Wireless Audio Cable - System Block Description

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The overall wireless audio cable system contains several subsystems, which contribute to the functionality of the system as a whole. The figure shown below is the system block diagram, and an explanation of each of the subsystems follows.

Fig. 1 – System Block Diagram

In this system, there are two main stages, transmission and reception of the audio signal. The transmission stage begins with the audio source, which is main input to the system. The source can consist of any analog audio signal (a CD player will be used for implementation). The signal is then conditioned before the compression process because the audio source may output a power level that is too high or too low for the components of the FM transmitter. Conditioning interfaces the audio source with the compression process, and is done to maintain compatibility between different devices. After conditioning, the audio signal undergoes compression, so that the eventual transmitted signal uses less bandwidth. The FM transmitter modulates the audio signal and transmits it through the antenna to be received by the FM receiver's antenna. The FM transmitter is described in more detail later.

The reception stage begins with the FM receiver, which will be explained in more detail later, obtaining the signal from the antenna. The receiver then demodulates the signal and it then goes through an expansion process to restore the audio signal to its level before the initial compression. The signal is then passed on to a variable gain amplifier. The amplifier has a variable gain to permit audio sources of different signal levels to be used. The signal is then heard with speakers, or relayed to another audio device if desired.

There is also a test feature where a known signal is sent through the transmitter, and if the receiver successfully receives it, a LED will light up showing that the FM radio link is working.
FM Transmitter

The input of the FM transmitter is a control voltage that is multiplied by a carrier signal with a voltage-controlled oscillator (VCO), and the result is a frequency-modulated signal (see figure 2).

Fig. 2 – Voltage Controlled Oscillator

The FM transmitter is essentially a voltage to frequency converter. The transmitter will have an input signal with a varying voltage level, $V_L$ to $V_H$. This voltage signal is the control voltage of the VCO, $V_{FM}$ (see figure 3).

Fig. 3 – $V_{FM}$ Control Voltage

For discussion purposes, this control voltage will consist of a single tone sine wave. The frequency output of the VCO will change according to the control voltage and the conversion gain, $K$, of the VCO (see figure 4).

Fig. 4 – FM Signal
The VCO will output a frequency according to the equation:

\[ F_I = F_C + K \cdot V_{FM} \]

\[ \Delta F = K \cdot V_{FM} \]

Since the assumption is that the voltage to frequency conversion is a linear process, the larger the difference between the \( V_L \) and \( V_H \), the larger the output frequency range (see figure 3). The slope of the line in figure 3 represents the conversion gain of the VCO.

\[ \text{Fig. 3 – Conversion Gain} \]

In other words, larger voltage difference means larger bandwidth used. The bandwidth of a FM signal can be approximated by Carson's Rule, which is defined below.

\[ BW = 2 ( \Delta f + B ) \]

\[ B = \text{Bandwidth of control voltage signal} \]

According to FCC regulations, the system is limited to a certain power and bandwidth. This is why the compression process will be used to decrease the bandwidth. The compression process reduces the maximum value of \( V_H \), which causes a decrease of the maximum value \( f_H \), and therefore decreases bandwidth. The bandwidth of the VCO’s output signal depends on both the frequency of \( V_{FM} \), and \( \Delta F \). When \( \Delta F \) is much less than the frequency of \( V_{FM} \), it is called Narrowband FM, and the bandwidth is approximately \( 2 \cdot B \), which is shown in figure 4. When \( \Delta F \) is much greater than the frequency of \( V_{FM} \), it is called Wideband FM, and the bandwidth is approximately \( 2 \cdot \Delta F \), and this is shown in figure 5.
Further investigation is required to determine the actual conversion gain of the FM Transmitter needed for this project, however, the system will most likely be Wideband FM.

**FM Receiver**

The FM receiver demodulates the signal using a phase lock loop. It is essentially a frequency to voltage conversion process. The receiver is a reverse process of the transmitter. It receives the carrier signal with the modulated waveform and breaks it back down into the original signal.