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Establish the Semiconductor Communication and Control System: An Investigation on System Cognition and Interdisciplinary Curriculum

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Abstract: In the current diversified society of rapid scientific and economic change, the industrial field looks forward in the direction of interdisciplinary integration, since the talent and knowledge of a singular profession will no longer function as industry begins to change. This has seriously become the direction strived for by academic circles, that an engineering education cultivates interdisciplinary talents and knowledge and the ability to integrate them in an effort to balance the talent supply and demand among industrial and academic circles. In this study, we take the equipment of the vacuum coating process, and designs and establishes the semiconductor standard communication and control system (SCCS) with the SECS (Semiconductor Equipment Communication Standard) interface. By doing this, the study attempts to understand how to effectively lead in information, as well as the semiconductor process relevant in the Department of Electrical Engineering (EE) curriculum with the hopes of giving EE students a more diversified interdisciplinary knowledge, more appropriate for the expectations and demands of the industry after graduation.

Keywords: Interdisciplinary, Semiconductor communication and control system (SCCS), engineering education, mechatronics, human machine interface

Introduction

In recent years, the rapid development of advanced technological industries has accelerated a change in higher education, and development between the university and industry has become inseparable [3][6]. On the one hand, university education relies on industrial development. On the other hand, capacity enhancement, new product development and technology development in the field of industry need new knowledge and technology provided by the university and laboratories. Both an interdependent relationship and a contradiction within educational purposes exist between the university and industry because the university is an educational and cultural institute, and its purpose focuses on the application and development of new knowledge. However, industry views new knowledge development as only a means to an end rather than a sole purpose. The industrial field is concerned about the market value of new knowledge and technology. The “educational objective” of the university refers to the career and professional achievement which shall be reached by students after graduation [15]. “Core ability” refers to ability and knowledge of the career, as well as professional achievement which shall be reached by the students before graduation; that is, competitive talent, knowledge and technology which shall be possessed by students when faced with the prospective environment of society or employment [4][11]. Thus, the draft of educational objective and core ability shall make reference to the dimension, e.g. social rhythm and educational development, industrial development and workplace demand, and construct a definite educational objective and core ability pursuant to school orientation and features.

In the current diversified society of rapid scientific and economic change, the industrial field is looking forward in the direction of diversified domain integration. Taiwan' s industrial structure has also made drastic adjustments in recent years on account of the high speed change of global industry, and the demand for talent in the industry field has shown a drastic correction. The academic circle feels the effects of environmental change generated by scientific progress, and although it aggressively aims to make adjustments in the engineering educational structure, the adjustment speed cannot catch up with the demand of industry. Therefore, the mission of school education must be to cultivate the talents used by society and industry to solve the disordered phenomenon of the demand structure of industry and academia. In other words, the abilities which should be possessed cannot be acquired from attention to a single subject but needs the study of many subjects and the integration and application of an interdisciplinary knowledge [13]. The instruction transfers from the past single subject orientation to cultivating a contingent ability and skill set of students to face a diversified society in the future. Outcome-Based Education (OBE) heads toward the curriculum design objectives of knowledge, skills and attitude, all of which should be possessed by students and which focuses on learning methods and self evaluation with students as the main body [12][16].

After the electromechanical engineering subject is mutually integrated by both mechanism and electronics, Mechatronics continuously responds to product demand to adopt more advanced technology. With the rapid development of information technology, the Mechatronics subject also begins to integrate itself with the information technology subject and further encourages the vigorous development of current industrial automation. Production informationization has been applied extensively in many businesses. With every advantage in speed and cost brought by informationization, every business aggressively incorporates relevant information technology in expectation of applying that information technology to acquire accurate decision-making information and thus enhance their company' s competitiveness [9][18]. Therefore, in the current Mechatronics subject, possessing and mastering a single technology has been unable to satisfy the increasing demand for omniscient talents for Mechatronics in the field of industry.

To summarize the aforementioned, the supply and demand drop for talent between the field of academics and that of industry is in need of an urgent solution, and a way to cultivate the more qualified talents to meet the expectations of the industrial circle is currently one of the goals of every college and university in Taiwan. According to the OBE theory, continuous feedback and a corrective can change the academic circle in a way that steadily responds to the demands of industry and society, and feedback provides the opinions of talent needed by the field of industry so that the academic world can refine curriculum design and teaching activities [13][15]. This study expects to take the coating process equipment of the semiconductor process as an example to implement the process equipment information integration system with the SECS interface, to survey the benefit of the system to enhance the competitiveness of their process equipment, to give suggestions about school educational curriculum planning to obtain the talent needed and to make students possess interdisciplinary subject knowledge of electric machines, general information and the semiconductor process, as well as the "core ability" of coordination and integration with different domain personnel.

