CBRS Deployment Guidelines for Installers

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Contributors

The following individuals made significant contributions to this document:

Editors:
- Kumar Balachandran

Authors:
- Kumar Balachandran, Ericsson
- Virgil Cimpu, Ericsson
- Nancy Y. Lee, Nokia
- Masoud Olfat, Federated Wireless
- Navin Hathiramani, Nokia
- Idan Raz, Airspan
- Zaheer Syed, CableLabs

CBRS Deployment Guidelines Technical Report

1 Introduction

The Citizens Broadband Radio Service (CBRS) will allow a novel three tier spectrum sharing scheme for mobile broadband users deploying Citizens Broadband Radio Service Devices (CBSD) [1][2]. CBSDs can be deployed in a variety of environments and could or could not be professionally installed. The installation of a Category A CBSD does not need to be done by a Certified Professional installer if the CBSD is capable of automatic geo-location to within 50 m horizontal accuracy and ±3 m vertical accuracy. All other CBSDs will be installed by a Certified Professional Installer (CPI). Category B registration is required by the FCC rules for all CBSDs with registered EIRP between 30 dBm and 47 dBm or if the CBSD is installed outdoor with its antenna at a Height Above Average Terrain (HAAT) above 6 m.

The installer of the CBSD attests whether it is operating indoors or outdoors as part of the registration parameters.

2 Scope

This Technical Report sets forth informational guidelines for deployment of CBSDs. In particular, the document addresses less obvious scenarios such as indoor classification of CBSDs and the matter of registering CBSDs representing distributed antenna placements.

This document is not to be interpreted as normative. It is however available as a reference to installers and is referenced in the CPI Training curriculum [3].

3 References

[1] Report and Order and Second Further Notice of Proposed Rulemaking, Amendment of the Commission's Rules with Regard to Commercial Operations in the 3550-3650 MHz Band, GN Docket No. 12-354, Federal Communications Commission, 21 April 2015.

[2] Order on Reconsideration and Second Report and Order, Amendment of the Commission's Rules with Regard to Commercial Operations in the 3550-3650 MHz Band, GN Docket No. 12-354, Federal Communications Commission, 2 May 2016.

[3] WINNF-TS-0247 Version 1.0.0, "CBRS Certified Professional Installer Accreditation Technical Specification."

[4] WINNF-TS-0016 Version 1.2.2, "Signaling Protocols and Procedures for Citizens Broadband Radio Service (CBRS): Spectrum Access System (SAS) – Citizens Broadband Radio Service Device (CBSD) Interface Technical Specification."

[5] WINNF-TS-1001, "CBRS Operational and Functional Requirements (Release 2)", Wireless Innovation Forum

[6] WINNF-TS-3002,:"Signaling Protocols and Procedures for Citizens Broadband Radio Service (CBRS):Extensions to Spectrum Access System (SAS) - Citizens Broadband Radio Service Device (CBSD) Interface Technical Specification (Release 2)"

[7] FCC KDB 935210 D02 Signal Boosters Certification
https://apps.fcc.gov/oetcf/kdb/forms/FTSSearchResultPage.cfm?switch=P&id=20673

4 Abbreviations and Definitions

4.1 Abbreviation

CBRS: Citizens Broadband Radio Service.
CBSD: Citizens Broadband radio Service Device
CPI: Certified Professional Installer
DAS: Distributed Antenna System
EUD: End User Device
EIRP: Effective Isotropic Radiated Power
HAAT: Height Above Average Terrain
TP: Transmission Point
RU: Radio Unit
BBU: Baseband Unit

4.2 Definitions

Transmission Point (TP): is an antenna deployed at a fixed location. An RU can be connected to a single TP or multiple TPs. CBSD requirements apply to each TP even if the network management and communication with the SAS is accomplished via a single network interface.

Passive DAS: A network of spatially separated TPs powered by an RU, in which there are only passive elements (feeders, splitters, diplexers, etc.) between the RU and each of the TPs.

5 Deployment Guidelines for general CBSDs and Passive DAS

5.1 General

The following deployment topics are addressed:
1) The FCC rules do not specifically define when a device is indoor, but at registration a CBSD is required to declare whether it will be operated indoors or outdoors. Guidelines augmenting the FCC rules are provided to assist an installer in making this determination.

