KCSU: Going Digital
Second Semester Report
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Abstract

The equipment in which Colorado State University’s student-run radio station, KCSU, relies on for its broadcasting is in great need of an upgrade. Most of the equipment used to run the station is terribly outdated, while the world of radio at large is rapidly moving to superior broadcasting technology. KCSU wants to upgrade much of their equipment in order to stand side-by-side with the rest of the industry.

As a senior design team within the department of Electrical and Computer Engineering at Colorado State University, we have reached the midway point in our collaboration with KCSU with the goal of laying out plans for the upgrade. This team has used a ‘divide and conquer’ approach to learning all about radio stations and selecting specific products to recommend to KCSU for purchase. That is, we distributed the tasks among team members, who then brought their results back to the team for group discussion and decision.

We have learned all about the inner workings of radio stations in general and the technology necessary for their operation. Using this knowledge, we have made an exhaustive recommendation of equipment for KCSU to purchase given budget and user constraints.
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Chapter I – Introduction

Colorado State University is the proud home to a student-run radio station that reaches over 250,000 people. Broadcasting at 10,000 watts, KCSU is one of the largest college radio stations in the country. One of the defining characteristics of KCSU is the huge variety of programming that the station produces. As a student-fee supported radio station, KCSU has a great deal of freedom in its programming. According to the station’s mission statement, “The music is selected to appeal to the 18-34 year-old audience interested in a daring, innovative, cutting-edge sound” (www.kcsufm.com). It is this radio station in which we have invested ourselves as design engineers.

Thousands of radio stations are now moving to higher-end, digitally-based systems as the core of their studios. This new technology is allowing these stations all over the world to provide listeners with clearer, more reliable sound; all while simplifying and optimizing the inner workings of the studios themselves. KCSU is certainly not one wanting to be left behind. Currently, the majority of KCSU’s in-studio equipment is horribly outdated. So in an effort to change this, the station’s Broadcast Operations Manager, Mario Caballero, requested that a team of electrical engineering students be formed to consult with KCSU with the goal of laying out plans to upgrade most of the equipment used in the studio. This is a report of this design team’s results through collaborating with KCSU in accomplishing this task.

The project was divided in two parts corresponding to the two semesters during which we were engaged in it. During the first semester of the project, we focused on the goal of selecting the proper equipment to purchase for the station’s upgrade. During the second semester, we designed the studio layout, which meant determining just how every piece of equipment would be connected together, then developing an exhaustive wiring diagram of the two studios, plus selecting the proper furniture for an efficient studio setup.

At the start of the project, we set ourselves to the task of learning as much as possible about the operation of radio stations in general and specifically KCSU. We immersed ourselves in radio news magazines and papers, perused hundreds of websites pertinent to the field and even shadowed a KCSU disc jockey, all in attempt to gain a deep understanding of the inner workings of this radio station. We did this because we understood, as a consulting design team, that we would only be able to effectively make decisions for the benefit of KCSU if we were expertly knowledgeable about the world of radio.

With our priority list in hand, it became our goal to actually go about selecting specific products to recommend for purchase by KCSU. The radio industry is flooded with products for every imaginable purpose. Due to the daunting nature of the task, we chose to split the project up into manageable sizes by assigning each member of the team one type of product at a time to research.
and then make a recommendation to the rest of the team as to which specific product to buy. Chapter II is a summary of each product chosen and our reasons for choosing it, specifically.

Once all the products were selected, our task became to determine how they would all be connected together to form a working radio station. Section 4.19 discusses all the wiring for the new studio design in great detail. We were also required to iron out a great deal of details to finalize our proposal.

This report is, therefore, a review of our steps during two semesters as a consulting design team for KCSU. Our mission was to aid KCSU in developing a plan for upgrading much of their equipment to current standards. Often, this means choosing devices that process signals digitally, rather than in the analog domain. We therefore declare that KCSU is “going digital”.

Chapter II - How A Radio Station Works

At the beginning of our project, we were not completely sure how a radio station got from the studio to the antenna onto our FM radio receivers. Mario Caballero gave us a lot of insight when he drew up a diagram (refer to appendix C) of all the interconnection components at the KCSU radio station. It was very helpful in showing how the components are connected together and how the radio signal is transmitted from beginning to end. There were many radio components that we were not aware of that existed in a radio station and how exactly each one functioned and connected with the other components. Even after extensive research on many of the radio components and knowledge of the interconnecting parts, we were still unclear as to how each component worked with the others. We were able to go on an educational trip to the radio antenna tower for KCSU and intimately see how the radio tower received and sent the radio signal. We were also privileged to visit another radio station, that already went digital, and gain a better understanding of how a radio station operates.

There are many elements involved in how a radio station functions. In regards to turning an outdated radio station into a digital radio station, our focus will be on how the components that make a radio station operate together. It begins at the audio console, where the DJ or automation system controls what goes into the audio console and what is sent out. The audio console is the heart of many input components, which includes microphones, telephones, automation software, CD players, a phone codec, and turntables. Once the audio console is set with the desired mix of the various inputs, the analog or digital signals are sent to the equipment rack. The signal is first sent through an emergency alert system which will cut off the signal if there is an emergency alert signal which can be triggered by various authorities. It is then passed to an audio cross point switch which determines if the signal should be sent to the main air room or to the production room. Next, the audio processor processes and cleans up the signal to protect from over modulation that would damage the studio to transmitter link (STL). Note that the STL is used only when the transmitter for the station is not located at the station. STL is a way to get the signal out to the transmitter. The STL transmitter’s hardware takes the signal and modulates it, to ~950 MHz in many cases, and then sends it to the STL antenna which sends the microwave signal to the receiving antenna at the large radio transmitter site. The STL antenna focuses the signal in one direction only, pointing it directly to the receiver. The STL receiver then picks up this signal and sends it to an audio processor which makes the signal stereo and determines the
equalization which is specified by the user inputs of the audio processor. The signal is then passed to an FM exciter which amplifies the signal. Next, the FM transmitter modulates the signal to the appropriate frequency for listeners to dial in on their receivers. The FM transmitter takes this signal and sends it through the transmission line to the radio antenna. Different radio stations have different values of effective radiated power. KCSU’s antenna broadcasts at 10kW of effective radiated power. This effective radiated power makes KCSU’s radio signal available to all of Fort Collins and many surrounding areas. Residents who have a working FM radio receiver are able to hear all of KCSU’s great entertainment and sporting event coverage at 90.5MHz.

Chapter III - Education

3.1 - Initial Education

The implementation of the KCSU project for moving from analog to digital involves both an educational background and personal efforts of our group. This education can be explained by the allocation of resources such as web, vendors, catalogs etc., visiting radio stations and transmission sites, and the use of our educational background. As of personal efforts, we’re talking about the time and dedication we put into work.

On August 27, we had our first meeting with the KSCU Operations Manager, Mario Caballaro, to talk about the possible ways of implementing the KCSU project. From Mario’s input and needs, we gained an idea of how we were going to approach this work. We requested the block diagram of the current radio station (Appendix C). After that, we had a group meeting to discuss the related issues, how to start it, and what to do next. We decided to start doing some research on the internet about digital equipment for a radio station, to learn how they work, and how beneficial they can be for the radio station. Not only did we search on the internet, but we also extended research to catalog reading and calling vendors of different brands.

This work was reported weekly in our meetings and the personal work was shared among us. The need for that was to get an insight of all the components before we started thinking about the appropriate devices and the costs related. This was also a learning tool for all of us because we were able to exchange ideas and improve our work plan. Along with these works, we sometimes met with Mario to talk about the progress and clarify some needs.

