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Independent Microcomputer-Based Controller of an Innovative Automotive Rear-View Mirror

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Abstract:
To increase the operating efficiency and driving safety, it has becoming an indispensable strategy for many automobile makers in the world to design a new external automotive rear view mirror. This paper presents a new controller of the proposed system based on an independent microcomputer electronic control unit (ECU). Not only is dual-axis inclined angles adjustment function still kept for user, but also two novel operating methods are involved together with the conventional one. A microcomputer-based ECU is in conjunction with both the dc-motor driving circuit and two pairs of inclined angle sensory circuit to form a close-loop controlling structure. Since the dual-axis inclined angle fast memory and restoration functions are embedded in the ECU of the proposed system leading to no patent problem with the other automobile makers in the world. The other operating issues such as the distance between the user's and the mirror too long are overcome. For experimental convenience purpose, a prototype of new proposed system was established in the laboratory. Some experiments were carried out by using the experimental prototype under different conditions. Finally, experimental results showed that the designed and implemented controller with fast memory and restoration functions of the proposed system is actually feasible.

Keywords: Automotive rear-view mirror, Electronic control unit (ECU), Single chip, Controller.

INTRODUCTION

There is a closing relationship between the performance of the automotive rear view mirror and the driving safety of the vehicle's driver. Better performance of automotive rear view has, more the driving safety of has. At present, more or less blind zones are still existed in every kind of vehicles although an interior and a pair of exterior automotive rear view mirrors are installed beside driven vehicle. As a result of the vision width of drivers is not enough results in critically affect their driving safety. As the automotive electronic degree is increasingly high, the automotive electronic controlling method becomes one of a very important developed technology in the global automobile industry. Lots of automobile makers in the world highlight this technology too. Compared to the conventional mechanical control method used in most vehicles, the control precision and responding speed of the electronic control method are much better than the former. To apply the electronic controlling technology to design the automobile's rear view mirror has been becoming one of a considered innovation approaches by the researching and developing department of automobile makers in the world. Some critical disadvantages are existed in the conventional mechanical exterior automotive rear view mirror, for example, inconvenience, inefficiency, bad availability, and poor performance. The researching and developing engineers of automotive rear view mirror then would pay their attention on the using convenience from the view point of most consumers. Most of the present automotive rear view mirror is only provided to adjust the dual-axis inclined angles regardless of they are controlled by manual or electronic control method [1-5, 6, 8,15]. Their function of the controlled rear view mirror is still inefficient for most automotive drivers. Therefore, both the memory and restoration functions concerning with dual-axis inclined angles of the automotive rear view mirror are required to be integrated with the original adjustment function by many vehicle makers. Consequently, the operating efficiency and using convenience of the new proposed product are greatly improved [13].

Up to now, the automotive rear view mirror controlled by electronic controlling method has been used in general vehicle and has almost become a standard feature. As long as they press any button inside of the automobile, the drivers can adjust the dual-axis inclined angles using easy, fast, convenient, and correct ways. To solve longer vision distance problem when driver want to adjust the dual-axis inclined angles in the external right-side automotive rear view mirror. The conventional manual controlled automotive rear view mirror has always been installed in most of middle-end and high-end vehicles have almost been replaced by using the electronic controlled automotive rear view mirror or the proposed new system now[18,19]. General speaking, as the electronic technology is constantly progressed, the required function associated with automotive rear view mirror is certainly made progress too. After both the memory and restoration functions have been in conjunction with the original adjustment function. Every automobile driver will adjust dual-axis inclined angles of their automotive rear view mirror to obtain a better rear and side visions when they start driving their vehicle according to their personal height and personal driving habit. Moreover, these optimal dual-axis inclined angles can also be memorized in the single-chip memory. Whenever the driver wants to recover the memorized dual-axis inclined angles at any time and as soon as possible, she/he only needs to press a restoration button and a fast key on the system control panel. Two group of optimal dual-axis inclined angles, they have four bytes, are belong to two external rear view mirrors are immediately remembered from the memory. In fact, every fast key represents that four bytes of memory address which are reserved for storing the dual-axis inclined angles in the right-side and left-side automotive rear view mirror. Compared to the conventional manual controlled mirror, the mechanical mechanism of the proposed new system becomes more complex and more functions are included. Of course, the manufacturing cost is higher than the former one.

Taking the manufacturing cost into consideration, the proposed new system associated with memory and restoration functions is only installed in a high-end vehicle. Both low-end and middle-end vehicles' user always can't enjoy the convenience of the proposed new system [7, 9-12]. The electronic control unit (ECU) is embedded in the proposed system is based on a microcomputer. The control of ECU is entirely independent of the automotive computer system. Not only is the adjustment of the dual-axis inclined angles kept, but also the memory and restoration functions are also integrated into the proposed system. Therefore, the operating efficiency of the proposed system is greatly improved. As a result of the driver's vision range is broadened, and the number of traffic accidental events for every one year should be reduced too.

The Structure of the Proposed System

Fig. 1 shows the functional block diagram in the proposed new system. Notice that the mechanical mechanism is not included. The new proposed system includes two dc motors, a dc-motor driving circuit, dual-axis inclined angle sensory units, and an ECU. The new proposed system associated with memory and restoration functions is a typical electronic control system. Its control kernel is based on an 8 bits single chip. Consequently, it is also called as microcomputer-based control system. The ECU can be further divided into a dc-motor driving circuit, some mechanical switches utilized for ordering operation command, and a single chip. As shown in Fig. 1, there is single DC voltage source, +12 V, is served as the operating voltage of the ECU, which is also the standard output voltage of the general automobile battery.

