Wireless Streaming of Multiple Audio Channels into a Telephone line

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***Abstract*--** The goal of the project is to develop a conferencing system using a normal telephone. The most important feature of the so developed system would be independent wireless microphones for each and every participant (the number of participants is taken as 8). The aim is to increase the ease of participating in a phone conference by transmitting the voice wirelessly to the receiver interfaced with the phone, thus giving a factor of portability to the user. The task would start with selecting the proper technology, the required ASIC's components etc., designing the circuit and implementing the same by interfacing it to a telephone line. An attempt has been made to make the existing technology cheaper and more portable which can co-exist with other wireless devices being operated in the same frequency band. Some of the main hurdles included accommodating 8 channels, interfacing with the telephone, developing programming interfaces etc. which would be successfully overcome by proper selection of the ASIC's.

Index Terms—Telephone, conferencing, portable, ASIC, wireless, interfacing, frequency, technology, channels.

1. Introduction

This thesis describes the work done on the project titled 'Wireless Streaming of Multiple Audio Channels into a Telephone line' i.e how the problem statement was identified and how the solutions were obtained for the same.

The problem was mainly dealing with conference room situations. The conferencing facility available in the conference rooms of Bosch were basically based on using a normal phone in speaker mode where the participants huddle together and speak. This caused many problems the most important one being the clumsiness (the speaker phone could not pick up voices unless the persons were close enough) and lack of portability where in one of the participants had to go to the drawing board to explain something etc.

The solutions available in the market were more sophisticated than the purpose needed by us and were costly as well, so the target here was to develop a cheap portable system. At Bosch the philosophy was to find solutions to the problems rather than outsourcing the problems to others hence it was decided that a system would be built from the scratch.

A. Communication and need for conferencing

Communication is an activity of sharing messages or signals through a medium with proper interface based on the appropriate application. We have telephone, E mails, IM's etc for this purpose.

In the corporate world telephone and Emails are the main outlets of communication that are used. Associates exchange information with a client over the phone or through email.

The need for conferencing comes when there has to be a discussion between two groups of people generally between the customer group and the engineers or R&D group. The sessions can seamlessly go on for as long as required to discuss and identify the problems and come to an understanding and is especially helpful when the two concerned parties are geographically far apart and travelling to meet becomes less feasible. Thus conferencing provides a cheaper and faster solution for such meetings.

B. Existing Wireless Conferencing Systems

There are a few conferencing systems that have already included the wireless aspect into it thereby solving at least some of the problems mentioned earlier. So why go for an idea that is already there?

Because the existing systems do have certain features which can be improved. Some of the existing systems do not offer the feature of adding 8-12 users in the conferencing.

Companies like Confidea do have wireless conferencing systems which are quite sophisticated but the feature that is missing is portability. The present technology is quite sophisticated and cannot be installed easily. And the third drawback is that these systems are very expensive.

At Industry people believe in developing their own solutions rather than buying them or outsourcing the work to others. So IP rights were applied for this project and we went about trying to tackle the abovementioned problems thus developing a low cost, portable and easy to use wireless conferencing system which can accommodate a minimum of 8 users.

2.**Selcting technology and components**

C. Description of the block diagram

Since we are now aware of our requirements, it can be depicted in a simple above block diagram shown

D. Selecting wireless technology/protocol

Various wireless technologies are available at various frequency bands which can be used for specific wireless applications. Various available options were analyzed and one was finalized upon.

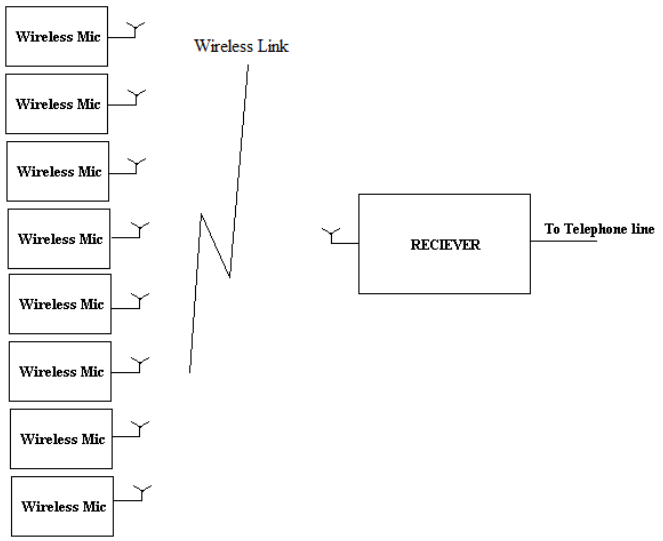


Fig: Block diagram

Bluetooth:

