

3.10 Design a microcomputer-based system for the high-fidelity sampling and digital storage of music (like the compact audio disk or digital audio tape).

The design requirements are:

- The signal frequency range is from 10 to 20,000 Hz.
 - Only consider music that is detected with microphones, such as classical or opera.
 - The maximum microphone output signal is 10 mV peak-to-peak.
 - The microphones and amplifiers produce white noise (constant noise power in each frequency band) from 0 Hz to 100 kHz.
 - The A/D converter you are using has a -5 to $+5$ V input range.
 - The digital resolution must be $<0.002\%(2 \times 10^{-5})$ of the full A/D range.
 - Your design will include a device for storing large quantities of digital data. (In the recording industry, magnetic tape is used to store the digital master recordings.)
 - The time interval between samples must be constant to one part in 10^6 .
 - You have rejected commercially available data-acquisition circuits as being too slow, too inaccurate, or too costly and have decided to design your own using parallel I/O ports and counters/timers circuits similar to those in the laboratory exercises.
- (a) Draw a block diagram of your design, starting from one of the microphones and showing all necessary components and interconnections.
 - (b) According to the Nyquist theorem, what is the minimum sampling frequency necessary for subsequent recovery of the signal?
 - (c) Practically, what would be a good design value for the sampling frequency of the system? Explain your reasoning.
 - (d) Describe the A/D requirements in terms of number of bits and conversion time.
 - (e) Which type of A/D converter would be most appropriate? Explain. (Consider integrating, tracking, successive approximation, and flash.)
 - (f) What capacity (in megabytes) is required for the digital storing of 1 hour of music at the sampling rate from (c) above?
 - (g) What is the maximum aperture time jitter of the sample-and-hold amplifier that will guarantee $1/2$ LSB accuracy at the maximum frequency of 20,000 Hz? ($1 \text{ ns} = 10^{-9} \text{ s}$.)
Circle one choice:

121 ns 12.1 ns 1.21 ns 0.121 ns 0.0121 ns