Team 12 Presents

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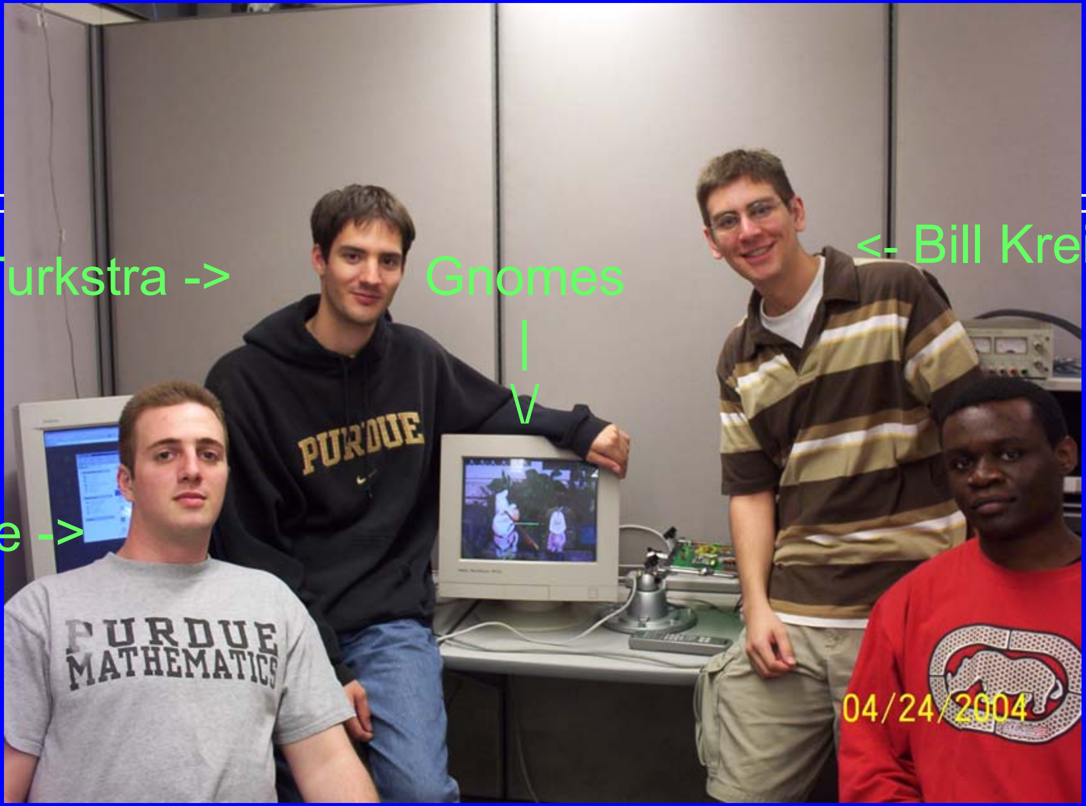


"DiPFI"

"Digital Picture Frame Interface"

A "Black Box" solution to turning old monitors into digital picture frames

Outline of Presentation

- Project Overview and Motivation
- Block Diagram
- Professional Components
- Design Components
- Demonstration of Outcomes
- Conclusions and Questions

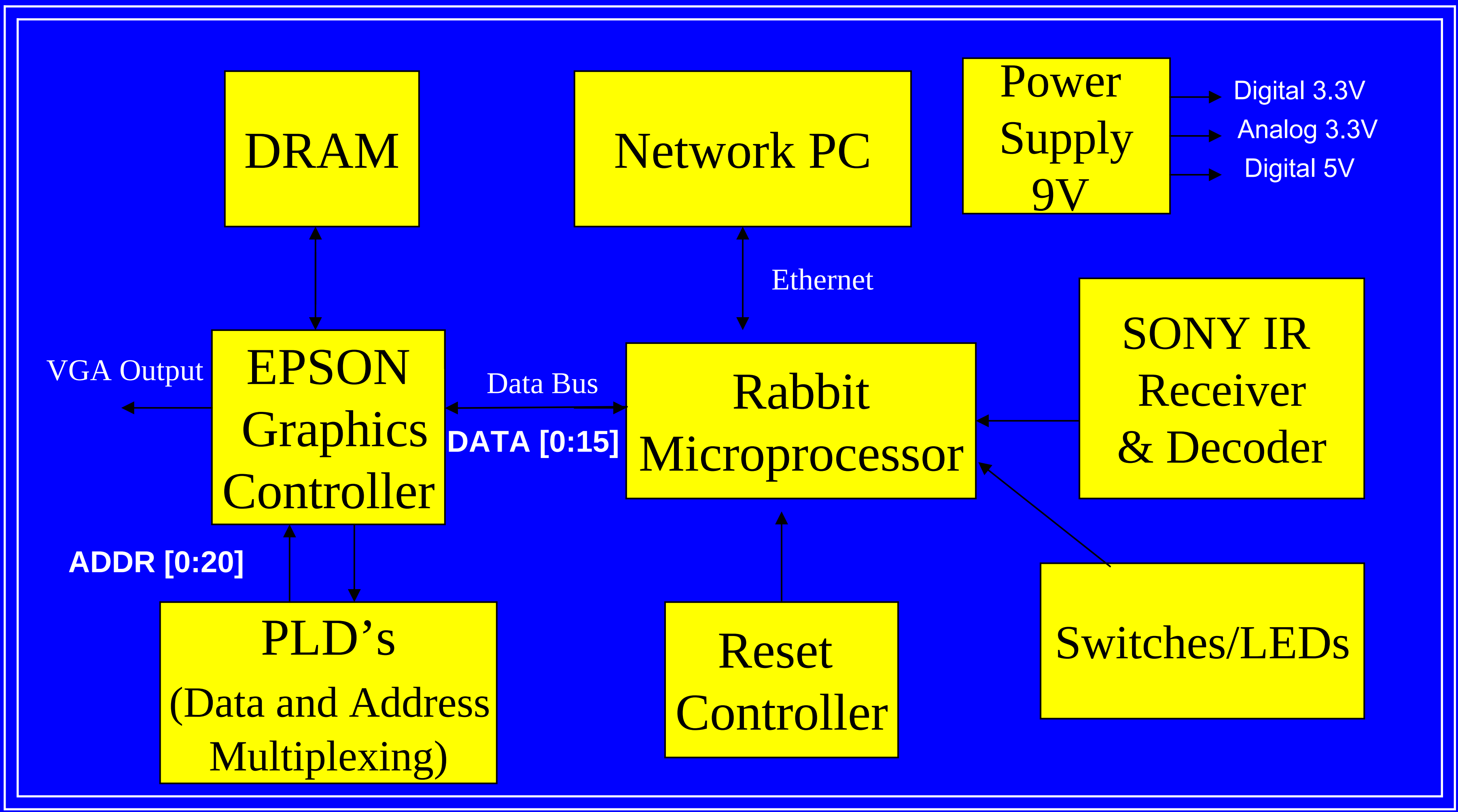
DiPFI features

- Interfaces between a PC and a VGA controlled display (network VGA adapter) to display pictures
- Image data provided via Ethernet to Rabbit Microcontroller.
  - VGA display is done via Epson controller interfacing with a 4MB EDO DRAM memory chip.
  - Address/Data Multiplexing achieved via a PLD hack
  - Epson driven by 25.175 MHz oscillator
- Display controlled by on-device pushbuttons and remote control
- IR remote control allows product to be placed out of reach
  - Allows one to change the picture with just a push of a button!
  - Utilizes channel and volume up/down on any Sony compatible Remote control
- Status LEDs indicate transmission of a picture

Motivation

- Idea originated as a Digital Picture Frame
- DPF requires expensive, sizeable LCD screen
- Isolation of image processing increases flexibility and portability
- Applications
  - replacement for concert band sheet music
  - displaying a photo album digitally
  - Graphically view any image data stored on remote PC

DiPFI Block Diagram



Component Selection Rationale and Constraint Analysis

1. Specific Design Constraints Required for the Graphics Chip and Microcontroller

2. Comparison of Selected Chips to Alternatives

Required Functionality of the Graphics Controller

- Ability to create and refresh all the analog RGB signals necessary to display an image independently
- Standard DRAM interface for the frame buffer
- Large enough frame buffer size to hold a standard SVGA image

Contestant #1: Epson Embedded RAMDAC LCD/CRT Controller

- Onboard analog RGB output
- Support for external standard EDO/FPM DRAM chip up to 2 megabytes
- Surface mount with 128 pins
- Detailed 500 page technical manual

Contestant #2: Cirrus Logic System-on-a-chip with CRT/LCD Controller

- Onboard analog RGB output
- Support for external standard EDO/FPM DRAM
- Surface mount with 240 pins
- ISA bus, onboard ARM
- controller, sound output, and PS/2 serial interface

Which graphics controller better suits the needs of our project?

Cirrus Logic

- 240 pins
- Poor documentation
- External frame-buffer
- Unnecessary additional features: ISA bus, ARM controller, etc.

Epson

- 128 pins
- 500+ page technical manual including timing diagrams, interfacing examples, etc.
- External frame-buffer

Winner? Epson S1D13505

- Additional features of the other chip are not applicable to our project
- Detailed Documentation
- Fewer pins

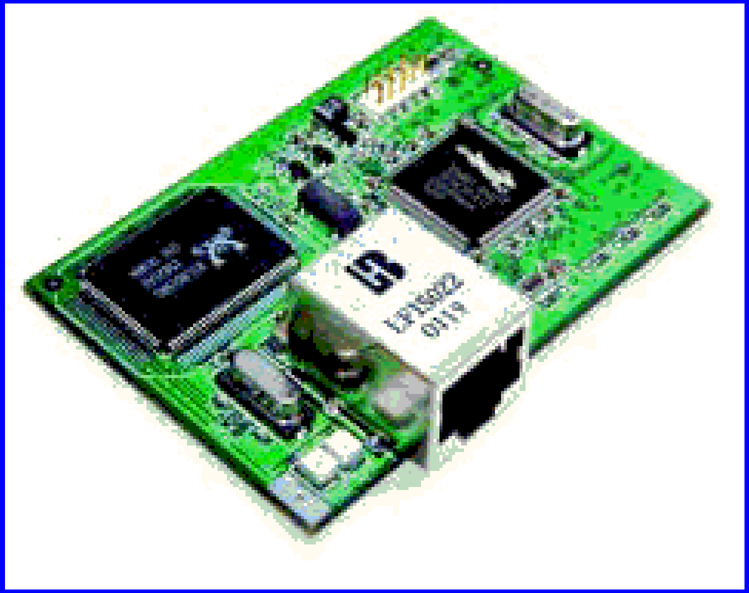
Required functionality of the Microcontroller

- Large number of I/O pins to communicate with the Epson’s huge bus(21-bit address, 16-bit data) and an IR chip
- Enough computability to buffer large amounts of data
- Integrated network adapter
- Efficient development environment

Contestants? No contest.

- Due to the network requirement, a Rabbit controller is ideal
- Need a large model to accommodate the I/O pin demand
- High speed required to buffer large amounts of data
- Modest amount of flash memory and RAM to buffer data

Winner? Rabbit 3010 Core Module (based on Rabbit 3000)



- Total of 52 I/O pins(46 pins required for the Epson alone)
- 256kb of Flash Memory
- 128kb Static RAM
- 29.4 Mhz clock

Patent Liability Analysis

- Results of Patent Search

1. 6,037,989 -- *Still image transmitting device* [9]
2. 6,058,428 -- *Method and apparatus for transferring digital images on a network* [10]
3. 6,111,586 -- *Electronic photo album editing apparatus* [11]
4. 6,167,469 -- *Digital camera having display device for displaying graphical representation of user input and method for transporting the selected digital images thereof* [12]
5. 6,442,573 -- *Method and apparatus for distributing picture mail to a frame device community* [13]

Patent Liability Analysis

5. 6,442,573 – Method and apparatus for distributing picture mail to a frame device community[13]

-- Device is a “Digital Picture Frame” in the truest sense
-- Users upload pictures to a central repository
-- Frame device utilizes modem and dials in to repository at night to download images for that user
-- Marketed to consumers with little to no computer experience
-- Requires purchasing display and subscription to repository
-- Slide show feature

Patent Liability Analysis

The Product in ?

www.ceiva.com

Cost = ~$150.00

Patent Liability Analysis

Direct Infringement

** Probably Not **

Doctrine of Equivalents

** Maybe **

The question: Does the product perform "substantially the same function in substantially the same manner?"

