Application Note:

Deployment Examples and Guidelines for GPS Synchronization

For Multipoint and PTP Wireless Links

This document provides deployment examples and guidelines for GPS synchronization networks using Solectek's GPS MAC protocol. GPS synchronization is a useful tool for co-locating radios and is strongly recommended for densely deployed networks where multiple radios are mounted in close proximity at a tower of rooftop site.

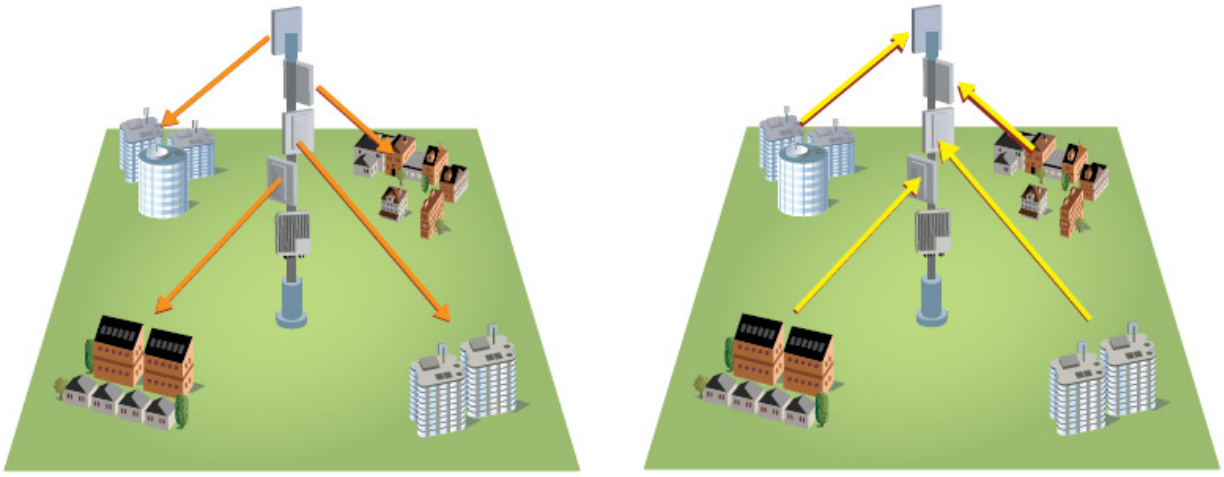
For details of how GPS synchronization and Solectek GPS MAC works, please refer to the white paper titled "GPS Synchronization" available for download at Solectek web site, www.solectek.com.

Version 1.3

Examples of Proper GPS Synchronization Deployment

Case I: Single Base Station Site

The simplest and most common case involves a single site deployment comprised of multiple base station sectors. All base stations are synchronized. The following diagram illustrates what happens during downlink and uplink time slots. Any one of available D/U ratios (1:9 to 9:1) can be used with this configuration, but it is important to note that all of the synchronized radios must be configured with the same D/U ratio, once you select one D/U ratio for the network.



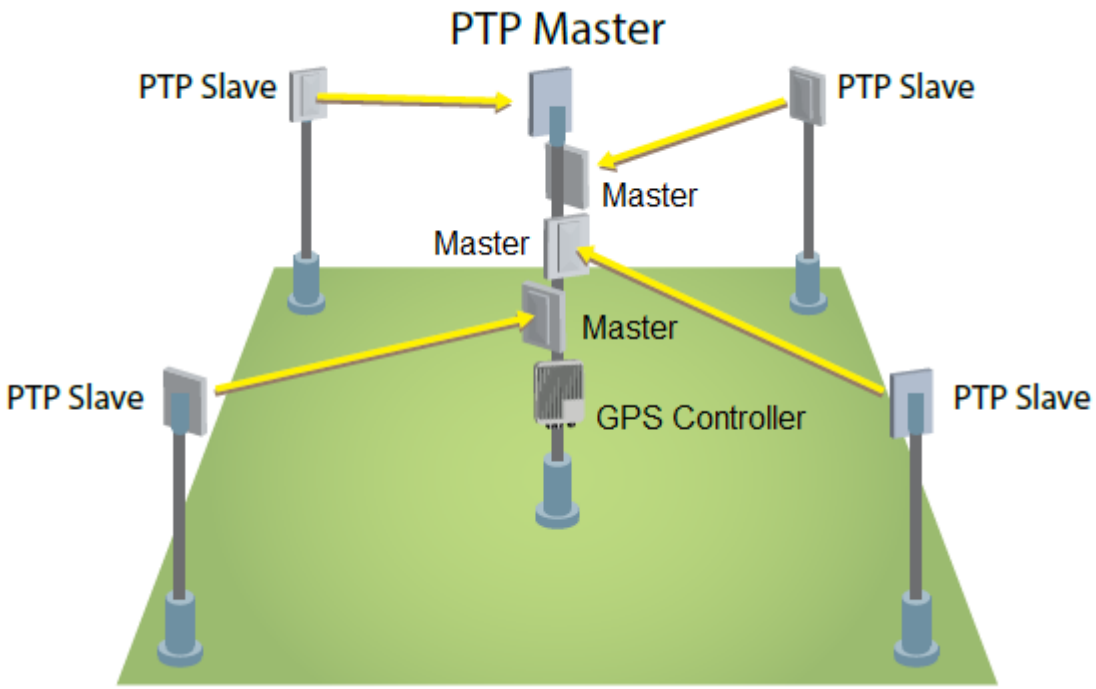
The left diagram indicates a downlink time slot during which all base stations are transmitting and sending data to subscriber units. The right diagram indicates a time slot during which all base stations are receiving data from subscriber units.

