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Application System for Setting Values on High Voltage Power Supply Using MCP4725 Module Based on ATmega328P Microcontroller

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Abstract

Applications of power supply systems to supply sensors that require high voltage values are widely available in the market in the form of modules. However, in general, setting the voltage value is open by providing a voltage value from the potentiometer or trimmer component which is rotated manually. This becomes less flexible because the operator must always be nearby. The solution option is to implement automatic regulation via a potentiometer attached to an interface component connected to the microcontroller via a serial communication line called I^2C. Furthermore, the microcontroller is programmed to receive regulatory commands and monitor the desired voltage value from a computer or mobile phone. This study uses the ATmega328P microcontroller, the MCP4725 DAC module and the CA12P-5TR series HV module from EMCO products. The results of this study are the design, implementation and prototype scheme.

Keywords: *Voltage Value Setting, MCP4725 DAC Module, ATmega328P Microcontroller*

1. Introduction

Power supply application systems to supply sensors that require high voltage values are widely available on the market in module form. However, in general, setting the voltage value is still open by providing a voltage value to the potentiometer or trimmer component which is rotated manually [2], [3]. This of course becomes less flexible because the operator has to operate directly on the power supply system [5]. To ensure flexible operation, the solution option is to implement automatic settings that can be operated remotely using a computer or cellphone connected to an internet network or what is known as internet of things technology [6], [21].

The automatic regulation system implements a potentiometer mounted on an interface component which is then connected to a microcontroller via a serial communication line called I2C [7], [22]. Next, the microcontroller is programmed to be able to receive setting commands and monitor the desired voltage value via internet computer network devices and cellphones from various distances [8], [23].

This research applies the ATmega328P microcontroller [1] as a regulator, the MCP4725 DAC module [4] as an interface, and the CA12P-5TR series HV module from EMCO products as a regulated high voltage module [24]. The results of this research are design schemes, implementation and application system prototypes [9].

2. Method

The concept of automatically setting voltage values on a high voltage module based on the ATmega328P microcontroller is shown in Figure 1. The microcontroller regulates the voltage value by sending digital commands to the MCP4725 DAC module via the I2C communication line located on the microcontroller legs and the corresponding MCP4725 DAC module legs [10].

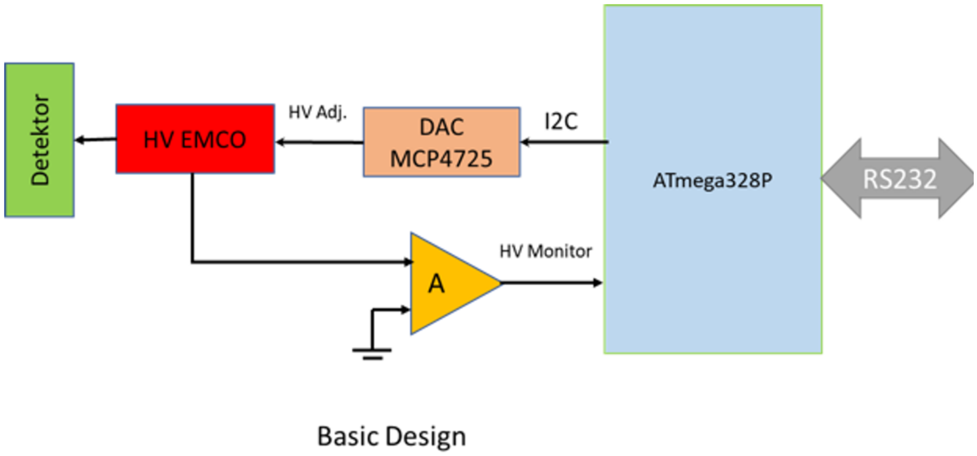

Figure 1. Microcontroller Based High Voltage Regulation Value System Concept

The function of the ATmega328P microcontroller which is used to communicate with the MCP4725 DAC module via I2C consists of the clock signal generation function (SCL pin: A5) and the command data distribution function (SDA pin: A4) [11], [26]. On the other hand, the function of the leg used to get feedback about the voltage value from the Emco high voltage module output is to convert the analog signal to digital (pin A0) [12].

In the interface module, the clock signal generated from the ATmega328P is fed to the MCP4725 DAC module marked SCL (pin 3) [14], [25]. Likewise, the SDA data line originating from the ATmega328P is connected to the MCP4725 DAC module via the input pin marked SDA (pin 4) [13], [28].

The high voltage module (HV Emco module), gets an analog signal from the setup command from the MCP4725 DAC module (Aout) [15], [27]. Meanwhile, information on the results of setting the voltage value on the Emco HV module is sent directly to the microcontroller via the ATmega328P analog leg (pin A0) [16]. The connection diagram between the MCP4725 DAC, Emco HV module and ATmega 328P is shown in Figure 2.

