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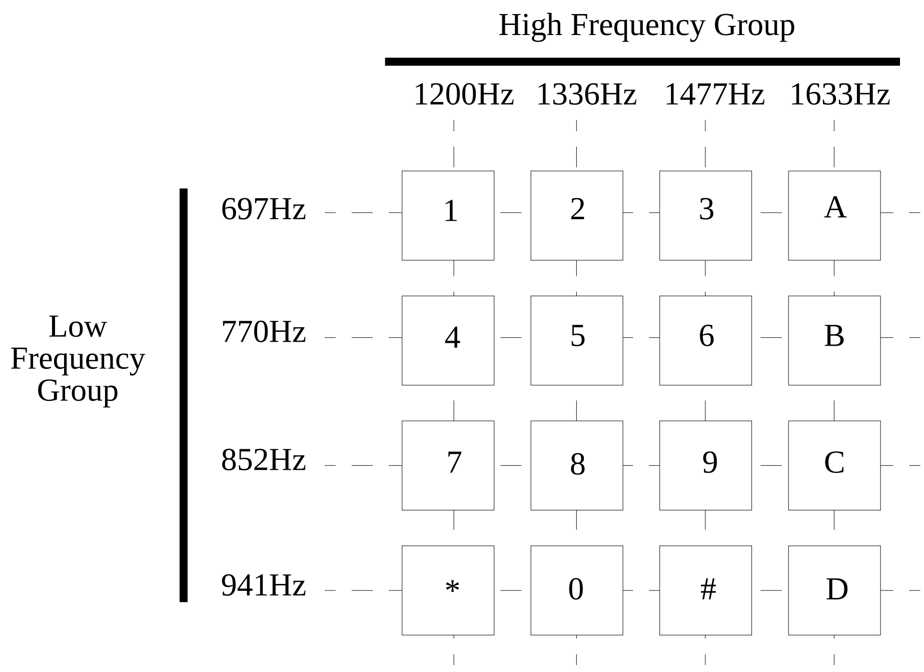
DTMF Design Description