It is one of the most popular wireless technology standards or exchanging data over short distances (using short-wavelength radio transmissions in the ISM band from 2400–2480 MHz) from fixed and mobile devices, creating personal area networks (PANs) with high levels of security.

RF module(433MHz):

An RF Module (Radio Frequency Module) is a (usually) small electronic circuit used to transmit and/or receive radio signals on one of a number of carrier frequencies. RF Modules are widely used in electronic design owing to the difficulty of designing radio circuitry. The frequency used is a free one thus no operating license is required. It is commonly used in remote control cars, garage opener etc.

But further study concluded that this frequency is not preferred for audio signal transmission as many devices operate in this particular frequency and it will be difficult to co-exist leading to interference issues and signal loss.

Pure path wireless technology:

Searching for wireless audio solutions I stumbled upon TI's Purepath Wireless Audio which provides the perfect platform to develop wireless audio solutions.TI's PurePath™ Wireless audio products feature robust and high-quality 2.4 GHz devices for wireless digital audio streaming.

The proprietary PurePath technology provides a solid wireless audio link and 16 bit / 44.1/48 KHz uncompressed audiowith no unwanted noise or dropouts. It uses a number of RF channels dynamically chosen for lossless audio transmission,resulting in minimal interference with other RF devices in the 2.4 GHz band.

PurePath Wireless supports digital streaming for up to four audio channels and single-chip USB wireless audio products make the solution ideal for PC centric applications. The low and fixedprogrammable audio latency and distributed audio clock ensure perfect time synchronization between speakers. Combinedwith the easy-to-use configuration tool and application reference designs, TI's PurePath wireless audio solution ensuresflexibility, cost-efficiency and a fast time-to-market.

It is also used for audio applications in case of wireless headsets which can be paired to mobile phones to hear music wirelessly. But we had to eliminate this option because Bluetooth does not allow multicasting i.e multiple devices sending different data to a single receiver at once is not possible.

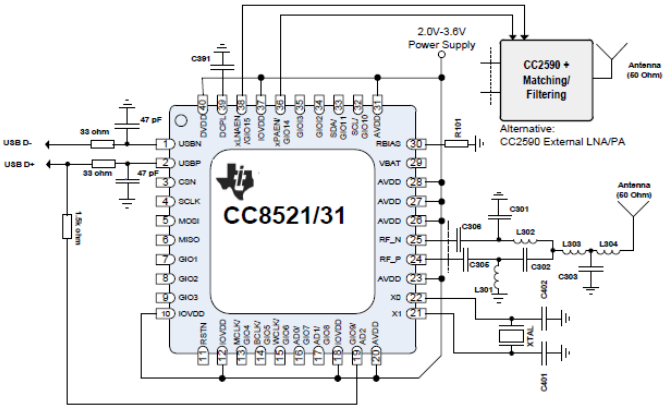
E. Main components for implementing the project

the technology has been identified we have to move forward and decide upon the main components to be used, which will form the backbone of the conferencing system. Purepath Family itself has a lot of options which can be selected from according to our suitability and requirements. In our project we have to design the wireless mic units as well as the receiver unit. From now we will call the wireless mics as Slaves and the receiver as Master.

Transmitter(slave):

Generally while selecting a transceiver the main thing we have to decide upon is the range it covers and the frequency band it uses. Then comes the fact that we have to accommodate a certain number of channels. Another important aspect would be if it requires a LOS (line of sight) communication or not. Once all these aspects are decided upon we can fix a transmitter ASIC for our design.

