Specification and Design of a Video Phone System

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Motivation:

Our main goal is to provide a solution beyond the basic functionality provided by a phone. In addition to implementing video and answering machine capabilities, other features are included by making use of basic hardware components already included in the system, therefore providing a competitive and feasible solution for the embedded system in the least amount of time.
Introduction

Description of the problem:

**GOALS:**

- Simplicity
- Portability / Design
- Power Consumption
- Versatility (extra func.)
- Design Time
- Easy of use
- Performance
- Expandability
- Cost
Introduction

Approach / Project Frame:

System Partitioning: Functional (controller oriented)
- Better size/performance tradeoffs, fewer objects, permits hardware/software solutions.

Phase I – Design / Implementation
- Behavior and State Machine Hardware Design
- Component Selection/Specification
- Memory Management

Phase II – Simulation
- VHDL Software Development
- FPGA Hardware Testing
Specification

- The phone should use the POTS telephone system.

- Compatibility with other videophones that follow the H.324 standard.

- Handle analog to analog communication (for compatibility with regular phones) and digital to digital communication (with other videophones).

- The phone gives users a “video” option, which allows the users to send to each other images to be viewed on the videophone’s LCD screen every 12 seconds.

- The phone can be used as a digital picture frame by displaying stored images when idle.
Specification

• The videophone has an answering machine feature that can record both voice and images.

• The phone can store up to 30 one minute messages and 5 images per message. (1 image every 12 sec)

• The phone uses MPEG compression on the voice messages that it stores. It uses JPEG compression on any images that it stores.

• The phone has four modes. *Playback*, *Playback Voice Only*, *Playback Image Only*, *Call*.
 Specification

• The phone contains the following buttons:

  * **Dialpad** - For dialing numbers
  * **Mode** - Switching between the 4 modes
  * **Play/Reverse** - Begin playing messages. If messages are already playing reverse the direction of play.
  * **Delete/Undelete** - Delete the current message after messages are done playing/cancel delete.
  * **Skip** - Skip this message, play the next or previous message according to direction of play (Forward/Backward).
  * **Stop** - Stop message playback.
  * **Rec. Announcement** - Record the announcement.
  * **Hear Announcement** - Hear the announcement
  * **Memo** - Record a memo as a voice message
  * **Video** - The phone signals another Videophone and then starts sending it images every 12 sec.
Components

- Microphone
- A/D
- Speaker
- D/A
- Memory
- Controller Unit
- Push Buttons
- Modem
- Image Compression/Decompression Unit
- Camera
- LCD Display
- Audio Compression/Decompression Unit

Figure 1 Block Diagram of the system components
Components

1- Memory: (removable)

Compact Flash Memory / and Slot: 8MB

Dimensions: 1.43" x 1.68" x .13"
Memory Capacity: Up to 96MB (upgradable)
Endurance: 300,000 cycles per logical sector
Data Retention: 10 years
Media Transfer Rate: Up to 3.5MB/sec.
Interface Transfer Rate: Up to 8MB/sec.
Average Seek Time: 10.8 ms.
Sleep/Standby Current: 0.5 mA (typical) 2.0 mA (max.)
Read/Write Current 45 mA (typical) 75 mA (max.)
## Components

### 2- Digital signal processor: (2)

<table>
<thead>
<tr>
<th>Texas Instruments</th>
<th>TMS320LC549-80</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency (MHz)</td>
<td>80 (MIPS 80)</td>
</tr>
<tr>
<td>Cycle Time (ns)</td>
<td>12.5</td>
</tr>
<tr>
<td>Data / Program Memory (Words)</td>
<td>64K/8M</td>
</tr>
<tr>
<td>RAM (Words)</td>
<td>32K</td>
</tr>
<tr>
<td>ROM (Words)</td>
<td>16K</td>
</tr>
<tr>
<td>Timers 1 (used for date and time)</td>
<td></td>
</tr>
<tr>
<td>Total Serial Ports</td>
<td>3</td>
</tr>
<tr>
<td>Boot Loader Available</td>
<td>YES</td>
</tr>
<tr>
<td>Core Supply (Volts)</td>
<td>3.3</td>
</tr>
</tbody>
</table>

