		40	
Static load	KPa	-		-		5	

Earthquake conditions for outdoor equipment:

Earthquake test conditions are in accordance with ETS 300 019-2-4 Amendment A1.
As the Outdoor Base Station can be mounted on top of buildings using a structure of high rigidity, following test conditions apply:

Parameter	Description	Severity
Earthquake intensity	Strong/very strong Richter > 7	ag = 5 m/s² ZPA = 15 m/s²
Frequency range	-	1 – 35 Hz
Excitation	-	Single axis, 30 s

The Outdoor Base Station survives test without major damage to equipment. Interruption of operation is allowed. Re-start of operation after test is possible. Minor damages, if any, can be repaired in the field.

Climatic conditions for transportation:

Environmental parameter	Unit	transportation ETS 300 019-1-1 Class 1.2
Low air temperature	°C	-25
High temperature, air in unventilated enclosures	°C	+70
High temperature, air in ventilated enclosures or outdoor air	°C	+40
Change of temperature air/air	°C	-25/+30
Change of temperature air/water	°C	+40/+5
Relative humidity, not combined with rapid temperature changes	% °C	95 +45
Relative humidity, combined with rapid temperature changes air/air at high relative humidity	% °C	95 -25/+30
Absolute humidity, combined with rapid temperature changes air/air at high water content	g/m^3 °C	60 +70/+15
Low air pressure	kPa	70
Change of air pressure	kPa/min	no
Movement of the surrounding medium air	m/s	20
Precipitation, rain	mm/min	6
Solar radiation	W/m^2	1120
Heat radiation	W/m^2	600
Water from sources other than rain	m/s	1
Wetness	none	Conditions of wet surfaces

Mechanically active substances for transportation:

Environmental parameter	Unit	transportation ETS 300 019-1-1 Class 1.2
Sand in air	g/m^3	0.1
Dust (sedimentation)	$mg/(m^2h)$	3

Mechanical conditions for transportation:

Environmental parameter	Unit	transportation ETS 300 019-1-1 Class 1.2		
Stationary vibration, sinusoidal				
- Peak displacement amplitude	mm	3.5		
- Peak acceleration amplitude	m/s^2		10	15
- Frequency range	Hz	2 to 9	9 to 200	200 to 500
Stationary vibration random				
- Acceleration spectral density	m^2/s^3	1		0.3
- Frequency range	Hz	10 to 200		200 to 2000
Non-stationary vibration				
- Shock response spectrum I:				
Peak acceleration	m/s^2	100		
- Shock response spectrum II:				
Peak acceleration	m/s^2	no		
Free fall				
- Mass < 20 kg	m	0.25		
- Mass 20 to 100 kg	m	0.25		
- Mass > 100 kg	m	0.1		
Toppling				
- Mass < 20 kg		Toppling around any of the edges		
- Mass 20 to 100 kg	none	no		
- Mass > 100 kg		no		
Rolling pitching				
- Angle	degree	no		
- Period	s	no		
Steady state acceleration	m/s^2	20		
Static load	kPa	5		

5.2 Electromagnetic Compatibility (EMC)

All EVOLIUM™ A9100 Base Stations fulfill the requirements of the European Directive ETSI ETS 301 489 -1 and 8.

5.3 Acoustic noise

The EVOLIUM™ A9100 base station complies with class “environmentally sensitive areas to ETS 300 019-1-4 class 4.1” according to GSM recommendation 11.22 with a maximum sound pressure level of less than 55 dB(A) for daytime operation.

5.4 Safety

The EVOLIUM™ A9100 Base Station complies with following safety standards:

- IEC 215 (EN 60 215): Safety requirements for radio transmitting equipment
- IEC 950 (EN 60 950): Safety of information technology equipment

5.5 Product Environmental Attributes

Alcatel is committed to develop and improve operations and technologies taking into consideration the efficient use of energy and materials, giving preference to renewable resources, minimizing waste and adverse environmental aspects.

Alcatel develops and manufactures products and services that are safe for their intended use, efficient in their use of energy, protective to the environment and that can be recycled or disposed of safely, including their packaging.

