SOFTWARE BASED VIDEO SIGNAL PROCESSING

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1 Software Radio Concept

A software radio [1] performs the basic modulation and demodulation steps in software. At the transmitter, waveforms are generated in software as samples and then a DAC converts the waveform into an analog waveform that can be upconverted if required and then transmitted. At the receiver, the downconverted I.F waveform is sampled and the samples are then analyzed by a code. The term "Software Radio" was coined by Joseph Mitola in 1991. A more recent concept is "Cognitive Radios", referring to a class of software radios that employ several complex algorithms in planning and learning radio etiquettes.

1.1 Advantages of Software Radio

The several advantages of Software Radio concept are listed below.

- As more and more functions are implemented in software, there is a greater flexibility in implementation and reconfigurability. As the programming environment for a PC is much more general than the programming environment for say DSP kits, there can be better code reuse and in turn reduced development time.
- More than one standard can be implemented on a single system. This allows mobile service providers to serve phones working on different standards at the same time using the same hardware. Also it is much more easier to reflect evolution in standards as this simply amounts to changing the software and not the hardware.
- Since both the demodulation and applications that use demodulated data (for example web browser, video player) are often implemented on the same hardware, the performance can be jointly optimized. This means that according to the need, the cycles saved in one operation can be utilized in another [2].
- The processing speeds are increasing fast and hence the power of software radio is expected to grow over time. This justifies the research thrust in this area.

1.2 Disadvantages

Several issues need to be sorted out before software radios can challenge the existing paradigms in radio. Some of them are listed below

- On a general purpose computing platform, the uncertainty in execution time and availability of resource can be a major consideration when it comes to reliability of the system.
- Even when sampled at I.F, there is a need for very high speed ADC's and data handling capacities. Such high speed ADC's are currently very expensive.

1.3 Some examples of Software Radios

A few software radios are being used for commercial and military purposes. They are listed below

- **SPEAK** The primary goal of the SpeakEasy project is to utilize programmable processing to emulate more than 10 existing military radios, operating in frequency bands between 2 and 200 MHz . Further, another design goal was to be able to easily incorporate new coding and modulation standards in the future, so that military communications can keep pace with advances in coding and modulation techniques [3] .
- **Vanu Inc.** Founded by an MIT graduate and his lab members, Vanu Inc. is the pioneer in Software Radio based cellular base station system provider. As part of the Mid-Tex Cellular radio access network, Vanu, Cambridge, Mass., installed a software radio GSM base station in DeLeon, Texas, in June 2003. The trial installation consisted of two base station transceivers (BTS) and a base station controller (BSC), with each running on an industry-standard HP ProLiant DL380 server with dual Intel Xeon 2.8 GHz processors. All of the signal processing, protocol processing, and BSC functionality was implemented as application-level software running on top of the Linux operating system. The BTS systems used the ADC Digivance Long Range Coverage Solution as an RF interface [4] .

2 GNU Radio

The GNU Radio project [5] was initiated and is currently maintained by Eric Blossom . In essence, GNU Radio is a collection of open source software that lets your computer construct and analyze radio waveforms with some basic R.F hardware and ADC/DAC kits. It is more popular in the open source community as a tool that lets you "hack" the electromagnetic spectrum. The hardware required is a Measurement Computing PCI DAS card, a sound card for listening to the output and in some the sound card can also act as a narrow band ADC for signal input (example AM transmission) . GNU Radio is currently available on Linux platform and apart from the GNU Radio core files, there is a driver for PCI DAS card, that can sample at 20 Msamples/sec. As of now GNU Radio team has been able to get FM and HDTV working with the software. FM can work in realtime but HDTV is much slower. Simultaneous reception of two FM stations is also possible.

3 Objective

Objective of the project is to study the GNU Radio platform and to build upon it a video decoding system that can decode PAL/NTSC composite video signal and display it on a computer screen. As GNU Radio is currently available on the Linux platform, the code development will also be Linux specific, using Linux drivers for display and other tasks. We propose to sample the composite video output of a CD Player using a Measurement Computing PCI DAS card [6] and then perform all the signal processing in software.

