Care and feeding of
Passives for Distributed Antenna Systems

Passives defined

There are many types of passive devices that show up in distributed antenna systems. They encompass the universe of non-powered devices that filter, split or route RF power. Here's the primary categories which we'll explain in more depth.

- Power Dividers – aka "Splitters and/or combiners"
- Hybrid Couplers – aka "Hybrids or Hybrid Combiners"
- Directional Couplers – aka "Couplers"
- Power Tappers – aka "Taps or Tappers"
- 50 Ohm Terminations – aka "Loads"
- Duplexers – These separate uplink from downlink bands
- Filters
  - Notch, Public Safety sub-band filters
- Cross Band Couplers – aka "Diplexers"
  - Dual-Band, Tri-Band, Quad-Band

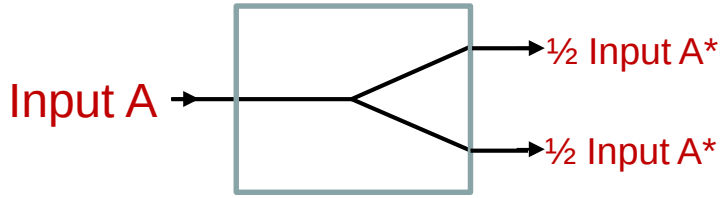
Splitters

The most basic type of passive RF device is a splitter. These evenly split RF power between 2 or more ports. They can be used to split the power from the BDA to 2 or more antennas. However differing coax lengths will create an imbalance of power between antennas. To solve the imbalance we use directional couplers or tappers which we'll explain later.

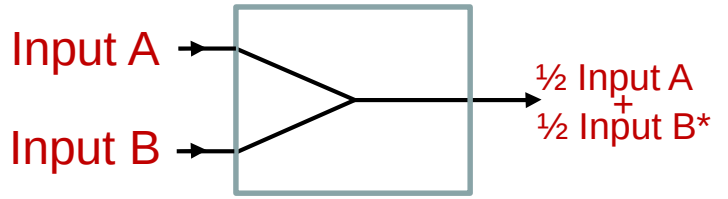
There's 2 types of splitters: Reactive (aka high power) and Wilkinson (aka low power). They can typically be interchanged within a DAS. Reactive splitters will typically have lower insertion loss making them somewhat favorable. But Wilkinson splitters are more compact which are important if these devices need to go inside junction boxes. Wilkinson splitters can however be used as a combiner, so long as it's for low power. The output ports on a Wilkinson splitter will typically offer 20dB of isolation between ports whereas a reactive splitter typically only provides a few dB of isolation. When a Wilkinson splitter is used as a combiner de-rate the power to 1/10th per port.

Reactive vs Wilkinson Splitters

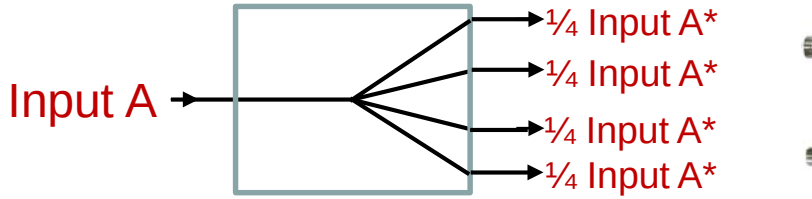
- Wilkinson (low power) splitters typically have one input and 2, 3, 4 or 8 outputs
  - A two way splitter takes one signal and splits it to two outputs with half the power out each port
  - When used as a combiner takes two inputs and half of both comes out the output (half the power of each is lost)
- Reactive (high power) splitters are typically available in 2, 3 or 4 outputs.
  - Can be used interchangeably with Wilkinson splitters in a DAS
  - Outputs are split evenly
  - Lower insertion loss than Wilkinson
  - Typical rating 300 to 500 watts



Splitter Block Diagram



Combiner Block Diagram



4 way Splitter Block Diagram

*Note – Output powers are theoretical and do not include insertion loss. Refer to specs for actual power out

Combiners

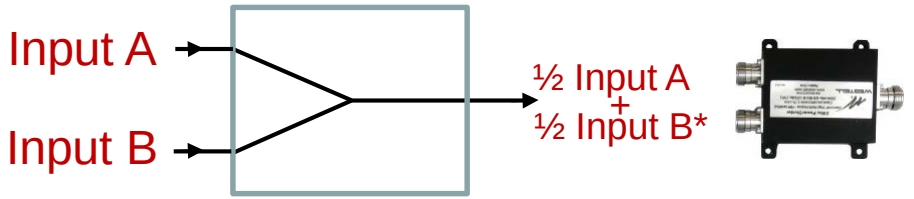
In the previous page I mentioned that Wilkinson splitters can be used as a combiner. However there's another product more suited to such use, a Hybrid Coupler/Combiner. Each will typically provide similar port to port isolation, but the Hybrid Coupler/Combiner will handle much more power than a Wilkinson splitter.

