DIGITAL SIGNALS

Radio frequency* Measurements

This article looks at the various measurements and the parameters that must be respected, explaining, where necessary, the different behaviors of digital and analog signals.

FIG 1: RADIO FREQUENCY SPECTRUM

On the left you can see the spectrum of an analog signal, 1 prog. for each channel; you can see the video carriers, audio and color. On the right you can see the spectrum of a digital signal, many programs for each channel. You can not see the single contributions.

The difference between an analog and digital signal is evident: 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 tuning the programme selected by the user. What interests an installer is to measure the received "field", and to see if there is a difference between an analog and digital situation, to see how things are:

Analogue Signal: You measure the voltage of a single video carrier and express it in units. The most suitable unit, used by almost everyone, is dBµV. Remember that 60 dBµV is the famous 1 milliVolt magic number, that expresses the ideal level required for an analog TV system to work.

Digital Signal: This measures the power of the complete channel, 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: 0 dBµV = 1 microVolt

Channel power

Fig. 2 shows what you see if you expand the spectrum of the individual carriers. Obviously you will not be able to see this with all spectrum analyzers, given the resolution of the required band.

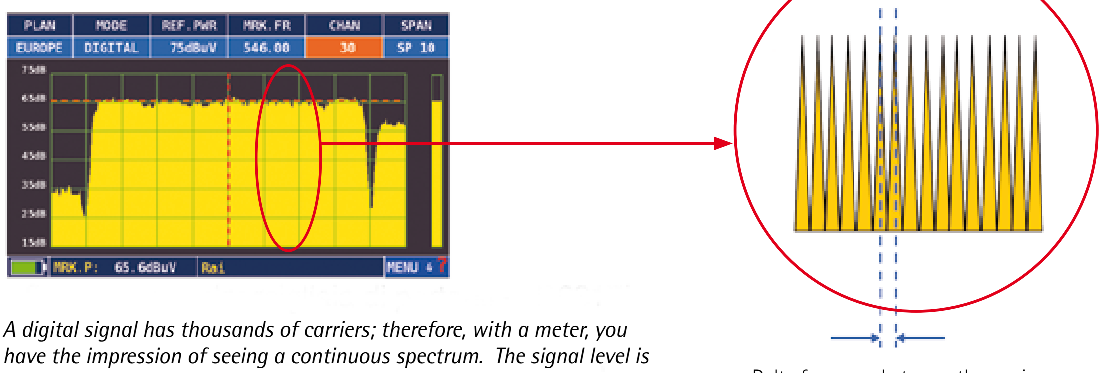
The function that allows you to find out the total power of all carriers is called the "Average Channel Power".

With professional analyzers you can choose different measurement modes, whereas in portable analyzers this is fixed and always active for radio frequency 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 calculating the total of the partial powers. However, the result is the average power, called RMS (Root Mean Square value).

FIG 2: CHANNEL POWER



A digital signal has thousands of carriers; therefore, with a meter, you have the impression of seeing a continuous spectrum. The signal level is the sum of all the carriers. On the right you can see the space between each carrier, equal to 1.116 Hz.

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

RF Level Measurement

The digital signal's power is always measured in dBµV, but it is different from analog.

With an analog signal it is the true voltage measured at the field strength meter's input, but only of the video carrier, and it is established that a specific value is necessary (approximately 1 millivolt, equal to 60 dBµV) to obtain a quality picture. With a digital signal the measurement is derived from the average power, related to the bandwidth of the measurement filter of the instrument, because it is not possible to measure all of the signal's eight thousand carriers. The result is however expressed in dBµV, a well known, familiar measurement unit.

Please note:

- The power of the received field is not as important in DVB-T. It only needs to have a required minimum level that is about 40 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.

- Using the numbers shown in **Fig. 4**, you can pass very quickly from dBm to dBµV and viceversa: just add or subtract the number 108.7, which is valid for 75 Ohm systems. In the case of 50 Ohm, the fixed number is 107. However in all meters you can select the measurement unit you prefer to use: dBm or dBµV.

DVB-T Modulation

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

In fact it is very similar, because the information is random and randomly variable. 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 oscillate at random 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.

