TTPA Installation Guide (draft version)

Disclaimer

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Acronyms and Abbreviations

APDU	Alarm and Power Distribution Unit
BTS	Base Tranceiver System
CI	Current Injector
DMM	Digital Multi Meter
ESD	Electro Static Discharge
LED	Light Emitting Diod
LNA	Low Noise Amplifier
MTBF	Mean Time Between Failures
MTTR	Mean Time To Replace
NF	Noise figure
TTA	Tower Top Amplifier
TTPA	Tower Top Power Amplifier

1. General Information

Overview

The physical installation of each part of the TTPA system is described in separate chapters. Testing and functioning check is described in a separate chapter. Different kinds of system configurations are described in the last chapter.

Note that at some stages during the installation, the BTS must be turned off. To prevent extensive downtime it may be useful to finish the stages of the installation of both TTPA, APDU and CI when the BTS still is active. The BTS then has to be shut down only once for finishing the installation of all included parts.

Note that all information in this manual may change without any notice. Refer to the technical specifications for the latest information on the TTPA products.

Safety Considerations

The TTPA is equipped with a pole clamping unit. This enables the installation personnel to first install the relatively light mast clamp, and then easily hook on the actual amplifier. This feature reduces the risk of accidents during installation.

It is important for everyone involved in the installation, operation, and maintenance of the TTPA, APDU and CI to understand the following points:

- The TTPA, APDU, and CI are designed to amplify the uplink signal from the mobile phone and the downlink signal to the mobile phone. The TTPA system must be used exclusively for this purpose and no other.
- No units included in the system (TTPA, APDU or CI) may be repaired in the field. All malfunctioning parts must be sent back to Allgon Systems for repair or replacement.
- Always use an ESD bracelet during installation of electrical equipment and when touching the BTS connectors, or when handling electrical equipment, to prevent ESD damage.
- The mounting of the TTPA on high masts, poles or roofs must be done by skilled personnel, authorised to work on high masts, poles, or roofs. The personnel must be aware of security regulations and use appropriate security equipment.
- The coaxial cable insulation is made of PTFE, polytetrafluoroethylene, which gives off small amounts of hydrogen fluoride when heated. Hydrogen fluoride is poisonous. Heating tools must not be used when stripping off coaxial cable insulation. No particular measures are to be taken in case of fire, because the emitted concentration of hydrogen fluoride is very low.

2. Installation of the TTPA

Outdoor conditions

The TTPA is environmentally protected (IP 65), and can be mounted without any kind

of protection from bad weather conditions. However, it is not permitted to install the TTPA in bad weather conditions. If the bad weather conditions are of a short duration, and the TTPA and all other connectors that are to be connected during the installation are protected, the installation may continue not less than one hour after the adverse conditions have ended.

Dimensions

Weight is 12 kilos for TTPA unit, 3 kilo for clamping unit.

Mounting equipment

A standard mounting kit is delivered with each TTPA. It contains one holder used for both pole mounting and wall mounting, and screws needed for the mounting. The brackets for pole mounting fit poles with diameters of between 50 and 120 mm.

A torque meter is needed for tightening bolts and connectors. Amalgamated tape for insulating the connectors is not required, but may be used.

Checklist before mounting and installation

- Are all the necessary adapter cables available and are they long enough? Normally, a 1 meter long adapter cable is needed for the connection between the TTPA and the antenna.
- Are the 7/16 connectors to be connected to the TTPA of the correct sex?
- Are brackets of the right size available?
- Are sufficiently long grounding straps available?
- Is the place where the TTPA is to be mounted the optimal location, considering cable lengths and length of grounding straps?
- Is there a distance of free air of at least 0.5m from top and bottom sides, and 0.2 m from all other sides except the backside?

Installation procedure for TTPA

Before the actual installation is started, read the safety information at the beginning of this guide.

Phase 1: The first phase of the installation, that is the mounting of the TTPA and grounding cable, can be carried out with the BTS still active.