Materials

The above described product does not contain:

- asbestos,
- cadmium (in plastic materials, packaging and inks),
- mercury,
- ozone depleting substances, according to those categories that are already banned in the Montreal protocol
- chloroparaffins with chain length 10-13 C atoms, chlorination greater than 50% contained in the mechanical plastic parts heavier than 25g,
- lead contained in mechanical plastic parts heavier than 25g,
- PCB or PCT,
- polybrominated biphenyls and their ethers (CAS 32534-81-9, 32536-52-0, 1163-19-5, 13654-09-6) contained in mechanical plastic parts heavier than 25g,

in concentrations exceeding the natural background.

Disassembly

The system is designed for easy disassembly, by using screws and rivets for mechanical assembly of racks and modules

Batteries

Alcatel uses as backup batteries state-of-the-art valve regulated lead acid (VRLA) batteries with an extended service life-time. These VRLA AGM (absorptive glass mat) battery types are classified as non-hazardous. This is because in the VRLA AGM cells, the dilute sulphuric acid is absorbed in a special, highly porous micro-fibre glass separator. This, together with a high density pillar seals and hermetic container-to-lid bonding, ensures that acid is unable to leak out.

The batteries are designed and manufactured according to recognized international standards as

- IEC 60896-2
- 91/157/EEC (hazardous substances)
- BS 6290 Part 4
- ICAO/IATA Special Provision a 67
- US DoT regulation 49 CFR section 173.159

The weight of the batteries backup units amounts to

- BU 90Ah 140 kg (4 cells with a weight of 35 kg each)

Batteries, battery cases, battery acid, lead and lead compounds must not be burned, must not be disposed of in accordance with the appropriate national/international legislation, and Local Waste Disposal Authority Rules and regulations.

Product packaging

The packaging of the EVOLIUM™ A9100 Base Stations complies with the Directive 94/62/CE concerning packaging and packaging waste. Depending on the means of transportation the BTS are packed in a cardboard or wooden box, which can easily be recycled after use. Environmental harmful materials are not used for packaging. The packaging materials are marked according to ISO 11 469. If required by the customer and agreed by both parties, Alcatel can take care of the proper disposal of all packaging materials.

Take back information

On request of the customer, Alcatel can take care of the take back of the depreciated equipment and of the ecological safe and appropriate disposal. For that purpose, Alcatel co-operates with qualified recycling companies.

Documentation

In order to reduce the paper consumption for Customer Documentation, Alcatel delivers the Generic Customer Documentation as a CD-ROM. This allows the operator to put the documentation on a server accessible by all relevant people without any additional paper copies.

Additionally more specific documentation as e.g. information about products and solutions, services and support, training events etc. will be provided by means of an Extranet accessible by all customers. This will allow distribution of up-to-date information very quickly and without wasting natural resources.

6. POWER CONSUMPTION, BACKUP TIMES AND POWER DISSIPATION

6.1 Introduction

Power consumption is a characteristic of BTS equipment that can be used for different purposes:

- Assessing the requirement for internal batteries or for external Power Supply Systems in order to guarantee a backup time in case of mains power failure
- Assessing the average energy requirement, and hence the average energy bill
- Assessing the characteristics of the energy distribution system: e.g. how should fuse or breakers be dimensioned.

Although these aspects are all related to power consumption, it's not the same kind of power consumption that should be taken into account in each case:

- "DC power consumption for backup" is the power consumption to consider to determine which batteries should be used to provide a given backup time, or what backup time can be expected with given batteries; this is applicable for example to AC powered BTSs when they are running on their backup batteries; this power consumption

    - considers only the DC power consumption of the modules, not including the power consumption of the AC to DC conversion that takes place in the AC powered BTSs (and that typically adds another 12%)
    - considers an average power consumption: the purpose of such a power consumption figure is get a reasonable estimate of the power consumption on a long period of time (typically between 2 and 8 hours): typical assumptions are:

        - either "one TRX "full power", the other at 60%" in each sector", or, if Auto Shutdown feature is enabled, "one TRX "full power" in each sector" ("full power" and "60%" respectively mean "with all the TimeSlots used", or with "5 out of 8 time slots used")
        - no consideration of power consumption of modules such as Heating Units (they are supposed to be used for a very short time at BTS start-up only; normally, they are not in operation during a backup period) or Battery Charging for the AC powered BTSs including batteries (by definition, battery charging does not take place during a backup period since the mains are not available)