Another advantage of a Hybrid is they can be used as both a combiner and splitter in one. Notice on the next page where a 2 way splitter has 3 ports total, a 2x2 hybrid has 4 ports. The Hybrid Coupler can be used to combine two BDAs then feed 2 antenna systems. The RF signals going in each direction are combined and sent to both ports on the opposite side. If only using one output port be sure to add a 50 ohm termination load to the unused port. The load should be rated at least half the total input power of both BDAs that are feeding the Hybrid (BDA1 + BDA2 / 2).

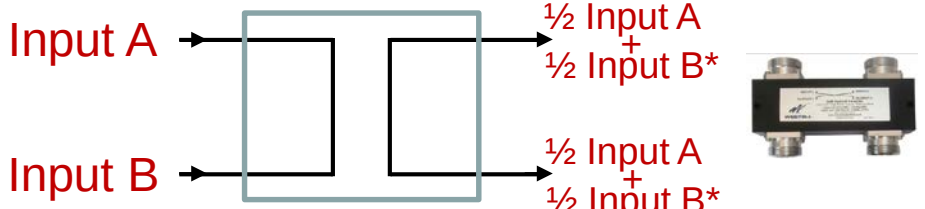
Note: the power rating on a Wilkinson splitter's spec sheet is for use as a splitter. For example the Westell low power splitters are rated at 50 watts. However, when used as a combiner they only handle about 1/10th of their rated power, in our case 5 watts.

Wilkinson Splitters vs Hybrids when used as a Combiner

- Wilkinson (low power) splitters when used as a combiner typically have one output and 2, 3, 4 or 8 inputs
  - A two way combiner takes two inputs and half of both comes out the output (half the power of each is lost)
  - A 3, 4 and 8 way combiner will also have the same loss in both directions, typically 5, 6 and 9dB respectively (not including insertion losses).
- Hybrid have multiple inputs and multiple outputs
  - Typically used to combine multiple sources
  - Half of both inputs comes out both outputs
  - The power is conserved using a hybrid if going to multiple outputs



Combiner Block Diagram



Hybrid Block Diagram

*Note – Output powers are theoretical and do not include insertion loss. Refer to specs for actual power out

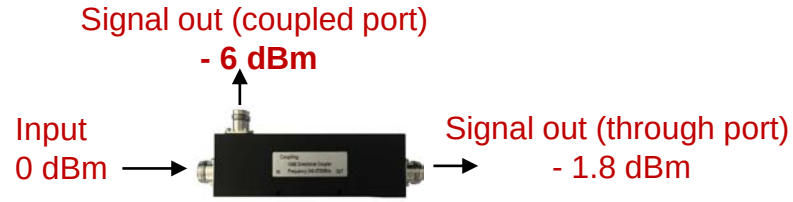
Directional Couplers vs Tappers

Like the two types of splitters, Couplers and Tappers are interchangeable in most applications. When used in the server (indoor) side of a distributed antenna system both tappers and couplers will work interchangeably. However there are slight differences. Directional Couplers have slightly higher insertion loss, however their VSWR on all ports is typically better. Tappers benefit from lower insertion loss, but the tap and out ports have slightly higher VSWR. These differences are generally not highly noticeable however, so I'll maintain they are interchangeable.

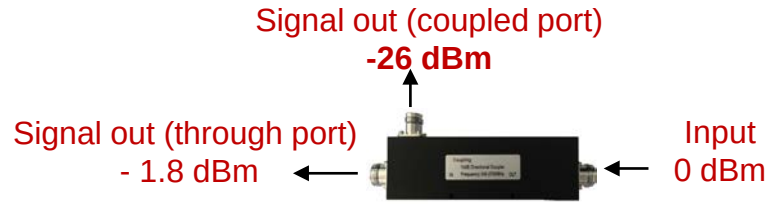
The biggest difference comes in the reverse path. Tappers exhibit no directionality whereas couplers do. Look at the examples on the next page to better understand how the reverse path varies. Another difference is in how they are rated. A directional coupler is rated by the ratio of the input port to the coupled port. A Tapper is rated by the ratios of the tap port to the output port. So a 6dB coupler is the same as a 5dB tapper, a 4.8dB coupler is the same as a 3dB tapper. However at values of over 10dB the difference become minimal.