If the TTPA unit is to be mounted on a wall, you'll need to take away the four tabs for pole mounting on the mounting plate (see picture below). The easiest way is to bend them away with a pair o pliers.

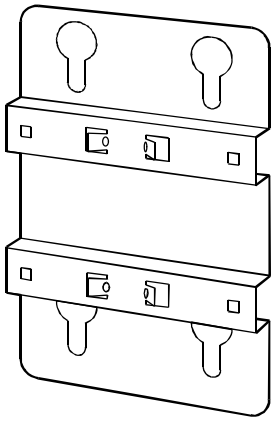


Figure 1: Mounting plate

- Attach the mounting plate for the TTPA to the wall or the mounting pole. Use the clamps or screws and plastic plugs provided with the unit. The cable connectors of the unit must be on the bottom side of the unit. Tilt must not exceed 10 degrees.

  Pole mounting: Note that the inner nut (with a flange) is kept in position while it is locked by the outer nut.

  Wall mounting: Note that the holes shall be 10 mm in diameter, and about 60 mm deep, and that the plastic plugs included in the mounting kit shall be used.

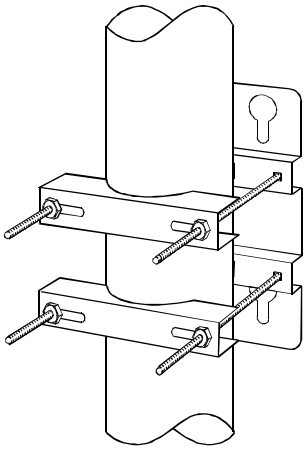


Figure 2: Pole mounting

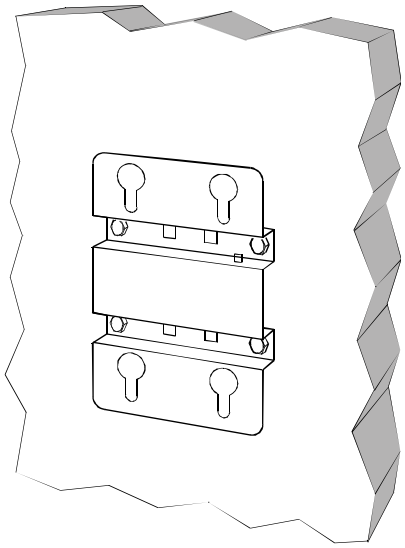


Figure 3: Wall mounting

- Attach the TTPA to the mounting plate according to the figure below. When the TTPA has been mounted on the plate, press it downwards until it sticks. Tighten the two bottom nuts.

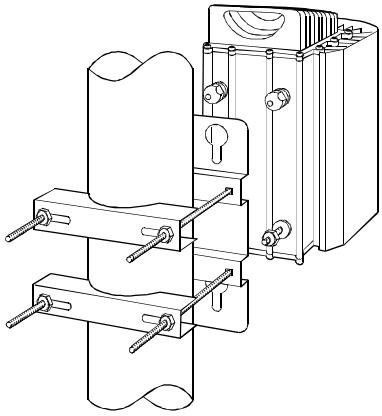


Figure 4: Attaching the TTPA to the mounting plate

- Ground the unit through a grounding strap, mounted to the ground screw and a ground connection on the pole or mast, or to the ground cable between antenna and earth.

Phase 2: The second phase of the installation, that is the attachment of cables between antenna and TTPA, and TTPA and BTS, must be carried out with the BTS shut down.

- Shut down the BTS.
- Attach the cable between antenna and TTPA, and between TTPA and BTS.