All of this work could not be done without some schooling background. Going through some device specifications, we have to be able to understand some technical terms used such as voltage, current, power, decibels etc. Understanding these was very important to determine the difference between the analog and digital devices. An example was to determine the negative decibel number that an analog device takes versus digital to perform some functions.

In addition, we had consulted with an expert and also visited sites such as radio stations and a transmission site. On October 8th, we went to visit the KCSU transmission site. This trip was made by our senior design group, our advisor Dr. Rockey Luo, and Mario Caballero. On site we learned how the transmitter processes signals, how it is set up, and how much power it takes to process the signals.
On October 29th, we made a visit to KUNC in Greeley, a station that has recently gone digital. There, we met with Larry Selzle, the broadcast engineer, who gave us a tour of the radio station and explained how it operates. Larry was able to answer all of our questions related to the conversion to a digital radio station. It was a very satisfactory visit because we learned many new things that we didn’t know. Some examples were the soundproofing of the production room and some thoughts on touch screens for controlling the audio console and that they are limited in functionality and therefore not recommended.

This educational background gave us insight on how we were going to implement this project. Moreover, time efforts and dedication were also key to come to the end of this project. The weekly searches and meetings exemplified our overall dedication to this work.

3.2 - DJ Interviews

As a team, we thought that getting feedback from the DJ’s would help us significantly in the redesign of KCSU. We brainstormed many questions which ranged from what the DJs liked best, what they would want to keep the same, to their opinion about a future layout of the rooms. We were able to interview several DJs for KCSU who have been working as DJs there for more than three semesters. All of them had a lot of information to share and both had many similar answers, which helped us dramatically in planning our new layouts of the rooms. Each DJ played different instruments which they said they would like to play live over the air. They both wanted an area for a band to come into the radio station and record their music live, they both also mentioned about how the space was extremely limited. One of the DJs brought up the fact that the monitor and microphone stands got in the way of the DJ and interviewees but that they liked the "floating" monitors, which he could move around when he needed. A DJ also said that in the production room there was not much space behind the desk when there was more than one person, which was often the case in the production room because multiple DJs would be there editing sound tracks while another DJ was working with the automation system. We took these suggestions into consideration as can be noticed in the new layouts of the rooms (Appendix G).

Chapter IV – Components

4.1 Audio Consoles

The heart of a radio studio is the audio console. This is where most manipulating and mixing between various devices occurs. An audio console is in a sense a glorified keyboard that is capable of managing various inputs and sending them out to the transmitter as one mix. A few of the different components that plug into the audio console include CD players, phone hybrids, microphones, automation equipment, and turntables. An audio console is the device that has multiple faders; this is how most people think of it.

The current equipment is very old, nearly ten years. As part of ‘going digital’, this is a big piece to upgrade because even if all the equipment is digital but the audio console is analog, there is a loss of signal that occurs that could be avoided otherwise. The console used currently in both studios is the Airwave 12. It has been a very reliable board and will be upgraded because of its
We started out by narrowing down a list of audio console companies that we found in a Radioworld magazine. We decided on four companies to strongly consider: Wheatstone, Harris, Axia, and SAS. A few of the big guiding principles we followed were quality and strength of brand name, simplicity of the console, and ease of installation. It was important that the console not be too complicated as new DJ’s are added yearly and it is important to have a setup that offers valuable experience to persons that have little or no radio experience. We called and emailed several of these companies and pursued quotes on different system topologies offered. We decided to go with Wheatstone and the E-squared system topology (Appendix G). The Wheatstone boards are very simple to use and yet very powerful. The Evolution series boards are fully digital and are able to accept both audio and digital inputs via the various modules that are connected to the board using a network switch.

4.2 - Audio Processors

An audio processor is a rack-mounted piece of equipment which takes an incoming signal and optimizes it according to the user’s specifications. Normal radio stations (KSCU included) have two audio processors between the DJ room and the antenna. The first of these in the chain has a very simple purpose: to perform automatic gain control and limiting in order to protect the STL line (microwave transmitter) from receiving a signal which might damage it. The automatic gain control also serves to make the quiet parts of the program louder and vice versa, thus regulating the overall volume of the signal.

The second processor lives out at the transmitter site near the Foothills campus, this processor serves as the final step in signal processing prior to broadcasting. This processor performs the final EQ, compression, and other DSP actions to make the signal sound as ‘good’ as possible before it is sent to the air. Of course, ‘good’ is a subjective concept to be determined by the user.

KCSU’s transmitter site processor is an Orban Optimod FM 8400 which we determined, along with the advice of Mario, was still new enough to not need replacement. Buying a new processor for the transmitter site would cost about $9,000, an expense that we felt would be wise to not pursue since the current transmitter site processor is not actually outdated. In essence KCSU would be paying a lot of money for a product that has hardly any advantage over the current one.

However, the current studio-side processor, an Orban Optimod 8200, is quite old and does need to be replaced. Our research led us to choose to replace this processor with an Omnia One processor. A phone conversation with a representative from Omnia revealed that the Omnia One is Omnia’s highest selling audio processor. It is popular for its small size while still having lots of processing power. The other product we considered was the Orban Optimod 6300, which has comparable features for our purposes, but costs nearly twice as much. A spec that we looked at between the two products was their analog and digital inputs and outputs, which were not much different in terms of connection types and their digital output levels.
4.3 - Band/Patch Bay

The north end of the on air studio is currently used for storage of some of KCSU’s miscellaneous equipment. In the new design of this studio, we propose that this space be used for live bands to perform on the air. This would mean removing the cabinets and cleaning up the area so that the surrounding walls can be treated with sound foam.

We recommend that an XLR patch bay be used to make for easy access to the inputs of the Wheatstone squares. This will allow musicians and DJs to plug in instruments, etc. into the system without having to scramble around behind the racks looking for the inputs. The Hosa PDR-369 is a good XLR patch bay, though there are many other options.

4.4 - Cabling

Certainly any studio of this size will need a plethora of different cables running around, to be used for a wide variety of tasks. It is our recommendation that all audio cables be purchased from sweetwater.com. Sweetwater has their own brand of cables manufactured by ProCo which are very good quality. But if their cables do break for any reason (and they mean any reason) Sweetwater will replace them for free. This policy even includes the more expensive cables such as the DB-25 cables necessary for our studios.

For the RJ-45 inputs and outputs of the Wheatstone squares, specific adapters made by StudioHub+ are necessary.

For the CAT6 cable, it is our recommendation that a spool of bulk CAT6 cable be purchased, then cut to custom lengths and connectors attached at either end of the lengths. This will be the cheapest solution, and will eliminate coils of excess CAT6 cable from cluttering the rear of the racks in the studios.

More specific information regarding what kinds of cables are needed is detailed in the wiring diagram section. This diagram, however, does not include any information on cable length. It was decided that the calculation of the cable lengths was not desirable at this time, since it would be smarter not to purchase the XLR cables, etc. until all the new furniture and equipment has been purchased and set in place. Then a much more accurate estimation of necessary cable lengths can be made.

4.5 - Desk Configuration

One of our main goals for our second semester of design was to investigate and develop a plan not just for new furniture but also for the placement of it. This was a much more involved process than simply picking out some colors and materials. To be able to get the best perspective on different configurations we put extensive time into constructing 3D models of each of the studios using Google Sketch-Up which are included in Appendix G. We obtained measurements
and locations of furniture, pillars, cabinets, windows, equipment, and walls to get the best 3D representation possible of the studios.