1. Mechatronics and the system architecture

Mechatronics is the knowledge of integrating machinery and electric machines [2][5]. In the past, machinery and electric machines belonged separately to two different subjects and developed in their own direction with little overlap. Afterwards, the demand for integration emerged on account of the demands of industry. In recent years, with the continuous development of technology, electromechanical products have continuously adopted more advanced technology to maintain its market competitiveness. To date, Mechatronics is not only a combination of the machinery and electric machine subjects, but also incorporates information science and technology. Consequently, Mechatronics is a science combining machinery, electric machines and information science and technology to be applied in the element, module, product and system [5][7].

The current constituents in production and manufacturing of equipment are mainly the mechanism component, sensor component, control component and Human Machine Interface (HMI). In the Mechatronics field, the HMI monitor can clearly show the operator the machinery status, control machinery action and skip the traditional panel control to make mechanical manipulation more automated and user friendly. The HMI is the user interface which allows the manipulator and the automatic equipment to interact and makes the manipulator acquire every piece of automatic equipment information in order to take control of production status and achieve automatic production [8][10]. Although automatic production can enhance production efficiency drastically, on the premise that a business faces globalized market competition, a business not only must enhance production efficiency but also needs to integrate process information from every piece of equipment on the production line to ensure that the products produced possess a high quality and yield rate to effectively reduce production cost.

In the electronic industry, the monitoring system of process equipment is also covered in the Mechatronics field, and its architecture is shown in the figure 1. The system body consists of the mechanism, sensor, driver and I/O control component. I/O communication refers to the communication between the controller and HMI, while the HMI serves as the communication interface between human beings and machinery. Furthermore, in order to establish the SCADA (Supervisory Control and Data Acquisition) [1] on the basis of the computer, the SECS communication protocol needs to be provided to help the IT specialist integrate the information. Thus, how to make the production equipment possess the SECS communication protocol seriously becomes an important topic that electromechanical integrates into its abilities [14][17].

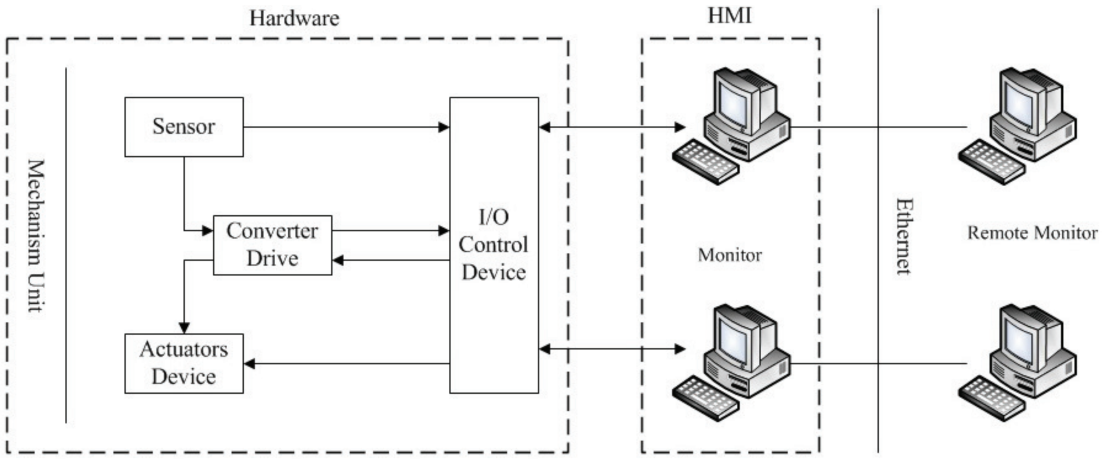

Figure 1. The architecture of the process equipment

2. The SCCS system design

The SCCS is mainly a set of systems which makes the process equipment meet the SECS, and it not only provides the operator on site immediate production information via the HMI of the SCCS, but also allows the production management system to extract the immediate process data of process equipment via the SECS protocol and set and download the parameter or Recipe. SCCS design and development are described in detail as follows.
SCCS design is generally divided into three stages: SECS Interface, IO Server and HMI. The SECS Interface mainly serves as the communication interface with the production management system. The IO Server is responsible for immediate information communication with every instrument of the process equipment and the controller. The HMI shows every piece of information on it so that the manipulator can monitor, design and select the process parameter and Recipe. In the system's design, the process equipment action and communication processes must be understood first to make the system meet the features of the process equipment.

