Massachusetts Institute of Technology
6.101 Project Proposal
NTSC Transmission through Optic Fiber

Hugo Malpica
Germain Martinez
Khaled Moharam

April 14, 2015

Motivation:

TV transmission was considered one of the most sophisticated communication systems. These systems employed complicated circuitry to communicate live audio and video to a general audience. Since then, the machinery for the transmission of information has largely been unchanged, even though the format of the information has changed from being purely analog to purely digital. Our motivation is to re-implement the old analog techniques used for TV transmission but with the extra challenge of using optical fiber as a transmission medium.

We have always been interested in communication theory and circuitry. Our first exposure to communication theory was in 6.003, Signals and Systems. We were thrilled by the elegance of the methods used to transmit and receive signals. In 6.101 we were first exposed to building a communication system using analog circuity in Lab 1. This lab experience introduced us to the challenges and difficulties of implementing a communication system.

Project Overview:

Our goal is to build a system that will transmit an NTSC signal from a camera through optic fiber. The output from the camera will be displayed on a TV unit. This is a way to emulate a real TV station that broadcasts at different frequencies.

The scheme that we will follow is depicted in Figure 1. The acquired signal from the camera will consist of two parts: a video signal and an audio signal. The audio signal will be FM modulated on a carrier frequency of 25MHz; the video signal will be passed into the system as-is. These signals will then be multiplexed, or combined into one signal, and transmitted through an optic fiber. At the receiving end of the optic fiber, a demultiplexer will be responsible for separating the audio and video signals. The audio signal will be demodulated at this point. Finally, both signals will be amplified to the proper output format and then sent to the TV.

Germain, Hugo and Khaled will be dividing the project into three parts: modulation, demodulation, and transmission and receiving. Germain will work on the modulation component which includes frequency modulation of the audio signal. Hugo will be responsible for the transmission and receiving component which includes the multiplexer and the tuner. Khaled will be responsible for the demodulation/amplification component, which includes the detection of the video and audio signals, amplification and outputting of final signals.

