**FINAL SPECIFICATIONS / COMMENTS FOR EXTENSIONS (FM)**

**TRANSMITTER -- XR2206**
- Transmitting frequency (over powerline): 1200kHz
- Frequency Deviation: less than 400KHz
- Modulation Index: 4
- Transmission Bandwidth*: 1000kHz

*Using Carson’s Rule
Transmission Bandwidth is 1.4MHz using the Bessel Tables.

For XR2206: Frequency to Voltage Conversion Constant (k)**: -384Hz/V
\[ k = -0.32/RC. \quad R=20k \text{ potentiometer}, \quad C=\text{capacitor between pins 6 and 7}. \]

**RECEIVER -- NE564**
- Minimum Lock Range*: 800kHz to 1600kHz
- Minimum Capture Range*: 1000kHz to 1400kHz

*approximated values

**FORMULAS**

**Transmitting Frequency:**
\[ f=1/(RC) \]
- R = value of timing resistor (potentiometer),
- C = frequency setting capacitor

**Frequency Deviation Constant:**
\[ k = -0.32/RC \text{ Hz/V} \]

**Bandwidth:**
- Carson’s Rule: \[ B_T = 2(\beta + 1)B \] where \( \beta = \Delta F/B \)
- \( B_T = \text{Total Bandwidth}, \)
- \( B = \text{bandwidth of modulated signal (highest modulating signal frequency)}, \)
- \( \beta = \text{Modulation Index}, \)
- \( \Delta F = \text{Frequency Deviation} \)

using Bessel Tables: \( B=2(n*f_m) \text{ (Hz)} \)
look up modulation index to find n
\( n = \text{number of significant sidebands}, \)
\( f_m = \text{highest modulating signal frequency (Hz)}, \)
\( B=\text{Bandwidth} \)

**Lock Range:**
- minimum 40% of \( f_o (+/-) \)

**Capture Range:**
- minimum 20% of \( f_o (+/-) \)

**Calculation for resistor R2 in NE564**
\[ R2 = \frac{(Vcc - 1.3V)}{(I_{R2})} \quad \text{where} \quad I_{R2} = 100\mu A \]

**PARTS JUSTIFICATION** (see final schematics in Applet)

**TRANSMITTER** (Transmitter - FM Subsystem, 42-1-2 in notebook)
1) De-amplifier -- LM318 Op-Amp

This part was needed to decrease the amplitude of the signal leaving the AM subsystem. The voltage to the XR2206 needs to be less that 618mV, so that the frequency deviation is less than 400KHz (the approximate minimum lock range of the receiver). This section could be eliminated.
when combined with the last filter in the AM subsystem. Also, the value of 618mV could be lower to minimize the bandwidth further.

2) XR2206

This chip frequency modulates the signal by means of a voltage-controlled oscillator. See XR2206 specification sheets for schematic that the design was based on.

A) The pot is used to adjust the input frequency of the system, to get it to lock with the receiver. The 1kohm resistor is there to prevent a short when the pot is turned completely.

NOTE: \( fc = \frac{1}{RC} \), where R is the value of the potentiometer, and C is between pins 6 and 7.

B) The resistive network that goes to pin 3 is used to set the output amplitude of the system. From the specifications: "Maximum output amplitude is inversely proportional to the external resistor \( R3 \) [50k pot], connected to Pin 3. For sine wave output, amplitude is approximately 60mV peak per kΩ of \( R3 \); for triangle the peak amplitude is approximately 160mV peak per kΩ of \( R3 \). Thus, for example, \( R3 = 50 \) kΩ will produce approximately 13V sinusoidal output."

NOTE: There is a typo in the specs, the specs read "13V sinusoidal output", however the correct number is 3V.

C) All other values are from the spec sheets. However, pins 13-14 SHOULD have a 200ohm resistor tied to it, not a 1kohm as shown in the final diagram. Also the sine/triangle wave output is from Pin 2 (sine if 200ohm resistor between pins 13-14 exist, triangle if the connection between pin 13-14 is left open), and the square wave output is from pin 11. For my design, the sine wave output was used.

3) Amplifier -- LM318 Op-Amp

The amplifier acts as a buffer to the power-line, and also amplifies the signal by a factor of two. It could easily be altered to be a unity gain buffer, if the design required it. It is possible that it is not necessary, but for now, it stays.

A) The 100kohm resistor shown in the final design SHOULD NOT be there. That was done for experimental purposes (to simulate the probe) and was not taken out in the final design schematic.

4) Filter Subsection

The filter subsection is a high pass filter that eliminates the 120V 60Hz signal from the power-line, and also allows the high frequency 1.2MHz signal to be transmitted through it. The current cutoff frequency is 8kHz (PSpice), however this would be altered if we had smaller size high voltage capacitors. Also, more subsections could be added to change the cutoff frequency. The value of 8kHz was chosen because of the components we had available (0.1uF capacitors @ 400V). Also, 1kohm resistors were necessary so that the signal would transmit across the filters.

RECEIVER (Receiver - FM Subsystem, 43-1-2 in notebook)

1) Filter subsection -- same as transmitter.

2) NE564 -- Pin 2 has a 36kohm resistor tied to Vcc. This value is changed based on the voltage level of the power supply. At a 10V supply the value is 87kohm (82 or 91kohm standard). Other values from specifications.

3) The final amplifier is there to amplify the system for the AM subsystem.

FINAL DISCUSSION / SUGGESTIONS

Perhaps a better implementation of this project for AUDIO would be the use of standard FM transmission, where the left and right channels are combined in a matrix network to form the L+R and L-R audio channels. This would also greatly minimize bandwidth on the power lines, which would allow for other
data to be transmitted. Also, if only one channel was needed for the design, FM would be the only modulation technique that would need to be used, since it is immune to noise on the power lines.