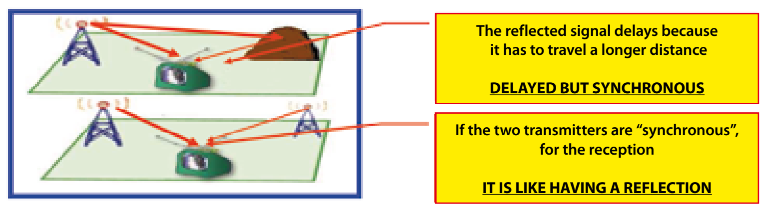
DTT RECEPTION

# Propagation effects

*With analog reception the reflection causes a double image on the television. A digital DVB-T signal, however, does not suffer from signal reflections. A degrading exists, but it does not have any effect on the picture quality.*

When it is said that a DVB-T system is immune to reflections, this is not completely true. The reflected signal acts exactly like a noise disturbance that lowers the MER and raises the BER; this causes errors in the received signal, but we know that the system is perfectly capable of defending itself, especially when you have an adequate noise margin. At this point we will introduce a new topic and a new source of noise disturbance and an operational difficulty arises immediately:

FIG 1. PROPAGATION EFFECTS




*Unlike the analog signal, DVB-T does not suffer from signal reflections: a degrading exists, but it does not have any effect on the picture quality.*

- **in ANALOG**, you can distinguish immediately, by looking at the picture, which type of noise disturbance you are facing. It is clear that the double image is produced by a reflection, while the noise causes the snow effect, compression crushes synchronisms, etc.;
- **in DIGITAL**, any kind of interference and reflections generate the same effect, that consists of a lowering of the MER and BER deterioration.

We will see later an almost infallible method to detect the presence of reflections and to know how to act. Of course it is very important to discover what is causing the interference, because the actions required to eliminate it can be different according to the type you are experiencing.

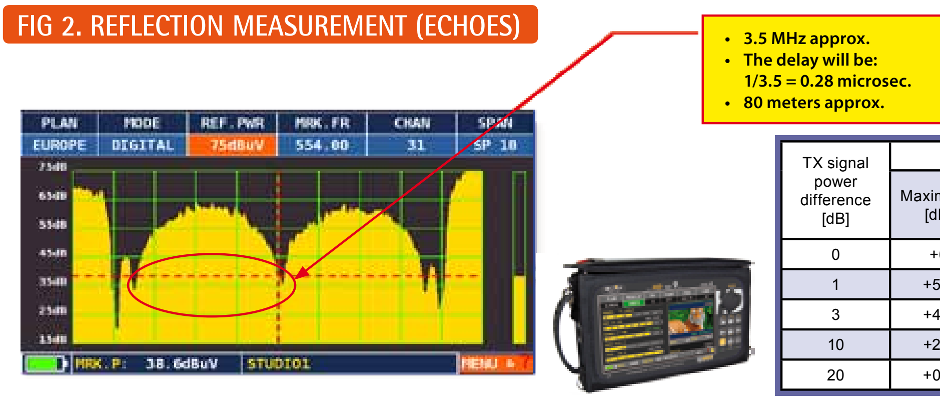
## Reflection Measurement Examples (Echoes)

Let us assume that the electromagnetic signals (light and electromagnetic radio waves, but also X-rays:

- 300 meters per microsecond;
- 3.3 microseconds to travel one kilometer;
- 224 microseconds to travel 67 kilometers

Of course, everything comes from the speed of light of 300.000 kilometers per second.