2.1 SECS Interface

SECS Interface mainly serves as the communication bridge between the HMI and the SECS Host, transforms information from the SECS Host to a format accepted by the HMI and relatively transforms information which must be uploaded from the HMI to SECS to be provided to the SECS Host. As for the SCCS and SECS Host transmission, this study accepts the HSMS (High-Speed SECS Message Services) as the form of transmission. The HSMS transmission needs to be set by the SECS Host parameter, while the HMI is identified by Tag. SECS Interface needs to establish the coupling between the SECS Host and the HMI to repay accurate information to the SCES Host.

2.2 Human Machine Interface

The HMI is the communication bridge between human beings and the machine, just as its name implies. Its purpose is to show every piece of immediate information of process equipment on it, to provide the manipulators with the necessary information to monitor, design and select the process parameter and Recipe and to simplify the complicated manipulation interface of the traditional control panel (Figure 2). It selects Wonderware InTouch as the implementation tool of the HMI. InTouch and its communication equipment transmit information mainly via an IO Server, while the communication coupling between InTouch and the IO Server needs to establish an Access Name and set access information with a Tag Name mechanism. In a nutshell, an Access Name is the communication that establishes equipment, while a Tag name accesses its information.

2.3 IO Server

IO Server mainly takes Virtual Studio C++ as the developmental environment and is divided into two parts: a. DDE/SuiteLink Handler, which is responsible for collecting the information requested by the HMI and examining its validity via the DDE/SuiteLink protocol. b. Practical communication part, in which the IO Server delivers a message to equipment and receives the responsive message from the IO Server in light of the

Master/Slave model. The job of the DDE/SuiteLink Handler is to handle the complicated DDE/SuiteLink communication protocols. When the DDE/SuiteLink Handler receives the DDE/SuiteLink message, it will set and examine whether all the messages requested are valid. If the messages are valid, the IO Server will establish information so that it can read information from the equipment terminal.

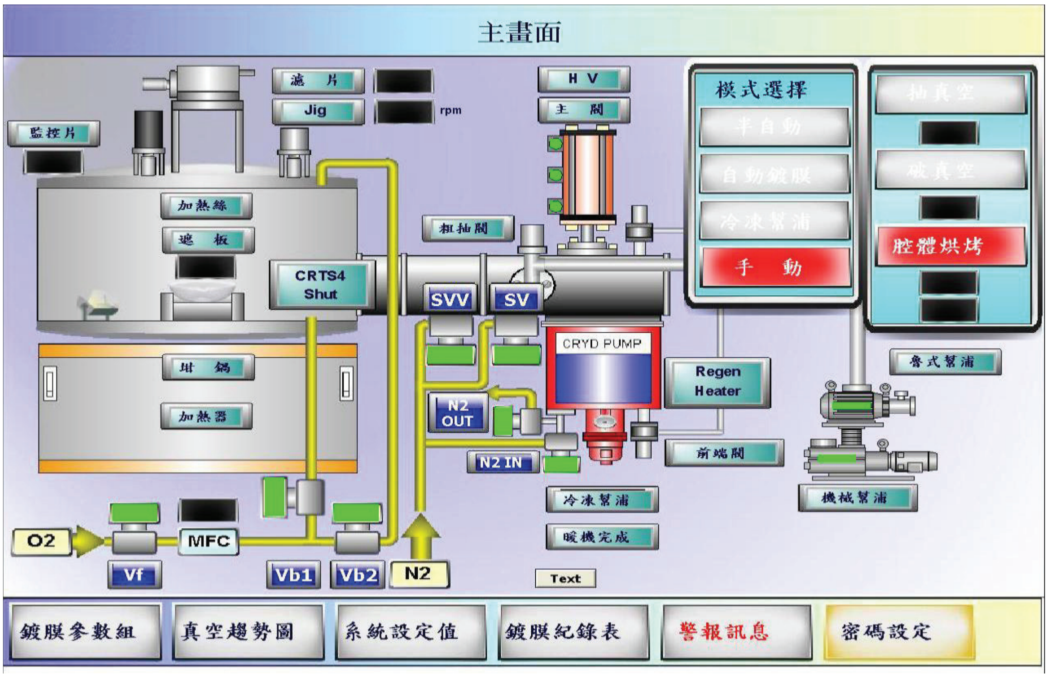

Figure 2. HMI for SCCS

3. Results

Verification of this study is divided into two parts. The first part is to understand the SCCS benefit to the industry, and is further divided into two dimensions (cognition and usability). The second part is to make the industry understand SCCS, to provide the industry with a system able to enhance the competitiveness of the industrial field and to give curriculum arrangement suggestions for relevant EE via industry experience under the educational objective of cultivating interdisciplinary talents.

