Defence Science Journal, Vol. 63, No. 2, March 2013, pp. 153-156, DOI: 10.14429/dsj.63.4257

RESEARCH PAPER

Stroke Symbol Generation Software for Fighter Aircraft

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ABSTRACT

This paper gives an overview of the stroke symbol generation software developed by Hindustan Aeronautics Limited for fighter aircraft. This paper covers the working principle of head-up-display, overview of target hardware on which the developed software has been integrated and tested, software architecture, hardware software interfaces and design details of stroke symbol generation software. The paper also covers the issues related to stroke symbol quality which were encountered by the design team and the details about how the issues were resolved during integration and test phase.

Keywords: Head-up-display, pilot display unit, mission computer, main processor module, symbol generator module, real time operating system

1. INTRODUCTION

The head-up-display (HUD) system is a vital LRU for the military and commercial aircraft. It enhances the Pilot's situational awareness by providing navigational, weapon aiming and release data along with target information on the Pilot's forward field of view.

A typical HUD comprises of the following functional elements[1]

- Optics assembly: A set of optical elements comprising the final collimating lens for the collimating HUD and the fold mirror with coatings and filters.
- Combiner: A pair of optically flat parallel glass plates for the collimating HUD with semi-reflective coatings turned to the peak spectral emission of the CRT phosphor.
- CRT: A high-brightness, high resolution CRT whose electron beam is usually electro-statically focused and electro-magnetically deflected.
- X and Y deflection amplifiers: Usually dual mode high bandwidth, high-precession amplifiers that source current onto the CRT *X* and *Y* magnetic deflection yokes.
- Ramp generator: This strip synchronization pulses from the sensor video and generates the raster scan wave form to align correctly/harmonize the sensor video with the outside world view.
- Video amplifiers: Usually dual mode amplifiers to modulate the CRT beam current by adjusting the CRT cathode bias with respect to grid electrode.
- High voltage power supply: The high voltage power supply sources the high voltages required by the CRT, the final anode potential (around 18 kV), the focus potential (2-4 kV)) and the grid potential (200 V).

The Fig. 1 shows the functional block diagram of HUD.

2. HARDWARE OVERVIEW

The stroke symbol generation software developed by MCSRDC, HAL has been integrated and tested on open

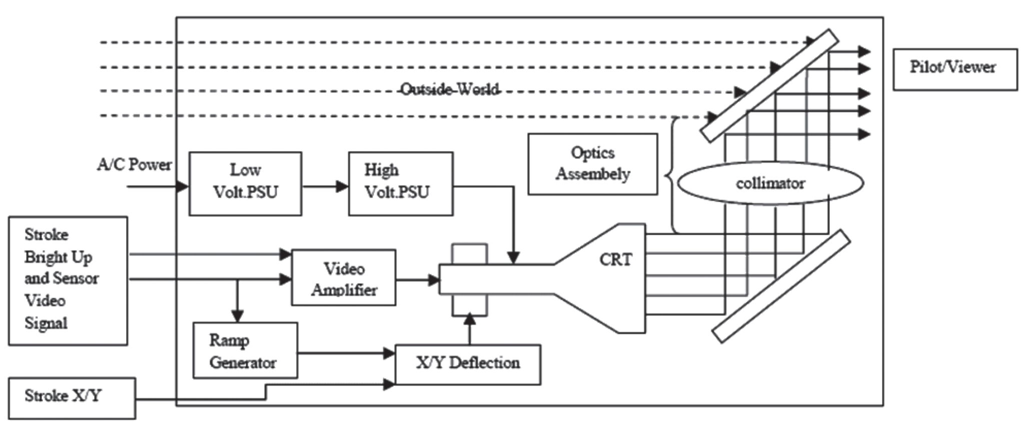

Figure 1. Functional block diagram of hud.

Received 11 September 2012, revised 08 February 2013, online published 23 March 2013

system architecture mission computer (OSAMC) platform. The OSAMC design is based on PowerPC architecture. The OSAMC consists of four intelligent modules, I/O modules and VITA46 Back plane.