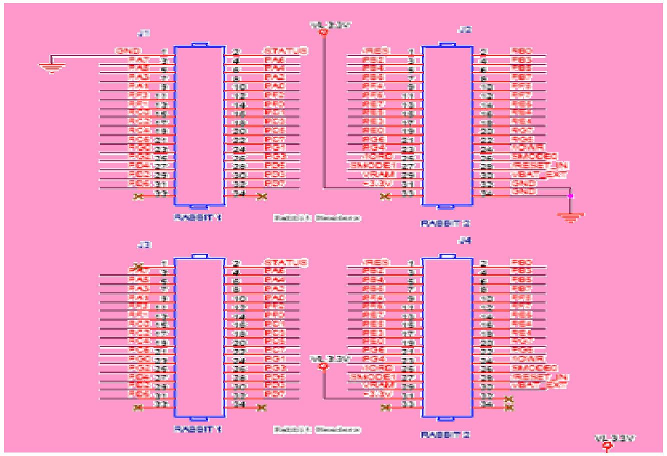
The answer: We feel that the final realization of our product would not infringe because it would improve upon Ceiva's product as it forgoes the need to purchase the LCD device and thus could be cheaper as a used monitor could be used.

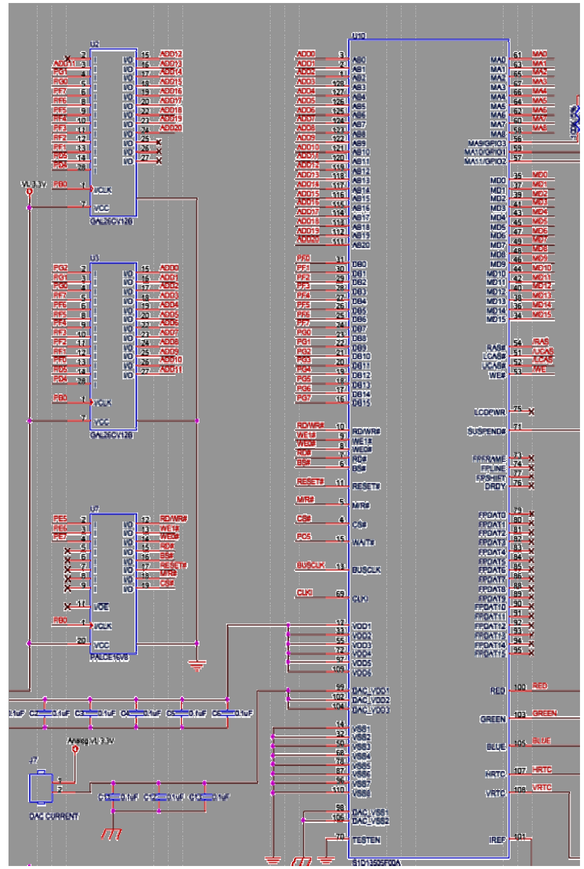
What can be done: Professional patent searches, contact patent attorney, do not market DiPFI

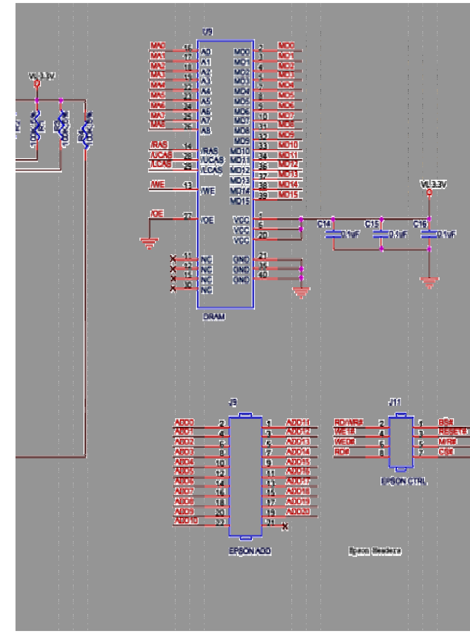
Reliability and Safety Analysis

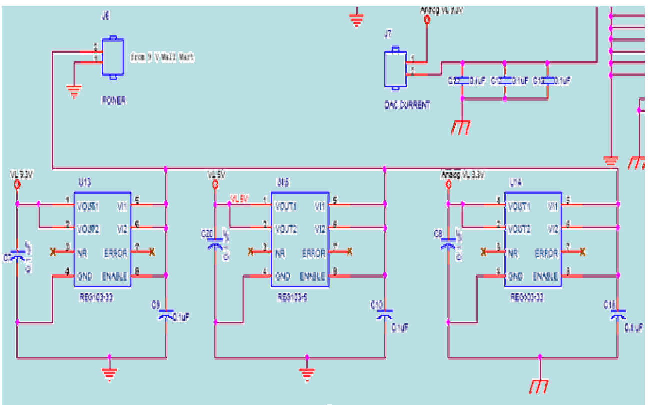
- Project related issues: component error, durability, image processing accuracy.
- Analysis of 5 components most likely to fail due to complexity, operating temperature or constant use.

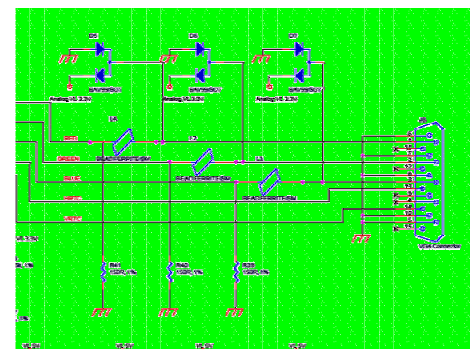
Component	λp / 10^6 (hours)	MTTF (years)
Rabbit 3000 Microprocessor	7.64	14.94
EPSON Graphics Controller	2.06	55.31
LDO Voltage Regulator (9V – 5V,3.3V)	1.45	78.73
EDO DRAM	0.88	129.72
IR Decoder	0.24	467.84

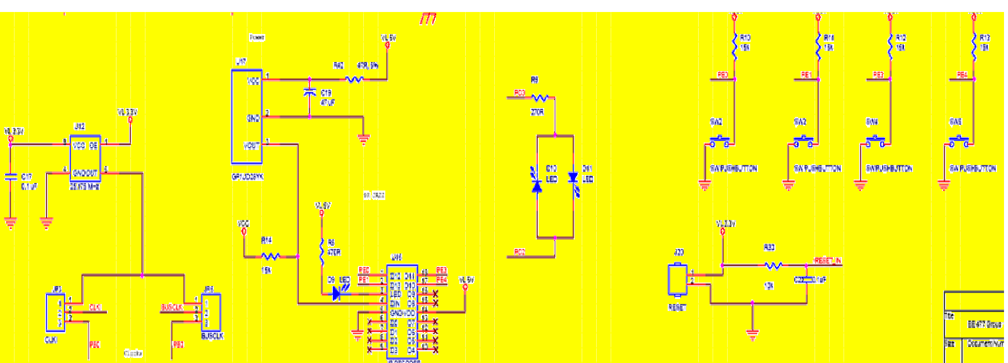












Power Supply	9V Wall Wart, Voltage Regulators
User Interface	Push buttons, IR Decoder and Receiver
Physical Connectors	VGA Connector, (RJ-45 on core module)
Graphics	EPSON, DRAM, PLDs, Crystal Oscillator
Microcontroller	Rabbit 3000 (Headers)

