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Development of a Bluetooth-based web camera module

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2003-09-18

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vid Linköpings Tekniska Högskola, Campus
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Utveckling av en Bluetooth-baserad web kamera

Författare
Robert Johansson & Jimmy Linder

Sammanfattning
Abstract

This report is the result of a thesis work done at Linköpings University. It was performed at the Institution of Science and Technology (ITN) at Campus Norrköping in cooperation with TDK Systems Europe Ltd, Emblaze Semiconductor and Eclipse. The aim was to design a fully functional prototype of a Bluetooth web camera and a PCB-layout. The web camera was created by combining a Bluetooth intelligent serial module from TDK Systems Europe Ltd and a development kit from Emblaze. The development kit contained their ER4520 multimedia coprocessor and was designed as a web camera. A PCB layout was designed using Protel DXP and is to be manufactured. The resolution achieved is QCIF (176 x 144) and 16 fps.

Nyckelord
Keyword

Bluetooth, web camera, electronics design, Protel DXP, system design, Eclipse, TDK Systems Europe, Emblaze Semiconductor

Notice:

The information related to Emblaze and TDK Systems Europe Ltd in this report is proprietary and cannot be copied or distributed without written permission!

Abstract

This report is the result of a thesis work done at Linköpings University. It was performed at the Institution of Science and Technology (ITN) at Campus Norrköping in cooperation with TDK Systems Europe Ltd, Emblaze Semiconductor and Eclipse. The aim was to design a fully functional prototype of a Bluetooth web camera and a PCB-layout. The web camera was created by combining a Bluetooth intelligent serial module from TDK Systems Europe Ltd and a development kit from Emblaze. The development kit contained their ER4520 multimedia coprocessor and was designed as a web camera. A PCB layout was designed using Protel DXP and is to be manufactured. The resolution achieved is QCIF (176 x 144) and 16 fps.

Preface

This report is the result of a thesis work done at Linköpings University. It was performed at the Institution of Science and Technology (ITN) at campus Norrköping in cooperation with TDK Systems Europe Ltd, Emblaze Semiconductor and Eclipse.

We would like to thank all people from TDK Systems Europe Ltd and Emblaze that have helped us with technical support and supplying devices. We also would like to thank Shaofang Gong, Qin-Zhong Ye and all other teachers and supervisors for all their help. Special thanks to the Managing director of Eclipse, Mike Scott, for funding our work and giving us new ideas.

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Abbreviations List

Expression	Abbreviation
TDK Systems Europe	TSE
Emblaze Semiconductor Ltd	Emblaze
Special Interest Group	SIG
Bill of Material	BOM
Printed Circuit Board	PCB
Light Emitting Diode	LED
Radio Frequency	RF
Ball Grid Array	BGA
Frames per second	FPS
Quarter Common Intermediate Format	QCIF
Industrial Scientific Medicine	ISM
Voice Band Audio Processor	VBAP

1 Introduction

The need for a wireless web camera has grown and some of the large manufacturers have started to develop web cameras that use radio waves. There are already some wireless web cameras on the market, but none of them is using the Bluetooth technology. The camera that has been designed is most likely the first one of this kind. The reason that no one has done this before is likely due to the fact that Bluetooth SIG has not yet specified video over Bluetooth.

The main task for this thesis work is to make a hardware design of a Bluetooth camera module using a Bluetooth module and a known camera reference design. The camera is based mainly on two parts, one is the Bluetooth module from TSE and the other is a multimedia coprocessor and reference design from Emblaze. This design has been made with Protel DXP from Altium.

1.1 Background

This project has been made as a diploma work for a Master of Science degree in Electronics Design at Linköpings University. The project has been made in cooperation with Eclipse, TSE and Emblaze Semiconductor. Eclipse has supported the students with personal compensation and technical support. TSE has supported the work with their Bluetooth intelligent serial module and technical support. Emblaze has supported the work with their ER4520 multimedia coprocessor, a serial camera and technical support. The University has contributed with knowledge and design and lab tools.

In return for all involved parts, everyone can utilize of the result, such as the report, schematics, BOM and the PCB layout.

1.2 Purpose

The purpose of this thesis is to develop a wireless Bluetooth web camera using a Bluetooth module from TSE and a serial camera from Emblaze Semiconductor. The purpose is also to learn more about Bluetooth and hardware design.

The outcome of the thesis will result in a camera prototype and finally a Master of Science degree.

1.3 Structure of the report

The purpose with this report is to describe how the problem has been solved and how the camera has been designed. The report also describes some theoretical background of Bluetooth, the camera and the main components. The report aims to give the reader a good understanding of the technique that has been used to design the camera.

2 Presentation of the involved companies

2.1 Eclipse

The main concept of Eclipse is to design and manufacture state-of-the-art home automation products using the Bluetooth radio technology.

The Eclipse group consists of HQ and Design Center based in southern Spain, and a manufacturing plant in southern Thailand.

The group started work in August 2002 with backing from the Investment Plus group, a long established European company with sizeable assets in diverse fields.

The company has brought together high-level expertise in the fields of Bluetooth RF disciplines, Microcontroller hardware and software development and Display/touch panel technology to embark the field of "Home Automation".

After some research the company created a product range titled "5isAlive", with the aim producing the world's first, truly universal and wireless, home automation system.

5isAlive will be sold as a micro-sized control system that works with existing switches and sockets. After installing 5isAlive the customer are still able to use the switches as before. The customer can choose how he/she wants to control the system, for example voice, touch screen, pocket remote, phone, palm top device, Internet. 5isAlive can control anything that works on electricity. Eclipse is developing their own Bluetooth modules and is now working on high-resolution video over Bluetooth, using MPEG4 compression chips. [4]

2.2 TDK Systems Europe LTD

TDK Electronics Europe GmbH was established in Düsseldorf, Germany, in 1973. Today it is the headquarters of a rapidly growing European business for electronic components, factory automation products and anechoic chambers.

Along with the expansion of the sales network, TSE is continuously strengthening its local research & development activities as well as its production bases. The company has seven European sales offices, two manufacturing plants, a Components Engineering Laboratory and support through a wide distribution network.

TSE started as Grey Cell Systems over ten years ago. As one of the early players in the mobile communications business, TSE's track record includes an impressive range of 'firsts'. [2]

In the early 1990s, it was one of the first companies in Europe to offer credit card sized network cards for notebook computers and among the first to make modems easy to use in different countries using software configuration. It pioneered the way in combining technologies such as LAN, modem, ISDN and GSM onto a single credit card sized product. Success with its PC Card (credit card sized) mobile products attracted direct investment from TDK Corporation who acquired the company in 1997 to establish their European mobile communications research and development center.

Over the last ten years the company has grown considerably – it now employs over 65 people and has a network of international local offices.

Having been one of the first companies to develop Bluetooth hardware and applications under the ‘go blue’ brand, TSE is now uniquely placed to succeed in bringing developing wireless technologies such as Wi-Fi, Wi-Fi5 and HiperLAN to market.

2.3 Emblaze semiconductor Ltd

Emblaze are specializing in highly integrated digital multimedia chips for the consumer, mobile and cellular markets.

Emblaze Semiconductor is a leading IC company, providing semiconductor-based solutions for high volume mobile multimedia appliances for the telecommunication, consumer, and security markets. Emblaze Semiconductor offers its customers the power to rapidly develop and implements multimedia capabilities into high volume mobile/wireless information devices such as cellular phones, PDAs, digital cameras, toys, etc. The programmable mobile multimedia ICs support a wide variety of services and applications, including audio and video streaming, recording & playback, messaging, conferencing, gaming, and editing. All ICs are fully compliant with international standards and formats such as H.263, MPEG-4, MS-ASF, MP3, AAC, 3G-324M, JVT (H.26L). The combination of a programmable environment, enhanced by dedicated hardware, enables high quality, efficient (at low power consumption) and cost effective yet flexible solutions.

Emblaze Semiconductor is headquartered in Ra’anana, Israel. The company also maintains sales and marketing offices in Korea, China, UK, US, and Singapore.

Emblaze Semiconductor is a member of the Emblaze Group, leading the global transformation towards rich media personal communication. Other companies in the group include Emblaze Systems, Orca Interactive and AlphaCell Wireless.

Emblaze Semiconductor has developed high-performance low-power chips for multimedia applications on mobile devices. The chips are based on a combination of a programmable RISC for flexibility, and hardware macros for heavy-duty multimedia processing and reduced power consumption. These multimedia coprocessor chips can be used in a variety of mobile devices, including cell phones, smart phones, PDAs, communicators, mobile music players, and digital image and video cameras.

The Emblaze mobile multimedia chips support industry standard compression algorithms, including MPEG-4, H.263+, JPEG, MP3, AAC, and GSM-AMR. The H/W macros of the mobile multimedia chips, which enhance video and audio processing, can be licensed as cores for integration into a customer's application chip, Bluetooth chip, baseband chip, etc.

Emblaze Semiconductor is leading the standardization activities in the area of multimedia streaming and communication, through its leadership position in the Wireless Multimedia Forum, and its membership in the Bluetooth SIG and MPEG-4 Industry Forum. [3]

3 Theory

The theory chapter describes relevant information for the project, which can be useful for better understanding of the report. If the reader is already familiar with the terms, it is not necessary to read this chapter.

3.1 Bluetooth

3.1.1 Introduction

Bluetooth is an always-on, short radio hook-up that resides on a microchip. Bluetooth is a global standard for wireless connectivity. It was initially developed by Ericsson, a Swedish mobile phone maker, in 1994 as a way to make laptop computer to call over mobile phones. Since then, several thousand companies have signed on to make Bluetooth the low-power short-range wireless standard for a wide range of devices. The Bluetooth technology facilitates the replacement of the cables normally used to connect one device to another, with one universal short-range radio link. For example, the Bluetooth radio technology built into both the mobile telephone and the laptop could replace the traditional (serial) cable used today to connect these devices or it can replace the cable between a web camera and a computer.

Beyond facilitating the replacement of cables, Bluetooth technology can also act as a universal medium to bridge the existing data networks or to form small private ad hoc groupings of connected devices away from fixed network infrastructures. Bluetooth is designed to operate in an environment of many users. Up to eight devices can communicate in a small network called a piconet. Ten of these piconets can coexist in the same coverage range of the Bluetooth radio. Two Bluetooth devices can talk to each other when they come within a range of 10 meters to each other. Due to their dependence on a radio link, as opposed to an alternate technology such as an infrared connection, Bluetooth devices do not require a line-of -sight connection in order to communicate. Therefore, a laptop could print information on a printer in a neighbouring room.

3.1.2 The name Bluetooth

The Bluetooth wireless technology is named after Harald Blåtand ("*Bluetooth*"), who was the King of Denmark from 940 to 981. He was the son of Gorm the Old, the King of Denmark, and Thyra Danebod, daughter of King Ethelred of England. Harald was remembered for peacefully uniting Denmark and Norway. The Bluetooth wireless technology is expected to unite devices such as PDAs, cellular phones, PCs, headphones and audio equipment, using a short-range, low power and low cost radio technology.

3.1.3 The development of the Bluetooth technology

The Bluetooth technology was developed by members of a Special Interest Group, SIG. The participating companies agree not to charge royalties on any Intellectual Property (IP) necessary to implement the technology. The SIG started initially with the promoters, who were the primary developers of the technology, and then expanded to include early adopters and adoptees.

3.1.4 About Bluetooth

The concept behind Bluetooth is to provide a universal short-range wireless capability. Using the 2.4 GHz band, available globally for unlicensed low-power uses, known as the Industrial, Scientific, and Medical (ISM) band, two Bluetooth devices within 10 m of each other can share up to 720 kbps of capacity. Bluetooth is intended to support an open-ended list of applications, including data, audio, graphics and video.
Bluetooth provides support for three general applications areas using short-range wireless connectivity:

- **Data and voice access points:** Bluetooth facilitates real-time voice and data transmissions by providing effortless wireless connection of portable and stationary communication devices.
- **Cable replacement**: Bluetooth eliminates the need for numerous, often proprietary, cable attachments for connection of practically any kind of communication device. Connections are instant and are maintained even when devices are not within line of sight. The range of each radio is approximately 10 m, but can be extended to 100 m with an amplifier.
- **Ad hoc networking:** A device equipped with a Bluetooth radio can establish instant connection to another Bluetooth radio as soon as it comes into range. [5]

The Bluetooth radio is designed to operate in a noisy radio frequency environment. It uses a fast frequency-hopping scheme to make the link robust. Bluetooth radio modules avoid interference from other signals by hopping to a new frequency after transmitting or receiving a packet. Compared with other systems operating in the same frequency band, the Bluetooth radio typically hops faster and uses shorter packets. This makes the Bluetooth radio more robust than other systems. Short packages and fast hopping also limit the impact of domestic and professional microwave ovens, which also operate in the 2.4 GHz radio band. [6]

3.1.5 Protocol architecture

The Bluetooth protocol is described as a set of specifications defining various layers of the protocol stack, consisting of core protocols; cable replacement and telephony control protocols, and adopted protocols. See Figure 1.

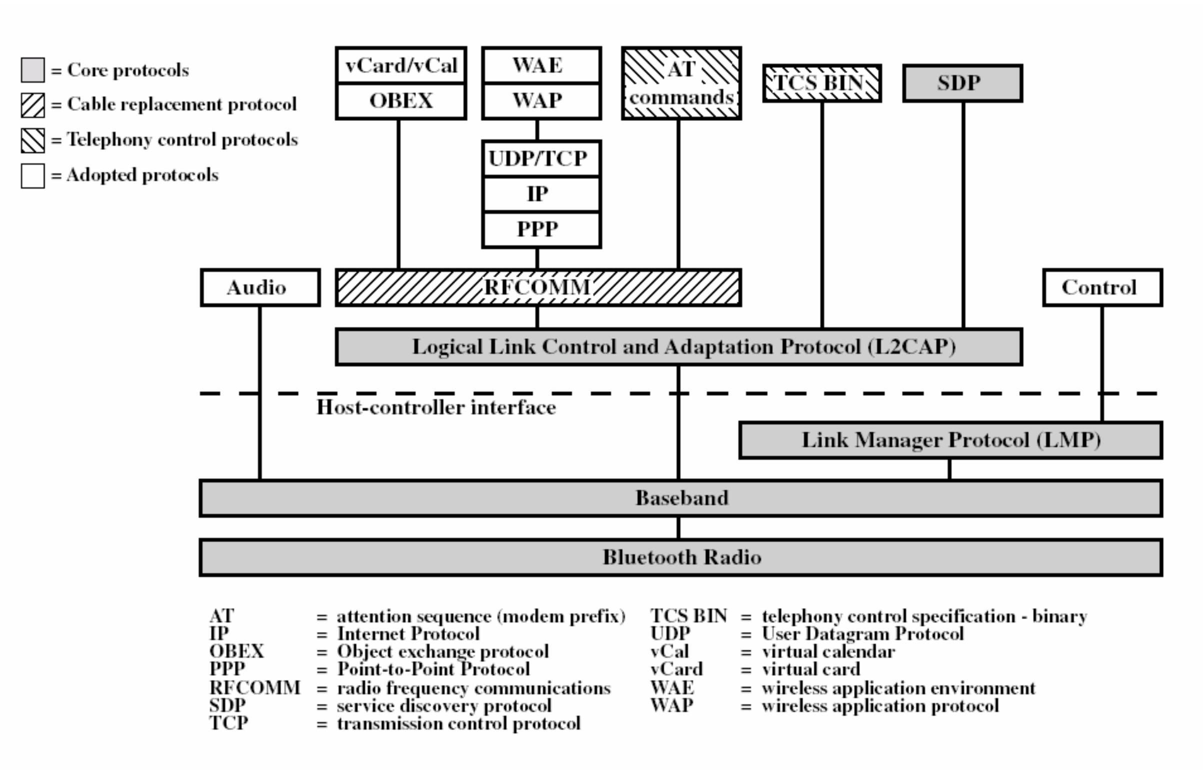

Figure 1. The Bluetooth Protocol Stack

The Bluetooth core protocol employs five layers, each responsible for performing various functions on the data to be transmitted or received. These "layers" are implemented by software and hardware means. The top layer is the Application Program Interface (API) and Service discovery protocol (SDP) and allows applications on the computer or other device to

access the Bluetooth system. This is the first layer that the transmission data will "pass through". The next layer down is the **Logical Link Control and Adaptation Protocol (L2CAP)**. This layer is responsible for maintaining individual links to other devices, data formatting from the application type to Bluetooth transmittable formats, and multiplexing of the various links into one stream. The **Link Manager (LM)**, the third layer down, is responsible for establishing and terminating links to other devices. This layer is also responsible for authentication of new links, in order to preserve security. The fourth link is the **baseband** and many low level tasks are performed here. The data is sequenced into packets while error correction and encryption data is added as headers on the payload (the user's data). The final layer is the actual **radio** transmitter and antenna. This layer, implemented purely in hardware, accepts the data stream from the baseband and converts it from digital to analog. The analog signal is then sent to the antenna for actual transmission.
The opposite process occurs for receiving analog data in a Bluetooth device. The antenna receives a signal and passes the analog stream to the Bluetooth radio. The analog signal is converted to a digital stream and passed to the baseband. The baseband reads and strips the headers from the original payload, then decrypts and corrects the data if necessary. The stream then moves upward to the Link Manager and L2CAP where it is reassembled and converted back into the application data types. Finally it passes through the API back to a program. [7]

RFCOMM is the **cable replacement protocol** included in the Bluetooth specification. RFCOMM presents a virtual serial port. The serial port is one of the most common types of communications interfaces used in computing and communication devices. Hence, RFCOMM enables the replacement of serial port cables with the minimum of modification of existing devices. RFCOMM provides for binary data transport and emulates RS-232 signals over the baseband layer. [5]

Bluetooth specifies a **telephony control protocol**. TCS BIN (telephony control specifications – binary) is a bit-oriented protocol that defines the call control signalling for the establishment of speech and data calls between Bluetooth devices. In addition it defines mobility management procedures for handling groups of Bluetooth TCS devices. [5]

The adopted protocols are defined in specifications issued by other standard-making organizations and incorporated into the overall Bluetooth architecture. The Bluetooth strategy is to invent only necessary protocols and use existing standards whenever possible. The adopted protocols include the following; PPP, TCP/UDP/IP. OBEX, WAE/WAP. [5]

3.1.6 Topology

The Bluetooth system supports both point-to-point and point-to-multi-point connections. Several piconets can be established and linked together in an ad hoc manner. Each such piconet is identified by a different frequency hopping sequence. All users participating in the same piconet are synchronized to this hopping sequence. [6]

3.1.7 The Piconet

Bluetooth devices can interact with one or more other Bluetooth devices in several different ways. The simplest scheme is when only two devices are involved. This is referred to as point-to-point. One of the devices acts as the master and the other as a slave. This ad hoc network is referred to as a piconet. As a matter of fact, a piconet is any such Bluetooth network with one master and one or more slaves. In the case of multiple slaves, the communication topology is referred to as point-to-multipoint. In this case, the channel (and bandwidth) is shared among all the devices in the piconet. There can be up to seven active slaves in a piconet. Each of the active slaves has an assigned 3-bit Active Member address. There can be additional slaves, which remain synchronized to the master, but do not have an Active Member address. These slaves are not active and are referred to as parked. For the case of both active and parked units, the master regulates all channel access. A parked device has an 8-bit Parked Member Address, thus limiting the number of parked members to 256. A parked device remains synchronized to the master clock and can quickly become active and begin communicating in the piconet. The full-duplex data rate within a multiple piconet structure with 10 fully loaded, independent piconets is more than 6 Mb/s. [6]

3.1.8 The Scatternet

When two piconets are close to each other, they have overlapping coverage areas. This scenario is provided for in the Bluetooth specification and is referred to as a scatternet.
A typical example: one might have a piconet consisting of the mobile phone and the PC in one's cubicle, see Figure 2, while the person in the neighbouring cubicle may have a piconet consisting of a mobile phone, headset, and business card scanner. Slaves in one piconet can participate in another piconet as either a master or slave. This is accomplished through time

division multiplexing. In a scatternet, the two (or more) piconets are not synchronized in either time or frequency. Each of the piconets operates in its own frequency-hopping channel while any devices in multiple piconets participate at the appropriate time, via time division multiplexing. In the previous example, the person in cubicle #1 may use the neighbour's business card scanner on mutually agreed upon terms. [6]

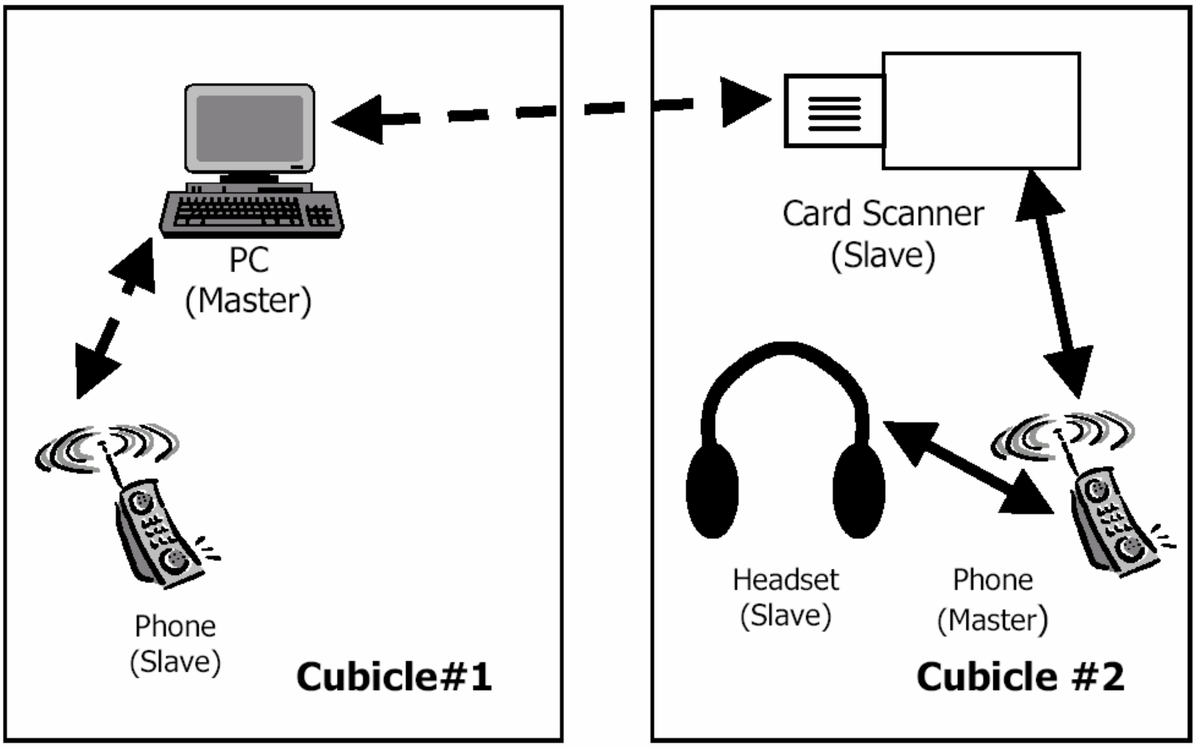

Figure 2. Cubicle

3.1.9 Bluetooth Standards

The Bluetooth standards are divided into the following parts:

• Core

• Profile

The Core documents describe the implementation aspects of Bluetooth technology for the various layers of the Bluetooth protocol. These documents also cover the interoperability and testing requirements. The Profile specifications describe the implementation aspects for various usage models of the Bluetooth technology. Essentially, these documents describe how the Bluetooth technology could be used in a particular application.