One of the intelligent modules of OSAMC is the symbol generator module (SGM) which is responsible for generating stroke symbols for display on HUD. Hardware configuration of SGM module is shown in Fig 2. The SGM consists of a carrier card and a processor mezzanine card (PMC). The carrier card consists of PowerPC based processor, DDRSDRAM, FLASH memory and PCI express switch. The stroke PMC consists of four dual port RAMs (DPRAM-1 and DPRAM -2 for Front HUD, DPRAM-3 and DPRAM-4 for rear HUD), FPGA, DAC and operational amplifiers.

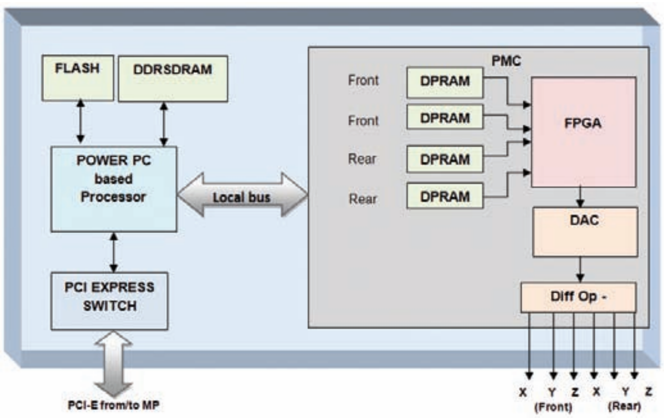

Figure 2. Hardware configuration of symbol generator module.

The SGM carrier card receives the stroke symbol control data through the PCI Express switch configured as non transparent bridge (NTB). The SGM carrier card generates the stroke symbol data based on symbol control data received through the PCI Express switch and writes the stroke symbol data in the DPRAM of stroke PMC through local bus. The data sharing between carrier card and PMC is through DPRAM. The FPGA in stroke PMC reads the stroke symbol data stored in DPRAM and drives the DAC for generating the HUD deflection signals.

3. SOFTWARE ARCHITECTURE AND HARDWARE-SOFTWARE INTERFACES

The stroke symbol generation software for HUD has been designed and developed in-house at MCSRDC, HAL. The stroke symbol generation software design is as per the concept of layered architecture[3] keeping in mind the complexity and portability aspects. There are two parts of stroke symbol generation software. One part resides in the main processor (MP) module which receives inputs from onboard sensors and LRUs and provides the symbol control data (display state, symbol position, HUD mode selected by pilot, navigation/ weapon parameters required for drawing the symbol). The other part of the software resides in symbol generation module (SGM) which generates the symbol as per the symbol control data received from MP module and stores the symbol data in dual port RAM (DPRAM) for display on pilot display unit (PDU) of HUD as shown in Fig 3. The symbol control data is transferred from MP module to SGM module using VITA46 backplane.