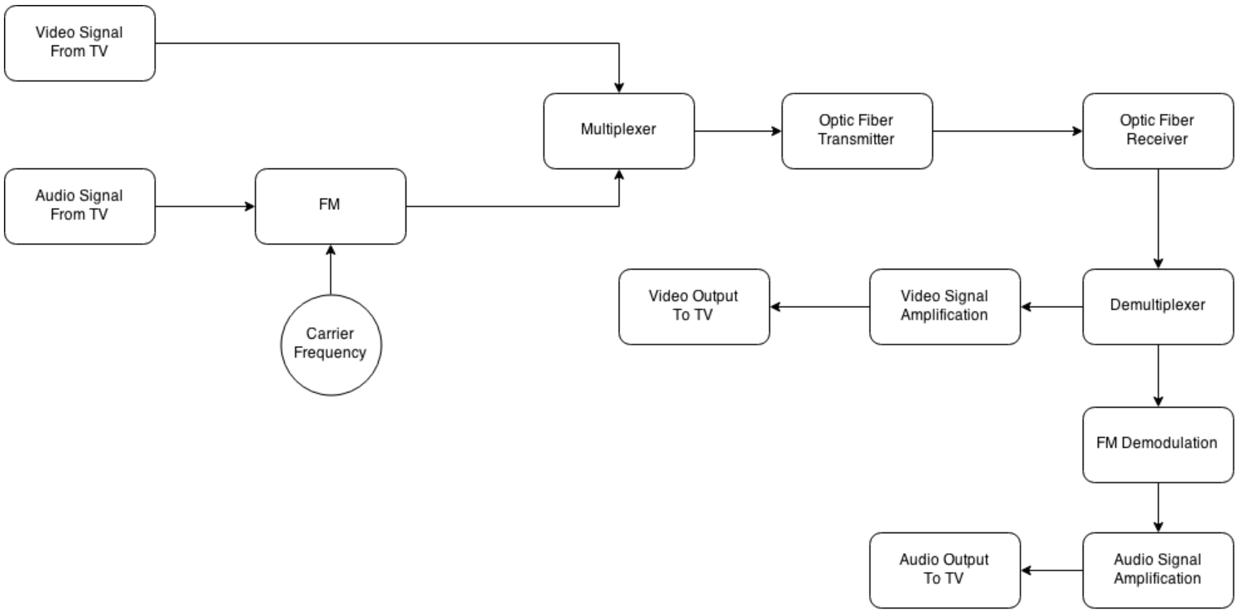

Figure 1: High level system block diagram detailing major sub-blocks and inter connections between them.

<u>Description of Subsystems:</u>

Input and Modulation:

The video signal carries a lot of data, so it normally has a bandwidth of about 8.4 MHz. Luckily, the video signal can be transmitted as-is without having to use a modulation scheme. However, this means that the audio signal cannot be combined with the video signal as it stands. We need to move the overall frequency content of the audio signal so that it is higher than the highest frequency content of the video signal. This is done through frequency modulation. This ensures that neither signal will interfere with the other when we combine the two in the multiplexer block.

In the frequency modulation (or FM) block, the input audio signal will be combined with another signal with a predefined frequency, called the Carrier Frequency. It will be combined such that the carrier signal changes its frequency depending on the information conveyed in the audio signal. For testing purposes, we will focus on generating a 25 MHz carrier signal.

Multiplexer and Optic Fiber Transmitter:

The multiplexer will take in the FM modulated signals and combine them to produce a final signal ready for transmission. This signal will then be fed into the optic fiber transmitter and sent to the optic fiber receiver through optic fiber cable.

The signal from the multiplexer gets fed to the transmitter, which can be modeled as a light-emitting diode, or LED. With the correct choice of current biasing for the LED, if we feed the signal from multiplexer into the LED then the intensity of the light emitted from the LED changes based on the strength of the signal.

Optic Fiber Receiver and Demultiplexer:

The signal will be received using an optic fiber receiver in this block. The receiver can be modeled as a photodiode. When the light from the transmitter reaches the receiver through the optic fiber connection, the changes in light intensity results in a change in the current flowing through the photodiode. By monitoring this change in the current, we can retrieve the transmitted signal from the transmitted light. The received signal will be separated, or demultiplexed, into the video signal and the modulated audio signal using filters.

FM Demodulation and Output:

The audio signal is currently not ready to be output since it was frequency modulated. Thus, we will have to demodulate the audio. A main contestant for FM demodulation is Quadrature demodulation. The FM modulated signal will be fed through a Phase shift RLC circuit. The signal will be phase shifted by 90 degrees. This signal will be fed along with the original signal into a Phase detector. The output of the phase detector will be fed into a low-pass filter to extract a dc voltage that is proportional to the phase difference between the mixer input signals. Another suggested method is to differentiate the FM signal and pass it through an envelope detector.

The extracted video signal will be amplified using a video amplifier. The extracted sound signal will be amplified using a sound amplifier. The amplified video and sound output will be connected to RCA cables to be displayed on a TV unit.

<u>Proposed Enhancements:</u>

If we are able to finish the implementation described above with extra time left, then we would like to add the following enhancements to our implementation.

The first addition to our implementation would be to another audio channel to our transmission scheme, which would give us stereo audio instead of mono audio. This enhancement would add some complexity to our circuit since now three signals have to be combined for transmission instead of two. We would have to frequency modulate this new signal with a different carrier frequency, but other than that the scheme we would use to add another channel would be similar to the one we are already using to transmit the audio signal.

A second addition would be to use a variable frequency modulator. The audio signal will then be transmitted at different adjustable frequencies. On the receiving end, we would employ a local oscillator/mixer circuit to transform our signals into and IF frequency signal. The purpose of this addition is to imitate the superheterodyne receiver concept.

Timeline:

Week of April 13	Design Finalized, Parts Ordered, Begin Building and Testing Blocks
Week of April 20	Continue Building and Testing Blocks, Integrating Blocks
Week of April 27	Debugging and Fine-Tuning
Week of May 4	Demonstration of Completed Project

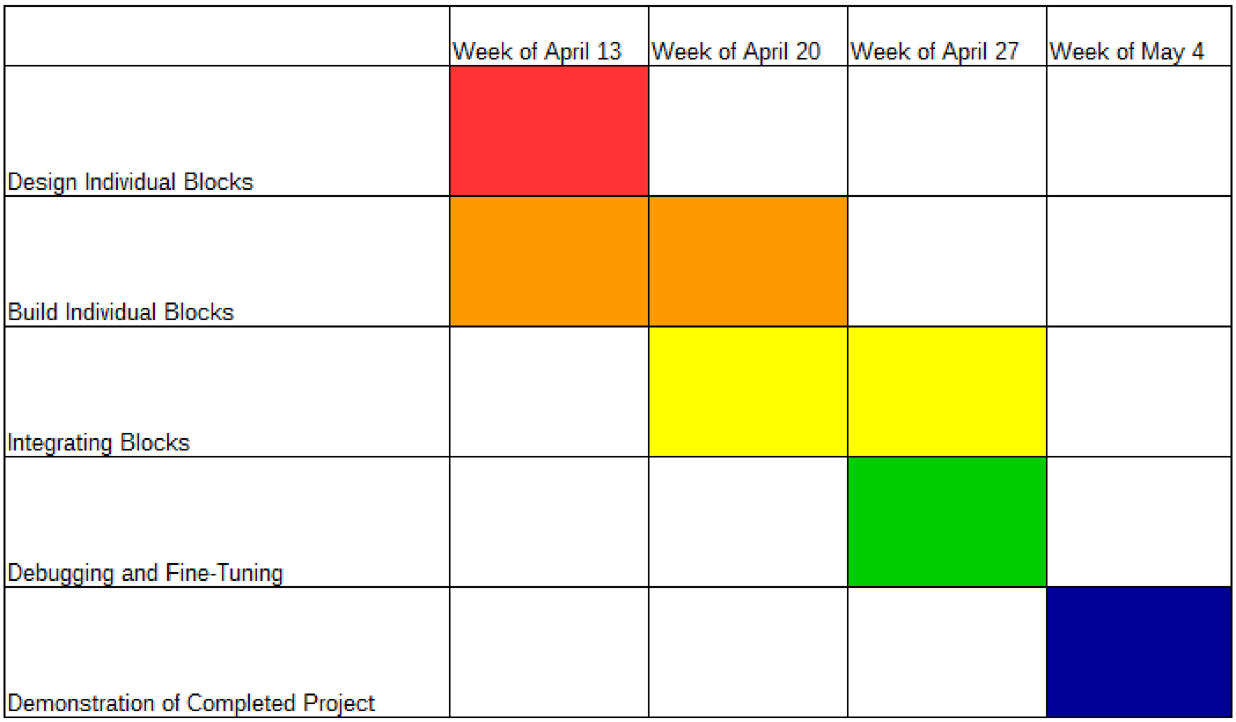

Figure 2: Gantt Chart of proposed schedule.

Conclusion:

The resulting system will be a complete TV transmission unit. Audio and video signals will be properly modulated, transmitted, and received. The receiving end will properly demodulate and display the signals on a TV unit. There are three risky/challenging features of the project: building a stable FM modulator circuit that avoids frequency drift, properly biasing the transmitting diode for linear transmission, and building an FM demodulation circuit with reliable performance and low signal distortion. With the techniques that we have learned in the class, we are confident that we can overcome the challenges described above in our pursuit of a successful NTSC transmission implementation.