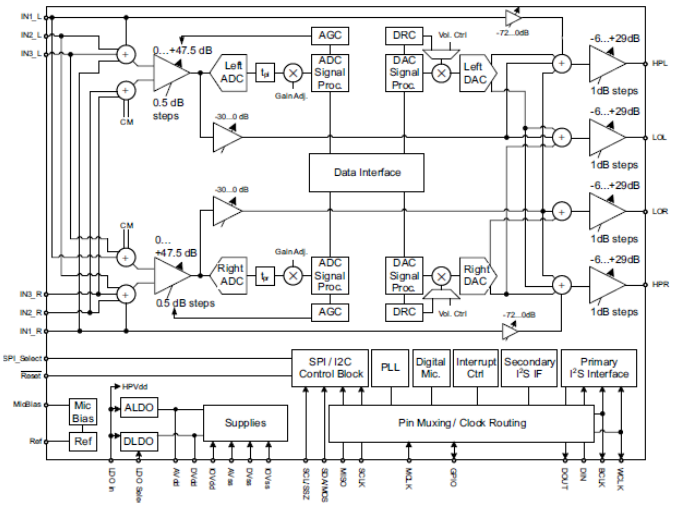
For our slave the range required is not much as we are confined in a closed room environment and LOS communication is not required. We need to transmit only a single channel. Thus we decided upon using CC8531 from the Texas Instruments range of wireless products.



Receiver (Master):

The selection criteria for a receiver too will have the similar parameters that have to be matched. So for our receiver we need an asic which can receive upto 8 channels. Since we could not find anything that has a capability of 8 channels it was decided to use two 4 channels receivers for our purpose.

CC8531 is capable of receiving 4 channels too (it is a transceiver).Thus the design would include two of these ASICs. Application circuit for the receiver will be same as that for the transmitter.



Selecting code:

An audio codec is a device or computer program capable of coding or decodinga digitaldata stream of audio.Inhardware, audio codec refers to a single device that encodes analog audio as digital signals and decodes digital back into analog. In other words, it contains both an Analog-to-digital converter (ADC) and Digital-to-analog converter (DAC) running off the same clock. This is used in sound cards that support both audio in and out, for instance.

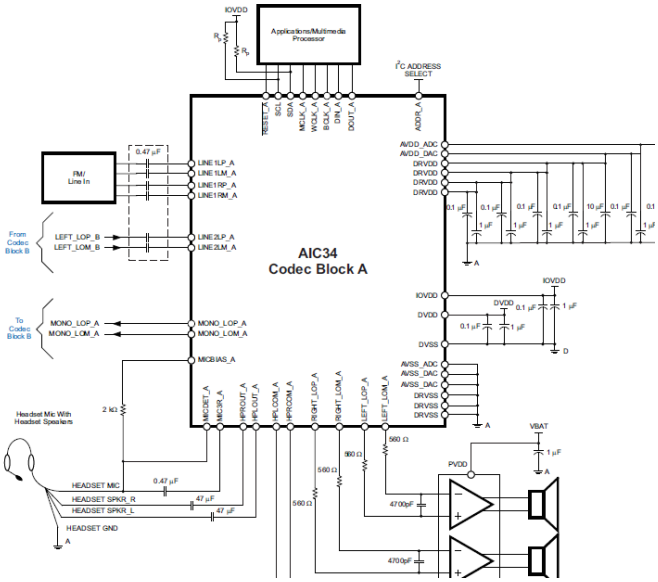
While selecting a codec we have check whether it is compatible with the transmitter/ receiver used and also if it accommodates the number of channels required.

In case of the Slave we need to transmit only one channel so we have decided upon using TLVAIC3204 which is another Texas Instrument product.

In case of the master we need to accommodate 8 channels but there are no codecs which support that configuration. So we again break it up into two parts, four channels with each CC8531 receiver. So the codec suitable for this is TLV320AIC34 which supports upto 4 channels. Thus we can use two of these for our master board.

Summer circuit:

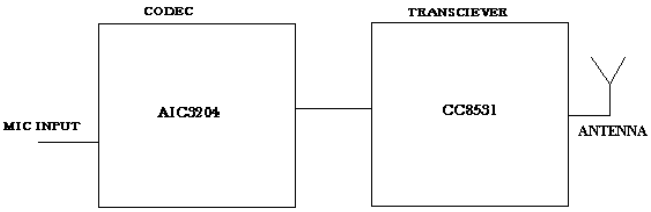
Now that we have a mechanism to receive the 8 audio channels we need to find a way to combine all these signals so that they can be sent as one single stream into the telephone line which we will interface with. So for this we need to fix a summing circuit to prevent data loss.