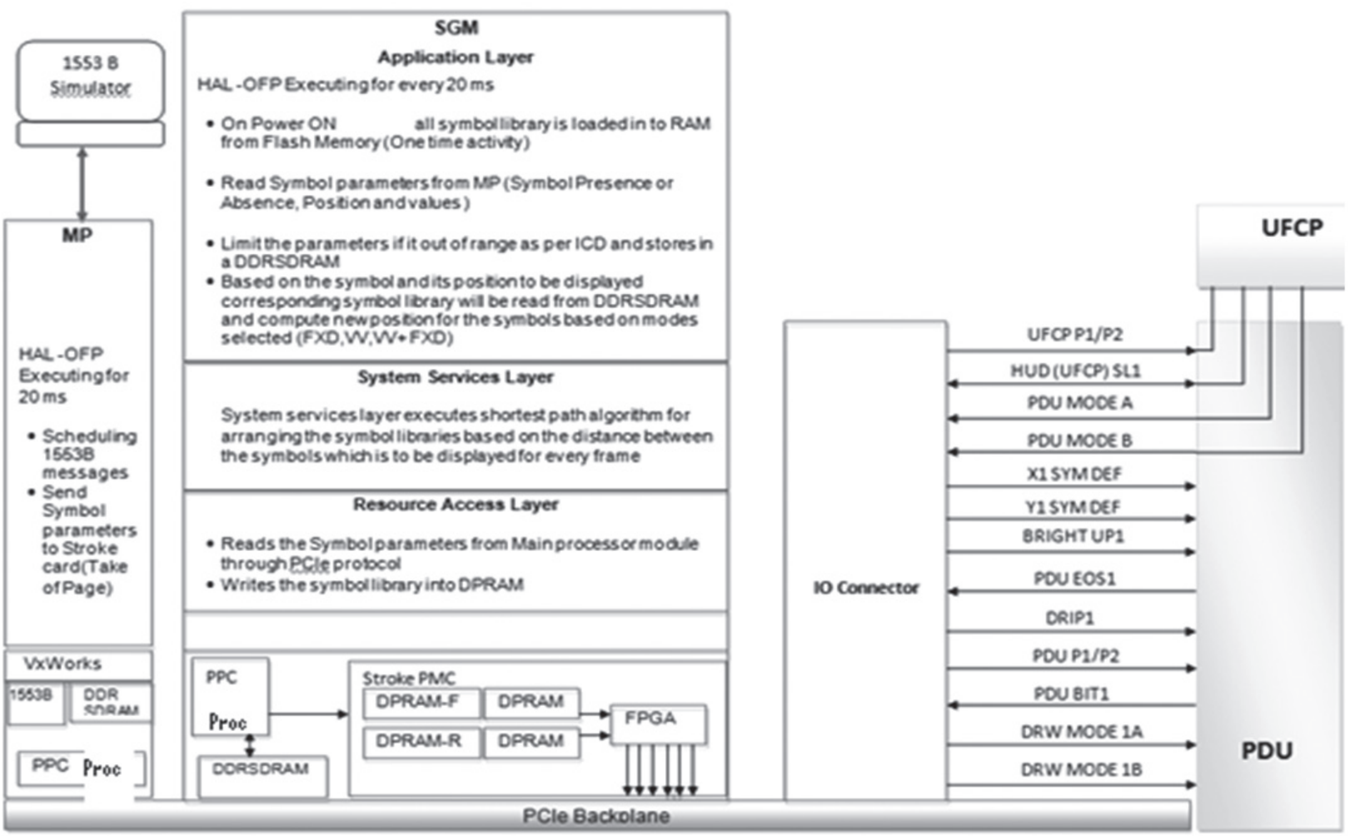

Figure 3. S/W architecture and H/W – S/W interfaces for symbol generation software.

4. SOFTWARE DESIGN

The software generates the stroke symbols with the help of symbol parameters received from MP Module and by using the basic primitives like line, arc etc. The software is responsible for generating and displaying navigation, weapon, and radar related symbols on HUD-based on system modes and pilot's selections.

4.1 Generation of Symbol Library

The coordinates for each symbol are generated using a tool which is developed in Microsoft Visual C++. The tool uses line generation and arc generation algorithms which enables drawing of primitive shapes like line and arc. The outputs from the tool are symbols coordinates in pixel position referenced to CTFOV of HUD as shown in Fig. 4. The generated coordinates from the tool are stored in the form of a library and is a part of symbol generation software.