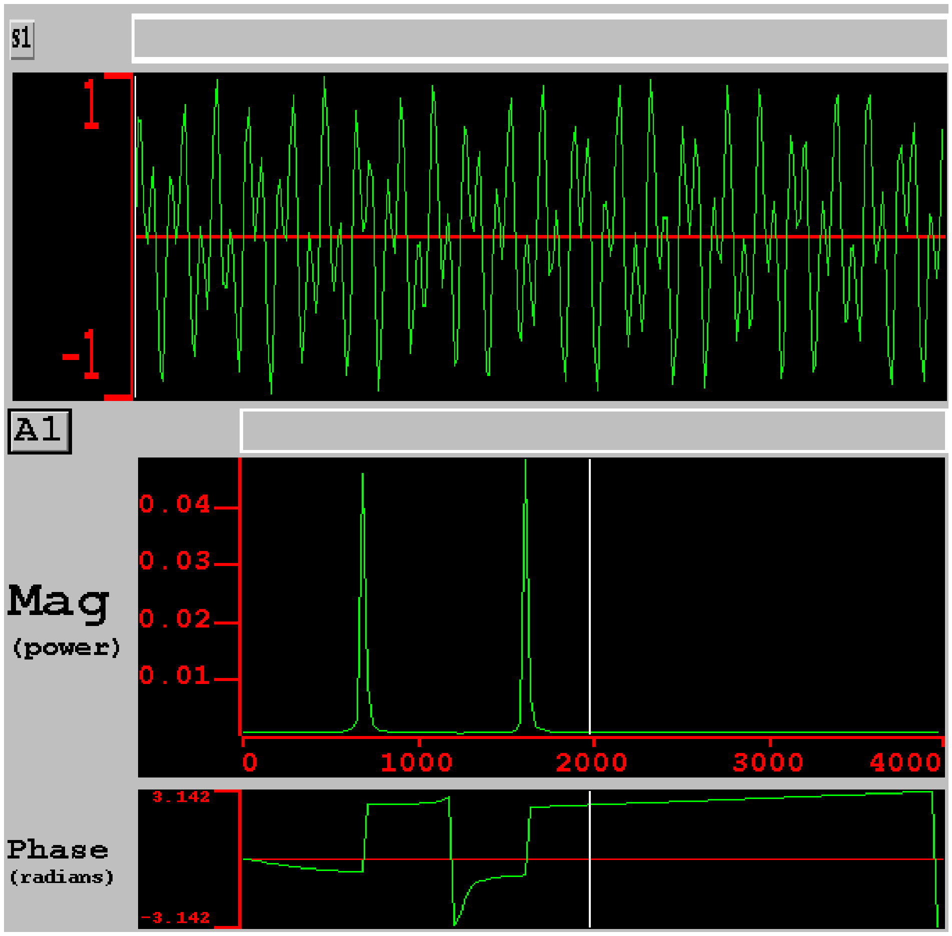
DTMF Receiver Overview

In a telephone network, two basic techniques are used for transmitting information between network entities: in-band and common channel signalling. In-band signalling shares the transmission facility for signalling and voice data. Common channel signalling uses one transmission facility for all signalling functions for a group of voice channels.

One common form of in-band signalling is dual tone multifrequency, or DTMF. DTMF signals are commonly generated by “Touch-Tone” telephones; most of us probably have this type of telephone in our homes today. Here is a layout of a standard DTMF keypad:



Notice that keys “A”, “B”, “C”, and “D” are not usually on telephones for home use. They are mainly used in commercial applications with special instruments. Pressing a key will cause the telephone to generate the indicated pair of tones, one from the high frequency group, and one from the low frequency group.



Above is a DTMF signal along with its frequency response.

Telephone specifications, such as *Touch-Tone Calling - Requirements for Central Office (*AT&T Compatibility Bulletin No. 105, August 8, 1975) define a DTMF digit as follows:

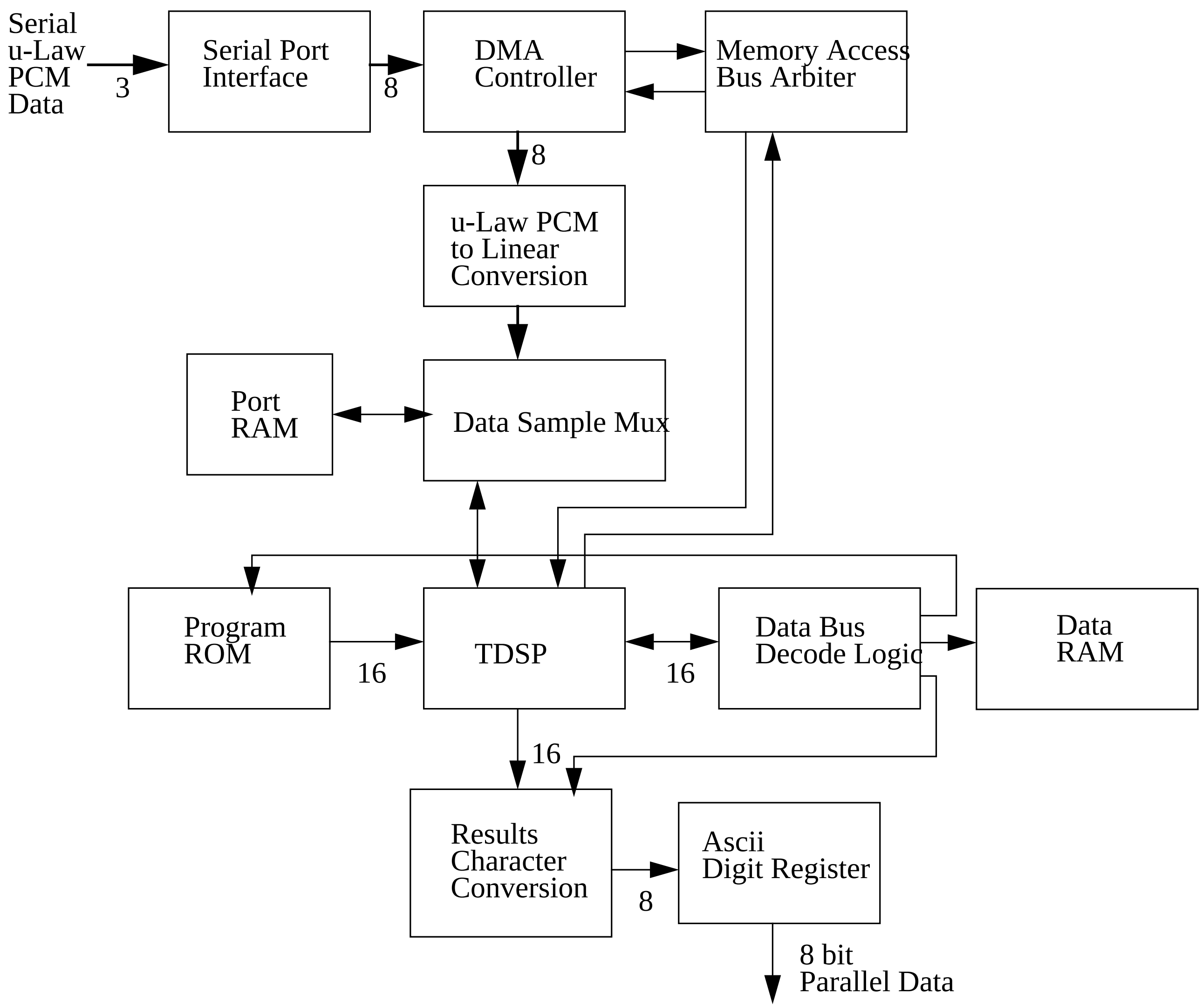
- A pair of tones, one from the low frequency group, one from the high frequency group
- A nominal level, per frequency, of -6 dBm0
- A maximum rate for DTMF signalling of10 digits per second (or typically 100mS per digit)
- A DTMF digit must be present for at least 45 mS
- An inter-digit “quiet period” must exist between digits for at least 45 mS
- Upon reception, the signal difference between the low frequency tone and high frequency tone does not exceed 8 dB
- Upon reception, the signal difference between the high frequency tone and low frequency tone does not exceed 4 dB