Reliability and Safety Analysis

- FMECA (Failure mode effects and criticality analysis)
- Criticality Examples:
  - LOW : Non critical to main function, display not affected ; $\lambda < 10^{-9}$
  - HIGH : Design critical to main display function; $\lambda < 10^{-4}$

Failure No.	Failure Mode	Possible Causes	Failure Effects	Method of Detection	Criticality	Remarks
B1	No response to push buttons	SW2, SW3, SW4, SW5	No new pictures obtained	Observation	LOW	Limits the users control method to IR remote
D4	EPSON not working correctly	U10, Q1, J20, U13	No meaningful data buffered in DRAM or sent to VGA output; Unpredictable	Observation	HIGH	User gets incorrect data from PC. Product is not useful. Easily detected.

Reliability and Safety Analysis Summary

- Rabbit most likely to fail (MTTF = 14.98yrs)
- Core module additional components (SRAM, Flash, Ethernet) will further lower reliability
- Adding heat sink to EPSON, LDO regulators especially will extend lifetime and improve operation
- High criticality failures: Power to chips, Valid data sent to connectors, Pixel Addressing and Buffering, Rabbit communication and interfacing

Ethical and Environmental Analysis

- Ethical issues
  - User safety
    - Enclosed in a box, so not an enormous problem
    - Appropriate warnings should be placed on box as well is in the user manual
    - Minimize risk of shorts/component failures resulting from jarring of the device
    - Potential current monitoring to detect shorts (i.e., liquid is spilled on device)
  - Product quality/reliability
    - MTTF from earlier
    - Ensure that software is complete and “bug free” at ship time
    - User friendly menus and controls
  - Testing
    - Ensure devices remain cool (namely the LDO regulators)
    - Test for weird button combinations/scenarios and plan against them

Ethical and Environmental Analysis

- Environmental issues
  - Manufacturing process
    - Avoid lead-based solder and components
      - If unavoidable, ensure that byproducts are properly contained
    - Use techniques to reduce waste
      - Minimize number of IC's (larger PLD instead of 4 smaller)
      - Minimize board area, traces and size
  - Normal usage
    - Minimize IR interference
    - Electricity
      - Minimize electricity usage
    - Ensure that no extraneous EMF is generated by digital components (FCC compliance)
  - Product disposal
    - Recycle components if possible
    - Warn user that PCB (and potentially other components) contain lead and should therefore be disposed of accordingly

Packaging Design Considerations

- Design Requirements
- Commercial Product Comparison
- Unique/adapted features

Packaging Design

- DiPFI Physical Features
- - RJ-45 network connector

  - 15 pin female VGA connector

  - Power and Busy LED’s

  - Push buttons (Next, Previous, Function, Power)

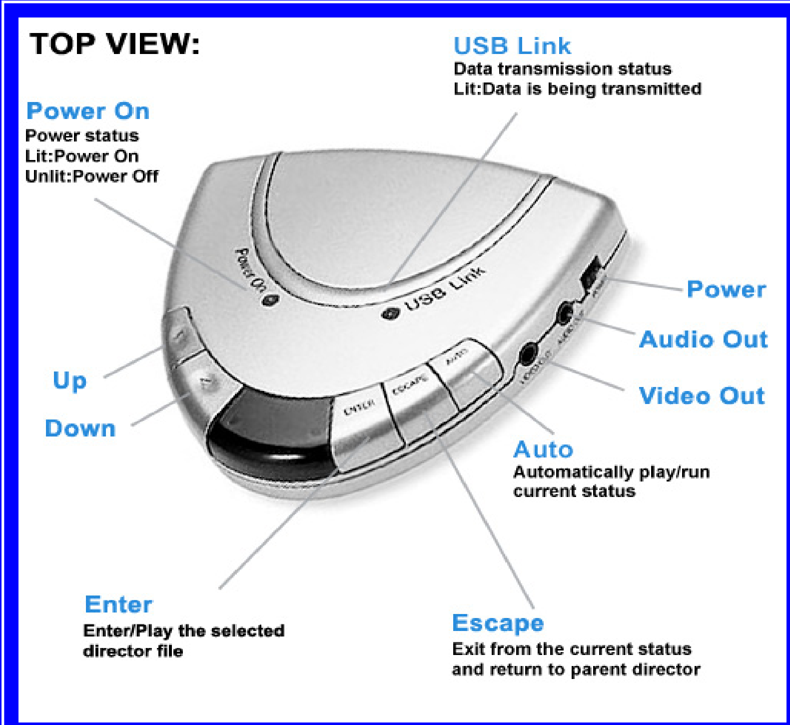
  - Internal electronics :

