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# SECOND ICTP - URSI - ITU/BDT SCHOOL ON THE USE OF RADIO FOR DIGITAL COMMUNICATIONS IN DEVELOPING COUNTRIES, INCLUDING SPECTRUM MANAGEMENT

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## INTRODUCTION TO RADIO MEASUREMENT TECHNIQUES

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# *Introduction to Radio Measurement Techniques*

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## *We will speak about:*

*During set up and maintenance of a Radio Link / Network a set of instruments is commonly used (and required). Now we are going to familiarize with some of them and we'll understand the information they give us.*

- **Units / Terms**
- **Most Common Instruments**
  - *Power Meter*
  - *Frequency Counter*
  - *Spectrum Analyzer*
- **Exercise Description**

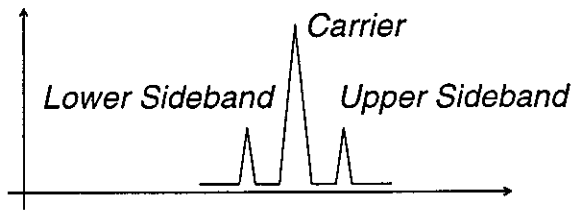
# Units

- How do we measure power:
  - [dBm]=10 Log [mW]

| dbm | watt |
|---|---|
| 0 | 0.001 |
| 10 | 0.01 |
| 20 | 0.1 |
| 30 | 1 |
| 40 | 10 |

# Terms

- Bandwidth
  - Whenever a carrier is modulated sidebands are produced. The modulation process create two sidebands. The width of each sideband is equal to the highest frequency component in the baseband. The occupied bandwidth is that between lower and upper limits of the signal where the mean power id 0.5% (-23dB) of the total power. It can be measured using a spectrum analyzer, or calculated.

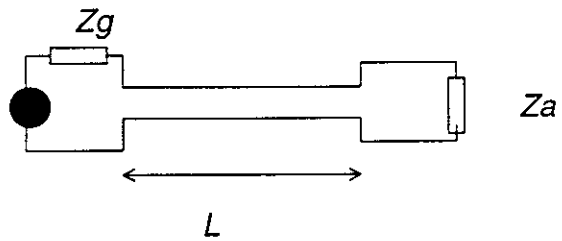


# Terms - Deviation

- *FM - Frequency Modulation / Deviation*
  - *When an applied modulating signal increase (decrease) the carrier frequency of the TX.*
  - *The change of the of the carrier frequency (FREQUENCY DEVIATION) is proportional to the instantaneous amplitude of the modulating signal.*
  - *If the receiver respond ONLY to frequency change,and is insensitive to amplitude variation it will discriminate against most forms of noise, particularly impulse noise (ignitions systems)*

# Terms - Transmission Lines VSWR

- *In practical applications of transmission lines one calculation should be kept in mind: the manner in which the source (RTX) and the load (ANTENNA) are connected.*




- *The ratio of the voltage in the reflected wave to that of the voltage in the incident wave is defined as the VOLTAGE REFLECTION COEFFICENT ρ*

## Terms - Transmission Lines VSWR

$$\rho = \sqrt{\frac{(R_a - R_0)^2 + X_a^{\,2}}{(R_0 + R_a)^2 + X_a^{\,2}}}$$

- *If $R_a$ is equal to $R_0$ and the output reactance $X_a$=0 (pure resistive load) the reflection coefficient is 0 … matched condition*
- *If $R_a$ is 0, regardless of the value of $X_a$ the reflection coefficient is 1. This means all the power is reflected by the load, in the same manner as a mirror reflect light.*

## Terms - Transmission Lines VSWR

- *If there are no reflections from the load, the voltage distribution along the line in constant.*
- *If reflections exists a standing wave pattern will result.*

$$VSWR = \frac{1+\rho}{1-\rho}$$

- *An alternative way to represent ρ is:*

$$\rho = \sqrt{\frac{P_r}{P_f}}$$

*Pr= The power of the reflected wave*
*Pf= The power of the forward wave*

# Measurements - Power

- To measure power a POWER METER is commonly used it could be of two type:
  - THRULINE POWER METER
  - END LINE POWER METER

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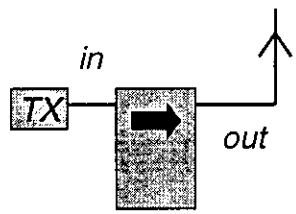
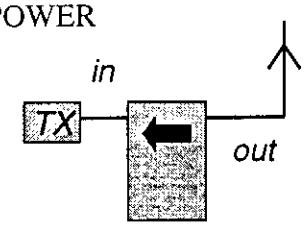
# Thruline Power Meter

