AN EMBEDDED COMPUTER CONTROLLED MULTIFUNCTIONAL HIGH POWER TEST SYSTEM

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Abstract

An embedded computer controlled multifunctional accelerating guide high power test system is developed in the accelerator lab of Tsinghua University, Beijing, China. The system can test magnetron-driven S-band, C-band and X-band accelerating guides used in medical and nondestructive evaluation accelerators. The system is controlled by a PC/104 embedded computer named PCM-3350. The test procedure including key experimental data, the user information, the system status and the error message can be saved as permanent records in the computer, which is convenient for the management and maintenance of the system. The whole control system is small and low-cost while maintaining reliability and low power dissipation. All control processes are visible on a LCD and very friendly to users. The implementation of this system is discussed herein.

INTRODUCTION

The high power test is one of the most important processes of the accelerating guide manufacture. As an R&D lab of accelerator, we have studied a series of linac structure for more than thirty years. It is necessary to provide a multifunctional platform to take high power test of these structures under different RF bands. For a laboratory of Tsinghua University, an actual and easy-to-use high power test system is helpful for the student education. Furthermore, as a main accelerating guide manufacturer of China, we provide over a hundred products including S-band, C-band and X-band accelerating guides every year (which was 108 in 2004). So there is a lot of high power test work to do.

For these purposes, we started to develop a multifunctional high power test system in 2001[1]. The system contains three high power RF test facilities which can be used in S-band, C-band and X-band accelerating guide test. Controlled by a PC/104 embedded computer and several PLCs, the system integrates Web monitoring, remote diagnosis and history logging functions. A user-friendly Windows CE based control and monitoring program is developed to provide versatile and efficient use. The whole system is small and low-cost while maintaining reliability and low power dissipation. This design helps to work under special harsh environment.

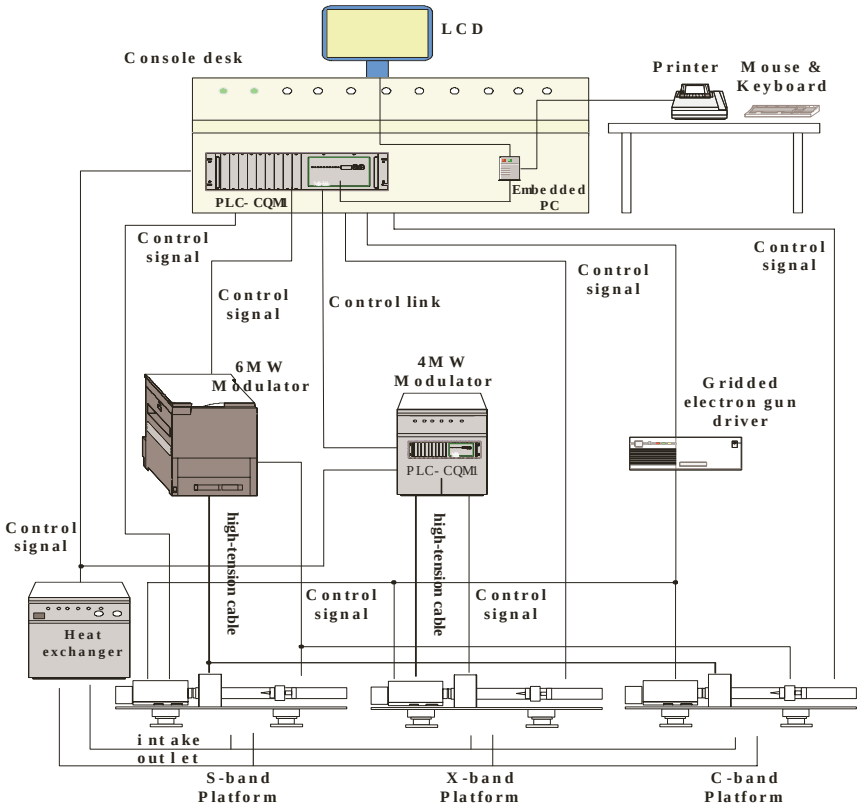

Figure 1: Layout of the test system.

SYSTEM DESCRIPTION

General layout of the test system[2]

The key feature of the test system is to provide experiments using different types of magnetrons and test instruments. So we integrate two modulators, three microwave test facilities, one heat exchanger, and tens of special power packs. The control, measurement, function shift and management of these equipments can be easily achieved with an embedded PC and several PLCs. The layout of the whole system is shown in figure 1. The details of the main subsystems are introduced as following.

Console desk

Figure 2: The console desk.

Figure2 shows the console desk of the system. There are many meters, switches and indicator lights on the console desk to show the current status and maintain the operations of the whole system. As the display unit of the embedded PC, a 15-inch TFT LCD is put on the top of the console desk. Users can get more information of the system status and operation procedure clearly and efficiently from the LCD.