    Epson, Rabbit, IR Receiver/Decoder, PLD’s

  - Power input

  - Plexi-glass Casing

Commercial Product Analysis - #2



Vosonic Multi-media Viewer – 80

WxHxD : 98 x 89 x 15 mm

Weight : 81g

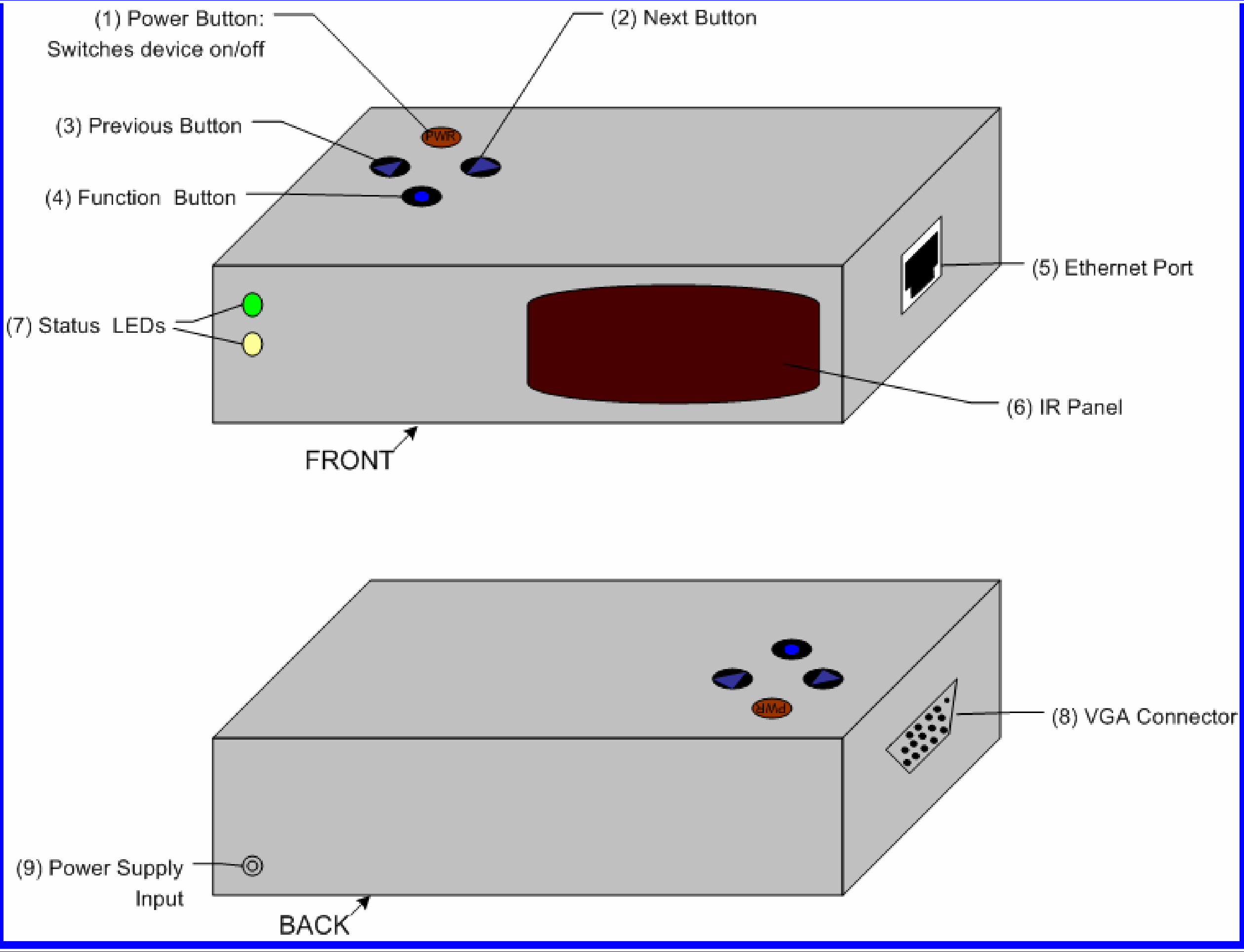
- Features

  - Plays JPEG/MPEG/MP3 file formats
  - Supports various memory cards and has USB driver
  - compatible with Windows and Mac OS
  - Interfaces with NTSC/ Pal TV's or TFT monitors
  - IrDA remote control

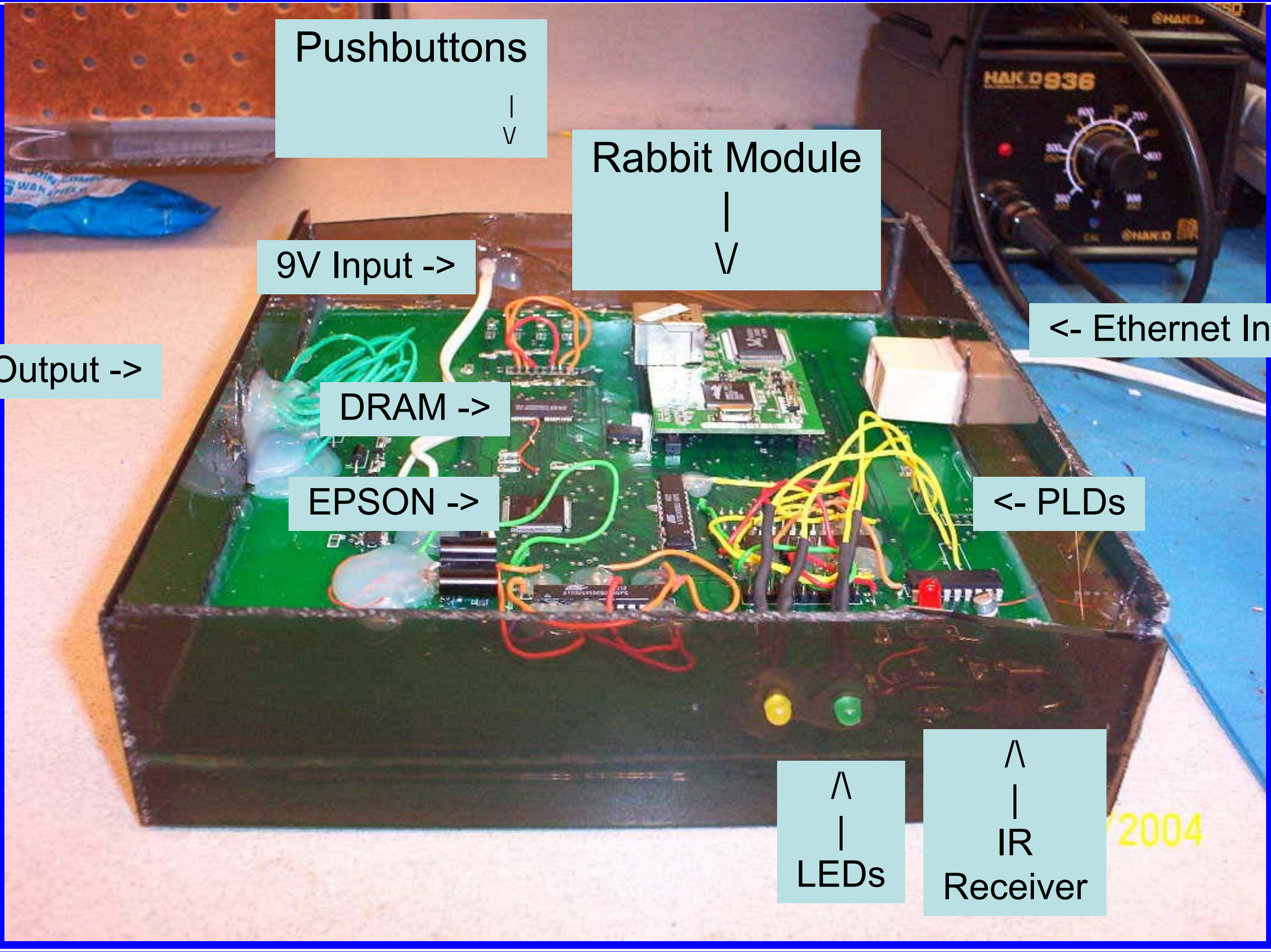
Product features we adapted to our design

