Laceys.tv™

Bit Error Ratio & Modulation Error Ratio

What does it mean?

How will it help me?

Presented by

Mark Bryant

for

Laceys.tv™

UNAOHM

INTRODUCTION

Laceys.tv™

- Bit Error Ratio (BER) what does it mean?
- CH BER before error correction.
- PV BER post Viterbi correction.
- RU Reed Solomon Uncorrected.
- Carrier to Noise (C/N)
- Modulation Error Ratio (MER)
- QEF (Quasi Error Free) Failure point.
- Practical demonstration.
- Adaptive Equalizer Response (AER)

UNAOHM

COMPARISONS BETWEEN DIGITAL AND ANALOGUE

Laceys.tv™

Effect of noise on Analogue Systems (Gradually Poorer C/N)


45dB C/N


35dB C/N

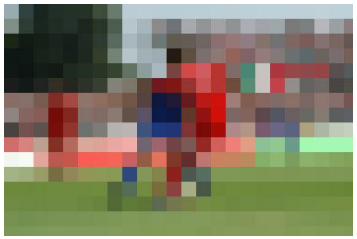

25dB C/N


20dB C/N

Effect of noise on Digital Systems (Gradually Poorer MER)


35dB MER


18dB MER


<QEF> 17dB MER


16dB MER

Noise has very little effect on Digital systems until the system fails completely.

UNAOHM

ERROR CORRECTION

Laceys.tv™

- BER is an error correction system developed by Dr. Andrew J Viterbi and is commonly used in digital systems today. The Viterbi error correction system is used in our set top boxes and is also present in quality test instruments.

- **BER is a ratio of data to the amount of errors arriving into your stream.**

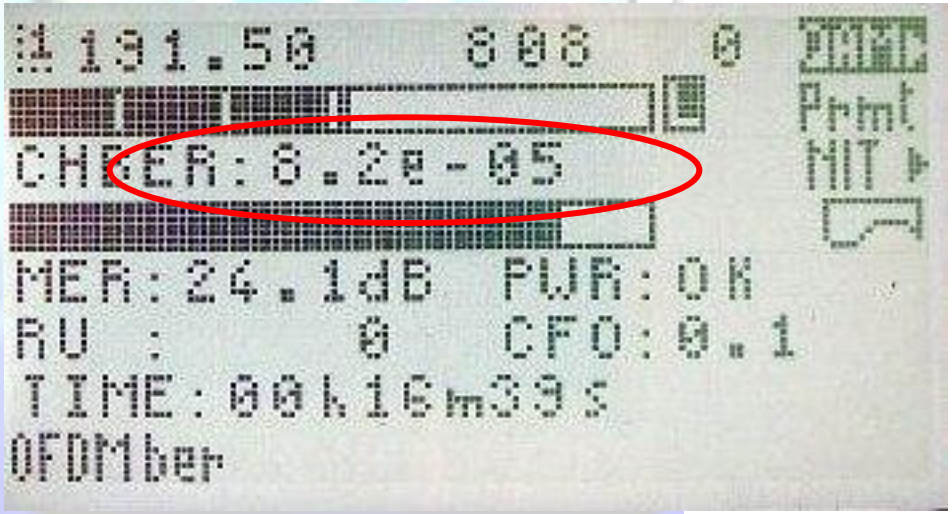
UNAOHM

BIT ERROR RATIO (BER)

Laceys.tv™

Because the count of data is so high, we measure in an exponential format eg;

E-05 or errors present every 5 zero's or every 100,000 bits of data.



