

Case Study 011 – GPS Signal Re-Radiating in Tunnel Networks

This case study describes the application of RF over fibre technology to overcome problems of transporting GPS, Galileo and Glonass signals through tunnel networks.

Introduction

The use of GPS signals is now pervasive in everyday technology as they provide high accuracy location or timing data. This enables devices that range from tracking systems through to cellular phone networks to function effectively over wide geographic areas. Taking the example of a cellular network, the base stations require accurate timing information to ensure successful hand over of connections between the cell sites. Depending on the topology employed this timing can be provided by either E1 sync source from the backhaul network to which the remote site is connected or from a GPS signal directly received at the cell site. With the emergence of IP based networks, time synchronisation via GPS will become more prominent as no time reference is provided within the core network structure.

Network Synchronisation

Where GPS signals are used in network synchronisation, significant issues may arise when the base station does not have direct line of sight to the GPS satellite. This issue is overcome by fitting a remote antenna that has line of sight and can feed the base station with the GPS signal. Often the positioning of such remote antennas for optimum signal reception can be some distance from the base station. GPS signals are very weak which means that the signal may be too weak to use when carried over copper cabling. This problem is solved by routing the signal over fibre from the remote antenna to the base station equipment.

Applications

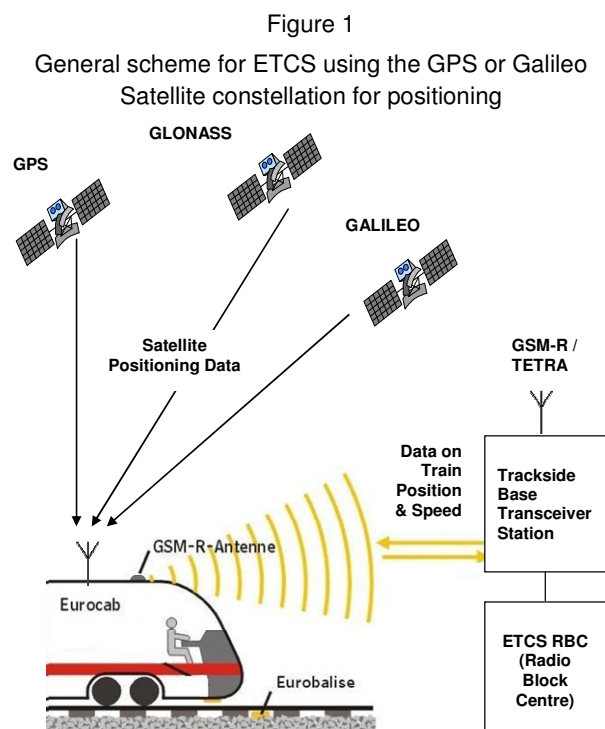
The requirement for GPS re-radiation within buildings and subterranean locations such as mines and tunnels continues to attract much attention. In response to market needs for remote GPS antennas within high-rise office blocks, PPM successfully launched Metro GPS, a turnkey fibre optic remoting solution. Metro GPS overcomes two problems presented in high-rise building GPS installations. First, by making use of a preinstalled single mode fibre networks that normally exist in high-rise buildings the GPS signals can be routed long distances from roof top antennas to equipment located in the basement.

Secondly, Metro GPS offers up to three RF channels so that fully redundant systems can be accommodated in situations where multiple antennas feed one equipment location. Metro GPS provides a point to point signal transfer system, but PPM have also provided other systems that cope with point to multi point requirements. Variants of the Metro GPS system can be used to transmit a variety of RF signals up to 4GHz in bandwidth.

GPS in Tunnel Networks:

Case Study: European Train Control System (ETCS)

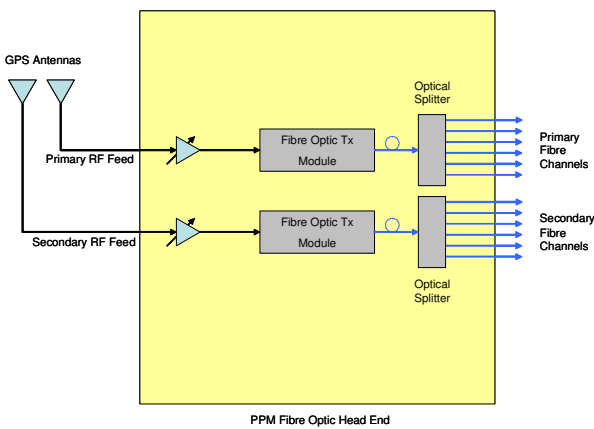
ETCS is the automatic train control system and will be a unifying standard for rail networks across Europe, Russia and beyond. The system utilises the GSM-R or TETRA radio network to communicate train position information to a remote control centre. Train position is currently identified by trackside sensors and radio beacons (Eurobalise) but in future GPS and Galileo positioning will be used as a primary reference as shown in figure 1. An important element of this system will be to provide GPS signals within tunnels along the route of the railway so that the train position is always known.



