# S-26.3120 Radio Engineering, laboratory course

## Lab 2: GSM Base Station Receiver

### Pre-study report

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# 1 Measurement and setup descriptions

*Present all the required measurement setups (draw a figure) and procedures. Take into account the attenuation of the cables. In which range is the attenuation of coaxial cables at 900 MHz? Pick the most suitable measurement equipment if there are several options to choose from.*

The figure on page 8 in [1] suggests that for a standard PE coax cables the attenuation ranges between $0.32 \ldots 1.36$ dB/m at a frequency of 900 MHz. Even lower losses may be achieved with more expensive cables (down to roughly 0.2 dB/m, as suggested on page 29 in [1]). Similarly, some maltreated cables may have an attenuation in excess of 2 dB/m. In addition, one should not overlook the attenuation from connectors and connecting.

When it comes to this lab course and our measurements, an attenuation of roughly 0.5 dB/m would most likely be a realistic estimate.

## 1.1 1 dB compression point of the RX pre-amplifier block

*The compression point is a measure of maximum power at which the input amplifier works in linear mode and sets limit to the received signal power level. The frequency of 900 MHz is conveniently around the center of the RX band.*

The measurement setup suitable for this measurement is shown in Fig. 1. A signal generator is used as a signal source, and the generated signal is passed through the DDU module before detection with a (precalibrated) spectrum analyzer. The input and output connections used in the DDU module are ANT and $\mathrm{RX}_1$, respectively. An attenuator is used between the generator and the DDU module, if necessary. While the operator's manual of the R&S SML03 signal generator does not explicitly mention the power range, the testing range defined in the *Performance Tests* suggests a (reliable) minimum output power level of $-80$ dBm.

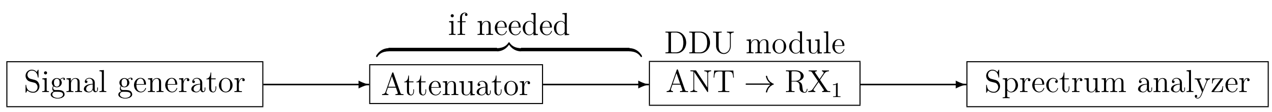


Figure 1: Measurement setup used in the first measurement task.

The measurement itself is basically a power sweep at a constant frequency of $f = 900$ MHz. We start off with a power level well above the receiver sensitivity level ($P_{\text{min, BS}} \approx -112.5$ dBm), say $-100$ dBm. From there we gradually increase the power in suitable steps of $1 \ldots 5$ dB, depending on the current position on the $P_{\text{out}}(P_{\text{in}})$ transfer curve. That is, we'll decrease the step size as we get close to the "sweet spot".

This power sweep is continued until we experience a compression of more than the required 1 dB. While one could just measure the input power required for the output to be 1 dB less than the expected value, this type of "on-the-fly" comparison is prone to error. Thus it's better to measure a full power sweep and leave the comparison to be done after the measurement and against a fitted straight representing ideal behaviour.

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Since we are dealing with a GSM receiver, we may use the same settings for the spectrum analyzer as we did in the first labs – except for the averaging factor. They were as follows: an averaging factor of 500, zero span and 30 Hz video and resolution bandwidths. An averaing factor of 500 would make the measurement quite lengthy, especially if dense power "grid" is used. Averaging over 100 measurements will most likely be more than adequate.

## 1.2 Gain of the RX pre-amplifier block

*The bandwidth of the RX block should account for the GSM specification for the RX band limits. Measure the 3 dB bandwidth of the block and determine approximately the equivalent noise bandwidth (graphically using the additional material) and the TX-band (stop band) attenuation.*

Wasn't this already covered in the first laboratory assignment as a part of the diplexer characterization? Fig. 2 presents the measurement setup used there. The DDU module is simply connected between the two ports of a precalibrated VNA; ANT and $RX_1$ connectors of the DDU module are connected to ports 1 and 2 of the VNA, respectively. In the VNA, measurement power shoud be as high as possible due the stop band-attenuation, yet simultaneously small enough not to cause compression in the pass-band (in neither the VNA nor in the pre-amp itself).

