Supplementary material for TFSAP book Section 13.2: "Communication Over Linear Dispersive Channels: A Time-Frequency Perspective"[1]

The additional material[2] in this file is provided by Prof Boashash to assist the reader to better understand and use Section 13.2 of the TFSAP book.

A. Supplementary Codes:

The MATLAB functions and scripts listed below are used to reproduce some of the supporting figures for Section 13.2.

MATLAB Functions:

- *mySTFT*: It computes the short-time Fourier transform (STFT) of an input signal.
- *myISTFT*: It computes the inverse short-time Fourier transform (ISTFT) of an input STFT. Note that this function is provided as a protected MATLAB file (.p). Thus, it cannot be edited, but can only be used by the reader.

MATLAB Scripts:

SM_Sec_13_2

- Description: This script produces results that are similar to the ones depicted in Fig. 13.2.1(a), on page 759 of the book.
- Process: It creates binary sequence data and performs BPSK and CDMA modulations. Then, it transmits the modulated data through a noisy Rayleigh channel. After that, it performs Rake receiver in the temporal domain and in the time-frequency domain with different bandwidth-duration product (BT) values. Finally, it plots the BER *vs.* SNR to compare the performances of each method.

B. Additional Related Supplementary Materials from Other Chapters:

The reader may also benefit from accessing the code and/or other supplementary materials (SM) from the following related Chapters of the book: 1.3.2, 3.5, 13.5, 11.5, 17.3.3 and 17.3.5 as detailed below.

1. Related Supplementary Material in Chapter 1.3.2:

The effect of the BT on the resolution of time-frequency representations (TFRs), is depicted in Fig. 1.3.2 on page 54 of the book. Run the MATLAB script *gaussch.m* to reproduce these

[1] B. Boashash, Ed., "Communication Over Linear Dispersive Channels: A Time-Frequency Perspective", Supplementary material for Chapter 13.2; in B. Boashash (ed.), *Time-Frequency Signal Analysis and Processing*, 2nd Edition (London: Elsevier / Academic Press, pages 753-760, December 2015); ISBN 978-0-12-398499-9.

[2] All of the book supplementary materials can be found here.

results. The plots illustrate the Instantaneous Frequency (IF) and the Spectral Delay (SD) of a Linear Frequency Modulated (LFM) signal for two values of BT, and show that high BT products result in concentrated TFRs.

2. Related Supplementary Material in Chapter 3.5:

The meaning of Ambiguity Function (AF) is discussed in Chapter 3.5 in the context of a simple radar experiment. To compute the AF of an input signal using the TFSAP Toolbox[3] in the user's own code, call the function `ambf` in the MATLAB command window as shown below.

```
af = ambf(signal, lag_res, window_length );
```

Inputs:

`signal` = One dimensional input signal to be analyzed.

`Lag_res` = number of lag to skip between successive slices.

`window_length` = number of signal samples used for analysis.

Output:

`af` = ambiguity function representation.

For more details, see the help of function *ambf* by typing `help ambf` in the MATLAB command window after adding the toolbox to the MATLAB path.

3. Related Supplementary Material in Chapter 13.5:

Shift keying methods other than binary phase-shift keying (BPSK), i.e. binary frequency-shift keying (BFSK) and 4-frequency-shift keying (4FSK), are discussed in Chapter 13.5 in a modulation parameter estimation context. Figs. 13.5.3, 13.5.4, 13.5.6 and 13.5.8, on pages 782, 783, 785 and 787 of the book respectively, illustrate the TFRs of different BFSK and 4FSK signals. Run the MATLAB scripts *Fig_13_5_3.m*, *Fig_13_5_4.m*, *Fig_13_5_6.m* and *Fig_13_5_8.m* to produce the results.

4. Related Supplementary Material in Chapter 11.5:

A time-frequency subspace noise suppression technique is discussed in Chapter 11.5. Run the MATLAB script Sec*_11_5_Figures1_to_5.m*, provided in the SM of Chapter 11.5, to produce results that are close to the ones depicted in Figs. 11.5.1-11.5.5, on pages 671 and 673-675 of the book.

5. Related Supplementary Material in Chapter 17.3.3:

Simulated and real time-domain signals can be generated by accessing the TFSAP Toolbox functions either by using the GUI model or by using the MATLAB command window (see Section 17.3.3 of the SM of Chapter 17).

6. Related Supplementary Material in Chapter 17.3.5:

Quadratic Time-Frequency distributions, e.g. the Wigner-Ville distribution and the Spectrogram, of a time-domain signal can be computed and plotted by accessing the

[3] TFSAP Toolbox can be found here.

functionalities of the TFSAP Toolbox either by using the GUI model or by using the MATLAB command window (see Section 17.3.5 of the SM of Chapter 17).

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