E-01 = 10

E-02 = 100

E-03 = 1000

E-04 = 10,000

E-05 = 100,000

E-06 = 1,000,000

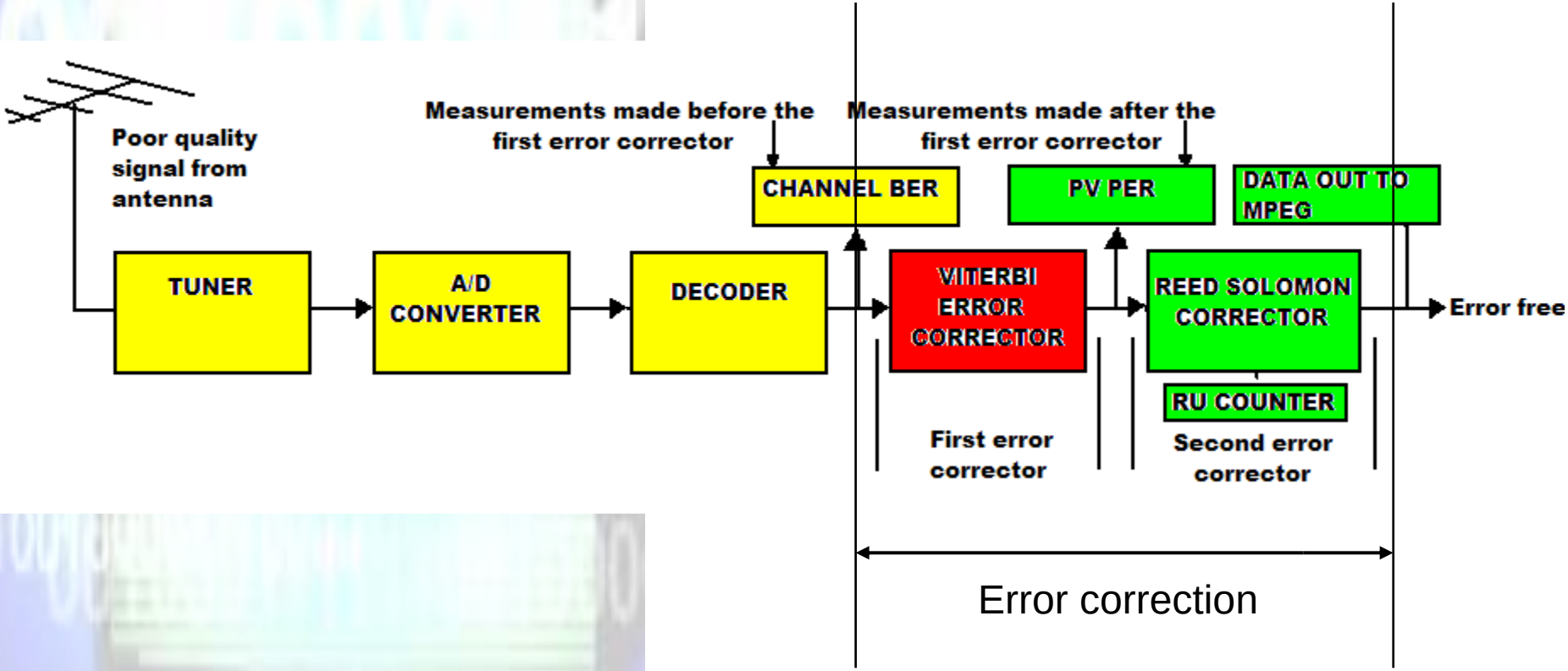
E-07 = 10,000,000

E-08 = 100,000,000

UNAOHM

DIGITAL BER FLOW CHART

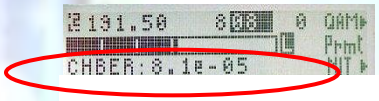
Laceys.tv™



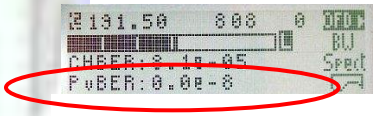
UNAOHM

ERROR CORRECTORS

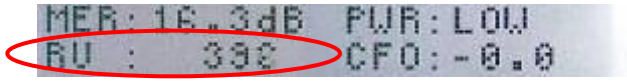
Laceys.tv™



Before correction

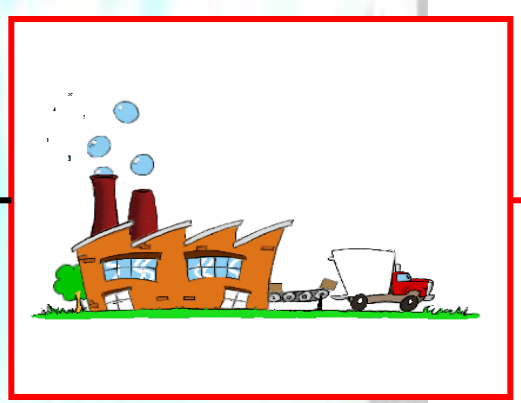


After the Viterbi corrector

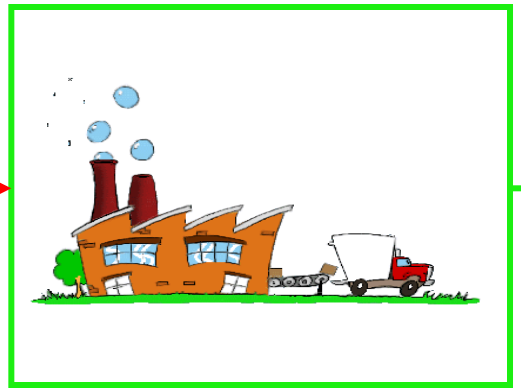


Errors present after second corrector," Reed Solomon"

Errors in



Viterbi Error Corrector



Reed Solomon Corrector

Error free

E-01 = 10

E-02 = 100

E-03 = 1000

E-04 = 10,000

E-05 = 100,000

E-06 = 1,000,000

E-07 = 10,000,000

E-08 = 100,000,000

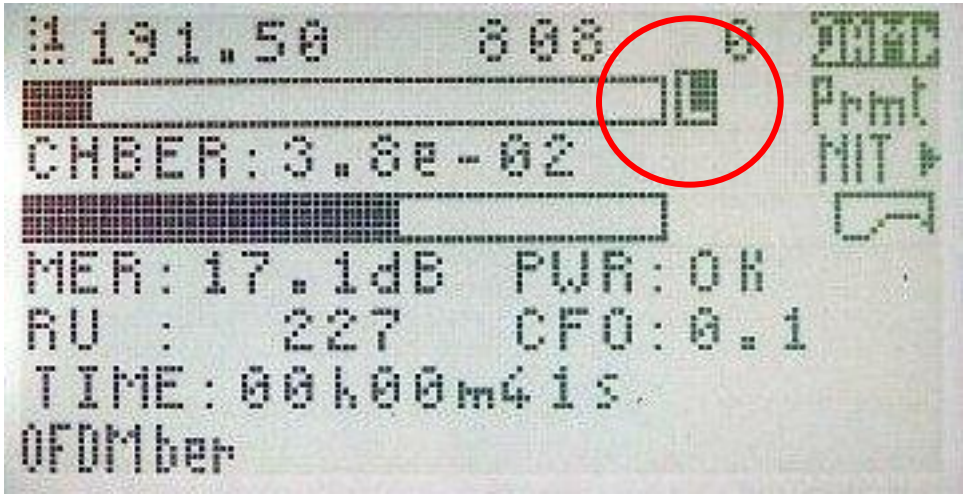
UNAOHM

- When testing system integrity we use 5 different Digital measurements.

- **LOCKED INDICATOR**

“LOCKED INDICATOR”

- “Locked” indicator could be considered the first digital measurement.
- Indicating a locked status shows us that our instrument has started counting data, even below a set top boxes functional ability.



DIGITAL MEASUREMENTS

Laceys.tv™

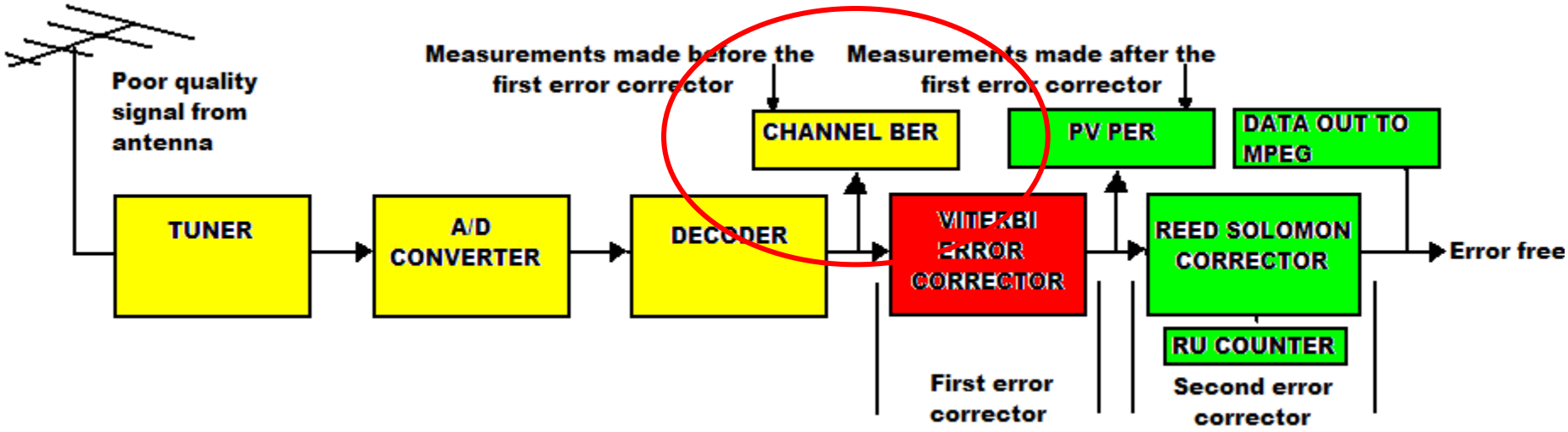
- When testing system integrity we use 5 different Digital measurements.

- **LOCKED INDICATOR**
- **CHANNEL BER (PRE FEC)**

UNAOHM

CHANNEL BER

Laceys.tv™

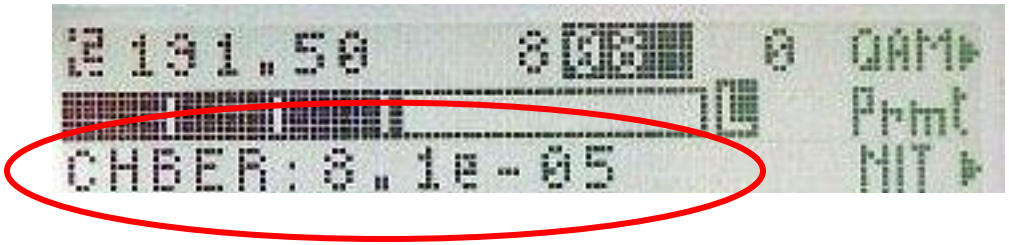


UNAOHM

CHANNEL BER

Laceys.tv™

- Channel BER could be considered the “King of Digital Measurements”
- This measurement indicates any errors present before any correction has taken place.