Testing was done using some basic op- amp summer circuits but the results provided were not satisfactory and the size of the circuit was also increasing.The use of op amp also required an inverting power supply which was not a feasible condition for us and hence complicated the problem furthermore. Hence we fixed upon using an ASIC for the summing operation which would reduce the size as well as provide good quality summed output.

The ASIC we decided to use was PCM3070, which is just another codec but has additional feature of being able to sum up atleast 4 different audio channels.

F. Block diagram and description of slave circuit:



As described in the previous section since we are dealing with audio signals we use a codec to convert it into a proper format before transmitting it. While designing the schematic we have to look at the datasheets of both the ASICs the transceiver and the codec to make the pin to pin connections as well as the power supply for each of them.

We wanted our system to be able to run on a battery and also be capable of USB charging. So the IC we are going to use for that purpose is BQ2015 which is a DC-DC charger which can directly power our circuit when the battery is not connected and charge the battery when it is connected.

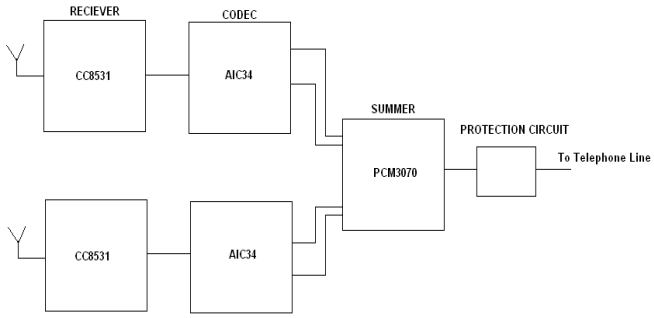
There are 3 clock pins (MCLK, BCLK, WCLK) for the codec and transceiver which have to be connected and synchronized for smooth transfer of data between then codec and the transceiver. The audio data given to the codec is compressed and sent via DOUT pins (digital data packets) to CC8531 from which it is transmitted wirelessly to the master. The power requirements for AIC3204 are as in Table 1. (power supply pins)

TABLE I

Recommended Operating Conditions

			MIN	NOM	MAX	UNIT
LDOIN	Power Supply Voltage Range	Referenced to AV_{SS} (1)	1.9		3.6	V
AV_{DD}			1.5	1.8	1.95	
IOV_{DD}		Referenced to IOV_{SS} (1)	1.1		3.6	
DV_{DD} (2)		Referenced to DV_{SS} (1)	1.26	1.8	1.95	

Block diagram and description of Master circuit:



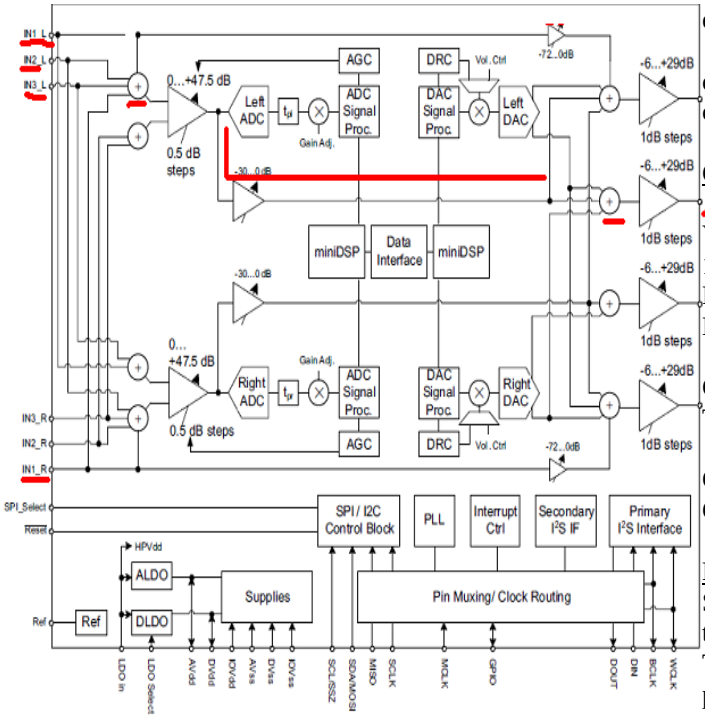
The methodology followed for design of the master schematic will be similar to the one followed for design of the slave as well. There is a significant increase in the number of components so the space constraint has to be taken into account and there is a change in certain components too so the interfaces have to be taken care of as well.