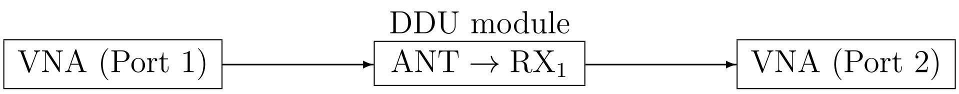


Figure 2: Measurement setup used when determining the gain of the pre-amplifier block.

The following figure (Fig. 3) shows the results obtained in the first measurements. The noise bandwidth is found using the formula given in the lecture supplement handout:

$$B_{\mathrm{n}} = \frac{1}{G_{\mathrm{T,\,max}}} \int_0^{\infty} G_{\mathrm{T}}(f)\, df, \tag{1}$$

or more specifically, it's numerical approximation in the frequency range of $850 \ldots 1000$ MHz.

## 1.3 Noise temperature of the RX pre-amplifier block

*Determine the noise temperature of the RX block (consisting of bias tee, diplexer and pre-amplifier) with the Y-coefficient method. Use the noise diode as active noise source (and as passive noise source at room temperature when supply voltage is switched off).*

Text here.

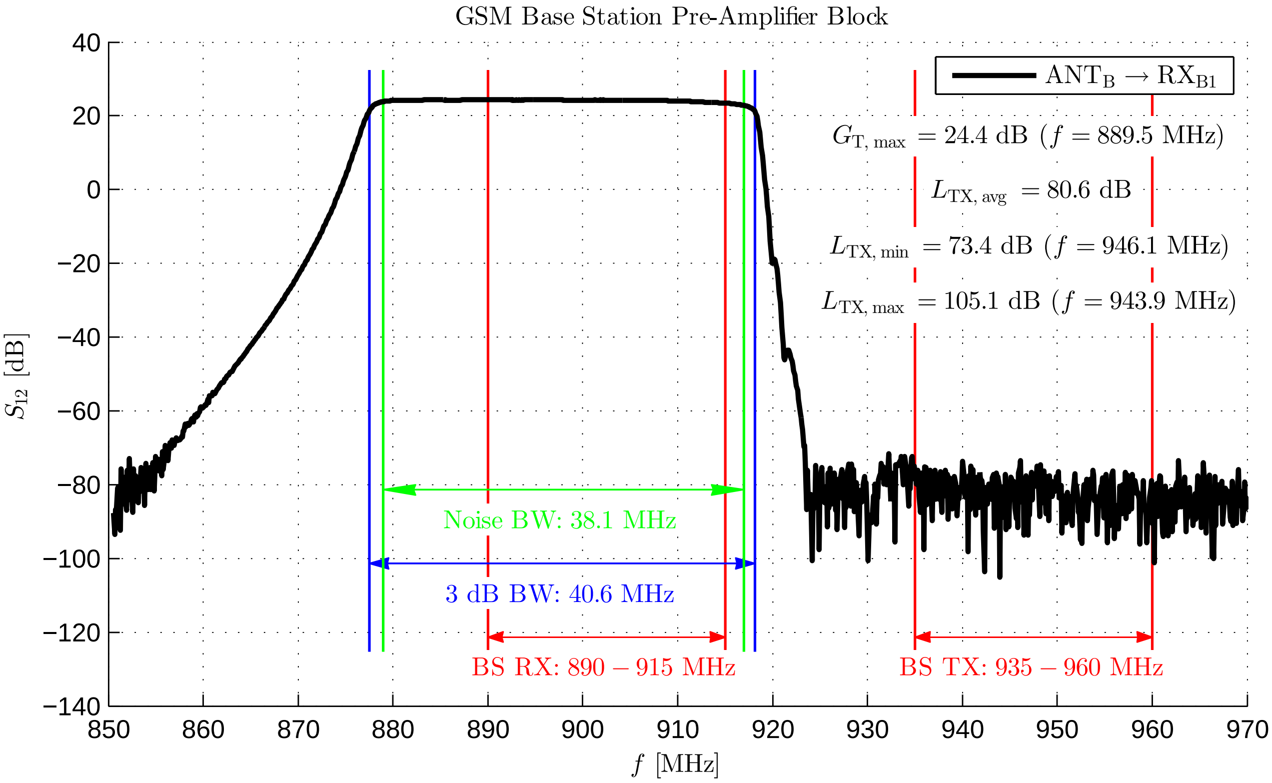


Figure 3: Results from the diplexer characterization.

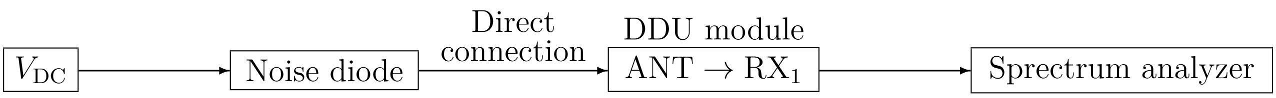


Figure 4: Noise temperature measurement setup

## 1.4 Sensitivity of the RX pre-amplifier block

*Measure the sensitivity of the RX block using suitable equipment.*

Text here.

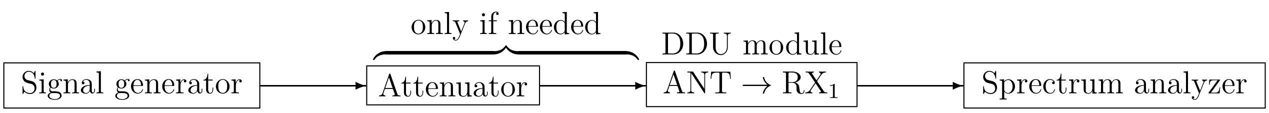


Figure 5: Measurement setup used in the sensitivity measurement.

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# 2 Pre-study calculations and related tasks

The following subsections will present answers to pre-study tasks 2.2 – 2.4.

## 2.1 Mismatch attenuation

*A signal generator is connected to the input of the RX pre-amp block. The VSWR (voltage standing wave ratio) of the pre-amp is 2.0 and the VSWR of the output of the signal generator is 1.6.*

*a) What is the range of additional attenuation due to this mismatch in the measurement of the pre-amp block?*

*b) In what range is the attenuation due to mismatch, when an ideal 10 dB attenuator is connected between the signal generator and the pre-amp block? What is the benefit/drawback of inserting this attenuator?*

Text here.

## 2.2 Noise temperature

*The noise temperature of the pre-amp block is determined using the Y-coefficient method. The noise level of the spectrum analyzer HP8596E is* $P_{\mathrm{SA}} < -125$ *dBm when the input is matched and the resolution bandwidth is 30 Hz.*

*a) How much gain is required from the LNA in order to measure the noise temperature with the HP8596E? The noise figure of the amplifier is 2.8 dB and the attenuation of the bias Tee and the diplexer is 0.7 dB and 0.4 dB, respectively.*

*b) Does the order (i.e. which is first in the chain) of the amplifier, bias tee and the diplexer in the pre-amp block have any influence on the result of Y-coefficient measurement? If yes, say why.*

Text here.

## 2.3 Requirements with evolving standards

*Discuss briefly the major changes in the requirements for the RF performance of the blocks in the RX chain when we move from 2G to 3G to 4G systems.*

Text here.

# References

[1] Huber + Suhner, *RF Cables*, Edition 2013/09. Available online at `http://ipaper.ipapercms.dk/HUBERSUHNER/Technologies/Radiofrequency/RFCablesEN/` [Retrieved: January 10th, 2014].

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[2] D. M. Pozar, *Microwave Engineering*, J. Wiley & Sons, 4th Ed., 2012. ISBN: 978-0-470-63155-3.

[3] M. Steer, *Microwave and RF Design – A Systems Approach*, SciTech Publishing, 2010. ISBN: 978-1-891-12188-3.