Exercise Report
(Lab2-M10)

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| **Subject of this exercise:** | Performance Evaluation of a 915-MHz FSK SoC Radio Transceiver |
| **Students – Student code:** | <me>-student code<myself> -student code<I> -student code |
| **Course/code:** | <course>, <group> |
| **Date & time:** | 20<YY>. <MM>. <DD>. |
| **Lecturer today:** |  |

Measurement equipmments used

|  |  |
| --- | --- |
| Oscilloscope | Agilent 54622A |
| Spectrum Analyzer | Agilent E4411B ESA-L |
| RF Signal Generator  | Agilent E4430B ESG-D |
| Power Supply | Agilent E3630 |
| Function Generator | Agilent 33220A |
| Digital Multimeter (6½ digit) | Agilent 3440A |

Exercises

1. First use of the RF measuring instruments
	1. Generate an AM modulated signal using the RF signal generator with the following parameters: carrier frequency=1 MHz, power level=0 dBm, AM modulation with modulating frequency=10 kHz and modulation index=10%.
	2. Study the AM signal and its components (the modulating signal and the carrier) in the time domain using the oscilloscope.

<Experience collected during the completion of the measurement>

* 1. Vary the RBW[[1]](#footnote-1) (2 different values: 1kHz/3kHz), VBW[[2]](#footnote-2) (2 different values: 30Hz/300Hz) and SPAN[[3]](#footnote-3) (as given: 100kHz) parameters of RF spectrum analyzer and study the spectrum of AM signal observed applying the different analyzer settings.

<Experience collected during the completion of the measurement>

2 Generation of an unmodulated signal with the TRF6900A transmitter

* 1. Turn on the evaluation board[[4]](#footnote-4) and run the TRF6900A.exe control software.
* Suggested settings
	+ Power supply: 8.5VDC
	+ Desired frequency = 915.199921 MHz

(output frequency at the chip – in the TRF6900A control SW push *Send Words Now* (F12) button to activate the settings)

* + SPAN = 200 kHz
	+ RBW = 1 kHz
	+ VBW = 30 Hz
	1. Connect the output of the evaluation board to the spectrum analyzer and send the control word to the evaluation board. Measure and record the actual value of the output frequency. Does the measurement result meet the expectation?

<Experience collected during the completion of the measurement>

* 1. Correct the error in clock frequency using the TRF6900A software. What are the sources of this error?

<Experience collected during the completion of the measurement>

* 1. Measure and record the actual value of output power level in dBm at each
	Pwr Amp[[5]](#footnote-5) settings.

<Experience collected during the completion of the measurement>

* 1. Based on the measured spectrum estimate the closed-loop bandwidth of the PLL. Explain the estimation technique applied[[6]](#footnote-6).

<Experience collected during the completion of the measurement>

* 1. Measure and record the spurious signals in dBc as a function of frequency[[7]](#footnote-7).

<Experience collected during the completion of the measurement>

1. Generation of an FSK modulated signal with the TRF6900A transmitter
	* + Duble click into the Help field of the TRF6900A control SW makes the block diagram view of the transceiver chip pop up. Push the PLL/Modulation Options button to set the parameters of FSK modulation as follows: in the deviation register DEV, DV6=0 and all the rest bits are 0 that correponds to 50kHz deviation. Send Bits button calculates the parameters of the modulation. The frequencies corresponding to Bit ’0’ and Bit ’1’ in FSK shown in fields Tx\_Data Low and Tx\_Data High, respectively, while 2\*deviation is given by Delta\_Fout.

Pushing Send Words Now (F12) enters the FSK modulation paramters into the chip. By pushing the TXData button you can generate manually (in a static way) the frequencies corresponding to Bit ’1’ and Bit ’0’ in the FSK. These frequencies have to be measured using the spectrum analyser. Hint: use the Max Hold function of the spectrum analyser.

* + - Suggested settings on the spectrum analyser
		- SPAN = 1 MHz
		- RBW = 1 kHz
		- VBW = 30 Hz
	1. Generate a binary FSK signal with large frequency deviation. Measure and record the

 a) two output frequencies of binary FSK carrying bit “1” and bit “0”,

<Experience collected during the completion of the measurement>

 b) spectrum of FSK signal,

<Experience collected during the completion of the measurement>

c) bandwidth of FSK signal[[8]](#footnote-8).

<Experience collected during the completion of the measurement>

1. Reception of an FSK signal with TRF6900A receiver
* In the block diagram window of the control software turn off the transmitter (the PA block has to be blacked out) and turn on the blocks of the receiver (turn into green the black boxes). Switch the LNA into high gain mode (vivid red).
	1. Generate a binary FSK signal by the RF signal generator[[9]](#footnote-9). Connect the output of the RF signal generator to the RF input of the TRF6900A evaluation board!
* A Suggested settings of RF signal generator
	+ carrier frequency = 915.200 MHz
	+ output power = -50 dBm
	+ internal FSK modulation (internal analog FM modulation with square wave modulation)
	+ source signaling speed = 20 kbit/s (therefore set the modulating frequency = 10 kHz)
	+ deviation = 50 kHz.
	1. Calculate and upload the required local frequency[[10]](#footnote-10) via the control software. Calculate and record the input level of the TRF6900A receiver at the receiver input (do not forget to take into consideration the effect of the attenuator placed between the physical connector and the receiver input).

<Experience collected during the completion of the measurement>

* 1. Connect a binary FSK modulated signal to the input of the TRF6900A receiver. Measure and record the demodulated signal before (Amp\_out) and after (Rx data\_out) the data slicer, that is, the decision circuit.

<Experience collected during the completion of the measurement>

* 1. Turn off the FSK modulation and measure the RSSI characteristic by setting the signal level at the TRF6900A receiver input to -70 dBm and then to -40 dBm. Calculate the sensitivity (steepness) of the RSSI circuit.

<Experience collected during the completion of the measurement>

* 1. Record an eye-diagram-like waveform using both input channels of the oscilloscope applying signal inversion on either channel. The signal to be connected to both oscilloscope channels is that of the Amp\_out output. Reduce the level of the incoming RF signal until the ’eye diagram’ starts closing (tends to be noisy). (Ask for help if necessary!)

<Experience collected during the completion of the measurement>

* 1. Measure the transfer function of the frequency discriminator. Connect an unmodulated RF signal of power level -35 dBm to the receiver input and measure the frequency discriminator output while you keep changing the frequency of the incoming RF signal in 20kHz steps around its nominal value +/- 100kHz . Calculate the sensitivity (steepness) of the frequency discriminator. (Ask for help if necessary!)

<Experience collected during the completion of the measurement>

1. RBW: Resolution BandWidth – the bandwidth of the band-pass filter that ’sweeps the frequency range of the spectrum analyser display’ measuring the power of the signal that falls into its bandwith; spectrum is visualized by drawing this power level measured continuously – the narrower the filter bandwidth the better the „resolution” of the spectrum displayed [↑](#footnote-ref-1)
2. VBW: Video BandWidth - reduces the variance of the spectrum displayed when the VBW value is decreased [↑](#footnote-ref-2)
3. SPAN: the width of the frequency range analysed – the frequency range around the center frequency (CENTER), i.e., [CENTER+/-SPAN/2] [↑](#footnote-ref-3)
4. VDC=8.5V use the power supply [↑](#footnote-ref-4)
5. Practical usage of Pwr Amp: the receiver chip acknowledges the reception of too high level of incoming signal forcing the transmitter to reduce the radiated power level. Here, controlled attenuators are used to change signal levels. [↑](#footnote-ref-5)
6. Identification of a band-pass-like spectrum. [↑](#footnote-ref-6)
7. Relative to the carrier (see letter ’c’ in dBc for carrier): P\_dBc\_spur=P\_dBm\_spur-P\_dBm\_carrier [↑](#footnote-ref-7)
8. Hint: refer to the Carson rule! [↑](#footnote-ref-8)
9. The signal generator offers only FM modulation however FM modulation applying square-wave as modulating waveform can be considered as FSK. [↑](#footnote-ref-9)
10. The TRF6900A implements a superheterodyne receiver, i.e., an intermediate frequency (IF) stage is applied, here at 10.7MHz. Operation principle: the mixer (analog multiplier) multiplies the incoming RF signal with the signal of the local oscillator, i.e., the well-known trigonometrical identity 2\*cos(x)\*cos(y)=cos(x+y)+cos(x-y) can be exploited. After low-pass filtering the high frequency component only the substraction remains, i.e., (x-y)=10.7MHz. [↑](#footnote-ref-10)