One of the main difference is the codec used here i.e. TLV320AIV34. The receiver used is the same but now the interface will slightly differ from that of a transmitter.

The objective of the master is to receive 8 channels and the transceiver CC8531 can receive only a maximum of 4, hence we use two of these in master board. Two transceivers for audio signals imply the requirement of two codecs. And AIC34 can handle upto 4 channels, thus we use 2 of those to accommodate the 8 channels. The interface between the codec and the transceiver asics here too will be similar i.e. the wireless received data is transmitted to the codec in digital packets via the DOUT pins.

The AIC34 internal structure is divided into codec block A and codec block B, and each block on its own can handle upto two channels (mixing/muxing etc.) but they channels from one block cannot be combined with another. So we receive 4 channels in one codec combine it in each block and get an output of two streams (each consisting of two channels) and since we have two codecs that would mean 4 such streams hence accounting for all the 8 channels.

Now as discussed earlier, the summer module has to sum up all the eight channels into a single stream to prevent data loss. The summer ASIC as decided was PCM3070 which had an internal structure like a codec and the summing could be done in it for four analog inputs. Audio signals are of three levels Mic, Line and Headphone (in increasing order of their power). From the AIC34 Line out connections were made to the analog inputs of PCM3070. The summing is done in PCM3070 directly using the analog signals i.e. there is no need to convert the signals to digital format (no use for the ADC and DAC).



Internal block diagram of PCM3070 (Source : PCM3070 reference sheet)

Power supply for Master:

The power supply considerations and calculations for master will vary from that of slave because of the difference some of the ASICs used and hence we have to take care of the optimum operating conditions of each of the asic and create a common supply really and then having separate voltage regulators if necessary.

RECOMMENDED OPERATING CONDITIONS

		MIN	NOM	MAX	UNIT
AVDD_DAC, DRVDD(1)	Analog supply voltage	2.7	3.3	3.6	V
DVDD(1)	Digital core supply voltage	1.65	1.8	1.95	V
IOVDD(1)	Digital I/O supply voltage	1.1	1.8	3.6	V

Recommended Operating Conditions

		MIN	NOM	MAX	UNIT
AV_{DD}		1.5	1.8	1.95	V
IOV_{DD}	Referenced to IOV_{SS}(1)	1.1		3.6	
DV_{DD}(2)	Referenced to DV_{SS}(1)	1.26	1.8	1.95	

The same BQ2015 charger IC is used and since we have two pairs of transceiver and codec, we use two such ICs and two batteries.

The nominal voltage varies from PC3070 and AIC34. We need a minimum of 3.3 V to make AIC34 run and that voltage will suffice to power CC8531. But the summer ASIC PCM3070 has a nominal operating voltage of 1.8V. Hence here we face a situation where in we may have to use an external voltage regulator.

The calculations and design has to be done so that the output of the IC is 3.3 volts which forms the supply rail. The capacitor resistor bridge has to be appropriately changed.

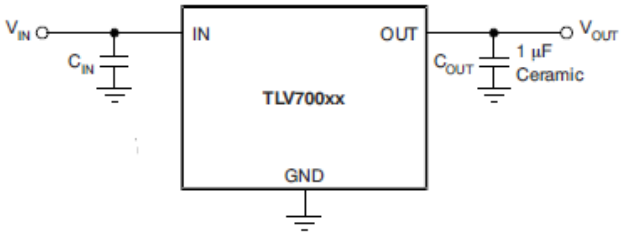
Calculations:

V_{OUT} = 3.3
1+R1/R2= 6.6 (FromEqn 4.1)
R1/R2=5.6
Hence R1= 560Kohm and R2=100Kohm

C1= 1/(2 x pi x 10000 x 560000)
Therefore C1=50pF

C2=R1/R2 * C1
C2=270pF (approximating it to the nearest available value)

External Voltage Regulator:
Since PMC3070 has different operating voltage conditions, in the schematic we include and external voltage regulator. TLV70018 is external regulator which will provide a regulated power supply of 1.8V to the summer IC thus stabilizing the power supply problems.

