New Technologies and Ergonomics in White Goods

BY

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ABSTRACT

The topic of the paper was to research and develop user interface with LCD display and touch screen for HOT, WET, and COLD white goods appliances. This kind of input and output device provides considerable flexibility in the design of user friendly graphic input/output interface for the appliance. Very dynamic and modern MENU driven user interface has been designed and developed for a new generation of high end appliances – washing machines, tumble dryers, refrigerators, freezers, ovens and cookers. This kind of input/output device may be properly priced and gives opportunity to implement a lot of additional and applicable functions for the target unit. This would not be possible with standard electro/mechanical solutions. The new device really provides the required flexibility in development of new user definable menus, icons and functions for white goods. This paper describes the basic technologies for the ergonomic user interface. It also attempts to evaluate certain experiences in design and application of this new kind of component for white goods. Special implementation of three embedded 16-bit and 8-bit microcontrollers has enabled optimal application. It is also prepared and ready for remote connection and is thereby Internet enabled.

Such application required the design and development of entirely new, specially customized graphic LCD display unit, with the resolution of 240X128 pixels, suitable for application in the production of white goods.

BACKGROUND

Large white goods consist basically of three main groups of appliances: HOT (cookers and ovens), WET (washing machines and tumble dryers) and COLD (refrigerators and freezers). Each of these groups requires a special approach to its design. A study was performed in order to show how to develop a new user interface which will be based on new technologies and will still offer appropriate appliance management, suitable for different users: traditional one and/or modern one. By the term new technologies we have in mind electronic control unit for the target appliance, using modern components: flash embedded microcontrollers, LCD type display units, sensors, triacs, SMPS type of power supplies, and so on. We decided on the implementation of sophisticated GUI (Graphic User Interface) with the touch panel LCD graphic display unit as input device. We believe that this kind of approach is able to offer best solutions not only to the users: using additional tools, optimization of target appliance may be performed by designers and developers, and even marketing people can work on it. We are going to describe our ideas to show the advantage of such LCD

with touch panel based input/output device for white goods.

The entire idea originates from a research project initiated three years ago, which included demo appliance design based on LCD display and touch panel for three major white goods groups: HOT, WET and COLD. The project was presented on the biggest European domestic appliance fair HOMETECH 2002 in Berlin. A very good response from the market encouraged us to go ahead and develop a new kind of user interface based on touch panel LCD display. Actually, LCD itself is not a new component in white goods market, but LCD with touch panel is.

Today it may be safely argued that the first step has been successful, and the first washing machine with the touch panel graphic LCD has been launched on the market. Soon, new type of appliances will join it.

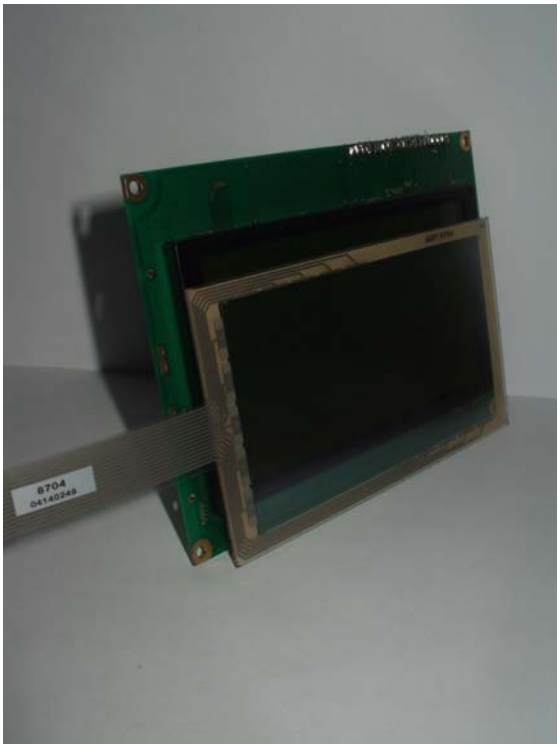
In devising the demo system we used a standard LCD display and added the touch panel with the following basic features:

- 114mm X 64mm viewing area,
- 240 X 128 pixels,
- two different colors: blue on white for WET and COLD and red for HOT application,
- a standard graphic controller with additional display drivers,
- 8 bit parallel interface,
- separated digital touch panel,
- white LED backlight.

The picture of this standard solution available on the market is shown in Figure 1. The photo shows LCD module with separated touch panel on the left, and a lot of silicon on the PCB of the LCD module on the right. The dimension of this solution is 143mm X 103mm X 12mm, which makes it too large.

This particular demo system used standard 8-bit microcontroller.

The paper contains description of experience gained in this research and development. It does not attempt to deal with ergonomics, but wants to discuss technologies and different possibilities which can be reached by this approach, and by application of additional tools enable optimization studies of user interface for appliances. We were guided trough all these activities by one basic objective: *"How to develop the appliance which will serve the customer the way he is expecting it to and at the same time use modern and advanced technology for this purpose, which will not represent a burden to the customer."* Whilst on the one side this approach discloses limited aspects of design, it also attempts to illuminate certain aspects of various design stages implying the ergonomics.



Front view: LCD screen and touch panel.

Back view: LCD controller and drivers.

Figure 1: Standard LCD with nonintegrated touch screen.

DESCRIPTION OF INTEGRATED TOUCH PANEL LCD

Our work started on the basis of previous experience gained from the demo project.

Standard solution for LCD, presented in the first chapter has a lot of weak points and disadvantages:

- non-compact appearance
- much too large mechanical frame,
- too much silicon,
- high cost.

So the first step in further activities after getting very good response from the market was of course to define, design and develop an appropriate and optimal LCD display device with an integrated/embedded touch panel. Basic requirements were:

- The component must be in one very compact piece for which the mechanical outline is defined by the designers of the appliances.
- The component must be suitable for all three basic white goods programs HOT, WET, and COLD.
- The color of the display and background is blue on white for all three different applications. A common image appearance is defined by this.
- The dimension of viewing area and the resolution

of the display are also defined by the designers of the appliance.

- The touch panel must be analogous type to allow dynamically re-definable buttons for command entry without limitations.
- Compact design is required because of mechanical outline limitation, which consequently requires a graphical controller and LCD drivers as single chip in a very large scale integration. The latest semiconductor technologies allow this approach.
- One very important requirement was operating temperature range, which is different for HOT, WET and COLD applications.
- This components must meet following basic requirements for ergonomic design of the Graphic User Interface (GUI):
    - graphic resolution 128X240 pixel,
    - dynamically redefinable entry buttons,
    - graphic display must be fast enough to display all information without unnecessary delays, and display animations.

Most of these features were marketing driven.

Due to all of these requirements, obviously no standard display device mentioned before would be appropriate, so we decided to develop the entirely new customized LCD display which would completely satisfy all these requirements. Partner for this development was searched and selected in the Far East, because their companies are able to supply advanced technology for such products for a suitable price. The photo of this LCD, which was developed and is now in production, is shown on Figure 2. Its entire mechanical and electrical outline is designed according to the specification – it is a completely custom designed component.

Following are its basic design features:

- Special frame with appropriate mechanical outline was designed and constructed in the following dimensions: 135mm X 80mm X 6mm (without installation brackets).
- Analogous touch panel is integrated and forms part of the display – it is embedded.
- Graphic controller and drivers are integrated in one circuit – single chip solution is implemented.

Figure 2. Custom designed LCD with integrated touch screen.

- LCD is connected to the main board trough flexible ribbon cable. Connection to the main microcontroller is trough 16-bit wide interface.
- LCD technology is STN blue.
- Picture resolution is in accordance with the requirements: 240X128 pixels.
- White LED back light is integrated.
- Viewing angle 12 o'clock or 6 o'clock.

Figure 3 shows the hardware structure of the LCD display.