- Compact light-weight design
- User-friendly button arrangement and labeling
- Arrangement of inputs and outputs allow for easy connection
- Wide front panel for easy IR signal reception
- Unique aspects:
  - ability to connect remotely to PC over Ethernet
  - capable of running web server

Final Packaging Concept



DiPFI Realization



Circuit Design and Schematic: Considerations

- Power supply considerations
  - Rabbit 3010 operates at 3.3 VDC
    - Can sink and source up to 6.8 mA current
    - Input pins are up to 5.5 VDC tolerant
  - IR module operates at 5 VDC
    - Requires 4 I/O pins @ < 2 mA operating current per pin
  - Epson Graphics Controller requires two separate power supplies
    - Analog 3.3 VDC
    - Digital 3.3 VDC
    - Separate Grounds

Circuit Design and Schematic: Considerations

- Power supply considerations
  - To achieve required voltages, a standard unregulated 9 VDC "Wall Wart" was used along with standard Low-Dropout Voltage Regulators to achieve:
    - 9 V to regulated VL 3.3V digital power
    - 9 V to regulated Analog VL 3.3V analog power
    - 9 V to regulated VL 5V digital power

Circuit Design and Schematic: Considerations

- VGA Connector
  - Standard VGA connector fed by Epson RGB signals
    - Ferrite beads for low-pass filtering
    - BAV99 double-diode for surge protection
- LED/Pushbuttons
  - Only consideration is meeting 6.8 mA Rabbit source/sink limits
- IR Remote
  - Utilizes channel/volume up/down for functions
    - Next picture, previous picture, send picture

Circuit Design and Schematic: Considerations

- Epson Graphics Controller considerations
  - 21 bit address bus
  - 16 bit data bus
  - Direct connection to 256k x 16 EDO RAM chip
  - **Standard VGA connections**
    - RGB outputs – RED/GREEN/BLUE
    - Horizontal/Vertical Controls – HRTC/VRTC
  - IREF
    - Requires 4.6 mA current reference for DAC supplied by NPN transistor
  - PLDs
    - Address is latched between each cycle of data transmission (every 16-bits).
    - This coupled with sending uncompressed image data via Ethernet causes image display to take a significant amount of time

PCB Layout Design Considerations

- Noise
  - Introduction of noise through power subsystem
    - Isolation of components sensitive to noise
      - “Digital” part of the board
      - Analog DAC present on the Epson
    - Separate voltage regulator for analog DAC
    - Separation of DAC and Digital ground via ferrite bead
  - Introduction of noise through magnetic coupling
    - Physically separate digital and analog portions of the circuit as much as possible
    - Perpendicular intersection of traces (on different layers)
    - Separate relatively “high power” components (+5VDC components were placed on the opposite side of the board)

PCB Layout Design Considerations

- Noise continued…
  - Generalized approach
    - Traces run on top layer were done from left-to-right whereas traces on bottom layer were done from top-to-bottom
      - Exception: region surrounding the Epson controller
        - » ~6.5mil pads, relatively small spacing constraints
    - Decoupling capacitors located close to IC's
      - Reduce noise and compensate for current spikes from unexpectedly high switching
    - Clock (crystal) location
      - As close as possible to the Epson (only externally "clock-driven" device on the board)
      - Traces as short as possible
      - Inductive loops avoided at all costs

PCB Layout Design Considerations

- Component functionality
  - VGA connector placement
    - Must be on board edge
  - IR receiver
    - Board edge also an ideal location…preferably away from the VGA (analog) portion of the board
  - Rabbit's Ethernet "socket"?
    - For routing simplicity, was not considered to be a concern
    - Solution: external "extender dangle" allows rabbit to be placed anywhere on the board

PCB Layout Design Considerations

- Component priority
  - Based on complexity and device “relationships”
    - Epson
    - DRAM
    - Address & Control PLD’s
    - Rabbit headers
    - LED’s / pushbuttons
    - “Analog” components
    - “IR” components
    - Debug headers

PCB Layout Design Considerations

- Traces
  - Size
    - Most were 12 mils
    - Notable exception – Epson
      - 6 mil trace size (required due to pad size)
    - Power subsystem
      - Larger traces (in some cases)
      - Generally also 12 mils for routing simplicity
  - Angles
    - 90 Degree (and smaller) angles avoided whenever possible
- Custom footprints
    - Screwed up Rabbit headers
    - Epson, DRAM

Software Design Considerations

Our Project Requires Two Main Software Projects:

1. TCP/IP server on the Digital Picture Frame Interface

2. Linux TCP/IP client on the PC

Overview: Custom TCP/IP Application Layer Protocol

- Used to synchronize communication between the picture box and PC client
- The picture box unit sends out the control signals: “Next Picture,” “Previous Picture,” and “Function.”
- “Next Picture/Previous Picture” cycle through the picture pointer on the PC computer
- “Function” tells the PC to send pixel data for an entire picture

Overview: Custom TCP/IP Application Layer Protocol

- PC sends out only pixel packets which consist of a 32 bit address and 16 bit color data
- Epson is byte addressable, so every pixel packet represents 2 address locations on the Epson
- Color values are formatted properly for the Epson on the PC

Overview: Picture Frame Interface Software Module on the Rabbit 3000

- “Listens” on a port 39 of the assigned internet address via DHCP or Static IP
- Once the PC client connects, the Picture Frame Interface controls the session by sending text commands whenever the user presses a pushbutton or remote control button
- Picture Frame Interface can hold one picture on the graphic controller’s frame buffer
- The internal Rabbit microcontroller buffers pixels destined for the Epson, and clocks in the pixel data to the Epson one pixel at a time
- The Rabbit has a web server where compressed images can be retrieved

Picture Frame Interface Software Module
Co-statements

- The Rabbit microcontroller uses a cooperative multitasking environment by separating the program into different processes or "co-statements"

- A "costatement" is a regular C function except that a current instruction counter is stored