2) The FCC rules require each antenna location to be registered as a separate CBSD with a unique identifier, but the FCC certifies radio equipment not antennas as CBSDs and expects FCC ID and manufacturers serial number to be sufficient to form a unique identifier for each CBSD. When deploying, for example, distributed antennas, remote radio heads, or multiple CBSDs

that are associated with the same radio equipment, a single FCC ID and manufacturers serial number for the radio equipment will have to be augmented to create a unique identifier for each CBSD.

3) Guidelines are provided for the determination of HAAT at the location of a CBSD.

The following guidelines only apply to passive DAS deployment:

4) Guidelines are provided for determination of the *eirpCapability* of every TP of a passive DAS, since each TP needs to be registered with SAS as a regular CBSD. TPs powered by the same RU will follow the formal SAS-CBSD communication protocol for each TP, and all TPs connected to the same antenna port of a single RU should transmit using the same frequency bandwidth. TPs are identified by the FCC-ID and serial number of the RU they are connected to, suitably augmented to provide uniqueness (see section 5.3).

5) Passive DAS support can be enabled by managing the TPs of an RU via a domain proxy, implemented within the RU as a logical function or within a domain proxy external to the RU, each RU still being subject to the requirements of Part 96 with respect to the behavior of the individual CBSDs (TP) to responses from the SAS.

6) In the case of Passive DAS, the CPI can rely on the expertise of third-party accredited DAS network planners/installers.

In this document, the term "installer" is used to refer to any person who installs a CBSD and calculates or sets installation parameters for CBSD registration.

5.2   Guidelines for Indoor/Outdoor Determination

1) An installer will determine whether a deployment environment is indoor or outdoor.

2) In general, CBSDs located in urban canyons and shadowed spaces, and that are not within the confines of a walled enclosure are declared as outdoors.

3) A CBSD located in a wholly enclosed space and primarily intended to serve EUDs within that space is declared as indoor; this includes enclosed spaces that have substantial amounts of glass in the construction.

4) An installer has discretion to register a CBSD as indoor under all the following simultaneous circumstances.

- Substantial wall covering[1] that results in significant attenuation to the CBSD transmission, e.g. within stadiums and arenas,

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[1] In this respect, the term *substantial wall covering* indicates the presence of a surrounding wall structure of determinable height above ground that surrounds the property being covered over more than 80% of the

- A location that is more than 3 m below the height of the enclosure around the CBSD at a point of closest approach to the location of the CBSD,

- The transmitted signal is adequately attenuated towards locations exterior to the premises, and

- Max EIRP less than 30 dBm/10MHz.

5) A CBSD located in a tunnel, underground location, or a cave can be classified as indoor at the discretion of an installer.

6) An installer can use discretion to declare that any relevant environment is outdoor. The installer is responsible for ensuring that the CBSD follows all necessary conditions for operation at the registered maximum power levels.

- An example is a point-to-point link in a stadium, meant for video transport

5.3   CBSD Identifiers for Sectors, DAS and remote radio placements

Identifiers exist for radio equipment, but the FCC requires each transmission site to be identified as a separate CBSD. This can result in some challenges when defining a CBSD for registration purposes. Installers, including CPIs, can be called on to register multiple CBSDs associated with the same radio equipment such as sectors of a single physical site, DAS antenna sites geographically separate from the physical radio hardware, and remote radio placements subsidiary to a controlling radio site, including those that are geographically distributed from that controlling radio equipment. The following guidelines are provided for generating CBSD identifiers to handle such cases.

Some deployments of radio equipment can divide the transmission into sectors, e.g. the three sectors or cells of a single physical site. Each sector of such a deployment that is registered with the same FCC ID and Manufacturer's serial number can be assigned a unique Sector ID by the installer.

Some deployments can further support one or more TPs mapped to a unique Sector ID of an equipment that has a unique FCC ID and Manufacturer' serial number.

For the purpose of unique CBSD identification, four deployment scenarios have been distinguished based on the number of sectors and the number of TPs per sector. Note that channel bandwidths transmitted from multiple sectors could be the same or different according to operator's network planning. However, all TPs belonging to a Passive DAS must transmit using the same channel bandwidth. Moreover, we assume multiple antenna systems (e.g. MIMO or beamforming systems), wherein multiple antenna ports are co-located on the same sector, and transmit on the same frequency, as one single TP. Examples of these scenarios are depicted in Annex A.