- Power consumption in normal circumstances: this figure allows to estimate the average energy bill; for DC BTSs, it is the same as the one described above; for AC BTSs, it takes into account the additional power corresponding to AC to DC conversion:

- applicable to DC and AC powered BTSs (i.e. outdoor BTSs and AC Indoor BTSs)
- considers the DC power consumption of the modules (as above) plus, for the AC BTSs, the power consumption of the AC to DC conversion
- in each sector, one TRX is taken for its full power, the others for their power at "60%"
- power consumption of Heating Units or Battery Charging is ignored

- Maximum power consumption: this figure allows to determine the characteristics of the power distribution circuit (ability to withstand important currents):

  - applicable to DC and AC BTSs (i.e. outdoor BTSs and AC Indoor BTSs)
  - considers the DC power consumption of the modules (as above) plus, for the AC BTSs, the power consumption of the AC to DC conversion
  - in each sector, all TRXs are taken for their full power,
  - in addition, one may consider:

    - the power consumption associated to battery charging when, after a backup period, the batteries have to be loaded to their full capacity
    - the power consumption of heaters; adding this to the previous power

    This should be used only to estimate the peak power consumption; the two additional power consumptions above take place during exceptional periods, and should not take place simultaneously:

    - battery charging is a permanent process; however, its associated power consumption is only significant when the battery have been discharged, i.e. after a backup period during which mains were not available
    - Heating Units, or heaters, are only used in very cold situations, at BTS start-up, to bring the BTS at a minimum temperature; they are not used during normal use of a BTS

6.2 Power consumptions

Power consumptions of main modules are given in following table:

	DC power consumption (W)		AC power consumption (W)	
	"Full Power"	"60%"	"Full Power"	"60%"
TRX 900	154	105	172	118
TRX 850	154	105	172	118
TRX 1800	141	96	158	108
TRX 1800 HP	246	162	276	181
TRX 1900	212	141	237	158
ANC	10		11	
MBO1 cabinet	170		190	
MBO2 cabinet	310		347	
MBI3 cabinet	50		56	
MBI5 cabinet	70		78	
Battery Charging			400	
Heating Units (1)			300	

(1) Power consumption of Heating Units is given for information; it should not be considered in the assessment of power consumptions below, since Heating units are only used for a limited time in specific situations where other components of the BTS have not reached their full power;

Power consumptions of a BTS configuration according to the possible hypotheses can then be derived as follows:

- For "DC power consumption for backup":

  - only the DC power consumptions have to be considered (even for AC BTS)
  - as far as TRXs are concerned, two situations can be considered:
    - taking, for each sector of a BTS, one TRX for its "full power", the others at "60%"
      or
    - taking, for each sector of a BTS, only one TRX for its "full power" and ignoring the others.
      This second possibility is based on the assumption that the "Auto Shutdown" is enabled, with all TRXs except the BCCH switched off after a given time has elapsed.

- For "Power consumption in normal circumstances":

  - DC or AC power consumptions have to be considered, depending on the type of BTS,
  - in each sector of a BTS, one TRX must be taken for its "full power", the others at "60%"

- For "Maximum power consumption":

  - DC or AC power consumptions have to be considered, depending on the type of BTS,
  - all TRXs must be taken at their "full power"
  - for outdoor BTSs, depending on the conditions that are judged typical, Battery Charging or Heating Unit Power consumption may be added

As an example, the power consumptions of an MBO2 3x4 TRX1800 are:

		Unit	Qty	Total (W)
DC Power consumption for Backup "Auto Shutdown" not enabled				
MBO2 3x4 TRX1800				**1627**
	MBO2	310	1	310
	TRX 1800 "full power"	141	3	423
	TRX 1800 "60%"	96	9	864
	ANC	10	3	30
DC Power consumption for Backup "Auto Shutdown" enabled				
MBO2 3x4 TRX1800				**763**
	MBO2	310	1	310
	TRX 1800 "full power"	141	3	423
	TRX 1800 "60%"	96	0	0
	ANC	10	3	30
Power consumption in normal circumstances				
MBO2 3x4 TRX1800				**1826**
	MBO2	347	1	347
	TRX 1800 "full power"	158	3	474
	TRX 1800 "60%"	108	9	972
	ANC	11	3	33
Maximum power consumption				
MBO2 3x4 TRX1800				**2676**
	MBO2	347	1	347
	TRX 1800 "full power"	158	12	1896
	ANC	11	3	33
	Battery charging	400	1	400

This example shows how to determine the power consumptions according to various hypotheses; it also shows that TRXs constitute the main factor, due to their power consumption and their number.

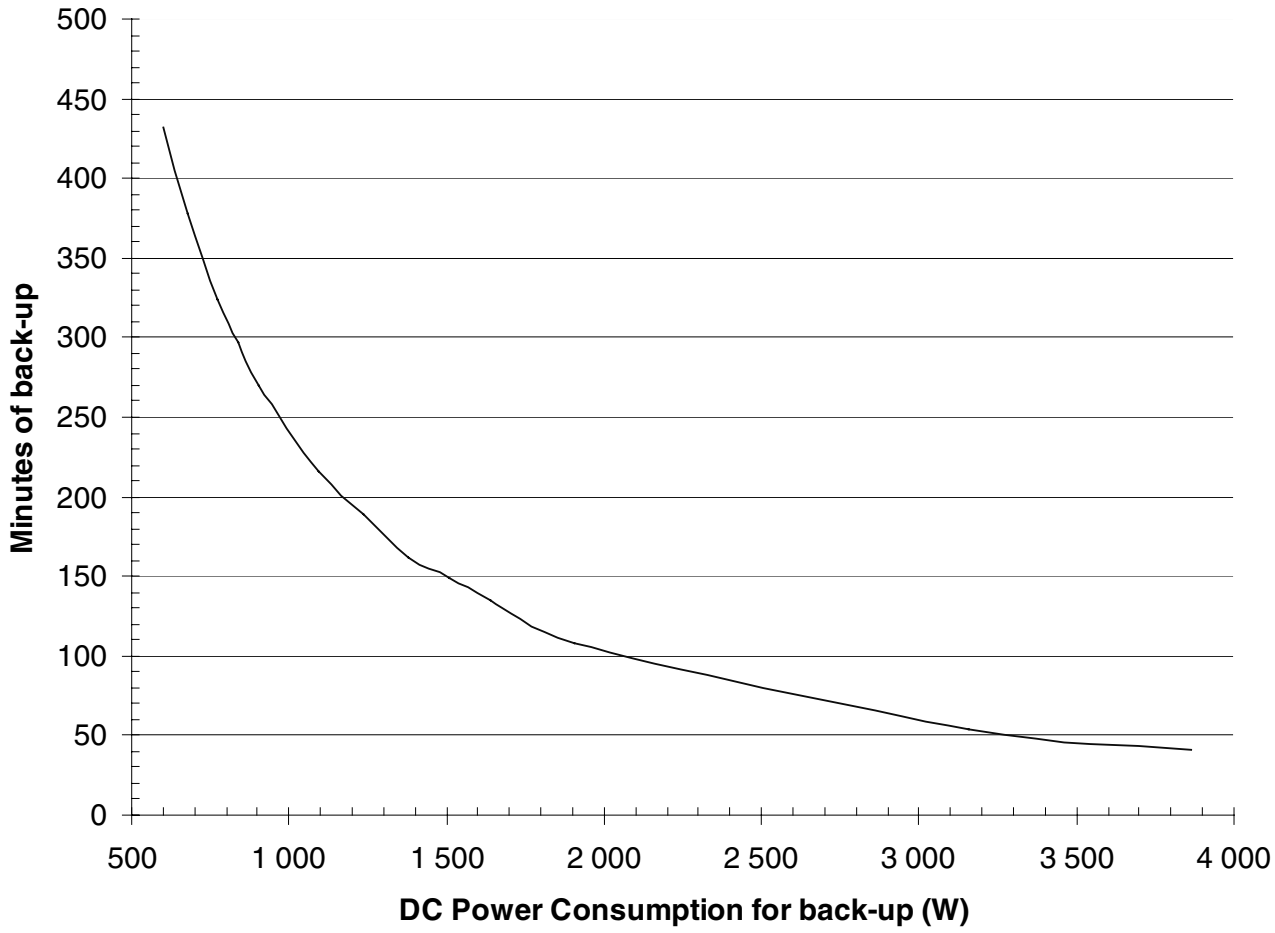
6.3 Backup times

AC BTS may include batteries that are providing a backup time in case of mains failure.

For Indoor AC BTS, two kinds of batteries exist: BU5 and BU90. The purpose of the BU5 is to allow withstanding short mains interruptions, in the range of some minutes; it is not considered in that chapter, that focuses on BU90 batteries, available for Indoor AC and Outdoor BTSs, and that are designed to provide a backup time of several tens of minutes - depending on configuration. The purpose of present chapter is precisely to show how backup times can be estimated from the BTS power consumption and the number of batteries.

The backup time available for a given BTS configuration, can be derived from the following curve:

- the x axis is the DC power consumption for backup, to be estimated as commented above (adding the power consumption of options that would be powered through the BTS)
- the y axis shows the number of minutes of backup if one BU90 is used; if two, or three such batteries are used, as external cabinets for batteries allow, this backup time has to be multiplied accordingly.



To assess the impact of "Auto Shutdown" feature with a given timer, one should:

- check the backup times with and without this feature enabled, i.e.:
  - with the feature enabled and the timer set to zero (all the TRXs, except the BCCH, are switched off as soon as mains disappear),
    and
  - with the feature disabled (all the TRXs are kept operating normally, even when a mains failure is detected)
- decide a reasonable value for the timer and make an interpolation

As an example, backup times for the MBO2 3x4 TRX1800 taken as example above would be:

- with "Auto Shutdown" not enabled:	120 mn	(as read on the curve above for 1620 W)
- with "Auto Shutdown" fully enabled (timer set to zero):	340 mn	(for 760 W)
- with "Auto Shutdown" enabled, and timer set to 120 / 2 = 60 mn:	230 mn	Interpolated as (120 + 340) / 2

The last case in table above corresponds to a situation where, after mains failure, the BTS operation is not affected for the first 60 mn of backup; after that time, and if mains are not back again, the TRXs others than BCCH are shut off in each sector to save power; the BTS will still be running, with reduced traffic capacity, for 170 mn.

6.4 Power dissipation

Power dissipation has to be considered for the dimensioning of cooling systems.

Power dissipation is related to power consumption:

- the power dissipated by a BTS is basically the power consumed by this BTS minus the power radiated through the antenna
- an estimate of the power dissipation might be obtained by subtracting the power emitted by the TRXs from the consumed power
- however, the full TRX power would give an over estimated value:
    - part of the time, the TRX are not emitting at their full power
    - part of the energy they are transmitting is lost in the coupling devices (in relation with their loss)
- to take this into account, a typical power dissipation of TRXs is introduced, an intermediate value between their "full power" and their power at "60%"; the power dissipated by a BTS can then be obtained by the sum of the relevant dissipated in the following table:

	DC BTS(W)	AC BTS(W)
TRX 900	125	140
TRX 850	125	140
TRX 1800	120	134
TRX 1900	180	202
TRX 1800 HP	210	235
ANC	10	11
MBO1 cabinet		123
MBO2 cabinet		213
MBI3 cabinet	50	56
MBI5 cabinet	70	78

It has to be noted that there is no power dissipation associated to Heating Units nor to Battery Charging:

- Power Dissipation is used to determine if a cooling system should be installed, and of what kind; what is meaningful is thus the power dissipation in a situation where the BTS environment may reach a high temperature.
- Heating Units are precisely used in circumstances where the temperature is low and where the problem is not dissipated power.
- in the battery charging process, most of the energy is used to charge the batteries, and is thus not dissipated in the environment; if there is residual dissipated power, it is at a low level, not worth considering in the computations.