One task that could have been daunting but turned out to be quite easy was deciding on a company to choose for our furniture production. We received several recommendations for a company named Arrakis that is nearby in Loveland. We were able to set up a team visit to the company to see their operation, talk with their representatives, and get to see sample furniture. This company is unique over a simple cabinet shop because Arrakis specializes in radio station furniture. This means that they take into consideration all of the characteristics standard in a radio station furniture as well as design their furniture with specific features. Such features include allowing for the desks to function as equipment racks and also including pods that are placed on top of the desks for CD players.

The company has several different furniture configurations that are ‘standard’ that we were able to use to construct desks to put in our Google Sketch-Up models. We have requested slight modifications like removing some of the equipment rack space to allow for me leg room for interviewees.

Currently the on air studio at KCSU has a desk configuration that contributes to a very unprofessional environment in the studio. Many people who enter the room quickly find themselves crowding the DJ as he or she tries to work. Another difficulty in the current on air room is that the space for interviewees is very limited. There is a very small space between the desk and the wall that is not suited well for interviews. Also, because of the limited walkway and the shape of the desk, the space on the far wall near the three cabinets is minimally usable. The current production room also implements an ‘L’ shaped desk. The main concern that we had in for this room, being that it is catered toward interviews, is that with all of the equipment situated on top of the desk and also the unnecessary depth of the desk, it is difficult for the DJ to have an unobstructed interaction with the interviewees. The ‘L’ shape of the desk that is near the wall also tends to become a clutter area because of its location.

After designing and reviewing several 3D model configurations, we decided on the configurations shown in Appendix G. Concerns that we maintained while choosing between configurations were the following. For both studios, as a matter of safety as well as approachability, we wanted to ensure that a DJ in each studio would have a direct line of sight to the door of their studio. Because of acoustics, we needed to put the DJ in a place that would allow perpendicular placement of the audio console with regard to the studio monitors. We strived to create an environment that would not get as cluttered with stuff or people and would also be inviting to interviewees that came into the studio. There are definitely pros and cons to all of the different configurations that we debated but we think that what we have proposed will be the better of all of the options.

4. 6 - Emergency Alert System

By law, every radio station is required to have Emergency Alert System (EAS) equipment in its output chain. This equipment lies inactive until it receives an emergency signal from the Federal communications commission (FCC). When this happens, the EAS equipment will automatically
interrupt the normal station programming to play the alert, warning listeners of dangerous weather, a homeland security alert, etc.

There are many vendors that are certified to produce EAS equipment, including TFT, the brand that KCSU currently uses. The current TFT EAS equipment has three components, the EAS 930A Receiver, the EAS 911 Encoder/Decoder, and the EAS 940A Transmitter/Program Interrupt Unit. Unsurprisingly, EAS technology does not change very rapidly, so even though KCSU purchased this equipment many years ago, a quick look at the TFT website will reveal that these units are still their standard products.

However, since we are ‘going digital’ it is desired that the output chain be kept entirely in the AES/EBU digital domain. KCSU’s current STL system already has this digital capability, as does the Omnia One we are proposing as the new studio-side processor. So then, with the new Wheatstone system, this EAS equipment is the only link in the chain that does not support AES/EBU input and output. Fortunately, KCSU would only have to replace one of the three TFT EAS units to allow for digital operation. The EAS 940A Transmitter/Program Interrupt Unit would need to be replaced with the EAS 619 Digital Insertion Unit. This will allow for KCSU’s program output signal to remain digital domain all the way through to the STL.

4.7 - FM monitors

An FM monitor is used to allow the DJ and other station staff to keep track of the quality of the signal coming off the air. The unit will allow for the user to monitor the accuracy of the frequency modulation visually in real time as well as provide audio outputs to send to studio monitors for listening to the audible signal.

This is a rather small product field in that there are simply not very many companies that make products for this purpose, so selection was rather easy. The Inovonics Model 531 was selected for its small size, modern design and use of LED indicator lights, which are easier to read than quick bouncing needles. The accurate LED indicator lights monitored total modulation, stereo program audio, subcarrier injection, incidental AM noise and signal strength and multipath. This FM monitor unit has more features than we feel that KCSU needs (like the ability to easily monitor several competitor radio stations as well), but other products with fewer features were still similarly priced, or even higher.

4.8 - ISDN

Integrated Services Digital Network (ISDN) started with using the analog cable by dividing it to two windows to send two signals in the same time without interference between the signals for quality service. However, in the meantime we are using a special cable for ISDN for adding more specification and complexity for better convenience. This way, sending back and forth more than two signals, gives us higher time efficiency for executing multiple tasks simultaneously. Also, keep in mind that we are using a digital signal which has a higher efficiency in communication than analog signals. The ISDN cable has the ability to transfer multiple signals with lower interference between the signals than the regular line phone. In addition, we can still detect the digital signals with less probability of errors than analog signals.
In more detail, ISDN works like a switch end-to-end that transmits voice, data, and video simultaneously. By using the duplex digital channel, one can use 128 to 512 kbps for high speed data applications for personal use which is referred to as Basic Rate Interface (BRI). On the other hand, you can use 23 channels to provide 1544 kbps for business use which is referred to as Primary Rate Interface (PRI).

Since ISDN is used for the transmission of the digitization signal over a telephone network, it has a lot of applications and configurations. Here we are concerned about how ISDN has been used in broadcasting. First, the service is provided from a phone company and the ISDN machines are in the end-to-end digital network. ISDN is one way of interviewing outside of the studio as in sports events. The announcer at the offsite location has one end and the studio has the other end. The ISDN machine has an input which can be set in two modes, microphone or line mode. The ISDN device takes the input and codes it to send it through a phone line to the studio and from the studio to the offsite location. However, in the studio the interviewer can equalize the levels of the input to match studio production levels. This helps the listeners when it gets broadcasted to listen to it normally without overlapping other signals or getting covered by other signals. Also, this way we get a fraction of a delay which is acceptable in broadcasting. In addition, in the studio we can modify the signal if we connect the output of the ISDN to the audio console which is always the case.

Looking through the feature we gain from using ISDN makes it an important element for broadcasting and as a backup plan for a radio station. However, in our case, the ISDN we have in KCSU is four years old and is still compatible to the current technology. Also, the ones in the market do not have significant features we need in addition to what we already have. We were directed by Mario that we would not update the ISDN so this is not included in the budget although we have learned about it and researched it.

<table>
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<th>Features</th>
<th>FeaturesZephyr Xstream (9402-0000)</th>
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</table>
4.9 - LCD Monitors

Both the production room and on air room require three LCD computer monitors. One is used for the automation computer, one for the Wheatstone control surface, and one for a general use computer connected to the internet.

In the production room, this general use computer has Adobe Audition installed for audio editing and production purposes. We feel it would be very convenient if this audio editing computer had a dual monitor setup. However, this would mean having four monitors on the desk in the production room. So depending on budget and desk space it may be more desirable to only have a single monitor for this computer.

We recommend using 17 inch LCD monitors. We feel that this is a nice medium size, large enough to be very usable, but not so large as to be ridiculous. And, of course, matching monitors would be best for the room aesthetics.

4.10 – Microphones

A quality microphone is a product that tends not to become outdated. For example, the industry standard vocal microphone for live music is the Shure SM58. This microphone was first adopted by musicians in 1966 and has been the most popular vocal microphone in the world ever since. We approached this part of the project bearing this in mind.