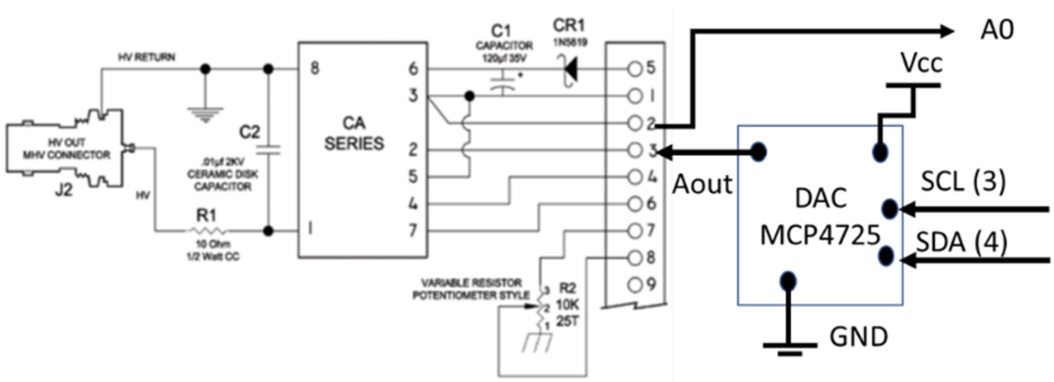

Figure 2. DAC connection from ATmega and to Emco HV Module

A description of the pin relationships between the ATmega328P module, MCP4725 DAC module, and Emco HV module is presented in tabular form [17], as shown in Table 1.

Table 1. Description of Connections Between Pins on the Module

Module Name	Module Pins from			Connection Between
	ATmega328P	MCP4725	HV Emco	
HV Setter	A0	-	Connector 2	ATmega328P and modul HV
	A4\SDA output	4/SDA input	-	I2C and SDA
	A5\SCL out	3/SCL input	-	I2C and SCL
	-	1/Analog out	Connector 3	DAC and HV

The method used in this research is to use a combination/synthesis scheme between hardware and software design [18]. The hardware design was carried out by assembling the ATmega328P microcontroller [29], [30], MCP4725 DAC module, and Emco HV module [19], [31]. Software design by first creating a flowchart related to the logic process of giving commands to the high voltage control system automatically on the Emco HV module based on a comparison of the desired or determined voltage value (set point) with the actual reading. voltage value (real point) [20], [32]. The hardware and software design was then integrated into a prototype value setting application system using the MCP4725 based on the ATmega328P microcontroller.

3. Research Results and Discussion

3.1. Hardware Design Results

The resulting hardware design is the ATmega328P microcontroller circuit schematic, and the MCP4725 DAC module and Emco HV CA series module for setting the system voltage value at the 500V and 750V set points. As shown in figure 3.

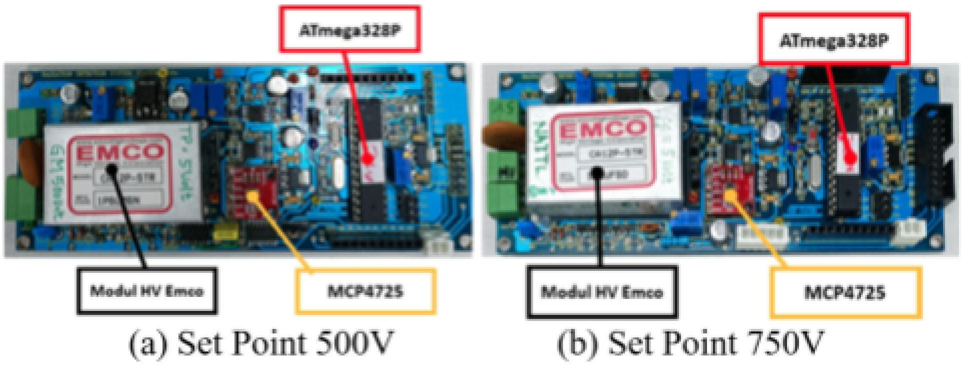

Figure 3. Value Setting System Circuit Scheme

The ATmega328P microcontroller functions as a controller in regulating the high voltage value of the Emco CA series module. The logic flow of voltage regulation carried out by the ATmega328P can be explained as follows:

1) The initial assumption of the system (consisting of three main modules) of the designed high voltage regulator is that it is in the off state. And, when the system is turned on, the ATmega328P then begins preparing the MCP4725 DAC module.
2) The MCP4725 DAC module is arranged in such a way that the initial voltage value of the Hv Emco module is ensured to be at 0 value.
3) Next, the ATmega328P microcontroller checks the voltage set point value given by the operator or which is determined by default when the ATmega328P is programmed.
4) The microcontroller then sends voltage setting commands in stages through the MCP4725 DAC module until it reaches the set point.
5) Gradual voltage changes are monitored by the ATmega328P by reading data sent by the HV module via the ADC A0 pin of the ATmega328P.
6) If the gradual adjustment is being carried out but the feedback voltage value from the HV module shows no change, the aRmega328P microcontroller will issue a notification signal.
7) Furthermore, if conditions are running normally, the setting will move gradually until it reaches the specified set point voltage.
8) When the setting has reached the set point value, the setting gradually enters the monitoring stage.