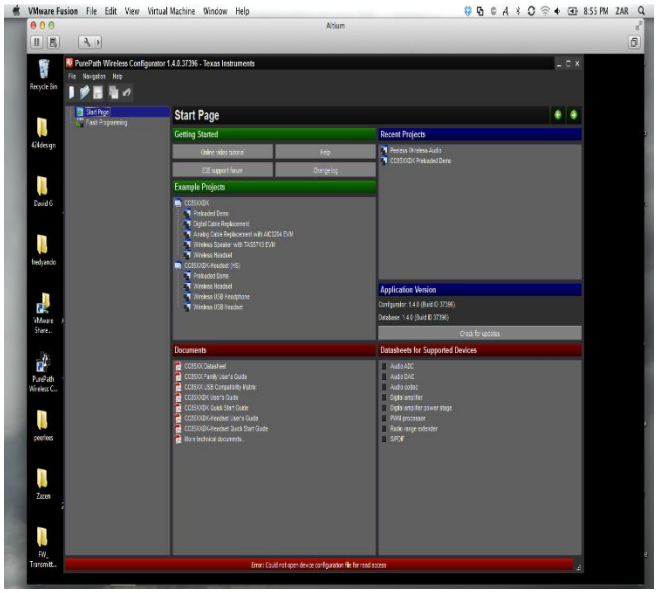


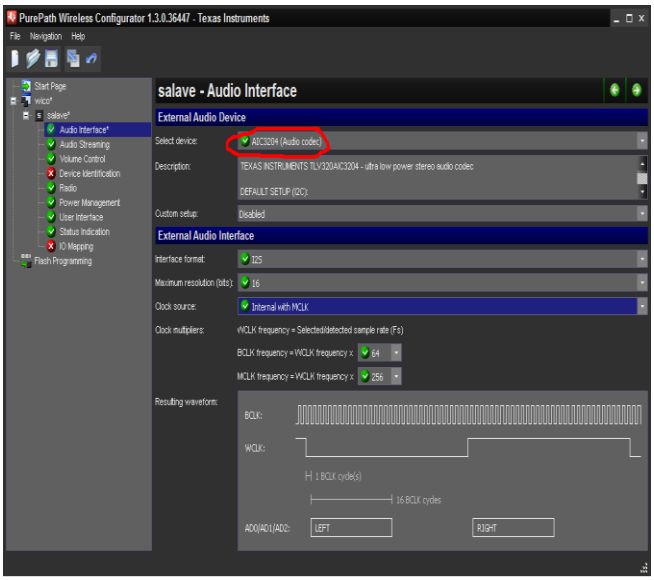
G. Software configuration of ASIC's:

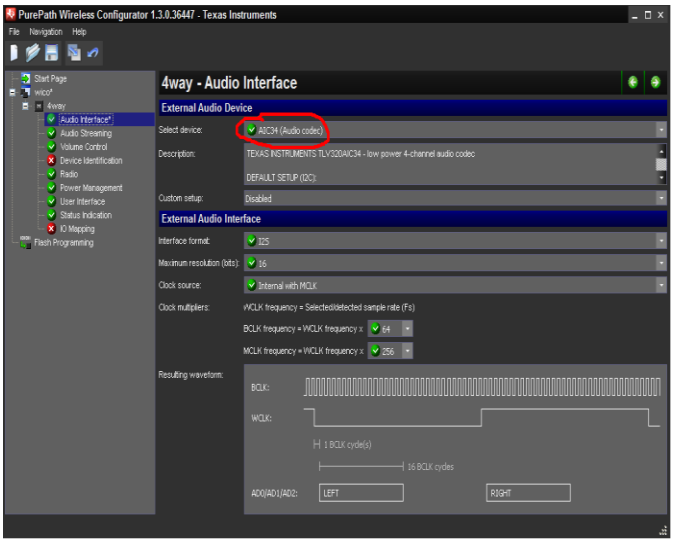
Configuration of CC8531 and AIC3204:

Both the above mentioned products are part of the Purepath Wireless audio family of Texas Instruments. Both the asics are register programmable but TI has provided a set of tools/software to help us configure the settings as per our requirement. One of the tools is Purepath Wireless configurator.