In order to implement the proposed system including memory and restoration functions, dc-motor driving circuit, dual-axis inclined angle sensory unit, and a single chip are integrated together to form a close-loop controlling structure, as shown in Fig.2. According the operating command ordered by driver through pressing the mechanical switch which is set on the control panel, the control signals generated by the single chip are used to turn on a pair of arms and results in inclined angle of the X-axis and Y-axis mechanical mechanism, respectively. The dual-axis inclined angle sensory units fixed on the X-axis and Y-axis mechanical mechanism will output a pair of linear analog values which is proportional to the dual-axis inclined angle in mechanical mechanism. The single chip is next to sequentially samples and holds the output linear analog voltage of the X axis and Y axis by the embedded A/D converter. These two analog voltages are then converted into two 10-bits digital data. If the memory action is ordered by user, two 10-bits digital data or four bytes are memorized in the single-chip memory. If the restoration action is order by user, the memorized four data will first be restored by the single chip on ECU and served as a reference values during the restoration process. Through comparison, identification, and modification actions, the final inclined angles in X axis and Y axis are almost same as their reference values. The restoration or tracking action of the proposed system is then automatically stopped.

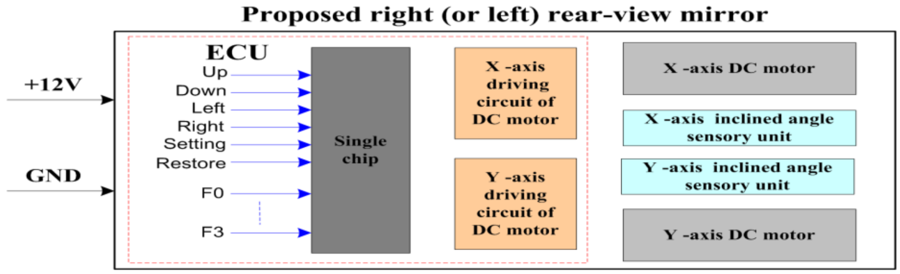

Figure 1. Draws the functional block diagram of the proposed system.

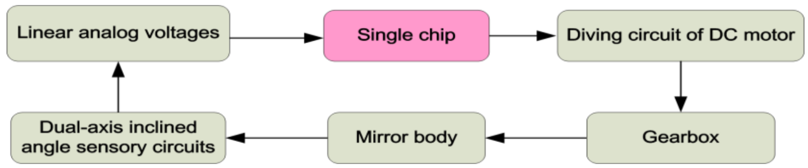

Figure 2. Sketches the close-loop control structure for implementing the restoration function.

Design of Hardware Circuit

All possible actions of the proposed system are designed only able to be controlled by using mechanical switches which they are set on a control panel. Twelve mechanical switches on the control panel are provided to user for the control of the dual-axis inclined angles adjustment, memory, and restoration. As the electrical circuit of part A shown in Fig. 3 [4,5], any one of the twelve mechanical switches is enabled to work when the output signal is a logical high voltage level. Whenever the user begins ordering one of the twelve operation commands, the first command would be ordered by user is to select external left-side or right-side rear view mirror as an active mirror through a mirror selection mechanical switch. Moreover, user needs to enable a function among the dual-axis inclined angles adjustment, memory, and restoration functions. After the operating function of the proposed system has been enabled, the corresponding subprogram of the active function embedded in the single-chip program is cyclically run and the other subprograms are temporarily terminated.Review Stage

Single Chip and Its Peripheral Circuit

As the electrical circuit, part A, shown in Fig. 3, an 8-bits single chip, labeled as 16F877A, is served as the control kernel of the ECU [14]. The logical level will be read by using single chip through its digital input pin, RB1. If the logical level appeared on the pin RB1 is high, it represents that the user enables the external automotive left-side rear view mirror to work. Otherwise, right-side rear mirror is enabled to work.

Since there are four types of external automotive rear view mirror are possibly selected to be the active controlled mirror. To make the same ECU can use to control the every type of rear view mirrors. And the corresponding subprogram is run by the single chip program according to the logical level combination of two single-chip pins RE0 and RE1. Whenever the memory or the restoration action is enabled to work, RA0 and RA1 will be initially programmed as two analog input pins. They are responsible for reading the dynamic dual-axis inclined angles of the proposed system. Fig. 3 shows that the port D of single chip is used to generate the controlling signals of the dc-motor driving circuit. Lower nibble pins are used to generate the control signals of the dc-motor driving circuit for the control of the external left-side rear view mirror, while the other nibble pins are used to generate the control signals of the dc-motor driving circuit for the control of the external right-side rear view mirror. Four LEDs respectively connected to the single-chip pins through a resistor in series, they are served as the operating status indicator of the proposed system.