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circumference of the property. It is the responsibility of the installer to ensure that a declared indoor CBSD is not in proximity of a clear field of view to areas that are considered exterior to the enclosing structure. When planning the installation, the installer is to pay regard to the effect of the CBSDs transmissions on incumbents in the vicinity of the location of the CBSD.

Category 1: A single-sector RU with a single TP per sector: One CBSD is registered in this case using the TP location, and the FCC-ID, and Manufacturers Serial Number of the RU.

Category 2: A multi-sector RU with single TP per sector: In this case, every sector of the RU can have a unique transmission location. Each sector is registered as a single CBSD using the FCC ID, and Manufacturers Serial Number of the RU combined with an additional Sector ID to uniquely identify each sector.

The Sector ID is not explicitly defined in the CBSD registration parameters, but it can be provided to the SAS using a suffix in the cbsdSerialNumber [4][6]. Specifically, Sector ID can be appended to the Manufacturers Serial Number with a delimiter character ':' preceding the Sector ID; the ':' character is unlikely to be used in manufacturer serial numbers or in Sector IDs. The SAS can then parse the sector ID and make use of it if desired.

Category 3: A single-sector RU deployed as a Passive DAS with multiple TPs. In this case, each TP of the DAS can have different transmission locations. Each TP is registered as a single CBSD using the FCC ID, and Manufacturers Serial Number of the RU combined with an additional TP ID to uniquely identify each TP. Examples of this scenario are depicted in Annex A Figures A.1, A.2, and A.3.

Similar to Category 2 deployment, the TP ID can be provided to the SAS using suffixes in the cbsdSerialNumber [4][6]. Specifically, the TP ID should be appended to the Manufacturers Serial Number with a delimiter character ':' preceding the TP ID; the ':' character is unlikely to be used in manufacturer serial numbers or in TP IDs. The SAS can then parse the sector ID and make use of it if desired.

Category 4: Multi-Sectored RU supporting multiple TPs in some or all of its sectors: In this case, the RU can support multiple sectors, with some or all of its sectors deploying Passive DAS, where multiple TPs would have different transmit locations. An example of this scenario is depicted in Annex A Figure A.4.

In this case, each TP of each sector is registered as a single CBSD using the FCC ID and Manufacturer Serial Number of the RU combined with additional Sector ID and TP IDs to uniquely identify each TP of each sector. Similar to Category 2 and Category 3, a TP requiring sector and TP identification could populate the FCC ID and Manufacturer Serial Number of the RU with cbsdSerialNumber [4[6] represented as Manufacturers Serial Number + ":" + Sector ID + ":" + TP ID.

5.4 HAAT Calculations

The height above average terrain is determined as detailed in https://www.fcc.gov/media/radio/haat-calculator. When registering HAAT for an indoor CBSD, the actual HAAT must be added to the height of the antenna above the ground level at the location of the CBSD.

5.5 eirpCapability Calculation for CBSDs that are Transmissions Points (TPs) that are part of a Passive DAS Deployment

Note: Passive DAS deployments are applicable for both WInnForum Release 1 specifications [4] and WInnForum Release 2 specifications [5][6]. The guidelines in this section are common for Passive DAS deployments following WInnForum Release 1 specifications [4] or WInnForum Release 2 specifications [5][6].

Each individual remote antenna of a DAS operating as a TP must be registered as a CBSD with a location corresponding to the fixed antenna location, and a category determined as per the EIRP of the individual TP. TPs connected to an RU could be category A or category B, as long as the maximum EIRP of the TP does not exceed the maximum certified EIRP of the RU.

All TPs must be registered as CBSDs to the same SAS.

All TPs controlled by a single RU could form a unique group, such that all TPs operate on the same frequency channel, and Heartbeats for each TP are managed by the BBU handling the RU or by a domain proxy on behalf of the RU in accordance with current WINNF protocols.

FCC-ID is allocated to the RU through FCC certification, and the CBSD-ID of each remote antenna (TP) is derived from the FCC-ID and Serial Number of the RU according to the process described in Section 5.3.