Modulators

Figure 3: The modulators.

Figure 3 shows the appearance of the two high power pulse modulators. The small one in light color is the 4MW modulator for X-band magnetrons and the other is the 6MW one for S-band and C-band magnetrons. The following is the main features for both of them:

- Peak voltage: 50KV (max.)
- Peak current: 120A (max.)
- Pulse length: 2~ 5μS (adjustable)
- Duty ratio: 0.15% (max.)
- Top ripple: ±1%
- Repetition rate: 5~300pps (adjustable)

RF Test facilities

Figure 4: S-band 2.6MW RF test facility.

The microwave subsystems of S-band, X-band and C-band are shown in figure 4 to figure 6. The general performances of them are shown below:

- Operating frequency: S-band : 2992 ~ 3001MHz
  X-band : 9290 ~ 9320MHz
  C-band : 5700 ~ 5725MHz
- Peak RF power: 1.5~3.1MW
- Mean RF power: 1~4KW
- VSWR: <1.06
- Insertion loss: <0.5dB
- Isolation: ≥30dB

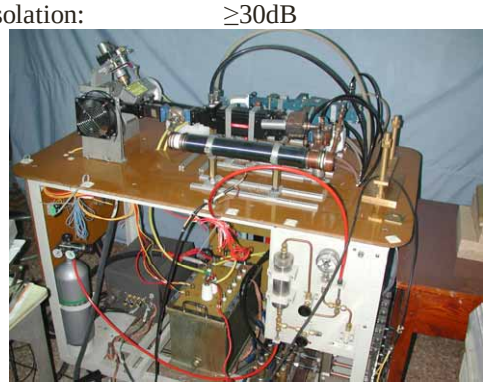

Figure 5: X-band 1.5MW RF test facility.

Figure 6: C-band 2.5MW RF test facility.

CONTROL SUBSYSTEM

Built-in host computer

The Built-in host computer is a general-purpose embedded PC module named PCM-3350 by Advantech (shown in Fig.7). The following are its main Features:

- Low CPU power consumption AMD GX1 processor
- Supports Compact-Flash™ SSD solution
- Simple, reliable fan-less operation
- Windows® CE ready
- 10/100BASE-T Fast Ethernet
- 18-bit TFT LCD support
- Full I/O port including 1 EIDE, 1 FDD, 1 K/B, 1 mouse, 2 RS232, 1 LPT, 1 x 115 Kbps SIR, IrDA 1.0 compliant, 2 x USB, Open HCI compliant

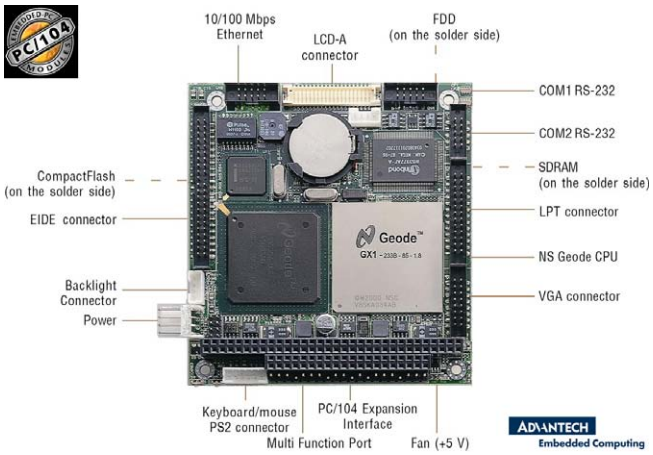

Figure 7: PCM-3350 front view.

The PCM-3350 has all the power and features indicative of larger CPU control boards, but checks in at the standard PC/104 size of 96 mm x 90 mm and the weight of 0.11 kg. Along with APM 1.1 power management and watchdog timer support, the PCM-3350 has all the features that make it a full-featured performer in any computer class. Figure 8 shows the board diagram.

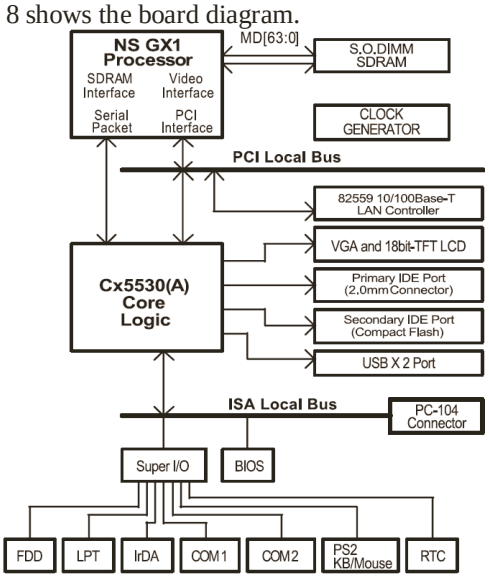

Figure 8: PCM-3350 board diagram.