  Often there is a low loss feeder between the BTS and the antenna, with the feeder attached to the antenna using an adapter cable. If this is the case, it may be easier

to disconnect the feeder and adapter cable from the antenna and attach it to the TTPA. Then connect the TTPA to the antenna using the short cable. If the feeder is attached directly to the antenna, or is easy to move, then it may be connected directly to the TPPA. Always first attach the cables to the connectors by hand, then use the torque meter to tighten the cables to 25 Nm. It is important that the torque does not exceed 30 Nm because of the risk of damage to the connectors. make sure that the antenna cable is connected to the ANT connector, and the BTS cable to the BTS.

Checklist after mounting and installation

- Check that the brackets or wall holders are properly tightened.
- Are the grounding straps connected and the screws tightened?
- Are all 7/16 connectors connected and tightened to 25 Nm (or by hand, if no torque meter is available)?
- Check that the feeder has not been forced to connect to the TTPA.
- **Applicable if no CI is used:** Are the DC cables connected to the TTPA DC connectors?

Note: The TTPA must be powered on within one day after unpacking and mounting, to prevent malfunction and damage due to moisture.

3. Installation of CI

General

Note that at some stages during the installation, the BTS must be turned off. To prevent extensive downtime it may be useful to finish the first stages of the installation of both TTPA, APDU and CI when the BTS still is active. The BTS then has to be shut down only once for finishing the installation of all included parts.

Outdoor and indoor conditions

The CI can be installed both indoors and outdoors. Normally, it will be strapped to a cable ladder or equivalent. It is environmentally protected (IP 65), and can be mounted without any kind of protection from bad weather conditions. However, it is not permitted to install the CI outdoors in bad weather conditions. If the bad weather conditions are of a short duration, and the CI and all other connectors that are to be connected during the installation are protected, the installation may continue not less than one hour after the adverse conditions have ended.

Information on environmental requirements for the CI is found in the Reference Manual.

Mounting equipment

- Crimp tool
- Torque meter

Checklist before mounting and installation

- Check that the CI is of the right type. Note that the TTPAs and TTAs must be connected with different CIs:

TTA: 8478.xx, 8484.xx, 9184.xx or 9221.xx, for 12 V_{DC}
TTPA: 9219.xx, for 48 V_{DC}

- Are the correct cables with the correct connectors and lengths present?
- Is the ground cable present?
- Are straps to secure the CI available?

Installation procedure for CI

Example of CI. Please note that connectors and connector gender may differ between the versions.

The Current Injector is weatherproof and can be mounted indoors or outdoors. Therre is no equipment for mounting the CI to walls or antenna tower, as it will form an integrated part of the TTPA cabling.

With the BTS still active:

1. Connect the antenna cable to the antenna port on the CI.
2. Connect the BTS cable to the BTS port on the CI.
3. Connect the grounding cable to a suitable grounding point (e.g. same as ADPU).
4. Connect the DC cable from the ADPU to the DC port on the CI.

Checklist after mounting and installation

- Check that the grounding straps (if used) are connected and the screws tightened?
- Are all 7/16 connectors connected and tightened to 25 Nm (or by hand, if no torque meter is available)?
- If you are using amalgamating tape to seal off the connectors, check that this is done.

4. Installation of APDU

General

Note that at some stages during the installation, the BTS must be turned off. To prevent extensive downtime it may be useful to finish the first stages of the installation of both TTPA, APDU and CI where the BTS still is active. The BTS then has to be shut down only once for finishing the installation of all included parts.

Outdoor and indoor conditions

The APDU can be installed both indoors and outdoors. It is mounted in a environmentally protected (IP 65) lockable box, and can be mounted without any kind of protection from bad weather conditions. However, it is not permitted to install the APDU outdoors in bad weather conditions. If the bad weather conditions are of a short duration, and the APDU and all other connectors that are to be connected during the installation are protected, the installation may continue not less than one hour after the adverse conditions have ended.

Information on environmental requirements for the APDU is found in the Reference Manual.

Dimensions

Figure x: APDU box (dimensions 200x300x150mm)

Mounting equipment

The APDU is mounted on the same kind of mounting plate as the TTPA. Check the TTPA mounting instructions for how to attach the mounting plate to the wall, and the ADPU to the mounting plate.