A simple DTMF detector could be built using a group of band-pass filters, each followed by a peak detector, which has a natural time constant of about 35 mS. The output of the peak detector would drive a threshold comparator, which in turn would drive a decision logic circuit. Get the picture? A bunch of analog circuits that would probably require “tweaking” on your assembly line.

To detect the tones, our DTMF receiver will utilize a modified discrete Fourier transform (DFT) algorithm known as the Goertzel algorithm. The Goertzel algorithm is a very efficient way of calculating a partial frequency spectrum using a second-order recursive computation (calculation of the DFT is known as the “direct form”). Indeed, we are only really interested in calculating the frequency response at the DTMF center frequencies. Because of the recursive nature of the algorithm, the Goertzel algorithm will run entirely in firmware on the Tiny Digital Signal Processor (TDSP).

Block Descriptions

Here is a block diagram of the major laboratory design database, the DTMF Receiver.



The following sections give a quick overview of each of the major blocks.

Serial Port Interface (SPI)

The serial port interface accepts u-law compressed PCM data, serialized LSB first, and reformats the data to byte orientation. The interface uses a clock signal to strobe the data on the signal's rising edge. A frame strobe is also used to indicate the start of a new data sample.

Once a character is received, the SPI signals the DMA controller that a new byte is ready to be moved to the Data Sample memory.

SPI will be coded as an explicit state machine.

Signal interface:

spi_clk - serial data clock input
spi_fs - serial data frame strobe input
spi_data - serial data input
clk - system clock input
reset - system reset input
dout[7:0] - parallel data output
read - parallel data output enable input
dflag - new data flag output
scan_input_1 - scan data input (chain 1)
scan_input_2 - scan data input (chain 2)
scan_enable - scan enable input
scan_output_1 - scan data output (chain 1)
scan_output_2 - scan data output (chain 2)

The serial interlace timing is represented in the following diagram: