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Reconfigurable Automotive Display System

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Abstract: A reconfigurable automotive display system was developed for the purpose of displaying multifunctional information in a space efficient area. The system features an 80 × 16 graphic dot matrix Fluorescent Indicator Panel and an advanced 8-bit microcontroller.

The performance of the system electronics was greatly improved due to the real-time processing capabilities of the microcontroller. By using the macroservice data transfer feature of the microcontroller, the CPU loading for the real-time task of refreshing the display was greatly reduced. The reduced CPU loading allows processing time for other system functions such as scanning the keypad inputs and servicing the J1708 serial communications interface.

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ABSTRACT

A reconfigurable automotive display system was developed for the purpose of displaying multifunctional information in a space efficient area. The system features an 80 x 16 graphic dot matrix Fluorescent Indicator Panel and an advanced 8-bit microcontroller.

The performance of the system electronics was greatly improved due to the real-time processing capabilities of the microcontroller. By using the macroservice data transfer feature of the microcontroller, the CPU loading for the real-time task of refreshing the display was greatly reduced. The reduced CPU loading allows processing time for other system functions such as scanning the keypad inputs and servicing the J1708 serial communications interface.

INTRODUCTION

In the past, automotive displays have primarily consisted of fixed segment patterns such as seven segment, british flag, and 5x7 dot matrix types [1,2]. Recently, however, full dot matrix configurations have appeared allowing multifunctional information to be displayed in a space efficient area [3,4,5]. Full dot matrix display systems provide the flexibility to display text messages of different sizes, locations, and font types as well as graphic symbols within a common hardware design. This means that several fixed segment display systems can be replaced with a single dot matrix display system to reduce cost and packaging space. Furthermore, complexity and development time can be reduced by using a common hardware design for multiple applications.

The high pixel count of the dot matrix display, however, can necessitate the use of a dedicated microcontroller or display controller to refresh the display [3,4,6]. Thus, a second microcontroller is required to perform the application tasks such serial communications, design that implements a single microcontroller to perform display refreshing, keypad scanning, and J1708 serial communications. The elimination of the display controller device is made possible by the reduced CPU loading that the macroservice data transfer feature of the microcontroller provides. The real-time task of refreshing the display is first discussed using a conventional CPU and then using a CPU incorporating macroservice capability to illustrate this conclusion. Also, the incorporation of an additional real-time task, SAE J1708 communications, is discussed.

SYSTEM IMPLEMENTATION

A block diagram of the reconfigurable display system that was developed is shown in Figure 1. The system consists of the dot matrix display, the display system electronics, the keypad, and a power supply.

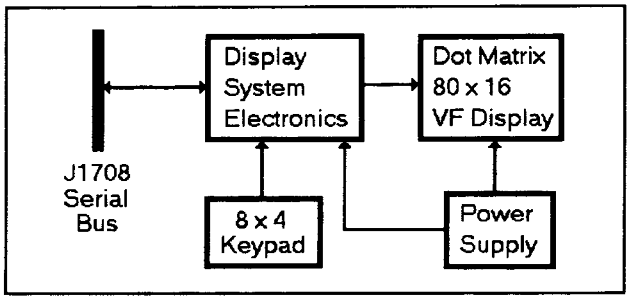

Figure 1 - Reconfigurable Display System Diagram

DOT MATRIX DISPLAY - The dot matrix display used in this system is a vacuum fluorescent type which is also know as a Fluorescent Indicator Panel (FIP). FIP's are the technology of choice in automotive applications because of their high quality, high brightness, and high reliability characteristics [2,7,8]. The FIP is composed of an 80 x 16 matrix of pixels in a 9.85 mm high by 50.5 mm long graphics area [9]. This configuration provides different text sizes and graphics symbols that are possible with this display are illustrated in Appendix I.

The FIP was designed such that a quadruplex anode matrix drive (quadmatrix) technique can be employed [10,11]. The quadmatrix drive provides the best display quality by preventing cross talk between adjacent grid phosphors (also called "ghosting").

DISPLAY SYSTEM ELECTRONICS - The display system electronics can be divided into four parts; the microcontroller, anode driver, grid driver, and J1708 transceiver as shown in Figure 2.