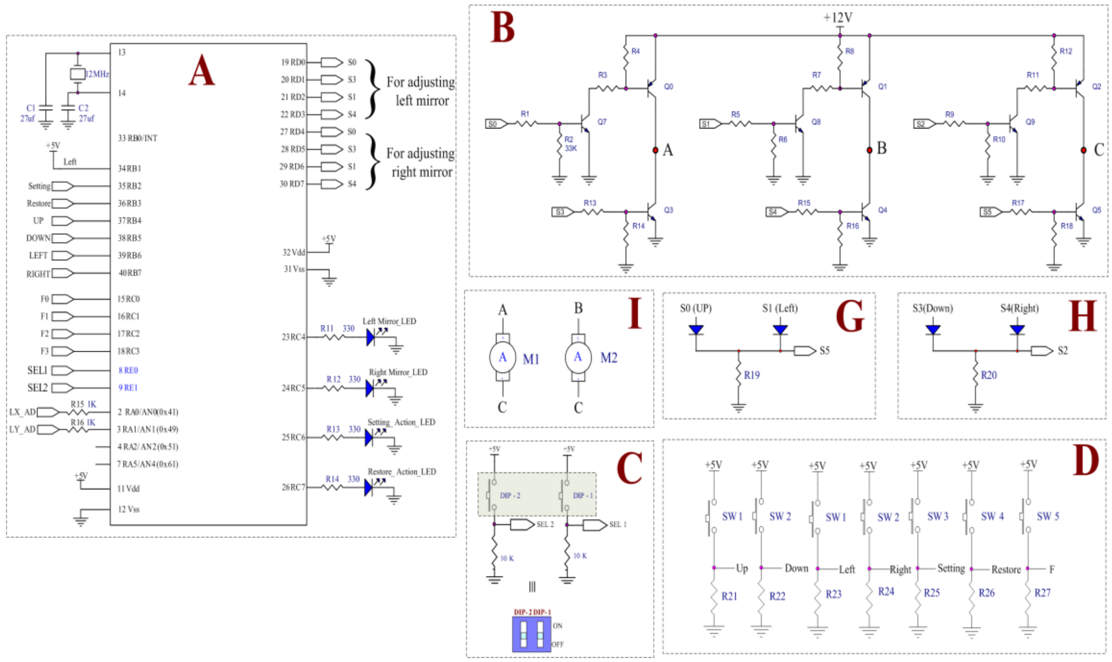

Figure 3. Draws the hardware-circuit diagram of the proposed new system.

B.Driving Circuit of DC Motor

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As the electrical circuit, part B, shown in Fig. 3, it is a driving circuit of two dc motor in a proposed system. In order to conveniently explain the working principle of the dc-motor driving circuit, the dc-motor driving circuit in part B is redrawn and demonstrated in Fig. 4. Every one automotive rear view mirror consists of two dc motors. They are used to drive the mechanical mechanism in X axis and Y axis, respectively. There are three terminals are prepared for being connected with the driving circuit. Fig. 4 shows that the dc-motor driving circuit is composed of three phases or six arms. One phase includes two arms. One arm is called as the upper arm, while another arm is called as the lower arm. Fig. 4 also indicates that one dc motor, labeled as M1, is connected across two terminals, such as A and C. Assumed that it is driven to rotate in the clockwise direction. The control inputs S0 and S5 should be applied logical high level at the same time by the single chip embedded in the ECU. The power transistors Q0 and Q5 are triggered to turn on. A circuitry loop, +12V, Q0, M1+, M1-, Q5, and GND, are formed. The flowing direction of the loop current is indicated by a dashed line with arrow. The output rotation torque of M1 rotor is converted into linear motion force through a speed reduction gearbox. The driven mechanical mechanism also intends to incline an angle.

When user presses a button for commanding the system controller to drive the dc motor in the opposite direction, the single chip embedded in ECU would output two signals with logical high level to drive the dc-motor driving circuit. These two control signals are connected with two terminals, such as S2 and S3 shown in Fig.4. Both the upper arm at third phase, Q2, and the lower arm at the first phase, Q3, is turn on. Two power transistors are turn on at same time. There is an electrical loop is formed by +12V, Q2, M1+, M1-, Q3, and GND. As observed in Fig. 4(b), the flowing direction of the current loop is indicated by a dashed line with arrow. It is apparently opposite to that shown in Fig. 4(a). Consequently, the dc motor, M1, will be driven to rotate in the counterclockwise direction.

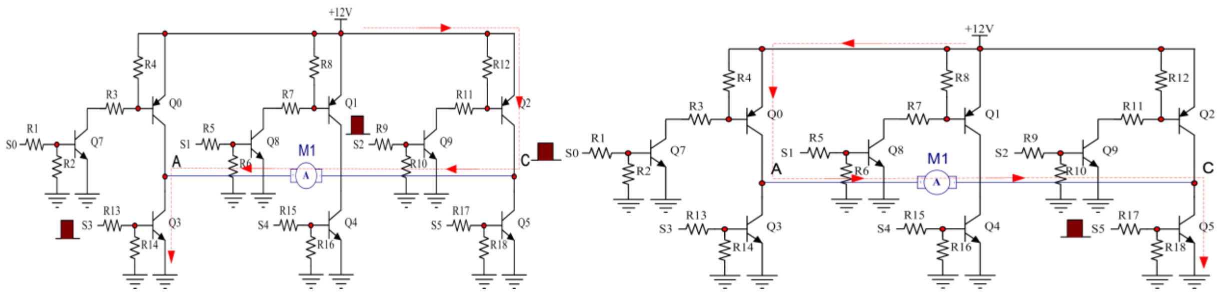

Figure 4 Explain the dc motor is driven by driving circuit to rotate in the (a) clockwise direction (b) counterclockwise direction.

C. Logical OR Gate

As the single-chip peripheral circuit shown in Fig. 3, the same hardware circuit of ECU is required to be used to control the external left-side rear view mirror or right-side rear view mirror. Meanwhile, the necessary pin number of the single chip is also required to reduce as less as possible. Therefore, the control signals of the dc-motor driving circuit are generated by only using four pins in the left-side rear view mirror and right-side rear view mirror, respectively. As indicated in Fig. 4, the control signals of the both the upper arm and the lower arm at third phase are generated by two logical OR gates. For simplifying the circuit structure of system controller and taking cost factor into consideration, one logical OR gate is only implemented by using two diodes and a resistor.