CH BER 8.1- E05=

8.1 errors present every 100,000 bits of data before error correction.

UNAOHM

DIGITAL MEASUREMENTS

Laceys.tv™

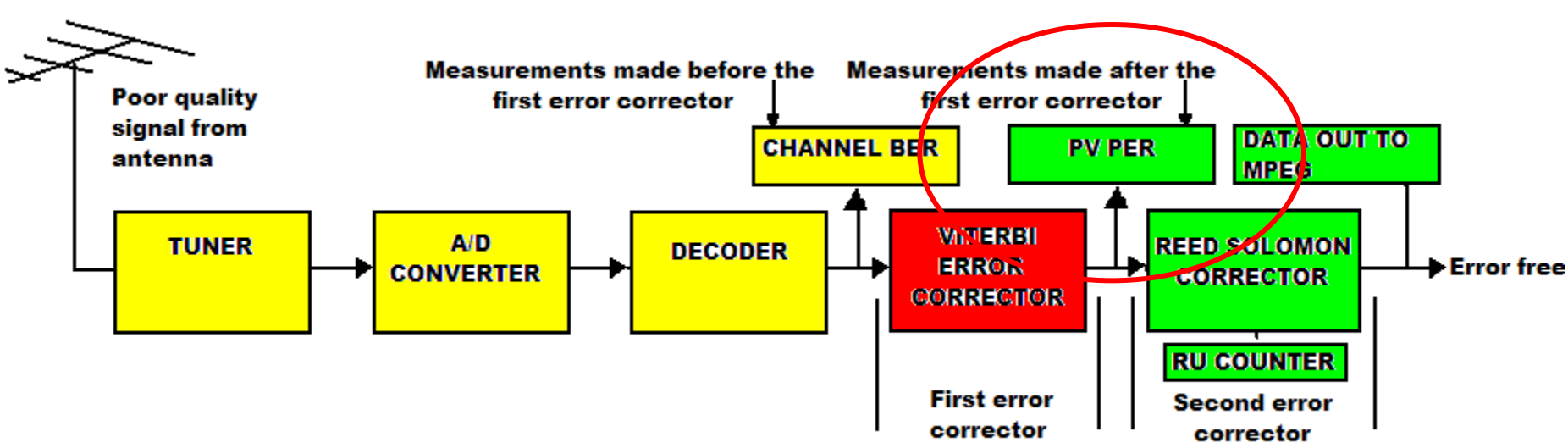
- When testing system integrity we use 5 different Digital measurements.

- **LOCKED INDICATOR**
- **CHANNEL BER (PRE FEC)**
- **POST VITERBI (POST FEC)**

UNAOHM

PV-BER (POST VITERBI) MEASUREMENT

Laceys.tv™

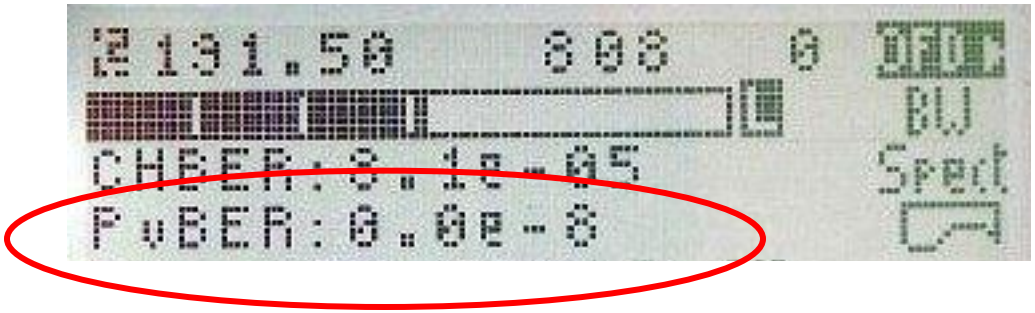


UNAOHM

PV- BER or POST VITERBI

Laceys.tv™

- PV-BER (Post Viterbi) is the first measurement after the Viterbi error corrector.
- The Viterbi corrector is working very hard processing the data to finally achieve an error free result!



PV-BER 0.0E-08 =

0.0 errors present every 100,000,000 bits of data after the first Viterbi corrector.

UNAOHM

DIGITAL MEASUREMENTS

Laceys.tv™

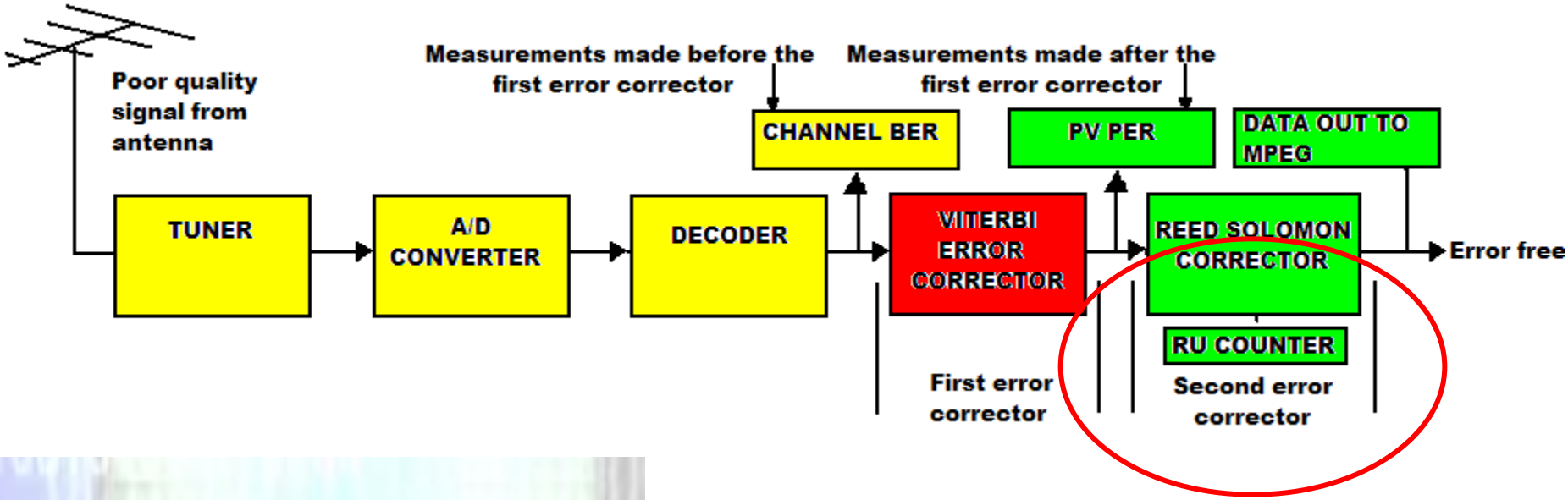
- When testing system integrity we use 5 different Digital measurements.

