

City University of Hong Kong

Course code & title: EE4115 Audio-visual Engineering

Session : Semester B 2014/15

Time allowed : Two hours

This paper has FOUR pages (including this cover page).

1. This paper consists of 3 questions.
2. Answer ALL questions.
3. Show clearly all essential steps and state any assumptions made.

This is a **closed-book** examination

Materials, aids & instruments permitted to be used during examination:

City University Approved Electronic Calculator

Special materials

Nil

Answer ALL questions

Question 1 (33 marks)

- (a) Illustrate with diagrams, the Layer Structure of the MPEG2 bit-stream from a video sequence to image blocks.

(11 marks)

- (b) The 4x4 DCT block shown in Figure Q1(a) is to be quantized with the quantization table given in Figure Q1(b). Each entry in the quantization table represents the step size that is used to quantize the corresponding coefficient in the DCT block. The quantized value X_q of an integer X is given by

$$X_q = \text{trunc}(X/s) \times s,$$

where s is the step size, and $\text{trunc}(Z)$ denotes the removal of all decimal places in the quantity Z . For example, if $X = 98$ and $s = 8$, then $X_q = \text{trunc}(98/8) \times 8 = 96$.

Illustrate with diagrams the quantized DCT block and the zigzag scan path. Show the sequence of AC quantized coefficients that are traced by the zigzag scan path.

(11 marks)

960	-65	81	120
97	5	6	1
-40	5	0	2
8	-6	7	2

Figure Q1(a)

1	2	8	16
2	16	24	32
8	24	32	48
8	16	48	32

Figure Q1(b)

- (c) A video signal with resolution of 1920 (horizontal) x 1080 (vertical) is encoded with MPEG2 and reconstructed on three different types of receivers. Each receiver can only decode MPEG2 encoded video bit-stream with maximum resolution listed in Table Q1.

Table Q1

Receiver	Maximum horizontal resolution	Maximum vertical resolution
A	1920	1080
B	960	540
C	480	270

Describe briefly with a diagram how the MPEG2 encoder can be made compatible with the three types of decoders with the use of spatial scalability.

(11 marks)

Question 2 (33 marks)

- (a) Determine the data-rate (bits per second) of a digital color video signal that is represented in the 4:1:1 YUV format, and having the following specification:

Rows per frame: 1080
Column per frame: 1920
Pictures per second: 25
Number of bits for representing a pixel in each component (i.e. Y, U, or V) before down-sampling: 8bits

(11 marks)

- (b) In the *PAL* video system, a Comb filter can be employed to separate the *U* and *V* components of a composite video signal.

- (i) Illustrate with a block diagram how the comb filter can be realized with a delay line and some electronic circuits.

(11 marks)

- (ii) Given that the delay time of the delay line in a comb filter is equal to $64\mu\text{s}$, determine the attenuation of the comb filter at 4423828Hz.

(11 marks)

Question 3 (34 marks)

- (a) The side-view of a listening room with a length of L meters is shown in Figure Q3(a). A sinusoidal traveling sound wave that propagates along the x direction is generated by a sound source at the left wall.

- (i) Assuming the room is empty and there is no absorbent on the walls of the room, derive an expression for the standing wave in the room along the horizontal (i.e. x) direction.

(10 marks)

- (ii) Determine the first standing wave frequency.

(6 marks)

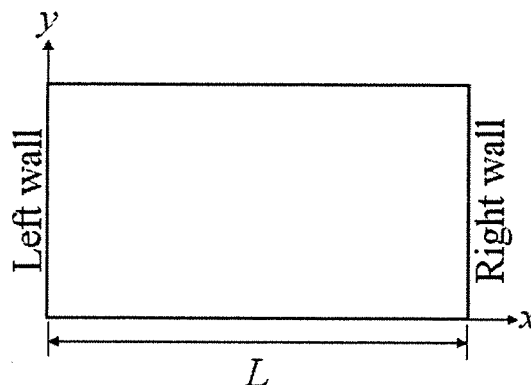


Figure Q3(a) A listening room of length L meters

- (b) A signal $x(n]$ is input into a noise shaping circuit to give an output $y(n]$ as shown in figure Q3(b). $e(n]$ represents the combination of dithering and quantization noise, H is a filter with the transfer function given by $H(\omega) = \frac{1}{e^{j\omega} - 1}$. $Y(\omega)$, $X(\omega)$, and $E(\omega)$ represent the Fourier Transform of $x(n]$, $y(n]$, and $e(n]$, respectively. Express $Y(\omega)$ in terms of $X(\omega)$ and $E(\omega)$, and determine the noise power gain at $\frac{\pi}{2}$ rads/sec.

(18 marks)

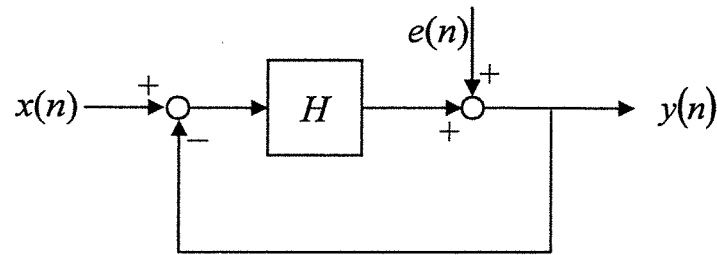


Figure Q3(b)

<-END->