Currently, KCSU uses one EV RE20 in each studio for the DJ’s voice and three EV RE27 microphones in each studio for interviewees. By the instruction of Mario, we’ve added six RE20 microphones to the budget to replace the RE27s in both studios, thus making all the microphones in both studios RE20s. The RE27 is, arguably, a superior microphone to the RE20 for its crisper high end sound that is closer to the way a condenser microphone would sound even though this is a dynamic microphone. Note the frequency response curves in Appendix E. The RE27 has a boost in the high frequencies, whereas the RE20 remains fairly flat all the way through the spectrum. Mario feels that the extra high frequencies added by the RE27 are unnecessary since the other audio processing in the system already increases high frequencies.

4.11 - Microphone Preamps

Microphone preamps receive an incoming signal from the microphone, process the signal slightly, adding presence, warmth, and gain to the sound, then output the signal into the radio console, or, in our case, the Wheatstone Squares. This ultimately results in a better sounding signal for listeners.

Microphone preamps vary widely in cost, from less than $100 to more than $8,000 for a single channel preamp. Our application requires at least 6 channels of preamps in each studio. Through product research, we discovered that one of the most popular preamps is the PreSonus BlueTube DP. This two-channel, tube-based preamp is popular for its high-fidelity sound and low cost, only $229.95.
However, after this research was done, we learned that Wheatstone offers to include an 8-channel preamp along with the Wheatstone system. This is the Focusrite OctoPre, a preamp with many more features than the PreSonus we had chosen from earlier research. It boasts Class A discrete transistor-based preamps, built in compressors/limiters on every channel, digital outputs up to 24bit and 96kHz, among other features, all in a 1U, 19inch rack mountable chassis.

Per channel, this preamp is essentially the same price as the PreSonus unit described above. Since it is recommended by Wheatstone for use with their system and has more features, we feel that this would be the best choice for use by KSCU.

4.12 - Phone Hybrid

The Telephone hybrid (sometimes called a Telephone Balance Unit) is a relatively simple electronic device used to connect a telephone line to the studio audio circuit. These are normally used in a radio station to connect callers into the air chain so that conversation may be broadcast. In a communication system, the volume difference between a caller and receiver or a person trying to record a conversation was a concern that spurred the invention of the phone hybrid. It was first an analog system, which was a box by itself called an equalizer and has the capability to modify the signal manually as the person feels comfortable to broadcast it. This amount of changing was measured in decibels (www.audiotheater.com).

The analog hybrid has some limitations because it cannot cancel out the entire sender’s audio as well as noise. Also, with the limitation in amount of information that can be sent through the regular phone line, engineers thought of a better way of solving this problem. Hence, the design of sophisticated Digital phone hybrid can be used to cancel out the entire sender’s audio. KCSU is currently using an analog hybrid, but due to this device limitation in its function, Mario Caballaro, the KCSU manager is requesting to switch to a digital hybrid.

In doing so, we tried to choose a couple of products out of what is available in the market. It was based on the purpose of the project as a college radio station and in the daily bases in the studio we narrowed our choices between the Telos and the Comrex phone hybrid. The inputs we got from the people in the studio were that they just use it when there is sport match to do live broadcasting. For example, if they want to broadcast a match in Boulder stadium, KCSU uses the ISDN line. Also, KCSU does not do many live interviews. They usually record them using the phone hybrid applications and broadcast it afterwards mainly for controlling what they broadcast. So the purpose of this device is to give a sufficient and reliable interaction with the phone line. We looked at what is more popular and found Telos and Comrex. KCSU is using Telos product for the ISDN but their equipment for phone hybrid is more sophisticated and is for big radio stations. Their equipment is capable of interacting with multiple lines. Telos is a high end company and you need to buy a set of three devices for the system to function properly. On the other hand, Comrex has the option of a single line interaction which fits it in a single rack space. It is a simple piece of equipment, easy to use by students, easy to train on, provides sufficient functionality like isolating the phone line from the studio until it is needed, equalizing the signal to a certain level, etc. Also, going with the Comrex phone hybrid saves us more than $1180 in budget, considering we need to for the project.
4.13 - Portable People Meter (PPM)

Due to new technology as well as influence from marketers, radio stations desire to have an accurate picture of their listener base. That is, they want to know how many people of different demographics are listening to their stations. This information affects their business with advertisers, their expansion in certain regions, etc. Until recently, the dominant method of obtaining such information meant that participants had to log their time listening to different stations on paper, then report on their listening habits at the end of the survey period. However, this method turns out to be fairly inaccurate since the participants don’t always log their listening time correctly. For example, a participant may think that they listened to a certain local station for only 5 minutes, when in fact it was more like 20 minutes. This ‘old fashioned’ system is entirely based on what the participants think their behaviors are, as opposed to what they really are, so unreliable results are inevitable.

Recently, technology has emerged that allows a more accurate measurement of listeners’ habits. The Portable People Meter (PPM) from Arbitron records information such as which stations people listen to, where they are when they listen, and what time of day that they listen. The PPM has been designed to better fit participants’ schedules. It also provides a much more accurate picture of their listening habits. The meter is designed to be worn around the participants’ neck and detect a signal from surrounding radios.

Radio stations that want to use the system must be registered with the FCC and with Arbitron. The station transmits an inaudible signal hidden inside their normal broadcasted signal that the meters worn around participants’ necks can detect. This means that the participants don’t need to keep track of what they listen to; they simply need to wear the devices for a certain amount of time daily. If a participant listens to a radio station for a five minutes in a fifteen minute block, that station gets credit for the listener’s time. Arbitron provides the radio station with the statistics upon request. They do hourly, daily, weekly, and monthly surveys. Arbitron will send the station the necessary equipment without charge, but they charge for each time they send statistics to the station.

KCSU is supported by student fees and does not play advertisements as a ‘normal’ station would, therefore the need for such a system is minimal since KCSU does not ‘compete’ with other stations in the traditional sense. After a consulting with Mr. Mario we decided not to purchase the PPM service, but we do see the research we have done on the subject as very valuable.

4.14 - RDS

RDS, an abbreviation for ‘Radio Data System’, allows song and artist information to be digitally encoded and transmitted along with the normal radio signal. Listeners with radio receivers capable of receiving this data will be able to see the song information on the LCD screens of their receivers. Typically, the transmitted data consists of song title and artist information, but may extend to whatever a DJ wishes.
Inovonics makes two models of RDS units that will work for adding this capability to KCSU. One is the RDS 720 and the other is the RDS 730. The unit will reside at the transmitter site and be connected between the FM stereo generator and the FM exciter.

The RDS unit can be programmed to send out a generic, unchanging data signal to listeners, such as one that reads, “You’re Listening to KCSU”. Or it can also display current song information, provided it has a communication link with the automation system in the studio. This could be a TCP/IP connection, or a one-way data link in the STL.

We assume there is no internet connection available at the transmitter site, and we don’t know for sure if the current STL system is capable of transmitting this data, so at this time we cannot say for sure whether or not KCSU will be able to use the RDS to display current song information. But the generic message will certainly work.

If an internet connection is available at the transmitter, and the STL cannot be used to transmit the RDS data, then we recommend KCSU purchase the RDS 730. If it is found that the STL can transmit the RDS data from the studio to the transmitter, then we recommend that KCSU purchase the Inovonics RDS 720. The 720 model does not have TCP/IP capability (and is about $500 cheaper), but if the STL can transmit the data, the TCP/IP capability would not be necessary.