FIG 2. REFLECTION MEASUREMENT (ECHOES)




| TX signal power difference [dB] | Spectrum Ripple | | |
|---|---|---|---|
| | Maximums [dB] | Minimums [dB] | Total, peak-peak [dB] |
| 0 | +6 | – | – |
| 1 | +5.5 | –19.3 | 24.8 |
| 3 | +4.6 | –10.7 | 15.3 |
| 10 | +2.4 | –3.3 | 5.7 |
| 20 | +0.8 | –0.9 | 1.7 |

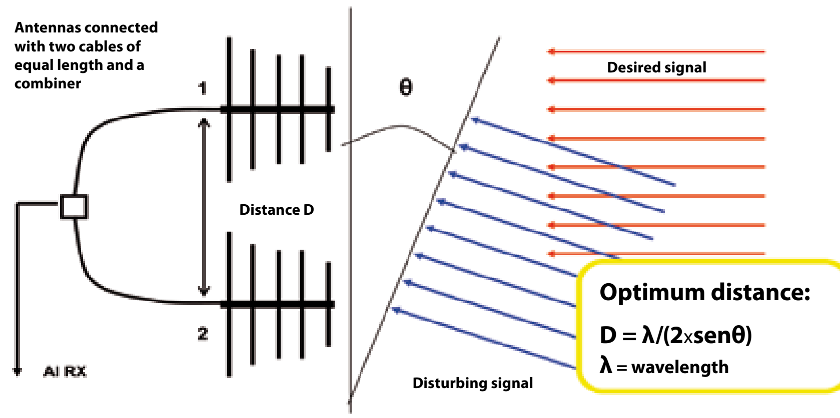
*The reflection measurement (echoes). The distance in MHz between two power dips in the spectrum and related delay in microseconds. These are inverse operations: Delay = 1/ (frequency interval). In the spectrum you can only see short delays from close obstacles.*

Obstacles, that act as mirrors, send to the receiving antenna a signal that is the same as the signal required, but this signal is delayed and attenuated. With an analog signal you will see a double image on the screen. If you have a large screen of about 50 cm, the shift is: as many µS as there are cm of displacement between the two images. Knowing this, sometimes you can derive the distance of the point of reflection. In DVB-T systems you cannot see the double image, but the spectrum display shows dips in the spectrum (ripple).

This can be explained considering that the signals become unphased along the way and the delay varies with frequency, resulting that in some areas of the spectrum there are signal reinforcements in some areas and in other areas signal drops.

Signals are equal to each other, the spectrum goes close to zero in the gaps and to +6 dB in the peaks. We will show you how instruments can provide easy and accurate systems to obtain the amplitude and distance of the reflections (ECHOES).

FIG 3. ELIMINATING REFLECTIONS




## Eliminating reflections

We will illustrate a laborious, but very effective, method to reduce the reflections that interfere with the desired signal.

Let's assume that with this system, whose success depends on the quality of the mechanical design, you can decrease the interference level by 15 dB and in some cases, with professional antennas, by up to 20 dB.

It is essential that there is the presence of only one interference source, from a known direction and that you are sure that the signal level does not vary much, undermining the job done.

Keep in mind that disturbing signals can vary by 20 or more decibels, with different weather conditions, and the more so if they come from far away or if they travel across lakes or seas.

The system works because it makes the disturbing signal take a longer path of exactly half a wavelength, before reaching antenna 1, so that it reaches the combiner with 180° phase rotation (anti phase). The desired signal, however, always arrives in phase, along the same route to reach the antennas, then to the combiner.

Result reached: more than 3 dB for the desired signal and 15 dB attenuation of the noise disturbance.

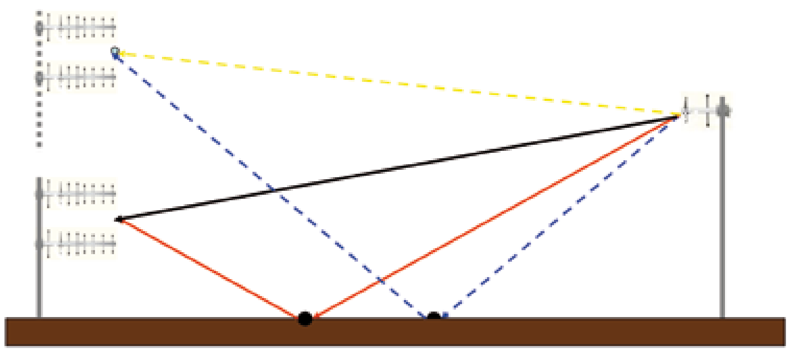
With analog it is difficult to eliminate a reflection entirely, whereas with DVB-T it is easier to gain the margin required to achieve good stability.