There are several advantages of demodulating the video signal in software. One advantage is that the PCI DAS card is a general I/O device that can be used for data acquisition in any application. Therefore we do not need any hardware specific to the application at hand. The same hardware (PCI DAS card) can be used for video signal demodulation at one time and for any other application at another time. The only thing specific to the application is the code. Thus we can use the same setup (PC + DAS) for any other application as well. Also we can include both the NTSC and PAL standard in the same software and switch from one to another in real time. Thus we have the benefit of runtime reconfigurability. Moreover depending upon the computational power available to us, we can fine tune our algorithms for better performance whenever resources allow us to.

3.1 Composite Video Signal Encoding and Decoding

The composite video signal (NTSC/PAL) combines the sync information, luminance and chroma information into one composite signal, that can be carried over a 75 Ohm coaxial cable. Two standards exist for encoding. NTSC is prevalent in US while PAL is prevalent in Europe and Asia. The difference lies in subcarrier frequencies, frame rates, resolution etc. The important thing to note about composite signal is that the RGB signal is transformed into intensity and chroma components. Moreover, in order to accommodate the chroma signal within the same bandwidth, the same is interleaved along with the intensity signal. To maintain backward compatibility with the existing monochrome television sets, the chroma information is mixed with the luminance information towards the higher frequency end of the bandwidth (see Fig. 3). Therefore at the receiver we need to filter out this luminance information from the chroma information and then convert this information back to RGB signals, which along with the extracted timing information will be used to display the video on screen. The encoding and decoding block diagrams are shown in Fig. 1 and Fig. 2. We propose to implement the decoding in software. Thus we propose to start with the sampled composite signal and then perform all the subsequent operations in software. We will use the GNU Radio software as the basic building block for

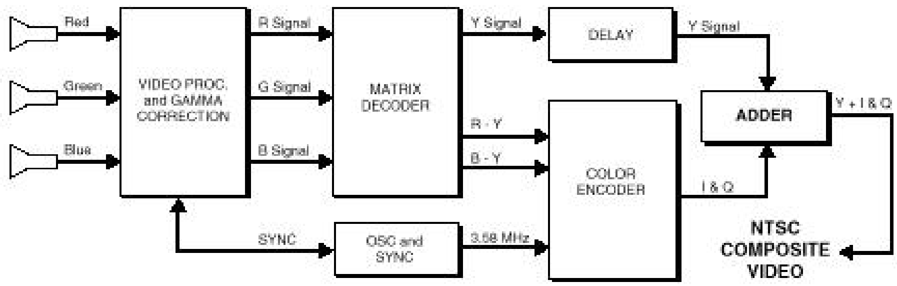

Figure 1: NTSC Encoding

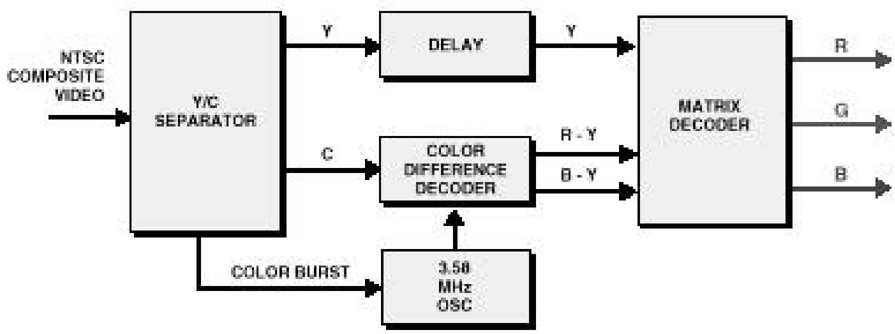

Figure 2: NTSC Decoding

implementing the various components such as the Y/C separator (comb filter) etc. Finally the RGB components will be used for displaying the frame. In the Fig.2, the Y anc C stand for Luminance and Chroma signals and RGB stand for Red, Green and Blue color signals [7] .

3.2 Challenges

The main challenge in composite signal decoding lies in separating the Y and C signals. Earlier television receivers used a notch filter, but following this approach, a significant amount of chroma information gets mixed with the luminance information and vice versa. This results in an effect known as the dot crawl. A better way is to use a single line comb filter which exploits the phase alternation of chroma signal in alternate lines to extract the Y signal. There are several variants of comb filter like 2 line, 3 line and 3D comb filters and they yield progressively better results at the cost of complexity. Another class of filter is adaptive comb filter. Thus the main challenge in decoding will be to build a comb filter which has good results and at the same time is practically implementable. The comb filter action on the composite signal is shown in Fig.3
.