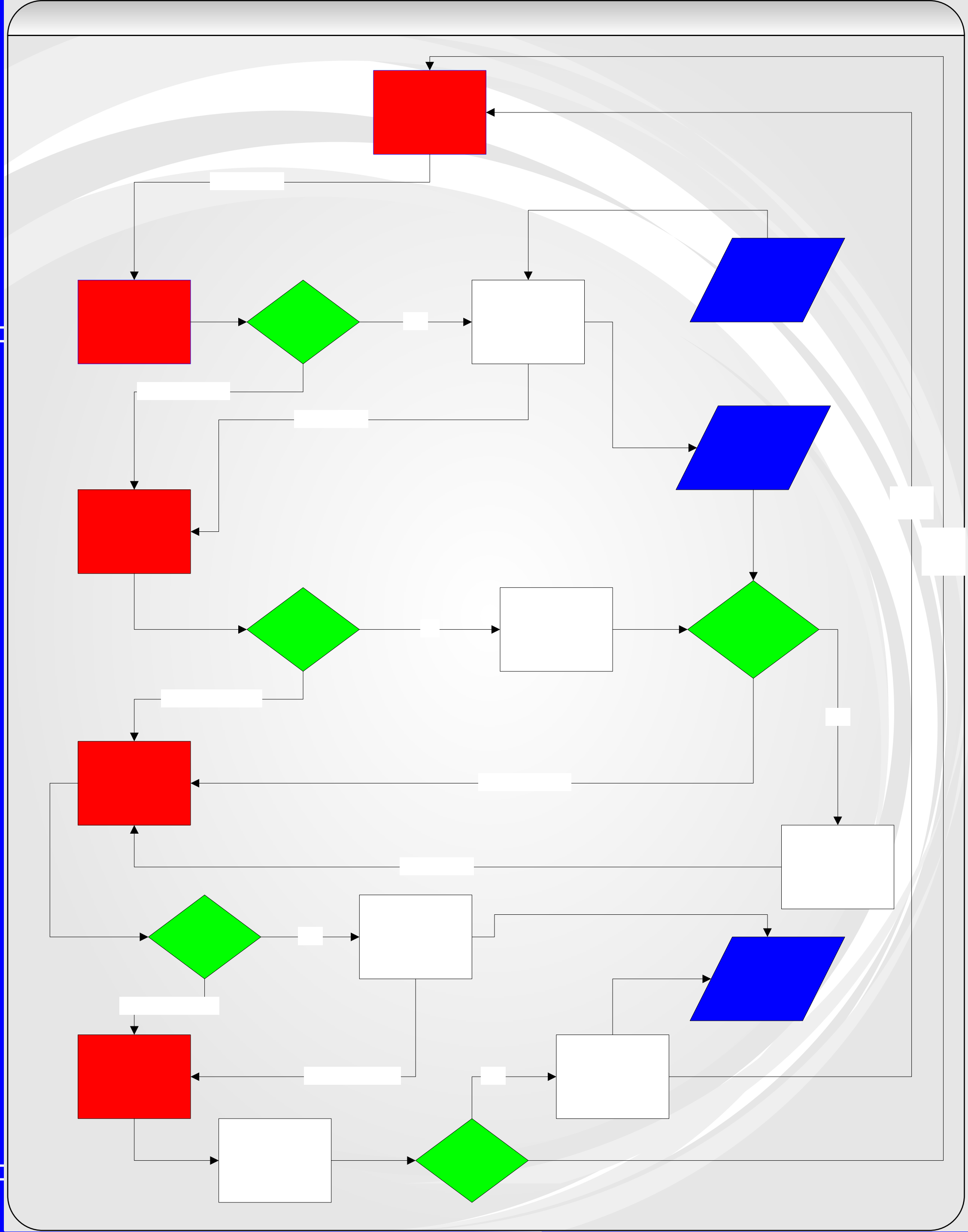
- A "yield" function is used to give up control to the next process, so that when control is returned execution starts at the <u>instruction following the "yield"</u> function

- An "abort" function is used to give up control to the next process, so that when control is returned execution starts at the <u>beginning of the costatement</u>

Picture Frame Interface Software Module
Round Robin Scheduling

- The Rabbit Software modules consists of several processes that execute in a Round Robin scheduling algorithm, which just means they are executed in order in an infinite loop

- Module 1: "incoming_tcp"- when an Ethernet connection is active, drop all incoming pixel packets into a circular buffer
- Module 2: "decodePCdata" - decode pixel packets stored in the circular buffer, and transfer a pixel to the Epson graphics controller for display
- Module 3: "monitorbuttons" – debounce input buttons, and sends the corresponding command via Ethernet if connected
- Function "DelayMs" – used along with co-statements to setup a timer interrupt so that after the specified number of ms a 1 is returned
- Module 4: "monitorIR" – sends commands via Ethernet like "monitorbuttons," but uses the IR input
- Module 5: "tcp_tick" – constantly run to update the TCP/IP stack



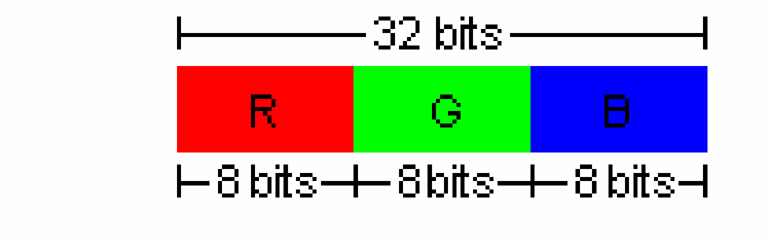
Incoming_

PC Client Software Module

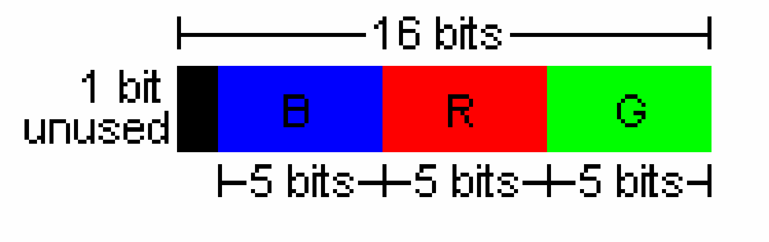
- Consists of a command line program that accepts two arguments: IP address and port number of the remote Picture Box
- Scans local directory for files with the .ppm extension and creates a list of all found
- Connects to the Picture box using the passed arguments
- Waits for commands from the remote Picture Box
- When a “Next Picture/Previous Picture” command is received, the PC just increments/decrements the pointer to the current PPM picture
- When a “Function” command is received, the current .ppm file is read pixel-by-pixel