3.1 Participants

The questionnaire of this study takes the Taiwan' s coating process equipment manufacturer as the main participants (n=30) of the questionnaire survey. The participants include the department supervisor of design and R&D, the engineering department, the customer service department, development designers and equipment engineers.

3.2 Verification of the SCCS Cognition Dimension

It can be seen pursuant to the table 1 that the examinees have proven an understanding of the SECS mentioned in the SCCS, as well as an understanding of the SCCS functions and purpose after reading the SCCS introduction in the SCCS cognition. Most of the respondents were shown to believe that developing the SCCS system is something very important (83.3% agree), but the company still does not develop the system of the same SCCS function, and the reason may be that developing the SCCS system is too difficult for the respondents.

Table 1. The responses to the cognitive construct

Item	Strongly agree	Agree	Undecided	Disagree	Strongly disagree	Mean
I have been heard the SECS standard communication in SCCS.	40%	46.7%	3.3%	10%	0%	4.167
I can understand the SCCS function and purpose.	23.3%	56.7%	3.3%	3.3%	0%	4.267
Our company has been developed the system of the same SCCS function.	6.7%	26.7%	33.3%	23.3%	10%	2.967
I believe that developing the SCCS is very important for our company.	10%	83.3%	10%	0%	0%	4
I think that developing the SCCS is difficult for me.	6.7%	30%	30%	23.3%	10%	3

3.3 Verification of the SCCS Usability Dimension

It can be seen pursuant to the table 2 that the examinees were shown to agree on several items in the SCCS availability, e.g. increasing the process equipment value of the SCCS, helping the company enhance product competitiveness, meeting the request of customers in data transmission and making customers further increase process equipment reliability. They also were shown to partly agree that the SCCS can drastically enhance both capacity and yield rate.

Table 2. The responses to the usability construct

Item	Strongly agree	Agree	Undecided	Disagree	Strongly disagree	Mean
I think SCCS can increase the value of process equipment.	26.7%	70%	3.3%	0%	0%	4.233
I think SCCS can help the company enhance product competitiveness.	33.3%	63.3%	3.3%	0%	0%	4.3
I think SCCS can meet the request of customers in data transmission.	33.3%	60%	3.3%	3.3%	0%	4.233
I think SCCS can drastically enhance both capacity and yield rate.	13.3%	63.3%	23.3%	0%	0%	3.9
I think SCCS can increase process equipment reliability.	26.7%	56.7%	16.7%	0%	0%	4.1

3.4 Interdisciplinary curriculum survey

The industry ranks the feedback opinions of the interdisciplinary curriculum with an average, in order programming language (4.57), object oriented programming (4.47), semiconductor automatic production (4.47), computer network (4.43) and data structure and algorithm (4.2). The results show that in addition to the Electric Machine subject as its basis, the design and development of the SCCS system still need to combine the domain knowledge of information engineering and semiconductor automatic production. However, EE students cannot study much about information engineering and semiconductor automatic production at the confined university stage, so the interdisciplinary integration curriculum is needed to make the students possess the diversified domain knowledge.

Conclusions

The SCCS system presented by this study aims for the process equipment home production of the semiconductor and photoelectric relevant industry to present a refined scheme and suggestions about the necessary subject knowledge that professionals must possess for the relevant EE, via the feedback opinions of the industrial field to make the students cultivated by the school more apt for the expectations of the field of industry. The results of this study are to establish a system which makes process equipment possess SECS communication ability, to verify whether the SCCS is beneficial for the industrial field via the analytical results of the questionnaire survey and to understand that the potential professionals needed by the industry cannot only possess a single professional knowledge but require interdisciplinary knowledge via the feedback of the industry. Thus, university education must move forward in the direction of diverse field integration and cultivate interdisciplinary abilities to enhance the core competitiveness of students

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