- **LOCKED INDICATOR**
- **CHANNEL BER (PRE FEC)**
- **POST VITERBI (POST FEC)**
- **REED SOLOMON UNCORRECTED**

UNAOHM

REED SOLOMAN (RU)

Laceys.tv™



UNAOHM

REED SOLOMON (RU)

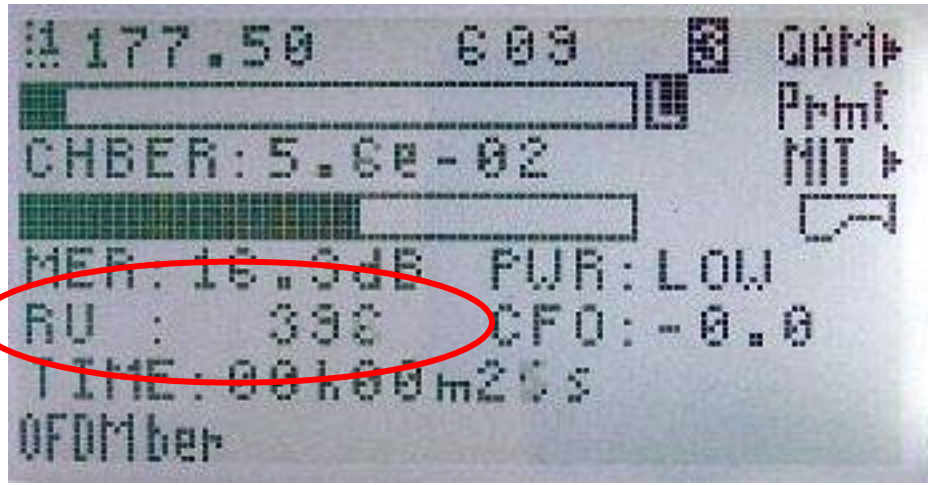
Laceys.tv™

- Once the data has passed through the Viterbi corrector, it then enters the second error corrector called;

  Reed Solomon.

- Any remaining errors still present after the Viterbi corrector will be repaired by the Reed Solomon corrector.

- If any errors are still present past the Reed Solomon corrector, you will see a count of *uncorrected* packets of information. This means you are at system failure!



Picture at “Cliff Edge”

UNAOHM

DIGITAL THRESHOLD "QEF"

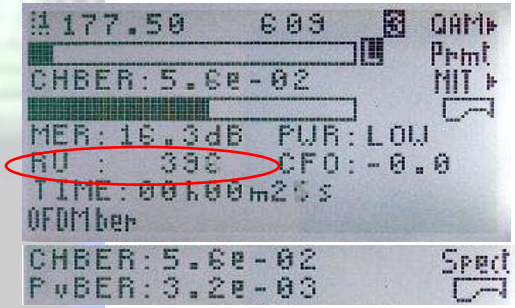
Laceys.tv™

QUASI ERROR FREE or "QEF"

- QEF is a measurement of system function above the failure point.
- Typical failure point for DVBT would be a measurement of; (Depending on FEC)

CH BER E- 02	PV-BER E- 04	MER 16dB

- We would know this because once the RU corrector indicates uncorrectable packets of information you are below QEF
- Knowing the QEF point, you can easily determine system headroom.

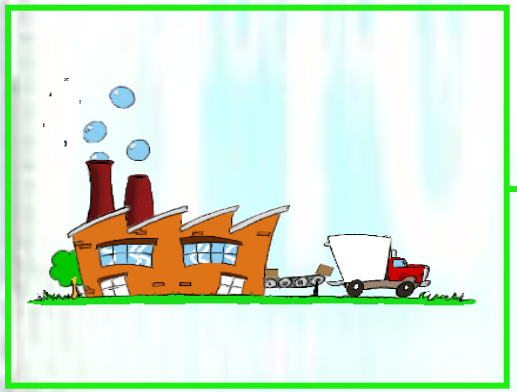


UNAOHM

DIGITAL THRESHOLD “QEF”

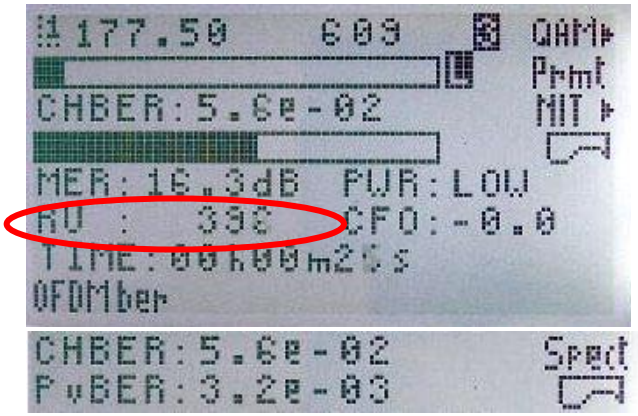
Laceys.tv™

Errors present after second corrector," Reed Solomon”



Error’s present

Reed Solomon Corrector



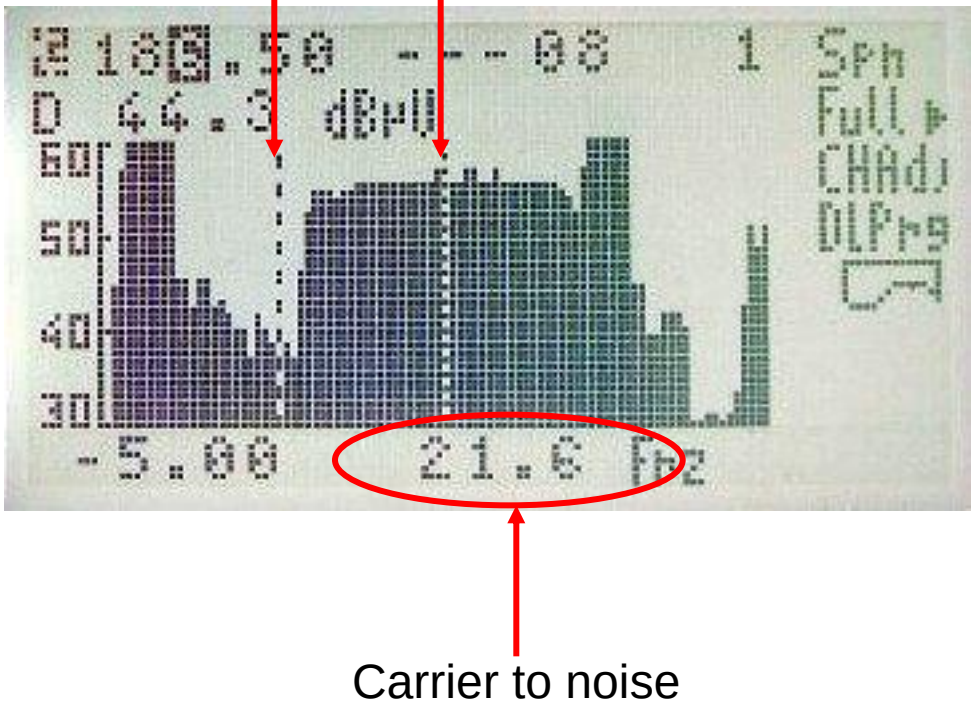
UNAOHM

Carrier to Noise

Laceys.tv™

- Carrier to noise ratio is simply an external measurement of channel power, noise and actual carrier expressed in dB.

- This type of measurement can also be measured on a digital channel, unfortunately it's not the answer.