TABLE 1. DISTANCE BETWEEN ANTI-REFLECTION ANTENNAS

CHART: DISTANCES BETWEEN ANTI-REFLECTION ANTENNAS

| ANGLE DEGREES | FREQUENCY IN MHz | | | | | |
|---|---|---|---|---|---|---|
| | 200 | 500 | 600 | 700 | 800 | 1000 |
| 3 | 14,33 | 5,73 | 4,78 | 4,09 | 3,58 | 2,87 |
| 6 | 7,18 | 2,87 | 2,39 | 2,05 | 1,79 | 1,44 |
| 9 | 4,79 | 1,92 | 1,60 | 1,37 | 1,20 | 0,96 |
| 12 | 3,61 | 1,44 | 1,20 | 1,03 | 0,90 | 0,72 |
| 15 | 2,90 | 1,16 | 0,97 | 0,83 | 0,72 | 0,58 |
| 18 | 2,43 | 0,97 | 0,81 | 0,69 | 0,61 | 0,49 |
| 21 | 2,09 | 0,84 | 0,70 | 0,60 | 0,52 | 0,42 |
| 24 | 1,84 | 0,74 | 0,61 | 0,53 | 0,46 | 0,37 |
| 27 | 1,65 | 0,66 | 0,55 | 0,47 | 0,41 | 0,33 |
| 30 | 1,50 | 0,60 | 0,50 | 0,43 | 0,38 | 0,30 |
| 33 | 1,38 | 0,55 | 0,46 | 0,39 | 0,34 | 0,28 |
| 36 | 1,28 | 0,51 | 0,43 | 0,36 | 0,32 | 0,26 |
| 39 | 1,19 | 0,48 | 0,40 | 0,34 | 0,30 | 0,24 |
| 42 | 1,12 | 0,45 | 0,37 | 0,32 | 0,28 | 0,22 |
| 45 | 1,06 | 0,42 | 0,35 | 0,30 | 0,27 | 0,21 |
| 48 | 1,01 | 0,40 | 0,34 | 0,29 | 0,25 | 0,20 |
| 51 | 0,97 | 0,39 | 0,32 | 0,28 | 0,24 | 0,19 |
| 54 | 0,93 | 0,37 | 0,31 | 0,26 | 0,23 | 0,19 |
| 57 | 0,89 | 0,36 | 0,30 | 0,26 | 0,22 | 0,18 |
| 60 | 0,87 | 0,35 | 0,29 | 0,25 | 0,22 | 0,17 |
| 63 | 0,84 | 0,34 | 0,28 | 0,24 | 0,21 | 0,17 |
| 66 | 0,82 | 0,33 | 0,27 | 0,23 | 0,21 | 0,16 |
| 69 | 0,80 | 0,32 | 0,27 | 0,23 | 0,20 | 0,16 |
| 72 | 0,79 | 0,32 | 0,26 | 0,23 | 0,20 | 0,16 |
| 75 | 0,78 | 0,31 | 0,26 | 0,22 | 0,19 | 0,16 |
| 78 | 0,77 | 0,31 | 0,26 | 0,22 | 0,19 | 0,15 |
| 81 | 0,76 | 0,30 | 0,25 | 0,22 | 0,19 | 0,15 |
| 84 | 0,75 | 0,30 | 0,25 | 0,22 | 0,19 | 0,15 |
| 87 | 0,75 | 0,30 | 0,25 | 0,21 | 0,19 | 0,15 |
| 90 | 0,75 | 0,30 | 0,25 | 0,21 | 0,19 | 0,15 |

FIG 4. REFLECTIONS FROM THE GROUND



*At the point of reflection the incoming and outgoing angles are the same. If you vary the antenna position, the point of reflection changes.*

## The distance between antennas

Table 1 is useful, even if it does not cover all frequencies and angles.

