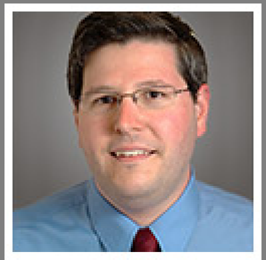
Single Frequency Network Structural Aspects & Practical Field Considerations

November 2011

Featuring GatesAir's

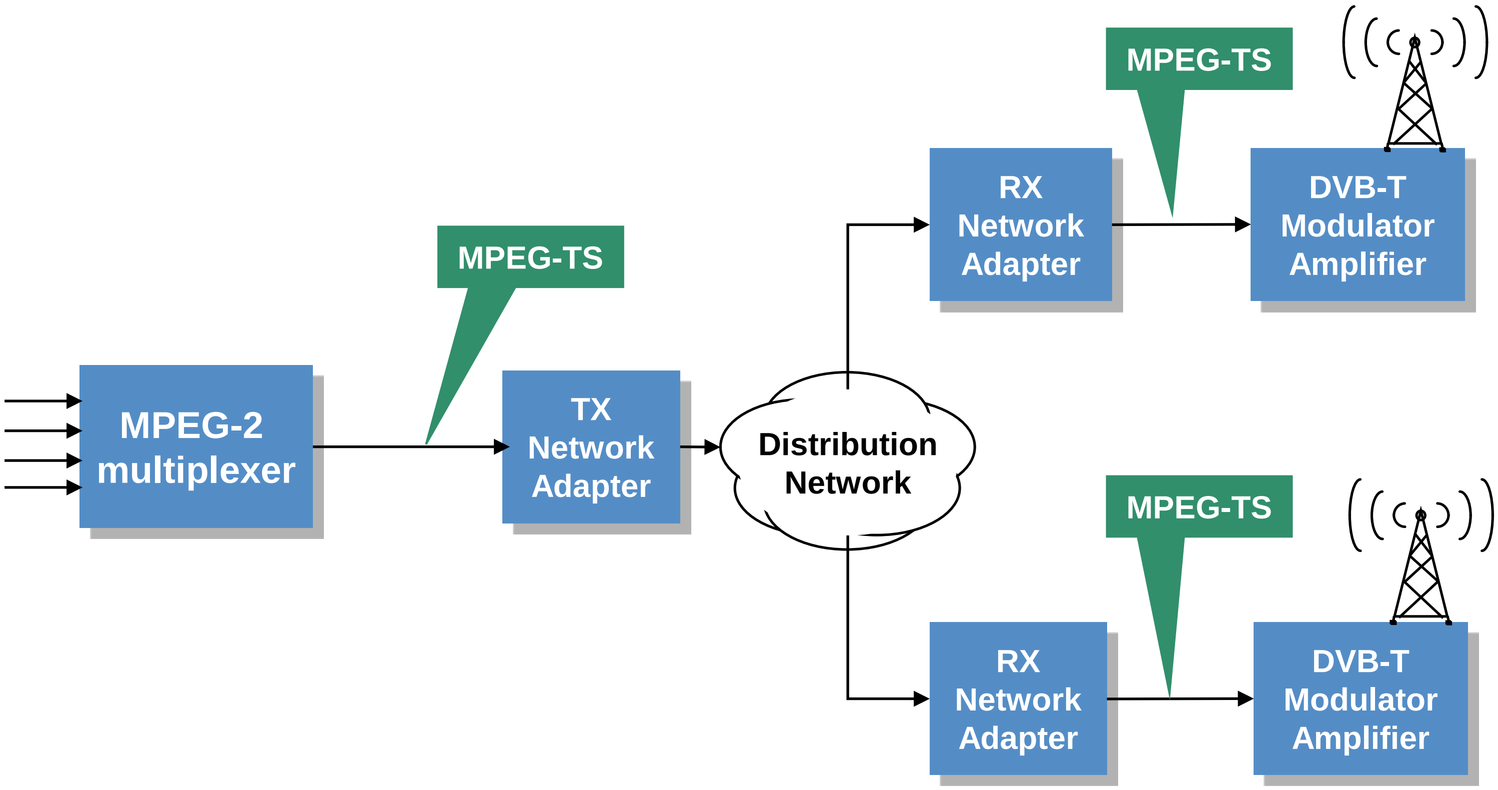


Rich Redmond
Chief Product Officer

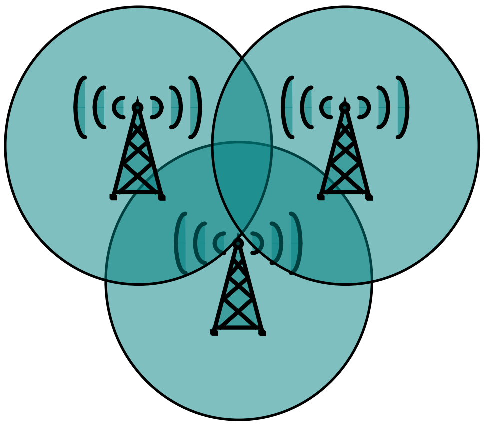
HARRIS

Single frequency network
Structural Aspects & Practical Field Considerations

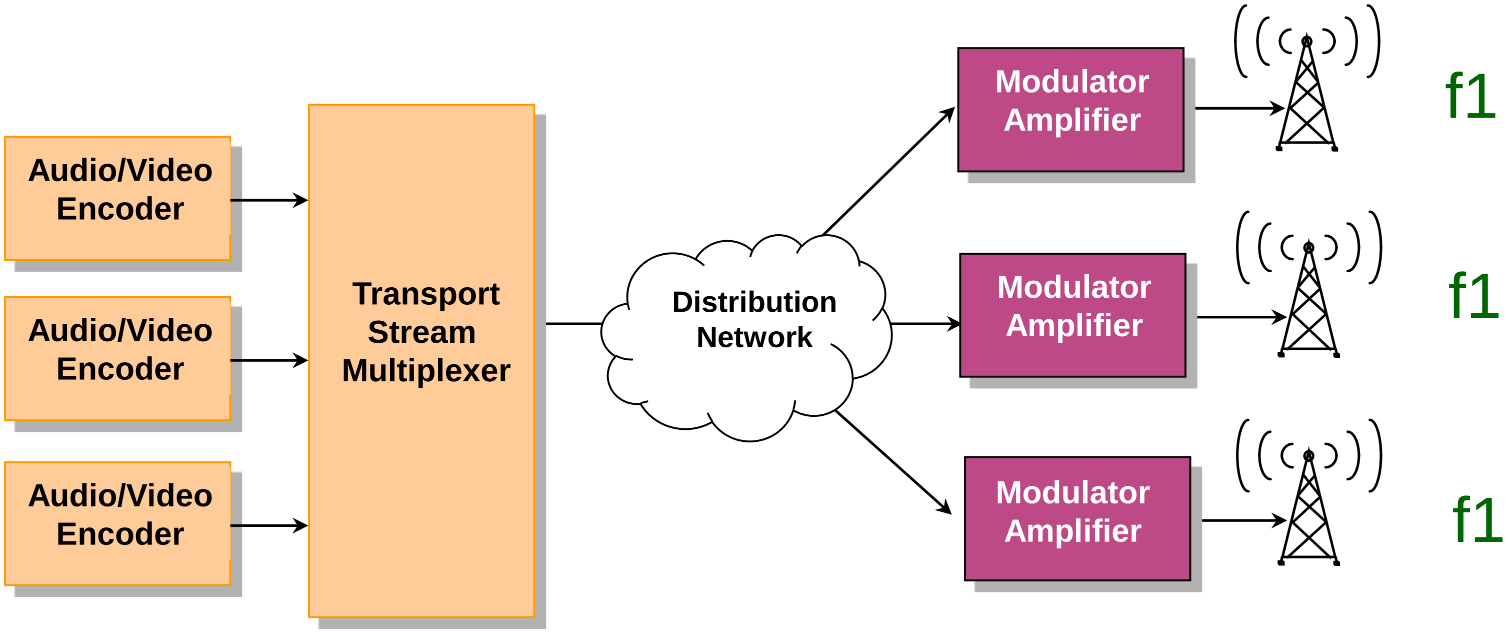
DVB-T Network Structure



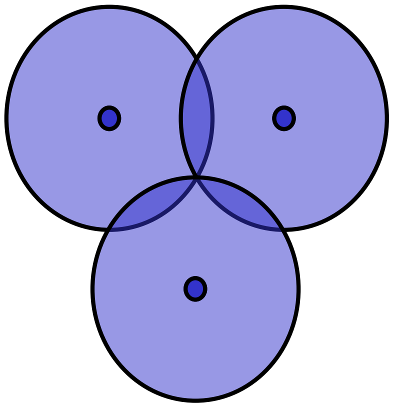
Single Frequency Networks

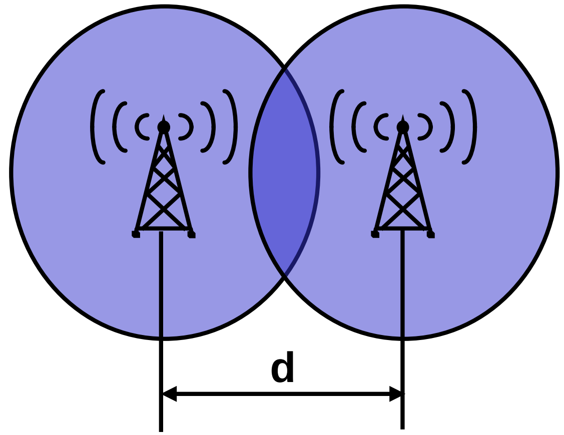


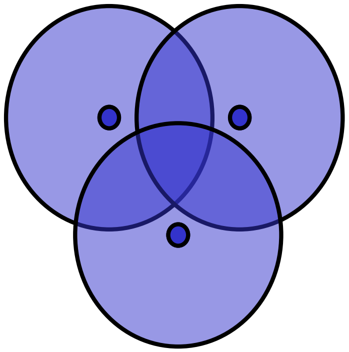