The radio hardware for Passive DAS deployment needs to comply with the FCC KDB 935210 D02 Signal Boosters Certification [7].

For Passive DAS, the maximum transmit EIRP of each individual TP must be calculated and entered through the optional "*eirpCapability*" parameter as part of CBSD Registration Request process.

The following flow chart describes the steps for Passive DAS deployment:
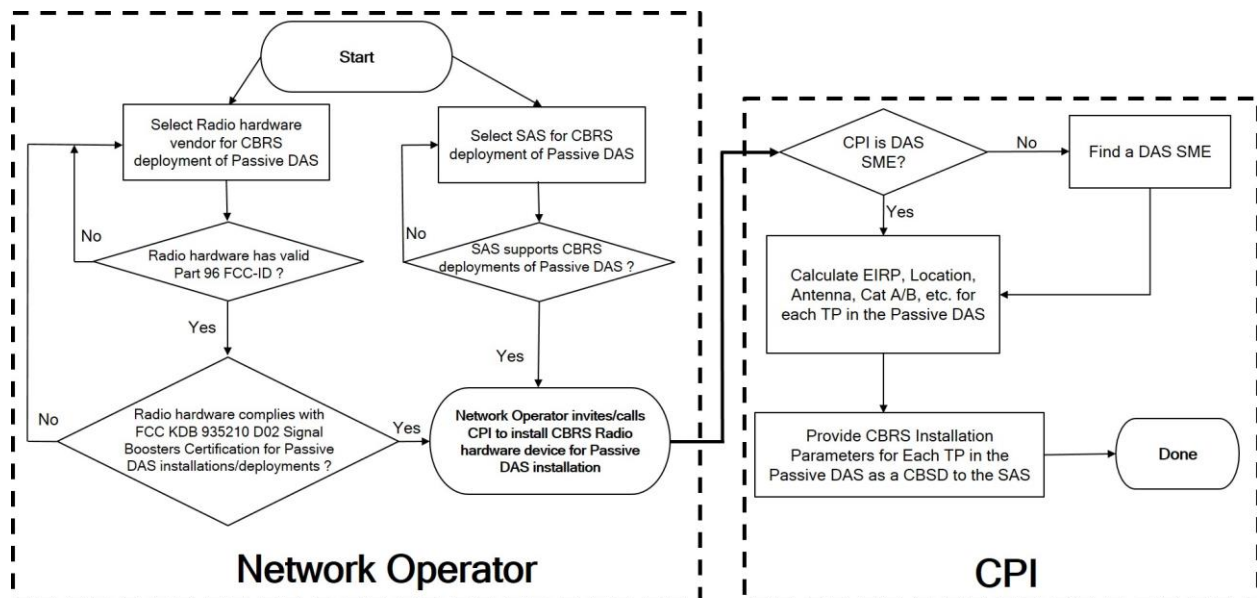
In the following, it is assumed that the RU connected to the DAS supports external antennas and has been certified by the FCC to operate with one or more antennas with possibly different antenna gains. It is also assumed that the FCC database contains the maximum certified EIRP for the RU.

Assuming the maximum transmit conducted power density of the RU, transmitted from all antenna ports, is *P dBm/10MHz*, and the maximum reference antenna gain submitted by the vendor is G, the maximum FCC certified EIRP density of the RU is *"EIRP = (P + G) dBm/10MHz"*. However, the transmit power of the RU might go through several layers of splitters, diplexers, cables and other passive elements (e.g. connectors and adapters) before reaching the TP, and the sum of the insertion losses from all these elements constitute the *feederLoss$_{TP}$* . Note that, as specified in *Equation 5.5.-2*, the *feederLoss$_{TP}$* includes the amount of cable losses, which might not be ignorable for some of the TPs.

