DASP3rd Chapter 5 - Exercises

1 DSPs

1. What kind of software commands are necessary for signal processing algorithms to implement digital filters, e.g. filters with finite-impulse response (FIR) which use FFT.

   Solution:

   - MAC instructions (multiply and accumulate)
   - simultaneous transfer of both operands for multiplication to the MAC (parallel move)
   - bit-reversed addressing (for FFT)
   - modulo addressing (for windowing and filtering)

2. What kind of hardware instructions are necessary assuming a RISC architecture? Think of the simplest calculations and operations. List them as bullet points.

   Solution:

   - load/store
   - add
   - multiply

2 Digital Audio Interfaces

1. How are AES/EBU and S/PDIF related to each other? Name differences and the used connectors.

   Solution:

   AES/EBU (AES3) is a digital two channel audio format used in professional applications. It uses XLR (or BNC) connectors. S/PDIF is used in consumer products and uses RCA or TOSLINK (fiber optic) connectors. They share the same protocol design (192 frames per block, 2 subframes, bi-phase mark code), but differ in the definition of the channel status information and the technical specifications for inputs and outputs.

2. Where is the audio data being transmitted in the HDMI cable? How does the transmitter know what kind of audio does the receiver supports?

   Solution:

   HDMI has three TMDS channels that contain video, audio and auxiliary data. The audio data is being transmitted during the video blanking intervals encapsulated inside the so-called Data Island Period. During initialization the receiver sends the transmitter the supported formats, standardized as Extended Display Identification Data (EDID), via the Display Data Channel (DDC) that is I^2C-based.

3. Calculate the data rate in Mbit/s for the following applications

   a) consumer grade stereo audio signal with a sampling rate of 48 kHz and 16-bit resolution (48 kHz @ 16 bit)

   b) studio recording of 16 channels with 192 kHz @ 24 bit

   c) Compare the calculated data rates to the net data rate of USB 2.0.

   Solution:

   a) $2 \cdot 48000 \cdot 16 = 1536000$ bit/s =1.53 Mbit/s

   b) $16 \cdot 192000 \cdot 24 = 73728000$ bit/s = 73.73 Mbit/s

   c) USB 2.0 achieves in High-Speed mode 480 Mbit/s. Even the 16-channel studio recording would only utilize 15.36%. With a 25% margin for overhead (packet headers, response on half-duplex, etc.) USB 2.0 would be capable of transmitting 78 channels (4.608 Mbit/s per channel) in total (transmit and receive) theoretically ($480 \cdot 0.75 \div 4.608 = 78{,}125$).

4. What is the main difference between network-based and internet-based audio protocols?

   Solution:

   In Network-based audio protocols audio data is mostly send as uncompressed PCM values. Internet-based audio protocols add encoding algorithms before sending the audio data that needs to be decoded before listening is possible again. Encoding the audio data adds delay and computational complexity but reduces the needed bandwidth.

5. What kind of network protocols can be used to create an audio connection in an already established network topology that was built with off the shelf hardware.

   Solution:

   Only Layer-3 network protocols or encoded (VoIP) protocols can be used. Layer-2 network protocols like AVB require hardware switches that are capable of that protocol. If that is not the case, a connection between to devices would fail.

6. Draw a diagram to visualize one audio transmission from one person to the other in a conference call. Start at the headset microphone in hardware and add the software and transmission layer to end at the speaker of another participant.

   Solution: Figure 5.16 from the book.