PC Client Software Module

- Each 32 bit .ppm color value consists of 8 bits for red, 8 bits for green, and 8 bits for blue

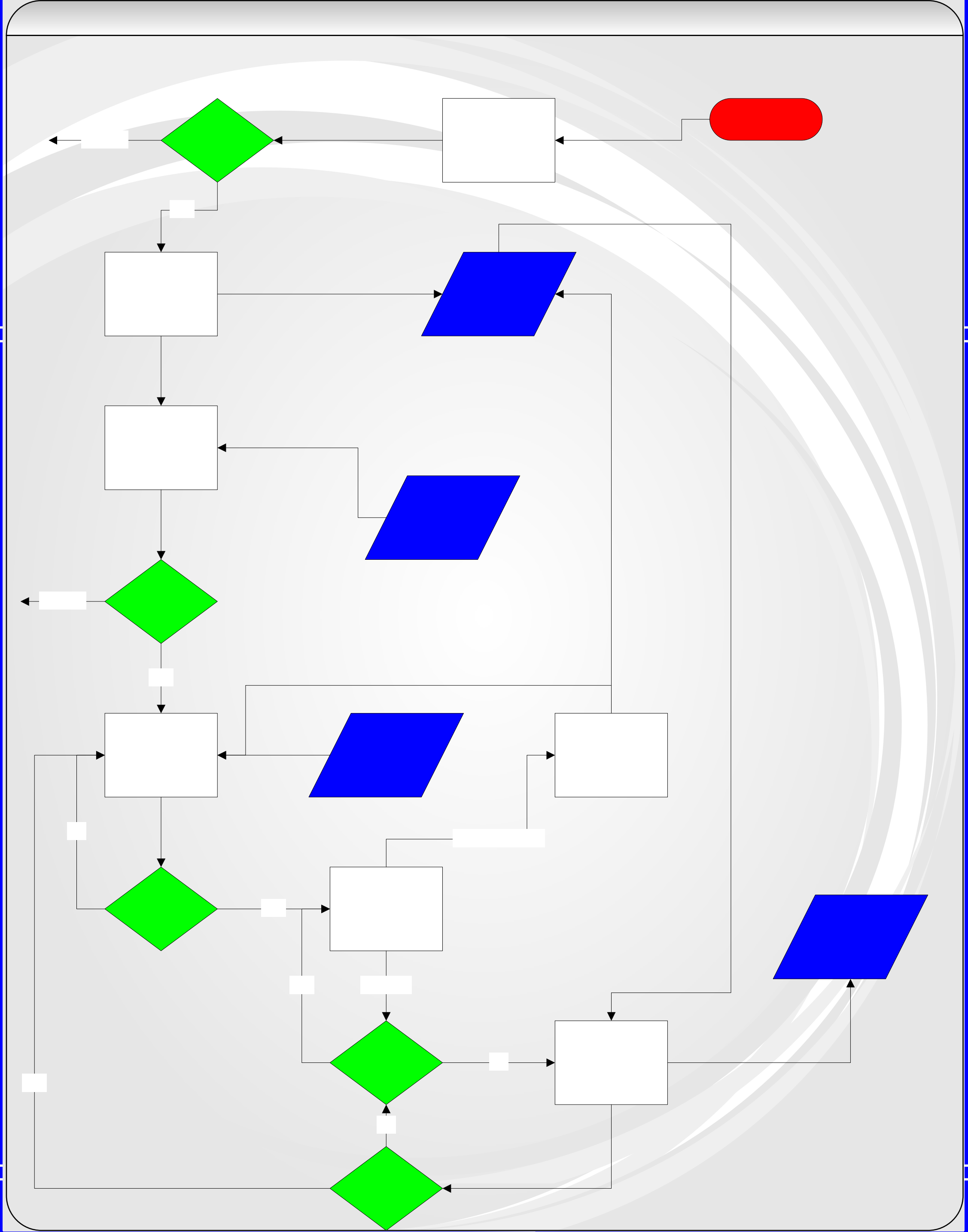


- Each color value is scaled down to 5 bits and packed into a 16 bit value so that the Epson can understand the data



PC Client Software Module

- The new scaled 16 bit color value is encapsulated in a network packet along with the 32 bit address
- The address is incremented by two after every pixel because the Epson is byte addressable and the 16 bit color value occupies two locations in memory
- Once the entire picture is sent, the PC software returns to waiting for remote commands



No, Exit

Y

Create lis
pictures a
current pic
pointer

Success Criteria

- **Outcomes**

1. Ability to interface to a VGA controller and display graphical data on a VGA device
2. Ability to receive and interpret IR signals from a remote
3. Ability to receive decoded image data via Ethernet
4. Ability to interface with pushbuttons and status LEDs
5. Ability to generate text overlay on VGA device

Video Demonstration

-

Individual Contributions

- Bill Kreider
  - IR subsystem
  - Webmaster
  - Parts Management
  - Assisted in debugging/soldering
  - Schematic
  - Prototyping
- Phillip Boone
  - Parts searching
  - Everything Software
  - Web server implementation
- Jeff Turkstra
  - Everything Epson (including software interfacing routines)
  - Layout x 2
  - NewsPro CGI setup (for notebooks)
  - Parts Ordering
  - Board Population
  - Assisted with Schematic
  - Programmed / Ensured correct operation of PLD's
  - Sacrificed video card for VGA connector
  - Developed JPEG decoding routine
- Egomaron Jegede
  - JPEG decoding
  - Software development and testing
  - Web server implementation
  - Packaging Design

What we learned ?

- New and more detailed aspects of overall design process
- Technical knowledge regarding what particular chips do
- Expanded our knowledge on interfacing (parallel)
- Digital logic analyzers are incredibly useful (if connectors are working properly)
- Orcad Layout, Schematic
- How to solder (small components)
- Patience is a virtue and necessity
- Hot glue is your friend (lots of hot glue)
- How to kill Rabbits – burn baby burn!
- It’s okay to be awake at 4am

Version 2

- Decrease PCB size with better component arrangement
- 2MB DRAM Chip
- Eliminate PLDs
- Use most recent Rabbit development software
- Increased functionality
  - Wireless capabilities 802.11??
  - Slideshow / Random picture display
  - On screen menu

DiPFI

? Questions ?