DESIGN EXAMPLE - AUDIO PLAYER

Theory of Operation and Requirements

Audio, players are often called MP3 players. The earliest portable MP3 players were based on compact disk mechanisms and the modem MP3 players use either a flash memory or disk drives to store music.

An MP3 player performs three basic functions:

(i) Audio storage,

(ii) Audio decompression, and

(iii) User interface.

(1) Audio Decompression

The incoming bit stream has been encoded using a Huffman style code, which must be decoded. The audio data itself are applied to a reconstruction filter, along with a few other parameters.

Audio compression is a lossy process that relies on perceptual coding. The coder eliminates certain features of the audio stream so that the result can be encoded in fewer bits. It tries to eliminate features that are not easily perceived by the human audio system.

Masking is one perceptual phenomenon that is exploited by perceptual coding. One tone can be masked by another if the tones are sufficiently close in frequency. Some audio features can also be masked if they occur too close in time after another feature.

In MP3 players, the following three layer standard defines the audio compression:

(i) Layer 1(MP1)

It uses a lossless compression of sub bands which is a simple masking model.

(ii) Layer 2 (MP2)

It uses a more advanced masking model.

(iii) Layer 3 (MP3)

It performs additional processing to provide a lower bit rates.

The various layers that supports several different input sampling rates, output bit rates, and modes such as mono, stereo, etc.

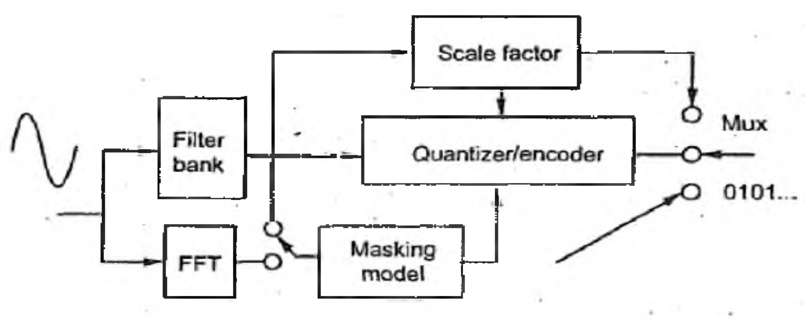


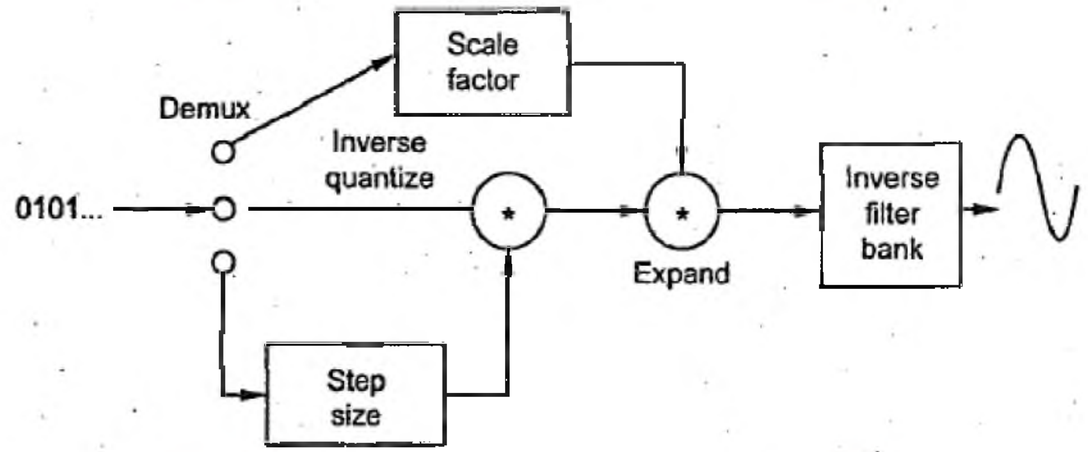
Fig gives a block diagram of a layer 1 encoder. The main processing path includes the filter bank and the quantizer/encoder. The filter bank splits the signal into a set of 32 sub bands that are equally spaced in the frequency domain and together cover the entire frequency range of the audio.

Audio signals are more correlated within a narrower band, so splitting into sub bands helps the encoder to reduce the bit rate.

The masking model selects the scale factors, which is driven by a separate Fast Fourier Transform (FFT). The filter bank principle could be used for masking, but a separate FFT provides better results.

The masking model chooses the scale factors for the sub bands, which can change along with the audio stream. The multiplexer at the output of the encoder passes along all the required data.

