ROVER INSTRUMENTS

A STEP AHEAD IN DIGITAL TELEVISION

UNDERSTANDING DIGITAL TV

- *Radio Frequency Measurements*
- *Propagation Effects*
- *Impedance & Matching*
- *SFN Networks and ECHOES*
- *Recommended Parameters & Limit Values*

Dear Users,

This document does not intend to explain how Digital Terrestrial Television (DTT) works (there is another Rover technical publication that clearly explains this called “An Introduction to DTT”), instead we hope to provide **practical, basic information about the transmission, propagation and reception issues of digital television signals**.

Above all we will look at how to improve reception in difficult locations and situations, especially in the case of complex SFN networks, or in the presence of urban sources of electromagnetic noise.

May we remind you that in 99% of the cases, reception improves by working on the antenna ; unfortunately no magic set top box or TV set currently exists.

We apologize in advance for any inaccuracies and invite you to notify us if you find any.

We hope you enjoy this and remind you that there is always business for competent and well equipped professional antenna installers.

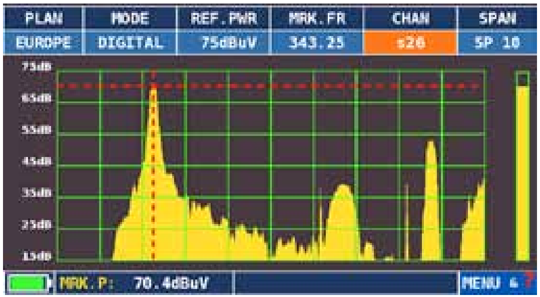
Some clarifications:

Each equipment manufacturer uses different names for the two BER’s, so we have decided to use the acronyms employed by the British, who were the first to introduce a DVB-T network in Europe in 1998.

- **bBER** = where “b” stands for “before”, i.e. measured before Viterbi error correction. This is also known as Pre BER or CBER.
- **aBER** = where “a” stands for “after”, i.e. measured after Viterbi error correction. This is also known as Post BER or even VBER.

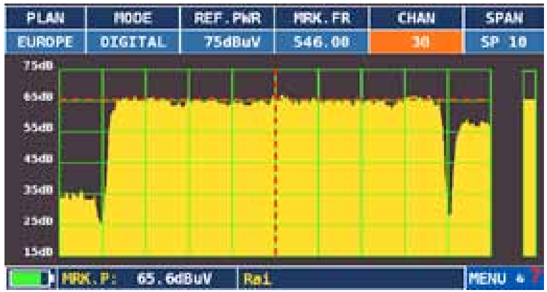
SUMMARY

RADIO FREQUENCY SPECTRUM



Analog, 1 program for each channel

You can see video, croma and audio



Digital, many programs for each channel

You cannot see the single contributions

The difference between the two signals is evident in that the digital signal is composed of thousands of carriers, which give the impression of a continuous spectrum.

Each of these carriers is modulated in amplitude and phase separately and independently from the others and brings with it a part of the total content of information. The user's decoder must then interpret and reassemble all the information, translating it into video signals and selecting the program required by the user.

The difference that interests an installer is to measure the received "field", it is a good idea to see if there is a difference between an analog and digital situation to see how things are:

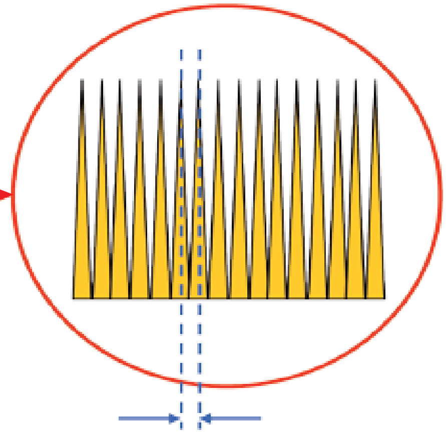
ANALOG - You measure the **voltage** of a single video carrier and express it in units. The most suitable unit, used by almost everyone, is dBµV, ideal value: 60 dBµV level.

DIGITAL - This measures the **power** of the complete channel (Average Channel Power), calculating the total power of each carrier (power, not voltage). The unit should be, logically, the milliWatt, or rather dBm (0 dBm = 1 milliwatt), but if you still use dBµV for convenience, ideal value 50 dBµV.

RADIOFREQUENCY MEASUREMENTS

AVERAGE CHANNEL POWER

This is what you see when you expand the spectrum of individual carriers.



Delta f = space between the carriers equal to approximately 1 KHz, or to be precise 1116Hz

Digital signal: thousands of carriers exactly 6817

The power can only be the total amount of all of them

The function that allows you to find out the total power of all carriers is called the "**Average Channel Power**".

With professional analyzers you can choose different measurement modes, whereas in portable analyzers this is fixed and always active for radiofrequency average power measurements.

Why is this strange way of measuring the power as a sum used?

Because every small carrier carries a piece of the entire channel and the quality of the signal depends on all of the carriers.

It is possible, as we will see later, to also lose a part of the carriers, or have some at a very low level, but it is the power of all the carriers that matters.

The meters on the market perform this measurement in various ways, they carry out the average operation by splitting the spectrum into several parts and then calculate the total of the partial powers.

The result is the average power, called **RMS** (Root Mean Square value).

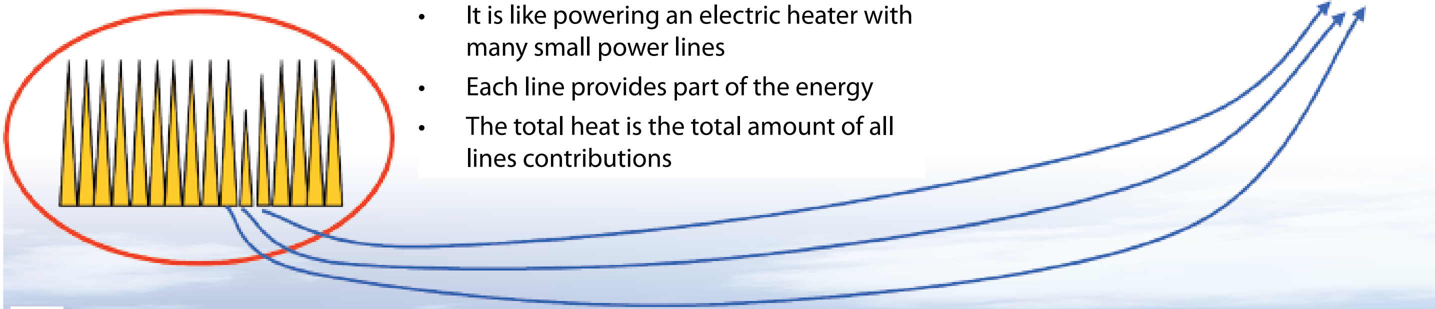
RF POWER MEASUREMENT

The mains RF Power/Level units:

RF DIGITAL POWER	RF ANALOG LEVEL
1mW = 0 dBm	1µV = 0 dBµV
0dBm = 108,7 dBµV	1mV = 60 dBµV
–58,7 dBm = 50 dBµV	1mV = 0dBmV (USA)

AVERAGE POWER IN DVB-T

- It is like powering an electric heater with many small power lines
- Each line provides part of the energy
- The total heat is the total amount of all lines contributions



The power of the digital signal is always measured in dBμV, but is different from analog:

ANALOG: Is the true voltage measured **only for the peak of the video carrier** and a certain amount is required (about 1 millivolt, equal to **60 dBμV**) to obtain a quality image, practically low level = low quality, high level = high quality pictures.

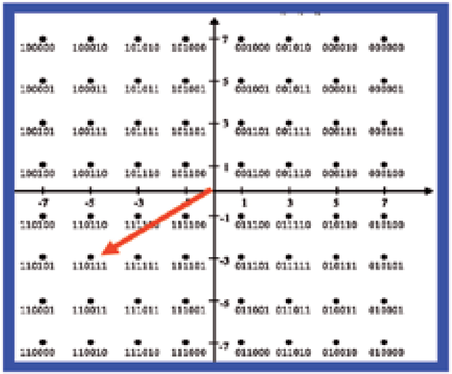
DIGITAL: This is a measurement derived from the average power, obviously it is not possible to measure 8000 signal carriers individually. The result is however expressed in **dBμV**, a well known, familiar unit.

PLEASE NOTE:

The power of the received field is not so important in DVB-T, it only needs to have a required minimum level that is about 40 dBμV (better 50 dBμV), after which it has no influence on the quality. In fact, it is better to avoid levels that are too high and that could saturate and degrade the set-top box and the quality of the signal received.

With numbers, as shown above, you can move very quickly from **dBμV** to **dBm** and vice versa: **just add, or remove the number 108.7**, which is valid for **75 ohm** systems. In the case of **50 ohms**, the number is **107**. In all the meters you can select the unit of measurement you prefer: **dBm** or **dBμV, or dVmV for USA**.

DVB-T MODULATION

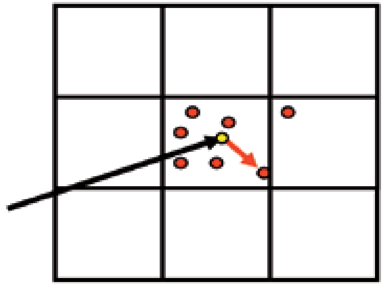


The carriers are modulated:

in Amplitude – vector length

in Phase – vector angle

Until the decoder detects that the vector falls within the right square, there is no error and reception is perfect.



Each carrier is modulated independently from the others.

Each carrier carries a piece of the total information.

The modulation is both for phase and amplitude, for example “**64QAM**” (the most used) or “**QPSK**” or “**16QAM**” (or “**256QAM**” for DVB–T2)

The modulation is the same type for each carrier, but carries different pieces of binary information and hence the amplitude and phase of the various carriers are different from each other. This gives a confused representation of the spectrum, that appears to have a beard like the noise.

In fact it is very similar, because the information is random and randomly variable, so that the British have coined the phrase "**noise like signal**", which gives the idea of a completely unrecognizable signal within the spectrum.

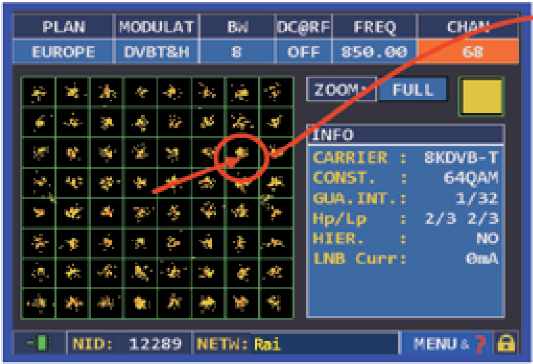
The noise picked up by the antenna, or interference, makes the carrier's vector moving randomly within its square; if the noise increases the amplitude, it can throw it out and then there will be an error and the video image will become unrecognizable **suddenly and without notice**.

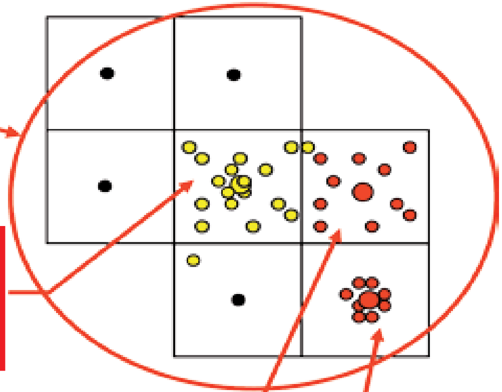
Instead, in an analog signal, the noise, or interference, has a progressive action and is immediately visible on the signal.

In the case of a digital signal, by observing the spectrum and the received power, it is not clear when the various carriers are received correctly, because you do not know how much noise disturbance there is, and how it affects the reception.