In the case of an analog signal, the noise, or interference, has a progressive action and is immediately visible on the signal.

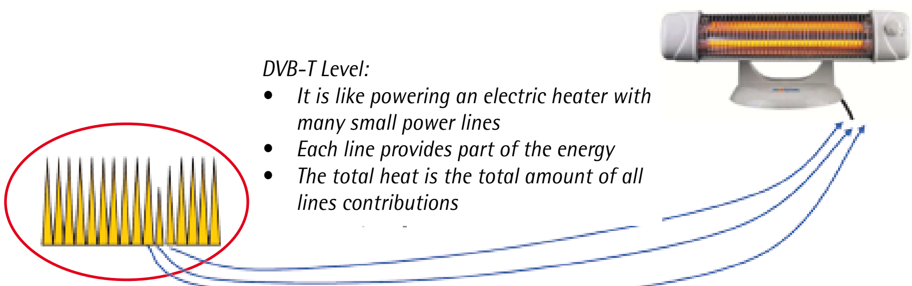
If you only observe the spectrum and received power of a digital signal, it is not clear when the various carriers are received correctly, because you do not know how much noise disturbance there is and how it affects the demodulation. Later you will see what to do when working on headends and antenna pointing, in order to obtain the best signal and work out how to measure the signal quality.

FIG 3. RF LEVEL MEASUREMENT

Units:

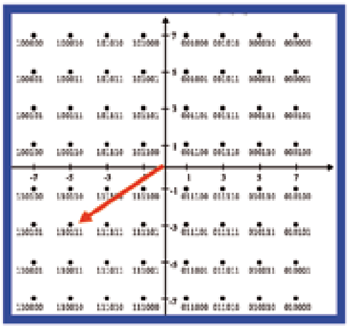
dBm = 1 milliWatt = 273 millivolt with 75 Ohm.

dbuV = dBm + 108.7 for 75 Ohm systems.



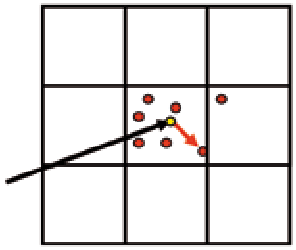
Using the numbers shown above, it is possible to pass from dBm to dBµV and viceversa: simply add or subtract the fixed number 108,7, valid for 75 Ohm; in the case of 50 Ohm systems, the fixed number 107.

FIG 4: 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.

Performance indicators

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 the carriers and alter their position, making it difficult to recognise 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 behaviour the FEC (Forward Error Correction), 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 in Fig. 5 was carried out by counting the errors: different instruments use counters that measure up to 999 errors, therefore the measurement takes some time.

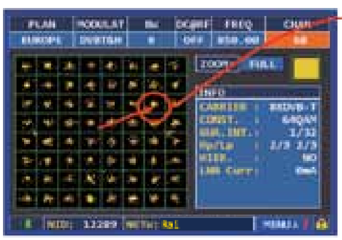
Important: remember that, even in the presence of errors, the signal is decoded correctly, maintaining the highest quality, so a method is required to determine the quality of the reception system. In other words find out how much the noise or interference can be increased, without affecting the quality of the received information (noise margin concept).

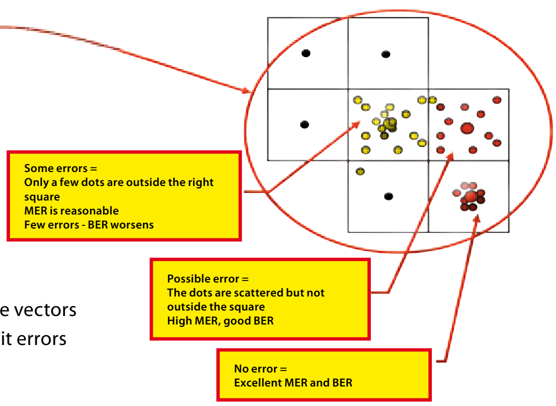
Locking threshold

The DVB-T signal has these behaviours, which have both advantages and disadvantages. *The advantages are:*

1. 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 maxiumum power, the quality is always high, regardless of the signal power strength;