D. Dual-axis Inclined Angle Sensory Unit

The mechanical mechanism of the proposed system should be driven to incline in the X-axis or Y-axis direction. In theory, as a result of the linear motion directions in both X axis and Y axis are perpendicular to each other. The mechanical mechanism in two axes is necessary to be decoupled. Namely, when the X-axis mechanical mechanism intends to incline an angle, the inclined condition in Y-axis mechanical mechanism is not affected at all. Fig. 5 shows the angle inclination in the X-axis or Y-axis direction. There is a virtual supporting point is located in the geometrical center of the proposed system. The rotation torque exerted on the dc-motor rotor is converted into a linear motion torque by means of a special gearbox with plastic material. Regardless of the mechanical energy loss, the output electromagnetic torque of dc-motor rotor should be equal to the multiplication of the linear force and the length of force arm, as described in the following:

$$T_2 = F_\ell \times \ell \quad (1)$$

In order to implement the memory and restoration functions of the proposed system, a pair of the inclined angle sensory units should be fixed on the dual-axis mechanical mechanism for dynamically sensing the dual-axis inclined angles at an external automotive rear view mirror. The inclined angle sensory unit is composed of a permanent magnet and a linear Hall Effect sensor IC [17]. The output of the incline angle sensory unit is a linear analog voltage. This value is proportional to the amount of magnetic intensity which acts on the linear Hall-Effect sensor IC. Fig. 6 demonstrates the relationship curve between the output linear analog voltage and input magnetic intensity. The linear Hall-Effect sensor IC is fixed on the mechanical mechanism and stationary. Relatively, the permanent magnet is fixed on the surface of the proposed system and rotatable.

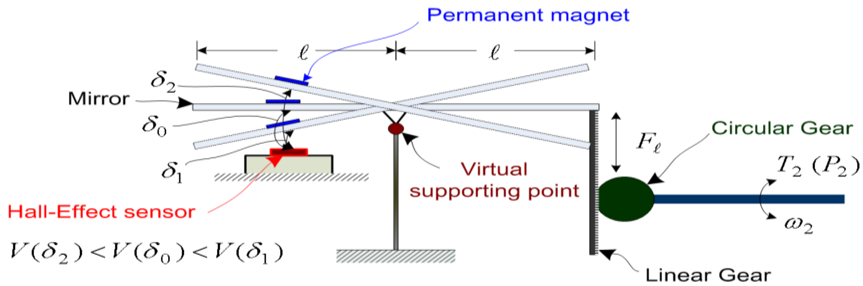

Figure 5 Show the motion of one-axis mechanical mechanism in a proposed automotive rear mirror.

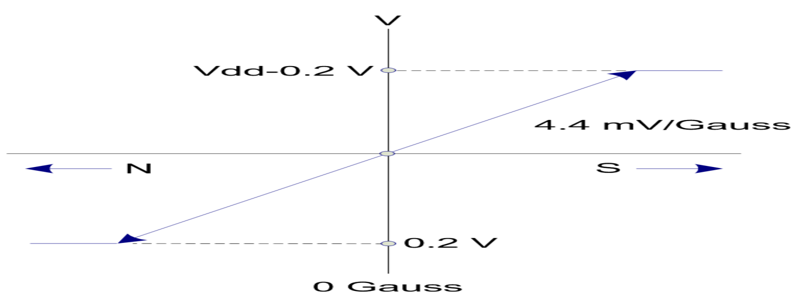

Figure 6 Draw the relationship curve between the applied magnetic intensity and the output linear voltage value.

E. Memory Function

In this paper, an 8-bit single chip, labeled as PIC16F877A, is used as the control kernel of the ECU. There are 256-bytes location exists in single-chip EEPROM memory. When the memory function of the proposed system is enabled to work, the single chip will first read two independent linear analog voltages of the dual-axis inclined angle sensory unit by using two analog input pins, both RA0 and RA1, which are programmed as analog input pins here. These two sampled linear analog voltages will be continually converted into digital data by the internal A/D converter embedded in single chip. Finally, the acquired four digital data, which represents the dynamical dual-axis inclined angles in external automotive rear view mirrors, are stored in the single-chip EEPROM memory.

After the user has pressed the memory key, the user will be required to continually select one of fast keys from F0, F1, F2, and F3. Thereafter, the system controller namely realizes the beginning address in EEPROM memory where they are reserved for storing these four digital bytes.

F. Restoration Function

When the user presses "restore" key, which is arranged on the system control panel, she/he is required continually to select and press one of fast keys from the F0~F3 keys. The purpose of this action is to inform the system controller regarding the beginning address of single-chip EEPROM memory where the dual-axis inclined angles of two external rear view mirrors are stored. After they have been read from the single-chip EEPROM memory, they are immediately served as the reference values in the later restoration process. The single chip, dc-motor driving circuit, dc motor, and inclined angle sensory unit are then form a close-loop controlling structure [16], the present axial inclined angle will be continually read and compared with these reference values by the single chip according to the requirement of the hysteresis algorithm shown in Fig. 7, the final present axial inclined angle of the proposed system is theoretically equal to the reference value. All the restoration process of the proposed system is simply described step by step in the following:

Step 1: The single chip embedded in ECU first reads the optimal four bytes data regarding to dual-axis inclined angles from its EEPROM memory. These four bytes data are served as the reference values of the hysteresis algorithm in the later automatic angle tracking process. Assumed that these read four bytes data are named as LX, LY, RX, and RY, respectively. The meaning of them is explained as follows:

LX: X-axis inclined angle at left-side rear view mirror;

LY: Y-axis inclined angle at left-side rear view mirror;

RX: X-axis inclined angle at right-side rear view mirror;

RY: Y-axis inclined angle at right-side rear view mirror;

increase the axial inclined angle. Table 1 lists all possible combinations both the control signals of the dc-motor driving circuit and the rotating direction of dc motor.