Later you will see what to do when working on headends and antenna pointing, in order to obtain the best signal and work out how to measure the signal quality.

PERFORMANCE INDICATORS





Some errors =
Only a few dots are outside the right square
MER is reasonable
Few errors - BER worsens

Possible error =
The dots are scattered but not outside the square
High MER, good BER

No error =
Excellent MER and BER

The **MER** shows bad positioning of the vectors

The **BER** tells you the percentage of bit errors

We know that signals can be "polluted" by noise or other interference.

These "uninvited guests" are often present and are added randomly, from time to time, to the vectors of carriers and alter their position, making it difficult to recognize groups of bits from the decoder.

It is not possible to predict the magnitude of the noise disturbance, which is constantly changing, but you can expect to constantly commit errors in the recognition of the bits.

To counteract this behavior the **FEC** (**F**orward **E**rror **C**orrection) mechanism has been introduced at the cost of reducing transmission capacity, it allows the correction of errors - of course there are limits to the correction capability.

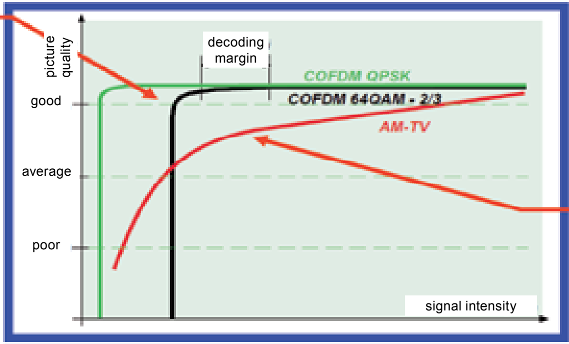
The measurement is carried out by counting the errors: various instruments record, using a counter, up to 999 errors and this is why the measurement takes a lot of time.

IMPORTANT:

Remember that, even in the presence of errors, the signal is decoded correctly, maintaining the highest quality, so a method is required to determine the quality of the reception system. Practically find out how many dB we can increase the noise or interference, without affecting the quality of the received information this is called "Threshold Point".

LOCKING THRESHOLD

DIGITAL
More noise, or interference,
Up to the threshold,
THEN CRASH!!



ANALOG
More noise, or interference,
less quality
PICTURES WORSEN SMOOTHLY
BUT IT CAN BE SEEN

- **DVB-T** implements powerful error correction (**FEC**)
- Even though there is interference, up to a point, it is corrected
- To understand how much margin is left before a crash there is the: **MER** (modulation error ratio)

The **DVB-T** signal has this behavious, which has both advantages and disadvantages:

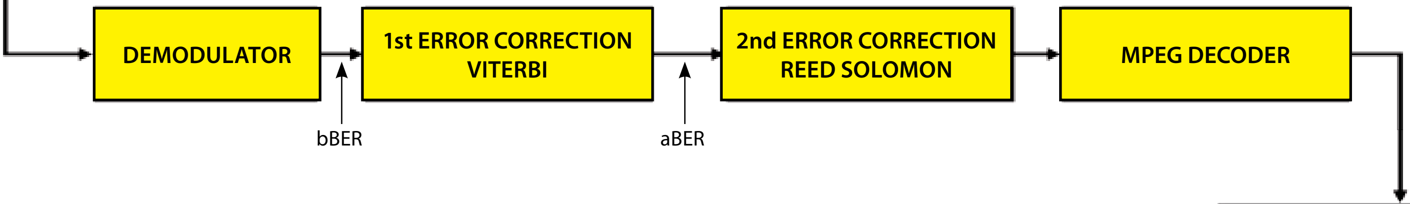
Advantages:

1. Obviously the quality is always high, even in the presence of noise disturbances.
2. The signal power is no longer critical, you do not have to worry about constantly bringing it to the maximum power, the quality is always high, regardless of the signal power strength.
3. The minimum power required is much lower than the level required for analog.

Disadvantages:

1. In the case of analog bad reception, if you could not do anything else, you could build the best reception system at its limit, warning the customer that he has to settle for poor quality.
2. In **DVB-T** this cannot be done: if there is increased noise, the decoder remains completely unlocked (threshold phenomenon).
3. Interruptions of a few seconds and "macroblocks" are much more disturbing in a momentary drop in analog quality, which resumes immediately.

BEFORE & AFTER VITERBI ERROR CORRECTION - NOISE MARGIN



- Absolutely minimum bBER and MER: **bBER=2x10^{-2}** and a **MER** of approx. 20 dB (You must remain above these limit values, 6 dB **noise margin** (with 64QAM)
- Viterbi reduces errors until 2 x 10^{-4} **(after Viterbi aBER)**
- Reed Salomon corrects what is left up to **BER 1 x 10^{-11}**
- This is **QEF** (quasi error free) – an error event statistically visible every 30 minutes

Here you can see a schematic block of the structure of a **DVB-T set top box**, where error correction is done in two stages, as is carried out in TV and SAT set top boxes.

The Viterbi circuit is common to all types of digital broadcasting and clears up most of the errors and adapts the system for the Reed Solomon error correction.

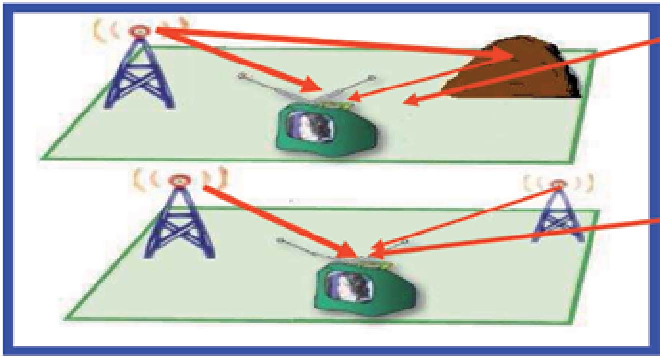
What happens is that the number of errors at the decoder input is highly variable, and after Viterbi error correction it is much lower and more consistent.

In the picture on page 18 you can see the error limits tolerated by the system, but as we already said, the limits must be much higher and if you want an acceptable and stable quality you must have some Margin (usually the **Noise Margin** in DVB-T must be 6 dB).

IMPORTANT:

The real innovation in the work of installation and development of an antenna system for digital signals (unlike analog), lies in the noise margin concept, to be respected for all digital systems, including cable and satellite distribution. Since the minimum values of various parameters to be analyzed differs between the various systems satellite, terrestrial and cable (see table on page 2), some meters automatically provide the signal quality FAIL–MARG–PASS, and this greatly simplifies the job.

PROPAGATION EFFECTS



The reflected signal delays because
it has to travel a longer distance

DELAYED BUT SYNCHRONOUS

If the two transmitters are "synchronous",
for the reception

IT IS LIKE HAVING A REFLECTION

- In analog the reflection causes a double image
- DVB-T does not suffer at all 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:

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.

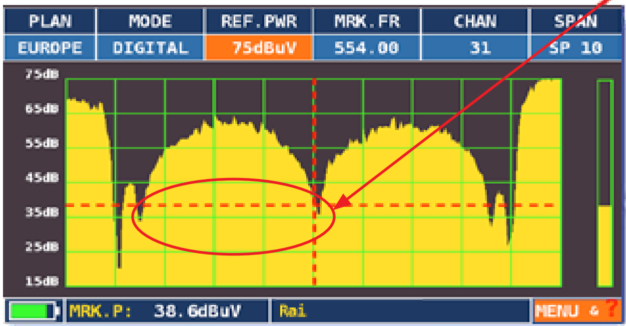
In DIGITAL, any kind of interference and reflections generate the same effect, that consists of a lowering of the MER and BER deterioration.

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)

- **3.5 MHz approx.**
- **The delay will be: 1/3.5 = 0.28 microsec.**
- **80 meters approx.**



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

Relationship between Frequency Interval 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).

Let us assume that the electromagnetic signals (light and electromagnetic radio waves, but also X-rays) propagate at the speed of light, in other words:

- **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.

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.

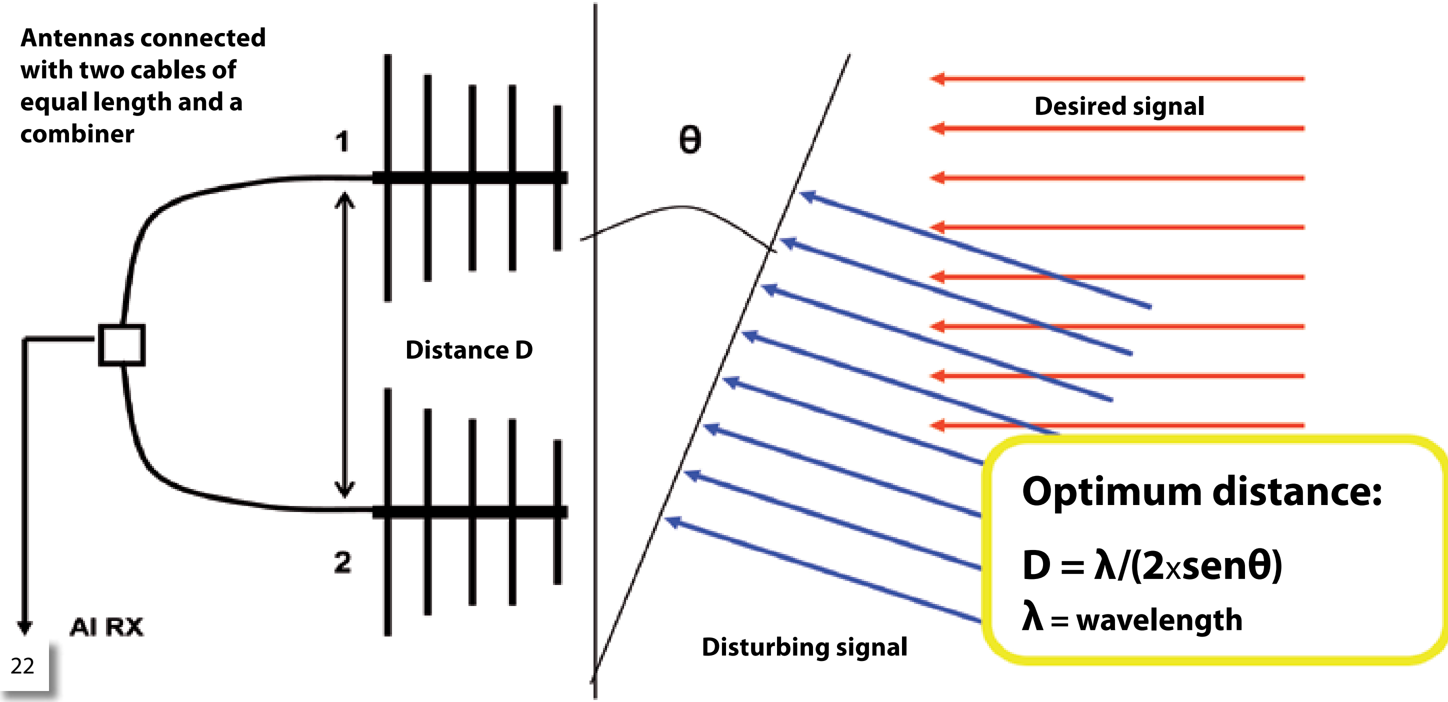
In **DVB-T** systems you cannot see the double image, but the spectrum display shows dips in the spectrum (ripple).

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 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).

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.

PROPAGATION EFFECTS

ANTENNA DISTANCE TABLE

Distances in meters

The values are critical, use the table only for the first approximation, then adjust the distance until you reach the maximum spectrum flatness

CHART: DISTANCES BETWEEN ANTENNAS ANTIREFLECTION

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

This chart 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.

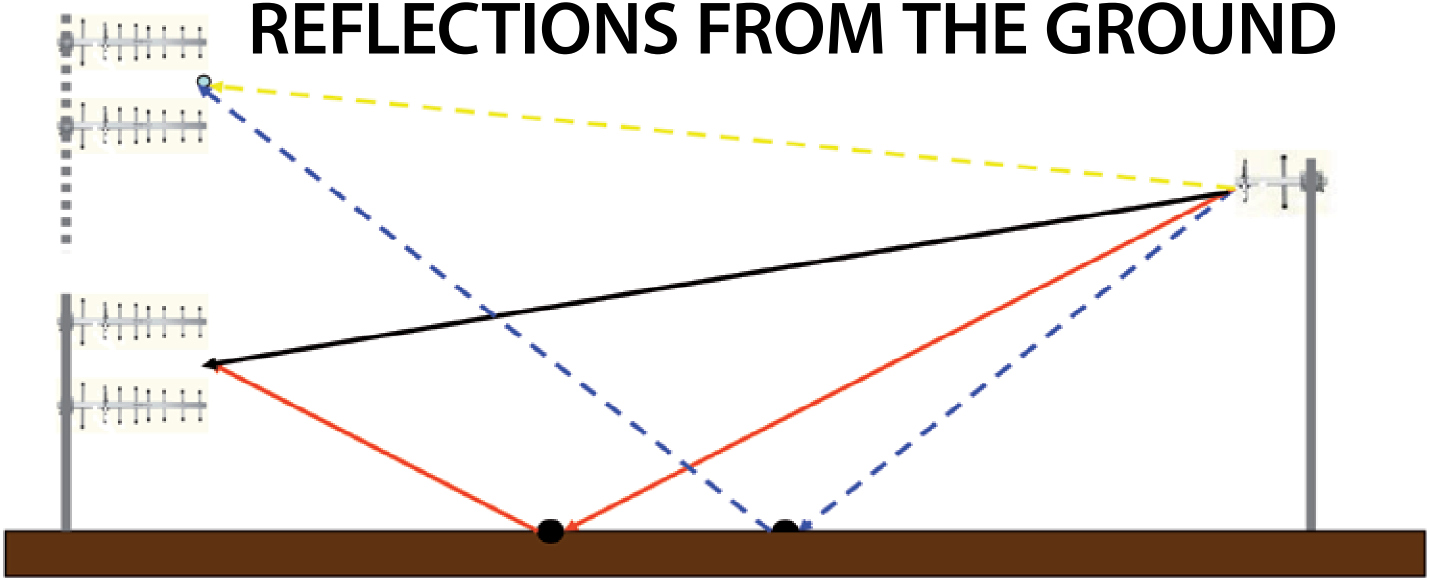
This is often found near lakes, or in the case of sea travel, but in these cases the angles are small.

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, basically it changes often during the day and night.

PROPAGATION EFFECTS

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!

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.

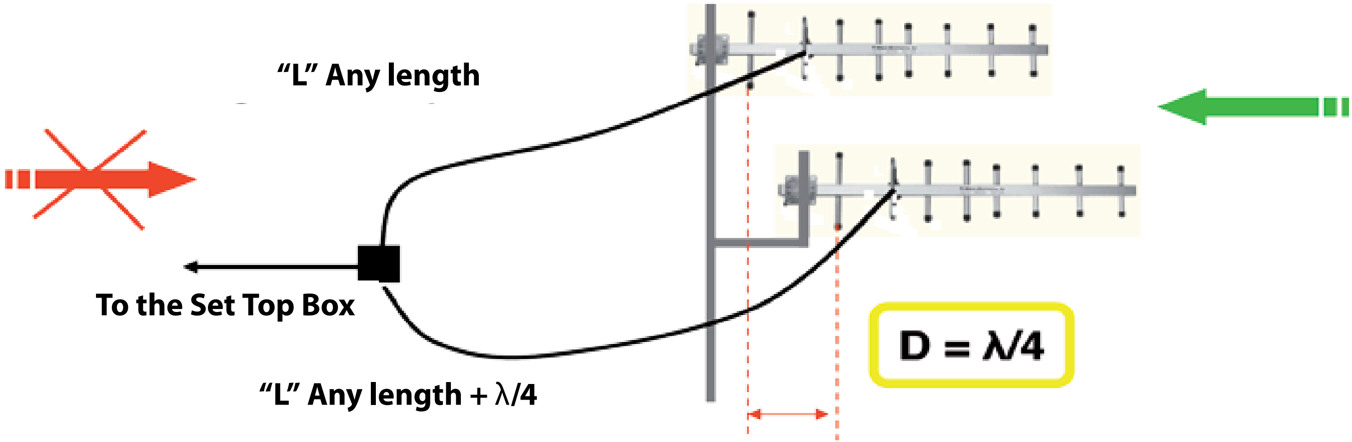
To see if there are reflections from the ground, measure the field and **slowly** vary the height of the antenna. If you notice any dB variations, there are sure to be ground reflections (see picture above).

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.

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.

PROPAGATION EFFECTS

THE BACK TO FRONT ANTENNA RATIO



From the front 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.

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:**

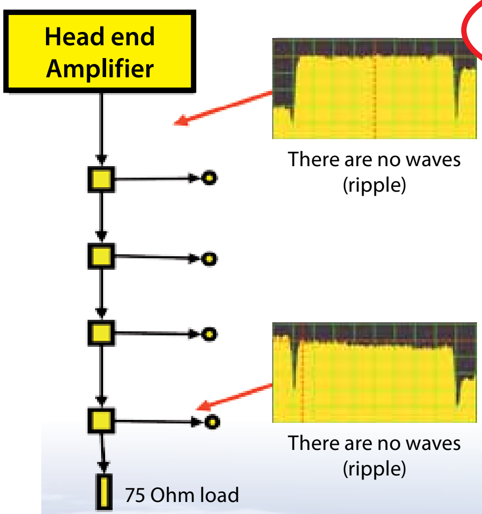
Increased cable length = length of quarter-wave multiplied by speed factor of the cable.

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

IMPEDANCE MATCHING
IN THE DISTRIBUTION SYSTEMS

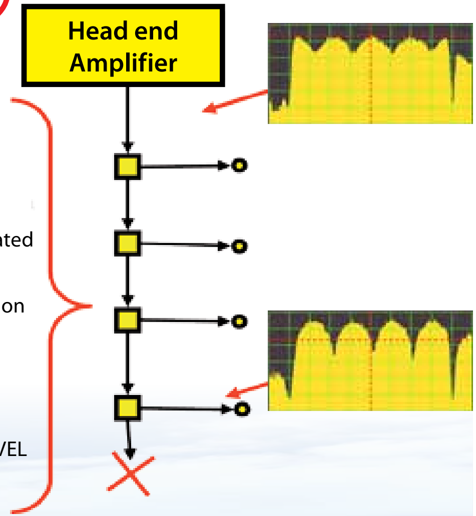
In DVB-T systems you can clearly see the effects of impedance mismatching

GOOD MATCHING



BAD MATCHING

1. The terminating resistor is missing
2. A reflected wave is generated that returns to the top
3. This behaves like a reflection captured by an antenna
4. The result:
   VISIBLE WAVES (ripple)
   UNPREDICTABLE RESULTS
   HUGE DIFFERENCES IN LEVEL



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.

There are two ways to express the mismatch:

1. **RL (R**eturn **L**oss):
   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.

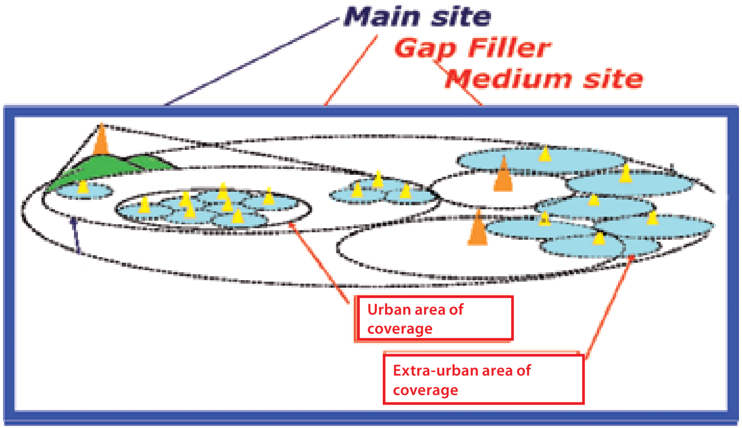
2. **VSWR** (**V**oltage **S**tanding **W**ave **R**atio):
   expressed as a linear number, this is the ratio between the maximum and minimum voltages along the cable. **It should be lower than 1.4–1.2.**

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.

In countries such as Spain, this test is required by law, see “ICT” regulations.

SFN (Single Frequency Network)



The reflected signal is delayed, but absolutely synchronous

The DVB–T system may tolerate delayed reflections up to 224 µSeconds, according to the modulation parameters

It is possible to run a network of synchronous transmitters all with the same frequency

Since the system is immune to reflections (within the limits), a network of completely synchronous transmitters can be put into action and already operating in some countries like Spain and Italy.

All you have to do is transmit the same bit at the same time and at the same frequency.

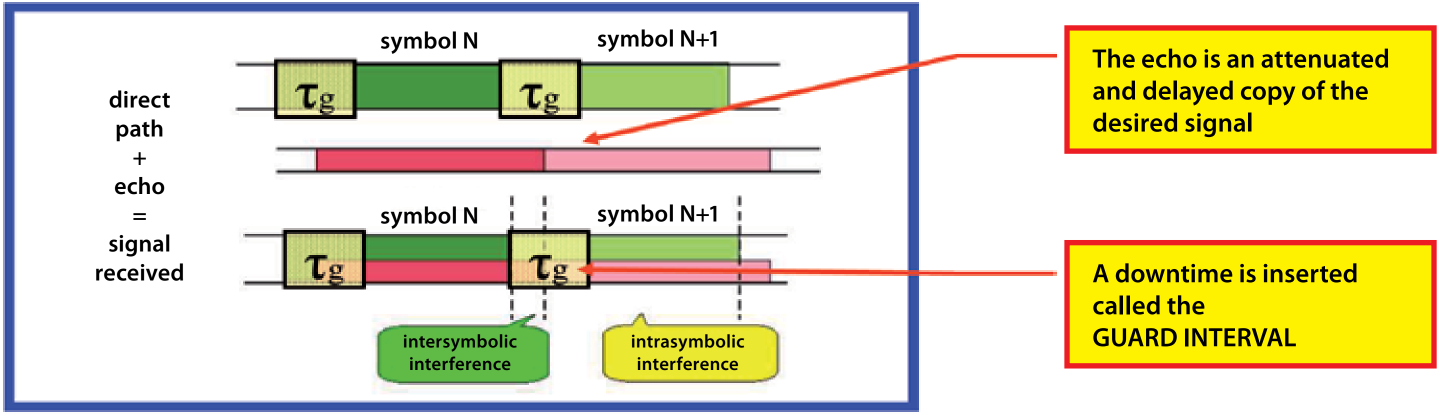
Achieving this goal is very complicated and expensive; completely synchronous digital distribution networks are required, many transposers will need to be converted into transmitters. Finally an accurate frequency reference at all sites must be guaranteed.

It is sufficient to say, for example, that the required accuracy is about 1 Hz for the frequency and few nanoseconds for the timing.

The following points clarify the topic:

1. A reflected signal, is still tolerable however far it is, but it must be at least 20 dB below the level of the desired signal, and does not reduce the margin too much (basically it is like any kind of noise).
2. If, however, the delay is below a certain limit, which depends on the transmission parameters, you could even tolerate a reflected signal at the same level as the one received.
3. It is a good idea to keep it about 6 dB lower than required, to make sure that it is safe from random deterioration and variations.

ECHOES AND GUARD INTERVAL



- If the reflections fall in the guard interval, they do not generate errors (the decoder simply throws away all the wrong information in the guard interval)
- As soon as they fall outside the guard interval, the decoder see them as interference and ... this is pain!

Operation is based on being able to delete the wrong part of the information from the delayed reflection.

It's as if, trying to talk in the presence of an echo, you could eliminate the first part of the pronounced syllables. An echo, if not too delayed, only ruins the first part of the syllable next to the one just pronounced. Of course you would need a whole synchronized system to be able to guess where to cut off.

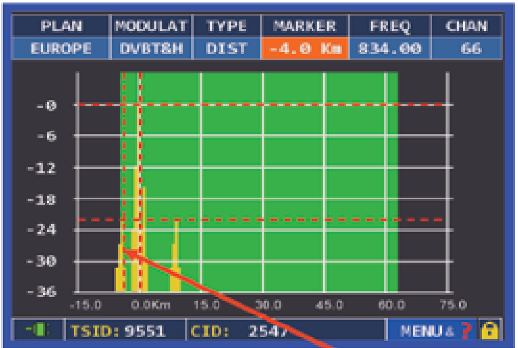
To function properly, the so-called **SFN S**ingle **F**requency **N**etwork, needs transmitters with power that is calibrated and not too high, so as not to get too far away, where it would have a delay, against to local transmitters, outside the maximum distance allowed.

The maximum delay is called the **GI, Guard Interval**, and is 224 microseconds for SFN mode (8k carriers).

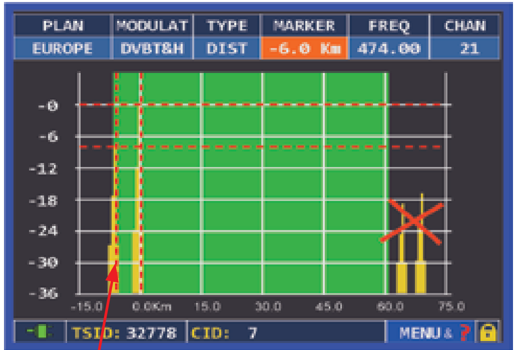
Often transmitters have intentional delays, inserted to adjust the arrival times of signals in the area, but it is not always possible to meet all the requirements in difficult territories.

In these cases, an installer should know how to search for and measure the various signals arriving at the antenna and to point it with accuracy in order to eliminate the signals that arrive with too many delays.

MEASURING THE NETWORK DELAY



- Measure the delay time between reflections
- Each received signal is shown as a vertical bar
- Horizontally you can read the delay in microseconds, or the distance in km



Example of <u>good reception in SFN networks.</u> There are two echoes, but they are inside the guard time

The "PRE ECHO" is shown here
A weak reflection that arrives first
Sometimes this can cause problems for some decoders

Example of <u>bad reception in SFN networks</u>. There are two echoes outside the guard interval.

Nearly every instrument has an SFN mode and many of them can show a graph like the one shown in the figure on page 38, where the various incoming signals are shown as lines, or vertical bars (remember that all the signals have the same frequency).

What you see from the SFN ECHOES screen:

1. The horizontal axis allows you to read the delays between the various signals. In general, the instrument takes the best signal and places it at zero and below each vertical bar you can read the delay of the individual signals.
2. The amplitude of each signal, with the indications given in dB on the vertical axis, are shown on the left scale.
3. Typically there is a coloured area (in these cases the green area), that represents the guard interval, so you can see at a glance if a signal is too strong and falls outside the guard interval.

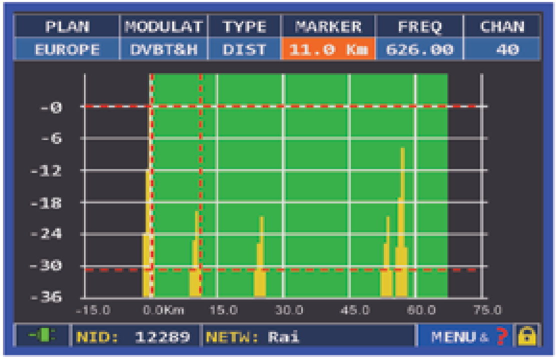
IMPORTANT:

Orientation of the receiving antenna must be optimized, to look mainly where you can make one signal stronger than the others and reduce the others that fall outside the guard interval.

It is worth remembering that it is better to reduce the ECHOES, especially those outside the GI, rather than just searching for the maximum power of the signal received.

SFN (Single Frequency Network)

REDUCING ECHOES



DVB-T (8 MHz)				
Modes		8K	2K	Max. Distance btw. SFN-TX
Symbol time		896 µsec	224 µsec	
Guard Interval Time & MAX distance			7 µsec	~ 2 km
			14 µsec	~ 4 km
	1/32	28 µsec	28 µsec	~ 9 km
	1/16	56 µsec	56 µsec	~ 17 km
	1/8	112 µsec		~ 34 km
	1/4	224 µsec		~ 67 km

- The signals travel at the speed of light
- They go at 300.000 km per second, 300 metres in a microsecond
- Roughly 3.3 microseconds per kilometer
- Map in hand, you know immediately if you are receiving a TX in or out of the guard interval distance

Here are a number of rules to improve management of SFN reception:

1. It is inevitable that when covering vast territory some areas will be in the shade; with digital DVB-T is more a problem of coexistence of SFN signals.
2. Even when the arrival times of signals are contained within the guard interval, it is dangerous to operate systems with SFN signals at the same level. **To obtain an adequate MER and BER margin echoes should be at least 10 dB below the main signal.**
3. There could, in theory, be a situation in which two antenna signals arrive at the same level and with the same delay, resulting in **no pictures or what is received is extremely unstable.**
4. Use directional antennas and take a close look at the SFN ECHOES screen, to check the best position of the antenna (for example, try to shield in the direction of unwanted incoming ECHOES).
5. Be very careful to combine 2 or more antennas: an antenna pointed in one direction will **inevitably pick up signals from another direction, causing, unwanted reflections (ECHOES)**.
6. Contributions outside the guard interval are considered interferent and **must be reduced by at least 25 dB**.

IMPORTANT:

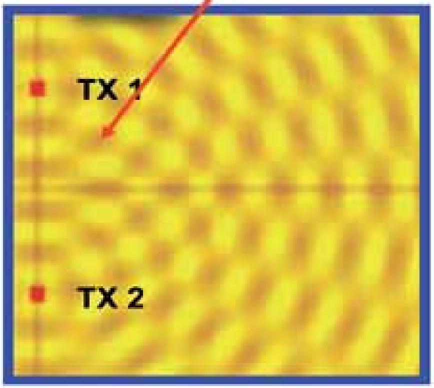
Orientation of the receiving antenna must be optimized, to look mainly where you can make one signal stronger than the others and reduce the others that fall outside the guard interval.

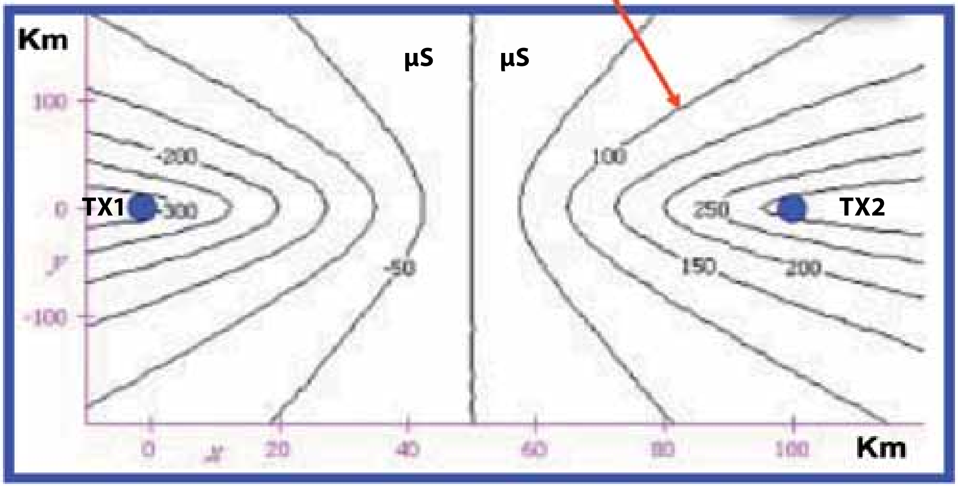
It is worth remembering that it is better to reduce the ECHOES, especially those outside the GI, rather than just searching for the maximum power of the signal received.

THE SUM OF THE SIGNALS BETWEEN TWO TX SITES

In the darker areas you have the phase sum: 6 dB increase

Along these lines you can see the delay in micro-seconds (50 µS each line)





This picture shows an example of an SFN network on a perfectly flat area, with no natural obstacles, and where there are two SFN transmitters.

When exploring an area, you will find locations where signals are added and others where they are detracted, due to phase variations and depending on the distance between the transmitters.

In areas, where the received fields from two sites are identical or very similar, variations are very strong. There are points where the signal goes to zero and points where it increases 6 dB, at a distance of about half a wavelength, because at every half wavelength there is a phase invertion:

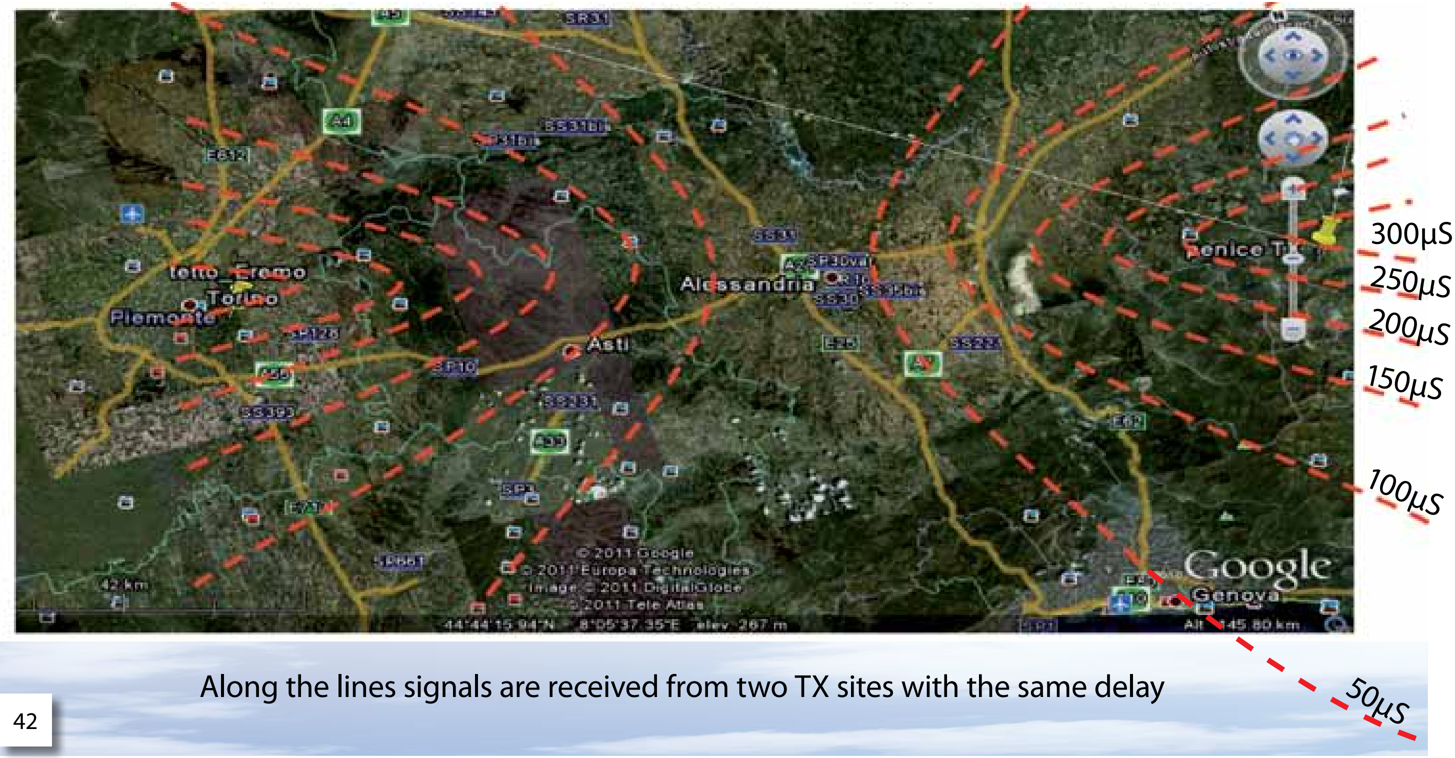
Wavelength λ = 300/frequency in MHz

When you move away from a TX site, its signals become weaker in comparison to the other TX, making phase shift less strong and with a flatter spectrum, because the phase shifts depend on the frequency and distance. Single Frequency Networks work only while delays are kept within the guard interval. The diagram shows an area of about 100 km, where delay in µS is constant along the curves: this delay is shown for each curve.

