SYSTEMS AND SERVICES TELECOMMUNICATIONS

PRACTICE 1:

Units of measure

Leandro Juan Llacer
José María Molina Garcia-Pardo
José Victor Rodríguez Rodríguez
María García Vigueras
Domingo J. Pardo Quiles
Juan Pascual García

Polytechnic University of Cartagena
SCHOOL OF TELECOMMUNICATION ENGINEERING
DEPARTMENT OF INFORMATION TECHNOLOGY AND COMMUNICATIONS

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1. Introduction.

On the first topic of the Telecommunication Systems and Services course, the fundamental concepts in the calculation and use of measures in the field of telecommunications are presented. It is therefore the object of this practice to allow the students to become familiar with the concepts and ideas presented in this issue.

This document is divided into three sections: a theoretical part with a summary of the concerned theory of the subject as well as the study approach which will take place in it. A second in which the student must perform certain tasks in the laboratory. And a third with practical issues.

Exercises in the theoretical part of this document should be read, understood and performed before starting the practice section.

2. Theory.

In the field of telecommunications it is required to take measurements (mainly voltage and power). Such voltages and powers can take values within a wide range, we are in the need to define new units of measure commonly used in real applications. As an illustrative example we could have a circuit that could comprise a very wide range of voltages from a few micro-volts upto tens of Kilo-Volt of high-voltage.

This measure is defined in terms of Power as followed:

$$P = 10\log_{10}\frac{P}{P_{ref}}\ \text{dB} \qquad (1)$$

This measure is dimensionless and it is expressed in decibels (dB). We can see that if the power ranges from 10 μV to 10 V, the range would be 10^6. But in logarithmic units it is only 60. The dBm is defined for a P_{ref} = 1 mW.

In the case of voltage we use the following expression:

$$P = 20\log_{10}\frac{V}{V_{ref}}\ \text{dB} \qquad (2)$$

If we take V_{ref} = 0.775 v. we measure dBu. This value is defined as the voltage difference that occurs in a resistor of value 600Ω when the power dissipated is 1mW. Thus, the relationship between dBm and dBu is given by:

$$\mathrm{P(dBm)} = 10\log_{10}\frac{\mathrm{P}}{\mathrm{1mW}} = 10\log_{10}\frac{\mathrm{V}^2/\mathrm{R}}{(0.775)^2/600\Omega} = 20\log_{10}\frac{\mathrm{V}}{0.775} + 10\log_{10}\frac{600}{\mathrm{R}} \qquad (3)$$

This expression converts dBm to dBu taking into account the circuit resistance. It is observed that in the case R = 600Ω the numerical value in dBm is equal to dBu.

In the expression (3) a correction factor is defined:

$$\mathrm{F} = 10\log_{10}\left(\frac{600}{\mathrm{R}}\right) \qquad (4)$$

For this practice is also necessary to review the concepts of dBr, dBm0 dBm:

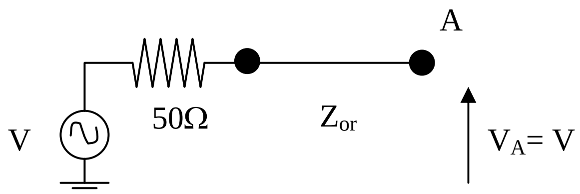
- dBm: Power measurement at one point. Can be obtained by measuring the voltage of a point and applying expression (3).
- dBm0: A measure of power in the reference point. It is constant for all points of the circuit. For example, if we define a reference point where the power is -5dBm, at all points of measurement in the circuit the level of the reference point will be -5dBm0

- dBr: it is the relative measure between a circuit point and the reference point. For example, if the reference measure is -5dBm=-5dBm0 and in another point in the circuit it is 4dBm, the difference will be 4dBm-(-5dBm0) = 9 dBr.

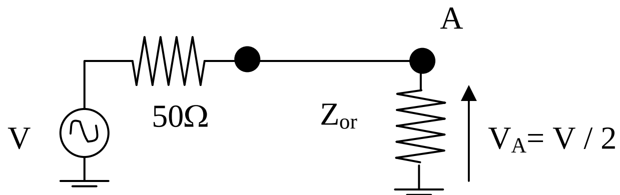
Any circuit point will comply with the following relationship:

$$L(dBm) = L(dBm0) + L(dBr) \qquad (5)$$

It is also necessary to revise impedance matching in transmission lines. When we have a circuit with no load, the voltage at the end of the circuit will be equal to the voltage of the generator and no current will circulate.



