
The Analysis on DSP-based hands-free car kit

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ABSTRACT

For the past several years, many countries have passed or have recommended legislation making it illegal to use in-hand mobile phones while driving and several manufacturers have released car kit solutions enabling hands-free operation of the mobile phone. But an automobile environment can pose extremely harsh physical conditions impacting audio quality, safety, and reliability. This article introduced a Car Kits that provided a total entertainment and telematics solution, which support all current features within the constraints of low power consumption, form factor, price, ease-of-use, manufacture ability, testability and high total quality.

키워드

DSP, Car Kits, Bluetooth, Navigation System

I. Introduction

For the past several years, some manufacturers have released car kit solutions enabling hands-free operation of the mobile phone. But Low-quality products in the market are causing unsatisfactory results. Short-range Bluetooth wireless technology has become a de-facto standard for most forms of mobile hands-free solutions. However, several challenges still need to be tackled by the hands free car kit vendors, as an automobile environment can pose extremely harsh physical conditions impacting audio quality, safety, and reliability. Bluetooth technology has also advanced by defining several new profiles, which enable highly desirable features.

Car kits are now expected to provide a total entertainment and telematics solution. The modular car kit platform should come with the capability to support all current features within the constraints of low power consumption, form factor, price, ease-of-use, manufacture ability, testability and

high total quality.

DSP has become more and more important in electronic product design because of its fast operation rate, programmability, and flexible interface. It will be a developing trend to design digital signal system with DSP devices.

II. Development background of DSP

DSPs are processors or microcomputers whose hardware, software, and instruction sets are optimized for high-speed numeric processing applications an essential for processing digital data representing analog signals in real time[1].

The marriage of digital signal processors with other technologies like accelerators and ARMs has enabled SoC-based innovation that is leading to exponential breakthroughs in previously un-thought of application spaces. Currently, those spaces are video and audio entertainment for the most part.

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But these are just the tip of the iceberg. Some scientists indicated that the applications of DSP have passed the second wave that entertainment-based applications as well as the first wave the applications of speech, now we are faced with the 3rd wave of DSP applications, in this wave, applications will be locked in the 4 field of transport (automotive), high quality of life, security, and green energy[2][3].

Let's take a look at the application that DSP-based hands-free car kit.

III. Hands Free Kit (HFK)

In 2009, the total number of mobile phone shipments will be expected to exceed one billion units, of which 40% are anticipated to be Bluetooth enabled. Bluetooth devices are projected to succeed 2 billion units by 2010 with a majority of the devices being mobile phones, headsets, and car kits.

Advanced digital signal processor (DSP)-based HFKs meet the growing need for a high-quality, cost-competitive solution (see Fig. 1) with superior audio-processing algorithms, intuitive and user friendly Bluetooth profiles to provide the best driving experience. Stringent automotive requirements and the sheer diversity of mobile phone vendors and models have made it very difficult for most offerings to provide the high overall quality and low cost. Current high-quality solutions are generally too expensive for the average user. Echo cancellation and noise reduction are essential features in a high-end HFK system, and are no longer considered luxury items.

The harsh physical environment such as extreme temperatures can affect sound quality. Electrical, wind, and other acoustic noises can be very diverse and have very dynamic levels that can easily saturate the input microphones. The device would have to sustain high levels of mechanical vibrations

and shocks. Sophisticated signal processing, robust design and rigorous testing are needed to ensure reliable device operation, and users usually have to pay a high price to obtain these benefits.

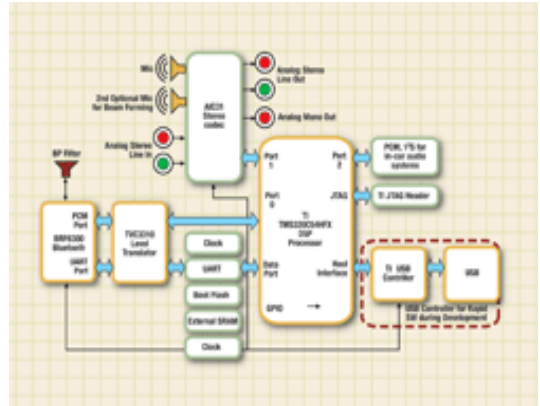


Fig. 1 A digital signal processor powers the hands-free-kit.