4.15 - Software

The major pieces of software that are used are Adobe Audition, Broadcast Electronics Vault Express, Audacity, and RCS Linker and Selector. While most of the radio station can be operated without any computers, the benefit of these programs is largely for automation and also for editing and mixing sound clips and interviews. Let’s take a look at what each piece of software does and then from there we will discuss the options and proposed updates we will make.

4.15.1 - Adobe Audition

Adobe Audition is a powerful audio manipulation software. It can be used for recording, mixing, editing, and mastering. This is the most used tools to edit audio at KCSU. About every option one would think of to do with audio clips can be done with this program. Multiple tracks can be used. Each track can be equalized. There are options to add in certain sound effects and digital musical instruments. A common occurrence is to record an interview and then use this program to edit the interview and add in a background track. KCSU also does small commercials to advertise certain events and businesses. This program would be used to create those commercials. The program can be used to batch process or to manipulate multiple files in the same way. It can also be used to slow down or speed up audio.

Currently KCSU has a license for version 2.0. We are proposing an upgrade to version 3.0. This would provide the newest features as well as the latest software support and patches to ensure reliability and maximize productivity.
4.15.2 - Broadcast Electronics Vault Express

This is the automation software that is used. While KCSU does not do as much automation as most radio stations, it still takes advantage of this tool to be able to arrange a playlist of songs and audio clips. Automation software is used to configure exactly how a radio show will go and is able to be executed automatically at a later time. This is especially convenient to be able to have a radio broadcast throughout the night while the DJ can be out of the studio. This software takes a text file and from there goes to the database of audio and constructs a playlist as dictated by the DJ.

After a discussion with a representative from Broadcast Electronics we determined that we do not have the newest version but the company will provide free updates. As all of the equipment updates take place the update to the newest version of Vault Express will also take place.

4.15.3 – Audacity

This is a piece of free software that is similar to Adobe Audition but with fewer features. It can be used to manipulate audio and add together tracks and make equalization adjustments. The newest version of the software will be installed.

4.15.4 - RCS Linker and Selector

Selector is a music scheduling program. It can be used to rip songs, or convert them into a format that allows them to be stored on a hard drive rather than on a CD. This is beneficial because a database can be created to store all of the music and is used with the automation software. It would not be possible to do the automation without this ability, to rip songs onto a hard drive. Selector is used to quickly browse the database of audio. It is also very powerful in that it helps in orchestrating song order based on the length of different audio clips and songs.

Linker is a scheduler. It is used for scheduling non-music files such as jingles, promos, and public service announcements. It works along with Selector.

The radio station will continue to use this software. We will recommend that the newest updates of the software be installed upon installation of the new hardware.

4.16 - Sound Treatment

The purpose of having sound proofing material in a radio station studio is to absorb sound waves that would otherwise bounce off of the walls and back into the microphones. In general, the goal is to create a studio which is acoustically ‘dead’, that is, sound waves will not readily reflect off of surfaces.

KCSU currently has soundproofing around the interiors of their on air studio and production studio. These soundproofing materials are old and of lower quality. We contacted a local
representative from the sound treatment company, Auralex Acoustics, who came to KCSU’s studios to investigate the current sound treatment material. He gave two quotes for new sound treatment material. The more expensive of these had many high quality products that would make KCSU sound amazing and have a more professional look. The less expensive package consisted of lower cost materials that would still make the KCSU studios sound much better and have a more professional environment, but perhaps not quite as much. The major differences between the two packages were that the more expensive one included Auralex Elite ProPanels, which are fabric-covered, acoustic absorptive panels designed to absorb slap and flutter echoes, providing a more pleasing and accurate listening environment, whereas the less expensive package included Auralex Studio Wedge panels, which effectively kill standing waves, flutter echoes, and can effectively tame the full frequency bandwidth in virtually any room. Both of the packages include a Screen 6 Cloud Diffuser kit which will be used for the new band area. The Screen 6 Cloud Diffuser kit takes the energy from the monitors or the sound that you’re trying to capture and spreads it out, removing the discrete reflection but keeping its contribution to the room’s reverberant tail.

We have included the less expensive of the two options in the budget, but both can be seen explicitly in the attached quote from Auralex. It is important to note also that the Screen 6 Cloud Diffusion kit is not absolutely necessary, but would especially improve the sound from the live bands dramatically.

4.17 - STL

Radio stations that do not have a transmission antenna in a different location do not have to transmit the signal to an offsite location. The signal in that case can simply be sent through a cable to the antenna perhaps situated just outside the station. However, for the radio stations that have their antenna far away from the studio they need to transmit the signal to the antenna which is typically located at a better location in order to best transmit to the listening audience. One way to send the signal is using the studio to transmitter link (STL) system. This system begins by taking the signal as either analog or digital and equalizing it to a certain level and then sends it to a relatively small antenna that shoots a microwave signal straight to the broadcasting antenna. It can transmit the signal from a few miles to hundreds of miles.

In KCSU’s case, the STL transmitter is used to shoot the signal straight to the antenna at Horsetooth Mountain. KCSU is using the Harris STL transmitter that takes the signal and samples it at a frequency of 44.1 KHz and transmits it with a modulation frequency at 950MHz to the antenna. There is an STL receiver at the antenna site that demodulates the signal to be processed and sends it through the main antenna at the desired frequency which is 90.5MHz. After talking to Mario and considering the research that we did in the STL transmitter we found that the STL receiver is still fairly new and has an AES/EBU input which takes digital input before it send it to the antenna. The newest STLS in the market do not have many features that we would need in our radio station. Also, due to the high cost for it we agreed with Mario to not buy a new one. (Some information provided from nicomusa.com)
4.18 - Studio Monitors

The world of studio monitors is a difficult one to wade through due to the massive number of different products available. Currently, KCSU uses a pair of JBL 4410a speakers (8-ohms, 10 inch woofer, 100 watts max output) mounted in each studio powered by an EV7100 amplifier. The amplifier provides these speakers with 75 watts per channel.

In choosing a replacement for these we first decided to go with a self-powered set of monitors, thus eliminating the need for an external amplifier. Another advantage of self-powered monitors is that the amplifier is engineered to the exact specifications of the speaker it will be driving. That is, the amplifier and speaker are perfectly matched together. Ideally, we would also like to choose monitors with a woofer at least 8 inches in diameter to aid in reproducing low frequencies.

Those above constraints help to narrow the field of products significantly. After this narrowing, we selected products based on popularity ratings from other users, and company reputation.

Our primary selection is the Yamaha HS80M, biamplified for a total of 120 watts per speaker (75 LF, 45 HF), each with an 8 inch woofer. They also have basic room control EQ and frequency response switches on the rear panel. These are sold for $350 each for a total of $1400 for four (two per studio).

Our backup choice if the budget becomes tight is the M-Audio Studiophile BX8a, also biamplified for a total of 130 watts per speaker (70 LF, 60 HF), and also with an 8 inch woofer. Unlike the Yamaha speakers, these do not have any EQ control. They are sold for $500 per pair for a total of $1000 to equip both studios.

4.19 - Wiring Diagram

Appendix D shows the wiring diagram for the proposed studio layout. Note that the two sides of the diagram represent the two studios. The direction of the arrows indicates the direction of signal flow in the cables. The color of the lines indicates the type of cable needed for the connection.

Boxes shaded in grey are the components of the Wheatstone system. This includes the gigabit switch (the electrical center of the system), the two control surfaces, the I/O squares, the microphone preamps and the mix engines. With the exception of the preamps, all of these components will be connected to the gigabit switch via CAT6 cable. The mic preamps can be connected straight into the squares via a DB-25 cable. The audio from the computers can be put on the network by connecting them straight to the gigabit switch once the audio over IP driver is installed (SPI-AoIP on the quote).