NOTE – For a single deployment case, GPS signal is NOT absolutely necessary for successful operation. Even if the GPS signal is lost or the GPS receiver module fails, the internal clock in the GPS Controller will continue to provide reference pulse signals to radio units and synchronization will be preserved. It is strongly recommended that the GPS failure is investigated and the GPS reference signaling is restored. You can check on the status of GPS signals by logging into the GPS Controller's GUI.

Case II: Single Aggregation Site of PTP Links

This configuration involves an aggregation of potentially a large number of PTP links. For example, images from surveillance cameras deployed region-wide need to be transported to a central monitoring center. Due to high-resolution requirements, the customer may want to use dedicated PTP links, but a large number of PTP links installed at a central site may cause cross-interference.

You can look at this in a similar way to Case I by considering PTP Master units to function similarly to base stations. Any one of available D/U ratios (1:9 to 9:1) can be used with this configuration. Again, all of the radios must be configured with the same D/U ratio, once you select one D/U ratio for the network.



At the central site, make sure to configure radios to be PTP Master units so that all co-located radios are transmit/receive synchronized. All of the Master PTP units need to be connected to the GPS Controller, shown at the bottom of the central site.

Case III: A Station Site with more than 5 radio units

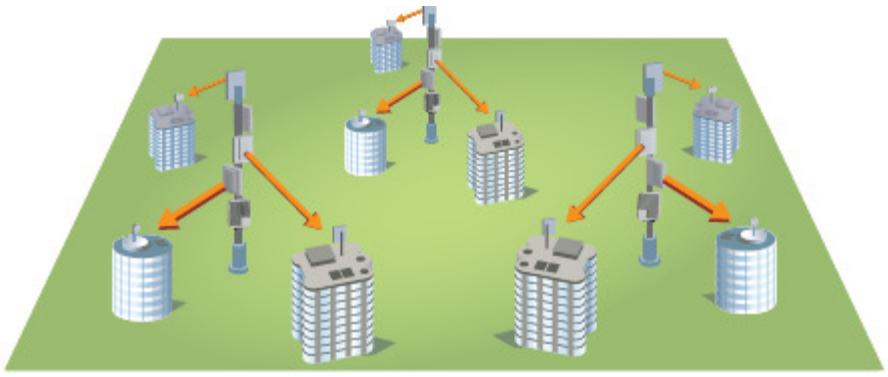
This configuration is for the case of locating more than 5 radios at a single tower. Each GPS Controller can support up to 5 radios. Deploying one more GPS controller will allow synchronization up to a total of 10 radios on a single tower. Each GPS Controller independently obtains GPS signals from satellites. Thus, there is no need for connection between GPS Controllers.

CAUTION – If there are two or more GPS Controllers deployed in your synchronized network, use of GPS signals as reference is critical. Internal clocks cannot be controlled precisely and signal drift can occur very quickly, causing loss of synchronization and potential degradation of network performance.

CAUTION – If synchronized radios are of mixed variety, multipoint base stations and PTP links, the requirement in Case V below must be satisfied.

Case IV: Multiple Base Station Sites

This is an extension of Case I where there are now multiple base station sites. This is a regional deployment scenario for larger area coverage. All base stations are synchronized by the controller at the site. All of the controllers are in turn synchronized by the common GPS signal. As with Case I, all D/U ratios can be used with this configuration.