Directional Couplers vs Tappers

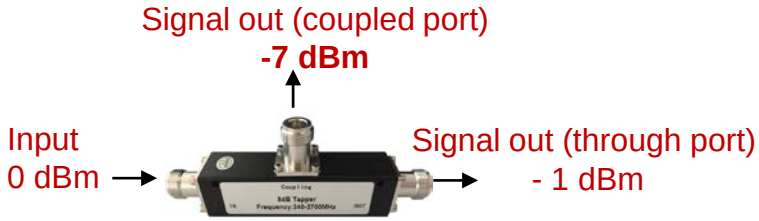
- Tappers and Couplers both operate as unequal splitters.
  - This is useful when balancing the RF power to a large number of antennas in a typical DAS.
  - Directional Couplers are designed to work in one direction. The coupled signal in the reverse direction is greatly reduced
    - Couplers are spec'd based on the power ratio between the input port and the coupled port
  - Tappers are not directional
    - Tapper port couples signal from both directions
    - Tappers are spec'd based on the power ratio between the through (output) port and the coupled port
    - Tappers are VSRW optimized on the input port, reverse paths will see slightly higher VSWR



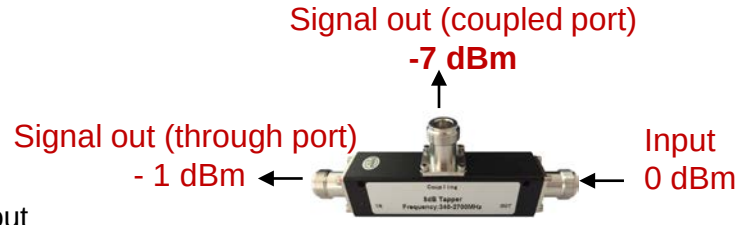
6dB Directional Coupler example



6dB Directional Coupler in reverse



6dB Tapper example



6dB Tapper in reverse

*Note – Output powers are powers are approximate and vary by frequency. Refer to specs for actual power out

Other Passive Devices

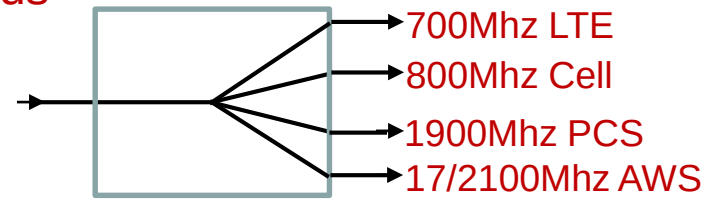
- 50 Ohm Terminations “Loads”

  Used to terminate unused RF ports

- Duplexers
  - Used to separate the uplink from the downlink frequency bands

- Filters
  - Notch, Public Safety sub-band filters
  - Used to filter out unwanted RF signals or bands

- Cross Band Couplers/Diplexers
  - Dual-Band, Tri-Band, Quad-Band
  - Used to separate or combine different frequency bands
  - Here’s a Quad Band cellular example



Westell offers 2 series of passives

When a passive device is used in a cellular DAS we are much more concerned with the PIM rating of the devices. With cellular's wide band modulation formats the likelihood of PIM showing up at a frequency that is disruptive is much greater. Plus the wideband technologies are much more sensitive to noise floor rise. PIM is still important in public safety and other narrowband systems, however it's not nearly as critical. Both because the narrow band technologies are more robust in some ways and the likelihood of PIM products showing up on a frequency that is noticeable is greatly reduced.

Westell offers 2 series of passives. Our low PIM series has been tested to verify a low PIM rating, and our non-PIM series is not tested during production in order to reduce manufacturing costs. Both are made to the same high quality standard, just the non-PIM isn't tested. Additionally our non-PIM passives are designed to operate down to 340Mhz, so they can operate in the most common commercial bands from UHF through 900Mhz and up.

Westell Public Safety Portfolio: Passives – Non-PIM Rated

Product Offering:

- Power Splitters →
- Directional Couplers →
- Power Tappers →
- Hybrid Couplers →