Apart from the basic needs of hands-free operation, several optional interfaces and features like wireless audio streaming (MP3, WMA, AAC), CAN, GPS, GSM, Wi-Fi, WiMAX, UWB, mass storage, high-definition video, etc, can be provided in a modular fashion enabling the HFK to become an in-car infotainment and telematics platform. Several driving scenarios stress the need for a quality HFK.

3.1 Hands-free mobile phone call

The HFK streams audio from a call through the car stereo speakers and from microphones located to pick up the driver's voice. A driver can also stream music from his Bluetooth-enabled music device to the car stereo speakers. If the driver receives an incoming call the music level will automatically lower and pause, since the phone rings through the car speakers. Once the call is completed, the music resumes and audio is automatically restored.

If a driver answers a call with the windows rolled down, audio using a quality HFK is crystal clear due to the advanced noise reduction and echo cancellation software. The person on the receiving end does not hear any wind noise, the sounds from outside the car, nor the bumps when tires pass over bumps and rough spots on the road. The driver also does not hear any voice echo, even if the speaker volume level is turned up and ambient noise level has increased significantly.

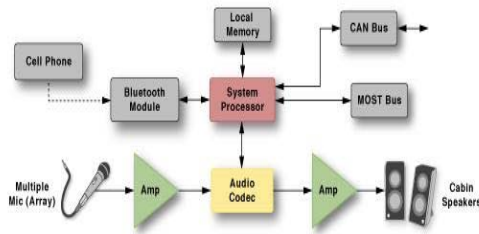


Fig. 2 A Bluetooth Handsfree Car Kit

A Bluetooth Handsfree Car Kit (HFCK) is a Digital Signal processing module for noisy automotive environments caused by engine, wind and other sources. The Wireless Bluetooth standard is highly compatible and easily integrates mobile phones to HFCK(see Fig 2). Advanced processor runs high quality acoustic echo cancellation AEC, noise reduction, Bluetooth protocol stack and necessary user profiles, and highest quality speech-text recognition.

3.2 Multimedia features

Phone numbers stored in a cell phone and be automatically updated into the HFK. Any changes are automatically synchronized.

A driver can load movies, songs, and games into a UWB-enabled laptop and transfer everything into

a quality HFK's storage via UWB within minutes. Movies can be viewed on the high-definition LCD screen, and Internet surfing is also enabled over the GSM/GPRS/WiMAX link with a Bluetooth HID-enabled keyboard. The fast wireless port can be used for firmware upgrade of the HFK platform.

3.3 Navigation system

A high-quality HFK should provide a GPS navigation system with of voice prompts, map displays and textual instructions, all simply via driver voice commands. The system connects to the central server over the Internet and retrieves the necessary navigation updates automatically. The navigation system could also interact with local traffic broadcast information and suggest the best possible alternate routes.

3.4 Vehicle diagnostics and telematics

The several microcontrollers in various parts of the car support extensive diagnostics capability and usually communicate with the vehicle central processor over CAN bus. The HFK can also interface to this processor and continuously monitor the health of the vehicle.

Any abnormal conditions can be flagged and the service center could be alerted over GSM. When the vehicle arrives at the garage, the center has all the information to effectively service the vehicle.

IV. DSP-based HFK system

A DSP-based system with high-quality Bluetooth software that allows simultaneous audio and data streaming can address all the forementioned driving scenarios. For instance, Texas Instruments' HFK reference design uses the audio-optimized TM S320C54HFKDSP for high- performance with low-

power operation and low cost.