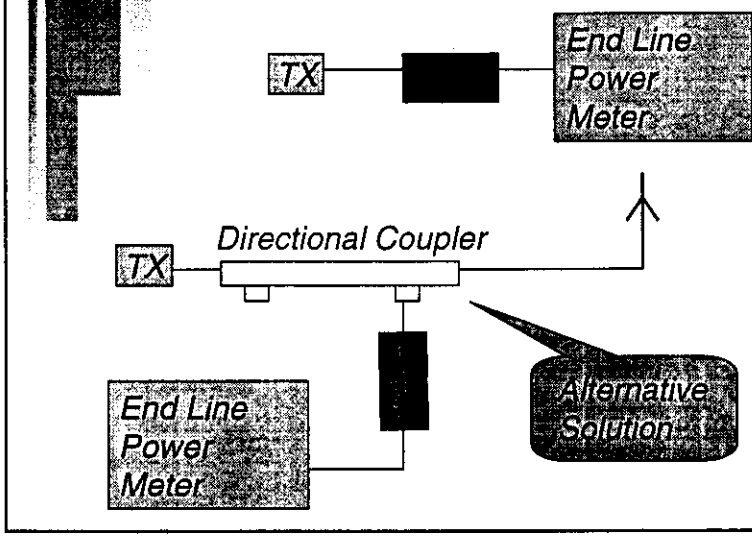



Direct (TRANSMITTED ) POWER



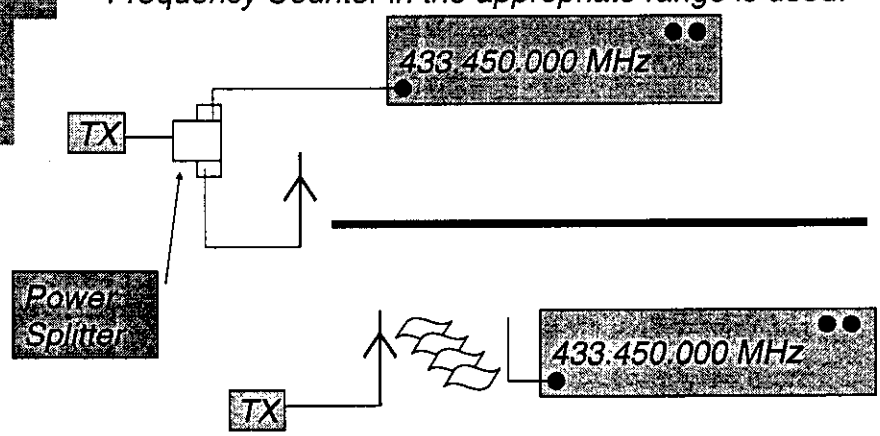

Reverse (REFLECTED ) POWER

# End Line Power Meter




# TX Frequency

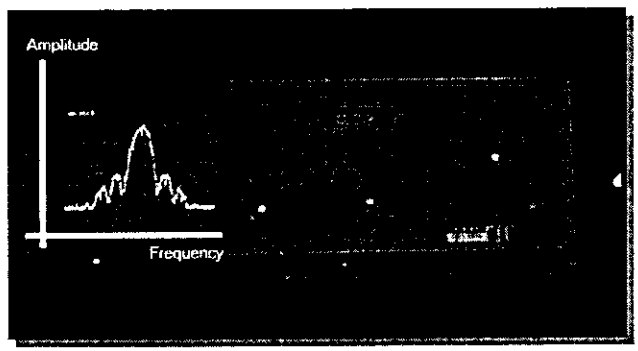
- To measure the working frequency of a RTX a Frequency Counter in the appropriate range is used.



# Spectrum Analyzer

- *The Spectrum analyzer is one of the most useful instrument in the field of radiocommunication. Unfortunately it is very expensive that not always it is affordable to have one. It can be seen as an equivalent to the OSCILLOSCOPE, but instead of working in the TIME DOMAIN it works in the FREQUENCY DOMAIN. From this view point it is also a wide band receiver, or a black box that does the FOURIER TRANSFORM of the input signal.*

# Spectrum Analyzer

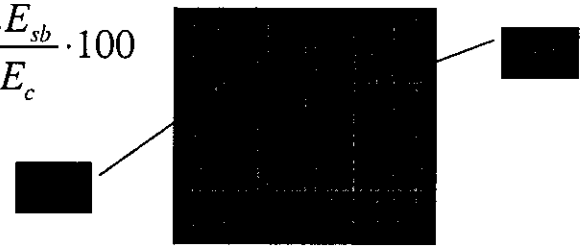



*The Spectrum Analyzer displays the amplitude and the frequency of each component of an input signal.*