9) In the monitoring stage, the voltage value obtained from the feedback signal information is compared with the set point voltage. If the feedback value is 1o% below the set point, the ATmega328P will increase the HV value. On the other hand, if the monitoring results show that the value is 10% above the set point value, then the ATmega328P will reduce the HV voltage value.
10) This setting is carried out continuously at regular intervals until the system is turned off or loses power.

The diagram in Figure 4. below shows how the HV setup is carried out by an ATmega328P based system.

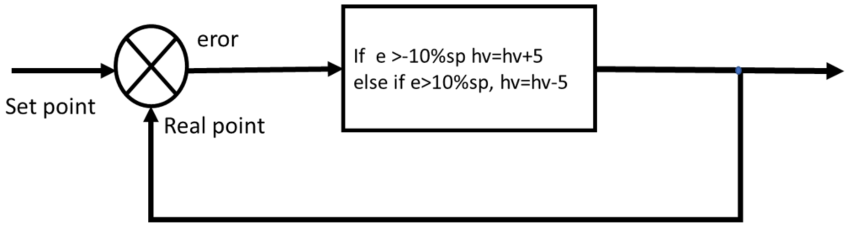

Figure 4. ATmega328P Based HV Arrangement Scheme

3.2. Software Design Results

The Emco HV module high voltage control system software design is divided into two programs, namely the main program and the high voltage regulation library program. The basic design schematic of high voltage rating software is as shown below.

```
main program;

#……………………………………
#include "aturHV.h"

void setup()
{
 ………………………………………;
 ………………………………………;
 resetNilaiHV(addr);
 setNilaiHV(setPoint);
}

void loop()
{

……………………………………………;
 mon=MonitorNilaiHV();
 If (mon<10%setPoint)
   setNilaiHV((1+10)setPoint);
 Else
   setNilaiHV((1-10)setPoint);
}
```

```
library program (aturHV.h);

1. resetNilaiHV(addr);
2. setNilaiHV(nilai);
3. monitorNilaiHV();
```

Setting the high voltage value of the ATmega328P based HV module is done by first creating a library which is responsible for managing the voltage value settings. The library contains three main functions, namely resetting voltage values, setting voltage values, and monitoring voltage values. The reset voltage value is intended to return the HV voltage value to zero the first time the system is turned on. The aim is to avoid damage to the detection system due to sudden high voltage values. Especially when the power supply system suddenly turns off and then turns back on. Next, after ensuring that the initial voltage value is zero, the system will change the positive voltage value gradually until it reaches the set point voltage value. When the voltage value has reached the set point value with a tolerance of about 10%, the voltage value setting stops and switches to monitoring status. In monitoring status, the microcontroller will instruct the MCP4725 to increase or decrease the HV module voltage value within the tolerance limit of the specified set point voltage value.

3.3. Voltage Regulation System Prototype Test

The design results were then built into a prototype high voltage value control system. There were two prototypes built to determine the performance of the design. The first prototype was to supply high voltage to a Geiger Muller (GM) detector. The second is a prototype for supplying high voltage to the NaI (Tl) detector. The voltage setting point for the GM detector high voltage system prototype is 500V, while the NaI (Tl) detector high voltage system prototype is 750V. From the test results of the two prototypes, real point results or stable HV feed back values were obtained, as shown in the tabulated test results in Table 2.

Table 2. Stress Value Measurement Results from Prototype Simulation

No	Protoptye untuk Pasokan HV dari	Titik Setel (V)	Titik Nyata (V)
1	Detektor Geiger Muller (GM)	500	510
2	Detektor NaI (TI)	750	735

4. Conclusion

Design of a high voltage value setting system using the MCP4725 module and the CA12P-5TR HV series based on the ATmega328P microcontroller, resulting in a prototype high voltage value setting application system. This prototype has been tested in two versions. First, to supply the GM detector voltage where with a set point of 500V, a real voltage value of 510V is obtained. Second, to supply the NaI detector voltage, where with a set point of 750V, a real voltage value of 735V is obtained.

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