Note that each room has two squares, one model 88a and one model 88ad. The 88a has 16 mono analog inputs (or 8 stereo, or any combination thereof) and 16 mono analog outputs (or 8 stereo, or any combination thereof). The 88ad has 8 mono analog inputs and 8 mono analog outputs as well as 8 digital inputs and 8 digital outputs (the digital ins and outs are in the AES standard,
which is a two-channel format, so it can be said that the 88ad has 4 AES inputs and 4 AES outputs).

In the wiring diagram, one can see that the ISDN unit and the Digital Hybrids may be plugged into the AES inputs and outputs since they have AES capability. The mic preamps also have AES outputs, though for the sake of wiring simplicity we recommend using the analog DB-25 outs. If it is desired to use the digital outputs on the mic preamp, a special adapter such as this one (http://www.audiolines.com/product.php?productid=20749) is required to convert the 9-pin connector to XLR connectors.

It is important to note that the inputs and outputs of the Wheatstone squares can be accessed either by the DB-25 connections or the RJ-45 connections. For DB-25 cables and XLR cables, we recommend the ProCo cables supplied by Sweetwater.com since they are high quality, medium price, and Sweetwater has a policy to replace them for free if they break. For all the RJ-45 connections, adapters from StudioHub+ are necessary. The studio monitors are one such example of this. An RJ-45 to XLRM adapter is needed to connect the output of the squares to two normal XLR cables, which then run to the studio monitors.

In the diagram, we’re using the analog outputs on the CD players instead of the digital ones. We had originally planned to use the digital outputs of the CD players, but further research discovered that the CD player outputs are in S/PDIF format, which requires conversion to communicate with the AES/EBU format inputs on the squares. For the sake of wiring simplicity, we feel it is better just to use the analog XLR outputs, but such a converter can be purchased from StudioHub+ if desired.

Our experience indicates that it is also a good idea to run the turntables through the preamp. Since there are some extra preamp channels, this can be done freely with any other signal the operator feels is necessary as well.

For the extra inputs in each studio, we recommend using a simple XLR patchbay to make those inputs more easily accessible on-the-fly. The patchbay would be connected to the squares using an XLRF to DB-25 snake.

Through the purchase of a new TFT unit for the EAS system (the TFT EAS 619), our output chain to the STL can be kept totally digital. StudioHub+ adapters can be used to connect the digital output of the 88ad square, through the EAS equipment, through the Omnia One processor, and finally into the STL. All while staying in the AES/EBU digital domain.

The analog mixer in the lower right corner of the diagram is not part of the proposal, but would be useful if a live band were to come and perform in the extra space in the on air studio. This would allow acoustic guitars and keyboards to plug in without needing direct boxes and for another person to take charge of mixing the band, allowing the DJ to focus on other tasks while the band is playing.
Chapter V - Future Expansions

This semester we have developed a proposal to modernize the KCSU’s studios. There are two projects that could potentially be left for future senior design teams: antenna relocation and changing the transmitter to broadcast a digital signal.

Currently, KCSU boasts a 10,000 watt transmitter. Certainly impressive, but most of that power is only necessary to counteract the relatively poor placement of the antenna. If the antenna were moved, perhaps up on the hills around Horsetooth Reservoir, the same area could be covered while consuming much less power. In fact, it has been estimated that this antenna relocation would reduce the necessary power consumption to only 1500 watts. Also, as the city of Fort Collins continues to grow and new buildings spring up, the direct ‘line of sight’ path for the microwave STL signal from the Lory Student Center to the transmitter site will become obstructed. This may make it difficult for the microwave signal to reach the antenna and maintain its fidelity. A future senior design team would need to look into the cost and the appropriate placement for the transmitter antenna.

The antenna currently resides on the CSU Foothills Campus. We assume that the ideal placement for the transmitter antenna relocation may not be on property owned by CSU, in which case, it would be unlikely that an antenna could be placed there. It is our assumption that the antenna relocation project will probably include lots of research in geography, discussion with landowners and city planners and not very much electrical engineering.

In the future, the ability for KCSU to actually broadcast a digital signal may be desired. Purchasing such a digital transmitter would depend on whether or not the consumer market is moving towards digital radio. Our experience indicates that this project of digitizing the transmitter would merely include some product research to determine the best new transmitter for KCSU to purchase, certainly an important undertaking since such a purchase would be very expensive, but not a very extensive senior design project.

It is therefore our opinion that there is not much ‘engineering’ left to do for digitizing KCSU, at least not enough to warrant another year-long project. Perhaps a future team of electrical engineering students could design a piece of equipment that would be incorporated into the station’s operation. Such a project would allow for much more creativity in engineering than simply researching the hills around Fort Collins looking for a good transmitter spot, or researching which digital transmitter would be best for KCSU to purchase.

Chapter VI – Conclusion

The goal of this project was to develop a proposal for Mario Caballero and KCSU recommending a plan for moving the KCSU studios into the digital domain.

As the project started we gathered some radio magazines to read and shared them with each other and discussed what we had learned in order to teach each other about how radio stations work. We learned how current technology and future technology was playing their part in today’s current radio stations across the world. We used this information to get an insight on how much
we would want to change KCSU. We met with Mario Caballero and discussed what he hoped to accomplish in this project as well as his expectations of us. We spent an enormous amount of our first semester doing product research to determine what would best fit the needs of KCSU. We were also able to visit the radio antenna tower and another local radio station KUNC, to continue our education. The trip to KUNC helped us a lot in our understanding of how a radio station transitions to digital since KUNC had recently made this jump and was already broadcasting in High Definition (HD). Having fully educated ourselves and made product selections based on KCSU’s needs. It became our job to determine how all of the equipment would fit together. An exhaustive wiring diagram was drawn up, with all cables labeled.

We know that this project has been a great success. We are all confident that our research and planning will be the catalyst for making KCSU a not just a fully functioning radio station, but also one that may boast of using cutting-edge broadcasting technology.
Appendix A – Abbreviations
AES/EBU - Audio Engineering Society/European Broadcasting Union
CD – Compact Disc
DSP – Digital Signal Processing
DJ – Disc Jockey
EAS – Emergency Alert System
EQ – Equalization
FM – Frequency Modulated
HD – High Definition
ISDN – Integrated Services Digital Network
KBPS – Kilobytes Per Second
KCSU – The ‘K’ is an FCC standard denoting that the station is west of the Mississippi River and ‘CSU’ stands for Colorado State University
KHz - Kilohertz
KUNC – Definition of K defined in above KCSU entry. UNC means University of Northern Colorado.
LCD – Liquid Crystal Display
LED – Light Emitting Diode
MHz – Megahertz
RDS – Radio Data System
STL – Studio to Transmitter Link
U – The Standard Unit for Rack Equipment equivalent to 1.75”
Appendix B – Budget
Proposed Plans for KCSU

2009 KCSU Budget Proposal

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<td>Inovonics</td>
<td>inovon.com</td>
<td>Model 531</td>
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<td>$1,748.36</td>
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<tr>
<td>Auralex</td>
<td>See Appendix H.5 of Report</td>
<td>Option A</td>
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<td></td>
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Furniture, Cable, and Construction Allowance

Grand Total $76,228.16

Budget from the department of Electrical and Computer Engineering:
We did not use any of our allotted $250 for either semester. We have no prototypes or expenses that would elicit any purchases.
Appendix C – Current Configuration Flow Chart
In from STL antenna on tower microwave 950MHz from studio at LSC