Checklist before mounting and installation

- Check that the CI (Current Injector) is of the right type. Note that the TTPAs and TTAs must be connected with different CIs:

TTA: 8478.xx, 8484.xx, 9184.xx or 9221.xx, for 12 V_{DC}
TTPA: 9219.xx, for 48 V_{DC}

- Is 48V_{DC} or 115/230 V_{AC} supply available?
- Does the supply cable for the APDU have the correct connector on the BTS side?
- Are the correct cables with the correct connectors between APDU and Current Incector available and are they long enough?
- Is the necessasy equipment and material to connect the alarm cable to the BTS external alarms available?
- Is the alarm cable of the correct type?
- Are a ground wire or heavy duty crimp terminals, cable and a crimp tool available?
- Are the 7/16 connectors to be connected to the CI of the correct sex?
- Are the DMM, cable ties and all the necessary tools available?

Installation procedure for APDU in BTS

Before the actual installation is started, read the safety information at the beginning of this guide.

Phase 1: This part of the installation can be carried out without switching off the BTS.

//picture of APDU connectors with explanation//

- Mount the APDU in its predefined location.
- Connect the APDU to the grounding point.
- Connect the supply cable to the APDU DC (or AC) input with the correct polarity.
- Connect the cable between APDU and CI.
- Connect the alarm cable between APDU and BTS to the APDU.

Phase 2: The second phase of the installation, that is the attachment of cables between APDU and BTS, may have to be carried out with the BTS shut down. Check with the BTS supplier.

- Connect the supply cable to the BTS 48 V or 220 V supply.
- Connect the alarm cable to the BTS.

An example of software configuration of the TTPA is dealt with in the Software Configuration of System chapter below.

Checklist after mounting and installation

- Check that the brackets or wall holders are properly tightened.
- Check that the grounding straps are connected and the screws tightened?
- If you are using amalgamating tape to seal off the connectors, check that this is done.

5. Commissioning

To be added

Appendix 1. TTPA Software Settings

Optimising coverage

The TTPA can optionally be equipped with soft gain control, both for up- and down link (i.e. receive and transmit branch). By carefully tuning the gain for each branch it is possible to significantly improve the coverage provided by the BTS.

In order to optimise the coverage with the TTPA soft gain control it is necessary to first characterise the particular BTS regarding the balance of the link budget, i.e. the distance covered by the BTS transmitter compared to the talk back distance of the mobile terminal. The unbalance, P_{ub}, and the feeder loss must be available to use the TTPA soft gain settings in an optimum way.

If the TTPA is deployed as a retrofit, there is a good chance that such a

characterisation already exists and that the BTS is balanced from a link budget point of view. If this is the case, skip step 1 in General link budget characterisation, step by step below and continue to step 2 or 3.

General link budget characterisation, step by step

1. Measure site link balance
2. Measure site feeder loss
3. Calculate theoretical maximum TTPA sensitivity gain
4. Add link balance and sensitivity gain to decide TTPA Tx gain
5. Set TTPA Tx and Rx gain
6. Measure site link balance to verify gain settings

1. To characterise the actual link budget in a cell, specific equipment is needed. This can be provided by the infrastructure supplier or the net planner. In general, a vehicle mounted channel monitor is needed, together with the BTS channel monitor.

The quality can be characterised by many different parameters and the choice should not affect the results. Below, RBER (Residual Bit Error Rate) have been used. A common quality setting is that the RBER should be <2%.

Place a call from a place well within the area covered by the BTS and slowly move towards the cell border while monitoring the call quality at both terminal and BTS. When RBER=2% for either the down link (monitored in the vehicle) or the up link (monitored in the BTS), stop the vehicle.