This creates problems for the weak GPS signals due to the distances involved. PPM has developed an optical re-radiation system to overcome this problem

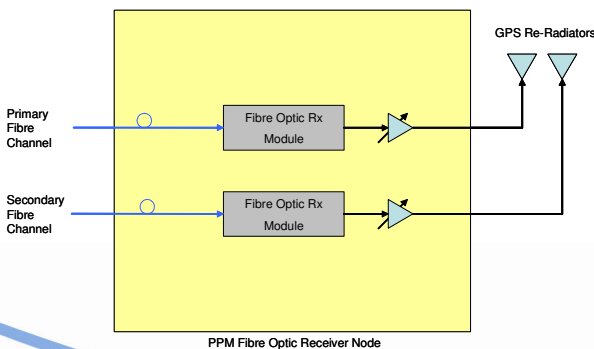
For the ETCS project PPM designed and manufactured the fibre optic head-end shown schematically in Figure 2. The electrical signal is converted into an optical signal which is coupled into a passive optical splitter that produces a customer defined number of optical feeds for distribution to the nodes in the tunnel. In this particular case both primary and secondary GPS (RF) feeds were used for redundancy purposes to maintain full signal integrity.

Figure 2
Schematic of Fibre Optic GPS Distribution Head-End



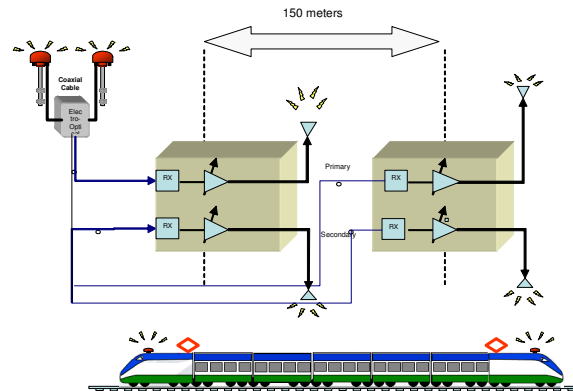
Each fibre channel feeds GPS signals over single mode fibre optic cable to a GPS receiving node (Rx) shown schematically in Figure 3. The receive nodes are located inside the tunnel and spaced every 150 metres apart. At each receiver node, the GPS signal is converted back into an electrical signal before being fed to GPS antennae for re-radiation within the tunnel

Figure 3
Schematic of Fibre Optic GPS Receiver Node (as used in a Point-to-Multipoint Install)



This technique enables GPS extension into the 1150m tunnel without any appreciable degradation to re-radiator performance. Figure 4 shows a representation of the deployed multiple fibre channel point-to-multipoint distribution used by the rail operator.

Figure 4
Deployment used by European rail operator, showing the GPS head-end outside the tunnel and receiving nodes spaced at 150 metres within the tunnel.



The fibre optic system outlined in this case study provides a transport platform that enables extended reach into tunnels, and can typically be deployed in tunnels over 30km in length. The point-to-multipoint configuration has a high level of redundancy already designed into the transmission fabric. The head-end hardware comprises a standard outdoor enclosure (IP65 rated & NEMA 13) populated with redundant converters and fibre optic splitters and distribution. Each re-radiation stage is housed in a standard enclosure (IP66 rated, NEMA 13 rated) that feed re-radiating antennae. This design provides a primary and secondary path for the GPS signals which are both in operation at all times.

Conclusions

This case study has described the principle of GPS transmission over fibre and some of the large number of applications that benefit from using this technology. The example of the ViaLite Metro GPS product is given for use in building distribution, and the case of the European rail operator that required GPS distribution through tunnel networks has been given in some detail.

The following links provide more general information on this topic.

- http://en.wikipedia.org/wiki/European_Train_Control_System
- <http://www.ertms.com>
- <http://www.uic.asso.fr/uic/spip.php?rubrique850>