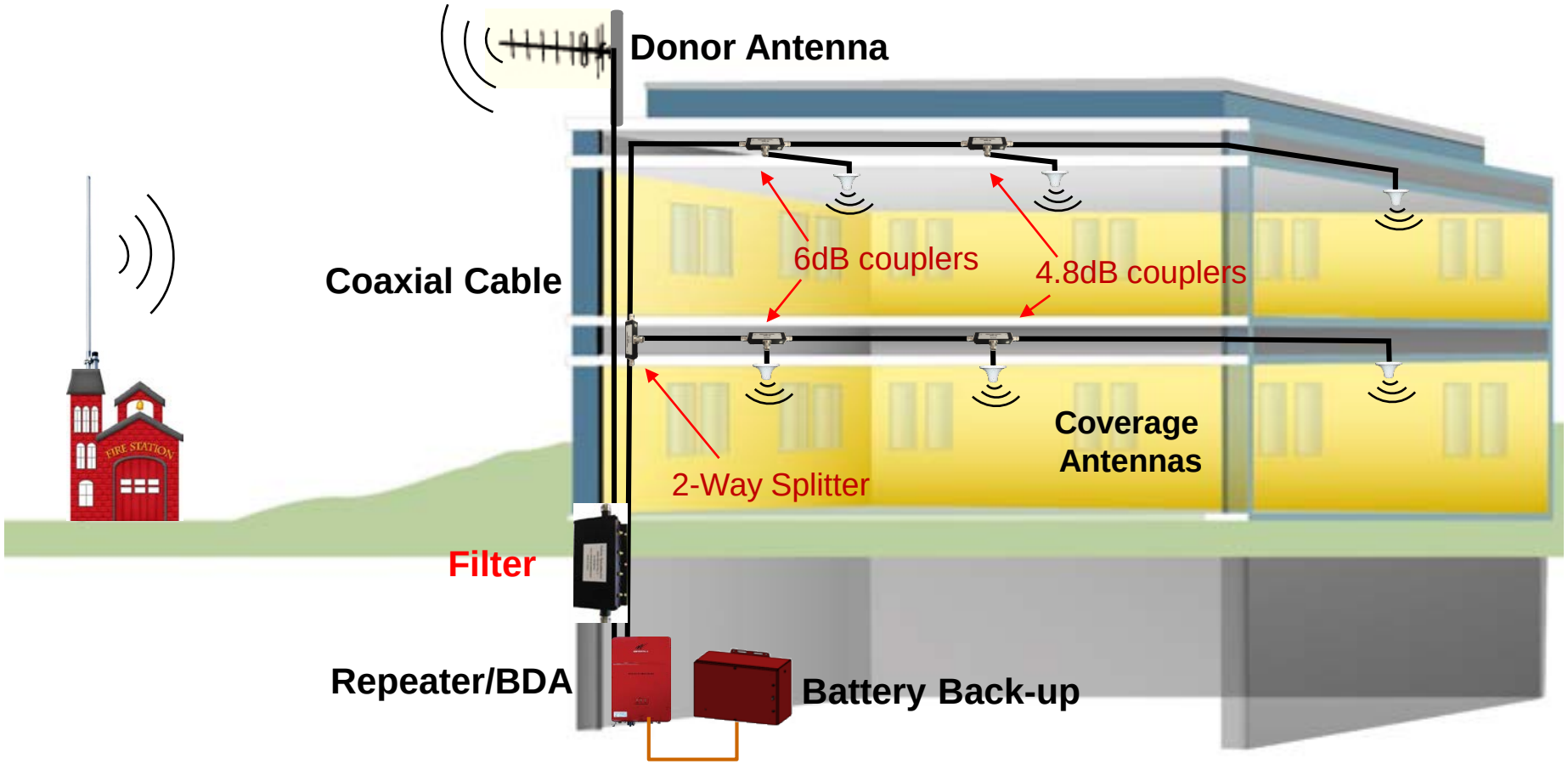
Features and Benefits:

- Frequency coverage 340-2700 MHz
- Low Insertion Loss
- Low VSWR
- IP-65 Ingress Protection Rated
- Inventory available with N(f) and 4.3-10(f) Connectors; 7/16 DIN(f) Special Order
- Carried by our distributers

Westell PIM Rated Passives

- Westell provides High Quality PIM Rated Passive Components
  - Operates from 617Mhz through 2700Mhz, covering all cellular bands
  - Passive return rate is .02%
- Customers asked and we listened
  - We Raised the Bar and now carry -154 & -161 dBc PIM Passives
    - First to Guarantee -161 PIM
    - We Guarantee all PIM specs to the advertised values
    - Some competitors use *"Typical"* on their specifications
  - Most Passives are available in 4.3-10, 7/16 DIN and N-type connectors.
    - N-Type connectors are not preferred for commercial applications any more but are still being used on Public Safety
    - 4.3-10 are becoming the standard
      - They are similar in size as N-type but higher performance low PIM

A Real World Example



In a typical example of a public safety DAS we see filters, splitters and couplers/tappers being used. By using a variety of coupler/tapper values the installer can evenly distribute RF power to each antenna to overcome the varying line losses in the coax cable. In this case the filter before the BDA is helping to manage potential interference from strong signals just outside the desired frequency band.

Push the Edge of Your Network
“Connect with Westell”

info@westell.com
Aurora, IL 60504
Toll-Free: (800) 377-8766