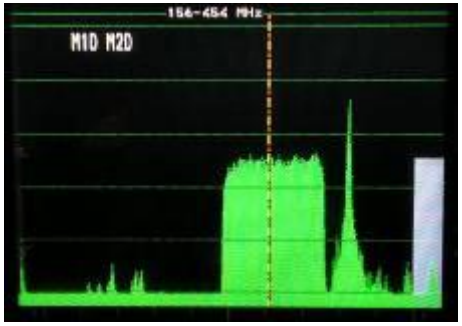


UNAOHM

Carrier to Noise

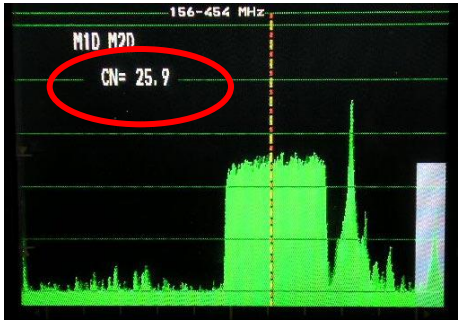
Laceys.tv™

- Carrier



- Noise

- Carrier to noise (C/N)



UNAOHM

DIGITAL MEASUREMENTS

Laceys.tv™

- When testing system integrity we use 5 different Digital measurements.

- **LOCKED INDICATOR**
- **CHANNEL BER (PRE FEC)**
- **POST VITERBI (POST FEC)**
- **REED SOLOMON UNCORRECTED**
- **MER**

UNAOHM

MODULATION ERROR RATIO or (MER)

Laceys.tv™

- **Even though C/N measurements are mathematically associated to Bit Error Ratio, it does not give us the complete picture.**
- MER is a measurement of the modulation
- MER can be considered a figure of merit for the OFDM signal that includes all types of impairments, internal & external, not just noise as in Carrier to noise measurements.
- Measuring MER in Digital signals is a critical part of determining how much margin the system has before failure.
- MER has also been referred to as a Digital version of C/N
- MER measurement is expressed in dB

UNAOHM

PRACTICAL DEMONSTRATION

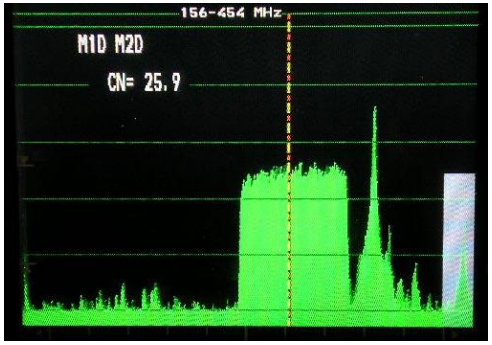
This exercise is to help understand the reasons why analogue measurements alone will not help you, and why Digital measurements are a must.

A simple test like this can be made by anyone, using a noise generator, a single channel filter and a quality Digital test instrument.

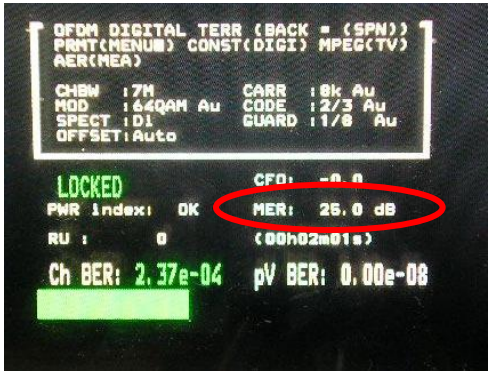
PRACTICAL EXERCISE

Laceys.tv™

Firstly lets measure the Carrier to Noise C/N = 25.9dB.



Looking at the Digital BER measurements all looks OK. Note the MER measurement of 25dB MER.



The MER and C/N measure alike.

C/N = 25.9dB
MER = 25.0dB

The Digital picture is perfect.

UNAOHM

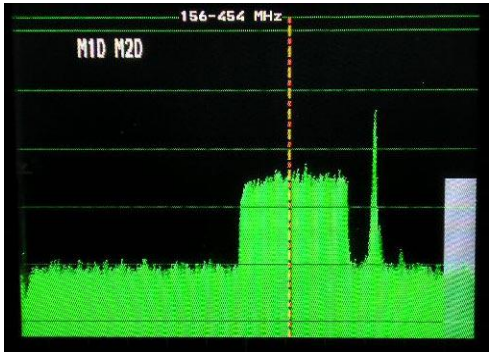
ADDING NOISE

Laceys.tv™

Adding a noise generator introduces broad band noise. This noise generator has attenuation in 2dB steps.

Spectral view of broad band noise

By simply adding the Digital carrier to the generated broadband noise, we have reduced the C/N & MER margin.

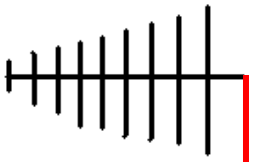


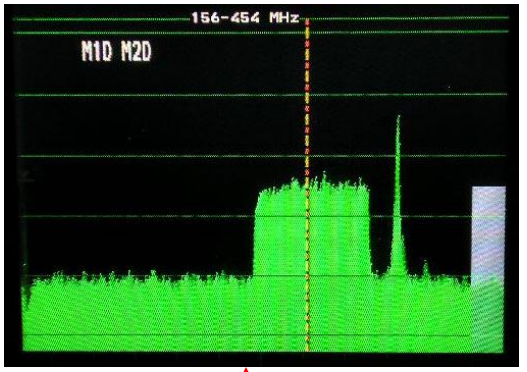
UNAOHM

NOISE AND ANTENNA SIGNAL COMBINED

Laceys.tv™

ANTENNA SIGNAL





NOISE GENERATOR

COMBINER

UNAOHM

NOISE FILTERED USING SINGLE CHANNEL FILTER

Laceys.tv™

By adding a single channel filter, we have created “in band noise”

Using in band noise, simulates the typical types of internal distortions that happens in the field.