4 Conclusions

This report introduces the basic concept of Software Defined Radios and some light is thrown on GNU Radio, an open source software for implementing software radio systems. A proposal for implementing a composite video decoding system based on GNU Radio has been made. Also some basic information is provided about the signal structure of composite video and some challenges in decoding are listed.

References

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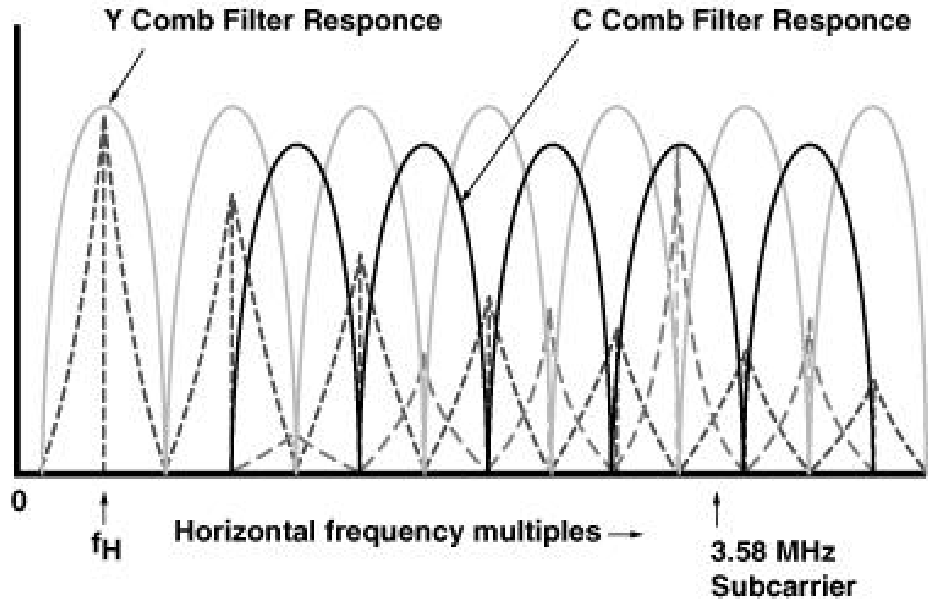

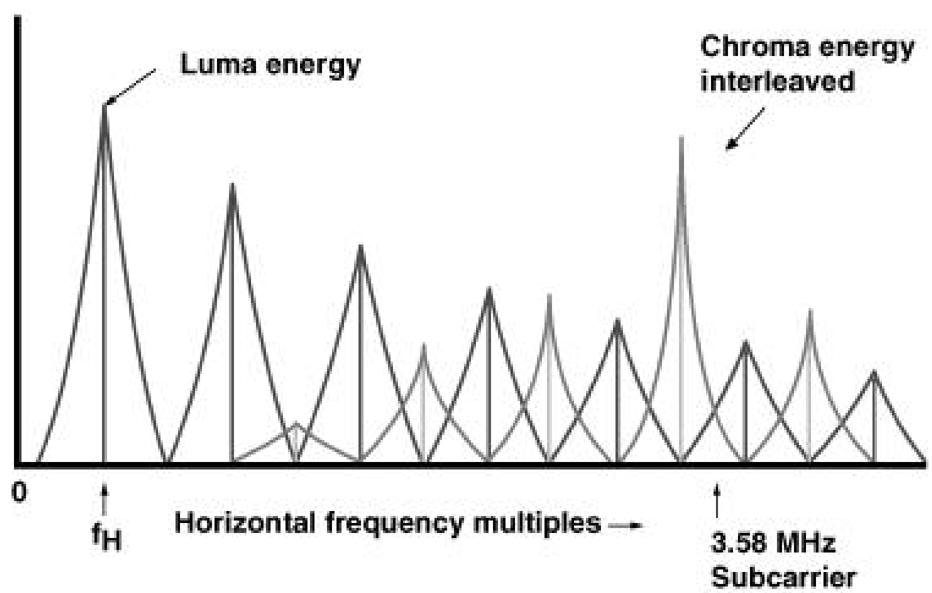

Figure 3: Comb Filter Action