# EE3DSD: Digital System Design (Coursework 1)

The following report details the first work undertaken while developing a decoder for the UK MSF and German DCF77 low frequency radio clock signals using the GNU/Linux VHDL toolchain. This beginning work is focused on using and analysing the received signals and the Logic Analyser component.

## Button bouncing

*At least 5 screenshots of waveforms showing buttons bouncing. It doesn't matter*

*which button as long as you have 5 distinct events captured.*

## Button behaviour

*Give typical timescales for the buttons to settle as measured from your*

*waveforms with GTKWave. Calculate the average time it takes for a button to*

*settle with standard deviation plus minimum and maximum time. You need to*

*analyse at least 100 events to get reasonable statistics.*

## DCF Signal

*Screenshots of your sampled DCF signals over at least one full minute showing*

*the start of the minute and the start of the next minute. You need to zoom in*

*sufficiently to be able to tell the duration of the pulses and be able to*

*identify the information encoded on them. Make the screenshots overlap, e.g. the*

*end of one screenshot should be the start of the next, so that when you put all*

*screenshots next to each other you get the full minute with all details of the*

*encoded information clearly visible.*

*An annotated trace file of your DCF signals as described above, which*

*corresponds to the DCF screenshots in your report.*

## MSF Signal

*Screenshots of your sampled MSF signals over at least one full minute showing*

*the start of the minute and the start of the next minute. You need to zoom in*

*sufficiently to be able to tell the duration of the pulses and be able to*

*identify the information encoded on them. Make the screenshots overlap, e.g. the*

*end of one screenshot should be the start of the next, so that when you put all*

*screenshots next to each other you get the full minute with all details of the*

*encoded information clearly visible.*

*An annotated trace file of your MSF signals as described above, which*

*corresponds to the MSF screenshots in your report.*

*The decoded bits from second 0 to second 59 for the MSF signal the decoded time*

*and date information from the decoded bits including a description how you*

*decoded them including the parity checks.*

## Sampling accuracy

*An annotated trace file showing the differences in arrival times of the DCF and*

*MSF second markers from one second to the next and between MSF and DCF. An*

*analysis of these to show the mean difference and standard deviation between*

*consecutive seconds and the two radio clocks. An estimate of the frequency error*

*of the local crystal oscillator on the development board including error margins*

*based on your data.*

## Propagation times

The MSF signal is broadcast at 60kHz (1), while the DCF77 uses a 77.5kHz carrier signal (2), placing both signals in the Low Frequency (LF) spectrum of radio waves. At these frequencies, long wave radio propagate along the surface and sky between two points at the speed of light. At standard temperature and pressure, the speed of light is negligibly slower than in a vacuum, meaning that the propagation time can be calculated as the distance between the transmitter and receiver divided by 3 × 108 m/s.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Clock** | **Transmitter** | **Receiver** | **Distance (km)** | **Propagation Time (ms)** |
| MSF | 54° 54′ 36″ N, 03° 16′ 48″ W | 52° 28′ 59″ N, 01° 53′ 37″ W | 284.9 | 0.9497 |
| DCF | 50° 00′ 56″ N, 09° 00′ 39″ E | 52° 28′ 59″ N, 01° 53′ 37″ W | 806.1 | 2.6870 |

From this we can derive an expected difference between propagation times of 1.7373 ms.

*A theoretical estimate of the expected time difference between DCF and MSF radio*

*clock signals and a comparison with your experimental results obtained plus*

*explanation of any differences.*

# References

1. **Various.** Time from NPL. *Wikipedia.* [Online] N.D. [Cited: 10th October 2013.] http://en.wikipedia.org/wiki/Time\_from\_NPL.

2. —. DCF77. *Wikipedia.* [Online] N.D. [Cited: 10th October 2013.] http://en.wikipedia.org/wiki/DCF77.