PLC

This system uses OMRON series PLC as control unit of the 4MW and 6MW modulators. Table 1 shows the specifications of PLCs used in the system.

Table 1: PLC Specifications

Module	Model	Power Supply	node
CPU	CQM1H-CPU51	DC24V	16(in)
Power	CQM1-PA206	AC100~240V	
Memory	CQM1-ME04R		
Input	CQM1-ID212	DC24V	16(in)
Output	CQM1-OD212	DC24V	16(out)
A/D	CQM1-AD041		
Communication	CQM1-CLK21		

Windows CE & MCGS

The OS of the control system is MS Windows CE which offers reliable core operating services to support the most demanding real-time embedded designs across a wide range of devices. Windows CE is designed to deliver [3]:

- Scalable wireless technologies to flexibly connect mobile devices.
- Reliable core operating system services for enabling demanding real-time designs.
- Innovative technologies to enable rich, personalized experiences that span devices, PCs, servers, and Web services.
- A rich, easy to use end-to-end toolset that increases developer productivity.

The monitoring program is developed by MCGS (shortened form Monitor and Control Generated System) which is one of the most famous Chinese industrial control computer software developed by Kunlun Tongtai Automation Software Technology Ltd. Co. Beijing, China. The software has the following distinctive features [4]:

- Low cost, small memory required.
- Fast, true embedded real-time multiprocess system.
- Powerful, integrated serial communication, Ethernet, web browse and remote diagnostic functions.
- Stabile, none hard disk and with a watchdog inside.
- Safe, perfect security insurance.
- Easy to use, drivers of most popular devices available.

USER INTERFACES & OPERATIONAL PROCEDURE

The program in the embedded computer controls the PLC operation modes, sends control data to the PLC, acquires experiment data from the sensors and/or detectors, processes the whole test procedure, provides network processing to enable the web browse and remote diagnosis, and processes the external interfaces.

First of all, the system should be powered on according to the following sequence: the modulator, the heat

exchanger, the console desk, the PLCs and then the embedded PCM-3350. After the host PC power on, the monitoring program runs automatically. The login window is shown for users to input their authentications to access the system. The operating procedure, data transfer and acquisition will be saved under the name of the corresponding logged in user.

Figure 9: Initial interface.

The initial interface appears after the user logs in (figure 9). The communication status between PLCs and PC104 is shown by the status bar on the top of it. The user account and authentication can be managed by the user management button. There are several devices' icons on the bottom of the window including the 4MW and 6MW modulator of this high power test system. Click on one of them and the corresponding interface is brought out like being shown in figure 10.

Figure 10: Main interface.

A series of interlock indicator is put on the top of the interface for the fault indication, such as the low vacuum pump voltage or the EMERGENCY OFF switch status. If no interlock occurs, the system goes into preheating state. A preheating period indicator is on the right part of the interface. After the preheating is finished, the system is ready for the experiment. An analogue data acquisition window on the left part of the interface shows the experiment parameters and acquisitive data. The gridded gun power control module is on the bottom of the interface, by which the parameters can be changed easily and freely. There are also some switches and indicators to control other devices, such as the electromagnet of magnetron.

During the whole operation procedure, the main parameters of all subsystems and every error message are recorded in database. This information can be reviewed by the user with permission through the operation log and error history interface.

When the test is over, the user should power off the related devices in right sequence.

CURRENT STATUS

Since late 2001, the system has tested more than ten different types of accelerating guides including 2.5MeV, 4MeV, 6MeV, 9MeV S-band and 2.5MeV, 6MeV X-band tubes for the medical and NDT use. More over, nearly a hundred students were trained on the system.

This system also acts as the beam source in some fundamental physics and applied experiments such as the research on Mossbauer Effect, Thomson Backward Scattering X-Ray Source and high power microwave pulse compression. The system has done a great deal of good for these experiments and will do more in the future.

FURTHER WORK

- Fix some bugs in the control program.
- Update to new hardware such as PCM-3370 with 1^{+}GB CF card for more complicated task.
- Improve the data log and remote diagnosis function.
- Complete the online user help system.

CONCLUSION

The multifunctional accelerating guide high power test system allows us to study different accelerating structure for R&D, teaching experiments and manufacture. The system is proved to be reliable and efficient. Further improvement will be done soon.

ACKNOWLEDGEMENT

This work is a result of a continuous effort by many teachers, students and engineers over 4 years. In particular, the efforts of Engineer Wang Nianfeng and Hu Zhangping from COWELL MV and Du Fei from NUCTECH were instrumental to the results achieved to date. We also wish to thank COWELL MV and E2V for the persistent supports during the manufacturing and testing of components.

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