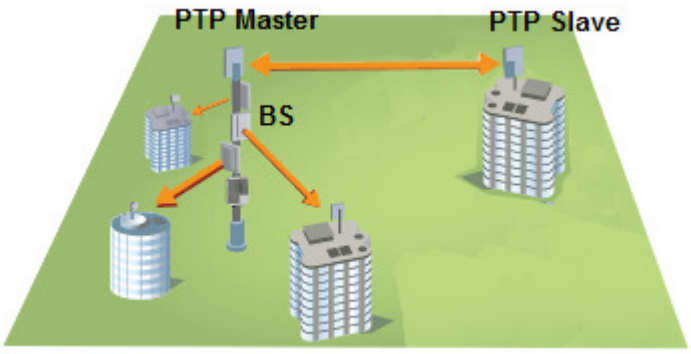
Shown here are three different sites. Each site has multiple base stations co-located. Through the use of a common GPS signal, all of these base stations can be synchronized.

CAUTION – Unlike the case of a single site deployment, multi-site synchronization WILL require GPS signals as the common reference for ALL of the radios to be synchronized.

Case V: Single Base Station Site, PTP Backhaul to Center

This is the case where you want to add a backhaul PTP kit to a synchronized base station site. This is useful when your backhaul PTP kit is operating in the same frequency band as the base stations on site. This works well when the D/U ratio is set to be 5:5. However, when the asymmetric ratio is used, there is traffic mismatch and information overflow could occur.

For example, consider you are using the 2:8 ratio, uplink heavy, multipoint network for camera backhaul, along with the PTP link at the same site. A PTP Master unit is synchronized with base stations. During the camera upload cycle, multipoint base stations and PTP Master unit are in received mode, which represents 80% of the cycle. Unfortunately, this means that PTP link time slot is configured as 80% from central to base site and 20% from base site to central. The PTP link then has to squeeze all of the camera images in its 20% time slot (and 80% time slot is mostly wasted). This creates a bandwidth imbalance between the multipoint networks and PTP backhaul, the effect being more pronounced for highly asymmetric ratios like 1:9 and 2:8. Given this, this type of setup with asymmetric D/U ratio is NOT RECOMMENDED for field deployment.

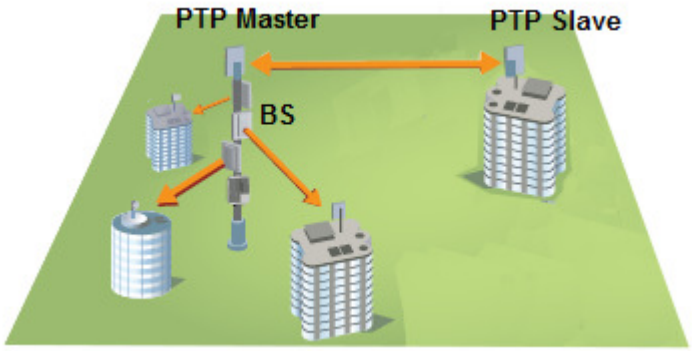


In the above diagram, the site on the left has many base stations co-located. A PTP link is used to backhaul the base station traffic to another site (central gathering point, for example). A PTP Master unit is located at the base station site on the left and it is connected to the PTP Slave unit at the other site.

Case VI: Multiple Base Station Sites, PTP Backhauls to Center

This is an extension of Case III where there are multiple base station sites and aggregated traffic from each site needs to be brought to a central site, using PTP kits operating in the same frequency band.