The PurePath Wireless Configurator (PPWC), a PC-based,graphical configuration tool, is used with the CC85xx to set upthe desired functionality and parameters of the target systemapplication. PPWC works on precompiled image files. Basedon input from the user, PPWC will patch these to generate adownloadable firmware image. The designer can the CC85XXdevice directly in PPWC through the CC Debugger tool(included in CC85XXDK development kit) or output it to anIntel HEX-file (for production programming). No extra thirdparty tool is needed for the development.



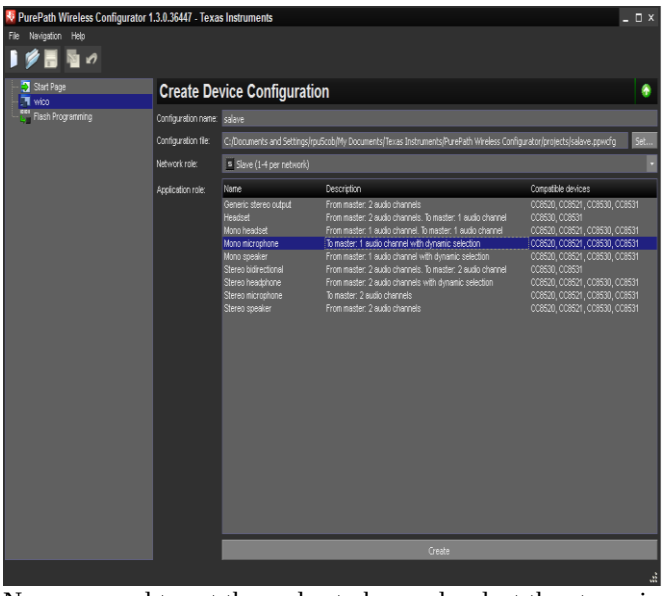




Configuring AIC3204:

There are various parameters that have to be set in the Purepath wireless configurator for getting the configuration we desire.

This involves selecting the framework that is Master or slave, unidirectional or bidirectional etc. The Mono Microphone configuration will support the use of CC8531.



Now we need to set the codec to be used, select the streaming format and the internal clock source.

In a similar way we set the Audio streaming format, Volume control, Device Identification, Input Output mapping etc. and thus create a device configuration. When we build this configuration, we will get the image file that can be burned into the flash of the CC8531. While we are setting the power settings, there is a facility to monitor the battery voltage (VBAT pin) which will indicate if the battery level is going below the optimum value and may hinder the performance of our device.

Configuring CC8531 and AIC34:

The above settings were for configuring the slave and now we will see how to configure the master board.

The master will receive upto 4 channels and the codec used is AIC34 so it has to be set that way in the Purepath wireless configurator.

H. Conclusion and future scope:

Thus the problem statement titled 'wireless streaming of multiple audio channels into a telephone line' was solved. The major hurdle faced during a conference was removed by developing an individual wireless microphone for each and every participant of the conference. The developed system was comparatively cost effective and easy to use and the sophistication was less because only an analog telephone with speaker was needed and the telephone line could be plugged into the master for the system to go online.

The schematic design was robust and we learnt the various steps involved in systematically developing a schematic. The software configurations too were challenging and we managed to familiarize with the required IDEs and configure the settings as per our requirement. The inclusion of a protection circuit ensured the protection of the system from various unexpected surges in the telephone line.

The project also gave a few ideas that could be implemented in the future. Since the way to stream multiple audio channels wirelessly was found out, we could use it innovatively in automotive entertainment systems, car to car communication etc. A high feature design is also possible in the future wherein the wireless microphones would also have headphone feature thereby eliminating the need of speaker phone.

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