The "*eirpCapability*" for each TP must be calculated by Equation 5.5-1:

Equation 5.5-1

$$eirpCapability_{TP}\left(dBm/10MHz\right) = EIRP\left(dBm/10MHz\right) - G(dBi) + maxAntennaGain_{TP}(dBi) - feederLoss_{TP}(dB) - N_{RU\_TP}(dB)$$

where *feederLoss$_{TP}$ (dB)* is the aggregated insertion loss from the cables, splitters and other passive elements which are part of the connection between the RU and the TP, and it can be either:

1. Measured in the field by the DAS installer using measurement devices calibrated for the CBRS band frequency range

2. Obtained from an RF or deployment planning tool which has been configured with the list of materials (cables, splitters, connectors) used in the installation

3. Manually calculated using Equation 5.5.-2

Equation 5.5-2

$$feederLoss_{TP}(dB) = \sum_{c=0}^{C} cableLoss_c(dB) + \sum_{s=0}^{S} splitterLoss_s(dB) + otherLosses_{TP}(dB)$$

The calculated *eirpCapability* per TP must not exceed the maximum allowed EIRP of the RU as recorded in the FCC database during the certification process.

In Equation 5.5-1, *EIRP (dBm/10MHz)* represents the maximum allowed EIRP of the RU by the FCC obtained from FCC database, *G(dBi)* is the maximum antenna gain of the reference antenna submitted by the RU vendor through FCC certification process, *maxAntennaGain$_{TP}$(dBi)* is the maximum antenna gain of the TP, and *N$_{RU\_TP}$ (dB)* represents the ratio of the number of RU antenna ports, to the number of the antennas connected to each TP in dB domain. For passive DAS, the total conducted power of the RU is equally divided by the number of ports coming out of the RU.

Annex A: Examples of Passive DAS and eirpCapability Calculation

A.1 Example of Passive DAS using Single-port Antennas

Figure A.1 contains an example of a passive DAS connected to an RU, assuming that the RU has been certified by the FCC with a max EIRP of *45 dBm/10MHz* using a maximum antenna gain of *15 dBi*.
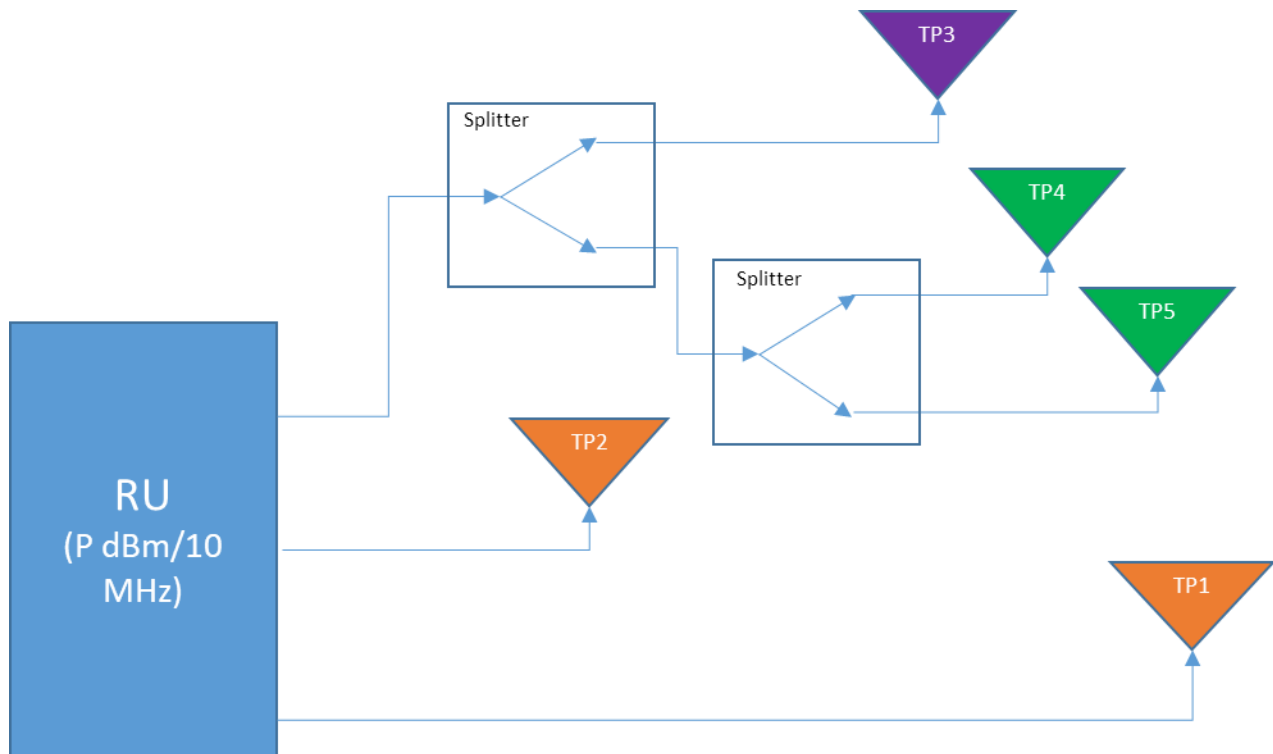
A.1: Passive DAS Example