- All transmitters in the SFN send the same signal at the same time on the same frequency
  - careful network planning required
  - synchronisation (timing !)
  - low frequency demand



Transmitter Spacing in an SFN







Wide Transmitter Spacing

low “on-air” redundancy
lower number of sites
with higher powers

The maximum allowed distance between two transmitters in a SFN is defined by the Guard Interval

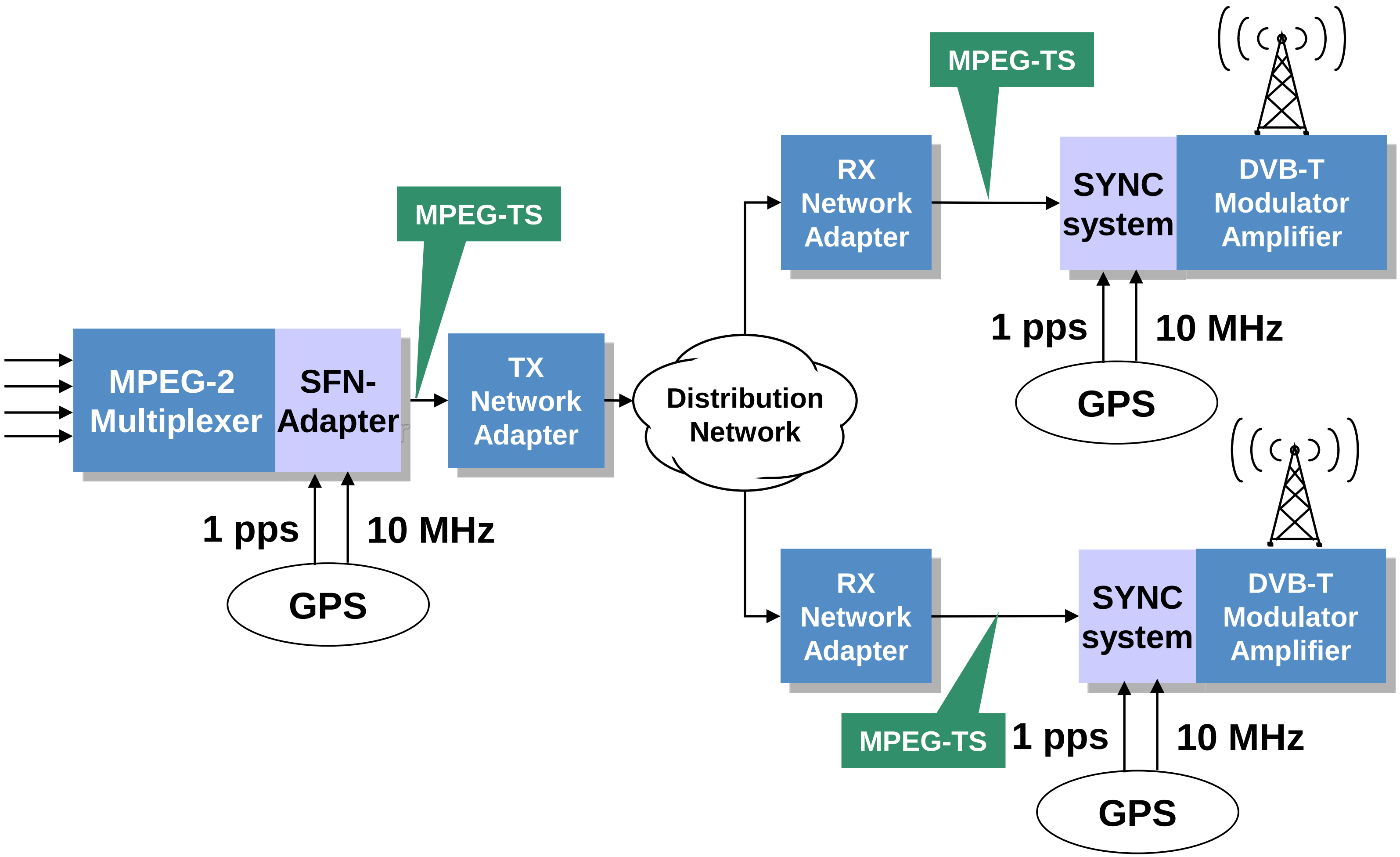
DVB-T (8k, GI 1/4): 224µs→ $d \leq 67$ km
DVB-T (8k, GI 1/32): 28µs→ $d \leq 9$ km
DVB-T (2k, GI 1/4): 56µs → $d \leq 17$ km
DVB-T (2k, GI 1/32): 7µs → $d \leq 2$ km