The values are calculated exactly, but you must carry out an experimental set-up, because you will never exactly know which direction a signal is coming from.

It is especially useful if you want to see if a mechanical system is physically possible, given that sometimes very large distances are involved.

If the distances are too small and the antennas are touching, just double the distance to obtain an acceptable one.

The system works very well, especially in the case of reflections from the terrestrial surface, with antennas fixed to a mast, one below the other.

This is often found near lakes, or in the case of sea travel, but in these cases the angles are small.

A good test is to vary the height of the receiving antenna. If this causes ripples in the spectrum, that vary with height, then you can be certain that there is a reflection from the ground.

If the depth of the ripples is considerable, or part of the spectrum is missing, then you must be careful, especially if the reflection takes place on water, given the inherent variability of the situation.

## Reflections from the ground

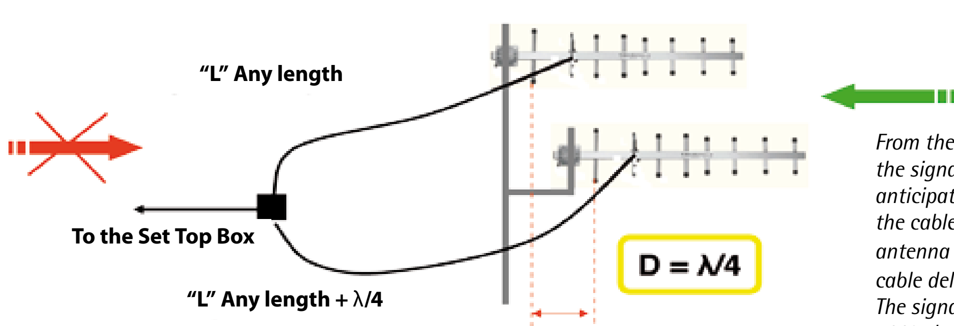
Another situation where the antenna is shown to be the most important component for improving reception is that of "reflections from the ground." This system is useful for many towns located close to large water surfaces, e.g. lakes or the sea, where reflections are strong and there are rather large angles, given the short distances from the transmitters. In the case of very distant transmitters, however, the angles are small and force long distances between the antennas. With professional antenna towers, you can make systems work with distances in the order of 30 or 40 meters.

For example, a transmitter 1000 meters high at a distance of 10 km, is seen under an angle of about 5 degrees, which requires a distance of about 3 meters.

To see if there are reflections from the ground, measure the field and slowly vary the height of the antenna. If you notice any dB variations, there are sure to be ground reflections (see picture above).

In this case positioning the antenna at the maximum point may not be enough to solve the problem, because reflection conditions vary with weather conditions. It is not the reflected signal's change in amplitude that causes problems, but the variation of the point and the reflection phase, which takes you from a maximum to a minimum point.

FIG 5. THE BACK TO FRONT ANTENNA RATIO




*From the front (green arrow) the signals are in phase and the anticipation is compensated by the cable. From the back, the lower antenna is delayed λ/4 and the cable delays again λ/4. The signals reach the combiner with 180° phase rotation (ANTIPHASE) and cancel the other signals.*