<u>If the up link is limiting, i.e. RBER=2% is monitored in the BTS:</u>

The terminal should now be transmitting at its full power. Note the output power of the BTS, P_0. Decrease the BTS output power step by step until RBER=2% is monitored in the vehicle. Note the output power of the BTS, P_1. The unbalance is given by:

$$P_1 - P_0 = P_{ub} \qquad (P_{ub} \text{ should be } <0)$$

<u>If the down link is limiting, i.e. RBER=2% is monitored in the vehicle:</u>

The BTS should now be transmitting at its full power. Note the output power of the terminal, P_0. Decrease the terminal output power step by step until RBER=2% is monitored in the BTS. Note the output power of the terminal, P_1. The unbalance is given by:

$$P_0 - P_1 = P_{ub} \qquad (P_{ub} \text{ should be } >0)$$

2. Meassure the feeder length and use the manufacturers typical loss per meter data to decide the site feeder loss, L (any other method will do as long as a value for the feeder loss is present….).

3. The LNA in the TTPA will significantly improve the BTS sensitivity. How much is easily calculated by using Friis' formula. Input parameters are, apart from TTPA Rx gain (G_{Rx}) and noise figure (NF_{Rx}), site feeder loss, L, and BTS transceiver input noise figure, NF_T. The total system noise figure before and after deployment of the

TTPA will be:

With no TTPA:

$NF_{BTS1} = L + NF_T$

With TTPA:

$NF_{BTS2} = NF_{Rx} + (L - 1)/G_{Rx} + (NF_T - 1)L/G_{Rx}$

Hence, the sensitivity improvement will be $NF_{BTS1} - NF_{BTS2} = S_G$.

The value of S_G can also be calculated using the free Allgon LinkPlanner tool.

4. Now it is possible to calculate the gain setting of the TTPA Tx branch, G_{PA} to maximise cell coverage:

$$P_{ub} + S_G = G_{Tx}$$

Please note that the two gain values are valid only if the original BTS output power setting remains.

It is possible that the receiver sensitivity improvement is so large that there is not enough Tx gain available to balance the link budget. Such a scenario is possible on sites where the feeder loss is extremely high. In such cases the sensitivity gain, S_G, must be reduced to balance the maximum value of the TTPA Tx gain, $G_{Tx,max}$ and the link balance value $P_{ub:}$

$$S_G = G_{Tx,max} - P_{ub}$$

S_G is reduced by decreasing the value of the TTPA Rx gain, G_{Rx}, in Friis' formula.

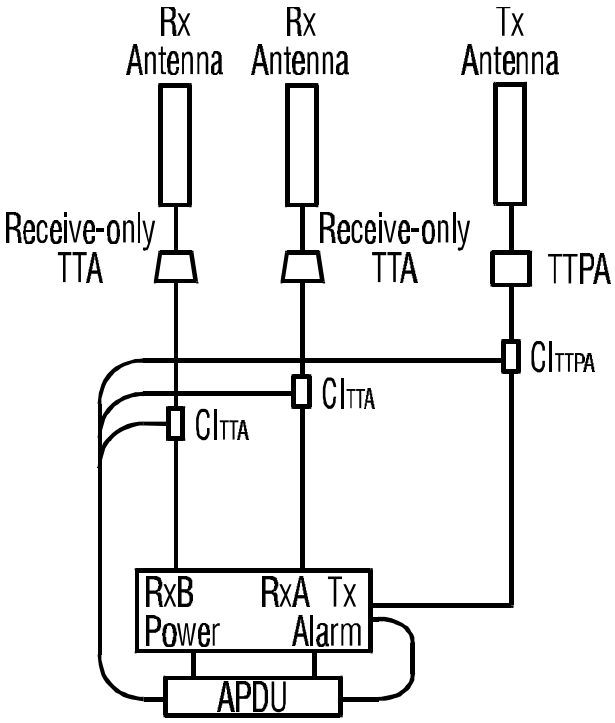
5. Set the TTPA values of G_{Tx} and G_{Rx} through the APDU user interface.