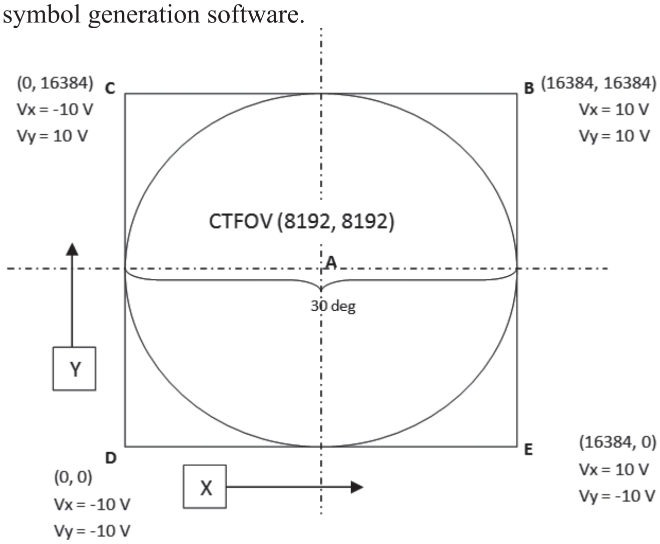

Figure 4. Coordinate mapping on hud.

4.2 Generation of Final Symbol Data for Symbol Display on HUD

Stroke symbol generation software receives symbol control data from main processor (MP), fetches the corresponding symbol data from symbol library and employs various in house designed and developed algorithms such as translation, rotation and shortest path on symbol data and generates the final symbol data (x, y and z) as output where x and y are coordinates in terms of pixel position and z is the command (Pen-Up and Pen-Down) for controlling the movement of CRT beam of HUD.

The final symbol coordinates (x, y and z) are stored in DPRAM. The FPGA reads the symbol data stored in DPRAM and drives the DAC to generate the corresponding X, Y, Z deflection voltage which finally goes to HUD[2].

4.3 Mapping of Symbol Coordinates with HUD Field of View

HUD total field of view is 30 deg circular. HUD X-Y coordinate axis is defined such that its origin lies at the lower left corner. Range of voltage along x and y axis is - 10 V to + 10 V. As 16 bit DAC card is used this can generate 16384 different voltage combinations. Hence, the chosen HUD X-Y space is divided into 16384 pixel points both in X and Y direction as shown in Fig 4.

The mapping between symbol coordinates as received from MP module and their corresponding X, Y, Z deflection voltages is achieved by deriving mathematical equation.

4.4 Conversion of Symbol Coordinate (mill radians to pixels)

Pixels per degree on each axis = 16384/30 = 546.133333 Pixels

1 degree corresponds to 17.453292 mill radians (mR)

$$1 \text{ mR} = \frac{546.133333}{17.453292} \text{ Pixels} = 31.291135 \text{ pixels} \quad (1)$$

With the help of above equation, each symbol coordinates can be converted into corresponding pixel position on HUD.

4.5 Mapping of Symbol Coordinate with HUD FOV (pixels to voltage deflections)

Voltage per deg for the HUD TFOV is = 20/30 V = 0.6666667 V (2)

$$1 \text{ mR} = \frac{0.6666667}{17.453292} \text{ V} = 0.03819718938 \text{ V} \quad (3)$$

From Eqn. (1)

31.291135 pixel = 0.03819718938 V

$$1 \text{ pixel represents} = \frac{0.03819718938}{31.291135} \text{ V} = 0.0012207032244\text{V} \quad (4)$$

With the help of above equation, each symbol coordinates (in pixels) can be converted into corresponding voltage deflections on HUD.

From the above Eqns (1) to (4) a given symbol can be drawn accurately on the required location on HUD.

4.6 Synchronization between OSAMC and HUD

The FPGA of stroke PMC handles command and control (PDU mode, drawing mode, drawing in progress (DRIP), end of slew (EOS), Front/Rear port, etc) between OSAMC and HUD. One cycle of HUD operation takes 20 ms. Out of this, HUD takes 16 ms to draw the symbol and remaining 4 ms to perform the built-in-test (BIT) operation.