Narrow Transmitter Spacing

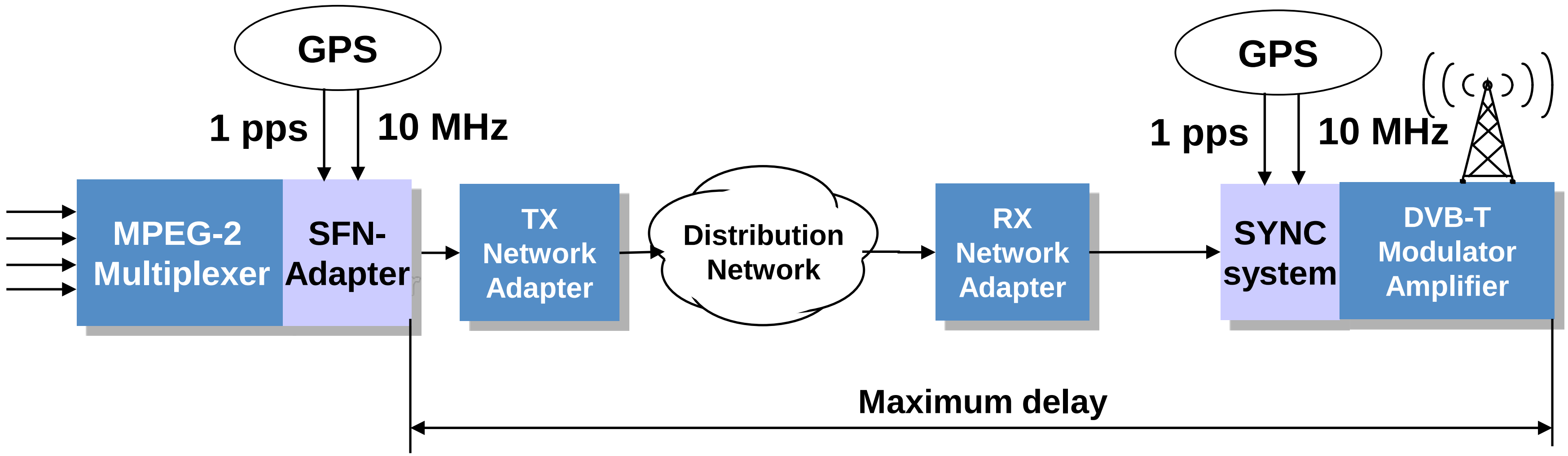
high “on-air” redundancy
higher number of sites
with lower powers

Max. Distance = Guardintervall * c (speed of light)