KCSU
Transmitter

Harris CD
Link STL receiver

Orban
Optimod
8400 Audio Processor

Harris FM Exciter

Harris 5kw
FM Transmitter

Transmission line

4 bay antenna to create 10kw Effective Radiated Power

FM radio receivers tuned to 90.5
Appendix D – Proposed Wiring Diagram
Appendix E - RE20 and RE27 Frequency Response Curves

Frequency Response Curve for the EV RE27 N/D

Frequency Response Curve for the EV RE20
Appendix F – Wheatstone E-Squared Topology

**E Square System Topology**

- **Model 885 Mix Engine**
  - Creates Control Surface Mixes
  - 12 Universal Logic Ports

- **Model 885 Mix Engine**
  - 8 AES Inputs
  - 4 AES Outputs
  - 4 Stereo (8 Mono) Inputs
  - 4 Stereo (8 Mono) Outputs
  - 12 Universal Logic Ports

- **Model 880a**
  - 8 Stereo (16 Mono) Analog Inputs
  - 8 Stereo (16 Mono) Analog Outputs
  - 12 Universal Logic Ports

- **Model 880c**
  - 8 AES Inputs
  - 8 AES Outputs
  - 12 Universal Logic Ports

**Note:**
- All Components connect to the central gigabit switch.
- Edge switches may be used for signal aggregation.
- Each surface has an associated Model E Mix Engine.
- Audio I/O is on DR15 or EM5 (Squares have both rear connector types).
- Both audio and logic control for automation systems are over IP.

CAT-5 or CAT-6 Ethernet
Appendix G – Proposed Layout of the On Air and Production Studios
Appendix H – Equipment Price Quotes
H.1 – Arrakis Furniture

Quote

ARRAKIS SYSTEMS
6604 Powell Street
Loveland, CO 80538
Phone: 970.461.0730
Fax: 970.663.1010

Sales Representative
Ben Palmer
Ext: 309
Email: benp@arrakis-systems.com

Jesse Parker
KCSU
Email: jmparker@engr.colostate.edu

<table>
<thead>
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<th>Total Cost</th>
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<td>ACC-CLL</td>
<td>2</td>
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<td>$10,600</td>
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| Accent Furniture Long L
| Sit Down Configuration
| (No Added Costs for Customization) |
| ACC-8RU       | 2        | $700           | $1,400     |
| Tabletop Equipment Pod |

Total: $12,000.00

Notes: Offer good for 60 days.
# Quotation

**Quotation No:** QTSTD00241205  
**Date:** 10/30/2000

**Billed To:**  
COLORADO STATE UNIVERSITY  
ACCOUNTS PAYABLE  
FORT COLLINS, CO 80523-6003  
USA

**Shipped To:**  
COLORADO STATE UNIVERSITY  
CAMPUSET DELIVERY 1301  
COLLEGE OF ENGINEERING  
FORT COLLINS, CO 80523-1301  
USA

**Attn:**  
JESSE PARKER

**Phone:** (970)491-0643 Ext  
**FAX:** (970)491-0600 Ext 0000

<table>
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<td>OMNIA6EX</td>
<td>Omnia-SEX HD+FM On-Air Processor (2001-09125)</td>
<td>$12,519.00</td>
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<td>OMNA</td>
<td>OMNIA1FM</td>
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<td>$2,955.00</td>
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Dated: ____________  
PO#: ____________

**Subtotal:** $32,429.06  
**Tax:** $0.00  
**Freight:** $555.46  
**Total Due:** $32,984.54
# H.3 – BSW Phone Hybrid

## Quotation

**Quote No:** QT STD00248067

---

**Billed To:**

COLORADO STATE UNIVERSITY  
ACCOUNTS PAYABLE  
FORT COLLINS, CO 80523-6003  
USA

---

**Shipped To:**

COLORADO STATE UNIVERSITY  
FORT COLLINS, CO 80523-1301  
USA

---

**Attn:** STEVE PARKER  
Phone (670)491-0043 Ext

FAX (000)000-0000 Ext 0000

---

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<td>KELLEY S.</td>
<td>FEDEX-GROUND</td>
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<td>1</td>
<td>COMREX</td>
<td>D-50</td>
<td>Digital Hybrid with Acoustic Echo Cancellation</td>
<td>$1,795.00</td>
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The above quote is accepted by: ____________________________

Dated: _______________

PO#: _______________

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Page 1 of 1
### PRODUCT PRICE SCHEDULE - March 2008

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<th>AUDIO PROCESSING EQUIPMENT</th>
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<tr>
<td>222-00 AM Broadcast Processor 10kHz NRSC Cutoff</td>
<td>$850</td>
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<td>01,02,03 AM Broadcast Processor - Special Frequencies Available: 9kHz, 6.4kHz, 5kHz</td>
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<td>235-00 AM Broadcast Processor / AGC / Limiter / 10kHz NRSC Cutoff</td>
<td>$2200</td>
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<td>01,02,03 AM Broadcast Processor - Special Frequencies Available: 9kHz, 6.4kHz, 5kHz</td>
<td>$2245</td>
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<td>255-00 FM Stereo AGC / 3 band Compressor / with Smart Limiter</td>
<td>$2100</td>
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<td>260-00 FM Stereo AGC / Compressor / Limiter Specify 115v or 230v</td>
<td>$1350</td>
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<td>261-00 Digital - FM or Utility Stereo AGC / Compressor / Limiter / Analog-Digital Ins-Outs</td>
<td>$1500</td>
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<td>264-00 Quad Leveler / 4 Independent Channels / Alarmed Outputs</td>
<td>$1600</td>
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### FM AUDIO PROCESSING / STEREO GENERATORS

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<tr>
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<tbody>
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<td>Omega_{FM} Digital - FM-IBOC Broadcast Proc. / AGC / 4 band Leveling / Limiter / Stereo Gen.</td>
<td>$6300</td>
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<td>716-00 David II Digital-Synthesis FM Stereo Gen. / AGC / PWM / Composite Processor</td>
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### FM STEREO GENERATORS

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<td>708-00 Digital-Synthesis FM Stereo Gen. / Composite Processor / Metering</td>
<td>$1890</td>
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### BROADCAST INSTRUMENTATION

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<td>525-00 AM Modulation Monitor / Tunable Off-Air / Alarms / LCD Metering / Antenna Included</td>
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<td>531-00 FM Modulation Monitor / Tunable Off-Air / Alarms / SCA Injection / AM Noise</td>
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### SCA-RDS MONITORING

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<td>510-00 RDS/RBDS Decoder-Reader / Front Panel LCD Display / With RS-232 Software</td>
<td>$1700</td>
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<td>540-00 SCA Monitor - Demodulator / SCA / RDS / High-Speed Data</td>
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<td>RS232 RS-232 Plug in option for 540 with software to display RDS Data on a PC</td>
<td>$195</td>
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### RDS/RBDS SCROLLING ENCODERS

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<td>702-00 RDS/RBDS PC-programmable &quot;Mini Encoder&quot; USB connectivity Specify 115v or 230v</td>
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<td>713-00 RDS/RBDS / Supports Dynamic Updates / TCP/IP – USB – RS232</td>
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<td>720-00 RDS/RBDS / Updates via PC or Automation / USB – RS232 / LCD Diagnostics</td>
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<td>730-00 RDS/RBDS / Updates via PC or Automation / TCP/IP – USB – RS232 / LCD Diagnostics</td>
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### FM “RELAY” (RE-BROADCAST) RECEIVER