6. To verify the new cell coverage and link balance, repeat step 1 above. If done correctly the value of P_{ub} should read very close to 0.

Appendix 2: System Configuration Examples

Configuration I

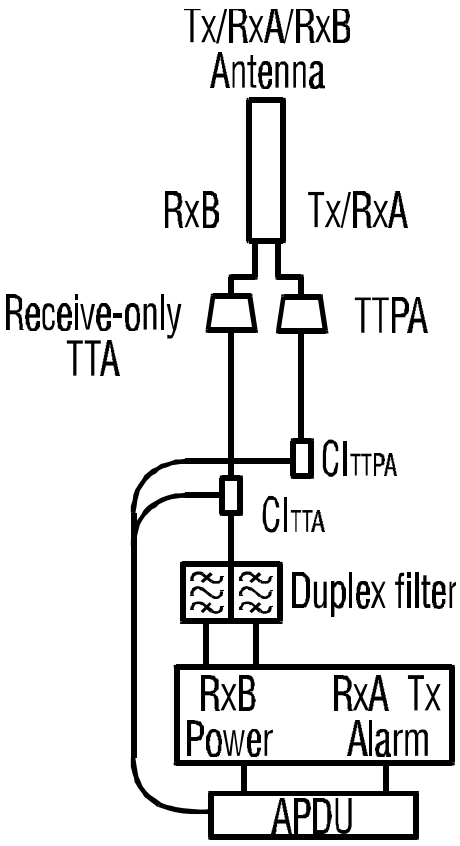
One duplexed antenna and one diversity receive antenna with duplex filter in BTS. Power fed via single port Current Injectors.



Equipment for one three sector site: 3 TTPA (one per sector)
3 Receive-only TTA (one per sector) 3 single port Current injectors for TTPA 3 single port Current injectors for TTA 1 APDU
Equipment for one two sector site: 2 TTPA (one per sector)
2 Receive-only TTA (one per sector) 2 single port Current injectors for TTPA 2 single port Current injectors for TTA 1 APDU
Equipment for one omni site: 1 TTPA
1 Receive-only TTA 1 single port Current injectors for TTPA 1 single port Current injectors for TTA 1 APDU

Configuration II

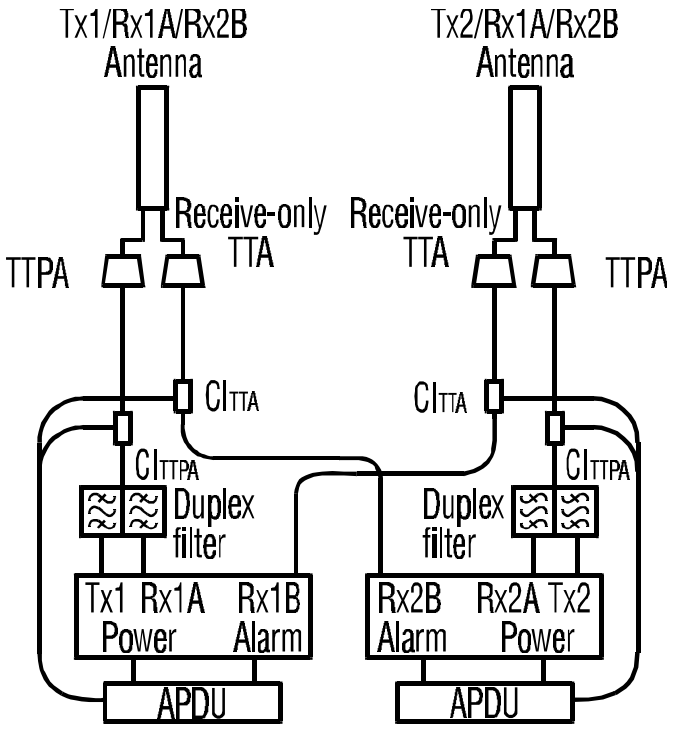
One dual polarized duplexed antenna with duplex filter in BTS. Power fed via single port Current Injectors. A Duplex TTA could be preferred in stead of the Receive-only TTA as this will prepare the system for a build out with another transceiver.