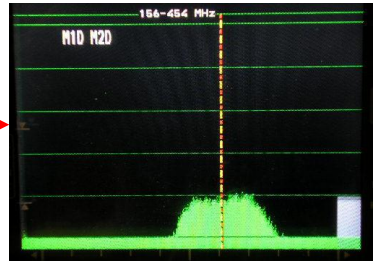
Noise

NOISE GENERATOR

SINGLE CHANNEL FILTER

COMBINER

In band noise

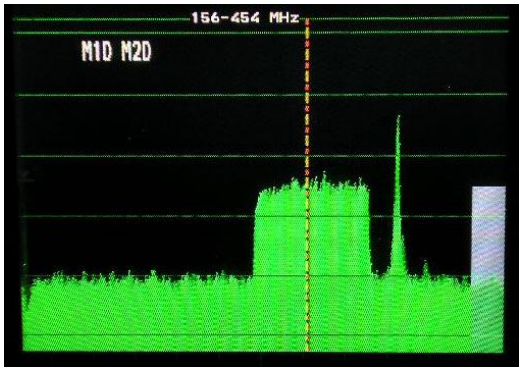


UNAOHM

NOISE HIDDEN INTERNALLY

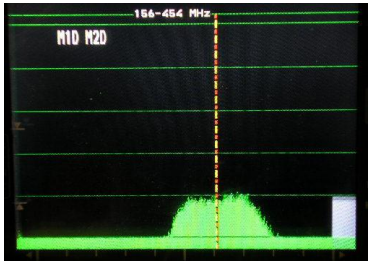
Laceys.tv™

ANTENNA SIGNAL



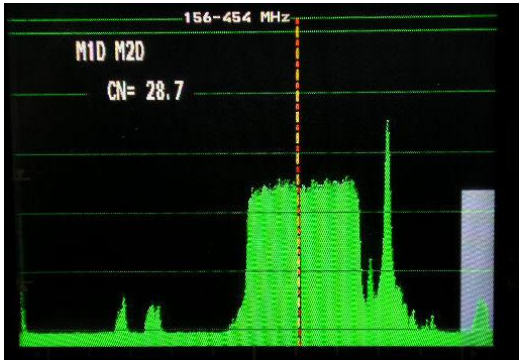
NOISE GENERATOR

In band noise +



SINGLE CHANNEL FILTER

COMBINER



In band noise hidden under the digital channel

UNAOHM

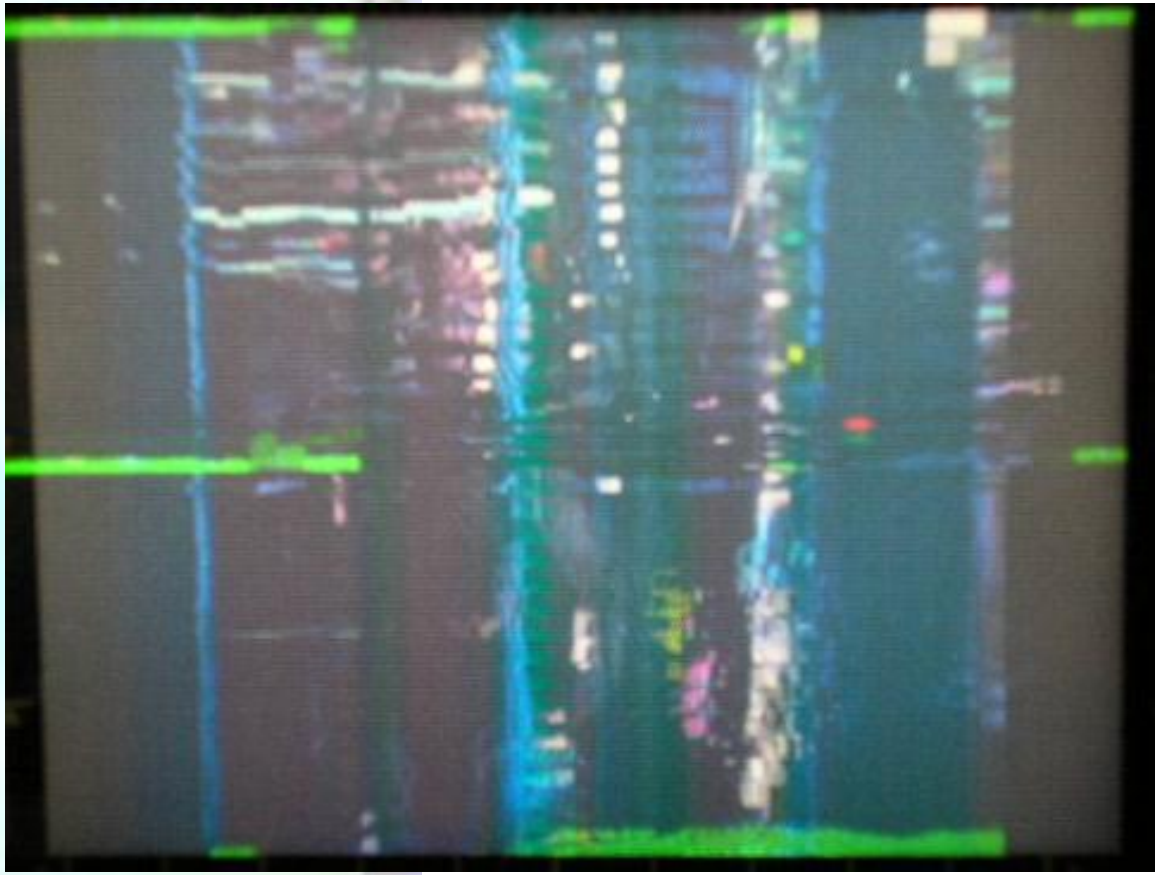
Laceys.tv™

SO WHAT HAPPENS NEXT?

UNAOHM

CLIFF EDGE

Laceys.tv™

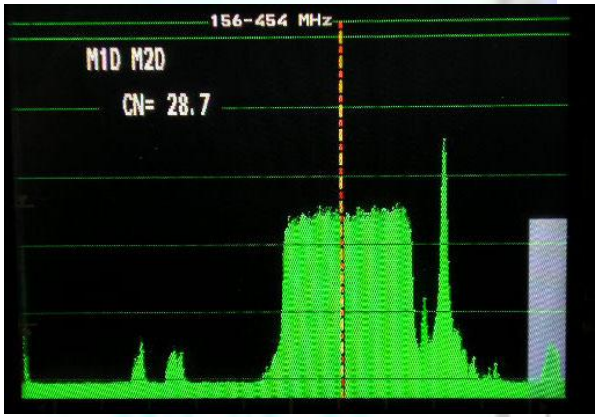


FAILURE!

UNAOHM

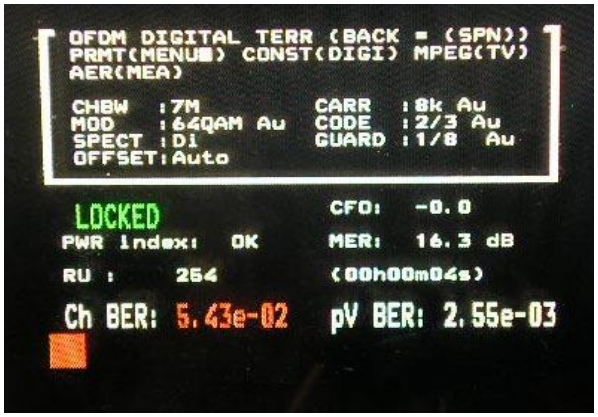
ANALOGUE MEASUREMENTS VERSES DIGITAL MEASUREMENTS