The TMS320C54x DSP family consumes 0.54mW/MIPS; therefore, 80MIPS * .54mW/MIPS = 43.2 mW.
Components

3- Microphone

Panasonic Omnidirectial (directivity) Microphone:
- Sensitivity: -45 +/- 4dB
- Frequency: 20-16,000 Hz
- Power Consumption: 0.5mA
- S/N ratio: more than 58dB
- I/O: Terminal 1 Output, Ground, +Vs

4- Speaker

Shihpei speaker

<table>
<thead>
<tr>
<th>Model</th>
<th>Diameter</th>
<th>Impedance</th>
<th>Sensitivity</th>
<th>Frequency Range</th>
<th>Max Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ø</td>
<td>13.5mm</td>
<td>16~150</td>
<td>103~124dB</td>
<td>20~7kHz</td>
<td>30mW</td>
</tr>
</tbody>
</table>
## Components

### 6- LCD Display

**Sharp TFT LQ039Q2DS02**

- Display size: 14.5 [5.7] cm [ˈɪn]
- Resolution (H x V): 320 x RGB x 240
- Power Consumption: 3.9W
- Input: 6-bit Analog
- Operating Temp.: -10 to +70 °C
- Wide viewing angle: (Horizontal: 130° Vertical: 105°)
- Backlight type: 1CCFT
- Outline Dimensions (W x H x D): 44.0 x 104.6 x 13.0 mm
- Weight: 220g

### 7- LCD Controller
Components

8- Modem

Conexant V.90/K56flex/V.34/V.32bis RC56LD

- 56 kps data transfer
- Voice/Data Detection
- Full duplex speakerphone
- Power Consumption: 550mW max.
- MDP (modem data Pump) handles Multiplexing functions
- ROM sector is upgradable
Components

9- Camera

Panasonic color board camera GP-CX161 Series

- NTSC
- Uses a built-in 10-bit DSP
- Horizontal Scanning Frequency = 15.734 kHz
- Vertical Scanning Frequency = 59.94 kHz
- 30 frames per second
  Pin1: +Vs    Pin2: Gnd    Pin3: Video Out
  Pin4: Gnd    Pin5: IC SCL    Pin6: IC SDA
- Dimensions: 26mm(W) x 22 mm(H) x 13.3 mm (D)
- Power Consumption: 160mA (5V input logic)
Components

10- Controller

-The controller, the main focus of our project, will be implemented using state machines. VHDL is used for synthesis and simulation.

11- Alternative implementations considered:

a) processor

Motorola DragonBall

b) storage

StrongARM 1110

Motorola DragonBall

StrongARM 1110
Controller

- Behavior of Machine

- State Diagrams
  - Playback
  - Other operations

- Implementation and Simulation in VHDL
  (in progress)
Making a Call to another digital videophone

call mode

digit 0.9
store and display digits
talk button
modern dials number
talk button
modern dials number

hang up:
reset modem, delete #'s, clear screen
cancel button
digit 0.9

signal busy

signal ringing

signal not busy
busy

display connecting

voice chat

voice chat and display images

control data

voice chat and send images

video button

video button

voice chat and display and send images
receiving a call from another digital videophone

playback mode

modem ringing

output ringing

call mode

modem ringing

output ringing

delete oldest message and use memory space

counter = 30

find memory address for this message

display "Recording incoming call"

play announcement

talk button

beep
talk button

start recording voice

talk button
caller hangup, memory for message done

stop recording

update display and messages

These are the states from the previous diagram.

hang up

talk button

voice chat

talk button

display connecting

talk button

caller hangup

output ring?

output ring?

output ring?

output ring?

output ring?

output ring?
Recording announcements

- Record button
  - Delete previous announcement
  - Record announcement
    - Allocated memory full
    - Record button
      - Exit