TABLE 1 LIST THE POSSIBLE COMBINATIONS BOTH THE CONTROL SIGNAL OF DC-MOTOR DRIVING CIRCUIT AND THE PRACTICAL ROTATING DIRECTION. (CW: CLOCKWISE; CCW: COUNTERCLOCKWISE)

Action	S0	S1	S2	S3	S4	S5	Remark
M1, CCW	0	0	1	1	0	0	Inclined to positive X axis
M1,CW	0	1	0	0	0	1	Inclined to negative X axis
M2,CW	1	0	0	0	0	1	Inclined to positive Y axis

M2,CCW	0	0	1	0	1	0	Inclined to negative Y axis

IV. Software Programming

All the behaviors of the new proposed system are controlled by means of manually pressing the mechanical switch on a control panel. This control panel is generally installed inside vehicle. Different actions are necessary for the new proposed system leading to some simple mechanical switches is required to be set on the control panel. Every kind of controlling action is ordered by user through manually pressing a corresponding mechanical switch. User can order the system controller to complete the adjustment, memory, and restoration of the dual-axis rear view mirror by pressing these mechanical switches arranged on the control panel. The single-chip main program will be interrupted when Timer 0 overflow and enters into the service routine program. The ordered command will be checked and fed back to the single-chip main program by using a special flag. The single-chip main program immediately runs the corresponding action or subprogram according to the feedback special flag.

Working Flowchart of the Main Program

The single chip is the control kernel of the system controller. Regardless of the adjustment, memory, or restoration action is selected to execute by user, the real action is only achieved by the single chip, peripheral circuits, and related mechanical mechanism. Because user may use one of these three actions at any time, the single-chip main program continually polls the system state in the interrupt service routine program at every regular interval. Fig. 8 shows the working flowchart of interrupt service program when single-chip Timer 0 overflows. When the interrupt service program begins to be run, the main program will check each single-chip interrupt flag to realize the enabled interrupt source. If the interrupt source is Timer 0, the single chip enters into the interrupt service routine. Theoretically, one of adjustment, memory, and restoration actions would be occurred. An action flag will be set and taken back to the main program. The main program then executes the corresponding action according to the taken special flag. Table 2 lists every possible combination between the mechanical switches and the corresponding action. There are three kinds of working modes and one exception. The defaulted action mode in the system controller is manual adjustment action. The interrupt flag, Manual_Action_Flag, would be initialized to one. When the interrupt program ends, it returns Manual_Action_Flag to the main program. Next, the single chip reads the logical status of the mechanical switch, Left_or_Right_Selection by using its I/O pin. If the result logical state of Left_or_Right_Selection flag is equal to one, this means that the user hopes the system controller to manually adjust the external left-side rear view mirror. There is a LED, named as Left_Mirror_LED, is connected with the digital input pin RC4 is lighted too. Otherwise, the required action of user is namely to manually adjust the external right-side rear view mirror. Of course, there is a LED, named as Right_Mirror_LED, is also connected with the single-chip digital input pin RC5 would be lighted at the same time.

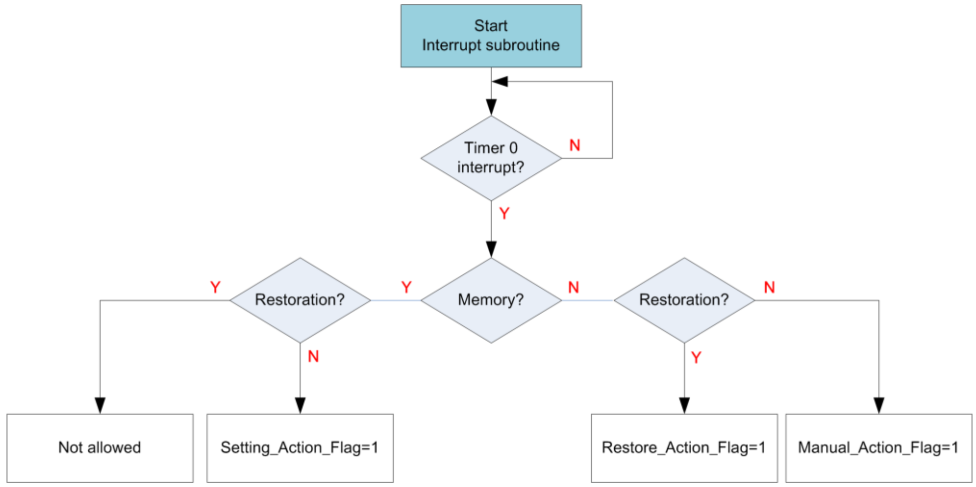

Figure 8. Sketches that the flowchart of interrupt service program when Timer 0 overflows.

Figure 9. Demonstrates the operation flowchart of single-chip main program.

TABLE 2 LIST EVERY COMBINATION BETWEEN THE THREE MECHANICAL SWITCHES AND THE CORRESPONDING ACTIONS.