# Impedance and Matching

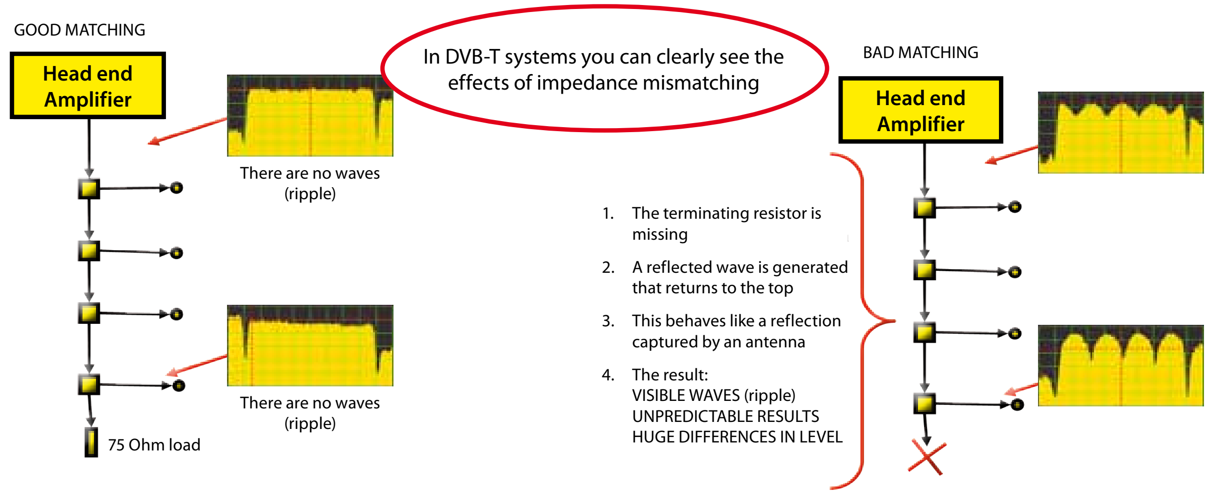
The reflections caused by a mismatch are the same as those caused by a reflecting obstacle in the antenna.

The difference is that distribution lines can be adapted, thus producing an excellent result, whereas when it comes from the antenna ... sometimes you can not do anything.

The return wave is added or subtracted from the direct wave according to the positions where the two waves are in phase or in antiphase.

Ci sono due modi per esprimere il disadattamento:

1. **RL – Return Loss:** expressed in dB, showing how much the reflected wave is attenuated compared to the transmitting wave and the higher it is the better the matching. It should be higher than 10–12 dB.
2. **VSWR – Voltage Stand**ing Wave Ratio:
   expressed as a linear number, this is the ratio between the maximum and minimum voltages along the cable. It should be lower than 1.4–1.2. The best way to measure the VSWR is to use a reflectometer, but it can be observed if the distribution network alters the flatness of the spectrum, changing the shape compared to the one received from the antenna. A noise generator is very useful to easily test all distribution systems, because it shows all the TV or SAT bandwidth on a single screen.




A very effective system is to shield the antenna from the reflected beam, by lowering it and using the roof of buildings to shield it from the reflected signal.

## The back/front ratio

Il The back to front antenna ratio is the difference, expressed in dB, between the antenna's response to signals coming from the two directions, front and back.

In the case of SFN networks, on flat ground, where there are no natural barriers to prevent propagation from very distant and powerful transmitters, there are wide areas that receive signals from the back of the antenna.

The proposed system is very useful and practical, given the small distances between the antennas.

It may be convenient to mount two small antennas, instead of trying to find an expensive, huge aerial with a very high back/front antenna ratio. Large antennas are very difficult to find and almost always cause problems when you are forced to move the antenna across the mast, that, being metal, in many cases distorts the antenna diagram.

Our only warning: the distance between the antennas must be exactly one quarter of the wavelength, while the length of the longer cable should be calculated as follows:

**Increased cable length = length of quarter-wave multiplied by speed factor of the cable.**

This factor is provided by all manufacturers: for compact insulation (polyethylene) it is 0.66, whereas for expaned cable it is around 0.87.

*Taken from the 'Understanding Digital TV' booklet, produced by Rai Way, Eurosatellite school and Rover.*
*The complete booklet can be found at the following address:*
**http://www.roverinstruments.com/news.php?lingua=5&idnews=76**