If we do not consider the complex structure of single chip LCD graphic controller with LCD drivers – today's semiconductor technology is able to produce such component – the structure of the LCD module is simple and does not need special explanation. It simply consists of the LCD glass itself – LCD panel, glass with the touch panel, embedded graphic controller and LCD drivers, LED back light and FFC (Flexible Flat Cable) type 16-bit parallel data interface. We can call such solution an embedded LCD device with highly integrated components and touch panel. It is also not our intention to give here the descriptions of LCD technology and component driver system.

All described LCD features have important impact to ergonomic features of the unit:

- Analogous touch panel allows the design of user friendly input functional-

ities – dynamically redefinable input buttons.
- Graphic display with selected resolution allows the design of user friendly GUI type of interface.
- 16-bit wide parallel interface between microcontroller and graphic LCD controller allows fast interface.

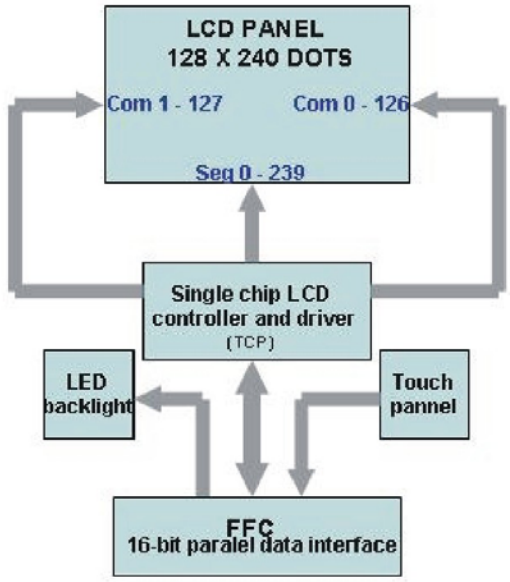


Figure 3: LCD display hardware structure.

These features assure optimal user interface design without bottlenecks.

HARDWARE IMPLEMENTATION - ELECTRONIC CONTROL UNIT

Development of electronic control unit for target appliances was carried out parallel with the LCD design and development. Description below brings general approach to hardware design with emphasis on the hardware interface for the LCD to assure optimized design in respect to ergonomics. There are of course a lot of particularities to affect the design of individual appliances, but the objective of the paper is to describe our approach and steps to the design of LCD hardware, and show how this approach and hardware structure can be important for the ergonomics of the target appliance in mind. Figure 4 shows the picture of hardware structure. Similar hard-ware structure is used for all three main types of appliances: HOT, WET and COLD.

The main 16-bit microcontroller with external 4/8 Mbit FLASH program memory functions as driver for LCD display and processes all GUI functionalities which are implemented in the target appliance. Three types of such GUI's are described in Chapter 5, while the one used here was a high speed 16-bit microcontroller. This means that the LCD display is driven trough high speed 16-bit bus. Due to relatively long FFC type (Flexible Flat Cable) of interface cable an additional EMI filtering is required. The interface to the touch panel was installed parallel via the same cable. An external 12 MHz crystal was used for internal oscillator. Bus frequency was 50 MHz. An external Real Time Clock (RTC) was added to get real time clock for the target application. An 8-bit microcontroller drives the appliance actuators and sensors directly and it is directly connected to the mains.

This consequently means that we need galvanic separation between LCD and touch panel circuitry and 8-bit circuit driving the appliance. This was made by means of optically insulated serial interface between the two microcontrollers.