We must ensure that in the area, where the delay exceeds the guard interval, you receive signals from only one TX, using antennas with a good back to front antenna ratio, as already seen and shielding it from the other TX.

SFN (Single Frequency Network)

RECEPTION EXAMPLE BETWEEN TWO TX SITES



Along the lines signals are received from two TX sites with the same delay

As an example, we have superimposed a network of curves, with a constant level, onto a geographical map of the Padana Valley in North-West Italy. Here there is an SFN network, designed and built by the Italian broadcasting company Rai Way, which implements a few sites with high power transmitters that cover a very wide area.

You can see that the distance between the TX sites of Mount Penice and Mount Eremo is so far that the delay exceeds the guard interval. To the east of Mount Penice there is Mount Venda, another high power TX site, and this is also in SFN with TX sites covering the regions of Friuli and Emilia Romagna, North East of Italy.

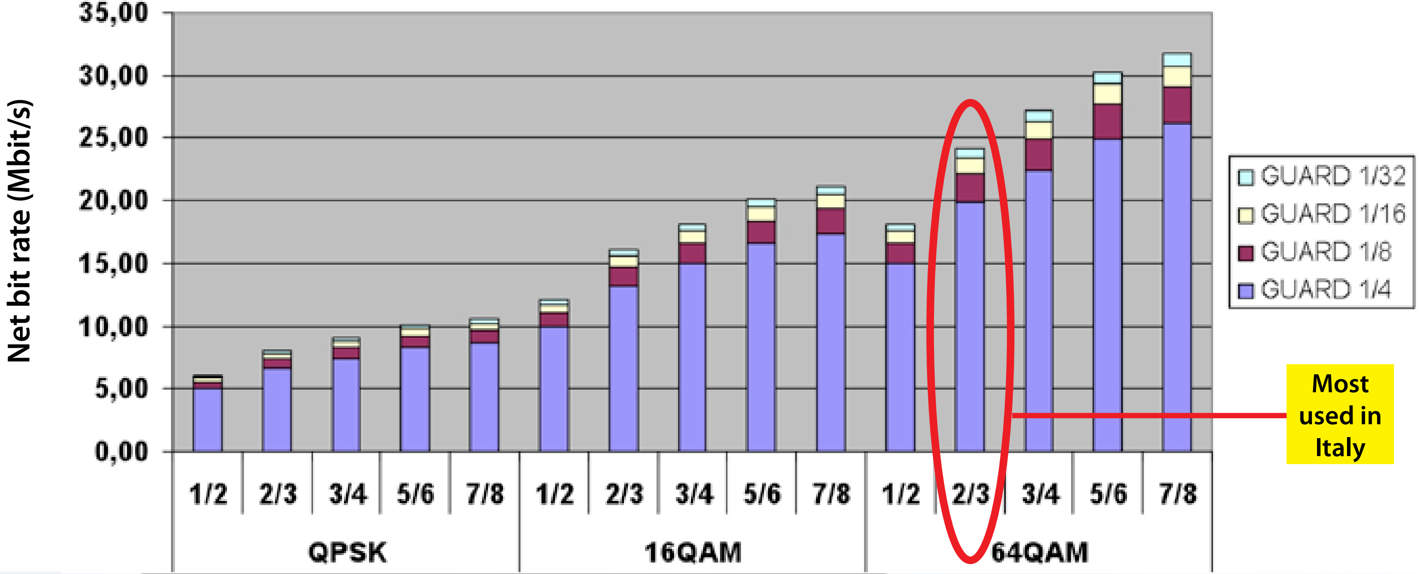
In cases like these it is very difficult to make the delays fall within the guard interval by inserting artificial delays at the various sites, because what you gain in one direction, you lose in the other.

However natural obstacles can help to prevent propagation beyond a certain distance (see the hills to the east of Turin) as well as the careful design of antenna diagrams and the calibration of power in transmission.

The directivity of the receiving antennas is of fundamental importance.

International planning bodies, who dictate broadcasting regulations, have established that a basic antenna should have an attenuation of **10 dB** for signals from an angle exceeding **25 degrees** and about **15 dB** for cross-polarization.

MODULATION PARAMETERS AND LIMIT VALUES



Showing relation between: transport capacity with various Modulations, F.E.C. and Guard Interval

The diagram clearly shows the transport capacity of the **DVB-T** transmission system, with various modulation layouts (constellations).

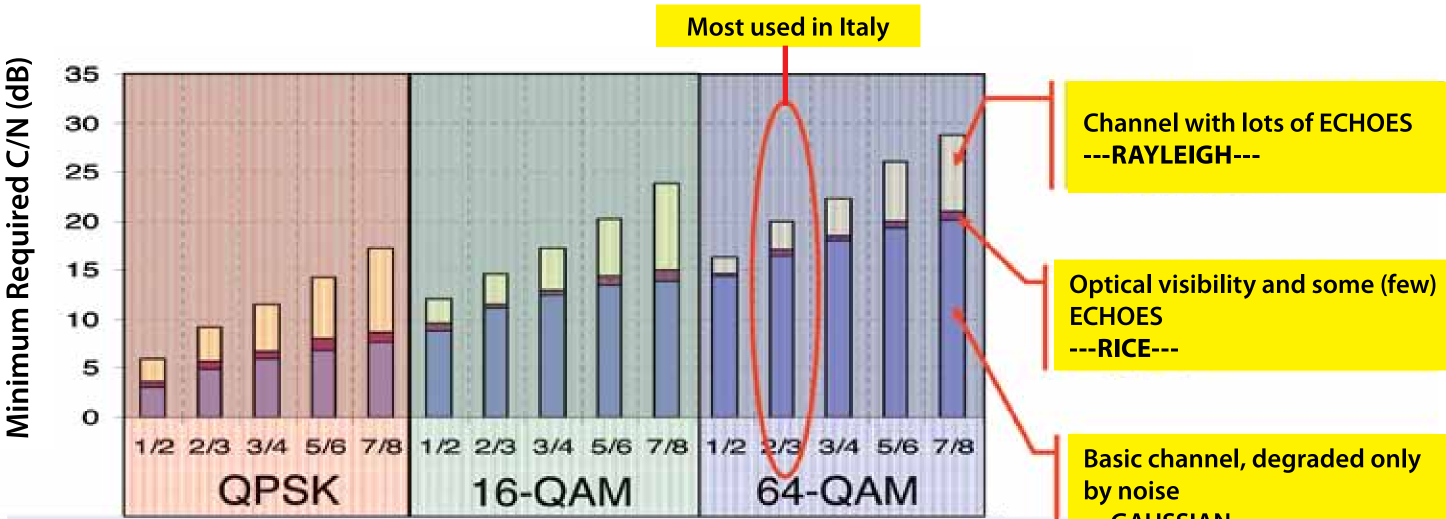
They range from a capacity of about 7 Mbit / second to a capacity of about 35 Mbits / second, which means being able to transmit from 1 to 4 or 5 programs, some in high definition.

As you can see what you get in transmission capacity, you pay in terms of signal robustness and vice versa..

If you want to manage an SFN network, you need to dedicate part of the capacity to the guard interval and FEC, as shown by the length of the histograms.

The system chosen is shown, which combines a good ability to correct errors, given the high FEC, and a good Bit Rate capacity; this is accomplished by using **64 QAM** modulation, which needs an adequate margin of MER and BER, as we shall see next.

THE LOW LIMIT FOR Q.E.F. RECEPTION
QEF = Quasi Error Free



Showing relation between: Carrier to Noise and Modulation parameters to obtain Q.E.F.

To obtain minimum reception stability, there should be the following conditions:

QEF - Quasi **E**rror **F**ree; Reception “almost” free from error.

Do not allow yourself to be misled by the word “almost”. Its meaning is clear: you must not tolerate more than one error per hour in the demodulated digital signal.

This translates into a maximum number of errors tolerated at the antenna, which can reach up to bBER 1×10^{-2}, i.e one bit error out of the 100 transmitted.

In normal reception conditions, usually the main source of degradation is thermic noise, in other words the interference that causes “the snow effect” in analog systems.

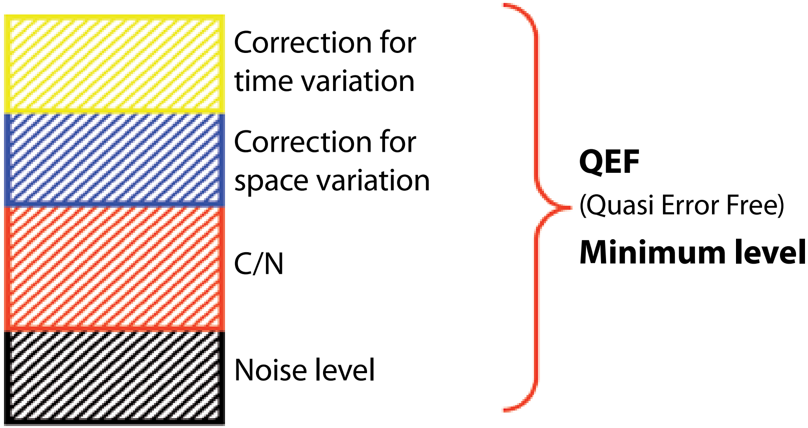
In the case of satellite reception, this is the only condition you could find because there are no obstacles along the way that could cause reflections and no interference, except for very few cases.

So for **DVB-T** reception the main problem is still thermic noise. In the diagram you can see, from the height of the bars, the **C/N** - signal to noise ratio required for reception at the limit of the locking threshold, in other words, without any **N**oise **M**argin, but in **QEF** conditions, this means that for good and stable reception you must add some dB.

It shows three kinds of reception (Rayleigh–Rice–Gaussian), using the names of famous scientists, who studied the statistics used to find these values.

Since no one can accurately predict the electromagnetic fields found at the home of each user, field predictions have been carried out, that adhere to International standards and that can effectively calculate on a 200 X 200 meter grid.

MINIMUM POWER & THRESHOLDS



The received fields are not checked in all points of the served area.
Statistic corrections are inserted against the signal variations in space and time.

These predictions are verified when the transmitters are activated, making point by point measurements (once again following the appropriate regulations).