Now, if the circuit is loaded, the voltage being measured at the terminals of the impedance, when impedance matching is applied, will give half of the source value. Physically, this adaptation is because it behaves like a voltage divider spliting the energy between the internal resistance of the AC generator and the load resistance.

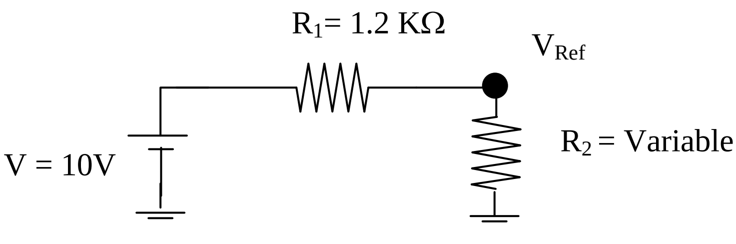


To summarize please remember that a hipsogram is a graph representing the x-axis in different points of the circuit and the ordinate axis shows power both in absolute level and in relative level.

Before performing the practice two theoretical studies are previously proposed.

Previous theoretical 2.1 Study: Part.

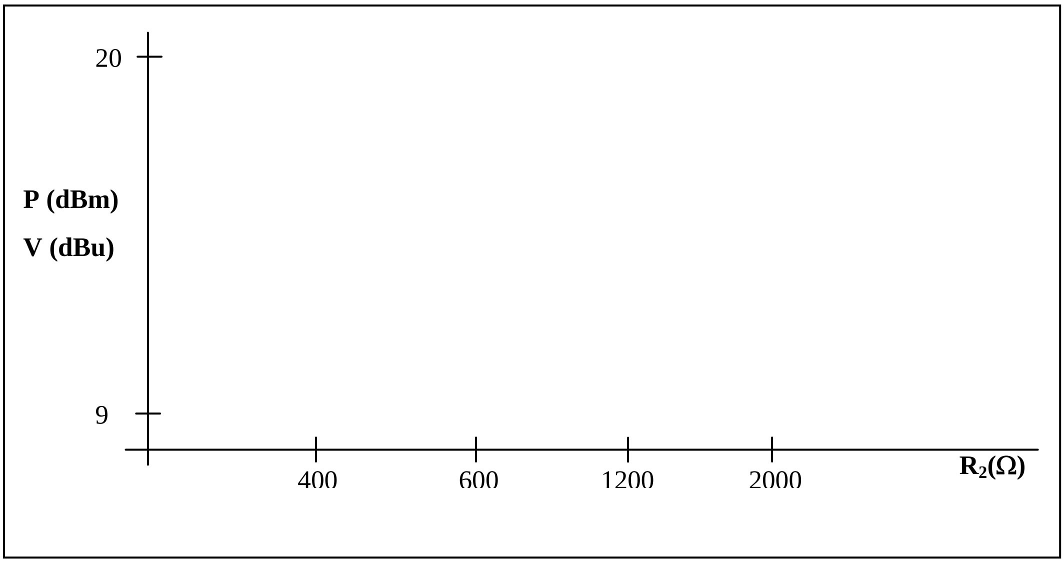
In this first part we will analyze a continuous current circuit and will made some basic calculations. The circuit is depicted in the following figure:



First we calculate the theoretical values of voltages and power of the circuit and complete the following table:

R_2	$R_2 = 400\Omega$	$R_2 = 600\Omega$	$R_2 = 1.2K\Omega$	$R_2 = 2K\Omega$
V_{ref} (V)				
P_{ref} (W)				
V_{ref} (dBu)				
P_{ref} (dBm)				
P_{ref} (dBm) - V_{ref}(dBu)				
Correction Factor. Theoretic				