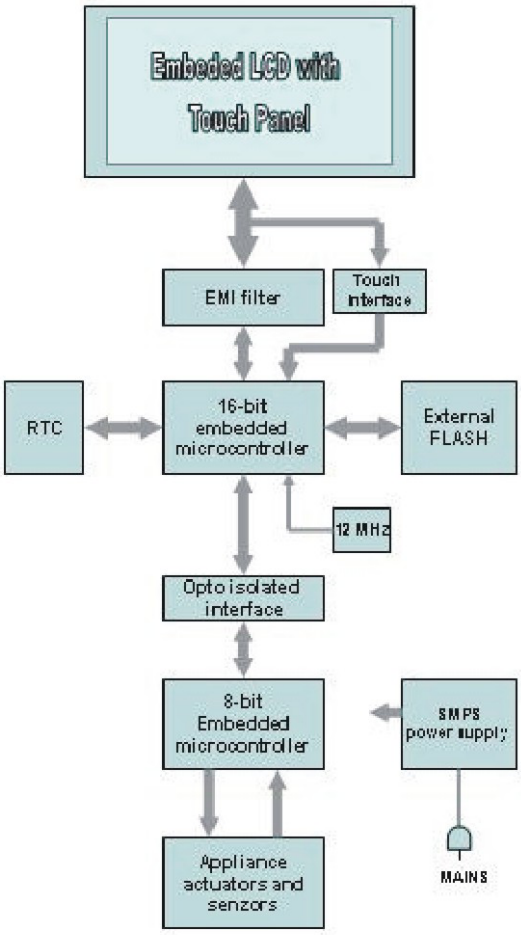


Figure 4: Hardware Structure.

To achieve ergonomic features of the design we were governed by the following basic rules in the hardware design:

- The microcontroller which serves as GUI processor and display driver is 16-bit type. Processing power of the selected processor is 25 MIPS, which is good enough to reach display refresh rate without flickering. It additionally allows such processing power to display simple animations used to improve user friendly feature of the GUI. *We got optimal processing power for optimal user friendly GUI.*
- Parallel interface between 16-bit microcontrollers is 16-bit wide. *With this feature we get maximum possible data transmission speed to LCD.*
- Internal bus speed of the microcontroller is 50 MHz which additionally assures enough MIPS for this application.
- FLASH program memory is at least 4 to 8 Mbit. This gives enough memory size and enough space for complex text oriented MENU system with many languages (34 different languages have been integrated for European market requirements). All texts, icons pictures, and animations have direct random access, and this allows fast display response without flickering.

All described hardware features are very important, and allow GUI design in the selected resolution and display size (240 X 128 pixels) practically without limitation. User cannot see any side effects on the display.

SOFTWARE IMPLEMENTATION

Software design of course corresponds to the hardware structure and application itself. As the hardware consists of two main micros, one 16-bit which serves as GUI processor and an 8-bit which serves as appliance processor, the software is structured from two main processing/operating systems communicating trough the serial hardware connection and appropriate software protocol, and with a synchronization mechanism implemented between the two systems. Actually a stream of commands and status reports is used for communication between these two systems. Of course the appliance processor works as slave processor. There is an additional third microcontroller (also slave one) with the electronics in the washing machine for the motor drive, but we have no intention to describe the appliance driving mechanism.

Software structure is shown on Figure 5.

Software organization can be displayed in layer structure. The main parts of two subsystems are two operating systems. One part is running on main 16-bit microcontroller which serves as appliance main management sys-tem as a real time operating sys-tem and the other part is running on an 8-bit microcontroller and serves as appliance kernel and a driving mechanism for the appliance.

