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Study on Design of MTP Module and Performance Evaluation

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1. Introduction

MTP(Maintenance Test Panel) in nuclear power centers is composed of PC-based SBC(Single Board Computer) system. And software is based on commercial OS(Operating System) or Real-time OS. Therefore, Graphic Library or GUI(Graphic User Interface) Tool is being used for GUI. There are some difficulties in V&V(Verification & Validation) for hardware and software like those systems so that it couldn't be applied to safety systems.

On this study, module configuration able to be applied to safety system was realized and embedded module configuration's hardware platform was developed, out of conventional MTP design concept. The results of firmware & applied software on the basis of Non-OS were introduced. Finally, for this module, GUI processing capability and algorithm execution capability were verified.

2. Design of MTP module

2.1. Hardware structure of MTP module

MTP module like PC based system wasn't applied but it was designed as embedded system. Common type CPU of x86 core at SBC wasn't used and the specialized module which has only necessary functions of maintenance test panel was developed.

For performance of microprocessor applied to this module, ARM9 Core which is capable of 200MIPS instruction at 180MHz operation Clock, considering graphic processing capability for 15” TFT-LCD Panel was selected. And on behalf of graphic processing card used for GUI screen at SBC, CRT and TFT-LCD panel are able to interface with TFT-LCD driving and dual driving of TFT-LCD and CRT respectively. And it makes it possible for the transferred isolated data at safety system to do optic communication and interface with digital devices after digital I/O expansion. The following figure 1 shows internal block diagram of MTP module.

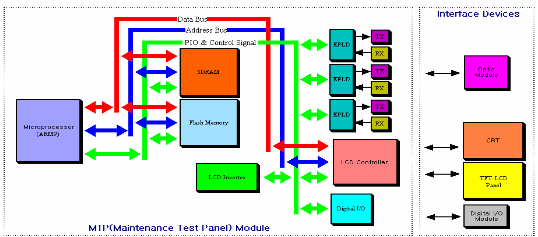

Figure 1. Block diagram of MTP module

2.2. Structure firmware and application software

Structure of MTP module software largely consists of ROTS based software and Non-OS based software. Currently, at figure 2, two-type software structure was applied and realized and it was divided in order to apply according to non-safety class or safety class of the plant.

Especially for software directly related to safety class, V&V is so important that it’s required to develop on a basis of Non-OS. Code for GUI processing was made by Samchang and applied because GUI Library and Embedded GUI Tool were not used here. In addition, most of the software parts except GUI processing parts were maximally made by assembler for firmware, H/W Initialization, and device driver. In order to take advantages while doing V&V, the software was applied.

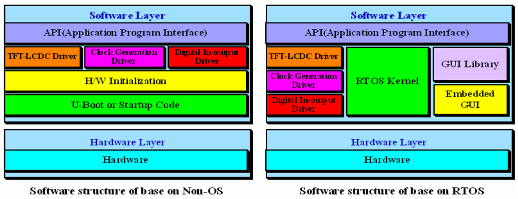

Figure 2. Software structure of MTP module

3. Performance evaluation

3.1. GUI processing evaluation

Evaluation of GUI processing is based on MTP specifications which have 15” panel, 800x600 resolution, and 16 Bit color depth at Non-OS base. For conversion speed of GUI background screen including animation operation, the results from response time at commercial PC and response time at MTP module were measured, compared and then evaluated. For Images from experiment, 4 of MTP screen design images and 20 frame images of animation were executed and it’s operating time was processed by MTP module. At the end, returning time of all results was measured by debug port. PC couldn’t be used for graphic card by the method of benchmarking so that time value of real time clock was returned and measured while pixel data on screen was being finally processed. At figure 3, four background images were from design screen of real MTP and the screen was converted by inputting key values through digital I/O. And animation screen was applied by the same method like above. Figure 4 shows responses of these experiments. It represents that processing time is increasing entirely because image data which will be processed at the beginning takes a long time to load on image buffer memory of LCDC. Actually there is the difference of experiment and response time comparing to high level PC but it proved that response performance in comparison with processing rate including price at embedded system is superior.

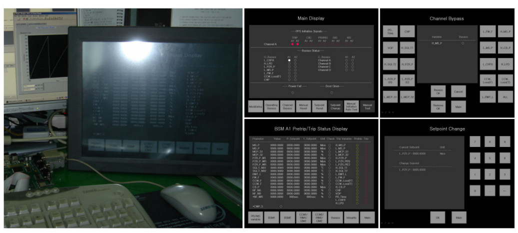

Figure 3. Processing of GUI background image

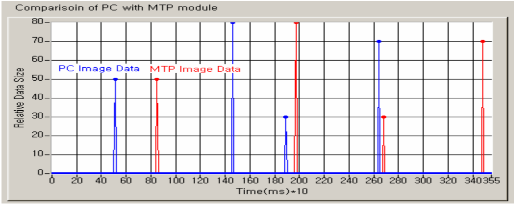

Figure 4. Time of image data processing

3.2. Complex control evaluation

Even though LCD controller processes images at MTP module, GUI processing provides high load to microprocessor. Therefore, more loads were forcibly given to module and then processing capability was verified after composing PID controller of measurement and control. Experiment was compared and verified on a basis of ROTS and Non-OS respectively.