DVB-T Network Structure
Using Dynamic Delay Compensation



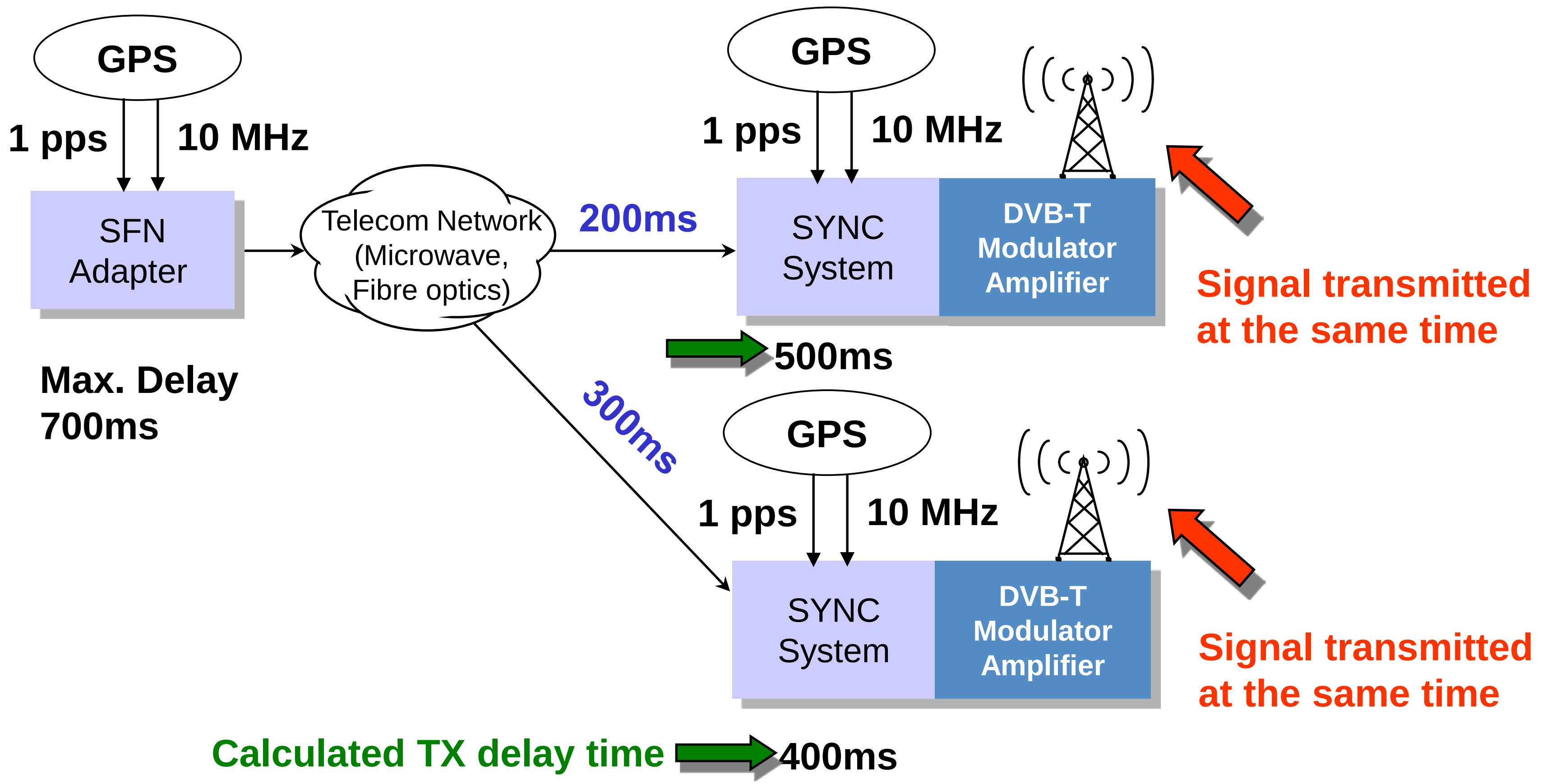
Maximum Delay



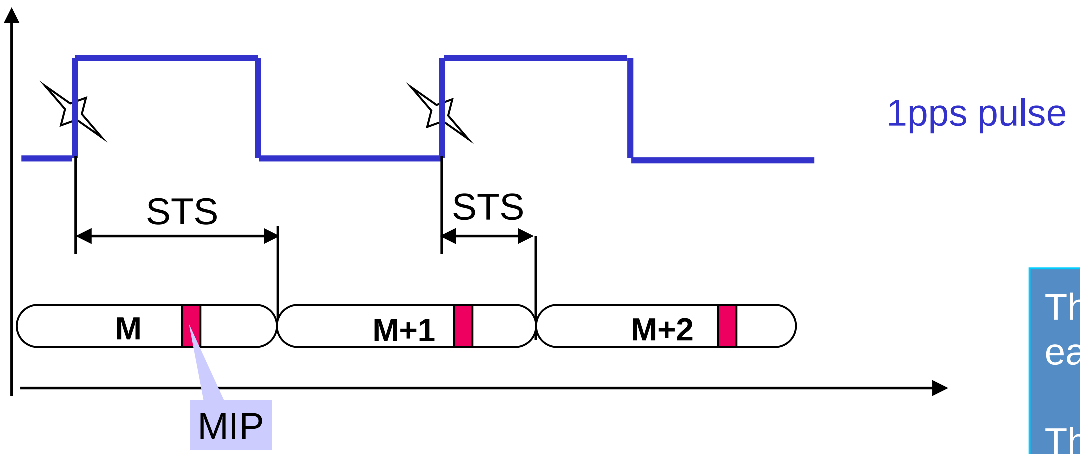
Maximum delay:
The maximum delay describes the difference in time between a specific Mega-frame leaving the SFN adapter and the corresponding COFDM Mega-frame available at the antenna output of each Transmitter in the SFN.

The maximum delay is a value adjustable in the SFN-Adapter. The set value has to be always higher than the longest actual network delay. The value is transported in each MIP

Transmitter Synchronisation
Dynamic Delay Compensation



Synchronisation Time Stamp



The STS is carried in the MIP of each Mega-frame.

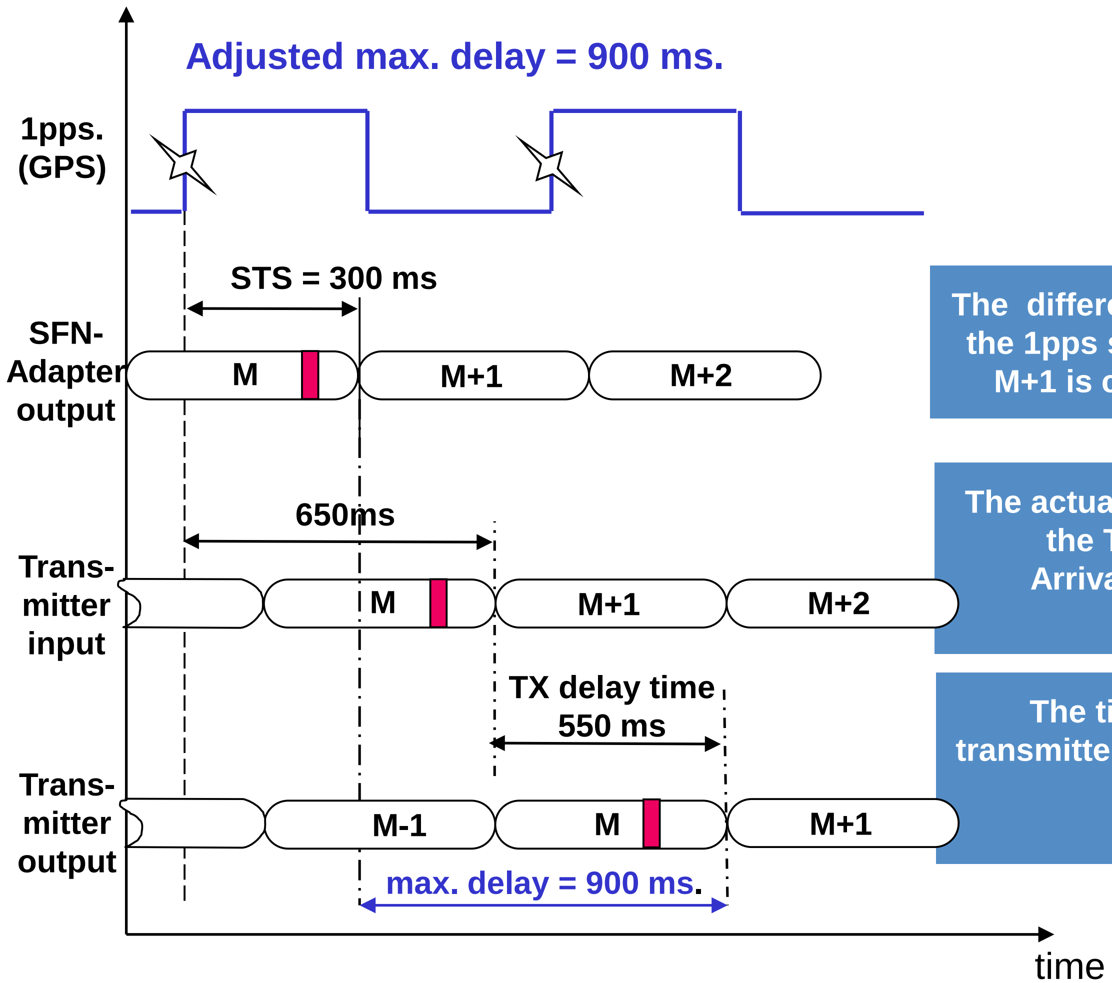
The STS carried in the Mega-frame M describes the beginning of the Mega-frame M+1

The STS carried in the Mega-frame M+1 describes the beginning of the Mega-frame M+2

etc.