For this example, it is assumed that splitter loss for both splitters in the Figure is *3.5 dB*, and that the cable loss for each segment of the cable is *2 dB* (including the connector losses). The DAS TPs have omni antennas antenna with a maximum antenna gain of *1 dBi*.

The RU has 3 antenna ports, and each TP is connected to one port, with one antenna connected to each TP. Hence the $N_{RU\_TP}(dB)$ for all TPs will be equal to *10*log(3/1) = 4.77 dB*, which means each of the 3 RU ports has a *4.77 dB* power reduction compared to the total RU EIRP.

The *feederLoss$_{TP}$ (dB)* for each TP can be calculated as follows:

- For TP1 and TP2 (zero splitters, one cable segment): *feederLoss$_{TP}$ (dB) =0+2=2 dB*

- For TP3 (one splitter and two cable segments)*: feederLoss$_{TP}$ (dB) = 3.5 dB + 2 dB + 2dB = 7.5 dB*

- For TP4 and TP5 (two splitters and three cable segments: *feederLoss$_{TP}$ (dB) = 3.5 dB + 3.5dB + 2 dB +2 dB + 2 dB= 13 dB*

For *Figure A.1*, the *eirpCapability* can be calculated as follows:

- For TP1 and TP2, *eirpCapability (dBm/10MHz) = 45 – 15 + 1 – 2 – 4.77 = 24.23 dBm/10MHz*

- For TP3, *eirpCapability (dBm/10MHz) = 45 – 15 + 1 – 7.5 – 4.77 = 18.73 dBm/10MHz*

- For TP4 and TP5, *eirpCapability (dBm/10MHz) = 45 – 15 + 1 – 13 – 4.77 = 13.23 dBm/MHz*