## Spectrum Analyzer

- Measurement of Modulation Frequency AM Signal, Modulation Index AM Signal

$$m(\%) = \frac{2E_{sb}}{E_c} \cdot 100$$

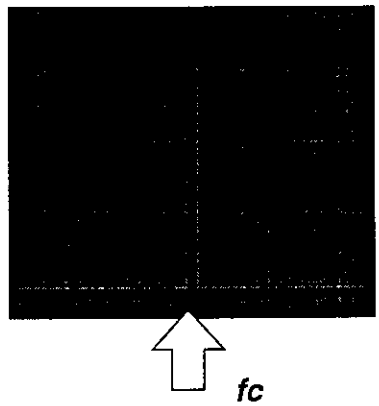


## Spectrum Analyzer

- Generally, when observing FM waves, frequency of the carrier wave fc, the frequency of the modulated wave fm, the deviation of the frequency $\Delta f_{peak}$, modulation index m, occupied bandwidth, etc are measured.

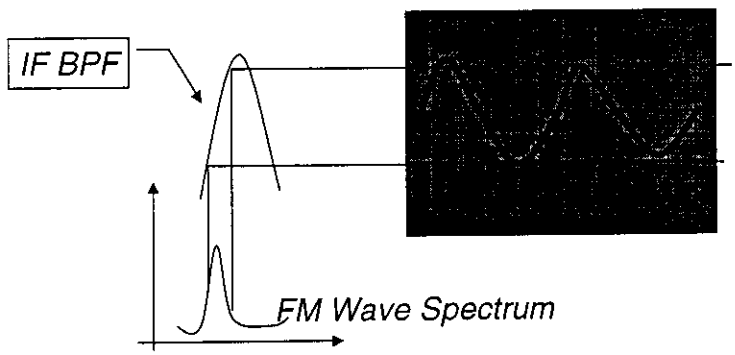
# Spectrum Analyzer

- Carrier wave



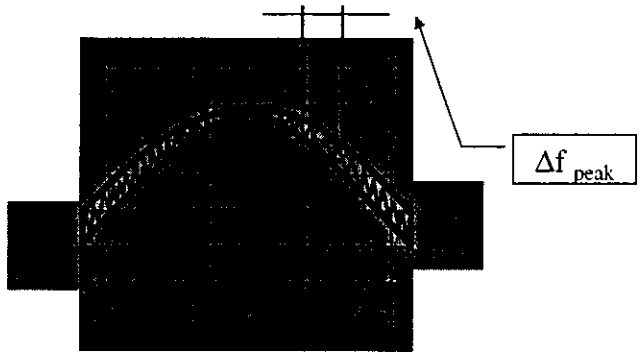

# Spectrum Analyzer

- When the modulated frequency is low, setting the horizontal axis of the analyzer as ZERO SPAN, it operates as a fixed tuning receiver, and set in the time axis.



## Spectrum Analyzer

- Deviation of the frequency $\Delta f_{peak}$




## Spectrum Analyzer

- Modulation Index

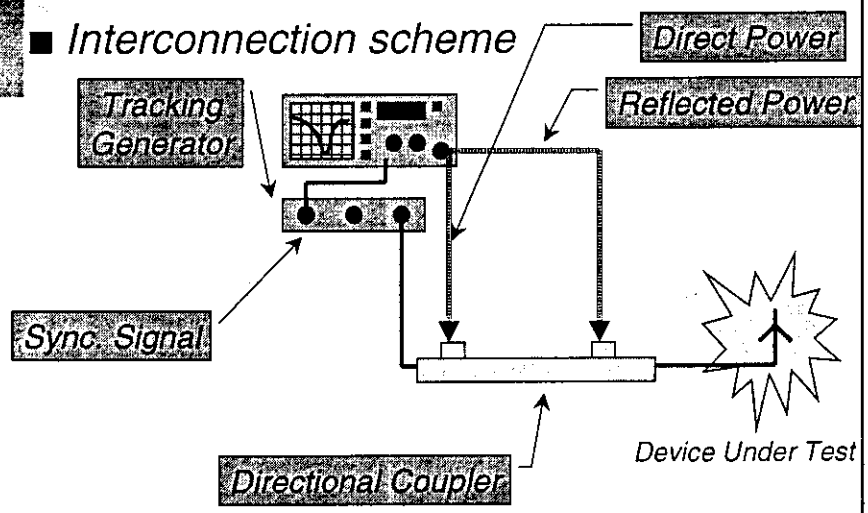
$$m = \frac{\Delta f_{peak}}{f_m}$$

## Spectrum Analyzer / Tracking Generator

- *This is one of the most interesting application of a Spectrum Analyzer. combined with a Tracking Generator, is possible to see the SWR of an Antenna system or the Band Pass shape of a filter, etc etc.*
- *The Tracking Generator is a variable frequency generator, synchronized by the Spectrum Analyzer.*

## Spectrum Analyzer / Tracking Generator

- *Interconnection scheme*



*Introduction to radio measurements technique*

The end. Relax