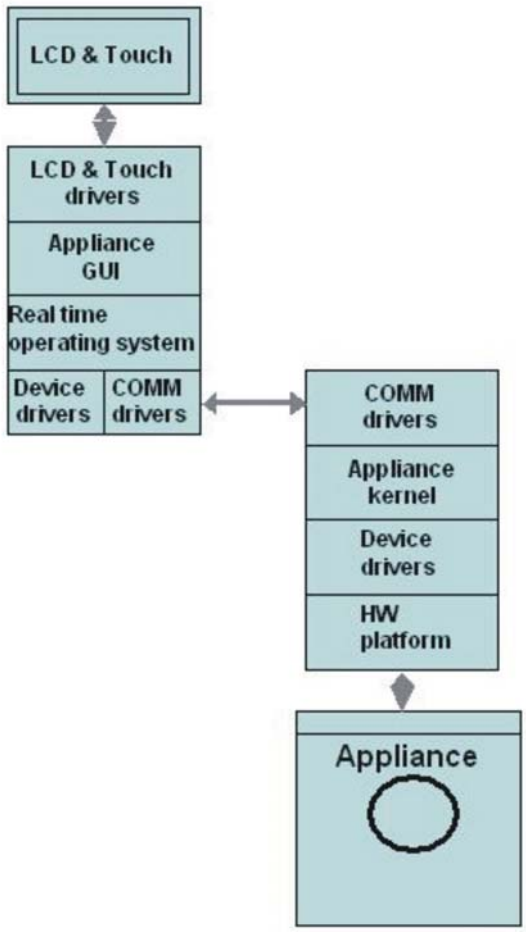


Figure 5: Software structure.

Such layer structure of the software for our LCD based system brings flexibility in soft-ware maintenance and further development. We have implemented a special layer Appliance GUI (see Figure 5), handling the LCD management system – a MENU type of a user interface. This brings a lot of flexibility in designing the ergonomics of the target system. We can change only one part of the Software – Appliance GUI and we get practically new user interface.

All hardware and other software parts remain the same, and we can practically get a new ap-

pliance. *Ergonomics of the appliance can be optimized and improved during the appliance exploitation. Improvements can be based on feedback from the market.*

DESCRIPTION OF GUI

We will shortly describe and show real photos of three different possible approaches in GUI design for three main groups of target appliances

- WET (washing machines and dryers)
- COLD (refrigerators, freezers, and combos)
- HOT (ovens and cookers).

Following are three different menu types:

- Text oriented GUI - WET.
- Icons oriented GUI - COLD.
- Mixed GUI - HOT.

W show also the real photos of this menus.

Text oriented GUI

First example shows text oriented GUI on Figure 6, displaying basic menu of washing machines. We can select:

- Basic programs
- My programs
- Wizard
- Tools.

These functions are selected by pressing the field with the relevant text. On the right side there are buttons for additional selection.

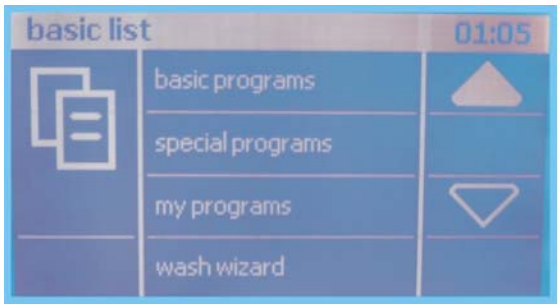


Figure 6: Menu oriented GUI

Of course this is not the place to describe user interface for the washing machine, so here are just three basic possibilities:

- Conventional users can start washing in three steps by pressing the sequence: *"Basic programs > White > START"*.
- The user with not much knowledge about washing can use for example the following sequence: Wash *"Wizard > White > Normally Soiled"*.
- And the advanced user can use *My Programs, Additional programs, Tools*, or other implemented functions, and play with the appliance, setting it up according to individual desires.

Icons oriented GUI

Figure 7 shows other type of GUI – icons oriented. This menu displays mainly icons. Field with the icon is at the same time a command button. By pressing the appropriate field the user selects

corresponding function. Text can of course be in different languages, as indicated on Figure 7: the word *hladilnik* means *refrigerator* in Slovenian language. The user can of course select the desired language by applying proper function.

Figure 7: Icons oriented GUI

Mixed type GUI

Figure 8: Mixed GUI

Figure 8 shows third type of GUI – mixed type. Both sides of the display are occupied with icons and buttons. Display contents also show appropriate text to go with the icons.

The above three examples show that this technology is really flexible and allows many possibilities to design an advanced, modern and user friendly user interface for a variety of user tastes.

We are able to actually design intelligent and adaptable GUI with all modern display structures found for example in PC windows environment:

- Buttons,
- Checkboxes,
- Radio buttons,
- Labels,
- Memos,
- Scrollbars,
- List boxes,

and of course many others, even such of our own design.

It is obvious that such adaptable user interface is very flexible and can be used in many different ways.

Different approaches in user interface as GUI can be used in the design stage.