The Example depicted in Figure A.1 shows a Passive DAS deployment using multi-port RU. The multi-port RU might be as a result of an internal splitter. However, some Passive DAS realizations can be similar to the example depicted in Figure A.2. Both Equation A.1 and A.2, and all the above calculation would hold for Figure A.2, by setting N_{RU_TP} =10*log(1/1)=0 dB. Note that in this case, the *feederLoss$_{TP}$(dB)* for each TP must account for the insertion loss of the 3-way splitter and the cable loss of the cable that connects the RU to the 3-way splitter.
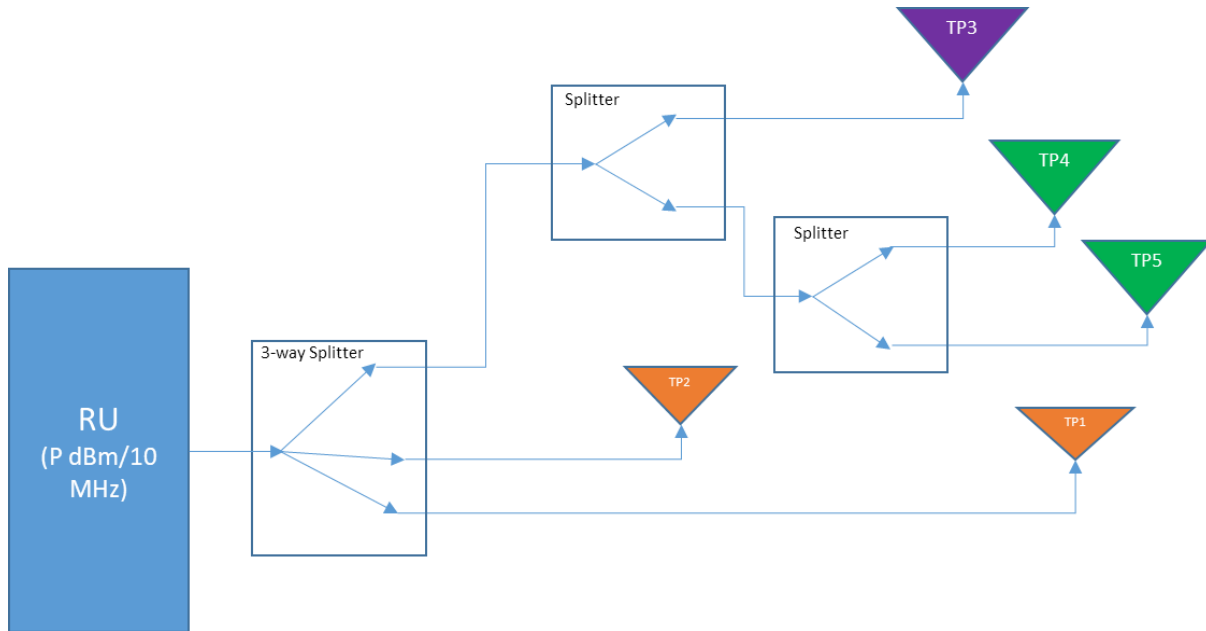
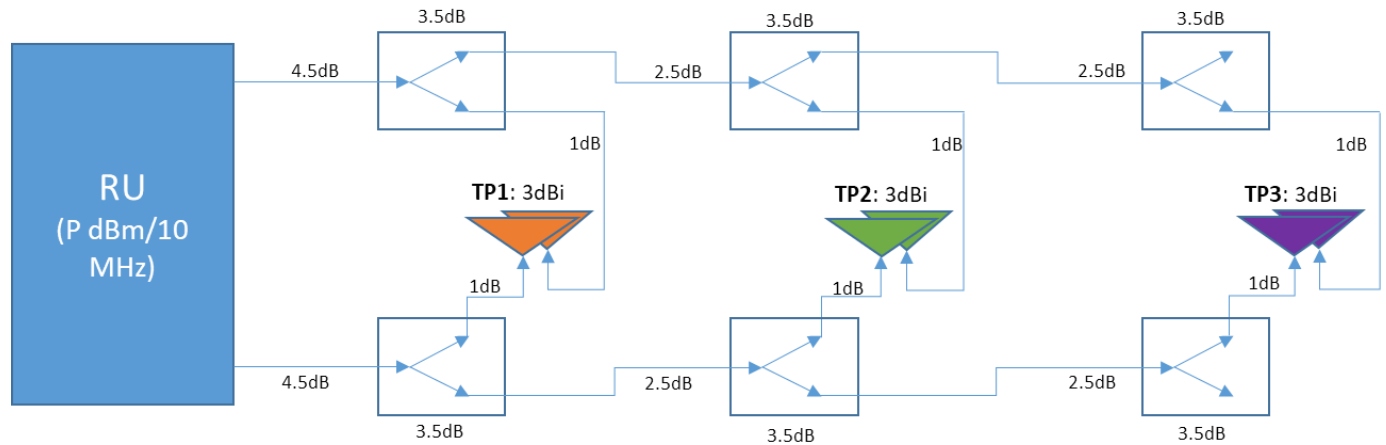**A.2: Passive DAS Example**

A.2 Examples of Passive DAS using Multi-port Antennas

A more realistic example of a passive DAS deployment is the one using multi-port antennas for MIMO deployments. Figure A.3 shows an RU with 2 antenna ports, supporting 2x2 MIMO, feeding several DAS antennas, each antenna with 2 ports.

Since the number of RU antenna ports is equal with the number of TP antenna ports, the $N_{RU\text{-}TP}$ = $10*log(2/2) = 0\ dB$.

Assuming the cable losses as represented in Figure A.3 along with:
- the splitter loss of *3.5 dB*
- TP peak antenna gain (*maxAntennaGain$_{TP}$*) of *3 dBi*
- RU certified maximum EIRP = *47 dBm/10MHz*
- RU peak antenna gain used in certification (*G(dBi)*) = *12 dBi*

A.3: Passive DAS using dual-port antennas for 2x2 MIMO deployments, with cable loss examples