MPEG data streams are divided into a frame which carries the basic MPEG data, error correction codes, and additional information. Fig 9.9 shows the format of an MPEG layer 1 data frame.



A block diagram of MPEG layer 1 decoder is shown in Fig . After disassembling the data frame, the data are unsealed and inverse quantized to produce sample streams, for the sub band.

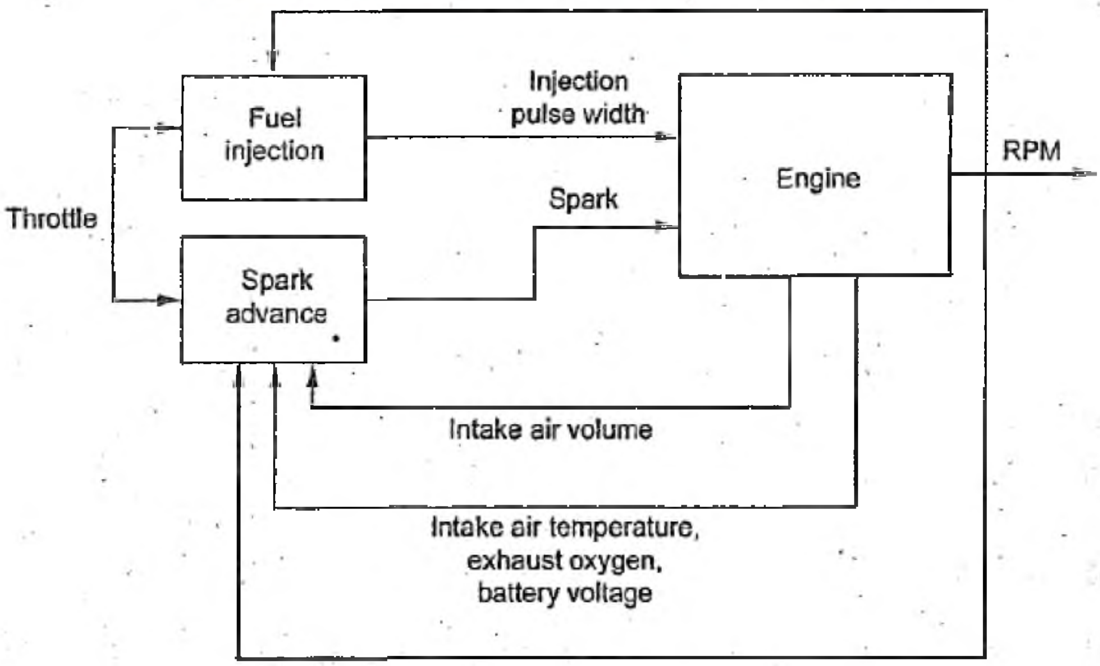
An inverse filter bank then reassembles the sub bands into the uncompressed signal.

Name	Audio player
Purpose	Play audio from files.
Inputs	Flash memory socket, on/off, play/stop, menu up/down.
Outputs	Speaker
Functions	Display list of files in flash memory, select file to play, play file.
Performance	Sufficient to play audio files at required rate.
Manufacturing cost	Approximately $25
Power	1 AAA battery
Physical size and weight	Approx. 1 in × 2 in, less than 2 oz

ENGINE CONTROL UNIT (ECU)

We will design a simple Engine Control Unit (ECU) which controls the operation of a fuel-injected engine based on the several measurements taken from the running engine.

Theory of Operation and Requirements



We can design a basic engine controller for a simple fuel injected engine as shown in Fig . The throttle is the command input and the engine measures throttle, RPM, intake air volume, and other variables.

The engine controller computes injector pulse width and spark. This design does not compute all the Outputs required by a real engine, we only concentrate on a few essentials. Our requirements chart for the ECU is shown in table .

Name	ECU
Purpose	Engine controller for fuel-injected engine
Inputs	Throttle, RPM, intake air volume, intake manifold pressure
Outputs	Injector pulse width, spark advance angle
Functions	Compute injector pulse width and spark advance angle as a function of throttle, RPM, intake air volume, intake manifold pressure
Performance	Injector pulse updated at 2-ms period, spark advance angle updated at 1-ms period
Manufacturing cost	Approximately $50
Power	Powered by engine generator
Physical size and weight	Approx 4 in × 4 in, less than 1 pound.

VIDEO ACCELERATOR

We consider the design of a video accelerator which is specifically a motion estimation accelerator. Digital video is still a computationally intensive task, so it is well suited for acceleration.