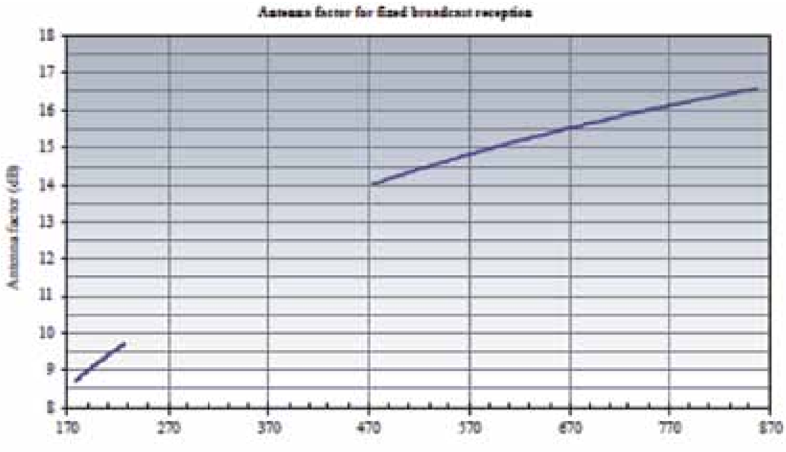
Due to the particular behaviour of **DVB-T**, it can generate interruptions of service instead of reducing the quality, the field is increased to ensure the statistical coverage of all users.

A similar increase was made to prevent variations from interfering signals, this is very dangerous because interferences often fall outside the guard interval and some times they are very strong, in the case of random propagation conditions.

For this reason a Power Margin must be guaranteed, with a minimum of 6 to 10 dB more than minimum sensitivity.

From laboratory tests, carried out on commercial decoders, it was concluded that almost all begin to decode QEF at about 29 dBμV power! This is a very low value, but corrections must be added. As explained next, you will see that you get about **39 dBμV as the absolute minimum, but it is better to keep it around 49 dBμV.**

EM FIELDS AND RECEPTION POWER



Antenna factor calculated for an antenna with 10 dB gain

Example at 500 MHz:

Antenna: 10 dB gain
Level measured: 41 dBµV
1. Read the antenna factor .... 14.5 dB
2. Add the level 41.0
3. Total .... 56.5 dBµVm

The electromagnetic field is measured in **dBµV**/m

The received power is measured in **dBµV**.

Both of these measurement units make the various calculations very easy when you need to find out the various levels in a distribution system: just add or subtract gains or, respectively, attenuations encountered by the signal along its path.

In fact, all you need is a table showing the minimum values required by the various distribution systems, then by adding the cable attenuations and subtracting the amplification gain, expressed in dB, you can find out the value of the power signal, always expressed in **dBµV**.

The antenna factor is useful because the planning values are given in terms of electromagnetic field, i.e. in dBµV/m.

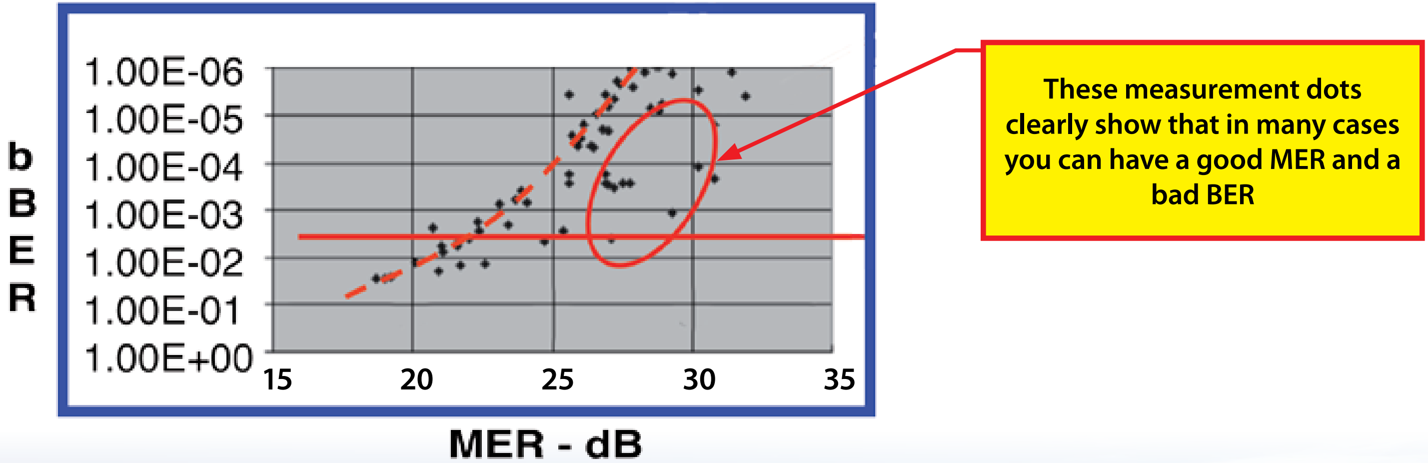
The antenna installer, who knows the antenna gain or uses a graph similar to the one shown, is able to predict with sufficient accuracy, the signal power available at the decoder input, or at the measuring instrument input.

In summary: the amount in **dBµV**/m indicates "how much field falls on a roof", while the antenna factor tells us how much "electromagnetic rain " you can capture with your antenna.

NOTE: For antennas with a gain higher than 10 dB, subtract from the reading on the graph, the difference in gain.

E.g.: F = 470 MHz; antenna G = 13.50 dB, antenna F reads 14 dB
You must subtract: (13.50 - 10) = 3.5, then antenna F = 10.5 dB,
viceversa, if the antenna gains less than 10 dB, you must add the difference.

CORRELATION BETWEEN MER & BER



Results of a series of measurements carried out after activating an experimental SFN network in 1999.

Even if the MER is a good indicator of quality, there are some important exceptions.

There are cases that complicate operation and create confusion due to the loss of coherence between data, which seem not any more comparable. You could start by saying that, only in the presence of pure thermal noise, the MER and C/N almost coincide.

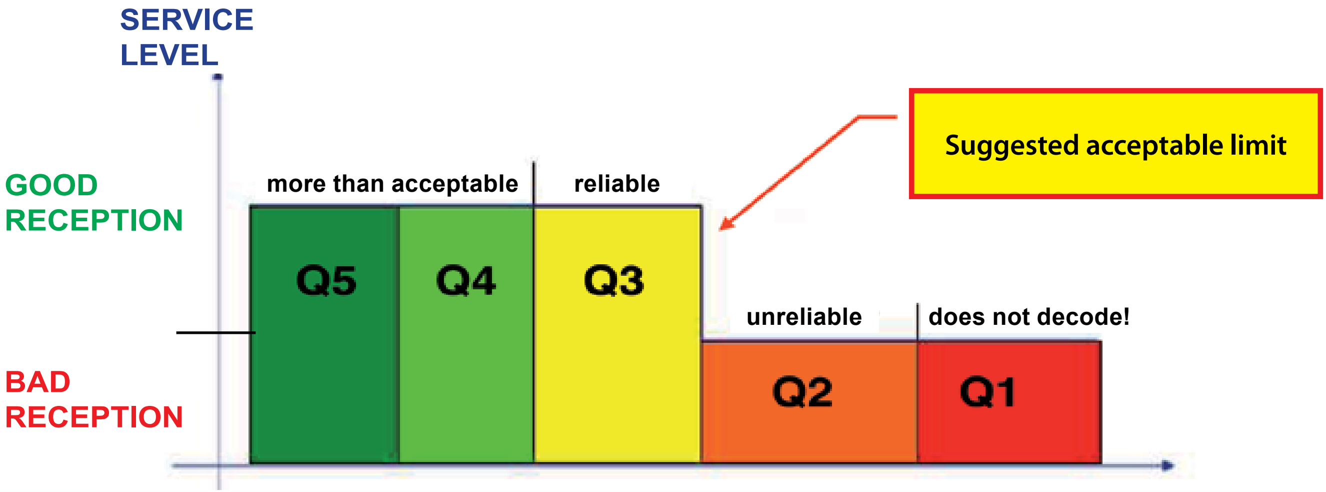
The BER before Viterbi error correction **(bBER)** is an index that can be used to determine the overall quality of a signal, but sometimes the best MER does not correspond to the good BER, or that this does not improve even if the MER has very high values. This is normal behavior, and it was mentioned earlier. The graph clear shows that the two parameters are not consistent, which is evident in the case of impulsive interferences or pre-echoes.

You must always carry out both measurements and remember that quality is essentially dependent on the BER. You must make any adjustment to the system, e.g. to the orientation of the antenna or any other modification, but you must check the MER and BER and pay less attention to the received power. Use the MER as an index to check the quality of amplifiers and especially converters, based on the deterioration introduced between input and output of the various elements of the systems.

N.B. Because each instrument manufacturer names the two BER in a different way, we have decided to use the acronyms used by the British, who were the first to introduce a DVB-T network in Europe in 1998.

- **bBER** = “b” means “before”, i.e. measured before Viterbi error correction and is also called Pre BER or CBER.
- **aBER** = “a” means “after”, i.e. measured after Viterbi error correction and is also called Post BER or even VBER.

RADIOELECTRIC RECEPTION QUALITY



With DVB-T you should distinguish between radioelectric reception quality and video quality.
The main parametrs are: **bBER and channel power**

The diagram shows once again the threshold behavior of DVB-T and is the base to measure the quality of a signal or for a complete distribution system.

The aim is to carry out a measurement that says, with certainty, how far we are from the threshold, which marks the boundary between unstable and unsatisfactory reception and a situation which gets better and better, until you reach the optimum.

Obviously, in this step, all reception parameters raising on values that get better and better, from dark red to dark green.

After the necessary measurements have been carried out, results can be put in a graph, and then you can see the level of quality of service provided to the user.

Do not ever confuse the five levels of quality with analog ones, where a number from 1 to 5 indicated "how the picture was seen": starting from unacceptable = grade 1, to a perfect picture = grade 5.

DVB-T gives you a number that indicates the quality, which is not connected in any way with the quality of the video picture, which remains the same when the decoder begins to lock without interruptions.

Instead, quality is linked to the stability over time: interference, noise, echoes and so on are highly variable over time, so we have to make sure we reach the best measurement parameters over the minimum allowed.

Radioelectric quality

ITU STANDARD PROCEDURE

Power received increasing in the direction of the arrow

Table of values to determine the quality

Over 40	Q2	Q3	Q4	Q5
40 dBµV	Q2	Q3	Q3	Q4
34 dBµV	Q1	Q2	Q2	Q2
	$4x10^{-2}$	$2x10^{-3}$	$2x10^{-4}$	better than $2x10^{-4}$

bBER improves in the direction of the arrow

KEY:

bBER = before Viterbi (measured before Viterbi error correction) also known as C BER

aBER = after Viterbi (measured after Viterbi error correction) also known as V BER

CBER, or bBER before Viterbi error correction, is the most important parameter.
The after Viterbi error correction Ber (aBER) must be better than 2x10-4, the minimum limit for the decoder to lock.
Many meters automatically supply a quality index and this makes work much easier.

This table is calculated for systems with a FEC equal to 2 / 3, but in practice it can be considered valid in all cases.

The parameters used for evaluation are the bBER and the Power of the received channel, practice has proved the validity of this measurement system.

A similar table is used when we predict the quality of reception in the design phase, using the field in **dBµV/m**.

The values shown can be used as an approximation, the absolute level of quality is not so important, but the most important thing is to have an adequate Noise Margin.

Some meters, currently available on the market, have built-in software that calculates the quality and expresses it very simply using three levels: **Pass, Marginal, Fail**.