FIG 5: PERFORMANCE INDICATORS



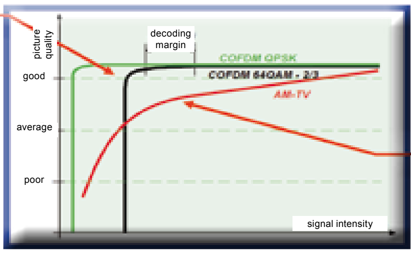


The **MER** shows bad positioning of the vectors
The **BER** tells you the percentage of bit errors

The position of the various dots in each square determines the MER (vector position error) quality and BER (Bit Error Rate). The measurement is carried out by counting the errors: various instruments register, using a counter, up to 999 errors and this is why the measurement takes a lot of time.

FIG 6: LOCKING THRESHOLD

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



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).

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

3. The minimum power required is much lower than the level required for analog.

The disadvantages, however, are:

1. In the case of bad analog 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. In DVB-T this cannot be done: if there is increased noise, the decoder remains completely unlocked (threshold phenomenon);
2. Interruptions of a few seconds and "macroblocks" are much more disturbing in a momentary drop in analog quality, which resumes immediately.

Before and after Viterbi, noise margin

In **Fig. 7** 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 Satellite set top boxes.

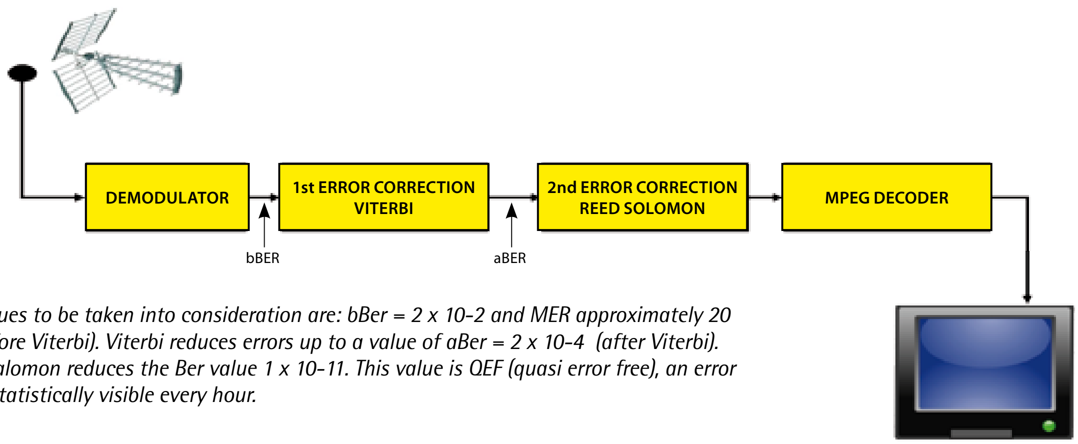
The Reed Solomon circuit is common to all types of digital broadcasting, ie satellite and cable, whereas the Viterbi circuit, reduces most of the errors and adapts to the system, whether it is satellite or DVB-T.

What happens is the number of errors varies considerably at the decoder input; after Viterbi error correction it is lower and more constant. The picture shows the error limits tollerated by the system but, as we already said, the limits must be much higher and if you want an acceptable quality, you must have a good noise margin.

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 stellite distribution. Since the minimum values of various parameters to be analyzed differs between the various sytems satellite, terrestrial and cable, some meters automatically provide the signal quality and this greatly simplifies the job.*

** This article was taken from the technical booklet 'Understanding Digital TV' produced by Rai Way, Eurosatellite and Rover. The complete booklet can be found on the Rover website:* **http://www.roverinstruments.com/news.php?lingua=2&idnews=76**

FIG 7: BEFORE AND AFTER VITERBI



The values to be taken into consideration are: bBer = 2 x 10-2 and MER approximately 20 dB (before Viterbi). Viterbi reduces errors up to a value of aBer = 2 x 10-4 (after Viterbi). Reed Salomon reduces the Ber value 1 x 10-11. This value is QEF (quasi error free), an error event statistically visible every hour.