Items	Switces status	Corresponding flag	Operating mode
1	Setting=0,Restore=0	Manual_Action_Flag=1	Manual operating mode
2	Setting=1,Restore=0	Setting_Action_Flag=1	Memory operating mode
3	Setting=0,Restore=1	Restore_Action_Flag=1	Restoration operating mode
4	Setting=1,Restore=1	Not Allowed	Not allowed

If the returned interrupt flag, Setting_Action_Flag, is equal to one, this represents that user hopes the system controller to run the memory action. The following steps are included in the memory action. All working sequence is sequentially listed and simply described in the following:

Step 1: A LED, named as Setting_Action_LED, is always turned on during the memory action process.

Step 2: Waits for the user to select and press a fast key among four mechanical switches F0, F1, F2, and F3.

Step 3: Once a fast memory key has been pressed, this represents that the system controller has realized the beginning memorizing address inside of single-chip EEPROM memory. Four byte locations are reserved for memorizing the dual-axis inclined angles of two external rear view mirrors.

Step 4: If the system controller has completed the memory action and there is no another new command is order by user again, the system controller automatically returns to the defaulted manual adjustment action mode.

Regularly, the single chip will timely acquire the user's command by cyclically reading and judging the dynamic status of all command keys (mechanical switches). Whenever the user presses the "restore" key on the control panel, the single chip immediately receives this command during the execution process of an interrupt subroutine program. A special flag, Restore_action_flag, this flag represents that the restoration command has been ordered by user is set to one and returned to the single-chip main program. The main program realizes the restoration action mode has been enabled to work through reading the status of Restore_action_flag during an execution of a interrupt subprogram program. Single chip starts running the defaulted restoration action of the proposed system. All the restoration actions and sequences are listed and described as follows:

Step 1: A LED, it is called as Restore_Action_LED, is always turned on when the restoration action has not been finished.

Step 2: Waits for user to select a fast key from among F0, F1, F2, and F3.

Step 3: The single chip reads four bytes data from the single-chip EEPROM memory. They represent those dual-axis inclined angles. They are also served as the reference values in the executing process of the hysteresis algorithm.

Step 4: Reads the present dual-axis inclined angles from the outputs of a dual-axis inclined angle sensory unit.

Step 5: Once the restoration action has been completed by the proposed system, the Restore_Action_LED is turned off right now. The proposed system automatically returns to the manual adjustment action mode.

In the restoration action process, the present dual-axis incline angles are acquired by reading the outputs of a pair of inclined angle sensory unit which are fixed on the X-axis and Y-axis mechanical mechanism, respectively. To complete the tracking of the dual-axis reference inclined angles, there are lots of method can be used, for examples, the hysteresis tracking method, zero or maximum tracking and reference-point tracing and so forth. For simplification, the hysteresis tracking method is adopted as the controlling algorithm during the restoration action process. The final controlled precision of the proposed system depends on the both the precision of dual-axis mechanical mechanism and the default upper and lower limitations in hysteresis tracking algorithm. More the upper and lower limitations are, greater angle error is.

V. Experiments and Discussions

Mechanically Decoupling Experiment Between X axis and Y axis

In theory, the mechanical mechanism in X axis and Y axis in the same explored automotive rear view mirror should be decoupled each other. The motion in the X-axis and Y-axis directions are always in perpendicular in space. When the X-axis mechanism is driven to incline an angle in the clockwise or counterclockwise direction, the Y-axis mechanism should not affected at all. Contrarily, it is true too. This outstanding characteristic of the mechanical mechanism of the proposed system is often necessary for user to achieve automatically restoring the memorized dual-axis inclined angles at controlled mirror as soon as possible.

Fig. 10 and Fig. 11 show that the X-axis (or Y-axis) mechanism is driven to incline an angle. The Y-axis (X-axis) mechanism is almost kept at stationary position leading to unchanged output analog voltage of the incline angle sensory unit. The rotation of the X-axis mechanical mechanism is not affected by the Y-axis mechanical mechanism. In other words, they are mechanically decoupling each other. It is helpful for the new proposed system to run the restoration action.

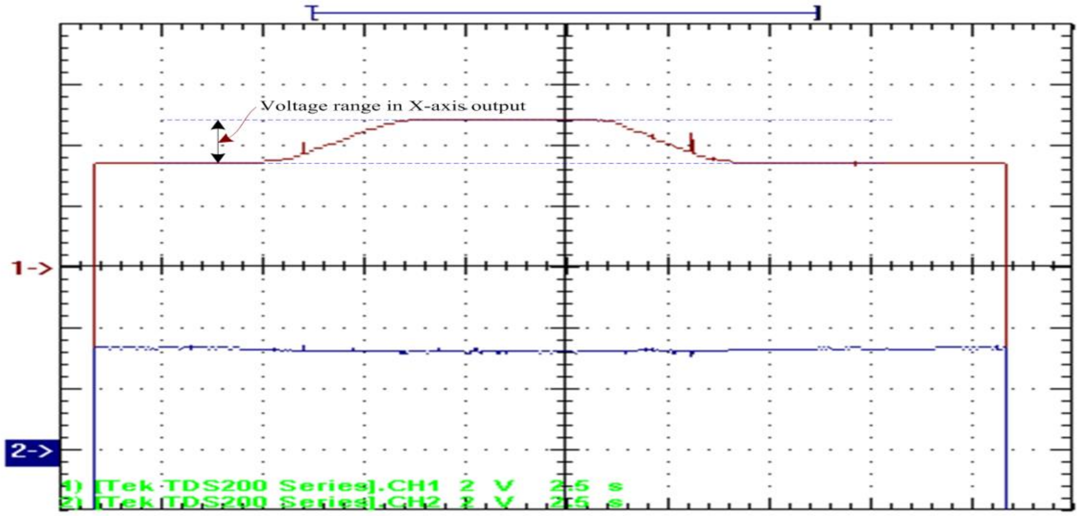

Figure 10. Shows the inclined angle in the Y-axis mechanism is almost affected when the X-axis mechanism intends to incline an angle.