3.1.10 Usage models

A number of usage models are defined in Bluetooth profile documents. In essence, a usage model is a set of protocols that implement a particular Bluetooth based application. Each profile defines the protocols and protocol features supporting a particular usage model. The highest priority usage models are listed below.

- **File transfer:** The file transfer usage model supports the transfer of directories, files, images and streaming media formats. This usage model also includes the capability to browse folders on a remote device.
- **Internet bridge:** With this usage model, a PC is wireless-connected to a mobile phone or cordless modem to provide dial-up networking and fax capabilities.
- **LAN access:** This usage model enables devices on a piconet to access a LAN. Once connected, a device functions as if it were directly connected (wired) to the LAN.
- **Synchronization**: This model provides a device-to-device synchronization of PIM (Personal Information Management) information, such as phone book, calendar, message and note information
- **Three-in-one phone:** Telephone handset that implements this usage model may act as a cordless phone connecting to a voice base station, as an intercom device for connection to other telephones, and as a cellular phone.
- **Headset:** The headset can act as a remote device's audio input and output interface. [7]

3.1.11 Wireless Functionality

Bluetooth's wireless functionality, reliability, and security are achieved through its modulation and packet scheme. Bluetooth uses the 2.4GHz ISM band, specifically, 2.402GHz - 2.480GHz. 79 different channels are defined for use in America and most of Europe, where the available band is split into 79 channels, each spaced 1MHz apart. In France, the available band only provides 23 channels, each spaced 1MHz apart. Devices using the smaller spectrum will be compatible worldwide while devices using the full spectrum will only be supported in their local nations.

The actual modulation scheme used by Bluetooth is Gaussian Frequency Shift Keying (GFSK). In this method, a positive frequency shift is equal to a binary 1, while a negative frequency shift is equal to a binary 0. The signal is passed through a Gaussian filter to eliminate noise above and below the target frequency.

Bluetooth divides the data to be sent into packets. Each packet is sent within a 625µs slot. A frame is normally defined as a transmit and/or receive slot, providing full duplex communication between a slave and a master in one time frame. To avoid noise and other interference, Bluetooth hops to one of the 79 different channels each time frame. The channel that it hops to is determined by an algorithm that uses the master's ID number and previous channel to calculate the next channel. This algorithm repeats itself indefinitely. For example, if there is severe noise between 2.408GHz and 2.410GHz, it will be avoided the majority of the time. Also, when multiple Bluetooth masters are within the same scatternet, their clocks are not synchronized. There is little contention, which would otherwise result from both masters picking the same channel at the same time. Because of channel hopping, packet error is kept to a minimum, despite interference or highly dense scatternets.
Master devices can use this frame division to communicate to each slave on the piconet consecutively, with 1 frame each, or masters can devote multiple frames to a single slave device, as priority dictates. Masters can also send a single packet to multiple slaves within the same slot. However, there is no return slot from the slaves when this occurs.

There is two kinds of packages that can be sent during each time slot, depending on the type of data to be transmitted. Voice communications use Synchronous Connection Oriented (SCO) type packets, while standard data uses Asynchronous Connection-Less (ACL) type packets. With SCO connections, the master and one slave have a direct point-to-point full duplex link between each other. A certain amount of bandwidth is allocated just for the link, by reserving slots for the target slave only. With ACL connections, the bandwidth varies, and the packets can be lagged, or resent when needed. Packets can be sent to one slave directly, providing a point-to-point full duplex connection, or can be sent to any number of slaves, where a point-to-multipoint simplex connection is present. These packet types can change every time frame, allowing for varied communications between all the devices. [7]

3.1.12 The Bluetooth Clock

Every Bluetooth unit has an internal system clock, which determines the timing and hopping of the transceiver. The Bluetooth clock is derived from a free running native clock, which is never adjusted and is never turned off. For synchronization with other units, only offsets are used. These offsets, when added to the native clock, provide temporary Bluetooth clocks, which are mutually synchronized. The Bluetooth clock has no relation to the time of day and can therefore be initialized to any value. The Bluetooth clock provides the heart beat of the Bluetooth transceiver. Its resolution is at least half the TX or RX slot length, or 312.5µs. If the clock is implemented with a counter, a 28-bit counter is required that wraps around at 228 -1. The LSB ticks in units of 312.5µs, giving a clock rate of 3.2 KHz. [6]

3.1.13 States

Figure 3 shows a state diagram illustrating the different states used in the Bluetooth link controller. There are two major states: STANDBY and CONNECTION; in addition, there are seven sub states; page, page scan, inquiry, inquiry scan, master response, slave response, and inquiry response. The sub states are interim states that are used to add new slaves to a piconet. To move from one state to the other, either commands from the Bluetooth link manager, or internal signals in the link controller are used. The STANDBY state is the default state in the Bluetooth unit. In this state, the Bluetooth unit is in a low-power mode. Only the native clock is running. The controller may leave the STANDBY State to scan for page or inquiry messages or to page or perform the inquiry itself. When responding to a page message, the unit will not return to the STANDBY state but enter the CONNECTION state as a slave. When carrying out a successful page attempt, the unit will enter the CONNECTION state as a master. [6]

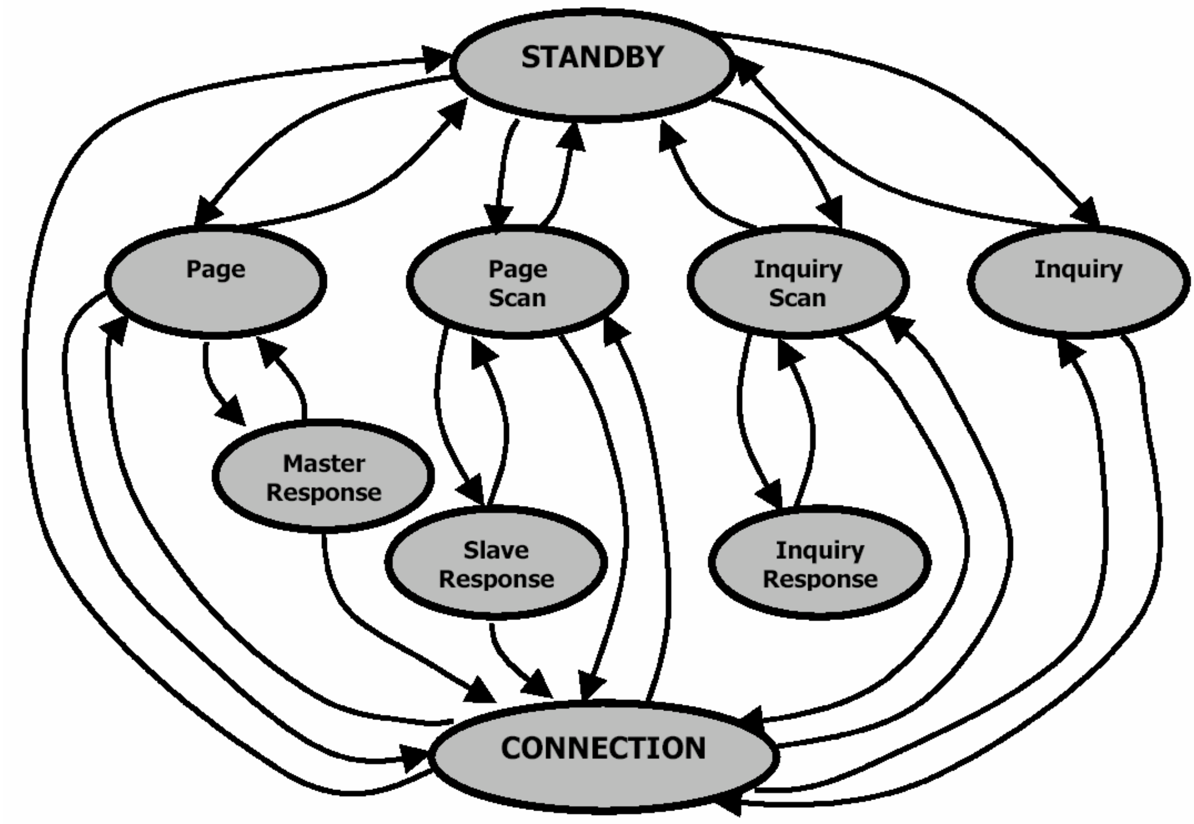

Figure 3. Bluetooth states

3.1.14 Security

The Bluetooth baseband specification defines a facility for link security between any two Bluetooth devices, consisting of the following elements:

- Authentication
- Encryption
- Key management and usage

The security algorithm uses four different parameters:

- **Unit address:** The 48-bit device address, which is publicly known
- **Secret authentication key:** A secret 128-bit key
- **Secret privacy key:** A secret key of length from 4 to 128 bits
- **Random number:** A 128-bit random number derived from a pseudorandom generation algorithm executed in the Bluetooth unit

The two secret keys are generated and configured with the unit and not disclosed.

The purpose of **authentication** is to verify the claimed identity of one of the two Bluetooth devices involved in an exchange.

User information can be protected by encryption of the packet payload; the access code and the packet header are never encrypted. Encryption is performed using an encryption algorithm known as E_0. When encryption is enabled, the master sends a random number, RAND, to the slave. For each packet transmission, a new encryption key is generated using RAND, the master's address, the current clock value, and a shared secret key.

Bluetooth offers different levels of security:

- **None**—all Bluetooth devices are allowed to connect.
- **Authorization**—the local device operator must authorize a remote device connection, usually by physically clicking an on-screen button.
- **Authentication**—remote devices must provide a password that matches that of the local device.
- **Encryption**—connections with remote devices can be encrypted for additional security. Some Bluetooth devices do not support encryption. If a device or service is

configured to use encryption and attempts a connection with a device that does not support encryption the connection may fail unexpectedly.

3.1.15 Bluetooth Summary

Bluetooth has the potential to connect many devices in the home, offices, and on the road, increasing both productivity and entertainment. Currently backed by over thousands of companies and with Bluetooth integrated chipsets and radios dropping drastically in price over the next few years, Bluetooth is easily to become a common household name. Mobile phones, PDAs, computer peripherals, and even cars are now retailing with Bluetooth support. However, it is ultimately up to the consumers to decide the fate of this new wireless technology.

3.2 TDK Bluetooth Intelligent Serial Module

Notice: Most of this part is taken from TDK Systems Europe Ltd.

3.2.1 Introduction

This is a description of the hardware interface of the TDK Bluetooth Intelligent Serial Module. This is a module that is designed to be built into a device and to provide a simple and low cost Bluetooth interface. The module is designed to integrate with a wide range of applications and platforms with a simple electrical and software interface using AT commands.

3.2.2 Facts

The Serial Module contains a complete Bluetooth interface and requires no further hardware to implement full Bluetooth communication. The module has an integrated, high performance antenna together with all RF and Baseband circuitry. It interfaces to the host over a serial port using AT commands. The module runs specific firmware within the virtual processor that includes a serial Port Profile and AT command interpreter. The module can be configured so that it can be attached to a ‘dumb’ terminal or attached to a PC or PDA for cable replacement applications. The module provides access to 5 General I/O lines and 2 analogue I/O lines to provide Bluetooth connection to simple devices such as switches or LEDs without requiring any processing at the module end.

Table 1. TDK Bluetooth intelligent serial module.

Feature	Implementation
Bluetooth Transmission	Class 1
Frequency	2.400- 2.485 GHz
Max Transmit Power	+6dBm
Min Transmit Power	+0dBm
Receive Sensitivity	Better than –85dB
Antenna Gain	+2dBi
Range	200m
Data Transfer rate	Up to 200Kbps
Serial Interface	RS-232
Baud rate	Configurable from 9600bps
Physical size	24 x 69 x 5 mm
Fully Bluetooth pre- qualified	Bluetooth 1.1 PRODUCT listing
Current consumption	Less than 36mA during data transfer
Temperature Range	Normal operation –20°C to + 75°C
Interface levels	3.3V
Audio	Audio can be transferred over SCO channels through the PCM interface at 64kbps

3.2.3 Interface

The Serial Module is equipped with a 40-pin 0.5mm pitch board-to-board connector that connects to the application platform. The connector includes the following parts, which will be described more lately.

- Serial Interface
- Power supply
- Electrical specification of the interface

3.2.4 Serial Interface

UART_TX, UART_RX, UART_RTS and UART_CTS form a conventional asynchronous serial data port. The interface is designed to operate correctly when connected to other UART devices such as the 16550A. The signalling levels are nominal 0V and 3.3 V and are inverted with respect to the signalling on an RS232 cable. The interface is programmable over a variety of bit rates; no, even or odd parity; stop bit and hardware flow control. The default condition on power-up is pre-assigned in the external Flash. Two-way hardware flow control is implemented by UART_RTS and UART_CTS. UART_RTS is an output and is active low. UART_CTS is an input and is active low. These signals operate according to normal industry convention. By writing different values to the S register the UART_RI can be continuously polled to detect incoming communication. The UART_RI signal serves to indicate incoming calls. UART_DSR is an active low input. It should be connected to DTR output of the host. When the module is running in high-speed mode, this pin should be asserted by the host to ensure connection is maintained. A deassertion is taken to mean that the connection should be dropped, or an online command mode is being requested. The module is designed for use as a DCE. Based on the conventions for DCE-DTE.

3.2.5 Power Supply

The power supply for the Serial Module has to be a single voltage source of Vcc= 3.6V-6V. It must be able to provide sufficient current in a transmit burst which can rises to 65mA. The module includes regulators to provide local 3.3V and 1.8V.

3.2.5.1 Power-On-Reset

The Module is provided with an active high reset pin (Hirose 40way DF12C connector). This pin is pulled to ground through a 10K resistor. Upon the application of power, the Power On Reset circuit built into the module will ensure that the unit starts correctly. However the module utilises a split rail design with some components working at 3.3 V and some at 1.8 V. Under certain extreme conditions, for example when the supply voltage to the module experiences a Brown-Out (momentary dip in the supply voltage level), or a rapid power cycle i.e. the power is switched off and then on within 1 second, there is a possibility that the module can enter an unknown state of operation. To avoid this problem the design uses a

Power-On-Reset circuit with a Brown-Out detection capability. This is to guarantee that under all circumstances the module will operate in a known state.

3.2.6 SPI Bus

The module is a slave device that uses terminals SPI_MOSI, SPI_MISO, SPI_CLK and SPI_CSB. This interface is used for program firmware update.

3.2.7 Parallel PIO Port

Five lines of programmable bi-directional input/outputs (I/O) are provided. GPIO[1:5] are powered from VCC. The mode of these lines can be configured and the lines are accessed via S Registers 621 to 625. Auxiliary functions available via these pins include an 8-bit ADC and an 8-bit DAC. This function is not implemented at this time.

3.2.8 PCM CODEC Interface

PCM_OUT, PCM_IN, PCM_CLK and PCM_SYNC carry up to three bi-directional channels of voice data, each at 8ksamples/s. The format of the PCM samples can be 8-bit A-law, 8-bit ì-law, 13-bit linear or 16-bit linear. The PCM_CLK and PCM_SYNC terminals can be configured as inputs or outputs, depending on whether the module is the Master or Slave of the PCM interface. The serial module is compatible with the Motorola SSI TM interface and interfaces directly to PCM audio devices.

3.2.9 Mounting the Serial Module onto the application platform

There are many ways to properly install the Serial Module in the host device. An efficient approach is to mount the PCB to a frame, plate, rack or chassis. Fasteners can be M1.8 or M2 screws plus suitable washers, circuit board spacers, or customized screws, clamps, or brackets in 2.2mm diameter holes. Note that care should be taken to ensure the head of the fixing does not interfere with the circuit. Nylon fixings are recommended. In addition, the board-to-board connection can also be utilized to achieve better support. The antenna (Brown square component on top side of PCB) must not be influenced by any other PCBs, components or by the housing of the host device. The proximity of the antenna to large metallic objects can affect the range and performance of the system.

3.2.10 Electrical and radio characteristics

3.2.10.1 Absolute Maximum ratings

Absolute maximum ratings for supply voltage and voltages on digital and analog pins of the module are listed below, exceeding these values will cause permanent damage.

Table 2. Ratings

Parameter	Min	Max	Unit
Peak current of power supply	0	100	mA
Voltage at digital pins	-0.3	3.7	V
Voltage at POWER Pin	3.3	7	V

3.2.11 Power Consumption

The current drain from the Vcc power input line is dependent on various factors. The three most significant factors are the voltage level at Vcc, UART Baudrate and the operating mode. The hardware specification for the serial module allows for a voltage range of 3.6 to 6.0V at Vcc. Tests have shown that there is no significant difference in current draw when Vcc is 5 or 6V. Therefore the data presented below, pertains to Vcc levels of 3.6 and 5V only. Tests have shown that where power drain is an issue, it is best to keep Vcc at the lower end of the range. The UART baudrate has a bearing on power drain because, as is normal for digital electronics, the power requirements increase linearly with increasing clocking frequencies. Hence higher baudrates result in a higher current drain. Finally with regards to operating mode the significant modes are; idle, waiting for a connection, inquiring, initiating a connection and connected. With connected mode, it is also relevant to differentiate between no data being transferred and when data is being transferred at the maximum rate possible. The AT command Set document describes how to configure the module for optimal power performance. The serial module has 2 LEDs, which can be configured to display connection status.

3.2.12 RF performance

3.2.12.1 Transmit Power

Conducted Transmit Power: min: 1.0mW(0dBm) max: 4mW(6dBm) Power class 1

Antenna Gain: +2dBi typ.

Effective Transmit Power: min: 2dBm max:8dBm

3.2.12.2 Receive Sensitivity

Receive Sensitivity: -86dBm (at 25oC)

Antenna Gain: +2dBi typ.

Effective Receive Sensitivity: -88dBm (at 25oC)

3.2.12.3 Range

See Data Transfer Rate vs. distance. The data throughput of the Serial adapter is limited to 200Kbps by the parsing of the data being transferred through the AT command processor. The graph below shows the best case data though-put with and without the AT command processing. Distances are measured in free space between 2 Serial Modules.

Figure 4. Data Transfer Rate vs. Distance

3.3 ER4520 Multimedia and Application Coprocessor

The Emblaze Semiconductor ER4520 is a mobile multimedia SOC design for the wireless and mobile market enabling a variety of wireless multimedia applications. Applications include cell phones, PDAs, mobile and multimedia accessories such as digital still/video cameras. The ER4520 is a full duplex audio/video codec based on the ARM920T core as a high-performance, fully programmable processor. Built-in additions include audio/video capture, encoding and video display hardware accelerator blocks for enhancing performance and quality while reducing power consumption. The chip comprises of a rich set of peripheral interfaces to reduce the system component count and power consumption.

Key Features

- Optimized architecture for variety of multimedia applications
- Superior multimedia performance at lower system level power consumption
- Rich set of peripherals allow developers to customize their products as needed
- Small 180 pin FlexBGA package eases design in space constrained devices
- Fully integrated solution supporting all standard protocols
- Download to media flash
- Audio/video local player
- MP3 player
- Audio/video streaming (live and on demand)
- Audio/video messaging
- Digital still camera
- Full duplex video phone

3.3.1 Supported Wireless & Multimedia Applications

3.3.1.1 Video Codec Features

- QCIF[1] resolution (176x144) up to 144 Kbps
- Video streaming – 30 fps decode only

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[1] QCIF (Quarter Common Intermediate Format) The resolution associated with CIF is 352x288 pixels and 30 fps.

    - Video mail – 15 fps encode only
- Video phone (full duplex) – 12 fps encode and decode
- Advanced error resilience and error concealment algorithms
- Advanced pre and post processing to improve picture quality
- PIP (picture in picture) support
- JPEG encode/decode up to VGA resolution

4 Method

The project started with literature study of the Bluetooth technique and the data sheets for the TDK Bluetooth serial module and the Emblaze ER4520 chip. With this as a starting point the work went on with elaborating with the different devices, first as standalone devices and then together. The aim was to design a fully functional prototype of a Bluetooth web camera.

The literature that was studied was mostly Bluetooth related books and technical documentation about the different parts. To get a better understanding of what the project was all about some other literature was studied, such as RS232, Mpeg4 and USB etc. These will not be parts of the report.

4.1 Test of equipment

Available equipment for the project when it started was an evaluation board for the ER 4520 chip. This was in the form of a serial web camera, and a motherboard for the Bluetooth Intelligent Serial module. The different equipment was tested as standalone devices at the beginning. The camera was connected to a computer via the RS232 interface and worked well. The TDK Intelligent Serial Module was first connected to a motherboard and the motherboard was then connected to a computer. To test communication between two Bluetooth modules, they were connected to two different computers and AT commands were used to initiate communication. The program for AT commands was supplied by TSE. TSE also supplied the work with a document that described the protocol used to control and configure the Bluetooth Intelligent Serial Module. The protocol is similar to the industry standard Hayes AT protocol used in telephony modems due to the fact that both types of devices are connection oriented. Appropriate AT commands have been provided to make the module perform the two core actions of a Bluetooth device, which is make/break connections and Inquiry. Many other AT commands are also provided to perform ancillary functions, such as, pairing etc.

Just like telephony modems, the serial module powers up into an unconnected state and will only respond via the serial interface. In this state the module will not even respond to Bluetooth Inquiries. Then, just like controlling a modem, the host can issue AT commands, which map to various Bluetooth activities. To make sure that they could handle more than AT commands, a file transfer was also tested. The test was made between one module connected to a motherboard and one module connected to the computer with USB. In this way Windows could be used to handle the communication.