Synchronisation Timestamp (STS)
The synchronisation timestamp value is the difference in time between the rising edge of the 1pps Symbol and the beginning of a mega-frame M+1

Functional Description of SFN Synchronisation



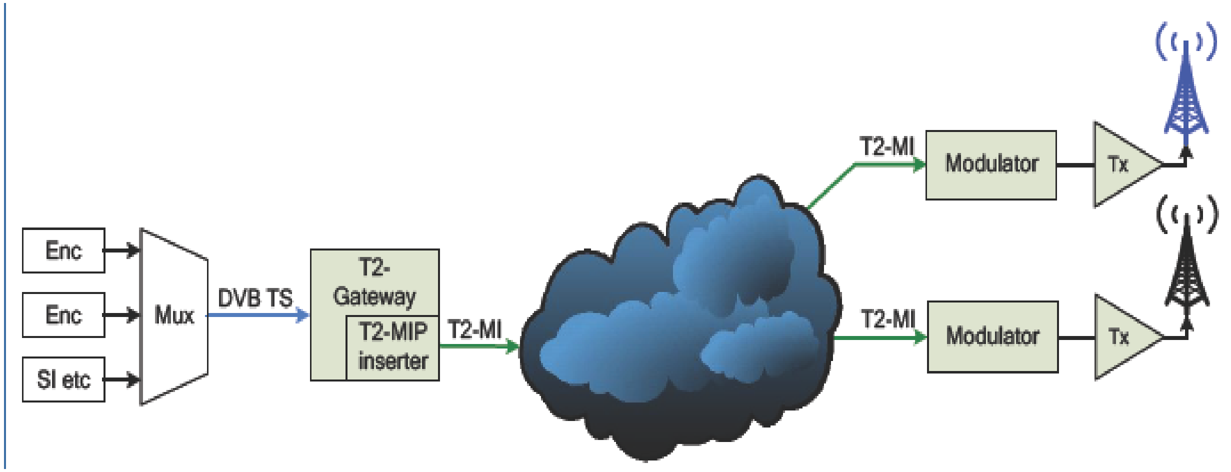
The difference in time between the latest pulse of the 1pps signal and the start of the Mega-Frame M+1 is copied into the MIP of Mega-Frame M

The actual delay of the M+1 frame at the input of the Transmitter is calculated like this:
Arrival time of frame (M+1) - STS value
= 650 ms - 300 ms = 350 ms

The time a frame has to be stored in the transmitter before it is sent is calculated like this:
Max. delay - actual delay
= 900 ms - 350 ms = 550ms

SFN DVB-T2

- All transmitters in the SFN send the
- same signal with SISO or MISO processing
- at the same time
- on the same frequency



Some specific aspects of SFN

The main feature of SFN DVB-T/T2 network is a high spectrum efficiency. A large number of programs can be broadcast on the same frequency in a local, regional or nationwide transmitter's network.

Various modulation schemes with FFT sizes and guard intervals allow construction of SFN networks designed for different applications: from low bit-rate but robust mobile reception to the high bit-rate fixed reception for domestic and professional use.

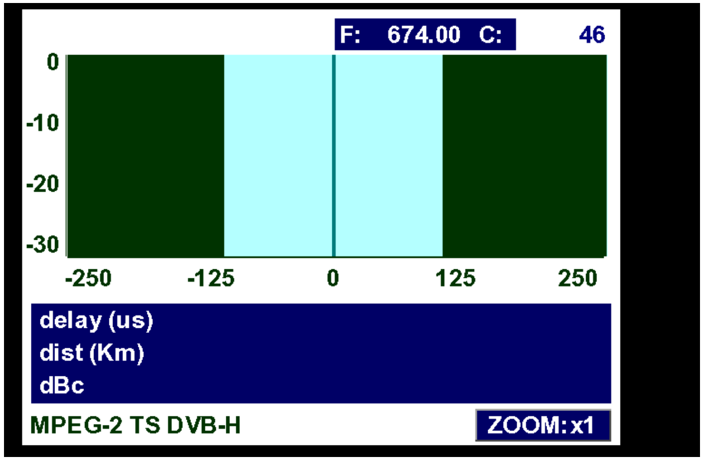
In general, the SFN mode has many advantages but one drawback is the frequency selective fading in DVB-T or DVB-T2 network in SISO configuration. Depending on phase relationship signals may cancel each other and this will appear as a "notch" or a slope across the band.

Some specific aspects of SFN

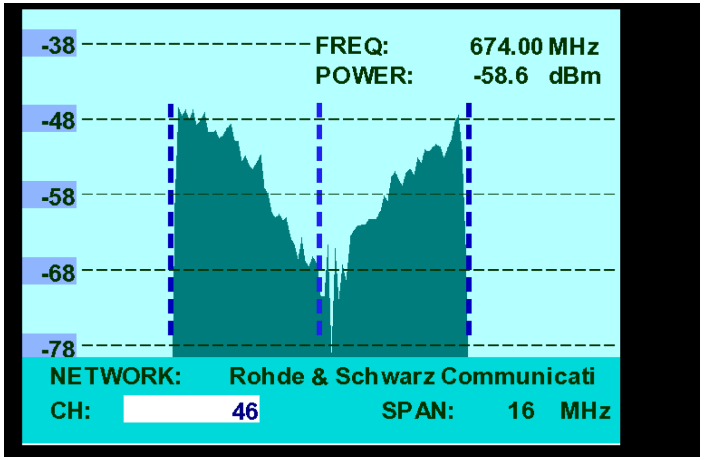
The notch depth will depend on the relative amplitude of the receiving signals and delay.

The worst case will happen if the RX signals have the same amplitude and delay.

Measured results are shown below.

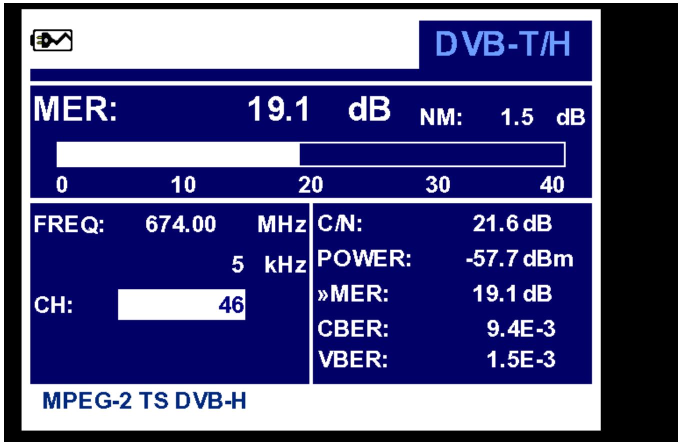


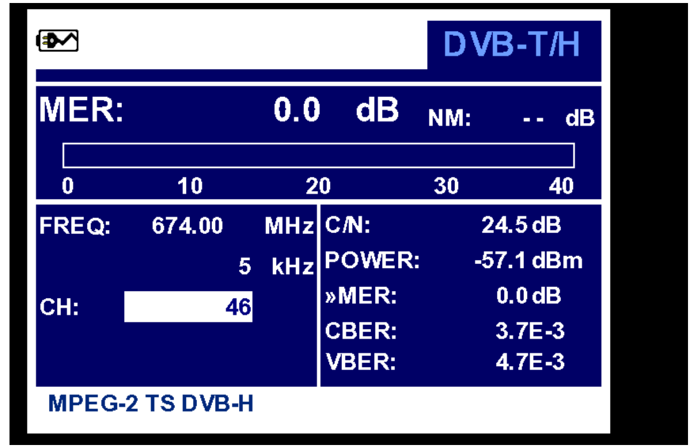
Amplitude/Delay differences between two RX signals are “zero”