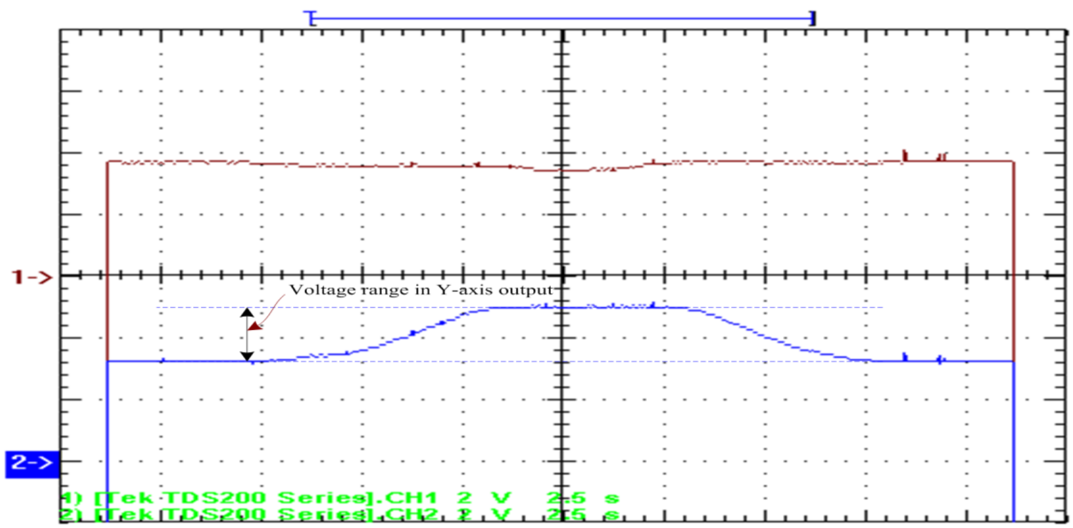

Figure 11. Shows the inclined angle in the X-axis mechanism is almost affected when the Y-axis mechanism intends to incline an angle.

B. The Completed Prototype of the Proposed New System

Fig. 12 demonstrates the completed prototype picture of the proposed system. The mechanical mechanism of the proposed system is acquired from the modification of the conventional electric automotive rear view mirror. A pair of dual-axis inclined angles sensory units is respectively fixed on the X-axis and Y-axis mechanical mechanism of the conventional system, as shown in Fig. 12. One-axis inclined angle sensory unit is composed of a permanent magnet and a linear Hall-Effect IC. The output voltage of an axis inclined angle sensory unit is a linear analog voltage and proportional to the physical mechanical inclined angle.

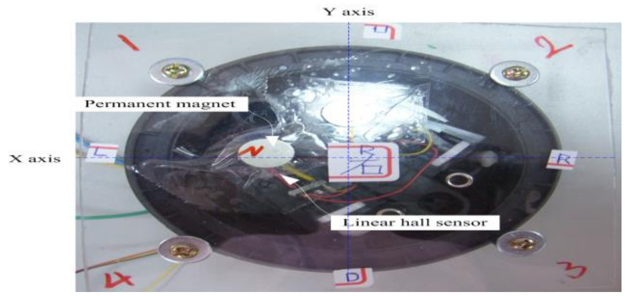

Figure 12. Demonstrate the completed prototype picture of the proposed automotive rear view mirror.

C. Integration of Hardware Circuit and Software Program

According the above-mentioned the designing ideas regarding to the function of hardware circuit and the operating flowchart of software program of the proposed system, a experimental prototype has been completed in the laboratory. The completed prototype is taken picture and shown in Fig. 13. The proposed system consists of three possible different operating modes. The operation of all possible actions accompanies to the prototype is described as follows:

(1) Manual operating mode: If no operating mode is set, the system is default to work in the manual operating mode. Meanwhile, the single chip reads the switch status in L/R_CS. If the logical level of this switch is high, the system control aims to work for the external left side automotive rear view mirror. A LED, named as Left_Mirror_LED, will be lighted. Otherwise, the system control aims to work for the right side automotive rear view mirror. In the similar manner, a LED, named as Right_Mirror_LED, is lighted too.

(2) Memory operating mode: After the user have pressed the “Setting key”, a LED, named as Setting_Action_LED, is immediately turn on. On the one hand, the purpose is to inform of user about that the current system is performing the memory operation mode. On the other hand, the system is waiting for user input shortcuts for memorizing the dual-axis inclined angles in the left and right rear view mirrors. Both the Setting key and shortcut have been pressed, the system controller will immediately memorized dual-axis inclined angles of two rear view mirrors into single-chip EEPROM momory. The LED, Setting_Action_LED, is turn off right now when the memory operating mode ends.

(3) Restoration operating mode: After the user have pressed the Restore key, a LED, named as Restore_Action_LED, is turn on right now. On the one hand, the purpose is to inform of user about that the current system is performing the restoration operation mode. On the other hand, the system is waiting for user input shortcuts for restoring the dual-axis inclined angles in the left and right rear view mirrors from the single-chip EEPROM memory. Both the Restoring key and shortcut have been pressed, the system controller will immediately remembered dual-axis inclined angles of two rear view mirrors from the single-chip EEPROM momory.The LED, Restore_Action_LED is turn off right now when the restoration operating mode ends.