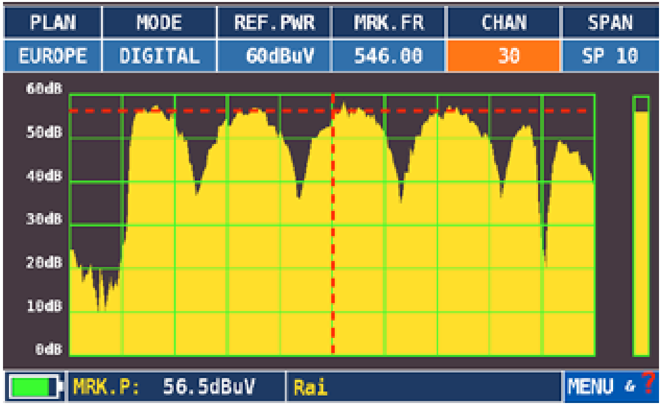
This is all that is required for a quick evaluation of the reception conditions: in practice the first step of the scale has been omitted, but this has virtually no importance. In difficult reception cases, or with signals at the limit of decoding, determining the quality becomes very difficult and useless.

In very difficult cases it makes no sense to measure the quality, you should seek only the best reception possible and this can only be done by measuring the various parameters and trying to maximize them with the antenna.

In these cases, any improvement is determined by the quality of the antenna and its position, as described previously.

The antenna is always the most important component of a system, as experience with analog reception has shown.

CASE STUDY – MICROINTERRUPTIONS



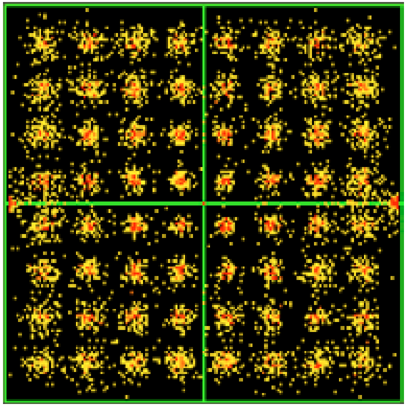


Fig.1: You can see the spectrum with high signal power, but related constellation diagram, showing slight degradation

Micro-interruptions are not always due to industrial noise disturbance, but also due to the quality of the signal received signal.

You can evaluate signal quality by using a field strength meter, this usually provides the **Power, BER** and **MER.** When these values are within the suggested parameters, should you be satisfied?

The digital signal is different from analog, especially for its behaviour at the threshold point. More faryou are from this point the more the signal quality is guaranteed, “we need a Noise Margin”. This concept should be considered 24 hours a day, 365 days a year.

Short interruptions cause breaks in the use of the received program, causing problems that were not perceived with analog reception.

1% inefficiency can be tolerated, but if that 1% inefficiency occurs during an important television scene, the affected user would consider this bad quality.

It is important to understand what signal stability means and the spectrum function in a field strength meter is very useful to do this. If the received signal approaches the theoretical form of a DVB-T signal, square and flat, everything is OK, but if the signal received has a lot of ripples (waves), it could be at risk from micro-interruptions.

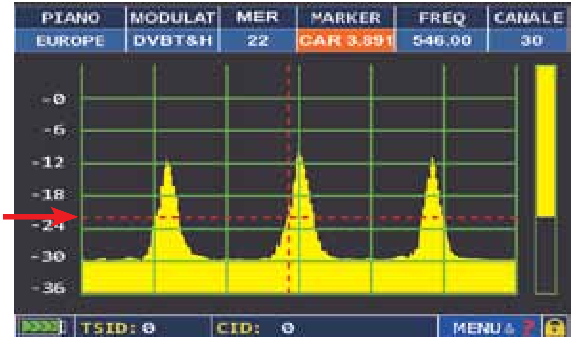
The measured power is an average of 8 MHz of bandwidth (7 in VHF) and can change according to the propagation. The same considerations should be made for **BER** and **MER**. The first value is the result of a statistical calculation and the second is the average value of the **MER** for all carriers.

You immediately notice that the ripples (waves) penalizes some of the DVB-T carriers as you will see on the next pages.

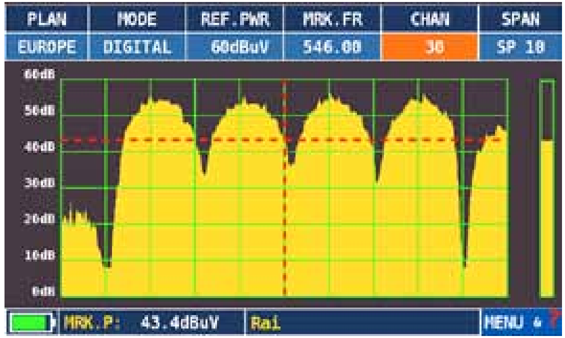
Case study – microinterruptions

MER VERSUS CARRIER

Average MER



Channel Spectrum



Displaying the MER measured on each single carrier, clearly shows the frequency position of the interferences in the received channel and helps to find out the cause, for example interferences from analog channels or other interferences. Unfortunately only few meters can do these measurements.

So ripple (waves) in the spectrum penalizes some of the DVB-T carriers.

The system architecture of DVB-T takes into account these propagation effects and spreads out data among the various carriers, so that a selective attenuation of some carriers is not destructive for a set of close data, but the damage is spread across all the texture in order to limit the effects on the pictures.

The graph shown is very explicit and refers to the situation described on the previous page. You can see the **MER** refering to the carriers and, to the right, you see the corresponding dip on the spectrum, with the lowering of power at the peak and worsening **MER**. This mode of representation is not available on all instruments and is therefore not very familiar.

The graph describes the **MER** of each carrier, while the red line describes the average. It is clear that a large deviation from the average indicates a signal degradation. If the propagation and the quality of the corrupted carriers were to get slightly worse this would affect the system's ability to correct data and we lose the pictures.

Case study – microinterruptions

THE “SIGNAL STRATIFICATION” EFFECT

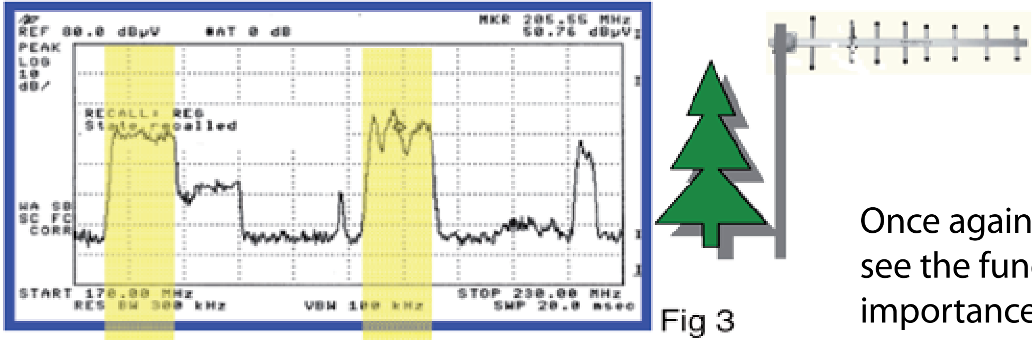


Fig 3

Once again you can see the fundamental importance of good antenna positioning

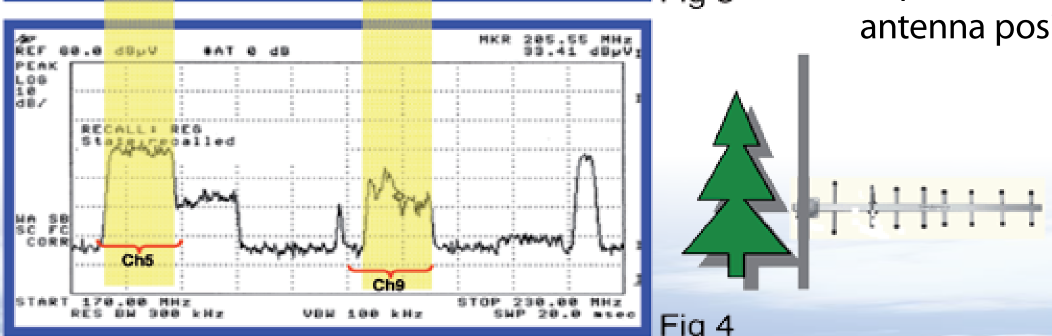


Fig 4

In Figure 3 and 4 you can see the stratification effect on the signal.

By varying the antenna height, with reception of ch.9, in the center of the graph, the signal changes from 60 **dBµV** to 47 **dBµV** in figure 3 and in fig. 4. This also happens for **BER** and **MER**.

It is clear that the signal in figure 3 is much less at risk of disruption than that of Figure 4.

Of course the signal is totally different on ch.5, the first on the left, which maintains both its level and shape. This different behavior is due to the different location of the transmitter and the orography of the territory.

In conclusion, in addition to the power and error, consider the shape of the signal spectrum and avoid ripples (waves) that are too deep.

The choice of the antenna and its positioning are crucial, because they determine the quality of the entire system.

IMPULSE NOISE

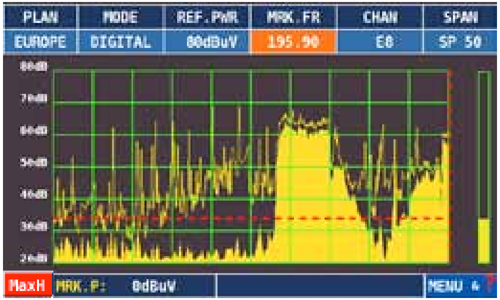


Fig.5

- This RAI photo shows the effect of impulse noise disturbance on analog signals (bands of small white dots).
- The spectrum shows a manifestly background noise that, but at this level, does not influence digital reception at all.
- We will take a look at more critical cases.

Figure 5 shows DVB-T signal ch.8 that, despite an manifestly background noise due to discharges, works perfectly. The user gets an excellent quality. The discharges are generated by electric mains.

If instead of DVB-T there were an analog signal, it would certainly have been disturbed by the discharges would show the effect of the first analog image with a band of white dots.

The noise disturbance in the example shown in Figure 5 becomes problematic if the intensity of the noise disturbance grows and exceeds DVB-T's typical margin of corrections. In this case, since continuous noise disturbance over time is fairly easy to reduce by moving the antenna and shielding it from the source of the disturbance.

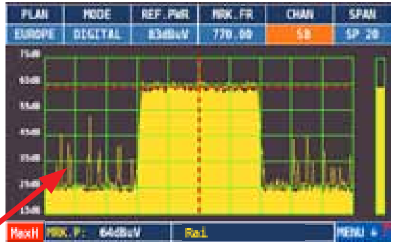
It is more difficult to find a solution when the noise disturbances are short and intermittent (impulse noise) with a similar power to the signal.

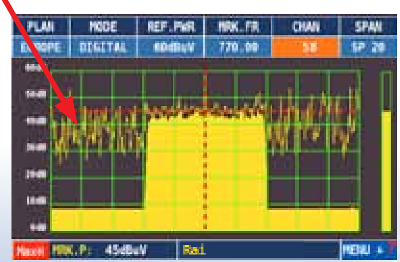
In analog reception this type of impulse noise disturbance does not cause the loss of the pictures because it is too fast.

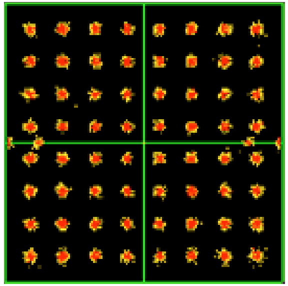
On the contrary to DVB-T there are annoying effects because brief but intense noise disturbances block signal decoding, the picture becomes “blocky” or even a black square and interrupts reception continuity. Then, if the fault is frequent, reception becomes problematic.

MEASURING IMPULSE NOISE DISTURBANCES

The level of the disturbance can only be seen by analyzing the memory peak trace that holds the memory of the maximum values (MAX HOLD function)

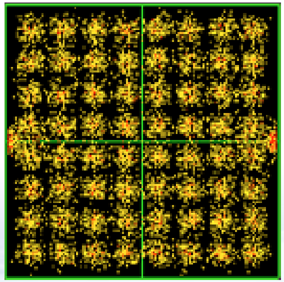






Using a very directive antenna

Fig 6a



Using a not very directive antenna

Fig 6b

Using this case study you can see how to deal with the problem. The examples show the spectrum of ch.58, interfered by impulsive noise. In full yellow you can see the signal (Live) and in light yellow the peak of interference values stored in Max-Hold function, and to the right, the related constellation.