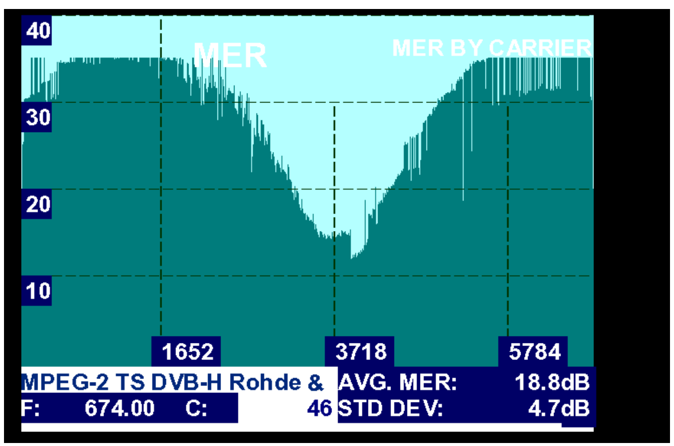
Notch in the spectrum

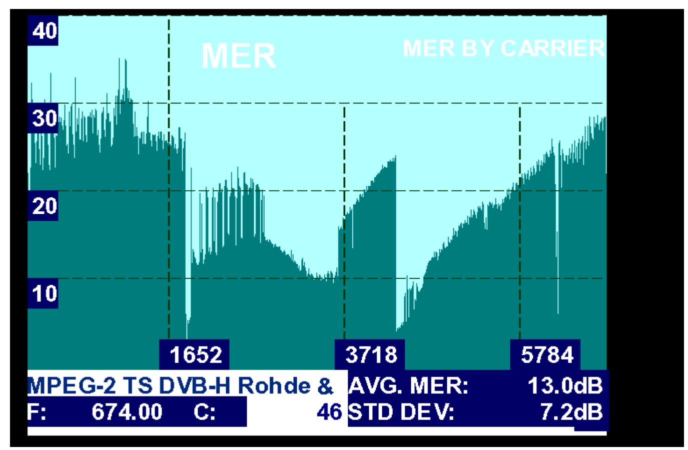
Continued: Amplitude/Delay differences between two RX signals = 0





Variations of MER values





Variations of MER by carriers

Some specific aspects of SFN

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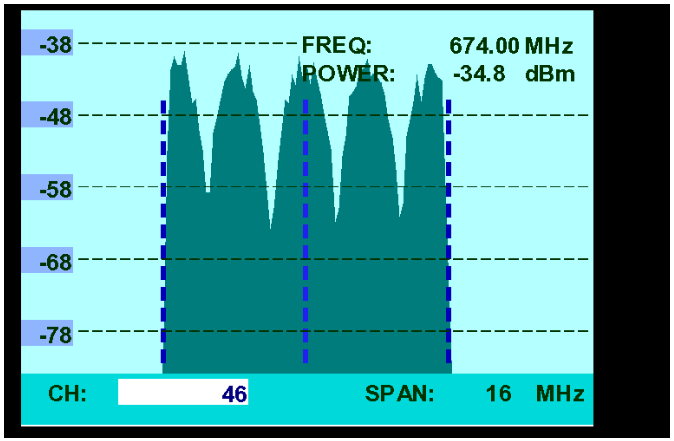
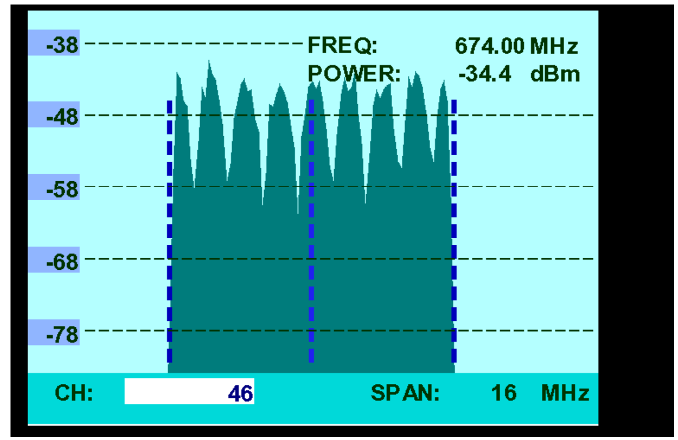
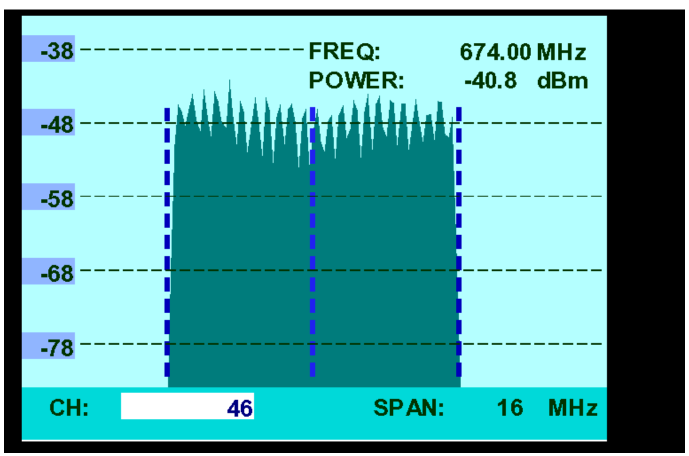
Continued: Ripple in the spectrum



Delay difference between two RX signals is 0.5us



Delay difference is 1us



Delay difference is 3us

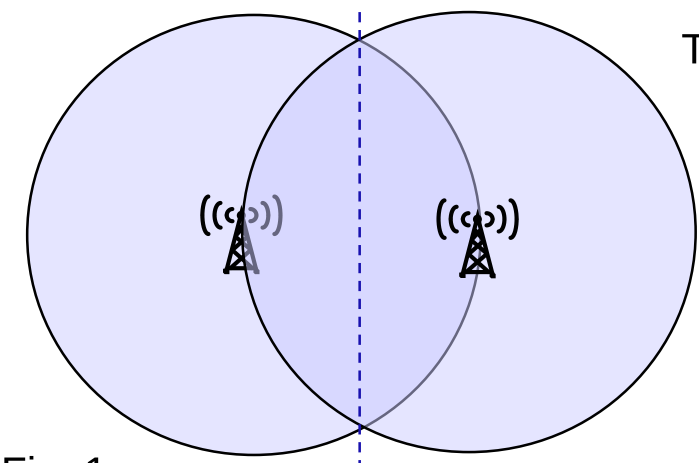
Amplitude difference between two RX signals is 0 dB

An increase of the SFN offset delay in one of two transmitters will decrease the notches and improve the signal quality of receiving signal.