Laceys.tv™



C/N = 28.7dB

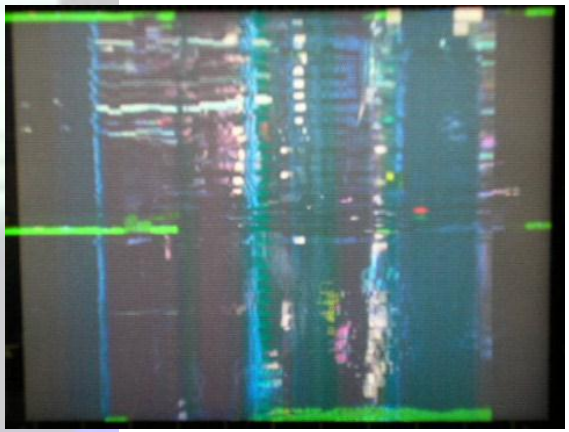
+



MER 16.3dB

NOTE THE DIFFERENCE BETWEEN C/N & MER

=

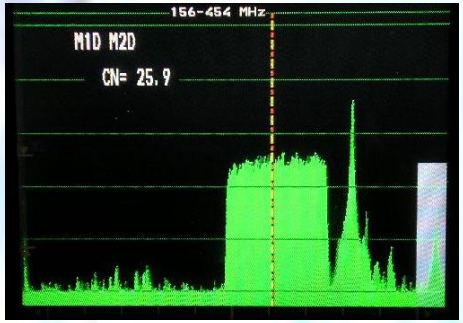


QEF
CH BER E-02
PV BER E-04
MER 16dB

UNAOHM

SUMMARY

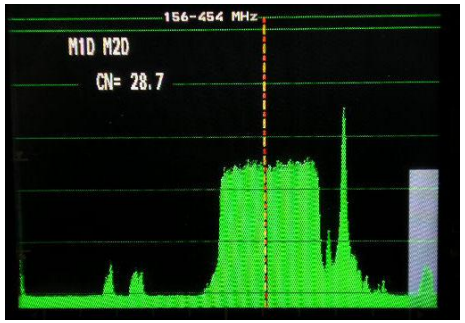
Laceys.tv™

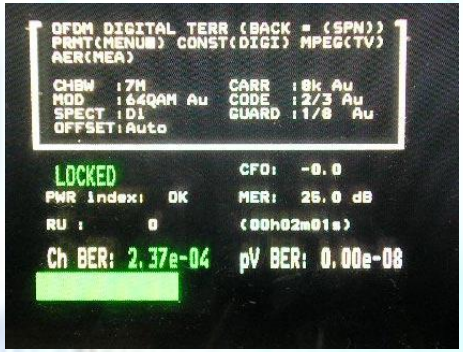


WORKING

ANALOGUE MEASUREMENTS LOOK RELATIVELY THE SAME

NOT

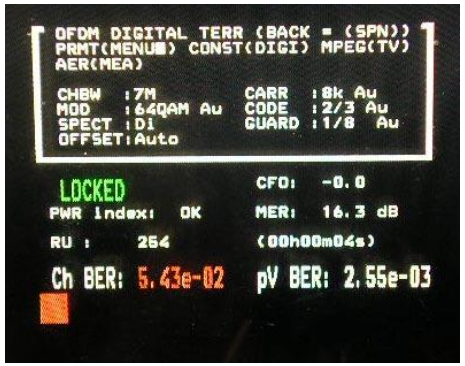


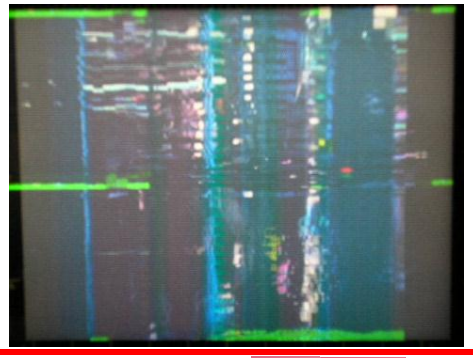


WORKING

DIGITAL MEASUREMENTS TELL THE COMPLETE STORY

WORKING



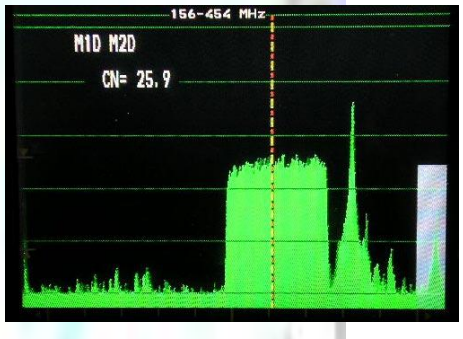


QEF POINT

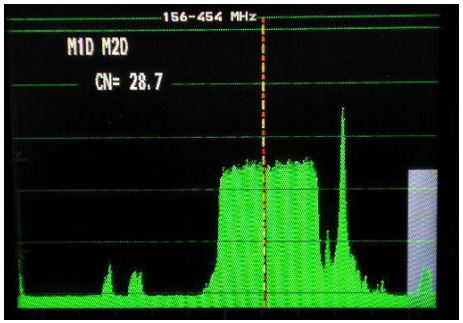
CH BER E- 02 **PV-BER E- 04** **MER 16dB**

UNAOHM

CONCLUSION



WORKING



NOT WORKING

THIS IS WHY YOU CANNOT RELY ON ANALOGUE MEASUREMENTS ALONE WHEN MEASURING A DIGITAL SIGNAL.

CARRIER TO NOISE MEASUREMENTS ARE NOT ENOUGH.

BER & MER MEASUREMENTS ARE A MUST!

Laceys.tv™

Adaptive Equalizer Response or “AER”

The measurement of digital reflections

Also known as “digital echo’s”

- Digital carriers can be very sensitive to reflections caused by a variety of problems such as:

Buildings
Hills
Tree foliage
Bad terminations
Poor splitters
Kinks in the cable
Single frequency networks or “SFN”

These are all contributing factors that can cause **“ECHO’S”**

To compensate for these reflections all set top receivers have an adaptive equalizer built in that detects the number of reflections and compensates for them.

It’s quite important to measure how hard the adaptive equalizer is working compensating for reflections.

If the adaptive equalizer is working too hard, any further degradation in the signal may be too much for the adaptive equalizer to handle and a catastrophic loss of data may result….. (cliff edge).

Satellite Eurosat magazine 2004.

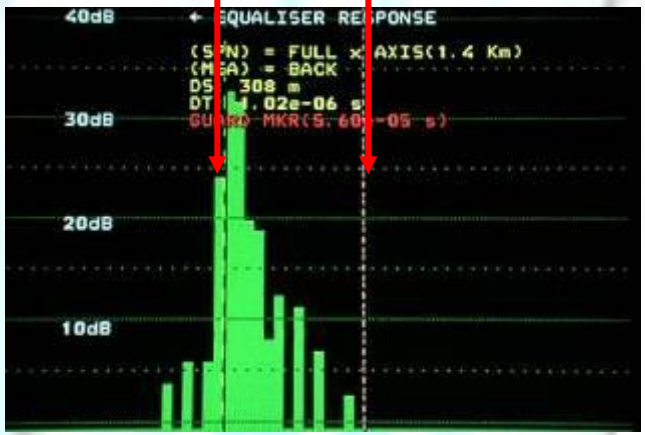
AER

Laceys.tv™

Primary signal in time

Reflections

1



Reflection at 3630 meters

2

Primary signal, reflection and guard interval displayed

3

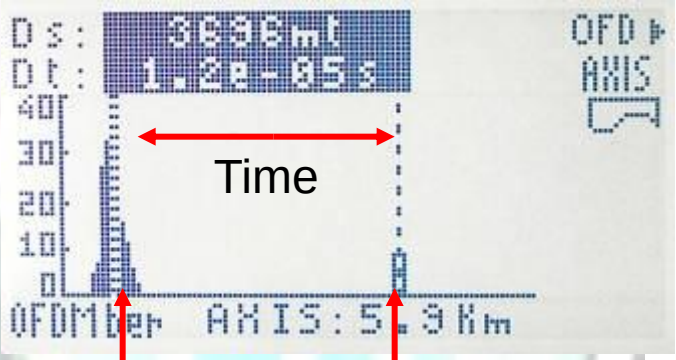
Channel's guard interval end of FEC range

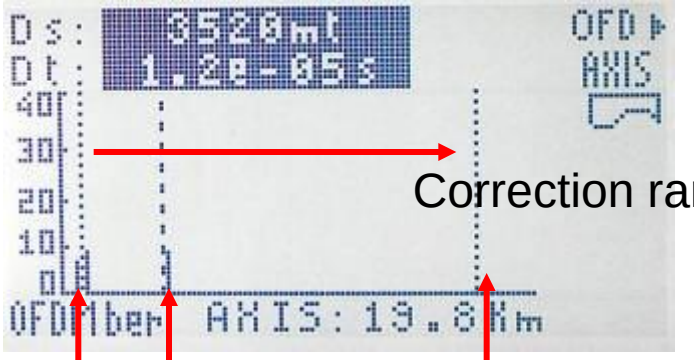
EP3000EVO

UNAOHM

T40a

Echo delay = 000001.2 sec.