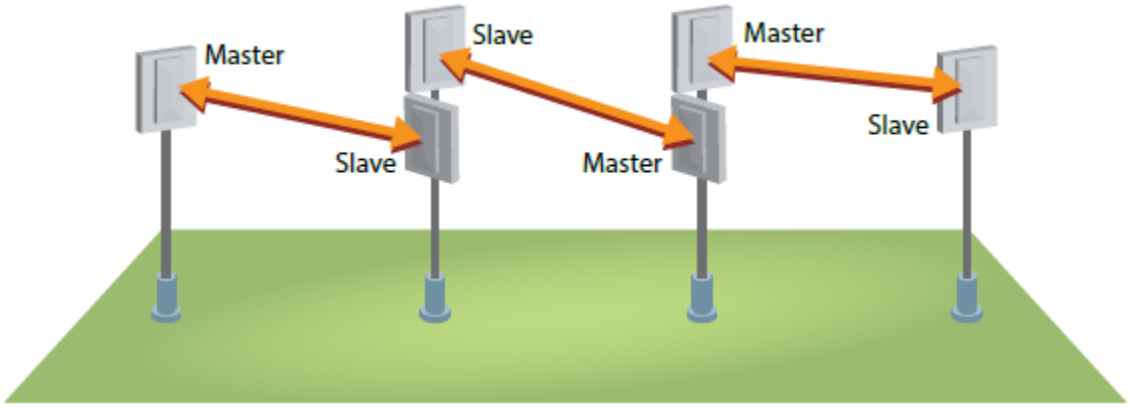
The same rules apply to this case as Case III. Technically, it will work well for the 5:5 symmetric D/U radio. Any asymmetry will create an unbalanced traffic pattern between base stations and PTP backhaul kits.



In the above, there are two separate sites shown. Each site has multiple co-located base stations. The two sites are connected using a PTP link. This is NOT allowed because a PTP Slave unit must be located at one of the two sites and it cannot be co-located with base stations.

Case VII: Daisy-Chain of PTP Links

This is a case of having a series of PTP links using intermediate sites. The user must make sure that each site must have the same type of PTP units, either master units or slave units, but not mix them together.

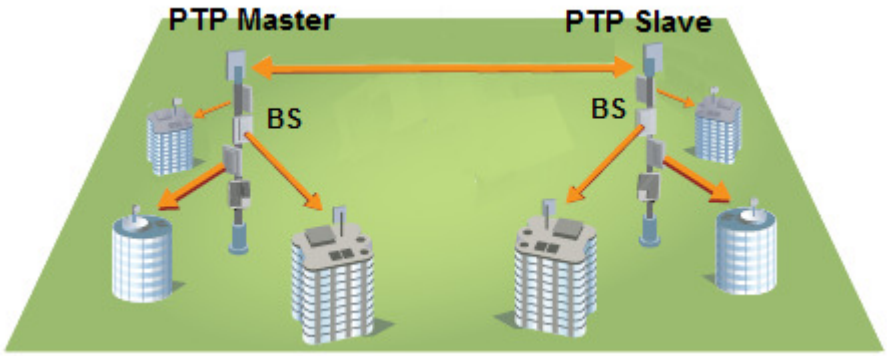


Improper Uses of GPS Synchronization

The following cases are NOT proper use of GPS synchronization and should be avoided.

Counter Case I: Two Base Station Sites, connected with PTP Backhaul

This case will **NOT** work. When all base stations are in time slots to uplink (client to base direction), the synchronized PTP kit is also in the uplink mode, meaning the Slave unit is transmitting and the Master unit is receiving. During this time slot, the Slave unit transmitter is interfering with base station receivers, causing cross-interference between the two units.



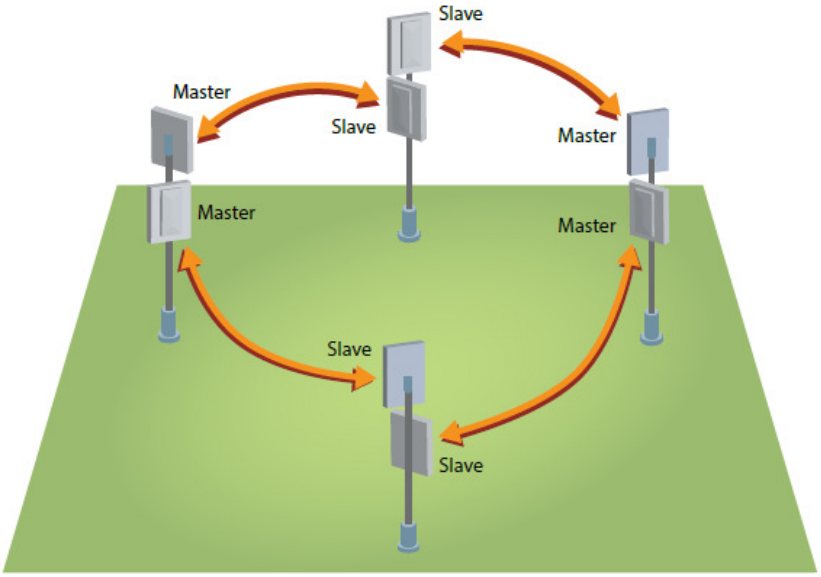
NOTE – In many case, it is more practical to backhaul the traffic to central using completely different frequency band so you can leave the PTP link outside of the synchronization network. A common choice is licensed microwave links operating in 6 -38 GHz.