The difference between the two signals is due to the different directivity of the antenna used.

In Fig. 6a the antenna is very directive, the relationship between the signal and the impulse noise is good, the constellation is excellent.

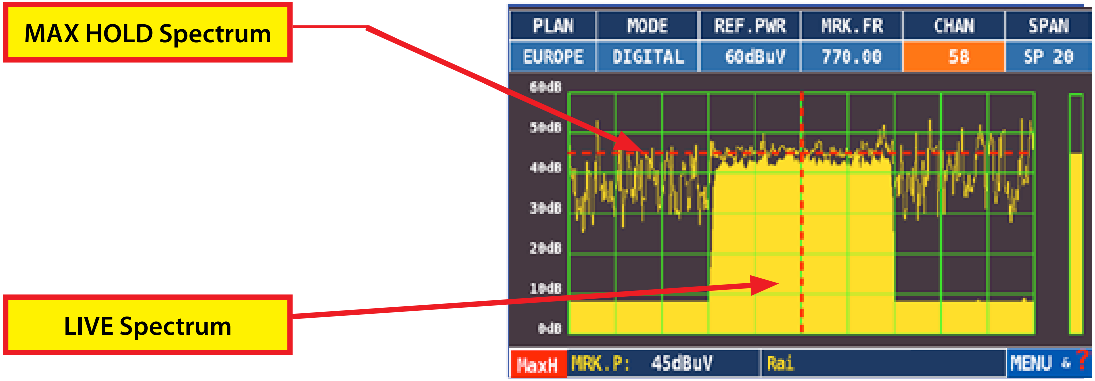
In Fig. 6b the antenna is not very good (not very directive) and you can see the difference immediately.

If the constellation is very bad the Noise Margin is insufficient. This example helps us understand the importance of the choice of the antenna, (more or less directly as possible with less secondary lobes), its positioning and the importance of looking not just at the signal, but to check all the parameters that your meter provides.

So far we have described the problems added to the antenna signal, but in many cases the interference is received due to a poor screening of the distribution system.

Some meters allow you to visualize the maximum level power that is updated continuously (Max Hold function), allowing fine analysis such as the one previously described.

IMPULSE NOISE INTERFERENCE SPECTRUM



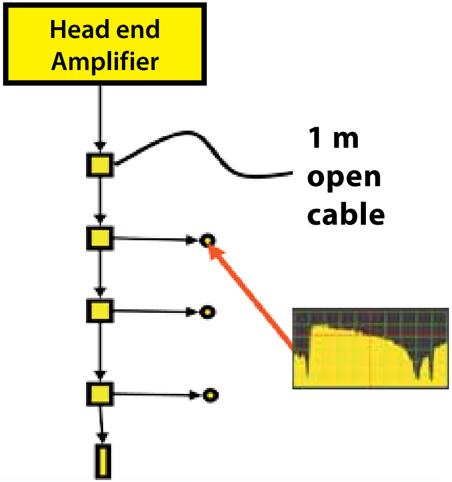
- The impulse noise (or discharges) are sporadic and not always displayed by instruments and analyzers that do not have the "MAX HOLD" (peak memory) function.
- The "MAX HOLD" spectrum captures and stores the maximum values reached in the time and allows you to clearly visualize the build-up of the impulses (discharges) received.

Directive 2004/108/EC requires that electrical and electronic equipment do not generate electromagnetic disturbance, and then discharges in the example should not exist. The same legislation requires that electrical and electronic equipment typically have a level of immunity to disturbances in the expected conditions of use that they are intended. It is at this point where you see the difference between a new well done distribution system and old or bad job.

An old splitter or amplifier with components “in the open air”, not shielded, is an excellent antenna to receive impulsive disturbance. The industry has been very careful about this and, not only provides higher performance antennas, but more accurate components, built in metal boxes that protect the electronics from disturbances. Cables are also categorized according to their losses and declare the type and quality of their shielding (A A + etc...)

Compared to the past, there has been a significant evolution of the products offered, it is important to be aware of the risk you take in assembling low cost products that do not respect the current technical requirements. Repairing a system with these low cost products is very expensive, primarily because the discharges are random and their identification causes you to waste a lot of time. Replacing the nonconforming products costs more than what was saved initially using cheap products.

MISMATCHING & DISTRIBUTION



Case 1

Use a very well isolated socket:

If you disconnect a set top box and leave a 1 m cable connected to the socket you do not generate any variation to the other subscriber in the system

Case 2

Use a very bad or not isolated socket:

If you disconnect a set top box and leave 1 m cable connected to the socket, you generate big variations in some channels to the other subscribers in the system

The diagram shows the real case of a community system with the cascade distribution, case 2, made by unqualified "DO IT YOURSELF" staff.

We compared the following two situations:

1. **Case 1 – Use a very well isolated socket:**
   If you disconnect a set top box and leave a 1 m cable connected to the socket you do not generate any variation to the other subscriber in the system.
2. **Case 2 – Use a very bad or not isolated socket:**
   If you disconnect a set top box and leave 1 m cable connected to the socket, you generate big variations in some channels to the other subscribers in the system

You notice immediately that there is a very strong alteration in the spectrum response, case 2 highlighted. The alteration consists of one or more gaps, which depends on the length of the cable.

The alteration is caused by a reflection that comes at the end of cable that was left open (unterminated), this combines with the signal coming from the headend. This reflection is combined with a phase shift that depends on the frequency and length of the cables involved and which differs from socket to socket and also depending on the channel. In fact there is a net loss of 15 dB on channel 36.

You can immediately see how risky this situation is, because the outcome is unpredictable and cancels out the work carried out in optimizing the system at the beginning.

In regulated systems this fault does not happen, because proper installation and radioelectric characteristics of the sockets and splitters, provide the necessary separation between units and the subsequent cancellation of reflected waves in the case of open cables or short circuits.

ROVER INSTRUMENTS

DVB T2/C2/S2 MPEG4

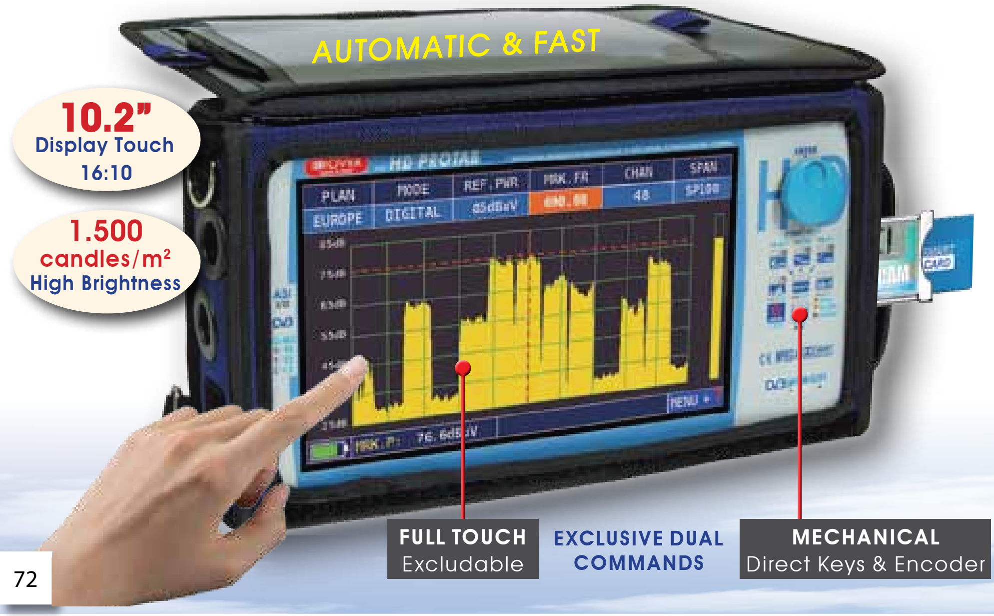
HD PROTAB STCOI

SAT TV CATV OPTIC IP TV

DOLBY APPROVED

PROFESSIONAL BROADCAST HD ANALYZER for:

DVB–T2 / C2 / S2 & ATSC / ISDB–T / GB20600 / J83B



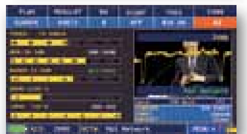
10.2”
Display Touch
16:10

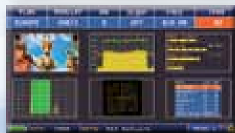
1.500
candles/m²
High Brightness

FULL TOUCH
Excludable

EXCLUSIVE DUAL COMMANDS

MECHANICAL
Direct Keys & Encoder





DVB T2/C2/S2 MPEG4

ROVER INSTRUMENTS

REAL TIME SPECTRUM • 6-HOUR BATTERY CAPACITY

75Ω "F" Connector

RF IN

- FREQ. RANGE 4-2.250 MHz
- DVB-S2 MULTISTREAM
- DVB-T2
- DVB-C2
- AN-TV
- FM RD
- DAB
- SPECTRUM
- GSM
- LTE
- ITU QUALITY COVERAGE

50Ω "N" Connector

ASI T.S.

- INPUT/OUTPUT
- DVB-T NETWORK DELAY
- T.S. ANALYZER
- RECORD/READER

IP TV

- ASI TO IP
- IP TO ASI
- IPTV ANALYZER

LAN

- T.S. LIVE STREAMING
- T.S. RECORDING
- REMOTE CONTROL

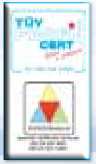
OPTIC

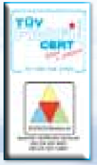
- POWER METER
- POWER LOSS
- POWER GRAPH
- SAT & CATV SPECT

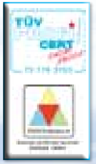
GPS

- POSITION
- 10 MHz & 1 PPS
- ANTENNA QUALITY TEST

- SAT: QPSK-8PSK
- TV: COFDM
- CATV: QAM
- GPS: REF/POS
- OPTICS: FTTX/PON/RFOG
- IP-TV: RTP/UDP
- ASI: IN/OUT/T.S. AN







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mod. HD FLASH STCO

THE PROFESSIONAL & ACCURATE ANALYZER

TFT 7” 16:10

- DVB-T2 opt.
- OPTIC INPUT opt.
- FULL MPEG2 & 4 SD & HD
- REAL TIME SPECTRUM with MAX HOLD
- LCN PROGRAM CODE
- MER Versus CARRIERS MEASUR. opt.
- TOUCHSCREEN opt.
- ECHOES, MICROECHOES & PREECHOES in REAL TIME
- Auto/Manual "LTE" FILTERS opt.
- CONDITIONAL ACCESS
- 8h LI-ION POL. BATTERIES

DVB T2/C2/S2

DUAL COMMANDS:

- *Mechanical*
- *Touch (excludable)*

lte T2 LCN DOLBY APPROVED

mod. HD COMPACT STC

ROVER INSTRUMENTS

THE MOST ADVANCED & ACCURATE INSTALLATION METER

TFT 4,3"
16:10

- DVB-T2 opt.
- FULL MPEG2 & 4 SD & HD
- 4h LI-ION POL. BATTERIES
- LCN PROGRAM CODE
- MER VERSUS CARRIERS opt.
- ECHOES, MICROECHOES & PREECHOES in REAL TIME
- REAL TIME SPECTRUM with MAX HOLD

Lte T2 LCN DOLBY APPROVED DVB T2/C2/S2

ROVER would like to thank the engineers at the Italian State Broadcasting company RAI and the Italian school for professional installers EUROSATELLITE in Sansepolcro (AR) for their invaluable contributions to this booklet

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