The further the reflection in time, the harder the adaptive equalizer is working

If the reflection arrives outside of the guard interval, the incoming data will be corrupt.

Laceys.tv™

Single Frequency Networks “SFN”

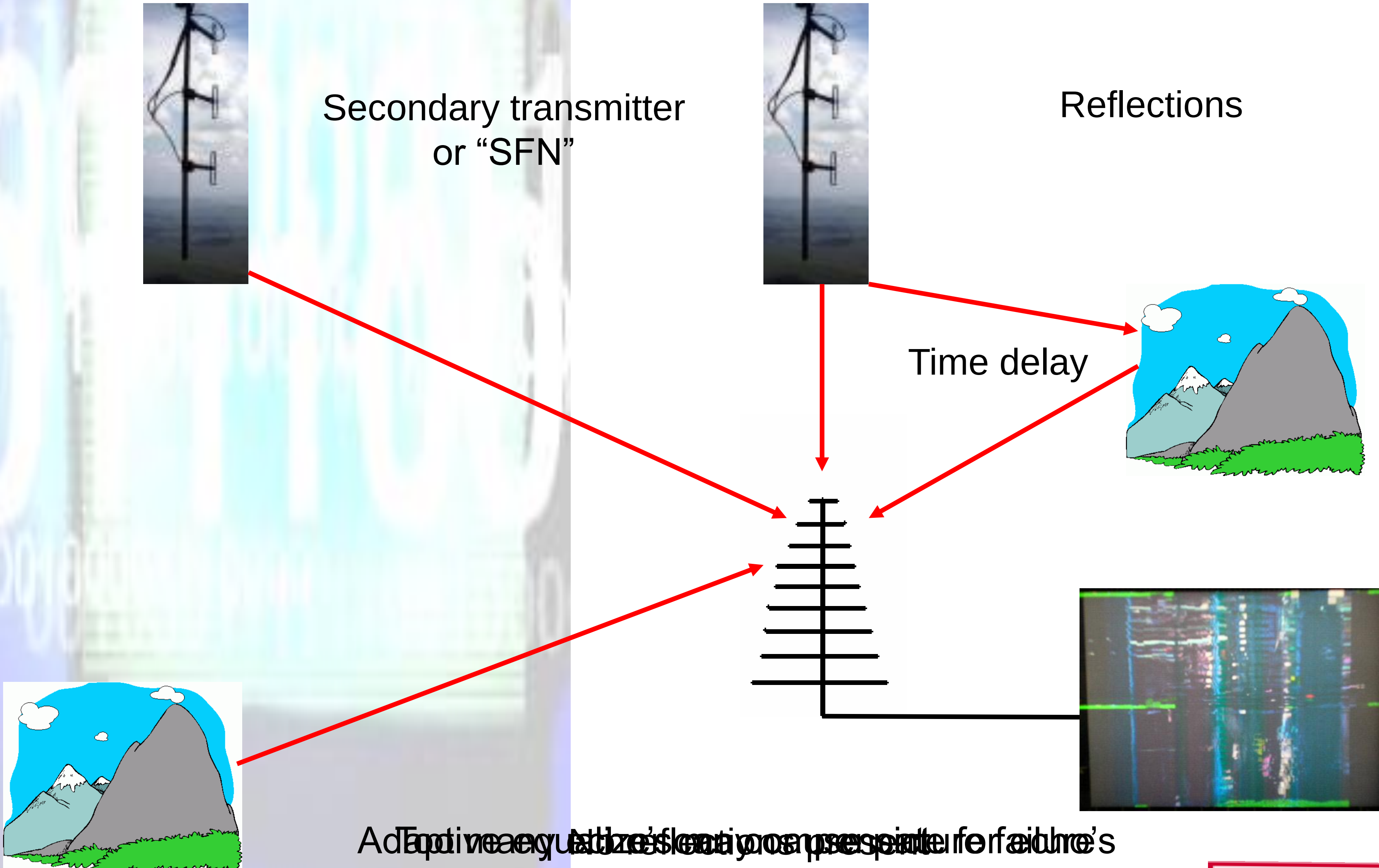
With the introduction of the secondary transmitter sites, also introduces the single frequency networks.

A single frequency network is a group of transmitters transmitting on the same frequencies. On analogue transmitters this would be displayed as “co channel” interference.

With digital transmitters it can become “echo's”

Echo's

Laceys.tv™



Adaptive equalizer's compensate for echo's

Too many reflections cause picture failure

UNAOHM

How do I reduce any present “echo’s”?

- Reduce the reflected or secondary signal
- Mechanical attenuation: trees, roofline
- Antennas with a better front to back ratio
- Antennas with narrower beam width performance

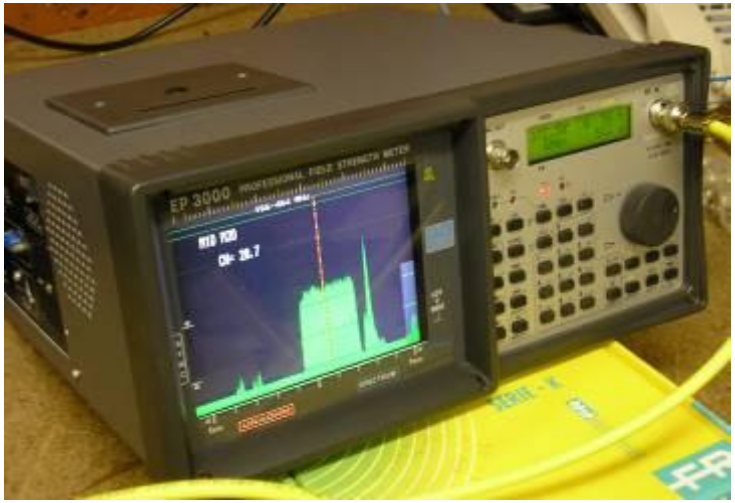
Test Instruments

Laceys.tv™

UNAOHM have a range of professional test equipment available.

For this presentation we used the entry level T40a & semi broadcast level EP3000.

T40a



EP3000

UNAOHM

THANK YOU

Laceys.tv™

Bit Error Ratio & Modulation Error Ratio

What does it mean?

How will it help me?

Presented by

Mark Bryant

for

Laceys.tv™

UNAOHM