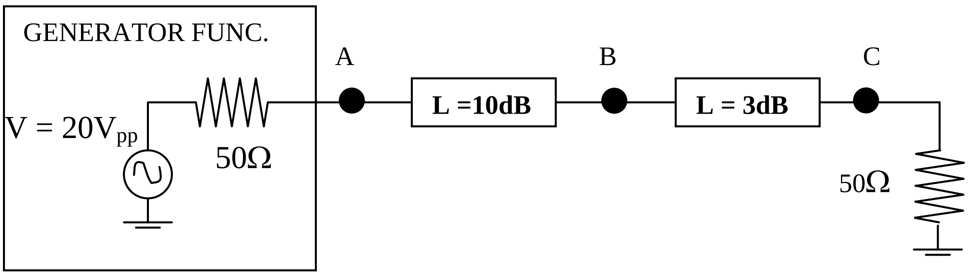
Once data in the table has been filled in, student will plot a graph representing the values of power both in dBm and dBu voltage as a function of the different resistance values R_2.



Previous theoretical study 2.2: Part Two.

In this second part, new concepts of relative levels, hipsograms and alternating signals are introduced.

Analyze the circuit shown in the figure below:



Note: The voltage at point A, in terms of impedance matching, will be half of the source.

The table to be filled in when the reference point is A is:

	A	***B***	***C***
V_{pp}			
V_{ef}			
V (dBu)			
P (dBm0)			
P (dBm)			
P (dBr)			

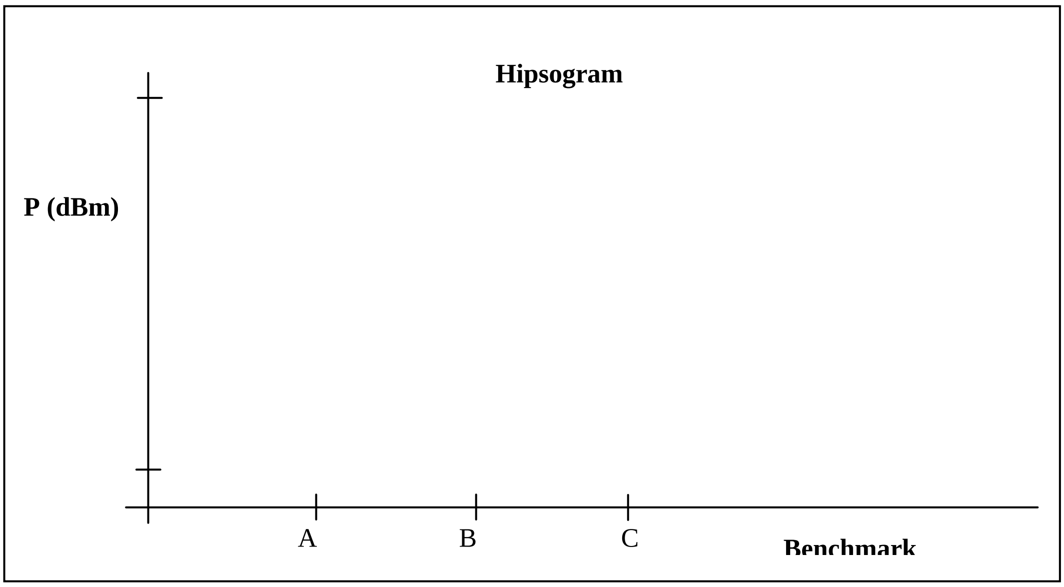
The complete table is as follows when the reference point is B:

	A	***B***	***C***
V_{pp}			
V_{ef}			
V (dBu)			
P (dBm0)			
P (dBm)			
P (dBr)			

The complete table is as follows when the reference point is C:

	A	***B***	***C***
V_{pp}			
V_{ef}			
V (dBu)			
P (dBm0)			
P (dBm)			
P (dBr)			

Then to draw a hipsogram with both dBm levels and three lines which determine the three levels dBr = 0 is required



3. Laboratory.

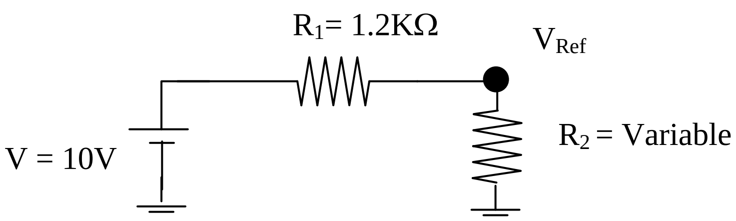
Having read and understood the theoretical part, practical exercises for students to complete understanding of the basics of measurement units will be performed.