A video accelerator significantly speeds up the updating of images on a screen which makes CPU free to take care of other tasks. Simply, it act as a video card with integrated processor and memory. It is mainly used ,

(i) To increase the overall capabilities of video graphics.

(ii) To provides critical speed ups for low-latency I/O functions.

Video Compression

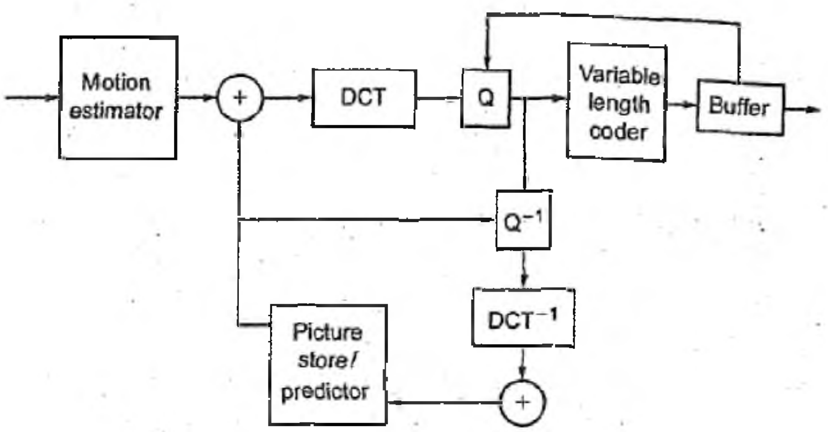


Fig shows the block diagram for MPEG-2 video compression algorithm which is the basis, for US HDTV broadcasting. This compression uses several component algorithms together in a feedback loop.

The Discrete Cosine Transform (DCT) used in JPEG also plays a key role in MPEG-2. In the still image compression, the DCT of a block of pixels is quantized for lossy compression and then subjected to lossless variable-length coding to further reduce the number of bits required to represent the block.

A The MPEG-2 encoder also uses a feedback loop to further improve image quality.

(1) Motion-Based Coding

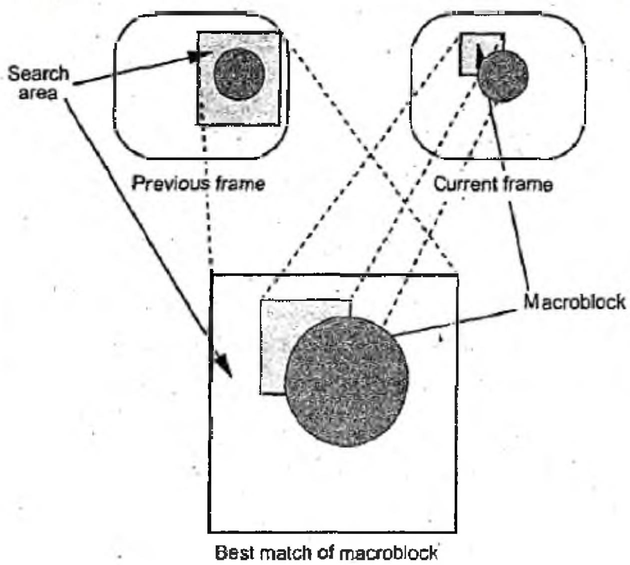
MPEG uses motion to encode one frame in terms of another. Some frames arc sent as modified forms of other frames using a technique known as block motion estimation.

Block Motion Estimation:

A block matching algorithm is a way of locating the matching macroblocks in a sequence of digital video frames for the purpose of motion estimation.

During encoding, the frame is divided into macroblocks which is identified from one frame in other frames using correlation.

The frame can then be encoded using the motion vector that describes the motion of the macroblock from one frame to another without explicitly transmitting all of the pixels.



The concept of block motion estimation is illustrated in Fig 9.19. The goal is to perform a two-dimensional correlation to find the best match between regions in the two frames,

We divide the current frame into 16X16 macroblocks. For every macroblock in the frame, we want to find the region in the previous frame that closely matches to the macroblock.

Requirements

We will build the system using an FPGA connected to the Peripheral Component Interconnect (PCI) bus of a personal computer. We clearly need a high-bandwidth connection such as the PC1 between the accelerator and the CPU.

Name	Block motion estimator
Purpose	Perform block motion estimation within a PC system
Inputs	Macroblocks and search areas
Outputs	Motion vectors
Functions	Compute motion vectors using full search algorithms
Performance	As fast as we can get
Manufacturing cost	Hundreds of dollars
Power	Powered by PC power supply
Physical size and weight	Packaged as PCI card for PC