The following EIRP capabilities can be calculated for each TP:
- TP1
  - *feederLoss$_{TP1}$ = 4.5+3.5+1 = 9 dB*
  - *eirpCapability$_{TP1}$ = 47 -12+3-9-0 = 29 dBm/10MHz*
- TP2
  - *feederLoss$_{TP2}$ = 4.5+3.5+2.5+3.5+1 = 15 dB*
  - *eirpCapability$_{TP2}$ = 47 -12+3-15-0 = 23 dBm/10MHz*
- TP3
  - *feederLoss$_{TP3}$ = 4.5+3.5+2.5+3.5+2.5+3.5+1 = 21 dB*
  - *eirpCapability$_{TP3}$ = 47 -12+3-21-0 = 17 dBm/10MHz*

Another example of a Passive DAS deployment is included in Figure A.4, where a 4-port RU is used to drive two sectors, each sector using a 2x2 MIMO configuration. For this case, $N_{RU-TP} = 10*log(4/2) = 3\ dB$.
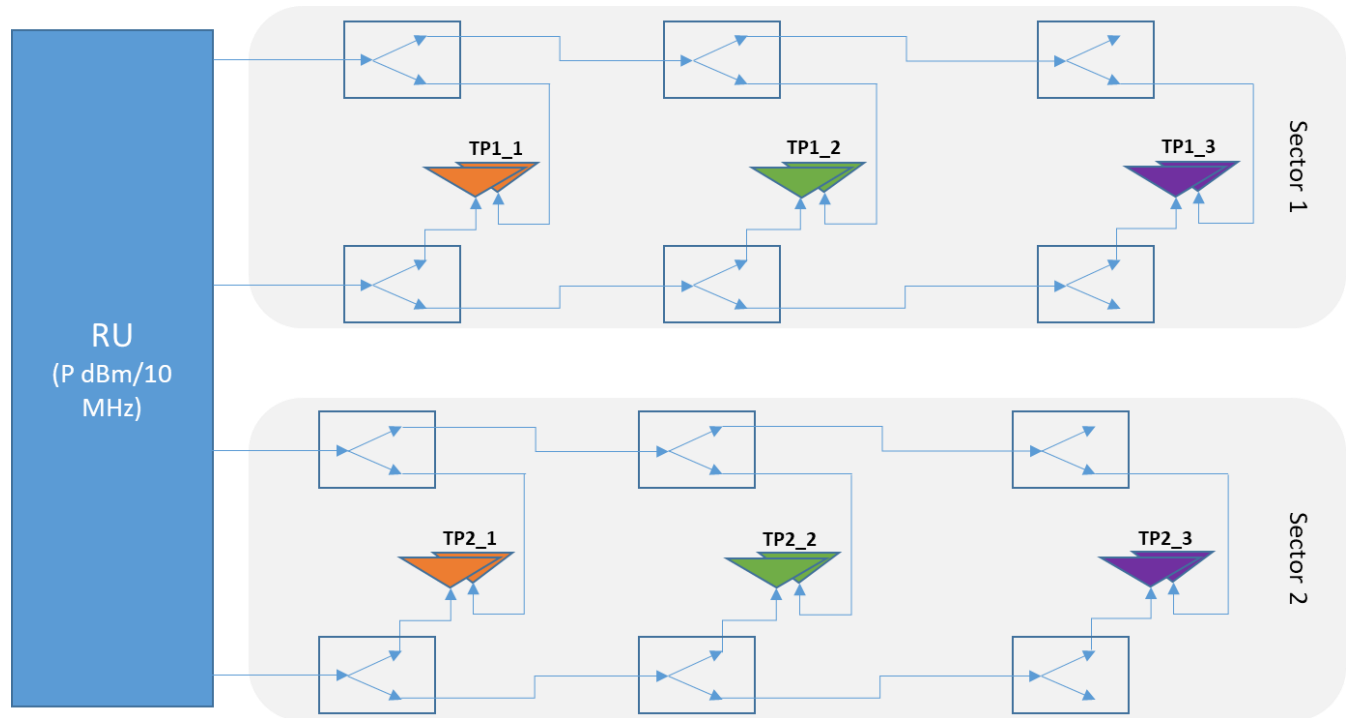
A.4: Dual-sector Passive DAS using dual-port antennas for 2x2 MIMO deployments

6   Document History

Document history		
V1.0.0	11 Dec 2018	Initial version
V1.1.0	31 March 2020	Added the guideline for Passive DAS
V1.2.0	8 September 2022	Updated Passive DAS to make it release independent