Figure 5 shows block diagram of PID controller. After executing PID control algorithm at MTP module, count values for PWM signal were printed out and then data was transferred by UART communication. And at virtual plant of PC, waves are displayed through converting form digital to analog. Finally, Magnitude of error happened here feeds back into MTP module.

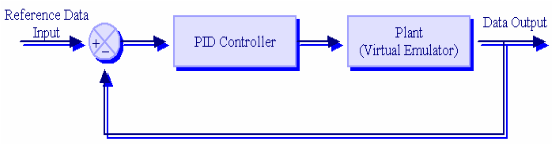

Figure 5. Block diagram of PID feedback system

Transfer function of PID Controller is shown at formula (1) and Plant function is shown at formula (2).

$$H(s) = K_p(1 + \frac{1}{T_i}s + T_d s) \qquad (1)$$

$$G(s) = \frac{1}{s^3 + 3s^2 + 2s} \qquad (2)$$

Transfer function N(s) of opened loop system including P controller is shown at formula (3) and Transfer function M(s) of closed loop system is shown at formula

$$N(s) = H(s)G(s) = K_p \times \frac{1}{s^3 + 3s^2 + 2s} \qquad (3)$$

$$M(s) = \frac{Y(s)}{R(s)} = \frac{N(s)}{1 + N(s)} = \frac{K_p}{s^3 + 3s^2 + 2s + K_p} \qquad (4)$$

$$K_p(Proportional\ gain) = 0.4K_p = 2.44908$$
$$T_i(Integral\ gain) = 0.35P_c = 1.654 \qquad (5)$$
$$T_d(Derivative\ gain) = 0.08P_c = 0.375$$

Step response for closed loop system of PID controller which was obtained by using turning method of Zigler-Nichols is finally shown at figure 6.

$$H(s) = K_p(1 + \frac{1}{T_i}s + T_d s) \qquad (6)$$
$$= \frac{0.11510676\ s^2 + 0.2142945\ s + 0.099738132}{s}$$

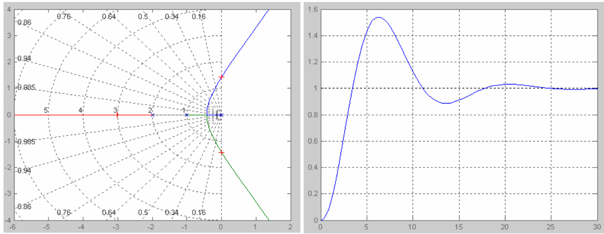

Figure 6. Obtainment of critical gain K_p and Step response of closed loop system

Parameters obtained here were applied to MTP module. Each experimental environment of Non-OS and ROTS is shown at figure 7. Output waveforms with this application at the plant were able to verify at figure 8. Comparing output waveform at Non-OS with output waveform at ROTS as the aspect of results, printout is stable without any relation of forcible load. Consequently, it proves that processing capability at MTP module of Non-OS is not inferior.

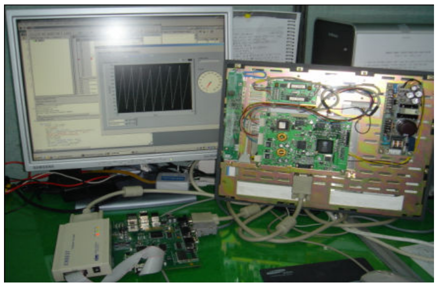

Figure 7. Experimentation of complex control

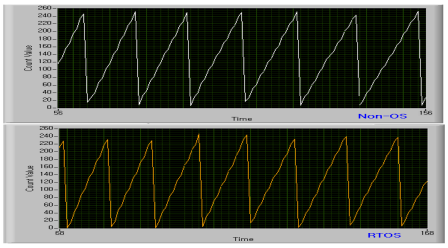

Figure 8. Waveform comparison of Non-OS with RTOS

4. Conclusion

On this study, as the new type of module was developed out of MTP system in existing nuclear power centers, there would be advantages of easy maintenance for hardware and software. In addition, there are no worries from problems of verification of ROTS & commercial OS and bugs from OS because it was designed for MTS module to apply to Non-OS base. Eventually, its current module could be being used at safety system, there are advantages to overcome those problems of maintenance, reliability, and V&V's difficulities.

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