CONNECTIVITY AND ERGONOMICS

Connectivity in white goods is becoming more and more attractive for the market. Future appliances will become a terminal in the worldwide system of services which will be brought to the appliance trough the global service network. Appliances functioning as terminals of such global network will become more and more sophisticated with a lot of additional features. Such appliance is Internet enabled. The use of such appliance will be very complex and will require trained or at least very open-minded user. For a modern user such sophisticated appliance will not be a burden. It will be very important that such unit has proper and adequate

possibility to develop a friendly user interface with easy access to many different functions. LCD with touch screen is certainly a suitable device for such purpose. For a home system with connected appliances we certainly need user friendly interface. Ergonomics is important approach in designing such system. The user will be able to access such appliance very easily trough the sophisticated and friendly local user interface and through the remote application which running on some sort of a home gateway, and trough many different input devices: monitor, PDA, mobile phone, CTV, etc.

CONCLUSION

LCD with a touch panel is not a new input/output component. It has already been in use in many units: measuring equipment, notepads, PC monitors and others. But with the described implementation it is new in the area of white goods. We think that described features of our LCD with touch panel and implemented solutions can have important impact to ergonomic features of the appliances and to its future design. Below is a summary of these features.

- Analogous touch panel allows the design of user friendly input functionalities – dynamically redefinable input buttons.
- Graphic display with selected resolution allows the design of user friendly GUI type of interface.
- 16-bit wide parallel interface between microcontroller and graphic LCD controller allows fast interface.
- The microcontroller which serves as GUI processor and display driver is 16-bit type and with 50 MHz bus speed. Processing power of selected processor is 25 MIPS, which is good enough to obtain display refresh rate without flickering. W*e get optimal processing power for optimal user friendly GUI.*
- FLASH program memory is at least 4 to 8 Mbit. This gives enough memory size and enough space for a complex text oriented MENU system with many languages.
- The layer structure of the software for our LCD based system brings flexibility in software maintenance and further development and brings a lot of flexibility in designing the ergonomics of the target system.

We believe that there is a future in the described approach and with the described LCD component. We are convinced that development of such component for white goods will go ahead in the future.

Nove tehnologije in ergonomija v beli tehniki

POVZETEK ČLANKA

V članku opisujemo raziskavo in razvoj uporabniškega vmesnika zasnovanega na osnovi grafičnega LCD prikazovalnika, ki je občutljiv na dotik in primeren za aplikacijo v aparatih bele tehnike. Te vrste vhodno/izhodna naprava nudi veliko fleksibilnosti pri načrtovanju uporabniško prijaznega grafičnega vmesnika za upravljanje aparatov. Oblikovali in razvili smo dinamičen in sodoben uporabniški vmesnik za novo generacijo aparatov najvišje kakovosti – pralne stroje, sušilnike perila, hladilnike, zamrzovalnike, pečice in kuhališča. Ta vhodno/izhodna naprava je cenovno primerna in nudi možnosti za implementacijo množice dodatnih in uporabnih funkcij za ciljni sistem, kar nebi bilo mogoče z uporabo običajnega elektro-mehanskega upravljanja. Ta nova naprava v resnici nudi zahtevano fleksibilnost pri razvoju menujskega upravljanja v različnih oblikah za belo tehniko. V tem članku smo opisali osnovne tehnološke rešitve, ki so primerne za implementacijo ergonomskega uporabniškega vmesnika. Hkrati smo poizkušali povzeti nekaj izkušenj pri načrtovanju in aplikaciji te komponente nove vrste za belo tehniko. Posebna implementacija treh 16-bitnih mikrokrmilnikov z vdelanimi funkcijami omogoča optimalno izvedbo aplikacije. Aplikacija je tudi pripravljena za povezavo na daljavo – naprava je lahko dosegljiva preko Interneta.

Za to aplikacijo smo morali oblikovati popolnoma nov in prirejen grafični LCD prikazovalnik z resolucijo 240X128 grafičnih točk, ki je primerna za aplikacijo v beli tehniki.