3.1. Making practice: Part One.

In this first part measures will be practiced in a continuous current circuit. The following materials will be needed:

- Electrical test board.
- DC generator.
- Two banana-banana cable to connect the source to the board.
- Copper wires.
- 1.2 KΩ resistor.
- 2KΩ potentiometer.
- Multimeter.
- Calculator.

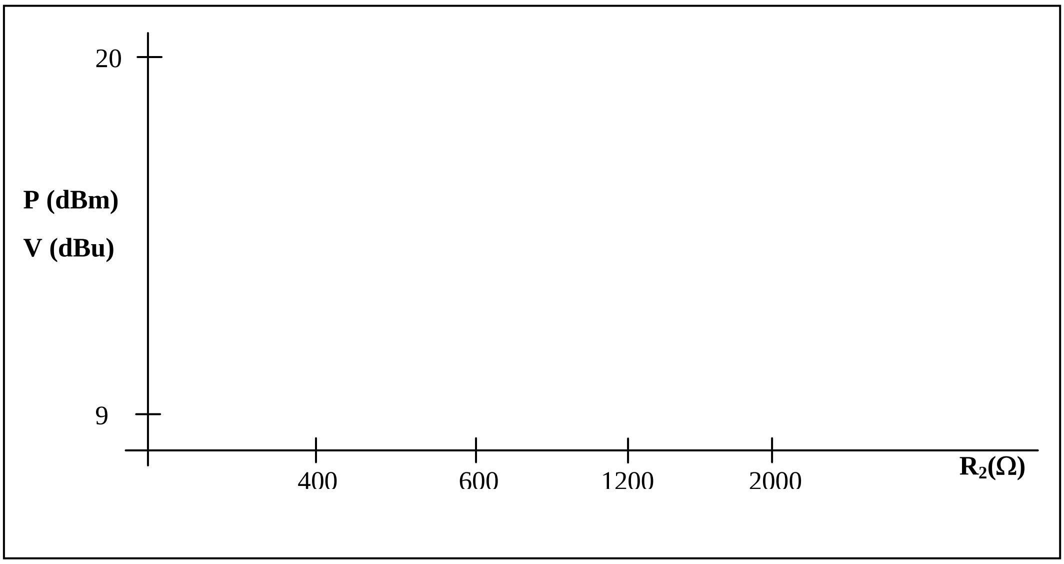
The circuit of Figure must be mounted:



This first part of the practice consists in taking measures of voltages with the voltmeter at the point of reference and completing the following table:

R_2	***R_2= 400Ω***	***R_2= 600Ω***	***R_2= 1.2KΩ***	***R_2= 2KΩ***
V_{ref}(V)				
P_{ref} (W)				
V_{ref}(dBu)				
P_{ref} (dBm)				
P_{ref} (dBm) - V_{ref}(dBu)				
Correction Factor. Theoretical				

Once data in the table is filled in, student will plot a graph representing the values of power both in dBm and dBV voltage as a function of resistance values R_2.



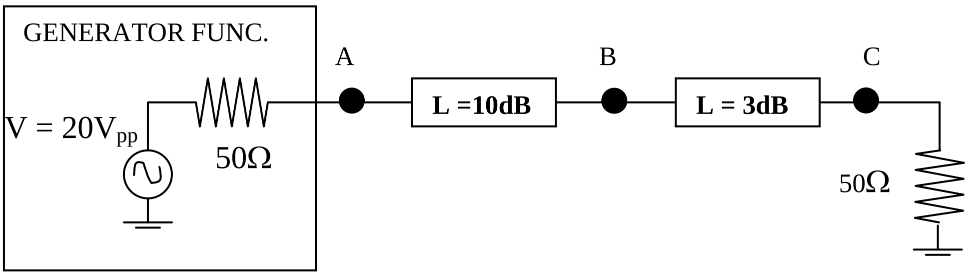
3.2. Making practice: Part Two.

In this second part we will revisit the concepts previously discussed in section 1.4 and we'll also include the ideas of relative levels, hipsograms and alternating signals.