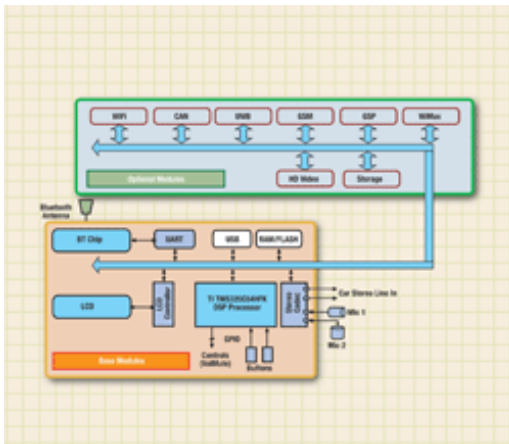


Fig. 3 HFK hardware architecture supports hands-free operation and playback of hi-fi streamed audio.

The reference design includes complete hardware schematics, Gerber files, software drivers, libraries, APIs, example application source code, project files and ready to use binary. The hardware is designed for testability and manufacturability.

The basic design supports Bluetooth-based hands-free operation and playback of hi-fi streamed audio (see Fig. 3). Phonebook synchronization, voice recognition, audio streaming, video playback, GPS navigation, internet connectivity, storage management and vehicle diagnostics can be added on to the HFK to meet specific requirements. Interfaces are provided to connect to the car audio system.

The C-Blue Adanya Computing Technologies' BQB1.2-certified Bluetooth protocol stack is implemented with minimum protocol processing overheads and zero-copy architecture. The SBC codec for audio streaming and the DSP algorithms for voice processing are optimized and consume very few CPU cycles[5].

The device drivers use DMA extensively relieving the DSP from the task of moving data. Only those parts of the circuits needed for the

current operation are enabled or clocked, reducing power consumption.

The processor bus is terminated on several headers to enable easy expansion of the system. The board can also be used as a flexible hands-free development kit, as the JTAG debug port is brought out at a convenient header.

An additional software package, C-BlueProf, provides headset and hands free profiles, audio streaming and control profiles, device drivers for various peripherals and the application integrating the user interface with the stack and platform (see Fig. 4).

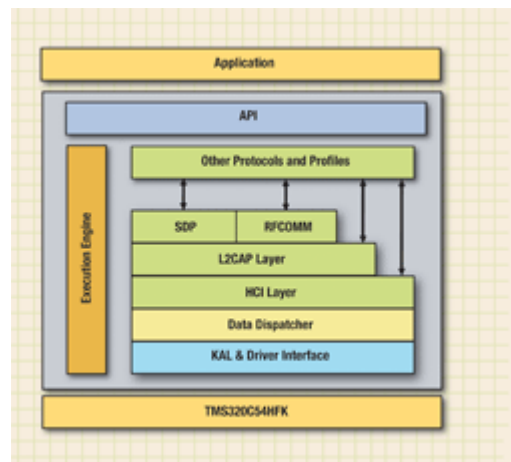


Fig. 4 The C-Blue Bluetooth protocol stack architecture is optimized to consume very few CPU cycles.

The echo cancellation and noise reduction algorithms are provided by Acoustic Technologies. The protocol stack supports EDR (enhanced data rate) and is highly compact, portable, and time-tested under the most demanding Bluetooth application scenarios.

State-of-the-art echo cancellation and noise reduction algorithms are used in the solution to provide clear, crisp audio absent of background noise interference even under the most distracting environment. Wireless streaming of hi-fi audio is

achieved over AV profiles defined in Bluetooth.

V. Conclusions

As more and more people spend more time in the car, the action constitutes by the car navigation and car audio components' application have become an indispensably part in car-driving life.

DSP-based advanced Hands Free Kits (HFKs) can meet the growing need for a high-quality, cost-competitive solution, and provide the best driving experience.

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