Recording a Memo

- Memo button
  - Check number of messages
    - Msgs = 23
    - Msgs = 20
    - Delete first two messages, decrease msg counter
  - Memory full
    - Memo button
      - Exit
  - Turn on warning
    - Msgs = [0-22], [24-29]
    - Record memo in appropriate area of memory
Message Playback

Diagram showing the states and transitions for message playback:
- Toggle del status
- Go to next msg
- Play/Reverse
- Skip/Back
- Del/Undelete
- Play/Reverse
- Stop/End of msgs
- Repeat
- Exit

(on exit, delete marked messages)
Memory Management

a) Requirements:

- Images
  
  \[(320 \times 240 \text{ resolution}) \times (12 \text{bit/pixel}) \div (8 \text{bits/byte})\]
  
  \[= 115.2 \text{ KB per image (uncompressed)}\]

  at 20:1 JPEG compression ratio
  
  \[= 5.76 \sim 6 \text{ KB per image}\]

  5 images/message * 6 KB/image
  
  \[= 30 \text{ KB max per message}\]

- Audio

  \[(8000 \text{ samples/sec} \times 16 \text{ bits/sample}) \times (60 \text{sec}) \div (8 \text{bits/byte})\]

  \[= 960 \text{ KB per 1 min message (uncompressed)}\]

  at 6:1 MPEG compression ratio

  \[= 160 \text{ KB per 1 min}\]
Memory Management

b) Partitioning:

- 160 KB voice + 30 KB images
  = 190 KB per message
- Each page = 192 KB = 30000h Bytes
- 30 pages or 5.625 MB of RAM are for storing messages.
- There are 2.375 MB left
  - User stored pictures 96 MB (5 pages)
    160 JPEG images can be stored
  - Index Table, Variables, Compression Algorithms booted into the DSPs
  - Status Messages
Memory Management

c) Message Index Table:

- A linked list of nodes used to keep track of messages
- Kept in video unit DSP
- Original copy in Flash RAM, so if there is ever a power out loaded into DSP’s memory when DSP is booting.
- 30 nodes in the index table, one for each message page
- Node Structure

| Audio Address | Image Address | Image Flag | Delete Flag | Addr next index | Addr prev index |
Feasibility Study

- Modem:
  ~ $30.00

- Memory: 1 Compact flash 8MB
  $41.00

- Memory drive: (compact flash slot)
  ~ $20.00

- DSP: (in qt. 5000+) 19.71600 each (x2)
  $39.43

- Analog to Digital / Digital to Analog Converter: (in qt. 500+)
  $1.98

- Microphone: (in qt. 100+) $3.03 each (in 100)
  $3.03

- Speaker: (in qt. 100+) $3.16 each (in 100)
  $3.16

- Digital Camera:
  $54.00

- Color LCD Screen: (in qt. 100+)
  $91.73

- LCD Display Controller: (in qt. 100+)
  $7.00

- Box: (enclosure)
  ~ $5.00

- Engineering Design Costs: $100,000 per worker
  - 5 employees for 1 year = $500,000 / 100K units
  $5.00

- Manufacturing Costs: $1,000,000 / 100K units
  ~ $10.00

- Other Costs: discrete, RC components, buttons, ports ($0.43 each)

Total Estimated Cost per unit: $321.33
Cost including $32 (10%) profit: $353.46
Competition
(what is out there?)

• **ViewStation MP-2200-08666-001**
  
  ![ViewStation MP-2200-08666-001](image1)
  
  $8999.00
  
  Used for video conferencing, probably by firms not individuals.

• **Panasonic Victpro Video Phone System**
  
  ![Panasonic Victpro Video Phone System](image2)
  
  $1194.99

• **ECES 488 Class Projects**

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EEAP 488 – Embedded Systems

Professor: Papachristou
Competition
(what is out there?)

- **VP-41**
  
  $698.95

- **AIPTEK HyperVPhone 2000C Video Phone**
  
  $505.53

- **HYPERVPHONE 2000S VID PHONE SET TOP BOX**
  
  $326.77

Most economic standalone found.
Conclusion