When both the Bluetooth and camera devices were tested the next step was to connect them to each other and test them together. A serial male-to-male cable made the connection between the Bluetooth intelligent serial module and the camera. Since a standard serial cable is male-to-female, a gender changer must be made to fix this. The connection did not work with this cable. When consulting the manual a null modem cable was going to do the work. This cable was created in the lab (see connections in appendix A). The communication between the TDK serial module and the Bluetooth module on the computer is a virtual COM port (serial port). When the camera is connected to the Serial module it works exactly as if it was connected directly to a computer via a cable. The camera software makes no difference between a virtual COM port and a physical one.

The picture quality (resolution) was not as good as expected. The first idea was to find another camera that uses RS232 serial communication. Contacts were made with different manufacturers to find a new camera. However no camera was found because all manufacturers said that serial communication is too slow to transfer streaming video. To get around this problem other cameras were tested with different interfaces, both parallel cameras and USB cameras. On these cameras the resolution was much better. When using these cameras some other problems arise. The parallel camera is in conflict with serial module that uses the serial interface. There was no easy way to get around this problem, so this alternative solution was ignored. The problem with the USB camera was that the BT module could not handle the USB interface. To solve this, two other solutions were tried. First was to use an USB-to-Serial adapter to make the USB interface into a serial interface. This did not work because of two reasons: (1) the adapter can only make a serial port from a USB port, not a USB port from a serial port, and (2) a USB connection must be between a host and a device. Not as in this case a device to device. Adding a USB host controller between the devices can solve this problem. This solution was not as good as it first appeared, so it was ignored. Second, different Bluetooth modules were used that had USB inputs. The same problem appeared here, USB connection could only be between a host and a device. Neither of the Bluetooth modules that were tested had a USB host controller and could not be used as a host. To implement a host controller would make the camera bigger and more expensive.

The reason that the picture quality was not good enough is because of the limited bandwidth from ER4520. The problem was evaluated to see the possibilities of using USB instead of serial communication. The Bluetooth specification has not yet given any thought about streaming video with USB. Because of this one must design a new stack in the Bluetooth protocol to use USB. While this project is made as a diploma work, this solution will take too much time to implement.

After some time of investigating different solutions the work carried on with the camera from Emblaze and the Intelligent Serial Module from TSE. This seemed to be the best solution considering the circumstances. All alternative solutions would take to much time to implement.

4.2 The Design

As mentioned before the main task of this thesis was to make a hardware design for a Bluetooth web camera. To do this, the big issue was to find a way to connect the Bluetooth module to the camera. Schematic for the camera was supplied by Emblaze.
To connect the Bluetooth module it was decided to use a socket, not to implement all the components from the module on the PCB. By doing this the Bluetooth intelligent serial module will be connected as a complementary unit afterwards. With this solution it will be easy to change serial module if needed. The Power to the system is taken from MAX1705. It is to be seen in Power1.SchDoc.
Both the Bluetooth and camera devices use UART that converts to RS232. When making the hardware design the RS232 circuits were found superfluous and were therefore skipped. The communication was instead established directly with UART. By doing this, the connection was made directly between the Bluetooth socket and the ER4520.
It was also decided that the camera should be able to handle both battery and wired power. To do this a connector with a switch was used, which would disconnect the battery when the cord is plugged in to the socket. The reason for this is that the camera could be used either as a stationary or as a mobile device. The complete schematic is shown in Figure 5.

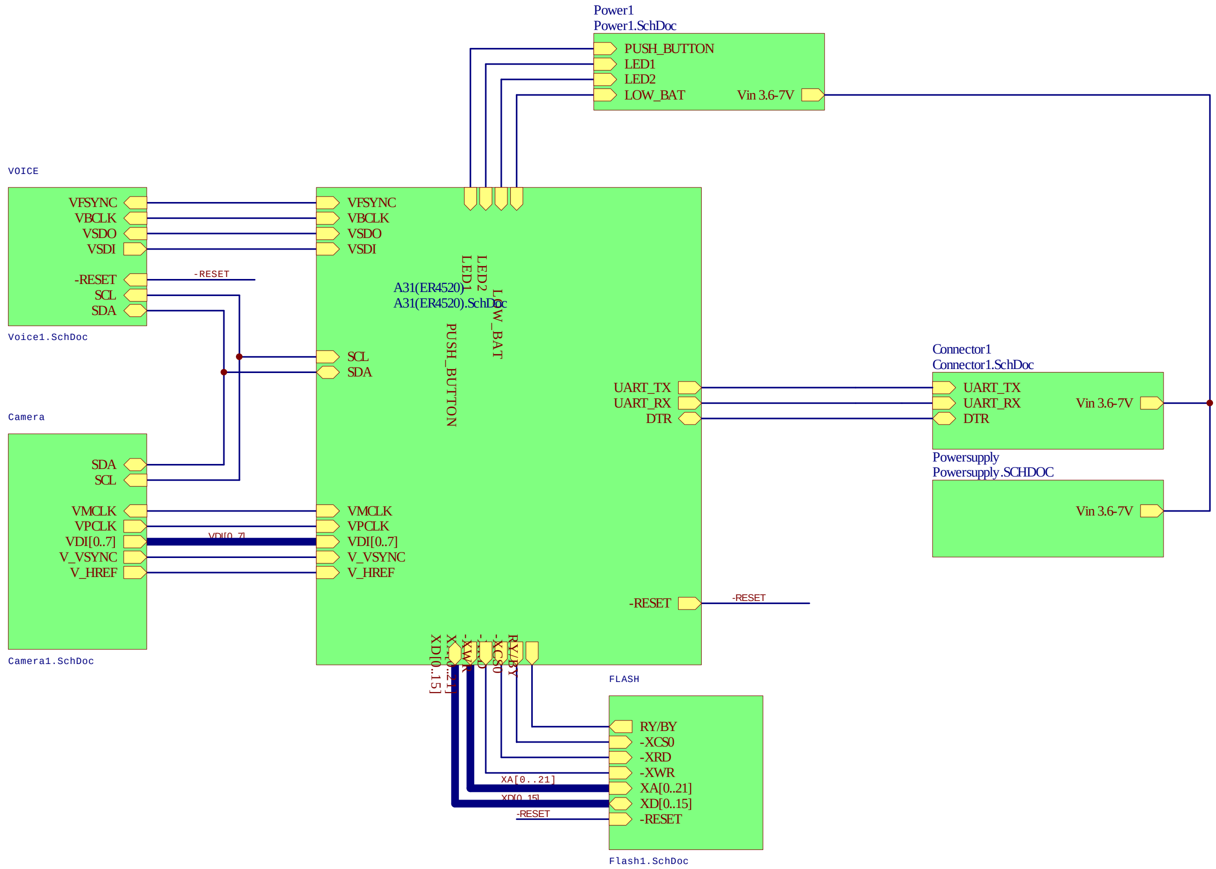


Figure 5. Block Diagram1.SchDoc

When the schematic was finished the next step was to find footprints and fitting components for each symbol. Protel had some footprints integrated already, but all others had to be made.

The schematic with its footprints was transferred to a PCB, see Figure 6.

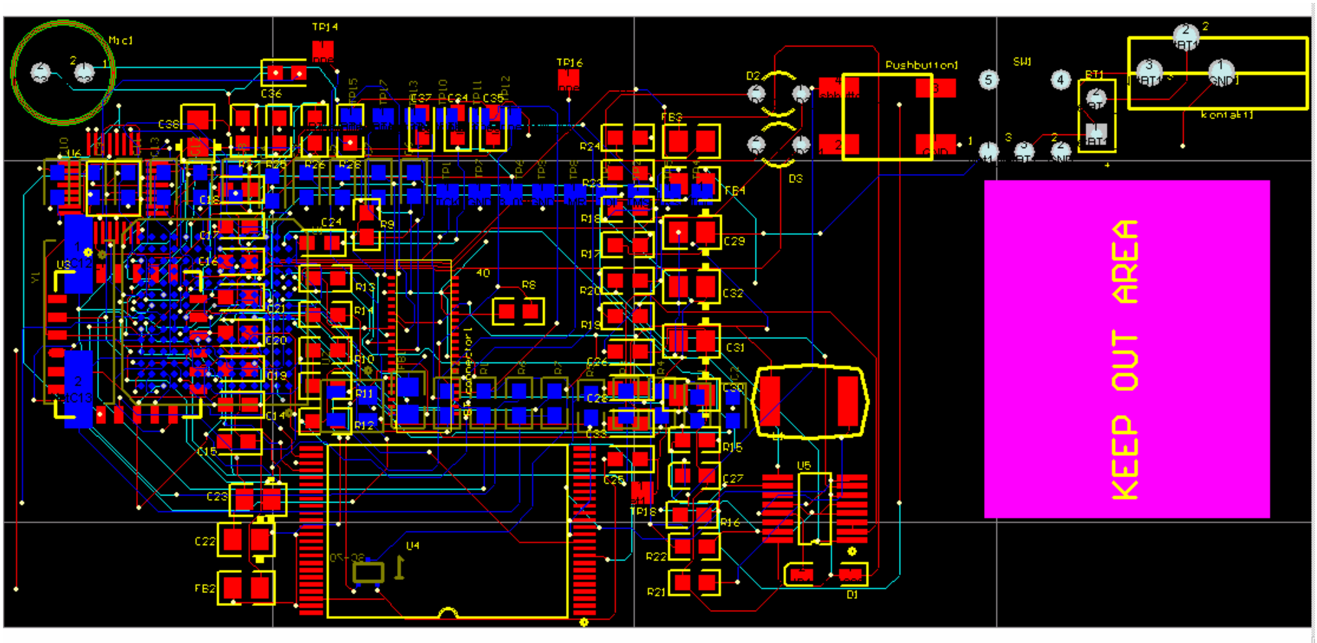


Figure 6. PCB

It was decided to use a 4-layer PCB board with components on both sides. The PCB had to be at least four layers because of the ER4520 (BGA). It was important to decide how the PCB should look like. The CMOS sensor and the microphone were placed on the front side. The Bluetooth intelligent serial module must also be placed on the front side, so that the beam direction of the antenna will be to the front. In addition, it could not have any components near the antenna, in order to avoid electro field interferences. Considering this, there had to be a keep-out area made under the antenna. The big problem with the design was routing the components. Protel has an automatic function for routing, but it did not work satisfactory. This meant that most of the routing had to be made manually. The different layers of the PCB are: top layer, internal plane, mid layer and bottom layer, see Figure 7. On the top and bottom layer all components are mounted. The mid layer, together with top and bottom layers, is used for routing. The internal plane is a power plane, which is divided into different segments for 3 V, 1,8 V and GND. This was done to reduce the length of the tracks. The used track width is 0,1 mm. To connect the different layers, through-hole vias was used. Most of the components are 0603; this can easily be reduced to 0402 to obtain a smaller PCB.

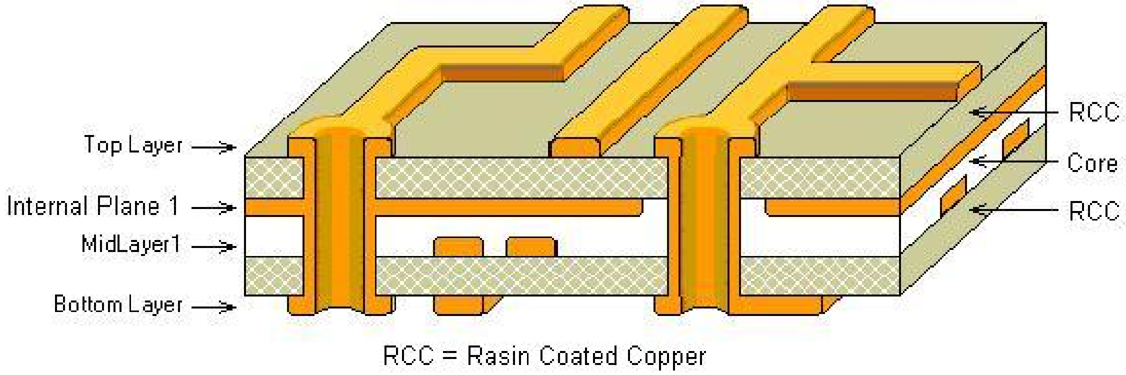


Figure 7. Layers

4.2.1 The different blocks

In this chapter all different schematics are described. Under each description there is also a picture of the circuit. For larger pictures, see Appendix D: Schematics. All component facts are from respective manufacturers homepages.

4.2.1.1 Voice1.SchDoc

This is the part where the microphone is connected, see Figure 8. It is connected to a TWL1103, i.e., a Voice Band Audio Processor. The VBAP is designed to perform transmitting with encoding analog/digital (A/D) conversion and receiving decoding with digital/analog (D/A) conversion and filtering for voice-band communications. The device operates in either the 15-bit linear or 8-bit companded (u-law or A-Law) mode, which is selectable through the I^{2}C interface. The VBAP generates its own internal clocks from a 2.048-MHz master clock input. [12]

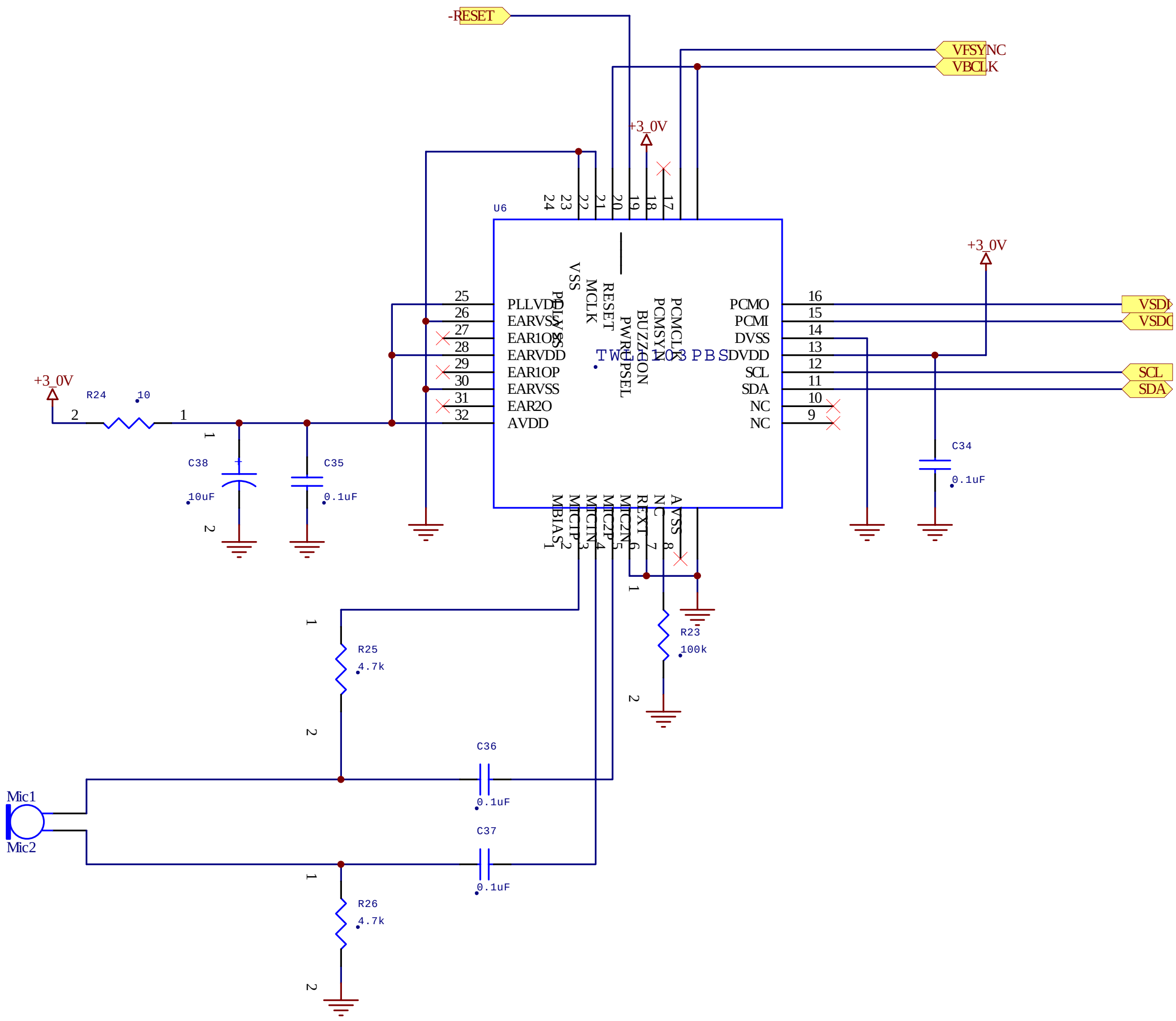


Figure 8. Voice1.SchDoc

4.2.1.2 Flash1.SchDoc

This block contains only the memory, see Figure 9. The MBM29DL163BD is a 16M-bit, 3.0 V-only Flash memory. The device is designed to be programmable with a 3.0 V VCC supply. The device can also be reprogrammed in standard EPROM programmers. MBM29DL163BD is organized into two banks, Bank 1 and Bank 2, which are considered to be two separate memory arrays for operations. It is the Fujitsu's standard 3 V only Flash memories, with the additional capability of allowing a normal non-delayed read access from a non-busy bank of the array while an embedded write (either a program or an erase) operation is simultaneously taking place on the other bank. The standard M29DL163BD offers an access time around 80 ns, allowing operation of high-speed microprocessors without wait states. [10]

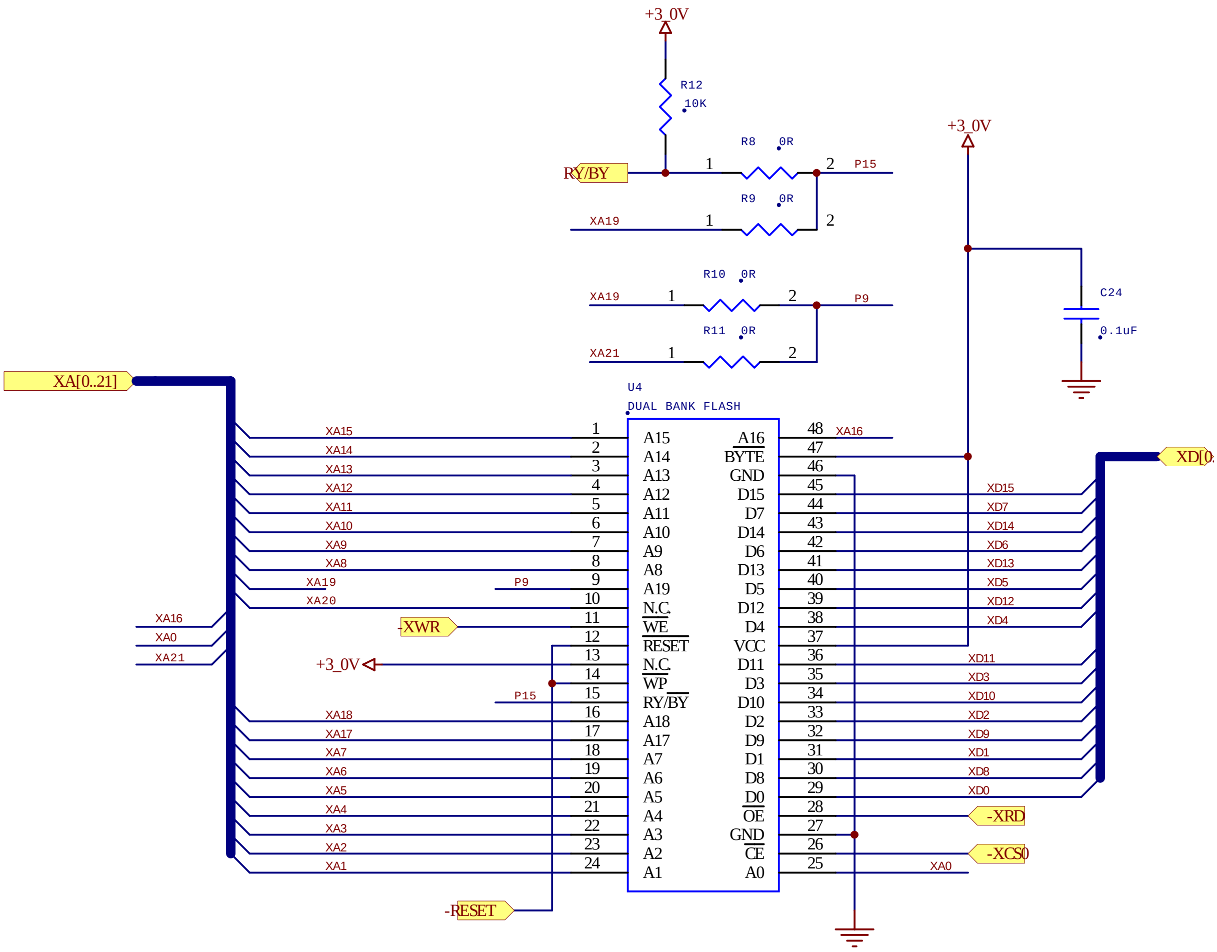


Figure 9. Flash1.SchDoc

4.2.1.3 A31 (ER4520).SchDoc

This block mainly contains the ER4520 chip from Emblaze, see Figure 10. It also contains a CMOS microprocessor (µP) from Maxim. The MAX6315 low-power CMOS supervisory circuit is designed to monitor power supplies in µP and digital systems. It provides excellent circuit reliability and low cost by eliminating external components and adjustments. The MAX6315 also provides a debounced manual reset input. This device performs a single function: it asserts a reset signal whenever the VCC supply voltage falls below a preset threshold or whenever manual reset is asserted. Reset remains asserted for an internally programmed interval (reset timeout period) after VCC has risen above the reset threshold or manual reset is deasserted. The MAX6315's open-drain RESET output can be pulled up to a voltage higher than VCC.

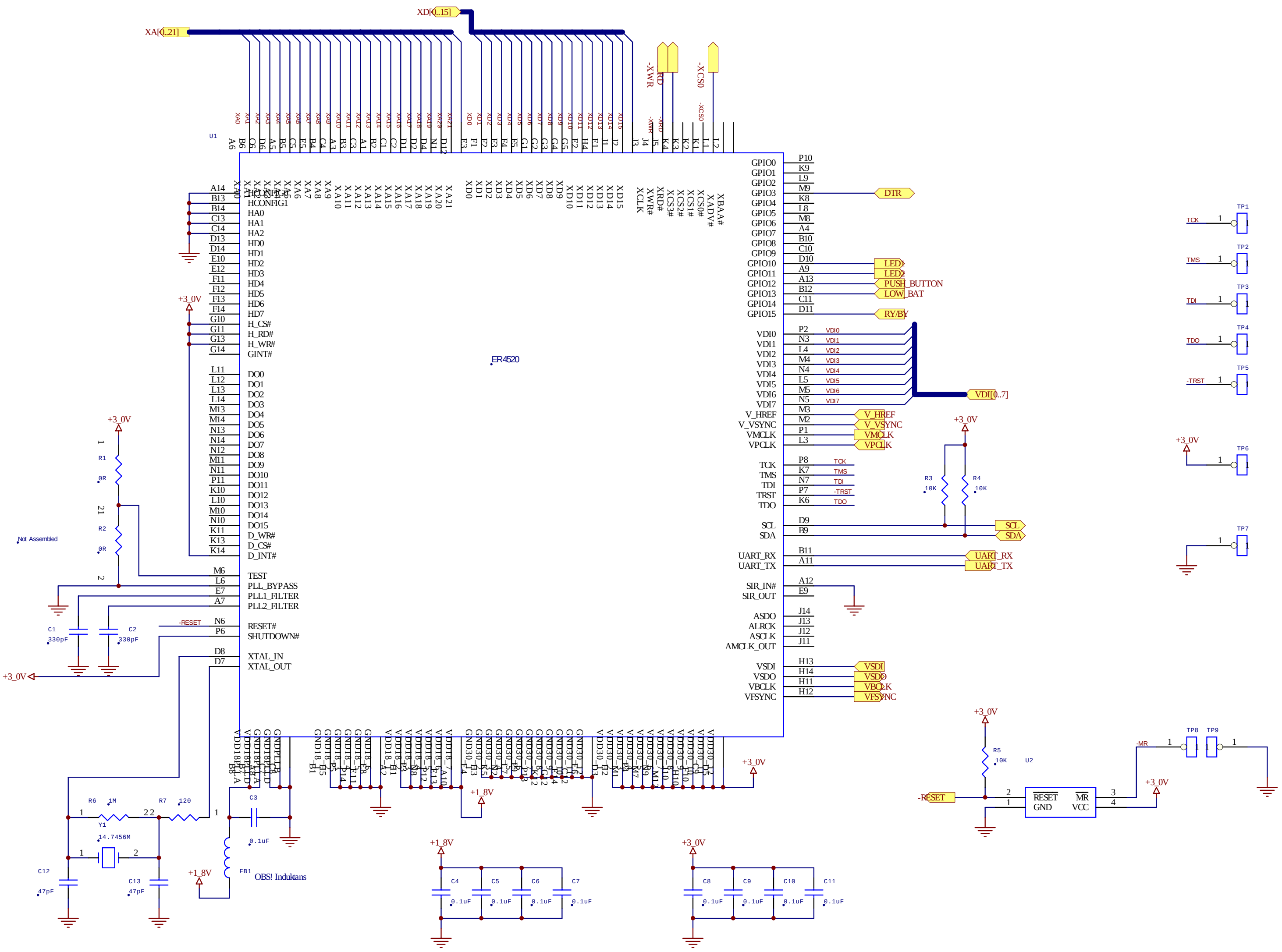


Figure 10. A31(ER4520).SchDoc

4.2.1.4 Power1.SchDoc

This block contains among other things a push button, LED:s and a MAX1705 circuit, see Figure 11. The Push button is used for changing modes (see Appendix B: Users Manual). LED is used to indicate in what mode the camera acts. The MAX1705 is a high-efficiency, low-noise, step-up DC-DC converter with an auxiliary linear-regulator output. These devices are intended for use in battery-powered wireless applications. They use a synchronous rectifier pulse-width-modulation (PWM) boost topology to generate 2.5V to 5.5V outputs from battery inputs, such as 1 to 3 NiCd/NiMH cells or 1 Li-Ion cell. The MAX1705 has an internal 1A N-channel MOSFET switch and has a built-in low-dropout linear regulator that delivers up to 200mA. It also features a pulse-frequency-modulation (PFM) standby mode to improve efficiency at light loads, and a 1μA shutdown mode. An efficiency-enhancing track mode reduces the step-up DC-DC converter output to 300mV above the linear-regulator output.

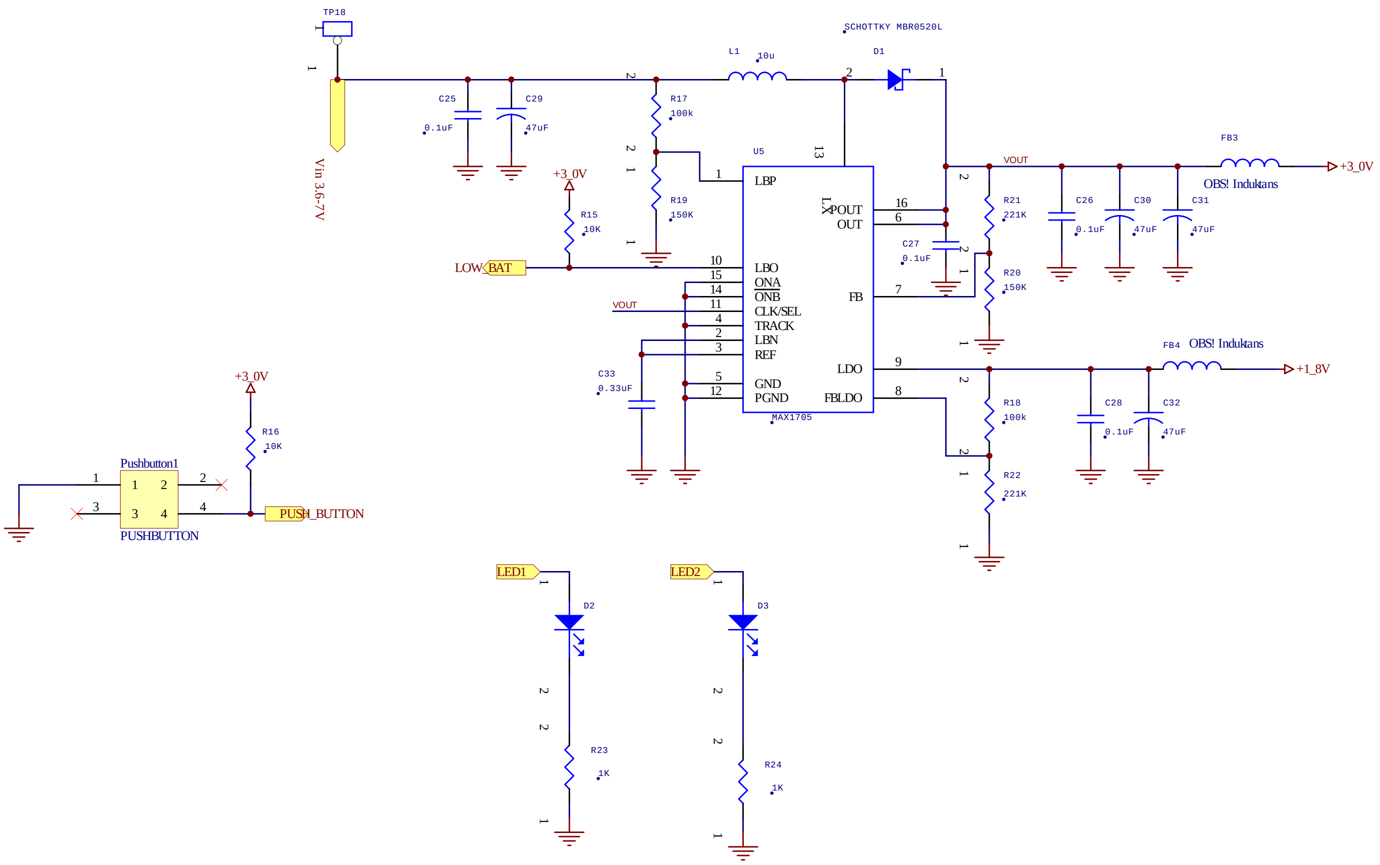


Figure 11. Power1.SchDoc

4.2.1.5 Camera1.SchDoc

In this block the CMOS sensor is placed, see Figure 12. The CMOS sensor is from OmniVision and is named OV6645. The OV6645 (color) CMOS Image sensor is a single-chip video/imaging camera device designed to provide a high level of functionality in a single, small-footprint package. The device incorporates a 352 x 288 image array capable of operating at up to 60 frames per second. Proprietary sensor technology utilizes advanced algorithms to cancel Fixed Pattern Noise (FPN), eliminate smearing, and drastically reduce blooming. All required camera functions including exposure control, gamma, gain, white balance, color matrix, color saturation, hue control, windowing, and more, are programmable through the serial SCCB interface. The device can be programmed to provide image output in different 8-bit formats.

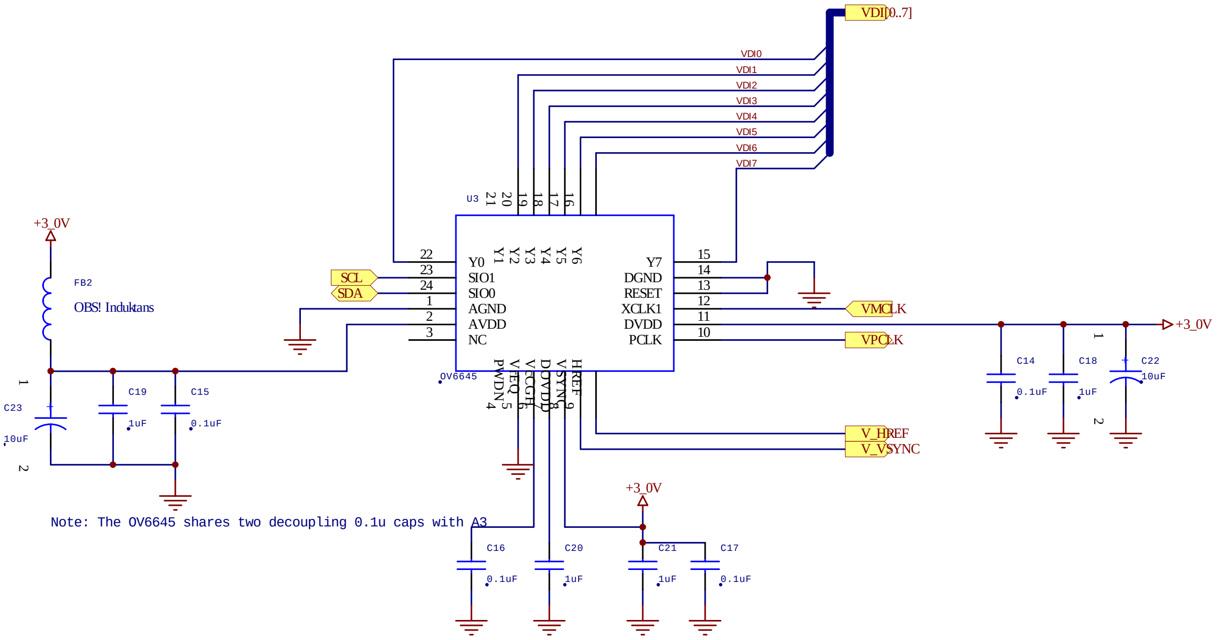


Figure 12. Camera1.SchDoc

4.2.1.6 Powersupply.SchDoc

The block called Power Supply contains one input for battery and one input for wired power, see Figure 13. It also contains a switch so that the power can be closed. The input for wired power also contains a switch to disconnect battery power, when wired power is connected. With this solution the camera can be both mobile and stationary.

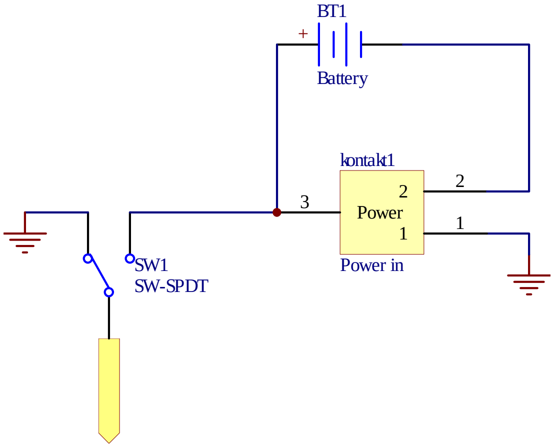


Figure 13. Powersupply.SchDoc

4.2.1.7 Connector1.SchDoc

This block only contains the Hirose DF12 (3,5)-40DP-0.5V(81), see Figure 14. This is where the Bluetooth intelligent serial module will be connected.

The Bluetooth intelligent serial module is provided with an active high reset pin. This pin is pulled to ground through a 10K resistor. Upon the application of power, the Power On Reset circuit built into the module will ensure that the unit starts correctly. However the module utilises a split rail design with some components working at 3 volt and some at 1,8 volt. Under certain extreme conditions, for example when the supply voltage to the module experiences a Brown-Out (momentary dip in the supply voltage level), or a rapid power cycle i.e. the power is switched off and then on within 1 second, there is a possibility that the module can enter an unknown state of operation. To avoid this problem the module needs a Power-On-Reset circuit with a Brown-Out detection capability. This will guarantee that under all circumstances the module will operate in a known state. The Maxim MAX6382XR26D3-T is used to perform the reset – it has an active high push-pull output, a 2.63V detection threshold, and an active reset period of 140ms. The device is used to monitor the output of the

voltage regulator on the module (through pin 27), and drives the Reset line (pin13) high when the supply voltage falls out of tolerance.
[11]

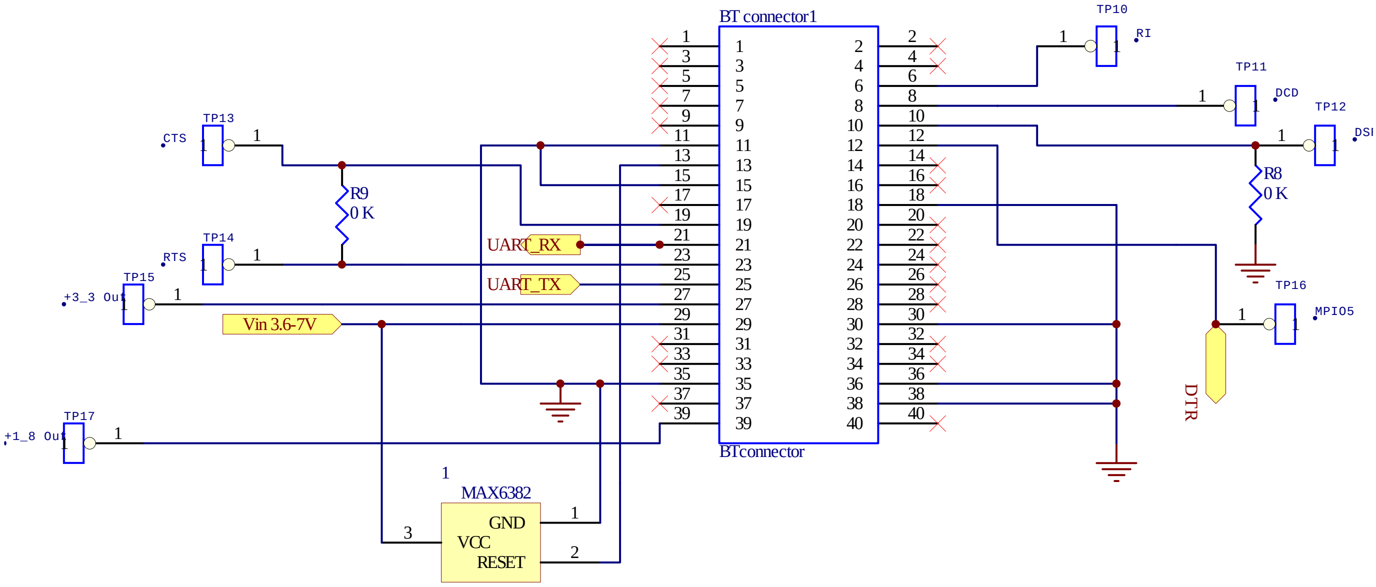


Figure 14. Connector1.SchDoc

4.2.1.8 Block Diagram.SchDoc

In this block, all blocks are connected, see Figure 15. In the middle is the ER4520. The power supply goes from “Powersupply.SchDoc” into “Connector1.SchDoc” and “Power1.SchDoc”.

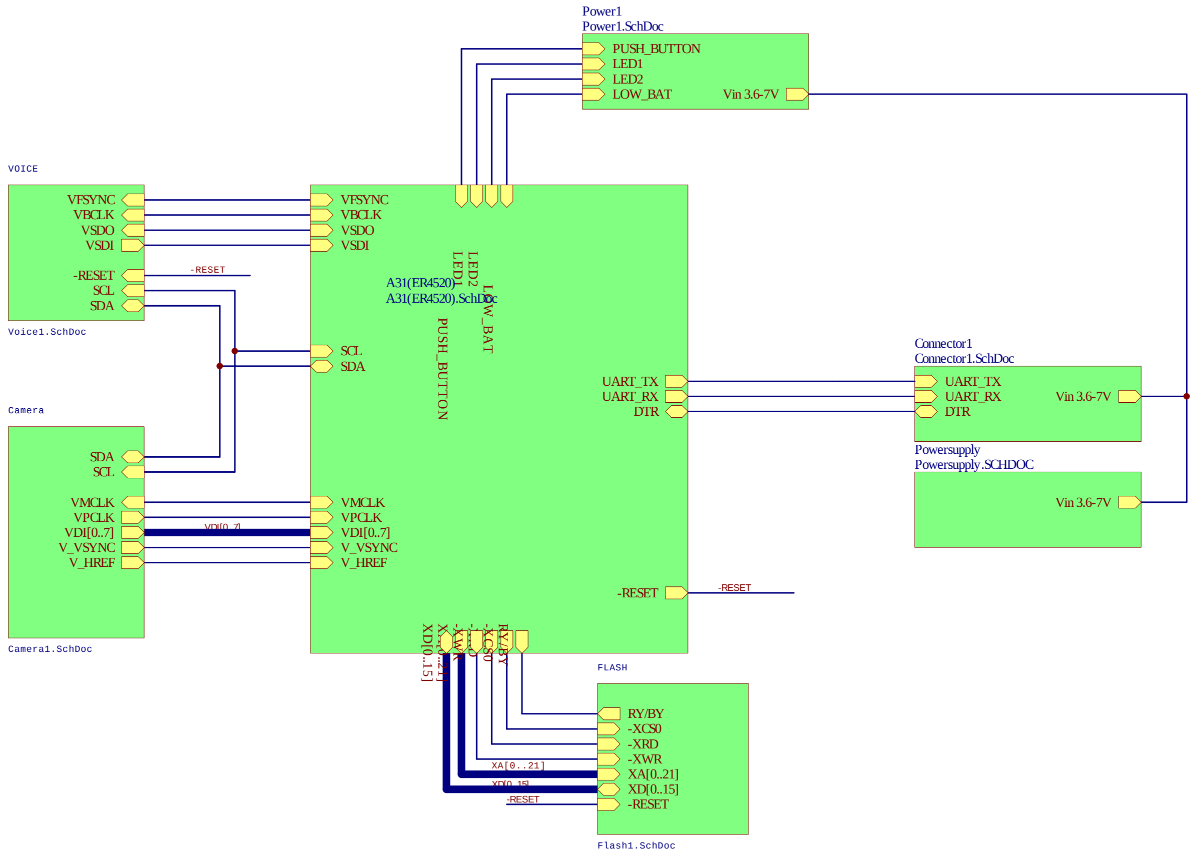


Figure 15. Block Diagram1.SchDoc

4.2.1.9 PCB

In Figure 16, the PCB layout is shown. There are also pictures of the different layers in Appendix D: Schematics. The colors of the layers are:

Top Layer - Red

Internal Plane - Green

Mid Layer - Turquoise

Bottom Layer - Blue

Keep Out Layer - Purple

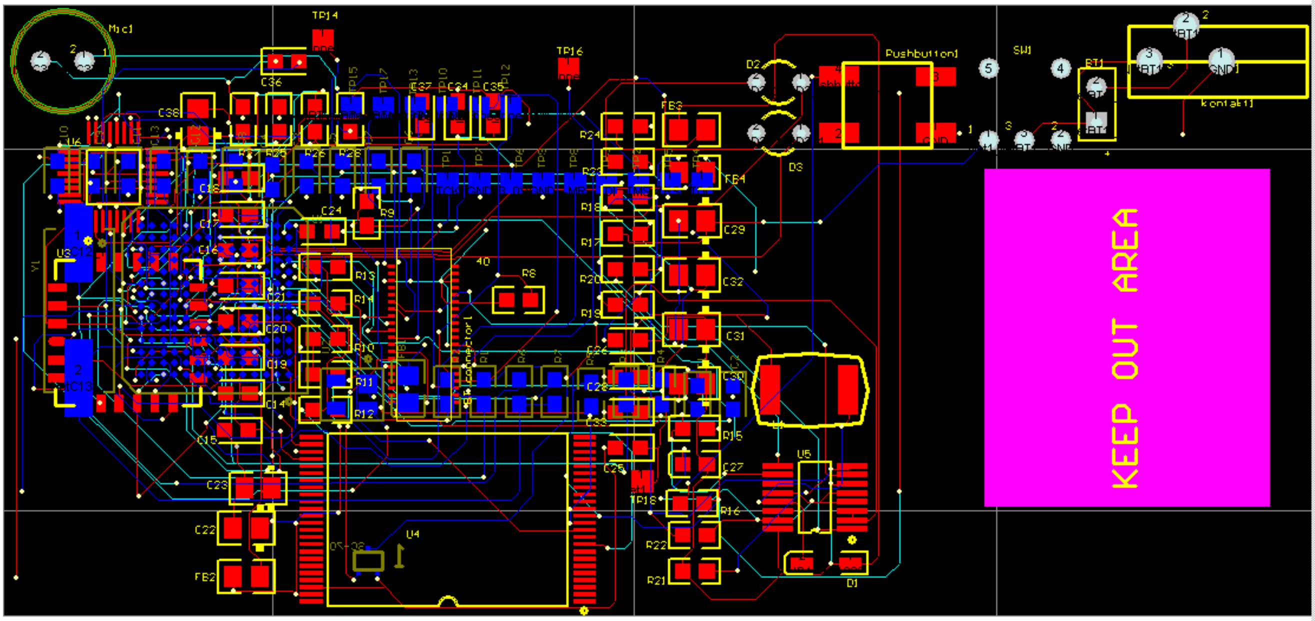


Figure 16. PCB

5 Facts

5.1 Settings

The camera and the Bluetooth intelligent serial module must be programmed with some initial firmware or settings.

5.1.1 Camera

The camera memory must be programmed with firmware. The firmware that is used comes from Emblaze.

5.1.2 TDK Bluetooth Intelligent Serial Module

To make the Bluetooth Intelligent serial module work with the camera some registers must be set. The camera must be detectable for all Bluetooth devices in the neighborhood. The camera is supposed to connect automatically when another device is calling. The Bluetooth connection is using HV1 packets with no encryption.
The settings used for the serial module:

Table 3. AT Commands

Command	Description
AT&F	Medium power consumption, UART baudrate unchanged, Left LED off, Right Led = DCD
ATI42	Returns current mode
AT+BTX	Changes mode (Idle, Command mode, Connected)
ATS512=4	Set S register 512=4, Specify power-up state. Will accept incoming connection from any device and will also be discoverable.
ATS2=43	Set S register 2=43, Escape sequence character.
ATS0=-1	Set S register 0=-1, Number of RING indication before auto answering an inbound connection. If -1, then auto answer on one RING and do NOT send RING/CONNECT response to the host. This emulates a serial cable replacement situation.
AT&W	Writes current S Register values to non-volatile memory so that they are retained over a power cycle.

5.1.3 PCB Dimensions

Table four shows what dimensions that have been used for the PCB.

Table 4. PCB dimensions

Description	Dimension
Track width	0,1 mm
Via hole size	0,1 mm
Via pad	0,3 mm
Through hole	1,5 mm
Through hole pad	1,9 mm
Standard component size	0603

5.1.4 Calculations

The image resolution that is used is QCIF, 176 x 144 pixels and 16 fps. It's needed to transmit 16 frames per second; the total number of bits per second would be 8x176x144x16 (=3244032 bits per second). The camera OV6645 uses 8 bits per pixel raw data when transmitting. Since UART limits the bandwidth to 115200 bits per second the compression rate will be:
8x176x144x16/115200 = 28,16
The bandwidth limit for Bluetooth is 720000 bits per second, and with the compression ratio of 28,16 the maximum resolution could be as much as 157609 pixels, which will give the resolution of 458 x 344 pixels and 16 fps. When comparing to CIF (352 x 288) using 8 bits per pixel and 30 fps, it is not possible to transfer this standard using current compression. The compression ratio needed is:
8x352x288x30/720000 = 33,80

The compression rate varies a lot when using MPEG-4 codec, so the compression ratio can just be estimated. The number of bits used to represent one pixel varies between 4 and 12 for MPEG-4. [13]

6 Manufacturing

The hardware design will be sent to a sub-contract for manufacturing. This is due to the fact that the PCB lab at the university cannot handle BGA circuits.

6.1 Bill Of Material

The Bill of Material is to be seen in Appendix E. It is created with Protel DXP. It contains all components used in the design.

7 Software

The software that is used for streaming video is Emblaze's camera program, EmblazeCAM. To watch a recorded file, a different Emblaze program called Emblaze Player is used. Since the file is encoded in Mpeg4 it is possible to use other players to watch the recorded files. To watch jpeg files, any program that supports that file format can be used.

8 Results

The purpose of the thesis work was to design a Bluetooth web camera. This purpose was achieved. The maximum resolution achieved with this camera is QCIF (176 x 144) and 16 fps. The maximum bit rate with current software is 70 kbit/s. This means that the ER4520 has an estimated compression rate of about 28 times. The maximum resolution that can be used over Bluetooth, if the compression rate is 28 times, using 8 bits per pixel, is 458 x 344 and 16 fps. To use CIF over Bluetooth the compression ratio has to be at least 34.

As shown in Figure 6, a hardware design has been made. However in the moment of writing this report the camera has not yet been manufactured. A Bluetooth web camera has been designed with available parts and is to be seen as a first step to the final product. However the hardware design cannot be verified before the camera is manufactured.

8.1 Improvements

The camera can be improved in many ways. These are some of them:

- Make the PCB smaller and even in another shape.
- Use a better encoder chip that can compress at a higher speed.
- Use USB instead of UART, this will result in better picture quality and it is also possible to reach a higher frame rate. With this improvement it is possible to choose almost any camera on the market.
- Another and probably even better solution is to connect the camera directly to the Bluetooth device and avoid the use of serial communication. With this solution extra devices such as a USB controller is not needed.
- Use a different sensor for example CCD.
- Add a plastic cover to the camera module.
- Add a battery charger to charge the batteries when the cord is plugged in.

8.2 Conceivable usage areas

The camera can for example be used for:

- Surveillance
- Watch the baby
- See who's knocking on your door
- Videoconference between PDA's

8.3 Media Attention

The project attracted some media attention. The University newspaper *"Lite Nytt"* made an interview with the students and wrote an article about their work.
The local newspaper *"Norrköpings Tidningar"* also made an interview and wrote an article about the work that was presented on their homepage and in the newspaper. A local radio station, "Radio Östergotland", made a live interview about the project.
The work was also presented at the grand opening of Eclipse's new factory in Phuket, Thailand. This was done using a videoconference in the presence of the Royal family of Thailand, the Minister of Technology and Communications, and ambassadors from UK, USA, Spain and Germany. Plus 150 VIP guests from the government, media and industry.

9 Conclusions

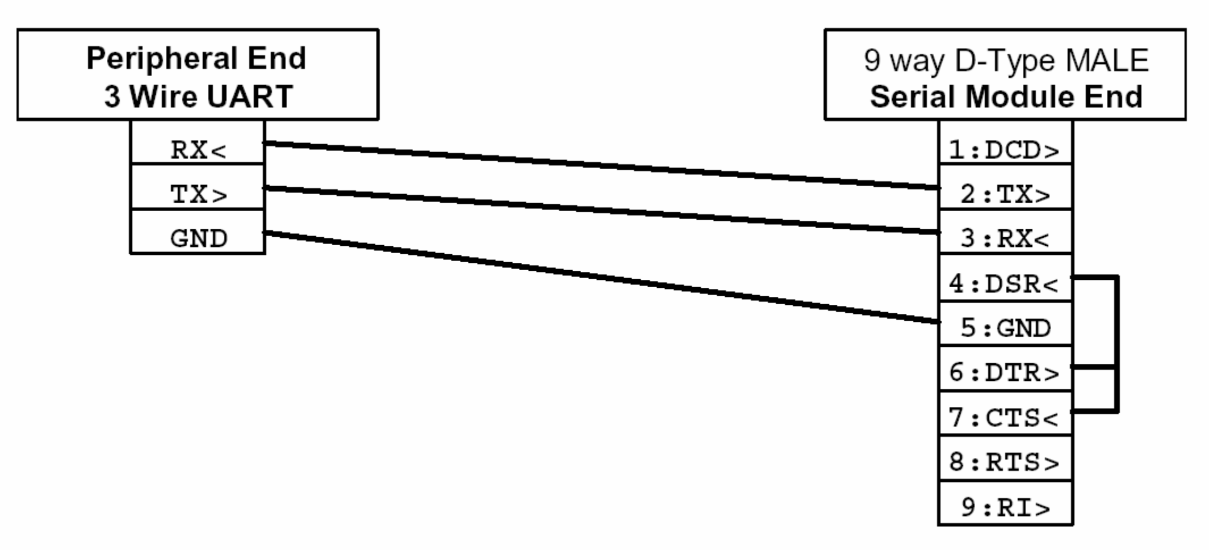
It is possible to create a wireless web camera using the Bluetooth radio technology. The resolution that is achieved with this camera is QCIF (176x144) and 16 fps. If it is possible to use all Bluetooth bandwidth the resolution could be as much as 458 x 344, 16 fps and 8 bits per pixel. With a higher compression ratio, CIF (352 x 288, 30 fps) can be achieved. The camera can be used in many applications such as surveillance, watch the baby and videoconferences. For these applications this picture resolution is sufficient. The picture resolution can be improved. However this requires lots of changes. The Bluetooth SIG is working on developing a standard for video over Bluetooth. With a better picture resolution the possibilities of the camera increases and the camera can be compared to existing USB cameras.

The camera including ER4520, from Emblaze, that has been used for this project is the bottleneck for the picture resolution. Bluetooth can handle much higher transfer rates than 115,2 kbit/s (even though the maximum speed of this module is limited to 200 kbit/s).

10 References

1) The official Bluetooth website, http://www.bluetooth.com (Acc 2003-08-13)
2) TDK Systems Europe Ltd, http://www.tdksystems.com (Acc 2003-08-13)
3) Emblaze Semiconductor, http://www.emblazesemi.com (Acc 2003-08-13)
4) Eclipse, http://www.es-eclipse.com (Acc 2003-08-13)
5) W Stallings, 2001, *Wireless Communications and Networks*, Prentice Hall, New Jersey, ISBN 0-13-040864-6
6) P Bhatt,2000 ,Bluetooth Technology Review#2000-3, http://www.tcs.com/0_whitepapers/htdocs/Bluetooth.pdf (Acc 2003-08-13)
7) CheeZ, 2003, Bluetooth, an Overview, http://www.lanaddict.com/review.php?ID=54 (Acc 2003-06-30)
8) Bluetooth Specification, http://www.Bluetooth.org (Acc 2003-08-13)
9) B Miller & C Bisdikian, 2001, *Bluetooth Revealed*, Prentice Hall, New Jersey, ISBN 0-13-090294-2
10) Data Sheet for the Flash memory, http://www.fmi.fujitsu.com/pdf/e520874.pdf (Acc 2003-08-13)
11) Data Sheet for Hirose connector, http://www.hirose.co.jp/cat2002e/500/e53700036.pdf (Acc 2003-08-13)
12) Data Sheet for the microphone, http://www.imp.com.tw/cd/owa/siw_main.display_map?pi_org_id=7000608724&in_current_page=specs&template_id=3&prod_id=8813916205&enable_button=1 (Acc 2003-08-13)
13) http://www.chiariglione.org/mpeg/standards/mpeg-4/mpeg-4.htm (Acc 2003-09-11)

Appendix A: Null modem cable



Appendix B: Users Manual

Emblaze™Cam

User Manual

Version ECP-B01.02.00

Last update: 25 November, 2003

Emblaze Research Confidential and Proprietary

1 Overview

Emblaze™Cam is a video camera accessory reference design and demo tool based on the Emblaze ER4520 chip. EmblazeCam features built-in image, audio and video compression, and enables capture, messaging and video telephony applications when connected to other devices, such as PCs, PDAs and cellphones.

This document describes how to use the EmblazeCam device in standalone mode, and in conjunction with host software which runs on PC and PDA platforms. The host software enables preview and download of audio, video and images captured by EmblazeCam.

2 System Architecture

The EmblazeCam device includes a CMOS sensor, microphone, and the ER4520 chip. The audio and video captured from the camera and microphone is compressed by the ER4520, and sent to the PC/PDA host using over a serial (UART) connection. The host decodes the compressed audio and video streams, displays the video on the screen and renders the audio to the speaker. The host software can store the audio and video streams received from EmblazeCam in a standard MPEG-4 file, which can then be played back by an MPEG-4 file player. The host software also enables setting the camera parameters, downloading images and clips from the camera's FLASH memory, and controlling the capture process.

3 Supported Platforms

3.1 PC

The Emblaze™Cam host software currently supports the following PC platforms:

- 500Mhz Pentium III or higher
- At least 128Mb RAM
- Windows 98 and Windows 2000
- Sound Card

4 Codecs and Protocols

Emblaze™Cam currently supports the following codecs and file formats:

- **Video Codecs:** MPEG-4 Simple Profile
- **Audio Codecs:** GSM-AMR
- **File Format:** MPEG-4 File Format
- **Image Codec:** JPEG

5 Installation

5.1 Directory Structure

The EmblazeCam package includes the following directories:

- **Doc** - Product documentation
- **ECA- xxx.xx.xx–** Host application software for PC, PocketPC and PocketPC 2002
- **ECS-xxx.xx.xx–** Multimedia engine library (SDK) for the host application software. Includes the library itself (DLL file), registry files, the install program for the PC MPEG-4 codec, and various other codec DLLs.
- **ECF-xxx.xx.xxand ECC-xxx.xx.xx–** Embedded software for the EmblazeCam device. Includes the software itself (bin files), and PC utilities for updating the software.
- **ECH-xxx.xx.xx–** Hardware documentation (PCB and schematics)
- **Players –** Installation files for the Emblaze Player program, which enables playback of MP4 files captured by the EmblazeCam host application.
- **AutoInstallations** – Includes the self install applications for all platforms.

5.2 Installation on Windows 98 / 2000

1. In Windows 2000, login as Administrator, or a user with local Administrator rights. In Windows 98 Login as usual.
2. Run ECInstall application located in the AutoInstallations\PC directory on the release CD.
3. Follow the instructions in the Auto installation.

4. Go Start->Programs and activate ECSampleApp

5.3 Embedded Software Installation on EmblazeCAM

5.3.1 Introduction

The EmblazeCam Programload utility enables dowloading of new firmware to the EmblazeCam prototype unit. The software on the EmblazeCAM device has two parts: the CORE itself, and the firmware. The CORE code consists of the application required to enable the ProgramLoad process itself. This software only runs after a special initialization process (see below). The firmware includes the camera software, which is the software running on the camera as a default. Note that the ProgramLoad utility only enables replacement of the firmware, not the CORE itself.

The Programload utility runs only on PC Windows 98/2000 platforms.

This version of ProgramLoad only supports devices with CORE code ECC-B02_00_01.bin and later.

5.3.2 Initialization

The Firmware located on the EmblazCAM's flash is protected against accidental overwrite by a safety mechanism.

1. In order to enter program load mode, the EmblazeCam device should be turned on while holding the push button (see next chapter for 'push button' explanation) down for a few seconds. Successful operation is indicated by two leds flashing together (in normal operation only the left led flashes).
2. Connect the EmblazeCAM device to COMM port 1 on the PC by using the PC cable.
3. Start the 'ProgramLoad' application located in the ECC-xxx.xx.xx directory on the release CD. A popup window stating the CORE and Firmware version will appear immediately. Refer to the Troubleshooting section if you have any problems.
4. Perform the following Download Firmware and/or Core code in accordance to the Release Notes.

5.3.3 Downloading the Firmware

1. Make sure you have new batteries installed prior to starting the process
2. Select the Firmware file located in the ECF-xxx.xx.xx directory on the release CD by using the browse button.
3. Press the "Download File" button and wait for the popup window indicating the Firmware version loaded.

Important – Do not disrupt the connection during the whole process.

4. Close the application and turn-off the EmblazeCAM.

5.3.4 TroubleShooting

1. If the Program load does not connect to the device, make sure that the device is connected to COM1, and that no other application (such as the EmblazeCam) is running and occupying the com port.
2. If after following the above the device is still not connecting, close the application, and make sure you are restarting the device according to 6.4.2 (e.g. turning the device on while pressing the button), and that the ProgramLoad application is run only after the device is turned on.
3. The firmware downloading is protected by a CRC check. If, for any reason a problem was encountered during the download (for example an error on the UART), the CRC check in the end of the download process will result an error. If such an error occurs, an error message is given in the status line, indicating the error. Note that such an error is rare. To solve this problem, restart the download process from initialization (e.g re-start the device and the PC software), and try again.

6 The EmblazeCam Device

Operating the EmblazeCam device is done using a push button and two LEDs. This section explains how the device is operated in various modes, both stand-alone and when connected to a host running the EmblazeCam host application.

1. **Init mode:** While powering-on, EmblazeCAM enters the Init mode. In this mode the software goes through an initialization procedure. The button is not active in this mode. When initialization is finished, the LEDs flash several times alternatively, and EmblazeCam enters Standalone mode.

2. **Standalone Mode:** In this mode, the software enables capturing JPEG pictures and MPEG files to the FLASH memory. There are two sub-modes to this mode: JPEG and MPEG. In JPEG sub mode, the right LED flashes slowly, while in MPEG sub mode, the left LED flashes slowly. As default, after Init, the EmblazeCAM enters JPEG sub mode. Switching from JPEG sub mode to MPEG sub mode and vice versa is done by a long button press. In JPEG sub mode, each press captures a new image, compresses it to JPEG format, and stores it to FLASH memory. The FLASH memory is limited in size: it currently supports up to 20 JPEGs, if no MPEGs are stored. When the FLASH memory is full no indication is issued, but the JPEG is not stored. In MPEG sub mode, the first button press starts the MPEG audio/video capture and encoding process, while the second button press stops the process and stores the file to FLASH memory. The default bitrate for the MPEG file generated is 65kbit video, and 4.750kbit audio. Thus, the 1.5MB FLASH can store a clip of about 170 seconds. If you configure the MPEG capturing to different bitrates, the amount of time that the FLASH can capture will change accordingly. No indication is given when the FLASH is full. When the EmblazeCam device is connected to the host (via serial interface) and the Host application is launched, the EmblazeCAM receives an initialize command from the host (PC/PDA) and switches to Connected mode.
3. **Connected Mode:** In this mode, the software sends real-time audio/video streams and JPEG pictures to the host device. There are two sub-modes to this mode: JPEG and MPEG. As default, after Init Mode, the EmblazeCAM enters JPEG sub mode. In JPEG sub mode, the right LED is continuously lit, while in MPEG mode, the left LED is continuously lit. Switching from JPEG mode to MPEG mode and vice versa is done by a

long button press, or by selecting the JPEG or MPEG buttons on the host. The operation of these two sub-modes from a user perspective is the same as in standalone mode, but the embedded application behavior is different. In both modes, the camera sends a real-time audio/video stream to the host SW, which is displayed in the preview window. In JPEG mode, each press of the button stops the audio/video stream, captures a new image, compresses it to JPEG format, sends it to the host, and resumes the audio/video stream. In MPEG mode, the first button press sends a command to the host to start recording the stream, while the second button sends a command to the host to stop recording the stream. When in connected mode operation of the camera is also possible via the host buttons (see below). If the camera is disconnected from the host for more then 5 seconds, it will switch back to Standalone mode.

The following table summarizes the behavior of the button and LEDs in the various modes:

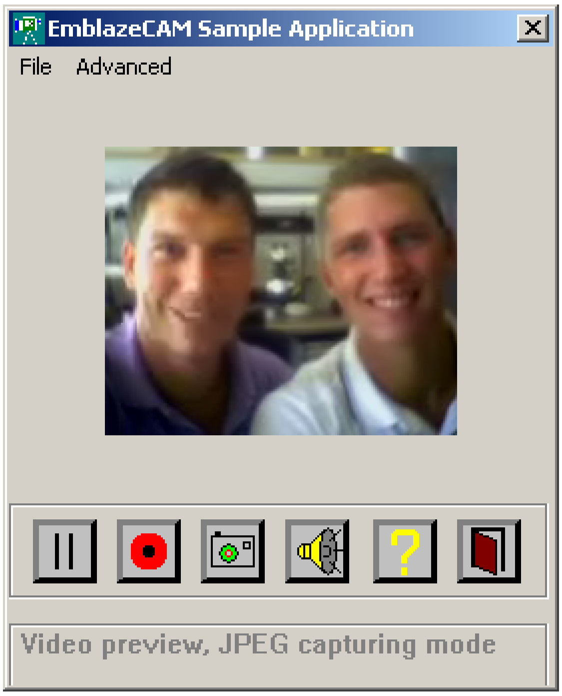
Mode	**Button Operation**	**Left LED**	**Right LED**
Init	None	Off initially, flashes when Init ends	Off initially, flashes when Init ends
Standalone – JPEG	Each press captures a picture to FLASH	Off	Flashes
Standalone – MPEG	First press – start stream, second press – stop stream and save to FLASH	Flashes	Off
Connected - JPEG	Each press captures a picture and sends to the host	Off	On
Connected – MPEG	First press – start recording on host, second press – stop recording on host	On	Off

Notes:

1. When an internal error is detected by the EmblazeCam device in any mode, both LEDS will flash together rapidly. This is in contrast to Init mode, where both LEDs flash alternatively.
2. When connected to the host, capturing a JPEG image is also possible using host commands (see section 8.3).
3. After the user presses the button (or the software receives a host command) to capture a JPEG image, the left LED flashes rapidly during the capture, encoding and saving process.
4. Capturing MPEG files on the EmblazeCam device is not enabled in this version. However, MPEG files can be captured on the host by the host application software, during the real-time audio video preview from the EmblazeCam device (see section 8.4).

7 The EmblazeCam Host Software

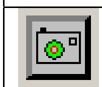
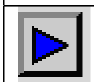
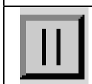
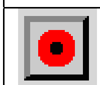
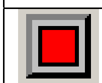
The Emblaze™Cam host software implements a Dialog-based GUI for controlling the video preview and record operations, camera parameters, and downloading of images and video clips from the camera.

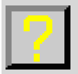
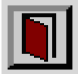


Jimmy and Robert, the authors of this report.

7.1 Buttons

The EmblazeCam host software GUI includes the following buttons:

Button	Name	Action
	**Snapshot**	Capture a JPEG picture (see section 8)
	**Start Preview**	Start the audio/video preview
	**Pause Preview**	Pauses the audio/video preview
	**Start Recording**	Starts recording the audio and video into a file
	**Stop Recording**	Stops recording the audio and video into a file

	**Audio Mute**	Enables or disables audio preview
	**About**	Opens the EmblazeCam About Dialog (See section 7.4.6)
	**Exit**	Closes the application

When the host doesn’t detect an EmblazeCAM device, only the About and Exit buttons are enabled.

7.2 Advanced Menu Options

The EmblazeCam host software GUI includes the following Menu options:

- File / Exit: Closes the application
- Advanced: Enables advanced options (See section 7.3)

7.3 Advanced Options

The “Advanced” menu enables accessing the following options for controlling EmblazeCam:

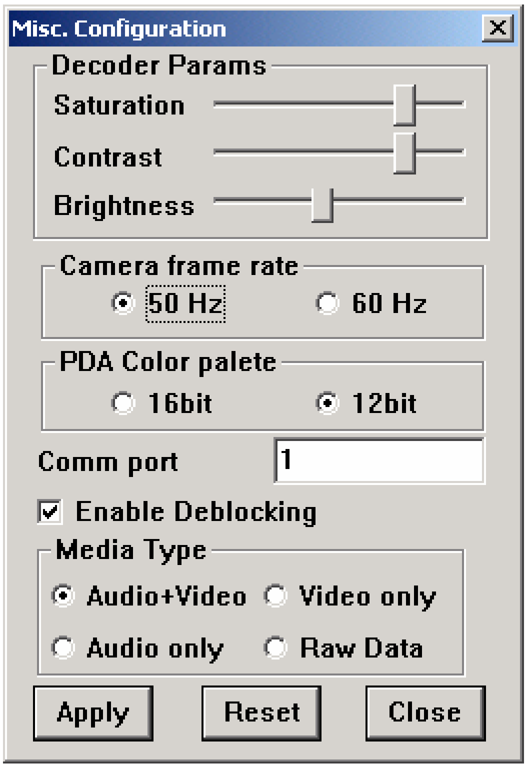
- **Misc Config:** Opens the Miscellaneous Configuration dialog box (see section 7.4.1)
- **Encoder Config:** Opens the Encoder configuration dialog box (see section 7.4.2)
- **Config I2C:** Opens the Config I2C dialog box (see section 7.4.3)
- **Set Directory Location:** Open the EmblazeCam directory locations dialog (see section 7.4.4)
- **File Cam Config:** Sends the camera configuration file to the CMOS sensor
- **File Processing:** Opens the EmblazeCam file dialog (see section 7.4.4)

Some of these advanced options open dialog boxes, which are described in the following section.

Note that only the first two options are enabled when no EmblazeCAM device is connected to the host.

7.4 Dialog Boxes

7.4.1 Miscellaneous Configuration



The Misc. Config dialog box is used to configure the following image parameters of the EmblazeCam camera:

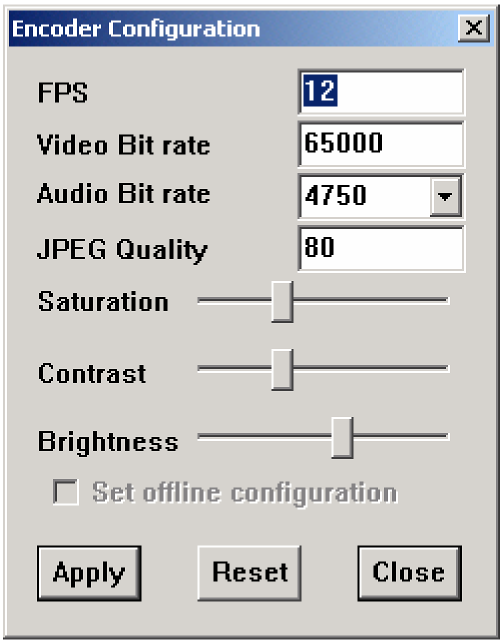
- **Saturation, Contrast and Brightness**: Controls the color and brightness parameters of the decoder.
- **Camera frame rate:** Controls the number of frames per second captured by the image sensor in EmblazeCam. This rate should be adjusted to the local electricity frequency (50 Hz or 60 Hz) in order to avoid line interference in the captured images.
- **PDA color palette:** Controls the number of colors displayed in the video preview screen. For PDAs which are limited to 4096 colors, such as the iPAQ 3660 and 3760, this parameter should be set to 12 bit. For PDAs which support 64K colors, such as the iPAQ 3850 and 3870, this parameter should be set to 16 bit. Note that this setting will only be applied after re-starting the application.
- **Comm. Port:** Sets the serial communication port to be used for connecting the EmblazeCam device. Note that this setting will be only applied after re-starting the application

- **Enable Post Processing:** This option enables deblocking, and saturation, brightness and contrast setting after decoding.

- **Media Type:** Selects the media types to capture: Video only, audio only, Audio+Video or Raw Data for YUV pictures.

When the “Apply” button is pressed, these parameters are sent to the camera. When the “Reset” button is pressed, the parameters return to their default values.

7.4.2 Encoder Configuration



The Properties dialog box is used to control the parameters of the audio/video stream generated by EmblazeCam.

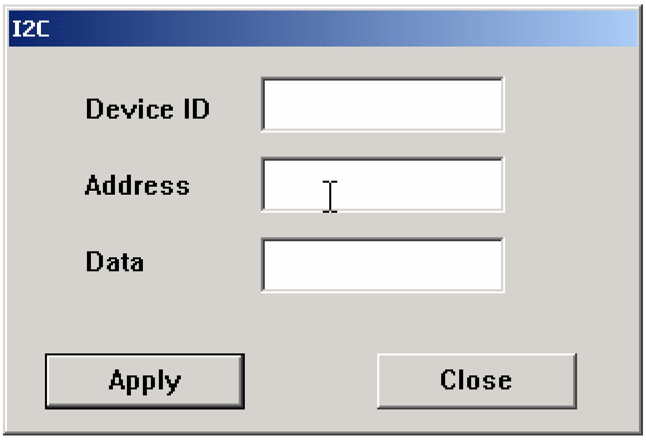
The following parameters can be specified:

- **FPS:** Specifies the number of frames per second for the captured video stream
- **Video Bitrate:** Specifies the bitrate of the captured video stream
- **Audio Bitrate**: Specifies the bitrate of the encoded GSM-AMR audio stream
- **JPEG Quality:** Controls the quality of the captured JPEG images.
- **Saturation, Contrast and Brightness**: Controls the color and brightness parameters of the encoder on the Camera (Pre-Processing).
- **Set offline configuration:** When the checkbox is checked pressing the OK button updates the offline parameters of the camera device. These parameters are used when the camera

operates is in stand-alone mode. The offline parameters updates include the camera framerate, as well as all parameters from this dialog box.

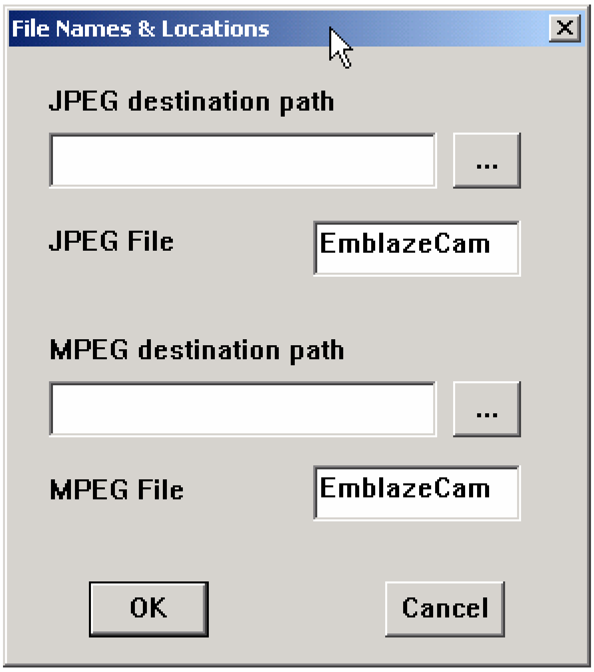
Note that when this box is checked the on-line parameters are not updated.

7.4.3 Config I2C



The Config I2C dialog box enables setting parameters directly to the image sensor through the I2C interface. The Device ID, address, and data are specified for each parameter. This dialog box is used for debug purposes only.

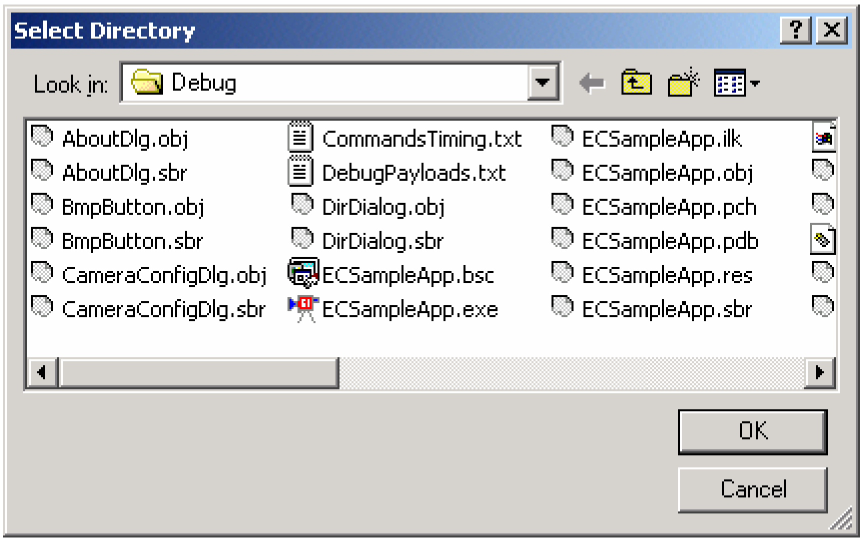
7.4.4 Set Directory location



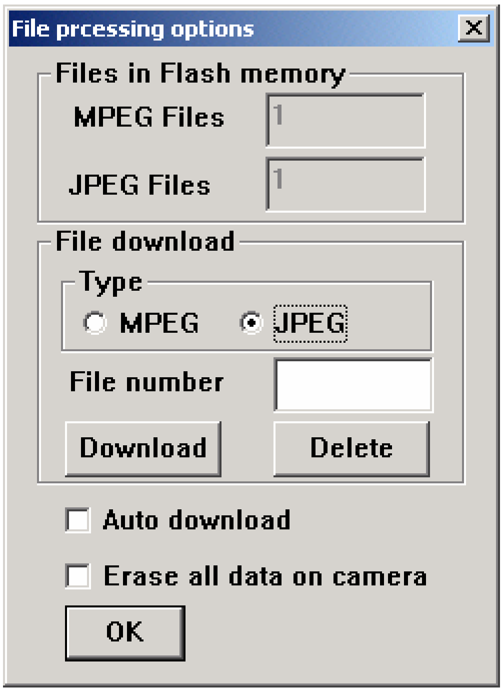
The File Location dialog box controls the directory location and names of the JPEG and MPEG files captured by the EmblazeCam host software. Setting the target directory for each file type is done by pressing the corresponding "…" button. For usage of this dialog, see below. The file name prefix is set in the corresponding edit box. Files will be numbered sequentially based on the file name prefix. In the above example, JPEG files will be named EmblazeCam1.jpg, EmblazeCam2.jpg etc. and MPEG files will be named EmblazeCam1.mp4, EmblazeCam2.mp4, etc.

The default destination path is c:\. On the iPAQ, the default directory is 'My Documents' folder.

Folder browsing: On PC:
Below is the folder browsing dialog used to browse for the destination folder.
This is a standard dialog.



7.4.5 File Processing

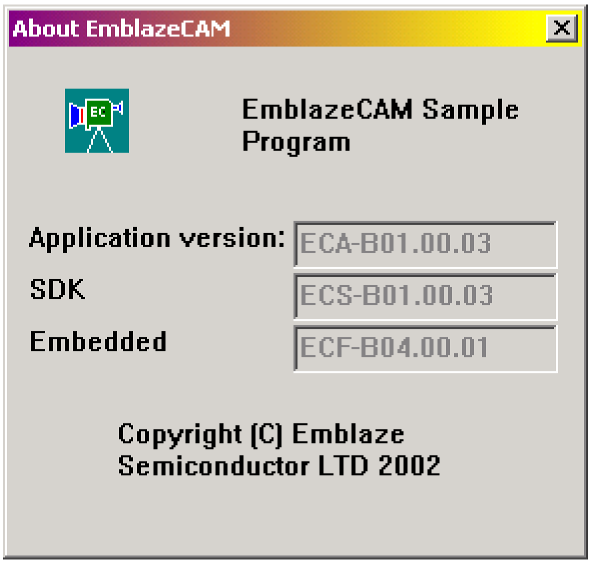


The File Processing dialog box is used to download media files from the camera's flash memory. The two top edit fields display the number of available MPEG files and JPEG files. The "File Type" radio button enables specifying which type of file (JPEG or MPEG) to download or delete, and the "File Number" field specifies which file to download or delete. The "Delete" button is used to delete the specified file, while the "Download" button is used to download the specified file. The downloaded files are numbered sequentially by the EmblazeCam Host software in each directory. When a new directory is chosen, the numbering is restarted.

Auto-download: selecting this option downloads and deletes all JPEG and MPEG files stored on the EmblazeCam.

Erase all data on camera – selecting this option deletes all data on the device Flash. Use this option to delete all files on the Flash, or as described in troubleshooting.

7.4.6 About dialog



The About dialog box displays the software version of the EmblazeCam host application, the EmblazeCam host multimedia engine library, and the EmblazeCam embedded software.

7.4.7 Status Line

Following is a list of all possible status line message, and their description:

Initializing please wait	The application is initializing and trying to connect to the camera device
Video preview, JPEG capturing mode	Video preview is running, and the camera is in JPEG sub mode
Video preview, JPEG record	The camera device is in the process of capturing a JPEG picture and transmitting it to the host
Video preview, MPEG capturing mode	Video preview is running, and the camera is in MPEG sub mode
Video preview, MPEG record	The host is saving the currently previewed video clip to memory
Ready	Camera is connected, no preview running
Erasing Flash memory, please wait	Erasing stored pictures and clips on the device flash. Note that erasing these files may take a few seconds.
Downloading Jpegs, please wait	Downloading Jpeg pictures from the flash
Downloading Mpegs, please wait	Downloading Mpeg pictures from the flash
Camera is disconnected	The host is initialized, but can’t connect to any camera device. See troubleshooting section to solve the problem.
Deleting Jpeg, please wait	Deleting Jpeg pictures from the flash
Deleting Mpeg, please wait	Deleting Mpeg pictures from the flash
Setting camera offline parameters, please wait	Setting the camera offline parameters

8 Typical Usage Scenarios

This section describes how the EmblazeCam device can be used in together with the host software to perform various functions.

8.1 Getting Started

To operate the EmblazeCam device with the host software, the following steps should be performed:

1. Connect the EmblazeCam device to the host device through the serial port. This is done using the supplied cable for PC. Configuring the serial port to which EmblazeCam is connected is done through the Properties dialog box (see section 7.4).
2. Turn on the EmblazeCam device by switching the On/Off switch at the back to the upper position ("On"). Both LEDs should blink rapidly a few times during the EmblazeCam device initialization process, until its completeness. Then, the right LED starts blinking slowly.
3. Launch the EmblazeCam host application on the PC or PocketPC. When the application launches, all buttons are disabled except the exit button. After initialization is complete, the preview video stream from the EmblazeCam device will appear on the application screen and all buttons will be enabled. If the video does not appear, see the Troubleshooting section (section 0).

8.2 Audio/Video Preview

In the default mode of the EmblazeCam application, the real-time audio/video stream, which is compressed by the EmblazeCam device, is decoded and rendered by the EmblazeCam application. Audio and video preview can be started and stopped using the Start/Pause Preview buttons and the Audio Mute button (see section 7.1). Various parameters of the audio and video streams can be controlled using the application buttons and menus (see chapter 7).

8.3 Capturing Images

Capturing still images during video preview is done by pressing the "Snapshot" button. When this button is pressed, the following steps occur:

1. Real-time audio/video preview is paused, and the left led turns off.
2. The EmblazeCam device takes a snapshot JPEG picture and sends it to the host. In the process the left led turns on briefly.

3. The host saves the image in the specified location (see section 7.4.4).
4. Real-time audio/video streaming is resumed, and the right led turns back on.
5. During the process, the status line will change from the initial “Video preview, JPEG capturing mode” to “Video preview, JPEG record”, and back.

While the previewed video is QCIF size (176x144 pixels), the captured JPEG images are CIF size (352x288 pixels). These images can be viewed with various PC and PocketPC software applications, such as Microsoft Paint, Microsoft Photo Editor or Internet Explorer.

8.4 Recording Video Files

Recording video files is done by pressing the Start Recording button during Audio/Video preview. Stopping the recording is done by pressing the Stop Recording button. During recording, the audio/video streams from the EmblazeCam device are previewed on the screen, and saved to disk using the MPEG-4 File Format. The files are saved in the location specified by the user (see section 7.4.4). These files can later be played by the Emblaze Player which is a separate application supplied as part of the EmblazeCam package.

Note that video recording is not possible if the audio/video preview is paused. However, if the audio mute button is pressed, the resulting MP4 file will still contain audio (the audio mute button affects the preview only).

8.5 Downloading images from the EmblazeCam Device

The EmblazeCam can take pictures in standalone mode, and store them on the internal flash memory (see section 5.3). These images can be downloaded to the PC using the File Processing dialog box (see section 7.4.4). The downloaded files are stored in a directory specified by the user, and are numbered by the EmblazeCam Host software sequentially. When a user chooses a new directory to place the files, file numbering restarts from 1. Note that the internal numbering of pictures in EmblazeCam memory (which is used for downloaded picture selection) is not related to the host numbering of the pictures. The internal numbering is always consecutive, and if pictures are deleted, the remaining pictures are re-numbered.

8.6 Capturing still pictures and video clips in Stand Alone mode

Capturing still images and video clips in stand alone mode is done by pressing the device button.Turning between JPEG and MPEG sub modes is done by a long press on the button. When this button is pressed, the following steps occur:

1. In JPEG sub mode: The EmblazeCam device takes a snapshot JPEG picture and saves it to the FLASH. In the process the left led turns on briefly.
2. In MPEG sub mode: The EmblazeCam device starts recording a clip to the FLASH memory. In the process the right led flashes. When the device button is pressed again, the device stops recording.

After reconnection of the device to the host, downloading the pictures and video clips from the device can be done from the file processing dialog (See 7.4.4 above).

9 Troubleshooting

1. If the video preview does not appear or stops after a few seconds, or you witness other unexpected behavior, it might occur due to weak batteries on the EmblazeCam device. Replacing the batteries may solve the problem. Note that typically alkaline batteries enable 2-3 hours of constant audio/video capture.
2. If you get the error message "Couldn't open video decoder GMP5", re-install the Emblaze MPEG-4 Codec and reboot (for installation instruction, see section 5).
3. If you get the error message "Couldn't find acm codec", you should re-install the Emblaze audio codec and reboot (for installation instruction, see section 5).
4. If the camera is turned off or physically disconnected during operation, the system behavior is unexpected, so the application should be re-started.
5. If the EmblazeCam host application does not show any video, make sure you have a sound blaster installed, and working properly.
6. If the camera device hangs after trying to download/erase a file on it’s flash, it may indicate that the flash may be corrupted. To solve this problem erase the flash (See “File processing”).
7. If the EmblazeCam host application does not show any video, it may be caused by incorrect COM port settings are incorrect. You should make sure that the application is configured to use the communication port to which EmblazeCam is connected. This is done using the Properties dialog box. To see the communication ports on the host device, perform the following steps:

- In Windows2000, right click on the "My Computer" icon and choose “Properties”, choose the “Hardware” tab, push the "DeviceManeger" button and check "Ports (COM & LPT)"
- In Windows 98, right click on the "My Computer" icon and choose “Properties”, choose the “DeviceManager” tab and check "Ports (COM & LPT)".

Appendix C: Project definition

Development of a Bluetooth-based webcamera module

(Diploma work for a Master of Science degree in cooperation with TDK Systems Europe Ltd and Emblaze)

1. **Background**

   TDK Systems Europe Ltd (TSE hereafter) have developed an Intelligent Serial Module that is a very useful building block for developing Bluetooth-based applications. TSE can provide ITN, Linkoping University full technical specifications of the Bluetooth module.

   TSE 's interest at the moment is passing video over a Bluetooth connection. TSE have a sample of a camera with embedded MP4 encoder that has RS232 connection (look at http://www.emblazesemiconductor.com). TSE have successfully attached this to the serial Bluetooth module in their lab.

   The next idea is to connect the serial module to a web-server (look at http://www.ipsil.com) so that the webcam can be viewed via the internet. This has significant security and even domestic applications.

2. **Objective**

   System development of Bluetooth-based applications.

3. **Tasks**

   Hardware design of a Bluetooth camera module using the TSE serial module and reference design from Emblaze (or equivalent): **1 or 2 students, Supervisors: Qin-Zhong Ye and Lennart Lundström.**

4. **Basic education required**

   System development, TCP/IP and Bluetooth protocols.

5. **Technical support and expected results**

   TSE provide the Bluetooth adapters and modules required for this project together with technical support. In return TSE would like to receive from the diploma worker the circuits, BOM and source code of applications. If the project were successful TSE expect to take the design and modify it to meet manufacturing and customer requirements.

Emblaze will provide the webcam reference design as appears in their web site and technical support by e-mail. Emblaze would like to get a copy of the final work with all the relevant documentation and code. If successful, Emblaze would like then to get also a fully functional system so they can demonstrate it to their customers.

6. **Financing**

ITN provide design and lab tools, but no personal compensation. Students are encouraged to find their own sponsors who are interested in outputs of the project.

7. **Examiner**

Qin-Zhong Ye, ITN, Linkoping University.

Students

Robert Johansson, 790701-2715, robjo668@student.liu.se
Jimmy Linder, 780105-4995, jimli128@student.liu.se

Appendix D: Schematics

Voice1.SchDoc

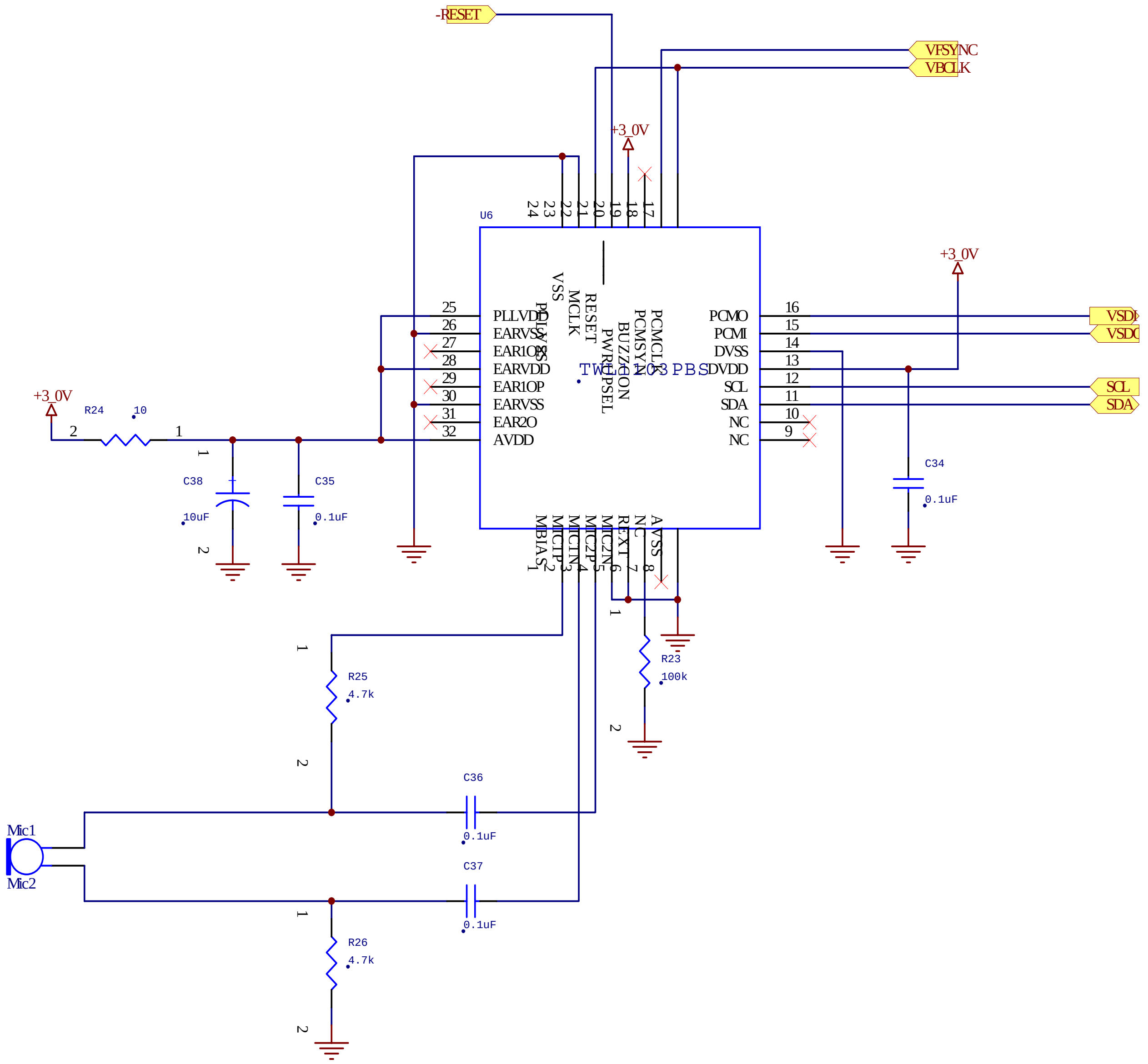


Figure 17. Voice1.SchDoc

Flash1.SchDoc

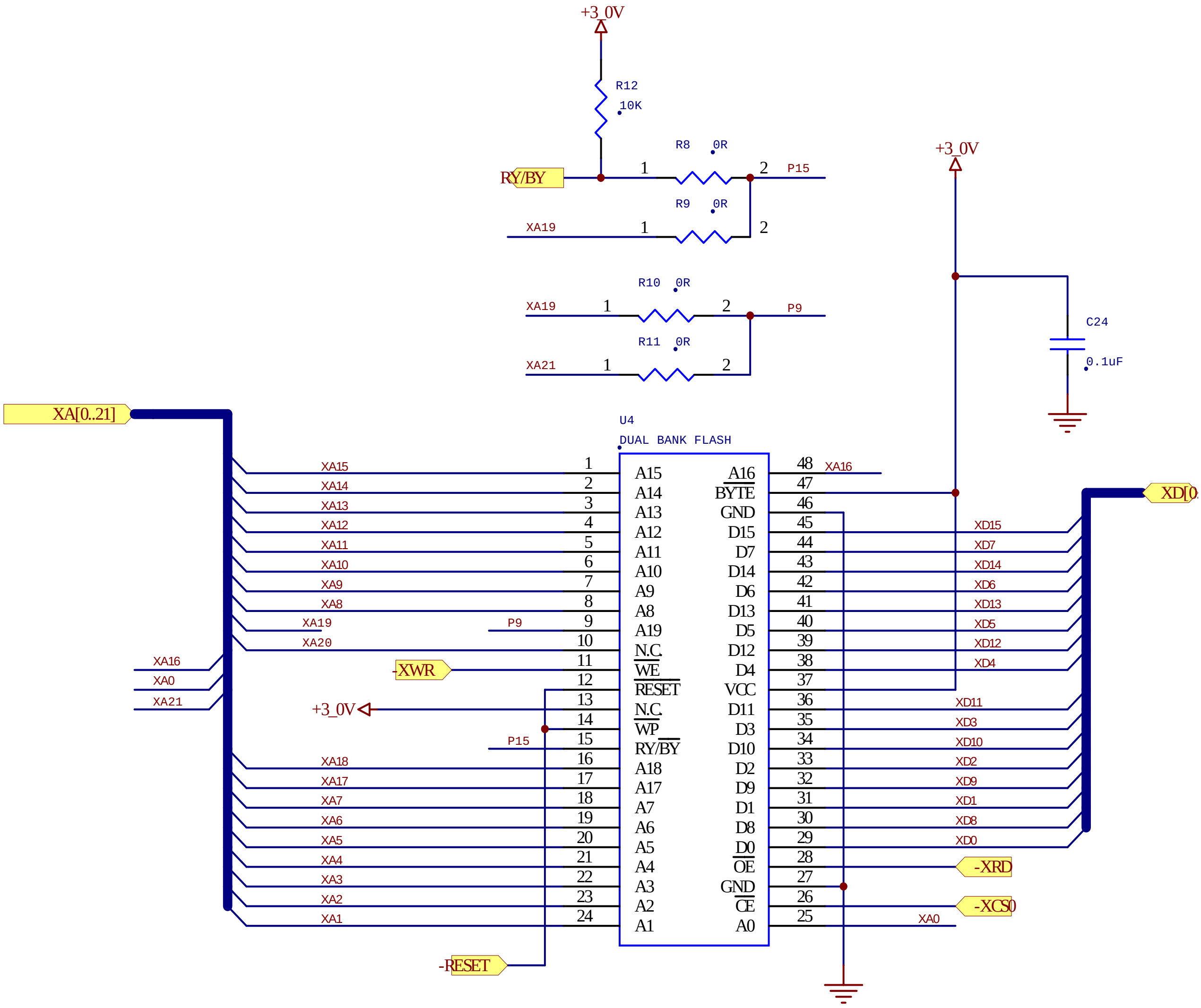
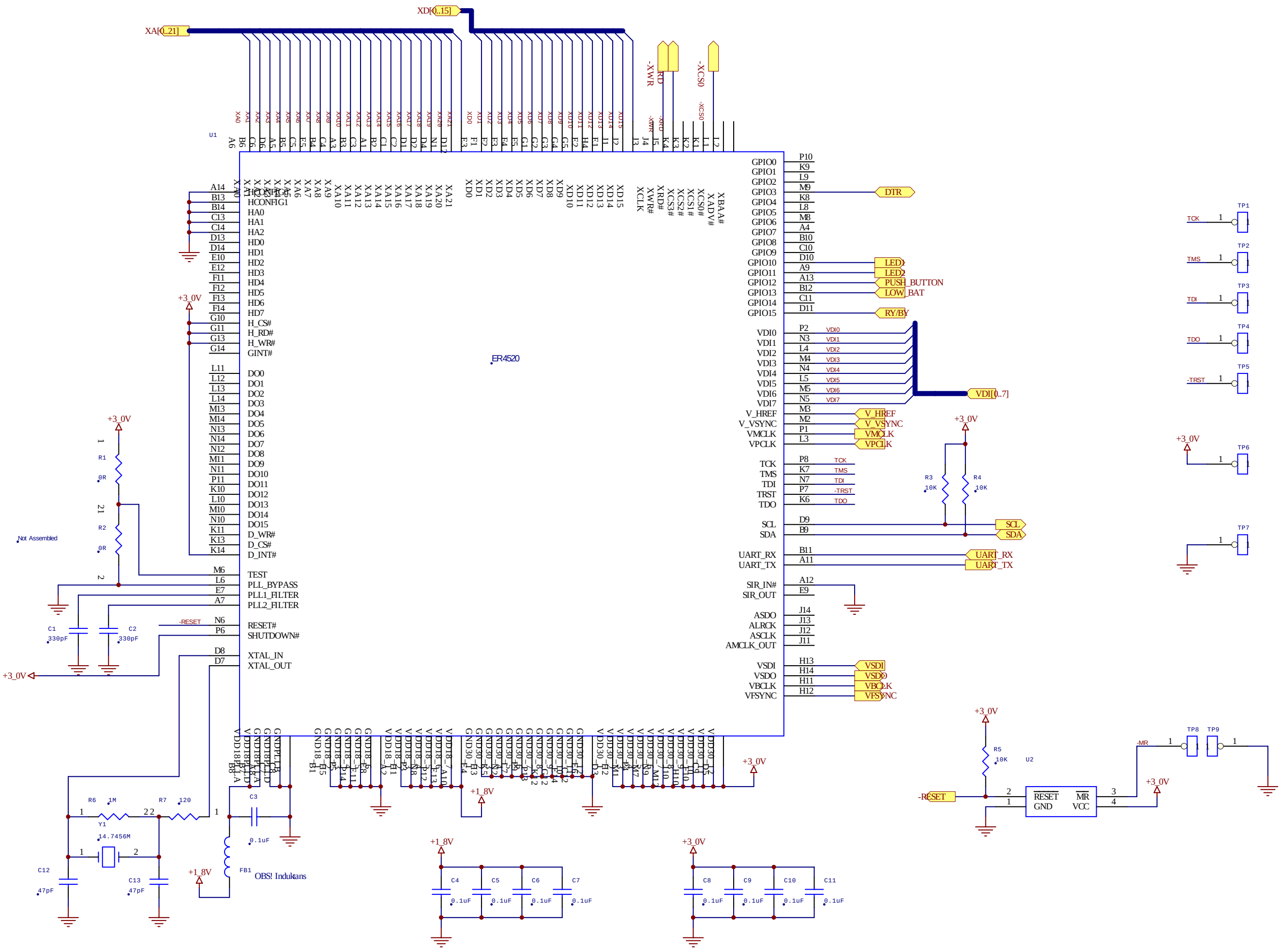


Figure 18. Flash1.SchDoc

A31(ER4520).SchDoc



Figur 19. A31(ER4520).SchDoc

Power1.SchDoc

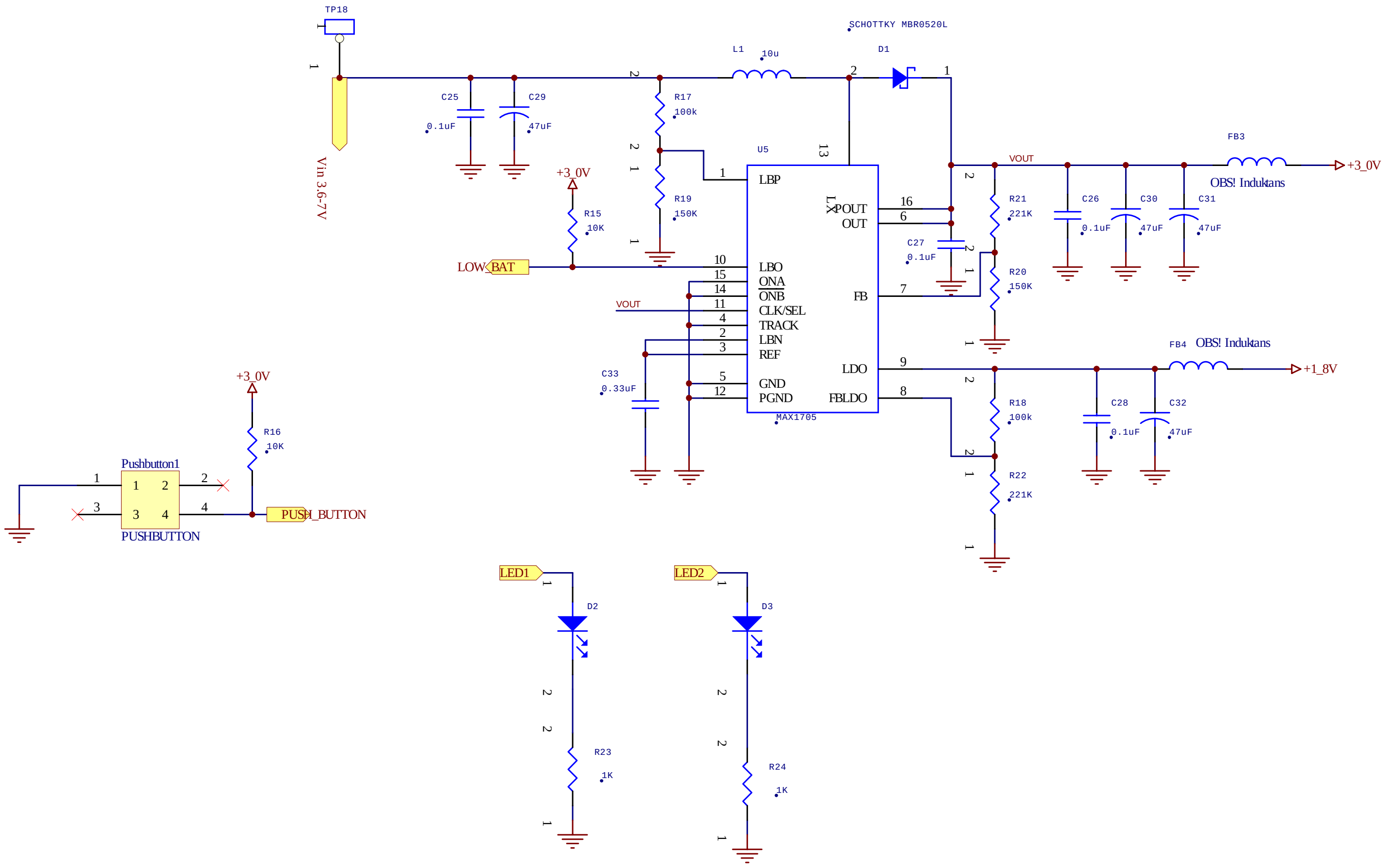


Figure 20. Power1.SchDoc

Camera1.SchDoc

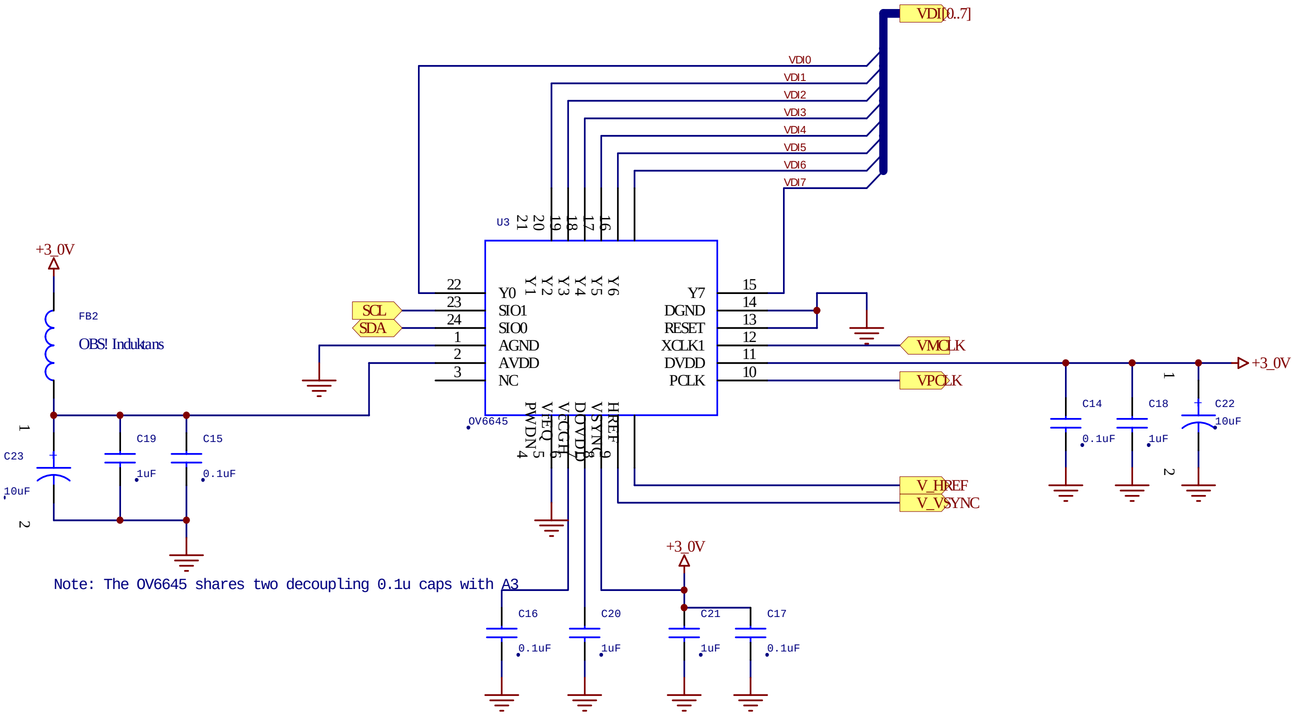


Figure 21. Camera1.SchDoc

Powersupply.SchDoc

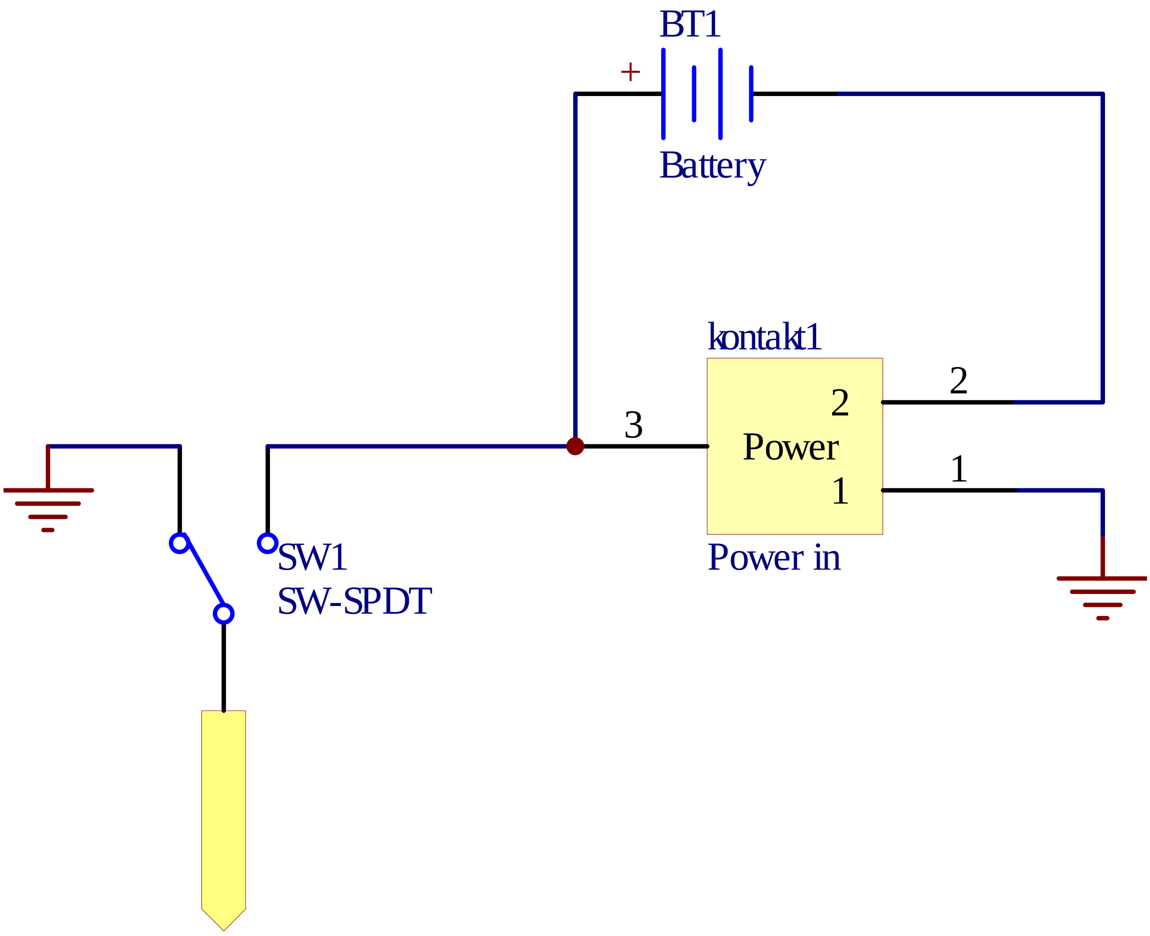


Figure 22. Powersupply.SchDoc

Connector1.SchDoc

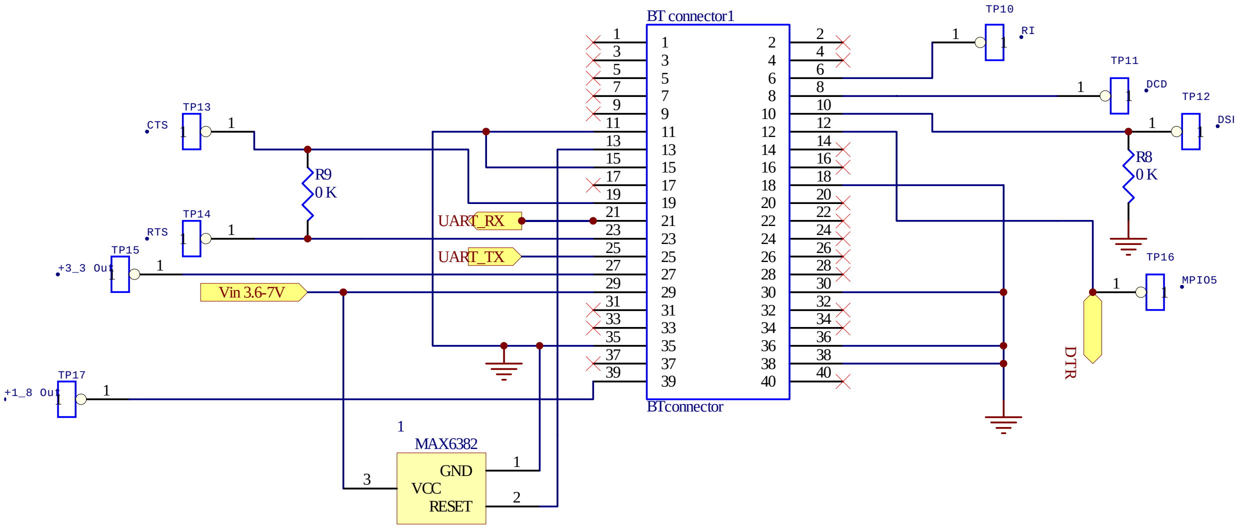


Figure 23. Connector1.SchDoc

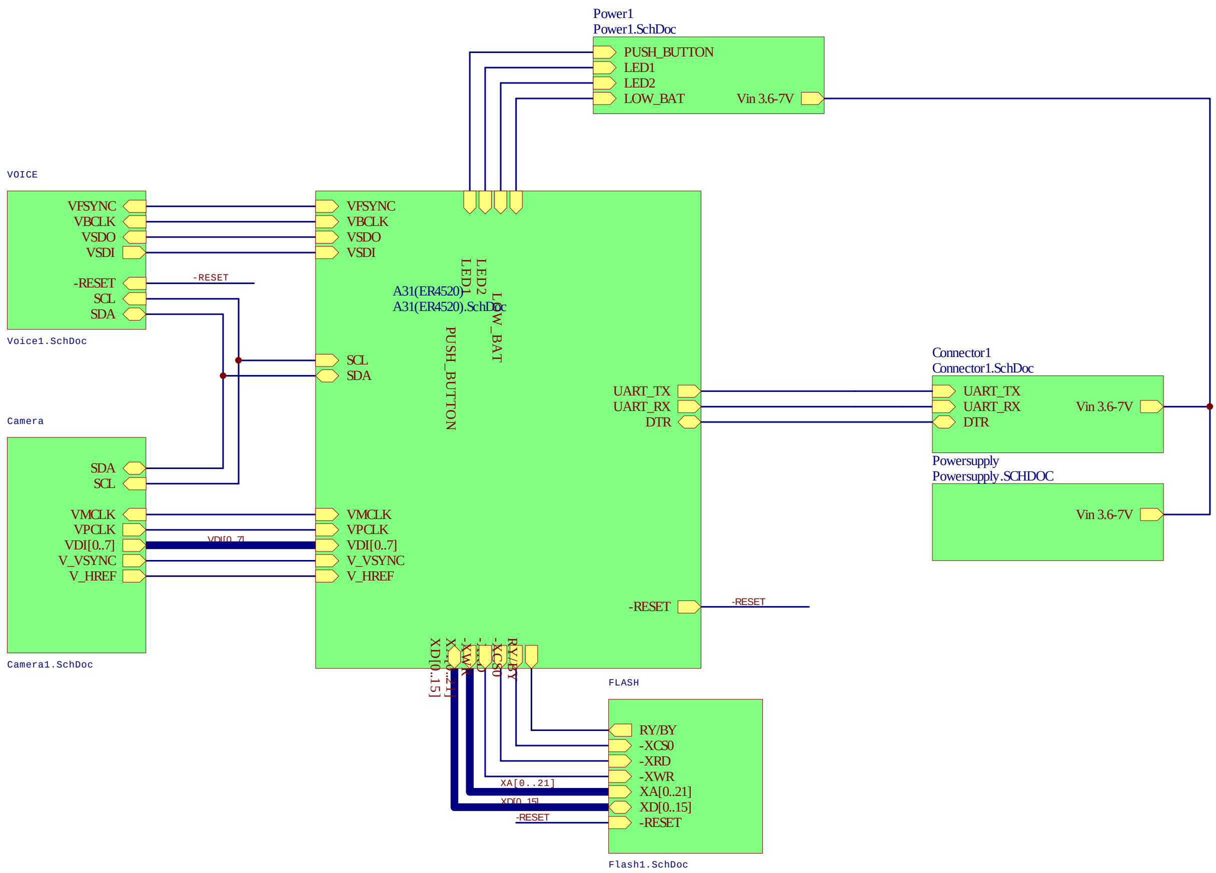


Figure 24. Block Diagram1.SchDoc

PCB

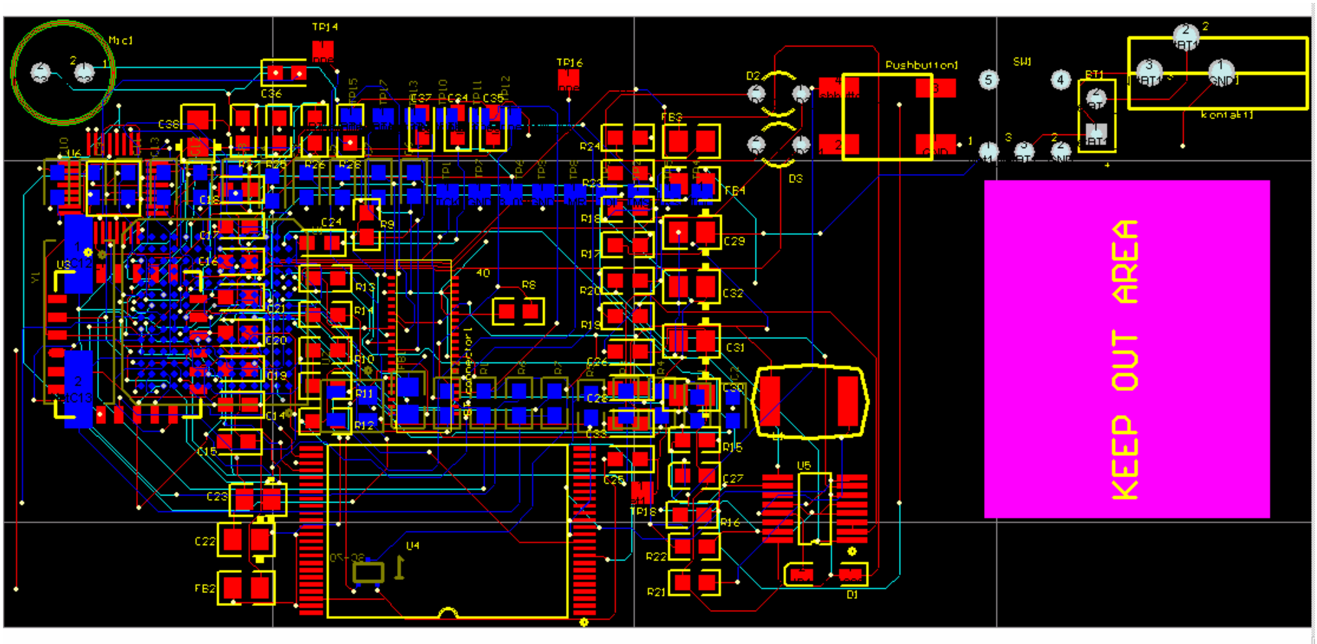


Figure 24. PCB

Layers

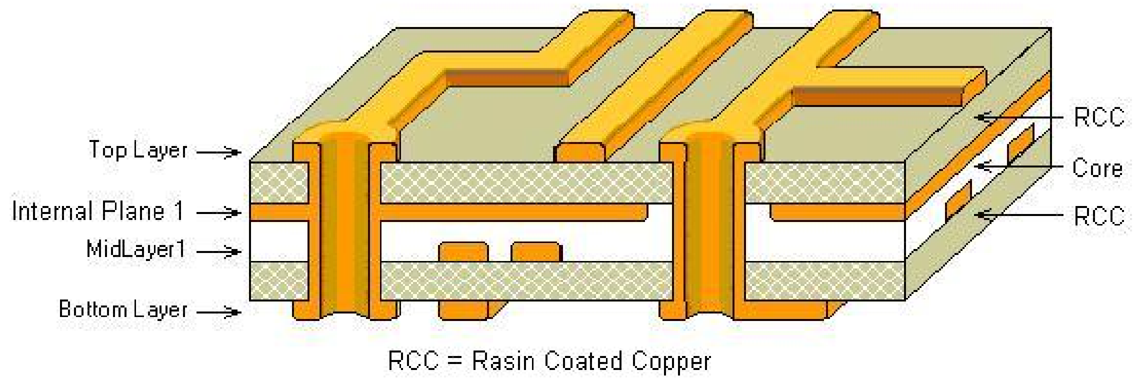
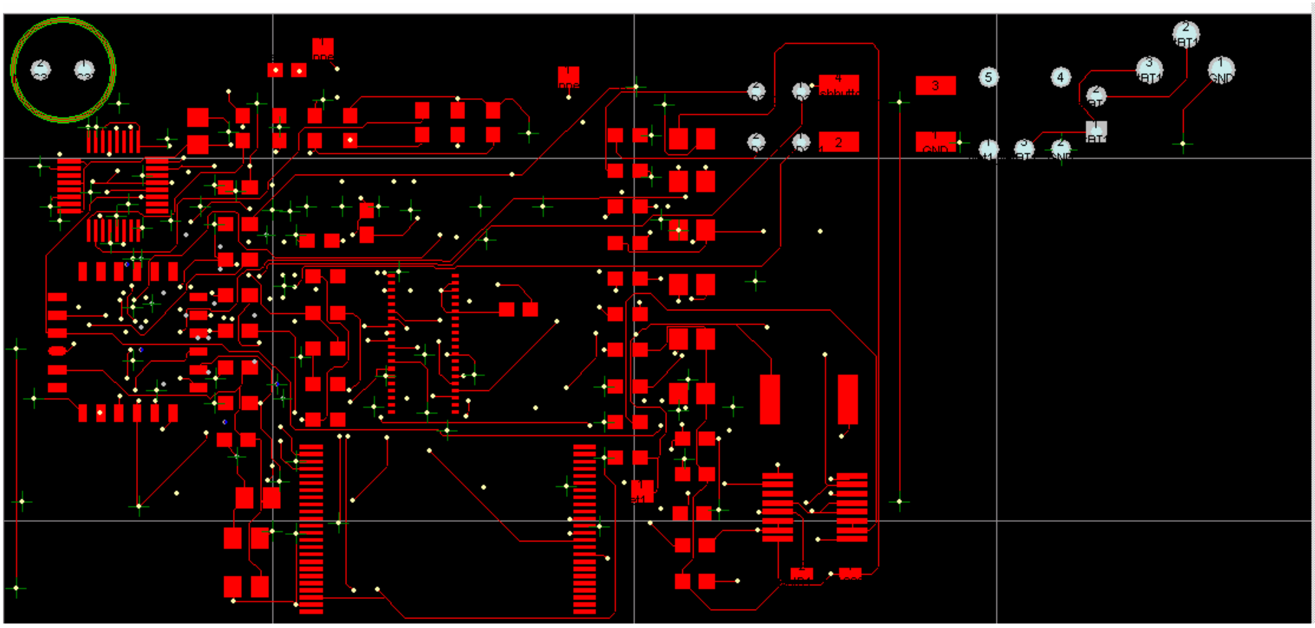


Figure 25. Layers



Figur 26. Top Layer

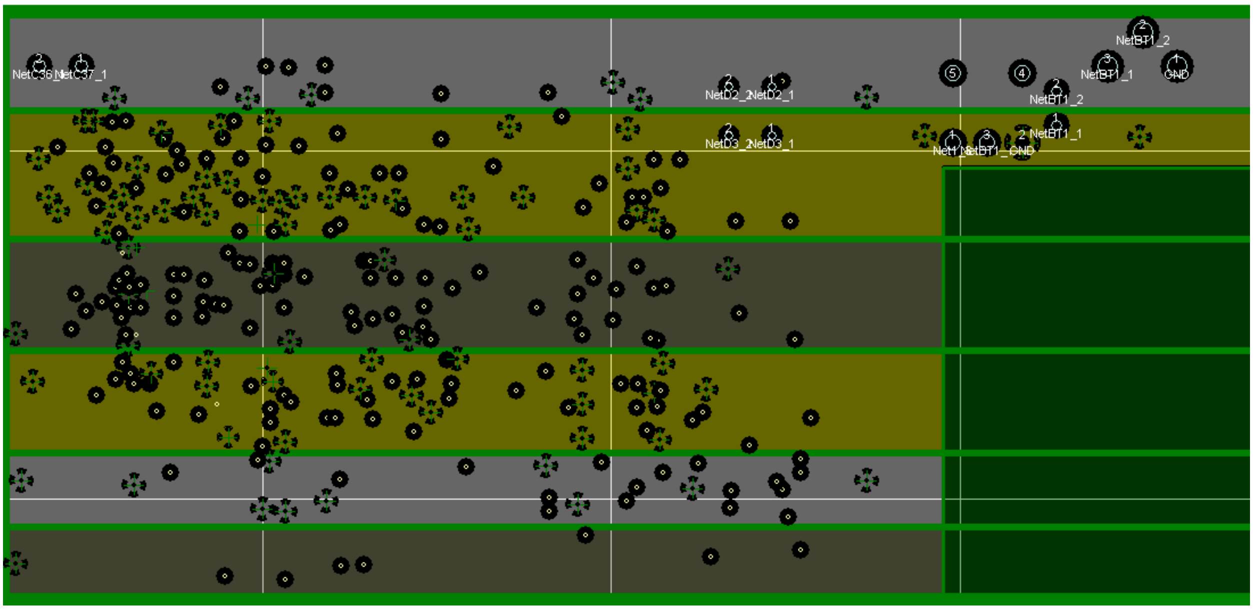


Figure 27. Internal Plane

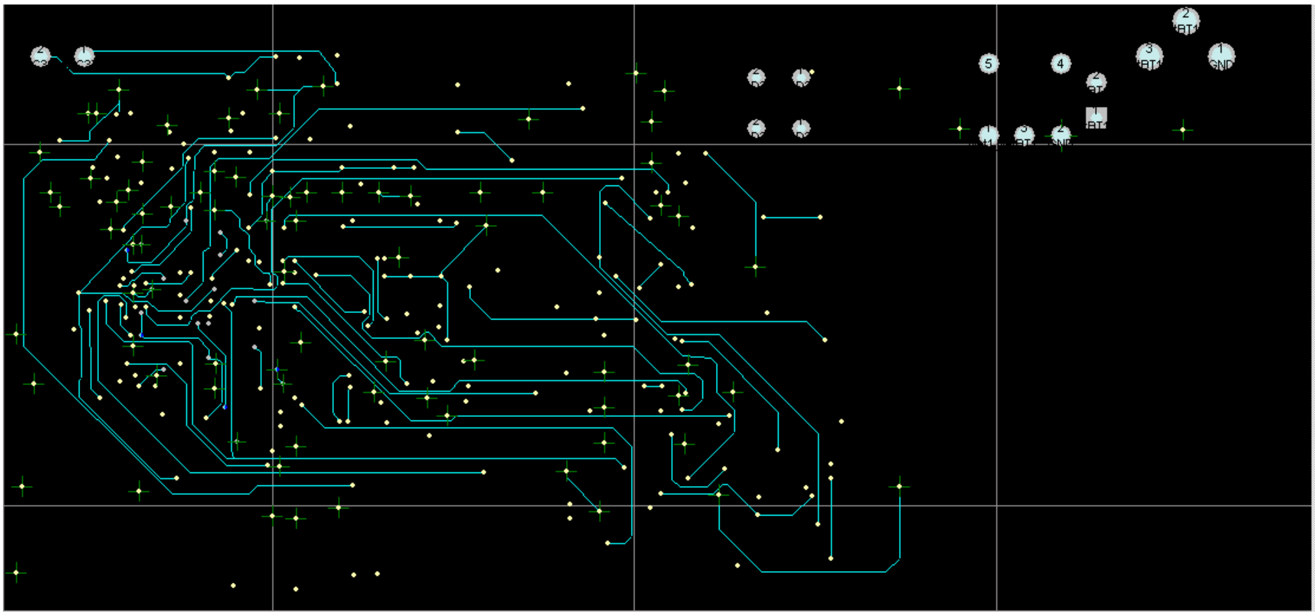


Figure 28. Mid Layer

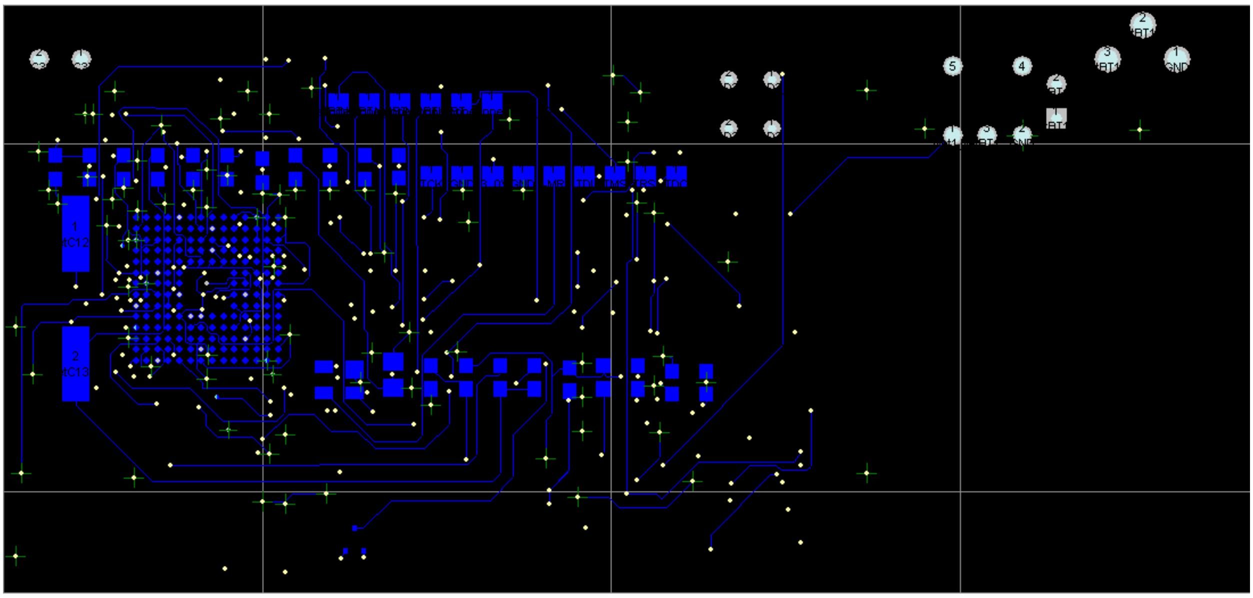


Figure 29. Bottom Layer

Appendix E: Bill of Materials

Table 1: Bill of Materials

Description	Designator	Comment	Footprint	Quantity
	1	MAX6382	SC-70	1
Battery	BT1	Battery	BAT-2	1
Header	BT connector1	BTconnector	PCBComponent_1	1
	C1	330pF	CC1608-0603	1
	C2	330pF	CC1608-0603	1
	C3	0.1uF	CC1608-0603	1
	C4	0.1uF	CC1608-0603	1
	C5	0.1uF	CC1608-0603	1
	C6	0.1uF	CC1608-0603	1
	C7	0.1uF	CC1608-0603	1
	C8	0.1uF	CC1608-0603	1
	C9	0.1uF	CC1608-0603	1
	C10	0.1uF	CC1608-0603	1
	C11	0.1uF	CC1608-0603	1
	C12	47pF	CC1608-0603	1
	C13	47pF	CC1608-0603	1
	C14	0.1uF	CC1608-0603	1
	C15	0.1uF	CC1608-0603	1
	C16	0.1uF	CC1608-0603	1
	C17	0.1uF	CC1608-0603	1
	C18	1uF	CC1608-0603	1
	C19	1uF	CC1608-0603	1
	C20	1uF	CC1608-0603	1
	C21	1uF	CC1608-0603	1
	C22	10uF	CC2012-0805	1
	C23	10uF	CC2012-0805	1
	C24	0.1uF	CC1608-0603	1
	C25	0.1uF	CC1608-0603	1
	C26	0.1uF	CC1608-0603	1
	C27	0.1uF	CD1608-0603	1
	C28	0.1uF	CC1608-0603	1
	C29	47uF	CC2012-0805	1
	C30	47uF	CC2012-0805	1
	C31	47uF	CC2012-0805	1
	C32	47uF	CC2012-0805	1
	C33	0.33uF	CC1608-0603	1
	C34	0.1uF	CC1608-0603	1
	C35	0.1uF	CC1608-0603	1

	C36	0.1uF	CC1608-0603	1
	C37	0.1uF	CC1608-0603	1
	C38	10uF	CC2012-0805	1
	D1	SCHOTTKY MBR0520L	SOD123	1
	D2	RED	BCY-W2/D3.1	1
	D3	RED	BCY-W2/D3.1	1
	FB1	BEAD	CD2012-0805	1
	FB2	BEAD	CR2012-0805	1
	FB3	BEAD	CR2012-0805	1
	FB4	BEAD	CR2012-0805	1
Chassi connector with switching contact	kontakt1	Power in	Powerconnector	1
	L1	10u	EL36	1
Microphone	Mic1	Mic2	Mic	1
pushbutton	Pushbutton1	PUSHBUTTON	Pushbutton	1
	R1	0R	CR1608-0603	1
	R2	0R	CR1608-0603	1
	R3	10K	CR1608-0603	1
	R4	10K	CR1608-0603	1
	R5	10K	CR1608-0603	1
	R6	1M	CR1608-0603	1
	R7	120	CR1608-0603	1
	R8	0 K	CR1608-0603	1
	R9	0 K	CR1608-0603	1
	R10	0R	CR1608-0603	1
	R11	0R	CR1608-0603	1
	R12	0R	CR1608-0603	1
	R13	0R	CR1608-0603	1
	R14	10K	CR1608-0603	1
	R15	10K	CR1608-0603	1
	R16	10K	CR1608-0603	1
	R17	100k	CR1608-0603	1
	R18	100k	CR1608-0603	1
	R19	150K	CR1608-0603	1
	R20	150K	CR1608-0603	1
	R21	221K	CR1608-0603	1
	R22	221K	CR1608-0603	1
	R23	1K	CR1608-0603	1
	R24	1K	CR1608-0603	1
	R25	100k	Cr1608-0603	1
	R26	10	CR1608-0603	1
	R27	4.7k	CR1608-0603	1
	R28	4.7k	CR1608-0603	1
Single-Pole, Double-Throw Switch	SW1	SW-SPDT	Slidebutton	1
	TP1	TEST POINT	TP	1
	TP2	TEST POINT	TP	1
	TP3	TEST POINT	TP	1
	TP4	TEST POINT	TP	1

	TP5	TEST POINT	TP	1
	TP6	TEST POINT	TP	1
	TP7	TEST POINT	TP	1
	TP8	TEST POINT	TP	1
	TP9	TEST POINT	TP	1
	TP10	RI	TP	1
	TP11	DCD	TP	1
	TP12	DSR	TP	1
	TP13	CTS	TP	1
	TP14	RTS	TP	1
	TP15	+3_3 Out	TP	1
	TP16	MPIO5	TP	1
	TP17	+1_8 Out	TP	1
	TP18	GND	TP	1
	U1	ER4520	BGA13x13-B180	1
	U2	MAX6315	SOT143	1
	U3	OV6645	LCC24	1
	U4	DUAL BANK FLASH	TSSO12x20-G48/P.5	1
	U5	MAX1705	SSO-G16/G3	1
	U6	TWL1103	F-QFP5x5-G32/N	1
	Y1	14.7456M	HC49/4H_SMX	1