The synchronization between OSAMC and HUD for displaying stroke symbol is implemented in FPGA through DRIP and EOS signals. When EOS signal is received to FPGA from HUD, FPGA reads the stroke symbol data from DPRAM and drives the DAC to generate X, Y, Z deflection voltages for HUD and also generates DRIP signal (HIGH) for 16 ms. In the next 4 ms, FPGA generates DRIP signal (LOW) to indicate to HUD that drawing is not in progress. This cycle gets repeated every 20 ms by FPGA. This FPGA operation of stroke PMC synchronizes the stroke symbol generation operation by OSAMC and stroke symbol drawing operation by HUD to avoid the lag between stroke symbol generation operation and stroke symbol display operation. The overall symbol drawing schematic is shown in Fig. 5.

5. OUTPUT OF STROKE SYMBOL GENERATION SOFTWARE

The Fig. 6 shows the typical HUD page generated by Stroke symbol generation software.

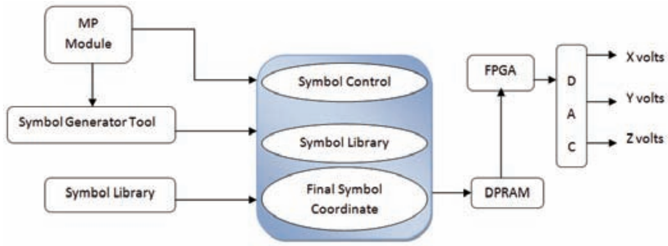

Figure 5. Symbol drawing process.

Figure 6. Typical stroke symbols displayed on hud.

6. MAJOR ISSUES PERTAINING TO SYMBOL QUALITY AND THEIR RESOLUTION

6.1 Traces between the Symbols

Traces were observed between the symbols when displayed on HUD. Several tests were conducted and analysis was carried out. It has been observed that when the electron beam movement/jump from one symbol to another symbol is more than a degree i.e. end point of one symbol and start point of the next symbol is more than a degree then the traces are appearing. To avoid the traces, Pen-up and Pen-down logic (moving the electron beam with predefined steps without Bright–up condition) were implemented in the design, when the distance between the two symbols is greater than one degree.

6.2 Drawing Objects

While drawing objects such as circle, the circle was not getting closed completely. There was a little gap visible where the circle was getting closed. To rectify this problem, several tests were conducted and analysis was carried out. After analysis, it was found that after drawing the circle, the electron gun moved to next position for drawing the symbol. Due to sudden movement or jump in the electron beam, there was a little gap visible between the end point and the start point of the circle. To avoid this, wait state has been introduced at the end point of the circle with bright–up condition to steady the beam before moving to the next symbol position.

7. CONCLUSION

In-house development of stroke symbol generation software has resulted in expertise development in MCSRDC, HAL in the area of system software design and development for head up display system. The developed software has been successfully integrated and tested on target platform. The software can be used for various aircraft upgrade programs.

REFERENCES

1. System Specification for HUD controls and display. Mission and Combat Systems R&D Center, Hindustan Aeronautics Limited. Document No. MCSRDC/DARIN-III/SPEC/001, Rev. 01, Oct 2011, pp.7-119.
2. Interface control document for 967 HUD System for Jaguar. Electro Optics Industries Limited, Document No.EI4510-0000-00, April 2000. pp.1-55,
3. MCSRDC software development life cycle process. Mission & Combat Systems R&D Center, Hindustan Aeronautics Limited, Document No. MCSRDC/SPAG/SDLC/01/00, Rev. 00, Dec 2010. pp.15-29.
4. Aircraft display symbology. Department of Defense USA, MIL-STD-1787B Standard, April 1996, pp. 5-39.
5. Software requirements for stroke driver for OSAMC. HAL Edgewood Technology Limited, Document No. HETL/OSAMC/SRD/Stroke/111, Revision 00, pp. 6-11 Mar 2011.
6. Software design document for stroke driver for OSAMC. HAL Edgewood Technology Limited, Document No. HETL/OSAMC/SDD/STROKE/112, Mar 2011, pp.14-110.
7. Jukes, Malcom. Aircraft display systems. *In* Progress in Aeronautics, American Institute of Aeronautics and Astronautics, 2004, **204**, pp.124-151.

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