7. RELIABILITY AND AVAILABILITY

Ideally, an equipment should be available for its main function (carrying traffic as far as BTS is concerned) 100% of the time. From a practical point of view, some failures may lead to an interruption of this main function; the anticipated degree of availability of an equipment can then be estimated by figures such as:

- equipment unavailability, expressed as the share of time during which the equipment is not functional,
- mean down time for a reference period, i.e. the average time during which the equipment will not be available out of a reference period.

The process to carry out such evaluations, is the following:

- a value has to be taken as hypothesis for the Mean Time To Repair (MTTR), i.e. the time during which the equipment will remain unavailable, following a failure, until it is repaired; this includes the time for appropriately skilled personnel to go to the site of the equipment; the commonly used value is MTTR = 4 hours.

- the modules that have to remain functional in order for the full equipment to remain functional, have to be identified; for a BTS, these modules are:

    - the ANc,
    - the SUMA.

  It must be noted that since a given user is typically under coverage of a given sector, only one ANc is considered, even in a sectorized BTS, for availability assessment.
  The other modules are ignored, since they have virtually no failures (e.g. the BTS cabinets) or their failure have no immediate impact on the function of the BTS; e.g.:

    - Fans are redundant,
    - in most circumstances, TRXs are "redundant": loosing a TRX has no significant impact on the function of the BTS, since other TRXs are still available

- the Failure Rates (FIT) of these modules must be estimated

- the total Failure Rate of the equipment is then computed as the sum of the FIT of its modules; the other following quantities may then be computed as follows:

  Total FIT = FIT of SUMA + FIT of ANc
  Total MTBF = 1/Total FIT
  System unavailability = MTTR / (MTBF + MTTR) ≈ MTTR / MTBF, because
  MTTR << MTBF

System availability = 1 – system unavailability.
MDT = system unavailability x 365 X 24 (it is expressed in h/year)

The following table gives the unavailability and downtime for the BTS, according to the principles above; the values are those of the GSM 900 BTS, but are very similar for other frequency bands:

FIT of SUMA	3 328.2 x 10E-9
FIT of ANc	2 359.6 x 10E-9
Total FIT	5 687.8 x 10E-9
Total MTBF (h)	175 815
System unavailability	2.275 x 10E-5
System MDT (h/year)	0.2

System unavailability and downtime

8. GLOSSARY

ACMU	AC Mains Unit
AD	Antenna Diversity
AMR	Adaptive Multi-Rate
ANc	Antenna Network, type c
ANy	Antenna Network, type y
BBU	Battery Backup Unit
BCF	Base station Control Function
BTS	Base Transceiver Station
DDF	Digital Distribution Frame
DR	Dual Rate
E-	Extended-band GSM
EDGE	Enhanced Data rates for GSM Evolution
EFR	Enhanced Full Rate
FIT	Failures In Time
GPRS	General Packet Radio Service
GPS	Global Positioning System
GSM	Global System for Mobile communication
HDSL	High-bit-rate Digital Subscriber Line
HP	High Power
HR	Half Rate
HSCSD	High-Speed Circuit Switched Data
IDU	InDoor Unit for microwave entity
LNA	Low-Noise Amplifier
MAB	Mast-head Amplification Box
MBI	Multistandard BTS Indoor
MBI3	MBI with 3 sub-racks
MBI5	MBI with 5 sub-racks
MBO	Multistandard BTS Outdoor
MBO 1	MBO basic rack
MBO 2	MBO 1 + MBOE
MBOE	MBO Extension rack
MDT	Mean Down Time
MP	Medium Power
MTBF	Mean Time Between Failures
MTTR	Mean Time To Repair
NTL	Network Termination Link
OML	Operation and Maintenance Link
PCM	Pulse Code Modulation
PDU	Power Distribution Unit
PIDU	Plug in IDU
PM12	Power Module, type 12
REK	Range Extension Kit
RFE	Radio Front End
RFH	Radio Frequency Hopping
RSL	Radio Signaling Link
SUM	Station Unit Module
TMA	Tower-Mounted Amplifier
TRX	Transceiver
TS	Time Slot
U	Unit used in mechanic design for the height of modules: 1U = 1.75” = 44.45 mm

UPS	Uninterruptable Power Supply
VSWR	Voltage Standing Wave Ratio
WBC	Wide-Band Combiner

End of Document