Practical consideration

In the field there are many different configurations of SFN DVB-T/T2 networks but here will be considered three:
-Transmitter spacing is within the safety distance for SFN with high on-air redudancy (Fig.1)
-Transmitter spacing is within the safety distance for SFN with low on-air redundancy (Fig. 2)
-Transmitter spacing is out of the SFN limit (Fig.3)

It is supposed that all transmitters have the same ERP (Effective Radiated Power) and the SFN offset delay.



Type 1.

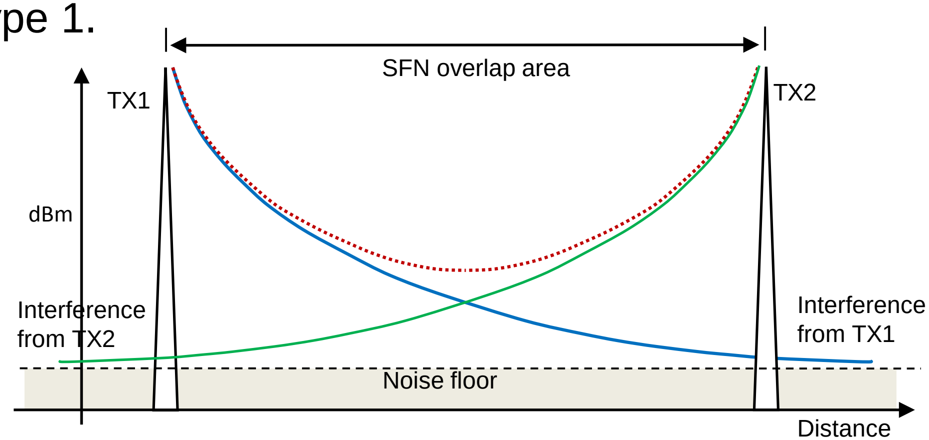
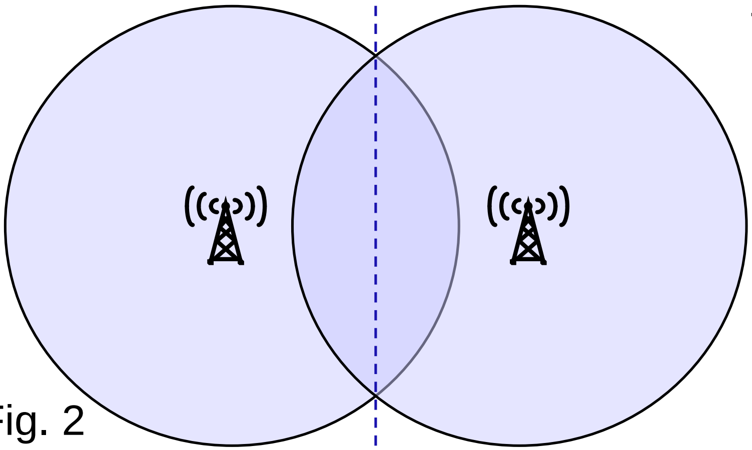


Fig. 1

In the middle of the SFN overlap area (dashed line) can occur the „notches“ in the spectrum

Practical consideration



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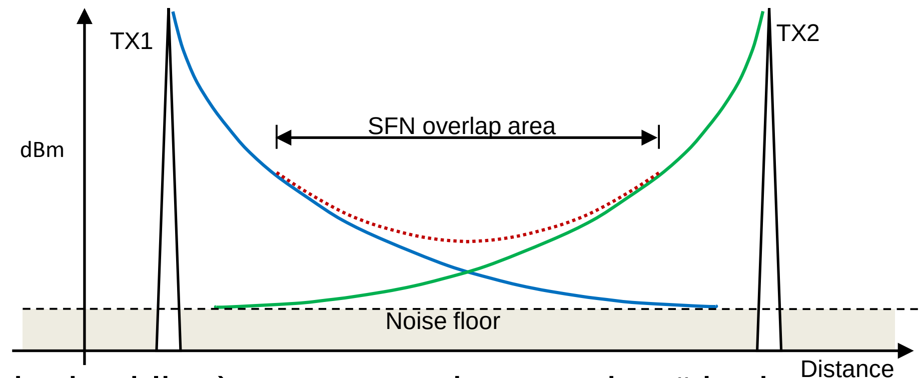
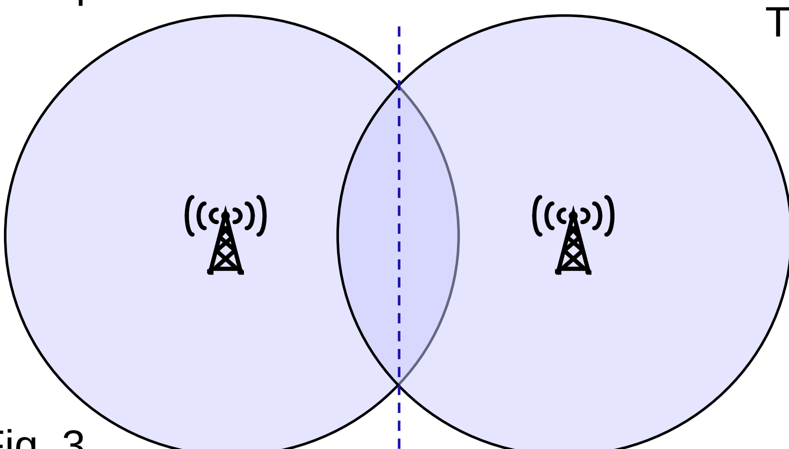


Fig. 2

In the middle of the SFN overlap area (dashed line) can occur the „notches“ in the spectrum



Type 3.

