# A Fully Integrated Audio, Video, and Data VLC Transceiver System for Smartphones and Tablets

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*Abstract*—Today, the Bluetooth transceiver is integrated into almost all modern mobile devices. Although it can transmit audio signals, it is unable to transmit video signals. But VLC can. With advances in visible light communication (VLC) research, it is likely that one day mobile equipments would include the visiblelight transceiver for wireless optical access to the Internet and visual and audio information. An audio/video (A/V) transceiver and a data transceiver that can connect to Android platforms are presented here. Real-time video and pulse-position modulated stereo audio signals are transmitted by a white LED over free space. For file exchanges, a USB Android host IC FT311D is used to bridge smartphones to any external VLC UART peripheral.

# I. INTRODUCTION

Over the last decades, researches have been conducted on the transfer of audio [1], video [2], and data signals [3] via white light. The integration of VLC video and audio devices into our communication gadgets would see easier and faster interaction between people, and probably more fusion between people and machines, particularly multimedia entertainment. It can revolutionize aircraft communication and security and decentralize street surveillance by having cameras installed on street lamps. The Android operating system is the current open standard for mobile devices propelled by the Open Handset Alliance [4], a consortium of technology companies including Google, HTC, Samsung, Sprint Nextel, T-Mobile, Qualcomm, and Texas Instrument. Handset applications are developed in Java language using the Android SDK. On the IT market, serial communication apps that are suitable for UART RS232 connections (e.g., Slick USB, AL Mass Storage) have already been developed and are available for download. What the market lacks is a UART VLC transceiver. It will offer a choice to consumers along with Bluetooth. Our plug-in VLC device for file transfer works on UART. It connects to smart devices via an Android bridge chip. The three transceivers can be either built as an external accessory or included into the motherboards of mobile phones.

# II. VLC AUDIO CIRCUIT

In the stereo audio prototype, the transmitter (Fig. 1) mainly consists of a stereo encoder, a band-pass filter (BPF), and a PPM modulator. The receiver (Fig. 2) consists of a preamplifier, a PPM demodulator, a low-pass filter (LPF), and a stereo decoder. Audio signals from a Samsung S3 first passes through a stereo audio encoder to combine the left and right audio channels. Then it goes into the 19 kHz BPF to remove high frequency components. After filtering, the signal is passed into the pulse-position modulator (LM555) and the PPM signal exits through the LED. At the receiver, the photodiode first captures light signals in the form of current and passes it to the pre-amplifier. The pre-amplifier converts the current to voltage and amplifies the signals with a suitable gain. The signals are then PPM demodulated by the 555 timer. Next, it enters an 8th-order LPF to remove unwanted high-frequency components. After filtering, the signals go into the stereo audio decoder for left and right channel decoding. The *L* and *R* signals are eventually delivered to the speaker via audio cables.



Fig. 1. Full circuitry of the stereo transmitter. Supply voltage = 4.6V.

#### III. VLC VIDEO CIRCUIT

The video transceiver protoype (Fig. 3) is able to transmit TV and CCTV video signals in color. It is a simple circuit using only a pair of LM7171 amplifiers and negative voltage converters 7660S. As its datasheet mentions, this IC can be used in video amplifers, professional video cameras, HDTV amplifiers, and CATV. The size of this transceiver is small. With some modifications, it can be included into a smartphone.

# IV. A MULTIMEDIA SYSTEM: INTEGRATING VIDEO AND AUDIO SIGNALS

The 74HC4053 (Fig. 4) is a 2-channel analog multiplexer/demultiplexer used to multiplex and demultiplex the



Fig. 2. Full circuitry of the stereo receiver. Supply voltage = 6V.



Fig. 3. Schematic diagram of the VLC video transmitter and receiver.

audio and video signals. A clock signal higher than 5.5MHz is required.

# V. VLC SERIAL DATA TRANSCEIVER FOR ANDROID

The transceiver circuit (Fig. 5) consists of two operational amplifiers LF357N. The first functions as a preamplifer and buffer, while the second functions as a comparator as well as a low-pass filter. The D flip-flop 74HC74 accepts data and clock signals (from the crystal oscillator) to generate state-triggered signals for transmission. Without the clock oscillator, there will be no continuous light. The MAX232CPE IC is used to convert signal levels between RS232 and TTL. This work is an extension of our research in VLC USB systems [3]. It can be integrated into motherboards that use Android Version 2.3.4 and above, powered by the USB voltage from the host device.

# VI. CONCLUSION

VLC video, audio, and data prototypes have been presented. This work opens up greater possiblilities of integrating VLC with portable communication devices. The advantages of the VLC A/V system include real-time interaction and simultaneous availability of sight and sound. The VLC dongle for



Fig. 4. (Left) Block diagram of integration between the video and audio modules; (right) the use of 74HC4053 for combining and splitting video and audio signals.



Fig. 5. Full schematic for VLC data dongle for Android smartphones based on the latest FT311D bridge.

smartphones will be an essential part of data communication in our everyday lives when the revolution of LED indoor lighting spurs in a decade.

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