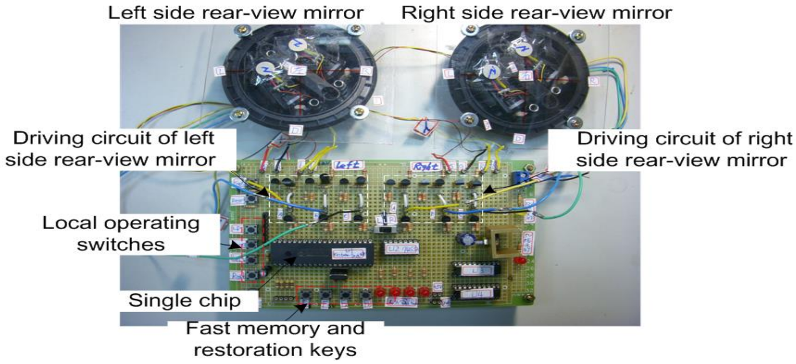

Figure 13. Shows the appearance of the completed prototype picture.

VI. Conclusions

In order to adjusting the dual-axis inclined angles in the left and right sides of rear view mirror, some mechanical switches are used as the system controller in the conventional electric automotive rear view mirror. As the driving-safety knowledge is increasingly more for most of automotive consumers, the system operating efficiency and function are also required to promote. In addition to the dual-axis adjustment function, like the conventional one, a new external automotive rear view mirror with both memory and restoration functions is designed and produced. The function of this new proposed system is increased. The mechanism becomes complex and the manufacturing cost increases too. At present, this new proposed system is only used in the high-end class vehicles by the automobile maker. Compared to the conventional rear view mirror, the operating efficiency of the new proposed system is very outstanding. The human-machine operating interface can be accepted by lots of automobile consumers. The operation of the new system controller is independent of the original automobile computer system. It is no use connecting each other. Moreover, it is not required to obtain the original automobile plant patents. It is very suitable for the middle-end and low-end cars in the after market. The proposed new system can improve the user convenience and driving safety.

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REFERENCES

[1] K. T. Song, C. H. Chen, and C. H. Huang, “Design and Experimental Study of an Ultrasonic Sensor System for Lateral Collision Avoidance at Low Speeds,” IEEE Intelligent Vehicles Symposium, 2004, pp. 647 – 652.

[2] Y. A. He and W. B. Zhang, “Modern Analysis and Prospect of the Rear-view Mirrors,” Hai Xia Ke Xue, Vol. 10, 2010, pp.147-149.

[3] T. Wada, M. Yoshida, S. Doi and S. Tsutsumi, “Characterization of Hurried Driving Based on Collision Risk and Attentional Allocation,” 13th Int. IEEE Conf. on Intelligent Transportation Systems, 2010, pp. 623 – 628.

[4] J. Zheng and X. Chen, "The Research of Vehicles' Rear-View Mirror Contours' Visual Pattern Based on Machine Vision," Remote Sensing, Environment and Transportation Engineering (RSETE), Int. Conf. on Remote Sensing, Environment and Transportation Engineering (RSETE), 2011, pp. 5461 – 5464.

[5] S. Pardhy, C.Shankwitz and M. Donath, "A Virtual Mirror for Assisting Drivers," Proc. of the IEEE Intelligent Vehicles Symposium, 2000, pp. 255 – 260.

[6]Chatchik B. "An Overview of the Bluetooth Wireless Technology,"IEEE Communication Magazine, 2001,39(12), pp.86-94.

[7] K. C. Hu, F. Y. Lin, C. C. Chien, T. S. Tsai, C. H. Hsia, and J. S. Chiang, "Panoramic Image Stitching System for Automotive Applications," IEEE Int. Conf. on Consumer Electronics - Taiwan (ICCE-TW), 2014, pp. 203 – 204.

[8] S. Pardhy, C. Shankwitz, and M. Donath, "A Virtual Mirror for Assisting Drivers," Proc. of the IEEE Intelligent Vehicles Symposium, 2000, pp. 255 – 260.

[9] R. L. Zheng, J. F. Qian, and J. Yong, "The Control System of Electric Memorial Back Mirror in Automobile,"Automobile Technology, Vol. 2, 2005, pp. 23-26.

[10] M. B. van Leeuwen and F. C. A. Groen, "Motion Estimation in Image Sequences for Traffic Applications," Proc. of the 17th IEEE Conf. on Instrumentation and Measurement Technology, Vol. 1, 2000, pp. 354 - 359.

[11] J. Morrell and K. Wasilewski, "Design and Evaluation of a Vibrotactile Seat to Improve Spatial Awareness While Driving," IEEE Haptics Symposium, **2010**, pp. 281 – 288.

[12] S. Pardhy, C.Shankwitz, and M. Donath, "A Virtual Mirror for Assisting Drivers," Proc. of the IEEE Intelligent Vehicles Symposium, **2000**, pp. 255 – 260.

[13]Bray J., Sturman C. F., Bluetooth Connect Without Cables, Second Edition, New Jersey: Prentice Hall PTR, 2002.

[14]Microchip PIC16F877A IC Datasheet, http//www.microchip.com/.

[15]App Inventor website, http://appinventor.mit.edu.

[16] B. C. Kuo, Automatic Control Systems, John Wiley & Sons, Inc. 8th Edition, 2003.

[17] WSH137, Linear Hall-Effect Sensor IC, http://www.winson.com.tw/Data%20Sheet/WSH137.pdf

[18] R. J. Fisher., Memory Positioning System for Remote Control Rear-view Mirror: U.S., 678295, 1987-07-07.

[19] R. F. Hansen, Memory Mirror Control System for Vehicles and the Like :U.S., 4929878, 1990-05-29

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