Counter Case II: PTP Ring

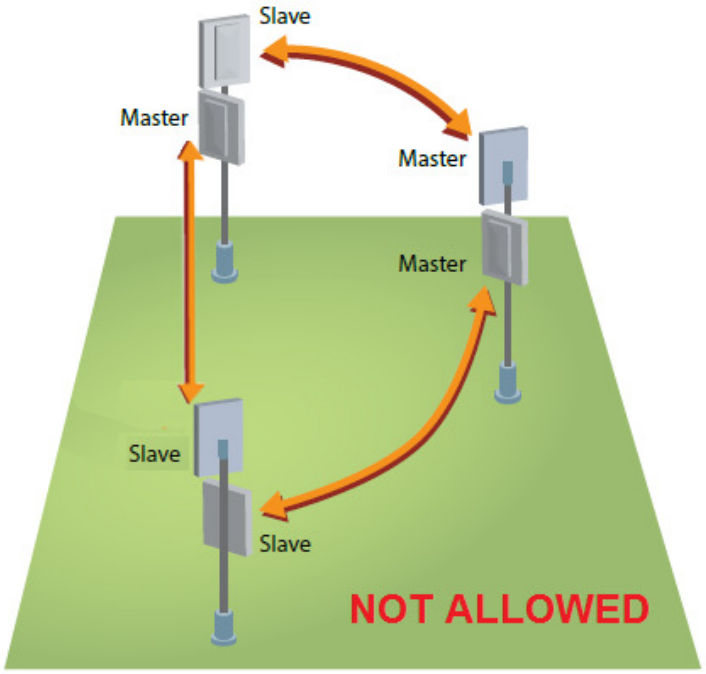
This represents a common use case for customers who would like to achieve fail-over redundancy. The topology consists of a ring around all of the nodes by connecting with PTP links.

The trouble with this scenario is that successful configuration depends on the number of nodes involved in the design. Basically, each site must have two PTP units of the same type, either Slave units or Master units. If there is an even number of nodes in the ring, the scheme will work out. For odd numbers, however, you will be forced to put one Master and one Slave on two of the nodes, which defeats the purpose.

Also, even in even-node cases, if you were to put multipoint base stations on ring node sites, you can only put them on sites where PTP Master units are located, so only half of the sites can be used with multipoint systems.



In the above ring case with an even number of nodes, you can make the co-location work at every site. Note that you may not co-locate multipoint base stations at nodes with PTP Slave units.



In the above ring case with an odd number of nodes, you cannot make the co-location work at one of the sites. One site (the top site in this example) has to have a slave and a master unit, not an allowable condition for GPS synchronization.

General GPS Deployment Guidelines

As you can see from the above cases, there are general “rules” that must be followed in all cases

- If two or more GPS Controllers are used in your synchronization network, make sure that the GPS reference signal is working properly. You can log into the controller GUI to verify this.
- The GPS D/U ratio (1:9 to 9:1) and choice of frame sizes (10ms or 20ms) must the same across the entire GPS synchronization network.
- If you want your backhaul PTP link to be a part of your synchronization network, make sure to understand the impact of using an asymmetric D/U ratio. The bandwidth imbalance may cause instability in your network.
- As a general rule of thumb, only PTP master units can be co-located with base stations at the same site. If a Slave unit is co-located with base stations, cross-interference will occur and the synchronization will not work.
- Sometimes, a link is simply not suitable for inclusion in your synchronization network. In that case, it is best if you do not force the situation. Keep it outside of the synchronization network and make sure that its operating channel is well separated from the rest and that there is a good physical separation from other radio units.

In addition, the following steps must be taken from the radio configuration perspective.

- When operating in 20MHz channel sizes, it is best to avoid adjacent channels on the same tower. A channel center separation of 40MHz is sufficient for normal operation for co-location. For a 40MHz channel size operation, adjacent channel deployment is allowed.
- Users should take care to set the Tx power at the optimum levels. In general, sufficient link margins should be maintained, but in short distance links, Tx power levels may need to be reduced to prevent radio receiver saturation. In addition, excessive Tx power levels may contribute to higher chances of interference in densely deployed areas.
- When planning base station sectors, make sure that the sector overlap is minimized. Some subscriber units may see signals of equal strengths from two base stations, which may cause degradation of performance for that substation.