Equipment for one three sector site: 3 TTPA (one per sector)
3 Receive-only TTA (one per sector) 3 single port Current injectors for TTPA 3 single port Current injectors for TTA 1 APDU
Equipment for one two sector site: 2 TTPA (one per sector)
2 Receive-only TTA (one per sector) 2 single port Current injectors for TTPA 2 single port Current injectors for TTA 1 APDU
Equipment for one omni site: 1 TTPA
1 Receive-only TTA 1 single port Current injectors for TTPA 1 single port Current injectors for TTA 1 APDU

Configuration III

Two dual polarized duplexed antennas with duplex filters in BTS. Power fed via single port Current Injectors. Instead of using e.g. one 8-ch. combiner, two 4-ch. combiners can be used, distributing the Tx-signals over two Duplex antennas. The insertion loss and power handling (heat sink & peak power) will be more advantageous. A Duplex TTA could be preferred in stead of the Receive-only TTA as this will prepare the system for a build out with another transceiver.



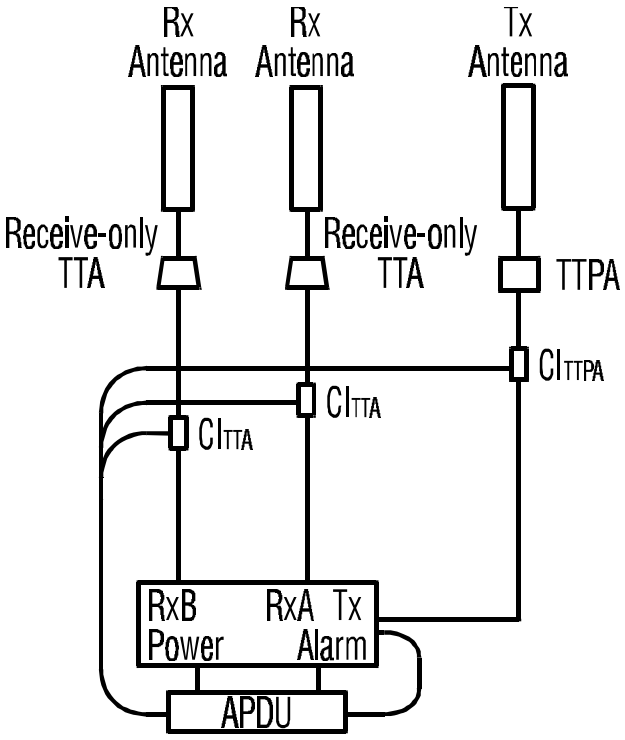
Equipment for one three sector site: 6 TTPA (two per sector) 6 Receive-only TTA (two per sector) 6 single port Current injectors for TTPA 6 single port Current injectors for TTA 2 APDU

Equipment for one two sector site: 4 TTPA (two per sector) 4 Receive-only TTA (two per sector) 4 single port Current injectors for TTPA 4 single port Current injectors for TTA 2 APDU

Equipment for one omni site: 2 TTPA 2 Receive-only TTA 2 single port Current injectors for TTPA 2 single port Current injectors for TTA 1 APDU

Configuration IV

One transmit antenna and two receive antennas (main and diversity). Power fed via single port Current Injectors.



Equipment for one three sector site: 3 TTPA (one per sector) 6 Receive-only TTA (two per sector) 3 single port Current injectors for TTPA 6 single port Current injectors for TTA 2 APDU

Equipment for one two sector site: 2 TTPA (one per sector) 4 Receive-only TTA (two per sector) 2 single port Current injectors for TTPA 4 single port Current injectors for TTA 2 APDU

Equipment for one omni site: 1 TTPA 2 Receive-only TTA 1 single port Current injector for TTPA 2 single port Current injectors for TTA 1 APDU