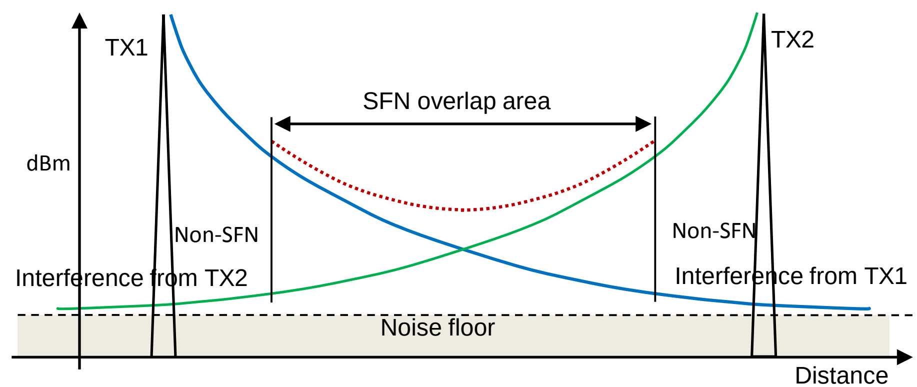


Fig. 3

In the middle of the SFN overlap area (dashed line) can occur the „notches“ in the spectrum

Problem solving

To avoid the notches in the spectrum an SFN offset delay should be introduced in one of two transmitters.
This could move the problem to another location if the delay is relative small (3us…5us…)
The delay should guarantee a reliable reception which will happen at the distance where the amplitude difference between two RX signals are relative large. If possible this distance should be set outside the overlap area.

Based on the propagation curves defined in the ITU Recommendation ITU-R P.370-7 (see Annex) it is possible to determine the distance and using the formula:

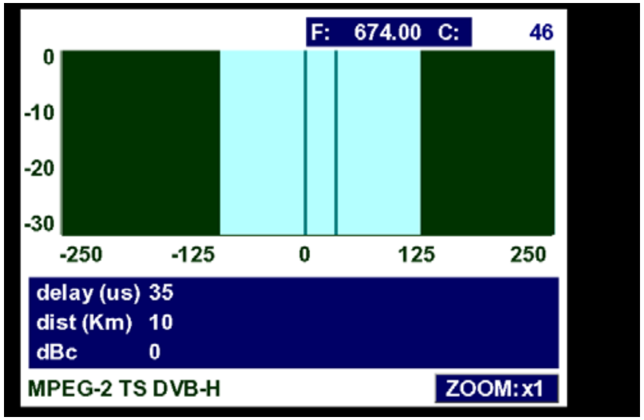
Delay [us] = (Distance [km] / Speed of light [km])*10^6

to calculate appropriate SFN offset delay.

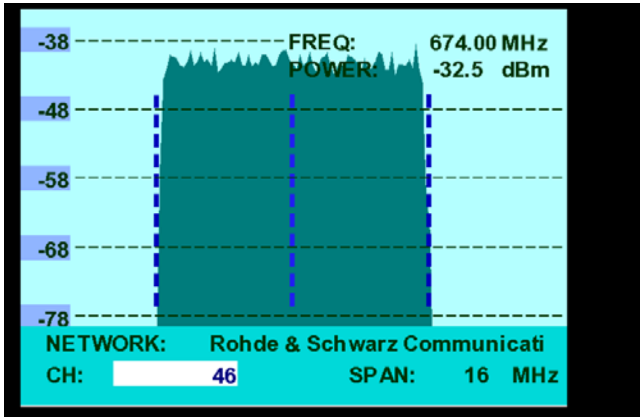
Setting up of transmission site delays in the SFN

Example:

An SFN offset delay 35us will avoid the “notches” in the middle of the SFN overlap area and move this “problem” to the distance 10 km far away where the amplitude difference between two RX signals is large enough to prevent an reoccur of the notches.
In general, the SFN offset delay will reduce the safety distance for SFN and could lead to the scenario 3 (see Fig. 3). This will not cause a problem if the power level between signals from TX1 and TX2 is greater than 35 dB in this Non-SFN area.



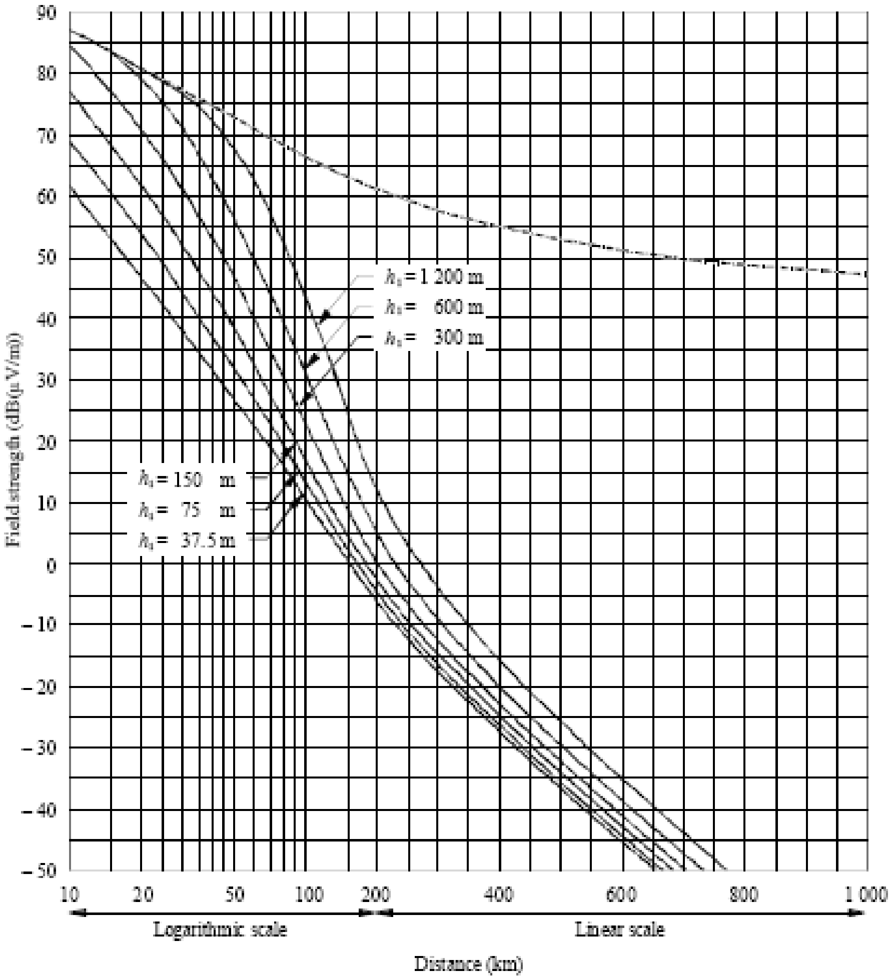
Delay: 35us



RX Spectrum

Annex

Field strength (dB(μV/m)) for 1 kW e.r.p.



For Coverage estimation

the free-space path loss (FSPL) formula can be used given by:

$$\mathrm{FSPL(dB)} = 20\log_{10}(d) + 20\log_{10}(f) + 32.45$$

where f (frequency) is in MHz and d (distance) in km,

and the propagation curves defined in the ITU Recommendation ITU-R P.370-7