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<tr>
<td>631-00 Tunable / Metering / Composite, L/R Outputs / Dual IF B/W – F Connector - 75Ω Ant. Input</td>
<td>$1490</td>
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<td>631-01 Tunable / Metering / Composite, L/R Outputs / Dual IF B/W – N Connector - 50Ω Ant. Input</td>
<td>$1490</td>
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### TELEPHONE LINE SWITCHING

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<tr>
<td>PBX-00 56k Compatible / Up To 7 Devices Can Share 1 Standard Telephone Line</td>
<td>$490</td>
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**NOTE:** Most items ship within 24 hours of ordering. All prices are US DOMESTIC “FACTORY LIST” and are subject to change without notice. Consult Innovonics Inc. or your preferred equipment supplier to confirm domestic and export pricing, product availability and specific ordering information.
H.5 – Octane Sound Treatment

Quote

7333 Triangle Drive
Fort Collins, Colorado, 80525
T 970.217.8925
F 970.669.0455
sales@octaneaudio.com

Employee: Greg Sanders          #: KCSU Auralex Quote

To: Chunfa Lee

Chunfa,

Thank you for the opportunity to bid the Acoustification of the KCSU Studios. It is important to understand that both of these quotes will achieve the desired 50 - 69% absorption desired in Broadcast / Post Production environments. I would like to talk you through these quotes and explain the benefits vs. cost between the packages. As always, this is the recommendation given based upon use. We can alter packages as needed, but may sacrifice performance. Thank you.

<table>
<thead>
<tr>
<th>Description</th>
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<th>Quantity</th>
<th>Unit Price</th>
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<td><strong>Pro Package Option A</strong></td>
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<tr>
<td>Beautiful, Fuller Midbass pick up than StudioFoam, More aesthetically pleasing option with longer lasting characteristics.</td>
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<td><strong>Auralex Elite Pro Panels B24</strong></td>
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<td><strong>Auralex Elite Pro Panels B22</strong></td>
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<td><strong>Auralex Elite Pro Panels Elite CT45015S</strong></td>
<td>$149.00</td>
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<td>**Screen 6 Cloud Space</td>
<td>Coupler**</td>
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<td>Diffuser Kit- Ceiling Mounted</td>
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<td>Diffuser (for use in Live Band area)</td>
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## Quote

7333 Triangle Drive  
Fort Collins, Colorado, 80525  
T 970.217.8925  
F 970.699.9455  
sales@octañaudio.com

### StudioFoam Option A (not including freight)

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<tr>
<td>Professional Installation</td>
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<td>Shipping (Actual Costs)</td>
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<td><strong>Total for Option A (not including freight)</strong></td>
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### StudioFoam Option B - Functional / Effective & Cost efficient

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<td>$369.00</td>
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<tr>
<td>Auralex Studio Wedge Panels - 2 in. depth / 9 sq. ft. / 12pk</td>
<td>$149.00</td>
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<tr>
<td>Auralex LENRD Bass Traps - 1.36 NRC / 8pk</td>
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<td>Screen 6 Cloud Diffuser Kit</td>
<td>$1,398.00</td>
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<tr>
<td>Auralex T/Fusor Room Diffuser</td>
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<td>8</td>
<td>$712.00</td>
<td>$712.00</td>
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<tr>
<td>Professional Installation</td>
<td>$1,500.00</td>
<td>1</td>
<td>$1,500.00</td>
<td>$1,500.00</td>
</tr>
</tbody>
</table>
## Quote

7333 Triangle Drive  
Fort Collins, Colorado,  
80525  
**T** 970.217.8925  
**F** 970.699.9455  
sales@octaneaudio.com

<table>
<thead>
<tr>
<th>Description</th>
<th>Retail</th>
<th>Quantity</th>
<th>Unit Price</th>
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<td>Shipping (Actual Costs)</td>
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<td>Total for Option B (not including freight)</td>
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Terms: 50% down upon order, balance due upon installation. 15% Restocking fee on all returned / cancelled merchandise.

Sign to initiate order: _____________________________ date: _____________________________
# Proposal Summary

**Proposal Date:** 10/22/2008

**Prepared By:** Phil Owens

**Project Reference:** Colorado State E Square System

**Proposal To:** Colorado State University
175 Edwards Hall
Fort Collins, CO 80521

**Attn:** Jesse Parker
**Phone:** 415-342-7443

**Proposal #:** 1022C51

<table>
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<td>Wheatstone Evolution 6 Digital Audio Control Surface</td>
<td>$20,064.00</td>
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<tr>
<td></td>
<td>E-6-16</td>
<td>16 Input Faders</td>
<td>INC</td>
<td>INC</td>
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<tr>
<td></td>
<td>E-6-16</td>
<td>1 BBE Mix Engine Square for E6 Surface</td>
<td>INC</td>
<td>INC</td>
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<tr>
<td></td>
<td>E-6-16</td>
<td>1 BBE 8 x 8 Stereo (16 x 16 Mono) Analog Input / Output Square</td>
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<tr>
<td></td>
<td>E-6-16</td>
<td>1 BBad 4 x 4 Stereo Analog, 4 x 4 AES Input / Output Square</td>
<td>$2,995.00</td>
<td>2,995.00</td>
</tr>
<tr>
<td>1</td>
<td>MicPre</td>
<td>8 Channel Rack Mount Mic Preamp</td>
<td>$995.00</td>
<td>995.00</td>
</tr>
</tbody>
</table>

**Production**

| 1   | E-6-12      | Wheatstone Evolution 6 Digital Audio Control Surface | $17,675.00 | 17,675.00 |
|     | E-6-12      | 12 Input Faders | INC | INC |
|     | E-6-12      | 1 BBE Mix Engine Square for E6 Surface | INC | INC |
|     | E-6-12      | 1 BBE 8 x 8 Stereo (16 x 16 Mono) Analog Input / Output Square | $2,995.00 | 2,995.00 |
|     | E-6-12      | 1 BBad 4 x 4 Stereo Analog, 4 x 4 AES Input / Output Square | $2,995.00 | 2,995.00 |
| 1   | MicPre      | 8 Channel Rack Mount Mic Preamp | $995.00 | 995.00 |

**TOR**

| 1   | 8 x 8 Audio | 8 x 8 Stereo (16 x 16 Mono) Analog Input / Output Square | $2,995.00 | 2,995.00 |
| 1   | 8 x 8 AES  | 8 x 8 AES Input / Output Square | $2,995.00 | 2,995.00 |

| 2   | SPI-AxIP     | Wheatstone AxIP driver for Automation: PCs or Workstations | $230.00 | 500.00 |

**NOTES:**

E6 Control Surfaces require a user supplied standard VGA Monitor for metering.
The E Square system proposed requires a 10 port Gigabit switch (Linksys SRP2008 or similar)
Typical street price $450.00

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**Total Equipment Price in U.S. Dollars:** $56,199.00

**Loss Educational Discount:** -8,481.35

**Sales Tax, If applicable:** Total Price in U.S. Dollars: 45,717.65

| Non-Refundable Deposit Due with Order: | 16,423.00 |
| Balance Due prior to Shipment:        | 33,344.65 |

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**Notes:**

Payment Terms: Deposit due with Order. Balance due prior to Shipment.
Estimated Ship Date: 45-60 Days. Upon receipt of Order and Deposit.
Shipment: Ex-Works - Factory, New Bern, North Carolina, USA
Validity: The prices in this offer are valid for a period of 30 days from the date of this proposal.
I have read and accept this order and terms in its entirety.

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**Authorized Signature**  
**Title**  
**Date**