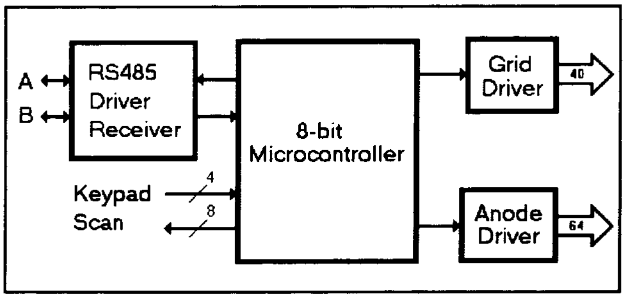

Figure 2 - Reconfigurable Display System Electronics Diagram

Microcontroller - A high performance 8-bit microcontroller was used in this design to process all display, serial communications, and keypad functions. The use of a dot matrix FIP requires the CPU to transfer a large amount of data to the display drivers to perform the display refresh task. Thus, a microcontroller with a hardware data transfer architecture [12,13,14,15] was desired. The 78K2 microcontroller [12] was chosen because it implements an architecture with a macroservice logic unit and a low cost 8-bit CPU. The macroservice logic unit provides automatic data transfers between peripheral registers and memory without CPU intervention. This architecture will be discussed in more detail later and is responsible for performing the display refresh task with low CPU overhead. Other features of the microcontroller include 16K ROM, 512 RAM, 8 channel A/D, UART, ect.

Display Anode Driver - Due to the quadmatrix construction of the FIP, every fourth column of pixels is wired in parallel across the sixteen rows of anode pixels resulting in 64 anode terminations. A 64 bit high voltage driver was used in this design as the anode driving device [16]. The microcontroller interfaces to the anode driver by means of a clocked serial interface (CSI). The CSI data is clocked into an input shift register on the anode driver where it can then be latched to the output buffers when signaled.

Display Grid Driver - The quadmatrix FIP construction also places a grid over every two columns of anode pixels for a total of 40 grids. A 40 bit high voltage driver was used as the grid driving device [17]. The microcontroller interfaces to this driver using general purpose output port pins.

J1708 Interface - This system was designed to obtain information over a SAE J1708 type serial communications data link [18,19]. A RS-485 driver/receiver was used as the physical layer device [20]. The microcontroller interfaces to this device using the UART Tx and Rx pins. An IBM PC was used to simulate an automotive multiplex network by exchanging message information with the reconfigurable display system over the J1708 interface.

Component Packaging- The FIP, microcontroller, and display drivers are all packaged as surface mount devices. This results in a very compact circuit board design to help conserve the instrument panel area that it occupies. The FIP can also be modified such that the drivers are die bonded to the internal glass substrate. This can further maximize the packaging density and also reduce the number of interconnects to the FIP resulting in a much lower pin count and higher reliability. This technology is referred to as chip-in-glass (CIG) [10,21].

Display Memory Implementation - The microcontroller ROM was used to store the different display templets in bitmapped form [22]. The bitmap format stores each pixel state on the display as a bit in the microcontroller memory. The 80 x 16 FIP configuration results in 160 bytes per bitmap. The structure of a bitmap in the microcontroller memory is shown in Figure 3.

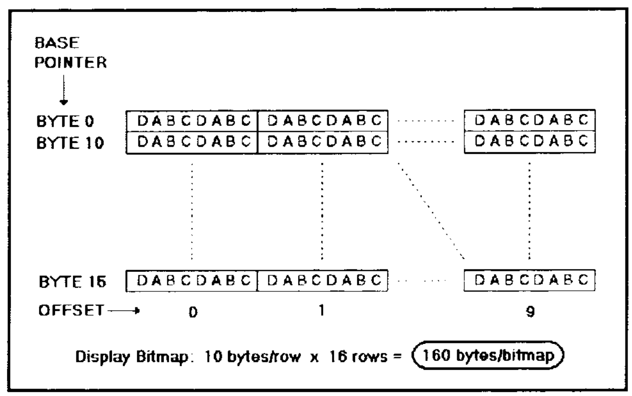

Figure 3 - Display Memory Structure

To update the display with a new message, the appropriate bitmap templet is copied from ROM to display RAM. This templet provides a generic display pattern for the type of message to be displayed (radio, trip computer, ect.). The appropriate RAM locations are then overwritten with the specific parameter information (radio station, trip miles, ect.) to build the final display pattern in RAM.

DISPLAY REFRESH TASK

The display refresh rate was chosen to be 125 Hz so that flickering would not be detectable by the human eye [4]. The 125 Hz refresh rate equates into an 8 millisecond refresh period. As shown in Figure 4, the refresh period is divided into 40 grids to produce the 200 microsecond grid periods. The 40 grid periods must each be updated

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