For this section, you will need following components:

- Function generator.
- Two BNC cables to the generator and the oscilloscope.
- An oscilloscope.
- Terminal resistive load of 50Ω.
- Attenuator L=10dB and L=3dB.
- A T-join to access to different parts of the circuit with the oscilloscope.

Mount the circuit of Figure:



A 200 kHz signal with an amplitude of 20 V_{pp} is injected to the circuit. By means of a cable and a BNC BNC-T voltages at different parts of the circuit are measured. It should bear in mind that in order to use the expressions for the calculation of dBm and dBu is necessary to use effective voltages.

The complete table is as follows when the reference point is A:

	A	***B***	***C***
$\mathbf{V_{pp}}$			
$\mathbf{V_{ef}}$			
V (dBu)			
P (dBm0)			
P (dBm)			
P (dBr)			

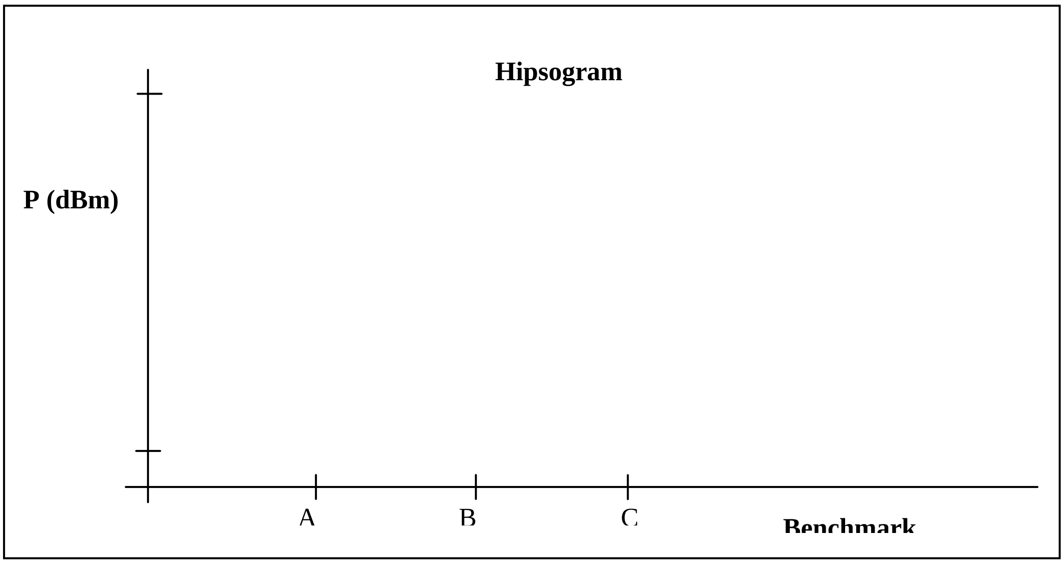
The complete table is as follows when the reference point is B:

	A	***B***	***C***
$\mathbf{V_{pp}}$			
$\mathbf{V_{ef}}$			
V (dBu)			
P (dBm0)			
P (dBm)			
P (dBr)			

The complete table is as follows when the reference point is C:

	A	***B***	***C***
$\mathbf{V_{pp}}$			
$\mathbf{V_{ef}}$			
V (dBu)			
P (dBm0)			
P (dBm)			
P (dBr)			

Then it is required to draw a hipsogram in dBm levels as well as lines which determine the three levels at dBr = 0.



4. Questions

This section will consist on several questions to verify whether the student has fully understood topics of this practice or not.

For paragraph 3.1:

1. At what point of the drawn plot the voltage figure expressed in dBu matches the expressed dBm power? Why?

2. What sign has the correction factor for resistors with a nominal value greater than 600Ω?
3. And with a resistor value of less than 600Ω?

For paragraph 3.2:

1. What would the voltage be at point A of the circuit in case of disconnecting the rest of components which are drawn to its right?

2. When do values in dBr coincide with the attenuation in dB of the attenuators?

3. Propose a method to calculate the attenuation of an attenuator of unknown value.

4. Provided a dBm0 level in the circuit, does this figure change when measuring in whichever other point of the circuit?